CERN/SPC/1090
CERN/FC/6124
CERN/3310
Original: English
26 May 2017

Medium-Term Plan

for the period 2018-2022 and Draft Budget of the Organization for the sixty-fourth financial year 2018

Action to be taken		Voting Procedure
For recommendation to Council	**SCIENTIFIC POLICY COMMITTEE** 304th Meeting 12-13 June 2017	–
For recommendation to Council	**FINANCE COMMITTEE** 360th Meeting 13-14 June 2017	Chapters I and IV.1: Simple majority of Member States represented and voting (abstentions are not counted) and 70% of the contributions of the Member States represented and present for the voting (abstentions are counted as votes against) and at least 51% of the contributions of all Member States. Chapter III: Two-thirds majority of Member States represented and voting (abstentions are not counted) and 70% of the contributions of the Member States represented and present for the voting (abstentions are counted as votes against) and at least 51% of the contributions of all Member States.
For approval	**COUNCIL** 185th Session 15-16 June 2017	Chapters I and IV.1: Simple majority of Member States represented and voting (abstentions are not counted). Chapter III: Two-thirds majority of Member States represented and voting (abstentions are not counted).

GENEVA, June 2017

Council is invited to:

- approve the overall strategy for the reference period as outlined in Chapter I of the document and elaborated upon in the Appendices (Chapter IV.1);
- take note of the Resources Plan for the years 2018 to 2022 (Chapter II);
- approve the 2018 Draft Budget in 2017 prices (Chapter III).

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I. OVERALL STRATEGY AND OBSERVATIONS OF THE DIRECTOR-GENERAL

Scientific objectives

The Medium-Term Plan (MTP) presented in this document describes CERN's scientific strategy and financial plan for the next five years and gives a longer-term view over ten years. The scientific strategy reflects the priorities outlined in the 2013 update of the European Strategy for Particle Physics (ESPP). The next update of the ESPP will take place after the end of the LHC Run 2 and is scheduled to be adopted by the Council in May 2020. This is an important milestone for the field as the conclusions of the ESPP update will have an impact on CERN's plans for the period after 2020. For this reason, the ten-year view for the part of the programme other than its major component, the LHC and its upgrades, inevitably comprises a degree of uncertainty beyond 2020.

In accordance with the current ESPP, CERN's scientific strategy has three main strands:

- full exploitation of the LHC through the high-luminosity phase;
- maintaining and updating a diverse complementary programme serving a broad community, including neutrino activities in support of Europe's participation in accelerator-based projects in the US and Japan;
- preparing for a post-LHC high-energy accelerator project through design studies and vigorous accelerator R&D.

Studies of the opportunities offered by post-LHC high-energy accelerators, and by other future projects nourishing a diverse scientific programme, are aimed at providing extensive input for the ESPP update, so that informed decisions can be taken on the future direction of the field, along with the latest results from the LHC and from other ongoing experiments at CERN and elsewhere in the world.

The MTP described in this document implements these scientific objectives within a technically and financially affordable plan.

Full exploitation of the LHC, the most powerful collider in the world today and for many years to come, requires first the successful completion of Runs 2 and 3 (with target integrated luminosities of 150 fb^{-1} until the end of Run 2 and 300 fb^{-1} until the end of Run 3 for the general-purpose experiments ATLAS and CMS) for which the existing schedules are unchanged: Run 2 will continue until the end of 2018 and Run 3 will start in 2021 after a two-year long shutdown (LS2). The high luminosity phase of the LHC will then commence in the middle of the next decade, after another long shutdown (LS3, 2024-2026), with the aim of providing 3000 fb^{-1} to both ATLAS and CMS after about ten years of operation. This large integrated luminosity will enable precise measurements of the Higgs boson properties, including access for the first time to the couplings to the second-generation fermions through the rare $H \to \mu\mu$ decay, as well as improved sensitivity to new physics through direct searches.

After a very successful run in 2016, with unprecedented challenges for and performance of the accelerators, detectors and computing, the extended year-end technical stop (EYETS) saw the installation of a new pixel detector in the CMS experiment and the replacements of the SPS beam dump and one dipole magnet in sector 1-2. The LHC operation parameters for 2017 were defined following the annual LHC performance workshop held in January. The peak luminosity is expected to reach 1.7-1.9 x 10^{34} $cm^{-2}s^{-1}$ (limited by the cooling capacity of the inner triplet quadrupoles), and the integrated luminosity to be ~45 fb^{-1} for both ATLAS and CMS over 145 days of proton-proton running. It was also decided to continue operation at 13 TeV until the end of Run 2 and to move to 14 TeV in Run 3 if the dipole bypass diodes can be consolidated during LS2 (see below for more details). The LHC Injectors Upgrade (LIU, installation in LS2, 2019-2020) and the High-Luminosity LHC (HL-LHC, installation in LS3, 2024-2026) projects have entered the construction phase. A second cost and schedule review, which took place in October 2016, reported excellent progress and provided assurance about the solidity of the cost and schedule of both projects[1]. The four major LHC experiments have also entered the construction stage of their Phase-1 upgrades, aiming for installation mostly during LS2; both ALICE and LHCb plan major upgrades in LS2. The second phase of the upgrades, mainly for ATLAS and CMS, will take place during LS3; both experiments are now developing detector designs and prototypes, with most of the Technical Design Reports expected to be submitted in 2017 and 2018.

The diverse scientific programme includes the ongoing experiments and projects at the Booster, PS, SPS and their upgrades, as well as the Neutrino Platform. The HIE-ISOLDE upgrade, aiming at eventually post-accelerating isotopes up to 10 MeV/nucleon using a superconducting Linac, achieved energies of 5.5-6.8 MeV/nucleon in 2016 with the operation of the first two cryomodules. A third cryomodule was installed in January 2017 and will come into operation later in the year. The HIE-ISOLDE upgrade will be completed in 2018 with the installation of the fourth and final cryomodule. In 2016, the installation of the TSR storage ring at HIE-ISOLDE was the subject of an in-depth review of the estimated cost and personnel requirements. Regrettably, due to the limited resources available at CERN, notably in terms of personnel, the project could not be pursued. The vibrant programme at the Antiproton Decelerator (AD), the only dedicated antiproton facility in the world, is currently based on six experiments (of which one, GBAR, under construction) aiming at very precise measurements of antiprotons and anti-hydrogen atoms, including spectroscopic and gravity measurements. A remarkable milestone was reached in 2016, with the first measurement of the spectral line of antihydrogen 1s → 2s transition by the ALPHA experiment. Commissioning of the ELENA ring, which will provide lower-energy (100 keV), lower-emittance antiproton beams enabling larger experimental trapping efficiency, is well advanced and the GBAR experiment will be connected in 2017. The fixed-target programme continues apace, including hadron structure and spectroscopy at COMPASS/NA58, heavy-ion and neutrino-related cross-section studies at SHINE/NA61, and the search for rare kaon decays at NA62, amongst others. The CLOUD experiment studies the impact of cosmic rays on cloud formation (relevant to climate change) using proton beams from the PS. Non-accelerator projects include the axion-search experiments OSQAR and CAST.

The Neutrino Platform provides infrastructure and support for R&D on neutrino detectors, a new hall in the North Area (NA) for beam tests of (large) detector prototypes, and construction of detector components. The refurbishment of the ICARUS liquid-

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[1] 2nd LIU-HL/LHC Cost & Schedule Review Executive Summary

argon time-projection chamber (TPC) for use in the short-baseline neutrino programme at Fermilab was successfully completed early in 2017, and the detector is now ready to be shipped to the US. Construction of prototype liquid-argon detectors for the DUNE long-baseline experiment at Fermilab, based on the single-phase and double-phase TPC technologies, has begun, with CERN providing the infrastructure and the cryostats. The plan is for both prototypes to take test beam data at the NA before the end of 2018, although the schedule is tight. CERN is also building the cryostat for the first (of four) module of the DUNE detector, housing a 17-kton liquid-argon TPC and based on the membrane technology used for liquefied natural gas; the design is well advanced. The construction of the Baby MIND magnetic spectrometer for the WAGASCI experiment at J-PARC is nearing completion and the detector will be shipped to Japan in summer 2017 after a beam test at the PS.

The Physics Beyond Colliders (PBC) study group, established at the beginning of 2016, had a very successful kick-off meeting in September 2016 and is now fully operational with an organisational structure comprising several working groups. The goal is to prepare the future of the scientific diversity programme by exploring unique opportunities offered by the CERN accelerator complex to address some of today's outstanding questions in particle physics through projects complementary to high-energy colliders and other initiatives in the world. Options currently being studied include a beam-dump facility at the NA, primarily to search for dark-sector particles, an electrostatic storage ring for proton EDM measurements and several projects dedicated to ultra-precise measurements or to searches for light, extremely-weakly-coupling particles. A report will be produced by the end of 2018, in time for the update of the ESPP.

Preparation for a future high-energy accelerator proceeds along two lines: a vibrant accelerator R&D programme (including high-field superconducting magnets, high-gradient accelerating structures and novel acceleration techniques); and design studies for future accelerators: CLIC (Compact Linear Collider) and FCC (Future Circular Colliders).

After the completion of the Conceptual Design Report in 2012, the main goals of the CLIC collaboration for the next update of the ESPP are to develop a plan for a staged implementation of the accelerator (starting at a centre-of-mass energy of 380 GeV for Higgs boson and top quark measurements), to review the project's cost and schedule, and to complete key R&D work relating to technical feasibility. Several design and R&D studies of accelerator and detector components are being carried out in synergy with the International Linear Collider (ILC), a possible future project to be sited in Japan. The tests of CLIC's two-beam acceleration scheme at the CTF3 facility were completed in 2016. The CTF3 80-220 MeV electron Linac is now available for users as a new standalone facility, called CLEAR (CERN Linear Electron Accelerator for Research).

The FCC design study targets a ~100 TeV proton-proton collider in a ~100 km ring, using 16 T superconducting magnets based on niobium-tin (Nb_3Sn) technology. Progress has been made e.g. on geological studies of the tunnel, on the definition of the accelerator baseline parameters, layout and optics, and on the design of the superconducting magnets. An electron-positron collider in the same tunnel, providing ultra-precise measurements of Z, W, Higgs bosons and top quarks, is also being examined as a possible first step, as well as an electron-proton collider option. Also included in the FCC study is the so-called High-Energy LHC (HE-LHC), which would deploy the magnet technology being developed for the FCC proton-proton collider in the existing LHC tunnel, allowing for proton-proton collisions at ~28 TeV in the centre of mass and re-use of a large part of the existing infrastructure. The goal of the FCC studies is to produce a Conceptual Design Report, including first cost estimates, by the end of 2018, as an input to the ESPP update.

The AWAKE project aims to demonstrate a novel acceleration technique based on wakefield acceleration of electrons in a 10-m plasma cell. The uniqueness of AWAKE, compared with similar projects elsewhere in the world, is that the plasma wakefields are produced by high-energy, high-intensity protons from the SPS. The goal is to achieve electron acceleration of 1-few GeV per metre before LS2, which would open the door, in the long term, to reaching multi-TeV energies with compact machines. A major milestone was achieved during the first physics run at the end of 2016, with the observation of self-modulation instabilities of the proton bunches in traversing the plasma. The plan for 2017 is to commission the electron beam line and to demonstrate first electron acceleration.

Other activities

Safety is a key priority for the Organization, aiming at protecting people, the environment and the infrastructure. Ongoing or planned projects in this area include: bringing the SPS into full compliance with fire safety standards during LS2; radioactive waste management and safe elimination at least at the same pace as in 2016, when 1200 m^3 of weakly-radioactive waste was eliminated (out of a total of 7500 m^3 on site), four times more than was produced over the same period; enhancing safety training opportunities for employed members of the personnel, users and contractors in preparation for LS2; following up on safety inspections by addressing identified non-conformities; increasing awareness of environment protection aspects and minimising the Laboratory’s impact on the environment. In the latter regard, a CERN Environmental Protection Steering board (CEPS) was established in 2016 and started to work in 2017 with the goal of defining objectives and implementation priorities for 11 key topics[2].

The main **technical and general infrastructure** projects over the coming years include: the civil engineering work at the ATLAS and CMS experimental sites (during LS2) to provide service caverns and shafts for the installation of HL-LHC equipment; the extension of the SM18 hall to provide additional space for testing crab cavities and other HL-LHC accelerator components; the renovation of the East Area during LS2; the completion of ongoing building construction projects (e.g. Buildings 107 and 311).

In the area of **International Relations,** the process of geographical enlargement will continue in line with the strategy presented to the Council in March 2016, aimed at bringing ongoing application processes to a conclusion and ensuring targeted engagement with specific countries. India joined CERN as an Associate Member State in January 2017, Slovenia will become an Associate Member State in the pre-stage to Membership by August 2017 and Lithuania is expected to become an Associate Member State during 2017, subject to the Council’s approval. The Management is pursuing discussions with several countries that have expressed interest in Associate

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[2] Ionising radiation, air protection, water protection, soil protection, hazardous substances, environmental noise, waste management, energy management, non-ionising radiation, prevention of environmental accidents, protection of natural resources.

Membership, while countries with developing communities are engaged with the Organization through International Cooperation Agreements.

Additional education, communications and outreach (ECO) initiatives are being developed to promote CERN's mission and broad societal impact. Particular emphasis will be placed on maintaining relations with the community of former employed and associated members of the personnel through the new Alumni Programme, to be launched in June 2017; on expanding options for high-school students and teachers, notably through the new High School Student Internship Programme and S'Cool Lab Summer Camps; on pursuing a stronger web and social media presence; on developing plans and structures to expand the opportunities for visitors and to provide broader educational programmes. Two major outreach events are planned, namely participation as Honorary Host at the traditional *Automnales* exhibition in Geneva in November 2017, and an Open Day event in 2019 or 2020 (during LS2) to mark the 10th anniversary of the beginning of LHC operation.

Key Performance Indicators

Key Performance Indicators (KPIs) were introduced for the first time in the 2016 Annual Progress Report (APR) presented to the SPC, FC and Council in March 2017. Their scope will be further developed in future APRs, and a trend analysis showing their evolution over time will be added.

Overall strategy and changes since the previous MTP

The present MTP is the continuation of the 2017-2021 MTP. The budget allocated to the various projects and activities reflects the scientific strategy and compelling scientific programme outlined in the previous section. Resources are also secured for the consolidation and improvement of the Laboratory's technical and general infrastructure so as to ensure the safe and efficient operation of the experimental facilities and to provide satisfactory services to the (ever growing) worldwide user community[3].

The priorities of the field for the next decade will be defined in the framework of the update of the European Strategy for Particle Physics to be concluded in May 2020; nonetheless, this MTP includes preliminary budget allocations also for future projects other than the LHC upgrades. A "High-energy frontier" line, amounting to 30 MCHF per year, is retained beyond 2020 to preliminarily cover accelerator R&D activities for a future high-energy collider. Similarly, the Neutrino Platform activity continues to be funded beyond 2020, after completion of the cryostat for the first module of the DUNE detector, with a preliminary annual allocation of 6 MCHF. Finally, the "Physics Beyond Colliders" line, shown explicitly in this MTP for the first time, provides a budget allocation to these studies up to 2019 in order to prepare the necessary input for the ESPP update (e.g. to complete technical feasibility studies for a possible beam-dump facility at the North Area, and to perform initial civil engineering studies for a possible proton EDM ring at CERN); a nominal annual budget of a similar level is earmarked from 2020 to 2024 to pursue design and R&D studies for the project(s) identified as priorities

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[3] The number of users increased by almost a factor of two over the last ten years, exceeding 11,800 people in 2016.

in the updated ESPP, and a higher level of funds (for construction) after 2024.

Over the past months, a number of items that were only partially funded or not anticipated in previous MTPs have been identified. These items, which now require allocation of resources because of their urgency and criticality, include:

- In December 2016, the SPC, the FC and the Council were informed of the Management's intention to recruit about 80 additional staff on limited-duration (LD) contracts to cover key technical areas that were severely under-staffed (CERN/3281). This is intended as a one-off measure and not as a permanent increase in the staff complement. The cost is about 13 MCHF per year, i.e. some 65 MCHF over the period 2018-2022, to be covered by a reallocation of resources from the materials budget to the personnel budget.
- Following discussions at the annual LHC performance workshop in January 2017, and an in-depth resources evaluation, the Management has decided to consolidate the cold bypass diodes underneath the 1232 LHC dipole magnets (one diode per magnet to extract the current from the magnet in the event of a quench) in order to improve their electrical insulation. This decision follows the occurrence of two shorts to ground during training campaigns in 2015 and 2016 due to metallic dust (the likely remnants of the initial welding of some of the magnet components) falling by gravity inside the diode box during a quench. Although both shorts were successfully burned by electrical discharge from a capacitor, this method is rudimentary and success cannot be guaranteed; if the problem could not be solved in this way, it would be necessary to warm up one or more sectors and stop the LHC for at least three months. Risks of shorts are particularly serious every time the dipoles are retrained to 6.5 TeV after a thermal cycle, and as of today represent a major obstacle to raising the LHC energy to 7 TeV. LS2 provides a unique opportunity to consolidate the diodes because, unlike in LS3, little work is expected in the LHC tunnel, as most of the activities will take place in the injectors (LIU project). The cost of the diode consolidation work is about 10 MCHF.
- The consolidation of the electrical distribution network, which dates back to the LEP times (it was installed in 1985-1988), started in 2012. Recently, additional expenses amounting to about 20 MCHF (i.e. some 20% of the total cost of the project) were identified, due to cost underestimations, as well as omission of certain components (e.g. reactive energy compensation), when the consolidation project was initially defined.
- Over the past months, the four main LHC experiments have reviewed in detail their needs from CERN as host laboratory for the period up to and including LS2. Their requests have been discussed and scrutinised together with the relevant CERN departments and units (mainly EN, SMB, HSE) and include civil engineering work (e.g. extension of existing buildings to test detector components for the Phase-1 and Phase-2 upgrades), transport of equipment, connections to the electrical and cooling networks, etc., for a total cost to CERN of about 20 MCHF.
- Within the framework of the RRB (Resources Review Board), the Funding Agencies of the countries involved in the LHC experiments agreed to provide constant annual financial contributions to the worldwide LHC Computing Grid (WLCG), considering an expected 20% yearly increase in computing power for a fixed price (the so-called "Moore's

law”). However, the better-than foreseen performance of the LHC in 2016, similar expectations of over-performance in the years to come, as well as the observed “saturation” of Moore’s law are putting the WLCG resources under serious strain. The experiments have made extensive efforts to improve their simulation and reconstruction software and their computing models, so as to minimise the need for additional resources. Further measures (e.g. reduction of the trigger rates) will start to cut into their physics reach. The Funding Agencies have been asked to contribute more resources on a best-effort basis. CERN is the Tier-0 of the WLCG, and as such the custodial repository of the raw data and the site of the first-pass reconstruction. In the present MTP, CERN’s contribution to the WLCG resources has been increased by about 5% (about 1 MCHF per year) compared to the previous MTP, corresponding to a total of 8 MCHF over the period 2018- 2027.

- Additional funding, at the level of 1.7 MCHF per year, has been allocated to the operations budget of the IT Department. This represents an increment of about 10%, and is justified by incompressible expenses (e.g. licenses, whose costs increase with increasing number of users, and maintenance contracts) and the need to maintain crucial services for the users and for the operation of the Laboratory.
- Additional resources have been secured in this MTP to cover high-priority items in matters of safety, including: follow-up of electrical inspections, safety support to the LHC experiments, enhanced training capabilities with a view to LS2 (including a larger safety training centre), measures to minimise the impact on the environment in the framework of the CEPS board mentioned above (e.g. noise reduction close to the site of the ALICE experiment). The additional budget allocation over the period 2018-2022 is about 7 MCHF.
- Following a general increase in the level of security alerts in Europe over the past couple of years, the Host States have asked CERN to reinforce the site security. Measures taken or planned include the presence of guards at CERN’s entrances and LHC access points, automation of entrances, and additional cameras for closed-circuit video surveillance, for a total cost of some 9 MCHF over the period 2018-2022 and 14 MCHF over the period 2018-2027.
- Other additional expenses compared to last year’s MTP include: an Open Day event (2 MCHF), scheduled for 2019 or 2020 on the occasion of the 10th anniversary of the start-up of LHC operation (similar events in 2008 and 2013 each attracted more than 70,000 visitors); the provision of gas to the fixed-target experiments for operation and maintenance activities (total of 3.5 MCHF over the period 2018-2022), as part of the host laboratory responsibilities; a second network hub (2 MCHF) to provide essential redundancy in the event of a major incident in the computing centre building which houses the core network equipment and fibres.

The total additional expenses amount to ~160 MCHF over the period 2018-2022 and to ~200 MCHF over the period 2018-2027.

As part of the yearly MTP process, the Management scrutinised in detail all the budget lines, with the goal of securing resources for the full scientific programme and other high-priority activities while keeping the cumulative budget deficit (CBD) at the level of previous MTPs. Several savings were identified, including:

- A detailed review of the spending capability of projects and activities as a function of time allowed the re-profiling of some 30 MCHF of expenses over time, mainly for lower-priority and/or less-urgent items in the areas of infrastructure and technical consolidation, thus releasing the financial pressure in the coming five years when the bulk of the HL-LHC expenditure and the peak CBD are expected to occur.

- Last year's MTP included a budget (~30 MCHF) for the construction of a new building (Building 90), to provide office space for people presently located in Building 60 (Directorate, International Relations sector and related services and units) and other groups, as well as a new, bigger meeting room for Council meetings. This project has now been postponed to the end of the deficit period (start of construction in 2026), allowing the reprofiling of about 15 MCHF beyond the period covered by this MTP. On the other hand, the budget of 10 MCHF for the renovation of Building 60, in particular to bring it into full compliance with fire safety standards, has been preserved.
- In 2016, some operational savings were achieved as a result of resources optimisation arising from the new organisational structure. The Directorate's expenses were lower than foreseen, and savings were made in the central administrative services following the implementation of first streamlining initiatives. This trend is assumed to continue over the coming years in the financial plan described in this MTP. Other savings, not included here, are expected in the future from the implementation of the recommendations of the External Review Committee of Finance and Human Resources, whose report was submitted to the Directorate in March 2017.
- Reductions have been made in budget allocations for materials due to the negative Cost-Variation Index (CVI of about -5% for materials), mainly as a result of the higher purchasing power of the Swiss franc for goods paid in Euros. Even though the number of fellows increased significantly over the past ten years (from about 250 in 2005 to about 750 in 2016), the Management decided to preserve the central budget for fellows in full.

The above savings allow the additional expenses to be covered, as described in more detail in the next section.

Financial and budget considerations

The coming ten years will be characterised by the construction of the HL-LHC within a constant CERN Budget. CERN is therefore entering into a period of budget deficit. Significant efforts have been made in this MTP to keep the deficit to the lowest possible level and in particular, as in previous MTPs, to maintain the peak CBD below -390 MCHF and to below ten years the period during which the deficit exceeds CERN's annual cash management capacity of around 250 MCHF (thereby requiring drawdowns on the European Investment Bank, EIB, credit facility).

As described in the previous section, additional expenses at the level of 160 (200) MCHF over the 2018-2022 (2018-2027) period have been included in this MTP to cover new items, which are critical for the optimal execution of the scientific programme and the safe operation of the site and the facilities. These additional expenses are compensated as described below:

- Savings have been identified at the level of ~50 MCHF from deferring the start of construction of Building 90 to 2026 and from administration and other budget lines;
- The execution of certain lower-priority consolidation activities has been reprofiled (~30 MCHF);
- The reductions in budget allocations for materials to account for the negative CVI will provide savings at the level of 150 MCHF over the period 2018-2027 (with respect to 2016

prices) when applied to all projects and activities except the highest-priority LHC upgrade project (LIU, HL-LHC, CERN's contribution to the Phase-2 upgrade of ATLAS and CMS), where the Management believes the Cost-to-completion should be protected against CVI fluctuations. These savings over 2018-2027 will be used to cover some of the additional expenses listed in the previous section, while savings of ~40 MCHF from the strong Swiss franc in 2016 and the negative CVI in 2017 have been used to reduce the CBD.

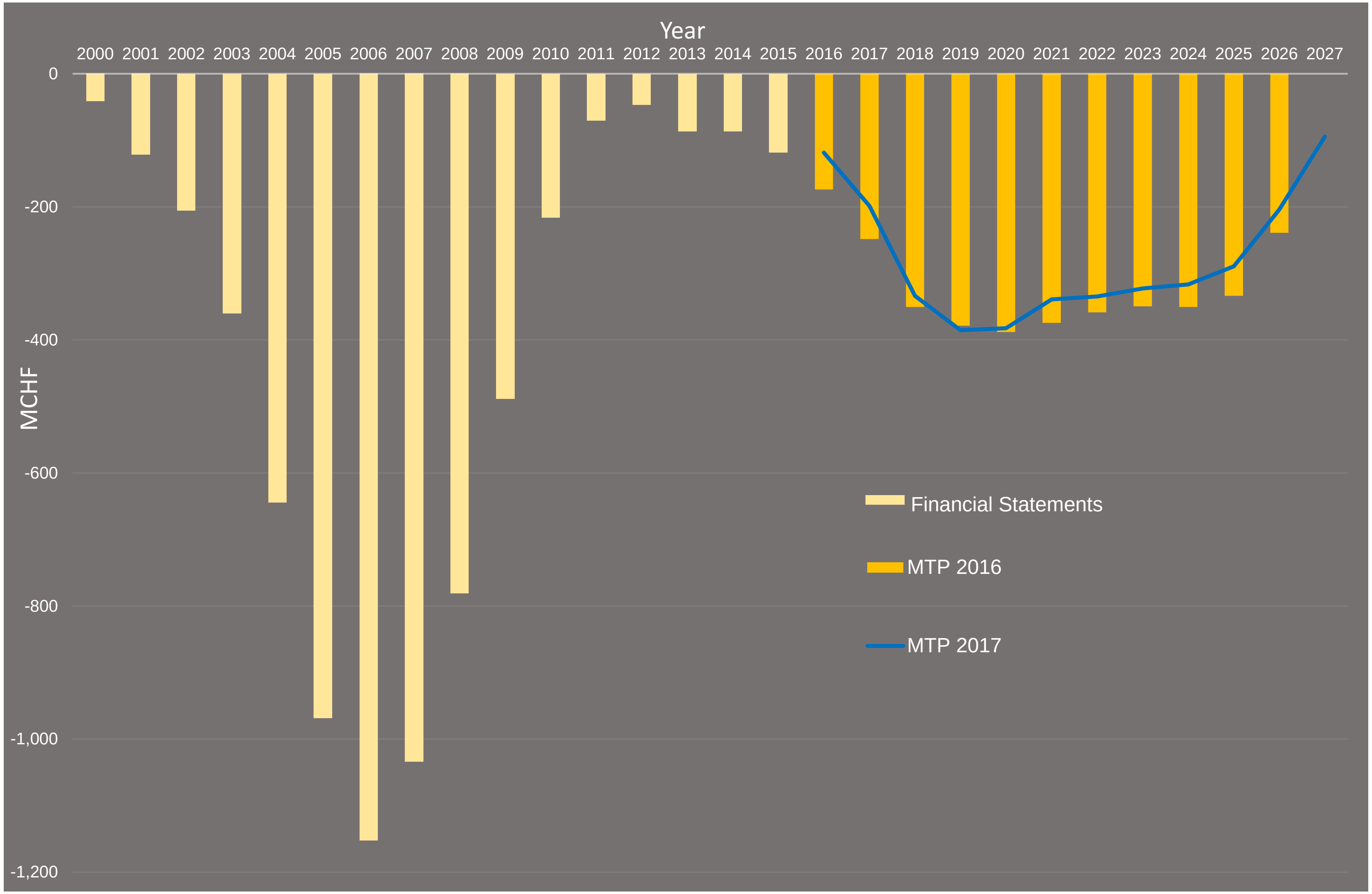
Should the CVI change substantially in the coming years, thus reducing the budget purchasing power, some of the additional expenses described in the previous section will have to be cancelled or postponed. The optimal strategy will be defined in due course based on the priorities and the available resources at the time.

The figure below shows the evolution of the CBD in MCHF as a function of time over the years 2000-2027. A substantial reduction of the CBD was achieved in 2016 (CERN/3294) and further reductions are expected in 2017, 2018 and in the years 2020 to 2026. The peak CBD is slightly lower than in previous MTPs (-385.5 MCHF, compared to -388.0 MCHF in the 2017-2021 MTP).

The 2018 budget balance is -333.7 MCHF (compared to -350.7 MCHF in the 2017-2021 MTP). No drawdowns on the EIB credit facility are needed in 2018. Potential cash shortfalls may appear towards the end of 2018 if payments of some contributions from Member States and Associate Members States are delayed, but these will be addressed within the yearly cash management process, possibly supplemented, towards the end of the year, by small short-term loans and bank overdrafts. Therefore, the period over which the EIB credit facility will be needed is reduced from eight to seven years. It is likely that the first tranche will have to be drawn down in 2019.

In conclusion, the financial plan presented in this MTP shows an improved CBD profile compared to the previous MTP (unchanged peak CBD and shorter deficit period), while allowing funding for additional crucial items, provided that no significant (positive) variations of the CVI occur in the coming years. CERN's compelling scientific programme is preserved in full.

Cumulative budget deficit over the years 2000-2027



II. RESOURCES PLAN FOR THE YEARS 2018-2022

1. REVENUES PLAN

Figure 1: Anticipated revenues

(in MCHF, 2017 prices, rounded off to 0.1 MCHF until 2022, 1 MCHF thereafter)	Revised 2017 Budget	2018	2019	2020	2021	2022	**Total 2017-2022**	2023	2024	2025	2026	2027	**Total 2017-2027**
REVENUES	**1,235.2**	**1,223.6**	**1,237.7**	**1,241.9**	**1,260.2**	**1,259.5**	**7,458**	**1,240**	**1,230**	**1,210**	**1,210**	**1,208**	**13,555**
Member States' contributions	1,119.9	1,119.9	1,119.9	1,119.9	1,119.9	1,119.9	6,719	1,120	1,120	1,120	1,120	1,120	12,319
Associate Member States' contributions	21.8	23.9	23.9	23.9	23.9	23.9	141	24	24	24	24	24	261
Contributions anticipated from new Associate Member States		2.0	2.0	2.0	2.0	2.0	10	2	2	2	2	2	20
Non-Member States contributions to HL-LHC			20.0	30.0	50.0	50.0	150	30	20				200
EU contributions	14.1	12.0	9.8	9.0	8.0	8.0	61	8	8	8	8	8	101
Additional contributions	8.1	1.2	0.9	0.8			11						11
for LINAC4, HIE-ISOLDE, ELENA, AWAKE, CLIC, FAIR	*8.1*	*1.2*	*0.9*	*0.8*			*11*						*11*
Personnel paid from team accounts	13.7	10.0	8.3	8.2	8.3	8.3	57	8	8	8	9	7	98
Personnel on detachment	1.0	0.8	0.8	0.7	0.7		4						4
Internal taxation	30.1	30.2	30.2	30.3	30.3	30.3	181	30	30	30	30	30	333
Knowledge transfer	2.3	1.7	1.5	1.1	1.1	1.1	9	1	1	1	1	1	14
Other revenues	24.2	22.1	20.5	16.0	16.0	16.0	115	16	16	16	16	16	195
Sales and miscellaneous	*6.9*	*6.5*	*6.0*	*6.0*	*6.0*	*6.0*	*37*	*6*	*6*	*6*	*6*	*6*	*67*
SCOAP3 revenues	*4.9*	*4.7*	*4.5*				*14*						*14*
OpenLab revenues	*2.3*	*0.8*					*3*						*3*
Financial revenues	*2.0*	*2.0*	*2.0*	*2.0*	*2.0*	*2.0*	*12*	*2*	*2*	*2*	*2*	*2*	*22*
In-kind[1]	*2.0*	*2.0*	*2.0*	*2.0*	*2.0*	*2.0*	*12*	*2*	*2*	*2*	*2*	*2*	*22*
Housing fund	*6.0*	*6.0*	*6.0*	*6.0*	*6.0*	*6.0*	*36*	*6*	*6*	*6*	*6*	*6*	*66*

[1] Theoretical interest on the FIPOI loan.

Comments on Figure 1:

The **Member States' contributions** include the contribution from Romania, which became a Member State in the third quarter of 2016.

The **Associate Member States' contributions** include the contributions from Cyprus and Serbia as Associate Member States in the pre-stage to Membership, and from India (which became an Associate Member State on 16 January 2017), Pakistan, Turkey and Ukraine as Associate Members. It is assumed that Serbia will become a Member State no later than 2018 and will pay 100% of its contribution as of 2018.

In accordance with the Council's decision on Greece's contribution (CERN/3258/RA), in 2018 Greece will pay 85% of its contribution for 2018 plus an annual instalment of the 15-year plan for the repayment of its arrears for the years 2014-2016. The remaining 15% of the 2018 contribution will have to be compensated as of 2019 under modalities yet to be decided.

Conservative assumptions are made for additional contributions from **new Associate Member States**, i.e. only countries at an advanced stage of negotiations are included: Slovenia is expected to become an Associate Member State in the pre-stage to Membership by August 2017 and Lithuania to become an Associate Member State during 2017.

This MTP includes all current agreements with the **EU** and future (conservative) contributions of about 8 MCHF p.a. These EU contributions are offset by expenses and thus have no impact on the budget balance.

Additional contributions are in-kind or cash contributions from collaborating institutes to projects such as HIE-ISOLDE, ELENA, AWAKE, or contributions to fund work made by CERN for other institutions (e.g. FAIR).

The compensation headings for **personnel paid from team accounts** or on **detachment** (i.e. funded by third parties) have no impact on the budget balance due to identical headings under expenses. These headings will be updated regularly to account for actual contract changes. **Internal taxation** is calculated for the book closing every year and will be adjusted (no impact on the budget balance due to the identical heading under expenses).

Knowledge transfer revenues are prudently assumed to remain at a constant level of 1.1 MCHF.

Other revenues:

- A conservative approach is maintained with regard to sales and miscellaneous. In the past, this heading proved to be significantly higher than expected and was therefore adjusted upwards to about 6 MCHF per annum, which is still conservative.
- External revenues from the SCOAP3 consortium are foreseen during the second phase of SCOAP3 (2017-2019). They are compensated by the same amount under expenses.
- The revenues and corresponding expenses for OpenLab for the years 2017-2018 are based on the contracts signed at the time of publication of this MTP.
- Financial revenues depend on when Member States' contributions are paid (the earlier they are settled, the higher this heading will be) and on the market interest rates.
- In-kind contributions are assumed to remain constant. They cover the theoretical interest on the FIPOI loans. The heading is kept at its current level for future years.
- The housing fund revenues are assumed to remain constant with time.

2. ESTIMATED EXPENSES AND BUDGET BALANCES

Figure 2: Estimated expenses and budget balances

(in MCHF, 2017 prices, rounded off to 0.1 MCHF until 2022, 1 MCHF thereafter)	Revised 2017 Budget	2018	2019	2020	2021	2022	**Total 2017-2022**	2023	2024	2025	2026	2027	**Total 2017-2027**
EXPENSES	**1,229.5**	**1,271.9**	**1,201.8**	**1,150.3**	**1,127.2**	**1,164.7**	**7,145**	**1,136**	**1,131**	**1,089**	**1,046**	**1,038**	**12,586**
Running of scientific programmes and support	**973.7**	**991.4**	**918.2**	**886.8**	**897.2**	**920.0**	**5,587**	**895**	**887**	**863**	**881**	**907**	**10,020**
Scientific programmes	**502.4**	**521.2**	**527.2**	**507.5**	**485.1**	**513.3**	**3,057**	**502**	**509**	**498**	**481**	**488**	**5,535**
LHC (machine, detectors, computing, including spares and consolidation)	*261.4*	*266.7*	*274.4*	*271.6*	*264.2*	*294.6*	*1,633*	*284*	*288*	*276*	*263*	*280*	*3,024*
Non-LHC physics and scientific support	*80.4*	*79.5*	*80.2*	*78.8*	*75.8*	*74.7*	*469*	*74*	*79*	*80*	*75*	*74*	*853*
Other accelerators and areas (including consolidation)	*160.6*	*174.9*	*172.7*	*157.1*	*145.1*	*144.0*	*954*	*143*	*142*	*142*	*143*	*134*	*1,658*
Infrastructure and services	**293.4**	**292.9**	**276.4**	**262.0**	**260.2**	**256.5**	**1,641**	**245**	**246**	**247**	**260**	**273**	**2,912**
General infrastructure and services (incl. admin, international relations, safety)	*252.1*	*258.5*	*258.4*	*246.3*	*241.7*	*230.4*	*1,487*	*227*	*228*	*229*	*230*	*229*	*2,631*
Infrastructure consolidation, buildings and renovation	*41.3*	*34.4*	*18.1*	*15.7*	*18.5*	*26.0*	*154*	*17*	*18*	*18*	*30*	*44*	*281*
Centralised expenses	**177.9**	**177.4**	**114.6**	**117.3**	**151.9**	**150.2**	**889**	**149**	**131**	**117**	**140**	**146**	**1,573**
Centralised personnel expenses	*36.3*	*36.3*	*36.3*	*36.3*	*36.3*	*36.3*	*218*	*36*	*36*	*36*	*36*	*36*	*400*
Internal taxation	*30.1*	*30.2*	*30.2*	*30.3*	*30.3*	*30.3*	*181*	*30*	*30*	*30*	*30*	*30*	*333*
Internal mobility, personnel on detachment, paid from team accounts	*15.0*	*10.8*	*9.3*	*9.4*	*9.5*	*8.8*	*63*	*9*	*9*	*9*	*9*	*9*	*107*
Budget amortisation of staff benefit accruals	*17.3*	*17.3*					*35*						*35*
Energy and water, insurance and postal charges, miscellaneous	*67.0*	*71.4*	*28.4*	*31.8*	*67.2*	*67.2*	*333*	*67*	*50*	*37*	*61*	*67*	*616*
Interest, bank and financial expenses, in-kind [1]	*12.2*	*11.3*	*10.4*	*9.5*	*8.6*	*7.6*	*60*	*7*	*6*	*5*	*3*	*3*	*83*
Projects and studies	**255.8**	**280.5**	**283.6**	**263.6**	**230.0**	**244.7**	**1,558**	**241**	**244**	**227**	**166**	**131**	**2,566**
LHC upgrades	**162.6**	**207.2**	**223.1**	**205.5**	**174.6**	**189.7**	**1,163**	**186**	**189**	**171**	**107**	**57**	**1,873**
LINAC4	*1.2*						*1*						*1*
LHC injectors upgrade (LIU)	*51.9*	*59.1*	*54.6*	*26.7*	*5.0*	*0.4*	*198*						*198*
HL-LHC construction	*71.9*	*102.8*	*118.8*	*124.6*	*133.1*	*153.7*	*705*	*154*	*167*	*149*	*96*	*43*	*1,313*
LHC detectors upgrade (Phase 1) and consolidation	*25.1*	*27.3*	*20.3*	*22.0*	*3.5*	*2.6*	*101*	*3*	*3*	*2*	*2*	*2*	*112*
HL-LHC detectors, including R&D (Phase 2)	*12.5*	*18.0*	*29.4*	*32.1*	*33.1*	*33.0*	*158*	*29*	*20*	*20*	*9*	*12*	*248*
Preparation for the future	**44.5**	**36.4**	**29.6**	**27.8**	**31.6**	**31.6**	**202**	**32**	**32**	**33**	**36**	**51**	**383**
Linear collider studies (CLIC, ILC, detector R&D)	*19.8*	*18.1*	*14.9*				*53*						*53*
Future Circular Collider study	*15.5*	*14.1*	*11.8*				*41*						*41*
High-energy frontier				*25.8*	*30.0*	*30.0*	*86*	*30*	*30*	*30*	*30*	*40*	*246*
Proton-driven plasma wakefield acceleration (AWAKE)	*8.4*	*2.7*	*1.7*	*1.1*	*0.6*	*0.6*	*15*	*1*	*1*	*1*	*1*	*1*	*18*
Physics Beyond Colliders study	*0.8*	*1.6*	*1.2*	*1.0*	*1.0*	*1.0*	*7*	*1*	*1*	*2*	*5*	*10*	*26*
Scientific diversity activities	**48.7**	**36.9**	**30.9**	**30.3**	**23.8**	**23.5**	**194**	**23**	**23**	**23**	**23**	**23**	**310**
ELENA	*5.1*	*0.5*	*1.3*	*0.1*			*7*						*7*
HIE-ISOLDE	*4.0*	*1.1*					*5*						*5*
CERN Neutrino Platform	*19.4*	*13.1*	*12.2*	*11.8*	*6.3*	*6.2*	*69*	*6*	*6*	*6*	*6*	*6*	*100*
R&D (incl. EU support) for accelerators, medical applications	*20.2*	*22.2*	*17.4*	*18.5*	*17.5*	*17.2*	*113*	*17*	*17*	*17*	*17*	*16*	*198*

BALANCE												
Annual balance	5.7	-48.3	35.8	91.6	133.0	94.8		103	99	121	163	171
Capital repayment allocated to the budget (Fortis, FIPOI 1, 2 and 3)	-25.9	-26.8	-27.7	-28.6	-29.5	-30.5		-31	-33	-34	-18	-1
Recapitalisation Pension Fund	-60.0	-60.0	-60.0	-60.0	-60.0	-60.0		-60	-60	-60	-60	-60
Annual balance allocated to budget deficit	-80.2	-135.1	-51.8	3.0	43.5	4.3		12	6	27	86	110
-Cumulative balance [2]- - 118.4	**-198.6**	**-333.7**	**-385.5**	**-382.5**	**-339.0**	**-334.7**		**-323**	**-317**	**-290**	**-204**	**-94**

[1] Including theoretical interest on the FIPOI loan (compensated by a corresponding heading in the revenues).

[2] The cumulative balance of -118.4 MCHF is the accumulated budget deficit as stated in the Financial Statements for 2016 (CERN/FC/6117, page 19). It does not include 2016 open commitments and reprofiled expenses of 57.2 MCHF carried forward to 2017 and later years (of which 53.2 MCHF were announced in the Final 2017 Budget).

Comments on Figure 2:

Figure 2 shows the estimated expenses and the annual balance. The latter is the difference between revenues (essentially constant due to the Member States' contributions) and expenses. Expenses include both, materials and personnel (M+P), and cover the operation of the current facilities and experiments as well as design studies and construction of new projects. Capital repayment for long-term loans and the contribution to the recapitalisation of the Pension Fund are allocated to the budget balance. The sum of these headings and the annual balance yields the annual balance allocated to the budget deficit.

The revised numbers for 2017 include the carry-forward from 2016.

The significant reduction of the **Centralised expenses** in 2019-2020 is due to the substantial reduction of energy consumption during LS2.

The Cost-to-Completion of the LHC Injectors Upgrade project has been confirmed by the second Cost & Schedule review held in October 2016. The next cost and schedule review is planned for Spring 2018. The project expenses are at their maximum over the period 2017-2019.

Similarly, the Cost-to-Completion of the HL-LHC project has been confirmed by the second Cost and Schedule review held in October 2016, in spite of an increase in the cost of the civil engineering work, which was compensated by staging or descoping some accelerator components. The project expenses will reach their maximum in the period 2022-2024.

The **Physics Beyond Colliders study** heading, shown explicitly in this MTP for the first time, reports the budget allocated to PBC studies until 2019 to prepare the necessary input to the ESPP (e.g. to complete technical feasibility studies for a possible beam-dump facility at the North Area, and to perform initial civil engineering studies for a possible proton EDM ring at CERN); preliminary yearly resources at the same level are allocated from 2020 to 2024 to continue design and R&D studies for the project(s) recommended by the ESPP, and larger (construction) funds as of 2025.

The construction of several projects (LINAC4, HIE-ISOLDE, ELENA and AWAKE) is completed or will be completed by 2020.

3. RESOURCES ALLOCATIONS AND EXPENSES

Figure 3: LHC programme

Fact sheet	(in MCHF, 2017 prices, rounded off)	Revised 2017 Budget	2018	2019	2020	2021	2022	Total 2017-2022
	LHC programme	**261.4**	**266.7**	**274.4**	**271.6**	**264.2**	**294.6**	**1,632.8**
1	**LHC machine**	**105.8**	**100.9**	**119.2**	**121.4**	**108.9**	**110.9**	**667.1**
	LHC machine and experimental areas	**100.7**	**97.5**	**116.1**	**117.2**	**105.6**	**107.7**	**644.8**
	Personnel	56.7	54.6	51.5	54.8	57.2	58.6	333.3
	Materials	44.0	42.9	64.6	62.5	48.4	49.1	311.5
	Spares	**5.1**	**3.4**	**3.1**	**4.2**	**3.3**	**3.3**	**22.3**
	Materials	5.1	3.4	3.1	4.2	3.3	3.3	22.3
1	**LHC machine and areas: reliability and consolidation**	**46.5**	**55.7**	**50.4**	**44.8**	**40.7**	**68.3**	**306.5**
	Personnel	14.3	14.1	12.6	9.5	11.5	14.5	76.5
	Materials	32.2	41.6	37.9	35.3	29.2	53.9	230.0
	LHC experiments	**64.7**	**64.8**	**61.5**	**61.7**	**72.3**	**72.8**	**397.8**
2	**ATLAS detector**	**19.2**	**19.5**	**17.8**	**17.6**	**19.8**	**20.0**	**113.9**
	Personnel	15.9	16.1	14.4	14.2	16.5	16.6	93.8
	Materials	3.3	3.4	3.4	3.3	3.3	3.3	20.1
3	**CMS detector**	**18.9**	**17.9**	**17.9**	**17.9**	**19.8**	**20.0**	**112.4**
	Personnel	15.0	14.6	14.6	14.6	16.5	16.7	92.1
	Materials	3.9	3.3	3.3	3.3	3.3	3.3	20.3
4	**ALICE detector**	**10.4**	**10.1**	**9.1**	**9.1**	**12.5**	**12.4**	**63.7**
	Personnel	8.8	8.2	7.1	7.1	10.6	10.5	52.2
	Materials	1.7	2.0	2.0	2.0	2.0	2.0	11.5
5	**LHCb detector**	**9.1**	**10.0**	**10.0**	**10.0**	**12.1**	**12.9**	**64.1**
	Personnel	8.3	8.4	8.3	8.3	10.4	11.2	54.9
	Materials	0.7	1.7	1.7	1.7	1.7	1.7	9.2
6	**Common items, other experiments (incl. Totem, LHCf, MoEDAL)**	**7.1**	**7.2**	**6.7**	**7.2**	**8.0**	**7.6**	**43.7**
	Personnel	5.0	4.8	4.6	4.9	5.5	5.1	29.8
	Materials	2.1	2.4	2.2	2.3	2.5	2.5	13.9
8	**LHC computing**	**44.4**	**45.2**	**43.2**	**43.8**	**42.3**	**42.5**	**261.4**
	Personnel	23.6	24.0	23.3	23.8	22.4	22.5	139.5
	Materials	20.9	21.2	19.9	20.0	20.0	20.0	121.9
	% of total revenues	21.16 %	21.80 %	22.17 %	21.87 %	20.96 %	23.39 %	

Comments on Figure 3:

This figure shows the costs directly related to the **operation and maintenance of the LHC programme.** Overall, expenses are similar during data-taking periods and shutdown years (2019 and 2020). The impact of the shutdown years is mainly visible in the reduction of the energy expenses in Figure 5.

The **LHC machine and areas reliability and consolidation** heading includes consolidation items such as electrical protection systems, cranes and lifts, access system, etc., as well as spares and consolidation in preparation for HL-LHC. Additional resources are allocated in this MTP for the consolidation of the electrical distribution network (21 MCHF), part of which over 2022 to 2024, and the consolidation of the dipoles cold bypass diodes (10 MCHF).

The personnel resources for the **LHC experiments** increase after LS2 as a consequence of the reallocation of the workforce assigned to the Phase-1 upgrades (see Figure 6). Some of this workforce is also be allocated to the Phase 2 upgrades (see Figure 6).

The materials budget for the operation of the four main **LHC experiments** is increased by 0.3 MCHF per experiment per year for the period up to and including LS2 to cover the experiments' requests from CERN as host laboratory (transport, survey, etc.).

LHC computing: The materials expenses include CERN's share of the required WLCG CPU and storage resources. This contribution is increased by 5% in this MTP compared to last year's MTP, corresponding to a total amount of 4 MCHF over the period 2018-2022.

In addition to the direct costs shown in Figure 3, the LHC programme has indirect costs included in Figure 4, “Other programmes” (scientific support, PS and SPS complexes and Accelerator support and services), as well as the largest part of Figure 5, “Infrastructure, services and centralised expenses”.

Figure 4: Other programmes

Fact sheet	(in MCHF, 2017 prices, rounded off)	Revised 2017 Budget	2018	2019	2020	2021	2022	Total 2017-2022
	Other programmes	**241.0**	**254.4**	**252.8**	**235.8**	**220.9**	**218.7**	**1,423.8**
9	**Non-LHC physics (experimental programme)**	**7.4**	**7.7**	**6.7**	**5.7**	**5.0**	**3.9**	**36.4**
	Personnel	5.4	4.9	3.9	3.4	2.9	2.6	23.1
	Materials	1.9	2.8	2.8	2.3	2.1	1.3	13.2
10	**Theory**	**11.1**	**11.1**	**10.2**	**9.8**	**9.5**	**9.5**	**61.3**
	Personnel	9.6	9.7	8.8	8.6	8.5	8.5	53.6
	Materials	1.5	1.4	1.4	1.2	1.1	1.1	7.7
11	**Knowledge transfer**	**6.8**	**5.0**	**4.8**	**4.2**	**4.2**	**4.2**	**29.1**
	Personnel	3.1	2.7	2.5	2.2	2.2	2.2	14.9
	Materials	3.7	2.2	2.3	2.0	2.0	2.0	14.1
12	**Scientific support (associates, computing, R&D detectors, tech. support)**	**55.2**	**55.7**	**58.5**	**59.2**	**57.1**	**57.1**	**342.6**
	Personnel	33.8	34.6	37.7	38.1	37.8	37.9	219.9
	Materials	21.3	21.1	20.8	21.0	19.3	19.2	122.7
13.a	**PS complex**	**63.3**	**66.6**	**63.0**	**55.2**	**53.2**	**54.8**	**356.2**
	Personnel	36.0	38.2	32.3	32.5	38.0	40.3	217.3
	Materials	27.4	28.3	30.8	22.8	15.3	14.5	139.0
13.b	**SPS complex**	**40.9**	**46.3**	**47.2**	**41.8**	**44.2**	**48.3**	**268.7**
	Personnel	20.3	21.1	18.0	18.0	22.8	22.8	123.0
	Materials	20.6	25.2	29.2	23.8	21.4	25.5	145.7
13.c	**Accelerator support and services**	**52.9**	**52.9**	**54.2**	**54.1**	**47.1**	**40.7**	**301.9**
	Personnel	37.7	38.2	38.7	38.6	36.4	30.1	219.7
	Materials	15.2	14.7	15.5	15.5	10.6	10.6	82.2
14	**East Area renovation**	**3.5**	**9.1**	**8.3**	**6.0**	**0.6**	**0.2**	**27.7**
	Personnel	0.6	1.5	1.4	1.3	0.3	0.2	5.3
	Materials	2.9	7.7	6.8	4.7	0.3		22.4
	% of total revenues	19.51 %	20.79 %	20.43 %	18.99 %	17.53 %	17.37 %	

Comments on Figure 4:

Non-LHC physics: This heading includes funding for non-LHC experiments (ISOLDE, n_TOF, AD, the North-Area experiments, etc.). The resources allocation decreases with time because some of the projects will reach completion, but is maintained at a level allowing extensions of current experiments and/or newly-approved ones. The provision of 0.7 MCHF per year for gas consumables for operation and maintenance activities of the fixed-target experiments, as CERN's host laboratory responsibility, is included in this heading.

The **Theory** allocation maintains a stable workforce for staff and constant materials funding. The visible reduction over the years is due to the end of current EU projects for which CERN will actively submit new proposals so as to maintain a constant annual number of visitors (about 800), fellows (around 40) and scientific associates (around 15). It should be noted that some 45% of the personnel budget covers the fellows of the Theory Department whereas the materials budget pays for the visitors' subsistence.

Scientific support: The materials heading covers support for detector and software developments, as well as cryogenics fluids and maintenance and operation of the cryogenics installations. Also included here are some 10 MCHF per year for scientific exchanges (students and scientific associates).

PS and SPS complexes: These headings include all costs for the operation of LINAC2, Booster (PSB), PS and SPS and for the technical groups linked to these complexes. They also comprise the operation of the n_TOF, ISOLDE, AD and North Area facilities, and of HIE-ISOLDE, ELENA and LINAC4. Also covered are accelerator consolidation items, such as: PS and SPS access systems, electrical distribution for the PS and SPS, (de)cabling campaign in the SPS, consolidation of the cooling and ventilation systems in the Booster and PS, etc.

The personnel reduction during LS2 is explained by a redeployment of resources from operation of the present complex to the LHC Injectors Upgrade and the HL-LHC project. On the longer-term, the decrease of the material budget for the PS complex is due to a redistribution of consolidation headings between machines: after a consolidation effort on the PS up to LS2 (in correlation with the LIU project), funds will be redirected to the LHC machine as of 2022 (in correlation with HL-LHC project). The cost of the operation of these injectors and of the associated accelerator support and services are mainly related to delivering beams to the LHC. Fixed-target experiments and tests beams can therefore be supplied with moderate incremental and directly linked costs.

Accelerator support and services is composed of accelerator controls, fluids, workshops and fabrication[4], CAD and CAE support as well as allocations for items that are common to all accelerators at CERN (e.g. vacuum and cryogenic infrastructure, polymer laboratory and magnetic measurements, Fluka simulations, survey). Also the upgrade of the SM18 magnet test facility is included under this heading (termination in 2021).

Resources are secured for the **renovation of the East area[5]**, expected to be completed by the end of LS2, with a material Cost-to-Completion of 22.6 MCHF. Such a renovation will lead to substantial energy savings after its completion.

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[4] These headings were previously reported under the factsheet 14 "*Manufacturing facilities (workshop, etc)*"

[5] It uses the factsheet number 14 previously dedicated to "*Manufacturing facilities (workshop, etc)*" and whose activities are now integrated in the factsheet 13c "*Accelerator support and services*"

Figure 5: Infrastructure, services and centralised expenses

Fact sheet	(in MCHF, 2017 prices, rounded off)	Revised 2017 Budget	2018	2019	2020	2021	2022	Total 2017-2022
	Infrastructure, services and centralised expenses	**471.3**	**470.2**	**391.0**	**379.3**	**412.1**	**406.7**	**2,530.7**
15	**General facilities & logistics (site maintenance, transport)**	**79.0**	**81.1**	**82.8**	**81.4**	**79.9**	**72.5**	**476.7**
	Personnel	36.1	37.7	39.3	40.8	38.7	32.4	224.9
	Materials	42.9	43.4	43.5	40.6	41.2	40.2	251.8
16	**Informatics**	**61.0**	**59.4**	**58.1**	**54.3**	**51.8**	**51.2**	**335.8**
	Personnel	37.6	36.9	35.5	36.8	33.9	34.0	214.7
	Materials	23.4	22.5	22.6	17.6	17.9	17.2	121.2
17	**Safety, health and environment**	**41.0**	**50.1**	**46.9**	**42.7**	**41.8**	**38.9**	**261.4**
	Personnel	27.3	27.9	26.8	26.4	26.0	25.6	160.0
	Materials	13.8	22.3	20.0	16.3	15.7	13.3	101.4
18	**Administration**	**52.2**	**50.4**	**52.1**	**52.2**	**52.8**	**52.3**	**312.0**
	Personnel	38.7	39.2	39.4	39.6	40.2	39.7	236.7
	Materials	13.5	11.3	12.7	12.6	12.6	12.6	75.3
19	**International relations**	**18.9**	**17.4**	**18.5**	**15.8**	**15.5**	**15.5**	**101.4**
	Personnel	11.4	11.8	11.5	10.9	10.8	10.8	67.2
	Materials	7.5	5.6	7.0	4.8	4.6	4.6	34.2
20	**Infrastructure consolidation, buildings and renovation**	**41.3**	**34.4**	**18.1**	**15.7**	**18.5**	**26.0**	**154.0**
	Personnel	2.5	2.0	1.9	2.0	2.1	2.1	12.5
	Materials	38.8	32.4	16.2	13.7	16.5	24.0	141.5
21	**Centralised expenses**	**177.9**	**177.4**	**114.6**	**117.3**	**151.9**	**150.2**	**889.4**
	Centralised personnel expenses	36.3	36.3	36.3	36.3	36.3	36.3	218.0
	Internal taxation	30.1	30.2	30.2	30.3	30.3	30.3	181.2
	Internal mobility and personnel on detachment	1.4	0.8	1.0	1.2	1.2	0.5	6.0
	Personnel paid from team accounts	13.7	10.0	8.3	8.2	8.3	8.3	56.7
	Budget amortisation of staff benefit accruals	17.3	17.3					34.7
	Energy and water	61.2	65.2	22.2	25.5	61.0	61.0	296.1
	Insurance, postal charges, miscellaneous	5.8	6.2	6.2	6.2	6.2	6.2	37.0
	Interest, bank and financial expenses	10.1	9.3	8.4	7.5	6.5	5.6	47.4
	In-kind	2.0	2.0	2.0	2.0	2.0	2.0	12.3
	% of total revenues	38.16 %	38.43 %	31.59 %	30.54 %	32.70 %	32.29 %	

Comments on Figure 5:

General facilities & logistics include technical infrastructure (such as workshops), site management (cleaning, guards, etc.) and logistics (goods reception, mail service, transports, etc.). The allocation takes into account recurrent running costs as well as new projects, such as the increased site security measures requested by the Host States. The allocation for building maintenance and cleaning has also been adjusted to take into account new facilities.

Informatics covers computing infrastructure (including service desk support, videoconferencing, telephone, etc.) as well as administrative computing. An additional operations budget allocation of 1.7 MCHF per year is granted in this MTP to cover incompressible costs (e.g. licenses and maintenance contracts) and thus maintain crucial services for the users and for the operation of the Laboratory.

Safety, health and environment covers central safety services, such as the Fire Brigade and the Medical Service, CERN-wide safety, safety training, and the part of radiation protection and safety inspections that cannot be allocated to the various programmes. Additional resources have been secured in this MTP to cover high-priority items, including: follow-up of electrical inspections, safety support for the LHC experiments, cables classification, fire simulations, enhanced training capabilities in view of LS2 (including a larger safety training centre), measures to minimise the impact on the environment (e.g. noise reduction close to the site of the ALICE experiment) in the framework of the recently established CERN Environmental Protection Steering (CEPS) board.

Administration: This heading includes the central administrative staff allocation (i.e. for the DG office and services, HR, FAP and IPT Departments). In 2016, some operational savings were achieved as a result of resources optimisation arising from the new organisational structure. The Directorate expenses were lower than foreseen, and expenses of the central administrative services started to be reduced also following the first implementation of streamlining initiatives. Other economies, not included here, are expected in the future from the implementation of the recommendations of the External Review Committee of Finance and Human Resources, whose report was submitted to the Directorate in March 2017.

International relations: This heading covers the activities of the International Relations Sector, including: relations with Member States, Associate Member States and non-Member States, relations with international organisations, education, communications and outreach. This MTP allocates resources (2 MCHF) for an Open Day event, scheduled in 2019 or 2020.

Infrastructure consolidation, buildings and renovation: This heading consists of two main items. The first one is a recurrent budget to renovate the CERN site in order to maintain and improve safety, operational efficiency, energy savings and reliability; it includes many small items, such as roofs, windows, toilets, swing space, roads, car parks, etc. The second one covers new buildings, the main ones currently being Building 107 (surface treatment, termination in 2018), Building 311 (magnetic measurements, termination in 2017), the polymer lab (termination in 2018), a flexible storage building in Prévessin (termination in 2019) and the renovation of Building 60 (2021-2022). The construction of Building 90, to provide office space for the Directorate, the International Relations sector, and related services and units, as well as a new, bigger meeting room for Council meetings, has been postponed to the end of the deficit period (after 2025).

Centralised personnel expenses: This heading mainly covers CERN's contribution to the health insurance premiums for pensioners, arrival and departure indemnities, unemployment benefit, etc.

Internal taxation: The estimate for 2017 and beyond is in line with the actual staff numbers and their position in the salary grid. It offsets the corresponding heading in the revenues. Personnel costs in all other headings are thus without internal taxation.

Personnel internal mobility is a central fund to ease the transfer from one organic unit to another, and to temporarily compensate for salary differentials.

Personnel on detachment relates to staff on detachment to other institutes. The expenses are compensated by corresponding revenues.

Personnel paid from team accounts: This heading has corresponding revenues and therefore does not impact the annual balance.

Budget amortisation of staff benefit accruals: This heading is a provision funding for “paid but not available” staff, i.e. staff members exercising their saved leave or compensation leave usually at the end of their career. The provision related to the old leaves scheme will be fully offset by the end of 2018.

Energy and water: This heading is dominated by the electricity consumption for the general infrastructure, the accelerator complex and the Computer Centre. It also includes water and heating expenses. The amount earmarked for electricity consumption is adjusted in constant prices to reflect the accelerator schedule. Energy consumption is substantially reduced during shut-down years.

Insurances, postal charges and miscellaneous: The budget estimates are constant.

Interest, bank and financial expenses: This heading covers the remaining interest for the long-term FORTIS loan being paid back with higher annual instalments as of 2011, which reduce with time and will end in 2026.

In-kind: This heading has corresponding revenues and covers the theoretical interest on the FIPOI loans.

Figure 6: Projects

Fact sheet	(in MCHF, 2017 prices, rounded off)	Revised 2017 Budget	2018	2019	2020	2021	2022	Total 2017-2022
	Projects	**255.8**	**280.5**	**283.6**	**263.6**	**230.0**	**244.7**	**1,558.2**
	LHC upgrades	**162.6**	**207.2**	**223.1**	**205.5**	**174.6**	**189.7**	**1,162.6**
22	**LINAC4**	**1.2**						**1.2**
	Personnel	0.8						0.8
	Materials	0.4						0.4
23	**LHC injectors upgrade (LIU)**	**51.9**	**59.1**	**54.6**	**26.7**	**5.0**	**0.4**	**197.7**
	Personnel	20.9	20.4	23.9	18.7	4.8	0.4	89.2
	Materials	31.0	38.7	30.7	8.0	0.1		108.5
24	**HL-LHC construction**	**71.9**	**102.8**	**118.8**	**124.6**	**133.1**	**153.7**	**704.8**
	Personnel	31.8	33.4	33.3	35.7	38.3	44.8	217.3
	Materials	40.1	69.5	85.5	88.9	94.8	108.8	487.5
25	**LHC detectors upgrade (phase 1) and consolidation**	**25.1**	**27.3**	**20.3**	**22.0**	**3.5**	**2.6**	**100.7**
	Personnel	16.7	16.8	13.6	12.9	0.9		60.9
	Materials	8.3	10.5	6.7	9.2	2.6	2.6	39.8
25	**HL-LHC detectors, including R&D (phase 2)**	**12.5**	**18.0**	**29.4**	**32.1**	**33.1**	**33.0**	**158.1**
	Personnel	10.6	9.8	13.5	12.0	12.6	12.6	71.2
	Materials	1.9	8.1	15.9	20.1	20.5	20.4	86.9
	Preparation for the future	**44.5**	**36.4**	**29.6**	**27.8**	**31.6**	**31.6**	**201.5**
26,27	**Linear collider studies (CLIC, ILC, detector R&D)**	**19.8**	**18.1**	**14.9**				**52.7**
	Personnel	10.3	8.8	7.1				26.3
	Materials	9.5	9.2	7.8				26.5
28	**Future Circular Collider study**	**15.5**	**14.1**	**11.8**				**41.4**
	Personnel	8.9	6.9	5.6				21.3
	Materials	6.6	7.2	6.2				20.1
	High energy frontier				**25.8**	**30.0**	**30.0**	**85.8**
	Personnel				13.9	13.5	15.3	42.8
	Materials				11.9	16.5	14.7	43.0
32	**Proton-driven plasma wakefield acceleration (AWAKE)**	**8.4**	**2.7**	**1.7**	**1.1**	**0.6**	**0.6**	**14.9**
	Personnel	2.5	1.4	0.8	0.4	0.4	0.4	5.8
	Materials	6.0	1.3	0.9	0.7	0.2	0.1	9.1
37	**Physics Beyond Colliders study**	**0.8**	**1.6**	**1.2**	**1.0**	**1.0**	**1.0**	**6.7**
	Personnel	0.6	0.7	0.1				1.4
	Materials	0.2	0.9	1.2	1.0	1.0	1.0	5.3
	Scientific diversity activities	**48.7**	**36.9**	**30.9**	**30.3**	**23.8**	**23.5**	**194.1**
29	**ELENA**	**5.1**	**0.5**	**1.3**	**0.1**			**7.0**
	Personnel	1.7	0.1					1.8
	Materials	3.5	0.4	1.3	0.1			5.2
30	**HIE-ISOLDE**	**4.0**	**1.1**					**5.1**
	Personnel	1.9	0.0					1.9
	Materials	2.1	1.1					3.2
31	**CERN Neutrino Platform**	**19.4**	**13.1**	**12.2**	**11.8**	**6.3**	**6.2**	**69.0**
	Personnel	3.5	2.8	2.2	2.1	1.9	1.8	14.3
	Materials	15.9	10.3	10.0	9.6	4.4	4.4	54.7
33	**Superconducting RF studies**	**5.0**	**5.6**	**3.5**	**3.4**	**3.5**	**3.4**	**24.3**
	Personnel	1.5	1.1	1.0	1.0	1.1	0.9	6.5
	Materials	3.5	4.5	2.5	2.5	2.5	2.5	17.8
34	**Superconducting magnet R&D (SCM)**	**1.7**	**6.2**	**3.4**	**2.3**	**1.6**	**1.3**	**16.6**
	Personnel	0.3	0.4	0.3	0.2	0.5	0.5	2.3
	Materials	1.4	5.8	3.1	2.1	1.1	0.8	14.3
35	**R&D for medical applications**	**5.3**	**3.9**	**3.6**	**3.3**	**3.1**	**3.1**	**22.2**
	Personnel	2.9	2.8	2.5	2.4	2.2	2.1	14.9
	Materials	2.3	1.1	1.0	1.0	0.9	0.9	7.3
36	**Other R&D (FAIR, ITER, ESS, EU, etc.)**	**8.4**	**6.5**	**6.9**	**9.4**	**9.2**	**9.5**	**49.9**
	Personnel	3.5	2.3	1.4	1.4	1.3	1.4	11.4
	Materials	4.9	4.2	5.5	8.0	7.9	8.1	38.6
	% of total revenues	20.71 %	22.93 %	22.92 %	21.22 %	18.25 %	19.43 %	

Comments on Figure 6:

LINAC4: The LINAC4 project has moved to operation in 2017. Connection to the Booster will take place during LS2, with resources now integrated in the LHC Injectors Upgrade heading.

LHC Injectors Upgrade: This heading covers the upgrade of the Booster, PS and SPS to provide the high-brightness beams required by the HL-LHC project, as well as the energy upgrade of the booster to 2 GeV.

HL-LHC construction: This heading covers all studies, R&D, and construction work to upgrade the LHC to ultimate performance, aiming to completion at the end of LS3 (2026) with the staging of some deliverables (Crab Cavities) beyond LS3. The Cost-to-Completion from the October 2016 Cost & Schedule review is 950 MCHF, of which up to 200 MCHF are expected to come from non-Member States' contributions.

LHC detectors upgrade (Phase 1) and consolidation: This heading includes the detector consolidation and enhancements needed to benefit from the luminosity increase provided by the LHC Injectors Upgrade. It also provides additional resources requested by the experiments from CERN as host laboratory for the period up to and including LS2, for activities like civil engineering, transport, connections to the electrical and cooling networks.

HL-LHC detectors, including R&D (Phase 2): This activity includes the R&D activities for the detectors operation in the HL-LHC phase, as well as CERN's share of the Phase-2 upgrades of ATLAS and CMS.

Linear collider studies: This heading includes funding for CLIC accelerator R&D and design studies, as well as CERN's participation in specific detector R&D activities for a future linear collider. Only previously agreed commitments with the CLIC collaboration are included, and no new commitments are taken.

Future Circular Collider study: This heading covers design and R&D studies for high-energy circular colliders, to be completed in time for the next update of the European Strategy for Particle Physics. The FCC project also includes the High-Energy LHC option, consisting of using new-generation 16 T magnets in the LHC tunnel.

Proton driven plasma wakefield acceleration: Operation of AWAKE started in 2016. The MTP allocation provides the resources needed to complete the first phase of the project (with the goal of demonstrating electron acceleration of several GeV per metre) before LS2. Resources at the level of 0.6-1 MCHF per annum are preliminarily allocated after LS2 (waiting for results on electron acceleration)

Physics Beyond Colliders: This heading is described in the "Comments on Figure 2".

ELENA: The Cost-to-Completion of 25.2 MCHF (of which 2.7 MCHF from external collaborators) remained unchanged since the cost and schedule review of November 2015. The GBAR experiment will be connected in 2017, while the connection of the other AD experiments will take place during LS2.

HIE-ISOLDE: The cost of the infrastructure is funded by CERN while the machine components are funded by the collaboration (except for 4.5 MCHF borne by CERN). The third experimental beam line is funded by CERN to allow installation of the externally funded HELIOS experiment.

CERN Neutrino Platform: This heading includes: the construction of a large test beam area (extension of the North Area EHN1 hall); basic infrastructure (e.g. refurbishment of buildings, consolidation of equipment); support for neutrino detector projects and related R&D activities, including items such as integration and cryogenics; construction of cryostats for detector prototypes; construction of the first cryostat for the DUNE experiment at the Long Baseline Neutrino Facility (LBNF) in the US.

Superconducting RF studies. This heading aims at maintaining in-house RF experience and contributing to the development of next-generation superconducting RF cavities. Funding is reduced to a materials budget of 2.5 MCHF p.a. as from 2019.

Superconducting magnet R&D aims at developing the technology for the next generation of high field magnets for future accelerator facilities. The budget covers R&D on materials alternatives to Nb_3Sn, as well as the upgrade of test facilities and the operation of FRESCA 2.

The materials heading of the **R&D for medical applications** includes the Medicis project which will start commissioning by end of 2017.

Other R&D covers activities done for other research institutes and projects, such as FAIR and ITER.

III. 2018 DRAFT BUDGET

1. OVERVIEW OF REVENUES

Figure 7: Overview of revenues

(in MCHF, 2017 prices, rounded off)	Revised 2017 Budget	2018 Draft Budget	Variation of 2018 Draft Budget with respect to Revised 2017 Budget
REVENUES	**1,235.2**	**1,223.6**	**-0.94 %**
Member States' contributions	1,119.9	1,119.9	
Associate Member States' contributions	21.8	23.9	9.73 %
Contributions anticipated from new Associate Member States		2.0	
EU contributions	14.1	12.0	-15.26 %
Additional contributions	8.1	1.2	-85.33 %
for LINAC4, HIE-ISOLDE, ELENA, AWAKE, CLIC, FAIR	*8.1*	*1.2*	*-85.33 %*
Personnel paid from team accounts	13.7	10.0	-26.92 %
Personnel on detachment	1.0	0.8	-25.37 %
Internal taxation	30.1	30.2	0.28 %
Knowledge transfer	2.3	1.7	-27.57 %
Other revenues	24.2	22.1	-8.92 %
Sales and miscellaneous	*6.9*	*6.5*	*-6.42 %*
SCOAP3 revenues	*4.9*	*4.7*	*-5.06 %*
OpenLab revenues	*2.3*	*0.8*	*-63.56 %*
Financial revenues	*2.0*	*2.0*	
In-kind[1]	*2.0*	*2.0*	
Housing fund	*6.0*	*6.0*	

[1] Theoretical interest on the FIPOI loan.

2. OVERVIEW OF EXPENSES

Figure 8: Overview of expenses

(in MCHF, 2017 prices, rounded off)	Revised 2017 Budget	2018 Draft Budget	Variation of 2018 Draft Budget with respect to Revised 2017 Budget
EXPENSES	**1,229.5**	**1,271.9**	**3.45 %**
Running of scientific programmes and support	**973.7**	**991.4**	**1.82 %**
Scientific programmes	**502.4**	**521.2**	**3.73 %**
LHC (machine, detectors, computing, including spares and consolidation)	*261.4*	*266.7*	*2.04 %*
Non-LHC physics and scientific support	*80.4*	*79.5*	*-1.13 %*
Other accelerators and areas (including consolidation)	*160.6*	*174.9*	*8.91 %*
Infrastructure and services	**293.4**	**292.9**	**-0.18 %**
General infrastructure and services (incl. admin, international relations, safety)	*252.1*	*258.5*	*2.54 %*
Infrastructure consolidation, buildings and renovation	*41.3*	*34.4*	*-16.76 %*
Centralised expenses	**177.9**	**177.4**	**-0.29 %**
Centralised personnel expenses	*36.3*	*36.3*	
Internal taxation	*30.1*	*30.2*	*0.28 %*
Internal mobility, personnel on detachment, paid from team accounts	*15.0*	*10.8*	*-28.23 %*
Budget amortisation of staff benefit accruals	*17.3*	*17.3*	
Energy and water, insurance and postal charges, miscellaneous	*67.0*	*71.4*	*6.71 %*
Interest, bank and financial expenses, in-kind [1]	*12.2*	*11.3*	*-6.95 %*
Projects and studies	**255.8**	**280.5**	**9.67 %**
LHC upgrades	**162.6**	**207.2**	**27.45 %**
LINAC4	*1.2*		*-100.00 %*
LHC injectors upgrade (LIU)	*51.9*	*59.1*	*13.92 %*
HL-LHC construction	*71.9*	*102.8*	*42.95 %*
LHC detectors upgrade (Phase 1) and consolidation	*25.1*	*27.3*	*8.92 %*
HL-LHC detectors, including R&D (Phase 2)	*12.5*	*18.0*	*43.45 %*
Preparation for the future	**44.5**	**36.4**	**-18.11 %**
Linear collider studies (CLIC, ILC, detector R&D)	*19.8*	*18.1*	*-8.48 %*
Future Circular Collider study	*15.5*	*14.1*	*-8.97 %*
Proton-driven plasma wakefield acceleration (AWAKE)	*8.4*	*2.7*	*-68.53 %*
Physics Beyond Colliders study	*0.8*	*1.6*	*93.37 %*
Scientific diversity activities	**48.7**	**36.9**	**-24.27 %**
ELENA	*5.1*	*0.5*	*-90.94 %*
HIE-ISOLDE	*4.0*	*1.1*	*-71.43 %*
CERN Neutrino Platform	*19.4*	*13.1*	*-32.47 %*
R&D (incl. EU support) for accelerators, medical applications	*20.2*	*22.2*	*9.71 %*

BALANCE			
Annual balance	5.7	-48.3	
Capital repayment allocated to the budget (Fortis, FIPOI 1, 2 and 3)	-25.9	-26.8	
Recapitalisation Pension Fund	-60.0	-60.0	
Annual balance allocated to budget deficit	-80.2	-135.1	
-Cumulative balance [2]- - 118.4	**-198.6**	**-333.7**	

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[1] Including theoretical interest on the FIPOI loan (compensated by a corresponding heading in the revenues).

[2] The cumulative balance of -118.4 MCHF is the accumulated budget deficit as stated in the Financial Statements for 2016 (CERN/FC/6117, page 19). It does not include 2016 open commitments and reprofiled expenses of 57.2 MCHF carried forward to 2017 and later years (of which 53.2 MCHF were announced in the Final Budget).

3. SCALE OF CONTRIBUTIONS OF THE MEMBER STATES FOR 2018

The percentage distribution of the scale of contributions for 2018 is presented to Council for approval in the document CERN/FC/6127-CERN/3312. The annual contribution in Swiss francs is based on 2017 prices, as the Cost-Variation Index proposal will be submitted to Council for approval in December 2017.

Figure 9 (1/2) : Scale of Contributions of the Member States for the Financial Year 2018

			Net National Income at factor costs			**Exchange rates**			**Net National Income at factor costs**	**2018 Theoretical Contribution**	**2018 Due Contribution**
			in millions in national currency			national currencies in Swiss francs			in MCHF		
	Country	Currency	2013	2014	2015	2013	2014	2015	Average 2013 to 2015	**in %**	**in %**
Member States	Austria	EUR	223 134	228 224	231 982	1.2308	1.2146	1.0681	266 534	2.14546%	2.14546%
	Belgium	EUR	283 244	286 521	292 199	1.2308	1.2146	1.0681	336 235	2.70652%	2.70652%
	Bulgaria	BGN	59 028	59 945	63 565	0.6293	0.6210	0.5461	36 362	0.29270%	0.29270%
	Czech Republic	CZK	2 521 246	2 672 082	2 816 697	0.0474	0.0441	0.0392	115 894	0.93289%	0.93289%
	Denmark	DKK	1 381 224	1 433 321	1 467 822	0.1650	0.1629	0.1433	223 914	1.80239%	1.80239%
	Finland	EUR	138 361	141 032	144 631	1.2308	1.2146	1.0681	165 355	1.33102%	1.33102%
	France	EUR	1 470 792	1 491 994	1 535 228	1.2308	1.2146	1.0681	1 754 039	14.11914%	14.11914%
	Germany	EUR	2 107 767	2 179 538	2 263 202	1.2308	1.2146	1.0681	2 552 903	20.54959%	20.54959%
	Greece	EUR	121 948	118 422	115 328	1.2308	1.2146	1.0681	139 035	1.11916%	1.11916%
	Hungary	HUF	18 831 382	19 989 982	20 654 406	0.0041	0.0039	0.0034	75 983	0.61163%	0.61163%
	Israel	ILS	754 213	789 437	831 805	0.2567	0.2560	0.2477	200 569	1.61448%	1.61448%
	Italy	EUR	1 094 320	1 107 403	1 118 641	1.2308	1.2146	1.0681	1 295 566	10.42866%	10.42866%
	Netherlands	EUR	489 298	483 933	493 980	1.2308	1.2146	1.0681	572 535	4.60862%	4.60862%
	Norway	NOK	2 330 554	2 434 341	2 410 385	0.1579	0.1454	0.1195	336 699	2.71026%	2.71026%
	Poland	PLN	1 210 713	1 249 754	1 303 339	0.2933	0.2902	0.2554	350 197	2.81891%	2.81891%
	Portugal	EUR	115 802	116 462	118 424	1.2308	1.2146	1.0681	136 822	1.10135%	1.10135%
	Romania	RON	457 951	478 893	510 339	0.2785	0.2733	0.2404	127 035	1.02257%	1.02257%
	Slovakia	EUR	51 105	51 183	53 256	1.2308	1.2146	1.0681	60 649	0.48819%	0.48819%
	Spain	EUR	733 202	740 703	769 944	1.2308	1.2146	1.0681	874 806	7.04175%	7.04175%
	Sweden	SEK	2 452 759	2 572 490	2 710 358	0.1423	0.1336	0.1142	334 100	2.68934%	2.68934%
	Switzerland	CHF	498 626	496 209	505 113	1.0000	1.0000	1.0000	499 983	4.02461%	4.02461%
	United Kingdom	GBP	1 288 833	1 337 921	1 373 700	1.4496	1.5065	1.4705	1 967 918	15.84076%	15.84076%
Total Member States									**12 423 130**	**100.0000%**	**100.0000%**
Associate Member States in Pre-Stage	Cyprus [1]	EUR	13 016	12 591	12 658	1.2308	1.2146	1.0681	14 944	0.12029%	0.01203%
	Serbia [2]	RSD	2 784 822	2 801 400	2 901 887	0.0109	0.0104	0.0088	28 323	0.22799%	0.22799%
Total Associate Member States in the Pre-Stage to Membership									**43 268**	**0.3483%**	**0.2400%**
Associate Member States	India [3]	INR	80 724 387	89 119 051	98 144 140	0.0152	0.0157	0.0148	1 357 679	10.92864%	1.09286%
	Pakistan [4]	PKR	16 081 936	18 039 772	19 731 056	0.0097	0.0088	0.0093	166 214	1.33794%	0.13379%
	Turkey [5]	TRY	1 308 099	1 495 197	1 693 711	0.4881	0.4181	0.3550	621 644	5.00392%	0.50039%
	Ukraine [6]	UAH	1 093 882	1 137 423	1 427 124	0.1159	0.0774	0.0004	71 823	0.57814%	0.05781%
Total Associate Member States									**2 217 360**	**17.8486%**	**1.7849%**

[1] Cyprus became an Associate Member State in the pre-stage to Membership on 1st April 2016 and will pay the statutory minimum contribution of 1 MCHF in 2018 as provided for in Council Resolution CERN/3034/RA.

[2] Serbia became an Associate Member State in the pre-stage to Membership on 15 March 2012 as provided for in Council Resolution CERN/2999/RA. It is assumed that Serbia will become a Member State. Serbia will pay 100% of its theoretical Member State contribution in 2018.

[3] India became an Associate Member State on 16 January 2017 and will pay 10% of its theoretical contribution in 2018, as provided for in Council Resolution CERN/3274/RA

[4] Pakistan became an Associate Member State on 31 July 2015 and will pay 10% of its theoretical contribution in 2018 as provided for in Council Resolution CERN/3142/RA

[5] Turkey became an Associate Member State on 6 May 2015 and will pay 10% of its theoretical contribution in 2018 as provided for in Council Resolution CERN/3106/RA.

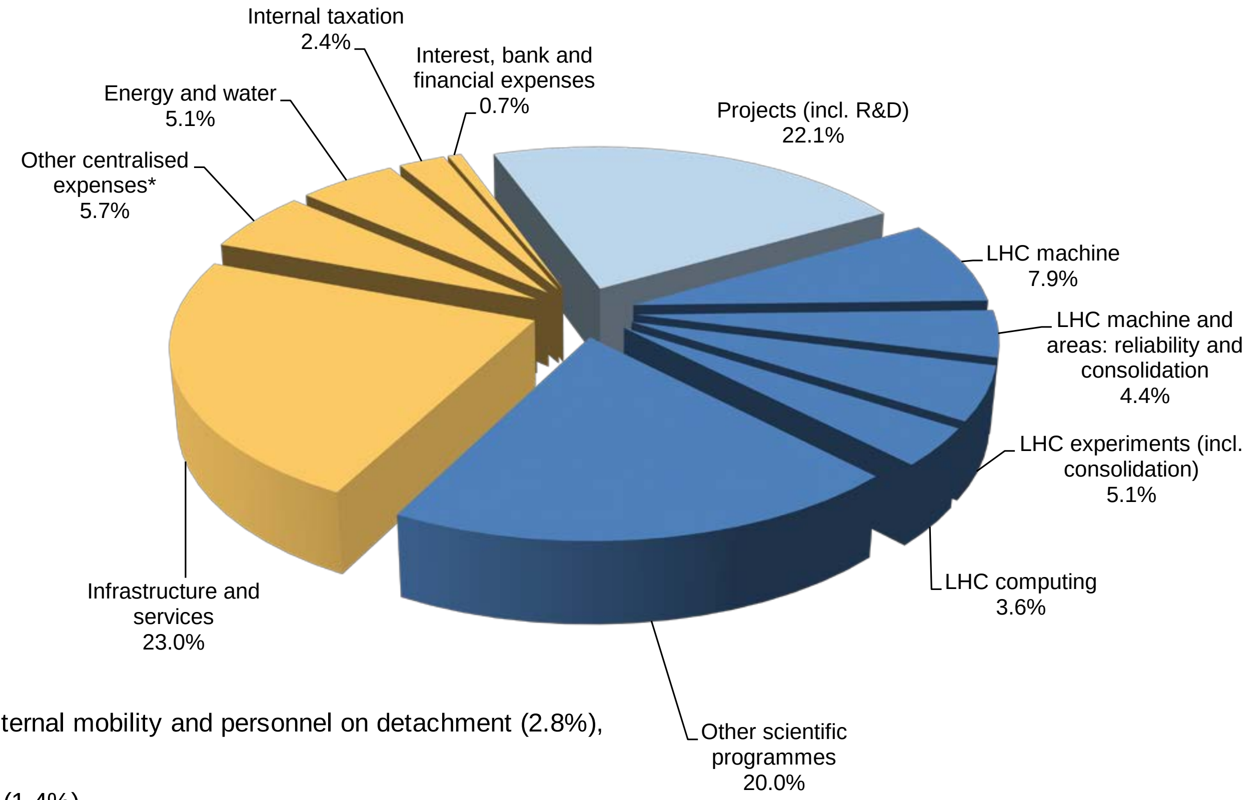
[6] Ukraine became an Associate Member State on 5 October 2016 and will pay the statutory minimum contribution of 1 MCHF in 2018 as provided for in Council Resolution CERN/3082/RA.

Figure 9 (2/2) : Scale of Contributions of the Member States for the Financial Year 2018

		2018 Annual contribution	**2018 Annual contribution**
	Country	**in CHF 2017 prices**	**in %**
Member States	Austria	24 027 000	2.14546%
	Belgium	30 310 300	2.70652%
	Bulgaria	3 277 950	0.29270%
	Czech Republic	10 447 450	0.93289%
	Denmark	20 184 950	1.80239%
	Finland	14 906 100	1.33102%
	France	158 120 300	14.11914%
	Germany	230 134 900	20.54959%
	Greece	12 533 450	1.11916%
	Hungary	6 849 650	0.61163%
	Israel	18 080 550	1.61448%
	Italy	116 790 550	10.42866%
	Netherlands	51 611 950	4.60862%
	Norway	30 352 200	2.71026%
	Poland	31 568 950	2.81891%
	Portugal	12 334 000	1.10135%
	Romania	11 451 750	1.02257%
	Slovakia	5 467 250	0.48819%
	Spain	78 860 550	7.04175%
	Sweden	30 117 900	2.68934%
	Switzerland	45 071 600	4.02461%
	United Kingdom	177 400 750	15.84076%
Total Member States		**1 119 900 050**	**100.0000%**
Associate Member States in Pre-Stage	Cyprus	1 000 000	
	Serbia	2 553 250	
Total Associate Member States in the Pre-Stage to Membership		**3 553 250**	
Associate Member States	India	12 239 000	
	Pakistan	1 498 350	
	Turkey	5 603 900	
	Ukraine	1 000 000	
Total Associate Member States		**20 341 250**	
Grand TOTAL		**1 143 794 550**	

4. EXPENSES BY SCIENTIFIC AND NON SCIENTIFIC PROGRAMMES

Figure 10: 2018 Draft Budget (Personnel, Materials and Interest & financial costs)



* Including centralised personnel expenses, internal mobility and personnel on detachment (2.8%),
Personnel paid from team accounts (0.8%),
Budget amortisation of staff benefit accruals (1.4%),
Insurance, postal charges, miscellaneous (0.5%),
In-kind (theoretical interest on the FIPOI loan) (0.2%)

Figure 11: Scientific programme

Revised 2017 Budget (2017 prices) (a)				Activity		2018 Draft Budget (2017 prices) (b)				Variation of 2018 Draft Budget with respect to Revised 2017 Budget
FTE	kCHF			Fact sheet		FTE	kCHF			
Personnel	Personnel	Materials	Total			Personnel	Personnel	Materials	Total	
808.2	**147,595**	**113,785**	**261,380**		**LHC programme**	**769.0**	**144,815**	**121,905**	**266,720**	**2.0 %**
331.0	**56,680**	**49,070**	**105,750**	**1**	**LHC machine**	**301.2**	**54,590**	**46,350**	**100,940**	**-4.5 %**
331.0	56,680	43,995	100,675		LHC machine and experimental areas	301.2	54,590	42,940	97,530	-3.1 %
		5,075	5,075		Spares			3,410	3,410	-32.8 %
90.7	**14,345**	**32,195**	**46,540**	**1**	**LHC machine and areas: reliability and consolidation**	**84.1**	**14,090**	**41,645**	**55,735**	**19.8 %**
281.3	**53,005**	**11,670**	**64,675**		**LHC experiments**	**276.2**	**52,095**	**12,735**	**64,830**	**0.2 %**
82.0	15,870	3,335	19,205	**2**	ATLAS detector	82.6	16,120	3,415	19,535	1.7 %
81.9	15,035	3,875	18,910	**3**	CMS detector	78.3	14,620	3,305	17,925	-5.2 %
45.3	8,750	1,660	10,410	**4**	ALICE detector	43.7	8,180	1,965	10,145	-2.5 %
43.1	8,340	740	9,080	**5**	LHCb detector	44.0	8,395	1,650	10,045	10.6 %
29.0	5,010	2,060	7,070	**6**	Common items, other experiments (incl. Totem, LHCf, MoEDAL)	27.6	4,780	2,400	7,180	1.6 %
105.3	**23,565**	**20,850**	**44,415**	**8**	**LHC computing**	**107.5**	**24,040**	**21,175**	**45,215**	**1.8 %**
796.3	**146,565**	**94,465**	**241,030**		**Other programmes**	**817.8**	**150,900**	**103,530**	**254,430**	**5.6 %**
30.0	**5,425**	**1,940**	**7,365**	**9**	**Non-LHC physics (experimental programme)**	**28.7**	**4,920**	**2,810**	**7,730**	**5.0 %**
59.3	**9,615**	**1,500**	**11,115**	**10**	**Theory**	**60.6**	**9,685**	**1,435**	**11,120**	**0.0 %**
18.3	**3,080**	**3,680**	**6,760**	**11**	**Knowledge transfer**	**15.3**	**2,740**	**2,225**	**4,965**	**-26.6 %**
171.4	**33,830**	**21,320**	**55,150**	**12**	**Scientific support (associates, computing, R&D detectors, tech. support)**	**181.3**	**34,570**	**21,100**	**55,670**	**0.9 %**
205.0	**35,970**	**27,360**	**63,330**	**13.a**	**PS complex**	**213.8**	**38,235**	**28,345**	**66,580**	**5.1 %**
117.9	**20,280**	**20,635**	**40,915**	**13.b**	**SPS complex**	**118.8**	**21,075**	**25,220**	**46,295**	**13.1 %**
191.4	**37,730**	**15,175**	**52,905**	**13.c**	**Accelerator support and services**	**192.5**	**38,210**	**14,720**	**52,930**	**0.0 %**
3.1	**635**	**2,855**	**3,490**	**14**	**East Area renovation**	**6.8**	**1,465**	**7,675**	**9,140**	**161.9 %**
1,604.5	**294,160**	**208,250**	**502,410**		**Grand Total**	**1,586.7**	**295,715**	**225,435**	**521,150**	**3.7 %**
	23.82%	16.86%	40.68%		% of total revenues		24.17%	18.42%	42.59%	

Comments on Figure 11:

Overall, the budget for the operation of the scientific programme is fairly stable over 2017 and 2018, since 2018 will be an operation year as 2017.

The **spares** heading is slightly higher in 2017 due to the carry forward of some items from 2016.

Under **LHC machine and areas: reliability and consolidation**, the electrical network consolidation is ramping-up in 2018, after a cost and schedule review in March 2017. A higher level of expenses is also planned for the Radiation to Electronics (R2E) project in 2018. Furthermore, the expenses related to the consolidation of the LHC access system are reaching their peak in 2018.

The heading for **Knowledge transfer** activities remains almost constant, with the 2017 budget including some external revenues and carry-forward from 2016.

The budget for the **PS and SPS complexes** increases in 2018, mainly due to the electrical network consolidation work, capacitor discharge power converters for the PS, SPS dipole corrector magnets power converters, high-voltage power supplies for the SPS RF, etc.

The **East Area renovation** project started in 2016 with a peak of expenses in 2018 and 2019, for completion during LS2.

Figure 12: Infrastructure, services and centralised expenses

Revised 2017 Budget (2017 prices) (a)				**Activity**		**2018 Draft Budget (2017 prices)** (b)				**Variation of 2018 Draft Budget with respect to Revised 2017 Budget**
FTE	**kCHF**			**Fact sheet**		**FTE**	**kCHF**			
Personnel	**Personnel**	**Materials**	**Total**			**Personnel**	**Personnel**	**Materials**	**Total**	
983.7	**252,280**	**219,000**	**471,280**		**Infrastructure, services and centralised expenses**	**941.4**	**250,035**	**220,210**	**470,245**	**-0.2 %**
207.4	**36,090**	**42,930**	**79,020**	**15**	**General facilities & logistics (site maintenance, transport)**	**211.0**	**37,680**	**43,445**	**81,125**	**2.7 %**
217.4	37,595	23,395	60,990	**16**	**Informatics**	**204.3**	**36,940**	**22,475**	**59,415**	-2.6 %
174.5	27,270	13,770	41,040	**17**	**Safety, health and environment**	**175.1**	**27,870**	**22,250**	**50,120**	22.1 %
206.7	**38,670**	**13,480**	**52,150**	**18**	**Administration**	**206.7**	**39,155**	**11,265**	**50,420**	**-3.3 %**
63.8	**11,390**	**7,485**	**18,875**	**19**	**International relations**	**65.3**	**11,765**	**5,625**	**17,390**	**-7.9 %**
17.2	**2,475**	**38,825**	**41,300**	**20**	**Infrastructure consolidation, buildings and renovation**	**13.8**	**1,990**	**32,390**	**34,380**	**-16.8 %**
96.7	**98,790**	**79,115**	**177,905**	**21**	**Centralised expenses**	**65.3**	**94,635**	**82,760**	**177,395**	**-0.3 %**
	36,335		36,335		Centralised personnel expenses		36,335		36,335	
	30,105		30,105		Internal taxation		30,190		30,190	0.3 %
3.6	1,365		1,365		Internal mobility and personnel on detachment	2.7	805		805	-41.0 %
93.1	13,655		13,655		Personnel paid from team accounts	62.6	9,975		9,975	-26.9 %
	17,330		17,330		Budget amortisation of staff benefit accruals		17,330		17,330	
		61,170	61,170		Energy and water			65,210	65,210	6.6 %
		5,785	5,785		Insurance, postal charges, miscellaneous			6,235	6,235	7.8 %
		10,115	10,115		Interest, bank and financial expenses			9,270	9,270	-8.4 %
		2,045	2,045		In-kind			2,045	2,045	
	20.42%	17.73%	38.16%		% of total revenues		20.43%	18.00%	38.43%	

Comments on Figure 12:

The overall budget allocation to Infrastructure, services and centralised expenses is similar in 2017 and 2018.

The budget for the **General facilities & logistics** heading increases in 2018 mainly due to the additional resources allocated to enhance the site security measures.

The increase in the materials heading for “**Safety, health and environment**” from 2017 to 2018 is mainly due to the start-up of the project to bring the SPS into fire conformity during LS2 and additional budget allocation in this MTP for electrical safety inspections, safety training, etc.

The decrease of the materials heading for **Infrastructure consolidation, buildings and renovation** is due to the completion of some projects: Building 107 (surface treatment, ending in 2018), Building 311 (magnetic measurements, ending in 2017), the polymer lab (ending in 2018).

The **centralised expenses** are expected to remain constant except for energy consumption, which is larger in 2018 due to a longer year of operation (2017 has an extended year-end technical stop).

Figure 13: Projects

Revised 2017 Budget (2017 prices) (a)				Activity		2018 Draft Budget (2017 prices) (b)				Variation of 2018 Draft Budget with respect to Revised 2017 Budget
FTE	kCHF			Fact sheet		FTE	kCHF			
Personnel	Personnel	Materials	Total			Personnel	Personnel	Materials	Total	
680.5	**118,395**	**137,380**	**255,775**		**Projects**	**591.5**	**107,580**	**172,940**	**280,520**	**9.7 %**
452.4	**80,895**	**81,675**	**162,570**		**LHC upgrades**	**434.7**	**80,345**	**126,850**	**207,195**	**27.4 %**
4.9	780	385	1,165	**22**	LINAC4					-100.0 %
133.0	20,935	30,970	51,905	**23**	LHC injectors upgrade (LIU)	117.8	20,395	38,735	59,130	13.9 %
187.3	31,840	40,080	71,920	**24**	HL-LHC construction	194.7	33,360	69,450	102,810	43.0 %
73.9	16,740	8,320	25,060	**25**	LHC detectors upgrade (phase 1) and consolidation	76.0	16,765	10,530	27,295	8.9 %
53.3	10,600	1,920	12,520	**25**	HL-LHC detectors, including R&D (phase 2)	46.2	9,825	8,135	17,960	43.5 %
135.7	**22,245**	**22,255**	**44,500**		**Preparation for the future**	**99.4**	**17,790**	**18,650**	**36,440**	**-18.1 %**
58.7	10,275	9,480	19,755	**26,27**	Linear collider studies (CLIC, ILC, detector R&D)	48.5	8,845	9,235	18,080	-8.5 %
54.5	8,875	6,620	15,495	**28**	Future Circular Collider study	37.7	6,865	7,240	14,105	-9.0 %
17.0	2,465	5,955	8,420	**32**	Proton-driven plasma wakefield acceleration (AWAKE)	7.3	1,395	1,255	2,650	-68.5 %
5.6	630	200	830	**37**	Physics Beyond Colliders study	6.0	685	920	1,605	93.4 %
92.4	**15,255**	**33,450**	**48,705**		**Scientific diversity activities**	**57.4**	**9,445**	**27,440**	**36,885**	**-24.3 %**
8.7	1,655	3,475	5,130	**29**	ELENA	0.6	105	360	465	-90.9 %
10.4	1,905	2,050	3,955	**30**	HIE-ISOLDE	0.1	5	1,125	1,130	-71.4 %
21.4	3,540	15,850	19,390	**31**	CERN Neutrino Platform	17.3	2,780	10,315	13,095	-32.5 %
9.7	1,450	3,515	4,965	**33**	Superconducting RF studies	6.5	1,080	4,490	5,570	12.2 %
2.3	285	1,375	1,660	**34**	Superconducting magnet R&D (SCM)	3.0	410	5,830	6,240	275.9 %
18.9	2,940	2,315	5,255	**35**	R&D for medical applications	16.9	2,790	1,080	3,870	-26.4 %
21.2	3,480	4,870	8,350	**36**	Other R&D (FAIR, ITER, ESS, EU, etc.)	13.1	2,275	4,240	6,515	-22.0 %
	9.59%	11.12%	20.71%		% of total revenues		8.79%	14.13%	22.93%	

Comments on Figure 13:

The variations in the budget allocations from 2017 to 2018 reflect the status of the various projects.

LINAC4 switched from construction to operation in 2017, **LIU** has a peak of expenses in 2017-2028, and the budget for **HL-LHC** construction and the **LHC detectors Phase 2 upgrade** is ramping up. The civil engineering work for the extension of existing buildings at the ATLAS and CMS sites for the assembly and test of upgraded detector components, whose cost is borne by CERN as host laboratory, will start in 2018.

ELENA and **HIE-ISOLDE** are nearing completion.

The budget for **Linear collider studies** starts to ramp down in 2017, as R&D work (e.g. CTF3) and design studies for the ESPP update near completion. The budget for **Future Circular Colliders** studies is also decreasing, reflecting the approaching completion of the work (Conceptual Design Report) for the ESPP.

The CERN **Neutrino Platform** started in 2015 with peak expenses in 2016 and 2017. The extension of the EHN1 hall to provide a test beam area for neutrino detector prototypes was completed in autumn 2016 and the refurbishment of the ICARUS detector ended at the beginning of 2017. The construction of the cryostats for two liquid-argon prototypes and of the cryostat for the first module of the DUNE experiment continues in 2018 and beyond.

After a peak in 2015 and 2016, the budget of **AWAKE** is ramping down as construction is essentially completed and commissioning is well advanced.

The budget for **Superconducting magnet R&D** in 2018 will be used mainly to upgrade the test facilities.

R&D for medical applications: this heading covers studies and projects related to medical applications of CERN technologies. The budget decreases in 2018 as the MEDICIS project starts operation at the end of 2017 (construction is completed).

The heading for **Other R&D** covers projected expenses for 2018 for EU projects (with corresponding revenues), tests of the FAIR magnets (externally funded), as well as some other R&D activities mainly in support to other research institutions.

Multi-annual projects

Figure 14 (1/3): Expenses – Details of projects included in the activity headings

It details the amounts of non-recurrent expenses for 2017 and 2018 split by program and project.

(in kCHF, rounded off)

Revised 2017 Budget (2017 prices) (a)			Programme	Project	2018 Draft Budget (2017 prices) (b)			Variations of 2018 Draft Budget with respect to Revised 2017 Budget	
								(c) = (b)-(a)	(d) = (c)/(a)
Personnel	Materials	Total			Personnel	Materials	Total	kCHF	%
22 155	**54 315**	**76 470**		**Sub-total LHC programme**	**20 435**	**61 735**	**82 170**	**5 700**	**7%**
	4 255	4 255	**LHC programme** Included in Figure 3	**LHC machine and experimental areas**		2 475	2 475	-1 780	-42%
	3 275	3 275		LHC spares		1 540	1 540	-1 735	-53%
	915	915		LHC magnet repair		935	935	20	2%
	65	65		Electrical Circuit Change for ALFA				- 65	-100%
14 295	31 190	45 485		**LHC machine and areas reliability and consolidation**	14 035	41 645	55 680	10 195	22%
965	1 440	2 405		Collimation system enhancements	730	500	1 230	-1 175	-49%
515	7 775	8 290		Electrical network 2025	760	12 825	13 585	5 295	64%
595	250	845		Experimental areas consolidation	855	515	1 370	525	62%
8 570	11 540	20 110		LHC consolidation	9 165	13 520	22 685	2 575	13%
3 650	6 010	9 660		Radiation to electronics (R2E)	2 525	8 320	10 845	1 185	12%
	995	995		POPS repair, spare and consolidation		1 410	1 410	415	42%
	3 235	3 235		Spare and consolidation in the framework of HL-LHC		4 555	4 555	1 320	41%
	- 55	- 55		CERN control centre consolidation				55	-100%
	65	65		**LHC detectors**				- 65	-100%
5 190	17 295	22 485		**LHC Computing Grid**	4 965	17 425	22 390	- 95	0%
2 670	1 480	4 150		**EU projects**	1 435	190	1 625	-2 525	-61%
	30	30		**TT projects**				- 30	-100%
21 985	**34 095**	**56 080**		**Sub-total Other programmes**	**21 195**	**39 265**	**60 460**	**4 380**	**8%**
355	30	385	**Other programmes** Included in Figure 4	**AEGIS**	360	50	410	25	6%
640	195	835		**NA62**	620	100	720	- 115	-14%
	220	220		**PCB Workshop Machine**		500	500	280	127%
70	- 5	65		**ISOLDE robots**				- 65	-100%
110		110		**Magnet Infrastructure Upgrade**	55		55	- 55	-50%
1 480	580	2 060		**SM18 infrastructure Upgrade**	1 440	- 10	1 430	- 630	-31%
175	1 090	1 265		**TE Infrastructure Consolidation**	135	140	275	- 990	-78%
1 885		1 885		**Cryogenic infrastructure Upgrade**	355		355	-1 530	-81%
	105	105		**EP Safety and Consolidation**		250	250	145	138%
110	285	395		**Timing development**				- 395	-100%
740	2 805	3 545		**AD consolidation**	650	2 965	3 615	70	2%
635	2 855	3 490		**East area renovation**	1 465	7 675	9 140	5 650	162%
910	2 045	2 955		**North area consolidation**	1 010	1 230	2 240	- 715	-24%
20	175	195		**66/18 kV loop PS consolidation**				- 195	-100%
860	2 945	3 805		**18 kV loop + substations SPS consolidation**	950	7 290	8 240	4 435	117%
8 955	13 625	22 580		**Accelerator consolidation**	10 180	16 240	26 420	3 840	17%
255	2 610	2 865		**PS and SPS spares**	215	1 095	1 310	-1 555	-54%
180	350	530		**Computer Security Hardening**	195	10	205	- 325	-61%
4 005	1 735	5 740		**EU projects**	3 130	1 310	4 440	-1 300	-23%
600	2 450	3 050		**TT projects**	435	420	855	-2 195	-72%

Figure 14 (2/3): Expenses – Details of projects included in the activity headings

(in kCHF, rounded off)

Revised 2017 Budget (2017 prices) (a)			Programme	Project	2018 Draft Budget (2017 prices) (b)			Variations of 2018 Draft Budget with respect to Revised 2017 Budget	
								(c) = (b)-(a)	(d) = (c)/(a)
Personnel	**Materials**	**Total**			**Personnel**	**Materials**	**Total**	**kCHF**	**%**
9 185	**62 190**	**71 375**		**Sub-total Infrastructure, services and centralised expenses**	**6 890**	**56 385**	**63 275**	**-8 100**	**-11%**
	810	**810**	**Infrastructure, services and centralised expenses** Included in Figure 5	**Manufacturing facilities**		**1 425**	**1 425**	**615**	**76%**
	810	**810**		Investment in new mechanical technologies		1 425	**1 425**	**615**	**76%**
15	**1 010**	**1 025**		**General facilities & logistics (site maintenance, transport)**	**15**	**2 795**	**2 810**	**1 785**	**174%**
15	1 010	1 025		Globe car park and "Esplanade des Particules"	15	500	515	- 510	-50%
				Building 38 (hotel renovation)		2 295	2 295	2 295	
2 240	**10 320**	**12 560**		**Informatics**	**1 205**	**7 015**	**8 220**	**-4 340**	**-35%**
	2 120	2 120		Computing network consolidation		1 620	1 620	- 500	-24%
	880	880		2nd Network Hub				- 880	-100%
	6 580	6 580		SCOAP3		5 360	5 360	-1 220	-19%
1 925	655	2 580		OpenLab	**835**	35	870	-1 710	-66%
315	85	400		AIS re-engineering	**370**		370	- 30	-8%
10	**515**	**525**		**Administration**		**95**	**95**	**- 430**	**-82%**
	30	30		HR projects				- 30	-100%
10	480	490		FAP projects		95	95	- 395	-81%
	5	5		Risk management				- 5	-100%
3 115	**7 195**	**10 310**		**Safety, health and environment**	**2 775**	**12 070**	**14 845**	**4 535**	**44%**
100		100		Radio infrastructure upgrade for firefighters	55		55	- 45	-45%
1 160	1 730	2 890		Ramses II light	870	2 625	3 495	605	21%
	645	645		Emergency		680	680	35	5%
1 630	3 960	5 590		Radioactive waste management	1 625	6 945	8 570	2 980	53%
200	740	940		SPS fire safety	200	1 715	1 915	975	
25	120	145		HLD Instrumentation upgrade	25	105	130	- 15	-10%
30	**2 350**	**2 380**		**International relations**	**60**	**445**	**505**	**-1 875**	**-79%**
	170	170		New microcosm exhibition				- 170	-100%
	470	470		IdeaSquare building		85	85	- 385	-82%
	170	170		Visitpoint				- 170	-100%
	285	285		Alumni		50	50	- 235	-82%
30	190	220		High School Students Internship Programme	60	215	275	55	25%
	625	625		Outreach 2017				- 625	-100%
	440	440		Other outreach projects		95	95	- 345	-78%
2 475	**39 335**	**41 810**		**Infrastructure consolidation, buildings and renovation**	**1 990**	**32 390**	**34 380**	**-7 430**	**-18%**
255	14 485	14 740		Building 107 (surface treatment)	130	7 385	7 515	-7 225	-49%
380	7 335	7 715		Building 311 (magnetic measurements)	110		110	-7 605	-99%
	200	200		Building 774 (Prévessin main building)				- 200	-100%
100	200	300		Building 90 (new main building)	50		50	- 250	-83%
	440	440		Building 156 (extension)				- 440	-100%
				Library reading room		525	525	525	
	50	50		Renovation Globe of Science and Innovation		1 415	1 415	1 365	2730%
	5	5		LHCb building				- 5	-100%
	- 130	- 130		Workshop and assembly hall in LHC point 8				130	-100%
15	1 635	1 650		Polymer laboratory consolidation		450	450	-1 200	-73%
				Replacement of Water-Cooled Cables		50	50	50	
1 725	13 480	15 205		Surface and technical infrastructure consolidation (roofs, facades, heating, etc.)	1 700	12 585	14 285	- 920	-6%
	685	685		Cooling tower Point 18		2 890	2 890	2 205	322%
	950	950		Flexible storage building Prevessin		7 090	7 090	6 140	646%
1 180	**625**	**1 805**		**EU projects**	**665**	**150**	**815**	**- 990**	**-55%**
120	**30**	**150**		**TT projects**	**180**		**180**	**30**	**20%**

Figure 14 (3/3): Expenses – Details of projects included in the activity headings

(in kCHF, rounded off)

Revised 2017 Budget (2017 prices) (a)			Programme	Project	2018 Draft Budget (2017 prices) (b)			Variations of 2018 Draft Budget with respect to Revised 2017 Budget	
								(c) = (b)-(a)	(d) = (c)/(a)
Personnel	**Materials**	**Total**			**Personnel**	**Materials**	**Total**	**kCHF**	**%**
112 285	**132 200**	**244 485**		**Sub-total Projects**	**102 125**	**169 355**	**271 480**	**26 995**	**11%**
80 150	**79 755**	**159 905**	**Projects** Included in Figure 6	**LHC upgrades**	**79 650**	**125 225**	**204 875**	**44 970**	**28%**
780	555	1 335		LINAC4				-1 335	-100%
20 885	30 970	51 855		LHC Injectors Upgrade	20 355	38 735	59 090	7 235	14%
31 145	38 230	69 375		LHC luminosity upgrade project (HL-LHC)	32 705	67 825	100 530	31 155	45%
16 740	8 080	24 820		LHC detectors upgrade	16 765	10 530	27 295	2 475	10%
10 600	1 920	12 520		R&D for HL-LHC detectors	9 825	8 135	17 960	5 440	43%
21 365	**21 830**	**43 195**		**Preparation for the future**	**17 210**	**18 275**	**35 485**	**-7 710**	**-18%**
6 920	8 655	15 575		CLIC	5 650	8 475	14 125	-1 450	-9%
2 775	420	3 195		Linear collider detector R&D	2 845	385	3 230	35	1%
8 720	6 620	15 340		Future Circular Collider study	6 750	7 240	13 990	-1 350	-9%
2 320	5 935	8 255		Proton Plasma wakefield acceleration (AWAKE)	1 280	1 255	2 535	-5 720	-69%
630	200	830		Physics Beyond Colliders study	685	920	1 605	775	93%
7 610	**27 655**	**35 265**		**Scientific diversity activities**	**3 395**	**19 945**	**23 340**	**-11 925**	**-34%**
1 605	3 475	5 080		ELENA	100	360	460	-4 620	-91%
1 905	1 925	3 830		HIE-ISOLDE	5	1 115	1 120	-2 710	-71%
3 210	15 755	18 965		CERN Neutrino Platform	2 485	10 070	12 555	-6 410	-34%
	240	240		SM18 extension for superconducting RF		2 575	2 575	2 335	973%
215	1 375	1 590		Superconducting magnets R&D	375	5 830	6 205	4 615	290%
150	1 525	1 675		MEDICIS	240		240	-1 435	-86%
525	3 360	3 885		Upgrade Building 180 test facility (FAIR)	190	- 5	185	-3 700	-95%
3 160	**2 785**	**5 945**		**EU projects**	**1 870**	**5 900**	**7 770**	**1 825**	**31%**
	175	**175**		**TT projects**		**10**	**10**	**- 165**	**-94%**
165 610	**282 800**	**448 410**		**Grand Total**	**150 645**	**326 740**	**477 385**	**28 975**	**6%**

5. SUMMARY OF EXPENSES BY NATURE

Figure 15: Materials expenses by nature (including interest and financial costs)

(in kCHF, rounded off)

Nature	Revised 2017 Budget (2017 prices) (a)	2018 Draft Budget (2017 prices) (b)	Variation of 2018 Draft Budget with respect to Revised 2017 Budget (b)/(a)
Materials expenses	**552,570**	**607,370**	**9.9%**
Goods, consumables and supplies	268,630	314,620	17.1%
Electricity, heating gas and water	61,170	65,210	6.6%
Industrial services[1]	132,170	136,740	3.5%
Service contracts	*126,570*	*131,140*	*3.6%*
Temporary labour	*5,600*	*5,600*	
Associated members of the personnel	41,085	41,285	0.5%
Other overheads	49,515	49,515	
Consultancy	*9,005*	*9,005*	
Contributions to Collaborations	*7,495*	*7,495*	
Miscellaneous[2]	*33,015*	*33,015*	
Interest and financial costs	**12,060**	**11,215**	**-7.0%**
Fortis bank	9,050	8,205	-9.3%
In-kind (FIPOI interest 0%)[3]	2,045	2,045	
Other financial expenses	965	965	
TOTAL MATERIALS	**564,630**	**618,585**	**9.6%**

[1] Following changes in the classification of service contracts at CERN (CERN/FC/6038/RA "Service contracts at CERN") the items reported previously under *Repair and maintenance* are included now in the Service contracts heading.

[2] Including insurances and postal charges, handling and transport, bank charges, depreciation of current assets.

[3] Theoretical interest at market rate for FIPOI 1, 2 and 3 loans at 0%. This heading is compensated by the corresponding revenue line "Other revenues / In-kind".

The electricity consumption in 2018 is larger than in 2017 because of the shorter year-end technical stop.

Figure 16: Breakdown of materials expenses by nature

Materials expenses: 98.2%

Interest and financial costs: 1.8%

* Total of industrial services: 21.2% + 0.9% = 22.1%.

** Including insurances and postal charges, consultancy, CERN contributions to collaborations, handling and transport, bank charges, depreciation of current assets.

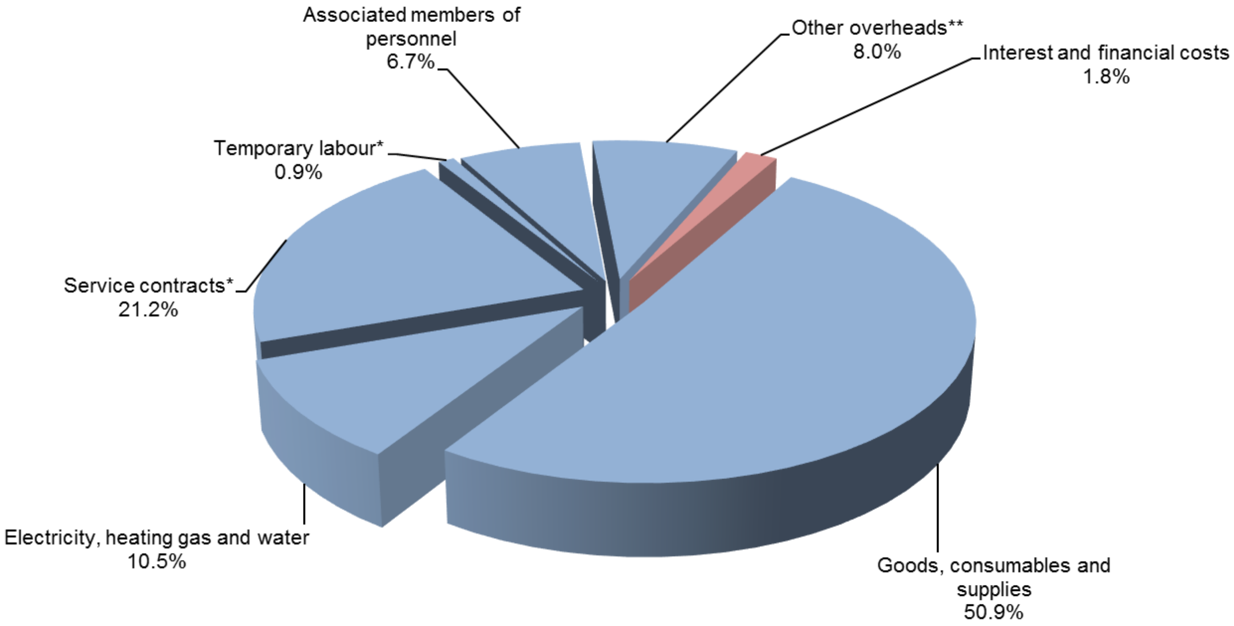


Figure 17: Personnel expenses by nature

Overall complement: The 2018 personnel budget covers 2615 FTEs staff (2537 FTEs on CERN's core budget, 8 FTEs on EU projects, 1.5 FTE on TT, 12 FTEs paid by external parties and 57 FTEs paid from team accounts) and 504.5 FTEs fellows (451 FTEs on CERN's core budget, 41 FTEs on EU projects, 1 FTE on TT, 5.5 FTE paid by external parties and 6 FTEs paid from team accounts).

(in kCHF, rounded off)

Nature	Revised 2017 Budget (2017 prices)	2018 Draft Budget (2017 prices)	Variation of 2018 Draft Budget with respect to Revised 2017 Budget
	(a)	(b)	(b)/(a)
Staff members [1]	**505,425**	**513,030**	**1.5%**
Basic salaries (incl Saved Leave)	***325,010***	***330,600***	***1.7%***
Basic salaries	326,455	331,965	
Performance payment (non-pensionable)	4,140	4,260	
Contribution to Saved Leave schemes	-5,585	-5,625	
Allowances	***66,455***	***66,525***	***0.1%***
Non-resident allowances / International indemnities	20,375	20,415	
Family and child allowances	25,105	25,135	
Special allowances	2,420	2,420	
Overtime	2,585	2,590	
Various allowances	15,970	15,965	
Social contributions	***113,960***	***115,905***	***1.7%***
Pension Fund	88,075	89,580	
Health Insurance	25,885	26,325	
Fellows [2]	**75,340**	**56,245**	**-25.3%**
Apprentices	**300**	**200**	
Centralised personnel budget	**66,440**	**66,525**	**0.1%**
Centralised personnel expenses	***36,335***	***36,335***	
Installation, recruitment and termination of contracts	6,280	6,080	-3.2%
Installation and removal costs	*2,130*	*2,020*	
Termination allowances	*4,150*	*4,060*	
Additional periods of membership in the Pension Fund for shift work			
Contribution to Health Insurance for pensioners incl. Long-term care	30,055	30,255	0.7%
Contribution to Health Insurance for pensioners	*27,250*	*27,450*	
Contribution to Long Term Care for pensioners	*2,805*	*2,805*	
Internal taxation	***30,105***	***30,190***	***0.3%***
TOTAL PERSONNEL	**647,505**	**636,000**	**-1.8%**
Budget Amortization of staff benefit accruals	17,330	17,330	
TOTAL PERSONNEL incl bud. amort. of staff benefit accruals	**664,835**	**653,330**	**-1.7%**

[1] Including staff paid from team accounts (10.77 MCHF in 2017 and 9.35 MCHF in 2018).

[2] Including fellows paid from team accounts (2.89 MCHF in 2017 and 0.63 MCHF in 2018).

Comments on Figure 17:

The total CERN Personnel Budget for 2018 amounts to 653 MCHF. This includes 10 MCHF for staff and fellows paid from team accounts.

The budget for 2018 staff members totals 512.9 MCHF. This amount increases by 1.5% compared to the Revised 2017 budget, which is partly due the expected recruitment of most of the additional posts presented to Council in December 2016 (CERN/3281), as well as the net result of advancement and retirements. As of 2017, a new advancement system (MERIT) has been implemented, comprising two components: 1) a granular salary increase, and 2) a lump-sum performance payment (non-pensionable), both based on the performance of the individual staff members.

The allowances heading for 2018 is comparable to 2017, the downward trend for the non-resident allowances / international indemnities being compensated by the increased number of new recruits. The increase in social contributions is linked to the number of staff members. The percentage contribution to the CERN Health Insurance Scheme (CHIS) is stable since 2016, after yearly increases as of 2011.

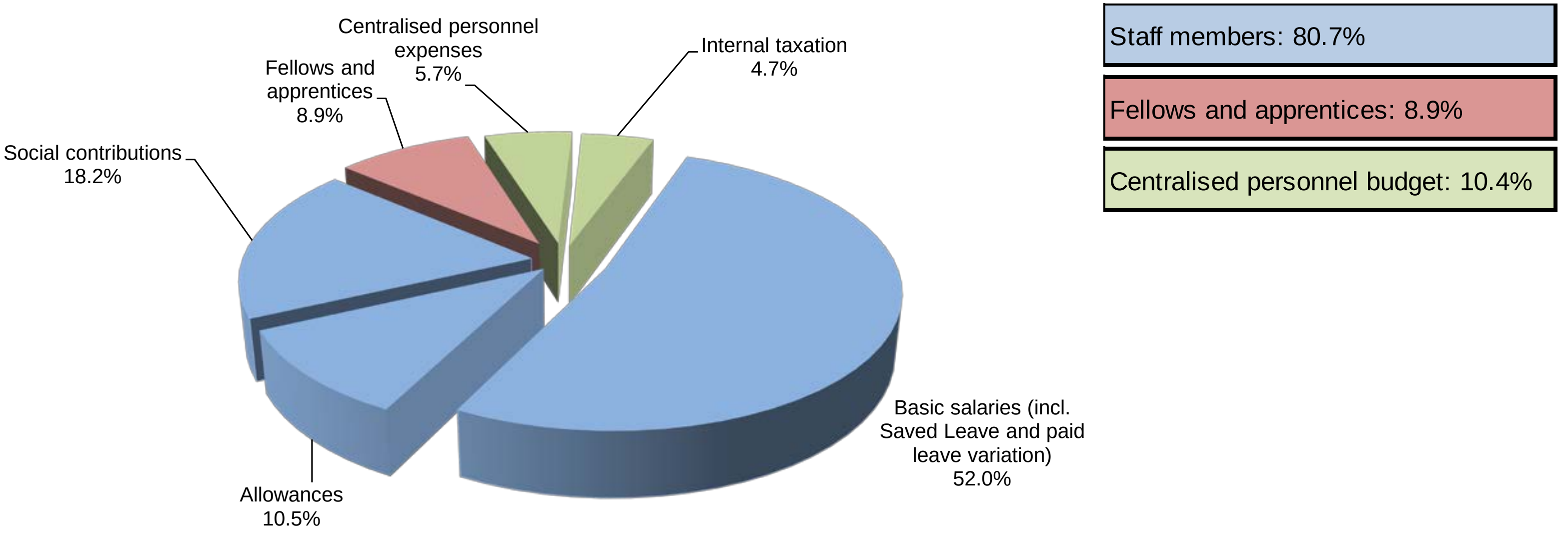
The contribution to the health insurance for pensioners has been increased, in line with the Council's approval in December 2016 of the modifications to certain CHIS benefits, contributions and affiliation conditions (defined in the document CERN/3282/Rev.).

Additional fellowship funding will be made available in the course of 2017 and 2018 from materials to personnel budget transfers in the context of the GET fellows programme and the Technical Trainees programme. This additional allocation will be made after the arrivals are confirmed. As of August 2016, apprentices are part of the associate members of the personnel (materials expenses); however the apprentices who had a contract before that date remain employed member of the personnel during their internship, so that the apprentices heading under personnel will gradually decrease until 2019.

The centralised personnel expenses total 36.3 MCHF.

Internal taxation is expected to amount to 30.2 MCHF and is compensated by an equivalent line in the revenues.

Figure 18: Breakdown of personnel expenses by nature



Energy and water

Figure 19: Expenses – Energy and water

(in MCHF, rounded off)

Nature	Revised 2017 Budget (2017 prices)	2018 Draft Budget (2017 prices)	Variation of 2018 Draft Budget with respect to Revised 2017 Budget
	(a)	(b)	(b)/(a)
Energy and water (baseload)	**14.20**	**14.40**	**1.4%**
Electricity	6.20	6.40	3.3%
Heating oil and gas	4.40	4.40	
Water and waste water	3.60	3.60	
Energy for basic programmes	**46.98**	**50.81**	**8.1%**
Experimental areas[1]	11.70	12.80	9.4%
Data handling	1.65	1.62	-1.8%
Accelerators:	13.06	14.94	14.4%
AD	*0.53*	*0.53*	*1.0%*
PS	*2.70*	*3.09*	*14.5%*
SPS	*9.83*	*11.32*	*15.1%*
LHC	20.57	21.45	4.3%
TOTAL ENERGY	**61.18**	**65.21**	**6.6%**

[1] This covers most of the experiments: LHC experiments including test beam into East, West and North Area, PS and SPS fixed target, ISOLDE.

Comments on Figure 19:

The electricity consumption in 2018 reflects a normal operation year. It is higher than in 2017, because of the shorter year-end technical stop.

6. FINANCIAL POSITION OF THE ORGANIZATION

Statement of cash flow

Figure 20: Estimated statement of Cash Flow for Financial Years 2017 and 2018

(in MCHF, rounded off, estimated as at 18/05/2017)	**2017** (2017 prices)	**2018** (2018 prices)
(A) START OF THE YEAR		
Liquid assets brought forward	155	* 108
Outstanding short-term loans	0	* 0
(1) CASH INFLOW	**1,283**	**1,280**
Contributions	1,120	1,126
Teams and collaborations	119	119
EU, KT, other revenues	44	35
(2) CASH OUTFLOW	**1,330**	**1,388**
Payments	1,111	1,169
Teams and collaborations	123	123
Interest, bank and financial expenses	10	9
Capital repayment Fortis and FIPOI	26	27
Recapitalisation of the Pension Fund	60	60
(3) VARIATION OF CASH POSITION	**-47**	**-108**
(B) END OF THE YEAR		
Estimated liquid assets	**108**	**0**
Estimated outstanding short-term loans	**0**	**0**

* For 2018, it is an estimated amount.

Comments on Figure 20:

The statement of Cash Flow is an estimate based on the assumption that Member States' contributions will be paid by the expected instalment dates. Under these assumptions, no short-term loans will be required in 2017 and 2018.

Short-term bank loans and overdrafts

No short-term bank loans and overdrafts are expected in 2017 and most likely not in 2018, provided that Member States' contributions are settled on the scheduled instalment dates and by the end of the year at the latest.

Loan from BNP Paribas Fortis bank

The outstanding amount to BNP Paribas Fortis Bank amounts to 248.4 MCHF at the end of 2017 and will reduce to 222.7 MCHF by the end of 2018. The loan will be fully reimbursed by the end of June 2026.

Loan from FIPOI

The FIPOI loans are interest free. The capital repayment for the existing three FIPOI loans amounts to 1.1 MCHF per year; the financial benefit is accounted for as in-kind.

IV. APPENDICES

1. DETAILS OF ACTIVITIES AND PROJECTS (FACT SHEETS)

LHC programme

1. LHC machine, reliability and consolidation

Goal	Reliable operation of the LHC at 13 TeV centre-of-mass energy proton-proton collider. Reliable operation of the LHC to collide $Pb^{82}+$ ions and to provide proton $Pb^{82}+$ collisions at an equivalent proton energy of 13 TeV.This heading also includes the continuing studies to improve the performance of the LHC complex.
Approval	1996
Start date	R&D 1990, Construction 1998
Costs	Total costs of the consolidation programme and of the continuing studies to improve the performance of the LHC are under continuous evaluation. The consolidation heading for LHC reliability is of a non-recurrent nature but on-going without an end date since it is comprised of many smaller-scale items necessary for reliable LHC operation. Collimation: the material Cost-to-Completion of the Collimation project including M to P transfers, CERN funding, is 27.1 MCHF. R2E: the material Cost-to-Completion of the R2E project including M to P transfers, CERN funding, is 78.9 MCHF up to 2025.
Running conditions	During Run 2, the LHC machine will run at 6.5 TeV per beam, the running period will last until end-2018, interrupted by a technical stop at the end of every year.
Competitiveness	Highest centre-of-mass energy collisions worldwide.
Organisation	Technical management via a specific committee structure. Overall organisation under the Directorate for Accelerators and Technology.
Risks	Ageing of the LHC and the technical infrastructure components: the risks are continually evaluated and mitigated. An extensive consolidation programme is under way to ensure their reliability and the availability of spare components. The consolidation projects are organised in such a way that during the year, if new insights in risk are obtained, priorities are shifted and the items with the highest priority will have budget allocated.
2018 targets	Proton run: the total integrated luminosity target is set at 100-120 fb^{-1} delivered to the high luminosity experiments during LHC Run 2, at an energy of 13TeV - the decision to keep running at an energy of 13 TeV has been taken during the LHC Performance workshop held in January 2017. The exact 2018 integrated luminosity objective will be defined during the same workshop at the end of January 2018. Special physics runs: these will be carried out upon approval of Physics committees and depending on the production of total integrated luminosity. Consolidation and upgrade of the accelerator technical infrastructure continues, with the following highlights for 2018: • Execution of LS2 LHC collimator contracts, including new dispersion suppression collimators, advanced primary, secondary and tertiary collimators;

1. LHC machine, reliability and consolidation (cont.)

2018 targets	• Production of a prototype of new injection collimator (TDIS) compatible with LIU beams and compliant with the operational feedbacks obtained during LHC Run1 & Run2; • Advanced study of an upgraded LHC beam dump core in order to increase reliability and to be compliant with HL-LHC beams; • Upgrade of the electronics Radiation Monitoring devices in all the LHC underground area; • Upgrade of the power-converter control in order to further minimize the risk of radiation induced failures, especially in the RRs. The 600A/4-6-8kA power converters will be entering production phase in view of LS2 deployment; • Consolidation and upgrade of the electrical network: new 400/66 kV substation, consolidation of 400 kV protection system; • Studies for the refurbishment of the LHC P18 cooling and ventilation system, i.e. the separation of the SPS and LHC cooling loops; • Replacement of one LHC lift. Preparation for large campaigns that will take place during LS2 will also start, such as the preparation to consolidate the standard LHC BLM (Beam Loss Monitor) and BPM (Beam Position Monitor) systems, the consolidation of quench protection racks (DYPQ - yellow racks), the reconstitution of the spares for the LHC fixed pumping groups for insulation vacuum and the manufacturing of LHC MQ cold mass.
Future prospects & longer term	In line with the European Strategy, full exploitation of the physics potential of the LHC will carry on with a collision energy between 13 and 14 TeV. The long-term luminosity goal is 300 fb^{-1} delivered to ATLAS and CMS before LS3. Continuation of the heavy ion programme as defined by the Physics committees, i.e. a total of 3 ion runs during Run 2, 3 during Run 3 and 3 during Run 4. Continuous efforts to increase the reliability, availability and performance of the machine: An outlined planned consolidation programme up to LS3 now exists and will continuously be refined on an annual basis based on a risks analysis. The R2E project is a continuous programme with the final goal to limit the number of dumps due to single event upset (SEU).
Specific Health & Safety issues	Losses throughout the LHC accelerator may produce some activated equipment. The beam-cleaning areas and the high-luminosity insertions will become particularly activated. Sites are identified for the treatment and storage of this equipment. Budget is set aside to deal with the disposal of activated accelerator components. RP plans and surveys all such operations following the ALARA principle.
Outreach	The LHC is highly visible in the press and public domain.

		Personnel (FTE)	Personnel (kCHF)	Materials (kCHF)	Total (kCHF)	Comments
CERN budget for 2018	**LHC machine and experimental areas**	**301.2**	54 590	42 940	**97 530**	
	Spares			3 410	**3 410**	
	LHC machine and areas: reliability and consolidation	**84.1**	14 090	41 645	**55 735**	

LHC experiments

2. ATLAS detector

Goal	Verify the Standard Model and search for new physics.
Approval	31 January 1996
Start date	1998
Costs	Total CERN share of Materials for construction of the current ATLAS experiment: 128.8 MCHF. Total Personnel and Materials (CERN share, project, tests and operation until 2008 incl.): 509.2 MCHF.
Running conditions	Runs up to full design luminosity. Ready to use any luminosity provided.
Competitiveness	ATLAS is competitive with CMS, and with even unique potential compared with other existing facilities.
Organisation	A total of 177 institutions from 38 countries with about 3,000 authors with PhD (or equivalent), students included. *Governing body*: Collaboration Board (one representative per member institution) and Chair. *Executive bodies*: Management: Spokesperson and two Deputies, Technical Coordinator, Resource Coordinator. Executive Board chaired by the Spokesperson. Subsystem Projects led by Project Leaders. Physics Working Groups with two co-conveners per working group. Interface with CERN through a dedicated CERN team. Change of ATLAS Spokesperson and the two deputy Spokespersons in March 2017. Technical Coordinator and Resource Coordinator remain in their position.
Risks	No major managerial, technical and financial risks are identified. General risk related to the operation of a very complex detector system including many different detector technologies.
2018 targets	Fully exploit the improved physics potential of LHC Run 2, benefitting from the higher LHC collision energy (13 TeV) at nominal luminosity, and the more performant ATLAS detector owing to its 4th pixel layer (IBL) and improved trigger capabilities (increased selectivity in the presence of pile-up, and rates increased to 100 kHz at Level-1 and 1 kHz at HLT). Continue to improve bandwidth of data acquisition systems and computing power to deal with increased luminosity. Continue preparations, procurement and construction of Phase-I upgrade projects. Continue as well the Phase-II upgrade R&D, and prepare the TDRs.
Future prospects & longer term	Continue data-taking for physics in Run 2, while constructing the Phase-I upgrade projects to be installed in LS2. Given the luminosity expected by the machine expect to further study the detailed properties of the Higgs boson. Searches for supersymmetry will continue, with possible discoveries up to masses of 2 TeV and beyond, and carriers of new physics up to masses of 2–4 TeV and beyond. Extend precision on other Standard Model parameters such as W/Z boson and top quark properties. Continue to plan the Phase-II upgrade and a continuation of the LHC operation with higher luminosity after LS3. Physics and detector performance studies as well as planning and R&D of the detector upgrades including TDRs, followed by the construction, integration and commissioning of the new detectors.

2. ATLAS detector (cont.)

Outreach	Organised by the Collaboration and documented in the ATLAS Communication Plan.
CERN contribution	Infrastructure in the experimental area. Strong contribution towards the technical coordination of the experiment including the subsystem installation. Providing Tier-0 centre as well as some analysis capability. Important contributions to all sub-systems of the operating detector and to subsystems for the Phase-I (6 MCHF CORE plus non-CORE) and Phase-II upgrades. A total of 128 MCHF was spent for the current ATLAS detector, financial contributions to Phase II need to be defined. At present, a total 78 staff, 52 fellows, 17 doctoral and technical students and 29 associates (staff 72.4 FTE equivalents). Very important contribution to the physics results.

CERN budget for 2018	**Personnel (FTE)**	**Personnel (kCHF)**	**Materials (kCHF)**	**Total (kCHF)**	**Comments**
	82.6	16,120	3,415	**19,535**	Of which M&O: 1.06 MCHF.

3. CMS detector

Goal	Verify the Standard Model and search for new physics.
Approval	29 April 1998
Start date	1998
Costs	Cost-to-Completion (CERN share of Materials): 127.8 MCHF. Total Personnel and Materials (CERN share, project, tests and operation until 2008 incl.): 488 MCHF.
Running conditions	Runs up to full design luminosity. Ready to use any luminosity provided.
Competitiveness	The CMS detector is a very versatile scientific instrument, capable of outstanding performances in hadron runs as well as in heavy ion runs.
Organisation	A total of 172 institutes finance the CMS experiment, funded by 44 Funding Agencies from 42 countries with 2065 signing scientists with PhD (or equivalent). *Governing body*: Collaboration Board (one representative per member institution) chaired by an elected Chairperson (2-year mandate). *Executive bodies*: Management Board, Executive Board, Finance Board. Spokesperson (2-year mandate), Technical Coordinator, Resources Manager, Subsystem Project Leaders. Interface with CERN through a dedicated CERN team.
Risks	No major managerial and financial risks identified, general funding risk linked to securing the remaining funds for the Phase-I upgrade and Phase-II R&D and upgrade. *Technical:* loss of humidity control in Tracker volume is the main risk, leaks in the detector and other general risks related to the operation of a very complex detector system including many different detector technologies. Risk of damage to the Magnet such as delamination of the magnet coil structure. Succession plan required for technical teams in order to ensure the expertise needed to maintain and run the detector during its lifetime. This should be implemented already during LS2, which will serve as a training opportunity for personnel assuming these functions in the future.

3. CMS detector (cont.)

2018 targets	With the successful installation of the Pixel Phase-I upgrade, the completion of the HF readout upgrade and the completion of the Trigger Phase-I upgrade, CMS is planning to collect with high efficiency data from LHC confident to be able to sustain luminosities up to 2×10^{34} $cm^{-2}s^{-1}$. Benefit from Phase-I upgrades and exploit the increasing luminosity expected to be delivered by the LHC in further searches for new physics as well as verification of the Standard Model, by performing fast data analysis and precision measurements. Among the physics objectives to note the aim to make a very precise measurement of the W boson mass. Install the Phase-I upgrade for the HE frontend during the YETS 2017-18. Intense R&D program for the Phase-II upgrades.
Future prospects & longer term	Complete Phase-I upgrades by the end of LS2, step up the R&D effort and launch the infrastructure preparations for the Phase-II upgrade. Continue to study the Higgs boson properties. Supersymmetry could be discovered up to masses of almost 2 TeV and carriers of new physics up to masses of 3-4 TeV. In LS2 complete most infrastructure preparations for the Phase-II upgrade. Construction must take place in parallel with shutdown work and Run 3 operation.
Outreach	Organised by the Collaboration and regularly reported to the Scrutiny Group for the activities financed by M&O-A. Linking regularly with CERN outreach efforts.
CERN contribution	Complete responsibility for the experiment infrastructure and common systems. Leading role in the DAQ, financially and technically. Other very important contributions to ECAL, Tracker, Muon Chambers and BRIL. Providing the CMS Centre infrastructure and Tier-0 facilities. Strong contribution to software tools and data analysis. Many CERN staff occupy top level managerial positions in CMS. Oversight of the technical work and resource utilization throughout the duration of the CMS Project to guarantee coherence and minimize risk.

CERN budget for 2018	**Personnel (FTE)**	**Personnel (kCHF)**	**Materials (kCHF)**	**Total (kCHF)**	**Comments**
	78.3	14,620	3,305	**17,925**	Of which M&O: 0.66 MCHF.

4. ALICE detector

Goal	Study of heavy ion collisions: measuring properties of strongly interacting matter at extreme energy densities where the formation of a quark-gluon plasma is expected. Study of proton-proton (pp) collisions: establishing reference data for the study of the quark-gluon plasma and studying properties of pp collisions where ALICE has unique capabilities thanks to particle identification and low-p_t acceptance. Study of pA collisions, fundamental to understand cold matter effects in heavy-ion collisions, but also to probe the nuclear structure at very high energy, accessing very low x values.
Approval	1997
Start date	1998
Costs	Cost-to-Completion (CERN share of Materials): 28.6 MCHF. Total Personnel and Materials (CERN share, project, tests and operation until 2008 incl.): 182.9 MCHF.
Running conditions	Dedicated heavy ion and proton-ion running and systematic pp running.
Competitiveness	ALICE is the only general-purpose detector dedicated to heavy ion physics at the LHC. It covers in a single experiment all the main measurements and allows major improvements for most variables in comparison to the RHIC experiments.
Organisation	124 institutes from 34 countries with 584 participants with PhD (or equivalent). *Governing body*: Collaboration Board with one representative each of the participating institutes, chaired by an elected Chairperson. *Executive bodies*: Management Board: Spokesperson plus two deputies, Technical, Resources, Computing, Upgrade and Physics Coordinators, Project Leaders, and elected members. Interface with CERN through a dedicated CERN team.
Risks	No major managerial and financial risks identified. The reorganisation of the collaboration for the upgrades, and maintaining coherence between analysis, Run 2 operation and the upgrade for Run 3/4, are challenges requiring organisational effort, but not major risks. *Technical:* no specific risks identified; general risk related to the operation of a very complex detector system including many different detector technologies.
2018 targets	The analysis of Run 2 data. ALICE will take data with proton beams for most of the year and with heavy-ion beams during the last month of operation before LS2. The objectives are to collect 0.5/nb of triggers events and about 150 M of central collisions to complete the program for Run 1 and Run 2 as well as collecting the final reference pp data sample.
Future prospects & longer term	At the moment ALICE is preparing a major upgrade of the detector and the computing system to be installed during LS2. In the years after LS2, ALICE foresees running again for one month per year with either PbPb or pPb collisions, at the higher rates, for at least six years of data-taking, complemented by pp running. In the current LHC plan this program extends to the 4th Long Shutdown LS4.
Specific Health & Safety issues	Nothing specific identified.

4. ALICE detector (cont.)

Outreach	Organised by the Collaboration, in collaboration with ALICE CERN Team. Effort to increase visibility of ALICE, and to guarantee the dissemination of correct information on the scientific results to the mass media.
CERN contribution	Overall scientific, technical and financial coordination, including safety. Experimental infrastructure and responsibility for installation and planning and execution of shutdown activities. Participation in detector construction, maintenance and operation projects: ITS (Project Leader), Si Pixel detector and level zero trigger, TPC (field cage, electronics), HMPID and Muon Arm (magnet). Contribution to PHOS and EmCal electronics. Financial contribution to Si Strip detector. Participation in other systems: responsibility for ACT, ECS, DAQ, DCS, electronic logbook, ALICE-LHC interface and infrastructure/installation, including test beam areas. Electronics coordination. Coordination of offline computing, including simulation and data processing. Development of offline computing framework, Physics coordination.

CERN budget for 2018	**Personnel (FTE)**	**Personnel (kCHF)**	**Materials (kCHF)**	**Total (kCHF)**	**Comments**
	43.7	8,180	1,965	**10,145**	Of which M&O: 0.56 MCHF.

5. LHCb detector

Goal	Search for physics beyond the Standard Model in CP violation and rare decays of beauty and charm hadrons.
Approval	September 1998
Start date	1998 (construction)
Costs	Cost-to-Completion (CERN share of Materials): 20.5 MCHF. Total Personnel and Materials (CERN share, project, tests and operation until 2008 incl.): 121 MCHF.
Running conditions	Levelled luminosity at 4 x 10^{32} $cm^{-2}s^{-1}$ (by locally displacing beams), compared to the LHC nominal luminosity of 10^{34}.
Competitiveness	Large number of beauty and charm hadrons produced by LHC compared to the existing facilities. Efficient inclusive heavy flavour trigger and hadron particle identification compared to the other LHC experiments. LHCb has submitted over 300 publications.
Organisation	A total of 71 institutes from 16 countries with 778 authors (PhD or equivalent), out of a total of 1225 participants (as of Dec. 2016), students included. *Governing body*: Collaboration Board (one representative per member institute) and Chair. *Executive bodies*: Management: Spokesperson and Deputy, Technical Coordinator, Resource Coordinator. Interface with CERN through a dedicated CERN team.
Risks	No major managerial and financial risks identified. *Technical:* no specific risks identified. General risk related to the operation of a very complex detector system including many different detector technologies.
2018 targets	Continue efficient data-taking at 4 x 10^{32} $cm^{-2}s^{-1}$ and 25 ns bunch crossings. Continue optimisation of the new trigger and HLT schemes (successfully carried out from 2015 to 2017), improve software efficiency and consolidate present farm and storage infrastructure. Continue detector construction for LHCb upgrade with LS3 starting in 2019 to be ready for 2021. Further define strategy, objectives and methods for the HL-LHC phase.
Future prospects & longer term	A physics run at 4 x 10^{32} $cm^{-2}s^{-1}$ luminosity is foreseen until Long Shutdown 2 (LS2). LHCb could be sensitive to new physics with the sample collected in 2011-12 along with that of 2015-18 in the areas of rare decays, and of CP violation in b or c hadron decays. Preparing for an upgrade during LS2 to enable the LHCb experiment to operate at 10 times the design luminosity, i.e. at about 2 × 10^{33} $cm^{-2}s^{-1}$, to collect a data sample of ~50 fb^{-1}. Plans on goals and technologies are continuing to define the HL-LHC phase.
Outreach	LHCb places a strong emphasis on communication to the general public as well as to specifically targeted interest groups, such as students, schools and journals.
CERN contribution	CORE contribution 13.5 MCHF plus iron blocks for the muon filter. Total cash investment to the experiment 23.1 MCHF, which also includes providing infrastructure and R&D. A total of 47 FTEs (staff plus fellows) paid by CERN.

CERN budget for 2018	Personnel (FTE)	Personnel (kCHF)	Materials (kCHF)	Total (kCHF)	Comments
	44.0	8,395	1,650	**10,045**	Of which M&O: 0.34 MCHF.

6. Common items, other experiments

6a. Totem detector

Goal	Measurement of total cross-section, elastic scattering and diffractive phenomena.
Approval	Research Board decision of July 2004.
Start date	2005 construction, physics with first LHC stable beams.
Costs	Cost-to-Completion (CERN share of materials): 2.7 MCHF. Total Personnel and Materials (CERN share, project, tests and operation until 2008 incl.): 10.8 MCHF.
Running conditions	Special runs: with large β^* (90 m, 1540 m and 2500 m) and with standard optics but reduced luminosity; continuous running under normal LHC beam conditions.
Competitiveness	The total cross-section and elastic scattering measurements have almost no competition. Diffractive studies are complementary to ATLAS and CMS, but TOTEM has the most complete proton measurements.
Organisation	A total of 11 institutes from 8 countries with ~70 participants with PhD (or equivalent). *Governing body:* Collaboration Board (one representative per member institute) and Chair. *Executive bodies:* Management: Spokesperson and Deputy, Technical Coordinator, Resource Coordinator. Management Board. Technical Board chaired by Technical Coordinator. Subsystem projects led by project leaders. Physics and Analysis groups chaired by physics and analysis coordinators.
Risks	Technical risks: radiation damage of detectors close to beam, for example silicon sensors in RPs; reinstallation of T1 and T2 at the end of LS1.
2018 targets	The TOTEM experiment has installed and commissioned a precise clock distribution system during EYETS 2016/17. A first series of TOTEM diamond detectors were installed and operated successfully during 2016 in CT-PPS Roman Pots at standard optics. In combination with the diamond detector packages which are currently under production, the vertical Roman Pots of TOTEM will allow vertex separation during high luminosity runs with beta* of 90m in 2018. The physics goals and requirements for the integrated luminosity have been outlined in the relevant TDR of the TOTEM timing measurements from the vertical Roman Pots (CERN-LHCC-2014-020). Furthermore, the TOTEM detectors T1 (presently at the surface in IP5) and T2 (installed in CMS) in combination with the Roman Pots of TOTEM, would allow the measurements of the total cross-section at maximum LHC energy. The preparation of T1 and T2 during YETS 2017/18 in particular the mechanical integration of the T1 detector in the CMS experiment will depend on the LHC running scenarios for 2018. In addition the interest in measuring the elastic scattering cross-section in the Coulomb-Nuclear interference region at injection energy has been announced to the LHCC. In view of standard optics, the main goal of TOTEM for 2018 is to run at full luminosity with CT-PPS to search for physics beyond the Standard Model. In this sense, the goals of the TOTEM experiment for 2018 have been outlined, but they depend on decisions from the LHCC on the machine energy reach and the time devoted for special runs at high beta* in that year.

6a. Totem detector (cont.)

Future prospects & longer term	Data-taking at the highest possible energy and at all possible β^* to measure total cross-section and elastic scattering. Very high β^* (≥1.5km) for Coulomb interference studies. Continue diffractive production studies at the highest possible luminosity permitted by the TOF systems, in common data-taking with CMS when appropriate, at low mass (~ GeV) as well as at high mass (several hundred GeV). In the medium term: implement a time reference system and install TOF detectors in Vertical Roman Pots. In the longer term: install rad-hard silicon detectors and high-precision timing in the new cylindrical Horizontal Roman Pots.
Outreach	Spin-off from the TOTEM development of edgeless silicon detectors and VFAT chips (front-end readout and trigger) for industrial applications.
CERN contribution	• Spokesperson. • Overall technical coordination for the experiment including the subsystem installation. • Infrastructure in the experimental area; coordination of the physics data analysis. • Leading responsibility in the Roman pot system including silicon detectors; run coordination. • Responsibility in online (incl. DCS) and coordination of offline computing. The CERN-TOTEM Team is 5 FTEs strong.

CERN budget for 2018	**Personnel (FTE)**	**Personnel (kCHF)**	**Materials (kCHF)**	**Total (kCHF)**	**Comments**
	5.1	1,095	280	**1,375**	Of which M&O: 0.25 MCHF.

6b. LHCf detector

Goal	Measurement of forward production spectra of pi0's and neutrons at the LHC energy for the purpose of verification of hadron interaction models for cosmic-ray physics.
Approval	June 2006
Start date	2006
Costs	Total Personnel and Materials: 2 MCHF.
Running conditions	Short low luminosity (~ 2 10^{29}) and high β^*(11 m or larger) runs. Runs with different energy would also be interesting to verify interaction models.
Competitiveness	Other zero degree hadron calorimeters in LHC experiments, but complementary to each other since the LHCf is dedicated to measuring EM components.
Organisation	32 members from 4 countries participating (incl. 22 PhDs, 9 students); spokesperson, deputy spokesperson, technical coordinator, GLIMOS.
Risks	No financial, technical or managerial risks identified.
2018 targets	Analyses of the data taken by 2016. Special care in the combined analyses with ATLAS, and analyses of collision energy dependence. Feasibility study of future light-ion collisions.
Future prospects & longer term	Beam test after the operation. Data-taking in proton-light ion collisions like oxygen.
Outreach	To communicate information to the public using web, publicity and press releases, etc. and to create interdisciplinary connection between cosmic ray physics and particle physics.
CERN contribution	Overall technical coordination for the experimental infrastructure, installation, planning and execution of shutdown activities. General interface to the machine before and during data-taking. GLIMOS, Computer administration and Outreach activities.

CERN budget for 2018	**Personnel (FTE)**	**Personnel (kCHF)**	**Materials (kCHF)**	**Total (kCHF)**	**Comments**
					No direct CERN contribution for Materials.

6c. MoEDAL

Goal	Monopole and Exotics Detector At the LHC (MoEDAL). The prime motivation of this experiment is to search for the direct production of magnetic monopoles at the LHC. In addition, MoEDAL is sensitive to a number of highly ionizing, slow moving, singly or multiply electrically charged particles from a number of new physics arenas including Supersymmetric and extra spatial dimension scenarios.
Approval	December 2009
Start date	2010
Running conditions	The MoEDAL detector consists of layers of Nuclear Track Detector plastic placed in the immediate vicinity of LHCb's detector, within the acceptance of the LHCb detector adjacent to the RICH detector and attached to the walls of the cavern that houses the VELO detector. There is also a "Trapping Detector" system consisting of approximately one tonne of aluminium volumes where stopping particles are captured for subsequent analysis using remote detector systems. Radiation conditions in the MoEDAL/VELO cavern are monitored by a TimePix pixel device array. Full deployment of the MoEDAL detector for running at 13 TeV in 2015 was achieved in the Winter of 2014.
Competitiveness	Complementarity to other searches at LHC thanks to full angular coverage, calibrated sensitivity to highly ionizing avatars of new physics such as magnetically charged particles and also slow moving electrically charged particles with excellent efficiency. MoEDAL's MMT array is the only LHC detector capable of directly detecting the presence of magnetic charge via detection of trapped monopoles in a remote SQUID array.
Organisation	Physicists from Algeria, Canada, CERN, the Czech Republic, Finland, Germany, Korea, India, Italy, Poland, Romania, Spain, Switzerland, United Kingdom and the US.
Risks	No financial, technical or managerial risks identified.
2018 targets	During 2018 fresh NTDs and MMT detector will be installed for running at Point 8 with estimated integrated luminosity of a few fb^{-1}. In addition, it is planned to deploy a small prototype of a proposed new sub-detector, MAPP (MoEDAL Apparatus for Penetrating Particles), to study experimental backgrounds.
Future prospects & longer term	Re-deployment of the 10x25 m^2 NTD array, MMT array and TimePix array in the Winter shutdown of each year of running until an integrated luminosity of > 10 fb^{-1} is obtained.

CERN budget for 2018	**Personnel (FTE)**	**Personnel (kCHF)**	**Materials (kCHF)**	**Total (kCHF)**	**Comments**
					No direct CERN contribution for Materials.

6d. Common items: support to LHC detectors

CERN budget for 2018	**Personnel (FTE)**	**Personnel (kCHF)**	**Materials (kCHF)**	**Total (kCHF)**	**Comments**
	22.5	3,685	2,120	**5,805**	

7. LHC detectors consolidation (ended)

8. LHC computing

Goal	Build, maintain, and operate a data storage and analysis infrastructure for the worldwide LHC physics community.
Approval	2001
Start date	2002
Costs	Total Personnel and Materials (CERN share, project and operation): 511 MCHF up to end 2016.
Running conditions	• Service to run 24hrs x 365 days a year; distributed infrastructure allows individual external sites to be down while maintaining overall service. • Typical data rates over 35 GB/s globally with significantly higher peak rates from CERN to Tier 1s, equivalent rates between Tier1/2 sites. • In 2017-2018, plan to manage well in excess of 2 M jobs per day. LHC Run 2, nominal luminosity is now exceeded, and expected to continue more than 50% higher than nominal; in addition the LHC live time is very much higher than expectations, leading to significantly higher computing requirements in 2017,18 than previously anticipated. The Tier 0 facilities will be used for simulation, processing and analysis, and the extension of the Tier 0 in Budapest is fully integrated in production. Updated computing models and infrastructure were documented in CERN-LHCC-2014-014.
Competitiveness	Largest ever computing endeavour to store and analyse massive amounts of physics data for access worldwide. WLCG is a unique facility.
Organisation	• CERN + 13 Tier 1 sites + 73 Tier 2 federations (~168 sites). • Dedicated boards (C-RRB, OB, MB, GDB, CB) and committees (LHCC, C-RSG, AF). • Resources mainly in IT Department, some EP, and external in the collaborating institutes. • Collaboration established with a Memorandum of Understanding signed by 45 countries.
Risks	• Indications of pledged resource levels for 2017-2018 are now significantly above the requirements estimated in 2014 due to the enhanced performance of the LHC; and the increases in requirements forecast for 2018 will not be matched by available funding in several countries. Pledges are made at flat budget levels, with “best-effort” to find additional resources to satisfy the needs. • Levels of effort for distributed computing development are still very limited, and in addition the experiments are losing skilled effort in software and computing. Necessary developments for adopting new technologies and optimising the system may not be feasible in the short term. This may in turn increase costs. • A new risk related to the commercial uncertainty of the tape market could have a serious and significant impact on the cost of storage in the medium and long term.
2018 targets	Support full worldwide workloads of the LHC experiments at high luminosity, live time, and data rates; including: • Data archiving volumes up to 50 PB per year, data ingest rates close to 10 GB/s into the Tier 0. • Distribution of full raw data volumes to 13 Tier 1 centres. • Full reconstruction, simulation, and analysis workflows of all experiments fully supported. Full use of Wigner centre as an integral part of the Tier 0.
Future prospects & longer term	Anticipate continual evolution of the computing models and infrastructure, tools and services in order to relieve the pressure on resources due to the enhanced performance of the LHC. New strategies may be required to fit within available resources which may be less than requested in 2018. Longer term planning and R&D for computing for the upgrades is in progress, with a community white paper and vision paper on new computing models planned for 2017, leading to a TDR for HL-LHC computing in 2020. Medium term.

8. LHC computing (cont.)

Future prospects & longer term	plans for Run 3 need input on likely LHC running scenarios, expected not before 2018. Work is ongoing on the integration of commercial and opportunistic resources seamlessly with WLCG resources.
Outreach	• Support from “Science Node” (replaces ISGTW). • Working with CERN OpenLab partners to improve knowledge transfer. • Frequent Computer Centre tours, and large number of VIP visits. • Up to date LCG website (http://cern.ch/WLCG), WLCG dissemination material; volunteer computing projects in the LHC experiments and LHC@HOME.
CERN contribution	Tier 0 and Analysis facility to provide ~15%-20% of total computer and storage resources. Project management and coordination of all activities.

CERN budget for 2018	**Personnel (FTE)**	**Personnel (kCHF)**	**Materials (kCHF)**	**Total (kCHF)**	**Comments**
	107.5	24,040	21,175	**45,215**	

Other programmes

9. Non-LHC physics (experimental programme)

Goal	***SPS fixed-targets*** **NA58** (COMPASS): The post-LS1 programme includes first polarized measurements of the Drell-Yan process with a pion beam and measurement of Generalized Parton Distributions with a muon beam and a new LH_2 target. Detector upgrades installed during the shutdown. **NA61**: Search for the critical point of strongly interacting matter. Continue to run with various ion species to map out the phase transition of the QGP. Measure cross-sections relevant for the neutrino programme. **NA62**: Measurement of kaon rare decays in-flight. Data taking underway. The main focus is the $K^+ \rightarrow \pi^+ \nu \nu$ process which provides insight to short distance fundamental interactions complementary to that achievable at colliders. **NA63:** Continued investigation of scattering of high-energy particles in crystalline structures. **NA64:** new experiment to search for light dark bosons (Z') coupling to photons. ***PS fixed-targets*** **PS 215** (CLOUD): continued exploitation of the state-of-the-art large volume chamber to study the influence of cosmic rays on climate and to reduce uncertainties in atmospheric aerosol/cloud radiative forcing and so sharpen climate change projections for the 21st century. ***AD, ISOLDE, n_TOF*** **AD**: use decelerated anti-protons and positrons to measure differences if any between hydrogen and anti-hydrogen. Three experiments (AEgIS, ALPHA-g and the new AD-7 experiment GBAR under construction) aim to measure the gravitational interaction of anti-hydrogen. **ISOLDE**: Study the structure of short-lived (exotic) nuclei and employ them in neighbouring disciplines (nuclear astrophysics, weak interaction studies, condensed matter physics, life sciences). **n_TOF**: Measure neutron-induced reaction cross-sections of relevance for nuclear astrophysics, advanced nuclear technologies and fundamental nuclear physics. **AWAKE:** Study of electron wakefield acceleration in a proton-excited plasma at the SPS. ***Non-accelerator-based experiments*** **CAST**: continue to search for axion particles from the sun, or other sources. **OSQAR**: optical research for QED vacuum magnetic birefringence, axion and photon regeneration. Each of these experiments uses a decommissioned LHC prototype dipole.
Approval	**ISOLDE**: first approved in 1964, latest approval for continuation in June 2007. **n_TOF**: first approved April 1999. **AD**: latest approval for continuation in December 2008.
Start date	**ISOLDE**: first beam 1967, at present location first beam June 1992. First post-accelerated beam October 2001. **n_TOF**: first beam November 2000 until 2004, resume operation end of 2008. **AD**: first beam July 2000.

9. Non-LHC physics (experimental programme) (cont.)

Competitiveness	These unique experiments have been recommended by the SPSC or INTC and approved by the Research Board. The facilities at CERN (SPS, PS, ISOLDE, n_TOF, AD) support the requirements of substantial communities and provide unique conditions for numerous experiments.
Organisation	Each experiment or facility has a specific organisation, similar for all collaborations. Each is controlled by a specific MoU.
Risks	The total number of protons which can be delivered to the experiments and the beam time for requested experiments and tests is lower than requested due to the many groups which wish to carry out experiments and tests. Progress in AD experiments is partly tied to future technical breakthroughs. A large fraction of the experiments currently in preparation approved for HIE-ISOLDE will not be able to take data before LS2, due to manpower and beam time limitations tied to the need to commission the new cryomodule before commencing physics.
2018 targets	**AD:** commissioning of ELENA, extraction of low energy antiprotons towards the GBAR experiment. **HIE-ISOLDE:** Installation, commission and operation of post-accelerated beams at the maximum energy 10 MeV/u, completing the Phase 2 of the energy upgrade. Commissioning and operation of the new ISS device. **NA62**: Measurement of kaon rare decays in-flight. Data taking underway. The main focus is the $K^+ \rightarrow \pi^+ \nu \nu$ process which provides insight to short distance fundamental interactions complementary to that achievable at colliders. **NA58** (COMPASS): The programme includes a measurement of Generalized Parton Distributions with a muon beam and a LH_2 target in 2017 and polarized measurements of the Drell-Yan process with a pion beam in 2018. A physics programme beyond 2020 has been presented at the Physics Beyond Collider workshop. **CAST:** Continue to take data for relic axions and solar chameleons with higher sensitivities. **CLOUD:** During LS2 (2019-2020) modify the T11-CLOUD beam-area as part of the East Area renovation project, still remaining operational for two data taking runs with cosmics during LS2.
Future prospects & longer term	**AWAKE:** first beam commissioning. **AD:** Increased efficiency for antihydrogen trapping and possibly cooling, enabling its spectroscopy. Beam formation; measurement of gravitational properties of antimatter. The new cooling ring (ELENA) will help increase the production and trapping of antiprotons by up to 2 orders of magnitude. Increase in the number of experiments, which will then run in parallel. **CLOUD:** Study formation of cloud-active aerosols, including consequences on climate impact. **North Area:** Commissioning of the GIF++ for testing high rate behaviour and radiation hardness of LHC detectors. COMPASS: Measure the Drell-Yan process on a transversely polarized proton target, followed by measurement of deeply virtual Compton scattering, which is sensitive to Generalised Parton Distributions. NA61: Take data on p-Pb collisions at several energies (13-158 A GeV/c), on Ar-Ca collisions at several energies and eventually on Xe-La collisions. Additional data collection relevant to neutrino physics in collaboration with US groups. NA62: Data-taking for rare kaon decays to continue until LS2, prepare input for Physics Beyond Collider study; analysis of the data. **n_TOF:** With two experimental areas n_TOF will pursue research on nucleosynthesis, nuclear data for nuclear reactors and nuclear waste transmutation and innovative nuclear cycles, and medical applications; the number of experiments and collaborating institutes is increasing.

9. Non-LHC physics (experimental programme) (cont.)

Future prospects & longer term	**ISOLDE:** Within the HIE-ISOLDE project, the superconducting linac has proven already its power and will reach the highest energy at the start of 2018. This boost in energy of post-accelerated beams has opened the facility to new types of nuclear reaction experiments with short-lived nuclei, strongly enlarging the community. The design study to achieve higher intensity and purity of the ISOLDE beams has been done and the implementation will occur gradually, being the need of beam dump exchange planned for LS3. **CAST:** Plans for running up to LS2 have been submitted to the SPSC. **OSQAR:** Upgrade apparatus for study of photon regeneration.
Specific Health & Safety issues	**ISOLDE**: Some experiments involve handling of open radioactive sources. For these cases individual training by RP is done. **n_TOF**: Safety issues related to the use of radioactive sample material for measurements, in particular for actinides; these have been cleared by CERN safety authorities. **AD**: Safety issues related to the use of radioactive sources; these have been cleared by CERN safety authorities. **CLOUD**: During East Area renovation special attention to safety matters, in close collaboration with EN-EA and HSE.
Outreach	Continue to promote the diversity of CERN physics, through visits, workshops, teacher and student programs.
CERN contribution	General support in line with the General Conditions applicable to experiments performed at CERN.

CERN budget for 2018	**Personnel (FTE)**	**Personnel (kCHF)**	**Materials (kCHF)**	**Total (kCHF)**	**Comments**
	28.7	4,920	2,810	**7,730**	

10. Theory

Goal	The main goals of the activities of the Theory Department are: • Produce cutting-edge research in all areas of theoretical particle physics. • Provide a centre where theorists from the international scientific community can meet, be informed of new developments, discuss with experts, study, and do research. • Promote the education of young theoreticians at the post-graduate level; let them gain experience and reach maturity, while preparing them to form the next generation of professors in European universities. Contribute to the activities of the Organisation at all levels: support for the experimental programme, data interpretation, planning of future facilities, training, educational and outreach programmes, promotion of scientific events.
Competitiveness	The CERN Theory Department continues to be one of the world’s most active and prestigious centres in theoretical particle physics.
Organisation	Theoretical Physics Department.
Risks	No financial, technical or managerial risks identified.
2018 targets	Besides the general goals, the physics of the LHC during Run 2 will be an immediate target for 2018. Every aspect of the LHC physics program will be covered by the activities of the Theory Department: formulation of new models and theories, higher-order calculations in QCD, electroweak processes, flavour physics, heavy ions collisions, development of computational tools, assessment of the discovery potential, interaction with the experimental community, and organisation of workshops and scientific events. Moreover, in 2018 the CERN Theory Department will be actively engaged in research aimed at the preparation of the documents to be submitted to the upcoming European Strategy on Particle Physics.
Future prospects & longer term	Maintaining its level of excellence in theoretical physics research remains a priority for the future of the Theory Department. Moreover, the Department plans to increase its openness towards the international physics community, by promoting the participation of external physicists in its scientific activities and by sharing its resources with the rest of the community. In particular, this will be achieved with an intense program of TH-Institutes and other initiatives organised together with external physicists. There are also plans to strengthen the research activities in string theory, formal aspects of quantum field theory, cosmology, astroparticle physics, and lattice field theory.
Outreach	The Theory Department has a long tradition in active participation in CERN outreach. Indeed, theoretical ideas uniquely inspire the public, attracting interest towards science. Members of the Department regularly give public lectures at CERN and outside, and play a leading role in all educational CERN programs (physics schools, academic training, summer students, high-school teachers).
CERN contribution	CERN contributes to the logistics and general support. The Department is run by 18 research physicists and 4 administrative assistants. CERN provides the resources for an intense visitor program, which is essential for achieving the scientific goals of the Theory Department. This program includes about 40 fellows, 10-15 scientific associates, and 800 visitors per year.

CERN budget for 2018	**Personnel (FTE)**	**Personnel (kCHF)**	**Materials (kCHF)**	**Total (kCHF)**	**Comments**
	60.6	9,685	1,435	**11,120**	The scientific associates’ budget is handled centrally.

11. Knowledge transfer

Goal / Activities	The main goal of the Knowledge Transfer (KT) group is to promote and demonstrate the impact that CERN has on Society. This is done through a number of activities carried out within the group and through highlighting knowledge transfer activities carried out in other groups and departments. The principal activities are: • Maximise the dissemination of CERN technologies and know-how. The KT group has developed and is implementing a strategy which includes several initiatives to increase the number of dissemination channels, going from the classical scheme (patenting – licensing) to more Open Science approaches. CERN's Open Hardware license, CERN Easy Access IP Scheme and the creation of Business Incubators in the Member States are examples of some of these initiatives. The best dissemination channel is chosen for each new technology on a case by case basis. • Strengthen the link with Industry, inform them about new technologies and foster collaboration projects. • Promote, in collaboration with other groups and services at CERN, KT activities carried out CERN-wide (within and outside the KT group). This includes targeted communication actions for our external stakeholders (industry, decision makers and governmental bodies in the Member States, general public, public and private research institutes, universities, the European Commission). • Promote KT activities inside the Organization and further promote an incentive scheme for CERN units involved in KT projects. Foster KT projects and their follow up in accelerators, detectors and ICT technologies performed within the technical sectors. • Foster knowledge-exchange across a number of European networks, for example the EIROForum and HEPTech. • Foster technology transfer of CERN technologies and know-how. • Participate to / manage EC funded projects, in particular for aspects related to KT. • Provide advice and support to the CERN community on matters relating to KT in general. Together with the researchers help to identify key technologies and provide advice on applications and collaborations beyond HEP. In some cases such actions can be started at the beginning by a very small seed money such as the KT fund. • Raise awareness and promote interaction of CERN with the external broader scientific community and society to show the relevance of physics in innovation that is on-going and feasible in the future.
Risks	The amount of external revenues depends on CERN's success to conclude new partnerships and KT contracts. Risk of not executing KT projects within the deadlines foreseen due to lack of resources. Risk of not being able to attract foreseen resources from the EC. Fluctuations of income for the KT Fund.
2018 targets	• Strengthen the liaison with CERN's Member and Associate Member States through the KT Forum and other targeted initiatives (such as participation of the KT group to events organised in the Member states). • Continue the coordination of / participation to EC funded projects (QUACO, ARIES, AIDA-2020), investigate other funding opportunities. • Communication activities (KT annual report, SME network newsletter, Technology briefs, KT Website, KT Seminars, contribution to the CERN Annual report and to other communication initiatives of the ECO group). • Continue to foster new applications to the KT fund, select the best projects and ensure a proper follow up to deliver maximum impact. • For the network of incubators, focus on the existing BICs to increase the number of incubatees, and continue to develop a culture of Entrepreneurship at CERN.

11. Knowledge transfer (cont.)

2018 targets	• Develop new strategic partnerships with companies in the Member States. • Actively scout for more projects aimed at demonstrating the impact that CERN has on Society through the dissemination of its know-how and technologies, in particular in the medical and aerospace applications fields. • Through the KT Medical Application Section, provide operational support for, and coordinate, CERN’s medical applications-related activities, within the existing decision-taking framework, and chair the CERN Medical Applications Project Forum.
Future prospects & longer term	Stimulate knowledge transfer and generate more partnerships. Promote CERN’s achievements and possibilities even further in all areas (research, technology, education, training). Identify new ways to properly recognise and highlight knowledge transfer from CERN to Society.

CERN budget for 2018	**Personnel (FTE)**	**Personnel (kCHF)**	**Materials (kCHF)**	**Total (kCHF)**	**Comments**
	15.3	2,740	2,225	**4,965**	

12. Scientific support (associates, computing, R&D detectors and technical support)

Goal	Support to the various experiments at CERN on: scientific software tools, detector mechanics and electronics development, design, construction, installation and maintenance (including associated service infrastructure) and provision of administrative and logistics services to the community of users. Design and manufacture of high complexity PCBs and prototype detector components where the production time and cost in industry would be too long/high. For the LHC physics centre at CERN (LPCC), coordinate and optimise existing resources, and introduce new initiatives, dedicated to the best possible exploitation of the LHC data. Participation in detector upgrade programs during the development, design, construction, installation phases through generic R&D detector collaborations or direct participation in projects, and provide centralised resources and expertise for development of future detector technologies. Generic R&D for future generation of detectors.
Running conditions	General scientific computing, technical, logistical and administrative support for experiments. The detector technologies (EP-DT) and electronics (EP-ESE) groups are involved in the operation of the experiments and provide on-call services. The resources are shared between operation and new initiatives, the sharing being adapted to the requests for operation and shut-down periods of the experiments and their upgrade programs. The EP-SFT group provides and maintains general applications software required for the reconstruction and analysis of experimental data or the corresponding simulations.
Competitiveness	The resources are used on a multi-projects basis focusing mainly on common activities for all experiments. The Physics centre at CERN is complementary to LHC analysis centres worldwide, and provides scientific support to the whole LHC community.
Organisation	Groups of EP involved: DI, DT, ESE and SFT. Steering boards involving representatives from experiments and EP management periodically review the current activities, agree on new common or specific activities, and define the priorities.
Risks	No major financial, technical or managerial risks identified, provided that the level of resources and equipment replacements is kept at least at the present level to preserve expertise and to provide support to the community of users.
2018 targets	**DT:** Construction of new detectors, related infrastructures (gas, CO_2 cooling, controls) and engineering efforts on detector installation and integration for some ALICE and LHCb subsystems will be near to completion. Mass production of large-size micro-pattern detector components for ALICE GEM-TPC and CMS GEM GE1/1 will be completed. The development phase for the ATLAS and CMS trackers for HL-LHC will have started and include the construction and validation of a full size demonstrator for ATLAS ITK and detector prototypes for the new CMS Tracker. Focused R&D on CO_2 detector cooling technologies for very large tracker systems will be at full swing, providing input to design of the future, highly distributed plants for LS3. R&D on gas systems technologies and gas mixtures will be continued to ensure reduction of gases exhausted from LHC systems. A vigorous R&D programme on detector technologies such as radhard silicon strips, pixels and MPGDs will continue to ensure full alignment with detector projects and studies of strategic value for the Organization. Contributions for Neutrino Platform projects—DCS, DAQ for ProtoDune SP and DP at CERN—and the design and engineering of the LBNF cryostat to be installed in the SURF facility (US) will be completed. **ESE:** The first prototypes of the lpGBT and versatile-link-plus modules will be available. These devices will be used by ATLAS and CMS for their HL-LHC upgrades. Similarly, new DC-DC converters able to survive the HL-LHC trackers' radiation levels will be available. The first RD53 ASIC (ATLAS/CMS/LCD project for developing a pixel readout chip in 65 nm CMOS in view of the HL-LHC upgrades) will be available and extensively used for testing pixel modules of ATLAS and CMS. The involvement in the upgrades for Phase I (ALICE ITS, LHCb Velopix, CMS muon, ATLAS trigger) and Phase II (ATLAS ITK, CMS tracker) will continue while the.

12. Scientific support (associates, computing, R&D detectors and technical support) (cont.)

2018 targets	involvement in NA62 will mainly be related to delivering Giga-Tracker modules. Radiation hardness studies of current and next IC technologies will continue in view of getting a reasonable understanding of their behaviour in the HL-LHC trackers. The R&D in the field of silicon photonics and wafer-to-wafer bonding will continue. **SFT:** A beta release of the new simulation toolkit (GeantV) is aimed for end of 2018, with vectorised versions of EM-physics processes and geometry navigation, and sufficient functionality for experiments to evaluate its performance and usability. The production simulation toolkit (Geant4) will continue its evolution with better physics models and supporting the experiments. Major parts of the ROOT framework will be redesigned to better exploit parallelism (machine learning, math, fitting, data analysis, etc.), and more modern C++ interfaces will be offered to the experiments to increase reliability and robustness for Run 3. The pilot web-based analysis service (SWAN) will be consolidated and its operation transferred to the IT department. Running CernVM services will continue to be supported, and further developments undertaken according to the specific needs of HEP users. The activities around the HEP Software Foundation (HSF) will be ramped up to offer a palette of software services to the HEP community and encourage collaborations to develop common software such as the Gaudi data processing framework.
Future prospects & longer term	Support operation, consolidation for running experiments, in particular during the long shutdowns. Support running experiments in their use of common software and continue consolidation of software tools used for the analysis of LHC data. Effort on R&D will increase in order to re-engineer common LHC software for improving performance on new CPU architectures. Support will also be given to activities important for the future of the laboratory (LCD, FCC). Participation in the HEP Software Foundation will continue ramp up with a view to expanding collaboration with software units in other HEP laboratories to provide community-wide software services. Contribute with engineering and technical expertise to new detector construction projects, and play a central role on detector R&D and new technologies. Design of electronic systems and ASICs for the upgrade of the LHC experiments (both Phases I and II). Development of a faster and lower power version of the GBT link. Standardization of xTCA infrastructure equipment for the experiments' upgrades. Preparation for deeper submicron technologies and silicon photonics. Increase the R&D effort on novel detector technologies (including aspects such as composite development, evaluation of new materials, quality assurance for detector component production, radiation hardness assurance of detector components), new control systems, gas and detector cooling systems to ensure LHC experiments' longevity. Provide an integral approach for detector design and technical support at all phases of the projects. Develop and retain know-how, technical space, concentrate resources and expertise related to detector development. Liaison with other CERN departments and groups to focus on the needs of future experiments or upgrades. Prepare for a future generation of detector systems. For the LHC physics centre at CERN (LPCC), continue organising scientific activities centred on the LHC physics programme and its future upgrades (workshops, lectures and working groups, combination of results).
Outreach	Publication and regular updating of activities on web sites. Publication of a DT Annual Report of activities. The expertise developed in the support groups is regularly consulted by external institutes (computing, detector technologies and electronics). Participation in R&D collaborations, European funded projects and KT activities.
CERN contribution	Administrative, logistical, computing, technical and general support.

12. Scientific support (associates, computing, R&D detectors and technical support) (cont.)

		Personnel (FTE)	Personnel (kCHF)	Materials (kCHF)	Total (kCHF)	Comments
CERN budget for 2018	**Scientific support**	**169.7**	31,790	11,710	**43,500**	
	LHC physics centre at CERN (LPCC)			155	**155**	
	R&D detectors	**6.8**	1,915	440	**2,355**	
	Scientific exchanges (students and associates)	**4.9**	865	8,795	**9,660**	

13. PS and SPS complex

13a. PS complex / Accelerator maintenance and consolidation / Experimental areas consolidation

Goal	This heading comprises the facilities forming the PS complex. Included are LINAC2, LINAC4, PS Booster, PS and AD. These machines provide a range of beams to several experimental facilities including ISOLDE, n_TOF, AD, and the PS fixed-target experiments and test beams (East Area). LINAC2, PS Booster, PS and SPS also form the main injector chain for the LHC. Concerning the PS complex, the goal is to deliver the requested intensities for the PS-complex experiments and provide beam to the SPS and LHC programme upon request. Included here are also the specific injector machines for the SPS and LHC heavy-ion programme (LINAC3 and LEIR).
Costs	The consolidation heading for injectors, experimental areas and infrastructure systems is of a non-recurrent nature and is an on-going activity since it is comprised of several smaller-scale items. For that reason, there is no Cost-to-Completion but a foreseen funding level.
Running conditions	Very dynamic optimisation of the operational machine cycles is needed to simultaneously deliver and maximize the availability of beam to all experiments. A prioritization between the different facilities will continue to be needed and is set following discussions between the Management and the relevant scientific committees.
Competitiveness	The CERN accelerator complex represents a unique facility over a range of particle types and energies.
Organisation	There is a specific organisation of each facility with CERN being in charge of the resources and technical operation. Overall organisation under the Directorate for Accelerators and Technology.
Risks	• Failure of LINAC2: LINAC4 is now commissioned and constitutes a potential replacement of LINAC2 in case of major failure before the LS2. This solution allows the production of desired LHC beam characteristics, it would however have an impact on the other physics programme. • Ageing of accelerators and technical infrastructure components: the risks are continually mitigated and an extensive consolidation programme is under way to ensure the reliability of machines and the availability of spare components. The consolidation projects are organised in such a way that during the year, if new insights in risk are obtained, priorities are shifted and the items with the highest priority will have budget allocated. In addition to the accelerators themselves, risks to the experimental programme exist due to the state of the beam line equipment and infrastructure systems. Up to LS2, mitigation will involve significant renovation and consolidation of these zones.
2018 targets	The complex will run a full range of physics in 2018 in the fixed-target experimental areas. This programme will be carried out in parallel with operation for LHC injection. Optimisation of the operational cycles of the machines is a continuous objective to ensure the delivery of the maximum beam time to all users. In particular for Linac4, the 2018 objectives are: complete the reliability run, prepare the linac for operation (transfer knowledge to operation team, standardize operational tools), complete foreseen repairs and consolidate the weak points discovered during the reliability run. Address the ion source performance for nominal and ultimate beam. The situation for consolidating equipment in the injectors' complex is under continuous evaluation, in particular in view of forthcoming projects like LIU and LS2. Considering mainly activities which do not need direct access to the accelerator tunnels, some of the highlights for 2018 are:

13a. PS complex / Accelerator maintenance and consolidation / Experimental areas consolidation (cont.)

2018 targets	• Detail design and tender work planned for LS2 in order to be ready to start the project from beginning 2019 (e.g.: PSB cooling, ventilation, chilled water, PS cooling plants, AD cooling and ventilation); • Continued PS low voltage distribution and cable clean-up consolidation; • Design and prototyping of a new PS internal beam dump; • Consolidation of the Capacitor discharge power converters for the PS extraction, as well as of the power converters of TT2 and n_TOF; • Global consolidation of the antiproton production target area, with a new target, magnetic horn and electron cooler; • Advanced design of a new n_TOF spallation target.
Future prospects & longer term	The PS complex will operate in parallel to LHC, throughout Run 2. The on-going AD consolidation program (target area and machine) will be completed during LS2.
Specific Health & Safety issues	Losses throughout the accelerator complex produce some activated equipment. Sites are identified for the treatment and storage of this equipment. Budget is set aside to deal with the disposal of activated accelerator components, especially the treatment of the used ISOLDE targets. The Radiation Protection Group plans and surveys all such operations following the ALARA principle.

CERN budget for 2018	**Personnel (FTE)**	**Personnel (kCHF)**	**Materials (kCHF)**	**Total (kCHF)**	**Comments**
	213.8	38,235	28,345	**66,580**	

13b. SPS complex / Accelerator maintenance and consolidation / Experimental areas consolidation

Goal	This heading comprises the facilities forming the SPS complex. Included is the SPS accelerator, which provides a range of beams to the SPS fixed-target experiments and test beams (HiRadMat and North Area). SPS is also the main injector for the LHC. The goal is to deliver the requested intensities for the experiments and provide beam to the LHC upon request.
Costs	The consolidation heading for injectors, experimental areas and infrastructure systems is of a non-recurrent nature and is an on-going activity since it is comprised of several smaller-scale items. For that reason, there is no Cost-to-Completion but a foreseen funding level.
Running conditions	Very dynamic optimisation of the operational machine cycles is needed to simultaneously deliver and maximize the availability of beam to all experiments. A prioritization between the different facilities will continue to be needed and is set following discussions between the Management and the relevant scientific committees.
Competitiveness	The CERN accelerator complex represents a unique facility over a range of particle types and energies.
Organisation	There is a specific organisation of each facility with CERN being in charge of the resources and technical operation. Overall organisation under the Directorate for Accelerators and Technology.
Risks	Ageing of accelerators and technical infrastructure components: the risks are continually mitigated and an extensive consolidation programme is under way to ensure the reliability of machines and the availability of spare components. The consolidation projects are organised in such a way that during the year, if new insights in risk are obtained, priorities are shifted and the items with the highest priority will have budget allocated. In addition to the accelerators themselves, risks to the experimental programme exist due to the state of the beam line equipment and infrastructure systems. These risks could be disruptive to institutes efforts and experimental programs. Up to LS3, mitigation will involve significant renovation and consolidation of these zones.
2018 targets	The complex will run a full range of physics in 2018 in the fixed-target experimental areas. This programme will be carried out in parallel with operation for LHC injection. Optimisation of the operational cycles of the machines is a continuous objective to ensure the delivery of the maximum beam time to all users. The situation for consolidating equipment in the injectors’ complex is under continuous evaluation, in particular in view of forthcoming projects like LIU and LS2. Considering mainly activities which do not need direct access to the accelerator tunnels, some of the highlights for 2018 are: • Upgrade of the SPS-to-LHC transfer line collimators to protect the LHC against injection errors of high intensity LIU beams; • Execution of a comprehensive study for an SPS Beam Dump facility, focusing on the target/dump and the associated target complex; • Design and start production of an advanced SPS internal beam dump (to replace the TIDVG) & associated shielding system compliant with the high intensity of LIU beams; • Build spares for the MBB magnets; • Consolidation of accelerator specific tunnel transport and handling equipment such as the modification of a crane to handle radioactive equipment such as the new SPS beam dump, the replacement of electrical tractors for Fire Brigade interventions, the procurement of an additional new custom built electrical side loader for the transport and handling of machine components in the tunnel;

13b. SPS complex / Accelerator maintenance and consolidation / Experimental areas consolidation (cont.)

2018 targets	• Continued SPS consolidation of electrical substations (high and low voltage), signal and DC cables, as well as RF power supplies; • Studies in preparation to bring SPS up to modern fire Safety norms, with the aim to be implemented during LS2. North Area consolidation: will continue during the YETS for the most urgent items. A pre-project study will be finalized in order to define the minimal LS2 requirements in order to guarantee safe operation beyond LS2.
Future prospects & longer term	The SPS complex will operate in parallel to LHC, throughout Run 2. In the North Area, a minimum consolidation effort for the most urgent items will continue.
Specific Health & Safety issues	Losses throughout the accelerator complex produce some activated equipment. Sites are identified for the treatment and storage of this equipment. Budget is set aside to deal with the disposal of activated accelerator components. The Radiation Protection Group plans and surveys all such operations following the ALARA principle.

CERN budget for 2018	**Personnel (FTE)**	**Personnel (kCHF)**	**Materials (kCHF)**	**Total (kCHF)**	**Comments**
	118.8	21,075	25,220	**46,295**	

13c. Accelerator support and services

Activities	This heading includes the following activities: • accelerator engineering: cryogenic fluids for non-LHC experiments, cryolab operation, polymer laboratory operation, magnetic measurements, vacuum infrastructure operation, as well as the SM18 infrastructure upgrade project; • controls and operation: hardware, software, interlocks; • accelerator general services: general technical and administrative support for accelerators, accelerator planning and safety support, Fluka simulations, survey, quality control; • engineering facilities and workshops: mechanical design, integration, production facilities and material sciences; • special technologies: vacuum special technologies and thin film coating.

CERN budget for 2018		**Personnel (FTE)**	**Personnel (kCHF)**	**Materials (kCHF)**	**Total (kCHF)**	**Comments**
	Controls	**17.0**	3,295	2,220	**5,515**	
	Engineering	**33.7**	6,385	2,120	**8,505**	
	General services	**95.8**	20,845	6,175	**27,020**	
	CAD and CEA support			1,635	**1,635**	
	Workshops and fabrication	**46.0**	7,685	2,570	**10,255**	

14. East Area renovation

Goal	The implementation of the East Area Renovation project will take place from 2018 and during LS2 in order to improve the operating conditions (safety, reliability and energy consumption) as from 2021.
Costs	The Cost-to-completion of the East Area renovation project is estimated to 22.6 MCHF based on a Cost and Schedule Review conducted in December 2016.
Running conditions	The East Area will remain operational until the end of 2018 where the experiments, facilities and users will not be impacted by the starting parallel renovation activities.
Competitiveness	Hosting the CLOUD experiment, unique test facilities (IRRAD, CHARM) and providing a dense test beam program for LHC experiments, detector R&D. For training and outreach, it also provides the annual “Beamline For Schools” organisation.
Organisation	Project management via an approved management structure with regular reports to the IEFC (Injectors and Experimental Facilities Committee) and LS2 Committee under the Directorate for Accelerators and Technologies.
Risks	Tight implementation schedule in order to ensure timely operation after LS2.
2018 targets	The renovation of the East Area complex enters in its final LS2 preparation phase. The first external building infrastructure consolidation will be implemented, focusing on external façade in order not to perturb the on-going physics operation.
Future prospects & longer term	A three-year consolidation program is being developed for the East Area in order to ensure long-term operation.
Specific Health & Safety issues	Losses in the primary beam area lead to activation of both air and beamline elements. The renovation project will include the implementation of a dedicated ventilation system of the primary area according to latest RP standards, as well as optimise the beamline design in order not only to increase reliability and redundancy, but also ease possible future interventions according to latest ALARA standards.

CERN budget for 2018	**Personnel (FTE)**	**Personnel (kCHF)**	**Materials (kCHF)**	**Total (kCHF)**	**Comments**
	6.8	1,465	7,675	**9,140**	

Infrastructure, services and centralised expenses

15. General facilities & logistics (maintenance, transport)

Activities	This consists of infrastructure systems (i.e. cooling and ventilation, electrical distribution, heavy handling, access and safety systems, fire and gas detection), site facility management (cleaning, guards, green areas, site management and registration services) and logistics (i.e. stores, shipping, goods reception, personnel transport/mobility and mail services). The materials cover essentially industrial service supplies and maintenance contracts. This heading is a stable baseload over time.
Risks	Although some consolidation and upgrade projects took place, many technical and general infrastructure systems still need urgent consolidation because they are at the end of their lifetime. Main effort shall continue with corrective maintenance, with preventive maintenance as long-term goal. Site and logistics services are mostly operated through industrial support. Budgets supporting the contractual commitments and regular investments shall be secured over time to maintain and operate the services. Keep the security infrastructures at the adequate level in the global security framework of CERN.
2018 targets	Ensure a similar level of service to the CERN community as in 2017. The site services will continuously be adapted to the evolution of requirements and available resources. Some of the highlights for 2018 are: • Continue the site consolidation program based on a risk analysis approach with the highest priority to safety and conformity related actions. Introduce KPI’s and root cause analysis of breakdown to drive the consolidation program and reduce the downtimes. • Continue to improve CERN security, with priority to the video surveillance and the access control policies. • Implement improvements to the supply chain as result of the study aiming at rendering the service more efficient, more agile and improve alignment with current and future CERN needs. • Continue maintenance and consolidation of transport and handling equipment. In particular, specialized vehicles need to be renewed: an additional 6t capacity low-loader truck for the transport of interchangeable ADR7 containers (conform to International Carriage of Dangerous Goods by Road regulations) that are required for the transport of dangerous and/or radioactive goods will be purchased, as well as a new 35 t capacity low loader trailer for faster loading and unloading (based on the RORO principle – Roll On Roll Off) of dangerous and/or radioactive goods. • Continue the optimisation of the CERN car fleet exploitation and of the mobility CERN services. • Pursue the efforts on the Service Management and Support, in particular widening the scope of services covered, improving the support for specific services benefitting from the framework in view of improving efficiency, and providing feedback to service managers through dashboards and KPI to enable the continuous improvement process to drive improvements in maturity.
Future prospects & longer term	Further improve services to the users and staff as well as the maintenance of the site for reliable operation. Optimisation of CERN supply chain. Assurance CERN resources are used to provide services in the most efficient (least resources) and effective (aligned with customer needs) way.

15. General facilities & logistics (maintenance, transport) (cont.)

		Personnel (FTE)	Personnel (kCHF)	Materials (kCHF)	Total (kCHF)	Comments
CERN budget for 2018	**Site facility management**	**53.7**	10,390	23,415	**33,805**	
	Technical infrastructure	**142.0**	24,710	13,555	**38,265**	
	Logistics	**14.4**	2,435	1,045	**3,480**	
	Stores activity			355	**355**	
	Housing fund	**1.0**	145	5,075	**5,220**	

16. Informatics

Activities	Informatics provides all the computing infrastructure, tools and environments for more than 10,000 CERN users and staff. This includes the Computer Centre operations, service desk support, local and global electronic communications including telephony, videoconferencing and computer networking. Support for databases and information services, including web services, for administrative and technical computing as well as desktop services such as mail, windows and mac support.
Risks	• Unavailability of services due to causes such as software or hardware failures, damaged data due to corruption, human errors or deliberate actions. • Computer Security continues to be a major concern due to CERN's high profile and the continuing high number of attacks attempts combined with their increased sophistication and the distributed nature of CERN's Informatics. • Continued trend in software licenses fees profiting from a market with few competitors. • Impact of successive, cumulative reductions in operations budget dominated by incompressible costs. • Some SCOAP3 partners in countries under financial duress do not contribute the financial resources agreed in the MoU. • Difficulties in providing the safety formation in preparation to LS2. • Preservation of the paper-based records. • Effectiveness of ERP study depends on participation of activity owners across CERN, and their ability to align their business processes to those offered by standard tools.
2018 targets	• Ensure adequate level of availability of the Informatics services including data loss protection (backups) against accidental errors or human mistakes for its user base, as well as perform capacity planning to anticipate the needs. Ensure prompt corrective actions in case of service failures. • Protect and educate against the risks of computer security vulnerabilities. In particular, continue hardening computer security measures in a view of recent threats and incidents. • Continue the rejuvenation of the CERN Wi-Fi network infrastructure and thereby reduce the scope of the renewal of the 20-year-old structured cabling infrastructure in the coming years. • Operate the activities of the international SCOAP3 consortium. Expand the initiative as agreed by its Governance and CERN Open Access strategy. • Begin the implementation of ERP study recommendations. • Review the means by which Property, Plant and Equipment (PPE) asset data is collected, stored, depreciated, consolidated and reported on.
Future prospects & longer term	• Proactive measures such as data backups, multi-site hosting and increased critical power for IT services all contribute to increased availability and performance while ensuring that the business continuity needs of the Organisation are met. • Reduce reliance on commercial software providers dominating the market. • Progress elaborating CERN's Data Protection Policy and its implementation in a view of EC's GDPR enforcement.

CERN budget for 2018	**Personnel (FTE)**	**Personnel (kCHF)**	**Materials (kCHF)**	**Total (kCHF)**	**Comments**
	204.3	36,940	22,475	**59,415**	

17. Safety, health and environment

Activities	Activities and related expenses for the implementation of the CERN Safety Policy, the CERN corporate Safety objectives and the agreements with the host states aiming at a continuous improvement in incident prevention and emergency preparedness covered by the following domains: **Occupational Health and Safety:** • Workplace safety including monitoring and diagnostic of specific risks such as asbestos and other infrastructure pollutants. • Safety training (face-to-face, e-learning, hands-on) and safety awareness campaigns. • Advice and expert support in matters of Safety. • Technical safety inspections and safety coordination. **Occupational Medicine & Emergency preparedness:** • Medical service; Work-related health studies/statistics; Preventive health campaigns; First aid. • Fire Brigade (57 fire-fighters); firefighting equipment, communication system; preventive measures. **Safe operation, maintenance and consolidation of CERN beam facilities:** • General and continuous safety consolidation of beam and experimental facilities. **Radiation protection:** • Operational radiation protection (risk assessments with respect to ionising radiation and its impact on workers and persons, job and dose planning, classification of potentially radioactive material). • Radioactive waste management (reception, intermediate storage, characterisation, treatment, validation, elimination). • Dosimetry and calibration service, export and import of radioactive goods, management of radioactive sources. • Design studies/estimates/simulations on radiological impact of CERN facilities, in particular in case of modifications, upgrades or new projects. • Radiation monitoring – maintain, upgrade and extend fixed installed network of sensors to control ambient dose rate levels as well as the releases of radioactivity by air and water. **Environmental protection:** • Protection of air, water, soils (analysis, studies, improvements) and environmental monitoring (effluents, noise, samples). • Waste management (conventional, industrial, special waste).
Risks	Lack of preventive measures might lead to incidents impacting people, the environment or investments. Insufficient safety measures could have operational and financial consequences as well as an impact on CERN's reputation. Lack of emergency preparedness might delay adequate response to alarms and increase the impact of incidents. Operational Radiation Protection: unjustified increase in individual and collective dose to workers; non-compliance with EU and Swiss radiation protection legislation, damage to CERN's reputation. Radiation Monitoring: maintenance and repair of outdated material, shortage of supplies might cause delays in starting up new facilities or stoppage of operating facilities. Radioactive waste management: insufficient level of elimination might lead to lack of storage in view of LS2.
2018 targets	**Occupational Health and Safety:** • Limit number of incidents (improved awareness/training/prevention, implement lessons learned from LS1 in view of LS2). • Improve hazard control (work procedures, choice of work methods, technological choice).

17. Safety, health and environment (cont.)

2018 targets	• Participation in CERN (existing & future) projects at all levels for integration of Safety as early as possible. • Safety Training: new editions of major courses (updates, improved didactic), training centre operation and extension/consolidation for LS2. **Occupational Medicine & Emergency preparedness:** • Assess the impact of stress-related diseases and initiate a prevention plan. • Improve the quality of the incident reporting for the emergency interventions on the CERN sites. • Initiate a 5-year consolidation plan for the FB equipment, covering infrastructure, facilities and equipment. **Radiation protection:** • Keep doses to persons As Low As Reasonably Achievable (ALARA) using consequent work planning and prediction software. • Research and development for the next generation of radiation monitoring equipment: produce a prototype for qualification. • Radioactive Waste Treatment Centre: continue enhanced elimination in view of LS2. **Environmental Protection and Environmental Panorama :** • Environmental impact studies for upgrade of facilities and new projects. • Further extension of monitoring installations, including hydrocarbon detection for water releases. • Extension of environmental laboratory allowing for physical separation of ‘conventional’ and radioactive samples.
Future prospects & longer term	Further improvement in the field of Occupational Health and Safety as well as Environmental Protection for both radiological and conventional aspects with reference to CERN’s Safety Policy and agreements with CERN’s host states. A CERN Environmental Protection Steering (CEPS) board has been set up by the DG with the aim to identify, prioritize and decide short and medium term action plans with respect to Environment Protection. The CEPS board derives from the CERN environmental protection strategy proposed by the HSE unit and endorsed by the Directorate beginning of 2017.

CERN budget for 2018	**Personnel (FTE)**	**Personnel (kCHF)**	**Materials (kCHF)**	**Total (kCHF)**	**Comments**
	175.1	27,870	22,250	**50,120**	Of which radioactive waste management: 7.5 MCHF.

18. Administration

Activities	Generic expenses of the Director-General's office and dedicated services, human resources management, financial services (accounting, planning, controlling) and purchasing. It also includes the expenses related to the Council and its Committees and the training budget for the EU fellowship programme.
Goal	Streamline administrative processes, regularly review and adapt processes and activities in order to be compliant with international norms (IPSAS), and establish best practices. Improve administrative processes to fulfil the needs, be transparent and service-oriented and provide high-quality services whilst limiting the total P+M cost so that it does not exceed the current level.
Risks	The surge in applications brought about by geographical enlargement, combined with increasing demands from the wider CERN population. Limited capacity to cope with increasing demands and additional constraints from the outside and higher number of members of personnel, particularly for HR in managing diverse programmes and national specificities, as well as for procurement and accounting/accounts payables as there is a strong increasing amount of contracts and orders to be issued.
2018 targets	**Human Resources:** The priorities will focus on short, medium and long term actions required to match CERN's workforce capabilities to the needs of the laboratory to fulfil its strategic objectives. Main objectives spanning 2017/2018: • Link Strategic workforce planning with the recruitment of the additional 80 LD positions. • Monitor and report on the implementation of diversity and new career structure measures implemented under the Five-Yearly Review. • Internal Mobility: evaluate and elaborate a policy for internal mobility. • Psychosocial risks: carry out a study related to psychosocial risks at CERN and evaluate possible actions. • Strategic workforce planning: update the recruitment, indefinite contract plans and incorporate succession planning. **Procurement:** • Re-organise the Procurement Service in order to handle increased activities for HL-LHC. • Continue the benchmarking and streamlining of processes in order to maintain or improve service levels within available resources in areas such as electronic archiving using e-files, Elaborate and implement the outcome of the ERP study, most likely with a phased implementation approach, implementation of a supplier evaluation system, review and modernize the Procurement Service Web-site, etc. • Improve sourcing in poorly balanced Member States and associate Member States. **Financial Services:** • Implement the reviewed planning processes, roles of stakeholders and tools for less resources intensive and yet more dynamic financial planning and reporting. • Review the tools to maintain the PPEs and intangible assets. • Advance towards quarterly reporting.

18. Administration (cont.)

Future prospects & longer term	Continuing streamline administrative processes and regularly review and establish best practices to maintain the service level with constant resources in spite of growing demands and users.

CERN budget for 2018	**Personnel (FTE)**	**Personnel (kCHF)**	**Materials (kCHF)**	**Total (kCHF)**	**Comments**
	206.7	39,155	11,265	**50,420**	

19. International relations

Goal / activities	**Goals** The International Relations (IR) Sector implements the Organization’s international relations strategy to generate and secure sustained political, financial and popular support for CERN’s scientific and broader societal missions. Target groups comprise Member State representatives, Host State authorities, decision-makers in Associate Member and Non-Member States, international organisations, the wider scientific community, global opinion makers, the media, the general public, secondary-level teachers and students, CERN alumni, the International Geneva community, the artistic community, as well as corporates, foundations and individuals with an interest in supporting the mission of CERN. The main goals for these different target groups include: • Strengthen cooperation between CERN and its Member States, • Maintain effective relations with the relevant Host State authorities, • Enhance links with Associate Member States and Non-Member States in the context of implementing CERN’s geographical enlargement policy, • Build partnerships with international organisations and other stakeholders to serve as a voice for fundamental research in global policy debates, • Increase awareness of and promote CERN’s achievements and potential in research, technology, education and training, • Advance public knowledge and understanding of CERN, fostering engagement with CERN and embedding science in mainstream culture through a variety of avenues, including website, social media, publications, audio-visual products and productions, as well as site visits, • Provide information to the wider CERN community, • Integrate CERN further into the local community, • Improve the knowledge of secondary-level school teachers about CERN research and provide them with teaching resources to enhance physics education at high-school level, • Inspire secondary-level school students with CERN science and motivate them to engage in further scientific studies, • Develop a constituency and generate support for education and outreach, innovation and knowledge exchange, and culture and creativity through the CERN & Society Foundation and the Foundation for the Globe of Science and Innovation, • Provide mechanisms for continuous connection and active engagement with the Organization for CERN alumni, • Ensure efficient protocol service for visiting dignitaries. The IR Sector consists of the Stakeholder Relations Group, the Education, Communications and Outreach Group, as well as a section for strategic planning and evaluation, and the protocol service. **Recurrent activities** ***For Member State representatives, Host State authorities, Associate and Non-Member States and international organisations*** • Maintenance of relations through thematic forums and other forms of on-going dialogue and information-exchange, • Outreach to Non-Member States to encourage institutionalization of engagement with CERN, including through Associate Membership, International Cooperation Agreements and other appropriate instruments, as part of the geographical enlargement policy,

19. International relations (cont.)

Goal / activities	• Continuous interaction with relevant international organisations, including the United Nations, the Inter-parliamentary Union and others, to promote the inclusion of a science perspective in global policy debates, • Organisation of 150+ high-level visits annually to the laboratory. ***For the general public, media and local community*** • Provision of information about CERN activities and achievements through the web, a variety of social media channels and publications, • Organisation of events and promotion around important CERN announcements (press conferences, media visits, video and photo coverage, participation at major physics conferences or public-facing science and outreach conferences), • Provision of guided tours of the laboratory and visits to the permanent exhibitions for some 120,000 visitors per year, • Provision of free access to permanent exhibitions (Universe of Particles, Microcosm), • Display of CERN travelling exhibitions (Accelerating Science, CERN in Images, LHC interactive tunnel) in Member States and other countries with an interest in CERN research and with a view to stimulating greater interest in and support for CERN's work, • Creation of new exhibitions and audiovisual materials (videos, photos, animations) for websites, media, schools and the general public to support education, communications and outreach, • Organisation of events to integrate CERN into the local community, • Implementation of the Arts At CERN programme as part of CERN's Cultural Policy for Engaging with the Arts. ***For the CERN community and researchers, and CERN alumni*** • Provision of information through CERN bulletin and news updates on internal websites, • Provision of information about high-energy physics world-wide through the CERN Courier and other channels, • As a new activity, implement a CERN Alumni Programme, facilitating the continued connection of the alumni community with CERN and leveraging this global community to strengthen support for the work of the Organization. ***For teachers and students*** • Organisation of high-school teacher programmes for some 1,000 teachers annually (30-40 one-week courses in national languages, one or two 2-week and one 3-week international programme in English) to deepen their knowledge about CERN-related science and technology, • Organisation of hands-on activities in modern physics for high-school level students in CERN's S'Cool LAB, to inspire students with modern science and motivate them to engage in scientific studies, including development and scientific evaluation of teaching methods and material, as necessary for delivery of the programme, • Implementation of the annual non-Member State Summer Student Programme. ***For foundations, trusts, corporates, individuals and other prospective donors with an interest in supporting the mission of CERN*** • Identification of prospects, cultivation and relationship-building with supporters, and preparation of related fundraising material and outreach. • Provision of substantive and administrative support to the CERN & Society Foundation and the Foundation for the Globe of Science and Innovation.

19. International relations (cont.)

Risks	The main risks associated with not reaching the stated objectives are as follows: • Lack of political support in Member States, Associate and Non-Member States impacts negatively on the long-term support for particle physics and CERN, • Poor integration of a science perspective in global policy debates undermines support for fundamental research, • Missed opportunities and unutilized potential to create awareness, improve understanding and generate support for the work of the Organization on a global level among key communities, including alumni, impacts long-term support, • Not responding to the needs and expectations of key stakeholders, including media and the general public, regarding CERN's transparency and provision of information, affects the Organization's reputation, • Not being equipped to identify potential crisis situations or reputational challenges and/or to handle a major actual crisis appropriately in terms of the required communications needs, undermines public confidence in the Organization, • Lack of talented young people from all countries pursuing careers in STEM with negative impact on the long-term quality of the Organization's work. These risks apply to the level of support for CERN more broadly and to the Organization's reputation, and can have a direct influence on the Organization's ability to operate. A deterioration of the quality of these programmes could undermine the ability to implement the long-term objectives of the Organization.
2018 targets	• Targeted outreach to select countries in line with geographical enlargement strategy, • Organisation of formal kick-off event for the CERN Alumni Programme, • Launch of the new CERN website, • Continuation of travelling exhibitions in Member States, Associate Member States and Non-Member States, • Development of plans and structures to enhance the options for visitors and for educational programmes, including capital development fundraising as necessary.
Future prospects & longer term	The IR Sector will continue to expand relations with relevant stakeholders and develop initiatives in education, communications and outreach to promote CERN's achievements and possibilities even further in all areas (research, technology, education, training). In view of the sustained extensive interest of the general public in visiting CERN, further development of the infrastructure and programmes available to visitors, in particular youth, is under consideration, together with an ongoing review of the possibilities for expanding and diversifying options for students and teachers. A large-scale Open Day initiative is envisaged for 2019, together with events to mark the 30th anniversary of the World Wide Web. The geographical enlargement strategy, aimed at concluding ongoing application processes and targeted engagement with specific countries with a view to Membership/Associate Membership will be pursued while working to ensure that new Member States and Associate Member States are integrated.

CERN budget for 2018	**Personnel (FTE)**	**Personnel (kCHF)**	**Materials (kCHF)**	**Total (kCHF)**	**Comments**
	65.3	11,765	5,625	**17,390**	

20. Infrastructure consolidation, buildings and renovation

Goal	General infrastructure covers machine, experiment and tertiary buildings, caverns and tunnels. Machine-specific infrastructures such as electrical power distribution and cooling systems are not included. Over the years since LHC project approval, the maintenance of this infrastructure has been kept to a strict bare minimum. Only vital repairs have been executed. During the next few years a major consolidation programme will be executed to allow the Organization to face the challenges of LHC operation in terms of site usage. In addition the evolution of sustainable development and responsible energy usage in tertiary applications, i.e. heating/air conditioning, etc., will have to be taken into account in line with developments in society in general.
Costs	The consolidation headings for general infrastructure are of a non-recurrent nature but an on-going activity since they include both large-scale multi-annual projects and multiple smaller-scale items.
Risks	Not pursuing the infrastructure consolidation entails serious risks for both the functioning of the accelerators and working conditions for the staff. Scarcity of personnel, which will determine the capacity to carry out the consolidation items.
2018 targets	Execution of the annual consolidation plan covering primarily safety, façade, roof, toilet block, HVAC and electrical installations in tertiary buildings and in technical galleries. Interventions are selected on a risk analysis approach with the highest priority to the safety related actions and the indications of CERN Masterplan 2030. Termination of the works on the Building 107. Termination of the works for the Building 311 (magnetic measurements). Completion of the building 771 (polymer lab). Works for the new SF18 cooling tower.
Future prospects & longer term	Refurbishment of the envelope (roof and façade) of accelerator-related buildings and office buildings. Refurbishment of overheated water and clean water network. Replacement of ageing HVAC and electrical installation. Safety upgrade and asbestos remediation, improving environmental impact through optimising energy consumption.
Specific Health & Safety issues	As in the 1950s and 1960s many buildings on the sites were constructed using asbestos technology. Their future refurbishment or demolition will incur major costs.

	Personnel (FTE)	**Personnel (kCHF)**	**Materials (kCHF)**	**Total (kCHF)**	**Comments**
CERN budget for 2018	**13.8**	1,990	32,390	**34,380**	Of which Building 107: 7.5 MCHF, Flexible storage building in Prevessin: 7.1 MCHF, Cooling tower: 2.9 MCHF

21. Centralised expenses

Centralised personnel expenses	Covering CERN’s contribution to the health insurance for its pensioners, installation and removal expenses for employed members of personnel. The heading scales mechanically as a function of number of recruits ,departures and CERN’s pensioners.
Internal taxation	Relating to the amount of basic salaries and stipends of employed members. The internal taxation percentages were reviewed in 2012 to take due account of the cost-variation index being applied to the basic salaries and stipends.
Personnel internal mobility	It is a central fund with limited funding to ease the transfer from one organic unit to another and to temporarily compensate for salary differentials by allocating these amounts to the supervising Department. Internal mobility is one of the key priorities for Human Resources management.
Personnel on detachment	It is linked to staff being detached to other organisations for which CERN recovers the expenses as revenues. The heading is updated regularly to take the contractual situation into account.
Personnel paid from team accounts	Are concerned staff and fellows working funded by third parties as shown also under revenues.
Budget amortisation of staff benefit accruals	Corresponds to the funding over 10 years of saved leave and shift work compensation of employed members of personnel as recognised for the first time in the balance sheet when implementing IPSAS. This item will disappear as from 2019 ownwards.
Energy and water	This heading contains the consumptions for both baseload as well as scientific programme.
Insurances, postal charges, miscellaneous	The budget was reduced taking into consideration reductions obtained on insurances premiums. Furthermore, a new insurance contract was established related to the assistance and security of the Member of Personnel during Official travel.
Interest, bank and financial expenses	Include the interest on the FORTIS bank loan, bank charges and financial expenses (i.e. exchange loss). There is the risk that interest payments can increase should CERN need to contract for short-term loans if Member States’ contribution are not paid in time.
In-kind	Relating to the fair value of CERN having been granted some interest free loans (also under revenues).
Annual balance	Any positive annual balance of the budget is used for capital repayment according to the schedule agreed with FIPOI and FORTIS banks as well as to limit the unavoidable increase of the cumulative budget deficit.

21. Centralised expenses (cont.)

		Personnel (FTE)	Personnel (kCHF)	Materials (kCHF)	Total (kCHF)	Comments
CERN budget for 2018	**Centralised personnel expenses**		36,335		**36,335**	
	Internal taxation		30,190		**30,190**	
	Internal mobility		40		**40**	
	Personnel on detachment	2.7	765		**765**	
	Personnel paid from team accounts	62.6	9,975		**9,975**	
	Budget amortisation of staff benefit accruals		17,330		**17,330**	
	Energy and water			65,210	**65,210**	
	Insurance, postal charges, miscellaneous			6,235	**6,235**	
	Interest, bank and financial expenses			9,270	**9,270**	
	In-kind			2,045	**2,045**	

Projects

LHC upgrades

22. LINAC4 (Activity ended in 2017)

23. LHC injectors upgrade

Goal	The LHC Injectors Upgrade Project aims at preparing the LHC injectors (LINAC4, PSB, PS, SPS as well as the heavy ion chain) for reaching the goals of the High-Luminosity LHC (HL-LHC) with protons and Lead ions.
Approval	Council approval of the proposed MTP for the LHC injector's upgrade.
Start date	This programme, named LIU has been defined in October 2010.
Costs	The LIU baseline for protons includes the increase of transfer energies from Linac to PSB to 160 MeV replacing LINAC2 by LINAC4, from PSB to PS to 2 GeV, and the upgrade of PSB, PS and SPS to allow the acceleration of the high-brightness beams required by the HL-LHC. Upgrade activities in the Pb ion injector chain are performed to meet the HL-LHC beam operation requirements as of 2021. Consolidation is assumed to proceed in synchronism. The material Cost-to-Completion of the LIU project including M to P transfers, CERN funding, is 177.7 MCHF.
Competitiveness	In order to maintain and subsequently significantly improve the discovery potential of the LHC until the end of its estimated lifetime (~2035-2040), the injector chain must be upgraded.
Organisation	The project has been organised with sub-projects in charge of each accelerator in the proton accelerator complex (PSB, PS, SPS) plus one sub-project following the Pb ion beam production from the source to the LEIR extraction (Pb ion beams in the PS and SPS are covered by the respective aforementioned machine sub-projects), together with the appointment of persons responsible. A technical coordinator for planning and installation has been also appointed to generate the detailed schedule of the hardware works relative to the LIU project within the assigned time constraints, and oversee its execution. A Work Breakdown Structure is established and CERN project management tools are used.
Risks	Technical: the HL-LHC machine will not reach its goal and deliver the expected integrated luminosity if the injectors do not deliver, on time and reliably, beams of proper characteristics.
2018 targets	Anticipated installation of LIU equipment will take place during the 2017-2018 YETS (Year-End-Technical-Stop) (e.g. some injectors beam instrumentation and SPS staged activities: internal beam dump civil engineering, vacuum chamber coating with new vacuum flanges installation and 200 MHz RF upgrade). In addition, the de-cabling campaign will carry on in the PS and the SPS, together with limited pulling of new cables. Most of the LIU components will be delivered during 2018, followed by assembling, testing and preparation for LS2 installation. Extensive simulation and beam test campaigns will take place during this last year of Run2. The LIU LS2 planning will be finalized, taking into consideration the constraints from other projects, and ensuring that all activities can take place as needed.
Future prospects & longer term	The LIU project defines and coordinates the work programme necessary for the LHC proton and ion injectors to meet the HL-LHC requirements in terms of reliability and beam characteristics. Beam simulation, machine development, hardware design and procurement, infrastructure preparation are taking place throughout Run2. Prototypes are installed, beam tests performed and crosschecked with beam dynamics expectations and related measures to ensure the beam intensity and brightness. The installation

23. LHC injectors upgrade (cont.)

Future prospects & longer term	of the main hardware upgrades is planned for the second long LHC shutdown (LS2). Proton beam commissioning with the upgraded hardware will take place throughout Run 3, while Pb ion beams will have to be ready for the ion run in 2021.
Specific Health & Safety issues	A Project Safety Officer has been appointed to assist the Project Leader in all safety aspects of the project. The health and safety issues resulting from the work and installations managed by the LIU Project are handled according to the instructions issued by the HSE unit and duly documented.

CERN budget for 2018	**Personnel (FTE)**	**Personnel (kCHF)**	**Materials (kCHF)**	**Total (kCHF)**	**Comments**
	117.8	20,395	38,735	**59,130**	

24. HL-LHC construction

Goal	The main objective of HL-LHC is to implement a hardware configuration and a set of beam parameters that will allow the LHC to reach the following targets: • A peak luminosity of 5×10^{34} $cm^{-2}s^{-1}$ with luminosity levelling, allowing: • An integrated luminosity of 250 fb^{-1} per year, enabling the goal of 3000 fb^{-1} twelve years after the upgrade. This heading contains: • The project for new High Field Large Aperture Quadrupoles in Nb_3Sn (new low-beta inner triplets) and all other magnets that need to be changed for HL-LHC: separation-recombination dipoles (D1-D2), matching section quadrupoles and the new corrector magnets. • The collimation project, which comprises actions already defined to reach ultimate beam intensity, and the new collimation system for the upgrade. • The project for an LHC 11T dipole (to be used for new collimation in the DS regions). • The development of a superconducting link, necessary for the cold powering of HL-LHC, that will also be an essential feature of the machine availability and reduction of radiation dose to personnel (ALARA principle). • The development of crab cavities in IP1 and IP5 for luminosity increase and pile up density reduction. • All necessary modifications and interventions on the LHC to make sure it will operate in high luminosity conditions with the necessary flexibility: modification and completion of the cryogenic-plants (in P4 to separate the cooling of superconducting RF from magnets; IP1 and IP5 to separate IR from Arc); new beam screens with W-shield, new diagnostics, and new absorbers for injection and extraction of a more intense beam, etc. The project includes as well the modifications required by the increase in luminosity of ion collisions and the increase in luminosity for proton collisions in LHC P8 (LHCb upgrade). • The improvement and modification of LHC Technical Infrastructure, including major Civil Engineering works, underground and at ground level, necessary for the installation of new equipment for the upgrade.
Approval	The HL-LHC study started in 2010 with the new MTP, following the closing of the Phase 1 upgrade. Part of the R&D for the new magnets in Nb_3Sn was approved in the White Paper of June 2007, as High Field Magnets (HFM). The project has finally been approved with the special session of the CERN Council of May 30, 2013 held in Brussels. During that session the new EU strategy for High-Energy Physics has been adopted, fully endorsing the goal of increasing the LHC luminosity design value by a factor ten, i.e. up to 3000 fb^{-1}. On 11 November 2013, HL-LHC has been kicked off as construction project in the presence of Directors from CERN and all other collaborating labs. Following the Cost & Schedule Review of March 2015, the Cost-to-Completion of the project has been integrated in the MTP 2016-2020. The HL-LHC project has been fully approved, with a Cost-to-Completion of 950 MCHF (2015 prices), by the CERN Council during the June 2016 session.
Start date	The associated FP7-EuCARD-WP7 (High Field Magnets) started on 1 April 2009. The HL-LHC project was defined in September 2010 including the previous Nb-Ti Inner Triplet project (also called Phase 1 upgrade), re-scoping the deliverables. The associated FP7 HiLumi Design Study, approved and partly supported by EC in 2011, started on 1st November 2011 and ended in 2015

24. HL-LHC construction (cont.)

Costs	The Cost-to-Completion of the HL-LHC construction was reassessed during the cost and schedule review held in March 2015. The material cost was fixed to 950 MCHF (2015 prices). The cost of 950 MCHF (2015 prices) has been confirmed by the second Cost & Schedule Review held in October 2016, despite an increase in cost of technical infrastructure, practically offset by a decrease in accelerator components cost. The personnel needs is evaluated to about 1800 FTE-y. The cost includes all hardware needed for the project baseline.
Running conditions	HL-LHC is a project that relies on external collaboration (see Organisation below). Its success is also closely linked to other internal CERN projects, such as: • LHC Injectors Upgrade (LIU) project, which will provide beam of appropriate characteristics to the HL-LHC machine. • The consolidation and R2E projects, which will implement hardware modifications in view of HL-LHC, such as electrical power converters, injection absorbers, old electronics, etc. and will take care of improvement of some collimators in view of HL-LHC. • Detectors Phase 2 Upgrade.
Competitiveness	On the time-scale of 2025-2040, HL-LHC will be a unique facility as Higgs production and for direct study of physics beyond the standard model, with no competitor and will constitute the big leap forward for HEP. It is also a unique test bed for testing technologies that are essential for future projects (like HE-LHC and FCC): operation of high field magnets (with coils made of Nb_3Sn), collimation in near-to-GigaJoule beam regime, Crab cavities for proton colliders, SC links to separate powering from radiation sources, etc.
Organisation	As a major CERN project with important external contributions, the organisation is subdivided into work packages (WP). The project is supervised by the Collaboration Board (CB). Representatives of institutes making a considerable in-kind contribution to the project are members of the CB. This is the case for institutes originating from Member States (France, Italy, Spain, Sweden and UK) and non-Member States (Japan, the US and, possibly, Canada and Russia). The CERN Management keeps a major share in the collaboration board, given the fact that the project is an upgrade of an existing facility run by CERN. A Coordination Group has been set to ensure a correct communication channel with the detectors phase 2 upgrade. The Coordination Group reports to the HL-LHC/LIU Executive Committee.
Risks	• For each equipment based on new technology a back-up plan is being identified. New machine studies are under way to understand possible limits, especially related to maximum beam current and to the effect of the long-range beam-to-beam interaction. • On the side of magnets, the CERN internal programs (Superconducting Magnet-SCM- and the HL-LHC project) and the associated US-LARP programme have shown that most of the issues can be solved. The test of the first full cross section Nb_3Sn quadrupole has been successful, considerably reducing the risk of underperformance. Magnet Protection can be fully tested only with the first long prototypes (2017 and 2018). The recently tested protection system (CLIQ) based on induced currents should however bring more redundancy. A global fall-back solution could be provided by large aperture NbTi quadrupole (a 2 m long quadrupole of NbTi called MQXC has been completed and tested in 2011-12). • Inability of using Crab Cavity: mitigation measure through the use of flat beams, whose performance may be enhanced by Long Range beam-beam compensation wires. • Delays in conductor deliveries or budget cuts from partners could have an impact on the readiness for the magnet design and the consequent luminosity upgrade. The shortage of personnel, due to competing programs is being partly alleviated by a more intensive use of external collaborators like in experimental collaborations.

24. HL-LHC construction (cont.)

Risks	The risk of lack of availability of people (and CERN services) during the LS2 period 2019-2020 is kept under scrutiny for prompt evaluation.
2018 targets	The project highlights for 2018 are: • Completion of the first 7.2 m long quadrupole (type Q2a/b) prototype entirely manufactured by CERN; • Completion and test of the first 5.5 m long prototype of the 11 T dipole; • Completion of the test of the first Crab Cavity cryomodule at SM18 test facility and/or in the SPS; • Commissioning of the mobile refrigerator that will be used for the Crab Cavity test in the SPS and for the LHC Superconducting RF cavity tests during main cryogenic shutdown; • Beam test of the new low-impedance collimators and evaluation of the best design and material choice for HL-LHC; • Test of a long prototype of superconducting link for cold powering; • Start of the excavation works for HL-LHC (New large pits in LHC-P1 and LHC-P5).
Future prospects & longer term	In conformity with the plan established in 2016, the project has developed a more detailed plan for the long term, which can be summarised as follows: • 2016: issue the Technical Design Report (TDR_v0.1) which includes the re-baselining done during summer 2016 that was scrutinised during the second Cost and schedule Review. This TDR includes engineering and constructive description of the baseline (and a restricted number of options) and addresses Technical Infrastructure as well. • 2017-2018: Test of main prototypes, both for Magnets and Crab Cavities (CC). Readiness of the first long superconducting link, of the Molybdenum based low impedance collimators and of the first prototype of Long Range Beam-Beam compensating wire. Issue the TDR_v1. • 2018: start construction of the main components that will be installed in LS2 and mainly in LS3. • 2021-2022: installation and test of a full Inner Triplet string (Q1-Q3-D1-shuffling modules-new electrical feedbox, superconducting link, new 17 kA power converter). • 2024: start de-installation of old triplets with procedures in line with the ALARA principle to reduce dose to personnel. • 2025 start installation of the main components of HL-LHC. The prospects are very positive for HL-LHC after the success of the first international Cost and Schedule review that has endorsed the cost of the Project. The signature of the International Co-operation Agreement between DOE and CERN (first step to secure USA contribution) in Spring 2015 and the signature of the Accelerator Protocol n.3 in December 2015 are first steps in view of securing the US contribution. The approval of FCC as H2020 EuroCirCol Design Study, as well the assessment of the maximum energy exploitation of the LHC, makes the technology developed for HL-LHC (11 T dipoles and 12 T large bore quads) pivotal for CERN's future, enhancing the importance of HL-LHC also as "necessary technological step".
Specific Health & Safety issues	The LHC insertions will be dismantled and new ones will be reinstalled after about 300 fb^{-1} of luminosity. The ALARA principle will be used to dismantle and design the components. A specific programme to cope with work in highly activated areas (based on remote operation/manipulation, augmented reality and robotics) is being launched in coordination with already existing R&D.

CERN budget for 2018	**Personnel (FTE)**	**Personnel (kCHF)**	**Materials (kCHF)**	**Total (kCHF)**	**Comments**
	194.7	33,360	69,450	**102,810**	

25. LHC detectors upgrade (Phase 1) and consolidation / HL-LHC detectors, including R&D (Phase 2)

Goal	The overall aim is to improve the performance of the detectors for the bulk LHC running (yielding typically 300 fb^{-1} at nominal energy) expected during the remaining years of this decade, as well as to prepare for an order of magnitude more luminosity at the HL-LHC in the following decade.
Approval	The upgrade programme of approved detectors is under continuous review by the LHCC.
Running conditions	This activity consists of many projects which will take place in the next 4 to 5 years. Thus the quantum is a sub-project, not the yearly budget. The requested budget corresponds to the CERN share of a substantial effort by all funding agencies. It does include HL-LHC detector R&D (old Phase II R&D) as well as the CERN share for the HL-LHC detector construction.
Costs	Total foreseen for the Phase I and II for 2014-2025: 356 MCHF (214 MCHF Materials + 142 MCHF Personnel), including R&D costs for the whole period of 75 MCHF. As part of the overall need to reduce the cumulative budget deficit, the R&D materials allocation was limited to 35 MCHF and ends in 2020. The project management is currently looking into the impact in terms of revising the scope and objectives.
Competitiveness	The high luminosity running at the nominal energy of 14 TeV will make it possible to fully exploit the discovery potential of the LHC accelerator
Organisation	The projects include contributions from many different institutions. They are organised by the management of the experiments, reviewed by the LHCC committee and technically coordinated by the Project Office led by the Technical Coordinator of each experiment.
Risks	Without these upgrades, the performance of the detectors would not be optimal and would not allow full profit to be taken of the luminosity of the LHC. Due to radiation damage and increased pileup, upgrades are mandatory for running the detectors during the HL-LHC phase.
2018 targets	**ATLAS:** Phase-I upgrades of the muon end-cap detector (new Small Wheel, nSW): start quality control of large electronic boards which serve as basis of the Micromegas detectors for the nSW. Complete test benches for nSW chambers which are assembled in the participating institutes, the construction sites, and start tests and QA on assembled chambers as delivered by construction sites. Start planning and preparation of the assembly facility of the nSW at CERN. Liquid Argon electromagnetic calorimeter (LAr): complete procurement of optical fibres and start the tests of fibres. Trigger and Data Acquisition (T/DAQ): complete development of new uCTPI for central trigger, development of DAQ software. Preparations and R&D for the Phase-II upgrade: Inner Tracker, ITL: finalise layout, including physics performance studies and optimisation. Continue development of Pixel Sensors and Module techniques and layouts. Start prototyping of a demonstrator ITK pixel stave based on light carbon-fibre support structures. T/DAQ: start overall system design and development of new CTP and TTC system. **CMS:** With the successful installation of the Pixel Phase I upgrade, the completion of the HF readout upgrade and the completion of the Trigger Phase-I upgrade CMS is planning to collect with high efficiency data from LHC confident to be able to sustain luminosities up to 2×10^{34} $cm^{-2}s^{-1}$. The installation of the Endcap Hadron Calorimeter Phase-I upgrade is now foreseen for the end of year technical stop, while the Barrel Hadron calorimeter Phase-I upgrade will be complete as foreseen in LS2. In 2018 CMS is planning to submit two of the main Phase-II projects' TDRs, namely for the Tracker and the Forward Calorimeter.

25. LHC detectors upgrade (Phase 1) and consolidation / HL-LHC detectors, including R&D (Phase 2) (cont.)

2018 targets	**LHCb:** Continue detector construction and infrastructure preparations for LHCb upgrade planned to be installed during LS2 (2019 to end-2020). Procurements and construction of components have started, following the numerous milestones that have been agreed with the LHCC. CERN is primarily involved with coordinating and managerial responsibilities in the VELO, RICH and SciFi detectors. Continue R&D and further define objectives and methods for the HL-LHC phase. An Expression of Interest for this phase has been submitted to the LHCC. Main strategy points to a two-step model, where small improvements could be achieved during LS3, moving towards a complete refurbishment of the detector during LS4. Consolidation of the existing LHCb detector aims to further improving reliability, stability and preparations for decommissioning during LS2. **ALICE:** The ITS Upgrade project is currently producing the silicon sensors which will be completed during 2017. The construction of detector modules and staves will start mid-2017 and is planned to take till mid-2018. The large detector support structures, based on composite materials, will also be manufactured in 2017. The development of the off-detector readout electronics will continue until summer 2017 and the production will start shortly after. The O2 project has implemented several key prototypes: calibration database, data quality control, control-configuration-monitoring, the ALFA demonstrator based on HLT components and will implement a first version of the ITS and TPC reconstruction. A first version of a GBT readout will be released.
Future prospects & longer term	Prepare for optimal exploitation of LHC at ultimate luminosity.

		Personnel (FTE)	Personnel (kCHF)	Materials (kCHF)	Total (kCHF)	Comments
CERN budget for 2018	**LHC detectors upgrade (Phase 1) and consolidation**	**76.0**	16,765	10,530	**27,295**	
	HL-LHC detectors, including R&D (Phase 2)	**24.6**	4,475	4,450	**8,925**	
	CERN contribution to HL-LHC detectors (Phase 2)	**21.7**	5,350	3,685	**9,035**	

Preparation for the future

26. Linear collider studies (CLIC, ILC)

Goal	Design-studies of an e+/e- multi-TeV high-energy frontier linear collider based on a novel two-beam accelerator scheme, with the goal of being able to propose CLIC as an option for a post-LHC accelerator project at CERN at the time of the next European Strategy Update. The main feasibility issues, cost and project timelines for CLIC have been developed, demonstrated and documented in a comprehensive Conceptual Design Report (CDR) completed in 2012. The work is now fully focused on developing a Project Implementation Plan for the next European Strategy update, when physics results from LHC running at full energy are available to guide the way for the future. The work-programme, technical R&D and design studies, are carried out by a collaboration of 50 institutes providing the overall (M&P) resources for the activities. The programme encompasses development of the basic acceleration technology, integrated design, specific technological studies, implementation studies and integrated system tests. The CLIC accelerator studies are closely connected with associated physics and detector studies for such a machine, using LHC physics guidance maximally for design optimisation of the accelerator and detectors.
Approval	Accelerated CLIC R&D by the CERN Council in 2004.
Start date	July 2004 with goal a CDR 2011-2012 demonstrating feasibility. The goals for the next European Strategy update – an optimised design of an electron-positron machine at the high-energy frontier and associated high gradient R&D – are set out in the European Strategy from 2013.
Costs	The material budget foreseen for the Linear Collider studies in the MTP is 24.7 MCHF (from 2017 to 2019). In addition 17.9 MCHF are planned for personnel on the same period. The CLIC collaboration provides important external contributions complementing the resources from CERN and 75 specific technical contributions from collaborators of 50 institutes in 25 countries are integral parts of the work programme for the period 2017-2019.
Running conditions	The CLIC Collaboration is organised like a physics experiment with members represented in a Collaboration Board and by a Spokesperson. The contributions of the collaboration members are described in MoU addenda and R&D contracts.
Competitiveness	The CLIC machine is the only possibility to reach multi-TeV e+e- collision energies with high luminosities in the foreseeable future. The construction of such a machine will need to be primarily motivated by physics requiring this capability. There are several collaborative efforts with the International Linear Collider (ILC) based on RF superconducting structures operating as a potential Higgs-factory, i.e. similar to a possible initial operation phase of a CLIC machine. Optimisation of studies/resources takes place under the LCC (Linear Collider Collaboration) heading. In general the energy and physics focus for the two machines are different with CLIC emphasizing the multi-TeV capabilities. However, an initial stage at 380 GeV for CLIC is currently a primary focus for the study. The main alternative for a future high-energy frontier machine at CERN would be a hadron machine with higher energy than the LHC, High-Energy LHC or FCC. There are also possibilities for collaboration with the studies in progress for such a machine, related to site issues, costing, schedules and possibly some technical items, as well as physics studies and specific detector challenges. Provided high-energy frontier machines – as CLIC and hadron options – are implementable at a reasonable cost, the best way forward is mainly a physics question that further LHC running will attempt to address.
Organisation	A CLIC nucleus study team hosted at CERN and reporting to the CLIC Collaboration Board with representatives of all collaborating institutes. Work packages are defined, distributed and followed up by the CLIC Steering Committee and executed by CERN groups

26. Linear collider studies (CLIC, ILC) (cont.)

Organisation	and/or external collaborators. The CLIC project is part of the international LC Collaboration. The organisation of CERN's involvement is under the Directorate for Accelerators and Technology.
Risks	Personnel: availability of staff and fellows in the coming 3 years for completion of a CLIC implementation plan Collaboration: progress also strongly depends on the continued effort from outside institutes, and the ability to engage these institutes fully in the future programme.
2018 targets	• Complete and document main results for the Implementation Plan by end 2018. • Summarize main results for the drive-beam klystron and modulator prototypes. • Pursue experimental tests of nanobeams in ATF2, FELs and Light sources. • Operate X-band test-stands for detailed tests of baseline CLIC accelerating structures and cost-reducing alternatives. • Complete cost and power revisions for the CLIC Project Implementation Plan. • Conclude the module programme with a complete technical design and cost estimate. • Follow and participate in ILC preparation activities in collaboration with European laboratories and universities and facilitate the European preparatory studies in selected technical domains.
Future prospects & longer term	Preparation of a Project Implementation Plan for the next European Strategy Update. The work-programme for this period has been re-defined and implemented with large collaboration participation and commitments. Initial planning of a Preparation Phase 2020-2025 focused on system performance optimisation, further industrial involvements and site authorization/preparation, as final steps before eventual construction.
Specific Health & Safety issues	High power and radiation issues for X-band components tests
CERN contribution	Overall coordination of the CLIC and hosting of the CLIC Collaboration. Validation, organisation and follow-up of the CLIC work-packages. Contribution to the ILC design and preparation through the LC Collaboration.

CERN budget for 2018	**Personnel (FTE)**	**Personnel (kCHF)**	**Materials (kCHF)**	**Total (kCHF)**	**Comments**
	29.1	5,650	8,650	**14,300**	

27. Linear collider detector R&D

Goal	Physics and detector studies for a future multi-TeV e^+e^- linear collider at the energy-frontier, with the goal of presenting CLIC as a mature option for a post-LHC accelerator project at CERN by the time of next European Strategy update. The project is closely related to the CLIC accelerator studies and to the ILC physics and detector studies. The study also exploits opportunities for common developments with the HL-LHC detector upgrades and with FCC physics/detector studies. The CLIC physics potential and the ability for CLIC to perform precision measurements have been demonstrated in the CLIC CDR (2012) and through more recent detailed Higgs boson and top quark studies. The aim of the work for CLIC is to provide a physics-motivated and technically detailed project implementation plan by 2018. On the hardware side this will include demonstrators of the key technology challenges for detectors at CLIC.
Approval	Project motivated by 2004 Council decisions on CLIC R&D and by the 2006 and 2013 European Strategy statements concerning e^+e^- colliders.
Start date	1 January 2009
Costs	In this development phase, ~3.5 MCHF per annum (P+M).
Running conditions	Use of test beams (inside and outside CERN) during ~8 weeks/year.
Competitiveness	TeV-scale e+e- colliders have a guaranteed excellent potential for precision Higgs and top quark measurements. Moreover, the development of a future e^+e^- collider at the multi-TeV energy frontier provides the prospect to expand the discovery potential after the LHC and therefore to stay at the forefront of particle physics. The main competitor is a higher energy proton-proton collider. High-energy LHC data will guide a future decision.
Organisation	The CLIC detector and physics study (CLICdp) is organised in a collaborative framework with CERN as the host lab. CLICdp currently (March 2017) comprises 29 institutes. CLICdp collaborates actively with the ILC detector concepts and Linear Collider detector R&D efforts. CERN LCD also participates in HL-LHC detector upgrades and FCC studies.
Risks	At this early stage, the risks attached to this project are limited and principally concern funding and engagement of partners.
2018 targets	*Preparations for the European Strategy Update:* Apart from a summary report on CLIC, to be drafted together with the accelerator team, the CLICdp collaboration plans to complete several overview documents in 2018 (overview of top quark physics at CLIC, overview of BSM physics at CLIC, CLIC detector R&D report, planning for the period 2020-2025). CERN LCD will play a central role in this effort. *Technical/scientific activities at CERN:* Physics studies at CLIC centre-of-mass energies. CLIC detector optimisation studies as well as engineering and integration studies. Detector technology R&D towards a low-mass vertex detector and a silicon tracker to CLIC specifications (pixelated, few-micron resolution, ns-level timing, low mass, power pulsing); hybrid options and HV-CMOS/HR-CMOS options under study, synergy with HL-LHC R&D groups. Participation in fine-grained calorimetry R&D for Linear Colliders (CALICE and FCAL collaborations). *Participation in other CERN priority projects at the energy frontier:* CMS HGCal (e.g. silicon sensor testing, beam tests and analysis of test data), FCC-hh (optimisation of the vertex and tracking detectors), FCC-ee (adaptation of a CLIC-like detector to FCC-ee experimental conditions). Close links and continued contributions to ILC (most prominent examples are software tools for event simulation/reconstruction, iLCDirac Grid production, calorimeter R&D).

27. Linear collider detector R&D (cont.)

Future prospects & longer term	Fulfil host lab responsibilities and participate in the CLIC detector and physics study (CLICdp); medium-term objective is to complete the CLIC implementation plan for the next update of the European Strategy for Particle Physics. On a continuous basis: interpret LHC physics results and adapt future CLIC physics goals accordingly, perform simulation studies for detector optimisation and pursue detector R&D to CLIC specifications. Main focus areas of LCD detector R&D at CERN: CLIC vertex and tracking detector R&D, fine-grained calorimetry, electronics readout including power delivery and power pulsing, engineering studies. Maintain links and exploit synergies with other future projects at the energy frontier (HL-LHC, FCC, ILC). Longer-term prospects will depend on a positive decision on CLIC at the next European Strategy update or on a possible ILC decision in Japan. Some of the R&D carried out in the framework of LCD carries longer-term interest for the particle physics community.
Specific Health & Safety issues	None for the moment.
Outreach	www.clicdp.web.cern.ch
CERN contribution	Physics studies, detector optimisation studies, core software development, vertex and silicon tracking detector R&D, assessment of PFA-based calorimetry, electronics readout developments, engineering and integration studies. A sizeable part of the CERN effort is invested in CMS HGCal (fine-grained calorimetry), FCC-hh (vertex and tracking detector optimisation) and FCC-ee (CLIC-like detector adapted to FCC-ee conditions).

CERN budget for 2018	**Personnel (FTE)**	**Personnel (kCHF)**	**Materials (kCHF)**	**Total (kCHF)**	**Comments**
	19.4	3,195	585	**3,780**	

28. Future Circular Collider study

Goal	The main goals of the FCC study are conceptual design report, technology demonstration and cost estimate for high-energy circular colliders' options in a new tunnel of 80 – 100 km circumference, in time for the next update of the European Strategy for Particle Physics by 2019-2020. The emphasis of the study is on the long-term goal, a 100-TeV energy frontier proton-proton collider (FCC-hh). The study also includes, as potential intermediate step, a high-luminosity electron-positron collider (FCC-ee) operating at centre-of-mass. Energies between 90 and 350 GeV and examines options for lepton-hadron scenarios (FCC-he). Parameter optimisation, optics design and beam dynamics studies for both colliders are part of the FCC study. Civil engineering and technical infrastructure studies, driven by the proton collider requirements, will also be carried out. Main goals for technology developments are: • Development of high-field superconducting magnet technology beyond HL-LHC requirements. Production of 16 T short magnet models based on Nb_3Sn, including magnet and coil design optimisation, wire and cable R&D, optimisation of coil production, impregnation and magnet assembly. Parallel program to demonstrate 20 T magnet technology based on high-temperature superconductors as inserts. • Optimisation of technology for large superconducting RF systems. Determination of the optimum cavity technology and cryogenic operating temperature, balancing complexity and power consumption of the cryogenic system against the difficulty to reliably reach large quality factors (Q_0) and accelerating gradients. R&D to significantly improve energy efficiency of RF power sources in continuous wave mode. In particular for FCC-ee, the RF system has to provide a total voltage of up to 12 GV to continuously compensate for synchrotron radiation losses of order 100 MW. • R&D for specific technologies, e.g. for synchrotron radiation handling, collimation, beam dump, and machine protection. The FCC study will also include the performance and cost analysis of a HE-LHC, housed in the LHC tunnel, and based on the same high-field magnet technology as the FCC-hh hadron collider. The FCC study also includes an elaboration of the physics cases, detector concepts for all three types of collider, as well as the conception of staging and implementation scenarios.
Approval	Following European Strategy Update 2013 approved by CERN Council in 2013.
Start Date	12 February 2014 (International FCC kick-off meeting).
Costs	The requested CERN staff resources are estimated to be 30 FTEs for a duration of 5 years (150 man-years) complemented by students and fellows (15 MCHF over 5 years). The material Cost-to-Completion of the FCC study including students and M to P transfers for fellows, CERN funding, is 32.8 MCHF (SC RF: 8.8 MCHF, SC Magnets 15 MCHF, others 9 MCHF). The FCC study collaboration is assumed to provide important external contributions complementing the resources from CERN.
Running Conditions	The FCC design study is organised as an international collaboration similar to CLIC. Participating institutes are represented in a Collaboration Board. The collaboration is based on the FCC Memorandum of Understanding, and individual contributions of collaboration members are described in specific addenda. The FCC Horizon 2020 design study application 'EuroCirCol', was approved at the beginning of 2015 by the European Commission and covers a subset of the FCC study, promoting the vision of a large-scale post-LHC research infrastructure under European leadership.
Competitiveness	The FCC-hh collider is the only possibility to reach collision energies at the 100-TeV scale in the foreseeable future, with high luminosity and at affordable power consumption. The FCC-ee collider, as potential intermediate step, would allow for important precision measurements of the Z, W, and H bosons and of the top quark, at luminosities higher than achievable with linear colliders,

28. Future Circular Collider study (cont.)

Competitiveness	indicating the energy scale at which new physics is expected. It would also enable the search of rare Higgs decays. The FCC-he collider option would enable high precision deep inelastic scattering and provide access to complementary Higgs physics.
Organisation	The FCC Study Coordination Group, constituted from a CERN core team together with a few global experts, organises and carries out the conceptual design study at international level. It reports to an International Steering Committee, consisting of 2-3 representatives per region, which is determining and refining the goals of the study, approving the work programme and reviewing the study progress. An International Collaboration Board, with one representative per institute, is reviewing the resources and the channeling of the external contributions. The Collaboration Board reports to the Steering Committee. An International Advisory Committee, consisting of 1 or 2 experts per technical area, reviews the scientific and technical progress of the study and submits recommendations to the Steering Committee.
Risks	Progress depends strongly on availability of CERN staff resources and contributions from outside institutes.
2018 Targets	First results from technology R&D programs, in particular on superconducting 16T Nb_3Sn magnets, superconducting septa, cryogenic beam-vacuum system experiments, and SRF (Superconducting RF) development. Completion and delivery of the FCC Conceptual Design Report for all collider options, detectors, physics and associated infrastructures (FCC hadron collider, FCC lepton collider, HE-LHC, and FCC lepton-hadron collider integration) presented at FCC Week 2018 – as input to the European Strategy Update – along with internal cost models, project schedule, and planning for the subsequent technical design phase.
Future prospects & longer term	CDR, short high-field racetrack-magnet prototypes, and cost estimate for end 2018, followed by technical design study and project preparation/approval phase from 2019 - 2023.
CERN contribution	Overall coordination of the FCC study and hosting of the global collaboration. Organisation, follow up and technical contributions for FCC study work packages.

CERN budget for 2018	**Personnel (FTE)**	**Personnel (kCHF)**	**Materials (kCHF)**	**Total (kCHF)**	**Comments**
	37.7	6,865	7,240	**14,105**	

32. Proton driven plasma wakefield acceleration

Goal	Advanced Acceleration Techniques: Contribute to the global effort on developing the use of plasma wake-fields for accelerating particle beams. To this end, construct and run a facility for studying the use of a proton beam to drive the plasma wake-fields (AWAKE).
Approval	Approval of the AWAKE experiment in the Research Board of August 2013.
Start date	A conceptual design for AWAKE was launched in 2012 with the start of construction end 2013.
Costs	The material Cost-to-Completion of the AWAKE project, CERN funding, is 12.3 MCHF. It is complemented by external in-kind contributions of 8.7 MCHF.
Running conditions	The facility is part of the AWAKE collaboration. The experiment is partly funded by external collaborations, with 8.7 MCHF (material) confirmed by collaborating institutes for equipment.
Competitiveness	AWAKE is a facility to study a new acceleration technology based on the use of a proton beam to drive plasma wake-fields. This will be a unique facility in the world since a suitable high-energy, high intensity proton beam cannot be found elsewhere.
Organisation	Along the lines of the CERN department structure with the project leader managing contributions from most CERN departments and external laboratories worldwide. Overall organisation under the Directorate for Accelerators and Technology.
Risks	• Issues encountered during hardware (e.g. diagnostics equipment, laser alignment) and beam commissioning (electron and proton beam in common beam line) could have an impact on the schedule and resources. • Issues during operation (e.g. laser alignment, ionization of the plasma) could have an impact on the physics results.
2018 targets	• Commissioning and physics run of the AWAKE experiment for electron acceleration in the plasma wakefield driven by the SPS proton beam; • Studies and preparation work for AWAKE Run 2, which is still to be approved; • Start studies on possible use of plasma wakefield acceleration technology for high-energy physics as ‘exploratory study group’ within the Physics Beyond Collider Working Group.
Future prospects & longer term.	The AWAKE experiment Run 1 performs benchmarking tests using proton bunches to drive wake-fields, to understand the physics of the self-modulation process in plasma, to demonstrate high gradient acceleration of a bunch of electrons in the wake of a proton bunch and to pursue R&D studies towards the TeV frontier. Plans to develop further and run the experiment after LS2 as well as studies on high-energy physics applications of this technology are in progress. The related costs and required resources will be verified for the next MTPs.
Specific Health & Safety issues	Installation work and operation will be carried out following the applicable safety rules and the ALARA principle.
Outreach	New acceleration technology that brought already many newspaper and media publications. Additional outreach issue will be covered when first experimental results are available (>2017).

CERN budget for 2018	**Personnel (FTE)**	**Personnel (kCHF)**	**Materials (kCHF)**	**Total (kCHF)**	**Comments**
	7.3	1,395	1,255	**2,650**	

37. Physics Beyond Collider (PBC)

Goals	Physics Beyond Colliders (PBC) is an exploratory study aimed at exploiting the full scientific potential of CERN's accelerator complex and its scientific infrastructure through projects complementary to the LHC, HL-LHC and other possible future colliders. These projects would target fundamental physics questions that are similar in spirit to those addressed by high-energy colliders, but that require different types of beams and experiments. A kick-off workshop was held in September 2016 identified a number of areas of interest. Following this meeting and consultation with the relevant communities, the study team has defined the structure and the main activities of the group and appointed conveners of thematic working groups. The scientific findings will be collected in a report to be delivered by the end of 2018. This document will also serve as input to the next update of the European Strategy for Particle Physics. Under the auspices of the PBC study are the feasibility studies for the SPS Beam Dump Facility (BDF). Resources for these studies were included in the 2016 MTP.
Approval	Presented to Council 2016
Start date	6 September 2016 (Physics Beyond Colliders kick-off)
Cost	Including the Beam Facility feasibility studies, the current allocated CERN staff resources are 6 FTEs for a duration of 2 years (12 man-years) complemented by students and M to P transfers for fellows. The required personnel is secured. The material Cost-to-Completion of the PBC and BDF studies including students, M to P transfers for fellows, CERN funding, is 24 MCHF up to 2027. The PBC study is assumed to accommodate external contributions complementing the resources from CERN.
Running conditions	
Competitiveness	The PBC study should provide input for the future of CERN’s scientific diversity programme, which today consists of several facilities and experiments at the Booster, PS and SPS, over the period until ~2040. Complementarity with similar initiatives elsewhere in the world should be sought, so as to optimise the resources of the discipline globally, create synergies with other laboratories and institutions, and attract the international community. CERN should be well placed to exploit opportunities that are identified for implementation.
Risks	
2018 targets	The key deliverable of the Physics Beyond Colliders study is a document summarizing the feasibility and science case of the options. This document is to be provided to the update of the European Strategy for Particle Physics, the process for which is scheduled to take place in 2019.
Future prospects & longer term	The long-term vision for the exploitation of the accelerator complex is to be explored. Backed by strong physics case, initiatives pursued could provide a valuable to complement to CERN’s collider program.

CERN budget for 2018	**Personnel (FTE)**	**Personnel (kCHF)**	**Materials (kCHF)**	**Total (kCHF)**	**Comments**
	6.0	685	920	**1,605**	

Scientific diversity activities

29. ELENA

Goal	The Extra Low Energy Antiprotons (ELENA) upgrade to the AD involves the addition of a small magnetic synchrotron and electrostatic beam lines whose design parameters have been carefully studied and agreed upon over several years. The ELENA upgrade will not only allow higher quality low-energy antihydrogen physics at CERN over the next decade, it will also be a decelerator test platform of use in developing the methods needed for future generations of low-energy facilities.
Approval	Approved by the CERN Research Board in spring 2011.
Start date	January 2012
Costs	The material Cost-to-Completion of the ELENA project including M to P transfers consists of 22.5 MCHF funded by CERN, complemented by in-kind external contributions with a value of 2 MCHF and external cash contributions of 0.7 MCHF. The construction of ELENA implies a longer lifetime for the AD machine itself (previously approved until 2016). Consolidation to extend the AD life-time by at least 10 years is foreseen within the consolidation project. Also, it is assumed that some existing (and ageing) installations (for example cooling water station) will be sufficient to operate ELENA in addition to the AD.
Running conditions	Project partly funded by external collaborations, with 2.70 MCHF confirmed. In addition to CERN personnel, about 15 man-years have been made available by external parties.
Competitiveness	ELENA will strongly improve the conditions for antiproton experiments by (i) further decelerating the antiprotons to 100 keV to improve the capture efficiencies by one to two orders of magnitude and (ii) splitting the available intensities into several bunches distributed to several experiments running in parallel mitigating the shortage in beam time for each experiment with more and more experiments becoming operational.
Risks	Any delay in the ELENA commissioning will have an impact on GBAR data taking.
2018 targets	During 2018, ELENA will be operational for the new experimental zone and provide 100 keV beams for the GBAR experiment. With the decision, taken together with representatives from the experiments and the CERN management, to postpone in LS2 the installation of the electro-static transfer lines to all remaining experiments of the AD-hall, no installation and commissioning activities are foreseen in 2018.
Future prospects & longer term	After LS2, ELENA will provide 100 keV beams to all AD experiments.
Specific Health & Safety issues	Standard health and safety issues for accelerators.
CERN contribution	Project fully controlled by CERN, integrating external contributions from institutions from Member and non-Member States.

CERN budget for 2018	**Personnel (FTE)**	**Personnel (kCHF)**	**Materials (kCHF)**	**Total (kCHF)**	**Comments**
	0.6	105	360	**465**	

30. HIE-ISOLDE

Goal	Build a 10 MeV/A SC Linac to post-accelerate radioactive ion beams from ISOLDE; design study for ISOLDE target intensity upgrade.
Approval	CERN Research Board September 2009.
Start date	January 2010. The project start-up has been deferred to the second half of 2011 with a view to completion in 2015/2016 following the Council's request to the Management in June 2010 to submit a revised MTP.
Costs	HIE-ISOLDE facility is planned in two phases: 5.5 MeV/A for phase 1 and 10 MeV/A for phase 2. The cost for the 3rd experimental beam line to be installed during phase 2, is included in this MTP, borne by CERN. The cost of the infrastructure is funded by CERN while the machine components are funded by the collaboration, excluding 4.5 MCHF borne by CERN. The material Cost-to-Completion of the HIE-ISOLDE project (Phase 1, Phase 2 and 3rd experimental beam line), CERN funding, is 27.1 MCHF. It is complemented by external cash contributions from the ISOLDE collaboration of 12.8 MCHF and in-kind external contributions of 0.4 MCHF.
Running conditions	Project partly funded by external collaborations, totalizing 12.8 MCHF for phase 1 and phase 2.
Competitiveness	All 700 radionuclides produced at ISOLDE from 1.4 GeV PSB beams can be post-accelerated efficiently up to 10 MeV/A. This capability will be unique worldwide. The complementarity of the HIE-ISOLDE to Spiral2 has been confirmed.
Organisation	Projects composed of 150 Work Units distributed into 50 Work Packages assigned to CERN groups. Project managed by Project Leader assisted by 6 coordinators on the field (safety, infrastructure and installation, beam commissioning, physics and design study for target intensity upgrade). Progress of work units controlled via appropriate monitoring tools. Overall organisation under the Directorate for Accelerators and Technology.
Risks	Technical: the complexity of the cryomodules, their assembly tooling and the assembly procedure, could lead to delays in the schedule. This has a direct impact on the cost of industrial support for the project (FSU for the cryomodule assembly and cavity preparation).
2018 targets	• Repair of the Cryogenic Distribution Line during YETS (Year-End Technical Stop) 2017/2018 to recover the full cryogenic performance needed to cool-down all four cryomodules. • Installation and hardware commissioning of the fourth high-beta cryomodule (CM4) during YETS 2017/2018. • Beam Commissioning at 10 MeV/A • Physics with Radioactive Ion Beams @ 10 MeV/A (with 4 cryomodules).
Future prospects & longer term	Provision of accelerated ions A=6 to A=238 between 3 MeV/A and 10 MeV/A to ISOLDE users by 2018. The third experimental beamline is foreseen in 2017. No allocations are foreseen for phase 3 (deceleration to 0.3 MeV/A).
Specific Health & Safety issues	Standard health and safety issues for accelerators including cryogenics.
CERN contribution	Project fully controlled by CERN, integrating in-kind contributions from Member and non-Member States.

30. HIE-ISOLDE (cont.)

CERN budget for 2018	Personnel (FTE)	Personnel (kCHF)	Materials (kCHF)	Total (kCHF)	Comments
	0.1	5	1,125	**1,130**	

31. CERN Neutrino Platform

Goal	This heading covers a number of neutrino-related R&D activities: 1. The main purpose is to provide to the experimental community an effective platform to develop at CERN a new generation of neutrino detectors based on various technologies; 2. Test and qualify such detectors in test beams at the SPS; 3. Assist the neutrino community in their efforts towards a short- and long-baseline type of neutrino experiments and infrastructures. These goals are in line with the 2013 European Strategy document (CERN-Council-S/106). Several activities have been approved as experiments at CERN by the CERN Research Board (NP01, NP02, NP03, NP04, NP05). They require a phase of construction with very large prototypes/demonstrators which will need at CERN basic infrastructure support in term of buildings, test facilities, cryogenics infrastructure, etc. An extension of the North Area test facility has been constructed in 2016 to host these large detectors as well several buildings at CERN where the assembly can be done in optimal conditions. Technical support in fields like LAr cryogenics, where CERN has a unique expertise, will also be part of these activities.
Approval	2014
Start date	Studies for future neutrino detectors: A design team has been set up during 2013 and has provided the basis for an effective start of the R&D activities in 2014. More refined details will be investigated and summarized in dedicated documents/publications.
Costs	The funding of the neutrino programme reflects the commitments towards the US Short and Long Baseline Neutrino Facility project at Fermilab described in previous MTPs and a commitment towards the T2K Japanese program. No new commitments are taken at this stage. A flat funding profile has been assumed for the Neutrino Platform activities beyond 2020, while waiting for the outcome of the European Strategy update. About one quarter of the cost is related to basic infrastructure support (new North Area experimental extension in particular), another quarter is related to hosting neutrino physics detectors project and related R&D activities, including items such as integration of services and cryogenics support. About half of the allocated resources will cover the in-kind delivery by CERN of the first cryostat for the LBNF/DUNE project to be operated in the underground neutrino laboratory to be constructed in South Dakota. The material Cost-to-Completion of the NEUTPLAT project until 2027 including M to P transfers is 120.8 MCHF.
Running conditions	The design study for future neutrino detectors and facilities is envisaged as a European and global international collaboration effort. Collaboration agreements are under preparation. Design studies are proceeding with the US partners at FNAL aiming at setting up possible synergies in neutrino physics between Europe and US, as indicated in the recent European Strategy document.
Competitiveness	The technologies developed within these programs are crucial for potential future projects in the field. For example, LAr based Time Proportional Chambers are key technologies in the present plan for a long- and short-baseline neutrino project. LAr cryogenics, LAr purity, large cryostats assembly, large solenoidal fields are a common denominator. State-of-the-art competence in design construction and testing of such technologies is essential for preparing these potential new large projects.

31. CERN neutrino platform (cont.)

Organisation	Embedded within the CERN department structures with the Project Leader managing contributions from most CERN departments and external laboratories worldwide. The overall organisation falls under the Directorate for Research and Computing, via an overall Project Leader.
Risks	Long delays in constructing the CERN facilities would be problematic for the collaborations and would impact directly on the overall neutrino program worldwide.
2018 targets	Test with CERN SPS beams the two large DUNE prototypes constructed and made operational by spring 2018. These prototypes will serve also as engineering module-0s and as a basis for the long-baseline far detectors, which will need to start mass production in 2019 within the large international Collaboration DUNE/LBNF. Start data taking in the Short Neutrino Baseline, with the detectors moved to FNAL and installed in 2017. Start the procurement process for the first far detector cryostat for LBNF, after all engineering aspects have been documented and approved.
Future prospects & longer term	The aim is an effective start of the neutrino detector R&D which will take many years to mature towards a new generation of the detector capable of the challenges of a long-baseline type of experiment. Assist the community in the preparation of the short- and long-baseline experiments and facilities.

CERN budget for 2018	**Personnel (FTE)**	**Personnel (kCHF)**	**Materials (kCHF)**	**Total (kCHF)**	**Comments**
	17.3	2,780	10,315	**13,095**	

33. Superconducting RF studies

Goal	This heading covers R&D on Superconducting RF (SRF), one of CERN's priorities to enhance a vigorous accelerator R&D programme, which are complementary to FCC developments. In addition this goal is to enhance the ability of CERN to maintain its present systems including in LHC and HIE-ISOLDE. R&D preparing the next generation of superconducting RF cavities; install, upgrade, operate and maintain the necessary infrastructure for fabrication and testing of material samples, single-cell and multi-cell cavities; improve design and engineering of cavities and cryomodules including ancillaries; study different materials for their application in SRF, both for thin-film and bulk; develop coating techniques for improved cavity performance; optimise for less cryogenic power consumption; coordinate with on-going international SRF R&D programs. This heading also covers the continuation of R&D activities undertaken in collaboration with international partners, highlighting the complementary strength of all partners.
Approval	In line with the recommendations of the European Strategy Update 2013 approved by CERN Council in 2013.
Start Date	July 2014
Costs	Combination of personnel and material resources required to run the fabrication, assembly and test facilities and necessary for projects and studies. Material: 2.5 MCHF/year, of which 0.5 MCHF reserved for fellows and students plus external contributions (Support of EU programmes and other contributions).
Running Conditions	SRF R&D requires collaboration and tight coordination with an existing successful global R&D program at CERN and in other Labs: • Partnerships are well established with ESS Lund (704 MHz cavities/cryomodules, test of 704 MHz MB-IOTs at CERN), with Universities in Rostock, Uppsala and Frankfurt, with JLAB and FNAL in the US as well as BINP in Russia and the STFC in UK. • Running conditions include the operation and development of SRF relevant facilities at CERN (e.g. electron-beam welding, surface treatments, sputtering, cryogenics, test platforms, specialized apparatus for sample testing, clean rooms for assembly and test)
Competitiveness	Superconducting RF technology is used in the present CERN accelerators (LHC, HIE-ISOLDE) and for their upgrades (HL-LHC). SRF technology is a common denominator and critical technology in many potential future projects (FCC, neutrino facilities, ILC …). State-of-the-art competence in design, construction and testing of superconducting RF cavities and their cryomodules is essential for preparing these potential new projects. To this effect, CERN is re-establishing its capacities in SRF in general, maintaining its leading competence in thin film technology and further developing its knowledge of fabrication techniques applied to SRF cavities.
Organisation	All SRF R&D activities, including those under projects and operation, are coordinated centrally in the BE department. The activities at CERN are concentrated in BE-RF, EN-MME, TE-VSC and TE-CRG, under the supervision of the Directorate for Accelerators and Technology.
Risks	This R&D program addresses technologies that entail high risk, but also high potential of significant performance improvement in future accelerators. Progress and success depend on the availability of the facilities and on the allocation of human resources. It is assumed that the cryogenic capacity of testing facilities is compliant with the R&D programme for Superconducting RF at CERN.
2018 Targets	Continue R&D activities on "high-Q" technologies with two main axes of development: Study and compare alternative coating techniques (e.g. HiPIMS, Energetic Condensation…), to be complemented by a study of the impact on RF performance of new materials (e.g. Nb_3Sn, V_3Si…) for thin film deposition. Other highlights for 2018 are: • Finalise SM18 extension and install infrastructure; • Consolidate the sputtering facility;

33. Superconducting RF studies (cont.)

2018 Targets	- Study the implementation of a dedicated RF coupler test facility; - Finalise and commission new QPR (quadrupole resonator) for sample testing; - Continue ESS collaboration with 704 MHz cavities/cryomodule and MB-IOT tests.
Future prospects & longer term	Retain and develop the know-how necessary for the design, prototyping, fabrication and testing of superconducting RF equipment. Lead cutting-edge research for next generation of SRF cavities: findings on improved coatings may lead to cost-effective cavities, possible operation at optimised cryogenic temperatures may lead to reduced operational cost. Keep operational facilities needed for the running of LHC, HIE-ISOLDE and HL-LHC cavities.

CERN budget for 2018	**Personnel (FTE)**	**Personnel (kCHF)**	**Materials (kCHF)**	**Total (kCHF)**	**Comments**
	6.5	1,080	4,490	**5,570**	

34. Superconducting magnet R&D (SCM)

Goal	R&D on superconducting magnets, especially on high-field magnets (HFM), is one of CERN's priorities in support of a vigorous accelerator programme. This heading covers the superconducting magnet R&D complementary to the HL-LHC project and the FCC design study, as well as design and prototyping of magnets that could be used in beam transfer lines (e.g. neutrino targets) or compact circular accelerators and storage rings. This item is the general technology driver for the next generation of high field magnets (16T and beyond) for future accelerator facilities. Specifically, the work covers: • Magnet technology: advances in high superconducting materials (Nb_3Sn and industrial HTS) and emerging alternatives, insulating materials, instrumentation, structural materials with increased strength and improved magnetic properties at cryogenic conditions to reduce mass and cost. • Material testing and characterization facilities relevant to HFM: critical current test facilities for wires/tapes with background field in the range of 16-20 T, cable critical current test facility with background field in the range of 13-15 T, magnet test facilities with very high current capacity, in the range of 20-50 kA. • Design alternatives to the present baseline geometry for accelerator magnets.
Approval	In line with the recommendations of the European Strategy approved by CERN Council in 2013.
Start Date	September 2014
Costs	Dominated by the materials budget to sustain conductor development (industry), and the cost of test installations at high field. Minor personnel and design contribution. The requested resources are complementary to the scope of HL-LHC and FCC. The profiling of the Superconducting magnet R&D request is adjusted yearly, and it depends on both HL-LHC and FCC scope and plans.
Running Conditions	The SCM R&D requires tight coordination with the existing global R&D programs, internal to CERN (HL-LHC, FCC) and within the scope of the EU-funded collaborations (ARIES, FUSUMATECH).
Competitiveness	HFM is a key technology enabling future accelerators ranging from high-energy hadron colliders, neutrino beams and medical accelerators. The CERN Superconducting magnet R&D is aiming at fostering this technology, maintaining existing and develop new unique worldwide testing facilities.
Organisation	All HFM R&D activities, including those under projects and operation, are coordinated centrally by the TE department, under the Directorate of Accelerators and Technology.
Risks	This R&D program addresses technologies that entail high risk, but also high potential of significant performance improvement in future accelerators, as well as high societal impact. Progress and success depends on the availability of the facilities and on the allocation of human resources.
2018 Targets	Continue the study for the upgrade of the strand and cable test facility for fields up to 18 T, and study options for 20 T. Produce installation scenario for implementation of FRESCA2 in the Superconductors Laboratory (B163). Procure HTS tapes and cables, and produce HTS small demonstrator magnets as part of the high field program beyond LTS (16 T). Consider the need and study options for additional test facilities for the test of HTS inserts in the range of 18…20 T bore field.
Future prospects & longer term	High-field cable test facility. Critical current test facility upgrade to 20 T. Design high-field transfer line magnet. Design open mid-plane collider magnet. Small size prototypes of alternative concepts for HFM, on the long term with fast-ramping ability. Develop and characterise heat resistant instrumentation for magnet diagnostic and protection (e.g. distributed optical fibre sensors). Develop and characterise rad-hard insulation for HFM.

34. Superconducting magnet R&D (SCM) (cont.)

CERN budget for 2018	**Personnel (FTE)**	**Personnel (kCHF)**	**Materials (kCHF)**	**Total (kCHF)**	**Comments**
	3.0	410	5,830	**6,240**	

35. R&D for medical applications

Goal	This heading focusses on R&D projects, using Technologies and Infrastructures that are uniquely available at CERN - accelerators, detectors and computing - with the aim to transfer know-how and technologies from CERN to the Medical community and disseminate the results of its work to society as widely as possible.
Approval	Medical Application Studies carried out by CERN have been grouped under an umbrella organisation from 2014 onwards.
Start date	January 2014
Costs	At steady state, a budget of 1 MCHF materials and 2 MCHF personnel per year is provided by CERN as seed funding for knowledge transfer for the benefit of Medical applications. This heading includes the Medicis project ending in 2017.
Running conditions	Projects shall be identified and established, taking into account, in particular: • The objective of maximising the impact of CERN's engagement; • Complementarities and synergies with the work in other laboratories of the Member States; • The existence of sufficient external funding to support each project; • The availability of resources, taking into account that CERN's priority is its core mission of fundamental particle physics research. The external stakeholders must provide the funding needed to deliver their project. CERN can provide a limited amount of seed funding for medical applications projects and has done so since 2014, as is reflected in the MTP and the annual budgets. As in the past, additional funding for CERN's medical applications-related projects may be obtained through the EC Framework Programmes. The CERN & Society Foundation is another potential source of funding. For projects that have an impact on CERN's resources (personnel, infrastructure, accelerator schedule, etc.), approval of the CERN Research Board shall be sought, both for the initial proposal and for the yearly programme. Council will be kept informed of medical applications-related projects through the annual approval process of the MTP. Projects of significant scope or having a substantial impact on CERN's resources will be explicitly flagged by the Director- General.
Competitiveness	CERN's medical applications-related activities shall focus on R&D projects, using technologies and infrastructures that are uniquely available at CERN. This approach seeks to minimise any duplication of research efforts taking place in CERN's Member States (MS) and to avoid overlap with the activities of external service providers, either in the market or otherwise. The most promising CERN technologies and infrastructure that are relevant to the medical domain shall be identified across the Laboratory's three technology pillars – accelerators, detectors, and computing. The results of this identification exercise shall be matched with the requirements of the medical research communities, in particular in CERN's MS, which must always be the drivers of CERN's engagement in this domain.

35. R&D for medical applications (cont.)

Organisation	The CERN Medical Applications Steering Committee (CMASC) selects, prioritises, approves and coordinates all proposed medical applications-related projects and their execution within their approved budget. It receives input from the International Strategy Committee (ISC), the CERN-Member States KT Thematic Forum, the Medical Applications Project Forum (MAPF) and the Medical Applications section of CERN's Knowledge Transfer group. Sessions of the CERN-Member States KT Thematic Forum will be dedicated to Medical Applications.
Risks	Such studies can only be undertaken as part of an international collaboration and with significant external funding, particularly by the European Union sponsoring.
2018 targets	Some highlights for 2018 are: • Continue to perform knowledge transfer for the benefit of medical applications, following the organisational framework and strategy laid out in the Strategy Document presented to Council in March 2017; • MEDICIS: deliver isotopes to final users in the collaboration; launching of the Phase B (subject to MoU approval); • BioLEIR: If the international collaboration is established, CERN will finalize the design (CDR and TDR). Then BioLEIR facility will be submitted to the CERN Research Board and to the Council for approval; • PIMMS-2 (Proton Ion Medical Machine Study): Subject to the approval by CERN's medical applications decision-making structure, an accelerator design study for future hadron therapy facilities will be carried out; • R&D activities in the field of dosimetry, medical imaging (notably with scintillating crystals and hybrid silicon pixel detectors), and Monte Carlo simulations are well established and have mostly been conducted as part of collaborative efforts. These activities will be monitored and reviewed periodically. • Computing for medical applications is a newly emerging strategic domain with a wealth of possible projects that will be assessed by CERN's medical applications decision-making structure. • Possible applications of high-field superconducting magnets are at an exploratory stage. Some initial projects can start in 2018.
Future prospects & longer term	MEDICIS will provide new isotopes for R&D in clinical studies. Bio-LEIR would provide a transnational infrastructure for a variety of experimental programmes covering the effect of hadrons at a variety of energies on biological systems. Such a facility would be complementary to other facilities in the world. Develop the PIMMS-2 conceptual design for second generation multi-ion hadron therapy facilities, which would look towards cheaper, more compact and simpler to operate machines. Explore the impact of CERN R&D in high-field superconducting magnets on MRI and NMR techniques. Study the possibility to develop synergies between personalised (precision) medicine and CERN data analytics, cloud and grids. Advanced detectors and associated instrumentation can be used in a variety of medical applications, such as medical imaging, spectroscopy of biological samples and dosimetry: CERN's unique competence in system integration should be fully exploited. Explore the possibility of building reliable and cheap imaging and treatment machines for challenging environments.
Specific Health & Safety issues	None for the moment.

CERN budget for 2018	**Personnel (FTE)**	**Personnel (kCHF)**	**Materials (kCHF)**	**Total (kCHF)**	**Comments**
	16.9	2,790	1,080	**3,870**	

36. Other R&D

36a. EU supported computing R&D

Activities	On-going projects: OpenAIRE2020, OpenAIRE2020 Connect, ICE-DIP, Indigo-DataClouds, EGI-Engage, EUDAT2020, AARC, AARC2 (starts 1 May 2017), HNSciCloud. DEEP-EST (starts 1 July 2017), UP2U
Goals	Ensure the distributed computing infrastructure deployed by the LCG project can continue to support the increasing data quantities and processing needs of the Laboratory's physics programme. Expand CERN's influence in a range of scientific disciplines through distributed computing, exascale data management and open access digital repositories. Explore means for introducing commercial cloud services to support the Organizations scientific programme.
Risks	Future direction and scope of European Open Science Cloud is unclear and it may a have reduced relevance for CERN activities. CERN may have insufficient funds to fully exploit the results of the HNSciCloud project.
2018 targets	Via HNSciCloud, bring the commercial cloud services providers through to pilot phase deployment. Participate as a partner in EINFRA-12-2017 proposal with EGI, EUDAT and Indigo-DataClouds
Future prospects & longer term	Interaction with the DG RTD and DG CNECT will hopefully lead to funding opportunities being included in their 2018-2020 work programme.

CERN budget for 2018	**Personnel (FTE)**	**Personnel (kCHF)**	**Materials (kCHF)**	**Total (kCHF)**	**Comments**
	2.2	310	3,880	**4,190**	

36b. Support to FAIR, ITER, ESS (with corresponding revenues)

Activities	CERN's support to other organisations such as FAIR, ITER, ESS, etc., for which some partial external funding exists are grouped under this heading. Personnel detached to and working on this external support compromises the available workforce for CERN's core activities.

CERN budget for 2018	**Personnel (FTE)**	**Personnel (kCHF)**	**Materials (kCHF)**	**Total (kCHF)**	**Comments**
	11.0	1,965	360	**2,325**	

2. LIST OF ACRONYMS

	Acronym	Meaning	Complementary information
A	AARC	Authentication and Authorisation for Research and Collaboration	
	ACT	ALICE Configuration Tool	
	AD	Antiproton Decelerator	Decelerator in use since 2000, decelerating the antiproton beam from the Momentum of 3.57 GeV/c to 100 MeV/c.
	AEgIS	Antihydrogen Experiment: Gravity, Interferometry, Spectroscopy	
	AF	Architects Forum	Coordination of common application – part of the LHC Grid organisation
	AIDA	Advanced European Infrastructures for Detectors at Accelerators	
	ALARA	As Low As Reasonably Achievable	Concept or philosophy that assumes that there is no “safe” dose of radiation. Under this assumption, the probability for harmful biological effects increases with increased radiation dose, no matter how small. Therefore, it is important to keep radiation doses to affected populations (for example, radiation workers, minors, visitors, students, members of the general public, etc.) as low as is reasonably achievable.
	ALICE	A Large Ion Collider Experiment	Experiment at the LHC
	ALPHA	Antihydrogen Laser Physics Apparatus	
	ARIES	Accelerator Research and Innovation for European Science and Society	
	ATF	Accelerator Test Facility	
	ATLAS	A Toroidal LHC ApparatuS	Experiment at the LHC
	ATS	Accelerator and Technology sector	
	AWAKE	Advanced WAKefield Experiment	The AWAKE project has been proposed as an approach to accelerate an electron beam to the TeV energy regime in a single plasma section.

	Acronym	Meaning	Complementary information
B	$\beta *$	Beam size at the interaction point	
	BDF	Beam Dump Facility	
	BE	Beams department	
	BE-RF	BE Radio-Frequency group	
	BIC	Business Incubation Centres	
	BINP	Budker Institute of Nuclear Physics	
	BLM	Beam Loss Monitor	
	BPM	Beam Position Monitor	
	BRIL	CMS Beam Radiation Instrumentation and Luminosity	
C	CAD	Computer-Aided Design	
	CAE	Computer-Aided Engineering	
	CALICE	CAlorimeter for LInear Collider Experiment	Collaboration to develop new, high performance detectors for high-energy positron-electron experiments at future International Linear Collider
	CAST	CERN Axion Solar Telescope	A solar axion search using a decommissioned LHC test magnet.
	CB	Collaboration Board	
	CBD	Cumulative Budget Deficit	
	CDR	Conceptual Design Report	
	CERN	Conseil Européen pour la Recherche Nucléaire	European Organization for Particle physics.
	CEPS	CERN Environmental Protection Steering	
	CESSAMag	CERN-EC Support for SESAME Magnets	
	CLIC	Compact Linear Collider	
	CLICdp	CLIC Detector and Physics study	
	CLIQ	Coupling-Loss Induced Quench System for Protecting Superconducting Magnets	

	Acronym	**Meaning**	**Complementary information**
	CLOUD	PS 215 experiment or CLOUD (Cosmics Leaving Outdoor Droplets)	A study of the link between cosmic rays and clouds with a cloud chamber at the CERN PS.
	CMASC	CERN Medical Applications Steering Committee	
	CMOS	Complementary Metal-Oxide Semiconductor	
	CMS	Compact Muon Solenoid	Experiment at the LHC.
	COMPASS	Common Muon and Proton Apparatus for Structure and Spectroscopy (NA58 experiment)	High-energy physics experiment at the Super Proton Synchrotron (SPS).
	CP	Charge and Parity	
	CPU	Central Processing Unit	
	C-RRB	(LHC) Computing Resources Review Board	
	C-RSG	Computing Resources Scrutiny Group	
	CtC	Cost-to-Completion	
	CTF3	CLIC Test Facility	
	CTP	Central Trigger Processor	
	CVI	Cost Variation Index	
D	DAQ	Data Acquisition System	
	DCS	Detector Control System	
	DG	Director-General	
	DG CNECT	Directorate-General for Communications Networks, Content and Technology (EU)	
	DG RTD	Directorate-General for Research and Innovation (EU)	
	DOE	Department of Energy (USA)	
	DUNE	Deep Underground Neutrino Experiment	
E	EA	East Area	
	EC	European Commission	

Acronym	Meaning	Complementary information
ECAL	Electromagnetic CALorimeter	Calorimeter part of CMS.
ECO	Education and Communication Group	
ECS	Experiment Control System	
EDM	Electric Dipole Moment	
EGI-ENGAGE	Engaging the Research Community towards an Open Science Commons	
EHN1		The Experimental Hall located on the Prevessin site, the largest surface hall at CERN
EIB	European Investment Bank	
EIROForum	European International Research Organisations Forum	
ELENA	Extra Low Energy Antiprotons	ELENA is a compact ring for cooling and further deceleration of 5.3 MeV antiprotons delivered by the CERN Antiproton Decelerator (AD).
EN	Engineering department	
EN-MME	EN Mechanical & Materials Engineering group	
EP	Experimental Physics Department	
EP-DT	EP Detector Technologies group	
EP-ESE	EP Electronic Systems to Experiments group	
EP-SFT	EP SoFTware Development for Experiments group	
ERP	Enterprise Resource Planning	
ESPP	European Strategy for Particle Physics	
ESS	European Spallation Source	Project to realize a research centre in Lund (Sweden) for the study of materials using beams of slow neutrons.
EU	European Union	EU is used in this document as short form for EU commission supported project.
EUDAT2020	EUropean DATa	Horizon 2020 project EUDAT: the collaborative Pan-European infrastructure providing research data services, training and consultancy for researches, research communities and research infrastructures and data centers

	Acronym	**Meaning**	**Complementary information**
	EVM	Earned Value Management	providing research data services, training and consultancy for researches, research communities and research infrastructures and data centers
	EYETS	Extended Year-End Technical Stop	Technical stop end of 2016-april 2017
F	FAP	Finance and Administrative Processes Department	
	fb-1	Inverse Femtobarn	A measure of the integrated luminosity.
	FCC	Future Circular Collider	
	FELs	Free Electron Lasers	
	FIPOI	Fondation des Immeubles Pour les Organisations Internationales	Non-profit organisation in Geneva to help International Organisations with office space via financing solutions, renting and consulting.
	FNAL	Fermi National Accelerator Laboratory (Fermilab)	
	FP7	Framework Program 7	
	FSU	Field Support Unit	
	FTA	Active Full Time Equivalent	This includes everybody who is not unavailable due to leave entitlements built up in the past.
	FTE	Full Time Equivalent	
	FUSUMATECH	FUture SUperconducting MAgnet TECHnology	
G	GBAR	Gravitational Behavior of Antihydrogen at Rest	Research program with the Antiproton Decelerator (AD) allowing to prepare a measurement of the effect of gravity on antihydrogen atoms.
	GDB	Grid Deployment Board	Dedicated board for the Worldwide LHC Computing Grid.
	GDPR	General Data Protection Regulation	
	GEM	Gas Electron Multiplier	
	GeV	Giga electron Volt	
	GIF	Gamma Irradiation Facility	
	GLIMOS	Group Leader In Matters Of Safety	
H	HE	Endcap, one of CMS Hadron Calorimeter subdetectors	
	HELIOS	HELIcal Orbit Spectrometer	New experiment at HIE-ISOLDE

Acronym	Meaning	Complementary information
HEP	High-Energy Physics	ICHEP (International Conference on HEP), EPS-HEP (Europhysics conference on HEP),IHEP (Institute for High-Energy Physics).
HE-LHC	Higher-Energy LHC	Higher-energy proton collider.
HF	Forward, one of CMS Hadron Calorimeter subdetectors	
HFM	High Field Magnets	
HIE-ISOLDE	High Intensity and Energy ISOLDE	
HiPIMS	High Power Impulse Magnetron Sputtering	
HL-LHC	High Luminosity LHC	
HLT	High Level Trigger	High-Level Trigger combines and processes the full information from all major detectors of ALICE in a large computer cluster.
HMPID	High Momentum Particle Identification Detector	Part of the ALICE detector.
HNSciCloud	Helix Nebula Science Cloud	
HR	Human Resources department	
HSE	Occupational Health and Safety and Environmental Protection Unit	
HTS	High Temperature Superconductor	
HUG	Hopitaux Universitaires de Genève	
HVAC	Heating Ventilation Airconditioning Cooling	
ICARUS	Imaging Cosmic And Rare Underground Signals	
ICE-DIP	Intel-CERN European Doctorate Industrial Program	European Industrial Doctorate scheme hosted by CERN and Intel Labs Europe
ICT	Information Communication Technology	
IEFC	Injectors and Experimental Facilities Committee	
ILC	International Linear Collider	
INTC	ISOLDE and Neutron Time-of-flight experiments Committee	

I

	Acronym	**Meaning**	**Complementary information**
	IP1, IP2, IP5, IP8	Collision points	IP1: at ATLAS, IP2: at ALICE, IP5: at CMS, IP8: at LHCb.
	IPSAS	International Public Sector Accounting Standards	
	IPT	Industry, Procurement & Knowledge Transfer	
	IR	Interaction Regions	
	IR	International Relations sector	
	ISGTW	International Science Grid This Week	
	ISC	International Strategy Committee	
	ISOLDE	On-Line Isotope Mass Separator	Facility dedicated to the production of a large variety of radioactive ion beams for many different experiments in the fields of nuclear and atomic physics, solid-state physics, materials science and life sciences. The facility is located at the PS Booster (PSB).
	IT	Information Technology department	
	ITER	International Thermonuclear Experimental Reactor	
	ITK	Inner Tracker	
	ITS	Inner Tracking System	
J	JLAB		Thomas Jefferson National Laboratory
	J-PARC	Japan Proton Accelerator Research Complex	
K	KPI	Key Performance Indicator	.
	KT	Knowledge Transfer	
L	LBNF	Long-Baseline Neutrino Facility	
	LC	Linear Collider	
	LCD	Linear Collider Detector	
	LCG	LHC Computing Grid	Global collaboration linking grid infrastructures and computer centres worldwide.

Acronym	Meaning	Complementary information
LEIR	Low Energy Ion Ring	LEIR turns low-intensity ion pulses injected from CERN’s LINAC3 into high-density bunches which are accelerated from 4.2 MeV/u to 72 MeV/u.
LEP	Large Electron Positron (LEP) collider	
LHC	Large Hadron Collider	http://public.web.cern.ch/public/en/LHC/LHC-en.html
LHCb	Large Hadron Collider beauty experiment	Experiment at the LHC.
LHCC	Large Hadron Collider Committee	
LHCf	Large Hadron Collider forward experiment	Verification of interaction model for very high energy cosmic ray at 1017 eV. The LHCf experiment uses forward particles created inside the LHC as a source to simulate cosmic rays in laboratory conditions.
LINAC2	LINear Accelerator 2	50 MeV linear accelerator for protons in use since September 1978.
LINAC3	LINear Accelerator 3	4.2 MeV/u Heavy Ion Linac in use since 1994.
LINAC4	LINear Accelerator 4	160 MeV linear accelerator that is built to replace LINAC2 as injector to the PS Booster (PSB).
LIU	LHC Injectors Upgrade project	
LPCC	LHC Physics Centre at CERN	
LS1	Long Shutdown 1	Shutdown of the accelerator complex in 2013-2014.
LS2	Long Shutdown 2	Shutdown of the accelerator complex in 2019-2020.
LS3	Long Shutdown 3	Shutdown of the accelerator complex in 2023-2025.

M

MAPF	Medical Applications Project Forum	
MAPP	MoEDAL Apparatus for Penetrating Particles	
MB	Management Board	
MCHF	Million Swiss franc	
MEDICIS	Medical isotopes collected from ISOLDE	Recuperation of the dumped CERN protons for the production of medical isotopes in the ISOLDE class A work sector.
MIND	Magnetised Iron Neutrino Detector	
MMT	Magnetic Monopole Trapper	

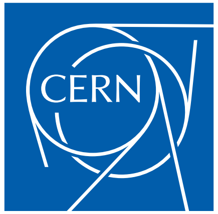
	Acronym	Meaning	Complementary information
	M&O	Maintenance and Operation	
	MoEDAL	Monopole and Exotics Detector At the LHC	Detector of the LHC that searches for the massive stable (or pseudo-stable) particles, such as magnetic monopoles or dyons, produced at the LHC.
	M&P	Materials and Personnel	
	MPGD	Micro-Pattern Gas Detectors	
	MQ	Main Quadrupole	
	MQXC	2 m long quadrupole of NbTi	
	MRI	Magnetic Resonance Imaging	
	MTP	Medium-Term Plan	
	MW	MegaWatt	
N	NA	North Area	
	NA58	North Area 58 experiment or COMPASS	Common Muon and Proton Apparatus for Structure and Spectroscopy.
	NA61	North Area 61 experiment or SHINE	Study of Hadron Production in Hadron-Nucleus and Nucleus-Nucleus Collisions at the CERN SPS.
	NA62	North Area 62 experiment	Experiment to measure the very rare kaon decay K+-> π+ nu nubar.
	NA63		Continued investigation of scattering of high energy particles in crystalline structures
	Nb_3Sn	Niobium-Tin	
	NDT	Nuclear Track Detector system (MoEDAL)	
	NMR	Nuclear Magnetic Resonance	
	NTD	Nuclear Track Detectors	
	n_TOF	neutron Time-Of-Flight facility	n_TOF is a pulsed neutron source coupled to a 200 m flight path designed to study neutron-nucleus interactions for neutron kinetic energies ranging from a few meV to several GeV.
O	OB	Overview Board	Dedicated board for LHC computing.
	openAIRE2020	Open Access Infrastructure Research Information	Horizon 2020 project

	Acronym	Meaning	Complementary information
	OSQAR	Optical Search of QED vacuum magnetic birefringence, Axion and photon Regeneration	
P	pA collisions	Proton-nucleus collisions	Collisions between one parton from the proton and the color fields of the nucleus.
	PBC	Physics Beyond Colliders	
	Pb^{82}	Lead ion	
	PCB	Printed Circuit Board	
	PHOS	PHOton Spectrometer	Part of the ALICE detector.
	PIMMS-2	Proton Ions Medical Machine Study	
	P+M	Personnel and Materials	An expression to describe total expenses, i.e. combined expenses in personnel and materials costs.
	pp	proton-proton	
	PPE	Property, Plant and Equipment	
	PS	Proton Synchrotron	
	PSB	Proton Synchrotron Booster	
Q	QA	Quality Assurance	
	QCD	Quantum ChromoDynamics	
	QGP	Quark–Gluon Plasma	
	QUACO	QUAdrupole Corrector	
R	R2E	Radiation to Electronics	The goal of the R2E Project is to study and propose mitigation actions (e.g. relocation or redesign of equipment, shielding, etc.) with the aim of increasing the mean time between failures of the LHC machine to one week for failures of controls electronics caused by radiation at ultimate beam conditions.
	RCS	Research and Computing sector	
	R&D	Research and Development	
	RF	Radio Frequency	
	RICH	Ring Imaging CHerenkov detector	

	Acronym	Meaning	Complementary information
	RP	Radiation Protection	
	RRB	Resources Review Board	
S	SC	Super Conducting	
	SCM	Super Conducting Magnet R&D	
	SCOAP3	Sponsoring Consortium for Open Access Publishing in Particle Physics	
	SEU	Single Event Upset	
	SHINE	North Area 61 experiment or SHINE	Study of Hadron Production in Hadron-Nucleus and Nucleus-Nucleus Collisions at the CERN SPS.
	SMB	Site Management and Buildings	
	SPC	Scientific Policy Committee	
	SPS	Super Proton Synchrotron	
	SPSC	Super Proton Synchrotron Committee	
	SQUID	Superconducting Quantum Interference Device	
	SRF	Superconducting Radio Frequency	
	STEM	Science, Technology, Engineering, and Mathematics	
	STFC	Science & Technology Facilities Council	
	SURF	Sanford Underground Research Facility	Underground laboratory near Lead, South Dakota, which houses multiple physics experiments in areas such as dark matter and neutrino research
T	T2K		Neutrino experiment in Japan designed to investigate how neutrinos change from one flavour to another as they travel. http://t2k-experiment.org/
	TDIS	Target Dump for Injection Segmented	
	TDR	Technical Design Report	
	TE	TEchnology department	
	TE-CRG	Cryogenics Group	

	Acronym	Meaning	Complementary information
	TE-VSC	Vacuum, Surfaces and Coatings Group	
	TeV	Tera electron Volt	
	TH	Theoretical Physics (Department)	
	TIDVG	Target Internal Dump Vertical Graphite	
	Tier-0	First layer of the computing grid	The first layer is the CERN Computing Centre
	Tier-1	Second layer of the computing grid	These are large computer centres with sufficient storage capacity and with round-the-clock support for the Grid. There are currently 11 of these centres.
	Tier-2	Third layer of the computing grid	The Tier 2s are typically universities and other scientific institutes, which can store sufficient data and provide adequate computing power for specific analysis tasks. There are currently 129 Tier 2 centres globally.
	TOF	Time of Flight	
	TOTEM	TOTal cross section, Elastic scattering and diffraction dissociation Measurement at the LHC	Experiment at the LHC.
	TPC	Time Projection Chamber	
	TSR	Test Storage Ring	
	TTC	Timing, Trigger and Control	
U	UNESCO	United Nations Educational Scientific and Cultural Organization	
	US	Unites States	
V	VELO	VErtex LOcator detector	Part of the LHCb detector.
	VFAT	Very Forward ATLAS–TOTEM	
	VIP	Very Important Person	
	V^{3}Si	Vanadium-Silicon	
W	WAGASCI	WAter-Grid-SClintilator-Detector	
	WLCG	Worldwide LHC Computing Grid	

	Acronym	Meaning	Complementary information
X	xTCA		Flexible and scalable infrastructure for designing complex control and data acquisition systems
Y	YETS	Year-End Technical Stop	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