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ORGANISATION EUROPÉENNE POUR LA RECHERCHE NUCLÉAIRE
CERN EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

Action to be taken		*Voting procedure*
For information	**SCIENTIFIC POLICY COMMITTEE** 260th Meeting **15-16 June 2009**	—
For recommendation	**FINANCE COMMITTEE** 325th Meeting **17 June 2009**	Simple majority of Member States represented and voting and at least 51% of the contributions of all Member States
For approval	**COUNCIL** 151st Session **19 June 2009**	Simple majority of Member States represented and voting

Annual Progress Report

of the Organization

for the fifty-fourth financial year

2008

GENEVA, February 2009

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Action to be taken		*Voting procedure*
For information	**SCIENTIFIC POLICY COMMITTEE** 258th Meeting **16 and 17 March 2009**	—
For information	**FINANCE COMMITTEE** 324th Meeting **18 March 2009**	—
For information	**COUNCIL** 150th Session **19 March 2009**	—

Annual Progress Report

of the Organization

for the fifty-fourth financial year

2008

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I. Executive Summary

In approving the new CERN governance principles, Council introduced the practice of the Annual Progress Report, which is to be presented in March each year and replaces the budget out-turn document. The purpose of the document is to compare the achievements by activity with the objectives agreed by Council and also to compare expenses by objective and activity with resources planning.

This initial Annual Progress Report is a first attempt to implement this component of the new reporting cycle. Given that the 2008 Budget was approved prior to the introduction of the new governance principles, the objectives for 2008 were not directly approved by Council. This year must thus be regarded as a transition period. This Annual Progress Report is therefore based on the highlights of 2008 and not on a comparison of the approved objectives with the achievements, as will be the case for future reports.

The main achievements and progress can be summarised as follows:

- The year 2008 marked the end of construction for the LHC machine, the initial particle detectors and the computing.
- The commissioning with beam on 10 September was a major success with circulating beams in both rings within hours. Media coverage was unprecedented.
- However, the incident in the machine in sector 3-4 only 9 days later prevented the start of normal operation and obliged CERN to concentrate all its resources on the repair as well as on improvement of the LHC's operating reliability. This event is the origin of the major deviation from the key 2008 objective of having colliding beams in the LHC detectors and the start of data-taking.
- The long shut-down for the LHC is forced by the sector 3-4 repair and the upgrade of the LHC protection system. The LHC collaborations are completing their detectors and using cosmic rays for commissioning.
- New initiatives started: notably, the civil engineering for LINAC 4 as well as the enhanced CLIC study, the PS2 and SPL R&D studies and the new LHC inner triplet magnet project. However, due to the necessary focus on the LHC, the progress was less than planned.
- Civil engineering work also started for the extension of building 40 (building 42).

The first part of this document summarises the achievements in respect of the LHC and other experiments before reporting on the accelerator complex and the non-scientific activities. The second part contains the final budget out-turn broken down by activity compared with the probable income and expenditure for 2008 as reported in the final 2009 Budget and compared to the approved final 2008 Budget.

II. Progress Report

1. LHC Programme

1.1. LHC Machine

End of construction and installation

The final machine components were assembled at the beginning of 2008, including in particular the accelerator “room temperature components”. The LHC is primarily a superconducting machine operating at a cryogenic temperature of 1.9 K (-271°C), but 12% of its magnets (153 magnets) operate at room temperature. These “resistive” magnets are situated in the straight sections of the accelerator located on either side of the experiments and in the insertion regions (where the beams are injected and extracted). 48 of these room-temperature magnets were built in Vancouver (Canada), 40 in Protvino (Russia), and 65 others in Novosibirsk (Russia).

The collimators (88 have been installed) are crucial for the protection of the superconducting magnets by intercepting (“cleaning”) the protons which are in the beam “halo”, thereby avoiding that these particles are lost in a superconducting magnet and possibly inducing a magnet quench. The collimators consist of 1 metre-long fiber-reinforced graphite jaws which are moved towards the beam so as to create a locally-reduced aperture. The two jaws can be moved close enough so as to leave an orifice of 2 to 3 mm for the beam path (compared to 58 mm when wide open). Many tests were done in 2008 to ensure correct functioning of the collimators. Each collimator is equipped with 10 position sensors which measure jaw positions down to one micron. The tests have shown that the requested jaw positions were achieved with a precision and stability better than 30 microns. On 10 September, the day of first LHC beam, the collimators were used to stop the beam before the experiments while the first turn was established. Installation of an additional 20 collimators started in December to complete the installation needed for physics data-taking in 2009 and 2010.

All LHC vacuum systems were completed and commissioned by end of August 2008. The first part included the insulation vacuum of the arc and standalone magnets (~24 km) and the insulation vacuum of the cryogenic transfer lines (QRL, ~27 km) as well as the arcs and standalone beam vacuum (~48 km), operated at a cryogenic temperature, were operational to their nominal conditions and commissioned on time for the start of the LHC cool-down. In parallel with the cool-down of the arcs, the long straight sections housing the radiofrequency cavities, the beam instrumentation and the collimation devices were completed, e.g. baked out and with the non-evaporable getter (NEG) coatings activated at the end of May 2008. The final pressures fulfilled the design specifications (<10-12 mbar or 10^{-10} Pa).

On 16 June 2008, the LHC beam vacuum was completed with the installation of the last beam pipe of the ATLAS experiment. These experiment vacuum systems combine the best of the vacuum technology with NEG coatings, very thin (0.2 mm in thickness) bake-out heating systems and an *in situ* ultra pure neon injection to allow for the safe interventions around the beryllium beam pipes (neon venting does not saturate the NEG coatings). Beryllium has been used for its excellent transparency for the particles escaping from the beam collision point towards the detectors.

Once cooled, each of the eight sectors which constitute the LHC ring was commissioned without beam. Each sector has 154 dipole magnets to steer the protons around the curve of the accelerator, 40 quadrupole magnets to focus the beam as well as tens of smaller correcting magnets. The currents in the coils of these superconducting magnets are driven by power converters (1700 for the whole machine), whose ratings range from 60 to 13000 A in 200 circuits. The hardware commissioning goal was to test the dipole magnet circuits up to 9310 amperes, which correspond to a beam energy of 5.5 TeV. A further goal was to have all the necessary components (cryogenics, quench protection , power, etc) function together as a system and to test all procedures and security systems. The hardware commissioning teams worked in two shifts of 8 hours. About a hundred people were involved, engineers assisted by specialists in each field (cryogenics, electrical engineering, instrumentation, etc). These multi-disciplinary and multi-cultural teams worked to a precise programme ensuring reproducibility of the procedures for each of the 200 circuits and the eight sectors. Data-processing tools were developed in parallel and during the tests in order to automate and improve the turn-around. As a result the last sector was commissioned in only 4 weeks in comparison with the 13 weeks necessary for the first sector. In the same manner, the recovery period after stops of the cryogenics system was substantially reduced from three days to one day and subsequently to only a few hours.

First phase of the commissioning

Exploitation tests without beam were carried out during 2008 to ensure that all the machine components function together as a system, and to identify any integration problems. These tests were crucial for debugging the system and for preparation of the machine for first beams. Then, four tests with beam were performed in August and early September just before LHC commissioning.

On 10 September 2008, a first beam was injected clockwise in the LHC at 9:35a.m. and at 10:26 a.m. after several launches of beam circulating each time longer into the ring, one beam did a complete loop of the LHC. The path was corrected in real time at each new trial on a new ring section.

The LHC beam instrumentation systems all worked extremely well during the LHC beam commissioning phase. The BTV system, imaging the beam using the light generated as it hits a screen, allowed the rapid set-up of the injection systems. The LHC beam position system, consisting of 1054 beam position monitors (BPMs) with 2156 acquisition channels, was successfully used to thread the beam around the machine, allowing circulating beam to be achieved in a matter of hours. During the entire commissioning phase the beam loss monitoring system, with its 4000 detectors, continually monitored any particle losses and was used to reconstruct several beam-induced magnet quenches. Many other dedicated beam instrumentation systems were also quickly made available and contributed to this very successful initial LHC commissioning phase.

Achievements:

- Finalised construction, successful cool-down and hardware commissioning.
- First beam within a few hours, followed by RF capturing after only a few days.

Incident, start of repairs and consolidation

Before first beam, seven out of eight sectors were fully commissioned for 5 TeV operation. The last sector, sector 3-4, remained to be commissioned for this energy. On 19 September 2008, the commissioning team took advantage of a stop of the beam (imposed by a faulty electrical transformer) to complete the final testing of sector 3-4 in preparation for higher energy beam operation. During this last test when the current in the dipole magnets was increased from 7000 to 9000 A, a serious incident occurred. The incident was caused by a small resistance and showed that the function tests could not have measured such low resistances. A task force was immediately set up. All the safety systems and procedures, including the essential intervention of the CERN Fire Brigade, were immediately activated and functioned effectively.

Progress

- The task force started work, allowing the incident to be fully understood in early 2009.
- Actions were launched to
    - Repair the sector 3-4.
    - Consolidate the LHC to avoid future incidents, mainly with the addition of an enhanced quench protection system and helium relief valves to avoid collateral damage.
    - Re-establish the spare part inventory.

1.2. LHC Physics

1.2.1 ATLAS

The initial construction project phase is now completed and the ATLAS detector is being prepared for data-taking in 2009. The initial detector construction ended with the installation of the last muon chamber in July 2008. The evaporative cooling plant for the Inner Detector silicon systems suffered a major failure of its compressors at the beginning of May 2008, and the repair and cleaning of the plant substantially dictated the critical path for the closure of the detector. Operation of the full magnet system was another major focus in 2008. The testing of the magnet system culminated in 2008 with a complete system test campaign of all magnets in August 2008, after some training quenches in the end-cap toroid coils. Since then the toroid system was operated routinely at the nominal 20.4 kA.

A highlight of 2008 was the successful recording and reconstruction of the first beam-related events on 10 September during the LHC start-up day. These first LHC beam-splash events, as well as the few beam-halo background events from the first stored single LHC beam runs, were used very efficiently for initial timing adjustments. After the LHC incident on 19 September 2008, the full detector was essentially continuously operated in cosmic-ray data collection mode. Two hundred million cosmic-ray triggers were collected with the full detector, with about 100k muons also passing through the smallest-volume detector, the Pixels. These events are very valuable for improving monitoring and data quality procedures, as well as for initial global alignments and calibrations.

The Collaboration-wide distributed computing infrastructure is fully embedded into the framework of the World-wide LHC Computing Grid (WLCG). In recent years, ATLAS and WLCG have successfully performed large data transfer exercises from the Tier-0 to all Tier-1s and Tier-2s. During the first half of 2008 the most significant such exercises were the Common Computing Readiness Challenge (CCRC) phase-2 run at the end of May 2008 together with the other LHC experiments, and the second phase of the ATLAS-internal Full Dress Rehearsal with large simulated data samples which ‘stress-tested’ the full data flow, various calibration and data quality steps, and distributed analysis using the whole Tier-1, Tier-2 and Tier-3 structures. The whole computing and software chain has been operational since the continuous cosmic-ray data-taking which started in summer 2008, and it demonstrated its efficiency during the first LHC beam-induced data taken during the LHC start-up on 10-11 September 2008.

Major achievements in 2008:

- Initial ATLAS detector construction completed.
- Extensive cosmic-ray runs used for alignment, calibration, and the testing of the online and offline chain.
- First beams used for timing and data acquisition system tests.

1.2.2 CMS

The main volume of the CMS detector is a cylinder, 21 m long and 16 m in diameter, weighing in total 12 500 tonnes. It is built around a large superconducting magnet, 13 m long and 6 m in diameter, which will be used to determine the momentum of charged particles from the curved tracks they follow in the magnetic field. In a unique strategy, the CMS detector was assembled above ground, at the same time as the excavation of the underground cavern.

The year 2008 saw the completion of the initial CMS detector, detection of first circulating beams on 10 September, and a month-long run to record cosmic-ray muons beginning in mid-October. The year began with the lowering of the last two of the eleven massive iron disks and wheels, a major milestone in the CMS assembly sequence. Final closure and checkout of the detector, beampipe, and trigger and data acquisition electronics proceeded throughout the summer, including the Semiconductor Tracker, Pixel Detector and the endcap electromagnetic calorimeter, which measures the energy of electrons and photons. In early September, after almost 20 years of design and construction, CMS started taking data with LHC beams. CMS took quality data and reacted quickly to changing beam conditions, providing pictures of beam-caused ‘events’ in real time.

In October, with the solenoidal magnet at full operating field (3.8 Tesla), CMS recorded the passage of cosmic-ray muons through the detector around the clock for a full month. Some 300 million muons were recorded, filling 400,000 Gigabytes of storage. These data have been used to exercise numerous aspects of the full CMS discovery analysis chain, including data transfers, reconstruction of events using millions of lines of computer codes, calibration and alignment of detector elements, and high-level analysis of the muons' trajectories and momenta.

The large amount of data expected to come from the detectors is a significant challenge for the LHC experiments. In 2008 the World-wide LHC Computing Grid (WLCG) was officially inaugurated, with CMS joining the other experiments in tests which demonstrated the Grid's readiness for LHC data. Throughout the year, CMS continuously used the Grid computers to simulate massive LHC data sets in order to prepare the computer programs used for analysis, and to rehearse all aspects of analyzing real data.

Major achievements in 2008:

- Initial CMS detector construction completed.
- Extensive cosmic-ray runs used for alignment, calibration, and the testing of the online and offline chain.
- First beams used for timing and data acquisition system tests.

1.2.3 ALICE

The construction and assembly of the Alice experiment continued during 2008 for the Transition Radiation Detector (TRD), which was fully approved and funded only in 2006, and for the Photon Spectrometer (PHOS), where currently sufficient $PbWO4$ crystals have been produced for 3 out of the 5 modules. The Electromagnetic Calorimeter (EMCal) construction started by mid-2008; the first two EMCal modules (out of 11) will be ready for installation in early 2009.

Detector integration and commissioning was a main activity, with two shorter cosmic runs of several weeks at the end of 2007 and in early 2008. Since May and until mid-October 2008 ALICE has been operated continuously (24/7) for about 6 months, taking cosmic and calibration triggers for global system commissioning, alignment and calibration. Parts of the silicon detectors were aligned with cosmics to about 10 micron precision and the Time Projection Chamber (TPC) gain and drift velocity calibration approached their target values. At that time up to 14 different detector systems were read out in parallel, with some runs lasting up to several hours. As far as could be verified with cosmic rays, the performance of all subsystems is very close to (or better than) specification.

In August the “first physics” configuration, consisting of Silicon Pixel Detector (SPD), Silicon Strip Detector (SSD), TPC, V0, the Forward Multiplicity Detector (FMD) and the Zero Degree Calorimeter (ZDC), was tested extensively using bunch crossing and simulated BPTX (beam pick-up) triggers. During LHC commissioning in September, only a subset of detectors was switched on because of the occasionally very high particle flux during beam tuning. Nevertheless, timing of most trigger detectors was verified and adjusted with beam. SPD, V0 and FMD were used to monitor the radiation produced in the various beam dumps and by the beam halo.

All online systems were in continuous use (24x7) as from March 2008. In 2008, they provided to the 16 detectors installed the equivalent of 309 days of data-taking in stand-alone mode (individual detectors) and the equivalent of 144 days of global data-taking (several detectors in common). This has resulted in 1.7 PBytes of data collected out of which 260 TBytes have been recorded. The full High Level Trigger (HLT) data path was tested and in use, providing online reconstruction, event visualization, and data compression.

Major achievements and progress in 2008:

- Construction and installation proceeded according to schedule.
- Extensive cosmic-ray runs used for alignment, calibration, and the testing of the online and offline chain.
- First beams used for timing and data acquisition system tests.

1.2.4 LHCb

The plans of the LHCb Collaboration for 2008 were to get the detector ready for data-taking, prepare various physics analyses and take physics data.

The detector was successfully commissioned using cosmic rays. The muon and calorimeter triggers were used to record tracks and to perform initial alignment in time and space. The vertex detector VELO, Tracking detectors Trigger Tracker (TT), Inner Tracker (IT) and Outer Tracker (OT), Muon System and Calorimeters were time-aligned to a few nanoseconds, and the Ring Imaging Cherenkov (RICH) detectors to about 15 nanoseconds.

On 22 August, during the final LHC synchronization test, the proton beam in the Super Proton Synchrotron (SPS) accelerator was stopped on the beam dump TED before it was injected into the transfer line to the LHC. Particle tracks from the proton interaction in TED were then immediately seen in the vertex detector VELO triggered by the Calorimeters. First events were also then seen later that day by the other LHCb sub-detectors.

During the first beam injections on 10 September 2008, the experiment's sensitive tracking detectors were not switched on, but the muon detectors, the calorimeters and the RICH detectors all recorded the particles produced by the beam. The tracking system was activated later during the day, recording the tracks from the LHC proton beam interactions. The LHCb detectors, trigger system, and data-acquisition system again worked perfectly.

Major achievements in 2008:

- Initial LHCb detector construction completed.
- Extensive cosmic-ray runs used for alignment, calibration and the testing of the online and offline chain.
- First beams used for timing and data acquisition system tests.

1.2.5 TOTEM

During 2008, the T1 Telescope, T2 Telescope and Roman Pot detector were tested with the final electronics and for each sub-detector a production line with final tests was established. The aim is to install the complete TOTEM experiment before summer 2009 with one exception: the Roman Pots at the high-radiation stations (147 m from the interaction point) will only be partly equipped in order to gain preliminary experience with the radiation and to avoid damage to the silicon detectors in the event of unexpectedly high radiation levels. In August 2008, the first quarter of the T1 Telescope was then installed in the CMS detector volume in view of obtaining first results from LHC collisions. All TOTEM Roman Pot stations have been mounted and integrated into the beam pipes of the outgoing beams on both sides of IP5.

The prototypes of the on-detector read-out cards were fully tested during 2008. The development of the required preliminary versions of firmware and software took much longer than expected which delayed the mass production, which was completed at the end of 2008. Some printed-circuit boards (e.g. the repeater and optocoupler card), which will be needed at a later stage for joint runs with CMS, are still being designed.

Production problems have been encountered with several read-out boards, such as a metallization problem on a significant fraction of hybrids, which required a new production launch.

Major achievement in 2008:

- All Roman Pot stations at 147 m. and at 220 m. from the interaction point have been installed in the LHC tunnel.

1.2.6 LHCf

LHCf is an approved LHC experiment without direct financial involvement from CERN. LHCf is an experiment dedicated to the measurement of neutral particles emitted in the very forward direction in LHC collisions.

LHCf makes use of two independent detectors, installed on either side of IP1 (ATLAS area), 140m away from the interaction point. Both detectors were installed in the LHC tunnel during January and February 2008. Control and data collection from the ATLAS counting room (USA15) via 200m signal cables and optical fibers were successfully performed. A dedicated control room for LHCf was operation in September 2008.

During this first beam circulation, the LHCf main calorimeters were at the garage position to avoid any accidental damage. However, the LHCf Front Counters (sub-detectors composed of thin plastic scintillators, located in front of the main calorimeters) were at the nominal position, allowing the monitoring of beam-related effects. On the morning of 12 September the Front Counters observed signals from beam-gas interaction events with an event rate compatible with what was expected from the beam intensity and the residual gas inside the LHC beam pipe. Timing calibration of all the LHCf electronics was completed by using these real particle events synchronized with the machine clock.

Major achievements in 2008:

- Final detectors ready for beam.
- First beams used for timing and data acquisition system tests.

1.3. LHC Computing

In 2008, the World-wide LHC Computing Grid (WLCG) successfully organised and ran the two phases of the Combined Computing Readiness Challenge (CCRC'08) in February and May, demonstrating that the computing Grid for LHC was capable of sustaining data transfers and workloads at the scale needed for the first years of LHC running. The WLCG Grid service is now in full production with workloads continuing to increase, supporting the experiments' simulations as well as analysis of real detector data from cosmic rays. All the data management workflows have been tested successfully with data replication from the experiment to the 11 Tier-1 centres via the CERN computer centre. The whole architecture was reviewed to prepare the long-term strategy for LHC data preservation and to ensure that current computing model will be flexible enough to cope with the highly demanding needs of the physics analysis of the LHC. With the change in schedule of the LHC, there is an ongoing reassessment of the experiments' requirements for 2009 and 2010. We must ensure that first data-taking is not limited by the available computing resources. Outstanding challenges are to ensure the reliability of the key Grid services and to fully test the analysis use cases.

The Tier-0 evolved by the removal of ~3000 machines and installation of 2500 new ones (more power efficient). To date, the CERN Computer Centre physics batch capacity includes ~1500 machines, 3000 CPUs, 10000 cores, 5 Petabytes of disk and 35 Petabytes of tape storage.

Work has started to address the power and cooling limitation of the CERN Computer Centre by 2011 with a study of 4 possible outline designs of a new Computer Centre in Prévessin.

Underpinning the WLCG is the Enabling Grids for E-sciencE (EGEE) project. EGEE is co-funded by the European Commission, led by CERN’s IT Department, and manages the world’s largest multi-science Grid infrastructure, bringing together more than 140 institutions across the world. In 2008 EGEE began the transition to a new model for European Grid Infrastructures, working in close cooperation with the European Grid Initiative Design Study (EGI_DS). EGEE is outlining the blueprint for the future of research Grids in Europe. CERN is also a key partner in GridTalk, a communications project showcasing the achievements of Grid computing projects and publishing *International Science Grid this Week*, a weekly newsletter promoting gGid computing.

CERN IT has an active supporting role in a number of other Grid computing projects and is involved as lead liaison contact among the operations and development teams of these projects and EGEE. BalticGrid-II, D4Science (DIstributed colLaboratories Infrastructure On Grid ENabled Technology 4 Science), ETICS2 (e-Infrastructure for Testing, Integration and Configuration of Software Phase 2), Health-e-Child and SEE-GRID-SCI (SEE-GRID for e-Infrastructure for Regional e-Science) are part of these projects. In 2008, among other things, CERN contributed essential know-how to gLite deployment, operations and support and was involved in integration and testing activities of the gCube system.

Major achievements in 2008:

- WLCG in full service.
- Tests with cosmic-ray data-taking successfully completed.

2. Other Programmes

2.1. Theory

The members and visitors of the Theory Unit, who have written about 250 publications in 2008, have carried out research in several areas of theoretical physics.

Review of the Safety of LHC Collisions − Members of the Unit reviewed existing safety reports dealing with the possible consequences of the production of new particles or states of matter at the LHC. The work focused on strangelets and stable microscopic black holes. The results confirm that the outcomes of LHC collisions do not pose any risk, and the final documents were reviewed and endorsed by the CERN Scientific Policy Committee.

QCD at Colliders − The primary focus has been the development of new ideas and tools for higher-order calculations of processes at large momentum transfer, for the description of final states with event generators, and for the study of a few production processes expected to be of high relevance for the Standard Model and Beyond the Standard Model physics at LHC.

Flavour Physics − The activity has been focused on the decays of B mesons, the main target of the LHCb experiment. They represent a probe for testing the Standard Model and for looking for new physics that is complementary to the high-energy searches pursued by ATLAS and CMS.

Physics beyond the Standard Model − In supersymmetric theories special attention has been devoted to the possible role of higher-dimensional operators. In theories with sectors hidden to the Standard Model interactions it has been proposed that the Higgs boson could have direct access to the new sectors.

Physics of Heavy Ions at the LHC - To characterize jets in a high multiplicity environment, they have developed Monte Carlo tools which encode in-medium parton propagation in the generation of parton showers. The group continued to explore string theory techniques to understand generic features of strongly coupled non-Abelian plasmas. The energy loss of highly energetic test quarks, and the spectral function of mesons in the hot plasma has been studied in detail.

Lattice QCD − The non-perturbative regime of QCD is studied by using lattice QCD with the help of numerical simulations. Building on last year's observation that in two-flavour QCD chiral symmetry is spontaneously broken in the expected way, members of the group have proposed new observables to probe the chiral regime of the theory. First numerical studies showed that spectral projectors allow for a very precise determination of the QCD chiral condensate, the parameter which drives the spontaneous breaking of the chiral symmetry. New techniques to reach even lighter quark masses in simulations of dynamical fermions have been also suggested.

Astrophysics and Cosmology − The research on astrophysics and cosmology addressed a variety of topics ranging from the exploration of gamma-ray bursts, the properties of the CMB anisotropies and the large scale structure of the Universe to the investigation of the most challenging cosmological puzzles such as dark matter and energy. Various high-energy particle physics models beyond the Standard Model, such as supersymmetry and physics of extra-dimensions as well as ideas for modifying gravity have been confronted with these puzzles.

String Theory − The group focused mainly on the theory in extreme situations of high curvature or strong coupling, and on the application of the insights achieved in particle physics phenomenology. Topological string theory techniques have provided new information about non-perturbative effects arising from world-sheet and space-time instantons. The physics of black holes turns out to be closely related to the phenomenology of strongly-coupled systems in gauge theories. Indeed, critical phenomena in gravitational collapse and black hole formation has been proposed to be due to gluon saturation phenomena in the Regge limit of QCD.

2.2. Non-LHC Physics

The production, study and use of exotic nuclei located far from stability are the focus of the On-Line Isotope Mass Separator (ISOLDE) facility, which over the last 40 years has garnered unique expertise in radioactive beams. Several hundred scientists from around the world make use of the broad range of isotopes available to study nuclear structure, nuclear astrophysics, atomic and solid state physics and applications to life sciences within more than 50 approved experiments.

During the 2008 campaign a new isotope of Radon, 229Rn, was discovered using the ISOLTRAP Penning trap system and simultaneously its atomic mass was measured with high precision. Collinear laser spectroscopy has been used to measure the charge radii of short-lived nuclei such as 11Be, furthering our understanding of neutron halos, which have been a long-standing subject of investigation at ISOLDE. Making use of 30Mg ions post accelerated by REX, collisions between a radioactive beam and a radioactive tritium target were studied to search for the elusive monopole excitation of 32Mg using both multi-element gamma-ray and charged particle detectors. Concerning the application of exotic nuclides to biophysics, new information about heavy metal toxicity in proteins was obtained by applying nuclear hyperfine spectroscopy using radioactive beams of mercury and lead.

The NA48/2 experiment at CERN studies the behaviour of 'kaons', a family of particles whose neutral members showed the first signs of a matter-antimatter symmetry violation effect back in 1964. In 2007, NA48/2 made precise measurements of one way that K+ and K- particles decay, and a by-product of this measurement is a very careful investigation in 2008 of the scattering of charged and neutral pion pairs that are produced in these decays. Two independent tests of Chiral perturbation theory have thus become possible, and have confirmed the validity of correspondingly refined calculations of the theory with a precision three times better than previous results.

In 2008, the DIRAC experiment has been improved to detect charged kaons in addition to pions, and has for the first time given indications of a bound state of a charged pion and a charged kaon, offering the possibility to study their scattering as well.

2.3. General Scientific Support

All communication services have run smoothly throughout the year, despite a major upgrade effort. In particular, the LHC experiment infrastructure installations are now complete and most of them are operated by the IT Department; the General Purpose Network infrastructure rejuvenation is close to completion (thousands of devices replaced); and the technical network core, used in particular for accelerator controls, will be completely upgraded by the end of April 2009. The Tier-0-to-Tier-1 connections have proved also to cope with the expected traffic. The emergency telephone infrastructure in the LHC was further secured, and the monitoring improved.

2.4. Accelerators and Areas (non-LHC)

ISOLDE

ISOLDE had a very good year without major incidents, and beam to the ISOLDE users was delivered with high availability and quality. The start-up and operation with the new cooler RFQ was extremely stable and successful. An ongoing issue was the intensity limitation imposed in 2007 due to air activation. In a joint effort by the AB/ATB and SC/RP groups, the intensity threshold was set appropriately for both front ends and no more radiation alarms were observed.

The operation of REX-ISOLDE (a charge breeder and linear accelerator, probing nuclear properties using transfer reactions and Coulomb excitation of exotic nuclear species) also went very well and without major problems. A major consolidation effort is continuing to bring the REX facility up to CERN standards, with large parts of the control system being rewritten.

PS Booster

The PS Booster had a very successful 2008 operation period without any major incidents. The alignment of the machine during the 2007/08 shutdown proved to be extremely beneficial for the machine performance. Highest priority was given to the delivery of the different flavours of LHC beams (pilot, probe, individual bunch physics beam, 25/50/75ns physics beams). The early LHC beams were delivered on request and within specifications for the LHC synchronization tests and commissioning. Besides the LHC beams, a wealth of physics beams were delivered with high availability and record intensities for the ISOLDE (4.25×10^{13} protons per pulse) and CERN Neutrino beam to Gran Sasso (CNGS) beams (3.8×10^{13} protons per pulse). On the machine development side, besides the production of beams for machine developments in Proton Synchrotron (PS) and SPS (e.g. PS multi-turn extraction, SPS impedance measurements), a variety of studies in the Booster was performed. One highlight was the first successful test of the single-batch transfer of LHC beams to the PS, an operation mode proposed for the Linac4 era.

PS

After another round of magnet renovation to run reliably for its clients, including the LHC, the nearly 50–year-old Proton Synchrotron was successfully restarted in 2008. All beams required for LHC commissioning were prepared at an early stage together with the beams for antiproton production, neutrinos to Grand Sasso and the slow extracted beam for the East Area experiments and tests. All these beams were produced and delivered successfully throughout the physics run.

On 10 September the PS crew noted with appreciation that the PS was operating efficiently, delivering beam for the LHC without missing a single shot. The beam characteristics were adjusted on demand to comply with the LHC's needs: low intensity, small transverse and longitudinal beams sizes.

In late October, one month before the winter shutdown period, the nTOF (neutron Time-of-Flight) facility, a PS client that had stopped using the PS beam in late 2004, was successfully re-commissioned . The beam with 7×10^{12} protons in a single 25 ns long bunch was sent down the transfer line to the newly designed nTOF target to produce neutrons of different energies. These neutrons were used by the experiments that quickly reproduced some of the previously obtained results.

On 12 November the PS was stopped for physics, but continued with tests on a new main power converter regulation that will be the first step towards a completely new power converter system. This new system should become operational in 2010 and will replace the motor-generator set currently used to power the PS main magnets.

On 1 December the machine was stopped for the winter shutdown during which the last round of main magnet renovations will take place. In April 2009 the PS will be ready again, with 50% of its main magnets renovated and a new main power converter regulation system, set to provide beam to its clients including the LHC.

SPS

As of 1 June 2008, the SPS delivered beam to the North area and CNGS. The CNGS run finished on the 11 November, having delivered 2.78×10^{19} protons on target. The North Area was stopped earlier than originally planned (6 October) in order to bring forward shutdown work so that the SPS can be ready with beam in May 2009 for the LHC re-start. In 2008 COMPASS, one of the heavy proton users, ran in a different mode which required less intensity than usual, leading to a moderate intensity of 2×10^{13} protons per cycle on the fixed target cycle throughout the run. With this intensity, transmissions of 97% could be obtained. The SPS also successfully delivered beam to the LHC during the injection tests and initial beam commissioning, at one point entering into interleaved mode, wherein alternate cycles of the SPS deliver beam to the clockwise and counter-clockwise rings of the LHC.

AD

The Antiproton Accelerator (AD) start-up period was cut very short due to the failure of an injection line dipole which occurred during the initial hardware tests. After rapid refurbishment of the spare unit followed by its installation in the target area, start-up with beam could resume and the physics programme started just one week later. Antiprotons were collected at 3.57 GeV/c and after deceleration to 100 MeV/c ejected in single batches to the experiments ATRAP and ALPHA, which were able to demonstrate trapping of antiprotons and formation of large numbers of antihydrogen atoms. Both experiments are now well on the way to trapping antihydrogen in their newly developed Penning-Joffe traps. ASACUSA which has a more varied programme with several sub-groups sharing the beam-time also had a successful run including the commissioning of several new apparatus. To keep conditions stable for all users, the ACE Collaboration, for which ejection takes place at 500 MeV/c, had exclusive use of the AD for 7 days of 24 hours for cell irradiation tests. At the end of the year, 3200 hours of physics had been clocked with a total uptime of 81% and an uptime of 93% for the AD machine.

Technical Infrastructure Operation

The Technical Infrastructure (TI) operation in 2008 was dominated by the integration of the remaining LHC systems such as safety, access control and ventilation. TI is now supervising a total of more than 50,000 parameters through the Technical Infrastructure Monitoring (TIM) control system which relays approximately 2 million data changes per day to control room operators and logging databases. TI recorded 54 “major events” in 2008 (compared to 41 in 2007 and 30 in 2006). The increase in the number of events can be explained by an increasing number of operational systems related to the LHC. Over 300 on-site interventions were made by the TI operators during the 2007-2008 shutdown period thanks to the secondment of the accelerator operators at the TI consoles during the shutdown period.

3. Non-scientific Programme

3.1. Infrastructure

The principal success of 2008 for the infrastructure and general services was the participation in the start-up of the LHC. This was the culmination of many years of effort in domains ranging from the central workshops, engineering and equipment data management, access control and safety systems, administrative information systems and civil engineering.

For the engineering computing this included the migration from EUCLID to CATIA, a Web version of the management system for electrical control follow-up (GESMAR), and an upgrade of the control system (SCADA).

The general facilities and logistics services completed the nursery school extension, the support to LHC events, the construction of the water treatment plant in Building 676, and the start of Building 42 construction (extension of Building 40).

Informatics covers desktop and computing infrastructure, administrative computing and scientific information services. The administrative computing prepared the EVM system for the new projects such as Focus Quadrupoles and LINAC 4. The OpenAccess initiatives launched in 2007 have progressed, with CERN playing a leading role in the movement which will permit a more equitable, cheaper and easy access to scientific information.

Despite an increasingly hostile environment, actions taken concerning the security of computing systems have managed to maintain the number of compromised machines at a constant and moderate level. Moreover, since its separation from the General Purpose Network, no machines on the Technical Network have been compromised.

3.2. Safety, Health and Environment

The main achievements in this area for 2008 are the advancement of the RAMSES project, (RAdiation Monitoring System for the Environment and Safety the LHC machine), the successful implementation of the safety policy by the services responsible (regular inspections for mechanical and electrical equipment and buildings), and three environmental projects:

- Radioactive water evaporating system in Building 378.
- Waste water pipe through the Prévessin site.
- New waste water treatment station (the construction started in 2008 and will be finished in April 2009).

3.3. Administrative Services

The year 2008 marked the introduction of the new CERN governance principles, with the focus on planning by activity-based objectives. A direct consequence is that the planning cycle is brought forward and allows for Council approval of the Medium-Term Plan and the Draft Budget for the following year in June. Therefore, CERN presented the Medium Term Plan in June 2008 in the new format. In this context, the administrative services successfully implemented a number of important changes:

- The IPSAS accounting rules were implemented for 2007 annual accounts.
- The resources planning and controlling processes were enhanced to adapt to the new CERN governance principles and planning cycle, allowing a coherent CERN-wide approach.
- The Financial Rules and Regulations were completely revised and the new Financial Rules and Implementing Regulations were approved by Council in December.
- Matters outstanding from the five-yearly review were finalized and the corresponding modifications were integrated into the Staff Rules and Regulations. This includes the regulation for shift and standby-duty working hours, vital to prepare the Organization for the start of LHC operation.
- Work progressed on the introduction of key performance indicators but only a first version for financial services was finalised. This was essentially due to the substantial work-load for the services involved, notably from the administrative computing services, as well as the mediocre quality of the results obtained from the external consultancy firm.

3.4. Education, Outreach and Technology Transfer

Major achievements in 2008 were the LHC public events such as the Open Day, the LHC First Beam, with unprecedented media-coverage, and LHC Inauguration. Important external contributions and sponsoring were realised for these events, such that the costs for CERN were reduced to about 50%.

In 2008, the CERN high school teacher programme organized 24 national courses with over 900 participants from 15 Member State countries, plus international courses with teachers from 10 additional countries. Lectures were mainly given by scientists from CERN or its Member States with the aims of increasing the enthusiasm of younger school students for modern science and the number of students choosing scientific branches. During the summer, the 3-week international ‘High School Teacher Programme’ took place, with 40 teachers from 20 different countries, including 5 Non-Member states.

The attractiveness of CERN’s student programmes is highlighted by the fact that the number of summer student candidates is increasingly significantly higher than the number of places. The number of Member States introducing national CERN student programmes further increased in 2008.

Technology Transfer activities increased with 24 contracts and partnerships now in place (with respect to 18 in 2007) and external revenues in 2008 of 2.4 MCHF with respect to 2 MCHF in 2007 (not counting income before 2007 reported in 2007 due to the IPSAS implementation).

4. Projects (construction, R&D)

4.1. CLIC

The purpose of the CLIC study is to assess the feasibility of an electron-positron collider with an energy of 3 TeV in the centre of mass. This collider, which could measure 48 km in length in its ultimate phase, will rely on a new two-beam acceleration principle: a train beam supplies energy to an accelerating structure resonating at high frequency (12 GHz) which accelerates the main beam with high electrical fields (100 MV/m). The CLIC Collaboration aims to present a feasibility study in 2010.

In 2008, the CLIC Collaboration was extended to 27 institutes in 15 countries. Its interest was confirmed during the workshop organized in October 2008 (CLIC08 Workshop): About 215 participants from 57 institutes in 18 countries took part in this workshop. During the year, the CLIC Project also formalized its collaboration with the ILC Project. The two collaborations put in place seven working groups to co-operate on topics with strong synergies between both projects, such as detectors, beam dynamics, positron production, small emittance beam generation and their focus on nanometer dimension, civil engineering, cost studies and schedules.

The CLIC Project technical development made significant progress in 2008.

The installation of the CTF3 test facility is complete, except for some specific experiment-dedicated equipment which will be completed in 2009 and 2010. CTF3 consists of a high-intensity and high-efficiency 150 MeV linear accelerator followed by two rings which multiply the intensity and the train beam frequency by beam manipulations: the delay loop and the recombination ring. The 30 A drive beam is then sent to the two-beam test stand where it circulates in parallel with the main beam generated by a photo-injector. The train beam is slowed down in a series of radio-frequency structures specially designed to generate RF power at high frequency (12 GHz) to speed up the main beam in electrical fields of 100 MV/m.

On 3 September, a beam circulated for the first time through the entire installation. A train beam was brought to the slowing-down structures generating radio-frequency power. In addition, the main beam was generated by a new installation, CALIFE, the result of a collaboration with the CEA laboratory of Saclay and of IN2P3 at LAL. Similarly, the teams tested the recombination ring and proved, as expected, a multiplication of intensity and frequency of the beam by a factor 2 in the delay loop and a factor 4 in the combiner ring.

Another technical step concerned the accelerating structures which should produce an accelerating field of 100 MV/m. A new accelerating structure, built and tested in 2008, achieved nominal acceleration gradient at nominal RF pulse length with a very low breakdown rate. This structure of 29 cm long is the result of a very successful international collaboration since it was tested at CERN, manufactured at Japan’s KEK Laboratory and tested at the SLAC Laboratory in the United States.

An extraction and power transfer structure, which will enable the extraction of the train beam energy to feed RF power to the accelerating structures, was manufactured in the CERN workshops and tested with preliminary and encouraging results at SLAC and in the CFT3 test zones specially installed by the Uppsala laboratory in Sweden and by Spanish contributions from CIEMAT.

Finally, the photo-injector system, which will generate a high-brightness main beam, was tested for the first time. The development of this system is the result of a collaboration supported by EU in the FP6 framework programme between CERN and France’s LAL laboratory, RAL in the UK and Frascati).

CLIC/ILC collaboration:
Following an ICFA recommendation in 2001, the most probable future facility to complement the LHC will be an electron-positron linear collider with a colliding beam energy which will strongly depend on the LHC physics results.

Two complementary studies are presently underway:

- The International Linear Collider (ILC) based on superconducting RF technology in the TeV energy range.
- The Compact Linear Collider (CLIC) based on a novel scheme of Two Beam Acceleration to extend Linear Colliders into the Multi-TeV colliding beam energy range.

Even if the technology of the major system of these facilities, namely the linac accelerating both kinds of particles, is different, a large part of the other systems have much in common. Therefore, the two studies decided at the end of 2007 to collaborate as much as possible on subjects with strong synergies in order to make the best use of the available resources, minimize differences between the two studies, develop a common knowledge and prepare the future evaluation of these technologies towards the facility best adapted to the physics requirements derived from LHC physics results. Seven common working groups have been recently created on subjects with strong synergies and are actively collaborating.

Such a fruitful collaboration has been extremely well supported by the international bodies like the CLIC and ILC Advisory Committees and the Funding Agencies for Large Colliders (FALC) as a welcome step towards a common linear collider community in the best interest of High Energy Physics.

4.2. LHC Upgrade Projects (sLHC)

The initial phase of the sLHC Project aims at increasing the nominal LHC luminosity by a factor of two to three by 2013. This project implies the consolidation of the LHC injector chain.

The sLHC also includes studies for the future upgrade of the LHC injectors such as the PS2 and Superconducting Proton Linac (SPL) studies, which have advanced in 2008.

Linac 4

The first major stage of the injection chain consolidation consists of replacing the linear accelerator, the first link in the chain. The construction of an 80-metre long linear accelerator, Linac 4, to produce beams of 160 MeV instead of 50 MeV for the current Linac 2, was approved in June 2007 by Council as part of the framework programme of additional activities. In 2008, civil engineering for this new linear accelerator started on an unoccupied piece of land on CERN’s main site in Meyrin.. This work entailed rasing a small mound and excavating 12 m below the surface as Linac 4 will be located underground at the same level as the PS. About 40 000 cubic metres of ground are to be removed. At the same time, developments on the accelerator have moved ahead. A test infrastructure of up to 3 MeV (corresponding to the first phase of linac acceleration), consisting of the ion source and a chopper line, both of which were made in the CERN workshops, was assembled and is currently being tested. One of the klystrons recuperated from LEP, which will produce the RF power, was tested in pulse mode. The design of the RF quadrupole (RFQ), the first stage of the acceleration line, has been completed and manufacture has been launched in the CERN workshops. A prototype Drift Tube Linac (DTL) was assembled and tested at low power. The PIMS (Pi-Mode Structure) prototype plans were completed and the prototype is also under construction at CERN. An agreement with the Russian Institutes in Novosibirsk and Snezhinsk for the manufacture of the CCDTL (Cell-Coupled Drift Tube Linac) accelerating structure was prepared and signed in December 2008.

Inner triplets

Another major aspect of the sLHC project concerns the modification of IR1 and IR5 of the LHC to increase the beam focus for collisions in ATLAS and CMS. The focusing magnets, referred to as triplets, will be replaced by wider-aperture, stronger focusing quadrupole magnets. Their electrical supply system and the dipole magnets located in this zone will also be modified. In 2008 the design of these new magnets was finalised. They will contain a 120 mm aperture coil (compared with 70 mm for the current magnets), but will keep the technology of the niobium-titanium superconductors cooled at 1.9 K. The existing LHC dipole cable will thus be re-used. Their length will be increased from the current 5 m up to 10 m. They will be equipped with new corrector magnets. In addition to the design, the teams worked on the tooling for the construction of a prototype magnet as well as the tooling for series magnets. Several collaborations with CERN were established to build the new interaction regions. The design work is being implemented within the SLHC-PP project under the 7th European Framework Programme. The special contribution of France covers the manufacture of all cryostat components (CNRS), of special quadrupole components and of all correctors (CEA). US laboratories will contribute to the design and will manufacture dipole magnets and a large proportion of the cold power transfer systems in the framework of the APUL project. About 50 people participated in this project in 2008 but this activity was slowed down after the LHC sector 3-4 incident which called on the services of a large part of the teams.

4.3. Consolidation

Consolidation consists of the major repair and upgrades of the accelerator and areas, technical, computing and general infrastructure.

The manpower-intensive consolidation work during the 2007-2008 shutdown was completed as planned. However, the delay in the start of the LHC operation and later the incident in sector 3-4 resulted in some hardware groups concentrating on the LHC repair so that the materials procurement of many Theme 1 consolidation items for LHC reliability is delayed to 2009.

It should be noted that the funds for general infrastructure consolidation were limited to the most urgent repairs.

5. Manpower plan: update and status

In October 2006 CERN presented two White Papers, one on medium- and long-term activities and the other relating to the corresponding manpower plan.

At that time, LHC completion to start physics data-taking was scheduled for 2007. This could not be achieved for several reasons (commissioning needs, inner-triplet repair, RF finger issues during warming-up). The manpower plan focused on the staff forecast and notably on the question of the transition from construction to operation of the LHC machine, its detectors, computing and infrastructure.

The Management committed to reducing the administrative and manual workforce by 170 FTEs over the medium-term plan period as part of the budgeted contribution to the manpower needed for the new initiatives.

In 2007, Council approved the staff plan with a target of 2250 FTEs in 2008 (paid for from the CERN budget by Member States' contributions).

The manpower plan also promoted the introduction of a higher staff rotation and a reduced conversion into indefinite contracts, notably for the staff in Categories 2, 4, and 5 (applied scientists and engineers, manual workers, craftsmen and administrative staff), thereby fostering an increased emphasis on Category 3 staff.

When the 2006 manpower plan is compared with the situation at the end of 2008, the following picture emerges:

- Overall staff reduction: Not counting staff paid by EU income on EU projects, the total staff FTE for 2008 reaches some 2255 FTEs, close to the 2250 FTE target for staff paid from Member States' contributions.
- Reduction in Categories 4 and 5 : Based on the totals at the end of 2006 counted as 100%, the end of 2008 figures show 83% for administrative staff and 85% for the manual workforce; thus the disproportionate reduction permits the promised re-deployment within the existing Medium-Term Plan of 170 FTEs towards the technical field.
- Delayed finalisation of LHC construction: The first operation with beam took place in September 2008 instead of 2007. In addition, the incident in sector 3-4 required substantial additional engineering work for the repair as well as for the upgrade of the machine protection system. Therefore, more engineers and academic staff than foreseen are still working on the LHC. The real shift with stable beam and physics data-taking will not start prior to the end of 2009.
- Recruitment focused in 2007 and 2008 on Category 3 (technicians) for the start of the LHC operation. The technical infrastructure manpower was reinforced with 15 posts for electrical distribution and for cooling and ventilation.
- Conversion into indefinite contracts: The conversion rates in 2007 and 2008 were 43% for engineers and applied scientists, 59% for technicians and 46% for administrative staff, thus very close to the targets of the 2006 plan.
- CERN was successful in obtaining through EGEE 3, SLHC-PP, Marie-Curie Fellowships and OpenLab important external income for about 50 additional staff member and fellow FTEs.

III. Financial Tables and Explanations

1. Summary of Income and Expenditure

Figure 1: Summary of Income and Expenditure

(in MCHF, rounded off)

2008 Budget CERN/FC/5169 (2008 prices)		2008 Probab. Income & Expend. CERN/FC/5304/Rev. (2008 prices)	2008 Out-Turn CERN/FC/5331 (2008 prices)	Variations of Out-Turn with respect to Probab. Inc. & Expend.
1,140.3	**INCOME**	**1,160.4**	**1,168.7**	**8.3**
1,075.9	Total regular contributions	1,075.9	1,075.9	0.0
23.7	Additional contribution from Host States	24.2	24.2	
12.3	EU contributions	15.3	16.5	1.2
*	Personnel paid on team accounts	** 7.6	9.9	2.4
*	Personnel on detachment	0.2	0.2	0.0
23.7	Internal taxation	23.7	24.2	0.5
2.5	Technology transfer	2.5	2.4	-0.1
2.2	Other income (including financial income)	11.0	15.3	4.3
910.9	**OPERATING EXPENDITURE**	**890.4**	**863.4**	**-27.0**
796.8	**Running of scientific programmes and support**	**786.7**	**773.1**	**-13.6**
468.6	**Scientific programmes**	**460.6**	**454.6**	**-6.0**
337.1	*LHC (including new initiatives support to detectors)*	*323.5*	*324.7*	*1.2*
45.8	*Non-LHC physics and scientific support*	*47.3*	*43.7*	*-3.7*
85.8	*Accelerators and areas*	*89.7*	*86.2*	*-3.5*
328.2	**General infrastructure and services**	**326.2**	**318.6**	**-7.6**
175.1	*Infrastructure & services*	*177.6*	*175.7*	*-1.9*
31.2	*Centralised personnel budget*	*31.2*	*27.5*	*-3.7*
23.7	*Internal taxation*	*23.7*	*24.2*	*0.5*
67.9	*Insurance & Communications, energy & water*	*65.3*	*63.4*	*-1.9*
30.4	*Interests and financial costs*	*28.4*	*27.6*	*-0.8*
	Personnel on detachment		*0.2*	*0.2*
114.2	**Projects, R&D and consolidation**	**103.7**	**90.3**	**-13.4**
22.4	*CLIC*	*23.4*	*19.5*	*-3.8*
11.2	*LINAC 4*	*4.5*	*6.5*	*2.0*
	Focus Quadrupoles (NbTi)	*0.9*	*0.9*	*0.1*
17.1	*R&D studies (PS2, SPL, detectors)*	*15.1*	*13.0*	*-2.1*
6.4	*R&D Computing (EU)*	*7.8*	*7.9*	0.1
57.0	*Consolidation*	*52.0*	*42.3*	-9.7
*****	**OTHER EXPENDITURE *****	**10.5**	**39.3**	**28.8**
	BALANCE			
229.3	Annual balance	259.5	265.9	6.5
-13.1	Capital repayment allocated to the budget (Fortis, FIPOI)	-13.1	-13.1	
216.3	Annual balance allocated to budget deficit	246.4	252.9	6.5
-817.6	**Cumulative Balance** **-1 033.9**	**-787.5**	**-781.0**	**6.5**

	For information:			
243.0	Capital repayment to EIB	243.0	243.0	
*	Budget amortization of staff benefits accruals ****	13.2	13.2	

* Not specified in 2008 Budget (CERN/FC/5169).

** In 2008 Probable Expenditure (CERN/FC/5304/Rev.) this number relates only to Staff.

*** Staff paid on team accounts, Housing Fund, Stores activity, Depreciation expenses, IPSAS reconciliation.

**** This number does not cover the accruals for the shift work compensation. It is planned to recognize it in the MTP 2009 (including the revised budget 2009), following the 2008 book closure.

2. Total Income

Figure 2: Total Income

(in MCHF, rounded off)

2008 Budget CERN/FC/5169 (2008 prices)		2008 Probable Income CERN/FC/5304/Rev. (2008 prices)	2008 Out-Turn CERN/FC/5331 (2008 prices)	Variations of Out-Turn with respect to Probab. Income
1 140.3	**INCOME**	**1 160.4**	**1 168.7**	**8.3**
1 075.9	Total regular contributions	1 075.9	1 075.9	0.0
23.7	Additional contribution from Host States	24.2	24.2	
12.3	EU contributions	15.3	16.5	1.2
*	Personnel paid on team accounts	** 7.6	9.9	2.4
*	Personnel on detachment	0.2	0.2	0.0
23.7	Internal taxation	23.7	24.2	0.5
2.5	Technology transfer	2.5	2.4	-0.1
2.2	Other income	11.0	15.3	4.3
2.0	*Sales and miscellaneous*	*3.7*	*** *7.5*	*3.8*
*	*Openlab income*	*1.1*	*1.5*	*0.4*
0.2	*Financial income*	*0.2*	*0.2*	*0.0*
*	*Housing Fund*	*6.0*	*6.1*	*0.1*

* Not specified in 2008 Budget (CERN/FC/5169).

** In 2008 Probable Expenditure (CERN/FC/5304/Rev.), this number relates only to Staff.

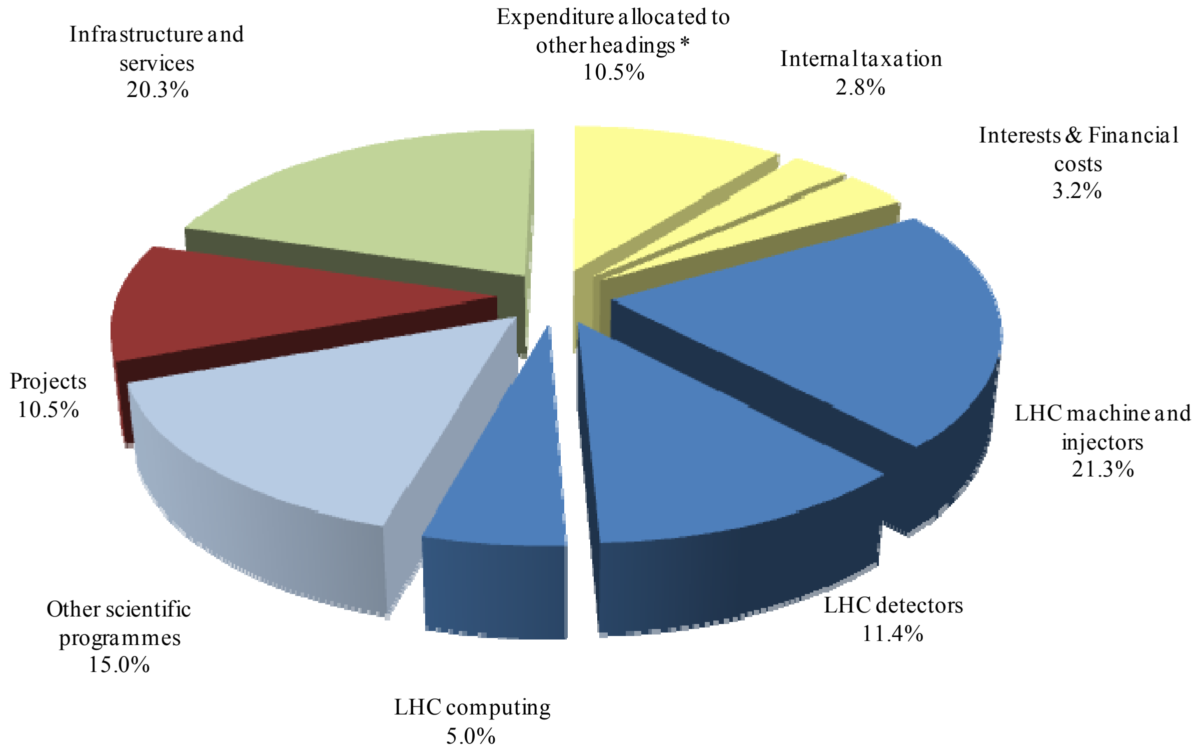
*** Including sponsoring LHC events 1.3 MCHF.

Explanations on Figure 2:

The Total Income increased further since the Probable Income, essentially due to extra EU contributions and other income. The heading Other Income increases due to sponsoring for the LHC events and additional realised sales. With the implementation of IPSAS, the previously separated accounting for the housing fund is now included in the CERN accounts.

3. Operating Expenditure by Scientific and Non-Scientific Programmes[1]

Figure 3: 2009 Budget (Personnel, Materials and Interests & Financial costs)



* Including Centralized Personnel Expenditure (3.2%),
Energy & Water (6.6%), Insurance & Communication (0.7%)

[1] Please note that this Section only details the operating expenditure. Other expenditure not linked to the scientific and non-scientific programmes is summarized in Figure 1.

3.1. Experiments (CERN's contribution to the collaborations and experiments on site) and Accelerators

Figure 4: Scientific Programme

2008 Budget CERN/FC/5169 (2008 prices) kCHF			Activity	2008 Probable Expenditure CERN/FC/5304/Rev. (2008 prices) kCHF			2008 Out-Turn CERN/FC/5331 (2008 prices) kCHF			Variations of Out-Turn with respect to Probab. Expend.
Personnel	**Materials**	**Total**		**Personnel**	**Materials**	**Total**	**Personnel**	**Materials**	**Total**	
191,120	**145,935**	**337,055**	**LHC Programme (incl. projects)**	**191,955**	**131,590**	**323,545**	**189,805**	**134,914**	**324,719**	**1,174**
96,100	**89,115**	**185,215**	**LHC Machine and Injectors**	**97,320**	**84,290**	**181,610**	**97,383**	**85,762**	**183,145**	**1,535**
77,090	**30,255**	**107,345**	**LHC Detectors**	**76,665**	**19,405**	**96,070**	**75,436**	**22,975**	**98,411**	**2,341**
23,875	4,245	28,120	ATLAS detector	24,045	3,285	27,330	23,319	4,328	27,647	317
24,500	3,535	28,035	CMS detector	24,715	3,395	28,110	25,437	4,495	29,932	1,822
11,800	2,865	14,665	Alice detector	11,800	2,925	14,725	10,979	3,254	14,233	-492
11,120	3,235	14,355	LHCb detector	11,120	2,800	13,920	10,139	2,650	12,789	-1,131
4,820	1,540	6,360	Common items, other experiments (inc. Totem)	4,820	2,000	6,820	5,562	1,881	7,444	624
975	14,835	15,810	Detectors Re-scoping	165	5,000	5,165		6,366	6,366	1,201
17,930	**26,565**	**44,495**	**LHC Computing**	**17,970**	**27,895**	**45,865**	**16,986**	**26,177**	**43,162**	**-2,703**
88,870	**42,645**	**131,515**	**Other programmes**	**88,740**	**48,300**	**137,040**	**87,576**	**42,280**	**129,856**	**-7,184**
4,400	**1,360**	**5,760**	**Non-LHC physics**	**4,430**	**1,920**	**6,350**	**2,998**	**1,622**	**4,620**	**-1,730**
31,770	**8,220**	**39,990**	**General Scientific Support**	**32,445**	**8,540**	**40,985**	**32,509**	**6,546**	**39,055**	**-1,930**
21,735	6,545	28,280	Scientific Support	22,260	7,030	29,290	22,024	4,951	26,975	-2,315
10,035	1,675	11,710	Theory	10,185	1,510	11,695	10,485	1,595	12,080	385
52,700	**33,065**	**85,765**	**Accelerators and Areas**	**51,865**	**37,840**	**89,705**	**52,069**	**34,112**	**86,180**	**-3,525**
5,680	3,305	8,985	ISOLDE, AD, n-Tof	5,660	2,785	8,445	5,767	2,437	8,204	-241
17,170	8,440	25,610	PS complex	16,310	5,990	22,300	15,546	5,771	21,316	-984
16,665	15,400	32,065	SPS complex (incl. CNGS)	16,665	11,995	28,660	13,523	11,948	25,471	-3,189
13,185	5,920	19,105	Accelerator Technical Services	13,230	17,070	30,300	17,233	13,956	31,189	889
279,990	**188,580**	**468,570**	**Grand Total**	**280,695**	**179,890**	**460,585**	**277,381**	**177,194**	**454,574**	**-6,011**
24.6%	16.5%	41.1%	% of total income	24.2%	15.5%	39.7%	23.7%	15.2%	38.9%	

Explanations to Figure 4:

The LHC machine construction ended within the revised CtC. The difference in materials is due to the creation of the magnet rescue facility project that is accounted for under accelerator technical services.

Detectors re-scoping refers to the earmarked new initiative heading of 24 MCHF in 2008 and 2009. In 2008, funds were transferred for the CERN contribution to CMS (ECAL, DAQ) and some funds for ALICE. The remaining funds of the 2008 initial allocation are carry-forward to 2009.

The commissioning with beam in September 2008 followed by the incident in sector 3-4 led to a shift in manpower allocation to accelerator technical services for repair. The incident also meant a delay in the starting of new initiatives such as the experiment re-scoping.

The concentration of the LHC and its infrastructure resulted in higher allocations in personnel and materials for general scientific support as well as accelerator technical services (which includes funds for the magnet rescue facility), whereas the earmarked allocations for non-LHC physics, and LHC upgrade were smaller, showing the delay in these activities.

3.2. Non-scientific Programme (Infrastructure and Supporting Services)

Figure 5: Infrastructure and services

2008 Budget CERN/FC/5169 (2008 prices) kCHF			Activity	2008 Probable Expenditure CERN/FC/5304/Rev. (2008 prices) kCHF			2008 Out-Turn CERN/FC/5331 (2008 prices) kCHF			Variations of Out-Turn with respect to Probab. Expend.
Personnel	**Materials**	**Total**		**Personnel**	**Materials**	**Total**	**Personnel**	**Materials**	**Total**	
164,640	**163,550**	**328,190**	**Infrastructure and services**	**166,480**	**159,675**	**326,155**	**167,022**	**151,551**	**318,573**	**-7,582**
55,840	**40,770**	**96,610**	**Infrastructure**	**56,510**	**40,070**	**96,580**	**58,101**	**38,766**	**96,866**	**286**
11,045	470	11,515	Manufacturing facilities	11,130	1,305	12,435	10,641	1,851	12,492	57
21,205	28,910	50,115	General facilities and logistics	21,505	28,615	50,120	23,764	28,737	52,501	2,381
23,590	11,390	34,980	Informatics	23,875	10,150	34,025	23,695	8,178	31,873	-2,152
16,245	**8,110**	**24,355**	**Safety, health and environment**	**17,415**	**7,845**	**25,260**	**19,044**	**4,673**	**23,716**	**-1,544**
30,390	**8,210**	**38,600**	**Administration**	**30,300**	**7,030**	**37,330**	**30,223**	**5,864**	**36,087**	**-1,243**
7,295	**8,245**	**15,540**	**Outreach and TT**	**7,385**	**11,065**	**18,450**	**7,730**	**11,286**	**19,015**	**565**
54,870	**98,215**	**153,085**	**Centralised expenditure**	**54,870**	**93,665**	**148,535**	**51,925**	**90,963**	**142,888**	**-5,647**
31,160		31,160	Centralised Personnel Expenditure	31,160		31,160	27,495		27,495	-3,665
23,710		23,710	Internal Taxation	23,710		23,710	24,208		24,208	498
	58,325	58,325	Energy & Water		58,325	58,325		57,362	57,362	-963
	9,535	9,535	Insurance & Communication		6,985	6,985		6,001	6,001	-984
	30,355	30,355	Interests & Financial Costs		28,355	28,355		27,601	27,601	-754
			Personnel on detachment				221		221	221
14.4%	14.3%	28.8%	% of total income	14.3%	13.8%	28.1%	14.3%	13.0%	27.3%	

Explanations on Figure 5:

Whereas the total expenditure for infrastructure is as predicted, the variations for general facilities and logistics is due to additional maintenance needs, compensated by less IT equipment purchases in 2008 as well as the implementation of the accounting rule which entails charging upfront license payments to the budget year concerned. This open commitment will lead to a budget carry-forward in line with the newly-approved Financial Rules.

Staff expenditure for safety, health and environment increased essentially due to the necessary payments of shift worker allowances of staff exercising their right to early retirement.

Materials expenditure for outreach increased significantly due to LHC events such as Open Days, LHC First Beam and the LHC Inauguration. It should be noted that 1.3 MCHF in sponsoring was received, thus limiting CERN’s expenditure to some 1.5 MCHF.

Centralised expenditure reduces, essentially due to a reduction of the centralised personnel budget since the end of contract indemnities are now charged to the activities of departing staff and the negative variation of the provision for untaken leave. The amount of internal taxation is equal to the income heading.

Energy expenditure reduced slightly due to the sector 3-4 incident ending the operation. It should be noted that most of the LHC energy is linked to the cryogenics and thus the reduction is not significant when most of the LHC is kept cold.

Expenditure for insurances and for financial costs (interests, bank charges) reduced, the latter essentially as a consequence of the reduced interest rates by national banks.

Personnel on detachment refers to staff on the CERN payroll who are charged to another organisation. This expenditure is equal to the corresponding income.

Figure 6: Energy and water

(in MCHF, rounded off)

2008 Budget CERN/FC/5169 (2008 prices)	Activity	2008 Probable Expenditure CERN/FC/5304/Rev. (2008 prices)	2008 Out-Turn CERN/FC/5331 (2008 prices)	Variations of Out-Turn with respect to Probab. Expend.
20.5	**Energy and water (baseload)**	**20.5**	**22.3**	**1.8**
8.9	Electricity	8.9	9.9	1.0
4.3	Heating oil and gas	4.3	5.0	0.7
7.3	Water and miscellaneous *	7.3	7.4	0.1
37.8	**Energy for basic programmes**	**37.8**	**35.1**	**-2.7**
1.8	Particle physics	1.8	1.9	0.1
1.1	Data handling	1.1	1.1	0.0
11.1	Accelerators:	11.1	11.2	0.1
0.4	*AD*	*0.4*	*0.4*	*0.0*
2.0	*PS*	*2.0*	*2.0*	*0.0*
8.7	*SPS*	*8.7*	*8.8*	*0.1*
23.4	LHC	23.4	20.5	-2.9
0.4	CNGS	0.4	0.4	0.0
58.3	**Grand Total Energy programme**	**58.3**	**57.4**	**-0.9**

* "Taxe de pompage" is not included (not being paid for 2008).

Explanations on Figure 6:

The overall reduction of the energy costs shows an increase for the base-load, i.e. electricity for offices and workshops on ongoing LHC commissioning, price increases in the first half of 2008 for heating oil and gas and water costs. This is offset by the reduction in the energy consumption and costs for the LHC following the sector 3-4 incident, which ended the operation earlier than planned.

3.3. Projects (construction, R&D)

Figure 7: Projects

2008 Budget CERN/FC/5169 (2008 prices) kCHF			Activity	2008 Probable Expenditure CERN/FC/5304/Rev. (2008 prices) kCHF			2008 Out-Turn CERN/FC/5331 (2008 prices) kCHF			Variations of Out-Turn with respect to Probab. Expend.
Personnel	**Materials**	**Total**		**Personnel**	**Materials**	**Total**	**Personnel**	**Materials**	**Total**	
44,935	**69,230**	**114,165**	**Projects**	**46,470**	**57,225**	**103,695**	**48,196**	**42,071**	**90,267**	**-13,428**
12,270	**10,105**	**22,375**	**CLIC**	**12,410**	**10,960**	**23,370**	**10,205**	**9,339**	**19,544**	**-3,826**
1,000	**10,230**	**11,230**	**Linac 4**	**765**	**3,705**	**4,470**	**3,897**	**2,617**	**6,513**	**2,043**
			Focus Quadrupoles (NbTi)	**185**	**690**	**875**	**735**	**198**	**933**	**58**
17,345	**6,195**	**23,540**	**R&D**	**17,810**	**5,135**	**22,945**	**17,378**	**3,559**	**20,937**	**-2,008**
10,375	3,220	13,595	R&D Accelerators (RF, coll., SPS, PS2, SPL,…)	9,345	2,380	11,725	8,805	1,518	10,324	-1,401
5,500	920	6,420	R&D Computing (EU)	6,720	1,100	7,820	6,921	974	7,895	75
1,470	2,055	3,525	R&D Detectors (Theme 3)	1,745	1,655	3,400	1,651	1,066	2,718	-682
14,320	**42,700**	**57,020**	**Consolidation**	**15,300**	**36,735**	**52,035**	**15,982**	**26,358**	**42,340**	**-9,695**
3.9%	6.1%	10.0%	% of total income	4.0%	4.9%	8.9%	4.1%	3.6%	7.7%	

Explanations on Figure 7:

Less manpower than planned could be deployed to CLIC due to the ongoing efforts for LHC and the start-up of the Linac 4 and the LHC Inner Triplet Quadrupoles projects.

Linac 4 staff was redeployed from generic accelerator R&D. The reduction in materials expenditure is due to the later start of the civil engineering with respect to the 2007 schedule.

The increase for R&D Computing stems from re-profiled and new EU projects with corresponding income.

The heading consolidation covers major repairs for the infrastructure, replacements and upgrades of IT infrastructure as well as the 'core' consolidation of the accelerator and technical infrastructure. The manpower was made available as foreseen for the intensive repairs during shutdown. However, the overall focus of the CERN staff on the LHC commissioning and later on the LHC repairs resulted in a delay in procurement of consolidation materials. Most of these funds are nonetheless committed (such as the replacement of the PS power converters), and the unspent project funds for these will be carried forward to 2009.

Figure 8: Expenditure for fixed assets projects

(in kCHF)

2008 Budget * CERN/FC/5169 (2008 prices)			Project	2008 Probable Expenditure CERN/FC/5304/Rev. (2008 prices)			2008 Out-Turn CERN/FC/5331 (2008 prices)			Variations of Out-Turn with respect to Probab. Expend.
Personnel	**Materials**	**Total**		**Personnel**	**Materials**	**Total**	**Personnel**	**Materials**	**Total**	
31 420	**111 875**	**143 295**	**Projects**	**27 790**	**96 780**	**124 570**	**35 934**	**78 922**	**114 856**	**-9 714**
5 400	23 370	28 770	LHC Machine & Experimental Areas	5 400	22 775	28 175	9 520	20 060	29 580	1 405
280	3 155	3 435	LHC Detectors	-	2 085	2 085	831	2 020	2 851	766
100	*350*	*450*	*CMS detector*	-	*240*	*240*	*2*	*276*	*278*	*38*
90	*1 210*	*1 300*	*Alice detector*	-	*800*	*800*	*829*	*755*	*1 585*	*785*
90	*1 595*	*1 685*	*LHCb detector*	-	*1 045*	*1 045*	-	*989*	*989*	*-56*
955	405	1 360	LHC Injectors	955	420	1 375	713	351	1 064	-311
4 725	21 610	26 335	LHC Computing	4 725	21 610	26 335	3 961	20 005	23 966	-2 369
12 270	10 105	22 375	CLIC	9 185	5 440	14 625	7 607	8 984	16 591	1 966
4 905	8 715	13 620	Accelerators consolidation	4 905	8 925	13 830	3 397	7 546	10 943	-2 887
-	11 995	11 995	Infrastructure consolidation	-	9 285	9 285	614	5 570	6 184	-3 101
-	-	-	Magnet rescue facility	-	6 270	6 270	1 378	3 811	5 189	-1 081
-	2 045	2 045	Extension building 40	-	750	750	175	556	730	-20
1 080	3 395	4 475	Radioactive waste management	950	3 390	4 340	95	949	1 044	-3 296
-	15 215	15 215	LHC improvement	-	10 390	10 390	2 316	5 526	7 842	-2 548
-	-	-	LHC Inner Triplet Upgrade	-	500	500	529	177	706	206
1 000	10 230	11 230	LINAC4	765	3 705	4 470	3 897	2 617	6 513	2 043
805	1 635	2 440	LHC detectors upgrade	905	1 235	2 140	902	752	1 654	-486

* 2008 Budget figures include EU projects.

Explanations on Figure 8:

Figure 8 summarises the non-recurrent activities and approved projects. Please note that these do not include expenditure covered by EU projects and related income. Most of these headings are included in Figure 7, the LHC headings and magnet rescue facility in Figure 4, radioactive waste management in Figure 5.

The variations are essentially for LHC Computing with the policy of buying as late as possible to profit from general price reductions for IT equipment. Personnel expenditure on CLIC varies between the recurrent and non-recurrent headings. As explained under Figure 7, materials expenditure for consolidation as well as the new initiatives and the civil engineering projects were delayed due to the personnel being focused on the LHC commissioning.

4. Operating Expenditure by nature

Figure 9: Materials expenditure by nature (including interests and financial costs)

2008 Budget CERN/FC/5169 (2008 prices)	Nature	2008 Probable Expenditure CERN/FC/5304/Rev. (2008 prices)	2008 Out-Turn CERN/FC/5331 (2008 prices)	Variations of Out-Turn with respect to Probab. Expend.
391,005	**Operating expenses**	**368,435**	**372,208**	**3,773**
298,520	***Supplies and consumables***	***279,210***	***257,380***	***-21,830***
184,495	Goods, consumables and supplies	157,540	140,765	-16,775
58,325	Electricity, heating gas and water	58,325	57,877	-448
55,700	Industrial services (service contracts)*	63,345	58,738	-4,607
92,485	***Other operating expenses***	***89,225***	***114,828***	***25,603***
46,940	Repair and maintenance (other indus. services contracts)*	36,585	33,272	-3,313
23,570	Third party payments and consultants	24,815	26,113	1,298
21,975	Other overheads **	27,825	55,442	27,617
30,355	**Non-operating expenses**	**28,355**	**27,601**	**-754**
30,355	***Interests and financial costs***	***28,355***	***27,601***	***-754***
14,995	Fortis bank	14,995	14,994	-1
6,600	EIB	6,560	6,545	-15
8,555	Short-term interests	6,595	5,811	-784
205	Bank charges	205	251	46
421,360	**TOTAL MATERIALS in kCHF**	**396,790**	**399,809**	**3,019**

* Variation for total of industrial services: -7,919 kCHF

** Including insurance and communication, CERN contributions to collaborations, depreciation expenses.

Figure 10: Breakdown of materials expenditure by nature

Supplies and consumables: 64.4%

Other operating expenses: 28.7%

Interests and financial costs: 6.9%

* Total of industrial services: 14.7% + 8.3% = 23%

** Including insurance and communication, CERN contributions to collaborations, depreciation expenses.

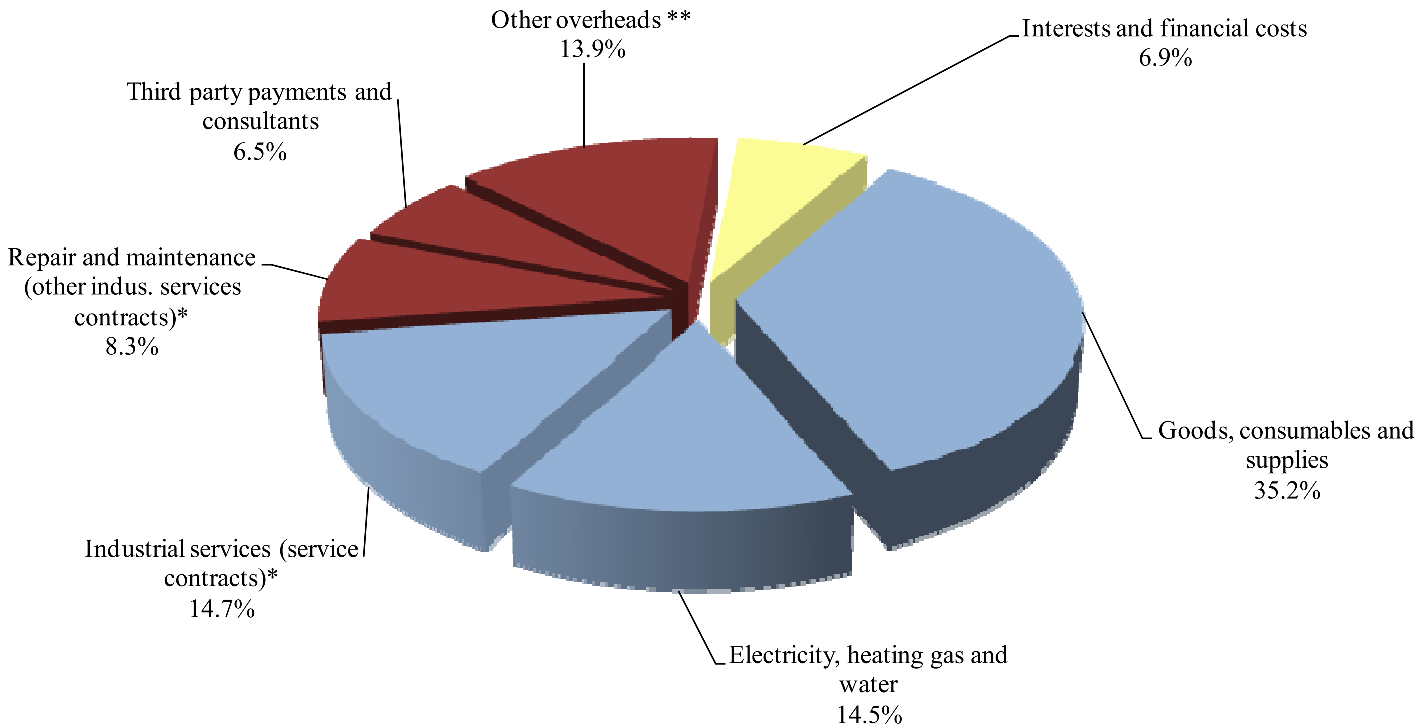


Figure 11: Personnel Expenditure by Nature

2008 Budget CERN/FC/5169 (2008 prices)	Nature	2008 Probable Expenditure CERN/FC/5304/Rev. (2008 prices)	2008 Out-Turn CERN/FC/5331 (2008 prices)	Variations of Out-Turn with respect to Probab. Expend.
454,050	**Staff members**	**457,500**	**459,265**	**1,765**
254,595	***Basic salaries****	***256,790***	***259,130***	***2,340***
61,090	***Allowances***	***61,610***	***63,556***	***1,946***
19,780	Non-residence	19,965	19,830	
20,550	Family allowances	20,740	21,151	
8,595	Special allowances (including LHC success premium)**	8,625	7,486	
1,900	Overtime	1,915	2,175	
10,265	Various allowances	10,365	10,092	
	Termination indemnities***		2,822	
83,495	***Social contributions***	***84,230***	***84,875***	***645***
65,125	Pension Fund	65,695	66,527	
18,370	Health insurance	18,535	18,349	
31,160	***Centralised personnel budget***	***31,160***	***27,495***	***-3,665***
8,155	Installation, recruitment and termination of contracts	8,155	7,502	
4,200	Additional periods of membership in the Pension Fund for shift work	4,200	4,239	
18,805	Contribution to health insurance for pensioners	18,805	19,415	
	Variation Paid leave****		-3,661	
23,710	***Internal taxation***	***23,710***	***24,208***	***498***
34,985	**Fellows & Associates (including overhead for students)**	**35,615**	**33,295**	**-2,320**
530	**Apprentices**	**530**	**423**	**-107**
489,565	**TOTAL PERSONNEL in kCHF**	**493,645**	**492,984**	**-661**

* Including the withheld salary for short-term SLS participations.

** Of the original 5 000 kCHF, 4 130 kCHF was paid as premium and 826 kCHF has been allocated in the form of 307 steps with average value 90 CHF per month.

*** In 2008 Budget and 2008 Probable expenditure under heading "Installation, recruitment and termination of contracts".

**** Introduced as a consequence of IPSAS.

Explanations on Figure 11:

The total CERN personnel expenditure exceeded the budget since the delay of the LHC commissioning and the repair of the sector 3-4 required granting extensions to LD staff. Furthermore, the need for additional engineering manpower for the technical infrastructure and manpower for cryogenics operation resulted in advancing recruitments foreseen originally in 2009 only.

The Centralized Personnel Budget reduces essentially due to a negative variation of the provision for untaken leave and termination indemnities being accounted now against activities of the departing staff.

The reduction in the fellowship expenditure is explained by a delay of the new initiatives programmes, notably for the focused R&D activities under Theme 3.

Figure 12: Personnel expenditure breakdown by nature