Flanders, Belgium and CERN

KVAB Thinkers in residence programme 2018

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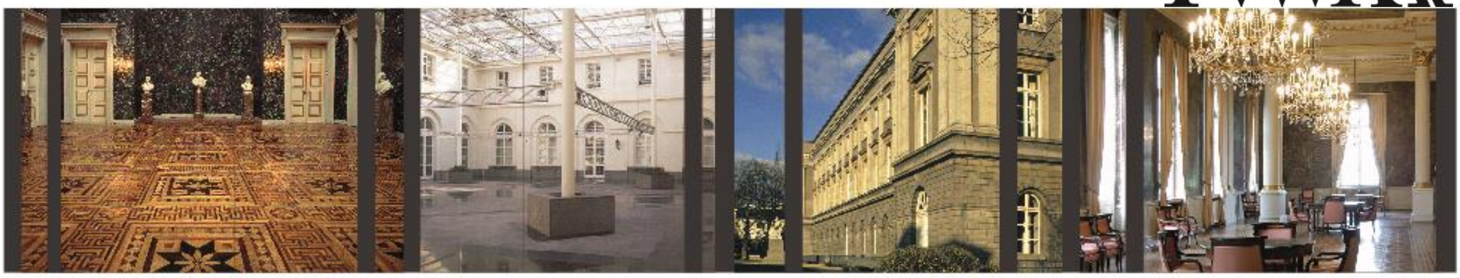

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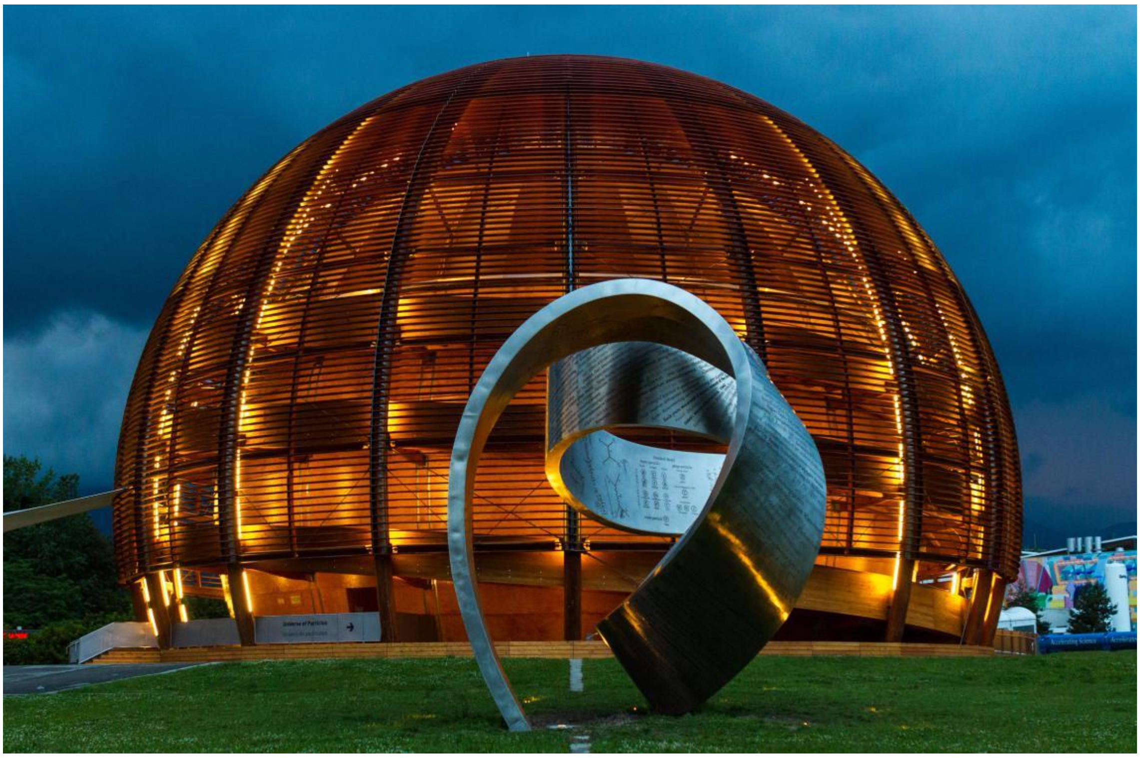


The 'Globe of Science and Innovation' at CERN, designed by Geneva architects Hervé Dessimoz and Thomas Büchi; in front of the Globe 'Pérégrinations à l'infini' designed by the Canadian artist Gayle Hermick.

Preamble

The Royal Flemish Academy for Sciences and Arts (KVAB) launched its 2018 "thinkers programme" at the end of 2017. Former Vice-President of the CERN Council, Prof. dr. em. Walter Van Doninck, was solicited to lead this reflection around the theme "Flanders, Belgium and CERN". He was assisted in this task by a steering committee shown at the cover of this report. The programme culminated with a symposium on November 30th, 2018 in the palace of the Academies in Brussels announced with the poster shown below.

Attendance was good and the symposium has been considered very successful.

1 Summary

In the framework of the “thinkers cycle” of the Royal Flemish Academy of Belgium for Sciences and Arts (KVAB), the 2018 programme of the class natural sciences featured the theme “Flanders, Belgium and CERN”. As “thinker in residence” Walter Van Doninck has been solicited to lead this reflection programme with the help of a steering committee of 12 eminent Belgian scientists. The “European Council for Nuclear Research” CERN exists since 1954 and developed into the world largest laboratory for fundamental research in particle physics. All aspects of the role of CERN for Belgium and Flanders will be addressed in this report. The unique infrastructure of the CERN laboratory, with the Large Hadron Collider as its flagship is made available to the Belgian researchers through the domestic financial support from the “Fonds voor Wetenschappelijk Onderzoek Vlaanderen” (FWO) and the “Fonds de la Recherche Scientifique” (F.R.S-FNRS). Through grants support is also provided from the European Research Council (ERC).

This report introduces CERN as an international organisation and as a laboratory. The specific contributions from Flanders and Belgium will be highlighted next in the fields of Nuclear Physics and Particle Physics. For the remaining part, the report is organised into sections dealing with CERN’s contributions to societal challenges. The broadening of knowledge leaving an important scientific legacy to mankind is the first theme. The important aspect of education and training is handled next. Although not part of the mission of CERN, its excellence in various high technology fields contributes to solving the challenge of energy production and storage on our planet. As a spin off from the development of accelerators and particle detection techniques the impact on modern health care is described in the next section. In the domain of information technology, CERN is well known for its development of the World Wide Web (WWW) and in particular it’s Hyper Text Transfer Protocol (http). The aspect of technology transfer and incubation of economic activity is developed next. Often the “CERN Model” has been followed for subsequent international organisations promoting global collaboration. The outreach activities of CERN and its connection to arts close this part of the report. After the conclusive remarks some observations and recommendations are formulated. In the addenda details on various aspects are given.

2 Samenvatting

In het kader van de denkerscycli van de Koninklijke Vlaamse Academie van België voor Wetenschappen en Kunsten (KVAB) heeft de klasse van de Natuurwetenschappen haar programma van 2018 geweid aan het thema: "Vlaanderen, België en CERN". Walter Van Doninck werd als denker gevraagd deze reflectie te verzorgen begeleid door een stuurgroep van 12 eminente Vlaamse wetenschappers. De "Europese Raad voor Onderzoek in de Kernwetenschappen" CERN bestaat sedert 1954 en heeft zich ontwikkeld tot s 'werelds grootste laboratorium voor fundamenteel onderzoek in de deeltjesfysica. Alle aspecten van de rol van CERN voor België en Vlaanderen zullen behandeld worden in dit rapport. De unieke infrastructuur met als vlaggenschip de Grote Hadron Botser (LHC) worden toegankelijk voor Belgische wetenschappers dankzij de domestieke financiële steun van het "Fonds voor Wetenschappelijk Onderzoek Vlaanderen" (FWO) en het "Fonds de la Recherche Scientifique" (F.R.S-FNRS). Via beurzen draagt eveneens de "Europese Raad voor Onderzoek" (ERC) bij.

In dit rapport wordt CERN ingeleid als internationale organisatie en als laboratorium. De specifieke bijdragen van Vlaanderen en België in de vakgebieden Kernfysica en Deeltjesfysica komen vervolgens aan bod. Verder is dit rapport geweid aan de verscheidene maatschappelijke uitdagingen waartoe CERN een bijdrage levert. De grensverleggende kennis die CERN als een erfenis nalaat aan de mensheid is het eerste thema. Het belangrijk onderwerp van onderwijs en training wordt vervolgens behandeld. Alhoewel het geen deel uitmaakt van de missie van CERN, zorgt de excellentie in verscheidene hoog technologische domeinen ervoor dat een bijdrage geleverd word tot uitdaging van de verwekking en het opslaan van energie op onze planeet. Als spin-off ten gevolge van de ontwikkeling van versnellers en detectie technieken van deeltjes, wordt de belangrijke bijdrage tot de moderne geneeskunde belicht. Op het gebied van informatie technologie is CERN vermaard voor de ontwikkeling van het "World Wide Web" (WWW) en in het bijzonder voor het internet protocol Hyper Text Transfer Protocol (http). Technologie overdracht en incubatie van nieuwe economische activiteit komen dan aan bod. Het "CERN Model" diende dikwijls als voorbeeld voor latere oprichtingen van internationale organisaties die globale samenwerking promoten. De uitstralingsactiviteiten van CERN en de betrekking tot kunst sluiten dit deel van het rapport af. Na conclusies worden enkele opmerkingen en aanbevelingen geformuleerd. Details en cijfergegevens over de verscheidene onderwerpen zijn in de addenda ondergebracht.

3 Observations and recommendations

3.1 Observations

- CERN plays a unique role worldwide. A very diverse community of scientists, engineers, technicians and administration collectively share a very clear goal of fundamental research in subatomic physics. This model of international collaboration and pooling of resources without any discrimination works in an optimal way and is followed in analogous structures.

- Since its creation, the CERN organisation has grown considerably. During the early seventies the ratio of CERN staff to the number of scientists using the CERN infrastructure to conduct their research (users) was about 1/1. Today this ratio has dropped to about 1/5. This is partly due to outsourcing of services but also to a reduction of CERN permanent staff, capped by Council to about 2500, and an important increase of the number of users that exceeds about 12000 today. About 25% of them are from outside the EU and this number tends to further increase.
In our opinion this ratio is close to its lower limit for CERN to function as efficiently in the future.

- For Belgium in particular, the two spearhead experiments at CERN are CMS for particle physics and ISOLDE for nuclear physics. They have about 4000 and 1400 members respectively. The about 150 Belgian users have managed to have very visible and leading roles in these experiments. The strategic choice to concentrate their efforts to a small number of projects has been important to achieve this result. For Flanders the former FWO Big Science programme has been crucial to support the strong position of their researchers at CERN. Recurrent financial support, enabling our scientists to engage in long term projects, is of paramount importance. Past difficulties with equipment budgets are now solved with the IRI programme.

- The fundamental nature of research at CERN is such that applications of developments or discoveries require a long time to be established. When applying for funding of projects it is often difficult to demonstrate a short-term societal relevance at this initial phase.

3.2 Recommendations

- The high profile of Belgium at CERN is partly due to a good representation in the CERN Council, the highest decision-making body. In the past and for a very long time, Paul Levaux secretary general of the then national FNRS-NFWO has been our "political" delegate, complemented by a Flemish scientist as the "scientific delegate". It has worked extremely well and we recommend to keep the binomial structure FR/NL for our delegation. Terms of office should be limited in time to ~5 years. One should allow for a toggle between the FWO and the F.R.S.-FNRS for the "political delegate" which would then also allow a scientist of the French speaking community to become the "scientific delegate". Transparency of the work of Council towards the research community should be improved. This could be achieved through a meeting twice a year, chaired by the Belgian Council delegates, involving all interested parties: the group leaders of the Belgian research groups involved at CERN, the funding agencies FWO and F.R.S.-FNRS and representatives of the ministries concerned (COORMULTI).

- Projects at CERN are of high technicity and complexity. They often have a rather long lifetime and need regular maintenance. For our Belgian groups to contribute significantly, the support of skilled technical manpower up to the level of engineer is mandatory. This technical support is insufficient today and ways should be developed to be able to also hire such manpower in sufficient numbers.

- CERN offers many programs of education and training at all levels. As compared to other member states, Belgium is not sufficiently taking advantage of these opportunities. Especially the teacher's program is largely underused by Belgian teachers. A stimulus in this direction would be highly welcomed. For Flanders the STEM platform could play an important role in this matter.

- For Flemish and Belgian companies to profit from the purchases of CERN and to maintain the high profile of industrial return it is important that they are part of CERN's database with a clear description of the services or goods they can offer. Possibilities are regularly offered to companies inviting them to exhibit their products or know-how at CERN. Just recently (20/3/2019) a delegation of AWEX (Wallonia, Brussels) and FIT (Flanders) have jointly visited CERN. Such interactions should be further encouraged and also involve the scientific community.

- CERN has established incubation centres in many member states upon their request. Such initiatives are still missing in Belgium. Within the framework of the close collaboration on the MYRRHA project, the SCK•CEN centre in Mol could be a good candidate for such a CERN incubation centre.

4 Waarnemingen en aanbevelingen

4.1 Waarnemingen

- De rol die CERN speelt op wereldvlak is uniek. Een heel diverse verzameling van wetenschappers, ingenieurs, technici en administratie scharen zich collectief achter een heel heldere doelstelling van fundamenteel onderzoek in sub-atomaire fysica. Dit model van internationale samenwerking en pooling van middelen zonder enig onderscheid van afkomst, werkt optimaal en dient als voorbeeld voor analoge structuren.

- Sedert de oprichting heeft de CERN-organisatie een belangrijke groei gekend. In het begin van de jaren zeventig was de verhouding tussen CERN-staff en wetenschappers die de CERN-infrastructuur gebruiken voor hun onderzoek (gebruikers) ongeveer 1/1. Nu is die gedaald tot ongeveer 1/5. Dit is gedeeltelijk het gevolg van uitbesteding van diensten maar ook van de afname van CERN-staff, die door de Raad beperkt werd tot ongeveer 2500, en de toename van het aantal gebruikers tot meer dan 12.000 op de dag van vandaag. Volgens ons zit deze verhouding dicht bij de onderste limiet om een efficiënte werking van CERN ook in de toekomst te verzekeren.

- Voor België in het bijzonder zijn de twee speerpunt-experimenten in CERN: CMS voor de deeltjesfysica en ISOLDE voor de kernwetenschappen. In de groep van respectievelijk 4.000 en 1.400 leden zijn de ongeveer 150 Belgische gebruikers er in geslaagd om een zeer zichtbare en leidinggevende rol te vervullen in deze experimenten. De strategische keuze van de onderzoeksgroepen om hun middelen te bundelen en te concentreren op enkele projecten is belangrijk om dit resultaat te verwezenlijken. Voor Vlaanderen was het vroegere FWO-programma Big Science van cruciaal belang om de sterke positie van onze vorsers in CERN te ondersteunen. Terugkerende financiële steun om onze wetenschappers toe te laten lange-termijnverbintenissen aan te gaan is van groot belang. De moeilijkheden in het verleden om uitrustingskredieten te verwerven zijn met het IRI-programma sterk verbeterd.

- Het fundamenteel karakter van het onderzoek in CERN is van die aard dat toepassingen van ontwikkelingen of ontdekkingen in het algemeen een ruime tijd nodig hebben om ook verwezenlijkt te worden. Het aantonen van maatschappelijke relevantie in de beginfase van zulke projecten is daarom moeilijk.

4.2 Aanbevelingen

- Het sterk profiel dat België aanhoudt in CERN is eveneens te danken aan een goede vertegenwoordiging in de Raad, het hoogste beslissingsorgaan van CERN. In het verleden en voor een lange periode was Paul Levaux, secretaris-generaal van het FNRS (voor de staatshervorming van 1988 ook het Nationale Fonds voor Wetenschappelijk Onderzoek, NFWO-FNRS) onze "politieke" afgevaardigde, aangevuld met een Vlaamse onderzoeker als "wetenschappelijk" afgevaardigde. Dat heeft uitstekend gewerkt en wij bevelen aan dat deze binomiale structuur FR/NL zou aangehouden worden voor onze Belgische afvaardiging. Een termijn van ~5 jaar lijkt ons optimaal. Men zou nochtans moeten zorgen voor een alternering tussen FWO en F.R.S.-FNRS voor de "politieke" gedelegeerde. Dit zou dan ook toelaten dat een Franstalige de functie van "wetenschappelijke afgevaardigde" zou uitoefenen. Meer transparantie betreffende de werking van de Raad naar de wetenschappelijke gemeenschap toe is vatbaar voor verbetering. Dit zou verwezenlijkt kunnen worden door een vergadering twee keer per jaar, voorgezeten door de Belgische afvaardiging, met deelname van de leiders van de onderzoeksgroepen, de financieringsinstellingen FWO en F.R.S.-FNRS en afgevaardigden van de bevoegde ministeries (COORMULTI).

- Projecten in CERN zijn van hoog technologische aard en zeer complex. Ze hebben meestal een lange levensduur en dienen regelmatig van onderhoud te worden voorzien. Opdat onze Belgische groepen verder een beduidende rol zouden kunnen blijven uitoefenen, is er dringend behoefte aan geschoold technisch personeel, tot en met het niveau van ingenieur. Deze technische ondersteuning is vandaag onvoldoende. Er dienen oplossingen gezocht om ook dit soort personeel te kunnen aanwerven in voldoende aantallen.

- Het CERN-aanbod voor scholing, bijscholing en training is zeer divers en gesitueerd op alle niveaus. In vergelijking met andere lidstaten maakt België ondermaats gebruik van deze geboden mogelijkheden. In het bijzonder in het programma lerarenopleiding scoort België bijzonder slecht. Een stimulus om dit aanzienlijk te verbeteren is dan ook zeer welkom. Voor Vlaanderen zou het STEM-platform hierbij een belangrijke rol kunnen vervullen.

- Opdat Vlaamse en Belgische bedrijven verder kunnen genieten van bestellingen uit CERN en onze gunstige industriële return hoog houden, dienen ze regelmatig het betreffende CERN gegevensbestand aan te vullen met een nauwkeurige beschrijving van de diensten en producten die ze kunnen aanbieden. Regelmatig worden er mogelijkheden geboden om hun producten en vaardigheden te tonen in CERN. Zeer recent (20/3/2019) hebben afvaardigingen van AWEX (Wallonië, Brussel) en FIT (Vlaanderen) samen CERN bezocht. Zulke initiatieven zouden verder aangemoedigd moeten worden en dit in samenspraak met de wetenschappelijke gemeenschap.

- Op aanvraag van verscheidene lidstaten heeft CERN in deze landen een "incubatiecentrum" opgericht. Dergelijke initiatieven zijn in België nog afwezig. In het kader van de intensieve samenwerking wat het MYRRHA project betreft is het duidelijk dat het SCK•CEN te Mol een goede kandidaat kan zijn voor het onderbrengen van een CERN-incubatiecentrum.

5 CERN as international organisation and as laboratory

After World War II Europe was left devastated and many prominent scientists left the continent. To contribute to fostering peace and limit the brain drain, some visionary scientists, politicians and diplomats in Europe and the United States identified the need for Europe to have a world-class physics research facility. Raoul Dautry, Pierre Auger and Lew Kowarski in France, Edoardo Amaldi in Italy and Niels Bohr in Denmark were among these pioneers. French physicist Louis de Broglie put forward the first official proposal for the creation of a European laboratory at the European Cultural Conference, which opened in Lausanne on 9 December 1949. A further push came at the fifth UNESCO General Conference, held in Florence in June 1950, where American physicist and Nobel laureate Isidor Rabi tabled a resolution authorizing UNESCO to "assist and encourage the formation of regional research laboratories in order to increase international scientific collaboration…" At an intergovernmental meeting of UNESCO in Paris in December 1951, the first resolution concerning the establishment of European Council for Nuclear Research was adopted. Two months later, 11 countries signed an agreement establishing the provisional council – the acronym CERN was born. The draft convention was completed in the following 18 months and approved unanimously by the representatives of the eleven countries that had signed the original agreement plus the UK, and the document was made available for signature. Belgium was among the 11 founding countries and the Belgian government of that time gave the credentials for the signature to Prof. Jean Willems of the University of Ghent who also became Belgium's first delegate to the CERN Council. Paul Levaux, secretary general of the FNRS, succeeded him in the 1970's and remained in function until the end of 2007. He made important contributions to the development of the organisation as Council President (1975-1977) and Vice President (1978-1980 and 1995-1997) and chair of the pension fund (1989-2002). The CERN convention established financial contributions, which are calculated on the basis of net national income over recent years so that each Member State pays according to its possibilities. CERN's convention states: "The Organization shall have no concern with work for military requirements and the results of its experimental and theoretical work shall be published or otherwise made generally available." The first meeting of the CERN Council quickly followed the signing of the agreement. It took place at UNESCO from 5-8 May 1952 with Switzerland's Paul Scherrer in the chair. At this meeting, governments wishing to host the new laboratory were invited to submit proposals before the end of July and the first five officials were appointed. Edoardo Amaldi was made Secretary General of the provisional organization, Cornelius Bakker from Amsterdam headed the group that would draw up plans for the laboratory's first machine -- a Synchrocyclotron with an energy of at least 500 MeV, Niels Bohr headed the theory group, and Odd Dahl from Norway got the job of exploring options for the originally conceived 'bigger, more powerful' machine that would bring together European science and scientists. Lew Kowarski was tasked with organizing and setting up an international laboratory, from financial procedures to buildings and workshops. The site was chosen near the Swiss village of Meyrin near the Swiss-French border in the Geneva area.

After the initial synchrocyclotron, the first proton synchrotron (PS) was built and started operation in 1959 to accelerate protons up to 25 GeV. The dipole magnets for this accelerator were manufactured by ACEC in Belgium. Today this machine is still in use and an important link in CERN's accelerator chain shown in Fig.1.

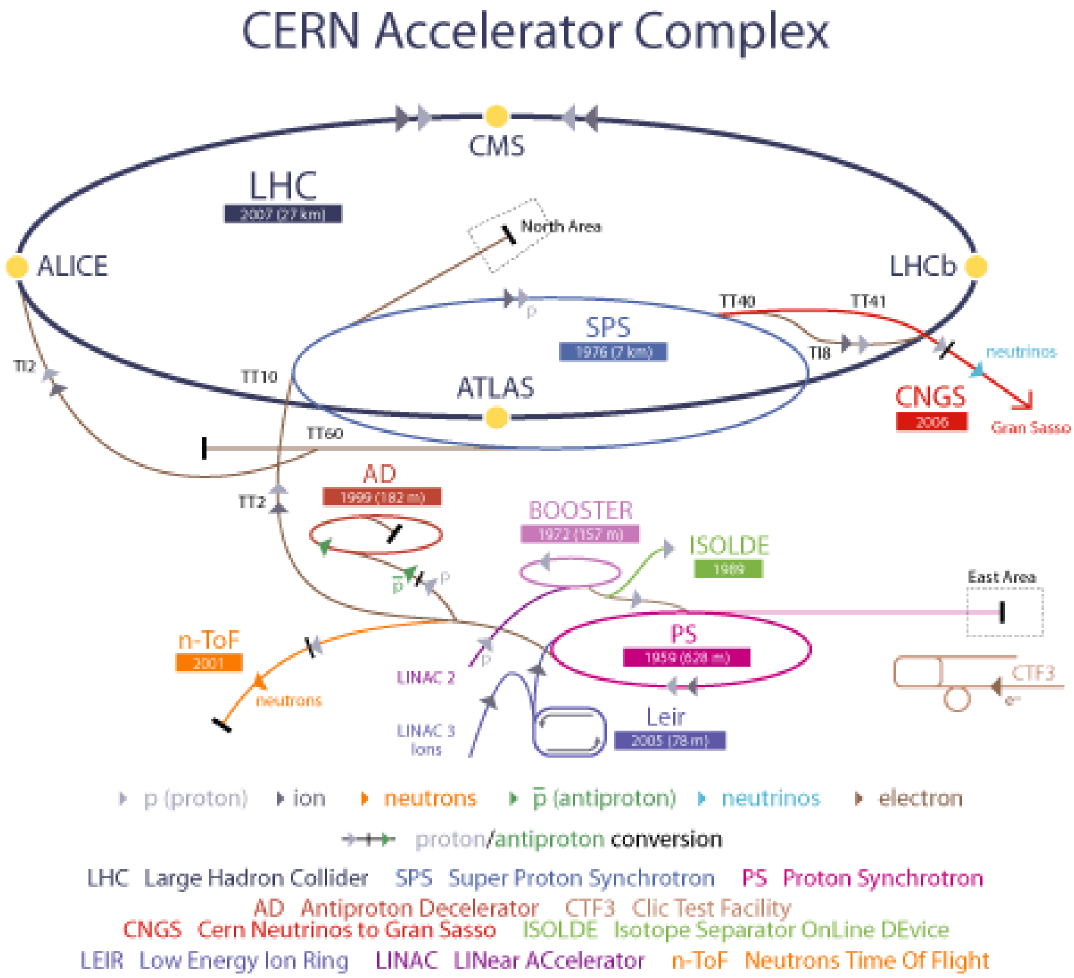


Figure 1: CERN's accelerator complex today

The "flagship" accelerator of the laboratory is the Large Hadron Collider (LHC) a storage ring of counter rotating proton beams reaching collision energies of 13 TeV in four intersection regions along the 27km circumference ring situated close to 100m depths below the surface. Today this is the collider with the highest energy on earth. There are 1232 main dipoles providing a magnetic field of 8.3 Tesla, each 15 metres long weighing 35 tonnes and 392 quadrupole magnets of 3m length each. All these magnets are superconducting hence cooled to a temperature of 1.9 degree Kelvin (-271.3^{0}C). Complemented with a large number of smaller corrector magnets they constitute the magnetic structure of the LHC. The table below shows the main characteristics of the LHC.

Circumference	26659 m
Dipole operating temperature	1,9 K (-271.3 ^{0}C)
Number of magnets	9593
Number of main dipoles	1232
Number of main quadrupoles	392
Number of RF cavities	8 per beam
Nominal energy, protons	7 TeV
Nominal energy Pb ions	2.56 TeV/u (energy per nucleon)
Nominal energy, protons collisions	14 TeV
No. of bunches per proton beam	2808
No. of protons per bunch (at start)	1.2 10^{11}
Number of turns per second	11245
Number of collisions per second	1 billion

Two other unique facilities of the CERN laboratory are the ISOLDE radioactive ion beams and the AD antiproton decelerator.

The highest decision making body of CERN is the Council where 2 delegates for each member state meet 4 times a year. Voting procedures involve one vote per delegation. Council is assisted by several subordinate bodies: Finance Committee (FC) advising in budget, financial and procurement matters, the Scientific Policy Committee (SPC) steering the scientific programme and options of the laboratory, the Tripartite Employment Conditions Forum (TREF), the Audit committee to provide independent guidance and the Pension Fund Governing Board dealing with the pension scheme of CERN and ESO staff. Composition of all bodies can be found on the website: http://council.web.cern.ch/en/content/news.

The European Committee for Future Accelerators (ECFA) provides an independent scientific and long-term vision. At present ECFA is chaired by Prof. J. D'Hondt (VUB) He has a standing invitation to all meetings of Council. Today CERN has 22 member states (Austria, Belgium, Bulgaria, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Israel, Italy, the Netherlands, Norway, Poland, Portugal, Romania, the Slovak Republic, Spain, Sweden, Switzerland and the United Kingdom), 3 associate member states in the pre-stage to membership (Cyprus, Serbia, Slovenia) and 5 associate members from outside Europe (India, Lithuania, Pakistan, Turkey, Ukraine). The Director-General, appointed by the Council for normally a 5-year term, manages the CERN Laboratory. He/she is assisted by a directorate and runs the laboratory through a structure of 9 departments. At present 2 department heads are Belgian (F. Hemmer IT, T. Lagrange IPKT). The CERN annual budget amounts to about 1.200 million Swiss Francs. In 2019 the Belgian contribution represents 2.68415%. About 54% of the expenses concern personnel costs the remaining is shared among materials 40% and energy 5%. The material costs mainly return to the member states through purchases and services. In this respect Belgium is doing rather well when averaged over several years as shown in Fig.2.

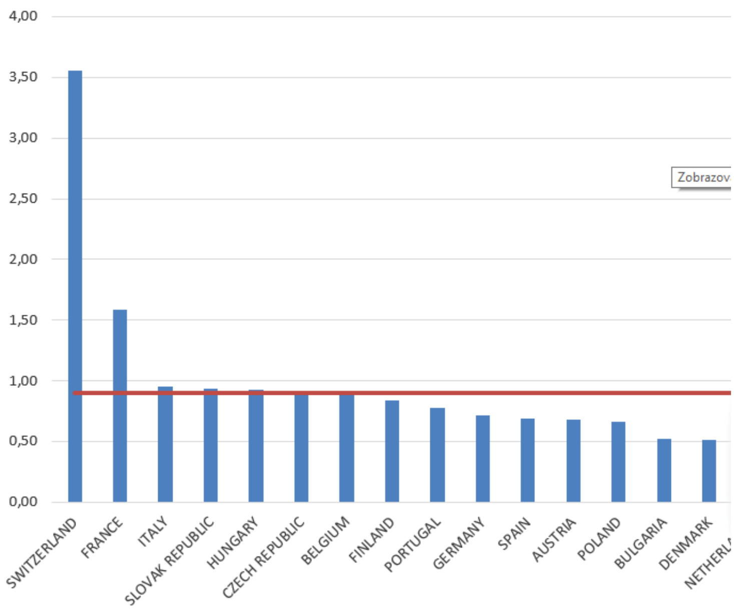


Figure 2: Industrial return to member states (source ECFA)

The CERN staff amounts in 2019 to 2633 members of which 106 are of Belgian nationality; this is far more than our 2.7% contribution. CERN staff operates and maintains CERN's complex infrastructures. Well over 12000 users regularly use these infrastructures to conduct their research. They come from more than 500 universities and institutes from over 100 countries worldwide. They cluster into international collaborations that provide the budget, exploitation and maintenance of the many experiments performed using CERN's infrastructures.

The mission of CERN is fourfold:
- Push forward the frontiers of knowledge
- Develop new technologies for accelerators and detectors
- Educate and train the scientists and engineers of tomorrow
- Unite people from different countries and cultures

All these aspects will be developed further in this report.

6 Specific contributions of Flanders and Belgium at CERN

The Belgian Nuclear and Particle physics communities are focusing their efforts at two major CERN experiments: the ISOLDE for research with radioactive isotopes in a variety of physics disciplines and CMS for the further scrutiny of the Standard Model and for searches of physics beyond it.

6.1 Flemish/Belgian involvement at the ISOLDE radioactive beam facility

The on-line isotope mass separator ISOLDE is a 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, astrophysics, fundamental interactions research, solid-state physics, materials science and life sciences. The facility is located at the Proton-Synchrotron Booster (PSB) at CERN, which delivers proton beams at 1.4 GeV to two ISOLDE target stations. ISOLDE is receiving typically 50-60% of all protons produced at CERN. Radioactive nuclei are produced by collisions of the proton beam on thick targets; the produced isotopes are then selectively extracted and distributed to various experimental stations for fundamental studies and applications. ISOLDE has the widest range of radioactive ion beams available worldwide (more than 1000 isotopes have been produced), at energies from a few keV up to 10 MeV/nucleon.

The ISOLDE facility is the oldest-running CERN experiment. It was approved in 1964, with first radioactive isotopes produced and accelerated to 60 keV in 1967 for radioactive decay experiments. The number of ISOLDE experimentalists, as well as the diversity of experiments using the radioactive beams, has steadily grown in the years that followed. In 1990-1992 the facility was moved from CERN's first accelerator, the Synchrocyclotron, to the current Proton-Synchrotron Booster and a large experimental hall was built to host more than ten different detection stations. At the end of the nineties it was proposed to post-accelerate the radioactive ion beams from ISOLDE: the ISOLDE hall was extended and the REX ISOLDE accelerator was built, starting its operation in 2001 and delivering accelerated beams with energies up to 2.3 MeV per atomic mass unit. A major upgrade program, HIE-ISOLDE, was approved in 2009 and has been implemented in stages. After another extension of the ISOLDE hall in 2013, a superconducting Linear Accelerator (Linac) has been installed, which is now delivering radioactive beams approaching 10 MeV per mass unit for the most neutron rich isotopes. As a spin-off from the many developments for producing pure beams of rare isotopes at ISOLDE, the MEDICIS facility was approved in 2013. At this facility further research on specific isotope production for medical applications is performed. The MEDICIS facility started operation in 2017 and is now delivering isotopes to several hospitals in Europe, who use these isotopes in trial studies searching for improved cancer therapies and better diagnostics.

The ISOLDE Collaboration has at present 16 member countries, each paying a similar collaboration fee: Belgium, CERN, Denmark, Finland, France, Germany, Greece, Italy, Norway, Poland, Romania, Slovakia, South Africa, Spain, Sweden and the United Kingdom. More than 1400 scientists from 46 countries and over 200 institutions are registered as ISOLDE users. Typically, about 500-600 scientist come to ISOLDE each year, for performing about 50 different experiments.

The ISOLDE Collaboration decides on the major scientific programmes and the technical developments at ISOLDE, through its ISOLDE Collaboration Committee (ISCC). Each member country has one representative in the ISCC, which meets three times per year. A Collaboration Chair, elected every 3 years among its members, leads the ISCC. A CERN staff member acts as the ISOLDE Physics Group leader for the local team of PhD students and post-doctoral fellows. This person is also the Spokesperson of the collaboration towards CERN and the international nuclear physics community. The Physics group leader is elected by the ISCC after an open call for candidates in the European nuclear physics community. This person is then nominated by CERN as the ISOLDE Section Leader for a period of three to five years typically. At present, the ISOLDE Physics Group leader and Collaboration Spokesperson is Gerda Neyens from KU Leuven.

The ISOLDE and Neutron Time-of-Flight (n-TOF) Experiments Committee (INTC) acts as an independent panel of international experts, who evaluate proposals for experiments in the diverse research disciplines of the ISOLDE and n-TOF facilities. The INTC meets three times per year and the INTC chairperson communicates its conclusions and recommendations to the CERN Research Board. The Research Board takes final decisions, in particular on approval of experiments. Next to the ex-officio members from CERN, the INTC consists of about eight scientists from over the world. Kristiaan Temst (KU Leuven) is presently a member of INTC, while Gerda Neyens, Nathal Severijns and Mark Huyse (all from KU Leuven), Kris Heyde (from UGent) and Marcel Arnould and Paul-Henri Heenen (from ULB) have served in the INTC for 2-6 years in previous years.

The INTC is one of the three Experiment Committees at CERN, next to the LHC Experiments Committee (LHCC), the SPS and PS Experiments Committee (SPSC). Nathal Severijns and Gerda Neyens have been members of the SPSC for 2-3 years each.

The Chairpersons of INTC, LHCC and SPSC are also ex-officio members of the CERN Research Board and of the Scientific Policy Committee (SPC) of CERN. The SPC is one of two subsidiary bodies to the CERN Council established by the Convention. It was created by the CERN Council at its first meeting in 1954. The task of the SPC is to generally advise the CERN Council on scientific matters related to the Organization. Next to the ex-officio members, it consists of 15 appointed members serving for three years (+ possible one other term).

Flanders has a long-standing and highly visible involvement in the ISOLDE and HIE-ISOLDE experimental programs at CERN from the experimental side (KU Leuven) as well as from the theoretical side (UGent), and recently a group from SCK•CEN joined R&D activities related to high-power targets. The involvement is not limited to proposing, performing, analysing and interpreting experiments but also in specifying the global scientific program and contributing to the technical developments at the different experimental facilities. More than ten experimental set-ups are managed by international research collaborations, some of them regulated by formal agreements. The researchers at KU Leuven have prominent roles in the collaborations to which they participate, both for experiments with low-energy (40-60 keV) as well as with accelerated radioactive beams. KU Leuven groups are founding members and principle investigators (PIs) of several experimental set-ups at ISOLDE. Piet Van Duppen has initiated the construction of the ISOLDE Decay Station (IDS), a modular and very efficient alfa, beta, gamma and particle detection system for decay spectroscopy on very rare isotopes. Gerda Neyens is co-PI of the COLLAPS setup for collinear laser spectroscopy and co-founder of the CRIS collinear resonance ionization spectroscopy set-up, in which Thomas Cocolios is responsible for a dedicated detection system to study isomerically pure beams produced with CRIS. Nathal Severijns has been the PI of the former WITCH and is presently co-PI of the WISArD setup for fundamental interaction studies. Lino Pereira and Andre Vantomme are focussing on materials research using the Emission Channeling (EC) and on-line Mossbauer experiments. At the HIE-ISOLDE post-accelerator, Piet Van Duppen and Mark Huyse are co-founders of the REX- and HIE-ISOLDE post-accelerators, as well as the Miniball gamma-ray detector collaboration. Riccardo Raabe is co-PI of the ISS solenoidal spectrometer collaboration, and PI of a new an active target detector, SpecMAT, which is currently under construction through an ERC funded grant. The MEDICIS installation for the production of radioisotopes benefits from the old Leuven mass separator magnet, which was transported to CERN from the Louvain-la-Neuve Cyclotron facility in 2015. Thomas Cocolios is co-PI for the MELISSA laser laboratory, currently under construction for producing pure isotopes at MEDICIS.

At the end of 2018, ISOLDE counted 128 actively running experiments that were approved by the INTC in the previous years. Flemish researchers are acting as the spokesperson for 23% of them and they are participating in 65% of all ISOLDE experiments. In the past 15 years, on average 10-15 PhD's per 5 years period have been defended on ISOLDE physics at KU Leuven (see Fig.3 below).

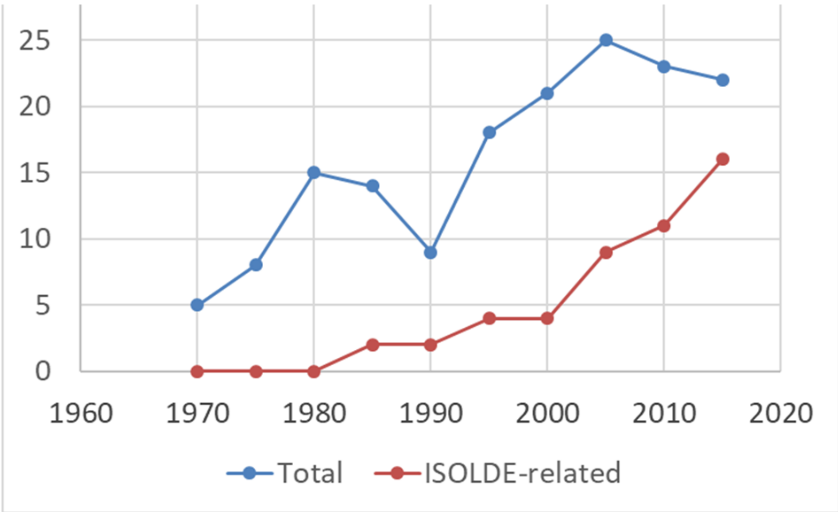


Figure 3: Number of PhD's defended per 5-year period at the Instituut voor Kern- en Stralingsfysica of KU Leuven (red: ISOLDE related, blue: total).

It is interesting to go into more detail on the development of post-accelerated radioactive ion beams at ISOLDE. In fact, the first post-acceleration of radioactive ion beams (worldwide) was achieved in Belgium where a collaboration between the universities of Louvain-la-Neuve (UCLouvain), Leuven (KU Leuven) and Brussels (ULB) succeeded in 1989 to post-accelerate radioactive ^{13}N, by coupling the two cyclotrons at Louvain-la-Neuve. This Belgian collaboration, funded through the first Interuniversity Attraction Poles programme, studied in 1990 the proton capture reaction on ^{13}N leading to the production of ^{14}O, an important astrophysical reaction in the so-called hot CNO burning cycle that takes place in the stars, the 'cooking pots' of our universe, were all matter is born. Based on this experience, Piet Van Duppen as ISOLDE Physics Group Leader in the early nineties, promoted the post-acceleration of ISOLDE beams and submitted in 1994, within an international collaboration, the REX-ISOLDE proposal to the INTC. It was approved by the CERN Research Board as an ISOLDE experiment, and financed mostly by the ISOLDE collaboration. Its key ingredient was an innovative charge- breeding scheme. The first physics experiment was performed in 2001. Very soon it moved from an experiment into a facility and became a permanent part of the ISOLDE infrastructure. The success of REX-ISOLDE was not only due to its universal scheme of post acceleration but also thanks to the performance of its auxiliary detection equipment, especially the high-resolution Miniball germanium detector in which Flanders strongly contributed through FWO grants.

The success of REX's experimental program illustrated the need for higher energies paving the way for the next major upgrade, the HIE-ISOLDE project, by increasing the beam energy from 3 MeV/u up to 10 MeV/u. The project was approved in 2009. Flanders played an important role in this project as a first Big Science grant provided the seed money for the R&D on niobium-on-copper sputtering superconducting RF cavities. In the crucial start-up of the project, Mark Huyse chaired the CERN HIE-ISOLDE Steering Committee from 2009 till 2013. In 2015, the first phase was realized and first physics experiments were performed using one high-beta cryomodule. In spring 2018, phase 2 of the project was finalised, and several highly successful experiments where performed just before CERN's Long Shutdown 2 period, with beam approaching 10 MeV/amu.

6.2 Flemish/Belgian involvement in experimental particle physics at CERN

Experimental Particle Physics in Belgium developed quite naturally from the study of cosmic rays towards accelerator based experiments. The creation of CERN boosted this evolution and during the 1960's -1970's, pictures taken in about every bubble chamber in the world were analysed in our country. This happened at the LIBHE (Laboratoire Interuniversitaire Belge des Hautes Energies 1961-1976), directed by F. Grard, a national laboratory and at the IIHE (Interuniversity Institute for High Energies 1972-present), co-directed by J.Lemonne and J.Sacton, a confederation of the HEP research groups from the universities of Brussels and Antwerp. Based at CERN, a group of Belgian researchers from the IISN-IIKW led by J.P.Stroot, developed electronic detectors for a series of experiments to which they participated. At the beginning of 1980 the landscape for experimentation in particle physics changed. Bubble chambers were phasing out and the use of electronic particle detectors was becoming the standard. The SPS, accelerating protons up to 400 GeV, came into operation. It produced high-energy neutrino beams and a new programme of fixed target experiments. In the neutrino sector the IIHE and UCL research groups contributed to the CHARM II and CHORUS experiments on the CERN site and to the OPERA experiment receiving a muon neutrino beam from the CERN SPS in the Gran Sasso National laboratory (LNGS) about 120 km east of Rome. In the fixed target programme Belgian researchers participated in several NA (North Area) experiments. In 1981 the SPS was transformed into a proton-antiproton collider. At the SPS collider, the IIHE participated in the UA5 experiment studying the collisions produced within a streamer chamber. Some 10 years after the intersecting storage rings (ISR), the era of high-energy colliders had started at CERN.

Also in 1981 the CERN Council approved the construction of the LEP collider; as of today the largest lepton collider ever built. The excavation of the 27 km long underground tunnel started in 1985 and took 3 years. In summer 1989 the experimental programme (LEP I) started at this new facility. Beams of electrons and positrons were brought into collision at 4 interaction regions with a centre of mass energy around 100 GeV, sufficient to produce abundantly the neutral massive Z^0 intermediate boson of the Weak Interaction. The IIHE and the university of Mons-Hainaut pooled resources to participate in the DELPHI experiment. They were given the responsibility to develop and build the forward-backward muon detector for this experiment. Two layers of muon chambers per end cap were designed, built and tested at the VUB premises and transported to CERN. Each layer consisted of 4 "quadrants" of drift chambers; hence 16 "quadrants" in total, plus one spare. Each "quadrant" was an assembly of two orthogonal layers of gas filled aluminium drift tubes operated in limited streamer mode with delay line read out along the central anode wire. The passage of muons through the stations was recorded with a spatial resolution of about 100 µm per coordinate and a time stamp of 2 nsec. Several members of the IIHE had major responsibilities: W.Van Doninck was appointed muon project leader succeeded later by C.De Clercq. J.Lemonne, D.Bertrand and J.Wickens held important positions in the DELPHI management and software areas. Some young talents promoted to their PhD in this experimental programme: J.D'Hondt and N.Van Remortel are a few examples. In a second phase (1995) the LEP energy was raised to reach the threshold of W boson pair production to finally reach its ultimate energy of 209 GeV.

During the 1980's with the successful operation of the CERN proton-antiproton collider at the Super Proton Synchrotron, the idea of a more powerful collider emerged at CERN: a proton-proton collider in the existing LEP tunnel of 27km circumference; the Large Hadron Collider (LHC). The CERN Council approved the project in December 1994. The LEP experimental programme was brought to an end in the year 2000 and LHC installation could start. Several proposals for experiments at this new facility emerged mainly from senior physicists involved at the proton-antiproton collider. Among these proposals, the concept for a Compact Muon Solenoid (CMS) was put forward. Since CMS has become the major or only HEP experiment performed at CERN by Belgian groups for still a few decades ahead, some more details will be devoted to this subject. At the IIHE it was realised that Belgium should not miss this opportunity to join the long-term future for the research field. In 1992

W.Van Doninck, soon followed by C.Vander Velde started a dedicated R&D programme with the aim to join an experiment at the LHC. In collaboration with NIKHEF in Amsterdam they developed wedge shaped Micro Strip Gas Counters (MSGC), a novel detector technology yielding comparable resolution to the already popular silicon Micro Strips but at much lower cost. In all proposed experiments such counters were envisaged to be part of the central tracking systems. In the same spirit as the participation in the DELPHI experiment, the IIHE, UCL and the University of Mons Hainaut (UMH) collectively joined the CMS project. This pooling of resources is the only way for a small country to gain visibility and importance within the steadily growing sizes of collaborations. Around the MSGC project for the CMS tracker, several collaborating institutes joined the Belgian groups: Aachen, Karlsruhe, Lyon, Strasbourg, Genova, Pisa and Novosibirsk. W Van Doninck was appointed chair of the MSGC steering committee. He also was a member of the CMS Management Board and Finance Board representing “other CERN member states” from 1992-2000.

The MSGC consisted of a pattern of alternating anode and cathode metallic (Au) strips deposited via photolithographic processes on a thin glass substrate. Together with a glass drift plane it enclosed a thin gas layer (2mm). The ionization produced by the passage of a charged particle through the gas drifts towards the substrate and gets amplified it the high electric field between anode and cathode strips. The total charge collected on the anodes delivers a sizable electronic signal. The know-how of the Interuniversity MicroElectronics Center (IMEC) in Leuven in producing micro pattern structures has been important in producing such prototype substrates. A close collaboration therefore developed between the IIHE and IMEC. The R&D phase of the MSGC project culminated with a series of extensive long-term milestone tests in a low energy pion beam at the Paul Scherrer Institute (PSI) in Villigen (CH) during 1998 and 1999. The results were outstanding, reaching above 98% detection efficiency and essentially no lost strips due to micro-discharges possibly initiated by heavily ionizing particles. In December 1999 the CMS experiment opted for a full silicon central tracker due to the falling cost of such detectors and the increase of the cost for suitable MSGC substrates, avoiding as such the presence of flammable gas in the heart of the detector.

In January 2000, W. Van Doninck left the IIHE for a sabbatical stay at CERN as scientific associate to help in the building of the CMS detector. Due to his past experience in muon systems from the DELPHI experiment, CMS solicited him to lead the effort of designing and building the forward-backward Resistive Plate Chambers (RPC) project for CMS. The collaborating institutions in this specific project were from China, Pakistan and South Korea. The presence of a European institution was highly wanted and the University of Ghent was invited to join this effort. In 2007 the research group from Ghent joined and successfully produced a sizeable fraction of the RPC detectors in Belgium for the 4th station together with India another newcomer in the project. W. Van Doninck was also invited to join the CMS group of technical coordination and was made responsible for the integration of the YE1 inner end caps, among the most complex elements of the gigantic CMS apparatus where amongst many other systems, the first 2 stations (out of 4) of the forward-backward RPC system had to be deployed.

In Belgium, between 2003 and 2008, part of the end caps of the silicon tracker was built at the IIHE and UCL. The carbon fiber mechanical structures to support the Si-sensors and the electronic read out hybrids were constructed at the IIHE for the entire end cap tracker.
Part of the about 16000 detector modules has been assembled at the IIHE using a gantry robot for a very precise positioning of the different detector elements. All groups involved have deployed electronic test set-ups to verify and validate the module performances. Then they have been assembled into larger structures, called petals due to their shape, and stress tested in a cold environment. All groups have then been involved in the integration of the petal structures into the final tracker end-caps and to the commissioning of the whole device at CERN.

At the university of Ghent the construction of large size, wedge shaped RPC’s has ramped up rapidly. This was quite a complicated project from the logistic point of view. With Bakelite of the right resistivity purchased in Italy, then assembled into gas-gaps at Seoul in Korea, mechanical support structures

purchased in China, to finally be assembled and tested in Ghent, Pakistan and India. China had chosen to assemble their share of detectors at CERN, sending manpower for that purpose.
All RPC chambers have been retested at CERN before installation into the CMS detector. The initial end-cap RPC system deployed 432 wedge shaped double gas gap RPC's. A fourth station of 144 chambers has been added in 2014. The electronics for the read out has been developed and deployed by groups in Lappeenranta (Finland) and Warsaw (Poland).

In Antwerp despites their involvement in the tracker project, they also contributed, mainly at the engineering level, to the CASTOR (Centauro And Strange Object Research) very forward colorimeter of CMS.

All experimental particle physics research groups in Belgium therefore collectively collaborate on the CMS experiment and in diverse subsystems. This strategy of united participation to a single experiment at the LHC pays off. For a rather modest financial investment of about 3%, Belgian scientists have access to one of the world's most unique and powerful scientific instruments. The visibility and responsibilities of Belgian scientists is well above "the fair-share":

3.7% of the PhD-titled authors are at Belgian institutions
4.4% of the authors on CMS publications
5.3% of the number of PhD students
6.6% of physics area conveners
8.3% of the major conference talks
14% (1/7) of the Collaboration Board chairs (J.D'Hondt 2014-2017)
33% (6/18) of the Best PhD Thesis Awards

By the fall of 2008 the CMS detector had been lowered into its underground cavern and was ready for data taking. It consists of a cylindrical barrel centered on the LHC interaction point and two end-caps that close both ends. The apparatus has a diameter of 15m and is 25m long. Its superconducting solenoid magnet produces a magnetic field of 4 Tesla. An iron yoke into which 4 muon stations are embedded surrounds it. The total weight is about 14000 Tons. Inside the solenoid the successive detector layers are the inner tracker, the electromagnetic calorimeter and a hadron calorimeter. The central tracker consists of about 1 m^2 pixel sensors (66 million channels) and about 200 m^2 of silicon micro-strip counters (9,6 million channels). The electromagnetic calorimeter is an assembly of 76000 lead tungstate ($PbWO_4$) scintillating crystals. The hadron calorimeter is a brass-scintillator sampling calorimeter.

In the meantime, the international collaboration had grown to the participation of more than 230 institutions worldwide from about 50 countries. Over 4000 scientists and engineers participate to this scientific adventure. CMS is organized in the following way. According to the Memorandum of Understanding signed between CERN and participating institutions, the exploitation of the CMS experiment is governed by the bylaws or constitution of the Collaboration. The last version of this constitution dates from October 2015 and is developed and signed by Jorgen D'Hondt, acting as Chairperson of the CMS Collaboration Board which is the governing body of the experiment making all major decisions. The Collaboration Board has several committees to discuss and draft policy on specific aspects of the international collaboration; examples are publications, conference presentations, authorship, awards, communications, international relations, careers, etc. The CMS Collaboration Board steers the management that is represented by a Spokesperson. Both the Chairperson of the Collaboration Board and the Spokesperson are so-called level-0 positions and are elected by the board. Each institution is represented in the board by a team leader, currently for Flanders Pierre Van Mechelen (UAntwerpen), Michael Tytgat (UGent) and Jorgen D'Hondt (VUB). The Spokesperson chairs the Management Board and the Executive Board, and is responsible for the scientific and technical direction of the experiment, following the policies agreed by the Collaboration Board. The Chair of the Collaboration Board represents the Collaboration Board in these boards. On the so-called level-1, there are several CMS-wide Coordination Areas each led by a Coordinator (or co-Coordinators) and Detector Systems each led by a System Manager. Each of these level-1 bodies has a longer list of level-2 entities where co-conveners observe a day-by-day coordinating and steering role. Examples of these level-2 entities are the working groups revolving around specific physics themes for which next to permanent researchers also several of the postdoctoral researchers at Flemish institutions have been selected. While the level-0 positions are elected, the selection for other positions follows a system of nominations and deliberation within a dedicated Search Committee chaired by the Collaboration Board chairperson. Researchers at Flemish universities have been elected and selected for several of these positions reported below. The Flemish participation in the CMS experiment is regulated via a Memorandum of Understanding, and funded via the FWO Big Science programme, now the International Research Infrastructure (IRI) programme of the FWO.

The visibility of a small country is thus of utmost importance in a collaboration of over 4000 scientists and engineers. For the analysis of the data gathered since December 2009, CMS is organized as a confederation of physics working groups led by a convener, for a limited term. Belgium institutions had and have quite a number of scientists in this position; a non-exhaustive list is given in addendum 2).
The CMS experiment produces about 100 refereed journal papers per year, an impressive record.

In 2016 the CERN Council approved the high luminosity upgrade of the LHC to be operational around 2026. A corresponding upgrade of the experiments is mandatory and planned. For CMS the currently operational Silicon Tracker will expire by 2023, i.e. its efficiency will degrade to the level that it has to be replaced. The recently designed new Silicon Tracker for the CMS experiment will operate at the HL-LHC from 2026 onwards in enhanced collision conditions. The consortium of Belgian institutions accepted the ambition to construct one end-cap of this new device; the other end-cap will be built in Germany. This is a major project of around 10M euros in core cost and will involve all technical and scientific staff. Although the project represents a unique scientific and technological challenge for the Belgian researchers, they can rely on their experience of assembling the current CMS Tracker instrument. Dedicated clean room infrastructures are being commissioned in our laboratories as well as specific equipment required for the precise construction. The joint UAntwerpen, UCL, UGent, ULB and VUB project is funded by the FNRS, the FWO and the EWI department via a successful application in the competitive Hercules call for large infrastructure with Jorgen D'Hondt as Spokesperson-promoter.

6.3 Funding of the Belgian/Flemish research at CERN

While the Belgian contribution to CERN, paid on the Federal level, is used to run, maintain and upgrade CERN's accelerator complex, the different experiments at CERN are funded through separate grants, mostly provided through the regions.

The ISOLDE and HIE-ISOLDE experiments at CERN are strongly supported through the FWO-Vlaanderen, that funded the operation, the upgrade and the maintenance of many ISOLDE and HIE-ISOLDE experiments through previous BIG-SCIENCE programs, which have recently been reorganized into the IRI (International Research Infrastructures) program. This 'recurrent' funding, from which also the ISOLDE MoU contribution is paid, is critical for the Flemish researchers to maintain a leading role in their experiments at ISOLDE, and to keep these experiments at an international state-of-the-art level.

In the table below, a summary of the major funding received through FWO-Vlaanderen since 2013 is summarized. Apart from that, KU Leuven researchers have also been successful in securing funding through different funding schemes at KU Leuven, the FWO and F.R.S.-FNRS Excellence Of Science (EOS) programme and the European Research Council (ERC). Also the former IUAP programmes have played a crucial role in the development of post-accelerated radioactive beams, as the first such beams were produced by a collaboration between KU Leuven, UCL and ULB researchers at the Cyclotron Research Centre of the UCL, funded through the first IUAP programme.

Project	Begin	Einde	Budget	Type	Titel
G0C2813N	1/01/2013	31/12/2018	€ 5 205 500	Big Science II	Het HIE-ISOLDE project in CERN
G0B3713N	1/01/2013	31/12/2016	€ 410 399	FO	Collineaire laser spectroscopie voor de studie van exotische kernen te
G0C0313N	1/01/2013	31/12/2016	€ 280 000	FO	Modificatie van GeSn-lagen op atomaire schaal, geïnduceerd door
G0C0813N	1/01/2013	31/12/2016	€ 700 000	FO	Vibrationele en elektronische eigenschappen van supergeleidende films
G0B3813N	1/01/2013	31/12/2016	€ 149 800	FO	Transfer-reactie studies op HIE-ISOLDE
G083914N	1/01/2014	31/12/2019	€ 257 848	FO	Laser- en vervalspectroscopie van neutron-arme radioactieve atoomkernen in het lood gebied (Z=282)
G0B3415N	1/01/2015	31/12/2020	€ 253 925	FO	Een nieuwe methode om het Vud quark-mengingselement te bepalen
G098315N	1/01/2015	31.12.2020	€ 258 225	FO	Magnetische adatomen op grafeen bestudeerd door middel van radioactieve ionen als lokale probes
G081716N	1/01/2016	31/12/2019	€ 220 000	FO	Coulomb excitatie metingen met behulp van radioactieve atomen van HIE-ISOLDE
G081218N	1/01/2018	31/12/2021	€ 456 000	FO	WISARD, beta-delayed proton decay as a probe for weak interaction studies
G0F6918N	1/01/2018	31/12/2021	€ 2 480 330	EOS	Heavy Element Research for Nuclear, Atomic and Astrophysics Studies
S005019N	1/01/2019	31/12/2022	€ 2 210 000	SBO	Tb-IRMA-V: Terbium ISOL Radioisotopes for Medical Applications in Flande
I002619N	1/02/2019	31/01/2023	€ 2 079 389	IRI	The ISOLDE facility at CERN
G083914N	1/01/2014	31/12/2017	€ 240 000	Postdoc	Laser and decay spectroscopy of neutron-deficient radioactive nuclei in the lead region (Z=82)
11L4216N	1/10/2015	30/09/2019	€ 180 000	Aspirant	Optimizing the collinear resonance ionization spectroscopy technique for studies on exotic neutron- rich Cu isotopes near the N=50 magic shell gap
11A4719N	1/10/2016	30/09/2020	€ 14 880	Aspirant	
1121818N	1/10/2017	30/09/2019	€ 7 440	Aspirant	
12ZF614N	1/01/2014	31/12/2014	€ 80 000	Postdoc Pegasus Short	FI@CRIS: Investigating Francium Isomerism at CRIS
		Totaal	**€ 15 483 736**		

For the CMS experiment the funding provided by the FWO Vlaanderen is shown in the table below. This table does not take into account the funding obtained before 2013 and for which the project is still running. Also contributions of IUAP's (former BELSPO) and ERC have been welcomed.

Project	Begin	Einde	Budget	Type	Titel
G0C3213N	01.01.13	31.12.18	€ 6'400'000	Big Science II	The CMS experiment at the Large Hadron Collider at CERN
G091109N	01.01.13	31.12.15	€ 200'000	ERA-NET ASPERA call 2(	Een gecoordineerd O&O programma voor lage-energie neutrino-detectoren (LOWE-Nus)
G014913N	01.01.13	31.12.16	€ 768'000	FO	Experimentele verificatie van elektrozwakke symmetrie breking met de Large Hadron Collider
G0C3913N	01.01.13	31.12.17	€ 763'205	Odysseus	Searching Dark Matter with the CMS detector at the current and Future Large Hadron Collider
G046916N	01.01.16	31.12.19	€ 393'946	FO	Search for supersymmetry with 13 TeV proton-proton collisions at the LHC with the CMS detector
G001916N	01.01.16	31.12.18	€ 180'000	FO-LA Oostenrijk	Search for natural supersymmetry with 13 TeV proton-proton collisions at the LHC with the CMS detector
11v3616N	01.10.15	30.09.19	€ 180'000	Aspirant	Search for Interactions of Top Quarks with Dark Matter with the CMS Experiment at the LHC.
12y5518N	01.10.17	30.09.22	€ 240'000	Postdoc	Study of the Higgs boson production in association with a pair of top quarks in final states with tau leptons with the CMS experiment at the LHC
12y5718N	01.10.17	30.09.20	€ 240'000	Postdoc	Search for Heavy Neutrinos using the CMS detector at the LHC
12J6717N	01.10.16	30.09.19	€ 240'000	Postdoc	Study of top-Higgs interactions and b-jet identification with the CMS detector at the LH
11V1315N	01.10.14	30.09.18	€ 180'000	Aspirant	Aspects of Beyond the Standard Model Phenomenology
G0G6118N	01.01.18	31.12.21	€ 1'689'486	EoS	The H boson gateway to physics beyond the Standard Model
G0A3817N	01.01.17	31.12.20	€ 440'000	FO	Precise top quark physics at the LHC in the search for Dark Matter particles
G021314N	01.01.14	31.12.17	€ 240'000	Postdoc	R&D towards a High Rate Particle Detector for the CMS Experiment at the LHC
12F6317N	01.10.16	30.09.19	€ 240'000	Postdoc	A novel study of QCD with final state jet correlations at the LHC.
G066018N	01.01.18	31.12.21	€ 472'000	FO	Color Entanglement in QCD and TeV Jets at Hadron Colliders
11B5714N	01.10.13	30.09.16	€ 180'000	Aspirant	Searching for supersymmetry signals with the CMS detector at the Large Hadron Collider
	27.04.18	26.04.23	€ 5'189'900	HERCULES	Silicon Tracker Endcap for the upgraded CMS experiment at the High-Luminosity LHC at CERN

7 CERN contributions to societal challenges

7.1 Pushing forward the limits of knowledge

7.1.1 Introduction

With about 28.000 journal publications with CERN related authors and more than 42.000 citable papers that cumulated over 1.8 million citations worldwide, it is almost impossible to do justice to the entire scientific legacy of CERN to mankind. Since the start of the LHC operations in 2010 the experiments produced more than 3.000 journal publications and more than 11.000 citable papers with more than 300.000 citations. The uncontested crown jewel of this subatomic research is the Standard Model of particles and fields that describes accurately the fundamental building blocks of matter and the forces that govern their interactions, the so-called "carriers" of the forces. It is probably the best-tested theory of modern physics. The contributions of research performed at CERN have been numerous and decisive to build this theory over more than 5 decades. This chapter of the report will concentrate on a few highlights of the discoveries that pushed forward the limits of knowledge, both in particle and in nuclear physics.

7.1.2 The weak force and the birth of the Standard Model

In 1973 the experimental discovery of "weak neutral currents" in the "Gargamelle" heavy liquid bubble chamber exposed to the first neutrino beam at the CERN PS revealed the existence of a neutrally charged carrier of the weak interaction. This rather unexpected experimental discovery marks the birth of the Standard Model. The two universities of Brussels (ULB, VUB) were part of the international collaboration that made the discovery. It raised renewed interest for the theoretical papers of Glashow, Weinberg and Salam where Electromagnetic and the Weak fundamental forces are unified and where such a neutral intermediate Boson was predicted. The latter were awarded the Nobel Prize in Physics in 1979 for their work. As a consequence of this unification the existence of a fourth fundamental quark ("charm") was predicted and found in 1974 in the US (SLAC and BNL).

The particle content of the Standard Model was gradually growing with contributions from several laboratories around the world: the Tau Lepton (1975 SLAC), the b quark (1977 FNAL), the gluon mediator of the strong force (1978 DESY) and the t quark (1995 FNAL). It required the CERN Super Proton Synchrotron, turned into a proton-antiproton collider, to discover the Z^0 and W^{+-} heavy intermediate Bosons of the Weak Force in the UA1 and UA2 experiments 10 years after the first manifestation of Z^0 exchange in weak neutral currents. Carlo Rubbia and Simon van der Meer shared the 1984 Nobel Prize in Physics for this achievement.

To study these carriers of the Weak Force in detail, the LEP electron-positron circular collider was built at CERN in an underground tunnel of 27 km circumference. It started operation in 1989 at collision energy of 100 GeV, sufficient to excite the Z^0 resonance (mass of 91.2 GeV). Millions of Z^0 Bosons have been produced and studied in 4 experiments installed at the LEP intersection regions: ALEPH, DELPHI, L3 and OPAL. Belgian scientists substantially contributed to these experiments and parts of the DELPHI detector have been designed, developed and built in Belgium. The most prominent among the many results obtained is the measurement of the number of light neutrino species, limited to 3.

In 1995 the LEP collider was upgraded to reach energies above the W pair production threshold (160,1 GeV). The Standard Model has been scrutinized in detail and all predictions were found to agree with the measurements at LEP. The mass of the top quark has been constrained well before its discovery. The ultimate collision energy that LEP has reached is 209 GeV.

7.1.3 The Large Hadron Collider and the discovery of the Brout-Englert-Higgs Boson

In the year 2000 the LEP collider was stopped and dismantled to make room for the installation of the Large Hadron Collider inside of the same tunnel. By that time the Particle Content of the Standard Model was complete with the exception of the fundamental particle that provides mass to the particles. A mechanism which had been developed and published already in 1964 by Belgian theorists François Englert and Robert Brout of the ULB and independently by Peter Higgs from the UK. That Brout-Englert-Higgs Boson has been searched for at all accelerators worldwide ever since. It had become the "Holy Grale" for the Large Hadron Collider (LHC) of CERN.

The LHC came into operation in 2010. In July 2012 CERN announced the discovery of the Boson. The Nobel Prize in Physics of 2013 was granted to F. Englert and P. Higgs and not to R. Brout who had unfortunately passed away before the discovery.

The citation of the Nobel committee is:
"*For the theoretical discovery of a mechanism that contributes to our understanding of the origin of mass of subatomic particles, and which recently was confirmed through the discovery of the predicted fundamental particle, by the ATLAS and CMS experiments at CERN's Large Hadron Collider*"
The last and most important piece of the puzzle had fallen in place.
The Standard Model of particles and force fields is schematically pictured in Fig.4.

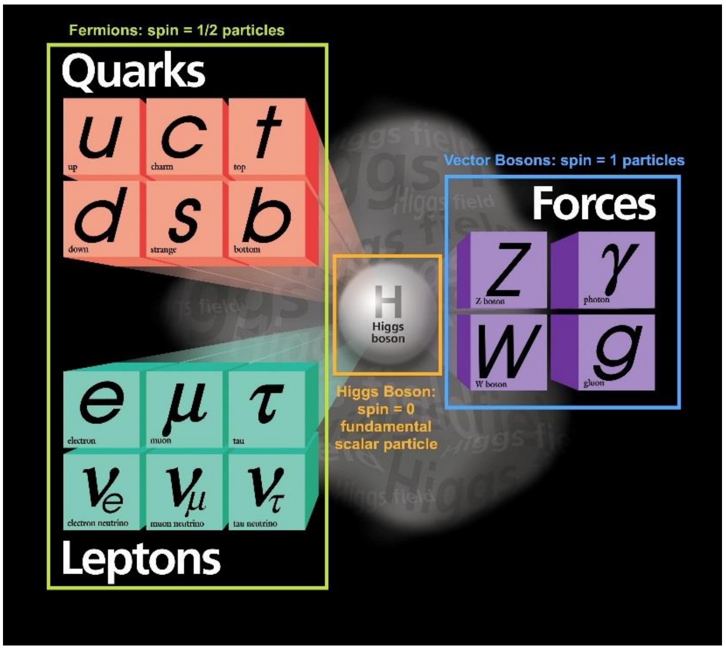


Figure 4: Illustration of particle content of the Standard Model

The Belgian contribution to these discoveries:
As described above, research groups from the Belgian Universities in Antwerp (UA), Brussels (ULB, VUB), Ghent (UGent), Louvain-la-Neuve (UCL) and Mons (UMH) join their forces to collectively participate in the CMS experiment. In this way the Belgian contribution to the discovery of the Brout-Englert-Higgs Boson is substantial and well visible in an international collaboration with about 4000 scientists and engineers. Large and important parts of the detector have been developed and built within their premises and integrated into CMS.

7.1.4 Further breakthroughs

Many other important breakthroughs for the broadening of knowledge have been obtained at CERN such as:

- The precision measurement of the muon g-2.
- The development of multi-wire proportional chambers; a novel technique for the detection of particles, crowned with a Nobel Prize in Physics in 1992 for the French scientist Georges Charpak.
- The first creation and storage of anti-hydrogen atoms in 1995.
- The observation of direct CP violation in 1999.
- And many more.

7.1.5 Nuclear Physics

In the field of nuclear physics, ISOLDE has played a key role from the very first years and until today, in deepening and even changing part of our basic understanding on how a nucleus is built up from its constituent protons and neutrons. The nuclear counterpart of the Particle Physics Standard Model is the so-called 'Nuclear Shell Model'. It has been developed in the late forties by Maria Goeppert Mayer and Hans Jensen, who received the Nobel Prize for their discoveries on 'the nuclear shell structure' in 1963. Ever since, nuclear physicists have put the shell model to the test, and until today unexpected features contained within the shell model picture have been discovered as more exotic isotopes (combinations of protons and neutrons) are produced and studied at facilities like ISOLDE at CERN.

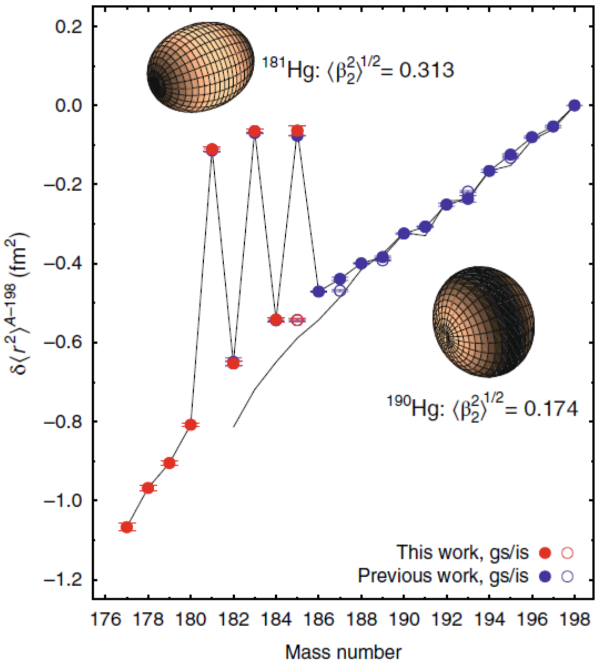
From the early ISOLDE beamline at the on-line separator in 1967 at the SC at CERN ...

... to the present ISOLDE hall with more than 10 dedicated beam lines, including a post-accelerator since 2001.

The highly-segmented MINIBALL high-purity Ge-detector array coupled to the HIE-ISOLDE post-accelerator.

In the early years of ISOLDE, studies of the masses, the decay properties, the ground state spins and the charge radii of very neutron rich Na isotopes suggested that the properties of these isotopes did not correspond with the early predictions from the shell model. In this model, isotopes with a so-called magic number of protons and/or neutrons are predicted to be more strongly bound as compared to their neighbors. Experiments resulted in the opposite i.e. showing that 31Na, and also 32Mg, both having a 'magic' number of 20 neutrons were more strongly bound. These data lead in 1980 to a theoretical paper with the title "Collapse of the conventional shell-model ordering…", concluding the onset of deformation and the need to also consider the possibility to take neutrons in the higher-lying shell into account. This proved to be the start of a long-term project in the nuclear physics community to understand the origin of this phenomenon. In 2005, an experiment led by KU Leuven researchers, measured for the first time the ground state spins, moments and radii of the neutron-rich Mg isotopes. The results revealed that also the 31Mg and 33Mg isotopes behave very different than predicted by shell model, as both nuclei exhibit a very deformed ground state structure as well.

It took many years and intensive experimental programs (many of them at ISOLDE), to realize that in a single nucleus, states with various nuclear shapes and nuclear deformation are appearing, with the spherical shape not necessarily occurring at the lowest energy for isotopes with a magic nucleon number (as predicted by the shell model). This phenomenon is now known as "shape coexistence" and thanks to many experiments at ISOLDE, it was shown that the phenomenon appears in many different regions of the nuclear chart. The extensive interactions between the experimental groups at Leuven and the theoretical nuclear physics group at the UGent, to a deep phenomenological understanding of the physics behind the appearance of 'shape coexistence'.

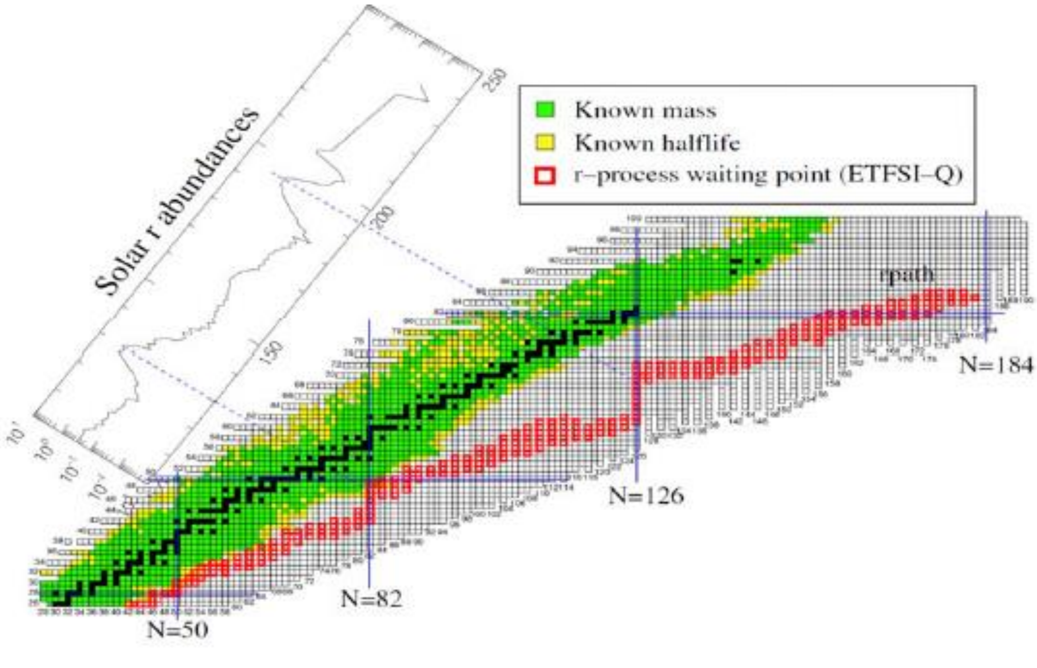


The observation of sharp changes in the nuclear radii of the neutron-deficient Hg isotopes in the seventies, were explained at that time as due to the appearance of a prolate and oblate deformation, coexisting in a single nucleus. By combining recent highly-sensitive experimental devices at ISOLDE to measure masses, charge radii, radioactive decay and magnetic moments, an international collaboration driven by KU Leuven researchers confirmed these early measurements and extended them to much more exotic isotopes. In collaboration with nuclear theory, and thanks to advances in computational power and state-of-the art nuclear shell model theory, after more than 3 decades, this has led to a better understanding on how the correlations between the many nucleons (protons and neutrons) can result in different and in many cases 'collective' behavior of the nucleons, and thus also to different shapes leading to 'shape coexistence". (Nature Physics 2018).

Another particularly important and major step in understanding 'strange' behavior of exotic isotopes, follows from the study of 'halo' nuclei such as 11Li. After it was discovered in the mid-eighties to have a matter radius almost equal to 208Pb, researchers from ISOLDE proposed soon after, that 11Li was built from a 9Li core with a halo of two extra neutrons around it. This picture was proven to be correct by experiments at ISOLDE in the beginning of this century (with Leuven participation), that measured the moments and charge radii of all Li isotopes, showing an identical charge radius for 11Li and its core nucleus 9Li. It was an essential step in understanding those strange systems, that were named "halo" nuclei. This was showing again that whenever new experimental set ups are developed and becoming available, a new window can open up and shine new light in order to understand the way nuclear forces can give rise to the appearance of a new class, called exotic light nuclei.

A major shake-up appeared recently also in the study of the fission process, which is a highly complex one, and is at present not yet fully understood. In a study of beta-delayed fission from 178,180Tl into 178,180Hg, led by a KU Leuven team, it was found that these isotopes split up in two unequal parts (called 'asymmetric' fission), while the fission was expected to happen symmetrically, in two equal parts. This resulted in a big stir in the fission community, pointing out the need to rethink earlier ideas on the fission process. This study at ISOLDE in 2010 caused a renaissance in fission research worldwide. Understanding how the very heavy nuclei that exist on earth, have been synthesized within stellar processes, is another very important and major question in contemporary nuclear physics research. Nuclear reactions that are taking place in the stars and that lead to 'nucleosynthesis', the birth of new elements, are now being studied at all major radioactive beam facilities. Therefore, the post-acceleration of radioactive beams at ISOLDE, available since 2001, has opened up this strong connection with the recent observation of gravitational waves (November 2017). It was shown that the observation of gravitational waves as induced by the neutron-star merger (called GW170817), and the simultaneous observation of a gamma-ray burst, associated to be associated with the rapid neutron-capture (r-process) has given strong indications that the birthplace of the very heavy elements is to be found in these type highly explosive events.

ISOLDE at CERN has also given room to experimental programs that use the atomic nucleus and the wide variety of isotopes with their different decay properties, as a sensitive "medium" to carry out studies e.g. in the field of condensed matter, biochemical sciences and for the study of the underlying symmetries at the basis of the standard model. At ISOLDE, tests of the standard electroweak model are performed through a variety of high-precision studies on the nuclear beta decay. Precision has been the guideline in those experiments, which may indicate glimpses of effects and improving upper limits, that already can lead to information on the description of the current electroweak interaction.



ISOLDE is also a unique place to perform atomic physics studies on elements that only exist as radioactive isotope. That are almost all elements with Z>83, above 209Bi. A recent highlight from such studies, is the first measurement of the ionization potential of the element Astatine (Z=85), by laser ionization spectroscopy in the ISOLDE RILIS laser ion source. This element only exists in trace amounts in nature. Its properties can therefore only be explored by the study of minute quantities of artificially produced isotopes or by performing theoretical studies (Nature Communication 2013).

7.2 Education and training

In the framework of Science-Technology-Engineering- Mathematics (STEM) education that is high on the agenda in Europe, CERN contributes with a variety of opportunities. Since 1998, CERN runs every year international and national teacher programmes. As of now 11.414 high school teachers have benefitted from these programmes. For Belgium and the Netherlands 110 teachers have joined a national programme and 25 in an international programme. These numbers could and should be increased substantially to reach the numbers of comparable countries. Another important training programme at CERN is the "S'Cool Lab" targeting high school pupils. More than 300 Belgian pupils have experienced "hands on" training in this programme. Since 2014 the beamline for schools competition shows great success. Students aged 16 or more propose and develop a research project using one of CERN's beamlines. 936 teams from 76 countries totalling some 8500 students have so far competed with 2 winning teams per year. So far only 2 teams from Belgium have joined this endeavour.

The High School Internship Programme invites students from 4/5 member states/year to spend two weeks at CERN to work out a project. The yearly summer student programme allows students from all over the world to experience working and learning at CERN for their summer vacation of typically 2 months. Here the intake is about 300/year with 3 such positions for Belgian students. At post graduate level CERN offers long term stays of several years for doctoral and technical students, fellowships at the post doc level. Apprentices and trainees can benefit from the high-level technological aspects of all CERN departments. The benefit of all these programmes for society is obvious since after their training at CERN some 45% return to their country and end up in industry. Some 36% go to research institutes and academia while the rest take jobs in other fields.
Additional details concerning the education and training programmes at CERN are given in Fig.5 and in the appendices.

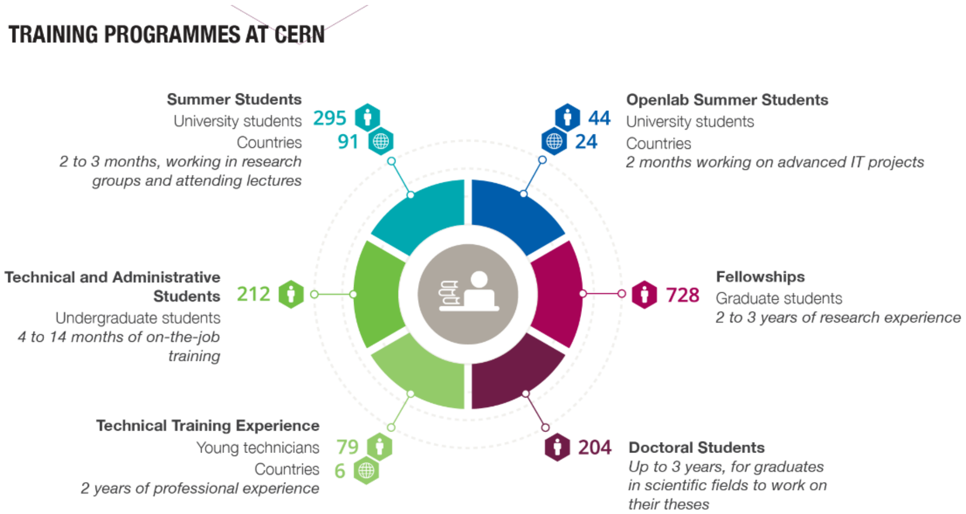


Figure 5: Training programmes at CERN in 2017, for post-secondary school students.

7.3 Energy

7.3.1 The Myrrha project

At present times the major societal challenge is the energy production and consumption in the world. Related to global warming and climate change, solutions for sustainable energy production and recuperation are a major concern for mankind. Although it is not part of CERN's remit, technologies developed at CERN can contribute to this issue. The idea of the "Energy Amplifier" was born at CERN (C. Rubbia and co-workers). It concerns a subcritical Nuclear Reactor driven by an accelerator and able to transmute long-lived radioactive waste of today's nuclear power plants to lower atomic masses, radio toxicity and lifetimes.

This project developed into the MYRRHA project, the only Belgian project on the ESFRI roadmap. The SCK•CEN centre in Mol has taken up this challenge and recently the Belgian government has allotted a financial envelope of 558 MEuro for developing the first phase of this project that may open a new era for clean nuclear power. It is well known that nuclear power has a negligible CO_2 footprint as compared to alternative production methods.

However, two major drawbacks have been recognized since long:
- The self-sustained character of the nuclear fission chain reaction allows for a run-away effect in case of unforeseen problems. Unfortunately the world has witnessed such events in the past leading to public disgrace for nuclear power.
- The waste left after the nuclear combustion cycle contains elements with very long lifetimes and high toxicity that require handling them with care and safe storage for many centuries.

Both drawbacks are potentially solved in the MYRRHA project. The primary neutrons required for nuclear fission are provided by a neutron spallation source driven by a proton accelerator. Any problematic event will immediately stop the accelerator and hence the fission cycle. Although transmutation of nuclear waste has been demonstrated experimentally at lab-scale, its demonstration at pre-industrial scale is mandatory for economic considerations. The fundamental measurements for neutron energies and cross sections for transmutations are measured in the n-TOF facility at CERN.

A close collaboration between SCK•CEN Mol and CERN has been set up around this project. Flanders and Belgium have to be proud to host this project that may fundamentally change the world's vision upon energy production.

7.3.2 ITER

Energy production by nuclear fusion is theoretically well understood but remains a major technological challenge. The sun and all other stars generate their energy by nuclear fusion. Building a controlled "sun" on earth has been a long-standing dream since the end of World War II. Several projects worldwide have tackled this engineering problem and have proven the feasibility to reach "break even" and beyond i.e. positive energy output.

This long-standing research is now concentrated in the truly global ITER project in Cadarache (France). The aim is to contain the hot plasma in a Tokamak magnetic bottle. As such CERN is not involved but the technology of strong magnetic fields with superconducting coils is a major competence of CERN.

After the LHC construction and commissioning, several high-level engineers moved from CERN to the ITER project.

SCK•CEN is actively involved in the development and testing of radiation resistant diagnostics vital for safe and sustainable ITER operation. The BR2 reactor and on-site nuclearized facilities serve to investigate neutron irradiation effects in materials comprising the first wall components to feed engineering database for the nuclear phase of ITER operation.

7.3.3 Vacuum technology for solar panels developed at CERN

On a smaller scale and as an example, thanks to scientists working on particle acceleration at CERN, the Geneva International Airport is the proud owner of a new array of solar panels that forms one of the largest solar energy systems in Switzerland. About 300 high-temperature solar thermal panels cover a surface of 1200 square meters on the rooftop of the airport's main terminal building. The panels are used to keep the buildings warm during the winter months and cool during the summer. The panels are derived from vacuum technology developed at CERN for particle accelerators. This new generation of solar panels is an innovative green technology, the byproduct of a long-term partnership between CERN and industry on the whole.

7.4 Health care

7.4.1 Hadron Therapy

Since long, radiotherapy of cancers with X-ray's has shown a certain degree of success in curing this disease. More recently it was recognised that irradiation with hadrons benefit from more accurate and localised ionisation of tumours thanks to the Bragg peak for this kind of exposure. Protons or Carbon ions are used; the latter providing stronger ionisation. CERN's know-how in particle accelerators contributed to the development of this technique called "Hadron Therapy". Former CERN staff member Ugo Amaldi initiated the "Tera foundation" for the promotion of Hadron therapy in Europe. The A.D.A.M. group at CERN deals especially with the Application of Detectors and Accelerators to Medicine. Several treatment centres exist worldwide and Belgium may be proud to host the IBA Company a world leader that delivers turnkey solutions for hadron therapy. The company was founded by a nuclear physicist from UCL. He and his team performed their research in the Louvain-la-Neuve cyclotron centre, where also many Flemish nuclear physicists were trained in the eighties and nineties. This therapy makes extensive use of software developed at CERN for the simulation of the passage of particles through matter. The first such centre in Belgium will soon start to operate in Leuven.

7.4.2 Radioisotopes in nuclear medicine

Radioisotopes have a variety of applications in the modern world. In industry they allow to investigate welding quality, leak detection, material fatigue etc. In environmental science they allow dating of fossils, study fluid flows etc. Their usage in nuclear medicine is overwhelming. Radioisotopes are widely used for functional imaging and are expected to play a major role in cancer treatment with new alpha emitters currently under development, e.g. at the MEDICIS facility (MEDical Isotope Collections from ISOLDE) at CERN. The ^{223}Radium chloride (Xofigo®) radiopharmaceutical is now used as a treatment and pain relief drug in advanced bone cancers resistant to hormones. However, either shortage in the supply of the commonly used ^{99m}Technetium or the lack of access to new chemical elements with adequate radioactive emission properties are a severe treat to the supply of these drugs or the development of personalized treatment that combine functional imaging and therapy, the so-called theragnostic. The MEDICIS facility was born out of the ISOLDE facility at CERN that provides radioactive beams for fundamental physics research since more than 5 decades. The Instituut voor Kern- en Stralingsfysica of the KU Leuven is one of the founding institutes. MEDICIS makes use at its core of a dipole magnet formerly used for radioactive ion beam research in Louvain-La-

Neuve by the Leuven team. The radioisotopes produced at MEDICIS are readily available for medical research, and projects at UZ Leuven Gasthuisberg (Radiopharmacy & Nuclear Medicine) are currently ongoing making use of 155Tb produced at CERN. Also the SCK•CEN centre in Mol has longstanding experience in the production of radioisotopes and collaborates with CERN for the development of its nuclear medical campus, aiming to apply the same technology at the new ISOL@MYRRHA radioisotope production facility.

The MEDICIS Marie Sklodowska-Curie Innovative Training Network of the Horizon 2020 EU program is based at CERN and started on 1st April 2015 for the benefit of medical research, including a Leuven-based early stage researcher investigating the production of 11C for PET-aided hadron therapy.

7.4.3 Medical imaging techniques

Medical imaging techniques are increasingly important tools for medical diagnosis. Prominent among them is the PET scanning technique or Positron Emission Tomography. A short-lived radioisotope is administered to the patient, for brain imaging mostly phosphor 18 in a sugar solution is used. Other elements prevail for other organs. The isotope emits positrons that immediately annihilate with electrons in the body. Two back-to-back gamma rays (photons) of 511 keV are emitted. To detect them and reconstruct their trajectories use is made of scintillating crystals.

These scintillating crystals have been developed for High Energy and Nuclear Physics experiments, in particular at CERN. Particle detection and identification is a core activity at CERN and large arrays of scintillating crystals have been developed and built there. A prominent example is the BGO (Bismuth-Germanium-Oxide) photon detector of the L3 experiment at CERN. In the CMS experiment at the LHC an array of over 80.000 crystals of Lead-Tungstate crystals is in use to measure and identify electrons and photons. One of the first prototype PET scanners for small animals has been developed and built at the VUB by Prof. S. Tavernier and his team. Since then it is a commonly used technique in hospitals worldwide. It allows providing 3-D imaging of the metabolism of organs and hence can reveal cancerous activity.

7.4.4 Microelectronics

Microelectronics is a long-term speciality at CERN. Micro-strip and pixel silicium detectors have been developed for HEP experiments worldwide for the digitalisation of particle trajectories. A long-standing collaboration between IMEC and ESAT in Leuven and CERN has culminated in the birth of the MEDIPIX chip, an indispensable tool for 3-D medical imaging. Here the role of Flanders and its Centres of Excellence in this matter has been of paramount importance.

7.5 Information Technology

The computing needs of CERN have always been important. HEP experiments produce in the course of time an increasing amount of data that need to be analysed, stored and shared. No wonder that the **World Wide Web was born at CERN** during the late 1980's. In particular the Internet protocol Http (Hyper text transfer protocol) and the first web browser were developed by Tim Berners-Lee and Belgian national Robert Cailliau. In 1991 this innovation was made publically available without patents or licenses. No doubt it is CERN's largest and most significant contribution to mankind at large. It is quite impossible to imagine the functioning of our global world today without the Internet. The worldwide impact is illustrated in Fig. 6.

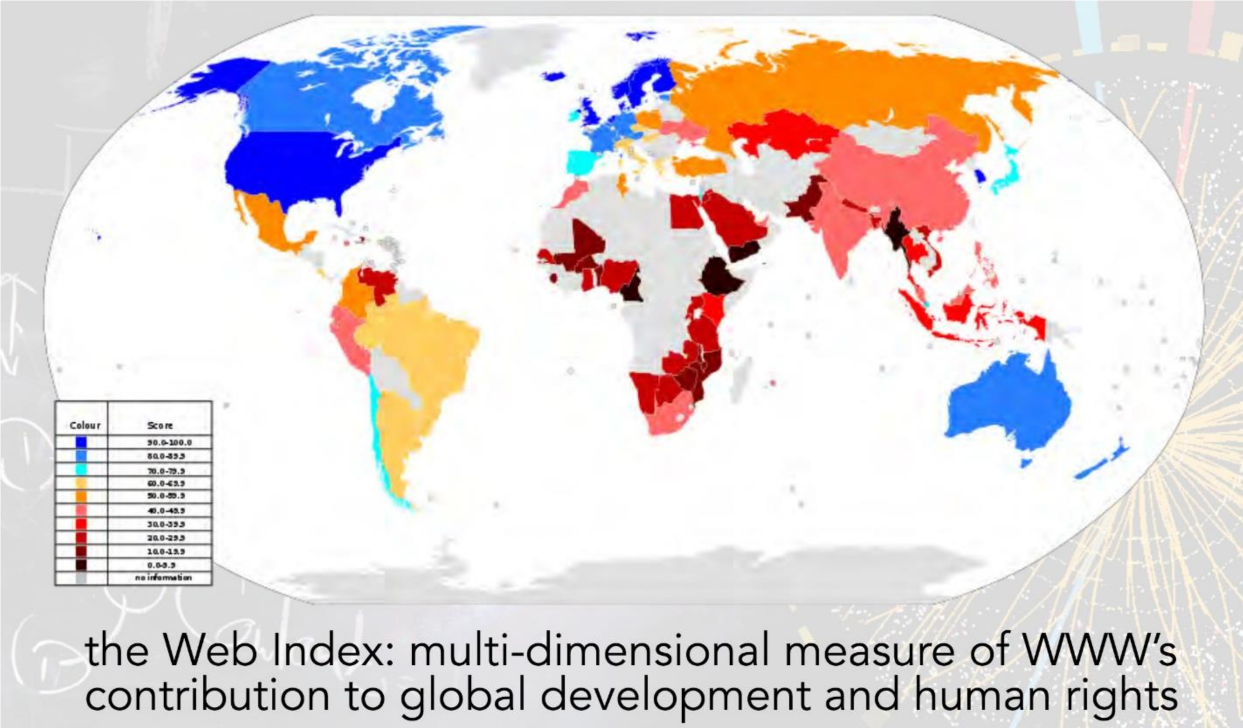


Figure 6.

The World Wide LHC Computing Grid allows access, distribution, management and analysis of the data from the LHC experiments. With more than 170 computer centres in 42 countries gathering over 1 million computer cores and running more than 1 million tasks per day this Grid is the result of many successive upgrades of the WWW. Its storage capacity approaches one Exabyte. In Belgium Begrid ULB-VUB and Belgrid at UCL are part of this global Grid.

Open access is a major leitmotif at CERN not only for publications but also for data. CERN took the lead in the SCOAP3 initiative.

7.5.1 Software development

Another important activity of CERN is the development of software to handle vast amounts of data and analyse them. Computer programmes emerging from CERN are freely available and are used extensively in a variety of other fields of science, medicine and industry. The simulation of the passage of particles through matter is only one of many examples.

7.5.2 Advanced education and training of the human resources

The universal aspect of computer skills in our digital world makes the turnover of personnel in the IT department rather high. People that have gathered working experience at CERN's computing infrastructure are highly wanted by many activity sectors in society and are offered attractive jobs there. This is also an important aspect of return to society from CERN.

7.6 Technology transfer

The core mission of the Laboratory is fundamental research in particle physics; it also has the remit to train the next generation of scientists and to bring nations together. Scientific advances at CERN require significant technological developments – these technologies have a positive impact on society globally. Part of the mission of the laboratory is also to make its knowledge and technologies available to society, often through technology transfer to industry, providing novel business solutions in many fields as depicted in Fig. 7. The department of industry, procurement and knowledge transfer (IPT) of CERN is the first point of contact for industry at CERN.

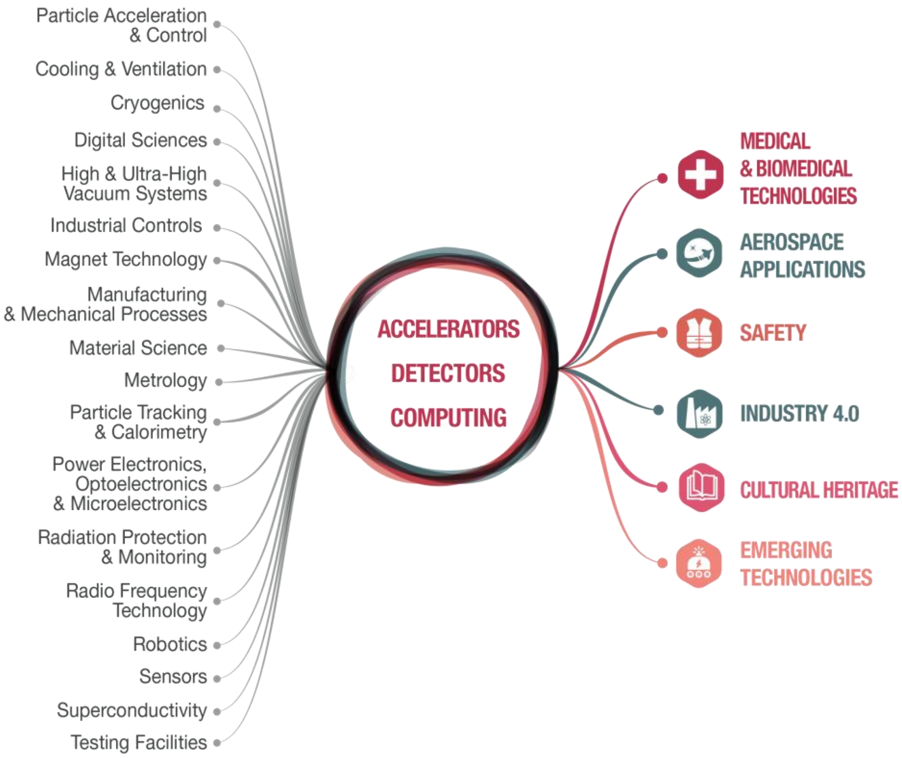


Figure 7: Through novel developments in technologies related to accelerators, detectors and computing, CERN technologies and know-how *(left)* contribute to applications in many fields *(right)*: from medical & biomedical technologies to aerospace applications, and from industry 4.0 to cultural heritage.

The return to industry from scientific research centers was first assessed at CERN: from 1 Swiss franc invested in research, 3 Swiss francs return to business. Recent studies have evaluated the benefits for companies in terms of technological learning and innovation gained from working with advanced technologies for the LHC. These benefits include improved competitive edge via technology acquisition and new product developments.

The IPT department also provides support for start-ups using CERN technologies, and has partnered with Business Incubation Centers in several Member States to host new projects. Several start-ups (listed in Fig. 8) have benefitted from this support. Unfortunately Belgium is still missing in this list.

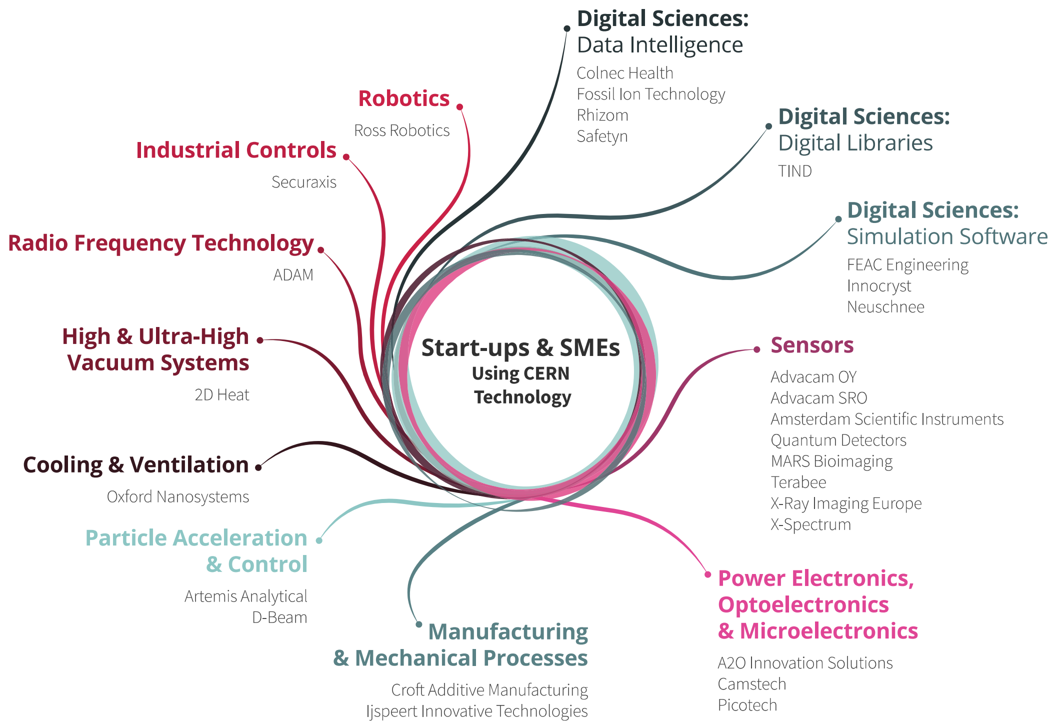


Figure 8: Start-ups based on CERN technologies

Such incubation centres are operational in 10 members states. Unfortunately, Belgium is still missing in this list.

7.7 Social and organisational issues

The CERN model for international collaboration has been widely adopted by subsequent organisations and institutions. By its very nature, science has no borders and is going more and more global. Pooling of resources to afford large research infrastructures is the key. A simple but strong convention, excluding military applications, for a given research field has allowed the success of CERN as an intergovernmental organisation. CERN has a global budget with payments by member stated according to their GDP. Voting procedures in the CERN Council grant one vote per member state irrespective of the size of their contribution.

In general, consensus is sought and often found. There are no national or other quotas for employment of personnel; only excellence is used as criterion. There are no barriers of nationality, religion, colour, age, gender or sex orientation. The concept of open access is handled for all fields: data, technologies etc. The example of CERN in promoting collaboration has for instance also been employed for the SESAME light source in Jordan. The hope is there to foster peace in the Middle East by bringing scientists of countries in this region to collaborate on scientific projects in a way similar to CERN in the early days of post war Europe.

7.8 CERN outreach and arts

The major asset of CERN in matters of outreach is the visit of its site and installations, including the underground. There are two permanent exhibitions: **Microcosm** and the **Globe of Innovation**. The first one is a pedagogical tour of the subatomic world of particles and forces and the link to modern cosmology. The second one is housed in a landmark building that was the Swiss pavilion at the World exhibition in Neuchatel and was offered to CERN for its 50th anniversary by Switzerland. According to TripAdvisor, CERN is Geneva's top tourist attraction, welcoming 136.000 visitors last year. Most of them are general public, pupils, students and teachers often coming from far away. CERN visits are also quite popular with important people from all over the world. 136 VIP protocol visits have taken place in 2017 meaning about 3 per week. In this respect Belgium is also doing quite well. Our 3 last Kings have visited CERN and lots of Belgian politicians and decision makers benefitted from this lifetime experience. Also the CERN travelling exhibition "Accelerating Science" visits member states and draws impressive numbers of visitors each year. Its agenda is already quite full for the year to come. **The CERN Courier** appears 6 times a year and is available on the Internet as well as the more frequently issued CERN bulletin. They keep you up to date with events in or connected to CERN.

The program "Arts at CERN" hosted 12 renowned artists from around the world, who visited the Laboratory or partnered with CERN scientists for periods of one or three months. The programs were fully supported by prominent arts institutions such as FACT in the UK, the Arts Council in the Republic of Korea, Kontejner in Croatia and ProHelvetia in Switzerland. A new scheme to support the production and exhibition of artworks resulting from the residencies was launched in collaboration with FACT.

8 Conclusions

This report is the outcome of a “thinkers’ program” of the class of Natural Sciences of the Royal Flemish Academy of Belgium (KVAB) on the theme: “Flanders, Belgium and CERN”. Ever since the creation of the CERN organization, Flemish and Belgian scientist and engineers have contributed to the buildup of the laboratory’s infrastructures or have used them to conduct their research. They have largely contributed to the evolution of what has become the largest laboratory for subatomic physics research Worldwide. Highlights of this collaboration have been shown in this document. Besides the very important legacy of scientific results left to mankind, other aspects of the role of CERN for Belgium, and Flanders in particular, have been described. In particular CERN’s contributions to solving several societal challenges in matters of energy production and storage, health care and information technology have been developed. The invention of the **World Wide Web** some 30 years ago is certainly the most famous heritage to mankind. The education and training performed at CERN is an important part of its mission and represents probably the most important return to the member states. Industrial return from CERN projects to Flanders and Belgium is quite good as compared to other member states and CERN has an active Technology Transfer department to help the dissemination of the many technologies developed at CERN. The CERN model of global collaboration and pooling of resources has often been followed by subsequent organizations. Its laboratory at Meyrin near Geneva is a top tourist destination and attracts well over one hundred thousand visitors per year. Science and arts are often combined in the permanent or temporary exhibitions that always encounter great success.

Belgian science can be proud of its important contributions in the past and have benefitted from the boost that the existence of CERN procures. By all means a continued support to CERN is recommended.

9 Addenda

9.1 Acronyms

ACEC	Ateliers de Constructions Electriques de Charleroi (BE)
AD	Antiproton Decelerator
ALEPH	Apparatus for LEP Physics at CERN experiment at LEP
ATLAS	A Toroidal LHC ApparatuS
AWEX	Agence wallonne à l'Exportation et aux Investissements étrangers
BELSPO	Belgian Science Policy Office
BNL	Brookhaven National Laboratory (US)
CERN	Conseil Européen pour la Recherche Nucléaire
CHARM	CERN-Hamburg-Amsterdam-Rome-Moscow collaboration
CHORUS	CERN Hybrid Oscillation Research apparatUS experiment
CMS	Compact Muon Solenoid
CNGS	CERN Neutrinos to Gran Sasso
COLLAPS	COLinear Laser SPectroscopy
CP violation	Charge and Parity violation
CRIS	Collinear Resonance Ionization Spectroscopy
CT3	Computerized Tomography
DELPHI	Detector with Lepton, Photon and Hadron Identification
DESY	Deutsches Elektronen-Synchrotron
ECFA	European Committee for Future Accelerators
ERC	European Research Council
ESO	European Southern Observatory
EWI	Economie Wetenschap Innovatie
FC	Finance Committee
FIT	Flanders Investment and Trade
FNAL	Fermi National Accelerator Laboratory (US)
FRS-FNRS	Fond de la Recherche Scientifique (Wallonie-Bruxelles)
FWO	Fonds voor Wetenschappelijk Onderzoek (Vlaanderen)
HEP	High Energy Physics
HIE-ISOLDE	High Energy ISOLDE
IIHE	Interuniversity Institute for High Energies
IIKW	Interuniversitair Instituut voor KernWetenschappen
IISN	Institut Interuniversitaire des Sciences Nucléaires
IPKT	Industry, Procurement and Knowledge Transfer
IPT	Industry and Procurement Transfer
IRI	International Research Infrastructure
ISOLDE	On-line Isotope mass Separator
IT	Information Technology
LEIR	Low Energy Ion Ring
LEP	Large Electron-Positron collider
LHC	Large Hadron Collider
LIBHE	Laboratoire Interuniversitaire Belge des Hautes Energies
LINAC	LINear ACcelerator
L3	Experiment at the LEP collider
MEDICIS	Medical Isotopes Collected from ISOLDE
n-ToF	neutron Time Of Flight
OPAL	Omni-Purpose Apparatus at LEP
OPERA	Oscillation Project with Emulsion-tRacking Apparatus
PS	Proton Synchrotron
REX_ISOLDE	Post accelerator at ISOLDE

SCK•CEN	The Belgian Nuclear Research Centre
SLAC	Stanford Linear Accelerator Centre (US)
SPC	Scientific Policy Committee
SPS	Super Proton Synchrotron
STEM	Science Technology Engineering Mathematics
TREF	Tripartite Employment Conditions Forum
UA1, UA2	Experiments at the SPS proton-antiproton collider
WISArD	Weak Interaction Studies with Argon decay
WWW	World Wide Web

9.2 Major Belgian responsibilities at ISOLDE and CMS

Leading roles of KU Leuven scientists at ISOLDE and CERN

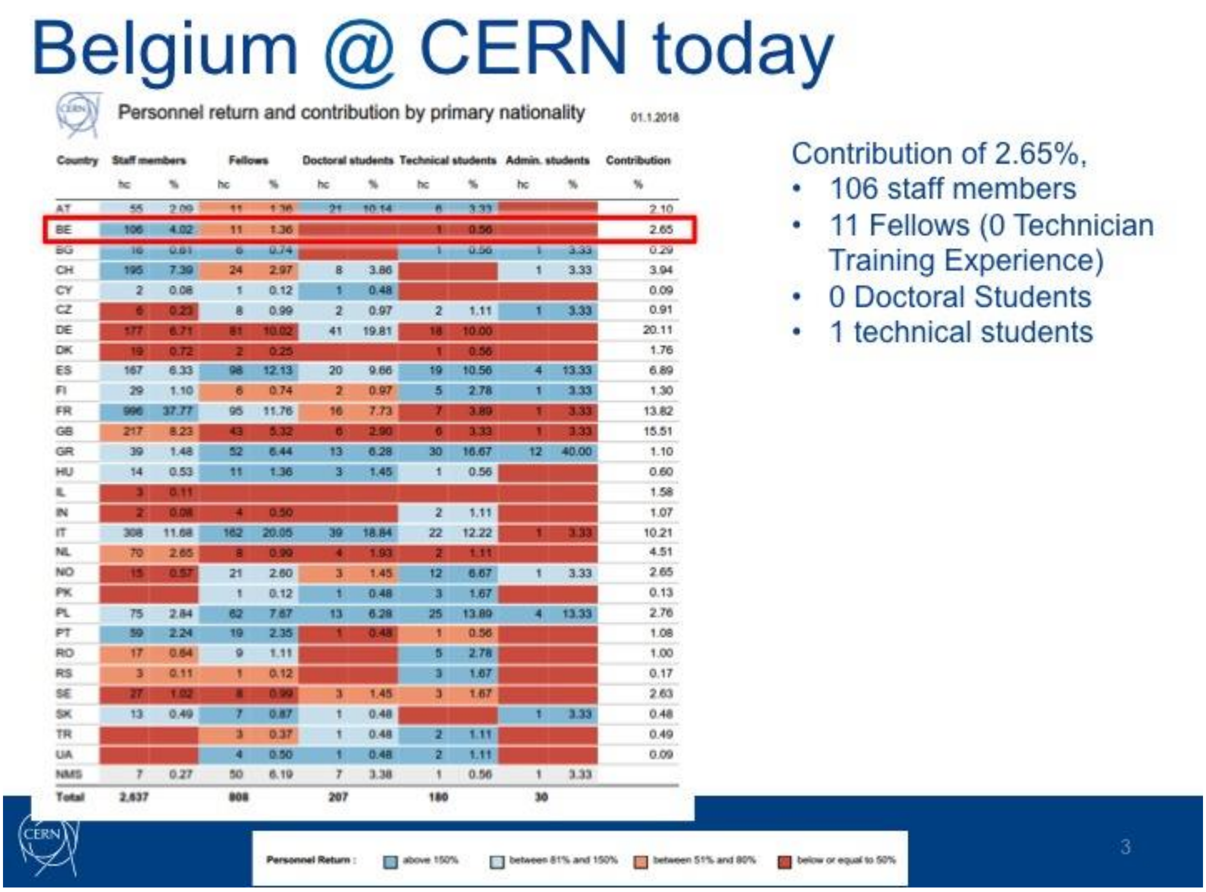
1993-1995	Piet Van Duppen, elected as ISOLDE Physics Group Leader and Collaboration Spokesperson, CERN staff member
1999-2002	Piet Van Duppen, elected as chair person of the ISCC
2006-2009	Mark Huyse, appointed as chairperson of the INTC
2014-2019	Mark Huyse, appointed member of the CERN Science Policy Committee (SPC)
2017-2020	Gerda Neyens, elected as ISOLDE Physics Group Leader and Collaboration Spokesperson, CERN staff member

Leading roles of Belgian scientists at CMS

Top quark physics	J'D'Hondt 2007-2008
Forward physics	P.Van Mechelen 2011-2012
Beyond 2 generation physics	F.Blekman 2013-2014
Muon reconstruction	D.Trocino 2014-2015
Heavy flavour tagging and vertexing	P.Van Mulders 2014-2016
Forward physics	H.Van Haevermaet 2016-2018
Heavy flavor tagging and vertexing	K.Skovpen 2017-2019
Jet physics and missing energy	R.Schoefbeck 2016-2017

At the collaboration level Belgian responsibilities are or have been as follows:
M.Tytgat, Deputy Muon-RPC Project Manager, 2011-2015
M.Tytgat, Deputy Muon-GEM Project Manager, 2011-2015
J.D'Hondt, Chair of the CMS International Committee, 2013-now
J.D'Hondt, Chair of the CMS Career Committee, 2012-2014
J.D'Hondt, Chair of the CMS Search Committee, 2014-2017
P.Van Mechelen, Deputy Chair, CMS Publication Committee, 2015-2017
M.Tytgat, Chair of the GEM Institution Board, since 2015.

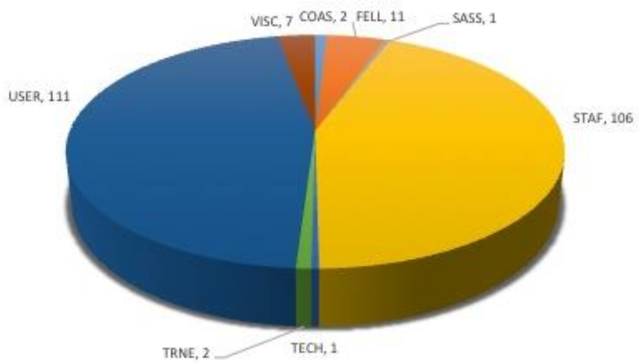
9.3 CERN personnel and job opportunities



Country	Staff members		Fellows		Doctoral students		Technical students		Admin. students		Contribution
	hc	%	hc	%	hc	%	hc	%	hc	%	%
AT	55	2.09	11	1.36	21	10.14	6	3.33			2.10
BE	106	4.02	11	1.36			1	0.56			2.65
BG	16	0.61	6	0.74			1	0.56	1	3.33	0.29
CH	195	7.39	24	2.97	8	3.86			1	3.33	3.94
CY	2	0.08	1	0.12	1	0.48					0.09
CZ	6	0.23	8	0.99	2	0.97	2	1.11	1	3.33	0.91
DE	177	6.71	81	10.02	41	19.81	18	10.00			20.11
DK	19	0.72	2	0.25			1	0.56			1.76
ES	167	6.33	98	12.13	20	9.66	19	10.56	4	13.33	6.89
FI	29	1.10	6	0.74	2	0.97	5	2.78	1	3.33	1.30
FR	996	37.77	95	11.76	16	7.73	7	3.89	1	3.33	13.82
GB	217	8.23	43	5.32	6	2.90	6	3.33	1	3.33	15.51
GR	39	1.48	52	6.44	13	6.28	30	16.67	12	40.00	1.10
HU	14	0.53	11	1.36	3	1.45	1	0.56			0.60
IL	3	0.11									1.58
IN	2	0.08	4	0.50			2	1.11			1.07
IT	308	11.68	162	20.05	39	18.84	22	12.22	1	3.33	10.21
NL	70	2.65	8	0.99	4	1.93	2	1.11			4.51
NO	15	0.57	21	2.60	3	1.45	12	6.67	1	3.33	2.65
PK			1	0.12	1	0.48	3	1.67			0.13
PL	75	2.84	62	7.67	13	6.28	25	13.89	4	13.33	2.76
PT	59	2.24	19	2.35	1	0.48	1	0.56			1.08
RO	17	0.64	9	1.11			5	2.78			1.00
RS	3	0.11	1	0.12			3	1.67			0.17
SE	27	1.02	8	0.99	3	1.45	3	1.67			2.63
SK	13	0.49	7	0.87	1	0.48			1	3.33	0.48
TR			3	0.37	1	0.48	2	1.11			0.49
UA			4	0.50	1	0.48	2	1.11			0.09
NMS	7	0.27	50	6.19	7	3.38	1	0.56	1	3.33	
Total	2,637		808		207		180		30		

Personnel Return : above 150% / between 81% and 150% / between 51% and 80% / below or equal to 50%

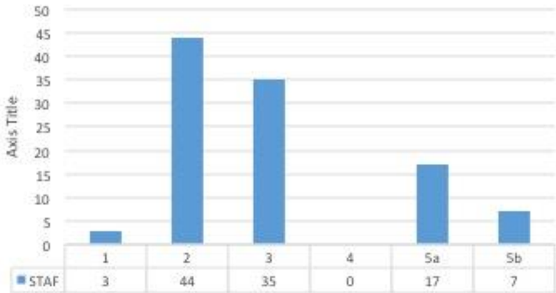
Belgium @ CERN – a closer look



VISC: Visiting Scientist
COAS: Corresponding Associate
DOCT: Doctoral Student
FELL: Fellow:
GPRO: Guest Professor
PJAS: Project Associate
SASS: Scientific Associate
STAF: Staff member
TECH: Technical Student
TRNE: Trainee

Data: 23 January 2018

Belgian Staff by Professional category and contract type



Belgian Staff Member evolution by Professional Category and Contract Type over the past 5 years

Professional category	2014		2015		2016		2017		2018	
	LD	IC	LD	IC	LD	IC	LD	IC	LD	IC
1				2		2		2	1	2
2			2	46	3	45	2	41	2	42
3			6	32	7	32	8	30	7	29
5A			4	9	4	9	5	13	5	13
5B			1	5	1	5	1	6	1	6
Total	0	0	13	94	15	93	16	92	16	92

NB: Includes BE as second nationality (+2 on IC)

Data: 23 January 2018

Fellows, Associates and Students: evolution of applications

Belgian FAS applicants evolution over the past 5 years

		2014			2015			2016			2017			2018		
		All	BE	%	All	BE	%	All	BE	%	All	BE	%	All	BE	%
Administrative Students	Application Received	389	5	1.29	357	2	0.56	439			550	2	0.36	432		
	Application Complete	239	3	1.26	210			272			336	1	0.3	241		
	Refused Offer	7			7			4			5			3		
	Selected	25			53			33			53			36		
Corresponding Associates	Application Received	25			33			43			49			55		
	Application Complete	20			25			31			42			37		
	Refused Offer															
	Selected	15			21			19			23			18		
Doctoral Students	Application Received	273			246	1	0.41	317	2	0.63	300	1	0.33	305	2	0.66
	Application Complete	167			156	1	0.64	212	2	0.94	205	1	0.49	233	2	0.86
	Refused Offer	2			10			5			9			6		
	Selected	54			98	1	1.02	87	1	1.15	85			97		

Data: 23 January 2018

6

Fellows, Associates and Students: evolution of applications

Belgian FAS applicants evolution over the past 5 years

		2014			2015			2016			2017			2018		
		All	BE	%	All	BE	%	All	BE	%	All	BE	%	All	BE	%
Fellowships	Application Received	2,764	22	0.8	2,208	24	1.09	2,592	30	1.16	3,021	29	0.96	2,796	25	0.89
	Application Complete	1,378	14	1.02	1,227	19	1.55	1,562	25	1.6	2,155	26	1.21	1,946	20	1.03
	Refused Offer	18			15	1	6.67	26			28	1	3.57	46	1	2.17
	Selected	272	4	1.47	295	7	2.37	340	7	2.06	396	5	1.26	354	3	0.85
High School Teachers Programme	Application Received	87	3	3.45	120			198	1	0.51	138					
Scientific Associates	Application Received	108			143	1	0.7	169			155	1	0.65	173		
	Application Complete	87			124			132			109	1	0.92	127		
	Refused Offer				1			3			1			1		
	Selected	53			55			52			52	1	1.92	56		
Summer Students	Application Received	4,113	17	0.41	4,181	39	0.93	4,264	30	0.7	4,279	21	0.49	5,092	23	0.45
	Application Complete	2,265	23	1.02	2,313	21	0.91	3,517	32	0.91	2,159	20	0.93	3,019	20	0.66
	Refused Offer	13			23			24			17			18		
	Selected	310	3	0.97	310	4	1.29	327	4	1.22	331	3	0.91	342	3	0.88
Technical Students	Application Received	1,213	14	1.15	1,348	11	0.82	1,511	16	1.06	1,485	12	0.81	1,458	8	0.55
	Application Complete	897	10	1.11	953	9	0.94	1,152	13	1.13	1,150	7	0.61	1,020	6	0.59
	Refused Offer	8			22			10			32	2	6.25	18		
	Selected	161	3	1.86	289	2	0.69	205	6	2.93	233			222	1	0.45
Total		14,963	121	15.81	14,843	143	20.59	17,546	169	16	17,398	134	21.97	18,151	114	10.04

Data: 23 January 2018

7

Belgian evolution of staff applications

Belgian Staff applicants evolution over the past 5 years

Status of applications	2014			2015			2016			2017			2018		
	All	BE	%	All	BE	%	All	BE	%	All	BE	%	All	BE	%
Application Received	10,583	135	1.28	12,573	182	1.45	12,084	143	1.18	12,177	137	1.13	14,434	174	1.21
Invited (Staff)	447	5	1.12	605	9	1.49	612	11	1.8	608	12	1.97	738	10	1.36
Not Attended	30			25			33			17			32	1	3.13
Refused Offer	3			16			8			9			13		
Selected	112	4	3.57	162	4	2.47	162	2	1.23	152	2	1.32	209	3	1.44
Total	11,175	144	5.97	13,381	195	5.41	12,899	156	4.21	12,963	151	4.42	15,426	188	7.14

Data: 23 January 2018

CERN 8

Next applications deadlines

- Fellowship (committee in May 2018):
  - cern.ch/fell
  - 5th March 2018
- Technical/Administrative student programme (committee in June 2018):
  - cern.ch/tech, cern.ch/admin
  - Opening early December 2017
  - Application deadline: 16th April 2018

- Summer student programme (selection in March 2018):
  - cern.ch/summies
  - 28th January 2018

- Technician Training Experience (open all year round with 4 selection committees per year):
  - cern.ch/tte
  - Next deadline 31st January 2018

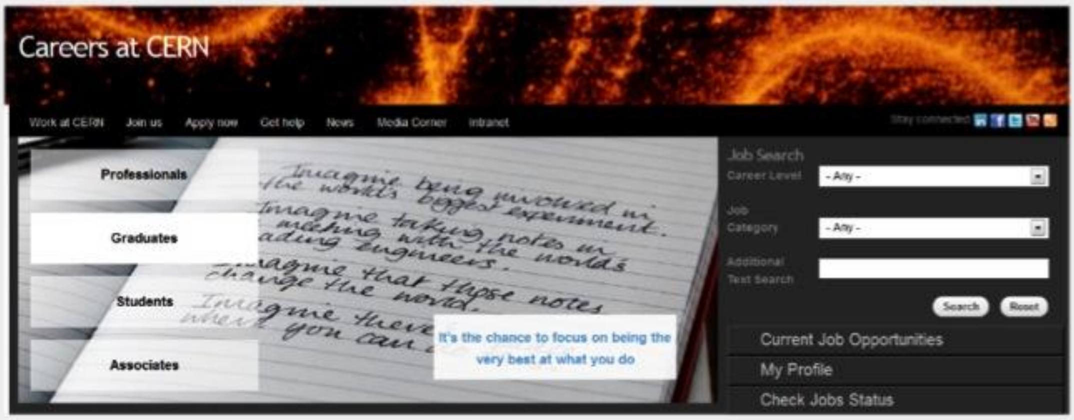
CERN 9

Promoting opportunities: "CERN Jobs"

@CERN_JOBS

"Job and project day" Outreach event, 16 October 2017 in Liege

Take part!



careers.cern

Technical Students programme

"It's a great place to start a career, it's a great place to learn new skills, make new friends…"

~ 200 positions/year

FIELDS :	applied physics, engineering, computing
LENGTH :	4 to 12 months
ELIGIBILITY :	18 months of technical undergraduate studies
FEATURES :	a technical project with a CERN supervisor a living allowance, incl. health insurance

Committees in June and December

Admin Students programme

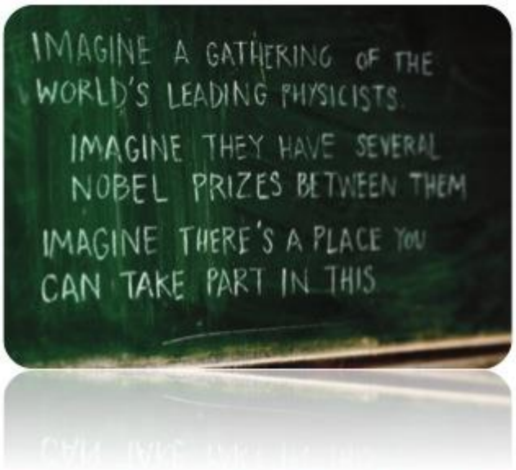
"My Admin Studentship was a great experience – I had exposure to more activities than I could have imagined"

~ 30 positions/year

FIELDS :	Translation, human resources, business administration, law, finance, librarianship, science communication, audiovisual, communication and public relations…
LENGTH :	4 to 12 months
ELIGIBILITY :	18 months of undergraduate studies
FEATURES :	an administrative project with a CERN supervisor a living allowance, incl. health insurance

Committees in June and December

Doctoral Student programme



"Gave me the opportunity to meet important people, especially in the research fields"

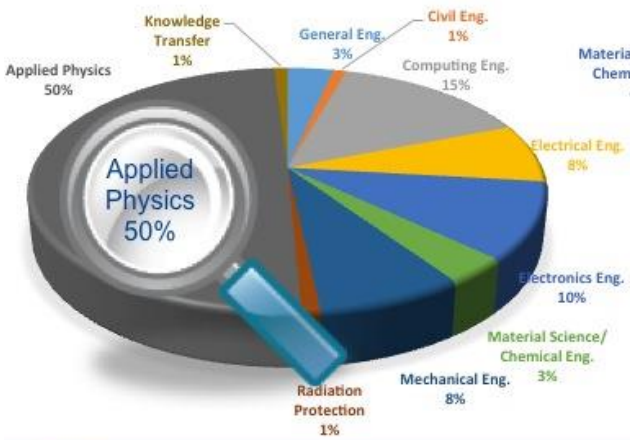
~60 positions/year

FIELDS :	applied physics, engineering, computing
LENGTH :	6 mths -3 years
ELIGIBILITY :	enrolled in a doctoral program in a Member State university
FEATURES :	a technical project, leading to a PhD thesis co-supervised by the university thesis advisor and a CERN staff member a living allowance incl. Health insurance

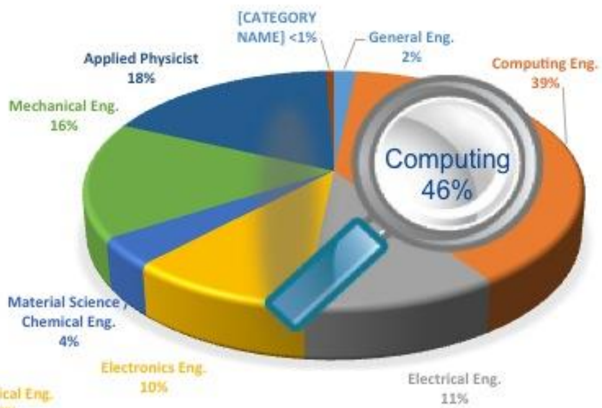
Committees in June and December

Students by Discipline

DOCTORAL STUDENTS



TECHNICAL STUDENTS



Summer Students programme

"Can't imagine a better way to spend my summer"

~200 positions/yr

FIELDS :	physics, engineering, computing
LENGTH :	8 to 13 weeks, during the summer
ELIGIBILITY :	3 years of full-time studies at university level
FEATURES :	high-quality lecture programs- lecturers leaders in their field/ world-wide
	visits and workshops
	living allowance
	accommodation in CERN hostel

Selection February

Over 6000 young scientists have benefitted to date...

Fellows

"An ideal place to follow the most recent ideas in physics and start new collaborations"

~250 positions/year

FIELDS :	physics, engineering, computing - from junior engineers to posst-doc research physicists
LENGTH:	**2-3 years**
ELIGIBILITY :	BSc, MSc or PhD
	no more than 10 years relevant post-MSc experience
FEATURES :	employment contract
	attractive salary incl. social benefits
	training and networking

Fellows are normally nationals of the Member States of CERN. There also exist a limited number of places for Fellows from non-Member States.

Committees in May and November

Marie Sklodowska-Curie

RESEARCH & INNOVATION
Marie Skłodowska-Curie actions

For university graduates

FIELDS :	physics, engineering, computing
DURATION:	up to 3 years
ELIGIBILITY :	MSc or PhD
	≤5 years post-degree experience
FEATURES :	funded by the European Commission
	an employment contract with CERN
	specific Marie-Curie vacancies published on CERN web pages
	an attractive salary, social benefits, allowances
	international network

Technician Training Experience

~30-50 positions/year

FIELDS :	Mechanics, electronics, electricity, etc.
ELIGIBILITY :	Technical diploma
	no more than 4 years relevant experience
SELECTION:	All applications for TTE opportunities will be considered by a panel of CERN specialists.
FEATURES :	An initial contract of one year renewable for a second year
	Project with CERN supervisor
	Training and networking (on the job, formal, languages)
	Employment contract with attractive salary incl. social benefits

"I never imagined the possibilities CERN would offer me."

Committees in June and December

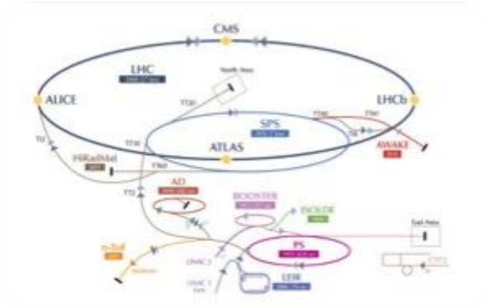
Staff positions

"It's the chance to focus on being the very best at what you do."

~ 150 positions/year

FIELDS :	physics, engineering, computing, technicians, administrative staff
ELIGIBILITY :	from apprenticeship to PhD
SELECTION:	advertised on cern.ch/jobs
	application via ATS
	Asynchronous video-screening (Sonru)
	Interview at CERN
FEATURES:	up to 5 year initial limited duration contract
	competitive salaries incl. social benefits
	relocation expenses
	training (language courses, technical training)

Associates



Scientific Associates
Experienced individuals on leave of absence mainly in physics
Normally 12 months (24 months max)

Cooperation associates / Users
Scientists (including PhD students in physics)

Corresponding Associates
Experienced individuals from smaller Member States on leave of absence mainly in physics
Up to 6 months

Project Associates
Physicists, engineers and technicians invited by Departments (according to agreements)
Up to 3 years

	Track Year					
	2012	2013	2014	2015	2016	2017
Job Programme	Application Track Count	Application Track Count	Application Track Count	Application Track Count	Application Track Count	Application Track Count
Administrative Students	2	5	2	-	2	-
Children of Members of Personnel	3	8	4	7	3	4
Doctoral Students	-	-	1	2	1	2
Fellowships	13	22	27	33	33	30
High School Teachers Programme	3	3	-	1	-	-
Scientific Associates	-	-	1	-	1	-
Special Programmes	1	3	5	7	-	5
Staff	276	252	248	184	185	239
Stagiaire	2	4	-	1	28	13
Summer Students	16	17	40	33	21	22
Technical Students	7	14	12	18	12	8
Grand Total	**323**	**328**	**340**	**286**	**286**	**323**

	Track Type Description		
	Application Received	Selected	Success Rate
Job Programme	Application Track Count	Application Track Count	
Children of Members of Personnel	4	3	75.0%
Doctoral Students	2	0	0.0%
Fellowships	30	4	13.3%
Special Programmes	5	1	20.0%
Staff	239	3	1.3%
Stagiaire	13	5	38.5%
Summer Students	22	3	13.6%
Technical Students	8	1	12.5%

	Track Year					
	2012	2013	2014	2015	2016	2017
Job Programme	Application Track Count	Application Track Count	Application Track Count	Application Track Count	Application Track Count	Application Track Count
Administrative Students	2	5	2	-	2	-
Children of Members of Personnel	3	8	4	7	3	4
Doctoral Students	-	-	1	2	1	2
Fellowships	13	22	27	33	33	30
High School Teachers Programme	3	3	-	1	-	-
Scientific Associates	-	-	1	-	1	-
Special Programmes	1	3	5	7	-	5
Staff	276	252	248	184	185	239
Stagiaire	2	4	-	1	28	13
Summer Students	16	17	40	33	21	22
Technical Students	7	14	12	18	12	8
Grand Total	**323**	**328**	**340**	**286**	**286**	**323**

9.4 Finances

1. SUMMARY OF REVENUES AND EXPENSES BY ACTIVITY

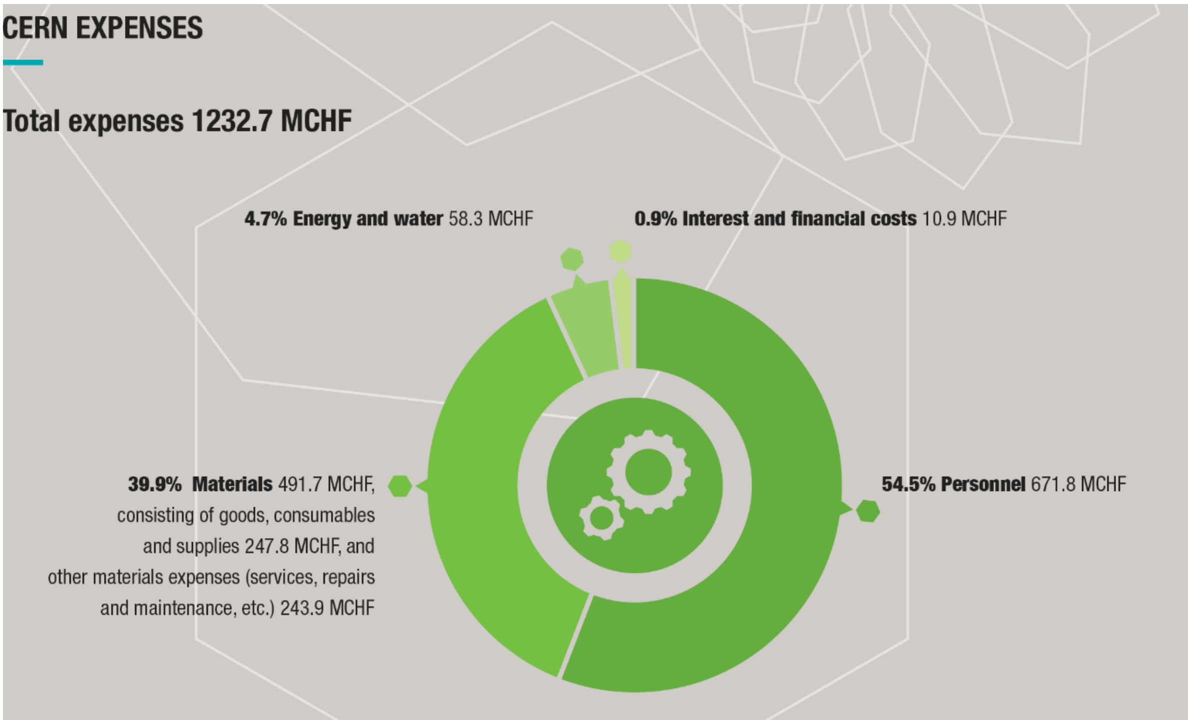
Figure 1: Summary of Revenues and Expenses by Activity

(in MCHF, rounded off)	Final 2017 Budget CERN/FC/6060[3] (2017 prices)	Revised 2017 Budget CERN/FC/6124 (2017 prices)	2017 Out-Turn CERN/FC/6206/Rev. (2017 prices)	Variation of 2017 Out-Turn with respect to Revised 2017 Budget	
				MCHF	%
		(a)	(b)	(c)=(b)-(a)	(c)/(a)
REVENUES	**1 230.1**	**1 235.2**	**1 271.9**	**36.7**	**3.0%**
Member States' contributions	1 119.9	1 119.9	1 119.9	0.0	0.0%
Associate Member States' contributions	10.2	21.8	22.3	0.5	2.3%
Contributions anticipated from new Associate Member States	10.0				
EU contributions	16.0	14.1	15.9	1.8	12.6%
Other revenues[1]	74.1	79.4	113.8	34.4	43.4%
EXPENSES	**1 202.5**	**1 229.5**	**1 232.7**	**3.2**	**0.3%**
Scientific programmes	503.0	497.4	476.1	-21.3	-4.3%
Infrastructure and services	287.6	298.4	292.2	-6.2	-2.1%
Centralised expenses[1]	178.4	177.9	196.7	18.8	10.6%
Projects and studies	233.6	255.8	267.6	11.8	4.6%
BALANCE					
Annual balance	27.6	5.7	39.2	33.5	
Capital repayment allocated to the budget (Fortis, FIPOI 1, 2 and 3)	-25.9	-25.9	-25.9	0.0	
Recapitalisation Pension Fund	-60.0	-60.0	-60.0		
Annual balance allocated to budget deficit	-58.3	-80.2	-46.7	33.5	
-Cumulative balance[2]- - 118.4	**-176.7**	**-198.6**	**-165.1**	**33.5**	

[1] Including 18.4 MCHF of revenue corresponding to materials expenses recharged to teams. This heading is separately shown for the first time in 2017 as agreed with the External Auditors.

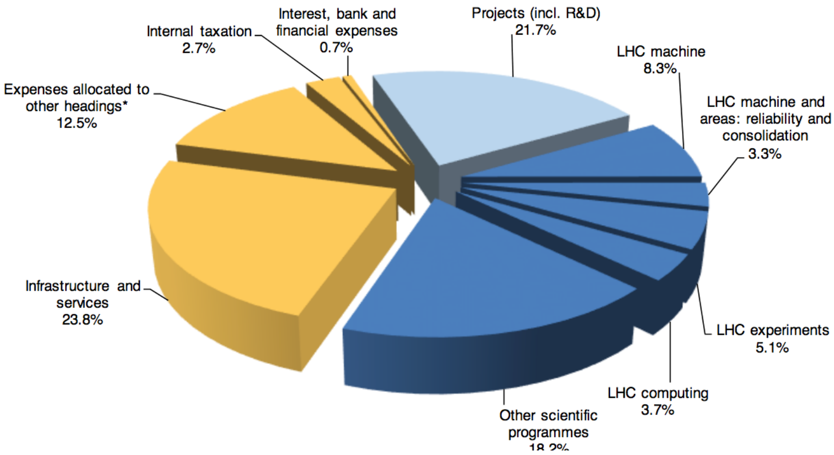
[2] The cumulative balance of -118.4 MCHF is the accumulated budget deficit as stated in the Financial Statements for 2016 (CERN/FC/6117, page 19).

[3] The breakdown of expenses by activity follows the structure introduced in the MTP 2017 (CERN/FC/6124).



4. EXPENSES BY SCIENTIFIC AND NON-SCIENTIFIC PROGRAMMES

Figure 4: Expenses breakdown by activity



Domestic financing of CERN related projects by FWO Vlaanderen

	A	B	C	D	E	F
1	Project	Begin	Einde	Budget	Type	Titel
2	G0C2813N	01/01/13	31/12/18	€ 5'205'500	Big Science II	Het HIE-ISOLDE project in CERN
3	G0C3213N	01/01/13	31/12/18	€ 6'400'000	Big Science II	The CMS experiment at the Large Hadron Collider at CERN
4	G091109N	01/01/13	31/12/15	€ 200'000	ERA-NET ASPERA call 2013	Een gecoordineerd O&O programma voor lage-energie neutrino-detectoren (LOWE-Nus)
5	G014913N	01/01/13	31/12/16	€ 768'000	FO	Experimentele verificatie van elektrozwakke symmetrie breking met de Large Hadron Collider
6	G0C3913N	01/01/13	31/12/17	€ 763'205	Odysseus	Searching Dark Matter with the CMS detector at the current and Future Large Hadron Collider
7	G0B3713N	01/01/13	31/12/16	€ 410'399	FO	Collineaire laser spectroscopie voor de studie van exotische kernen te ISOLDE-CERN
8	G0C0313N	01/01/13	31/12/16	€ 280'000	FO	Modificatie van GeSn-lagen op atomaire schaal, geïnduceerd door energetische interacties en dunne -filmgroei
9	G0C0813N	01/01/13	31/12/16	€ 700'000	FO	Vibrationele en elektronische eigenschappen van supergeleidende films en nanodeeltjes bestudeerd met vooruitstrevenden synchrotron- en theoretische method
10	G0B3813N	01/01/13	31/12/16	€ 149'800	FO	Transfer-reactie studies op HIE-ISOLDE
11	G046916N	01/01/16	31/12/19	€ 393'946	FO	Search for supersymmetry with 13 TeV proton-proton collisions at the LHC with the CMS detector
12	G001916N	01/01/16	31/12/18	€ 180'000	FO-LA Oostenrijk	Search for natural supersymmetry with 13 TeV proton-proton collisions at the LHC with the CMS detector
13	G081716N	01/01/16	31/12/19	€ 220'000	FO	Coulomb excitatie metingen met behulp van radioactieve atomen van HIE-ISOLDE
14	11v3616N	01/10/15	30/09/19	€ 180'000	Aspirant	Search for Interactions of Top Quarks with Dark Matter with the CMS Experiment at the LHC.
15	12y5518N	01/10/17	30/09/22	€ 240'000	Postdoc	Study of the Higgs boson production in association with a pair of top quarks in final states with tau leptons with the CMS experiment at the LHC
16	12y5718N	01/10/17	30/09/20	€ 240'000	Postdoc	Search for Heavy Neutrinos using the CMS detector at the LHC
17	12J6717N	01/10/16	30/09/19	€ 240'000	Postdoc	Study of top-Higgs interactions and b-jet identification with the CMS detector at the LH
18	11V1315N	01/10/14	30/09/18	€ 180'000	Aspirant	Aspects of Beyond the Standard Model Phenomenology
19	G0G6118N	01/01/18	31/12/21	€ 1'689'486	EoS	The H boson gateway to physics beyond the Standard Model
20	G0A3817N	01/01/17	31/12/20	€ 440'000	FO	Precise top quark physics at the LHC in the search for Dark Matter particles
21	G021314N	01/01/14	31/12/17	€ 240'000	Postdoc	R&D towards a High Rate Particle Detector for the CMS Experiment at the LHC
22	12F6317N	01/10/16	30/09/19	€ 240'000	Postdoc	A novel study of QCD with final state jet correlations at the LHC.
23	G066018N	01/01/18	31/12/21	€ 472'000	FO	Color Entanglement in QCD and TeV Jets at Hadron Colliders
24	11B5714N	01/10/13	30/09/16	€ 180'000	Aspirant	Searching for supersymmetry signals with the CMS detector at the Large Hadron Collider
25	G083914N	01/01/14	31/12/17	€ 240'000	Postdoc	Laser and decay spectroscopy of neutron-deficient radioactive nuclei in the lead region (Z=82)
26	11L4216N	01/10/15	30/09/19	€ 180'000	Aspirant	Optimizing the collinear resonance ionization spectroscopy technique for studies on exotic neutron- rich Cu isotopes near the N=50 magic shell gap
27	12ZF614N	01/01/14	31/12/14	€ 80'000	FO Pegasus Short	FI@CRIS: Investigating Francium Isomerism at CRIS
28	11R2414N	01/10/13	30/09/17	€ 180'000	Aspirant	A new precise measurement of the neutron electric dipole
29	G081218N	01/01/18	31/12/21	€ 456'000	FO	WISARD, beta-delayed proton decay as a probe for weak interaction studies
30			Totaal	€ 21'148'336		

Domestic financing of CERN related projects by F.R.S-FNRS

Les chercheurs permanents (CQ, MR et DR) du F.R.S.-FNRS de ces 5 dernières années (2014 à 2018) ont été identifiés comme « relatifs au CERN » si au moins un des critères suivants était rempli:
- Le profil du chercheur comprend le champ descripteur « PE2_2 Physique des particules »
- Le profil du chercheur comprend l'un des mots suivants : CERN, LHC, CMS, « physique des particules », « particle physics »

Les profils des chercheurs identifiés CERN ont ensuite été manuellement examinés afin de vérifier leurs activités. Un chercheur a été écarté de la liste pour cause de « congé politique ».
Il faut noter que les chercheurs travaillant dans le domaine de la physique des particules et ayant une approche plus théorique ont été conservés, certains pouvant être amenés plus ou moins directement à travailler avec le CERN.

Au final, **15** chercheurs différents ont été identifiés. Par année, les chercheurs affiliés CERN se répartissaient de la manière suivante :

Chercheurs identifiés	**Mandat**	**2014**	**2015**	**2016**	**2017**	**2018**
	CQ (Chercheur qualifié)	8	8	7	7	5
	MR (Maître de recherches)	3	3	3	3	4
	DR (Directeur de recherches)	2	2	3	2	3
	Total	13	13	13	12	12

Table 1. Nombre de chercheurs identifiés « CERN » en fonction chaque année

Les coûts annuels des salaires de ces chercheurs ont été calculés à partir du budget **estimatif** des coûts moyens annuels (Table 2).

Mandat	**2014**	**2015**	**2016**	**2017**
Chercheur Qualifié	92 800.00 €	94 700.00 €	96 600.00 €	98 600.00 €
Maître de recherches	99 600.00 €	101 600.00 €	103 700.00 €	105 800.00 €
Directeur de Recherches	120 700.00 €	123 200.00 €	125 700.00 €	128 300.00 €

Table 2. Budget estimatif des coûts moyens annuels des chercheurs permanents du F.R.S.-FNRS

Ne disposant pas des coûts annuels pour l'année 2018, nous avons calculé les salaires annuels 2018 sur base des coûts estimés en 2017.

Les coûts annuels estimés des salaires des chercheurs permanents identifiés CERN sont présentés Table 3.

Année	**2014**	**2015**	**2016**	**2017**	**2018**	**Total**
Coût annuel estimé	1 282 600 €	1 308 800 €	1 364 400 €	1 264 200 €	1 301 100 €	6 521 100 €

Table 3. Estimation du coût annuel des salaires des chercheurs permanents identifiés CERN, et coût total de 2014 à 2018

Crédits et projets :

Tableau 1 - Crédits et projets – Dépenses annuelles (par instrument)

Ces dépenses résultent d'octrois accordés à partir de 2010.

Instrument de financement	2013	2014	2015	2016	2017	Total par instrument
Crédit de recherche (CDR)	0,00 €	10.000,00 €	6.216,00 €	0,00 €	7.000,00 €	**23.216,00 €**
IISN Nouveau Projet (IISN NEW)	650.900,00 €	562.300,00 €	647.500,00 €	119.650,00 €	336.798,00 €	**2.317.148,00 €**
IISN Avenant (IISN AV)	207.900,00 €	1.877.870,00 €	1.693.467,00 €	1.886.983,00 €	1.546.144,00 €	**7.212.364,00 €**
IISN Prolongation (IISN PROL)	601.064,00 €	320.602,00 €	345.602,00 €	270.000,00 €	834.972,00 €	**2.372.240,00 €**
Logisticien de recherche (LOG)	0,00 €	47.000,00 €	188.000,00 €	141.000,00 €	0,00 €	**376.000,00 €**
Mandat d'impulsion scientifique (MIS)	107.600,00 €	0,00 €	0,00 €	0,00 €	0,00 €	**107.600,00 €**
Mandat d'impulsion scientifique - Prolongation (MIS PROL)	0,00 €	105.200,00 €	0,00 €	0,00 €	0,00 €	**105.200,00 €**
Total par année	**1.567.464,00 €**	**2.922.972,00 €**	**2.880.785,00 €**	**2.417.633,00 €**	**2.724.914,00 €**	**12.513.768,00 €**

Tableau 2 - Crédits et projets – Dépenses annuelles (par type de dépense)

Ces dépenses résultent d'octrois accordés à partir de 2010.

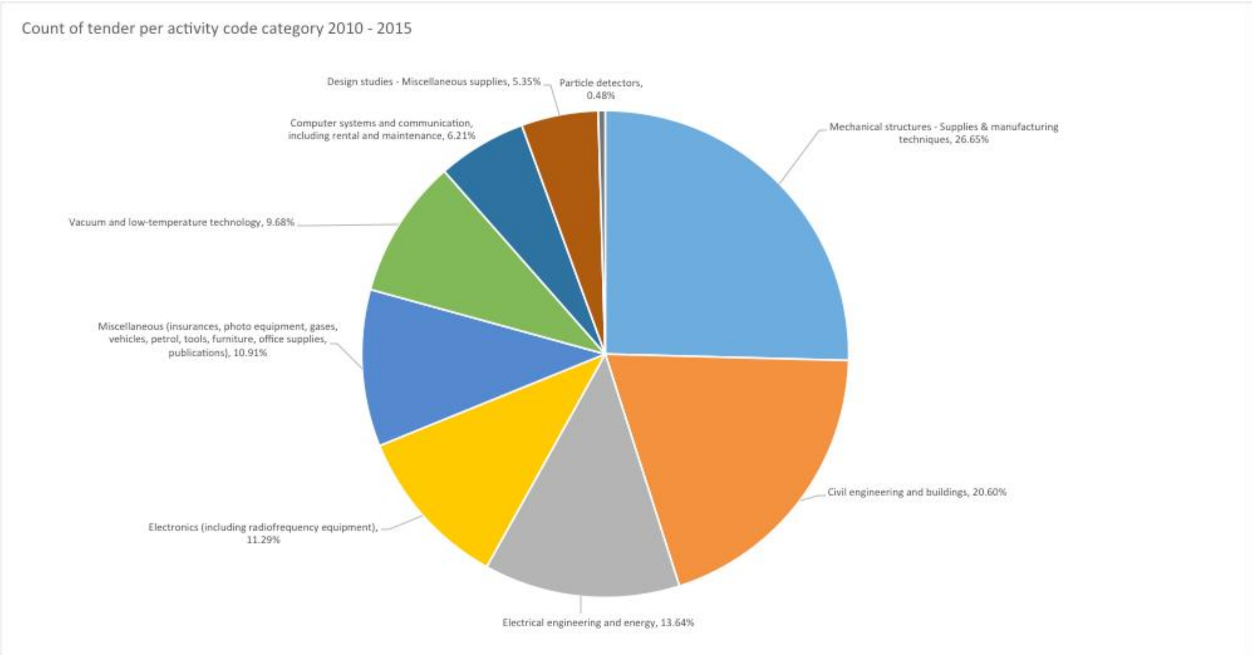
Type de dépense	2013	2014	2015	2016	2017	Total par type de dépense
Équipement	188.114,00 €	271.852,00 €	244.802,00 €	208.787,00 €	551.368,00 €	**1.464.923,00 €**
Fonctionnement	829.950,00 €	917.620,00 €	985.840,00 €	720.820,00 €	803.555,00 €	**4.257.785,00 €**
Fonctionnement de support	0,00 €	0,00 €	4.500,00 €	0,00 €	0,00 €	**4.500,00 €**
Personnel	549.400,00 €	1.733.500,00 €	1.645.643,00 €	1.488.026,00 €	1.369.991,00 €	**6.786.560,00 €**
Total par année	**1.567.464,00 €**	**2.922.972,00 €**	**2.880.785,00 €**	**2.417.633,00 €**	**2.724.914,00 €**	**12.513.768,00 €**

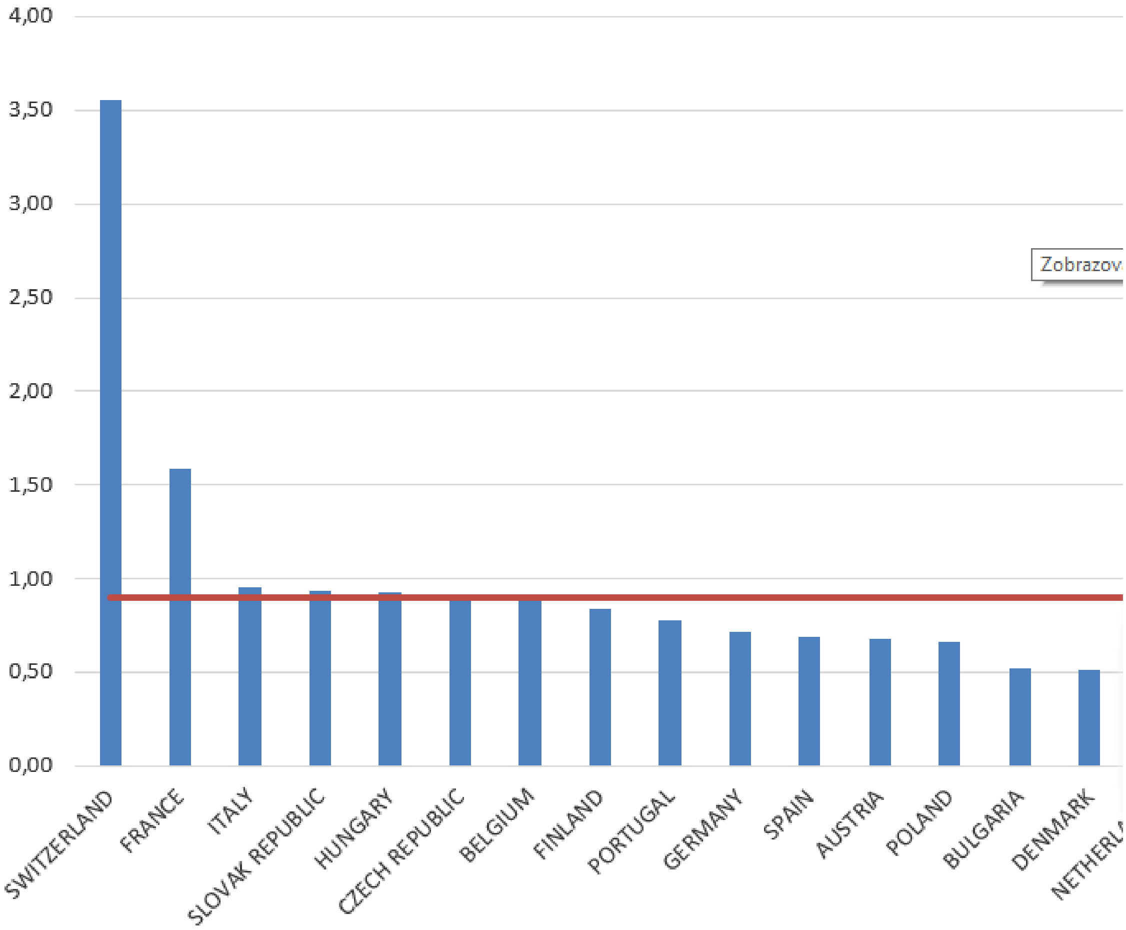
Mandats:

Tableau 3 - Nouveaux mandats octroyés chaque année, période 2013-2017

Mandats		Coût annuel moyen (2018)	2013	2014	2015	2016	2017	TOTAL	Nombre d'octrois relatifs au CERN / Nombre d'octrois
Doctorant	**Aspirant** (ASP - 2 ans)	38.800 €	1	0	1	1	0	**3**	**0,5%**
	Aspirant-renouvellement (ASP-REN, 2 ans)	38.800 €	3	2	1	1	1	**8**	**1,3%**
	FRIA-Bourse 1 (15 ou 27 mois)	35.200 €	4	3	1	1	2	**11**	**1,7%**
	FRIA-Bourse 2 (21 mois)	35.200 €	3	0	5	2	0	**10**	**1,5%**
Post-doctorant	**Chargé de recherche** (CR, 3 ans)	76.900 €	4	3	2	2	2	**13**	**3,0%**
	Chargé de recherche, 4e année de mandat (CR4, 1 an)	Supprimé	0	2	0	0	0	**2**	**1,4%**
Chercheur permanent	**Chercheur qualifié** (CQ)	100.600 €	0	1	0	0	0	**1**	**1,4%**
	Maître de recherches (MR)	108.000 €	0	1	1	0	1	**3**	**3,8%**
	Directeur de recherches (DR)	130.900 €	0	1	1	0	0	**2**	**4,4%**
Total		/	**15**	**13**	**12**	**7**	**6**	**53**	**/**

9.5 Industrial return





Supplier code	Supplier	NL FR	City	2003-2008-Amount CHF
GR2S67	ICARUS S.A. M. BUTTING GMBH & CO LTD	FR	HERSTAL	43'155'288.40
GR4S05	FABRICOM S.A.	NL	BRUXELLES	16'008'704.78
GR2T25	AIR ET CHALEUR SA	NL	BRUSSELS	10'225'099.30
GR3S52	GEOTOP	FR	NAMUR	8'662'607.26
COCK50	COCKERILL SAMBRE	FR	SERAING	4'237'102.59
INTA02	INTAS	NL	BRUXELLES	2'186'577.44
RESA01	RESARM ENGINEERING PLASTICS SA	FR	BARCHON	1'841'089.49
THAL04	THALES COMMUNICATIONS BELGIUM	FR	TUBIZE	1'553'533.91
GR3S22	AMEC SPIE BENELUX	NL	BRUXELLES	1'314'772.50
AIRC30	SPIE BELGIUM	NL	BRUXELLES	716'239.08
SCHN10	SCHNEIDER ELECTRIC NV	NL	BRUXELLES	713'405.22
AERI01	AERIANE S.A.	FR	GEMBLOUX	696'244.16
ENSI50	***DUPLICATE SEE EMB-02*** GROUPE ENSIVAL-MORET	FR	PEPINSTER WEGNEZ	588'489.25
CANB50	CANBERRA SEMICONDUCTORS N.V.	NL	OLEN	538'112.27
MPE-01	M.P.E. SA	NL	BRUXELLES	504'134.53
NETR01	MANAGEMENT COCKPIT	NL	BRUXELLES	502'554.31
BARC25	BARCO N.V. ***SEE MULT37***	NL	POPERINGE	450'953.24
CPS-03	CPS EUROPE	FR	CHATELET	443'078.43
EUR-26	***SEE IMEC75***EUROPRACTICE ASIC SERVICE	NL	LEUVEN	410'904.53
BARC25	BARCO ELECTRONIC MANUFACTURING ***SEE IPTE01***	NL	POPERINGE	386'859.40
STAR10	STAR-APIC	FR	ANGLEUR	341'422.13
BARC25	UCAMCO ***SEE UCAM01***	NL	GENT	327'813.67
GR2S66	AIR ET CHALEUR	NL	BRUXELLES	302'590.96
PAM-02	POLMANS ATELIER MECANIQUE	FR	VISE	295'902.46
GEMA01	GEMACO S.A.	FR	HERSTAL	291'984.93
ILSA01	ILSA INDUSTRIAL LIFTING NV-SA	NL	SINT-PIETERS-LEEUW	224'097.08
GR3S08	GHS CONSORTIUM	FR	NAMUR	205'350.70
EMB-02	ENSIVAL MORET BELGIUM	FR	THIMISTER-CLERMONT	152'129.82
EUR165	EUROVILLAGE ARDENNES	FR	HERBEUMONT SUR SEMOIS	152'063.84
BRIT87	BRITTE-MUSTAD	FR	VIVEGNIS (OUPEYE)	148'818.50
HAY-50	HAY GROUP SA/NV	NL	ZAVENTEM (DIEGEM)	146'731.47
SODE05	SODEC SA	FR	SERAING	145'248.71
CHER03	MITRA INNOVATIONS SA	FR	WAVRE	131'889.54
LOUV50	UCL UNIVERSITE CATHOLIQUE DE LOUVAIN	FR	LOUVAIN LA NEUVE	121'594.01
PRIM13	PRIMINFO SA	FR	NOVILLE-LES BOIS	118'200.00
MOCK01	MOCKEL KGAA S.C.A.	FR	BAELEN	91'996.18
BARC25	BARCO N.V.	NL	KORTRIJK	84'893.82
EUR143	N.V. MAYEKAWA EUROPE S.A.	NL	ZAVENTEM	72'065.20
IPTE01	CONNECT GROUP NV	NL	IPER	71'586.27
POWE15	POWER ONE	NL	WOMMELGEM	69'260.57
LIEG50	UNIVERSITE DE LIEGE	FR	ANGLEUR	65'264.90
IMEC75	***SEE MA01*** IMEC V.Z.W.	NL	LEUVEN	63'937.67
NBC-01	NOVOTEL BRUGGE CENTRUM	NL	BRUGGE	62'710.99
TRAC79	TRACTEBEL DEVELOPMENT SA	NL	BRUXELLES	56'026.01
VLAS01	VLASSENROOT NV SA	NL	GROOT-BIGAARDEN	53'461.76
MECA82	MECASOFT	FR	ANHEE	52'507.69
EUR144	LINKAGE WESTERN EUROPE	NL	BRUSSELS	48'633.85
BTN-01	BTN SA	FR	DISON	48'615.39
DECO09	DEDECKER PRECISION MECHANICS SA	FR	MOUSCRON	47'624.46
PNO-01	PNO CONSULTANTS NV	NL	ZAVENTEM	46'297.48
SEPT02	SEPTENTRIO NV	NL	HEVERLEE, LEUVEN	44'613.10
PROM09	PROMIND CONSULTING	NL	LINDEN	44'102.18
MECA52	MECANIC SYSTEMS S.A.	FR	BRAINE L'ALLEUD	41'755.08
ARCH06	FUJIFILM ELECTRONIC MATERIALS (EUROPE) NV	NL	ZWIJNDRECHT	41'476.92
GANT75	GANTREX SA	FR	NIVELLES	40'831.10
GABR01	GABRIELS ALGEMENE METAALWERKEN NV	NL	OPGLABBEEK	30'927.72
GLAV50	AGC GLASS EUROPE	NL	BRUXELLES	29'485.01
ORBO03	ORBOTECH S.A.	NL	BRUXELLES	28'673.19
BBS-02	BVBA BINAME SPRL	NL	GROOT-BIJGAARDEN	26'372.58
CANB50	***SEE MA01*** CANBERRA	NL	ZELLIK	24'569.79
HTMS01	HTMS HIGH TECH METAL SEALS NV	NL	MECHELEN	19'919.12
EUR163	GMA GARNET EUROPE	NL	ANTWERPEN	19'767.62
MICR60	MICROTHERM	NL	SINT-NIKLAAS	19'642.45
FILL01	FILLFACTORY NV	NL	MECHELEN	19'008.60
LOUV50	UCL UNIVERSITE CATHOLIQUE DE LOUVAIN	FR	OTTIGNIES/LLN	18'720.00
LEYD01	JEAN LEYDER	FR	LASNE	15'800.00
JDL-01	JDL TECHNOLOGIES SA	FR	HERSTAL	15'502.17
AERO05	***SEE EUR210*** AEROGO EUROPE NV	NL	EKEREN	15'469.70
FERO01	FERONYL S.A	FR	MOUSCROM	14'784.66
CARB06	CARBOMIN S.P.R.L.	FR	BRAINE L'ALLEUD	14'162.42
DECA02	MICHEL DECAMPS SA-NV	NL	BRUXELLES	12'520.11
INT120	INTERCONTINENTAL SERVICES INC.	NL	BRUSSELS	12'377.51
MMI-02	MIP MECANIQUE INDUSTRIELLE DE PRECISION S.A.	NL	BRUXELLES	11'348.05
SCK-50	SCK/CEN	NL	MOL	10'264.62
ECSI02	ECSITE AISBL	NL	BRUXELLES	9'718.95
CHIM02	S.A. CHIMIDEROUIL BELGIUM N.V.	FR	NIMY-MONS	9'615.75
CHAR09	CGK-GROUP	NL	WEVELGEM	9'526.22
MULT37	MULTIBOARD NV	NL	POPERINGE	8'634.16

HEN-01	HOISTING EQUIPMENT NV	NL	BORNEM	8'107.29
OPTE02	OPTEC S.A.	FR	HORNU	7'822.90
PRIM14	PRIMO-SOMADEC	NL	BRUXELLES	6'133.01
ALCA60	ALCATEL	NL	ANTWERPEN	5'952.00
ELIS03	E.L.I. SPRL	FR	CHARLEROI	5'760.00
INEL03	INELMATEC	NL	BUIZINGEN	5'665.61
NORS04	NORSATECH	FR	KELMIS	5'442.55
ELSY01	ELSYCA	NL	WIJGMAAL	5'085.60
CODU01	CODUME INDUSTRIE	NL	BRUXELLES	4'676.38
LOUV50	UCL – UNIVERSITE CATHOLIQUE DE LOUVAIN	FR	LOUVAIN-LA-NEUVE	4'304.30
ORAK02	ORAKEL N.V.	NL	RETIE	4'215.12
ROGE02	ROGERS N.V.	NL	GENT	4'174.95
CAND03	CANDLE CONCEPT	NL	DEURNE	4'074.49
ALCA60	ALCATEL ETCA	FR	CHARLEROI	3'813.53
EUR167	L'ATELIER EUROPEEN S.P.R.L.	NL	BRUXELLES	3'786.56
QEB-01	QUADRANT EPP BELGIUM NV	NL	TIELT	3'747.24
ICAR01	ICARUS SA	FR	HERSTAL	3'724.52
BARC25	BARCO MANUFACTURING SERVICES	NL	HEULE	3'280.05
GLYN04	GLYNWED NV	NL	KONTICH	3'206.19
VUB-50	VUB – T.W.	NL	BRUXELLES	3'067.19
MUNC01	MUNCK SERVICES S.A.	FR	SCLESSIN	3'046.87
EARM01	EARMA – EUROPEAN ASSOCIATION OF	NL	BRUXELLES	2'970.14
SESE01	SONY E-SOLUTIONS EUROPE B.V	NL	SAVENTEM	2'948.76
ZEL-01	ZIEGLER EXPO LOGISTICS	NL	BRUSSELS	2'296.11
CAPA02	CAPAUL S.A.	FR	EUPEN	2'249.94
WSJ-01	THE WALL STREET JOURNAL EUROPE	NL	BRUXELLES	2'089.80
EBVB01	EBVBA	NL	OOSTKAMP	1'975.63
SOFI05	SOFITEL BRUSSELS EUROPE	NL	BRUSSELS	1'791.61
ISSE01	ISSEP	FR	LIEGE	1'717.58
NANO03	NANOCYL SA	FR	SAMBREVILLE	1'643.20
EMER50	HENKEL ELECTRONIC MATERIALS	NL	WESTERLO	1'589.76
EUR-73	EUROCIRCUITS	NL	MECHELEN	1'389.90
SOCA07	SOCACHIM-XRF	NL	BRUSSELS	1'354.50
GSE-01	GSE	FR	HERSTAL	1'188.74
ELAN05	ELAN LANGUAGES	NL	HEUSDEN-ZOLDER	1'167.01
HEX-01	HEX-RAYS SA	FR	LIEGE	1'093.06
PBB-01	PEMCO BRUGGE BVBA	NL	BRUGGE	1'011.57
MANU25	MANUTAN	NL	BRUXELLES	1'002.78
SENS10	SENSY SA	FR	JUMET	965.69
WALO01	WALOPT	FR	GRACE HOLLOGNE	925.42
AUVI02	AUVIPARTNERS NV	NL	ANTWERPEN BORGERHOUT	838.38
ACKR01	ACKROYD PUBLICATIONS S.A.	NL	BRUSSELS	792.00
DLSM01	DME LASER SYSTEM MEANS SPRL	FR	MARCINELLE	759.03
ELLS01	ELLSWORTH ADHESIVES EUROPE	FR	HOUDENG-GOEGNIES	734.91
EUR119	NEXEN EUROPE GROUP N.V.	NL	WEMMEL	610.27
MELE03	MELEXIS	NL	TESSENDERLO	557.80
ECV-01	ECV SPRL	FR	GRACE-HOLLOGNE	552.55
SALU01	SALUC	FR	CALLENELLE	548.86
CORM02	CORMA & SAVA	FR	TILLEUR	473.44
HOTE77	HOTEL SILKEN BERLAYMONT	NL	BRUSSELS	441.84
EUR-71	MEC EUROPE	NL	GENT	434.85
BRUY50	ETS EMILE BRUYLANT	NL	BRUXELLES	430.63
VANE03	N.V. VANEFLON S.A.	NL	HAMME	319.02
ELDO53	ELDON SA	FR	BRAINE-L'ALLEUD	317.60
MULD01	MULDER-HANDENBERG	NL	STABROEK	232.73
FIER01	FIERS NV/SA	NL	KUURNE	225.22
EUR174	ELECTRO RENT EUROPE NV	NL	MECHELEN	216.54
FOER01	FOEHRENBACH APPLICATION	NL	MORTSEL	193.24
JARI01	JARI SYSTEM NV	NL	BAVIKHOVE	182.34
CLIP01	CLIPPARD EUROPE SA	FR	LOUVAIN-LA-NEUVE	171.58
OUTI02	OUTILAC	FR	JEMEPPE SUR MEUSE	134.64
TYCO02	TYCO THERMAL CONTROLS N.V.	NL	LUBBEEK	125.60
SCHI05	SCHILTZ	NL	BRUXELLES	76.32
BURE08	BUREAU DE NORMALISATION	NL	BRUXELLES	43.38

Supplier code	Supplier	NL / FR	City	2009-2014-Amount CHF
AIRC30	SPIE BELGIUM	NL	BRUXELLES	1'954'215.98
RESA01	RESARM ENGINEERING PLASTICS SA	FR	BARCHON	1'475'136.93
EMB-02	ENSIVAL MORET BELGIUM	FR	THIMISTER-CLERMONT	1'237'160.08
IMEC75	IMEC EUROPRACTICE ASIC SERVICE	NL	LEUVEN	974'585.96
VELD01	VELDEMAN GEORGES NV	NL	BREE	596'744.96
DIAM13	DIAMETAL NV	NL	HERENTALS	588'403.33
AVT-01	AVT AUTOMATISERINGEN VAN THILLO	NL	ESSEN	588'282.21
GR3S52	GEOTOP	FR	NAMUR	459'121.95
EUR-26	***SEE IMEC75***EUROPRACTICE ASIC SERVICE	NL	LEUVEN	445'021.37
HAMO55	HAMON THERMAL EUROPE	FR	MONT-SAINT-GUIBERT	437'352.58
MTGB01	MATHESON TRI GAS BELGIUM	NL	BRUSSELS	402'739.60
SMP-01	SMP SPRL	FR	HACCOURT	398'756.00
PAM-02	POLMANS ATELIER MECANIQUE	FR	VISE	393'706.40
FERR36	FERROMATRIX NV	NL	KORTRIJK (MARKE)	392'928.93
ORBO03	ORBOTECH S.A.	NL	BRUXELLES	347'981.72
IPTE01	CONNECT GROUP NV	NL	IPER	230'681.32
RACK03	GIG TECHNOLOGY NV	NL	LOCHRISTI	223'815.26
PLAN12	CONTENTRA TECHNOLOGIES-BVBA FONS	NL	BELSELE (PUIVELDE)	196'144.57
ISC-03	FIRE SAFETY CONSULTING SPRL	FR	ISNES, GEMBLOUX	191'802.66
CRES01	SPANTECH BELGIUM	FR	NIVELLES	179'573.34
DECO09	DEDECKER PRECISION MECHANICS SA	FR	MOUSCRON	167'352.21
BARC25	UCAMCO ***SEE UCAM01***	NL	GENT	152'609.18
UCAM01	UCAMCO	NL	GENT	148'251.74
NBC-01	NOVOTEL BRUGGE CENTRUM	NL	BRUGGE	139'693.64
LOUV50	UCL UNIVERSITE CATHOLIQUE DE LOUVAIN	FR	LOUVAIN-LA-NEUVE	127'123.27
MPE-01	M.P.E. SA	NL	BRUXELLES	109'855.30
SBP-01	SCIENCE BUSINESS PUBLISHING LTD	NL	BRUXELLES	106'954.10
ISP-03	ISP BELGIUM	FR	SAMBREVILLE	93'080.31
PNO-01	PNO CONSULTANTS NV	NL	ZAVENTEM	91'029.17
TECN48	TECNOLON WORKS S.A.	FR	MOUSCRON	89'602.93
CET-01	CE+T S.A.	FR	WANDRE	74'537.54
LOUV50	UCL UNIVERSITE CATHOLIQUE DE LOUVAIN	FR	LOUVAIN LA NEUVE	74'246.01
SOFI08	SOFICS BVBA	NL	GISTEL	72'991.50
HAFI01	HAFIBO	NL	BEVEREN-LEIE	65'877.86
HAY-50	HAY GROUP SA/NV	NL	ZAVENTEM (DIEGEM)	64'004.88
PROM09	PROMIND CONSULTING	NL	LINDEN	61'523.90
CANB50	CANBERRA OFFICE BELGIUM	NL	ZELLIK	60'200.07
BRIT87	BRITTE-MUSTAD	FR	VIVEGNIS (OUPEYE)	56'337.80
SWIF50	SWIFT SCRL	FR	LA HULPE	54'737.19
TEL-17	TELEVIC CONFERENCE NV	NL	IZEGEM	53'082.47
EMER50	HENKEL ELECTRONIC MATERIALS	NL	WESTERLO	51'962.62
ELE387	CERATEC ELECTRONICS SANV	FR	PLOEGSTEERT	49'289.81
DOMI07	JONKERS & PARTNERS SPRL	FR	GRATY	45'963.44
MECA82	MECASOFT	FR	ANHEE	45'741.96
AOS-03	AOS BELGIUM SA	NL	BRUXELLES	44'164.20
HTMS01	HTMS HIGH TECH METAL SEALS NV	NL	MECHELEN	44'109.07
TRAD13	TRAD-BEL (CENTRE D'ENTREPRISES	FR	OTTIGNIES LOUVAIN LA NEUVE	42'232.68
BURR04	BURRICK N.V.	NL	LOCHRISTI	42'210.03
BVJ-01	JOSE VVANCOILLIE & CO B.V.B.A.	NL	MOORSELE	42'079.66
STAR10	STAR-APIC	FR	ANGLEUR	40'260.38
SEPT02	SEPTENTRIO NV	NL	HEVERLEE, LEUVEN	39'085.62
MULT37	MULTIBOARD NV	NL	POPERINGE	38'968.72
JEMA50	JEMA SA	FR	LOUVAIN LA NEUVE	35'422.76
MAMP01	MAMPAEY ENGINEERING & CO N.V.	NL	TREMELO	33'112.53
INS201	TECH-SYS INSTRUMENTS	NL	BRUXELLES	29'698.44
TIPI01	TIPIK S.A.	NL	BRUXELLES	29'441.49
ELSY01	ELSYCA	NL	WIJGMAAL	29'051.67
LAYE02	3DSYSTEMS LAYERWISE	NL	LEUVEN	28'087.88
COLD01	COLD JET EUROPE	NL	ZELLIK	26'852.80
FTA-02	FTA BVBA	NL	LOVENDEGEM (GENT)	25'384.19
INGE28	INGELBEEN SOETE	NL	IZEGEM	23'247.73
ARCE04	ARCEO	FR	IVOZ-RAMET	22'947.40
NEME02	NEMETSCHEK SCIA NV	NL	HERK-DE-STAD	22'517.53
BTN-01	BTN SA	FR	DISON	22'409.12
FST-01	FLIR SYSTEMS TRADNIG BELGIUM BVBA	NL	MEER	21'721.22
BBS-02	BVBA BINAME SPRL	NL	GROOT-BIJGAARDEN	21'650.08
NETR01	MANAGEMENT COCKPIT	NL	BRUXELLES	20'957.05
EUR143	N.V. MAYEKAWA EUROPE S.A.	NL	ZAVENTEM	20'542.28
ARCH06	FUJIFILM ELECTRONIC MATERIALS (EUROPE) NV	NL	ZWIJNDRECHT	19'931.65
SODE05	SODEC SA	FR	SERAING	19'016.27
PRIN15	PRINCIPIAE BVBA	NL	KRAAINEM	19'006.83
INS-79	INST. VOOR KERN-EN STRALINGSFYSICA	NL	LEUVEN	18'936.90
EUR-73	EUROCIRCUITS	NL	MECHELEN	17'408.84
RPS-02	RP PROTECT SPRL	FR	WATERLOO	16'841.30
ROGE02	ROGERS N.V.	NL	GENT	15'305.30
CHIM02	S.A. CHIMIDEROUIL BELGIUM N.V.	FR	NIMY-MONS	14'237.10
MANA50	AMA EUROPE MANAGEMENT CENTRE EUROPE MCE	NL	BRUSSELS	14'188.22
COGE12	COGEBI	NL	LOT-BRUXELLES	13'519.88
ELPR09	ELPRINTA	FR	MOUSCRON	13'025.35
ESTR01	ESTRO	NL	BRUSSELS	12'212.50
GLAV50	AGC GLASS EUROPE	NL	BRUXELLES	11'164.12
AAD-01	ATELIER ANTOINE DIGHAYE	FR	HACCOURT	11'080.45
SPT-02	SBS PLASTICS TRAININGS & CONSULTANC	FR	GRAND-RECHAIN	10'621.34
FORT12	FORTIS BANK	NL	BRUSSELS	10'544.70

ENSI50	***DUPLICATE - SEE EMB-02*** GROUPE ENSIVAL-MORET	FR	PEPINSTER WEGNEZ	10'519.39
FRAN69	FRANKLIN INDUSTRIES NV	NL	HULSHOUT	9'859.87
CHER03	MITRA INNOVATIONS SA	FR	WAVRE	9'817.69
HIB-01	HARVEST IMAGING BVBA	NL	BREE	9'681.46
PBS-02	PLASTI-BAC SPRL	NL	KUURNE	8'840.56
ADVE03	ADVENTUS MANAGEMENT CONSULTANCY	NL	BRUSSELS	8'827.55
CANB50	***SEE MA01*** CANBERRA	NL	ZELLIK	8'382.38
NANO03	NANOCYL SA	FR	SAMBREVILLE	7'965.45
RODA02	RODAX	NL	ANTWERPEN	7'532.41
VOD-02	VAN OS - DURACOAT	NL	HEMIKSEM	7'388.57
LOCO01	LOCORDIA COMMUNICATIONS	NL	BRUSSELS	7'257.98
SOFI05	SOFITEL BRUSSELS EUROPE	NL	BRUSSELS	7'178.79
MECA52	MECANIC SYSTEMS S.A.	FR	BRAINE L'ALLEUD	6'973.95
THAL04	THALES COMMUNICATIONS BELGIUM	FR	TUBIZE	6'935.48
ECSI02	ECSITE AISBL	NL	BRUXELLES	6'651.72
EUR163	GMA GARNET EUROPE	NL	ANTWERPEN	6'479.67
ENGA01	ENGAGOR NV	NL	GENT	6'418.73
TEC398	PEO RADIATION TECHNOLOGY BVBA	NL	HOOGSTRAATEN	6'341.92
ALFA17	SACA GROUP HQ - ALFA.DIS	FR	MOUSCRON	6'324.82
TWS-05	THOMAS WELDING SYSTEMS	FR	JUMET	6'223.79
EUTE01	EUTECHSTRATEGY	NL	BRUXELLES	6'093.00
LIEG50	UNIVERSITE DE LIEGE	FR	ANGLEUR	6'050.58
TEC297	PLANMAN TECHNOLOGIES	NL	AUDERHGHEM	6'013.57
HUGH01	HUGHES DOUCHES DE SECURITE FRANCE SARL	FR	LILLE	5'706.15
SAD-01	SAD GROUP	NL	BRUSSEL	5'587.92
ANEM01	ANEMO ENGINEERING BVBA	NL	LEISELE	5'466.61
EBVB01	EBVBA	NL	OOSTKAMP	5'435.03
STAR10	STAR INFORMATIC FRANCE SA	FR	LYON	5'241.13
UPPL01	UN PAS PLUS LOIN SA	FR	WIERDE	4'851.00
PAIR01	PAIRCOACHING.NET	NL	DROGEN	4'537.80
MIND02	MINDCET NV	NL	LEUVEN	4'514.00
EGIL01	EGILIA	NL	BRUXELLES	4'445.53
BUZZ02	BUZZISPACE NV	NL	KONTICH	3'992.21
X---01	X-CENTER	NL	SINT-ANDRIES	3'914.19
NORS04	NORSATECH	FR	KELMIS	3'815.42
INT339	INTERFACEUROPE	NL	BRUXELLES	3'649.65
TEC472	BASE TECHNOLOGIES NVSA	FR	LOUVAIN-LA-NEUVE	3'442.60
AMOS50	AMOS S.A.	FR	ANGLEUR	3'306.20
RECT04	RECTICEL INSULATION	NL	WEVELGEM	3'202.58
ILSA01	ILSA - INDUSTRIAL LIFTING NV-SA	NL	SINT-PIETERS-LEEUW	3'122.16
COM-92	COMPASS GROUP BELGILUX	NL	BRUXELLES	3'120.30
SAFE14	SAFEI SPRL	FR	TIHANGE	3'052.65
EUR312	EUROPEAN FOUNDATION CENTRE PHILANTHROPY HOUSE	NL	BRUSSELS	3'041.86
FOUR11	FOUR PEES NV	NL	SINT-AMANDSBERG	3'016.11
CARB06	CARBOMIN S.P.R.L.	FR	BRAINE L'ALLEUD	2'955.24
HEX-01	HEX-RAYS SA	FR	LIEGE	2'934.12
MEDR01	MEDRAYSINTELL	FR	GREZ-DOICEAU	2'885.76
FRED03	FREDERIC TILLEMAN	NL	GHENT	2'837.50
GORR01	GORREUX	FR	BEUZET-GEMBLOUX	2'778.57
EUPE02	EUPEN METAL SA	FR	RAEREN	2'741.35
GOND55	GONDRAND	FR	VERVIERS	2'720.00
HOTEF0	CHELTON HOTEL	NL	BRUXELLES	2'673.12
CLUB06	CLUB DE LA FONDATION UNIVERSITAIRE	NL	BRUXELLES	2'451.23
SENS10	SENSY SA	FR	JUMET	2'309.29
GLAV50	AGC GLASS EUROPE	NL	MOL	2'232.00
EUR174	ELECTRO RENT EUROPE NV	NL	MECHELEN	2'219.82
MAGC02	MAGCAM NV	NL	LEUVEN	2'165.63
DLA-01	DLA PIPER	NL	BRUSSELS	2'112.00
ELE285	MEECH ELECTROSTATIK S.A.	FR	ST. VITH	2'013.77
IISA01	IISA - IIAS	NL	BRUSSELS	2'009.42
UNI345	UNIVERSITY OF LEUVEN KU LEUVEN	NL	LEUVEN	1'858.02
INS222	METIS INSTRUMENTS & EQUIPMENT N.V.	NL	LEUVEN	1'772.19
TRIS03	TRISLOT NV	NL	WAREGEM	1'743.64
MENN01	MENNENS BELGIUM NV	NL	ZWIJNDRECHT	1'708.88
HALL04	HALLDIS BELGIUM SA	NL	BRUXELLES	1'693.08
PARL01	PARLEMENT EUROPEEN	NL	BRUXELLES	1'670.86
DIAM14	DIAMKO	FR	STREPY-BRACQUEGNIES	1'640.84
CREO02	CREON	NL	MERCHTEM	1'630.15
EARM01	EARMA - EUROPEAN ASSOCIATION OF	NL	BRUXELLES	1'626.19
VERM02	VERMEIRE TRANSMISSIONS	FR	VERVIERS	1'610.73
EUR183	AZBIL EUROPE NV	NL	ZAVENTEM (STERREBEEK)	1'571.26
ICAR03	I-CARE SPRL	FR	MONS	1'528.19
DRYT50	DRYTEC	FR	ANGLEUR	1'484.39
ACT-03	ASME CORPORATE TRAINING	NL	BRUSSELS	1'457.78
EACD01	EACD - EUROPEAN ASSOCIATION OF	NL	BRUSSELS	1'267.40
JCP-02	JOBAT - CORELIO PUBLISHING NV	NL	GRAND-BIGARD	933.30
VUB-50	VUB - T.W.	NL	BRUXELLES	889.47
WELD04	WELDING COMPANY	NL	SCHELLE	847.21
TEC514	BCM SENSOR TECHNOLOGIES BVBA	NL	SCHOTEN - ANTWERPEN	841.52
EUR242	SERVERSCHECK EUROPE	NL	ZAVENTEM	839.36
EURO98	EUROPEAN COMMISSION - JOINT RESEARCH	NL	GEEL	786.83
IMMO03	IMMONODIAGNOSTIC SYSTEM SA	FR	LIEGE	784.59
ETIL50	ETILUX SA	FR	LIEGE	778.98
TEMP09	TEMPCO SA	FR	HERSTAL	694.23
JDF-01	JAN DARTHET FOTOGRAFIE	NL	BRUGGE	686.21
TEC420	IRIS TECH+	NL	FOREST - VORST	677.12

TEC420	IRIS TECH+	NL	FOREST VORST	677.12
BOLS01	BOLSENA SPRL	NL	BRUSSELS	669.52
CHER03	ALPHA TECHNOLOGIES SA	FR	WAVRE	628.11
DLSM01	DME LASER SYSTEM MEANS SPRL	FR	MARCINELLE	605.14
ERIK06	ERIKS BAUDOIN	FR	JUMET	561.75
MOTO04	S.A. MOTOR PRODUCTS N.V.	FR	SAINTES	511.65
CHEM18	CHEMVIRON CARBON	FR	FELUY	485.10
FOER01	FOEHRENBACH APPLICATION	NL	MORTSEL	471.36
BLIC01	BLICKLE BVBA	NL	BOECHOUT	468.50
MANU25	MANUTAN	NL	BRUXELLES	361.84
PRIM14	PRIMO-SOMADEC	NL	BRUXELLES	316.27
ARIA03	ARIAMP	FR	VIRTON	315.25
REDE01	REDEYE EUROPE MATERIALISE	NL	LEUVEN	312.50
AROS02	AROS BENELUX	NL	STERREBEEK	305.00
TEC571	FLANDERS TECHNOLOGY INTERNATIONAL	NL	MECHELEN	292.37
PCB-07	PRESS CLUB BRUSSELS EUROPE ASBL	NL	BRUSSELS	247.32
ASOW01	ART SUPPLIES ON WEB BVBA	NL	BERLAAR	213.23
OVER04	OVERTOOM	NL	TERNAT	213.22
FIER01	FIERS NV/SA	NL	KUURNE	211.93
INGE29	INGENIEURSBELGES.BE	NL	BRUXELLES	186.75
APBM01	APBMT	NL	ASSE	183.00
LESS01	LESSIUS ANTWERPEN	NL	ANTWERPEN	146.40
KWB-01	KANIGEN WORKS BENELUX	NL	GENK	101.68
SIRI04	SIRIEN SA	NL	BRUXELLES	-

Supplier code	Supplier	NL FR	City	2015-2017-Amount CHF
IMEC75	IMEC EUROPRACTICE ASIC SERVICE	NL	LEUVEN	5'298'714.99
RESA01	RESARM ENGINEERING PLASTICS SA	FR	BARCHON	877'627.52
SMP-01	SMP SPRL	FR	HACCOURT	775'630.45
SBP-01	SCIENCE BUSINESS PUBLISHING LTD	NL	BRUXELLES	356'790.10
RHEA01	RHEA SYSTEM SA	FR	WAVRE	337'905.85
ORBO03	ORBOTECH S.A.	NL	BRUXELLES	281'393.62
RPS-02	RP PROTECT SPRL	FR	WATERLOO	206'689.12
PAM-02	POLMANS ATELIER MECANIQUE	FR	VISE	202'003.01
RACK03	GIG TECHNOLOGY NV	NL	LOCHRISTI	176'771.31
MIC145	KEYENCE MICROSCOPE EUROPE	NL	MECHELEN	158'994.43
ADAM06	ADAM PUMPS	FR	THIMISTER	143'666.14
SOFI08	SOFICS BVBA	NL	GISTEL	131'574.00
CET-01	CE+T S.A.	FR	WANDRE	129'707.84
LOUV50	UCL UNIVERSITE CATHOLIQUE DE LOUVAIN	FR	LOUVAIN LA NEUVE	122'472.10
UCAM01	UCAMCO	NL	GENT	113'036.86
AMC-06	AC MANAGEMENT CONSULTANTS LTD	FR	RIXENSART	103'000.00
FAYM01	FAYMONVILLE AG	FR	BULLINGEN	100'330.91
SCK-50	SCK/CEN	NL	MOL	93'272.13
DIAM13	DIAMETAL NV	NL	HERENTALS	89'609.47
MAS-06	MEMNON ARCHIVING SERVICES SA	NL	BRUSSELS	87'005.41
HAY-50	HAY GROUP SA/NV	NL	ZAVENTEM (DIEGEM)	75'846.39
ADAM06	ADAM PUMPS	FR	ANDRIMONT	70'928.68
LAYE02	3DSYSTEMS LAYERWISE	NL	LEUVEN	67'135.93
EUR174	ELECTRO RENT EUROPE NV	NL	MECHELEN	63'237.17
TRAD13	TRAD-BEL (CENTRE D'ENTREPRISES	FR	OTTIGNIES LOUVAIN LA NEUVE	58'672.96
KARL05	KARL HUGO AG	FR	AMEL	57'355.99
MTUM01	M.T.U. (MTHODES ET TECHNIQUES D'USINAGE)	FR	HERSEAUX	55'318.89
CRES01	SPANTECH BELGIUM	FR	NIVELLES	53'810.98
BVJ-01	JOSE VANCOILLIE & CO B.V.B.A.	NL	MOORSELE	44'777.86
ADVE03	ADVENTUS MANAGEMENT CONSULTANCY	NL	BRUSSELS	44'673.17
OPLU01	OPLUSR	FR	MONTIGNY-LE-TILLEUL	42'246.32
MAMP01	MAMPAEY ENGINEERING & CO N.V.	NL	TREMELO	41'245.89
LOUV50	UCL UNIVERSITE CATHOLIQUE DE LOUVAIN	FR	LOUVAIN-LA-NEUVE	40'313.04
MECA82	MECASOFT	FR	ANHEE	38'272.55
COGE12	COGEBI	NL	LOT-BRUXELLES	34'831.88
PROM09	PROMIND CONSULTING	NL	LINDEN	29'003.94
BBS-02	BVBA BINAME SPRL	NL	GROOT-BIJGAARDEN	25'002.93
EUR424	EIRMA EUROPEAN INDUSTRIAL RESEARCH MANAGEMENT ASSOCIATION	NL	BRUSSELS	24'811.50
EFFI03	EFFICY SA	NL	BRUSSELS	24'458.33
ADDE04	ADDESTINO INNOVATION MANAGEMENT	NL	ZELE	22'028.00
JADI01	JADITION	FR	HANNUT	21'452.28
MIC150	OPTEC LASER MICROMACHINING SYSTEM	FR	FRAMERIES	21'022.50
AVT-01	AVT AUTOMATISERINGEN VAN THILLO	NL	ESSEN	20'933.20
ENGA01	ENGAGOR NV	NL	GENT	19'982.55
CABL56	CABLERIE D'EUPEN SA	FR	EUPEN	18'715.99
GLAV50	AGC GLASS EUROPE	NL	BRUXELLES	18'548.68
EUR143	N.V. MAYEKAWA EUROPE S.A.	NL	ZAVENTEM	18'219.57
RODA02	RODAX	NL	ANTWERPEN	17'274.59
EUR376	EUROSTORAGE	NL	GAVERE	17'156.24
SAFE14	SAFEI SPRL	FR	TIHANGE	15'963.50
ACM-08	ACM AGSA	FR	RECHT	15'364.97
BUZZ02	BUZZISPACE NV	NL	KONTICH	14'834.81
VUB-50	VUB T.W.	NL	BRUXELLES	12'799.74
EUR-73	EUROCIRCUITS N.V.	NL	MECHELEN	12'475.00
ALFA17	SACA GROUP HQ ALFA.DIS	FR	MOUSCRON	12'454.36
PLAS47	PLASTIRUB BVBA/SPRL	FR	EBEN-EMAEL (BASSENGE)	12'221.63
SWIF50	SWIFT SCRL	FR	LA HULPE	12'097.79
EUR-73	EUROCIRCUITS	NL	MECHELEN	12'012.76
ILSA01	ILSA INDUSTRIAL LIFTING NV-SA	NL	SINT-PIETERS-LEEUW	11'310.39
EMB-02	ENSIVAL MORET BELGIUM	FR	THIMISTER-CLERMONT	11'251.41
EUR408	EUROCASE	NL	WIJNEGEM	10'997.83
VOD-02	VAN OS DURACOAT	NL	HEMIKSEM	10'488.69
INS-79	INST. VOOR KERN-EN STRALINGSFYSICA	NL	LEUVEN	9'906.30
HTMS01	HTMS HIGH TECH METAL SEALS NV	NL	MECHELEN	9'900.76
PBS-02	PLASTI-BAC SPRL	NL	KUURNE	8'785.41
ROGE02	ROGERS N.V.	NL	GENT	8'692.10
OPEN07	OPENTELLY	NL	LEUVEN	8'679.09
INGE28	INGELBEEN SOETE	NL	IZEGEM	7'912.64
FIRE05	FIRE TECHNICS NV	NL	OOSTENDE	7'289.60
EUTE01	EUTECHSTRATEGY	NL	BRUXELLES	7'040.75
NEME02	NEMETSCHEK SCIA NV	NL	HERK-DE-STAD	6'680.21
TEL-17	TELEVIC CONFERENCE NV	NL	IZEGEM	6'611.92
GRAU01	GRAUX	FR	MOMIGNIES	6'495.22
INT444	VWR INTERNATIONAL EUROPE BVBA	NL	LEUVEN	6'400.62
CERH02	CERHUM SA	FR	LIEGE	6'267.78
WAEL35	WAELKENS N.V.	NL	OOSTROZEBEKE	6'009.24
QUAT06	QUATRIEME DIMENSION SA	FR	NAMUR (ZI NANINNE)	5'400.15
THAL04	THALES COMMUNICATIONS BELGIUM	FR	TUBIZE	5'223.15
FTA-02	FTA BVBA	NL	LOVENDEGEM (GENT)	4'692.68
NORS04	NORSATECH	FR	KELMIS	4'656.24
ECSI02	ECSITE AISBL	NL	BRUXELLES	4'430.45
ERIK06	ERIKS BAUDOIN	FR	JUMET	4'387.73
POWE37	POWER LIMIT S.A	FR	4102 OUGRE SERAING	3'969.94
GAZE02	GAZECHIM COMPOSITES NV	NL	WOMMELGEM	3'961.41
EBVB01	EBVBA	NL	OOSTKAMP	3'958.66
SCB-02	SOLID CURE BVBA	NL	BRUGGE	3'813.06
SCL-05	SPRL CHARLES LAMBERT & POLMANS	FR	VISE	3'745.13
CORB04	CORBIE	NL	MOL	3'510.16
CHIM02	S.A. CHIMIDEROUIL BELGIUM N.V.	FR	NIMY-MONS	3'275.34
ESTR01	ESTRO	NL	BRUSSELS	3'158.49
GLS-05	GLS CONSULT	FR	DHUY	2'952.50
LOUV50	UCL UNIVERSITE CATHOLIQUE DE LOUVAIN RMP CRC	NL	LOUVAIN-LA-NEUVE	2'904.12

ATIM01	ATIMA-TPIM S.A.	FR	PEPINSTER	2'729.37
BLUE18	BLUE VISION ACADEMY	NL	KONTICH	2'718.55
JOMY01	JOMY SA	FR	JUPRELLE (WIHOGNE)	2'508.48
HOTEI4	ATLAS HOTEL BRUXELLES	NL	BRUXELLES	2'398.20
MAGC02	MAGCAM NV	NL	LEUVEN	2'304.12
NANO03	NANOCYL SA	FR	SAMBREVILLE	2'244.58
AUTO25	AUTOMATION NV	NL	HALLE	2'177.27
TEL-61	WEEPEE TELECOM	NL	OOSTENDE	2'163.84
LEPA01	LEPAGE FRERES S.A.	FR	JUMET	2'135.79
NISK01	NISKAA GROUP	NL	DIEGEM	2'052.76
ELPR09	ELPRINTA	FR	MOUSCRON	2'017.74
SOME09	SOMERSAULT	NL	DIEST	1'791.88
SSS-17	SERVER STORAGE SOLUTIONS	NL	EKE-NAZARETH	1'598.56
BOBI03	BOBIMAT NV	NL	BOOM	1'528.32
HUGH01	HUGHES DOUCHES DE SECURITE FRANCE SARL	FR	LILLE	1'476.05
ACCR01	ACCREDITATION COUNCIL OF ONCOLOGY IN EUROPE (ACOE)	NL	BRUSSELS	1'171.61
EMER50	HENKEL ELECTRONIC MATERIALS	NL	WESTERLO	1'091.37
EUR312	EUROPEAN FOUNDATION CENTRE PHILANTHROPY HOUSE	NL	BRUSSELS	1'065.20
EUR396	BOUSSEY CONTROL EUROPE	NL	OUDENAARDE	1'046.17
PLAN12	CONTENTRA TECHNOLOGIES-BVBA FONS	NL	BELSELE (PUIVELDE)	1'034.80
TOPO04	TOPOSAT	NL	BIERGHES REBECQ	1'029.77
ELE285	MEECH ELECTROSTATIK S.A.	FR	ST. VITH	1'006.44
EUR344	EUROPEAN UNION OF MEDICAL SPECIALISTS	NL	BRUSSELS	987.34
MEDR01	MEDRAYSINTELL	FR	GREZ-DOICEAU	915.68
AAD-01	ATELIER ANTOINE DIGHAYE	FR	HACCOURT	811.20
IMIN01	IMINDS	NL	GHENT	750.69
VACO04	VACOM	NL	HOLSBEEK	709.45
AEB-03	ALMAX EASYLAB BVBA	NL	DIKSMUIDE	705.06
COM-92	COMPASS GROUP BELGILUX	NL	BRUXELLES	608.44
ARTI09	ARTICOM NV	NL	MECHELEN	502.12
BSS-05	DE BOECK SUPERIEUR SA	FR	LOUVAIN LA NEUVE	427.40
MULT48	MULTIBURO PARLEMENT EUROPEN	NL	BRUSSELS	390.69
KIDS01	KIDSCAB BVBA	NL	HASSELT	385.29
PREC33	PRECISION METALS NV	NL	MECHELEN	378.20
HAHE01	HELMO ASBL (HAUTE ECOLE LIBRE MOSANE)	FR	ANGLEUR (LIEGE)	351.15
INT428	SOLBERG INTERNATIONAL LTD.	NL	TEMSE	320.64
FIER01	FIERS NV/SA	NL	KUURNE	295.07
BELV01	BELV	NL	BRUSSELES	268.41
ALFA22	ALFAFLEX	NL	MECHELEN	255.52
FOUR11	FOUR PEES NV	NL	SINT-AMANDSBERG	214.92
MATT10	MATTHYS QUALITY EQUIPMENT	NL	VICHTE	177.02
GLAS11	GLASATELIER SAILLART BVBA	NL	MEERHOUT	142.79
LOCO01	LOCORDIA COMMUNICATIONS	NL	BRUSSELS	137.83
SCHI05	SCHILTZ	NL	BRUXELLES	130.20
AE--02	AE VALVES	FR	PETIT-RECHAIN	-
SIRI04	SIRIEN SA	NL	BRUXELLES	-
EACD01	EACD EUROPEAN ASSOCIATION OF	NL	BRUSSELS	-6.72

Count of PURCHASE REFERENCE	Answer				
Purchase procedure type	**DECLINED**	**INTEREST**	**NOREPLY**	**RETURNED**	**Grand Total**
Market Survey	31	82	411	8	532
Tender	120	69	251		440
Grand Total	**151**	**151**	**662**	**8**	**972**

9.6 References

A lot of the information in this report can be retrieved from the main website of CERN:
http://directory.web.cern.ch/directory/
and:
https://council.web.cern.ch/en/content/reference-documents
https://www.worldscientific.com/worldscibooks/10.1142/9441