KNOWLEDGE TRANSFER 2011

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Rolf Heuer, Director-General

CERN's mission is fundamental research in physics.
We push back the frontiers of human knowledge and, in doing so, drive innovation, develop forefront technologies, stimulate international collaboration and inspire tomorrow's leaders in science and technology.
It is part of our mission to share all this with society, through a knowledge transfer policy that reflects our core values.
In 2011, CERN's support for the transfer of its technical knowledge to society has been reinforced by initiatives aiming at maximising the benefits for other fields of research, industry and education. A licence governing the exchange of knowledge in hardware design, a range of projects for medical applications in the framework of international collaborations, the 2011 series of schools of excellence to train tomorrow's scientists, are just a few of the examples of CERN's commitment to knowledge transfer.
Through the KT Fund, a new financial scheme to support CERN's inventors, we gave six projects the help they needed to progress and have a positive impact on society in the near future.
Building on the results of new initiatives implemented in 2011, we look forward to 2012 and subsequent years as a promising era for CERN's knowledge transfer to society.

Knowledge Transfer group - Accelerating innovation

At CERN, the knowledge transfer process takes many forms and involves many people.

"When it comes to CERN's unique technical competencies and the related know-how, knowledge transfer is achieved by applying our technologies in other fields of research, such as medical imaging, cancer treatments, homeland security, astronomy, material sciences and many more," says Thierry Lagrange, head of the Finance, Procurement and Knowledge Transfer department.

Technical knowledge can be transferred to public and private research centres through the best intellectual property scheme, or it can be shared with researchers worldwide through training and educational initiatives. International and interdisciplinary networks are another effective means of increasing our capacity for R&D projects in many areas.

The support, facilitation and communication of the many forms of knowledge and technology transfer are key for maximising CERN's impact on society.

"This is the mission of the Knowledge Transfer group," says Giovanni Anelli, head of the group. "We strive to promote a culture of inventiveness, encouraging CERN's inventors to bring their ideas and competencies forward.

To the outside, we build bridges between innovative technologies and other fields of research, business and education, always giving priority to the dissemination of knowledge."

This publication reports to CERN's key stakeholders a selection of the knowledge transfer activities carried out at CERN in 2011, often in collaboration with universities, research institutes and companies in the Member States.

"The report offers an overview of the services provided by technology transfer and intellectual property management experts, the multidisciplinary projects in life sciences, the many applications of CERN's forefront technologies in diagnostics, the impact of information and communication technologies on innovation in the public and private sectors, the sharing of CERN's know-how in energy management, and the conversion of HEP technologies into clean technology," says Anelli. "Last but not least, the report highlights examples of excellence in training and education which continue to represent a powerful vehicle for sharing and transferring CERN's technical expertise to society through the people who work, study, train and collaborate with our Organization.

We all share the same passion: the transfer of knowledge from CERN to society."

Technology Transfer and Intellectual Property Management

The Technology Transfer and Intellectual Property Management section of the Knowledge Transfer group is a service-oriented unit providing support to all CERN technical departments willing to share their individual competences and innovative technologies with external partners.

"Our innovation model can lead to a significant long-term socio-economic impact"

In order to support and optimise the dissemination of the knowledge generated at CERN, the Organization provides internal and external stakeholders with the support of professionals in the fields of technology transfer and intellectual property management.

"The innovation model we have been implementing represents an optimal compromise between the pure Open Science Vision, typical of academic institutions and most appropriate to fostering exploratory early stage research activities, and a more Application-Oriented Approach, more adapted to encouraging the effective adoption and exploitation of relatively mature technologies fulfilling clearly identified needs," explains Enrico Chesta, head of the section. "This approach can lead to a significant long-term socio-economic impact, since it supports the competitiveness of CERN's innovation-driven financial partners in the Member States in order to help them bring to society the technological advances generated in the framework of CERN's ambitious scientific programme."

In 2011, the section successfully offered tailored services to the CERN community and to external partners willing to collaborate with CERN on projects of common interest. These services cover every phase of a typical Technology Transfer process. In the field of technology disclosures made by CERN's inventors, internal opportunities are encouraged by targeted awareness campaigns and the implementation of incentive policies. In this respect, the implementation of a dedicated fund in support of innovative knowledge trans-

fer projects has acted as a strong encouragement to new initiatives.

New technology transfer opportunities have also arisen from requests for support from external partners. In order to increase the number of external opportunities, the section has intensified the promotion of CERN's core areas of expertise to the outside. "This well-known approach aims at matching external partners' needs with the competences of CERN's staff ("market pull mode") and involving the external partners at the earliest possible development stage of a technology (typically in the framework of R&D collaboration agreements), rather than trying to find needs in the market which are satisfied by CERN's inventions ("technology push mode")," Chesta says. "In addition to this, CERN's technology transfer officers closely monitor industrial needs and reinforce a collaborative approach with potential external partners, be they companies or public and private research centres."

The new IP management strategy put in place in 2011 includes the exploitation of synergies with the Procurement group with the objective of keeping track of the knowledge transferred to industry while specifying demanding technical requirements to suppliers and suggesting possible solutions. The strategy includes investigating the possibility to propose dedicated IP clauses if this can increase the chances of exploitation of a given technology beyond CERN's applications.

New Technology Transfer Opportunities

New technology transfer opportunities can be divided into two categories: requests for support from external partners looking for technical collaborations, and requests for support from CERN inventors. This second category includes new invention disclosures and new projects applying for financial support from the KT Fund.

New external requests for support

In 2011 the Knowledge Transfer group received several external requests for support. All requests were given serious consideration in order to identify the potential for collaboration. In some cases these requests could not be followed up, either due to incompatibility with the Organization's principles or because the technical departments were not able to make the necessary resources available.

Three major requests led to the following developments:
- METAS Watt balance design: the objective of this project is to provide METAS (the Swiss Federal Office for Metrology) with a design for specific magnet circuits for use in a metrology research experiment aiming at linking the mass unit kilogram to fundamental constants of Nature by an extremely precise comparison of electrical and mechanical power.
- Radio Frequency Generator: a French company requested the support of experts from the CERN Beams department to help solve technical problems affecting the operation of RF generators used to supply the cavities of its medical isotope cyclotrons.
- CIEMAT Mini-cyclotron: CERN and CIEMAT, a Spanish public research agency, signed an agreement concerning the design, construction and commissioning of the smallest possible superconducting cyclotron capable of producing unit patient doses of ^{11}C and ^{18}F radiopharmaceuticals. The clinical use of PET is currently limited by the small number of licensed tracers that are produced by cyclotron systems. These systems are relatively large with big facility footprints which can usually only be accommodated in large research hospitals or dedicated manufacturing plants in industry. The two-hour half-life of ^{18}F allows physical distribution of ^{18}FDG to within a distance of 100 km but based on prescribed patient scheduling. ^{11}C has a half-life of only 20 minutes and so can only be produced inside the hospital and for a dedicated patient procedure. The objective of this project is thus to design the smallest possible PET isotope-producing cyclotron, using CERN's vacuum and superconducting technology to reduce the scale to the extent that it can be installed in a very small space within a radiopharmacy facility.

New invention disclosures

An invention disclosure is a technology developed for CERN purposes that has the potential to find alternative external applications.

In 2011, 14 new inventions were brought to the attention of the Knowledge Transfer group by researchers working in the Physics, Engineering, Technology, Beams and General Infrastructure Services departments and in the Safety group. In about 50% of the cases the disclosures also involved initial collaborations with external business or academic partners. The new disclosures were the subject of an initial assessment by TT Officers and subsequently processed.

As an example of promising new opportunities, the microstructured silicon cooling plates case concerns an initial collaboration between CERN and the Centre Suisse d'Electronique et de Microtechnique (CSEM) to develop a new technology for high-energy physics particle detectors. This technology allows the readout electronics of silicon detectors to be cooled with a very high efficiency, while at the same time minimising the quantity of materials needed for the cooling, a parameter of paramount importance to avoid affecting the trajectory of the particles to be tracked. This technology is also applicable to other domains, such as the cooling of integrated circuits or micro-electro-mechanical systems (MEMS).

"Technologies developed for CERN purposes can find alternative applications"

Disclosure Name	Dept/ Group	Inventors	Technology Domain	Potential Application Field	Initial Assessment Conclusions
Non return valve	TE/VSC	Patrick Coly Paul Cruikshank Jose Miguel Jimenez	Mechanics	Vacuum systems	1
RPL high-level dosimeter	DGS/ RP	Julia Brigitta Trummer Helmut Vincke Markus Fuerstner (PSI)	Electronics	Dosimetry	2
Collimators material	EN/ MME	Alessandro Bertarelli Stefano Sgobba	Material science	Aerospace	3
Mobile EAM application	GS/ ASE	David Widegren	Software	Equipment maintenance	3
High temperature high power RF loads	BE/RF	Silke Federmann Fritz Caspers	Radiofrequency	Energy recovery	4
Solid State Amplifiers	BE/RF	Eric Montesinos	Radiofrequency	Telecoms	5
Microstructured Silicon cooling plates	PH/DT	Paolo Petagna	Microfluidics	Electronics MEMS	3
Power coupler	BE/RF	Eric Montesinos	Radiofrequency	Accelerators	2
3D semiconductor detector	PH/ ESE	Michael Campbell Jan Jakubek (CTU) Thilo Michel (Un. Erlangen)	Electronics	Imaging	4
Microfluidic scintillation detectors	PH/DT	Alessandro Mapelli Benedetto Gorini	Microfluidics	Dosimetry	4
Composite Vacuum Chambers	TE/VSC	Mark Antony Gallilee	Material science	Vacuum systems	5
Data compression method for sparsely populated data	PH/ ESE	Walter Snoeys Piero Giubilato (Un. Padova)	Electronics	Data acquisition	4
Aluminum bellows	EN/ MME	Laurent Prever-Loiri Gilles Favre	Mechanics	Vacuum systems	3
RF loads stacked structures	BE/RF	Fritz Caspers Silke Federmann	Radiofrequency	Energy recovery	4

Initial Assessment Conclusions

1	Case abandoned because similar technology has been found on the market
2	Case on-hold: additional input needed from the inventors or the external parties
3	Promising case needing deeper assessment (work in progress)
4	Opportunity upgraded to TTcase: patent filed and/or KT Fund support granted
5	Case transferred to procurement

Patent Portfolio Management

Patents are a useful and sometimes indispensable tool for meeting technology dissemination and exploitation objectives. Patents are also real assets for any scientific organisation, and they are often considered valuable indicators of technological innovation. In addition, once published, patents become detailed and freely available descriptions of technology that are easily accessible even after they have expired. For this reason they can also be regarded as powerful communication tools.

CERN's patent portfolio is managed by the Technology Transfer and Intellectual Property Management section of the Knowledge Transfer group.

The management of the portfolio involves many different activities depending on the status of the patent application, from submission to withdrawal/expiry. The main decisions that need to be taken during the lifetime of a patent concern its initial filing, the choice of routing options, the geographical coverage, maintenance/abandon before cost escalation and the assignment of IP rights where applicable. In order to optimize the patent management process, it has been decided that all these decisions should be taken twice per year in dedicated "patent portfolio review" sessions.

A cost-effective and results-oriented patent management style needs to be dynamic. "The guidelines adopted in 2011 are built around a flexible approach, where "provisional applications" are given preference whenever possible", explains Telma Mantas, CERN's patent portfolio manager in the Knowledge Transfer group. "This is a newly identified filing route where 50% of the costs are postponed until the end of the priority year", continues Mantas. In this way it is possible to assess, during the first year and at low cost, the suitability of extending a patent internationally or modifying its scope."

Sharing the ownership of a patent with an external partner is also increasingly encouraged: although this increases the workload for the section on the one hand, on the other hand it allows the cost of the patenting process to be shared and ultimately increases the chances of technology exploitation. A comparative analysis was carried out and a search for a new software management tool allowing more effective and transparent storage and handling of all information relating to the patent portfolio and active TT cases was initiated, and the main requirements were identified.

CERN Patent Portfolio Overview

An overview of patent portfolio activities in 2011 is given in the table below:

At the end of 2011, CERN's patent portfolio consisted of 41 patent families covering a total of 262 patents and patent applications (regional and national extensions).

As result of the 2011 patent portfolio reviews it was decided to abandon 2 patent families due to the lack of potential applications. In one case the inventor decided to keep the IP right of the patent in his name and at his own cost. The geographic coverage of two patent families was reduced.

2011 patent portfolio activities overview

New patents filed	7
Patent families reduced in geographical coverage	2
Abandoned patent families	1
Transferred patent families	1
Final number of patent families	41

“Prior art” assessments

A valuable service provided by the Technology Transfer and Intellectual Property Management section is related to IP due diligence, which is important in many situations like decision-making processes before the launch of new R&D projects or the filing of new patent applications. Two main types of assessment are often requested: patentability studies and “freedom to operate landscapes”.

Patentability studies

These assessments are usually performed on promising technologies before a patent application is filed. The objective is to analyse the IP scope and strength of the invention and to identify the closest “prior art” in order to decide if a patent can and should be filed. In 2011, 6 patentability studies were performed for new technologies developed at CERN.

Freedom to operate landscapes

In a Freedom to Operate report the main goal is to understand what can be done in the framework of a new R&D project and with the IP generated from it. It is a search in the state of the art that takes longer than a patentability study and which can be repeated several times as long as the technology and its commercial potential have not been completely defined. In addition to the prior art search performed in a patentability study, the focus of this assessment is also on understanding how the IP that is going to be generated in the framework of a new project can be used (without infringing third-party rights).

In 2011 one Freedom to Operate report was requested in the context of the “Mini superconducting cyclotron” project: the first report was finalized in June 2011and focused on the general concept of a mini cyclotron with superconductivity magnets. More searches will be necessary as the design of the project progresses, with more focus on specific parts of the cyclotron, such as the magnets, the target, etc.

The table below summarizes all the IP due diligence reports requested and issued in 2011:

Technology/project	Type	Date
Dew Point Sensor	Patentability studies	04/03/2011
Mini Cooling CO2 system	Patentability studies	19/04/2011
Mini superconducting cyclotron	Freedom to operate	27/06/2011
Non-Return Valve	Patentability studies	27/07/2011
High temperature high power RF load	Patentability studies	04/08/2011
Collimator material	Patentability studies	23/08/2011
POPs - application as battery charger	Patentability studies	09/12/2011

New Patent Applications

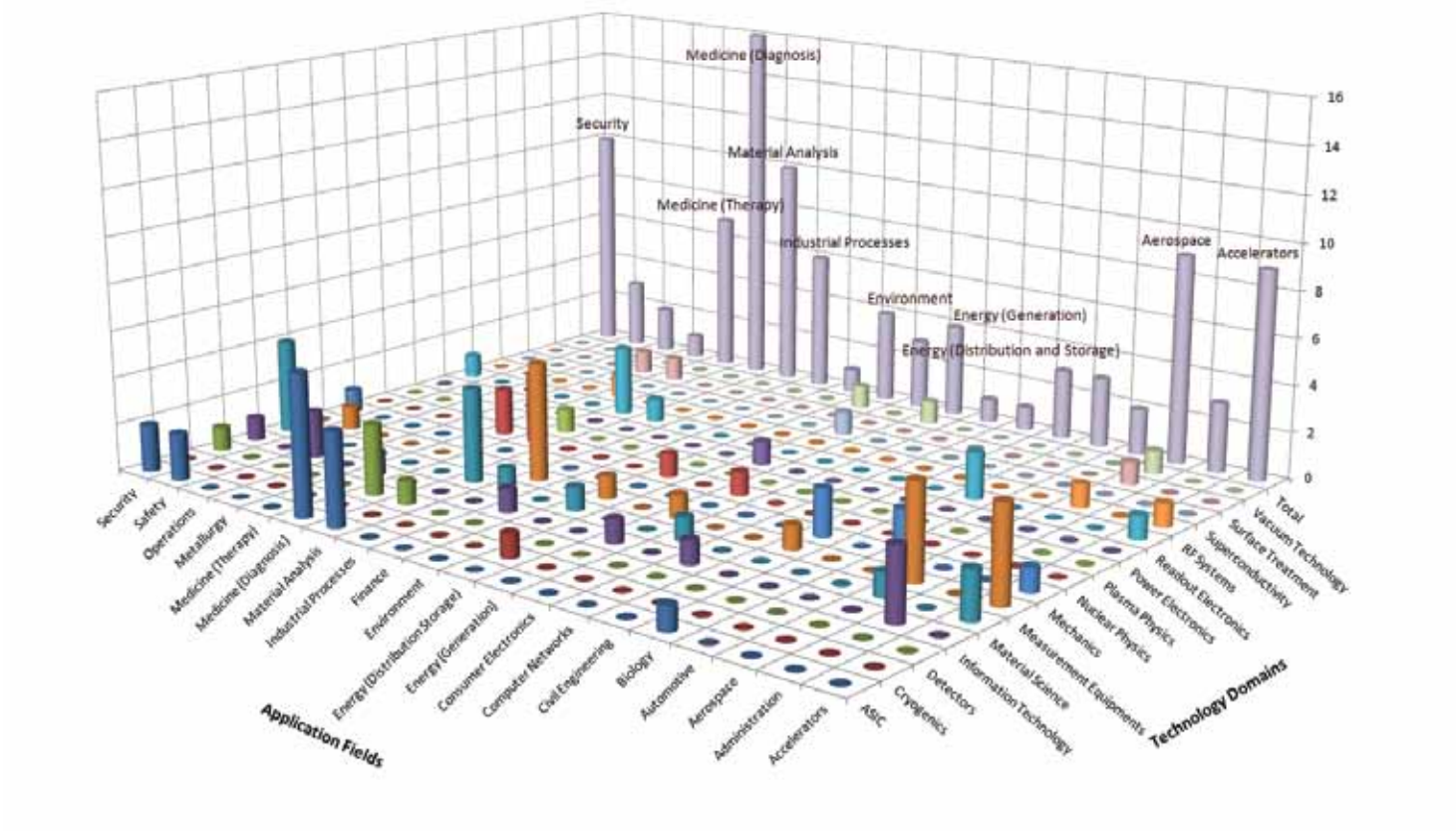
In 2011, CERN filed applications for 7 new patents:

Title	Priority date	Inventor(s)	Department	Ownership
Diaphragm System for permanent magnet motor	17/02/2011	Albert Ijspeert	/	CERN (100%)
The use of the “Diaphragm System” (previous CERN patent) principles for the assembly, positioning and fixation of permanent magnets in electrical motors.				
Piggyback resistive micromegas	26/08/2011	Ioannis Giomataris Rui de Oliveira	(CEA) TE	CERN (50%) CEA (50%
Interface between particle detectors (as micromegas) and readout systems without physical connection. This is done through a resistive layer and a dielectric layer adapted to the readout system by capacitive coupling.				
High temperature high power RF load	02/09/2011	Fritz Caspers Silke Federmann	BE BE	CERN (100%)
High temperature high power RF loads, able to work at temperatures exceeding 150°C and pressures above 20 bar. Two different types of loads are covered by the patent: a waveguide absorber and a coaxial absorber.				
Mini Cooling CO2 system	09/09/2011	Bart Verlaat	PH/ NIKHEF	CERN (50%) NIKHEF (50%)
The patent concerns an improvement of an existing cooling CO2 system (2PACL system developed at NIKHEF). The invention allows an accurate thermal control of distant set-ups with small additional cooling hardware, for example in hi-tech equipments.				

Title	Priority date	Inventor(s)	Department	Ownership
3D semiconductor detector	21/09/2011	Jan Jakubek Michael Campbell Thilo Michel	(CTU) PH (Un. Erlangen)	CERN (50%) CTU (25%) Un. Erlangen (25%)
A pixel detector comprising a single semiconductor sensor layer with a read-out electronics layer which allows the reconstruction of a 3D image of a charge deposition measuring the relative arrival times between neighbouring pixels. The final image gives information about the trajectory of the income beam.				
Architecture and Front End for imaging detectors	28/11/2011	Piero Giubilato Walter Snoeys	(Un. Padova) PH	CERN (50%) Un. Padova (50%)
Method for compressing data and the respective hardware to implement the method (front end), allowing acquisition of sparsely populated images with high spatial and time resolution plus a low power consumption.				
RF loads stacked structures	12/12/2011	Fritz Caspers Michael Betz Silke Federmann	BE BE BE	CERN (100%)
Robust resonant metallic low Q structures capable of operating at high temperatures (>150 ˚C). The patent also covers another embodiment, a very high temperature (up to 800 ˚C) air cooled load using a ceramic foam block inside a metal enclosure.				

CERN Technology Portfolio

In 2011, the CERN technology portfolio included a set of about 70 active technology transfer cases with applications in more than 20 different fields, as summarized below.



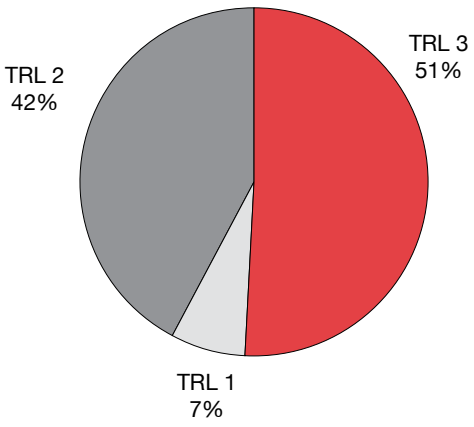
About half of the technologies in the portfolio are relatively mature (Technology Readiness Level 3).

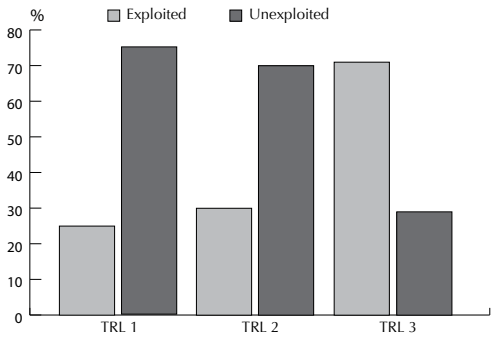
They are mostly exploited in the frame of licensing or service agreements. The technologies with a lower readiness level (TRL 1 or 2) can also be directly exploited, but this is more likely in the framework of longer-term R&D collaborations.

Globally, the exploitation level of CERN's technology portfolio in 2011 was about 50%.

TRL	Definition according to the Knowledge Transfer group
1	Technology application formulated and basic concept demonstrated
2	Functional validation in laboratory environment
3	Representative prototype fully qualified (technology ready to transfer)

Technology readiness level (left) and the relative exploitation percentage for each level (right)





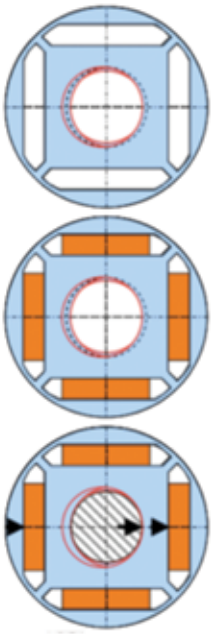
Technology Assessments

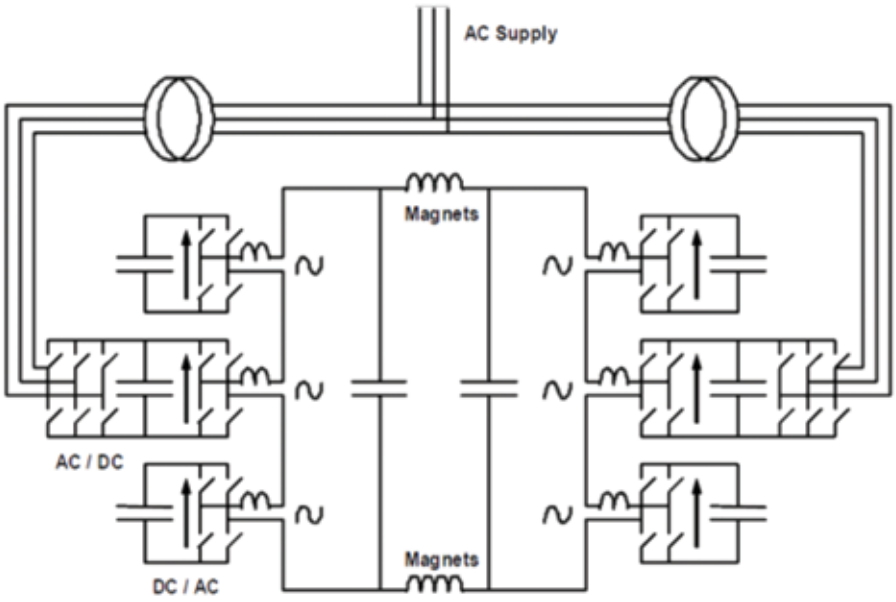
Technology assessments can be performed internally by KT Technology Transfer Officers, by students in the framework of dedicated screening sessions (for instance with NTNU in Norway or Wien TU in Austria), or subcontracted to external experts where very specific technical skills are required.

A valuable example of a new internal assessment in 2011 concerns the diaphragm system technology, further developed by its inventor (Albert Ijspeert) into a very flexible method for positioning and securing objects relative to each other. The assessment has shown that potential domains of application are the centering and clamping of magnet coils, the positioning and securing of permanent magnets and rotor shafts in electric motors, the centering of bars for the production of door-lock cylinders, the centering of twisted bars, vices for CNC machining, packing boxes holding a multiple of delicate components, and expansion dowels for the assembly of metallic profiles. About 15 companies have been directly contacted to investigate their interest in adopting this technology. A second patent has been taken to fully protect the IP related to this invention.

One assessment was performed by an external expert in 2011 and related to the POPS technology (power converters with an innovative electrical topology for effective capacitive storage). A recognised expert in the field of high-power electronics, Professor J. Laeuffer, was asked to find possible applications of the patent with or without modifications. His work covered very diverse applications and was substantiated by numerical analyses and simulations. The conclusions confirm that the technology has the potential to be successfully applied to industrial processes such as electromagnetic forming or electrostatic precipitators. Other possible applications (requiring modification of the patent) concern battery chargers for electric vehicles and radiological cinematography. The technology could also be applied (but with limited benefits with respect to alternative solutions) to high-power quality-control systems.

The market potential of two technologies, the quantum dosimeter (a CERN technology based on Medipix) and the carbon fiber composite material (a technology developed by the ATLAS Experiment Collaboration) was assessed in March 2011 by students attending the “Idea Generation” course held at the Institute for Entrepreneurship and Innovation of the Vienna University of Economics and Business.





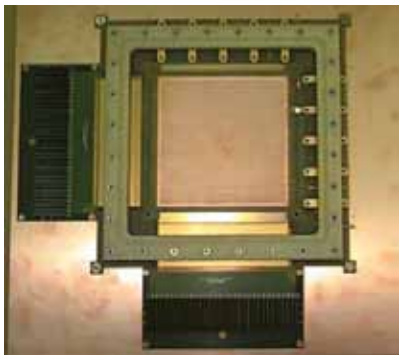
Agreements signed in 2011

In 2011, the following agreements prepared by the Knowledge Transfer group were signed:

Technology	Type of Agreement	Type of partner	Country
Read out boards for NINO chip	Exploitation License	Academic	US
Diaphragm Positioning and Fixation Systems	Sub-licensing license	Commercial	CH
Medipix 2	Production license	Commercial	ES
Roxie	6 Academic licenses	Academic	ES, SE, CN, JP, FR, DE
Medipix 2	Production license	Commercial	NL
Evacuable Flat Panel Solar Collector	Amendment to R&D Collaboration	Commercial	ES
Development of Dosepix Chip	Amendment to R&D Collaboration	Commercial	DE
Work on Accelerators for Medical Applications	Amendment to R&D Collaboration	Commercial	CH
Common development of a ring RF system	Amendment to R&D Collaboration	Academic	AT
Measurement Chains Test	Service Agreements	Commercial	DE
Watt balance design	Service and Consultancy Agreement	Academic	CH
CDS Invenio	2 Service Agreements	Academic	ES, DE
Mini Cyclotron	Collaboration and Consultancy Agreement	Academic	ES
Enterprise Europe Network	Operational Agreement	Academic	EC
Hadron Therapy	Framework collaboration agreement	Academic	IT
CRISTAL Kernel Package	Consortium agreement for SW exploitation	Academic	FR, UK
INFINHI	Consortium agreement	Academic	FR
CO2 cooling	Co-ownership agreement	Academic	NL
GEM	9 R&D licences	Academic	CN, IT, FI, FR, US, KR, DE

KT Fund
Funding innovation

In 2011, for the first time, six knowledge and technology transfer projects benefited from a dedicated fund made available by the Knowledge Transfer group.



A small size GEM detector assembly

GEM should be Gas Electron Multiplier detectors for flame detection and early earthquake prediction, radio frequency absorbers for energy recovery, and exotic radioisotopes for medical applications are among the projects funded by the new KT Fund. “CERN’s scientific programme generates a considerable amount of intellectual property, which is a natural driver for innovation,” explains Giovanni Anelli, Head of the Knowledge Transfer group. “Very often, though, financial support is needed to bring the newly-born technologies a step further and make them ready for transfer to other research institutes or to companies.”

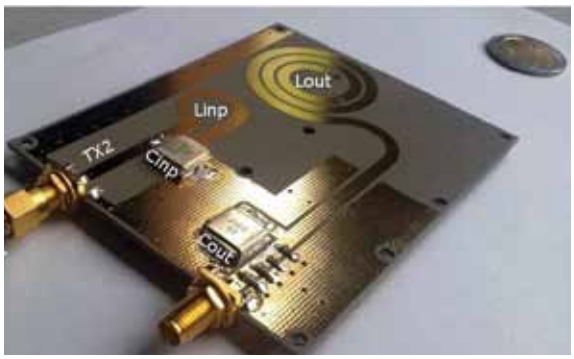
The KT Fund was created to provide vital support at any stage of CERN knowledge transfer projects, regardless of their field of application, as long as it is of use for society and in line with CERN’s principles. The positive response from CERN inventors confirmed the need for such an initiative. Projects were submitted from four departments –

The ISOLDE hall, a facility for medical radioisotope production

Physics, Beams, Engineering, and General Services and Infrastructure. They dealt with technologies with potential applications in a wide range of fields, from education to hadron therapy, astronomy, homeland security, environmental safety and energy recovery.

In order to qualify for support, the projects were evaluated by the KT Fund Selection Committee, which is chaired by Thierry Lagrange, Head of the Finance, Procurement and Knowledge Transfer Department, and includes all the heads of department and representatives of the KT group. “The quality of the projects submitted and their areas of application have been remarkable,” confirms Rolf Heuer, CERN’s Director-General. “In the spirit of maximizing the dissemination of our technologies and their positive impact on society, the Management has decided to increase the fund to fully support the initiatives.”

(more information: http://cern.ch/knowledgetransfer/technology-transfer/ip-management/kt-fund)



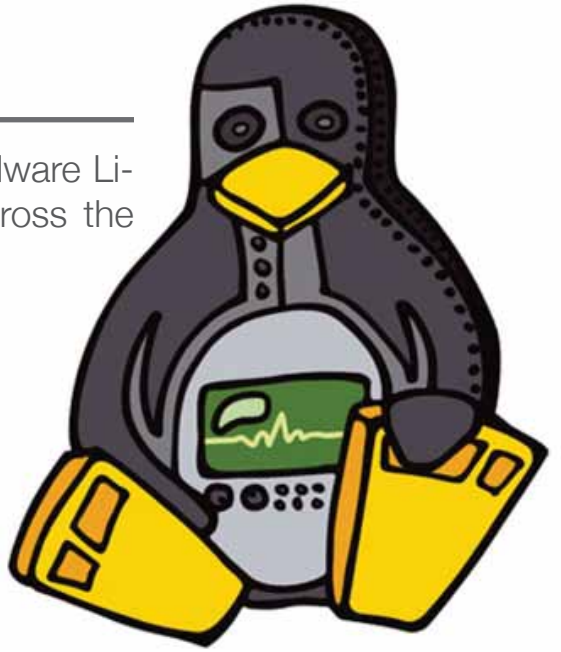
Prototype of a resonant RF to DC converter for energy recovery purposes

More about the KT funded projects:

GEM detectors for safety and environmental applications	PH	Project to develop two prototypes of resistive GEM sensors with safety (indoor flame detection) and environment (earthquake prediction) applications.
High temperature RF loads	BE	Project to build a demonstrator of a new type of high power dielectric free RF absorber designed to provide high temperature (up to 200°C)/ high pressure (up to 100 bar) outlet water for energy recovery.
Medical isotopes production facility in ISOLDE	EN	Project to design and assemble a pneumatic transport system to allow the irradiation of target materials using ISOLDE “wasted” proton beam and their transfer to a shielded cell for packaging. The final target is to create a production facility for small quantities of radioisotopes for medical research.
Microscint	PH	Project to develop scintillation detectors based on microfluidics for hadrontherapy online beam monitoring.
Photonic Crystals	PH	Project to test thin layer deposition to enhance light extraction from scintillators, with applications to medical imaging.
La Boîte	GS	Pedagogical project aiming at broadly diffusing a successful educational kit used to promote the scientific method to school kids.

CERN Open Hardware Licence

Issued in July 2011, the CERN Open Hardware Licence enhances knowledge exchange across the electronic design community.



Open Hardware mascot

In the spirit of knowledge and technology dissemination, the CERN OHL was created to govern the use, copying, modification and distribution of hardware design documentation, and the manufacture and distribution of products.

The introduction of the CERN OHL represents a novelty in which a clear policy has been adopted for the management of intellectual property in the sharing of hardware design. "The CERN OHL is to hardware what the LGPL (Lesser General Public License) is to software. It defines the conditions under which a licensee will be able to use or modify the licensed material," explains Myriam Ayass, legal adviser of the Knowledge Transfer group and author of the Licence.

Version 1.0 of the CERN OHL was published in March 2011 on the Open Hardware Repository, an initiative of electronics designers working in experimental-physics laboratories who felt the need to enable knowledge exchange across a wide community and in line with the ideals of "open science" being fostered by organisations such as CERN. "For us, the drive towards open hardware was largely motivated by the well-meaning envy of our colleagues who develop Linux device-drivers," says Javier Serrano, an engineer from CERN's Beams department and the founder of the OHR. "They are part of a very large community of competent designers who share their knowledge and time in order to come up with the best possible operating system. They learn a lot and have lots of fun in the process. This enables them to provide better drivers faster to our CERN clients," he continues.

Through the Open Hardware Licence and Repository, CERN is not only making hardware knowledge available, but it has also provided the OH community with a legal framework to share knowledge safely.

Through the Licence, in fact, "Everyone is able to see the design documentation, study it, modify it and share it" explains Ayass. "In addition, if modifications are made and distributed, it must be under the same licence conditions, ensuring that the whole community continues to benefit from improvements as everyone in turn will be able to make modifications to these improvements."

The fact that the designs are 'open' also means that anyone can manufacture a product based on the design – from individuals to research institutes to big companies – and commercialize it. This is one approach to technology transfer that nicely combines dissemination of the technology and of the accompanying knowledge. "This combining of an innovative business model and the OHL is finding a positive response in the commercial world and we are very excited because we are proving that there is no contradiction between commercial hardware and openness," says Serrano. Version 1.1 of the Licence was issued in July 2011 and sparked the interest of the Open Hardware movement: "The fact that the OHL was launched by CERN had a very strong impact on Open Source Hardware, since it establishes the necessary conditions for fair collaboration in open-source designs and provides a safe legal environment", says Serrano. "OSHW is a very welcome development for laboratories, academic and research institutions and companies", continues Serrano, "And it has proven to be an excellent tool for disseminating knowledge, which is part of CERN's mission."

(more information: http://www.ohwr.org/projects/cern-ohl/wiki)

Sharing Knowledge Transfer expertise

KT experts build a unique store of know-how in the fields of technology transfer and intellectual property management, which can be valuable for society.

Participants of the WIPO workshop in Manila, Philippines

In 2011, CERN's expertise in knowledge and technology transfer was called upon by other international organisations and research institutes and was shared through the participation of its KT experts in knowledge-sharing events.

In April-May 2011 Enrico Chesta, head of the Technology Transfer and IP Management section of the Knowledge Transfer group, was invited to take part as an external expert in a technical review organised by the European Space Agency (ESA) in support of the LISA Pathfinder (LPF) space mission. The exchange of knowledge between CERN and the ESA Steering Committee was particularly fruitful thanks to Chesta's expertise in the field of micro-propulsion systems but also his in-depth knowledge of CERN's broad set of competences, which allowed him to tackle the technical issues under assessment from new angles.

On 11 and 12 July 2011, Giovanni Anelli, head of the Knowledge Transfer group, attended the WIPO Conference on Innovation and Climate Change which took place in Geneva. This global forum was organised by and for entrepreneurs from governments, academia, IGOs, NGOs, industry and the general public to explore strategies and develop solutions to global problems through technology transfer and intellectual property management. Anelli moderated a session on "Real World Experiences of Technology Transfer", dedicated to the impact of technology transfer on the technical needs of developing countries, in accordance with environmental and sustainable development issues.

In September 2011, Myriam Ayass, legal adviser of the Knowledge Transfer group and author of the CERN Open Hardware Licence (OHL), was invited to present the OHL at the Open Hardware Summit. In October, she was also invited to give a presentation at the Open Hardware Workshop organized in the context of the 13th International Conference on Accelerator and Large Experimental Physics Control Systems in Grenoble, France. The workshop, attended by over 80 participants, discussed the legal framework of open hardware and possible business models, as well as tools and ongoing open hardware projects.

CERN's Patent Portfolio Manager, Telma Mantas, was invited to attend the event "Patenting in the field of High Energy Physics – Why, when and how", from 2 to 3 of November 2011. The seminar took place in Lisbon and Porto and was organised by LIP (Laboratório de instrumentação e física experimental de partículas) and by the Portuguese Government, represented by the national knowledge transfer officer, Emir Sirage. Mantas' lecture illustrated CERN's policy in the management of intellectual property and provided information on how LIP could benefit from the protection of its IP.

Bernard Denis, a special project coordinator for the Knowledge Transfer group, took part in the Regional Workshop for Development of Management Skills on Innovation, Technology Transfer and Successful Technology Licencing for Research and Development (R&D) Institutions in Asia Region. The workshop, held in Manila from 28 November to 1 December 2011, was organised by the International Atomic Energy Agency (IAEA), the World Intellectual Property Organization (WIPO) and the Government of the Philippines. As a lecturer, Bernard Denis showcased CERN's successful examples of technology transfer during sessions attended by senior scientists, technology managers and senior staff from the commercialisation offices of R&D institutes.

Networking innovators

The Knowledge Transfer group promotes and is a member of international and multidisciplinary networks designed to facilitate the exchange of relevant know-how and combine efforts in knowledge and technology transfer initiatives in the Member States.

EIROforum, Forum for European Intergovernmental Research Organisations

The EIROforum is a collaboration of eight European intergovernmental scientific research organisations (CERN, EFDA-JET, EMBL, ESA, ESO, ESRF, European XFEL and ILL.) On 1 July 2011 the rotating Chairmanship of EIROforum passed from EFDA-JET to CERN.

In September 2011, the Forum extended its areas of activity by setting up a Working Group on Innovation Management. On 15 September 2011, representatives of the EIROforum organisations met at EMBL in Heidelberg to establish the initial operational working plan of the group, which includes the setting-up of an EIROforum Innovation Prize, the organisation of multilateral matching events and a platform to exchange best practices and policies. In this working group, CERN is actively represented by Enrico Chesta, Technology Transfer and Intellectual Property Management section leader, and Giovanni Anelli, Knowledge Transfer group leader.

(more information: http://www.eiroforum.org/)

EEN, Enterprise Europe Network

In 2011, the KT group joined the EEN, a European Commission network helping small businesses to make the most of the European marketplace. EEN has close to 600 members, including chambers of commerce and industry, technology centres, universities and development agencies. Through the EEN website, database and PR activities, the KT group makes CERN's technology portfolio accessible to European companies and research institutes, facilitating the transfer of CERN's technologies.

In January 2011, CERN KT group signed an operational agreement with the European Commision / DG Enterprise and Industry, concerning the use of the services provided by EEN (Europe Enterprise Network), which operates in more than 45 countries in collaboration with about 580 local partner organisations to deliver business support focused on the promotion of technology offers and requests among the nodes of the network.

The formal meeting to launch this collaboration took place at CERN on 16 June, with the participation of the EC and the Chambre de Commerce et d'Industrie de Région Rhône-Alpes. A first technology offer from CERN was published (GEM technology) and others are in preparation.

(more information: http://www.enterprise-europe-network.ec.europa.eu)

ENET, CERN's Knowledge Transfer External Network

The Knowledge Transfer Group created and coordinates a network of technology transfer officers from all Member States. The Network held its annual meeting in March 2011. Detailed information on CERN's technologies and life sciences initiatives were presented by members of the KT group to encourage national TTOs to create connections with companies and research institutes in each Member State.

(more information: http://cern.ch/knowledgetransfer/network/enet)

INET, CERN's Knowledge Transfer Internal Network

The KT Group engages in several networking activities inside CERN. The INET network puts the KT Group in contact with KT officers in every CERN department and organises meetings. In 2011, an extension of the INET network was set in motion, and KT contact persons were identified at a more capillary level.

(more information: http://cern.ch/knowledgetransfer/network/inet)

ENLIGHT - The European Network for LIGht ion Hadron Therapy

ENLIGHT was established in 2002 to coordinate the common European efforts in hadron therapy, and now has more than 300 members from twenty European countries. The network has been co-ordinated by Manjit Dosanjh, CERN's Life Sciences advisor since 2006. A major achievement of ENLIGHT has been the blending of traditionally separate communities so that clinicians, physicists, biologists and engineers with experience and an interest in particle therapy work together.

In 2011, it was time for the European Network for Light Ion Hadron Therapy to develop strategic plans for the future, beyond the four EU-funded projects which are currently under its umbrella. A hundred members of ENLIGHT gathered in Marburg in September to not only review the status of these projects, but also to assess the current situation of hadron therapy worldwide. In fact, although this advanced form of cancer radiotherapy has largely shown its potential scientifically, the relative complexity and cost of the required infrastructures currently limits its exploitation.

The ENLIGHT community will be supporting the strive to treat patients in larger numbers and with increased efficiency. This will very likely open a way towards more cost-effective solutions.

(more information: http://cern.ch/enlight)

TTN, technology transfer network

CERN Council approved in March 2008 (CERN/FC/5231 – CERN/2778) the creation of a Technology Transfer Network (The TT Network), composed of Technology Transfer (TT) offices of public research organizations (Nodes) active in particle, astro-particle and nuclear physics, with the mandate of increasing the effectiveness of Knowledge and Technology Transfer activities in Member States.

The project run for three years, and in September 2011 CERN Council approved, at its European Strategy Session, the continuation of the TT Network for another three years, from 2012 to 2014 (CERN-Council-S/092/Rev.).
In 2011, on 16–17 February, CERN hosted the first industry-academia matching event on silicon photomultipliers (SiPMs) and related technologies. The event attracted around 140 participants from academia and industry, representing 43 public research organizations and 21 companies. A second event of this kind focused on beam instrumentation and measurement. The workshop was held at GSI Darmstadt on 10-11 November and attracted around 80 participants, including representatives of companies.

(more information: http://www.heptech.org/)

TTO Circle - European Technology Transfer Offices Circle

The JRC launched the European TTO Circle to bring together the major European national and international public research organisations to play a role in collectively driving changes in technology transfer practices. A preliminary meeting took place at the ESA technical centre in Noordwijk in April 2011, and the official founding event was held at CEA in Grenoble in October 2011 (an official collaboration agreement had been signed previously).

Three high-priority work packages were proposed and are currently under discussion: reducing IP barriers to facilitate joint exploitation of technologies, identifying common funding schemes and organising joint training programmes.

(more information: http://ec.europa.eu/dgs/jrc/index.cfm?id=3910&obj_id=3810&dt_code=EVN

Building bridges between CERN and biomedical research

The role of the Life Sciences section of the Knowledge Transfer group is to identify which particle physics technologies are interesting for biomedical applications, and to catalyse multidisciplinary collaboration between CERN scientists and researchers from medicine and biology–related areas.

State-of-the-art techniques borrowed from particle accelerators and detectors are increasingly being used in the medical field for the early diagnosis and treatment of tumours and other diseases. The computing and data management tools developed for the LHC also have potential applications in the field of e-health. "The successful transfer of knowledge and technology from fundamental particle physics research to the biomedical domain can be catalysed and enhanced if medical doctors, biologists, physicists and engineers exchange information, identify challenges and develop global strategies together," says Manjit Dosanjh, CERN's Life Sciences Advisor and Life Sciences section leader.

With this vision and challenge in mind, the Life Sciences section is actively fostering the connection between these various disciplines, so that scientists can understand which aspects of their research are relevant to one another: this helps to identify promising technologies and to start new multidisciplinary ventures. Successful examples of these activities are the European Network for Light Ion Therapy (ENLIGHT), co-ordinated by Manjit Dosanjh, and the Physics for Health (PHE) workshop, which was first held at CERN in 2010 and covered four major topics: radiobiology, radioisotopes, medical imaging and novel technologies in radiation therapy. The seminal role of CERN in developing a European roadmap to foster physics applications in the fields of disease prevention, diagnosis, therapy, and prognosis was acknowledged by the community attending this first workshop: CERN was requested to take the lead on three specific initiatives and to organise the PHE workshop regularly.

In 2011, the Life Sciences section was active both in the organisation of the 2012 ICTR-PHE conference, born from the merging of Physics for Health with the International Conference on Translational Research in Radio-oncology, and in the establishment of a research infrastructure for biomedical applications, which was one of the three initiatives defined by the first PHE workshop.

At the same time, since biomedical applications are not CERN core activities, the Life Sciences section is seeking external funding for research and training in this field. ENLIGHT has been instrumental in securing funding for hadron therapy projects, and the section now coordinates three EU-funded projects (PARTNER, ENVISION, ENTERVISION), as well as one of the three pillars of the EU infrastructure project ULICE. The total EU funding for these projects amounts to 24 million euros.

In 2011, the section was active in a range of communication and education activities (the CERN Teachers' Programme, articles for the general public, videos, etc.). The Life Sciences section also continued to be strongly involved in the efforts to strengthen CERN's connections with non-Member States, and in particular with developing countries. As an example, the head of the section was invited to iThemba LABS in South Africa, a research facility which has been treating oncological patients for 20 years. Its collaboration with CERN has been growing over the years, and iThemba LABS is now planning to buy a new medical-use proton cyclotron - the only one of its kind in the southern hemisphere. In this context, Manjit Dosanjh was invited to give input to and participate in the discussion about iThemba LABS' strategy and a possible approach towards the creation of a Public Private Partnership for the implementation of the project.

In 2011, the section became involved in EPLANET, a Marie Curie International Research Staff Exchange Scheme aim-

Annual meeting of the ENLIGHT network in Marburg

ing at fostering the collaboration between Europe and Latin America in HEP and associated technologies. The project had its kick-off in 2011, and Manjit Dosanjh co-ordinates the work package on medical applications.

ENLIGHT

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In fact, although this advanced form of cancer radiotherapy has largely shown its potential scientifically, the relative complexity and cost of the required infrastructures limit its exploitation. The ENLIGHT community will be supporting the strive to treat patients in larger numbers and with increased efficiency. This will very likely open a way towards more cost-effective solutions.

Another important objective for the future is to perform clinical trials in Europe, following dedicated protocols, which are necessary to gather data and prove the higher effectiveness of radiotherapy with protons and ions (in particular) compared to that with photons. The discussion on this topic started during the Marburg meeting.

PARTNER

PARTNER is a 4-year Marie Curie Initial Training Network that offers research and training opportunities to 25 young biologists, engineers, physicians and physicists in the multidisciplinary field of hadron therapy. 21 of them were enrolled as ESR (early-stage researcher) and 4 as ER (experienced researcher). Ten academic institutes and research centres and two leading companies are participating in PARTNER, which was launched in 2008 and is coordinated by CERN. During 2011, three training courses were organised, comprising theoretical lectures and some practical activities. The first, held at MedAustron in Vienna, focused on treatment planning for cancer radiotherapy with protons and ions. The second one was organized by CNAO in Pavia, and addressed the topic of clinical trials. Finally, a course on mathematical modelling for biological and physical processes was held at the university of Surrey, in UK. All trainings were attended by the PARTNER researchers as well as by young external participants involved in the field.

At the annual meeting held in Marburg in September, the presentations of the individual projects displayed clearly the variety of topics being addressed and the quality of the research. Four of the PARTNER researchers were hired at CERN, and are co-supervised by members of the Life Sciences section. Three of them are developing a prototype Hadron-therapy Information Sharing Platform (HISP), which will allow aggregation and sharing of data, ensure

Treatment room at HIT

the transfer of confidential patient information in a secure environment, and provide a common access point to medical data for clinicians and researchers. In 2011, a first version of the prototype was released, and the researchers are now integrating additional functionalities. The fourth CERN researcher focuses on improving the accuracy of Monte Carlo simulations of therapeutic ion beams in tissues, and participates in the FIRST (Fragmentation of Ions Relevant for Space and Therapy) experiment, designed to obtain high-precision data on interaction of ion beams with matter. In 2011, among other achievements, the ESR published a scientific article which was chosen by IOP Journals for their Featured Articles, a series of high-quality articles selected by the editors and referees for their novelty, high level of interest and potential impact on future research. The PARTNER researchers are all approaching the end of their grants: in 2011 the first PhD thesis was completed, and in the next months most of the other ESR's will obtain their PhD as well. The project is now in its fourth and final year, and in September it will be time to review the results that have been achieved in all the work-packages.

The project is funded by the European Commission within the FP7 People (Marie Curie) Programme, under Grant Agreement No 215840.

ULICE

The ULICE project, coordinated by CNAO (Pavia, Italy), was launched in 2009 by 20 leading European research organisations, including 2 major industrial partners. ULICE responds to the need for greater access to hadron therapy facilities for research and clinical use, and addresses the development of appropriate instruments for more effective and affordable hadron therapy, with particular emphasis on carbon ion therapy.

2011 was a crucial year for ULICE: the research activities delivered first encouraging results, and the Transnational Access protocol was set up to allow access to the existing European facilities for patients, clinical and experimental research, as well as for clinical training and education. These achievements were reported to the European Commission officers at the Mid Term Review meeting held in Marburg in September, where ULICE was evaluated positively and was granted the next two years of funding.

In terms of research activities, existing clinical-study protocols worldwide were reviewed to start defining common guidelines for patient selection, and important steps forward have been made in defining uniform methods and concepts for irradiation doses and tumour volumes in radio-oncology, to create a common language not only within the consortium but across all of the communities involved in different forms of radiotherapy.

Within the activities of Transnational Access, ULICE had the complex task of setting up a structure to allow access to the existing European facilities for patients, clinical and experimental research, as well as for clinical training and education. As of summer 2011, researchers from eligible countries can apply to take part in research activities or submit experimental proposals in the clinical, radiobiological and physical field at the University Hospital of Heidelberg and at CNAO. Applications for participation in the Transnational Access programme will be reviewed by a multicentre scientific committee, and successful applicants will be granted free access thanks to the European Union Transnational Access funding. In this context, the role of the Life Sciences section, which co-ordinates the Networking Pillar of ULICE, was crucial to implement the online tools for applying for a Transnational Access grant, and will be instrumental in the coming year to bring this possibility to the attention of the widest possible community.

ULICE is co-funded by the European Commission within the FP7 Capacities Programme, under Grant Agreement no 228436.

ENVISION

ENVISION is a collaboration of sixteen leading European research centres and industrial partners, co-ordinated by CERN, which aims at developing novel imaging techniques for safer and more precise hadron therapy. The project was launched in February 2010: after a year mainly devoted to recruiting and setting up the proper connections between the various research groups, 2011 saw the publication of the first results. The Life Sciences section followed closely the research activities by taking part in the meetings organised by each Work Package and organising regular Steering Committee meetings, thus ensuring the timely completion of six scientific deliverables over the year. The section also organised the Annual Meeting in February 2011 in Lyon together with the local hosts. The year was also heavy in terms of EC reporting, with the Annual Report and the Financial Report due at the end of February and of September, respectively: the section was responsible to collect all the relevant information from the partners and write both reports. The quality of the research activity within ENVISION is shown by the publication of six scientific papers and one PhD thesis.

The project is co-funded by the European Commission within the FP7 Cooperation Programme, under Grant Agreement N. 241851.

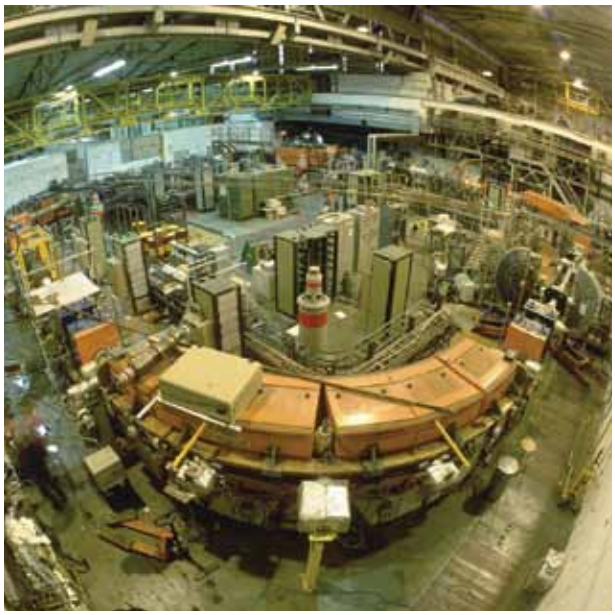
ENTERVISION

ENTERVISION is a Marie-Curie Initial Training Network which started in February 2011 with the aim of training young researchers in online 3D digital imaging for hadron therapy. ENTERVISION brings together ten academic institutes and research centres of excellence and the two leading European companies in particle therapy, and is coordinated by CERN. The research activities of the trainees will be connected to those pursued in ENVISION. In the first year, the collaborating institutions have been actively hiring the researchers, and the first network-wide training will take place in March 2012. Three ENTERVISION researchers are based at CERN, one of them within the Life Sciences section.

The project is funded by the European Commission within the FP7 People (Marie Curie) Programme, under Grant Agreement No 264552.

The legacy of the first workshop on Physics for Health in Europe

The first *Physics for Health* in Europe workshop held at CERN in February 2010 successfully showed how particle accelerators and detectors can become powerful instruments for early diagnosis and effective treatment of diseases. In 2011 three projects in medical physics, which emerged from the workshop, began to take shape.



LEIR accelerator, the Low Energy Ion Ring at CERN

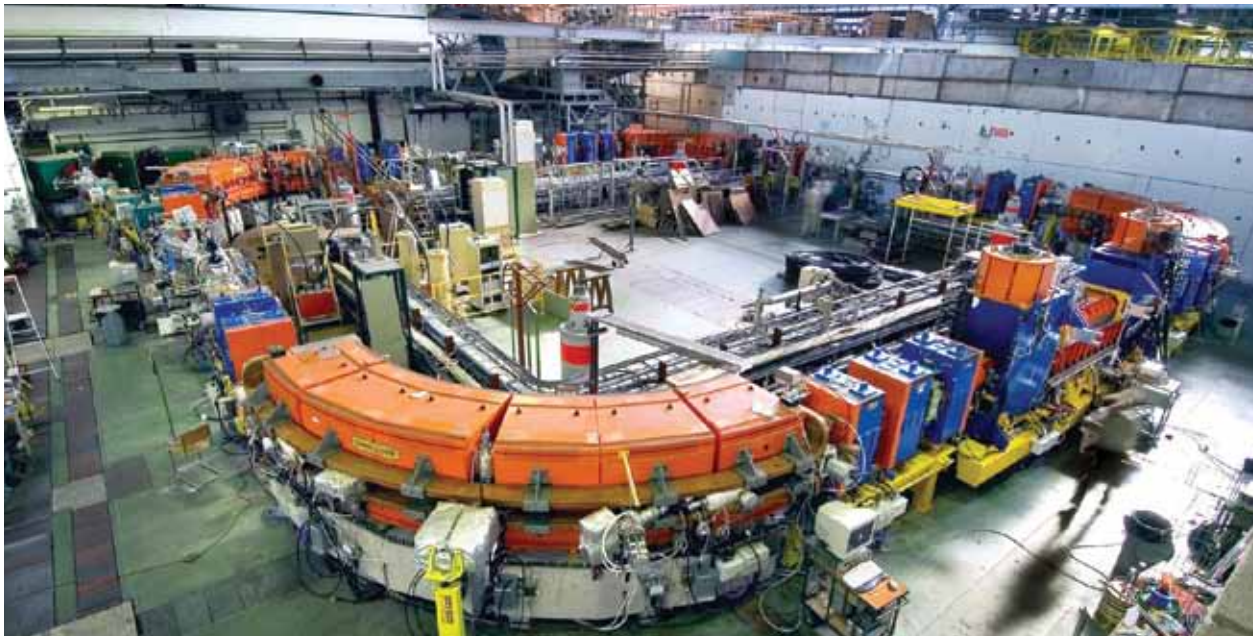
The multidisciplinary community of physicists, medical doctors and biologists attending Physics for Health asked CERN to take the lead on three initiatives in the medical physics field:

- the establishment of a research infrastructure for biomedical applications
- the creation of a virtual European facility for the production and use of innovative radioisotopes
- the launch of a new study for compact and low-cost accelerator systems for hadron therapy.

The three projects are led by Steve Myers, CERN's Director of Accelerators and Technology.

A CERNBIO R&D facility

A future biomedical facility should provide particle beams of different types and energies to external users interested in radiobiology fragmentation studies and detector development. The CERNBIO facility would help in assessing the biological effect of light and heavy ions, as the medical and radiobiological communities still lack systematic studies on the impact that different particles at different energies have on cells and biological material. Understanding biological effects is a key element in selecting the optimal ions to improve the treatment with particles. Further improvements



are expected by more precise measurements of fragmentation cross-sections in the energy range relevant for therapy. In addition, a CERNBIO facility would help improve the risk estimation for ion exposure. Under the co-ordination of Manjit Dosanjh, CERN started to investigate the possibility of using the LEIR accelerator, which is well suited to provide a range of ions and energies both for radiobiology and for detector developments, and is only used for LHC operation for part of the year.

Innovative Radioisotopes

Radioisotopes are playing an increasingly important role not only in cancer diagnosis but also for treatment and other clinical studies. The discussions during Physics for Health indicated that R&D isotopes have promising characteristics, but also that preclinical and clinical studies are required to show their advantages and potential usefulness, in particular for the alpha-emitters. Securing an adequate supply is the main problem for these radioisotopes, hence the formal recommendation for CERN to assess the viability of an "Isotopes for research" programme with the aim of creating a European user facility for the supply of innovative radioisotopes. The programme is co-ordinated by Dewi Lewis and Ulli Koester (ILL), and its objective is not to invest in the construction of a new facility, but to organize a virtual network across the existing facilities to satisfy the production needs. A steering group is being set up to confirm the viability of the programme, identify those radioisotopes with unmet production needs, and organise a European working group meeting.

PIMMS2

The third initiative starting to be implemented by CERN is a new study for an accelerator complex for cancer therapy. This PIMMS2 study is co-ordinated by Daniel Brandt and aims at designing an accelerator complex, which will have to be compact, use a reliable technology, and fulfil the most recent medical requirements. An additional challenge will be to come up with a design with a relatively low cost. In 2011, phase one of the project started with a call for proposals sent to a wide scientific community, asking to submit requirements and ideas for which accelerator type should be the focus of the new study. A committee is being set up to evaluate the merits of the proposals, and choose the one(s) to be pursued.

Uniting Biology, Medicine and Physics for better healthcare

CERN's Physics for Health workshop joins forces with the International Conference on Translational Research in Radio-Oncology to organise the first ICTR-PHE conference in Geneva, February 27 to March 2, 2012

Building on the positive response to the first Physics for Health workshop, CERN confirmed its commitment to contribute to improved healthcare by partnering with the well-established ICTR medical conferences. The result will be a 5-day event devoted to the latest advances in both diagnosis and treatment, with the aim of creating collaborations which will enhance the exchange of information between scientists from a variety of disciplines. The laboratory's strong support to this initiative is attested by the involvement of Sergio Bertolucci, CERN's Director for Research and Computing, and Steve Myers, CERN's Director of Accelerators and Technology, in the ICTR-PHE Executive Committee and Advisory Board. The conference is chaired by Jacques Bernier, Head of the Radiotherapy Department at the Genolier Clinic in Switzerland, and Manjit Dosanjh, CERN's Life Sciences Advisor.

For the Life Sciences section of the Knowledge Transfer group, 2011 was the year of preparation of this first ICTR-PHE conference. At the beginning of the year, the Executive, Scientific and Organising Committees were appointed and the scientific programme was outlined: the structure of the two original events was maintained, with the addition of a central day that will connect the PHE and ICTR communities, and will feature plenary lectures on the many synergies that exist between biology, physics and clinics. During spring, the conference website was set up and a first announcement was circulated. Registration and abstract submission opened in June, and almost 400 abstracts were received by the closing date in October. In the last two months of the year, the Scientific Committee selected the contributions for the various sessions and defined the list of invited talks, including a presentation open to the general public on "Treating cancer in the XXIst century: biology, physics and genomics".

Around 600 people have registered to attend the ICTR-PHE conference, which is expected to become a reference event to help connect Biology, Physics and Medicine for better healthcare.

About ICTR

The ICTR conferences started in 2000 to update the radiation oncology community on the most recent advances in translational research, reinforce the synergies among clinicians, biologists and medical physicists, and, last but not least, trigger personal and institutional contacts favouring a more efficient collaboration between laboratories worldwide. The last two days of ICTR-PHE are organised in the format which made the success of the previous editions of the ICTR Conference, with a combination of plenary and parallel sessions on translational research and pre-clinical strategies in radiation oncology.

About PHE

The first edition of the Physics for Health in Europe workshop was organised by CERN in February 2010 with the objective of reviewing the progress in the domain of physics applications in life sciences, stimulating the exchange between different teams and indicating the subjects most suitable for further studies in diagnosis and therapy. The first two days of ICTR-PHE will be articulated into the four major topics defined during the previous Physics for Health workshop: radiobiology, radioisotopes, medical imaging.

(more information: http://cern.ch/ictr-phe12)

Oncological hadron therapy takes off in Italy

Using accelerator technology to treat cancer is one of the most compelling examples of technology transfer from research laboratories to medicine. CNAO, Italy's National Centre for Oncological Hadron Therapy, treated its first patient in September 2011, signalling the take-off of hadron therapy of deep-seated tumours in Italy.

A hadron therapy treatment room in CNAO

On 22nd September 2011, CNAO in Pavia, Italy, the second protons and carbon ion therapy centre in Europe, finished treating its first cancer patient with proton beams. Hadron therapy is a type of particle therapy that uses beams of protons or ions to target cancerous tumours.

CERN has made significant contributions to the development of hadron therapy technologies. The construction of the CNAO facility is based on the optimised medical synchrotron designed in the framework of the "Proton Ion Medical Machine Study" (PIMMS) carried out at CERN from 1996 to 2000. With the goal of investigating the theoretical understanding and technical design of a cancer therapy synchrotron capable of accelerating light ions or protons, PIMMS was an international collaboration between CERN, the TERA foundation, the MedAustron project in Austria and Oncology 2000 in the Czech Republic. The study group also benefited from close contacts with the GSI laboratory in Darmstadt, Germany, where beams of carbon ions have been used for therapy purposes.

"PIMMS provided a design of the synchrotron and the beam lines, which have been simplified by TERA to reduce the required floor space," says Ugo Amaldi, founder and president of the TERA foundation, whose ideas gave birth to CNAO's creation. "On the basis of the TERA project, the CNAO foundation began constructing the centre in 2005 with very important contributions from INFN. The construction designs were later bought by MedAustron for the centre that is being built in Wiener Neustadt."
The CNAO facility includes a synchrotron and three treatment rooms equipped with horizontal fixed beam outlets; one of them housing an additional beam line from above. "The heart of CNAO is a 25 m diameter synchrotron," explains Roberto Orecchia, scientific director of CNAO and vice-president of the TERA foundation. "The accelerator and the beam lines are designed using the same principles and technology used for particle accelerators at CERN. They work perfectly and we are now looking forward to starting to treat patients with carbon ions in mid-2012 and to comparing their clinical effects with the ones produced by proton beams."The clinical interest in hadron therapy lies in the fact that it delivers precision treatment of cancerous tumours. While X-rays lose energy slowly and mainly exponentially as they penetrate tissue, hadrons deposit almost all of their energy in a sharp peak – the Bragg peak – at the very end of their path. Due to this fundamental property, protons and ions allow to target the tumour more precisely and to deliver smaller doses to the healthy tissues when compared to photons used in conventional radiation treatment. Protons have the same biological effects as X-rays and, according to the studies made in the framework of the European Network for Light Ion Therapy (ENLIGHT), about 12% of X-ray patients would receive better treatment with protons. Carbon ions have a superior radio-biological effectiveness and they can produce severe damage to the tumour. Thus they are more effective against hypoxic or slowly growing tumours that are in general resistant to photons and protons, opening the possibility to treat the 8% of tumors which are radioresistant.

(more information: http://www.cnao.it/)

Scintillating crystal technology from particle detectors to diagnostics

Medical diagnostics, homeland security, astronomy and industrial tests are some of the fields benefiting from the scintillating crystal technology used in calorimeter particle detectors. CERN's experts are collaborating with European research institutes, hospitals and companies to bring this knowledge to society.

The ClearPEM-Sonic camera installed in North Hospital in Marseilles

One CERN contribution to the advancement of diagnostic techniques comes from the application of scintillation crystal technology to medical imaging.

Inorganic scintillating crystals, thanks to their property of luminescence when excited by ionizing radiation, were studied by CERN's Crystal Clear Collaboration, which used them in electromagnetic calorimeters, such as those used in particle detectors. Today, 80,000 scintillating crystals are installed in the calorimeter of the Compact Muon Solenoid (CMS) detector, one of the experiments at the Large Hadron Collider. The collaboration soon became aware of the immense potential of the knowledge and technology generated by the development of these scintillating crystals and the associated photodetectors and readout electronics (120'000 avalanche photodiodes are used in the CMS electromagnetic calorimter) to be transferred from high energy physics to fields such as medicine and homeland security.

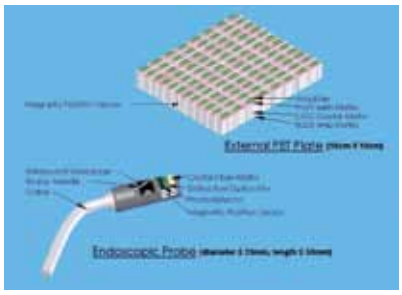
The latest result of this successful technology transfer is ClearPEM-Sonic, a new machine for medical imaging which was fully installed at the Hôpital Nord in Marseille, France in January 2011 and fully commissioned during the year. The innovative imaging system combines a mammography PET and a 3-D ultrasound and elastography system, allowing the combination of metabolic, morphologic and structural information for a better quality of diagnosis.

The machine has been developed in the framework of CERIMED, an international and multidisciplinary collaboration founded by CERN physicist Paul Lecoq, head of the Crystal Clear Collaboration. CERIMED brings together academia and research laboratories (CERN, Univ. Aix-Marseille II, VUB-Brussels, LIP-Lisbon, LMA-CNRS), companies (PETsys, SuperSonic Imagine) and clinical partners (AP-HM Marseille, Canceropole PACA, Inst. Paoli Calmettes Marseille.

"In our multidisciplinary activities, it is crucial to take account of the feedback provided by medical doctors and biologists who are the ones using our technologies," explains Lecoq. "This synergy is only possible if the scientific community can deliver a technology that is ready to be tested at patient level, so that it has a clear impact on medical practices."

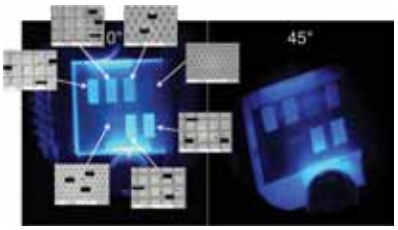
Phase 1 of the clinical trial will start in March 2012, following approval from the French sanitary authorities. The trial will be conducted on 20 patients to prove that ClearPEM-Sonic is suited for clinical use. In the future a complete exam protocol will be established for the patient, including X-ray mammography, ultra-sound, PET/CT, MRI and ClearPEM-Sonic, to provide fused images for any combination.

With the objective of increasing the synergy between physics, medicine and biology, CERIMED, the European Centre for Research in Medical Imaging, is presently under construction at the Timone university-hospital campus in Mar-



< The EndoTOFPET-US external PET plate and endoscopic probe

First results of the Photonic Crystals >



seille. It is running as an open campus for the advancement of medical imaging with a large technological, radio-pharmaceutical, pre-clinical (rodents and large animals) and clinical infrastructure. The Centre is open to international collaborations, with emphasis on education and training support.

ENDO TOFPET-US

In 2011, the successful story of the Crystal Clear Collaboration continued with the launch of ENDO TOFPET-US, a European project for the design of a high-performance medical imaging device for use in pancreatic cancer research.
The project, funded by the European Union's FP7 programme, is a collaborative effort between CERN's Physics department and 13 partners, including hospitals and companies. The project is coordinated by CERIMED.

"Capitalising on the unique expertise we have in the technologies involved, the technical coordination is under the responsibility of CERN, once again proving the Organization's role as an effective catalyser of knowledge transfer between different fields and institutes in Europe," says Lecoq, the project's technical coordinator.

With a budget of 5.5 million euros, ENDO TOFPET-US's primary objectives will be the design of a state-of-the-art endoscopic probe and the development of biomarkers, with a priority on markers for pancreas and prostate. "The ENDO TOFPET-US endoscope will have a dual-mode imaging system. We'll use an ultrasound probe with a biopsy attachment plus a PET detector head," explains Lecoq. The ultrasound signals will provide an anatomical image of the tumour, while the PET head will supply highly detailed information about its activity and, indirectly, the associated proteins. The results of the imaging will be correlated with the biological analysis of the tumour."

As a legacy for future R&D projects, ENDO TOFPET-US will also define a roadmap for the development of a new generation of multimodal endoscopic probes for different clinical applications.

Following four years of collaboration, the ENDO TOFPET-US probe is planned to be operational by December 2014.

(More information about ENDO TOFPET-US: http://cern.ch/endotofpet-us)

Photonic crystals

Inorganic scintillators can also be used in detection systems, which find applications in fields including physics detectors, astronomy, homeland security, medical imaging and non-destructive industrial testing.

In November 2011 a CERN R&D project received financial support from CERN's Knowledge Transfer group through the newly established KT Fund (see p. 18).
The project aims at using a thin layer deposited on the face of inorganic scintillators where they are coupled to the photo-detectors, called photonic crystals, to enhance the light extraction from scintillators.

"We have known about this effect for 20 years and it has been successfully implemented for bright LEDs on an industrial scale," explains Paul Lecoq, head of the project. "But our group at CERN is the first in the world to have worked on its implementation in scintillating crystals."

After a successful phase in which the proof of concept has been established, the project team is currently evaluating methods, such as nanoimprint technologies, to implement this approach on an industrial scale, which is the key for successful technology transfer.

The ClearPEM-Sonic collaboration comprises:
CERN, European Organization for Nuclear Research
Vrije Universiteit Brussel (VUB), Brussels, Belgium
Laboratório de Instrumentacão e Física Experimantal de Partículas (LIP), Lisbon, Portugal
Université de la Mediterranée (Aix-Marseille II), Marseilles, France
Assistance-Publique-Hopitaux de Marseille (AP/HM), Marseilles, France
Institut Paoli – Calmettes (IPC), Marseilles, France
Laboratoire de Mécanique et d'Acoustique (LMA), CNRS, Marseilles, France
Universita degli studii di Milano-Bicocca, Milan, Italy
Universiteit Gent, Gent, Belgium
Supersonic Imagine, Aix-en-Provence, France
PETsys-Medical PET Imaging Systems S.A, Oeiras, Portugal.

(more information: Crystal Clear Collaboration : http://cern.ch/crystalclear)

Foundation stone-laying ceremony for advanced ion-beam therapy and research centre in Austria

*Med*Austron is a project establishing one of the most advanced centres for ion-beam therapy and research in Europe. The accelerator design and construction is part of a partnership between CERN and EBG *Med*Austron GmbH. In March 2011 the foundation stone-laying ceremony for *Med*Austron took place in Wiener Neustadt, Austria.

MedAustron facility (simulation)
MedAustron facility (simulation): The conventional hospital building (reception area, rooms for medical preparation and offices) can be seen in the foreground on the right. On the left is the accelerator building with the synchrotron hall (at the back) and the four irradiation rooms along the extraction line (the long higher building at the back).

The MedAustron low-energy test beam line at CERN: from the particle source (blue cylinder) the beam passes through a spectrometer dipole (blue, in the centre). Vacuum tanks with beam diagnostics for analysing the particle beam are installed on the right.

*Med*Austron is designed for the treatment of up to 1,400 tumour patients per year and for non-clinical research in the areas of radio-biology and medical radiation physics, as well as in experimental physics. *Med*Austron is an interdisciplinary project, benefiting from close cooperation with and knowledge transfer between medical, scientific and research institutes on a national and an international level.

The heart of the *Med*Austron centre is the accelerator complex, consisting of ion sources, an ion linear accelerator, and a synchrotron as the main accelerator. The parameters and size are very similar to the LINear ACcelerator 3 (LINAC3) and Low-Energy Ion Ring (LEIR) accelerators, CERN's Large Hadron Collider's (LHC) ion pre-injector complex. Three medical irradiation rooms will allow quasi-permanent patient treatment during two shifts on working days. The remaining beam time will be used for non-clinical research applications in a dedicated fourth irradiation room.

A partnership agreement between CERN and EBG *Med*Austron GmbH on work relating to the design, manufacturing follow-up and construction of the *Med*Austron accelerator facility was signed in August 2008. The agreement provides for the integration of *Med*Austron personnel in the CERN technical groups during the accelerator design and construction phases. At the end of 2011, 47 *Med*Austron employees were present at CERN, benefiting from training and support in all accelerator-related technologies provided by the highly experienced CERN staff (7 Full Time Equivalent (FTE)). Additionally, nine technical students were involved in the MedAustron-related design work at CERN and three PhD theses were completed.

The procurement of the accelerator components is on schedule. The first elements, produced by industry, have already arrived at CERN for acceptance testing. These include normal-conducting magnets, power converters, an ion source, and vacuum and beam diagnostics systems.

With the start-up of the *Med*Austron low-energy test beam line – installed in a tunnel area of the former Intersecting Storage Ring (ISR) collider at CERN – the CERN–*Med*Austron technical team reached a major milestone in November 2011. The operation of both proton and carbon beams was technically demonstrated and the measured beam properties confirmed the expected performance of this first part of the *Med*Austron accelerator complex.

Both CERN and *Med*Austron benefited from exploiting their synergies in other areas, an example being the common development of a new Radio Frequency (RF) accelerating system to be used at CERN for the PS-Booster upgrade and at MedAustron for the synchrotron.

"The high reliability and availability required for a medical accelerator present major technical challenges. These are areas where CERN's experience and know-how from the development of the LHC are of highest relevance for design choices and technological decisions for the *Med*Austron project," explains Michael Benedikt, *Med*Austron project leader at CERN.

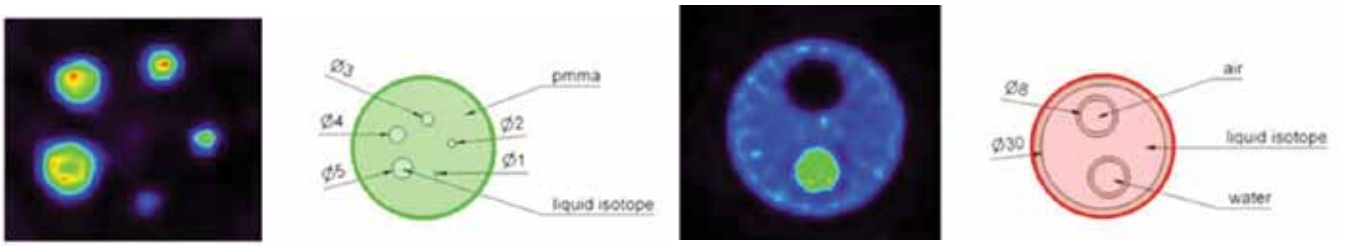
On the *Med*Austron site in Wiener Neustadt, some 40 km south of Vienna, the focus in 2011 was on the construction of the building. To date, the civil engineering work is virtually complete, and 2012 will be dedicated to the installation of technical infrastructure and interior finishing work. This phase will be followed by accelerator installation, starting in late autumn 2012. From spring 2013 onwards, test operation with beam will commence, in preparation for the first patient treatments planned for 2015.

"The strong collaboration with CERN is an essential ingredient for our project and an excellent example of large-scale technology transfer from CERN, high-energy physics and basic research," states Klaus Schneeberger, chairman of the *Med*Austron board.

(more information: http://www.medaustron.at)

Basic research for a new concept of Positron Emission Tomography

AX-PET is one of the successful examples of how knowledge and technologies developed in basic research can be used to improve medical imaging techniques. The project, which started at CERN in late 2007, focuses on the production of a demonstrator for a new concept of scanners for Positron Emission Tomography (PET).



Two slices of a NEMA NU4 Image Quality Mouse Phantom, recorded with the AX-PET demonstrator set-up (all dimensions in mm).

PET is a well–established, non–invasive diagnostic tool that allows functional information from living subjects to be visualised. Ideally, a PET scanner should be characterised by high spatial resolution and high sensitivity. In conventional PET, these two aspects are often mutually exclusive, whereas the AX-PET concept is designed to improve both sensitivity and resolution at the same time, the obvious benefit being a more precise diagnosis for the patient.

"With the AX-PET technology we manage to have images that are practically free of parallax errors," explains Christian Joram, coordinator of the AX-PET project and leader of the Detector Technology group at CERN. "We can achieve a true 3D reconstruction of the photons. This is possible thanks to the axial arrangement of elongated scintillation crystals combined with the wavelength shifter readout of the transverse co-ordinate."

From the original idea, the AX-PET project has evolved into an international collaboration.
In 2011 the AX-PET demonstrator scanner entered the phase of final performance characterisation. Measurements with phantoms filled with radiotracers were performed in the Small Animal PET Lab at the ETH Zurich, as well as at the company AAA, a producer of radiopharmaceuticals set up as a CERN spin-off in 2002.

"To fully exploit the potential of AX-PET, we faced the challenge of developing adequate simulation and image reconstruction software," says Magdalena Rafecas, a professor at the Institute of Corpuscular Physics (IFIC), University of Valencia, who is in charge of the AX-PET sub-project relating to software. "Our activities for 2012 include further development of dedicated reconstruction approaches, aimed at exploiting the system sensitivity and accelerating the computing-expensive reconstruction process."

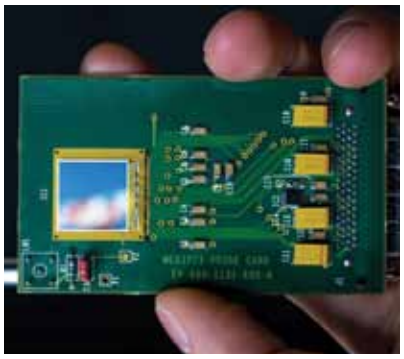
Additionally, new test measurements in a pre-clinical environment are planned for spring 2012. Discussions with industrial partners about possible commercial applications of the AX-PET principle are underway. The University of Oslo is already working on an AX-PET-inspired full scanner for pre-clinical applications (small animal PET). The Technical University of Tampere is also investigating a very special axial scanner for a specific application.

The AX-PET collaboration comprises: CERN, PH Department, Università e Sezione INFN di Cagliari (IT), ETH Zurich (CH), IFIC - CSIC / Universidad de Valencia (ES), INFN, Sezione di Bari (IT), University of Michigan, Ann Arbor (USA), Ohio State University, Columbus (USA), University of Oslo (N), Tampere University of Technology (FI)

(more information: https://twiki.cern.ch/twiki/bin/view/AXIALPET/WebHome)

The Medipix technology finds new fields of application

In 2011, 15 institutes and companies from around the world submitted requests to apply the Medipix2 technology in fields ranging from research, X-ray imaging systems, space exploration and dosimetry to education and homeland security.



The Medipix chip

Medipix2 continues to be a successful example of how technologies developed for high energy physics experiments are applied in other fields. A spin-off of the electronics developed for detectors used in the Large Hadron Collider, Medipix2 consists of an integrated circuit connected to a sensitive element to form a small particle detector. Both the sensors and the microchips - which together form a hybrid detector - are divided into tiny sensitive elements (pixels) that detect individual photons or charged particles. Its single photon counting feature enables it to produce X-ray images with high resolution which are practically noise-free. The same noise-free detection feature can be used with other charged particles, making Medipix2 a detector suitable for a very broad range of applications, including medical imaging, material analysis, sensor development, neutron monitoring and education.

The Medipix2 chip and its successor, the Timepix chip, were developed by a collaboration of 16 institutes from around the world. “In 2011, 15 requests to use chips from the Medipix2 family in diverse fields of application were received,” says Michael Campbell, spokesman of the Medipix2 collaboration. “In order to satisfy this high demand, it was decided that the best dissemination strategy would be to redirect these requests to spin-off companies emerging from members of the collaboration that would manufacture and sell the Medipix2 and Timepix assemblies.” New licenses were signed between CERN and two companies in 2011, making a total of three spin-off companies – from Germany, the Netherlands and Spain – producing and selling the Medipix2 and Timepix chips.

One unique application of the Medipix2 chip is in the field of education. On this front, a small device incorporating Timepix has been developed by the IEAP Institute in Prague. With this device connected to the USB port of any PC or MAC, users can actually ‘see’ in real time ionizing radiation absorbed by the detector. The potential for this device as an educational tool has been recognised and pioneered by Becky Parker, a physics teacher at the Simon Langton School in Canterbury, England. In the framework of the “CERN@school” initiative, prototype devices have been provided by the Medipix2 collaboration and the IEAP to a dozen high schools in the UK with the aim of stimulating interest in physics. Drawing from this initiative, the IEAP Institute is teaming up with a Czech company to develop a commercial product for the educational market and is planning to pilot the use of the first prototypes in Czech schools. More recently, one of the world leaders of integrated solutions for scientific training in schools and universities also displayed a strong interest in incorporating this product in its portfolio.

From 4th to 6th April 2011, the first workshop on medical applications of spectroscopic X-ray detectors was held at CERN. Industry took an active interest in the workshop, making up around one third of its participants. Having broken new ground in high-resolution X-ray imaging technologies, the key role played by the Medipix3 collaboration in recent developments of pixel detectors was highlighted during the workshop. Members of some of the 21 institutes from the collaboration concerned with electronics, detectors and medical imaging gave talks on the challenges and ongoing developments of the Medipix3 technology.

(more information: http://cern.ch/medipix)

CERN's accelerator technologies for the environment

Evacuated flat solar collectors based on CERN's ultra-high vacuum technologies will provide Geneva International Airport with clean energy.

UHV solar collector with cylindrical concentration systems

View of a UHV solar collector

300 flat solar panels covering an area of 1,200 square meters will soon be installed at Geneva International Airport, creating one of the biggest thermal solar power plants in Switzerland. This is the result of a contract signed in November 2011 between Geneva International Airport and SRB Energy, a Swiss-Spanish company, with the Spanish Segura Group owning 91% of the company. The company is co-founded by Cristoforo Benvenuti, a former CERN physicist.

The origin of the evacuated flat solar collector dates back to 1971, when the world's first proton-proton collider, the Intersecting Storage Rings, was being constructed. In order to cope with the machine's vacuum requirements, Benvenuti worked on ultra-high vacuum technology and realised the potential benefits of getters to provide large linear pumping speeds for accelerators. A few years later, when the Large Electron Positron collider project was approved, he proposed and implemented a linear non-evaporable getter (NEG) pump (about 23 km of NEG strip) which is able to trap residual gas molecules while keeping the average pressure low. During the construction of the Large Hadron Collider at the beginning of the 2000s, NEG pumping evolved from the initial strip to a coating of the vacuum chamber walls, produced by sputtering. Thin films of getter materials, comparable to a chemical sponge for molecules, recover their chemical reactivity and their pumping function by heating the coated chamber at temperatures as low as 180°C. Having developed this new technology, Cristoforo Benvenuti decided to exploit it in the field of renewable energy for the development of an evacuated solar panel, an idea he conceived at CERN in the 1970s. Vacuum is the best heat insulator. NEG pumps can be used to eliminate gas convection and molecular conduction. "Whereas ordinary flat collectors are only suitable for low-temperature applications, these new collectors can achieve temperatures of up to 300°C without the use of focusing mirrors," explains Benvenuti. "Moreover, they are specially designed to collect both direct and diffuse sunlight, which makes them very productive in terms of energy, as diffuse sunlight correspond to more than 50% of Central Europe's solar energy and cannot be collected by focusing mirrors."

For this reason evacuated flat solar collectors are suitable for industrial applications at temperatures from 80°C to 250°C, or even higher temperatures when coupled with cylindrical mirrors able to convey diffuse light to the panel. The applications of this technology not only cover the production of heat for industrial sectors (chemical manufacturing, sterilisation, agro-food) but also for cooling and air conditioning. "Innovation is often an uphill process, made especially challenging by the difference between the need for a large timescale for R&D and investors' need for a fast financial return," comments Benvenuti. "This might explain why although the SRB panels were produced industrially at the beginning of 2009 it took another two years for the market to react. Despite the present economic and financial turbulence, the innovative value of our technology is recognised and supported by the Cleantech network in Switzerland."

(more information: http://www.srbenergy.com/)

Accelerating sustainability

In collaboration with the European Spallation Source (ESS) and the European Association of National Research Facilities (ERF), CERN co-organised the first Joint Workshop on Energy Management in Large-Scale Research Infrastructures, which took place on 13-14 October 2011 in Lund, Sweden.

Being intrinsically energy intensive, large-scale research infrastructures like CERN have considerable know-how in energy management. In order to share this knowledge for designing mid- and long-term strategies for reliable, affordable and sustainable energy supply, CERN joined forces with ESS and ERF to organise the first workshop on "Energy Sustainability in large-scale Research Infrastructures". The workshop took place in Lund, where the ESS will be built as the first carbon-neutral research facility, and brought together around 150 international experts on energy and representatives from research laboratories and future large-scale research projects from all over the world.

The main objective of the workshop was to identify the challenges and best practice for energy efficiency, optimisation and supply at large research facilities and to consider how these capabilities could be better oriented to respond to this general challenge for society.

Big science is not just a big energy consumer: technologies emerging from the construction and running of particle accelerators can be further developed and used, for example, to recover energy and produce energy using renewable sources. In addition, research infrastructures employ some of the best technicians and applied researchers in the world, who are continuously trained in cutting-edge technology by responding to the technical challenges brought to them by the best researchers.

"Research infrastructures could be the test-bed for innovative research-based solutions, such as the use of superconducting lines to manage different energy flows, the installation of superconducting magnetic-energy storage for energy quality control, the transformation of energy between radio frequency and direct current, and other novel schemes involving advanced concepts," explains Frederick Bordry, head of CERN's Technology department and co-organiser of the workshop, "This event was also an opportunity for CERN's engineers to present technologies which can be used for the benefit of the environment."

Workshop participants recognised the need for an in-depth understanding of each laboratory's energy consumption by mapping existing and potential energy usage. With this aim in mind, in 2011 CERN appointed Helfried Burckhart as the Organization's first energy coordinator.

In collaboration with the GS Department, Burckhart will, among other things, gather information and conduct a quantitative audit of all forms of energy used at CERN. As energy coordinator he will also investigate possibilities for energy savings, work out proposals for the use of renewable energies and act as the contact person for external enquiries.

At the end of the two-day discussions on energy quality and efficiency, recover and clean technologies, participants expressed the unanimous wish for more opportunities to share knowledge on these topics.

"CERN is a candidate for hosting the second workshop on energy management in 2013," said Bordry. "It could be an opportunity for us to help develop a common approach to energy management for large-scale facilities."

Information Technology transfer

CERN's impact on the advancement and dissemination of information technology is manifold. CERN's IT competencies are transferred to society through synergy with industry, collaboration with international organisations, top-level training, educational projects and support for humanitarian missions.

The need to acquire and manage huge amounts of data across global scientific communities has been the driver for the most significant breakthroughs in information and communication technologies (ICT) over the last few decades. This need is still inspiring high energy physics scientists, both at CERN and in the framework of international collaborations, to push back the frontiers of ICT, developing skills and expertise and conveying them to society through professional networking events, training opportunities, and collaboration with industry and academia.

In 2011, through openlab, CERN's IT experts continued to collaborate with leading industrial partners to develop new knowledge through the evaluation of advanced solutions and joint research useful for the worldwide community of scientists working at the Large Hadron Collider. CERN's information technology expertise was shared with young scientists through the CERN School of Computing and the openlab summer student programme. By taking part in technical reviews, seminars and lectures, CERN's IT experts bridge the gap between basic science and society.

Transcending the borders of research organisations

Research organisations share the common problem of needing to identify individuals and grant them access to resources when they move between institutes.

On 9 to 10 June 2011, CERN organised and hosted a three-session workshop on a federated identity system for scientific collaborations as part of the activities of the IT working group of the EIROforum, the European partnership between eight of Europe's largest inter-governmental scientific research organisations.

85 participants from more than 40 institutes met at CERN to explore the requirements for federated identity management across the different disciplines, compare functionality, operational constraints and the state of deployment of current technologies, and formulate a roadmap for how such a service could be established in the future.

Facilitating business relations between research institutes and leading IT companies

Capitalising on the excellent relations developed over the last 25 years between CERN and Oracle, the IT department organized a meeting bringing together representatives of Oracle staff, including the Global Vice-President for Education and the Research Industry, and several research institutes and organisations.

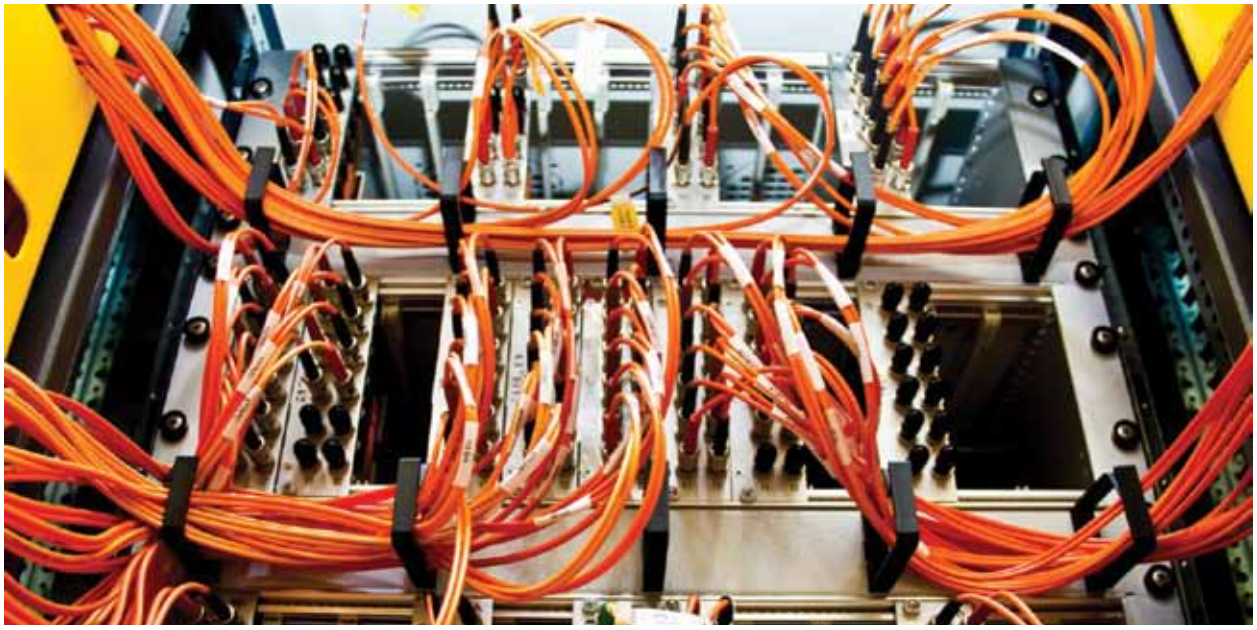
The meeting was hosted at CERN on 30 to31 August 2011, and was attended by representatives of EFDA-JET, ESA (ESRIN, ESOC, ESTEC), ESRF (all members of the EIROforum) and CSC, FNAL, IFAE, IN2P3, KIT and STFC.
The meeting succeeded in its goal of facilitating relations between Oracle and various research centres, giving the latter the opportunity to become stakeholders in the negotiation of contracts with major software companies.

The main outcome of the discussion was the willingness of the Oracle Corporation to consider research organizations as academic customers and to propose concrete actions in terms of support and escalation, licensing conditions, license agreements and special clauses for members of the EIROforum.

A follow-up meeting will be held on 18 to19 January 2012 at the ESA-ESTEC office in Noordwijk.

Accelerating a strategy for cloud computing in Europe

Triggered by the European Space Agency satellite data needs, CERN and ESA co-organised a workshop to dis-



cuss the strategic plan for European cloud computing. The event, which took place at ESA-ESRIN in Italy on 28 and29 June 2011, brought together potential European Cloud providers (including T-Systems, Cap-Gemini, Thales, Orange Business Services, British Telecom, Interroute, Atos and Deutsche Telekom), Cloud consumers (CERN, CNES, CNR, EMBL and ESA) and representatives of the European Commission for the first time.

The meeting resulted in an update of the European cloud computing strategic plan, which will include an R&D European cloud computing infrastructure to serve the needs of the European Research Area (ERA) and space agencies.

Improving library management

Originally developed at CERN to run the document server, Invenio has been managing over 1,000,000 bibliographic records in high-energy physics since 2002, covering articles, books, journals, photos and videos, and is today used by more than 30 institutes and library networks worldwide.

The community of developers continues to grow, and met at the fifth summit of information providers in astronomy, astrophysics and high energy physics. In 2011, the International Labour Organisation (ILO) and Cornell University adopted Invenio for the management of their document repositories. Cornell's information service team is working with CERN to migrate its access interface from arXiv to the Invenio platform.

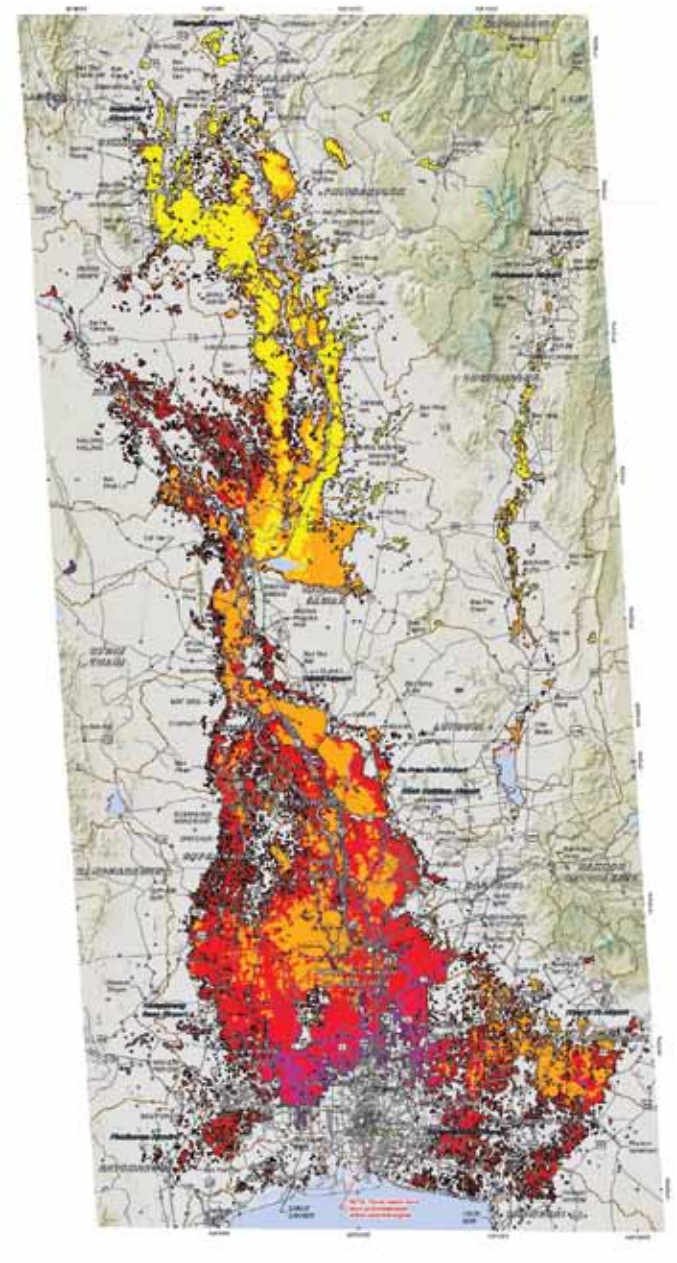
Making an impact in humanitarian missions

Since 2001, CERN has hosted UNOSAT – the Operational Satellite Applications Programme of the United Nations Institute for Training and Research (UNITAR) – since 2002. UNOSAT is a technology-intensive programme delivering imagery analysis and satellite solutions to relief and development organisations within and outside the UN system to help make a difference in critical areas such as humanitarian relief, human security, strategic territorial and development planning.

The information technology infrastructure used to store and process large amounts of data at CERN has created a robust and effective anchor for UNOSAT since its inception. Last year alone, the UNOSAT humanitarian mapping facility was activated 28 times.

"The work that UNOSAT does in support of the UN mandate and to help those affected by disasters and humanitarian crises would simply be impossible without the support we receive from CERN and its IT Department," says Francesco Pisano, UNOSAT Manager. "We are building on this positive relationship to develop joint initiatives involving citizens in science, IT, geospatial information and humanitarian assistance."

An example of collaboration between UNITAR and CERN is the provision of the operational basis for the Citizen Cyberscience Centre, which is a crowd sourcing project focusing



UNOSAT time-series analysis of flooding in Thailand in 2011

This map presents a time-series analysis of the southward progression of flood waters from the central provinces of Thailand towards the capital city of Bangkok, based on satellite data recorded from mid-August to 15 November 2011.

on humanitarian and development issues that are supported by fundamental science.

These collaborations and the technical infrastructure which CERN provides have assisted UNOSAT in performing satellite analysis, design integrated solutions in GIS and geopositioning for the United Nations, its member states, and communities in a variety of areas.

(more information: www.unosat.org)

CERN openlab

CERN openlab is a unique public-private partnership between CERN and leading information and communication technology (ICT) companies. Its mission is to develop new knowledge through the evaluation of advanced technologies and through genuine joint research, in order to accelerate the development of cutting-edge solutions useful for the worldwide LHC community. Through this close collaboration CERN acquires early access to technology. In return, the Laboratory offers expertise and highly demanding environments that push new technologies to their limits, leading to improvements and expanding markets for final products. Providing a neutral ground, CERN openlab also enables collaborative advanced R&D between the sponsor companies. Over the last ten years, CERN openlab has become a hotbed of innovation with a track-record of success.

The collaboration provides CERN with a means of sharing its vision of the future of scientific computing with its partners, through joint workshops and events, as well as of disseminating this to a wider audience, including partners' clients, the press and the general public. More than 180 participants attended the four two-day topical workshops for advanced developers on "Multi-threading and Parallelism", "Computer Architecture and Performance Tuning", the "Second International Workshop for Future Challenges in Tracking and Trigger Concepts" and the Intel workshop "An Introduction to OpenCL". Four seminars and colloquia were organised. A special series of lectures was also organised from mid-July to early August for the participants in the CERN openlab Summer Student Programme (which has hosted a total of 147 students since its creation in 2003). A group of Intel ISEF special award winners was also given lectures during a week-long visit to CERN. The CERN openlab researchers participated in various off-site events and education activities, all of which are listed in the CERN openlab annual report.

CERN openlab celebrated its tenth anniversary this year, marking the occasion during its Board of Sponsors meeting in the presence of the CERN Director-General, the partners and past and present team members.

2011 coincided with the last year of the third CERN openlab phase (2009-2011). During this phase, the technical activities were organised into four competence centres (CC): Automation and Controls (ACCC) in collaboration with Siemens, Database (DCC) in collaboration with Oracle, Networking (NCC) in collaboration with HP, and Platform (PCC) in collaboration with Intel.

Cybersecurity was one of the major focuses of the Automation and Controls CC in 2011. A study of programmable logic controllers (PLCs) was performed and was subsequently extended to the STEP 7 programming environment and the Supervision Control And Data Acquisition (SCADA). Another key focus was the addition of features to the STEP 7 and PVSS development environments, as well as the testing and definition of new facilities (ORACLE Archiver and Web clients) for the PVSS run-time environment, demonstrating how CERN openlab enables sponsor companies to collaborate on common projects.

In the Database CC, the joint efforts centred on integrated virtualisation, evaluation of the latest version of Oracle's Enterprise Manager and an in-depth study of three different replication solutions (Active Data Guard, Streams, and GoldenGate) in the context of the deployment of Oracle 11g. Detailed feedback has been given to Oracle on each of these activities with a view to improving the products. The best solution for replication in our environment was found to be a combination of Streams and ActiveDataGuard and deployment for the LHC experiments is now planned for March 2012 onwards. The DCC team was invited to make several presentations at Oracle OpenWorld in October and the UK Oracle User Group meeting in December.

In the Network CC, the R&D project team on wireless networks ("WIND") continued its in-depth investigations. Large amounts of analysis code have been written, allowing the collected data from wireless devices to be used in the context of troubleshooting, monitoring, improved security and reporting. After discussions with HP engineers, a modification was made to the wireless access points so that more precise data for channel time could be obtained and analysed. In addition, HP and CERN signed a new joint project agreement focussing on OpenFlow, which is an open interface for remotely controlling the forwarding tables in network switches, routers and access points.

In the Platform CC, several advanced software and hardware solutions from Intel were evaluated and benchmarked for suitability within the demanding Worldwide LHC Computing Grid environment. Additionally, some very preliminary joint development work with Intel was performed on an innovative co-processor solution. A testimonial for this work was delivered by one of the PCC researchers in a keynote speech with Justin Rattner (Intel CTO) at the Intel Developers Forum in San Francisco in September.

(more information: http://cern.ch/openlab)

Accelerating the dissemination of scientific information worldwide

CERN supports and implements initiatives aimed at accelerating the way scientific information is produced and disseminated. In the field of Open Access, CERN promotes and leads innovative projects, bringing its unique expertise to build international partnerships through its network of stakeholders in scientific research.

2011 was a crucial year for CERN's leading contributions to Open Access, a concept which aims to give anyone, anywhere and at anytime access to the results of publicly funded research, free of charge. This is a quintessential example of knowledge transfer from the academic sector, ultimately underpinning innovation.

In 2011, thanks to win-win agreements with leading publishers in the field, CERN published hundreds of articles describing the results of the LHC under the Open Access concept. These articles are published under "creative common licenses", which, unlike the restrictive copyright licenses prevailing in scientific publishing, allow unlimited re-use of the information. Another milestone in 2011 was the successful conclusion of the SOAP project, coordinated by CERN and co-funded by the European Commission. Through this project, leading publishers and funding agencies studied opportunities for a transition from a content-based, supply-side economy in scientific publishing to a service-based, demand-side structure for quality assurance.

Project coordinator Salvatore Mele, head of Open Access at CERN, explains: "A survey of thousands of scientists across disciplines worlwide revealed that 9 out of 10 scientists support the Open Access concept. But in reality, less than 1 in 10 articles is published in Open Access."

Through this survey and other initiatives, the SOAP project identified two important factors for scientists: on one hand there is a need for high-quality Open Access journals, free of charge; on the other hand, to ensure high quality, the corresponding peer-review service entails high costs. These two messages are important for the publishing industry and for funding agencies, and should guide them in making strategic decisions.

CERN's flagship Open Access project is SCOAP3, an international non-profit organisation acting as a clearing house connecting scientific publishers, researchers, libraries and funding agencies. Building on CERN's model of international scientific collaboration, its idea is to redirect funds currently used to purchase scientific journals (a "content economy"), to the purchase of a high-quality, peer-reviewed and quality-assured service (a "service economy"). Since its launch, SCOAP3, which is coordinated by the Open Access team within the CERN Scientific Information Service, federated a vast network of hundreds of stakeholders in 25 countries worldwide, pledging 8 million euros per year to the initiative - around 80% of its projected budget.

In April 2011, CERN hosted a meeting of the stakeholders of the global SCOAP3 initiative. Neelie Kroes, Vice-President of the European Commission and Commissioner for the Digital Agenda, addressed the audience and commended SCOAP3's vision to convert the publication of a whole scientific field to Open Access. "This is a radical approach and I applaud it," commented Kroes. "I wish this pioneering project a success [that] will be more than just a proof of concept. It will show us a passable way into the future of scientific publishing that others can follow. And SCOAP3 is the key."

SCOAP3 has now entered its implementation phase. In September 2011, a procurement process including all high-quality publishers in the field was launched to identify publishing partners.

(more information: SCOAP3: http://scoap3.org/)

Passing on our passion for science and technology to young generations

Cutting-edge research organisations like CERN represent an immense source of new scientific and technical information for society. CERN's High-School Teachers Programme helps transfer this knowledge to pupils worldwide by bringing together teachers and scientists.

Teachers from Italy visiting the CMS experiment in 2011

Educating pupils in scientific topics and motivating them to develop an interest in physics and engineering is part of CERN's return to society. A successful CERN initiative in the educational area is the High-School Teachers Programme. Starting with just 9 teachers visiting CERN in 1998, the programme supports teachers in forging new and exciting ways of teaching physics to younger students, helping them to master difficult concepts in an intuitive and non-mathematical way.

"In order to inspire students, we offer their teachers the possibility to access and acquire knowledge on CERN's science and technology directly from our scientists" explains Rolf Landua, Head of the Education and Outreach group. "Thanks to this close contact with the Laboratory, teachers grasp the essence of science in action, its timescales and its technical challenges," continues Landua.

In 2011, CERN organised 31 schools attended by 1112 teachers from more than 30 countries. The schools were held in three different forms:

• the in-depth three-week international High School Teacher Programme .

The school, held in English, offers participants lectures on particle physics, cosmology, accelerator and detector physics, as well as insights into the applications of CERN technologies outside high energy physics.

• The three-day weekend 'immersion' courses.

These courses, designed to inspire and enthuse teachers about modern physics, give a broad overview about the science and technology of CERN, through lectures and visits to CERN installations.

• The one-week national programmes

The school is dedicated to CERN's Member States. Lectures, visits and all teaching materials and recorded lectures are in the teachers' native languages.

In addition to the school-teacher programmes, 75000 visitors including more than 25000 school students and teachers came to CERN for guided tours of the CERN site.

CERN's education strategy includes an increasing number of video-conferences and lectures requested by European schools with broadband connections suitable for audio-visual transmissions. In 2011, the video-education initiative included more than 100 videoconferences with schools in Europe, the United States, Asia and South America.

"Experience shows that CERN's efforts in education have long-lasting and multiple benefits." concludes Landua. "When our passion for science is passed on from our scientists to a teacher, we can hope the same passion will reach the 1000 students this same teacher will have over 10 years."

(more information: http://cern.ch/teachers)

Disseminating technical knowledge through training

Each year, CERN organises schools as a key vehicle for promoting and disseminating the knowledge and technologies generated from CERN's research activities to the new generation of scientists.

CERN Accelerator School 2011 in Chios, Greece

CERN School of Computing

The CERN School of Computing is held annually with the aim to create a common technical culture in scientific computing among young scientists and engineers in particle physics or in sister experimental disciplines.
In 2011, the CSC was held from 15 to 26 August in Copenhagen, Denmark. 50 hours of lectures and hands-on exercises were delivered to 59 participants. The topics included data technologies, computer architecture, virtualisation and clouds, networking and performance tools, data analysis and software tools for physics computing.
iCSC2011, of the latest "inverted" school ("where students turn into teachers") took place at CERN in March.

(more information: http://cern.ch/csc)

CERN Accelerator School

The CERN Accelerator School holds training courses for accelerator physicists and engineers twice a year.
Two schools were held in 2011. The first took place in Bilbao, Spain from 24 May to 2 June. The topic was "high-power hadron machines" and included beam dynamics, cryogenics, vacuum technology and radiation protection technology. The second school, held from 18 to 30 September in Chios, Greece, focused on accelerator physics.

(more information: http://cern.ch/cas)

Excellence in Detector and Instrumentation Technologies (EDIT)

EDIT is a symposium of excellence for young PhD researchers and postdocs seeking to acquire a deeper knowledge of the major aspects of detector and instrumentation technologies. The practice-oriented approach of the school offers researchers the opportunity to explore the performance and limitations of the technologies that are used in state-of-the-art experiments.
In 2011, 89 students from 24 countries and more than 100 teachers participated in EDIT at CERN.

(more information: http://cern.ch/edit2011)

Joint Universities Accelerator School (JUAS)

JUAS is organised by the European Scientific Institute, with active support from CERN and 13 European universities. The two five-week courses, involving many CERN accelerator specialists as lecturers, cover the science and physics of particle accelerators, and the technologies and applications of particle accelerators.
JUAS was held in Archamps, France, from 3 January to 11 March 2011.

(more information:http://cern.ch/juas)

The US-CERN-JAPAN-RUSSIA Joint International Accelerator School (JAS)

The school complements the CERN Accelerator School by providing in-depth courses and seminars in specialised areas. The 2011 edition of JAS took place from 6 – 15 April in Erice, Italy. The programme focused on synchrotron radiation and free electron lasers. Lectures covered storage ring design, energy recovery linear accelerators, linear accelerators design, ultra-fast instruments, x-ray optics and electron sources.

(more information: http://uspas.fnal.gov/programs2/joint.shtml)

Bridging the gap between academia and industry

The second successful International School of Trigger and Data Acquisition co-organised by CERN confirmed the need for top-quality training in this field of interest for high energy physics (HEP) specialists with a wide range of applications in industry. The School, co-organised by INFN (National Institute for Nuclear Research, Italy) took place in Rome from 9 to16 February 2011.

Poster of ISOTDAQ 2011 in Rome, Italy

The second international school on trigger and data acquisition (TDAQ) systems comprised 7 days of theoretical lectures and laboratory sessions and was attended by 48 selected participants comprising physicists and engineers from over 20 countries. The high attendance bore witness to a need for professional training in this field in which HEP excels. This year's school, after being held in Ankara, Turkey, in 2010, was co-organised by CERN's Physics department and INFN and hosted by the Department of Physics of the University "La Sapienza", Rome. The EU-funded Marie Curie ACEOLE fellowship programme provided financial resources and made significant contributions to the organisation of the school, with 8 of its fellows acting as lecturers and tutors.

Acknowledging the need for a balance between theory and practice, the school consists of 50% lectures and 50% laboratory exercises. Leading experts in the field give lectures on various topics, ranging from the basics of data acquisition programming concepts (threaded programming, data storage, networking, input/output programming), to hardware bus systems (VME and PCI), trigger logic and hardware (NIM modules), PC-based readout systems and trigger design. Reviews of modern TDAQ systems from the LHC and fixed-target experiments are also included in the programme.

Leading the organisation of the school, CERN's role is twofold. Experts from all four big LHC experiments become lecturers in the school, their active involvement in a running experiment enabling them to share first-hand experience with the students. Apart from manpower, CERN also provides financial and material support. Most equipment was directly transported from a permanent laboratory at CERN to the host institute.
"Hosting an international event like this is an acknowledgement of our expertise in the field of TDAQ," says Speranza Falciano, former director of the Rome 1 Section of INFN. "Italian scientists are present in all four LHC experiments, contributing to the advancement of this very specific field. By co-organising and hosting ISOTDAQ, we have the opportunity to tell our colleagues in Italy about our competence in this field and our willingness to share this knowledge with them by applying our expertise in their area of interest."

Industrial partners were also invited to contribute by bringing their practical experience to the school, and also to give students an opportunity to network with industry. At the first two schools, experts from National Instrument gave lectures and organised a laboratory exercise about readout systems with LabView, a commercial off-the-shelf technology platform. Closely reflecting the collaborative mechanism between research and industry, ISOTDAQ's programme incorporates know-how from both spheres. As Livio Mapelli, deputy head of the CERN's Physics department confirms, "Data acquisition systems, especially at the hardware level, use a mixture of industrial and research products. Getting trained in both areas is important for students' future careers, be it in research or in industry. "

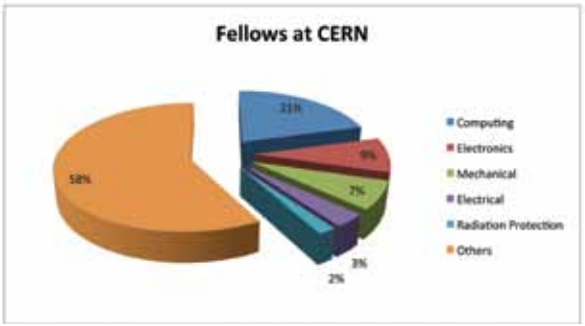
The 2012 edition of the school will be held from 1 to 8 February in the Cracow University of Technology and Institute of Nuclear Physics, Poland.

(more information: http://cern.ch/isotdaq)

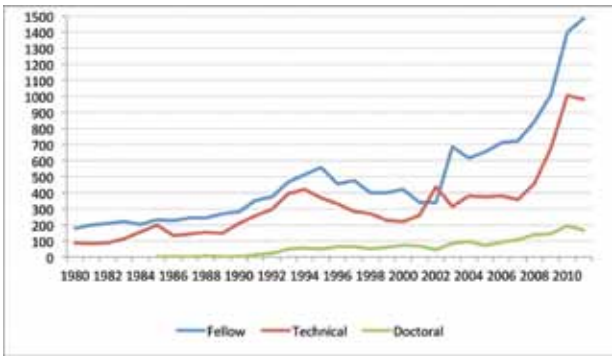
Training at the forefront of science and technology - Take part!

Hundreds of physics and engineering students participate in the Fellows, Associates and Students (FAS) programmes at CERN each year. In 2011, nearly 480 candidates were selected for these programmes, obtaining professional training and taking part in innovative work in the fields of accelerator and detector technologies, engineering, computing, operations and controls, applied physics and many others.

Summer students of year 2011



Fellows at CERN on 31.12.2011 by engineering discipline



Evolution of the number of applicants for the Fellow and Student programmes

CERN has a strong track record in delivering high-quality training and mobility initiatives. The FAS programmes serve and support the four cornerstones of CERN's mission – research, technology, collaboration and education – by providing young researchers with first-class training opportunities in a high-tech, multicultural and multilingual environment.

With a broad spectrum of research challenges, and staff with the skills needed to supervise young researchers, CERN is committed to enriching its research mission by means of knowledge transfer through training. Embedded within a network of experienced researchers, advanced facilities and multi-national collaborations, young scientists develop appropriate expertise for employment in a global job market.

"Through the FAS programmes, CERN gives young researchers from around the world access to its technologies, research enterprise and unique culture. And this not only in the field of particle physics, but also engineering," says James Purvis, head of the Recruitment, Programmes and Monitoring group in HR. "Our Graduate Engineer Training (GET) scheme, for example, offers young engineers possibilities for training and work experience in many technological fields."

The FAS programmes have seen a surge in the number of applicants for Fellowships and Doctoral and Technical Student placements in the last five years. The interest and prestige of these programmes may also be measured through the rise in external financial contributions, most significantly from the European Commission's Marie Curie Actions (People) under the Seventh Framework Programme (FP7). "The number of Marie Curie grants awarded to CERN projects has increased over the last 8 years. From a total of 15 projects coordinated by CERN at the end of FP6, there are currently 17 Marie Curie contracts being coordinated by CERN with another two years to run in FP7," confirms Seamus Hegarty, HR coordinator of the Marie Curie Fellowship Programme at CERN.

CERN's commitment to exploit every training opportunity for young researchers matches the objective of the European Commission's People programme, which is to strengthen the human potential in research and technology by supporting young researchers in their scientific career through career development and mobility.

(more information: http://cern.ch/jobs)

CERN
Knowledge Transfer group

Report on 2011 knowledge transfer activities to CERN Finance Committee (March 2012)

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