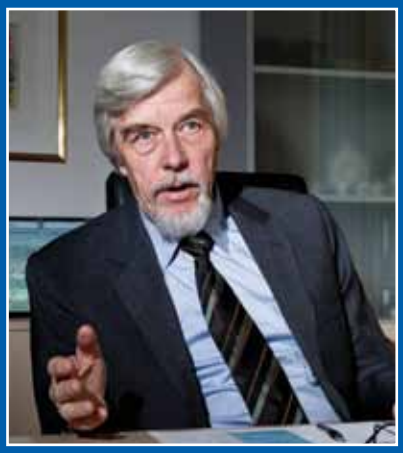
Knowledge Transfer **2012**

Contents



Rolf Heuer,
Director-General

The year 2012 marked the first major discovery for the LHC experiments, a defining moment in the history of science. The discovery of a new particle announced on 4 July by the ATLAS and CMS collaborations, which made headline news around the world, is testimony to the generation-spanning talent, dedication and patience of thousands of scientists and engineers from over 100 countries. The spirit of sharing knowledge that brings together this remarkable community also underpins CERN's frameworks for knowledge and technology transfer.

In 2012 CERN engaged in new partnerships to support the transfer of innovative solutions beyond its laboratory and beyond the high-energy physics community. Our Knowledge Transfer Group implemented a number of successful knowledge and technology transfer programmes while CERN also continued to foster collaboration with its many external partners, encouraging the distribution of knowledge in a number of key domains.

In this report you will find some examples of CERN's commitment to sharing its wealth of knowledge and technology, acquired while working at the frontier of knowledge. This engagement, enshrined in the CERN Convention, is increasingly part of our core business, every bit as important as the quest for understanding that drives our scientific programmes.

Executive summary

In 2012 CERN's knowledge and technology transfer activities were accelerated by new initiatives aimed at increasing the ways the Organization shares its innovation with society. During the year, the Knowledge Transfer Group enriched the portfolio of technology-transfer opportunities and established new collaborations with internal and external partners – academic and commercial.

The activities related to technology transfer and the management of the intellectual property generated at CERN have been consolidated around a coherent impact-driven model (overview in chapter 1).

With the support provided by the KT Group, researchers have embraced the importance of transferring knowledge and technology by increasing the number of technology disclosures, contributing to the richness of CERN's technology portfolio. The KT Fund (chapter 2) has proved to be an effective tool for bringing more inventions to market reality.

Efforts have been invested in improving the way spin-offs from the basic research can contribute to new high-tech business developments (chapter 3).

Collaboration and knowledge-sharing are part of the Organization's culture (chapter 4). Open approaches can be applied to many domains, from hardware to software to scientific publications. The exchange of knowledge and best practices in the field of knowledge transfer in the context of international platforms has seen the role of CERN becoming more prominent, thanks to the contributions of its experts.

The commitment to share this wealth of knowledge, technologies and collaborative way of working with medicine has been reinforced by a series of new initiatives and programmes, some of which are promoted and coordinated by the Life Sciences team (chapter 5). In this way, CERN affirms its role as a catalyser of medical-physics initiatives, coordinating multi-disciplinary and multinational collaborations and leading the way in the design of bio-medical R&D facilities.

A great deal of this knowledge and technical expertise is acquired and shared thanks to tailored education and training programmes (chapter 6). The attention dedicated to maximizing the know-how acquired by the community is demonstrated by the variety of these programmes.

This report presents an overview of the 2012 activities of the KT Group, and integrates the many contributions provided by researchers from other groups who, with their projects and programmes, build up the transfer of knowledge between CERN and society.

Overview of Technology Transfer and Intellectual Property Management

In 2012 CERN's Technology Transfer and Intellectual Property Management Section, led by Enrico Chesta, consolidated its service-oriented approach, improving the internal processes and establishing the basis for projects with potential long-term benefits for society.

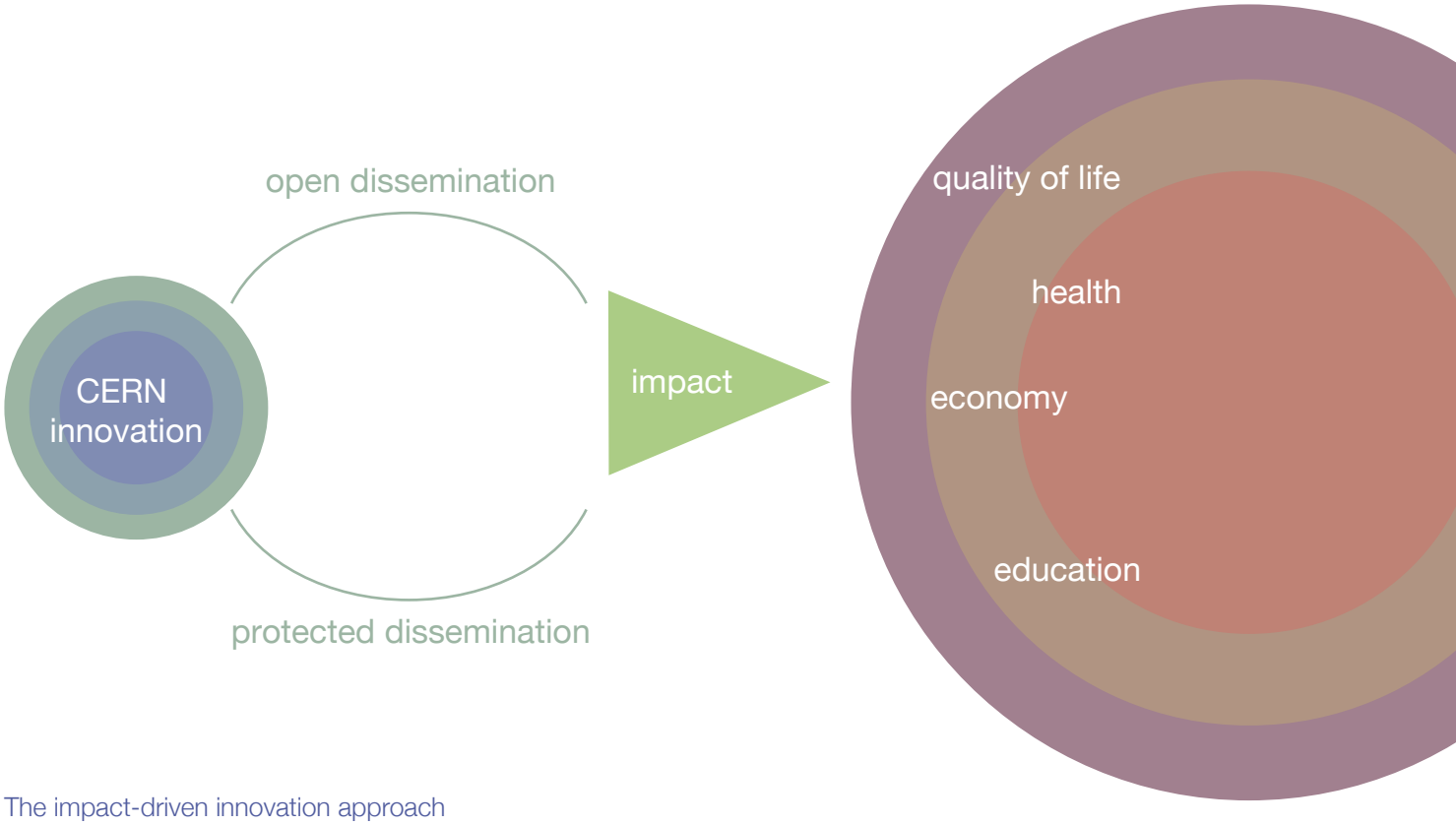
Emphasis has been put on the development of a coherent impact-driven technology transfer strategy, prioritizing choices that will lead to a long-term socio-economic impact and encourage the involvement of private partners.

The KT Fund, the internal financial support introduced in 2011, was demonstrated to be a powerful tool for supporting internal knowledge transfer initiatives: it was successfully used to implement the first phase of the six projects selected in 2011 and to bring forward six new, very promising projects.

During the year, the section focused much attention on the identification of new technology transfer opportunities within the Organization, achieving very satisfactory results. In particular, new internal invention disclosures significantly increased with respect to previous annual rates. The contribution of the internal network of departmental knowledge transfer officers (INET) was critical in increasing the awareness of knowledge transfer activities and in identifying new technology transfer opportunities across CERN.

An example of the implementation of the impact-driven strategy is the development of initiatives to encourage entrepreneurship and the exploitation of CERN's intellectual property (IP) through the creation of new high-tech companies in the Member States. These initiatives include the CERN Business Ideas Accelerator, an ambitious project that plans to create a pre-incubation structure at CERN, connected to a network of incubators in the Member States and a network of partner universities with suitable academic programmes in entrepreneurship. The STFC-CERN Business Incubation Centre in the UK and the organization of very successful technology-screening weeks with students from a Norwegian university entrepreneurship programme already go in this direction.

Protection of CERN's IP was considered only when it was clearly useful in order to protect investments and to encourage the commitment of external partners willing to contribute to the commercial exploitation of CERN's innovative technologies.



The impact-driven innovation approach

The importance of patents as valuable knowledge-dissemination tools was highlighted to the CERN community, and many researchers contacted CERN's patent portfolio manager to obtain patent-related information relevant for their own research activities. As a result, the group registered and handled a significant increase in IP due-diligence report requests.

Open Science approaches were adopted in several cases, both for software and hardware, facilitating knowledge dissemination while acknowledging the origin of the innovation. Some protected IP was proposed free of charge to companies through the initiative "CERN Easy Access IP", which was launched in June 2012 to raise interest from private companies in approaching CERN's technology portfolio.

The efforts to favour a market-pull approach, which carefully takes into account the market needs in a given sector, has allowed the tailoring of transfer-specific developments to address these needs and thereby increase the likelihood of a successful transfer. From the point of view of contracts, the implementation of this approach has allowed the establishment of collaborative agreements with bilateral knowledge exchanges so as to grant pure exploitation licences without extended technical support. In addition, an extended project aimed at showcasing CERN's main technical areas of expertise is being implemented in the hope of generating better focused requests of support from external partners.

In response to the growing demand for support in IP management, a new software tool is under development with the support of the GS Department. An electronic internal signature approval procedure has also been developed and adopted, with significant impact on the time needed to formalize contractual documents.

Relations with technology transfer partners in the Member States were facilitated by the coordination of the network of national knowledge transfer officers, ENET. The organization of thematic events such as the Superconductivity Workshop held in December (in collaboration with the HiLumi LHC Design Study and the TIARA project) was demonstrated to be a valuable way to establish contacts with industry and provide a service to technical departments.

The section was actively involved in the initial phase of bilateral collaboration agreements with other organizations, as well as in multilateral discussions within the framework of established international networks. In particular, during the EIROforum Director Generals' Autumn Assembly, CERN's Technology Transfer and IP Management Section leader was appointed to chair the EIROforum Thematic Working Group on Innovation Management and Knowledge/Technology Transfer (TWG-IMKTT) as from the 1 January 2013.

New Technology Transfer Opportunities

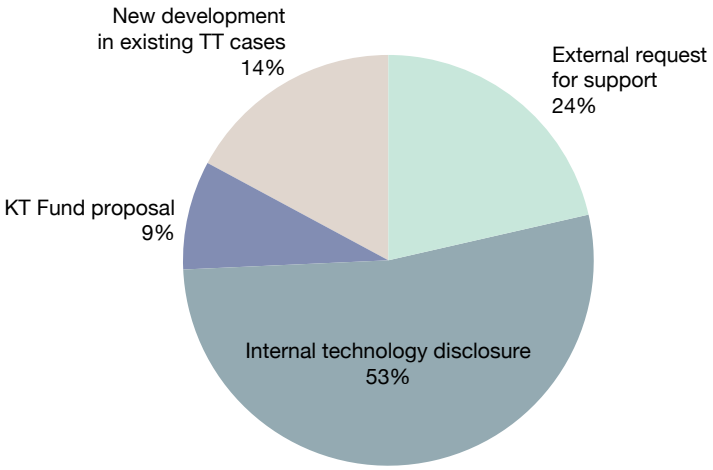
In 2012 CERN's Knowledge Transfer Group registered a significant increase in the number of technology transfer opportunities arising from several departments. This positive trend was facilitated by an increased effort in technology scouting and by a closer collaboration with CERN's departments.

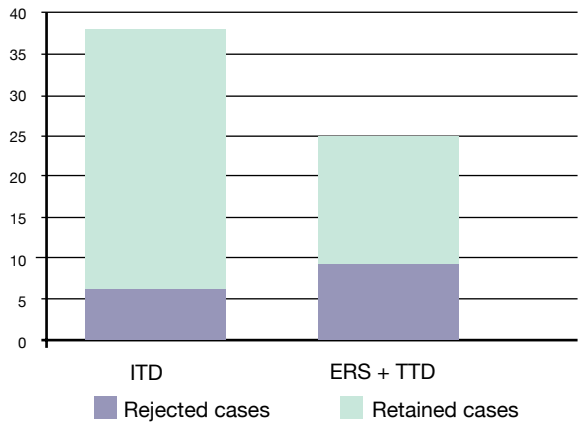
At CERN, experts in technology transfer (TT) and intellectual property (IP) management divide new opportunities into four main categories:

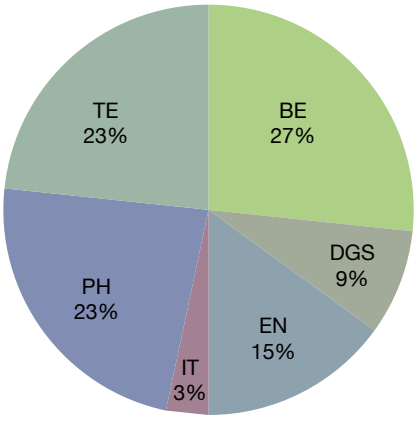
- internal technology disclosure (ITD)
- development in existing TT cases (TTD)
- external request for technical support (ERS)
- KT Fund project proposal (internal request for financial support)

After a preliminary assessment, new opportunities become new TT cases (if they are not already associated with existing ones) only if their potential is proven and if tangible work has been produced in support of their dissemination, in the form of draft contract documents or comprehensive and documented assessment reports. TT cases can subsequently generate IP assets (patents) or legal documents (contracts). A significant number of new opportunities (about 70 in total) were identified and preliminarily assessed in 2012. The diagram shows how they fall into the four categories. It is noteworthy that the increase in the number of internal technology disclosures with respect to previous years is quite remarkable (almost 3 times more).

Not all of the new identified opportunities were retained after the preliminary assessment; the global figures are shown in the histogram below. Details on the opportunities that successfully passed the initial screening are given in the following pages. A pre-selection made by the group of project proposals received by the KT Fund allowed the Selection Committee to be presented with a focused shortlist of six high-quality projects, all of which were finally retained. Some 25 new TT cases, consisting of both internal technology disclosures (ITD) and external requests for support (ERS), have been created based on promising opportunities identified in 2012.





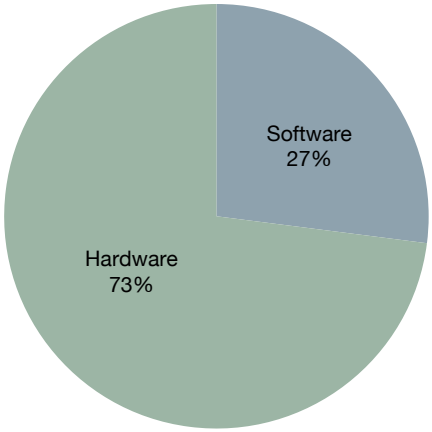


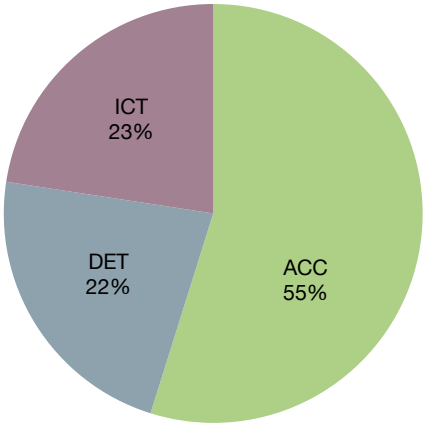
Left: Classification of new TT opportunities and their distribution between CERN's departments.
Opposite, top left to right: The distributions of new internal technology disclosures between: hardware and software; accelerators (ACC), detectors (DET) and information and communication technology (ICT). These have reached various phases, bottom right, and levels of maturity.
Above : Selection of new TT opportunities.

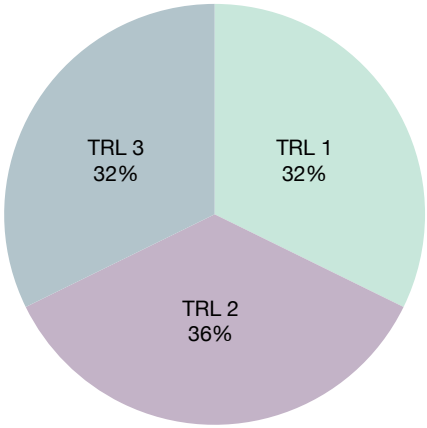
Internal Technology Disclosures

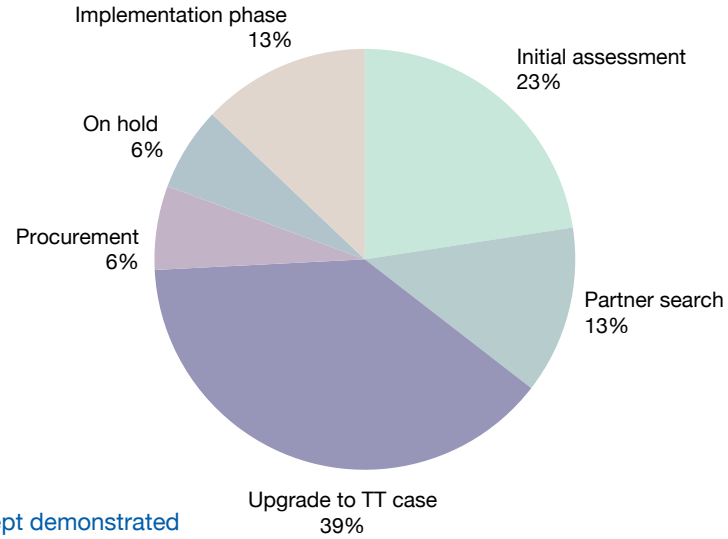
Of the 38 new internal technology disclosures identified in 2012, six cases have shown limited transfer potential after the initial assessment (or too low a maturity level) and will not be described in this report. The other 32 cases are summarized in the table (p.10-11).

More than half of the disclosures are accelerator-systems related, the other half split between detectors and information and communication technology (ICT). This year an increased effort was invested in identifying software tools with promising applications outside CERN, with visible results. In terms of origin of the disclosures within the Organization, the distribution is reasonably balanced, with contributions from all departments (a majority from BE).









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

The simplified classification in terms of Technology Readiness Level (TRL) is remarkably even. In 42% of the cases there is already an identified external partner interested in contributing to the development or exploitation of the technology.

The status “upgraded to TT case” is an indicator of the quality of the disclosure in terms of transfer potential, as is the category that includes cases in the implementation phase (a smaller number, showing that the transfer of new opportunities to the market is still a long process, especially in technology-push mode).

The technology fields and application domains are quite broad, with about one third of the cases not obviously applicable in fields other than that of high-energy physics accelerators but still flexible enough to be easily adopted by partner research institutes.

Internal Technology Disclosures

Status	Title	Summary
6	1 kW RF amplifier	1 kW RF amplifier design suitable for MedAustron
3	ActiWiz software	Software ranking material according to their activation in a radioactive environment
1	Beta NMR	Novel method for characterising biological molecules
6	Bore carbon coating	Training and consultancy on coating technology for neutron detection
2	Carbon coating process to reduce SEY	Carbon thin layer deposition process to reduce SEY at material surfaces
4	Collimator cables	High performance cables for embedded BPM in future collimators
5	Control card for precise magnet current regulation	Innovative electronics control card (and associated SW) to precisely regulate magnets current
6	CRYO-CERN EcoSim library	CRYOLIB is a CERN-developed library for EcoSim SW for dynamic simulations of large cryogenic systems
3	Cryogenic recirculation system low capacity	Complete low-capacity circulation system at cryogenic temperatures
2	Dependency analysis plugin	Plugin useful for SW development in large groups and interdependent code
2	Entwined	Software allowing more efficient allocation of oscilloscope resources to accelerator controls
6	e-SHIP	Software for radioactive material shipping & handling
3	Extended range readout system for RPL glass dosimeters	Readout system for RPL glass dosimeters covering extended absorbed dose ranges
4	Fast beam current transformer	Instrument to measure beam intensities without bunch length and beam position dependency
5	Fast neutron-triggered nuclear detection system	Study of outgassing capabilities and performance of neutron detection systems for homeland security
3	Gigatracker	Particle detector for various applications including medicine & life science
3	Large monolithic SiPMs with excellent timing	Silicon photomultiplier arrays with improved time resolution (for TOF-PET and mass spectrometry)
1	LHC alignment jacks	Jacks used for the alignment of the LHC cryomagnets
1	LHC SC magnets cold supports	Supports for superconducting cryo-magnets (precise positioning and minimized thermal load)
3	Magnetic biased cavities	Cavity tuning with ferrite 2-directional magnetic bias
1	Magnetic markers for B-trains	Sensors based on NMR or FMR phenomena that are used as precise and reliable field references
3	New method for ferrite material measurement	Shape measuring device to object instead of vice versa
3	New sensor for low temperatures	Temperature sensor allowing good sensitivity measurements over an extended range
3	Piezo switch for extreme environment	Piezo switch for ultra-high vacuum, low temperature and strong magnetic field conditions
3	Portable radiation survey meter operating in strong magnetic field	Radiation detector for use in magnetic fields
2	RAISIN	Software for managing radiactive areas of a plant
3	Rapid bellows compression tool	Tool based on two concentric articulated collars for fast axial compression/expansion of bellows
1	SixTrack	SW simulating particle trajectories in accelerators
3	Small pump for low temperatures	Piston pump for low-capacity circulation at cryogenic temperatures
6	Spallation targets	Development and test of new ceramic beam targets
1	System to empty non-regenerable cartridges	Method to recuperate non-regenerable cartridges by separation of radioactive resins from the container
1	X-band RF cavities for high precision Cs clocks	Development of X-band RF cavity/waveguide system for continuous Cs fountain clock

1 Initial assessment ongoing

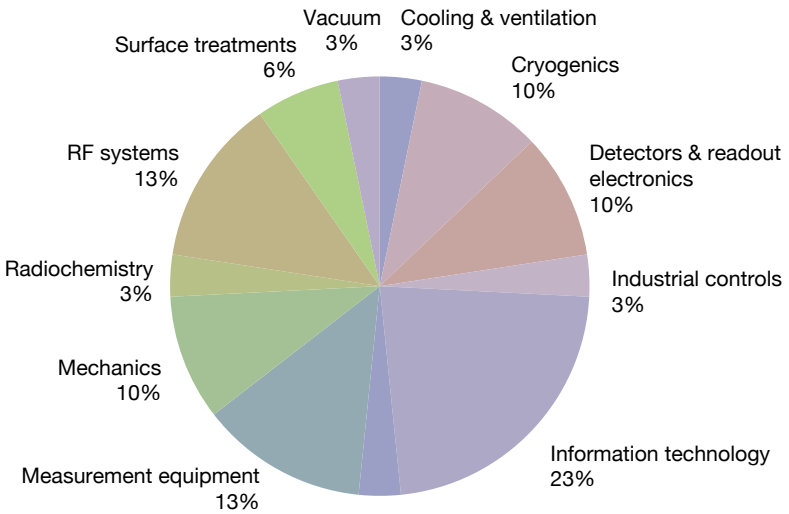
2 Initial assessment completed, dissemination strategy identified, no external partner yet

3 High-potential opportunity upgraded to TT-case level for deeper analysis and/or protection and/or negotiation with external partner

4 Case transferred to procurement

5 Case on hold: additional inputs needed from inventor or external partners

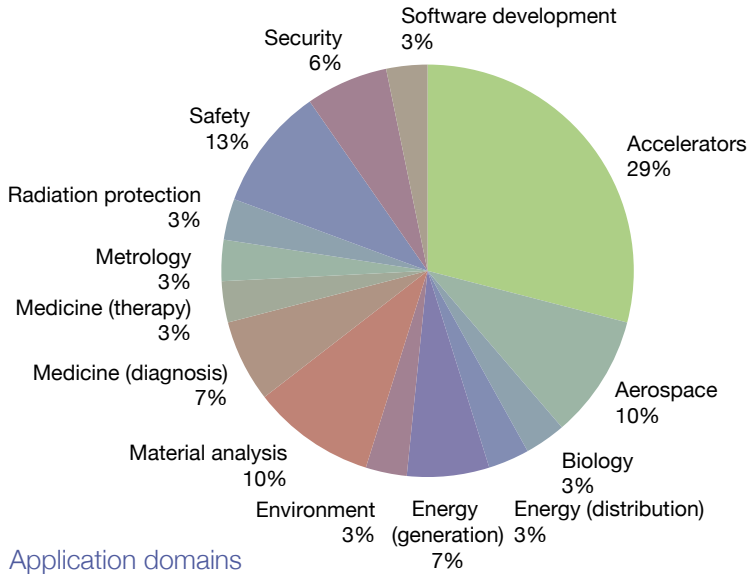
6 Transfer with identified partner in implementation phase or successfully completed



Technology domains

Technical Contact	Department-Group	Generic Classification	Technology Domain	Application Domains	TRL	*
M. Paoluzzi	BE-RF	ACC	RF systems	Medicine (therapy)	3	Yes
H. Vincke, C. Theis	DGS-RP	ICT	Information technology	Radiation protection	2	No
M. Kowalska	EN-ABT	ACC	Radiochemistry	Biology	1	No
S. Calatroni	TE-VSC	ACC	Surface treatments	Security	3	Yes
M. Taborelli	TE-VSC	ACC	Surface treatments	Aerospace	3	No
C. Boccard	BE-BI	ACC	Mechanics	Aerospace	2	Yes
Q. King	TE-EPC	DET	Industrial controls	Energy (distribution)	3	Yes
B. Bradu	EN-ICE	ICT	Information technology	Accelerators	3	Yes
F. Haug, D. Berkowitz	TE-CRG	ACC	Cryogenics	Material analysis	1	Yes
D. Csikos	BE-CO	ICT	Information technology	Software development	2	No
I. Koblik	BE-CO	ICT	Information technology	Accelerators	2	No
Y. Donjoux	DGS-RP	ICT	Information technology	Safety	3	Yes
H. Vincke, J. Trummer	DGS-RP	DET	Measurement equipments	Safety	2	No
L. Soby	BE-BI	DET	Measurement equipments	Accelerators	3	Yes
G. Vandoni	TE-VSC	ACC	Vacuum	Security	1	Yes
A. Kluge	PH-ESE	DET	Detectors & readout electronics	Medicine (diagnosis)	1	No
C. William, P. Lecoq	PH-CMX	DET	Detectors & readout electronics	Medicine (diagnosis)	1	No
V. Parma	TE-MSC	ACC	Mechanics	Accelerators	3	Yes
V. Parma	TE-MSC	ACC	Magnets	Accelerators	3	No
C. Vollinger, F. Caspers	BE-RF	ACC	RF systems	Accelerators	2	No
F. Caspers, M. Buzio	BE-RF, TE-MSC	ACC	RF systems	Accelerators	2	Yes
C. Vollinger, F. Caspers	BE-RF	ACC	Measurement equipment	Material analysis	2	No
A. Dudarev	PH-ADO	DET	Detectors & readout electronics	Accelerators	2	No
T. Kaltenbacher, F. Caspers	PH-SME, BE-RF	ACC	Cryogenics	Aerospace	1	No
M. Silari	DGS-RP	DET	Measurement equipment	Safety	2	Yes
N. Jacinto	DGS-SEE	ICT	Information technology	Safety	1	No
H. Rambeau, C. Garion	TE-VSC	ACC	Mechanics	Energy (generation), metallurgy	3	No
R. de Maria, M. Giovannozzi	BE-ABP	ICT	Information technology	Accelarators	2	No
F. Haug	TE-CRG	ACC	Cryogenics	Material analysis	1	No
T. Stora	EN-STI	ACC	Material science	Accelerators	2	Yes
J. A. Poirot, Y. Body	EN-CV	ACC	Cooling and ventilation	Energy (generation)	1	No
W. Wuensch	BE-RF	ACC	RF systems	Metrology	1	Yes

*** Identified Ext. Partner**



Application domains

Examples of Internal Technology Disclosures

The following paragraphs describe some particularly interesting new invention disclosures.

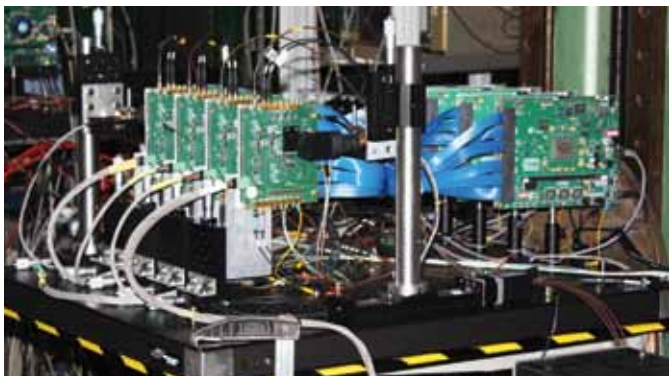
ActiWiz Software

ActiWiz is a piece of software written in visual C++ to rank different types of materials used in accelerators according to their activation capacity. Using a graphical interface, the end-user inputs the chemical composition of the material to be ranked, its location in the environment (from a predefined list of locations), exposure and cooling (or 'shutdown') periods. ActiWiz then ranks the material using pre-calculated Monte Carlo simulation data, specific to the environment the materials are placed in, and a risk-assessment model developed especially for this purpose. The result is relative rank number that allows a quick radiological-risk assessment for the different materials at the different locations. These results can then be assembled in a catalogue for quick reference. The team has produced a catalogue for all materials in the CERN Stores.

The software is configured for a specific environment (CERN accelerators), but an expert user could produce simulation data for another environment with different constraints (including time constraints), e.g. for a nuclear power plant or medical facility, and re-configure the software to rank materials for that specific environment. The data model remains the same. ActiWiz works mainly for proton machines but could also work for electron machines, provided the radiation environment is similar.

Gigatracker

This new technology is a silicon pixel detector designed to measure the arrival time and the position of incoming beam particles. It has been developed for the NA62 experiment, where it will be used in studies of a rare type of kaon decay. The particles from the accelerator are sent to the experiment at a very high rate but are not precisely pulsed, so their arrival time is unknown. The Gigatracker provides a precise measurement of this arrival time, with a resolution of less than 200 picoseconds. The time resolutions currently achieved are exceptional in the field of silicon pixel detectors. Besides their use in high-energy physics experiments, silicon sensors are also employed in imaging applications. The Gigatracker silicon pixel detector is relevant, in particular, in fields of science where images with sub-nanosecond precision in time measurement are required. Examples include: biomedical imaging based on the florescence lifetime imaging microscopy (FLIM), where the production of light by fluorescent molecules is measured; 3D time-of-flight imaging techniques used in high-tech cameras; and medical imaging for positron-emission tomography (PET).



NA62 Gigatracker prototype in a test beam

Magnetic markers for B trains

B-train markers are highly relevant for particle accelerators in which the beam energy is expected to vary rapidly and precisely following a mainly arbitrary pattern. This makes them extremely attractive for the latest generation of hadron therapy machines, where iron hysteresis and parasitic (eddy) currents affect the magnet performance in a dramatic, hardly predictable way. In addition, much broader applications could be envisaged for ferromagnetic-resonance-type sensors, which could form the basis of general-purpose teslameters thanks to their excellent characteristics, such as field-gradient insensitivity, high signal-to-noise ratio and simplicity of the related electronic acquisition system.

Portable radiation survey meter operating in strong magnetic fields

The need for this new technology arose when the radioprotection team at CERN was asked to perform measurements of the residual radioactivity in experimental halls and inside detectors with the magnetic field still on. As no commercially available instrument was able to meet these requirements, the team set about inventing a device.

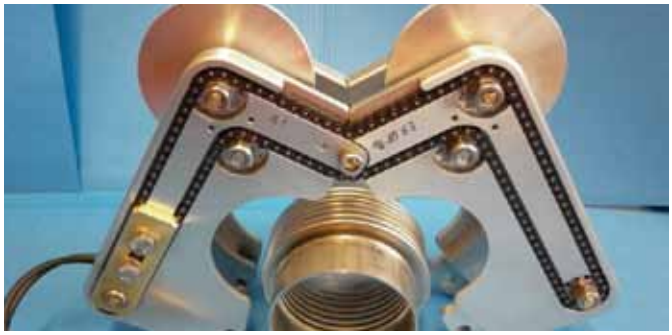
The resultant new technology is a radiation-monitoring apparatus specifically designed to be both portable and hand-held, for ease of use and for minimum disruption in working environments. It is capable of operating in the presence of strong magnetic fields up to 1 T and beyond and is able to detect particles across a range of energies.

As a radioprotection device, the technology is designed to survey radiation levels and as such may be used in a variety of situations where radiation monitoring of the environment is necessary within the presence of a magnetic field. The range of potential application domains beyond high energy physics is quite diverse and includes:

- Healthcare and medicine – at PET/MRI scanners where radioactivity is handled and administered to patients in the presence of the MRI magnetic field and at cyclotrons for production of radionuclides used in PET/SPECT diagnostics.
- Industrial mineral processing – techniques for the separation of magnetic particles are used for various purposes in the processing of ferromagnetic minerals. Natural radioactivity is present and the potential presence of orphan sources may be a concern and require monitoring.
- Metal casting – for monitoring radioactive contamination in continuous casting of steel and other metals, where a magnetic field is used to ensure quality of the casting process.
- Crystal-growing processes – for monitoring radioactive contamination in the Czochralski crystal-growing process, where single crystals of materials such as metals, semiconductors, synthetic gemstones and salts are produced.

Rapid bellows compression tool

This invention relates to a tool and method for compressing and expanding bellows, using two concentric articulated collars that permit quick opening and closing around the bellows. It allows fast, easy and precise installation/removal of bellows, typically in series installation and preventive maintenance operations. It can be adapted to bellows of different shape and diameter, located in areas poor of accessibility, or requiring controlled compression and precise mounting. The operator starts the rotation using serrated rollers, a crank or a motor. The invention can be used where bellows are present in the following fields: heating, ventilation, air conditioning, vacuum and high-vacuum technology, general engineering, couplings, solar technology.



Rapid bellows compression tool

Small pump for low temperatures

Cryocoolers are widely used to cool samples, sensors or superconducting magnets. Often, a first stage provides the cooling for a thermal shield surrounding the cold head, the condensate storage vessel, and/or the object to be cooled. A second stage supplies the cold head. All may be placed in a cryostat. Sometimes the sample is integrated into a larger unit and cannot be placed in a cryostat, cannot be directly connected to the cold head and is located remotely or in an environment that is not directly accessible. The invention relates to a compact and robust pumping system that is capable of providing a constant flow of a cryogenic liquid or gas to a remote load. It can be integrated into a standard cooling system, e.g. it may be directly coupled to the cold head of a cryocooler. It could be used together with cryocoolers that can re-cool and or re-condense fluids, in particular liquid helium, which are circulated to a “user”. It can also be applied to temperatures above the cryogenic range and is well suited for cooling remote objects, which may include sensors and superconducting magnets.

Spallation targets

Scientists at CERN are involved in an on-going project with a world-leading materials manufacturer to develop and test new ceramic beam targets. CERN has extensive experience in the design, development and testing of beam intercepting devices or beam targets, which are used for the generation of secondary beams of particles such as radioisotopes, antiprotons, neutrons or neutrinos. CERN also has experience in the use of nanostructures and porous materials for the manufacturing of targets that have good mechanical integrity and isotope release properties. The CERN team will combine this expertise with the project partner’s extensive experience in fabrication of ceramic materials to develop the new technology.

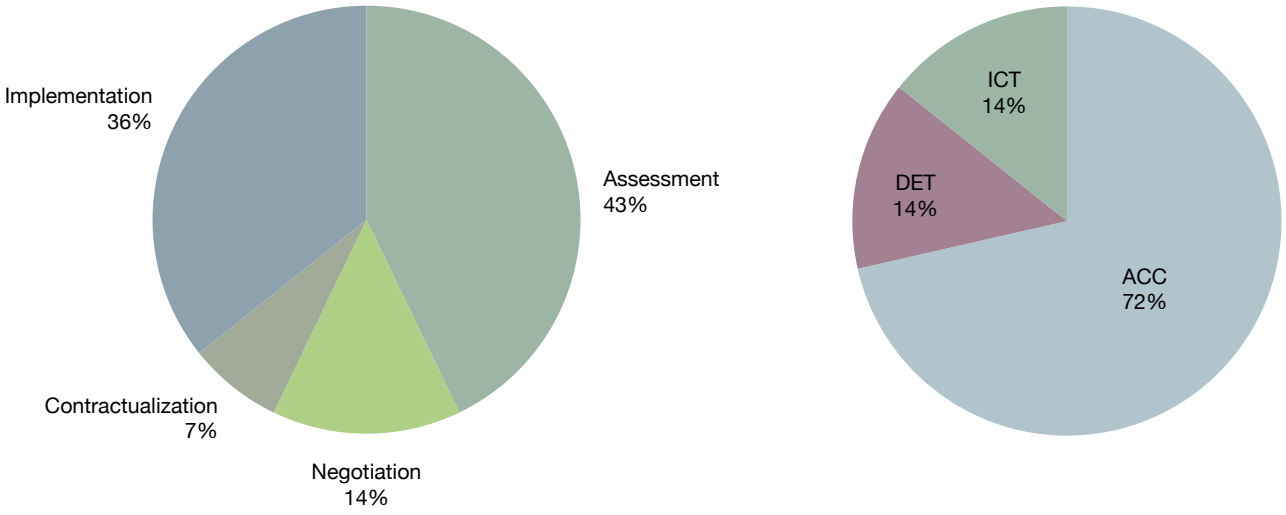
Developments in Existing TT Cases and External Requests

These two categories of opportunities include new specific requests for licensing or co-developing previously identified technologies from CERN's portfolio (12 cases in total) and generic traceable requests of support in technical fields belonging to CERN's main areas of competence (15 cases).

Some 50% of these cases have not passed the initial screening phase and will not be presented. The most common reason is that it was impossible to identify a collaborative and available internal expert who could provide the expected support.

This shows that external requests have a higher failure rate in their initial phase than internal technology disclosures. However, this is partially compensated for by the fact that the opportunities in this category that withstand initial filtering are likely to proceed faster than internal disclosures to the implementation phase, with relatively short negotiation and contract-finalization periods (as is typical of a market-pull approach).

About three quarters of the requests concern technologies related to accelerators and a significant portion of these are in the domain of vacuum and surface treatments. The application fields are diverse, but the share of technologies requested by partner institutions or suppliers for other accelerator-related applications is similar to that registered for internal disclosures (about one third of the total).



Left: Status of existing TT cases and external requests in 2012. Right: The distribution between accelerators (ACC), detectors (DET) and information and communication technology (ICT).

CERN's areas of expertise

In 2012 the Knowledge Transfer group launched a project on CERN's areas of technical expertise with the objective of gathering information on the many domains in which CERN – thanks to its scientists, technicians and infrastructures – achieves technical excellence. This excellence could represent a resource for external partners willing to make use of the rich source of knowledge and skill. The mapping exercise is in line with the group's market-pull strategy to create new and interesting partnerships with other research institutes, organizations and companies and to enhance the exchange of knowledge with CERN's Member States and beyond.

The first result of the project is the following list of macro-areas of technical excellence at CERN:

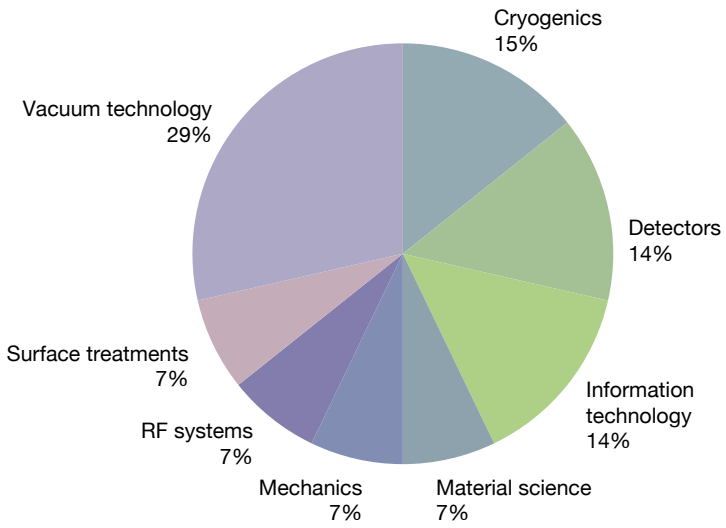
- Beam physics
- Cooling and ventilation
- Cryogenics
- Electrical power converters
- High and ultra-high vacuums
- High-performance detectors
- High-performance materials: development and characterization
- High-precision mechanical processes and measurements
- Industrial controls and simulations
- Large-scale distributed computing and data management
- Magnets
- Microelectronics
- Radiofrequency technology
- Software development
- Superconductivity
- Surfaces and coatings

Developments in Existing TT Cases and External Requests

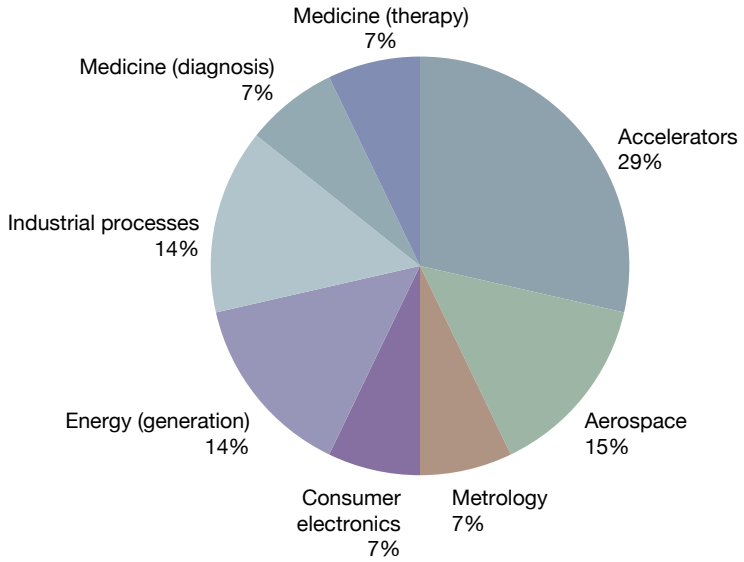
Status	Title	Technical Contact	Department Group	External Partner	Generic Classification
1	**Cryogenic optical fibre**	W. Scandale	EN-STI	Spanish company	ACC
1	**Cryogenic thermometers**	J. Casas-Cubillos	TE-CRG	ITER	ACC
1	**Diaphragm system**	A. Ijspeert	NA	German company	ACC
1	**DTL technical drawings request**	M. Vretenar, S. Ramberger	BE-RF	Italian research institute	ACC
2	**FLUKA**	R. Losito / P.Sala	EN-STI	Multinational company	ICT
2	**GEM**	F. Formenti	TE-HDO	American company	DET
4	**Hood clamshell tool**	P. Cruikshank	TE-MSC	French company	ACC
4	**Hood clamshell tool**	P. Cruikshank	TE-MSC	ITER	ACC
1	**Hood clamshell tool**	P. Cruikshank	TE-MSC	French research institute	ACC
4	**Microstructured silicon cooling plates**	P. Petagna	PH-DT	CSEM	DET
4	**NEG coating licence and training request**	M. Taborelli, P. Chiggiato	TE-VSC	LNLS	ACC
4	**New materials for collimators**	A. Bertarelli, S. Sgobba	EN-MME	Italian company	ACC
3	**ROOT**	F. Rademakers	PH-SFT	JRC	ICT
1	**Titanium polishing**	L. Ferreira, M. Taborelli	TE-VSC	Multinational company	ACC

1 External request received, verification of the suitability of requested technology on-going
2 Transfer in negotiation phase
3 Transfer in contractualization phase
4 Transfer in implementation phase (agreement finalized) or successfully completed

Technology domains



Technology Domain	Application Domain	Summary
Cryogenics	Aerospace	Easy Access IP request for possible application of cryogenic optical fibre technology in aeronautics
Cryogenics	Energy (generation)	Licence on cryogenic thermometer technology for build-to-print ITER tender
Mechanics	Industrial processes	EEN request from a German manufacturer of machines and tools for CERN/Ijspeert diaphragm fixation system
RF systems	Accelerators	Request of academic licence to use technical drawings of Linac 4 DTL
Information technology	Medicine (therapy)	Monte Carlo simulation software requested for medical applications
Detectors	Medicine (diagnosis)	Request of licence on GEM and single mask technology to produce for CERN needs and beyond
Vacuum technology	Industrial processes	Tool for junction leak testing – commercial licence request from private company
Vacuum technology	Energy (generation)	Tool for junction leak testing – academic licence request from ITER
Vacuum technology	Accelerators	Tool for junction leak testing – academic licence request from French laboratory
Detectors	Consumer electronics	Collaboration agreement with CSEM for the joint development of microchannel cooling devices
Vacuum technology	Accelerators	Academic licence and training on NEG know-how to LNLS laboratory in Brazil
Material science	Accelerators	Joint development and test of materials for collimator jaws and other extreme environment applications
Information technology	Metrology	Request for training and consultancy on ROOT software for storing and efficiently analysing large amounts of data
Surface treatments	Aerospace	Request for sample polishing to verify process suitability for aeronautical applications



Application domains

Examples

The following paragraphs describe some external requests for support or developments in existing TT cases where there are no confidentiality issues.

Cryogenic Thermometers

The international ITER project is conducting a tender with a build-to-print option involving CERN's Cryogenic Thermometer technology. A meeting has taken place and some companies have signed a non-disclosure agreement with CERN to review the technology. This is to be followed by a bid from the companies on the ITER tender and acquisition of a CERN licence for the CERN technology. ITER is currently reviewing the proprietary and build-to-print bids received.

GEMs

Because of limitations in production capacity, CERN needs to out-source production of specific detector-elements based on GEM technology. To this end, a non-exclusive and royalty-bearing licence on the patents for the purpose of manufacturing, using and commercializing GEM-based products will be negotiated with a suitable company, in order to cover the market needs of both CERN and other customers.

Hood clamshell tool

Patented in 2000, this technology uses helium to permit quick and easy detection of leaks in joints, junctions, pipes or tubes, even in complex or restricted places. In 2012, a royalty-bearing non-exclusive licence on the technology was given to a company to manufacture and commercialize devices and to provide services in the form of leak-tightness testing on third-party equipment and installations. Furthermore, a free non-exclusive licence was given to the ITER project to have devices manufactured for its needs, and to use them for testing the leak tightness of their vacuum system. Another request, from a French laboratory, is under assessment.

Microstructured silicon cooling plates

In the context of their high-energy physics research, CERN scientists and engineers have developed a new technology for the cooling of detectors and electronics. The technology is a micro-structured, silicon cooling-plate device that is designed to be incorporated into detectors for particle tracking. Taking inspiration from the fields of high-power computing and diagnostic microelectromechanical system (MEMS) technologies, the researchers have developed a device that is both thin and lightweight while also allowing for the high-pressure flow of coolant. In order to achieve the project, CERN has joined forces with its collaborators at the Centre Suisse d'Electronique et Microtechnique (CSEM) based in Neuchatel, Switzerland. CSEM brings its knowledge and experience in micro-fabrication, metal deposition and bonding to the partnership. The resulting technology will not only be a novel device for the field of high-energy physics, but will also be applicable to a range of domains beyond physics.

NEG coating academic licence and training request

Following a request from the Laboratório Nacional de Luz Síncrotron (LNLS), Brazil, CERN agreed to grant an academic licence (for internal scientific purposes) and to organize a training course on its recognized know-how in the field of non-evaporable thin film getters (NEGs). The training, organized by TE-VSC, took place in November 2012 with the participation of three vacuum experts from LNLS.

New materials for collimators

In 2012 CERN signed a partnership agreement with an Italian company, setting the framework of the collaboration between the two parties on the research, development, processing, manufacturing, characterization and testing of advanced thermal-management materials with high structural and thermal properties for applications to particle accelerators (in particular within the LHC phase II collimators) and beyond.

ROOT

The ROOT system provides a set of frameworks with all of the functionality needed to store and analyse large amounts of data in a very efficient way. Following a technology-screening week, students from the Norwegian University of Science and Technology (NTNU) showed a great deal of interest in the technology. Its ability to handle large sets of data and process them with complex mathematical functions allows its application in domains where large datasets are common. Examples of known applications include fields as diverse as flight-planning systems, seismic-data analysis, insurance, stock market applications, banking, pharmaceutical research, medical imaging, telecommunications, business intelligence and geology. Researchers at an institute of the Joint Research Centre in Belgium, who use the software and were previously unknown to CERN, requested specific advanced ROOT training and consultancy in order to deepen their knowledge of the software and apply its more advanced features to their research.

Titanium electropolishing

A major aerospace company has shown interest in CERN's electropolishing process. Following an on-line meeting, electropolishing experiments were performed on several specimens made of titanium and aluminum compounds. The results are now being analysed at the company's lab.

Patent Portfolio Management

At the end of 2012, CERN's Patent Portfolio contained 43 patent families (238 patents in total). The main activities related to the management of the portfolio are summarized in the table below.

Granted patents in 2012	6	Neutron-driven element transmuter (USA – Divisional) MCML sur Kapton (European Patent, Canada) Multifunctional detector (European Patent) Capacity storage supply (Japan) Quantum dosimetry (USA)
Abandoned patents	2	Economiseur de cryogène (Italy, UK)
New filings/New patent families	3	Microfabricated scintillation detector Small pump for low temperatures Rapid bellows compression tool
Families extended internationally	4	Centre and corner charge allocation MicroBulk Capacitive spreading readout board Mounting mechanism for cantilever
IP due-diligence reports produced	17	11 prior art searches 1 freedom to operate 4 statistical analysis 1 similarity search word report

New patent families

Three new patent families were filed in 2012.

Name	Priority date	Type	Owner(s)	Dep.	Inventors
Microfabricated scintillation detector	08/05/2012	PCT	CERN (80%) EPFL (20%)	PH PH NA	Alessandro Mapelli Pietro Maoddi Philippe Renaud
Small pump for low temperatures	31/05/2012	EP	CERN	TE	Friedrich Haug
Rapid bellows compression tool	07/08/2012	EP	CERN	TE	Herve Rambeau

Intellectual Property (IP) reports

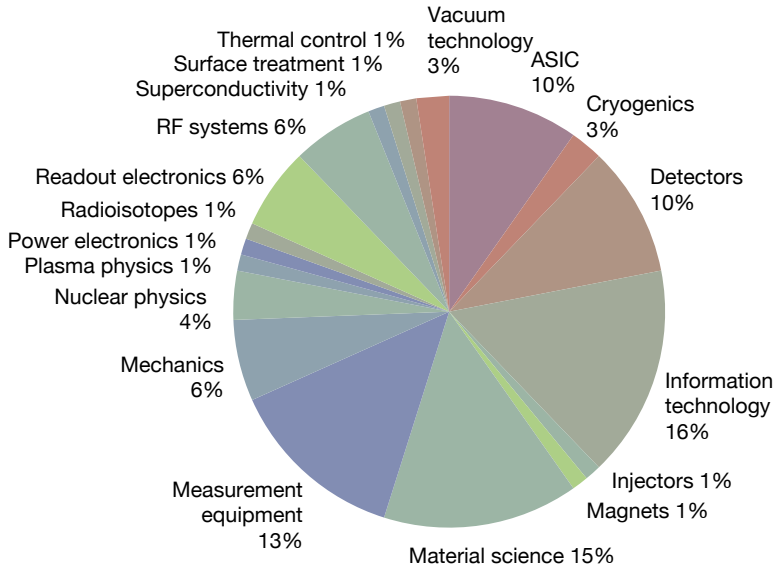
A significant number of IP due-diligence reports were produced during the year (17, about 3 times more than in 2011). This is a clear indication that this kind of service is increasingly appreciated by the technical departments, which are becoming increasingly aware of the potential benefits that professional IP searches can bring to their research and development activities.

Name	Dep	IP assessment	
		Type	Date
Mini cyclotron – Lab on a chip in PET	ext	Prior art search	19/01/2012
Medical isotopes project at ISOLDE – CERN	EN	Similarity search word report	21/02/2012
Mini cyclotron RF system	ext	Freedom to operate report	16/08/2012
Collimators material	EN	Statistics on patents	24/04/2012
POPS applications (1)	TE	Prior art search	26/03/2012
POPS applications (2)	TE	Prior art search + Statistics on patents	10/04/2012
Microfluidic channels	PH	Prior art search	17/01/2012
Small pump for low temperatures	TE	Prior art search	23/02/2012
Prompt detector	PH	Prior art search	06/02/2012
Portable radiation survey	DGS	Prior art search	20/04/2012
Portable radiation survey	DGS	Statistics on patents	14/05/2012
Rapid bellows compression tool	TE	Prior art search	10/05/2012
GEM	PH	Prior art search	30/05/2012
Cryogenic recirculation system low capacity	TE	Prior art search	15/10/2012
Readout for dosimeters_RPL	RP	Statistics on patents	26/11/2012
Readout for dosimeters_RPL	RP	Prior art search	27/11/2012
Large monolithic SiPMs with excellent timing	PH	Prior art search	12/12/2012

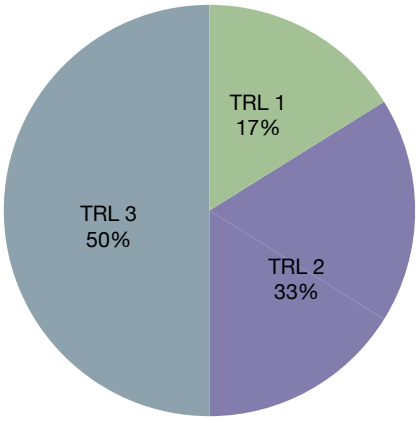
CERN Technology Portfolio 2012

CERN's 2012 Technology Portfolio is made up of all of the TT cases classified as "active". Including the new opportunities upgraded to TT-case level (internal technology disclosures and KT Fund projects) and some old TT cases considered closed that have been re-opened because of new developments, and taking into account a few TT cases that have been closed because the transfer was completed in 2012, the portfolio contains 82 technologies, described in the following charts.

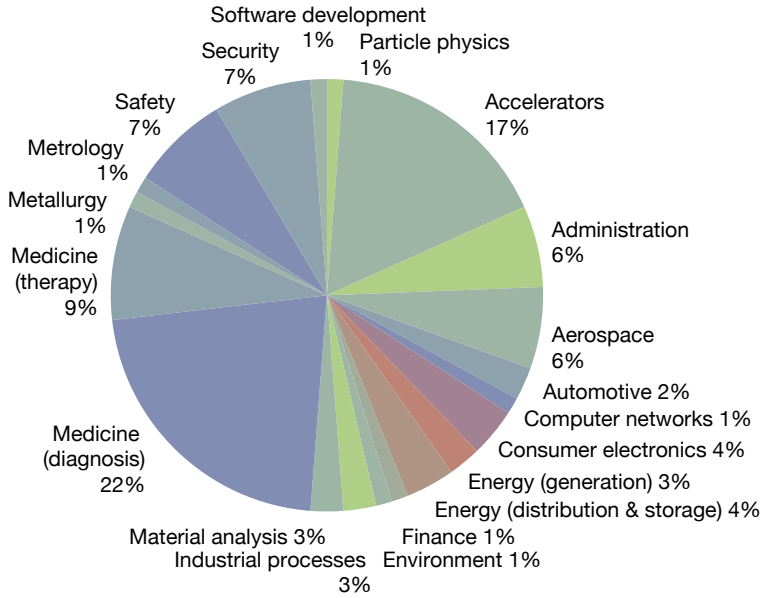
Technology Domains



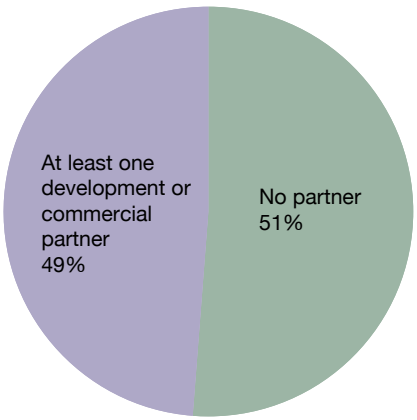
Technology Readiness Levels



Application fields

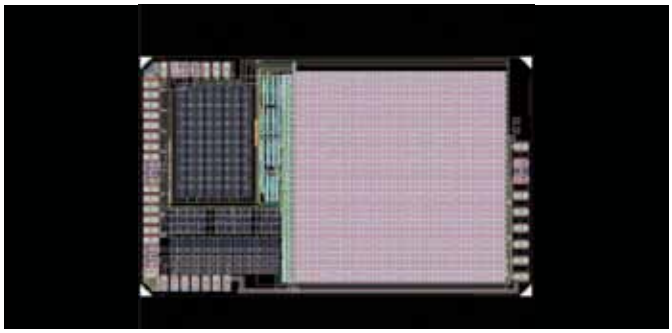


Exploitation level



Focus on: MEDIPIX

The members of the Medipix3 Collaboration will remember 2012 for the successful production of the new Medipix3RX chip. This chip, which is designed in 130 nm CMOS technology, uses lessons learned from the first version of the predecessor Medipix3 chip together with a modified hit-allocation algorithm to produce – for the first time – high-resolution X-ray images while conserving spectroscopic information.



Layout of the CLICPix prototype chip

Members of the Medipix2 Collaboration will also remember 2012 as the year that the Timepix chip arrived at the International Space Station. This was the culmination of efforts by collaboration members at the Institute of Experimental and Applied Physics in Prague and the University of Houston in Texas to use the chip for monitoring the radiation environment of the station. Five chips were plugged into the USB port of the station laptops and immediately started delivering data to the Earth-based team in Houston; they are now carefully analysing the data and comparing them with data from the more conventional but rather bulky area-monitors. In a separate development, the Timepix-based LUCID cosmic-ray detector, which was first proposed by pupils at the Simon Langton School in Canterbury, England, is now space qualified and ready for launch in the first months of 2013. The system will monitor cosmic rays from a satellite and beam that information back to the school from where it will be made available for analysis by other schools participating in the project.

Finally, the Medipix2 and Medipix3 Collaborations continue to deepen contacts with CERN experiments and activities. An upgrade of the ATLAS-MPX radiation monitoring system is being proposed. The Timepix3 chip, which will act as a prototype for the proposed LHCb-VELO pixel upgrade, is in the final stages of design verification. The Timepix chip is being evaluated by students employed by the Ardent EU project in CERN's Radioprotection Group. A first prototype pixel readout chip in 65 nm CMOS (CLICPix), aimed at the CLIC vertex detector, was designed and submitted to fabrication.

The Medipix Collaborations are led by Michael Campbell, Physics Department.

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

Focus on: Geant4

Geant4 is a toolkit for the simulation of the passage of particles through matter. Its areas of application include high-energy, nuclear and accelerator physics, as well as studies in medical and space science.

Simulation programs play a fundamental role in optimizing the design of particle-physics experiments. Geant4 was originally developed at CERN to address the requirements of the LHC experiments for detailed simulation of the interactions of all the particles emerging from high-energy collisions. These core capabilities have been extended with additional physics models useful for heavy-ion and precision-physics experiments. It is used for the analysis of experimental data and determination of the systematic effects of physics results.

Geant4's extended set of physics models, handling both electromagnetic and hadronic interactions can be used to address a range of medical applications, from conventional photon-beam radiotherapy to brachytherapy (using radioactive sources) and from hadron therapy to boron neutron-capture therapy. Simulation is equally important in space-based astroparticle physics. Most space probes have to operate for many years without the possibility of physical repair after launch. It is therefore essential to understand the behaviour of all components in the space environment and in particular the effect of radiation on on-board electronics and detectors.

Geant4 is developed and maintained by an international collaboration of physicists and computer scientists, from high-energy physics laboratories, national funding agencies, universities and the European Space Agency (ESA). The spokesperson of the collaboration is Makoto Asai of SLAC in the USA. The CERN team is led by Gabriele Cosmo and John Apostolakis, Physics Department. The open and collaborative relationship between the development team and its user communities has led to a two-way transfer of technology, since users in fields other than particle physics actively contribute.

The Geant4 team at CERN focuses on improving the parts of the Geant4 toolkit that are critical for simulating LHC detectors. Key responsibilities include the development and maintenance of the geometry modeller, as well as the improvement and validation of key physics models, such as models of the electromagnetic interactions of electrons, photons and nucleons, and the interactions of protons and neutrons at low energies. All of these also find application in the medical physics and space applications domains.

Geant4 and various applications and tools based on the software were used extensively in 2011 and 2012 for space missions at ESA. In particular, in the context of the recently selected ESA Large Class Science mission JUICE (JUpiter ICy moons Explorer), significant effort is ongoing to analyse and optimize the shielding of the spacecraft and its candidate instruments against the extremely severe radiation environment of Jupiter. Aside from the direct application of Geant4, novel developments in this context include reverse Monte Carlo capability in Geant4 for computational speed improvement, new models for solar-cell displacement damage calculations, shielding optimization procedures based on genetic algorithms, and Geant4-based tracing of charged particles in the local magnetosphere of the Galilean moon Ganymede.

more information: http://geant4.cern.ch

Focus on: FLUKA

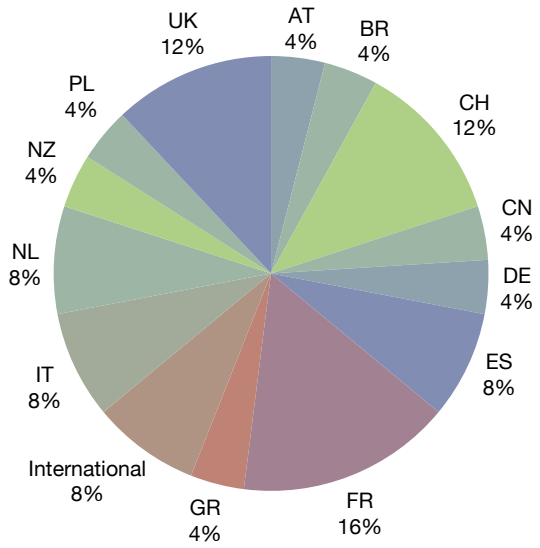
FLUKA is a fully integrated particle-physics Monte Carlo simulation package. It is a general purpose tool for calculations of particle transport and interactions with matter, covering an extended range of applications. The highest priority in the design and development of FLUKA has always been the implementation and improvement of sound and modern physical models that allow it to simulate with high accuracy the interaction and propagation in matter of about 60 different particles and the corresponding antiparticles, including photons and electrons from 1 keV to thousands of TeV, neutrinos, muons of any energy, hadrons of energies up to 20 TeV, neutrons down to thermal energies and heavy ions. The history of FLUKA goes back as far as 1962-1967. Initiated by Johannes Ranft, it was used mainly for radiation studies connected with the CERN SPS project. Since then the code has seen tremendous improvements and has been greatly expanded both in scope and functionality. Three generations of FLUKA code can be distinguished, with the current generation being completely different from code released before 1990. Today FLUKA represents 400,000 lines of Fortran 77 code, an order of magnitude more than in the 1987 version. Over the years, FLUKA has evolved from a code that was specialized in high-energy accelerator shielding into a multipurpose multiparticle code that has been successfully applied over a range of energies and fields, with many different applications.

INFN and CERN jointly own the FLUKA intellectual property rights. The current active development team is composed of Alberto Fassò (SLAC), Alfredo Ferrari (CERN, Engineering Department), Johannes Ranft (Universität Gesamthochschule Siegen), Paola Sala (INFN). A number of contributor authors have also been involved in the development effort over the years. FLUKA has a broad range of applications in experimental high-energy physics and engineering, shielding, detector and telescope design, cosmic-ray studies, dosimetry, medical physics and radiobiology. It is widely used by researchers not only because of the high accuracy of its physics models, but also because it provides flexible and efficient code and guarantees consistent results, which are frequently checked against experimental data.

FLUKA is used by many research facilities around the world – not only in high-energy physics – through non-commercial licences specifically for academic use. It has also been specifically licensed commercially to a major manufacturer of medical devices to validate device design and provide personalized therapy plans.

To facilitate and promote the commercial use of FLUKA with partners of different sizes and industries, a standard commercial licence has recently been developed and approved by the governing body of the FLUKA collaboration and both copyright holders. The aim is to provide a template agreement that allows the purpose and specific conditions to be specified on a partner-by-partner basis according to their needs, thereby encouraging the dissemination of the software to a wider commercial community.

more information: www.fluka.org



Knowledge Transfer Agreements in 2012

The following agreements have been formalized in 2012 through official contractual documents.
The list below does not include the 13 standard R&D licences associated with the sales of GEM foils.

Technology	Type of Agreement	Type of Partner	Country
Medipix2	2 Amendments to licence agreements	Commercial	NL
Evacuable flat-panel solar collector	Amendment to partnership R&D agreement	Commercial	ES
Diaphragm system	Amendment to licence agreement	Commercial	CH
Medipix3	2 Amendments to licence agreements	Commercial	NZ, NL
Medipix3	Collaboration agreement	Academic	International
Hadron therapy	Amendment to partnership agreement	Commercial	CH
Hadron therapy	Amendment to collaboration agreement	Academic	AT
CRISTAL kernel package	Amendment to consortium agreement	Academic	FR, UK
Software library Cryo CERN	Collaboration agreement	Commercial	ES
Non-evaporable thin film getters	Licence agreement	Academic	BR
Non-evaporable thin film getters	Licence agreement	Commercial	DE
Orthopix	Co-ownership agreement	Academic	IT
HPDTC (high-precision time-to-digital converter)	Licence agreement	Commercial	UK
Texturization of ceramics for spallation targets	Partnership agreement	Commercial	FR
Development of thermal management material	Partnership agreement	Commercial	IT
CERN-STFC BIC agreement	Collaboration agreement	Academic	UK
Microfluidic channels with through silicon vias	Collaboration agreement	Commercial	CH
Hood clamshell	Licence agreement	Academic	International
Hood clamshell	Licence agreement	Commercial	FR
e-groups Software	Licence agreement	Academic	FR
Augmented Reality	ATLAB Partnership agreement	Commercial	GR
GEM	Licence agreement	Academic	CN
GEM	Licence agreement	Commercial	PL

KT Fund

In 2011, the Knowledge Transfer Group implemented a scheme to support a selection of CERN's knowledge transfer initiatives, the KT Fund.

The KT Fund re-invests part of the revenues generated by knowledge transfer activities into new projects, which are selected yearly by the KT Fund selection committee. The committee, chaired by the Finance, Procurement and Knowledge Transfer Department Head, is composed of all CERN department heads, the KT group and section leaders. The committee met in October 2012 to evaluate the possible impact, probability of dissemination, proposal quality and the scientific value of the submitted projects.

KT Fund 2012 Projects

Photonic crystals production

The complete title of this proposal, a follow-up to the project initiated in 2011, is "Development of Nanoimprint Photonic crystal production in preparation for industrial technology transfer". The target is to demonstrate the technical feasibility of the imprint technology on different crystals and to validate the merit of this approach in a quantitative way (a proof of concept for a cost effective mass production of this technology is still missing). The detailed objectives of the project are the characterization of newly developed approaches (soft stamps) on bismuth germanate (BGO), their applications to other crystals, such as lutetium oxyorthosilicate (LSO), lutetium aluminium perovskite (LuAP) and lutetium aluminium garnet (LuAG), the quantification of the achieved improvements, the identification of the critical steps in the process, in terms of crystal surface quality and thickness control of the different layers, and finally, the proposal of a possible scheme for industrial production.
Project leader: P. Lecoq (Physics Department)

High-gradient structures for linacs

The complete title of this proposal is "High-gradient accelerating structures for proton therapy linacs". The idea is to adapt high-gradient accelerating radio frequency (RF) technologies developed for the Compact Linear Collider (CLIC) to low energy proton acceleration structures suitable for cancer treatment applications. The target is to double the current state-of-the-art accelerating gradient to reach about 50 MV/m, thus halving the length of therapy linacs (and making viable the realization and use of moving gantries such as TULIP – TUrning Linac for Protontherapy). The project would be carried out in collaboration with the TERA foundation and would focus on the design and manufacturing of two high-power prototype 3 GHz accelerating structures (one at low energy – 76 MeV, the other at high energy – 213 MeV, corresponding to the lowest and highest energy for the main part of a typical proton therapy linac). The requested budget would be used to procure the material and components needed for building the two structures (no additional resources are requested for the testing activities). An additional option was also presented: the operation in "recirculation mode", which could deliver a large reduction in required peak power (factor 9).
Project leader: W. Wünsch (Beams Department)

Materials for thermal management

The complete title of this proposal is "Development of Novel Advanced Metal Matrix Composites for Thermal Management Applications". The proposed project is based on the R&D work currently carried out within EN to develop new Metal Matrix Composites (MMC) materials based on copper or molybdenum with diamond or graphite reinforcement to be used for future LHC collimators. The extreme environmental conditions in which these materials are expected to operate require cutting-edge performances: in particular, high electrical and thermal conductivity and very low coefficient of thermal expansion combined with high operational temperature, strength and robustness and radiation hardness. The first set of requirements correspond to those of novel thermal management materials needed in a wide spectrum of applications, most notably high-end chipsets (and more in general electronic components

generating high heat fluxes). Materials to be developed for these applications may combine metal-based matrices such as copper and aluminum with a variety of reinforcements such as graphite, silicon carbide, diamond, carbon fibres. The project will consist of the definition, production and characterization of two batches of approximately 10 proof-of-concept samples of materials with very high thermal conductivity, low thermal expansion coefficient and fair mechanical properties.
Project leaders: A. Bertarelli, S. Sgobba (Engineering Department)

Indico world-wide impact

The complete title of this proposal is "Improving the worldwide impact of Indico".The goal of this project is to increase the visibility and the use of the Indico open source software beyond CERN, by improving the available package and the distribution website, by introducing tracking tools to monitor new installations, by allowing better customization and by developing promotional material. The requested budget will be mostly devoted to financing a technical student who will work on the required developments.
Project leaders: J. Gonzalez, T. Baron (IT Department)

Light ion front end for a future biomedical facility at CERN: a design study

The concept of having a facility at CERN dedicated to biomedical research has been discussed for the first time in the frame of the Physics for Health conference in February, and strongly reinforced by the open brainstorming discussion organized by KT-LS in June (p.44). The project would be integrated in the present CERN injector complex. Linac 3 and the Low Energy Ion Ring (LEIR) would need to be extended and modified to be able to deliver the requested types of beam. A preliminary design study is necessary to compare the alternative options that could be envisaged to provide LEIR with light ions: a new front-end for Linac 3 with partial re-use of existing equipment (current baseline), the use of a new linac (Linac 5), or the use of a commercial cyclotron.
Project leaders: D. Küchler, C. Carli (Beams Department)

Humidity fibre-optic sensors

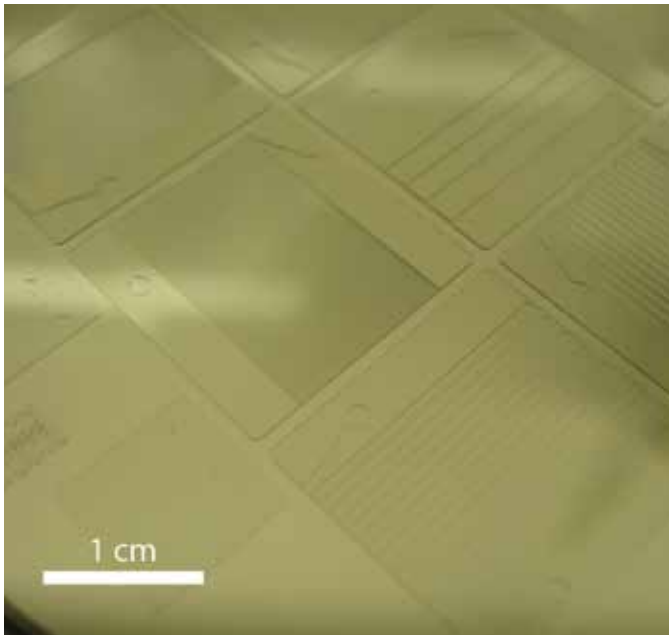
The complete title of this proposal is "Relative Humidity Fibre-Optic Sensors based on Long Period Gratings". The proposed idea is to start from the promising results already obtained in the framework of an R&D programme (performed in collaboration with the University of Sannio and CNR – Consiglio Nazionale delle Ricerche, both in Italy) to develop fibre optic sensors (FOS) for relative humidity (RH), and to push them a step further by integrating in the concept sensors based on fibre Bragg grating (FBG). The original idea is to develop a new class of RH FOS using long period gratings coated with selected hygrosensitive materials (such as tin or titanium dioxide) as refractive index transducers, with important improvements in response time and average sensitivity. In addition, this new class of sensors would be less subjected to aging problems and more radiation resistant than classical polymer-based sensors.
Project leader: P. Petagna (Physics Department)

Progress of KT Fund 2011 Projects

CERN-MEDICIS – MEDical Isotopes Collected from ISOLDE

The CERN-MEDICIS project is an ambitious, long-term initiative to create a dedicated radioisotope production facility at CERN for the clinical and life sciences communities. It will use the wasted proton beam at ISOLDE to irradiate specific targets, generating custom synthesized radioisotope batches for end-users. The main isotopes of interest in the first instance are intended to be those of copper, scandium, terbium and magnesium. It is anticipated that these radioisotopes will be used for both the treatment (targeted alpha therapy) and the diagnosis (through medical imaging) of suitable cancers. KT funds were sought to act as a catalyst to expand the project and to lead to further future funding, the KT fund project itself lasting three years. As outlined in the initial KT fund application, a pneumatic transport system, which will transport the radioisotopes along the production line from the target to a shielded hot cell for processing is currently being procured. The technical student, recruited to conduct modelling of radioisotope production, is in post and completing the first round of simulations. The project has also attracted an in-kind contribution of a mass-separator (online) from KU Leuven, Belgium. Partnerships are already in place with local hospitals and universities to carry out radiochemical and biological experiments using isotopes generated by the project. Preliminary bioavailability studies conducted using a ^{152}Tb-labelled compound in tumour-bearing mice showed good localization of the tracer molecule to the site of the tumour, with low toxicity compared to control experiments. This work shows promise for potential clinical use in humans. To date, the project is on-schedule and within budget. The future vision of the CERN-MEDICIS

The ISOLDE facility at CERN



MicroScint device

project is to supply complementary isotopes to those produced at other European institutions and in doing so, it hopes to contribute to form a European network of radioisotope production facilities, providing a full and comprehensive range of isotopes for research and medical science.
Project leader: T. Stora (Engineering Department)

MicroScint

MicroScint is a three-year KT funded project to design, build and test a novel particle detector based on scintillation, for applications in single particle tracking for hadron therapy, online beam monitoring, calorimetry and of course, high energy physics. The device will track charged particles with high spatial resolutions using a single microfluidic channel filled with a liquid scintillator material. The reduced thickness of the device compared to other beam monitors such as scintillating fibres, will allow online measurement of beam profiles and intensities. This will permit online characterization of the irradiation received by patients in a manner not previously possible. The planned project consists of five phases, starting with the design and fabrication of the devices and running through testing and characterization, to pre-production and partnership with hadron therapy centres for clinical appraisal. The project has already generated an IP asset in the form of a patent, filed by CERN in May 2012. The future vision of the project is to widen the spectrum of applications for hadron therapy by creating a device that allows previously unavailable online beam monitoring for the treatment of suitable cancers. In doing so, it is hoped that the device will assist in maintaining patient safety, reducing undesirable side effects and maximizing treatment efficacy. Overall, it will provide unprecedented characterization of the irradiation received by patients.
Project leader: A. Mapelli (Physics Department)

High temperature high power RF loads

This project aims to build a demonstrator of a new type of high power RF absorber designed to provide water or air at temperature and pressure levels capable of meeting energy recovery requirements. Two main concepts are currently under assessment. The first one aims to produce water at 150°C and 70 bar, and it is based on stacked waveguide geometry with the inside walls coated with a thin layer of ferrite. The second one aims at producing up to 800°C of air and is based on porous silicon carbide blocks. For the first concept, prototypes of thick coatings have been procured through a Chinese partner, and RF properties are being measured. A 100µm thin plasma sprayed ferrite layer has been produced in collaboration with external partners. First RF measurements of this material show promising results in terms of RF absorption; IR emissivity and vacuum outgassing remain to be tested. There is internal interest in this material as a candidate for RF cavity mode damping on beam diagnostic devices and also for kickers. Concerning

the hot air concept, the properties of the silicon carbide foam have been measured at CERN in more detail with a dedicated Transverse Electro-Magnetic (TEM) test cell. Analysis of these results is ongoing. Testing of the Eccosorb™ material has been successfully completed. There are also currently discussions with CEA Saclay for testing a 700 MHz waveguide type at high power when a prototype is available. A Patent Cooperation Treaty (PCT) patent application integrating the various concepts has been filed.

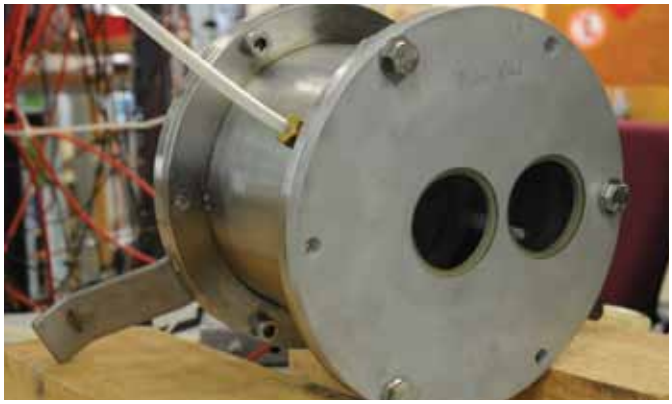
Project leaders: F. Caspers, S. Federmann (Beams Department)

RF loads

GEM-Type detectors for environmental and safety applications

This project proposes to develop two prototypes of resistive thick Gas Electron Multiplier (GEM) sensors. The first one will be sensitive to ultraviolet (UV) and contained in a sealed gas vessel, to be used as a high sensitivity / low cost indoor detector of flames, sparks and dangerous gases for safety applications. The second one will be sensitive to alpha (α) emitting elements (such as natural radon), to be used for environmental monitoring applications (and possibly for early earthquake prediction). Flame detector tests have been performed on two prototypes equipped with Resistive Electrode GEMs (RETGEMs), using both candle flame and pulsed UV source located at different distances from the detector – one flushed with neon (Ne) saturated with ethyl-ferrocene (EF) photosensitive vapours, the other one with caesium iodide (CsI) photocathode. A new sealed detector is in production. Two commercial devices have been purchased for sensitivity/performance comparison. Measurements on an alternative product available on the market have shown two and three orders of magnitude lower sensitivity with respect to EF and CsI RETGEM detectors, respectively. The radon (Rn) detector is under preparation. The intrinsic high sensitivity of a photodetector based on RETGEM coupled to EF or CsI can be exploited to increase the level of protection assured by flame and smoke detection system at a cost significantly lower than most commercial devices. The application of RETGEM technology for the construction of a Rn monitoring network, using hundreds of detectors distributed over seismic areas, will allow a large-scale systematic study of Rn as an earthquake precursor, which is not possible with the existing high-cost devices.

Project leaders: P. Martinengo, A. Di Mauro (Physics Department)

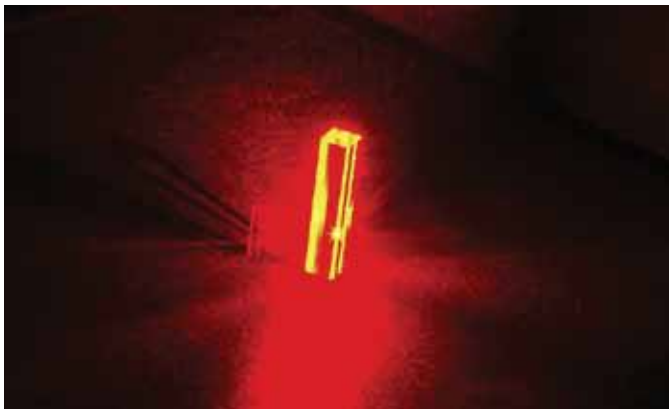


GEM technology

Photonic crystals development

The photonic crystals development 2011 KT Fund project is a year-long project to create and test prototype surfaces employing different types of photonic crystals. Photonic crystals are used to improve light extraction from inorganic scintillators. Current heavy scintillating materials cause much of the light produced to be trapped inside the crystal due to total internal reflection. This problem, however, can be overcome through the use of photonic crystals, whose light-scattering effects result in large yield improvements. Outside of high energy physics, it is anticipated that the first field of application for this technology will be in medical imaging, where maximum light extraction is critical. It would allow for better quality imaging, improved diagnosis and subsequent treatment of diseases, especially cancers. The potential of the technology in a wide range of other fields means it's impact is diverse, being potentially applicable to any scintillator-based detection systems including non-destructive industrial testing, national (homeland) security, astronomy and research & development uses. The preparation of masks is now complete,

the first tests on borosilicate glass have been successful and the BGO testing and characterization making good progress.
Project leader: P. Lecoq (Physics Department)

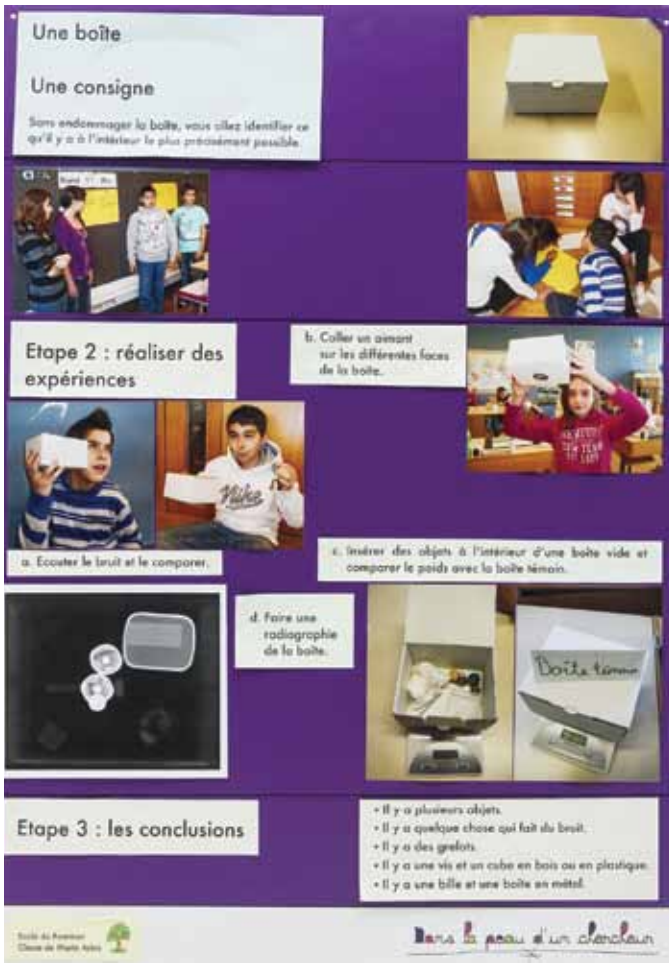


Photonic crystals

"La Boîte"

"La Boîte" is a pedagogical kit designed to teach the scientific method to children and to show them what it means to be a scientist. The core of the kit is a mysterious box that is presented to children, who are then invited to use the scientific method to investigate it: imagining a theory, designing experiments and predictions, running the experiments, analysing the results and communicating the conclusions and possible proofs. The box is accompanied by a booklet dedicated to teachers to guide the process. "La Boîte" is at the heart of the educational programme "Dans la peau d'un chercheur". This French-language programme was launched in 2011 as a joint initiative between the CERN Communication group, the University of Geneva, Education Nationale in France, the Département de l'Instruction Publique of Geneva and PhysiScope. The Knowledge Transfer group has been helping this project with development, industrialization and advertisement of the kit, making its availability broader than the local area.

In 2012, the 48-page booklet was written by pedagogy specialists with great care taken to produce an interesting and attractive result. A company was found and contracted, and a first series of kits was manufactured and delivered to dozens of schools within the framework of "Dans la peau d'un chercheur". More deliveries will follow in 2013. Over the year, several educational institutions have shown interest in "La Boîte", such as the physics department of the Université Libre de Bruxelles, the Université de Bourgogne, and the National Agency for Scientific Culture in Portugal. In June 2012, the President of the CERN Council, Michel Spiro, gave a speech to a hundred children who had worked on "La Boîte", emphasising the importance of science in society and that the children of today are the scientists of tomorrow. The head of the CERN Communication group, James Gillies, asked for a presentation of "La Boîte" to all CERN Member State representatives. This was done in November during the EPPCN (European Particle Physics Communication Network) meeting. The industrialization of the kit will allow them to get "La Boîte" and carry the same educational project locally. In 2013, it is intended to fulfil the requests to translate the booklet into English.
Project leader: S. Petit (General Infrastructure Services Department)



Poster made by school children taking part in the programme "Dans la peau d'un chercheur"

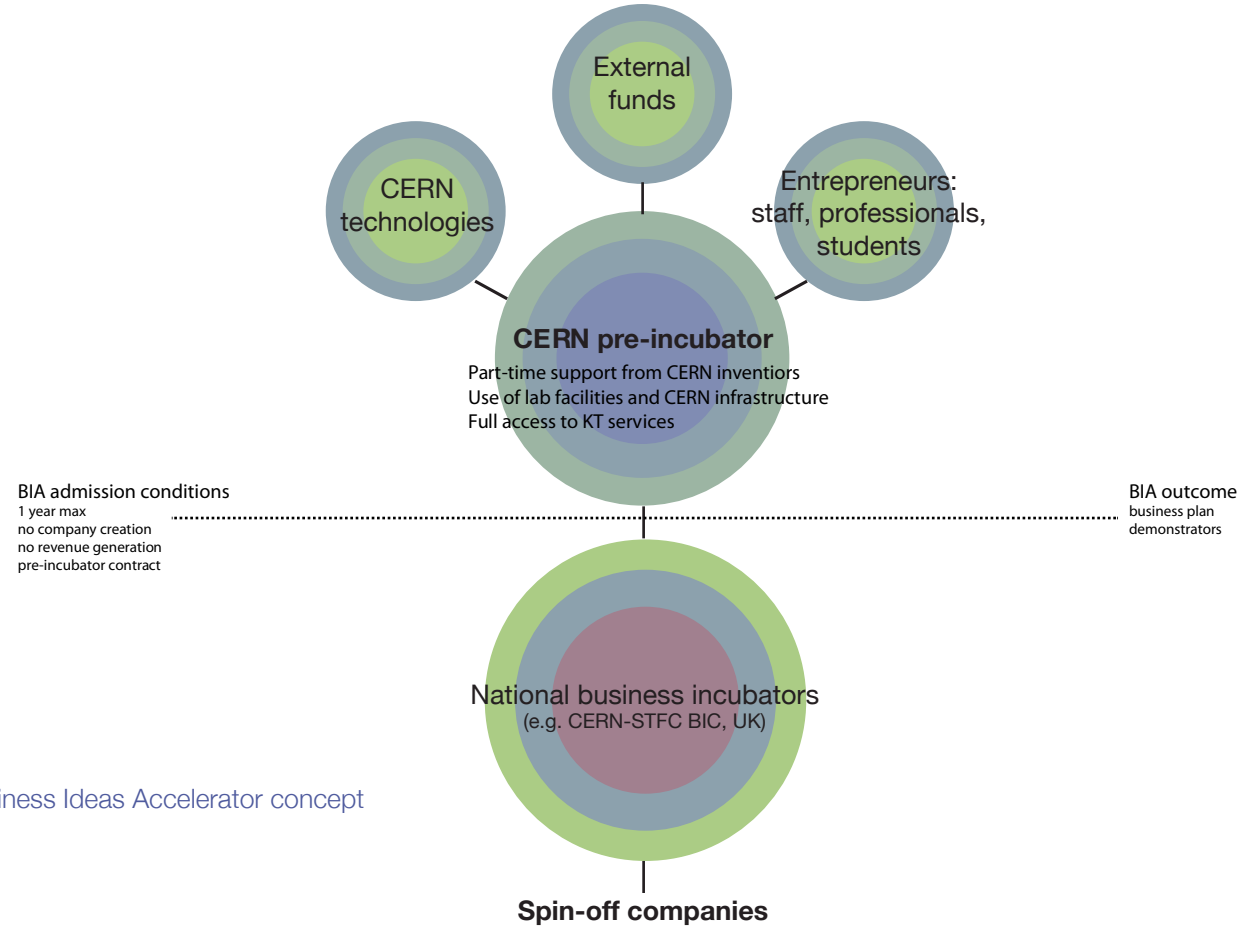
Innovation for business

The Knowledge Transfer Group has been working on many innovative projects in 2012, mainly aimed at increasing the chances of successful, high-impact dissemination of its technology portfolio, and at improving the visibility of its areas of technical excellence.

Some projects are specifically directed towards fostering the creation of CERN spin-off companies, for example the CERN Business Ideas Accelerator, which includes pilot initiatives such as the STFC-CERN Business Incubator Centre and the NTNU-CERN student technology screening week.

CERN Business Ideas Accelerator

A long-term, far-reaching project currently being developed is the CERN Business Ideas Accelerator (CERN-BIA). The global purpose of this composite project is to trigger and support entrepreneurship initiatives related to CERN. The core part of CERN-BIA would be a pre-incubator structure managed by the KT Group, able to provide basic support services to potential entrepreneurs, internal or external to the Organization but with projects related to the exploitation of CERN's intellectual property. Some of these services have been tested in 2012 on a few trial cases. For example, the KT Group has performed a professional assessment for one of its spin-off companies, ADAM (Applications of Detectors and Accelerators to Medicine). The study has gathered market intelligence and



CERN Business Ideas Accelerator concept

proposed a suitable marketing strategy for one of ADAM's new technologies, the in-vivo dosimeter (systems used in radiotherapy to monitor the radiation dose received by the patient during a radiotherapy treatment). Other examples are the support provided to CERN's most successful spin-off company SRB Energy on several issues, the preliminary screening of several candidate entrepreneur projects and the support to file applications for various external funding mechanisms. The pre-incubator will need to be fed with projects and with project-carriers. Students in entrepreneurship are valid candidates to take up the challenge of exploring new company-creation opportunities in collaboration with CERN. This possibility has been fine-tuned in 2012 with two technology screening week exercises in collaboration with the Norwegian University of Science and Technology (NTNU) (see the dedicated section below). Two cases appraised during the second sessions have been particularly promising: Invenio (CERN's integrated digital library and repository system software), and ROOT (CERN's object-orientated data analysis framework). With the support of the software developers and the KT Group pre-incubator structure, one or two small groups of students will return to CERN in 2013 to assess in detail the possibility of creating spin-off companies based on these technologies. In the future it is the KT Group's intention to strengthen even more the links with NTNU and to start similar initiatives with other universities in the Member States.

If a continuous flow of business creation projects is achieved, the new-born companies will be directed to a network of partner business incubators in the Member States for early -stage development and more extended support. CERN's first Business Incubation Centre (BIC) was launched in 2012 in collaboration with the UK's Science and Technology Facilities Council (STFC) (see the dedicated section below), on the Daresbury science and innovation campus, UK. Extensive discussions have been carried out with local authorities and with various national and regional entities to identify other suitable partner structures in the Member States, offering the best possible hosting conditions to CERN entrepreneurs.

Since proof-of-concept and pre-seed funding is often the most critical issue to be solved for early-stage companies, the CERN KT Group has taken an active role in initiatives with other public research organizations within the framework of the Technology Transfer Office (TTO) circle, to identify viable solutions to favour the creation of financial structures at a European level to support high-tech start-ups.

STFC-CERN Business Incubation Centre

In April 2012, CERN and STFC announced the launch of a Business Incubation Centre (BIC) at STFC's Daresbury science and innovation campus.
The BIC provides an ideal package of both funding and business support to accelerate innovative business concepts, including:

- £40,000 of total funding for use on intellectual property protection, design, prototyping, market studies etc.
- Access to up to 40 hours of CERN and 40 hours of STFC scientists and technical expertise.
- Use of CERN intellectual property under favourable conditions.
- Access to collaboration and networking opportunities at the Sci-Tech Daresbury science and innovation campus and through the STFC and CERN networks.
- Wider access to potential sources of financial support through STFC's links with venture capitalists and funding bodies.

John Womersley, Chief Executive at STFC, and Steve Myers, CERN's Director of Accelerators and Technology, announce the STFC-CERN BIC

The BIC can offer places on the programme for up to five businesses per year during the two-year pilot of the scheme. The BIC is for any high-tech entrepreneur, research group or small start-up company looking to develop innovative products and services from technologies originally developed for high energy physics. The STFC-CERN BIC sits within the Cockcroft Institute at the Sci-Tech Daresbury national science and innovation campus in Cheshire, which is also an enterprise zone and already home to more than 100 high-tech companies.

NTNU-CERN Technology Screening Weeks

Since 2008, the intellectual property section of the Knowledge Transfer group has organized hands-on training in technology transfer with the school of entrepreneurship of NTNU. The training, known as the CERN-NTNU technology screening week, is a practical exercise for groups of students who come to CERN to assess inventions selected from CERN's technology portfolio, under the guidance of technology transfer and intellectual property professionals. The ideal target is to have one or more groups of students selecting a technology from CERN for further work in their last year of studies at NTNU and for real business implementation.

In 2012 there were two editions of the screening weeks: one on the 3-17 February and the other on the 15-19 October. A total of 31 and 32 students participated in the two editions respectively, coming to CERN to work side-by-side with inventors and technology transfer officers, and assisted by the group's legal adviser and CERN's patent portfolio manager. The training week is a knowledge-exchange opportunity: students learn about technology transfer and about physics and engineering at CERN, while inventors and technology-transfer officers look at technology transfer opportunities from new angles.

This year's first edition of the screening week was similar to previous years' editions, despite being moved from the usual time in October to February. Five technologies were put up for screening, these were: Diaphragm System, Orthopix, Hood Clamshell Tool, Klystron Amplifier and Thermally Insulatable Vessel. The students identified new fields of applications and possible industrial partners and presented their work in the form of a presentation and a report. The commercial potential of the technologies and possible routes of exploitation were emphasized. The students reported that it had been a good learning experience.

In October, several changes were introduced in order to maximize the learning benefits for the students and to increase the chances of success. One of the novelties was that the KT Group pre-selected eight technologies out of the most promising ones currently available in the portfolio and sent the students the shortlist a month in advance in order to familiarize them with the technical contents while involving them in the final selection process. The students finally chose to work on Invenio, Compact Cryogenic Cooling Pump and ROOT. The reduced number of groups was a deliberate choice to allow a closer follow-up from the assigned technology transfer officers. In addition, the students were clearly informed that support would be sought in the possible implementation phase of their projects.

The students delivered a report on their work and a presentation. Two of the technologies, Invenio and ROOT, were deemed as possible technologies for the students to work on in their commercialization project, as part of their master studies, and the students seemed very optimistic about the possibility to start a company within the framework being established for CERN pre-incubation initiatives.

NTNU students and members of the Knowledge Transfer Group, February 2012

During the October screening week, the NTNU Rector Torbjørn Digernes, the Pro-Rector of Innovation and External Relations, two professors from the Department of Industrial Economics and Technology Management, and the Norwegian Industrial Liaison Officer (ILO) visited CERN. The visit, co-organized by the VIP Office and the Knowledge Transfer Group, was in part dedicated to the discussion of new collaborative projects, such as the setting-up of an NTNU-CERN incubator in Norway (similar to the one created in the UK), and the participation of NTNU students to initiatives related to the CERN Business Ideas Accelerator project.

CERN Easy Access IP

In June 2012, CERN adopted a new approach to knowledge transfer under the label of CERN Easy Access IP, an initiative to make it easier for businesses and entrepreneurs to access intellectual property generated at CERN in the course of its

research programme. CERN Easy Access IP involves granting a free licence for selected technologies from CERN's portfolio. The full portfolio is available through a wide range of channels including R&D collaborations, services and consultancy, support to spin-off companies and the creation of business incubation centres in CERN's Member States.

CERN Easy Access IP joins existing technology transfer opportunities offered by CERN to encourage our partners to evaluate and commercialize those technologies, thus making it easier for CERN and industry, both spin-off companies and established ones, to work together. CERN's Knowledge Transfer Group places selected CERN technologies in an Easy Access IP portfolio. Companies or institutions wishing to license CERN Easy Access IP technologies will be required to acknowledge CERN's contribution and report to CERN's Knowledge Transfer group on the development of the invention.The "CERN Easy Access IP" technology portfolio is available on the Knowledge Transfer website (cern.ch/knowledgetransfer).

Easy Access IP was first trialled by Easy Access Innovation, a collaborative project between the University of Glasgow, King's College London and the University of Bristol

Workshop on Superconducting Technologies

In December 2012, CERN, in collaboration with the European FP7 projects HiLumi LHC (the High Luminosity Large Hadron Collider Design Study) and TIARA (Test Infrastructure and Accelerator Research Area), invited high-tech companies to the first workshop on "Superconducting Technologies for Next Generation of Accelerators".

More than 100 specialists, about half from industry and half from European research laboratories and institutes, gathered at the Globe of Science and Innovation to explore the technical challenges emerging from the design of new accelerator machines, and to match them with state-of-the-art industrial solutions. Scientific presentations, industry talks and Q&A sessions focused on high- and low-field magnets, cryostats and superconducting links and superconducting cavities.

For this first event, CERN technical experts addressed the challenges arising from the next major upgrade of the Large Hadron Collider when the discovery potential of the machine will be extended by increasing its luminosity by a factor of 10 beyond its design value. This extraordinary technical enterprise will lead to a new configuration of the LHC, called High Luminosity LHC. The upgrade is coordinated by Lucio Rossi (Technology Department) and will rely on cutting-edge 13 tesla superconducting magnets, very compact and ultra-precise superconducting cavities for beam rotation, and 300-metre-long high-power superconducting links with zero energy dissipation.

New and more advanced superconducting technologies are at the very heart of other European big science such as FAIR (Facility for Antiproton and Ion Research) at GSI (GSI Helmholtzzentrum für Schwerionenforschung GmbH) in Germany, XFEL (the European X-Ray Laser Project) at DESY (Deutsches Elektronen-Synchrotron) in Germany and ESS (European Spallation Source) in Sweden. Most of the future projects envisioned for after the LHC are based on superconductivity, such as the ILC (International Linear Collider) and the High Energy LHC.
The workshop was the first of a series of initiatives aimed at connecting research infrastructures facing specific technical challenges with potential commercial partners, fostering R&D collaborations and knowledge exchange. The successful and active attendance at the workshop confirmed the importance of collaborative R&D activities between CERN and industry. Apart from the significant marketing reference benefits that companies derive by doing business with CERN, there are mutual technical learning and innovation benefits for companies and for CERN. Through a stronger synergy between CERN's procurement and technology transfer activities, the Knowledge Transfer Group strives to maximize these benefits by setting up schemes that facilitate knowledge exchange and innovation.

For 2013, the Knowledge Transfer Group will organize a new academia-industry event in collaboration with CERN's technical departments.

SUPERCONDUCTING TECHNOLOGIES

FOR THE NEXT GENERATION OF ACCELERATORS

WORKSHOP

ATLAB

In close collaboration with related CERN services, in particular with the Knowledge Transfer Group, ATLAS launched two European Union (EU) funded projects, TALENT (Training for cAreer deveLopment in high-radiation ENvironment Technologies) and EDUSAFE (Education in advanced VR/AR Safety Systems for Maintenance in Extreme Environments). They are both ITN Marie Curie programmes and are aiming at training young researchers related to the ATLAS upgrade activities. TALENT involves the development of an additional layer of sensitive semiconductor radiation sensors around the innermost detector inside ATLAS, called the Insertable B-layer (IBL). The second project, EDUSAFE, aims to minimize the time of maintenance tasks in radiation environments, by providing augmented reality tools to the intervention teams that are guided and monitored by experts outside the intervention areas.

Prototype of augmented reality tools being developed as part of EDUSAFE for dedicated ATLAS maintenance operations close to the beam pipe areas

For all EU-funded projects, ATLAS has created a dedicated interface called ATLAS Technology Lab, or ATLAB in short. The purpose of ATLAB is to make good use of supplementary funding for its upgrade-related R&D activities, while co-developing common core technologies in the spirit of open innovation with its external partners. This includes offering an inspiring educational environment for the young researchers and students involved, offering its external partners market intelligence of new potential commercial opportunities for the technologies developed together, and helping to improve networking between the small- and medium-sized companies (SMEs) that are involved. ATLAB is currently looking for a dedicated area at CERN for consolidating the related activities. Currently, ATLAB is in the process of submitting two new EU-funding initiatives and is ready to play a bigger role within the EU's Horizon 2020 programme.

The Knowledge Transfer Group supports ATLAB activities by offering help in intellectual property rights and related legal matters; scanning technology markets – with the crucial help of Vienna University; and helping to establish active external partners from European industry, in particular SMEs.

CERN openlab

CERN openlab is a unique public-private partnership between CERN and leading information technology companies. Its mission is to accelerate the development of cutting-edge solutions to be used by the worldwide community working on LHC data. This framework for R&D collaboration was created more than 10 years ago, to develop innovative, advanced IT systems required to cope with the unprecedented computing challenges of the LHC. It brings together the efforts of science and industry, working at the forefront of research to continuously push back technological boundaries. It also offers a neutral ground for companies to collaborate on common projects and develop synergies.

In 2012, the fourth CERN openlab three-year phase was launched. Its objective is to address new topics crucial to the CERN scientific programme, such as cloud computing, business analytics, the next generation of hardware, and security for the myriads of network devices. The four existing CERN openlab partners – HP, Intel, Oracle and Siemens – were joined by Huawei as a contributor.

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 disseminating this vision to a wider audience, including the general public, press, and partners' customers. More than 390 participants attended the 10 topical workshops promoting the work of the competence centres: platforms, databases, networking and controls. In addition, seven seminars and colloquia were organized. A series of 12 lectures especially developed for participants of the CERN openlab summer student programme was scheduled from mid-July to early August. Since its inception, 162 young computer scientists have participated in this programme. Lectures were also given to a group of 12

CERN openlab officially launched its fourth three-year phase this year at the occasion of its Board of Sponsors meeting, in the presence of the CERN Director-General, the partners, contributors, and team members

Intel International Science and Engineering Fair (ISEF) special award winners 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 on the CERN openlab website.

CERN openlab is led by Bob Jones, IT Department.

more information: www.cern.ch/openlab

Helix Nebula

In a similar way to Earth observation and large-scale genomic analyses in biomedical research, large experiments in particle physics are constantly confronted with the issue of acquiring, analysing and storing an enormous quantity of data. CERN's computing capacity needs to keep up with the vast amount of data coming from the LHC experiments, and to meet this big data challenge CERN is collaborating with other institutes and industry.

In March 2012, CERN, in collaboration with the European Molecular Biology Laboratory (EMBL), the European Space Agency (ESA), and leading IT providers, launched "Helix Nebula – the Science Cloud: big science teams up with big business", a public-private partnership to create a European cloud-computing platform. At CERN, Helix Nebula is being tested using ATLAS simulation software with a plan to expand the testing to more experiments in the future. Helix Nebula is supported by a European Commission project, led by Bob Jones at CERN.

Helix Nebula represents a radically new way of providing computing resources: instead of procuring the hardware and then maintaining and managing it, CERN procures the service from a commercial infrastructure provider within the Helix Nebula partnership, providing network access, storage and central processing units (CPUs).

more information: http://www.helix-nebula.eu

HELIX NEBULA
THESCIENCECLOUD

Knowledge sharing

CERN Open Source Software Licence Task Force

In 2011 a duration-limited Open Source Software Licence (OSL) task force was established with the mandate to formulate recommendations on which licence should be used for which class of software developed at CERN. Prior to this, guidance, in particular for newcomers, had been lacking on how intellectual property derived from software produced at CERN could be protected. As a result, software released by CERN had sometimes missing or invalid copyright statements. CERN, while being open and encouraging collaboration, needed to protect itself against misappropriation of its work.

The OSL task force delivered its recommendations in January 2012. These were inspired by, and consistent with, the CERN Convention, which states that the results of its experimental and theoretical work shall be published or otherwise made generally available. This philosophy of openness is also present in the CERN policy on the management of intellectual property in technology transfer activities, which states that the priority for CERN is to maximize the dissemination and visibility of technologies ahead of generating revenue. In particular, concerning software, the policy expresses a clear preference for an open source approach for CERN-owned software. Similarly, in the field of scientific publications, CERN has been a leader in the open access movement: all LHC collaborations actively promote publication of their results under open access conditions.

In line with these principles and traditions, the task force recommended that, whenever possible, software owned in whole or in part by CERN should be made available as open source. This encourages the creation of open communities and collaborations of users who can improve and complement the software and share their enhancements with the entire community. Another recommendation states that any software owned in whole or in part by CERN must contain in the notice a statement acknowledging the copyright of CERN and other copyright owners as applicable; the applicable licence; and CERN's special status as an Intergovernmental Organization.

The OSS Task Force, chaired by Francois Fluckiger from CERN's IT Department, identified four classes of software owned in whole or in part by CERN. Which open source licence to use depends upon whether the software was developed solely by CERN or in collaboration with partners, and whether it makes use of third-party software. The open source licences used for CERN-owned software should be widely used licences approved by the open source initiative (OSI). For software developed solely by CERN, the default licence is a "copyleft" licence. A practical guide for inserting licensing terms and a template for documenting open source software cases are now available. The next steps are to start an awareness campaign, and to work with the European Commission on adapting the terms of the European Union Public Licence to be compatible with the intergovernmental status of CERN.

High Energy Physics Unix Information Exchange

The HEPiX (High Energy Physics Unix Information Exchange) workshop series was established in 1991 to bring together technical managers and providers of IT services from the high energy physics (HEP) laboratories, institutes and universities. Workshops are held twice a year with an attendance of typically around 100 people. Many sites participate regularly, such as BNL, CERN, DESY, FNAL, IN2P3, INFN, JLAB, NIKHEF, RAL, SLAC, TRIUMF and others. The workshops cover all HEP-specific disciplines around scientific high-throughput and data-intensive distributed computing; they provide an excellent forum for exchanging information, discussing ideas in an early inception phase, identifying common needs, and agreeing on common technical directions. The workshops are less formal than most conferences, allowing for more open and constructive exchanges.

CERN participants have usually provided between 15 and 25% of the contributions to any given workshop. Alan Silverman, a former CERN staff member (now retired), was instrumental in launching the workshop series in 1991, and served as co-chair and in advisory roles for many years. He significantly helped shape the informal, yet goal-orientated, character of HEPiX. In spring 2012, Helge Meinhard, from CERN's IT department, was appointed European co-chair. Tony Cass, also from CERN-IT,

The HEPiX workshop in Prague, April 2012

completed his mandate as chair of the HEPiX virtualization working group.

The 2012 editions were hosted by the HEP division of the Institute of Physics of the Academy of Sciences of the Czech Republic (23-27 April) and by the Institute of High Energy Physics of the Chinese Academy of Sciences in Beijing (15-19 October). CERN representatives described in detail the approach chosen to refresh the way of operating the large (currently about 8,000 servers and expected to double between now and 2016) CERN computer centre, in particular for configuration management. This has created a lot of interest from other sites, with the likelihood of a working group for common configuration methods being established early in 2013. Other much appreciated contributions covered unified communications, deployment of IPv6, clouds, batch systems etc.

more information: http://information-technology.web.cern.ch/about/meeting/hepix

Open Hardware

During the year 2012, many Open Hardware projects at CERN reached the commercialization stage. One of the key advantages of this way of designing and supporting hardware is that one can get the best of both worlds: good support from companies and the flexibility allowed by open source. This still had to be checked in practice though, and the response of Member State electronics design companies was overwhelmingly positive.

Various price inquiries were published by the Beams Department for the procurement and support of electronic boards to be used in the controls and data acquisition system of accelerators. These included PCIe and VME64x FMC carrier boards, and ADC, TDC and fine-delay-generator mezzanines. All of these designs are now being commercialized by companies that were previously selling non-open hardware to CERN, giving the same level of support as before with the added bonus of openness and design flexibility. Most of the designs are actually commercialized by more than one company, something impossible in a proprietary paradigm.

The process of reaching the level of quality and features typical of commercial hardware has been a very productive collaboration between CERN and the different companies, resulting in mature products that the firms have been able to sell to other clients as well. The White Rabbit (WR) project illustrates well the advantages of Open Hardware. Originally developed to cope with the stringent synchronization requirements of CERN's accelerators, this technology is now commercialized by companies and is becoming a very compelling solution for the synchronization of all types of physics experiments outside CERN, such as Cherenkov light detection in Siberia, studies of the atmosphere in China and a deep-sea neutrino telescope.

All of the above designs are licensed under the CERN Open Hardware Licence (OHL), developed by the Knowledge Transfer group, which guarantees a clear and sound legal basis for licensers and licensees. The Open Hardware Repository created by Javier Serrano, Beams Department, is an ideal place to share all design information, and also a showcase for the different companies and design groups involved. In addition, because publishing these designs without constraints is an invitation to produce them, chip manufacturers also benefit from the publication. This has enabled design groups to negotiate attractive prices for the purchase of some chips.

Although the year has been very successful, some areas can still be improved in 2013. The current discussions in the CERN OHL mailing list will result in a better licence, tackling problems related to licence proliferation and compatibility. The licence itself is being developed in an open-source way, benefiting from the peer review of many competent legal experts worldwide. Finally, in order to increase the efficiency of sharing designs, the BE-CO-HT section has started actively contributing to two Free/Libre Open Source Software projects: the Kicad PCB design tool and the Icarus HDL simulator. The year 2013 should see a significant improvement in the features and quality of these two tools.

more information: http://www.ohwr.org

Hardware licensed under CERN OHL

Open Access

Open Access aims to bring the results of publicly funded research to anyone, anywhere and anytime, free of charge. It drives innovation by removing barriers between researchers and all other actors in the knowledge economy. As an ultimate knowledge-transfer process Open Access has attracted the attention of regional, national and transnational funding agencies and research-funding charities.

For many years, CERN has embraced Open Access, enshrined *ante litteram* in its own Convention, which over half a century ago stated "[...] the results of its experimental and theoretical work shall be published or otherwise made generally available". In 2012 all the LHC scientific results, more than three hundred articles, were made available at no cost to any reader, through win-win partnerships with leading scientific publishers. As a result, the general public is able to access, should they desire, the final published version of the articles describing the discovery of the Higgs-like particle. Such openness is an important aspect underpinning the spirit of scientific research and its perception in civil society.

CERN and a vast network of partners are now working with the publishing industry to expand the opportunities offered by Open Access well beyond the LHC results, to the entire discipline of high energy physics. This key project is SCOAP3 (Sponsoring Consortium for Open Access Publishing in Particle Physics), an international non-profit organization, structured like the CERN experimental collaborations. SCOAP3, led by Salvatore Mele, General Infrastructure Services Department, would act as a clearing-house connecting scientific publishers, researchers, libraries and funding agencies. Funds currently used to purchase scientific journals will be re-directed by libraries worldwide through a set of National Contact Points to SCOAP3, which, through CERN, will pay centrally for peer-review and publishing services in these high-quality, competitively selected, journals. Articles will be Open Access.

SCOAP3, co-ordinated by the Open Access team in the CERN Scientific Information Service, with the support of the Purchasing and Industrial Service and the Legal Service, is breaking new ground in a transition of scientific publishing from a "content economy" to a "service economy". This is the first large-scale experiment covering an entire scientific discipline, and both the publishing industry and funding agencies worldwide are actively participating, with the aim to generate further knowledge to transfer to other sectors. SCOAP3 was officially launched on 1 October 2012, after the successful conclusion of its procurement process.

Last but not least, in 2012, CERN generated and disseminated new knowledge in the field of Open Access through two multi-disciplinary research projects co-funded by the European Commission: SOAP and ODE. Through a vibrant network of funding agencies, publishers, research institutions and libraries, these projects identified drivers and barriers in Open Access to scientific publications and scientific data, across disciplines and around the world. Key drivers are the recognition of scientists for the efforts incurred in enabling others to build on their results. Immediate barriers are funding streams not tailored to support the additional resources needed to preserve and share results and data for further re-

use. This knowledge has been transferred to the publishing industry (both SMEs and large multinational corporations) and funding agencies in the Member States, as an input to key strategic decision-making in the field.

more information:

http://library.web.cern.ch/library/OpenAccess

Bilateral and multilateral exchanges with other organizations

CERN promotes and supports international and multidisciplinary knowledge exchanges with and among research institutes and international organizations. The exchange of knowledge with one single partner organization happens through cooperation agreements, which are prepared through the identification of technical issues of common interest between CERN and the partner organization. Partner organizations are typically other research institutes or other international organizations, or both.

In 2012, CERN KT experts contributed to the preparation of bilateral cooperation agreements with organizations such as ESA, WIPO, WHO, IRENA, and with the R&D and treatment centres CNAO and MedAustron.

In particular, on 25 May 2012, on the occasion of a visit from ESA astronaut Christer Fuglesang, a preliminary set of technology areas of common interest for particle physics and space applications were identified and discussed. Additional work in this direction has been planned for 2013, in view of future R&D effort optimization.

Exchange of knowledge and best practices is facilitated by networks and working groups dedicated to technology transfer and intellectual property management:

EIROforum TWG-IMKTT

The EIROforum is a partnership between eight of Europe's largest inter-governmental scientific research organizations that are responsible for infrastructures and laboratories. It is the mission of EIROforum to combine the resources, facilities and expertise of its member organizations to support European science in reaching its full potential.

In particular, the Thematic Working Group on "Innovation Management and Knowledge / Technology Transfer" (TWG-IMKTT) acts as a discussion forum and as a coordination platform to enhance the cooperation of the EIROforum organizations in the areas of IMKTT, for the successful translation of European academic research into tangible benefits for European society.

In 2012, CERN KT has been particularly active in the framework of the EIROforum TWG-IMKTT, bringing a critical contribution to the definition of the implementation plan 2012/13. Enrico Chesta, Section Leader of CERN's Intellectual Property Management and Technology Transfer Section, has been appointed Chairman of the TWG-IMKTT as from 1 January 2013 to serve a term of two years.

The TWG-IMKTT, established in May 2011, held its second group meeting at ESA headquarters in Paris on 27 March 2012 to review activities and take actions forward. During the autumn meeting in Munich (October), the implementation plan 2012/13 was discussed and details defined. It includes topics such as the identification of R&D areas of common interest (in collaboration with other TWGs, i.e. Instrumentation and IT), the sharing of good practices and of IP management tools, the organization of a pilot thematic EIROforum TT and Industry Brokerage Event in 2013, and the realization of a survey on policies related to entrepreneurship and incentives.

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

EEN, Enterprise Europe Network

EEN is 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.

The network invited CERN KT to present the organization and its technology transfer activities at their annual meeting in Lyon (CCIR Rhône-Alpes) in June. Some technology offers from CERN are regularly posted through the EEN web tools and EEN will help CERN in organizing a workshop on material science in 2013, with the strong involvement of European SMEs.

more information:

http://portal.enterprise-europe-network.ec.europa.eu/

ENET, knowledge transfer external network

CERN's Knowledge Transfer Group created and coordinates a network of national knowledge transfer officers from all Member States. The network promotes the exchange of information about technology transfer opportunities from CERN to Member States.
The ENET met in March 2012. In a half-day meeting CERN presented to national KT officers the achievements of the Knowledge Transfer Group in 2011.

more information: cern.ch/knowledgetransfer

INET, knowledge transfer internal network

CERN's Knowledge Transfer Group created and coordinates a network of representatives of all CERN's departments. The objective is to raise awareness on the activities of the group and build collaborations on knowledge and technology transfer projects. The INET met in June 2012. In a half-day meeting the Knowledge Transfer Group presented in detailnew technology transfer schemes and other initiatives, such as the KT Fund.

more information: cern.ch/knowledgetransfer

TTO Circle – European Technology Transfer Offices Circle

The European TTO Circle was created by the Joint Research Centre (JRC) to bring together the major European national and international public research organizations to play a role in collectively driving changes in technology transfer practices. The TTO Circle, sponsored by the JRC, organized three meetings in 2012: two plenaries (in April at ENEA and CNR premises in Rome and in October at Max-Planck and Fraunhofer premises in Munich), and a restricted meeting in Brussels in February. CERN KT took an active role in all of them. Substantial progress is being achieved in the various proposed Working Packages, especially in that concerning the creation of a "Technology Transfer Financial Facility" to support proof of concepts and seed funding with the involvement of the European Investment Fund. Another valuable initiative is the coordination of the IMPACTT Marie Curie proposal ("Instruments and Methods for the Professionalization and ACceleration of Technology Transfer"), submitted in November.

The next TTO Circle meeting in 2013 will take place in Geneva in June 2013, hosted by CERN and WIPO.

more information:

http://ec.europa.eu/dgs/jrc/index.cfm?id=6480

HEPtech, the high energy physics technology transfer network

HEPTech is a technology transfer network (TTN) bringing together leading European high energy physics research institutions. It provides academics and industry access to the skills, capabilities, technologies and R&D opportunities of the high energy physics community in a collaborative, open-science environment. The network is made up of 21 leading European institutions and universities from 16 different countries. Each of these research organizations works across a range of scientific areas to meet the technological challenges

of exploring fundamental particle, astroparticle and nuclear physics.In 2012, HEPtech organized three academia-industry matching events, either individually or in collaboration with the European Union FP7 projects ASPERA (AStroParticle European Research Area) and AIDA (Advanced European Infrastructures for Detectors at Accelerators):

- The third ASPERA Technology Forum, Industry meets Academia: Vacuum and Cryogenics, 13–14 March 2012 in Berlin, Germany
- AIDA – Academia meets Industry: Solid-State Position Sensitive Detectors, 26–27 March 2012, DESY at Hamburg, Germany
- Industry Academia Matching Event on Micro-Pattern Gaseous Detectors, 26–27 April 2012, Laboratoire d'Annecy-le-Vieux de Physique des Particules (LAPP) at Annecy-le-Vieux, France.

HEPTech
Leading HEP technologies for industry
Technology Transfer opportunities

In 2012, HEPtech elected a new co-ordinator: Ian Tracey, from the Science and Technology Facilities Council in the UK. Jean-Marie Le Goff from CERN is the chairman of the board.

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

EPS Technology Innovation Group workshop

In 2012 the European Physical Society Executive Committee decided to re-activate the EPS Technology and Innovation Group (TIG) by launching a three-day workshop, to examine ongoing and projected R&D and technological innovations in physics research and spin-offs to society. In October 2012, the TIG held a three-day workshop at the Ettore Majorana Foundation and Centre for Scientific Culture in Erice (Italy), organized by Horst Wenninger, EPS TIG Chairman, and by Manjit Dosanjh, CERN's Life Sciences Advisor and member of the TIG.

The TIG workshop focused on fundamental research as a key driver for technological innovation. More than 25 technology transfer experts and scientists were invited to present and discuss topics ranging from accelerator technologies to particle physics detectors, computing, and applications. Numerous talks were devoted to medical applications of high-energy physics technologies, such as Medipix, accelerators for hadron therapy, production of medical isotopes, medical imaging, and the LEIR biomedical facility. The CERN openlab model, which promotes joint ventures with leading information technology companies, was also presented.

more information: https://indico.cern.ch/conferenceDisplay.py?ovw=True&confId=215087

The EPS Technology Innovation Group workshop, Erice 2012

From physics to medicine

Many technologies developed at CERN for its fundamental physics research programmes find application in the medical sector. These applications have a high societal impact, and CERN is committed to sharing its expertise in particle accelerators, detectors and information technologies with fields beyond high-energy physics for the benefit of all. In addition, CERN continues to apply the well-established collaborative approach of particle physics to knowledge transfer projects in the health field.

Overview of Life Sciences Section activities

The Life Sciences Section of the Knowledge Transfer Group, led by Manjit Dosanjh, is actively involved in various initiatives including medical imaging, particle therapy, radiobiology, e-health and training of young researchers in these multidisciplinary fields. The section provides advice to the CERN community on these topics, and promotes public awareness on CERN's initiatives in the life sciences domain. The section has been instrumental in federating a multidisciplinary and multinational community, recognising the challenges and importance of exchanging knowledge between experts from different disciplines. These aspects are particularly relevant in the medical sector, where differences in the philosophy and approach between the developers and the end users are even larger than in other fields. Bringing these communities together has been one of the major achievements of the European Network for Light Ion Hadron Therapy (ENLIGHT), which celebrated its 10th anniversary in 2012. The ICTR-PHE conference (held in 2012, following the first successful PHE workshop in 2010) also fostered knowledge exchanges between physicists, biologists and medical doctors. The collaboration between research centres, technology transfer experts and enterprises is another focal point for medical applications: this was discussed extensively in 2012 at the first workshop of the European Physical Society Technology and Innovation Group.

In 2012, the proposal of a biomedical facility at CERN based on LEIR (low-energy ion ring), an initiative stemming from the first PHE workshop, took a defined shape: this could be a model project that would benefit from CERN's competence in particle accelerators and in managing complex multidisciplinary projects. Last but not least, the following pages will report on the 2012 progress of four projects funded by the European Commission (ENVISION, ENTERVISION, PARTNER and ULICE, all under the "umbrella" of ENLIGHT), which represent excellent examples of how CERN contributes to the field of medical imaging and hadron therapy.

The Life Sciences Section plays a prominent role in all the activities outlined above, and is also involved in strengthening CERN's connection with non-Member States, and especially with developing countries. An example of such involvement is EPLANET, a Marie Curie International Research Staff Exchange scheme between Europe and Latin America in the high energy physics field and associated technologies, where Manjit Dosanjh leads the work package on medical applications. Members of the section regularly present CERN's activities in the life sciences domain to students and teachers as well as to other stakeholders, including at the meeting of the Finance Committee in September 2012.

ENLIGHT: 10 years on

In 2012, the European Network for Light Ion Hadron Therapy (ENLIGHT) celebrated its 10th anniversary. Its inaugural meeting at CERN in February 2002 was attended by about 70 specialists from disciplines such as radiation biology, oncology, physics and engineering: this was a considerable achievement at a time when "multidisciplinary" was not yet a buzz word.

At a meeting in 2006, the community agreed that the primary mandate of ENLIGHT would be to develop strategies to secure necessary funding to sustain research into areas needed for improved and effective hadron therapy, and to establish and implement common standards and protocols for treating patients. These activities should be funded mostly through EC projects, while the network itself carries on without dedicated financial resources. At the same meeting, the community chose Manjit Dosanjh, CERN's Life Sciences advisor, as co-ordinator of the network.

Since starting in 2002, ENLIGHT has been growing steadily and it now counts some 400 participants from more than 20 countries across Europe. It entered its second decade with four EC-funded projects under its umbrella: PARTNER (which came to an end in September 2012), ULICE, ENVISION and ENTERVISION, with total EC funding of €24 million. All of these projects are directed towards the different aspects of developing, establishing and optimizing hadron therapy.

Members of ENLIGHT network at CNAO, Pavia (Italy)

ENLIGHT held its 10th anniversary meeting on 15 September 2012 at Centro Nazionale di Adroterapia Oncologica (CNAO), in Pavia, with a look back at its founding aims, current progress and future challenges. Richard Pötter, one of the founders of ENLIGHT proposed as a future key task for the network, the establishment of a European multicentre hadron therapy collaboration in close co-operation with ESTRO, EORTC and other key stakeholders in radiation oncology. Such an entity would gather under one umbrella the best clinical practices, research and development, together with education and training. He also pointed out that further progress in hadron therapy will come from joint efforts in basic and translational biology, clinical research and physics research, and that young leaders are needed to drive this process forward. Hopefully, the many young and talented participants at the 10th anniversary meeting will rise to the challenge.

more information: http://cern.ch/ENLIGHT

ICTR-PHE Conference

A broad community of scientists involved in disease diagnosis, treatment and cure, gathered to share and discuss their latest results at the ICTR-PHE 2012 Conference that took place in Geneva from 27 February to 2 March.

This large event resulted from the merging of two – formerly independent – successful gatherings: the International Conference in Translational Research in Radio-Oncology (ICTR), which had been held every two years since 2000, and CERN's Physics for Health (PHE), whose first edition took place in 2010.
ICTR-PHE 2012 was co-chaired by Manjit Dosanjh, CERN's Life Sciences advisor, and Jacques Bernier, Radiation Oncology, Genolier Clinic (Switzerland). The whole Life Sciences Section was engaged in the organization of the conference.

With more than 600 participants, 400 submitted abstracts, and 150 posters on display, the conference represented an important opportunity for researchers coming from different backgrounds to debate a variety of issues related to healthcare, and to establish or reinforce collaborations.

The scientific programme was articulated over five days. The first two were devoted to the four major topics defined during the previous PHE workshop: radiobiology, radioisotopes, medical imaging, and novel technologies in radiation therapy.

The third day connected the PHE and ICTR communities by featuring plenary lectures on the many synergies that exist nowadays between biology, physics and clinics. Finally, the last two days retained the format of the previous editions of ICTR, with a combination of plenary and parallel sessions on translational research and pre-clinical strategies in radiation oncology.

“This turns out to be an important meeting in order to get medical doctors, physicists, biologists and engineers to collaborate together”, pointed out Steve Myers, CERN’s Director for Accelerators and Technology. “On such occasions we – physicists and engineers – can find out what clinicians and biologists need and they can discover what we can give them in terms of technologies”.

This concept was strongly reiterated by Soren Bentzen, professor of Human Oncology at the University of Wisconsin, who gave a public lecture on “Treatment of cancer in the 21st century: biology, physics, and genomics”.

CERN’s Director-General (right) and the EC Director for Health (centre) open the ICTR-PHE Conference

ICTR-PHE 2012 also offered the opportunity to listen to and discuss with decision makers: in fact, the opening talk was given by Ruxandra Draghia-Akli, Director for Health at the European Commission.

Political issues were discussed by José Mariano Gago, Professor of Particle Physics and former Minister of Science and Technology in Portugal, who stated that “Health research must be a driving force for the renewal of science policy”.

The large participation and the request for a follow up to the ICTR-PHE 2012 conference showed that the interest around the defined research themes is high, as well as the will to foster collaborations between different scientific communities.

The next ICTR-PHE conference will take place in Geneva, 10-14 February 2014.

more information: http://cern.ch/ictr-phe

A biomedical facility at CERN

The first Physics for Health workshop identified a set of critical needs in the European landscape. One of the key issues was to cover the need for a biomedical research facility, supported by a consortium of laboratories, to be installed at CERN and made available to the international scientific community. Further to the feasibility studies carried out on the LEIR (Low Energy Ion Ring) accelerator, which were presented at ICTR-PHE, Manjit Dosanjh organized a brainstorming meeting at CERN on 25 June 2012 to gather input from a large multidisciplinary community of experts. More than 200 people from 26 countries registered for the meeting, which was also webcast to reach a wider audience. From this one-day discussion, it was evident that there is a broad agreement on the usefulness and scope of such a facility.

LEIR facility at CERN

To fully exploit the potential of particle therapy, significant research is needed in the radiobiological sector and the physics sector. Operational clinical facilities have to concentrate on clinical use and very little time is available for research. Furthermore, clinical centres work with standard beams, typically protons and carbon ions (possibly helium and oxygen in the near future). Research with alternative ions, which could have specific advantages or applications, cannot be performed due to lack of beam availability.

LEIR is the CERN facility that produces high-density ion beams for the LHC and for the SPS fixed target experiments. A new ejection system with new beam lines would be needed for LEIR to provide beams suitable for biomedical applications; a new ion source would also be needed. The biomedical-related activities could take place in "time-sharing mode", that is, also during LHC ion runs. The LEIR facility could provide ion species from protons up to at least neon ions. Bio-targets (i.e. human cells, both malignant and normal) could then be tested in the beamlines, as well as innovative dosimetry systems, radiation detectors, proton radiography and tomography devices.

The major points are summarised in two articles submitted to the *British Journal of Radiobiology* and to *Radiotherapy & Oncology*, and a strategy document was addressed to the European Particle Physics Strategy Group. The next crucial step will be to secure the necessary funding through the forthcoming EU scheme Horizon 2020 or other sources.

more information: https://indico.cern.ch/conferenceTimeTable.py?confId=193910#20120625

ENVISION

ENVISION (European NoVel Imaging Systems for ION therapy) is a collaboration of 16 leading European research centres and industrial partners, co-ordinated by Manjit Dosanjh, CERN's Life Sciences advisor, which aims to develop novel imaging techniques for safer and more precise hadron therapy. The four-year project was launched in February 2010, and the first months of 2012 were particularly intense for the ENVISION community, both scientifically and in terms of reporting to the European Commission.

At the end of February, most of the ENVISIONers gathered in Geneva for the ICTR-PHE conference. This was a good opportunity to measure the scientific productivity of the consortium. It turned out that in its first two years ENVISION has already been publishing interesting results, as proved by the high number of accepted contributions: a dozen talks in various parallel sessions, as well as a plenary talk on in-room imaging and a number of posters.

With the end of the second year of the project, it was also time for ENVISION to formally report to the European Commission. The mid-term review was held in April in Ciudad Real, and the presentations made in front of the EC Project Officer clearly showed that the consortium has fully entered into the research phase: hardware and software prototypes are being developed and tested, important evaluation studies on Monte Carlo models and motion monitoring techniques have been performed, and several collaborations across work packages are also taking place.

ENVISION passed the mid-term review successfully, and this motivated the community even more to pursue future collaborations in the field of medical imaging. The project is co-funded by the European Commission within the FP7 Cooperation Programme, under Grant Agreement No. 241851.

more information: http://cern.ch/ENVISION

ENTERVISION

ENTERVISION is a Marie-Curie Initial Training Network to train young researchers in online 3D digital imaging for hadron therapy. This four-year project brings together ten academic institutes and research centres of excellence and one leading European company in particle therapy, and is coordinated by Manjit Dosanjh. The research activities of the trainees connects to those pursued in the ENVISION project.

Since the kick-off in 2011, the participating institutes have been busy recruiting, with a total of 12 early stage researchers and three experienced researchers having now started their contracts. Three researchers are based at CERN, one of them within the Life Sciences Section.

The multi-disciplinary training programme of ENTERVISION began in March 2012, with the first training course on "Treatment Delivery Systems and Dosimetry", organized by the Heidelberg Ion Beam Therapy Centre (HIT) and GSI Helmholtzzentrum für Schwerionenforschung GmbH (GSI), and continued with the course "From physics to medical imaging through detectors" in Lyon. The researchers were also given the opportunity to join the PARTNER project courses on "Gantries and Imaging" and "Image guidance in hadrontherapy" at CNAO, Pavia, Italy. As well as scientific learning, the researchers are able to expand their knowledge in other areas. In 2012, a course on leadership development was organized at the University of Surrey, UK.

The ENTERVISION researchers have a mix of different academic backgrounds and come from all over Europe with a few coming from further afield (Brazil and China). Throughout the project they will be encouraged to build a multidisciplinary network that will not only help them in their future careers, but ultimately improve the transfer of knowledge between the various disciplines of cancer treatment.

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

more information: http://cern.ch/ENTERVISION

ULICE

The ULICE (Union of Light Ion Centres in Europe) project, launched in 2009 and coordinated by CNAO (Pavia, Italy), responds to the need for greater access to hadron therapy facilities for both research and clinical use. The four-year project addresses the development of appropriate instruments for more affordable and effective hadron therapy, with particular emphasis on carbon ion therapy, and is built around three pillars: Joint Research, Transnational Access and Networking Activities (co-ordinated by CERN's Life Sciences advisor Manjit Dosanjh).

The Transnational Access provided by ULICE allows researchers from all eligible countries to perform clinical and experimental research, as well as to receive clinical training and education, at

the Heidelberg Ion-Beam Therapy Centre (HIT) in Germany and the National Centre for Oncological Hadron therapy (CNAO) in Italy. In 2012, as co-ordinator of Networking Activities, the CERN Life Sciences Section played a key role in catalysing an increase in the number of applications from research groups by producing a promotional video on the application procedure (http://cdsweb.cern.ch/record/1475404).

This video was presented to the ULICE consortium and ENLIGHT network, at the annual meeting attended by more than 100 people at CNAO. In addition, in response to the request from the European Commission, increased efforts were made within the networking activities to promote transnational access at every opportunity. ULICE and the transnational access possibilities were emphasized during presentations given by the Networking Pillar at a global level. The activities

of this project were also advertised at the ICTR-PHE 2012 conference.

After the summer of 2012, the Networking Pillar also began to organize a series of one-month training courses at HIT and CNAO for medical doctors and medical physicists who are either working in one of the planned European hadron therapy facilities or who just want to update their knowledge in the field. ULICE is co-funded by the European Commission within the FP7 Capacities Programme, under Grant Agreement no 228436.

more information: http://cern.ch/ULICE

PARTNER

PARTNER (Particle Training Network for European Radiotherapy) was launched in 2008 as a Marie Curie Initial Training Network. The project ended in September 2012, having trained a total of 29 early stage and experienced researchers in a wide range of subjects such as physics, medicine, radiobiology and information technology, within the multidisciplinary field of hadron therapy. Ten academic institutes and research centres, as well as two leading companies in the field of particle therapy, have been involved in PARTNER, which was coordinated by CERN's Life Sciences advisor Manjit Dosanjh.

Five of the PARTNER researchers were hired at CERN, co-supervised by members of the Life Sciences Section. Three of them developed a prototype Hadron-therapy Information Sharing Platform (HISP)), and two of them contributed to the feasibility studies of the LEIR biomedical facility. The fifth researcher worked on the development of Monte Carlo simulations of therapeutic ion beams for patient treatment planning and delivery. Furthermore, he contributed to the FIRST (Fragmentation of Ions Relevant for Space and Therapy) experiment, an international collaboration that aims to provide high-precision data of nuclear cross sections to the hadron therapy community to improve patient treatment. During his time with PARTNER, he co-authored ten publications in peer-reviewed journals, five as first author. Some of his recent work was covered in a news story by MedicalPhysicsWeb.org.

PARTNER researchers at the final meeting, September 2012

During 2012, three training courses were organized, comprising theoretical lectures and some practical activities. The first, held at CNAO in Pavia, addressed the topic of dose fractionation. The second was organized by TERA and CNAO, and focused on accelerators and gantries. In July, a joint course on image guidance in hadron therapy and on the impact of gantries and imaging in hadron therapy was held at CNAO; the course was also open to the newly recruited Marie Curie researchers of ENTERVISION, allowing the two generations of trainees to get together and exchange their respective experiences. In September 2012, a meeting in Pavia celebrated the end of the PARTNER project and its numerous accomplishments. Several of the young researchers have received prizes and awards for their outstanding research, and many of them have already started a bright career in various institutes and hospitals involved in hadron therapy around the world. The latest results from some of the PARTNER research projects, covering a wide range of topics from radiobiology to physics to information technology and more, will be published in open access form in a special issue of the *Journal of Radiation Research* later this year. The project is funded by the European Commission within the FP7 People (Marie Curie) Programme, under Grant Agreement No 215840.

more information: http://cern.ch/PARTNER

Other medical physics initiatives

Beyond the Life Sciences Section of the Knowledge Transfer group, other CERN researchers are involved in health-related applications. Below are some of the 2012 highlights of CERN's involvement in medical physics initiatives.

PicoSEC-MCnet

PicoSEC-MCnet (Pico-second Silicon photomultiplier-Electronics- & Crystal research) is a four-year European Marie Curie training project. Started in December 2011, PicoSEC-MCnet will ultimately host 18 early stage and 4 experienced researchers, to take part in a multidisciplinary training and R&D project geared to develop a new class of ultra-fast photon detectors in positron emission tomography (PET) and high energy physics (HEP).

The R&D activities are: scintillators, optics and photodetectors for fast timing, electronics and data acquisition, detector integration and prototyping, image reconstruction, tracking-navigation, hardware and software.This R&D will be the core activity of a time of flight PET (TOF-PET) development for clinical applications, and would open up new perspectives in medical imaging and hence in the quality of patient treatment. In addition, future accelerators and particle physics experiments count on such detectors to cope with the new demands on luminosity when pushed to new limits beyond the existing LHC.

The PicoSEC-MCnet network is coordinated by Etiennette Auffray, from CERN's Physics Department, and is composed of seven public research centres and four companies located in six European countries (France, Germany, Italy, Portugal, Switzerland and the Netherlands). In 2012, in its first project year, PicoSEC-MCnet engaged as a first and crucial objective in the recruitment of researchers. This took place in each of the network's partner institutes. Worldwide job postings and a rich portfolio of unparalleled research opportunities in top public and commercial institutions have borne fruit and brought together excellent researchers from around the globe to start their work in the various host institutions, some as early as April 2012.

In parallel the network set up its managerial structure to consolidate its coordination across all work package boundaries and to build a solid communication platform within the partners of the project. Next to the large diversity of innovative research topics, the network stimulated and continues to promote other and more global training prospects for the young researchers to benefit from. Three PicoSEC-MCnet host institutes, CERN, Fibercryst and Kloé, have already launched two so-called Network Training Events that are dedicated to specific topics in their research environment. There, 14 network researchers and up to 6 "outside" students participated in lectures, hands-on training and social gatherings arranged by their hosts. Other benchmark activities were the active participation in reputed conferences, workshops and schools, where the young researchers presented their work to international audiences. Public acceptance of the network becomes increasingly visible thanks to a rich outreach programme put in place by the PicoSEC researchers through a series of initiatives aimed at the general public.

more information:

http://picosec.web.cern.ch/picosec/

ClearPEM-Sonic

ClearPEM-Sonic is an innovative imaging system combining a mammography PET and a 3D 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 (PET¬sys, SuperSonic Imagine) and clinical partners (AP-HM Mar¬seille, Canceropole PACA, Inst. Paoli Calmettes Marseille.

The ClearPEM machine

After ClearPEM-Sonic's installation in the North Hospital in Marseille, France, in December 2010 a period of commissioning in 2011 has shown that the design performance has been reached and in particular a spatial resolution of about 1.2mm over the whole field of view, which has to be compared to 5 to 6mm for commercial whole-body PET scanners.

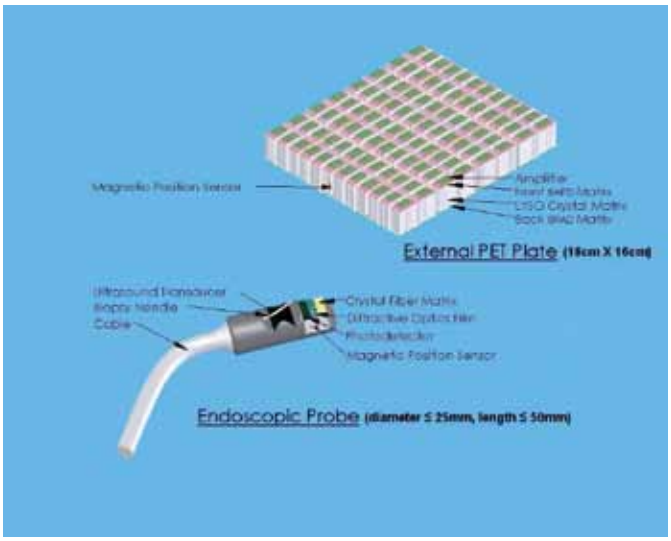
The next step was to launch the legal procedures to obtain authorizations for a Phase 1 clinical test. The proposed protocol foresees the recruitment of 20 patients, who have a proven breast cancer and were injected with 18F-Fluorodeoxyglucose for a whole-body PET/CT exam. All patients gave their informed written consent prior to being included in the study. This study was approved by the institutional review board and ethical committee of the "Assistance Publique Hôpitaux de Marseille".

PEM acquisition occurred just after whole-body PET-CT scan (Biograph16, True Point, Siemens Healthcare). A single 18FDG injection was made for both exams (4 MBq/kg, 150 s for each bed, acquisition at 60 minutes post injection for the PET/CT and about 90 minutes for the PEM). PEM acquisition lasts 15 minutes for each breast. Four angles around the breast are realized to have a correct 3D reconstruction. Visual analysis was made. A positive lesion was considered if there was an uptake superior to the breast tissue uptake around it. The gold standard was histology, obtained after biopsy or surgery. Correlation with ultrasound B-mode and elastography was made, as well as with breast MRI.The first results on the first ten patients confirm the excellent spatial resolution of the ClearPEM and a high detection sensitivity with a contrast recovery coefficient of 20% for 3 mm lesions and more than 80% for lesions of 5 mm and more. All the lesions seen on the PET/CT were detected on the ClearPEM. Moreover a small 2 mm contralateral tumour missed by the whole-body PET/CT was clearly visible on the ClearPEM. Multifocal lesions, which could not be seen as such on the whole body PET/CT because of lack of resolution, were also clearly identified and confirmed by the MRI exam.

more information: http://cerimed.web.cern.ch

EndoTOFPET-US

EndoTOFPET-US (Novel multimodal endoscopic probes for simultaneous PET/ultrasound imaging for image-guided interventions) is an approved European FP7 multidisciplinary project involving an international collaboration of six academic institutions (CERN, DESY, Delft Technical University, Lisbon LIP laboratory, University of Heidelberg, University Milano Biccoca), three university hospitals (Marseilles Timone, Lausanne CHUV, Münich Technical University hospital) and three companies (Fibercryst, KLOE, Surgiceye). This project is led by Paul Lecoq, from CERN Physics Department.



The Endo TOFPET-US endoscopic probe

The main clinical objective is the development of new biomarkers for prostate and pancreatic cancer, and, more generally, image-guided diagnosis and minimally invasive surgery.

In this project, it is proposed to design and build one prototype of a bi-modal PET-US (Positron Emission Tomography and Ultrasound) endoscopic probe combining in a miniaturized system a fully digital, 200 ps time resolution time of flight PET detector head (TOF-PET) coupled to a commercial ultrasound-assisted biopsy endoscope and to launch a pilot clinical study focusing on pancreatic cancer, after a first step of preclinical feasibility tests on pigs. As an example of novel development of biomarkers, promising antibodies already developed for pancreatic cancer will be pushed towards clinical application.

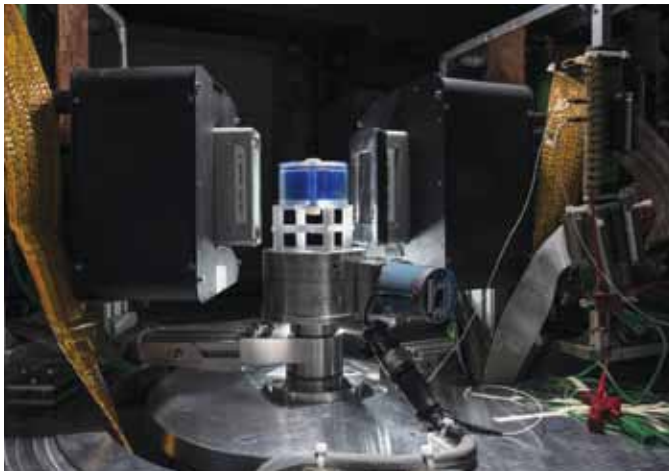
In order to achieve this very ambitious goal, this project implements a number of novel technologies, including a new generation of fully digital SiPM photodetectors, with single optical photon counting capability; a very compact diffractive optics coupling system between the crystal and the photodetector, to compensate for the reduced fill-factor of the latter; a low noise time over threshold frontend electronics, based on the NINO chip developed at CERN for the LHC ALICE experiment; and an elaborate tracking system to reconstruct in real time the six coordinates of the internal endoscopic probe and the external plate of the PET detection system.

First performance results of these different components include an impressive coincidence time resolution of 155 to 210 ps full width at half maximum (FWHM) obtained with crystals of realistic dimensions for the PET (for a length ranging between 5 mm and 20 mm respectively) using the NINO electronics and a commercial, not yet digital, SIPM photodetector.

more information: http://endotofpet-us.web.cern.ch

AX-PET

PET (Positron Emission Tomography) is a medical imaging tool that has been successfully used since the early days of nuclear medicine. The recent years have seen a significant progress in PET instrumentation, which takes advantage of migration of technologies originally developed for high energy physics. The AX-PET project is an excellent example, demonstrating how geometries and techniques inspired by calorimetry could be applied in PET detectors. AX-PET, an international collaborative effort, started at CERN in 2007, with the goal of constructing a demonstrator for a PET scanner based on a rather unconventional geometry. It is based on long axially oriented scintillator crystals read out by so-called SiPM photodetectors.



Tests of the AX-PET machine

At CERN, the project is led by Christian Joram (Physics Department). The project is now close to completion, with two AX-PET modules manufactured, fully characterized and successfully applied to PET imaging.

Measurement campaigns with various phantoms filled with radio-tracers demonstrated the as-designed resolution and sensitivity of AX-PET. A campaign on small animals, done in 2012 at the Small Animal PET Lab of the ETH Zurich, showed animal images of impressive quality. In parallel, continuous improvement of the reconstruction software on one side has been pursued, while evaluating – on the detector side – a new, cutting edge technology: novel digital SiPM photodetectors were shown to complement the AX-PET concept with superior timing performance.

Ultimate diagnostic performance would be reached when the high quality functional information of PET could be entirely combined with the morphological and functional information of MRI (magnetic resonance imaging). From the hardware point of view, this poses great challenges, requiring the PET detectors to work inside a high magnetic field and intense radiofrequency, without interfering with it. The knowledge acquired both in the AX-PET project and in the evaluation of the new digital photodetectors, are now converging towards the design of a fully MRI-compatible PET scanner.

CNAO

2012 marked a very important milestone for CNAO: on 13 November the first patient was treated with carbon ions at the CNAO hadron therapy facility in Pavia. The CNAO accelerator complex is based on the Proton Ion Medical Machine Study (PIMMS), a design study that took place at CERN from 1995 to 2000 and involved researchers from CERN, TERA Foundation and Med-Austron.

CNAO started treating patients with proton beams in September 2011, and so far almost 50 patients have been treated with protons in the framework of different clinical trials. The patient treated in November 2012, who was affected by a salivary gland carcinoma, is the centre's first clinical trial with carbon ions. These ions are heavy relative to protons and can destroy tumour cells that protons would leave intact. CNAO is the second centre in Europe to provide such ion beams for cancer therapy, after the Heidelberg Ion-Beam Therapy Centre (HIT) began clinical trials in 2009.

The treatment of patients with carbon ions was approved in July 2012 by the Italian Health Ministry after a detailed review of the data presented by CNAO on dosimetry and radiobiology, both in-vitro and in-vivo. These experimental activities were performed in the first part of 2012 thanks to the collaboration of the Italian Institute of Nuclear Physics (INFN) and the Japanese National Institute of Radiological Sciences (NIRS). The data presented at the Health Council of the Health Ministry confirmed the expected beam parameters specifications and also demonstrated the high standards of safety and quality reached at CNAO. The first months of 2012 were also important to adopt a quality management of the CNAO procedures and on 27 July, the certifications ISO9001 and ISO13485 were obtained. This is a fundamental step in view of the CE marking of CNAO. In fact, the CE marking of the different clinical protocols is mandatory to start the routine hadron-therapy treatments. In June 2012, a collaboration agreement between CNAO and EBG Med-Austron was signed. CNAO has been asked to produce five copies of the dose delivery system (DDS) to equip the beam lines of the Austrian facility under construction close to Vienna. The DDS is the key system used to master the dose painting of the tumour volume. It consists of a redundant set of monitoring devices that measure online the intensity, the position and the profile of the hadron beams in order to precisely hit the tumour cells inside the body of the patient. The measuring devices are used to steer the magnetic fields of two scanning magnets placed upstream from the treatment room and used to deflect the beam in the position required by the treatment planning.

In 2011, CERN and CNAO renewed their collaboration agreement in the fields of common interest, such as research and development in biomedical physics, training and networking in the technical and biomedical areas, developments and upgrades in accelerator technologies (e.g. beam diagnostics, RF systems and special magnets).

The treatment room at CNAO

CNAO's main objective for 2013 will be the increase of the patient throughput and the approval of most of the on-going clinical trials. At the beginning of the year the third treatment room will become operational and it will add one horizontal and one vertical beam line to the already active treatment rooms (two rooms with one horizontal beam each). Of the more than 120 000 Italian patients treated each year with radiotherapy, it is estimated that about five per cent of cases can be cured with hadron beams. Hadron therapy can be used in the treatment of sarcomas, paediatric tumours, cancer of the lung, pancreas, liver, prostate, eye, salivary gland, brain, spinal cord and on certain head of pelvic area cancers.

At full capacity the centre will provide hadron therapy treatments five days a week for 13 hours a day to about 2000 out-patients a year, with about 20 000 sessions being performed annually in the three treatment rooms with four beam lines. An experimental room dedicated to radiobiological and clinical research will also be available.

more information: www.cnao.it

MedAustron

MedAustron injector test stand at CERN in building 184

The partnership contract between the EBG MedAustron company and CERN concerns the development and production of a synchrotron-based accelerator complex for light ion therapy, to be installed in Wiener Neustadt, Austria. The accelerator project has advanced according to the established project plan.

One of the main goals for 2012 was the operation of a test stand at CERN, with the aim to qualify the injector's beam. This included an electron cyclotron resonance (ECR) ion source, part of the low-energy beam transfer (LEBT) with beam diagnostics and a newly developed radio-frequency quadrupole, as pre-accelerator. Test stand operation took place in the ISR hall 184 and finished successfully in December 2012, reaching nominal beam performance at RFQ exit. All test stand elements are now being shipped to Austria for installation in Wiener Neustadt.

The accelerator operation concepts, including injector radio-frequency, power converters, timing system and vacuum generation, have been successfully validated by setting up a vertical slice of the control system at CERN. Concerning hardware, most of the elements for the synchrotron and high energy beam transfer line are in production. Construction of the synchrotron radio-frequency system is advancing well, leveraging the synergies between MedAustron and the ongoing CERN PS-Booster developments.

The MedAustron building in Wiener Neustadt was completed in autumn 2012 and installation of the accelerator started with the injector elements in November. Two ECR sources, the LEBT and the IH-mode injector linac are already in place. Accelerator and person protection systems have been installed on site and successfully integrated with the local facility management systems and the delivered accelerator elements.

With the nearly finished accelerator development and the completion of the knowledge transfer from CERN to MedAustron, the focus of activities will shift to the operation site in Wiener Neustadt within 2013.

In 2012 MedAustron has so far given contracts to three young researchers finishing their training in the framework of PARTNER thanks to the outstanding training and networking possibilities offered by the EU funded project coordinated by CERN.

more information: www.medaustron.at

In 2012 the ENLIGHT community launched *HIGHLIGHTS*, a publication for the exchange of knowledge between experts in the field of hadron therapy

Education and training

Sharing the essence of science in action, with its timescales and its technical challenges, is one of the drives of education and outreach initiatives at CERN. CERN represents an immense source of new scientific and technical information for students and educators. This wealth of information is made available through a variety of initiatives that transfer CERN technical knowledge to students, educators and young researchers in the Member States and beyond. This chapter showcases some of the range of educational and training programmes carried out at CERN.

Schools of excellence

CAS – CERN Accelerator School

The CERN Accelerator School was established in 1983 with the main purpose of preserving and transmitting the knowledge accumulated at CERN and elsewhere on particle accelerators of all kinds. This provided a framework for a series of courses, either on general accelerator physics or on a specialized topic in the field – a format that has continued to this day. Courses are held in one of the CERN Member States, and are of between one and two weeks in duration, depending on the nature of the course. Students from all over the world are welcome to apply. In 2012, two schools were held: in spring a specialized school on ion sources was held in Senec, Slovakia, and later in the year an introductory school on accelerator physics was held in Granada, Spain. The specialized school attracted 70 participants of 25 nationalities from universities or companies in 19 countries. The introductory school proved to be extremely popular, with more than 200 applications leading to 140 participants being selected. These were of 25 nationalities and came from universities or companies in 18 countries, and about half were under 30 years of age.

director: Roger Bailey, Accelerators and Technology Sector

more information: http://cas.web.cern.ch

CSC – CERN School of Computing

Organized since the early 1970s, the CERN School of Computing (CSC) aims to create a common technical culture in scientific computing among scientists and engineers involved in particle physics or in sister disciplines.

In 2012, the 35th CERN School of Computing took place in Uppsala, Sweden, co-organized by Uppsala University. It was attended by 59 students of 23 different nationalities. The two-week programme consisted of 50 hours of lectures and

hands-on exercises. The themes tackled a range of domains in scientific computing, including data management, security, networking, advanced processors, virtualisation and data analysis.

The CSC is not a conference but a genuine summer university, a place to deliver academic knowledge. In order to maximize coherence and consistency, only a few lecturers participate, and all of the outside lecturers are university professors. Like any university, CSC delivers a diploma. In 2012, 55 students successfully passed the final examination and received the CSC diploma. In addition, since 2008 the quality of the CSC programme and lecturers, and the rigour of the examination process are audited by the hosting university. In 2012, for the fifth consecutive year, the audit was passed successfully and Uppsala University delivered 5 European Credits Transfer System (ECTS) credits to the students who obtained the CSC diploma.

director: Francois Fluckiger, IT Department

more information: http://csc.web.cern.ch

ESHEP – European School of High-Energy Physics

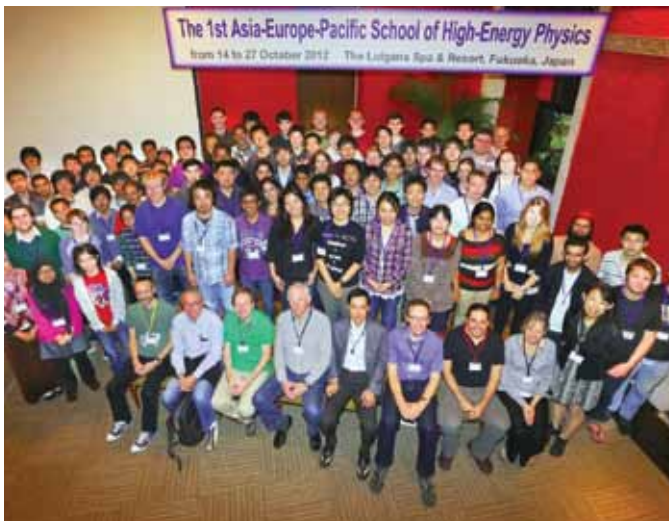
The ESHEP2012 was held from 6 to 19 June in Anjou, France. The school was organized by CERN and the Joint Institute for Nuclear Research (JINR) in Russia, together with the Commissariat à l'énergie atomique et aux énergies alternatives (CEA) and the Institut national de physique nucléaire et de physique des particules (IN2P3) in France. A total of 98 students of 32 different nationalities attended the school, mainly from CERN Member States and/or JINR, with a few from other regions. The participants were generally students in experimental high-energy physics in the final years of work towards their PhDs and typically about 25 years of age. The school was heavily over-subscribed and a competitive selection was made for the 100 available places from more than 170 applications. The programme included numerous topics in particle physics both within and beyond the Standard Model. A total of 33 lectures were complemented by daily discussion sessions led by six discussion leaders. The students displayed their own research work in the form of posters in a special evening session in the first week, and the posters stayed on display until the end of the school. Students in each discussion group also carried out a collaborative project, in which they made an in-depth study of a published analysis from an LHC experiment; a summary from each group was presented in a dedicated evening session in the second week of the school.

director: Nick Ellis, Physics Department

more information: http://cern.ch/PhysicSchool/ESHEP

AEPSHEP – Asia-Europe-Pacific School of High-Energy Physics

The first Asia-Europe-Pacific School of High-Energy Physics was held from 14 to 27 October 2012 in Fukuoka, Japan. CERN played a major role in the organization, together with the High Energy Accelerator Research Organization (KEK), Kyushu University and Saga University in Japan.



A total of 83 students from institutes in 21 different countries attended the school, about 70% from Asia-Pacific countries and most of the rest from Europe. The majority of the participants were students in experimental high-energy physics typically about 25 years of age and working towards their PhDs. The school was heavily over-subscribed with almost 200 applications for the available places. The programme included numerous topics in particle physics both within and beyond the Standard Model. A total of 34 lectures were complemented by daily discussion sessions led by six discussion leaders. The students displayed their own research work as posters in a dedicated evening session in the first week, and the posters were displayed until the end of the school. The students in each discussion group also carried out a collaborative project to make an in-depth study of a published analysis from an experiment; each group then presented a summary in a special evening session in the school's second week.

director: Martijn Mulders, Physics Department

more information: http://2012.aepshep.org

JUAS – Joint Universities Accelerator School

Now one of the major schools in the European Scientific Institute (ESI), the JUAS school was established in 1994 20 km away from CERN in Archamps, France. The school is well recognized and provides 10-week courses on particle accelerators. Four weeks, followed by an exam week, are dedicated to the science and physics of particle accelerators (course 1). Another four weeks, followed by an exam week, are dedicated to the technology and applications of particle accelerators (course 2). The school's website is regularly updated with all the practical information regarding the courses and the organization of the school.

The success of JUAS corresponds to a real need: in 2012, 37 participants followed course 1 and 40 participants followed course 2 representing 22 different nationalities. For course 1, there were 20 Masters students, 4 PhDs and 13 professionals, and for course 2, there were 21 Masters students, 8 PhDs and 11 professionals.

In addition to full-time courses, the JUAS students have the opportunity to visit three major laboratories: CERN, the European Synchrotron Radiation Facility (ESRF) in Grenoble, France, and the Paul Scherrer Institute (PSI) in Villigen, Switzerland, plus the Geneva hospital. One day of practical work is carried out in several CERN departments, with the possibility for the students to choose a topic from within the themes of magnets, radio-frequency, vacuum and superconductivity. An additional day at Bergoz Instrumentation company allows the students hands-on experience of constructing beam diagnostic devices.

The recognition of the final exam (by European universities associated with JUAS), allows students to get up to 20 ECTS from their universities. In 2012, Paris-Sud Orsay University joined JUAS as the 14th partner university. JUAS 2013 will take place from 7 January to 15 March.

director: Louis Rinolfi, Beams Department

more information: http://espace.cern.ch/juas

ISOTDAQ – International School of Trigger and Data Acquisition

The third International School of Trigger and Data Acquisition took place from 1 to 8 February 2012 in Cracow, Poland. The school was organized by CERN, Cracow University of Technology and the Institute of Nuclear Physics. Additional support was provided by the EU-funded Marie Curie ACEOLE (Data Acquisition, Electronics, and Optoelectronics for LHC Experiments) fellowship programme with four of its fellows acting as tutors. Participants included 48 Masters students and PhD students from 18 nations. Many of them had already been involved in trigger and data acquisition (TDAQ) projects or

were about to do so and saw the school as an ideal opportunity to extend their knowledge in this field.

As with previous years, the time was divided equally between theoretical lectures and practical exercises. The lectures were given by leading TDAQ experts from CERN, collaborating institutes and industry. The exercises allowed the students to work directly on TDAQ systems in small groups of four under the supervision of experienced tutors. The 2013 edition of the school will be held on 1–8 February 2013 at the Aristotle University of Thessaloniki, Greece.

co-organizer: Markus Joos, Physics Department

more information: http://isotdaq.web.cern.ch

High-school teachers programme and CERN-UNESCO schools

The CERN Teachers programme, coordinated by the Education and Outreach Group led by Rolf Landua, Physics Department, organized 36 schools attended by 1045 teachers from 35 countries. In particular:

- 40 teachers from 23 countries attended the in-depth three-week international High School Teacher Programme (with lectures on particle physics, cosmology, accelerator and detector physics, as well as insights into the applications of CERN technologies beyond high energy physics.)
- 1005 teachers attended the 3-5 day national programmes dedicated to CERN's Member States, with lectures, visits and all teaching materials and recorded lectures in the teachers' native languages.

The teachers came from Austria, Belgium, Brazil, Bulgaria, Burundi, Cameroon, Canada, Czech Republic, Ecuador, Estonia, France, Georgia, Germany, Ghana, Greece, Hungary, Israel, Italy, Japan, Madagascar, Netherlands, Poland, Portugal, Romania, Russia, Serbia, South Korea, Spain, Sweden, Switzerland, Thailand, Uganda, Ukraine, the United Kingdom and the United States.

CERN's knowledge sharing initiatives go beyond the laboratory, reaching countries where education is needed most. Since 2009, CERN and UNESCO (the United Nations Education, Science and Culture Organization) have had joint efforts to reach countries in Africa, providing physics-teacher training schools and digital libraries schools. To date, CERN-UNESCO schools have trained hundreds of teachers and students in Rwanda, Morocco, Senegal and Ghana, connecting CERN's science and technology experts with education ministries and local stake-holders.

Participants in the High-school teachers programme 2012

The digital libraries schools offer librarians and IT engineers at universities and research institutes in Africa the opportunity to get acquainted with the technology and the management principles required to operate digital libraries. The participants are trained in the use of CERN's up-to-date information technologies, metadata formats, the philosophy linked to open access publishing and technical aspects related to copyright – with the overall aim to promote the sharing of information and making valuable African research visible within the respective countries and to scientists around the world.

The digital libraries schools are promoted and organized by the Scientific Information Service Group, led by Jens Vigen, General Infrastructure Services Department, in collaboration with colleagues from the Collaboration and Information Services Group in the IT Department. Since 2009, colleagues from more than 15 African countries have successfully attended the digital libraries schools held in Rwanda, Morocco and Senegal. After each school, "champions" are selected to attend further training at CERN, enabling them to extend their knowledge and become a reference person for colleagues in their home countries.

The latest Digital Library School took place in Dakar, Senegal in November 2011 with 38 participants from eight West-African countries. This event was followed up with an in-depth training for six of the participants at CERN in June 2012.

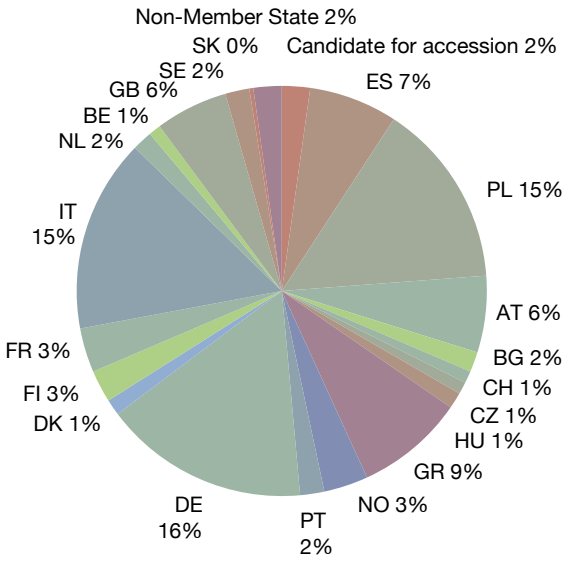
more information:

http://education.web.cern.ch/education/

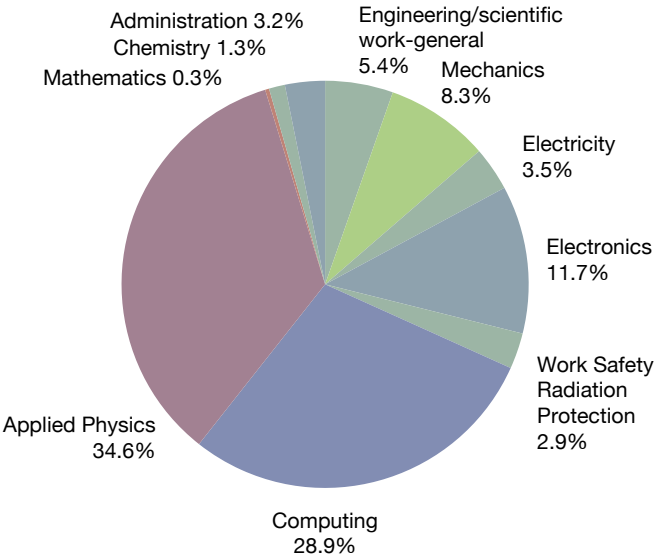
Training and Career Development

CERN provides a variety of on-the-job training, complemented by technical, language, management and communication training through the Learning and Development Group of the Human Resources Department. As well as this, a powerful vehicle for knowledge transfer to Member States is the training and work experience given through CERN's well-established students, fellows and associates programmes. In particular, the fellows programme has two strands in addition to the regular CERN programme that help foster this transfer: the Marie Curie (MC) actions and the Graduate Engineering Training scheme (GET).

Students by nationality



Students by discipline



Marie Curie actions at CERN in 2012

The seventh Framework Programme (FP7) that started in 2007 will finish in 2013. In the penultimate round of applications, CERN was successful with two Initial Training Network (ITN) proposals and the fourth COFUND grant for the Fellowship Programme. Further proposals were submitted in the final

round of applications at the end of 2012 (results are due early in 2013). Beyond FP7, CERN will apply for EC funding via Horizon 2020 from 2014 onwards.

A survey of researchers recruited on FP6 and FP7 MC projects at CERN showed encouraging results regarding career impact, with the MC fellowship considered to be an asset when looking for a position at the end of a contract. This benefit to subsequent positions shows the lasting value to researchers of the actions and the importance of measuring the programme's impact.

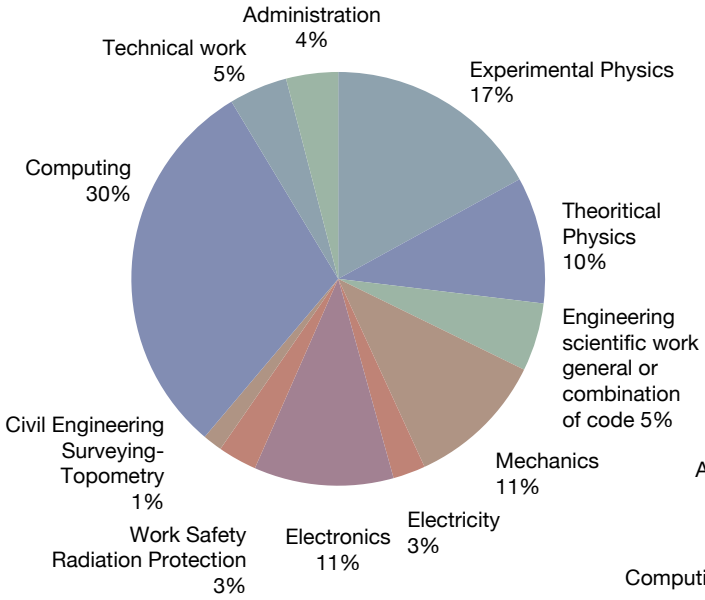
COFUND

Co-funding of Regional, National, and International Programmes (COFUND) grants have been a significant budget supplement to the CERN fellowship programme since 2009. An attractive feature for the COFUND fellows is the option of spending up to 12 months outside CERN as a career development measure. With moves in recent years towards enlarging CERN's membership, the aim is to use future COFUND grants to attract applicants from the Associate Member countries so that they may use the 12-month feature to return home with the knowledge and experience acquired at CERN. This will help new countries in their integration process at CERN following full membership.

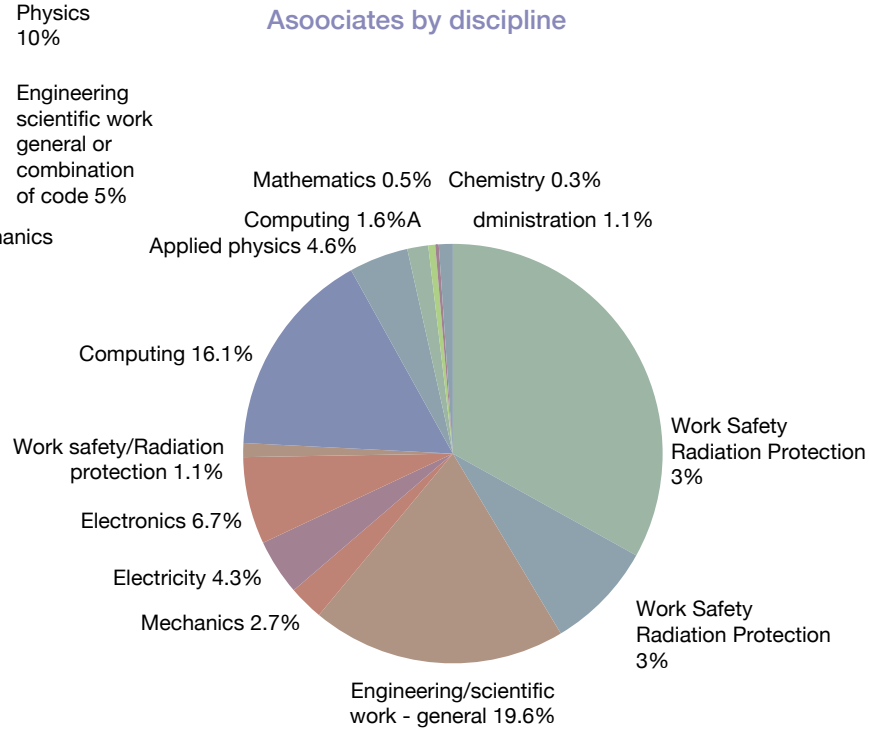
GET

With strong support from the CERN Management and the Member States, the Graduate Engineering Training (GET) scheme was implemented in 2010 to establish CERN as a top-class engineer employer. To date, there has been a significant increase in engineering applications, with GET firmly established as an essential source of additional engineers, without detracting from the strong particle physics component of the programme.

more information: cern.ch/jobs



Fellows by discipline



Asoociates by discipline

CERN
Knowledge Transfer Group
Communication Group

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