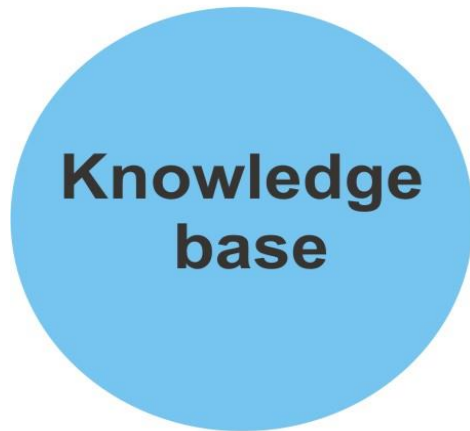


HEP technologies and transfer to industry

SCIENCE



knowledge transfer

PRACTICE



Vague but exciting ...

CERN DD/OC
Information Management: A Proposal
March 1989

Tim Berners-Lee, CERN/DD

Information Management: A Proposal

Abstract

This proposal concerns the management of general information about accelerators and experiments at CERN. It discusses the problems of loss of information about complex evolving systems and derives a solution based on a distributed hypertext system.

Keywords: Hypertext, Computer conferencing, Document retrieval, Information management, Project control

```
graph TD
    ThisDocument[This document] -- describes --> AProposal[A Proposal X]
    ThisDocument -- describes --> Hypermedia[Hypermedia]
    ThisDocument -- describes --> HyperText["HyperText"]
    ThisDocument -- includes --> CERNDoc[CERNDoc]
    ThisDocument -- refers to --> Comms[Comms]
    ThisDocument -- refers to --> ACM[ACM]
    ThisDocument -- wrote --> BernersLee[Tim Berners-Lee]
    
    AProposal -- describes --> ComputerConferencing[Computer conferencing]
    AProposal -- describes --> VAX[VAX/NOTES]
    AProposal -- describes --> CERNDoc
    AProposal -- describes --> CERNE[C.E.R.N.]
    
    ComputerConferencing -- includes --> HyperCard[Hyper Card]
    ComputerConferencing -- includes --> ENQUIRE[ENQUIRE]
    ComputerConferencing -- includes --> IBMTalk[IBM GroupTalk]
    
    VAX -- unifies --> uucp[uucp News]
    VAX -- unifies --> Hierarchical[Hierarchical systems]
    
    CERNDoc -- includes --> CERNE
    CERNDoc -- includes --> DD[DD division]
    CERNDoc -- includes --> MIS[MIS]
    CERNDoc -- includes --> OC[OC group]
    CERNDoc -- includes --> RA[RA section]
    
    HyperText -- includes --> HyperCard
    HyperText -- includes --> ENQUIRE
    
    CERNE -- includes --> MIS
    CERNE -- includes --> OC
    CERNE -- includes --> RA
    
    BernersLee -- wrote --> Comms
    BernersLee -- wrote --> ACM
```



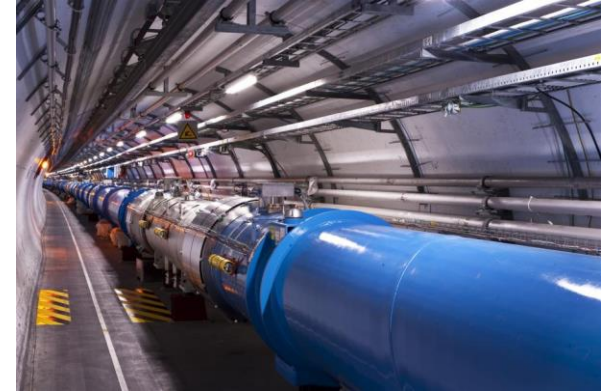
Tim Berners Lee with his NeXT computer that he used to invent the World Wide Web

The first web page address was

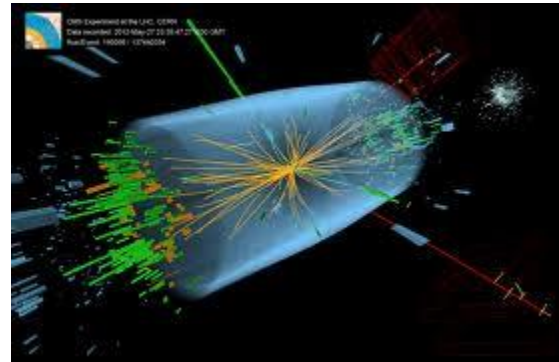
<http://info.cern.ch/hypertext/WWW/TheProject.html>



Accelerating particle beams



Detecting particles



Large scale computing (Grid)





LARGE HADRON COLLIDETR

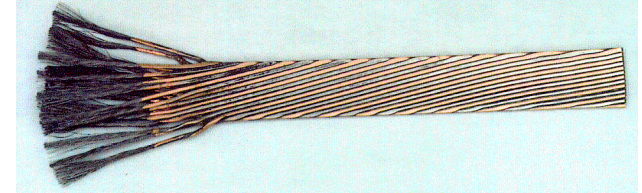
1232 Main Dipoles + 448 Main Quadrupoles
cooled by 120 Tons of Liquid Helium



To reach the required energy in the existing 27 km tunnel, the super conducting magnets operate at **83 Kilogauss** (200'000 x Earth's field) in super fluid helium.

Protons travel in a tube with **better vacuum & colder than interplanetary space** at $T = 4-20^{\circ} \text{K}$

Super conducting Niobium-Titanium cable.
Typical $2000 \text{ A/mm}^2 @ 4.2 \text{ K} @ 6\text{T}$

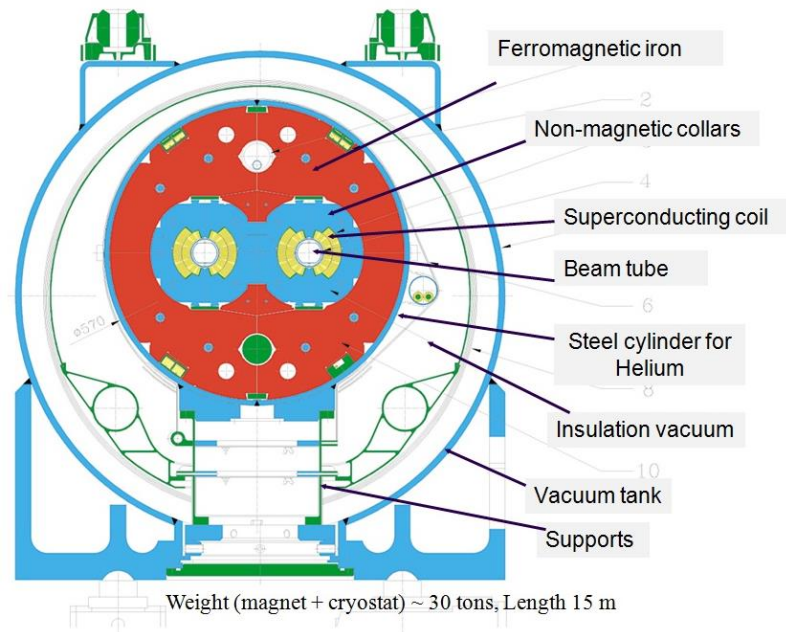


Vacuum
(10^{-13} atm)

Cryogenics
(1.9 K)

Superconductivity
(12kA)

Magnets
(8 T)



ANSALDO

Groups of scientists originated the basic R&D, which then continued in collaboration with large enterprise where also the production took place.

Those enterprises have now a high technological background for additional application



ASG Superconductors

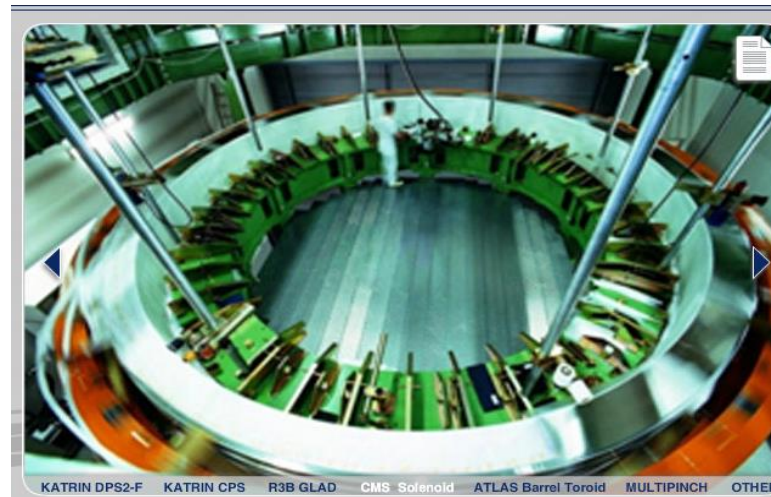
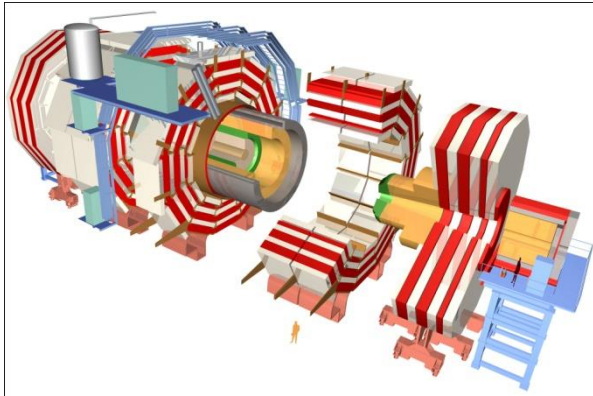
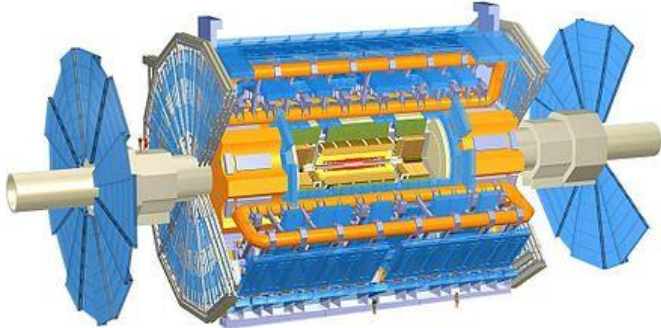
- ▶ Home
- ▶ Company
- ▶ Products
 - Accelerator Magnets
 - Magnets for thermonuclear fusion
 - Magnets for research applications
 - Magnets for medical applications
 - Other Products
- ▶ Contact
- ▶ Focus
- ▶ Press
- ▶ Link

Products

- Accelerator Magnets
- Magnets for thermonuclear fusion
- Magnets for research applications
- Magnets for medical applications
- Other products

ASG Superconductors S.p.A. Sede Operativa : 16152 Genova - Italy C.so F. M. Perrone, 73r Ph. +39 010 6489111 - Fax +39 010 6489277 info@as-g.it
Cap. soo. 4.794.000,00 Iv. C.F. e Reg. Imp. di Genova n° 01282370095 REA della C.C.I.A.A Genova 392616 Partita IVA IT 01234890992

The CMS solenoid and the ATLAS toroid have been designed by physicist but the prototyping and the construction was completed at external enterprises



There are many medical application of accelerators

Basic type of accelerators

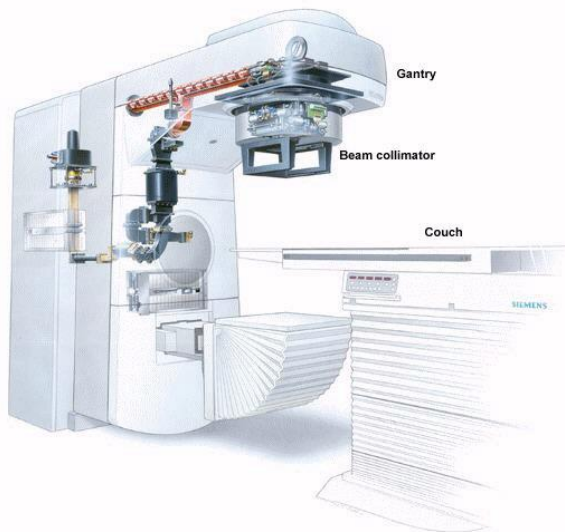
- Linear
- Cyclotron
- Betatron
- Synchrotron

Common medical application

- Radiation therapy (photon/electron)
- Isotope production (Cyclotron)
- Equipment sterilization
- Hadron therapy

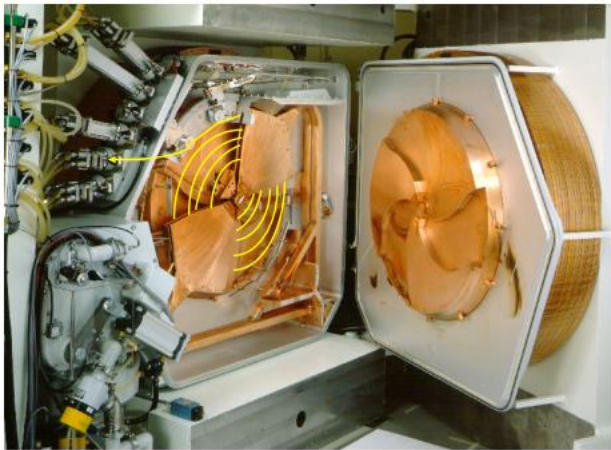
Future Application

- Angiography
- Boron neutron Capture Therapy



Accelerating particles for medical treatments

The synchrotron at CNAO for hadron therapy accelerates protons up to 250 MeV and carbon ions up to 4800 MeV



Cyclotrons for production of radio pharmaceuticals substances are now quite common



From high vacuum ...

NEG (Non-Evaporable Getter thin film coatings) technology used to create and maintain ultra-high vacuum in the accelerator vacuum chambers.



to solar energy

License and partnership with a start-up company for the development of a commercial product able to use diffused or indirect light and reach very high temperatures of up to 300 degrees



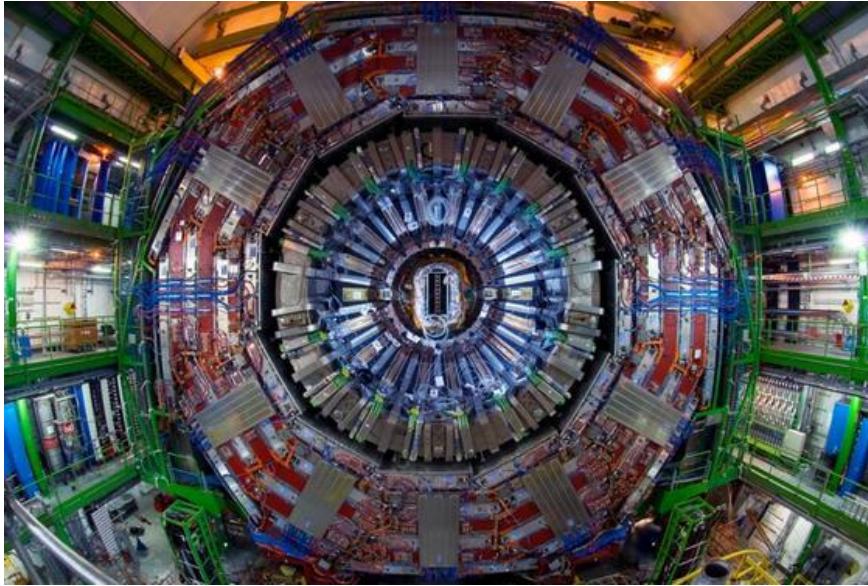
Civil-engineering company opened a new solar power plant

Environmentally friendly "solar field" heats close to 80,000 cubic meters of bitumen to 180 degrees.



Installation at GVA airport

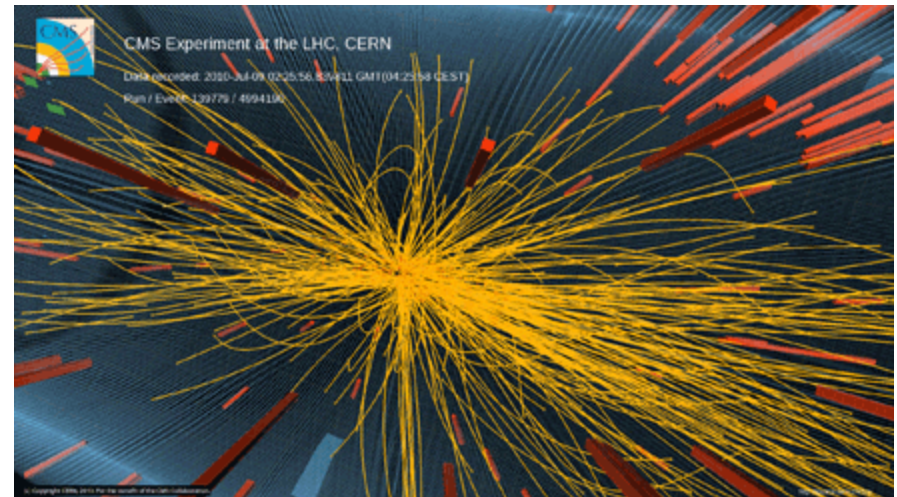


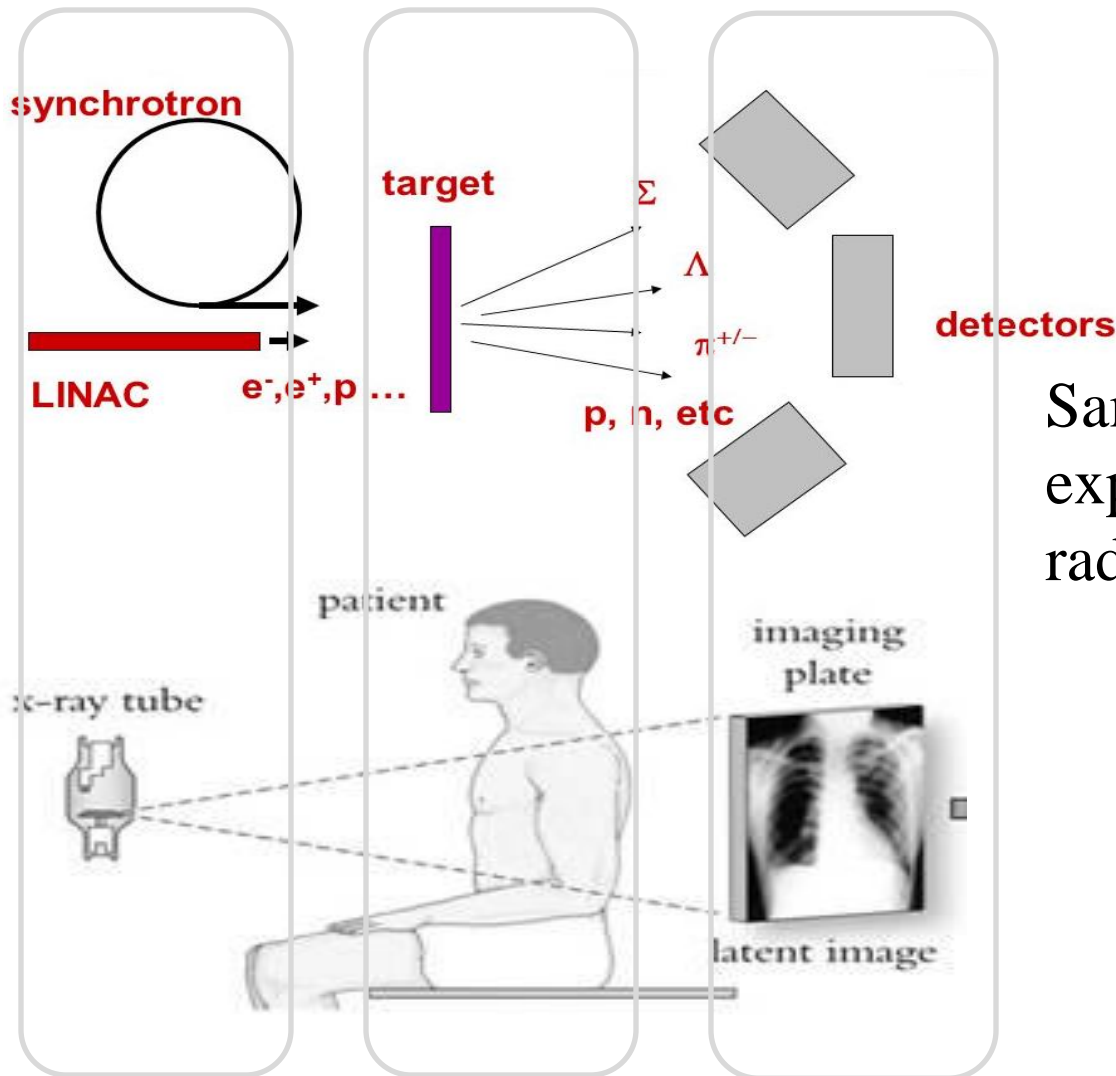


Detect 600 million proton-proton collisions per second

Sophisticated detectors to precisely measure the passage of a particle with time accuracies of 10^{-9} second and space accuracy of 10^{-5} meter.

- Crystal
- Gaseous detectors
- Silicon detectors

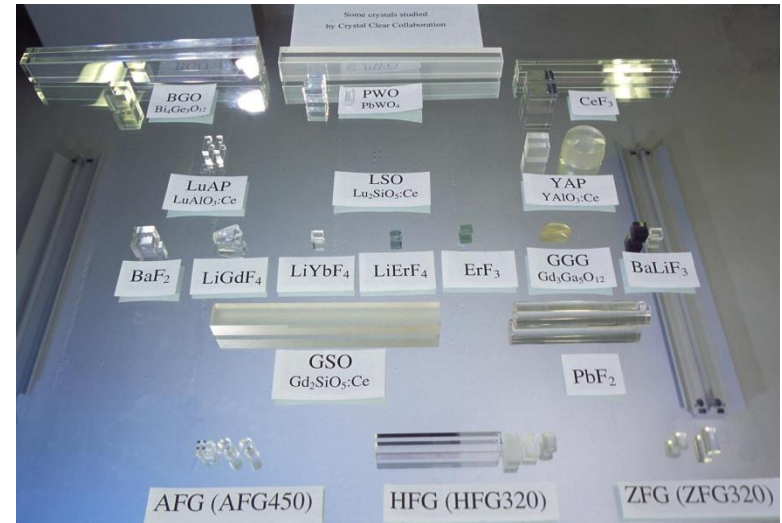
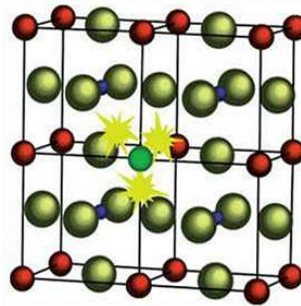




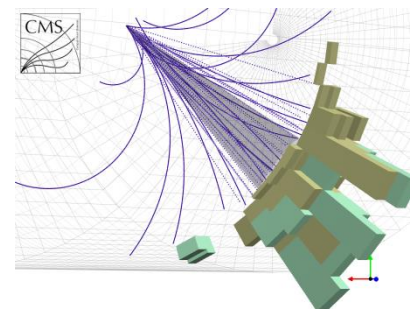
Same concept for an HEP experiment and a radiological investigation

Crystal detectors

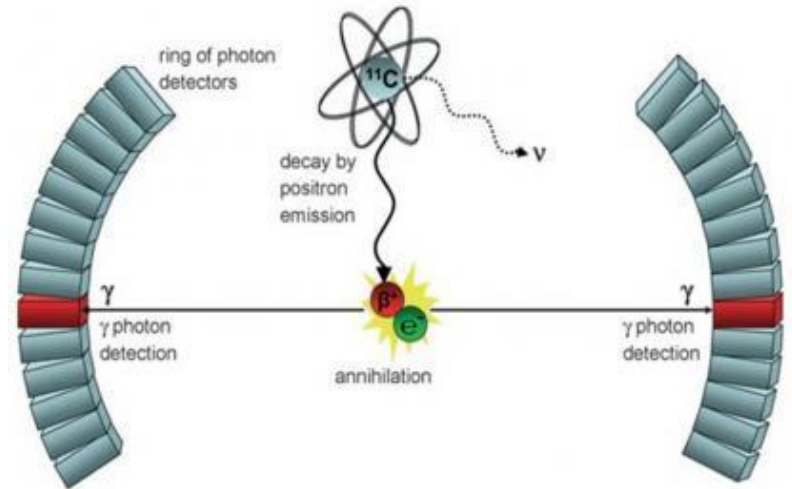
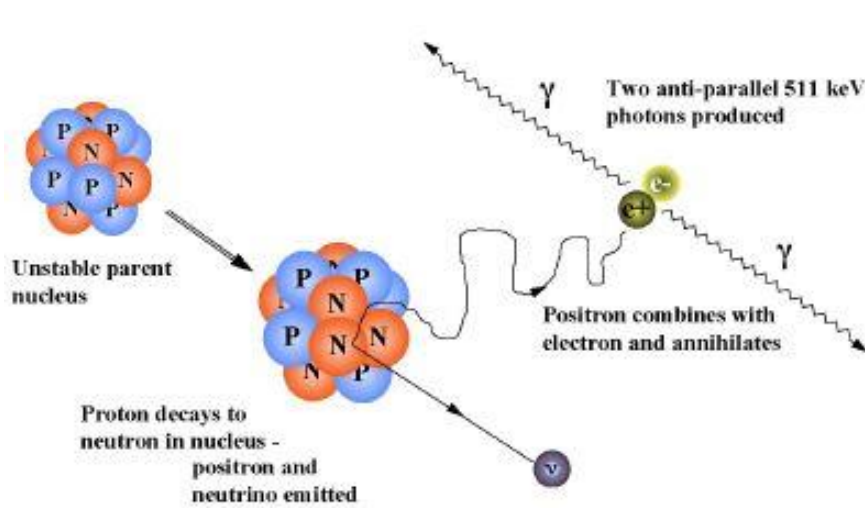
Scintillators are applied in high-energy physics to measure the energy of particles that are produced in particle physics experiments. Their use is motivated by the very good detection efficiency of these materials for hard radiation



The CMS electromagnetic calorimeter uses lead tungstate (PbWO_4) for the almost 80,000 crystals: a material with high density that produces scintillation light in fast, small, well-defined photon showers.

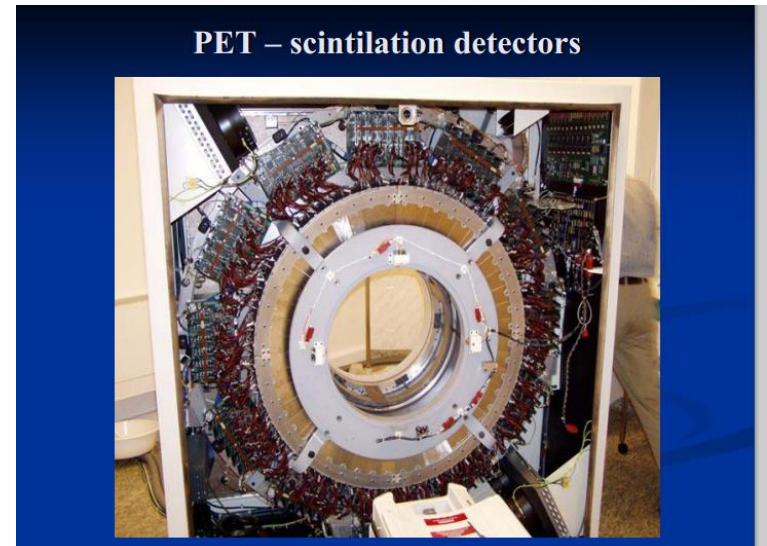


The PET concept



A PET detector is as complex as an HEP detector

Inorganic scintillators are widely used in PET imaging and medical imaging in general.





Polycrystalline Diamond

Developed for Beam Condition Monitoring

Radiation Hardness

High sensitivity

Good spatial and temporal resolution

Low (and stable) noise

Can fabricate robust, compact devices

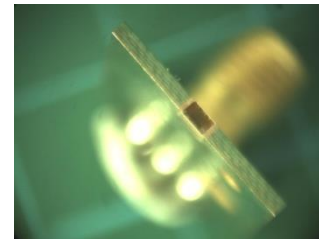
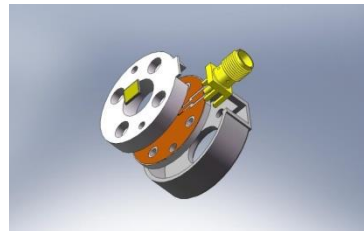
High temperature operation

Single particle counting
ATLAS @ CERN

Particle flux measurement
Babar @ Stanford
Belle @ KEK
CDF @ Fermilab

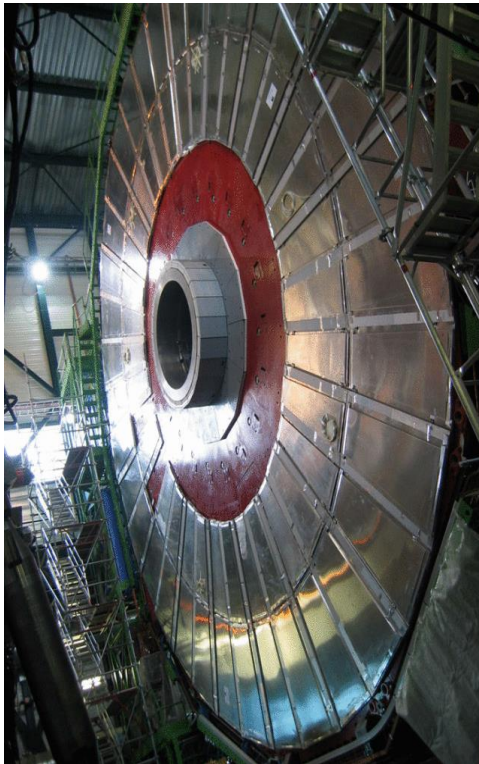
A wide range of detector applications

- Dosimetry: radiation therapy, equipment calibration, active exposure monitoring
- Nuclear applications: homeland security, nuclear reactors and fusion experiments
- Synchrotrons: white beam monitoring
- UV detectors: photolithography, flame detection and solar physics
- Alpha/Beta: air-Flow and survey meters, waste incineration



Gaseous detectors

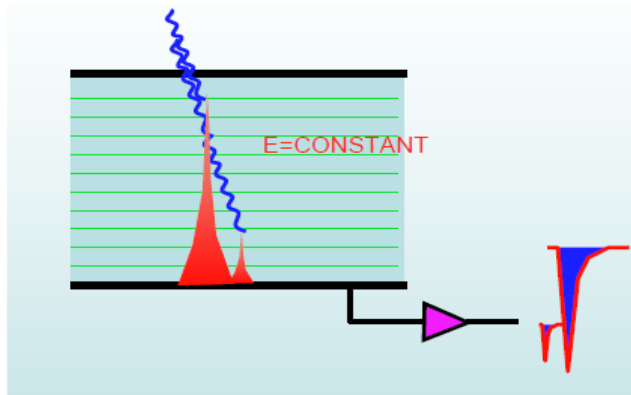
Various type of detectors, GEMs, RPCs, MRPCs, MICROMEGA, traditional WIRE CHAMBERS and DRIFT TUBES



Large areas, extreme time resolution, extreme spatial resolutions, high rate capability



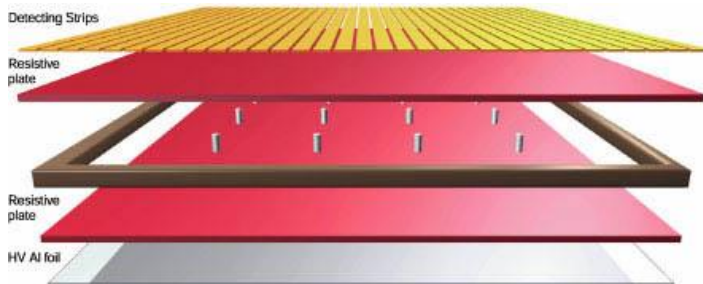
Gaseous detectors



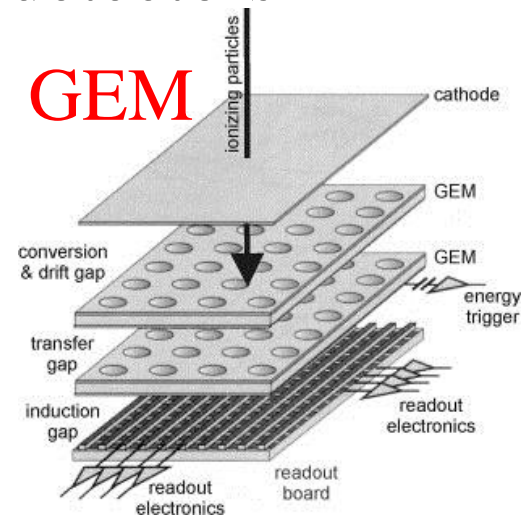
Use ionization in gas. Then collect the electrons on an appropriate electrode and produces a signal. To drive the electrons towards the electrode, an electric field is needed

Mostly used as muon detectors

RPC

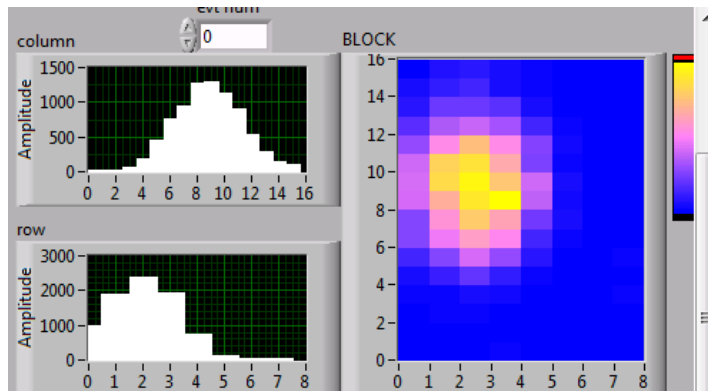
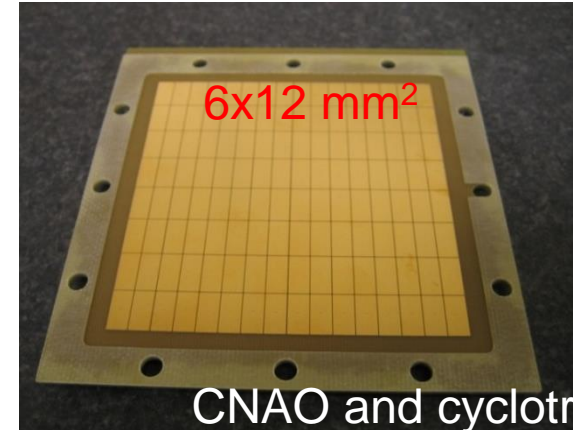
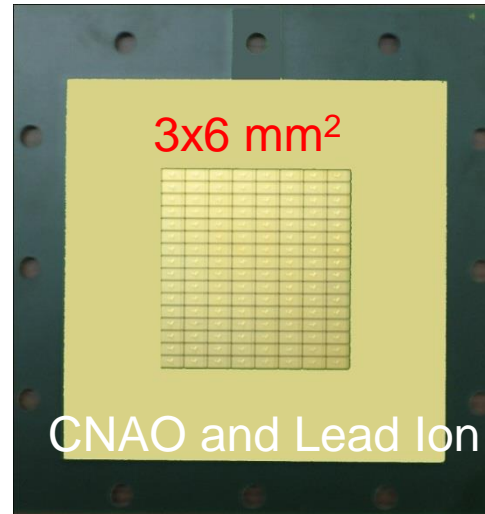
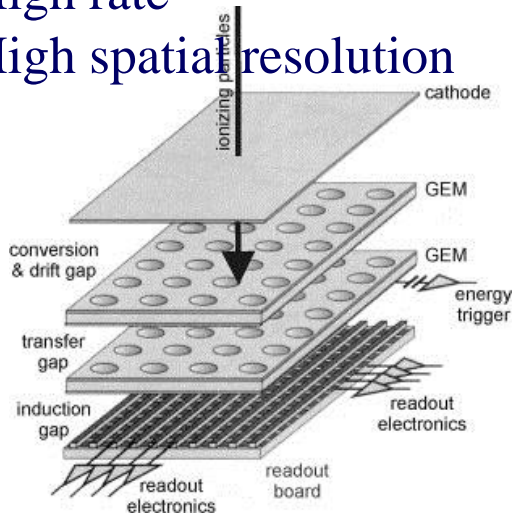


GEM



GEM

High rate
High spatial resolution



Monitor for a fast neutron beam with energies ranging from a few meV to 800 MeV. Tested at neutron beam of the Vesuvio facility at RAL-ISIS.

Courtesy of F. Murtas, INFN LNF

GEM



Non HEP Research activity



Fast and Thermal Neutron
Non destructive diagnostic
Biology
Nuclear Energy Plant
Tokamak Diagnostics
Chip Irradiation

Xray Low energy
Tokamak diagnostics
Radioactive waste

Pixelated GEM
Microdosimetry
Tissue Equivalent chamber
Direct measurements with real tissue
Radon Monitor

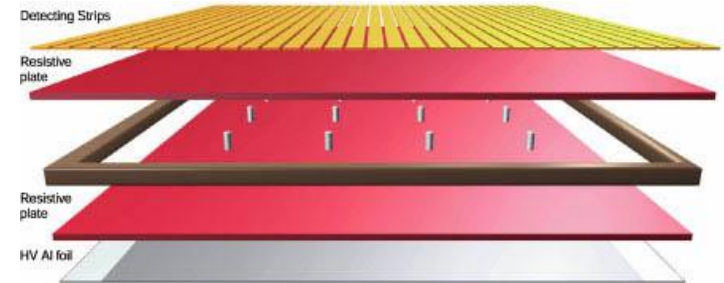
High Intensity Beam Monitors
Hadrotherapy
Ions Beam Monitor

Gamma High fluxes
Radiotherapy

Courtesy of F. Murtas, INFN LNF

RPC

- High time resolution
- High spatial resolution
- Large scale



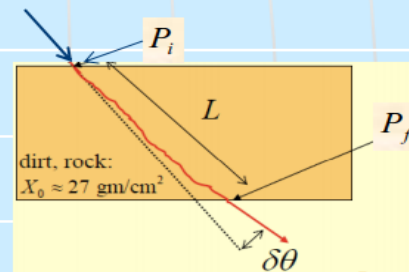
Muon Scattering

“Multiple Coulomb Scattering”

High energy muons undergo minimal scattering – travel in ~straight lines

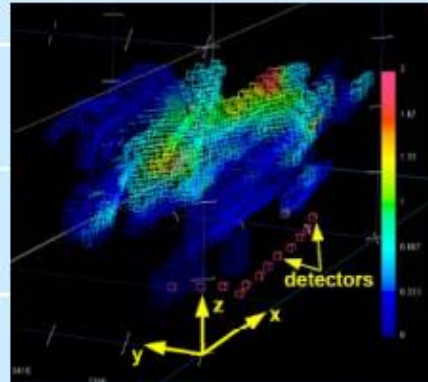
$$\delta\theta \sim \frac{13.6 \text{ MeV}}{\sqrt{P_i P_f}} \sqrt{\frac{L}{X_0}}$$

$$P_i - P_f = L \frac{dE}{dx}$$

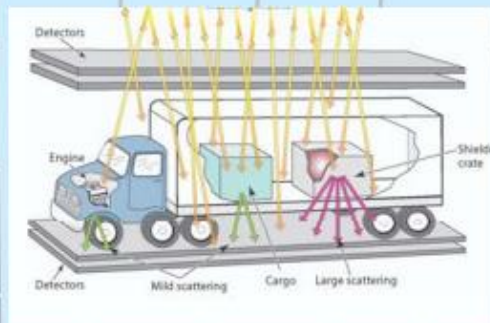


Angular deviation for $P > 300 \text{ GeV}$: $\delta\theta \leq 10 \text{ mrad}$;
10 mrad: 1 m at 100 m.

Muon Geotomography



Muon Tomography for Security Applications



Large scale gaseous detector with high spatial resolution are needed

Image reconstruction can spot material of different density

Reconstruction software is crucial

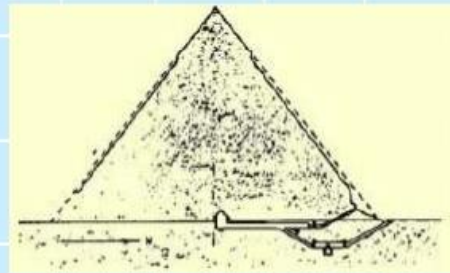
The concept is not new, but now we can profit of advanced instruments



Luis Alvarez
1965

Cosmic ray muons used to search for chambers at Giza.

Khufu's Great Pyramid



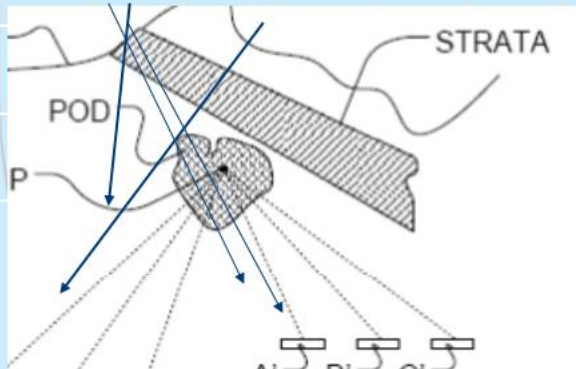
L.W. Alvarez et al., Science 167 (1970) 832. Photo Source: www.touregypt.net/featurestones/secretchambers1.htm by Alan Winston

An interesting application is the determination of high density object in mines

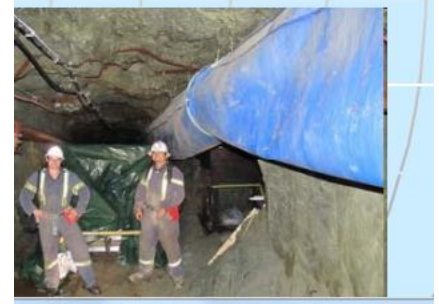
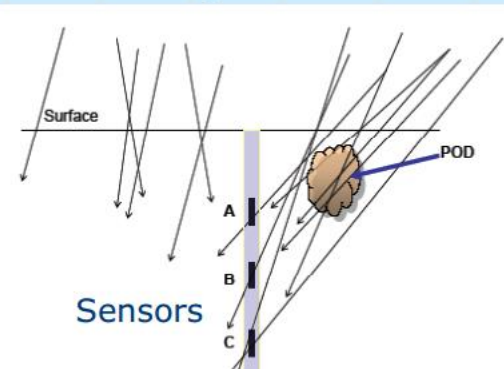
Geological Tomography and Exploration with Cosmic Rays

Attenuation of Cosmic Rays: Due to an additional high density object there is a deficit of cosmic ray muons in certain directions.

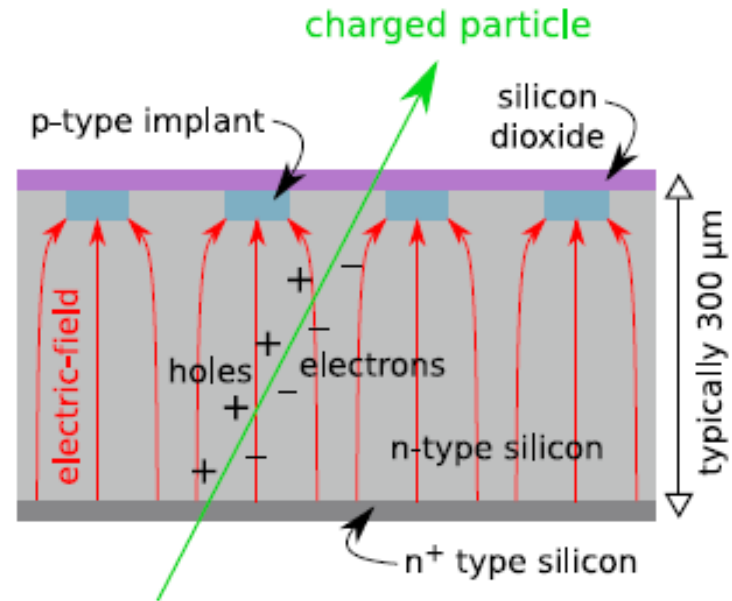
Brownfield Configuration



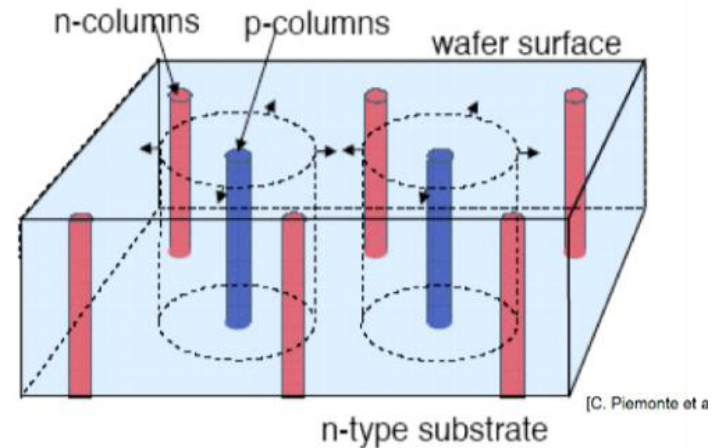
Greenfield configuration

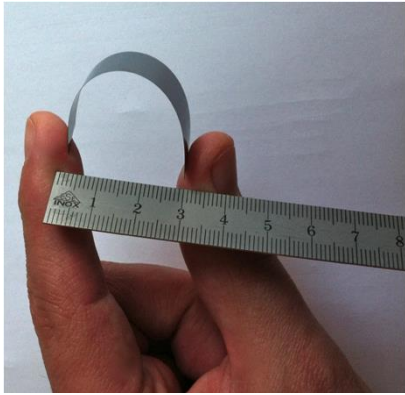


Silicon detectors



Innovative 3D Pixel Sensors





Thinning 8" wafers to 50 μm , wafer post-processing, interconnect techniques, hybrid module assembly and much more are of remarkable interest for industrial and bio-medical application



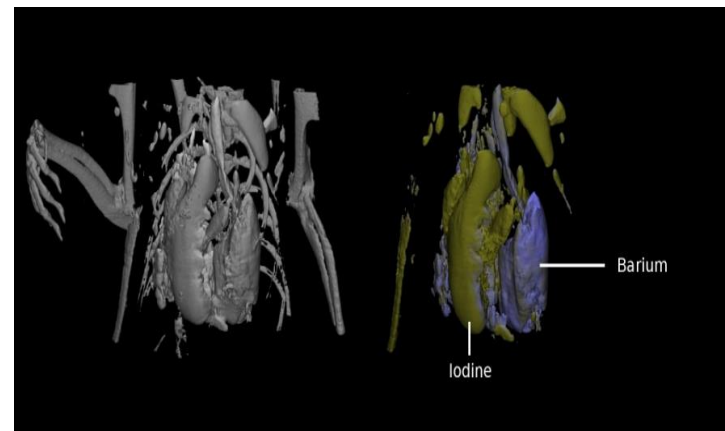
Pushing the industrial infrastructure to the limit of technical capabilities

MEDIPIX

- A family of single photon counting integrated circuits used in Hybrid Silicon Pixel Detectors
- The **Medipix collaborations** (close to 20 institutes) contributed to the development and dissemination of the technology

MARS project

Colour CT X-ray scanner based on the Medipix technology

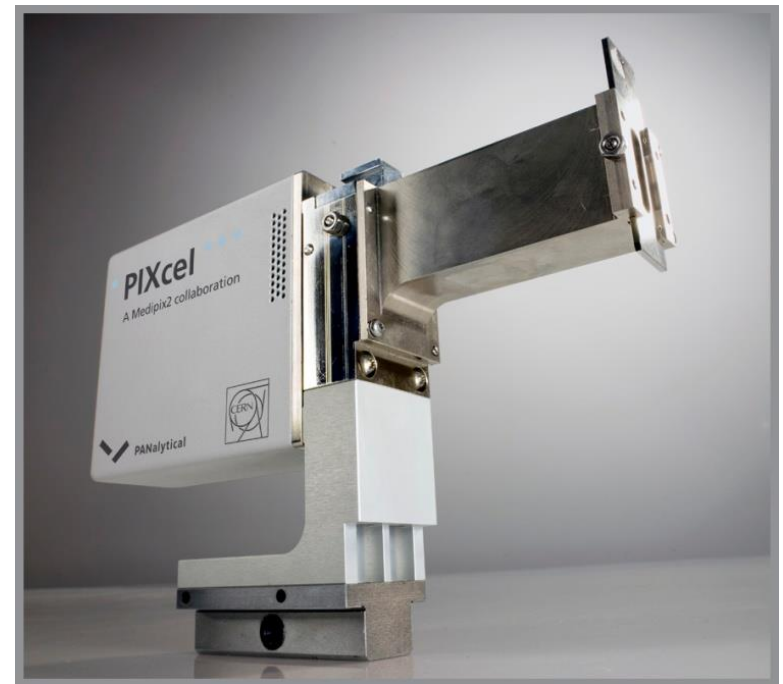


(courtesy of MARS Bioimaging Ltd)

Material analysis (CERN Development)

Partnership and license agreements with a company to build a X-ray diffractometer

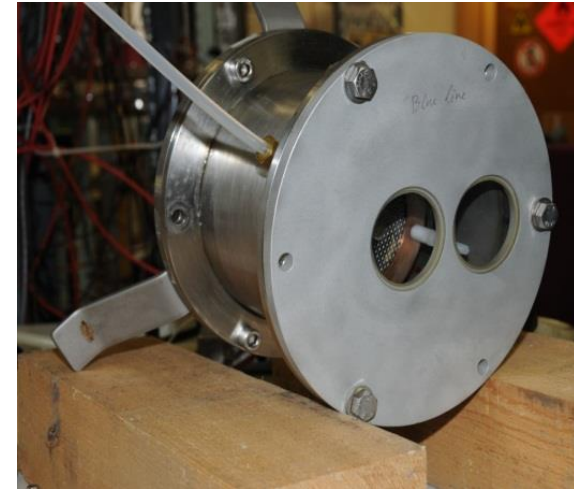
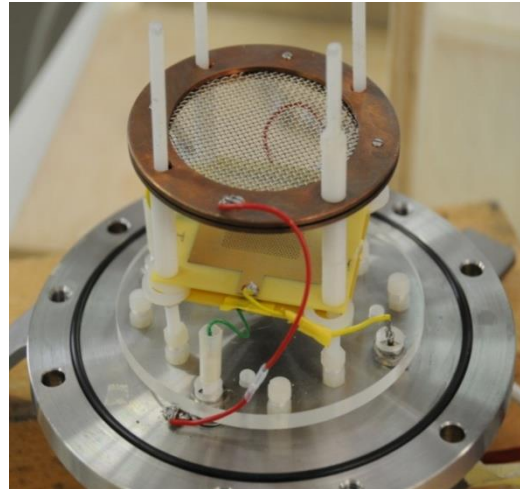
X-ray powder diffraction is one of the simplest and most widespread crystallographic techniques
it is possible to evaluate lattice parameters and to estimate internal stress and strain; using the peak shapes, it is possible to examine the sample microstructure.



Smoke detectors (CERN development)

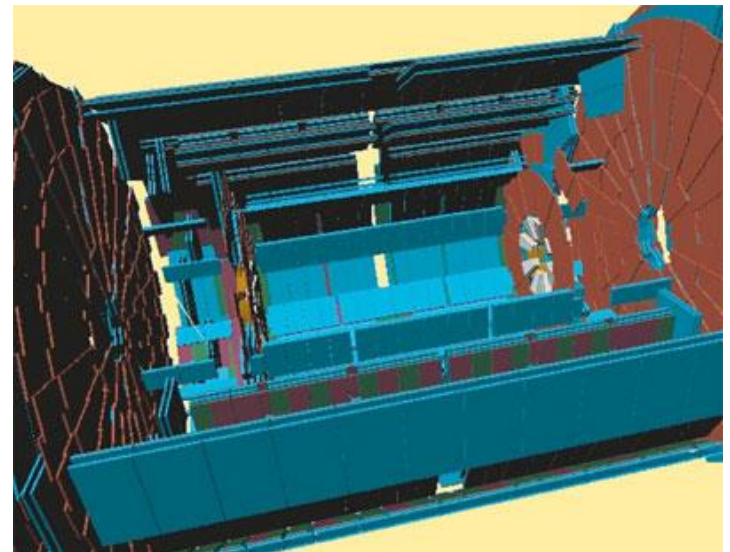
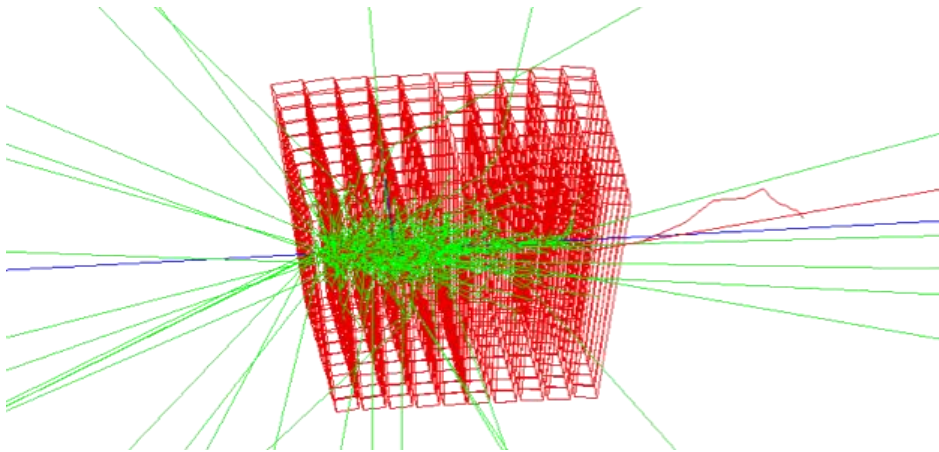
Comparison with best commercial devices shows at least a factor 10 improvement

A number of companies interested in the technologies



GEANT 4: The physics simulation toolkit

Geant4 is a toolkit developed at CERN for the simulation of the passage of particles through matter. The simulation reproduces in detail the detector geometry, the generation of events at the interaction point, the propagation of the resulting particles through the detector and the response of the detector to these particles. Detector response quantities are then used to construct candidate events which may analyzed as if they were real data.



GEANT 4: applications

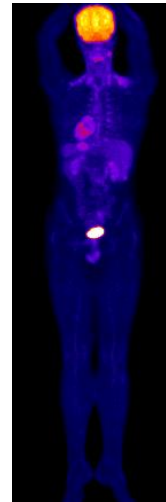
Because of its general purpose nature, Geant4 is well suited for development of computational tools for analysing interactions of particle with matter in many areas:

Space applications where it is used to study interactions between the natural space radiation environment and space hardware or astronauts;

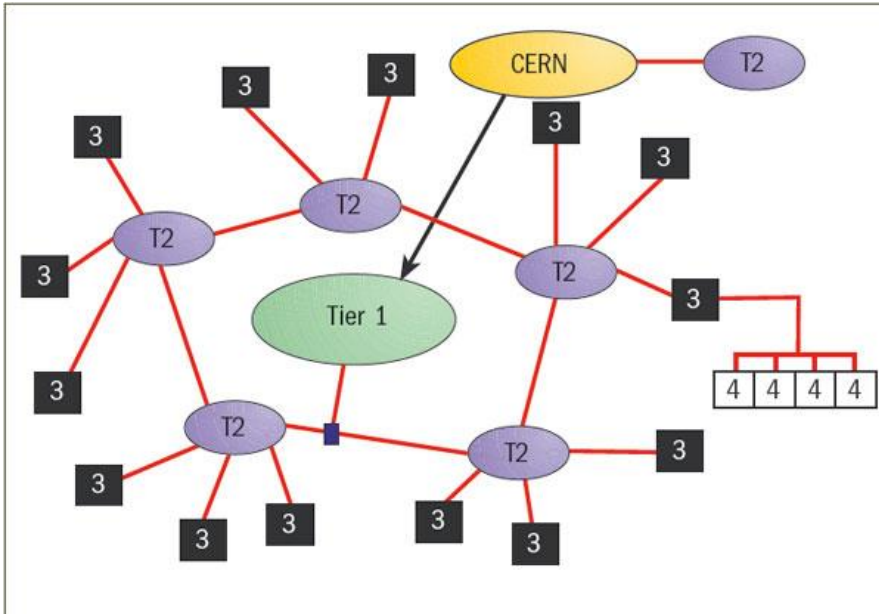
Medical applications where interactions of radiations used for treatment are simulated.

Nuclear physics where radiation effects in microelectronics semiconductor devices are modeled.

Simulations of Emission Tomography (Positron Emission Tomography – PET)

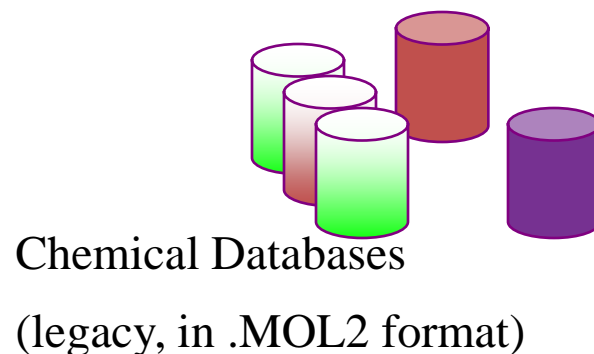
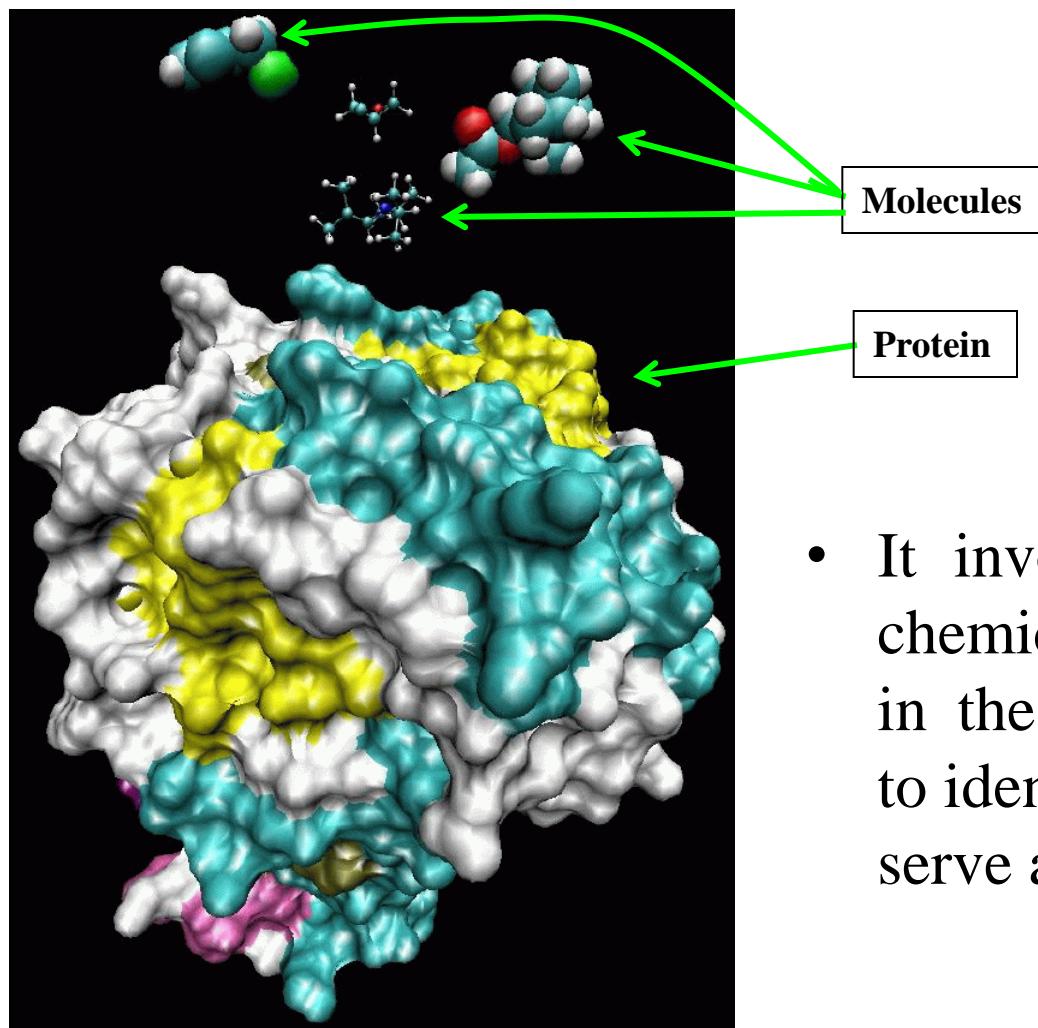


Worldwide LHC Computing Grid (WLCG)



The mission of the WLCG project is to provide global computing resources to store, distribute and analyse the ~30 Petabytes (30 million Gigabytes) of data annually generated by the Large Hadron Collider.

Drug Design: Data Intensive Computing on Grid



- It involves screening millions of chemical compounds (molecules) in the Chemical DataBase (CDB) to identify those having potential to serve as drug candidates.

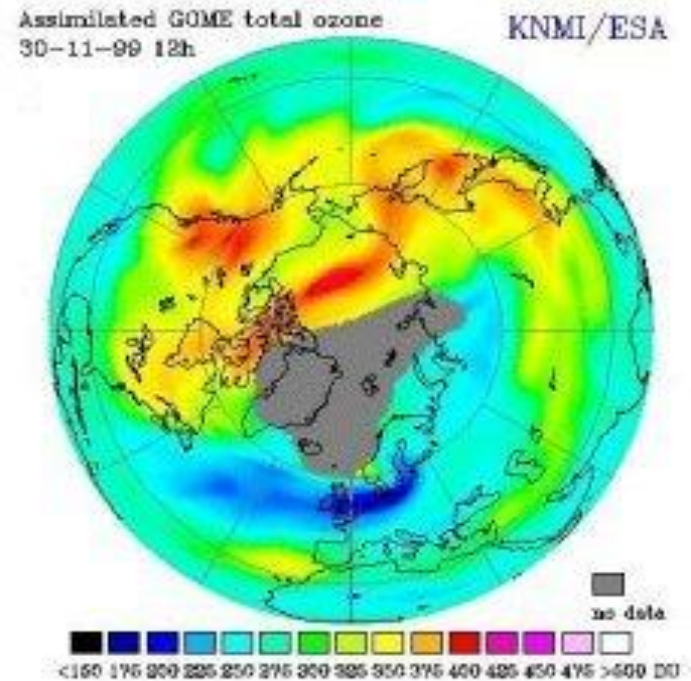
Genome Research

Data mining
Code management
Remote GUI interfaces



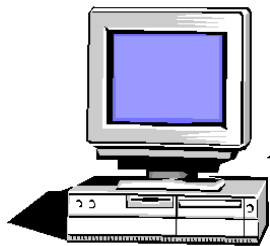
Atmospheric Ozone Observation

Large scale data collection



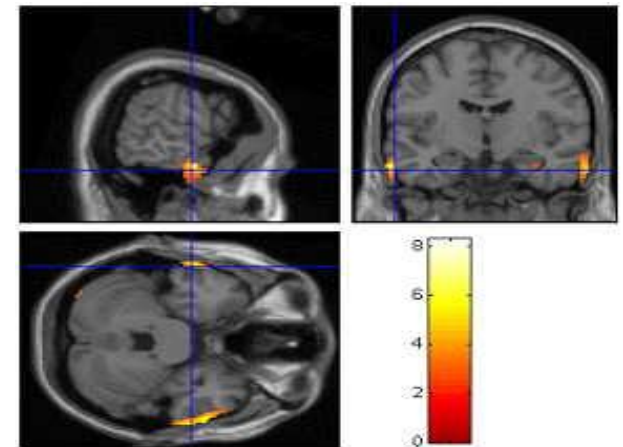
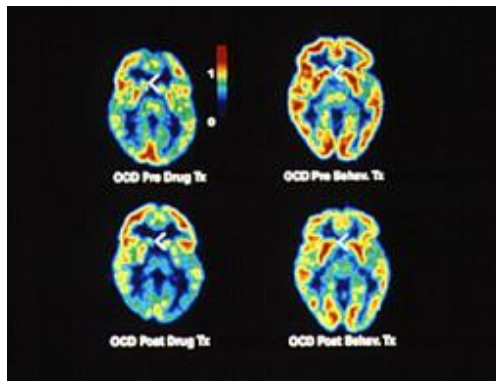
Distributed Data (Image) Analysis

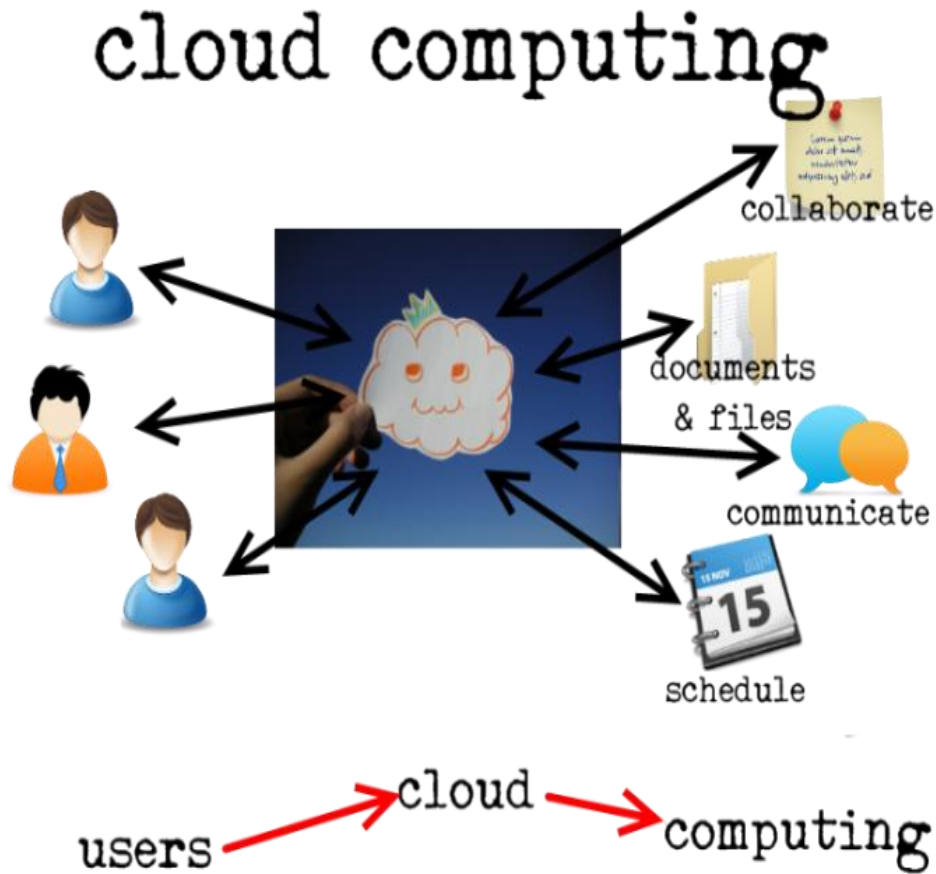
- Patient history (query to the MetaData Catalogue)
- Exam Comparison (download the previous exam(s))
- Comparison with reference data base



Analysis Station

Statistical analysis data base





Cloud computing is now developing fast in every day life: your smartphone, notebook and tablet are interconnected and exchange information through a database server

The screenshot shows the Google Cloud Platform homepage. At the top left is the Google Cloud logo. To its right is the text "Google Cloud Platform". Further right is a navigation link "Vai alla mia console | Esci" and a search bar with the placeholder "Search this site". Below the header is a navigation menu with links: "Why Google", "Products", "Solutions", "Customers", "Documentation", "Support", "Partners", and "Blog". There are two buttons: "Provalo subito" and "Contact Sales". The main content area features a large background image of server racks. The text reads: "Tools for modern applications". Below this is a paragraph: "Google Cloud Platform enables developers to build, test and deploy applications on Google's highly-scalable and reliable infrastructure. Choose from computing, storage and application services for your web, mobile and backend solutions." A "Try it now" button is located at the bottom left of the main content area.

Google

The screenshot shows the Amazon Web Services Solutions page. At the top left is the Amazon Web Services logo. To its right are language and user options: "English", "Sign In", and a "Sign Up" button. The main heading is "Solutions". Below this are three columns of content, each with an illustration and a description:

- WEBSITES & WEBSITE HOSTING**: Build your website on AWS – highly scalable, low cost, and low latency
- BIG DATA ANALYTICS**: From NoSQL to Hadoop, AWS delivers a complete big data portfolio
- BACKUP & STORAGE**: On demand, scalable, and reliable storage for your business needs

Below the solutions section is a heading: "What's New from Amazon Web Services".

Amazon

The European networks



Forum for European Intergovernmental Research Organisations



EEN, Enterprise Europe Network



TTN, Technology Transfer Network



TTO Circle - European Technology Transfer Offices Circle



The European Network for LIGHT ion Hadron Therapy

CERN Knowledge Transfer (KT) group

Visit the page : <http://knowledgetransfer.web.cern.ch/>

CERN Accelerating science Sign in Directory

CERN > KNOWLEDGE TRANSFER

Knowledge Transfer

[Home](#) [Technology Transfer Office](#) [Life Sciences](#) [Our team](#) [Contact us](#)


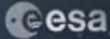
←

TECHNOLOGY TRANSFER
FROM PARTICLE PHYSICS AND SPACE RESEARCH

TECHNOLOGY TRANSFER FROM
PARTICLE PHYSICS AND SPACE
RESEARCH

HANNOVER MESSE 2014


CERN-ESA Stand at Hannover Messe 2014

→

Quick links

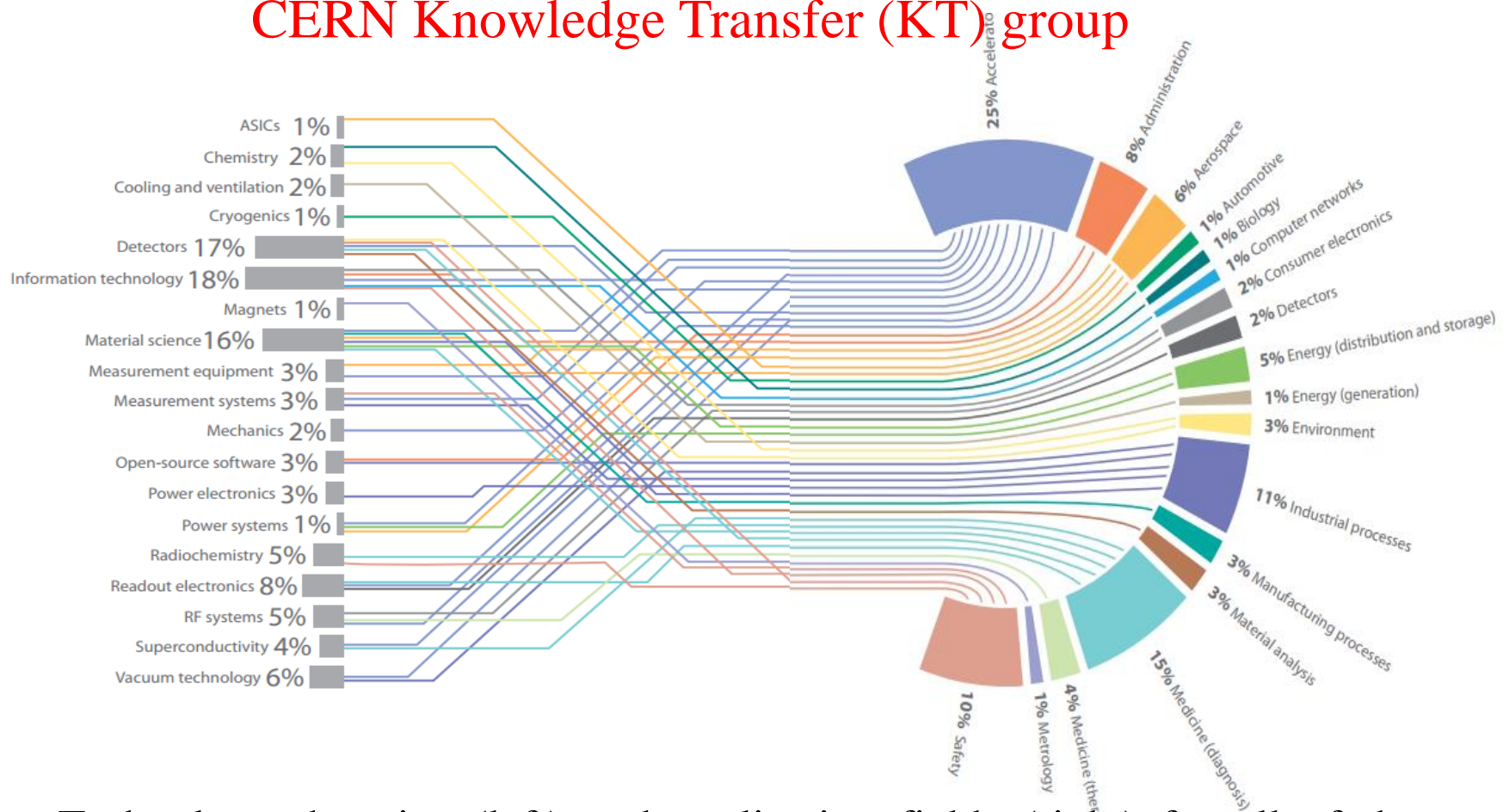
- [Technology Transfer Opportunities](#)
- [The KT Fund](#)
- [KT Networks](#)
- [Frequently Asked Questions](#)

 [Knowledge Transfer 2013 Report](#)

[see previous reports](#)

knowledgetransfer.web.cern.ch/article/technology-transfer-from-particle-physics-and-space-research-... **Energy Sustainability**

CERN Knowledge Transfer (KT) group



Technology domains (left) and application fields (right) for all of the 2013 new opportunities (internal technology disclosures, KT Fund requests)

Large impact of HEP projects on technologies development

Pushing industrial capabilities and developing new production protocols

Important impact for everyday life (medical diagnostic, sustainable energy, parallel computing)

Role of CERN (and other funding agency) is crucial