HEP technologies and transfer to industry

SCIENCE

Knowledge base

knowledge transfer

PRACTICE

Practical applications

A milestone case

WWW

Vague but exciting ...

CERN DD/OC — Tim Berners-Lee, CERN/DD

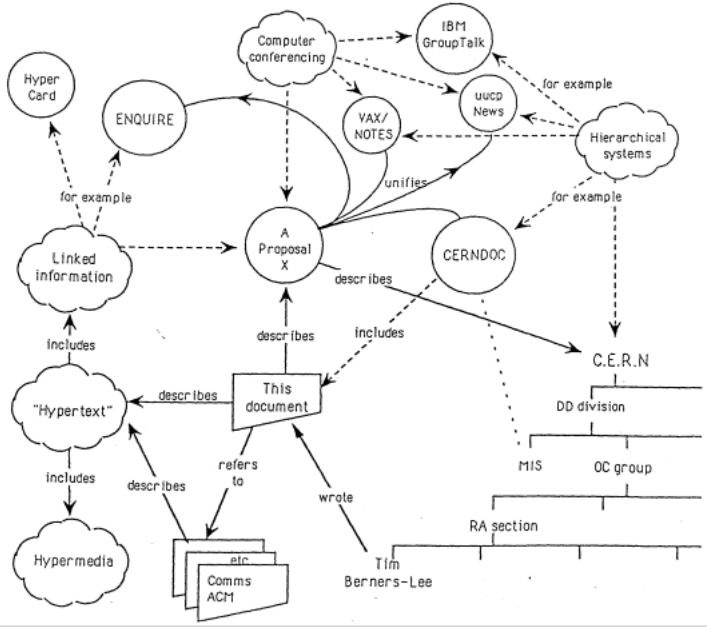
Information Management: A Proposal — March 1989

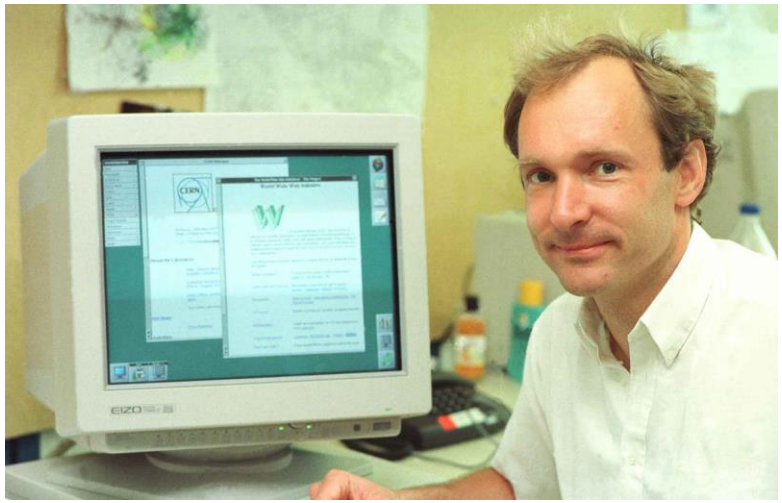
Information Management: A Proposal

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 sytstem.

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



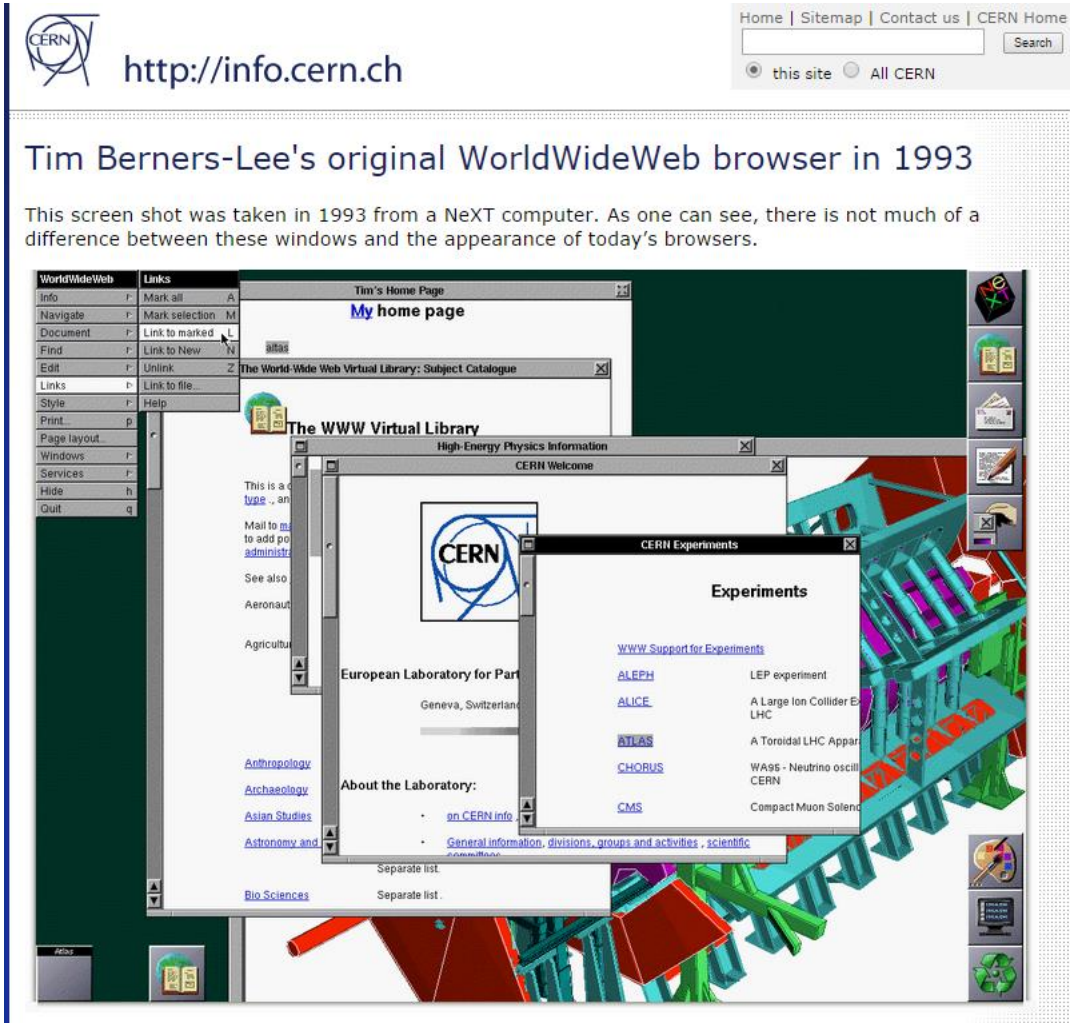


Tim Berners Lee with his NeXT computer that he used to invent the World Wide Web

A milestone case

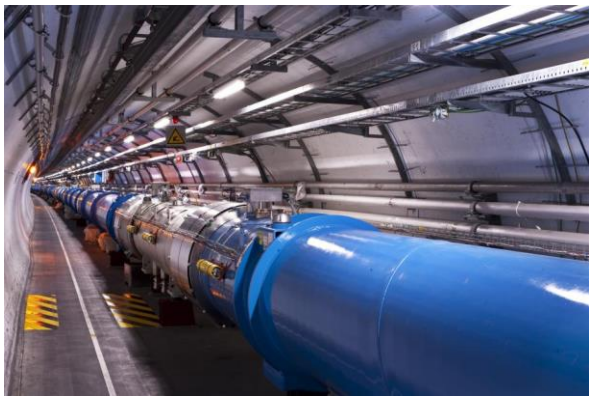
The first web page address was

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

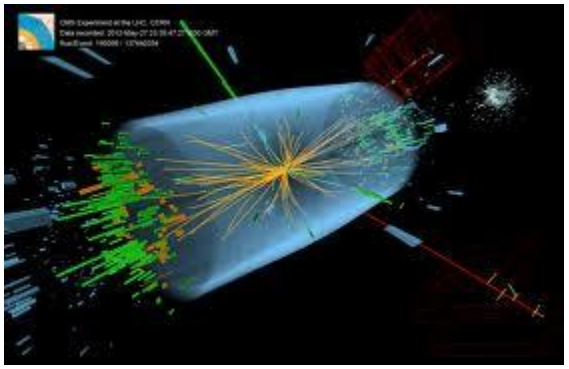


HEP technologies

Accelerating particle beams



Detecting particles



Large scale computing (Grid)

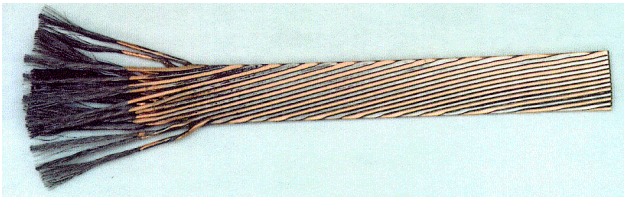
LARGE HADRON COLLIDETR

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 ^{o} K**

Super conducting Niobium-Titanium cable.
Typical 2000 A/mm^2 @ 4.2 K @ 6T

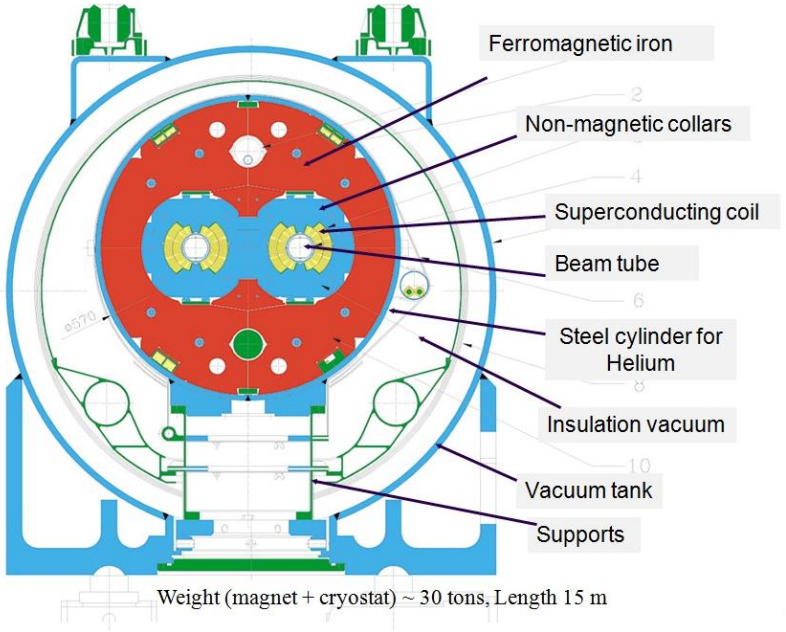


Vacuum
(10^{-13} atm)

Cryogenics
(1.9 K)

Superconductivity
(12kA)

Magnets
(8 T)

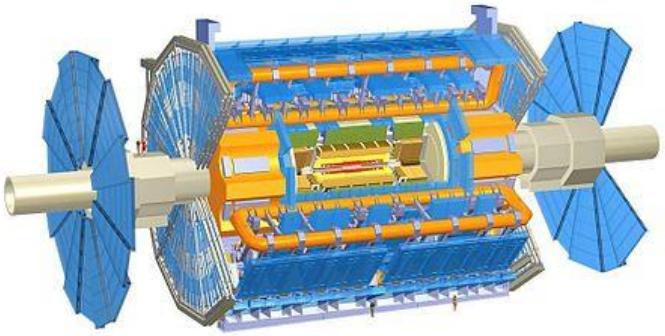


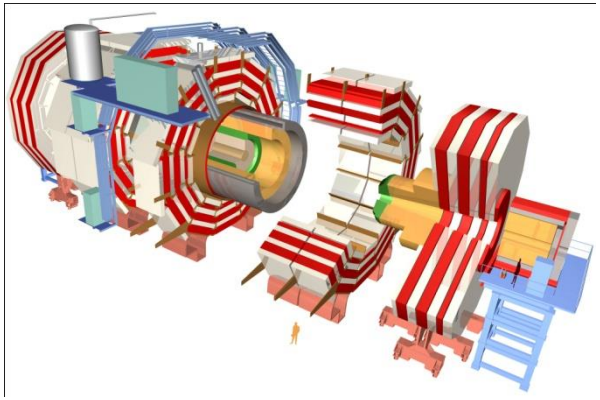
ANSALDO

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

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

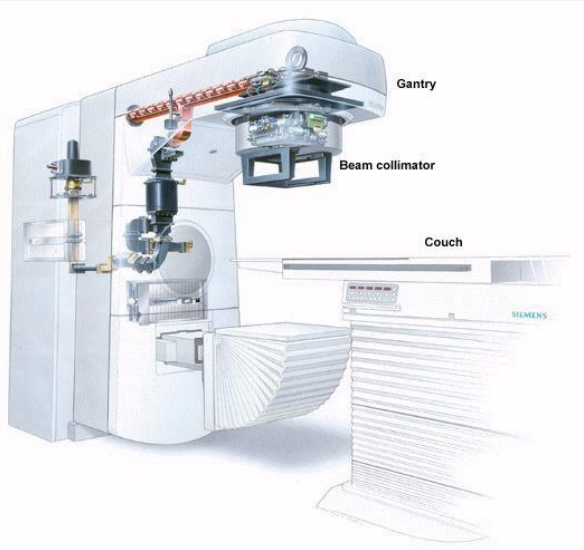




There are many medical application of accelerators

Basic type of accelerators

-Linear
-Cyclotron
-Betatron
-Synchrotron



Common medical application

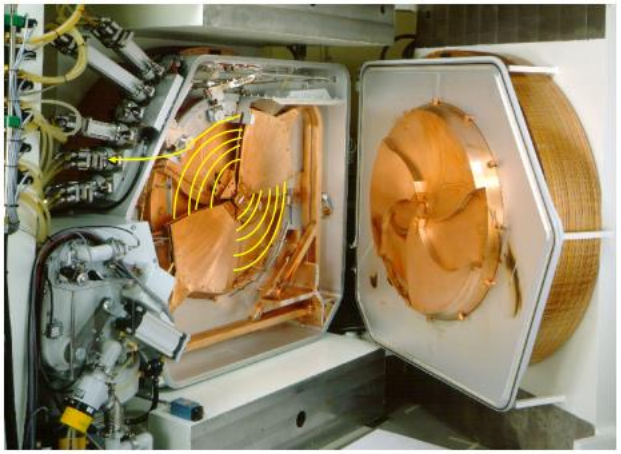
-Radiation therapy (photon/electron)
-Isotope production (Cyclotron)
-Equipment sterilization
-Hadron therapy

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 pharmaceutics substances are now quite common

es. $^{14}N + p \rightarrow {}^{11}C + \alpha + Q$ (MeV)

From high vacuum …

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

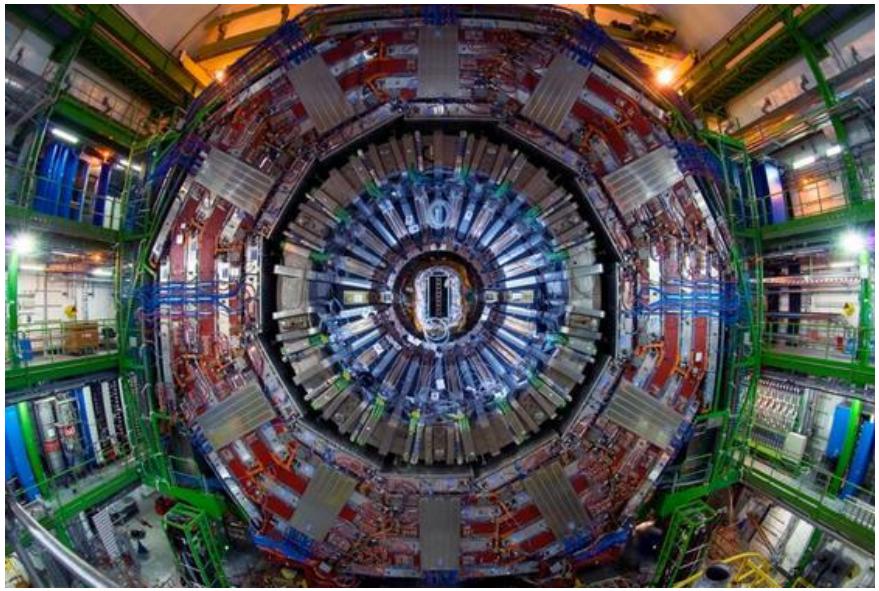
to solar energy

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.

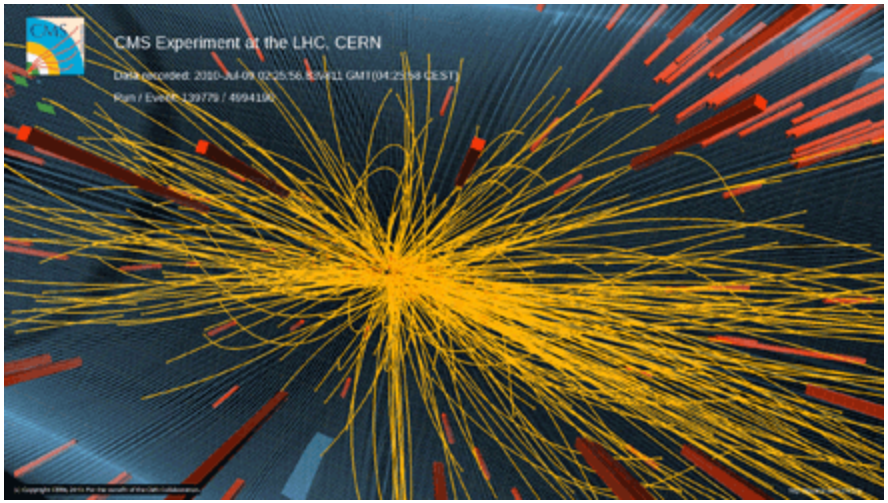
Installation at GVA airport



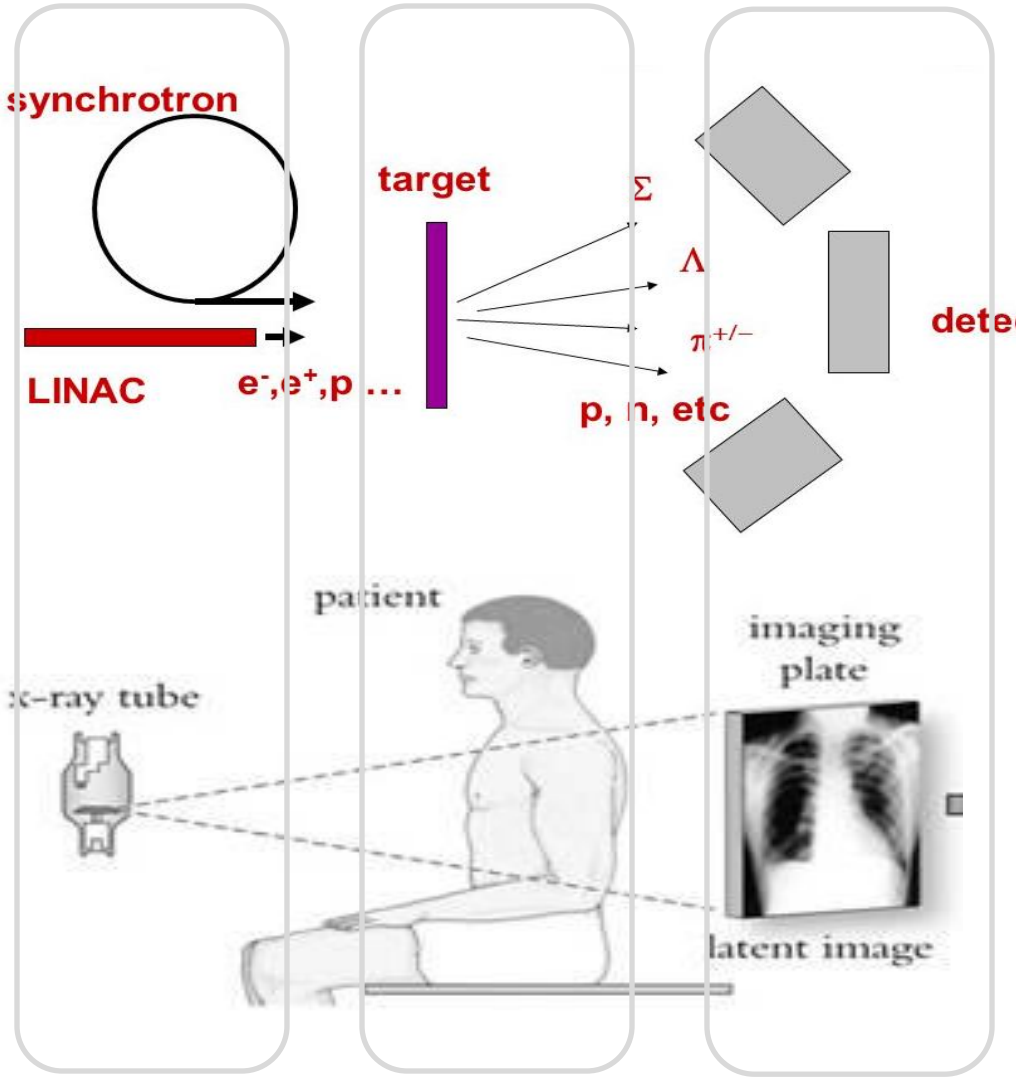
Detect 600 million proton-proton collisions per second

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



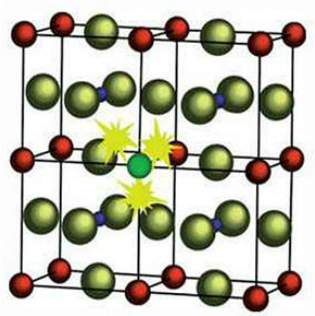
HEP technologies

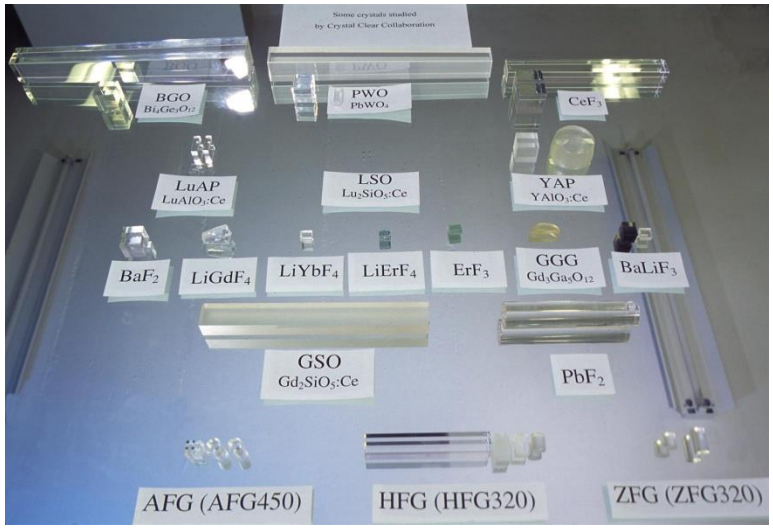


Same concept for an HEP experiment and a radiological investigation

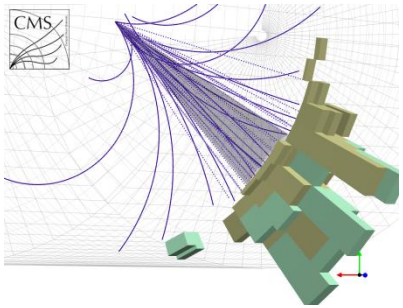
Crystal detectors

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

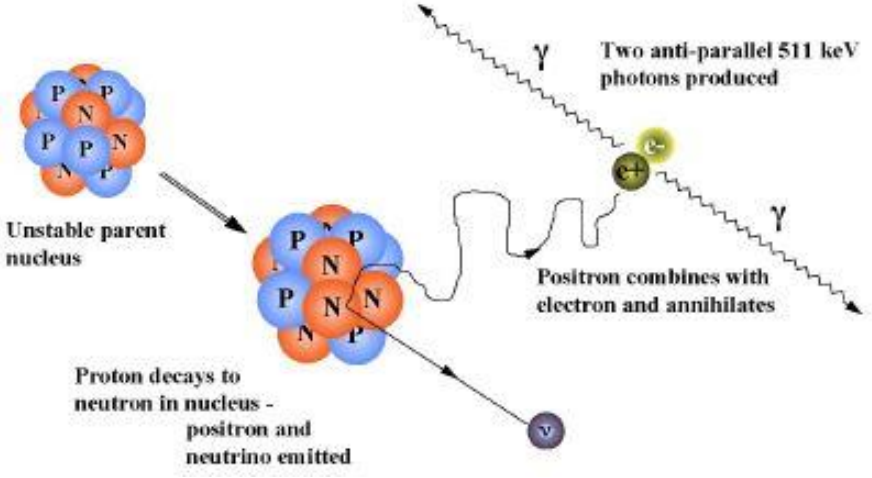


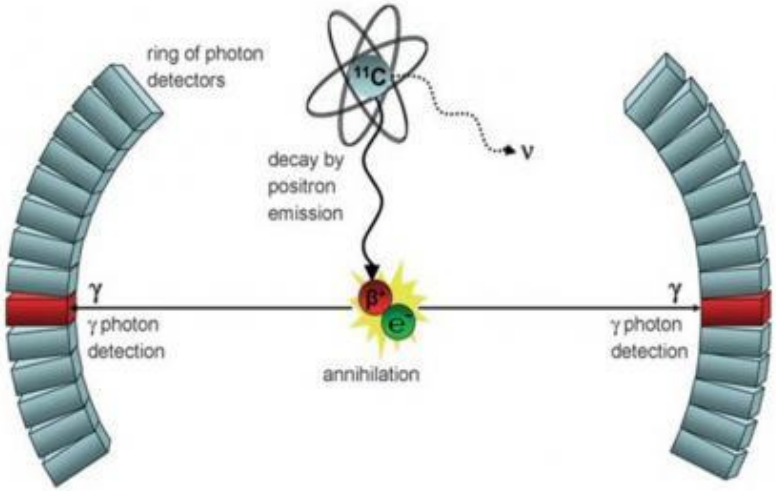


The CMS electromagnetic calorimeter uses lead tungstate (PbWO4) for the almost 80,000 crystals: a material with high density that produces scintillation light in fast, small, well-defined photon showers.



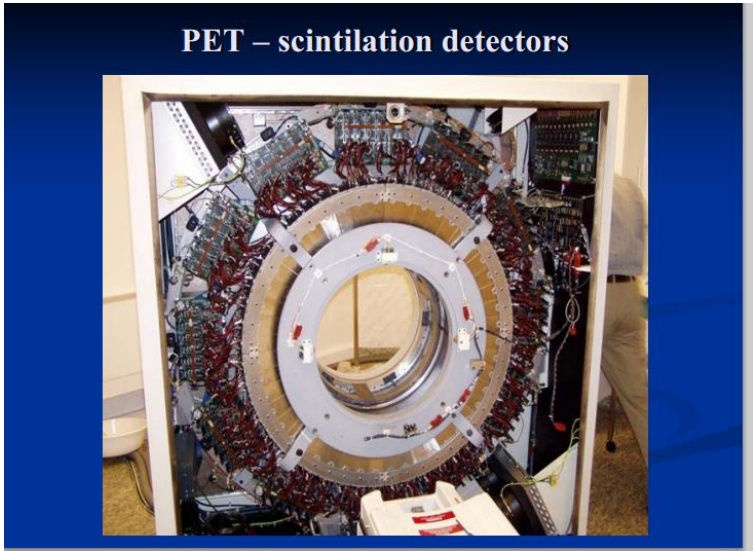
The PET concept

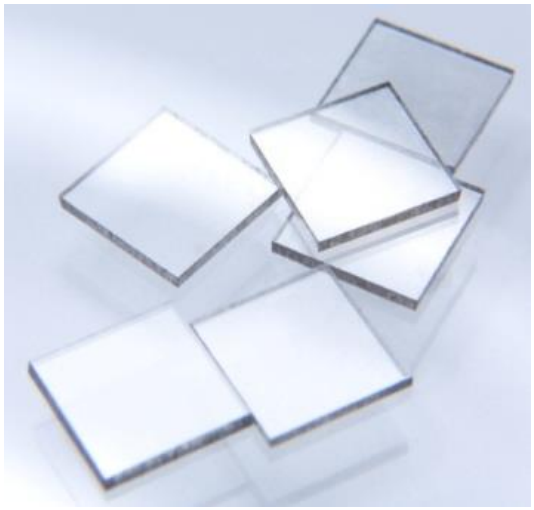




A PET detector is as complex as an HEP detector

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





Polycrystalline Diamond

Developed for Beam Condition Monitoring

Single particle counting
ATLAS @ CERN

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

Radiation Hardness

High sensitivity

Good spatial and temporal resolution

Low (and stable) noise

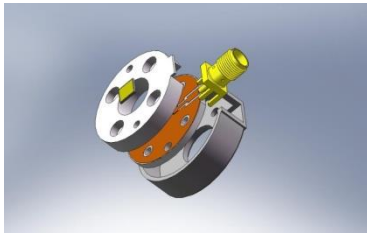
Can fabricate robust, compact devices

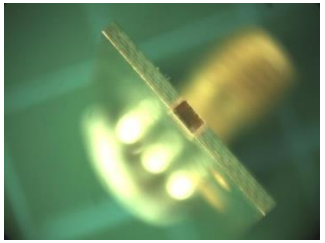
High temperature operation

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

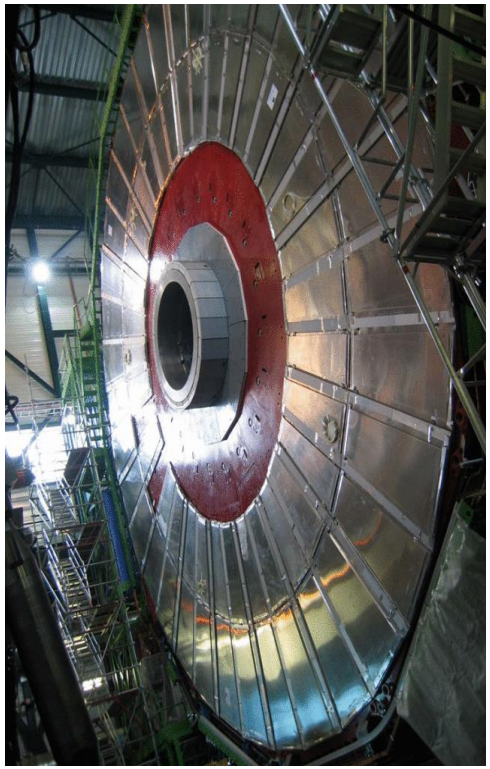
DIAMOND DETECTORS LIMITED





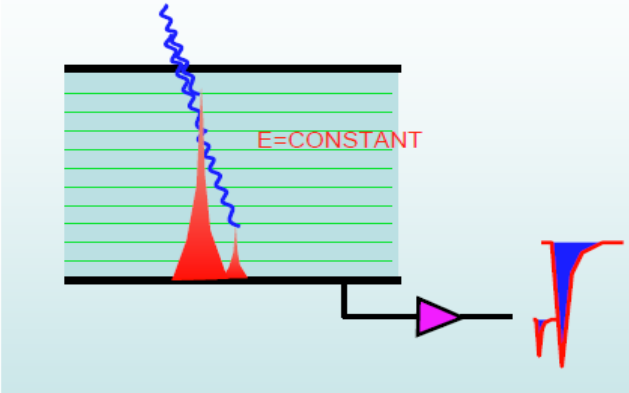
Gaseous detectors

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

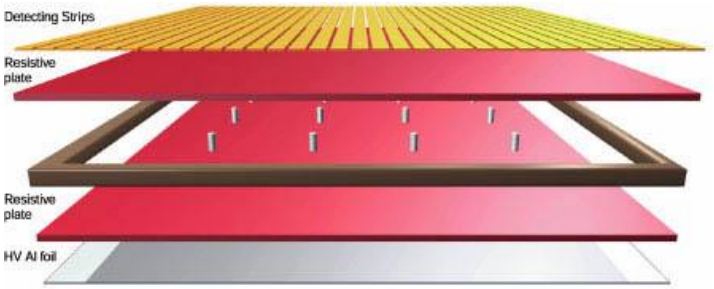
Gaseous detectors



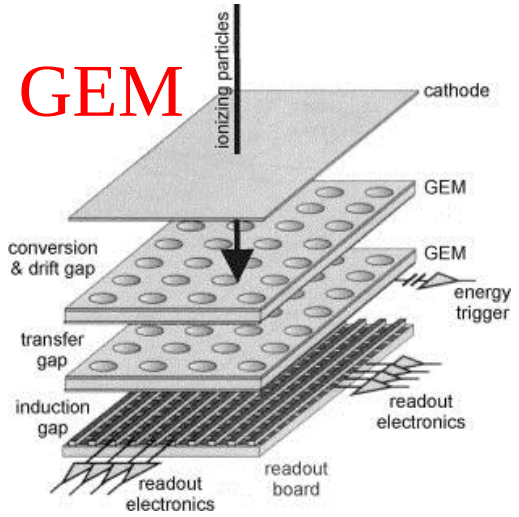
Use ionization in gas. Then collect the electrons on an appropriate electrode and produces a signal. To drive the electrons towards the electrode, an electric field is needed

Mostly used as muon detectors

RPC



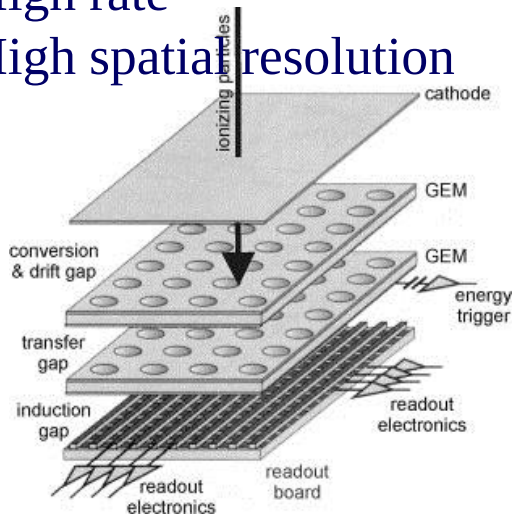
GEM

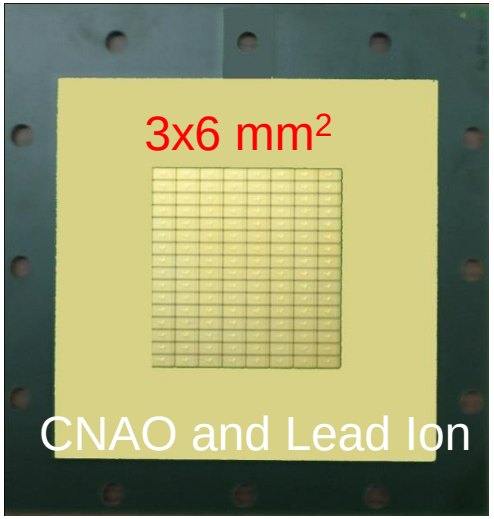


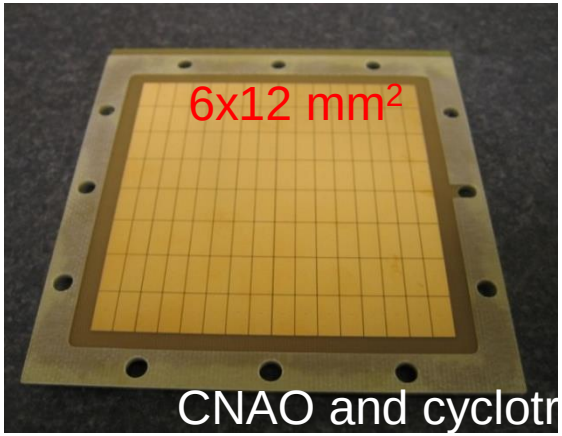
GEM

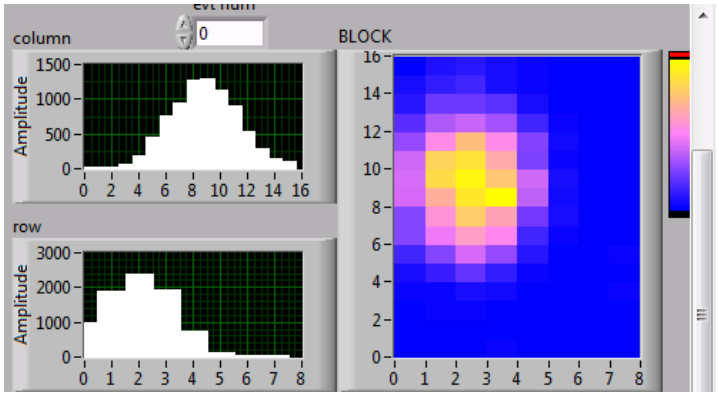
High rate

High spatial resolution







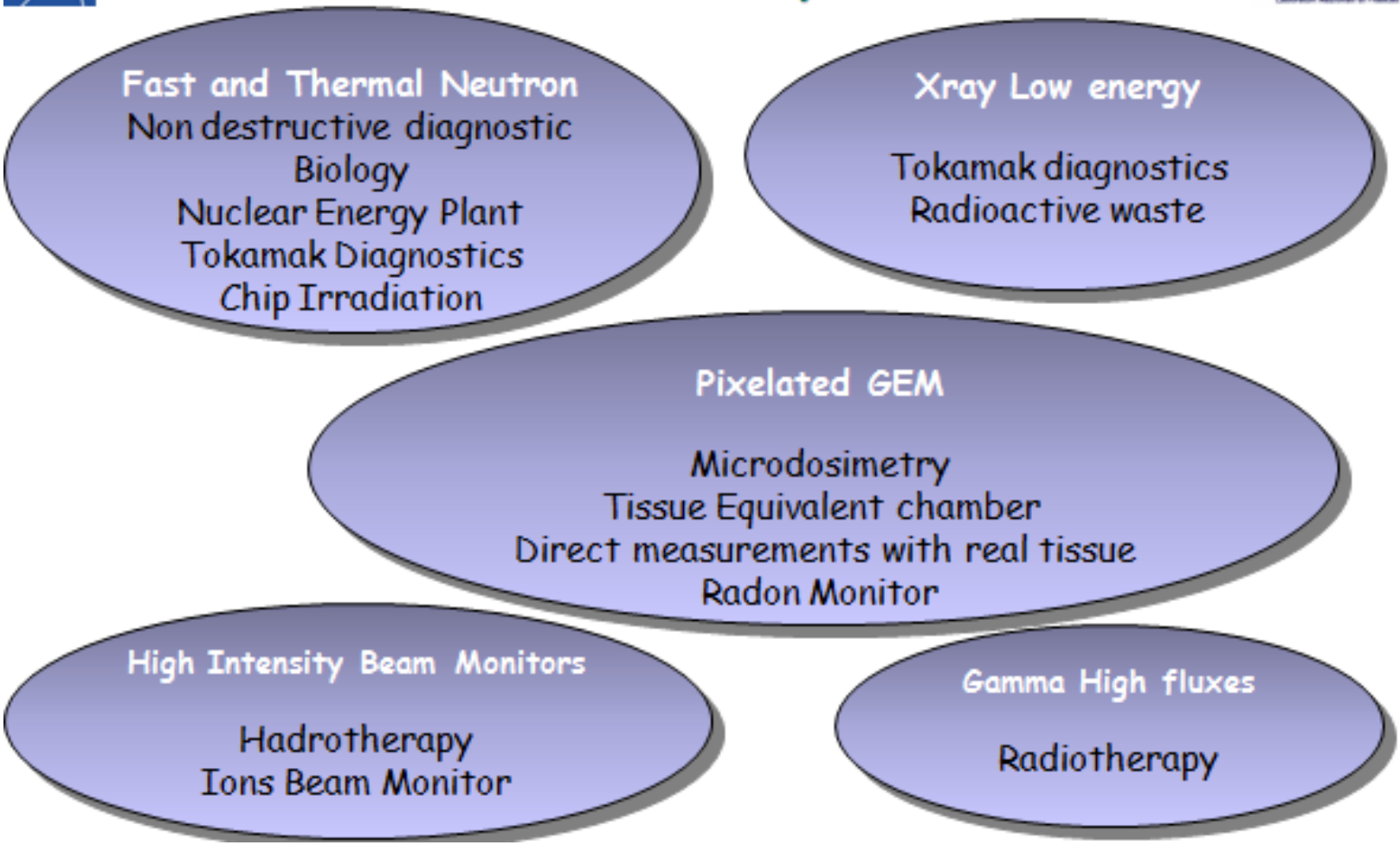


Monitor for a fast neutron beam with energies ranging from a few meV to 800 MeV. Tested at neutron beam of the Vesuvio facility at RAL-ISIS.

Courtesy of F. Murtas, INFN LNF

GEM

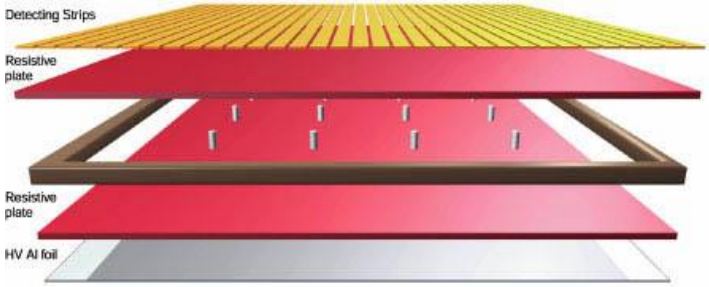
Non HEP Research activity



Courtesy of F. Murtas, INFN LNF

RPC

High time resolution
High spatial resolution
Large scale



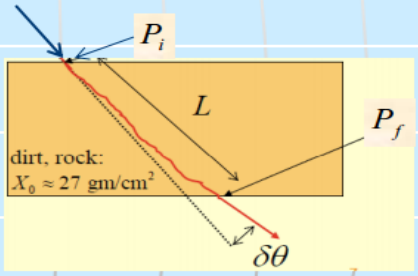
Muon Scattering

"Multiple Coulomb Scattering"

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

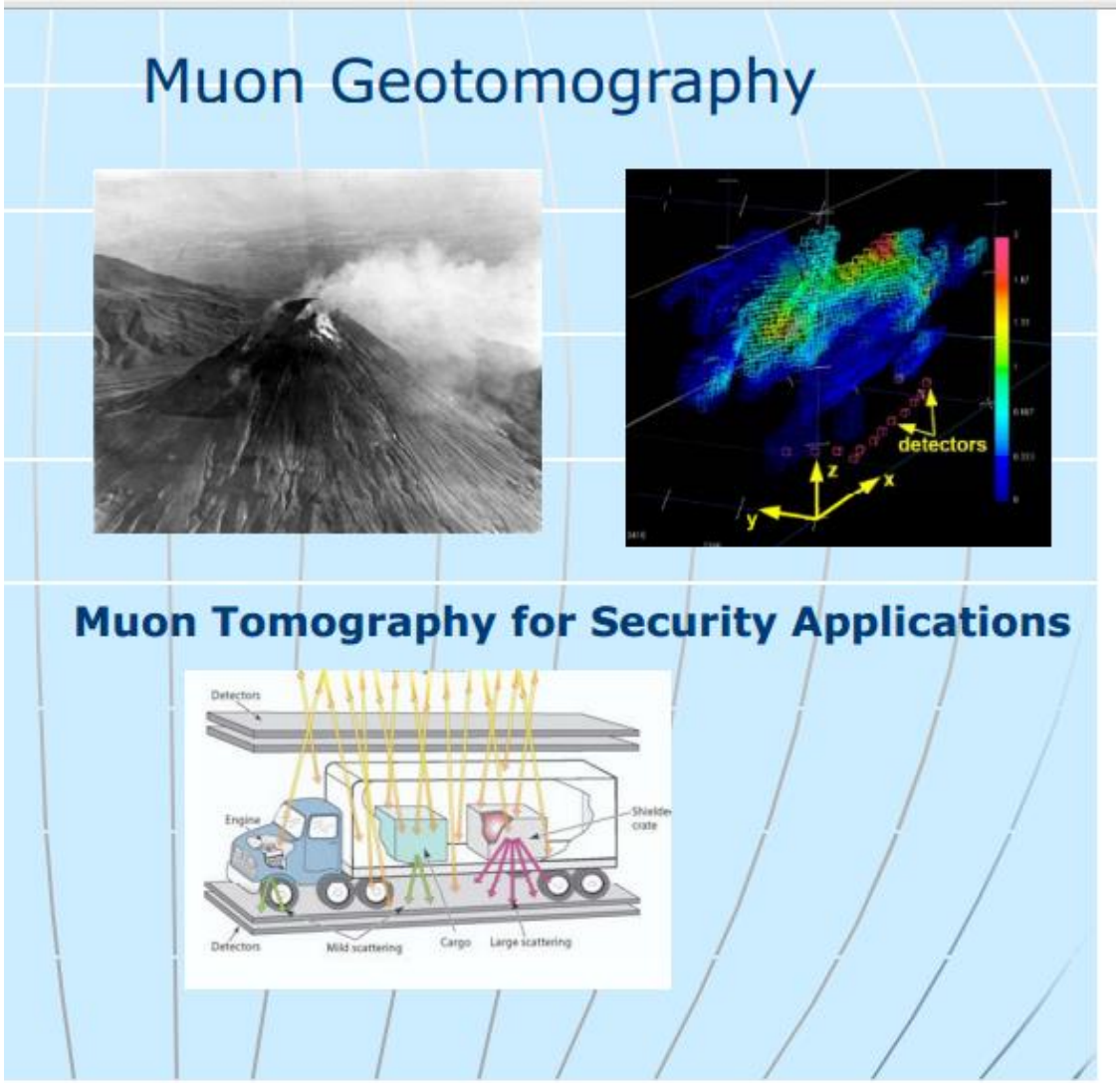
$$\delta\theta \sim \frac{13.6MeV}{\sqrt{P_i P_f}}\sqrt{\frac{L}{X_0}}$$

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



Angular deviation for P> 300 GeV: δθ≤10 mrad;

10 mrad: **1 m at 100 m.**



Large scale gaseous detector with high spatial resolution are needed

Image reconstruction can spot material of different density

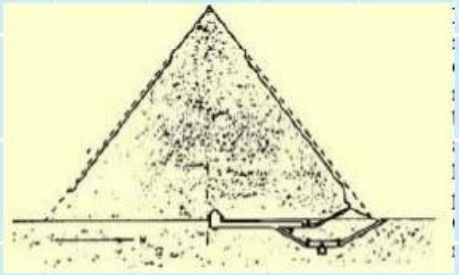
Reconstruction software is crucial

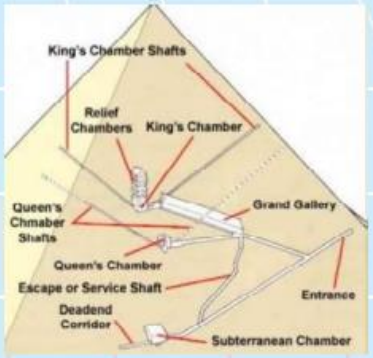
The concept is not new, but now we can profit of advanced instruments

Luis Alvarez
1965

Cosmic ray muons used to search for chambers at Giza.

Khufu's Great Pyramid





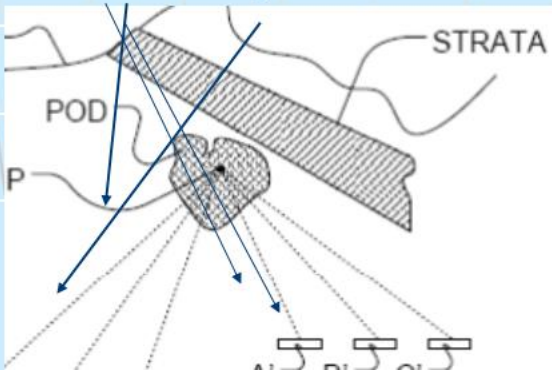
L.W. Alvarez et al., Science 167 (1970) 832. Photo Source: www.touregypt.net/featurestories/secretchambers1.htm by Alan Winston

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

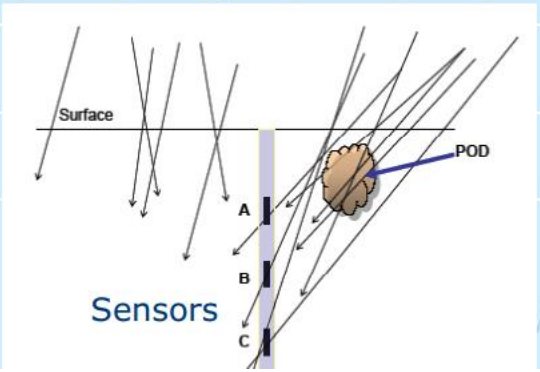
Geological Tomography and Exploration with Cosmic Rays

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

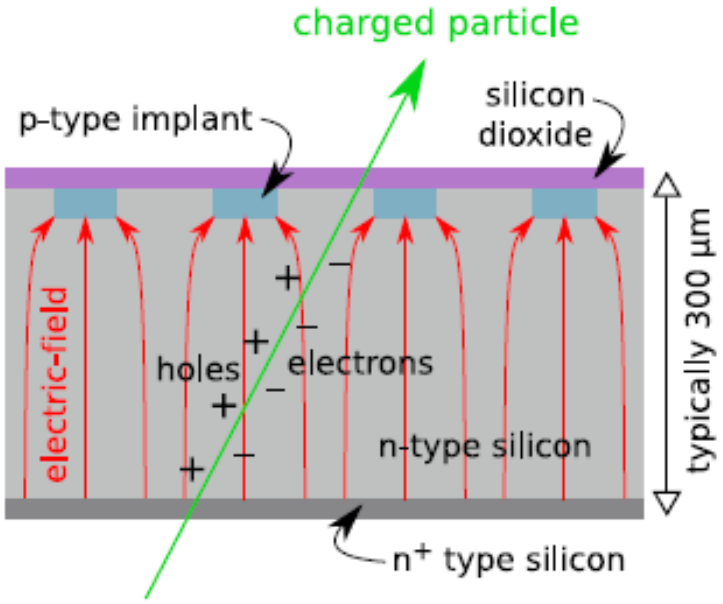
Brownfield Configuration



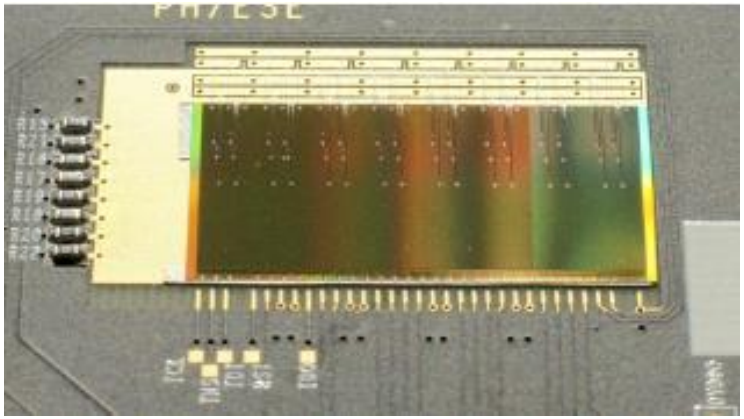
Greenfield configuration

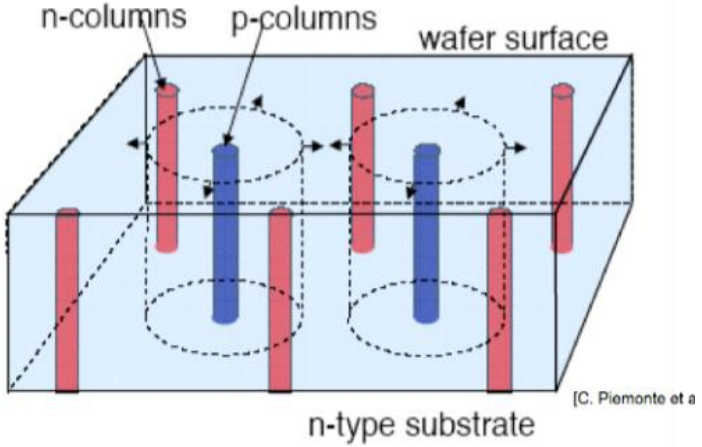


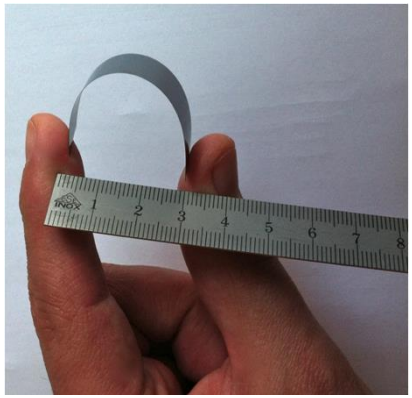
Silicon detectors



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

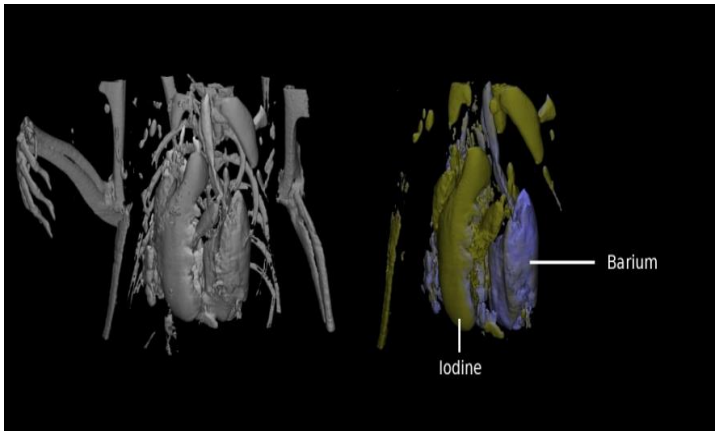
Pushing the industrial infrastructure to the limit of technical capabilities

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)

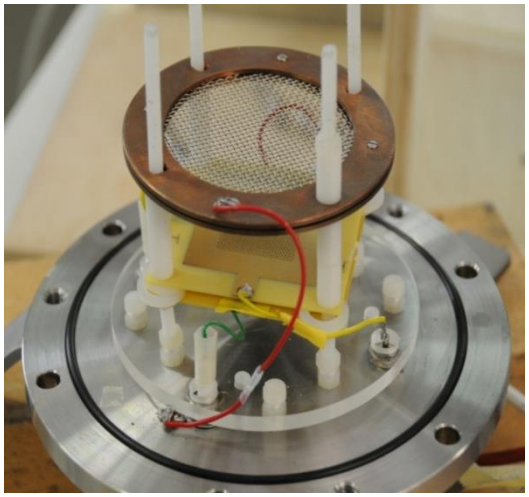
Partnership and license agreements with a company to build a X-ray diffractometer

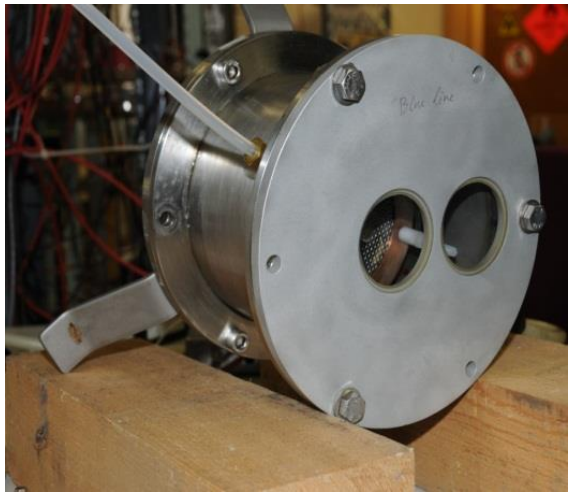
X-ray powder diffraction is one of the simplest and most widespread crystallographic techniques
it is possible to evaluate lattice parameters and to estimate internal stress and strain; using the peak shapes, it is possible to examine the sample microstructure.

Smoke detectors (CERN development)

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

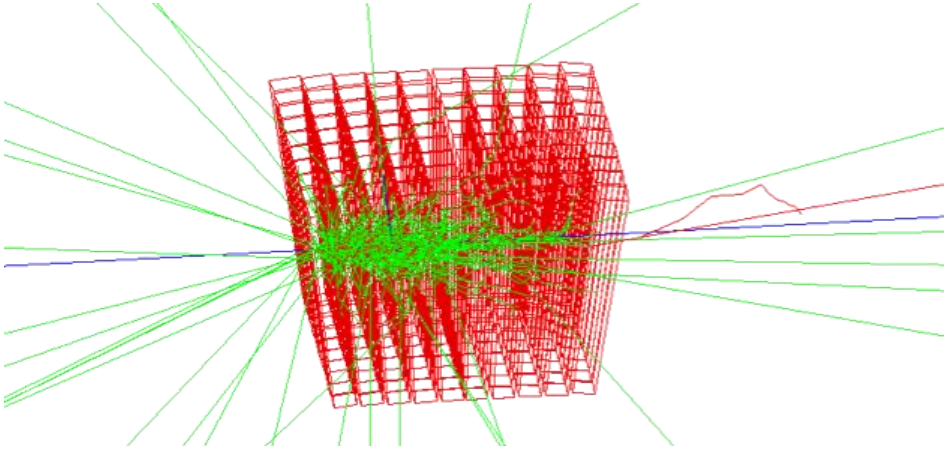
A number of companies interested in the technologies

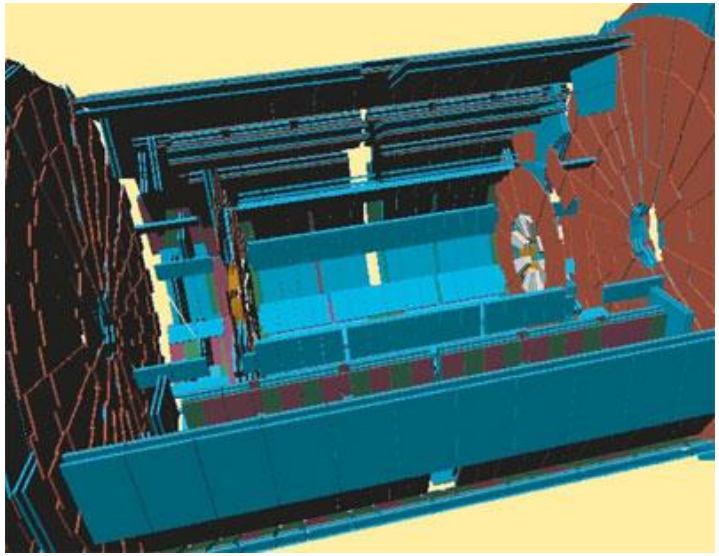




GEANT 4: The physics simulation toolkit

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

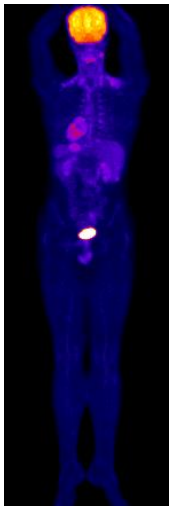
Because of its general purpose nature, Geant4 is well suited for development of computational tools for analysing interactions of particle with matter in many areas:

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

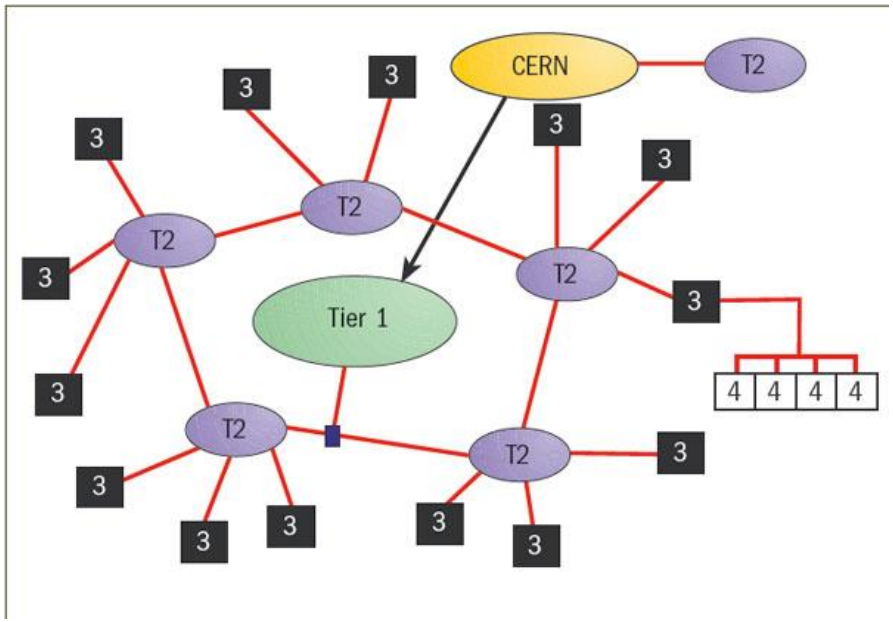
Medical applications where interactions of radiations used for treatment are simulated.

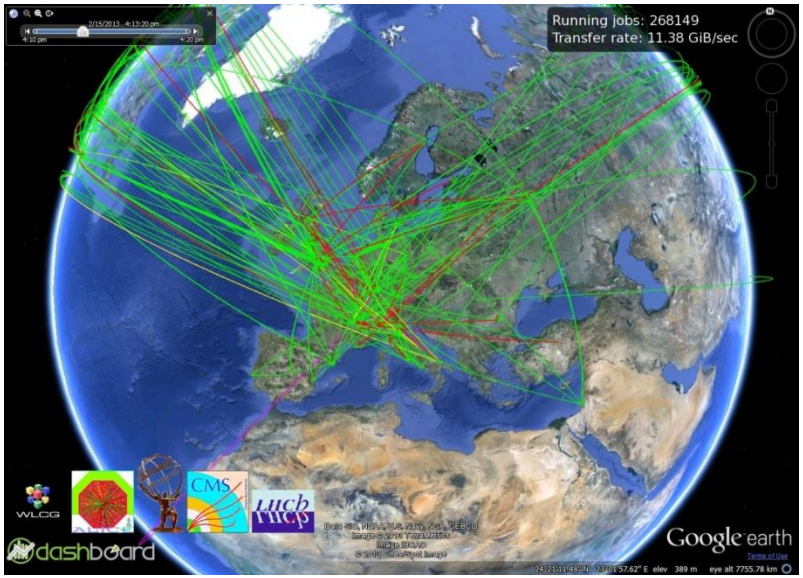
Nuclear physics where radiation effects in microelectronics semiconductor devices are modeled.

Simulations of Emission Tomography (Positron Emission Tomography – PET)



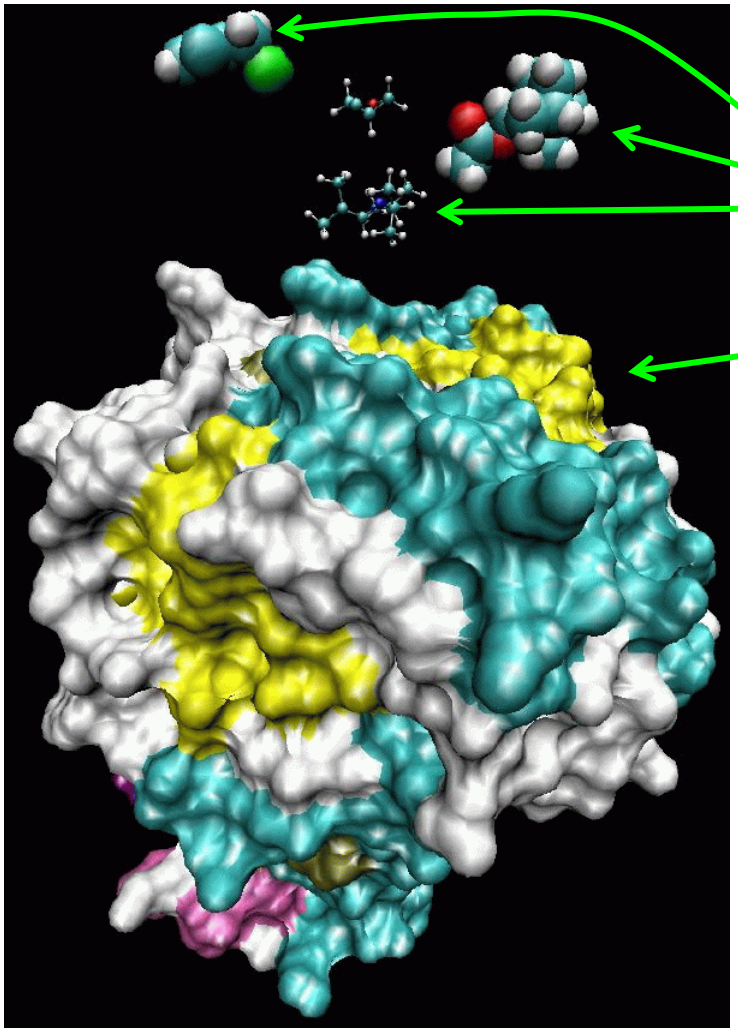
Worldwide LHC Computing Grid (WLCG)

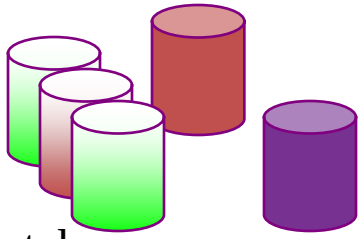




The mission of the WLCG project is to provide global computing resources to store, distribute and analyse the ~30 Petabytes (30 million Gigabytes) of data annually generated by the Large Hadron Collider.

Drug Design: Data Intensive Computing on Grid





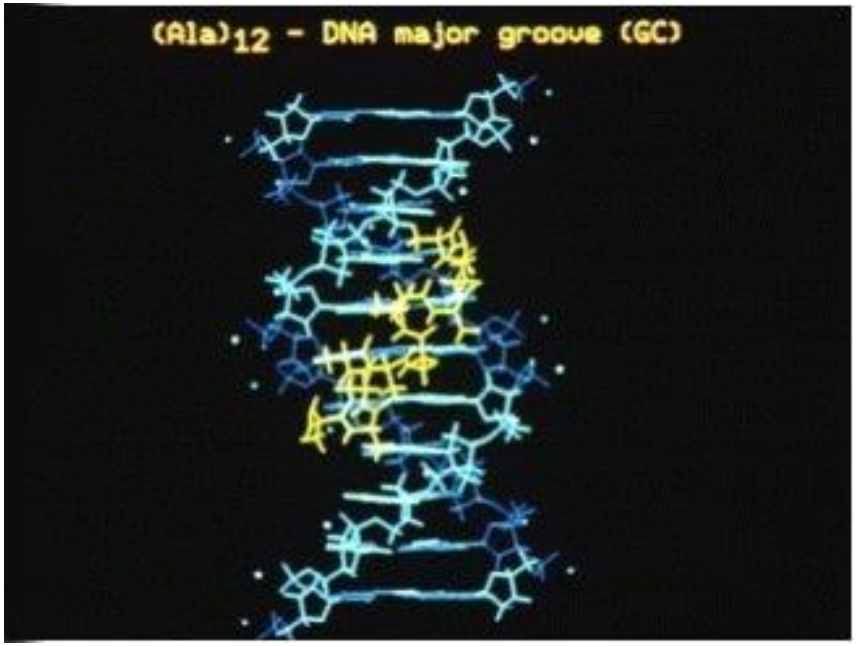
Chemical Databases

(legacy, in .MOL2 format)

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

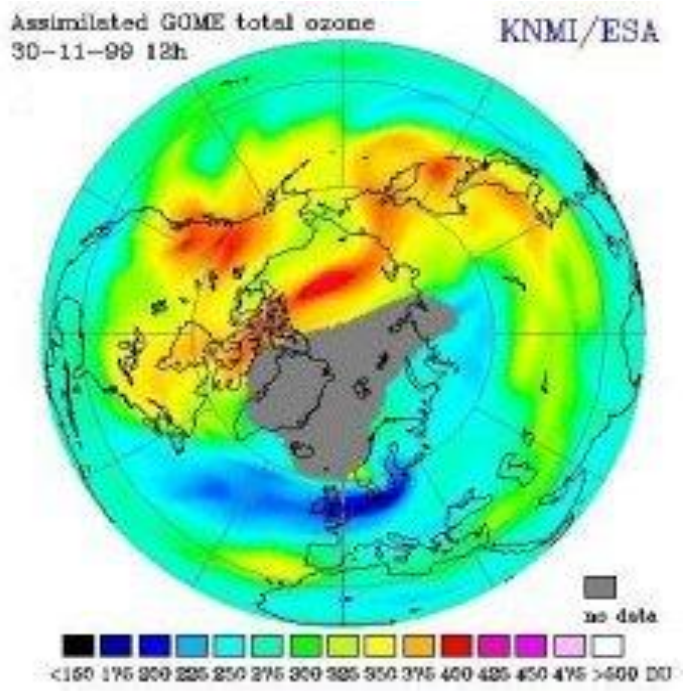
Genome Research

Data mining
Code management
Remote GUI interfaces



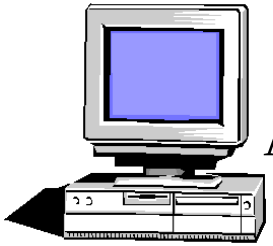
Atmospheric Ozone Observation

Large scale data collection



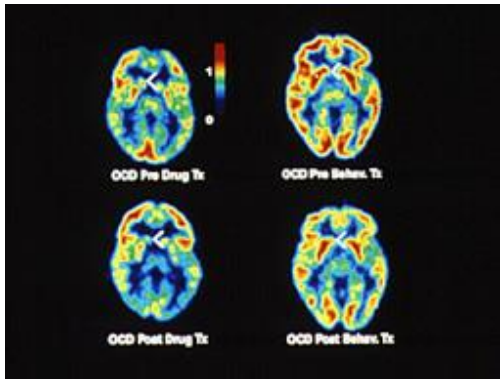
Distributed Data (Image) Analysis

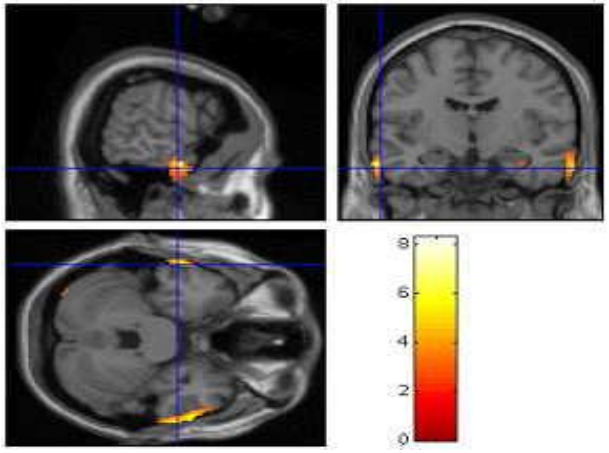
- Patient history (query to the MetaData Catalogue)
- Exam Comparison (download the previous exam(s))
- Comparison with reference data base

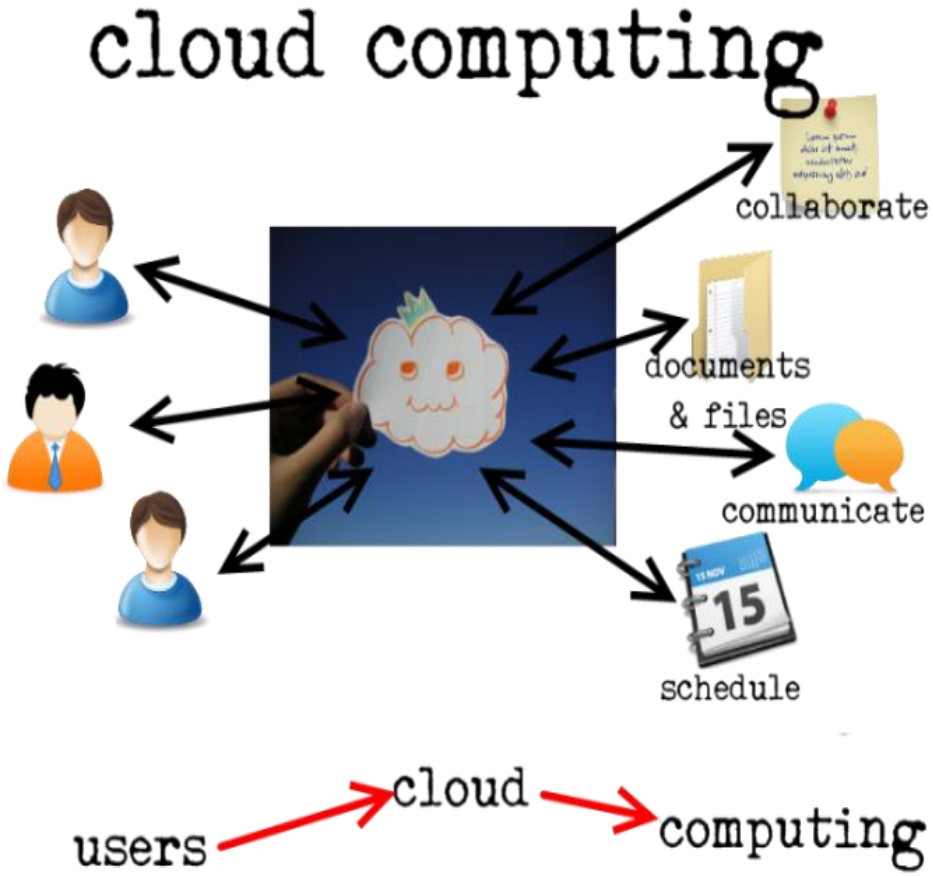


Analysis Station

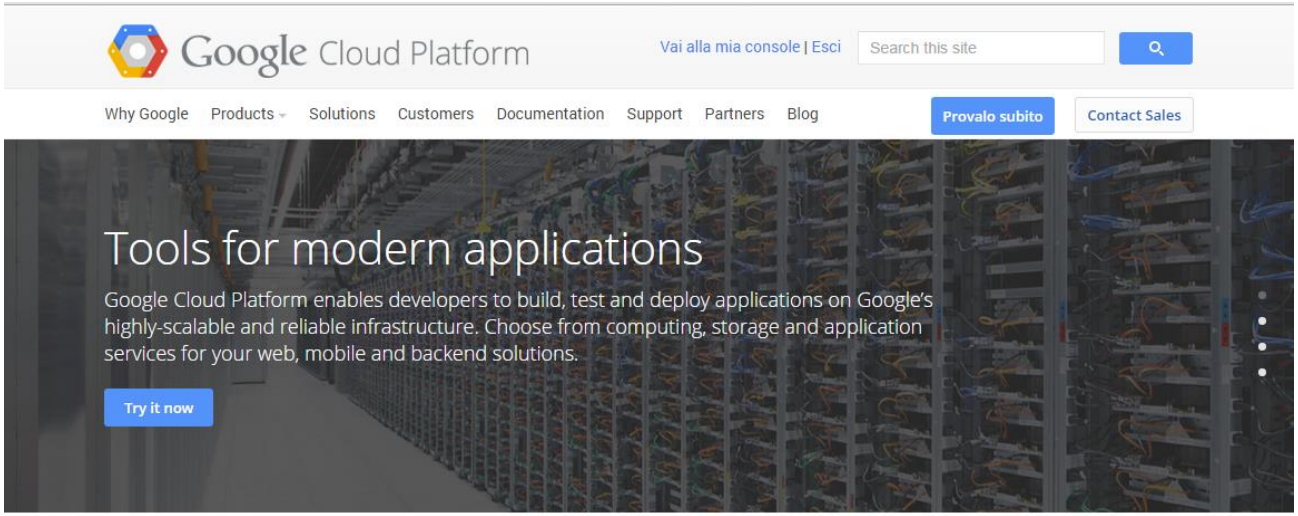
Statistical analysis data base



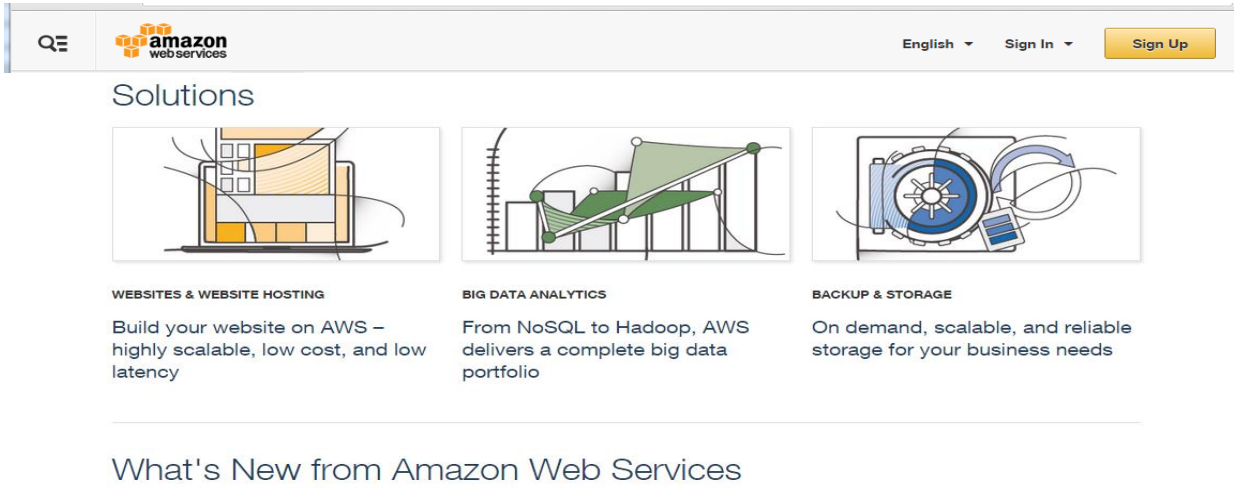




Cloud computing is now developing fast in every day life: your smartphone, notebook and tablet are interconnected and exchange information through a database server



Google



Amazon

Networks

The European networks

Forum for European Intergovernmental Research Organisations

EEN, Enterprise Europe Network

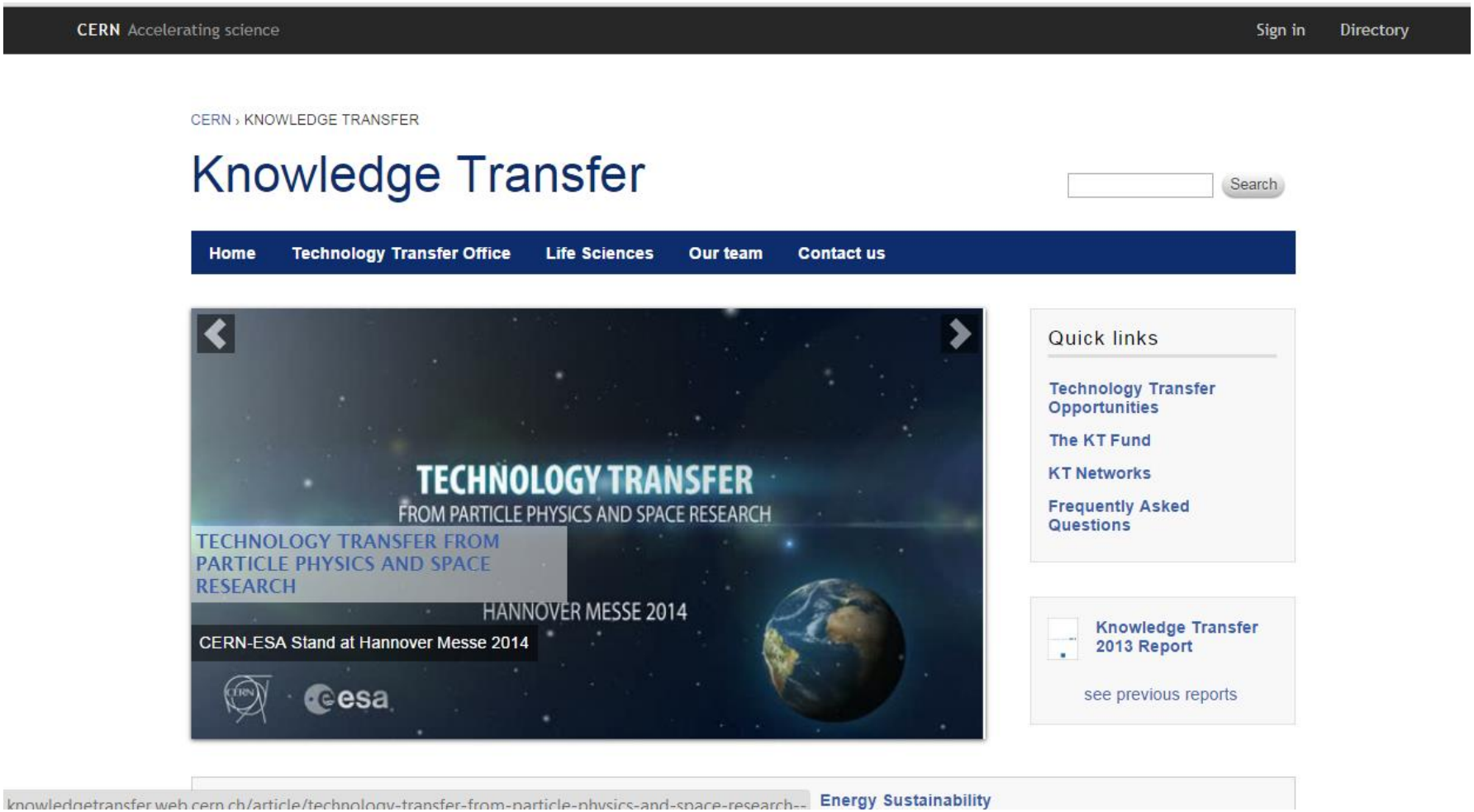
TTN, Technology Transfer Network

TTO Circle - European Technology Transfer Offices Circle

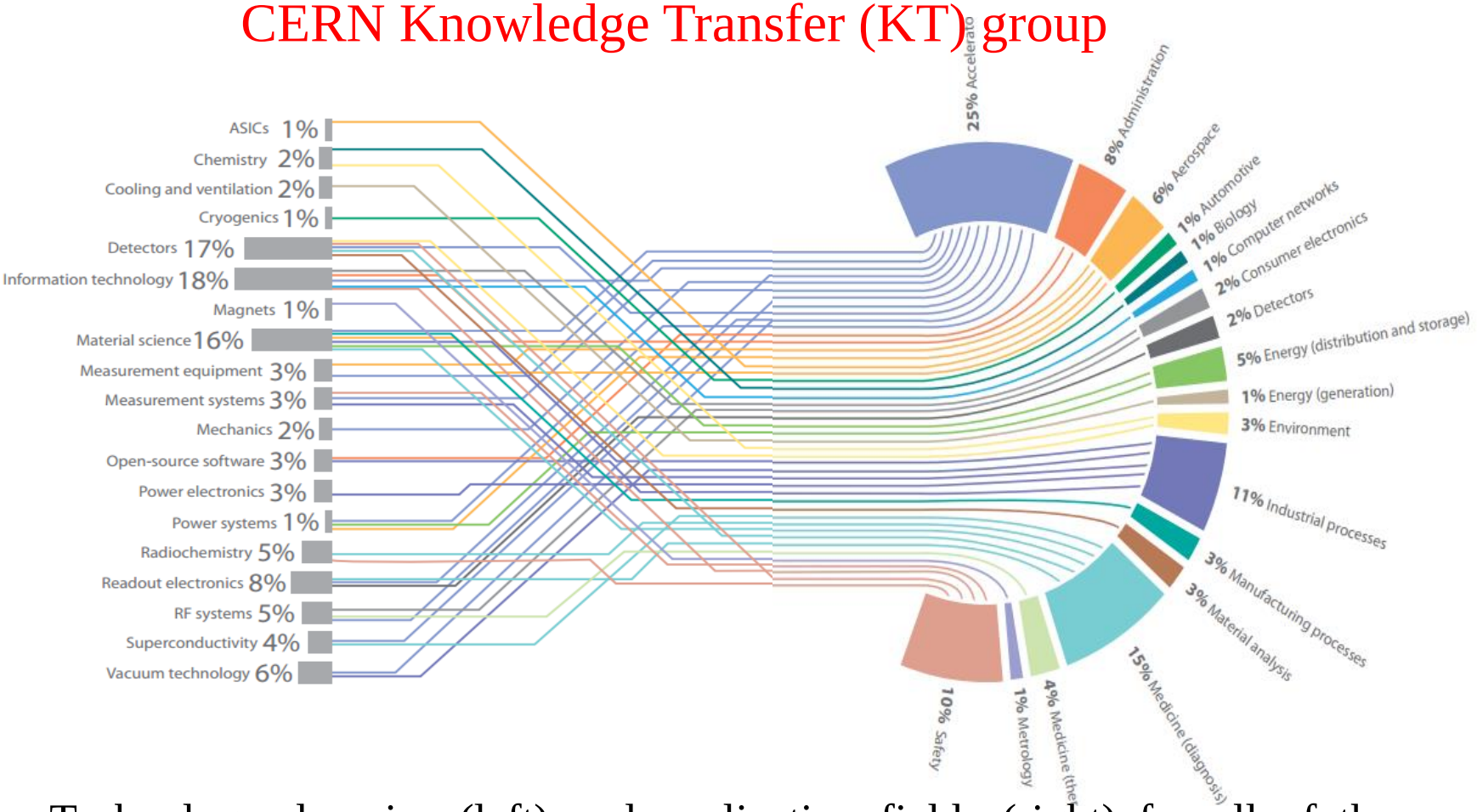
The European Network for LIGht ion Hadron Therapy

CERN Knowledge Transfer (KT) group

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



CERN 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