How High Energy Physics (HEP) technologies can transfer to industry

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Outlines

1- The largest experiment in the world Larger Hadron Collider (LHC)

2- Compact Muon Solenoid (CMS)

3- The Global Positioning Systems (GPS)

4- World Wide Web (WWW)

5- Superconducting Magnets

6- Accelerating particles

7- Detector technologies

8- Muon tomography

9- GRID computing

10- Conclusion

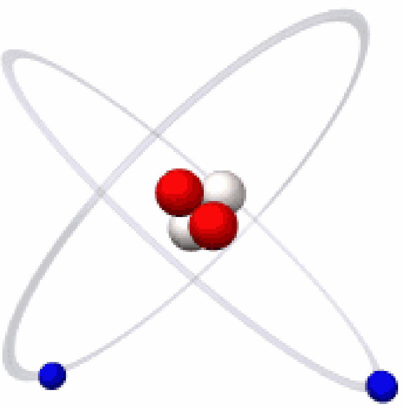
Powers of ten

The powers of ten are commonly used in physics and information technology. They are practical shorthand for very large or very small numbers.

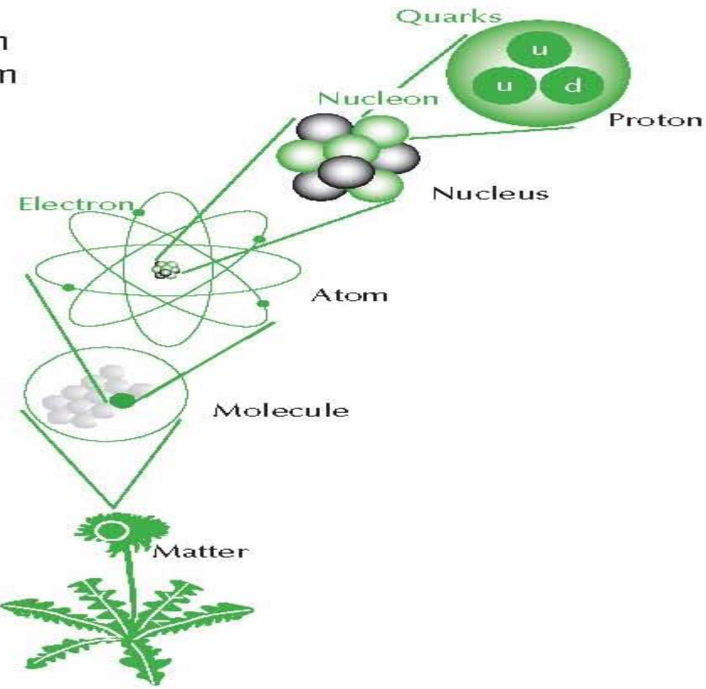
Power of ten	Number	Symbol
10^{-12}	0.000000000001	p (pico)
10^{-9}	0.000000001	n (nano)
10^{-6}	0.000001	µ (micro)
10^{-3}	0.001	m (milli)
10^{-2}	0.01	
10^{-1}	0.1	
10^{0}	1	
10^{1}	10	
10^{2}	100	
10^{3}	1000	k (kilo)
10^{6}	1 000 000	M (mega)
10^{9}	1 000 000 000	G (giga)
10^{12}	1 000 000 000 000	T (tera)
10^{15}	1 000 000 000 000 000	P (peta)

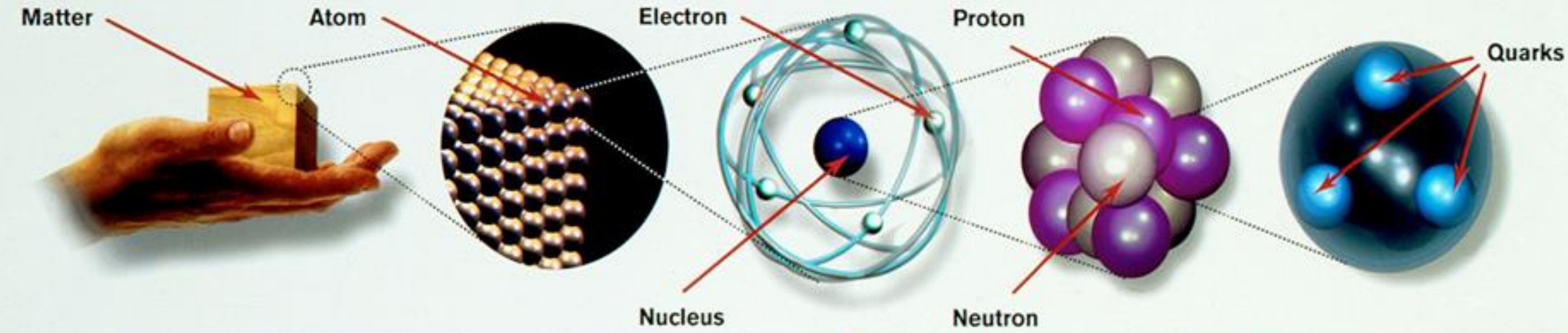
Particle physics studies the tinest objects of Nature. Looking into the very small and fundamental, it also looks very far back into time, just a few moments after the Big Bang. Here are a few examples of dimensions particle physicists deal with:

Atom: 10^{-10} m
Nucleus: 10^{-14} m
Quarks: $< 10^{-19}$ m



If the protons and the neutrons were 10 cm across, then the quarks and electrons would be less than 0.1 mm in size and the entire atom would be about 10 km across. More than 99.99% of the atom is empty space.





		LEPTONS		QUARKS	
Matter particles All ordinary particles belong to this group	FIRST FAMILY	**Electron** Responsible for electricity and chemical reactions; it has a charge of -1	**Electron neutrino** Particle with no electric charge, and possibly no mass; billions fly through your body every second	**Up** Has an electric charge of plus two-thirds; protons contain two, neutrons contain one	**Down** Has an electric charge of minus one-third; protons contain one, neutrons contain two
These particles existed just after the Big Bang. Now they are found only in cosmic rays and accelerators	SECOND FAMILY	**Muon** A heavier relative of the electron; it lives for two-millionths of a second	**Muon neutrino** Created along with muons when some particles decay	**Charm** A heavier relative of the up; found in 1974	**Strange** A heavier relative of the down; found in 1964
	THIRD FAMILY	**Tau** Heavier still; it is extremely unstable. It was discovered in 1975	**Tau neutrino** not yet discovered but believed to exist	**Top** Heavier still	**Bottom** Heavier still; measuring bottom quarks is an important test of electroweak theory

Force particles

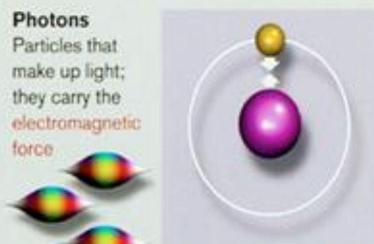
These particles transmit the four fundamental forces of nature although gravitons have so far not been discovered

Gluons
Carriers of the strong force between quarks

Felt by: quarks

The explosive release of nuclear energy is the result of the strong force

Photons
Particles that make up light; they carry the electromagnetic force



Felt by: quarks and charged leptons

Electricity, magnetism and chemistry are all the results of electro-magnetic force

Intermediate vector bosons
Carriers of the weak force

Felt by: quarks and leptons

Some forms of radio-activity are the result of the weak force

Gravitons
Carriers of gravity

Felt by: all particles with mass

All the weight we experience is the result of the gravitational force

GRAPHICS: PETER CROWTHER

Why the LHC

A few unanswered questions…

The LHC was built to help scientists to answer key unresolved questions in particle physics. The unprecedented energy it achieves may even reveal some unexpected results that no one has ever thought of!

Newton's unfinished business...
What is mass?

What is the origin of mass?

Why do tiny particles weigh the amount they do?

Why do some particles have no mass at all?

At present, there are no established answers to these questions. The most likely explanation may be found in the Higgs boson, a key undiscovered particle that is essential for the Standard Model to work.

An invisible problem...

What is 95% of the universe made of?

Everything we see in the Universe, from an ant to a galaxy, is made up of ordinary particles. These are collectively referred to as matter, forming 4% of the Universe. Dark matter (~25%) and dark energy(~70%) are believed to make up the remaining proportion!

Why is there no more antimatter?

We live in a world of matter – everything in the Universe, including ourselves, is made of matter. *Antimatter* is like a twin version of matter, but with opposite electric charge. At the birth of the Universe, equal amounts of matter and antimatter should have been produced in the Big Bang.

Why does Nature appear to have this bias for matter over antimatter?

Hidden worlds…

Do extra dimensions of space really exist?

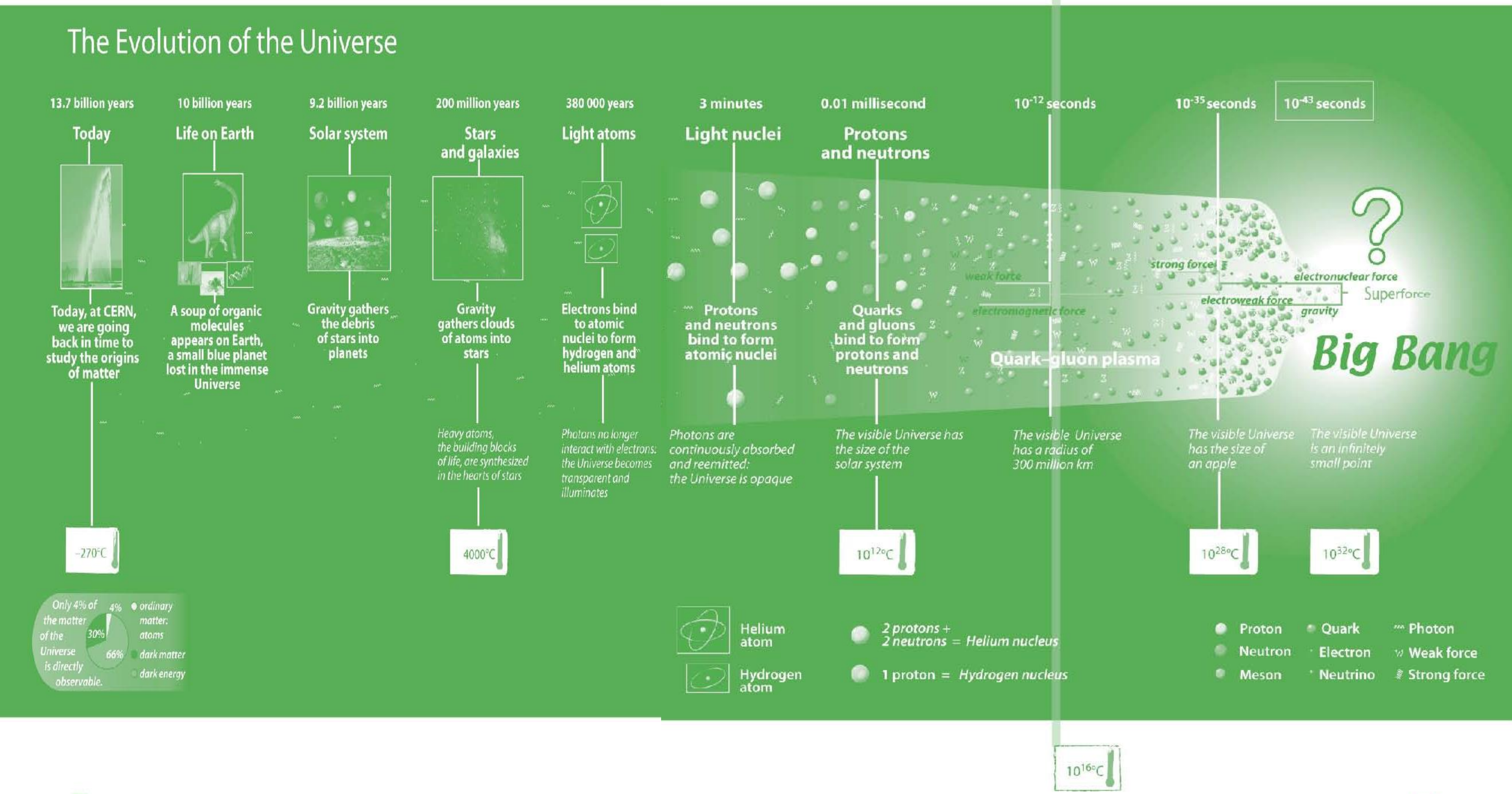
- Einstein showed that the three dimensions of space are related to time.
- Subsequent theories propose that further hidden dimensions of space may exist;

Secrets of the Big Bang

What was matter like within the first second of the Universe’s life?

Back to the Big Bang

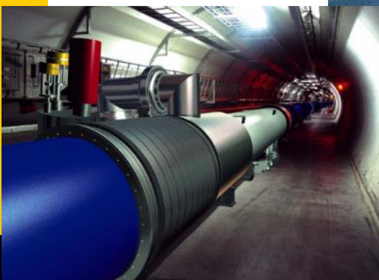
The energy density and temperature that will be made available in the collisions at the LHC are similar to those that existed a few moments after the Big Bang. In this way physicists hope to discover how the Universe evolved.

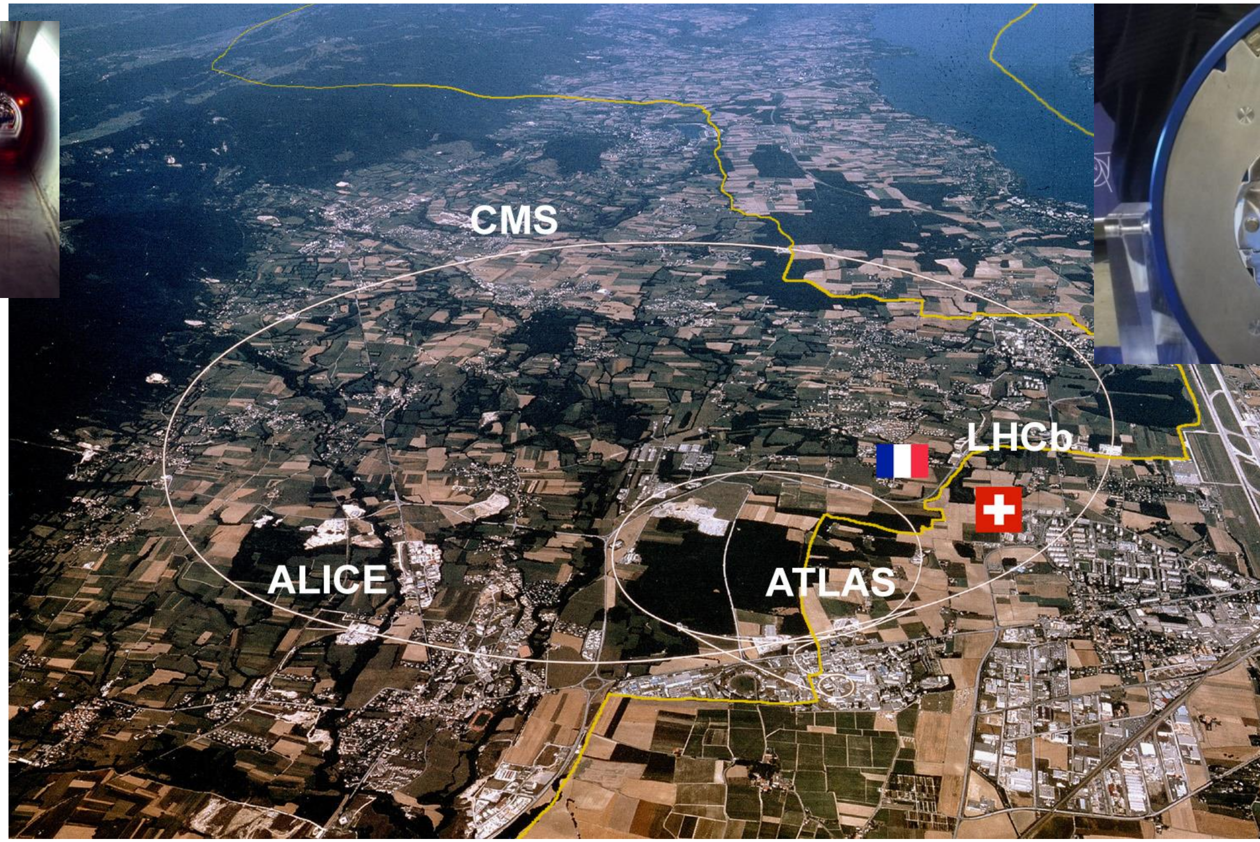


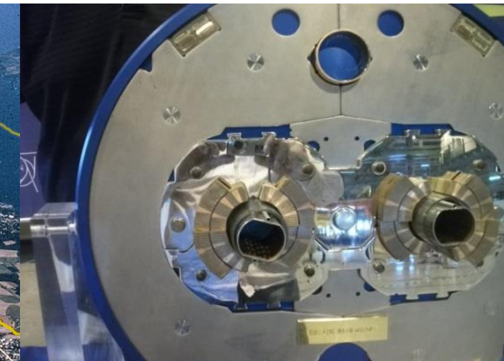
What does LHC stand for?

LHC stands for Large Hadron Collider. **Large** due to its size (approximately 27 km in circumference), **Hadron** because it accelerates protons or ions, which are hadrons, and **Collider** because these particles form two beams travelling in opposite directions, which collide at four points where the two rings of the machine intersect.

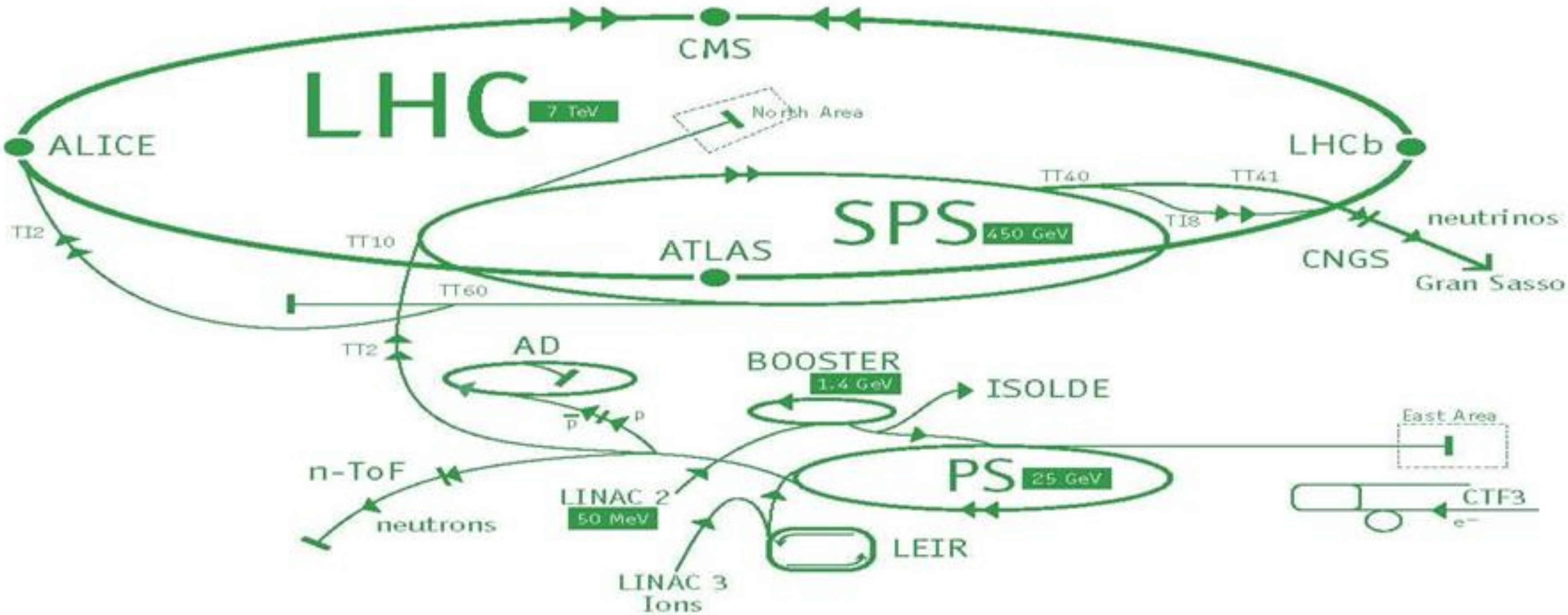
Large Hadrons Collider







LHC is the world’s largest and most powerful particle accelerator. It first started up on 10 September 2008. The LHC consists of a 27-kilometre ring of superconducting magnets with a number of accelerating structures to boost the energy of the particles along the way.



Kinetic energy of a proton (K)	Speed (%c)	Accelerator
50 MeV	31.4	Linac 2
1.4 GeV	91.6	PS Booster
25 GeV	99.93	PS
450 GeV	99.9998	SPS
7 TeV	99.9999991	LHC

Relationship between kinetic energy and speed of a proton in the CERN machines. The rest mass of the proton is 0.938 GeV/c^2

The following table lists the important parameters for the LHC.

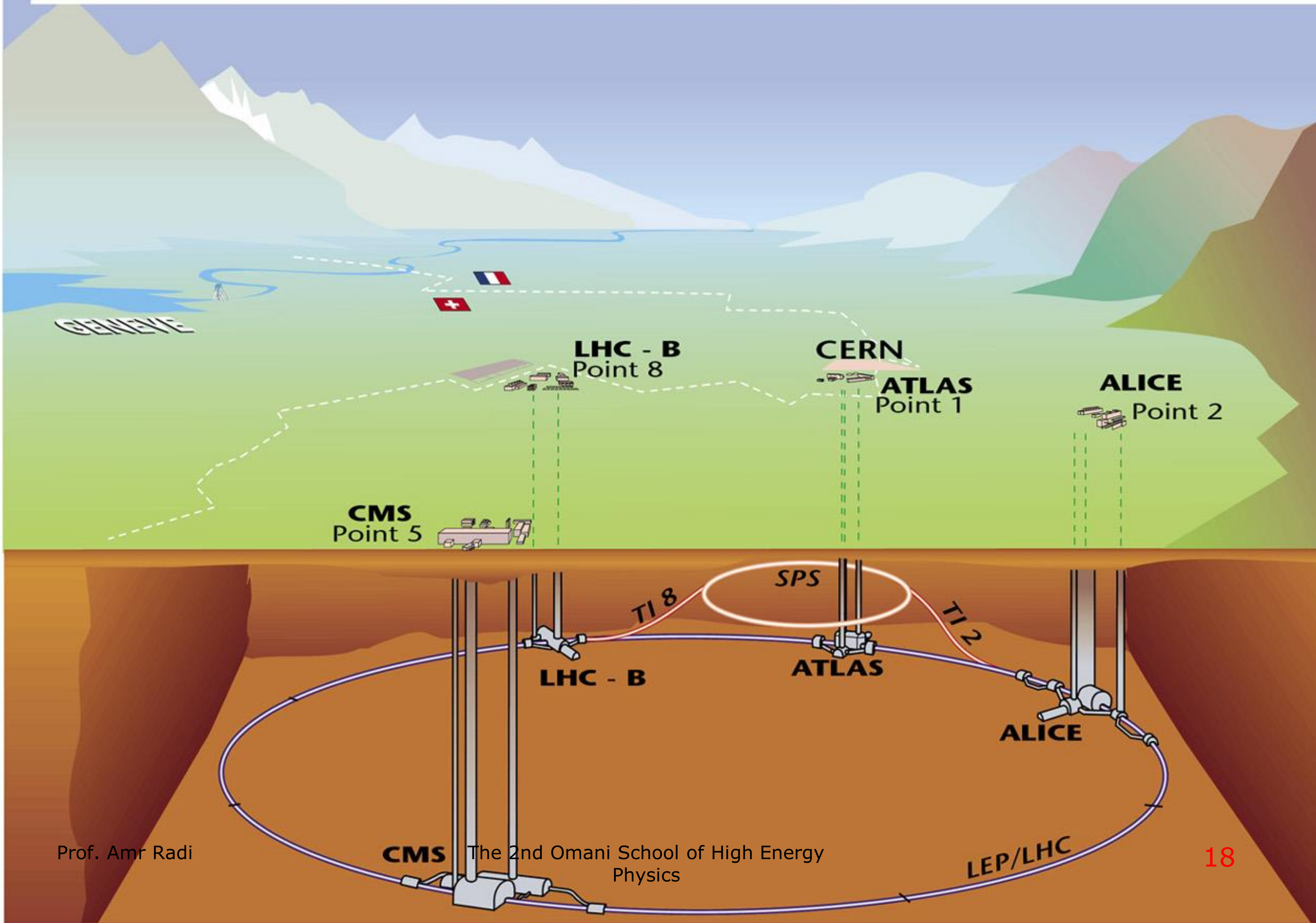
Quantity	number
Circumference	26 659 m
Dipole operating temperature	1.9 K (-271.3°C)
Number of magnets	9593
Number of main dipoles	1232
Number of main quadrupoles	392
Number of RF cavities	8 per beam
Nominal energy, protons	7 TeV
Nominal energy, ions	2.76 TeV/u (*)
Peak magnetic dipole field	8.33 T
Min. distance between bunches	~7 m
Design luminosity	10^{34} cm^{-2} s^{-1}
No. of bunches per proton beam	2808
No. of protons per bunch (at start)	1.1×10^{11}
Number of turns per second	11 245
Number of collisions per second	600 million

(*) Energy per nucleon


BW
ROCLA
L
ROCL

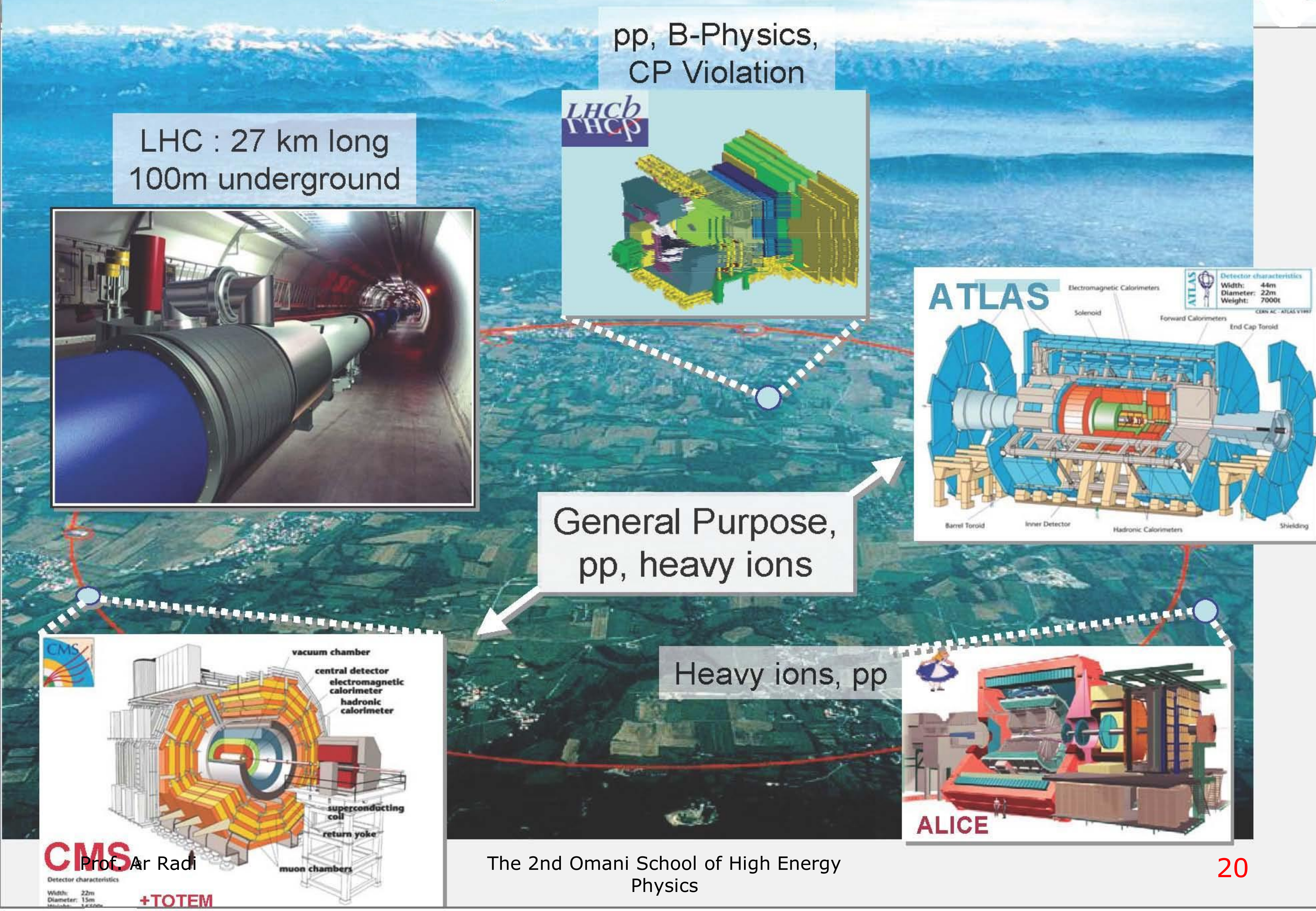

B2

Overall view of the LHC experiments.



LHC (Large Hadron Collider)

Towards physics at CERN with LHC



What is CMS?

CMS is a general-purpose detector designed to cover the widest possible range of physics at the LHC, from the search for the Higgs boson to supersymmetry (SUSY) and extra dimensions.

Size	21 m long, 15 high m and 15 m wide.
Weight	12 500 tonnes
Design	barrel plus end caps
Material cost	500 MCHF
Location	Cessy, France.

For more information, visit: http://cmsinfo.cern.ch/outreach/

The CMS Collaboration

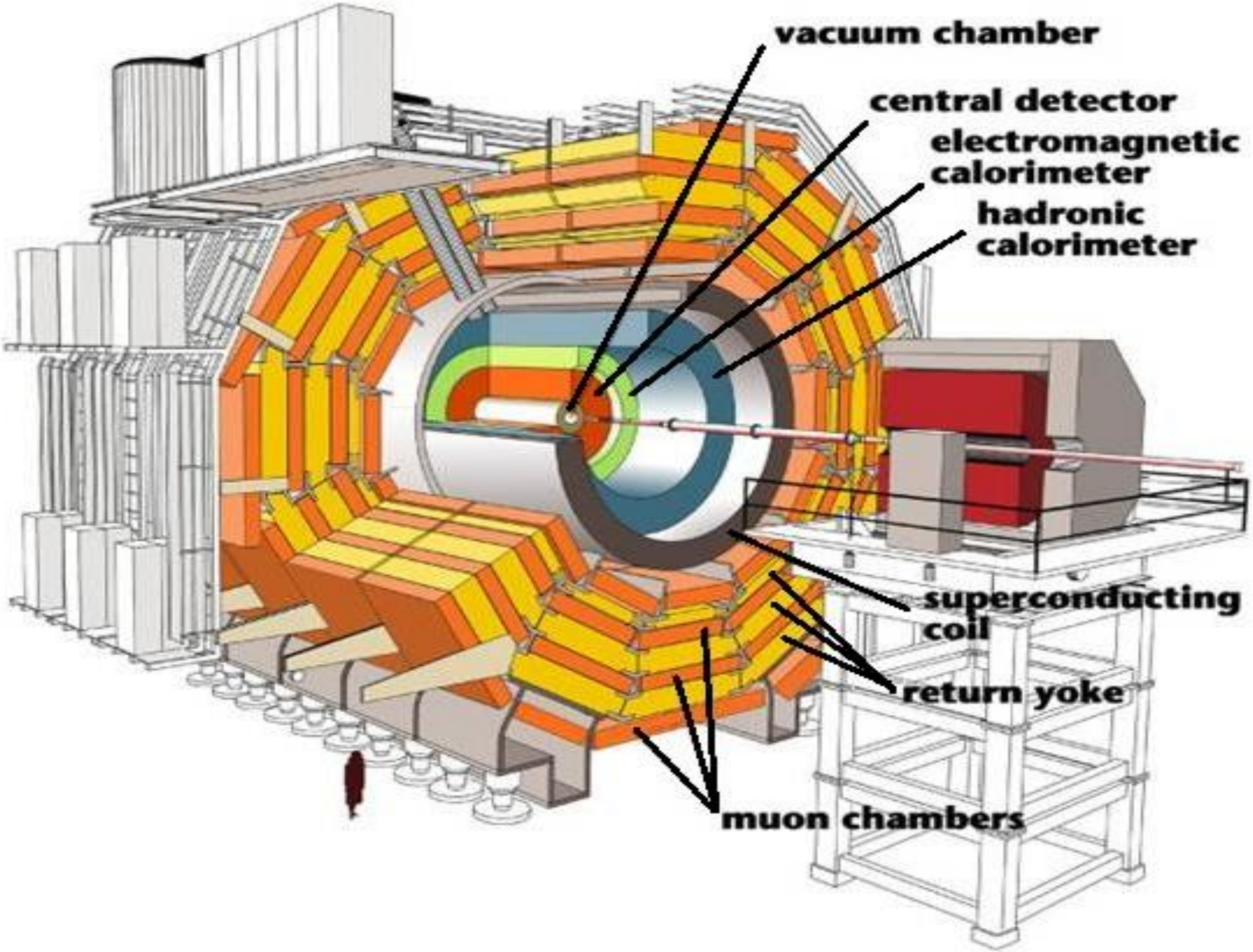
caveat: map is not up to date

Collaboration of institutes

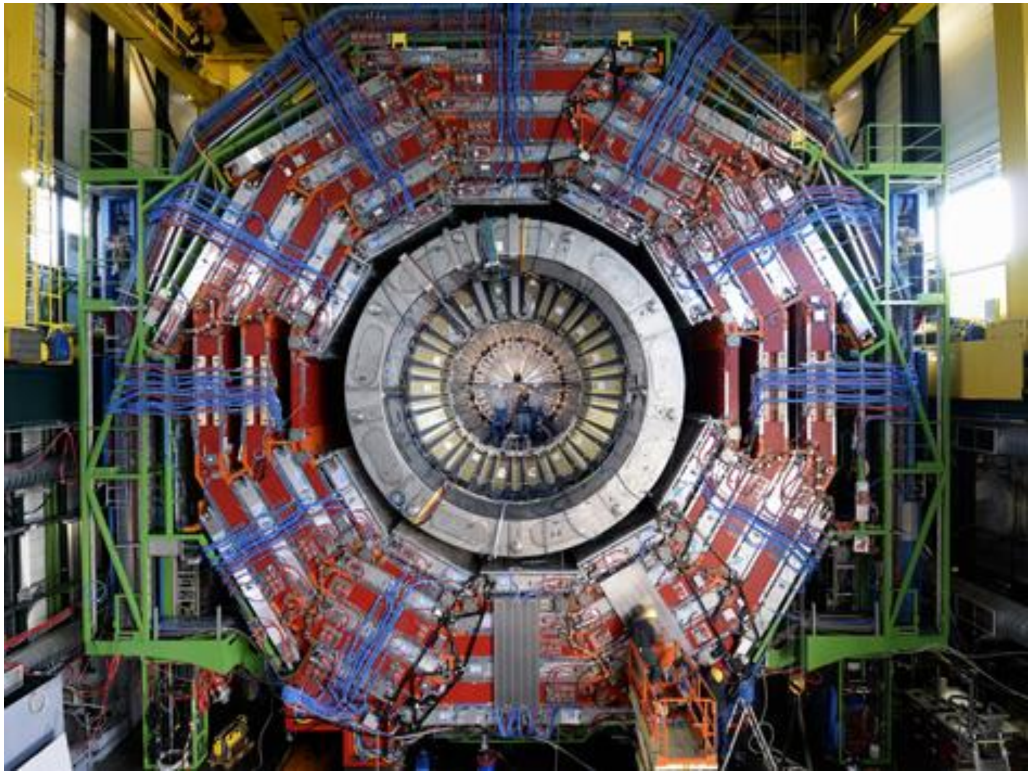
42 countries	183 institutes
1900 PhD physicists	950 PhD students
690 undergrads	850 engineers

(~ 83% men, ~ 17% women)

https://cms-users.web.cern.ch/cms-users/cms/Management/Stats/stats.html

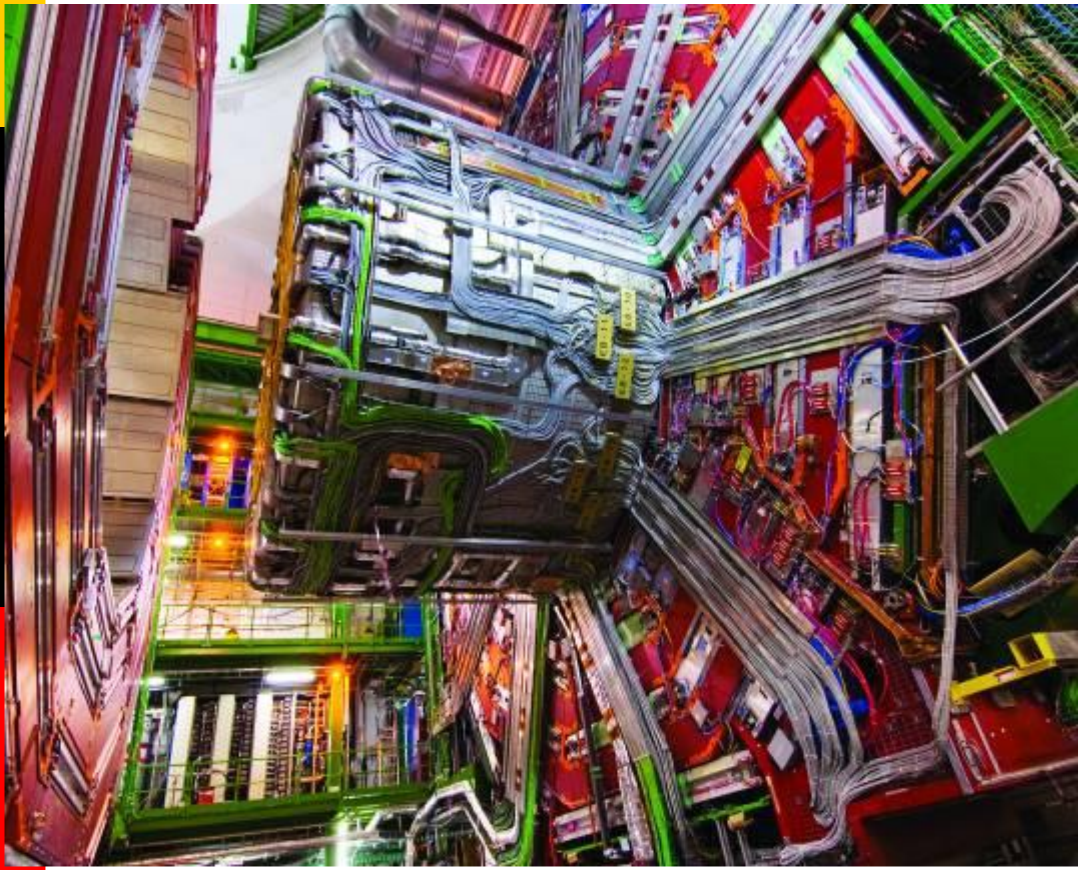

vacuum chamber
central detector
electromagnetic calorimeter
hadronic calorimeter
superconducting coil
return yoke
muon chambers

Using the **largest and most complex detectors** ever built



To select and record the signals from the 600 million proton collisions every second, CERN scientists are building huge detectors to measure the tiny particles to an extraordinary precision.

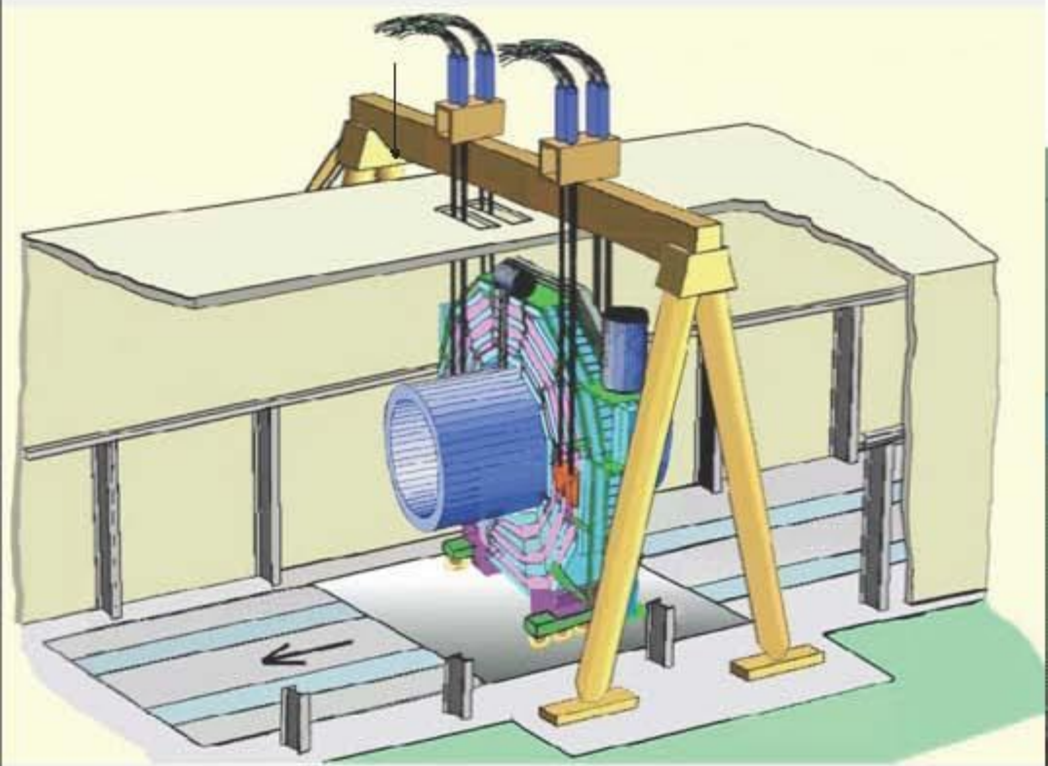
…is built with incredible **precision…**



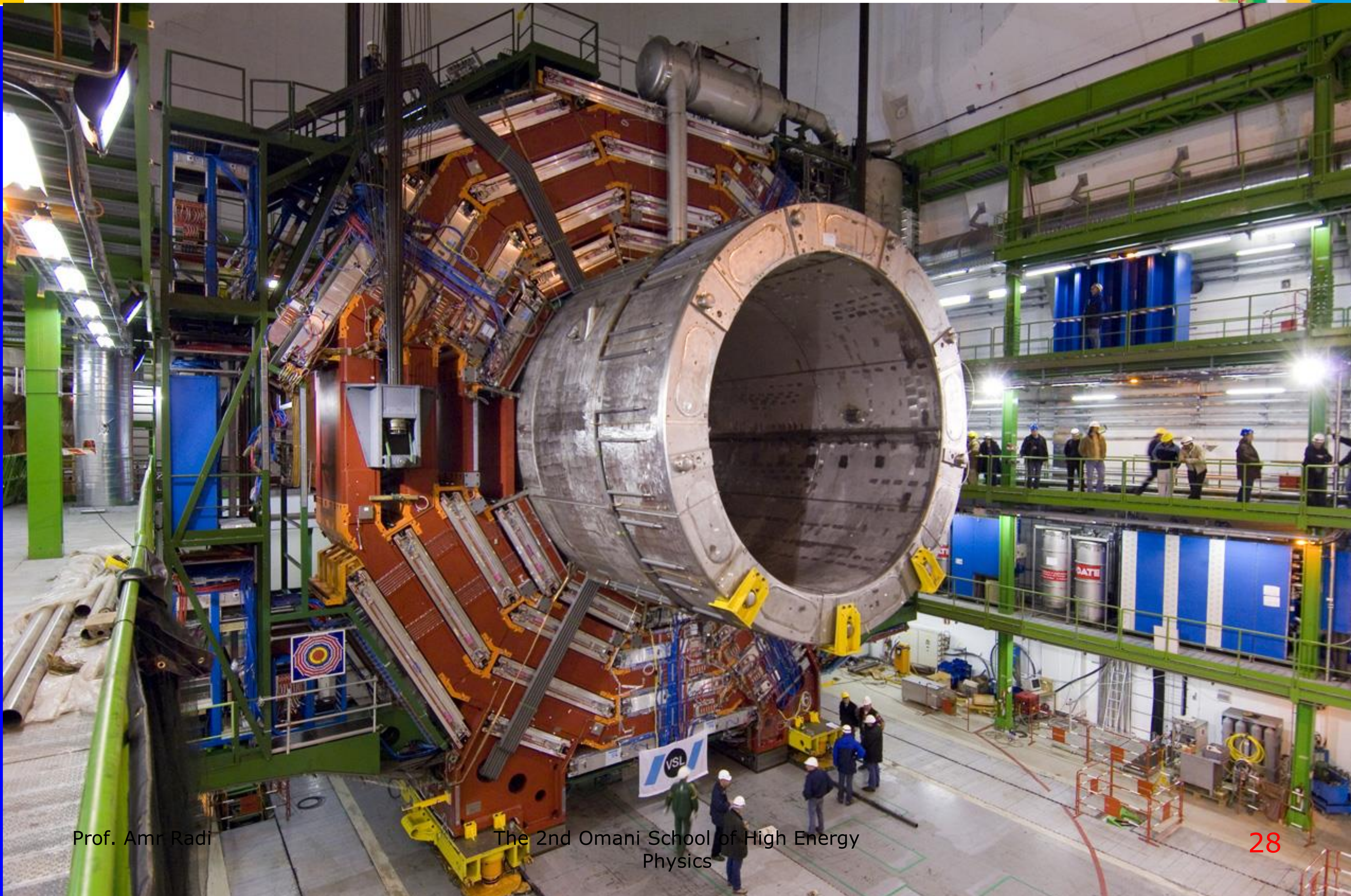
- Like a 75 million pixel 3D camera taking 40 million photos per second
- Cabling this central section too ~200 people 6 months!

Transfer CMS Underground

Gantry installed over PX56.



…on the surface and lowered 100m underground!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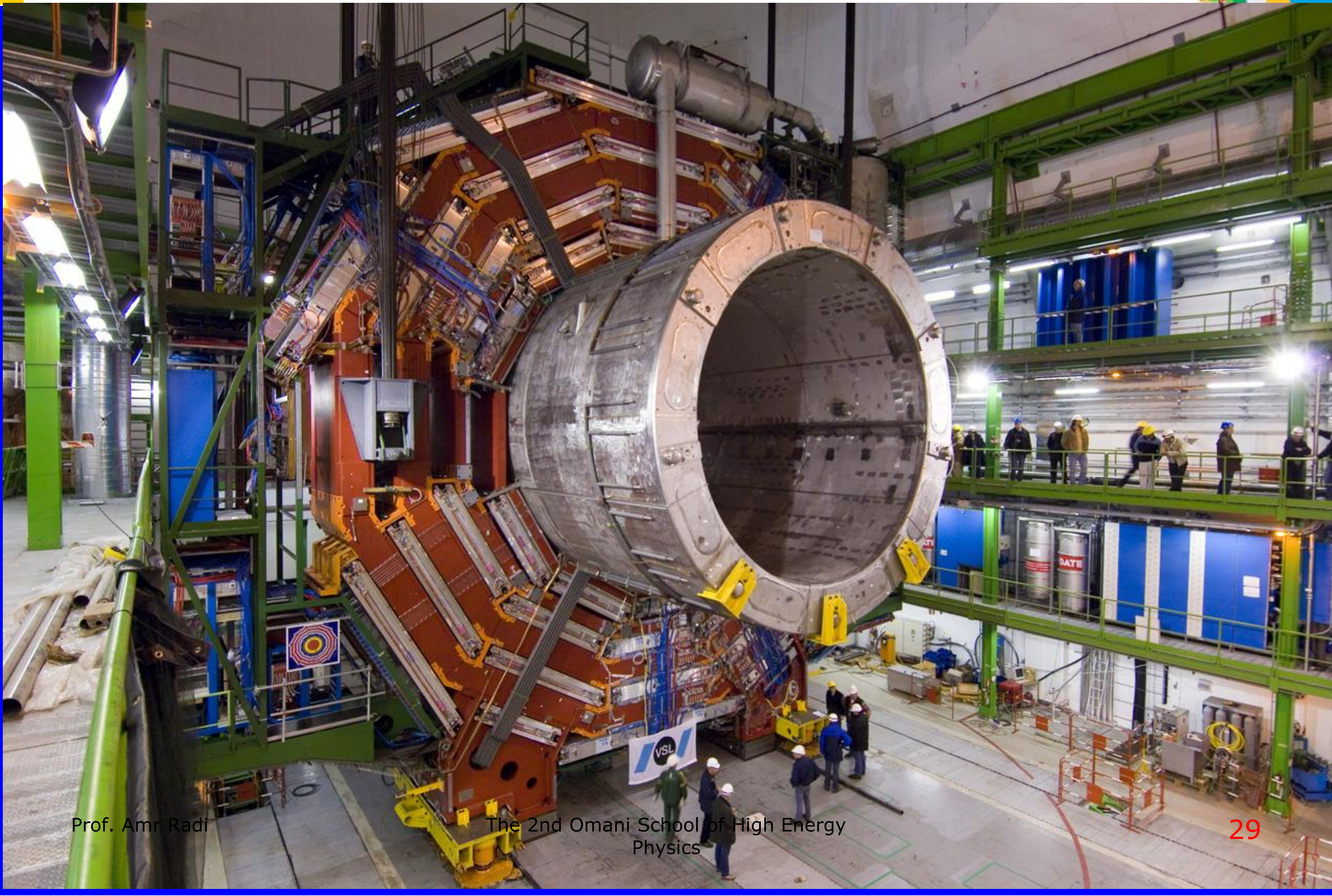
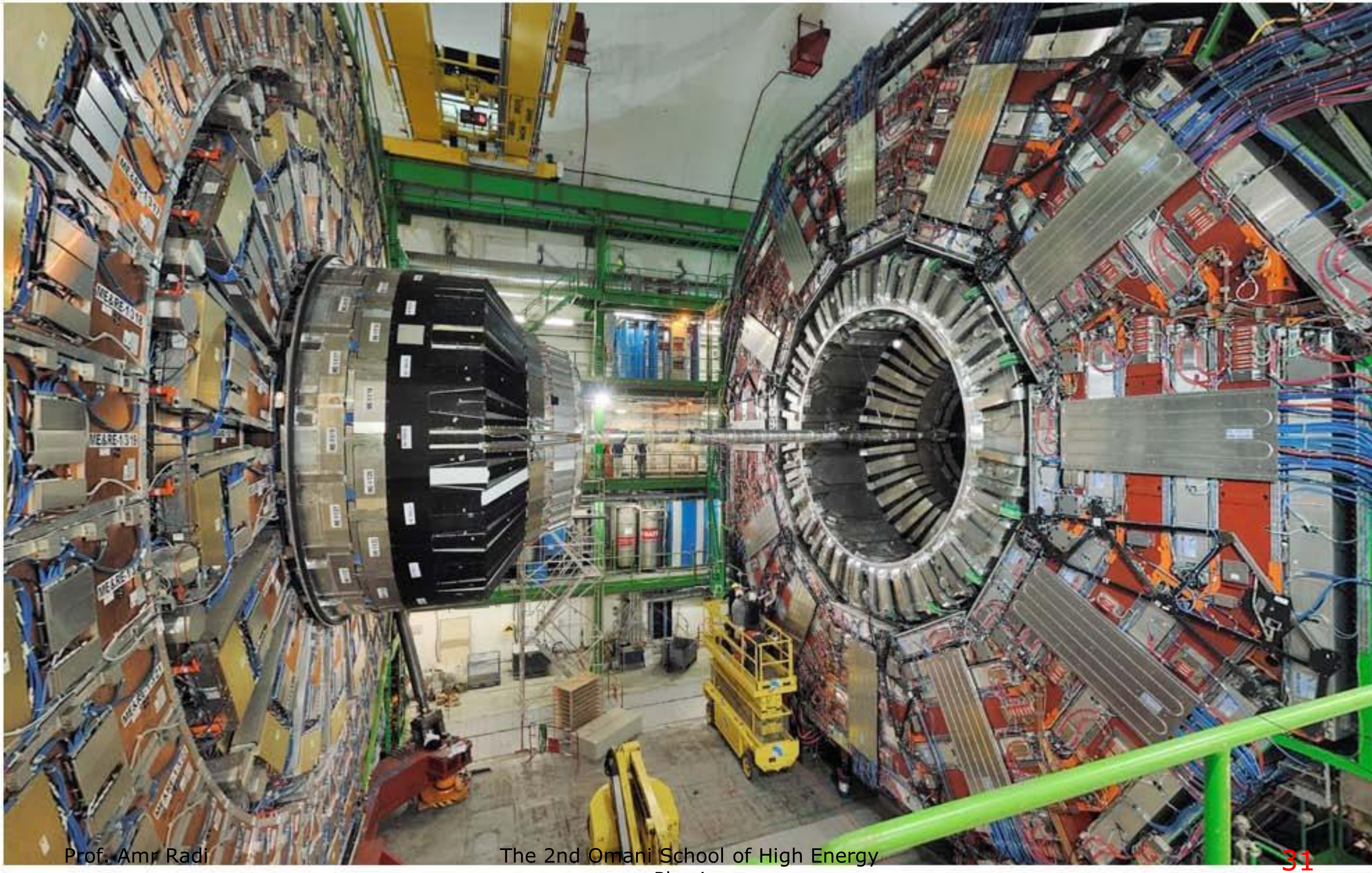

VSL
DATE

Central beam pipe installation

Ready to close



http://cms.web.cern.ch/cms/index.html

Activities in Sultan Qaboos University

- SQU-CMS research group (12 P, 2 CS, 1 ME)
- The Letter of Agreement (Expression Of Interest **EOI**) between College of Science at **SQU** and **CMS** was signed on 10th July 2015.
- In September 2016, CMS experiment (CERN) agreed to upgrade the agreement to be cooperation member in CMS for 2-3 years
- First training workshop in high energy physics from 7/2/2017 to 12/2/2017.
- The 2nd Omani School of High Energy Physics (including training workshop) from 28/3/2018 to 3/4/2018 .

Activities in Sultan Qaboos University

CERN visiting/research for Students

- Each year one of our students attended the CERN summer student program in 2015, 2016
- Eight students attended the CERN summer student program from 15/6/2017 to 31/8/2017.
- Ten students will attend the CERN summer student program from 25/6/2018 to 31/8/2018.
- 4 M.Sc. (two awarded their degrees) and 3 Ph.D. students (one is registered and 2 are preregistered) are working in CERN projects.

Activities in Sultan Qaboos University

CERN visiting/research for Staff

- Albert De Roeck (CERN senior) visited SQU in 9/12/2014 and from 16/4/2017 to 18/4/2017.
- Mohammed Attia (CERN senior) visited SQU as consultant from 10/9/2017 to 5/1/2018.
- Mudhahir Al-Ajmi and Amr Radi attend CMS week meeting collaboration in Geneva (CERN) from 2/4/2017 until 8/4/2017 and from 19/6/2016 until 25/6/2016.
- Amr Radi attended shifts and activities in CMS (CERN) from 15/7/2016 until 31/8/2016 and from 30/6/2017 until 30/8/2017.

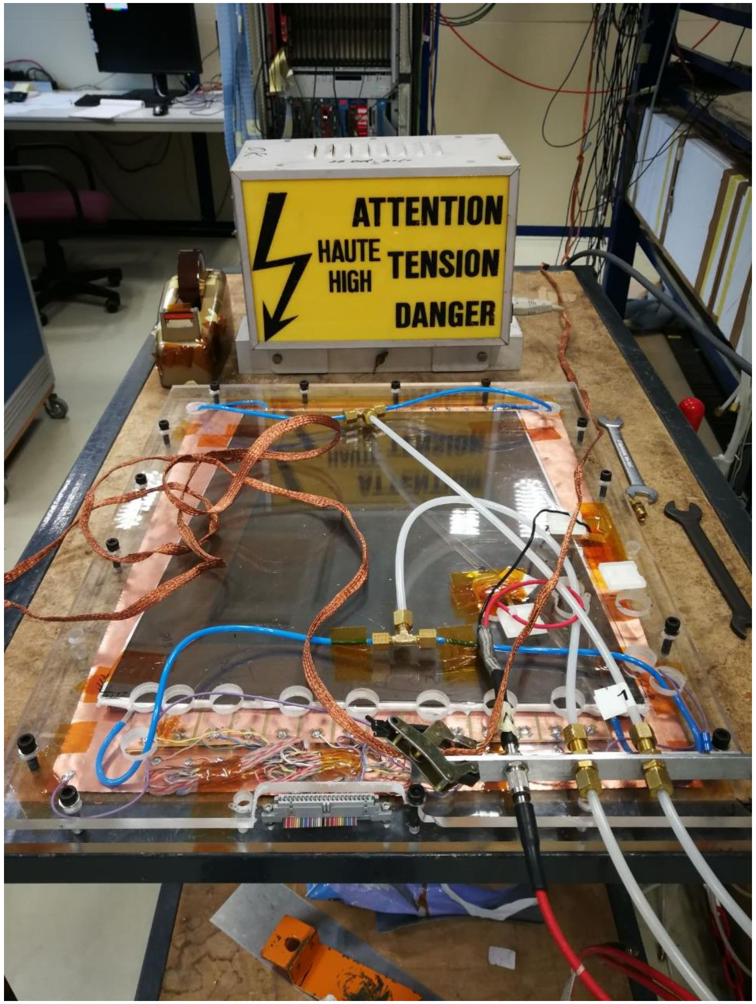
Activities in Sultan Qaboos University

Projects are running/Papers

- Amr Radi (college of sciences) has a project (Muon detector) with Prof. Gabriella Pugliese (CMS manager).
- Riadh Zaier (college of engineering) has a project (CMS robotics deign) with Prof. Martin.Gastal (CMS manager).
- Twenty papers published in international journals with SQU affiliation since 2015 (one paper published in Nature journal).

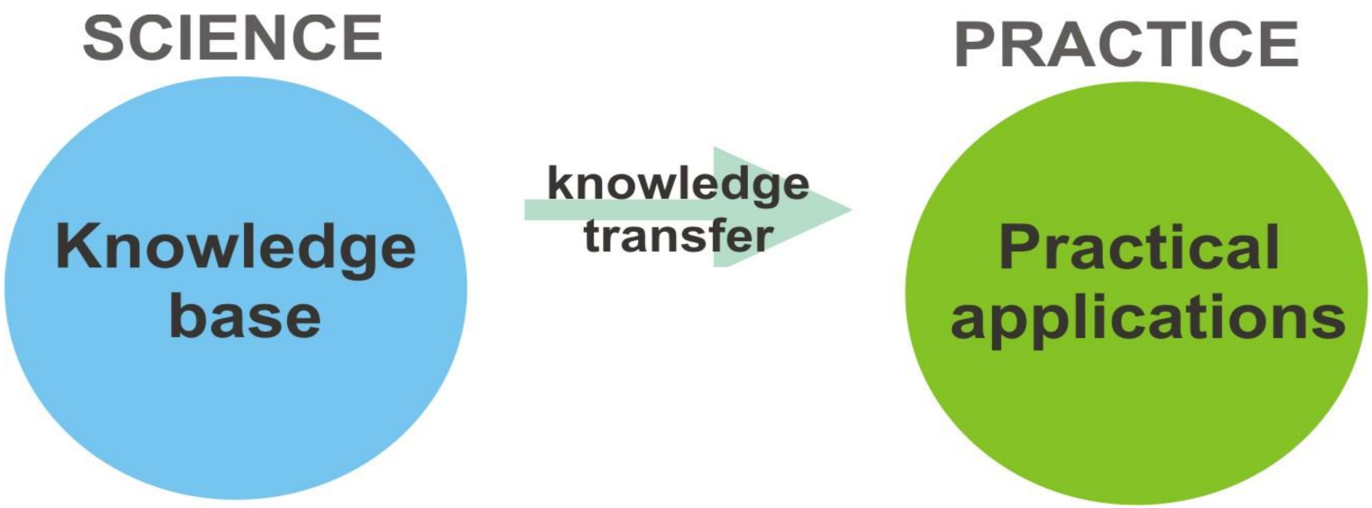
“In side the LHC”

SQU RPS designing and assembling



8 mins discussion questions

HEP technologies and transfer to industry



GPS

Physics underpins so much of modern life

The global positioning systems (GPS) that are used to achieve pinpoint position accuracy in today's most modern vehicles depend **on general relativity, Einstein's theory of gravity.**

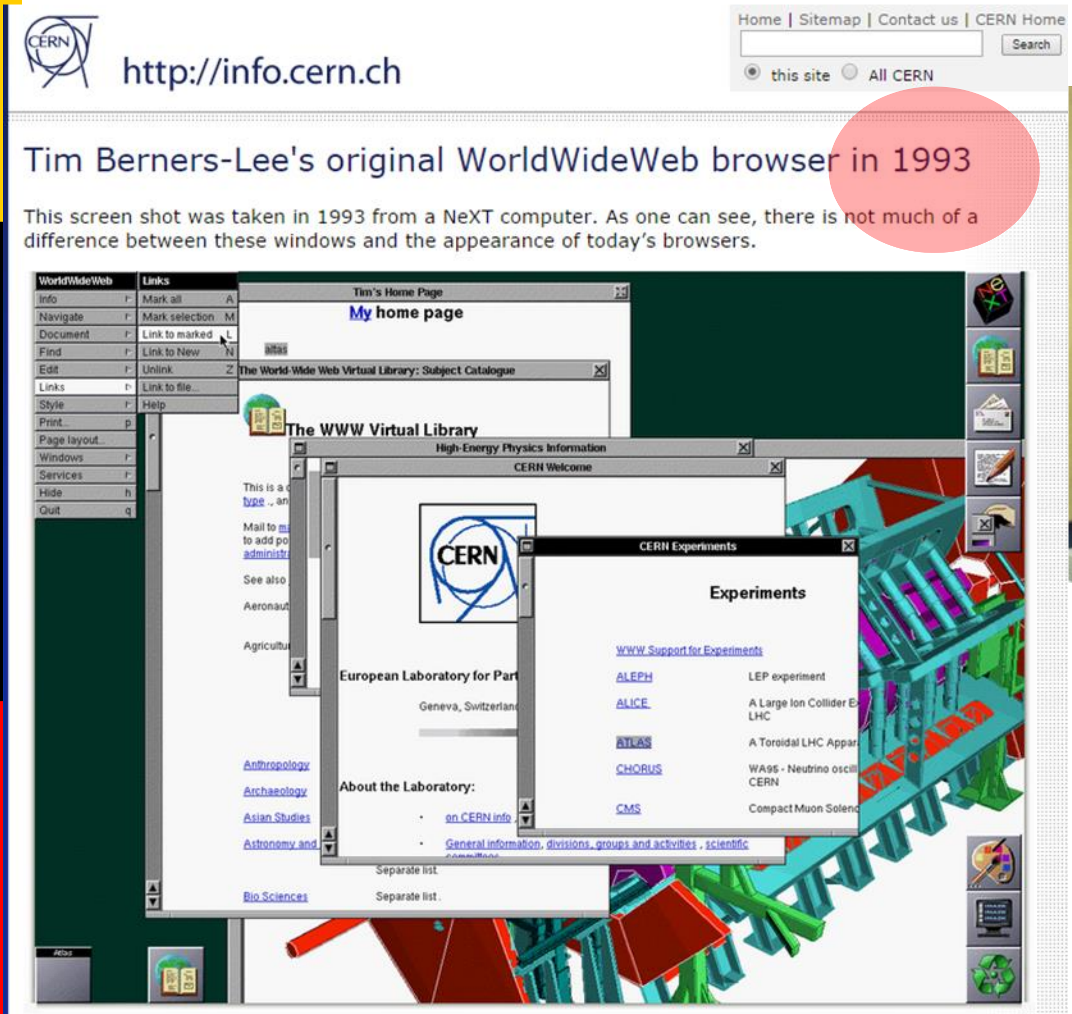
GPS

Physics underpins so much of modern life

Einstein's general relativity theory says that **gravity** curves space and time, resulting in a tendency for the orbiting clocks to tick **slightly faster**, by about **45 microseconds per day**. ... Without the proper application of **relativity**, **GPS** would fail in its navigational functions within about 2 minutes

A milestone case

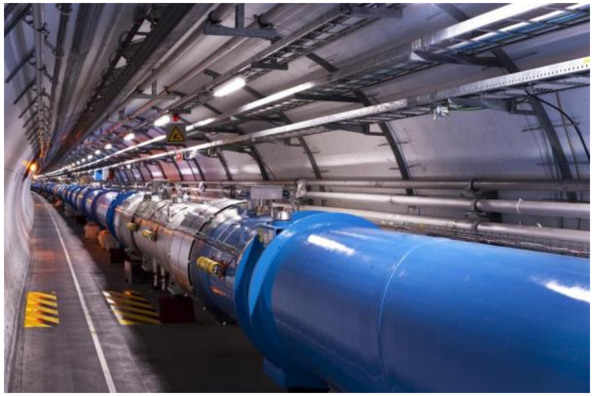
World Wide Web (WWW)



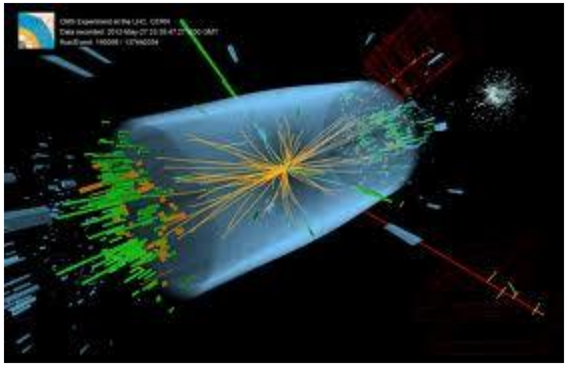
Tim Berners Lee with his NeXT computer that he used to **invent the World Wide Web**

HEP technologies

Accelerating particle beams



Detecting particles



Large scale computing (Grid)

HEP technologies

Accelerating particles

LARGE HADRON COLLIDETR

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

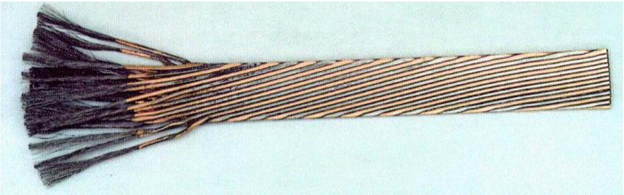
To reach the required energy in the existing 27 km tunnel, the super conducting magnets operate at **83 Kilogauss** (200’000 x Earth’s field) in super fluid helium.

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

HEP technologies

Superconducting Magnets

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

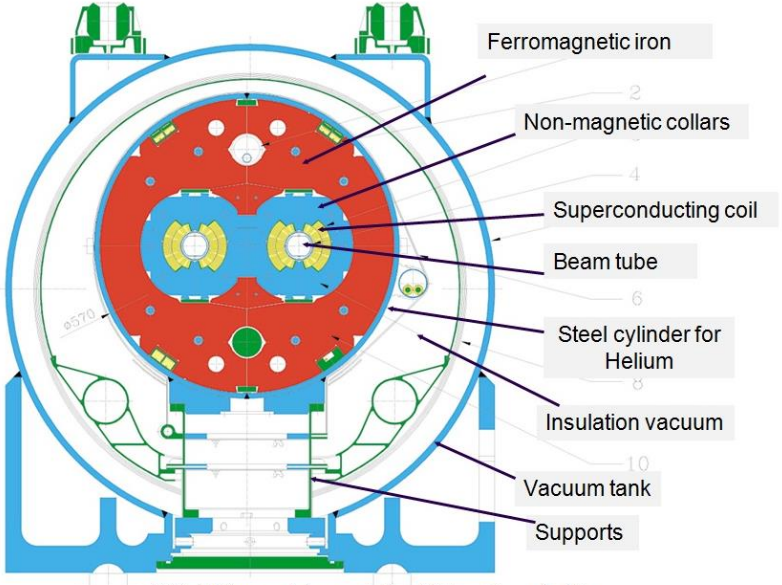


Vacuum
(10^{-13} atm)

Cryogenics
(1.9 K)

Superconductivity
(12kA)

Magnets
(8 T)

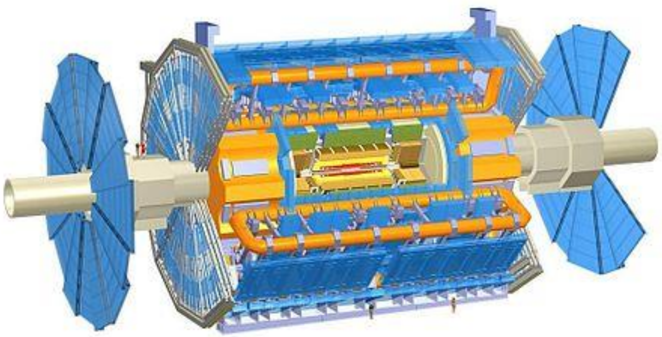


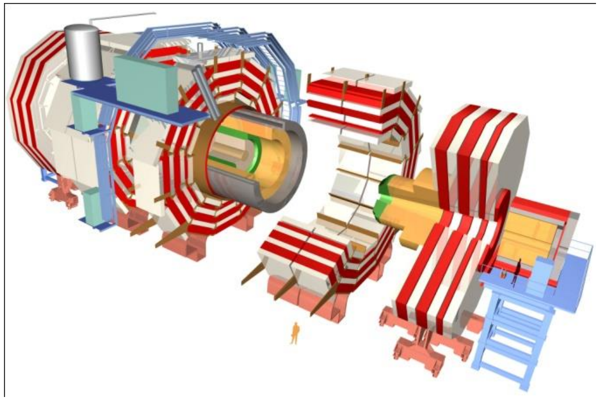
Weight (magnet + cryostat) ~ 30 tons, Length 15 m

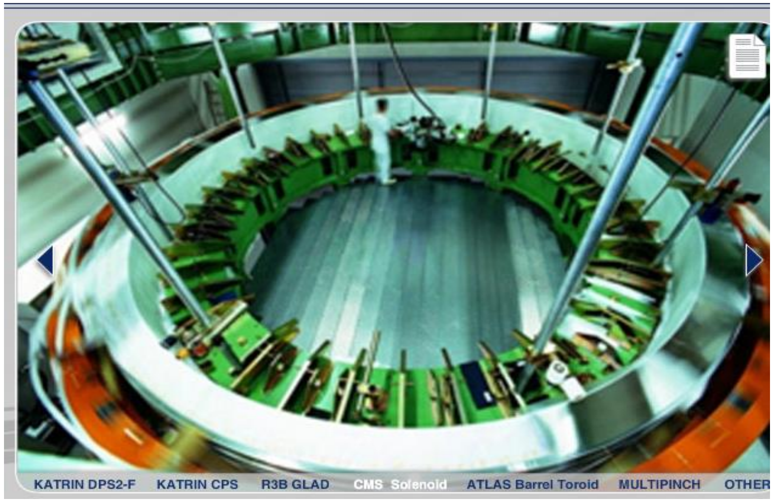
HEP technologies

Superconducting Magnets

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







Transfer to industry: ANSALDO

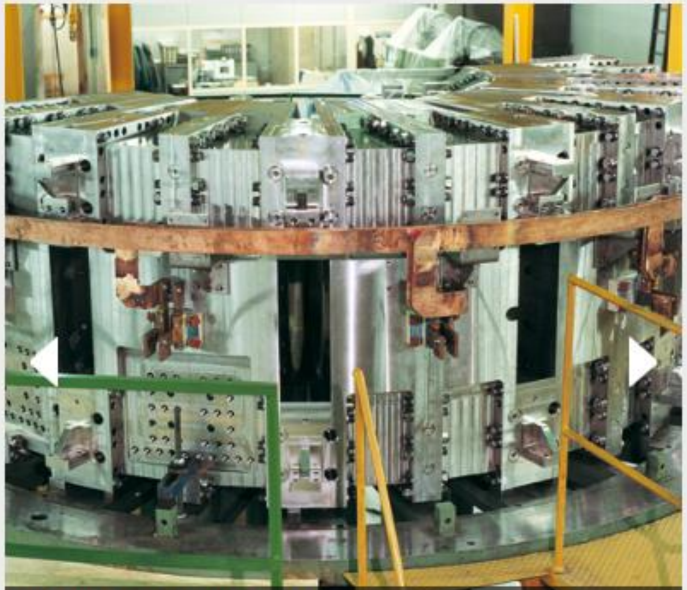
Magnets for nuclear fusion

The production of clean energy through nuclear fusion, which reconciles the energy needs of the modern world while safeguarding the environment, is a challenge that researchers and industries have been striving to meet.

The quality of ASG's nuclear fusion offering is the result of unequalled technical and productive expertise. ASG magnets have been used in all the main fusion experiments undertaken so far in Europe. ASG plays a leading role - as a supplier of magnets - in ITER (Europe) and JT-60SA (Japan), the two principal research projects which aim to study the feasibility of producing clean energy by replicating the process that takes place in the sun and stars.

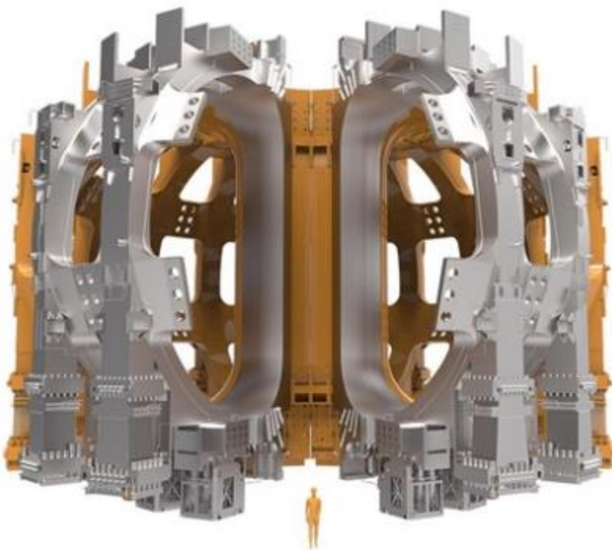
For nuclear fusion ASG produces:

- superconducting and resistive toroidal coils
- superconducting and resistive poloidal coils
- coils for divertors
- Central SC and resistive solenoid coils
- ELM coils
- Stellarator coils
- Gyrotron system coils.



FTU Toroidal coils modules assembly

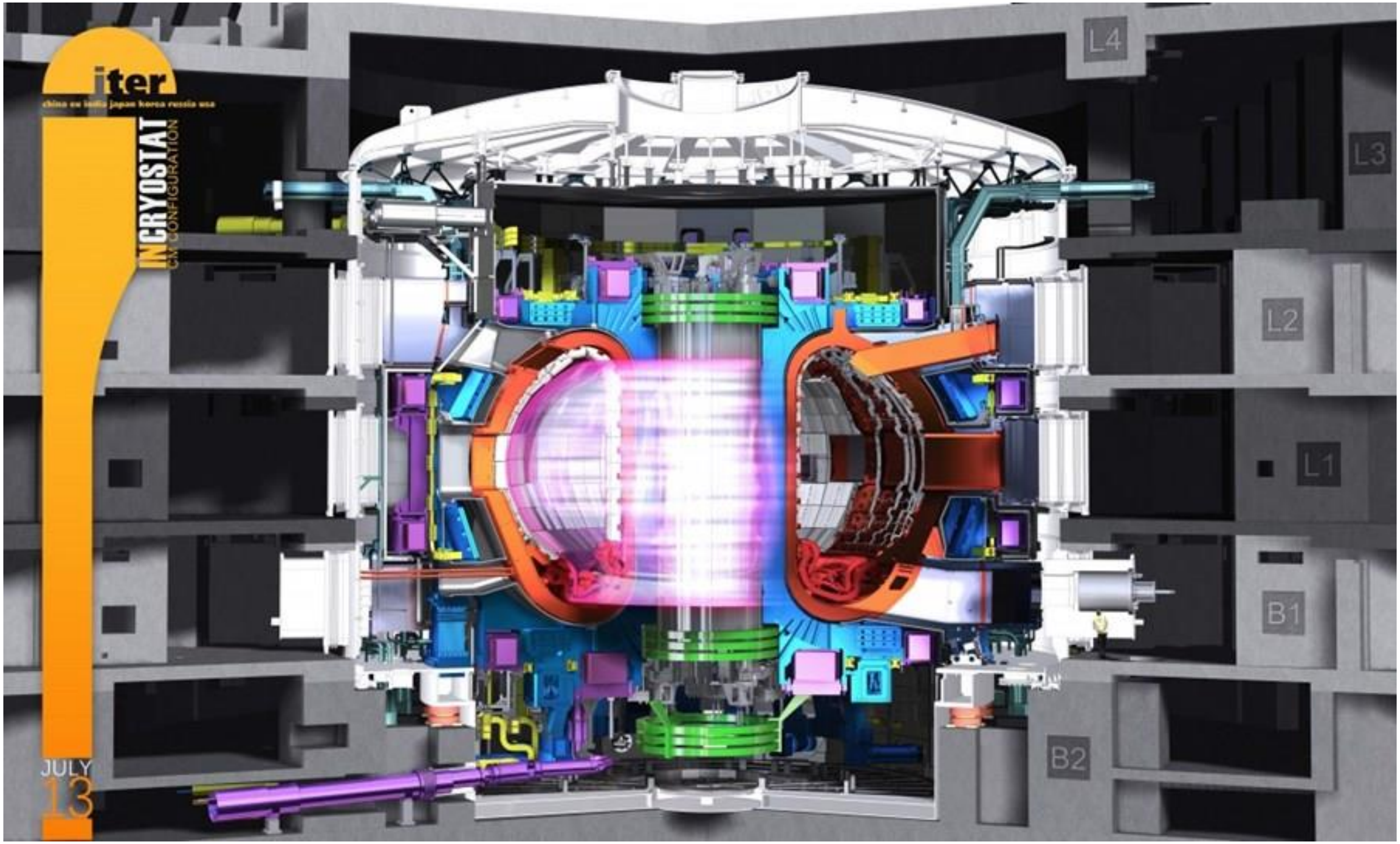
The ITER ("The Way" in Latin) **magnet** (fusion power) is one of the most motivated energy projects in the world today.



Eighteen "D"-shaped toroidal field magnets placed around the vacuum vessel produce a magnetic field whose primary function is to confine the plasma particles.

The toroidal field coils are designed to produce a total magnetic energy of 41 gigajoules and a maximum magnetic field of 11.8 tesla. Weighing 310 tonnes each, and measuring 9 x 17 m, they are among the largest components of the ITER machine.

The ITER magnet (fusion power)



HEP technologies

Superconducting Magnets

Transfer to industry: ANSALDO

Magnets for medical applications

CNAO HEBT and MEBT corrector magnets

Superconducting technologies and magnets are increasingly finding application in medical diagnostics and therapies.

Over the past 10 years, ASG has invested and created true innovation through its subsidiaries Columbus Superconductors and Paramed Medical Systems. Columbus produces an innovative superconducting "high temperature" cable using the peculiar characteristics of magnesium diboride (MgB_2), while Paramed operates in the healthcare sector for which it has realized an open, cryogen-free magnetic resonance system that reduces patients' sense of claustrophobia and allows for "load bearing "diagnostic analysis of patients.

Superconducting magnets are also used in hadron therapy and proton therapy for the treatment of numerous types of tumor. ASG supplied its magnets to the synchrotron at Pavia's CNAO as well as to the first of a series of synchro-cyclotron machines for IBA.

Capitalizing on skills and experiences derived from industrial collaborations, ASG is able to design and build the following types of magnets for medical diagnostics:

HEP technologies

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

Using this vacuum technology, CERN has developed an evacuable flat solar panel that collects direct and diffused sunlight at temperatures as high as 350^{o}C, even at latitudes above the 45th parallel.

The industrial market for accelerator in 2010

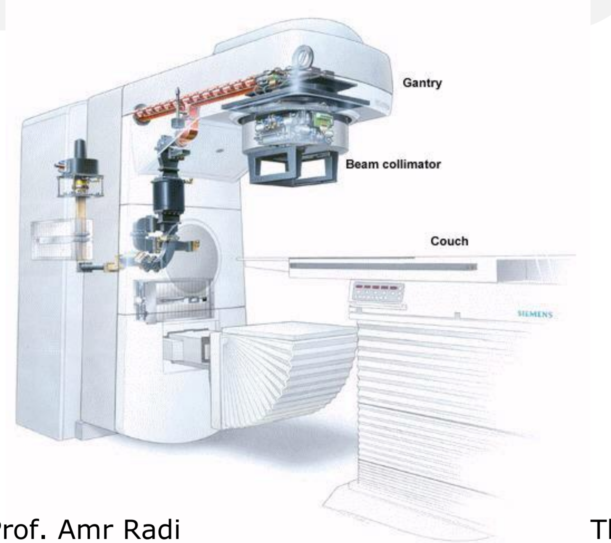
Application	Total systems	Systems sold/year	Sales/year (€ million)	System price (€ million)
Cancer therapy	9,100	500	1,800	2.0 - 5.0
Ion implantation	9,500	500	1,400	1.5 - 2.5
e^- welding & cutting	4,500	100	150	0.5 - 2.5
e^- and X-ray irradiators	2,000	75	130	0.2 - 8.0
Radioisotopes	550	50	70	1.0 - 30
Non-destructive testing	650	100	70	0.3 - 2.0
Ion analysis	200	25	30	0.4 - 1.5
Neutron generators	1,000	50	30	0.1 - 3.0
Total	**27,000**	**1,400**	**3,680**	

HEP technologies

There are many medical application of accelerators

Basic type of accelerators

-Linear
-Cyclotron
-Betatron
-Synchrotron

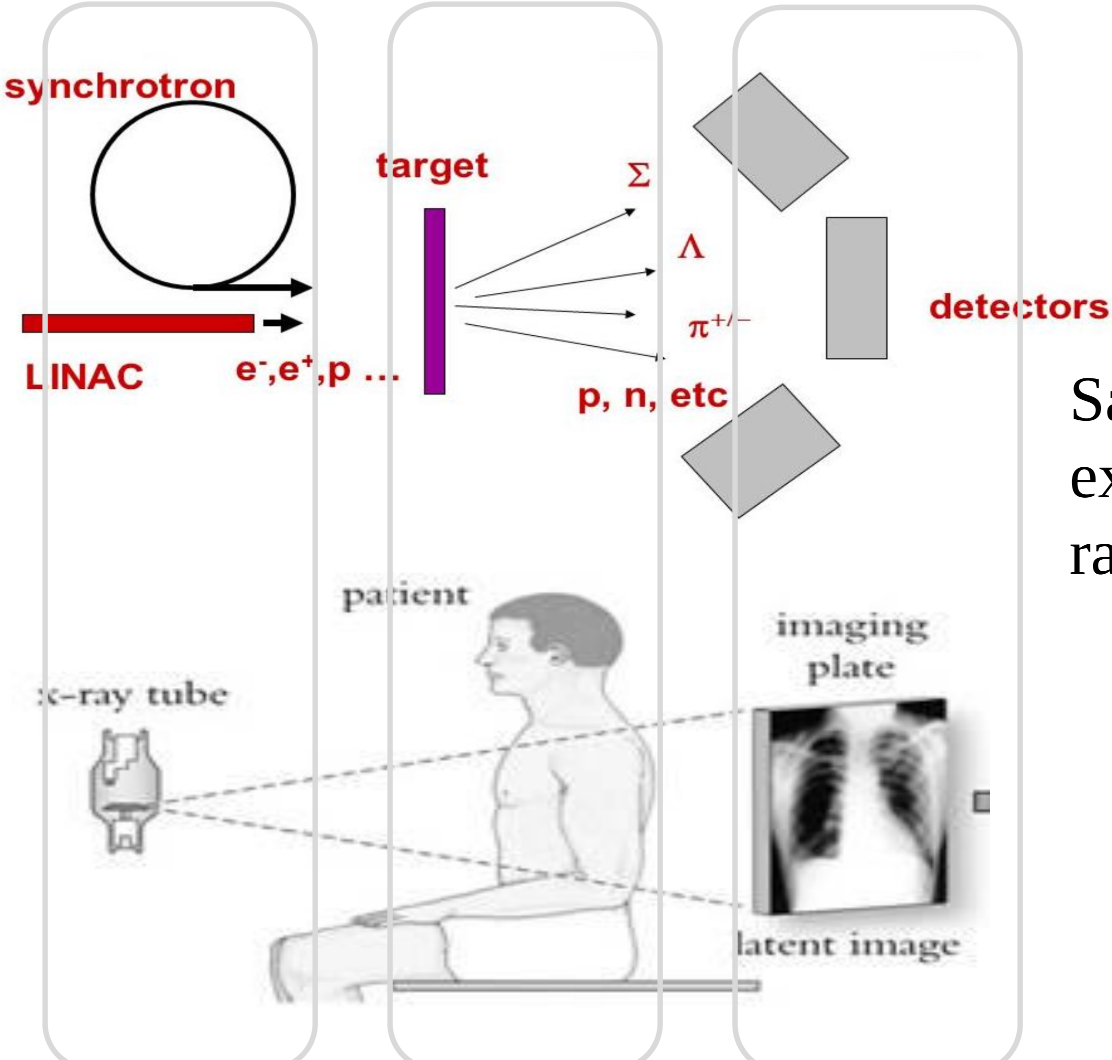


Common medical application

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

Future Application
-Angiography
-Boron neutron Capture Therapy

HEP technologies

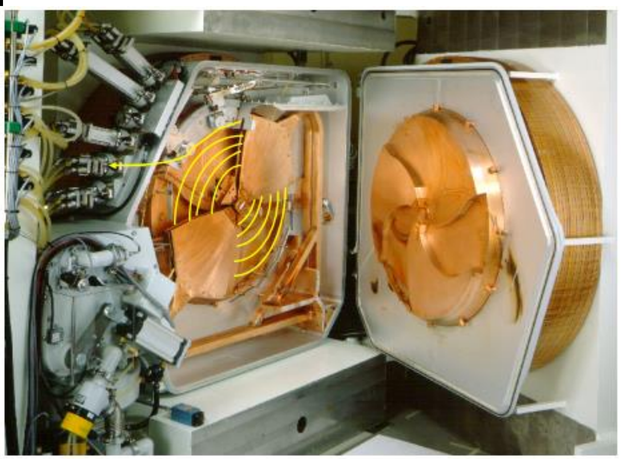


Same concept for an HEP experiment and a radiological investigation

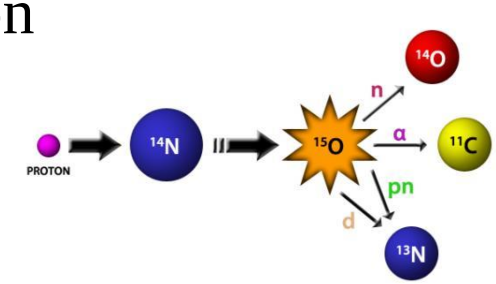
HEP technologies

Producing radioisotopes for medical treatments

1. Inserting target in a nuclear reactor - fine for longer-lived isotopes as some time is needed for processing and shipment
2. Using a charged-particle accelerator called a 'cyclotron' - needed locally for short-lived isotopes ($T_{1/2}$ ~ 1 to 100 min).

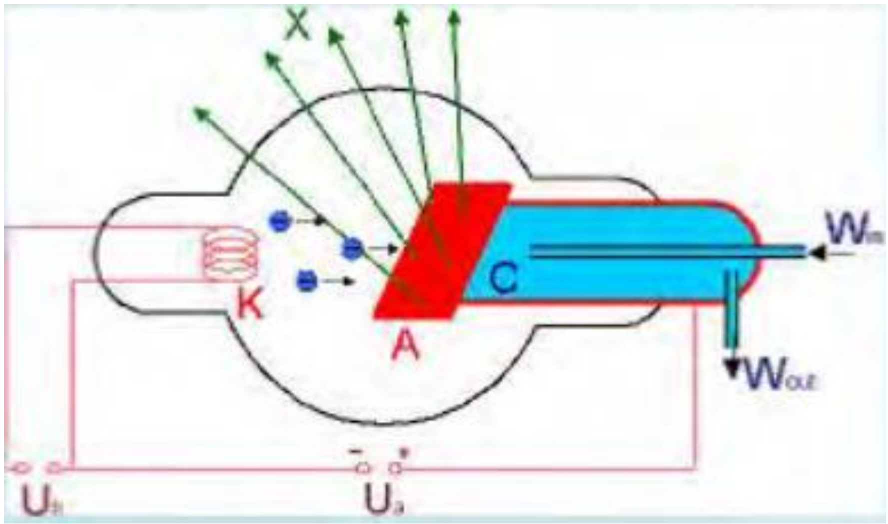


Cyclotrons for production of radio pharmaceutics substances are now quite common

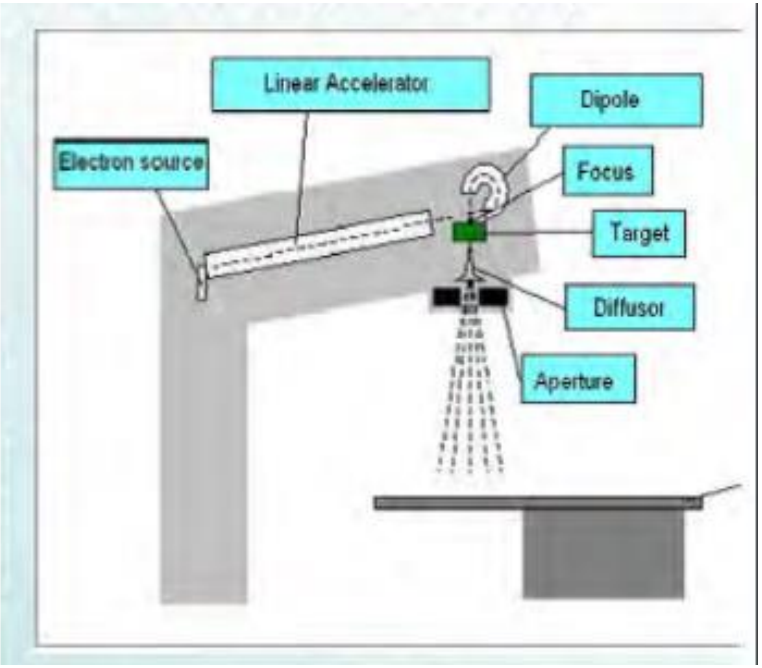


Linear accelerators (LINAC) for radiotherapy

Schematics of an X ray tube for an electrostatic accelerator



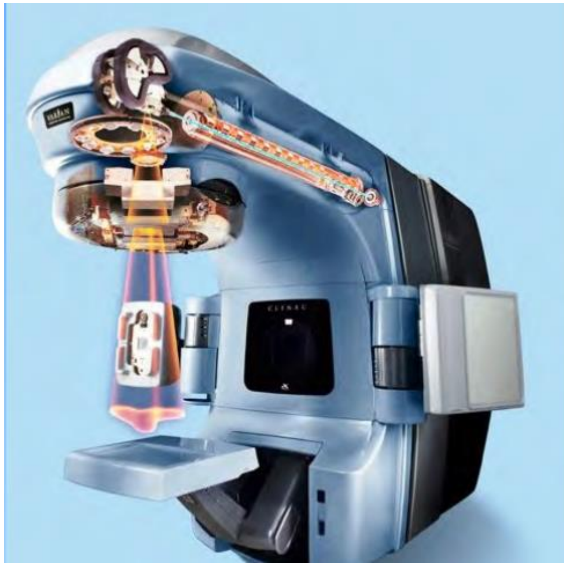
Modern LINAC concept



HEP technologies

Accelerating particles

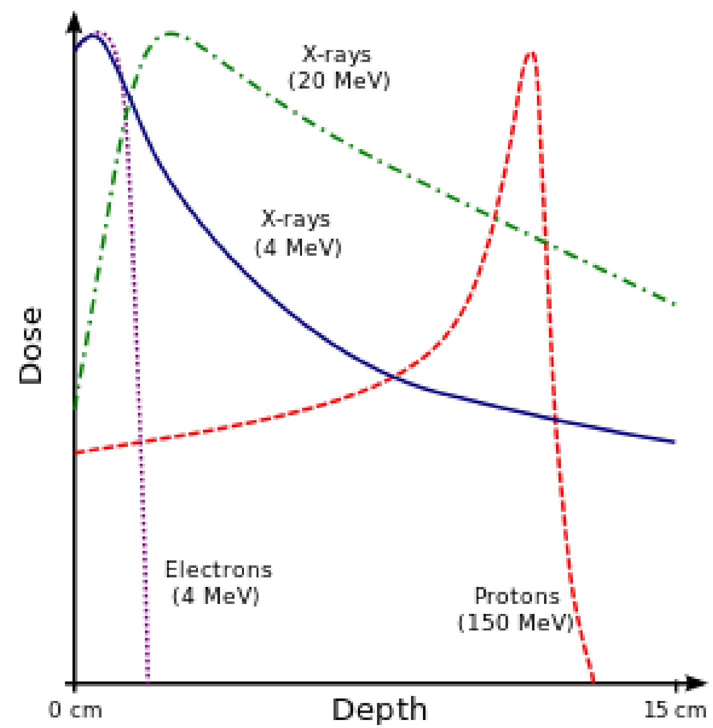
LINAC



LINAC uses microwave technology to accelerate electrons in a part of the LINAC called waveguide, then allows these electrons to collide with a heavy metal target. As a result of these collisions, high energy X-Rays (Photons) are produced from the target.

Hadron therapy

For protons and heavier ions the dose increases while the particle penetrates the tissue and loses energy continuously. Hence the dose increases with increasing thickness up to the Bragg peak that occurs near the end of the particle's range. Beyond the Bragg peak, the dose drops to zero (for protons) or almost zero (for heavier ions).



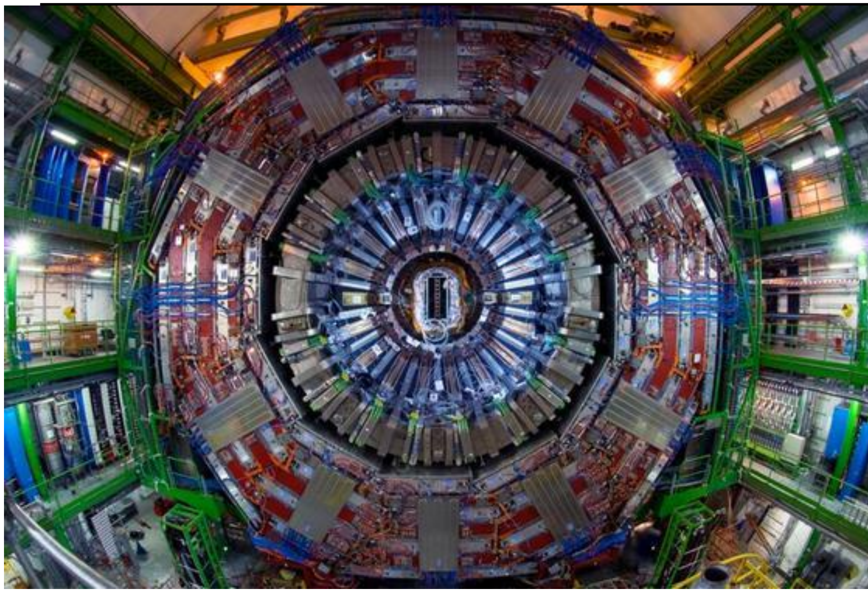
HEP technologies

Hadron therapy

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

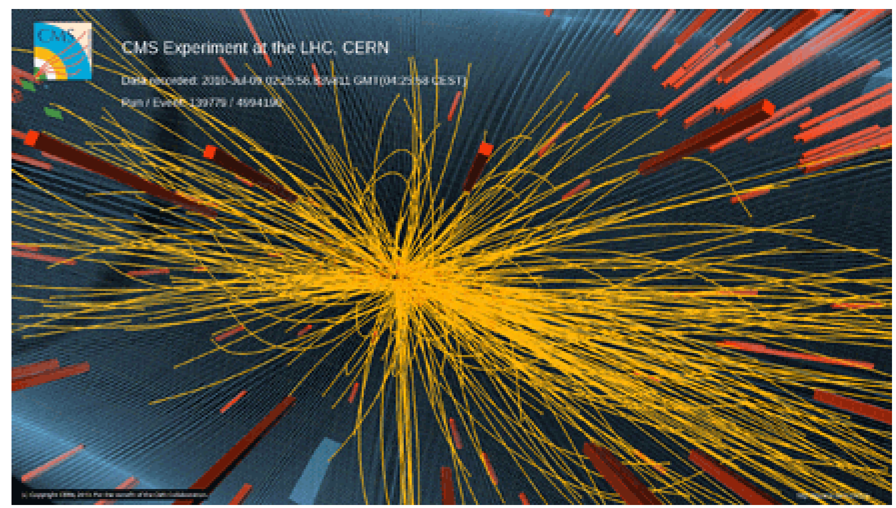
CERN, GSI (Germany), TERA (Italy), Med-Austron (Austria) and Oncology 2000 (Czech Rep.) all contributed to the conceptual. Five more are under construction in France, Germany, Austria and Sweden.

HEP technologies



Detect 600 million proton-proton collisions per second

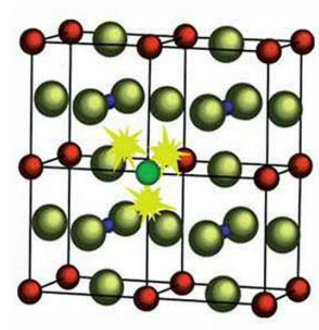
Sophisticated detectors to precisely measure the passage of a particle with time accuracies of 10^{-9} second and space accuracy of 10^{-5} meter.

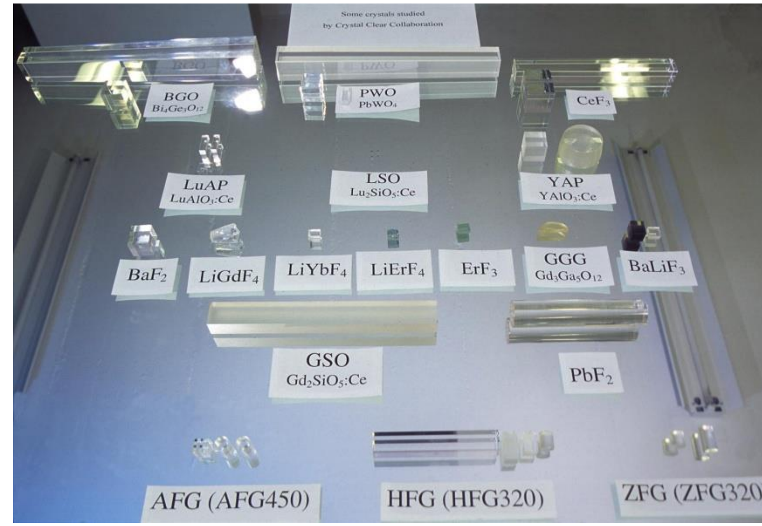


- Crystal
- Gaseous detectors
- Silicon detectors

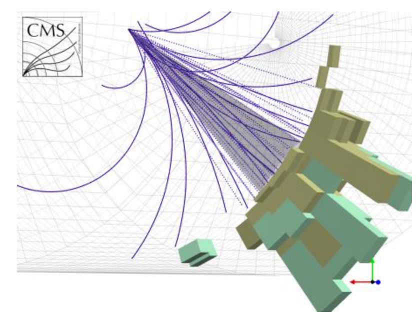
Crystal detectors

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

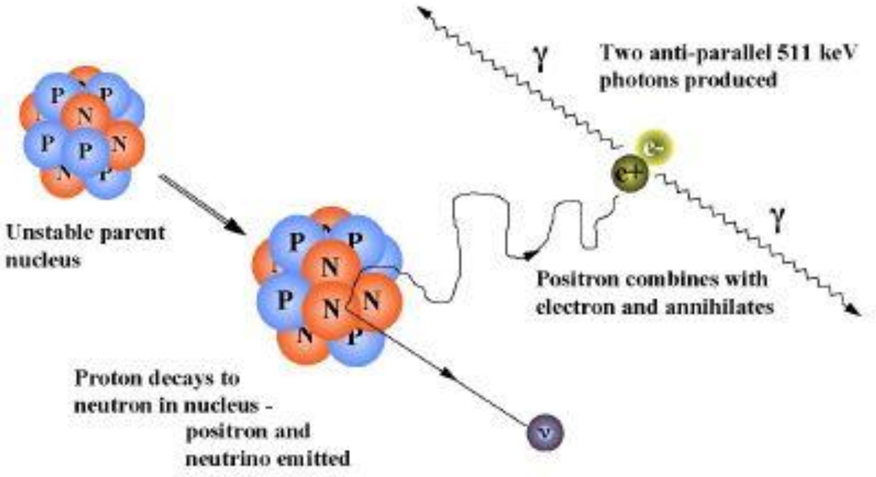


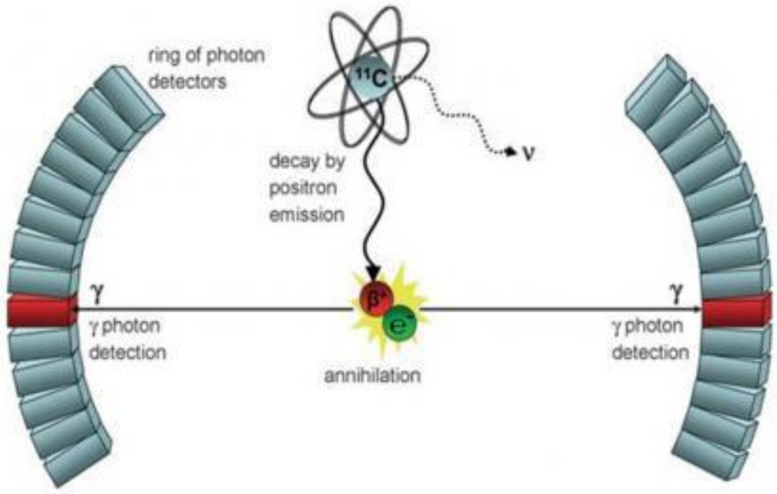


The CMS electromagnetic calorimeter uses lead tungstate (PbWO4) for the almost 80,000 crystals: a material with high density that produces scintillation light in fast, small, well-defined photon showers.



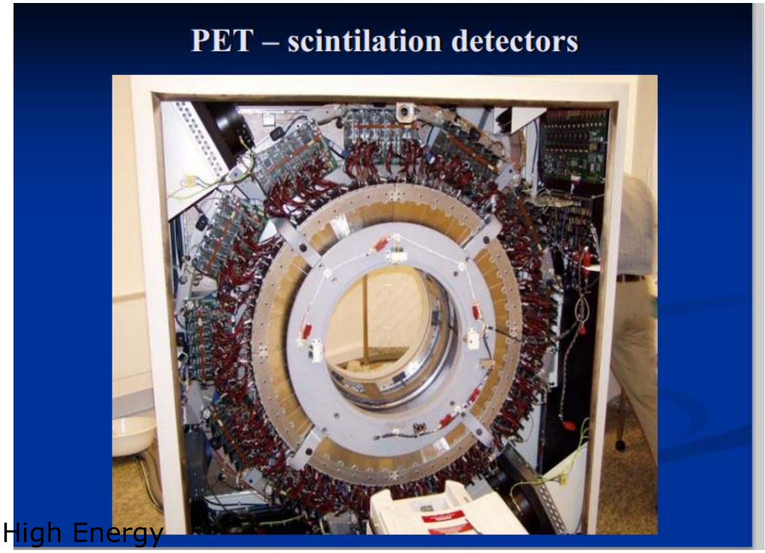
The Positron Emission Tomography (PET) concept





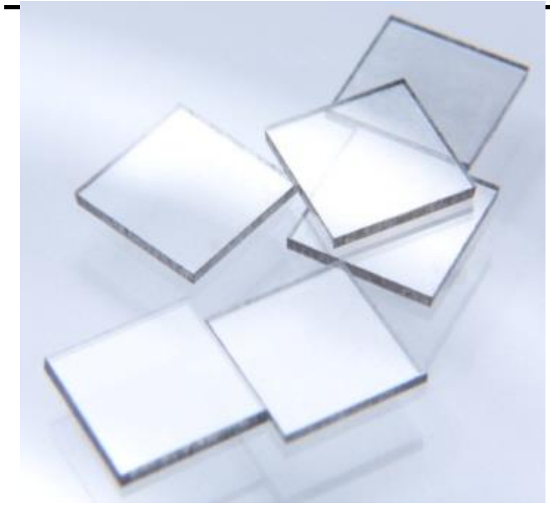
A PET detector is as complex as an HEP detector

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

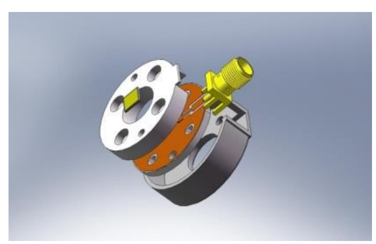
Can fabricate robust, compact devices

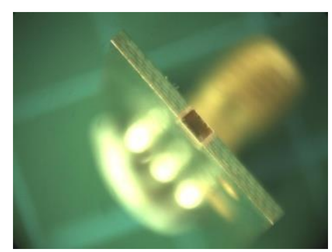
High temperature operation

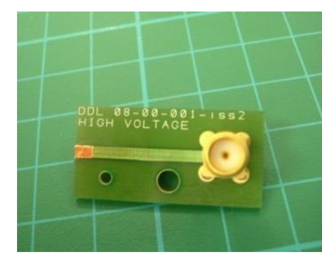
A wide range of detector applications

- 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

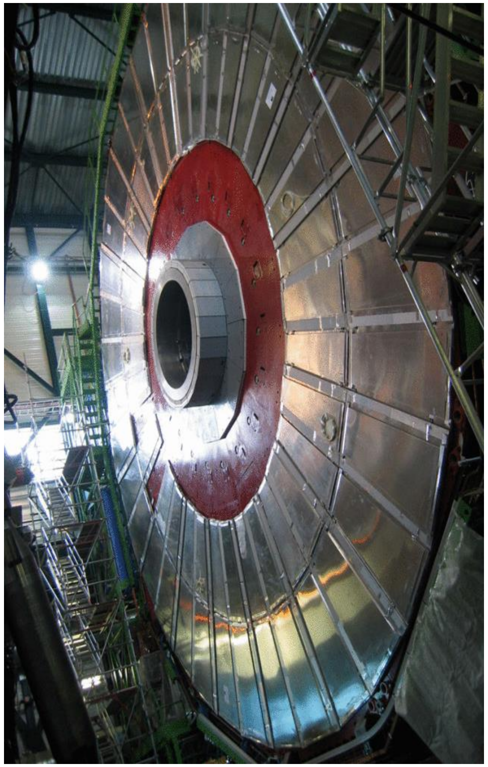






Gaseous detectors

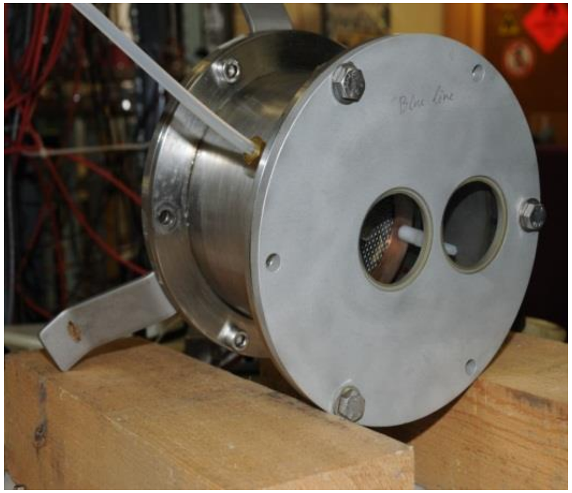
Various type of detectors, GEMs, RPCs, MRPCs, MICROMEGA, traditional WIRE CHAMBERS and DRIFT TUBES

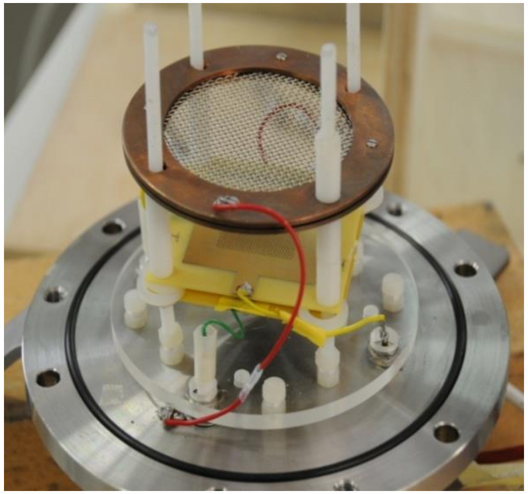


Large areas, extreme time resolution, extreme spatial resolutions, high rate capability

Smoke detectors (CERN development)

Wire and GEM-based gaseous detectors operate in proportional mode and can detect various flames, including sparks, in direct sunlight conditions. Combined with compact pulse UV sources they can detect simultaneously not only flames, but also smoke and some dangerous gases, for example benzene or toluene vapours. GEM-based detectors supplied with a lens can also provide information on the position of the flame and smoke.



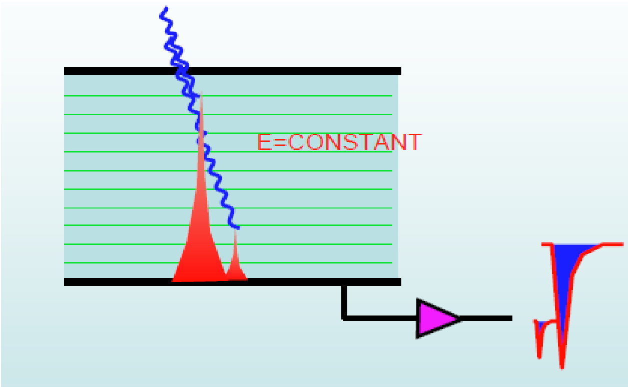


Material analysis (CERN Development)

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.

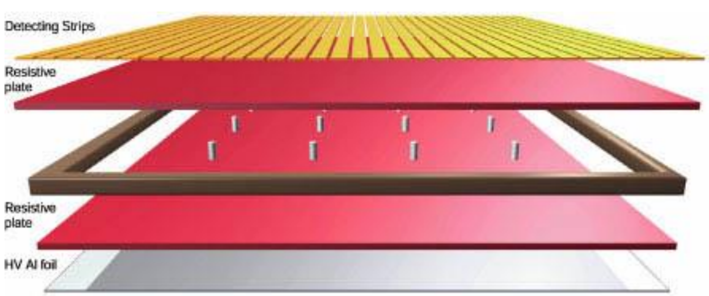
Gaseous detectors



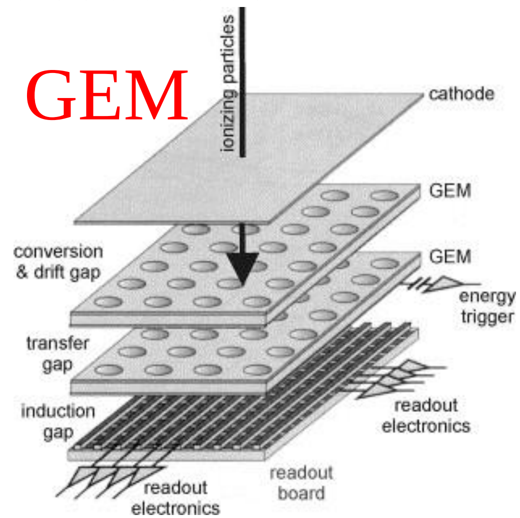
Use ionization in gas. Then collect the electrons on an appropriate electrode and produces a signal. To drive the electrons towards the electrode, an electric field is needed

Mostly used as muon detectors

RPC

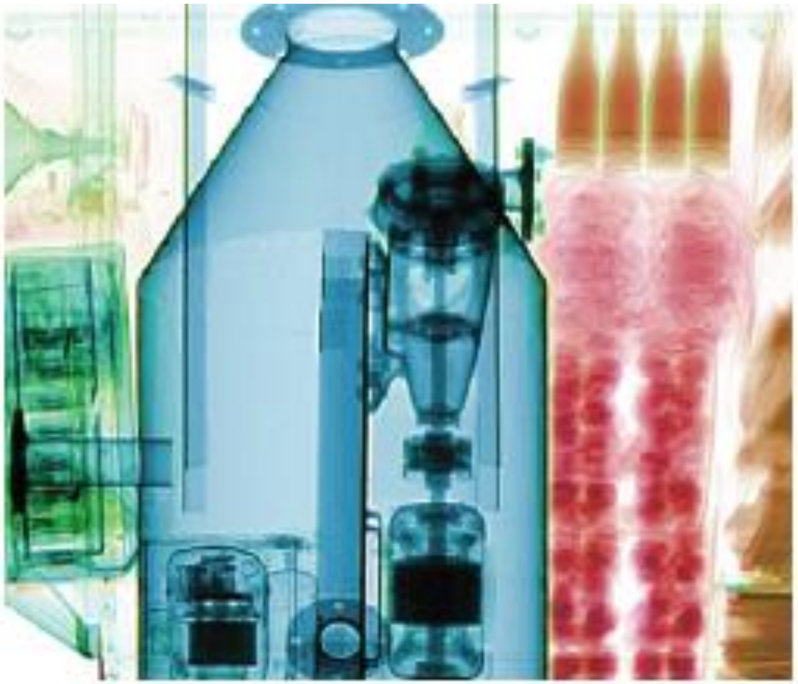


GEM



HEP technologies

GEM

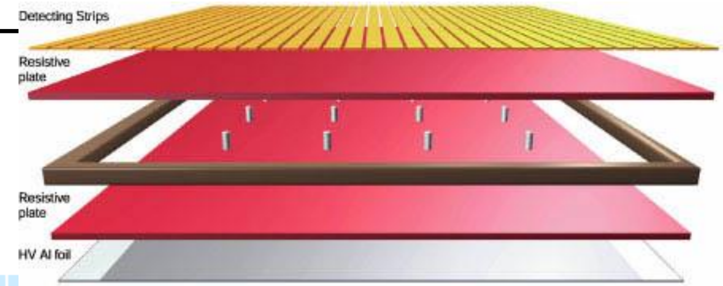


Air cargo screening

Large-area micro-pattern gaseous detectors with fast electronics can offer a unique opportunity for rapid air cargo scanning at affordable costs. Joint ventures with academia, industry and funding bodies to develop are in progress

HEP technologies

Muon tomography



RPC

High time resolution
High spatial resolution
Large scale

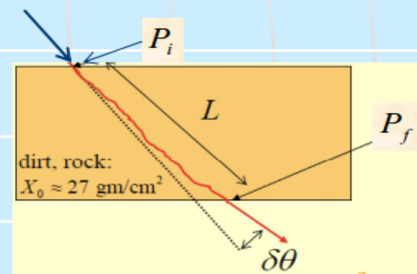
Muon Scattering

"Multiple Coulomb Scattering"

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

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

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

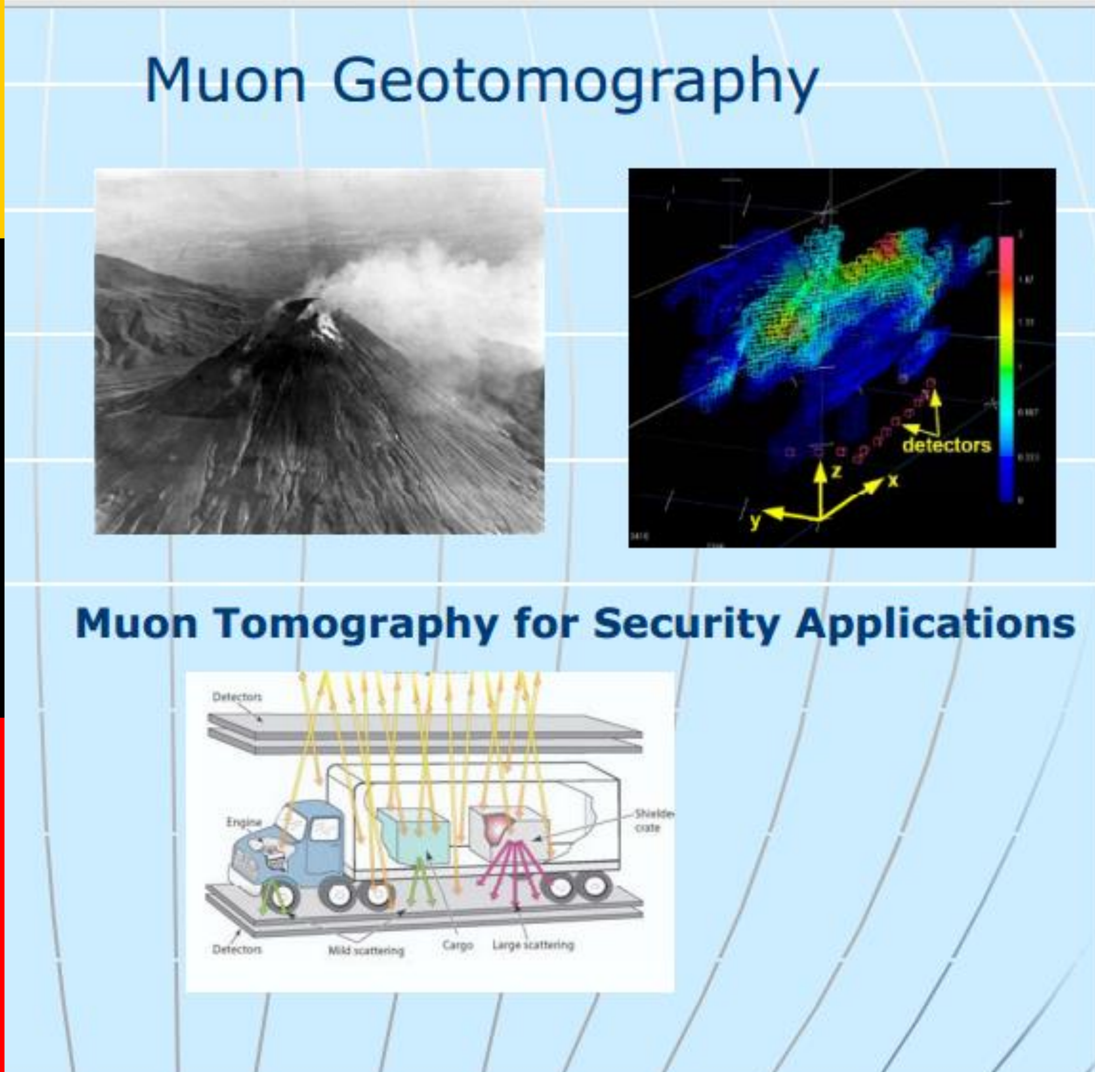


Angular deviation for P> 300 GeV: δθ≤10 mrad;

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

HEP technologies

Muon tomography



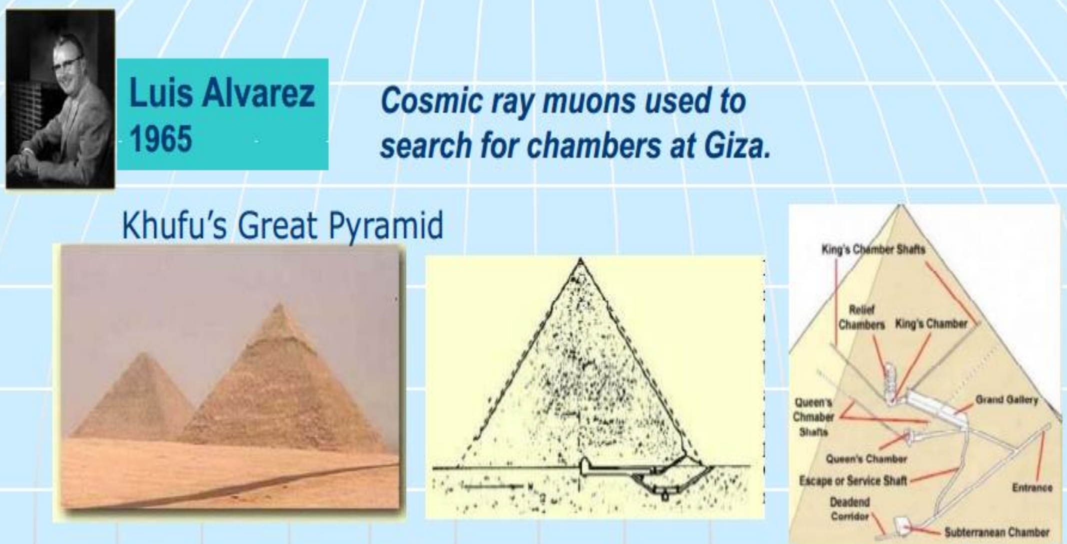
Large scale gaseous detector with high spatial resolution are needed

Image reconstruction can spot material of different density

Reconstruction software is crucial

HEP technologies

Muon tomography



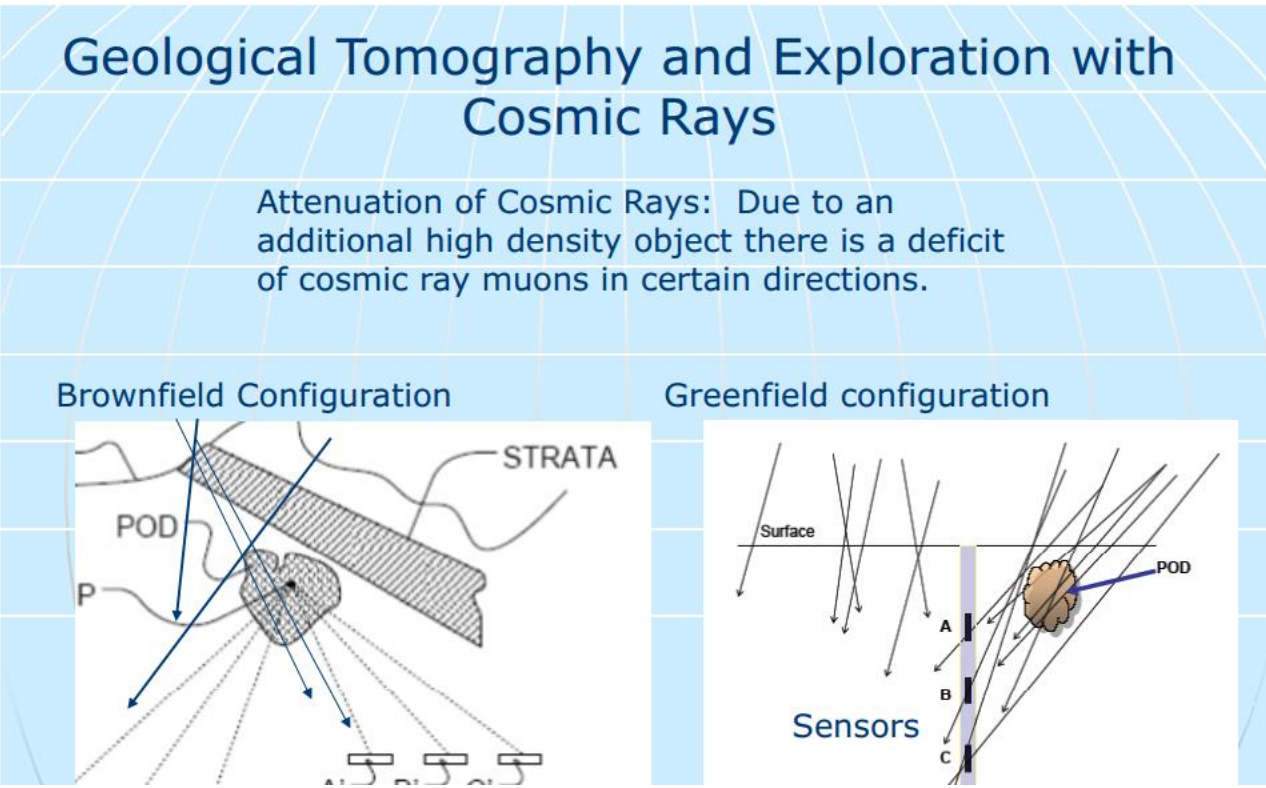
L.W. Alvarez et al., Science 167 (1970) 832. Photo Source: www.touregypt.net/featurestories/secretchambers1.htm by Alan Winston

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

This was when **Berkeley University** and **Ain Shams** University carried out a project to study the structure of the Second Pyramid of Giza is determined by cosmic-ray absorption at Giza in 1965.

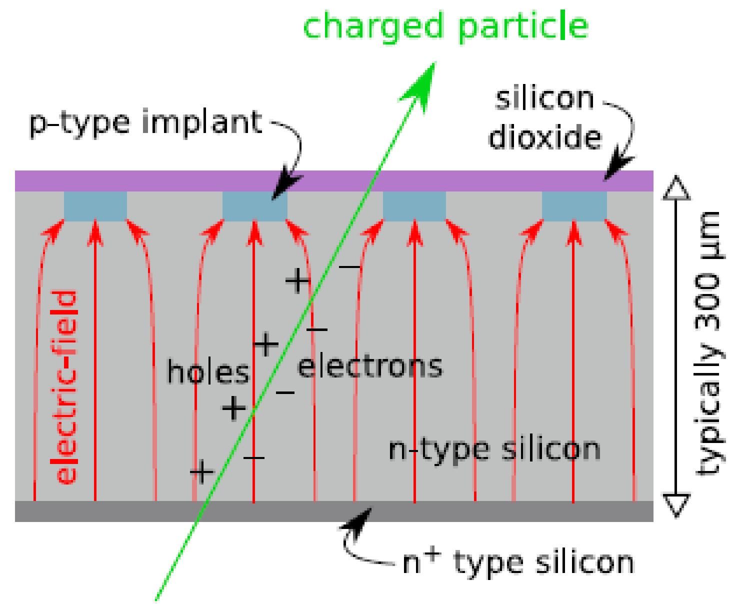
"Search for Hidden Chambers in the Pyramids", **Science** 06 Feb 1970: Vol. 167, Issue 3919, pp. 832-839

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

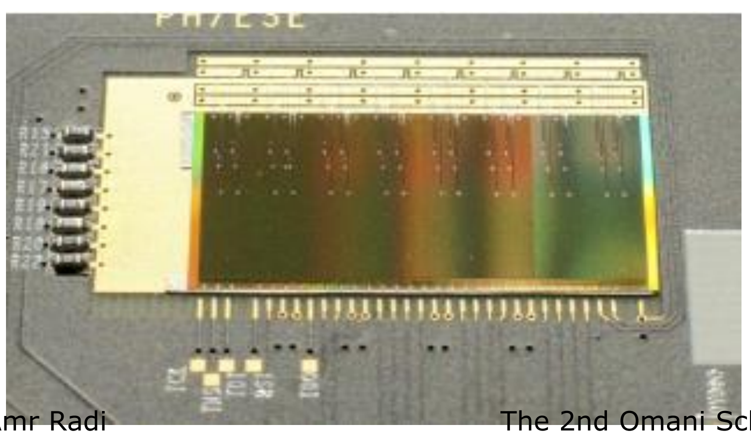


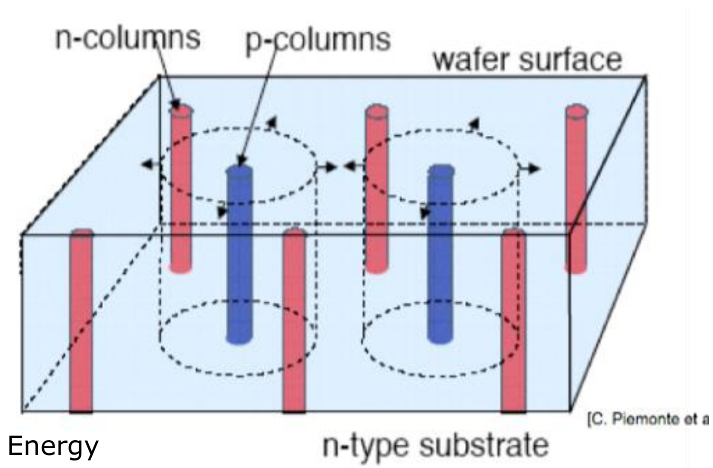
HEP technologies

Silicon detectors

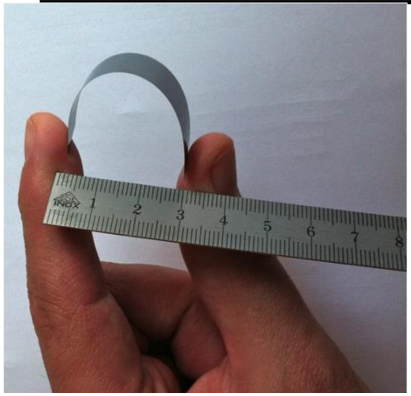


Innovative 3D Pixel Sensors





HEP technologies



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

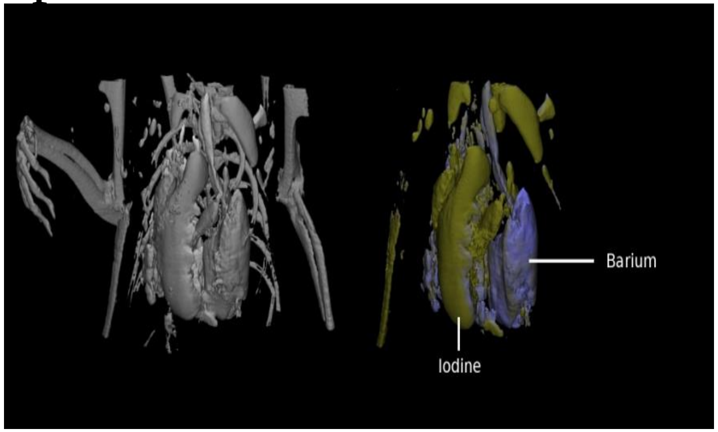
Pushing the industrial infrastructure to the limit of technical capabilities

MEDIPIX

- A family of single photon counting integrated circuits used in Hybrid Silicon Pixel Detectors
- Medipix is a family of photon counting and particle tracking pixel detectors developed by an international collaboration, hosted by CERN(Medipix collaborations) (close to 20 institutes) contributed to the development and dissemination of the technology

MARS project

Human settlement of Mars is the next giant leap for humankind.



Colour CT X-ray scanner based on the Medipix technology

(courtesy of MARS Bioimaging Ltd)

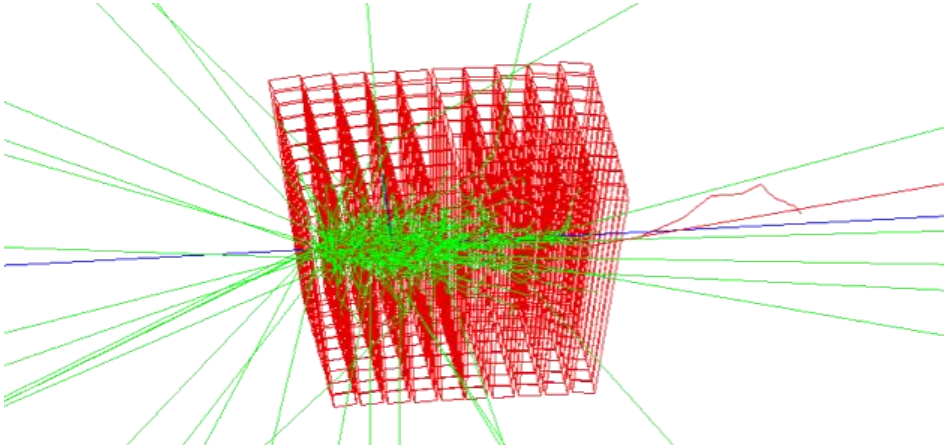
Semiconductor application

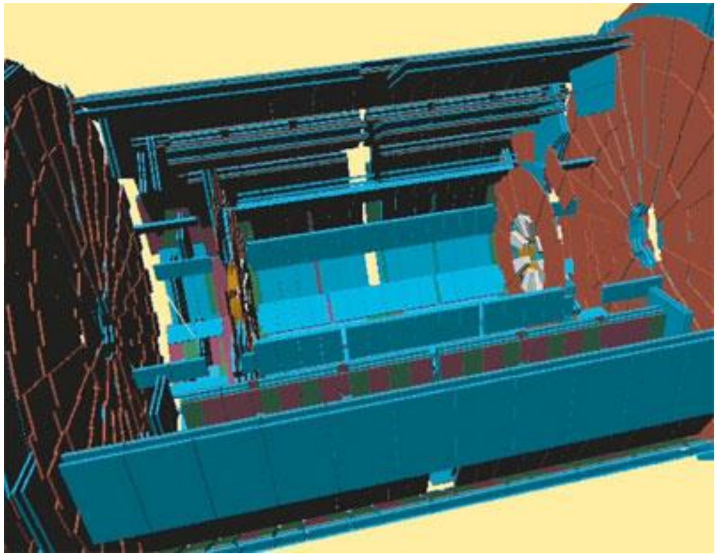
- Automotive Applications
- Computing & Peripherals Applications
- Industrial Applications
- Medical Applications
- Networking & Telecommunications Applications
- Power Supply Applications
- Circuit Protection Applications
- Consumer Applications
- LED Lighting Applications
- Military & Aerospace Applications
- Portable & Wireless Applications
- Motor Control Applications

Industry here has certainly overtaken Academy!!!!

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.





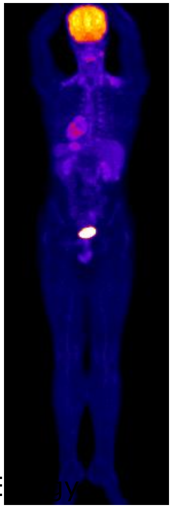
GEANT 4: applications

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;

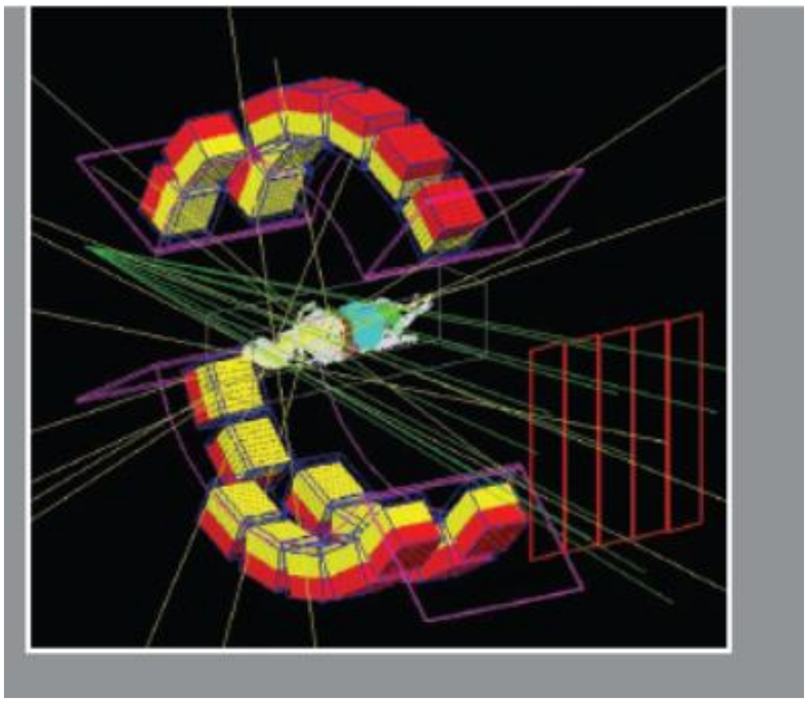
Medical applications where interactions of radiations used for treatment are simulated.

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



Simulations of Emission Tomography (Positron Emission Tomography – PET)

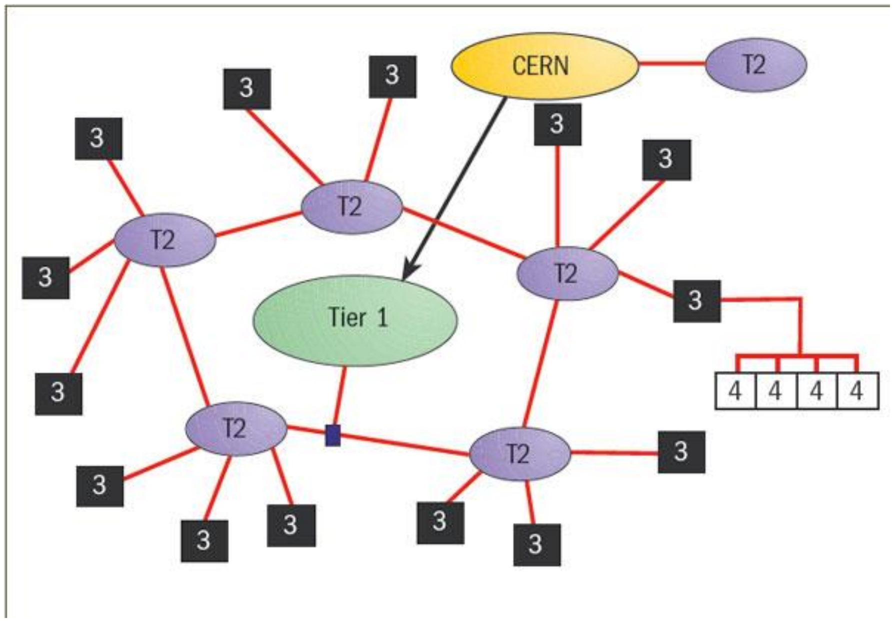
OpenGATE



OpenGATE is an extension of GEANT4, and provides a complete environment for simulating the behaviour of the next generation of nuclear medicine scanners, which may be used in clinics or for the development of drugs.

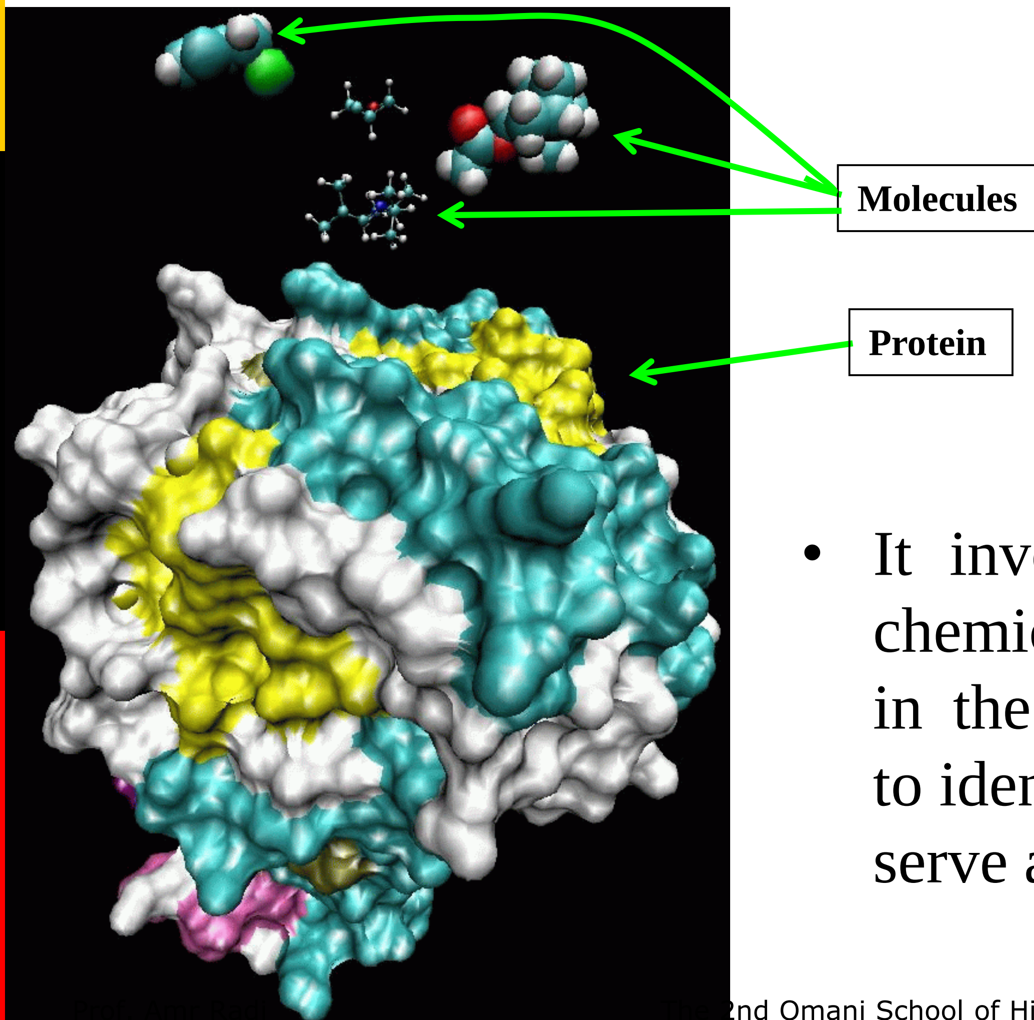
The simulation platform incorporates the basis of nuclear physics, the electronic response of the scanners, and various image reconstruction algorithms.

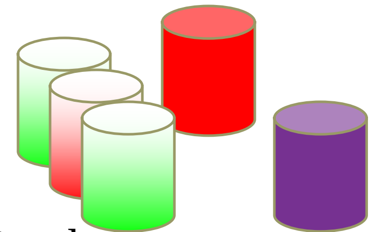
Worldwide LHC Computing Grid (WLCG)



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.

HEP technologies

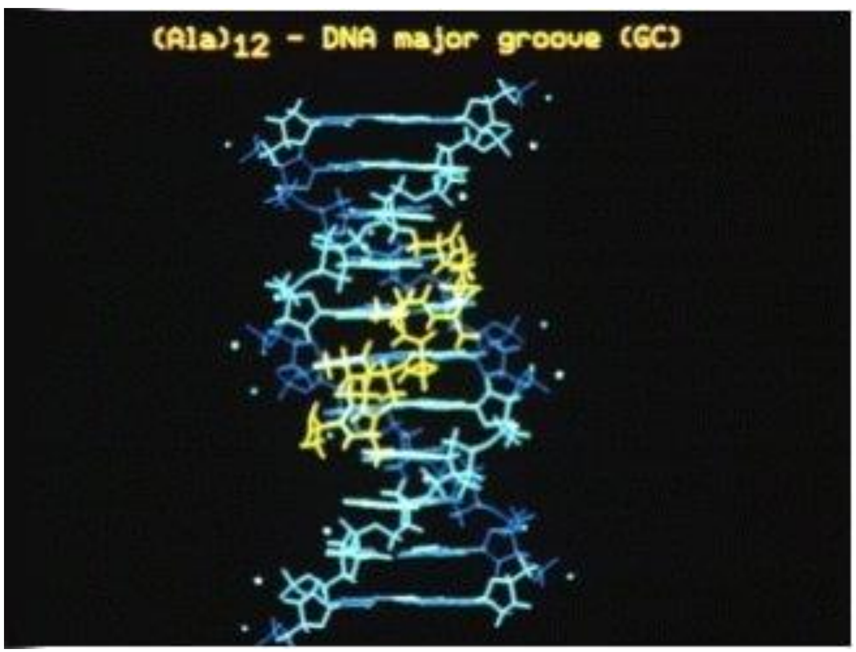
GRID computing

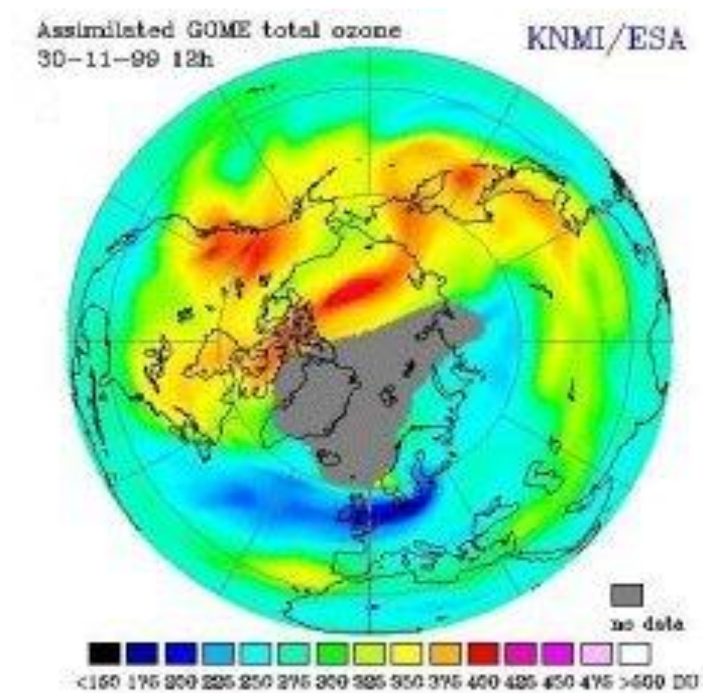
Genome Research

- Data mining
- Code management
- Remote GUI interfaces

Atmospheric Ozone Observation

Large scale data collection



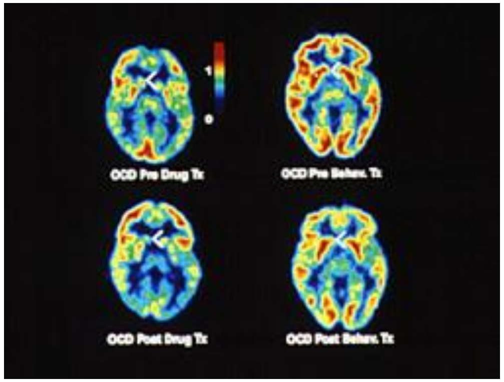


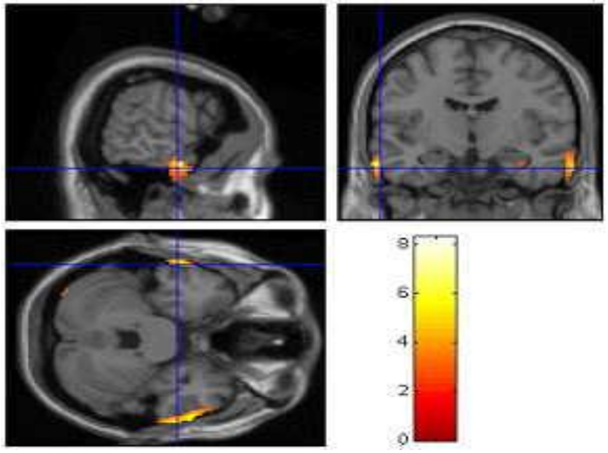
Distributed Data (Image) Analysis

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

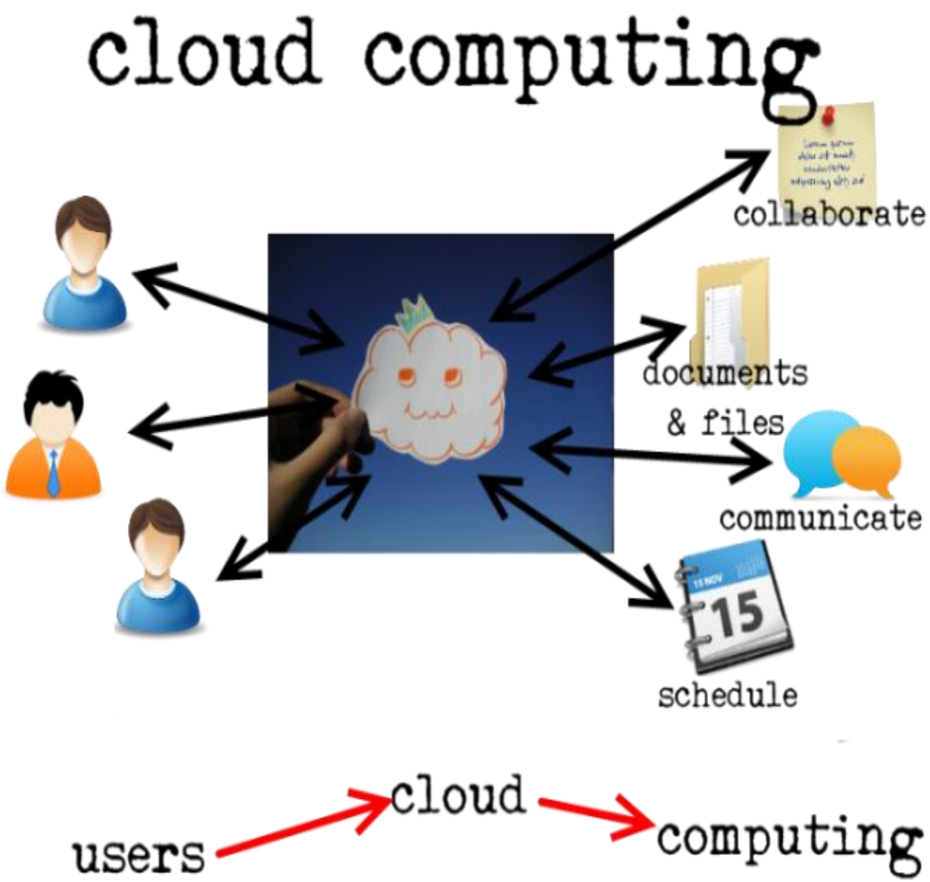
Analysis Station

Statistical analysis data base



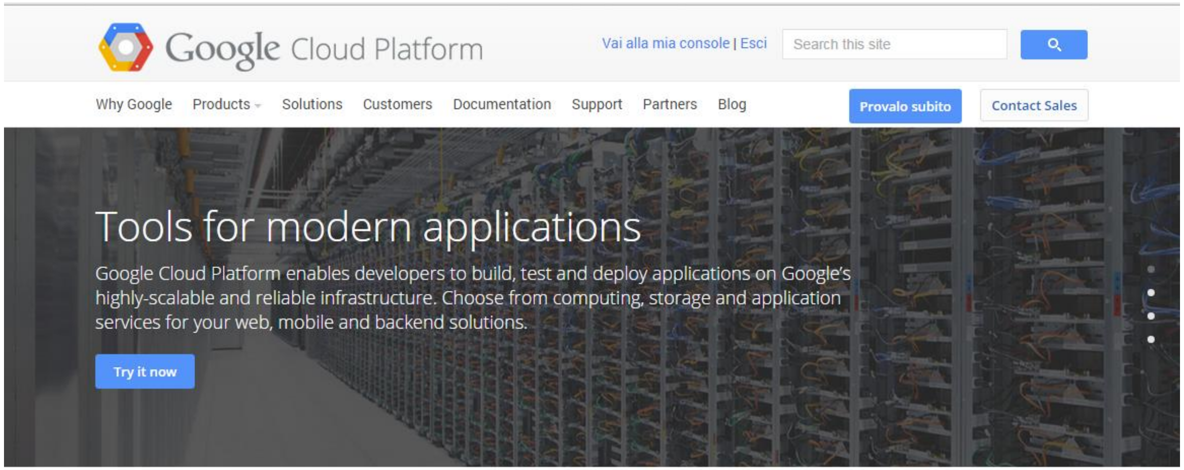


HEP technologies

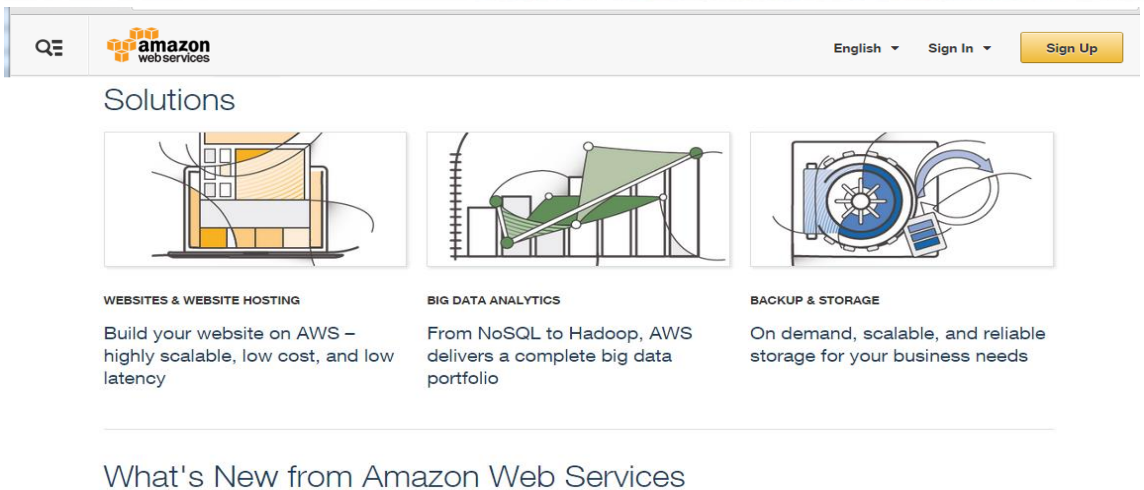


Cloud computing is now developing fast in every day life: your smartphone, notebook and tablet are interconnected and exchange information through a database server

Commercial platforms



Google



Amazon

Networks

The European networks

Forum for European Intergovernmental Research Organizations

EEN, Enterprise Europe Network

TTN, Technology Transfer Network

TTO Circle - European Technology Transfer Offices Circle

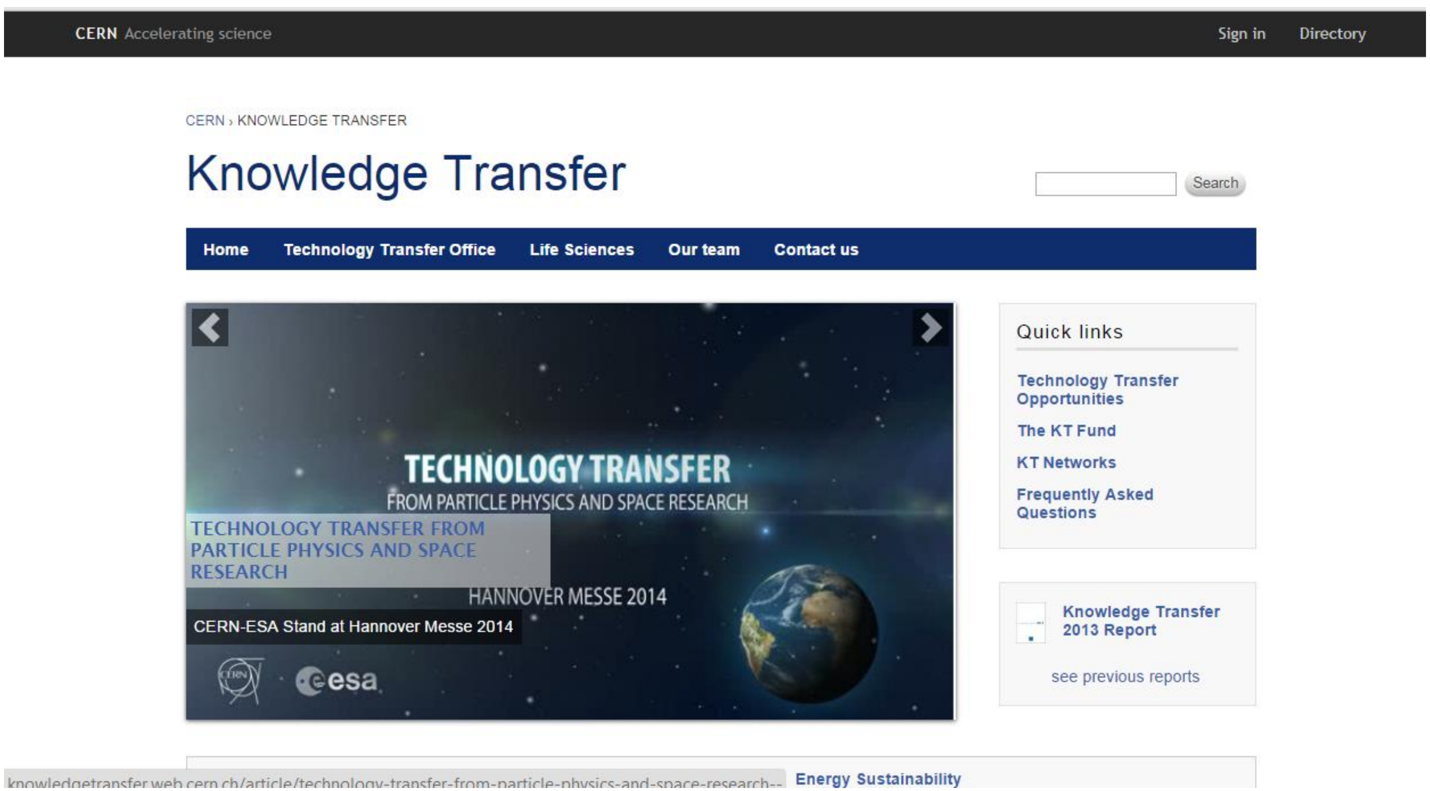
The European Network for LIGht ion Hadron Therapy

HEP technologies

CERN Knowledge Transfer

CERN Knowledge Transfer (KT) group

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



HEP technologies

- 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