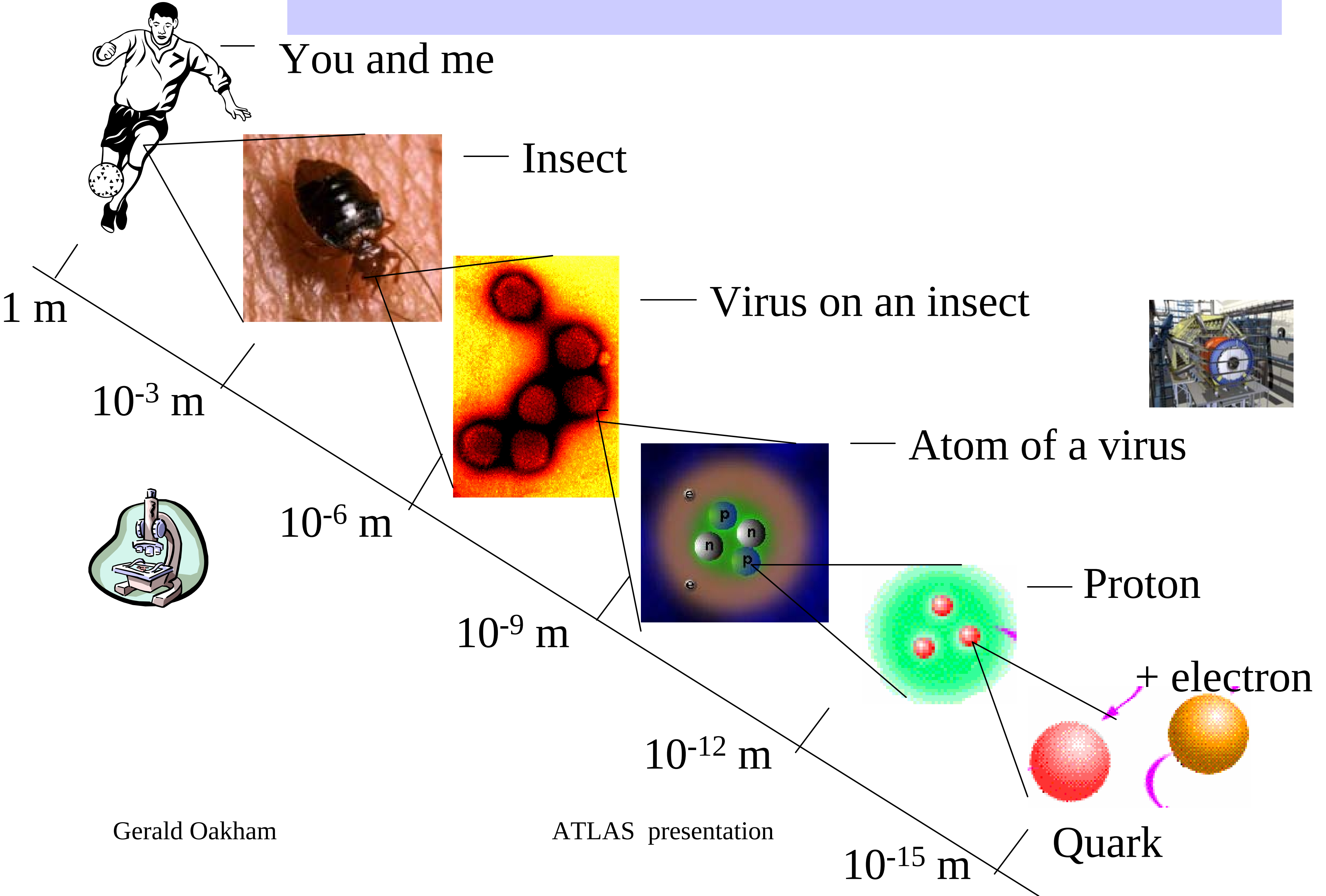
The scale of the subatomic world



CERN’s Beginning:-

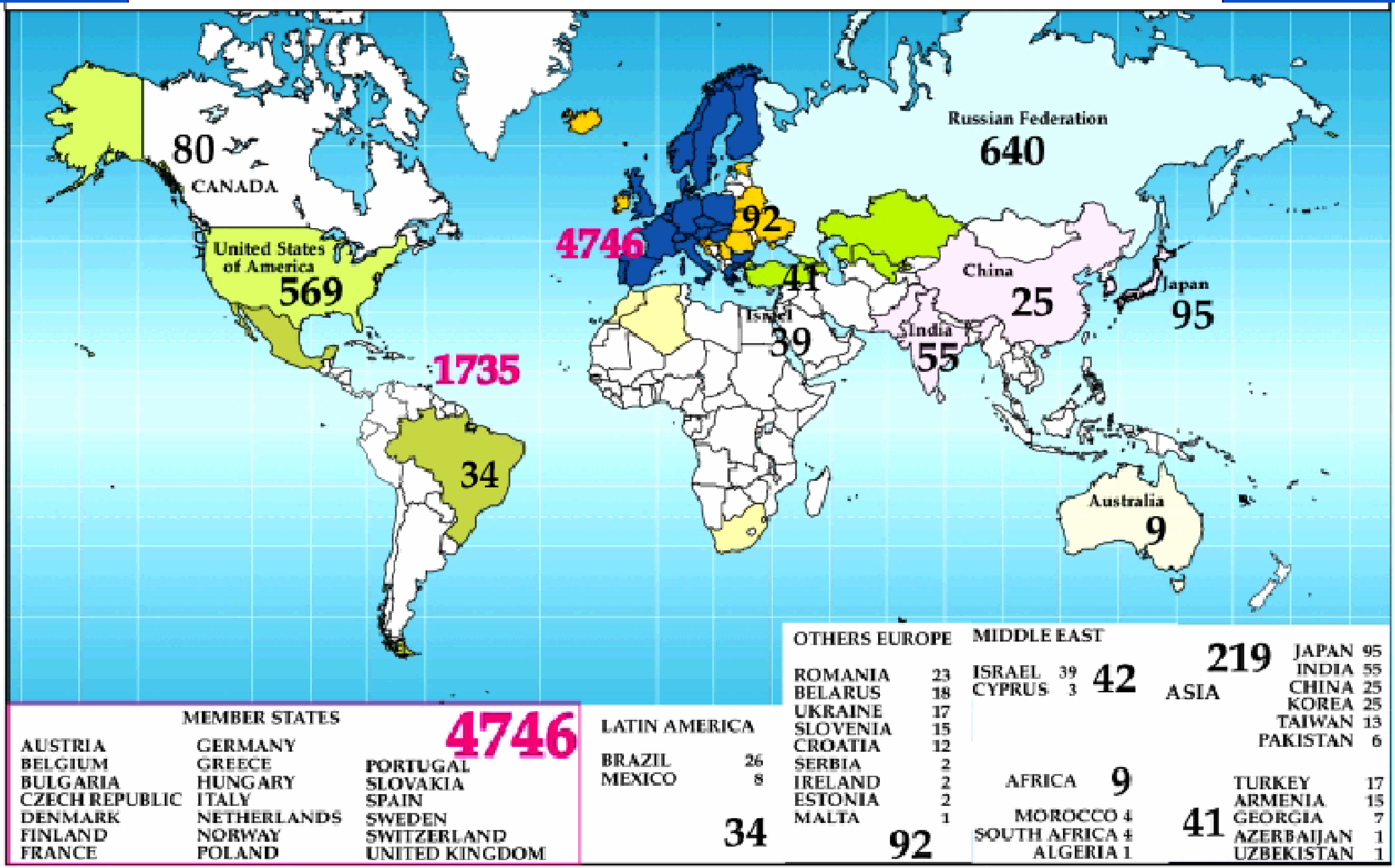
Geneva was selected as the site for the CERN Laboratory at the third session of the provisional Council in 1952. This choice was approved in a referendum in the canton of Geneva in June 1953 by 16539 votes to 7332. On 17 May 1954, the first shovel load of earth was dug on the Meyrin site under the eyes of Geneva officials and members of CERN staff.

The CERN convention states:

- The Organization shall provide for collaboration among European States in nuclear research of a pure scientific and fundamental character, and in research essentially related thereto. The Organization shall have no concern with work for military requirements and the results of its experimental and theoretical work shall be published or otherwise made generally available.

CERN Users

Distribution of CERN users, May 1, 2001



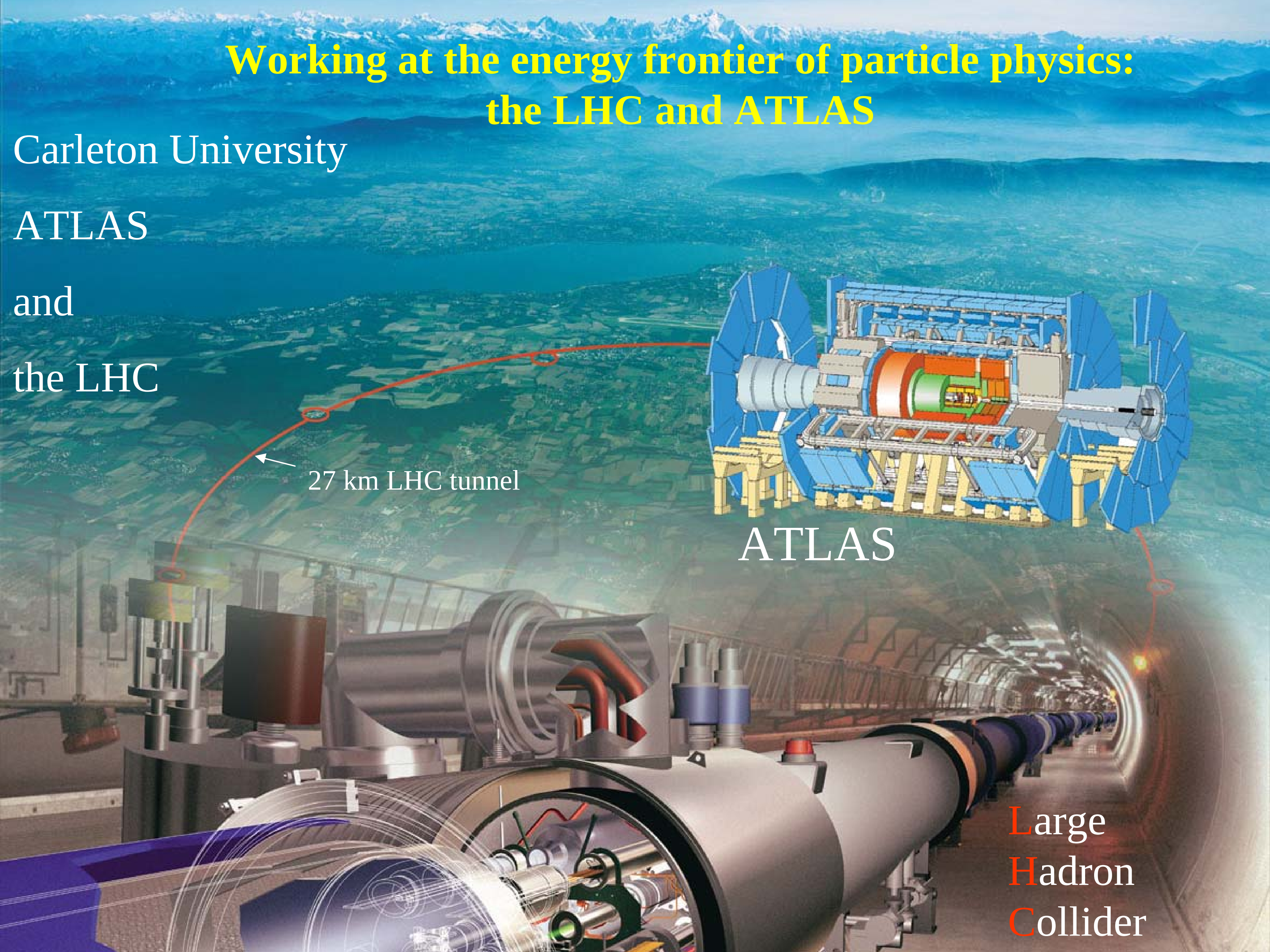
Working at the energy frontier of particle physics: the LHC and ATLAS

Carleton University

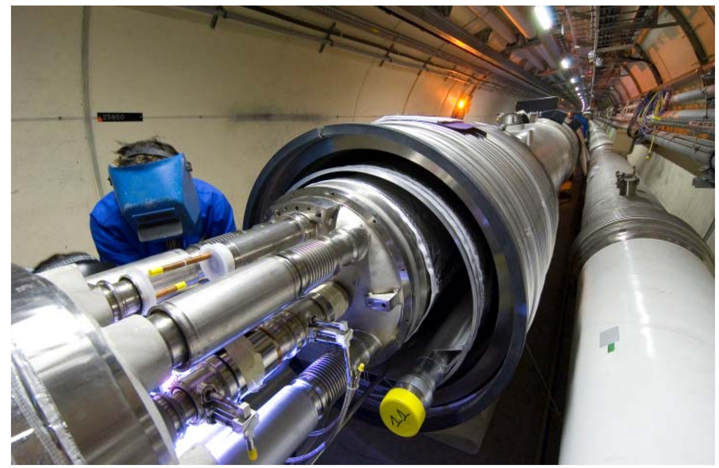
ATLAS

and

the LHC

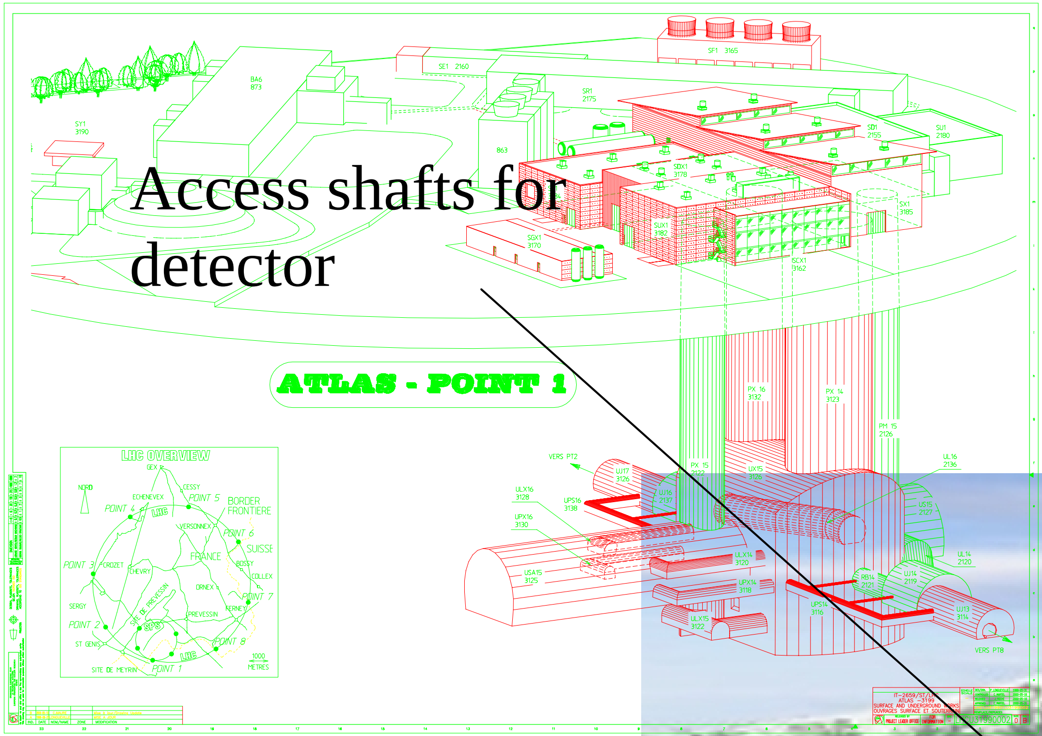


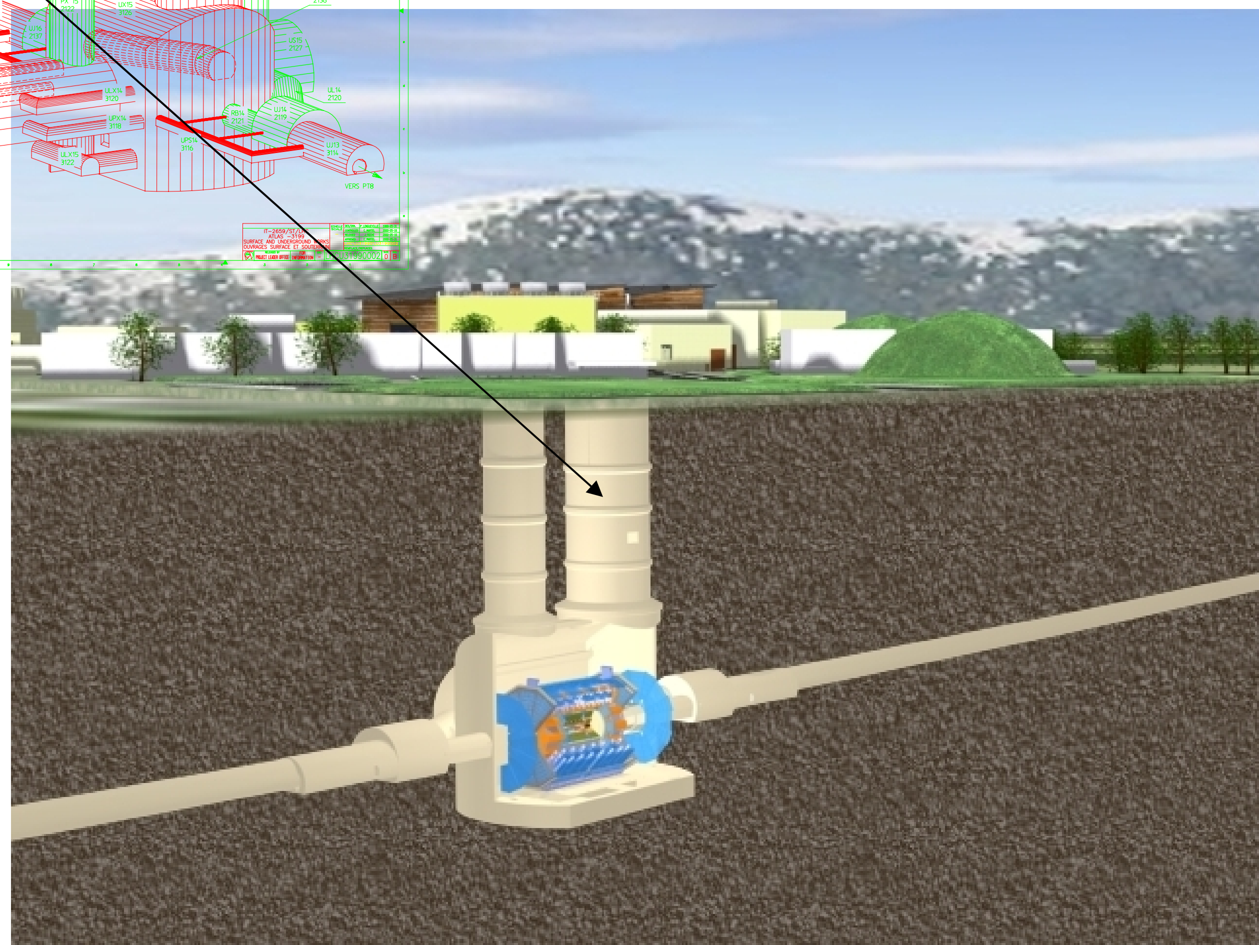
LHC – installation



The Underground Cavern at Pit-1 for the ATLAS Detector

Access shafts for detector



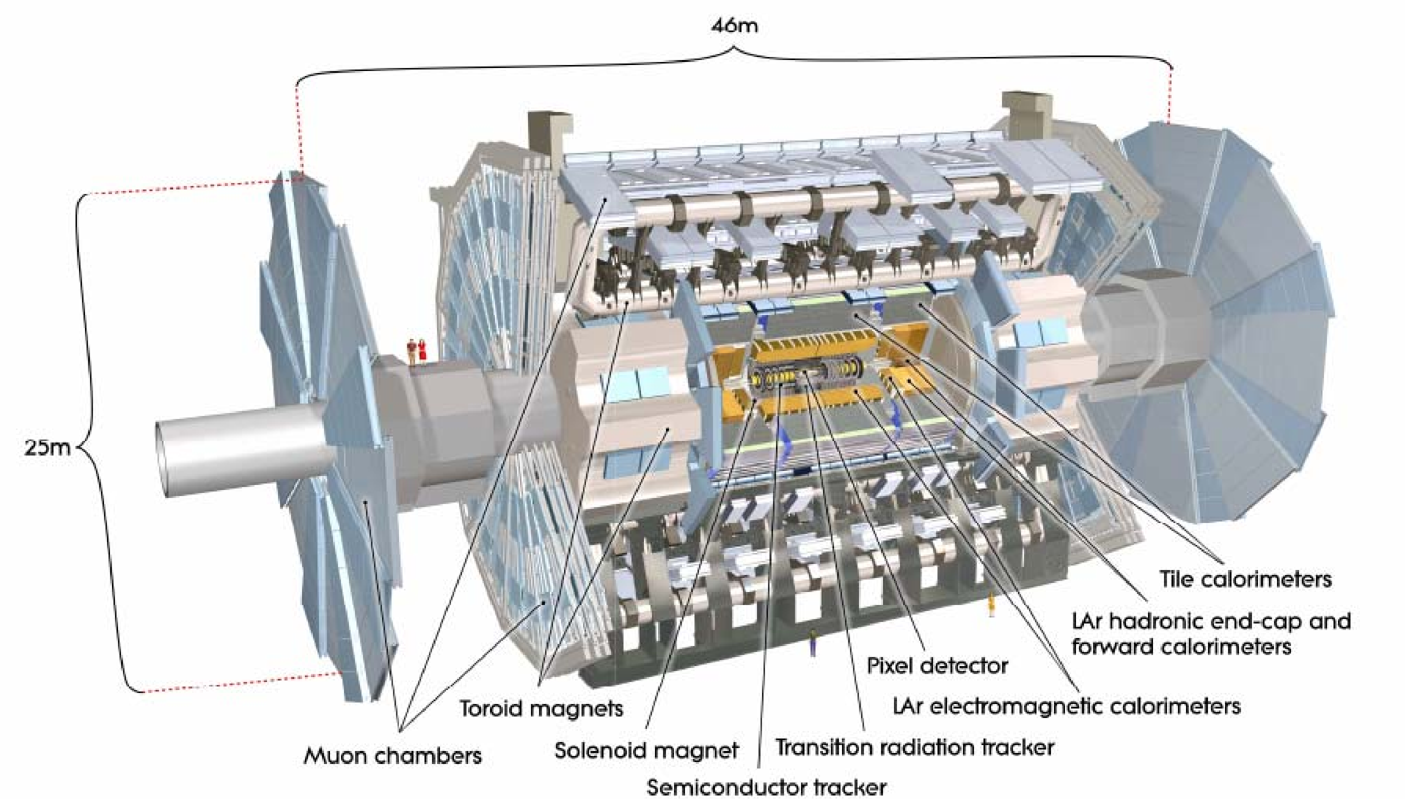


Length = 55 m
Width = 32 m
Height = 35 m

Gerald Oakham

The ATLAS detector is being installed 100 m underground on the LHC ring.

ATLAS superimposed to the 5 floors of building 40

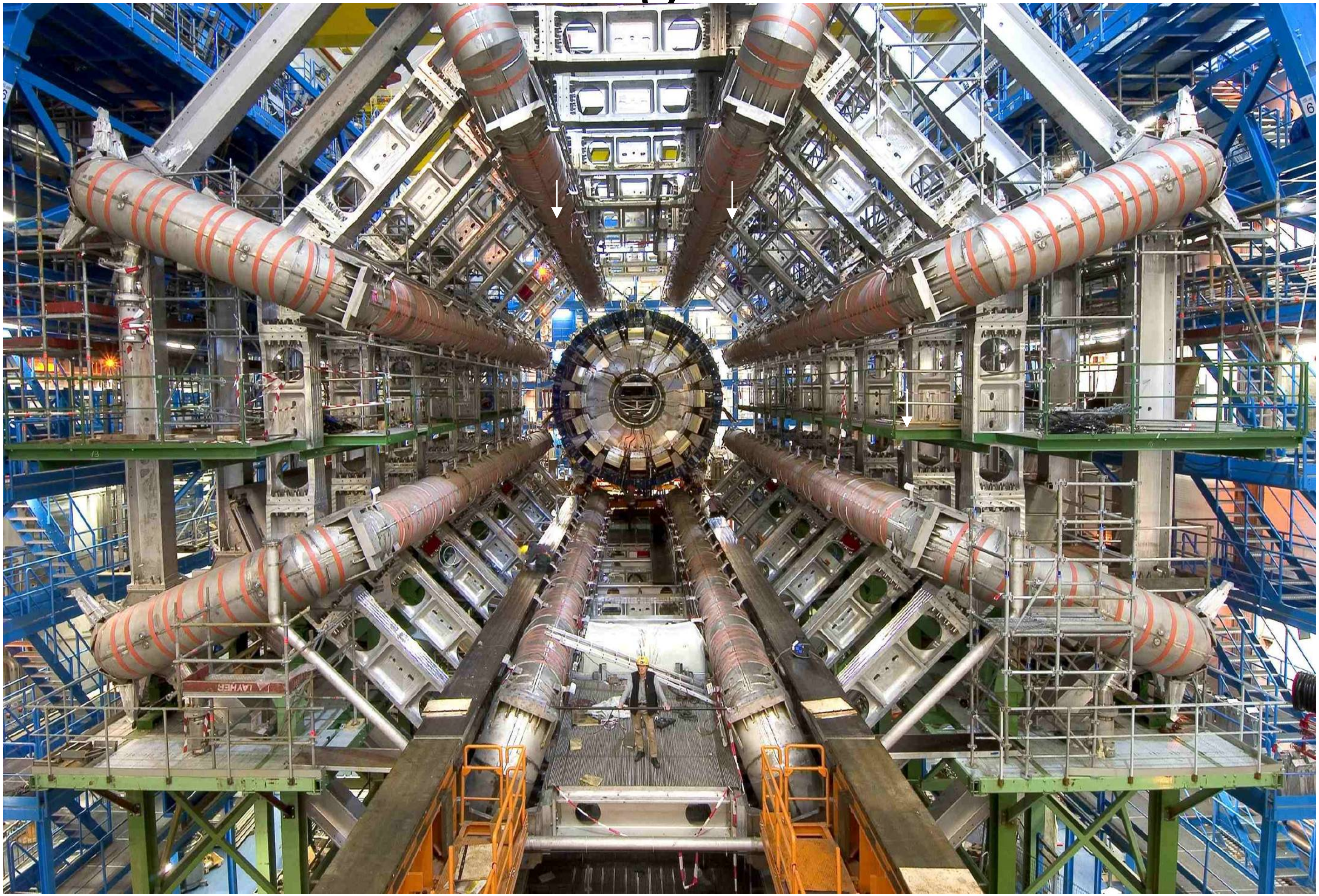


Gerald Oakham

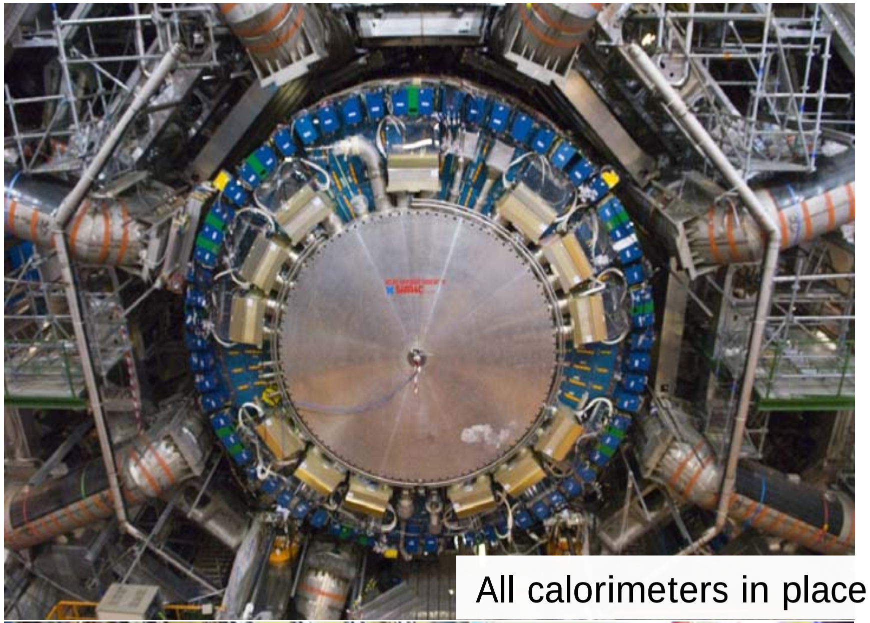
Diameter	***25 m***
Barrel toroid length	***26 m***
End-cap end-wall chamber span	***46 m***
Overall weight	***7000 Tons***

Underground cavern for the ATLAS detector Early 2005

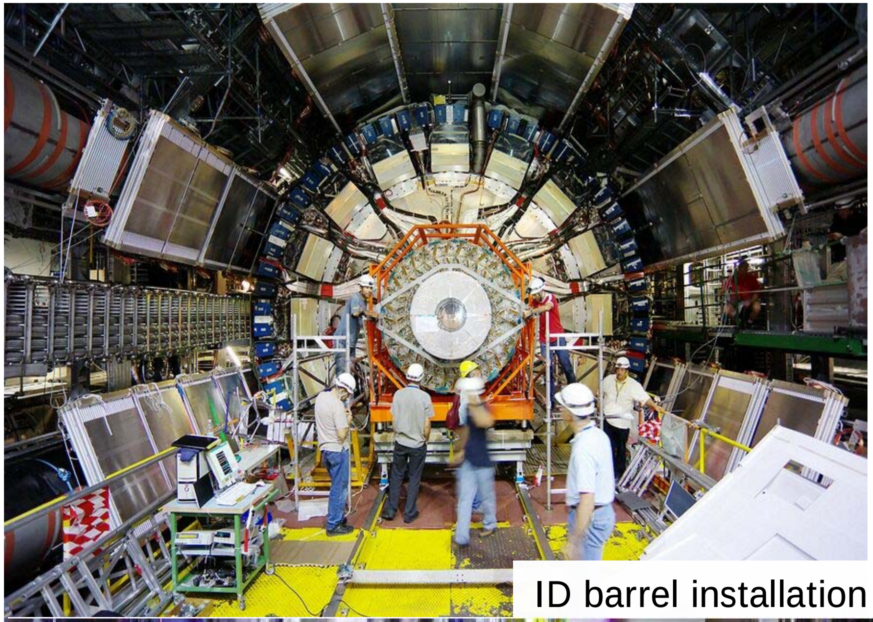
Barrel Magnet Toroid



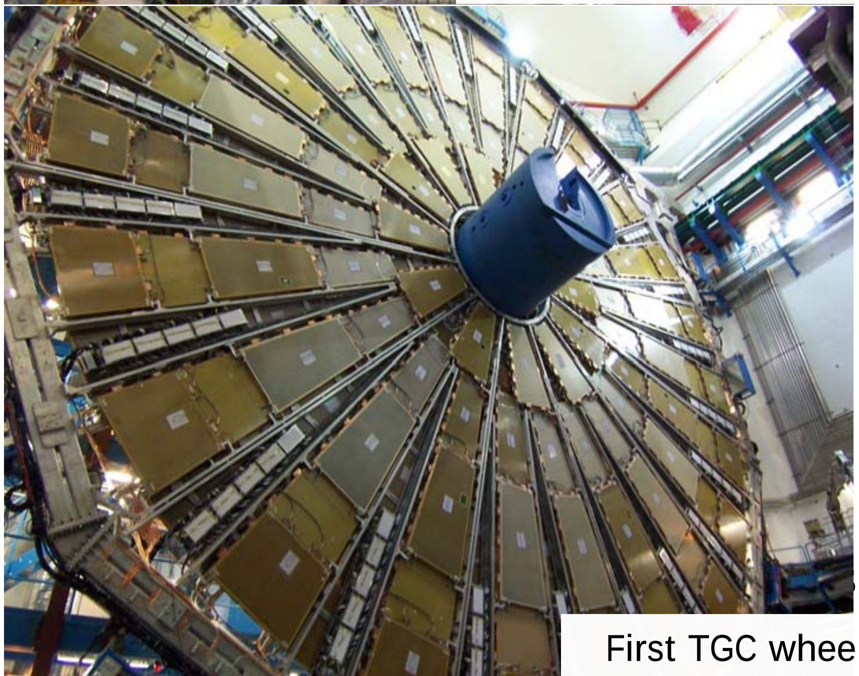
Pictures from the ATLAS pit



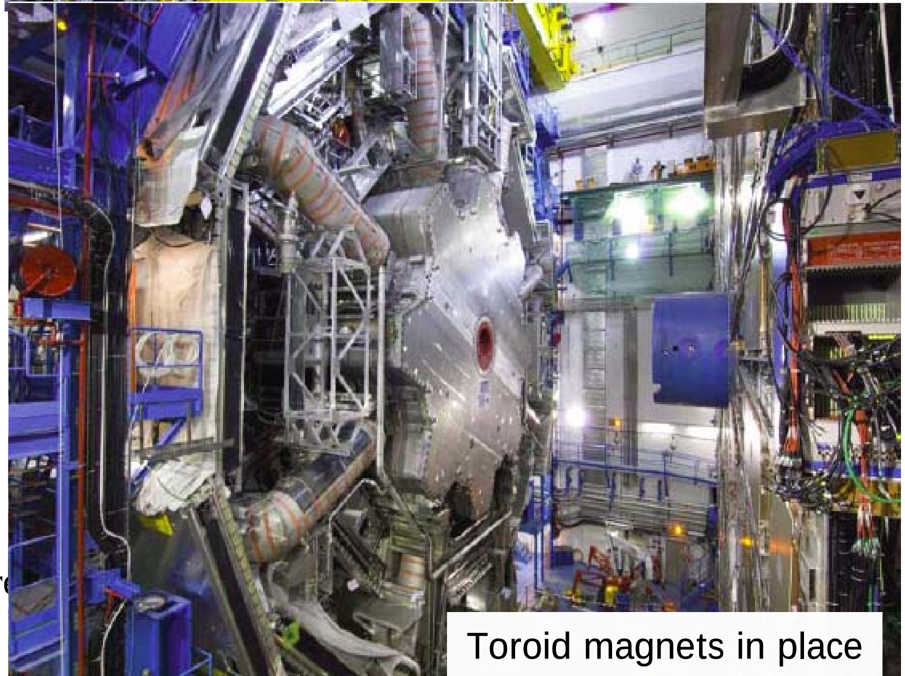
All calorimeters in place



ID barrel installation



First TGC wheel

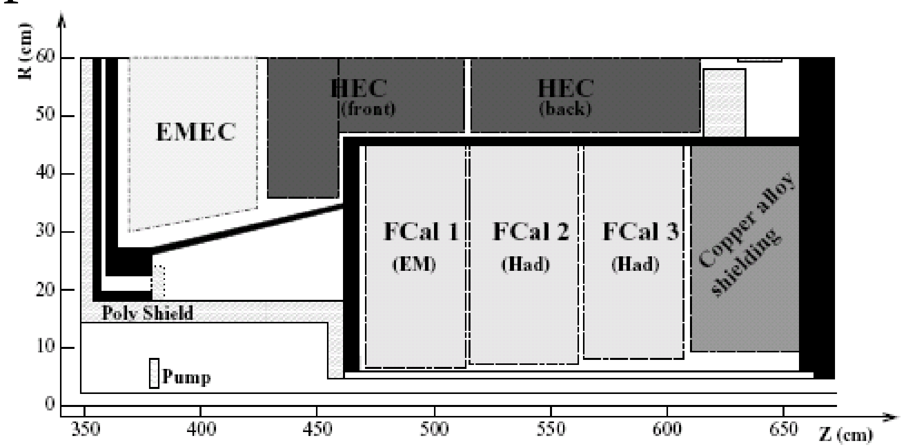


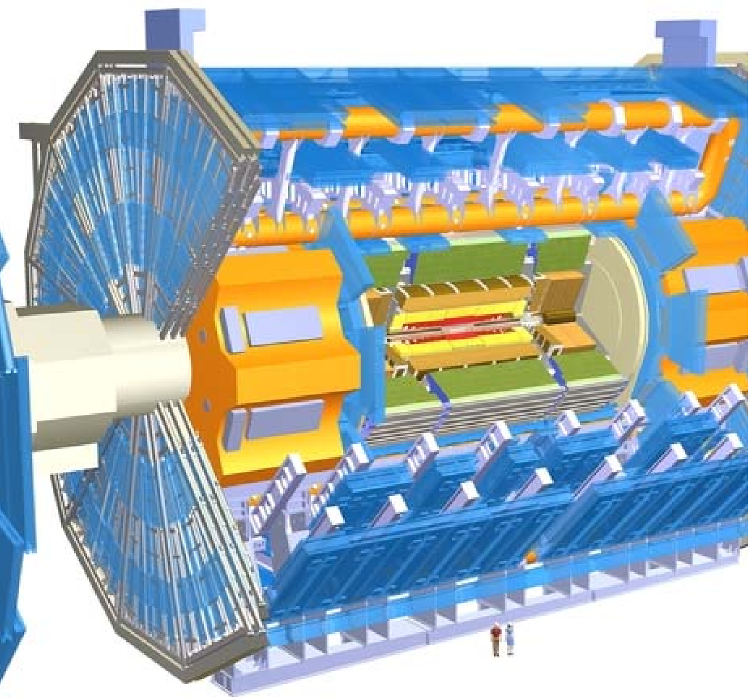
Toroid magnets in place

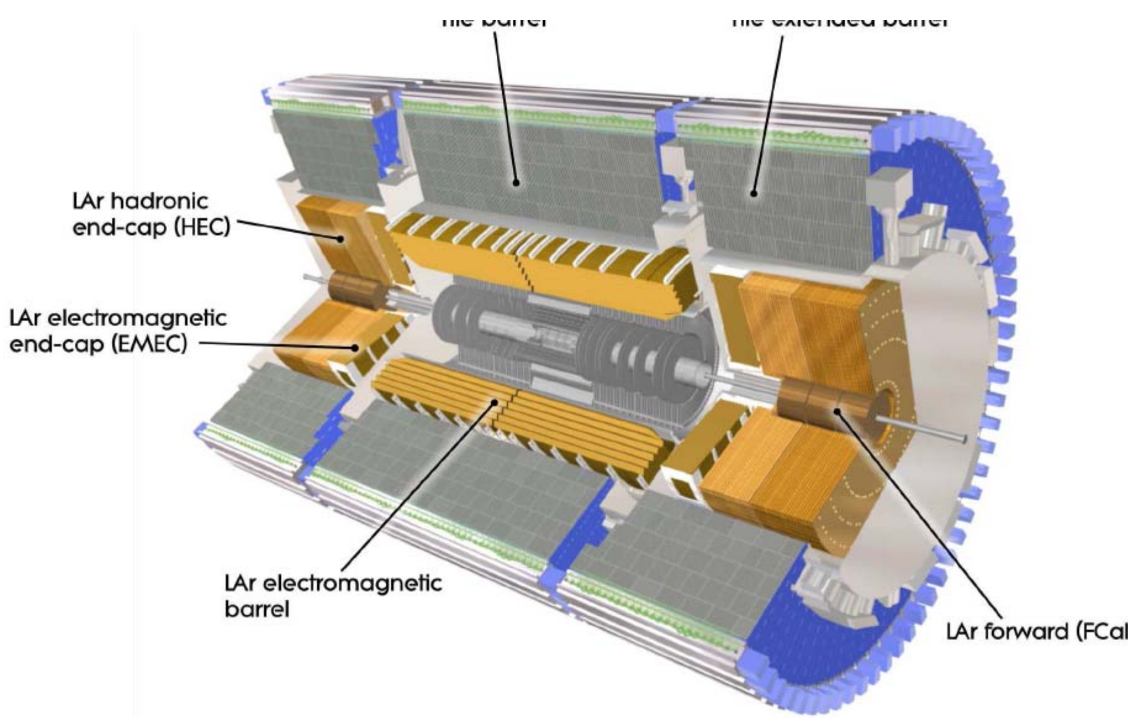
Carleton’s contribution to ATLAS

Modules for the Forward Calorimeter

Location of FCal





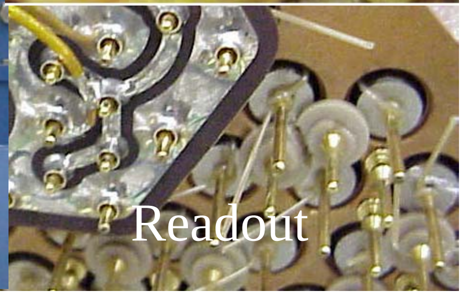


Carleton's contribution to ATLAS

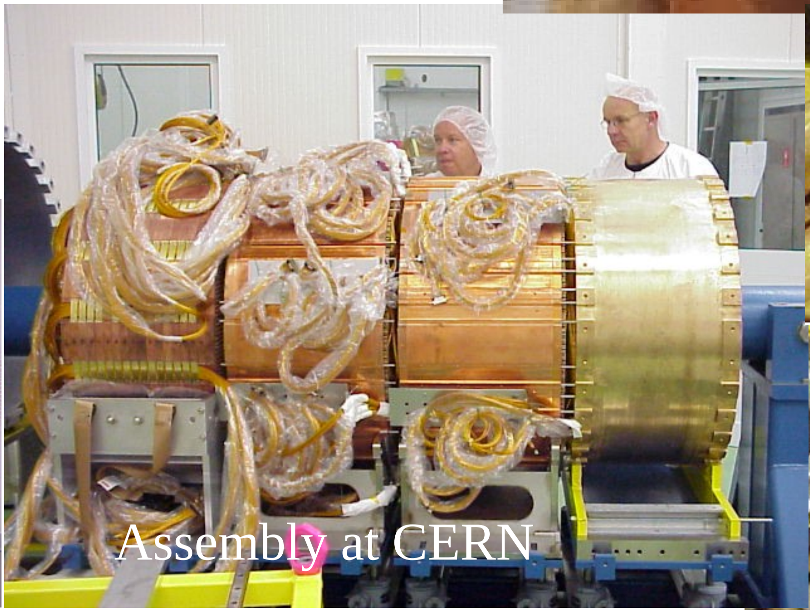
- Two detector modules
- Each module is 1m in diameter and weighs 4 tons.
- Each module contains 8000 rods and tubes and 650,000 tungsten slugs.
- Both modules completed, shipped and installed at CERN.


Undergraduate students assembling the detector


Slugs


Readout

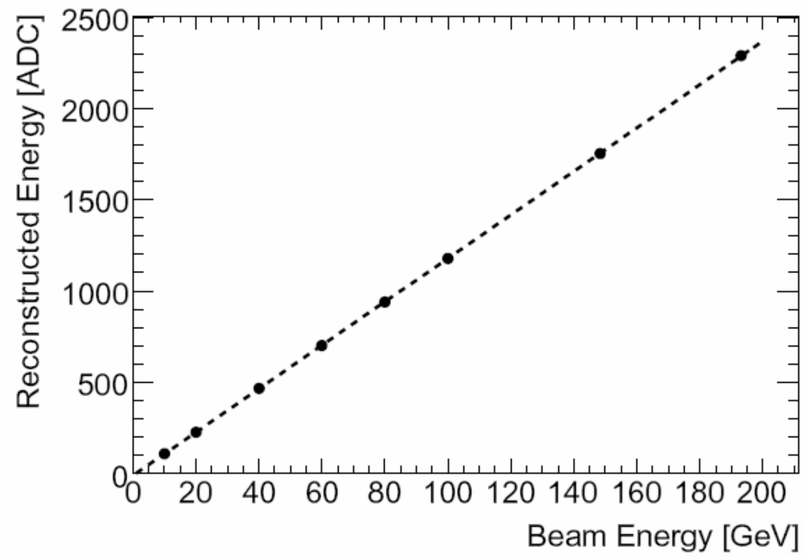

Shipping to CERN

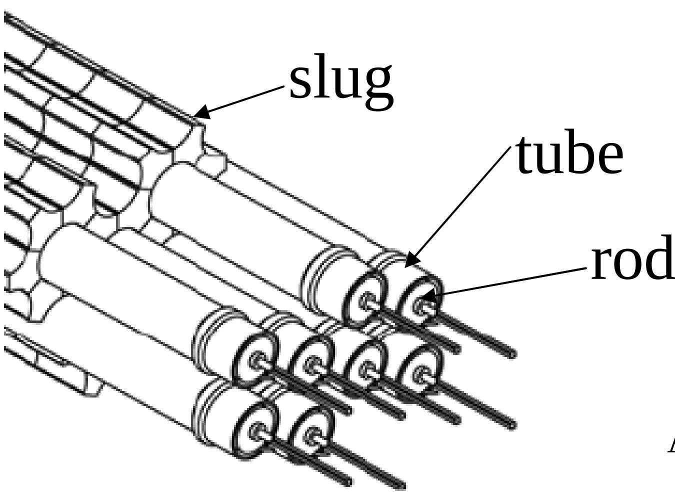

Assembly at CERN

Detector Calibration

- Two detector modules to measure the energy of particles
- CERN beam test for detector calibration performed in 2003
- Detectors now ready for first collisions

Calibration





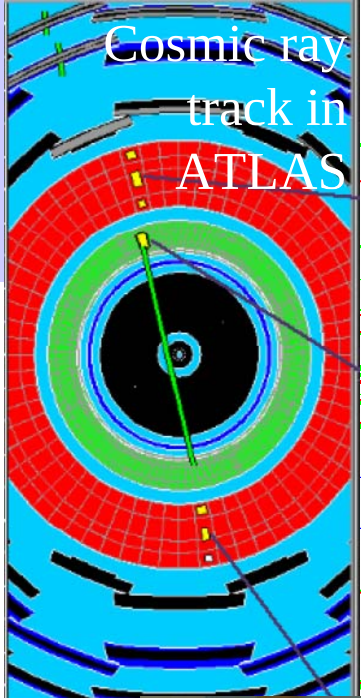
Commissioning the detector

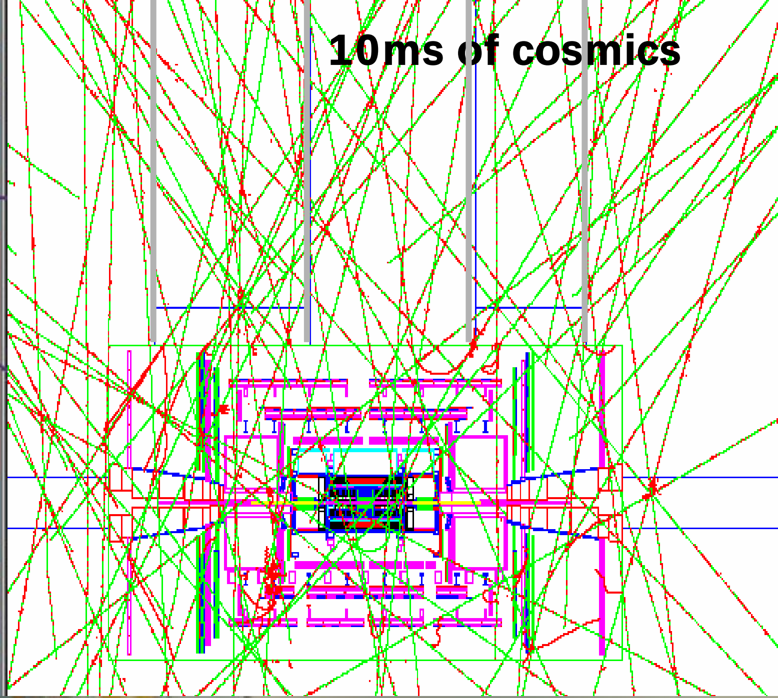
Detector operation

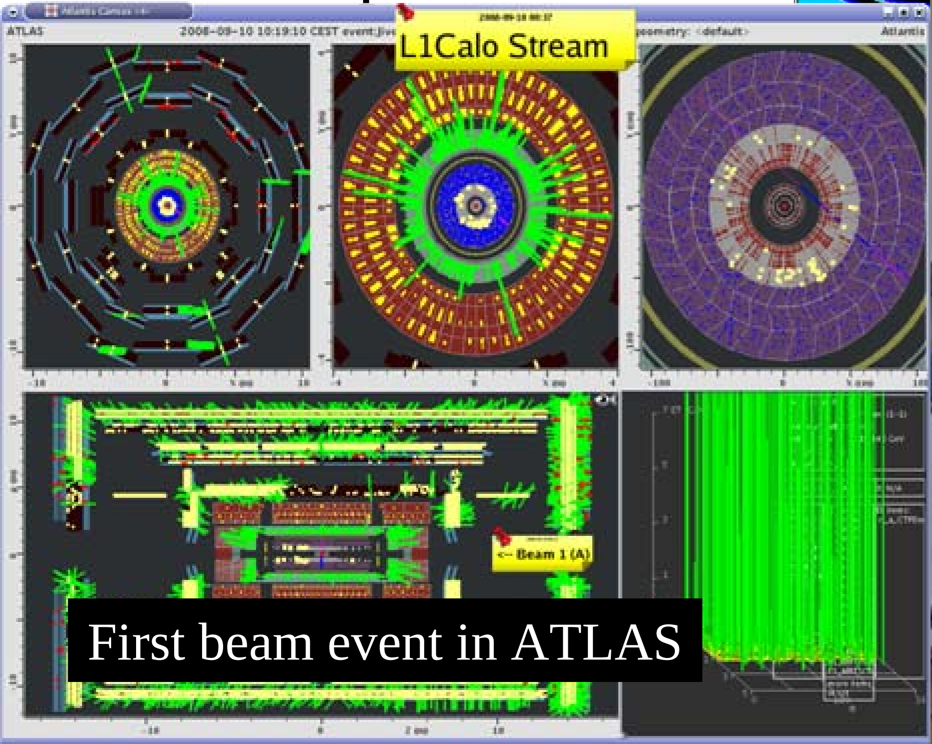
Cosmic rays

First circulating beams

on 10th September 2008







ATLAS Collaboration

35 Countries
165 Institutions
2000 Scientific Authors

Canadian teams working from the beginning (R&D started in 1990)

Alberta, Carleton, McGill, Montreal, Toronto, Regina, Simon Fraser, TRIUMF, UBC, Victoria

Albany, Alberta, NIKHEF Amsterdam, Ankara, LAPP Annecy, Argonne NL, Arizona, UT Arlington, Athens, NTU Athens, Baku, IFAE Barcelona, Belgrade, Bergen, Berkeley LBL and UC, HU Berlin, Bern, Birmingham, Bologna, Bonn, Boston, Brandeis, Bratislava/SAS Kosice, Brookhaven NL, Buenos Aires, Bucharest, Cambridge, Carleton, Casablanca/Rabat, CERN, Chinese Cluster, Chicago, Clermont-Ferrand, Columbia, NBI Copenhagen, Cosenza, AGH UST Cracow, IFJ PAN Cracow, DESY, Dortmund, TU Dresden, JINR Dubna, Duke, Frascati, Freiburg, Geneva, Genoa, Giessen, Glasgow, Göttingen, LPSC Grenoble, Technion Haifa, Hampton, Harvard, Heidelberg, Hiroshima, Hiroshima IT, Indiana, Innsbruck, Iowa SU, Irvine UC, Istanbul Bogazici, KEK, Kobe, Kyoto, Kyoto UE, Lancaster, UN La Plata, Lecce, Lisbon LIP, Liverpool, Ljubljana, QMW London, RHBNC London, UC London, Lund, UA Madrid, Mainz, Manchester, Mannheim, CPPM Marseille, Massachusetts, MIT, Melbourne, Michigan, Michigan SU, Milano, Minsk NAS, Minsk NCPHEP, Montreal, McGill Montreal, FIAN Moscow, ITEP Moscow, MEPhI Moscow, MSU Moscow, Munich LMU, MPI Munich, Nagasaki IAS, Nagoya, Naples, New Mexico, New York, Nijmegen, BINP Novosibirsk, Ohio SU, Okayama, Oklahoma, Oklahoma SU, Oregon, LAL Orsay, Osaka, Oslo, Oxford, Paris VI and VII, Pavia, Pennsylvania, Pisa, Pittsburgh, CAS Prague, CU Prague, TU Prague, IHEP Protvino, Regina, Ritsumeikan, UFRJ Rio de Janeiro, Rome I, Rome II, Rome III, Rutherford Appleton Laboratory, DAPNIA Saclay, Santa Cruz UC, Sheffield, Shinshu, Siegen, Simon Fraser Burnaby, SLAC, Southern Methodist Dallas, NPI Petersburg, Stockholm, KTH Stockholm, Stony Brook, Sydney, AS Taipei, Tbilisi, Tel Aviv, Thessaloniki, Tokyo ICEPP, Tokyo MU, Toronto, TRIUMF, Tsukuba, Tufts, Udine/ICTP, Uppsala, Urbana UI, Valencia, UBC Vancouver, Victoria, Washington, Weizmann Rehovot, FH Wiener Neustadt, Wisconsin, Wuppertal, Yale, Yerevan

Why have 1800 physicists and engineers joined together for 10 years to build a 7000 ton detector that sits on a 27 km circumference accelerator?

To explore the underlying structure of the world we live in.

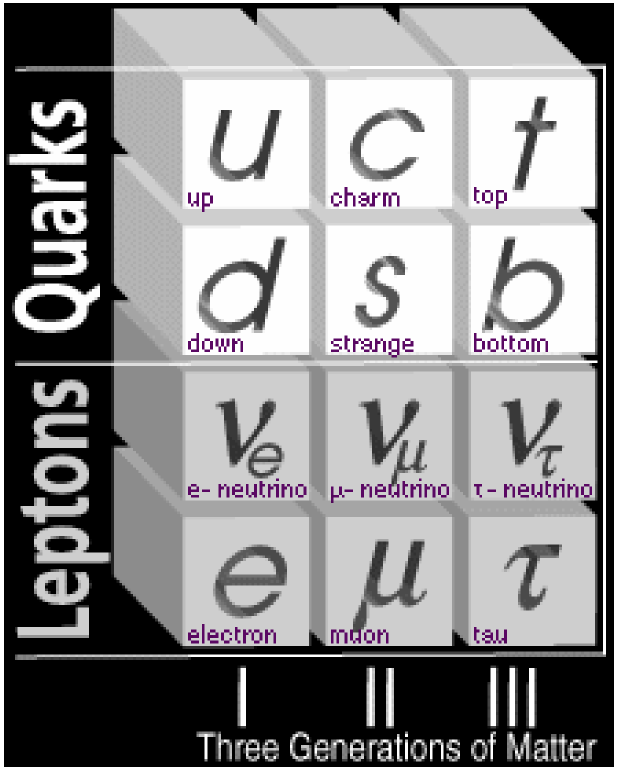
One of the things we are looking for is the origin of mass in the universe.

In other words, why you and I are heavy and not made of some ethereal insubstantial matter.

… Let's go back to the "standard model ..the world of quarks and gluons

What we know so far: The building blocks of the universe

Particles



Forces

Gravity ***(Graviton)***
(Keeps us stuck on the ground)

Weak ***(W and Z)***
(Related to radioactivity)

Electro-Magnetic ***(photon γ)***
(Electronics, radio waves)

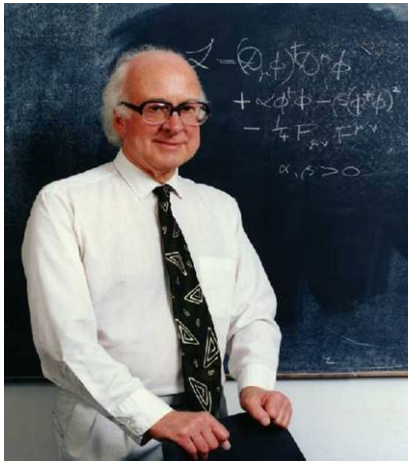
Strong ***(gluons)***
(holds nuclei of atoms together)

Quarks and gluons: The standard model

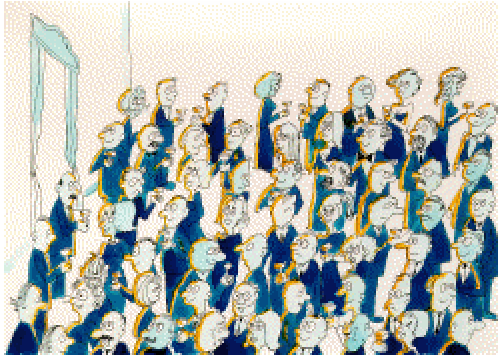
- This picture of our world works very well.
- But there are some problems …
- Why are there three and only three generations of particles?
- Why are the particle masses so different?
- Why do they have mass at all?

- Something is missing!
- Not clear what it is.
- Simplest answer is to add one particle: the Higgs particle.

Mr Higgs:-



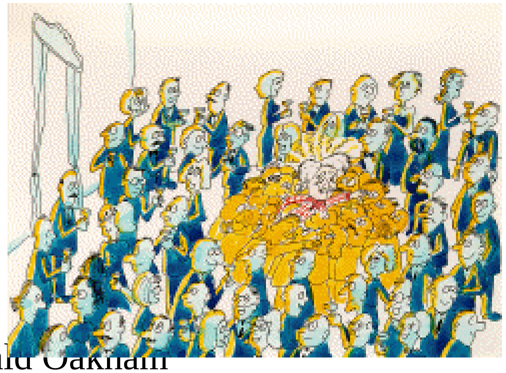
Peter Higgs' particle: how it works



Higgs particle creates field.

⇐ Higgs field (represented by a sea of people at the last Liberal convention).

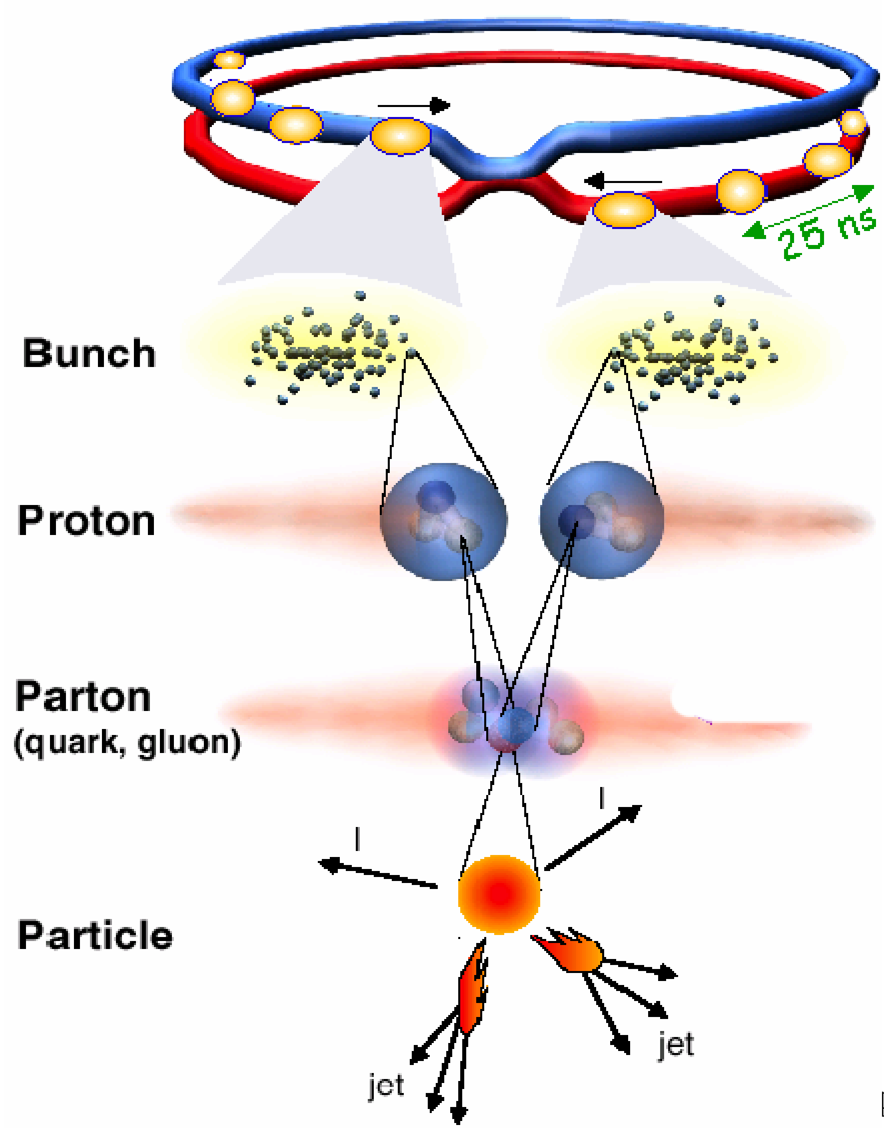
Particle travels through field (represents by Stephane Dion in Red –what happened to the green?).



Field clumps around particle impeding progress creating effect we know as mass.

(political acolytes gather round Mr. Dion slowing him down).

How the LHC accelerator will work



- Use accelerators to give particles like protons and electrons large amounts of energy. (LHC energy is 1,000,000,000 × energy of electrons in a standard TV set.
- Collide these particles together.
- This creates a state of pure energy.
- From this energy new particles are created.
- New particles decay to particles with which we are familiar and that can be detected.

presentation

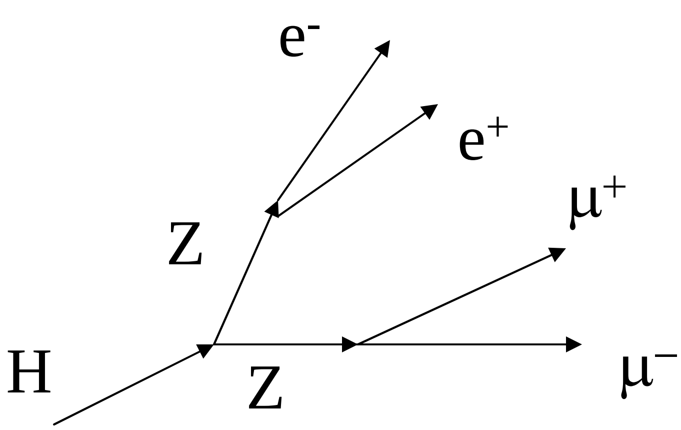
And how will we see the Higgs particle

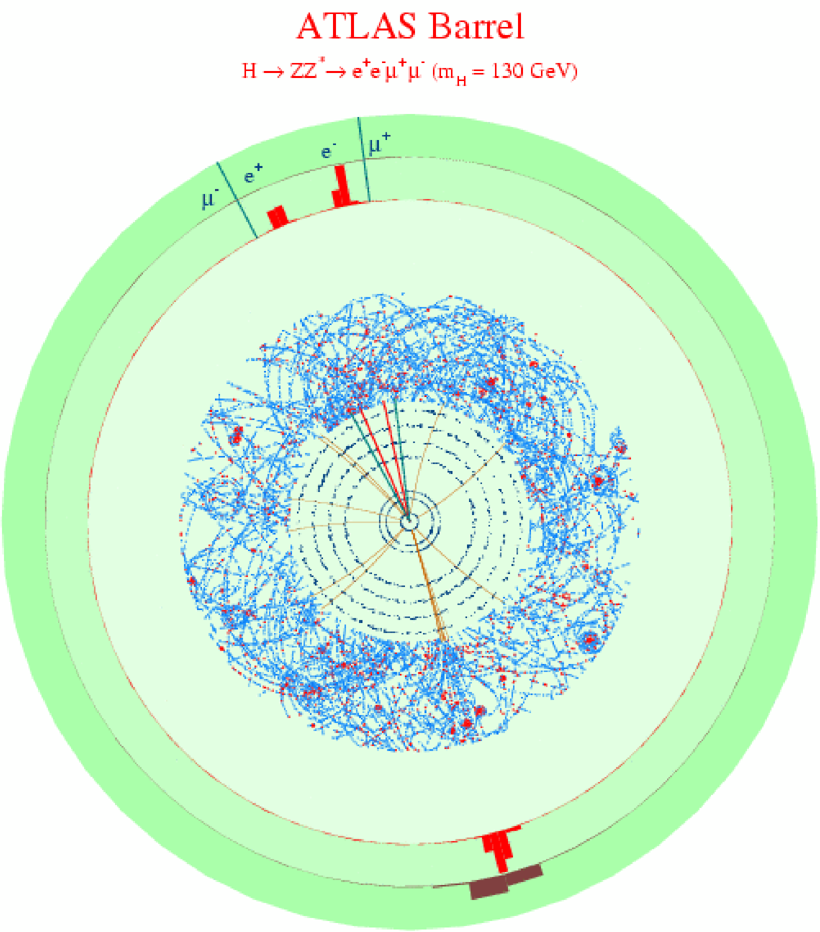
One possibility:

Higgs → two Z particles

One Z → electron + positron

Other Z → muon + antimuon





Gerald Oakham

ATLAS

Higgs hunting

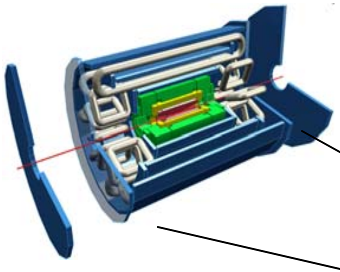
Standard model Higgs events are very rare.

Only 1 in 1,000,000,000 events will contain a Higgs particle.

The amount of data produced by the ATLAS detector will be enormous.

Need to collect, sort and store the right parts of the data stream.

Collecting the data



~Petabyte (Pb) of data/sec

At most 100,000 Higgs particles a year produced – not all detectable.

Event selection system

450 Mbyte/sec

CERN computer centre

9 Pb year stored

Fiber optic light Paths form LHC Computer grid

Canada

Japan

U.K.

1 peta-byte 10^{15} bytes = data on 200,000 DVD discs

… and if we don't find a Higgs particle

Many other candidate theories.

- Super-Symmetry:
  - Each of the current known particles has a super-partner
  - Doubles the number of fundamental particles
  - Expanded Higgs sector … more Higgs-like particles with different signatures
- Extra Dimensions
  - "Rolled up" extra dimensions change the way forces operate
- Substructure
  - Another layer of fundamental particles below quarks and leptons.
- Extra families of standard model particles
- And many more …

Some of these models do not have a particle that looks like a standard model Higgs.

In others the Higgs decays to particles we will not be able to observe in our detectors ….

Analysis preparation for ATLAS

The ATLAS group has been working on analysis tools using simulated data for some time.

Like other ATLAS groups Carleton is actively involved in this.

We have studies in:-

1. Higgs boson productions
2. SuperSymmetry
3. Studies of the heaviest quark the Top quark

Ready for data taking and analysis.

Current LHC status

Very successful start up on the 10th of September.

Beams circulated around the ring in both directions and through ATLAS

Unfortunate incident on Friday the 19th of September

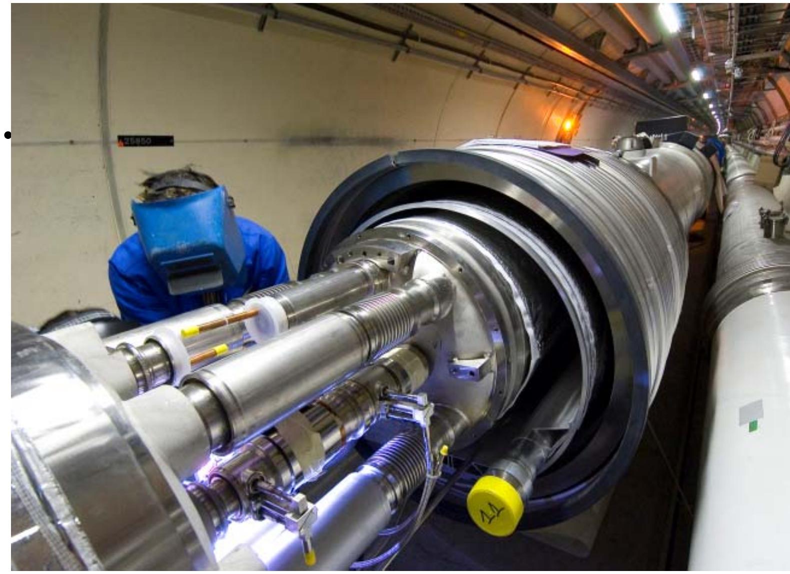
It appears that a coupling between magnets failed that subsequently lead to the loss of a large amount of helium

It will take 4 weeks to warm the affected 1/8th of the accelerator up before a full investigation is possible.

This leads to a minm 2 month repair time.

CERN shuts during the winter months

Scheduled startup is in spring of 2009



Summary

The LHC and ATLAS are poised to produce a wealth of new physics data.

First new thing to look for is Higgs particle

The ATLAS experiment is ready for data taking starting in the spring of 2009

For more information see:-

CERN - http://public.web.cern.ch/public/

ATLAS - http://atlas.ch/

The Last word..

ATLAS in 2009: a simulation