

The Large Hadron Collider and ATLAS

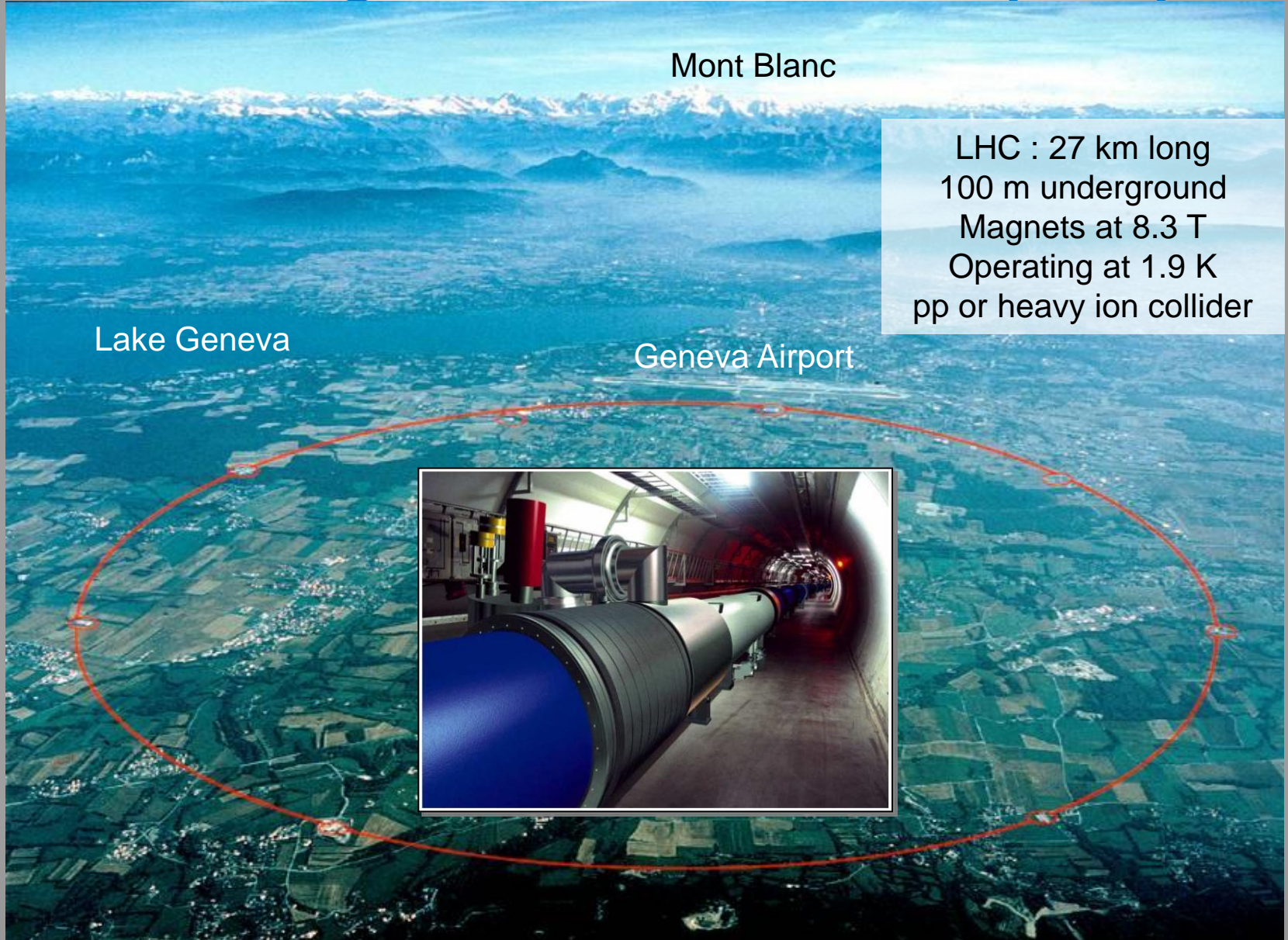


Hardeep Bansil
University of Birmingham

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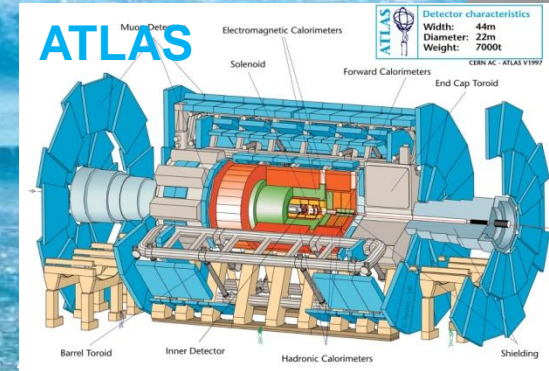
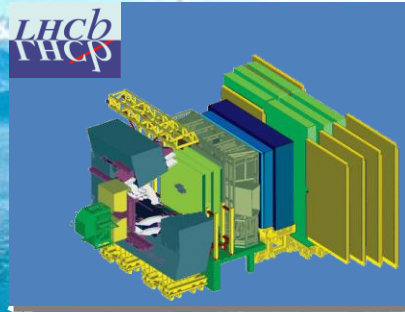
- The Large Hadron Collider (LHC)
- Collisions in the LHC
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- Detector components
- Event selection and data storage

The Large Hadron Collider (LHC)

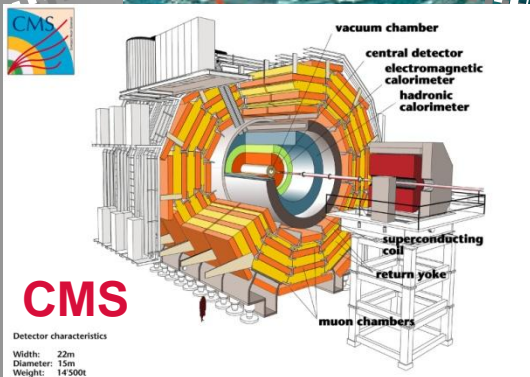


The LHC Experiments

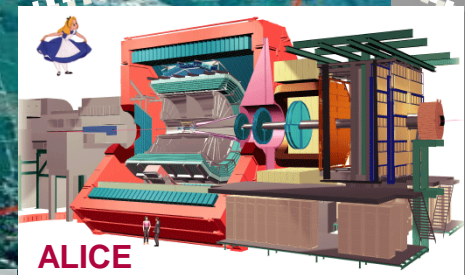
Matter-antimatter asymmetry



General Purpose
“discovery” machines

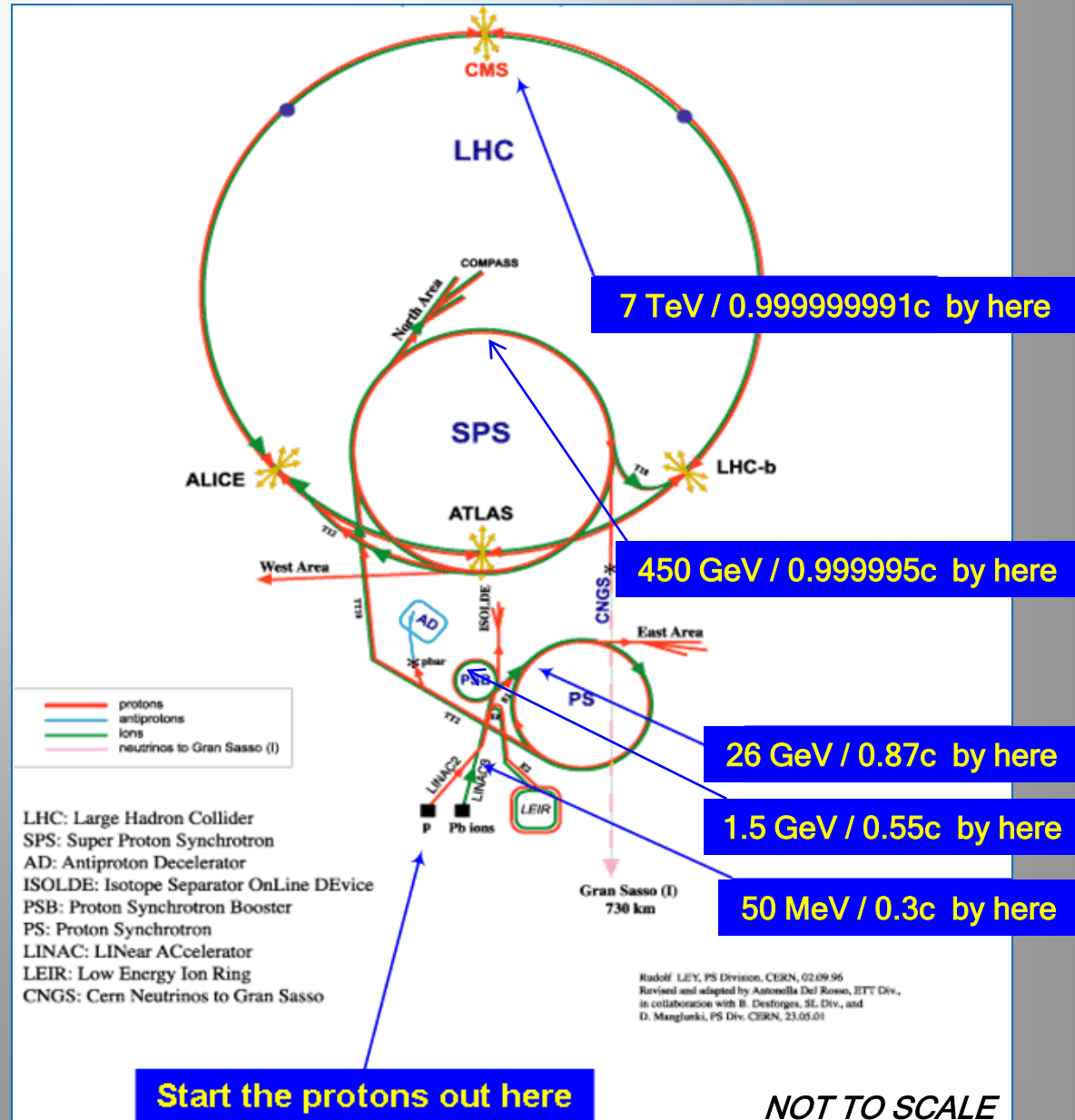


Quark gluon plasma



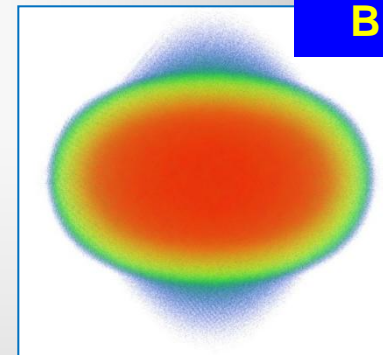
The LHC Accelerator Chain

Start off with a bottle of hydrogen gas!

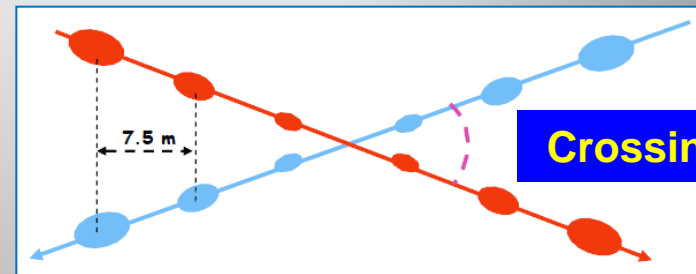


Collisions in the LHC

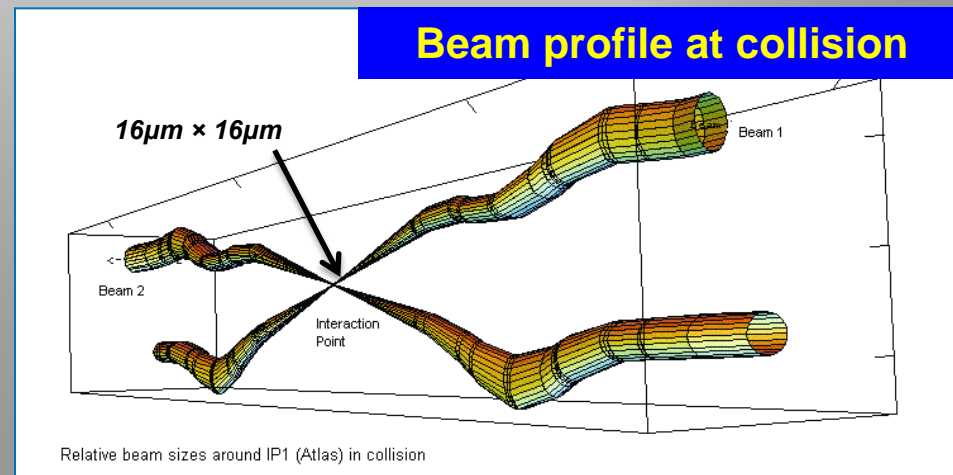
- 7 TeV protons colliding with 7 TeV protons
 - Centre of mass energy of 14 TeV
 - 100 billion protons per bunch (10^{-12} of a gram of H)
 - 2808 bunches in ring
 - Smallest beam size possible at the collision point
-
- We get 'only' around 20 collisions per crossing
 - 40 million bunch crossings per second
 - Close to 1 billion collisions per second



Bunch intensity



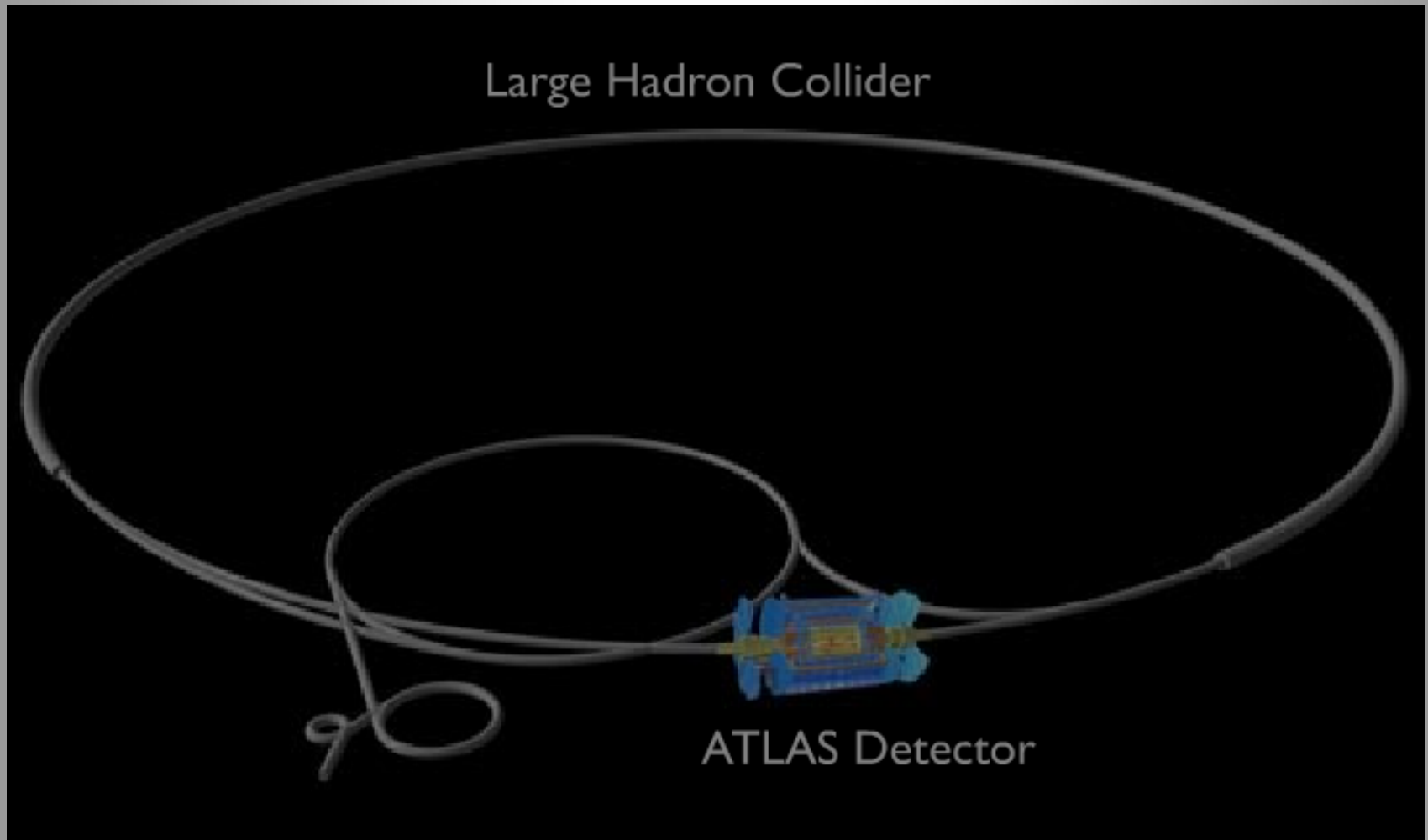
Crossing angle



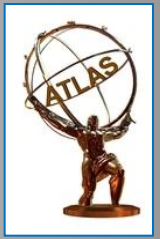
Beam profile at collision

Relative beam sizes around IP1 (Atlas) in collision

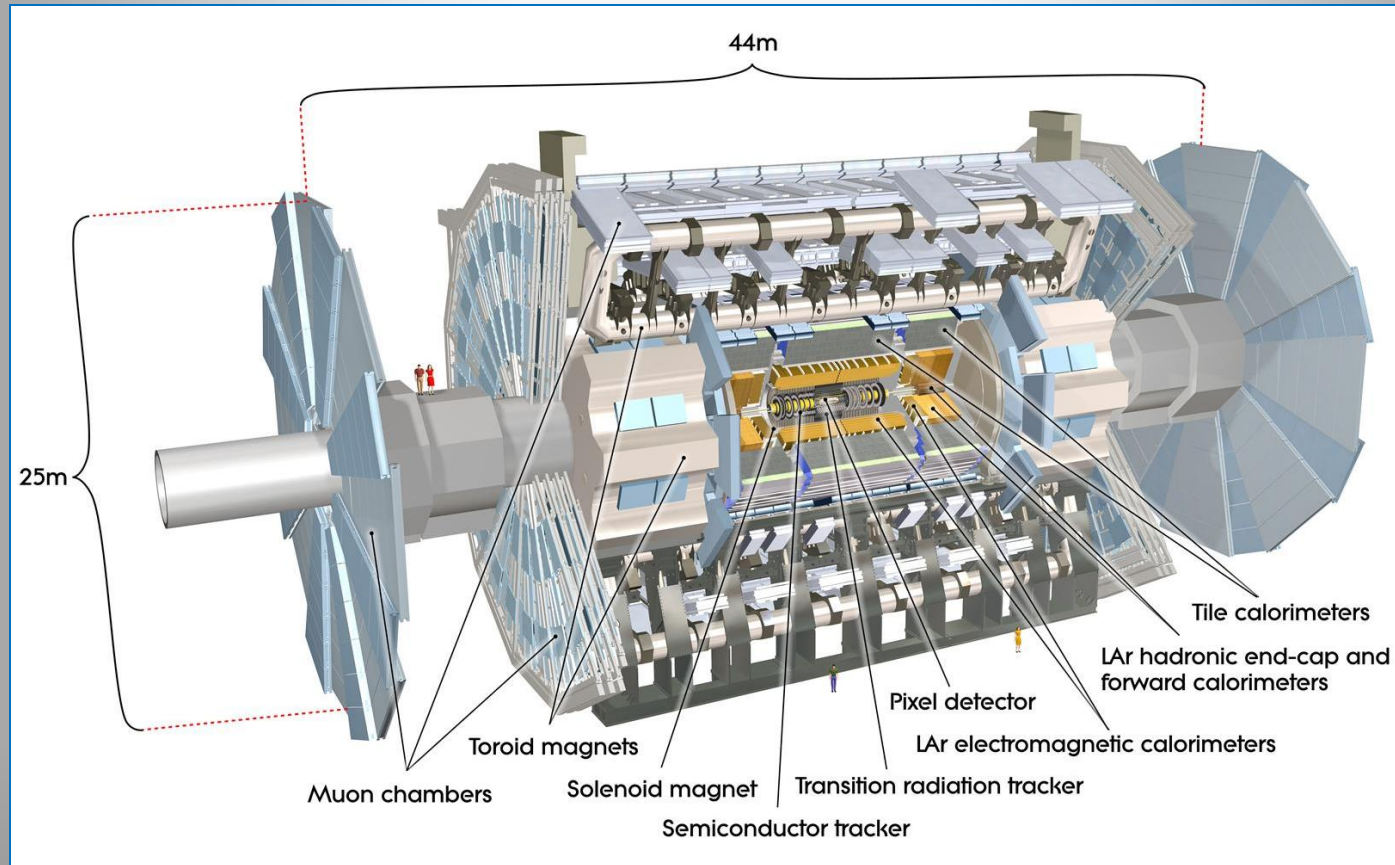
Collisions in action



The ATLAS Detector



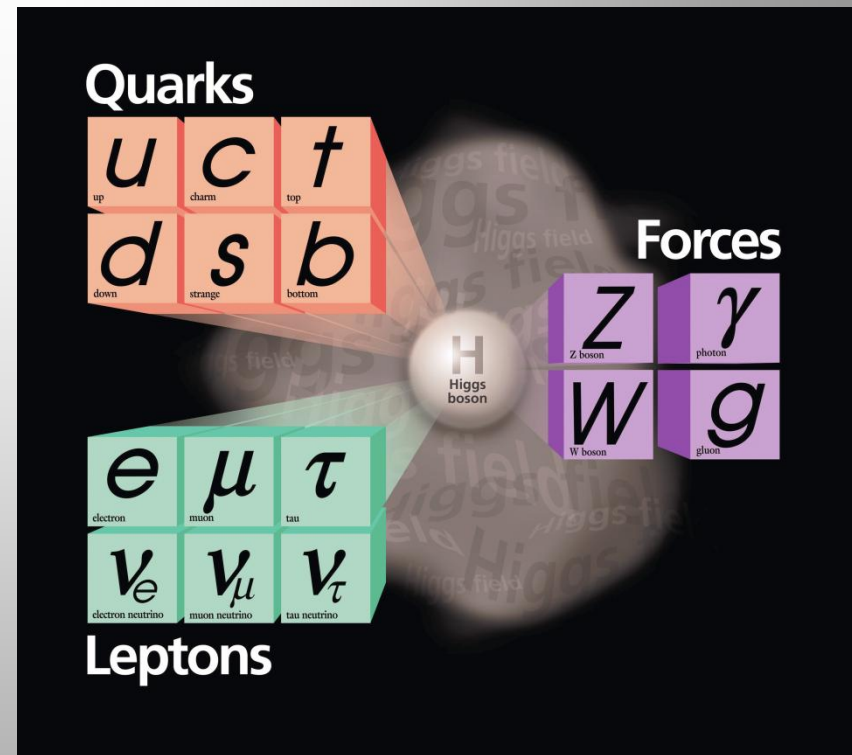
- 44m in length and 25m in diameter; weighs 7000 tonnes
- Cylindrical geometry as built around the interaction point at the centre of the detector



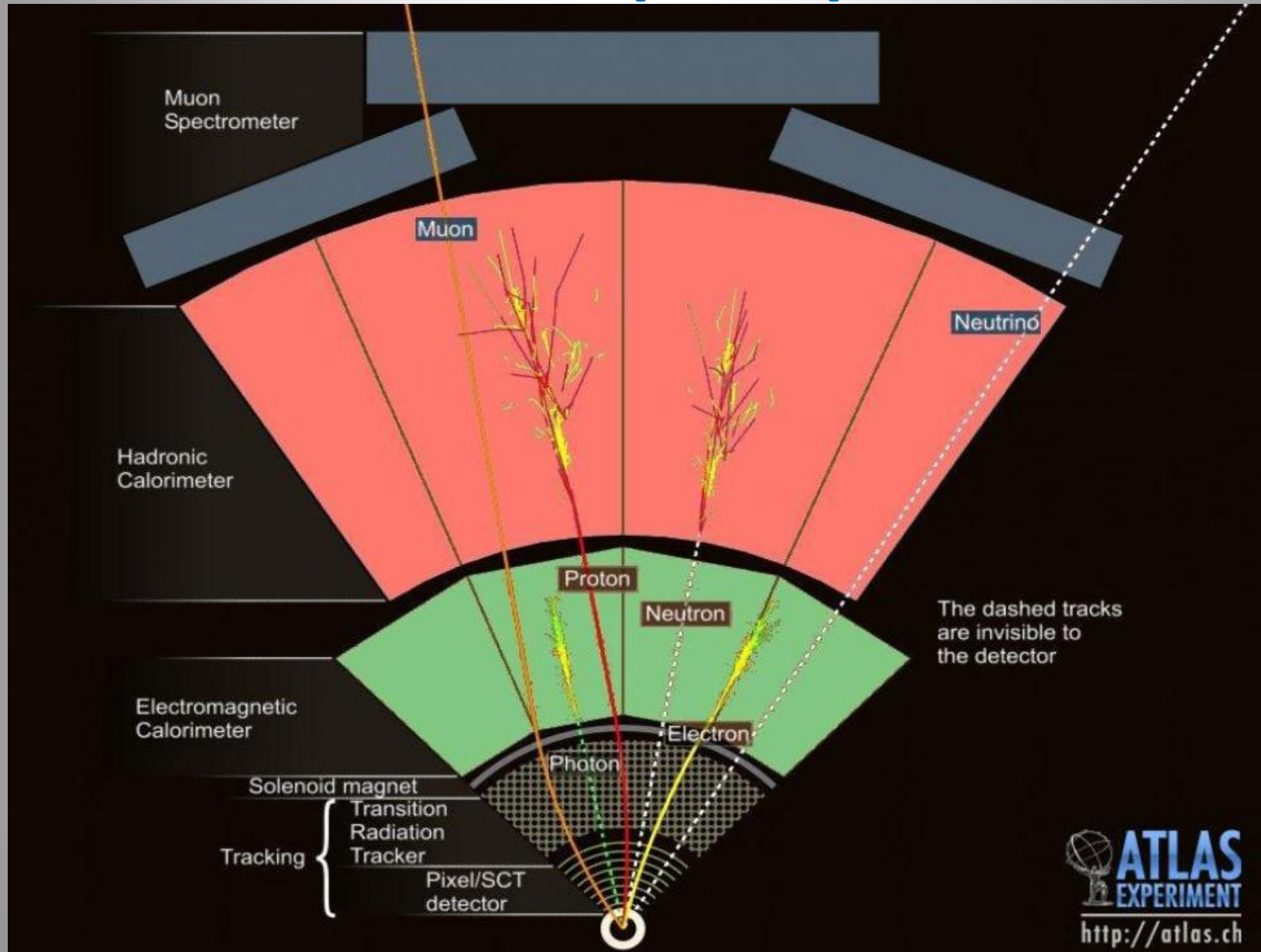
- The ATLAS experiment is a collaboration of approximately 3000 scientists from 173 institutions in 37 different countries

Physics aims of ATLAS

- To further our knowledge on how the universe is constructed and works:
 - Understand the origin of particle mass (Search for the Standard Model Higgs boson)
 - Look for physics beyond the Standard Model (Supersymmetry, Grand Unification Theories)
 - Are quarks and leptons elementary particles? Are there more generations?
 - Why is there a matter-antimatter asymmetry in the universe?
 - What is dark matter?
 - Can we see black holes?
 - Are there extra dimensions?
 - Perform high precision studies of particles such as B-mesons, top quarks, W and Z bosons

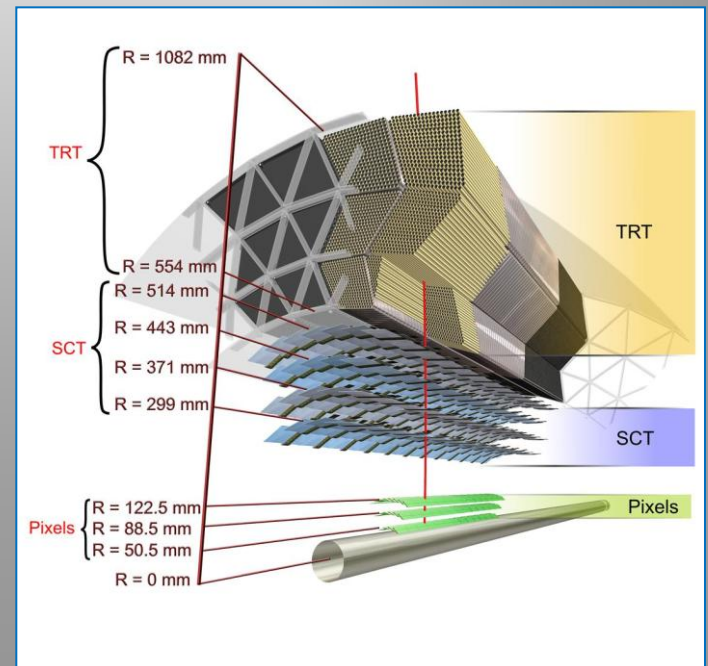
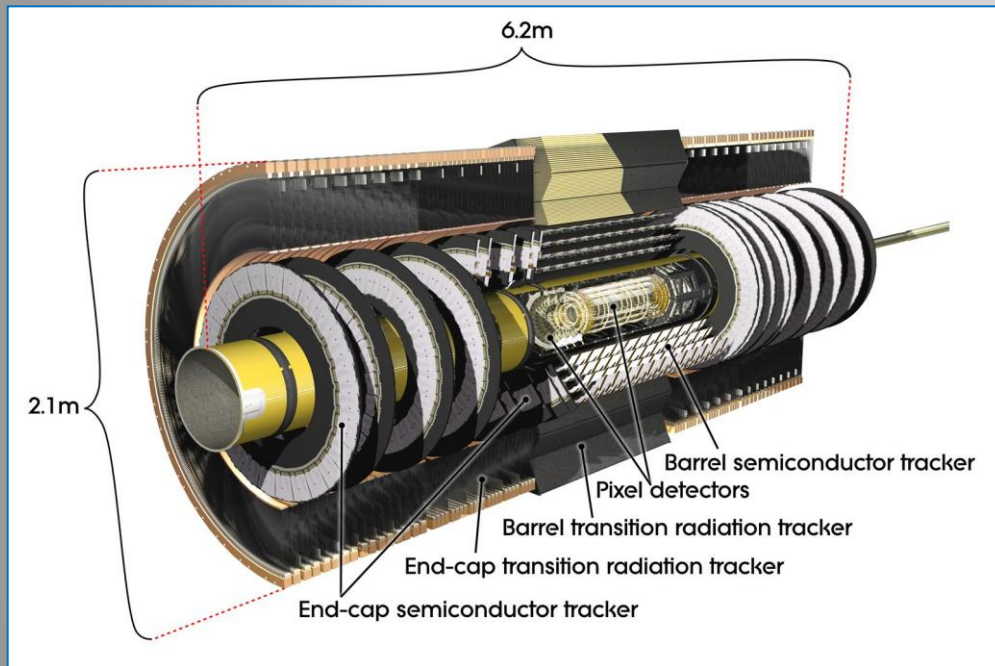
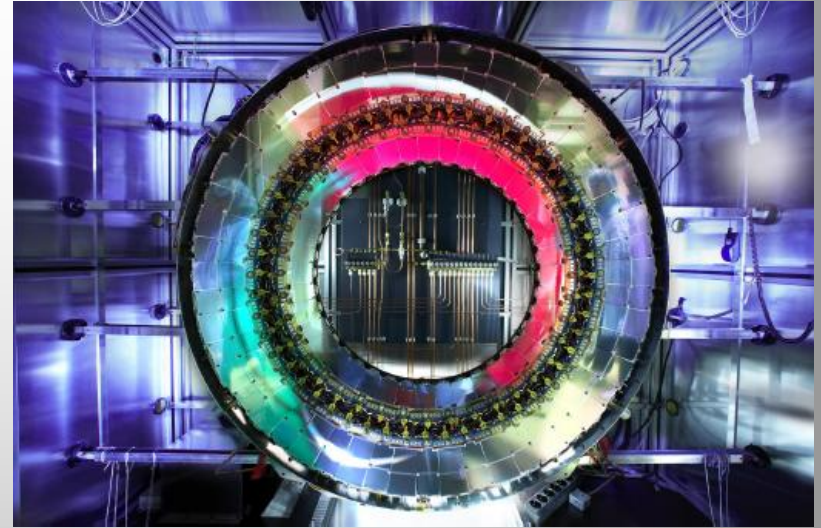


Detector principles



Inner Detector

- Tracking chamber
- Pixel detectors nearest the beam pipe
- Next is Semiconductor Tracker (SCT)
- Outmost is Transition Radiation Tracker (TRT)



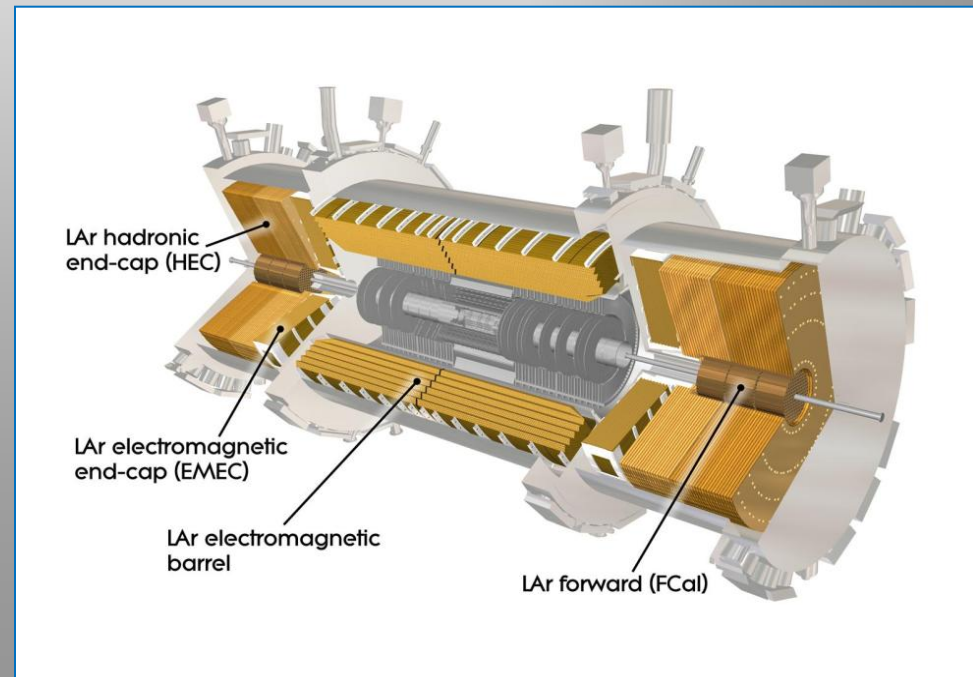
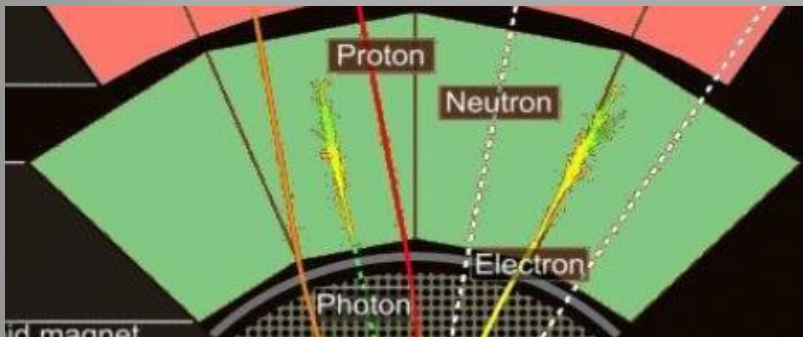
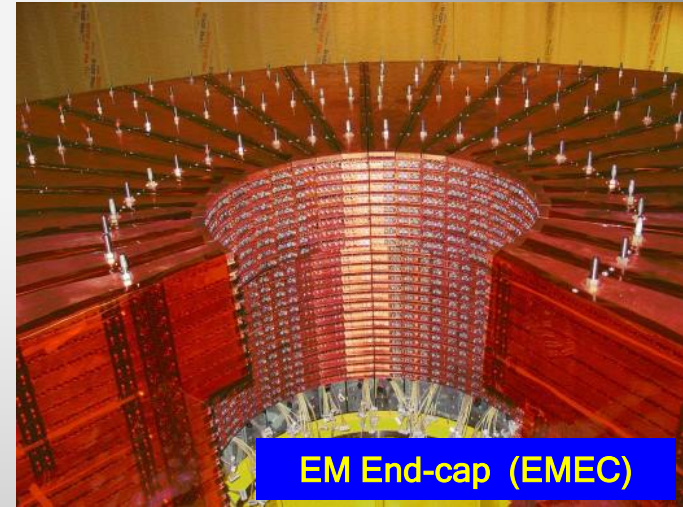
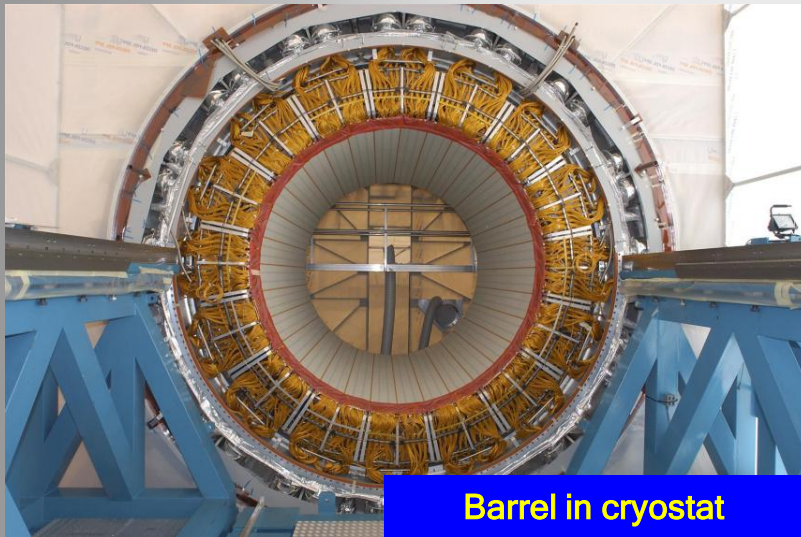
Solenoid Magnet

- Produces a 2T magnetic field parallel to beam axis
- Surrounds the inner detector and is contained in a cryostat, 4.5K He



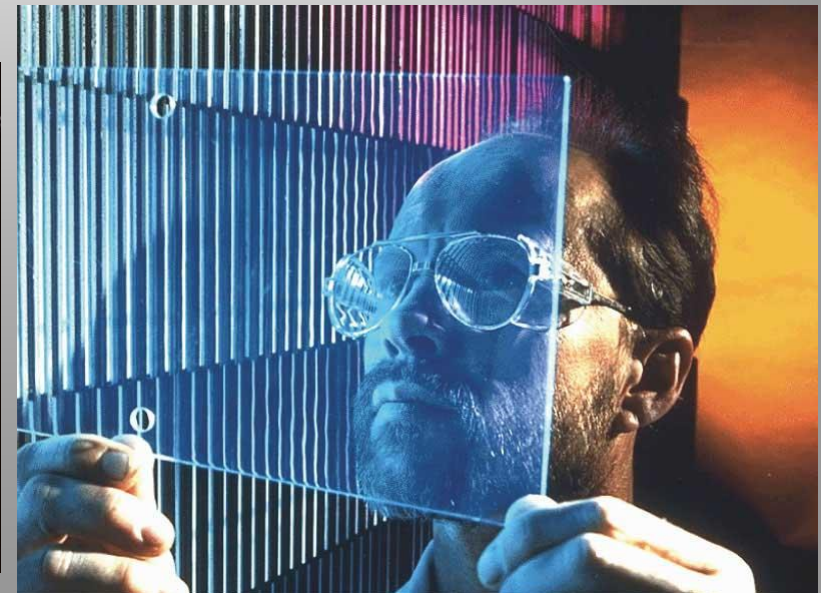
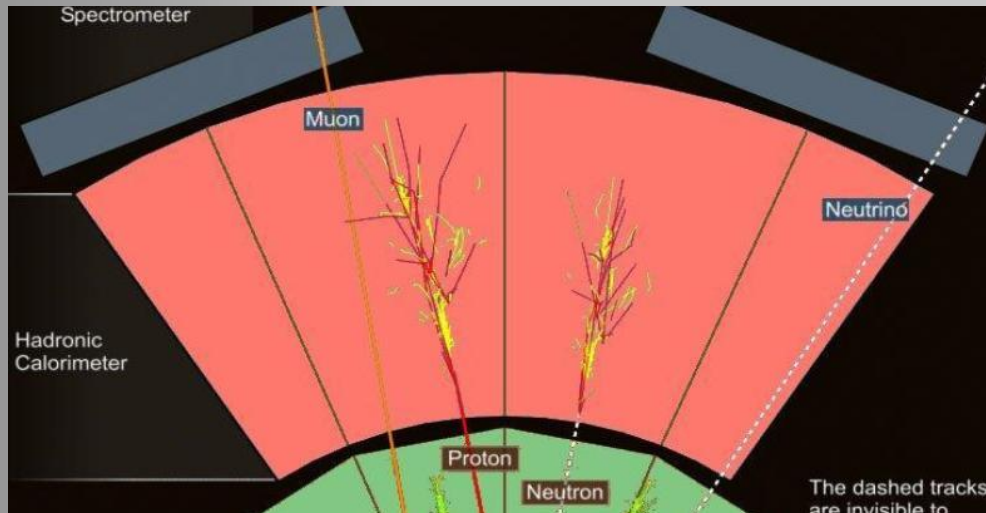
Electromagnetic (EM) Calorimeter

- Layers of lead absorber and liquid Argon sensing element
- Photons and electrons stopped by the amount of lead

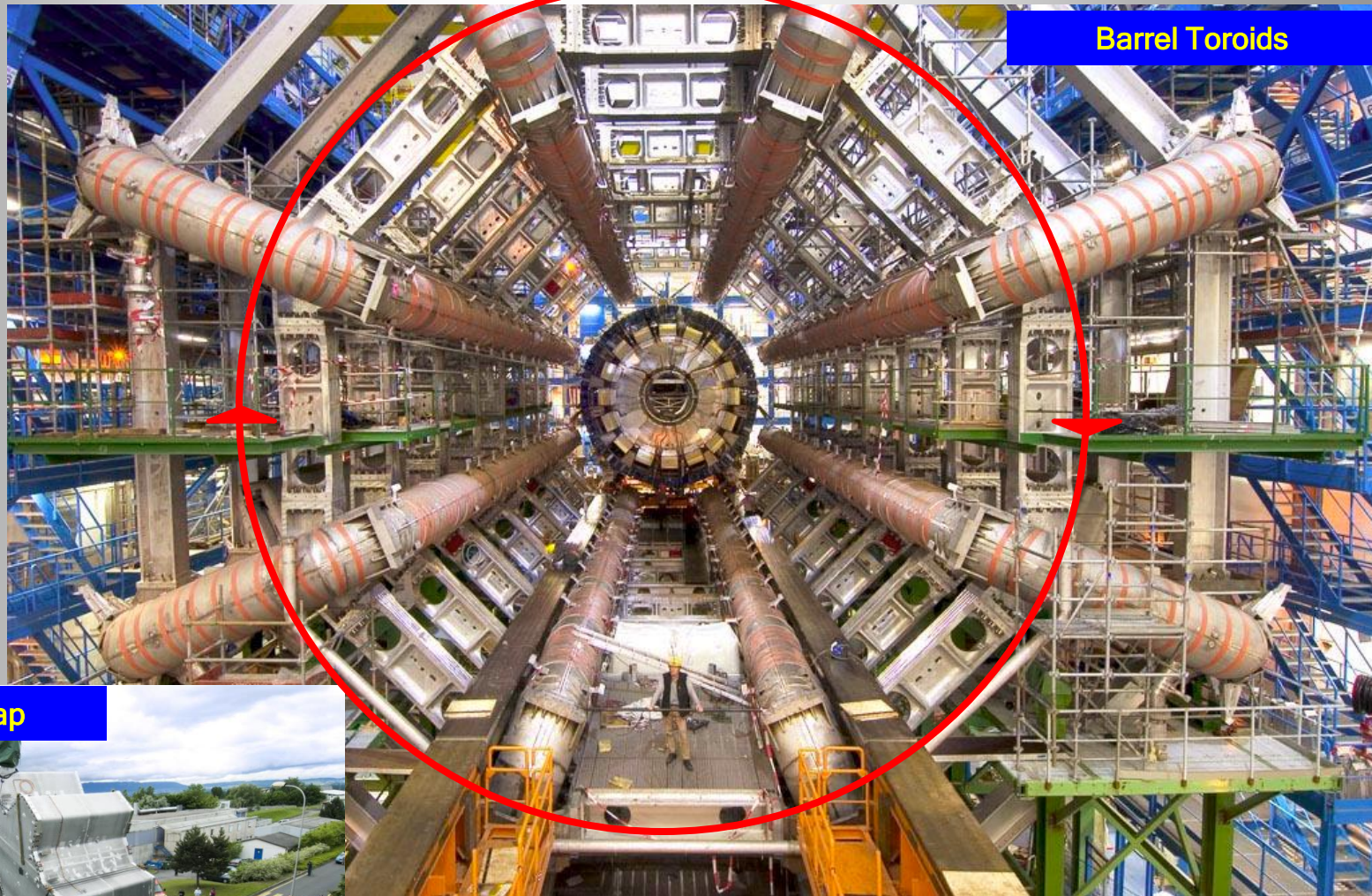


Hadronic Calorimeter

- Steel absorber
- Tiles of scintillating plastic (ionisation causes light emission)
- Photo-multiplier tubes collect light produced and convert this into an energy



Toroid Magnets



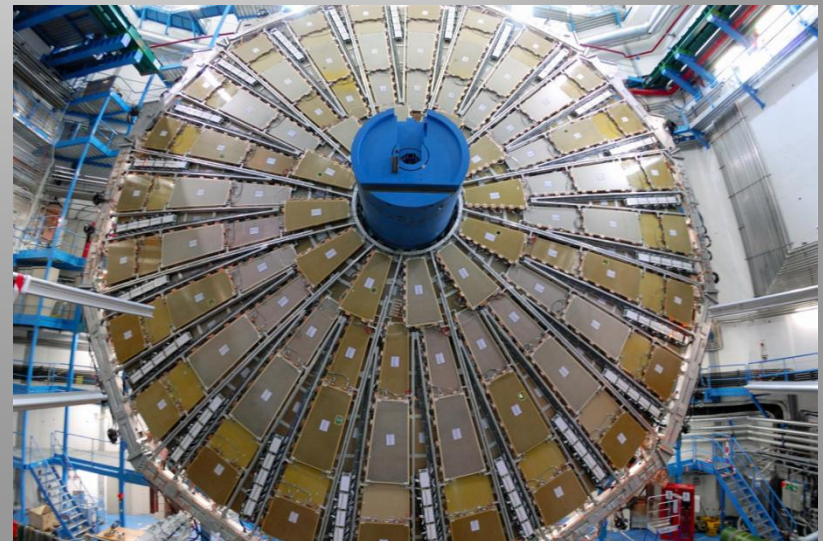
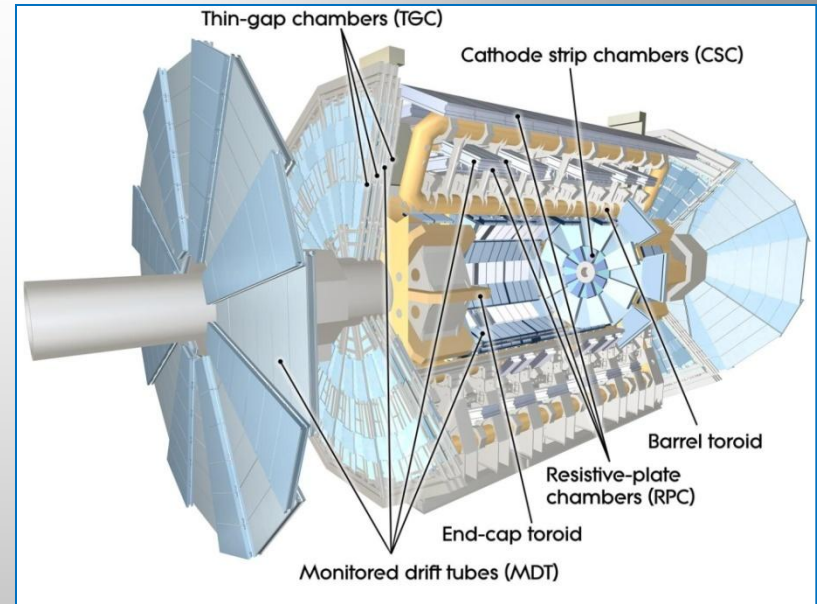
Toroid end-cap



- Superconducting coils – 5m wide, 25m long
- Magnetic field of 4T perpendicular to beam line

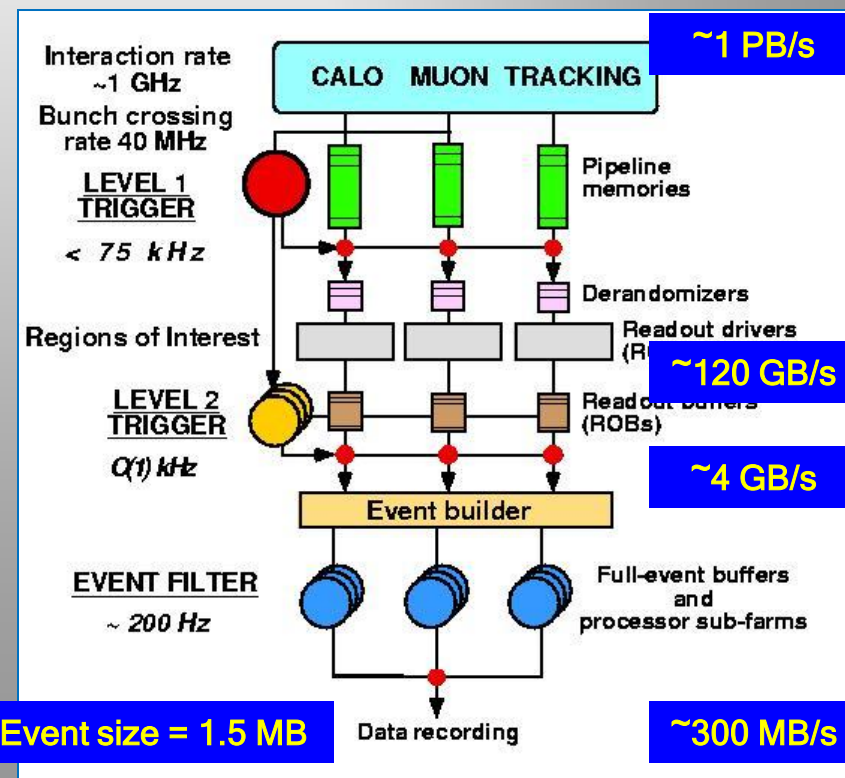
Muon Spectrometer

- Muons are the only charged particles which don't interact in the calorimeters
- Toroid magnet bends muon tracks and allows a momentum measurement
- Like the Inner Detector, the muon spectrometer measures the curvature of the muon tracks but more precisely

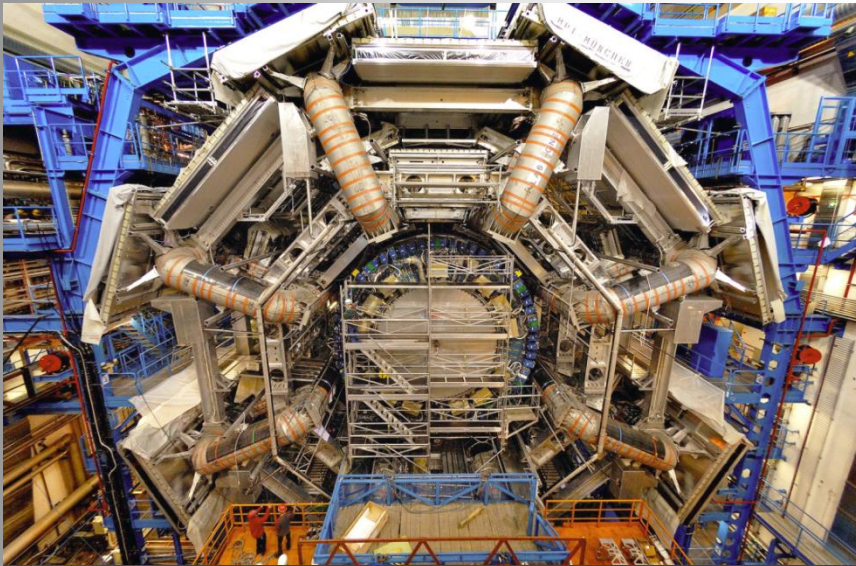


Event selection and data storage

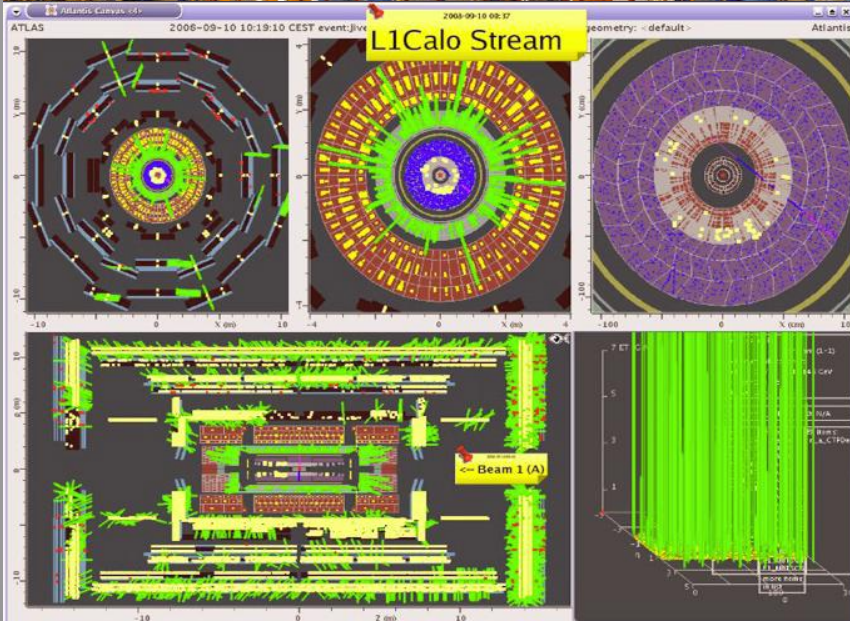
- Interaction rate $\sim 1\text{GHz}$
 - If all recorded to DVD this would be 14,200 DVDs / s
- ATLAS needs a complex triggering system to select interesting events to write to disk
- Recordable rate $\sim 200\text{ Hz}$
 - Keep 2 in 10,000,000 events (4 DVDs / min)
 - Much better!
- Data spread across world over Computing Grid



An eventful time for the LHC & ATLAS



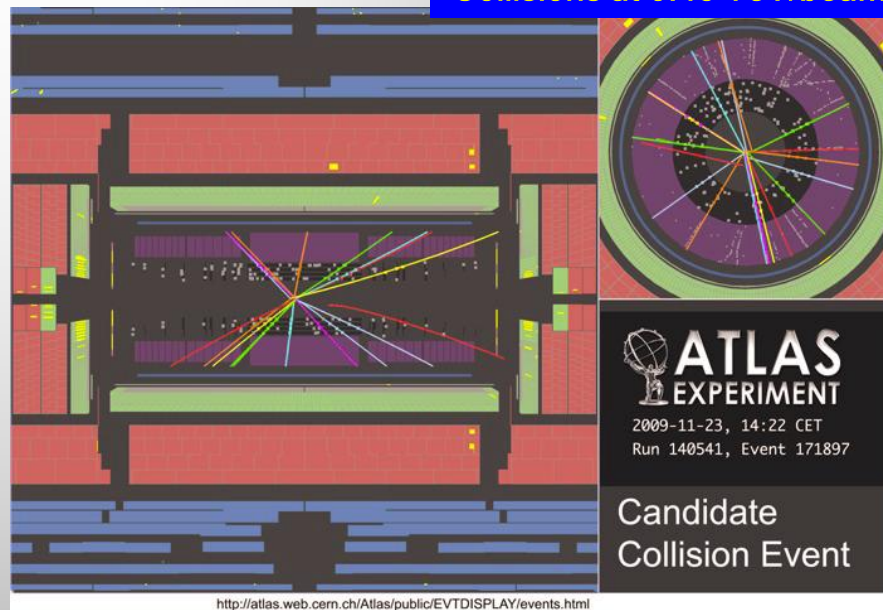
- Finished construction around Aug 2008
- First beam circulated in Sep 2008
- Big problems in LHC 9 days later
- LHC shut off for a year
- Commissioning to improve detector performance ongoing



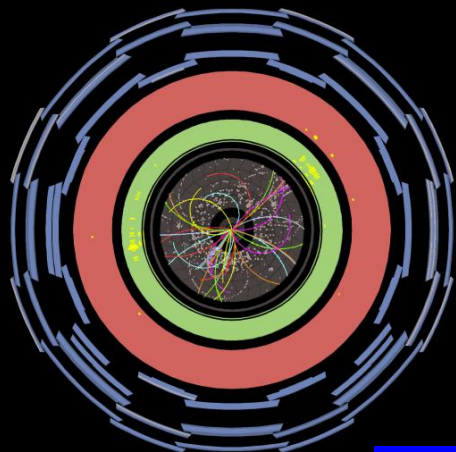
It works!

- Nov 2009 – first collisions ever data at 0.45 TeV per beam & 1.18 TeV per beam (world record)
- Apr 2010 - Successfully recording collisions at 3.5 TeV per beam until 2011

Collisions at 0.45 TeV/beam



<http://atlas.web.cern.ch/Atlas/public/EVTDISPLAY/events.html>



Collisions at 3.5 TeV/beam

- After repairs in 2012 will see collisions at 7 TeV per beam
- Big discoveries soon! 😊