The ATLAS detector

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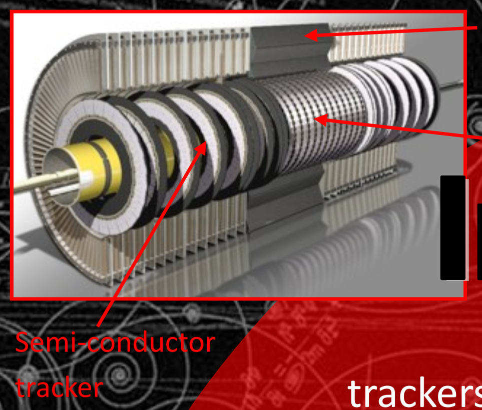
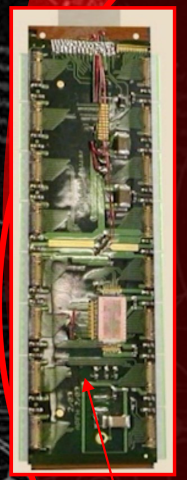
Inner detector

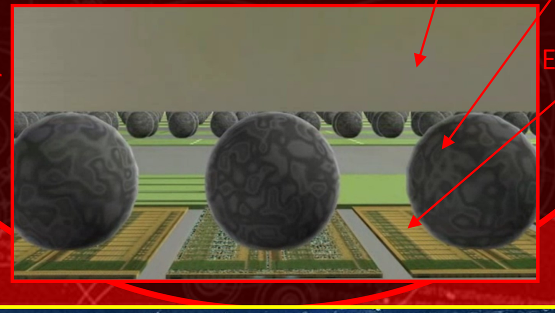


The inner detector is made up of three trackers; the Pixel detector module, the Transition radiation tracker (TRT) and the semi-conductor tracker (SCT). These measure the tracks of charged particles that are bent by the magnetic field of a thin superconducting solenoid magnet. The SCT is similar to the pixel detector but covers a larger surface area. It's used for tracking in the plane perpendicular to the beam.

Pixel detector module

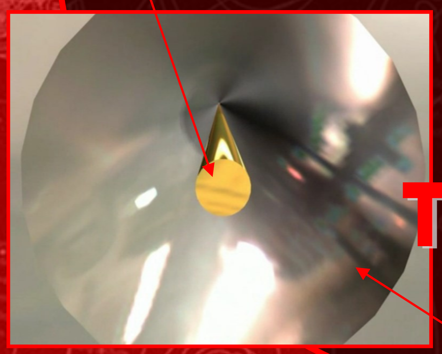
Each module is compromised of a top layer of silicon and a lower layer of electronics, connected by an array of cenospheres. When charged particles pass through the silicon layer, silicon molecules are ionised and the excess electron move to the bottom of the strip, creating an electric current in the cenospheres below. The signal is converted into binary which tells scientists the path in which the particle took.





Transition radiation tracker

The TRT distinguishes between different types of particles. Its made out of a large number of tubes filled with gas. When a charged particle enters the tube, it is ionised by the gas. The liberated electrons move towards a gold wire at the centre of the tube where they're measured. Different particles correspond to a different amount of negative charge measured in the gold wire, so ATLAS is able to distinguish between different particles.

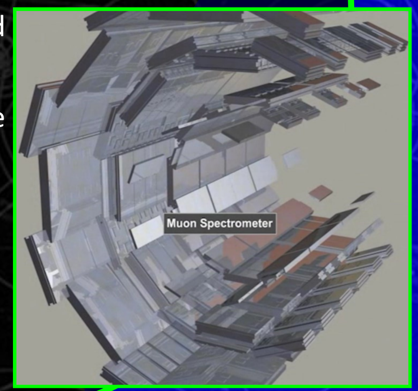


Solenoid magnet

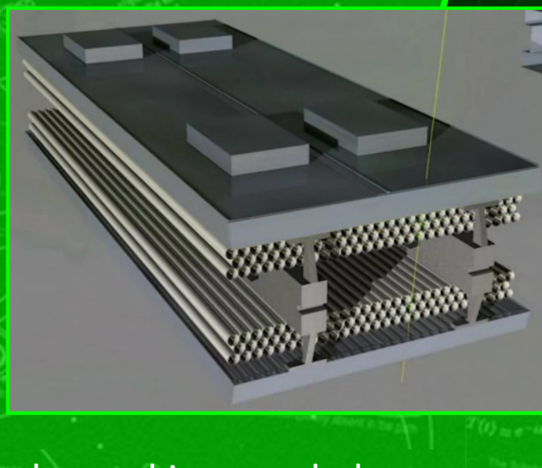
This magnet surround the inner detector, producing a 2 tesla magnetic field. This allows even the very high energy particles to curve enough for their momentum to be determined. A particle with a lower momentum will follow a more curved path than those with a greater momentum. It's nearly uniform direction and strength means these measurements can be made very precisely.

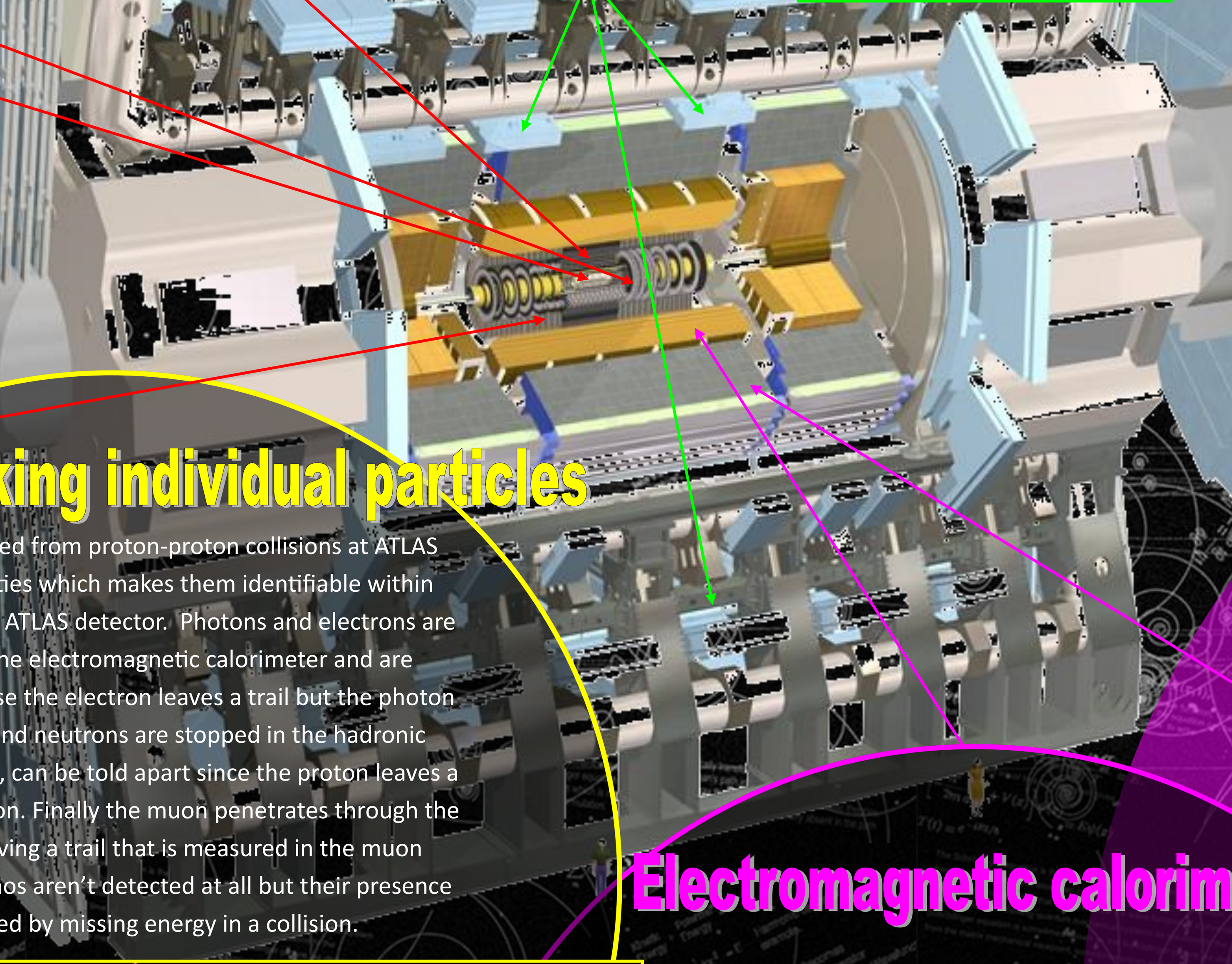
Muon spectrometer

The muon chambers in ATLAS cover a surface of several football fields. It measures the momentum of muons (particles similar to electrons but 200 times larger) that can travel through the calorimeters without being absorbed. The muon spectrometer is placed in the magnetic field of large superconducting toroidal coils. The tubes are similar to the drift tubes in the inner tracker, but with larger diameters.



Each segment of the muon chamber contains many tubes filled with gas. As a muon passes through these tubes, it ionises the gas atoms along its path, leaving a trail of electrically charged ions and electrons which drift to the central wire where they're measured. By measuring the time it takes for these particles to drift to the wire, it's possible to determine the path of the original muon as it passed through the chamber.



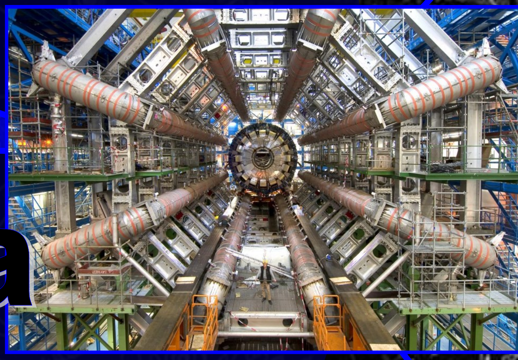


The computing system

The ATLAS computing system analyses the data produced by the ATLAS detectors. About 980Terabytes of information is recorded at ATLAS every year. To put that into perspective, the bible can be stored on a 1.4Megabyte floppy disc and 700 million such discs would be required to store ATLAS's annual data volume. Stacking these up would span from Geneva to Moscow! The computing power needed to analyse all this data is equivalent to 50 000 of today's PCs.

Dealing with data

With approximately a 40 million particle collisions per second at ATLAS, it's important to control the data flow. These three systems were devised to digest the enormous dataflow at ATLAS.



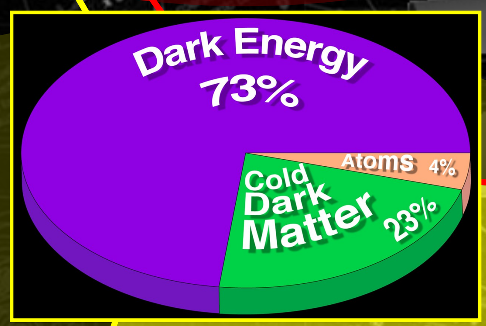
The trigger system

The trigger system discards 99.9995% of event at ATLAS, identifying the interesting events from the background to be stored and analysed. The trigger system is compromised of three parts:

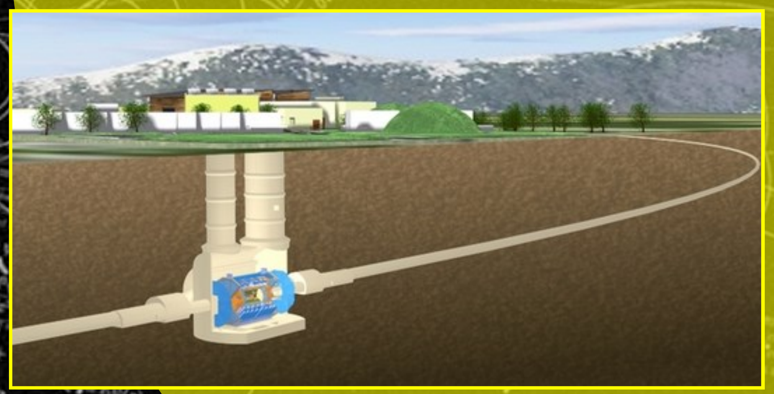
- Level 1 trigger- looks for regions in which a lot of energy is deposited and selects 100 000 of the total 40 000 000 events per second. This takes about a microsecond.
- Level 2 trigger- uses approximately 500PCs to access data in the region of interest (identified in level 1) and selects 3000 of the 100 000. This takes about a millisecond.
- Event filter– uses approximately 1700PCs using whole detector data to reduce the selected events to just 200 per second. This can take several seconds.

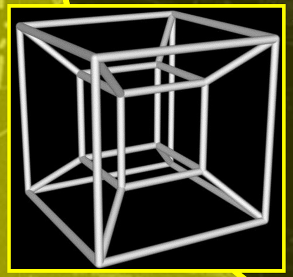
A search for darkness

In 1932, Jan Oort postulated the existence of matter invisible to our detectors, to account for the 'missing mass' in the orbital velocities of galaxies (the stars orbit too fast for the amount of visible matter in them, so there must be some more matter). It might be that the lightest supersymmetric particle (WIMP) might make up dark matter. ATLAS will investigate why the matter in the Universe is dominated by dark matter and elucidate the mystery of what dark matter is.



ATLAS is a general-purpose detector at the LHC in Geneva. Some of the physics research it's used for includes the search for the Higgs boson, extra dimension and dark matter. In order to detect such things the ATLAS detector measures the paths, momentum and energy of the particles thrown out of proton collisions, allowing them to be individually identified. At 46m long with a 25m diameter, the 7000 tonne detector is the largest volume particle detector ever constructed.



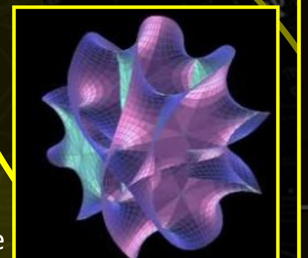


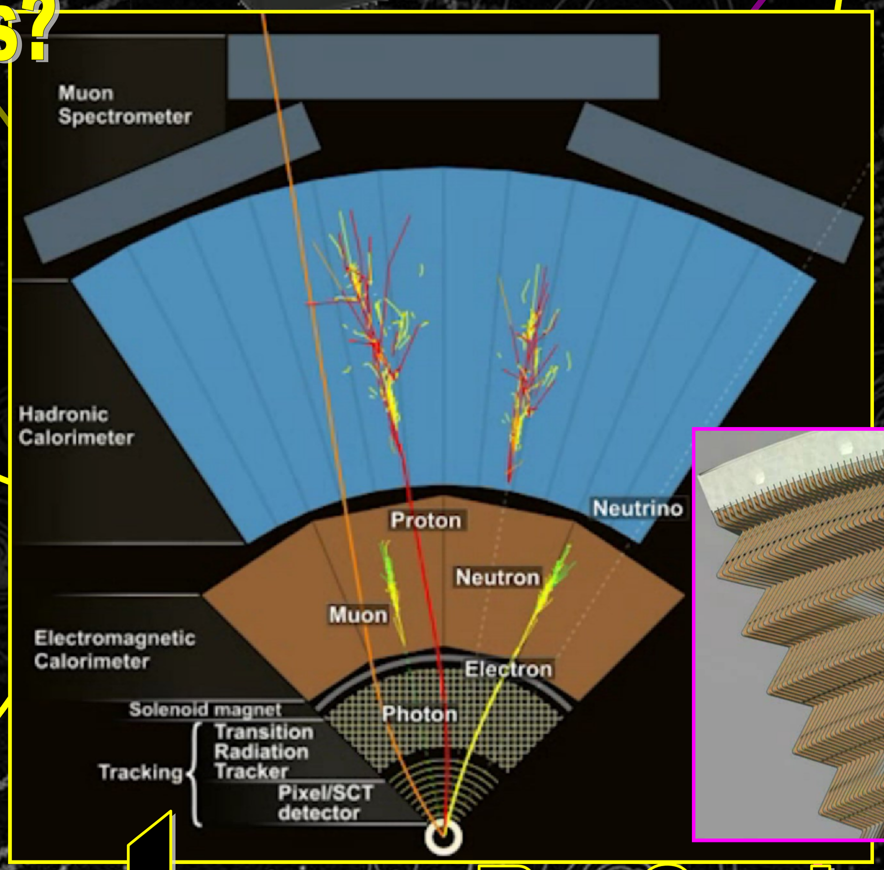
Tracking individual particles

The particles produced from proton-proton collisions at ATLAS have unique properties which makes them identifiable within particular areas of the ATLAS detector. Photons and electrons are both stopped by the electromagnetic calorimeter and are distinguishable because the electron leaves a trail but the photon does not. Protons and neutrons are stopped in the hadronic calorimeter and, again, can be told apart since the proton leaves a trail but not the neutron. Finally the muon penetrates through the whole detector leaving a trail that is measured in the muon spectrometer. Neutrinos aren't detected at all but their presence can be inferred by missing energy in a collision.

How many dimensions?

We're used to living in 3 dimensions but could it be possible for there to be more? Evidence for the existence of extra dimensions could be the extreme weakness of gravity compared to the other fundamental forces (electromagnetic, strong nuclear and weak nuclear) This weakness may be due to gravity's force field spreading into other dimensions. The ATLAS experiment might see evidence that extra dimensions exist via collision events in which a graviton particle (gravitational force carrier) disappears into other dimensions. ATLAS would detect a large imbalance of energy in the event.



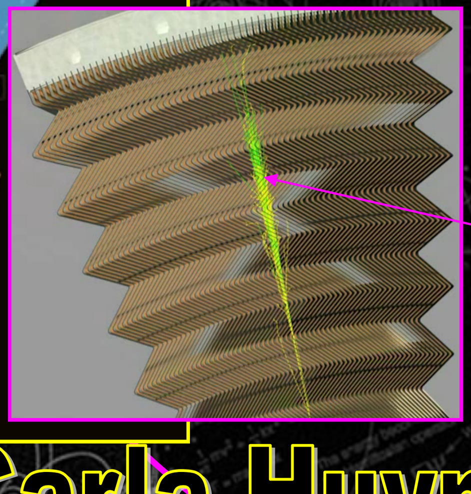


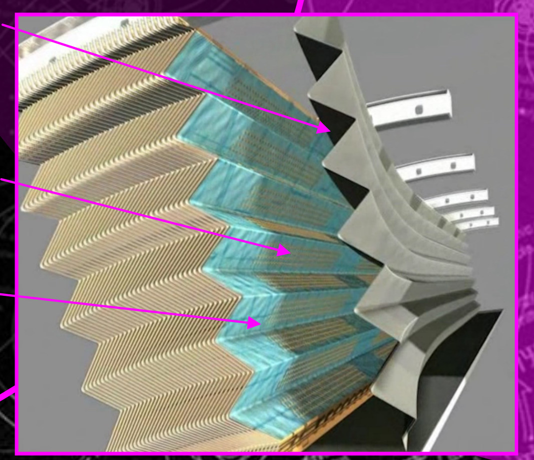
Calorimeters

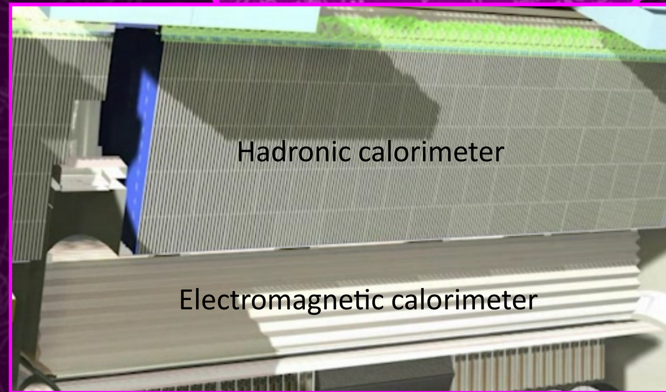
Calorimeters measure the energies of particles by absorbing them. A calorimeter consists of a dense absorber material to fully absorb incident particles and an active material to produce an output signal proportional to the input energy. These materials are arranged alternately, so energy is lost and measured at each layer as the particles travel outwards through the calorimeter.

Electromagnetic calorimeter

This inner calorimeter measures the energies of particles that interact electromagnetically (charged particles and photons). When a charged particle comes into contact with the absorbers, it interacts with the material and produces a shower of lower energy charged particles. These showers produced on the particle's way through the many absorber layers are then ionised by the liquid argon. The excess electrons produced during this ionisation are attracted to the copper electrodes where the charge is measured. The amount of charge deposited at the electrodes can be used to deduce the energy of the original particle.







Hadronic calorimeter

This outer calorimeter is used to measure the energies of hadrons (particles made out of quarks such as protons, neutrons and mesons). When a hadron comes into contact with the steel sheets, it interacts with the atomic nucleus, producing a shower of particles. This shower of particles enter the scintillator (a material that radiates light when exposed to a charged particle), causing it to radiate light. Long fibres then carry the light to devices where the light intensity is measured and converted into an electric current. The strength of this signal indicates the energy possessed by the original hadron.