ATLAS

Mapping the secrets of the universe

ATLAS in numbers

100m depth of the tunnel

7000t mass of the ATLAS detector

27km circumference of the LHC tunnel

3000km length of wires and fibres within the ATLAS detector

1 billion approximate number of proton collisions per second

10 billion km distance one LHC beam may travel in total as it circulates the equivalent of a return journey to Neptune

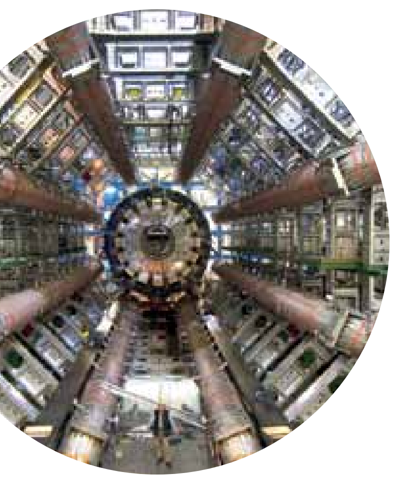
13TeV (tera electron volts) maximum energy of a proton-proton collision inside the ATLAS detector

46m long **25m** diameter - Dimensions of ATLAS

2808 maximum number of proton bunches within each beam

120 billion number of protons within each bunch

11,245 laps per second made by a proton in the LHC beam



The Experiment

ATLAS is one of the **four major experiments** at the Large Hadron Collider at CERN. It is a general-purpose particle physics experiment run by an international collaboration and, together with CMS, is designed to exploit the full discovery potential and the huge range of physics opportunities that the LHC provides.

ATLAS' scientific exploration uses precision measurement to push the frontiers of knowledge by seeking answers to **fundamental questions** such as: What are the basic building blocks of matter? What are the fundamental forces of nature? Could there be a greater underlying symmetry to our universe?

ATLAS physicists test the predictions of the **Standard Model**, which encapsulates our current understanding of what the building blocks of matter are and how they interact. These studies can lead to ground-breaking discoveries, such as that of the **Higgs boson**, physics beyond the Standard Model and the development of new theories to better describe our universe.

The years ahead will be exciting as ATLAS takes experimental physics into **unexplored territories** – perhaps with new processes and particles that could change our understanding of energy and matter.

The Collaboration

ATLAS comprises **3000** scientists from **180** institutions around the world, representing **38** countries from all the world's populated continents. It is one of the largest collaborative efforts ever attempted in science. Almost **1200** doctoral students are involved in detector development, data collection and analysis. The collaboration depends on the efforts of countless engineers, technicians and administrative staff.

ATLAS elects its leadership and has a collaborative organizational structure with self-managed teams and membership directly involved in decision-making processes. Scientists usually work in small groups, choosing the research areas and data that interest them most. Results are shared by all collaboration members and are subject to rigorous review and fact-checking processes before being made public. The success of the collaboration is driven by individual commitment to physics and the prospect of exciting new results that can only be achieved with a complete and coherent effort.

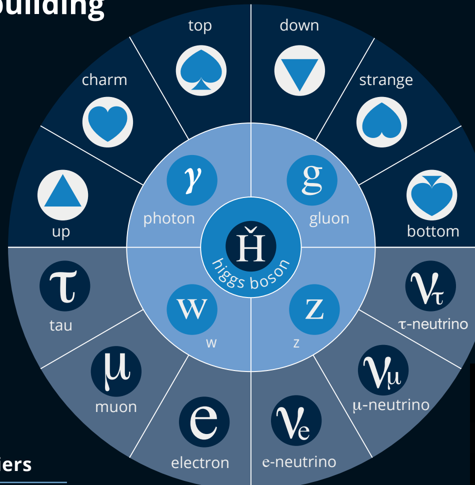
The only way to realize such a challenging project, with the required intellectual and financial resources and to maximize its scientific output, is through international collaboration. ATLAS is financially supported by funding agencies from the participating countries, CERN and member universities.

The Physics

ATLAS explores a range of physics topics, with the primary focus of improving our understanding of the fundamental constituents of matter. Some of the **key questions** that ATLAS addresses are:

What are the basic building blocks of matter?

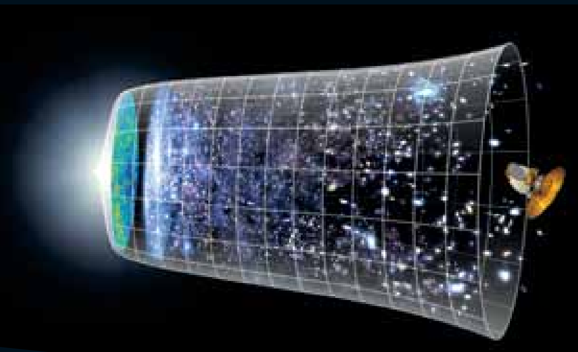
The Standard Model describes all known experimentally observed elementary subatomic particles in the universe. ATLAS studies these particles and searches for others to determine if the particles we know are indeed elementary or if they are in fact composed of other more fundamental ones.



FERMIONS - Matter: Quarks, Leptons

BOSONS - Force carriers: Gauge bosons, Higgs boson

What was the early universe like and how will it evolve?



Proton-proton and heavy-ion collisions delivered by the LHC recreate the conditions immediately following the Big Bang when the Universe was governed by high-energy particle physics and later by a primordial soup of quarks and gluons, and allow ATLAS to study fundamental issues such as the Higgs field or Dark Matter.

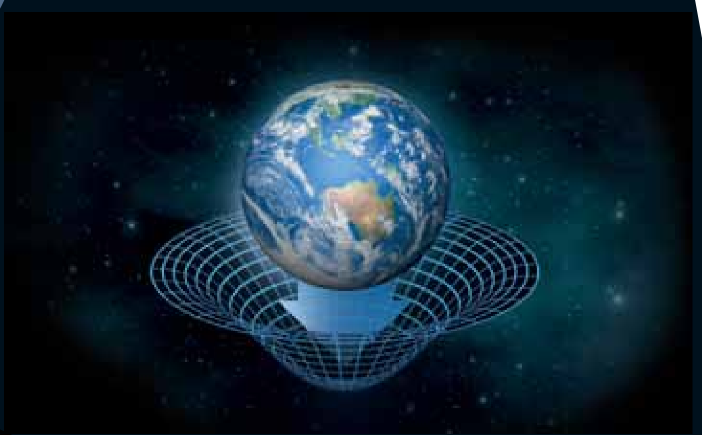
What is "dark matter"?

Astronomical measurements support the existence of matter that cannot be directly seen. ATLAS can observe this "dark matter" by searching for missing energy and momentum in proton-proton collisions

What happened to antimatter?

By searching for imbalances in the production of matter and antimatter, we seek to understand why our universe appears to comprise only matter.

How does gravity fit in?



Gravity is extremely weak when compared to the other forces. To explain the difference we look for such exotic phenomena as extra dimensions, gravitons, and microscopic black holes.

Anything else?

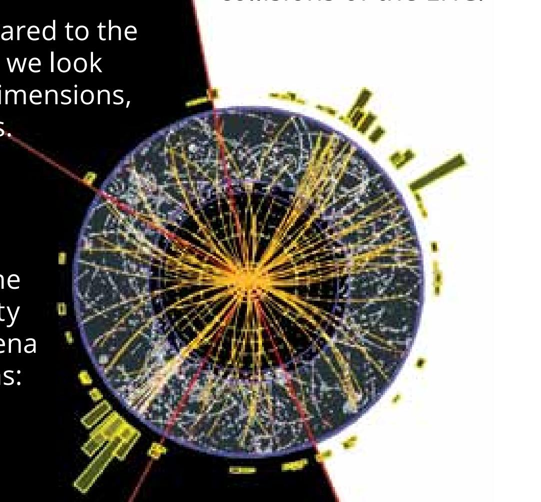
Perhaps the most exciting aspect of the ATLAS physics programme is our ability to explore and discover new phenomena beyond existing theoretical predictions: the search for the unknown.

The Higgs boson

In 1964, three teams of physicists independently proposed a mechanism to explain how the carriers of the weak nuclear interaction – the W and Z bosons – acquire mass. Their solution (the BEH mechanism) implied the existence of a particle, now referred to as the Higgs boson.

On 4 July 2012, the ATLAS and CMS experiments at CERN announced that they had independently observed a new particle, consistent with the Higgs boson. François Englert and Peter Higgs were awarded the Nobel Prize in Physics in 2013.

Subsequent studies have shown that the Higgs boson interacts with both bosons and fermions, supporting the Standard Model prediction that all elementary particles acquire mass via the Higgs field. The Higgs boson is now being used as an instrument by physicists to explore for new physics in the high-energy collisions of the LHC.



The ATLAS detector

ATLAS is the largest volume detector ever constructed for a particle collider. It is 46m long and 25m in diameter, and sits in a cavern almost **100m below ground.**

The detector consists of six different subsystems wrapped concentrically in layers around the collision point to record the trajectory, momentum, and energy of particles, allowing them to be individually identified and measured. A huge magnet system bends the paths of the charged particles so that their momenta can be measured as precisely as possible.

Beams of particles travelling at energies up to 7 trillion electron-volts, or speeds up to **99.9999991%** that of light, from the LHC collide at the centre of the ATLAS detector producing new particles, which fly out from the collision point in all directions.

Over a billion particle interactions take place in the ATLAS detector every second, a data rate equivalent to 20 simultaneous telephone conversations held by every person on the earth.

Only one in a million collisions are flagged as potentially interesting and recorded for further study.

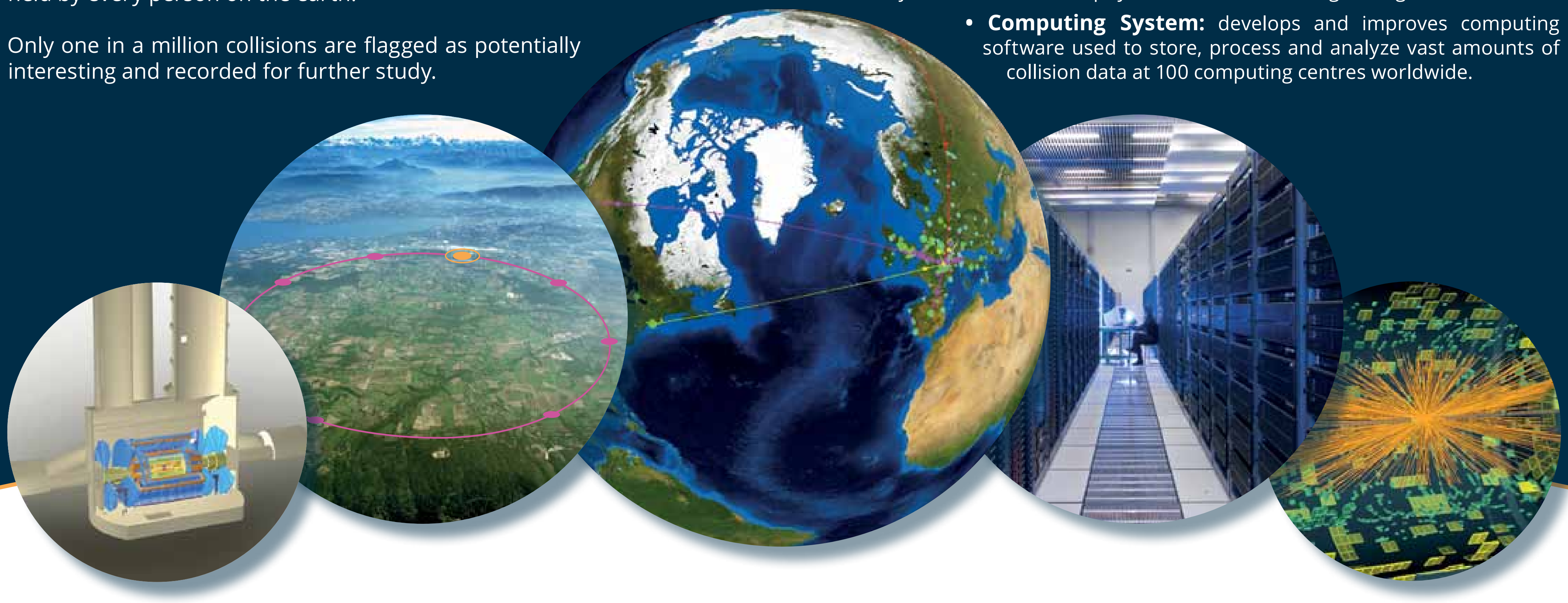
The detector tracks and identifies particles to investigate a wide range of physics, from the study of the Higgs boson and top quark to the search for extra dimensions and particles that could make up dark matter.

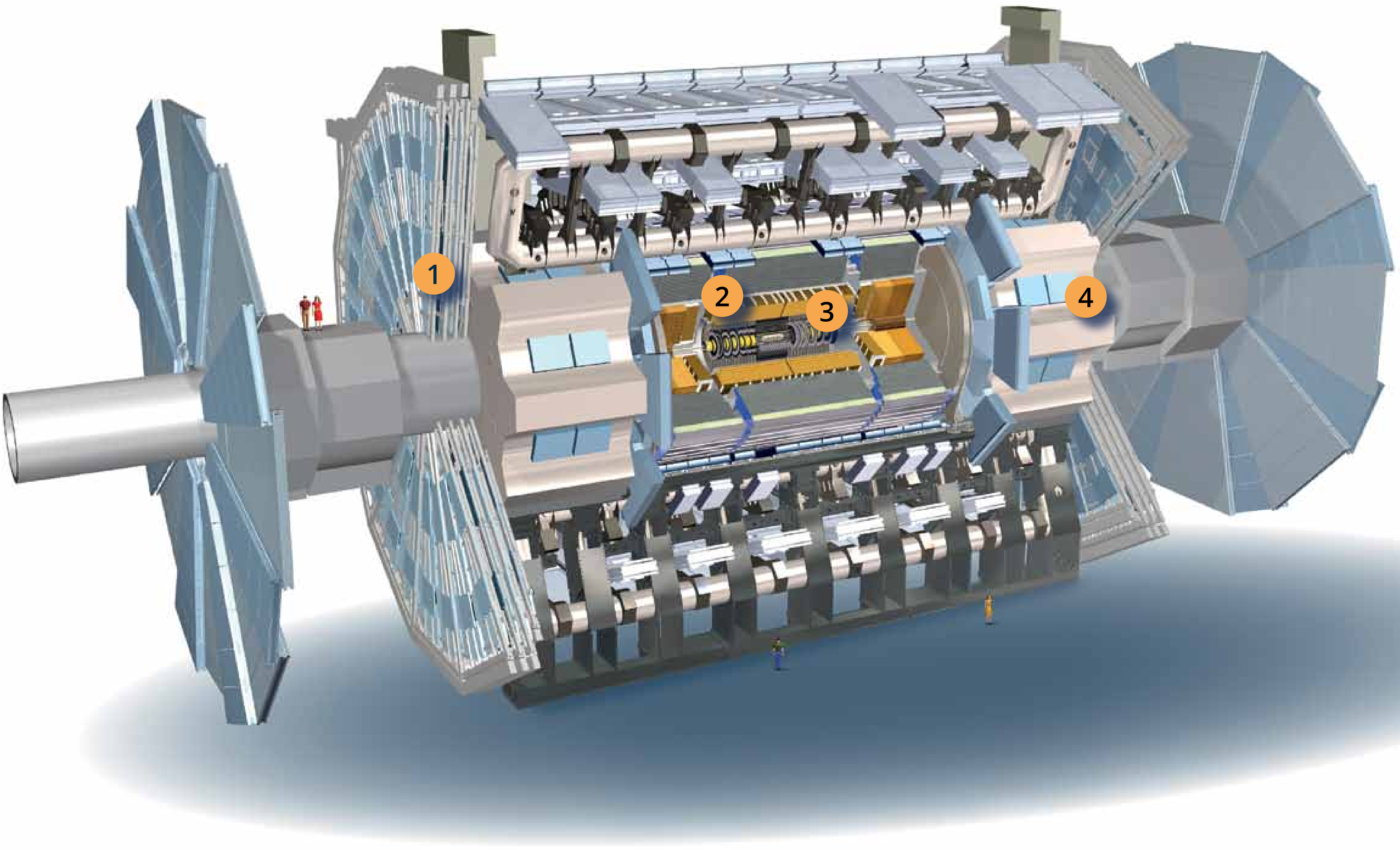
The **four major** components of the ATLAS detector are:

- **Inner Detector:** measures the momentum of each charged particle
- **Calorimeter:** measures energies carried by neutral and charged particles
- **Muon Spectrometer:** identifies and measures the momenta of muons
- **Magnet System:** bends the trajectories of each charged particle to allow the measurement of its momentum

Integrated with the detector components are:

- **Trigger and Data Acquisition System:** specialized multi-level computing system, which selects physics events with distinguishing characteristics
- **Computing System:** develops and improves computing software used to store, process and analyze vast amounts of collision data at 100 computing centres worldwide.





The four major components of detector

Muon Spectrometer
identifies and measures the momenta of muons

Calorimeter
measures energies carried by neutral and charged particles

Inner Detector
measures the momentum of each charged particle

Magnet System
bends the trajectories of each charged particle to allow the measurement of its momentum

Everyday applications

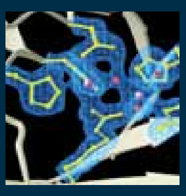
The search for answers to fundamental questions about the properties of matter and the forces of nature requires state-of-the-art research and development, which often leads to innovation. Here are a few examples of how ATLAS' knowledge and technological innovation have been applied to everyday life:

Superconducting magnetic energy storage

ATLAS' knowledge of the fabrication of super-conducting coils may enable the manufacture of high-performance energy storage systems.

Hadron therapy

Diamond sensors developed for the ATLAS detector's upgrade are used to monitor hadron therapy beams, which are more effective than x-rays or electron beams in destroying tumours while sparing healthy surrounding tissues.



Medical imaging

3D silicon sensors developed for the ATLAS detector's upgrade make visualisation of x-rays possible with enhanced resolution. Most medical imaging techniques require detection of photons in different energy ranges.

Retina project

Based on the silicon microstrip detector technology used in ATLAS, a recording system for large-scale neural activity has been developed. Experiments are able to understand how living neural systems process and encode information. This could one day give artificial sight for the blind.

Augmented reality

ATLAS is investigating innovative pattern recognition technologies, a key building block for augmented reality applications, which enables personnel involved in delicate maintenance operations to virtually visualize working procedures, minimizing the time of intervention and risk of errors. This technology has several industrial applications.

Sound reproduction

Precision optical image processing methods used to measure and align each of 16000 silicon detectors of the ATLAS SemiConductor Tracker can be applied to measuring precisely the shape of the grooves on mechanical sound carriers such as phonograph discs and cylinder records. This technology is being developed for use in recorded sound archives and collections to restore and preserve delicate or damaged samples and historical sound recordings.