The ATLAS Experiment

Mapping the Secrets of the Universe

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Protons will circulate in opposite directions and collide inside experimental areas

17 miles around

100 meters underground
The ATLAS Experiment

See animation
Large Hadron Collider Numbers

The fastest racetrack on the planet
Trillions of protons will race around the 17-mile ring 11,000 times a second, traveling at 99.9999991% the speed of light.
Seven times the energy of any previous accelerator.

The emptiest space in the solar system
Accelerating protons to almost the speed of light requires a vacuum as empty as interplanetary space.
There is 10 times more atmosphere on the moon than there will be in the LHC.
The hottest spot in our galaxy

Colliding protons will generate temperatures 100,000 times hotter than the sun (but in a minuscule space).

Equivalent to a billionth of a second after the Big Bang
LHC Exhibition at London Science Museum

Celebrating the world’s largest physics experiment

Building a particle smasher
Smashing particles together
Solving the mysteries
Play: Hunt for Higgs

This exhibition is supported by:

Science & Technology Facilities Council
The biggest most sophisticated detectors ever built

Recording the debris from 600 million proton collisions per second requires building gargantuan devices that measure particles with 0.0004 inch precision.

The most extensive computer system in the world

Analyzing the data requires tens of thousands of computers around the world using the Grid.
**Weight of ATLAS detector**
A hundred 747 jets (empty)

**Size of ATLAS detector**
About half the Notre Dame Cathedral

**Superconducting wire in magnets**
Is 122 km (76 miles) long,
plus 3000 km (1865 miles) of ordinary cables elsewhere.

**Data recorded each year**
3200 terabytes, equivalent to 7 km (4 miles) of CDROMs stacked on top of each other.

**Electronic channels**
About 100 million
Who builds and operates ATLAS?

1900 scientists from 164 universities and labs in 35 countries
LBNL People on ATLAS

- 6 Undergrads
- 7 Grad students
- 9 Postdocs
- 3 Engineers
- 4 Techs
- 5 Computer scientists
- 14 Senior physicists
- 48 TOTAL

Director Chu visiting ATLAS

Berkeley pixel team at CERN

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ATLAS Detector

Cut-away view

People
One beam is coming right at you.

The other is going away from you.
Why?

Let’s look at the Discovery Channel’s take on this.
(this is a shortened version)
New York Times talks about recreating the conditions a trillionth of a second after the Big Bang, and says:

“Whatever forms of matter and whatever laws and forces held sway Back Then — relics not seen in any part of space since the universe cooled 14 billion years ago — will spring fleetingly to life, over and over again in all their possible variations, as if the universe were enacting its own version of the “Groundhog Day” movie.”

— Dennis Overbye
Secrets of the Universe

- Identify dark matter
- Search for extra dimensions of space and mini-black holes
- Find “evidence” for string theory
- Find the Higgs Boson
- Understand antimatter
- Learn about the fundamental forces that have shaped the universe since the beginning of time, and will determine its fate.
An ATLAS expert explains the Higgs evidence to a layperson.
What is the origin of mass?

For **composite** particles such as atoms, it is often the masses of their constituents.

But what gives masses to **fundamental** particles such as quarks and electrons and why are they different?

Peter Higgs proposed that all of space is permeated by a field, the Higgs field. Quantum theory says that all fields have particles associated with them, so...

in this case...a **Higgs Boson**.
To understand the Higgs mechanism, imagine that a room full of physicists chattering quietly is like space filled with the Higgs field ...
Higgs Boson

... a well-known scientist walks in, creating a disturbance as he moves across the room and attracting a cluster of admirers with each step...

... this increases his resistance to movement, in other words, he acquires mass, just like a particle moving through the Higgs field...

-- Prof. David Miller
How a Higgs boson event might look in ATLAS

In this event, a “jet” was produced going downward, and a Higgs was produced going upward but decayed almost instantly.

\[ H \rightarrow Z + Z \]
\[ Z \rightarrow e^- + e^+ \]
\[ Z \rightarrow \mu^- + \mu^+ \]
In trying to resolve a number of theoretical problems and incorporate quantum mechanics, gravity and relativity in a single theory, some theorists have proposed a theory called String Theory.

Among its predictions are some extra dimensions of space and a new symmetry called “supersymmetry”.

String theory
For fundamental particles, supersymmetry says:

Every matter particle (fermion) should be associated with a massive “shadow” force carrier particle (boson).

Every force carrier particle should have a massive “shadow” matter particle.

This has possible implications for Dark Matter
Dark Matter

Dark matter ... Not dark matter

... except that’s not really true
Dark Matter

Much evidence for its existence
In galaxies and galaxy clusters
Dark Matter

See animation
What is Dark Matter?

We don’t know

But we have ideas

It might be one of those supersymmetric particles, but of course we have to find it to know for sure.
Extra Dimensions of Space
Extra Dimensions of Space

in art

SALVADOR DALI – TO RESEARCH OF THE 4TH DIMENSION

(Dora Maar series)
Extra Dimensions of Space

in literature

Narnia
Extra Dimensions of Space

in science? More than String Theory?

Gravity is extremely weak (compared to e-m).
Why is it so weak?
How can there be extra dimensions?

Think about an acrobat and a flea on a tight rope. The acrobat can move forward and backward along the rope. But the flea can also move sideways around the rope. If the flea keeps walking to one side, it goes around the rope and winds up where it started.

An acrobat can only move in one dimension along a rope.

...but a flea can move in two dimensions.
How can there be extra dimensions?

So the acrobat has one dimension, and the flea has two dimensions, but one of these dimensions is a small closed loop.

The acrobat can only detect the one dimension of the rope, just as we can only see the world in three dimensions, even though it might well have more.

This is impossible to visualize, precisely because we can only visualize things in three dimensions!
Mini-Black Holes

Mini-Black holes?

According to some theoretical models, tiny black holes could be produced in collisions at the LHC.

They would then very quickly decay and be detected by experiments (the tinier the black hole, the faster it evaporates).
Cosmic rays are continuously bombarding Earth's atmosphere with far more energy than protons will have at the LHC, so cosmic rays would produce everything LHC can produce.

They have done so throughout the 4.5 billion years of the Earth's existence, and the Earth is still here!

The LHC just lets us see these processes in the lab (though at a much lower energy than some cosmic rays).
Tentative Schedule

Protons in ring in May 2008

Protons collide in July 2008

Earliest physics results perhaps by end of 2008

Real excitement in ???
Inserting the Pixel Detector into the center of ATLAS.

A major Berkeley project
We placed a camera on one of the huge toroid magnets as it was lowered into the cavern.

So you can ride down with it.
The ATLAS Crawl

Very little space remains in ATLAS, so working in confined space is complicated.
All this and more on

[Image of YouTube logo]

Broadcast Yourself

http://youtube.com/TheATLASExperiment

and http://atlas.ch

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http://atlas.ch

The End
Public webpages: http://ATLAS.ch
Virtual Tour
New homepage for eTours

Welcome to the ATLAS eTours!

Choose one of four eTours

Introduction
An overview of particle physics experiments.

Physics
An overview of the physics goals of the ATLAS Experiment.

Experiment
How the ATLAS detector works.

Accelerator
A description of the Large Hadron Collider.
The ATLAS Store
The webcam on the Geneva side (A side) originally showed the opposite side of the cavern, the Jura (C side). Now that the detector is largely constructed, one sees the Geneva side (A side) only. Similar for the camera on the Jura side. In order to ensure traceability the old file name, as well as the text on the picture has been kept.

Jura side (C Side) | CERN
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Geneva side (A Side) | CERN

Image Log: | Current Camera | Former Camera | Jura (C Side) | CERN
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Image Log: | Current Camera | Former Camera | Geneva (A Side) | CERN

Image Log: | Jura (C Side) |
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Image Log: | Geneva (A Side) |
The ATLAS Student Event Challenge will make high school students part of the ATLAS Experiment by sharing actual ATLAS events with them and giving them the tools to analyze these collision events.
Student Event Analysis (AMELIA)

Interactive event analysis for students and public

ATLAS Multimedia Educational Lab for Interactive Analysis
Interactive event analysis for students and public

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Student Event Analysis (AMELIA)