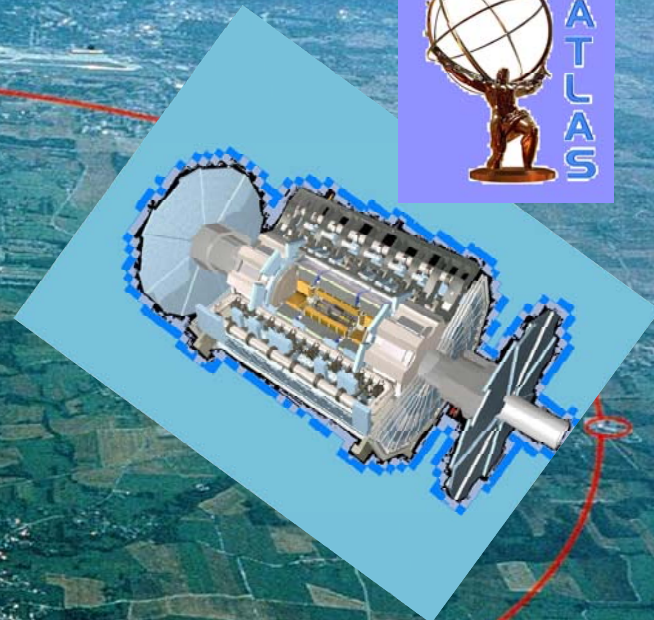


The ATLAS Experiment at the CERN Large Hadron Collider



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Center for Strategic and International Studies, June 1, 2009

Outline

- Orientation:
 - The nature of CERN
 - The experiments poised to start at the LHC
- Motivation for involving undergraduate students at CERN
 - the scientific education
 - the cultural experience
- The network of ATLAS institutions in the US
 - Institutions and people
 - The pool of young scientists
- Experiences from Duke University
 - The current Study Abroad Program
 - Student involvement in ATLAS research

CERN

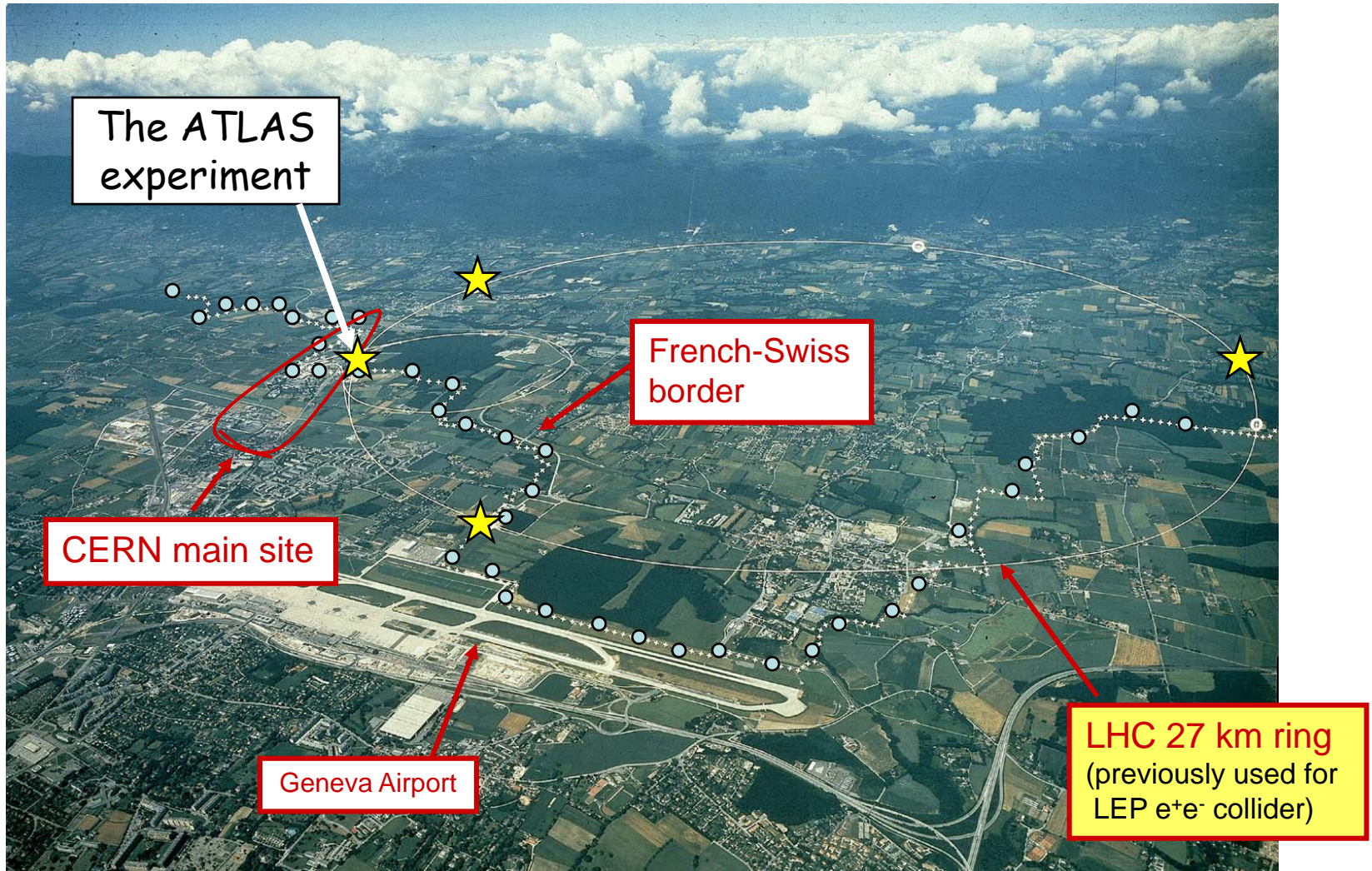
CERN = the **C**onseil **E**uropeen pour la **R**echerche **N**uclearie or now know as The European Organization for Nuclear Research

- Founded in 1954 as one of Europe's first joint scientific efforts.
- The largest HEP Laboratory in the world, employing ~ 2500 scientists and staff plus ~ 8000 visiting scientists.

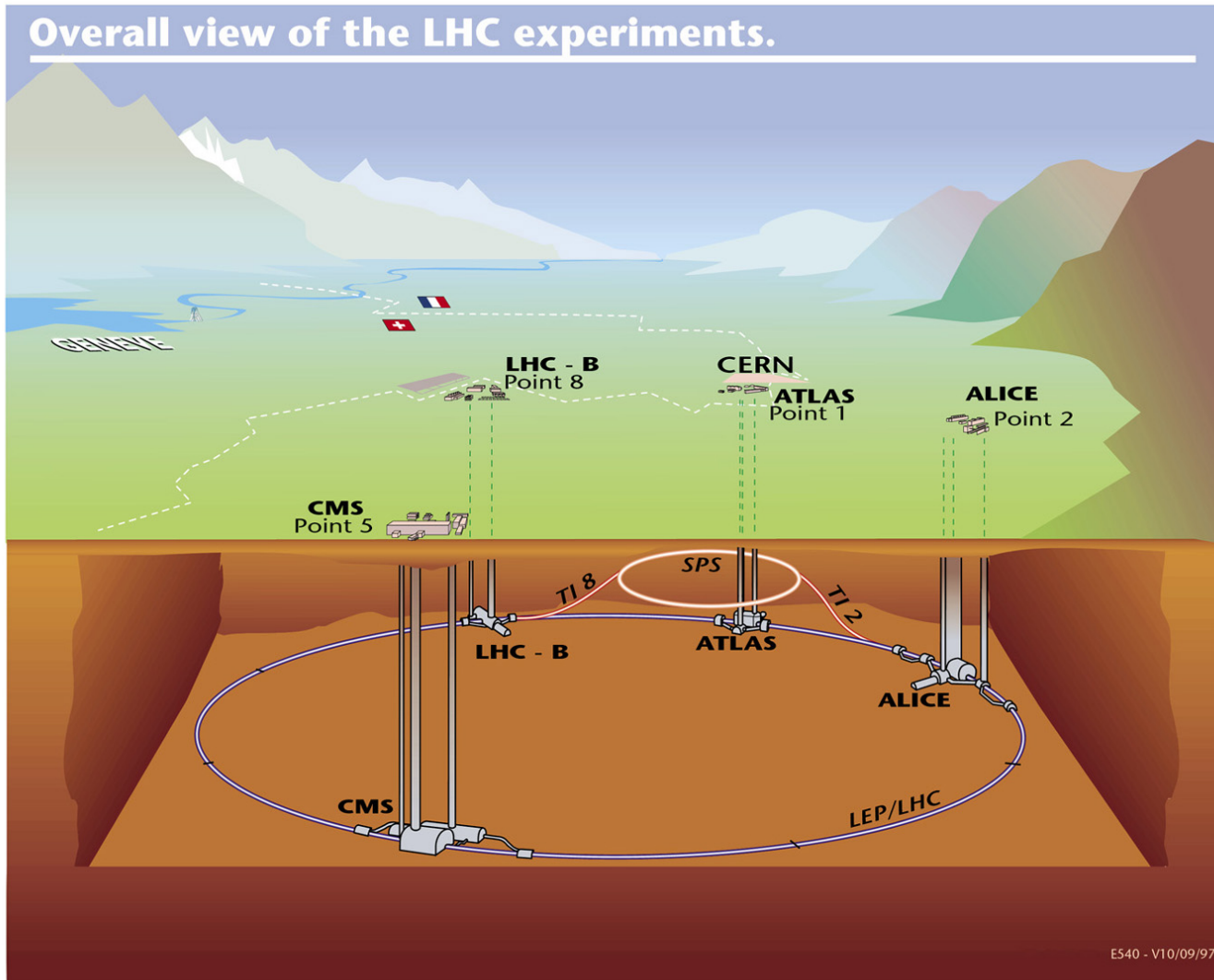


- A "United Nations" of science that serves as an wonderful example of successful international cooperation.
- The opportunity to involve students in research at CERN has both scientific and cultural benefits

CERN

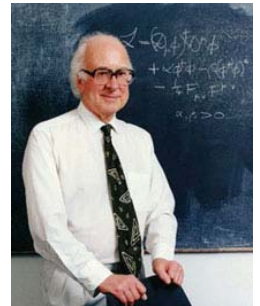


The LHC experiments



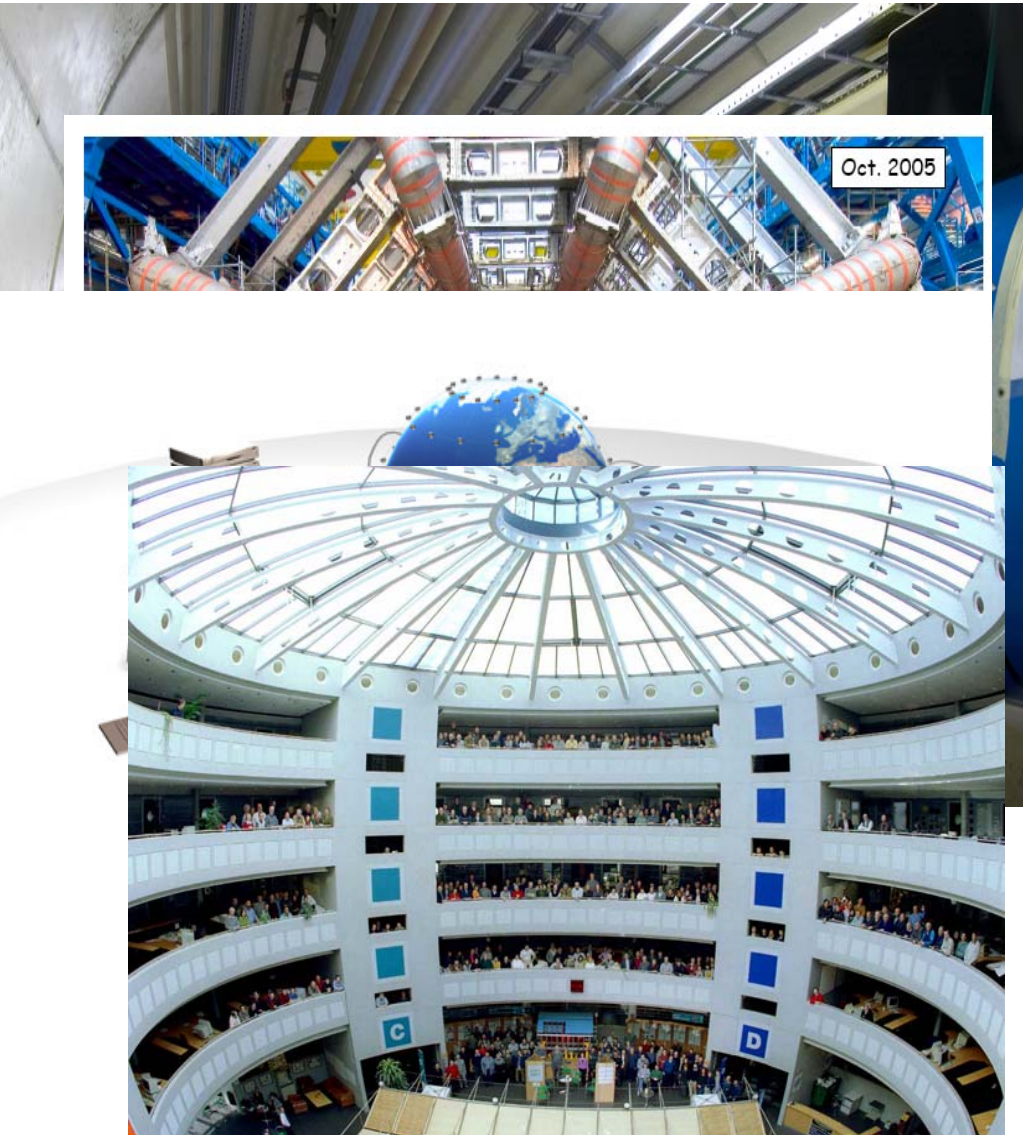
The scientific excitement at CERN

- We are at the threshold of a new era in fundamental science with the turn-on of the CERN Large Hadron Collider.
- Experiments have been built to probe some of the most puzzling questions about Nature.
 - Testing speculations about the origin of mass
 - Identifying the character of dark matter
 - Searching for dimensions in space beyond those we observe in our 4-dimensional world
 - Exploring mechanisms for producing a matter-dominated universe



QuickTime™ and a
TIFF (LZW) decompressor
are needed to see this picture.

This Requires.....



1. Accelerators : capable of accelerating particles to extremely high energies and bring them into collision with other particles

2. Detectors : that precisely record the particles as they “stream” out from the point of collision.

3. Computers : to collect, store, distribute and analyse the vast amount of data produced by the detectors

4. People : Thousands of scientists, engineers, technicians and support staff that can design, build and soon operate such complex “machines”

The educational opportunities at CERN

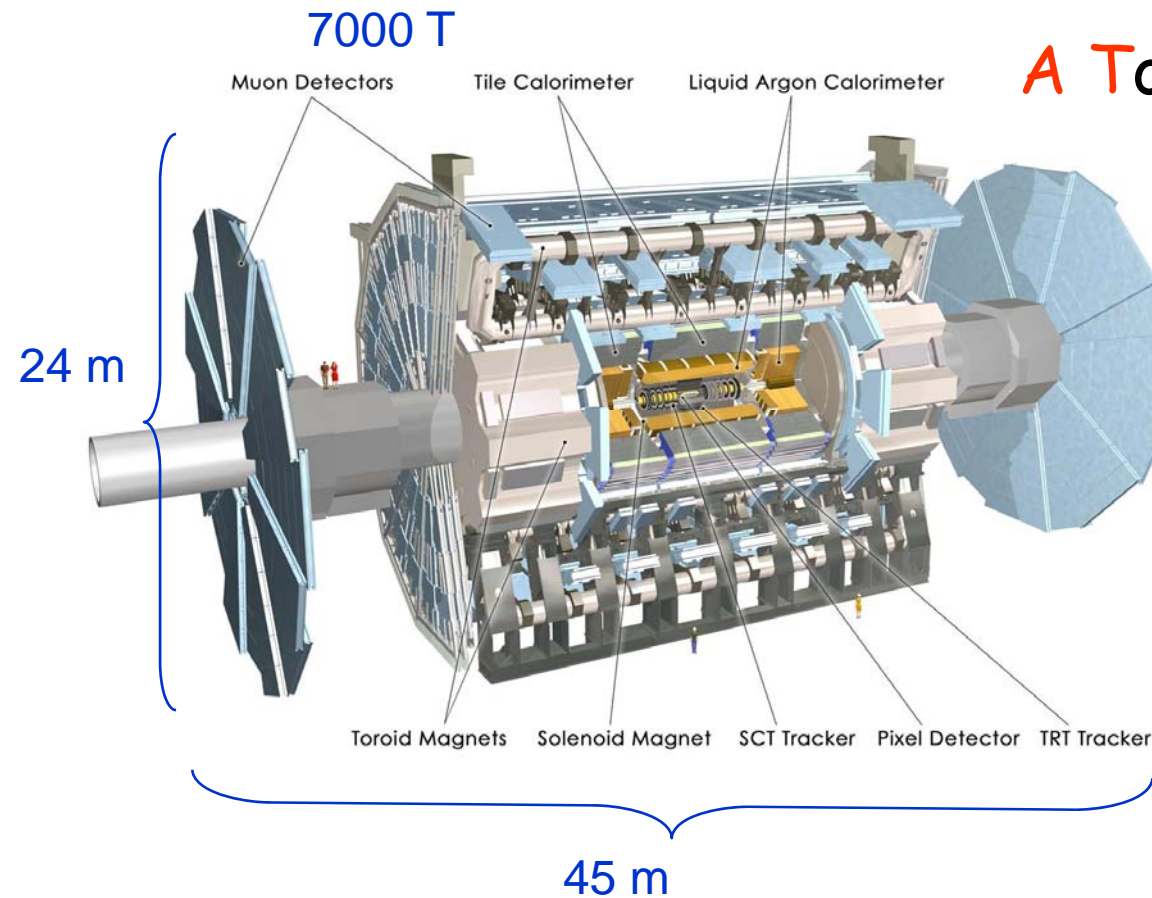
- This range of activities at CERN provides the opportunity for students to be involved in a broad range of physics and engineering programs:
 - basic elementary particle physics
 - manipulating large data samples and understanding advanced statistical analysis techniques
 - frontier computing hardware and software
 - particle detector design and construction
 - particle accelerators and their applications

US HEP Programs at CERN

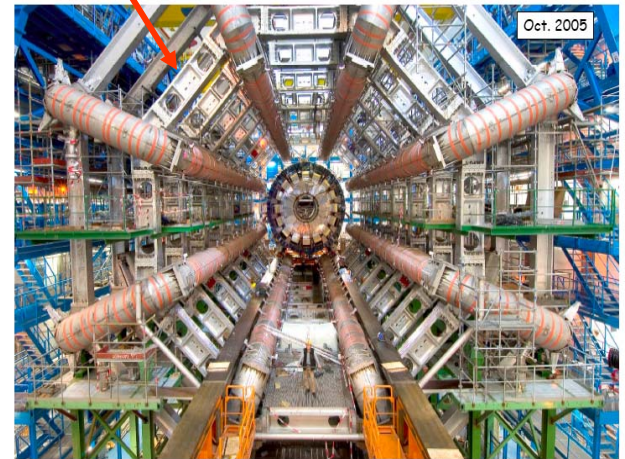
- Most HEP research groups in the US have historically had experimental programs based at US Laboratories (BNL, CLEO, Fermilab and SLAC).
- Fermilab will continue to be a major focus of international HEP activities. However the unique research opportunities provided by the Large Hadron Collider will result in most US-based HEP groups establishing programs at CERN for at least the next decade or two.
- This shift presents special challenges to Universities where the education of students is a central mission.

The ATLAS Experiment and US Participation

The ATLAS Detector



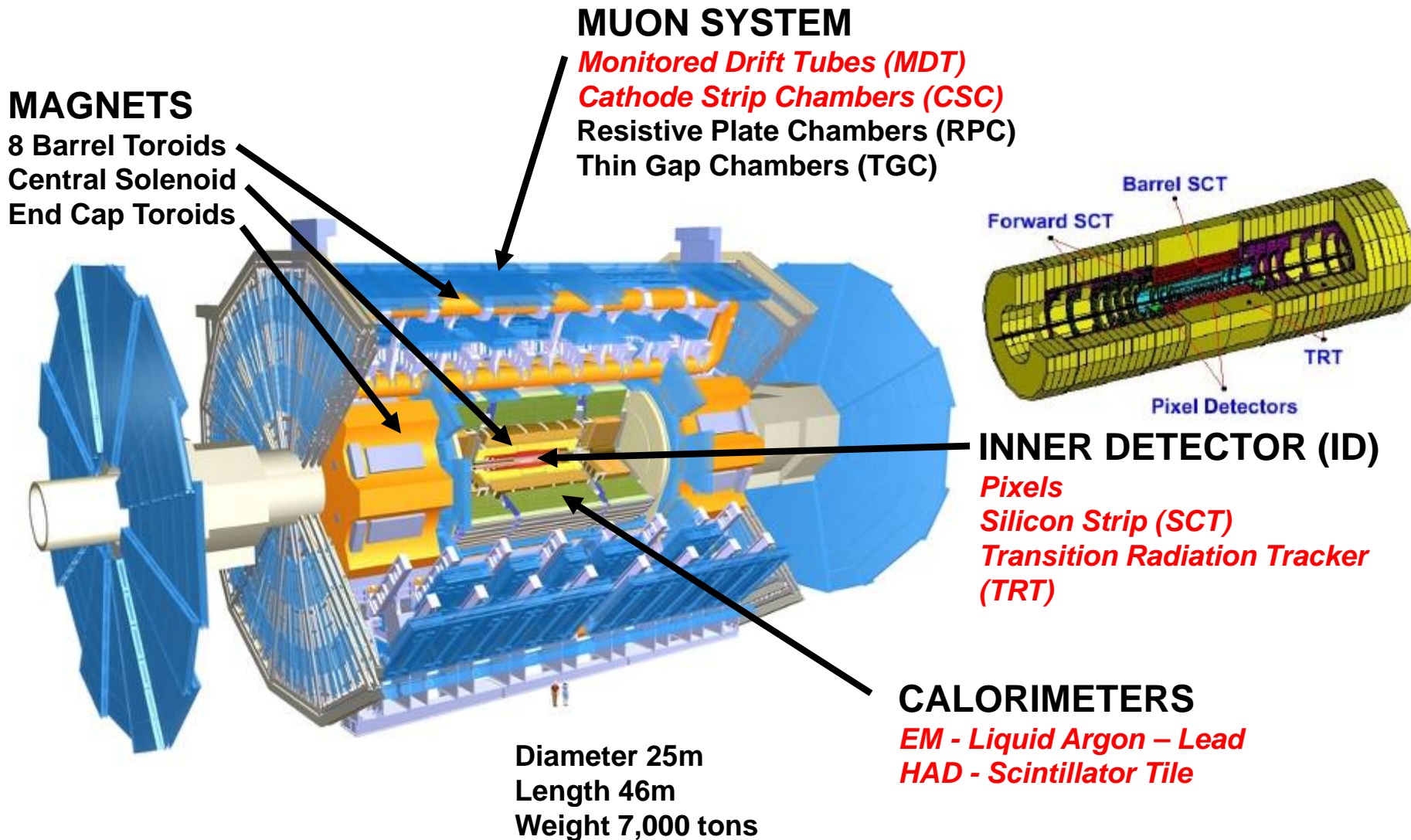
A Toroidal LHC Apparatus



The results of a simulated pp collision in the ATLAS detector (transverse view, the beams are perpendicular to the screen)

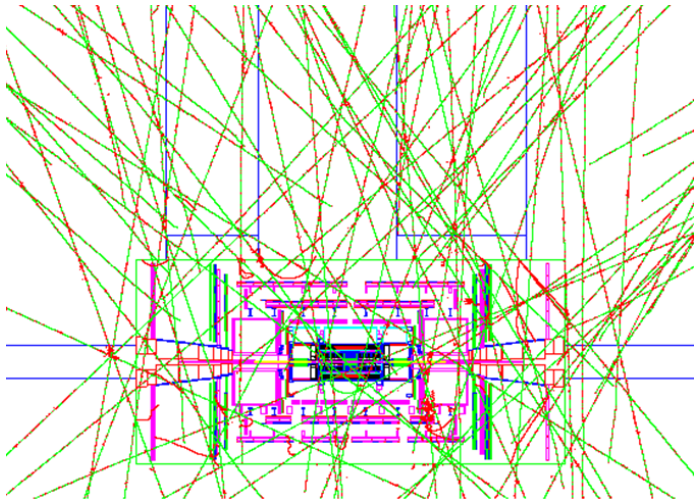
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The ATLAS Detector

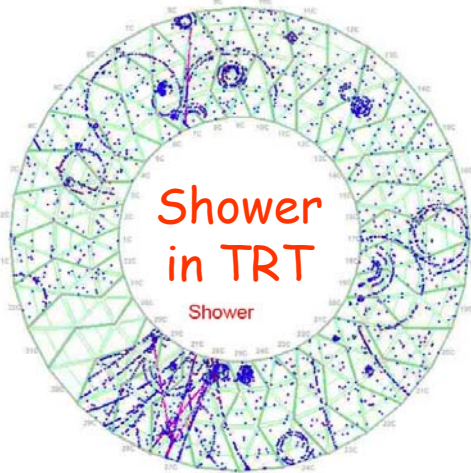


Towards data-taking: Cosmic Muons

**Simulated cosmic flux
in the ATLAS cavern**

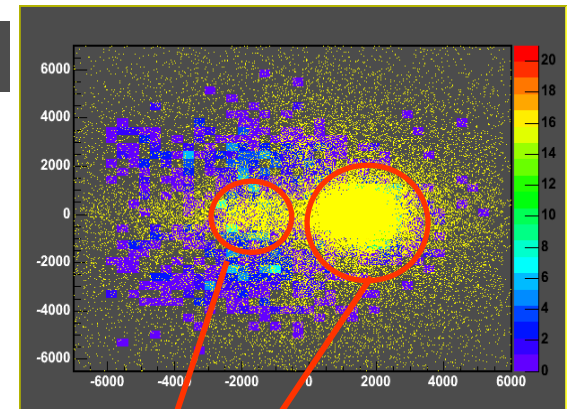


**Rate ~100 m below
ground:
~ O(15 Hz) crossing
Inner Detector**



**Muon impact points
Extrapolated to
surface
as measured by
Muon Trigger
chambers (RPC)**

x (cm)



z (cm)

Real Cosmic Events

ATLAS shafts

The US ATLAS Collaboration

- The US participation in the ATLAS experiment involves 44 Universities and **National Labs**:

Albany, **ANL**, Arizona, UT Arlington, Berkeley **LBL** and UC, Boston, Brandeis, **BNL**, Chicago, Columbia, UT Dallas, Duke, Fresno State, Hampton, Harvard, Indiana, U Iowa, Iowa State, UC Irvine, Louisiana Tech, Louisville, Massachusetts, MIT, Michigan, MSU, New Mexico, NIU, NYU, Ohio State, Oklahoma, Oklahoma State, Oregon, Pennsylvania, Pittsburgh, UC Santa Cruz, **SLAC**, SMU, South Carolina, SUNY Stony Brook, Tufts, Illinois Urbana, Washington, Wisconsin, Yale

- Currently 592 scientists (Ph.D's and graduate students) at these institutions participate in the ATLAS experiment. These make up 21% of the ATLAS world-wide collaboration.

Student participation in ATLAS

- University HEP groups will have a large student involvement in the experiments at the LHC. This will be done through virtual connections from CERN to the Universities, but will also require locating students at CERN.
- Currently the US ATLAS institutions have ~ 150 graduate students working on the experiment. When the LHC is in operation we expect this to continue, and in addition from 50-100 undergraduate students to be involved with research at some level based upon ATLAS data.
- Providing a health interaction of these students with the experiments at CERN is a major challenge. The use of Study Abroad Programs is a key component in providing these opportunities to undergraduate students.

Study Abroad Programs (using Duke as an example)

Student participation in ATLAS

- We are here to discuss a possible Study Abroad Program for students interested in participating in the scientific and cultural opportunities available at CERN.
- This can be incorporated into existing infrastructure at many Universities. I use Duke as an example.
- Duke encourages students to take a semester or year abroad as part of their academic program. In 2008 47% of Duke students studied abroad .

Duke Study Abroad Programs

- 🌐 Duke has operated Study Abroad Programs for over 25 years.

Semester

- * Duke in Berlin
- * Duke in China
- * Duke in Florence
- * Duke in France
- * Duke in Glasgow
- * Duke in Istanbul
- * Duke in Madrid
- * Duke in St. Petersburg
- * Duke in the Andes
- * Duke in Venice

Summer

- * Duke in Australia
- * Duke in Brazil
- * Duke in China
- * Duke in Flanders
- * Duke in Geneva
- * Duke in Ghana
- * Duke in Greece
- * Duke in Israel
- * Duke in Mexico
- * Duke in Oxford
- * Duke in Paris
- * Duke in Rome
- * Duke in Russia
- * Duke in Singapore
- * Duke in Spain
- * Duke in Turkey
- * Duke in Venice

Student participation in Duke HEP research

- Duke is a medium size HEP group. We typically have 5 graduate students and ~8 undergraduate students doing research with our faculty at CERN, Fermilab and neutrino physics in Japan.
- In the past our students have primarily been based at Fermilab, using housing and infrastructure provided by this Lab.
- As we change our research focus to CERN, we need to establish similar opportunities for our students in Geneva. We would welcome the establishment of a formal LHC Study Abroad program to help attain this goal.

Summary

- Experiments at the CERN LHC will be a major focus of elementary particle physics for for the next ten to twenty years.

All expectations are that what we find at the LHC will reform our understanding of nature at the most fundamental level.

- The discoveries made using data from ATLAS and other LHC experiments will involve 100's of US graduate and undergraduate students each year.
- Participating in this off-shore research program is a particular challenge for US undergraduate students.
- An LHC Study Abroad Program based in Geneva would be an important contribution to science education by allowing students to participate in the LHC adventure.