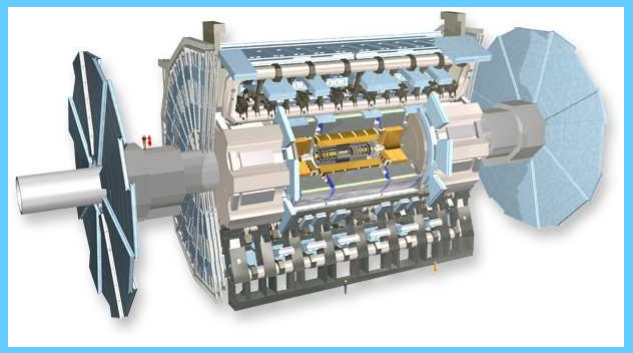
ATLAS
&
the Search for New Physics!



Dr Tracey Berry

Dr Tracey Berry

Overview

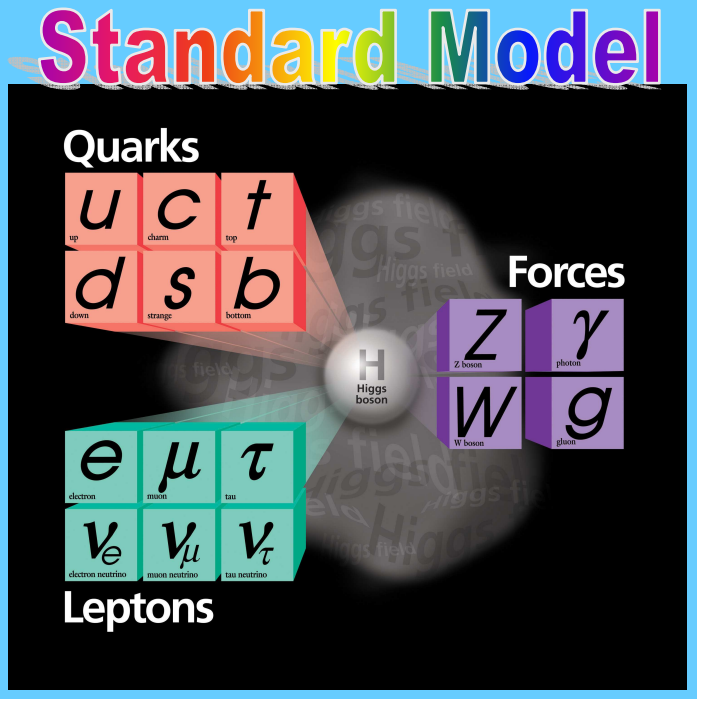
- Why we want ATLAS & LHC!
- Brief introduction to the LHC
- Introduction to ATLAS
- Searches for new physics using ATLAS
- Conclusion

Why build ATLAS & LHC?

To answer questions such as

- What is the universe made of?
- What are the fundamental constituents of matter?
- What is the mass of the particles?
- How do the particles get mass?
- How do these particles interact?

We want to test/verify our Standard Model



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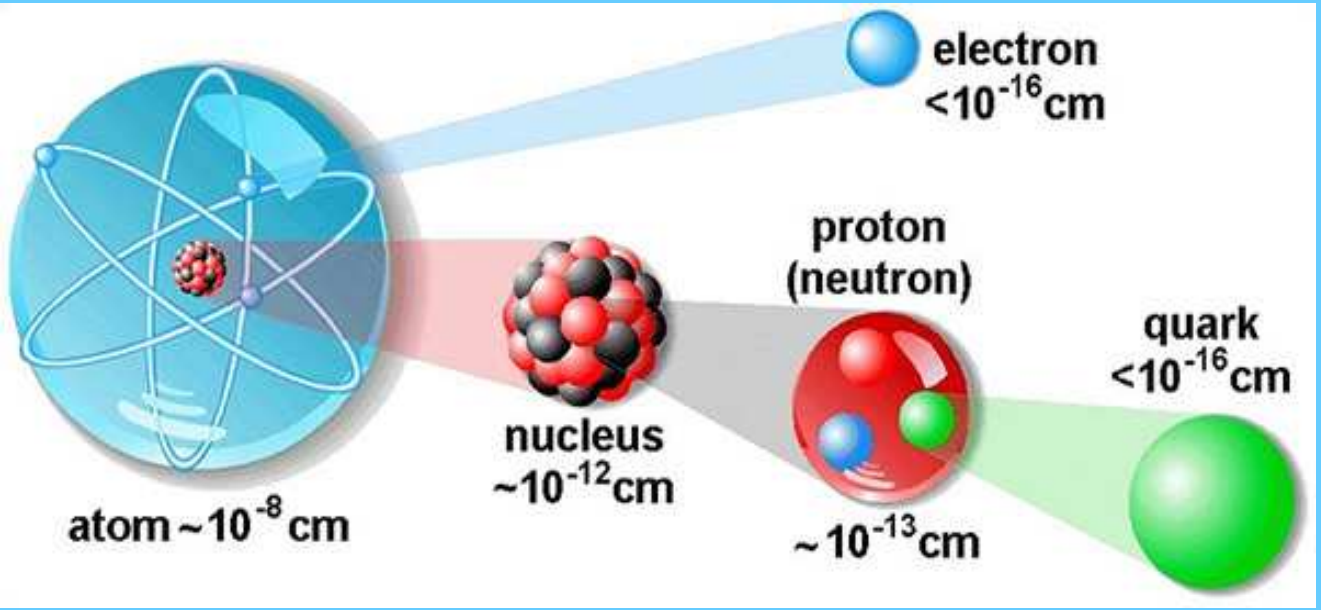
Particle Physics:

Understanding the Fundamental constituents of matter and their interactions



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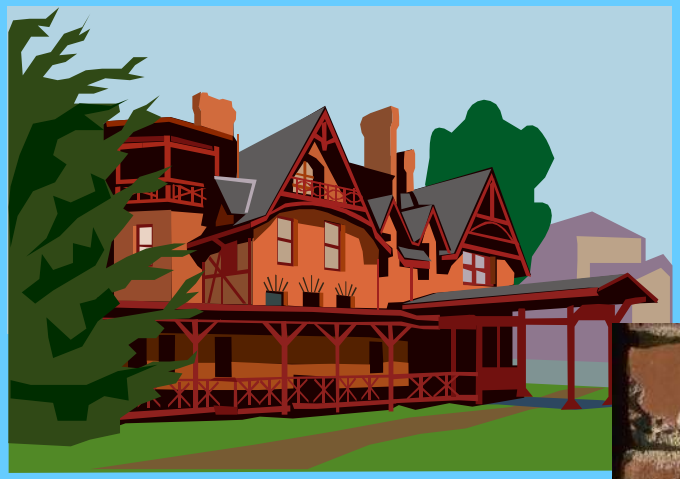
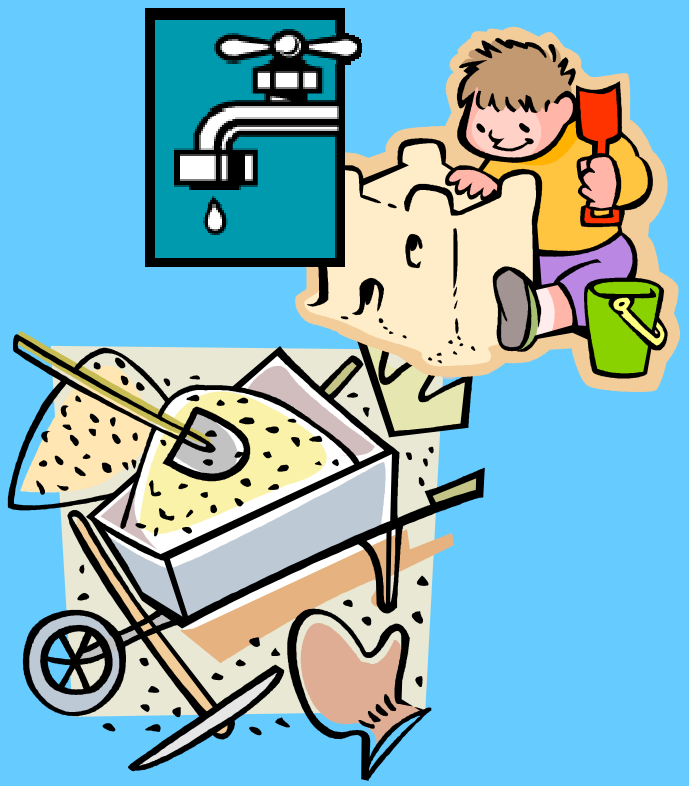
Example: What are the fundamental constituents of a house?





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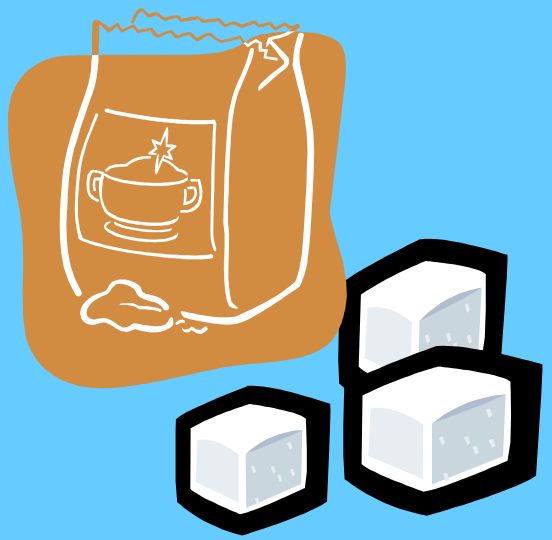
Other Buildings



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Particle Physics:

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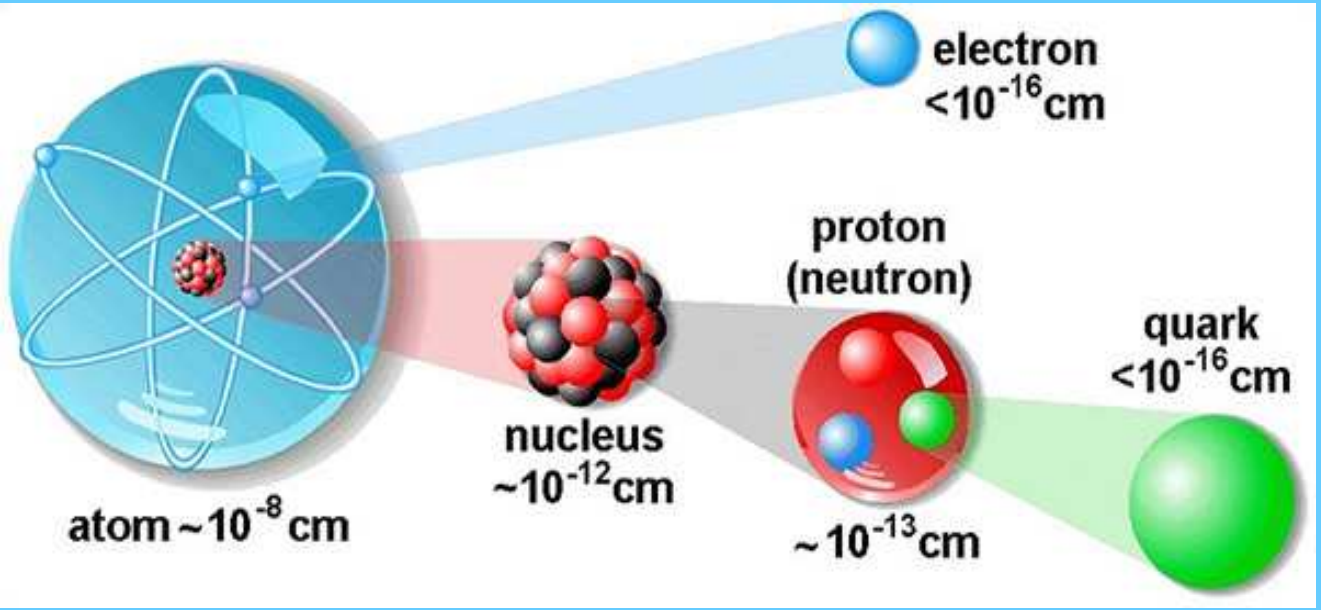

Fundamental constituents of matter:

6 leptons and **6 quarks**

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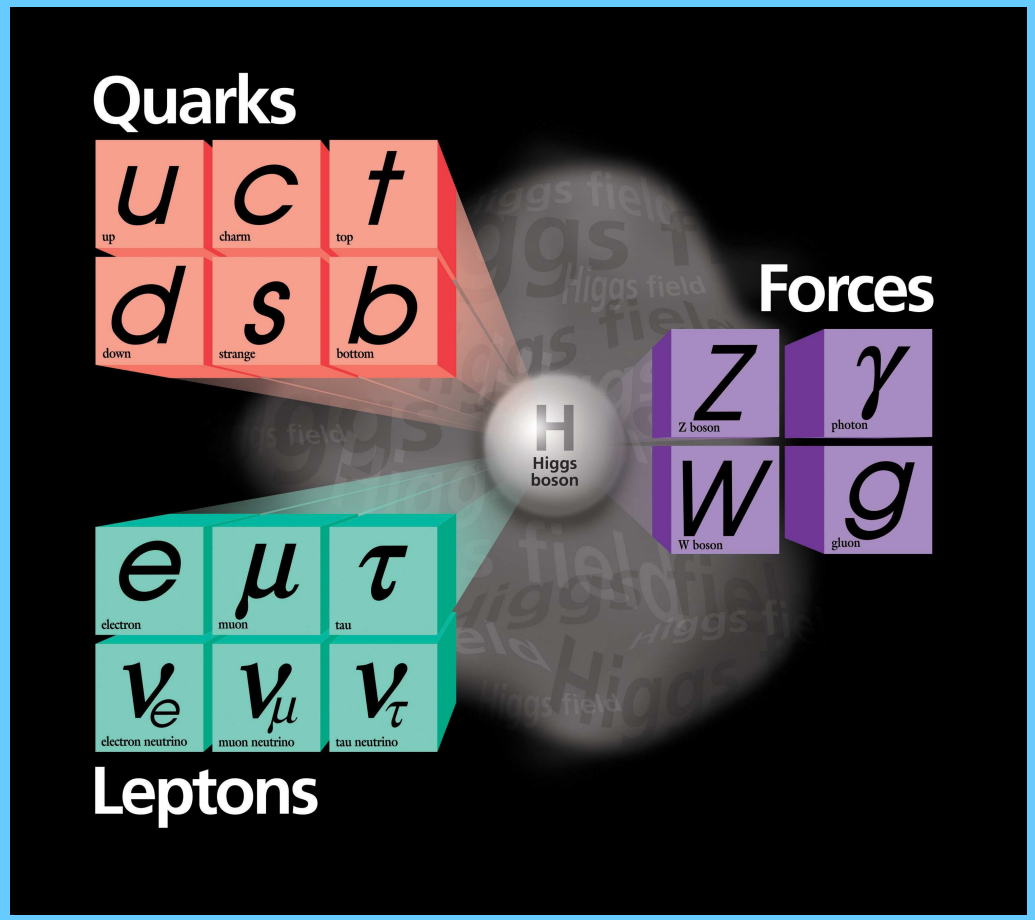
Particle Physics:

Standard Model

Describes constituents of matter:

Fundamental particles & their interactions (forces)



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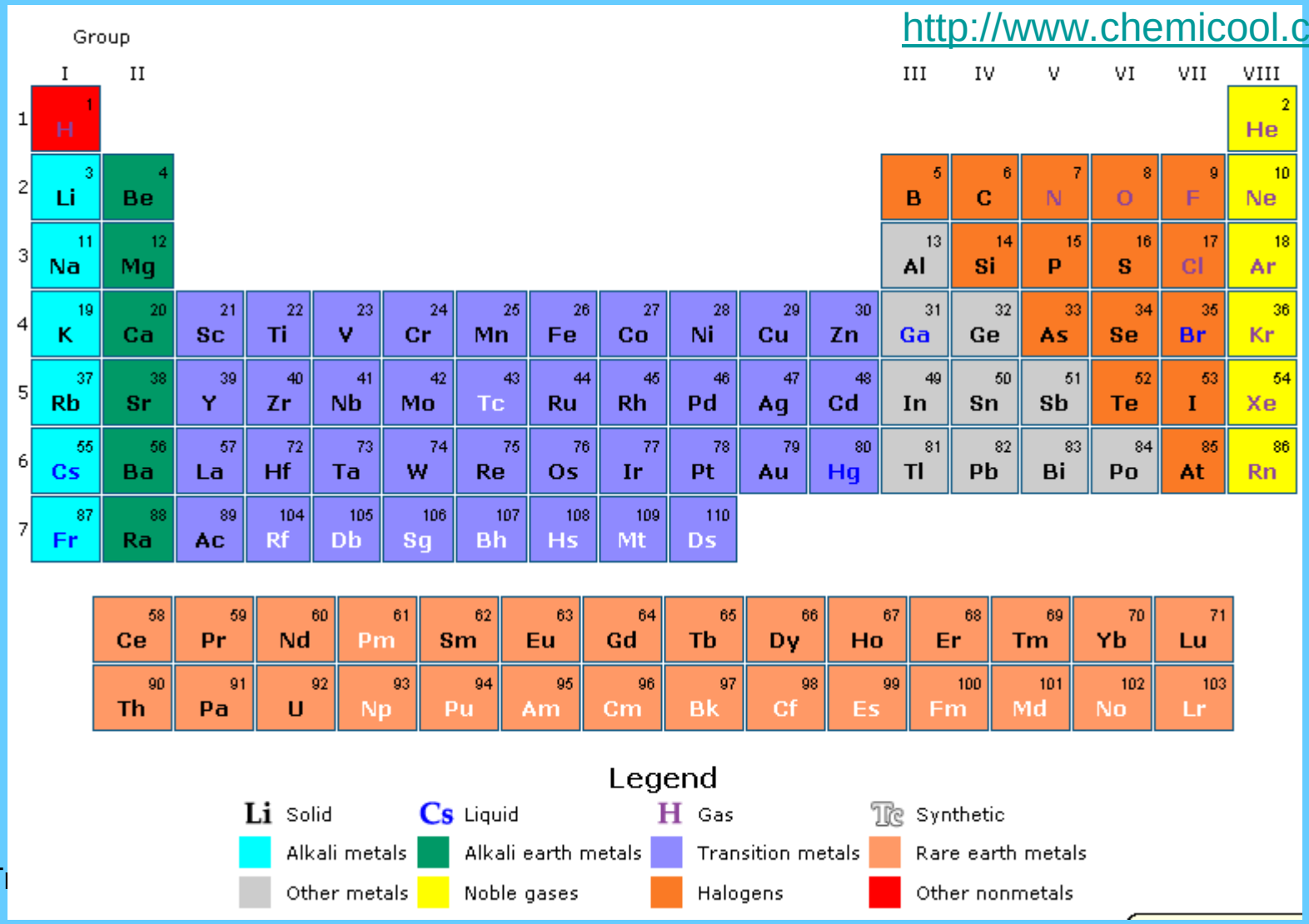
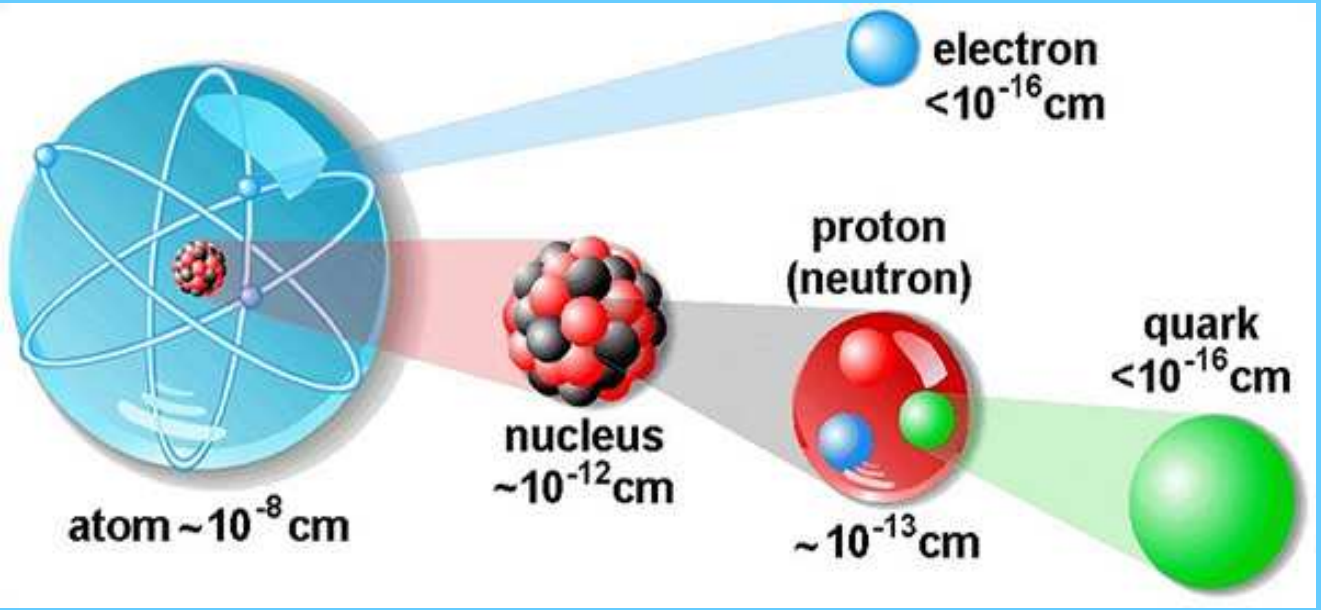
Chemistry: Periodic Table



http://www.chemicool.com/

Particle Physics:

Understanding the Fundamental constituents of matter and their interactions



Fundamental constituents of matter:

6 leptons and **6 quarks**

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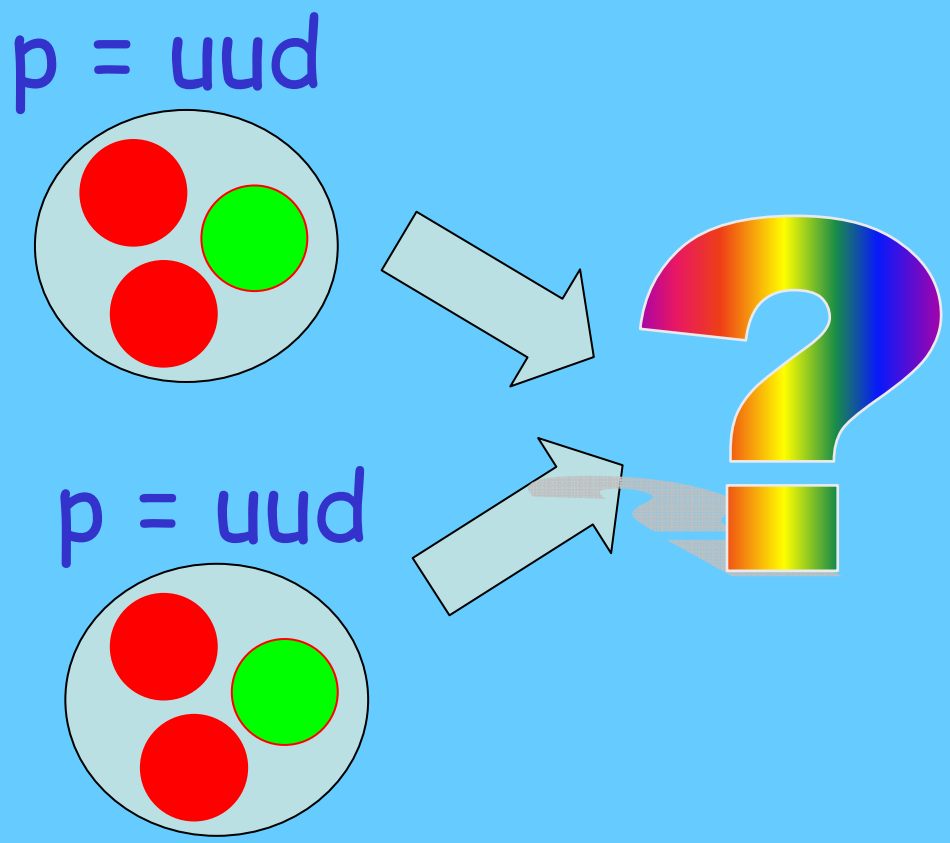
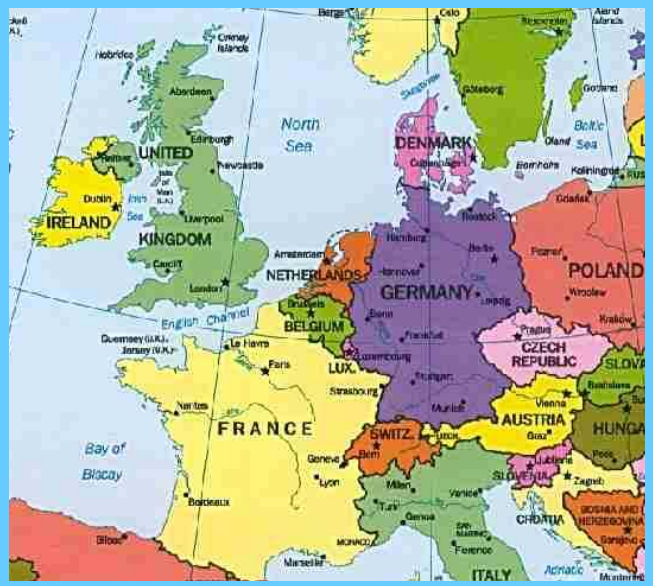
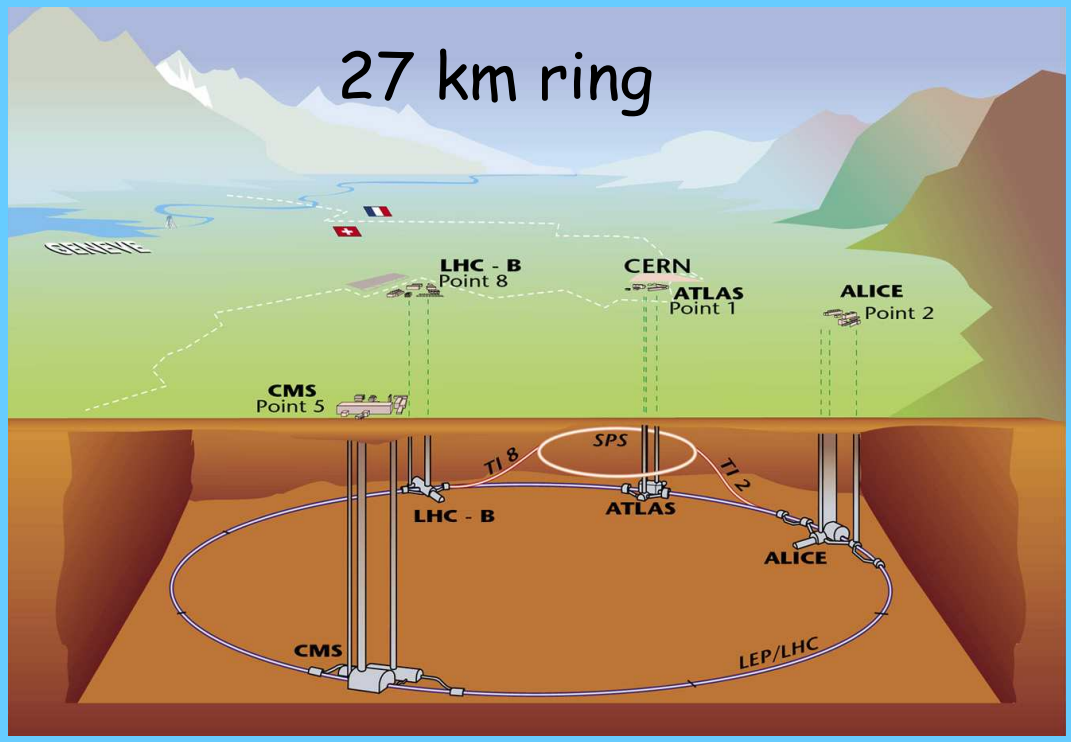
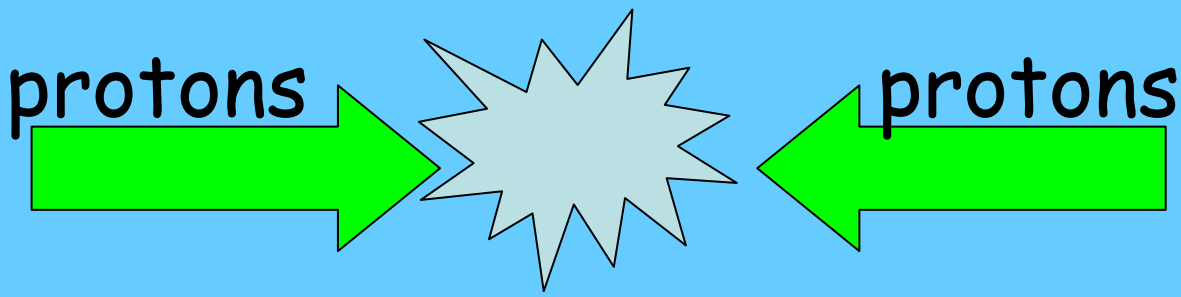
Need LHC to collide protons



Large Hadron Collider







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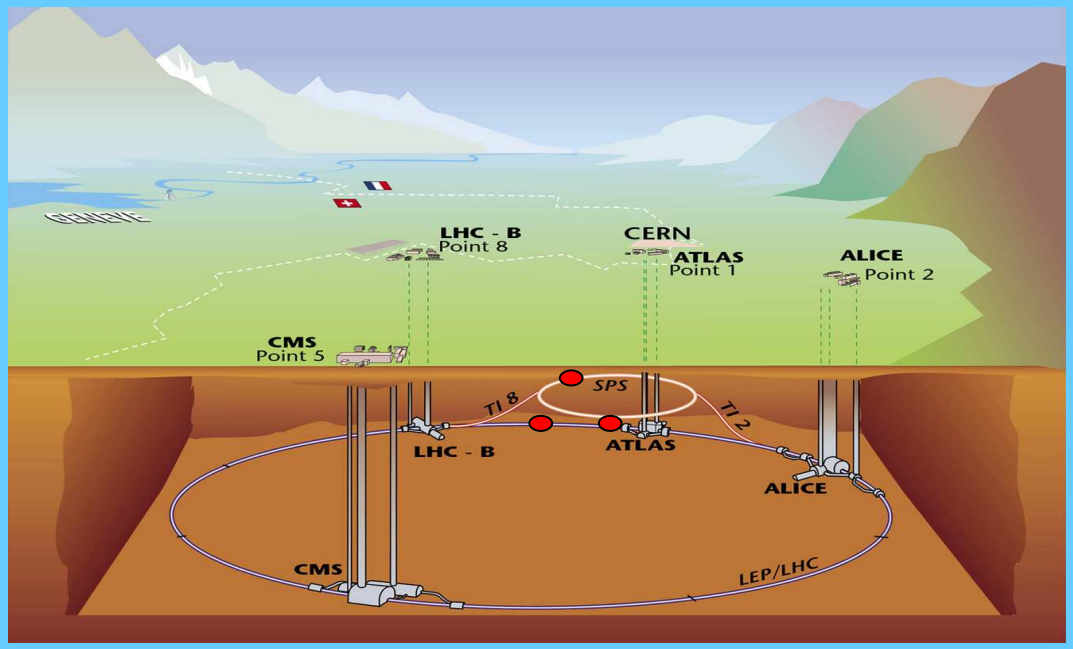
Large Hadron Collider

The is LHC the world's largest particle accelerator

It accelerates protons to 99.9999991 % of the speed of light!



A chain of accelerators to reach the required energy

Protons circle the 27km ring 11000 times per second!

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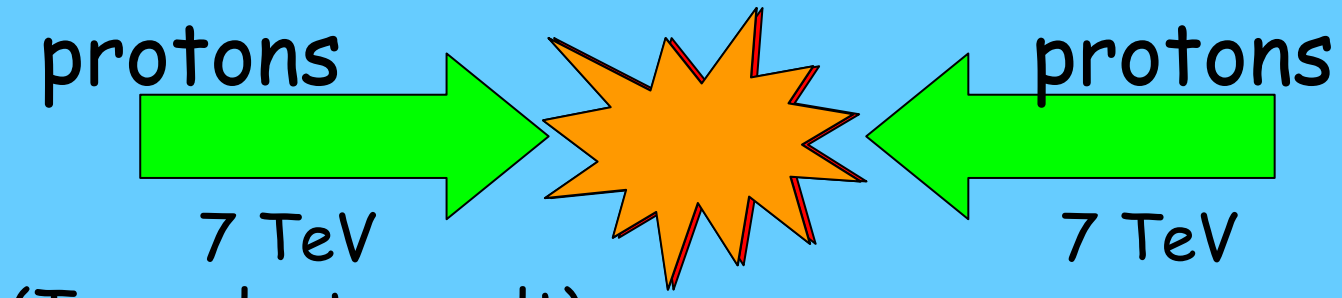
Inside the tunnel at the Large Hadron Collider

Collisions



head-to-head collisions energy = 14 TeV

7 times the energy of any previous accelerator

The collision generate temperatures more than
100 000 times hotter than the heart of the Sun!

600 million collisions per second

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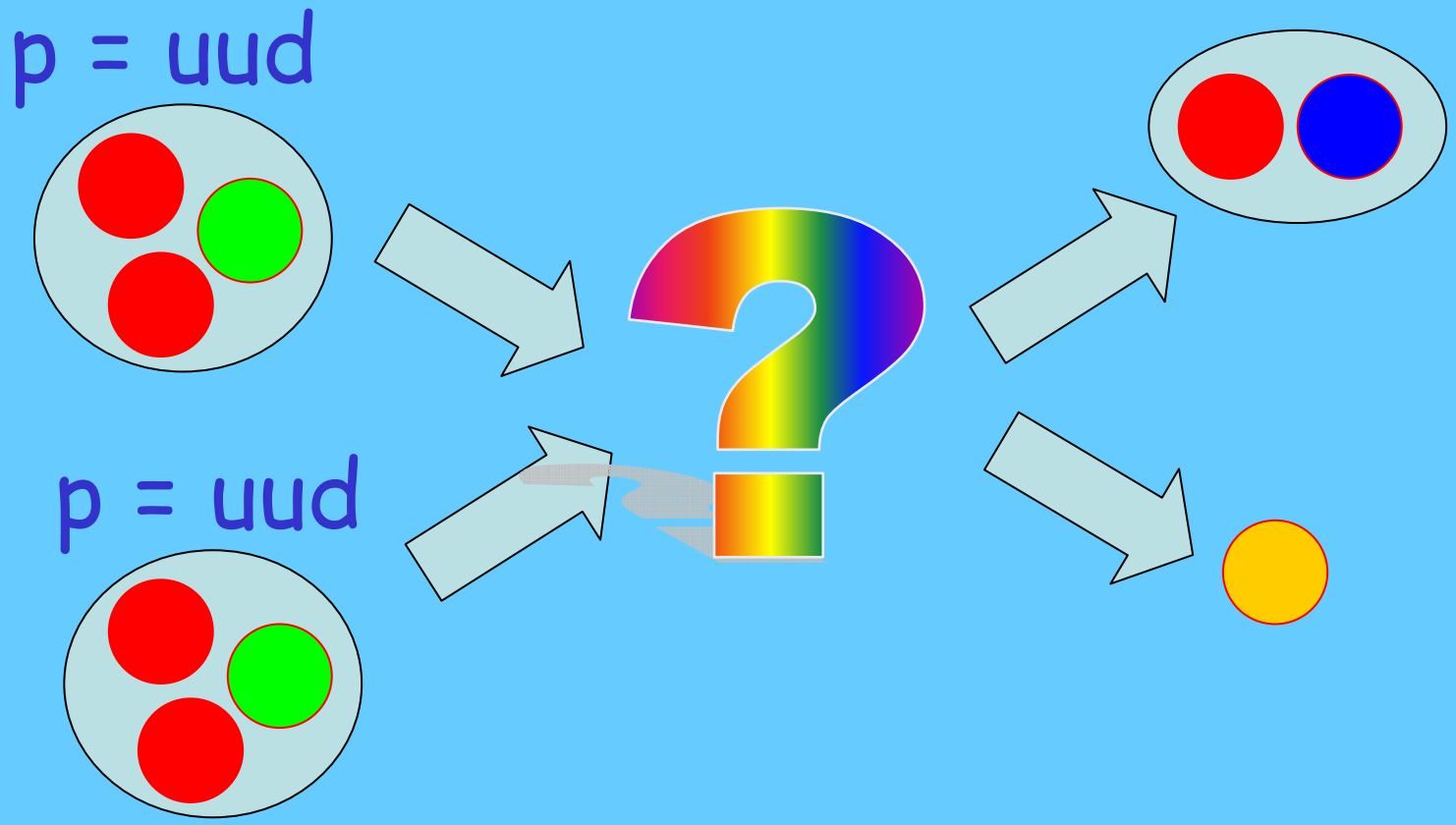
Need detectors (ATLAS) to observe the outcome of the collisions!



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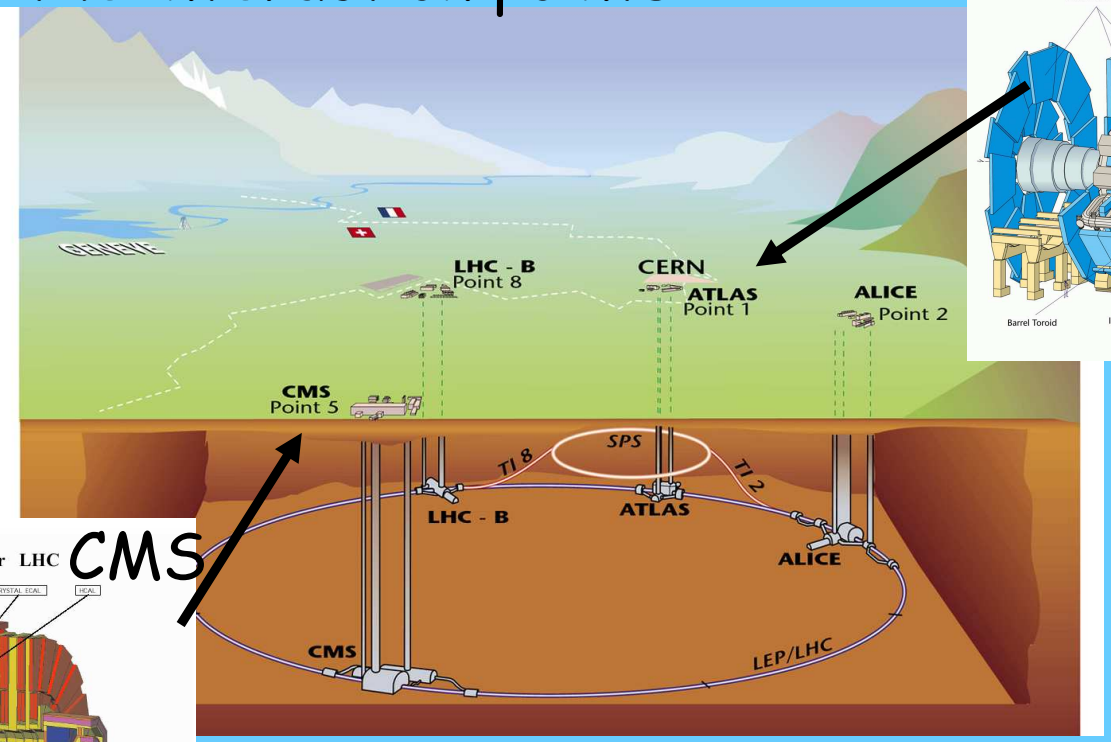
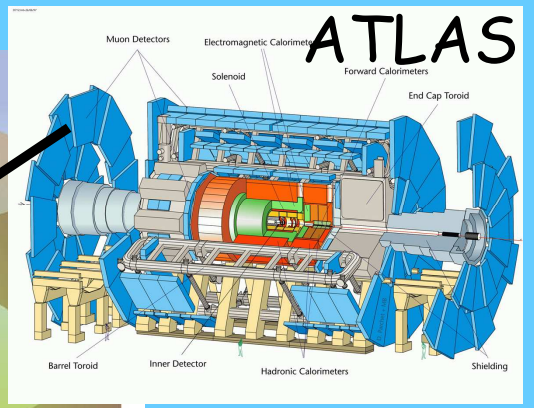
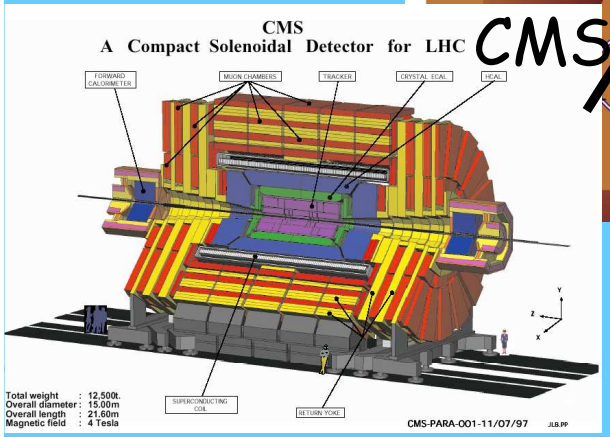
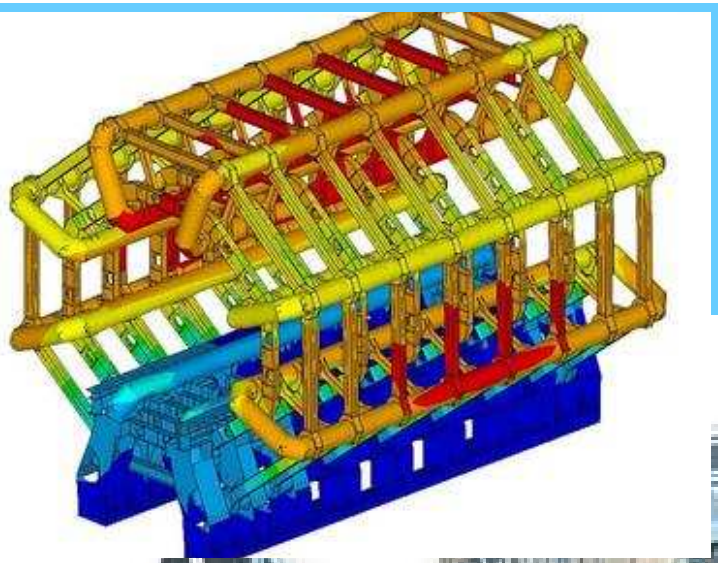
Detectors

Detectors are used to observe the collisions at the interaction points

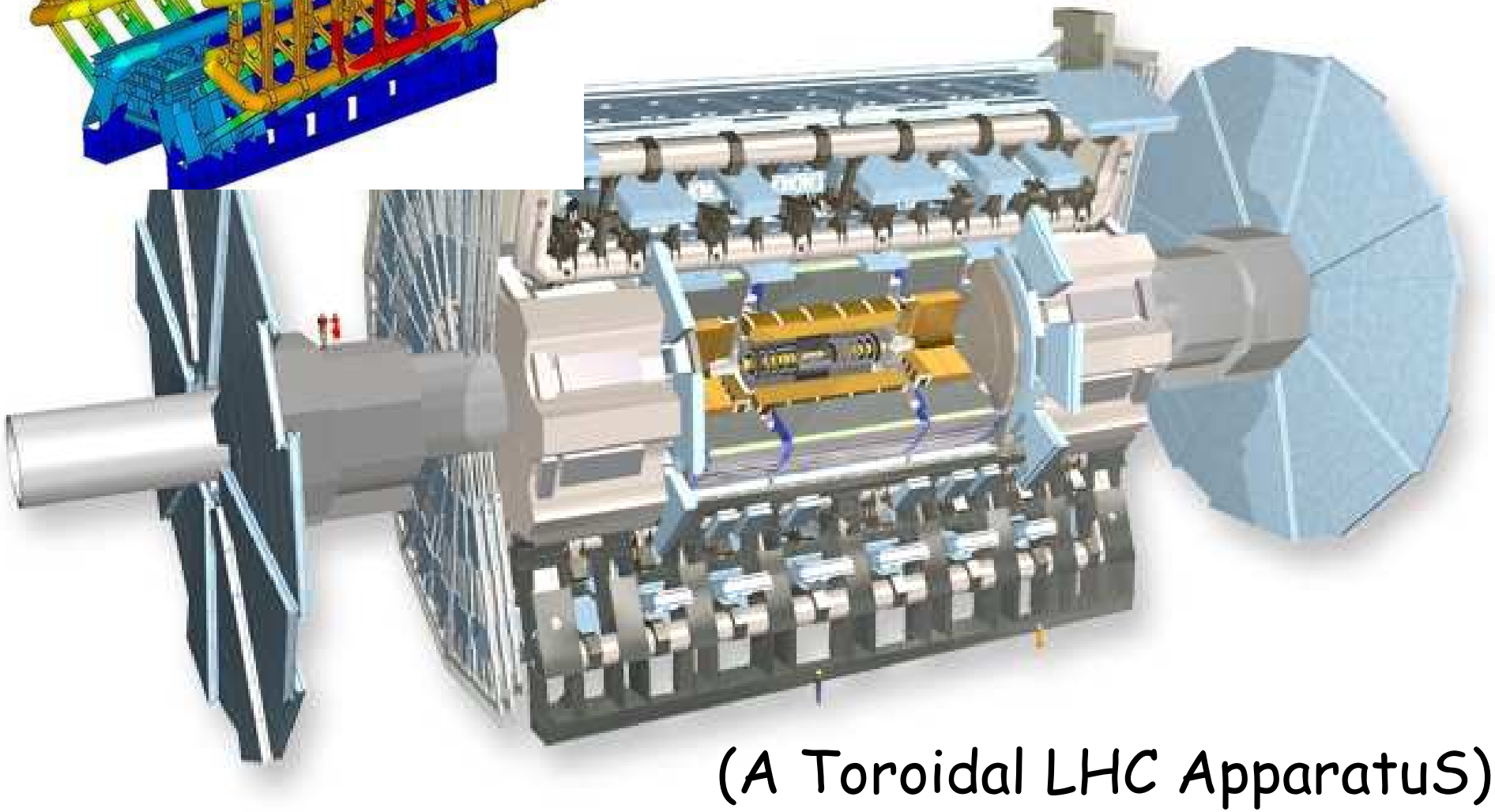








ATLAS

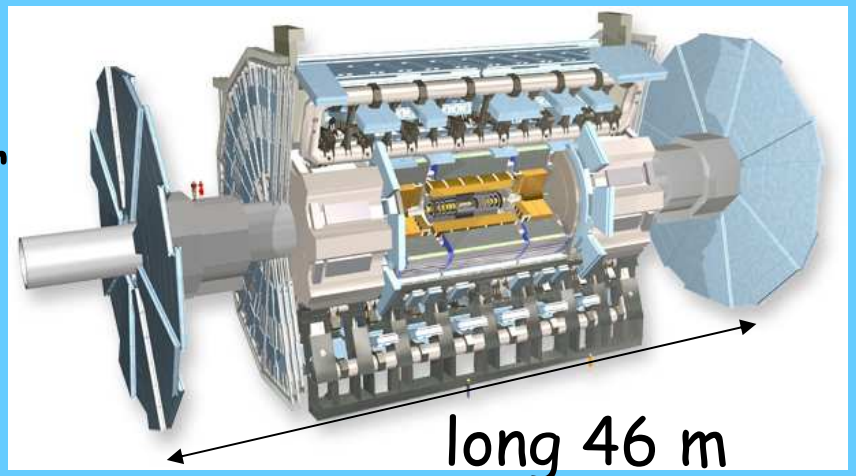


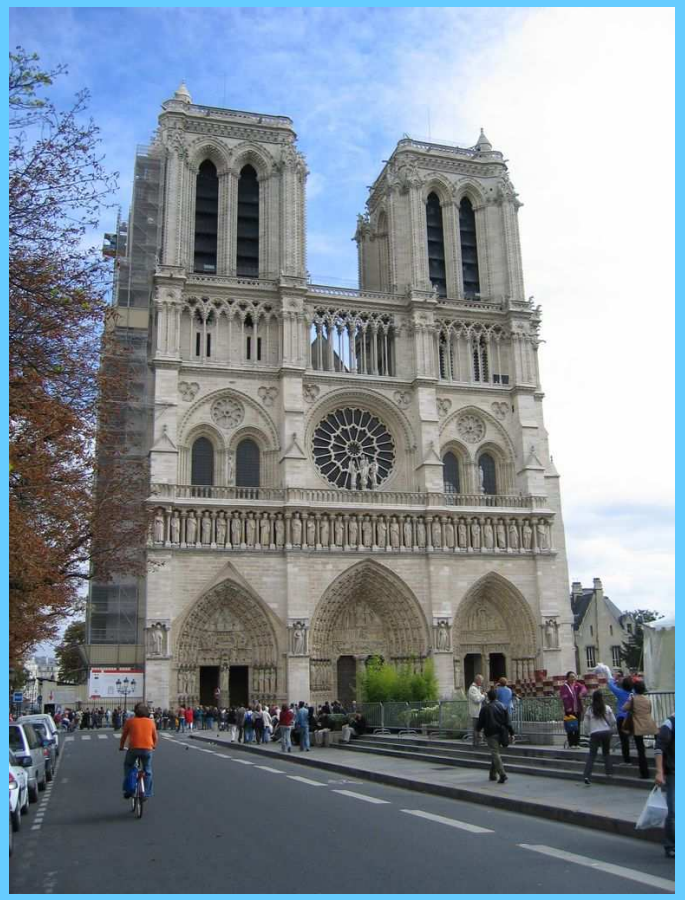
(A Toroidal LHC ApparatuS)

ATLAS

Largest volume particle detector ever constructed!

Overall diameter 25 m





ATLAS is half the size of Notre Dame Cathedral

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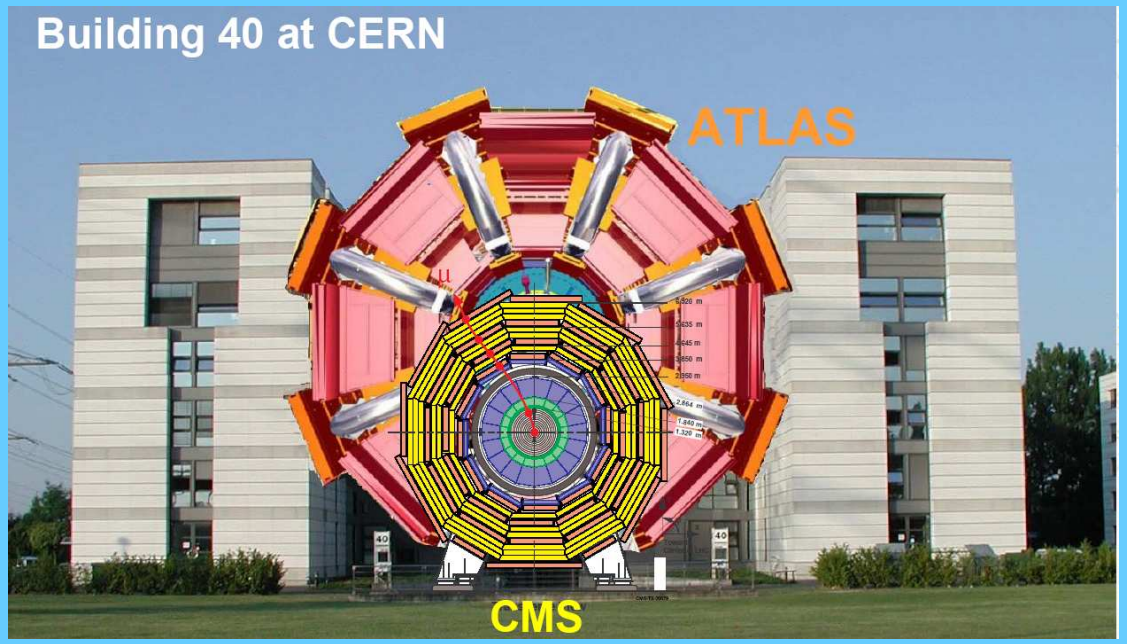
Detectors

6 storeys high



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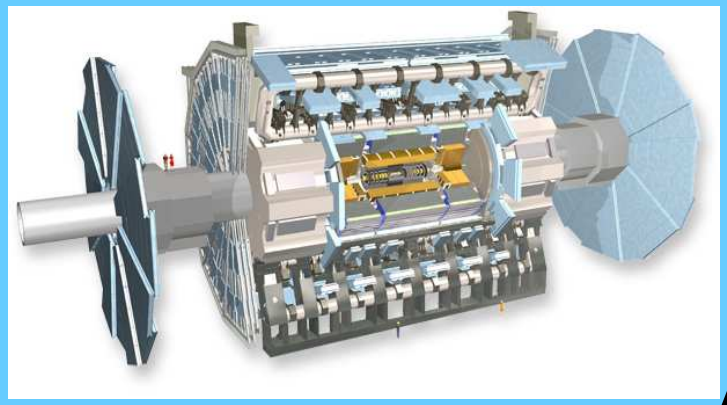
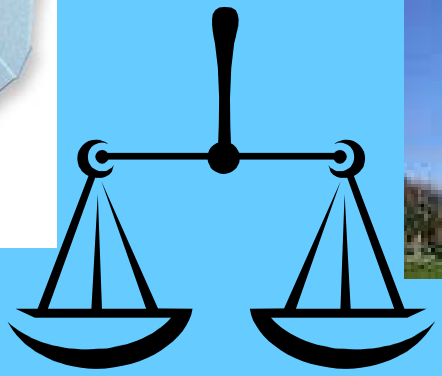
ATLAS

Total weight: 7000 tonnes = same as the Eiffel Tower





= 100 jets (empty)

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Eiffel tower picture from www.unm.edu

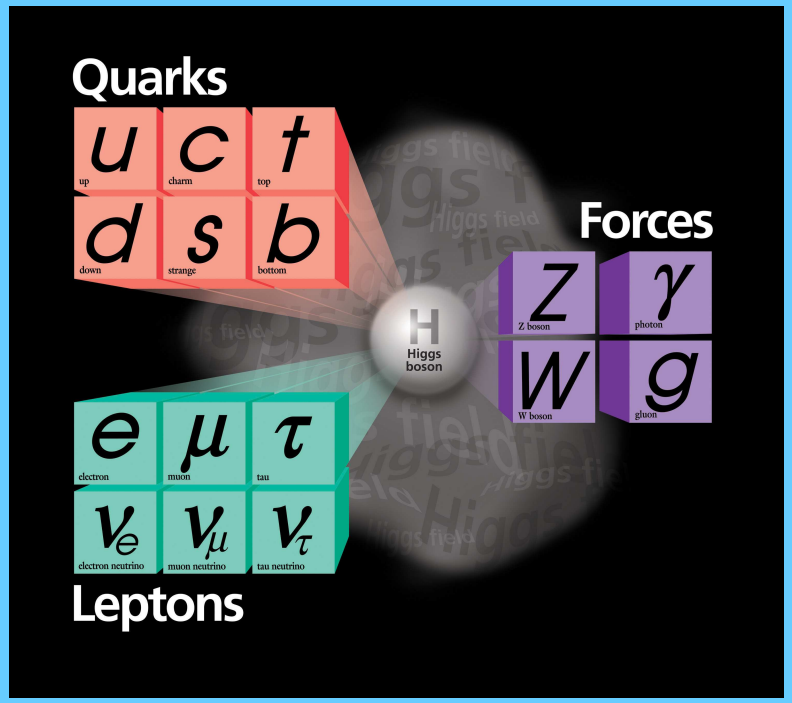
Searches at ATLAS

ALTAS (very high energy & lots of data)

enables physicists to:

- test the Standard Model
- look for new particles
- look for new symmetries

How do we identify the particles?



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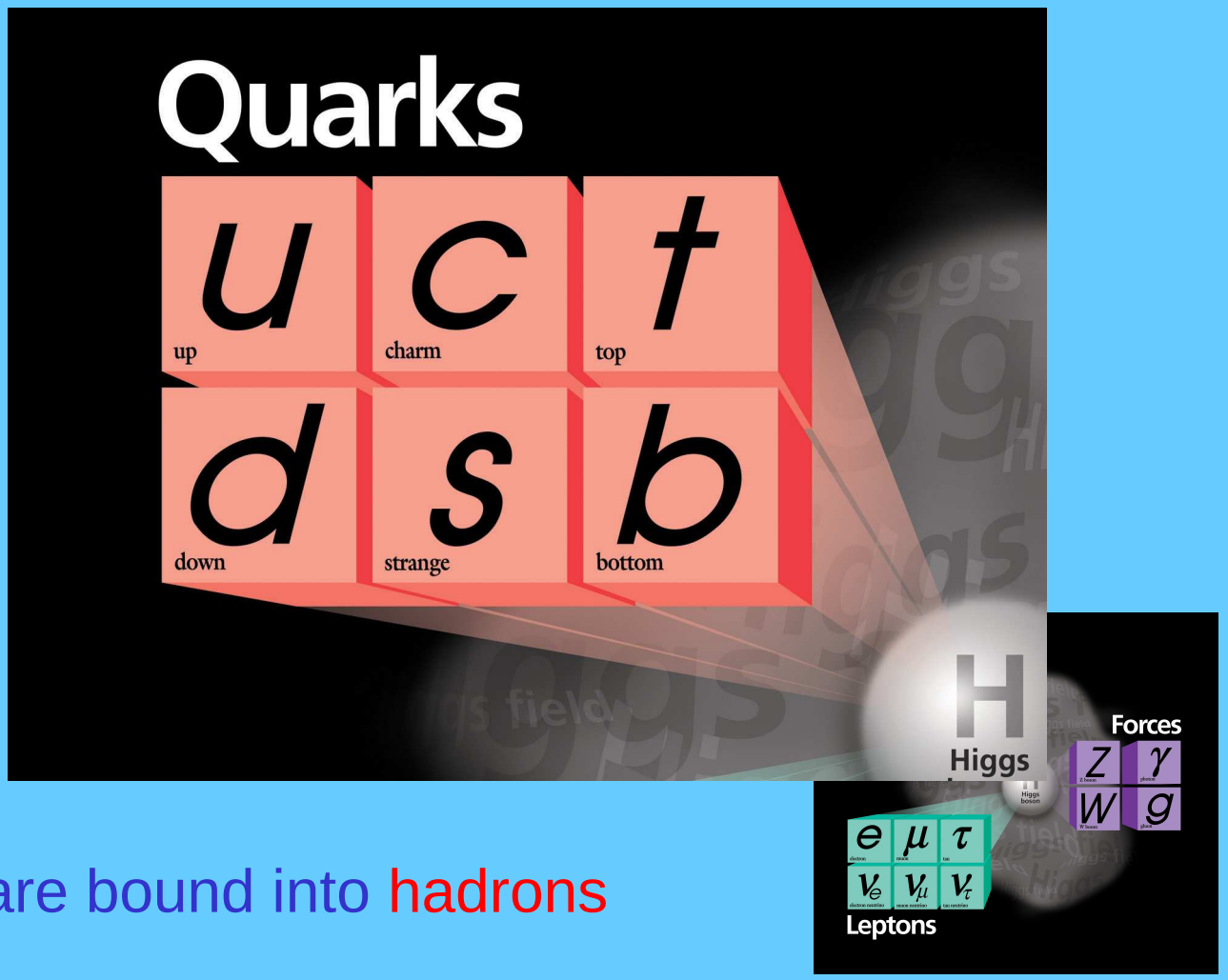
Quarks



Quarks are bound into hadrons

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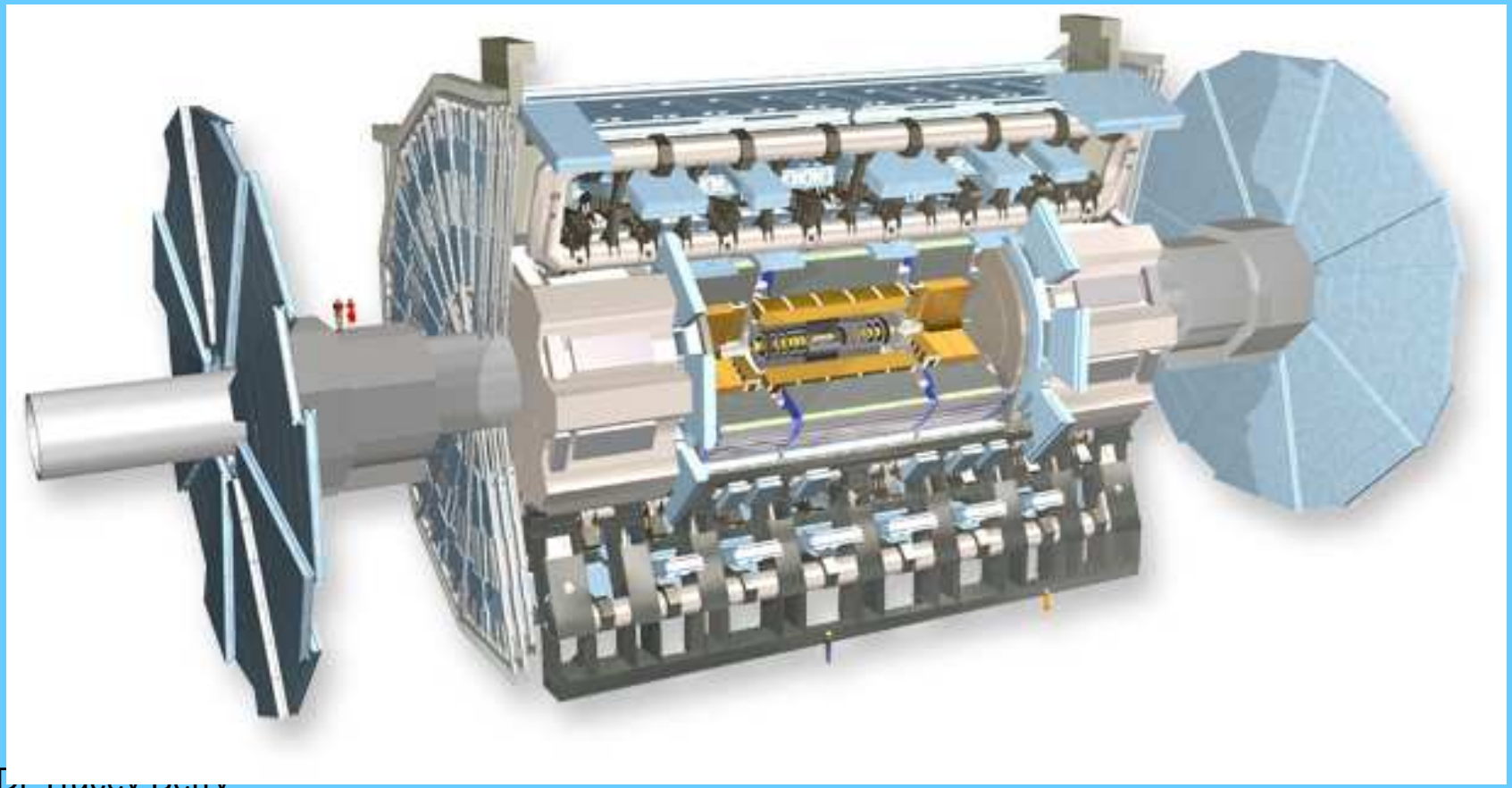
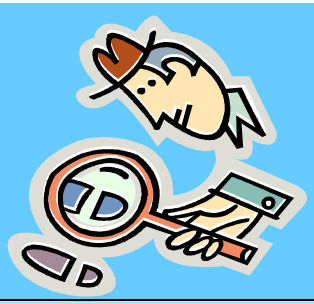
ATLAS

Detector subsystems are designed to measure:
energy and momentum of γ ,e, μ, jets



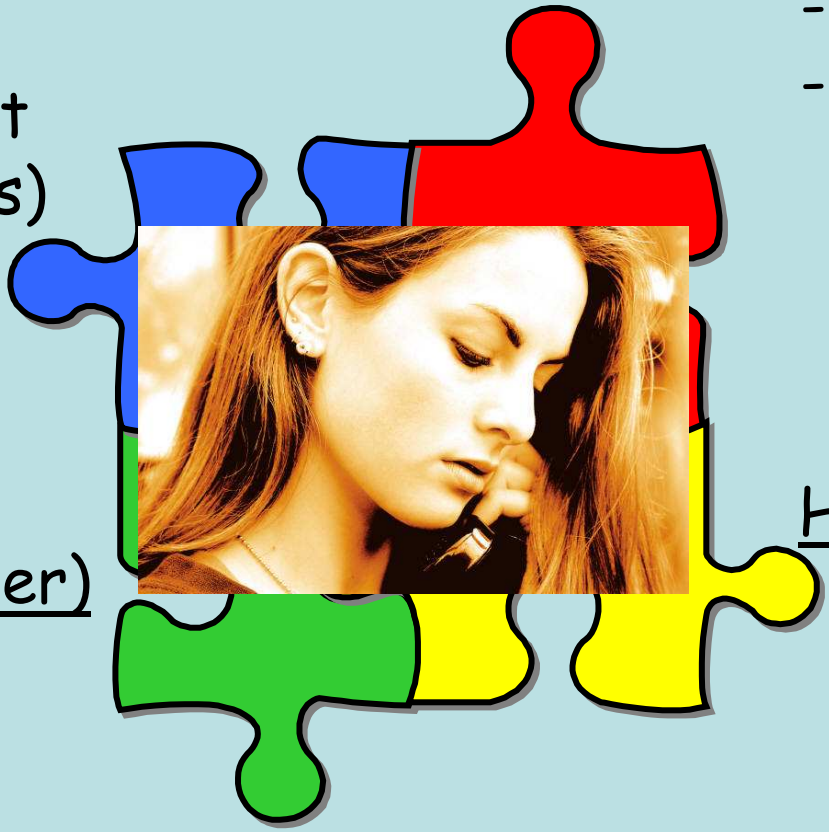


Identifying People

Tracking Detector (sandpit)
- was a footprint left?
  - tiny – child
  - large – adult

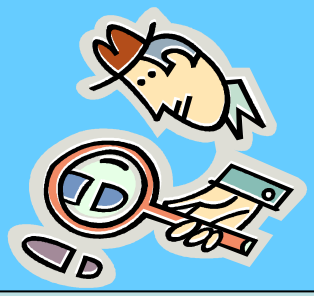
(stilletto/trainers)

Eye Colour (camera)
- blue eye?
- brown eye?



Height (meter ruler)
- small person
- tall person

Hair Colour (camera)



Identifying Particles

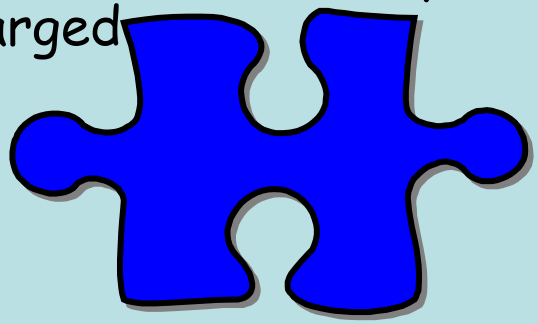
<u>Tracking Detector</u>

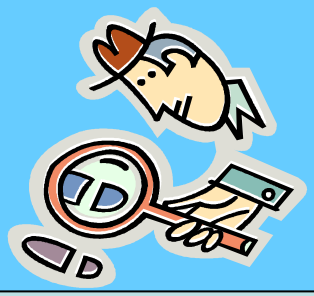
-Was a track left?

yes -> particle is charged

curvature -> momentum (mass x velocity)

no -> particle not charged





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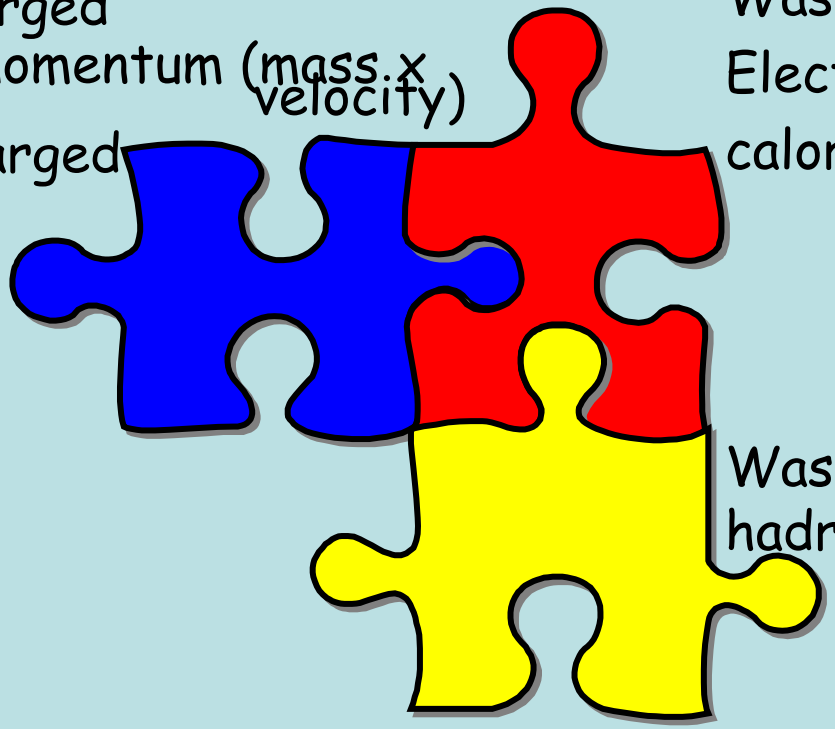
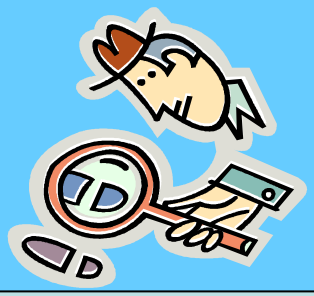


<u>Calorimeters</u>
Was energy left in the Electromagnetic calorimeter?

Was energy left in the hadronic calorimeter?



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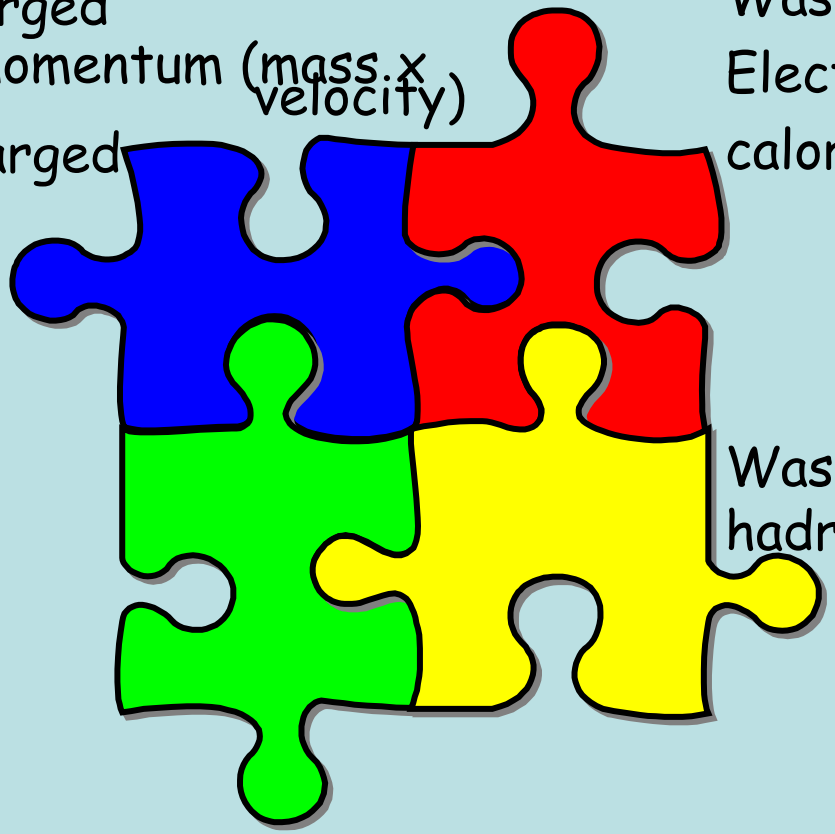
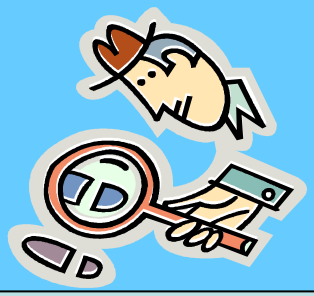


Was energy left in the hadronic calorimeter?

<u>Muon Detector</u>

-Was a track left in the muon detectors?



Identifying Particles

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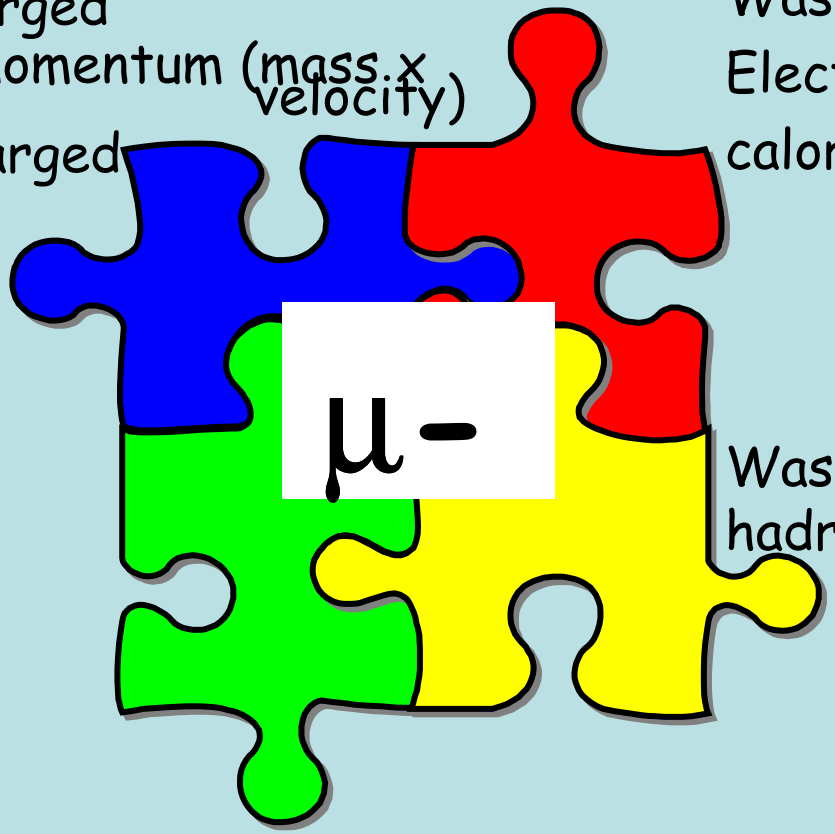

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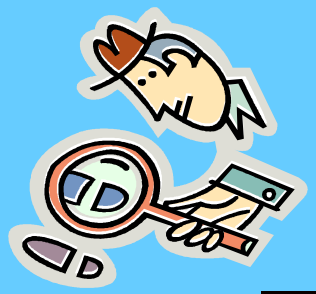
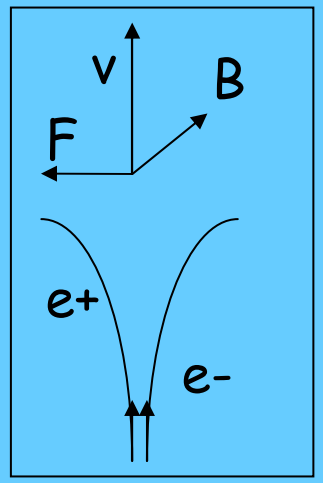
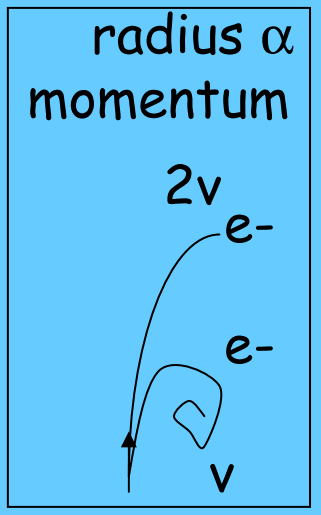
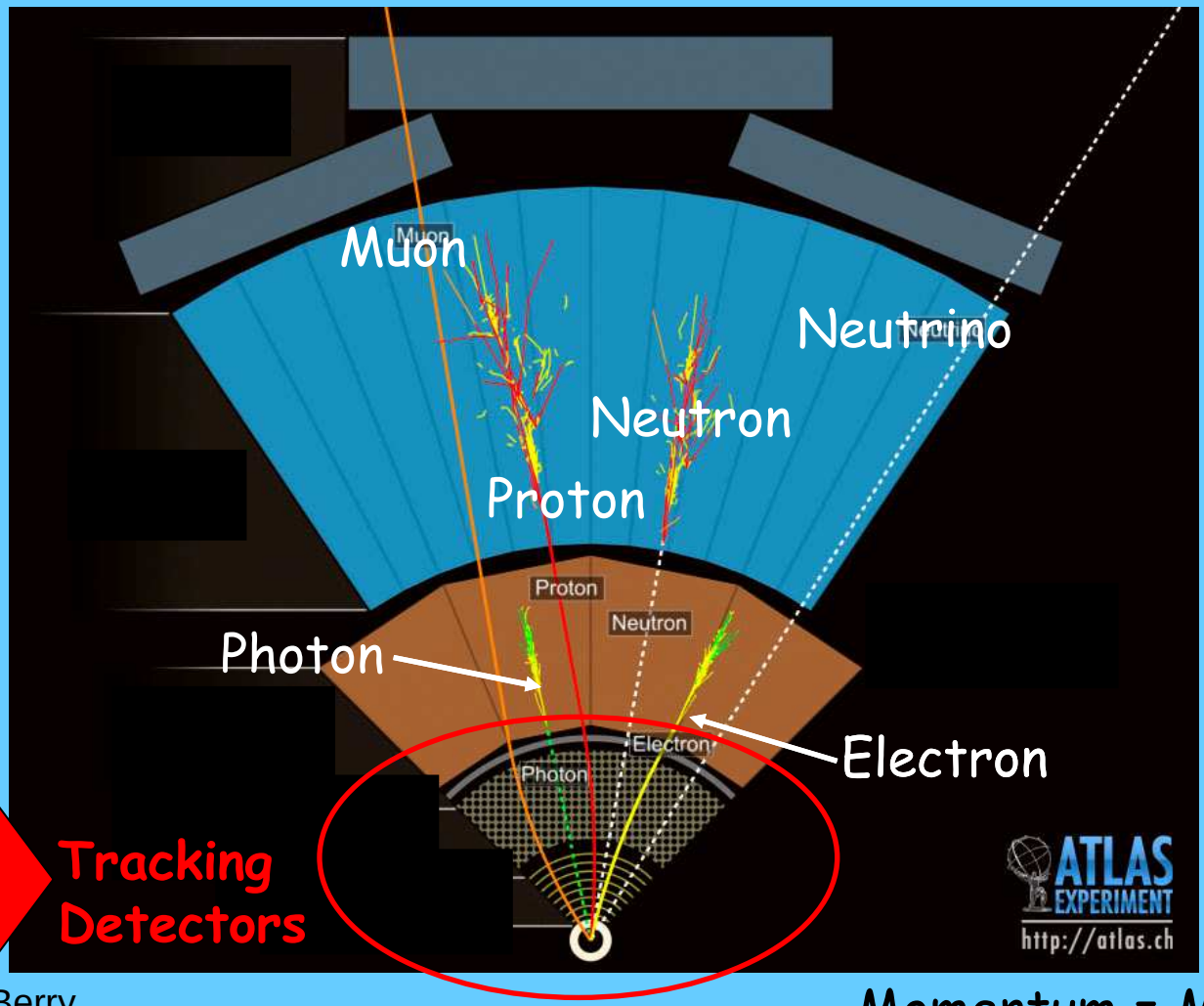


Identify Particles!







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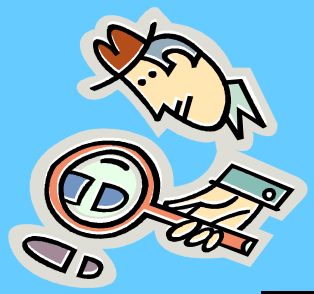
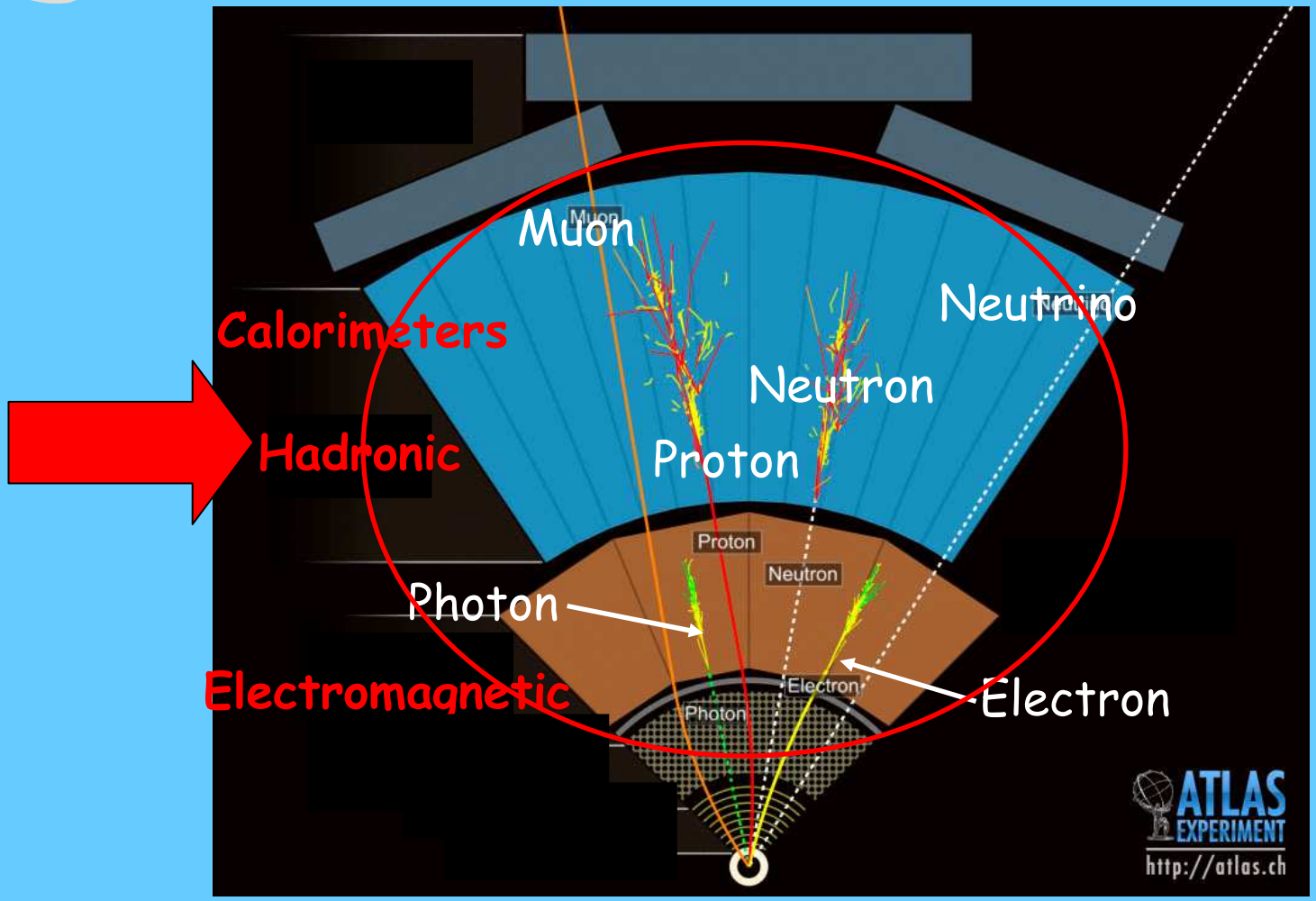
Momentum = Mass x velocity



Identify Particles!



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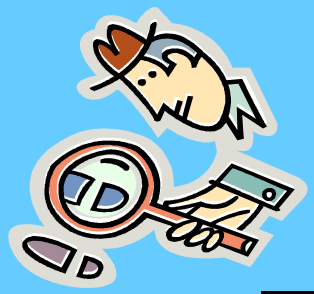

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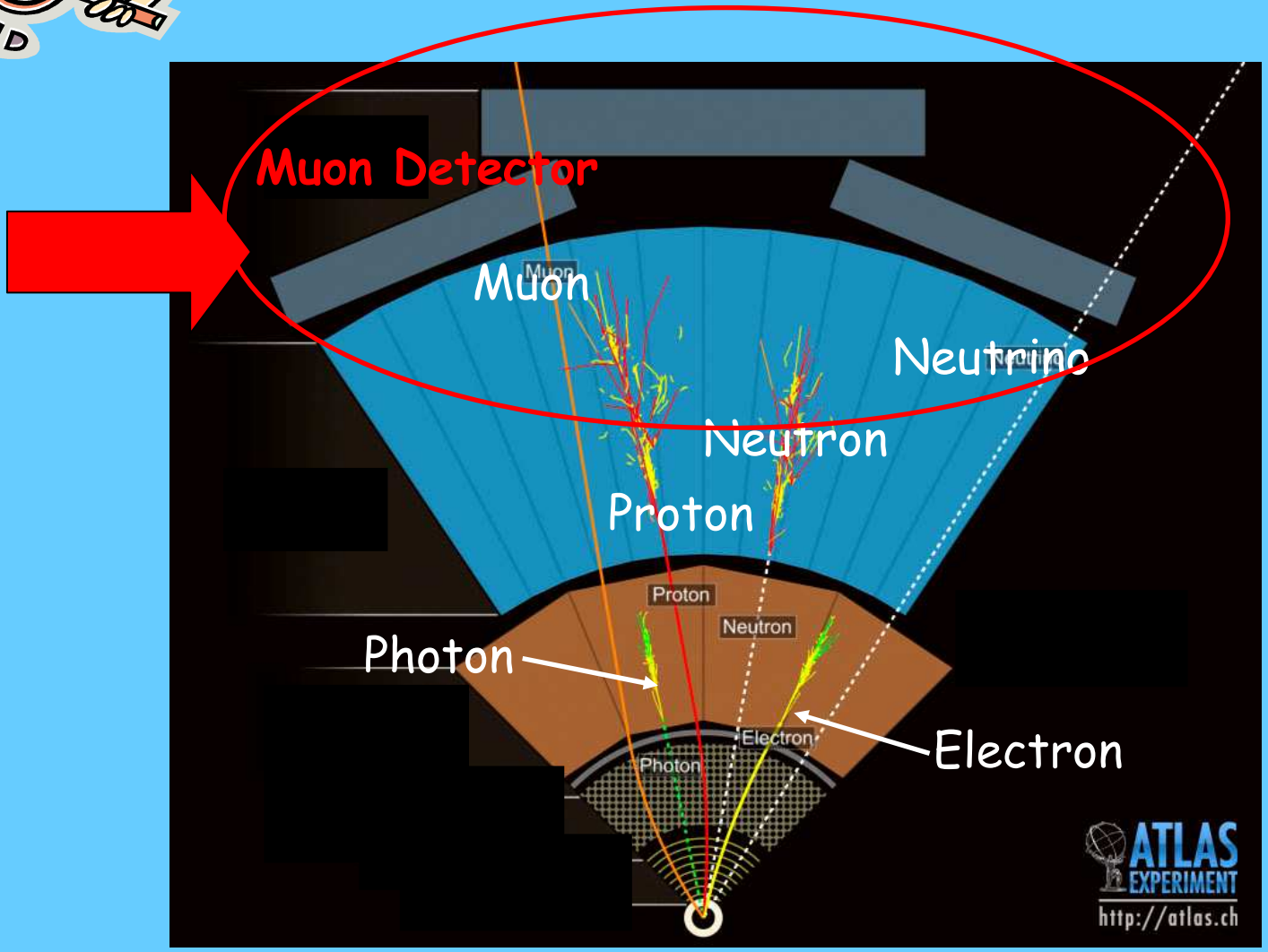

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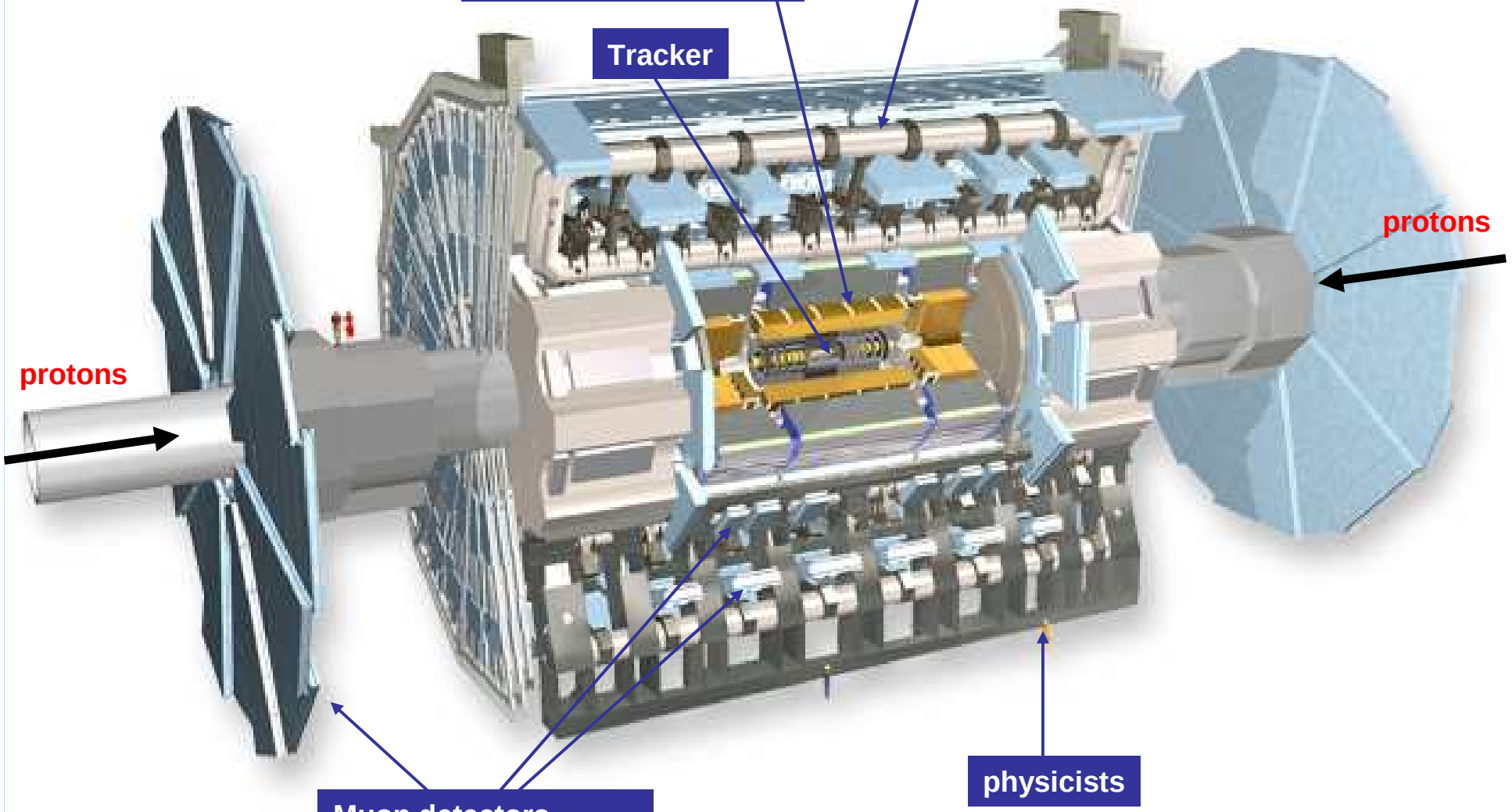
The ATLAS detector consists of 4 major components



ATLAS VIDEO!

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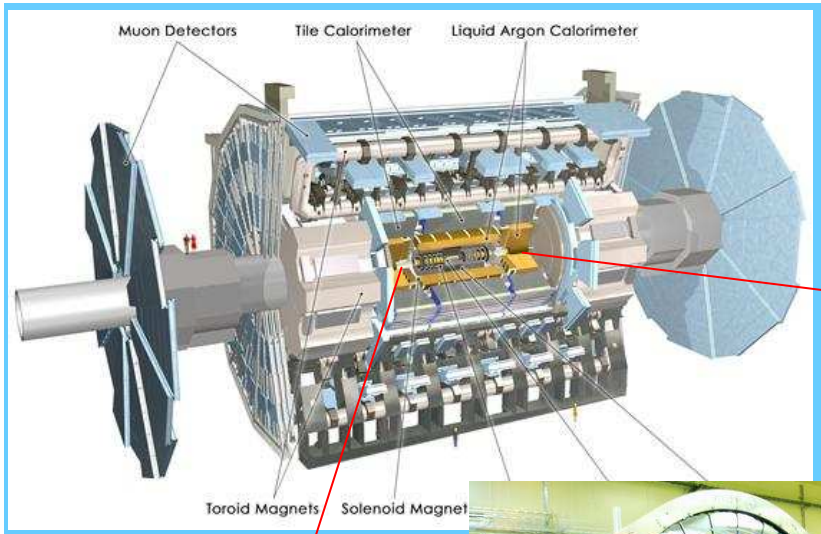
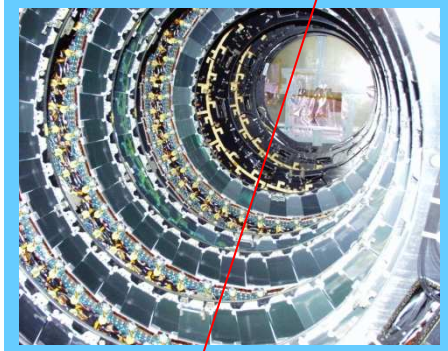
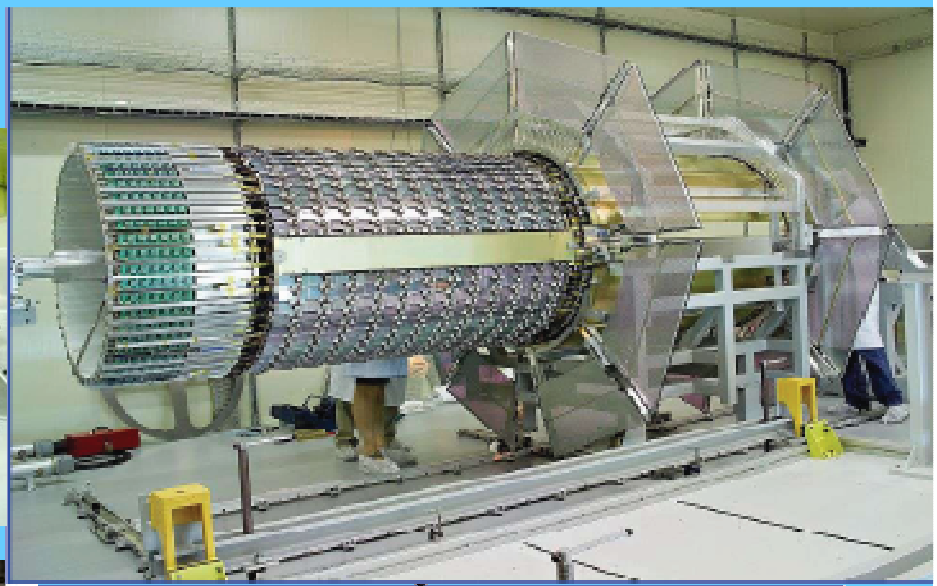
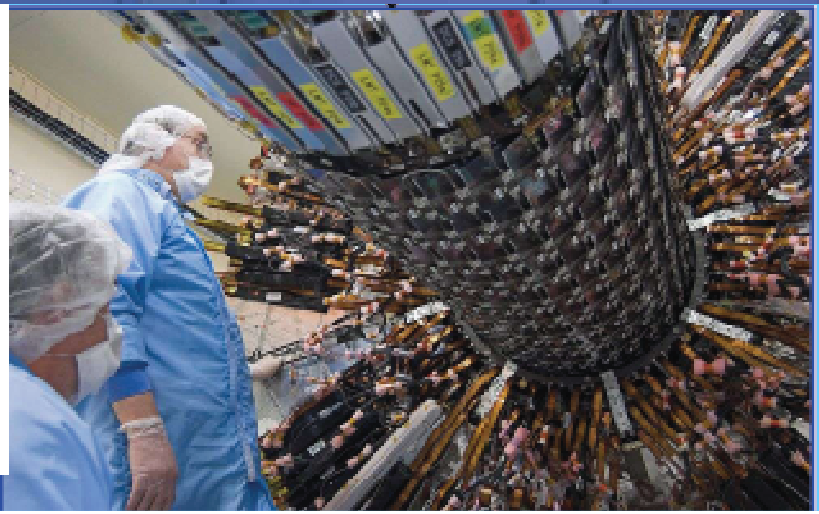


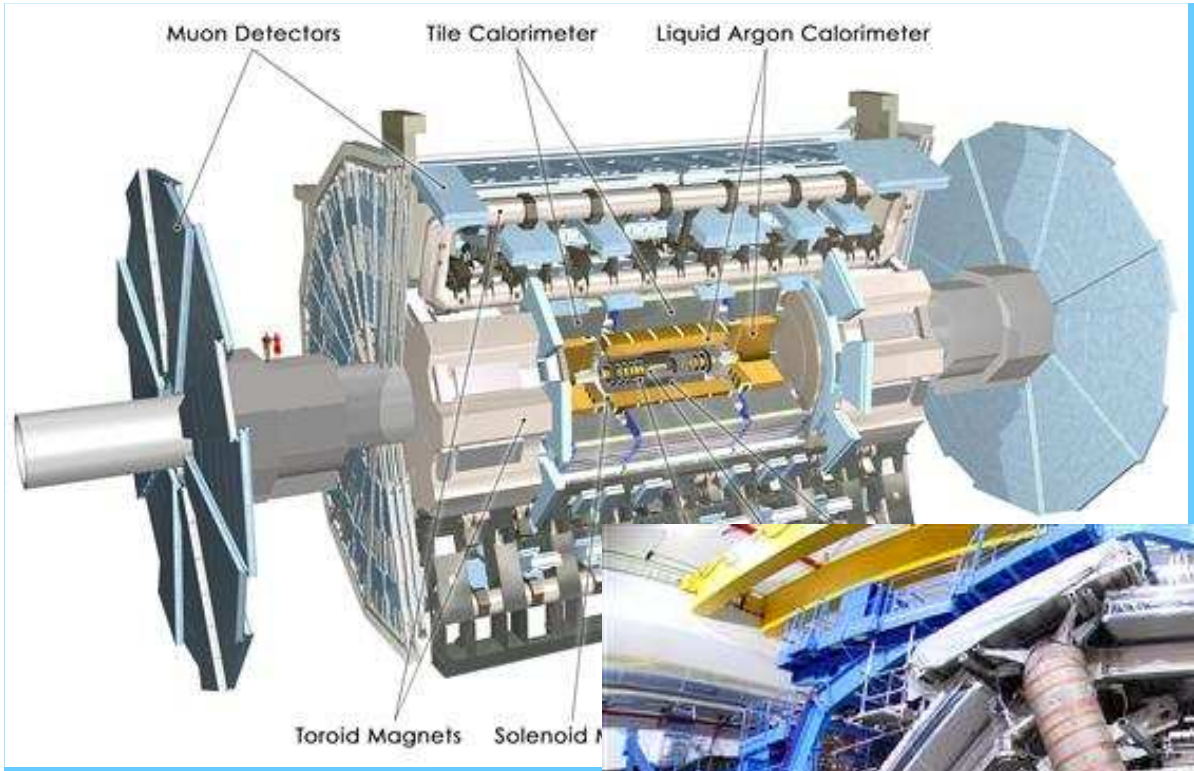
ATLAS SCT

(61m^2 of silicon sensors)









ATLAS Installation

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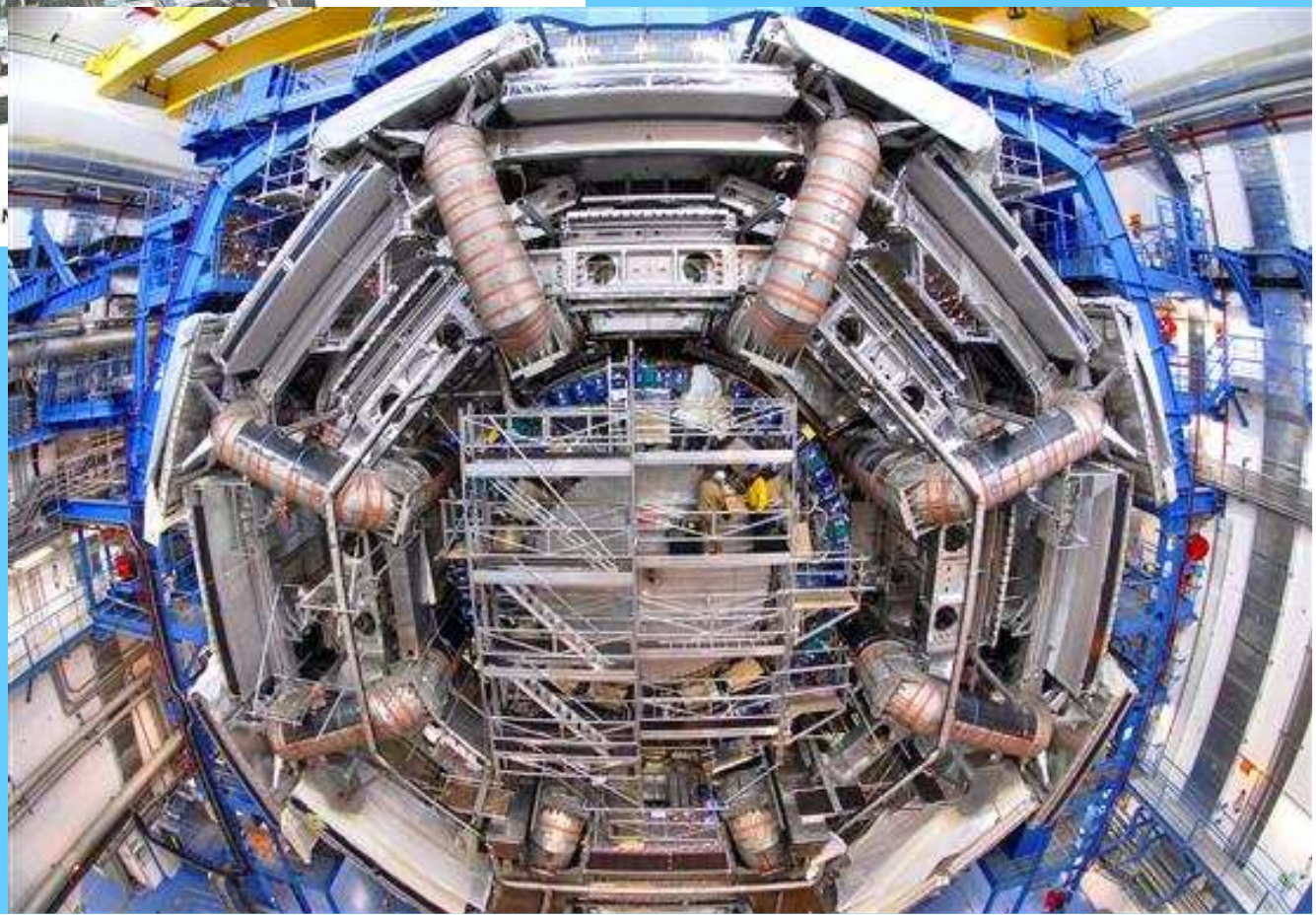

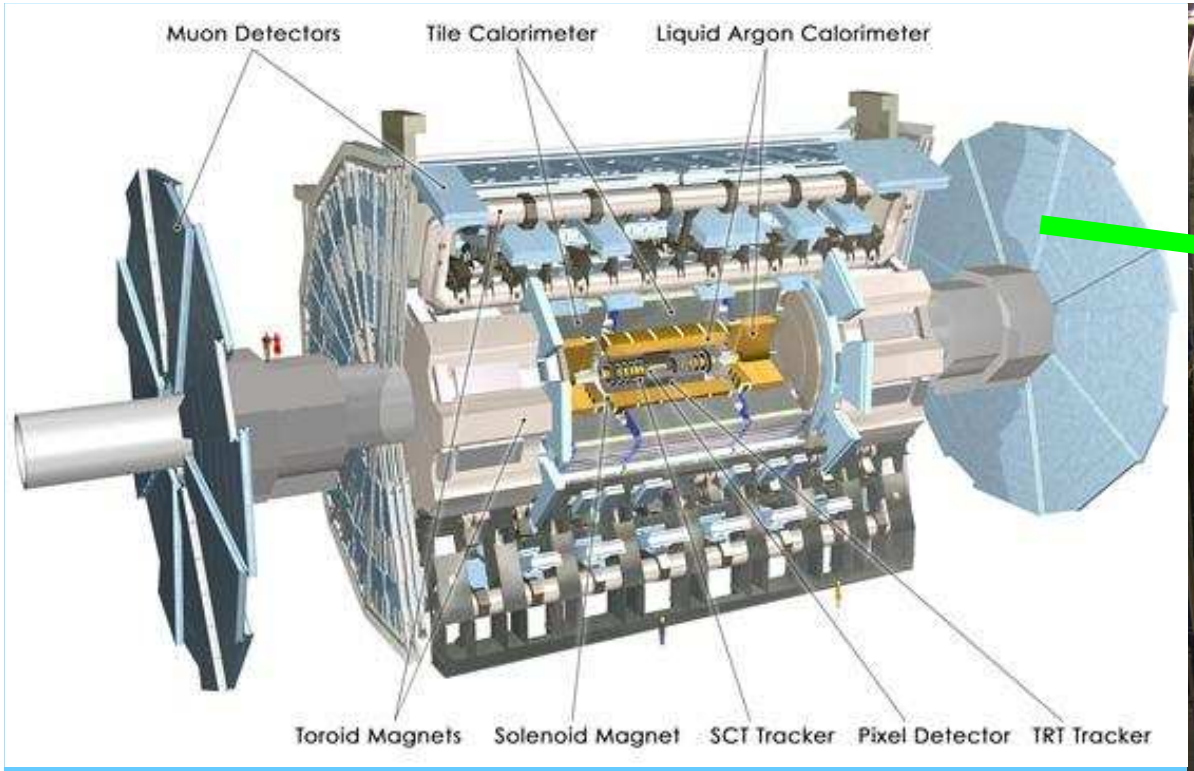

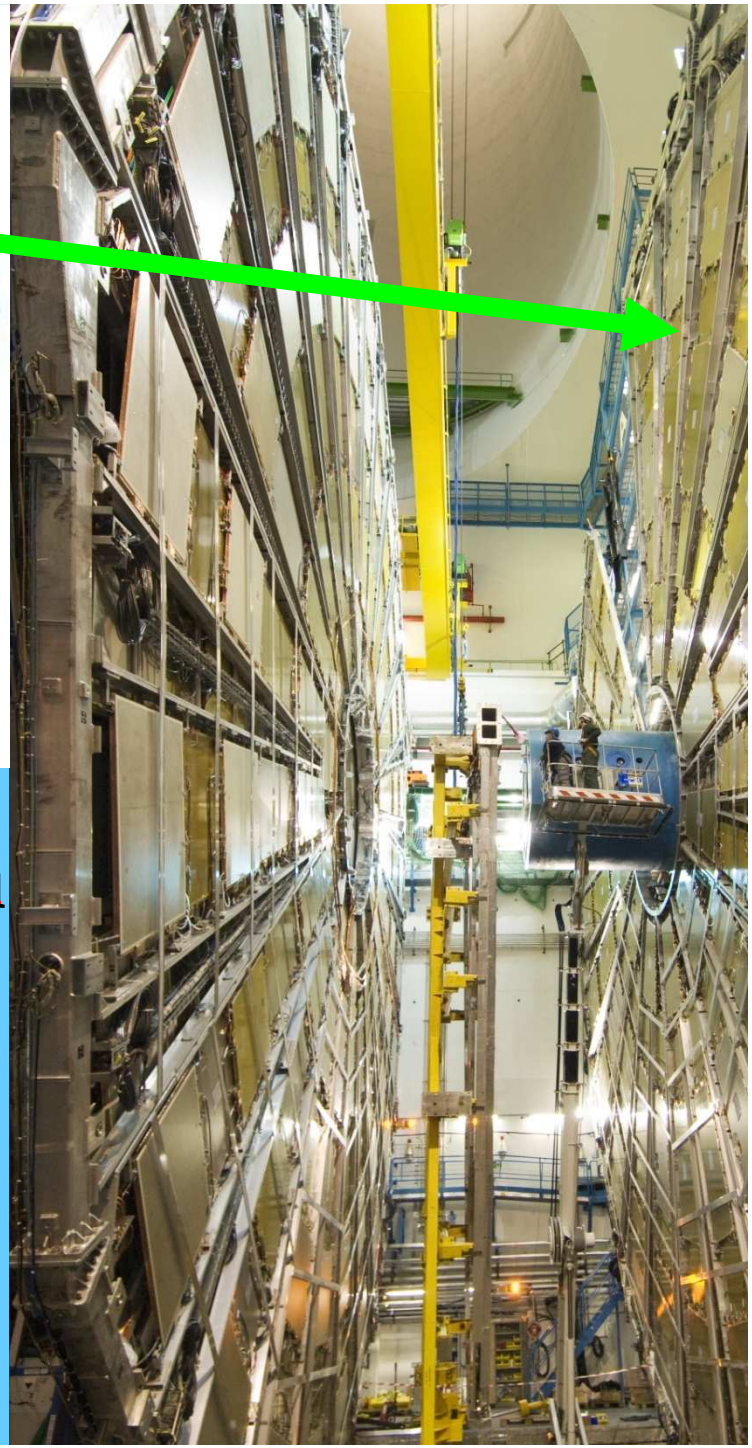

ATLAS Installation

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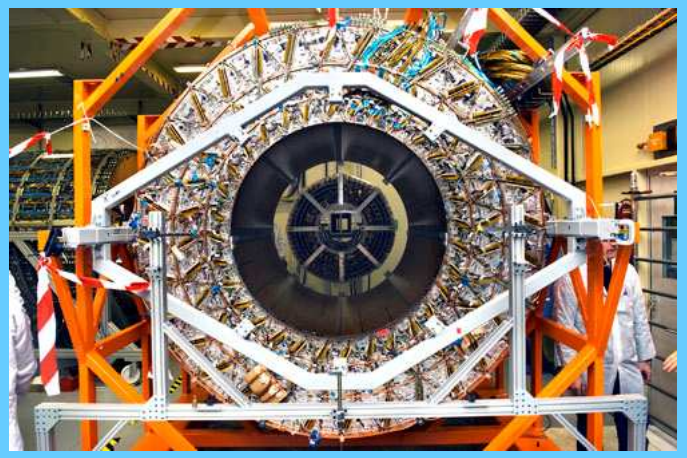
ATLAS

- 3000 kilometers of ordinary cable in ATLAS
- 100 million electronic channels - to read out channels to collect all of that information from all the detectors



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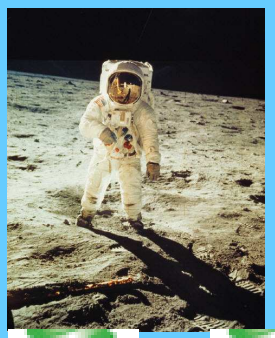
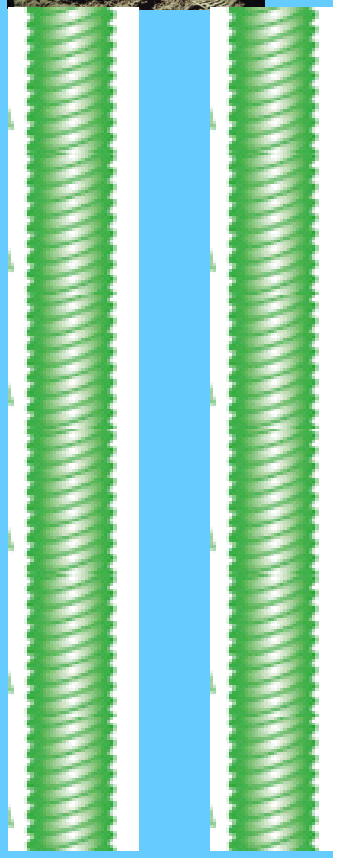
Data



If all the data from ATLAS would be recorded: this would fill **100,000 CDs per second**.

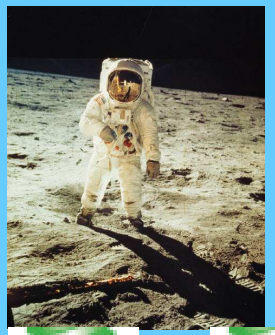
=450 feet high every second

Equivalent to a stack of CDs which would reach to the moon and back twice each year.



Data rate is equivalent to
50 billion telephone calls at the same time!

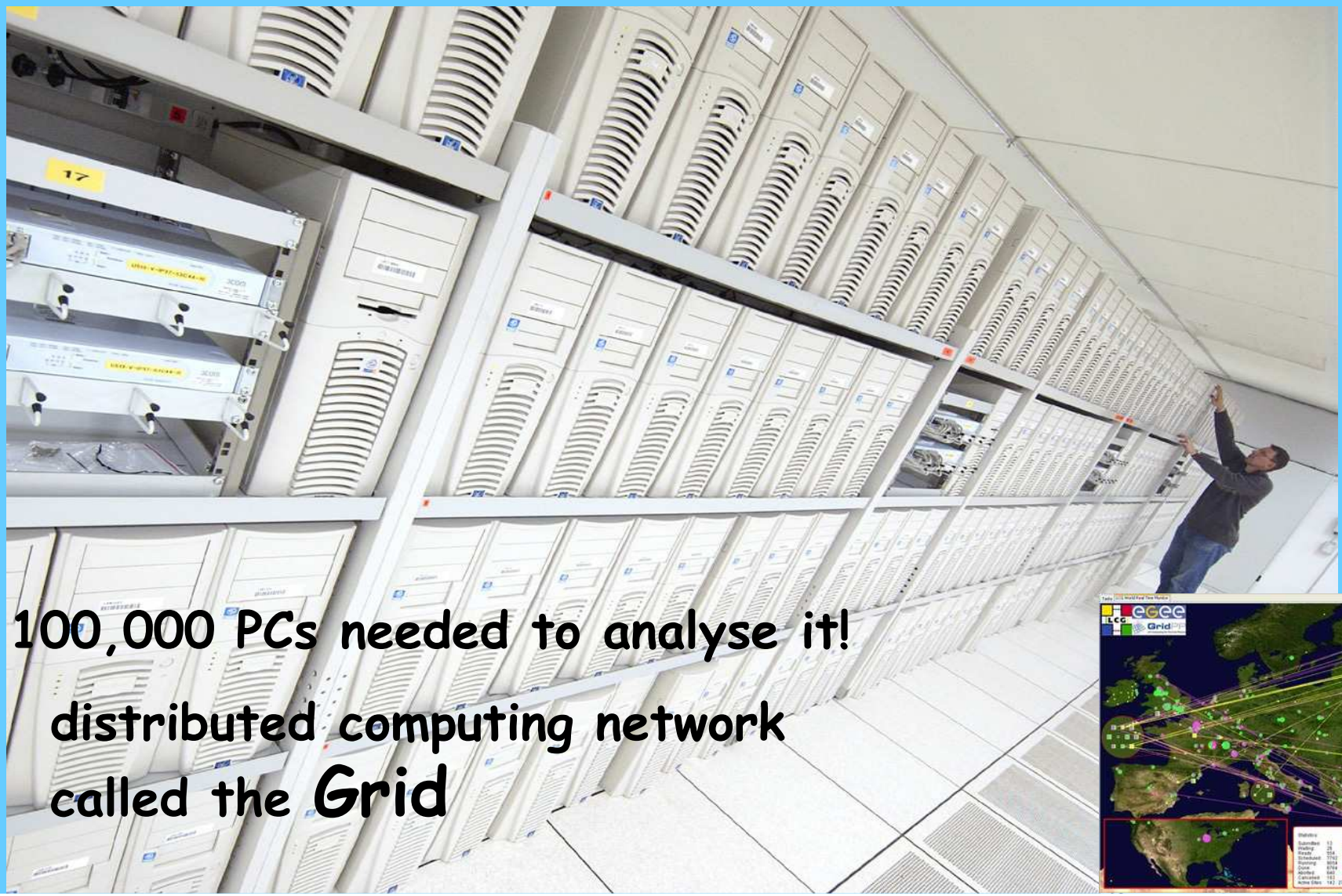
Data



If **all** the data from ATLAS would be recorded:
this would fill **100,000 CDs per second**.

ATLAS actually:
only records a **fraction** of the data
(those that may show signs of new physics)
and that rate is equivalent to
27 CDs per minute.

The Computing Challenge



100,000 PCs needed to analyse it!

distributed computing network

called the **Grid**

ATLAS Collaboration

- 2500 scientists

  (700 students)

- 37 countries

- 169 Universitys & Labs
- 11 UK Universitys

Designing, building and testing equipment and software, participating in experiments and analysing data

ATLAS Collaboration

- 2500 scientists

  (700 students)

- 37 countries

- 169 Universitys & Labs

Make use of virtual tools to communicate

- WWW was invented at CERN!

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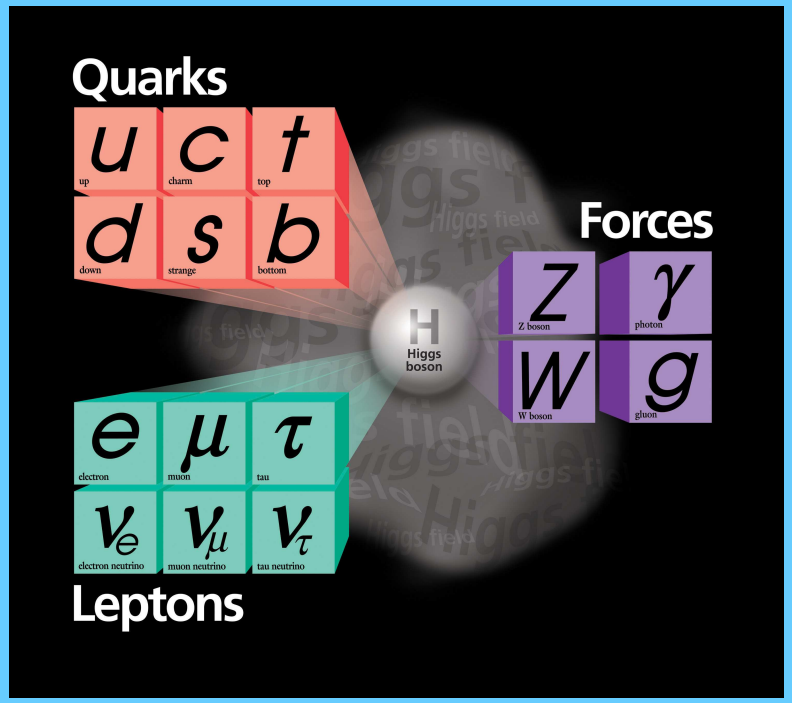
Searches at ATLAS

ALTAS (very high energy & lots of data)

enables physicists to:

- test the Standard Model
- look for new particles
- look for new symmetries



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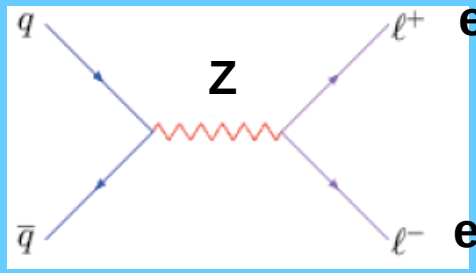
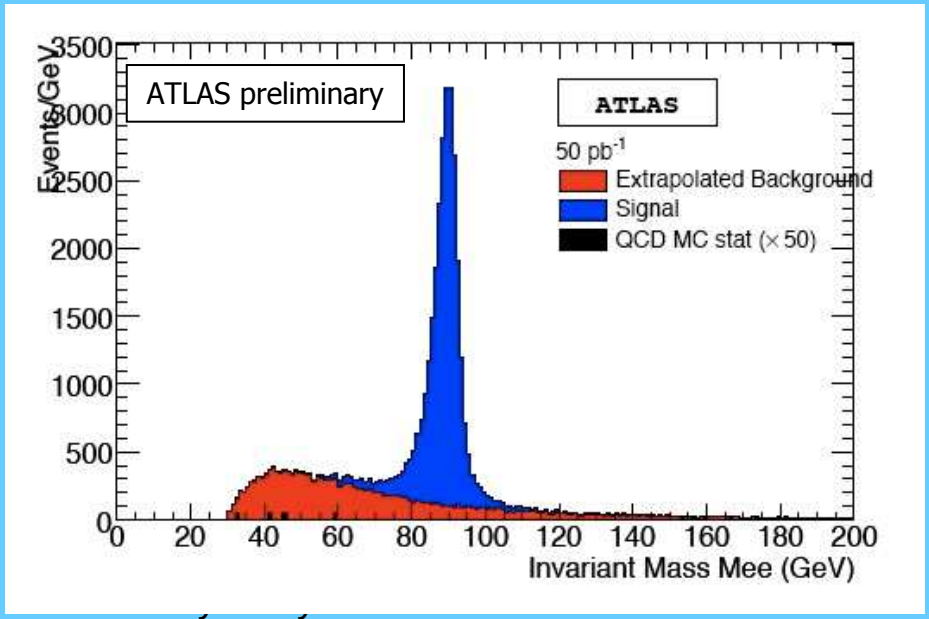
Testing the Standard Model

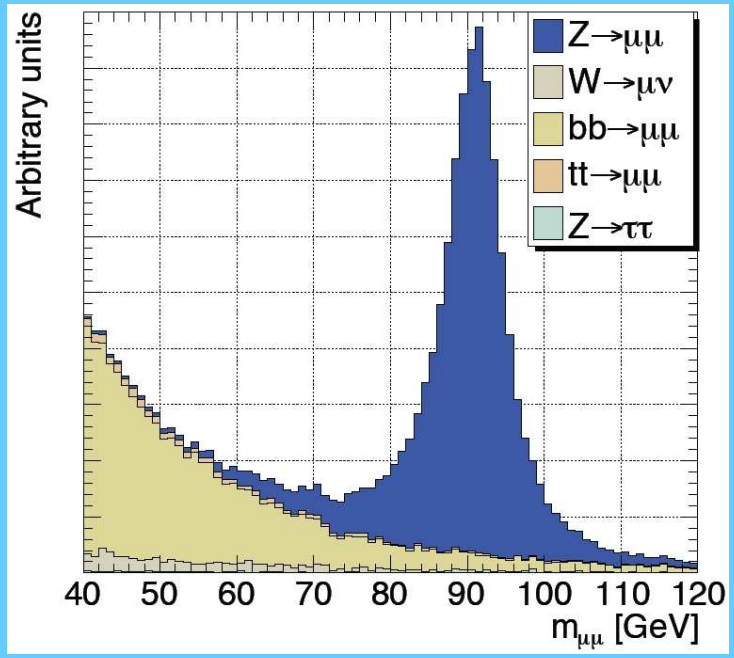
Test out predictions:

SM predicts that are an equal number of events with pp→Z → ee and pp→Z → μμ ?

But is this true – or is our model wrong?

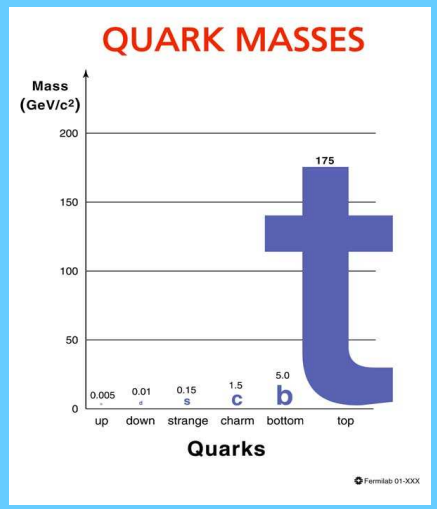


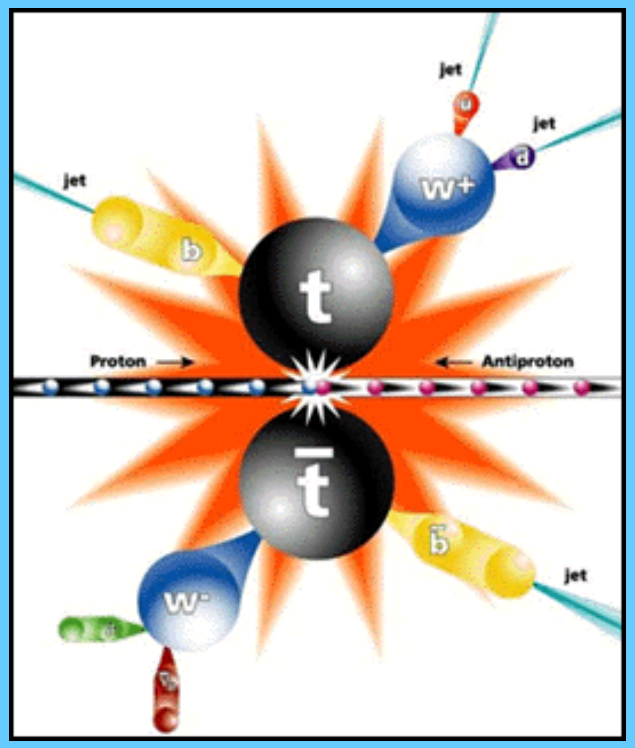


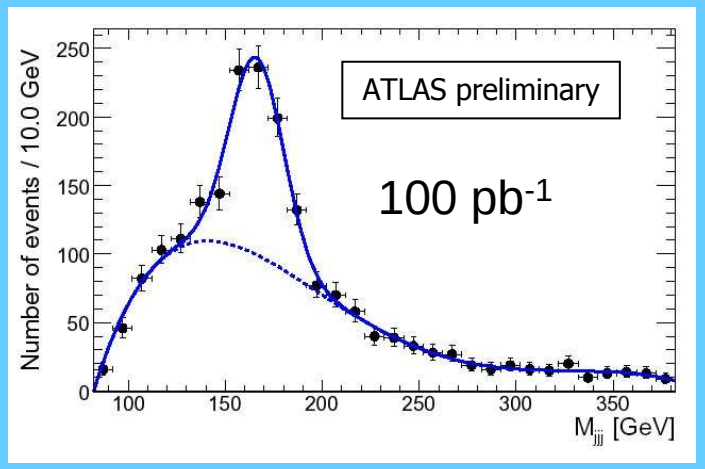


Top quark

- Studying properties of the known particles







ATLAS will try to observe the first top quarks in Europe! …

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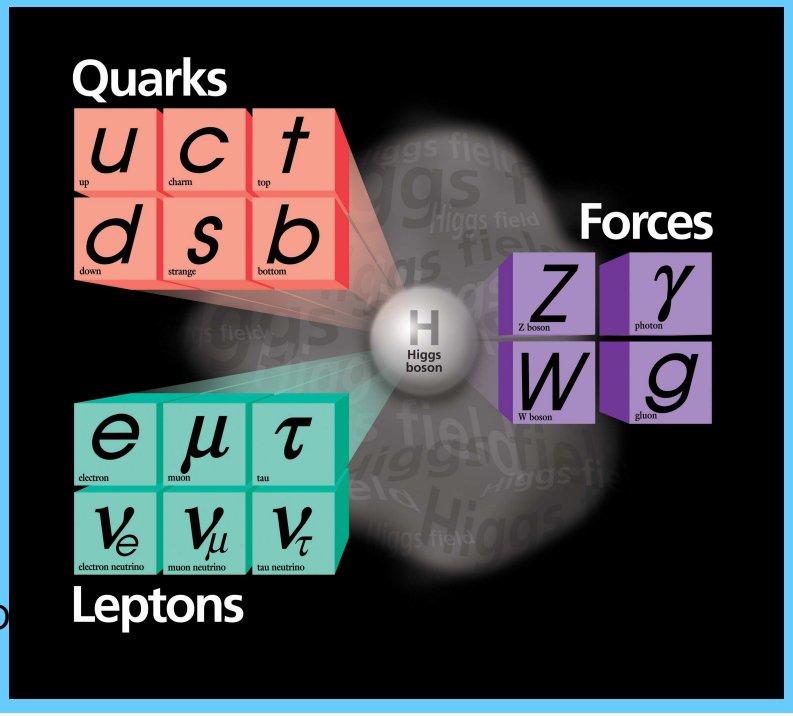
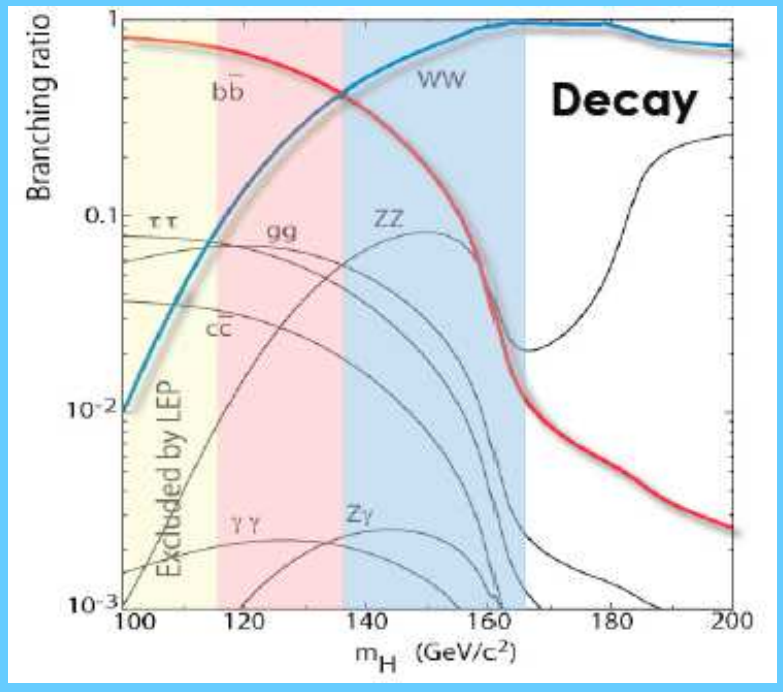
Searching for expected particles?

We want to search for particles we expect to find

– the elusive Higgs particle!

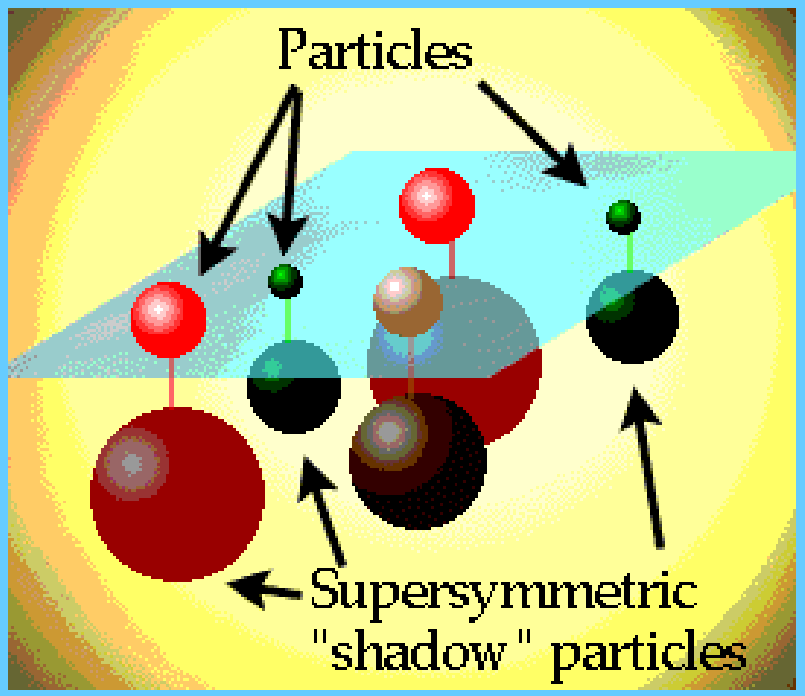
- Where does mass come from ?
- One idea is that it comes from the Higgs particle

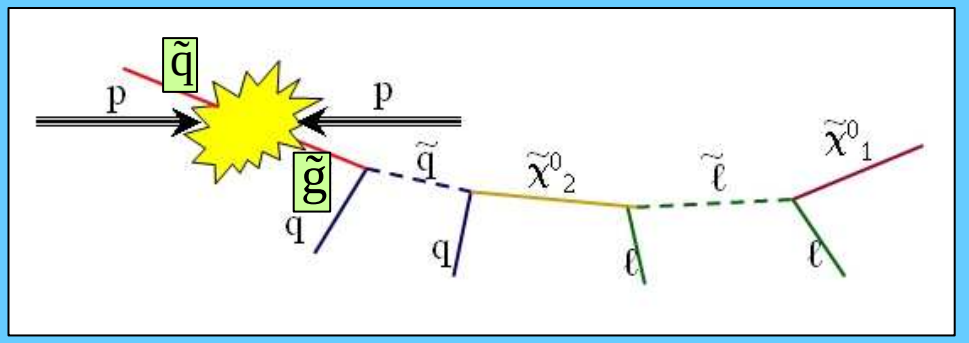




Supersymmetry

- Search for new symmetries?
- "SUSY": all particles have heavier partner particles





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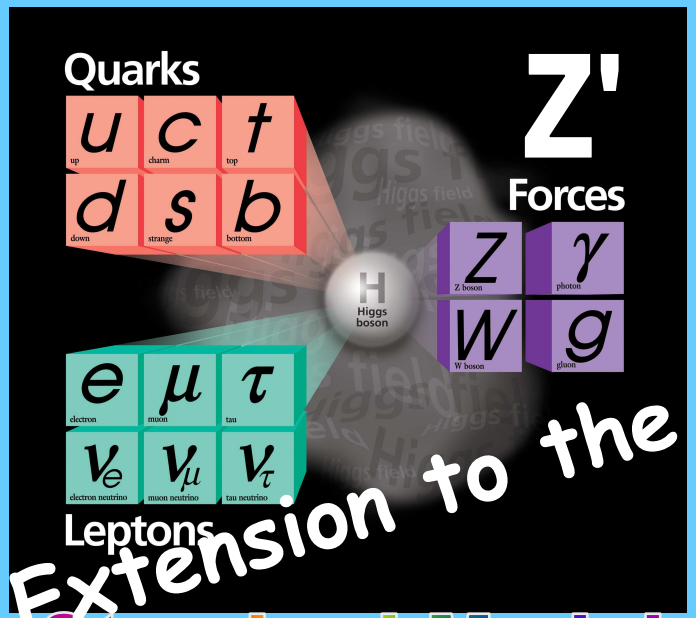
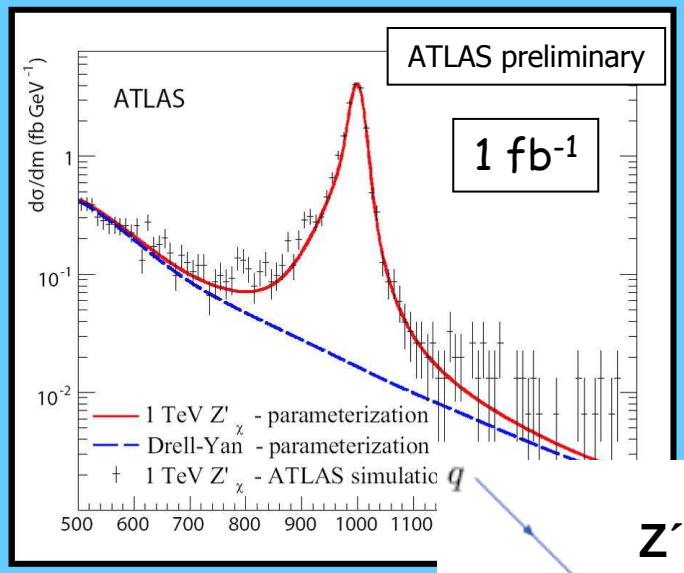
Other new/Exotic physics!

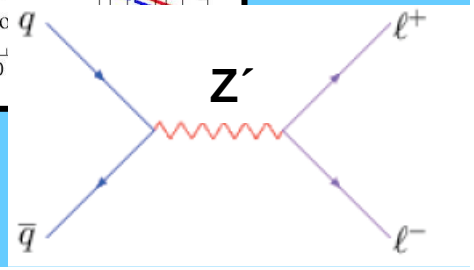
We want to search for new particles

Which could be introduced if we extend our Standard Model

e.g. Z' particle – heavier (>1000 GeV) version of the Z particle (90 GeV)







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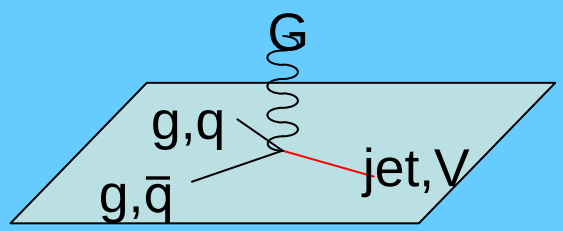
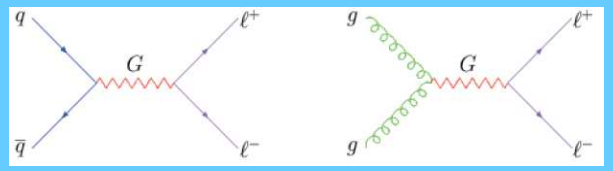
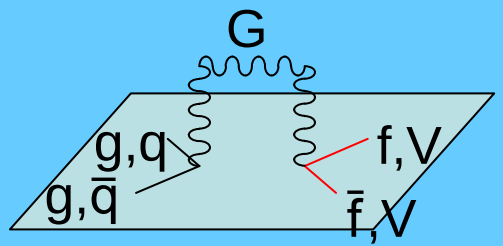
Extra dimensions?

- "String theories" predict that there are actually 10 or 11 dimensions of space-time
- The "extra" dimensions may be too small to be detectable at energies less than ~ 10^{19} GeV
  - To a tightrope walker, the tightrope is one-dimensional: he can only move forward or backward

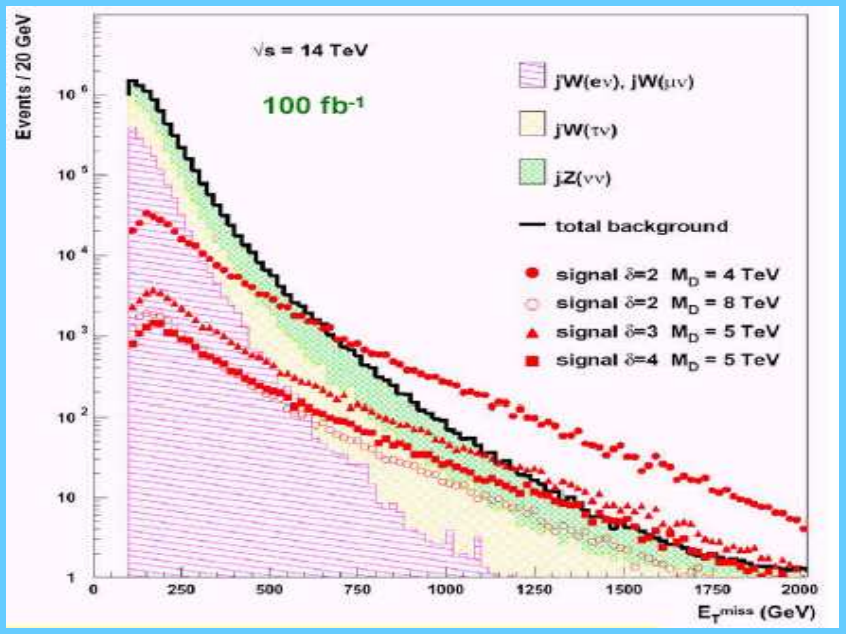
Extra Dimensions!







$pp \rightarrow jet + G^{KK} \rightarrow jet + Missing\ Energy$



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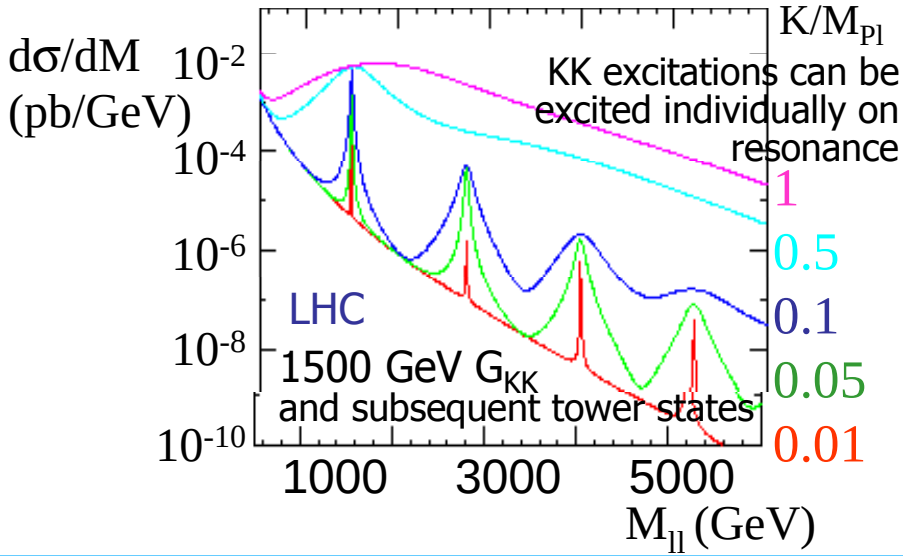
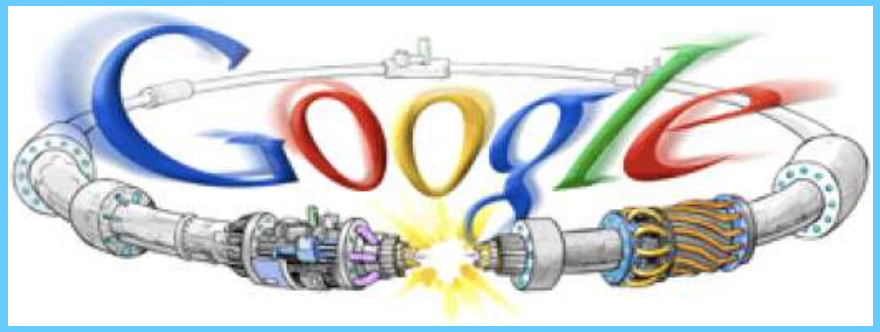
L.Vacavant, I.Hinchcliffe, ATLAS-PHYS 2000-016
J. Phys., G 27 (2001) 1839-50



Davoudiasl, Hewett, Rizzo
hep-ph0006041

Summary



- We hope to have collisions later this year

- We look forward to studying the data using the ATLAS detector

- We hope to learn more about the Standard Model & to search for evidence of new physics!

Conclusion!

- To quote Forest Gump:
  "Life is like a box of chocolates – you never know what you are going to get!"

- When the LHC turns on, who knows what we will find?
  - New particles? (Higgs/ Z'?)
  - Partner particles (Supersymmetry?)
  - Evidence for extra dimensions?

"Only ~~Smarties~~ have the answer"!

ATLAS & the LHC!

Dr Tracey Berry

The End!

Dr Tracey Berry

Image from: gooddeedaday.wordpress.com/.../