The Inside Story of CERN, LHC, ATLAS, and the Higgs Boson

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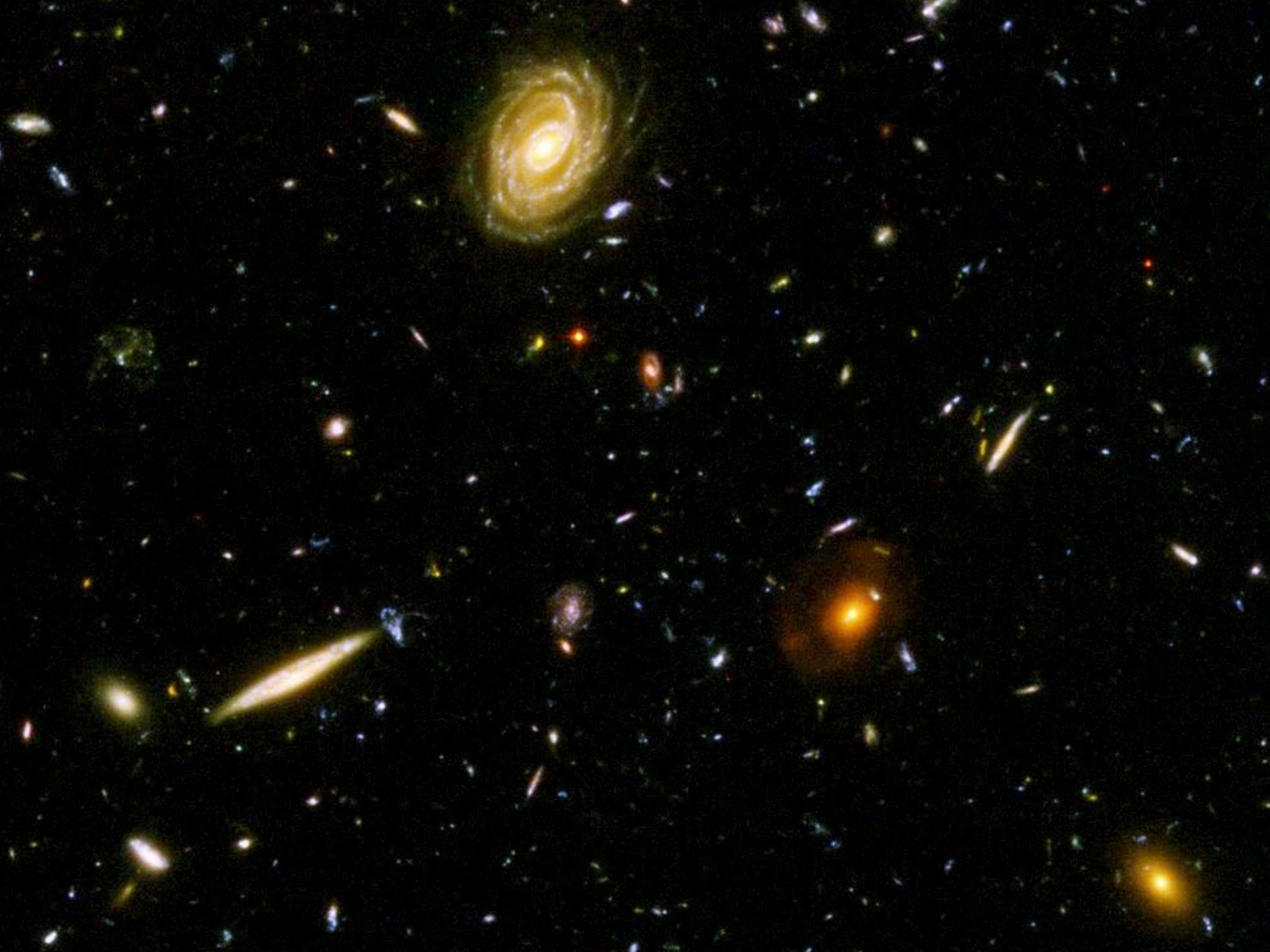
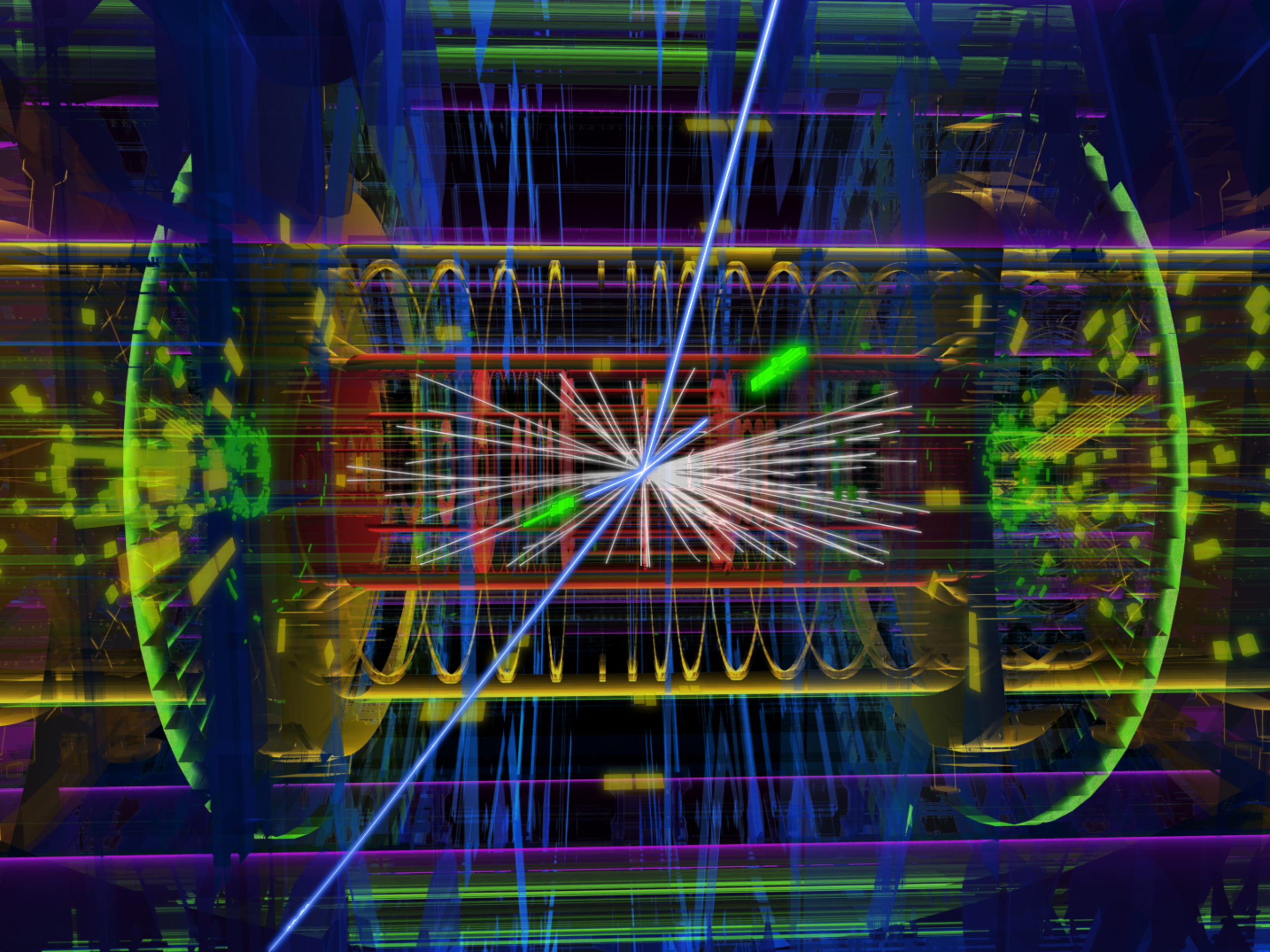
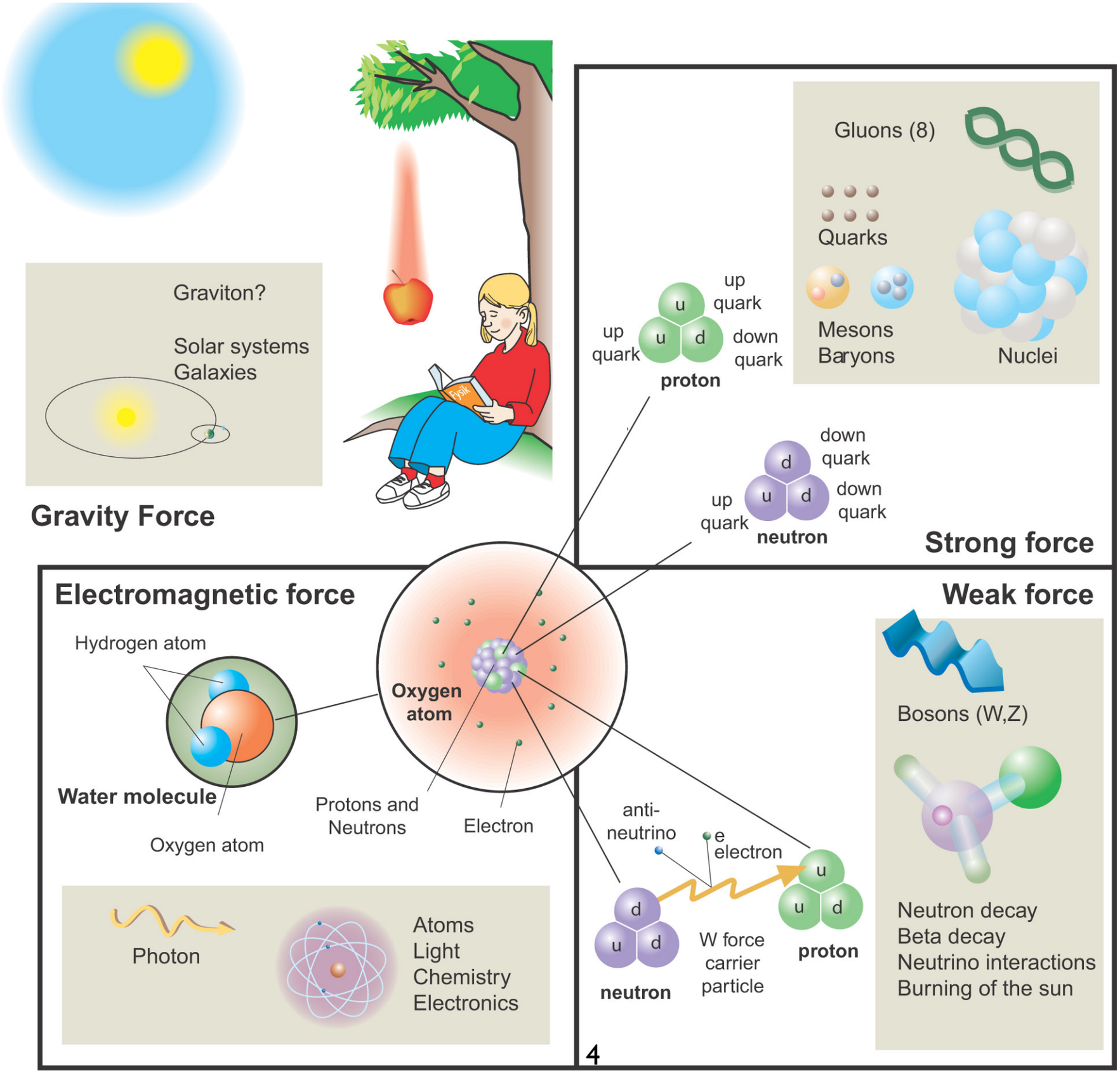


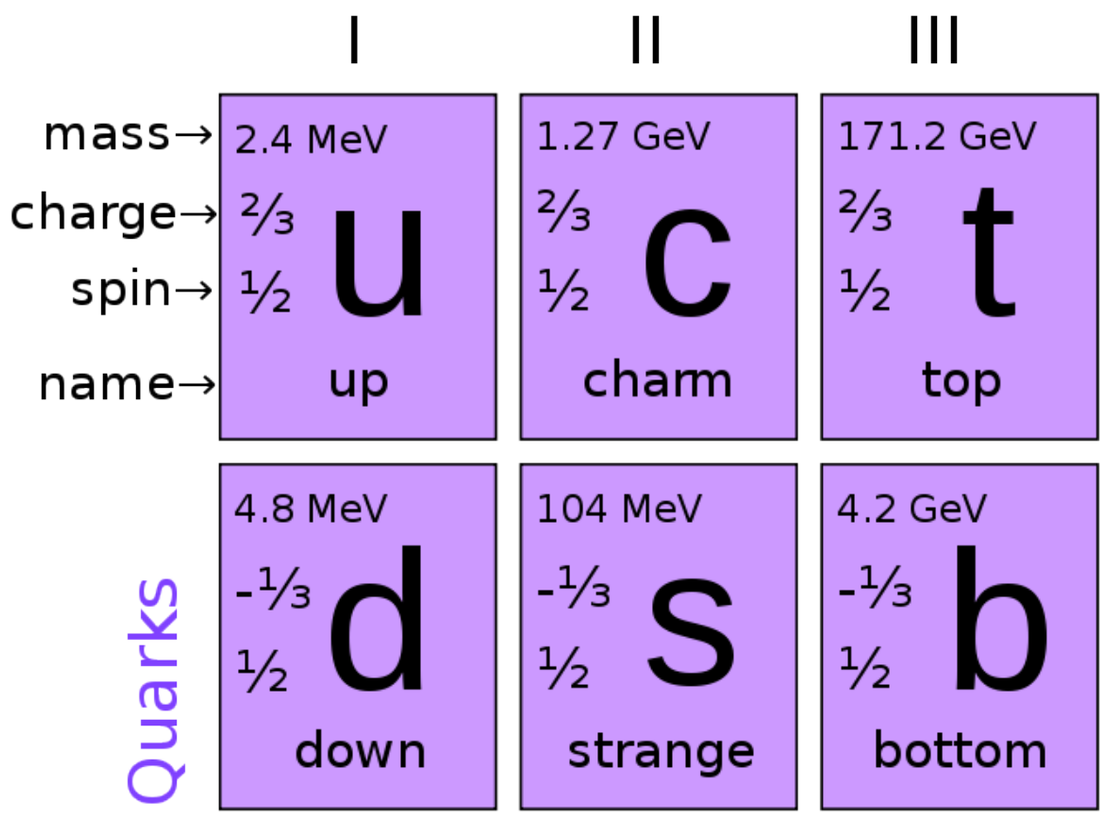


Forces of Nature



Known Cast of Particles

Three Generations
of Matter (Fermions)



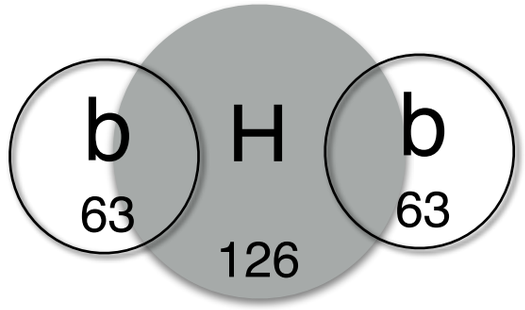
Why Should There Be a H

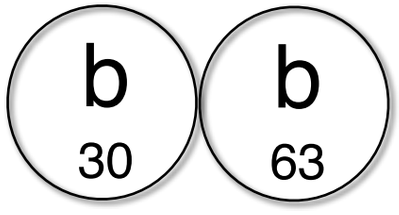
- As far as we know, all of these particles are point-like particles with fundamental masses
  - Then what is the "mass" of the particle?
- "Weak-ness" of the weak force attributed to large masses of W and Z boson force carriers

The Higgs mechanism is responsible for giving all of the fundamental particles their masses, through direct interaction with a pervasive Higgs field.

How Will We See the Higgs?

- Rest mass energy of the Higgs boson ($E=mc^2$) is converted to the energy of its decay products, ***which can be reconstructed***

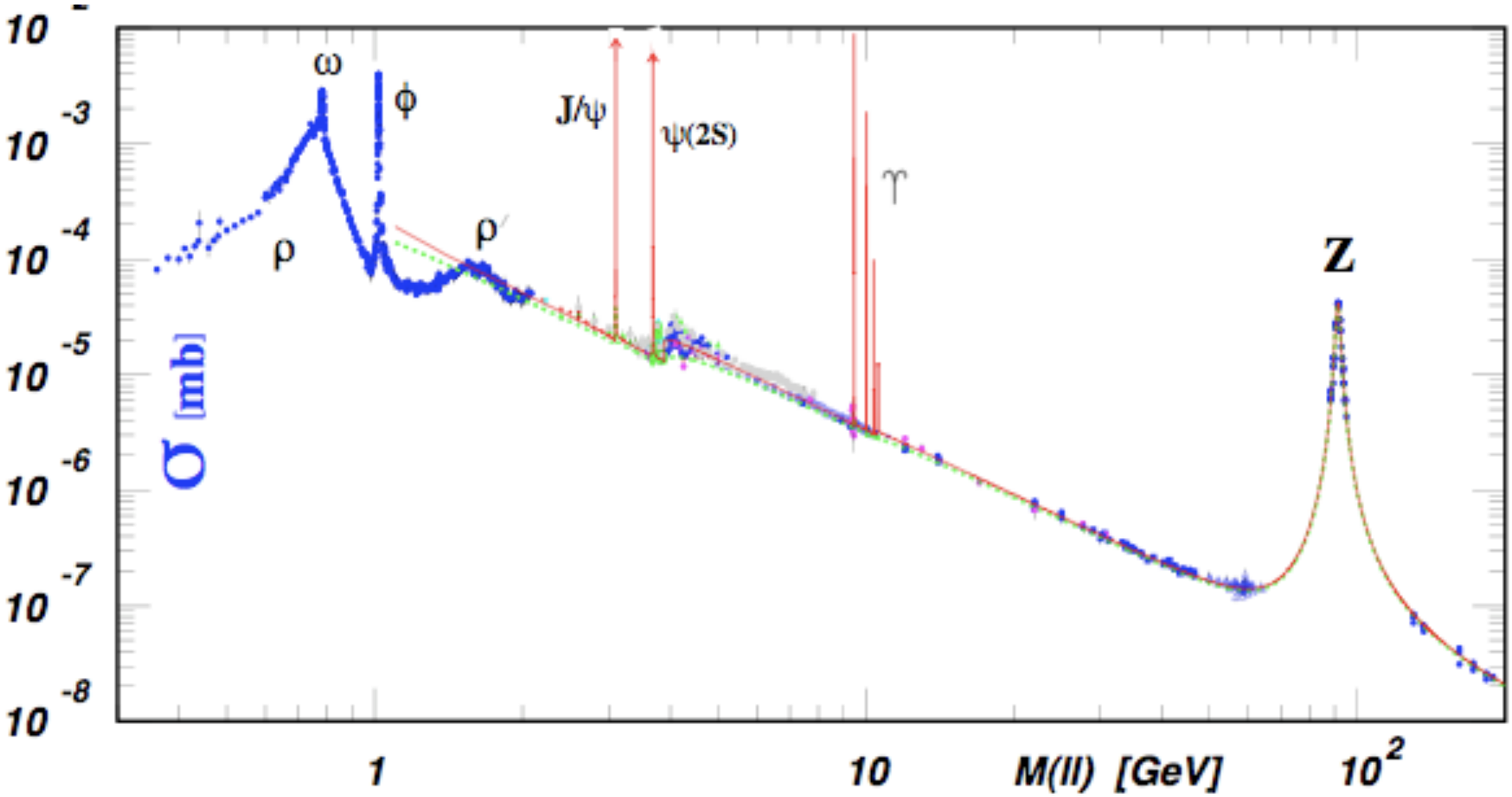




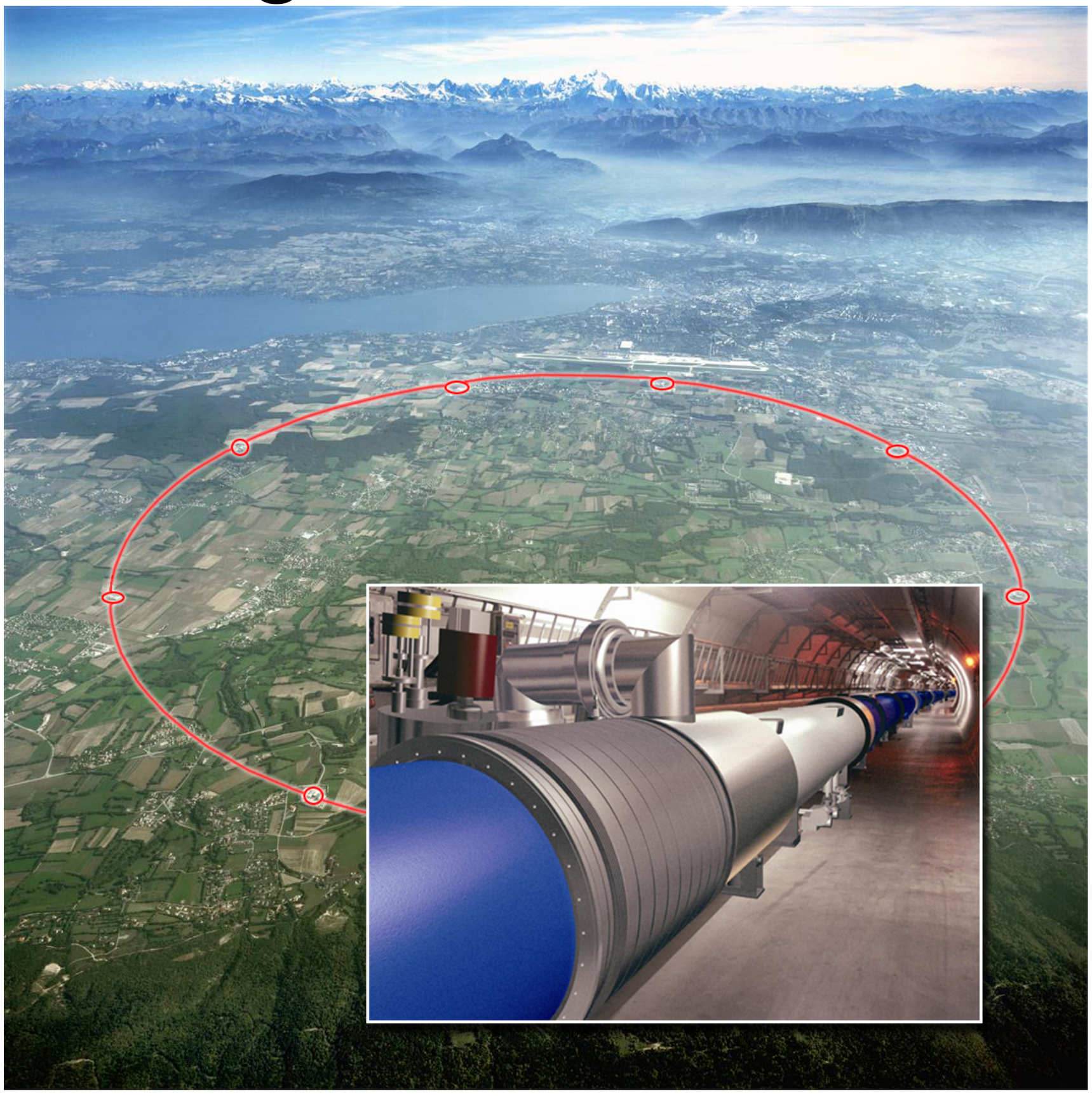
Not a Higgs boson!

New Particle Discoveries

Each one of these particles was discovered as a mass resonance at a high-energy particle collider

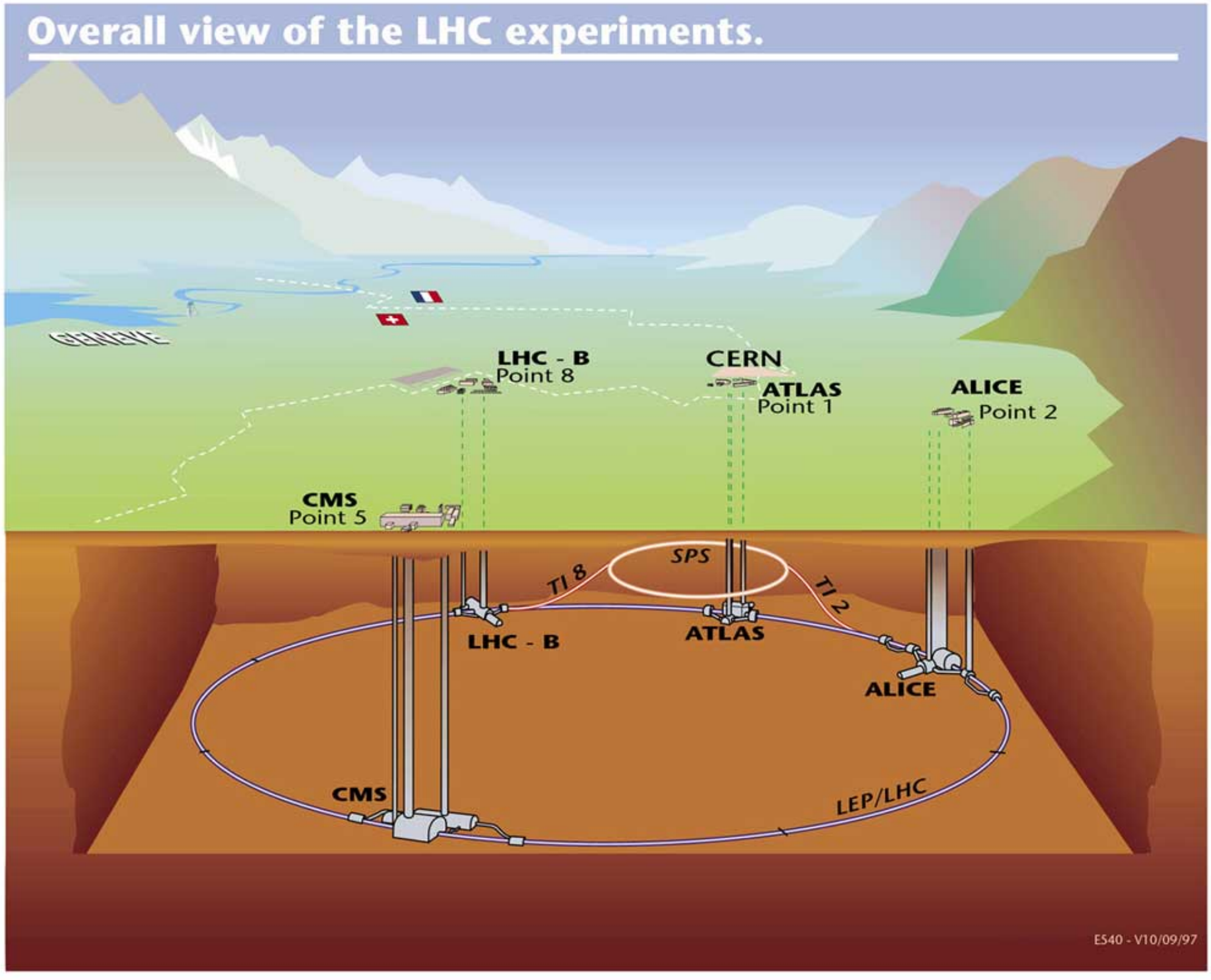


Large Hadron Collider

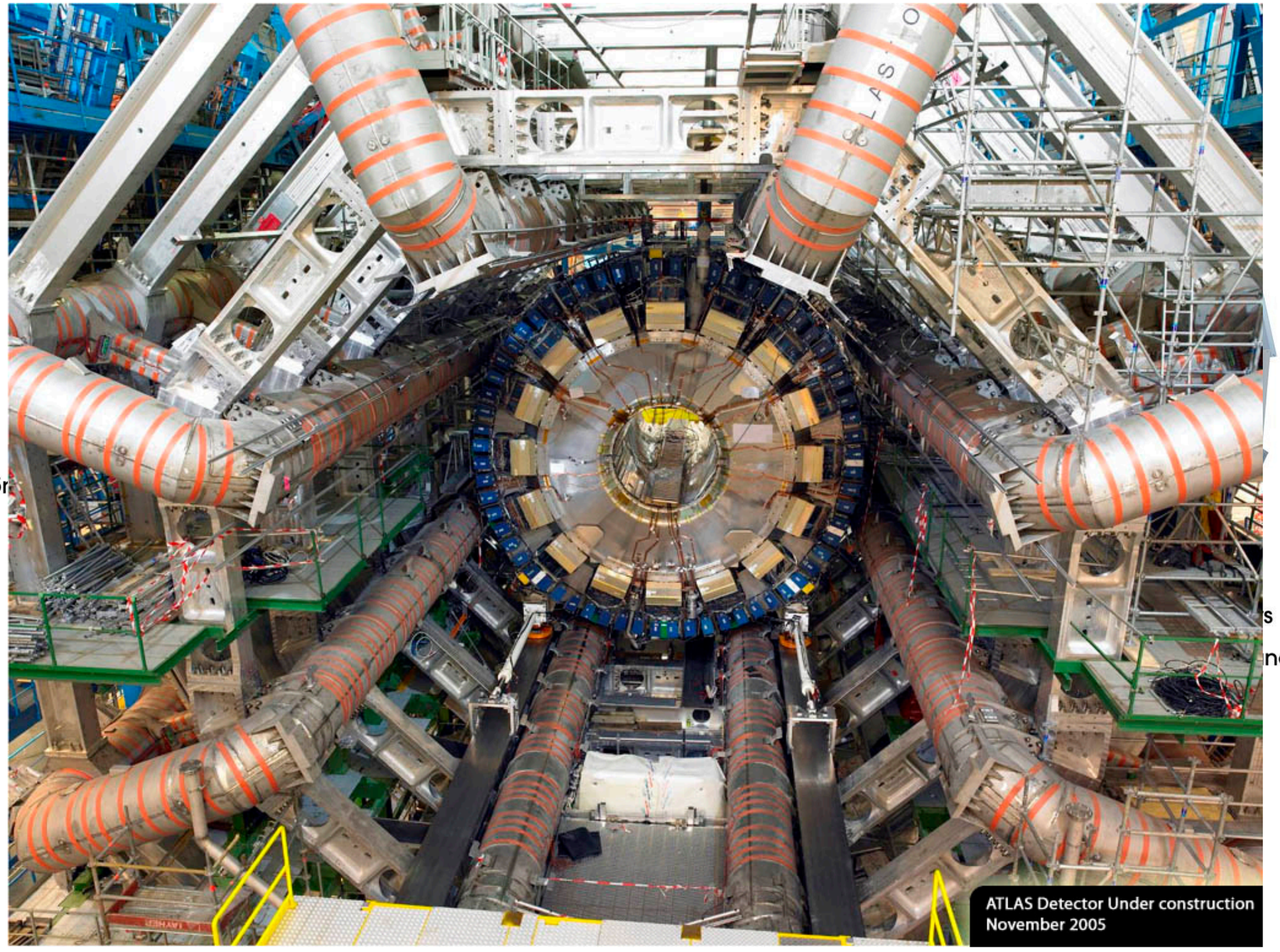


Dipole Bending Magnet

LHC Experiments



ATLAS Experiment



ATLAS Detector Under construction
November 2005

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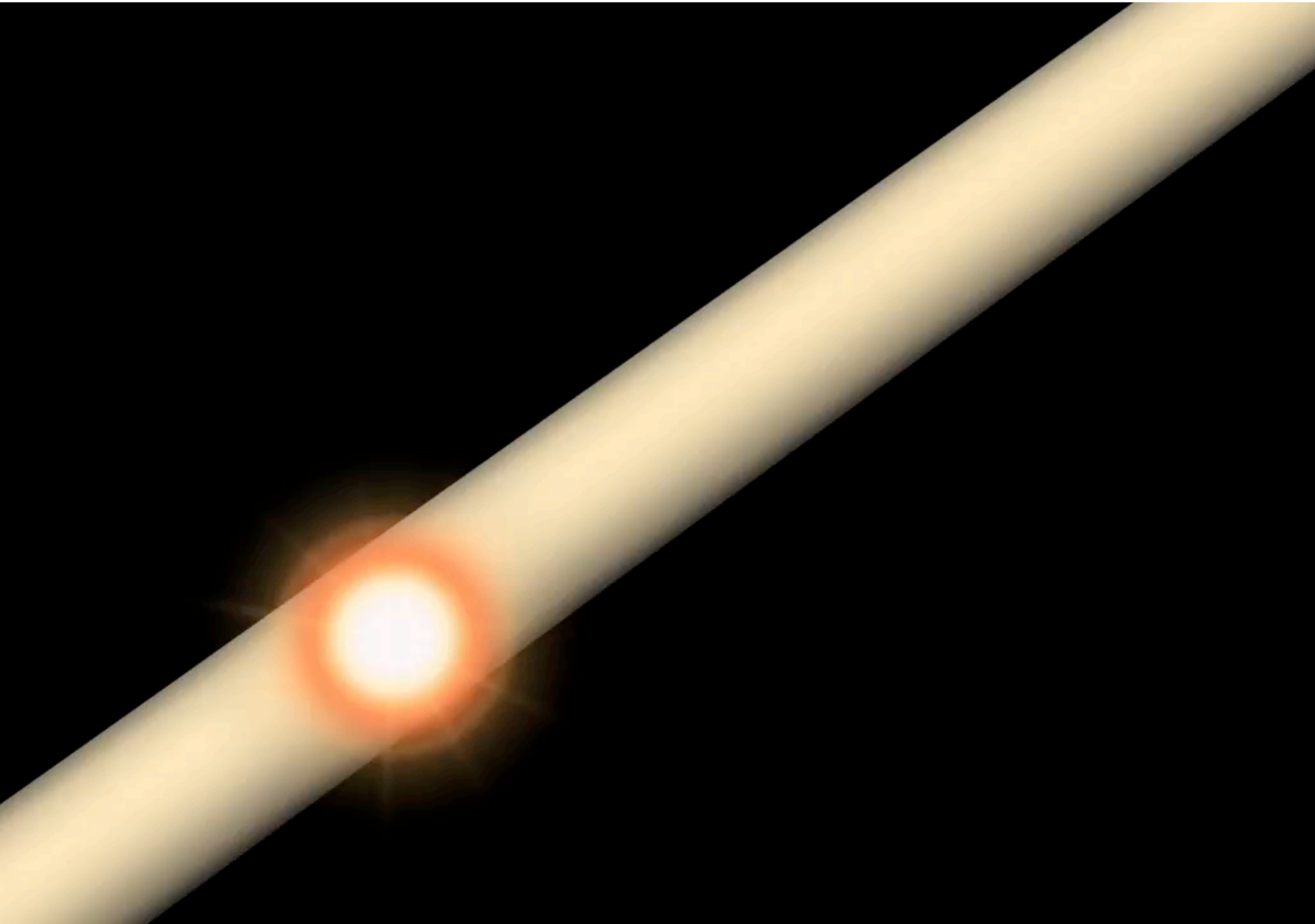
ATLAS Collaboration

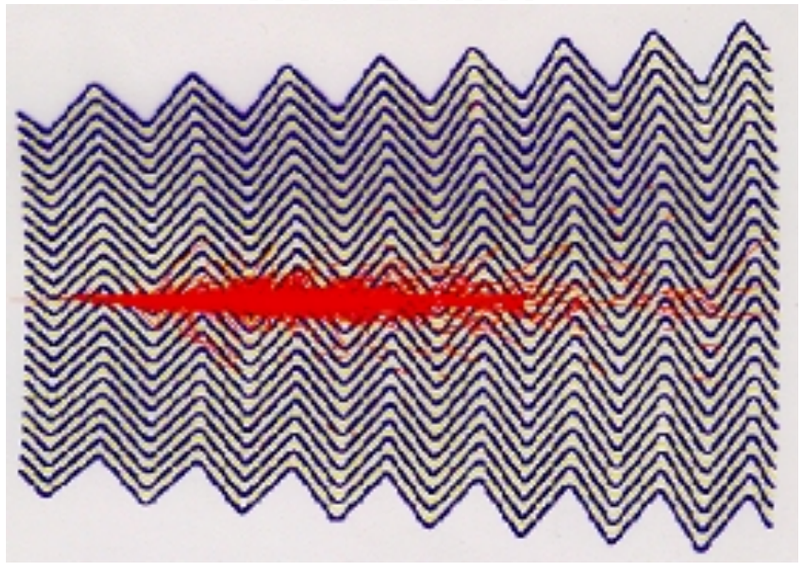
Colliding Beams



Why is the Experiment So Big?

Calorimeter

Particle deposits energy by showering in dense absorber medium

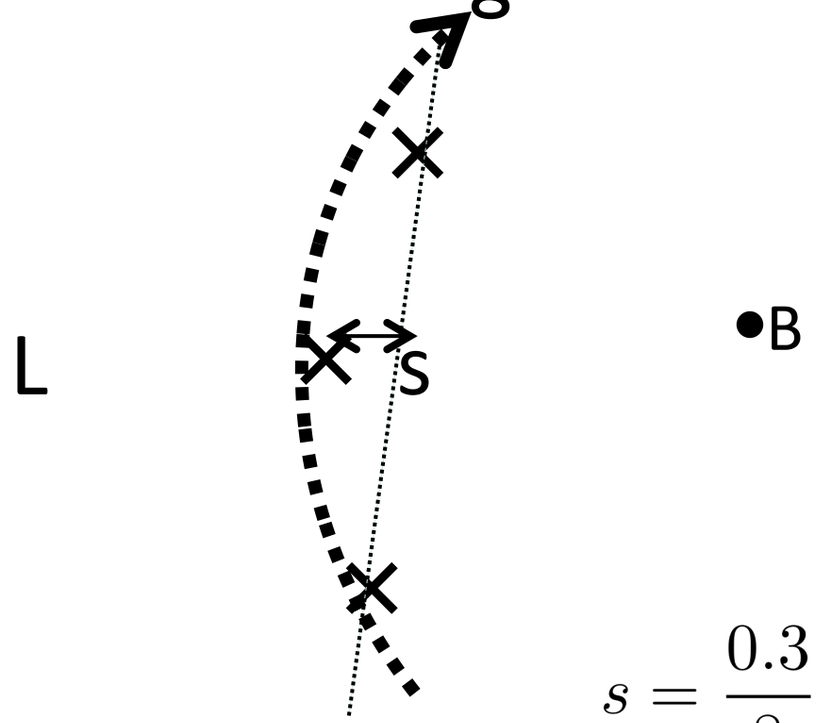


Uncaptured energy:

$$E(x) = E(0)e^{-\rho x/X_0}$$

Spectrometer

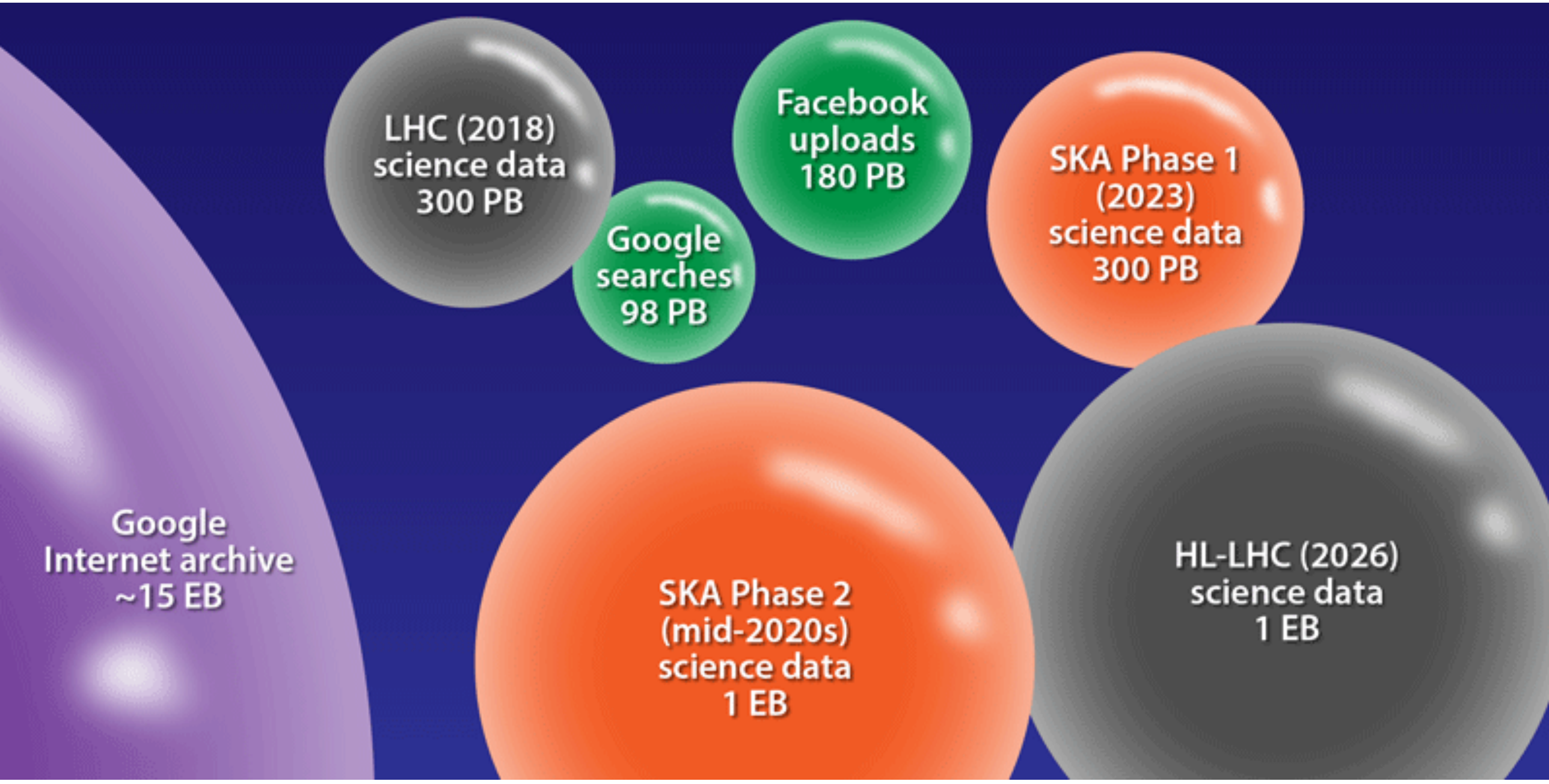
Charged particle moves along helix under influence of strong B field



$$s = \frac{0.3}{8}\frac{L^2 B}{p_T}$$

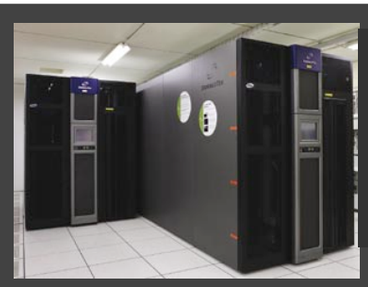
Measuring sagitta requires large L and B

LHC Physics qualifies as “Big Data”



LHC Computing Grid

ATLAS detector



CERN CASTOR: permanent high-volume tape storage

T1's

UK

Canada

BNL

AOD, 100kB

Japan

France, Italy, Netherlands, Nordic, Germany, Spain

24-48 h, calibrated, full data streams to T1's

T2's

OU, UTA

Indiana, Chicago

UM, MSU

BU, Harvard

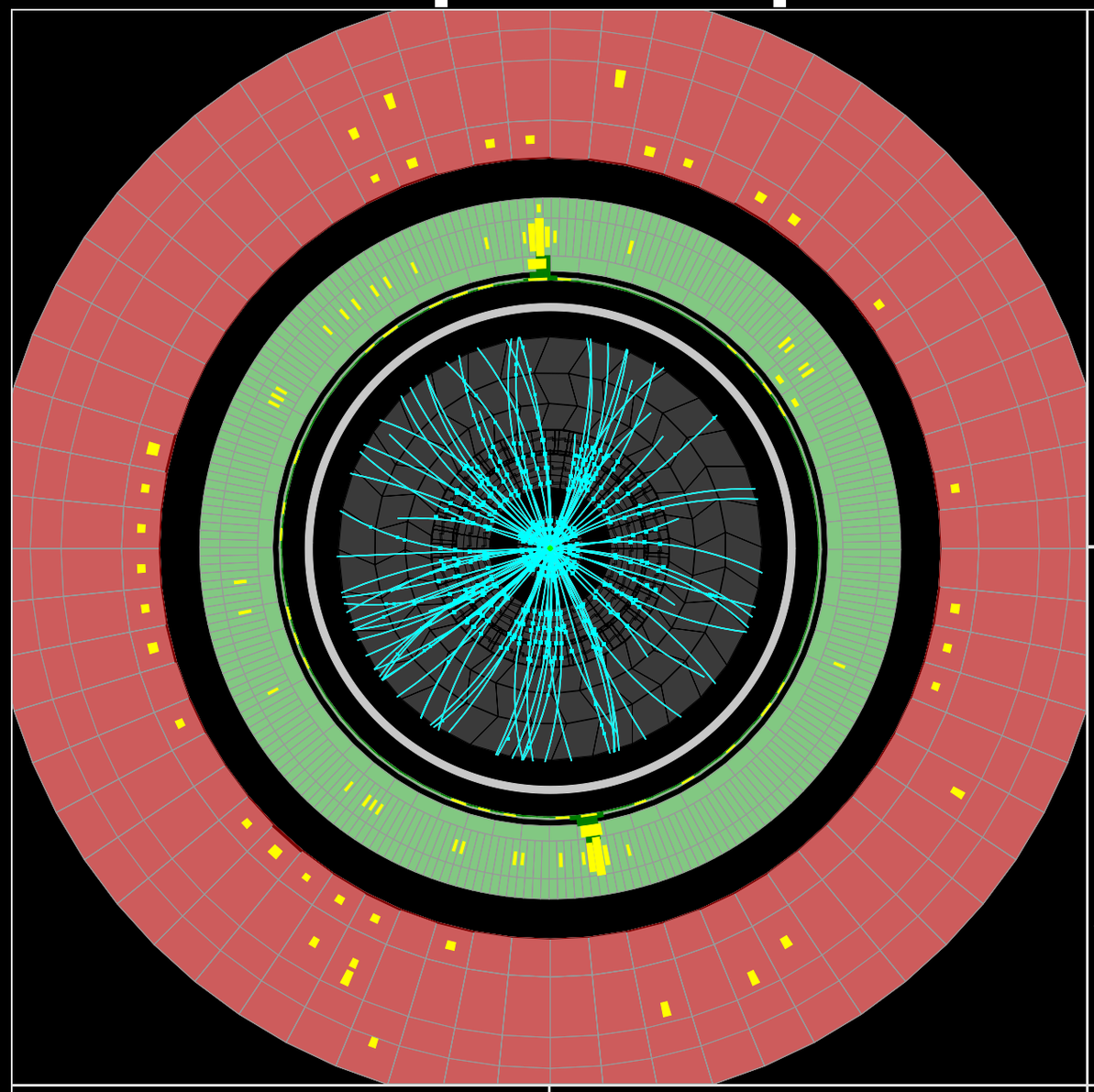
SLAC

"Grid"

"T3's & T4's"

UCSC

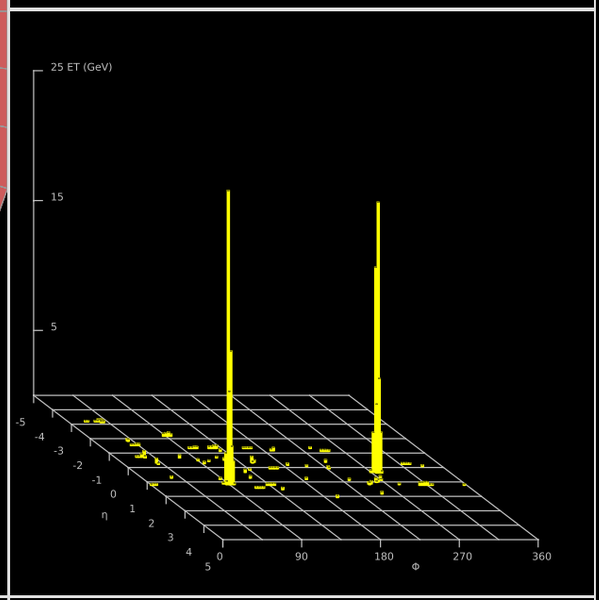
Example Diphoton Decay

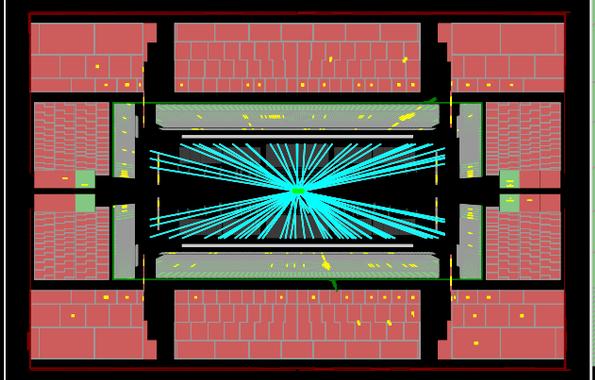


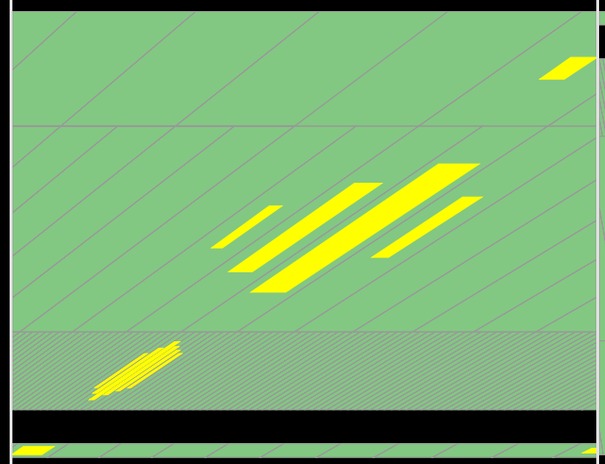
ATLAS EXPERIMENT

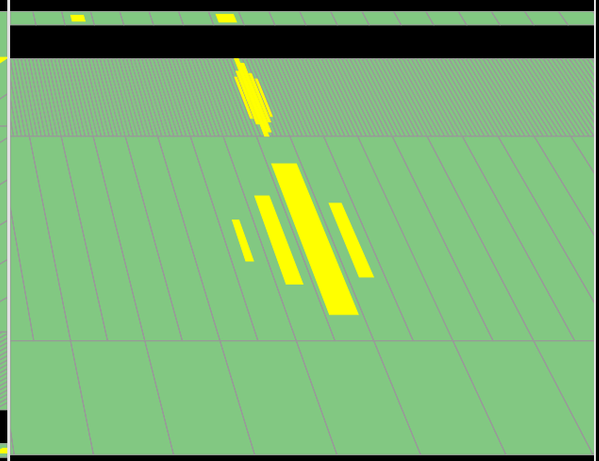
Run Number: 203779, Event Number: 56662314

Date: 2012-05-23 22:19:29 CEST





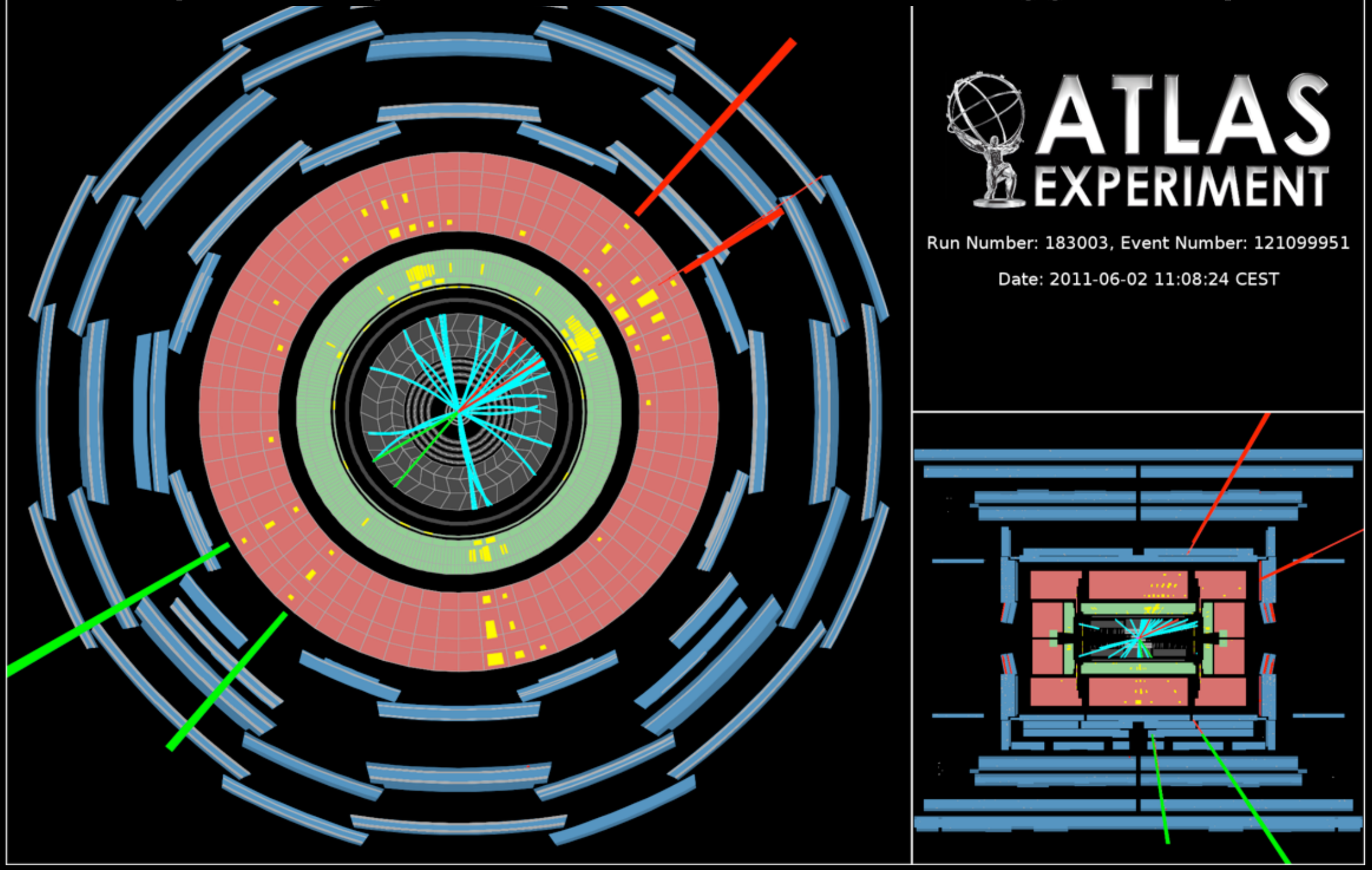




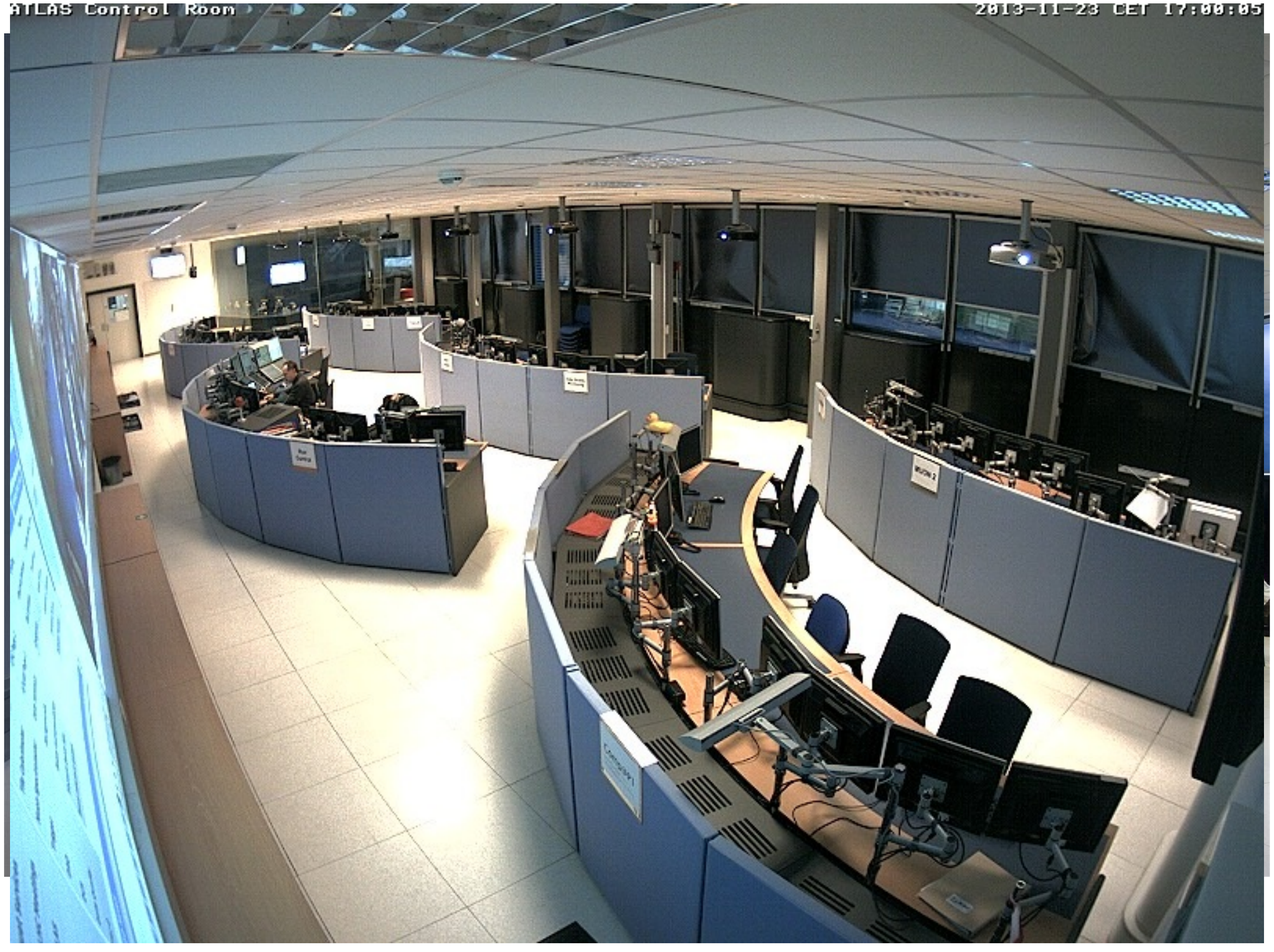
Another Higgs Decay to ZZ

Non-Higgs (Background) Events

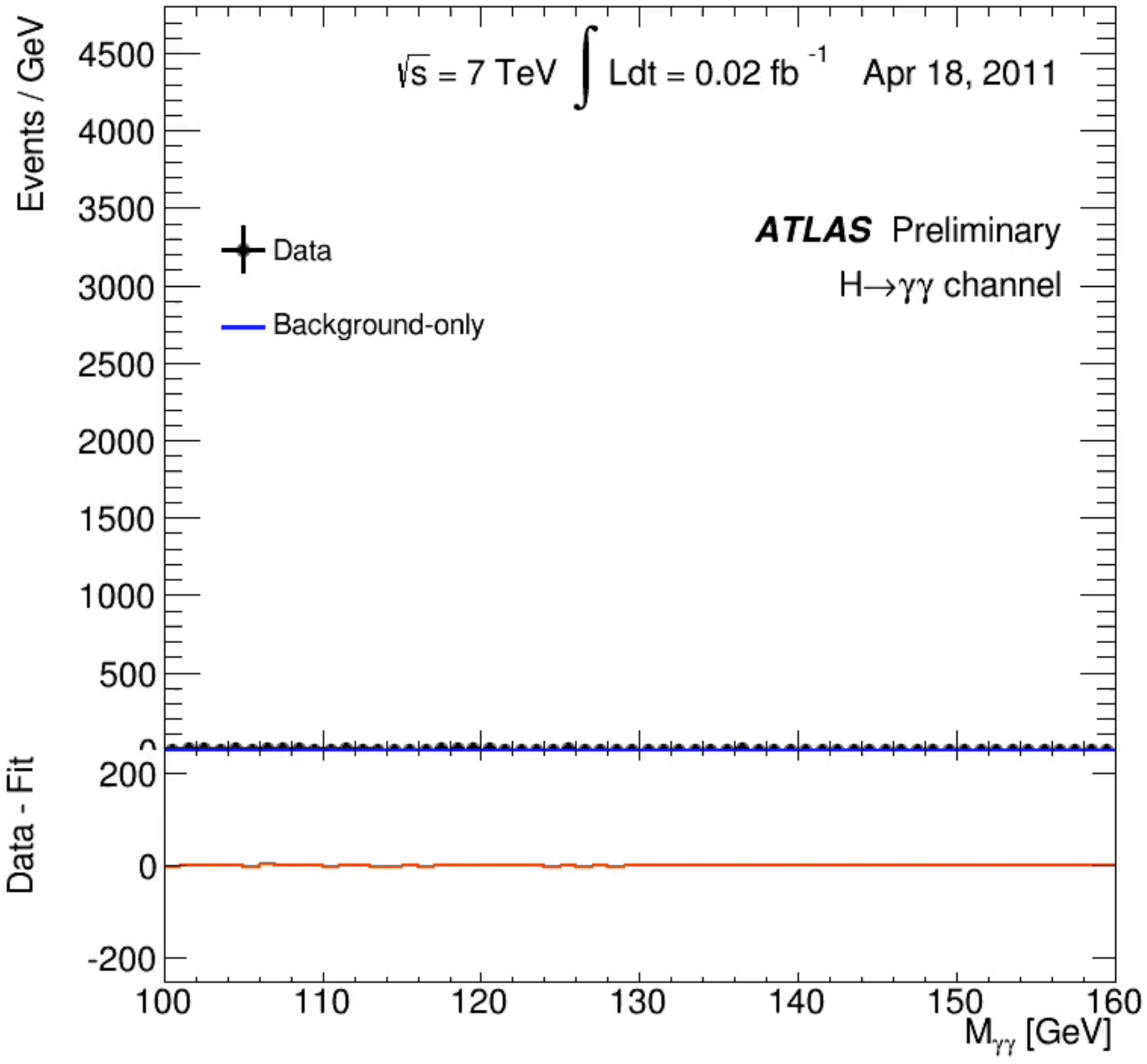
Example: ZZ production not due to Higgs decay



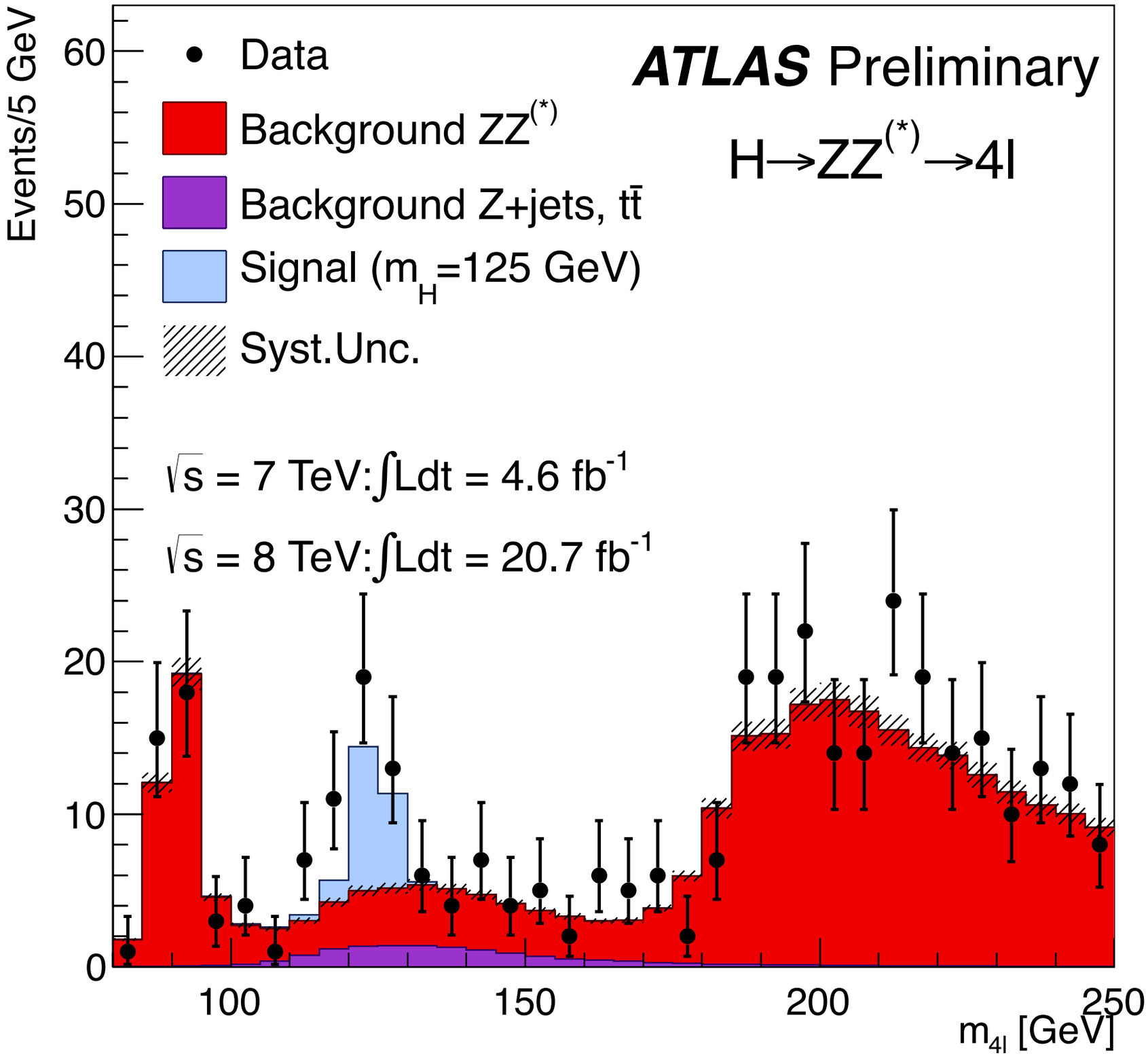
Inside the ATLAS Control Room



Timeline of Diphoton Data

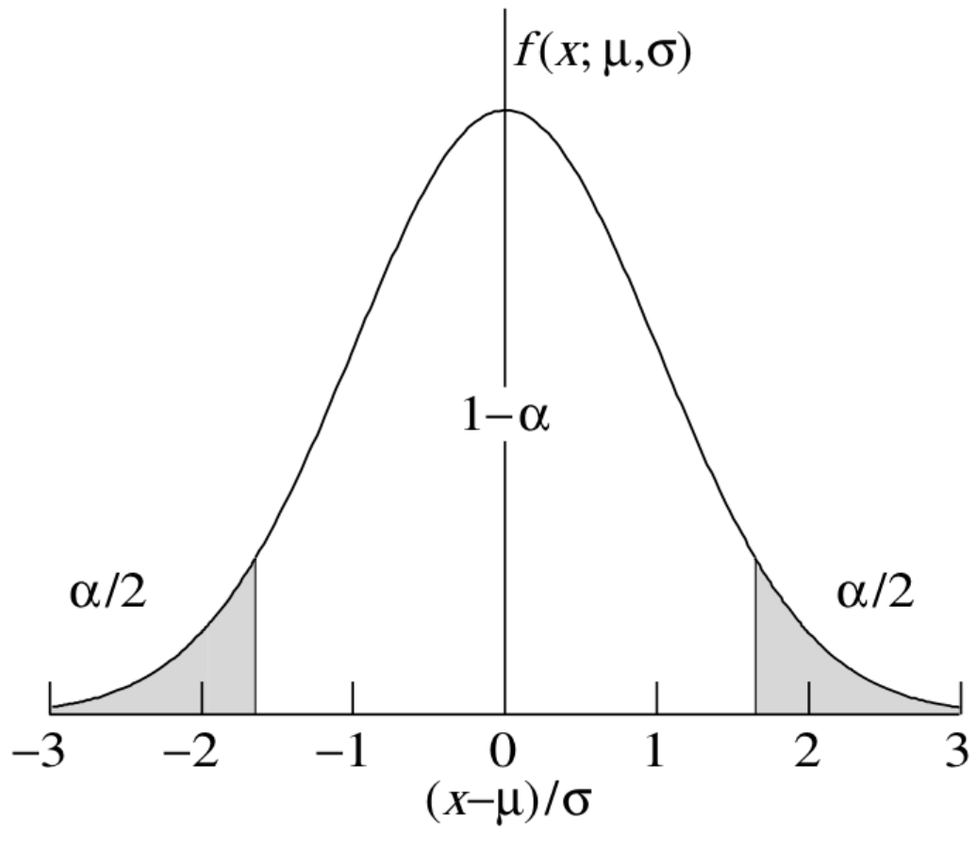


Final Results: Run 1 ZZ Data



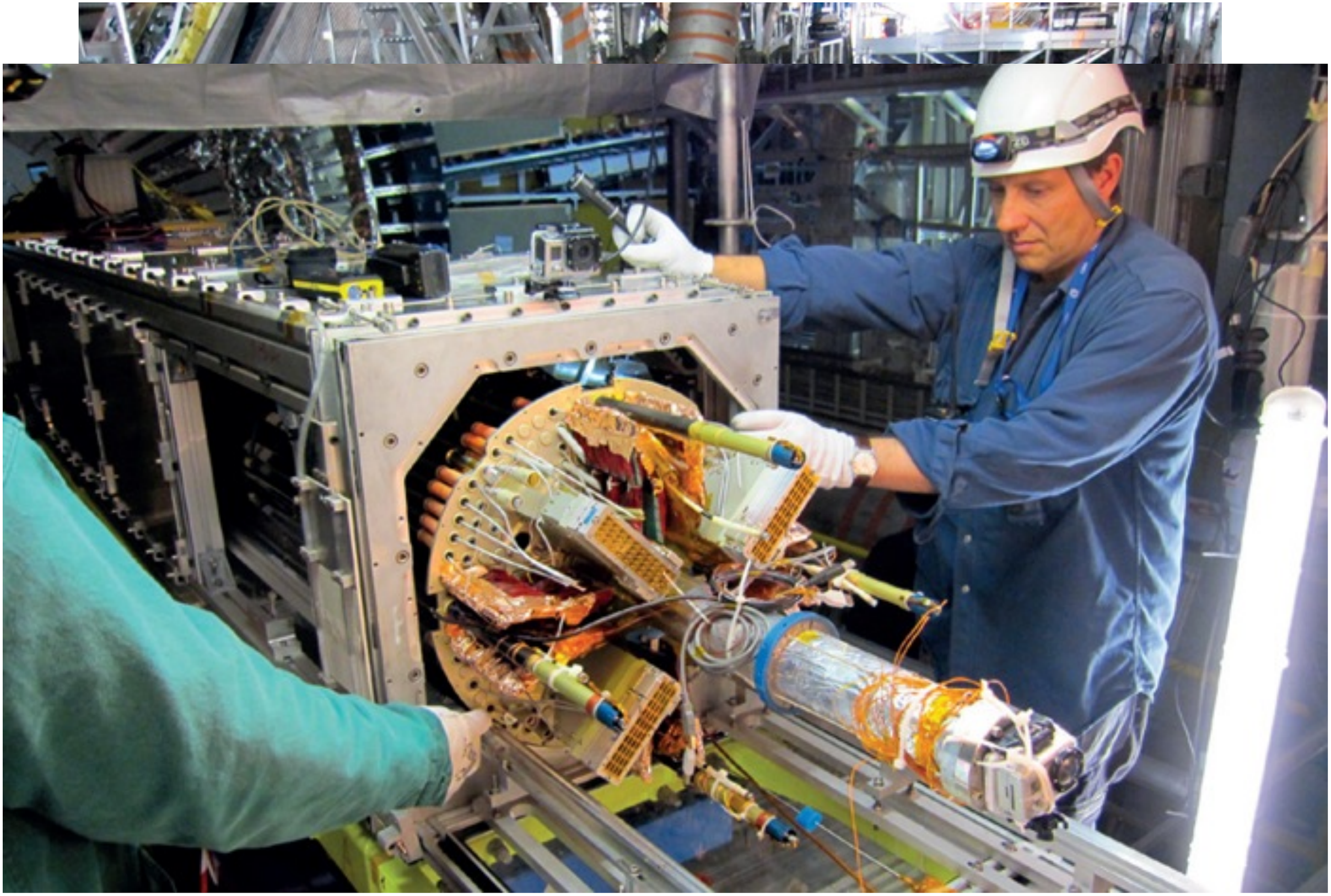
“5 Sigma” Discovery Criterion

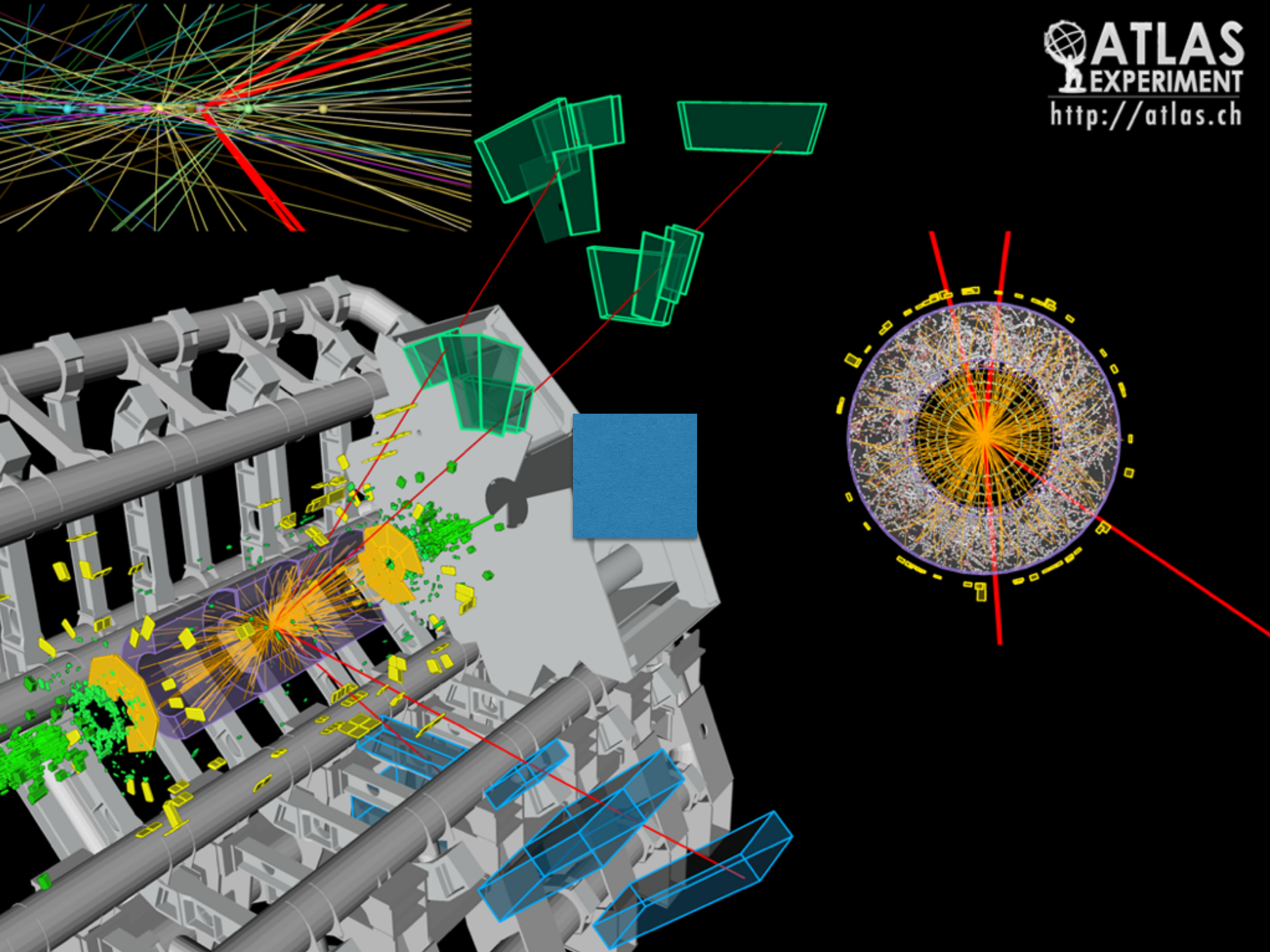
- We are looking for a result that can’t be explained by fluctuations in the number of background events
- Example from the famous dice game:
  - Rolling 1 “6” : 16% probability (1σ)
  - 2 “6”s: 2.3% (2σ)
  - 3 “6”s: 1.4 x 10^{-3} (3σ)
  - 8 “6”s: 2.8 x 10^{-7} (5σ)



Announcement: 5 sigma!

Detector Upgrades (Emily)




ATLAS
EXPERIMENT
http://atlas.ch