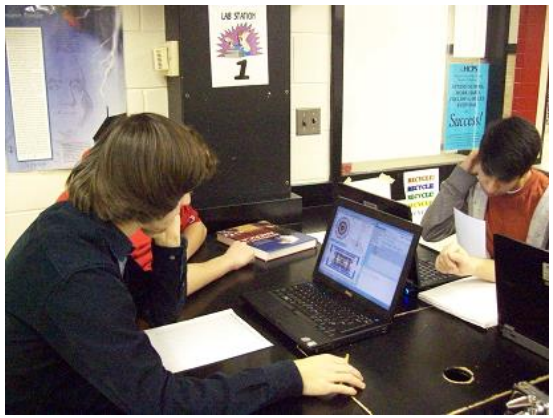
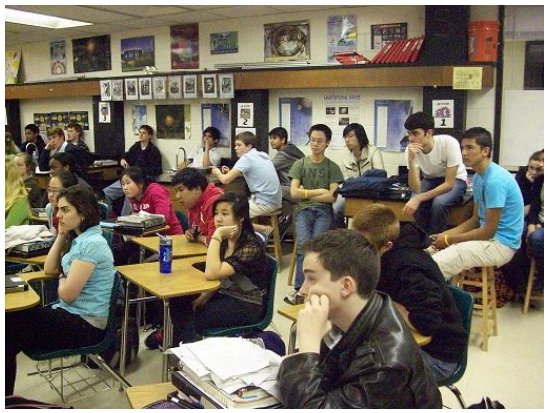
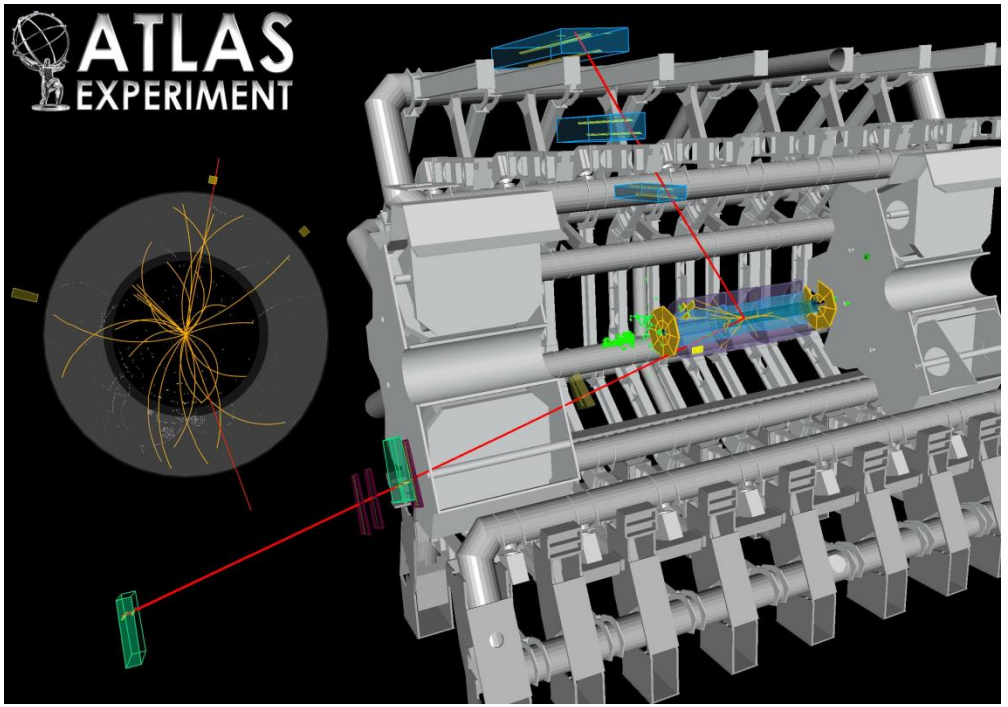
ATLAS Z-Path Masterclass







INTERNATIONAL MASTERCLASSES
hands on particle physics

Fermilab

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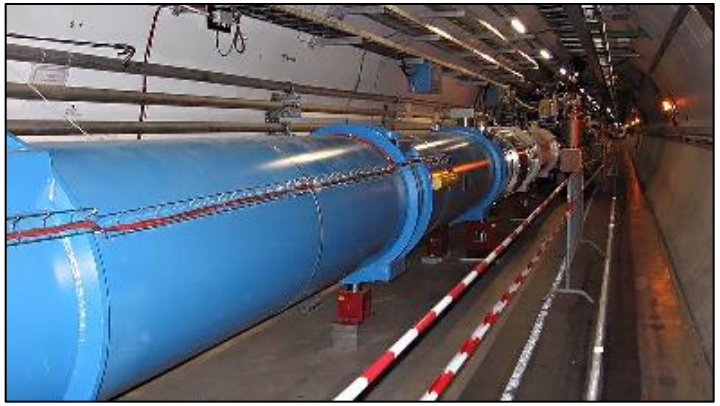
The LHC and New Physics

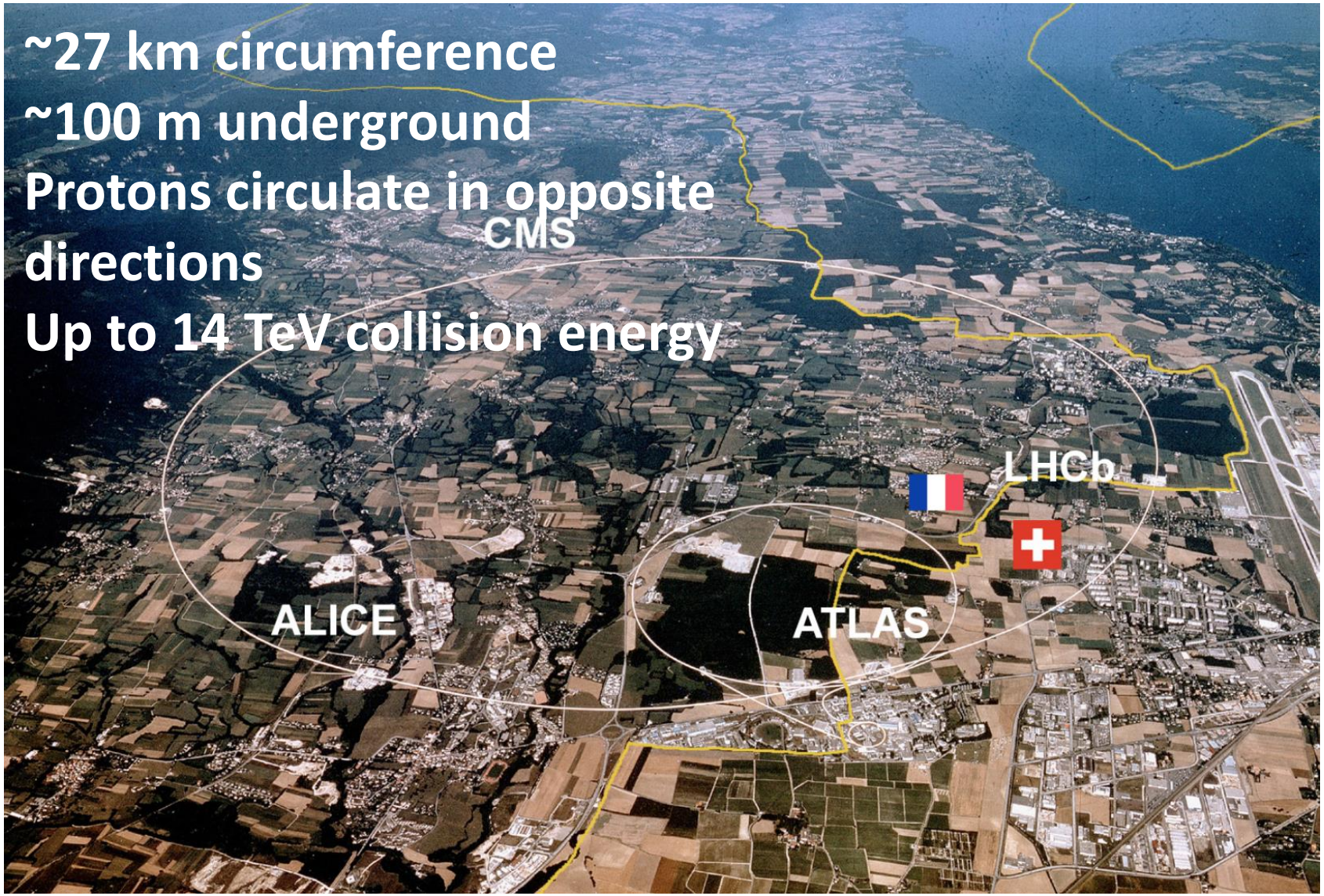


It's a time of exciting new discoveries in particle physics!

At CERN, the LHC is now in Run 3, with its highest collision rates and energies yet. At the same time, there are new questions as the few experimental results vary from the highly reliable Standard Model.

The LHC and CMS are where we need to be to explore these new mysteries.

LHC@CERN


~27 km circumference
~100 m underground
Protons circulate in opposite directions
Up to 14 TeV collision energy
CMS
LHCb
ALICE
ATLAS

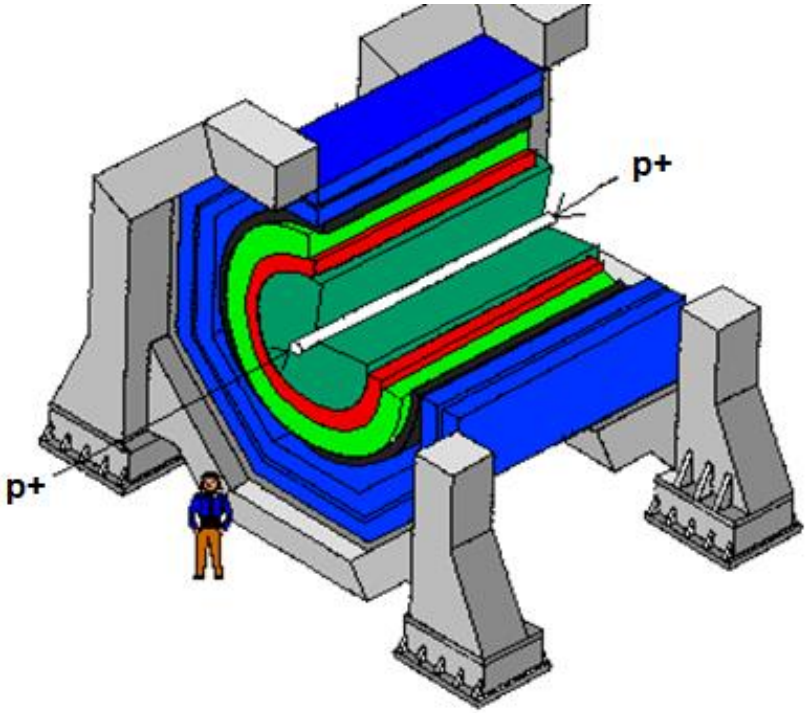
Detectors

Generic Design

Cylinders wrapped around the beam pipe

From inner to outer . . .

- Tracking
- Electromagnetic calorimeter
- Hadronic calorimeter
- Magnet*
- Muon chamber

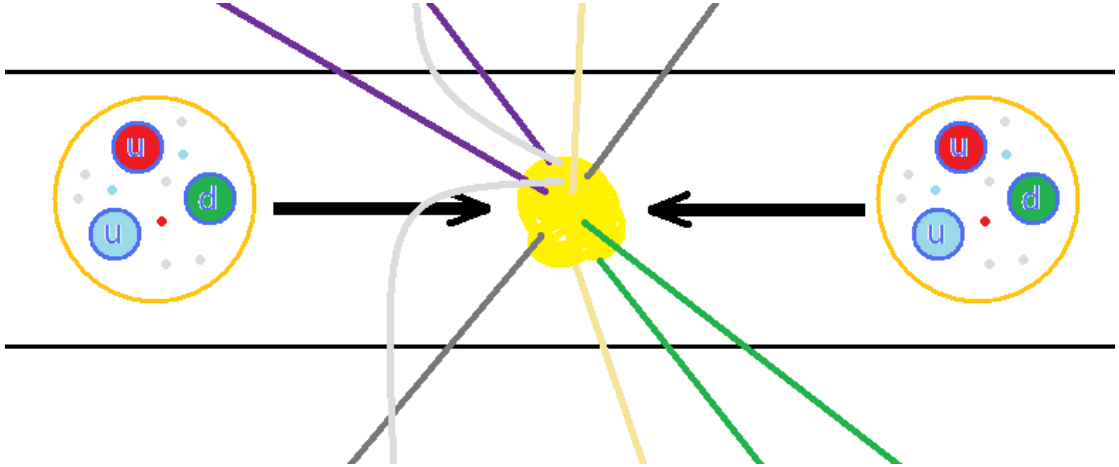


**Location of magnet depends on specific detector design.*

Protons collide inside ATLAS

The LHC accelerates protons to almost 7500 times the energy equivalent of their mass. The protons circulate in opposite directions and collide in the center of ATLAS.

But protons are not just particles: they are more like bags of quarks and gluons. When protons collide, all sorts of very short-lived particles can be made from all that energy.

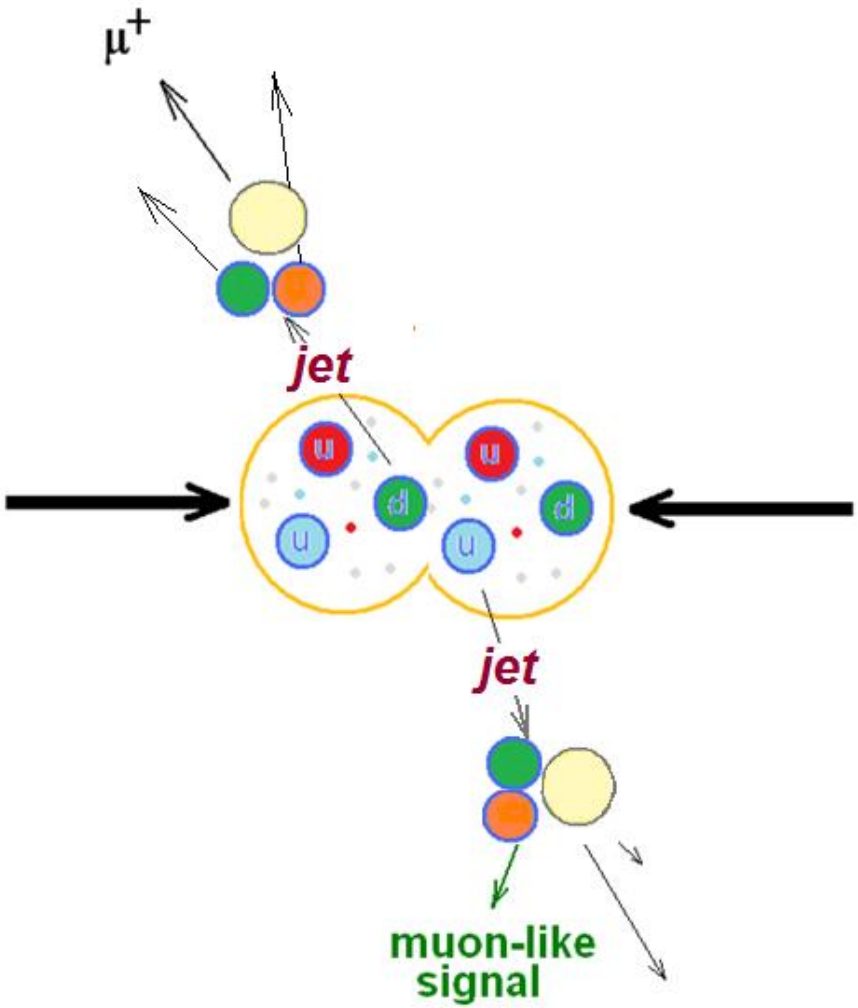


Particle Decays

Often, quarks are scattered in collisions.

As they separate, the binding energy between them converts to sprays of new particles called jets. Also, lower energy electrons and muons can emerge.

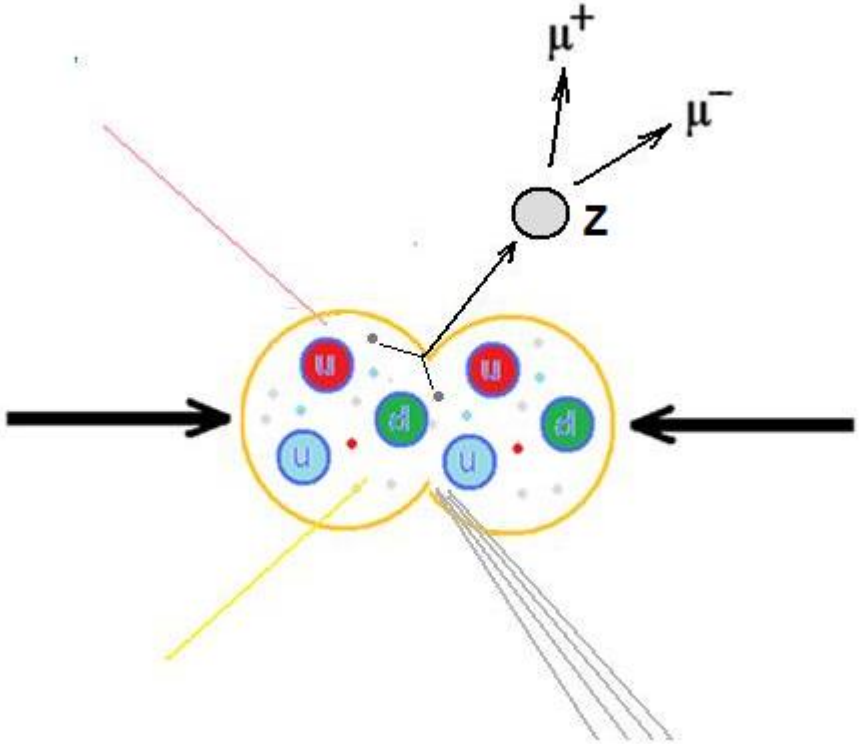
They are not what we are looking for.



Particle Decays

We are looking for the Z boson, a particle with no charge that decays into two muons or two electrons.*

What do we know about the charges of the muons or electrons? What is the charge of the Z?

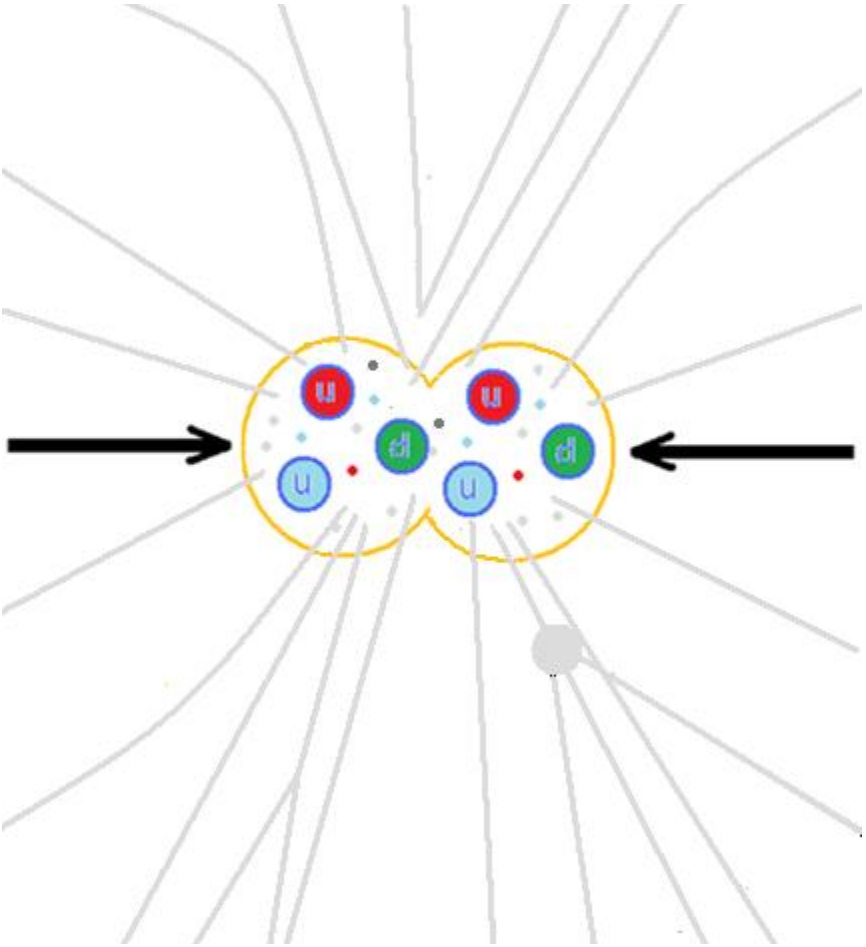


**The Z has other decays . . . but these are not what we are looking for.*

Particle Decays

A “dimuon” or “dielectron” event *might* be a decay of the particle that we are interested in.

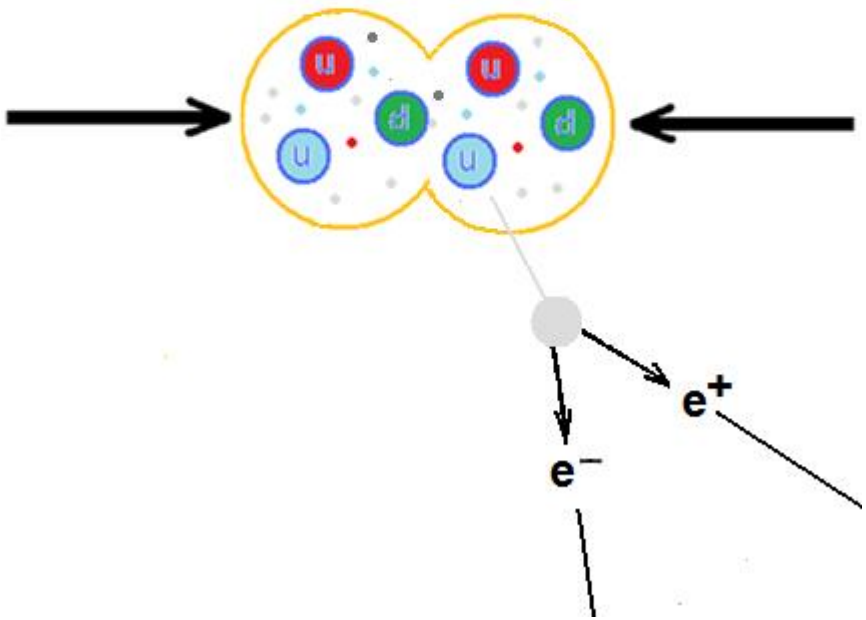
It may be hard to find the tracks we want unless we make a “cut” on low- energy tracks.



Particle Decays

If we cut out all tracks below, say, 5 GeV momentum, the picture is clearer.

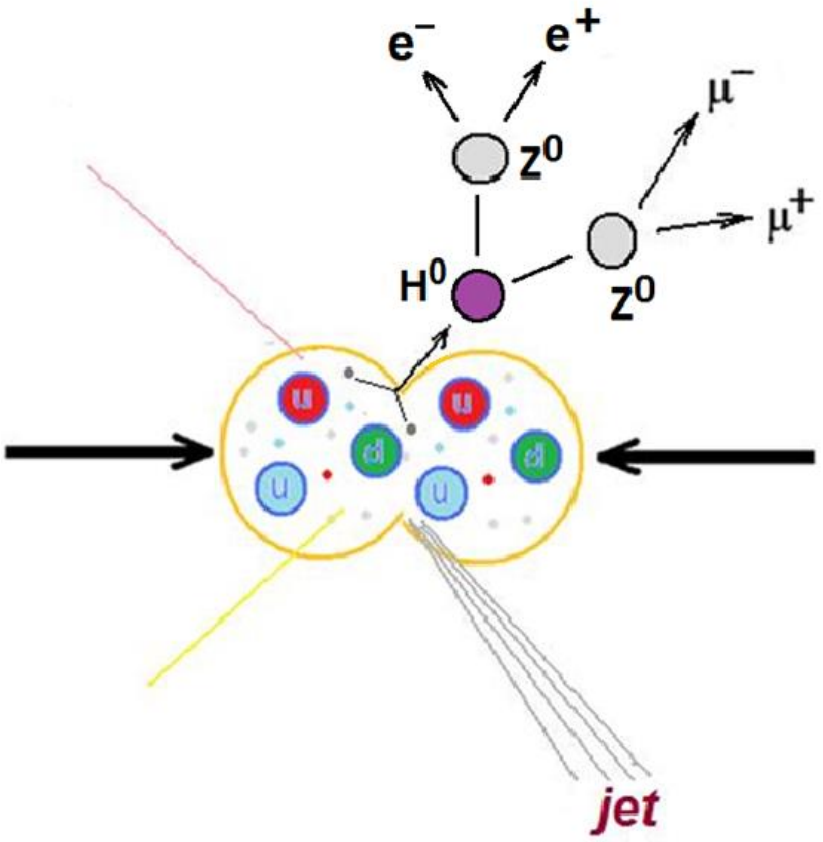
Today, we will filter many events to find Z→e e and Z→μ μ signals and use momentum information from these to find the mass of the Z boson.



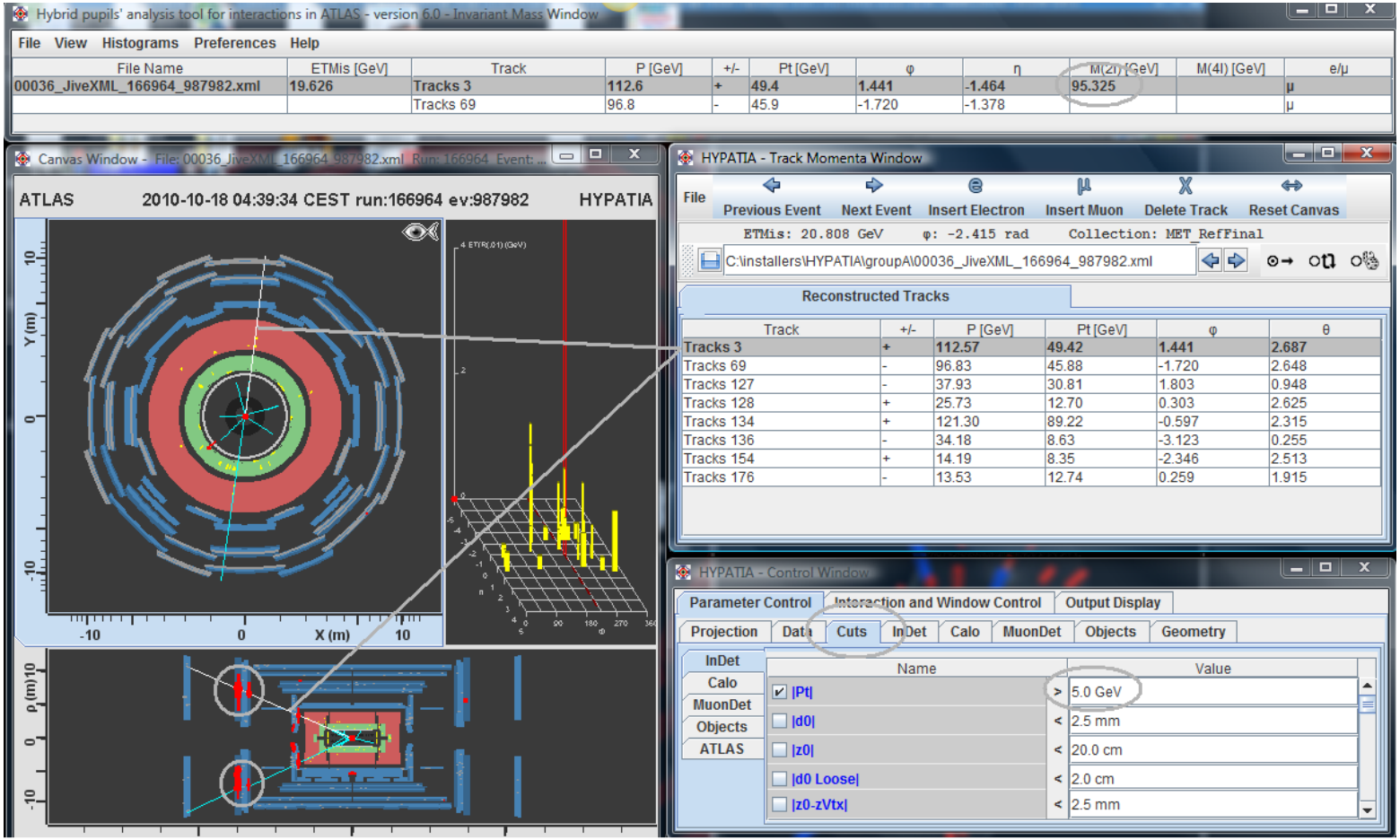
Particle Decays

The Higgs boson was discovered by CMS and ATLAS and announced on July 4, 2012.

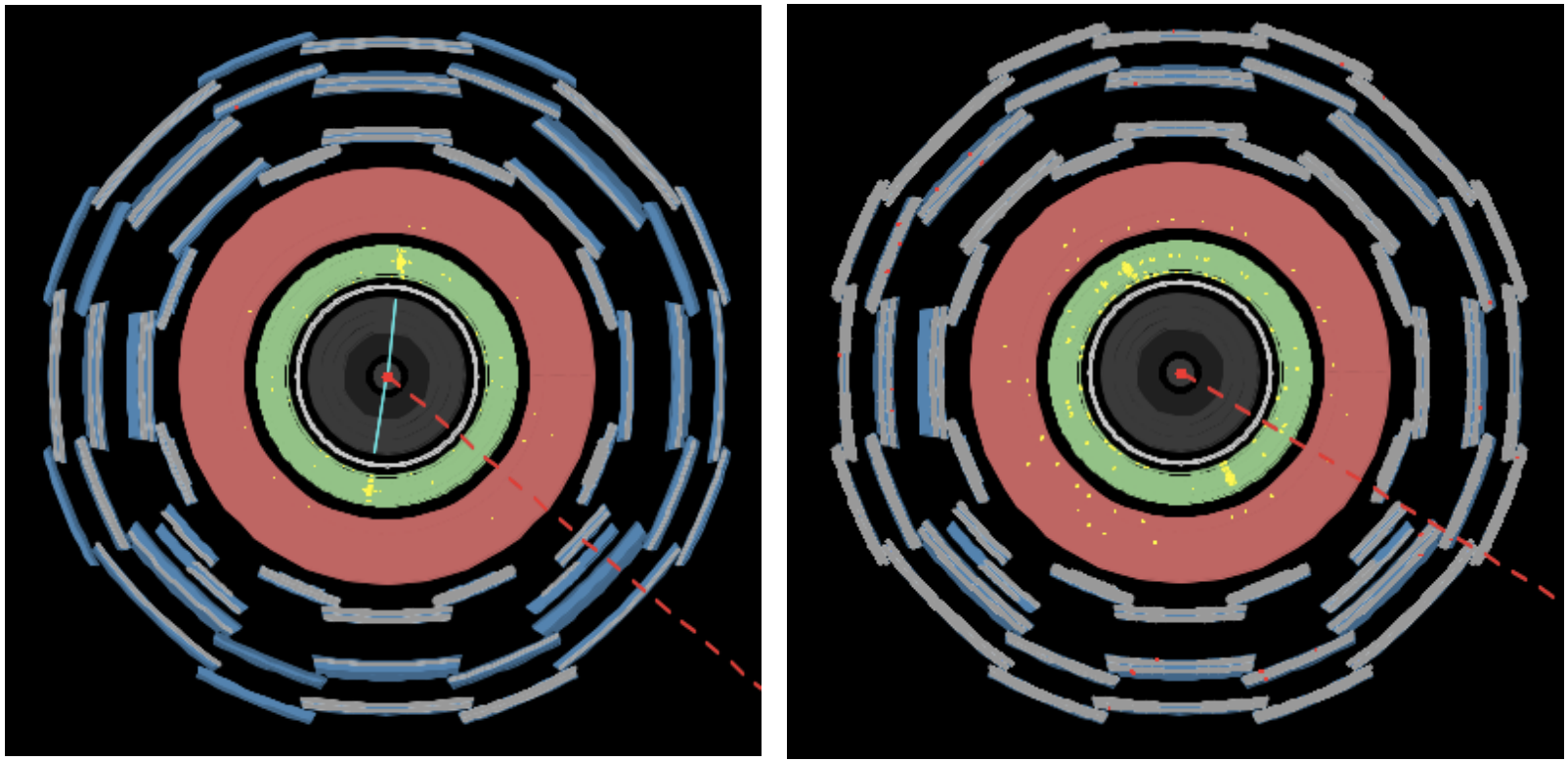
This long-sought particle is part of the “Higgs mechanism” that accounts for other particle having mass.



HYPATIA Event Display

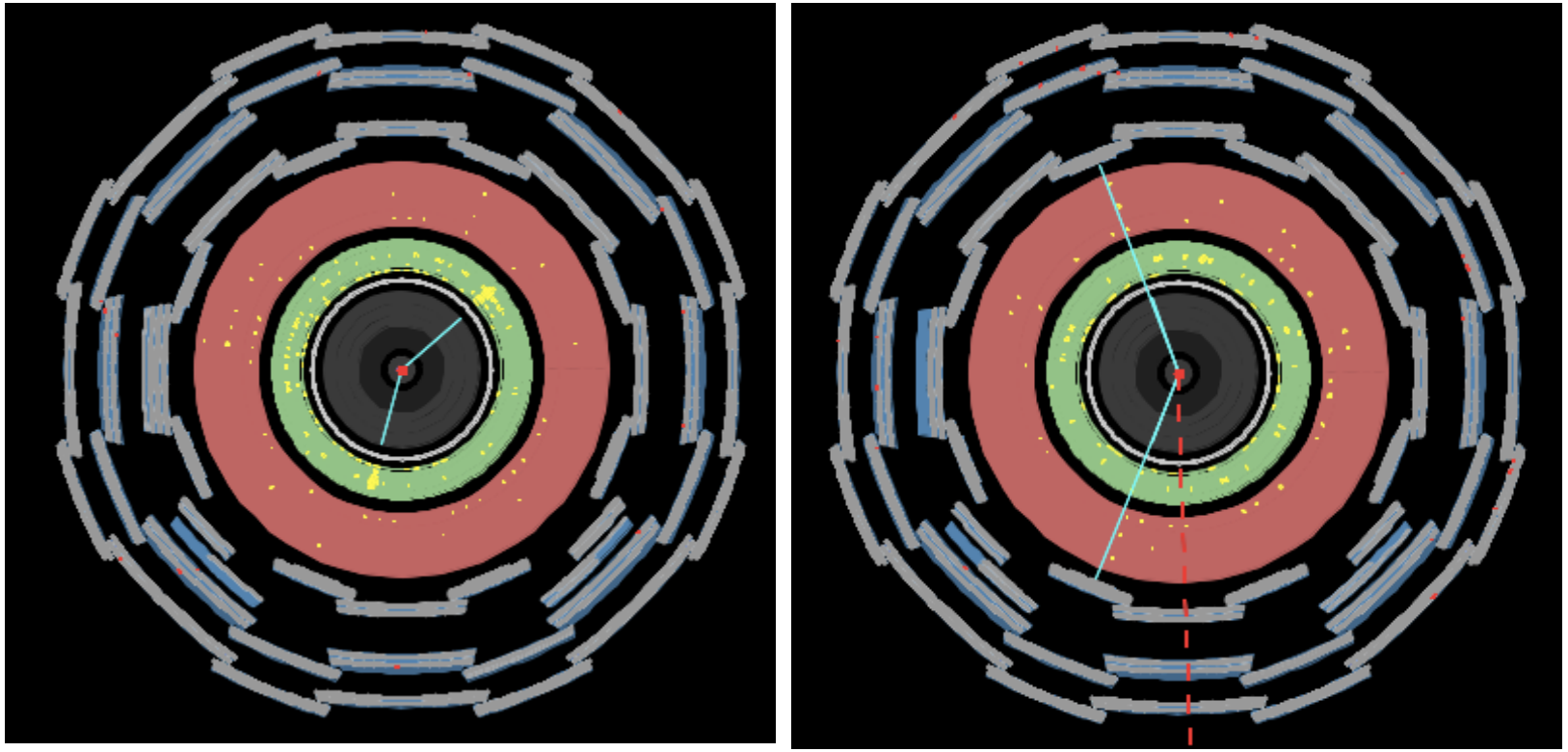


HYPATIA Event Display



How are these events similar? Different? Why?

HYPATIA Event Display



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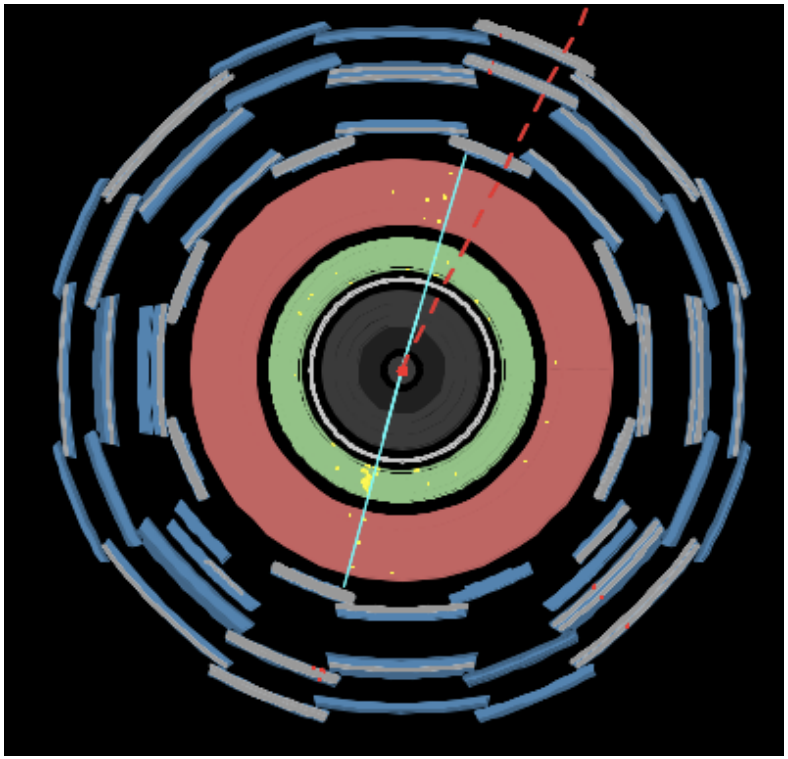
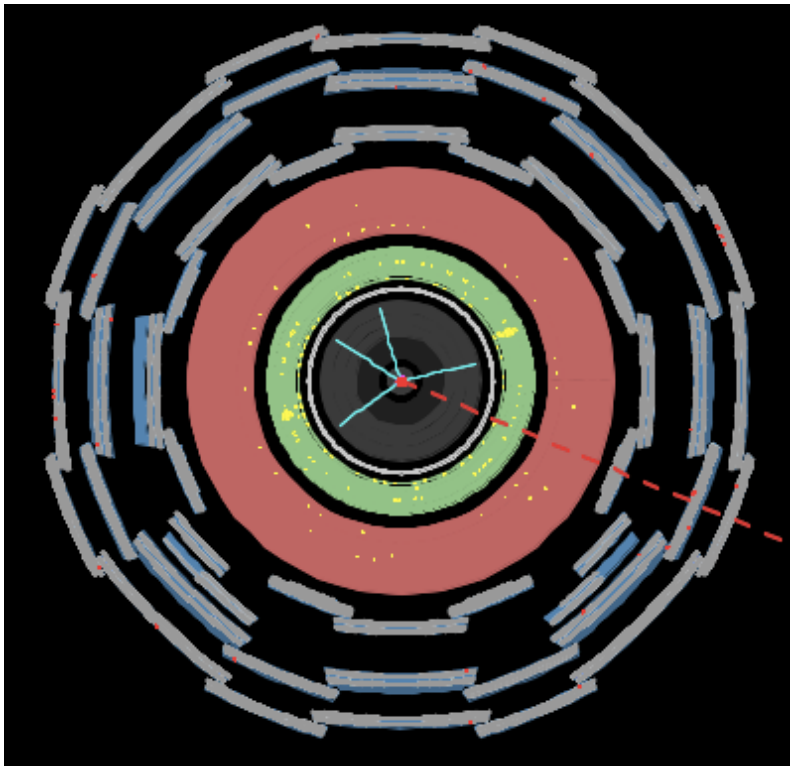
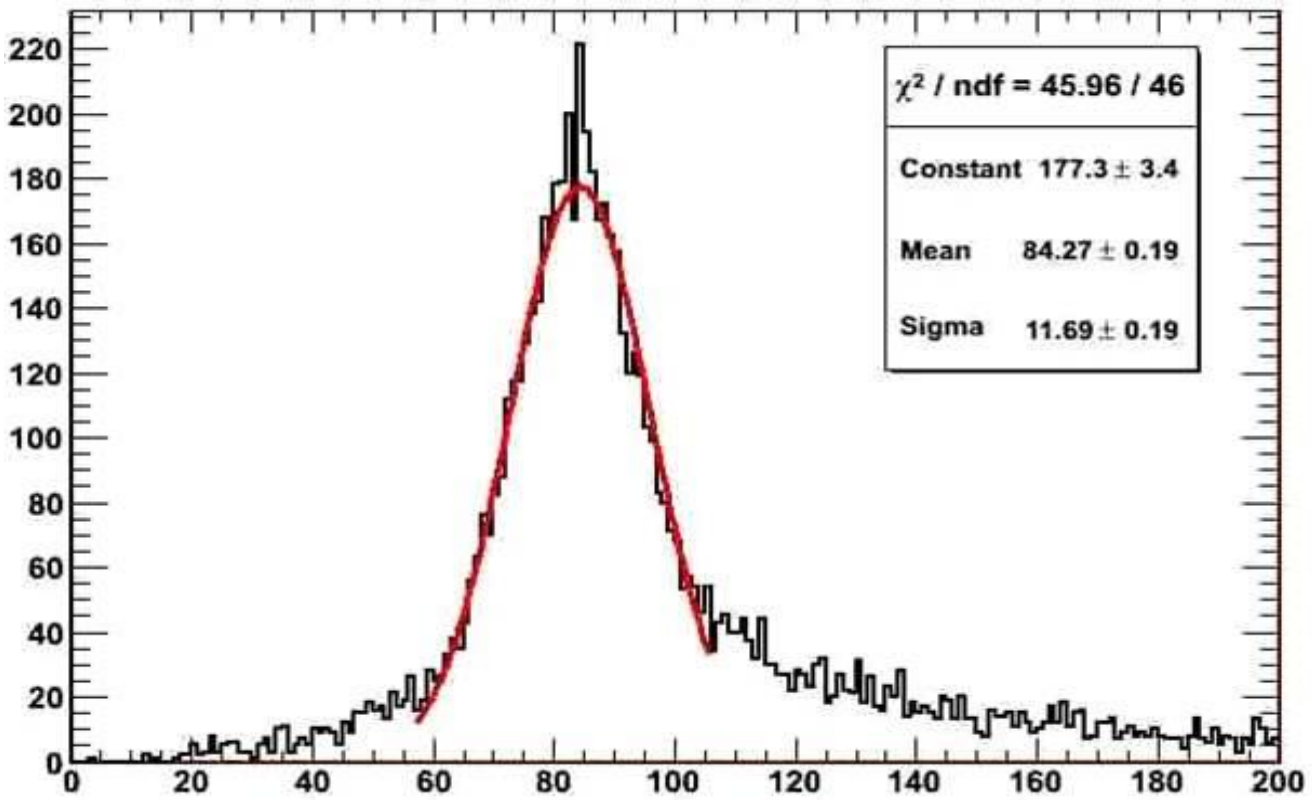




How are these events similar? Different? Why?

ATLAS Mass Plot



From: *W Mass as a Calibration of the Jet Energy Scale in ATLAS* (poster, 2008) Daniel Goldin, Southern Methodist University, for the ATLAS Collaboration http://cdsweb.cern.ch/record/1132028/files/ATL-SLIDE-2008-100.ppt

Keep in Mind . . .

"Science is nothing but developed perception, interpreted intent, common sense rounded out and minutely articulated." *George Santayana*

- Indirect observations and imaginative, critical, logical thinking can lead to reliable and valid inferences.

- Therefore: work together, think (sometimes outside the box), and be critical of each other's results to figure out what is happening.

Let's Analyze Events!

Make teams of two.

Practice.

Talk with physicists.

Find good Z and H candidates…and more.

Which events will be included in the mass plot?

AND plot the mass!

Report! Rapport! Rejoice! Relax!