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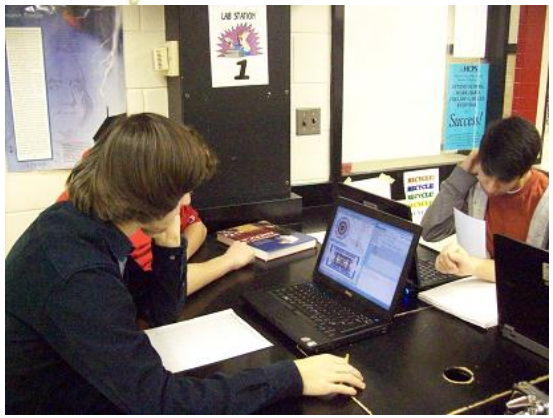
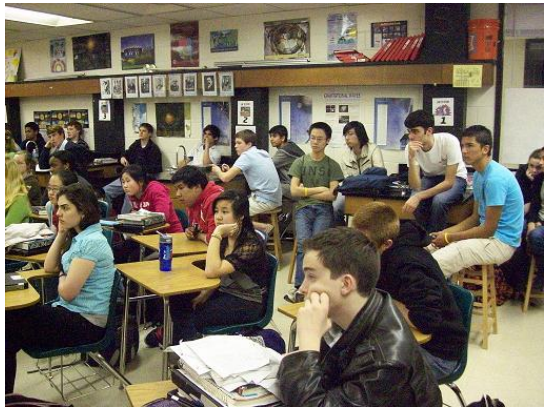
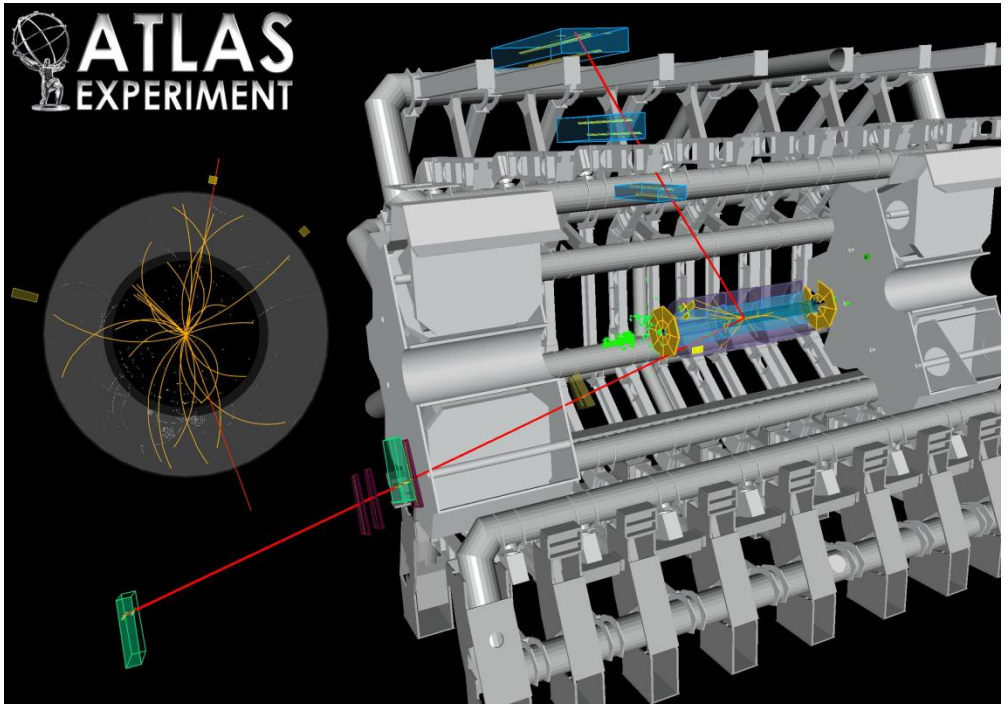


ATLAS Z-Path Masterclass 2011

INTERNATIONAL MASTERCLASSES
hands on particle physics





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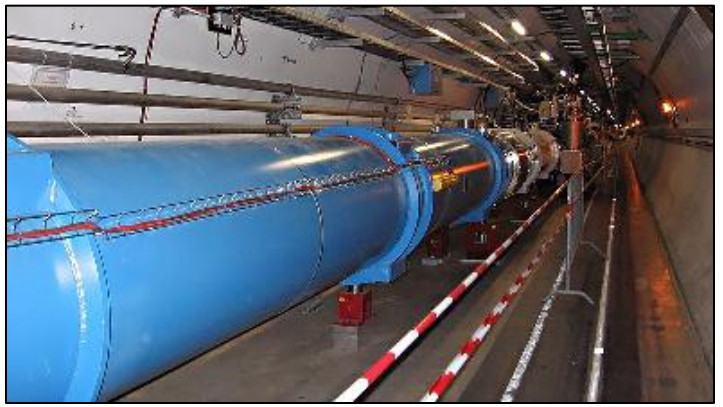
The LHC and New Physics

It's the dawn of an exciting age of new discovery in particle physics!



At CERN, the LHC and its experiments are tuning up.

The ATLAS detector has been taking data. Our job is to understand how the detector responds to data from a known Standard Model particle in the recent 7 TeV run.

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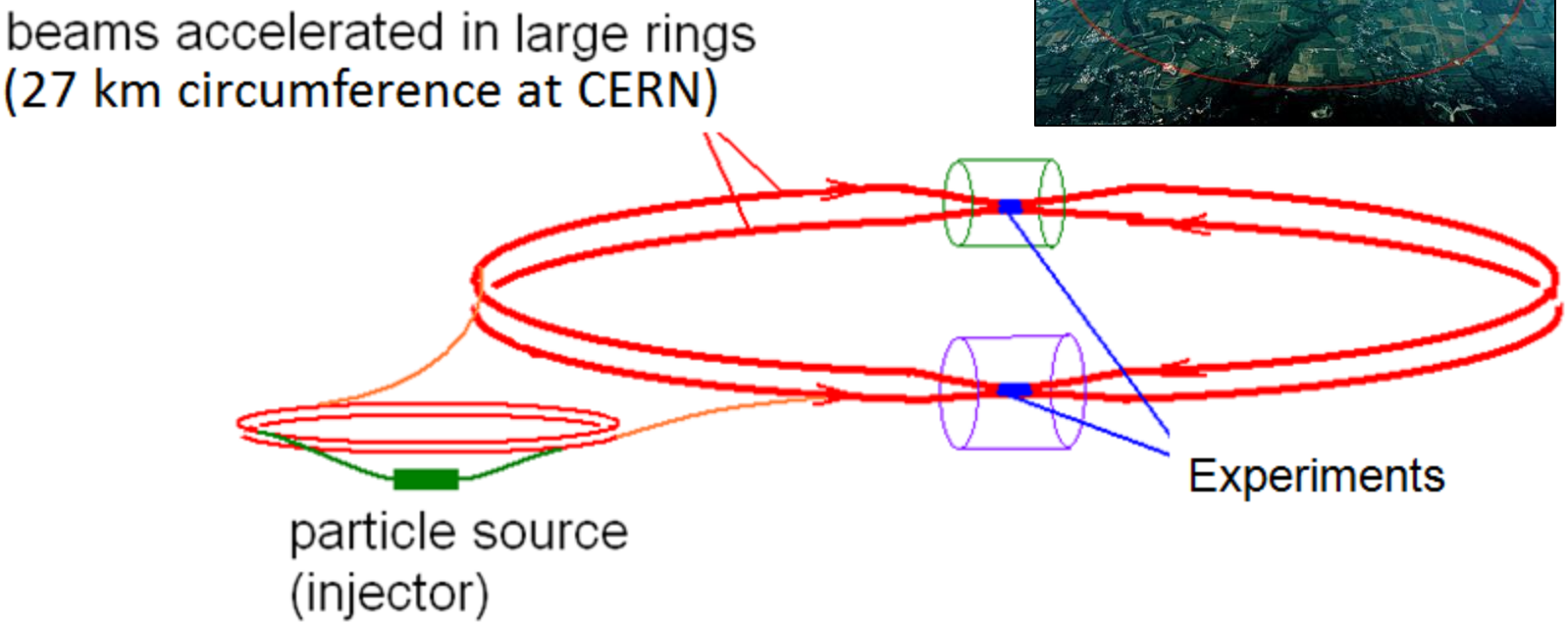
The LHC and New Physics

The LHC is buried ~100 m below the surface near the Swiss-French border.



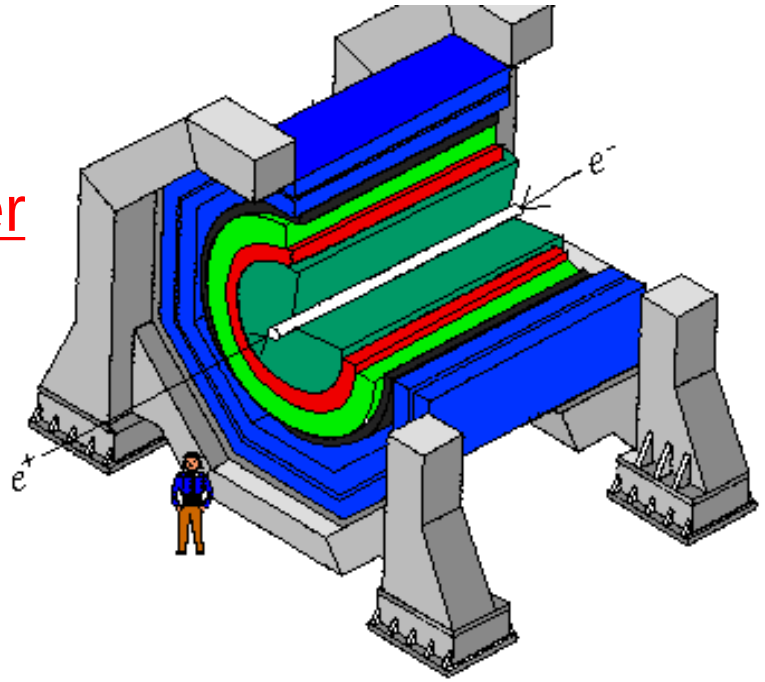
Detectors

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.*

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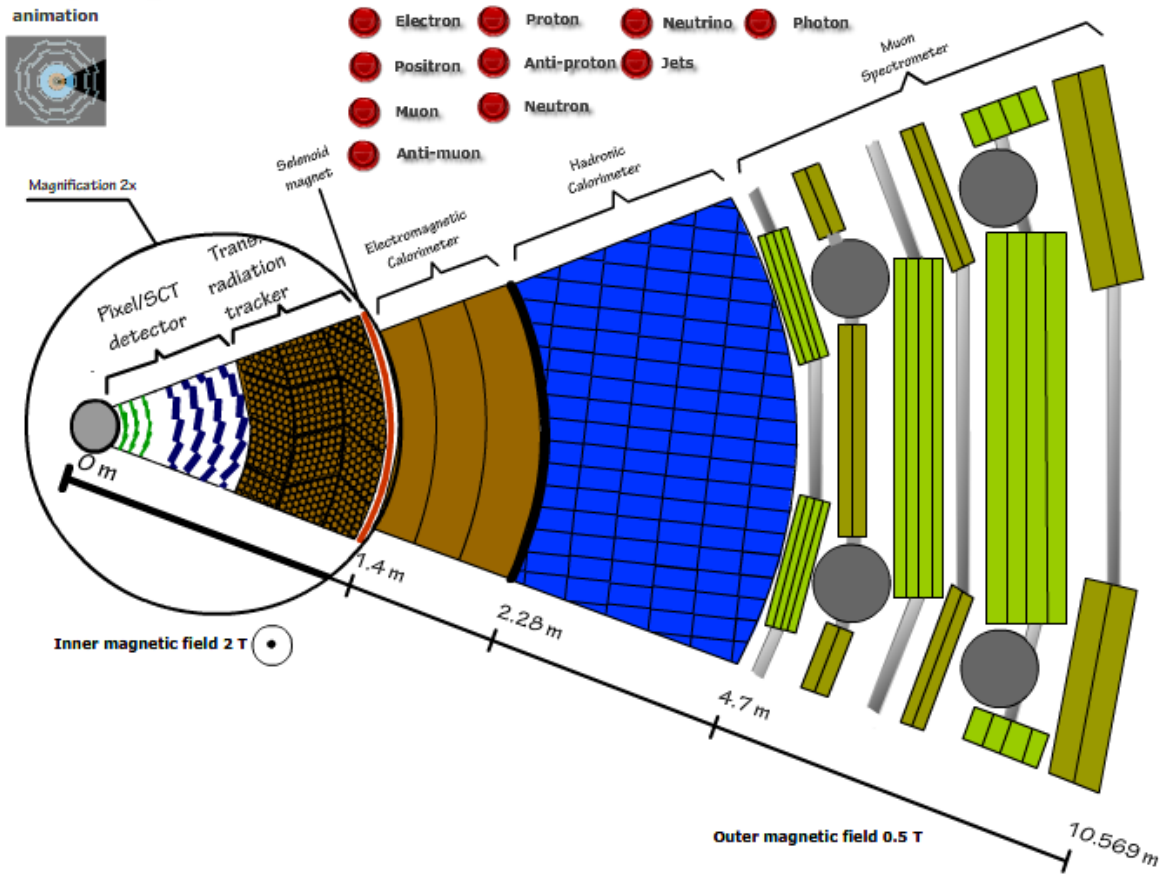
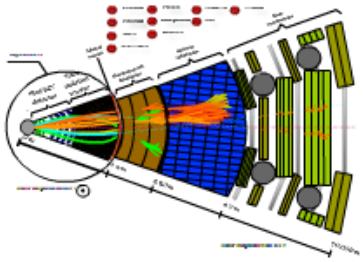
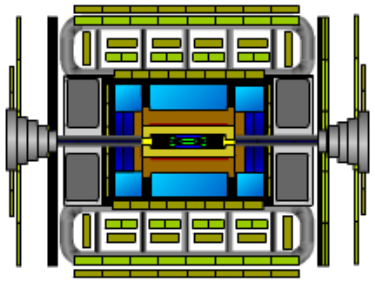
ATLAS Detector

ATLAS





End view



Side view

Created by Jeřábek, Jende 2010

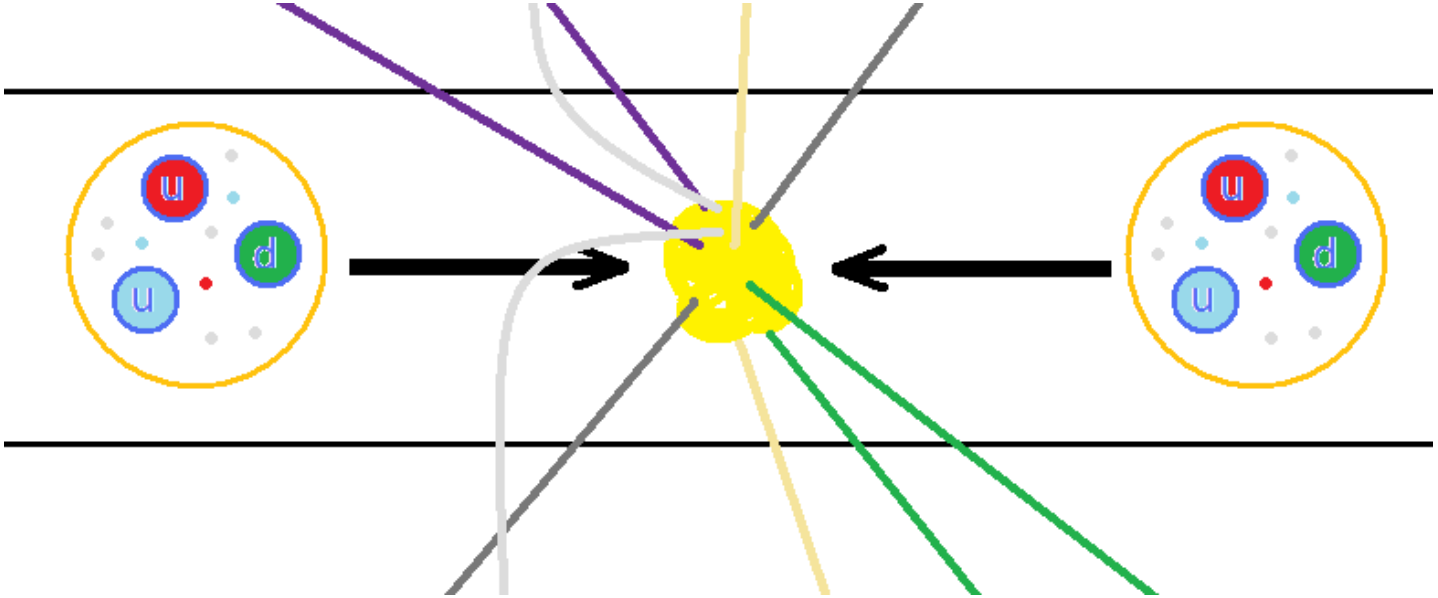
[View swf animation in browser.]

Proton Interactions

The beam particles each have a total energy of 3.5 TeV:

2 x 3.5 TeV = 7 TeV

The individual particles that make up the proton only have a fraction of this energy. New particles made in the collision *always* have a mass smaller than that energy.



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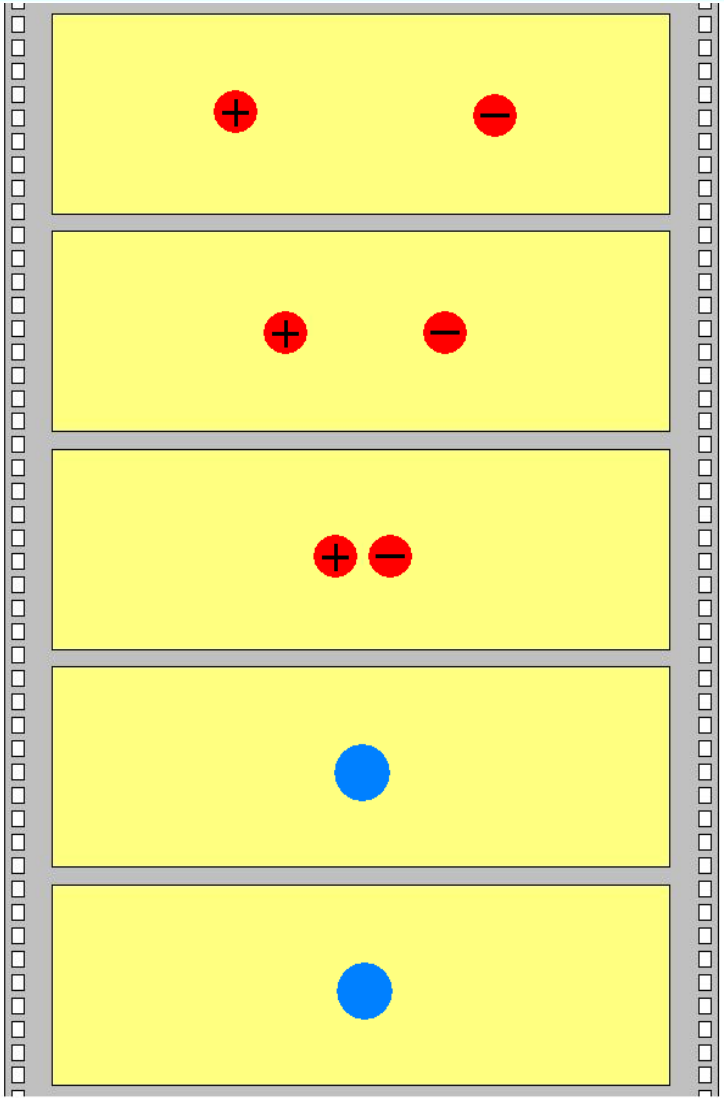
Particle Decays

The collisions create new particles that promptly decay. Decaying particles *always* produce lighter particles.

Conservation laws allow us to see patterns in the decays.

Can you name some of these conservation laws?

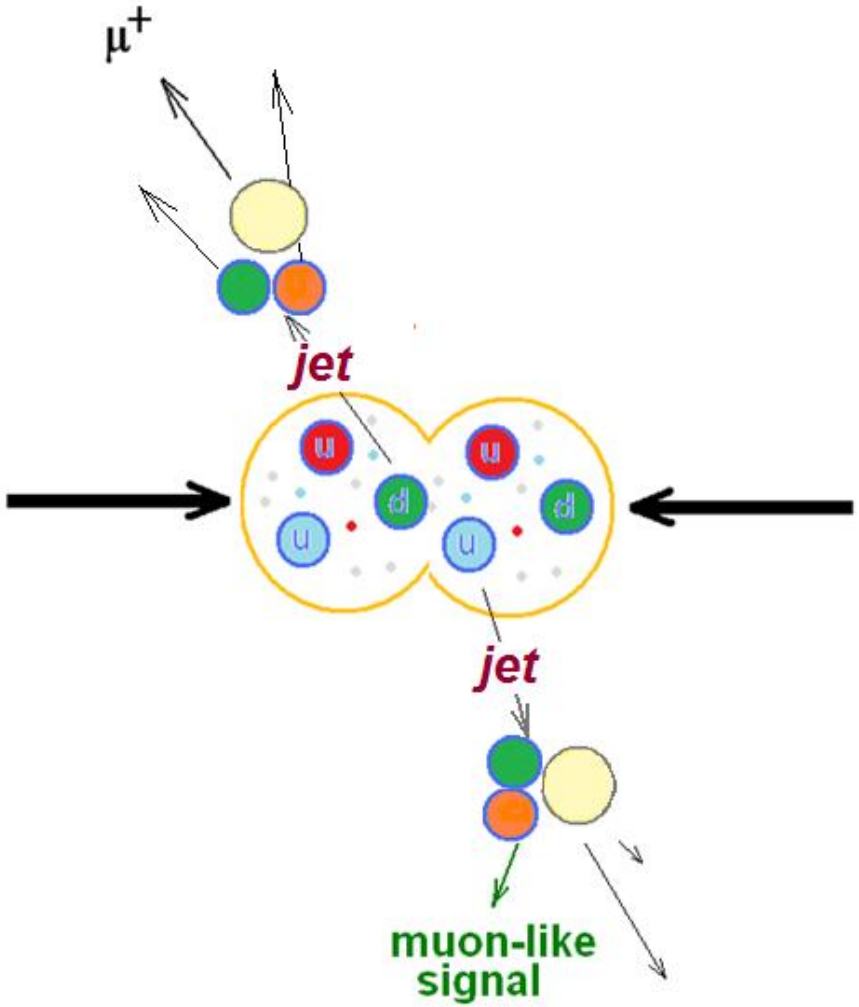


Particle Decays

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.



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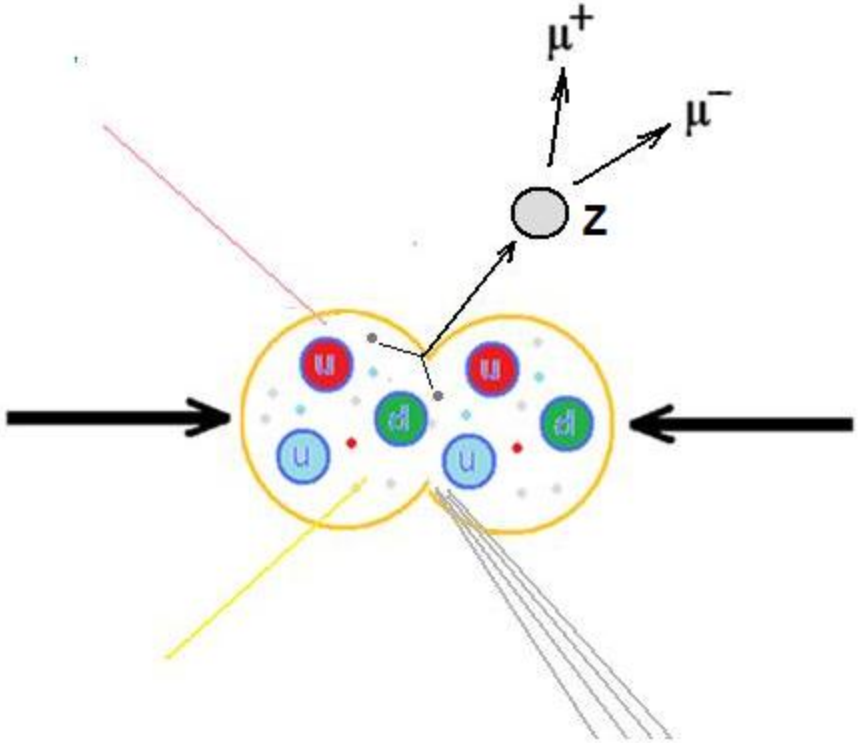
Particle Decays

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.*

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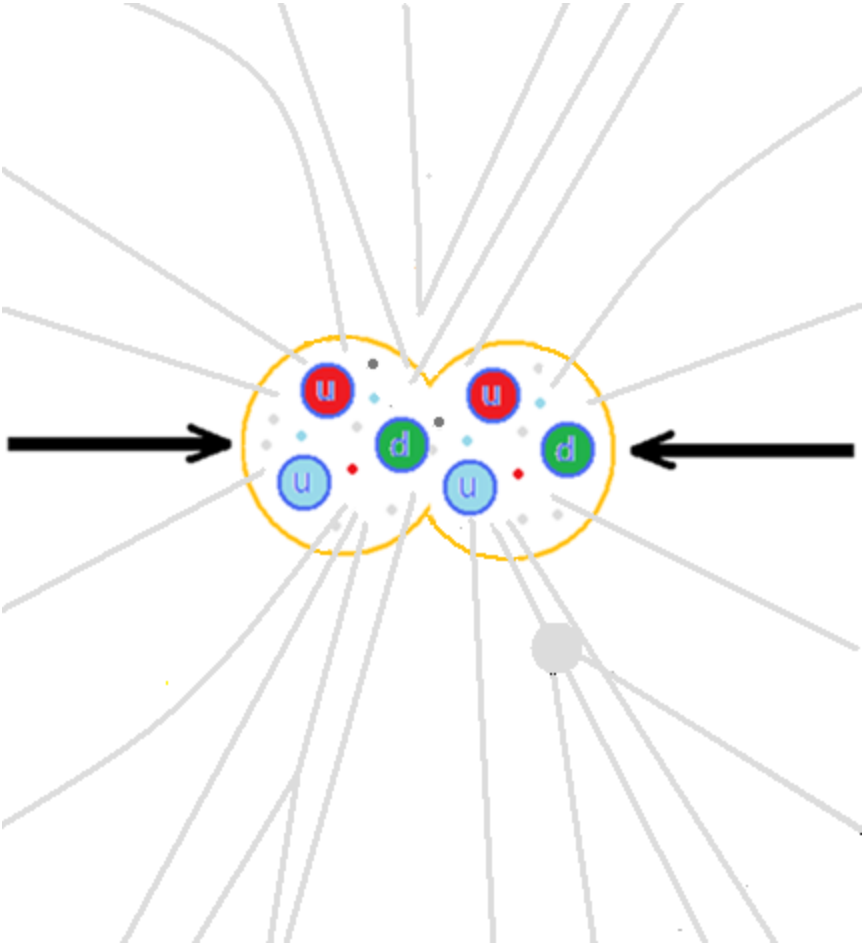
Particle Decays

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.



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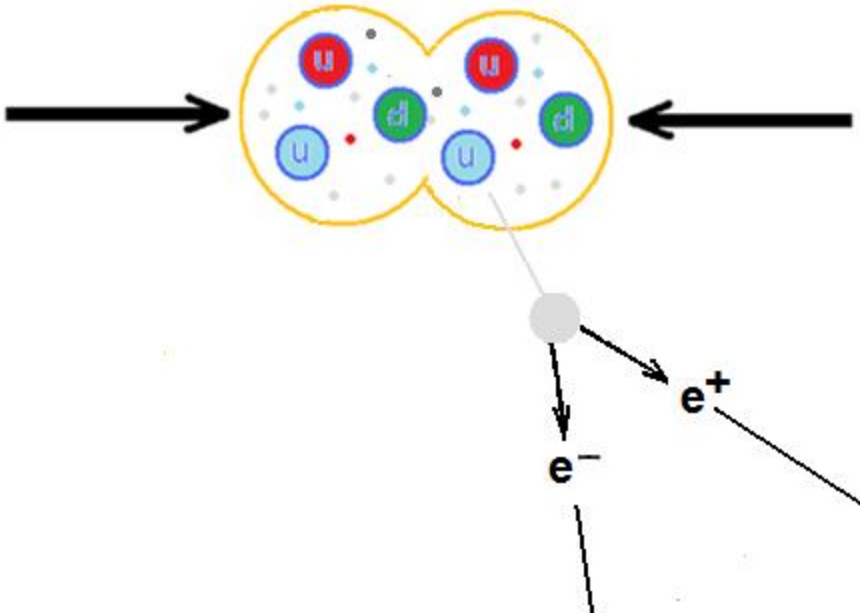
Particle Decays

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.



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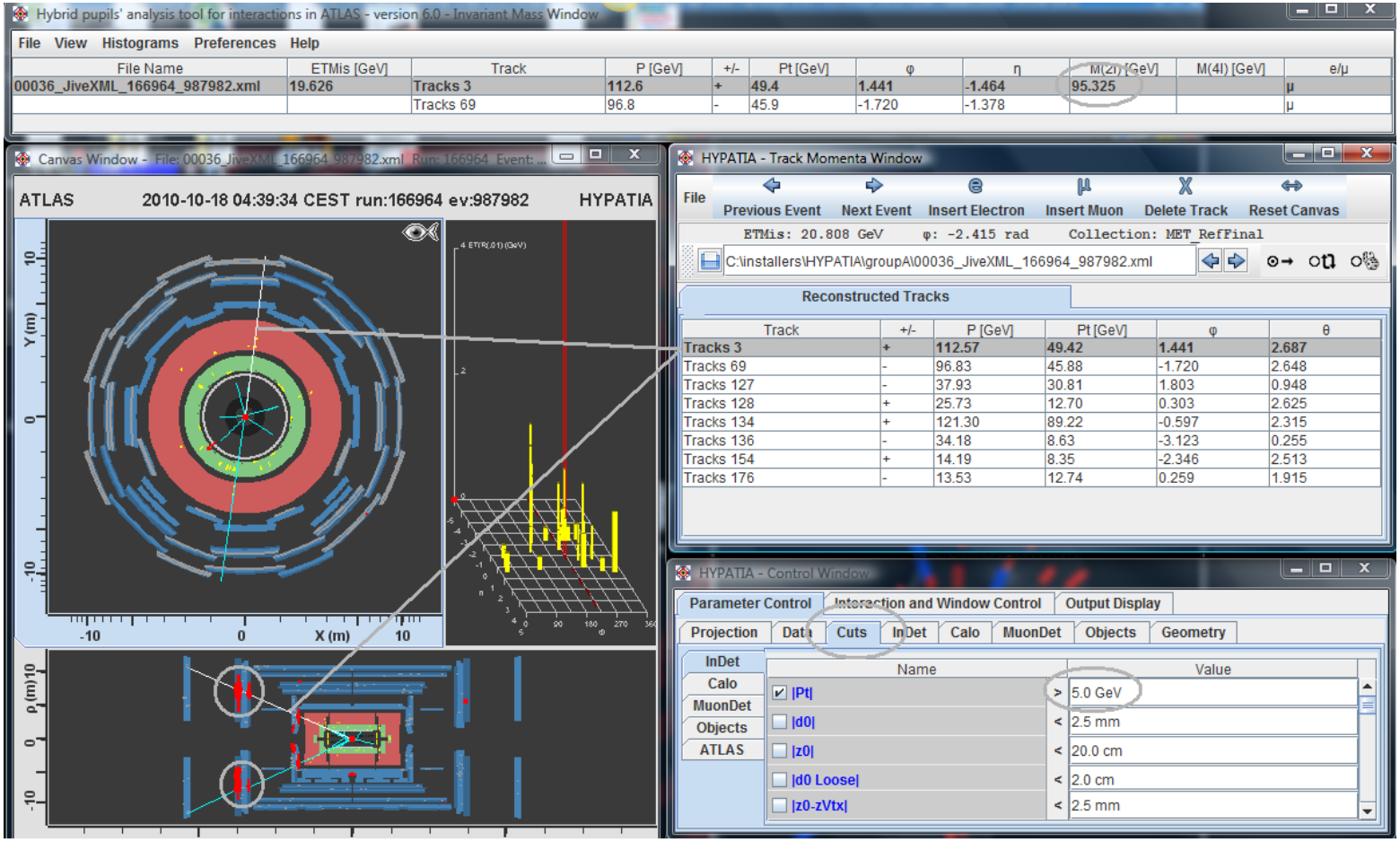
HYPATIA Event Display



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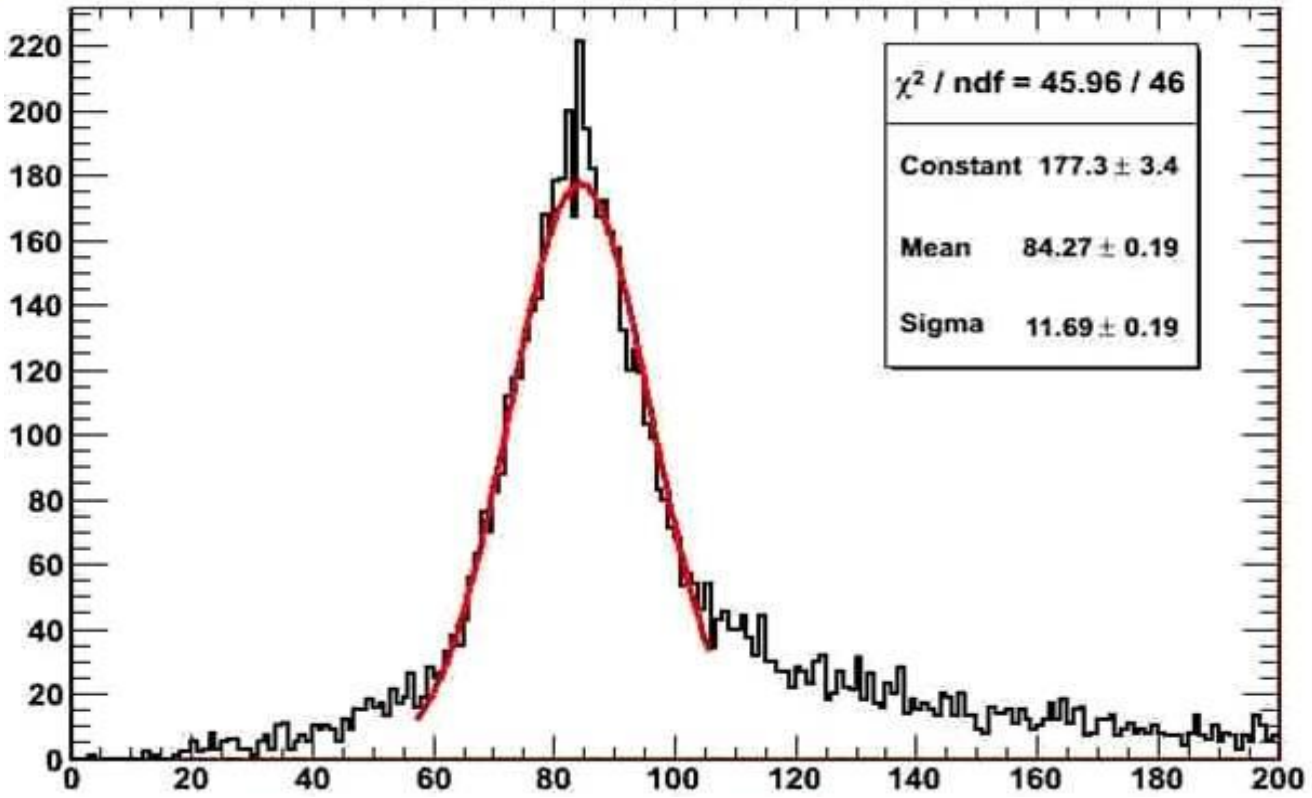
ATLAS Mass Plot



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

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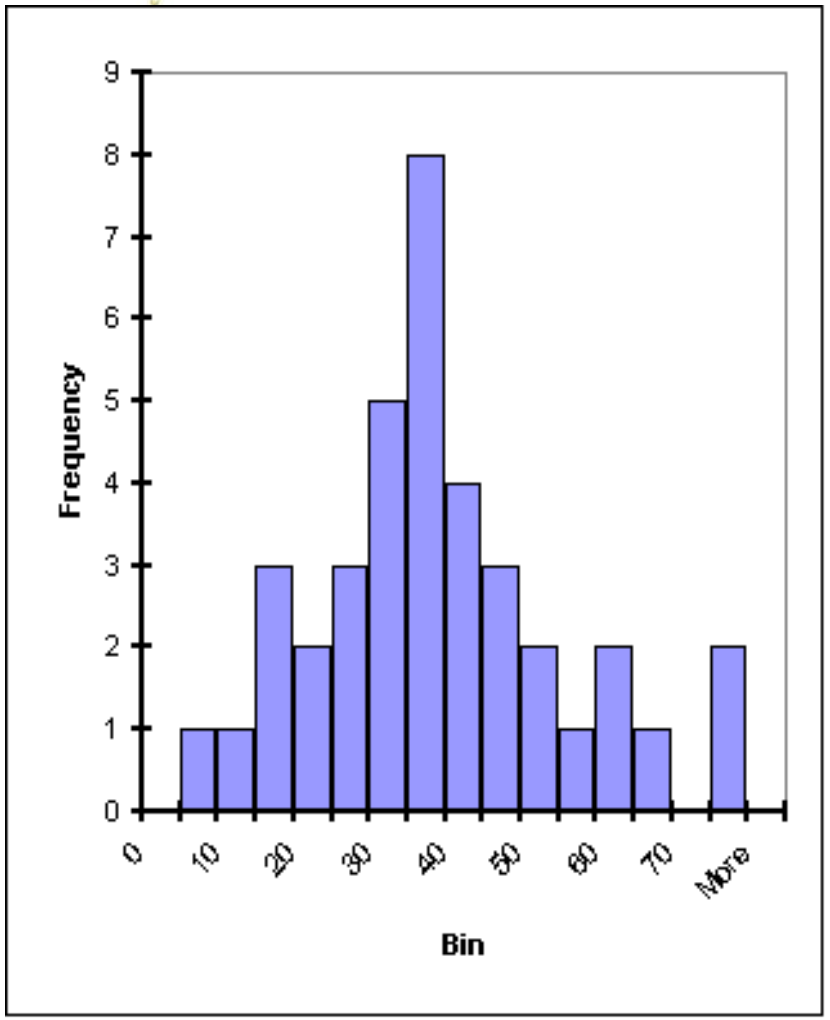
Histogram Review



Well-defined peak

Outliers: lower frequency

Where is the peak?

What is the width?

Is the "mass" precise?

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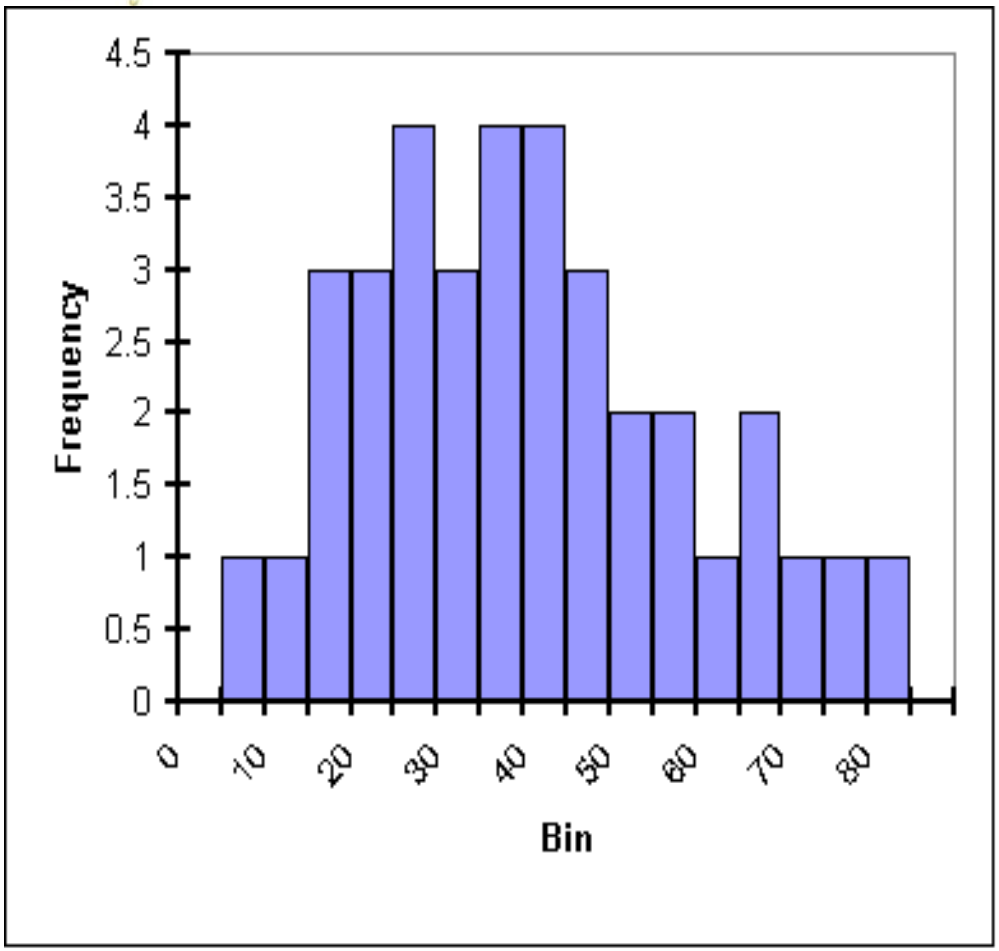
Histogram Review



Where is the peak?

What is the width?

Where are the outliers?

Not all histograms have same precision.

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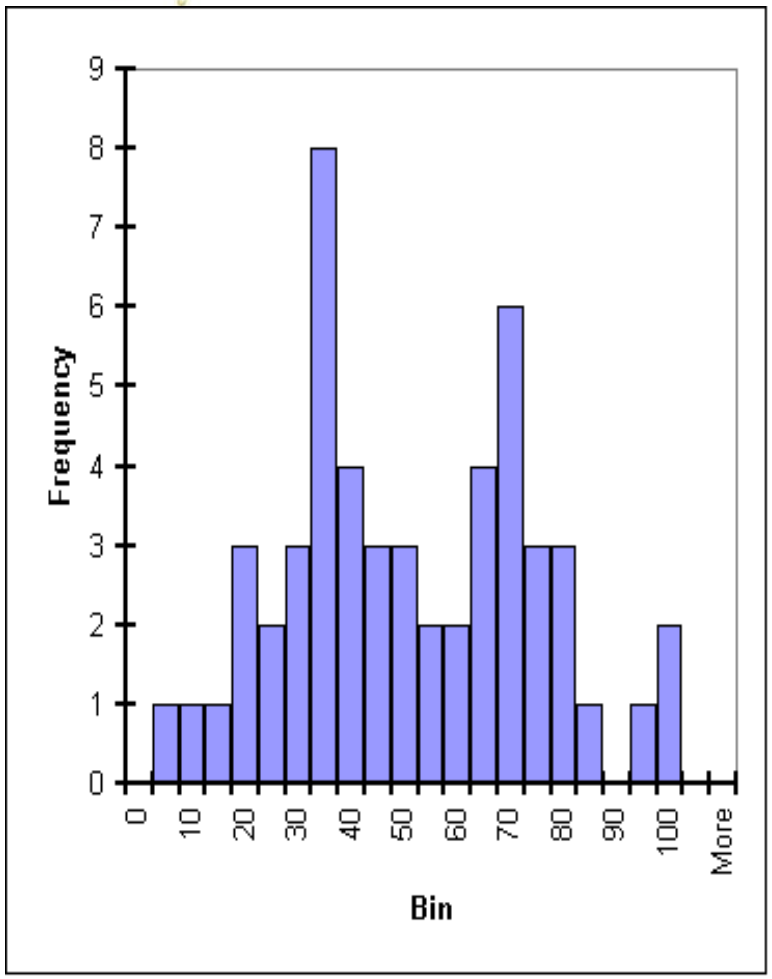
Histogram Review



Twin peaks:

- Poor definition of one signal or
- Two signals

In particle physics, could be:

- Two separate particles or
- Large signal as "background" and smaller "bump" showing actual particle under study.

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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.

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Let's Analyze Events!

Make teams of two.

Practice.

Talk with physicists.

Find good Z candidates.

Which events will be included in the mass plot?

AND plot the mass!

Report! Rapport! Rejoice! Relax!