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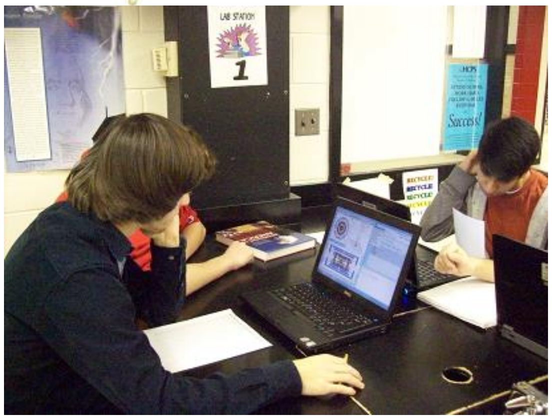
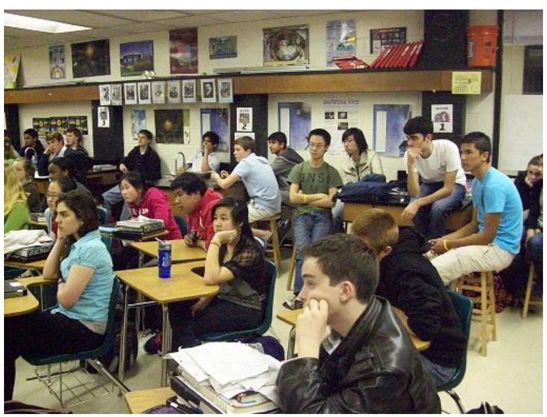
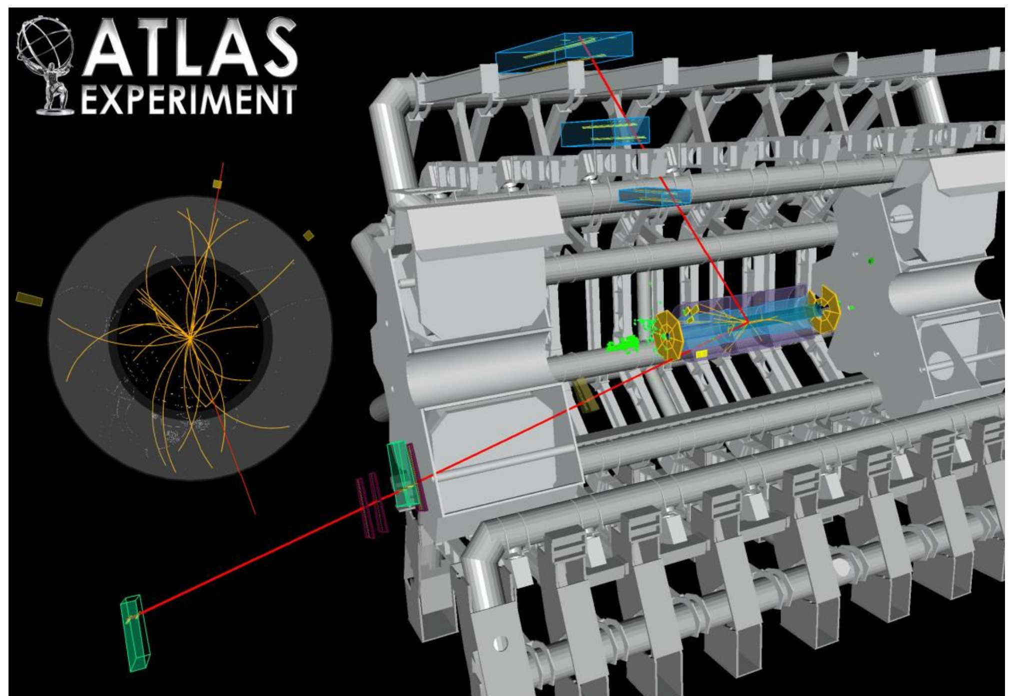


ATLAS Z-Path Masterclass 2018

INTERNATIONAL MASTERCLASSES
hands on particle physics





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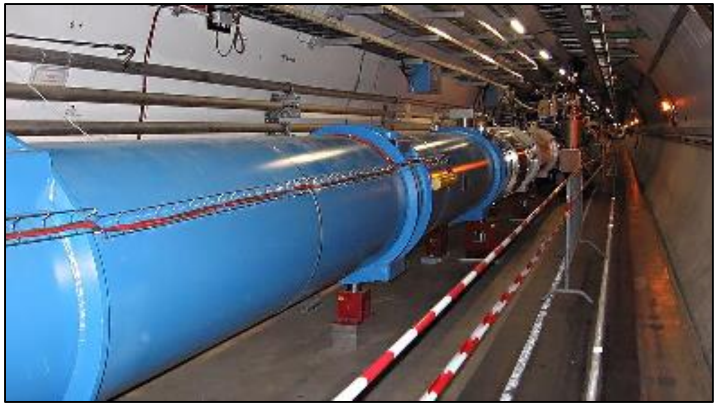
The LHC and New Physics

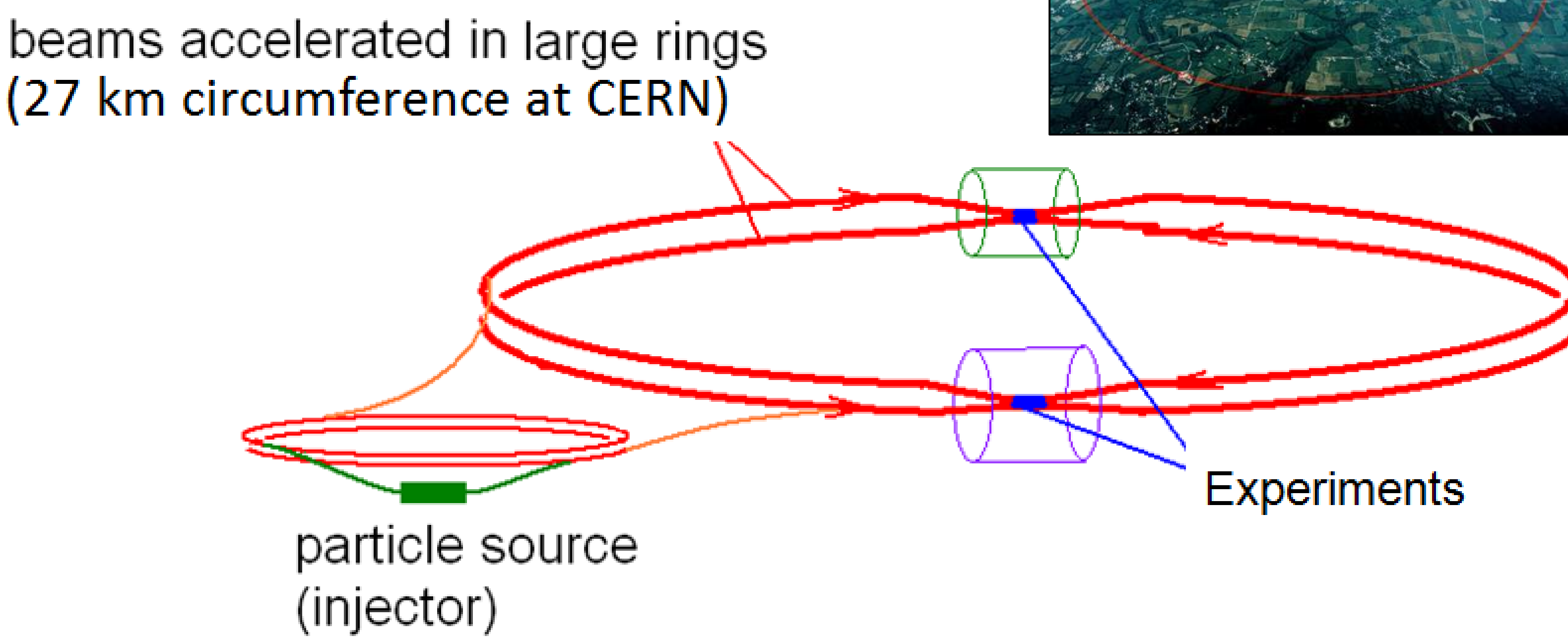


It's a time of exciting new discoveries in particle physics!

At CERN, the LHC succesfully completed Run I at 8 TeV of collision energy, confirming that the measurements correspond well to the ***Standard Model*** *and then finding the Higgs boson. The LHC is now into Run II at an amazing 13 TeV and the task is to look for new phenomena…and we are off to a great start.*

The LHC and New Physics

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



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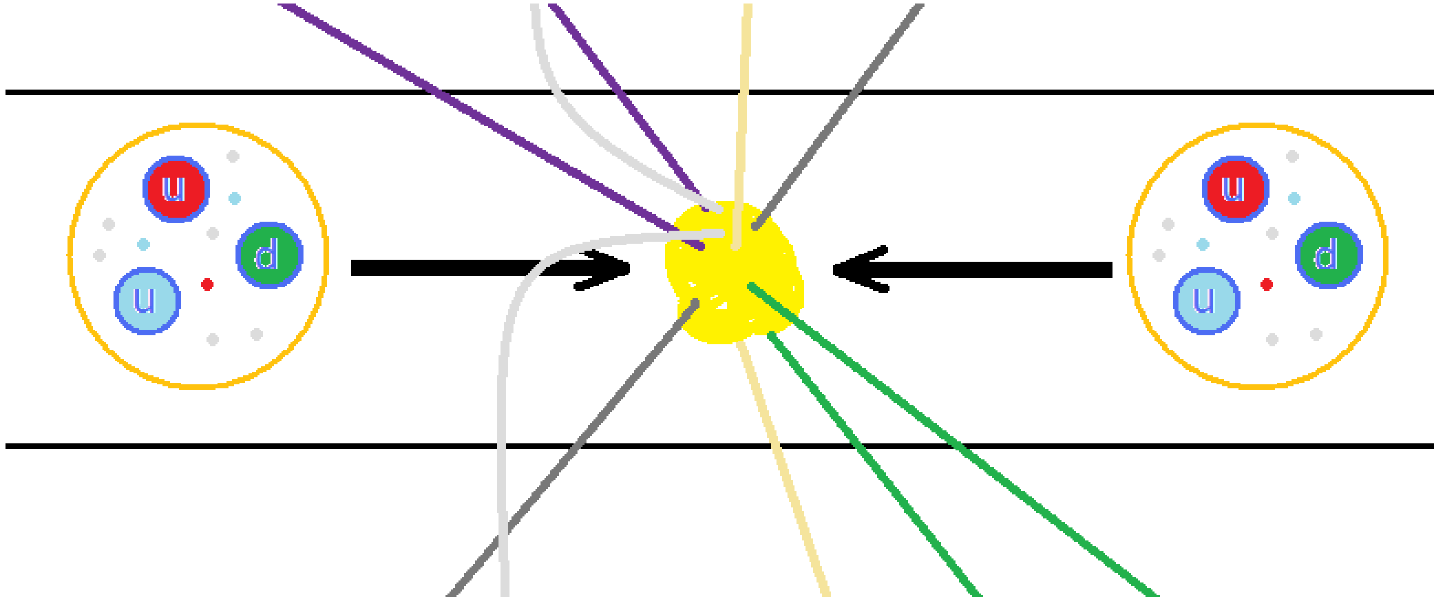
Energy & Particle Mass

We will look at Run I, in which proton energy is 4 TeV*.

- The total collision energy is 2 x 4 TeV = 8 TeV.
- But each particle inside a proton shares only a portion.
- So a newly created particle's mass ***must be*** smaller than the total energy.

**In Run II, this was increased to 6.5 GeV!*

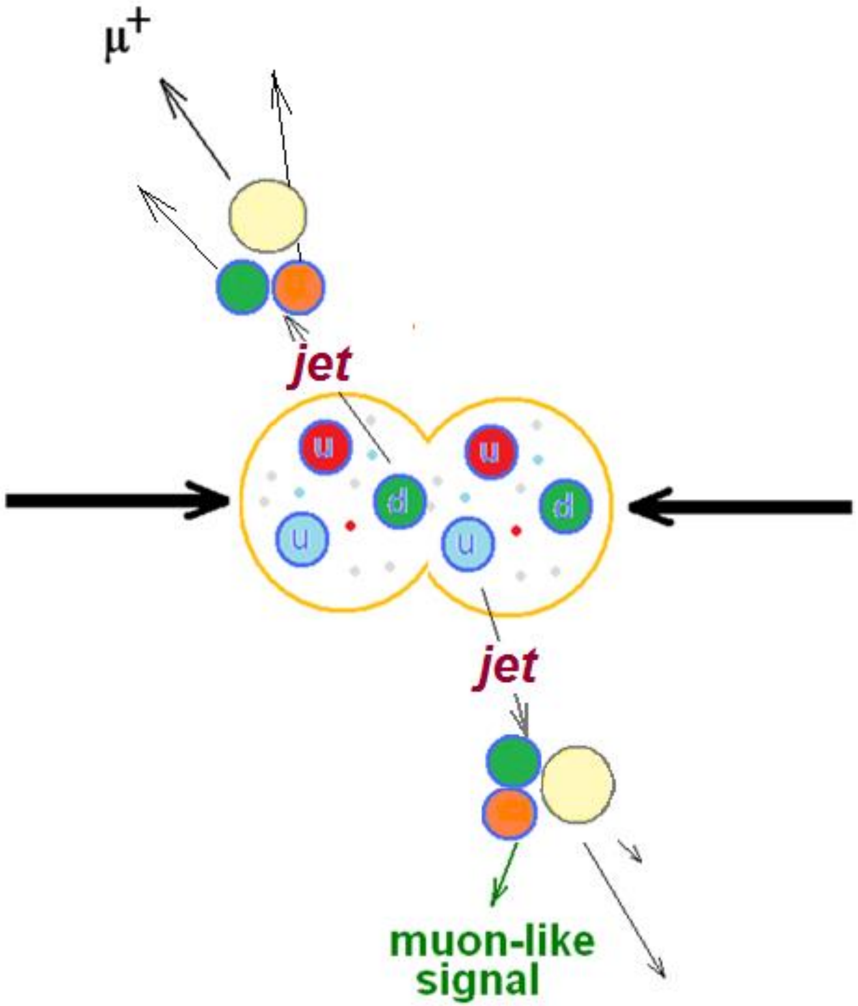


Particle Decays

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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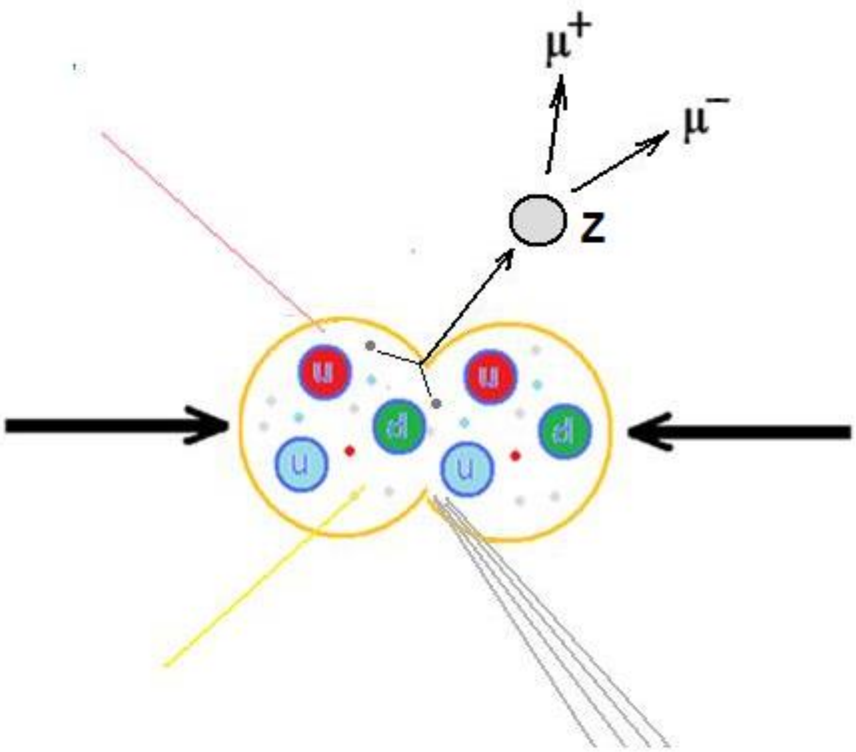
Particle Decays

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?

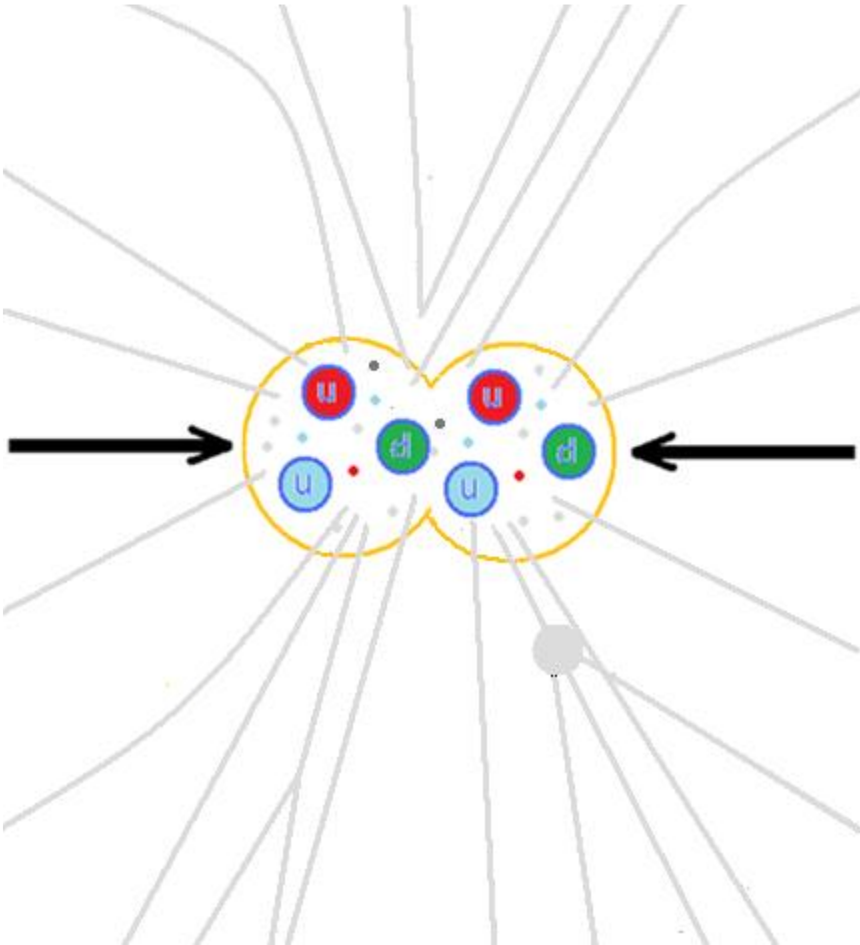


The Z has other decays . . . but these are not what we are looking for.

Particle Decays

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

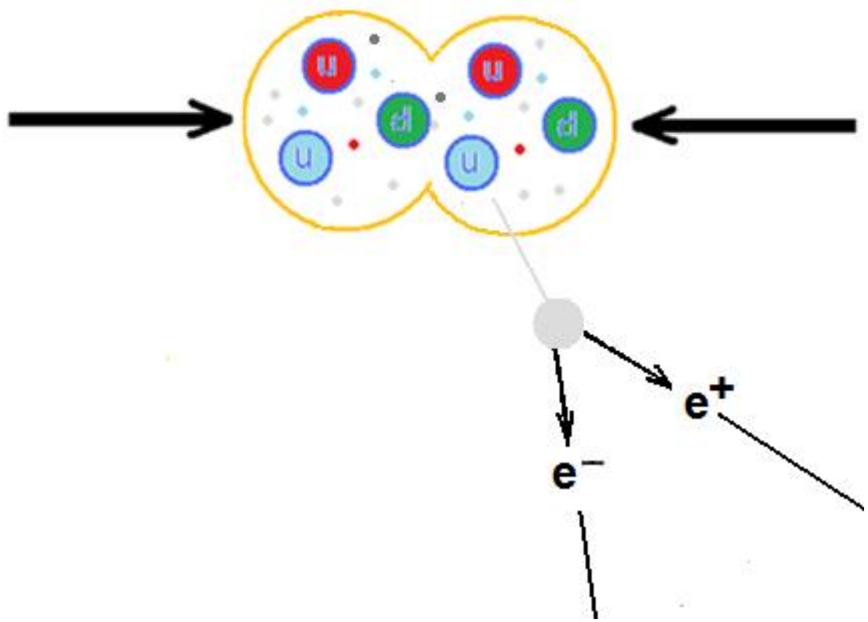
It may be hard to find the tracks we want unless we make a "cut" on low- energy tracks.



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.



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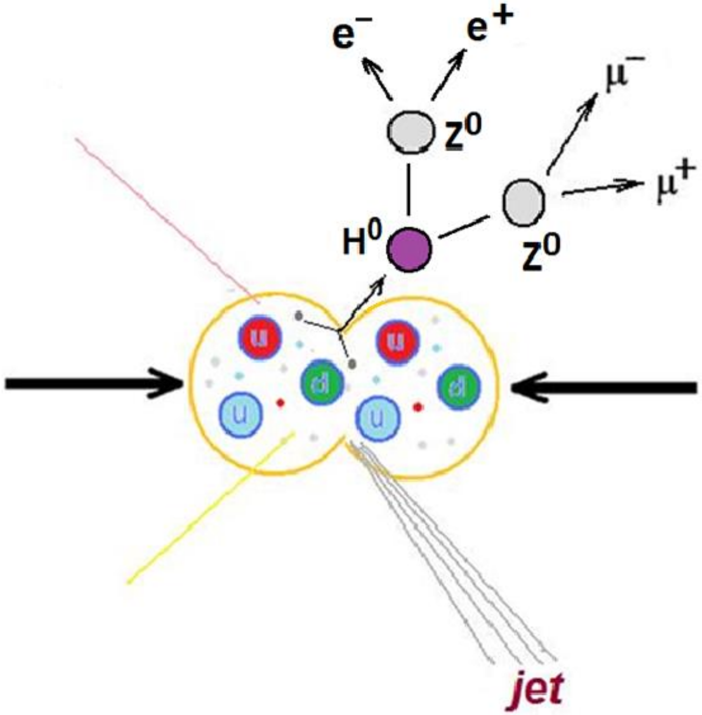
Particle Decays

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.



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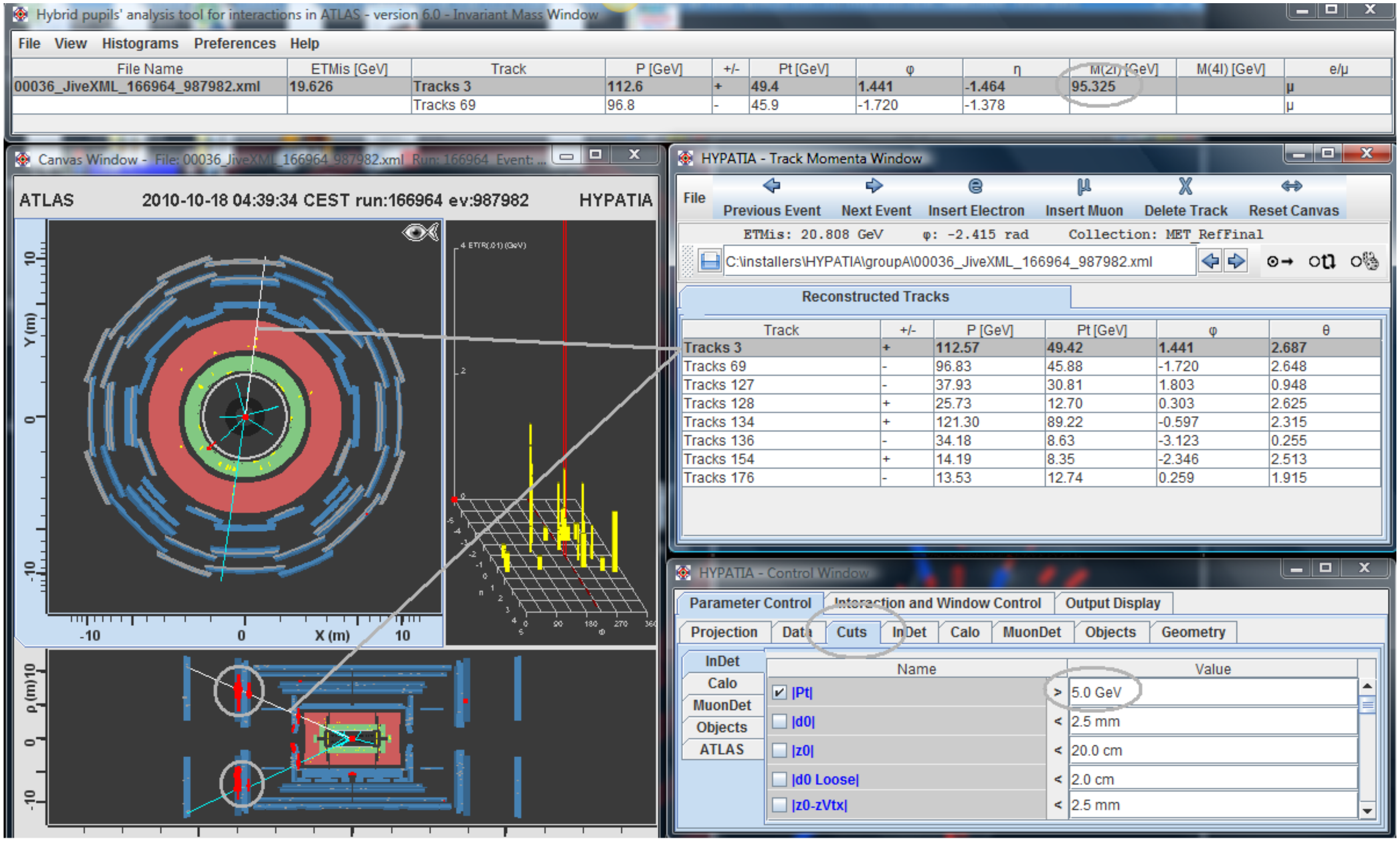
HYPATIA Event Display



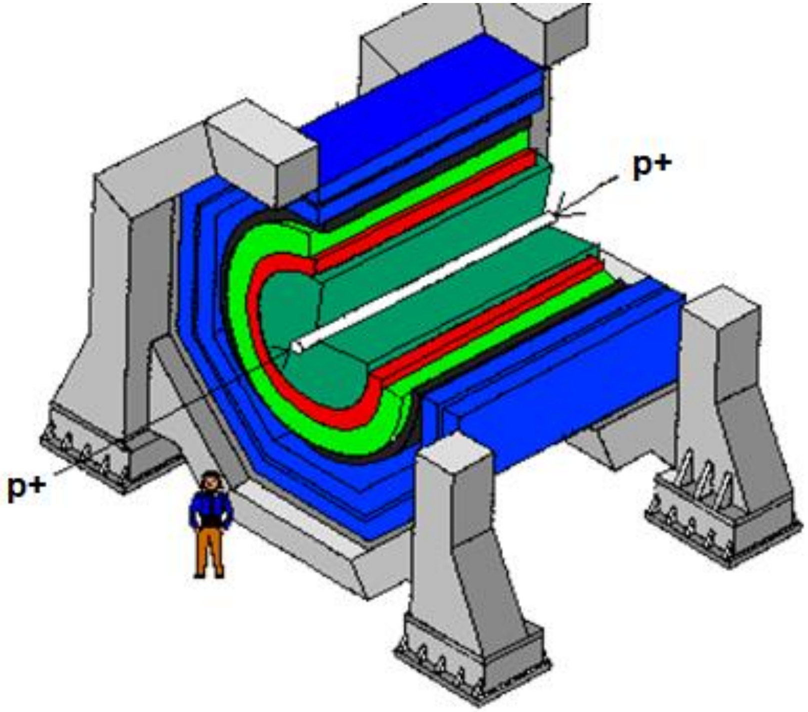
Detectors

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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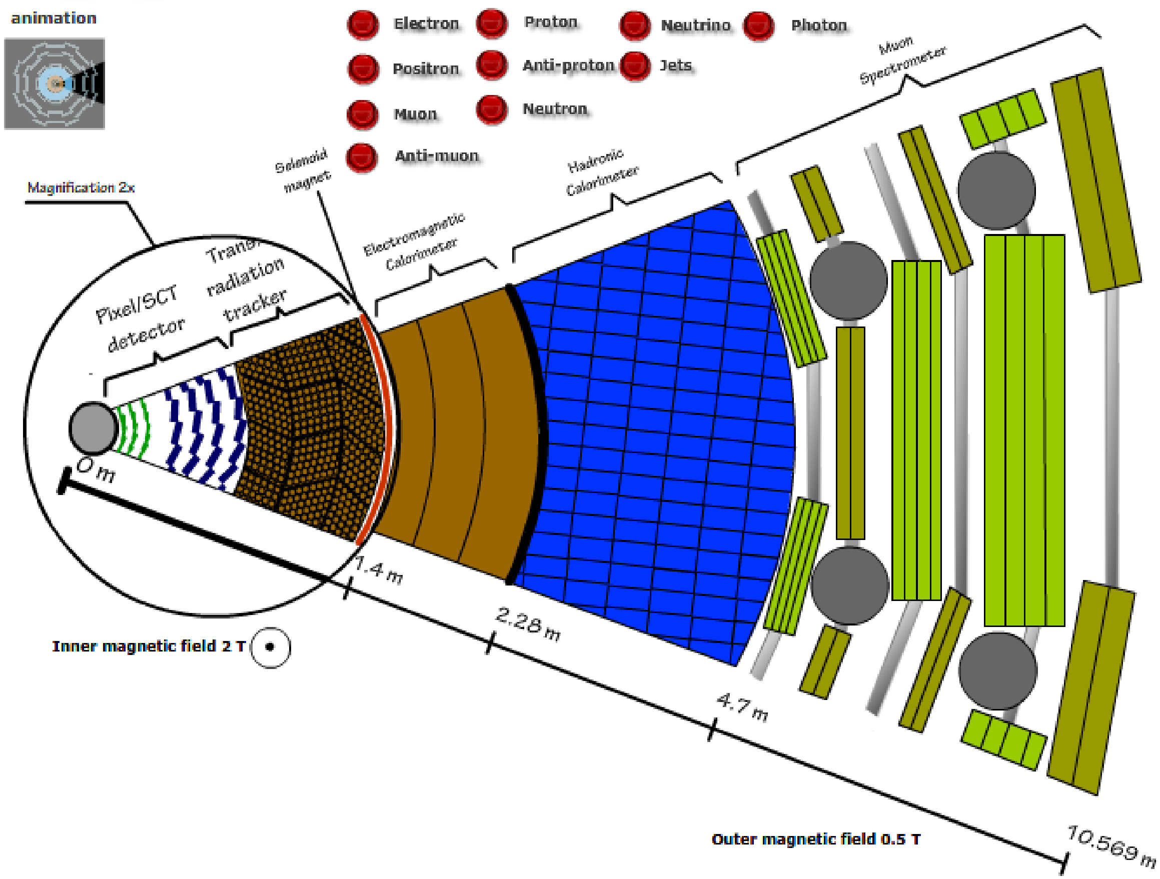
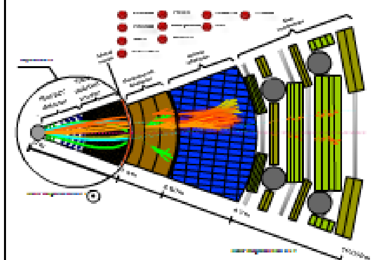
ATLAS Detector

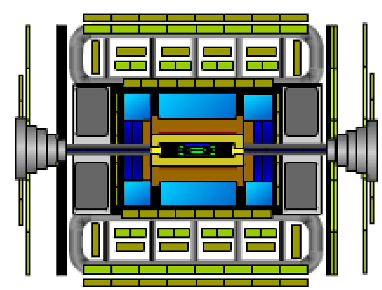
ATLAS

animation





End view



Side view

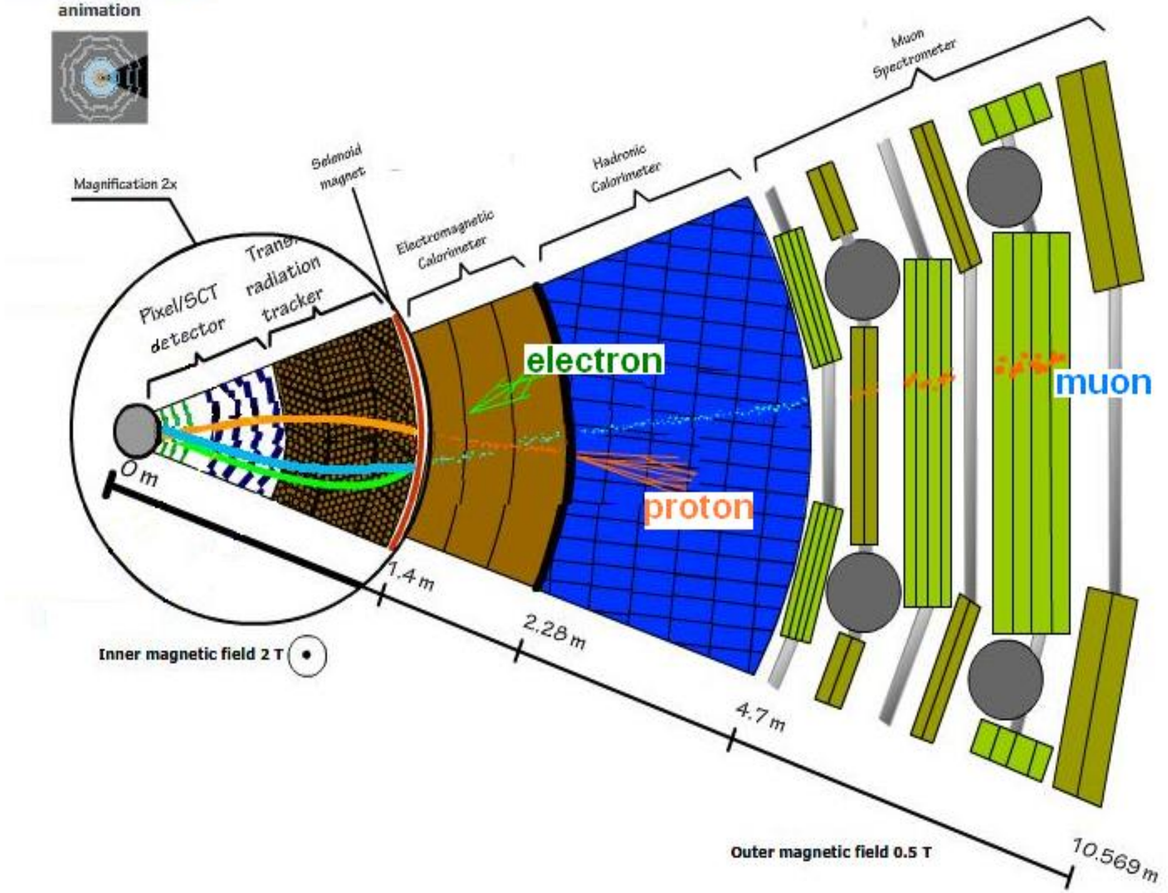
Created by Jeřábek, Jende 2010

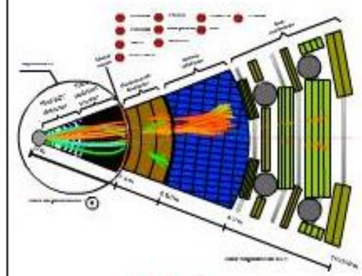
[Play with ATLAS online!]

ATLAS Detector

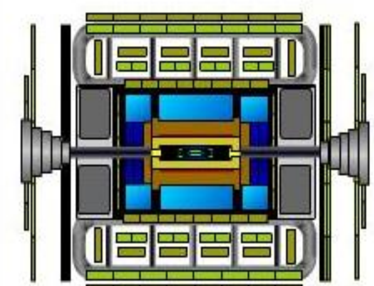
ATLAS

animation





End view



Side view

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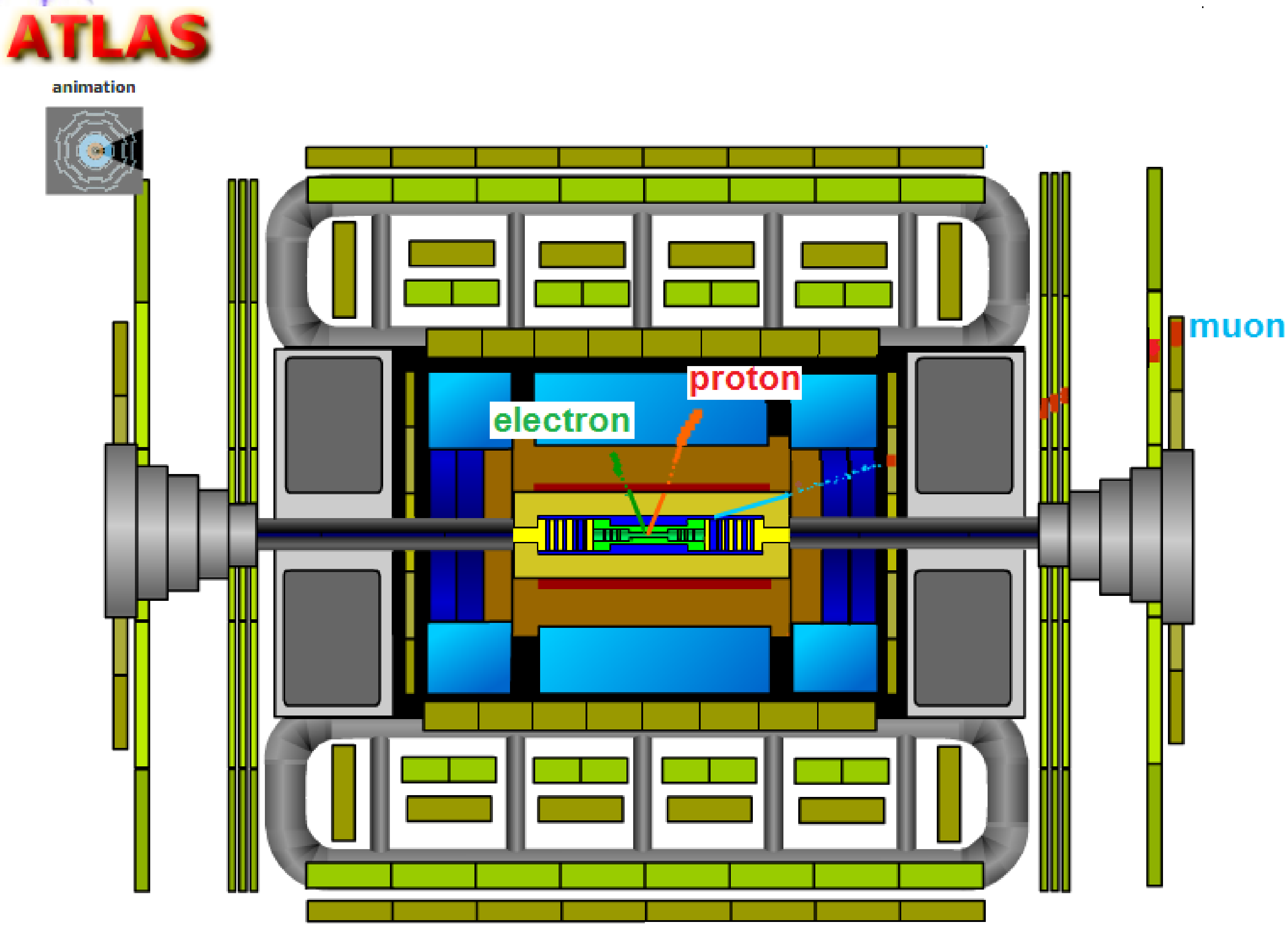
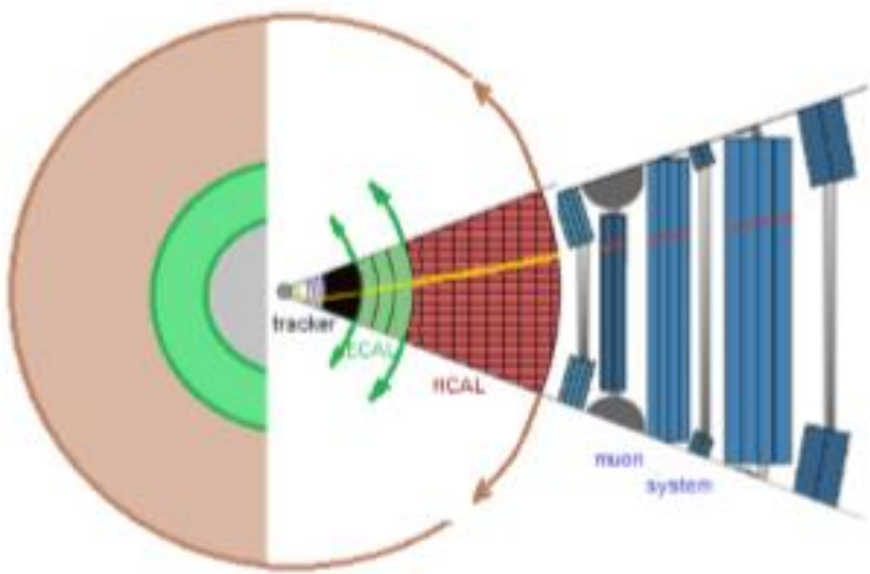
ATLAS Detector



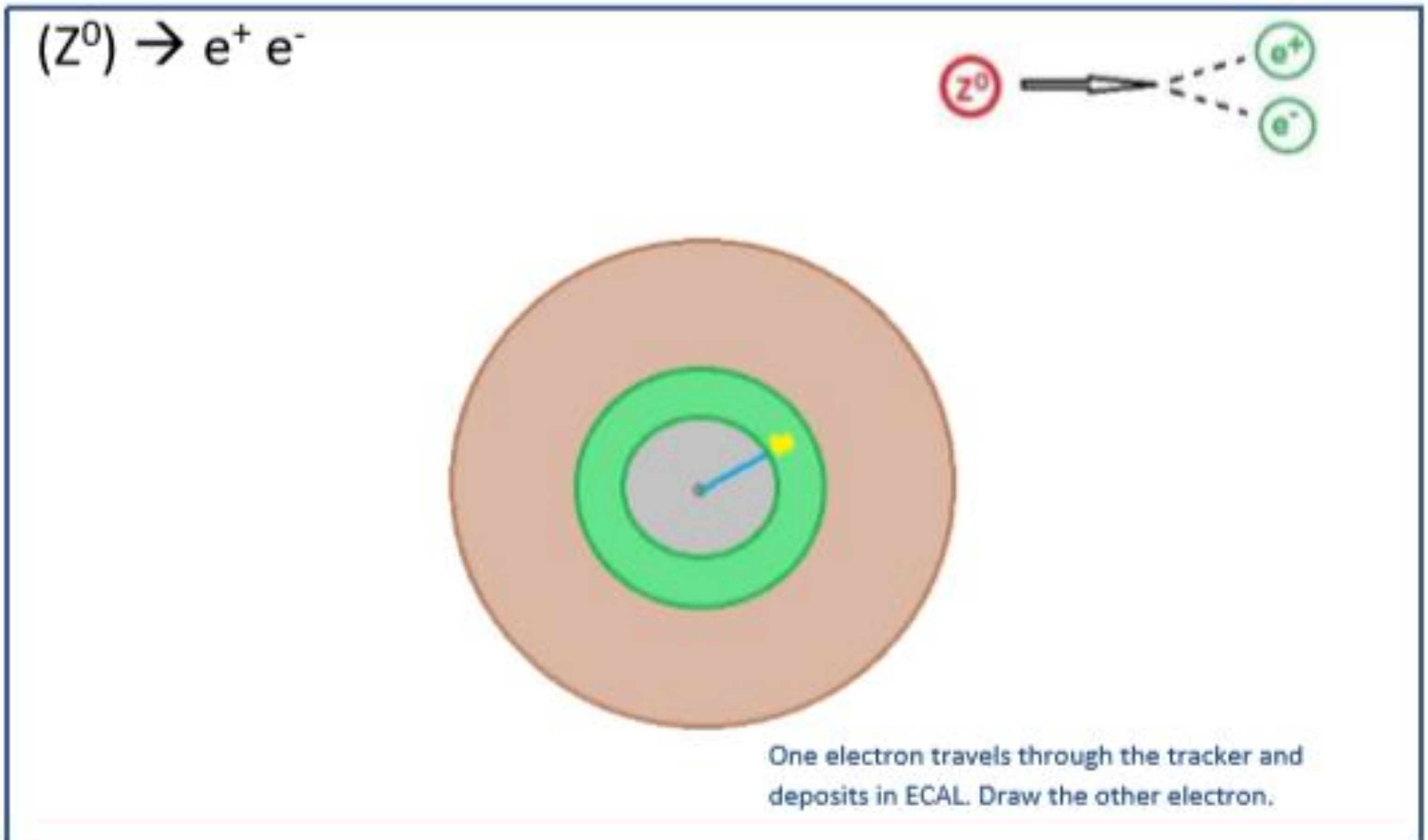
Sketch the tracks in ATLAS

$(Z^0) \rightarrow \mu^+ \mu^-$



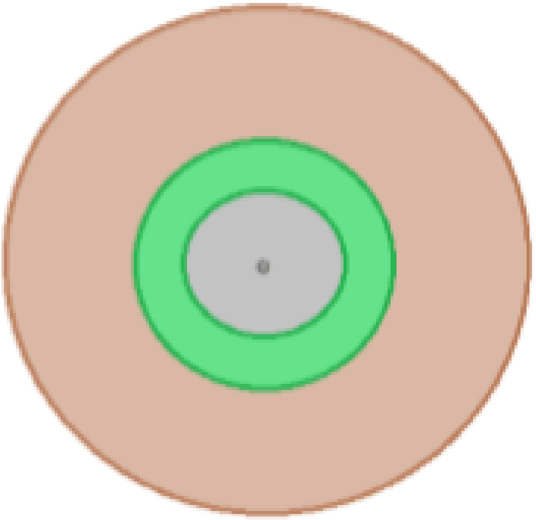
Complete the circles for ECAL and HCAL. One muon travels through the detector slice. Draw the other muon, roughly opposite from the vertex.

Sketch the tracks in ATLAS



Sketch the tracks in ATLAS

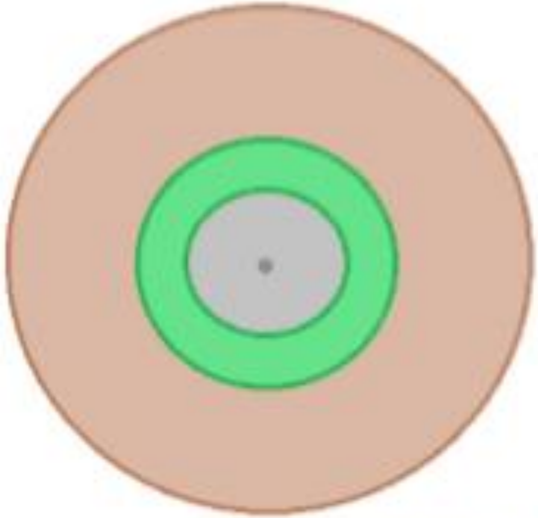
$(H^0) \rightarrow (Z^0 Z^0) \rightarrow$ 4 leptons



Each Z promptly decays into 2 muons or 2 electrons. Draw a combination of muons and/or electrons that results.

Sketch the tracks in ATLAS

$(H^0) \rightarrow \gamma\gamma$



Each photon (γ) is undetected by the tracker but leaves a deposit in ECAL. Draw them.

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!