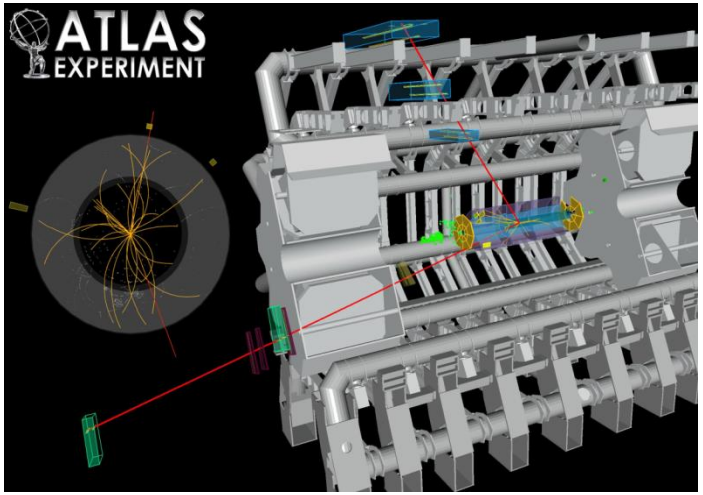
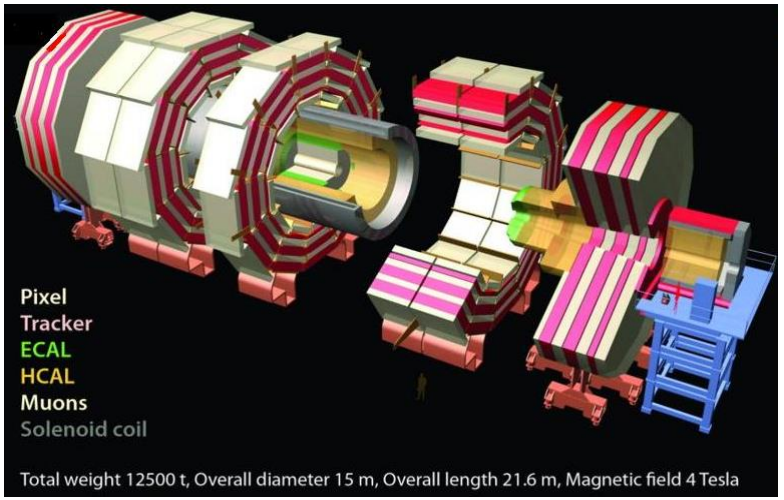
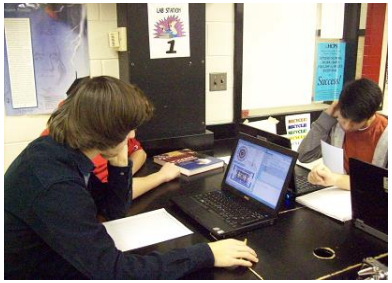
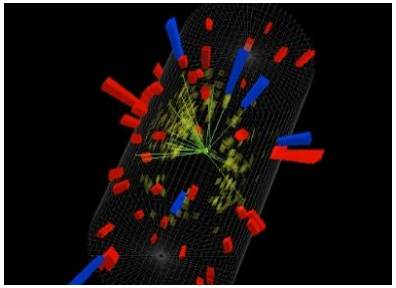
Compact W and Z Masterclass 2015









INTERNATIONAL MASTERCLASSES
hands on particle physics

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CERN

The LHC and New Physics

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

At CERN, the LHC and its experiments are underway.

The ATLAS and CMS detectors have been taking data. The first job was to confirm how the data corresponds to our understanding we call the ***Standard Model****.*

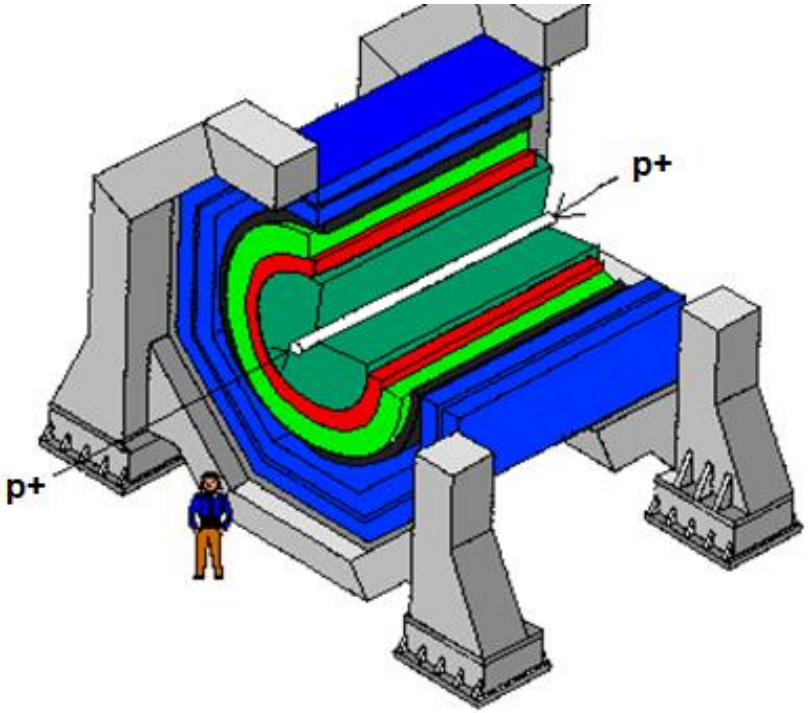
Detectors

Generic Detector Design

Cylinders wrapped around the beam pipe

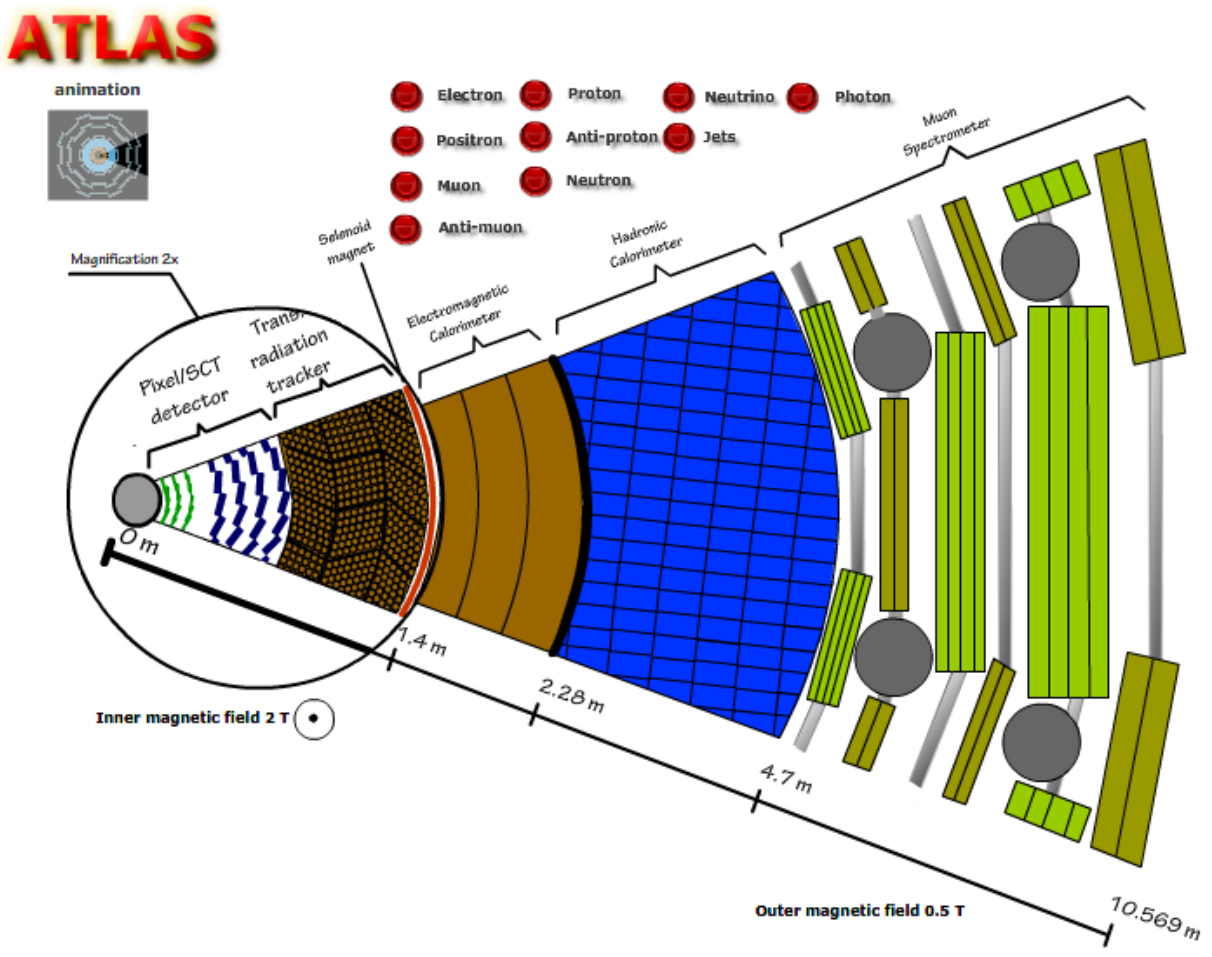
From inner to outer . . .

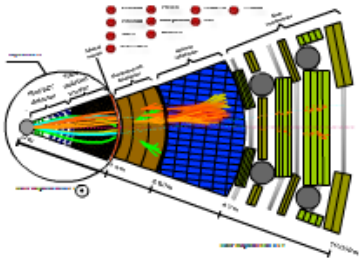
- Tracking
- Electromagnetic calorimeter
- Hadronic calorimeter
- Magnet*
- Muon chamber



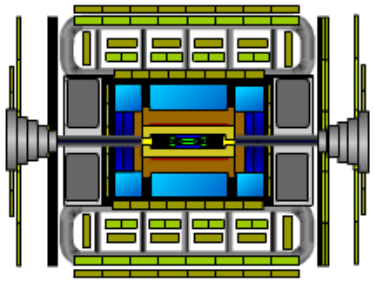
**Location of magnet depends on specific detector design.*

ATLAS Detector





End view

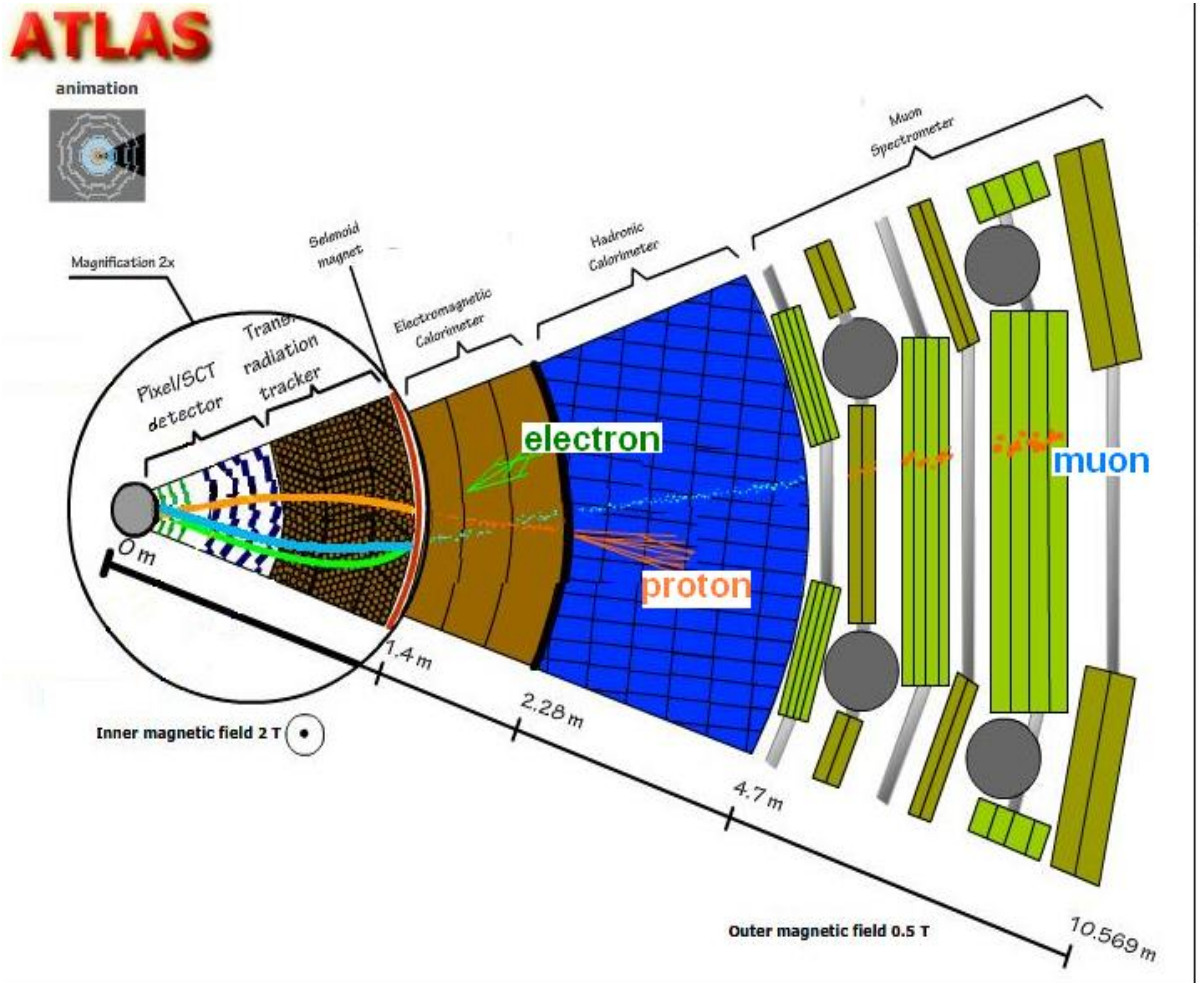


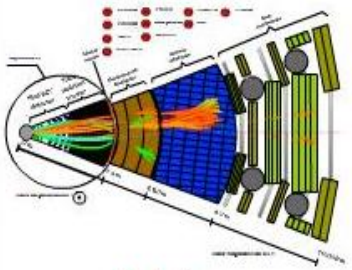
Side view

Created by Jeřábek, Jende 2010

Play with ATLAS online!

ATLAS Detector





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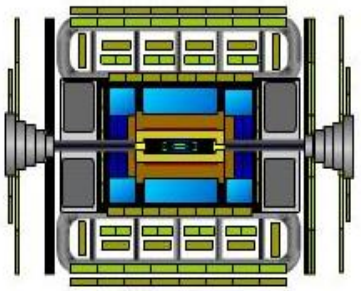

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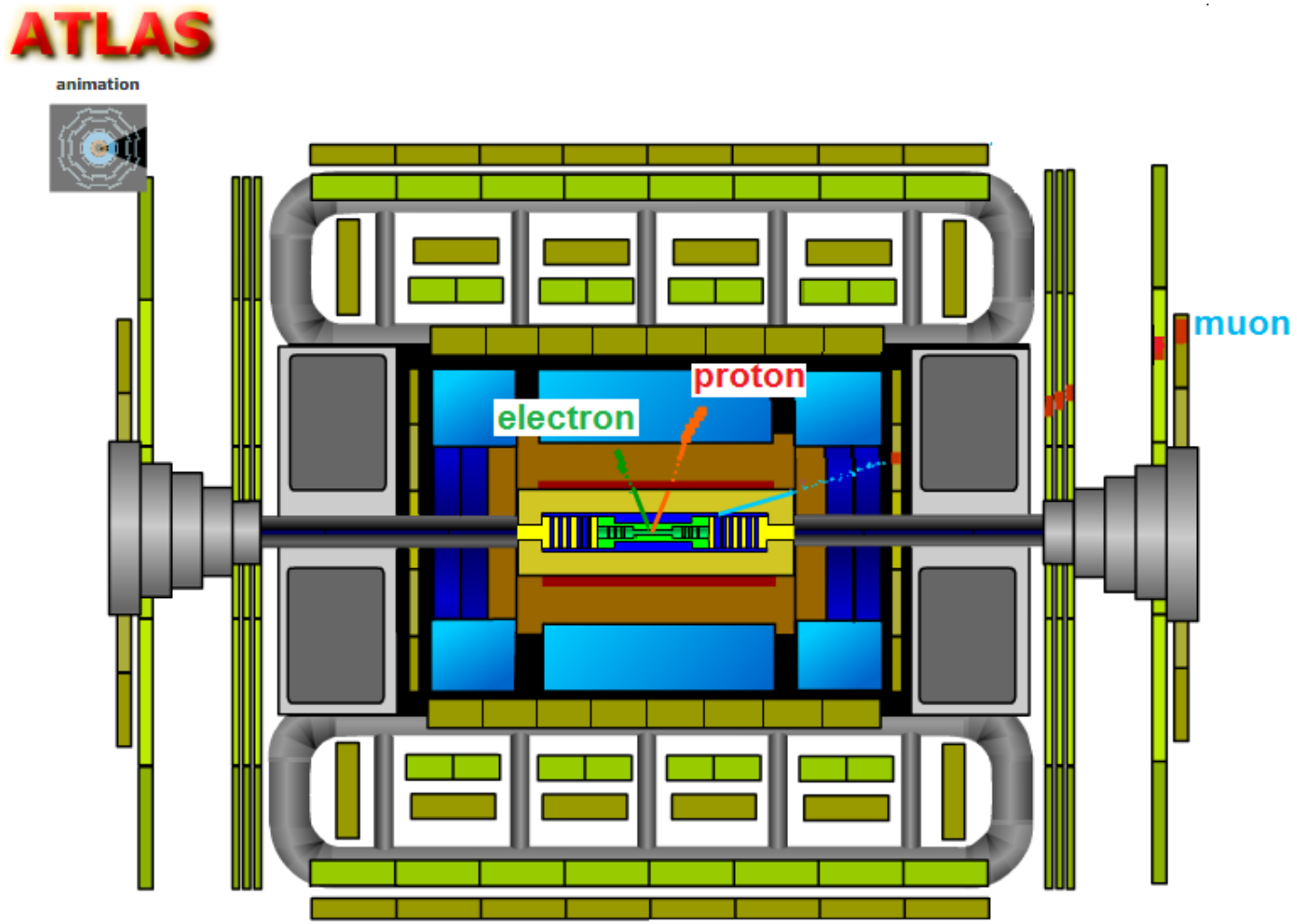
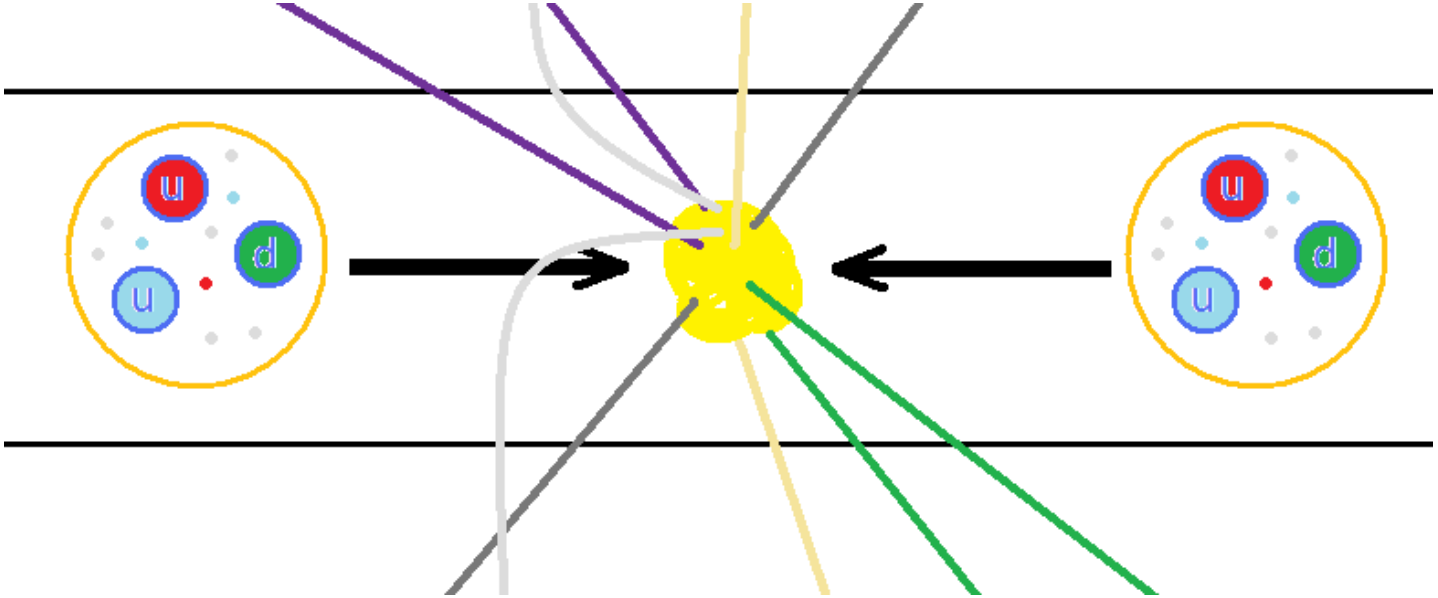
ATLAS Detector



Proton Interactions

If each beam proton has energy 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.

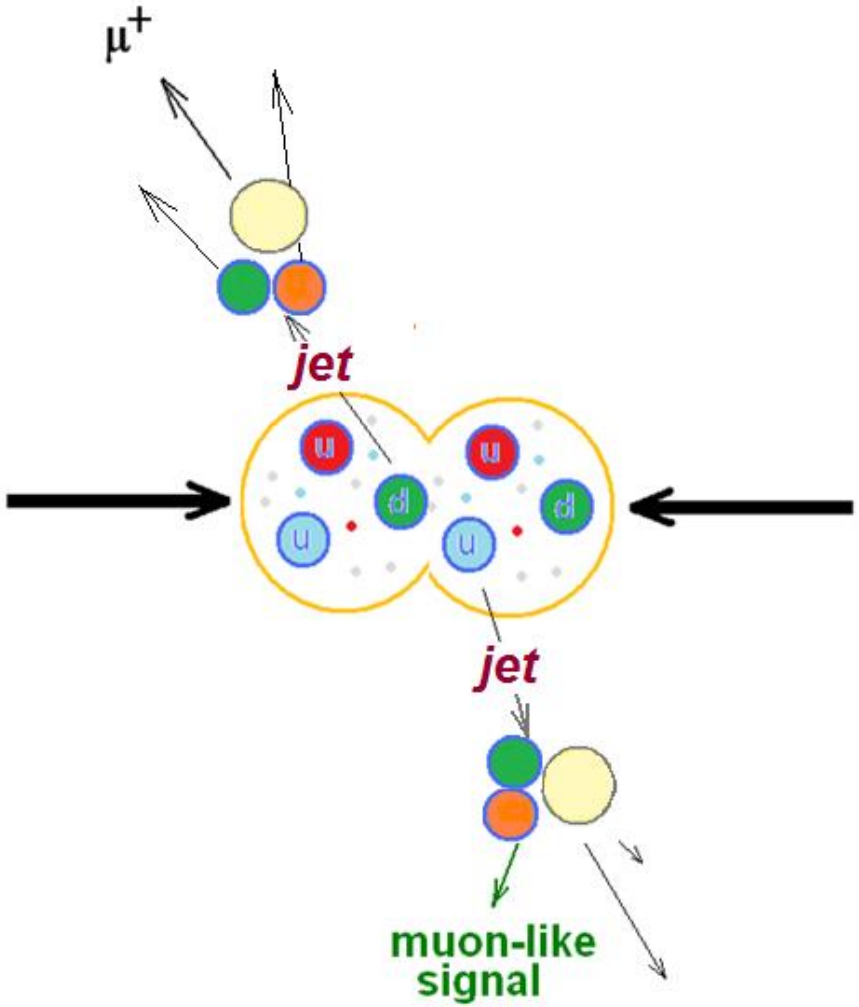


Particle Decays

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.

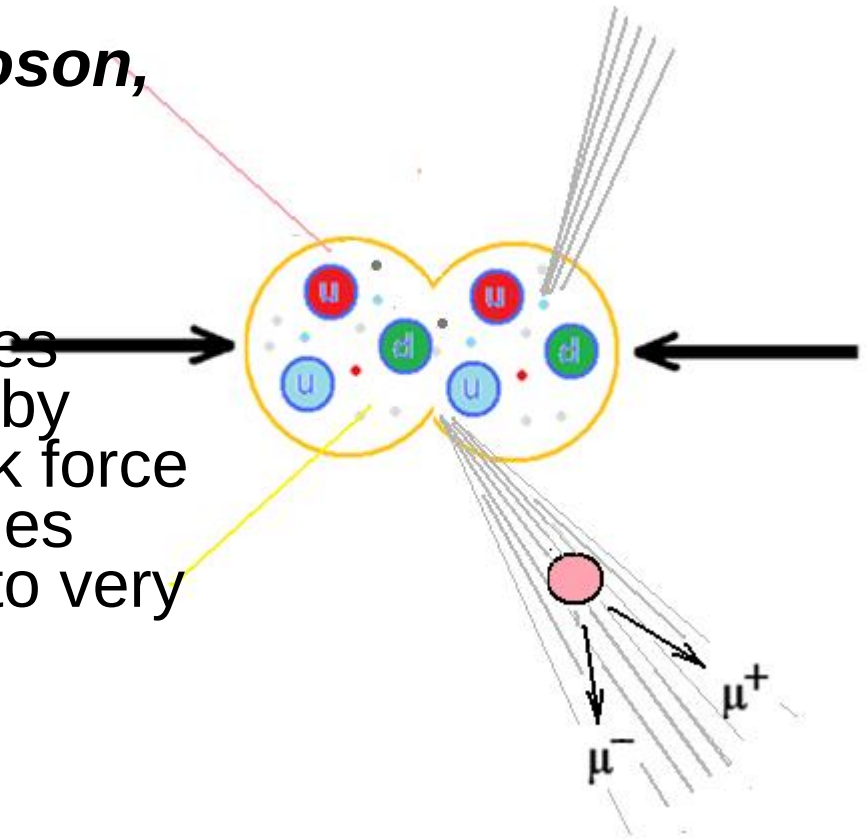


W and Z Particles

We are looking for the mediators of the ***weak interaction;***

- electrically charged W^+ ***boson,***
- the negative W^- ***boson,***
- the neutral ***Z boson***.

Unlike electromagnetic forces carried over long distances by massless photons, the weak force is carried by massive particles which restricts interactions to very tiny distances.

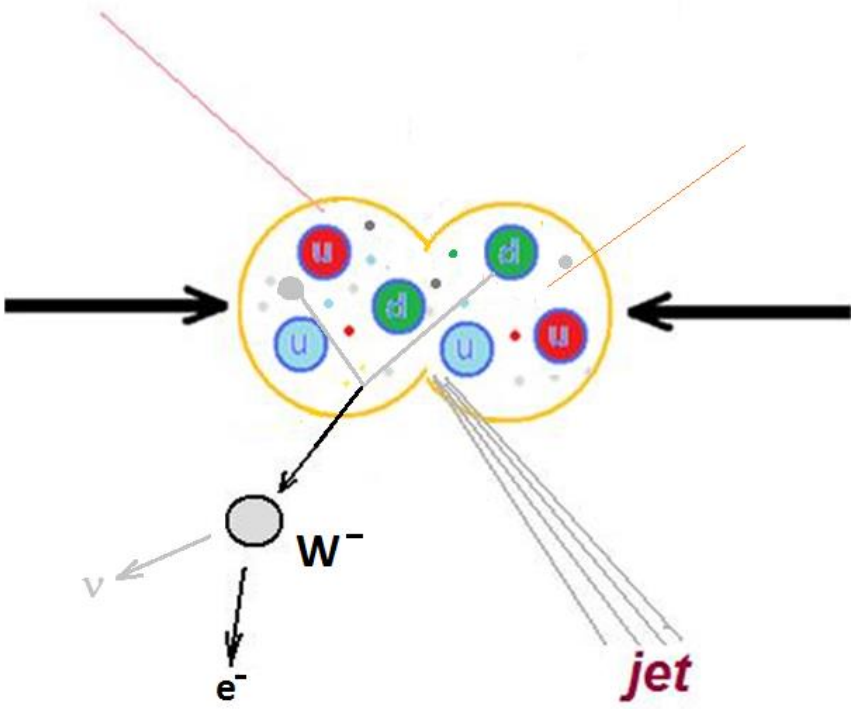


W and Z Particles

The W bosons are responsible for radioactivity by transforming a proton into a neutron, or the reverse.

Z bosons are similarly exchanged but do not change electric charge.

Collisions of sufficient energy can create W and Z or other particles.



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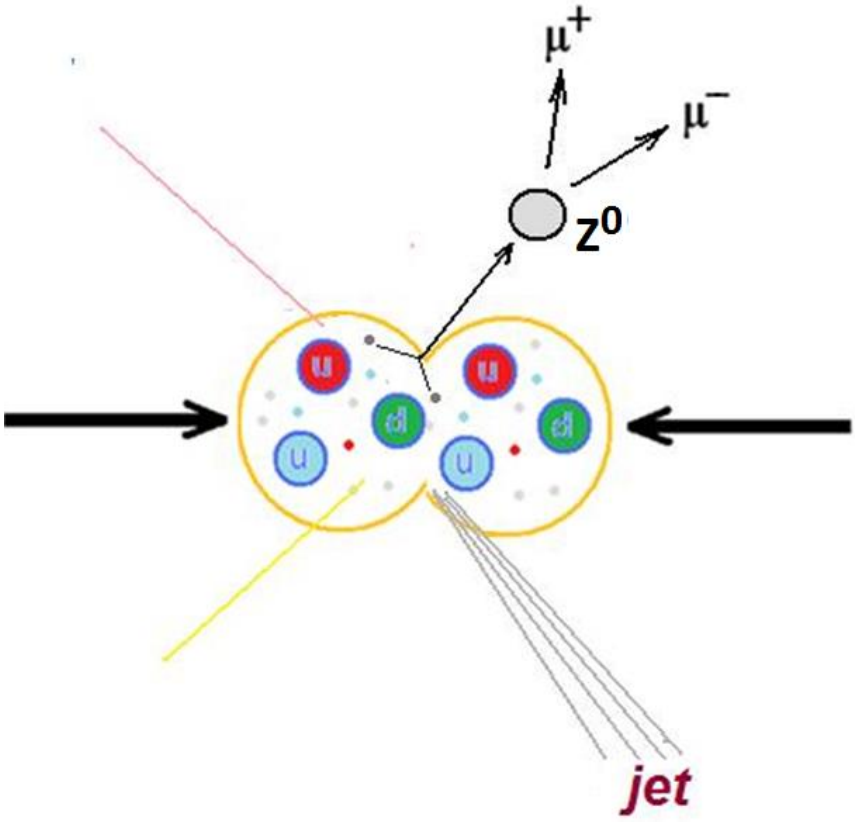
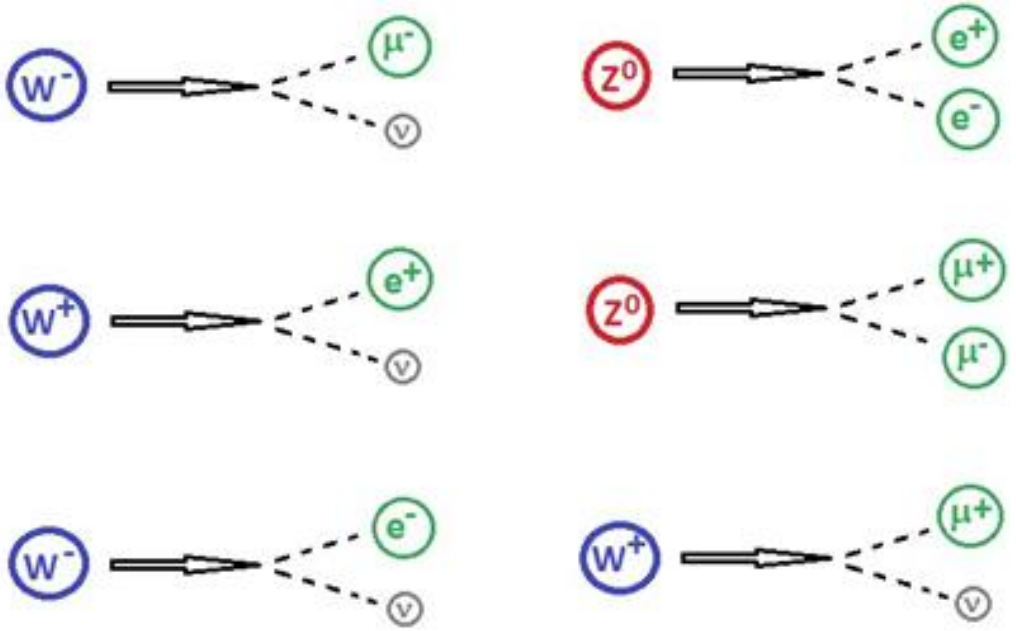


W and Z Decays

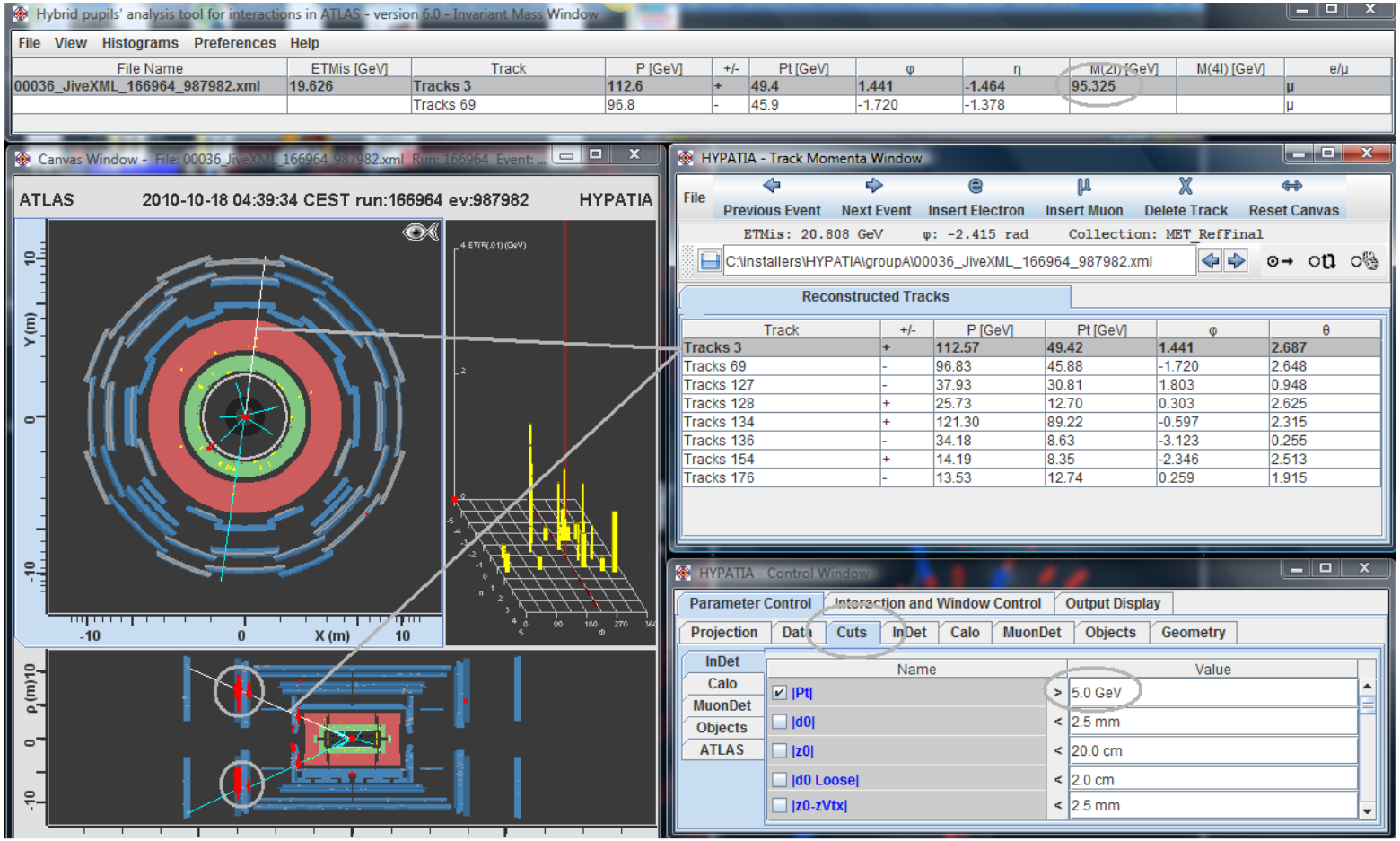
Because bosons only travel a tiny distance before decaying, ATLAS and CMS do not “see” them directly.

We *can* detect :
- electrons
- muons
- photons

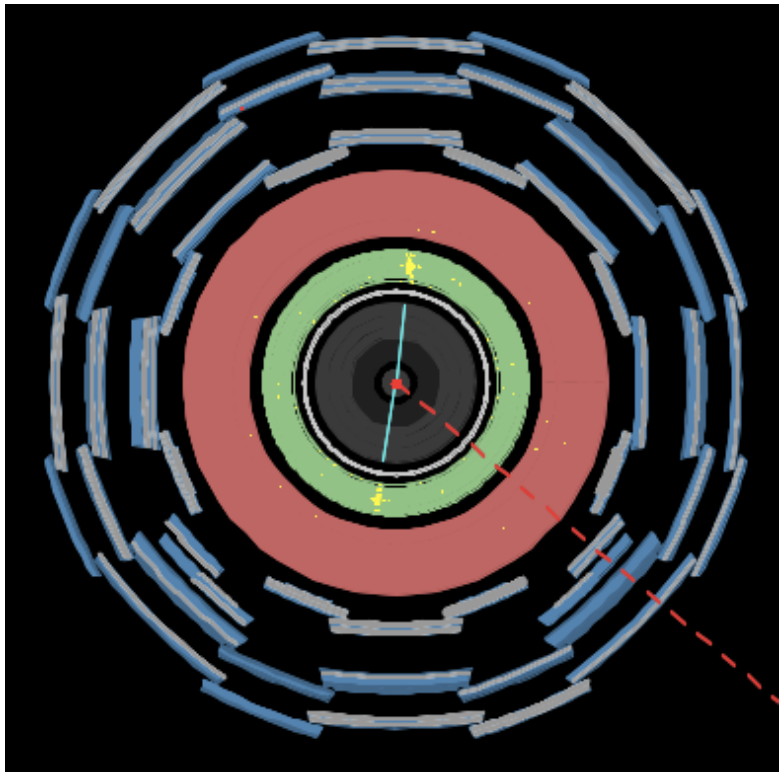


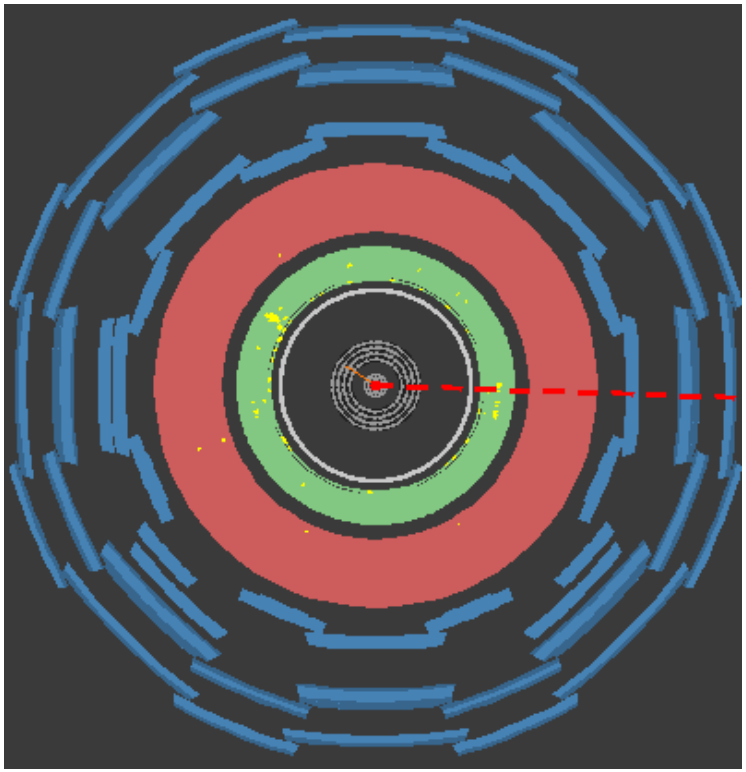
We can infer:
- neutrinos from “missing energy”

ATLAS Event Display



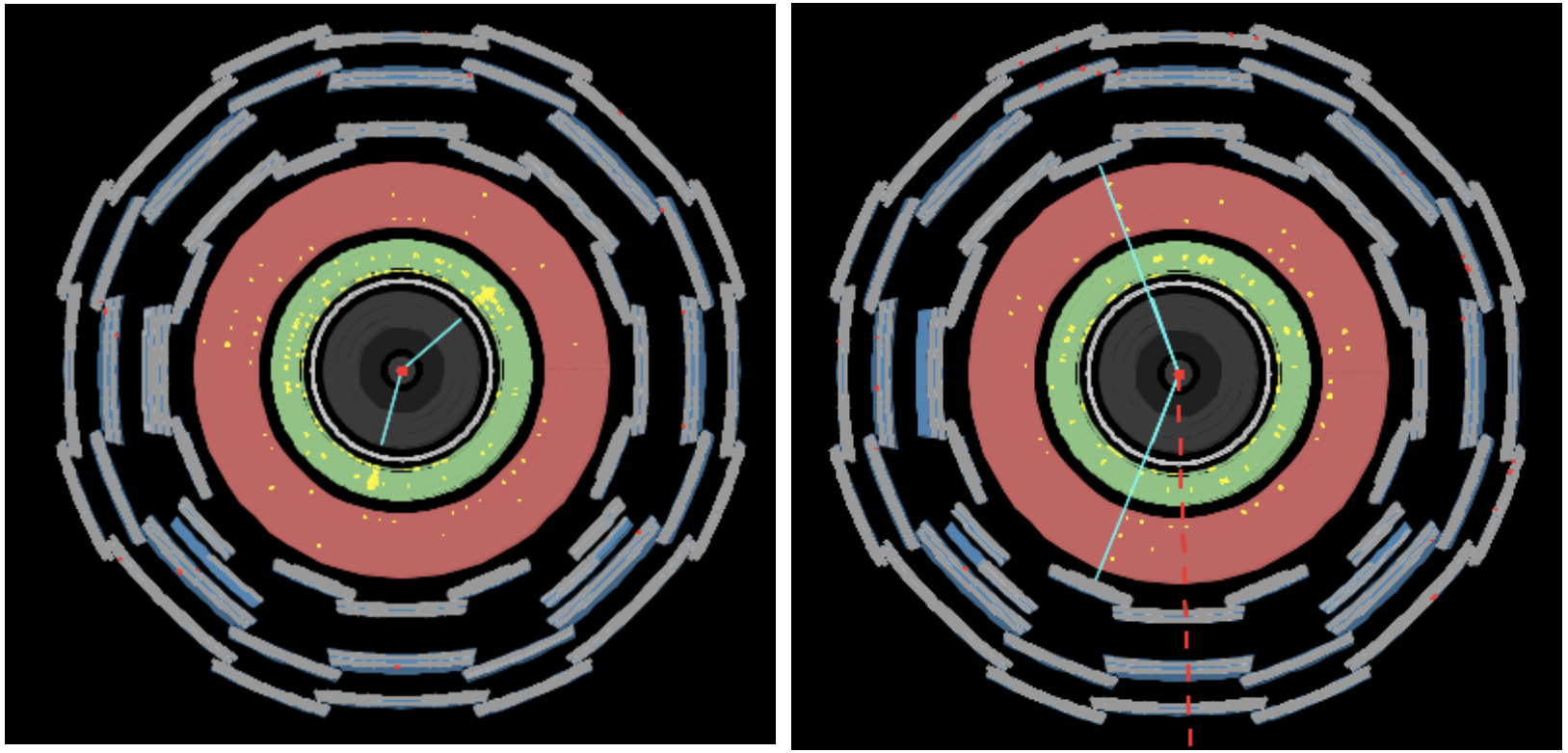
ATLAS Event Display





How are these events similar? Different? Why?

ATLAS Event Display



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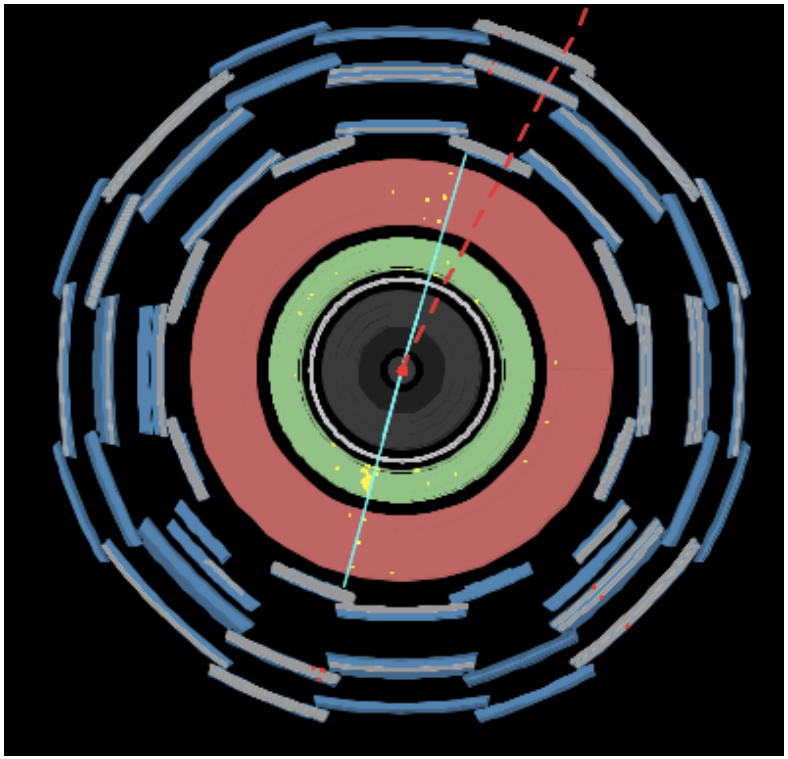

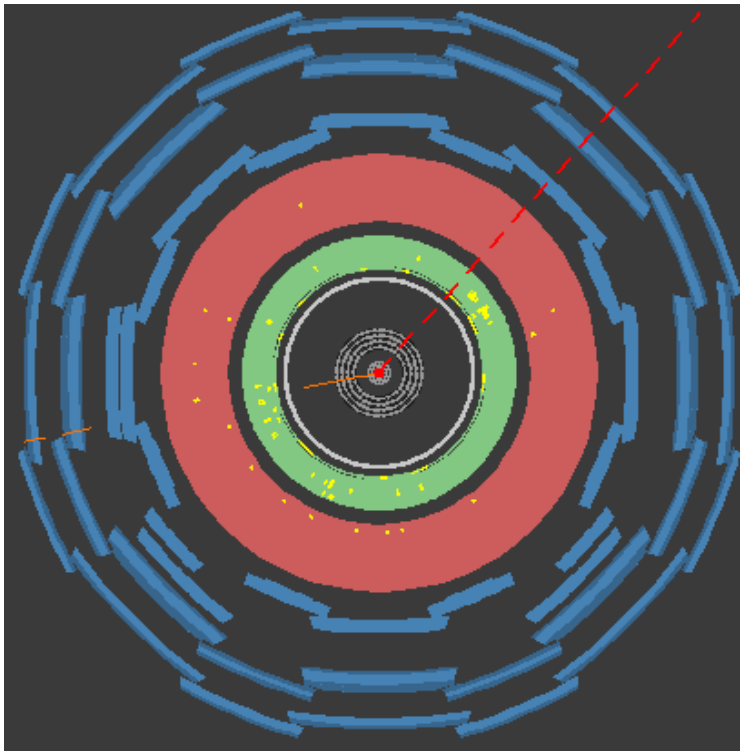

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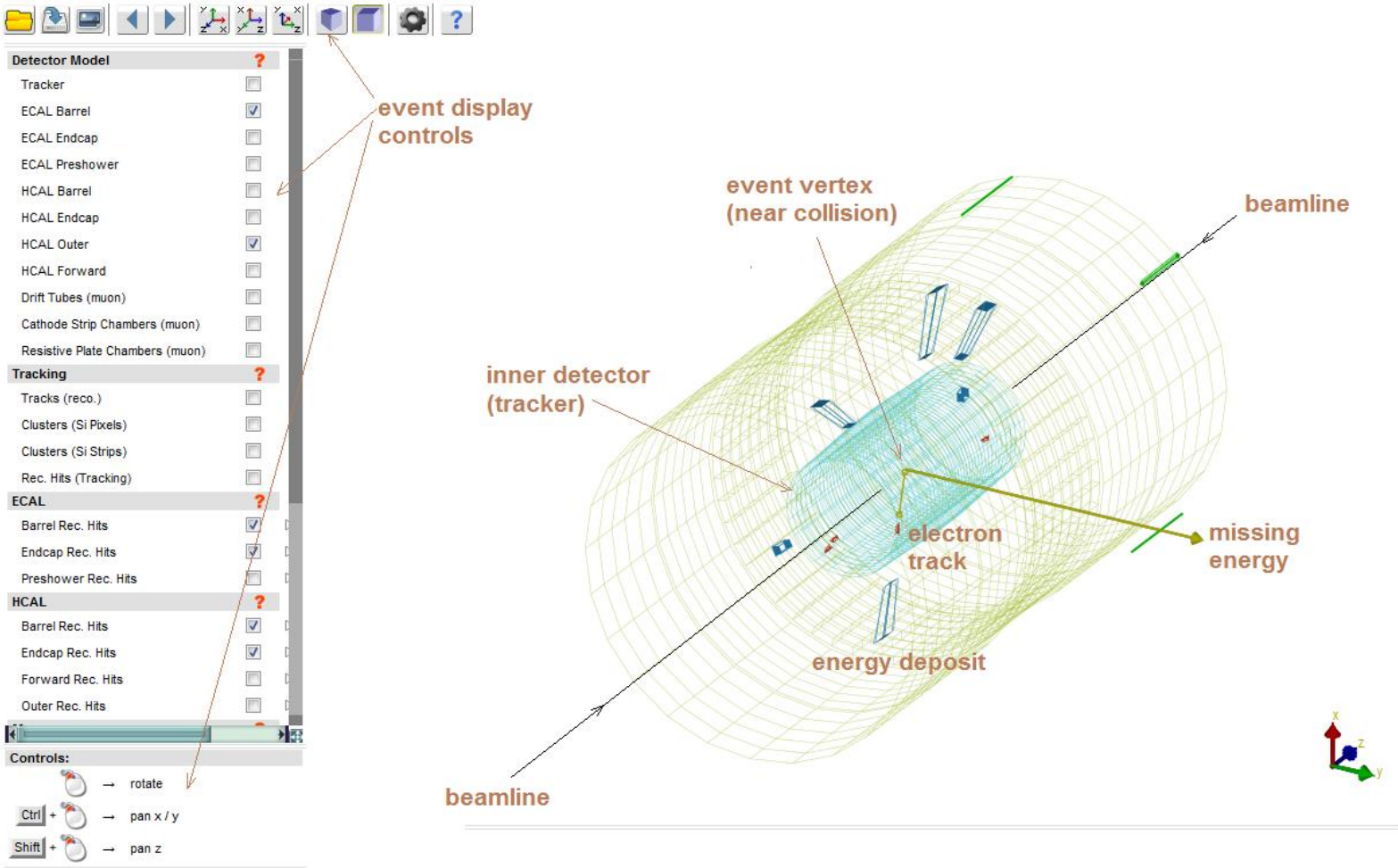
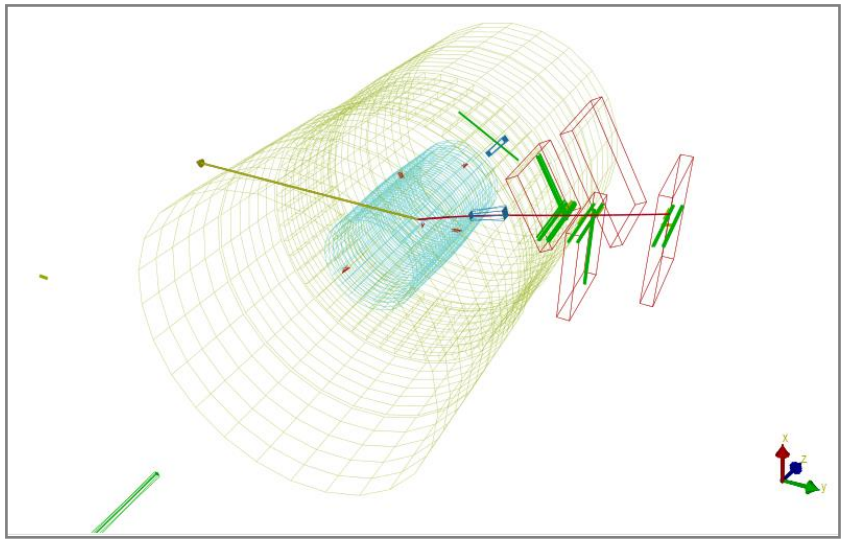
CMS Event Display

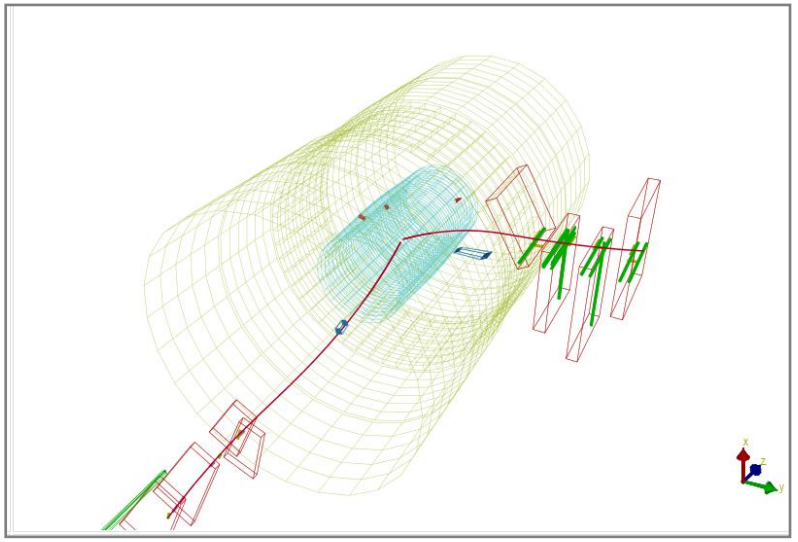


CMS Event Display

Use new data from the LHC in iSpy to test performance of CMS:

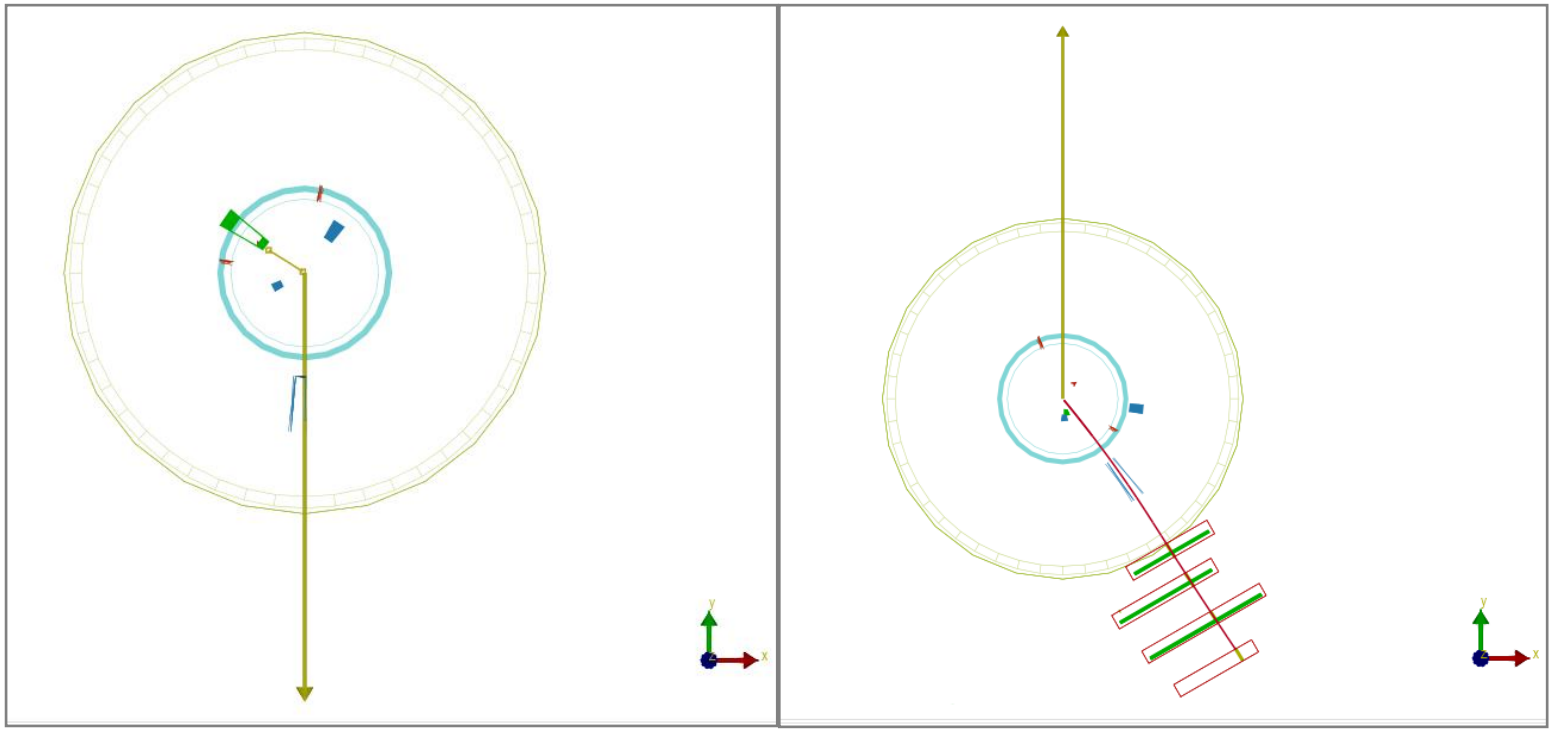
- Can we distinguish W from Z candidates?





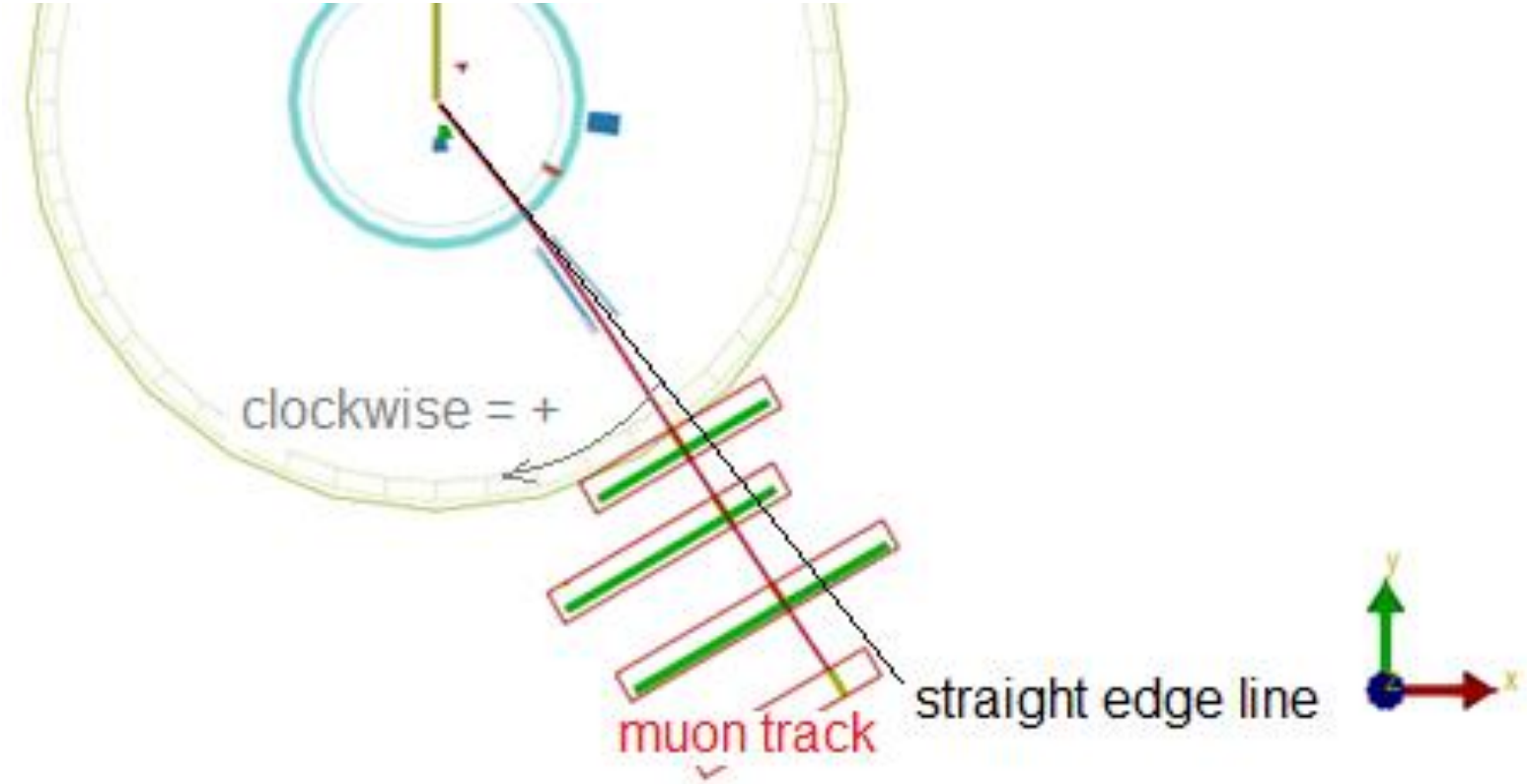
CMS Event Display

- Can we calculate the e/μ ratio?



CMS Event Display

- Can we calculate a W+/W- ratio for CMS?



Analyze Events!

Make an ATLAS team and a CMS team.

Practice events.

Find good Z and W candidates…and more.

Which events will be included in the mass plot? Which will give us W+/W- ?

Report! Rapport! Rejoice! Relax!