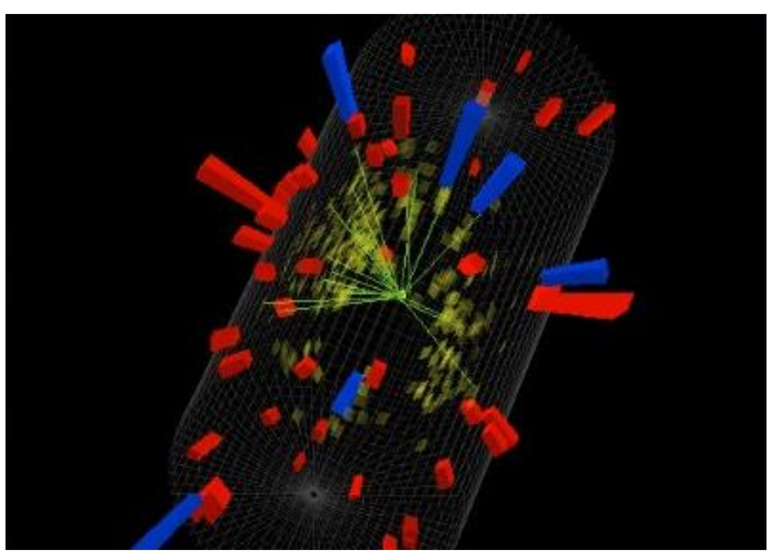
Helping Develop America's Technological Workforce

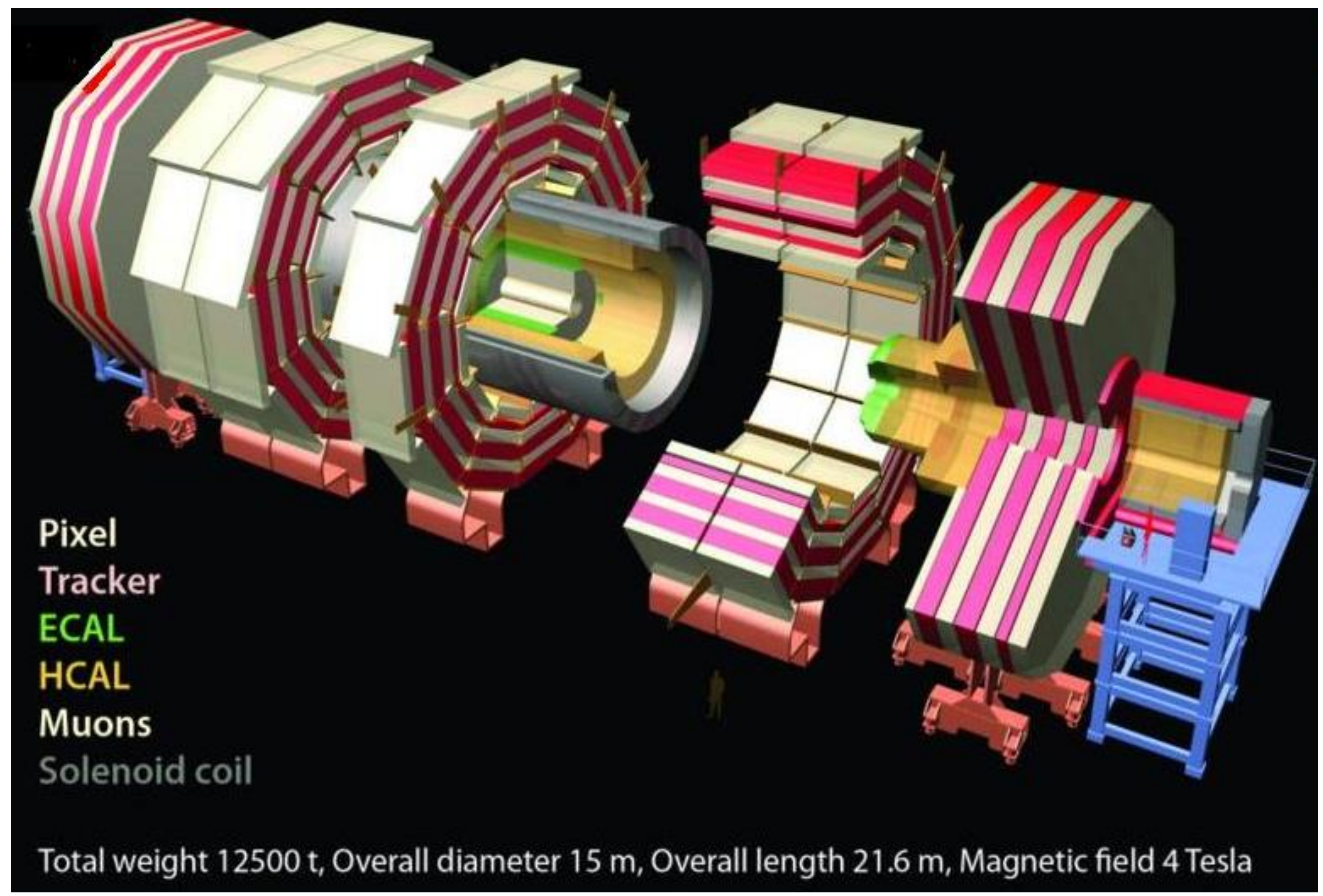
QuarkNet

INTERNATIONAL MASTERCLASSES

hands on particle physics

CMS Dielectron Analysis





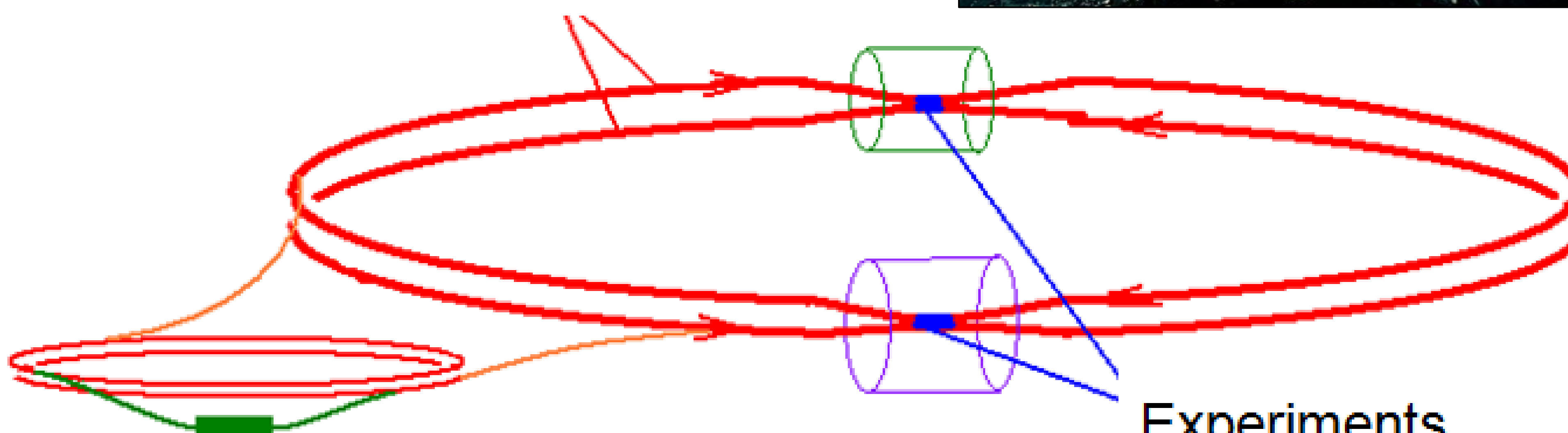
The LHC and New Physics

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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Detector Design

Generic Design

Cylinders wrapped around the beam pipe

From inner to outer . . .

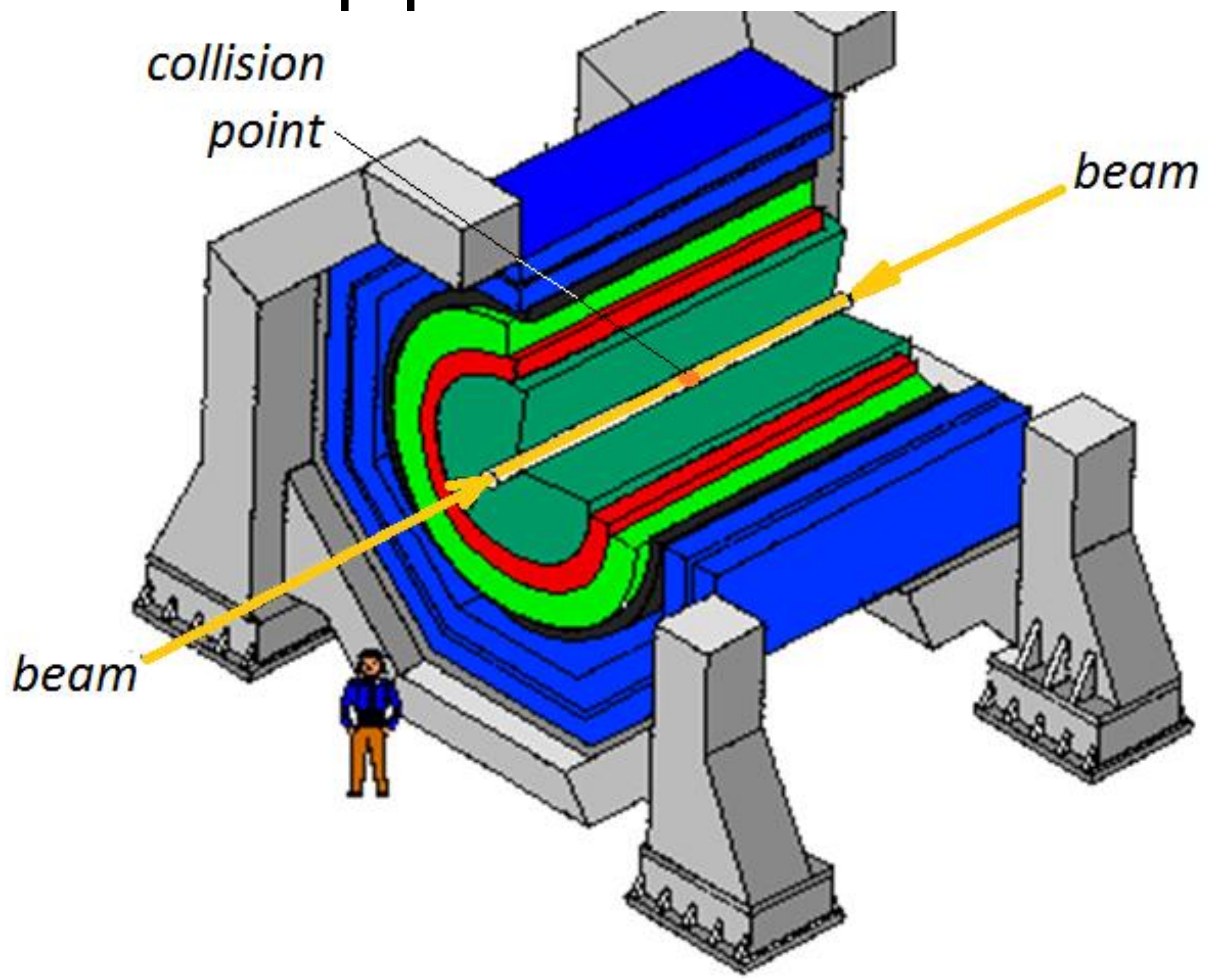
Tracking

Electromagnetic calorimeter

Hadronic calorimeter

Magnet*

Muon chamber



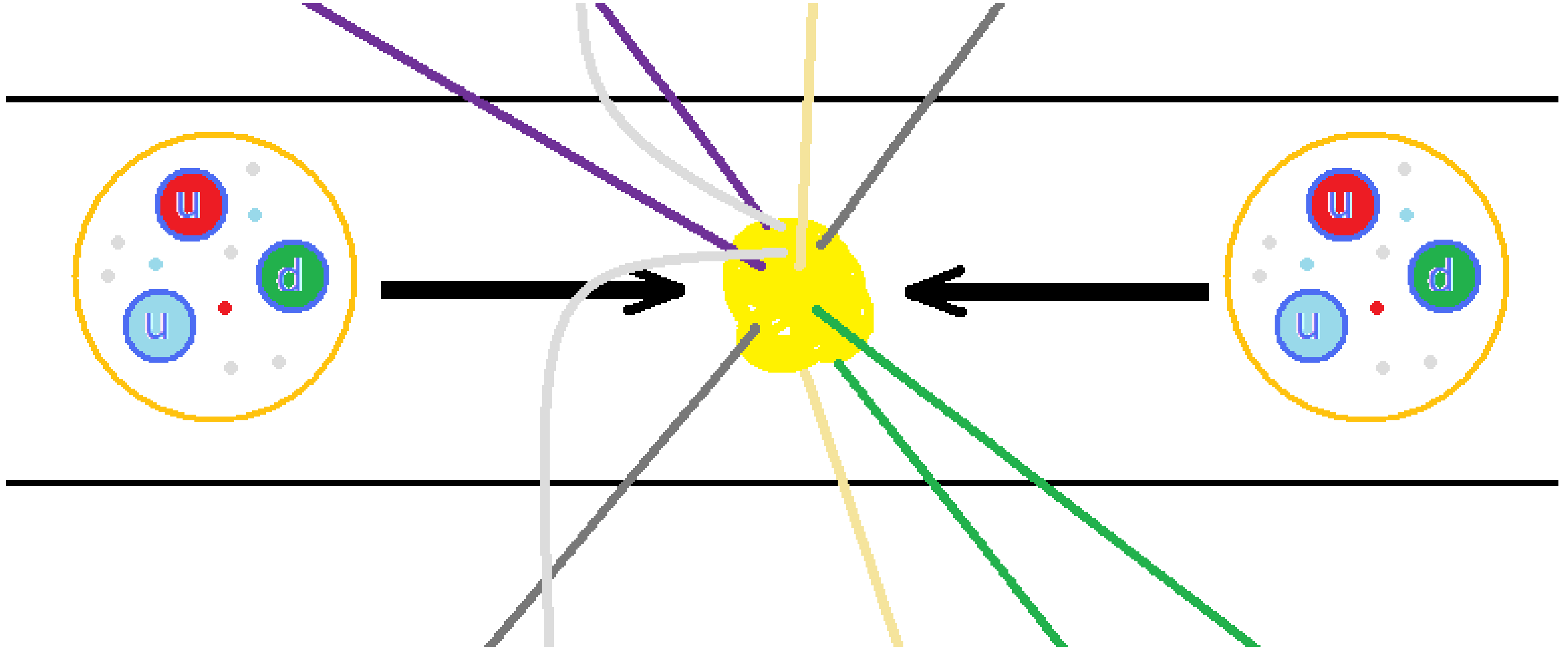
* *location of magnet depends on specific detector design*

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!*

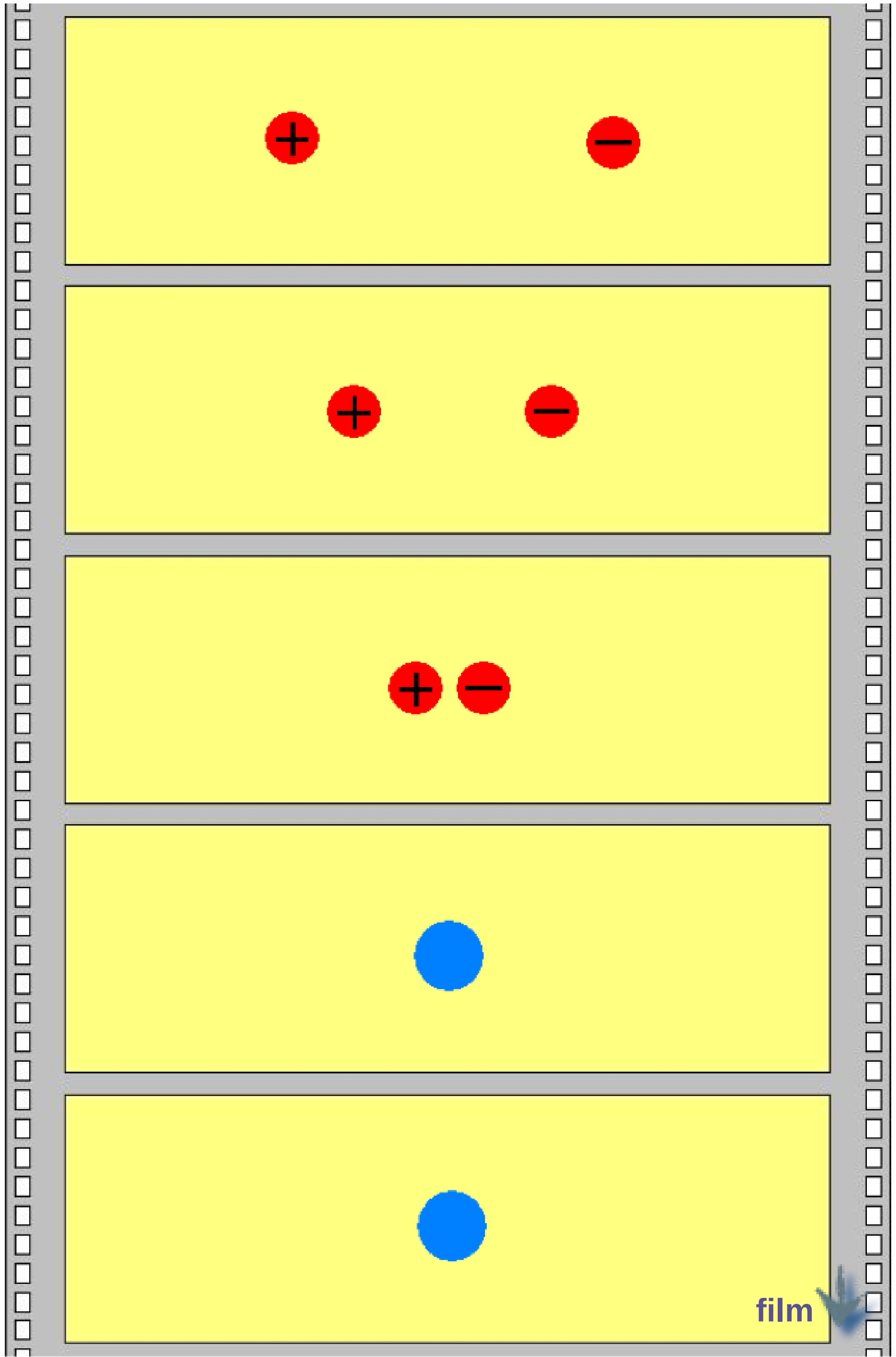


Particle Decays

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

Conservation laws allow us to see patterns in the decays.

Try to name some of these conservation laws.



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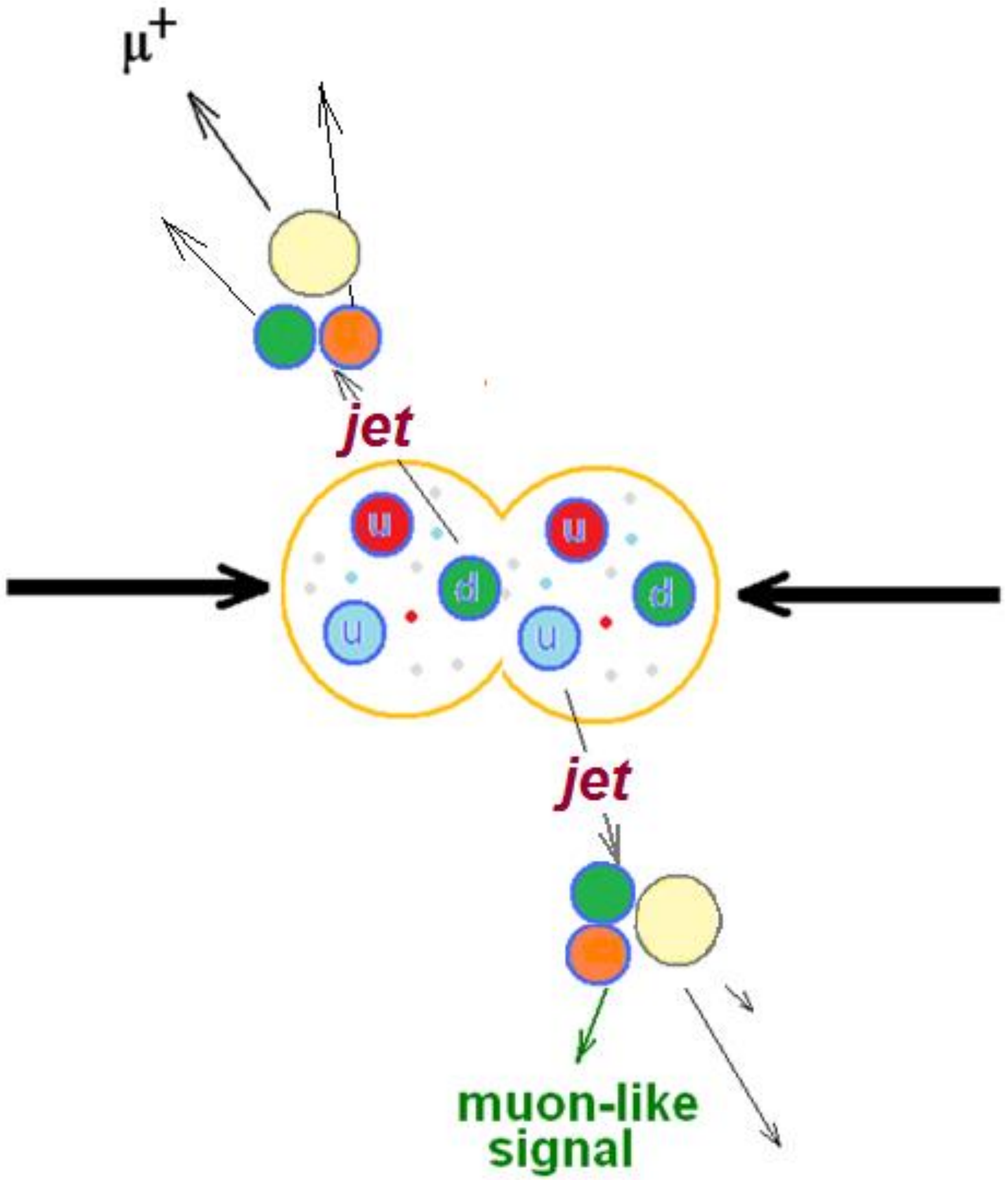
Background Events

Often, quarks are scattered by proton collisions.

As they separate, the binding energy between them converts to sprays of new particles called ***jets.*** Electrons and muons may be included in jets.

Software can filter out events with jets beyond our current interest.

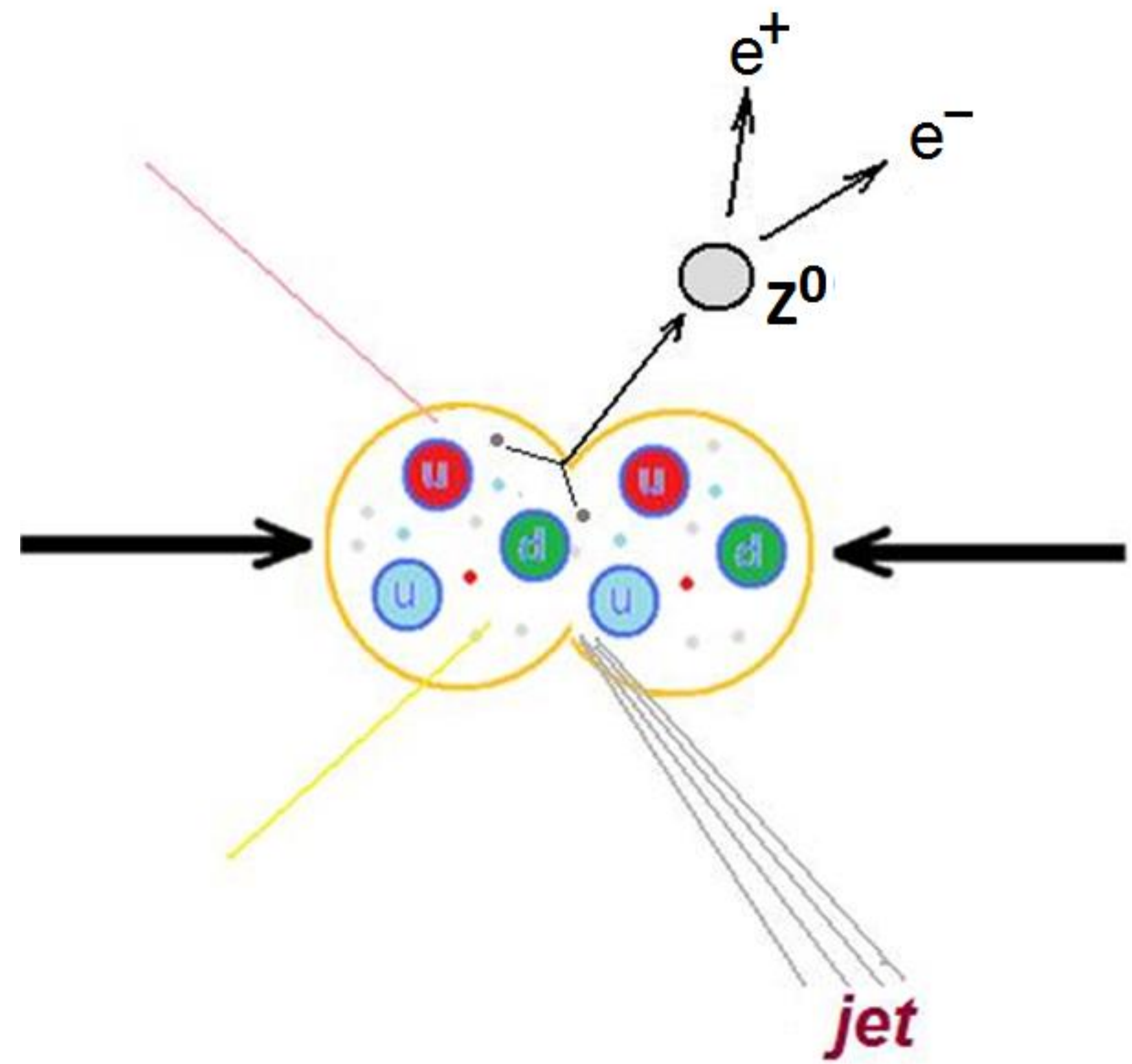


W and Z Particles

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.

We are looking for Z bosons that decay into electrons and positrons.



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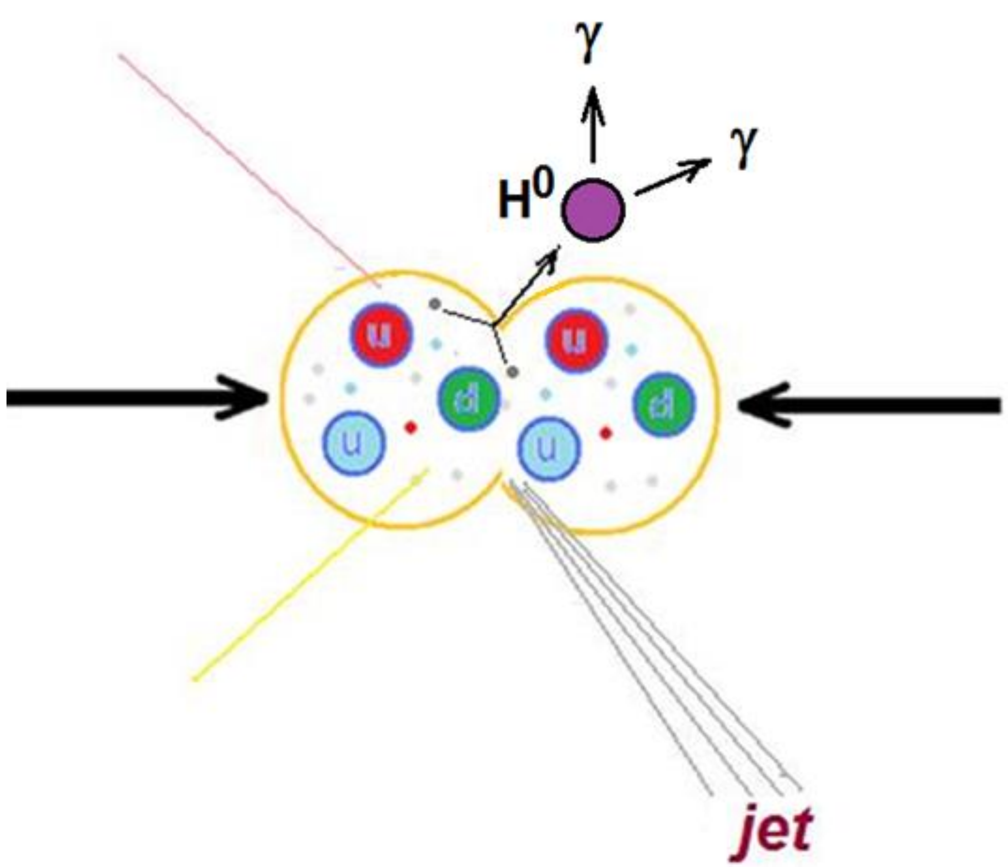
Higgs Particles

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

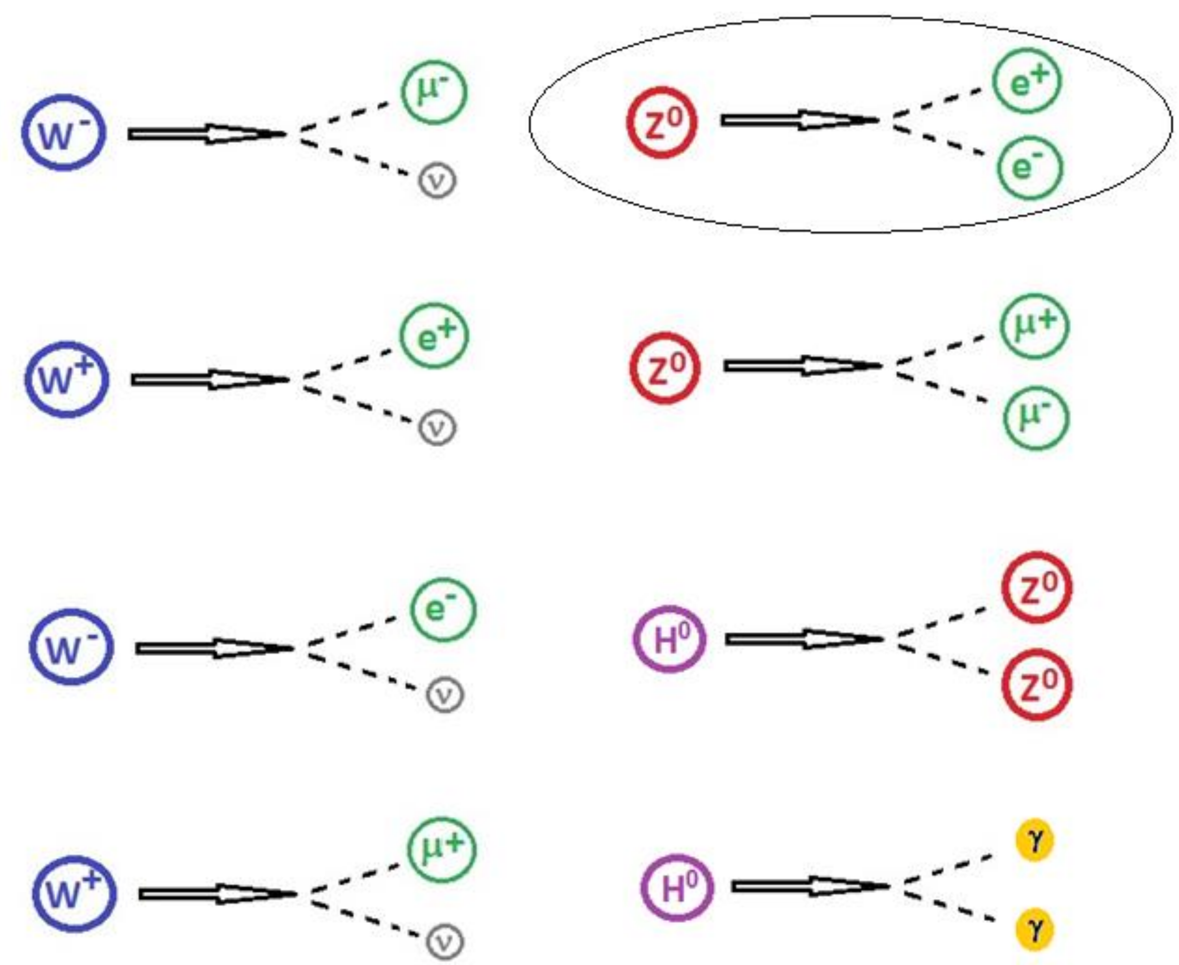
This long-sought particle is part of the "Higgs mechanism" that accounts for other particle having mass.



W and Z Decays

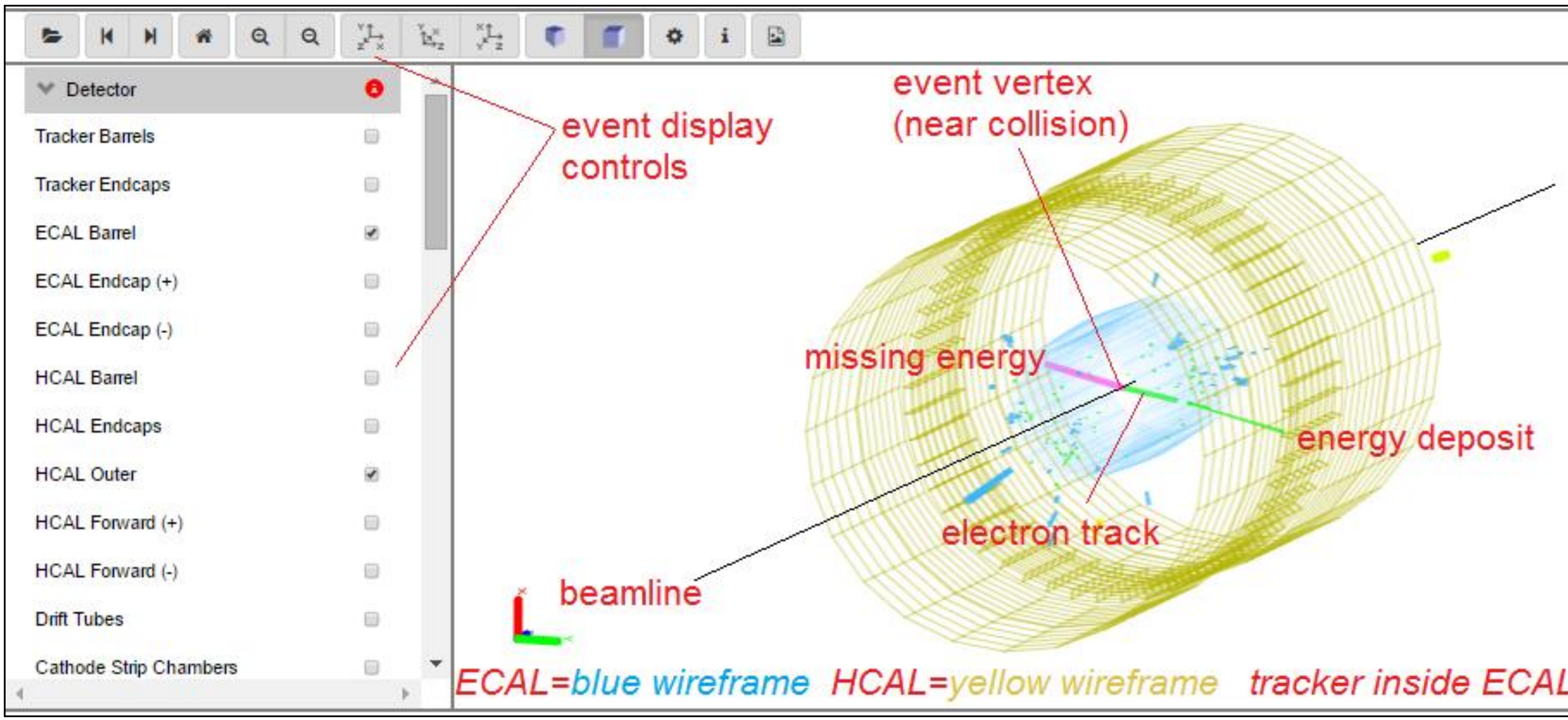
Because bosons only travel a tiny distance before decaying, CMS does not “see” them directly.

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



CMS can infer:
- neutrinos from “missing energy”

iSpy-webgl


Detector
Tracker Barrels
Tracker Endcaps
ECAL Barrel
ECAL Endcap (+)
ECAL Endcap (-)
HCAL Barrel
HCAL Endcaps
HCAL Outer
HCAL Forward (+)
HCAL Forward (-)
Drift Tubes
Cathode Strip Chambers
event display controls
event vertex (near collision)
missing energy
energy deposit
electron track
beamline
ECAL=blue wireframe
HCAL=yellow wireframe
tracker inside ECAL

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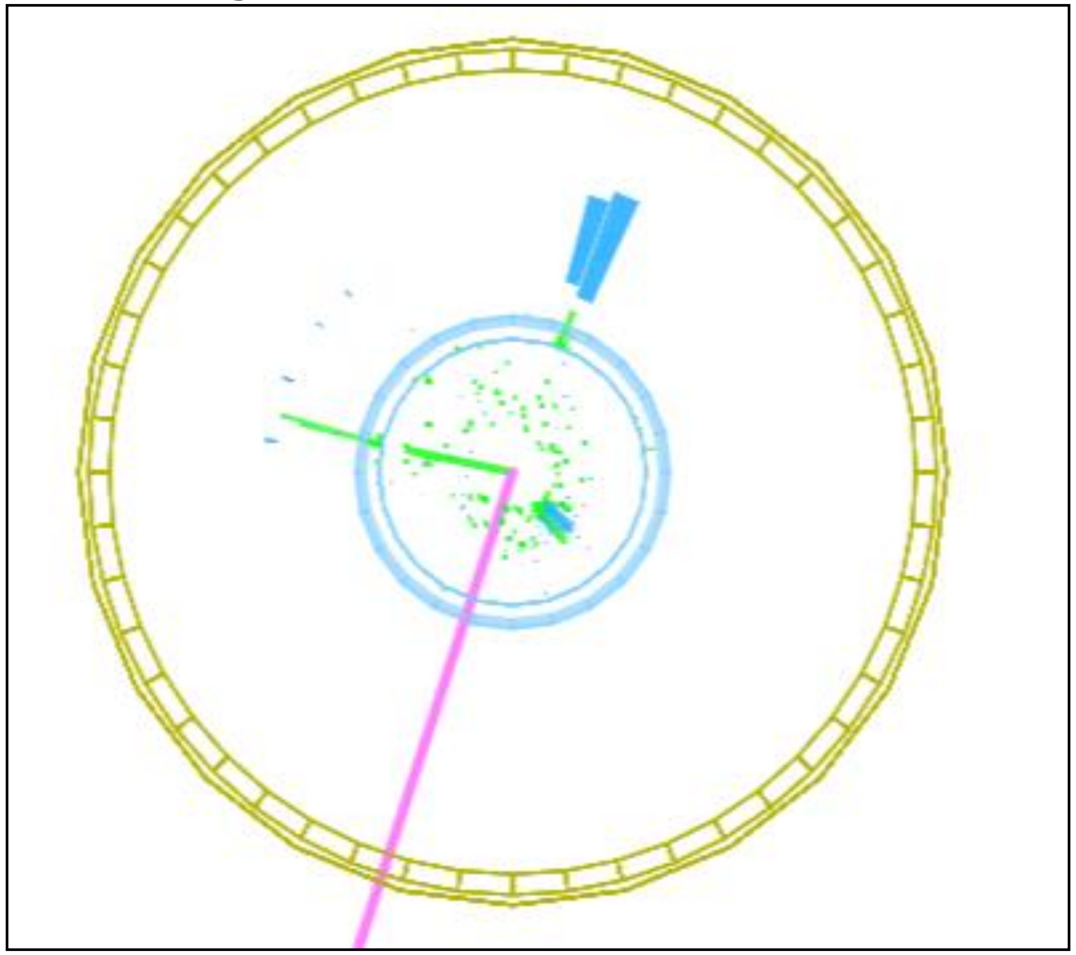
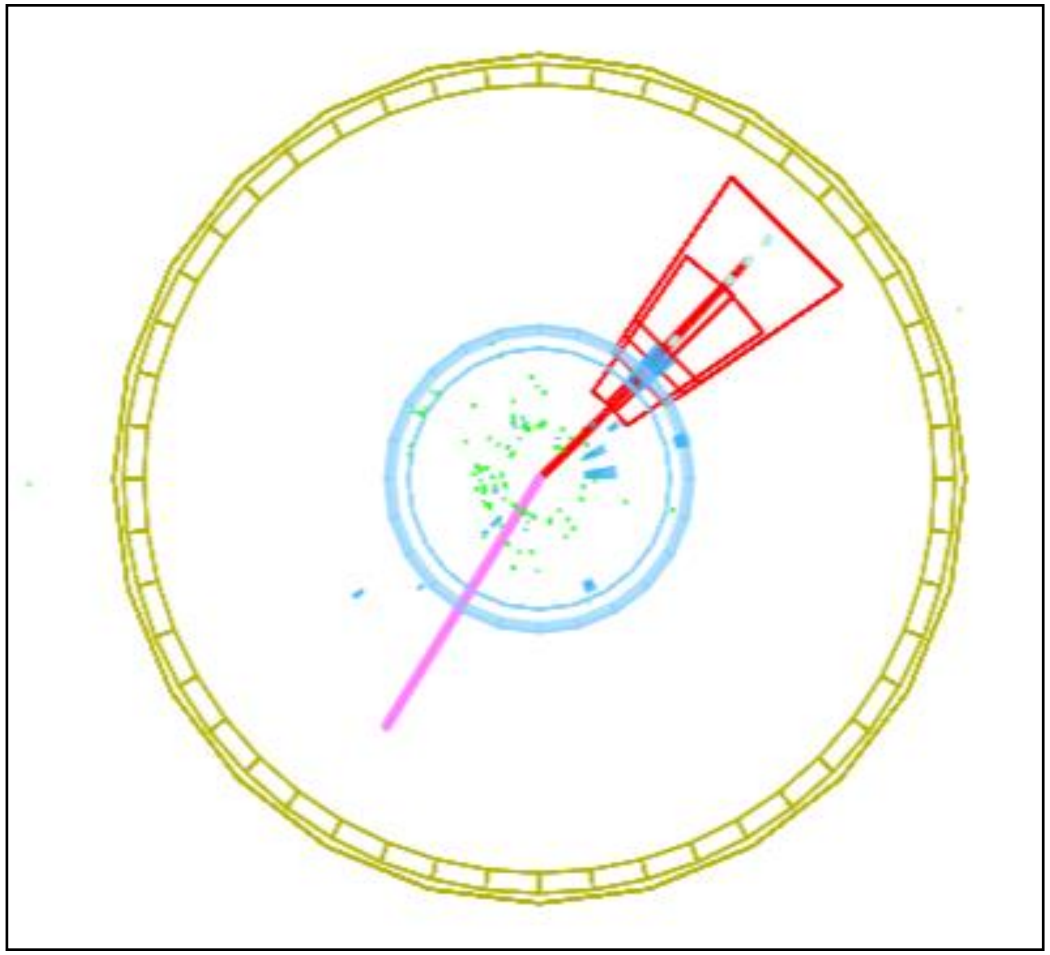
Today's Task

Which has an electron track? Is one of these a Z decay to e+e-?





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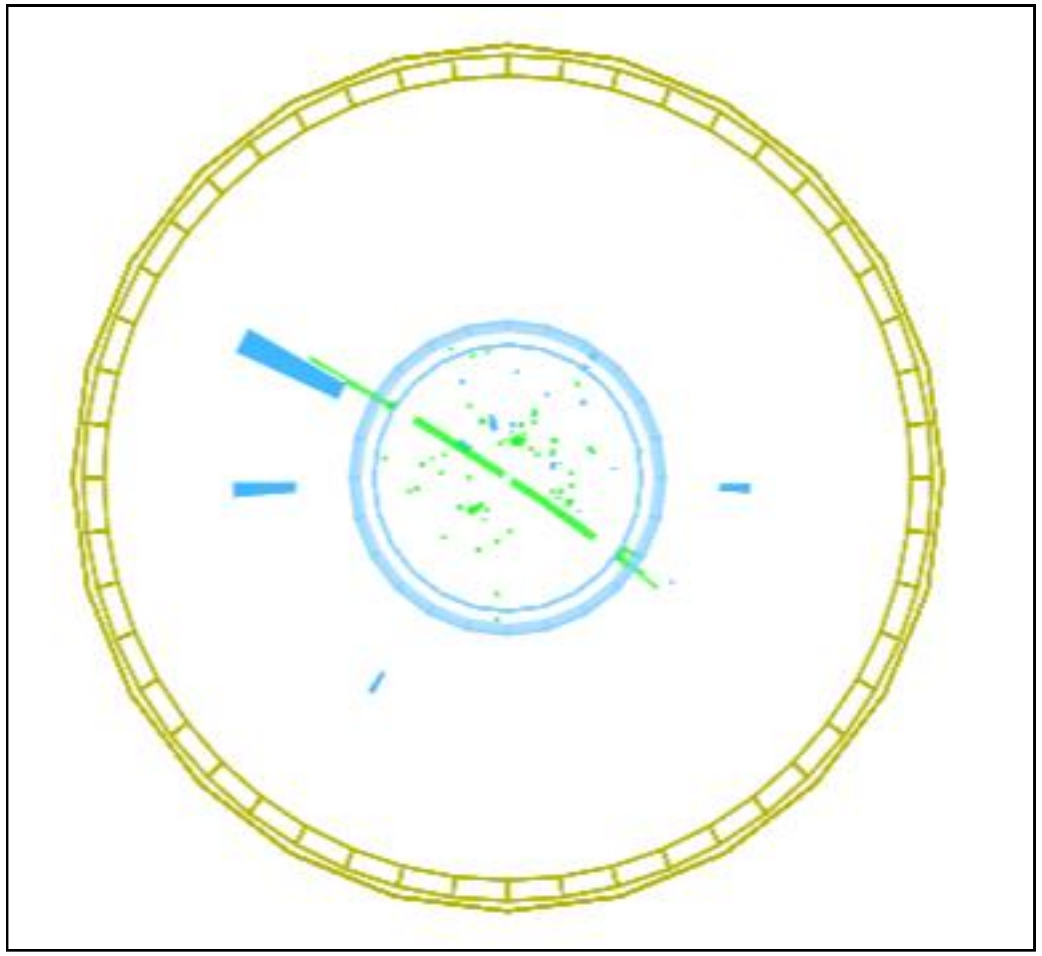

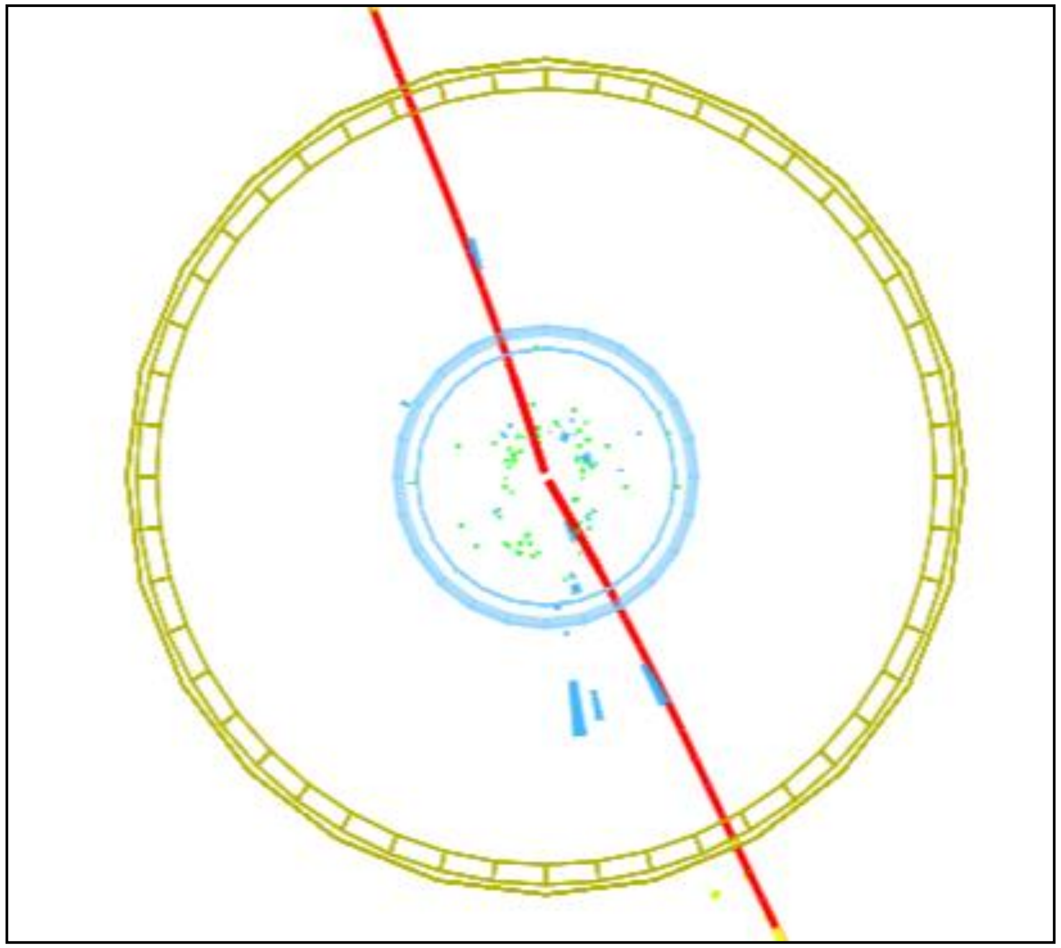

Keep in Mind . . .

"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: <u>work together</u>, <u>think</u> (sometimes outside the box), and <u>be critical</u> of each other's results to figure out what is happening.

Form teams of two. Each team analyzes 100 events.

Talk with physicists about interpreting events. Pool results.