Search for Vector-like Leptons

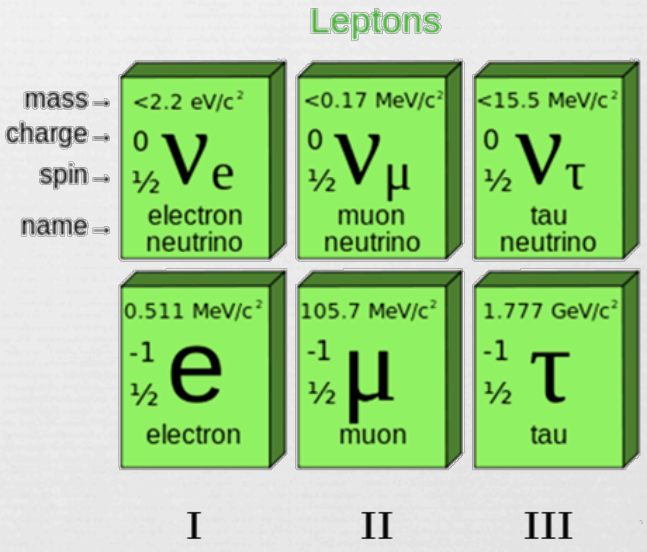
Miranda Brugman
REU with Dr. Abbott

Standard Model

What is a vector-like lepton?

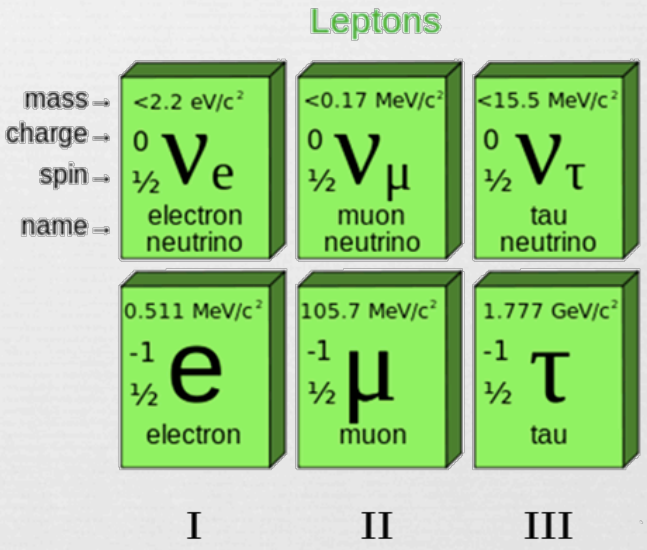
- Very heavy (theoretically about the same as an iron atom)
- Don't know mass yet
  - Must be > 100 GeV
- Written as

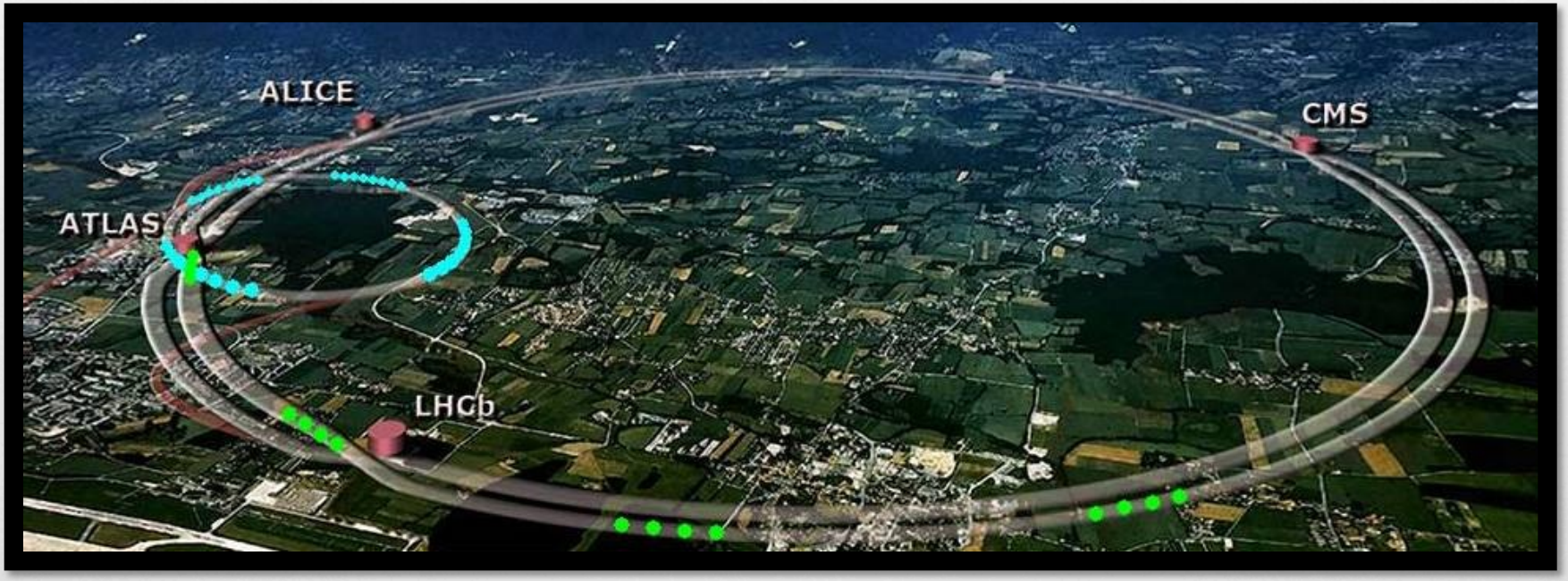
τ'



Why it's worth investigating

- Existence of fourth generation could reconcile gauge couplings and redefine bound of lepton flavor violation
- String theory predicts vector-like particles

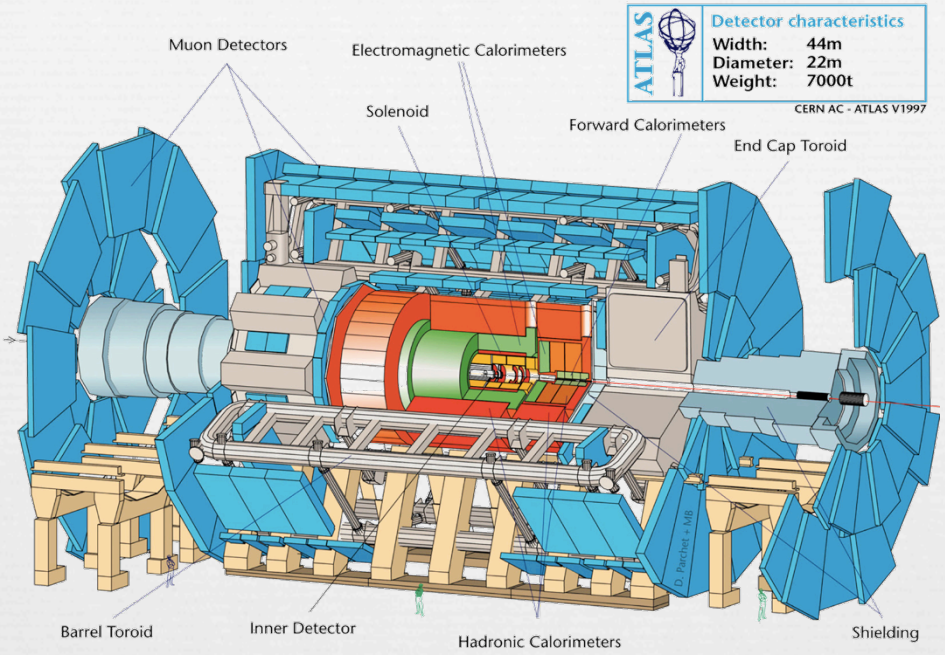




CERN

Built on the Franco-Swiss Border
Largest collider in the world functioning at the highest energy

$$\sqrt{s} = 13\ TeV$$



ATLAS Detector

~ 40 Million collisions/s, recording only ~1000

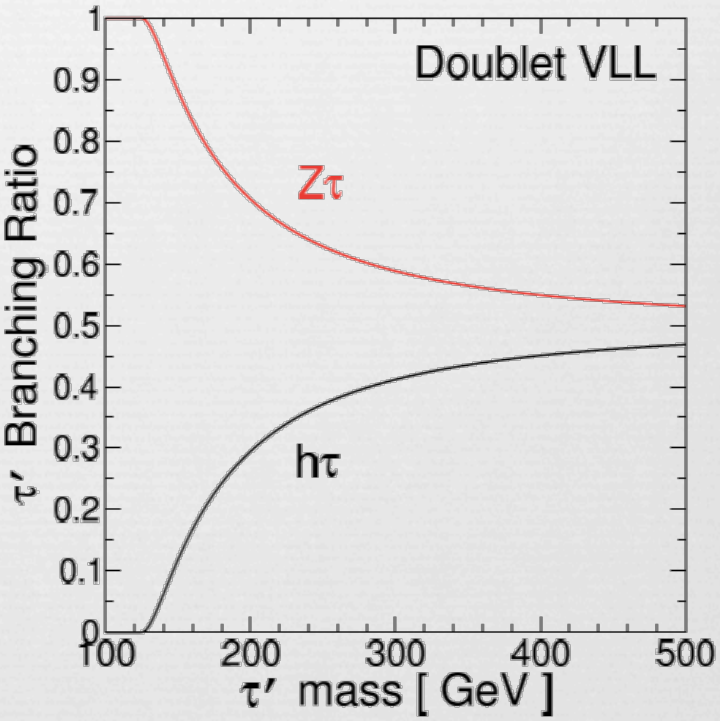
$> 10^{10}$ events/year

Computational Challenges

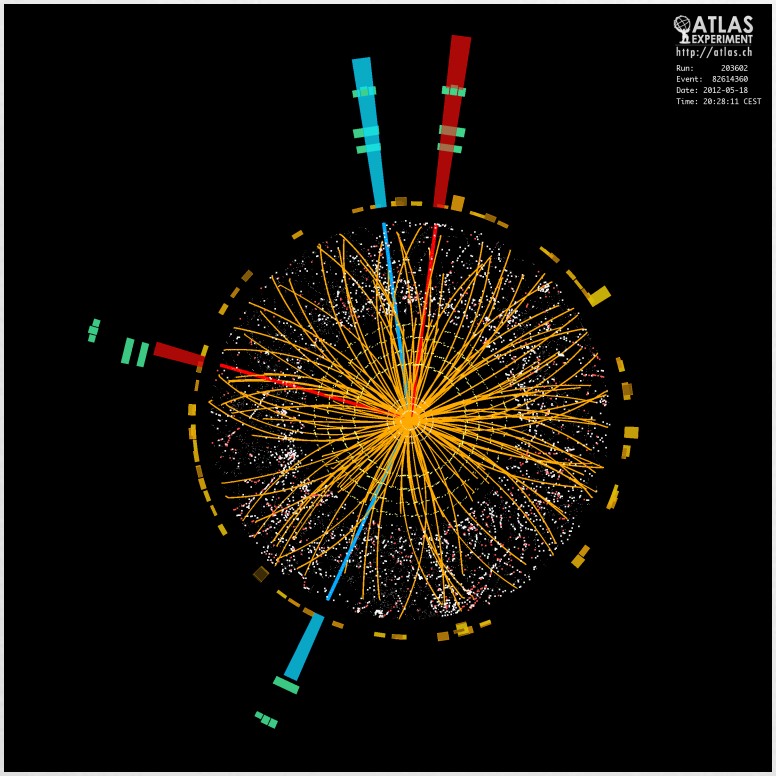
- Volume of data
- Complex behavior of data
  - Need some knowledge of particles, detector's various layers, computing for large quantities of data

How are particles discovered?

- Look at theoretical behavior of particle
- Look for rare signatures
  - Decays to tau/boson pairs
  - Decays with more than 2 leptons are rare in standard model, but common in theoretical decay of τ'



How are particles discovered?



- Statistical Analysis
  - Find signal regions with small but measurable background
  - Find probability of seeing a fluctuation to the size of the signal

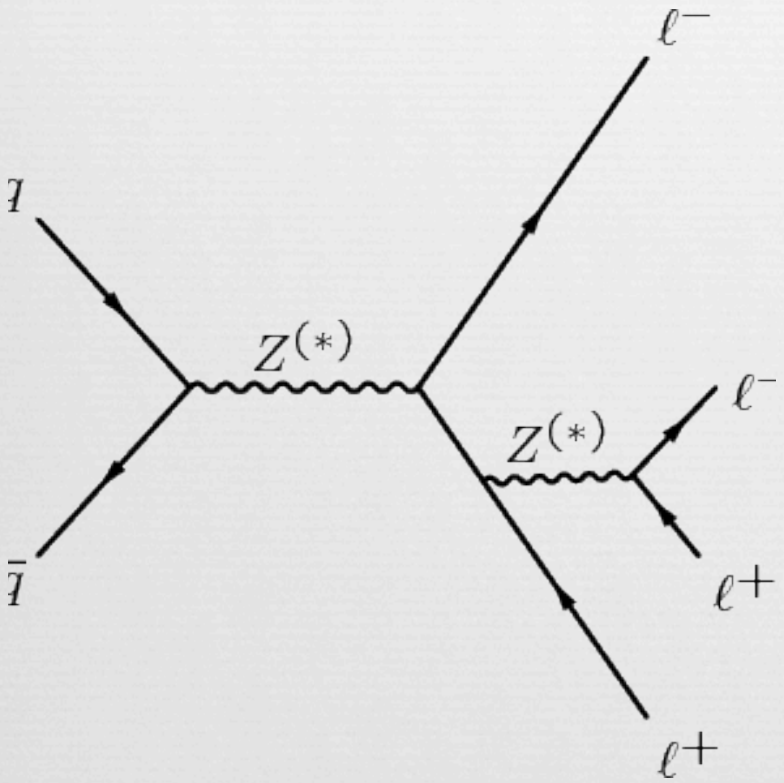
Further Challenges

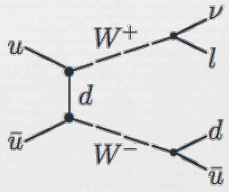
- Need to find to high precision – a discovery is generally considered when over 5 sigma (1/35 million chance of being wrong)

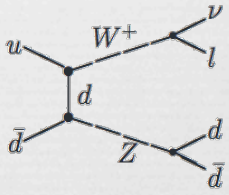
Further Challenges

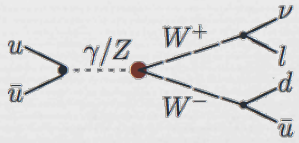
- Need to find to high precision – a discovery is generally considered when over 5 sigma (1/35 million chance of being wrong)
- Must consider other decays with similar signatures

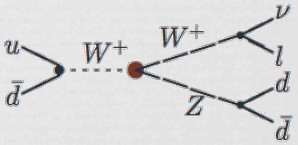
Similar Decays





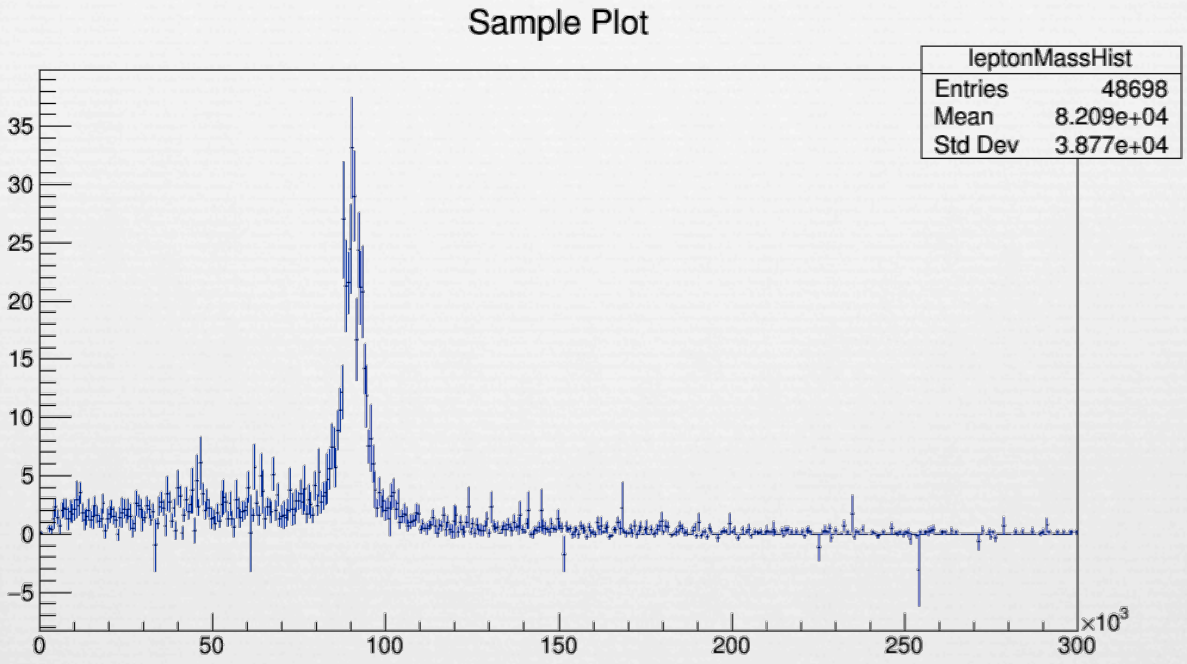






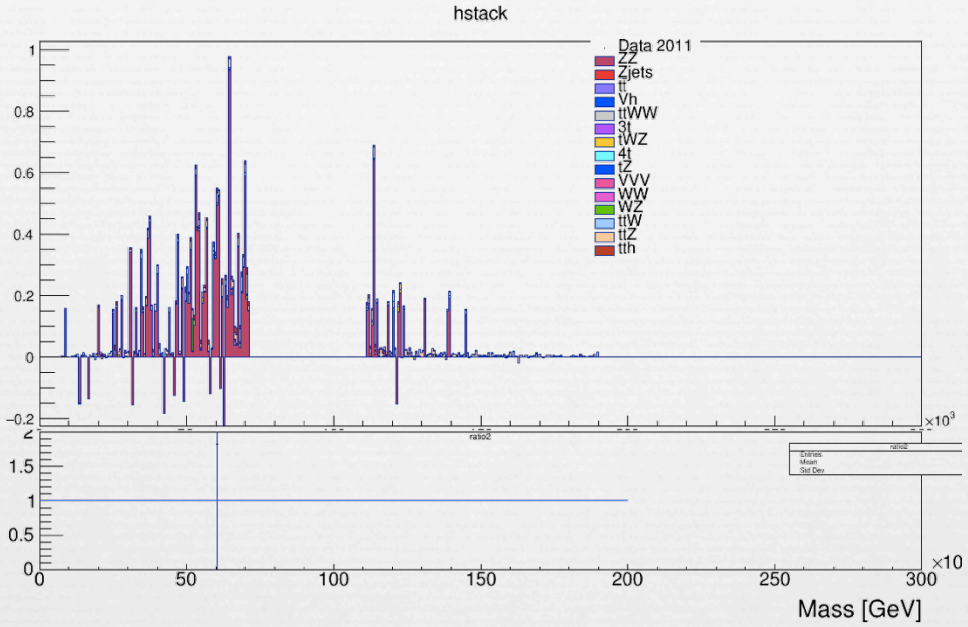
Further Challenges

- Need to find to high precision – a discovery is generally considered when over 5 sigma (1/35 million chance of being wrong)
- Must consider other decays with similar signatures
- Blind analysis



Plot of lepton pair masses

Run over ZZ simulated decays

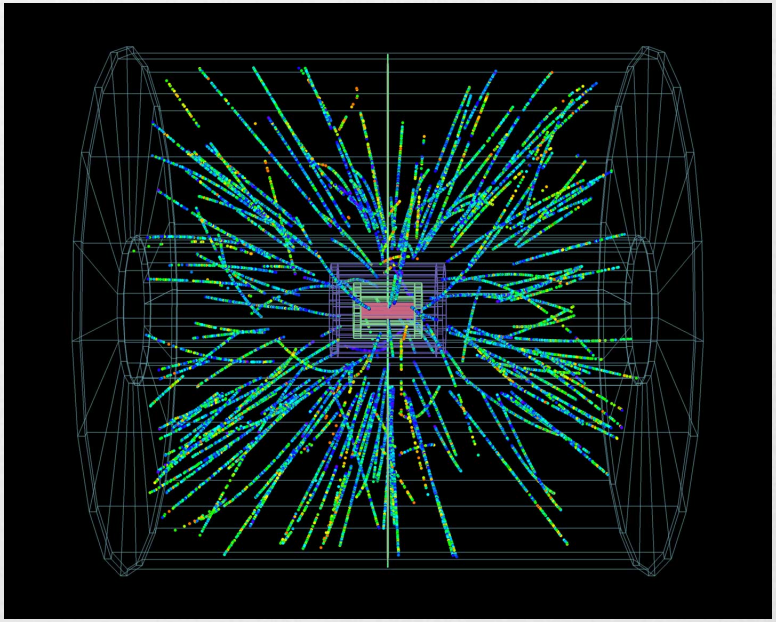


Optimization

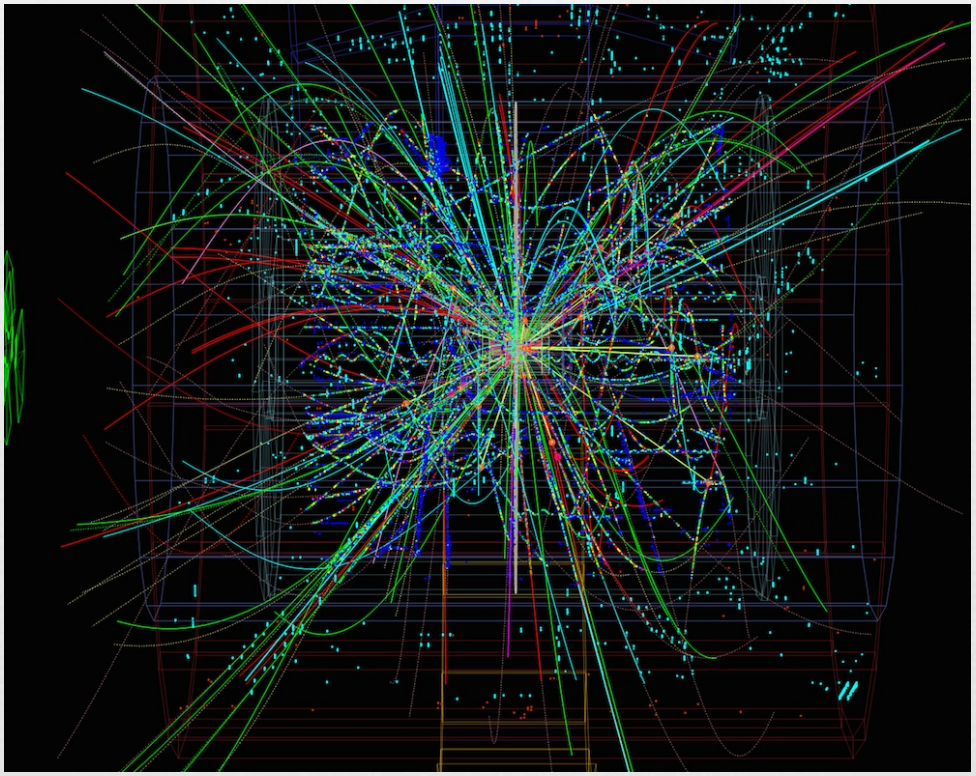
Can’t see actual data
Work from simulations

Where we are at now:

- Built Simulations
- Chosen cuts from simulations
- Created more than 15 potential signal regions to choose from
  - Expecting to be sensitive up to 500 GeV
- Preparing for actual data



Questions?



Lagrangian of quantum electrodynamic relation between electrons

$$\mathcal{L} = -i\bar{\psi}_e\gamma^\mu(g_v + g_A\gamma_5)\psi_e Z_\mu + e\bar{\psi}_e\gamma^\mu\psi_e A_\mu$$

Doublet model