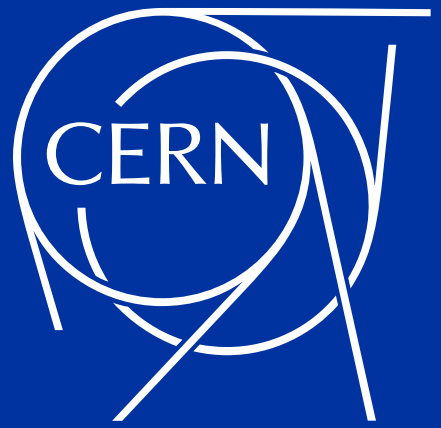


Discovering the Higgs boson in H→ZZ channel using the ATLAS open data

Marija Petrovic, Rastko Kalaver, Petar Rusov

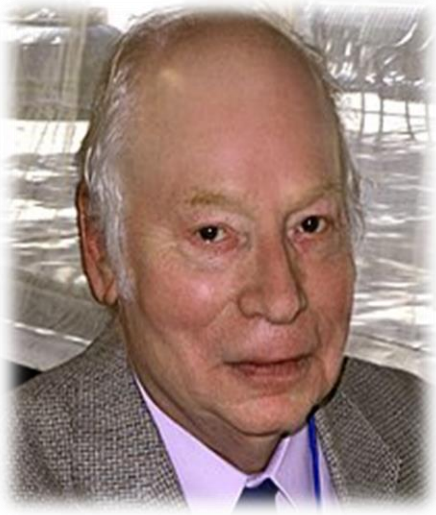
Supervisors: Marko Stamenkovic, Predrag Milenovic

The building blocks of our world?

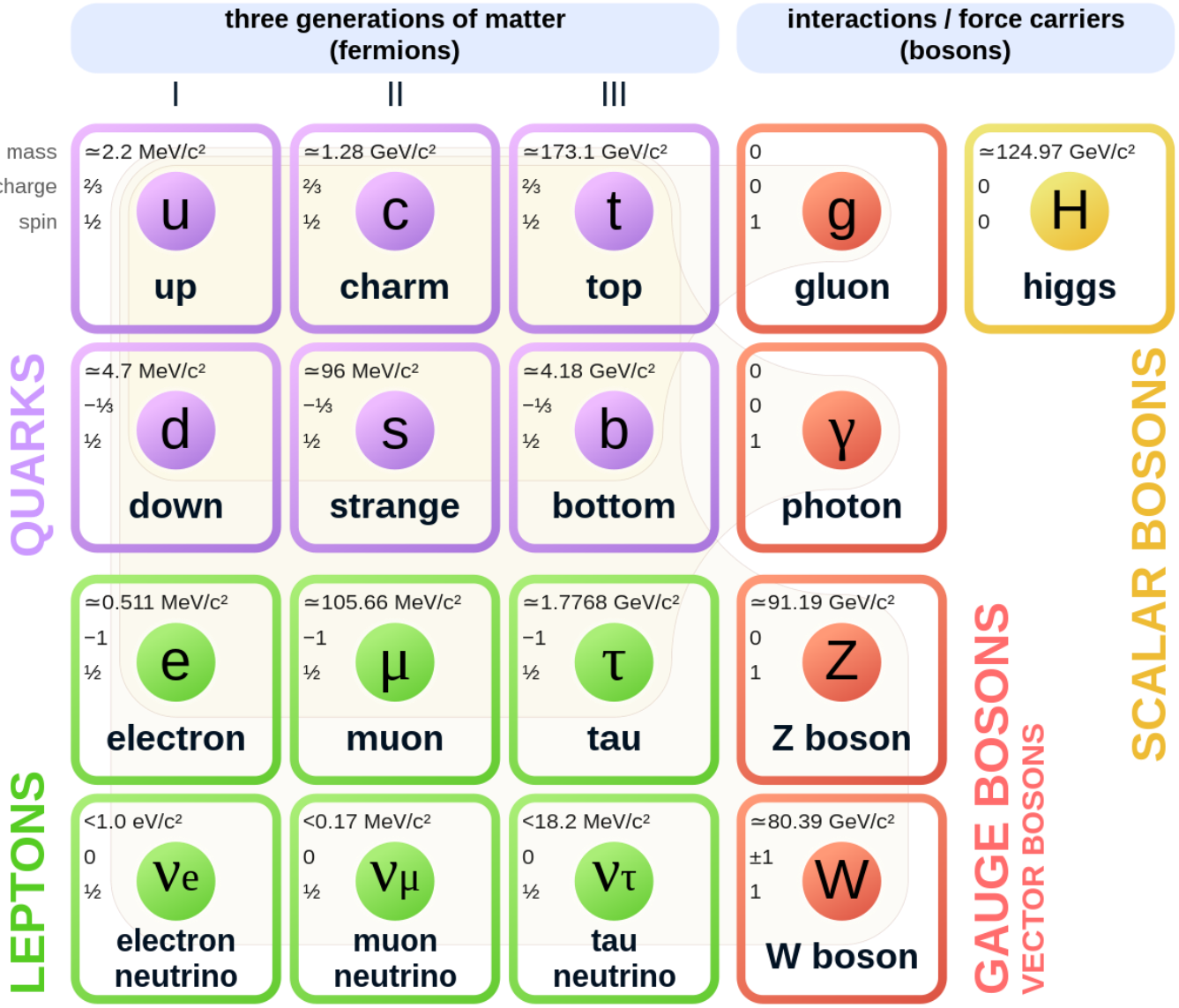
- What makes up the world around us?
- What gives us mass?





Standard Model of Elementary Particles



Great success!

Since all models are wrong, the scientist must be alert to what is importantly wrong. It is inappropriate to be concerned about mice when there are tigers abroad.

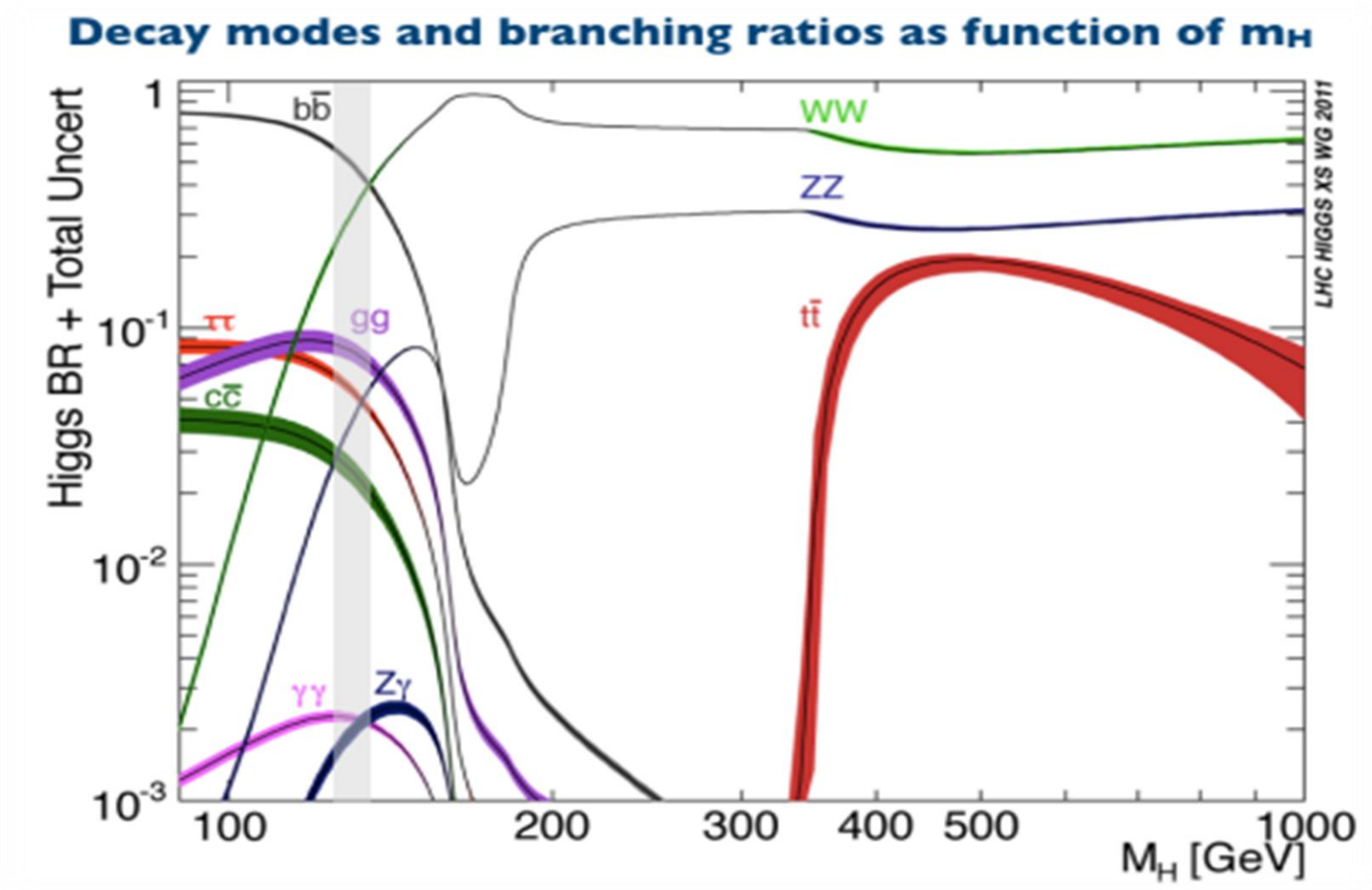
– George Box

Problems with the Standard Model

- Unexplained phenomena:
  - Grand Unified Theory? → Quantum Theory of Gravity
  - More matter than anti-matter? → Baryon asymmetry
  - Universe's accelerating expansion?
  - What is 95% of the universe made of? → Dark matter & dark energy
  - Neutrino oscillations? → Small mass of neutrinos
- Predicted particles:
  - Top quark (1995)
  - Tau neutrino (2000)
  - **Higgs boson** (2012)

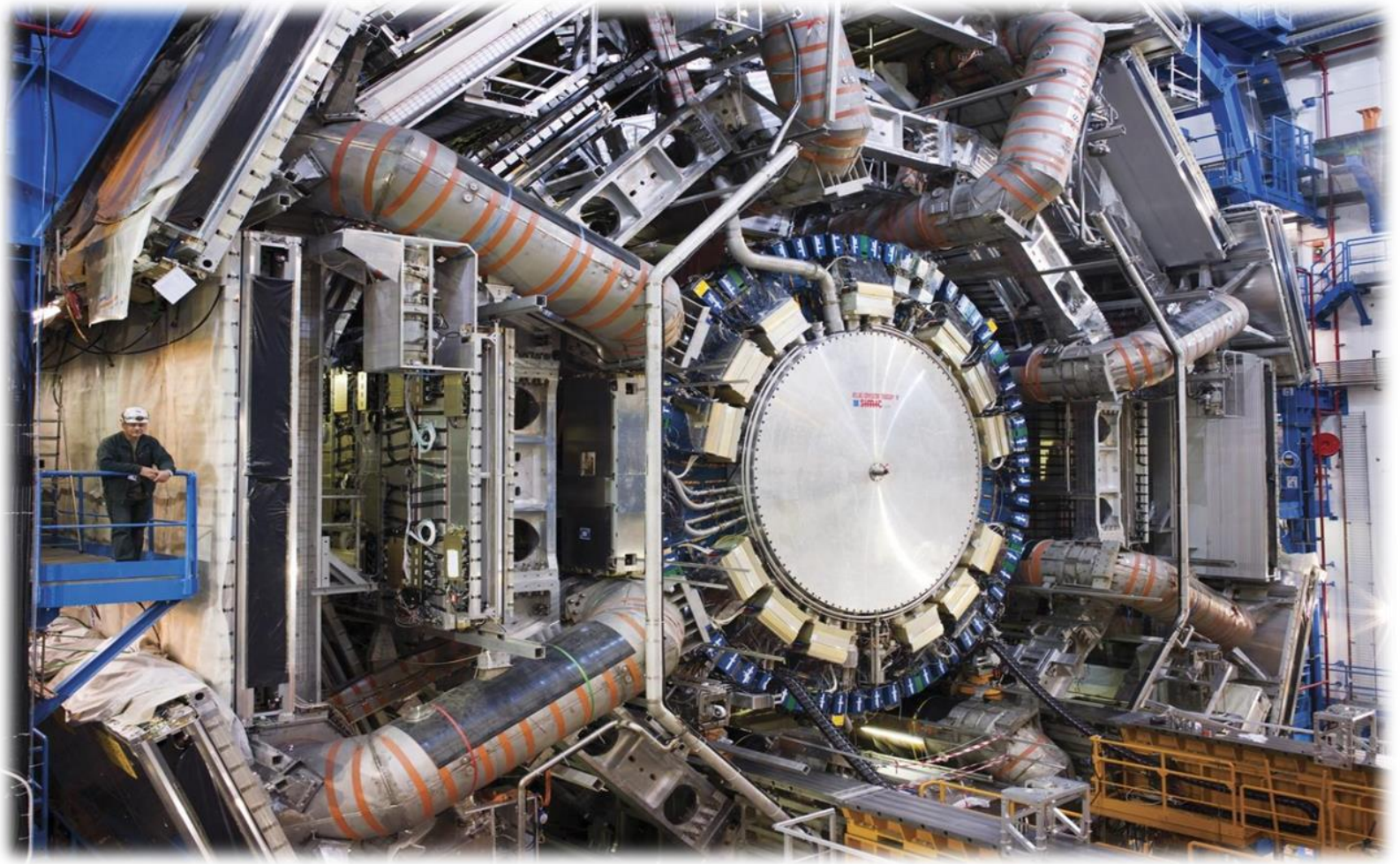
Higgs boson decay into four leptons

- Only **two out of 100** decay into a pair of Z bosons
- **Seven out of 100** Z bosons decay into 2 leptons (electrons or muons)
- **One out of 10000** - branching fraction

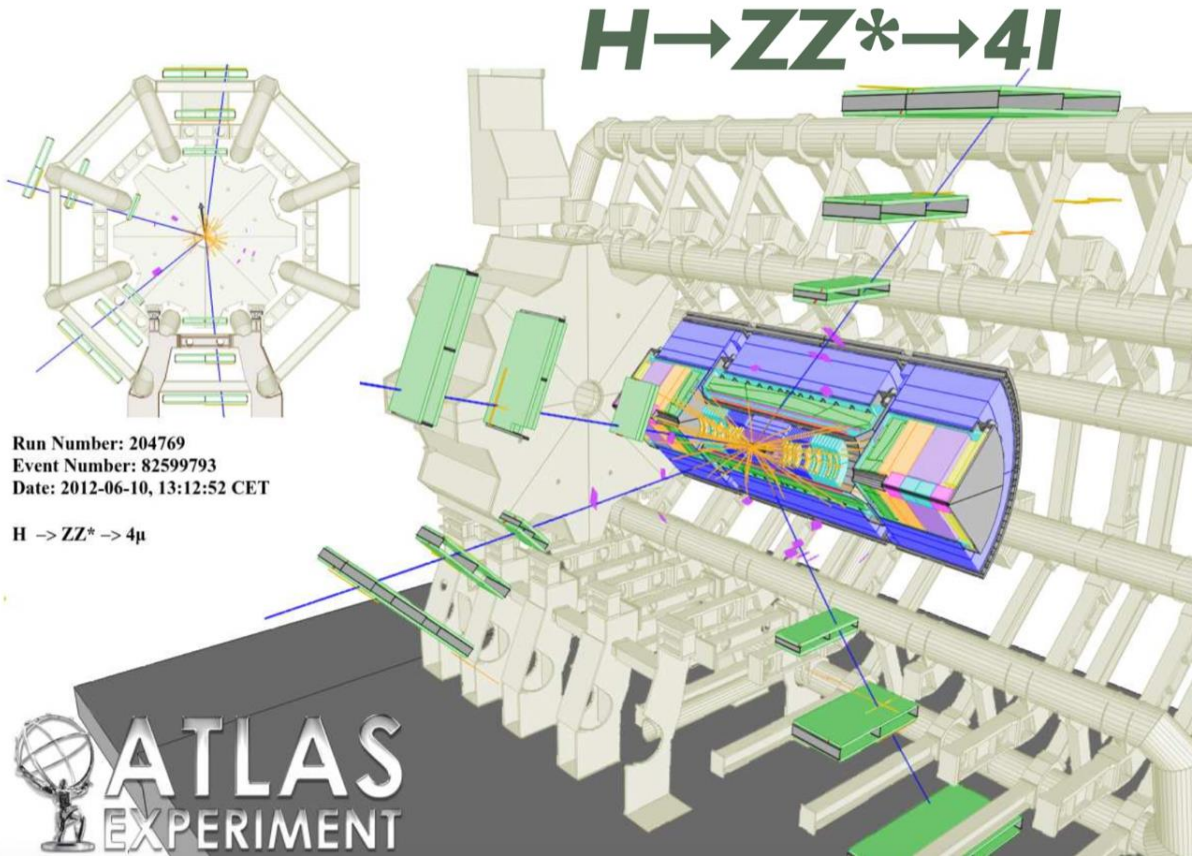


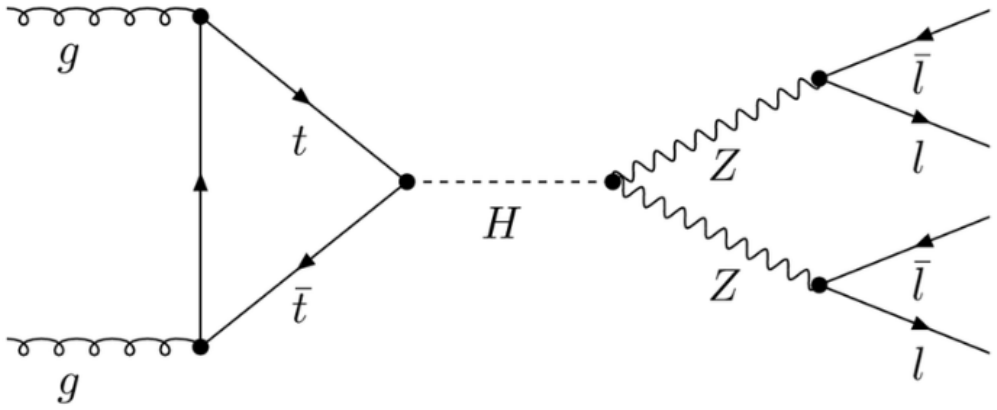
ATLAS detector and its triggers

- The largest detector ever constructed
- Made to gather clues about the particles – speed, mass and charge
- 40 million collision events every second → only 1000 selected

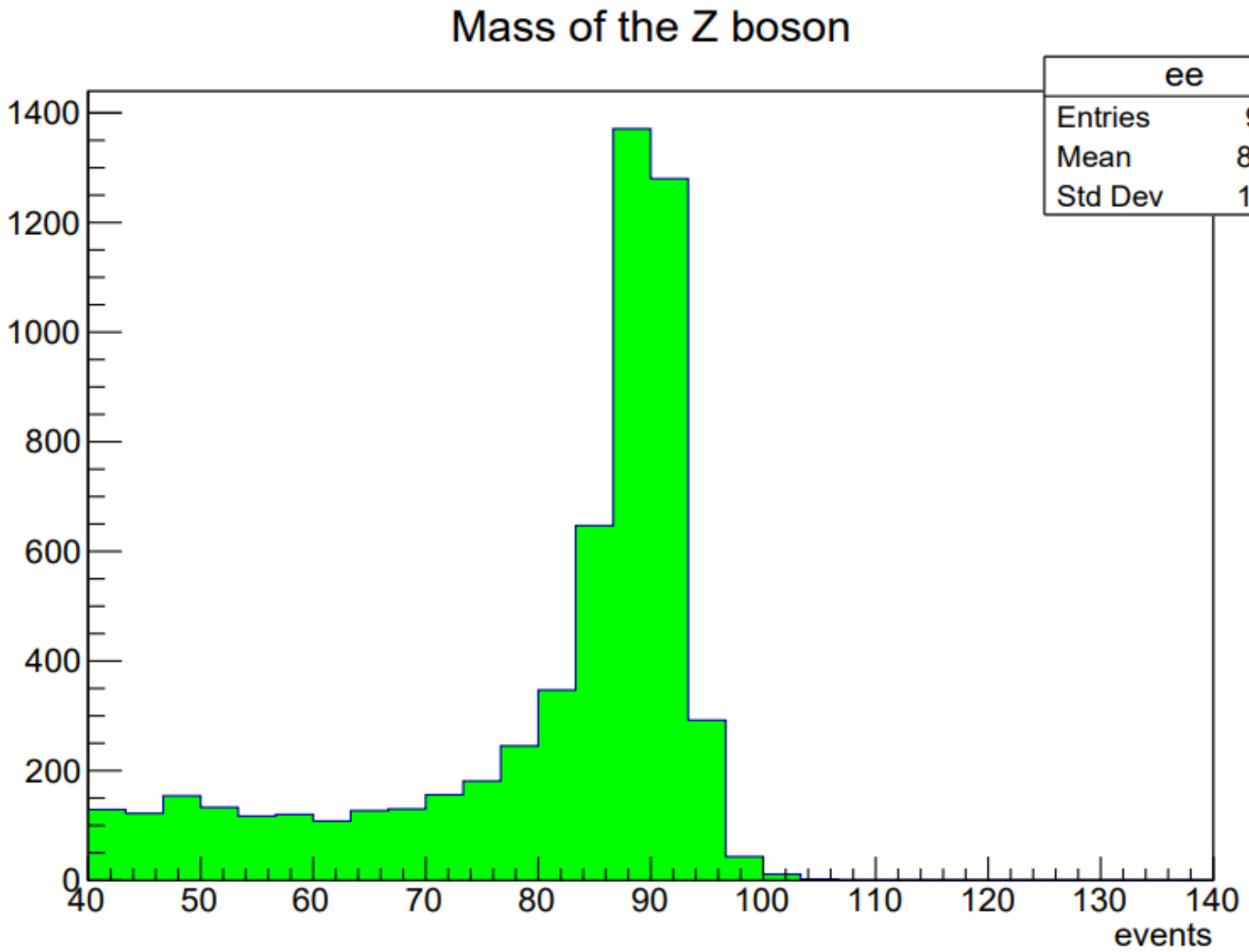


HZZ decay – real event



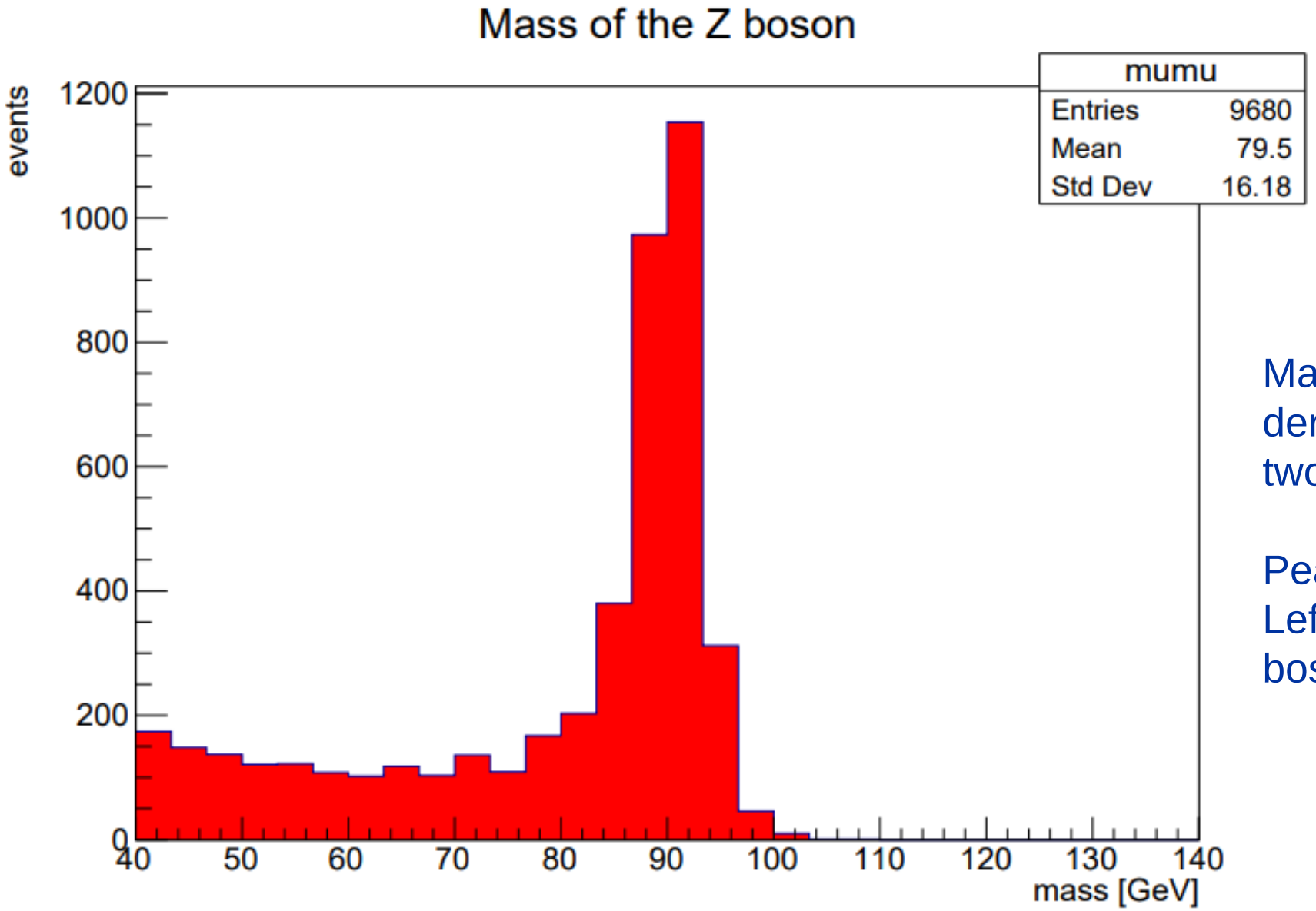


- Actual 2012 event
- Production od 4 muons
- Higgs boson production and decay diagram



Mass of the Z boson derived from the mass of two electrons

Peak at 90 GeV
Left tail: one off-shell Z boson



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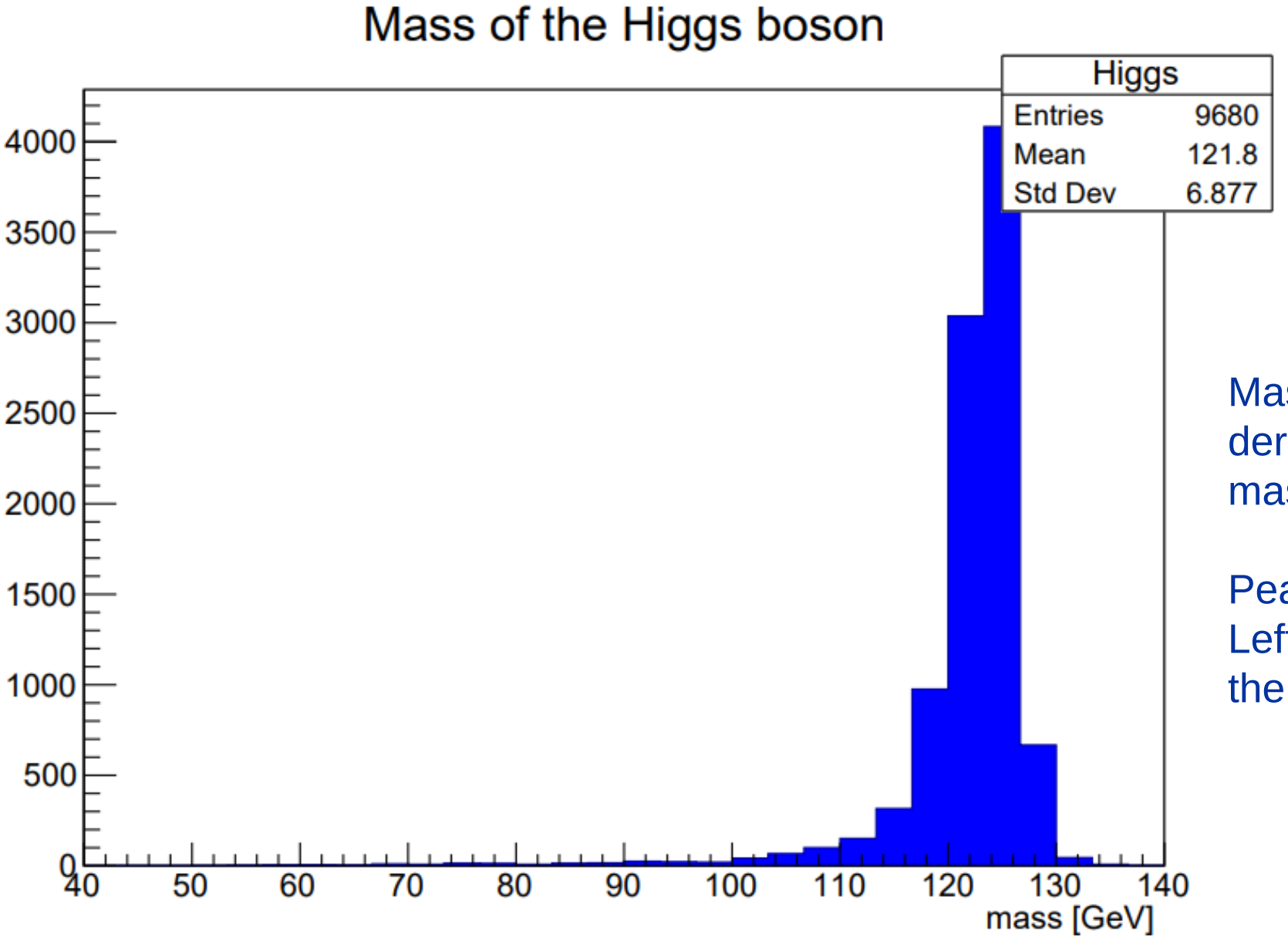
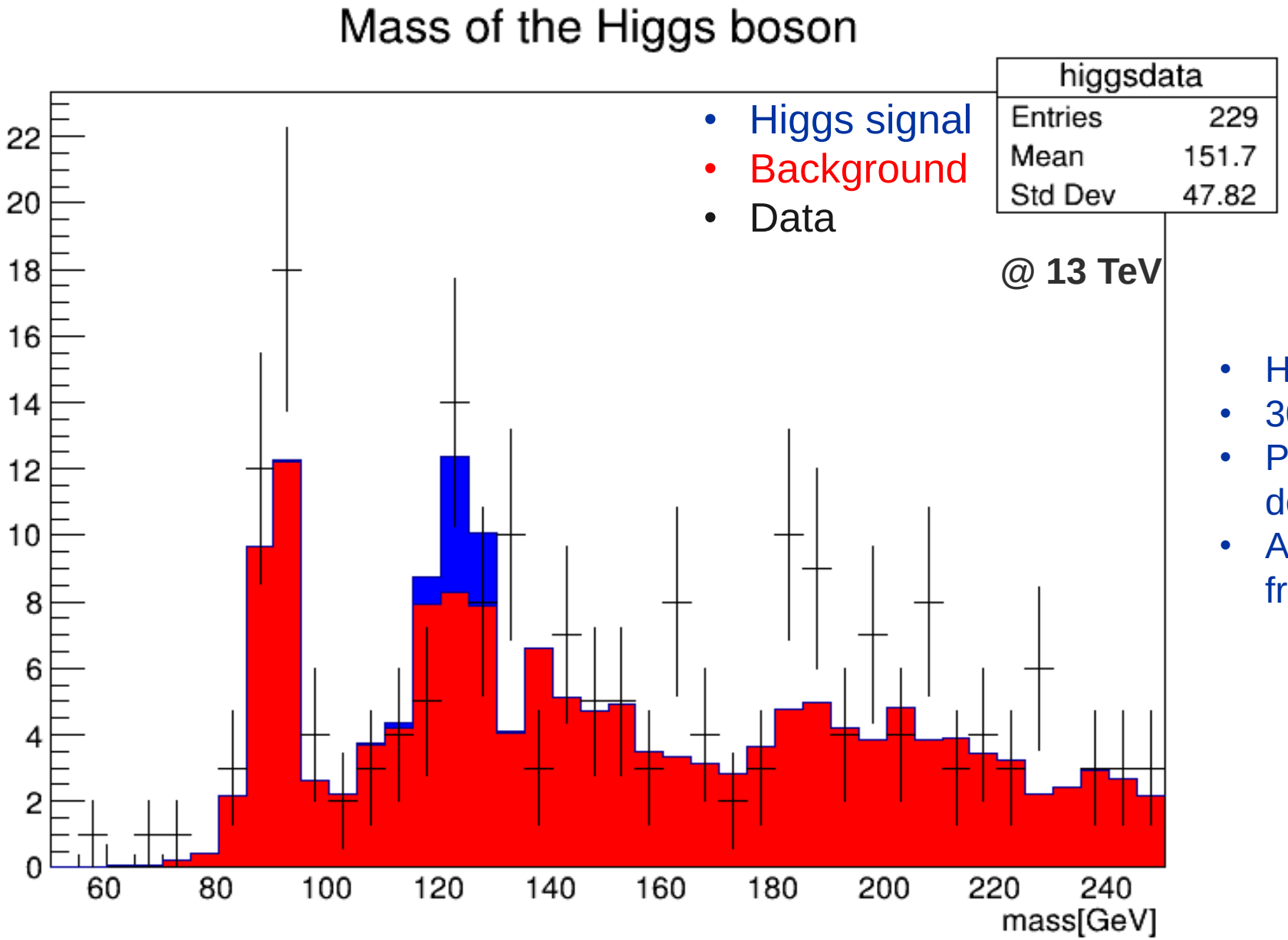
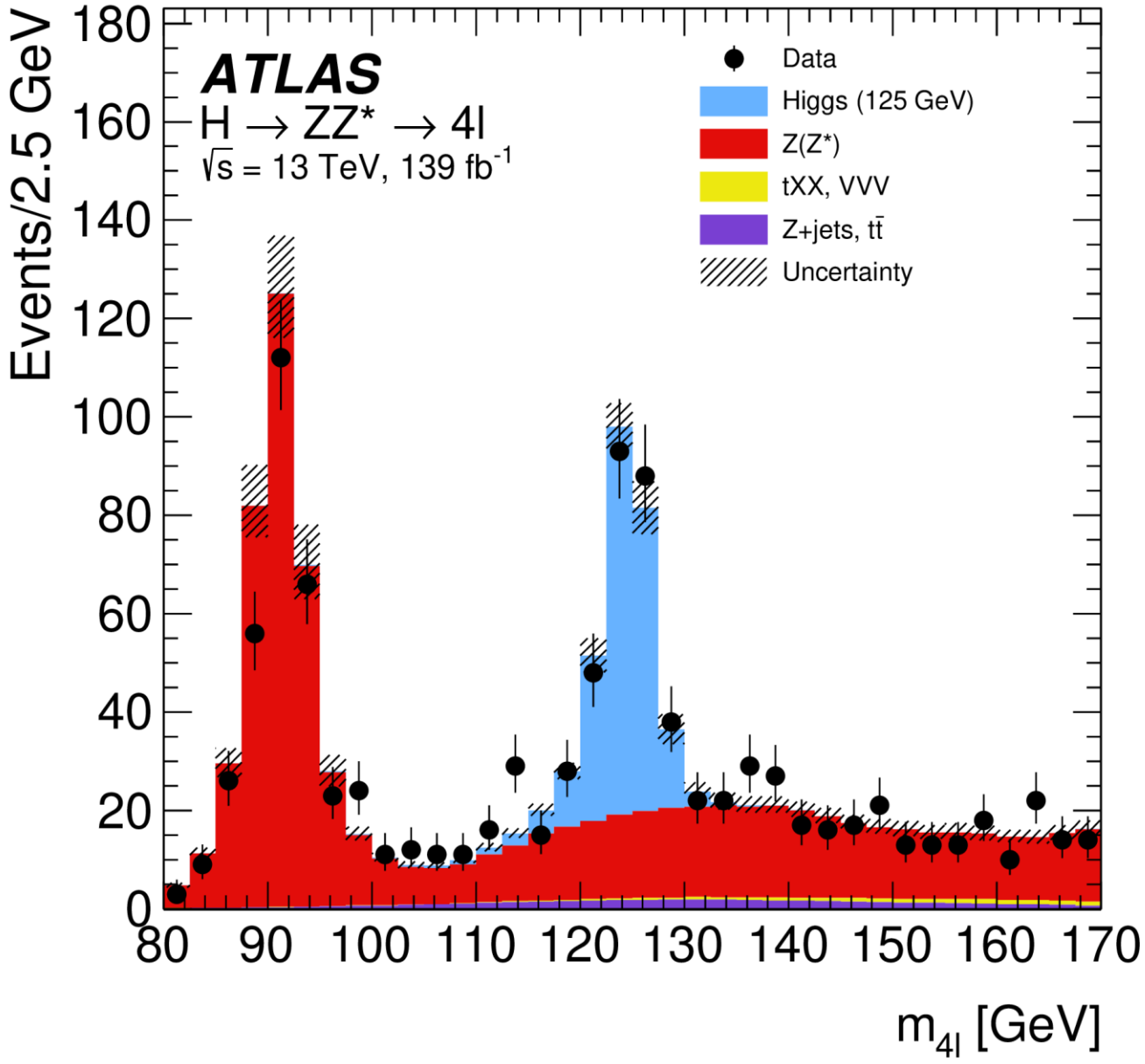


Mass of the Higgs boson derived from muon and electron mass measurements

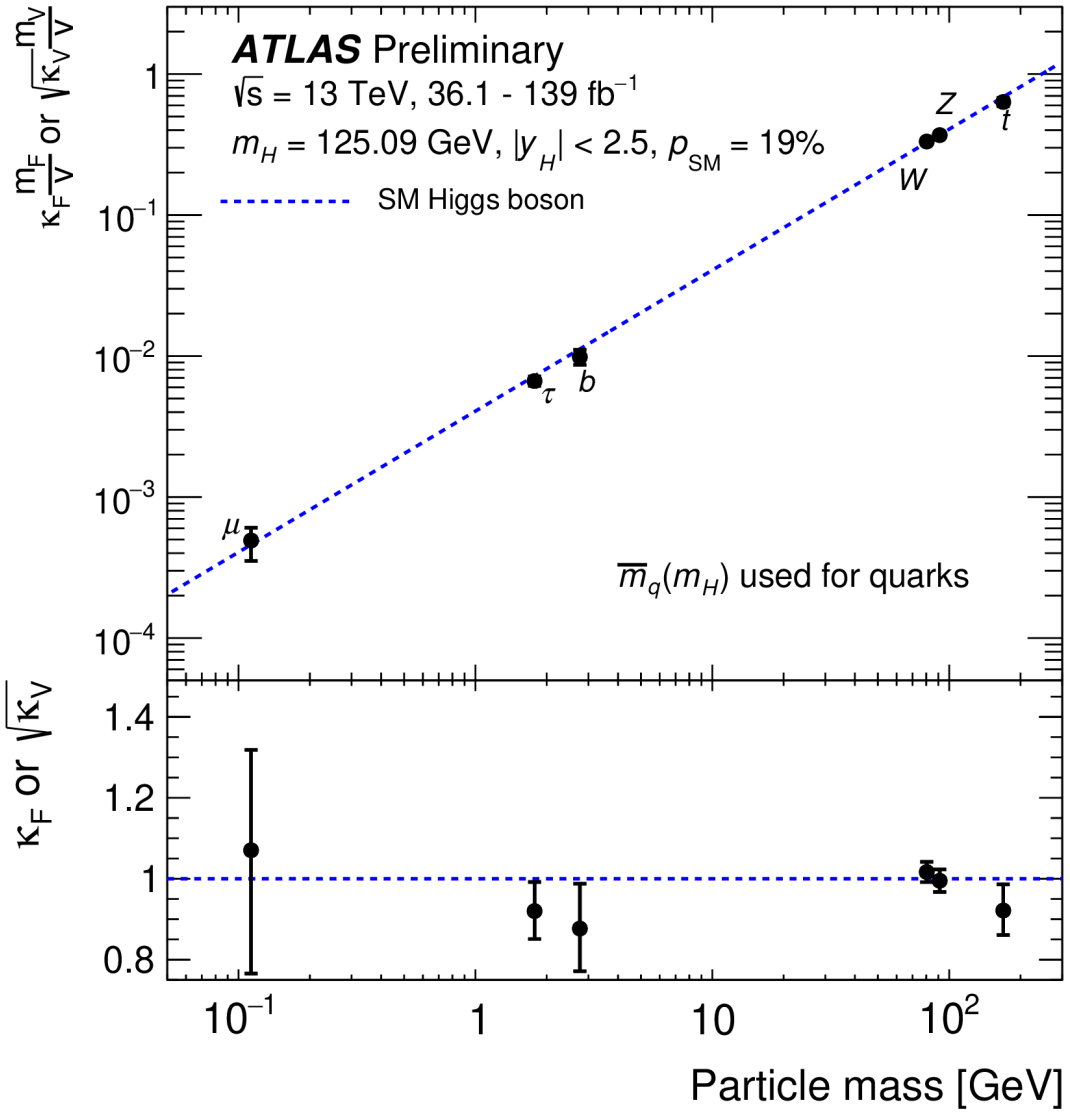
Peak at 125 GeV
Left tail: small loss of energy on the lepton



- Higgs peak at 125 GeV
- 30 events
- Peak at Z mass (likely from Z decay to four lepton)
- A small bump at 180 GeV (possibly from two Z background)



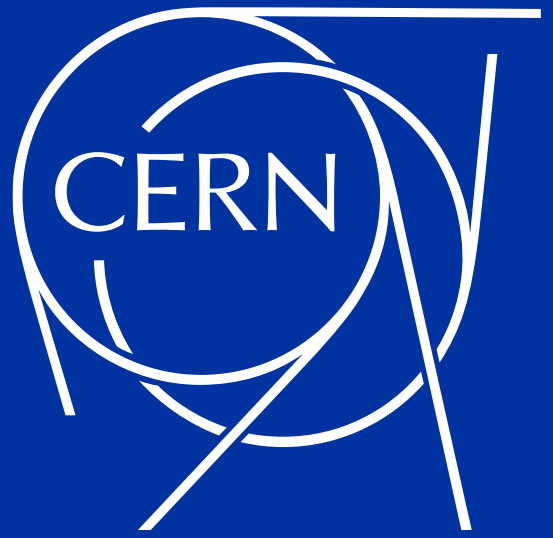
- Ten years after the discovery (more precise)
- How well do we compare?
- Two peaks, little uncertainty



- Standard Model → a very successful theory
- So far measured interaction of Higgs boson with: top, Z, W, bottom, tau, muon
- Left to measure: Higgs, charm, strange, down, up, electron

The need to do research is a part of our humanity… So, I think there will always be a CERN.

– Maria Fidecaro



Thank you for your attention!