The Top Quark

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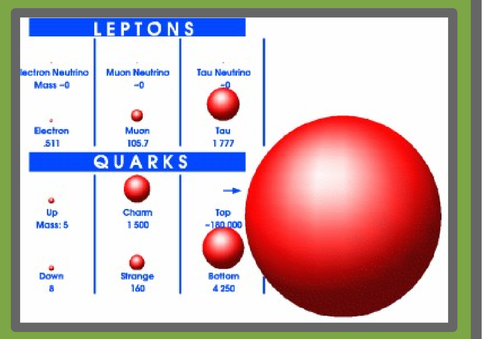
What is the Top Quark?

The Top quark was discovered in 1995 at the Tevatron in Chicago. It is a third generation quark, partnered with the bottom quark and has a charge of +2/3. It is today, the most massive of all elementary particles. Because of its large mass, it does not hadronize, but decays rapidly.

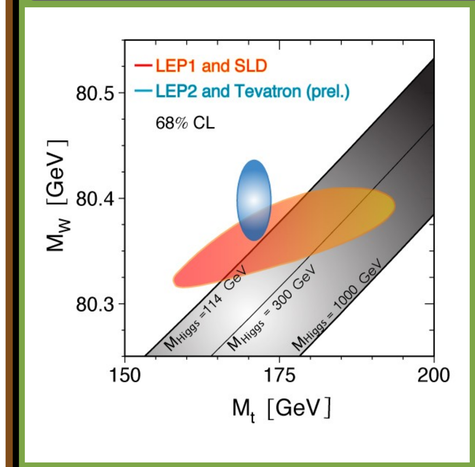


Due to the top quark's unique properties, such as its strong interactions and weak interaction decay and the fact that it passes its spin information to its decay products allows for a very unique environment to study the Standard Model and beyond.

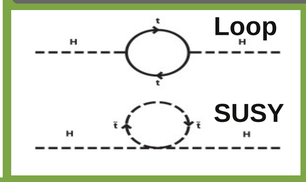
Why is it so Interesting?

- It is the heaviest of elementary particles, weighing about as much as a Gold nucleus!
- It lives for only .00000000000000000000000001 seconds!
- As a result, it allows us to see a "single" quark before hadronization, passing all its information to its decay products.

From the top quark we can study the fundamental forces which govern our universe – QCD / QED / EW

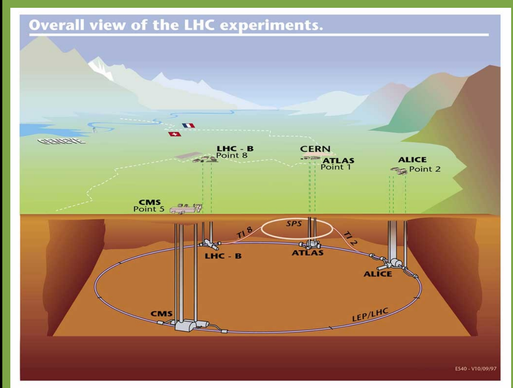


The Top Quark Mass also gives a range for the Higgs Boson mass within our Standard Model. A precise measurement is important to validate the Higgs and Standard Model.



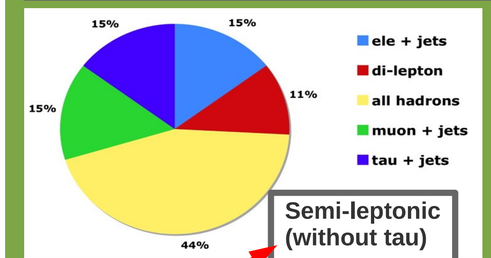
Creating...

To produce top quarks, we need a high energy collider. The LHC at 14 TeV will create one top quark pair every second. Quarks (10 % of the time) and gluons (90 %) inside the two colliding protons create top and anti-top pairs. This is known as "Top quark pair production".



...Decaying...

The Top quark pair "always" decays into two W bosons and two b quarks. How the W's decay determines the decay of the top quark. The W can decay into two quarks or two leptons. If both W's decay into quarks it is referred to as "All Hadronic". If one goes into quarks and one into leptons "Semi-leptonic", or both leptons "Di-leptonic".



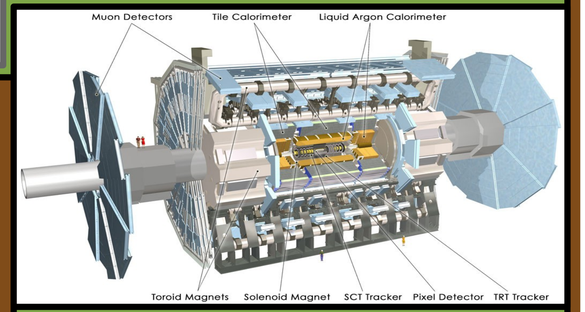
Tau decays further!

Semi-leptonic (without tau)

e + jets 15 %
μ + jets 15 %

...Detecting!

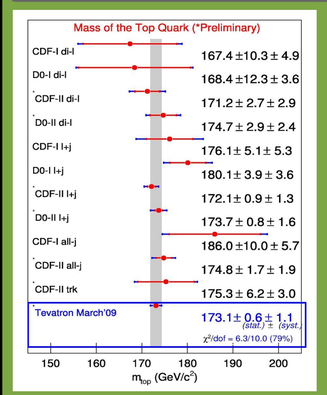
The decay products are then detected using the ATLAS detector. The unique semi-leptonic top pair decay produces an identifiable signal in the detector. Two b quark jets which may be identified by a secondary vertex (b tagging) within the pixel section of the inner detector, and electron or muon from the decay of the W boson. This can be identified from tracks, energy deposition in the calorimeter or a hit in the muon spectrometer. The neutrino however escapes without being directly detected.



- 44 m long (144 ft)
- 22 m high (77 ft)
- 7 000 000 kg
(15 428 000 lbs)
- Interaction every 25 ns

Measuring the Mass

One method to measure the mass of the top quark is called the template method. Templates of different mass points are created and compared to data.



The Template Method

1) Create templates of signal and background for different mass points.
2) Compare to data, obtain a Likelihood from statistical difference.
3) BAT is used to calculate the Likelihood.

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