First look at top mass using 2012 data in mu+jets channel using kinematic fit

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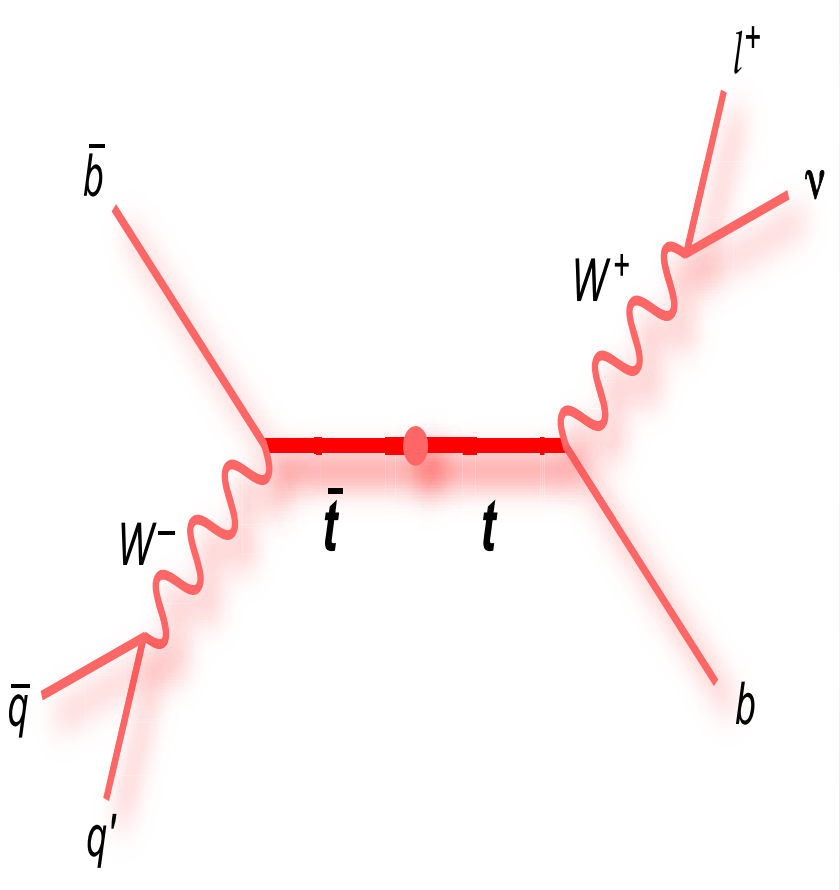
Mass of the top

- I worked this summer on CMS analyzing the top quark mass m_t
- Top mass is important: it is the heaviest fundamental particle, couples strongly to Higgs, b, among others
- Already well measured to be 172.5 GeV
- Continued measurements at higher energy are still needed to verify consistency (pileup, etc) as well as improve uncertainty



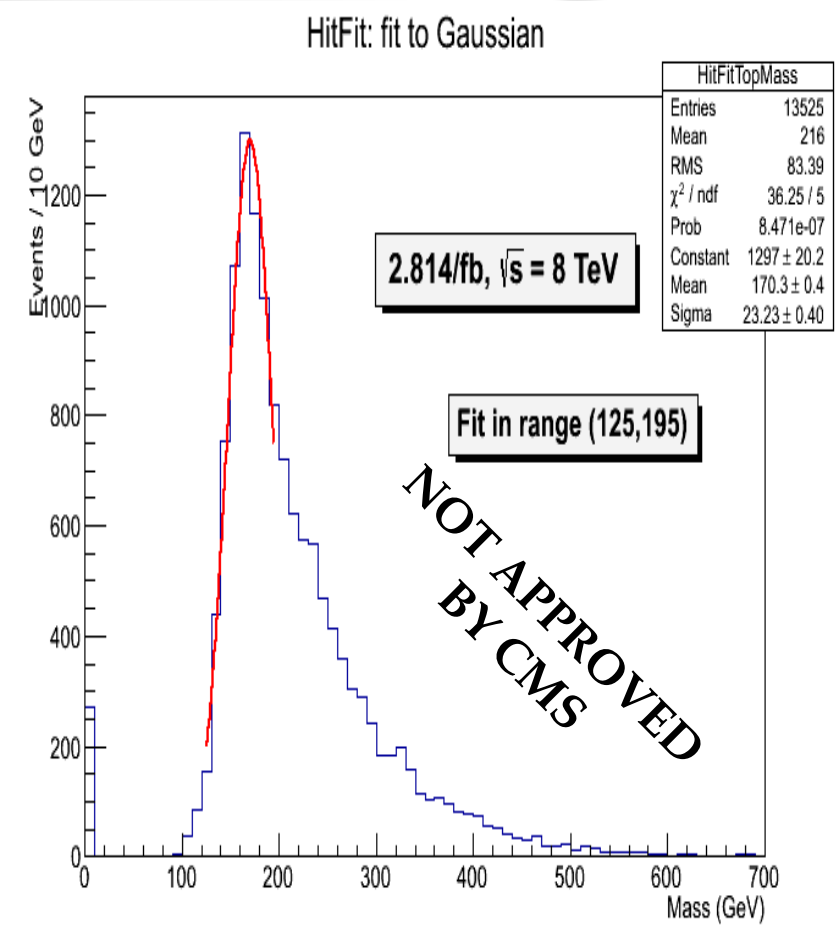
Methods: cuts

- I worked at my computer in Building 40 writing code to analyze this year's data (2012B; first year at $\sqrt{s}$ = 8 TeV)
- Top decays with Br ~ 100% to Wb; W then decays either to two jets or l+v; semileptonic channel means we start with ttbar and one does each
- Final state signature is then lepton + MET + 4 jets (two of which are b's)
- Apply new jet energy corrections, then do cut based analysis: one muon with p_T > 23 GeV, four jets > 30 GeV, one of which > 45 GeV
- Require either one or two b-tags (efficiency vs. purity)

Methods: calculations

- "Quick and dirty" way to get mass is to assume that three highest-p_T (summed) jets come from one of the tops: "M3" method
- Can improve this method somewhat by requiring exactly one of the jets to be b-tagged
- A better method is kinematic fit: adjust measured values within uncertainties to match constraints (m_W= 80.4 GeV), solve neutrino p_z, assign χ^2 based on amount of adjustment needed, reject event if not possible
- I used HitFit for this; worked as blackbox

Fitting & Uncertainty



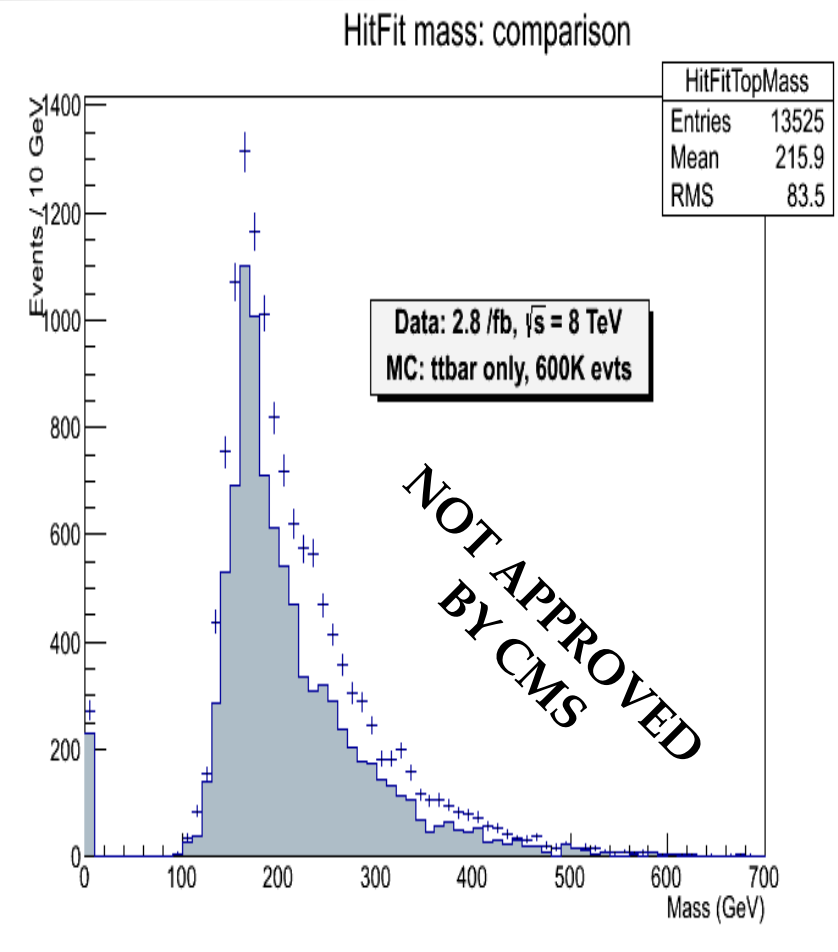
- Fitting is a complicated process for determining the most likely signal value from a histogram that includes some background
- In this short amount of time I had to use a much simplified method: fit a Gaussian in range around peak
- Uncertainty was just that from this fit; did not take many other factors into account (PU, lumi, background, JEC, etc etc)

Pileup

- Pileup refers to number of collisions in each bunch crossing; increases with luminosity and energy
- I divided the selected events into pileup groups and found mass peaks for each
- M3 is not consistent over whole PU spectrum; kinematic fit is; this is a useful result

PU range	M3 (GeV)	HitFit (GeV)
< 12	171.7 +/- 1.3	170.6 +/- 0.8
[12, 17]	169.7 +/- 1.0	170.1 +/- 0.7
> 17	167.5 +/- 1.1	170.5 +/- 0.9

Results



- My Gaussian fit to the kinematic fit results gave m_t = 170.3 +/- 0.4 GeV
- Same in MC gave 170.8 +/- 0.5 GeV
- MC is produced with m_t assumed to be 172.5 GeV; perfect analysis would reproduce this
- Detailed analysis would take months; for now I adjust both data and MC up by 1.7 GeV to get a measured value of **172.0 +/- 0.4 GeV**

Next steps

- These results are extremely preliminary and are stated without detailed errors
- "A number without an uncertainty is meaningless"
- Should have both statistical and systematic uncertainties quoted taking effects at all steps into account
- Should also improve fit method; a Gaussian in a specified range is a little ad hoc
- A full top-mass measurement takes at least a year, maybe more, and is a thesis-level project

The Experience

- I have learned a lot very fast; when I got here I knew next to nothing about C++/ROOT/experimental particle physics
- It takes a LONG time to do this kind of analysis
- Met a lot of wonderful people I hope to stay in touch with after this summer
- Switzerland is perhaps the most breathtakingly beautiful place I have been but they put asphalt at 2600 meters; it's hard to find true wilderness in the mountains
- They also charge you 9 francs for a falafel; I thought my city was expensive

Thanks!

- Foremost to my advisors for all their help and guidance
- To CERN, NSF, and UofM for funding and organizing the program
- I had a great summer and will miss this place and these people