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

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9 Aug 2012
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 \( \text{Br} \sim 100\% \) to \( Wb \); \( W \) then decays either to two jets or \( l+\nu \); semileptonic channel means we start with \( \text{ttbar} \) 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 \( p_T > 23 \text{ GeV} \), 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 $\chi^2$ 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 the 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 the whole PU spectrum; the kinematic fit is; this is a useful result.

<table>
<thead>
<tr>
<th>PU range</th>
<th>M3 (GeV)</th>
<th>HitFit (GeV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 12</td>
<td>171.7 +/- 1.3</td>
<td>170.6 +/- 0.8</td>
</tr>
<tr>
<td>[12, 17]</td>
<td>169.7 +/- 1.0</td>
<td>170.1 +/- 0.7</td>
</tr>
<tr>
<td>&gt; 17</td>
<td>167.5 +/- 1.1</td>
<td>170.5 +/- 0.9</td>
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</tbody>
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Results

- My Gaussian fit to the kinematic fit results gave $m_t = 170.3 \pm 0.4$ GeV
- Same in MC gave $170.8 \pm 0.5$ 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 $172.0 \pm 0.4$ 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