Journal club minutes - July 18th -Top minutes

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Top production - Part 1: Xiangyang chairs, Marjorie is expert.
Minutes do not claim to be coherent or complete.

Topics:

- What's the top quark properties (mass, spin, parity)
- How is top quark produced at Tevatron and LHC (leading production modes)

- Decay channels and branching ratios, features of each decay channels

- What are the measurements can be performed at Tevatron or LHC?

Details:

- We discuss the basic properties of the top on Xiangyang's first slide. With regards to the lifetime: you can use the uncertainty principle to figure out what the approx. hadronization time scale is. In this case if the lifetime was > 1e-24 then it wouldnt be a bare quark decay we'd be looking at!
- What kind of top quark properties can we measure?
    - mass
    - the total inclusive cross section: how often it occurs
    - differential cross-section, useful for specific kinematic regions
- Marjorie points out that in the days before the Top discovery, we did know it should exist but that the mass scale wasn't defined so we didn't really know what it was going to decay to and had to scan different regions of the mass-scale that progressively opened up different decay regimes.
    - Patrick notes that the SM had the quarks and doublets so it had to exist because otherwise the SM would diverge.
    - Marjorie continues: getting rid of neutral currents meant that we needed a unitary CKM matrix, and as soon as the b was found there had to be a top. It was also considered that this could be a source of CP violation, although now we know now it's not quite enough.
- Rebecca mentions the top-to-Higgs loops mentioned in the PDG and Marjorie clarifies that the reason this is so small is the CKM matrix couplings

- We discuss single and ttbar production mechanisms in both LHC and tevatron including those with qq initial states and gg.
- Xiangyang asks: what does it mean that the cross-section curves from the Tevatron and LHC converge on plot 61.7 in the PDG 2018 review (linked on commons page)? Neha: Because at high enough energies glu-glu takes precedence.
- Single top is production modes all contain EWK interactions, which is really nice because it can be used to measure the CKM matrix.
- Greg: Clarify that semi-leptonic refers to b+leptons as opposed to semi-leptonic for the ttbar pair decays.
- We now move on to Top decays:
    - The mass of the W is low enough that, even for a physical W, the mass difference between it and the top is large and so tau is also included as a feasible decay mode for the W
    - We then go through the decay modes on the board and try and figure out the branching ratios on slide 2 of Xiangyang's slides. If we conclude that there are two possible W->qq final states (multiplying by a factor of 3 to account for color), and 3 for each of the lepton-neutrino pairs, then there are 9 final states for the W decay, when the W is coming from the top decay. So to get two all-quark (or allJet) final states wed need (6/9)^2 (because there's two) which is ~46%. The other BR follow accordingly.

- Then we talk about the features of the decay modes:
    - there are some features we can extract from the all-jet decay like b-tagged jets, and the jet multiplicity, can reconstruct the top mass with the jets
    - with the lepton+jet decays you can use the MET or the muon (for the muon case) to trigger. This has the advantage of removing part of the QCD background from the all_jets
        - Marjorie reminds us that the b-tagging was a game-changer in CDF and really cleaned up the signal
    - dilepton: very clean, you can use this as a control region.
        - Marjorie: very good for b-tagging studies as it's so clean. MET is no good for actually reconstructing the top mass so the two neutrinos don't help.
    - We can also do ttbar associated with ISR, e.g. ggF->H you can see top mass from the additional jets

- Xiangyang: I'd like to discuss the helicity in the tp quark decays.
    - See his slides on helicity and the cos theta* distribution.
    - Marjorie: This was important because it showed that this really was the top because it showed that the W did have negative helicity here
    - forward backward asymmetry is very easy to see in places like LEP because of the V-A coupling preferentially to the matter/anti-matter and the fact that you're colliding the two but in LHC we need ISR to see an asymmetry and this doesn't actually tell us anything.
    - Marjorie: Top decays via FlavourChangingNeutralCurrent, e.g. top decaying to

charged higgs, are a good way to search for new physics

- In the last 5 minutes we briefly discuss the masses: pole vs. ‘short-distance or MS’ mass. Marjorie; If have a LEP collider we can scan the masses and look for the quark peak and that’s closely related to the pole mass. Otherwise we need this running mass because we’re measuring the decay products of the top.

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Next week: ttbar production cross-section sections 1-4
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