# Summary of Top Quark Session at HQL2010

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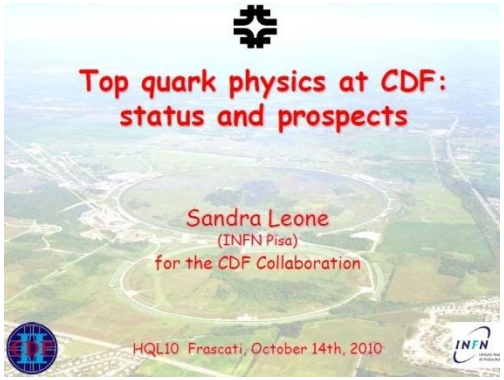
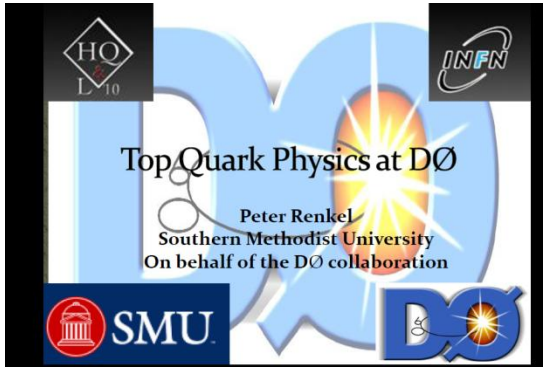
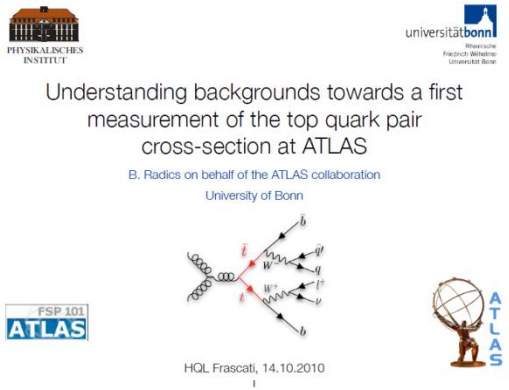
Fermilab

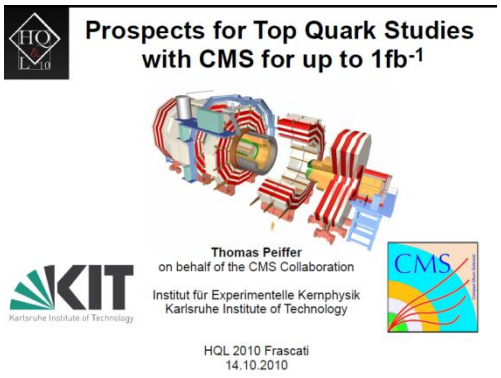
# Thanks to the Five Speakers








for their excellent talks!

# Aspects of Top Physics

- Top as an elementary particle of the Standard Model
- Top properties as a potential indicator of new physics
- Top as a decay product of new physics

For new experiments such as CMS and ATLAS, a “standard” candle with known properties with which to “commission” basic “analysis objects”:

1) b tagging (b jets)
2) Missing Et

# Top Quark Pair Production via Strong Interaction

- CDF, D0 results based on 4-6 $fb^{-1}$
- Strong production of Top pairs
  - CDF: Dileptons; leptons+jets; MET + b jets
  - D0 : Toplogical; dilepton; b-tag
    - Also, $d\sigma/dp_T$
- Cross section for pair production
  - **~7.5 pb**
  - **Error ~ 6%**

# Single Top Production by Electroweak Interaction

- Electroweak Production of single top
  - Signal Lepton plus small number of jets
    - Main background is W plus small number of jets
  - Cross section ~2.8 pb
    - Not small compared to pair production but backgrounds are larger
  - Uncertainty~20%
  - D0 separates t-channel diagram from s-channel
    - Number of jets, kinematics
- $V_{tb}$ is a fundamental constant of nature
  - Expected to be very nearly 1 in SM
  - Single top cross section ~$|V_{tb}|^2$.
  - **$V_{tb} = 0.91 \pm 0.9$ , consistent with 1.0**
  - **Uncertainty is ~ 10%**

# Top Quark Mass and Width

- Mass is obtained from Leptons +jets and dileptons
  - **CDF: $m_{top}$=173.0±0.7(stat)±0.6(JES) ±0.9 (syst) GeV**
    - **Best individual top mass measurement in the world to date, based on 5.6 $fb^{-1}$.**
  - **Tevatron July 2010 combination:**
    - **$M_{top}$= 173.3 ±1.1 (total) GeV/$c^2$ ΔM/M ~ 0.61 %**
- Width
  - CDF: reconstruct mass event-by-event
    - **Γtop< 7.5 GeV@ 95% C.L.**
  - D0: Single top t-channel amplitude
    - **$\Gamma_{top} = 1.99^{+0.69}_{-0.55}$ Gev vs $\Gamma_{top}^{SM}$ = 1.3 GeV**
- Mt – Mtbar
  - **CDF: Leptons + jets vs lepton charge**
    - **ΔM= -3.3 ±1.4(stat)+1.0(syst) GeV/$c^2$**
  - **DO:**
    - **ΔM = 3.8±3.7 GeV with 1 $fb^{-1}_{-1}$**

# Asymmetries

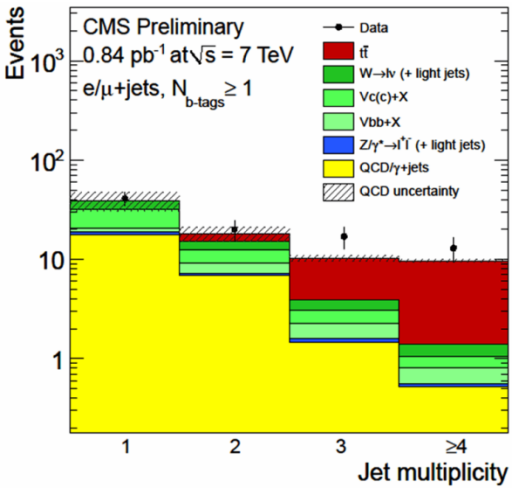
- T-tbar spin correlation
  - Original spins are preserved since top quarks decay before hadronizing
  - Study asymmetry in opposite vs same sign helicity
    - New physics could change this from SM expectation of 0.78
    - D0 result looks like it is not especially consistent with SM but statistical precision too low to get excited yet
      - $K = -0.2^{+0.6}_{-0.5}$
- Forward -Backward asymmetry
  - DY = Y top – Y anti-top relative to proton direction
  - SM has a small asymmetry (a few per cent)
  - New physics can alter this
  - Statistics too low to tell much yet

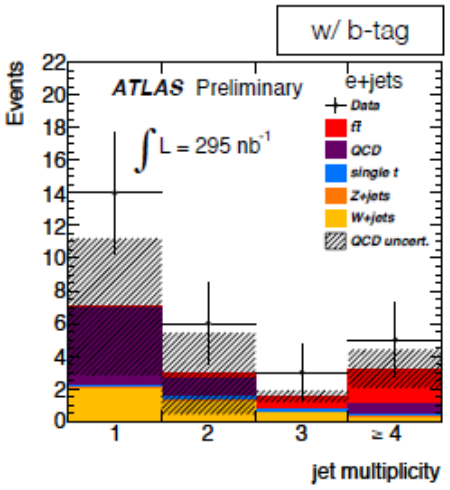
# Search for

- Search in leptons plus jets
  - T’ → T + W
  - Limits
    - D0: above 296 GeV/$c^2$
    - CDF: above 335 GeV/$c^2$
- B’ → T + W → bWW
  - Limits:
    - CDF: Above 385 GeV/$c^2$

# First Observations of the Top Events at the LHC

- Data sets in CMS and ATLAS approaching 15 $pb^{-1}$
  - Top results are for 0.84 $pb^{-1}$ (CMS) and 0.295 $pb^{-1}$ (ATLAS)
  - Invaluable tune-up of analysis (see slide 3)
  - Using dileptons and leptons plus jets
  - Seeing the correct rate of t-tbar events compared to NLO cross sections given the uncertainties
  - Next step is to publish the cross section at 7 TeV



# Prospects at LHC with 1 $fb^{-1}$

- Should be equivalent to ~20 $fb^{-1}$ at Tevatron
- Search for electroweak single top quarks, cross section is a direct measure for $|V_{tb}|$.
  - Might be able to observe single top quarks with 1$fb^{-1}$.
  - Single top is different at 7 TeV
    - More t-channel relative to s-channel
    - t-W channel (15%)
- Measurement of *R=B(t→Wb)/B(t→Wq) in top pair production to measure* $|V_{tb}|$.
  - A precision of ~10% is expected.
- Spin correlations are also different in strong top production due to different weighting of quark and gluon diagrams
- Search for resonances in the top-antitop mass spectrum;
  - Special reconstruction and selection methods required for "boosted tops" for very high energy tops from very heavy resonances
    - For "boosted tops" all decay products from a top may wind up in one fat jet

# Medium Term and Long Term Prospects at the LHC

- σ(7 TeV) ~ 140 pb; σ (14 TeV) ~ 850 pb
- LHC performance
  - 1 x $10^{32}$ $cm^{-2}s^{-1}$ reached **yesterday** (first 7 TeV beam on Mar 30@ $10^{26}$ $cm^{-2}s^{-1}$)
  - Single bunch current is now higher than the $10^{34}$ design
  - Emittance is smaller than expected
  - Dynamic aperture in quadrupole triplets is larger than expected (now β* is 3.5m, can go to 1m)
  - Operating at ONLY 312 bunches out of 2808
- For medium term, CERN is "considering "
  - a new, higher luminosity goal of several $10^{32}$ $cm^{-2}s^{-1}$
  - 8 TeV Center of Mass Energy
  - Running in 2012
    - Integrated Luminosity goal would be 5 $fb^{-1}$
- The above suggests that the LHC should approach 10 $^{34}$ $cm^{-2}$ $s^{-1}$ at ~13-14 TeV in LHC Run Period 2 (through 2015)
  - Integrated luminosity of ~65 $fb^{-1}$ hoped for by end of 2015 (on current schedule)
  - **At these luminosities, TOP production at LHC is equivalent to b-production at KEKB or PEPII B-factories, > $10^7$/year, an awesome concept**