p-p Physics at LHC

Minimum Bias events. W/Z Production

Lecture 3

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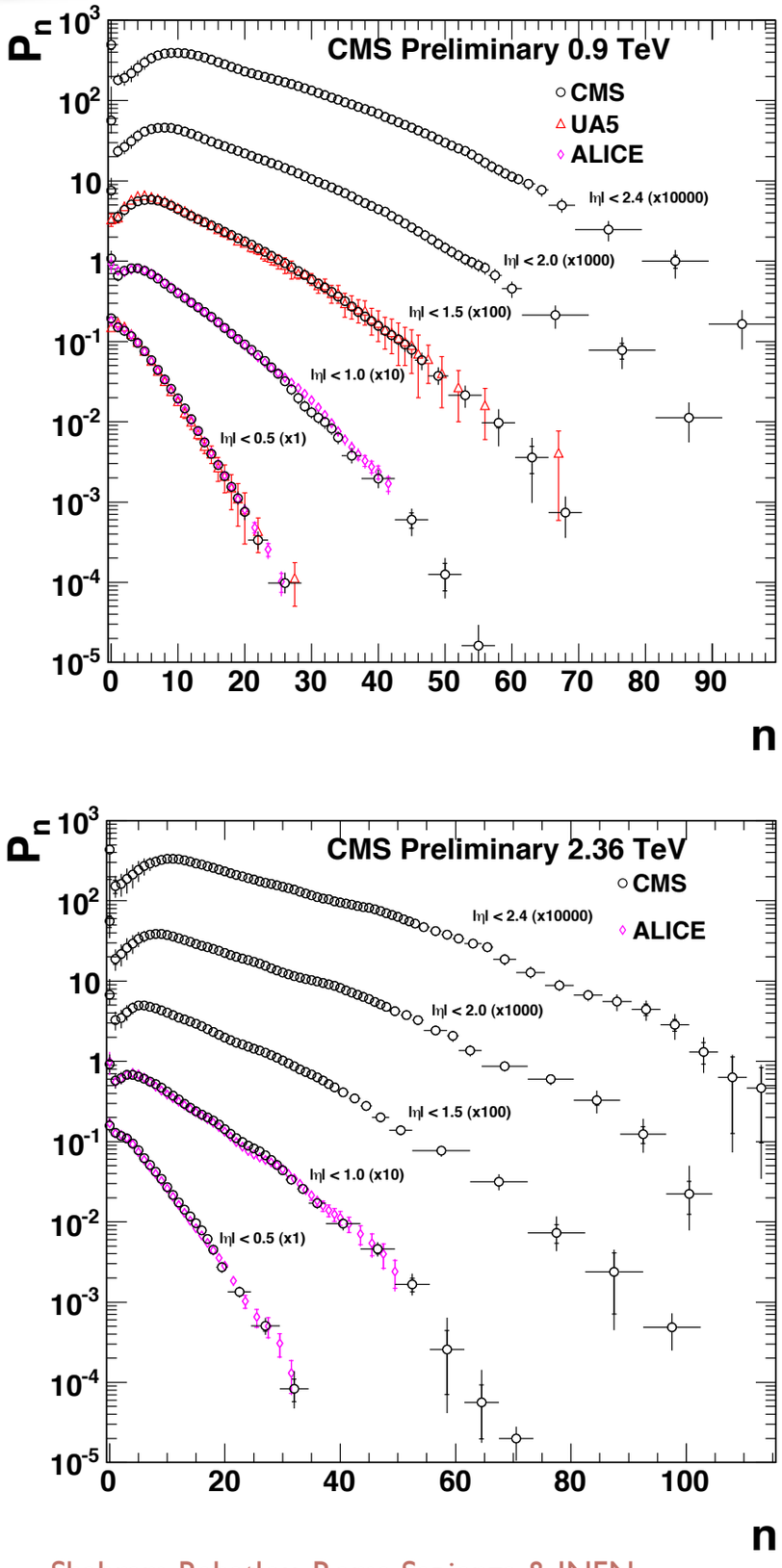
Minimum Bias Events

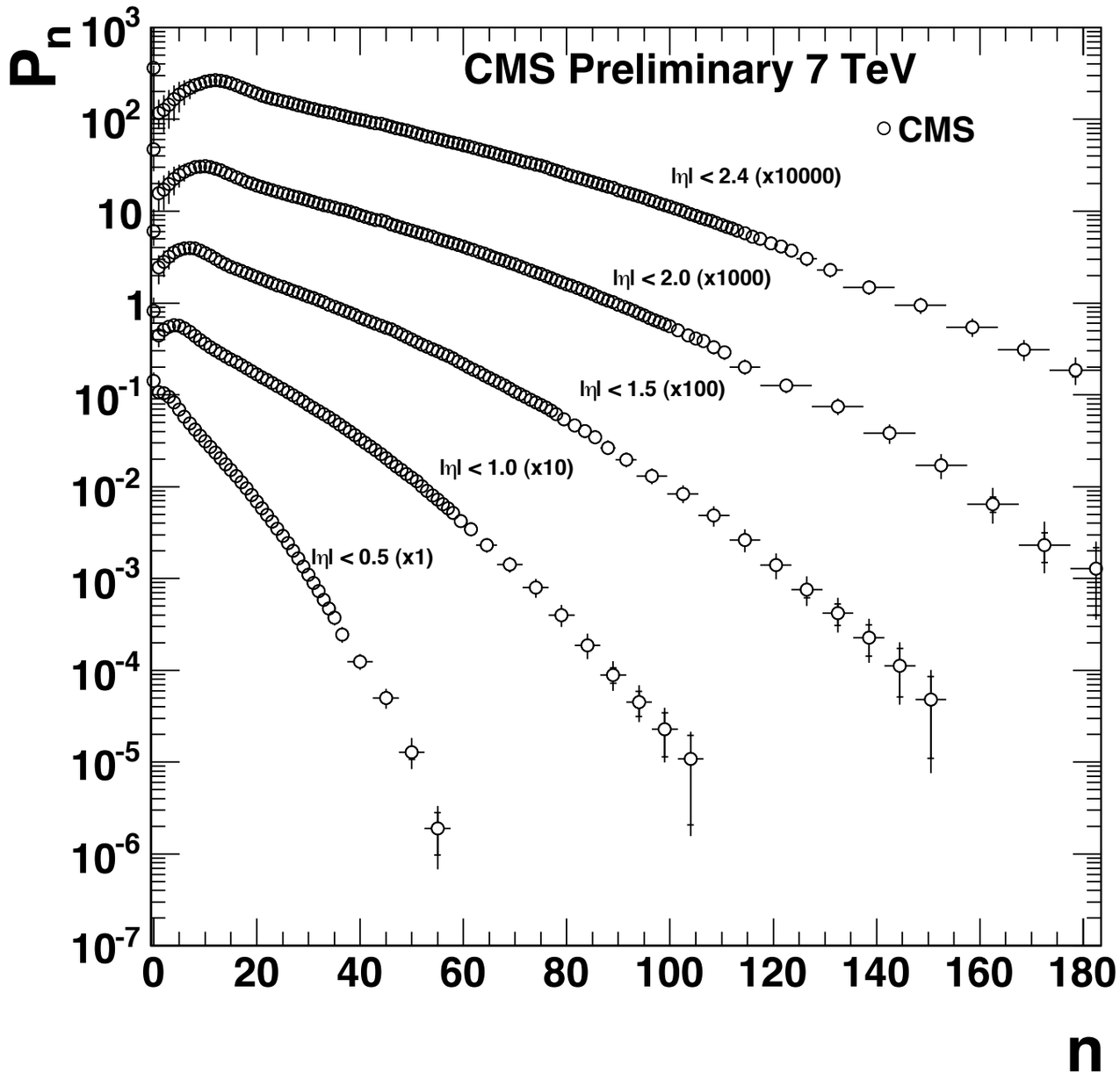
- Trigger requirements 'bias' the type of events towards interesting hard scattering processes
  - single high pt lepton
  - 2 high pt leptons
  - high pt jet(s)
  - large missing energy
  - jets + missing energy

- Majority of events produced in collisions are due to QCD and not represented by the events triggering and written to tape

- Minimum bias: minimize as much as possible requirements on tracks and energy deposits in order to have an unbias sample of all type of events
  - very low pt requirements
  - use beam scintillators to trigger presence of beams and collisions
  - require presence of at least one primary vertex

TRACK MULTIPLICITY

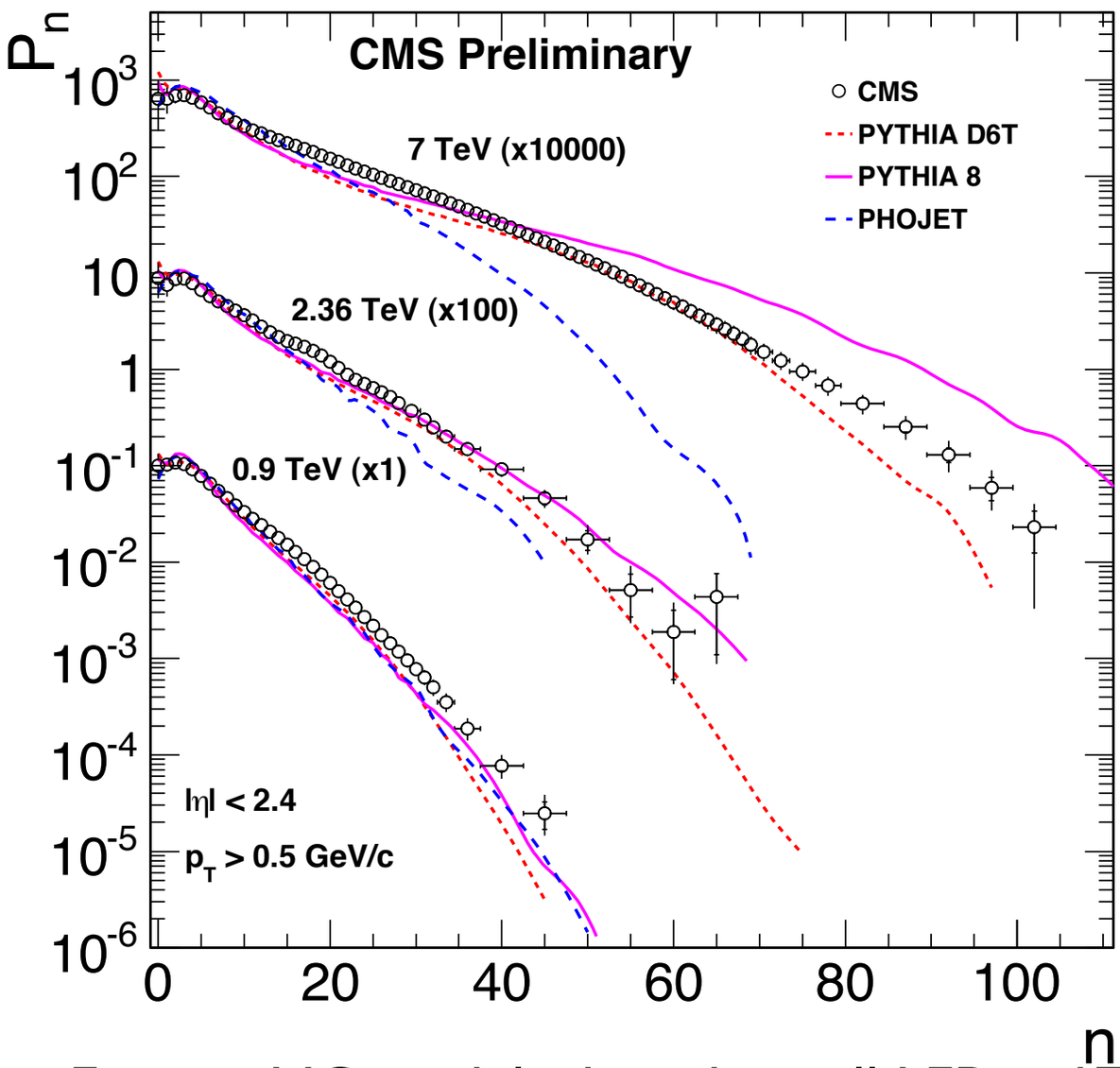




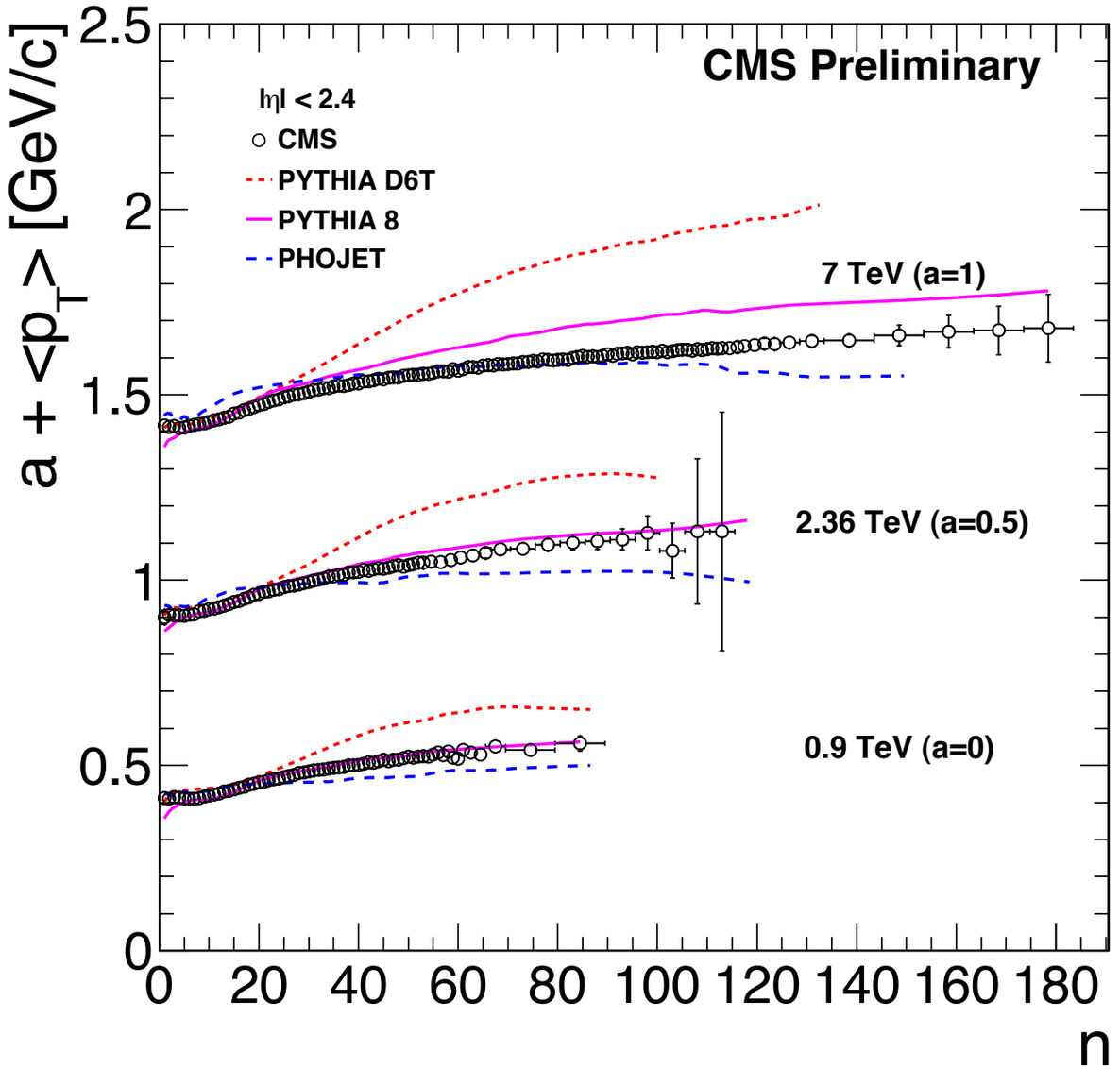
- Count number of charged tracks (pt > 100 MeV)for different center of mass energies and different pseudo-rapidity intervals

MONTECARLO TUNING WITH 7 TEV DATA

Charged Track Multiplicity

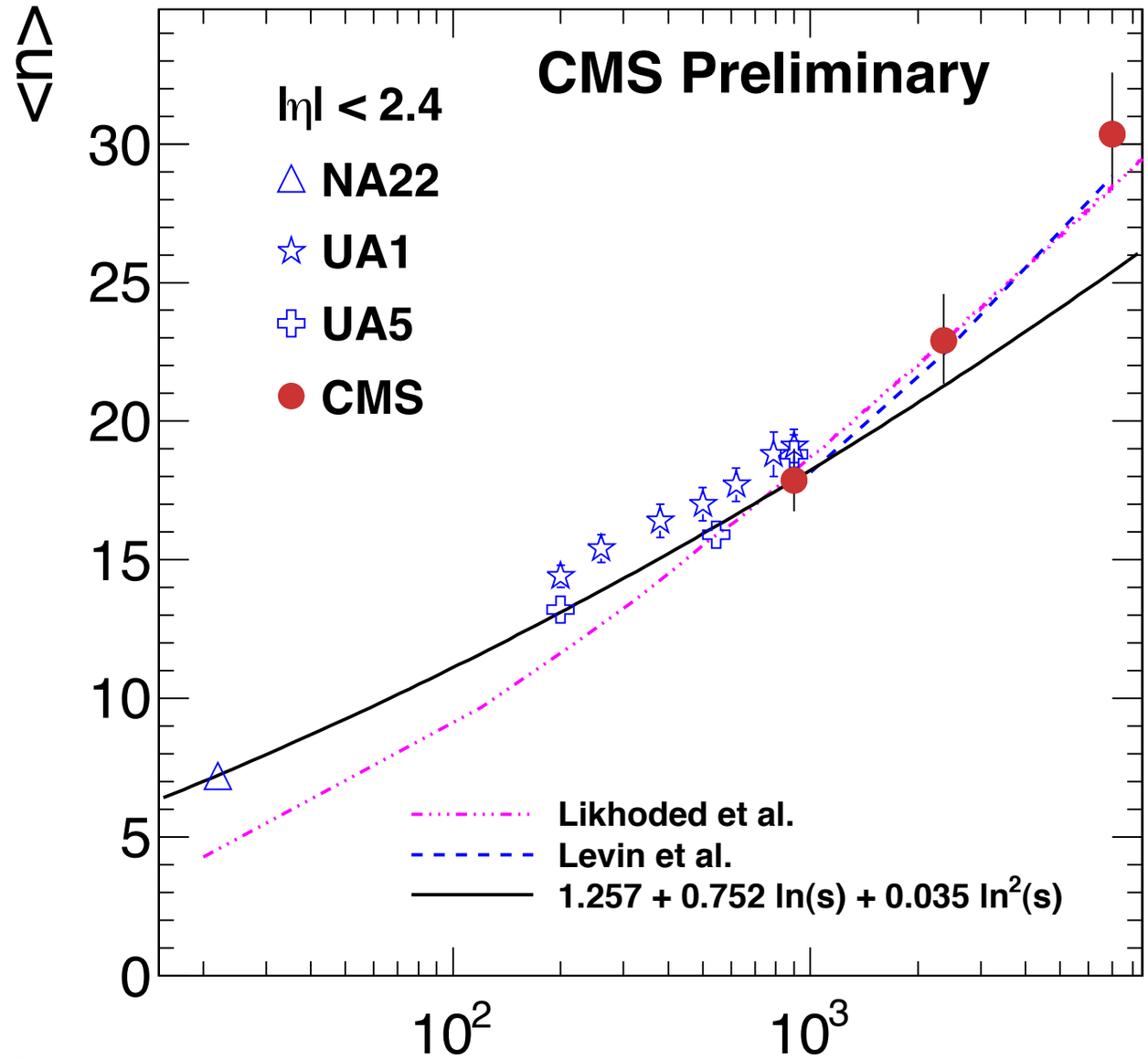


pt spectrum



- Existing MC models describe well LEP and Tevatron data BUT fail to describe current LHC data
  - Early LHC data (even just few days) to improve MC predictions before more sophisticated measurements

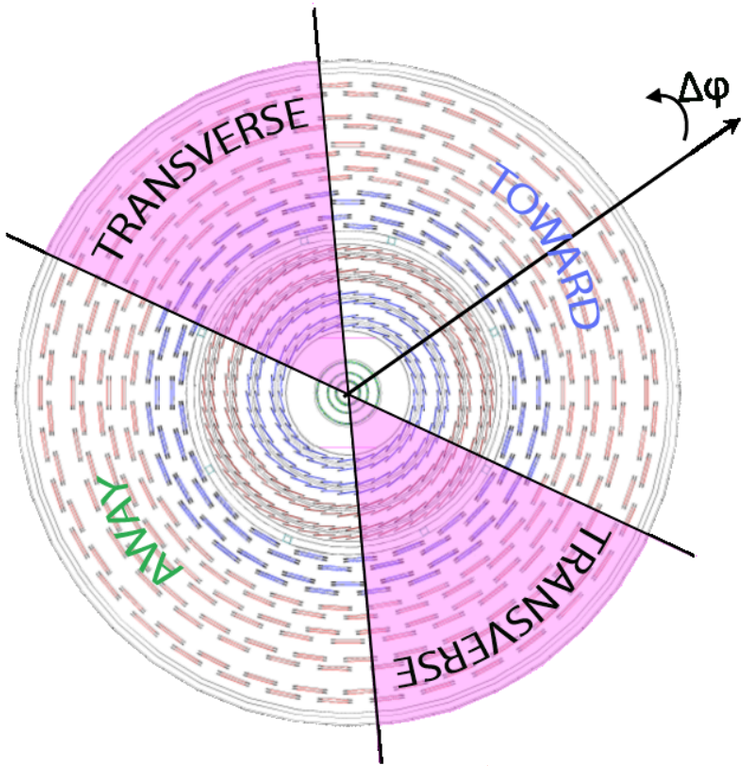
TRACK MULTIPLICITY SCALING

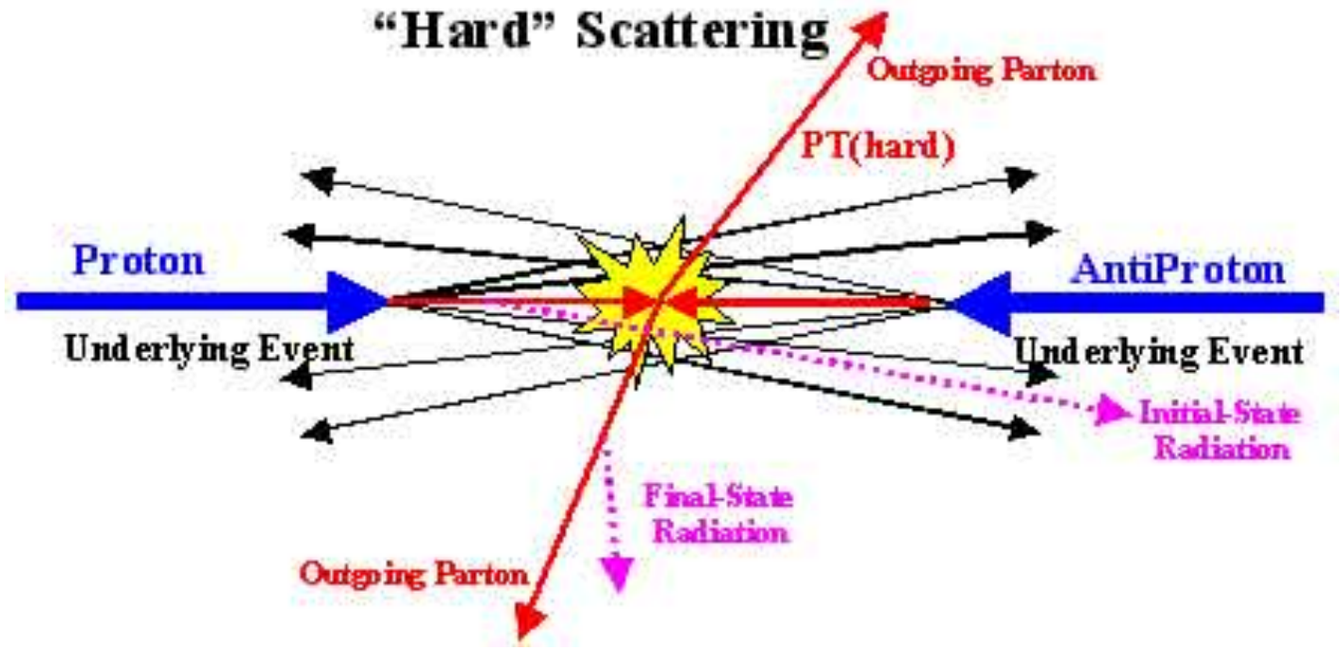


- Faster rise at higher energy

UNDERLYING EVENT

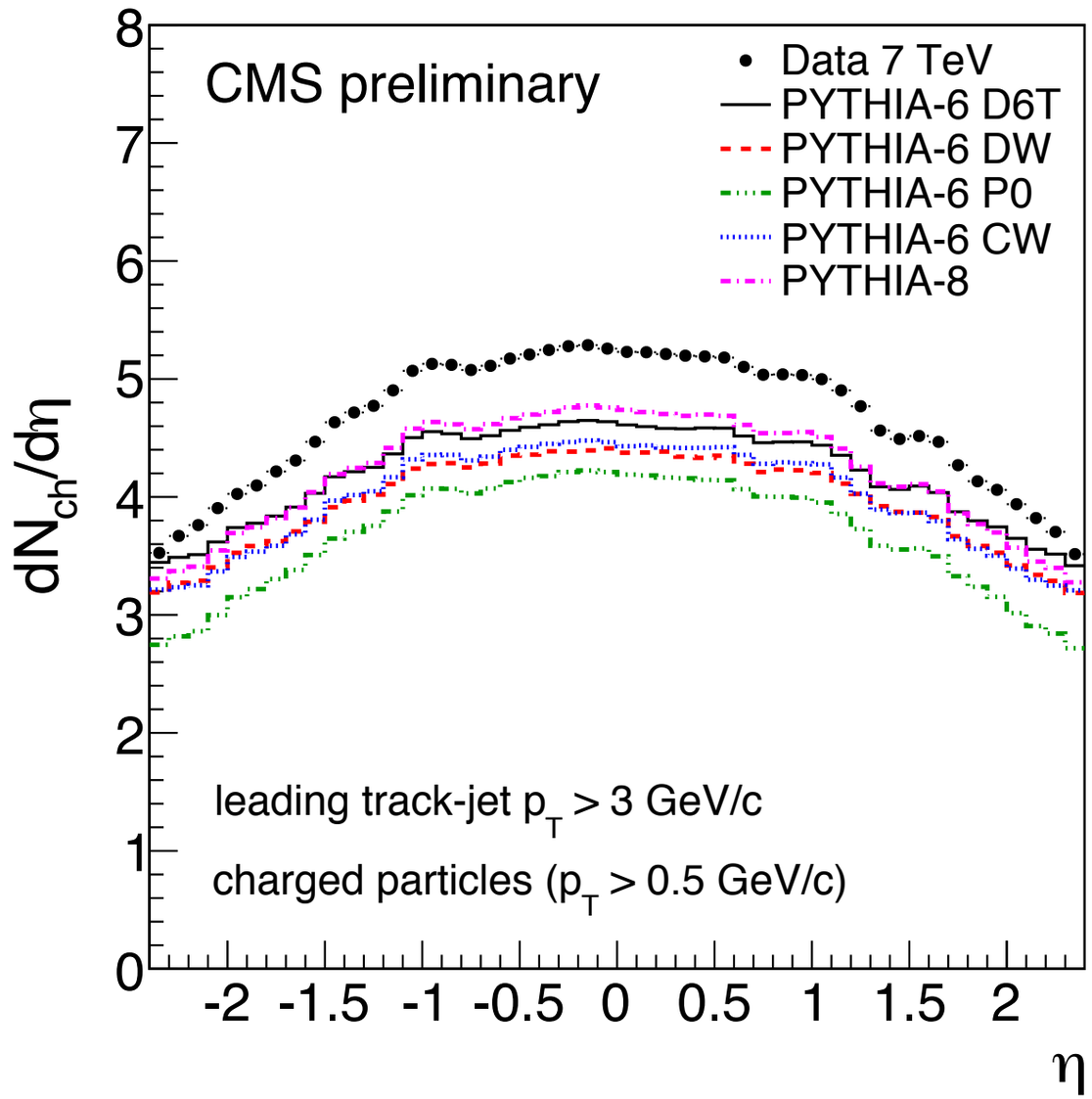
Leading track jet

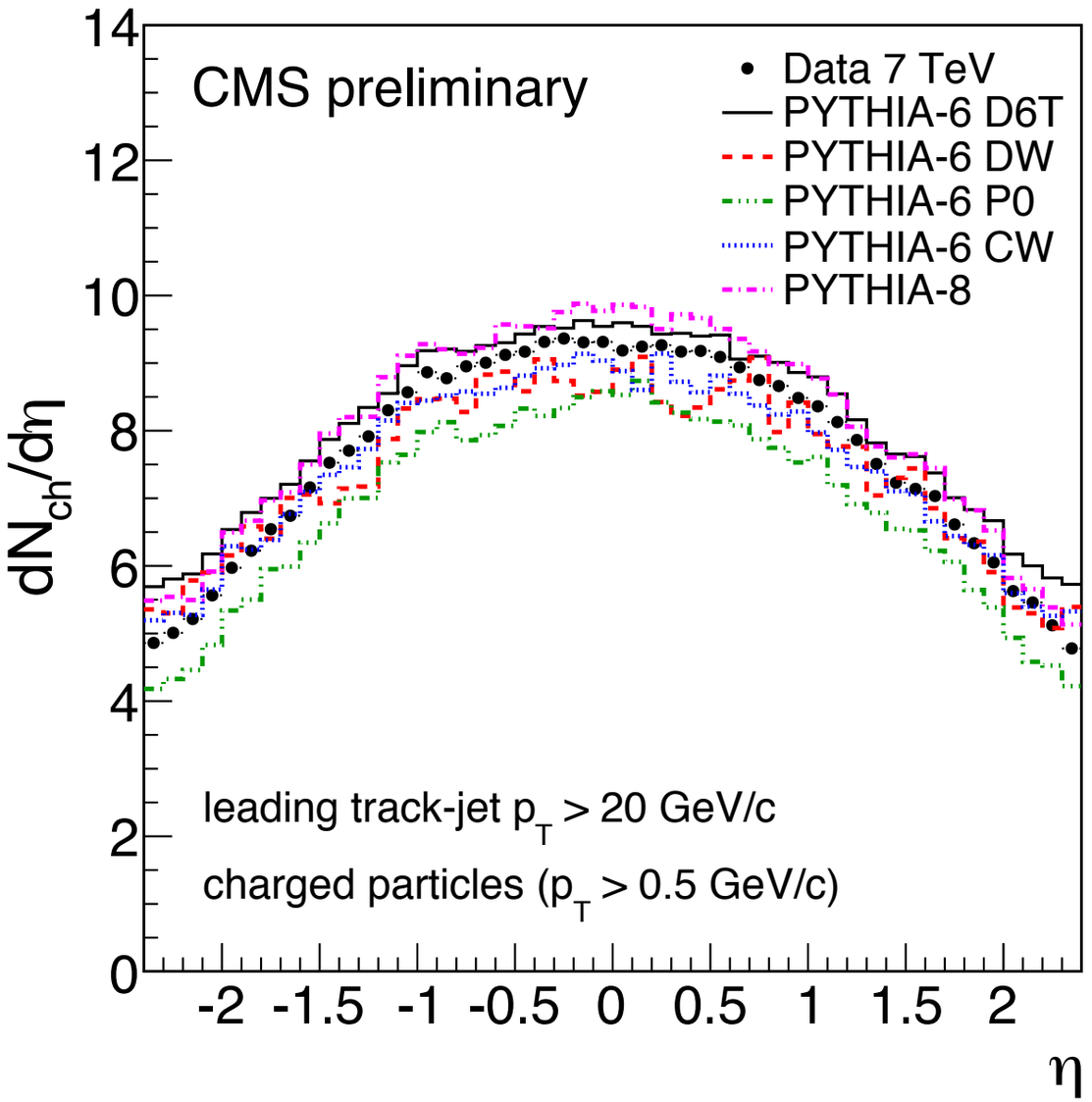




- Jet reconstruction with only charged tracks
- Use leading jet (jet with highest pt in the event) to define forward direction
- Study activity in 4 different regions

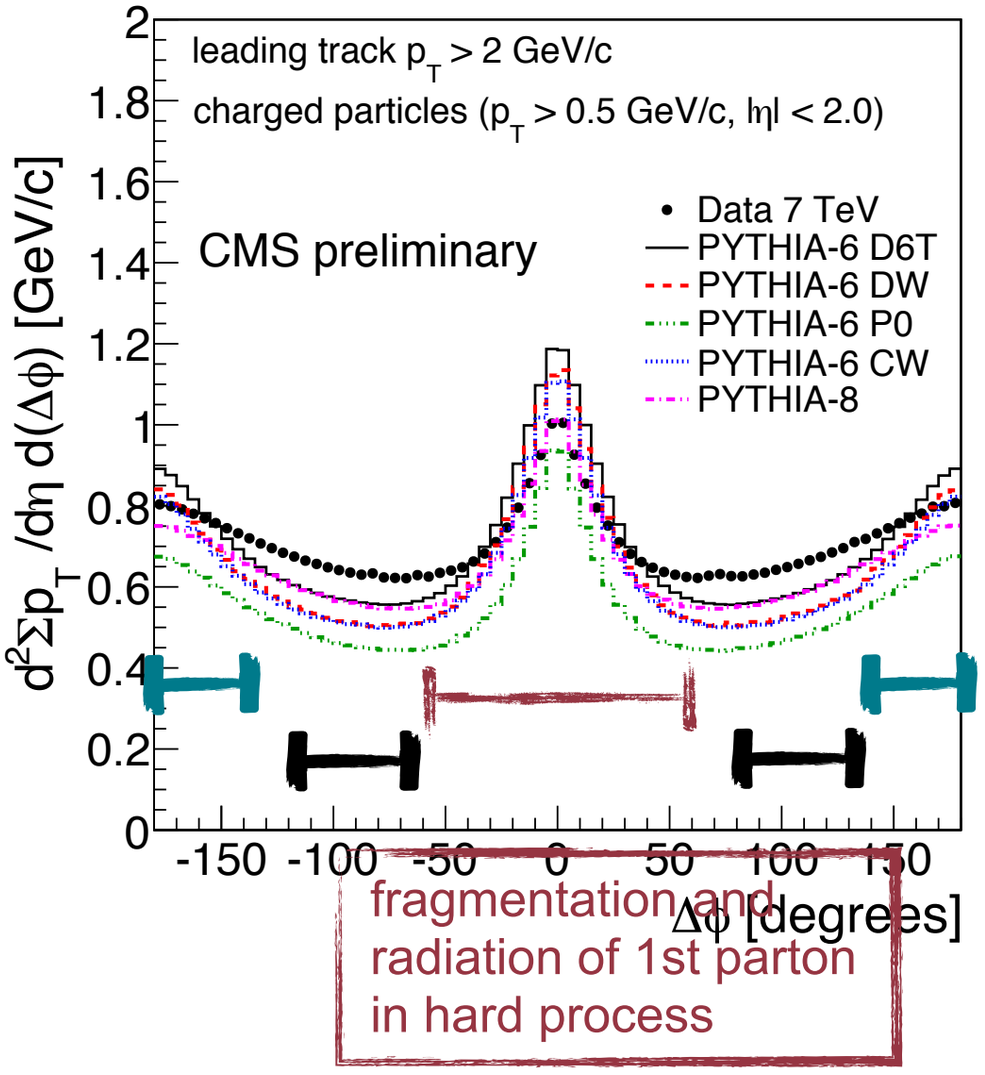
H SPECTRUM

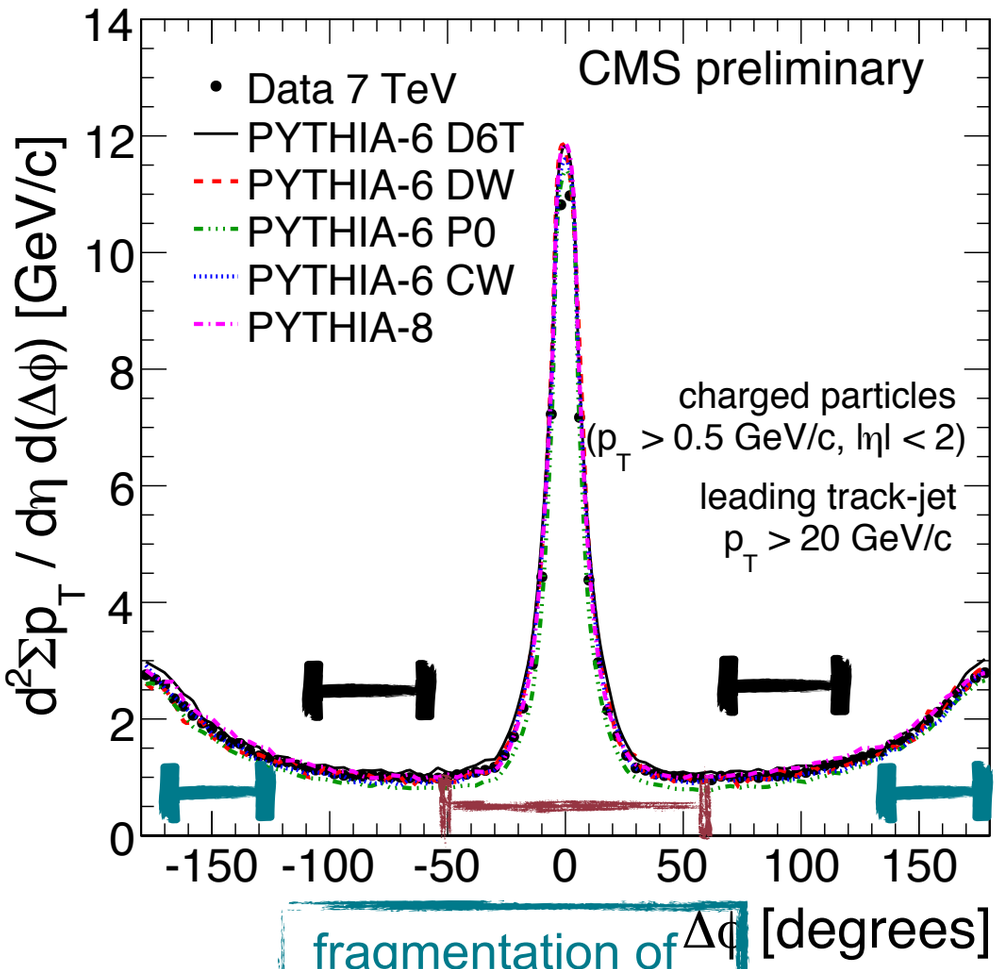




- MC predictions agree in shape but fail (specially at low momentum) the normalization
  - discrepancy up to 25%
  - possible causes: description of parton fragmentation and radiation and of underlying event

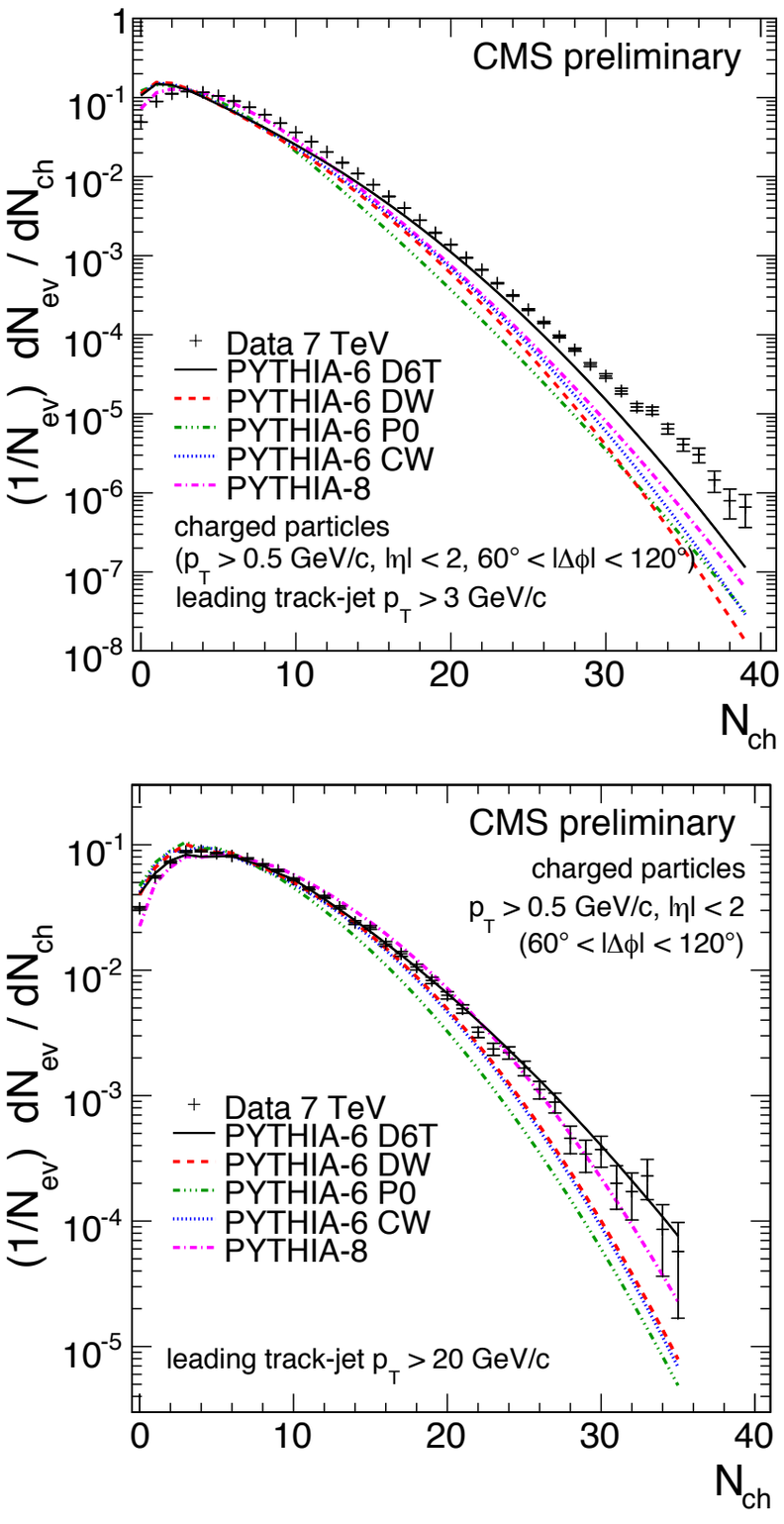
TRANSVERSE ACTIVITY

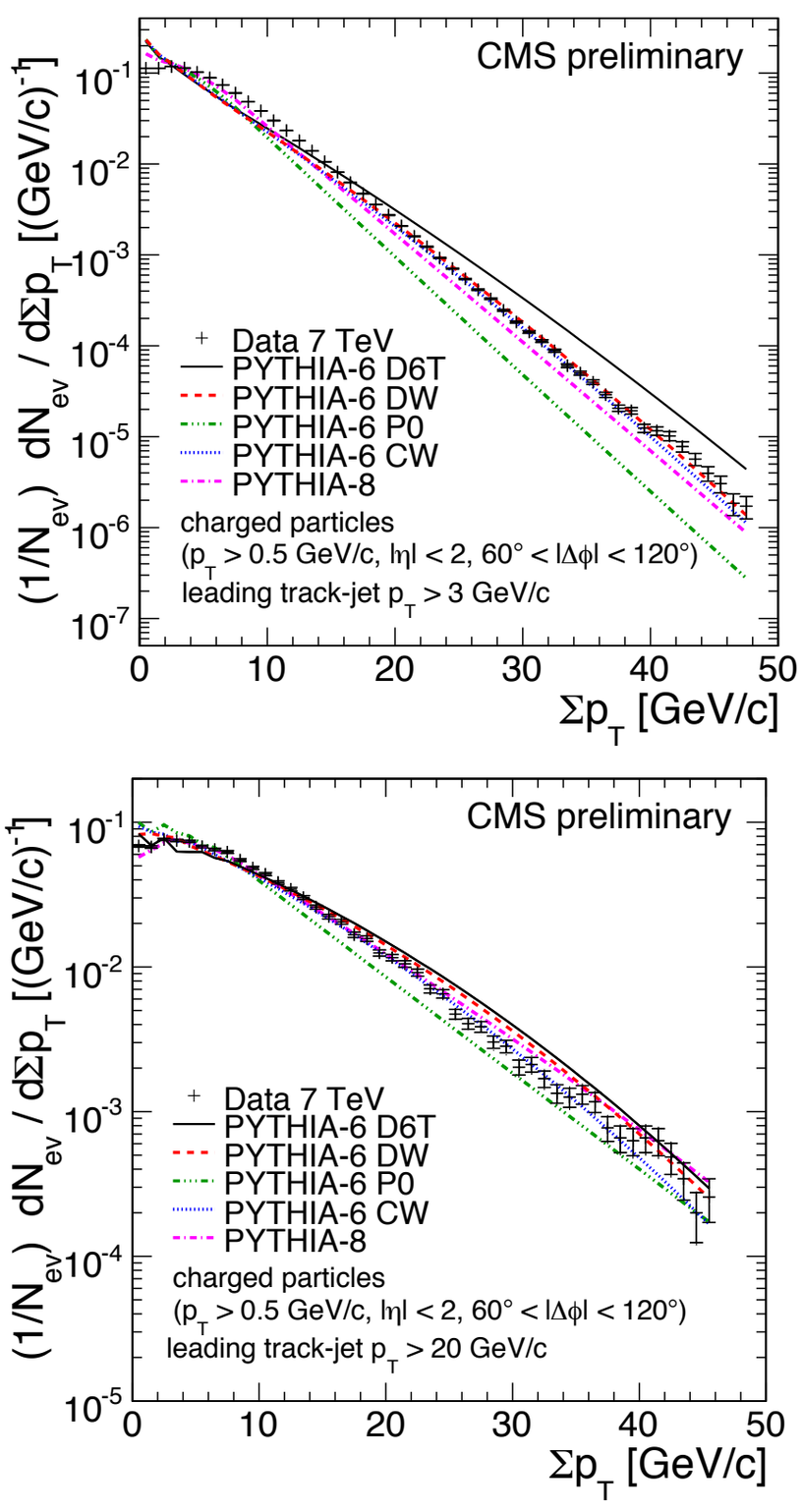


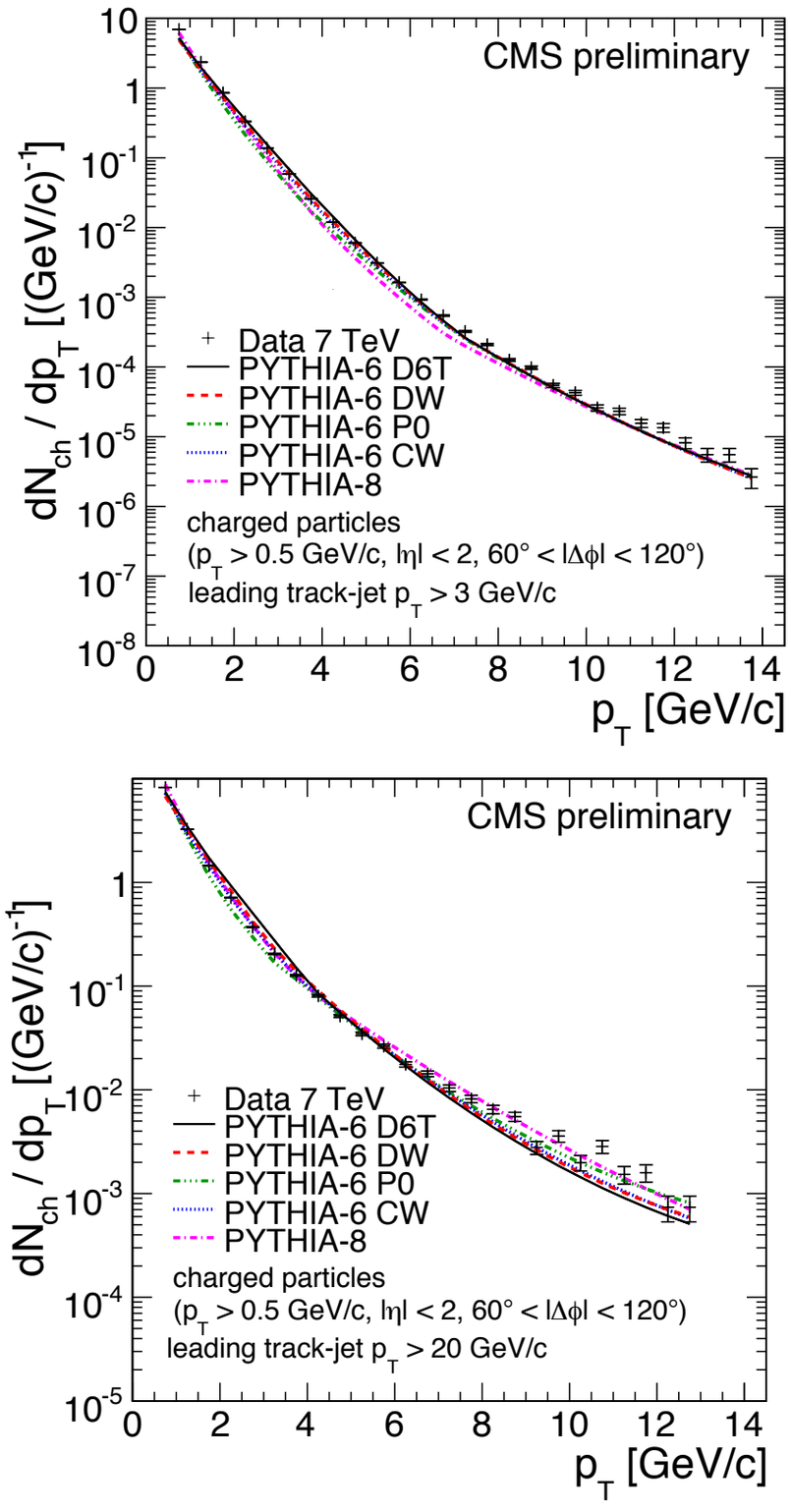


Largest discrepancy in transverse region at low momentum: multiple parton interaction (MPI) description

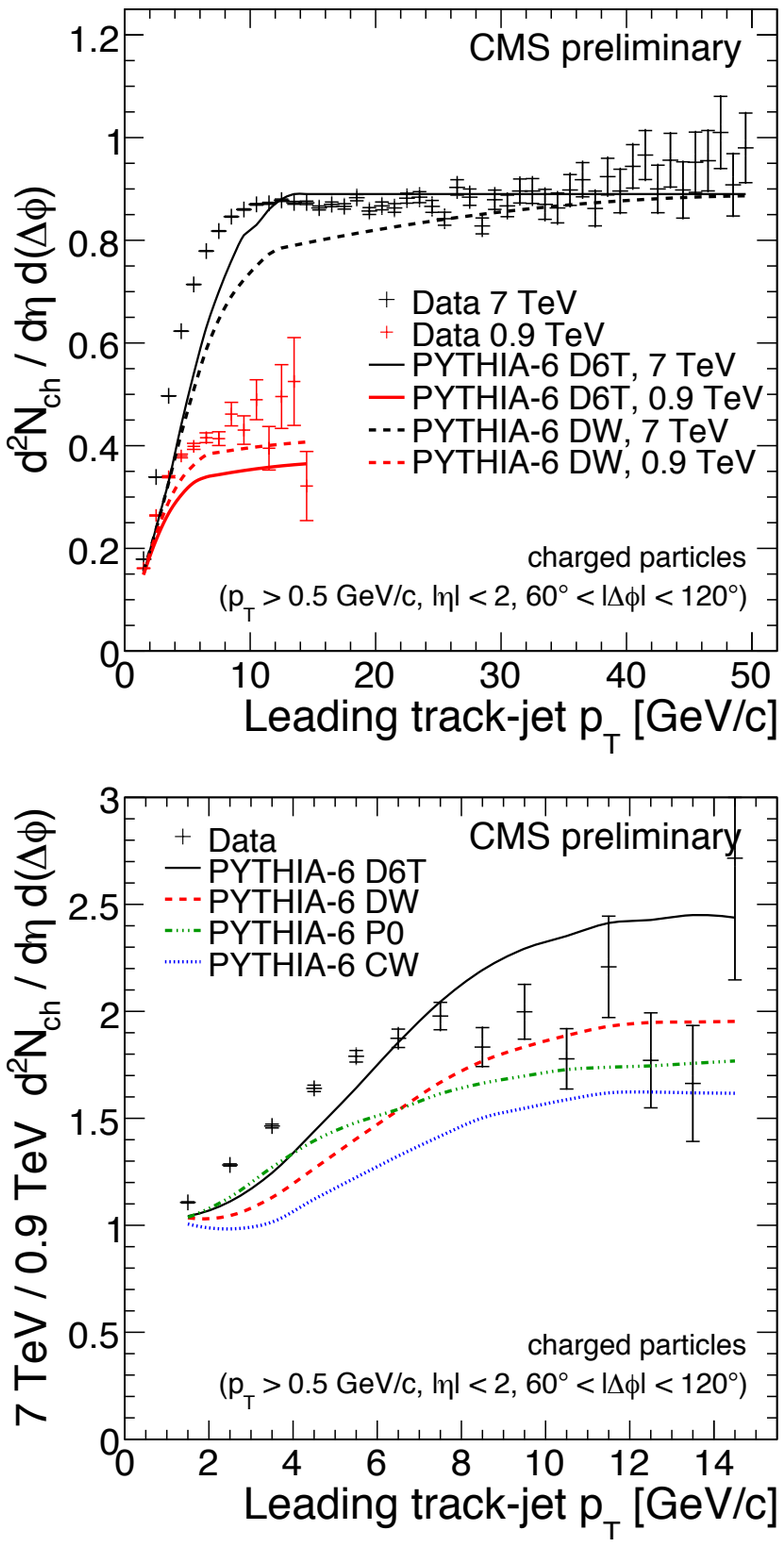
PT AND MULTIPLICITY

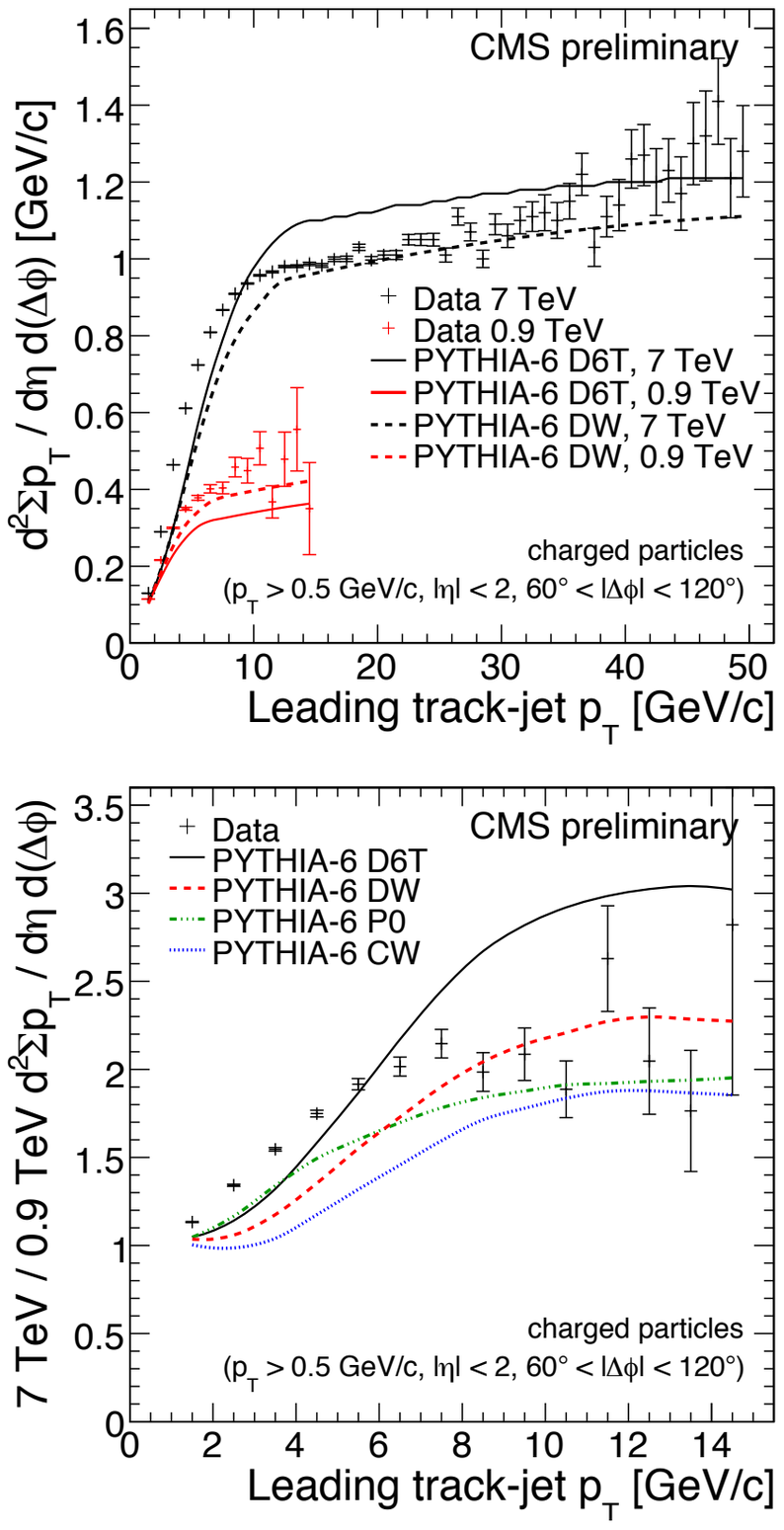






TRANSVERSE ACTIVITY WITH √S





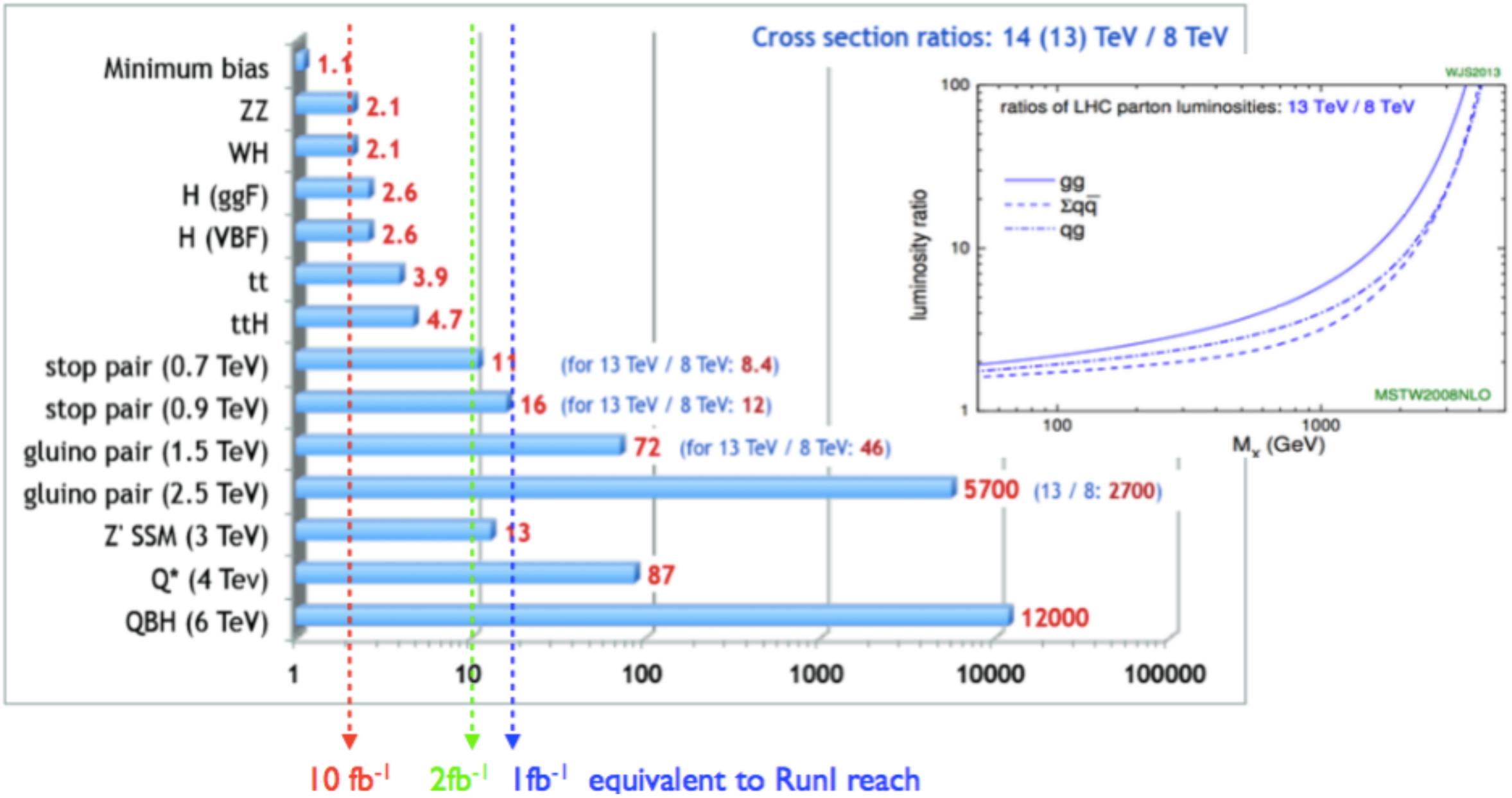
What Did We Learn?

- Strong underlying activity both in number of tracks and total transverse momentum
  - Different models agree at different levels but large discrepancies remain
  - Discrepancies much larger at lower momentum scale

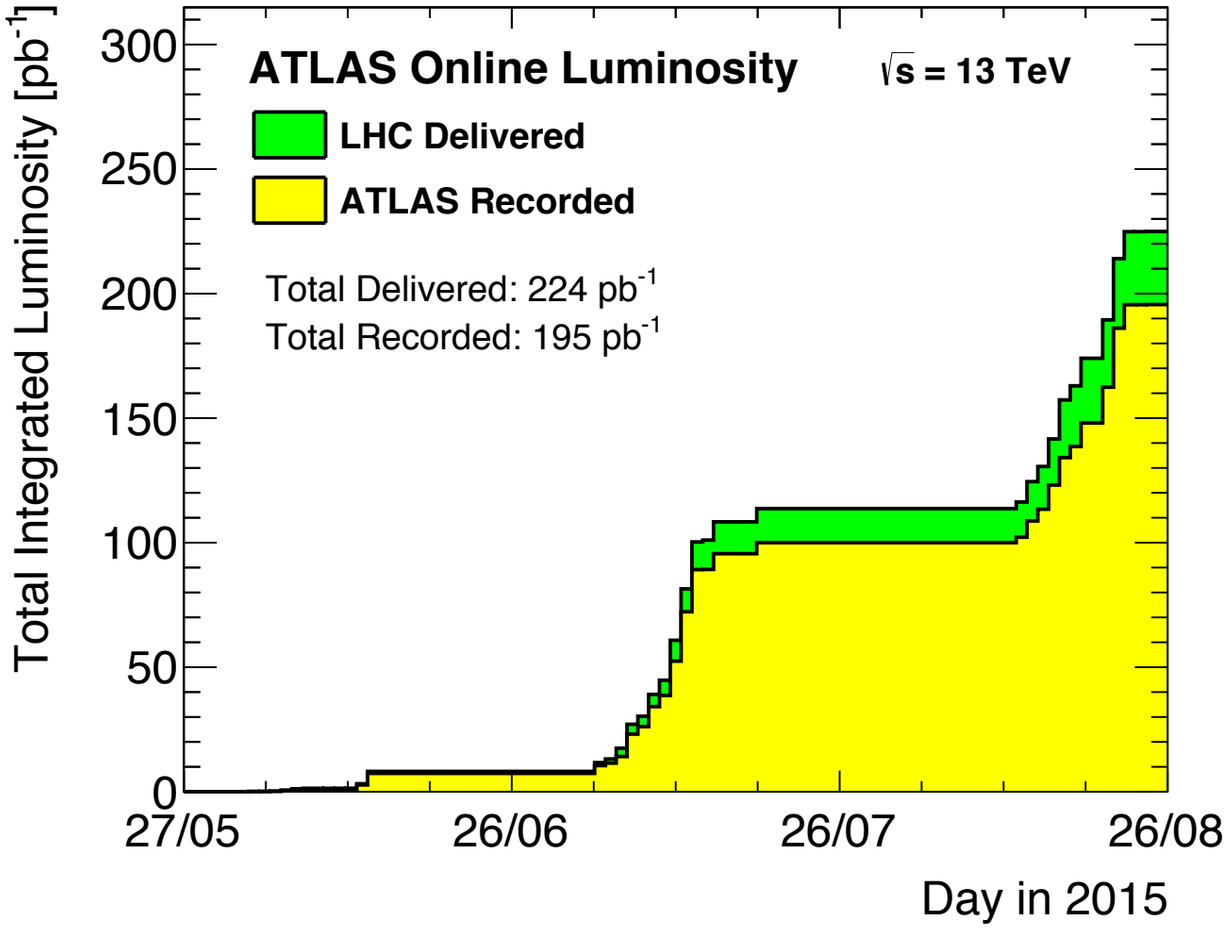
- Transverse activity grows with center-of-mass energy beyond prediction
  - compare 0.9 TeV and 7 TeV data

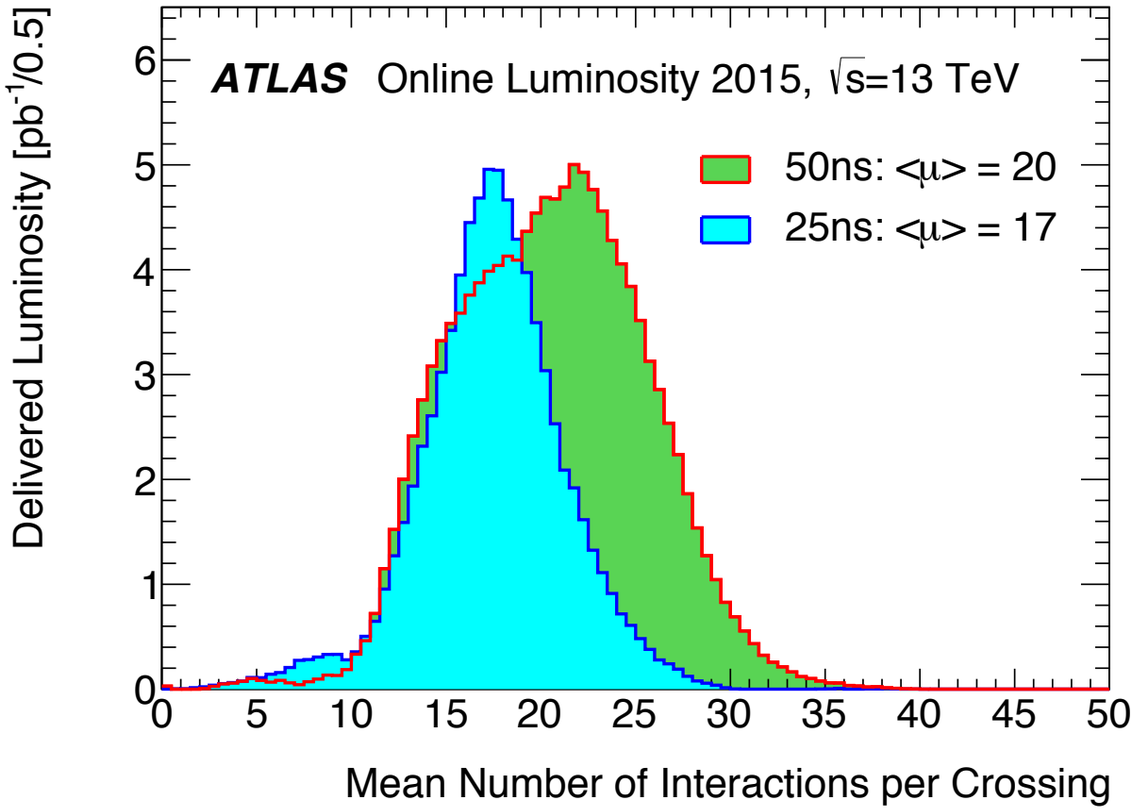
- Differences in models include
  - parton fragmentation
  - parton radiation
  - Multiple parton interaction description and dependence on $\sqrt{s}$
  - LHC runs at 13 TeV and 14 TeV will improve our understanding

Energy Increase to 13 TeV

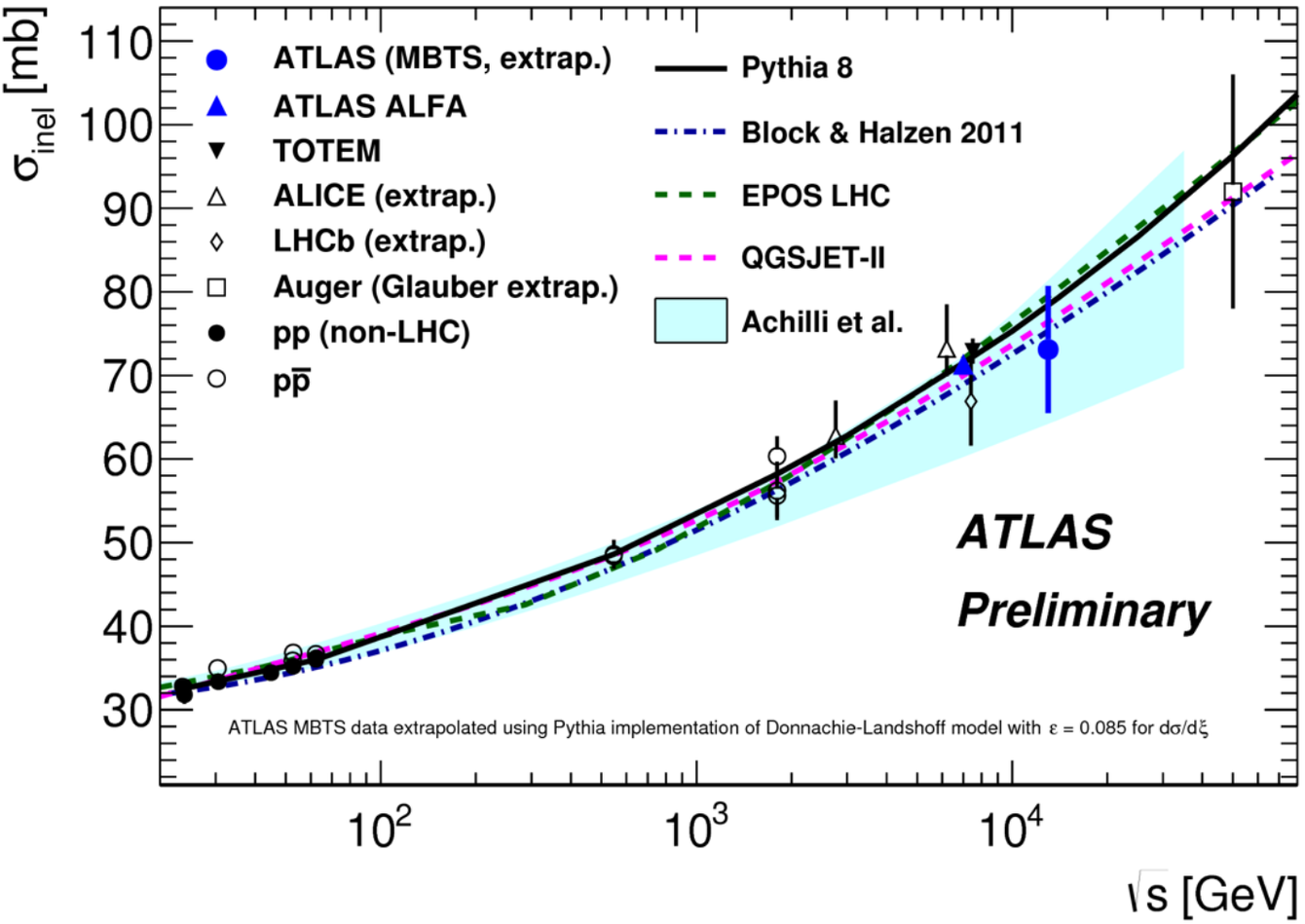


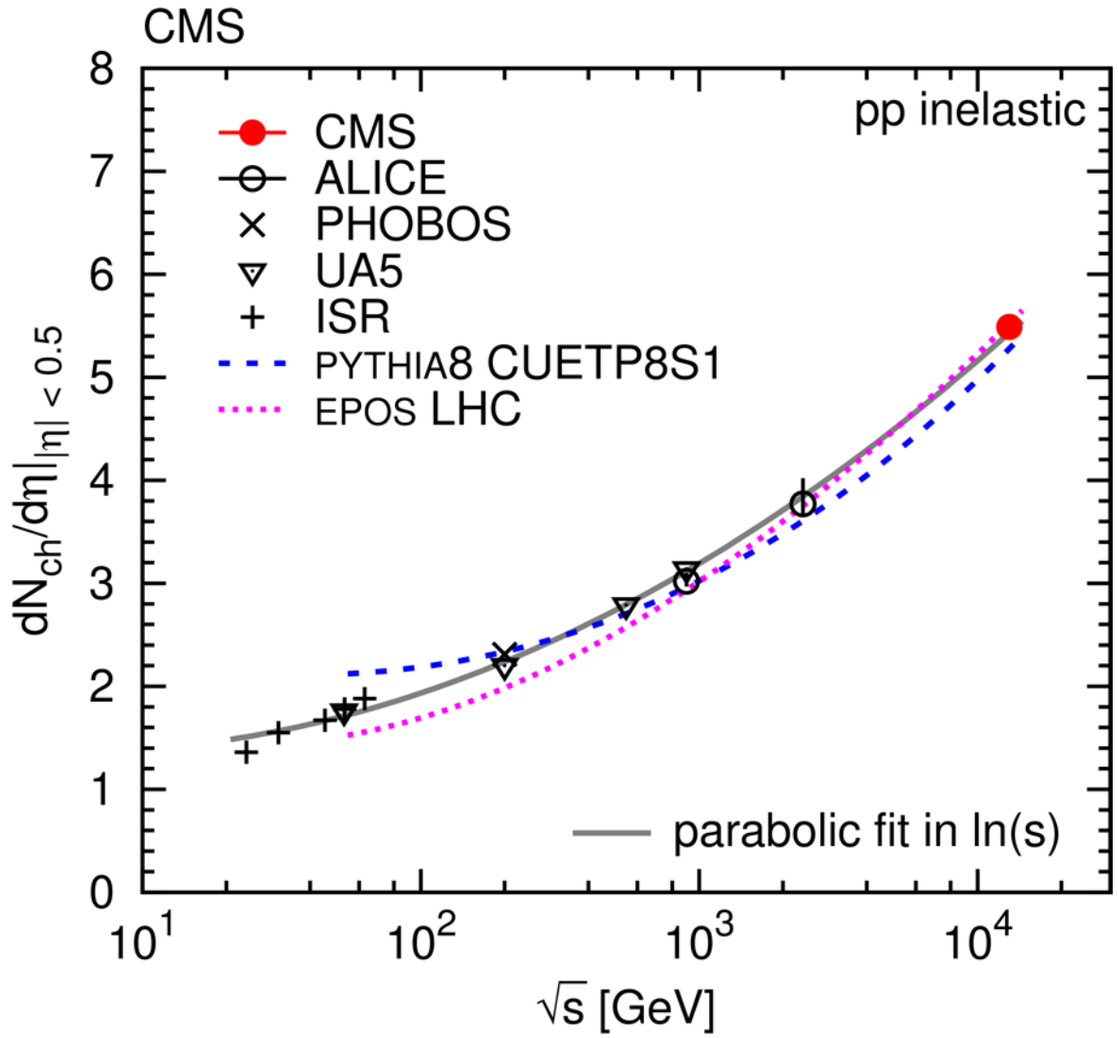
First 13 TeV Data



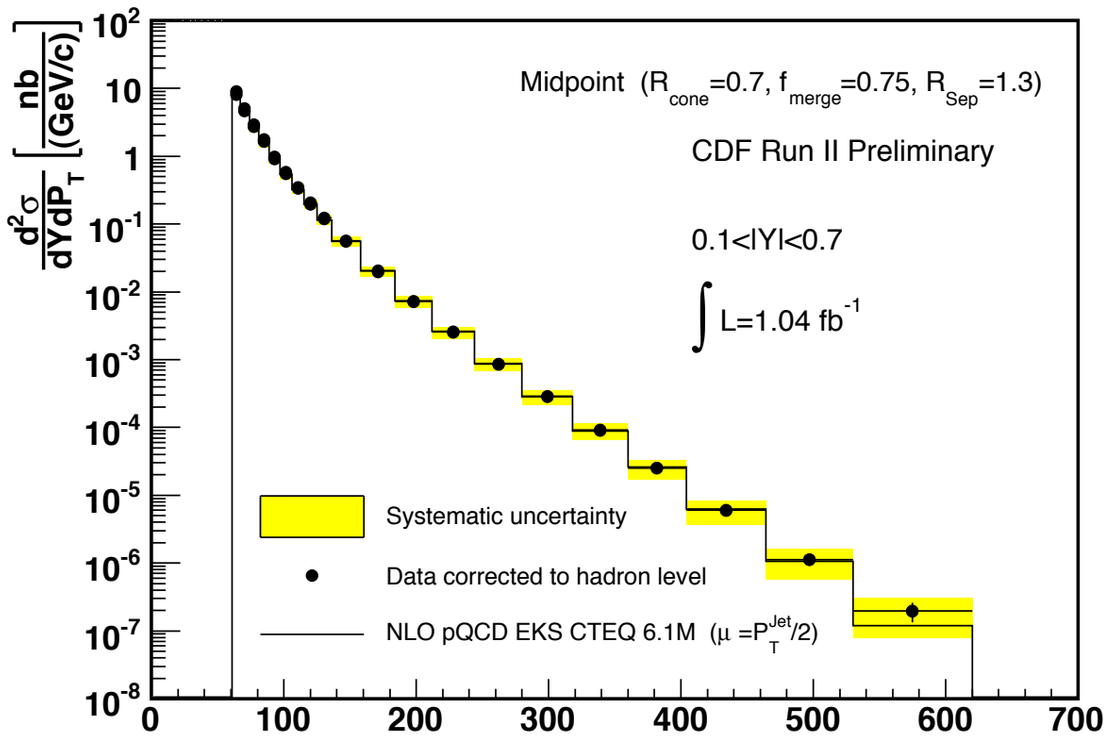


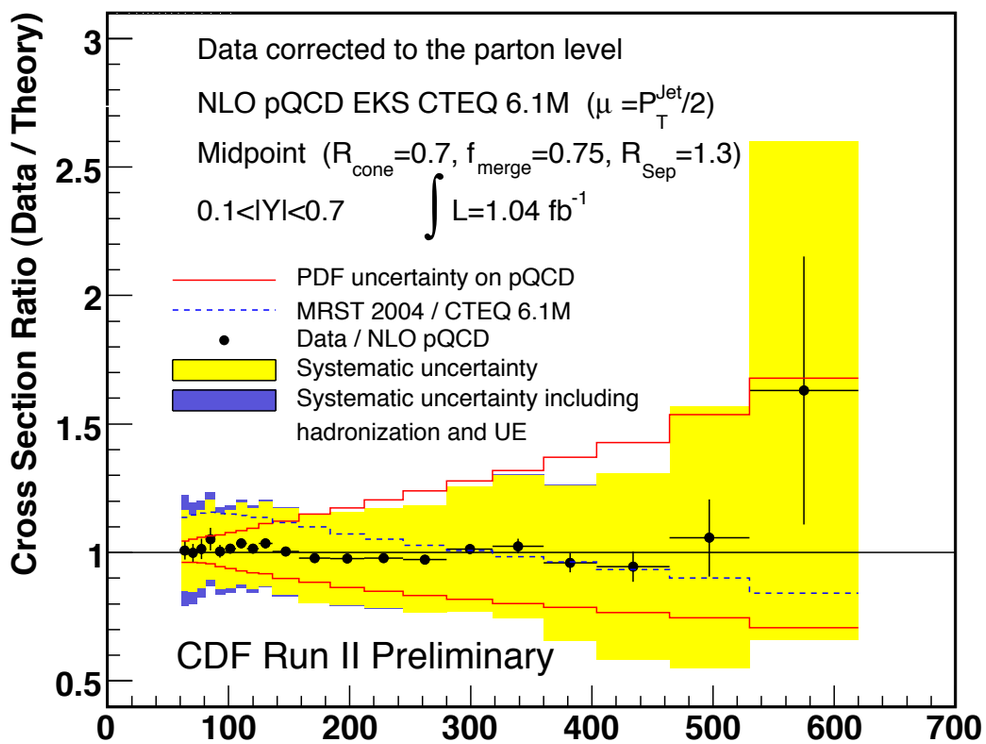
INELASTIC SCATTERING AT 13 TEV





INCLUSIVE JET CROSS SECTION





- Very nice agreement between data and theory predictions at Tevatron
- Experimental challenge
  - Jet detector response: determine 'true' energy of the jet from measured energy
    - jet algorithms
    - Jet Energy Scale: calorimeter response and containment
  - Determine corrections from jet to parton level in order to compare to theory
    - e.g. evaluate contamination from underlying event for a given radius in jet algorithm

INCLUSIVE JET CROSS SECTION @ LHC

- Analysis does not require enormous data
  - systematically limited
- Almost 1/150 of total accumulated luminosity at end of 2010 run
  - 5 fb^{-1} in 2011 @ 7 TeV
  - 16 fb^{-1} in 2012 @ 8 TeV