Inclusive Forward Jets, Forward-Central Dijets and Ratios of Dijet Production Cross Section

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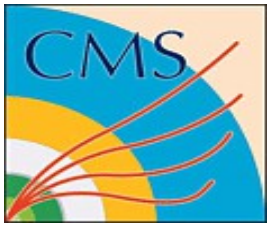
CMS Collaboration



MPI @ LHC 2012
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Outline

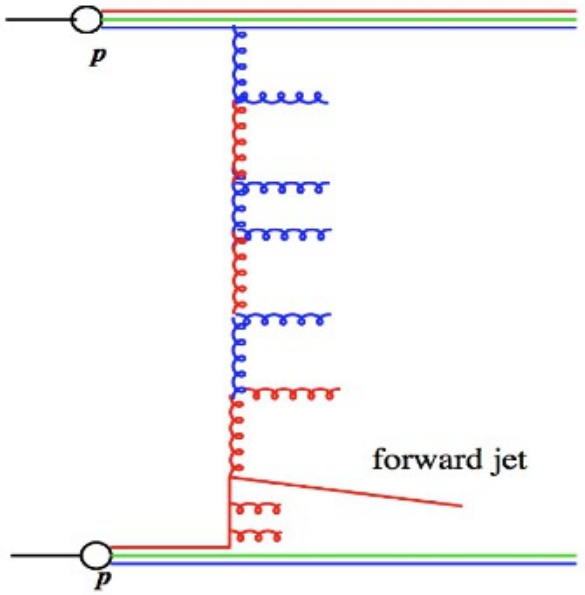
- Inclusive Forward Jets → DOI: 10.1007/JHEP06(2012)036
- Forward-Central Dijets → DOI: 10.1007/JHEP06(2012)036
- Ratios of Dijet Production Cross Section → DOI 10.1140/epjc/s10052-012-2216-6
- Conclusion

Inclusive Forward Jets

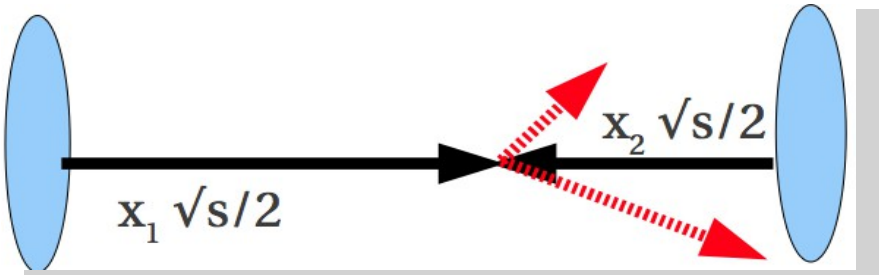
Motivation

Jets in hadron-hadron collisions

- Forward jets allow to probe the low-x domain (10^{-5}) region sensitive to alternative parton dynamics and non-linear QCD effects.
- Better understanding of the parton density functions (PDFs).
- Sensitivity to parton radiation.

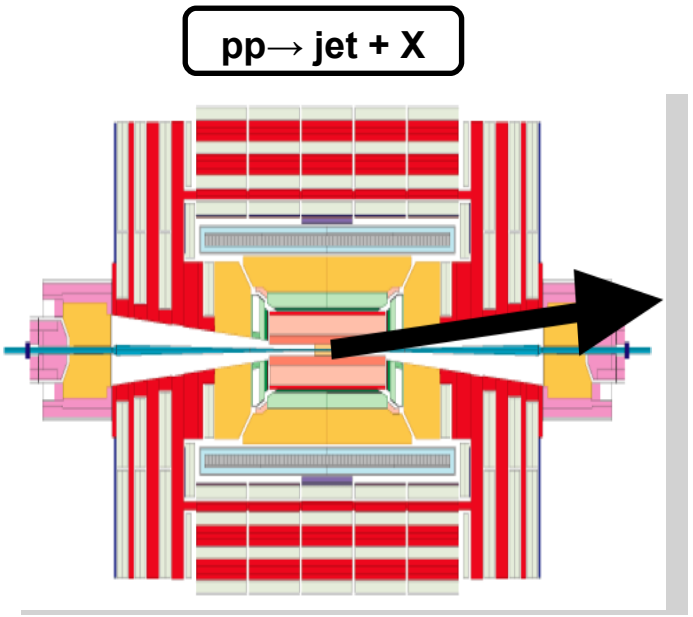


$$x_2^{min} \approx \frac{p_T}{\sqrt{s}} \cdot e^{-y} = x_T \cdot e^{-y}$$



- Forward jets in LHC – access to $x \sim 10^{-6}$
- Forward jet in HF with $p_T > 35$ GeV: $x \sim 10^{-4}$

Inclusive Forward Jets

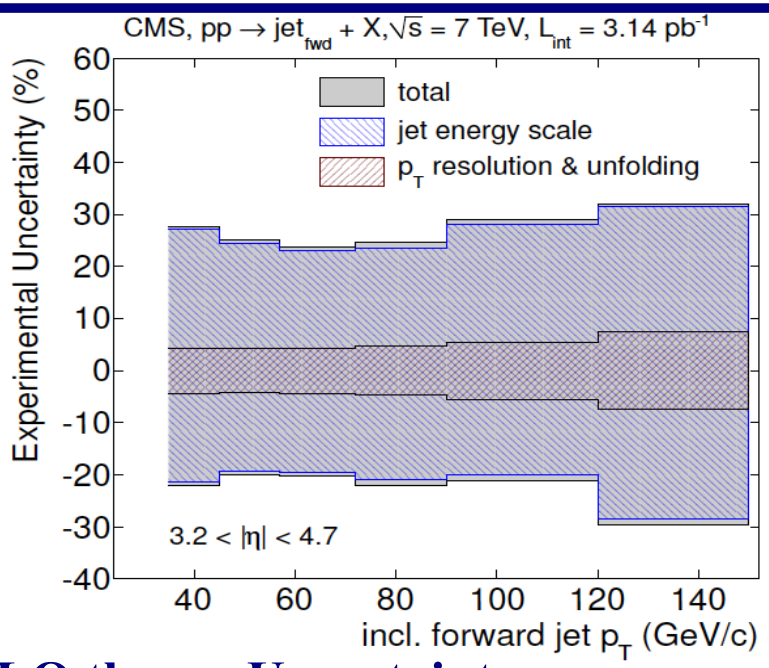


- 3.14 pb^{-1} from 7 TeV 2010 (low pile-up)
- Anti-k_T (R=0.5) jet clustering algorithm
- Single jet trigger with p_T>15 GeV
- Jet identification criteria
- Good primary vertex
- Jets are selected with p_T>35 GeV in HF acceptance: $3.2 < |\eta| < 4.7$

- L is the integrated luminosity.
- C_{had} accounts for bin-to-bin migrations due to p_T resolution and detector to particle corrections.
- Δp_T and $\Delta\eta$ are the transverse momentum and pseudorapidity bin sizes.
- ε_t is trigger efficiency of the jet trigger.

$$\frac{d^2\sigma}{dp_T d\eta} = \frac{C_{had}}{L\cdot\varepsilon_t}\cdot\frac{N_{evts}}{\Delta p_T\cdot\Delta\eta}$$

Inclusive Forward Jets



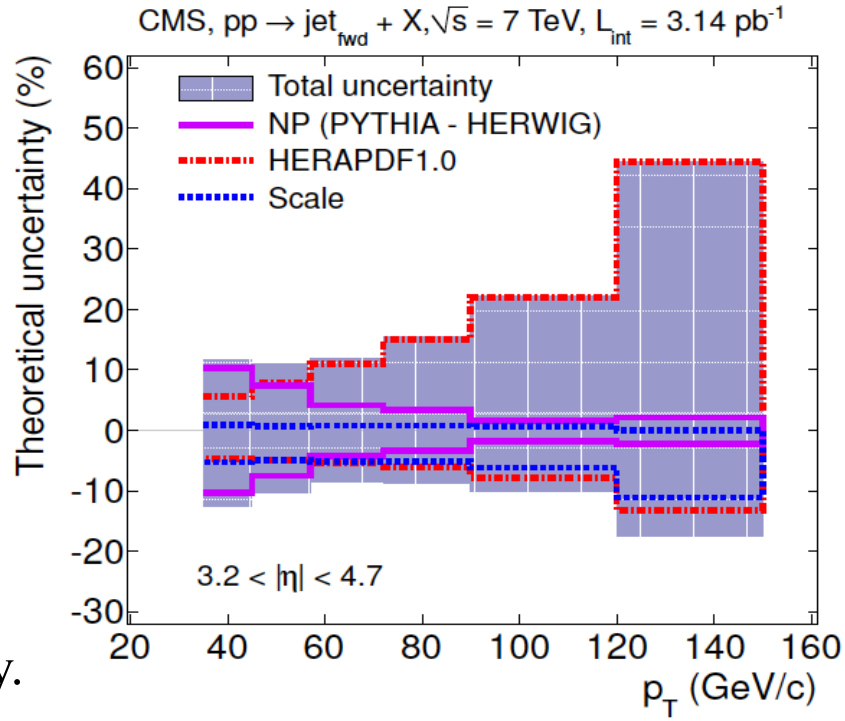
Experimental Uncertainties:

- Jet energy scale uncertainty → 20-30%
- Unfolding procedure and p_T resolution → 3-6%
- Luminosity uncertainty → 4%

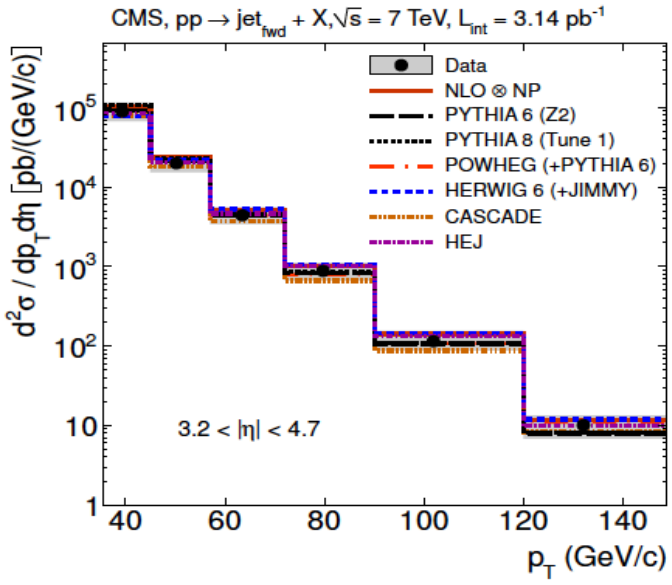
NLO theory Uncertainty:

- Non perturbative effects (Hadronization and UE)
  → dominates at low pT 10%
- PDF uncertainties → up to 40%
- Scale uncertainty → 5-10%

These three uncertainty are added in quadrature into a single band representing the NLO theoretical uncertainty.



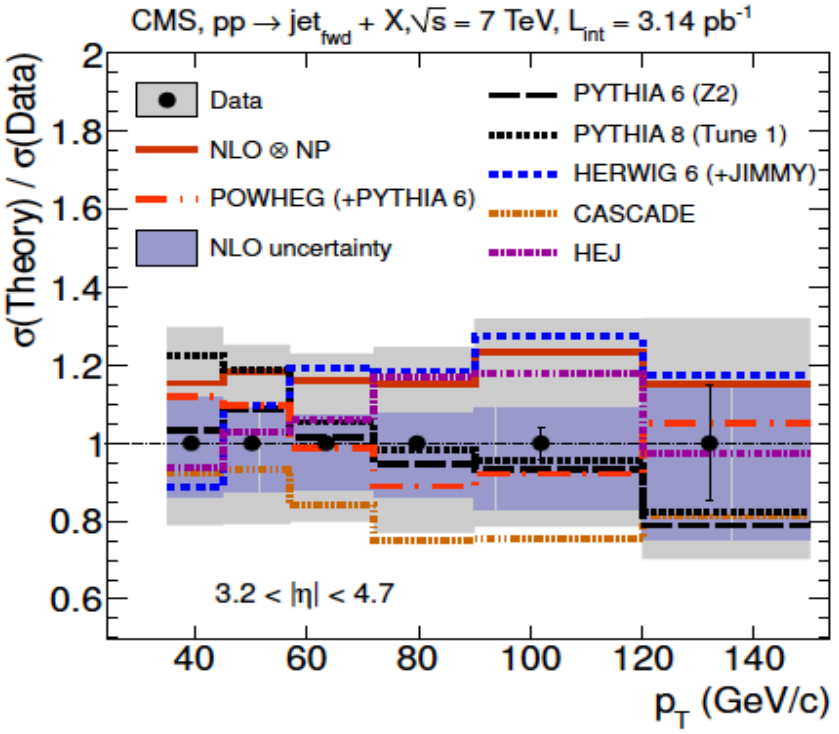
Inclusive Forward Jets



- Inclusive forward jet cross section fully corrected and unfolded.
- Compared to predictions from approaches in perturbative quantum chromodynamics.

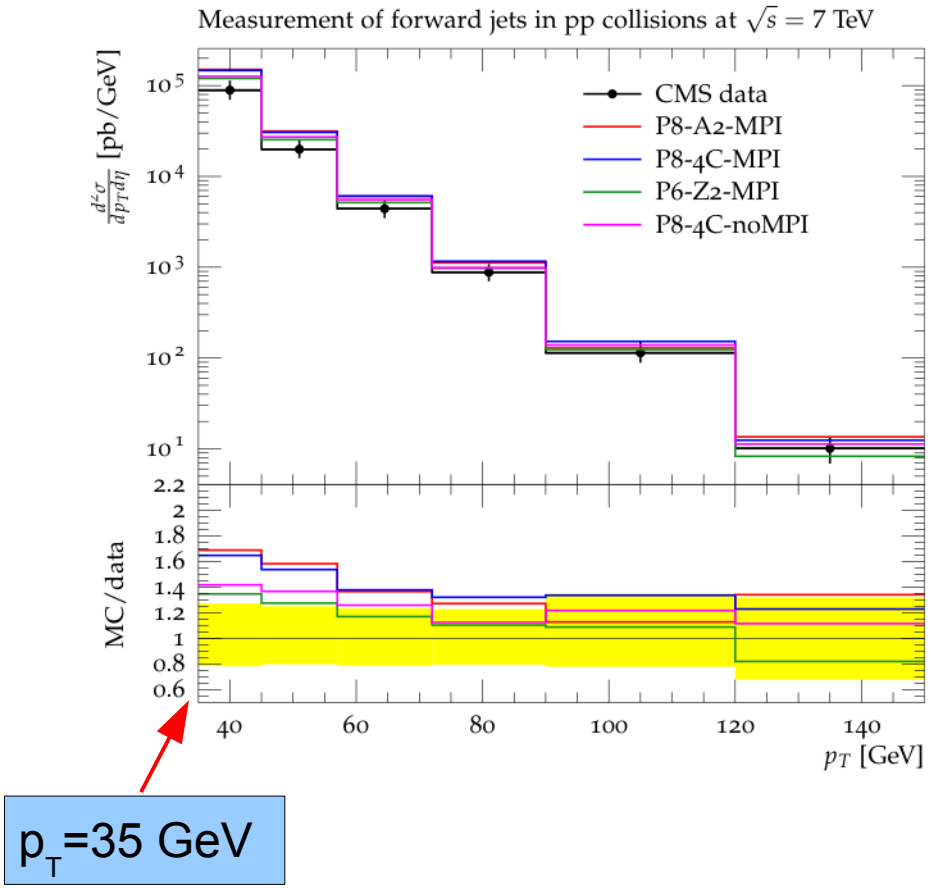
- Within the experimental and theoretical uncertainties
  - Perturbative QCD calculations as implemented in the parton-shower event generators PYTHIA and HERWIG
  - CCFM calculation CASCADE
  - HEJ model

are in good agreement with the measured inclusive single-jet cross section

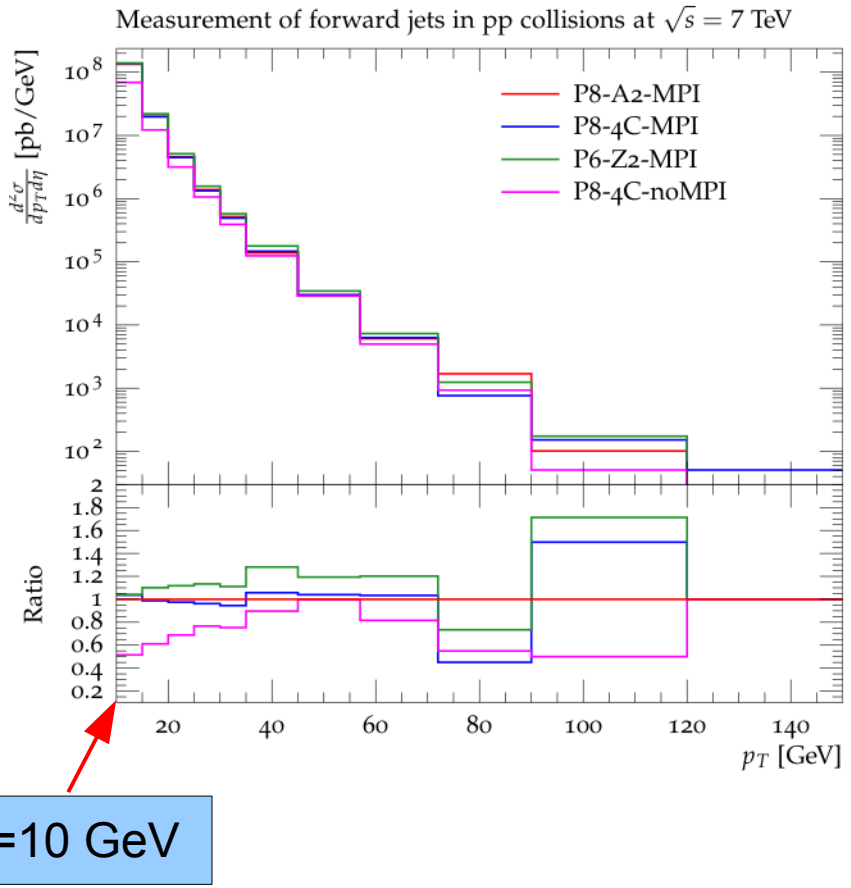


Inclusive Forward Jets

Rivet: arXiv:1003.0694



p_T=35 GeV



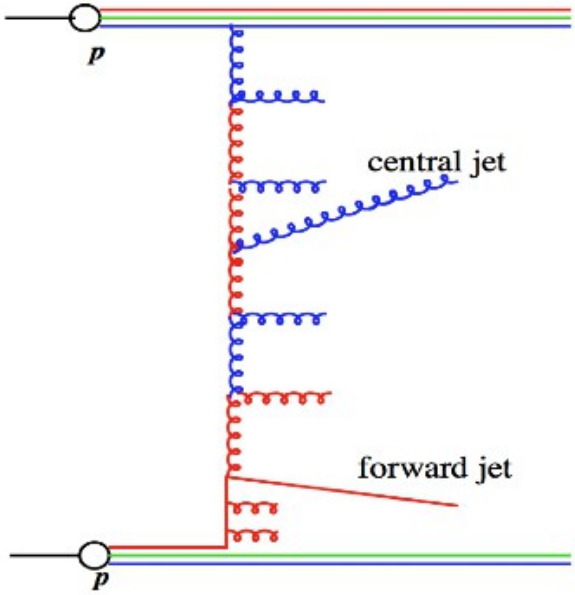
p_T=10 GeV

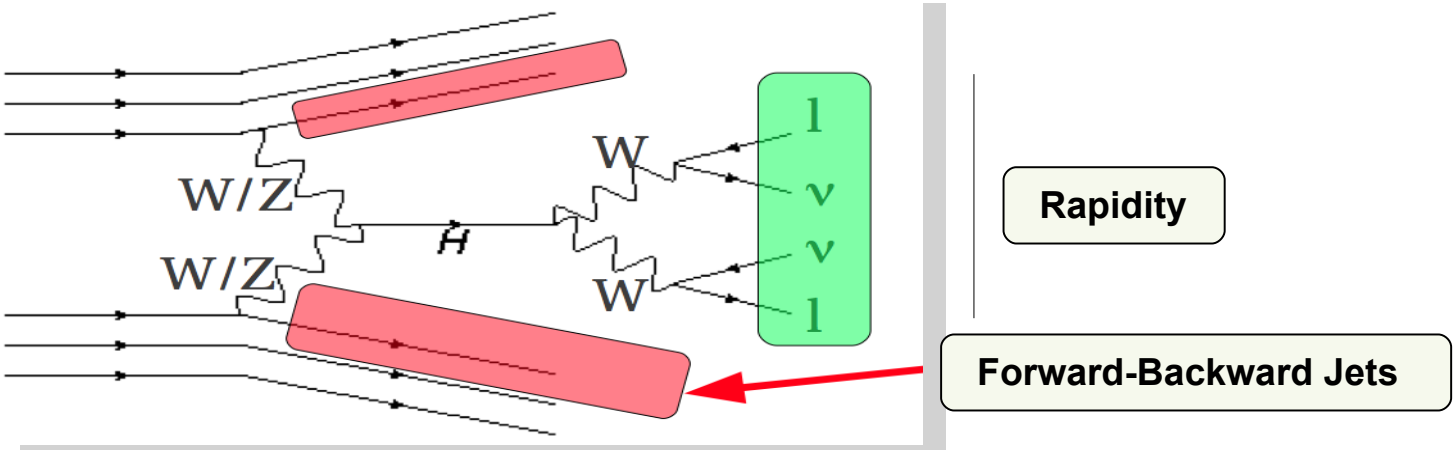
- There is a very small dependence on MPI when we consider our analysis cuts.
- But in lower p_T region, where we expect to see BFKL, the MPI effect can be seen clearly.

Forward and Central Dijets

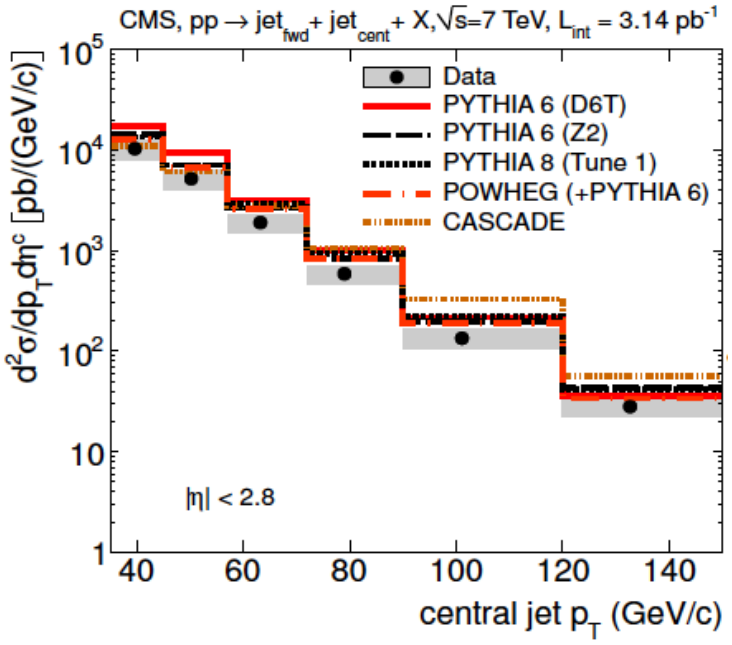
Motivation

- Give information on multi-parton interaction and multi-jet production.
- Allow to study different types of parton radiation dynamics as implemented in the DGLAP, BFKL or the CCFM evolution equations.
- Necessary for searches exploiting forward jet signatures.
- For example: VBF cross section, is fundamental to understand the EWSB mechanism

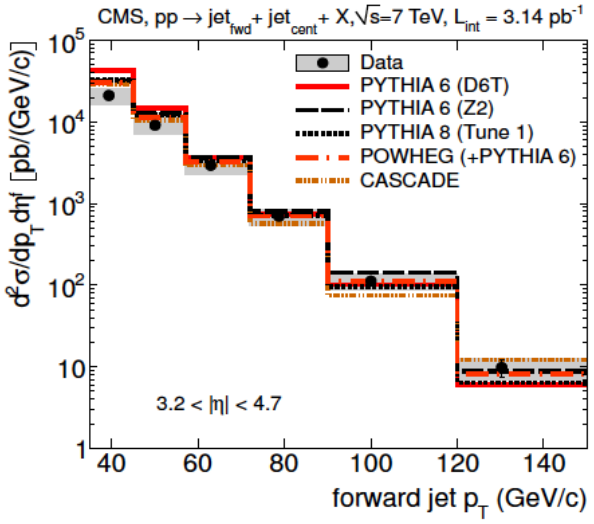


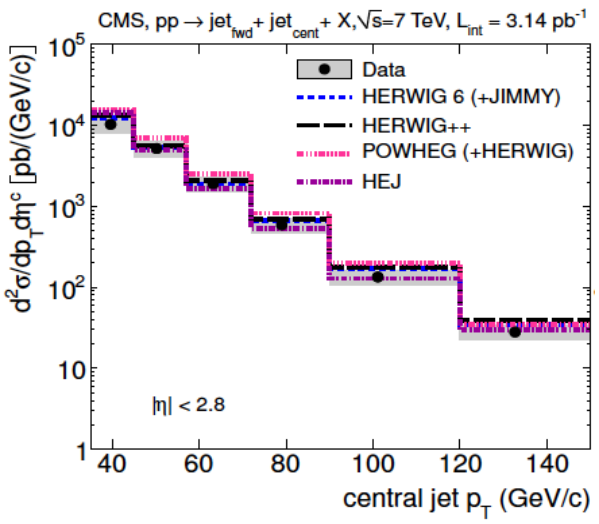


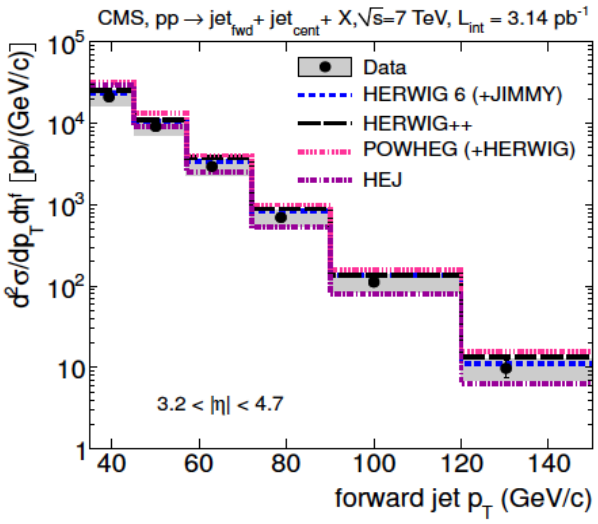
Forward-Central Jets



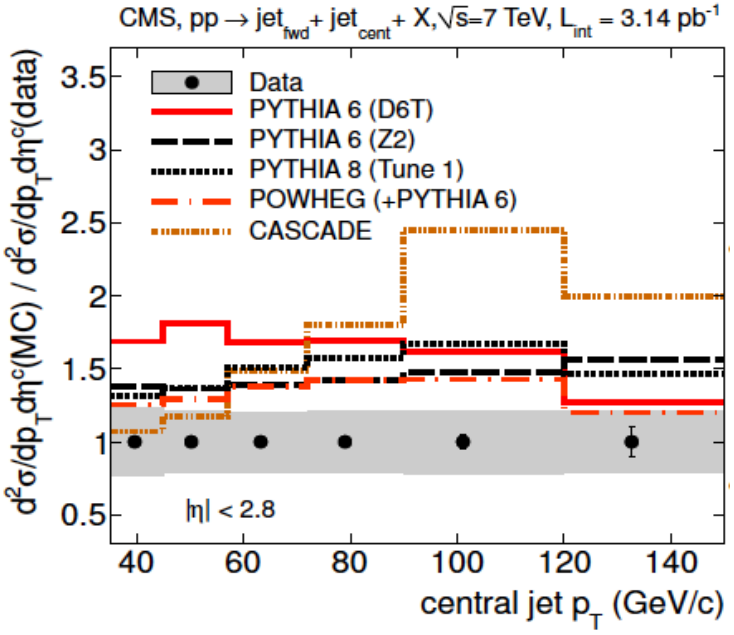
- Similar event selection with inclusive forward jets
  - with p_T>35 GeV
  - In two region:
    - Central region: $|\eta| < 2.8$
    - Forward region: $3.2 < |\eta| < 4.7$
- Fully corrected jet cross section compared to Monte Carlo generators with different tunes.



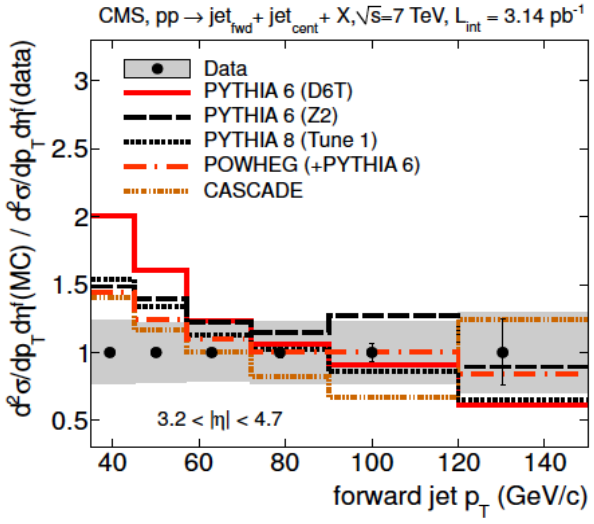


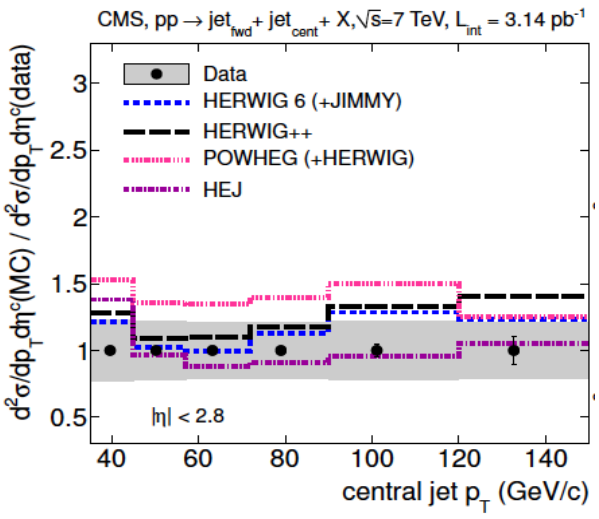


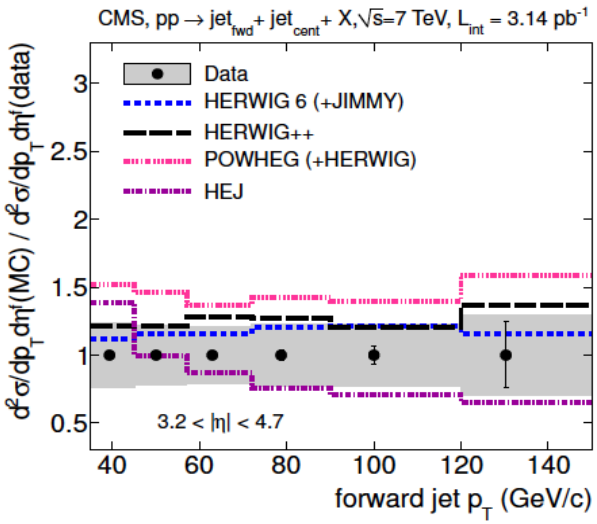
Forward-Central Jets



- All PYTHIA tunes have poor agreement for entire central-jet spectrum and at smallest p_T for forward jets.
- HERWIG event generator provides a better description of both differential cross sections.
- BFKL type model, HEJ, show reasonable agreement with data.
- CASCADE Monte Carlo do not reproduce the central-jet spectrum very well.

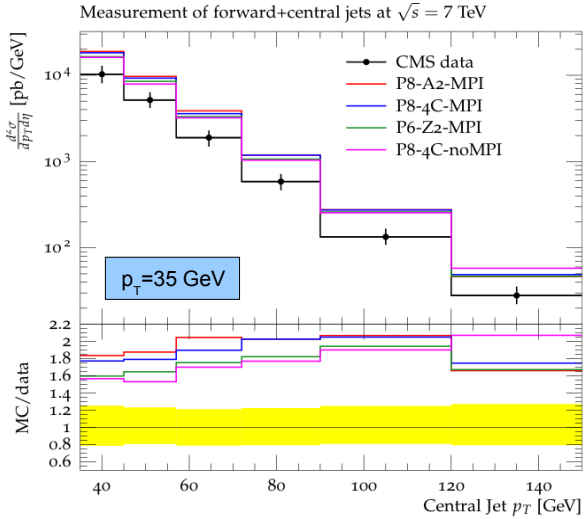


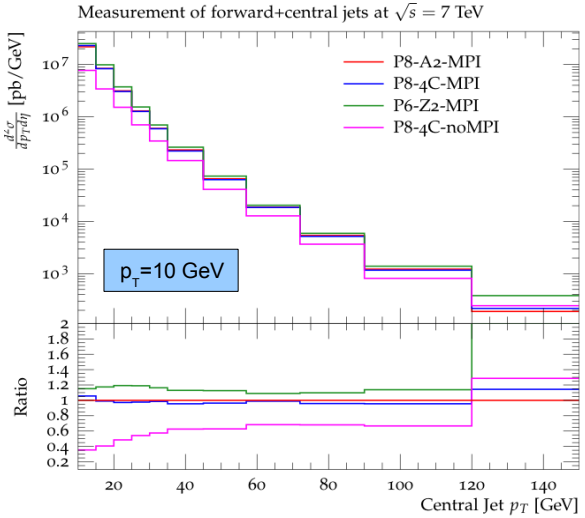




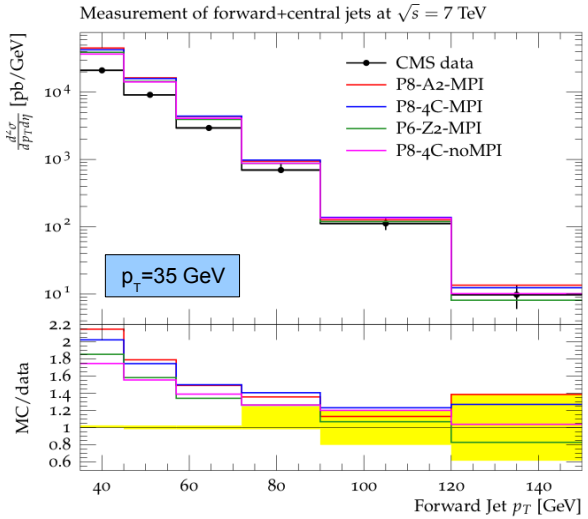
Forward-Central Jets

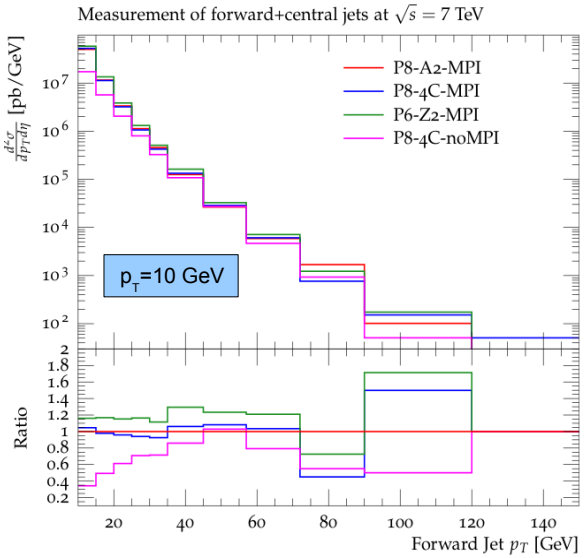
Rivet: arXiv:1003.0694





- Central jet cross section with and without MPI contribution.
  - MPI effect is dominant in low p_T region.

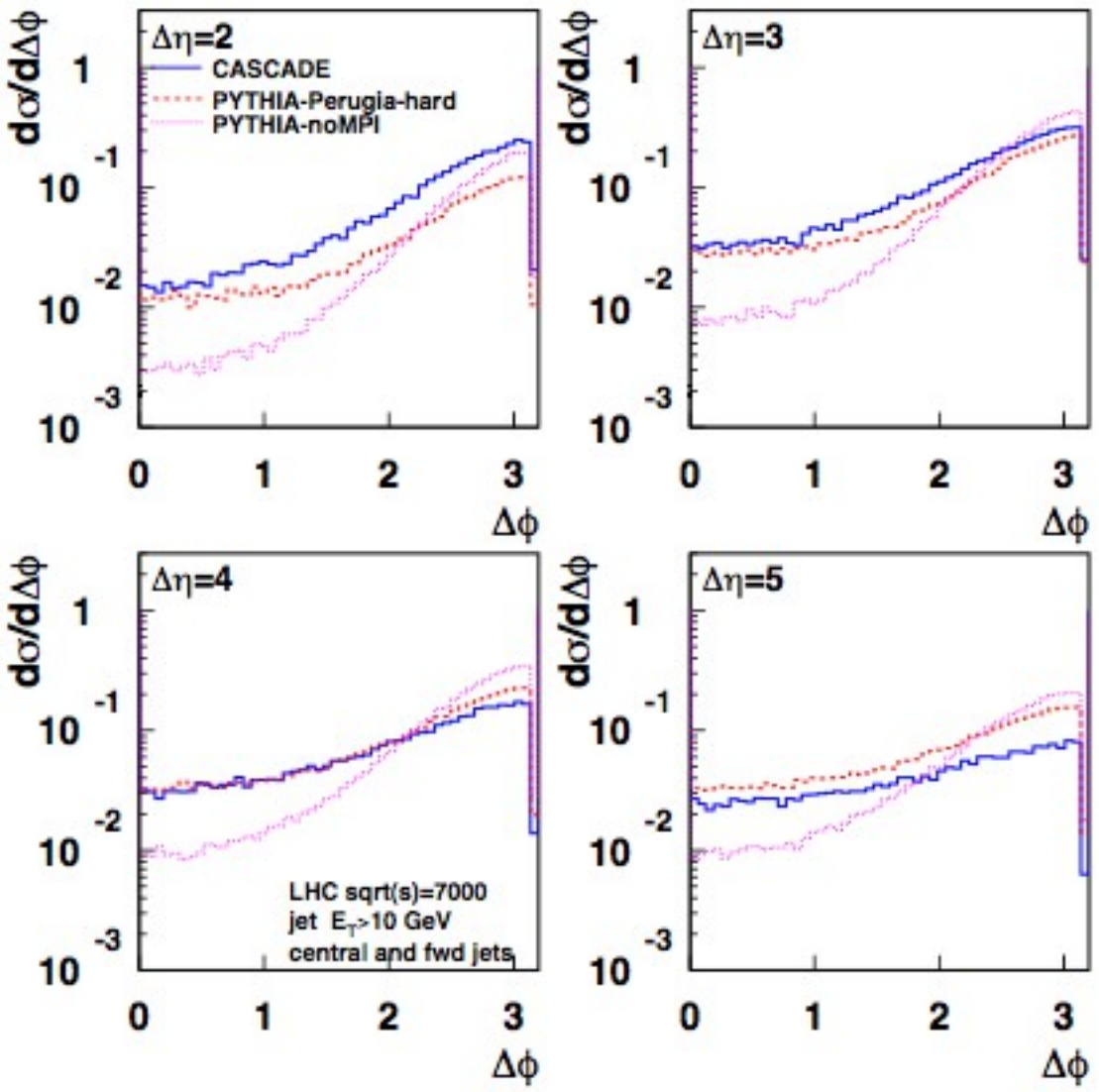




- Forward jet cross section with and without MPI contribution.
  - MPI effect is dominant in low p_T region.

Forward-Central Jets

arXiv:1012.6037v2



- Taken from "Forward-Central Jet Correlations at the Large Hadron Collider"
- The difference of MPI to CCFM.

Ratios of Dijet Production

Ratios of Dijet Production

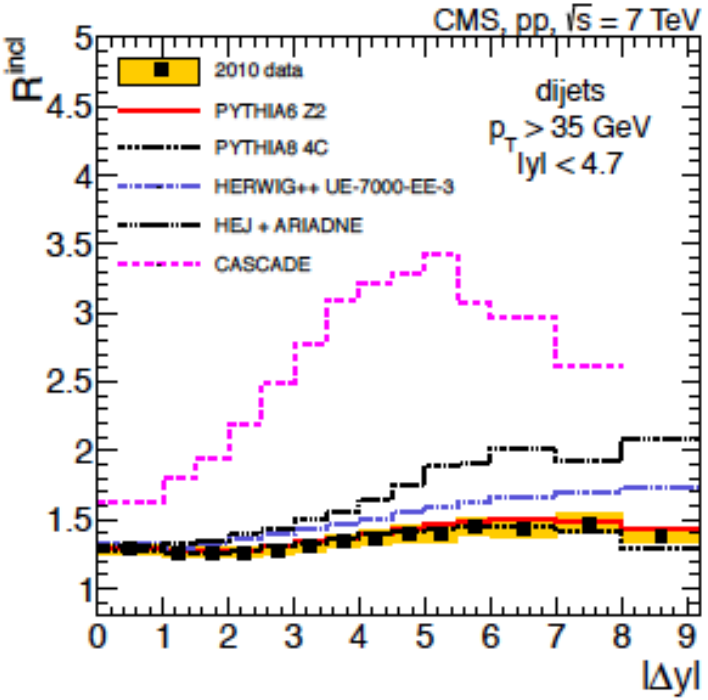
Goal → To perform the first measurement of **ratio (R)** of inclusive to exclusive dijet production and **ratio (R)** of Mueller-Navelet to exclusive dijet production as a function of rapidity separation between jets and test it for deviations from DGLAP predictions.

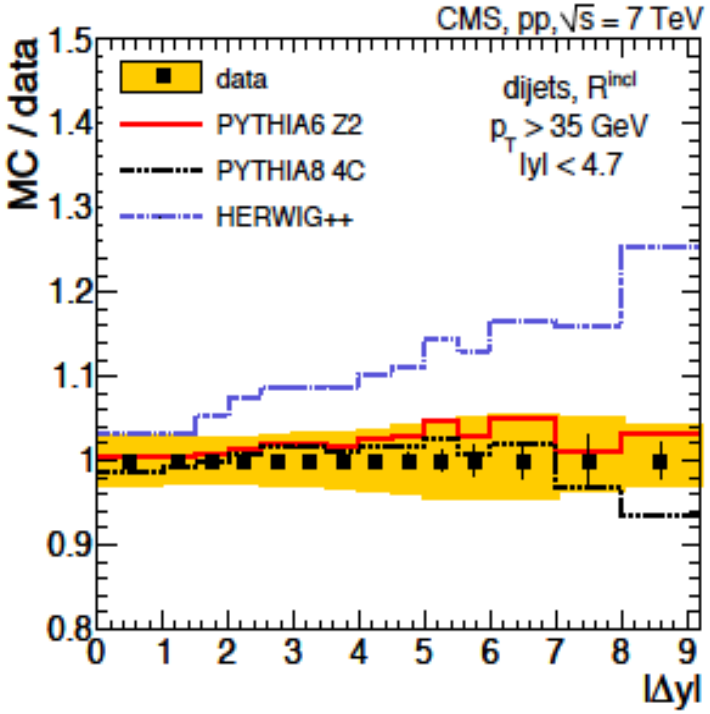
- Jets, described below are selected with $p_T > 35$ GeV and $|y| < 4.7$
  - Inclusive dijets: all jet pairs
  - Exclusive dijets: just two jets in the events
  - Mueller-Navelet jets: subset of inclusive dijet class (Most forward-backward jets)

- Cross section for events from the each sample is calculated as a function of $|\Delta y|$ between the jets and below ratios have been obtained.

$$R_{incl} = \frac{\sigma_{incl}(dijet)}{\sigma_{excl}(dijet)} \qquad R_{MN} = \frac{\sigma_{MN}(dijet)}{\sigma_{excl}(dijet)}$$

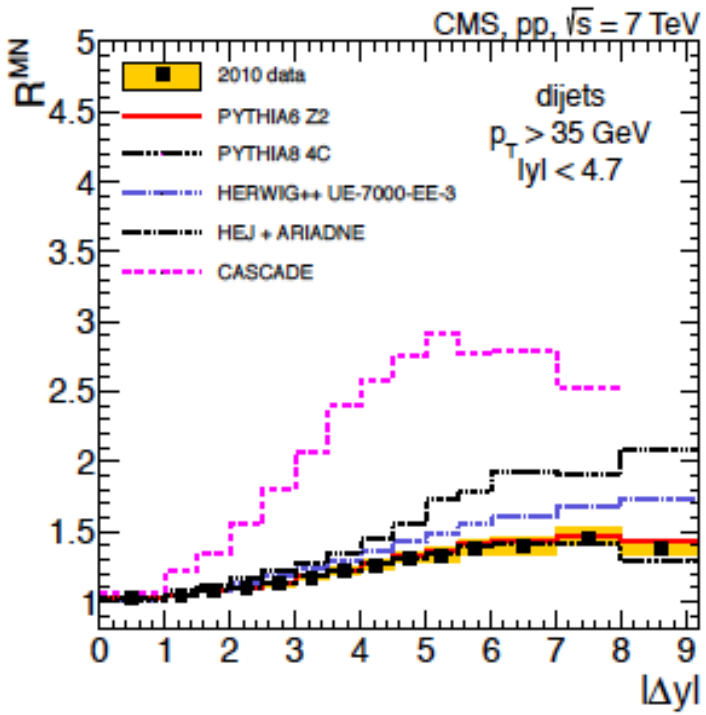
Ratio of Inc. to Exc. Dijet Production

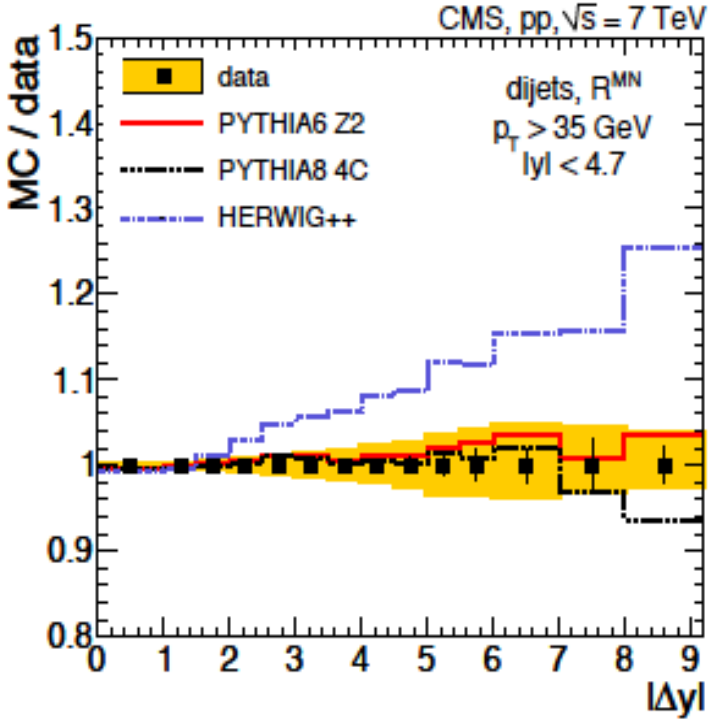




- Inclusive cross section is 1.2-1.5 times larger than exclusive cross section.
- The ratio R^{incl} rises with increasing $|\Delta y| \rightarrow$ due to the increased phase space for hard parton radiation.
- At the highest $|\Delta y|$, R^{incl} decreases $\rightarrow$ due to emission of an extra jet is suppressed due to energy-momentum conservation.
- PYTHIA6 and PYTHIA8 agree well with measurement. HERWIG++ overestimates the ratio R^{incl} at medium and large rapidity intervals.

Ratio of MN to Exc. Dijet Production

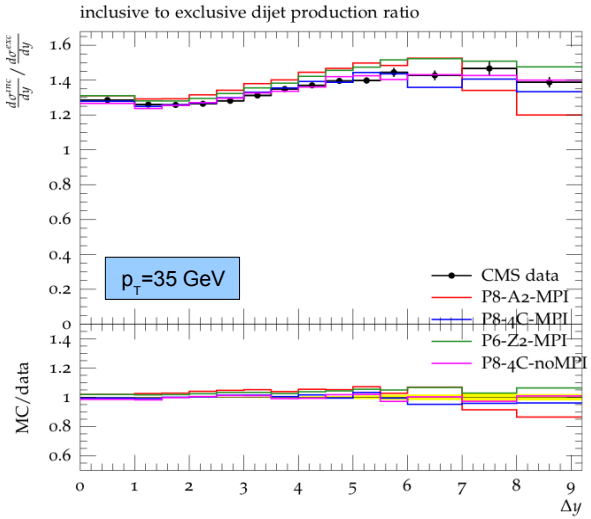


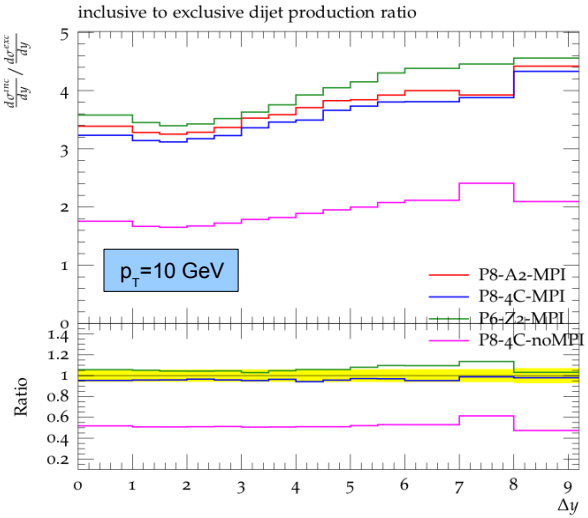


- At large $|\Delta y|$, R^{MN} approaches R^{incl} as extra jet radiation contributing to R^{incl} tends to concentrate at moderate rapidities.
- CASCADE and HEJ+ARIADNE overestimate the measurements for both R^{incl} and R^{MN}.

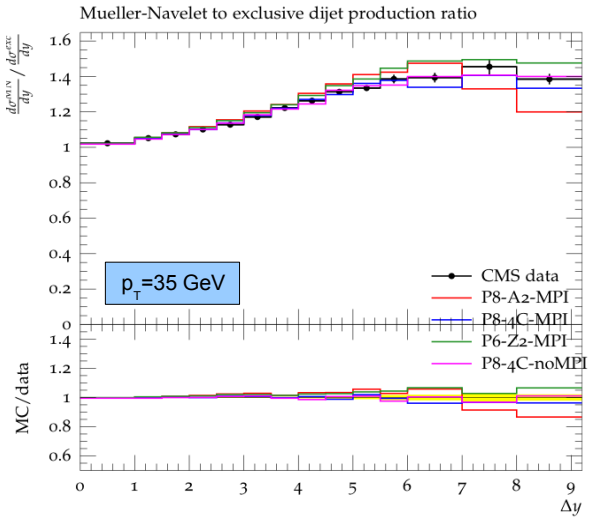
Ratios of Dijet Production

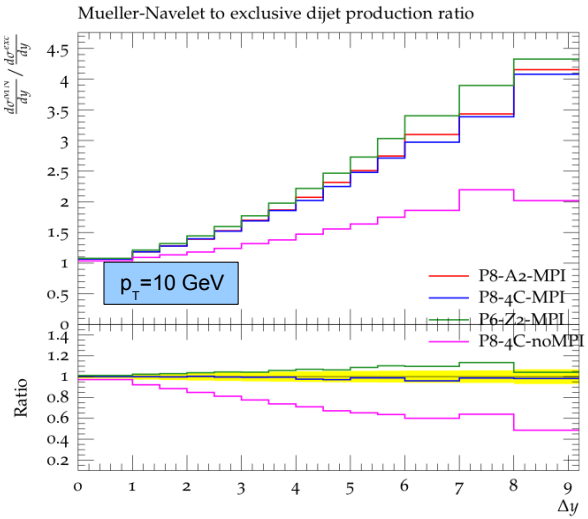
Rivet: arXiv:1003.0694





- MPI contribution to R^{incl}
  - The effect become clearer in low p_T and increase with increasing $|\Delta y|$





- MPI contribution to R^{MN}
  - The effect of MPI could be seen clearly with increasing $|\Delta y|$

Conclusion

Inclusive Forward Jets

- PYTHIA and HERWIG parton-shower event generators, CASCADE and HEJ models are in good agreement with the measured inclusive jet cross-section.
- NLO predictions for different PDF are similar and consistent with the data

Central-Forward Jets

- The agreement for all PYTHIA tunes is poor for the entire central jet spectrum and at smallest p_T for forward jets.
- The HERWIG generator provides a better description, however CASCADE do not reproduce the central-jet spectrum.

Ratios of Dijet Production

- The predictions of the PYTHIA6 and PYTHIA8 generators agree with measurements.
- The predictions of the HERWIG++ generator are larger than the measurement.
- CASCADE and HEJ+ARIANDE predict a significantly stronger rise than observed.

MPI Contribution → The published results are very little affected by MPIs. However when going down in p_T , where we expect to see low-x dynamics, MPIs are important.