Using Substructure Techniques to Study MPI

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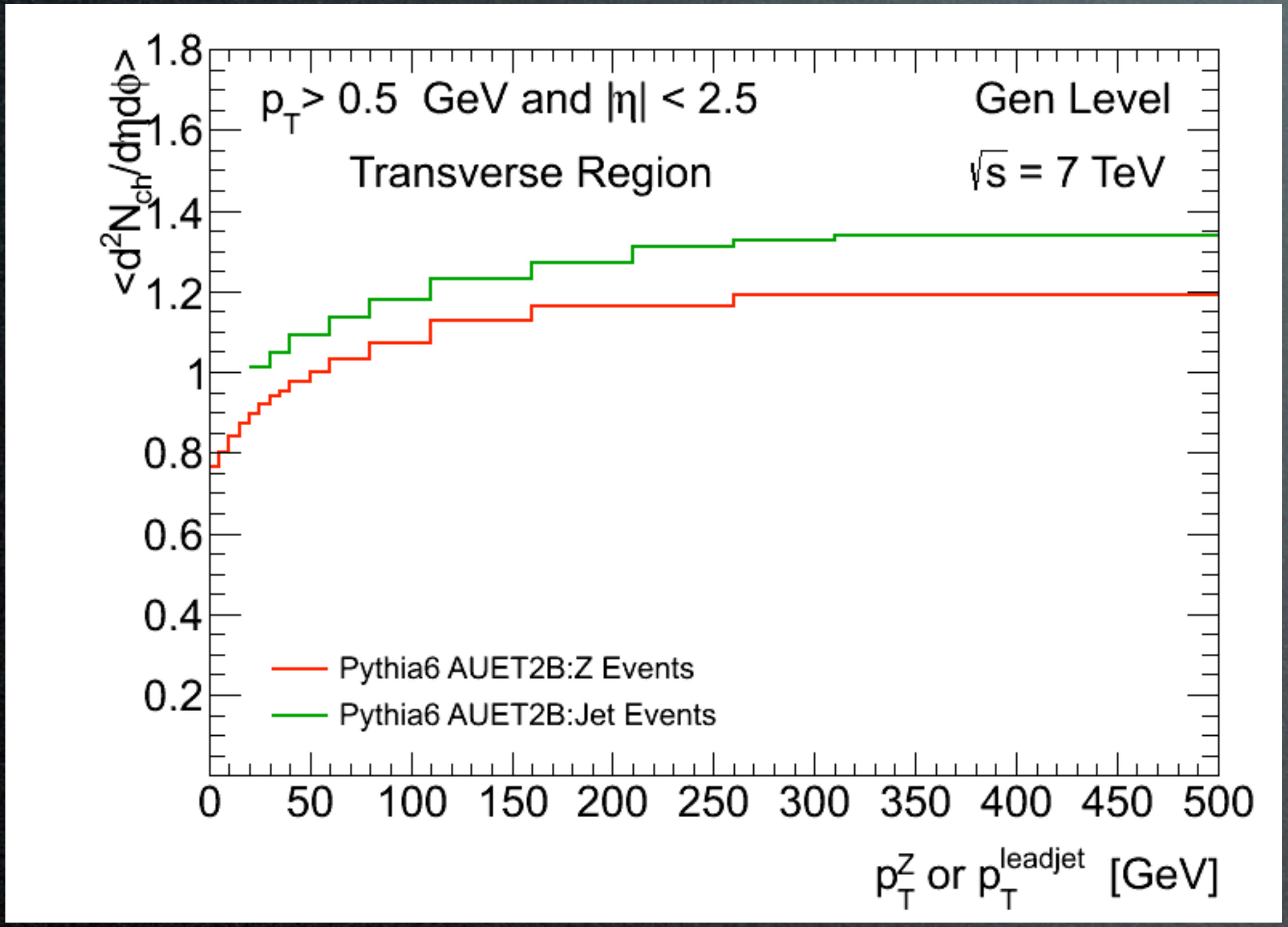
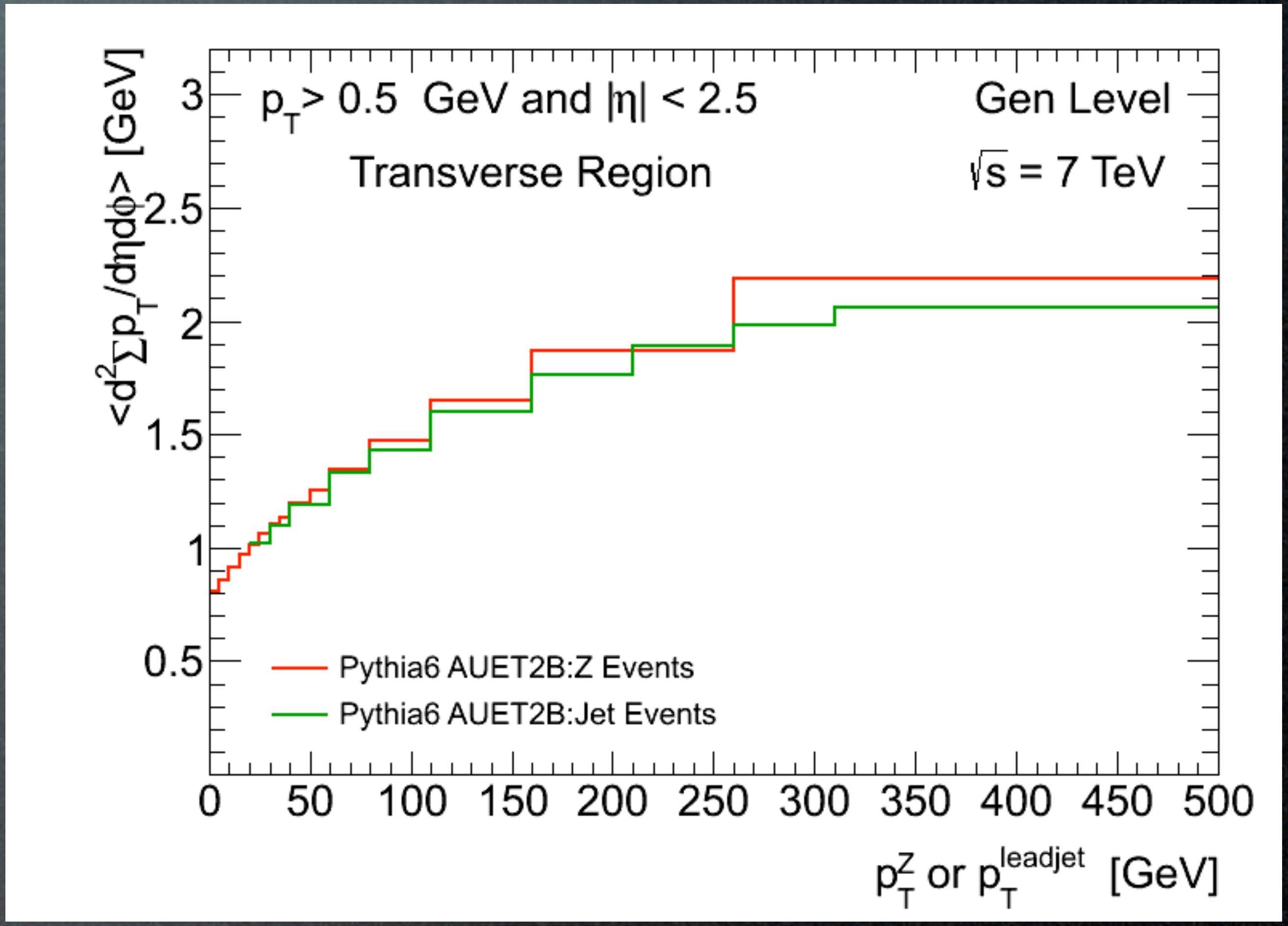
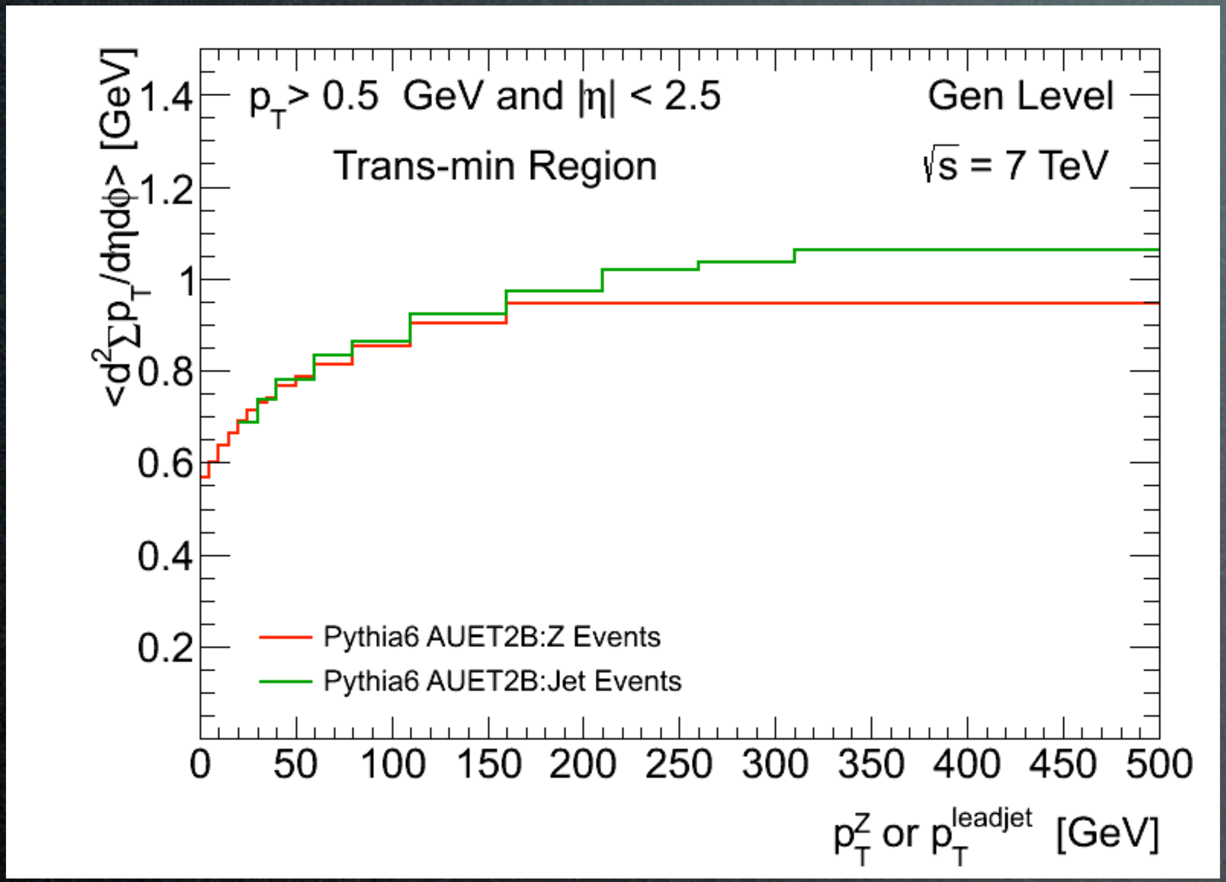
UE Results Extending to Higher Energy Scale

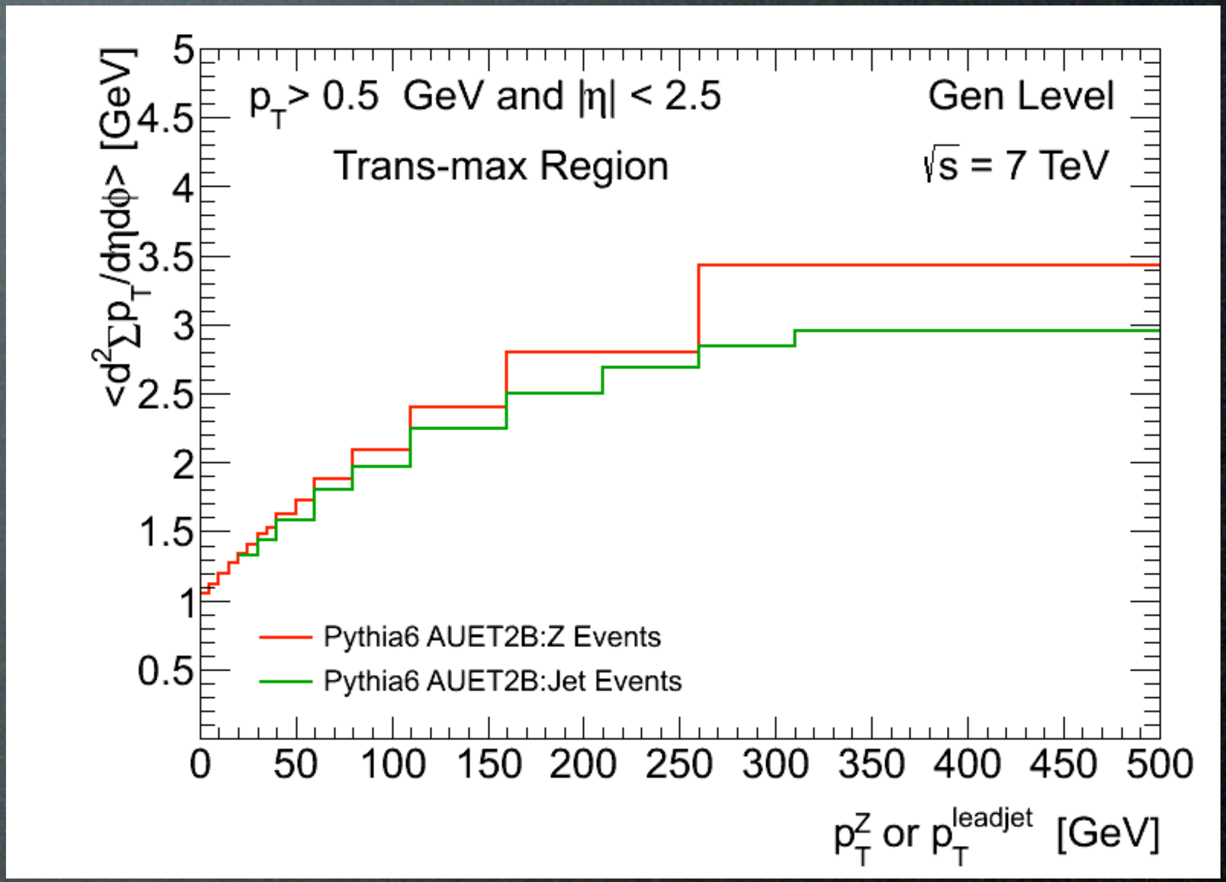




Generator level (Pythia6): Not much difference

Trans-max/min Regions

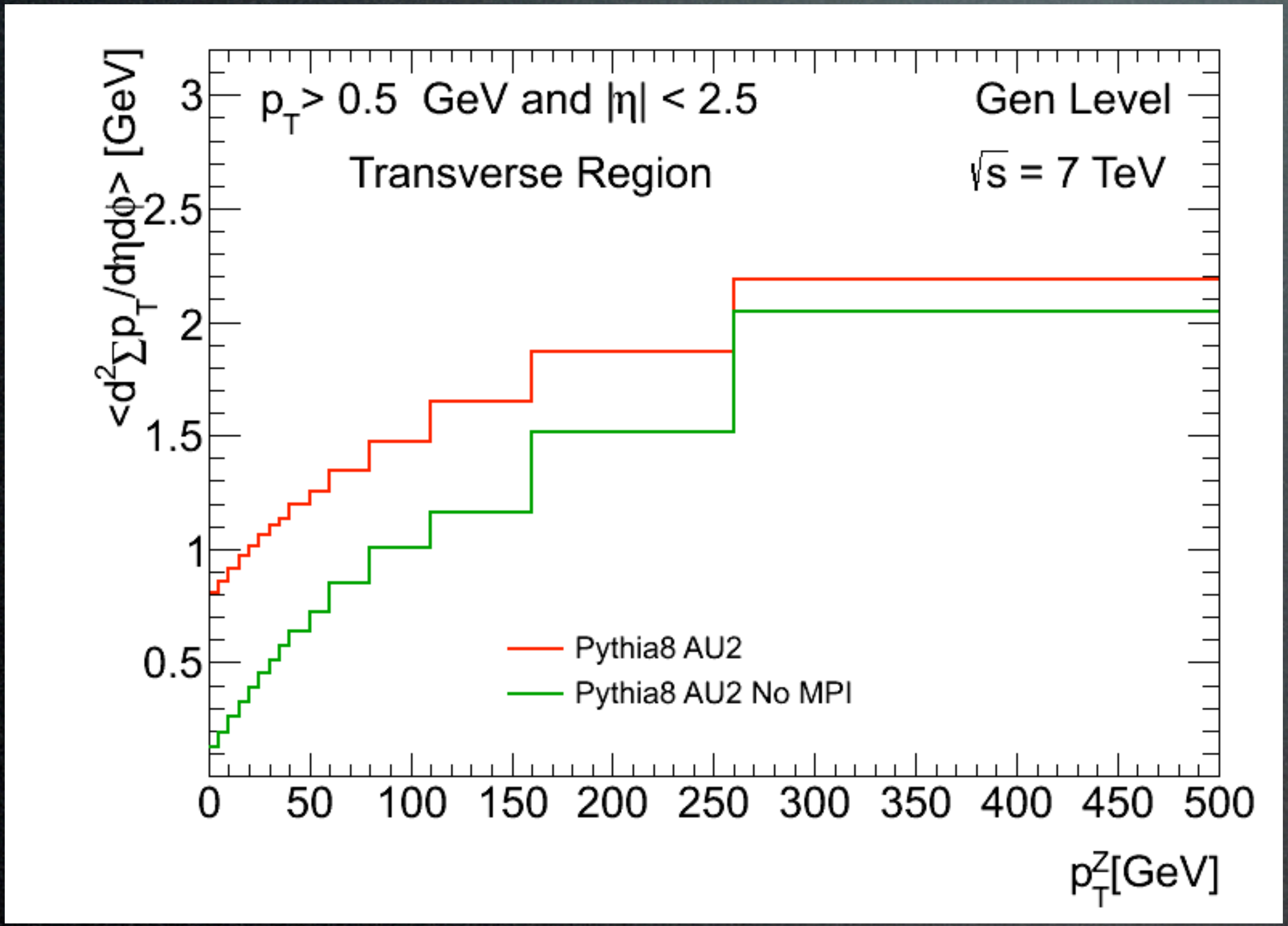




There is a pronounced difference here!

The activities are still similar, with a caveat.

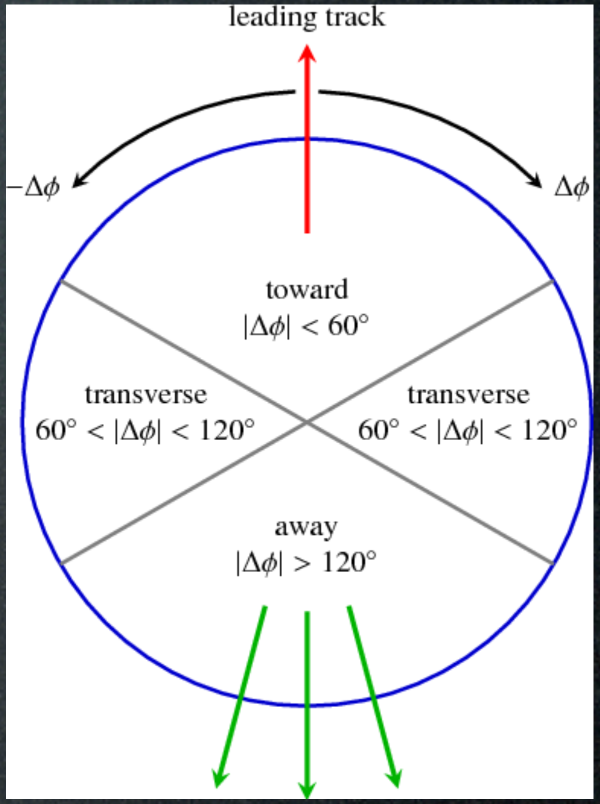
How much of the UE is UE?



Even without MPI, the "UE" activity is catching up.

Indicative of additional hard (non-MPI) jets

Isolating the UE



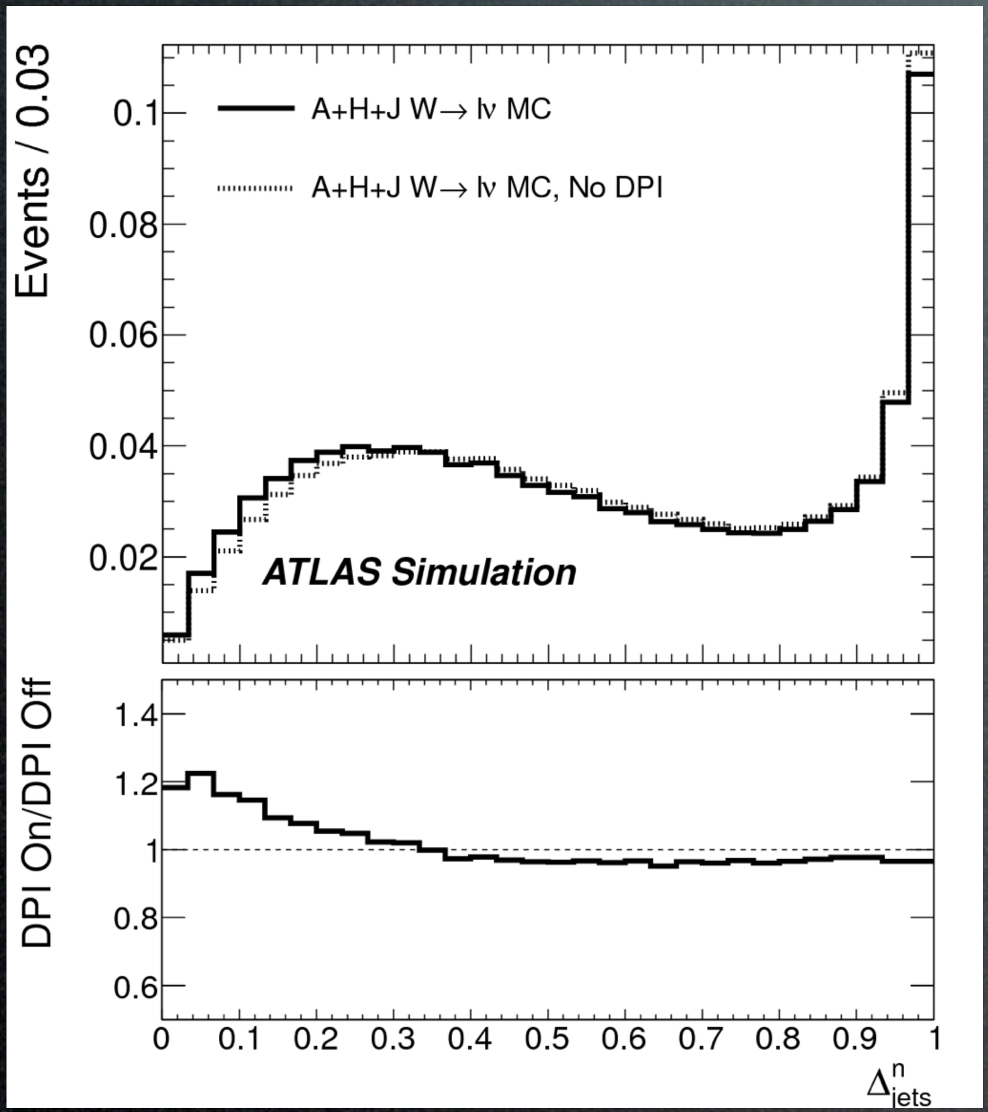
- Full transverse (or trans-max) regions are described better by NLO or multileg generators than pure LO ones.

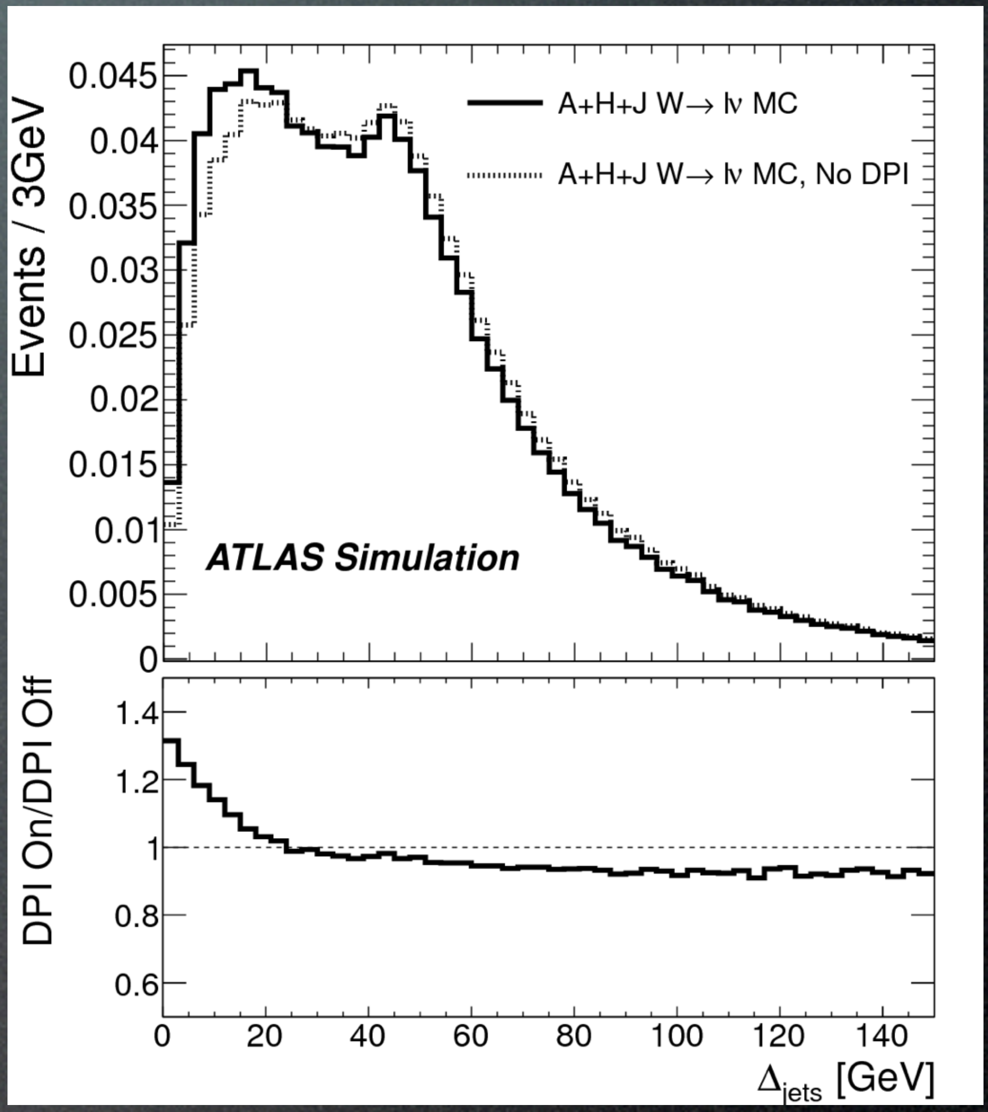
- Trans-min (and towards region for Z-boson events) were thought to be populated by "pure" UE.

- But at LHC, even those are not flat.

- Need more UE/MPI sensitive Observables.

MPI Discriminating Observables





Creating templates from DPI off/on distributions

New J. Phys. 15 (2013) 033038

Angular Correlation Function

(or jet substructure without trees)

$$\mathcal{G}(R) \equiv \sum_{i \neq j} p_{\perp i} p_{\perp j} \Delta R_{ij}^2 \Theta[R - \Delta R_{ij}]$$

$$\Delta R_{ij}^2 = (\eta_i - \eta_j)^2 + (\phi_i - \phi_j)^2$$

Fractional mass contribution from constituents separated by an angular distance R or less.

Martin Jankowiak, Andrew J. Larkoski; arXiv:1104.1646

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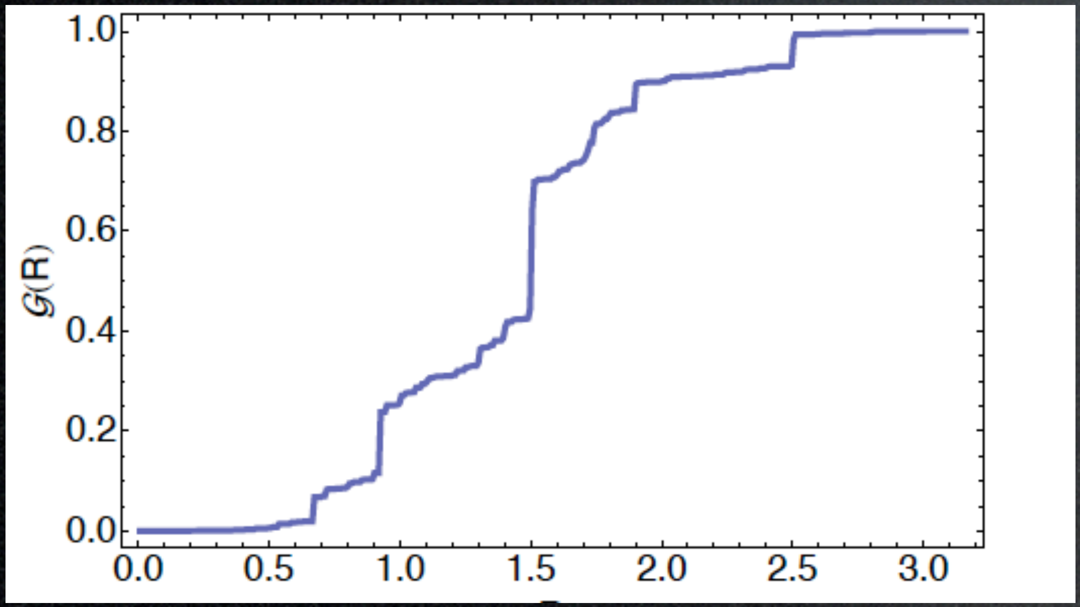
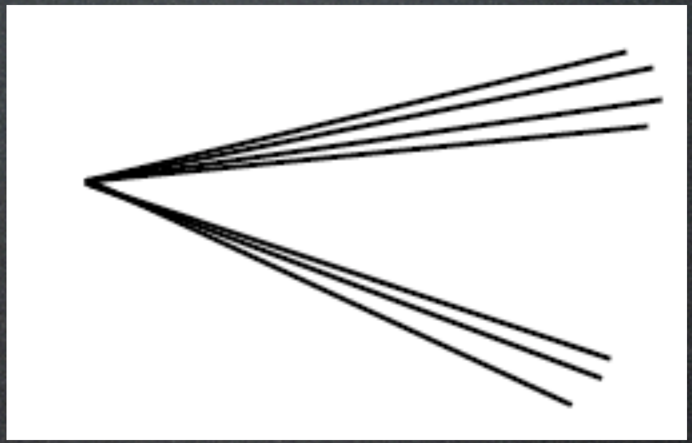
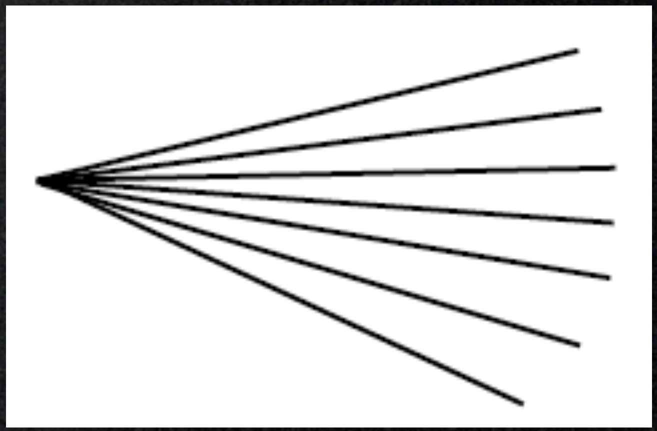




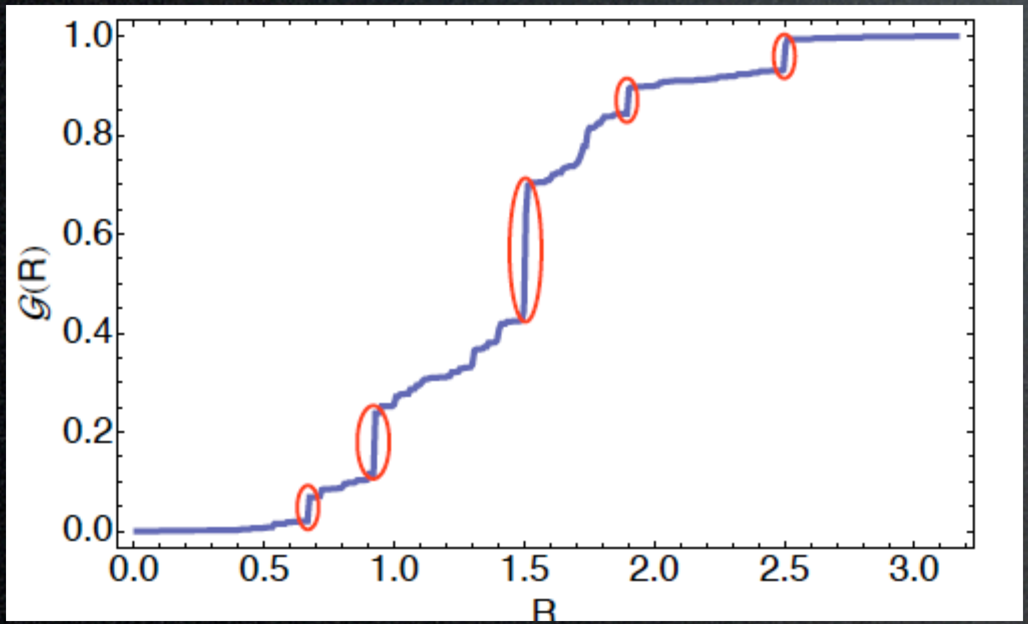
vs.

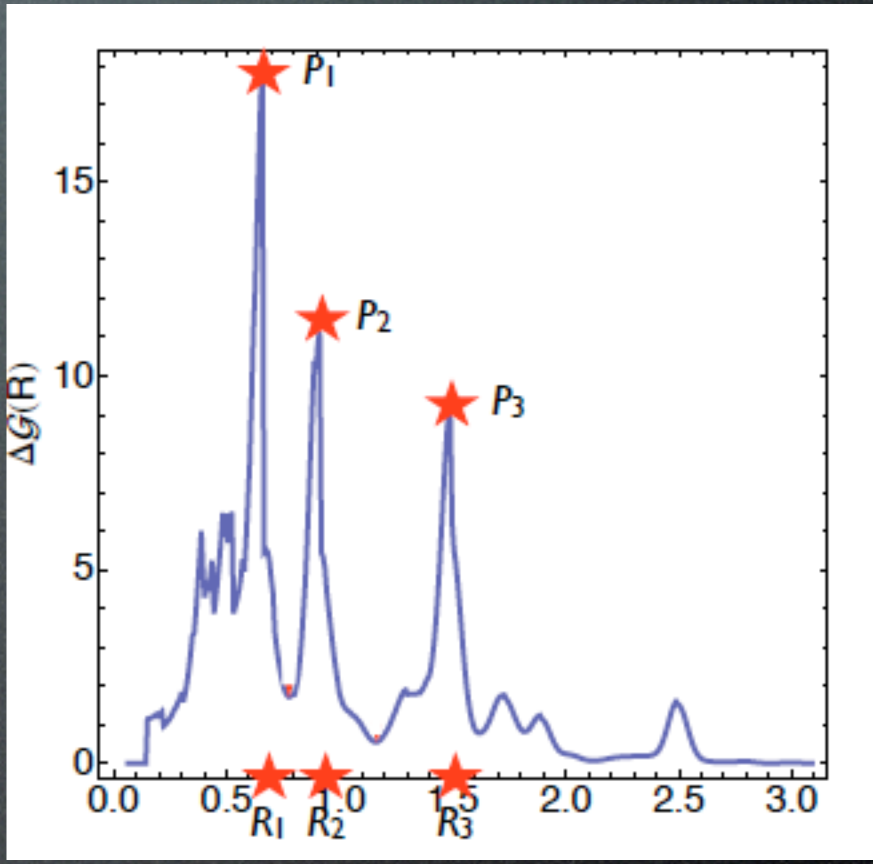


Martin Jankowiak, Andrew J. Larkoski; arXiv:1104.1646

Angular Structure Function

$$\Delta\mathcal{G}(R) \equiv \frac{d\log\mathcal{G}(R)}{d\log R}$$





- Location of the peaks
- Height of the peaks
- Number of peaks

Martin Jankowiak, Andrew J. Larkoski; arXiv:1104.1646

New Toolkit?

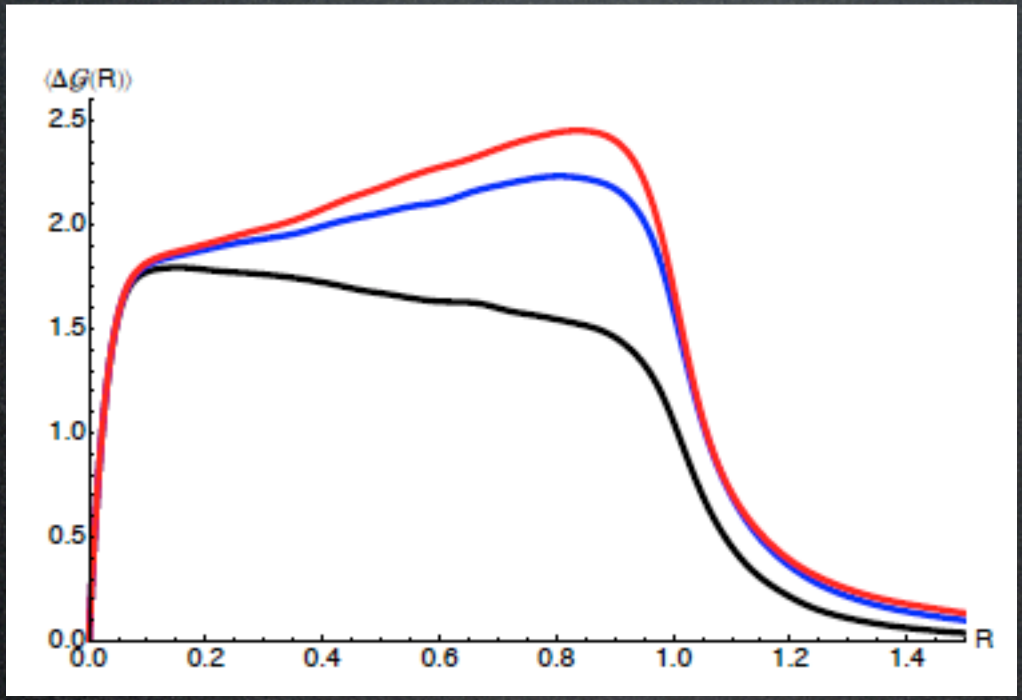
Average ASF:

$$\langle \Delta \mathcal{G}(R) \rangle \equiv R \frac{\frac{d}{dR}\langle \mathcal{G}(R) \rangle}{\langle \mathcal{G}(R) \rangle}$$

Average ASF Results

ACF = (Pert-Pert correlations) +
(Pert-UE correlations) +
(UE-UE correlations)

$$\langle \mathcal{G}(R)_{\text{with UE}} \rangle = \langle \mathcal{G}(R)_{\text{no UE}} \rangle + \frac{\pi}{2} p_{\perp \text{jet}} \Lambda_{\text{UE}} R^4$$



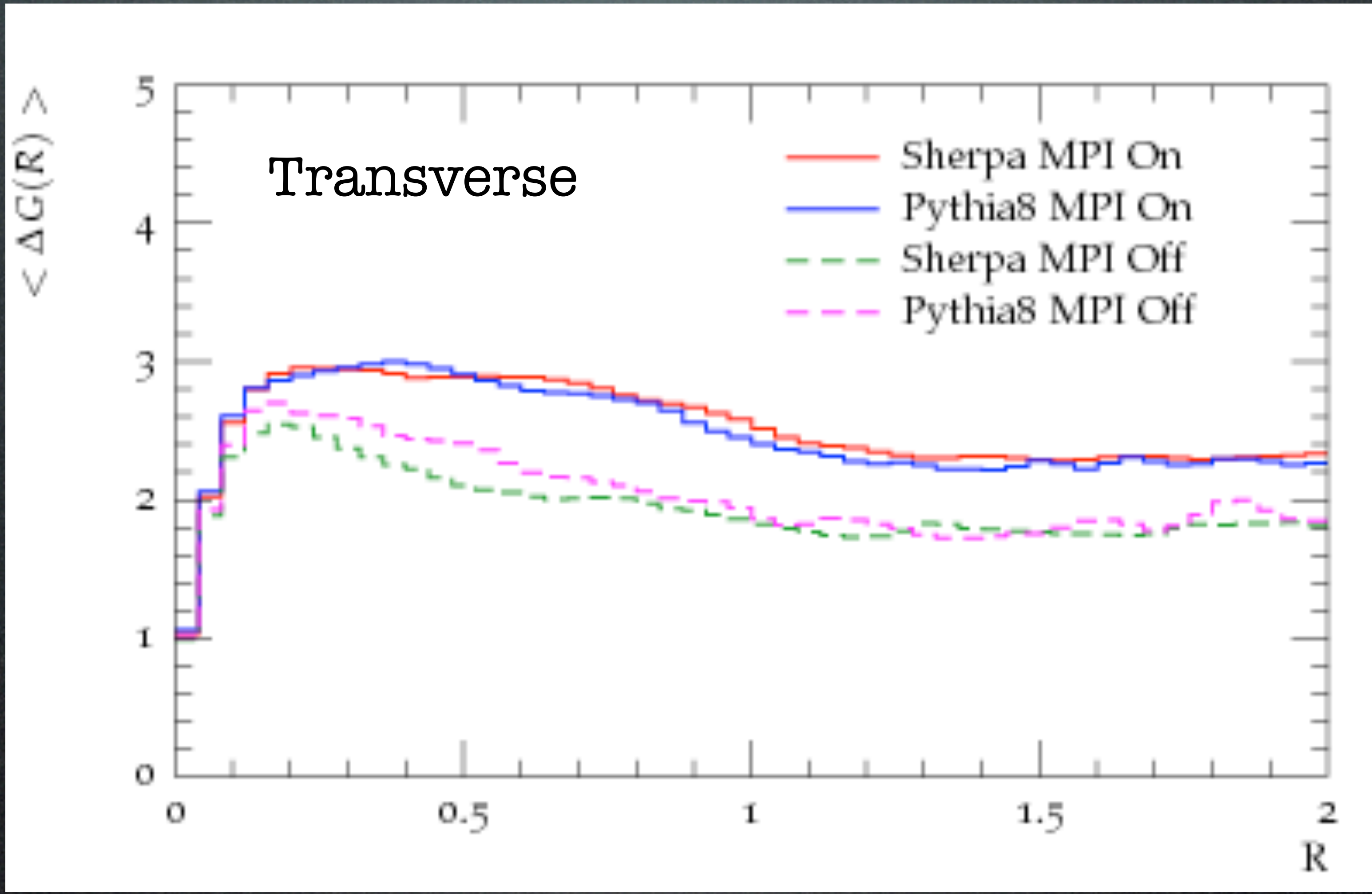
Pythia8: with UE & ISR (blue, red);

red = 2x MPI cross section;

Tune 4C

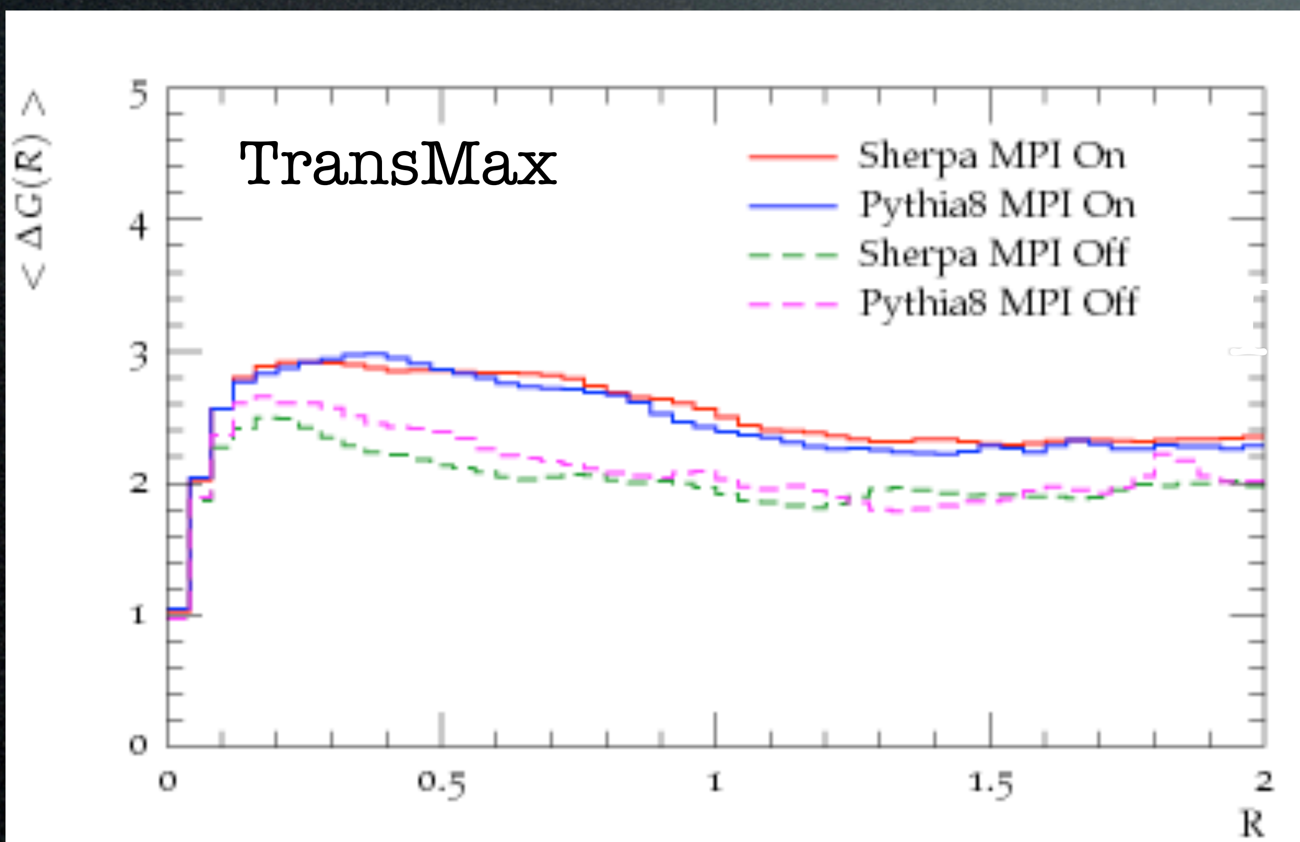
Martin Jankowiak, Andrew J. Larkoski; JHEP 1204 (2012) 039

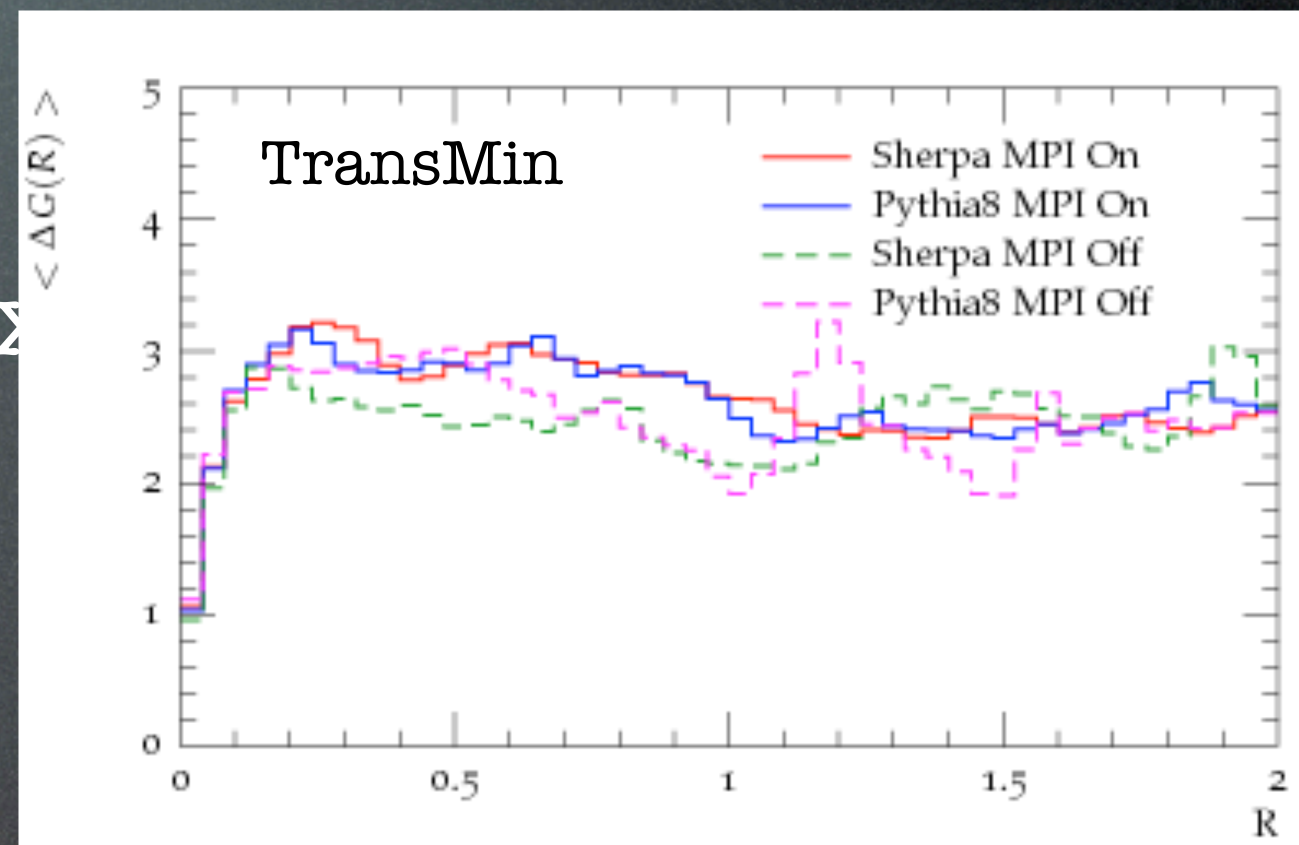
Transverse Region



Leading R=0.6 anti-k_t jet with $p_T > 30$ GeV,
All charged particles with $p_T > 0.5$ GeV, $|\eta| < 2.5$

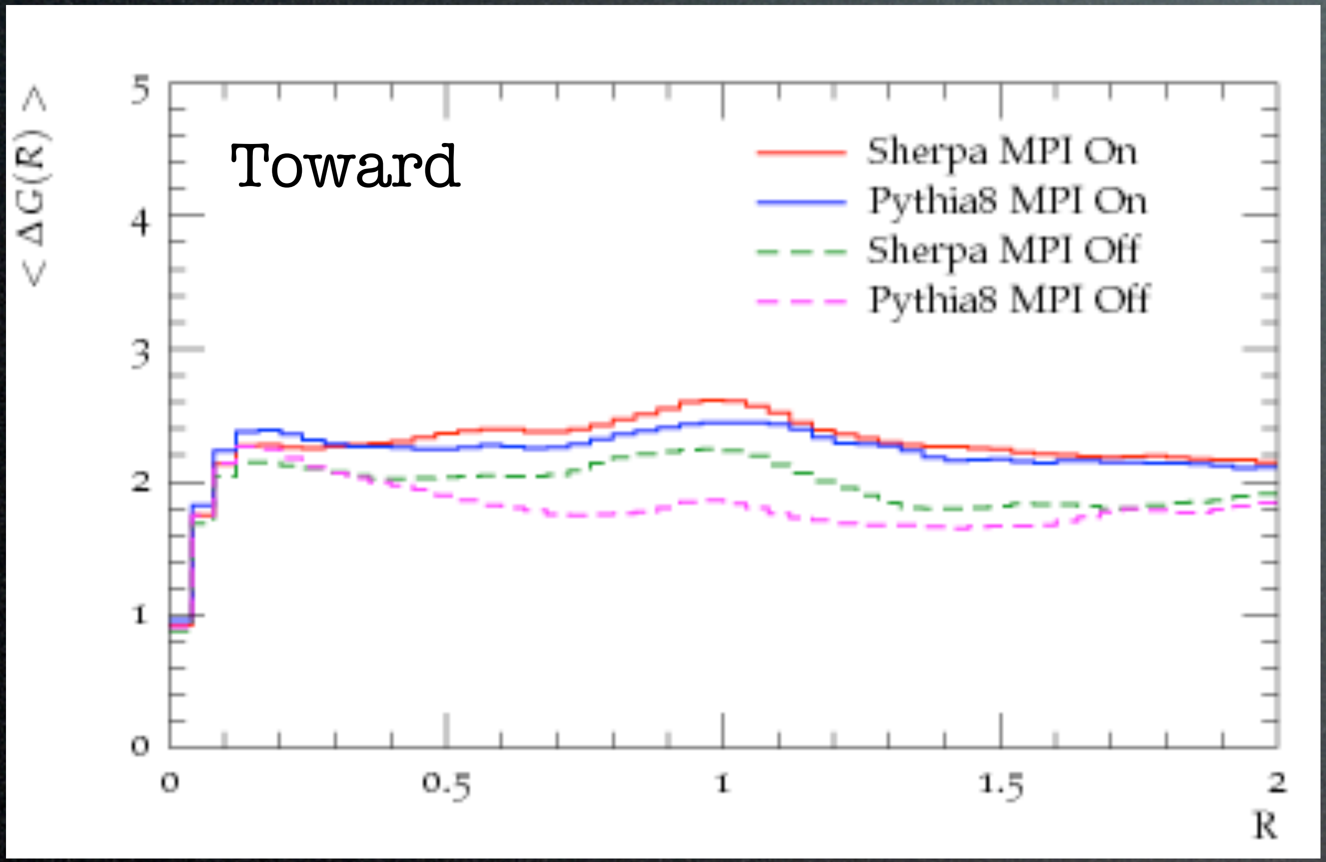
Transverse Regions

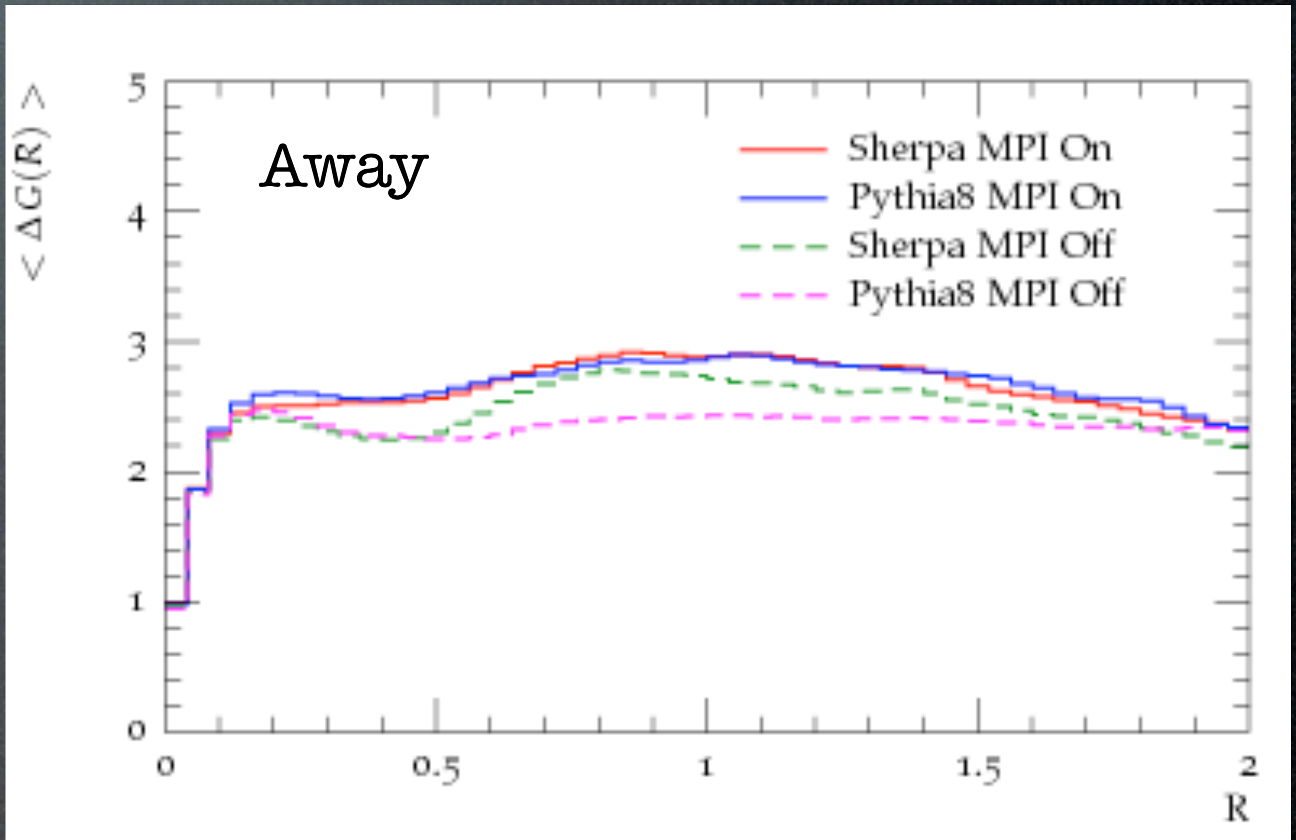




Similar level of difference for Sherpa and Pythia8

Toward/Away Regions





Toward dominated by MPI?

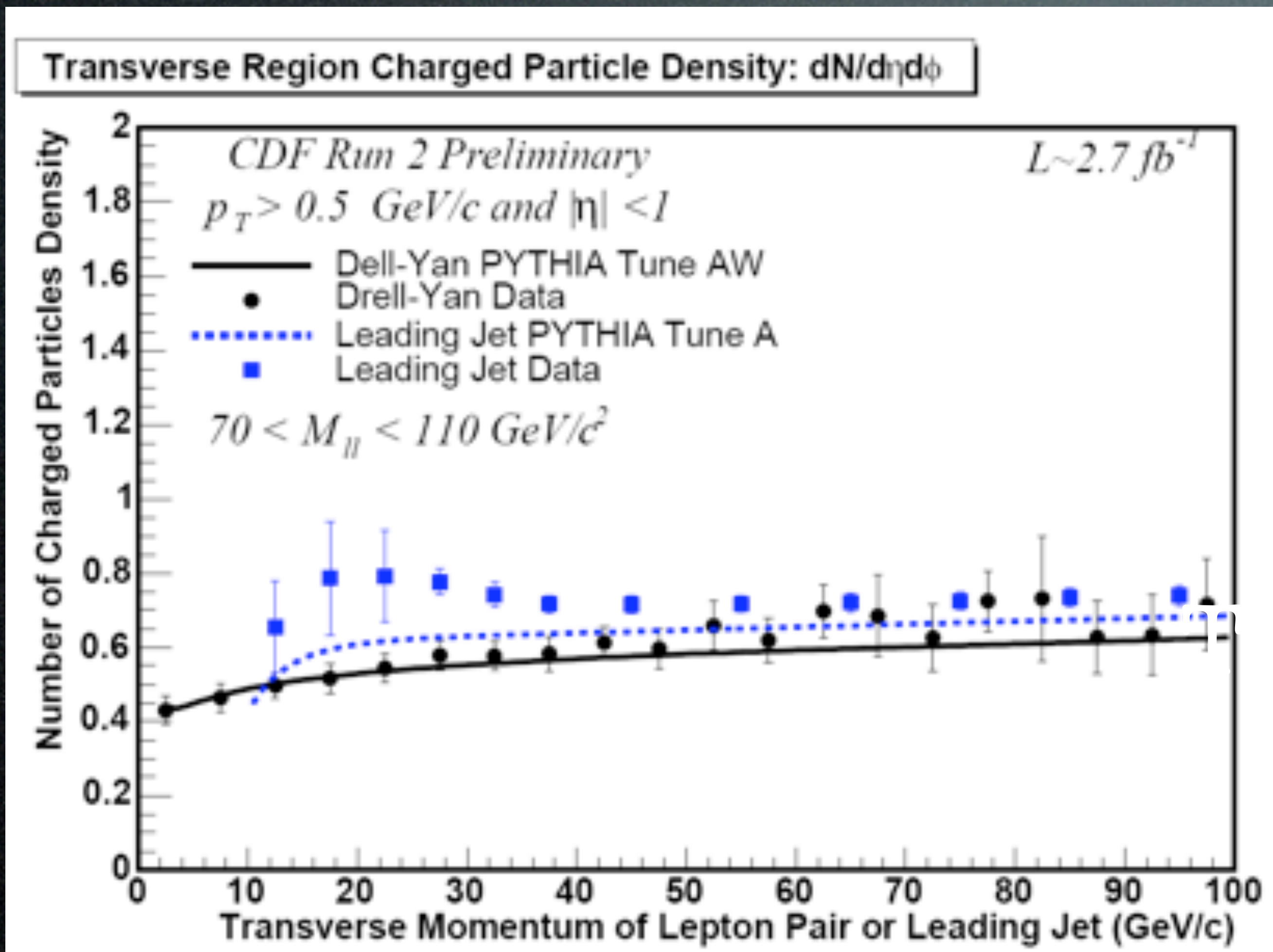
Looking Forward

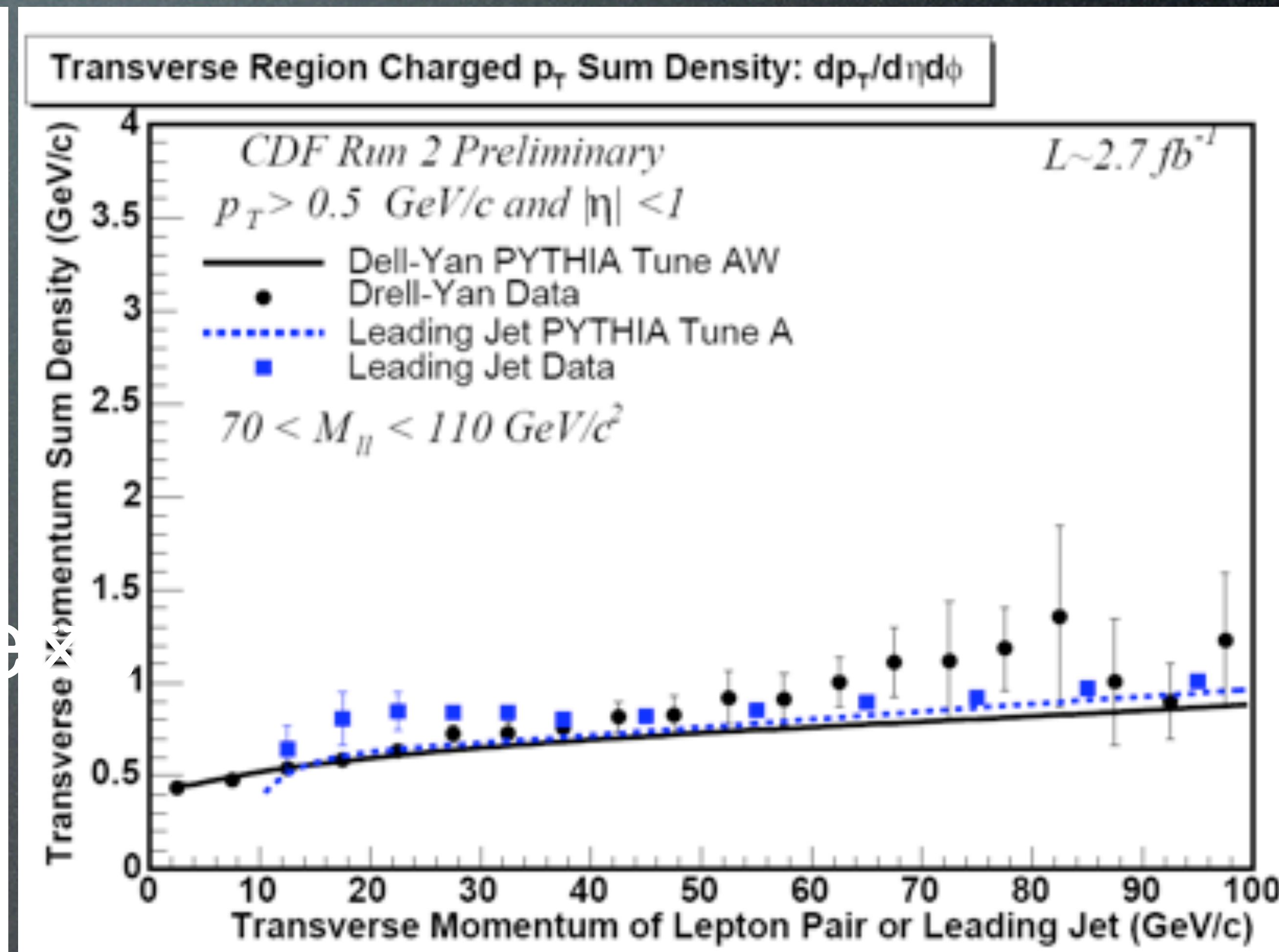
- Estimating MPI contribution is crucial in many searches, and measurement in most prrocess are lacking.
- Average ACF can be another discriminating variable.
- More studies, data comparison ...

Backup

CDF Results

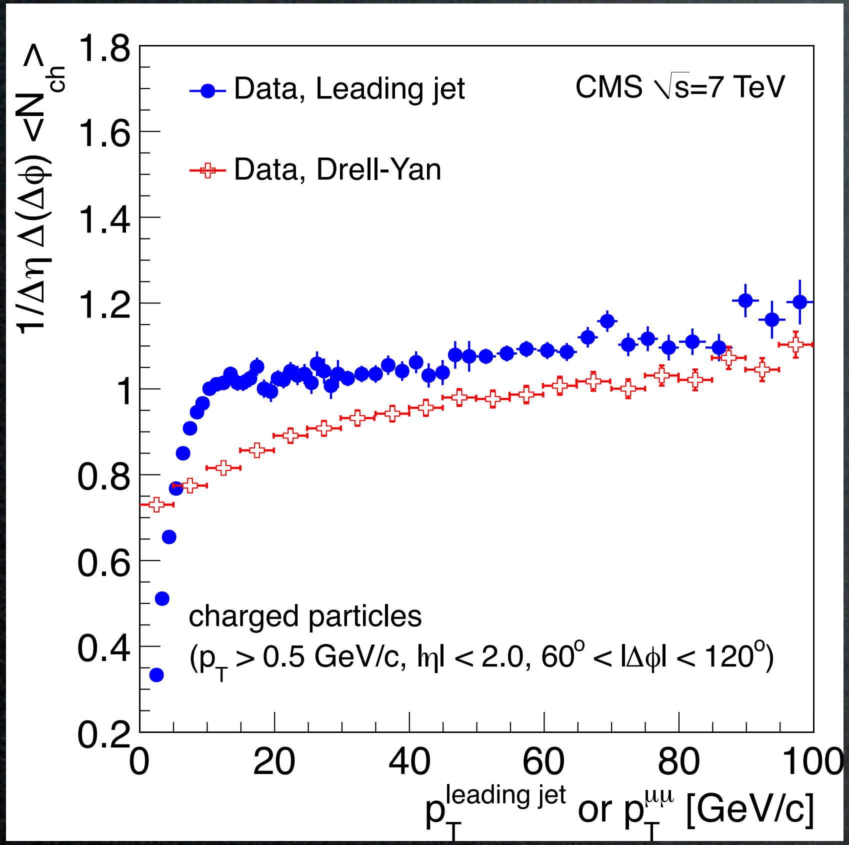
Phys.Rev. D82 (2010) 034001

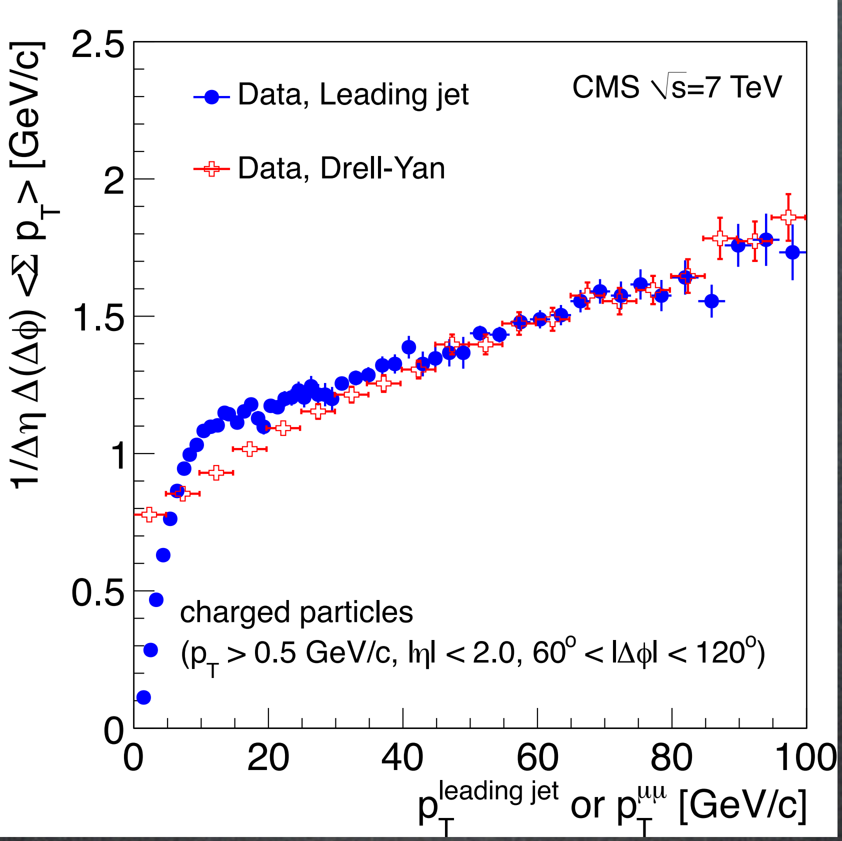


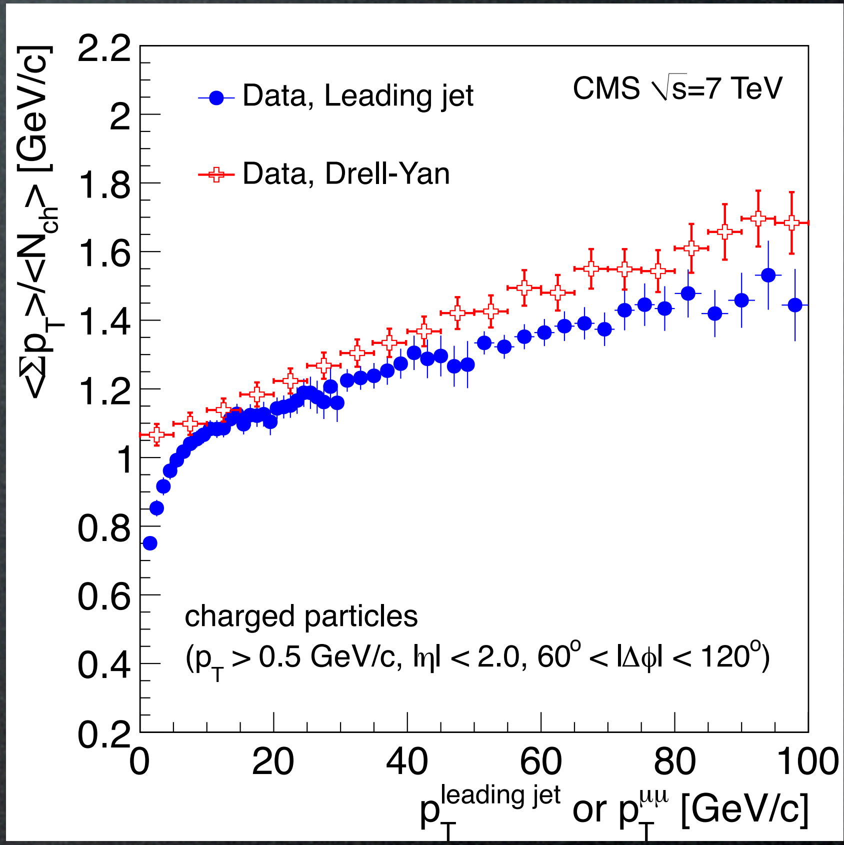


UE activity in Z-boson and jet events fairly similar in Tevatron.

Coming back to Z-jet UE difference







Eur. Phys. J. C 72 (2012) 2080

CMS results show they are still similar

14 TeV UE Predictions