Underlying Event Studies at the Tevatron and the LHC

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University of Glasgow

ISMD, 17th October 2013, Chicago

UE can hide ...

... the interesting part!

Stepping back in time …

Multiplicities and Underlying Event

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University of Florida
(On behalf of the CDF Collaboration)

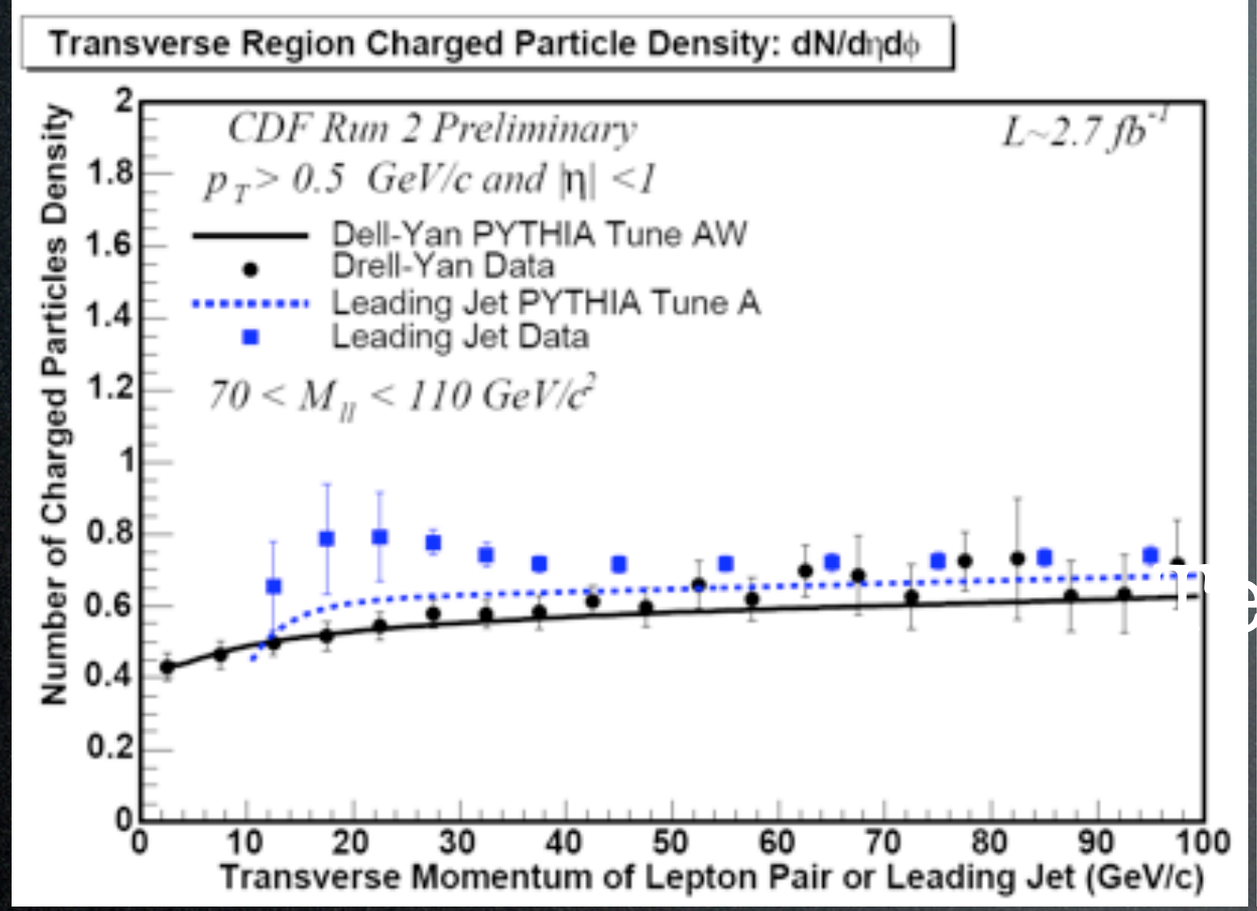
Moving Forward to LHC

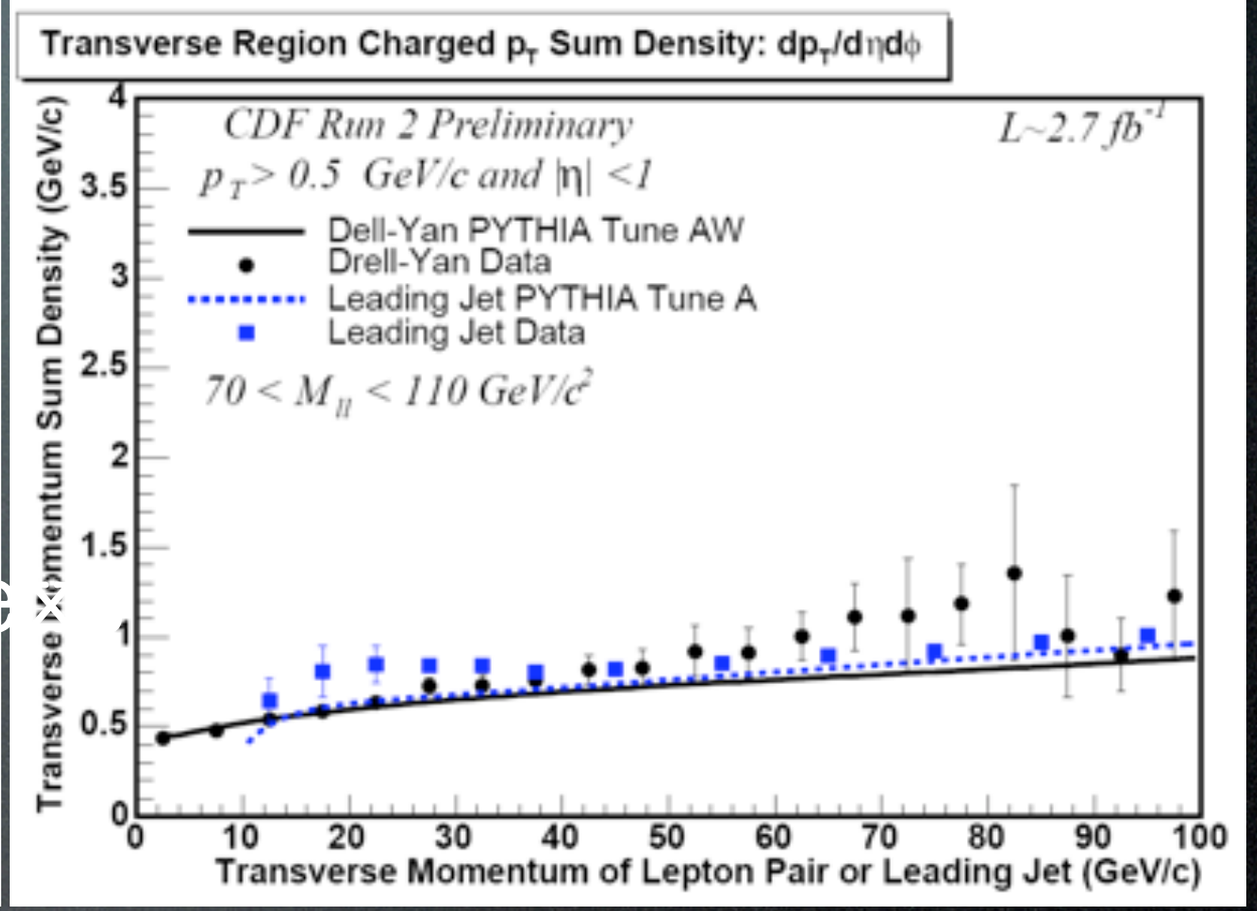

News Site of the Year | The 2008 NewspaperAwards
TIMESONLINE
NEWS | COMMENT | BUSINESS | MONEY | SPORT | LIFE & STYLE | TRAVEL | DRIVING
UK NEWS | WORLD NEWS | POLITICS | ENVIRONMENT | WEATHER | TECH & WEB | TIMES ONLINE TV
Where am I? › Home › News › UK News › Science News
From The Times
September 10, 2008
Scientists cheer as protons complete first circuit of Big Bang machine

- The UE measurement plan at the LHC benefits from the solid experience of the CDF studies.
- Predictions on the amount of activity in transverse region at the LHC are based on extrapolations from lower energy data (mostly from the Tevatron).
- All the UE models have to be tested and adjusted at the LHC, in particular we know very little about the energy dependents of MPI in going from the Tevatron to the LHC.

Results then:

Phys.Rev. D82 (2010) 034001

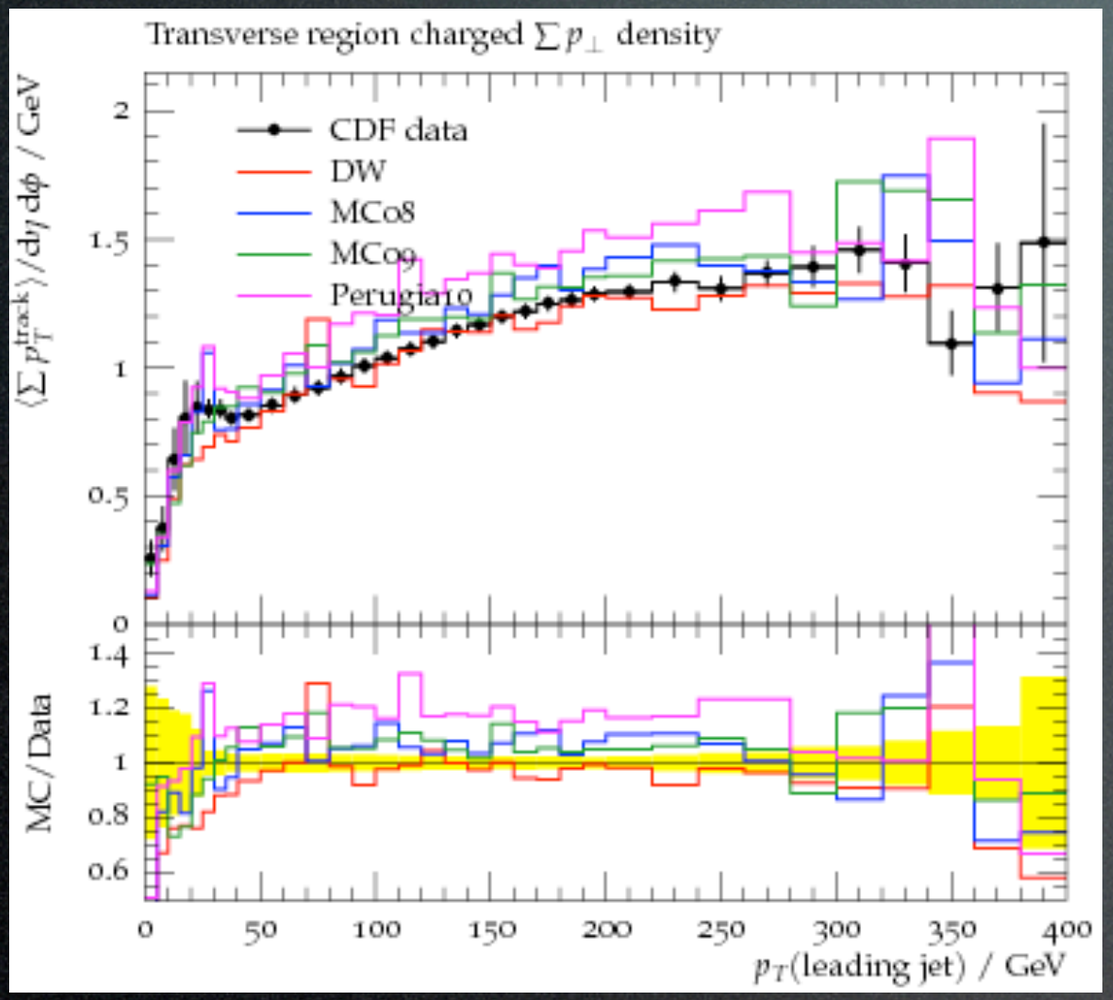


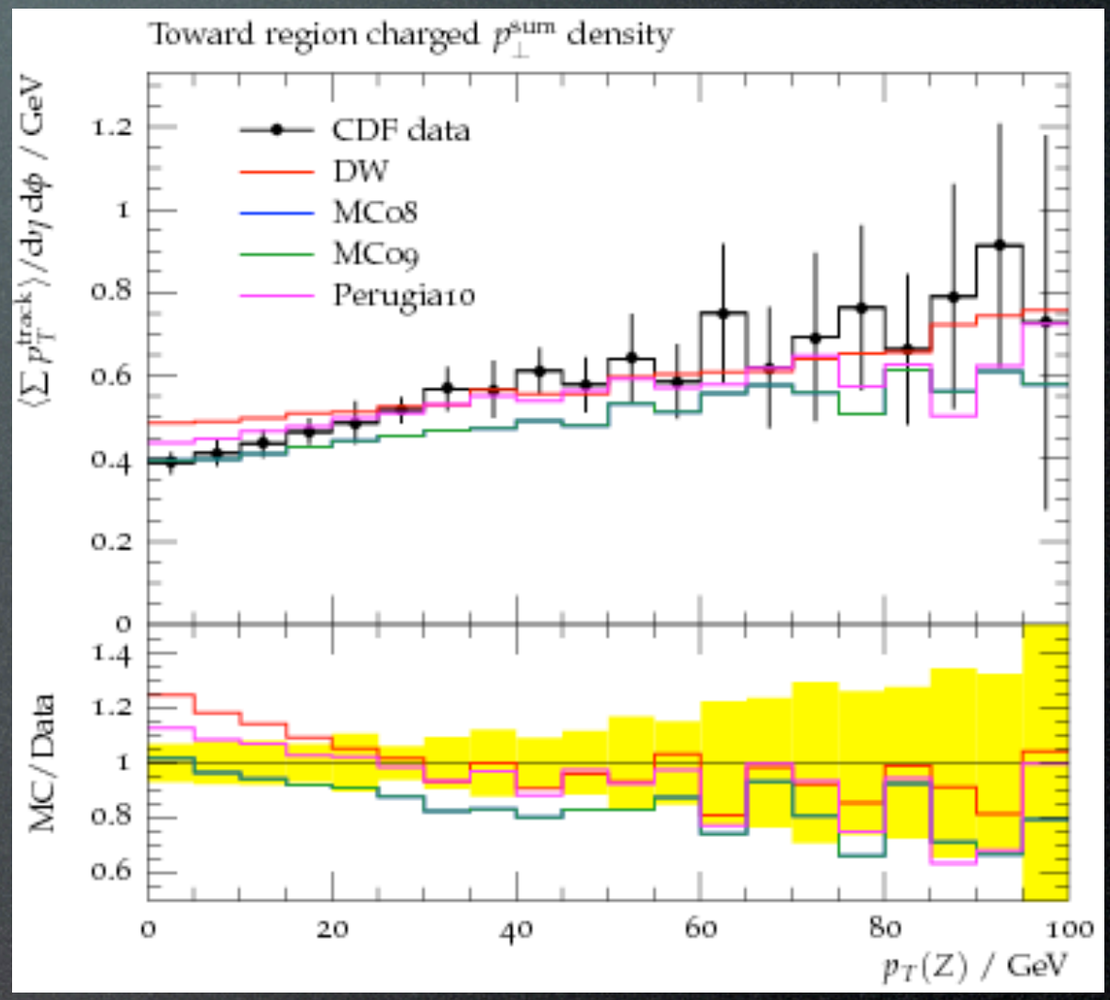


UE activity in Z-boson and jet events fairly similar in Tevatron.

Is it still the case at the LHC?

Pre-LHC tunes compared to CDF data





Phys.Rev. D82 (2010) 034001

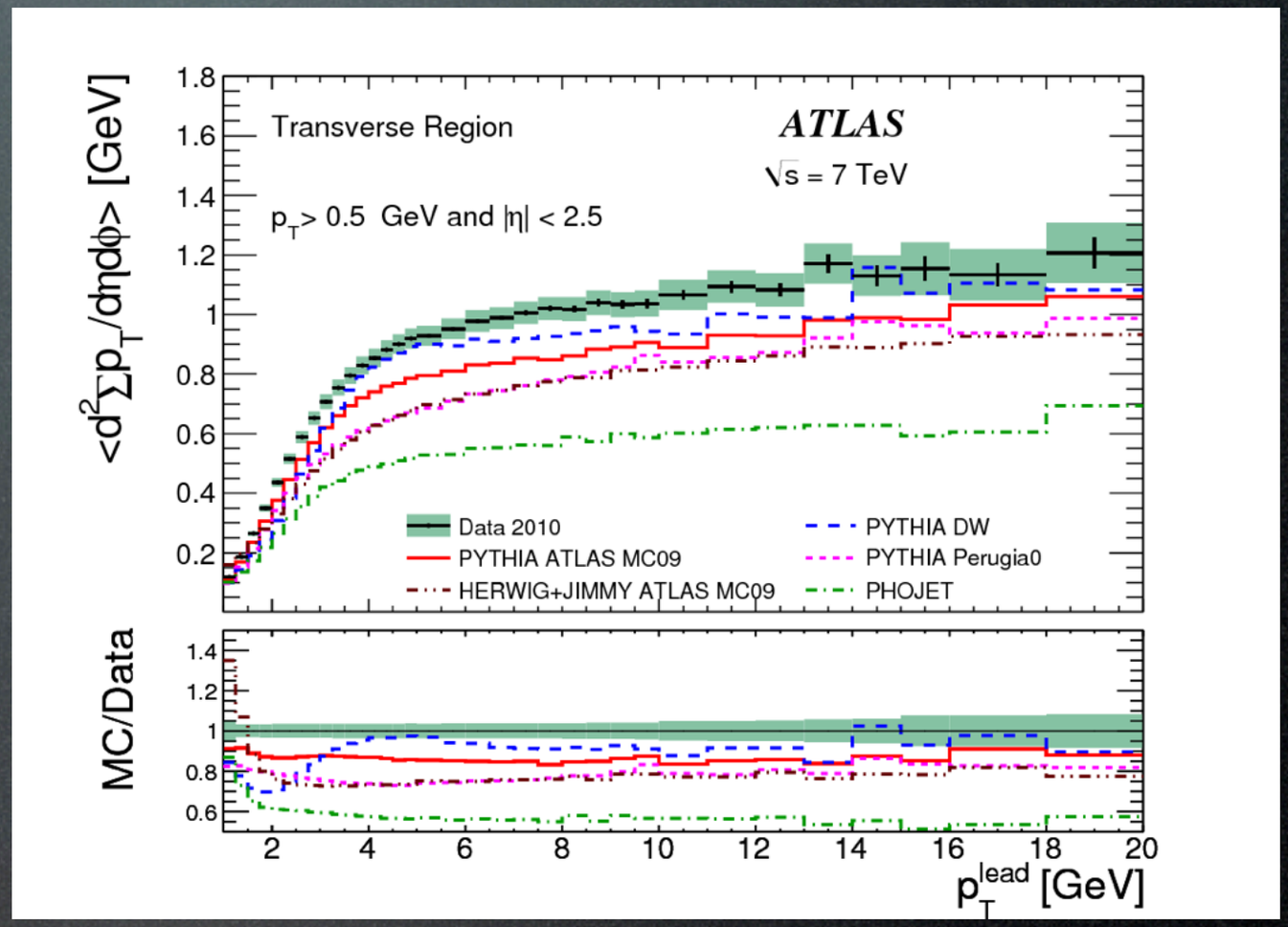
The tunes do quite well ...

Did they work at the LHC?

Then came the LHC

Pre-LHC tunes severely under-predict the UE activity

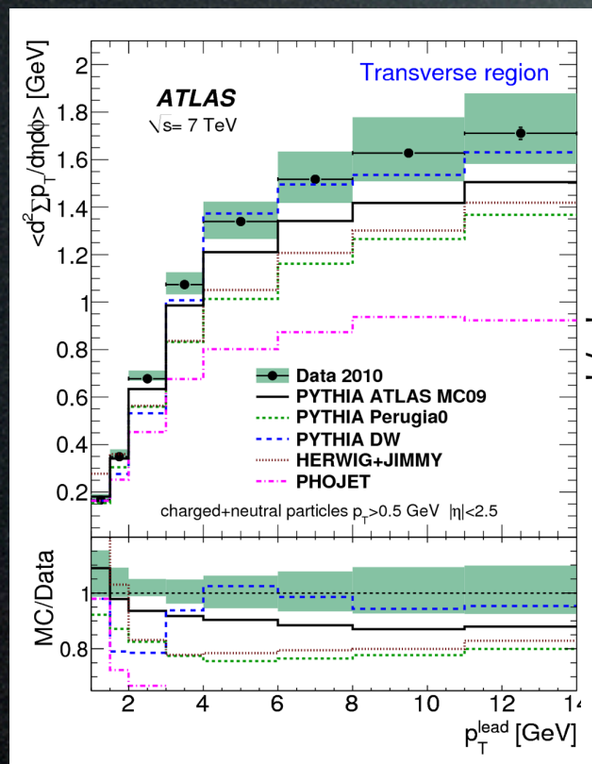
(Lesson 1)

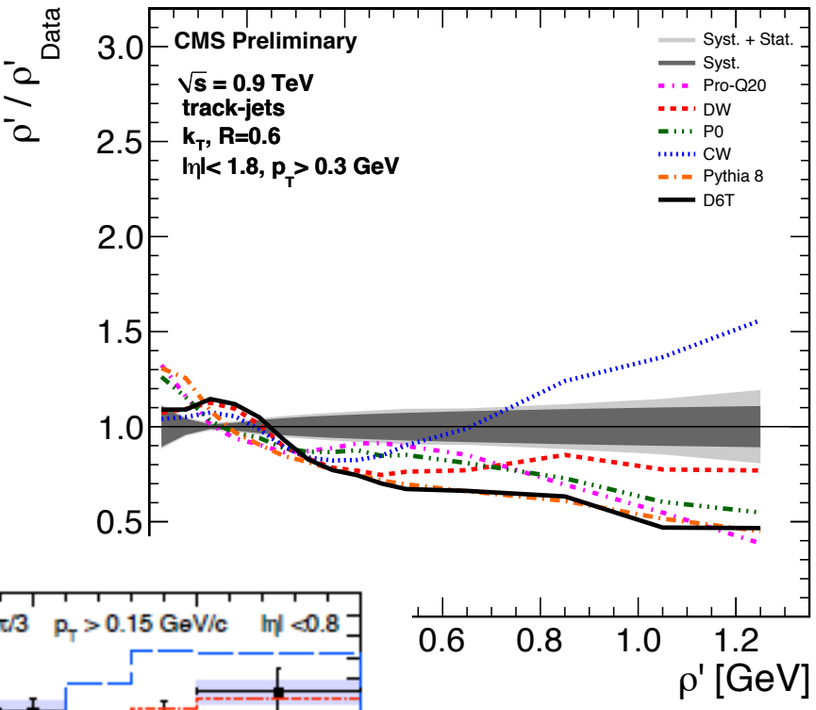


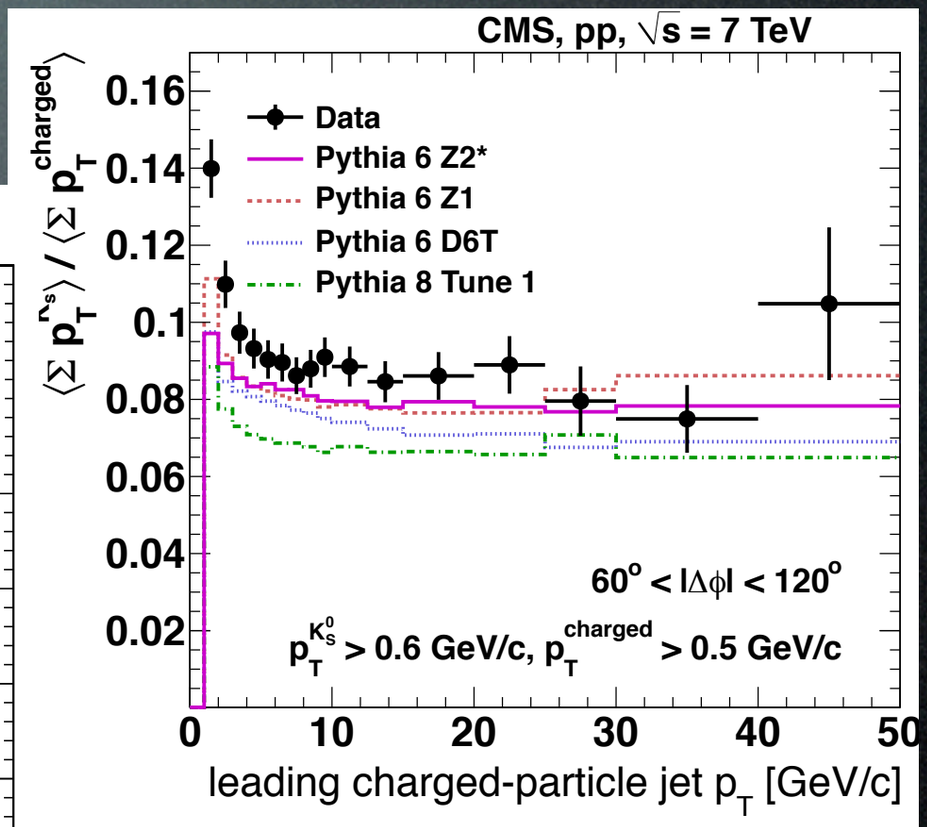
Phys. Rev. D 82 (2010) 034001.

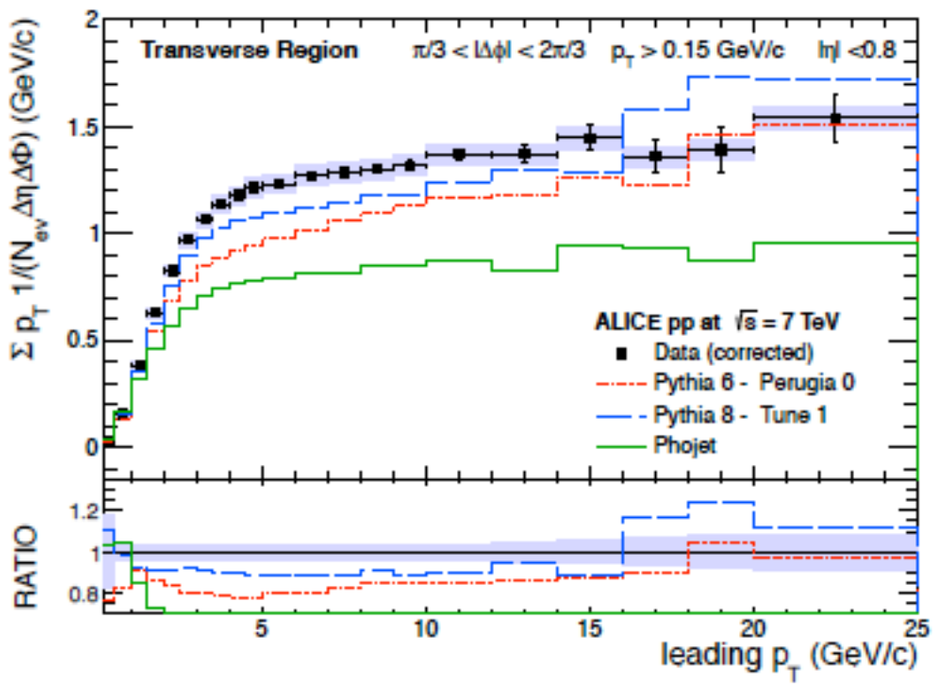
P.S - we used the LHC data to come up with better tunes.

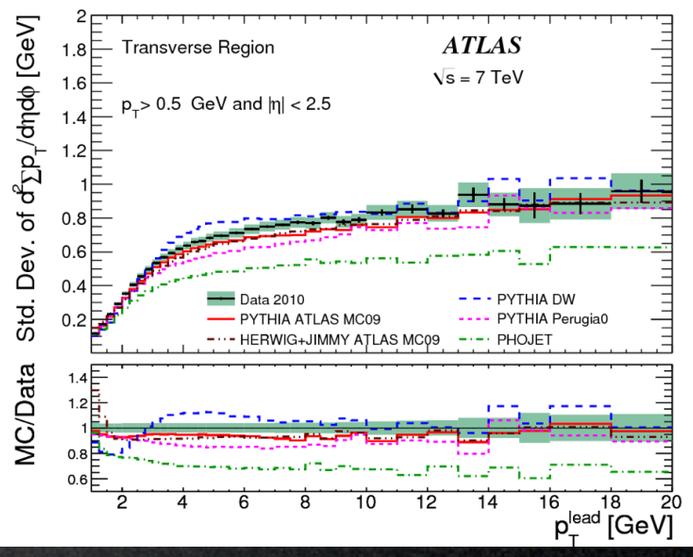
Many LHC UE Analyses



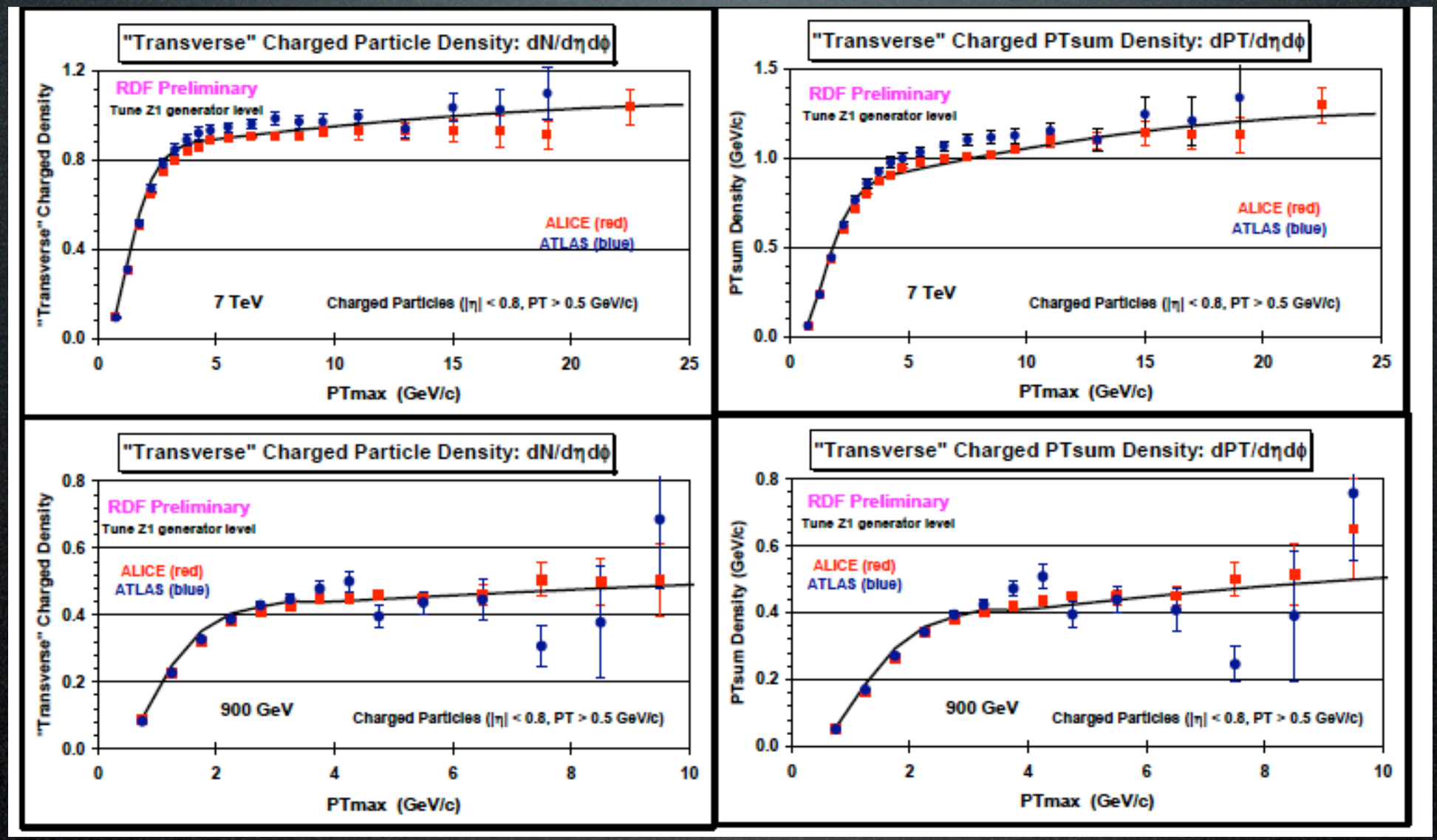






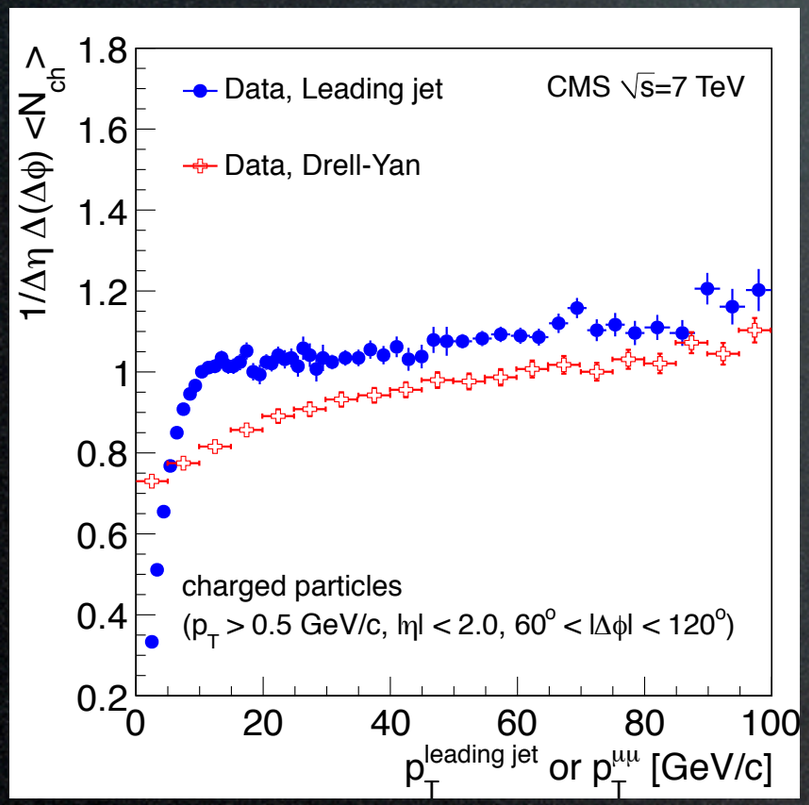


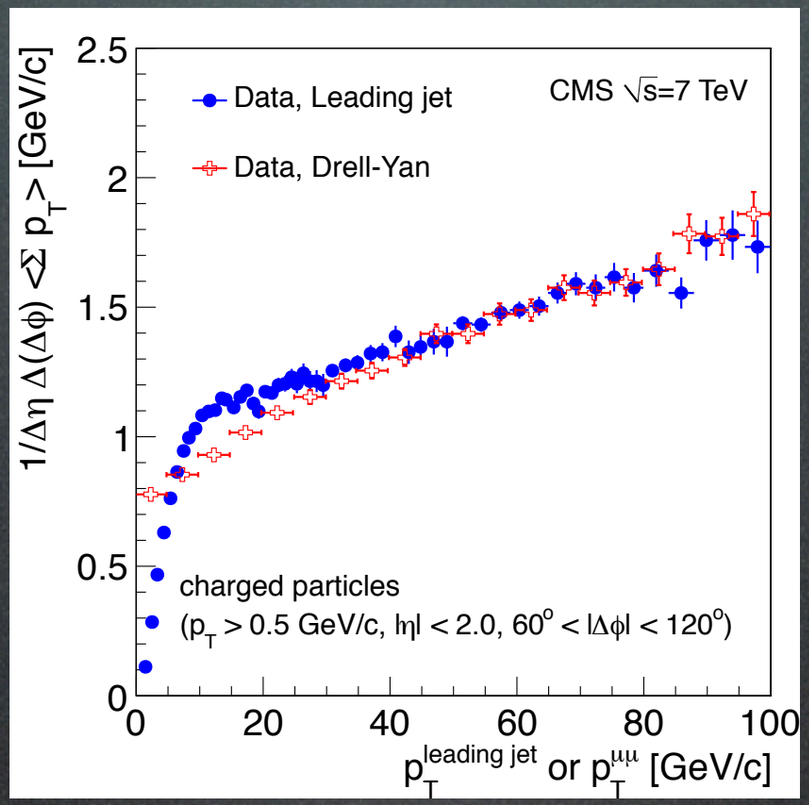
LPCC UE&MB WG

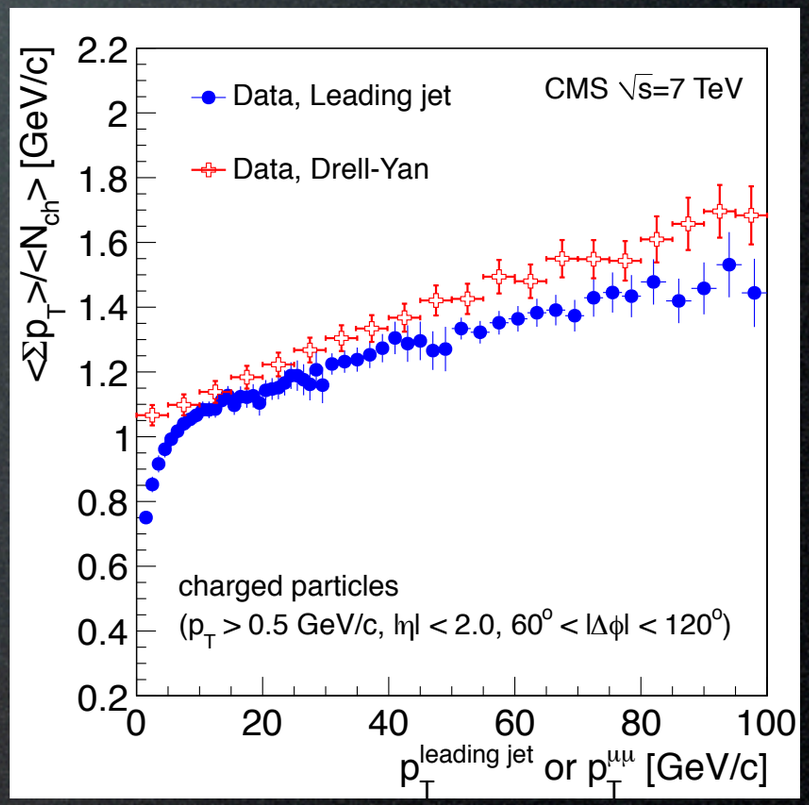


Rick Field: WG meeting, 17th June 2011

Coming back to Z-jet UE difference



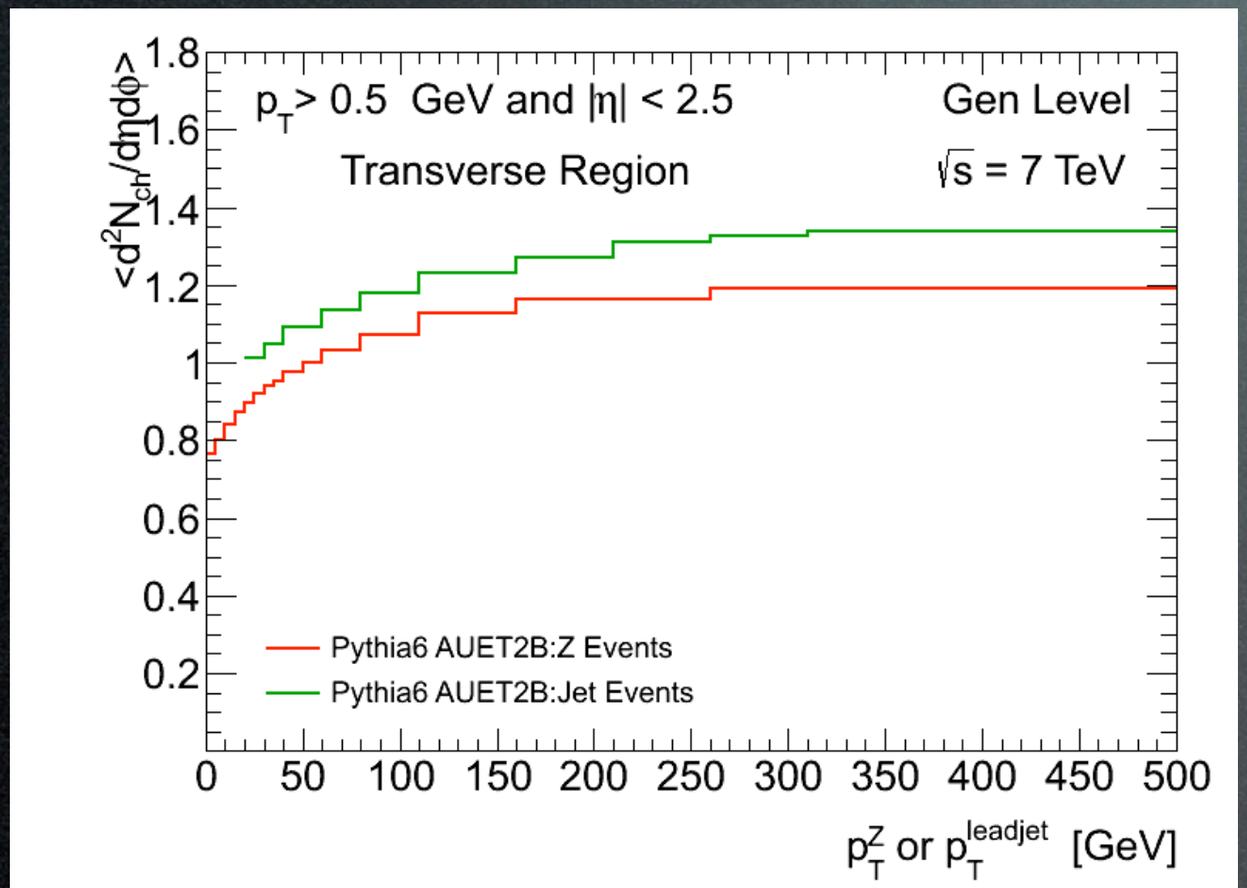


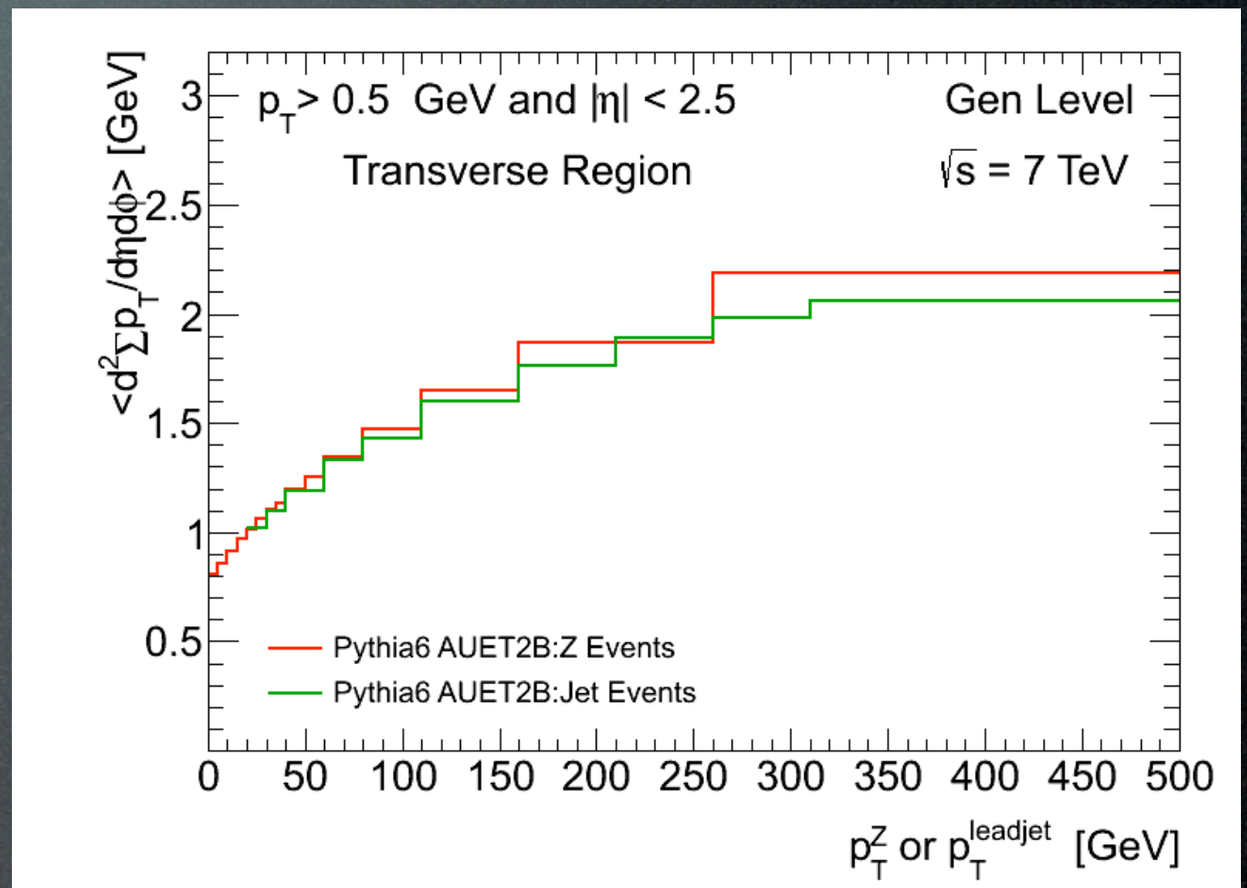


Eur. Phys. J. C 72 (2012) 2080

CMS results show they are still similar

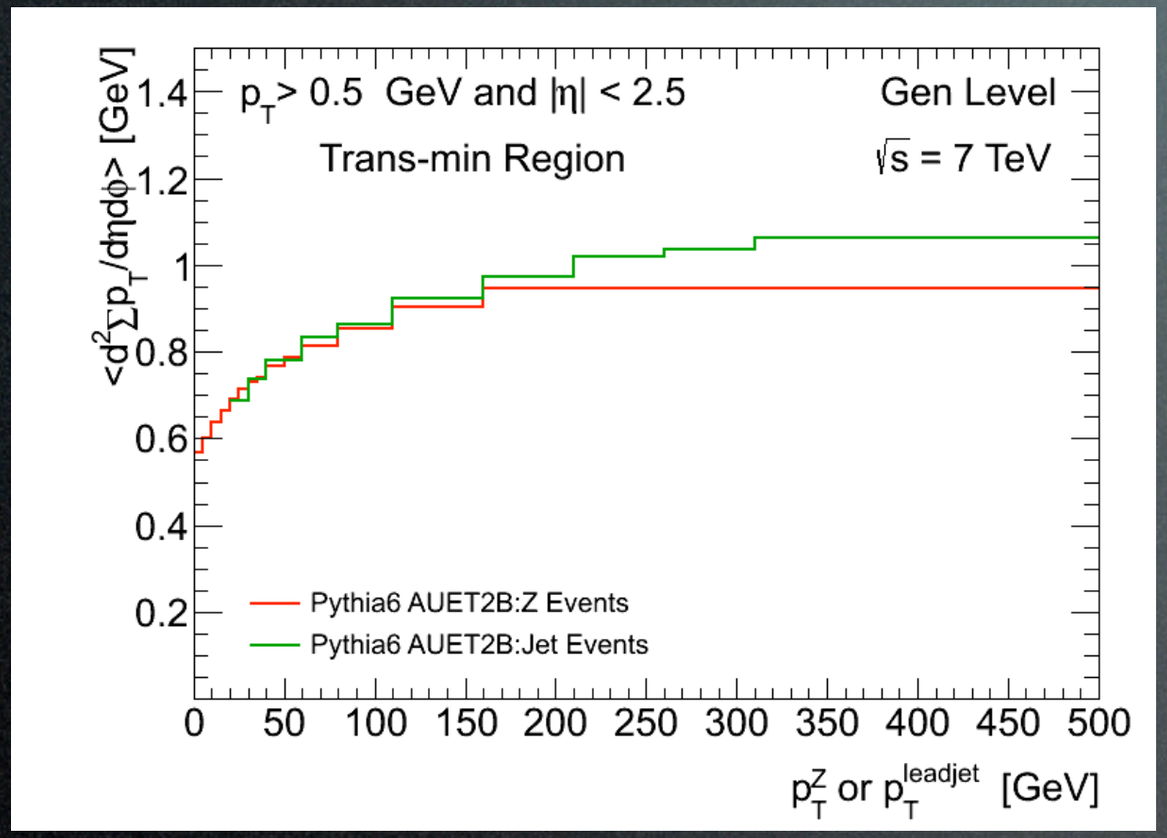
Extend to Higher Energy Scale

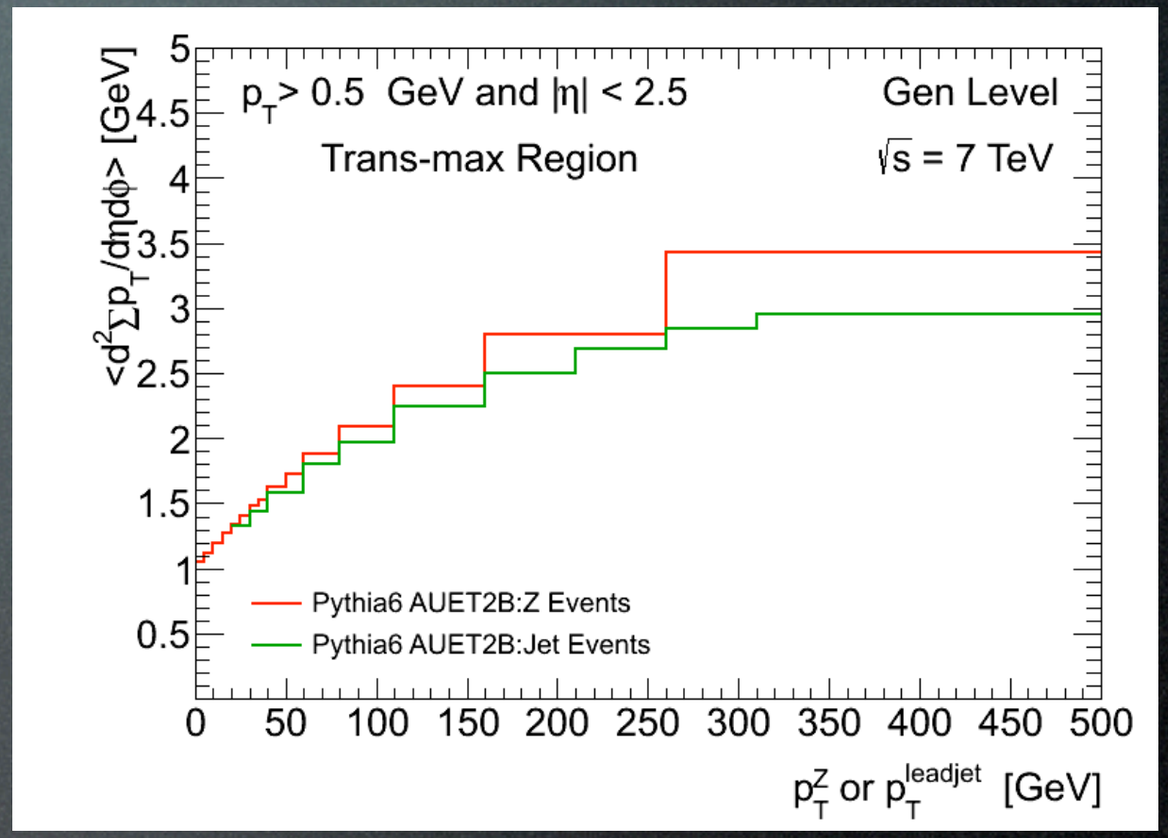




Generator level (Pythia6): Not much difference

Trans-max/min Regions



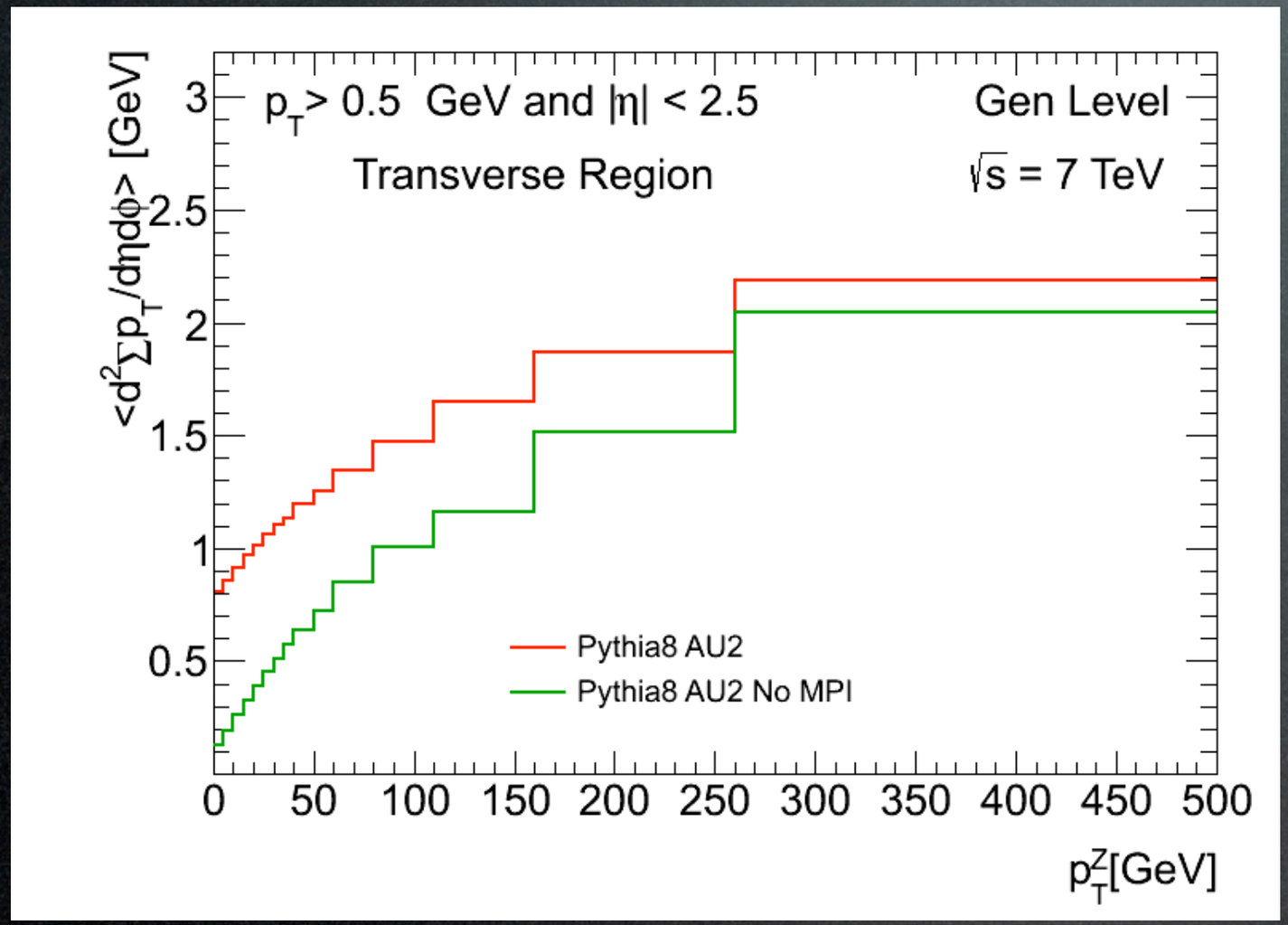


There is a pronounced difference here!

The activities are still similar, with a caveat.

(Lesson 2)

How much of the UE is UE?

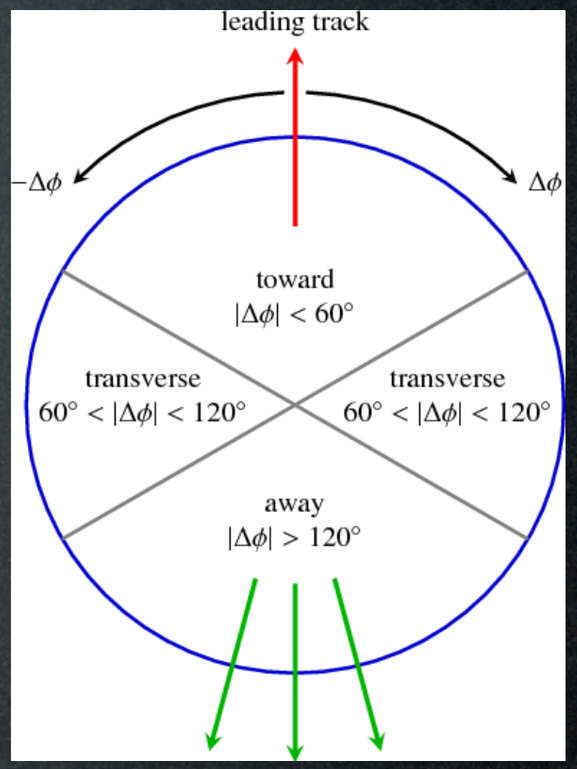


Even without MPI, the "UE" activity is catching up.

Indicative of additional hard (non-MPI) hard jets

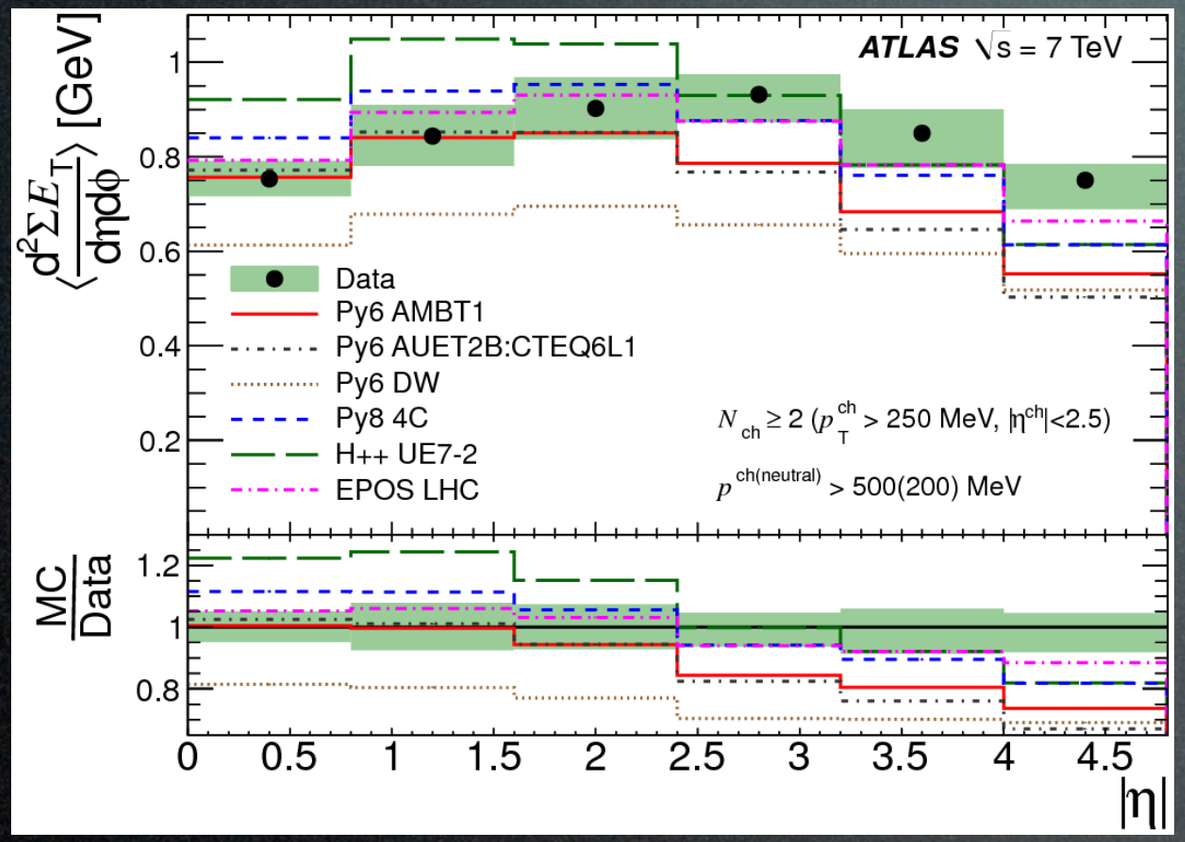
(Lesson 3)

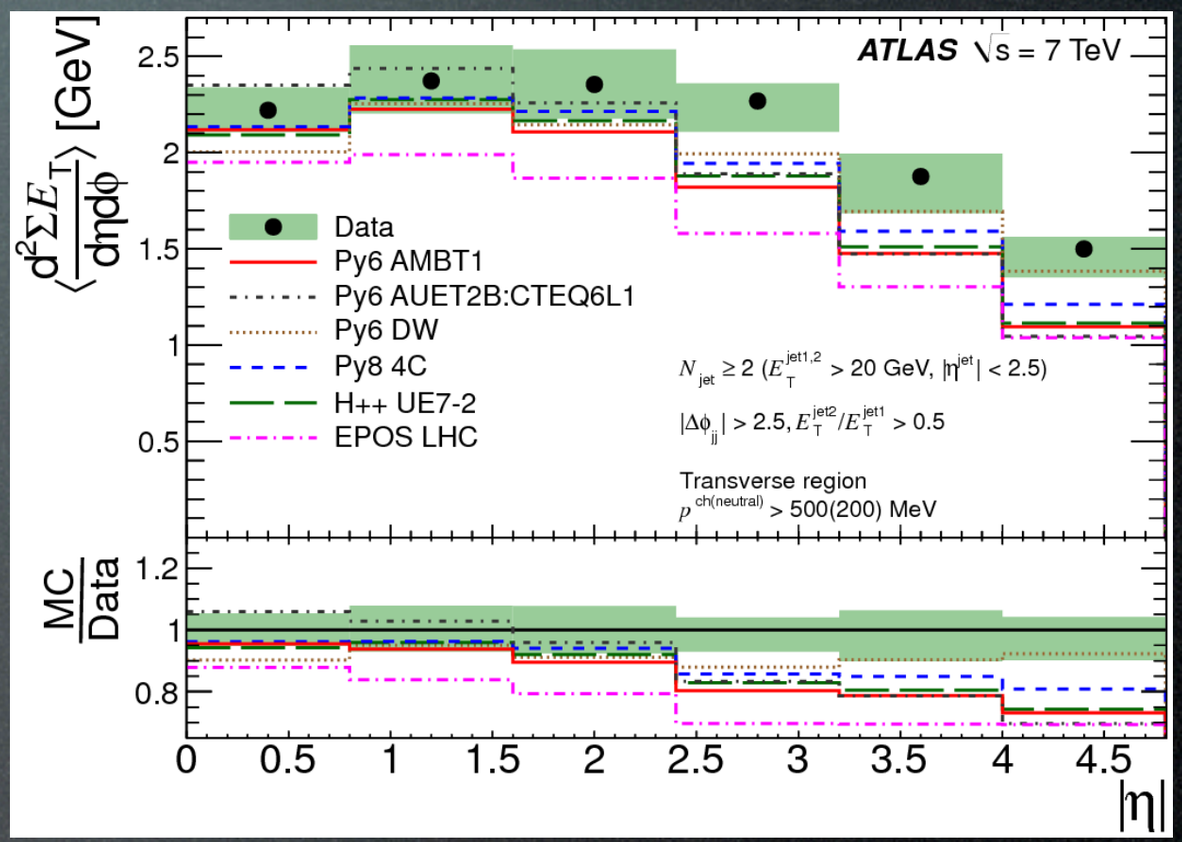
Isolating the UE



- 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.

UE-sensitive Observables

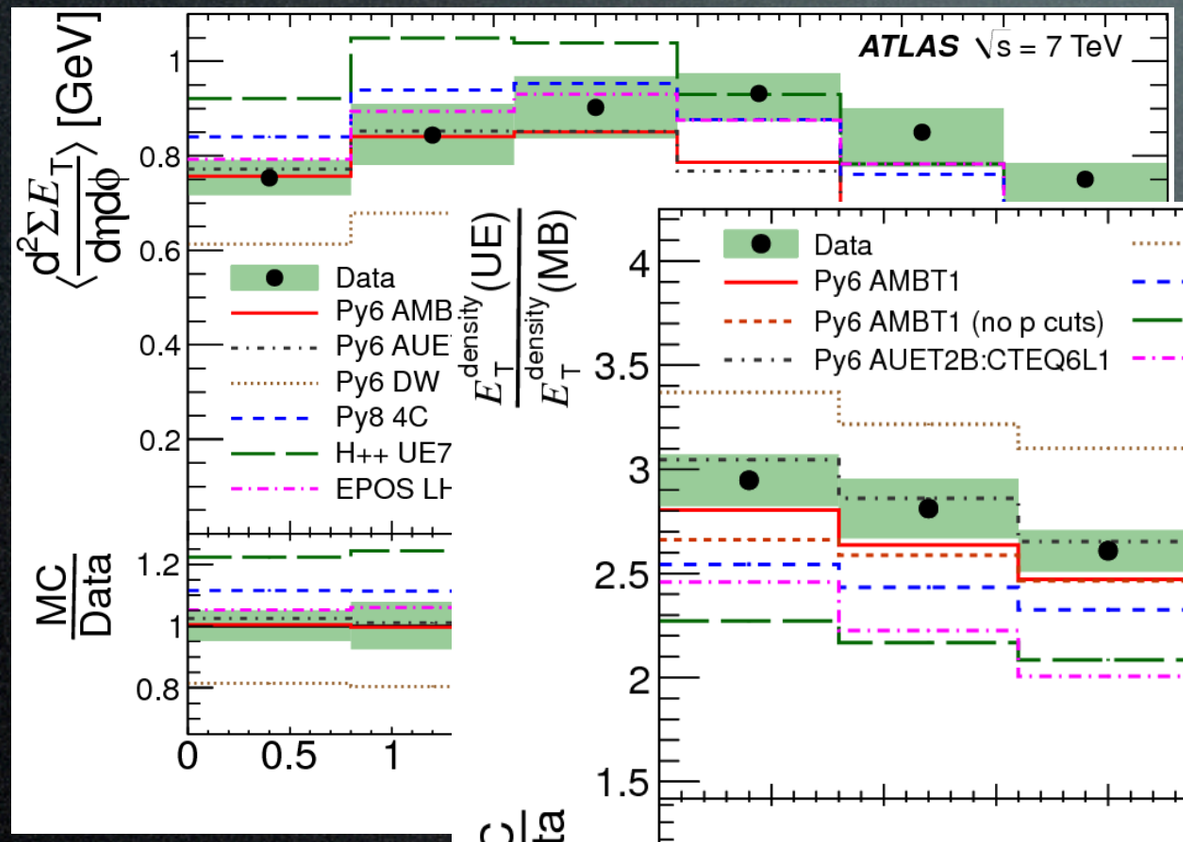




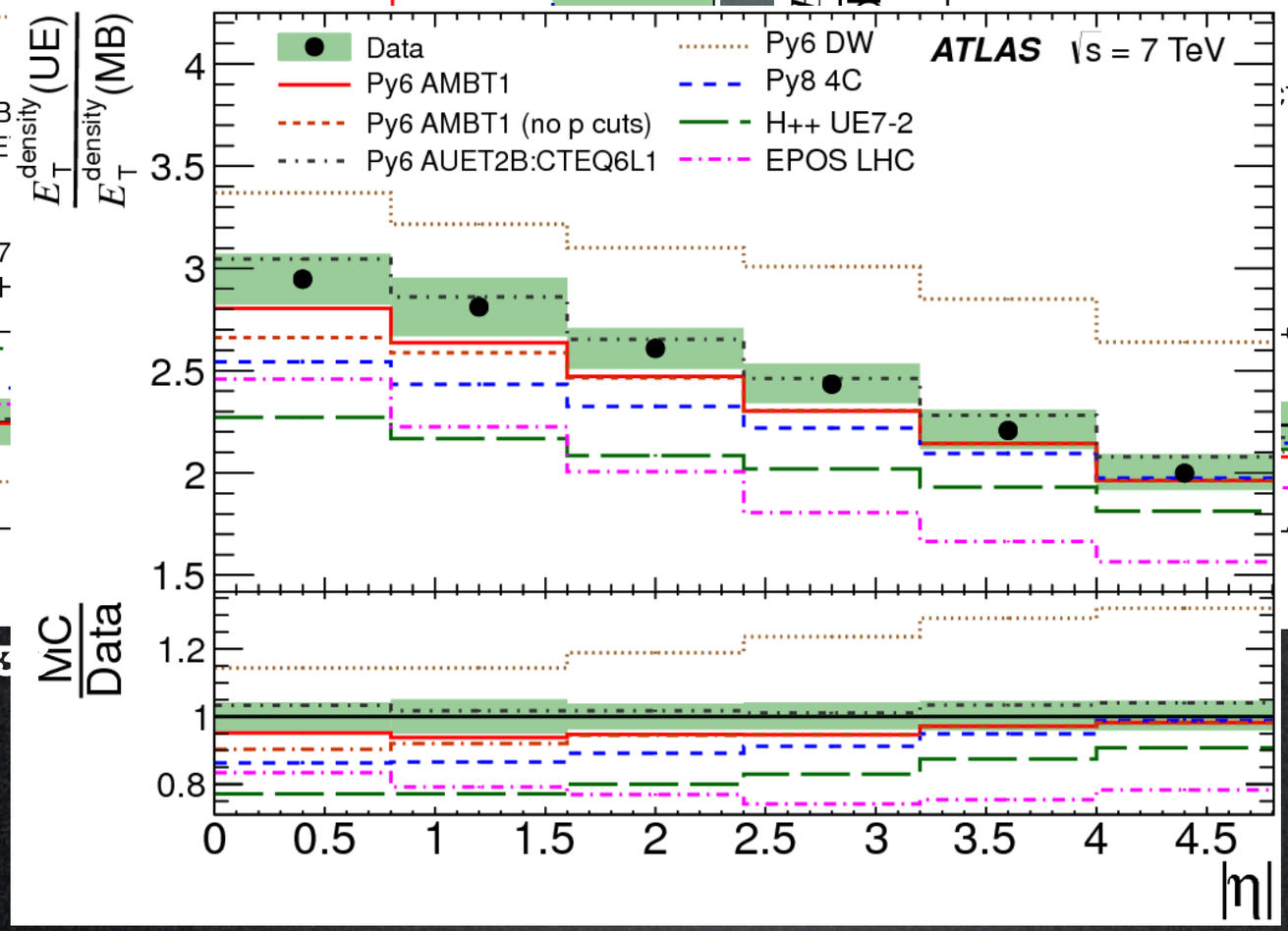
JHEP11 (2012) 033

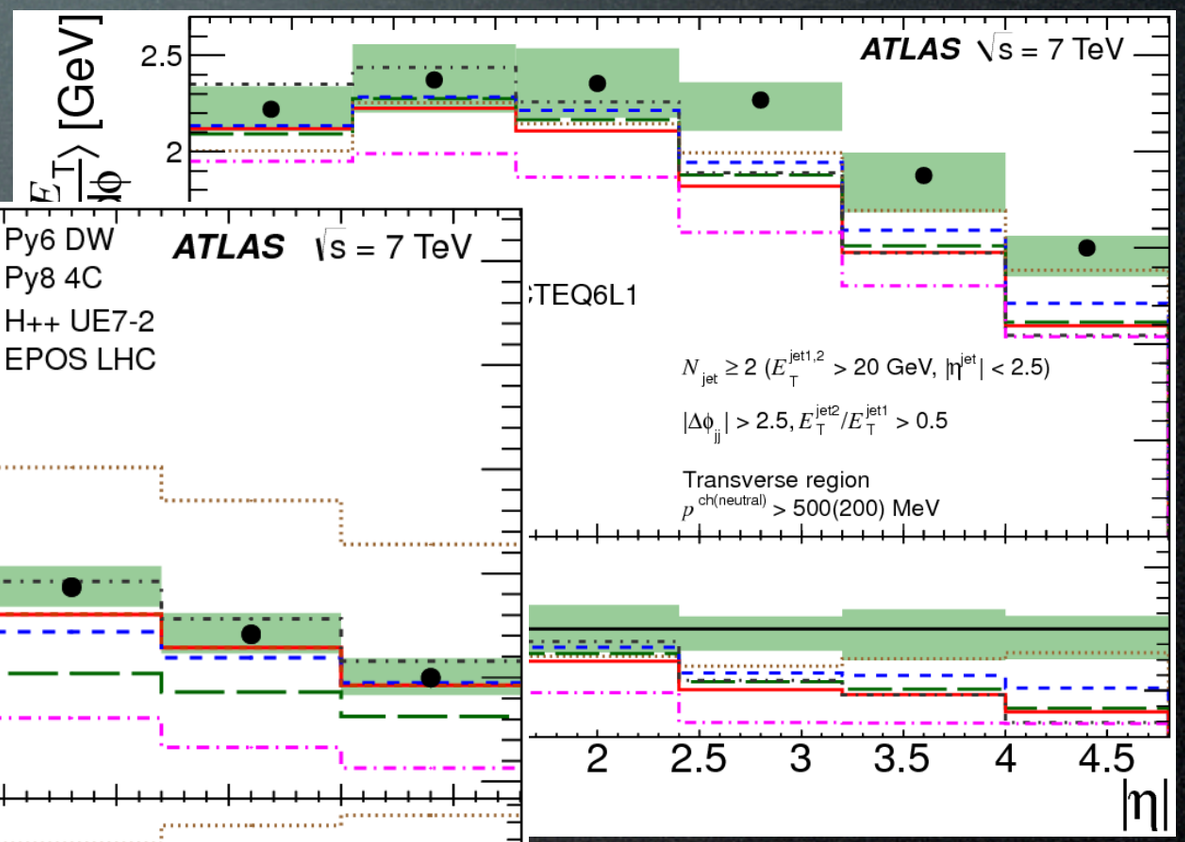
Transverse energy flow: all models bad in forward region

UE-sensitive Observables



JHEP11 (2012) 03

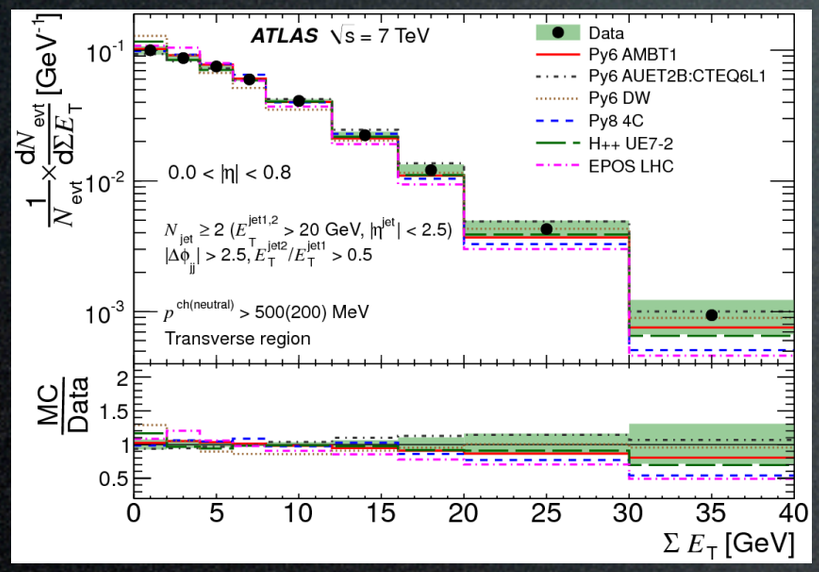


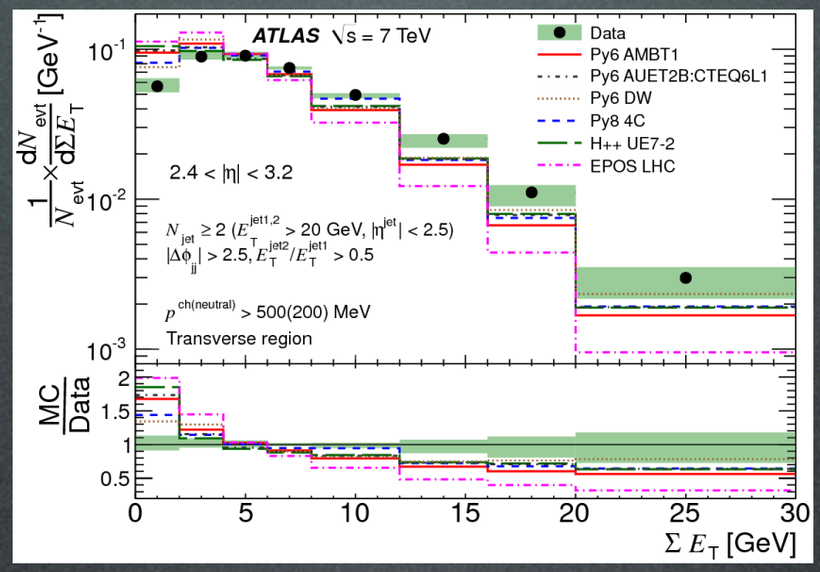


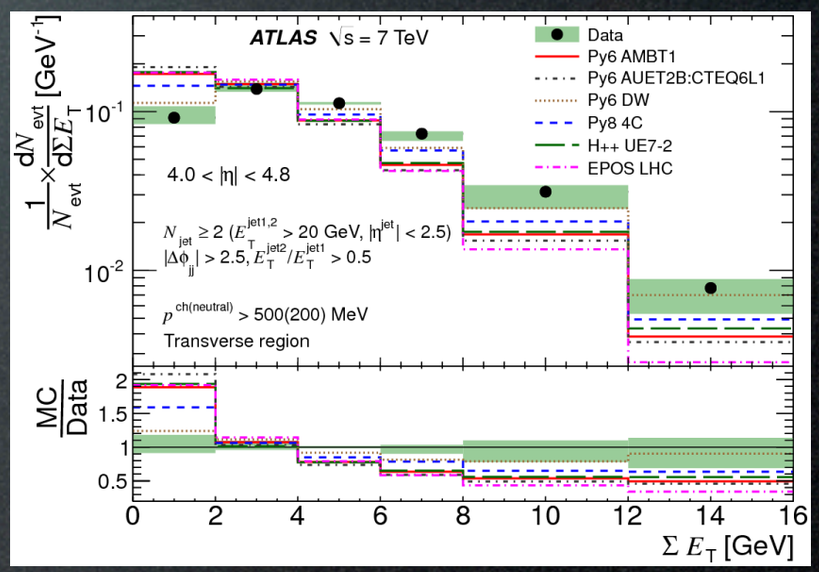
More energy in dijet events!

From Central to Forward

low η → **high η**







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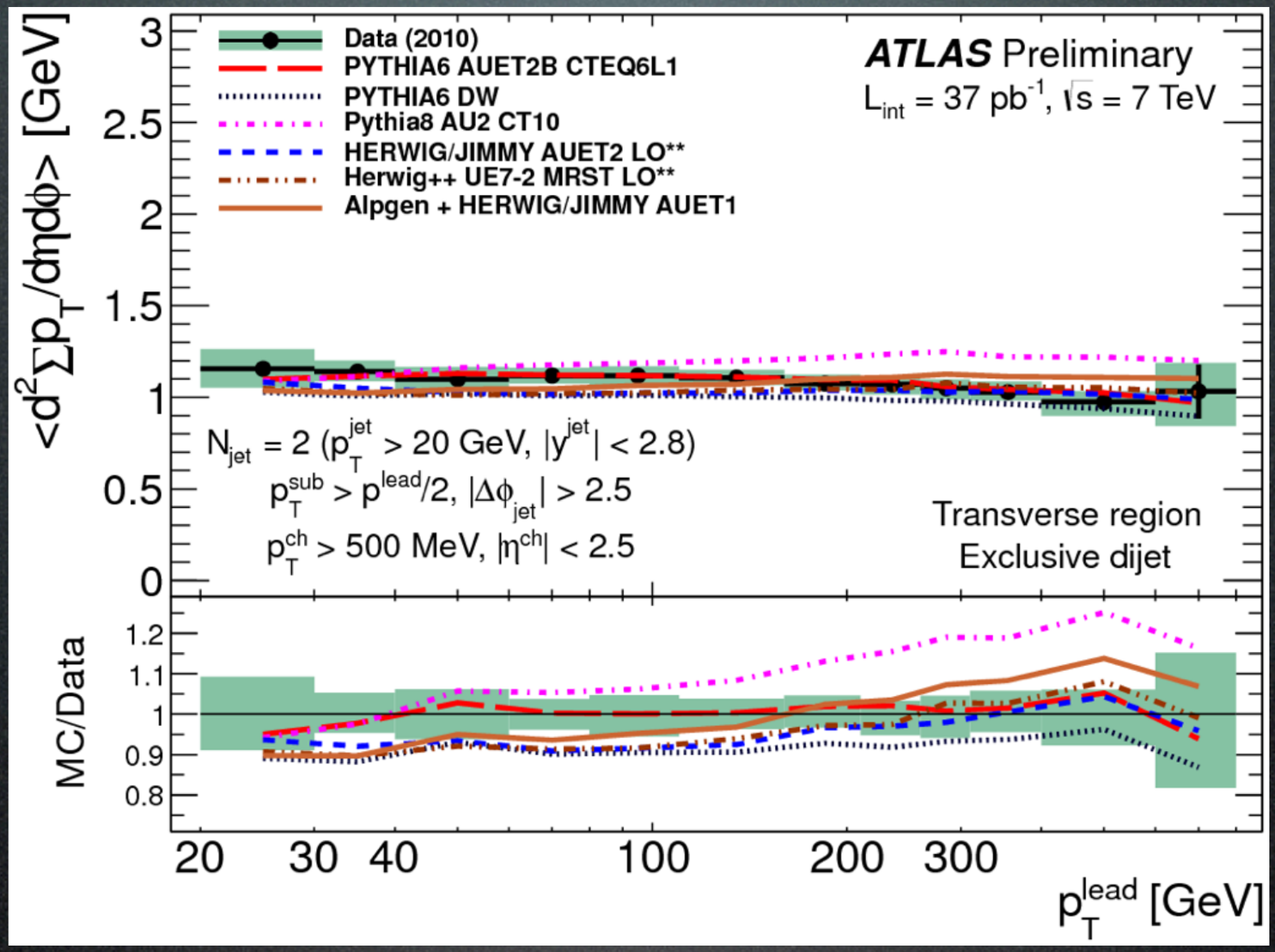
UE tunes do better overall

Exclusive Dijet Topology

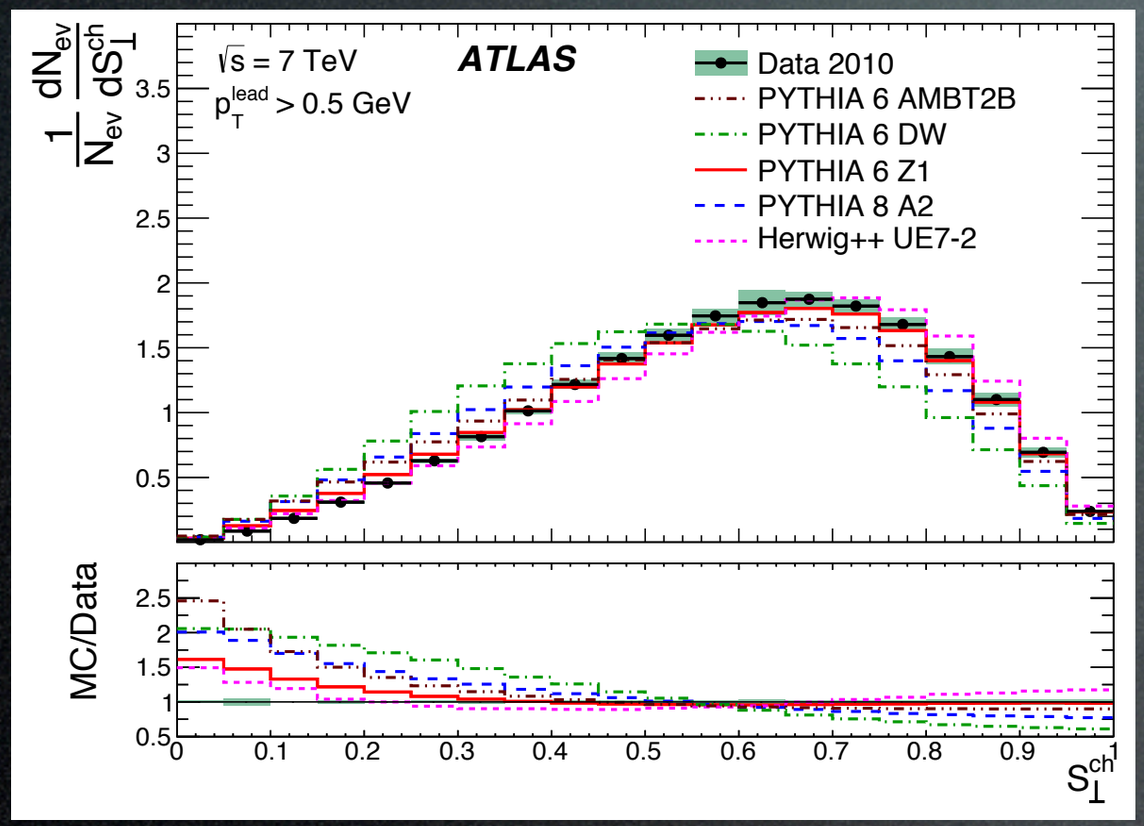


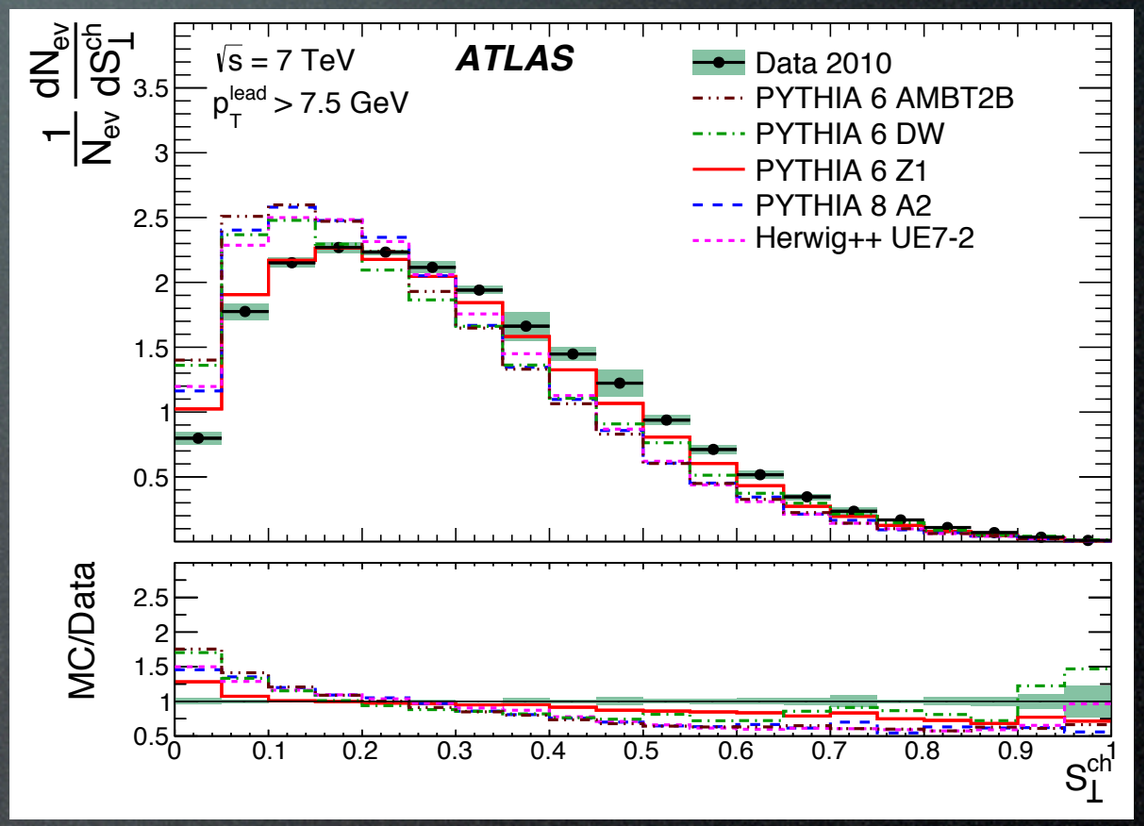
ATLAS-CONF-2012-164

Can inadvertently cut out "UE" jet; but MC models do better

Event Shapes

Low lead p_T → High lead p_T

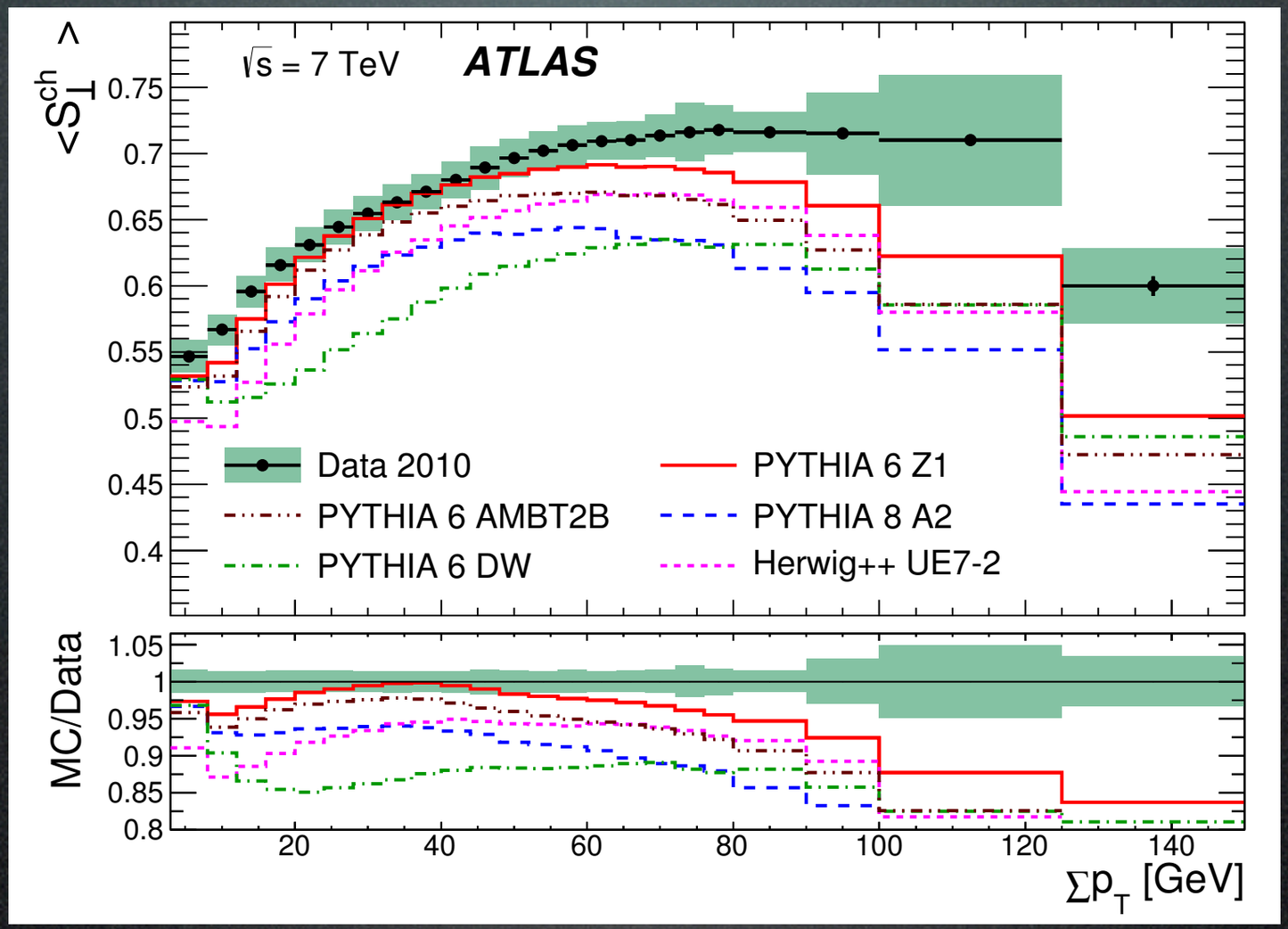




Phys. Rev. D 88, 032004 (2013)

UE starts taking over....

Event Shape Profile



Phys. Rev. D 88, 032004 (2013)

Emergence of jets?

New Observables?

ACF:

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

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

ASF:

$$\begin{aligned} \Delta\mathcal{G}(R) &\equiv \frac{d \log \mathcal{G}(R)}{d \log R} \\ &= R \frac{\sum_{i \neq j} p_{\perp i} p_{\perp j} \Delta R_{ij}^2 \delta[R - \Delta R_{ij}]}{\sum_{i \neq j} p_{\perp i} p_{\perp j} \Delta R_{ij}^2 \Theta[R - \Delta R_{ij}]} \end{aligned}$$

Average ASF:

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

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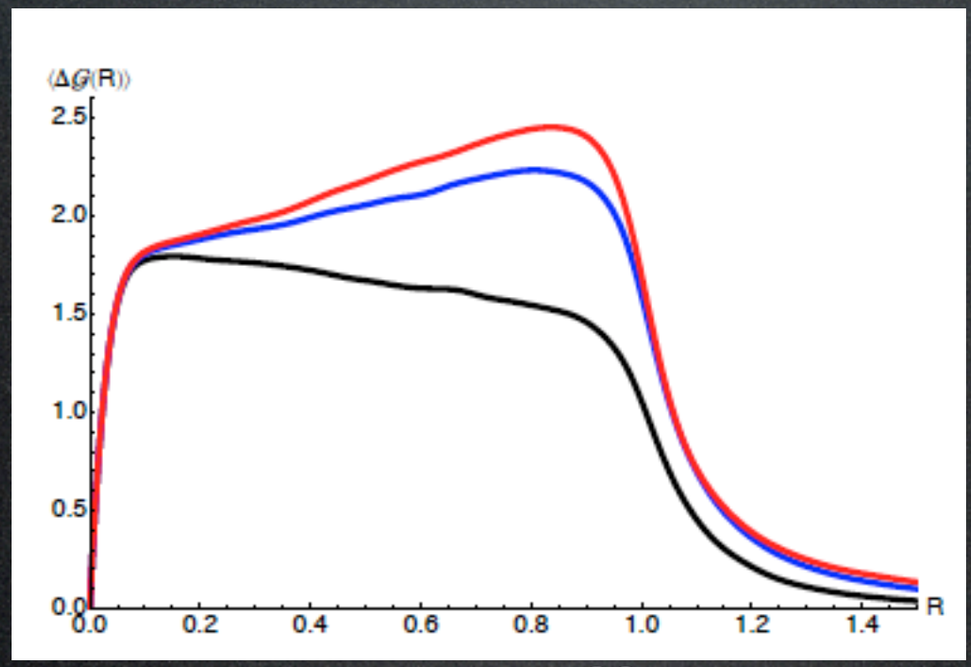
Average ASF Results

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

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Looking Forward

- A diverse set of UE (and related) measurements available from Run I.
- They are not just important for testing/ improving MC models, but for precision measurements and searches.
- Many analyses/data are available in Rivet/ Hepdata, but experiments should try to have MC-independent final results, and make sure they are included in Rivet/Hepdata.
- LHC Run 2, are we ready?

14 TeV UE Predictions