Introduction to WG1: Minimum bias and Underlying Event

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MPI@LHC, Chiapas, Mexico
27th November - 2nd December, 2016

Introduction to WG1: Looking back at Tevatron and LHC Run 1 results

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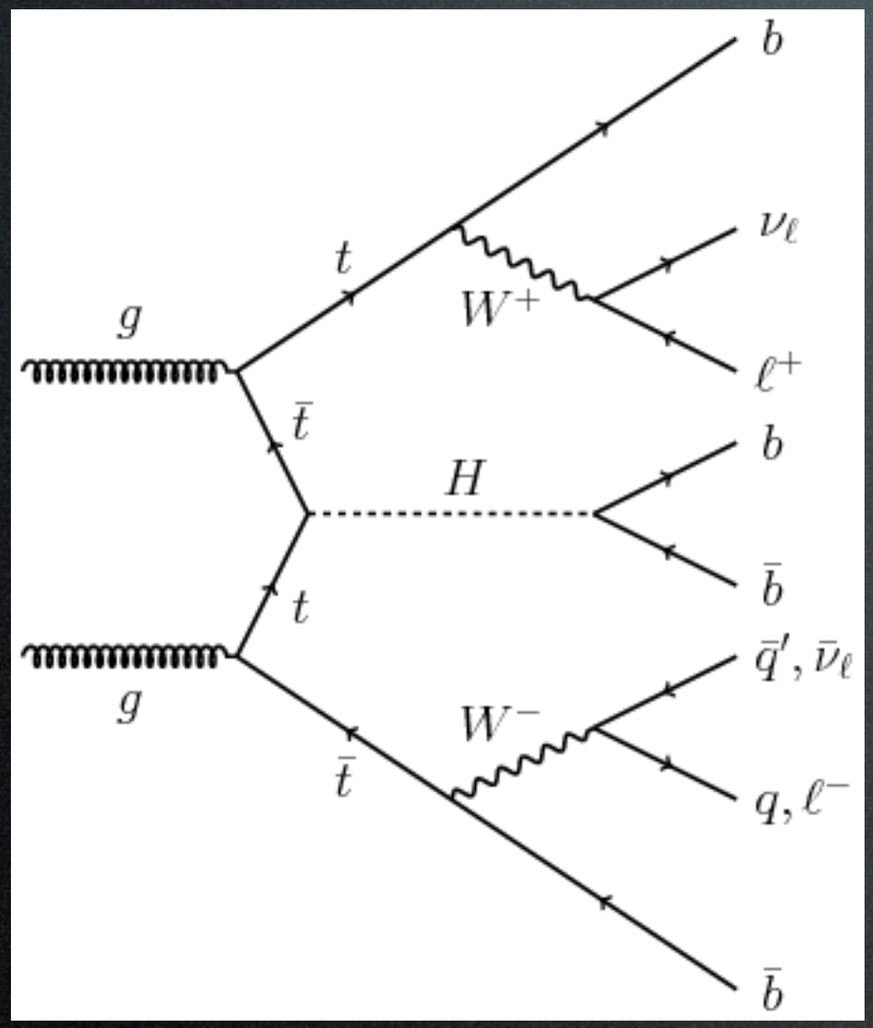
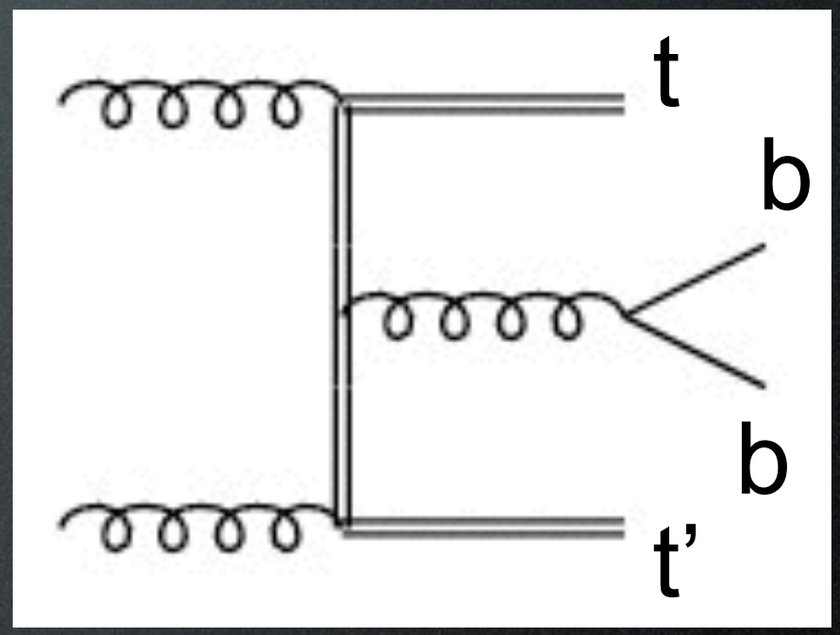
Important in New Physics Searches ...

One of the hardest measurements:



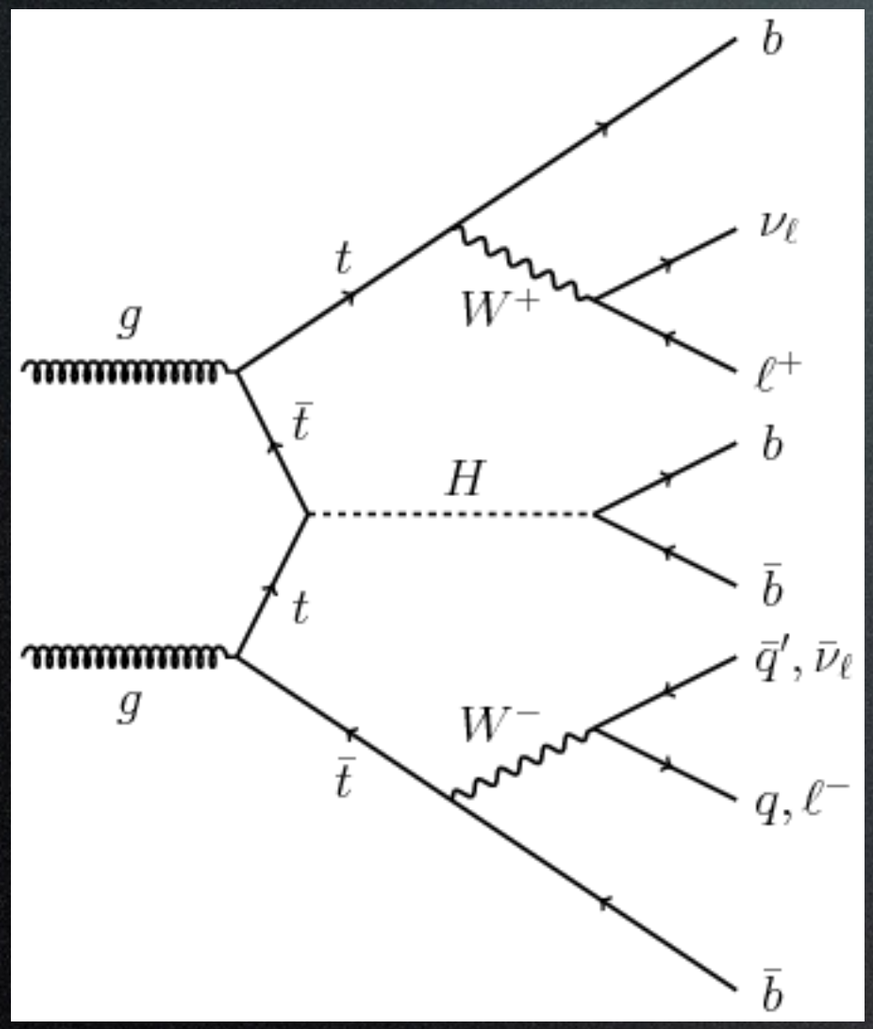
Signal: ttH(bb)



BG: ttbb

important for measuring Yukawa couplings

One of the hardest measurements:



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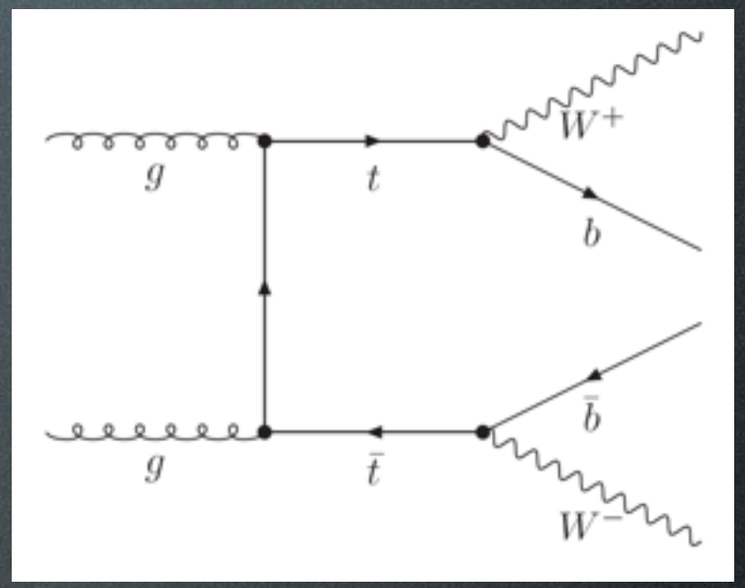
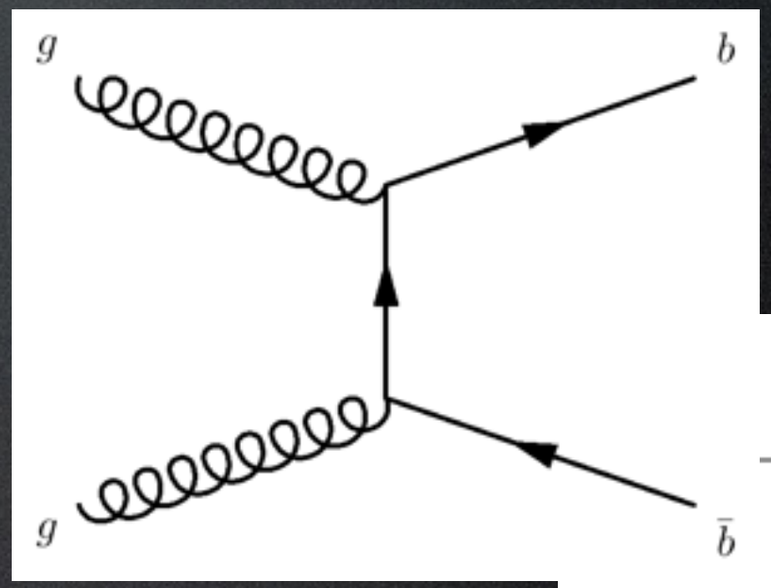
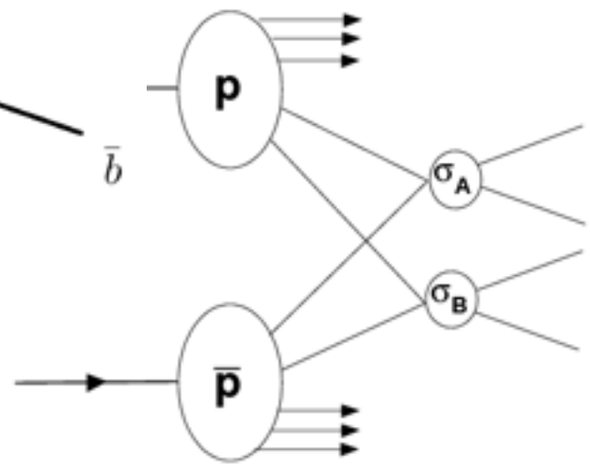


tt

+



(DPI) bb



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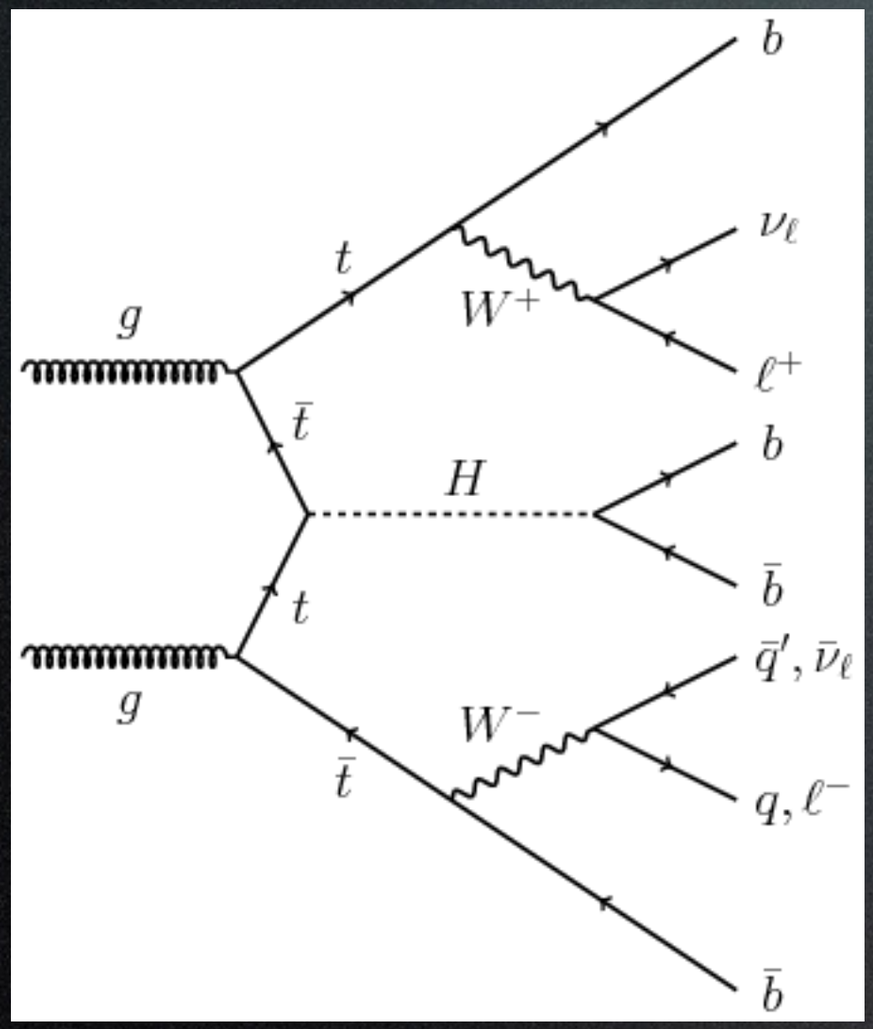

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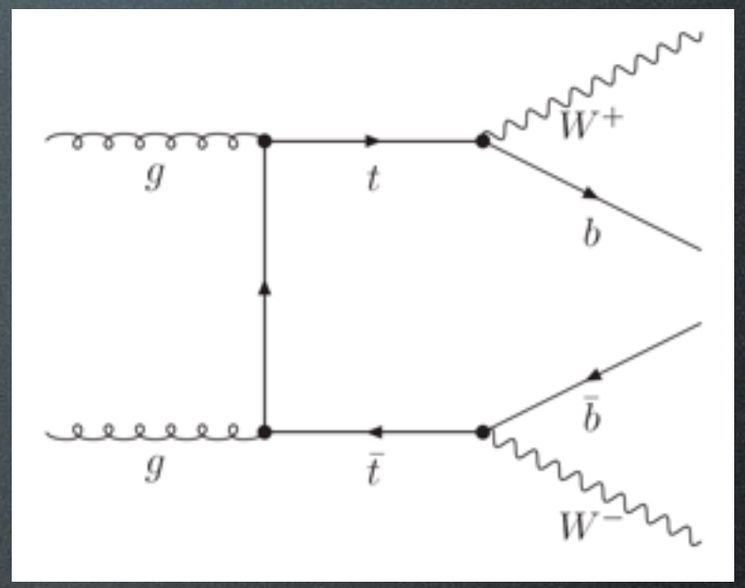
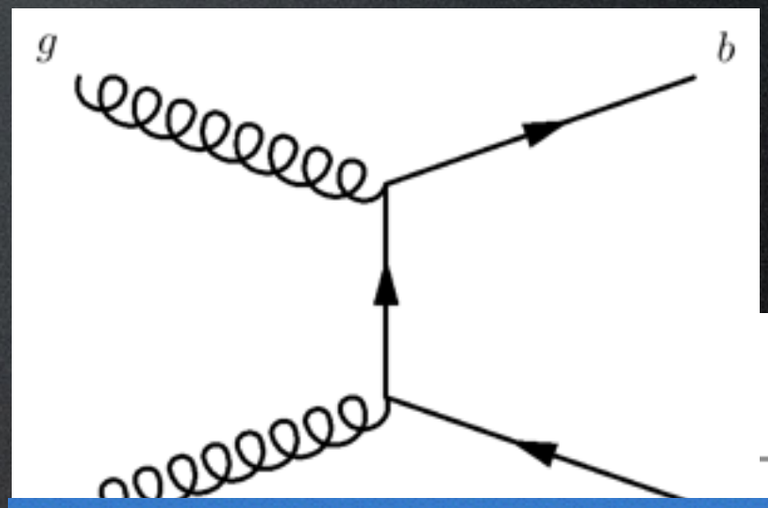


tt

+



(DPI) bb

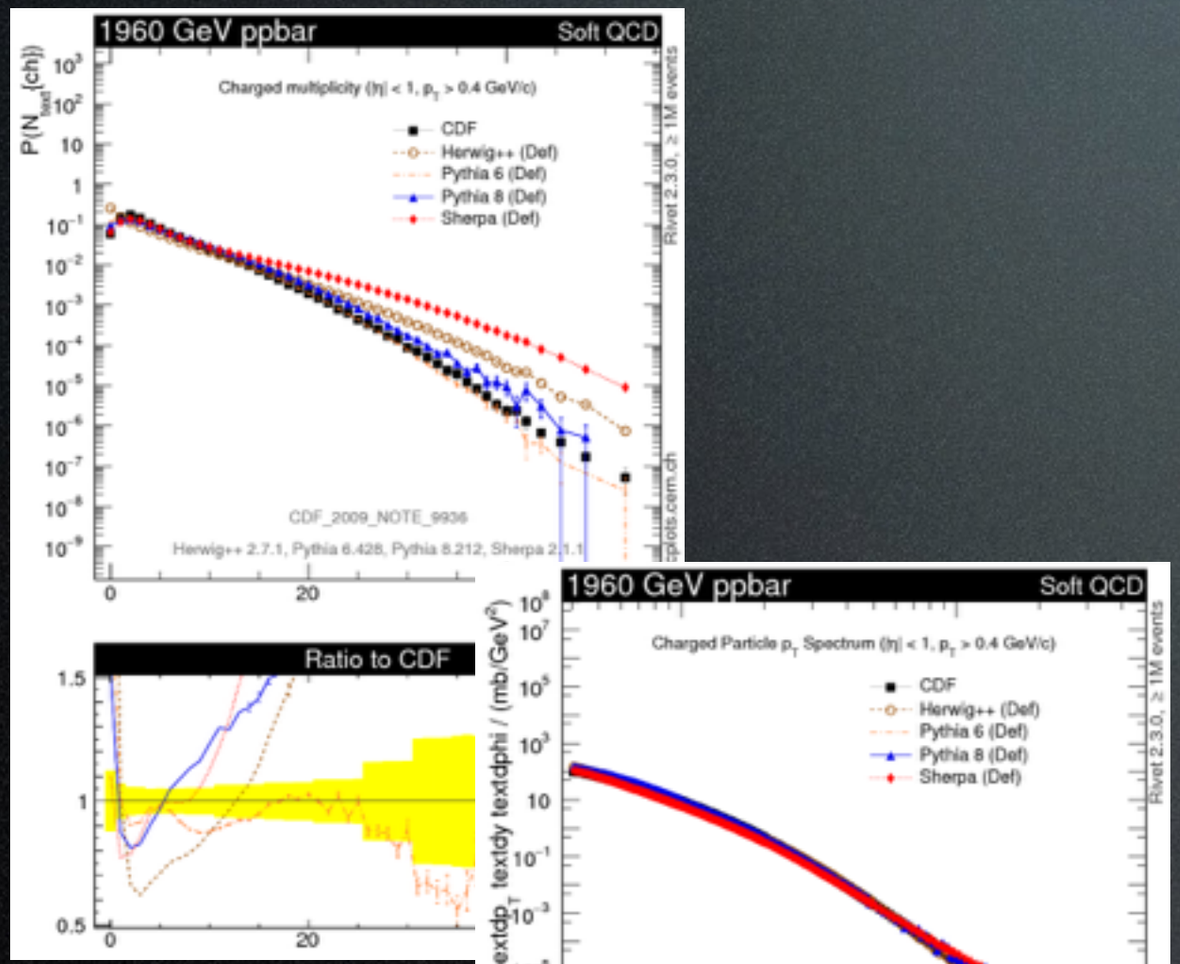
Upto 10% of BG cross-section

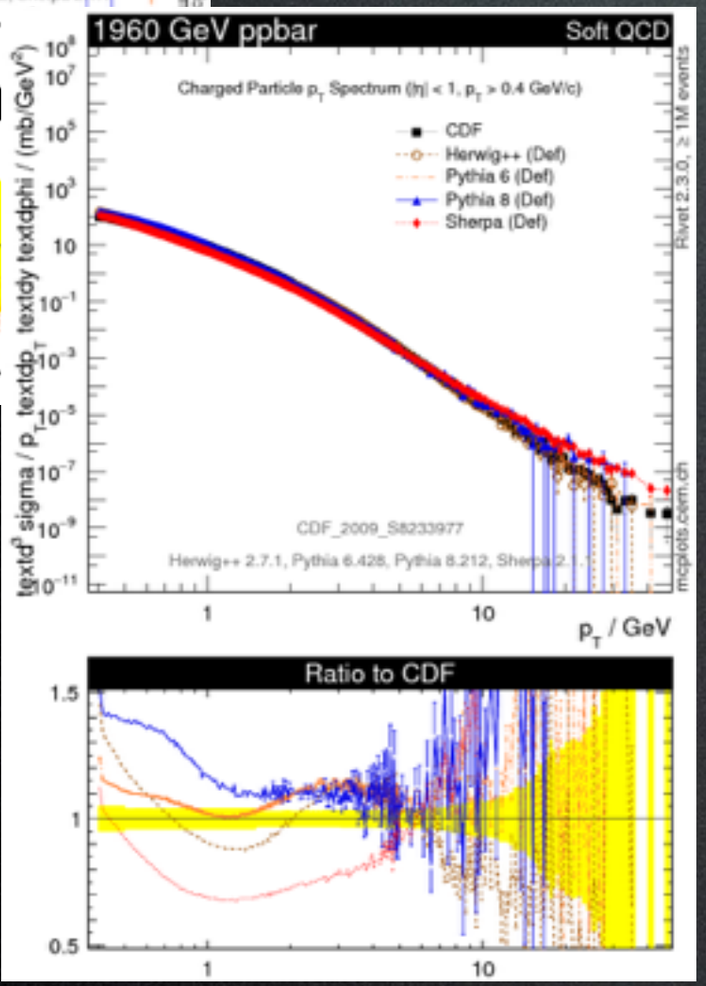
Then and Now

2010

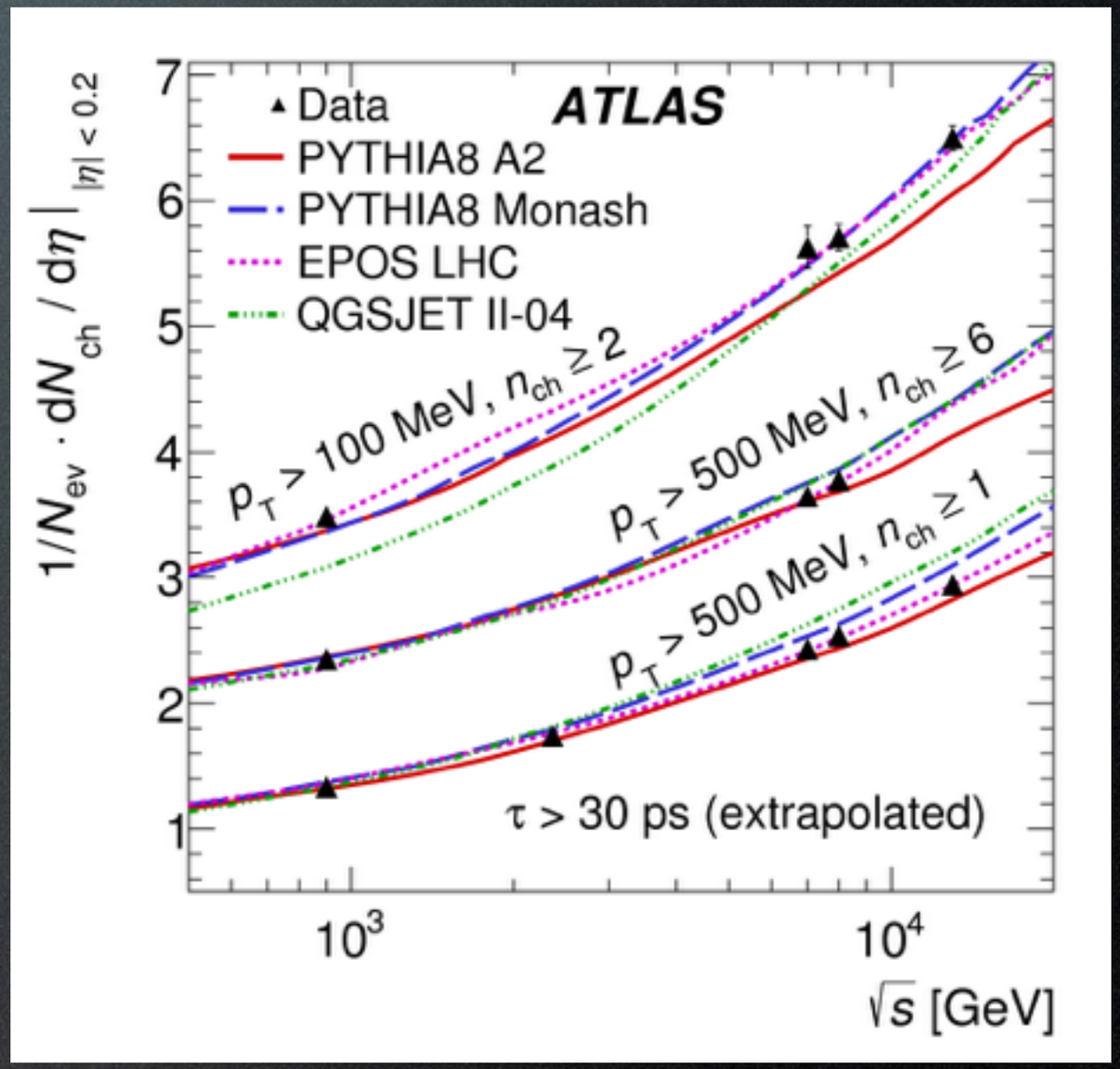
2016

Then and Now: MB



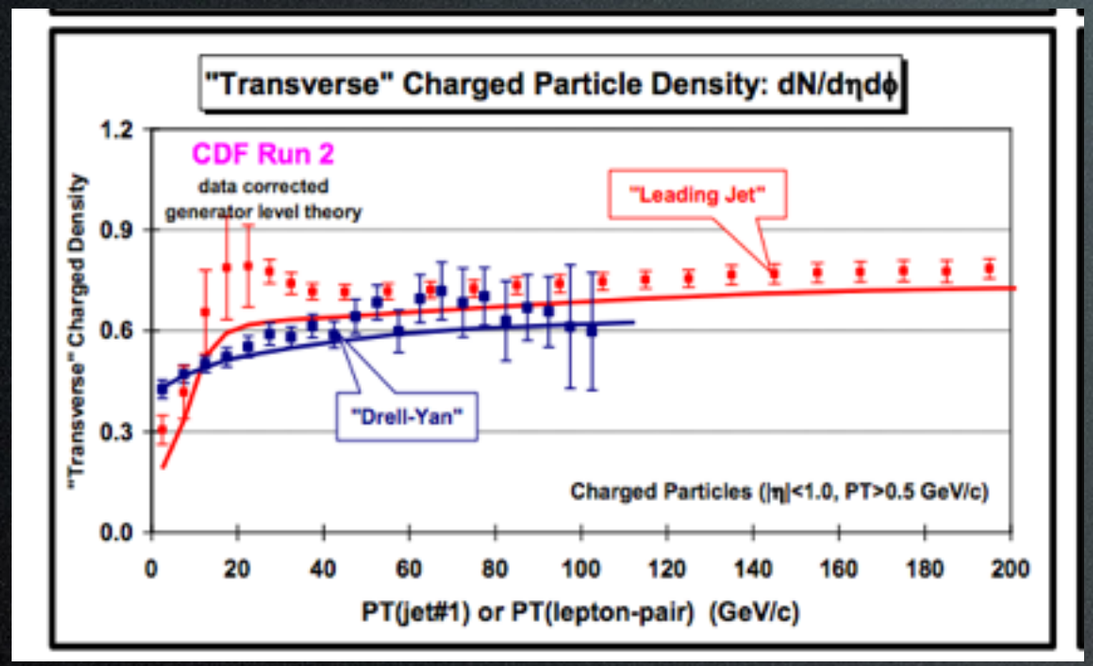


2010



2016

Then and Now: UE



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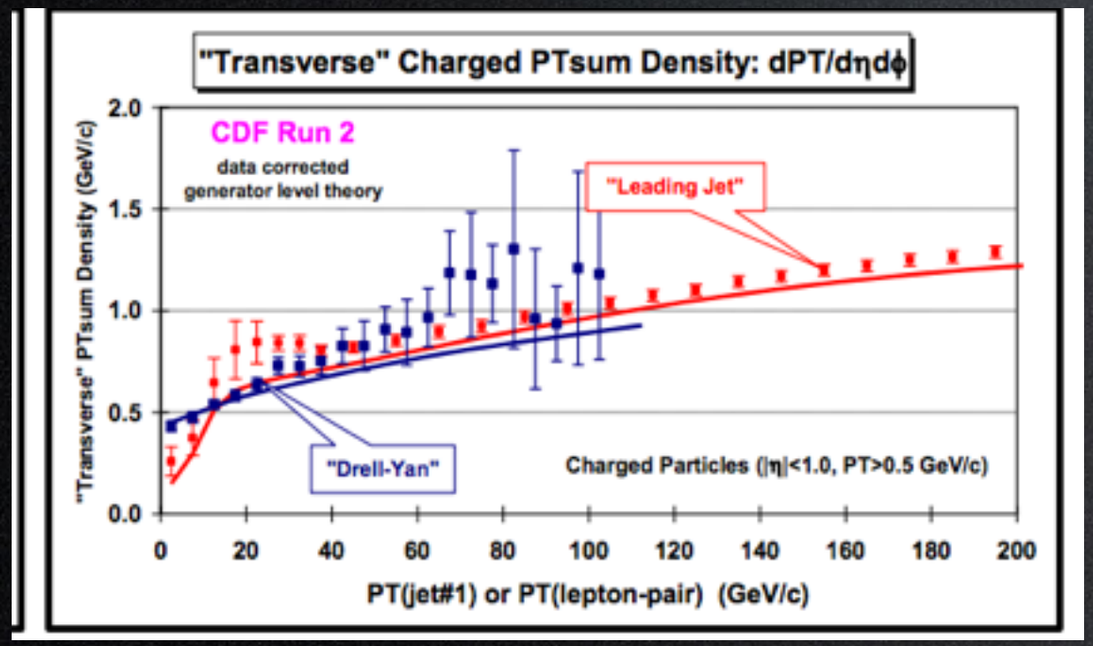
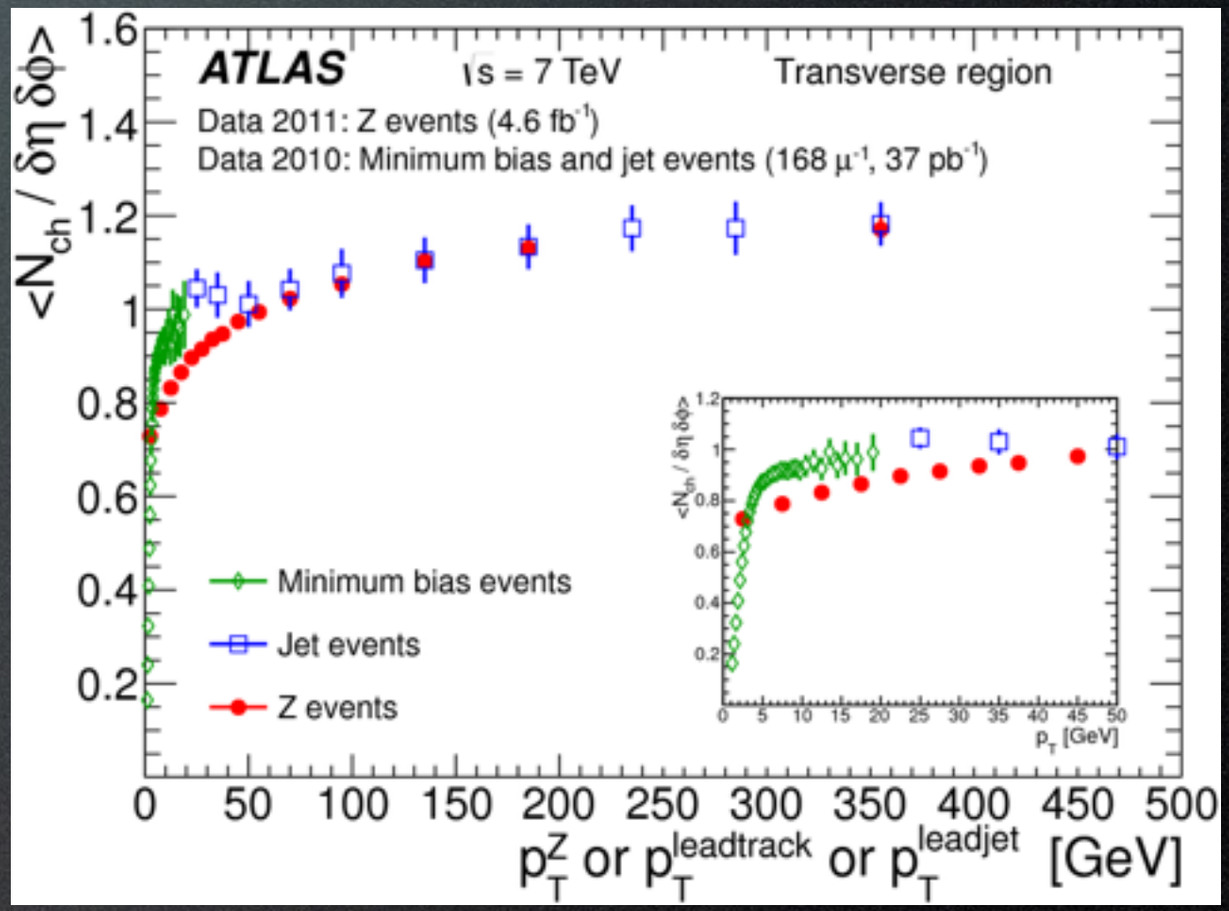


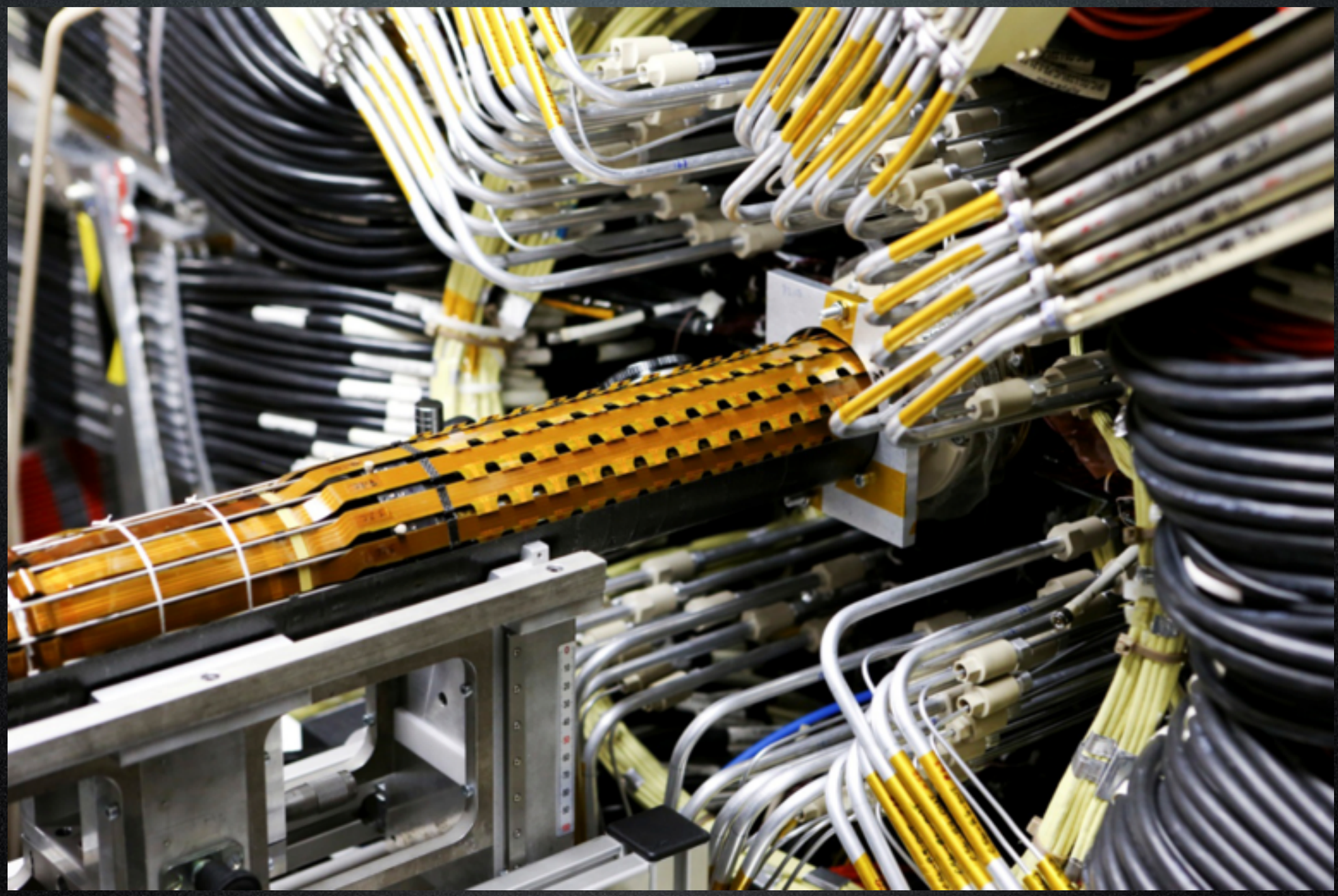


2016

At Tevatron

- Data-MC Discrepancy in MB tails
- UE modelled reasonably well
- UE activity in leading jet and Z-boson events seen to be similar

Minimum Bias



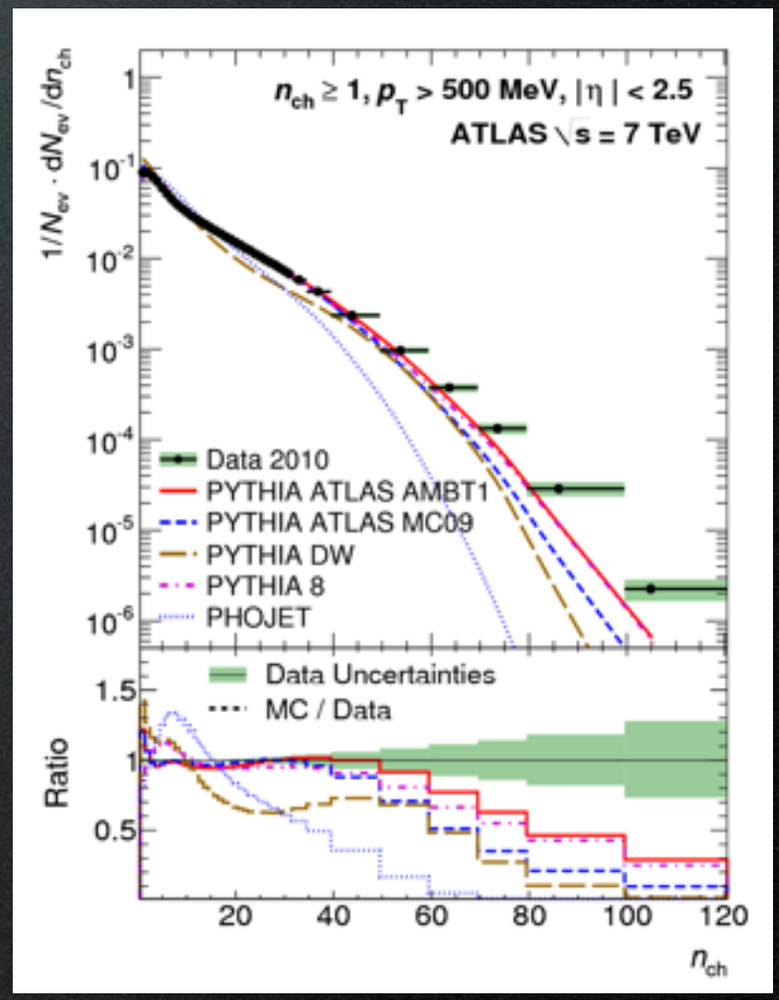
New IBL at ATLAS

Then Came the LHC (Run 1)

- Measurements at the beginning of Run 1 showed bad description of data by then-existing (mostly from Tevatron) Monte Carlo models and tunes

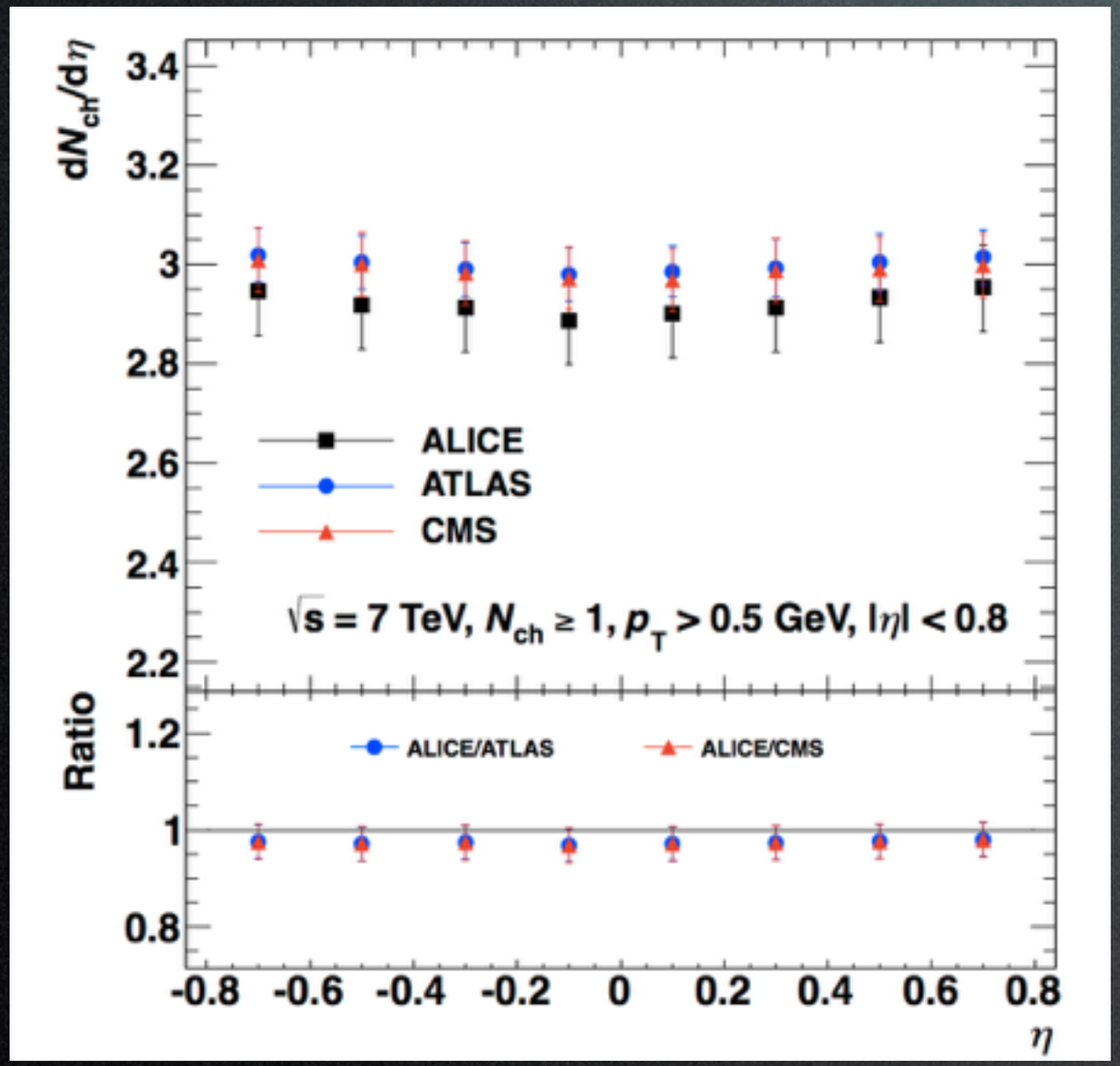
- Significant effort went in both theory and experimental communities to improve the modelling, using LHC Run 1 data

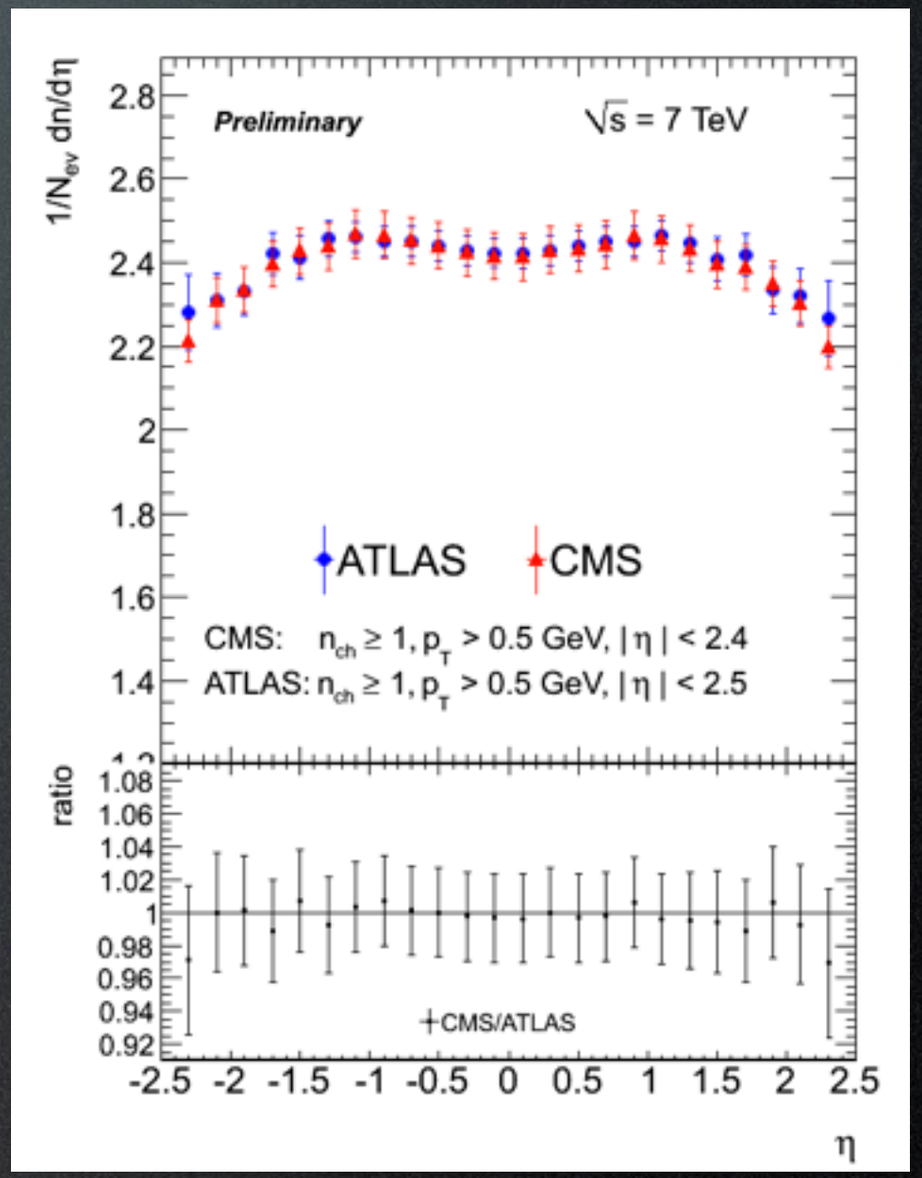
- Big question we had at the beginning of Run 2: can these models describe the 13 TeV data?



New J. Phys. 13 (2011) 053033

Experiments Agreed!

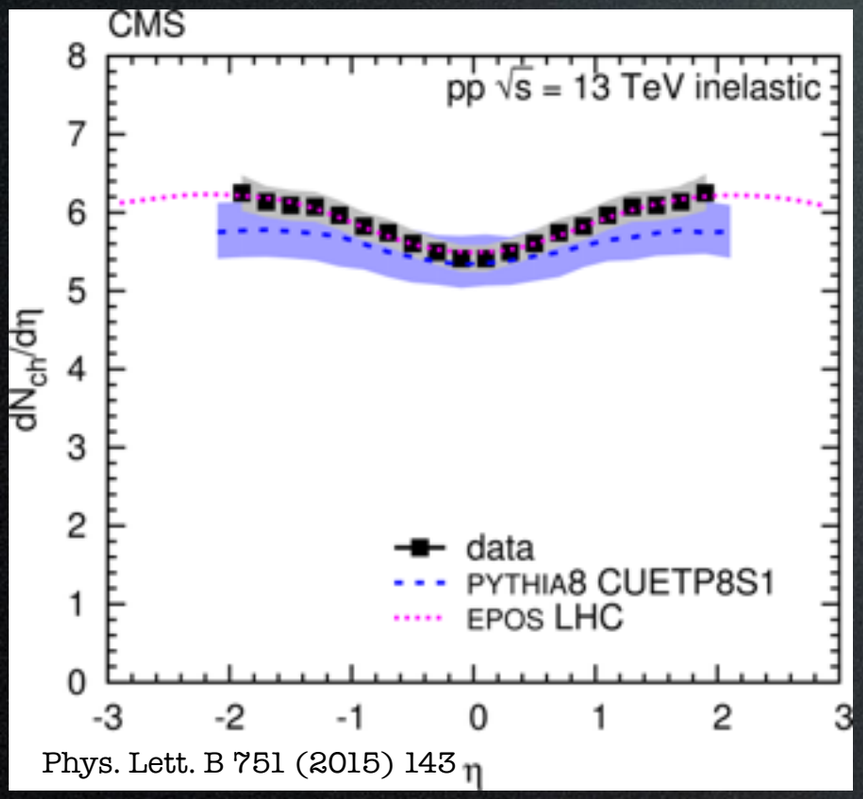




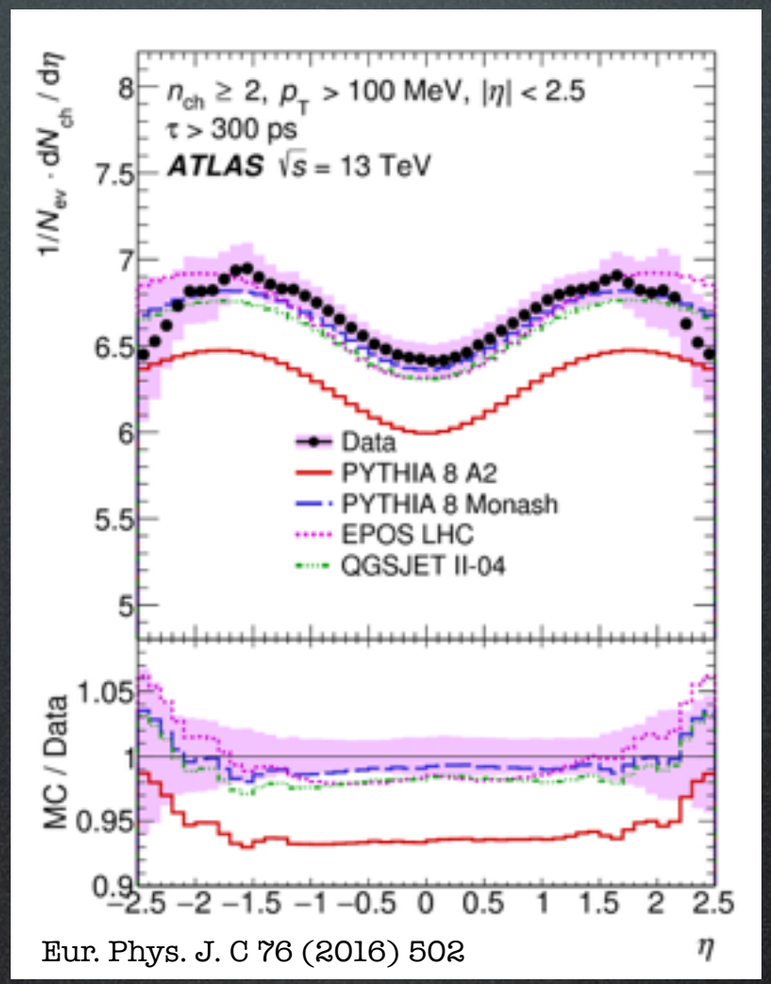
LPCC MB&UE WG

Run 2

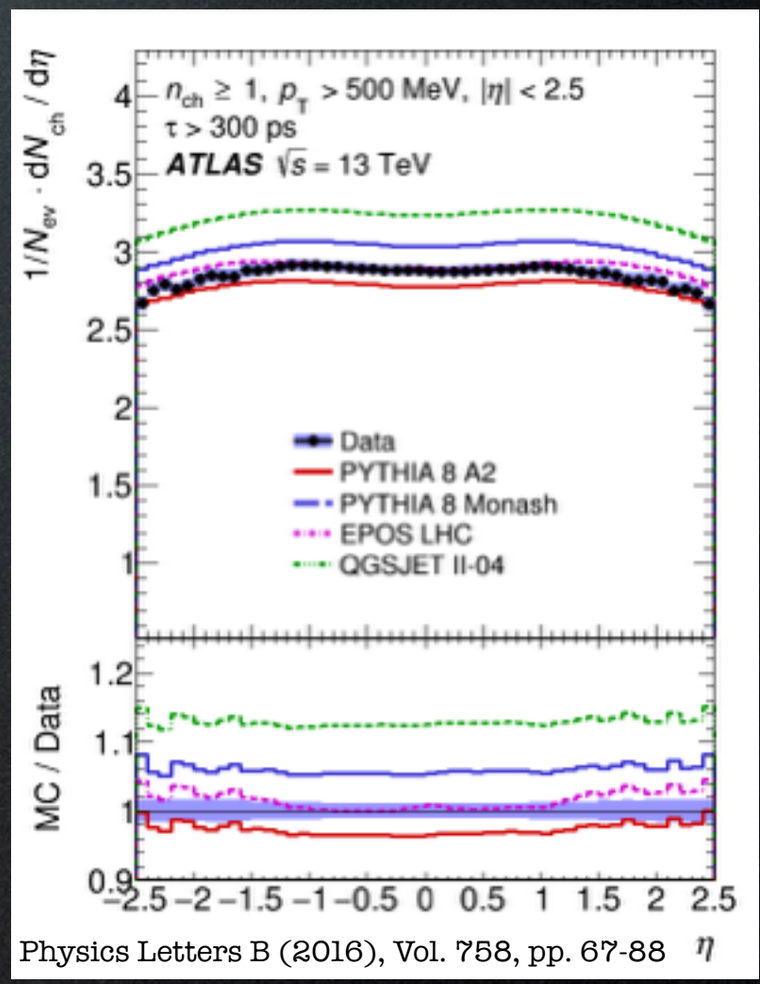
Higher transverse momentum threshold



Phys. Lett. B 751 (2015) 143



Eur. Phys. J. C 76 (2016) 502

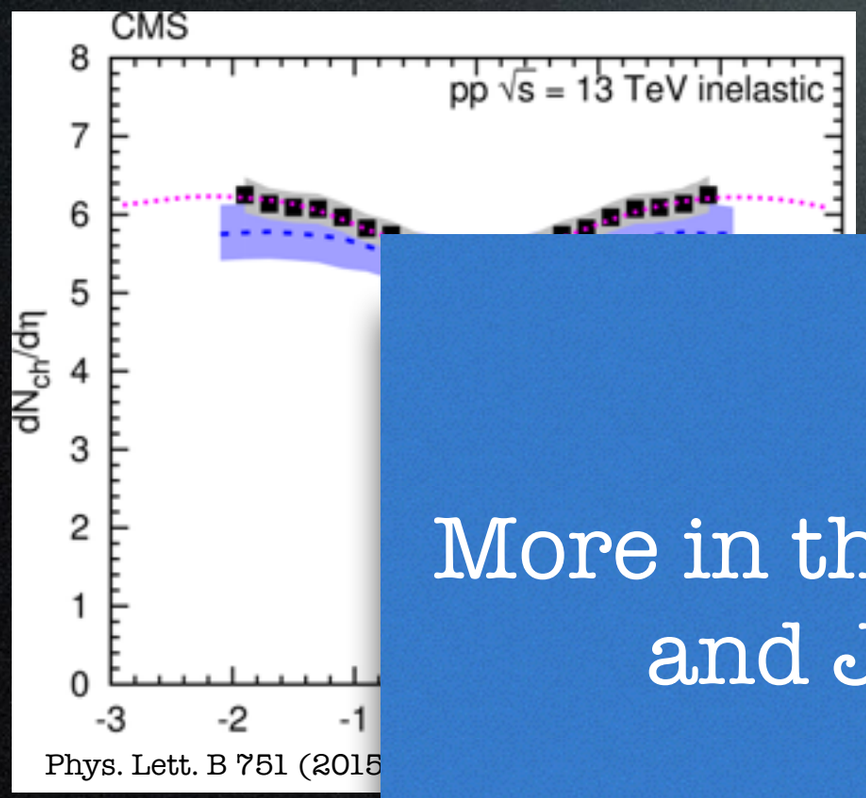


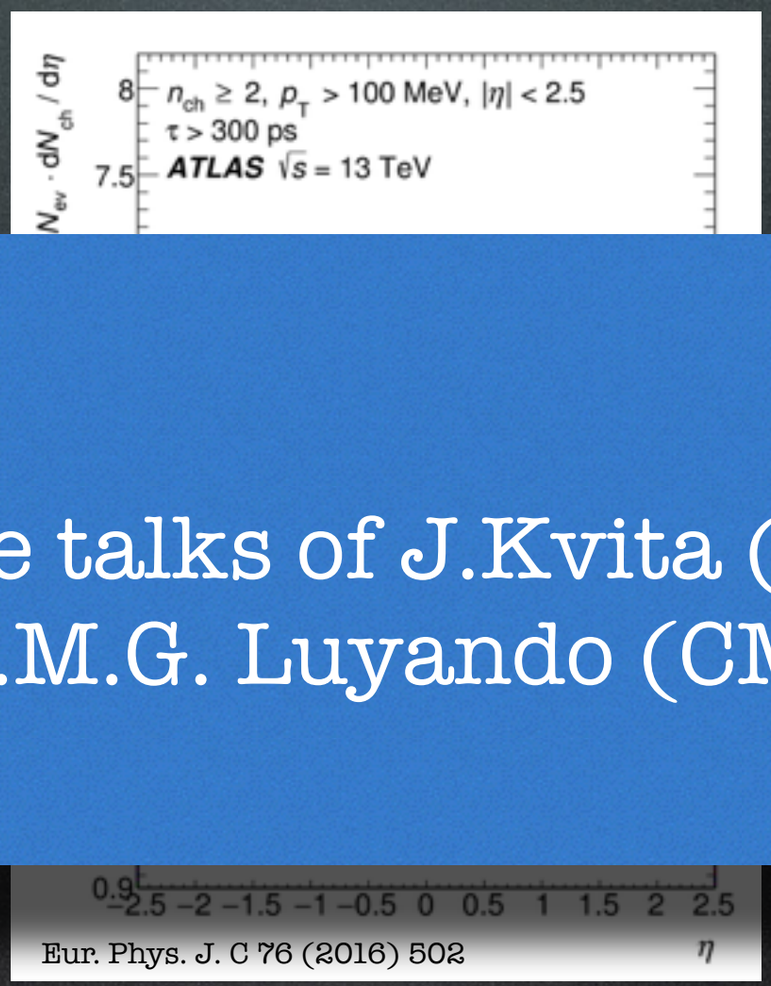
Physics Letters B (2016), Vol. 758, pp. 67-88

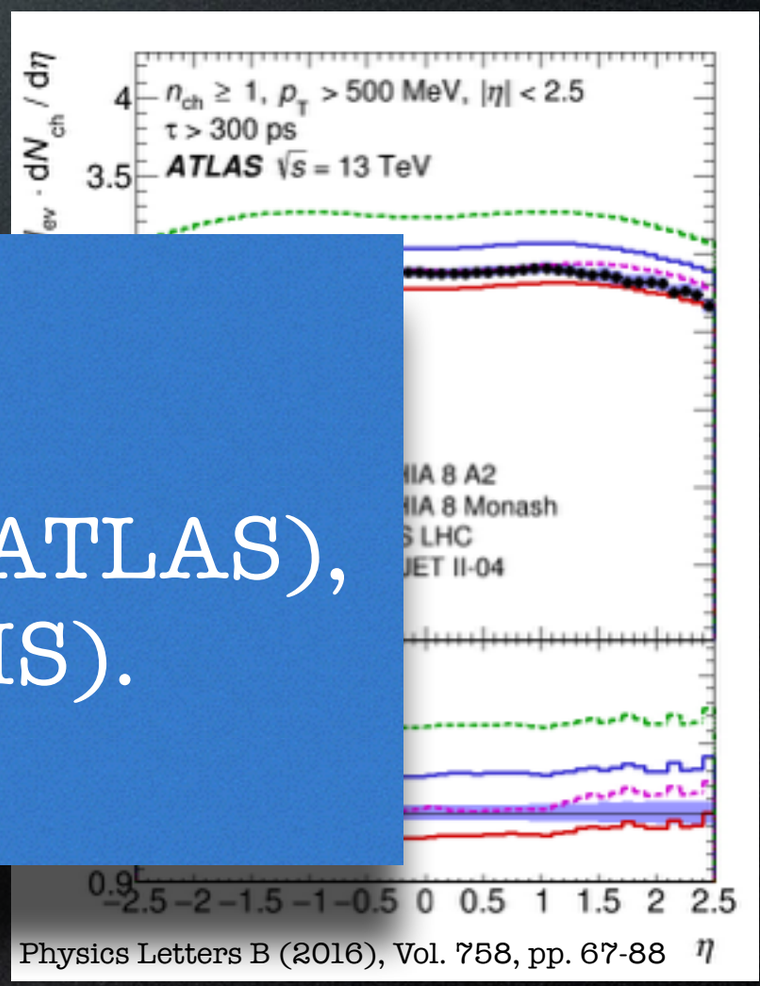
Measurements at different phase spaces, no catastrophe!
(but many interesting observations ...)

Run 2

Higher transverse momentum threshold





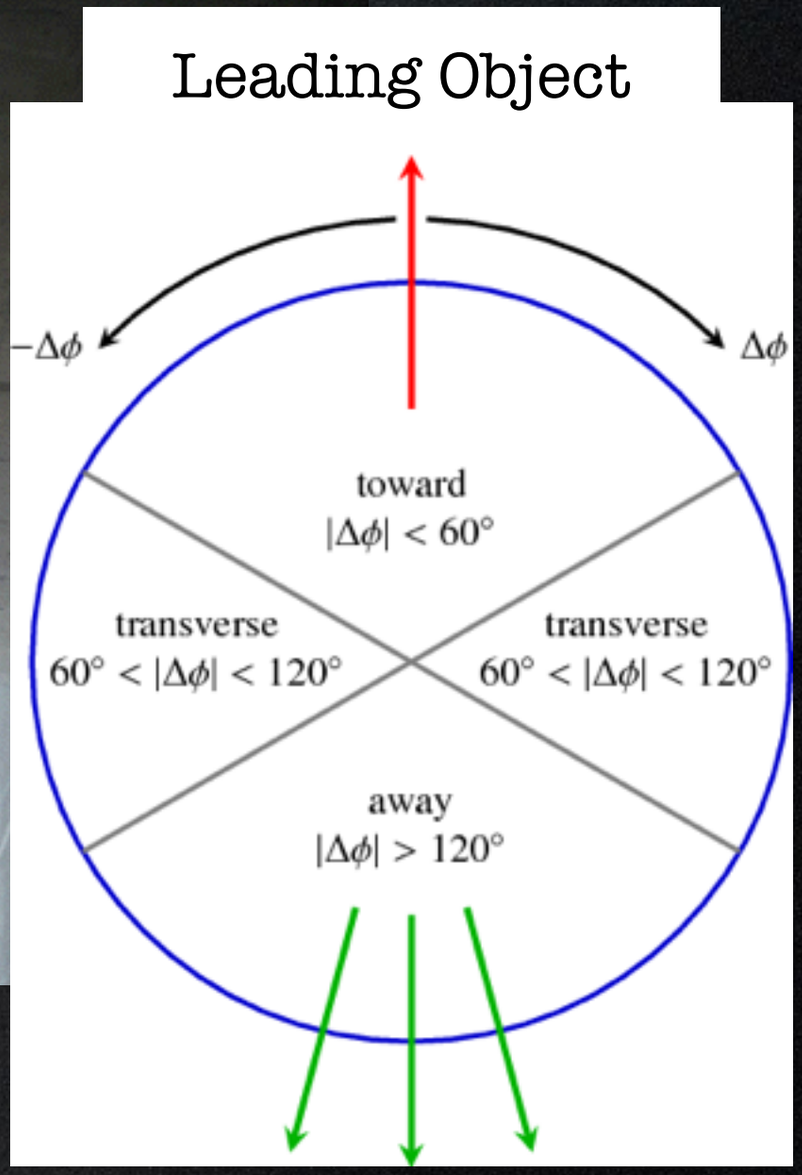


More in the talks of J.Kvita (ATLAS), and J.M.G. Luyando (CMS).

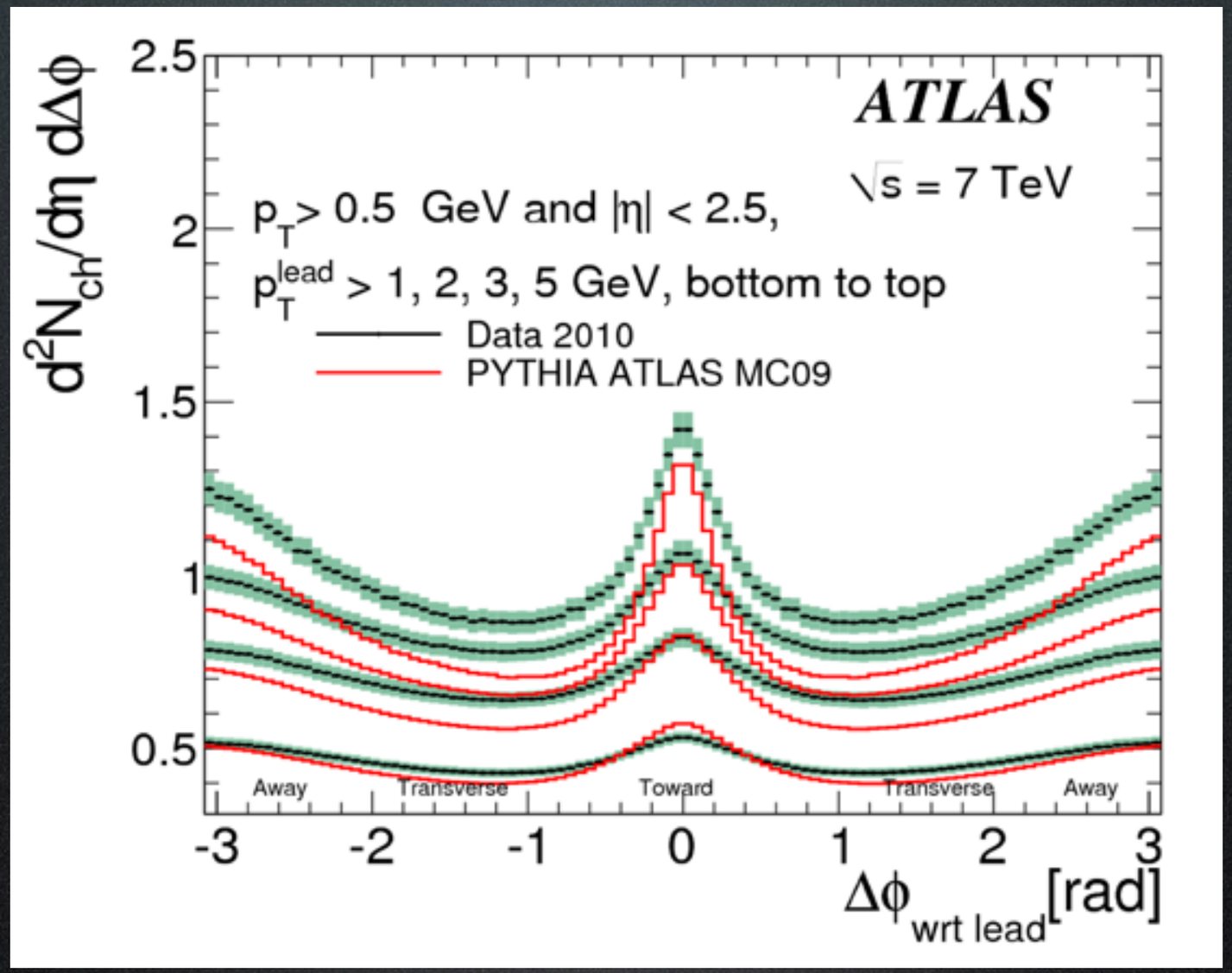
Measurements at different phase spaces, no catastrophe!
(but many interesting observations ...)

Underlying Event

Underlying Event



Then Came the LHC



Tevatron tunes did not agree with the early underlying event data

Run 1 UE Results

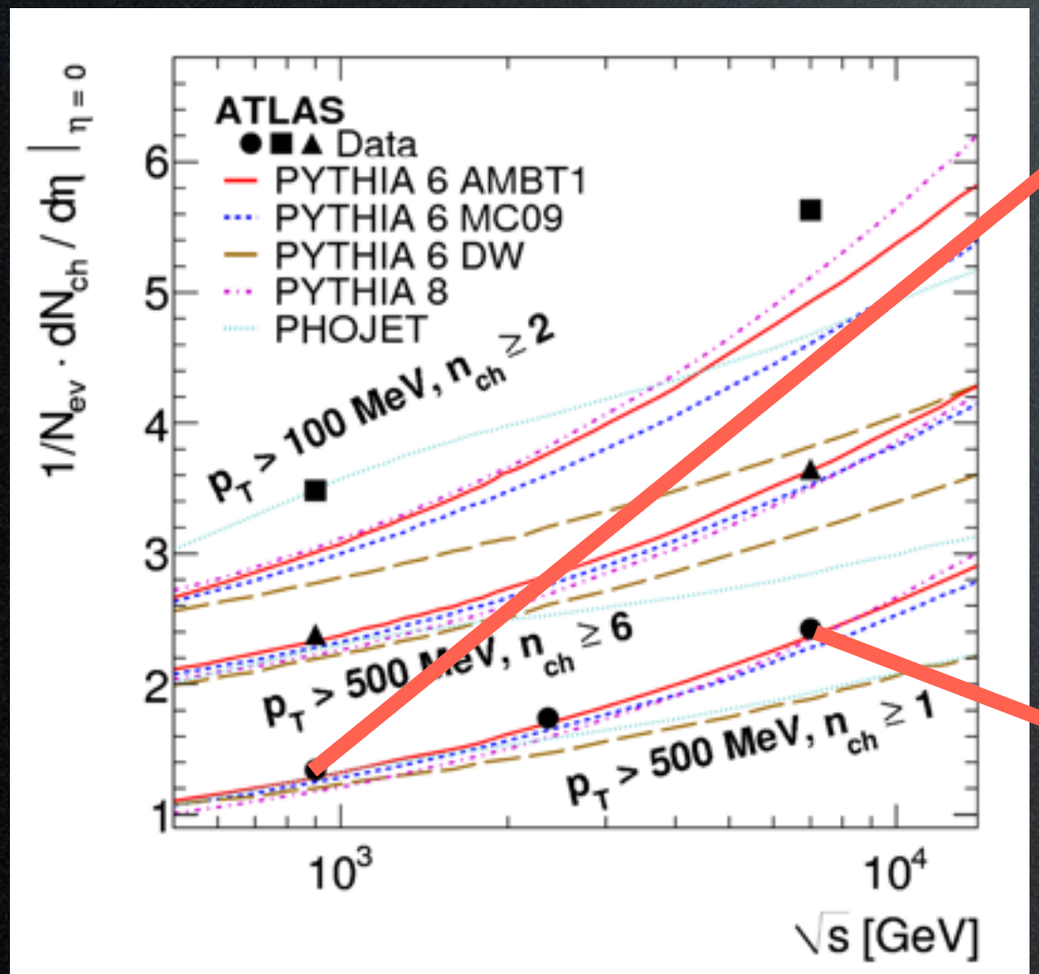
0.4 ->2.5

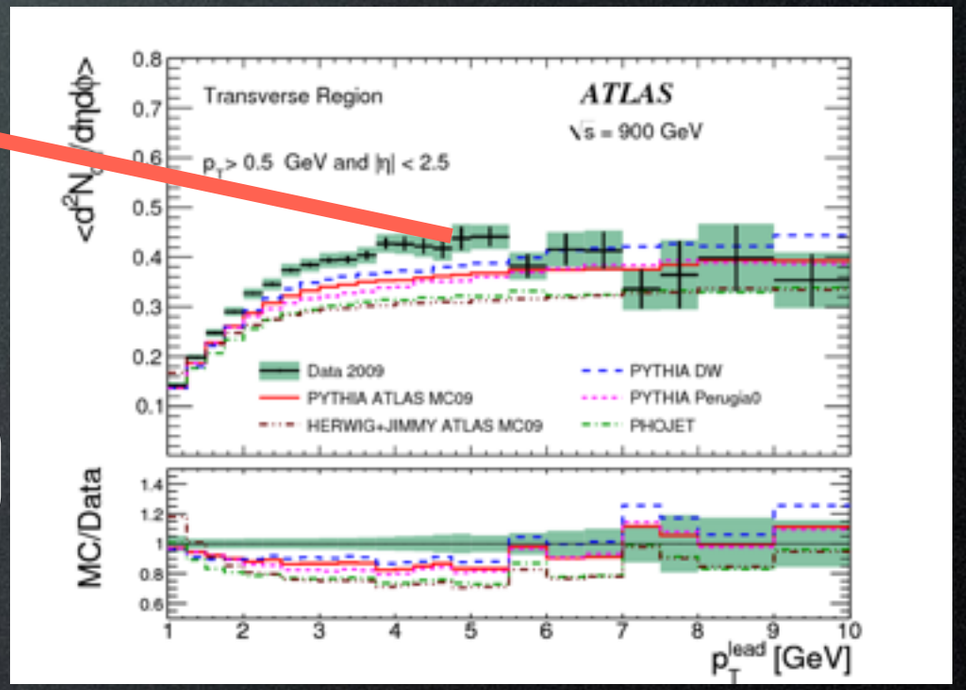
~1.3

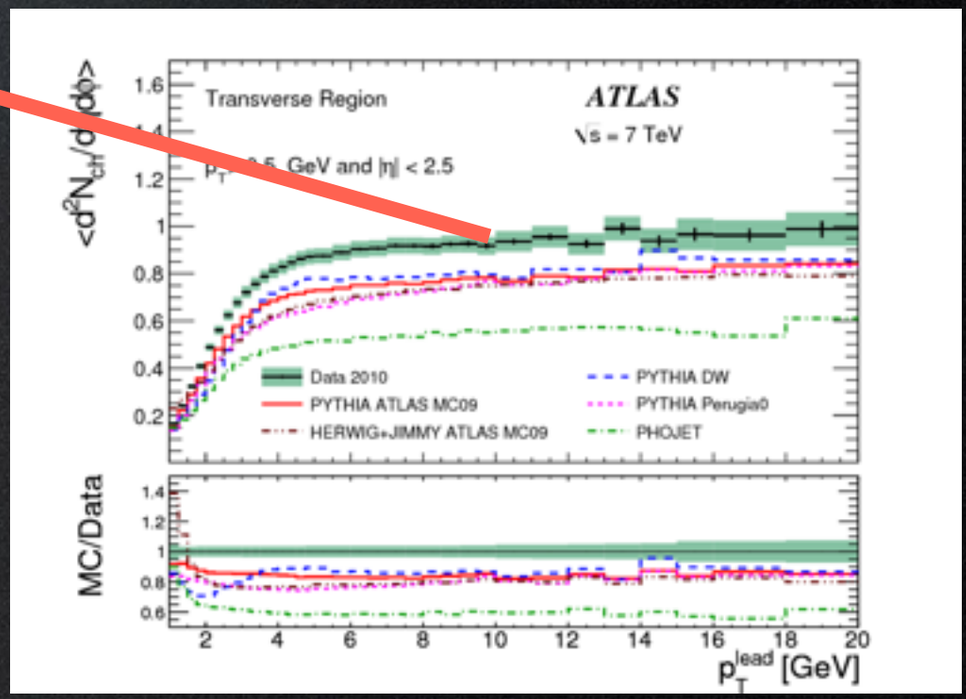
factor of 2!

0.8 -> 5

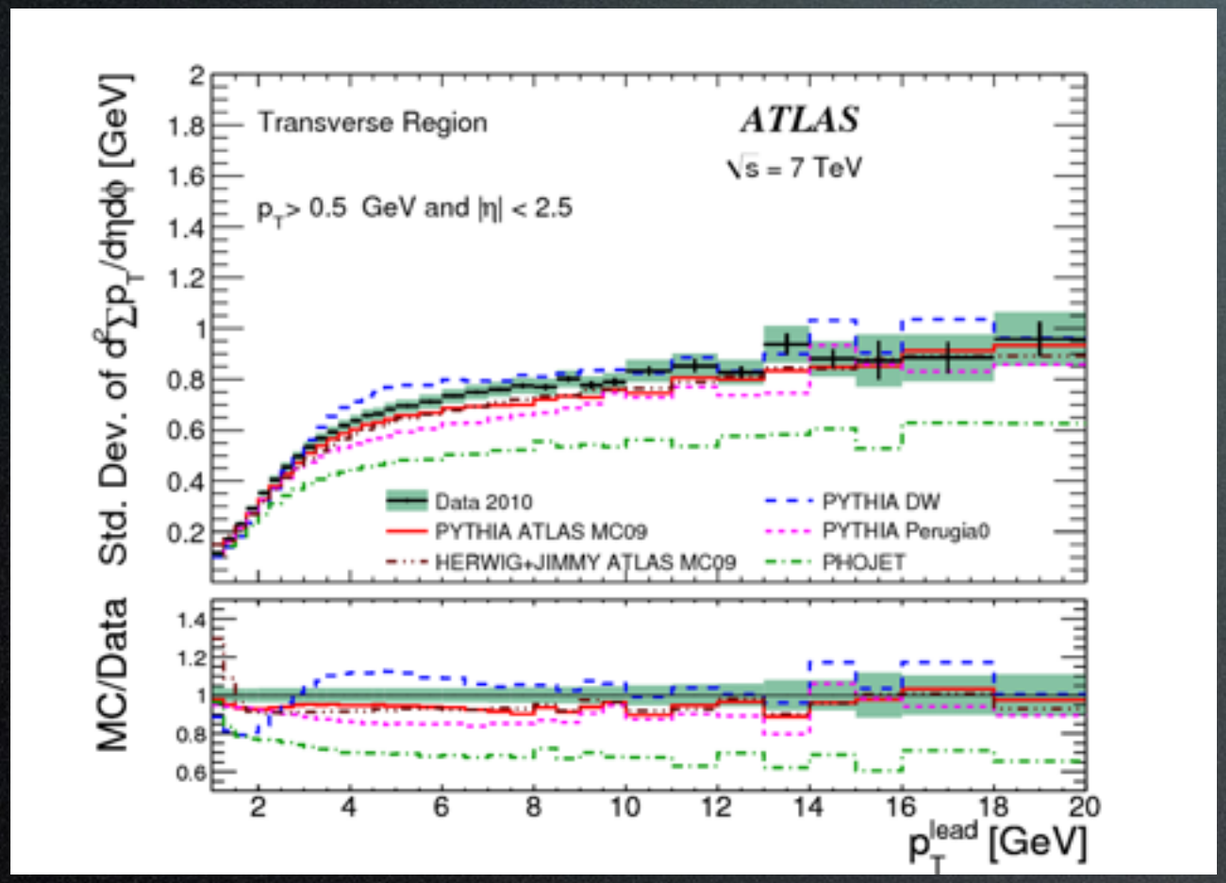
~2.4





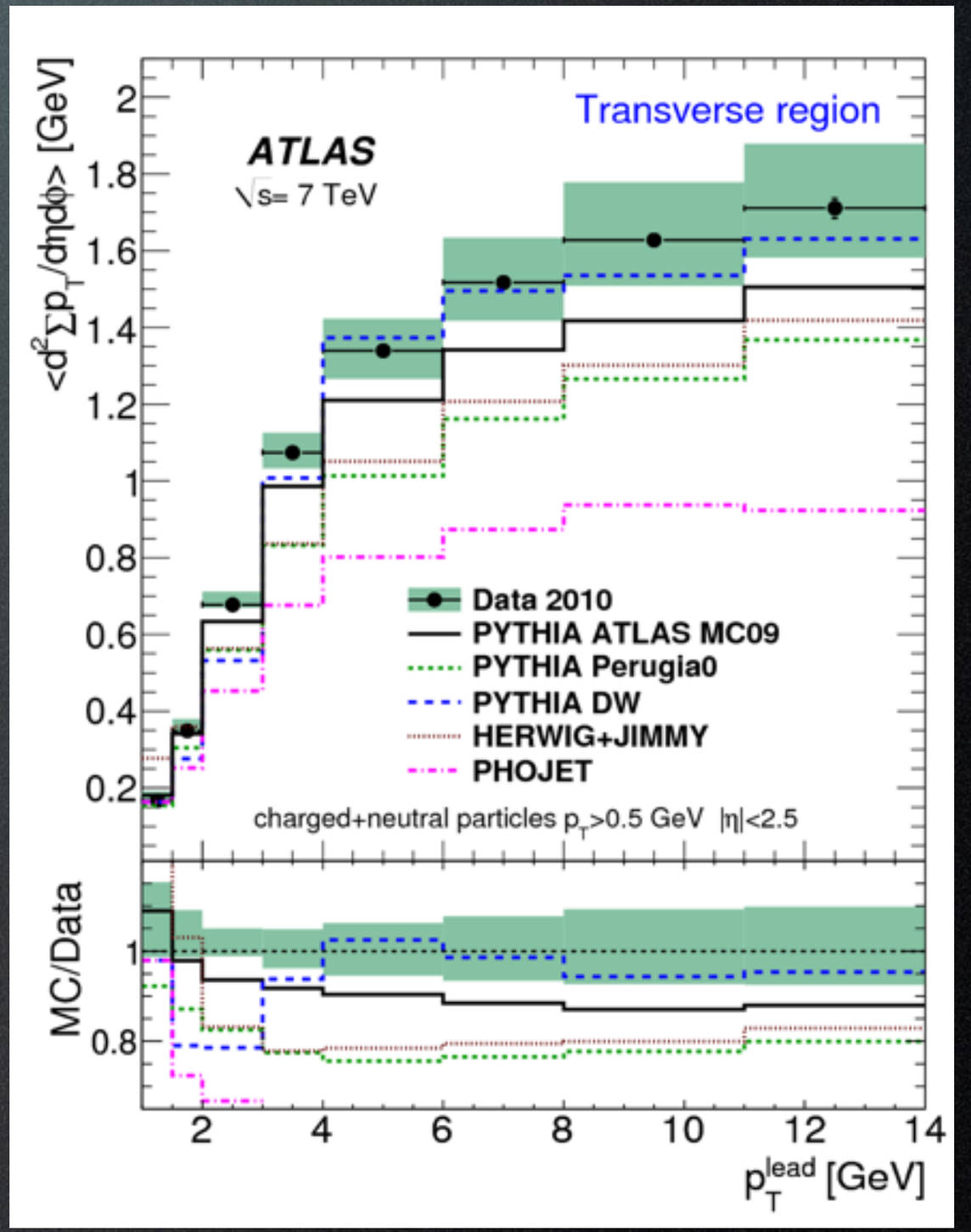


Run 1 UE Results

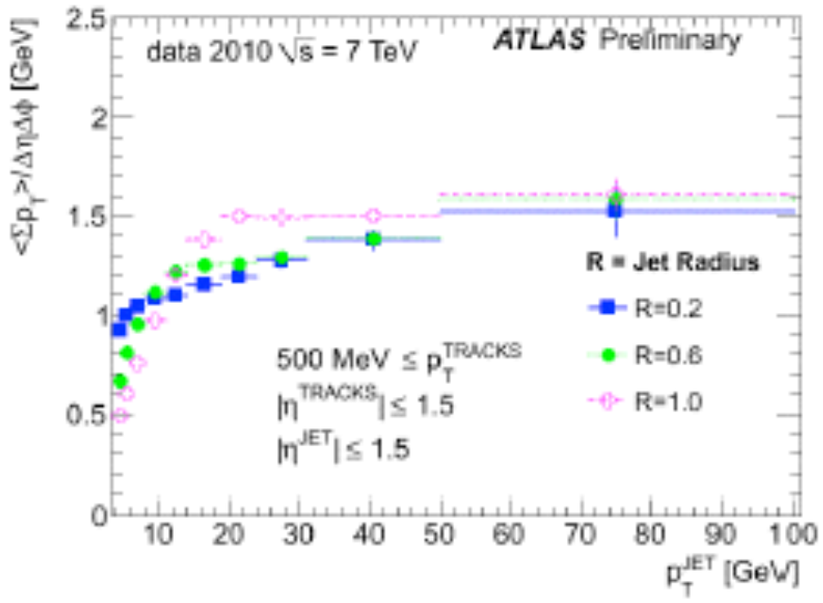


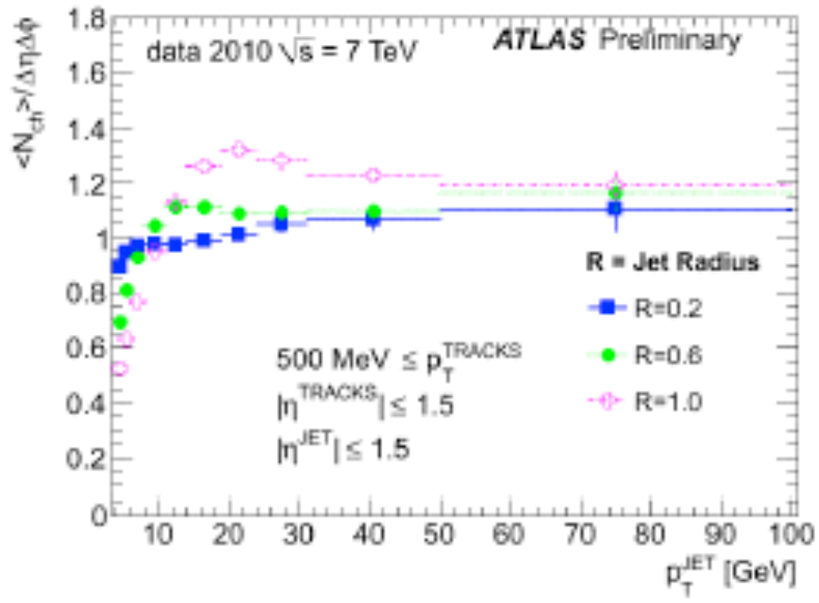
shows UE activity can not be subtracted as an average “pedestal” from each event.

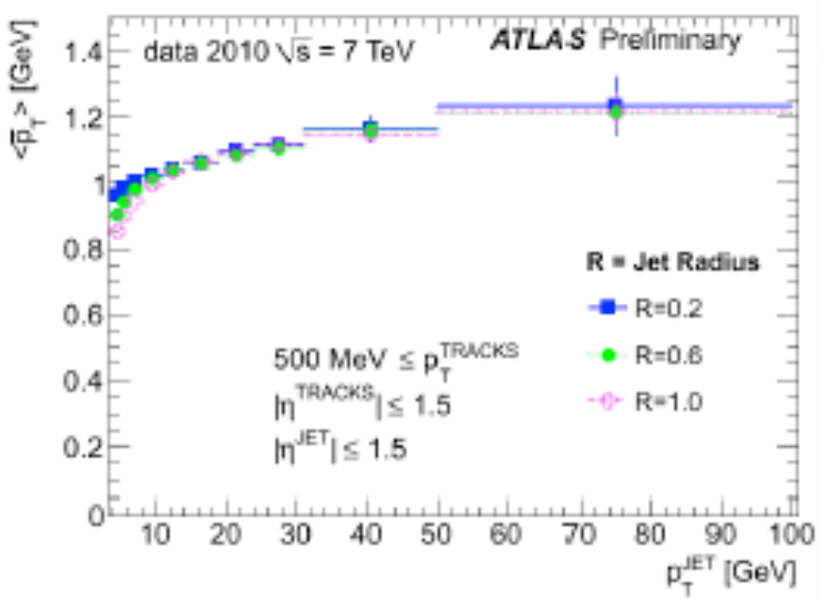
Sensitive to both charged and neutral component of UE.



Jet Radius Dependence

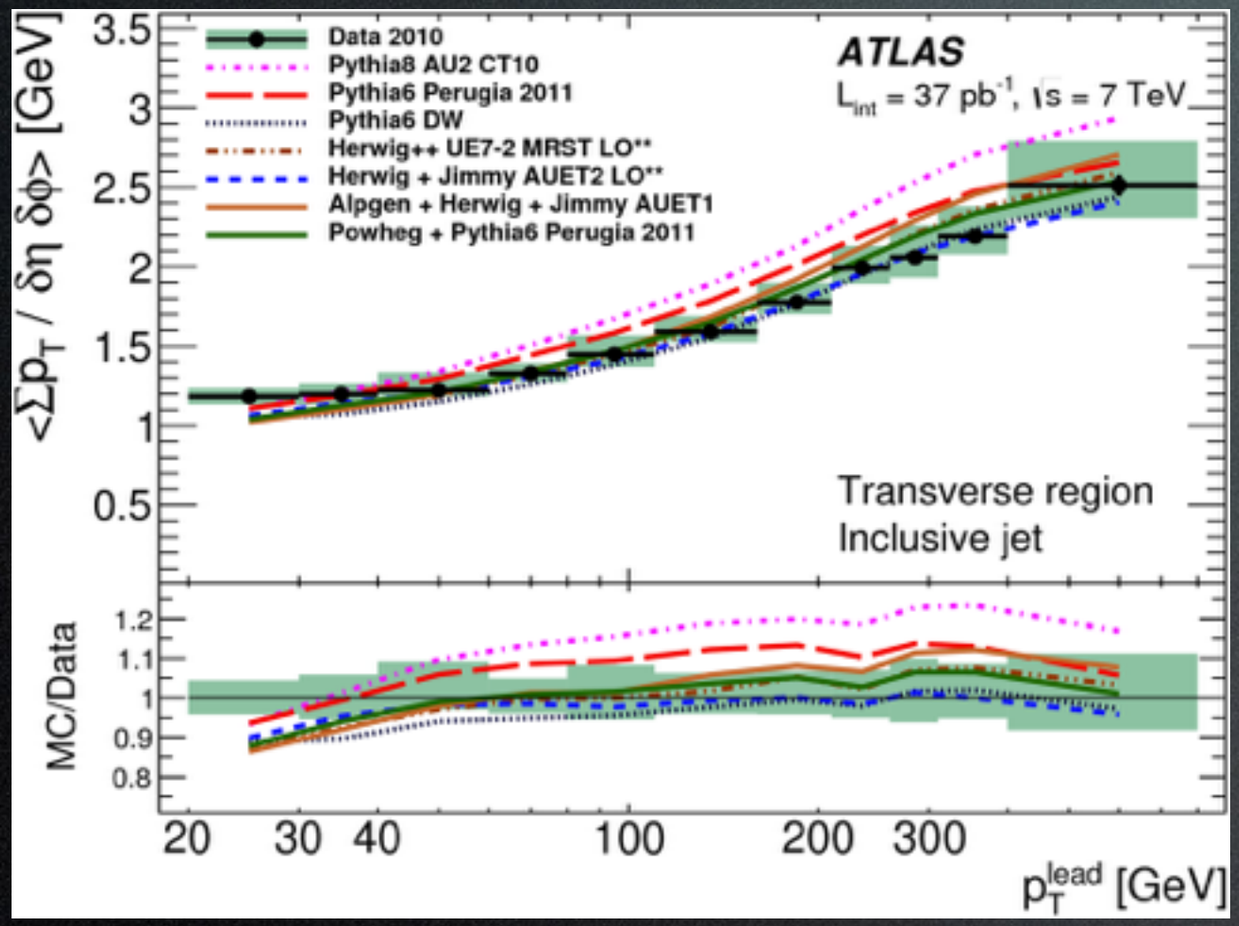


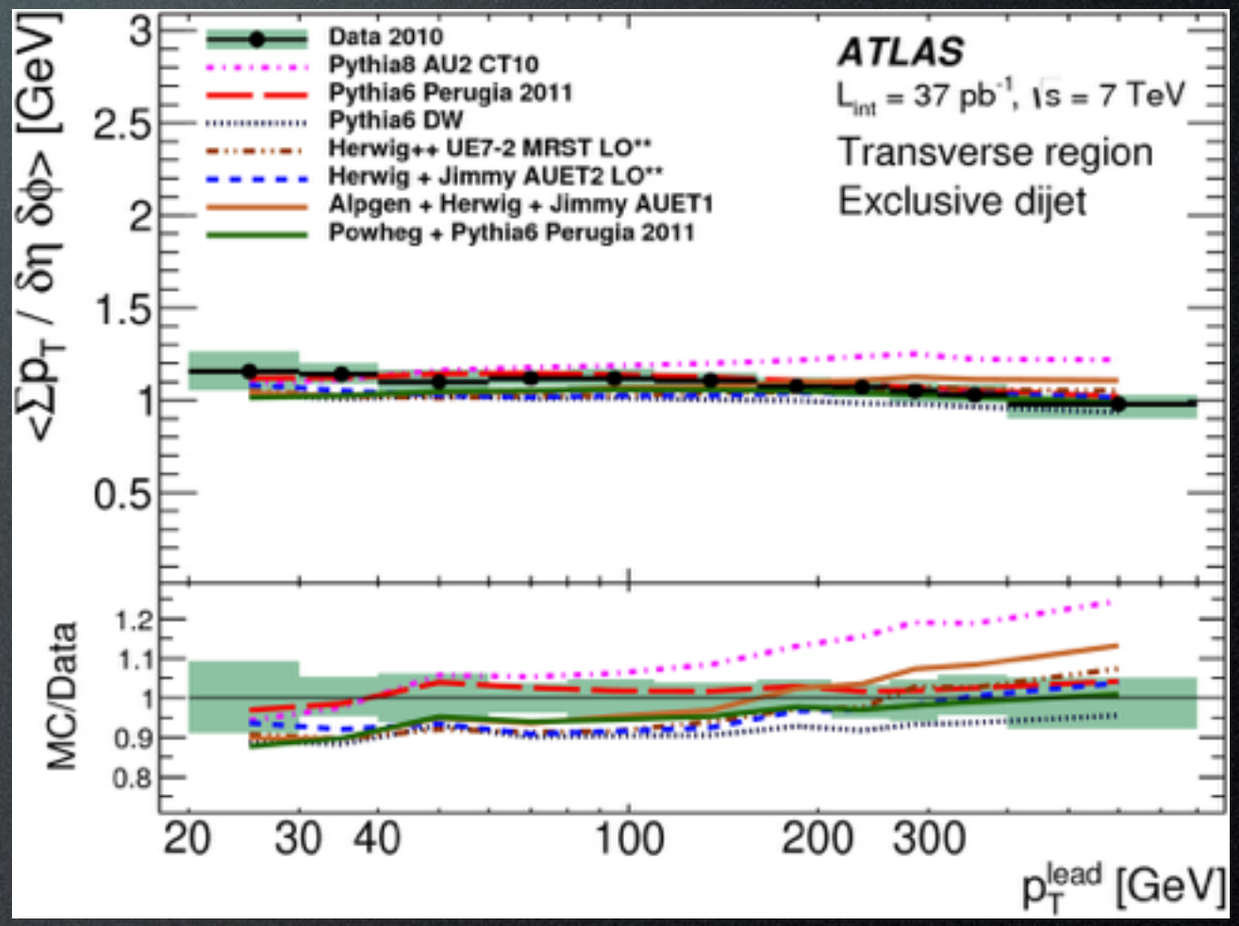




More UE activity for higher jet radius.
Why?

ATLAS Jet UE

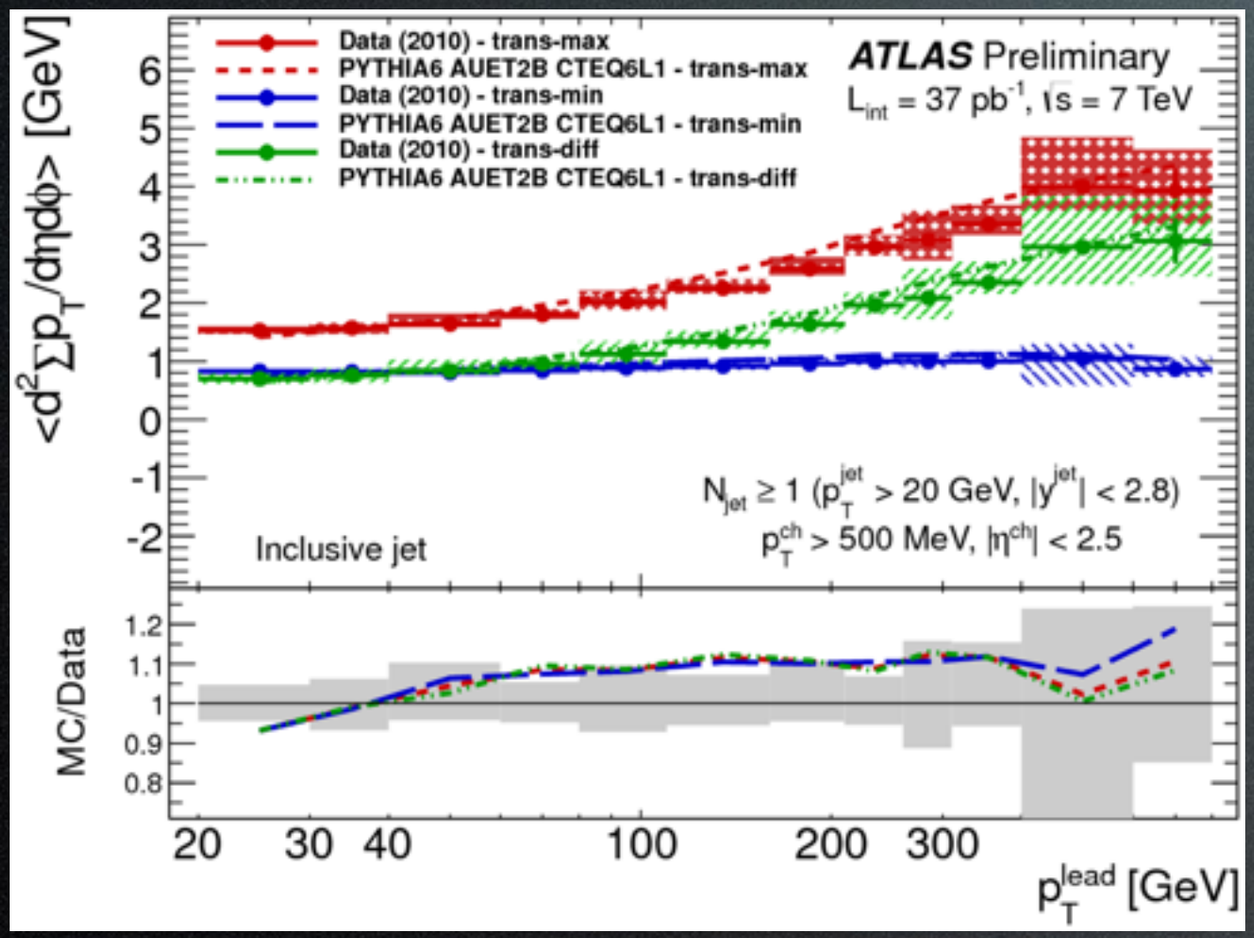


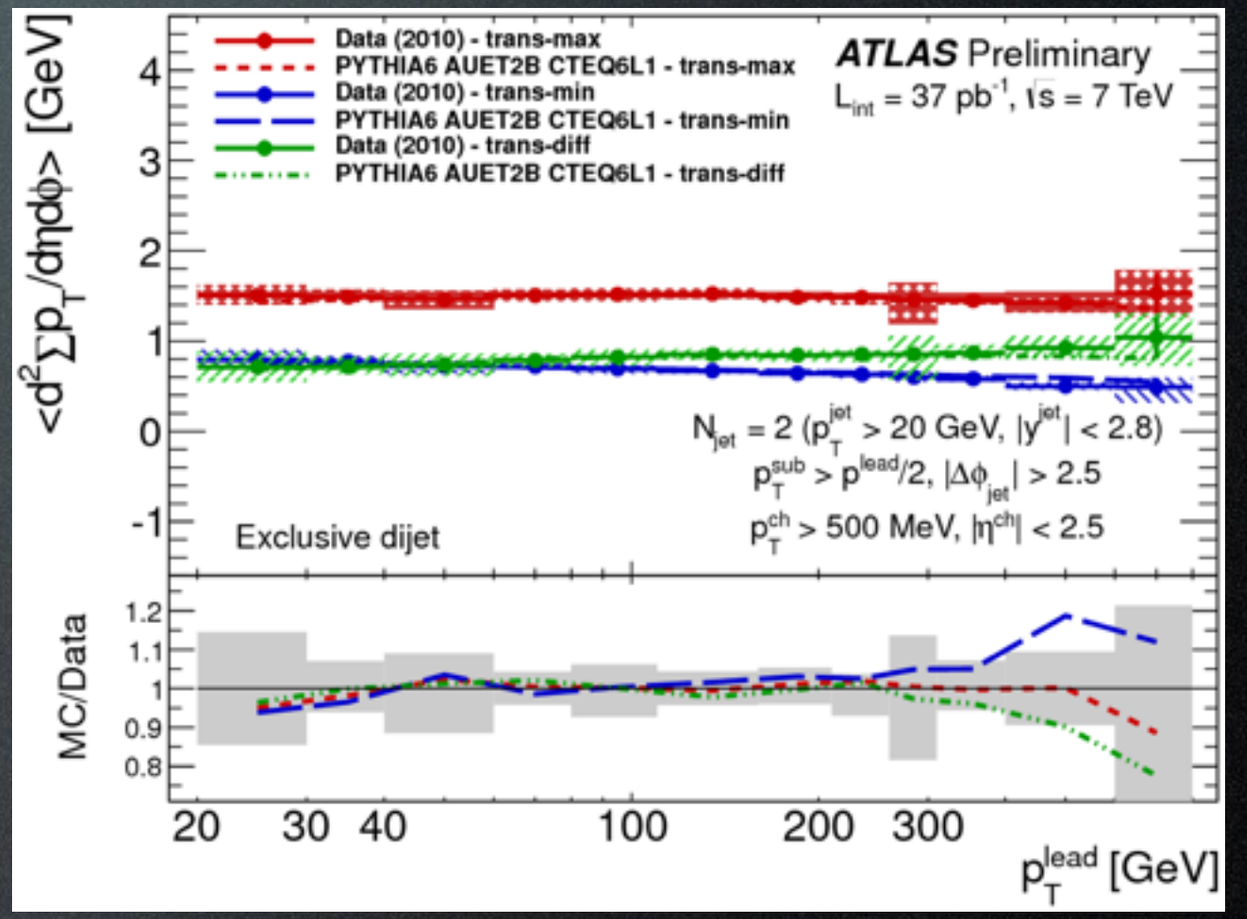


Rise in inclusive, almost flat in when requiring exactly 2 jets .
Models better describe exclusive profile.

arXiv:1406.0392 [hep-ex]

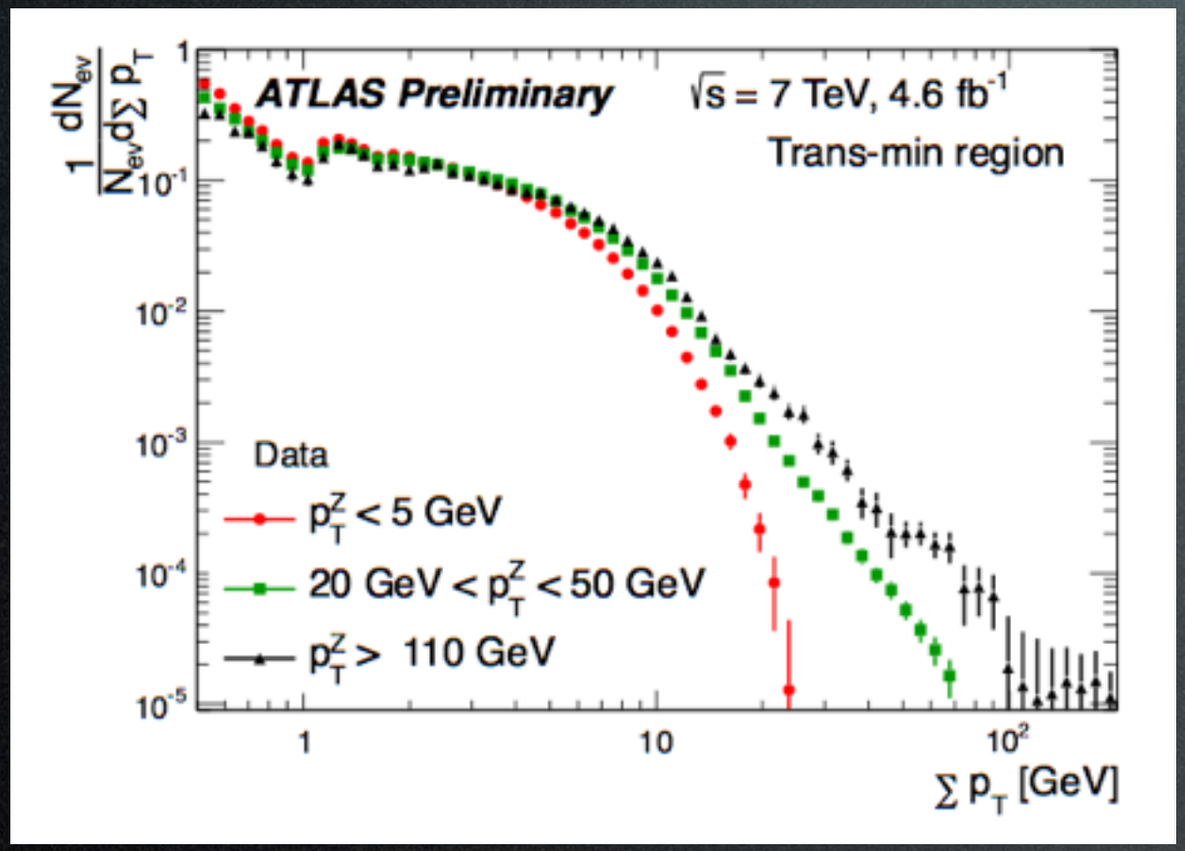
Transmax/min

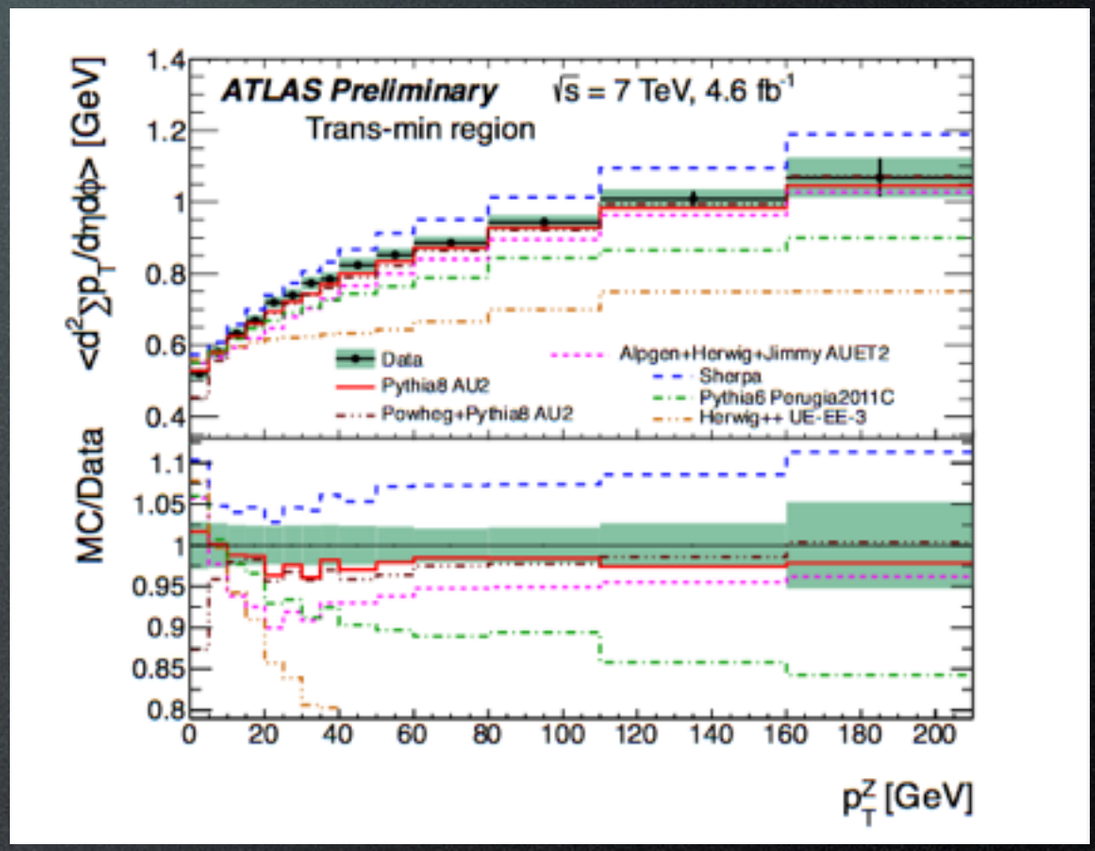




Max/min gets closer in exclusive

ATLAS Z UE

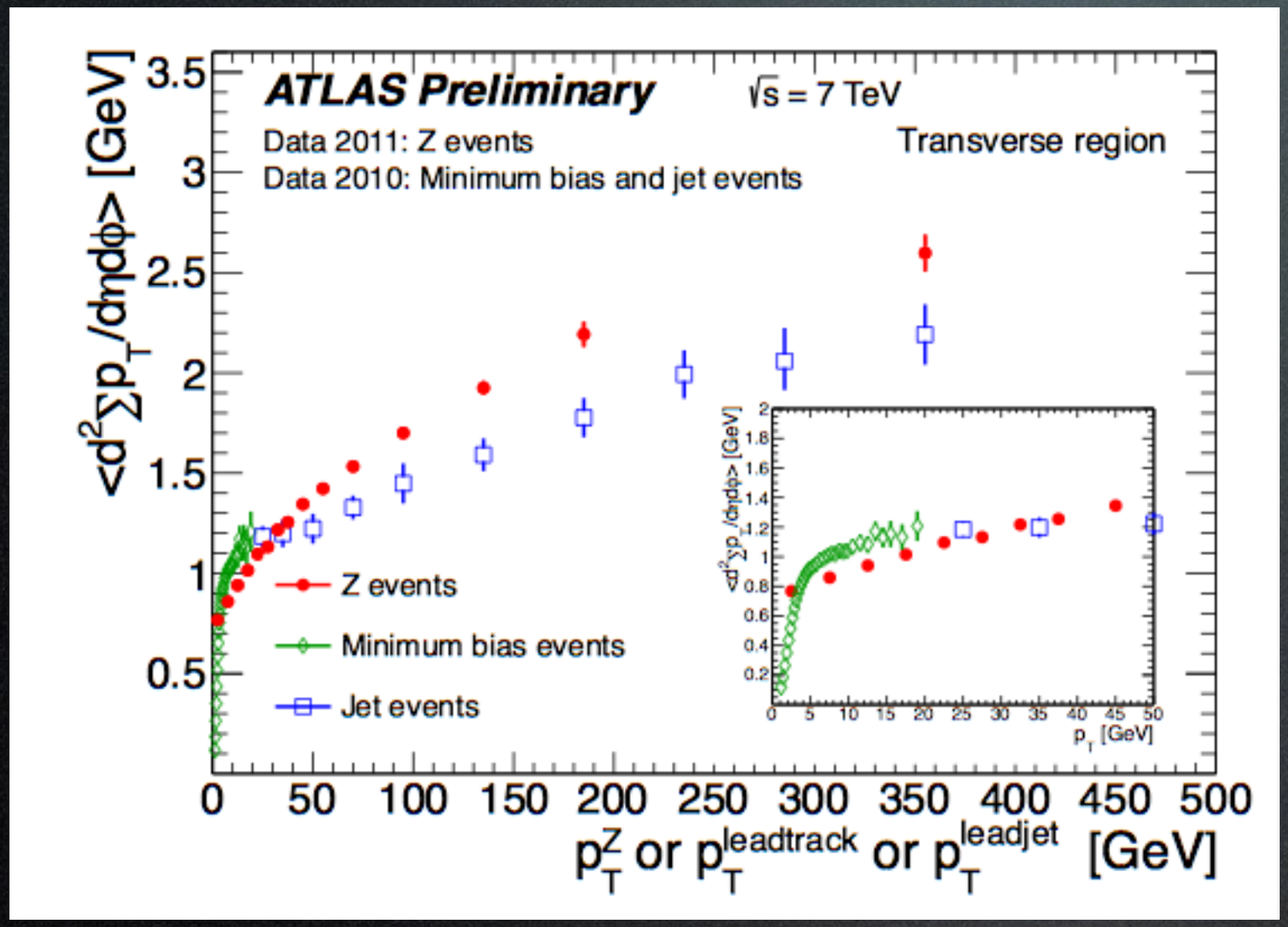


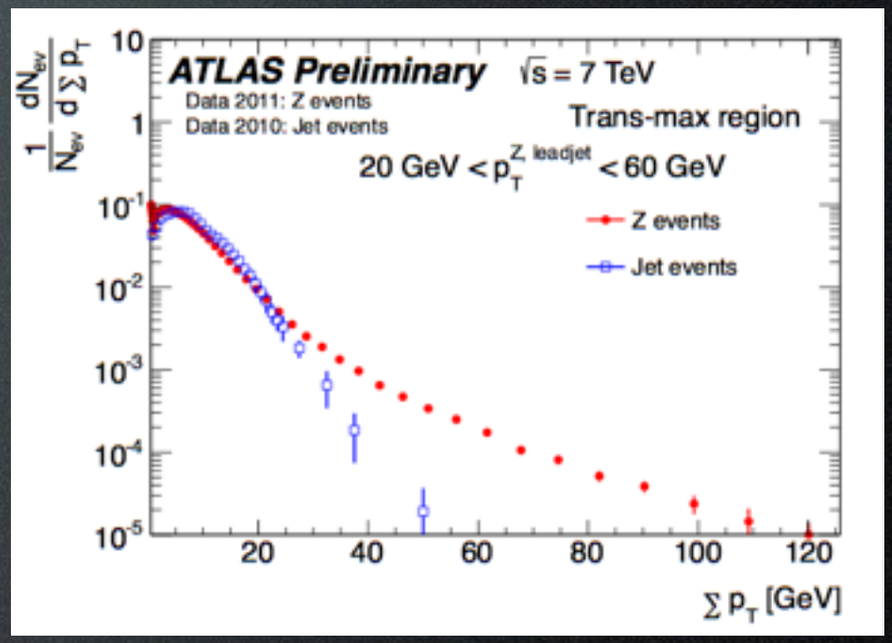


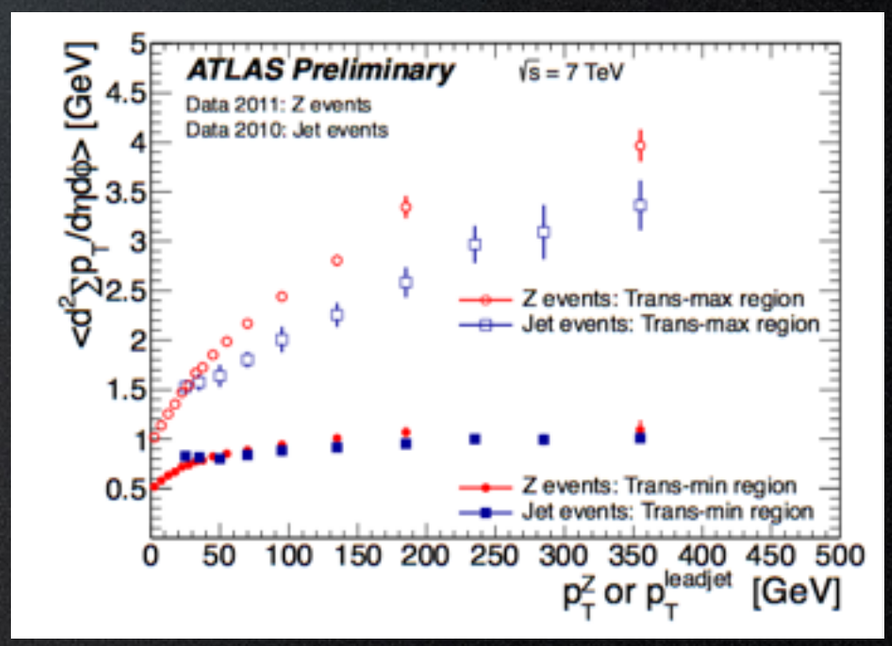
Transmin independent of Z p_T till about 10 GeV, profile best described by Pythia8 and Powheg+Pythia8

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

Z/Jet UE Comparison





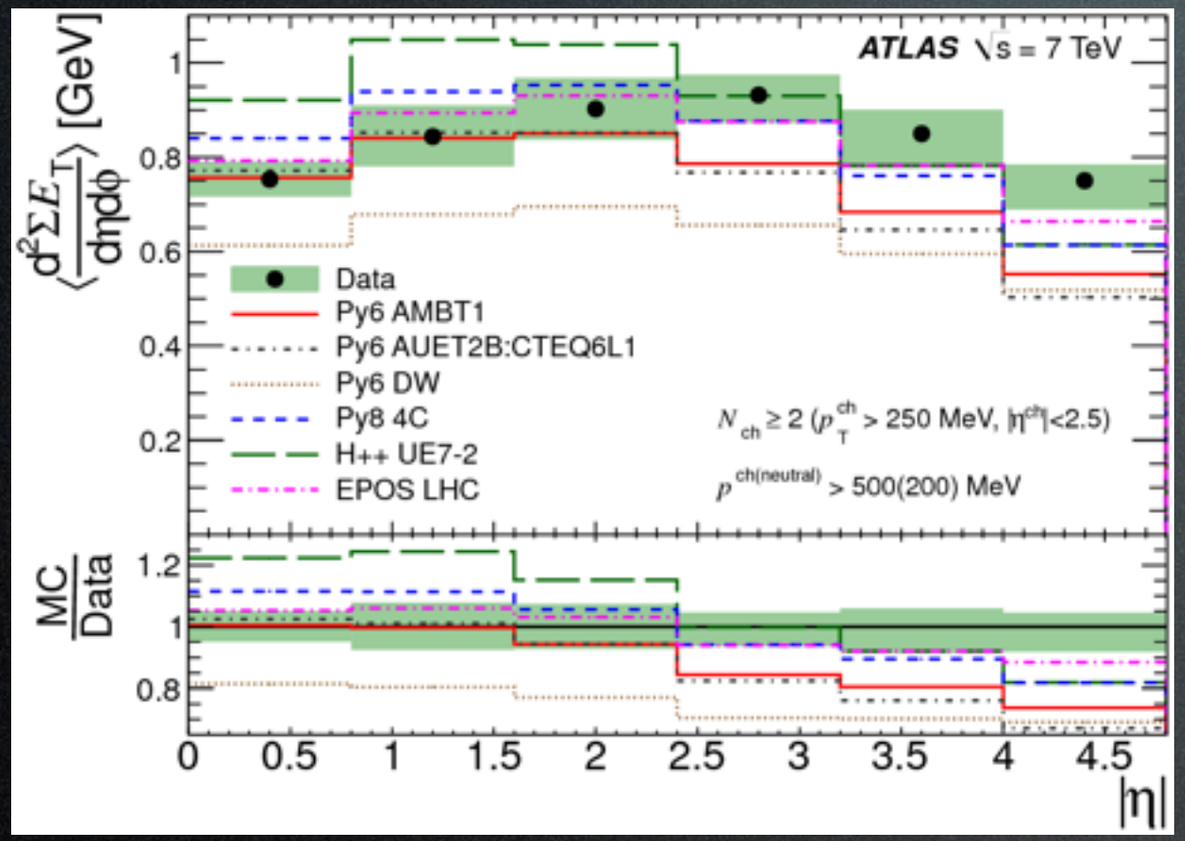


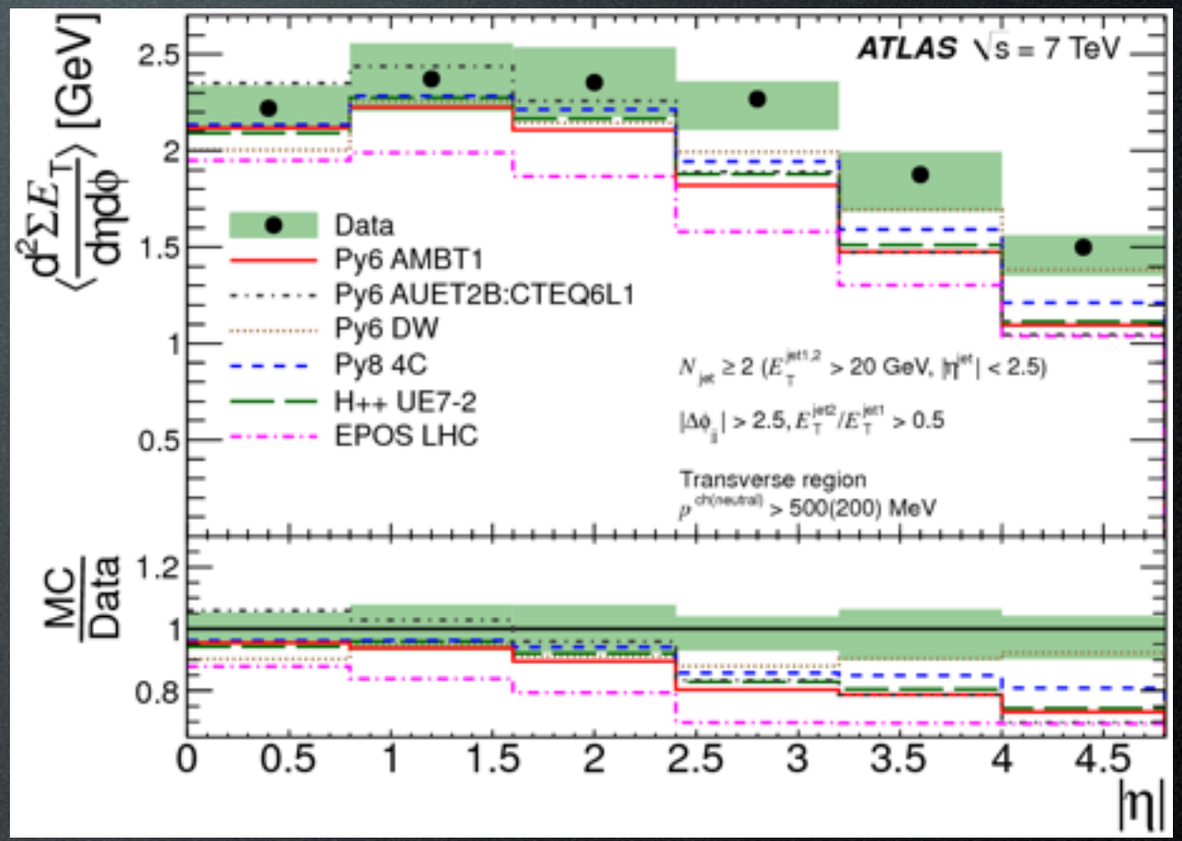
Discrepancy due to selection bias, trans-min identical.

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

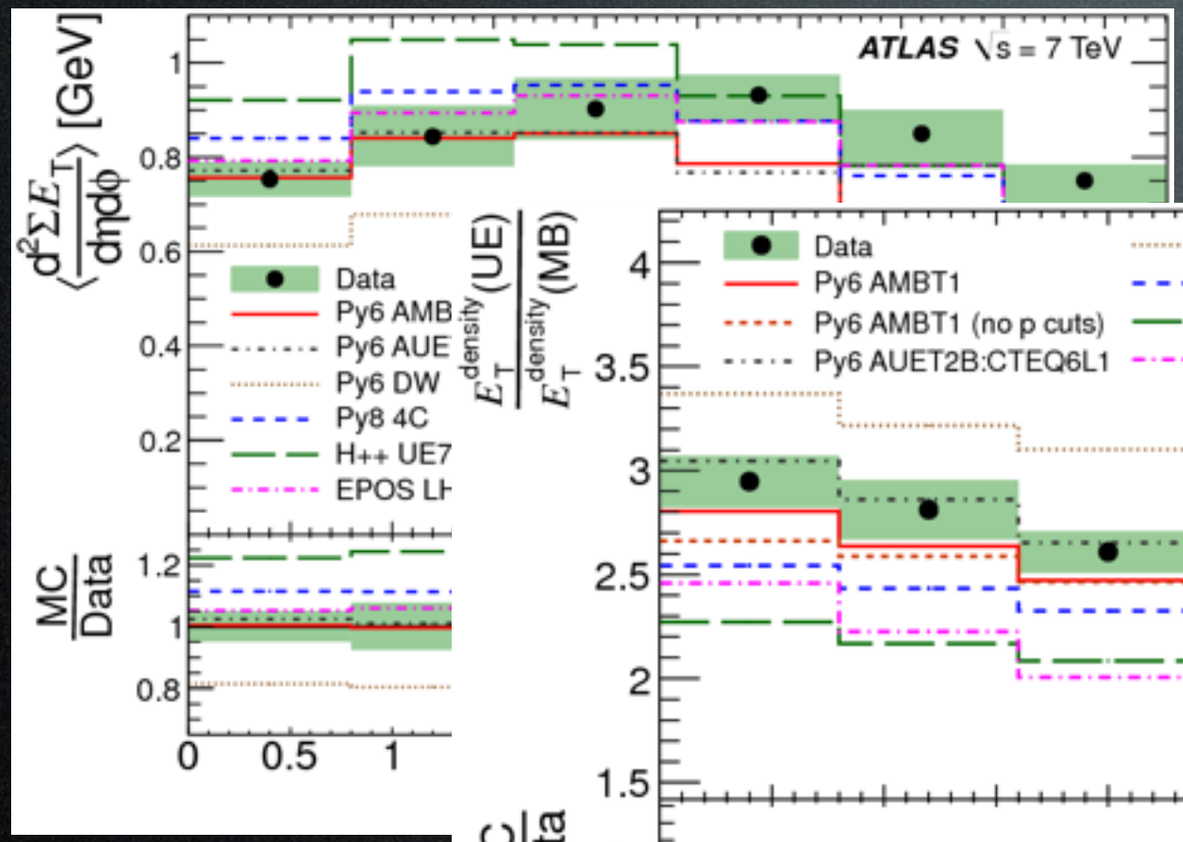




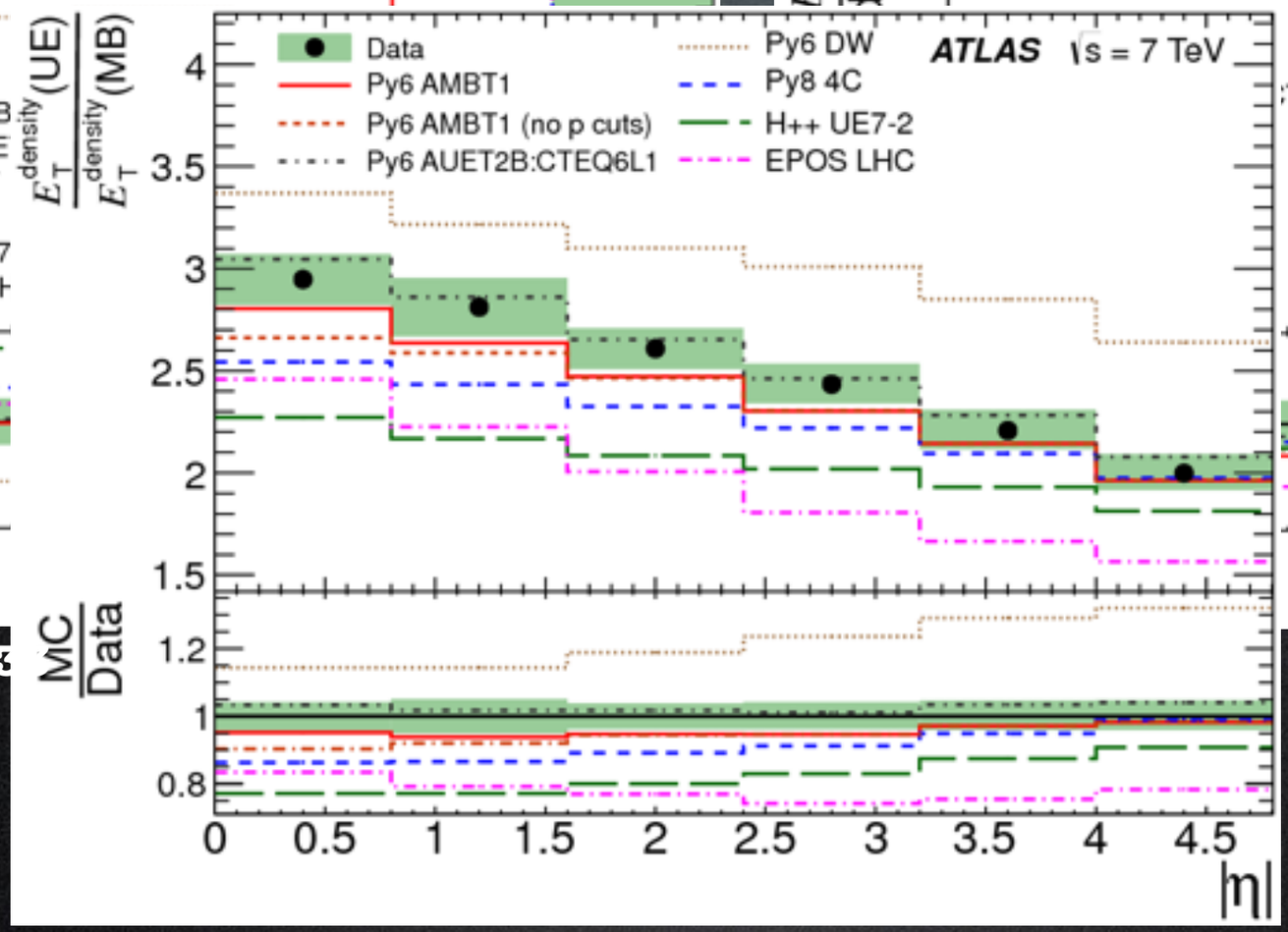
JHEP11 (2012) 033

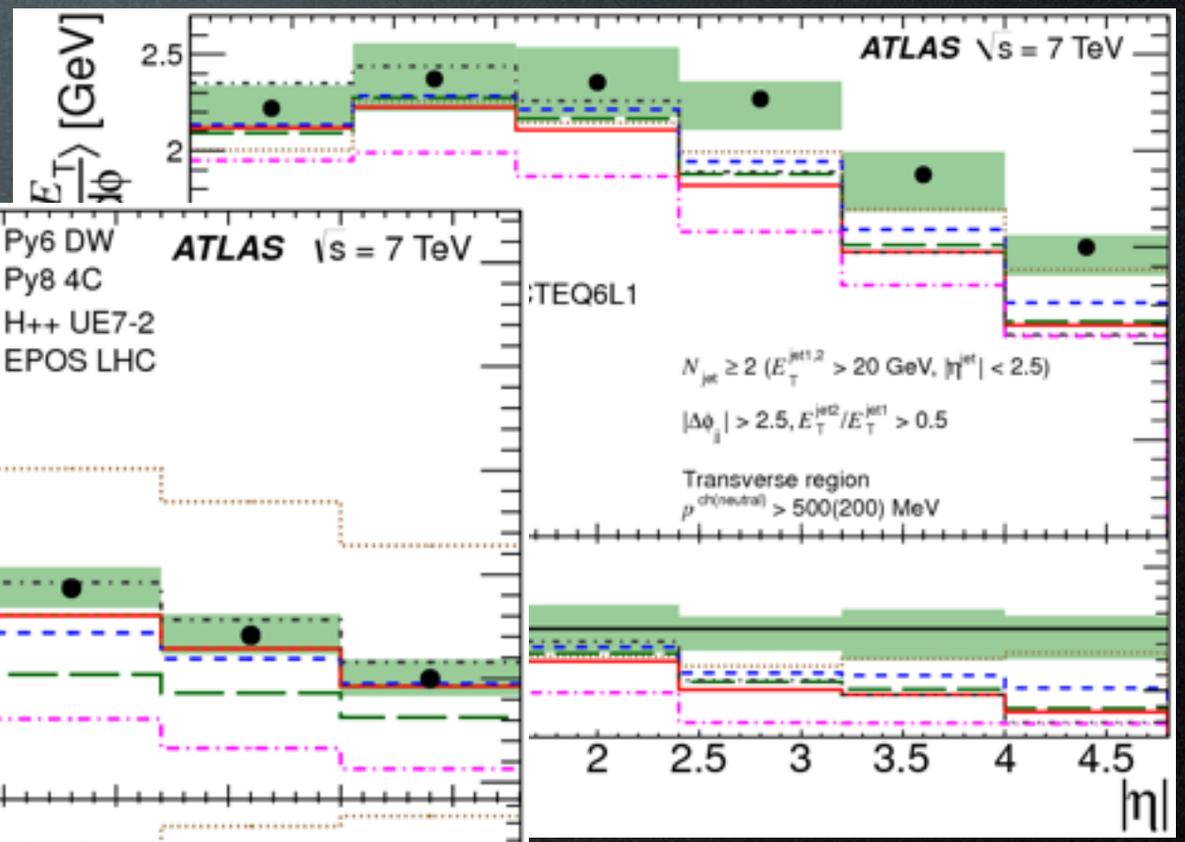
Transverse energy flow: all models bad in forward region

UE-sensitive Observables



JHEP11 (2012) 03

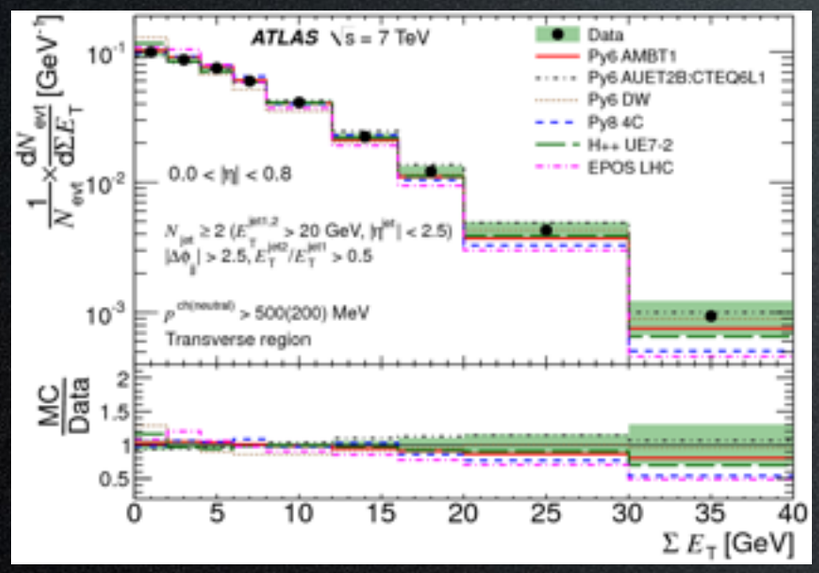


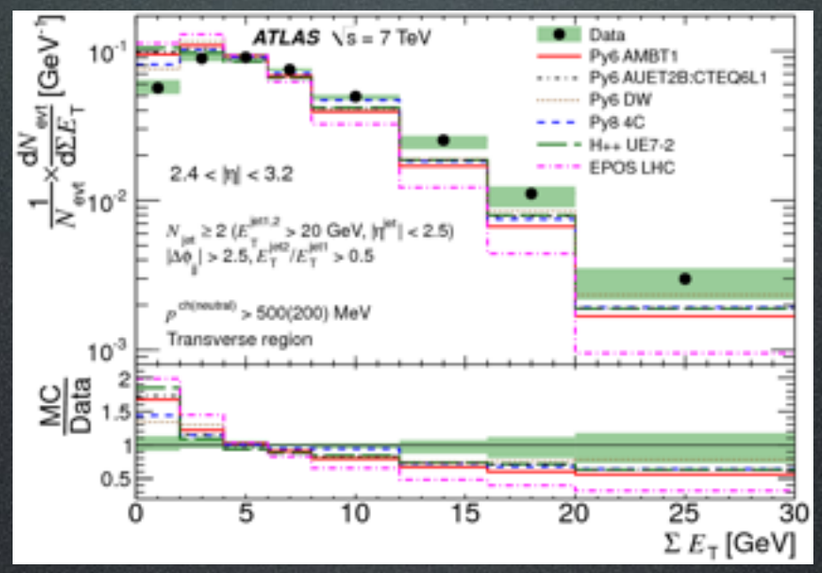


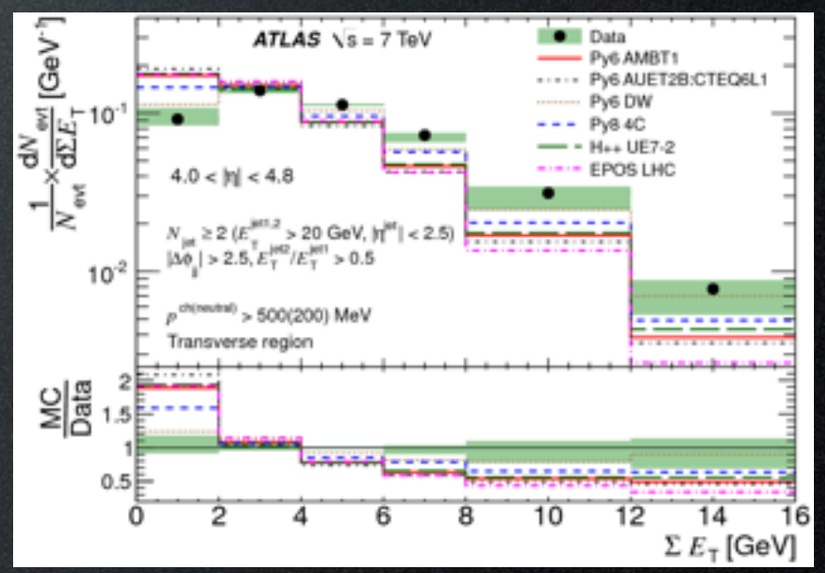
More energy in dijet events!

From Central to Forward

low η → **high η**





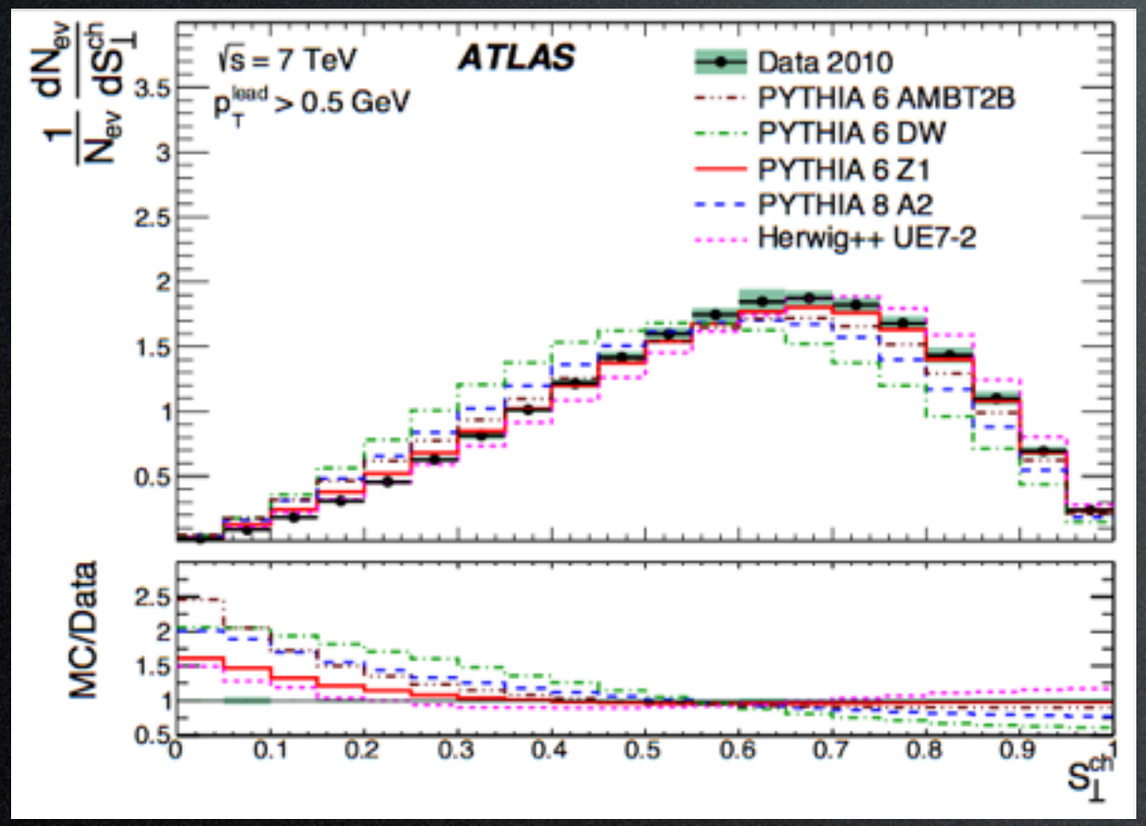


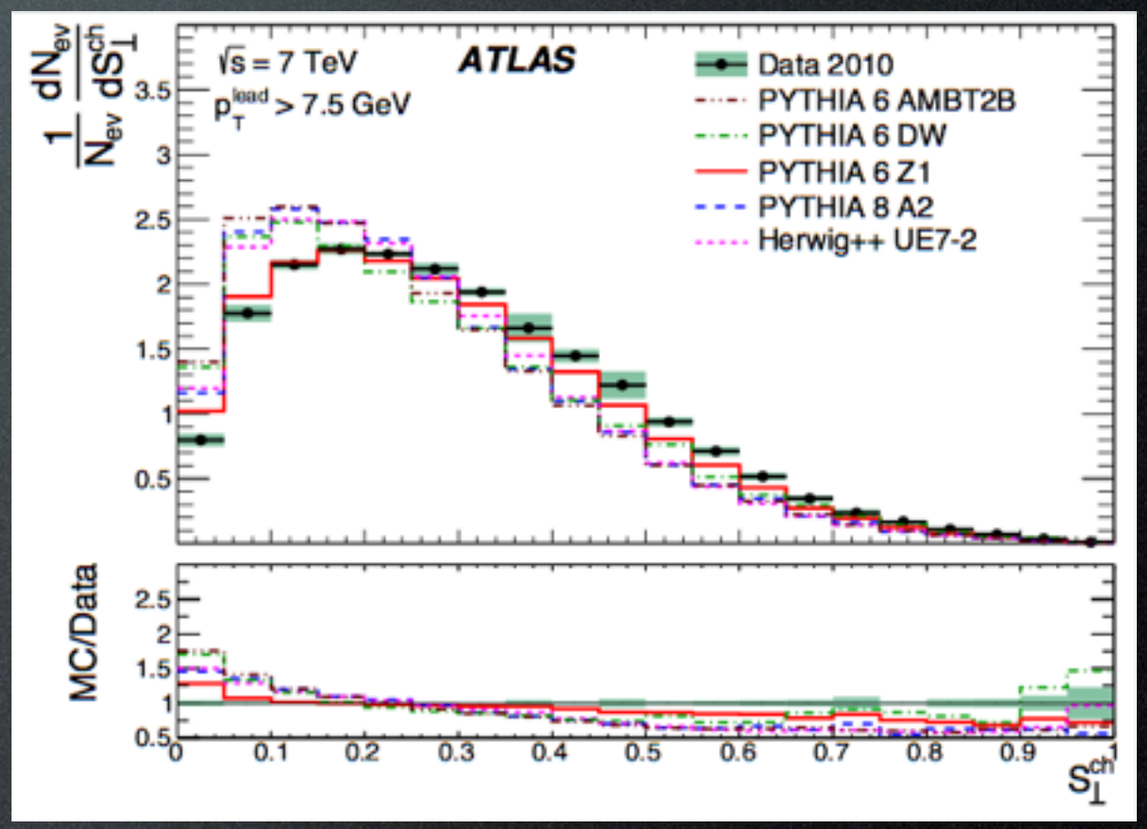
JHEP11 (2012) 033

UE tunes do better overall

Event Shapes

Low lead p_T → High lead p_T

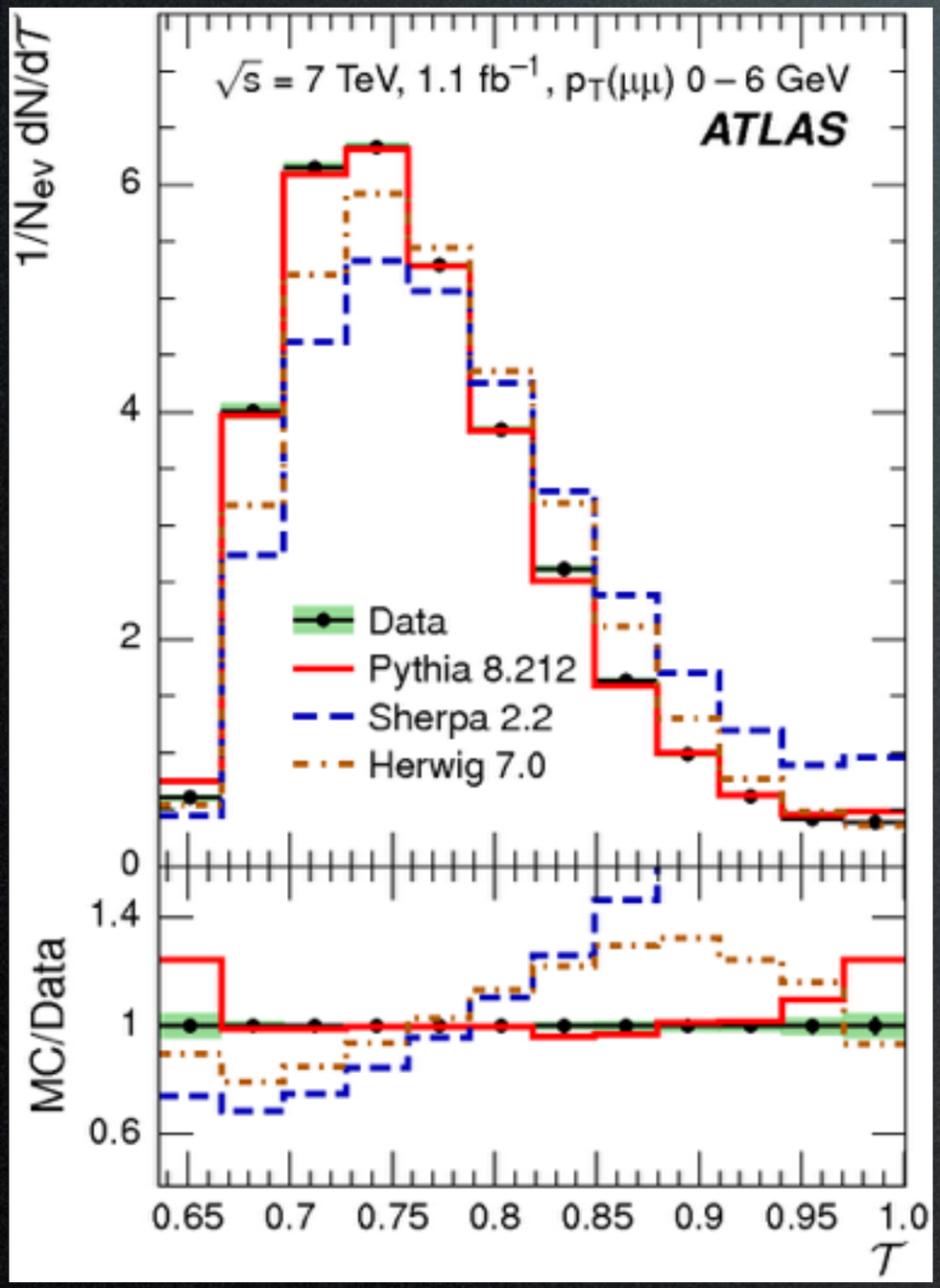




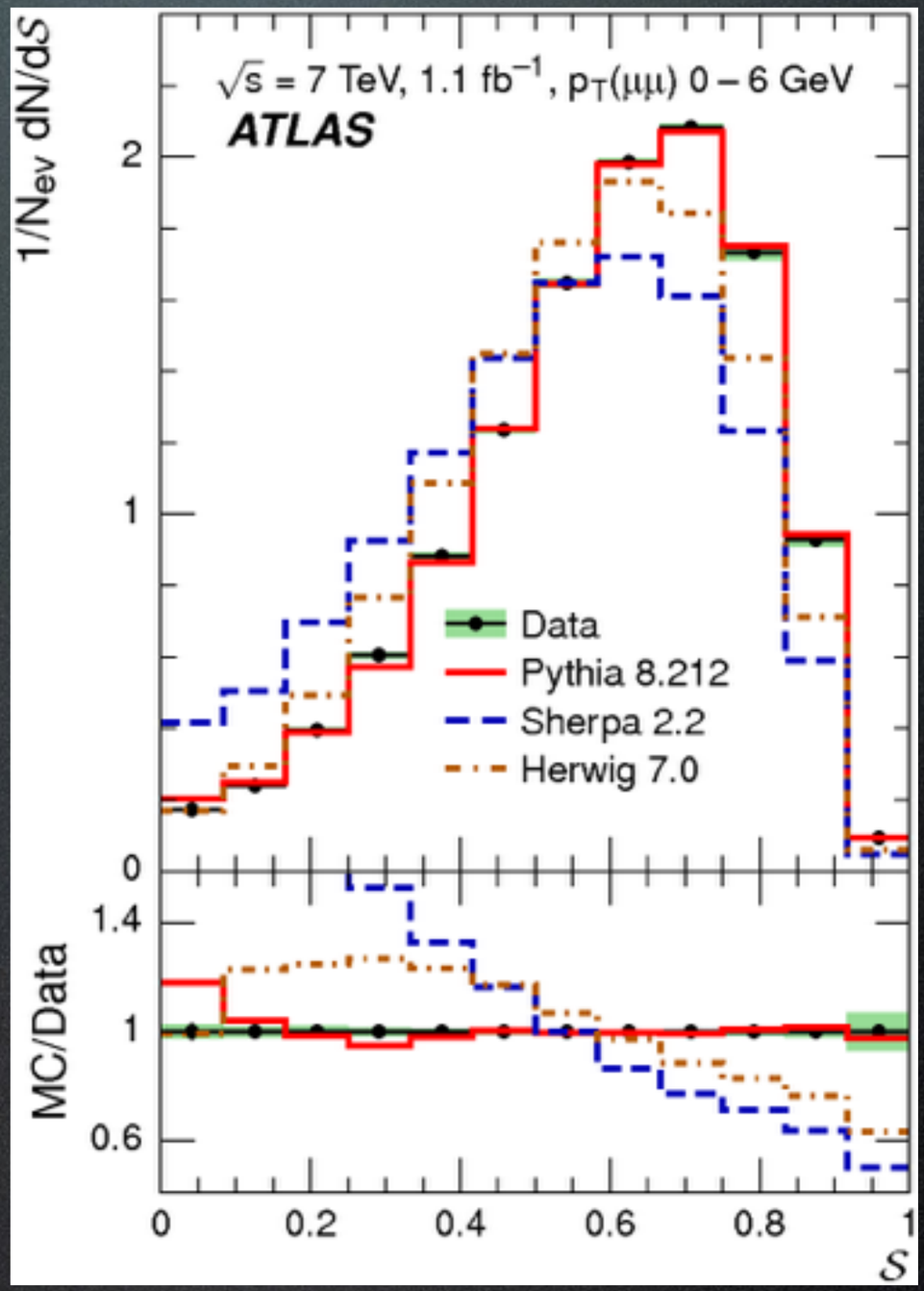
Phys. Rev. D 88, 032004 (2013)

UE starts taking over....

Event Shape in Z Events



Eur. Phys. J. C 76(7), 1-40, (2016)

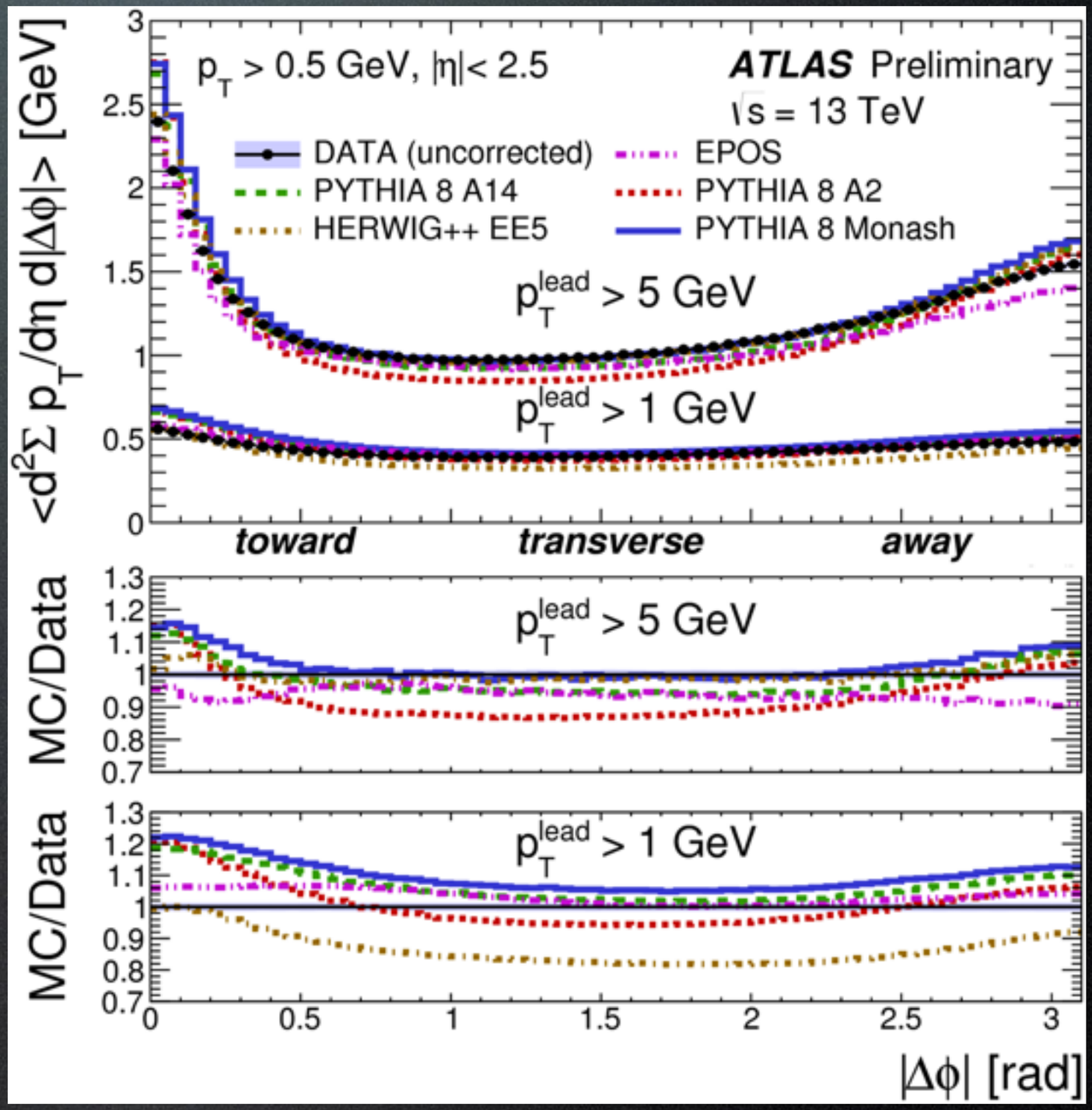


Eur. Phys. J. C 76(7), 1-40, (2016)

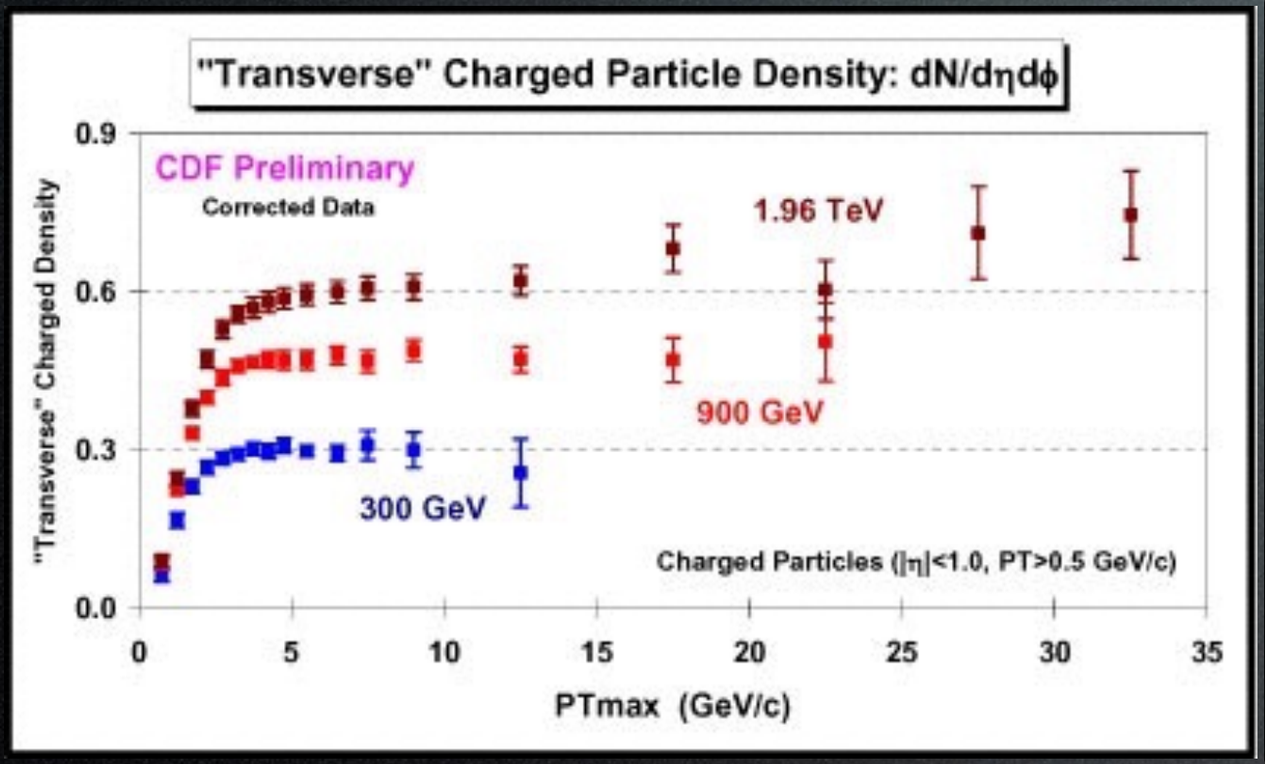
Sensitive to MPI at low pT of the Z-boson

Run 2: Detector Level

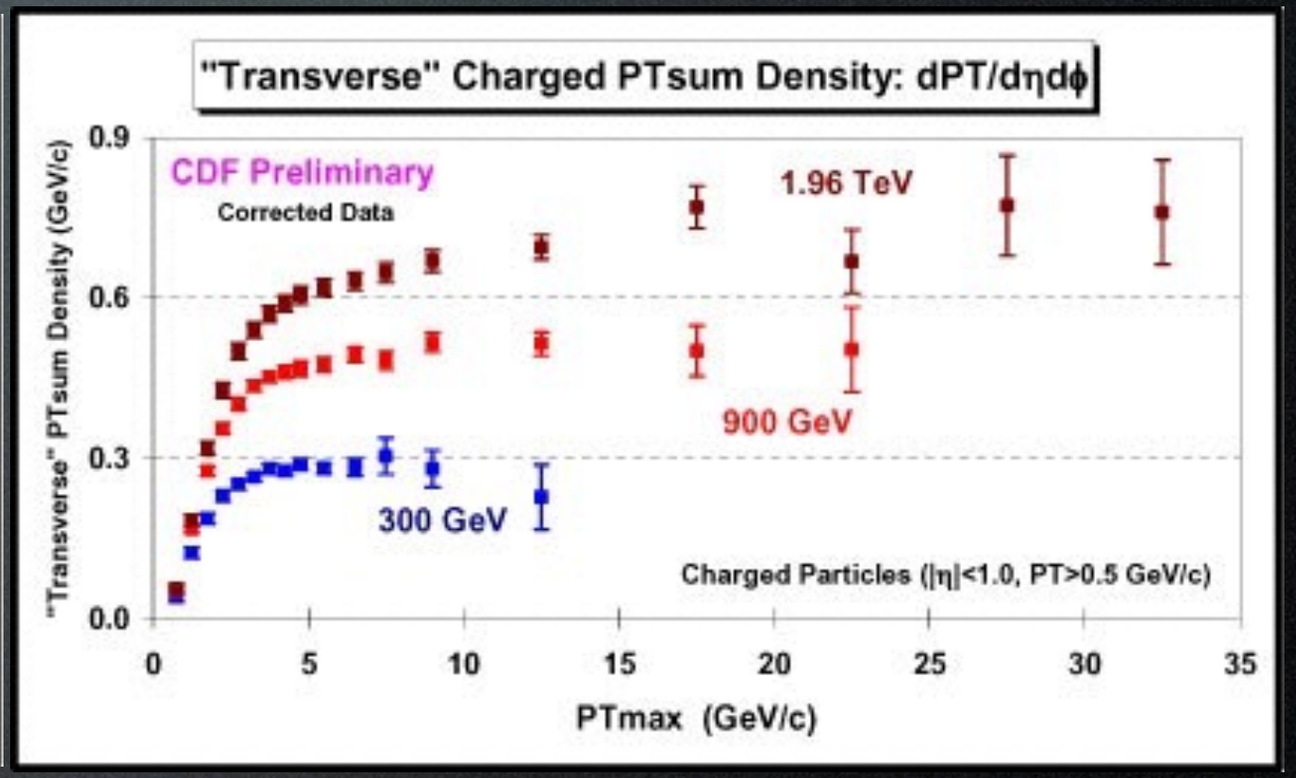
Overall decent agreement, MB tunes do better for lower lead p_T, while UE tunes for higher



CDF UE Energy Scaling



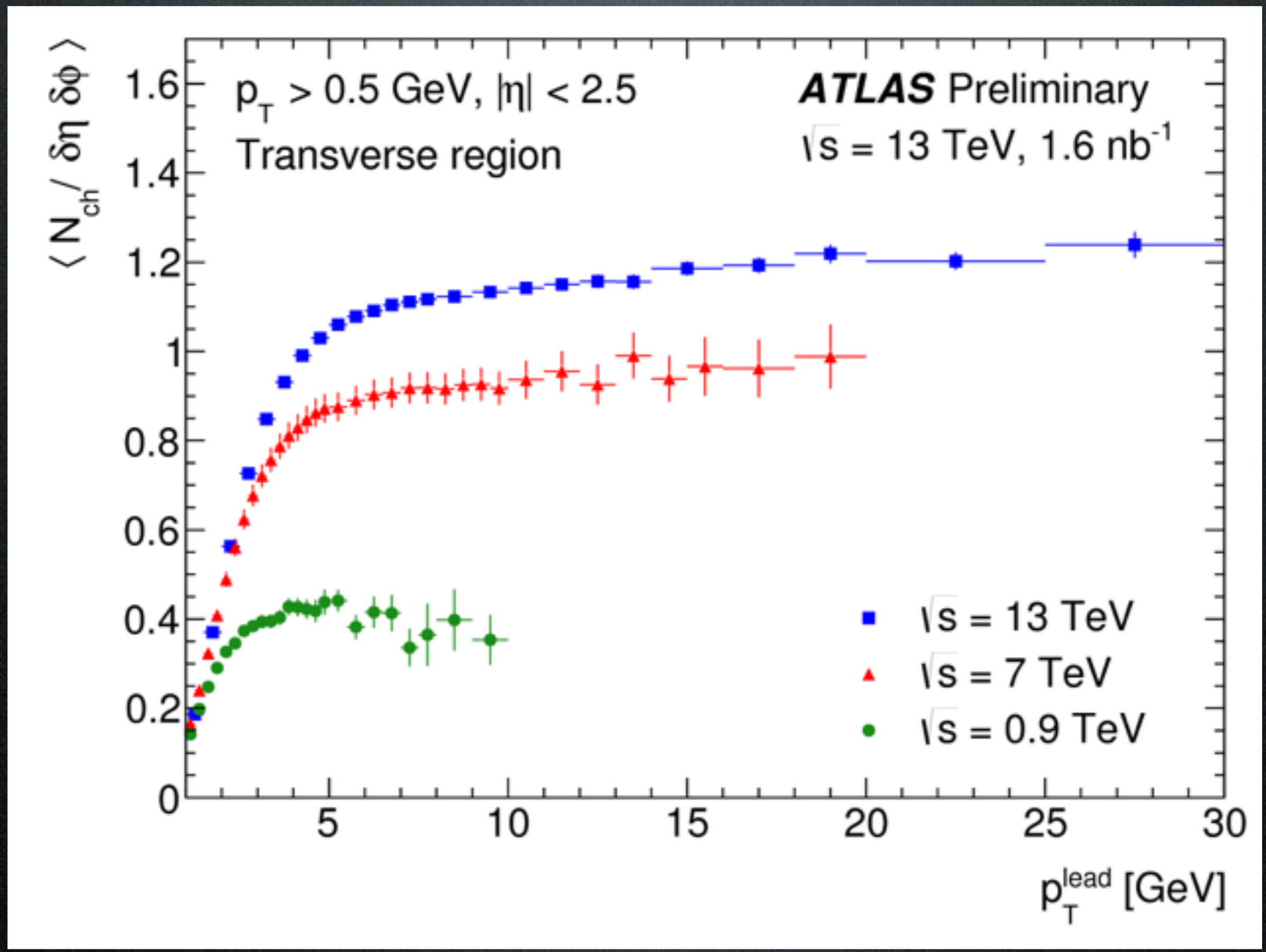
Phys.Rev.D.92, 092009



Phys.Rev.D.92, 092009

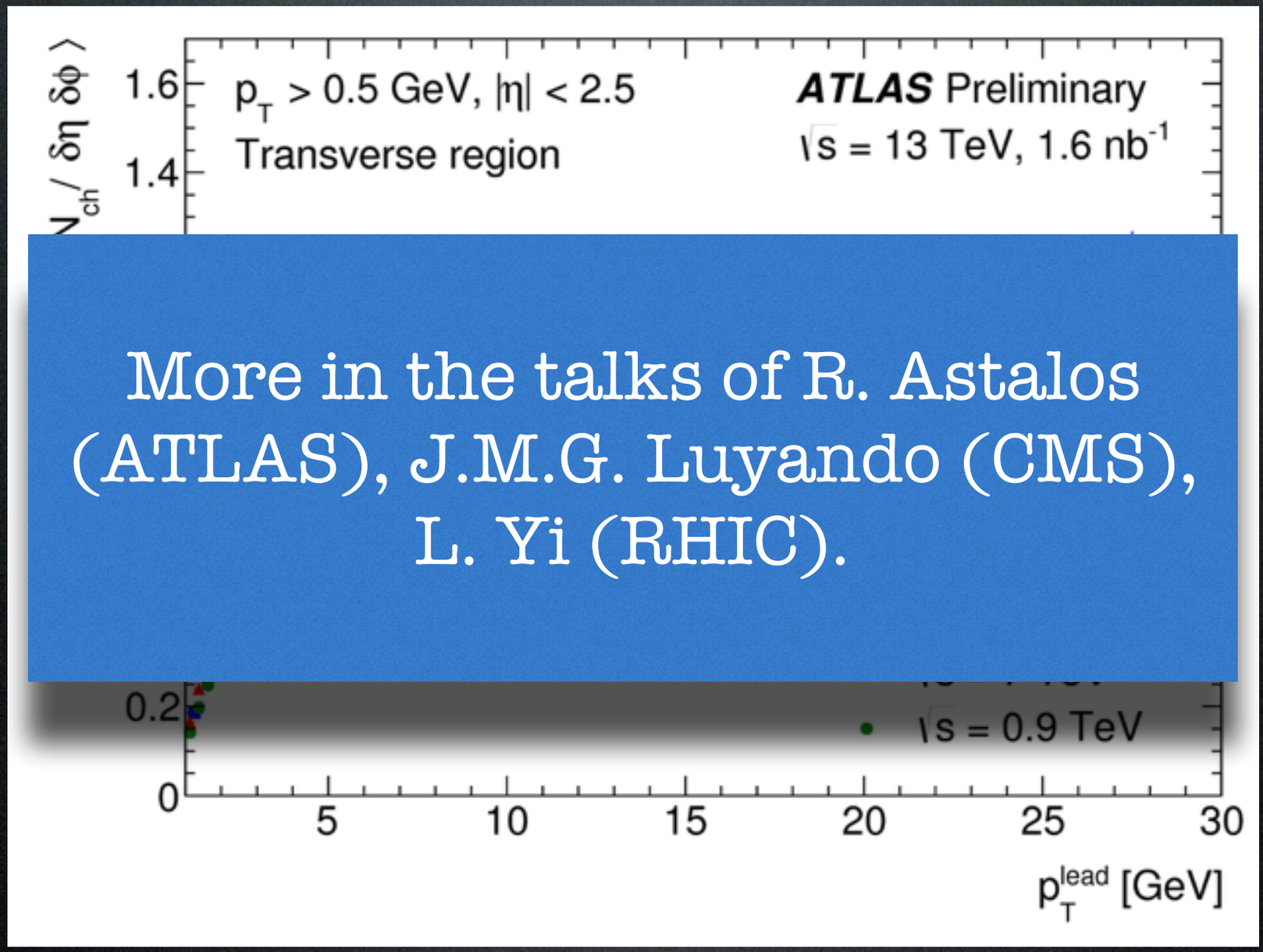
Do we finally understand the collision energy dependence of MPI, i.e. the height of the UE plateau?

LHC UE Energy Scaling



Do we finally understand the collision energy dependence of MPI, i.e. the height of the UE plateau?

LHC UE Energy Scaling



More in the talks of R. Astalos (ATLAS), J.M.G. Luyando (CMS), L. Yi (RHIC).

Do we finally understand the collision energy dependence of MPI, i.e. the height of the UE plateau?

Looking forward to an exciting set of results!