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Division of Particles and Fields
Mexican Physical Society

Underlying event studies using LHC data

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Presentation based on our publication in *Phys. Rev. D 96 (2017) 114019*

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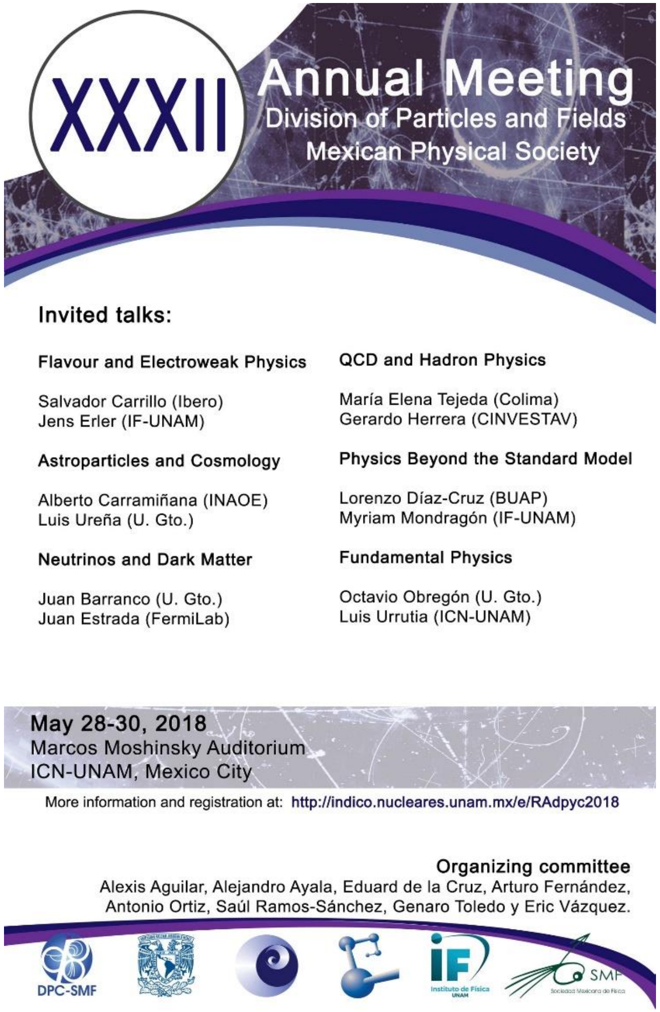
Content

Physics motivation

Experimental measurements

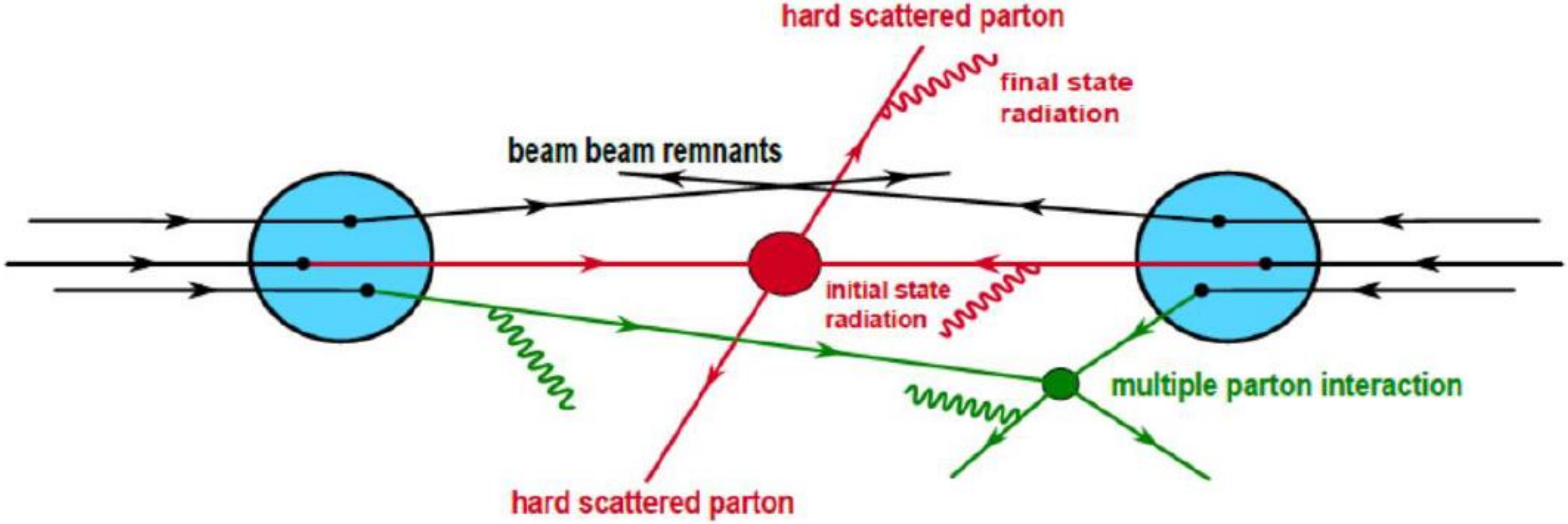
Results and discussion

Summary



PHYSICS MOTIVATION

UE and its importance

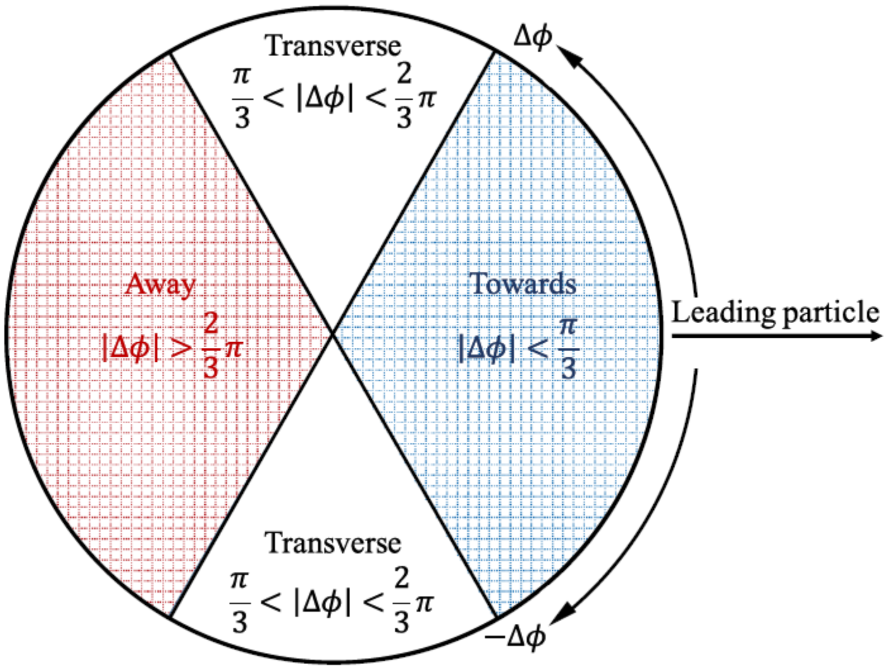


Underlying event (UE): everything in single particle collision except the hard scattering process: MPI, ISR, FSR and beam remnants.

Why do we want to study the UE?

- Can't be understood by using perturbative QCD, requires phenomenological models.
- Description of UE provides a better modeling of Monte Carlo simulations.
- The UE allows to access deep information of the hadronic structure.

UE observables



UE measurements are performed according to the azimuthal direction of the leading particle:

- Towards with $|\Delta\phi| < \pi/3$.
- Away with $|\Delta\phi| > 2\pi/3$.
- Transverse with $\pi/3 < |\Delta\phi| < 2\pi/3$.

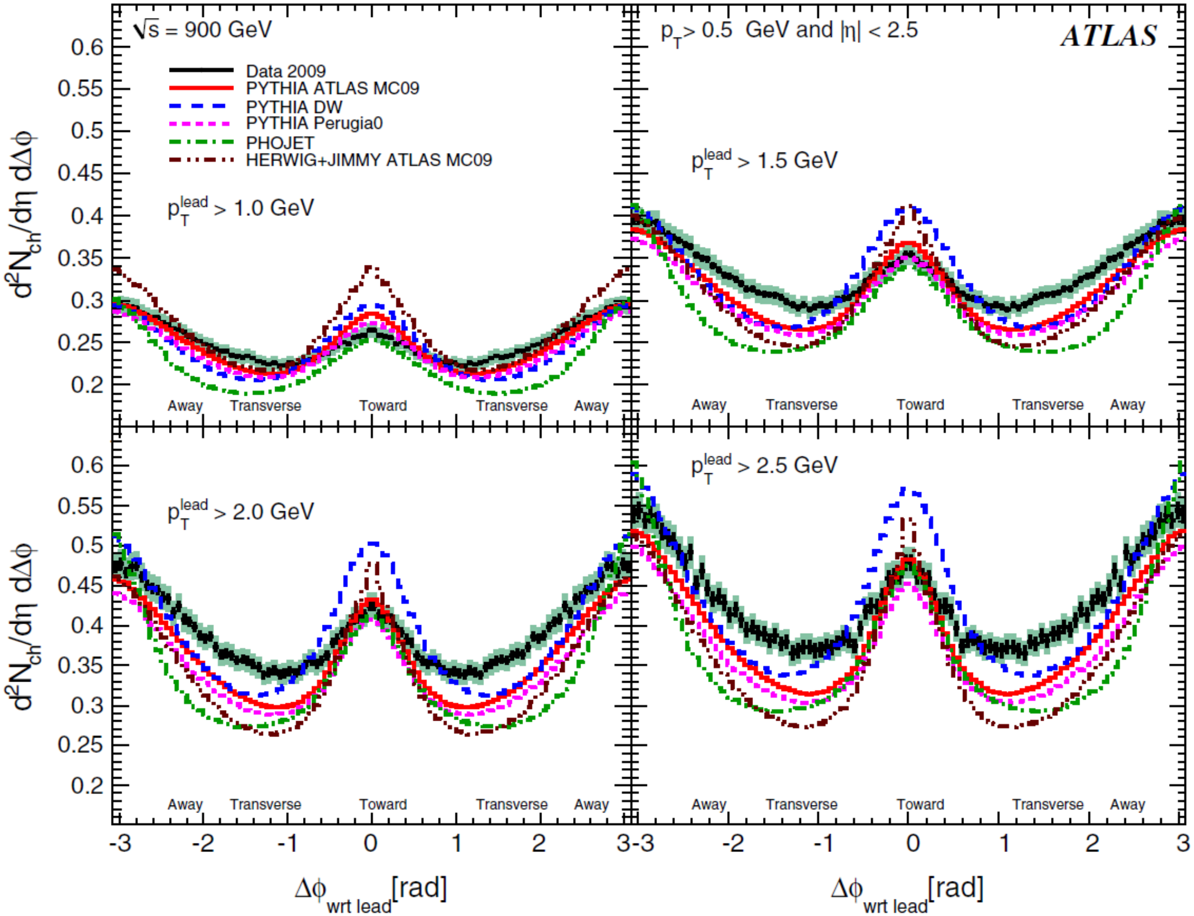
With $\Delta\phi = \phi_{\text{Leading}} - \phi_{\text{Any}}$ the azimuthal separation.

UE observables:

- Number density, average number of primary charged particles per unit of pseudorapidity and per unit of azimuthal separation $< Nc_h/\Delta\phi\Delta\eta >$
- Summed transverse momentum, the mean scalar p_T sum per unit of pseudorapidity and per unit of azimuthal separation $< \Sigma p_T/\Delta\phi\Delta\eta >$

EXPERIMENTAL MEASUREMENTS

Early measurements at the LHC

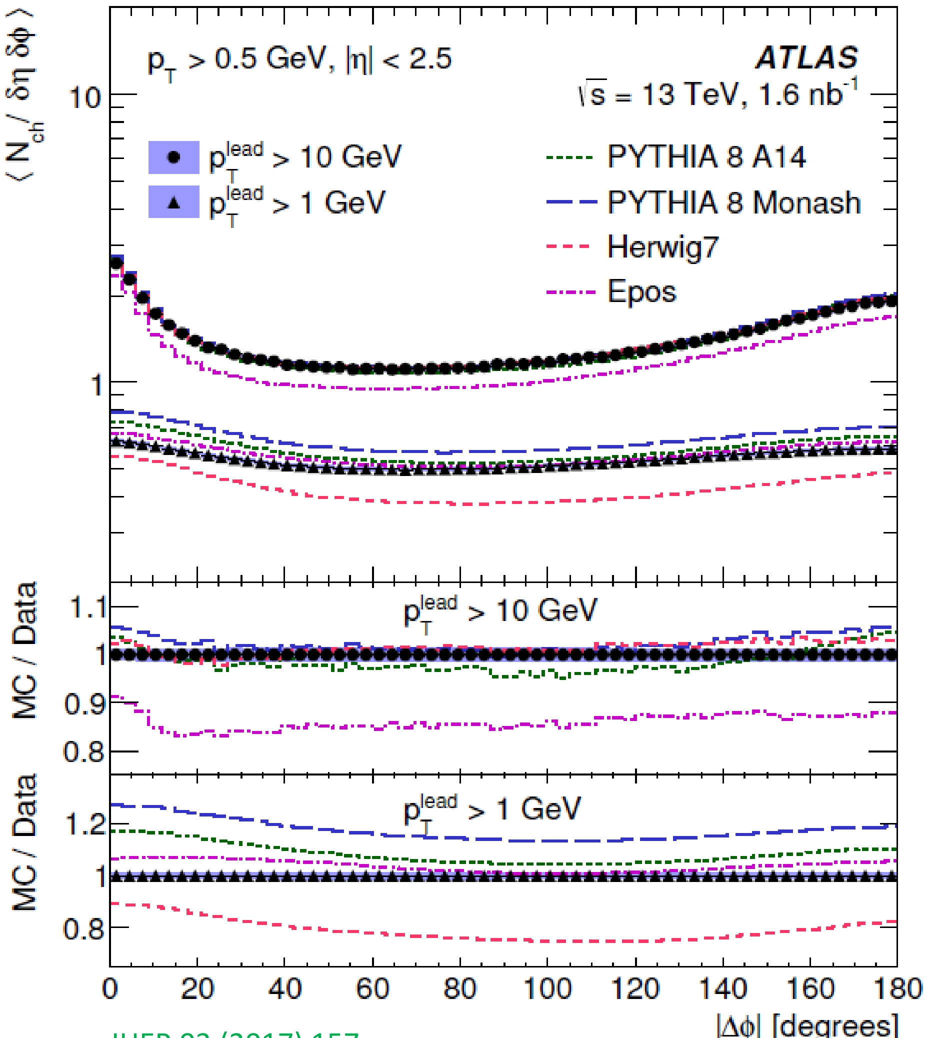


PRD 83 (2011) 112001

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

Such discrepancies are more pronounced as the leading track p_T cut is increased.

Recent measurements at the LHC



JHEP 03 (2017) 157

Latest results from the LHC show an improvement on the description of the UE by new Monte Carlo tunes, in particular for high-p_T leading track cuts.

Pythia 8 A14: dedicated ATLAS's UE tune, it is based on the NNPDF2.3 LO parton density function.

Pythia 8 Monash: has a more general purpose/low-p_T emphasis tan A14. It also uses NNPDF2.3 LO.

EPOS: QCD-inspired effective-field theory describing, simultaneously, the hard and soft scattering.

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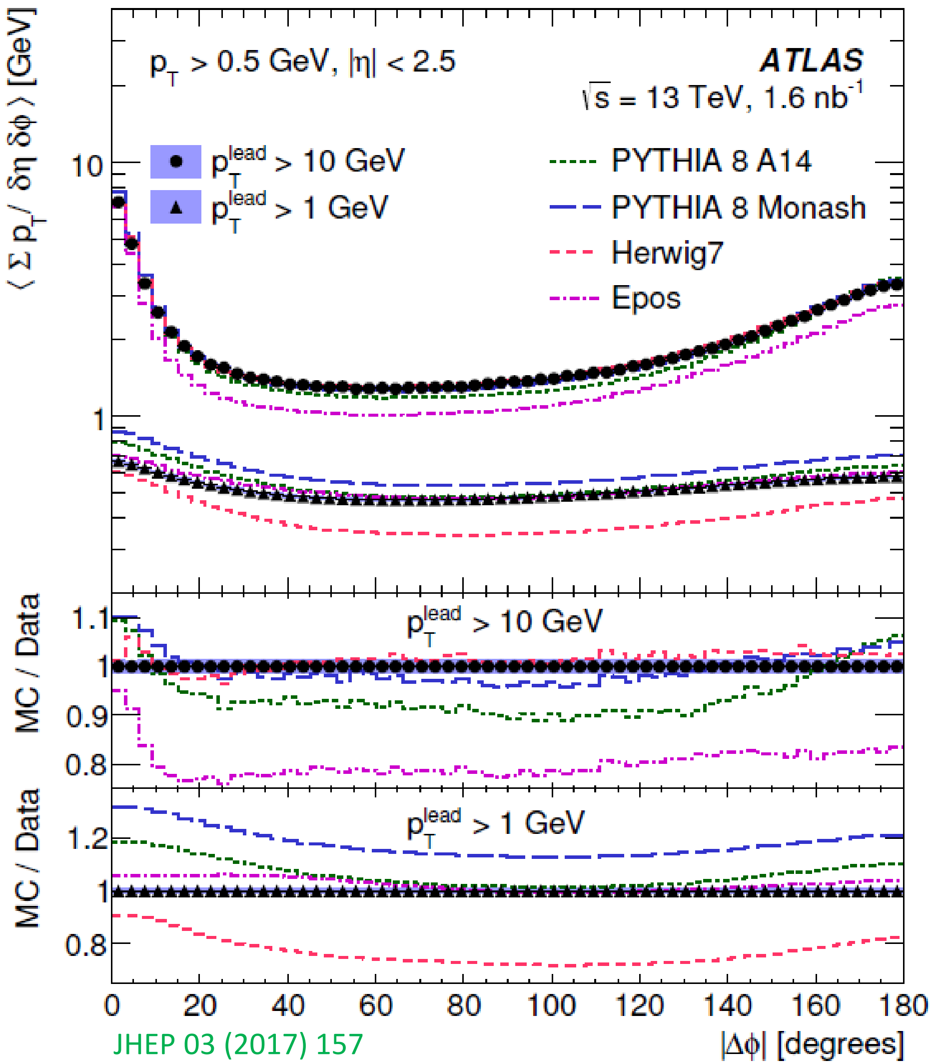

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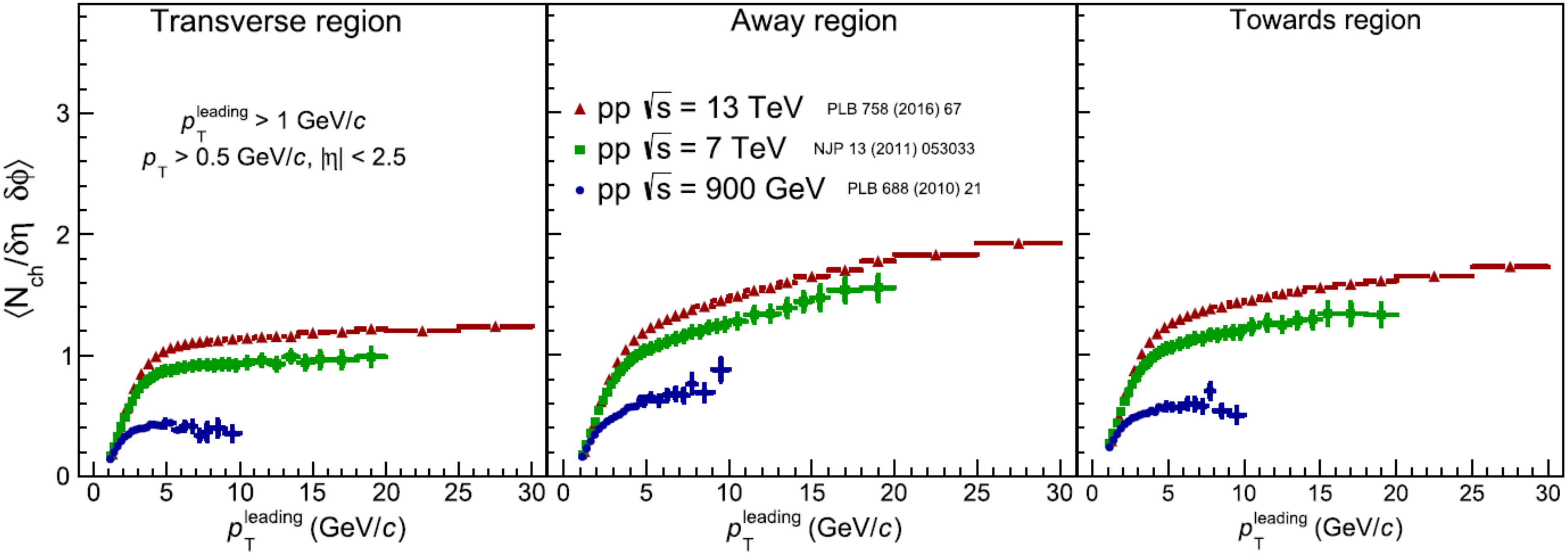
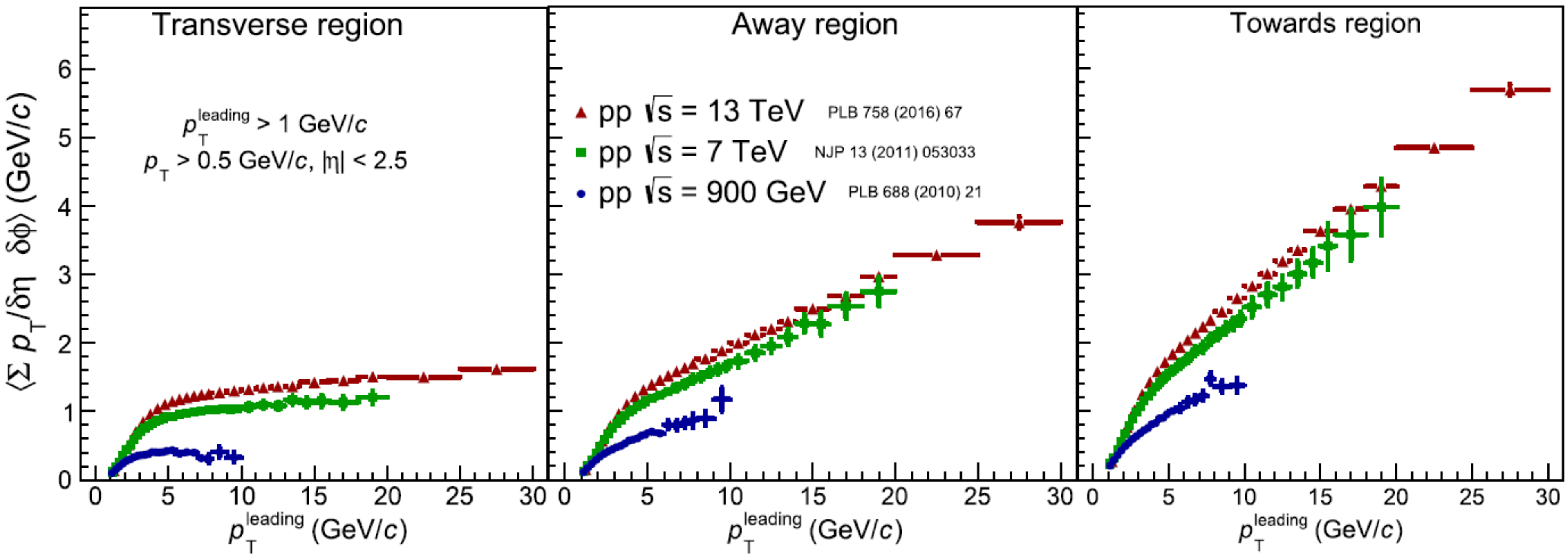
Energy dependence of the UE



Clear energy dependence of the UE but qualitatively the same behaviour for different $\sqrt{s}$ in the three regions.

Would it be posible to find a scaling factor for each region? Or even better: would it be posible to find a **global** scaling factor that can be applied to any región?

Energy dependence of the UE



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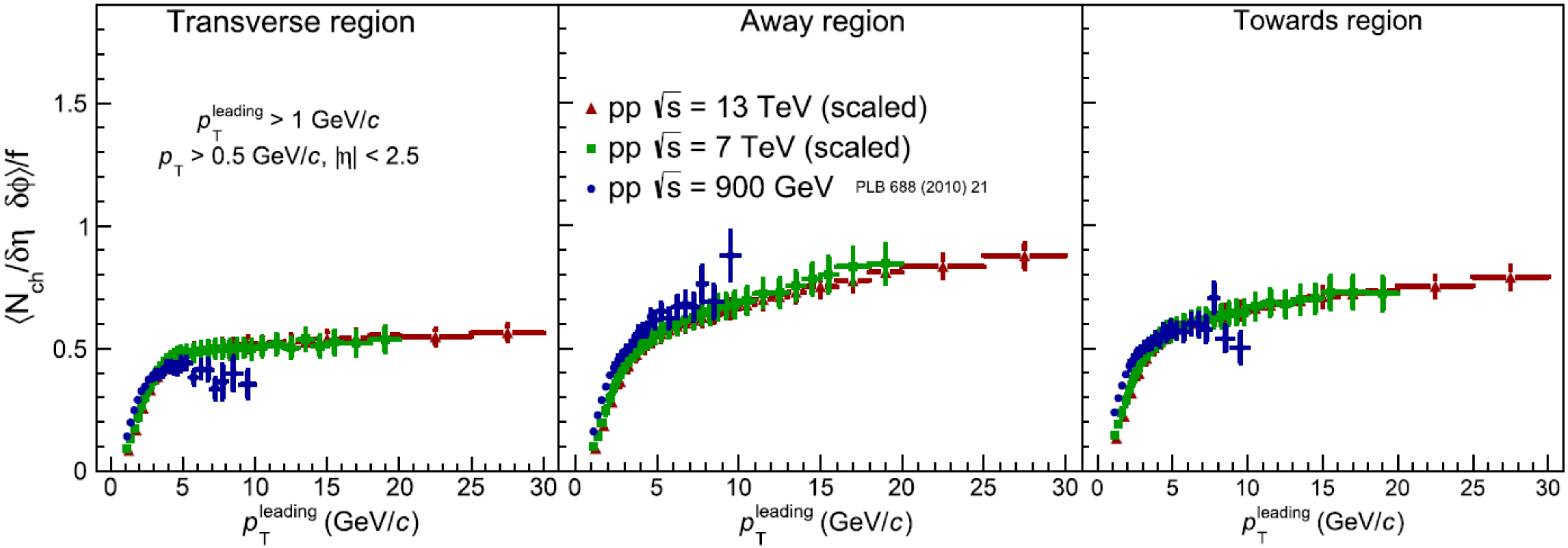
RESULTS AND DISCUSSION

Scaling in ATLAS



The scaling factor (f) used is the relative variation of the average charged particle multiplicity with respect to pp collisions at $\sqrt{s}$ = 900 GeV. The same scaling factor is applied in the three regions.

$$f = \frac{\langle dN_{Ch}/d\eta \rangle^{pp\ \sqrt{s}=X\ \text{TeV}}}{\langle dN_{Ch}/d\eta \rangle^{pp\ \sqrt{s}=0.9\ \text{TeV}}}$$

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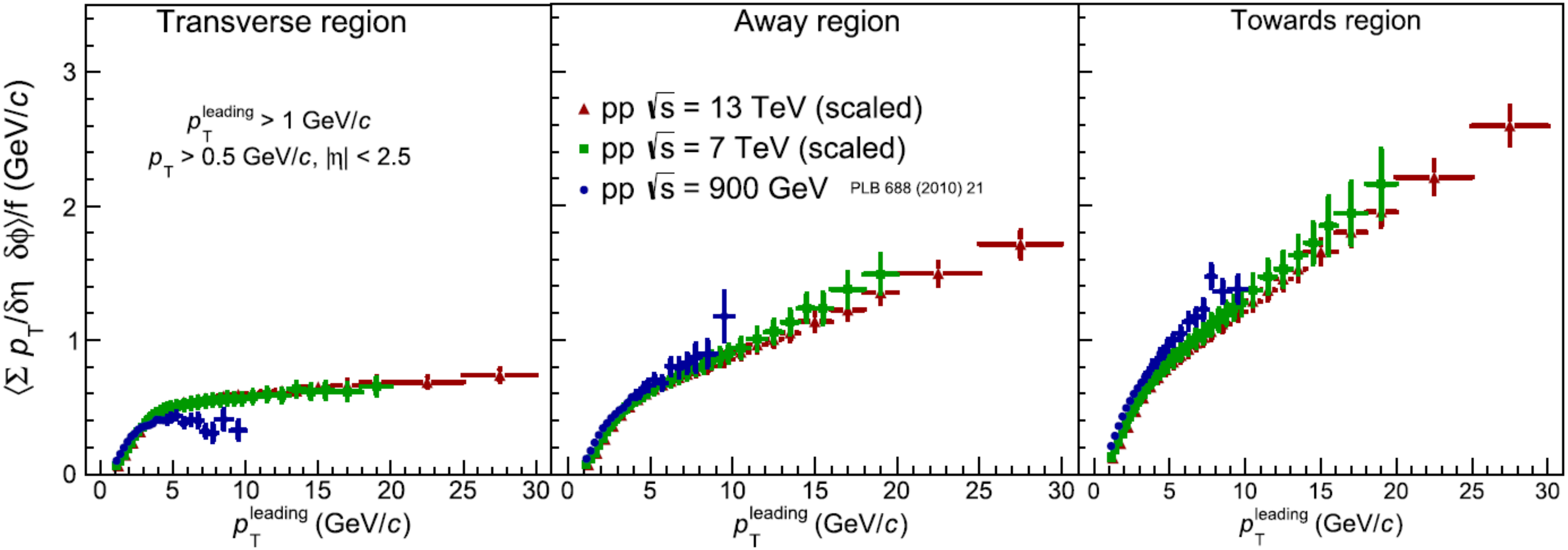

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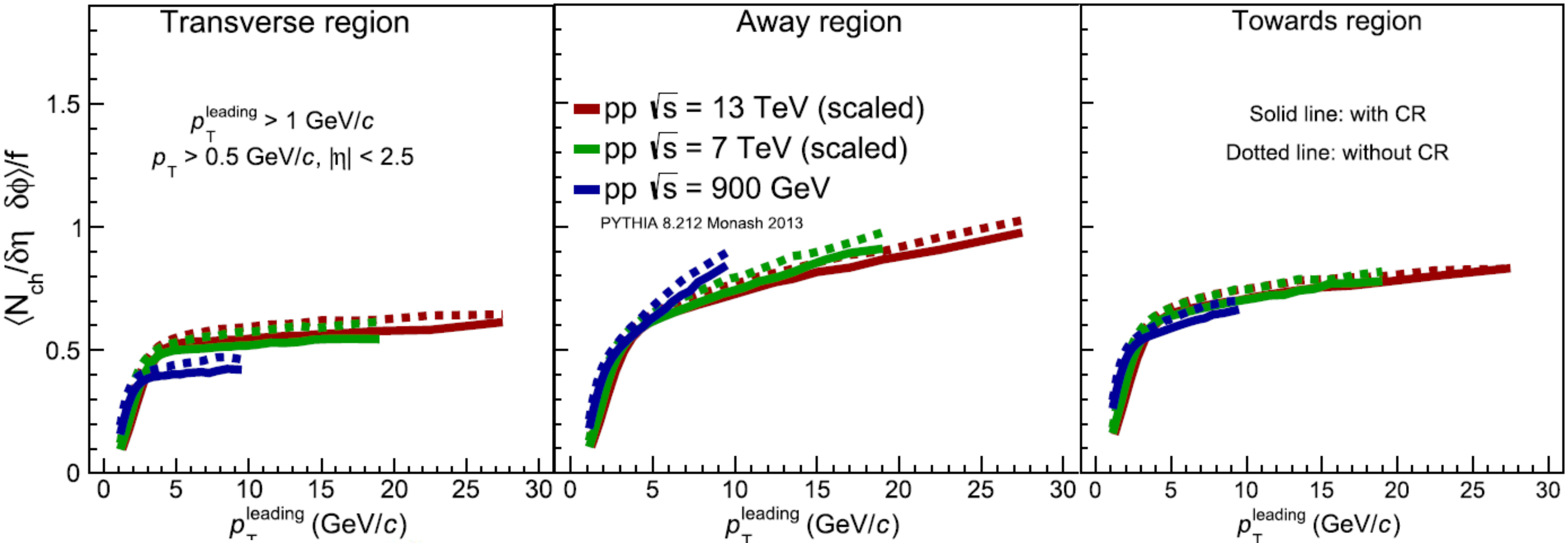
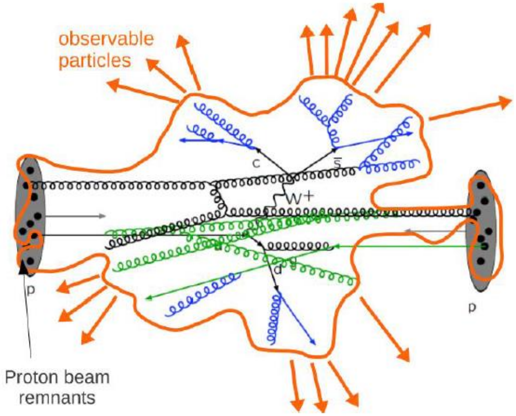
Scaling in ATLAS (MC)





Color Reconnection (CR): microscopic mechanism in which final partons are connected by color string, in this way the total string length becomes as short as posible.

CR does not play a role in the scaling of the UE.

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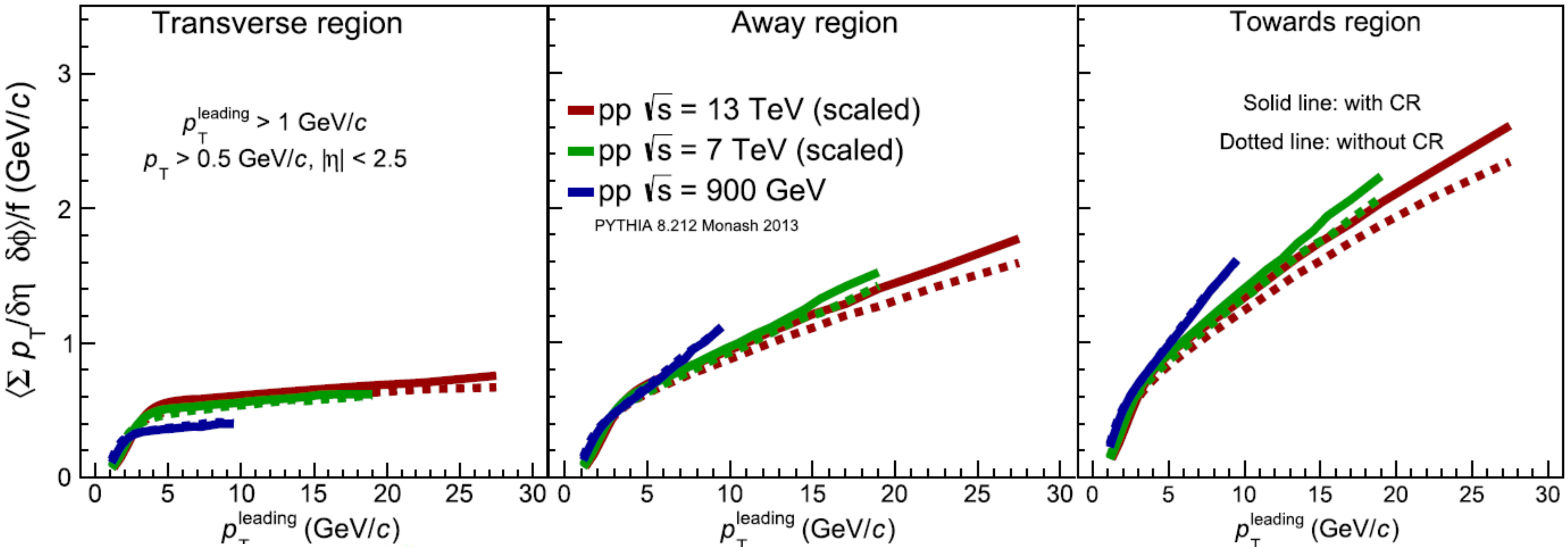

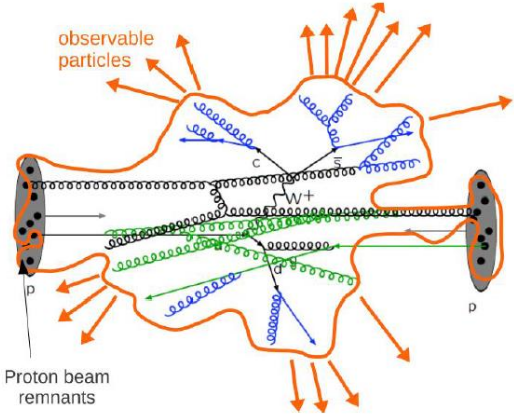

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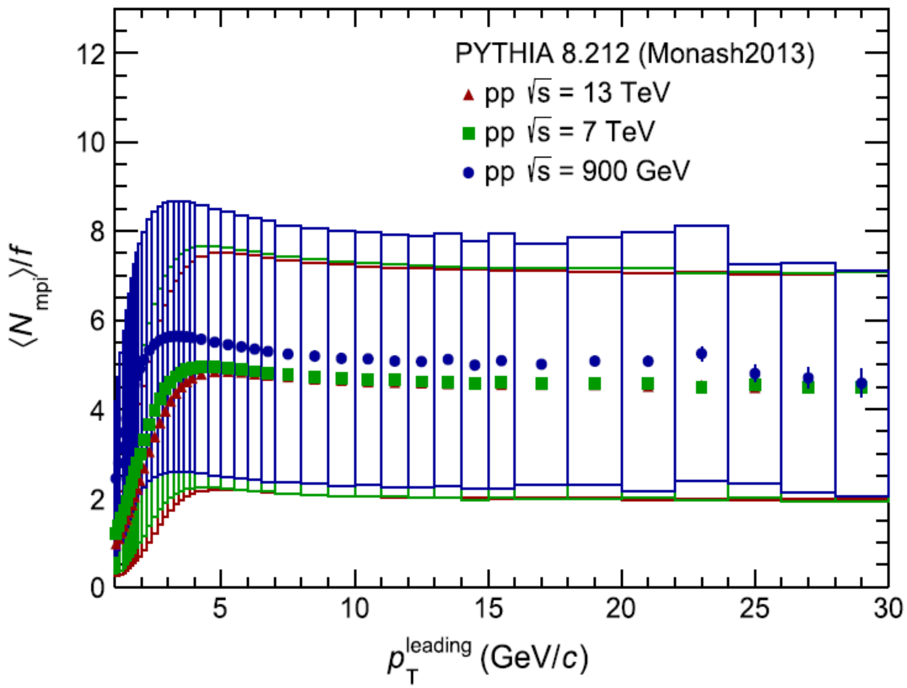
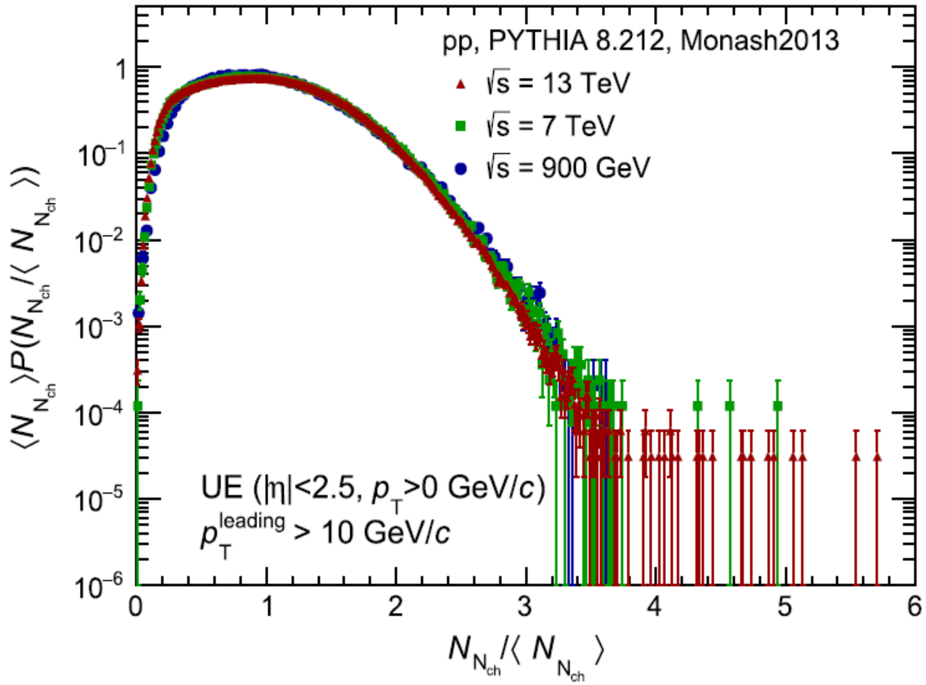
MPI and KNO scaling

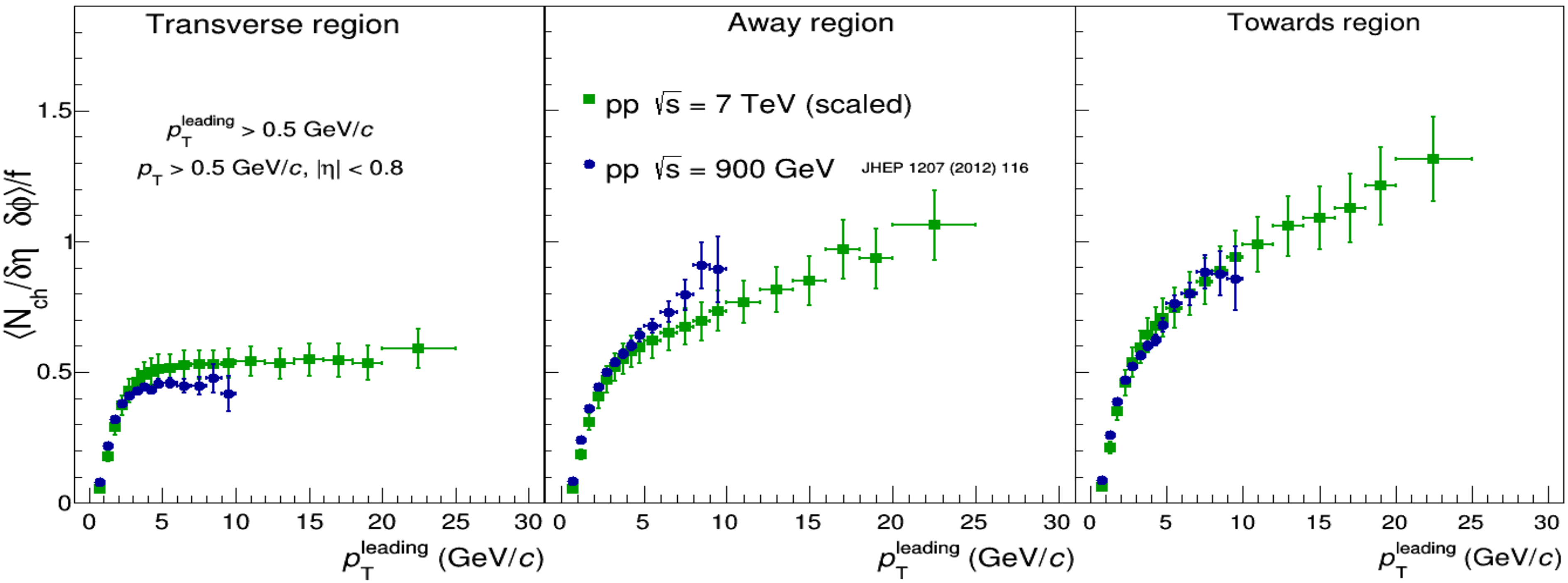




Average number of MPI exhibits the same scaling properties and it remains constant for leading $p_T > 8$ GeV/c.

The scaling suggest a KNO behaviour for the most central collisions, i. e., there is a collapse of the multiplicity distributions onto a universal scaling curve

Scaling in ALICE



Same scaling factor (f) used, but now with ALICE data.

Scaling is also valid, although ALICE acceptance is narrower: $|\eta| < 2.5$ in ATLAS and $|\eta| < 0.8$ in ALICE.

$$f = \frac{\left\langle dN_{Ch}/d\eta \right\rangle^{pp\ \sqrt{s}=7\,\mathrm{TeV}}}{\left\langle dN_{Ch}/d\eta \right\rangle^{pp\ \sqrt{s}=0.9\,\mathrm{TeV}}}$$

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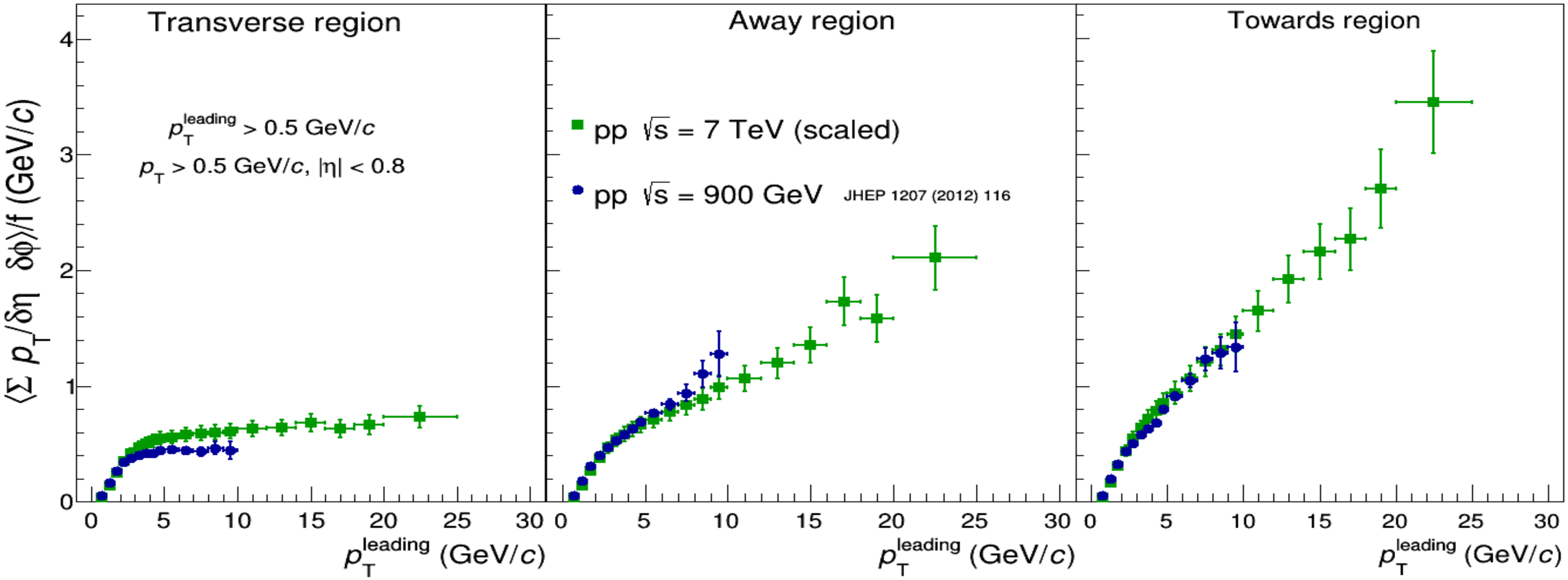

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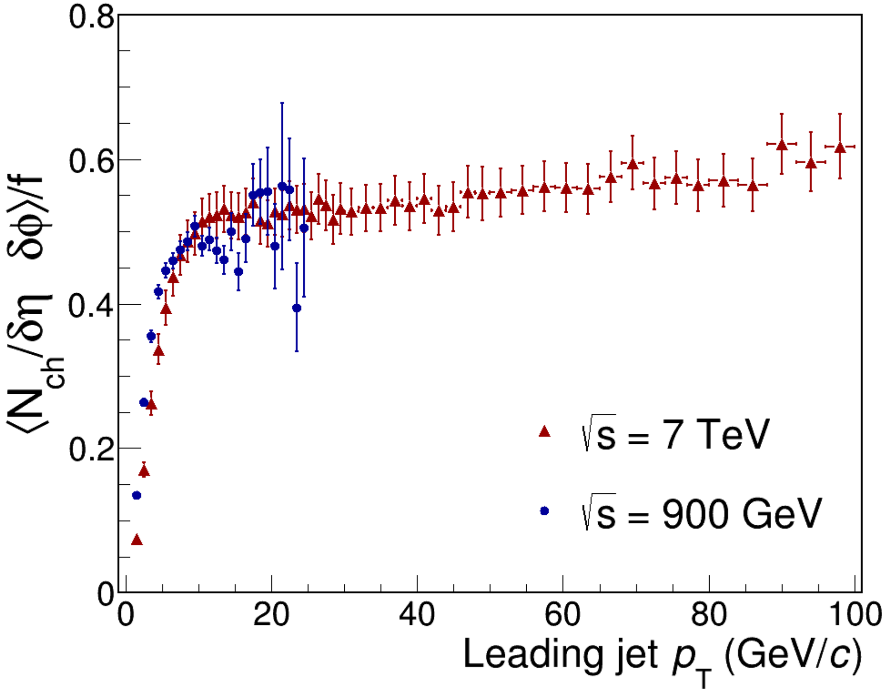
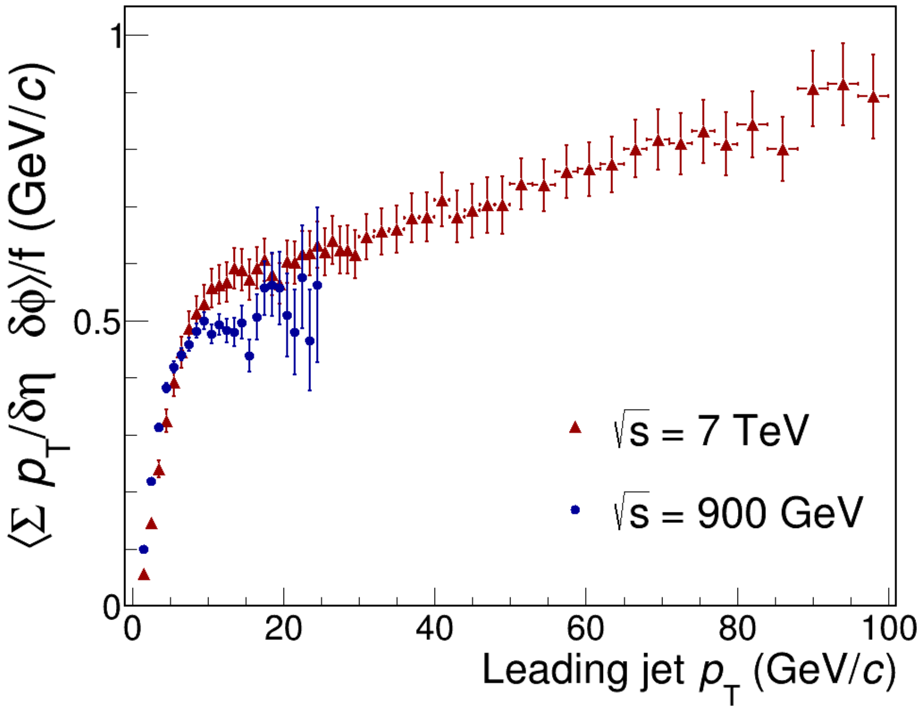
Scaling in CMS





CMS: jets instead of leading particles ➔ higher p_T reach in a broad acceptance (|η| < 2.5 for the jet algorithm and |η| < 2 for the UE).

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SUMMARY

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The UE is a key feature in the understanding of non-pQCD processes of a hadronic collision.

Theoretical models and MC tunes have improved their description of the UE during LHC Run 1 and 2.

UE measurements for different $\sqrt{s}$ from ALICE, ATLAS and CMS have been found to scale according to the rate of change of the multiplicity.

Furthermore, such scaling is the same in the towards, away and transverse región.

The average number of MPI also exhibits the same scaling properties.

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Thanks for your attention

BACKUP

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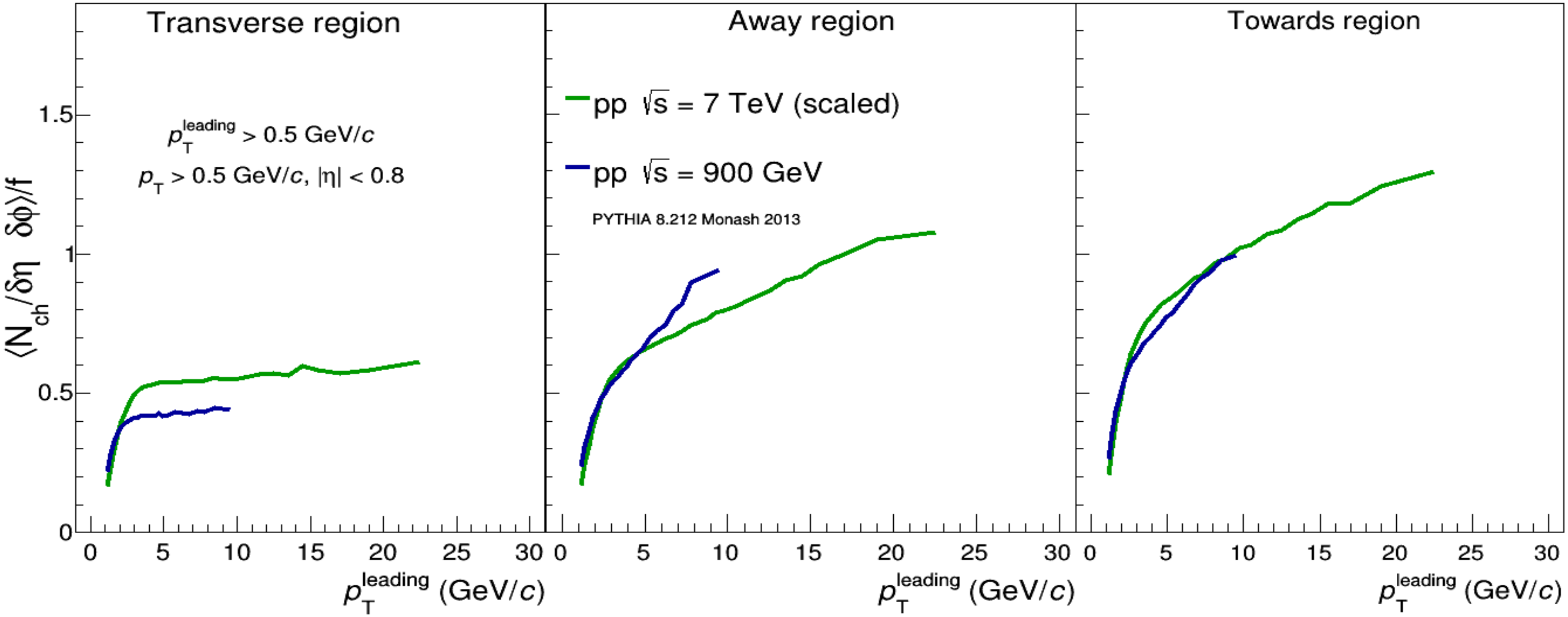

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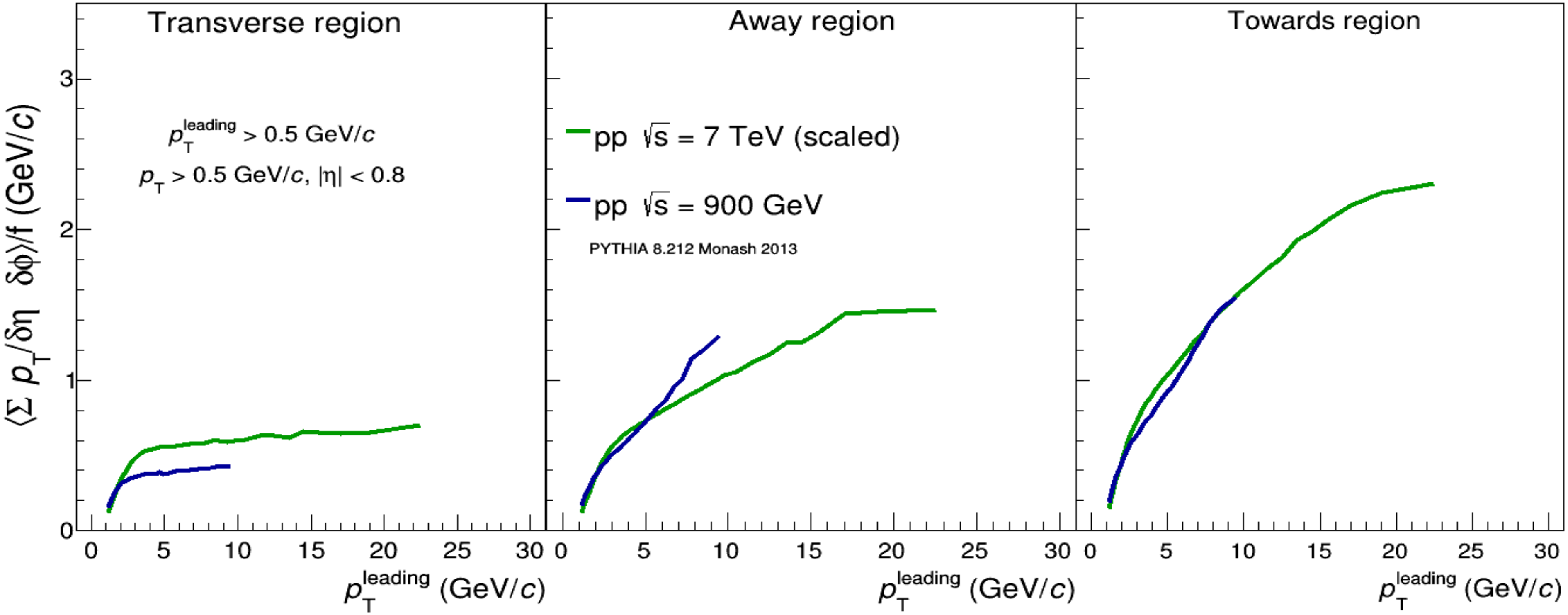

Scaling in CMS (MC)