Particle spectra in Minimum Bias events at 13TeV

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MPI@LHC 2015 Trieste, Italy

Motivation

Probe the different components of hadron production

- The transition from the perturbative to the non-perturbative region
- Behaviour of QCD at small-x
- Multiple parton interactions
- Saturation of parton densities
- Soft diffractive components

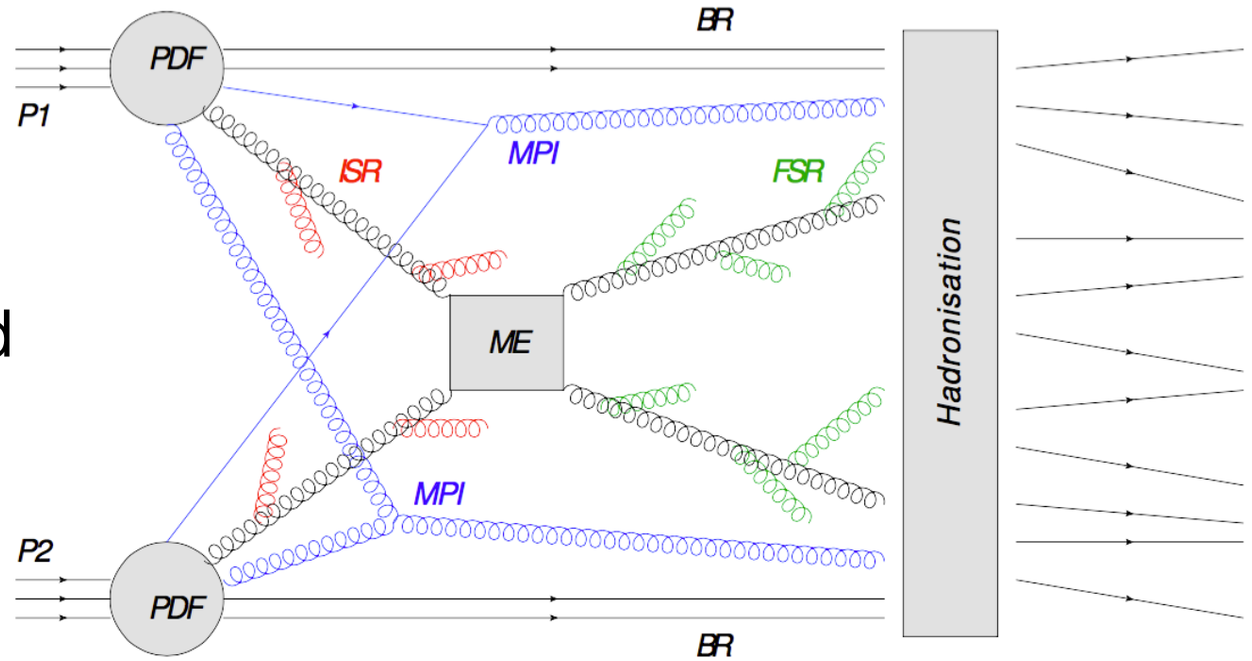
Tune the modeling of these contributions

- Center-of-mass energy dependence
- Taming of the cross section in the low p_T *region*

Multiple Parton Interactions

Multiple Parton Interactions

- Soft to semi-hard interactions
- Phenomenological models
- Tuning of the model parameters based on experimental data



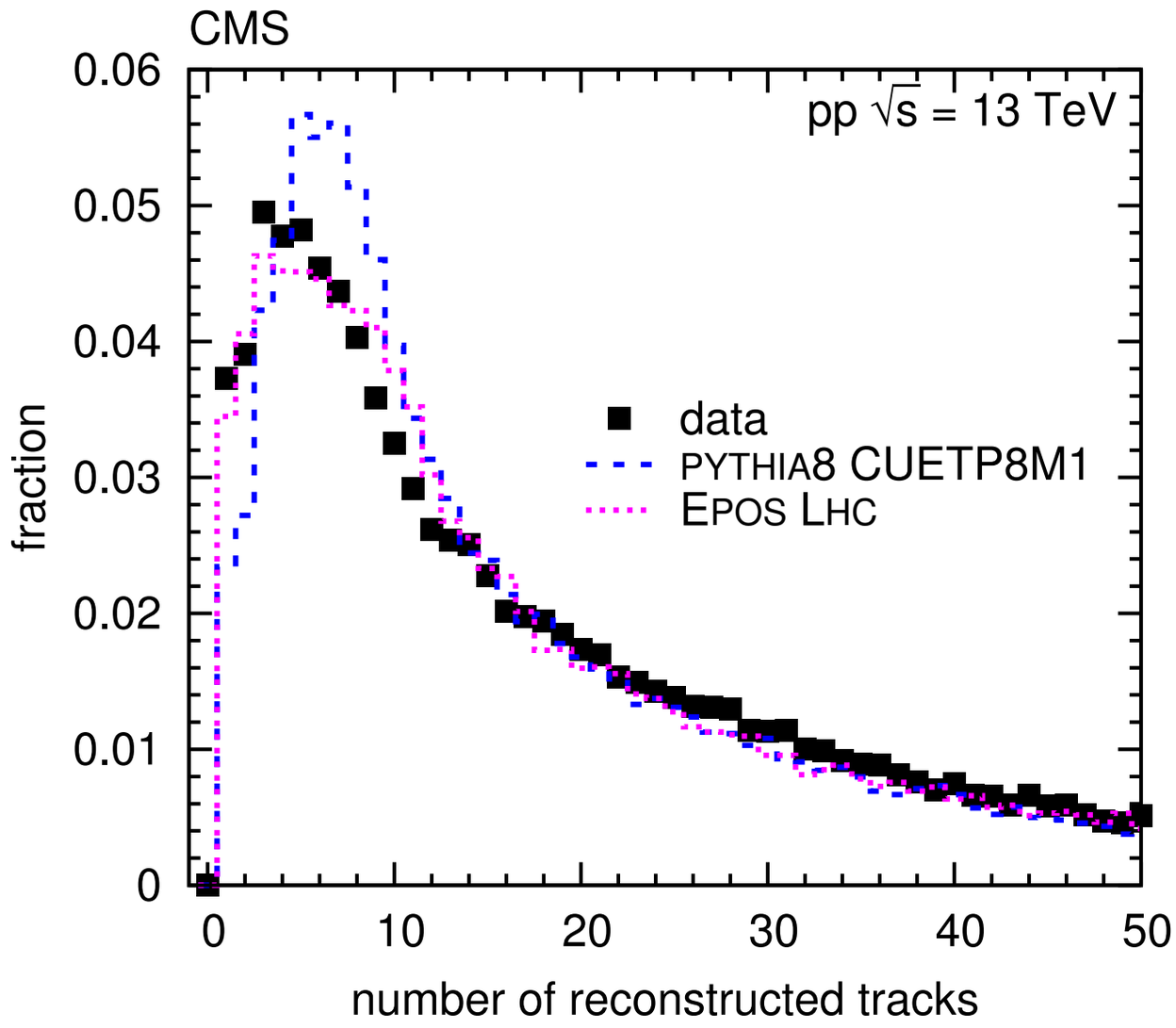
Comparison to the new CMS tunes

- Simultaneous fits to CDF UE data at 0.9 and 1.96 TeV, and CMS UE at 7 TeV
- Energy dependence of the MPI parameters
- Different parton densities
- **Theoretical uncertainties** from allowed parameter space

Pseudorapidity at 0T

- Measurement of pseudorapidity distribution of charged hadrons in proton-proton collisions at **√s = 13 TeV**

  - Presented for **inelastic events**
  - No minimum transverse momentum requirement (**measurement done at 0T**)
  - Corrected to primary **long-lived charged hadrons (no leptons)**



Phys. Lett. B 751 (2015) 143–163

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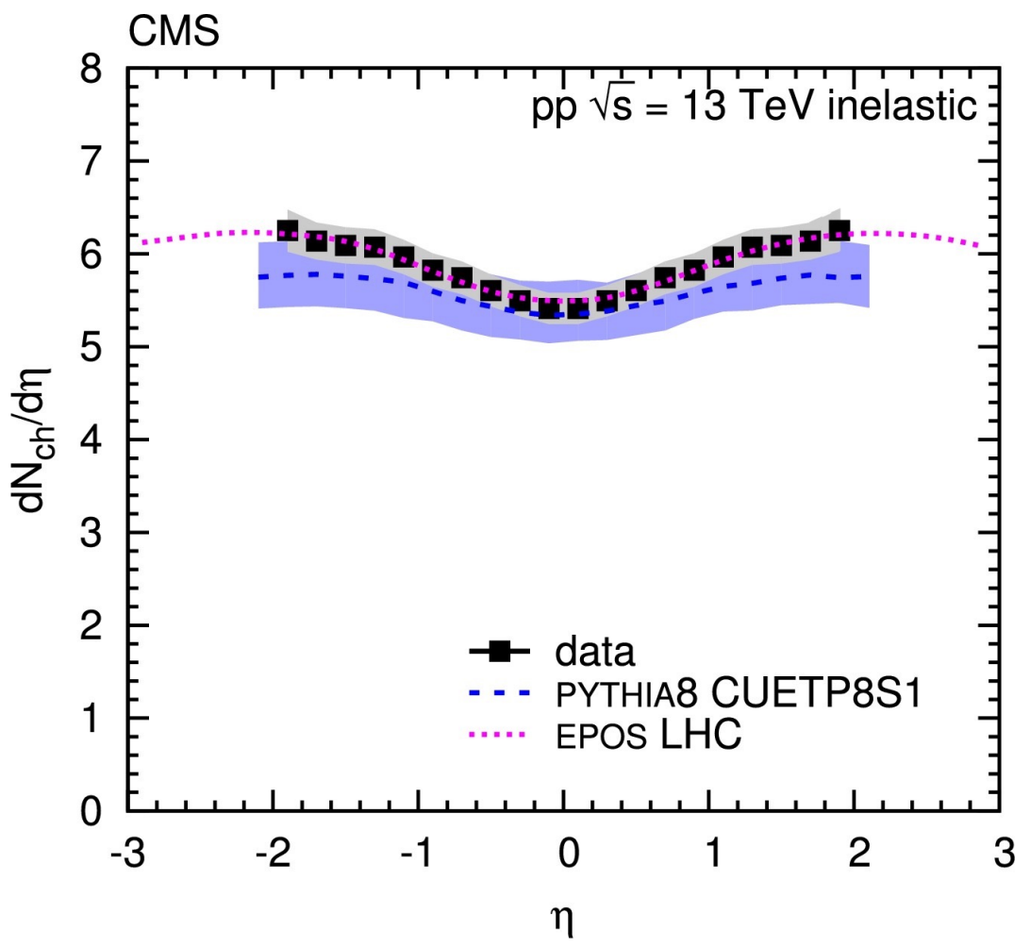

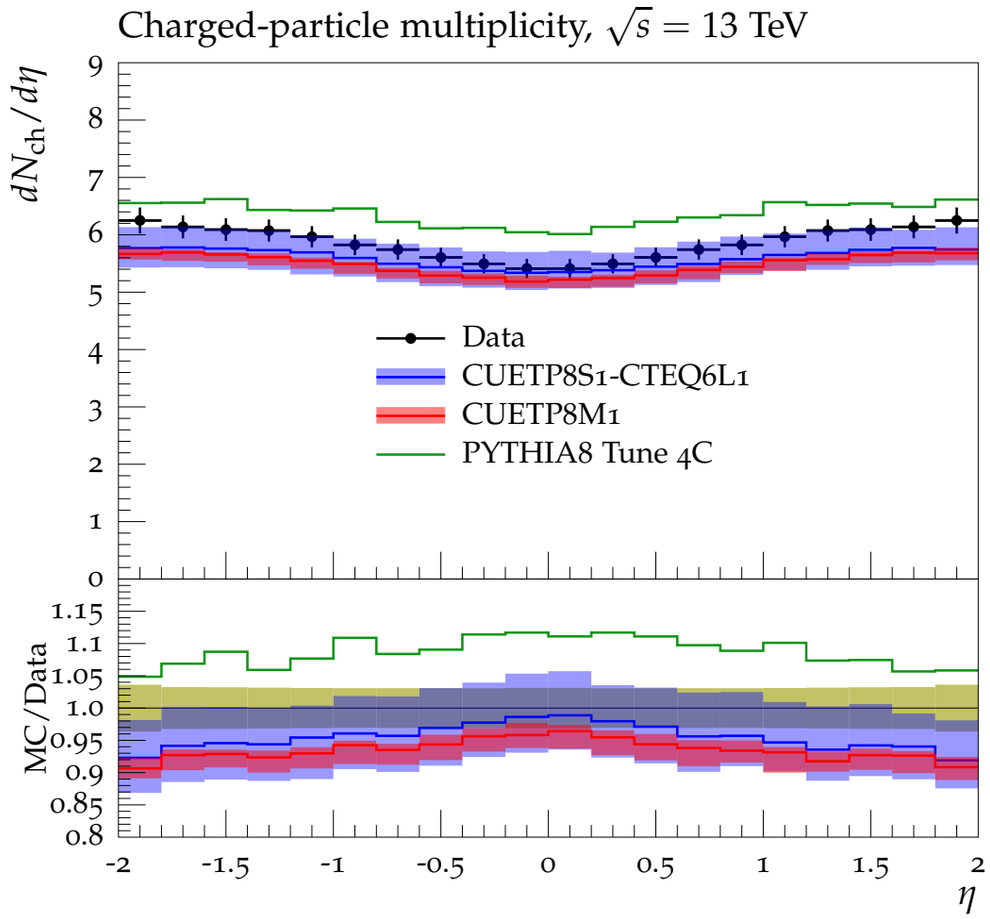

PHYTHIA8 (CUETP8M1 and CUETP8S1) and EPOS LHC agree with the measurement within the error bands

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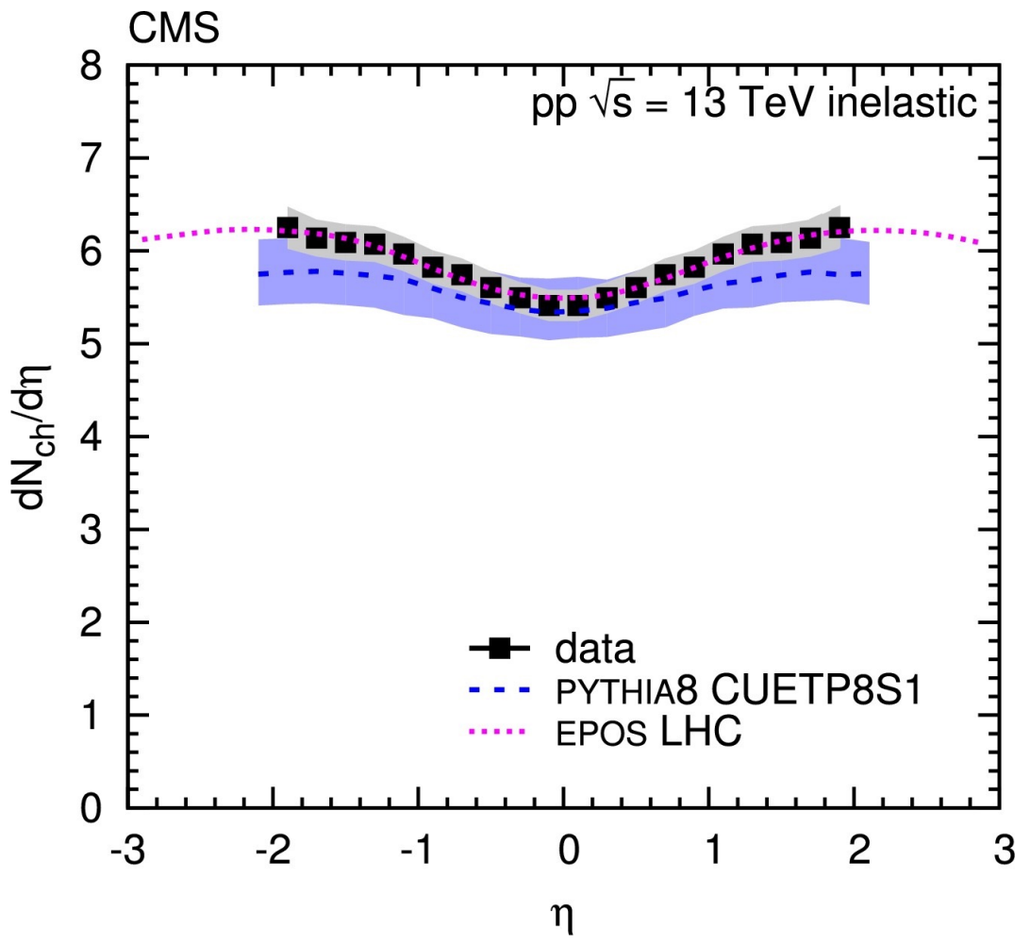

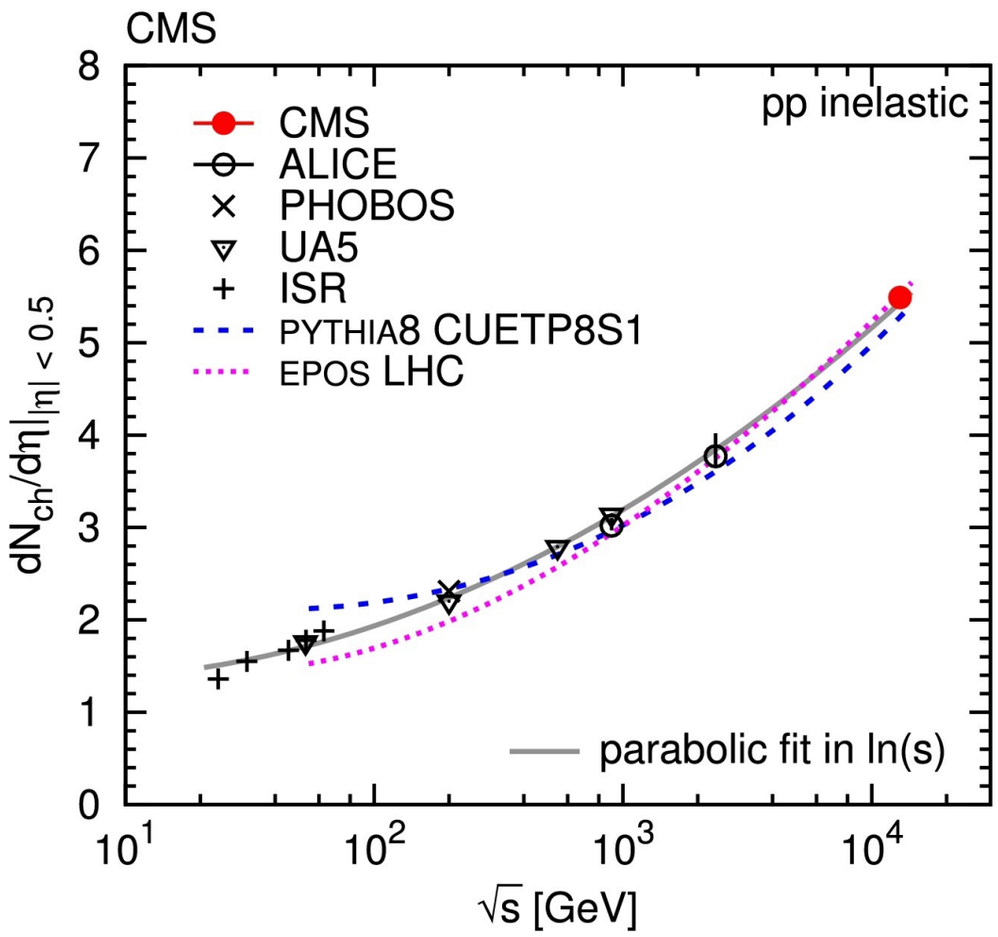

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Pseudorapidity at 8 TeV

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  - Presented for different **diffractive event selections (TOTEM event selection)**
  - Corrected down to zero transverse momentum
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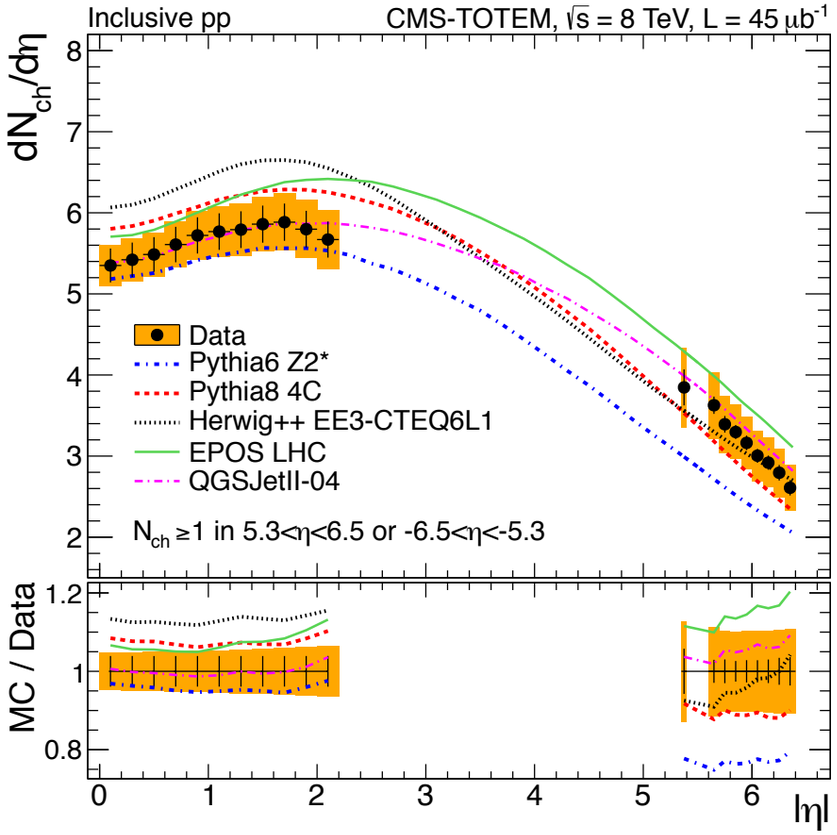
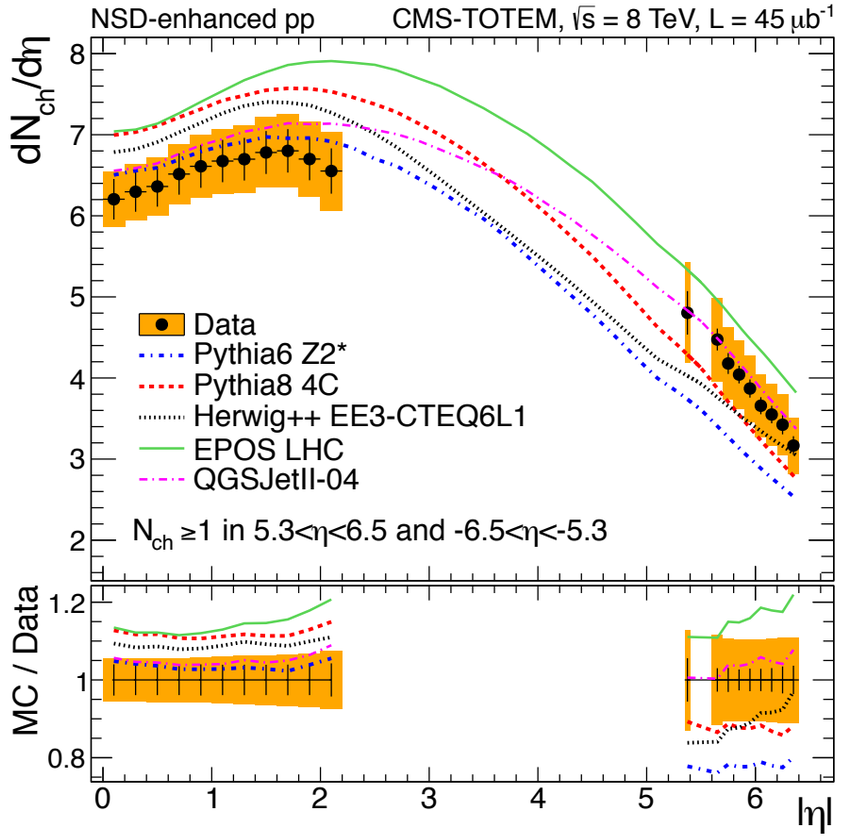
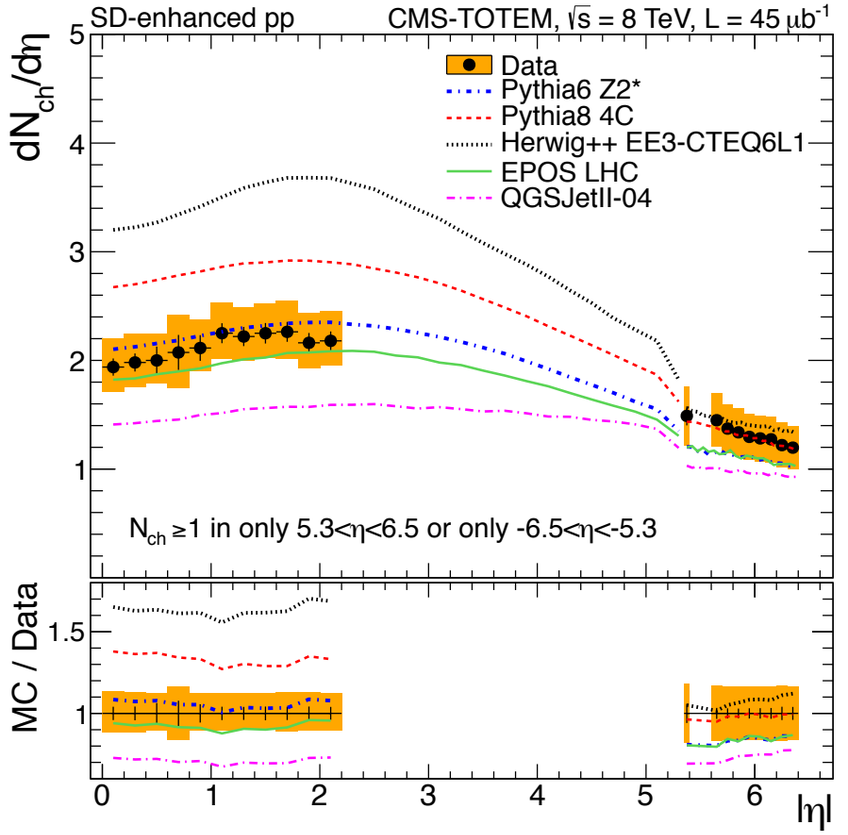
TOTEM acceptance: $5.3 < |\eta| < 6.4$







Eur. Phys. J. C (2014) 74:3053

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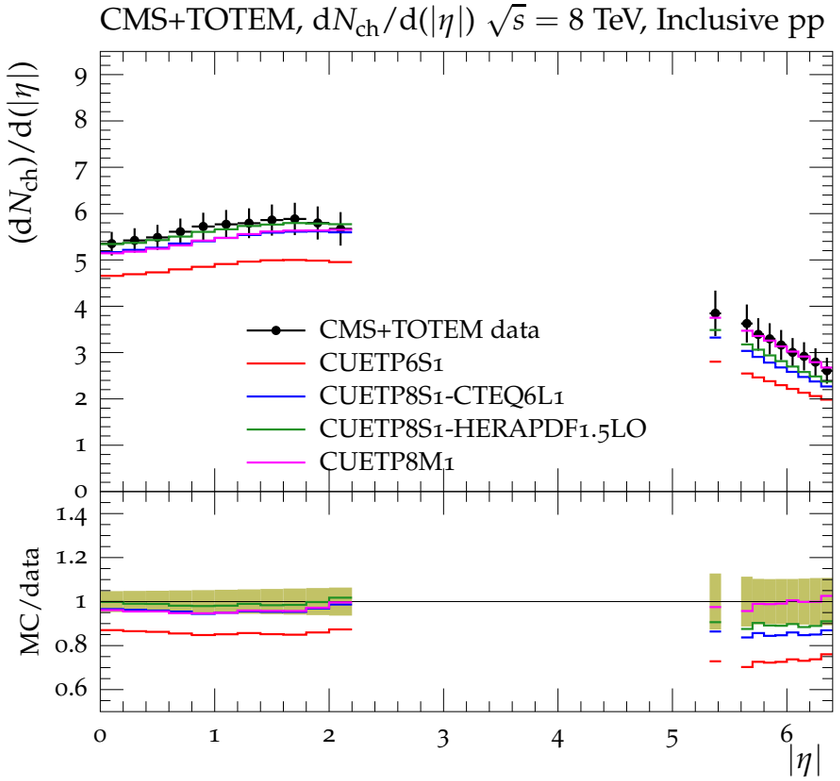
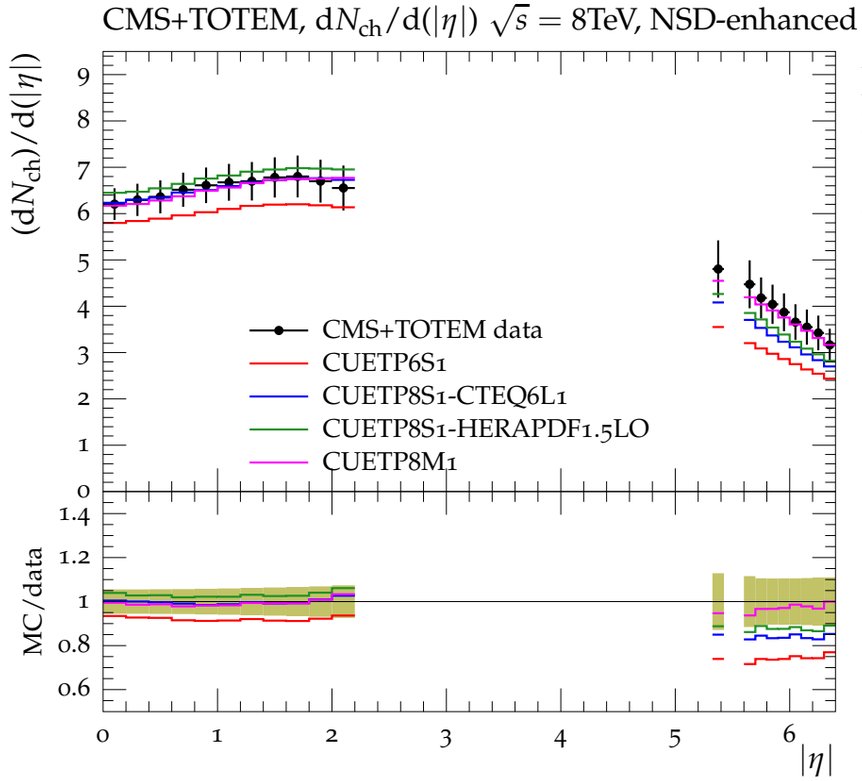
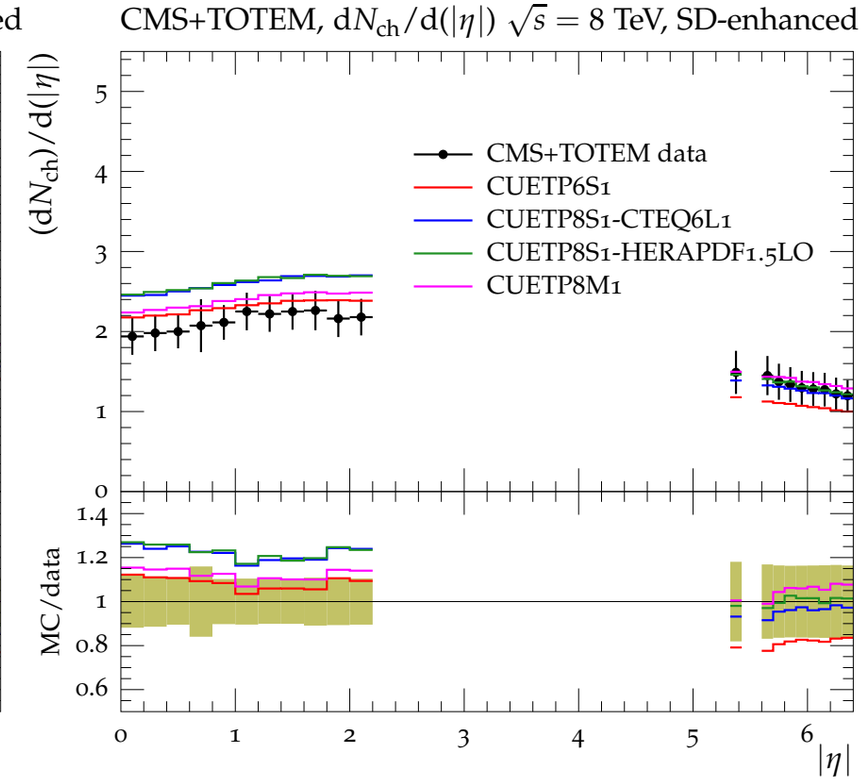






Results after tuning

[Eur. Phys. J. C (2014) 74:3053]

Pseudorapidity Predictions

Event selection

We can implement a similar event selection but instead of TOTEM we use particles in the range $3 < |\eta| < 5$ (HF calorimeter) in the following way:

- **Non-Single Diffractive enhanced:** at least one **particle** with E>**5**GeV on each side.
- **Single Diffractive enhanced:** at least one **particle** with E>**5**GeV on one side. Other side **no particle** with E>**5**GeV.
- **Inelastic enhanced:** at least one **particle** on either side with E>**5**GeV.

Particle selection

- $-2.4 < |\eta| < 2.4$ (Tracker acceptance)
- $pT > 500MeV$
- Final State Charged particles

Pseudorapidity at 3.8T and diffractive events. Predictions

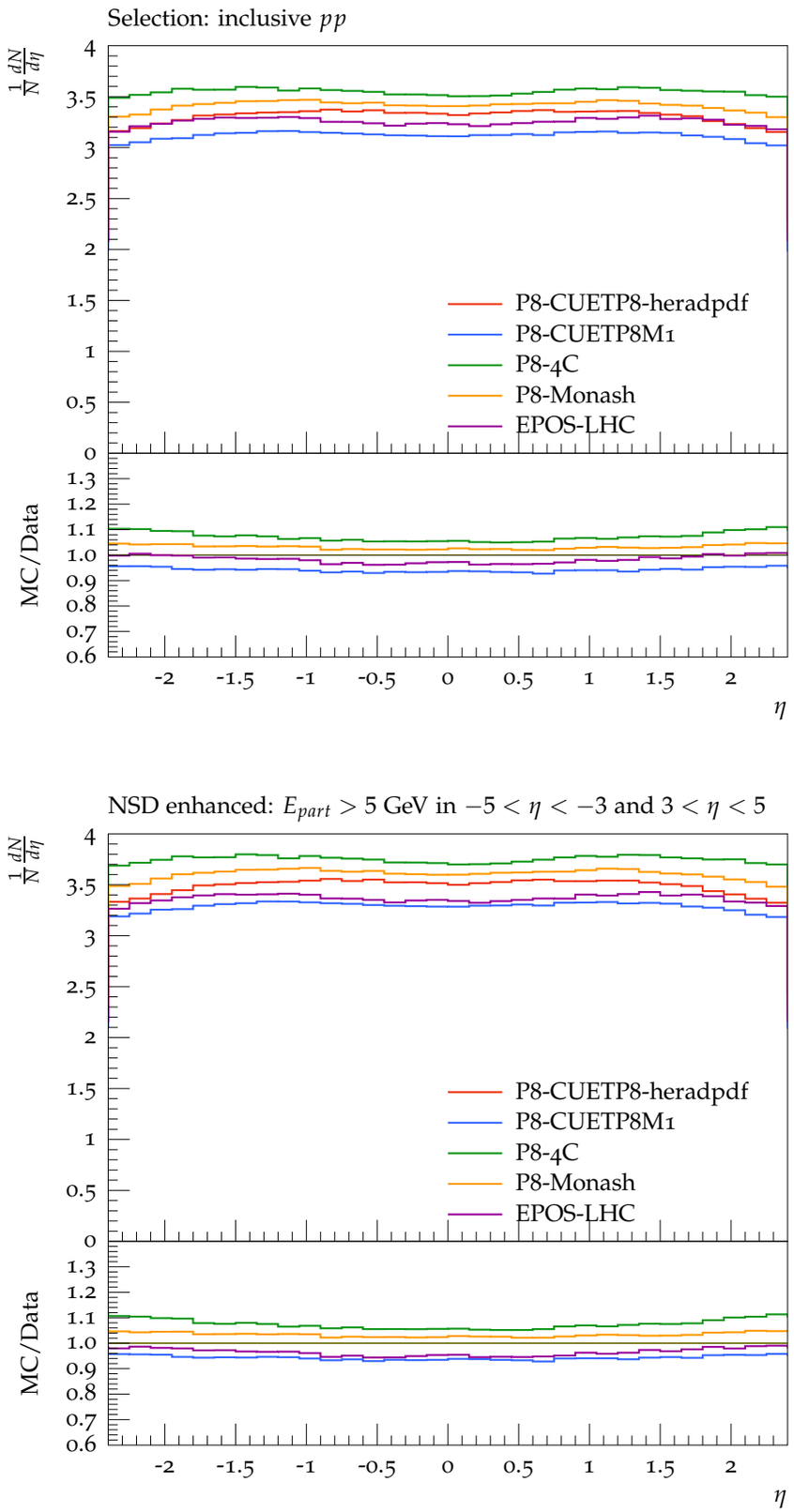
The **shape** of all the predictions **for the inclusive and inelastic** selections is **very similar**, only changing the predicted value by ~0.5 particles per η unit.

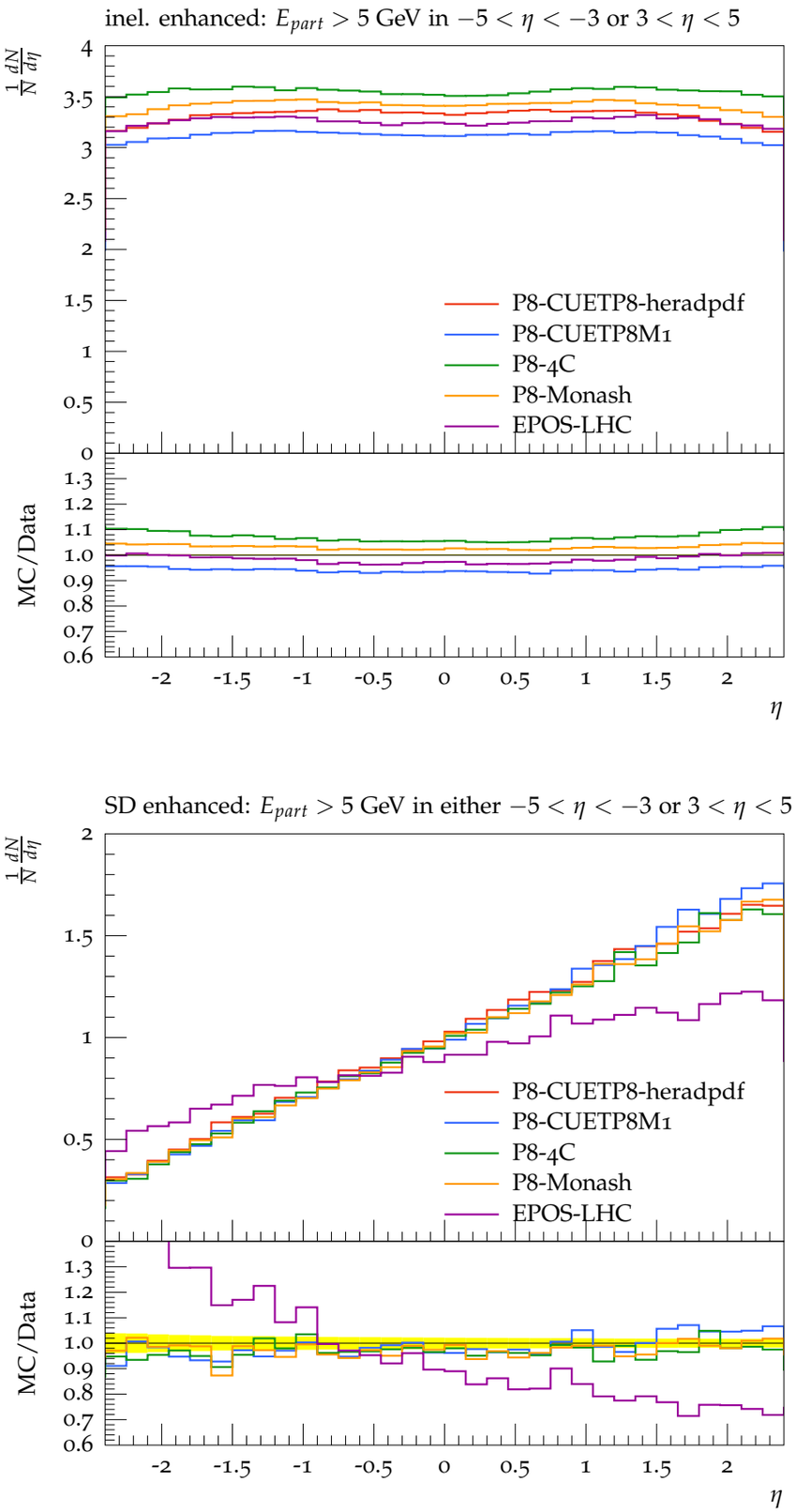
For the **NSD selection**:

PYTHIA8 Tunes predict the same shape with different values, while **EPOS-LHC** has a valley in the central region.

For the **SD selection**:

PYTHIA8 Tunes predict significantly different behaviour than **EPOS-LHC**.





Integrated-pT

Measuring on different diffractive event topologies

- Will provide further constrains for the models
- Show where each model does a good/bad description

Integrated pT spectrum

- Total 2 —> 2 partonic cross section:

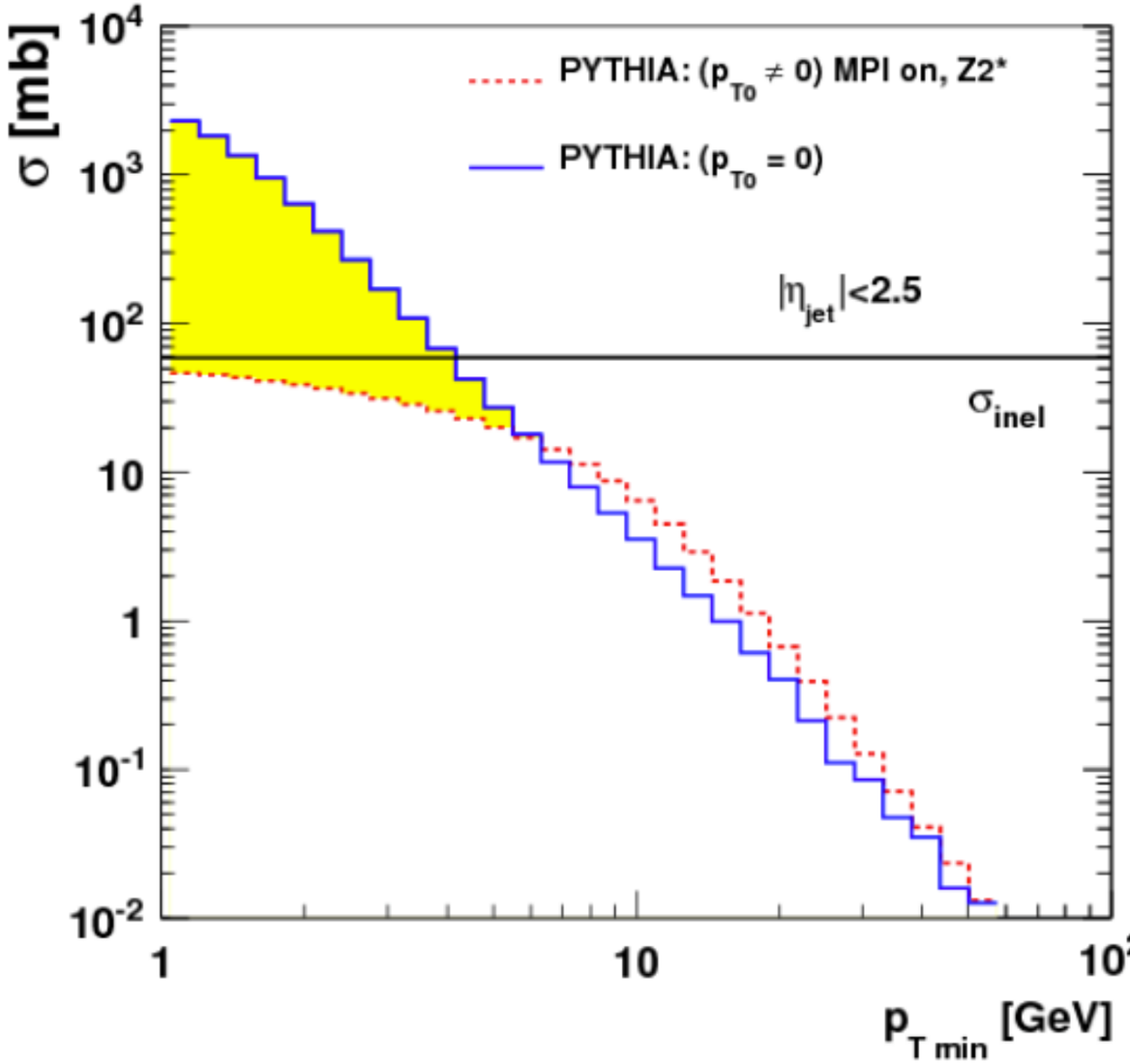
$$\sigma(p_T) \propto \frac{1}{p_T^2}$$

- Divergent towards low pT

$$\sigma(p_T) > \sigma_{inel}$$

—> phenomenological factor

$$[\alpha_s^2(p_{T,0}^2 + p_T^2)/\alpha_s^2(p_T^2)][p_T^4/(p_{T,0}^2 + p_T^2)^2]$$

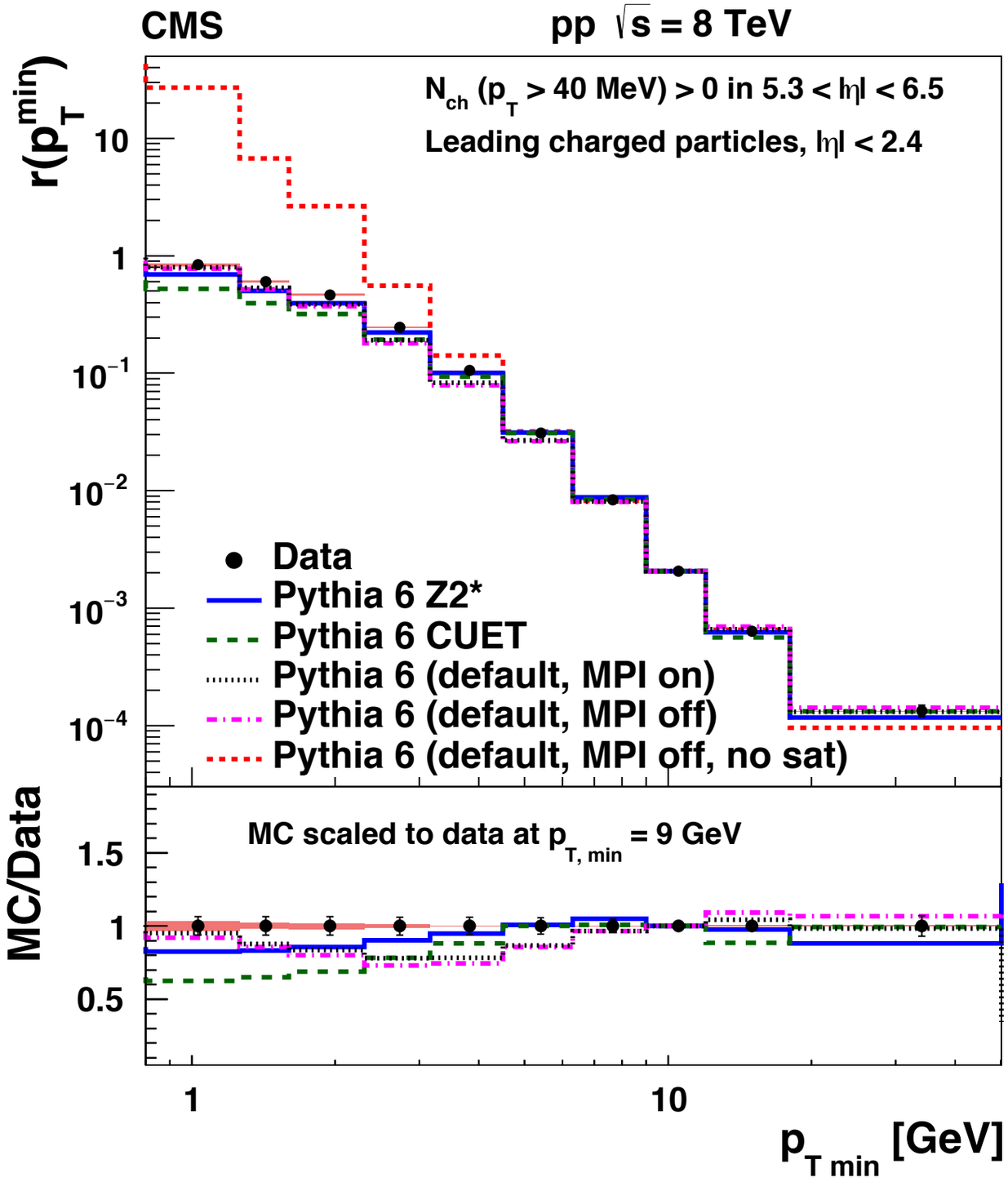


Phys. Rev. D 86 (2012) 117501

Integrated-pT at 8 TeV

Integrated pT spectrum

- At **√s = 8 TeV** the turn over happens at pT-min ~ 5GeV



arXiv:1507.00233

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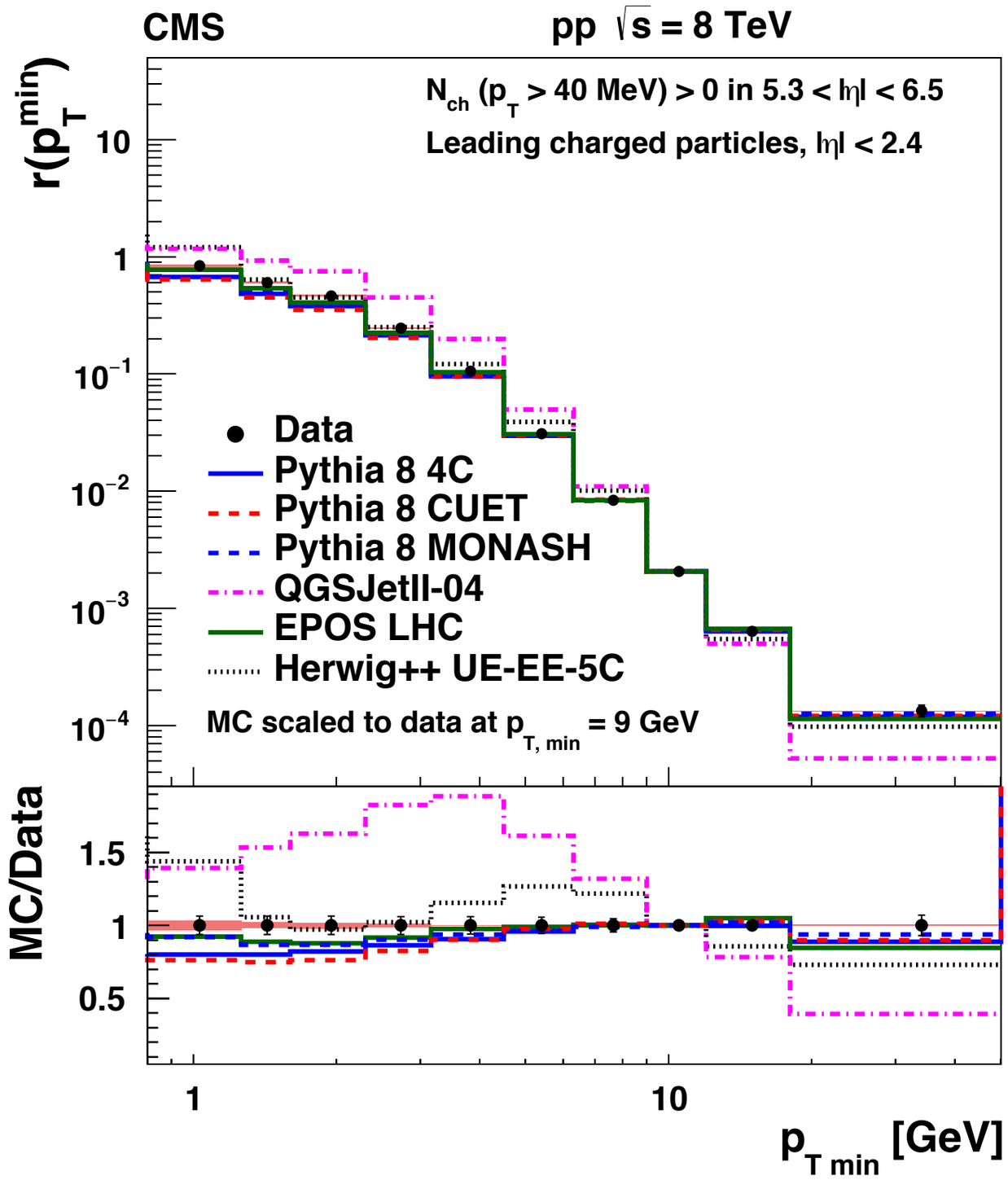
How does it look at **different center of mass energies??**

How does it look for **different diffractive topologies??**



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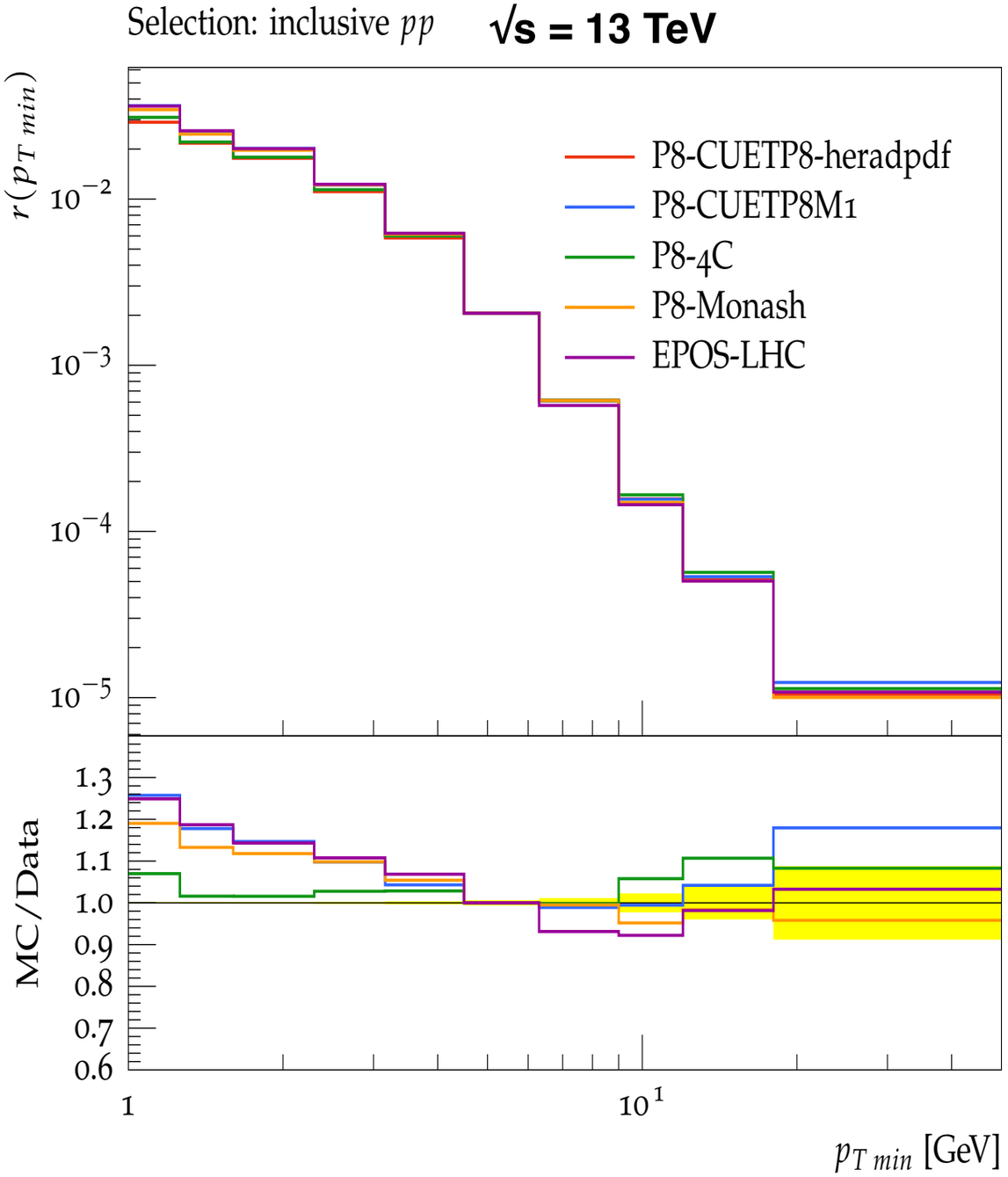
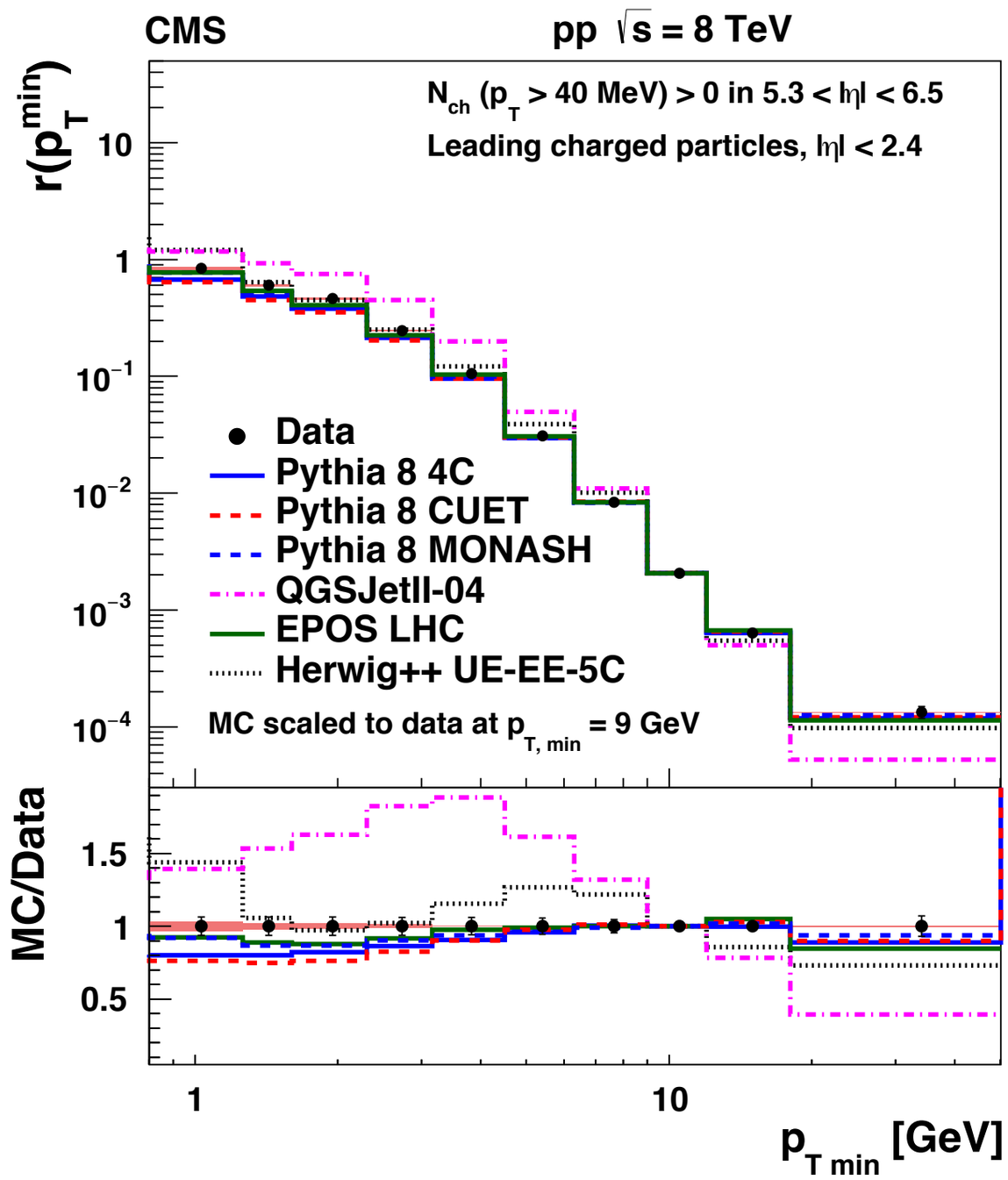
Integrated-pT at 13 TeV. Predictions



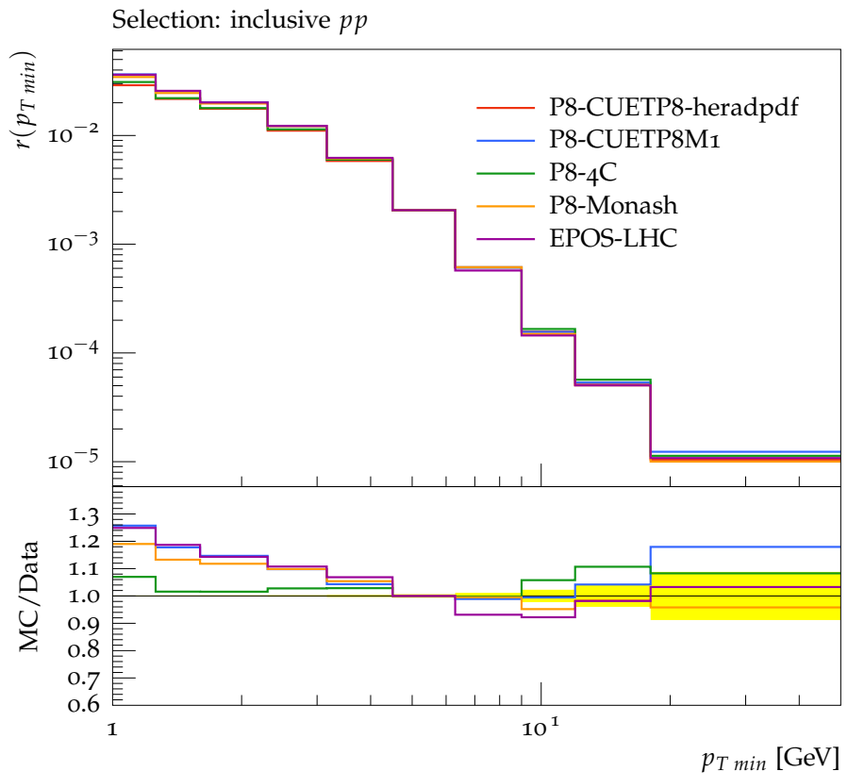


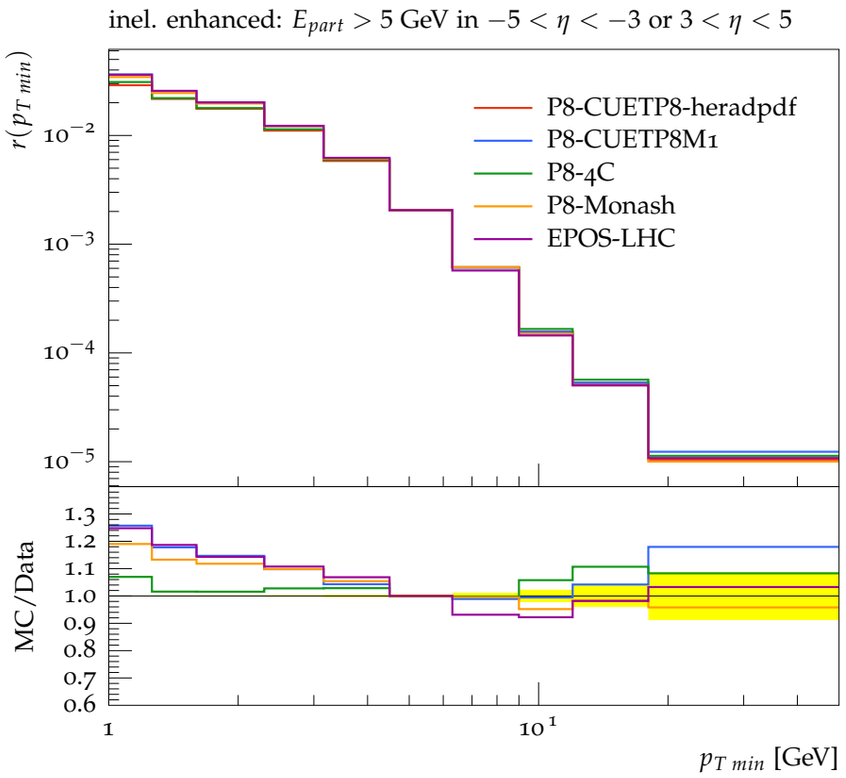
- Similar turn over value

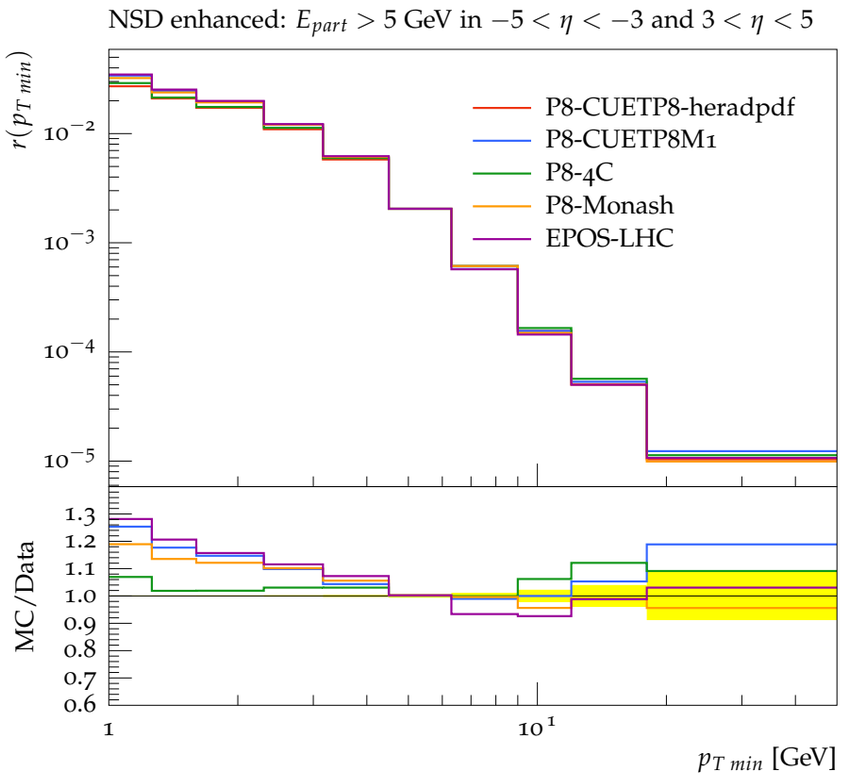
arXiv:1507.00233

Integrated pT leading distribution. Predictions

For inclusive, inelastic enhanced and NSD samples the turn over happens at the same pT-min value



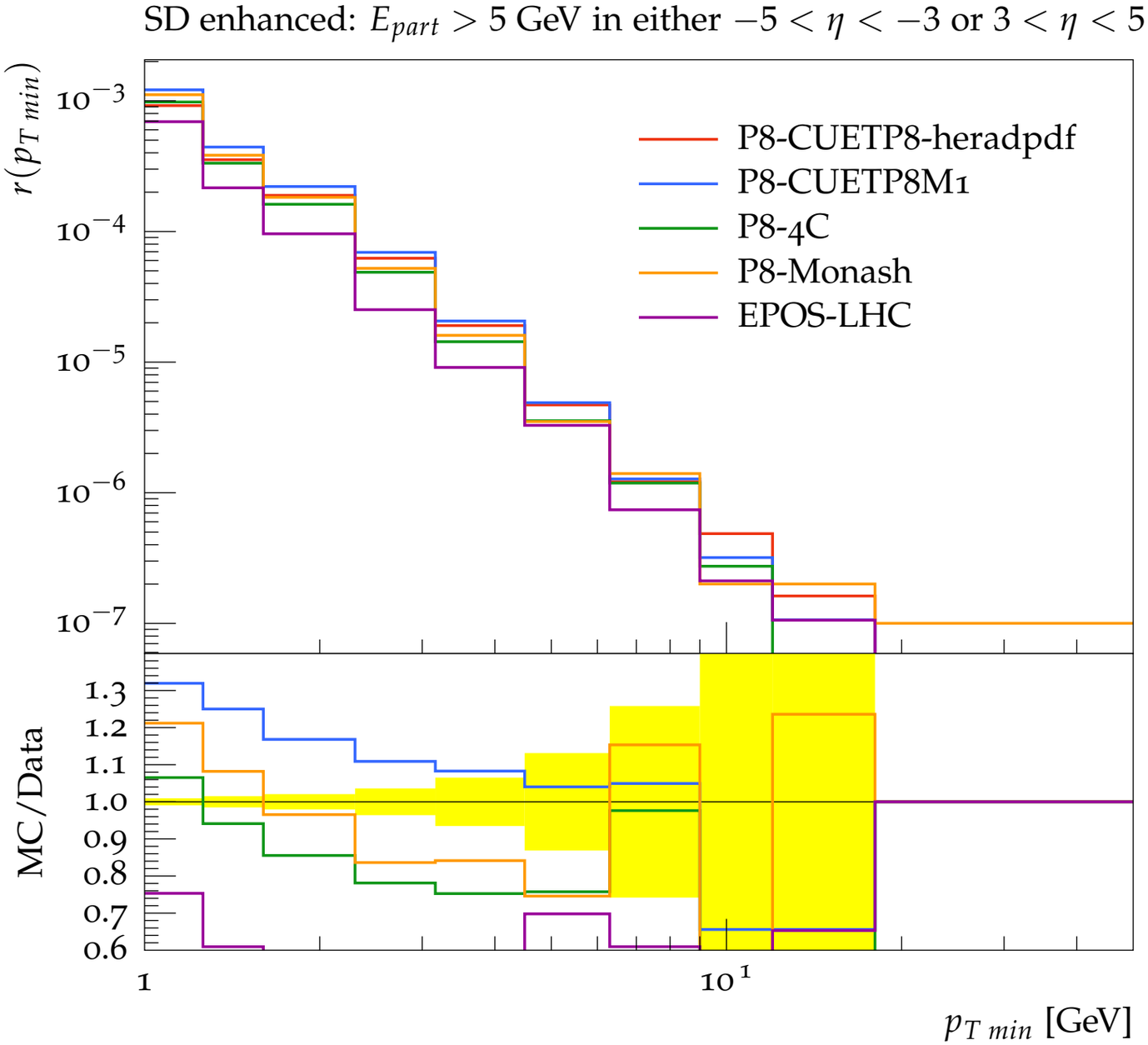




Integrated pT leading distribution. Predictions

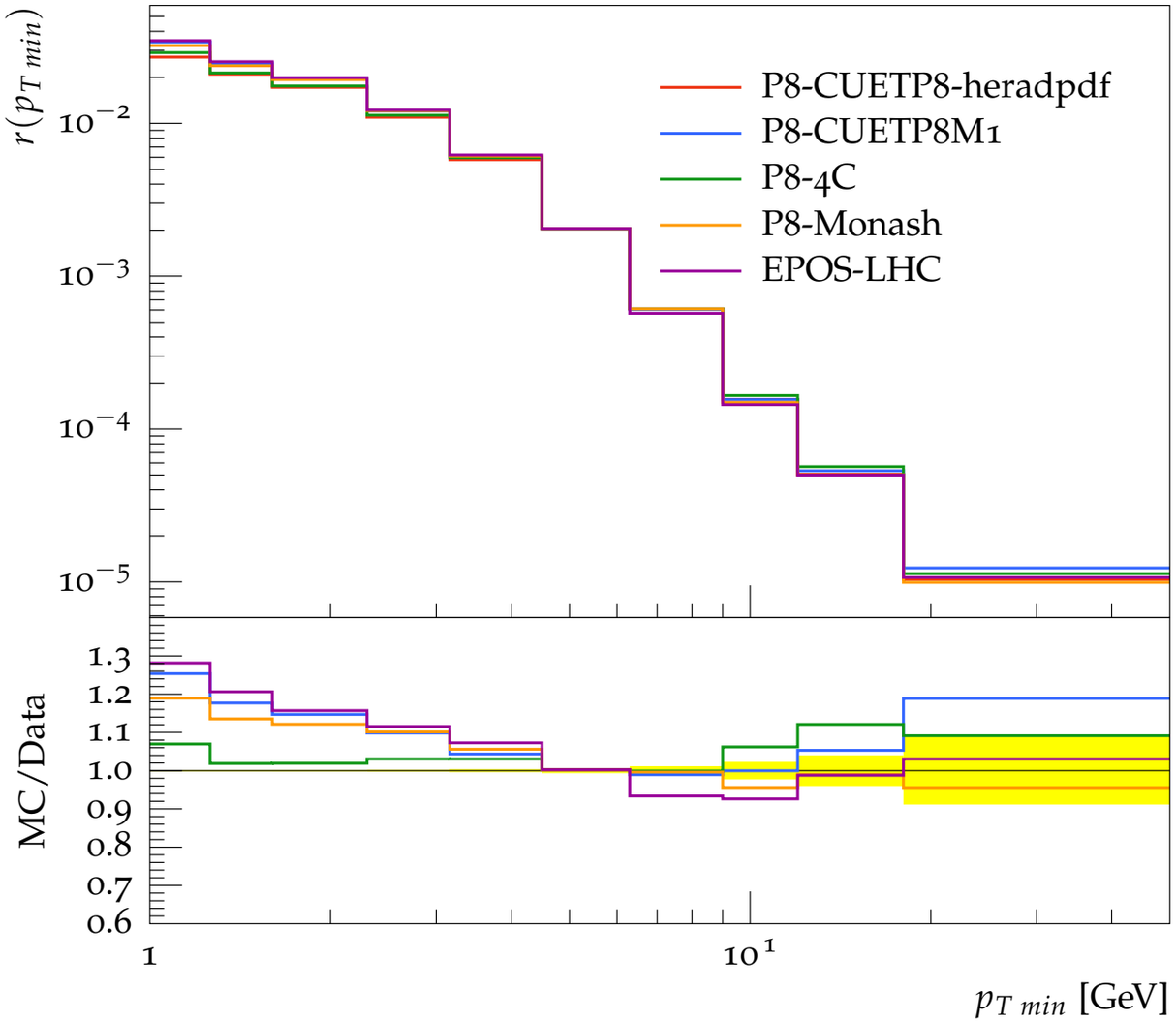
SD enhanced

- Sensitive to smaller effective CM energy — $M_x < s$
- Turn over happens at smaller values of pT-min
- Measuring the $r(p_{\mathrm{T\ min}})$ as a function of Mx one can access the energy dependence of saturation scale



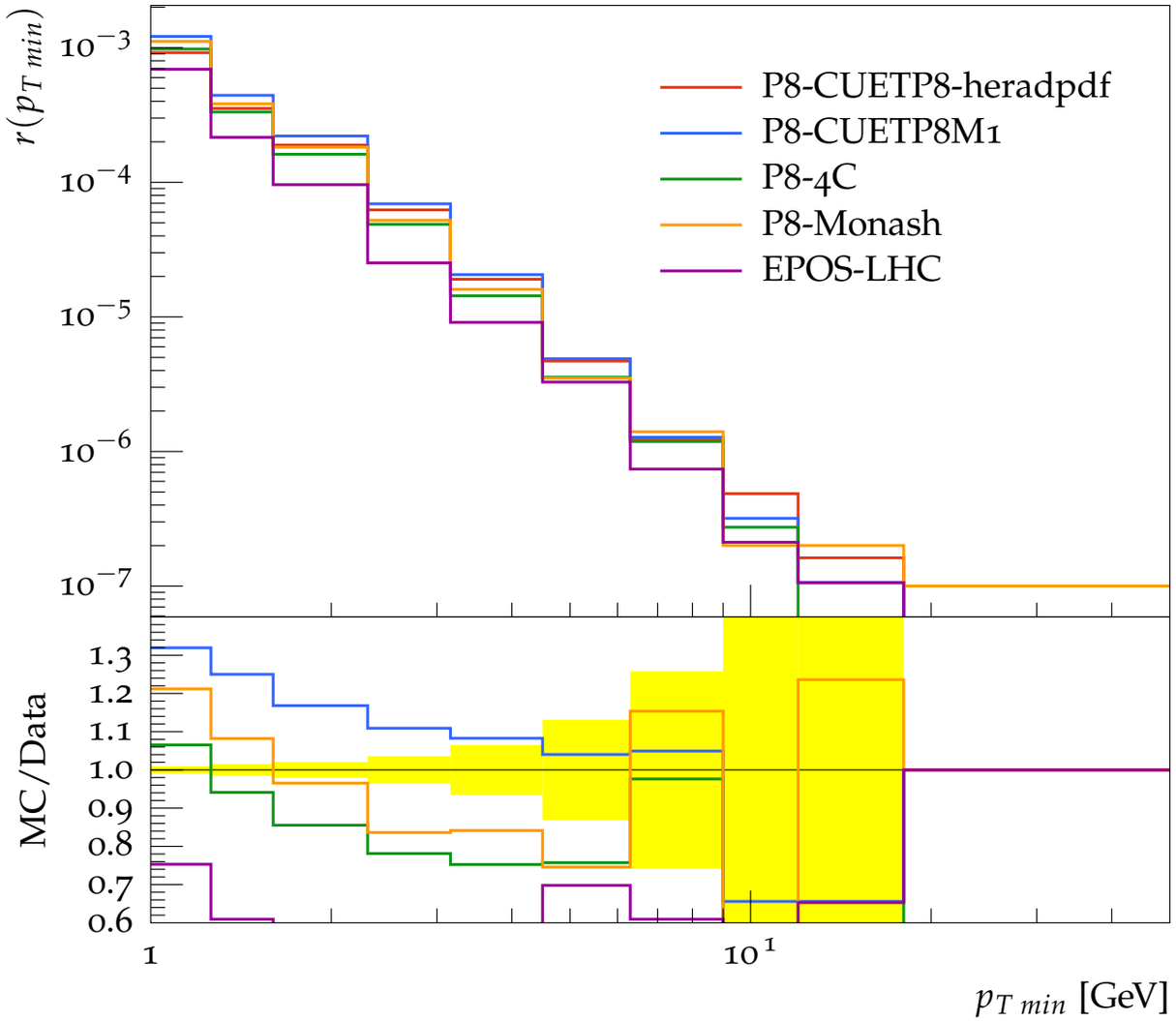
Integrated pT leading distribution. Predictions

NSD enhanced: $E_{part} > 5$ GeV in $-5 < \eta < -3$ and $3 < \eta < 5$



NSD extends to higher pT-min values

SD enhanced: $E_{part} > 5$ GeV in either $-5 < \eta < -3$ or $3 < \eta < 5$



Turn over shifted to small pT-min

Summary

- Pseudorapidity distribution at $\sqrt{s}$ = 13 TeV for inclusive events
- Predictions for the pseudorapidity density at $\sqrt{s}$ = 13 TeV for different event selections
- New proposal for extracting information about the energy dependence of the saturation scale
- Experimental results to be released soon