Measurement of the Underlying Event in pp collisions at 13 TeV with ALICE at the LHC

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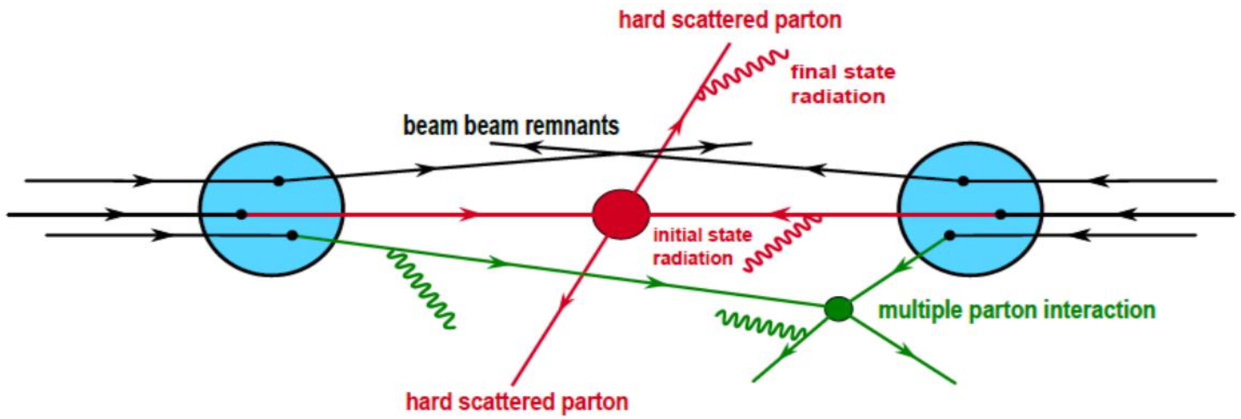
Outline

- Physics motivation
- ALICE detector
- Analysis procedures
- Results: charged particle density and sum p_T density
- Comparison: ALICE vs. ATLAS in Transverse region
- Conclusion and outlook

Physics motivation

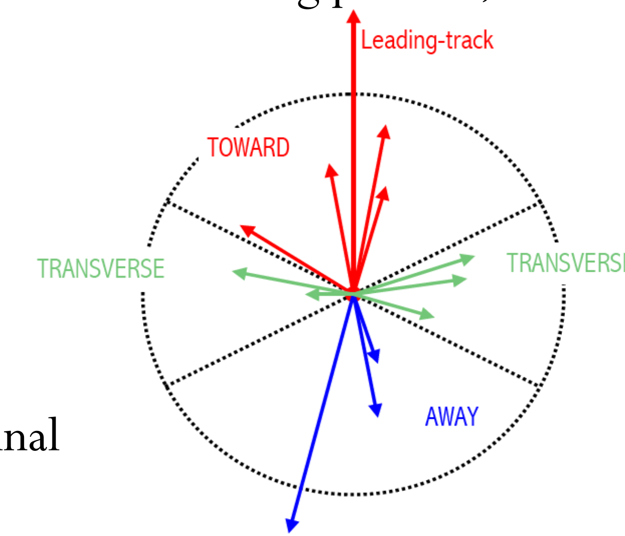
- Underlying Event: everything in single particle collision except the hard process of interest.
  - MPI, initial and final state radiations, beam remnants etc.



- Why it is important to study Underlying Event(UE)?
  - UE measurement is a basic step of event characterization process.
  - The UE allows to access deep information of the hadronic structure, it has also impact on Isolations, jet pedestals, etc.
  - While searching for energetic particles produced in the collision, we must have a good idea about the ambient activity in the event.

Observables

- Traditional UE measurement: according to the azimuthal direction of leading particle, we define three distinct topological regions,
  - Toward $|\Delta\Phi| < \pi/3$.
  - Away $|\Delta\Phi| > 2\pi/3$.
  - Transverse $\pi/3 < |\Delta\Phi| < 2\pi/3$.
    - ✓ Maximal: the fragmentation products of the semi-hard final state radiation.
    - ✓ Minimal: soft component of the UE, such as beam remnants, MPI.



- The main observables in UE measurement.
  - Average charged particles density vs. leading track p_T.

$$\frac{1}{\Delta\eta\Delta\Phi}\frac{1}{N_{ev}\left(p_T, lead\right)}N_{ch}\left(p_T, lead\right)$$

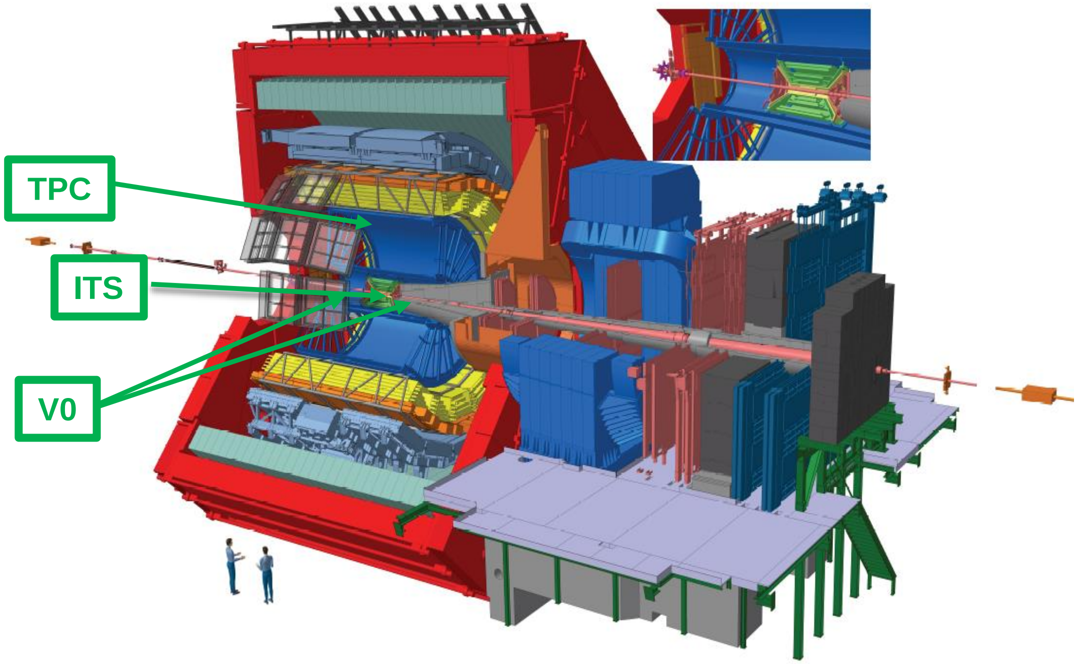
  - Average sum-p_T density vs. leading track p_T.

$$\frac{1}{\Delta\eta\Delta\Phi}\frac{1}{N_{ev}\left(p_T, lead\right)}\sum p_T\left(p_T, lead\right)$$

ALICE detector

Inner Tracking system(ITS)

- $|\eta| < 1.3$
- SPD, SDD, SSD
- Vertex reconstruction
- Charged particle tracking
- Event trigger



Time projection chamber(TPC)

- $|\eta| < 0.9$
- Charged particle tracking
- Particle identification

V0

- V0A: $2.8 < \eta < 5.1$, V0C: $-3.7 < \eta < -1.7$
- Multiplicity
- Event trigger

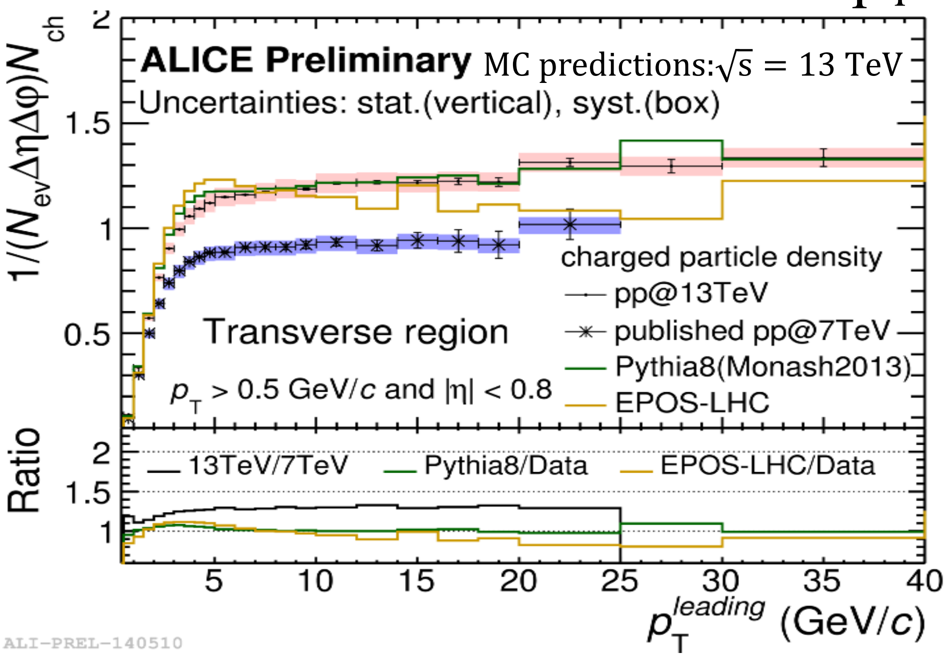
Data: ALICE collected data in pp collision at 13 TeV in 2016.

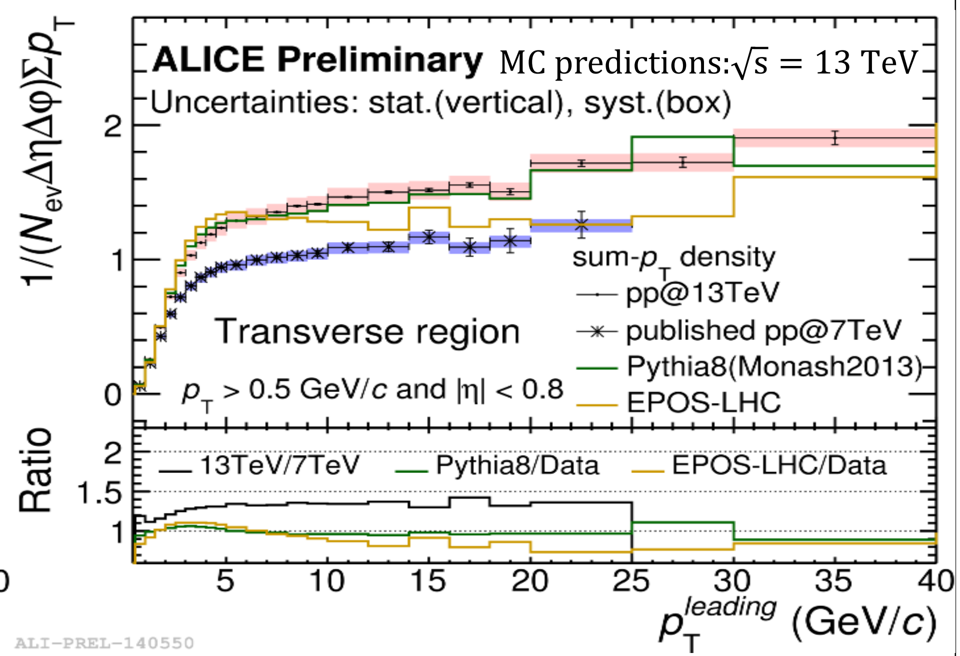
Monte-Carlo: PYTHIA8(Monash2013), EPOS-LHC.

Analysis procedures

- Event and track selection
  - Minimal bias event, reject pile up event, $|Z_{vtx}| < 10$ cm.
  - Remove secondaries, three track p_T cuts: 0.15 GeV/c , 0.5 GeV/c , 1 GeV/c .
- Correction procedures.
  - Leading track misidentification: the true leading track is not reconstructed .
    - ✓ bin migration or topological rotation of overall event.
    - ✓ Data driven method and pure Monte-Carlo method.
    - ✓ Only affects the range of leading track $p_T < 5$ GeV/c.
  - Tracking efficiency: undetected particles due to the insensitive regions of the detector.
  - Track contamination: remove secondary tracks.
    - ✓ PYTHIA cannot describe the strangeness production well.
    - ✓ A strangeness bias correction is considered.
  - Vertex reconstruction: the events which have a negligible number of reconstructed tracks.
    - ✓ Effect on low leading track p_T bins.
- Systematic uncertainty
  - All the essential systematic uncertainty sources have been considered.

Charged particle density and sum p_T density in transverse region for track p_T>0.5 GeV/c

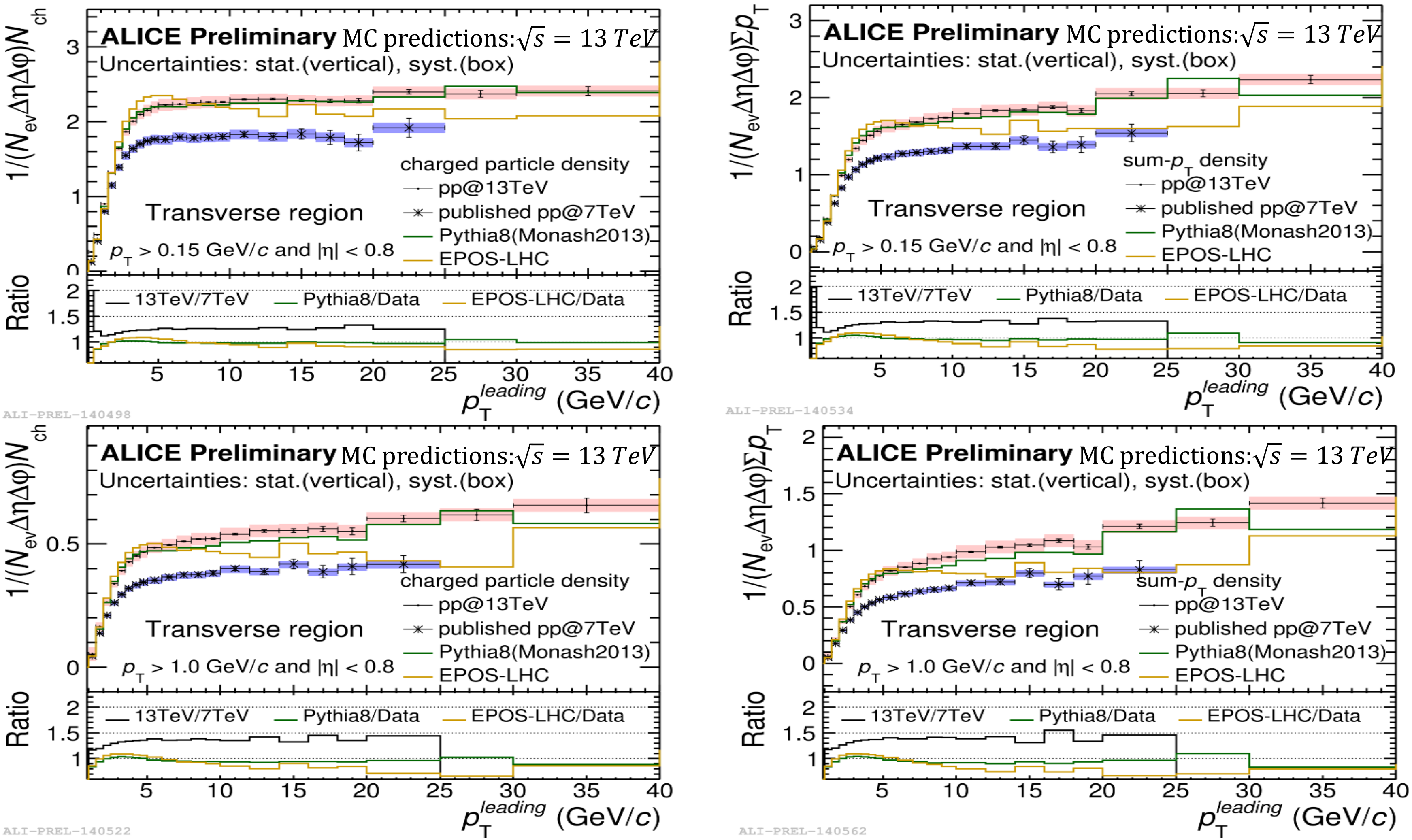




- 7 TeV results: JHEP 07 (2012) 116, ALICE published paper.
- Saturation value: mean value of a line fit in plateau range(10 GeV/c < p_T < 40 GeV/c).
  - Only statistical uncertainty is considered.
  -

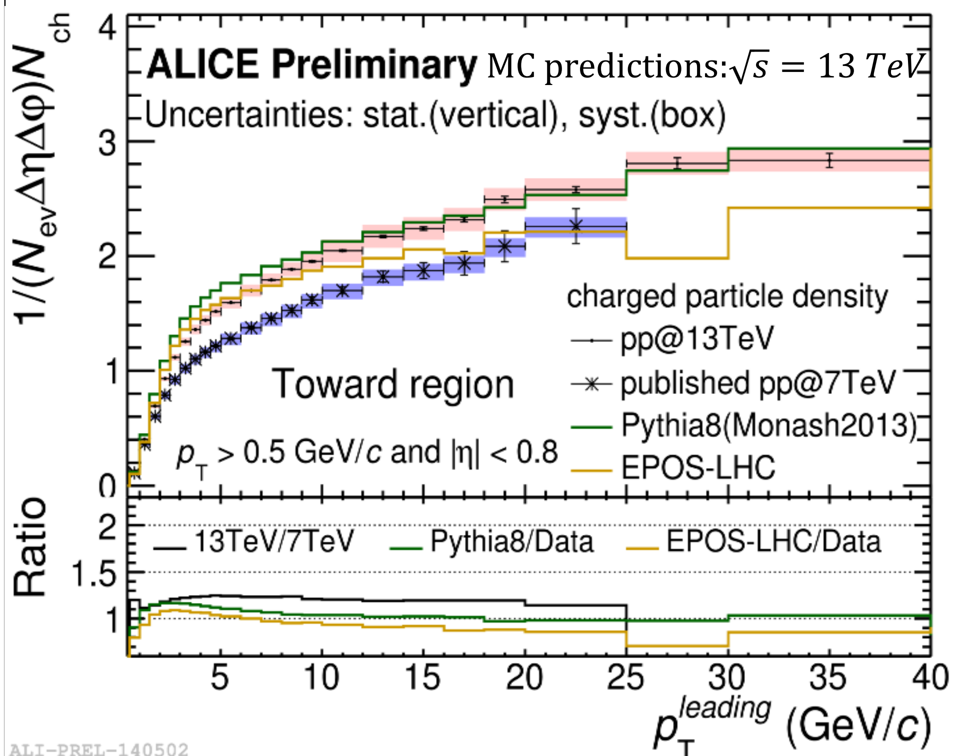
	13 TeV	7 TeV
p_T>0.15 GeV/c	2.34 ± 0.03	1.82 ± 0.06
p_T>0.5 GeV/c	1.28 ± 0.02	0.95 ± 0.03
p_T>1.0 GeV/c	0.60 ± 0.01	0.41 ± 0.01

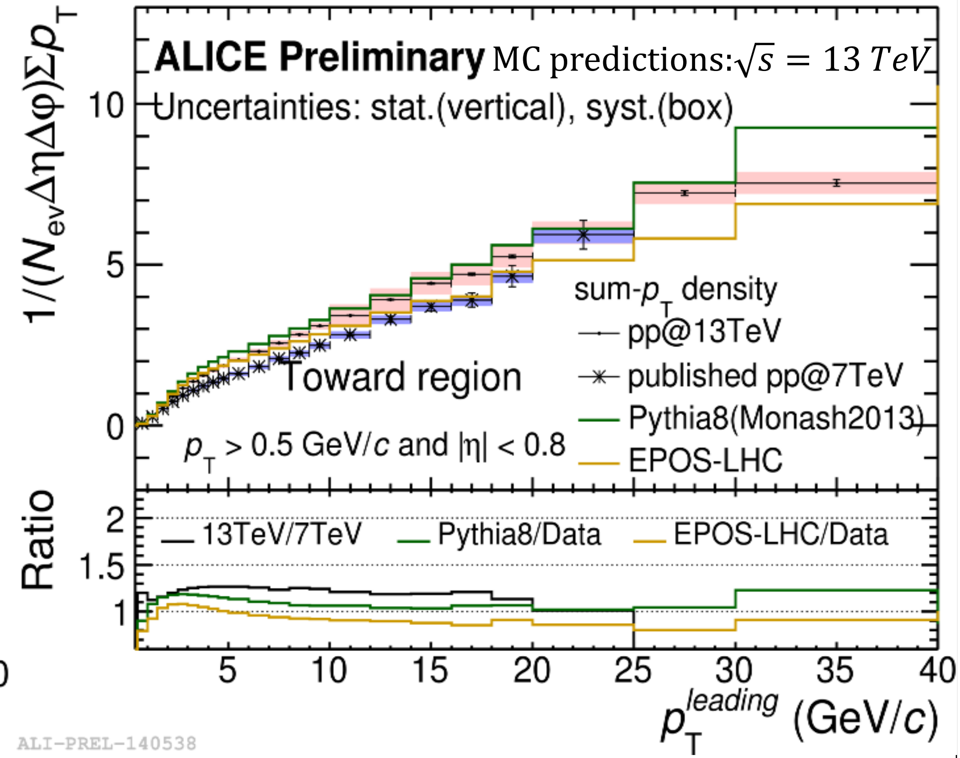
Charged particle density and sum p_T density in Transverse region for track p_T>0.15 GeV/c and p_T>1.0 GeV/c



- There distributions are similar for both observables with different track p_T cuts .

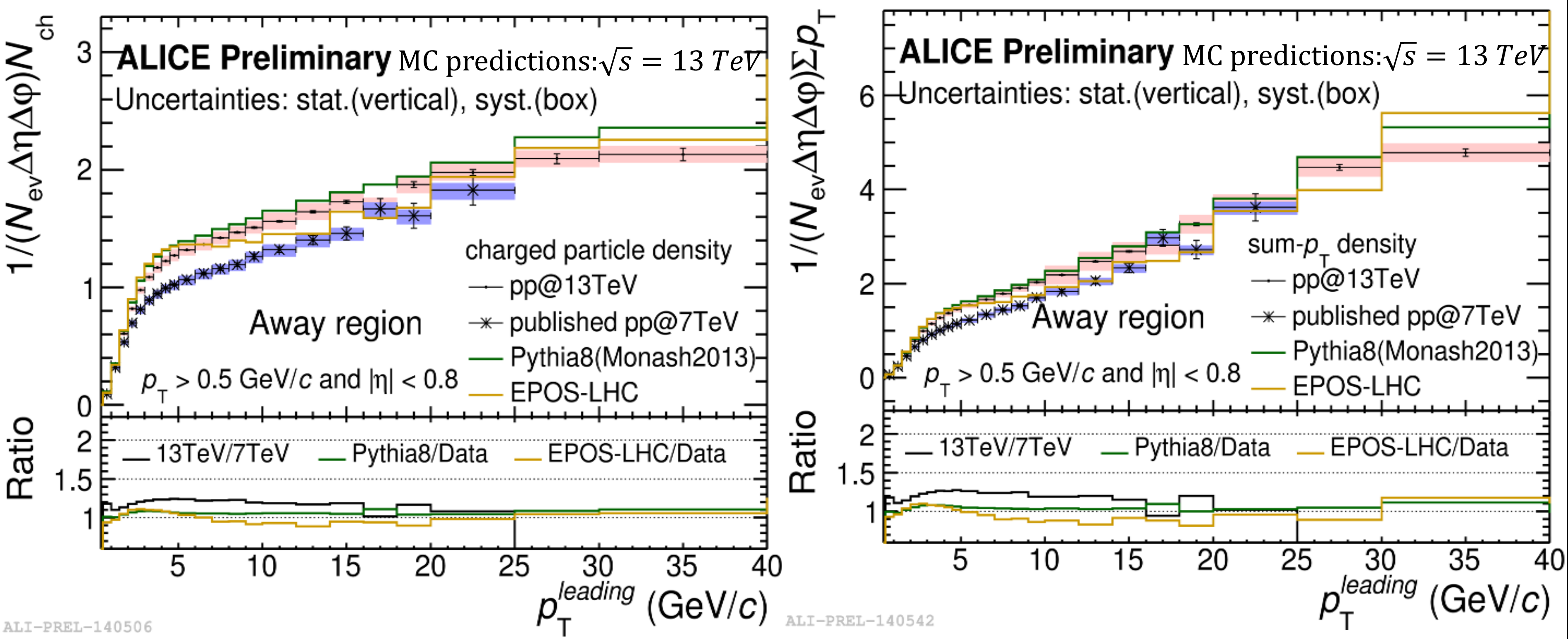
Charged particle density and sum p_T density in Toward region for track p_T>0.5 GeV/c





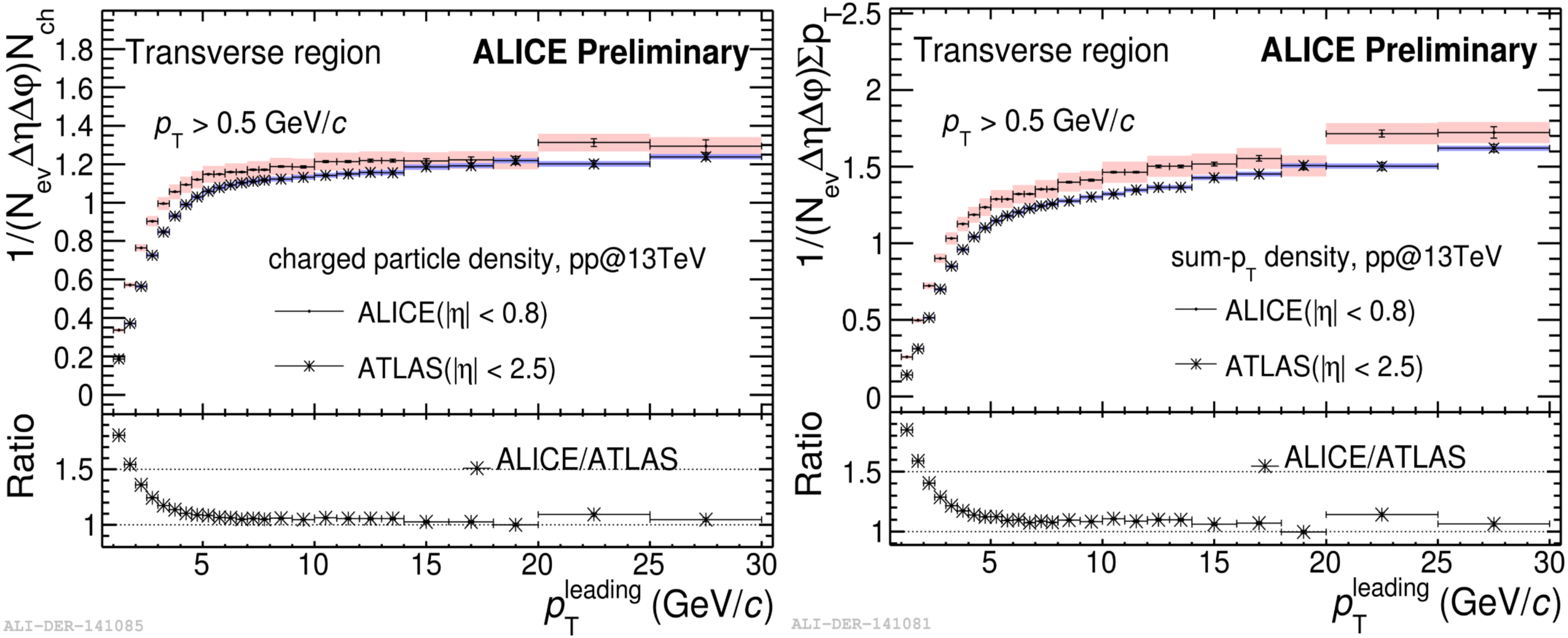
- Components: near-side jet + UE.
- Neglect the leading charged particle contribution.
- Distributions increase monotonically with leading track p_T.

Charged particle density and sum p_T density in Away region for track p_T>0.5 GeV/c



- Components: away-side jet + UE.
- Distributions increase monotonically with leading track p_T.

Comparison: ALICE vs. ATLAS in Transverse region



- ATLAS: JHEP 03 (2017) 157, ATLAS published paper.
- In general, ALICE results are higher than ATLAS results, the ratio rises at low leading p_T and flattens at higher leading p_T.

Conclusion and outlook

Conclusion

- Underlying Event measurements of the charged particle density and sum p_T density in pp collision at 13 TeV with ALICE have been presented.
- Similar distributions for both observables with different tracks p_T cuts.
- In general, PYTHIA8 describes the observed trends better than EPOS-LHC, in particular for high leading p_T.
- ALICE results, narrower η range, are in general higher than ATLAS results. This is most likely due to the larger influence of the leading interaction in a restricted η range.

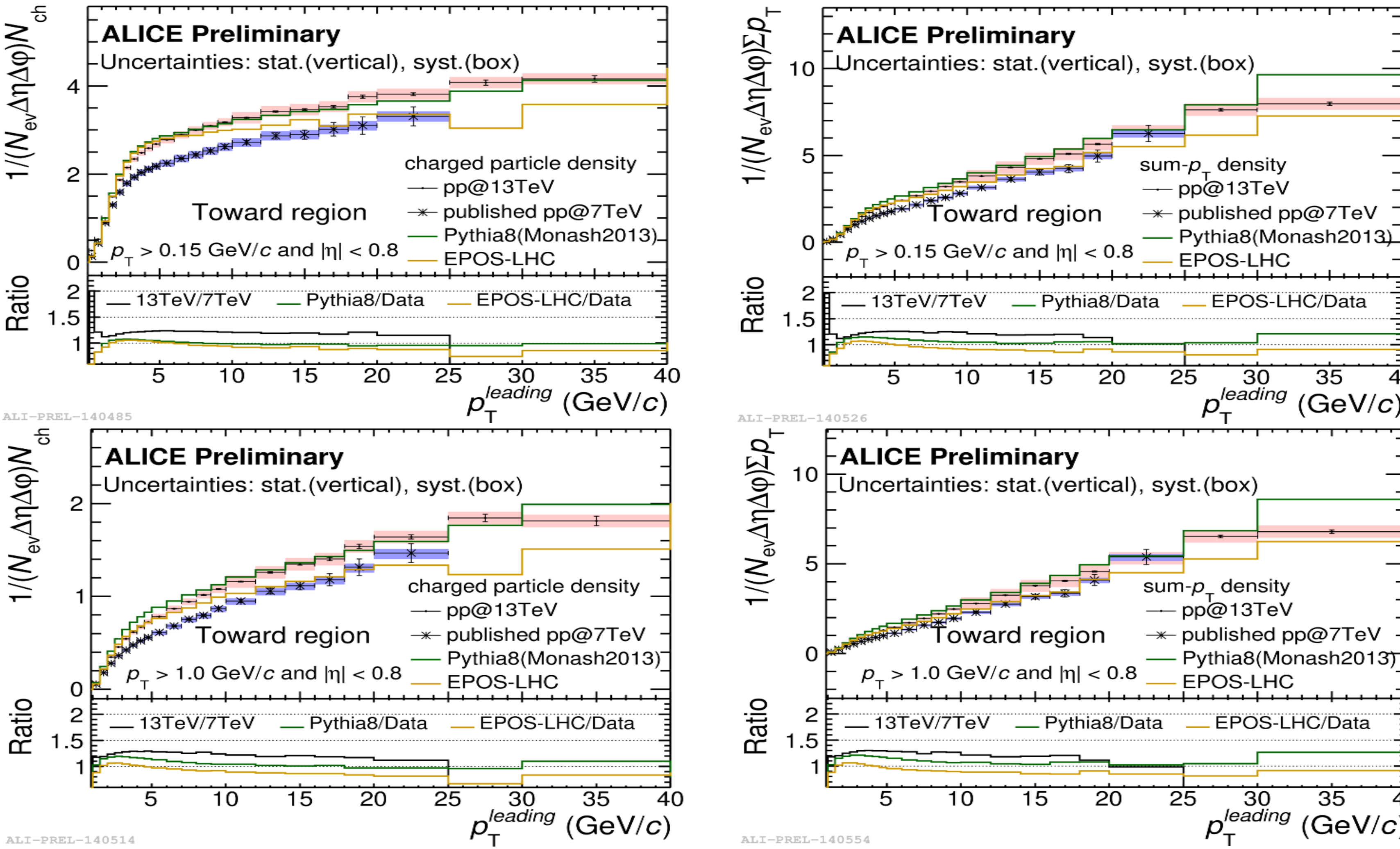
Outlook

- Comparisons between different collision energies (CDF: 1.8 TeV, ALICE: 0.9 TeV, 2.36 TeV, 7 TeV and 13 TeV).

Thank you for your attention !

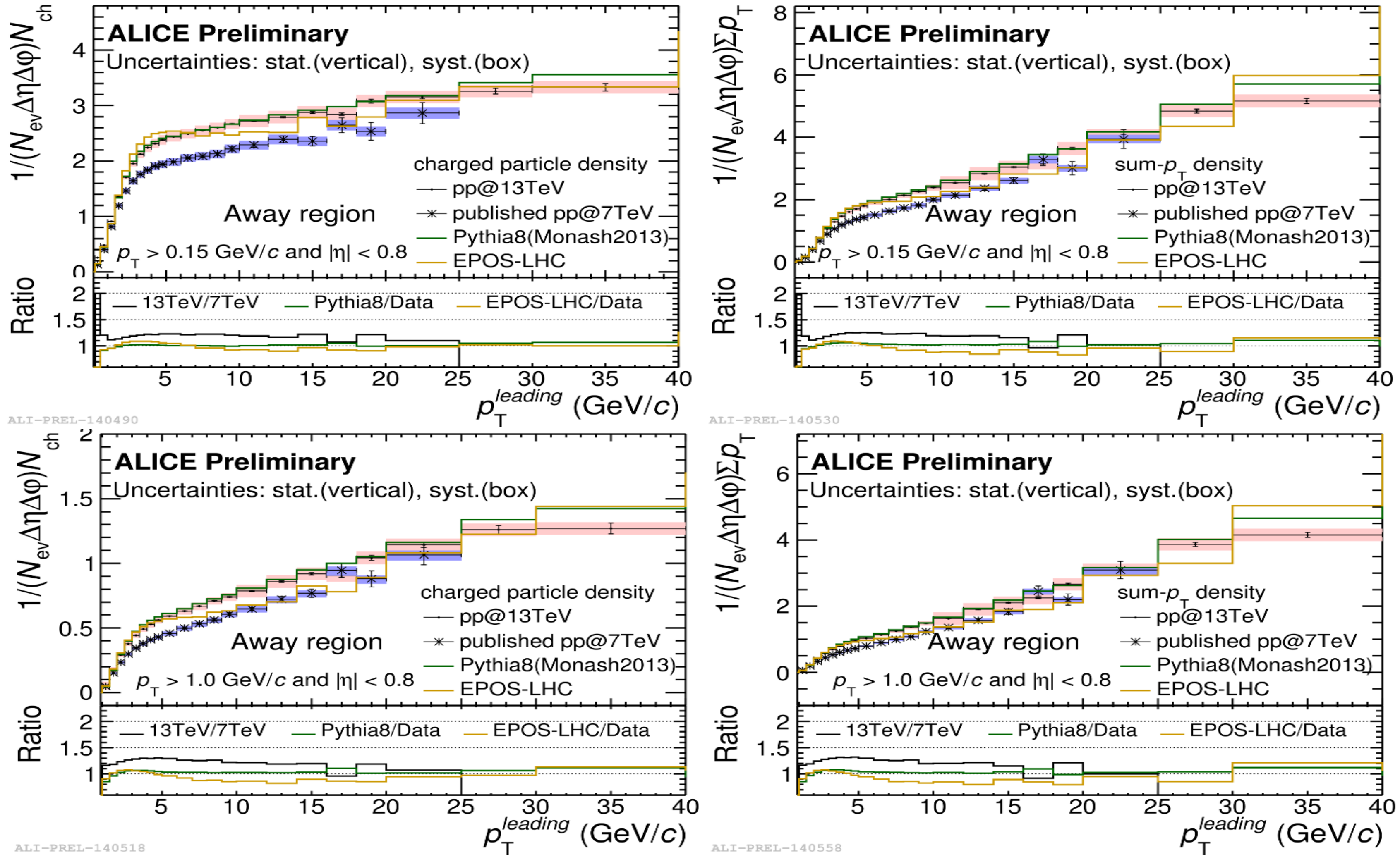
Backup

Charged particle density and sum p_T density in Toward region for track p_T>0.15 GeV/c and p_T>1.0 GeV/c



- There are similar distributions for all two observables with different track p_T cuts .

Charged particle density and sum p_T density in Away region for track p_T>0.15 GeV/c and p_T>1.0 GeV/c



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