Underlying Event Observables in pp and p-Pb Collisions at $\sqrt{s_{\mathrm{NN}}}$ = 5.02 TeV.

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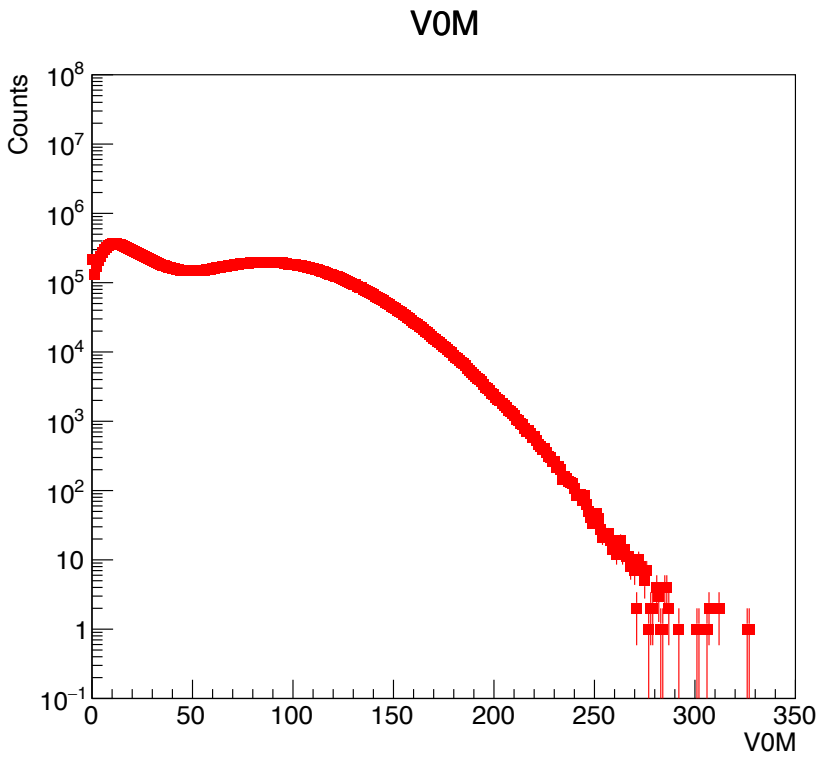
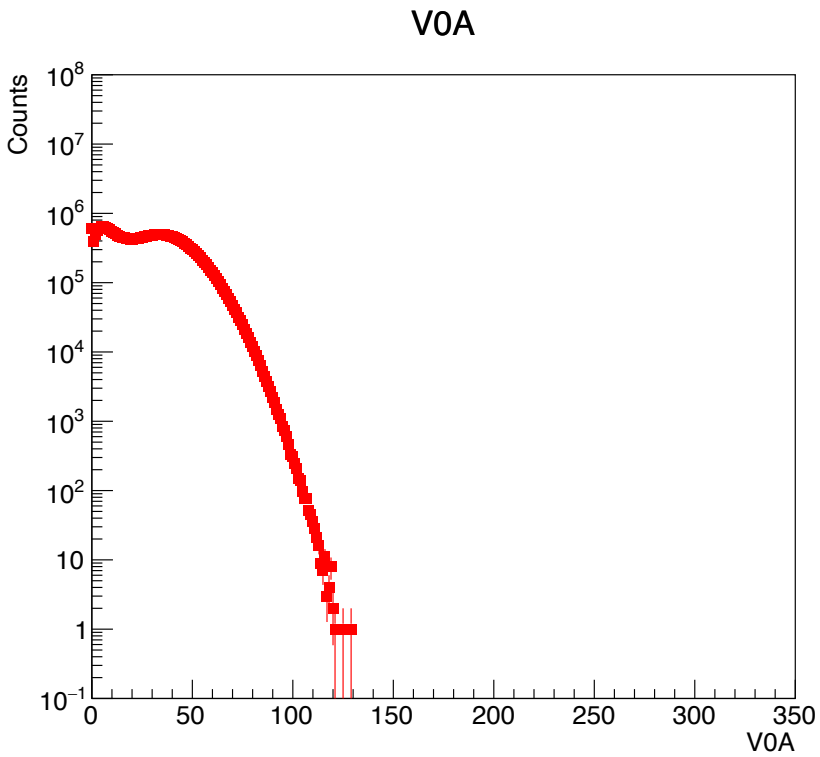
Daicui Zhou

14-April-2021

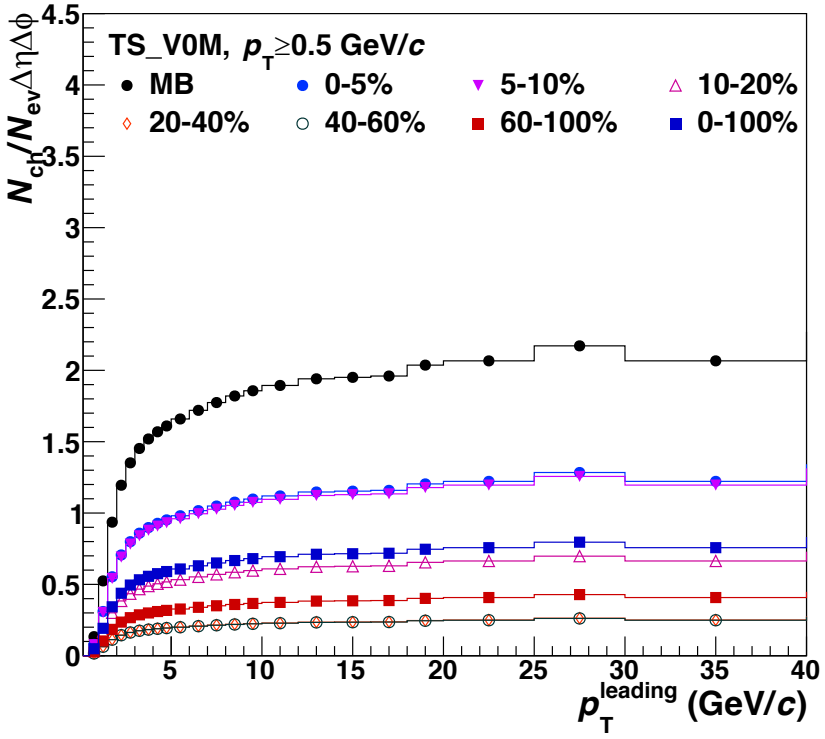
Cross checks by PF

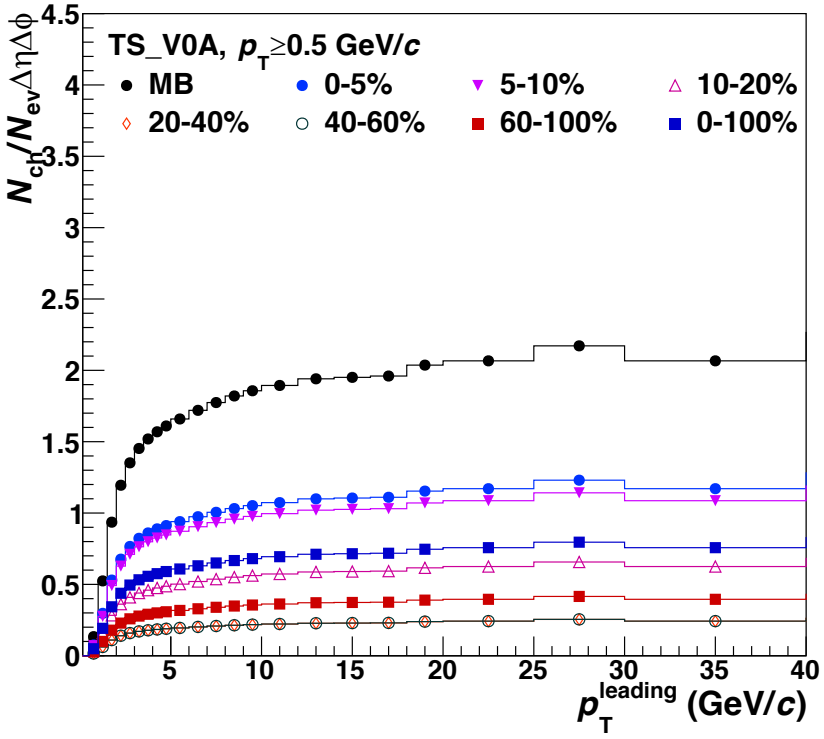
Different Multiplicity estimators for EPOS LHC(p-Pb)



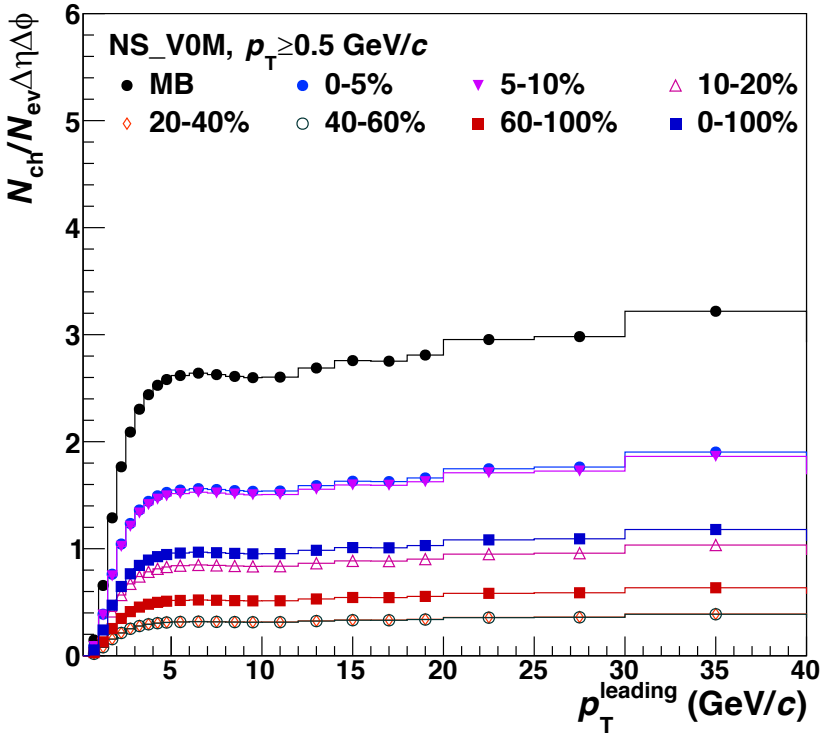


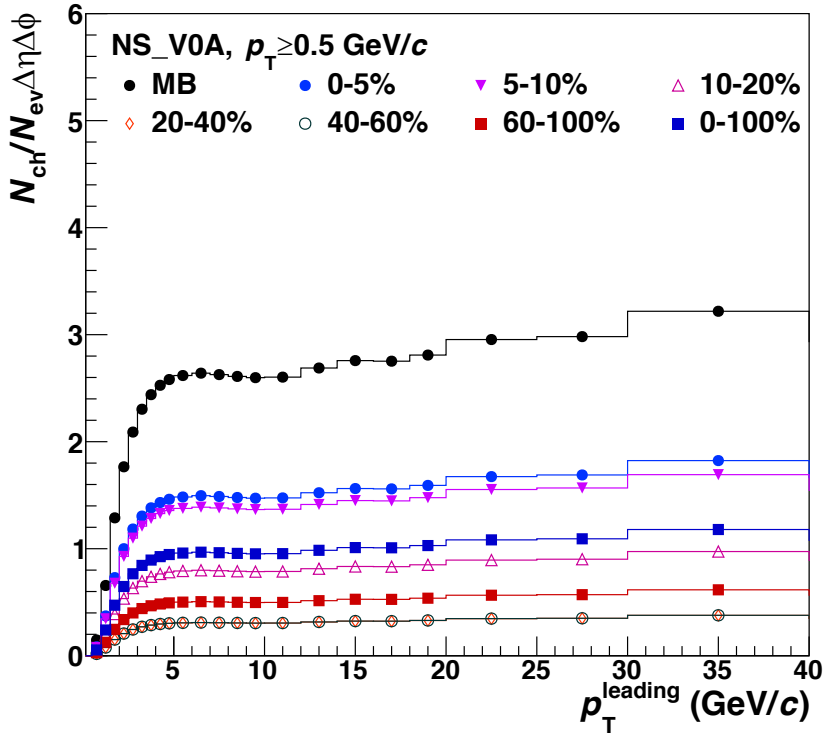
Number density with different Multiplicity estimators (EPOS LHC, p-Pb)



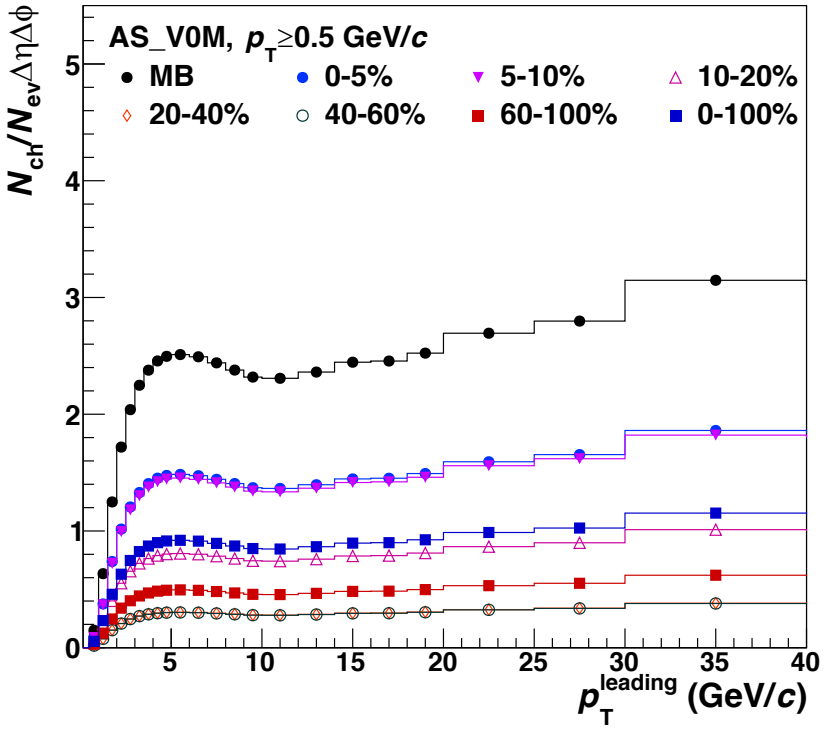


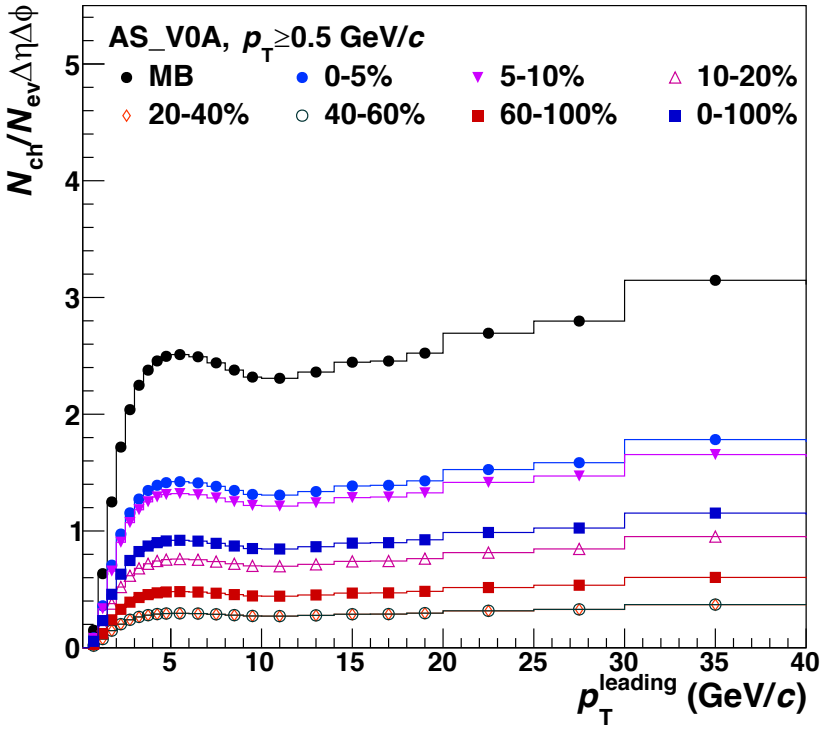
Number density with different Multiplicity estimators (EPOS LHC, p-Pb)





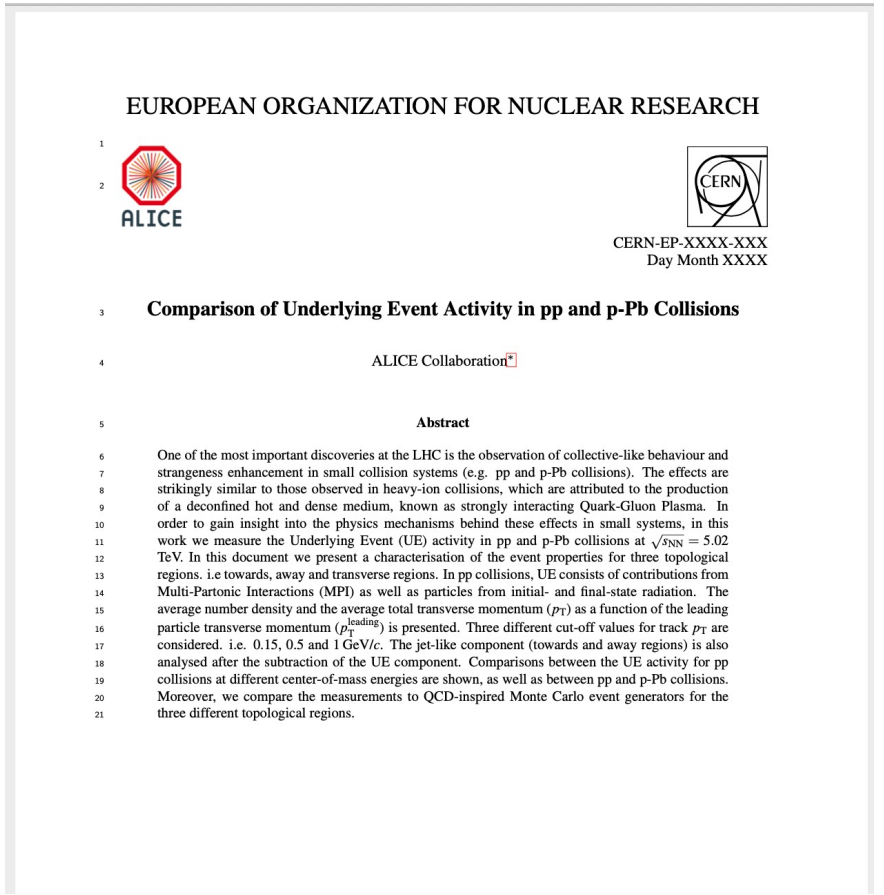
Number density with different Multiplicity estimators (EPOS LHC, p-Pb)





Paper proposal

- Compare the UE observables (number density and the summed transverse momentum in the towards, away and transverse sides) in pp and p-Pb collisions for similar event classes (same $p_{\mathrm{T}}^{\mathrm{leading}}$ and same $\sqrt{s_{\mathrm{NN}}}$). **paper proposal** for publication.



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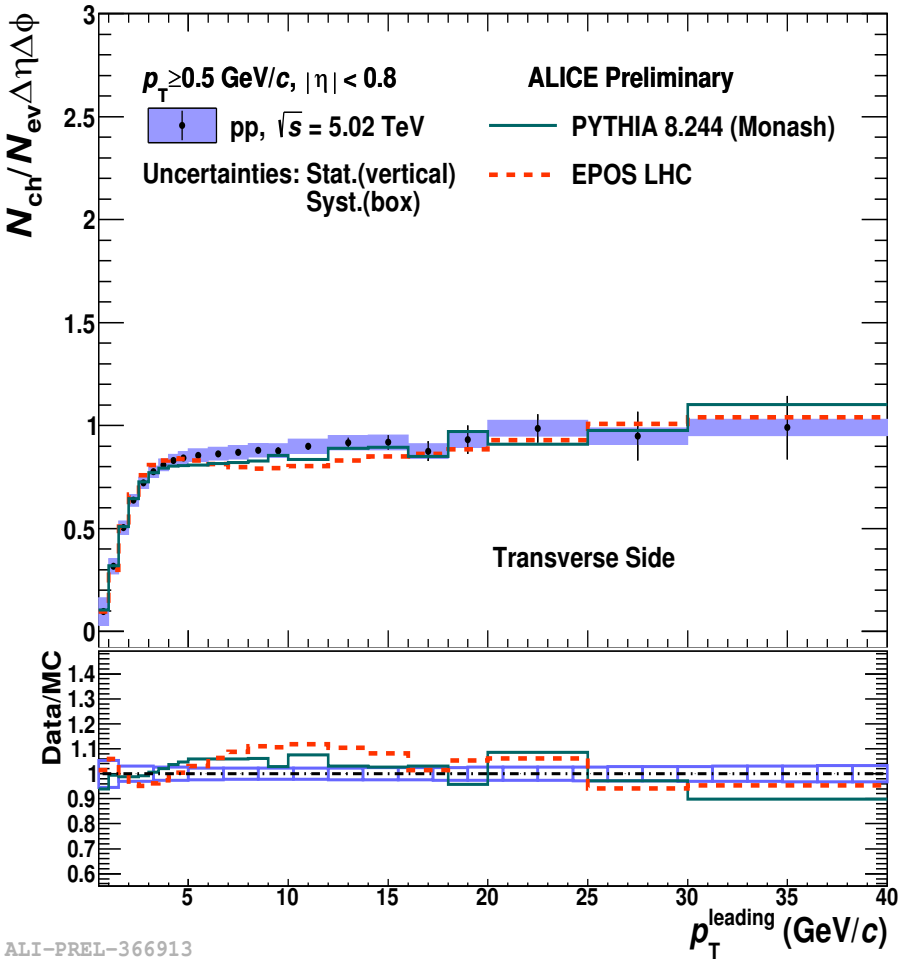
Comparison of Underlying Event Activity in pp and p-Pb Collisions

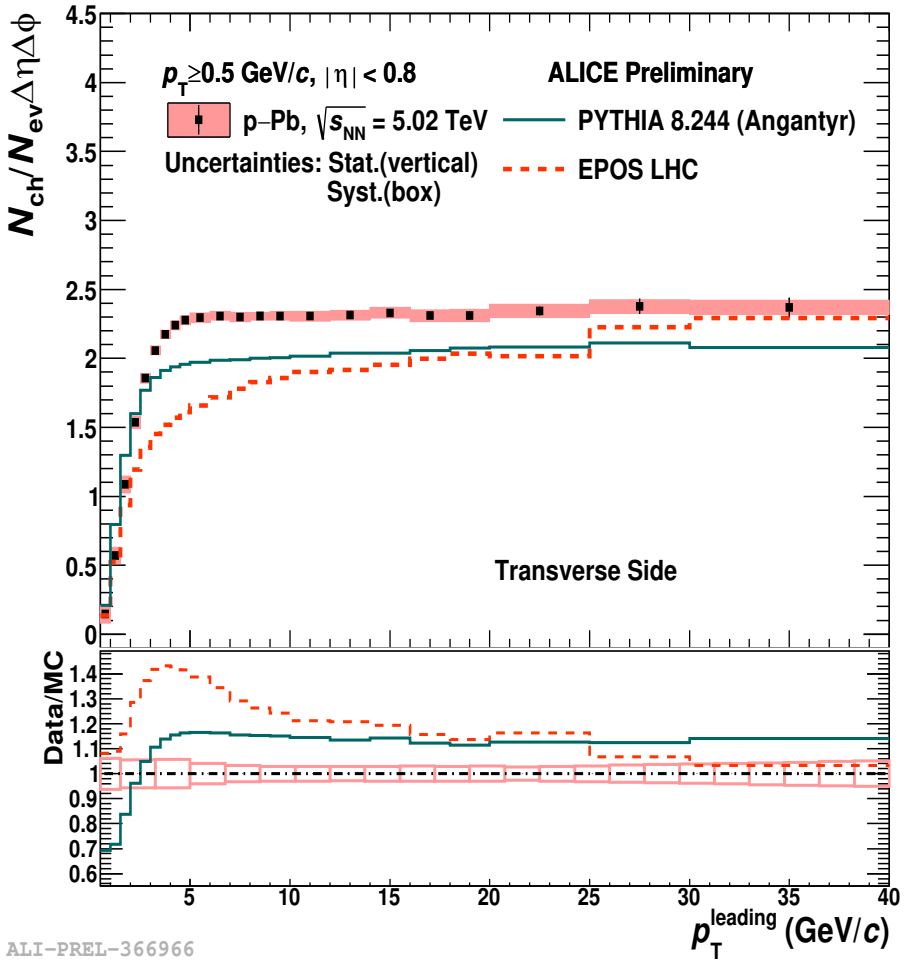
ALICE Collaboration*

Abstract

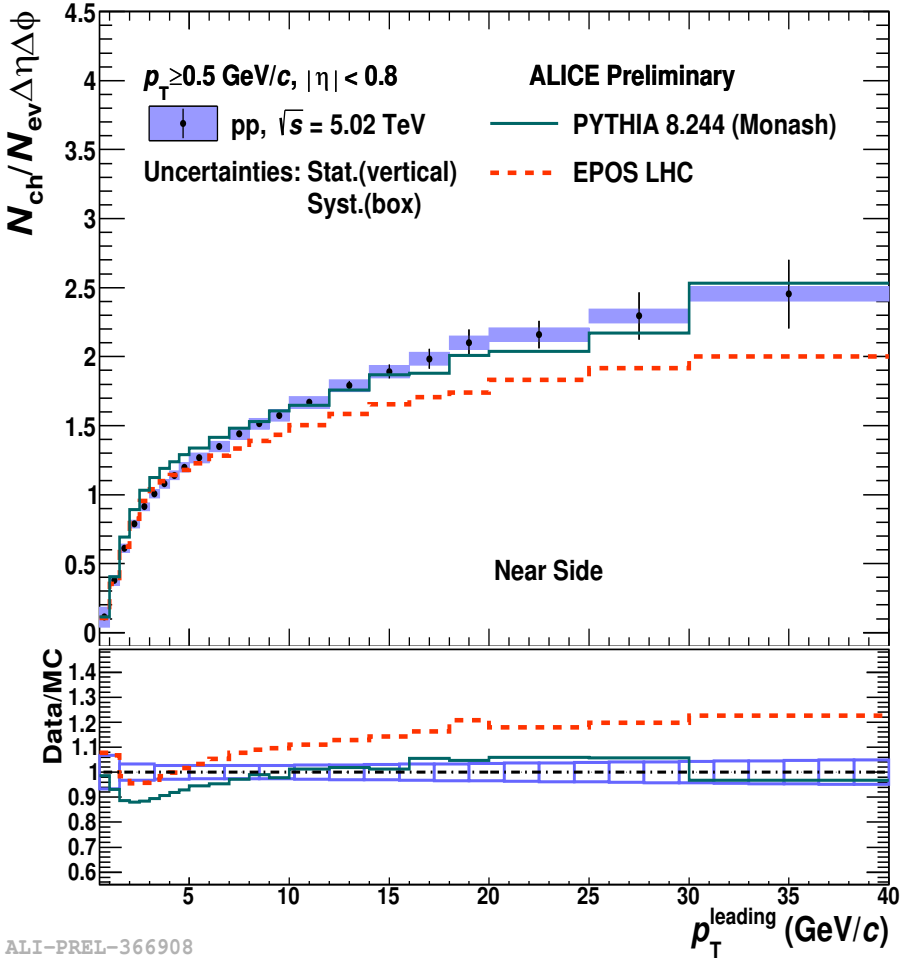
One of the most important discoveries at the LHC is the observation of collective-like behaviour and strangeness enhancement in small collision systems (e.g. pp and p-Pb collisions). The effects are strikingly similar to those observed in heavy-ion collisions, which are attributed to the production of a deconfined hot and dense medium, known as strongly interacting Quark-Gluon Plasma. In order to gain insight into the physics mechanisms behind these effects in small systems, in this work we measure the Underlying Event (UE) activity in pp and p-Pb collisions at $\sqrt{s_{\mathrm{NN}}} = 5.02$ TeV. In this document we present a characterisation of the event properties for three topological regions. i.e towards, away and transverse regions. In pp collisions, UE consists of contributions from Multi-Partonic Interactions (MPI) as well as particles from initial- and final-state radiation. The average number density and the average total transverse momentum (p_{T}) as a function of the leading particle transverse momentum ($p_{\mathrm{T}}^{\mathrm{leading}}$) is presented. Three different cut-off values for track p_{T} are considered. i.e. 0.15, 0.5 and 1 GeV/c. The jet-like component (towards and away regions) is also analysed after the subtraction of the UE component. Comparisons between the UE activity for pp collisions at different center-of-mass energies are shown, as well as between pp and p-Pb collisions. Moreover, we compare the measurements to QCD-inspired Monte Carlo event generators for the three different topological regions.

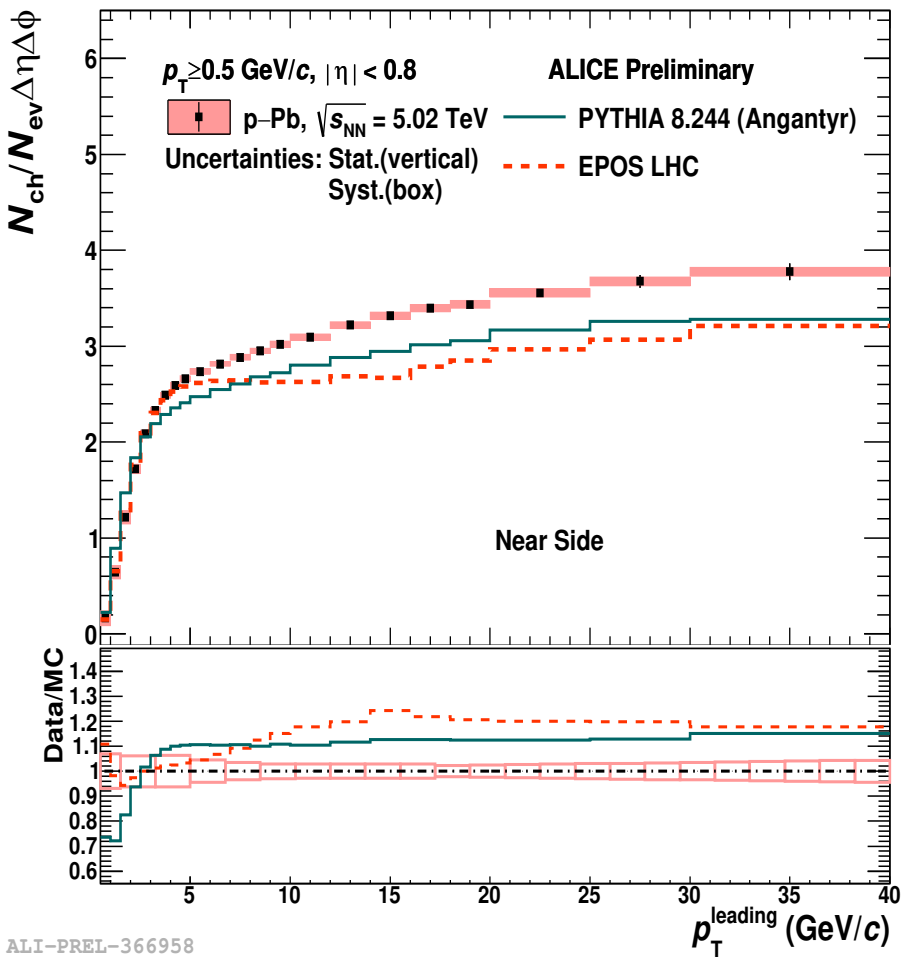
Number density (NumDen) Transverse Region (TS) for p_{T} cut ≥ 0.5 GeV/c (Data vs MC)



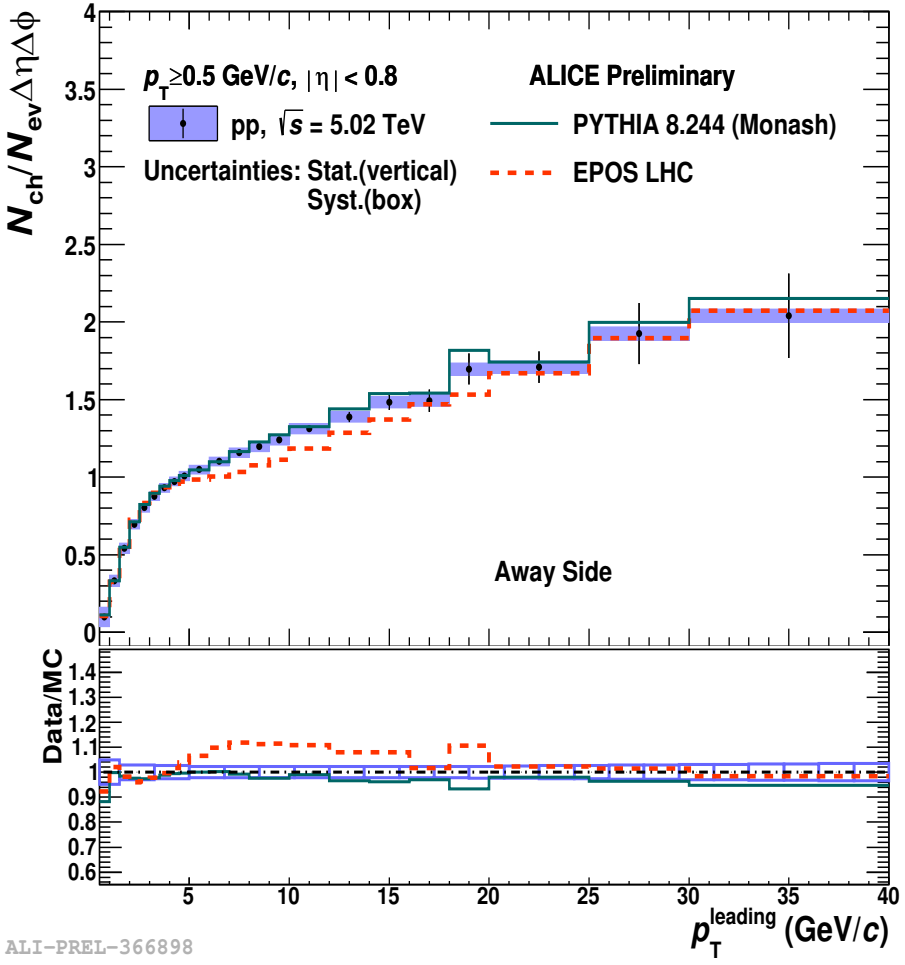


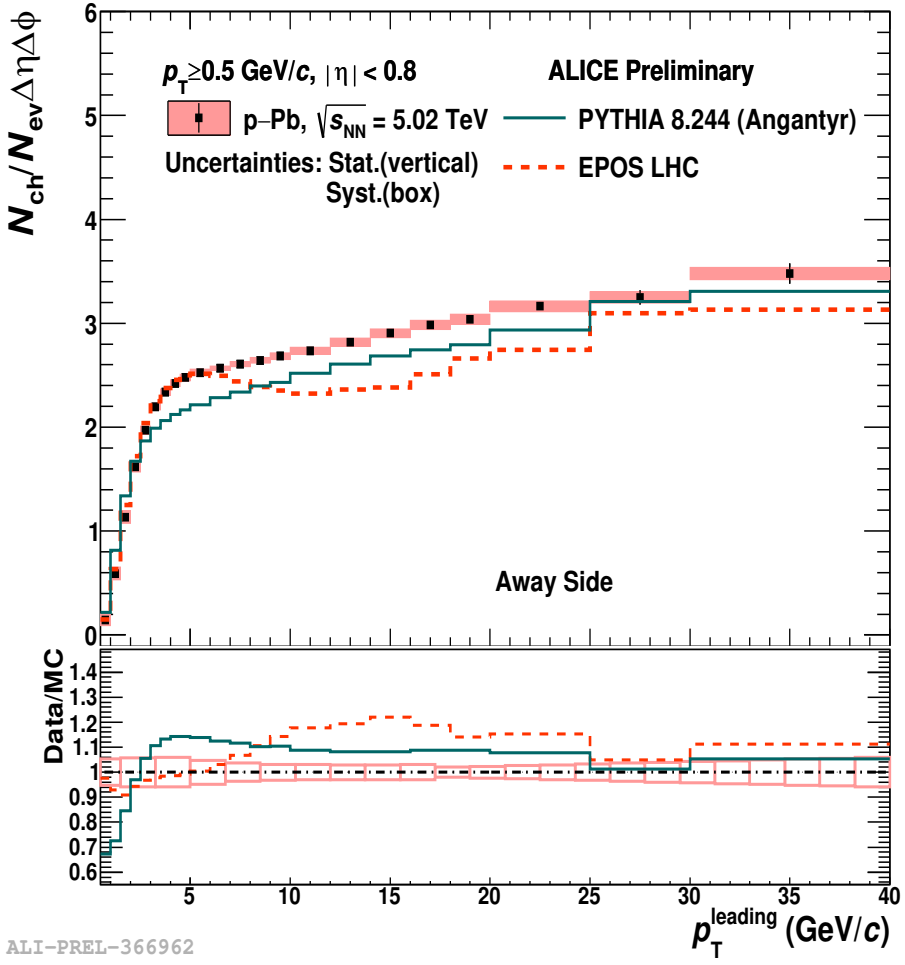
Number density (NumDen) Towards Region (NS, near side) for p_{T} cut ≥ 0.5 GeV/c(Data vs MC)



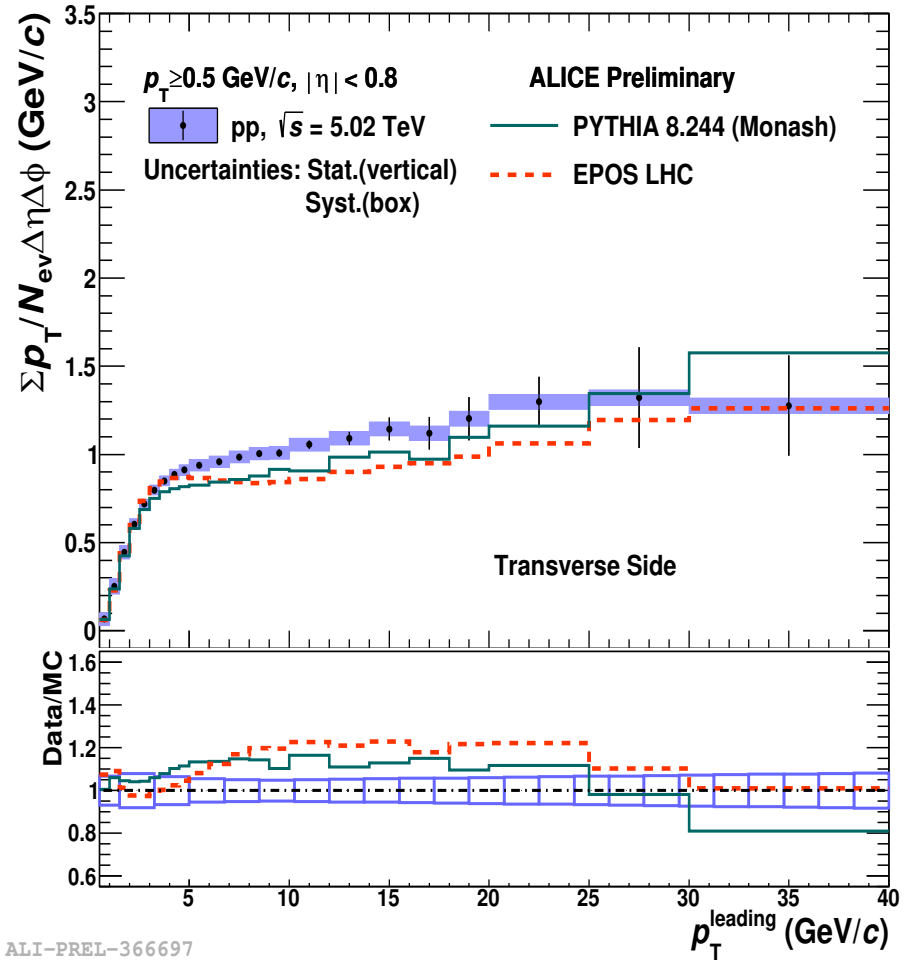


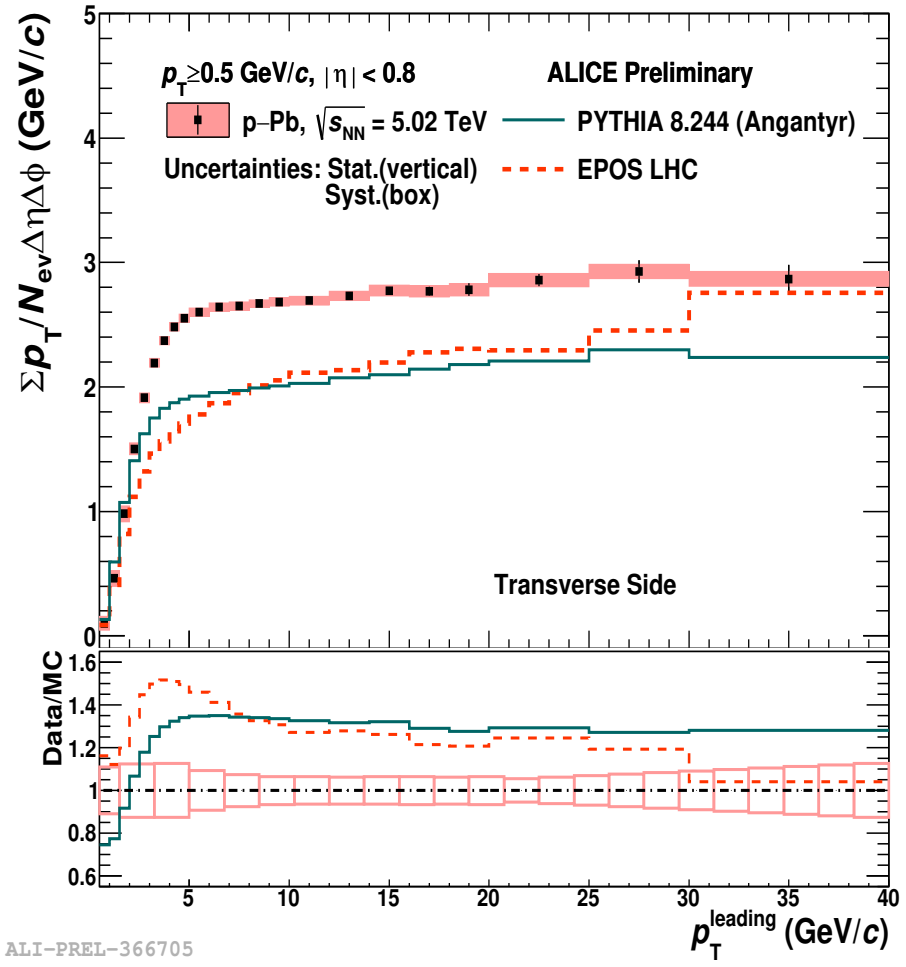
Number density (NumDen) Away Region (AS, away side) for p_{T} cut ≥ 0.5 GeV/c (Data vs MC)



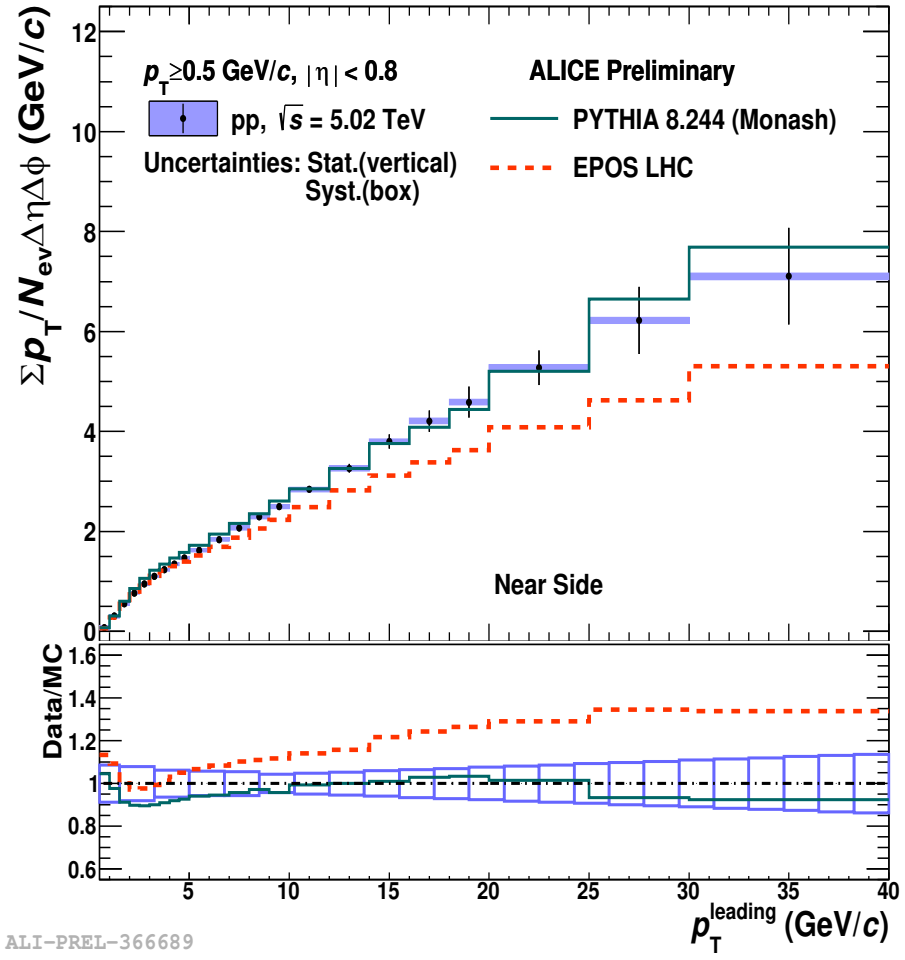


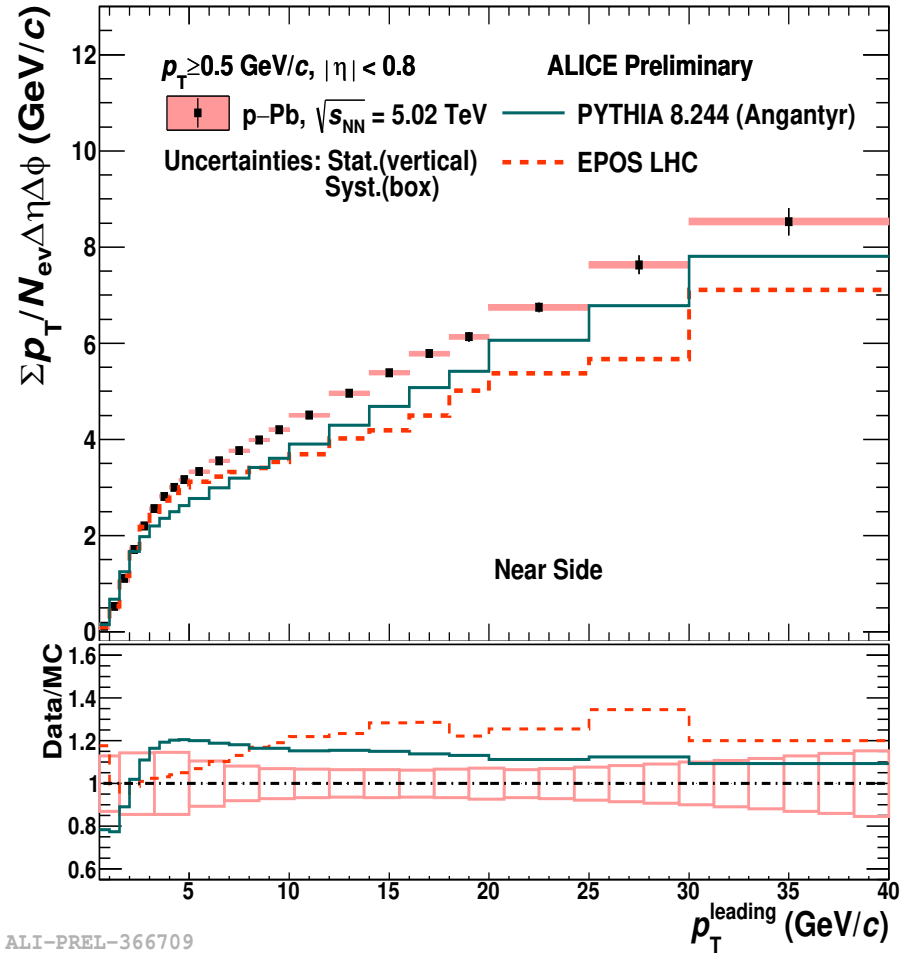
Sum p_T density (SumPt) Transverse Region (TS) for p_T cut ≥ 0.5 GeV/c (Data vs MC)



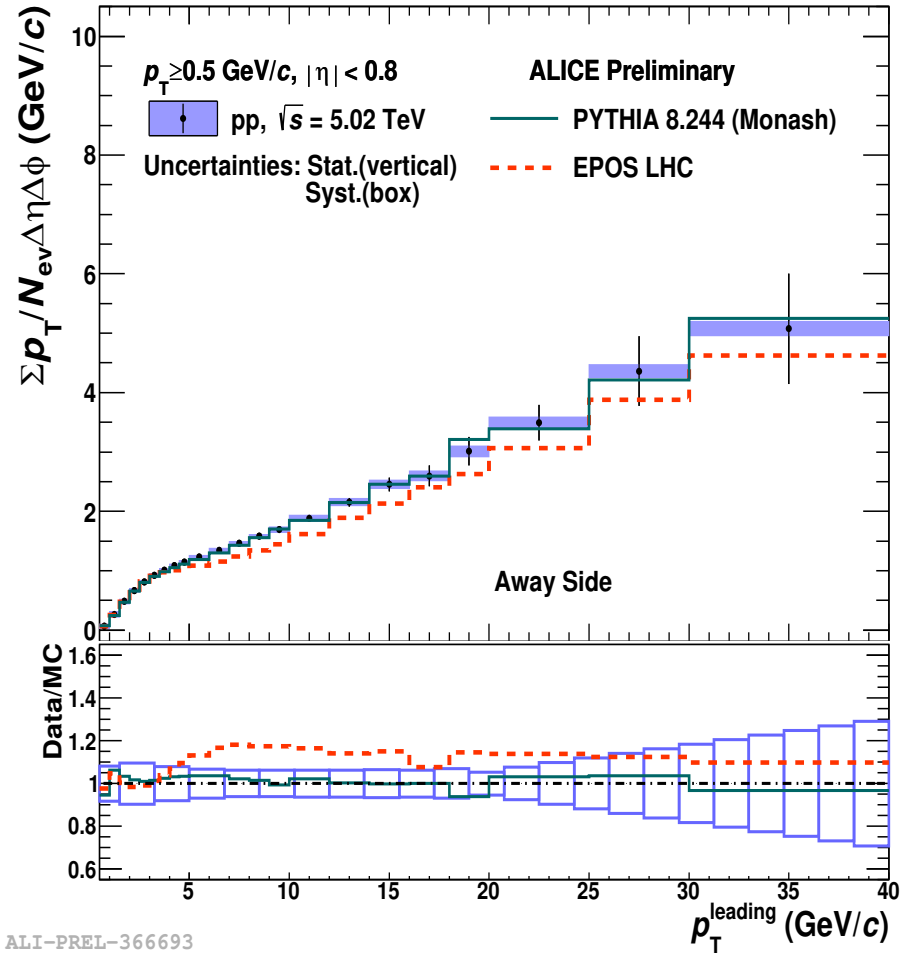


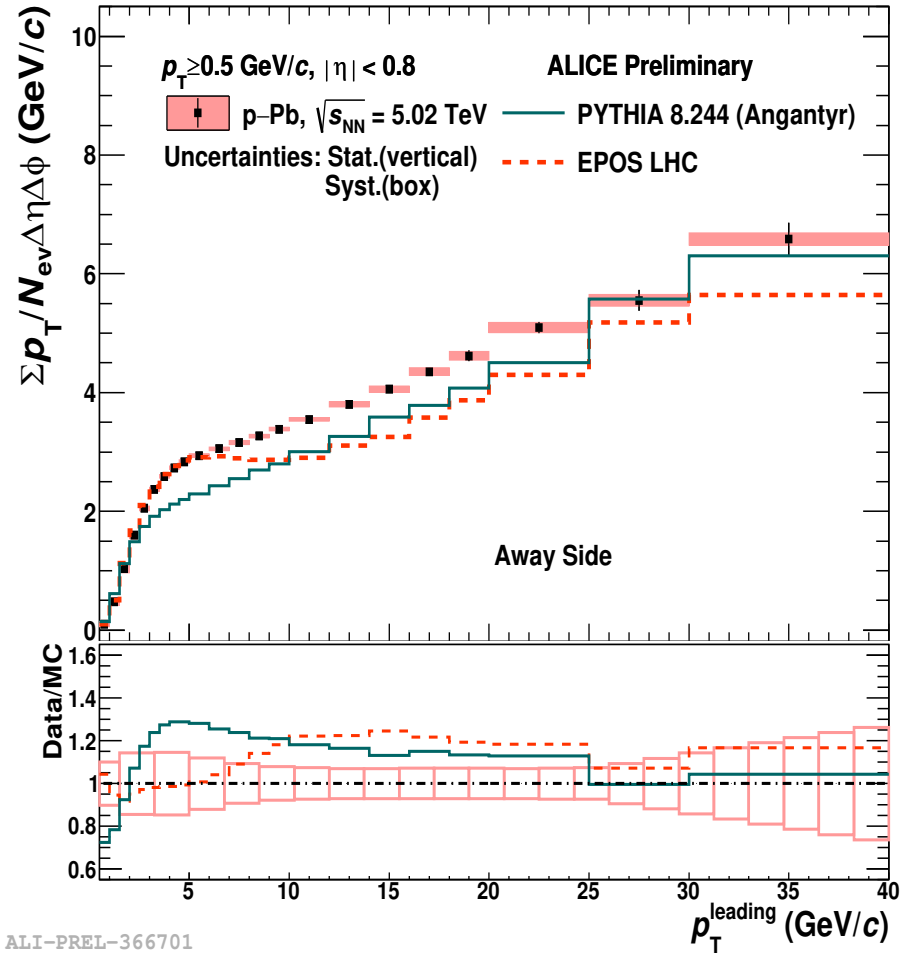
Sum p_T density (SumPt) Towards Region (NS, near side) for p_T cut ≥ 0.5 GeV/c (Data vs MC)



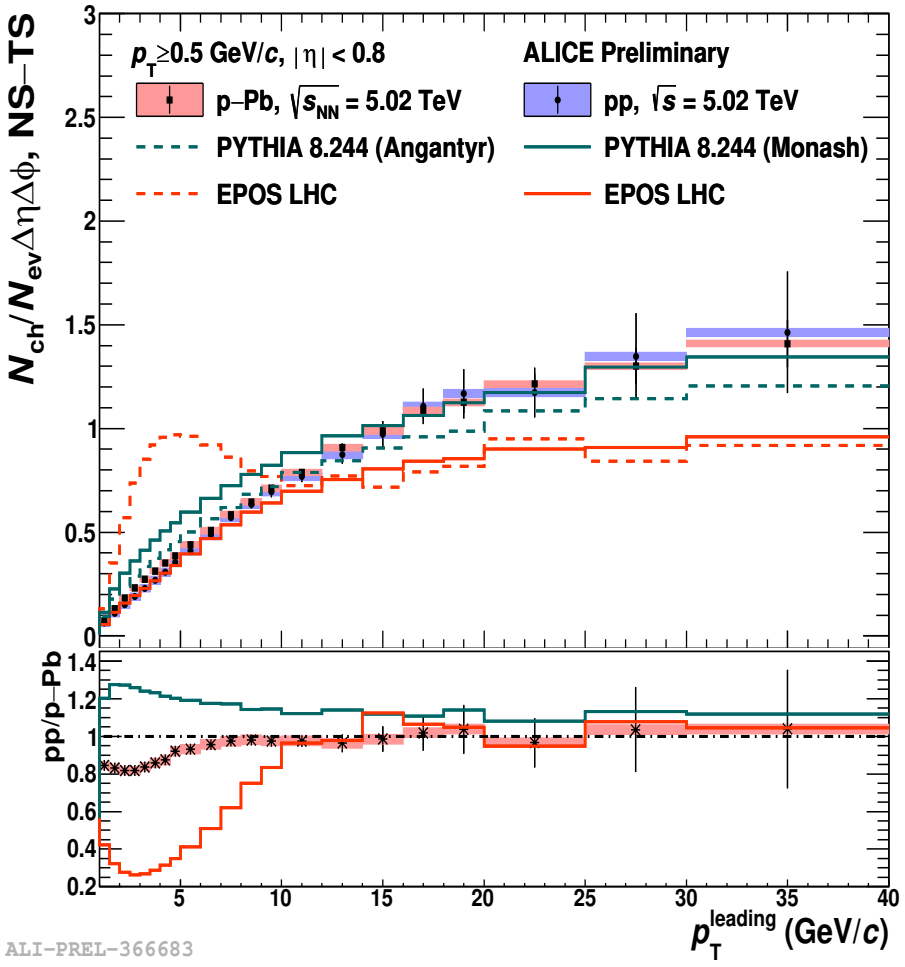


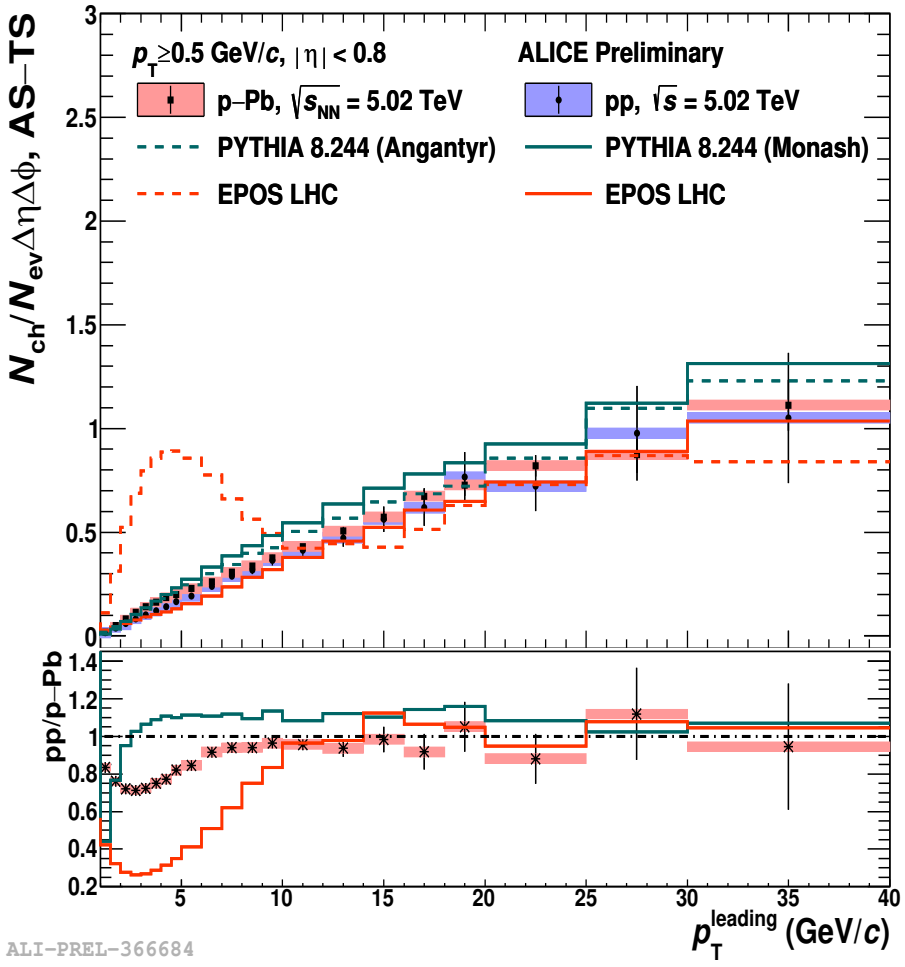
Sum p_T density (SumPt) Away Region (AS, away side) for p_T cut ≥ 0.5 GeV/c (Data vs MC)



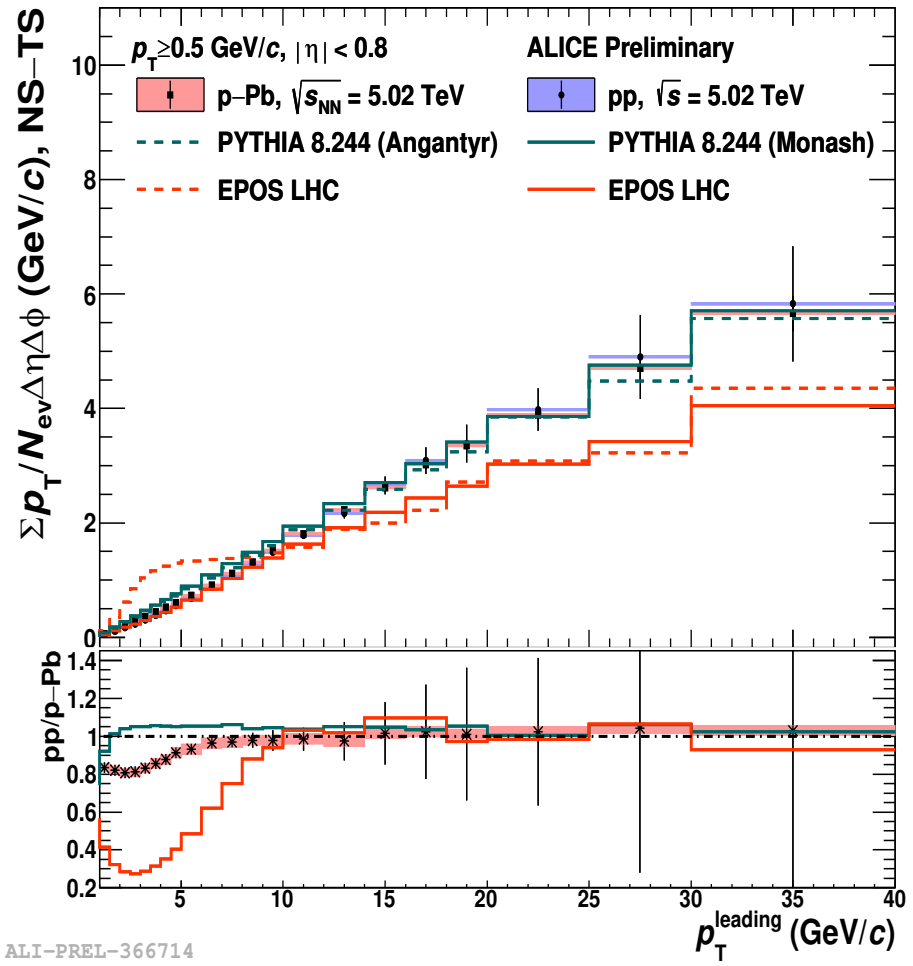


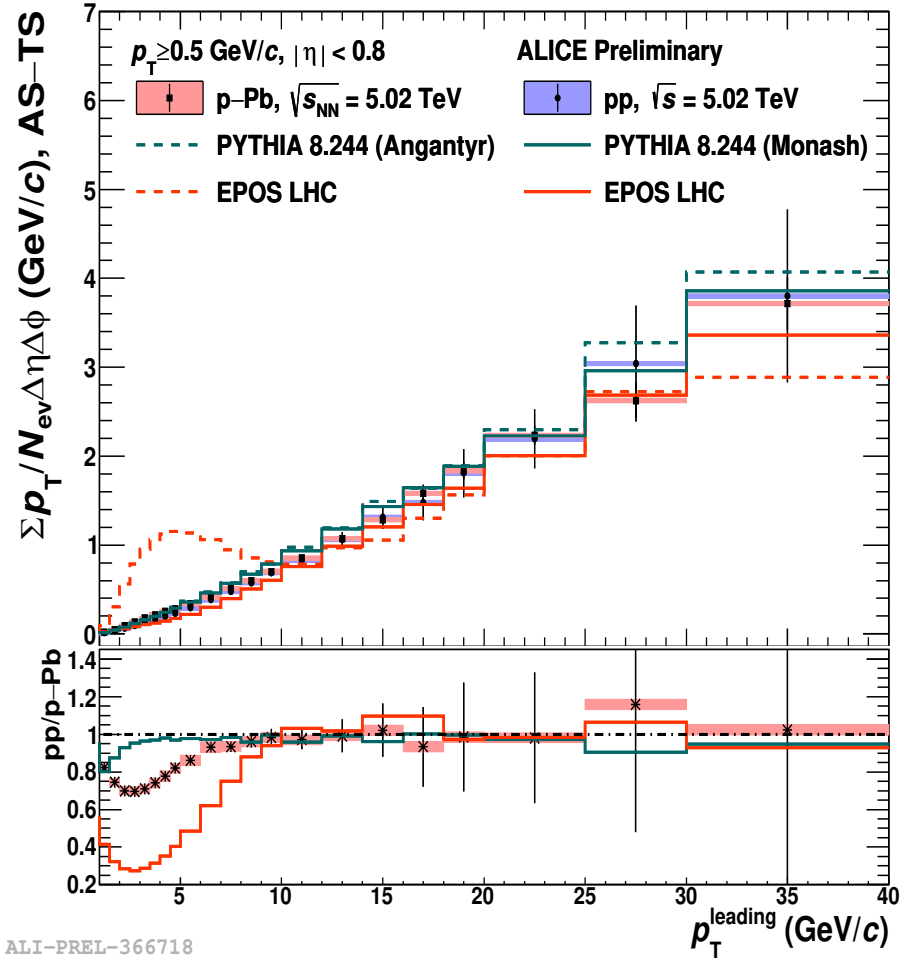
Comparison Number density NS-TS and AS-TS for $p_{\mathrm{T}} \geq 0.5$ GeV/c for pp and p-Pb @ 5.02TeV (Data vs MC)



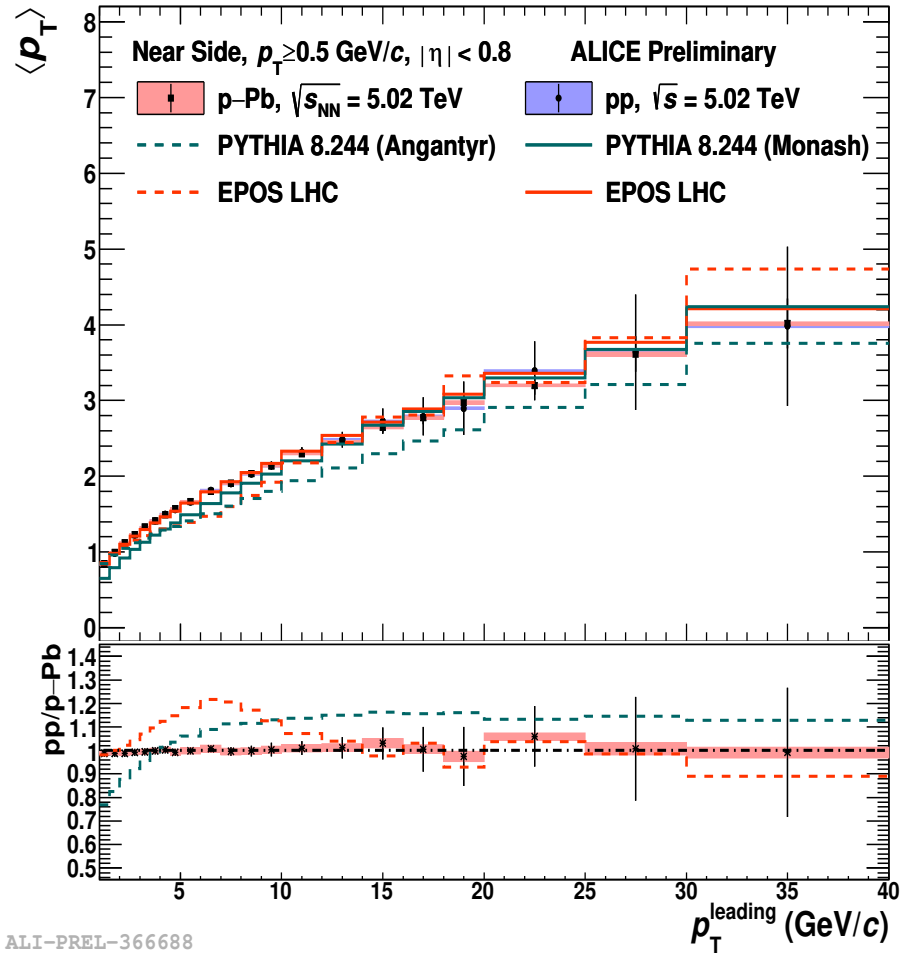


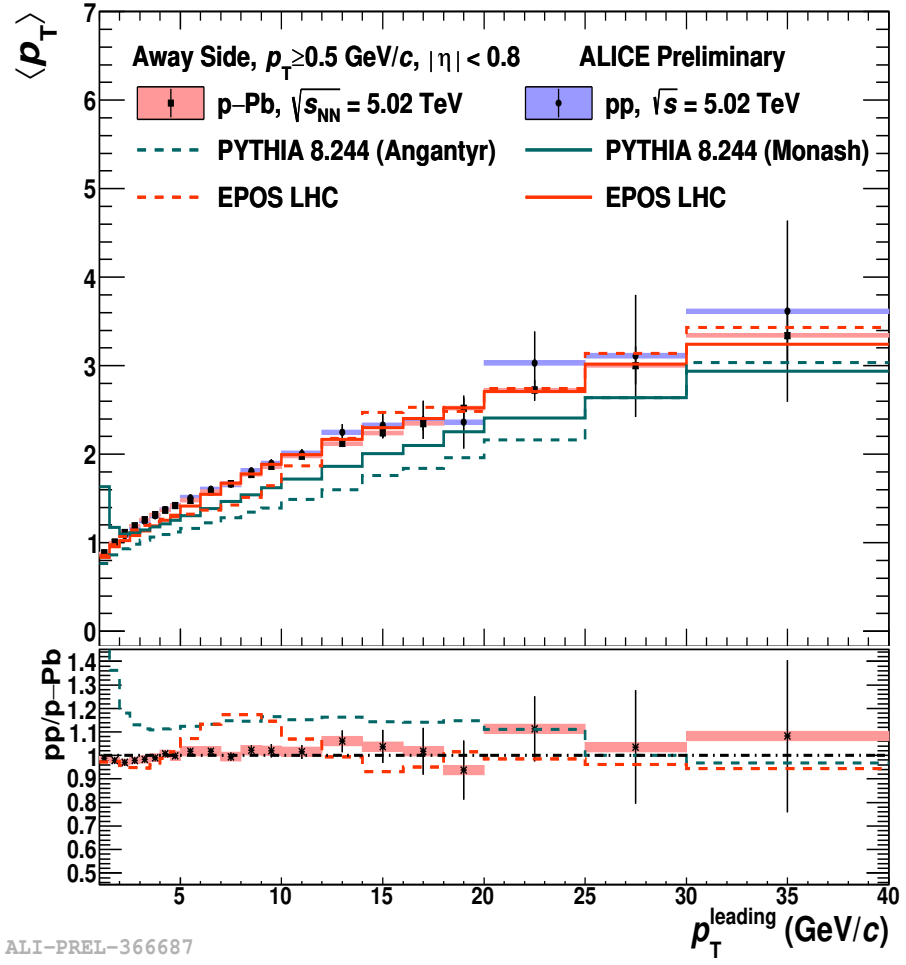
Comparison Sum p_{T} density NS-TS and AS-TS for $p_{\mathrm{T}} \geq 0.5$ GeV/c for pp and p-Pb @ 5.02TeV (Data vs MC)



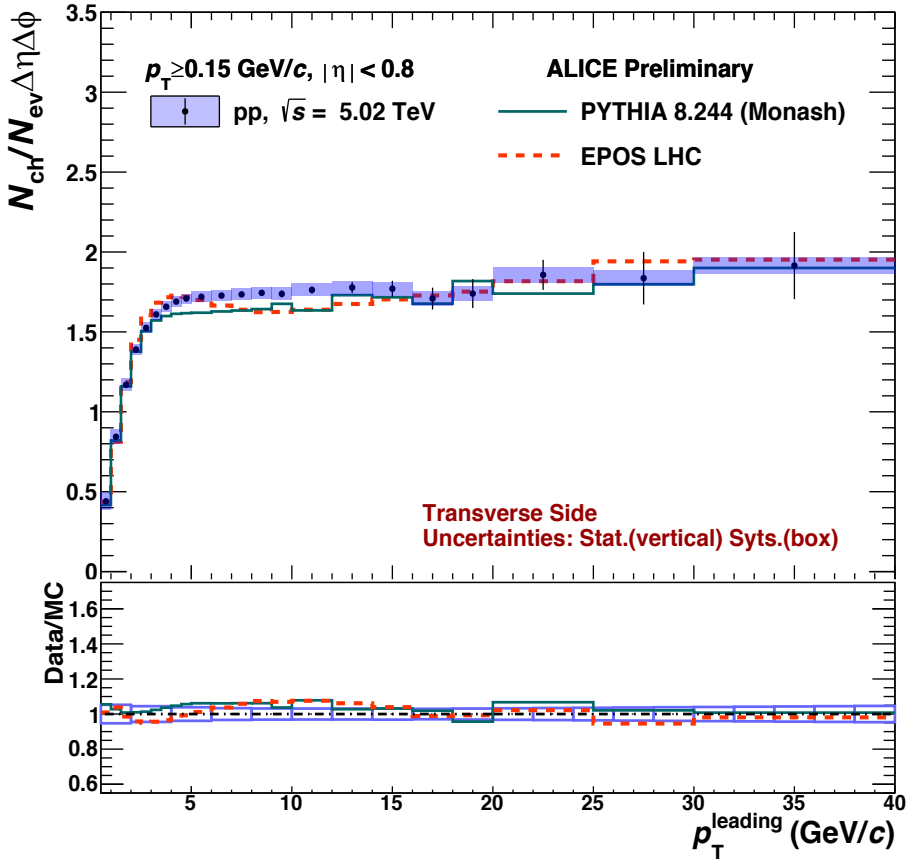


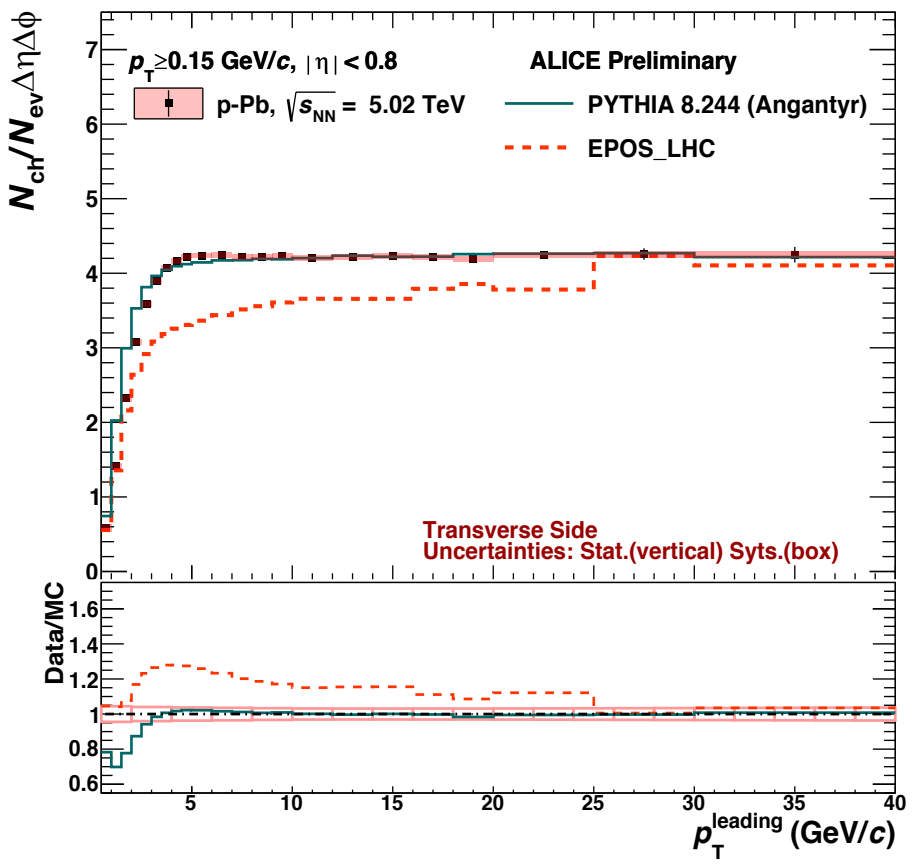
Average < p_{T} > for Near Side and Away Side for $p_{\mathrm{T}} \geq$ 0.5 GeV/c for pp and p-Pb @ 5.02TeV (Data vs MC)



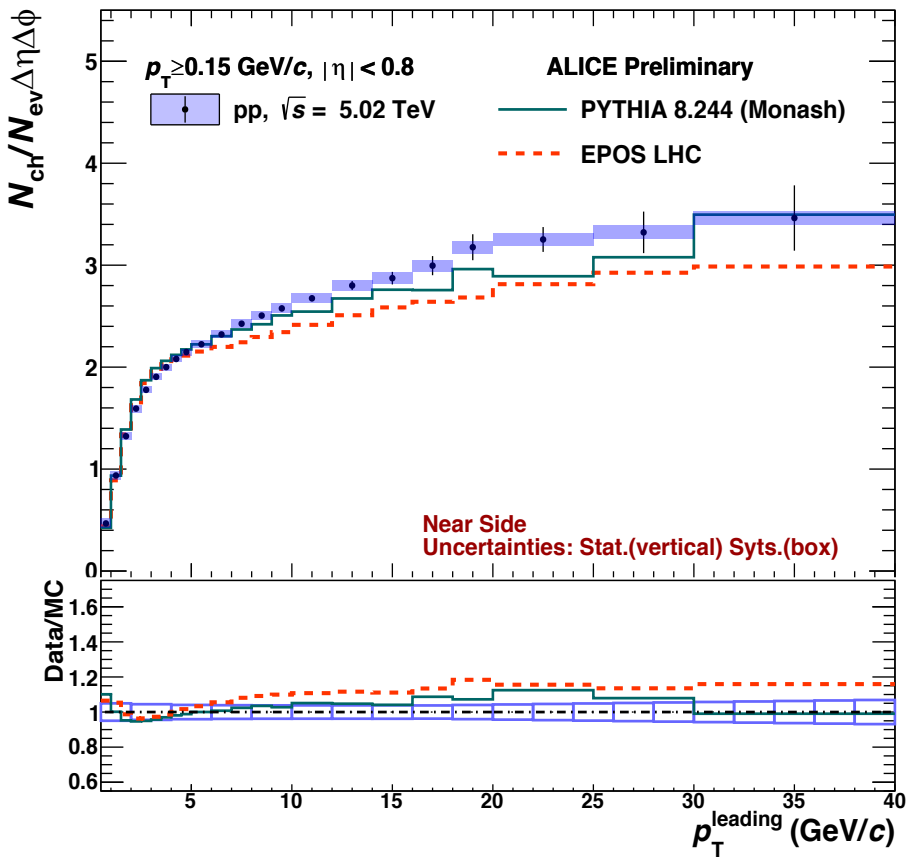


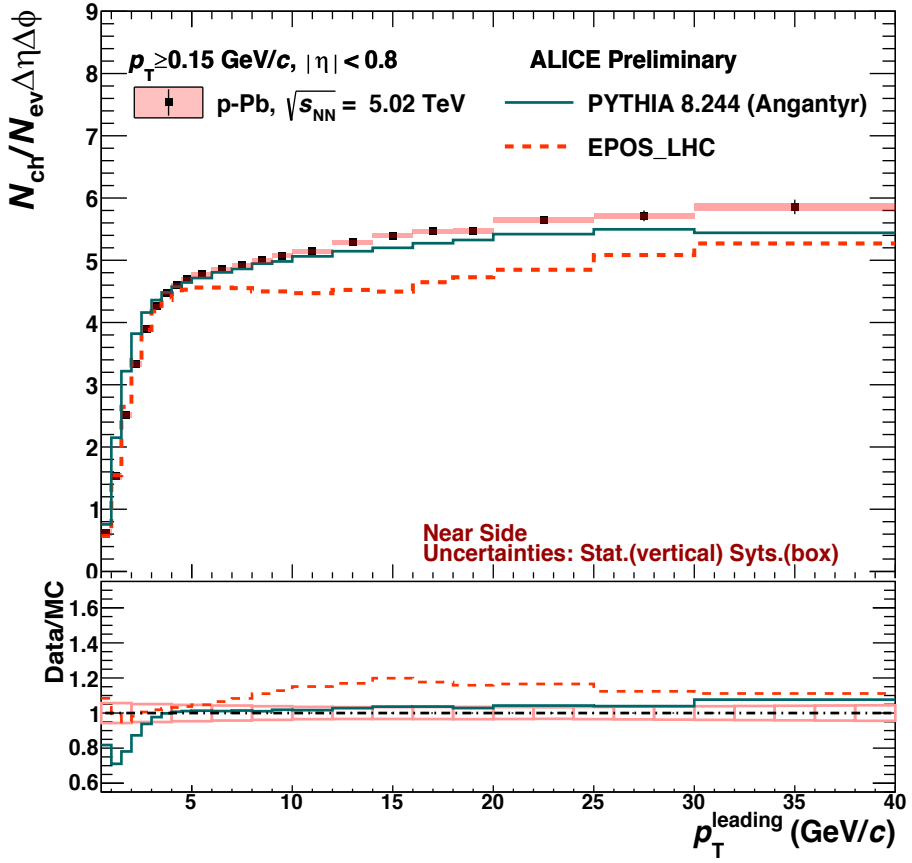
Number density(NumDen) Transverse Region(TS) for p_{T} cut >0.15 GeV/c



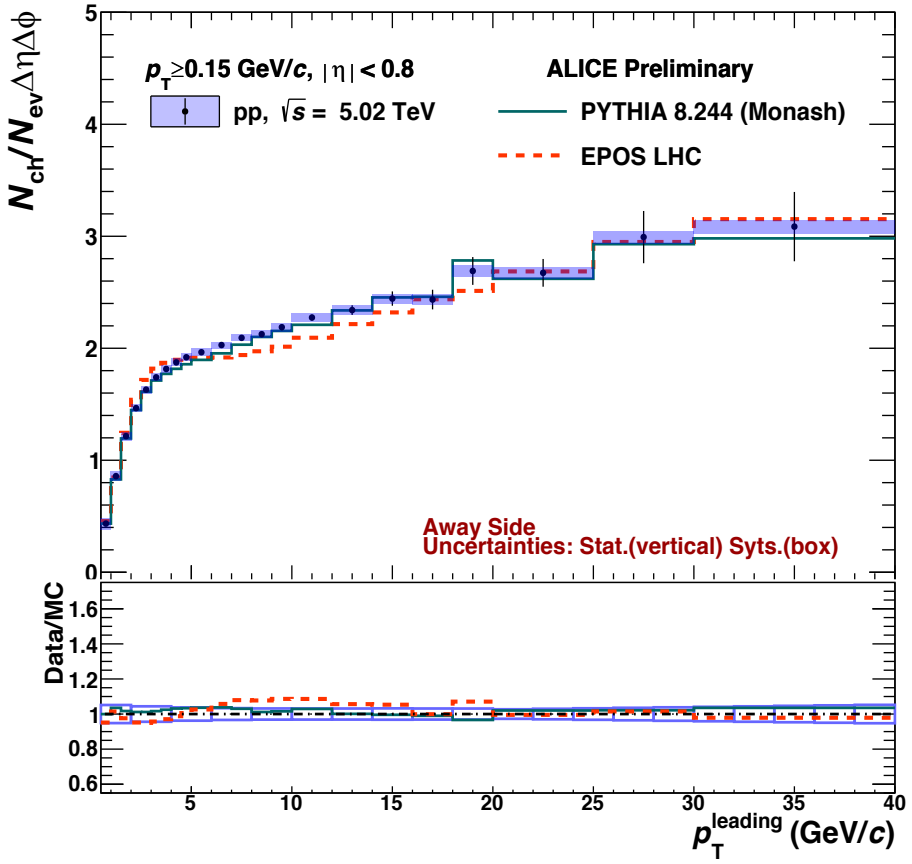


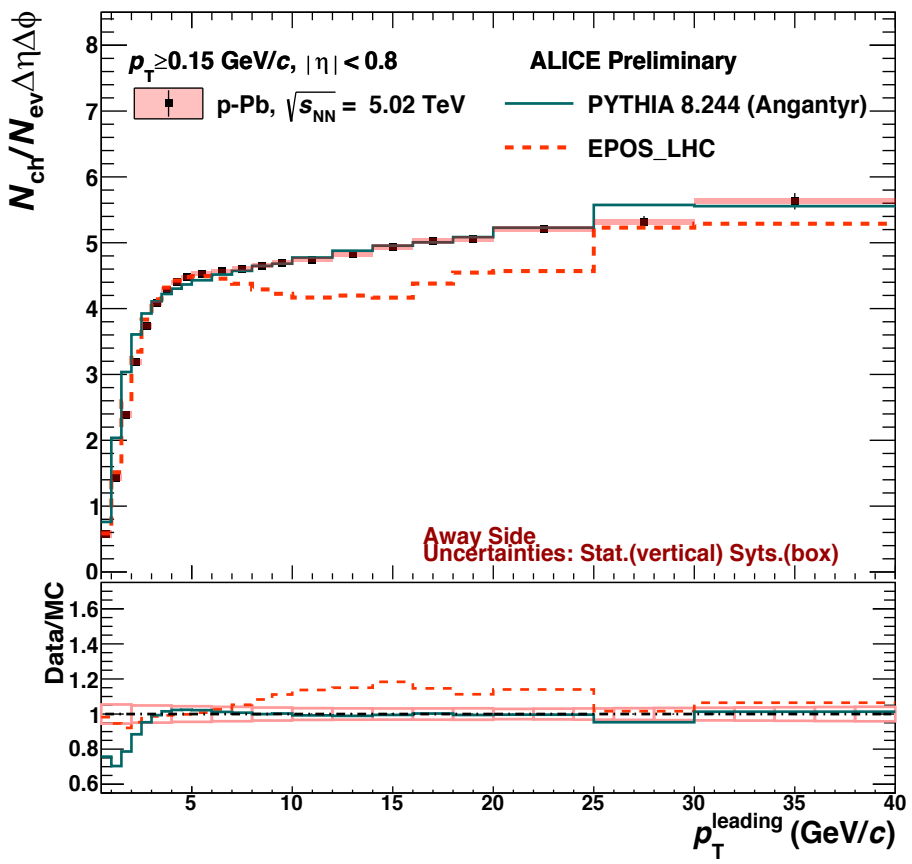
Number density(NumDen) Towards Region(NS, near side) for p_{T} cut >0.15 GeV/c



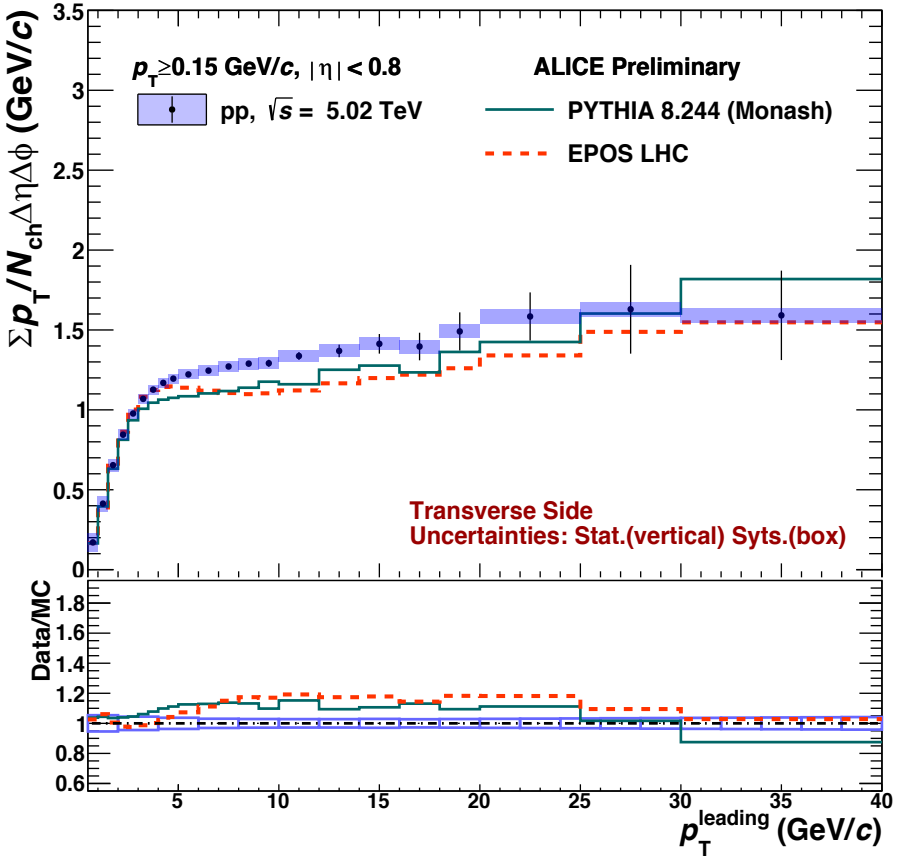


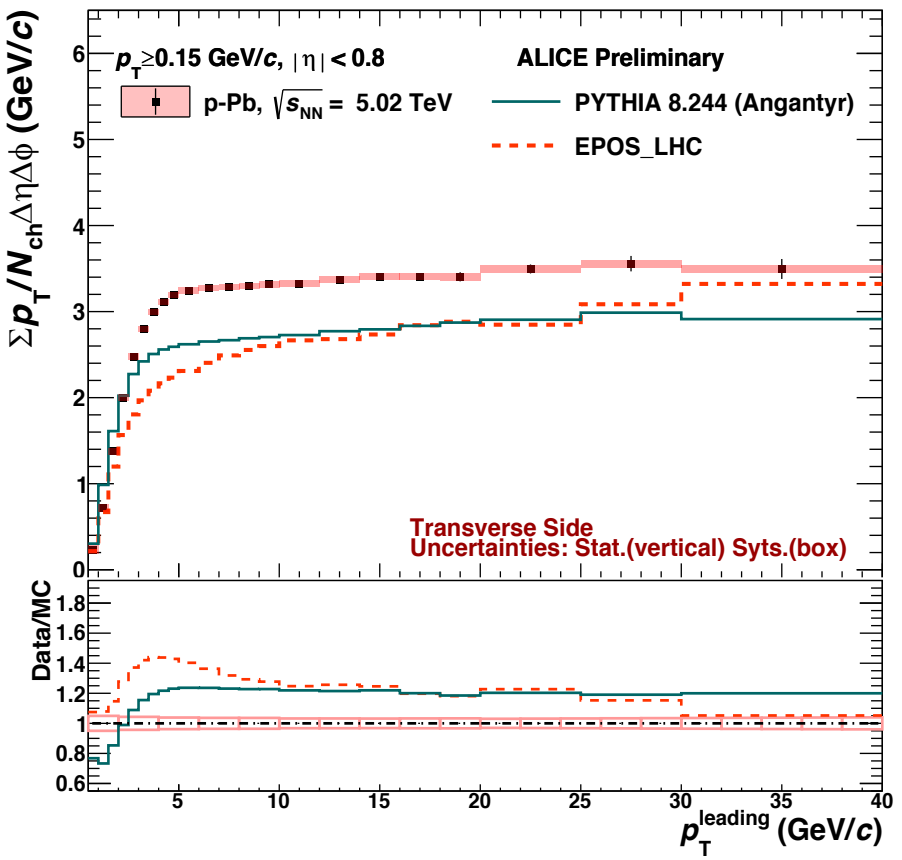
Number density(NumDen) Away Region(AS, away side) for p_{T} cut >0.15 GeV/c



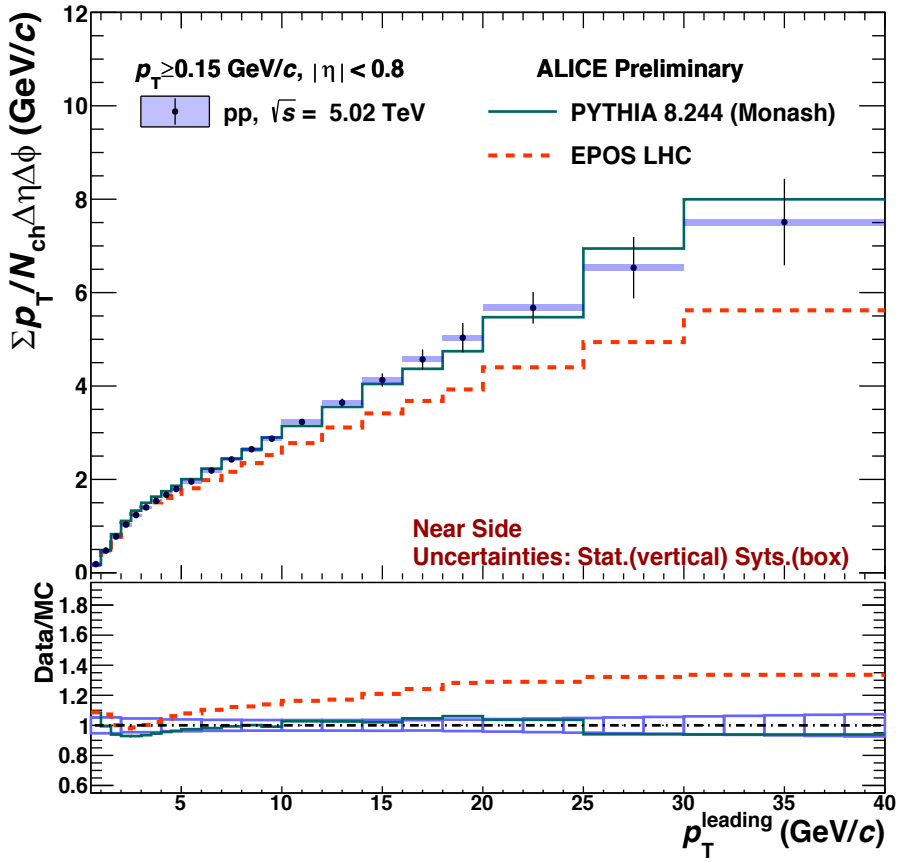


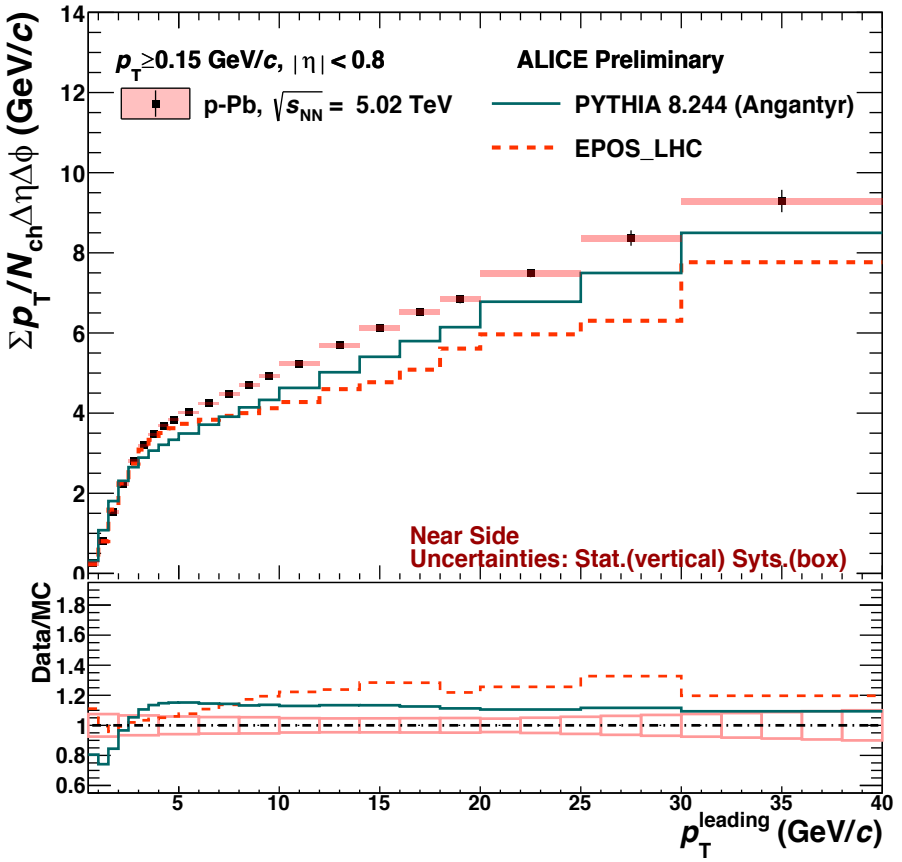
Sum p_{T} density (SumPt) Transverse Region(TS) for p_{T} cut >0.15 GeV/c



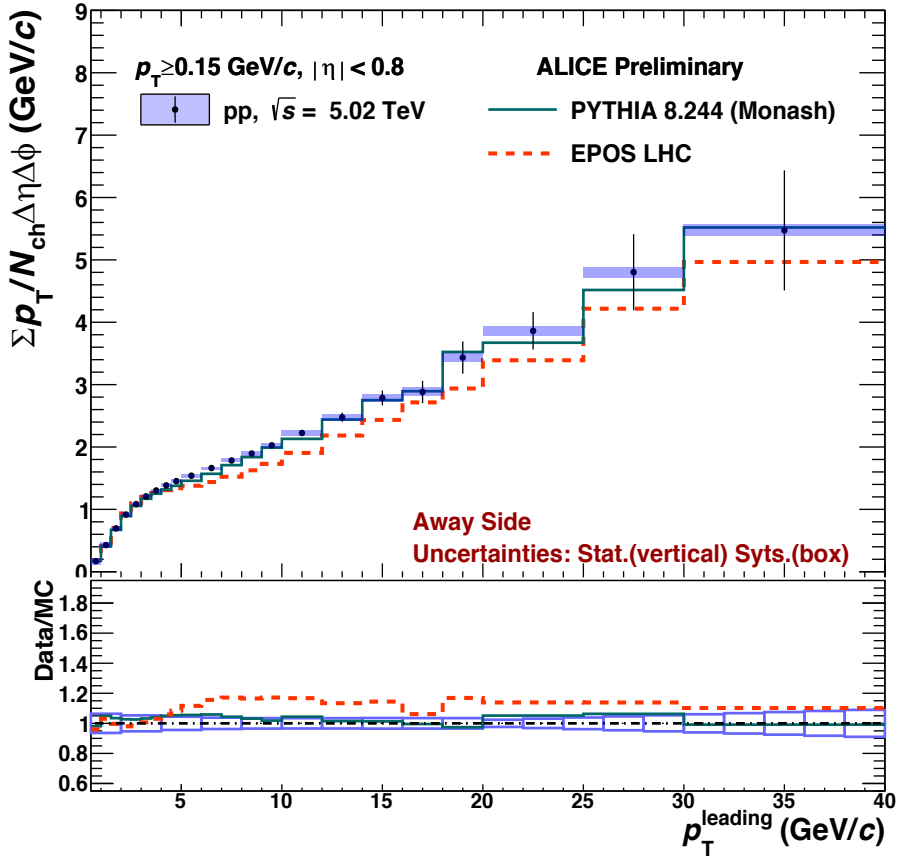


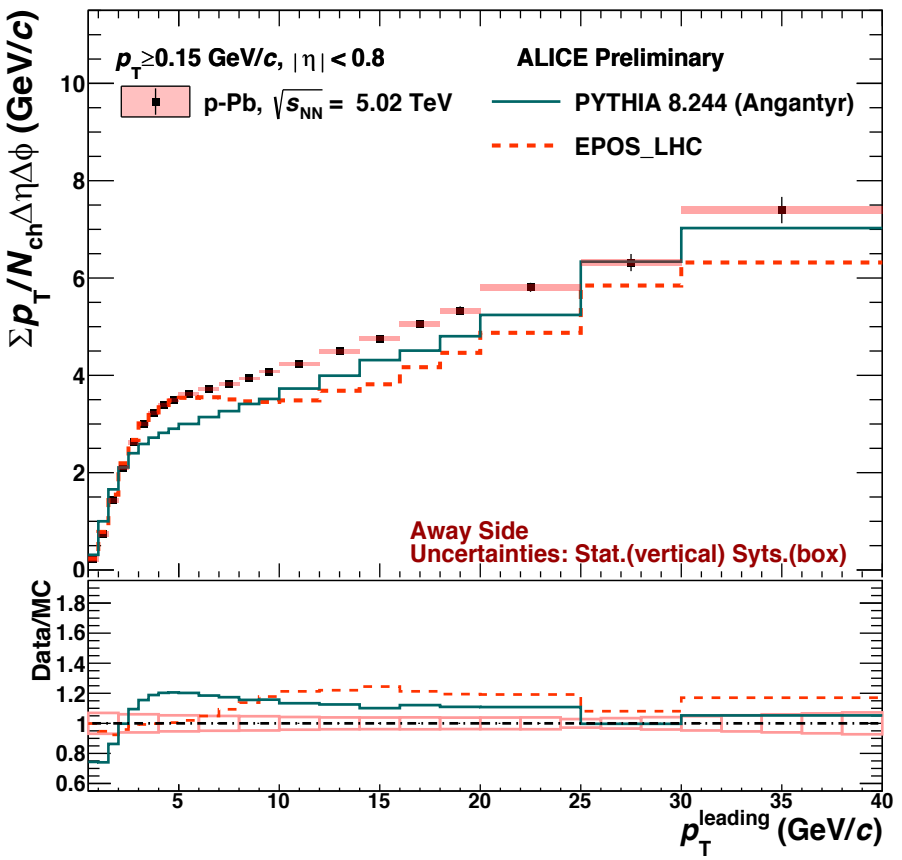
Sum p_{T} density (SumPt) Towards Region(NS, near side) for p_{T} cut >0.15 GeV/c



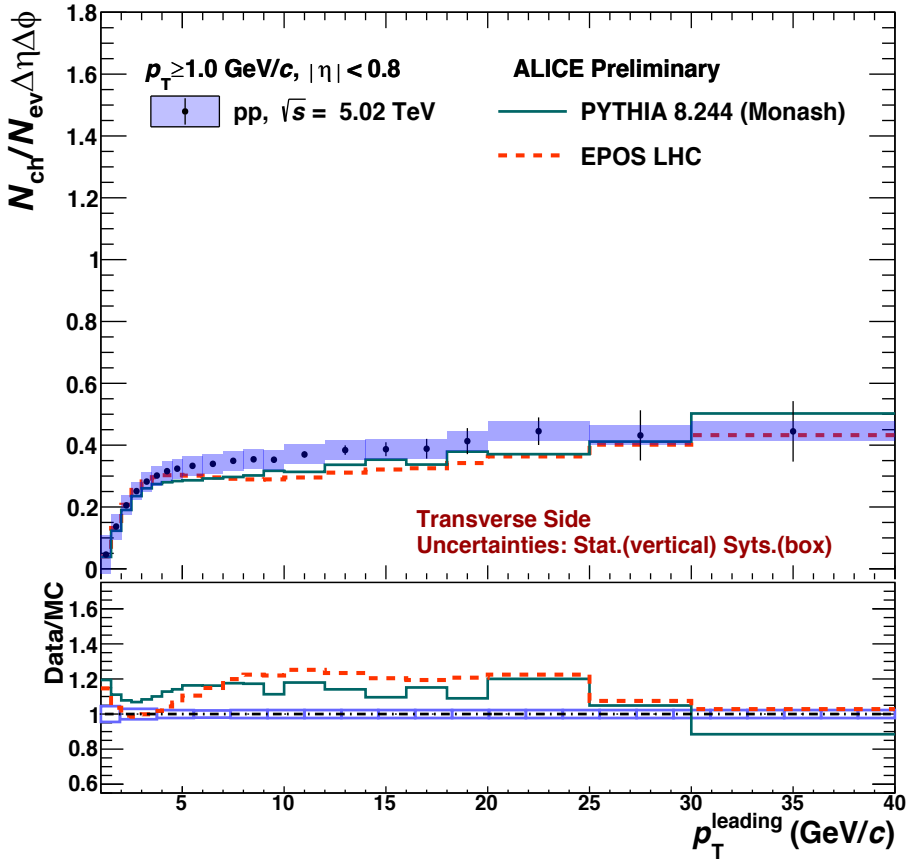


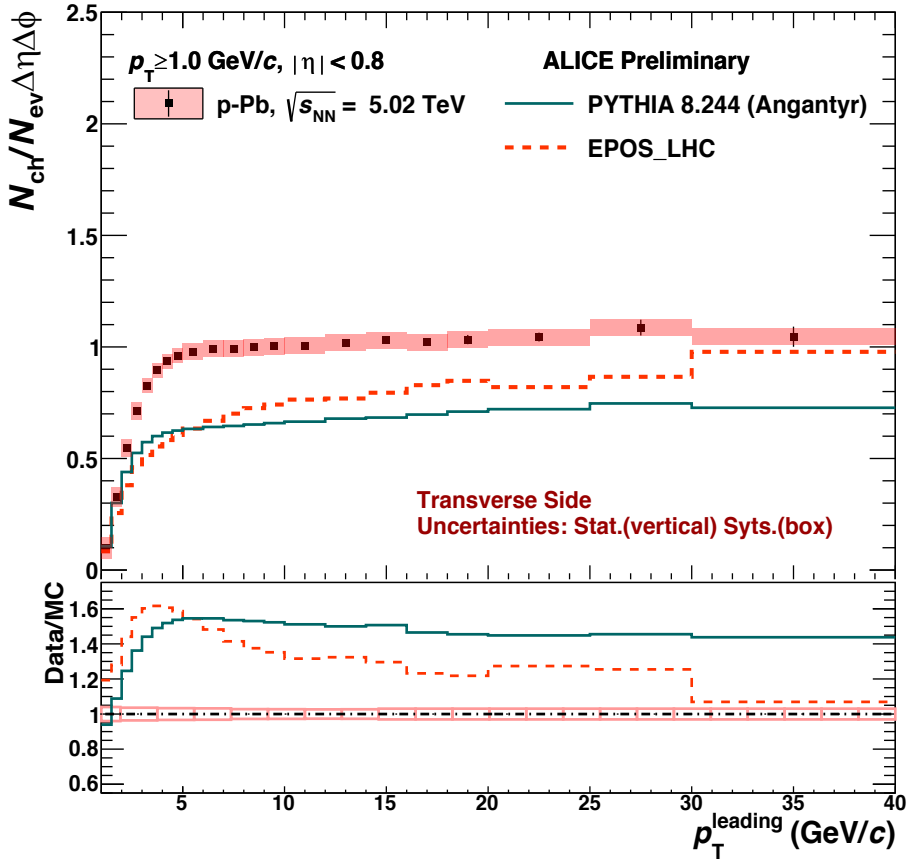
Sum p_T density (SumPt) Away Region(AS, away side) for p_T cut >0.15 GeV/c



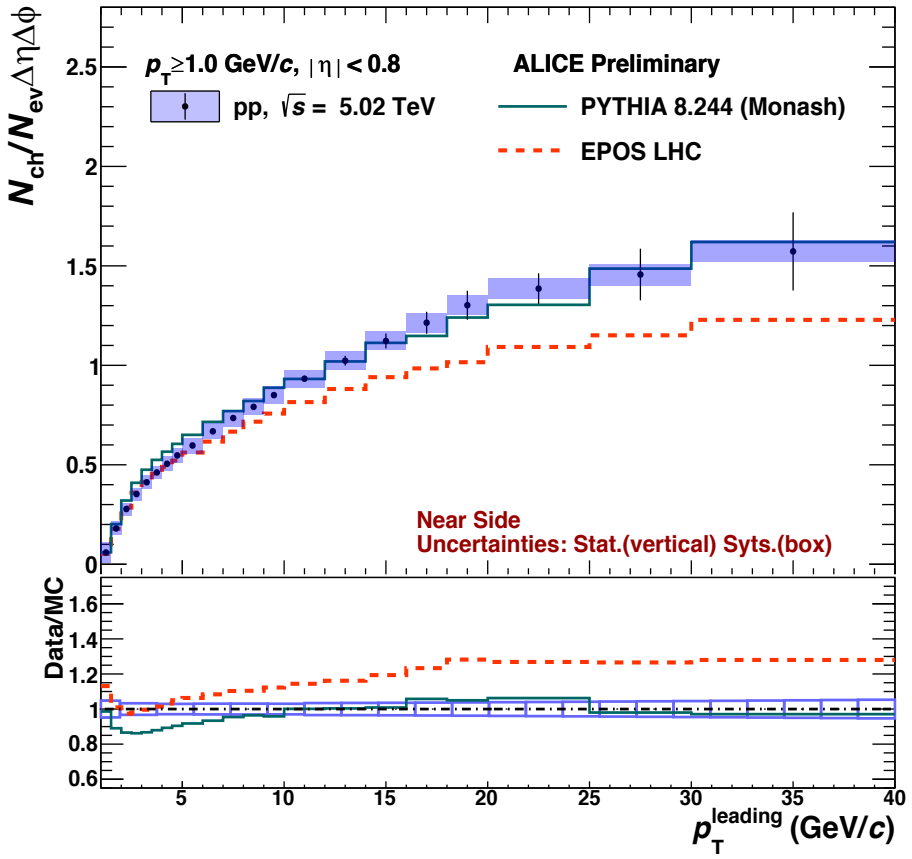


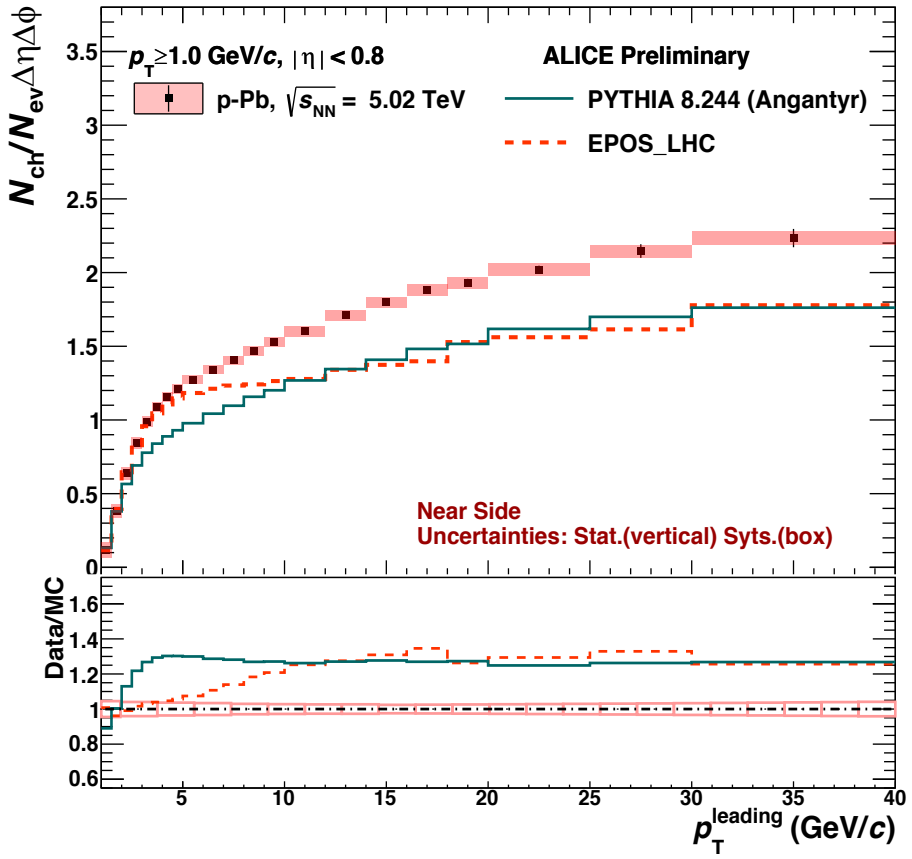
Number density (NumDen) Transverse Region (TS) for p_T cut >1.0 GeV/c



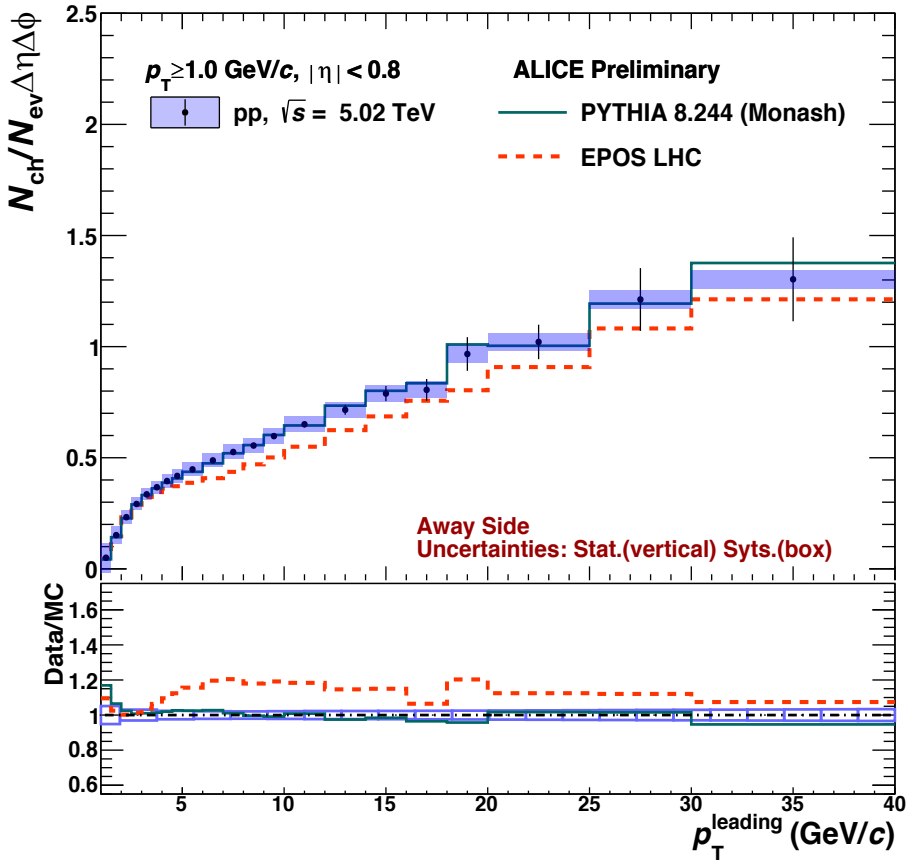


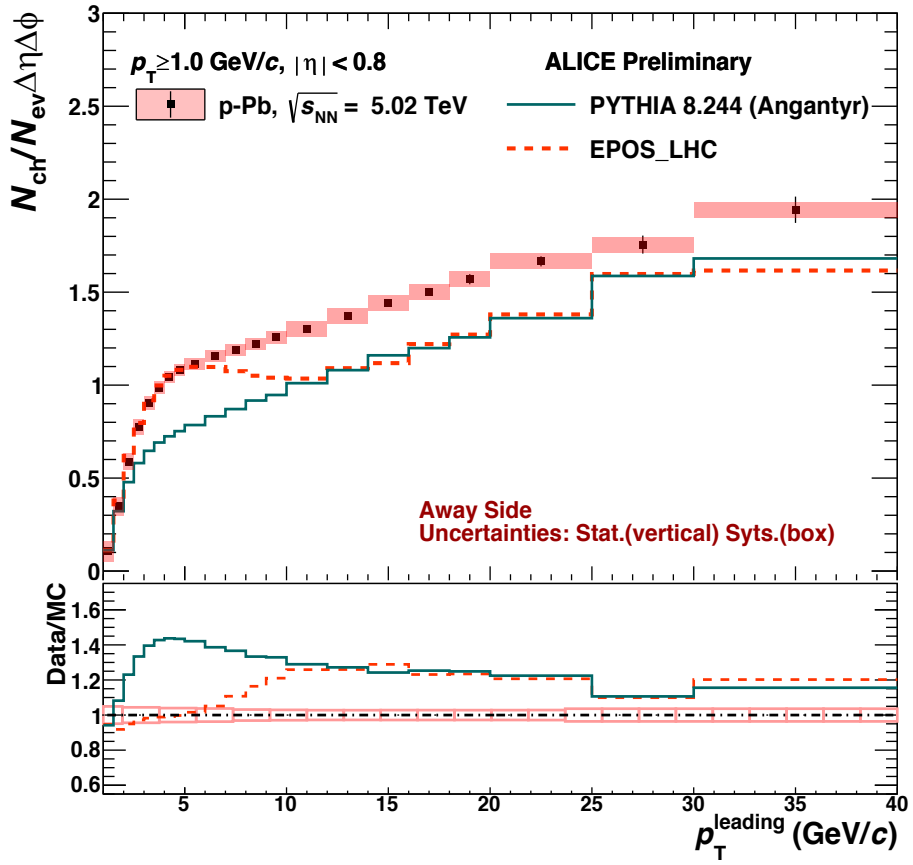
Number density (NumDen) Towards Region (NS, near side) for p_T cut >1.0 GeV/c



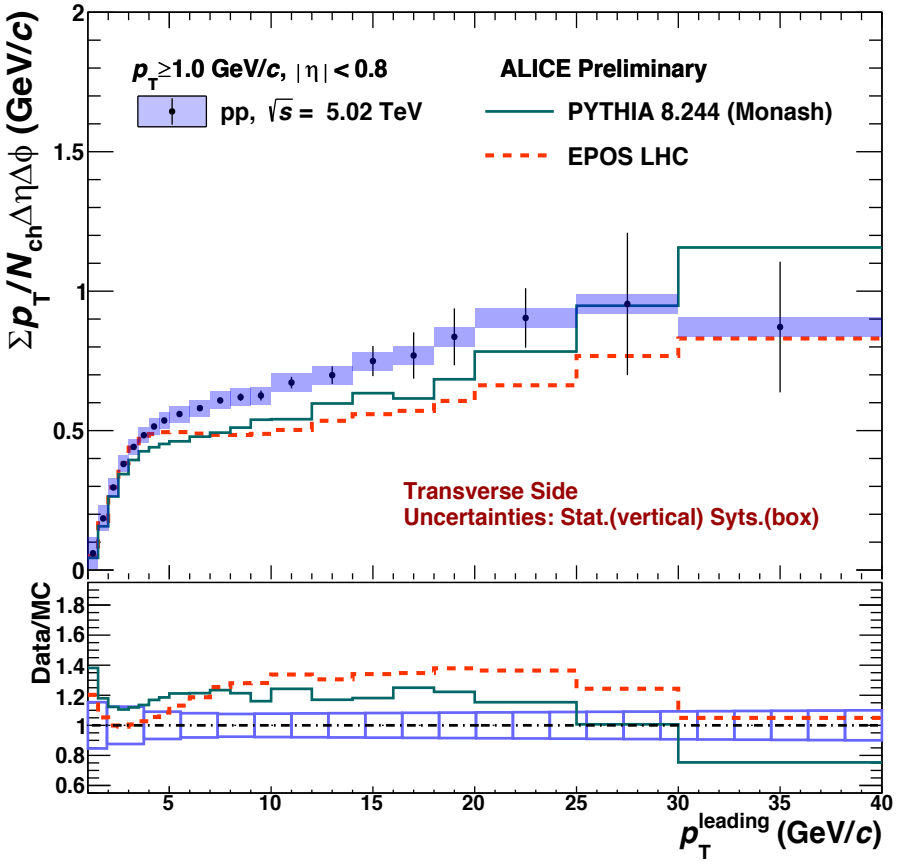


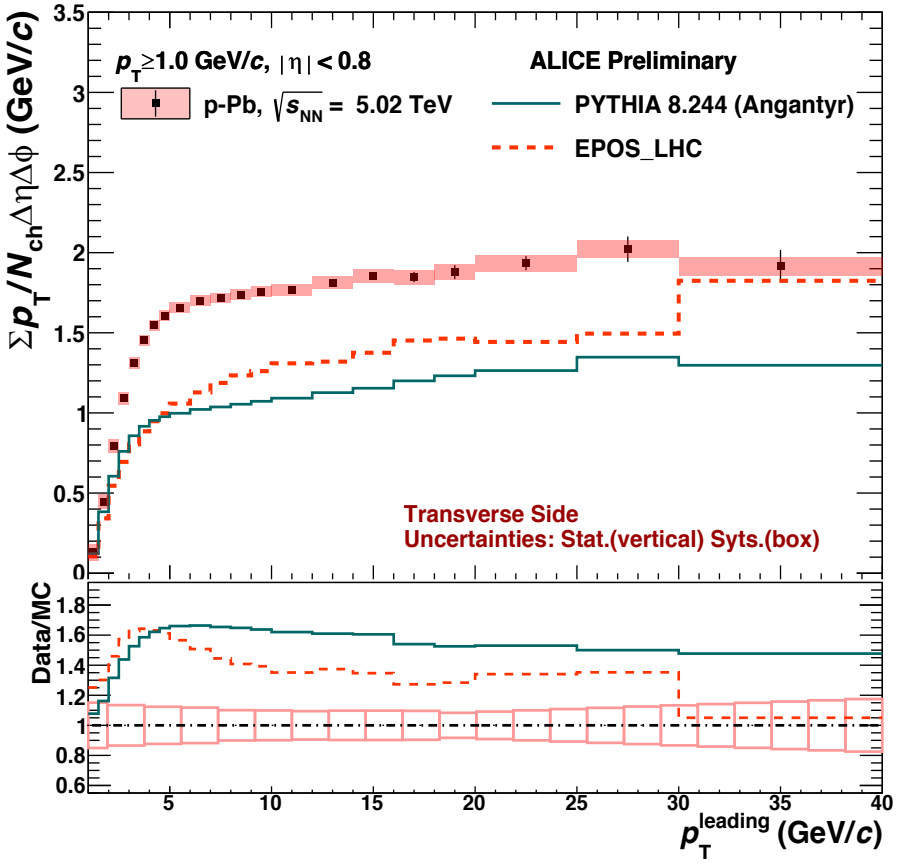
Number density (NumDen) Away Region (AS, away side) for p_T cut >1.0 GeV/c



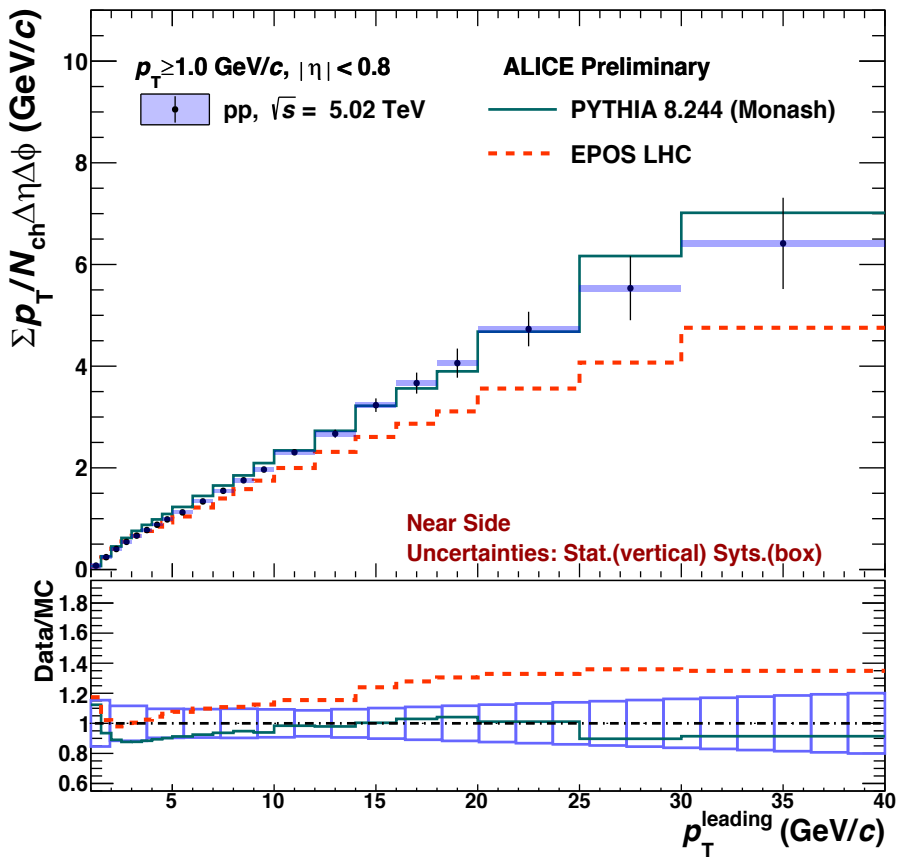


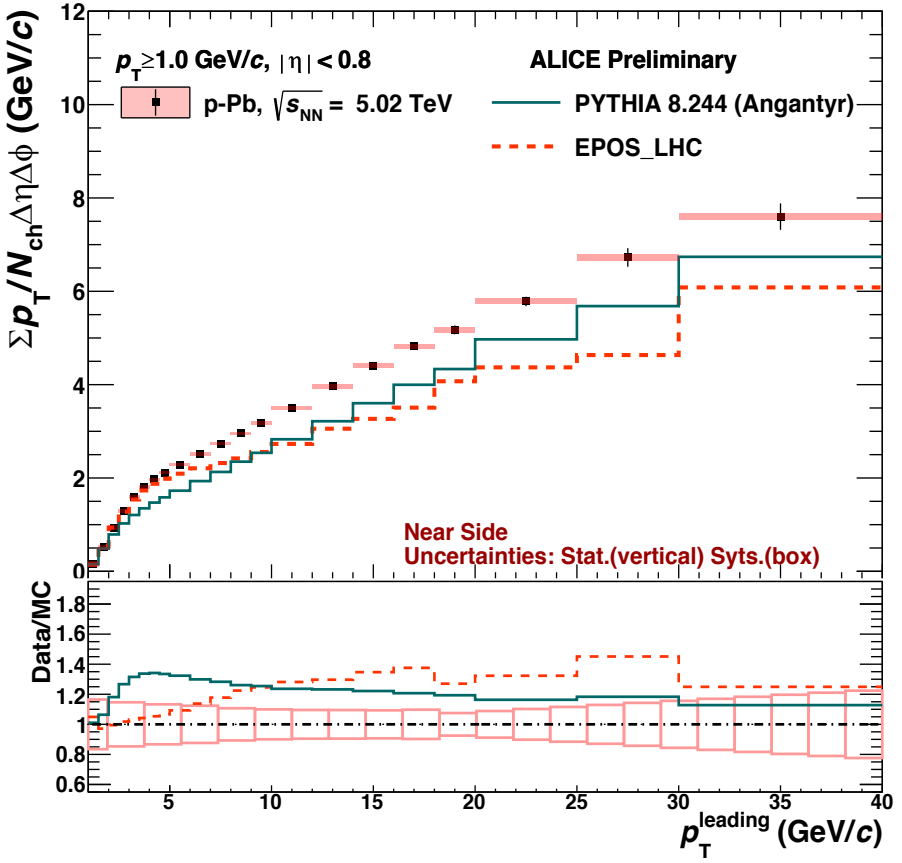
Sum p_T density (SumPt) Transverse Region (TS) for p_T cut >1.0 GeV/c



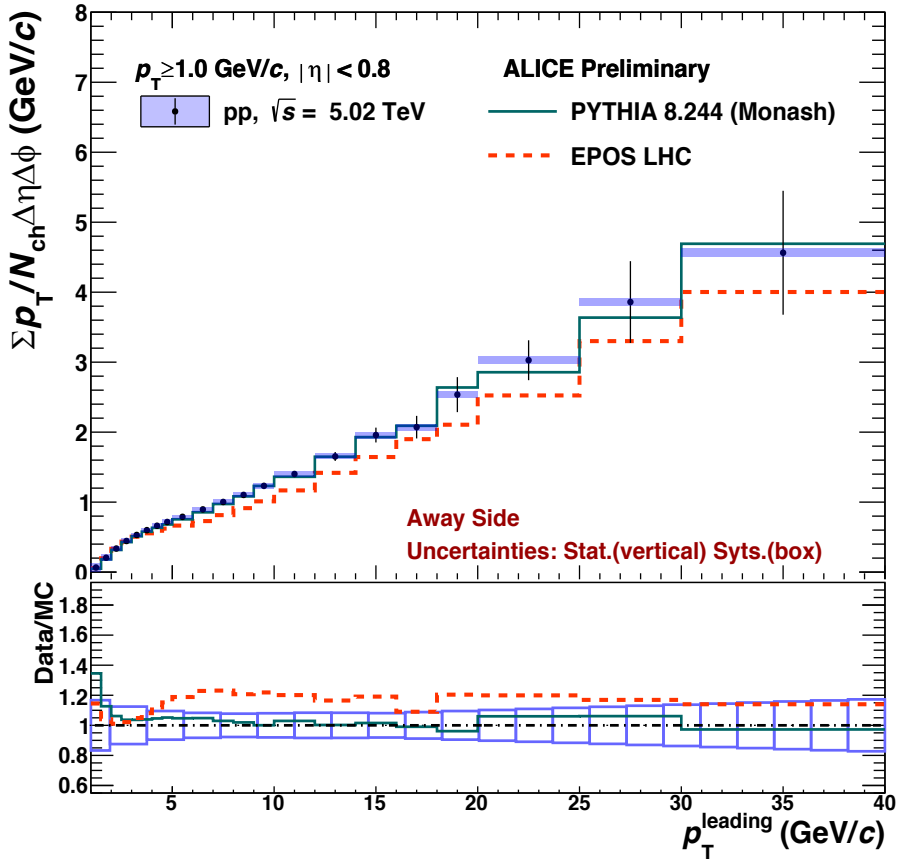


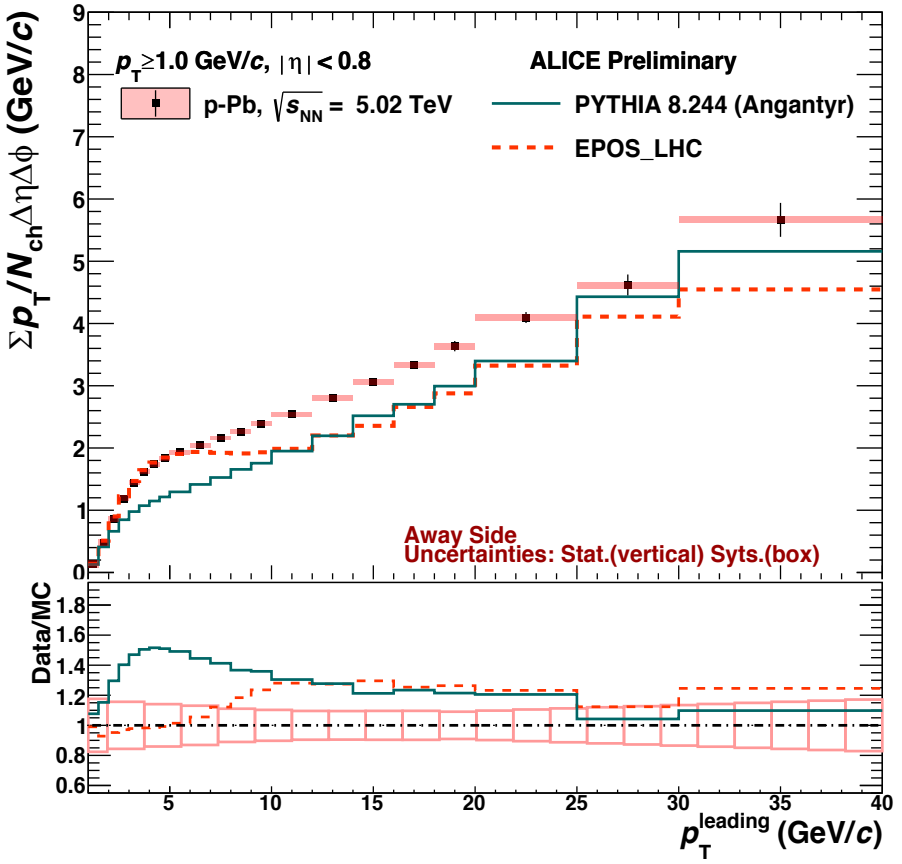
Sum p_T density (SumPt) Towards Region (NS, near side) for p_T cut >1.0 GeV/c



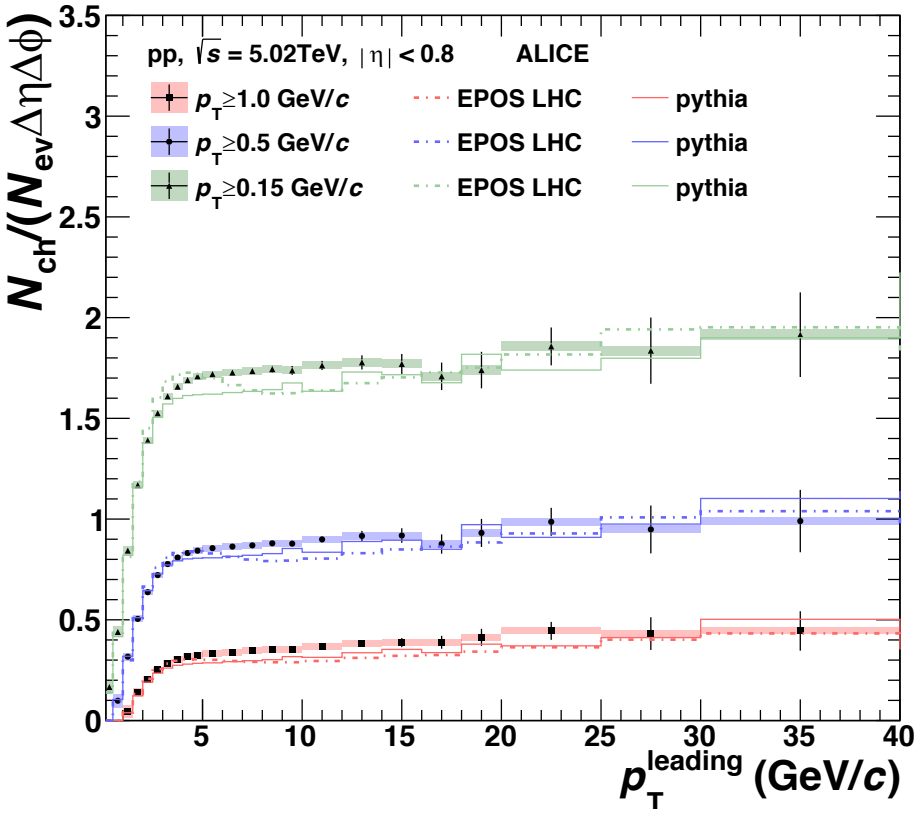


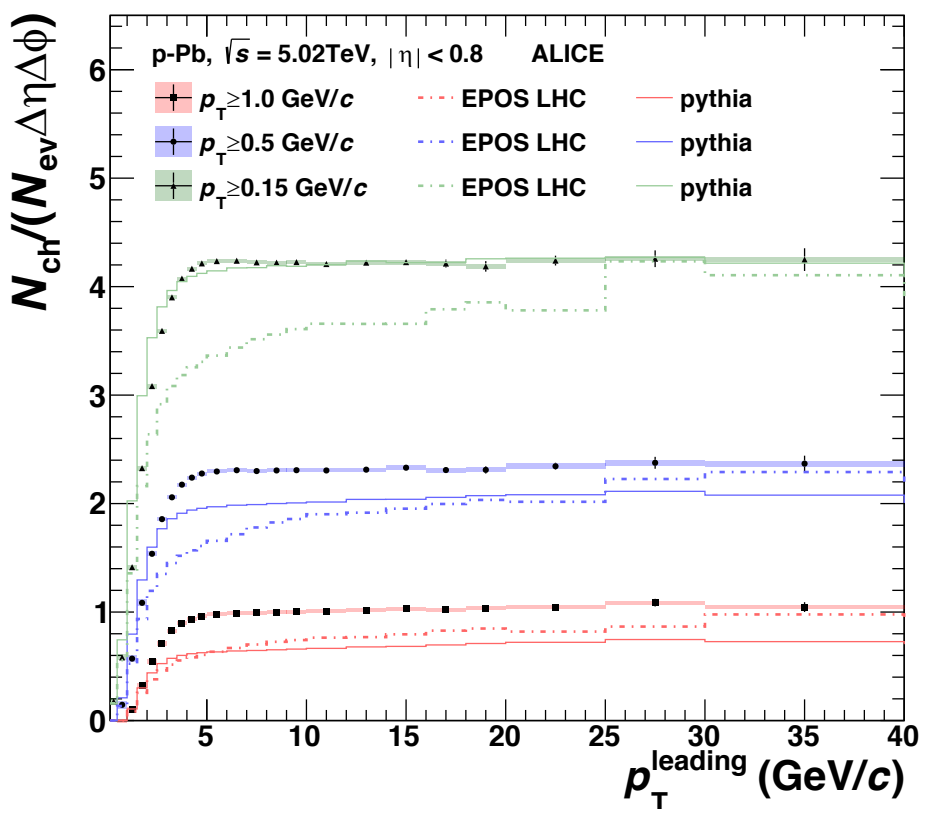
Sum p_T density (SumPt) Away Region (AS, away side) for p_T cut >1.0 GeV/c



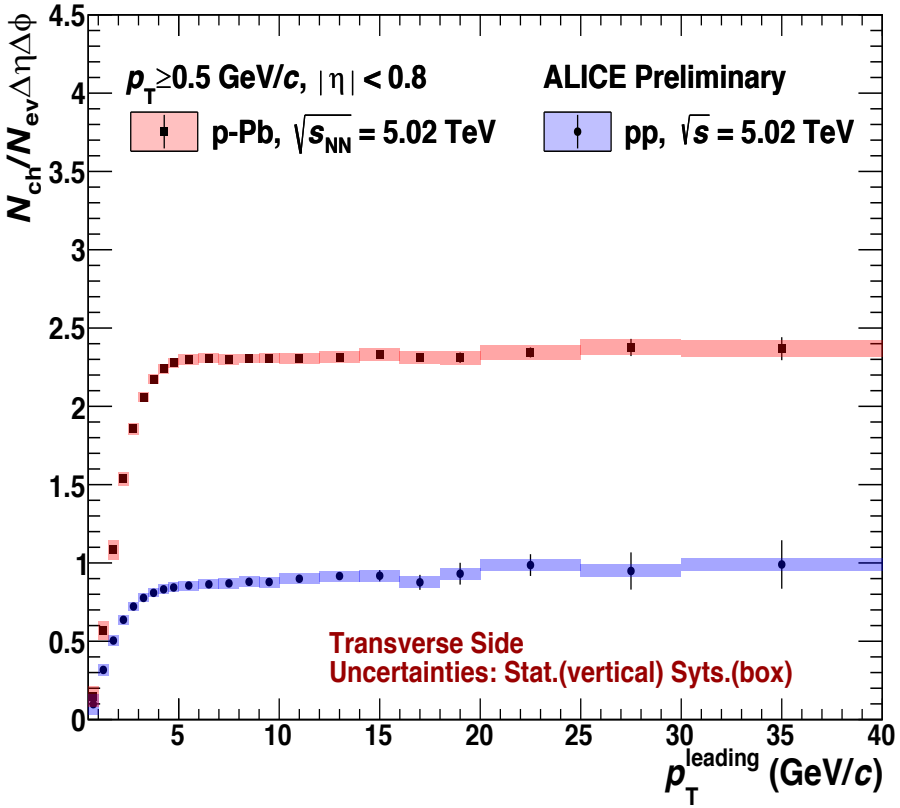


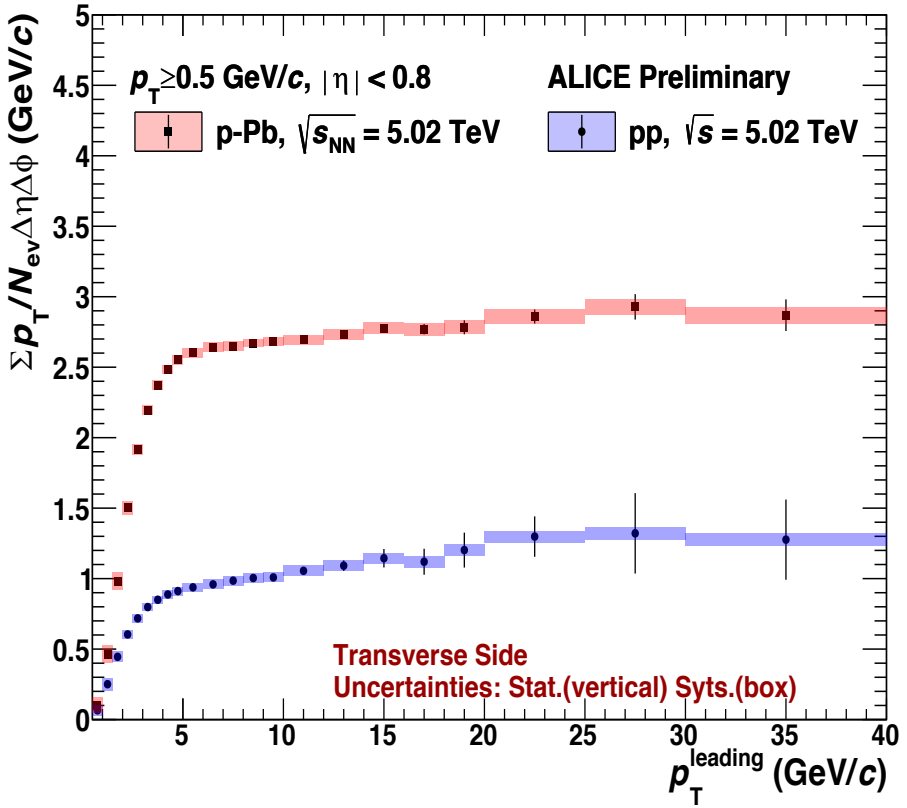
Number density(NumDen) Transverse Region(TS, transverse side) for p_{T} cut >1.0, 0.5, 0.15 GeV/c for pp and p-Pb





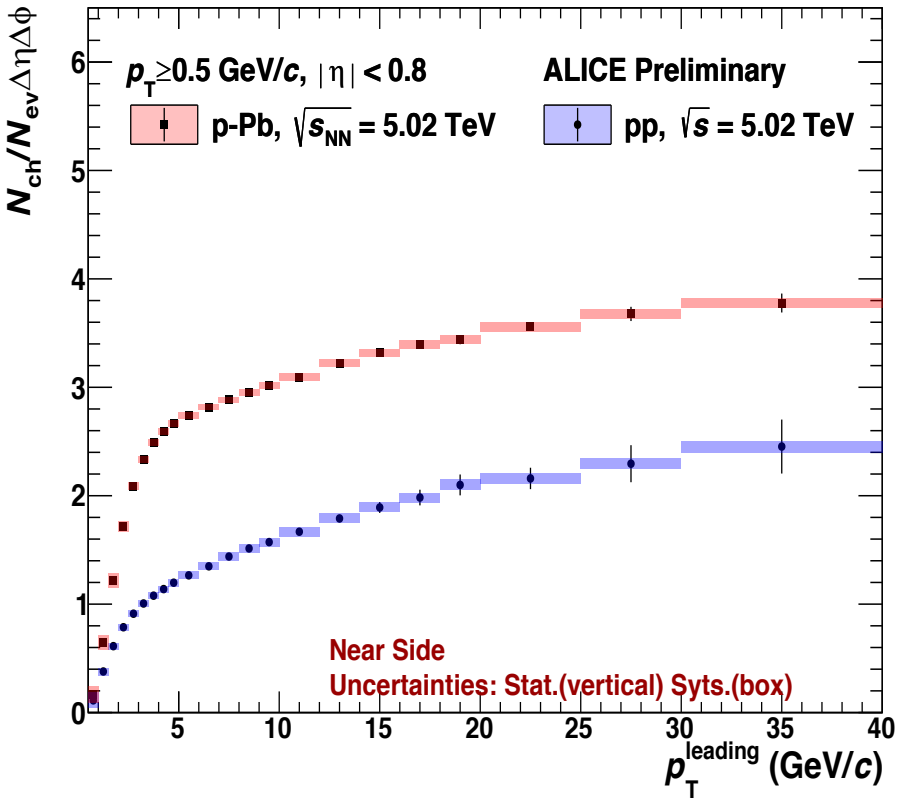
Number density and Sum p_T density for $p_T \geq 0.5$ GeV/c (pp vs p-Pb)

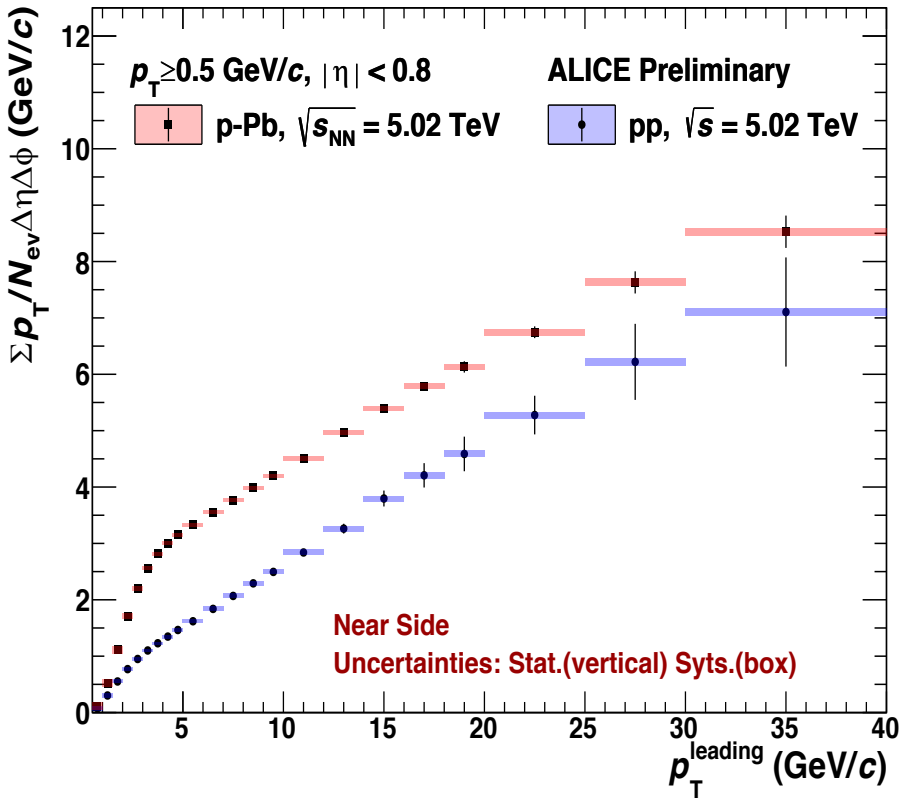




Transverse side: we observe a saturation of the activity for p_T leading greater than 5 GeV/c. This is consistent with results at other center-of-mass energies, and can be explained in Pythia due to the saturation of MPI which can be achieved in "central" pp collisions. For the first time we observe a qualitatively similar behavior in p-Pb collisions. We are investigating the scaling properties.

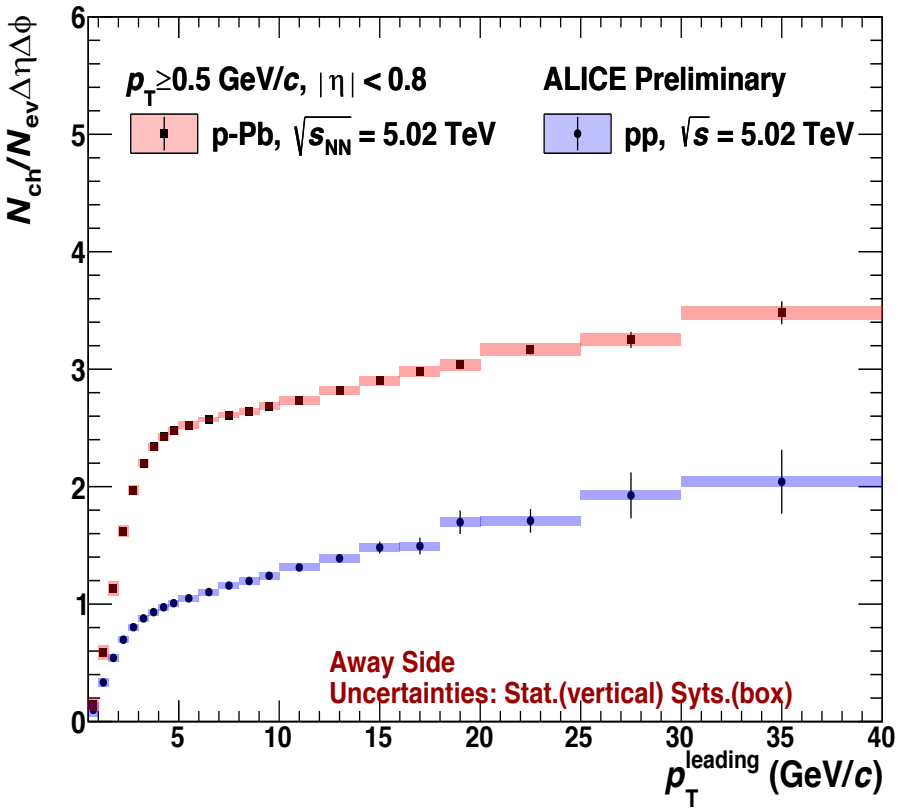
Number density and Sum p_T density for $p_T \geq 0.5$ GeV/c (pp vs p-Pb)

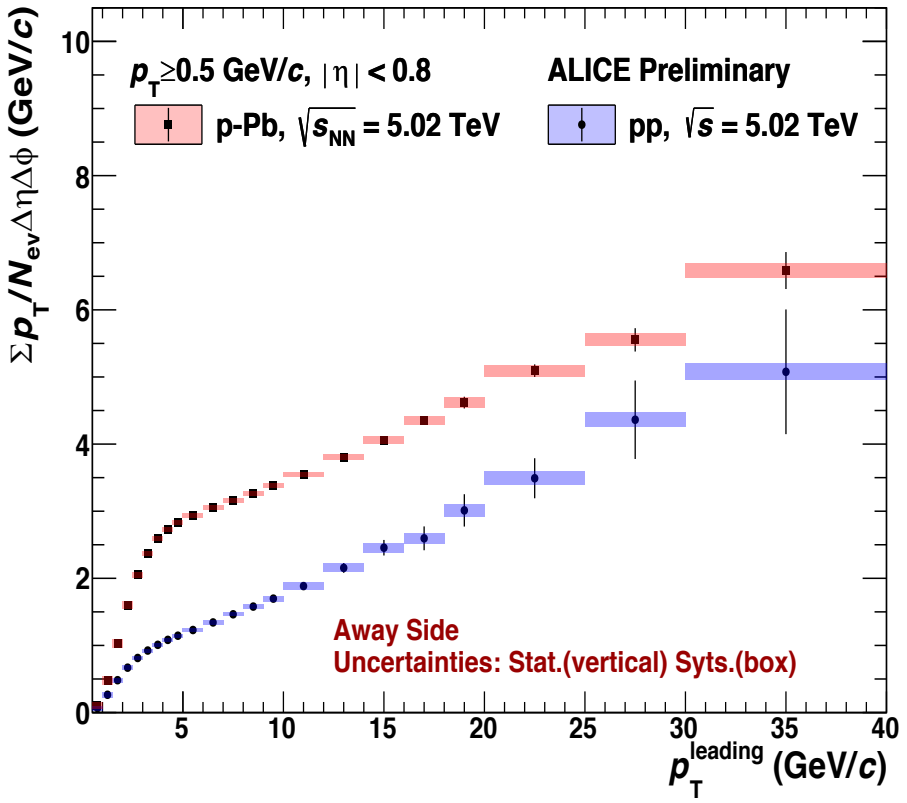




Towards region: The activity in pp increases faster with p_T leading than in p-Pb, this is because the "UE activity" in p-Pb is higher than in pp. For this reason we also investigate the particle production in the jet-like region after the subtraction of the transverse side from towards side [this will be shown at the end of the presentation].

Number density and Sum p_{T} density for $p_{\mathrm{T}} \geq 0.5$ GeV/c (pp vs p-Pb)

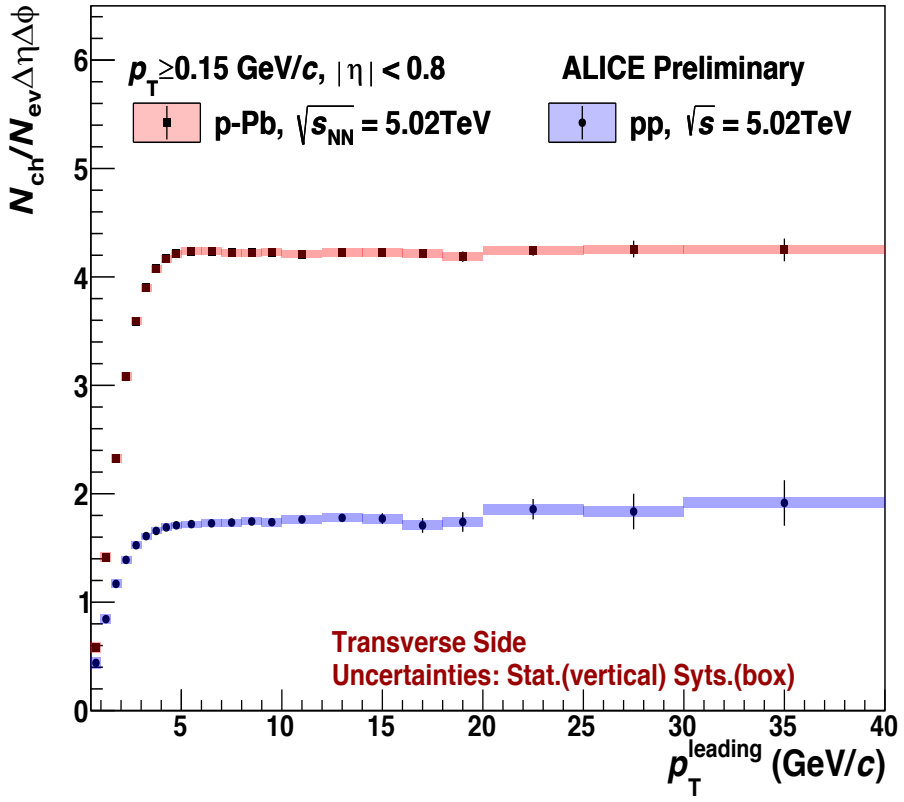


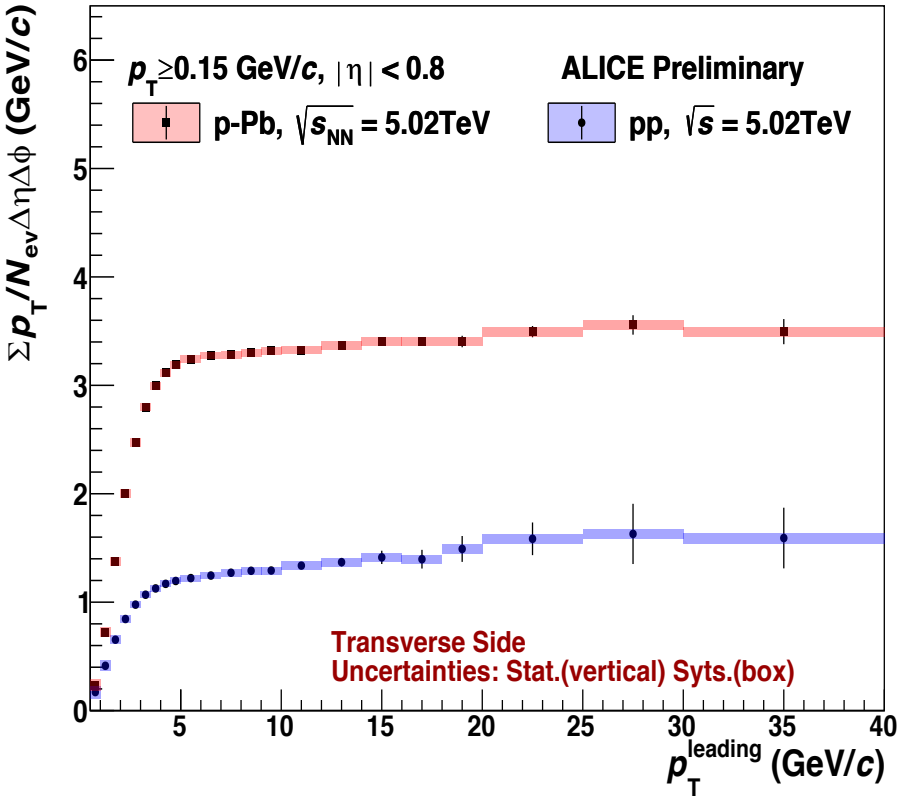


A similar behavior is observed for the away side.

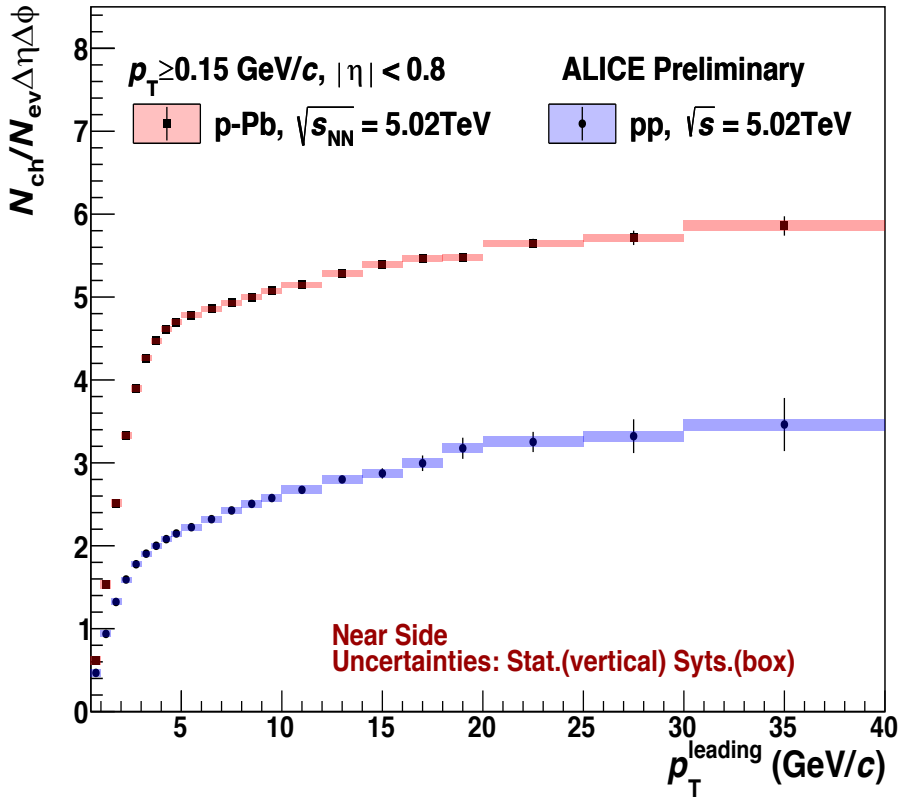
Results for other $\mathrm{p_T}$ cuts can be found in the backup.

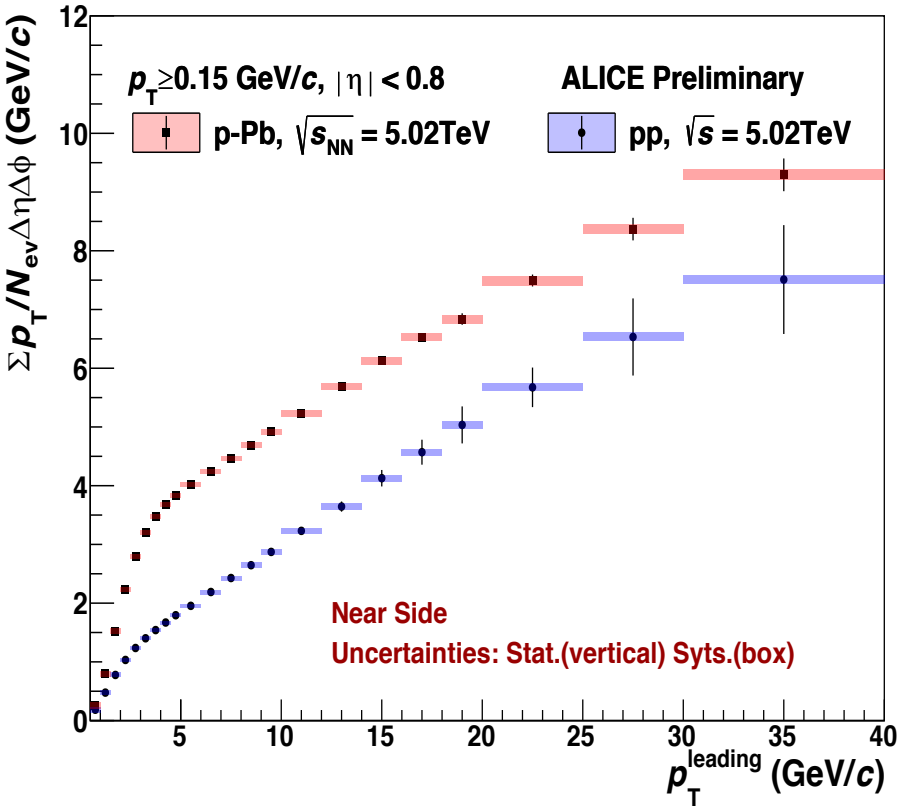
Number density and Sum p_T density for p_T cut >0.15 GeV/c





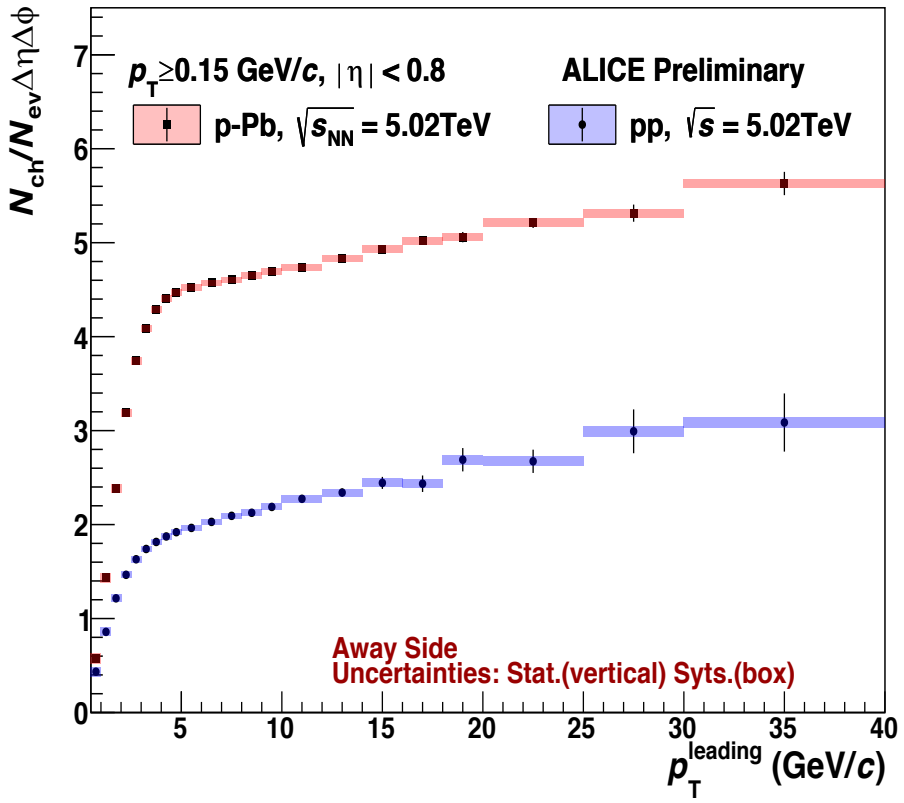
Number density and Sum p_T density for p_T cut >0.15 GeV/c

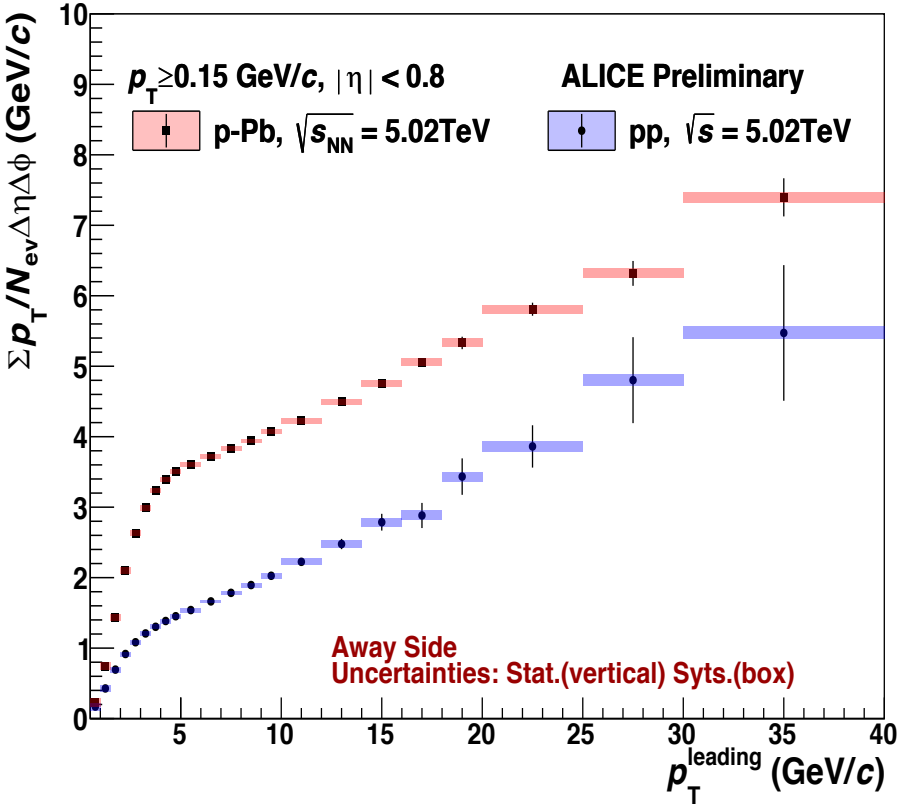




Number Density and Sum p_T Density in Near Side with Statistical and Systematics Uncertainty

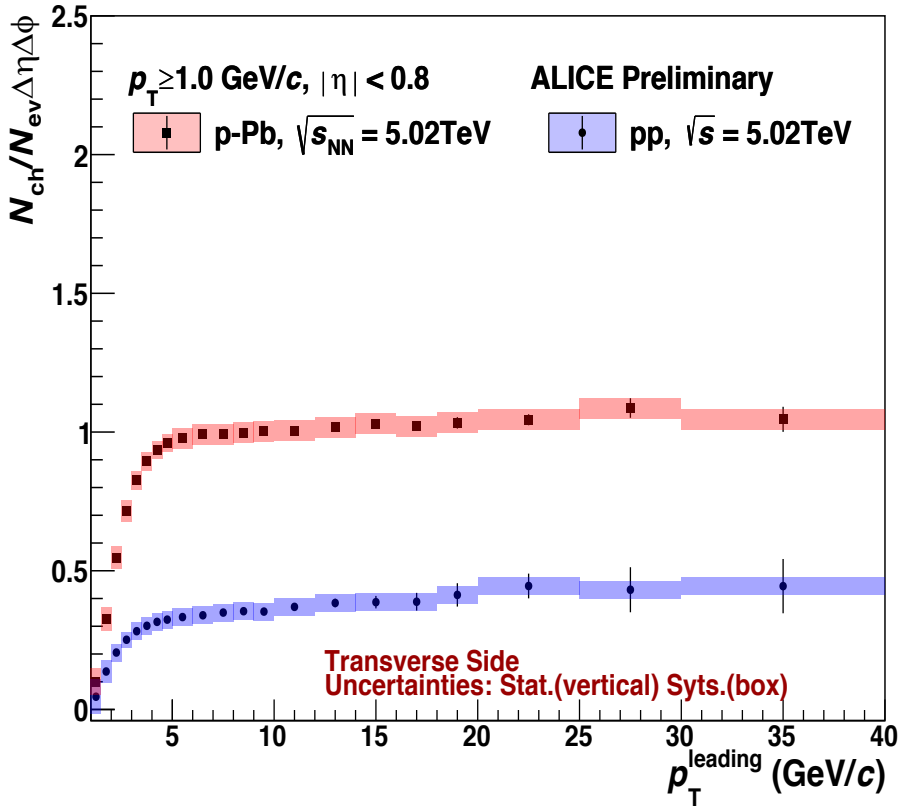
Number density and Sum p_T density for p_T cut >0.15 GeV/c

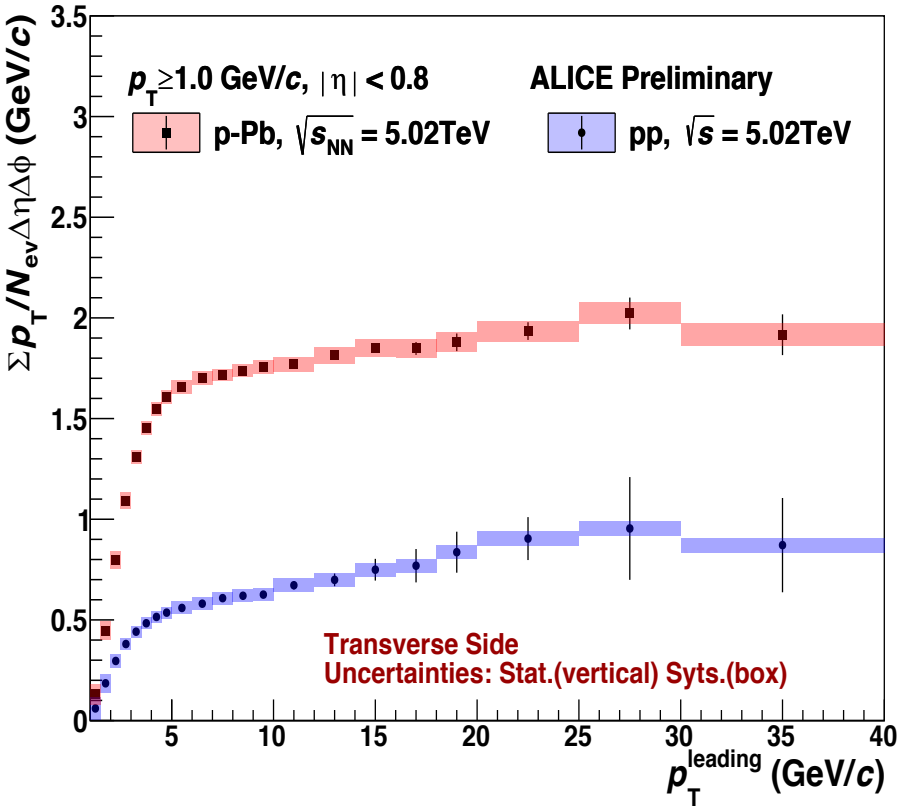




Number Density and Sum p_T Density in Away Side with Statistical and Systematics Uncertainty

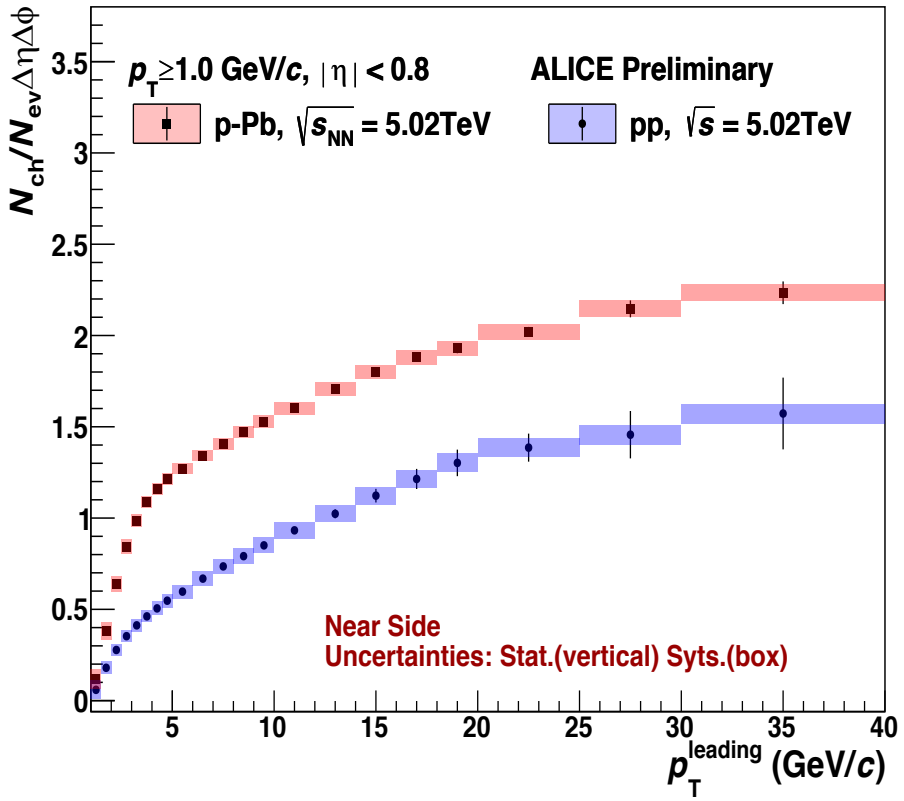
Number density and Sum p_T density for p_T cut >1.0 GeV/c

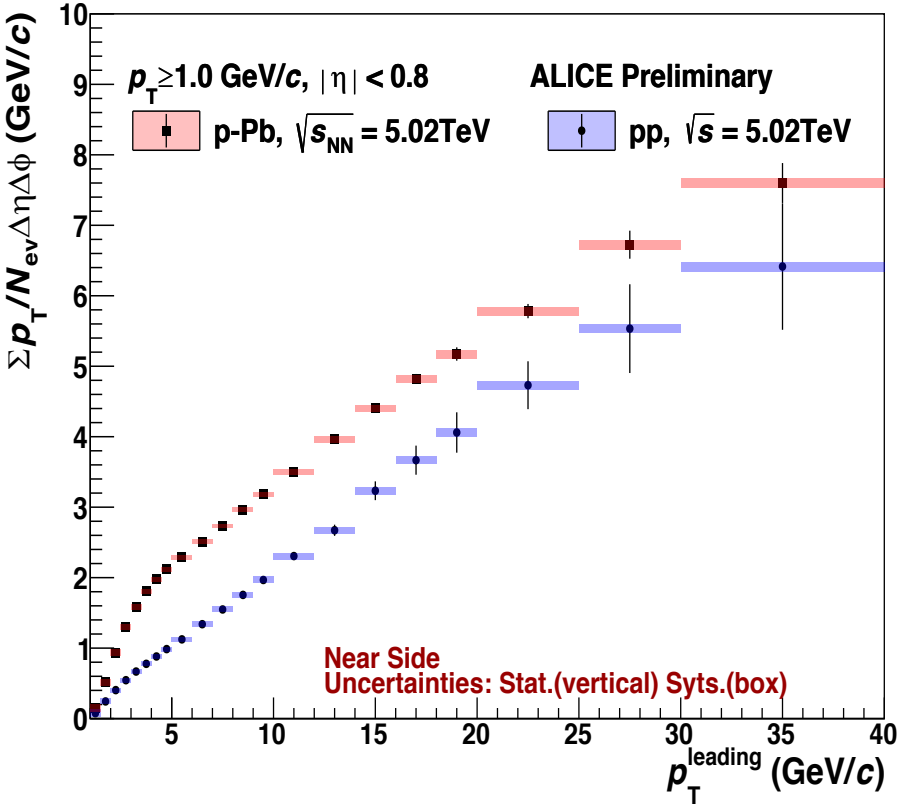




Number Density and Sum p_T Density in Transverse Side with Statistical and Systematics Uncertainty

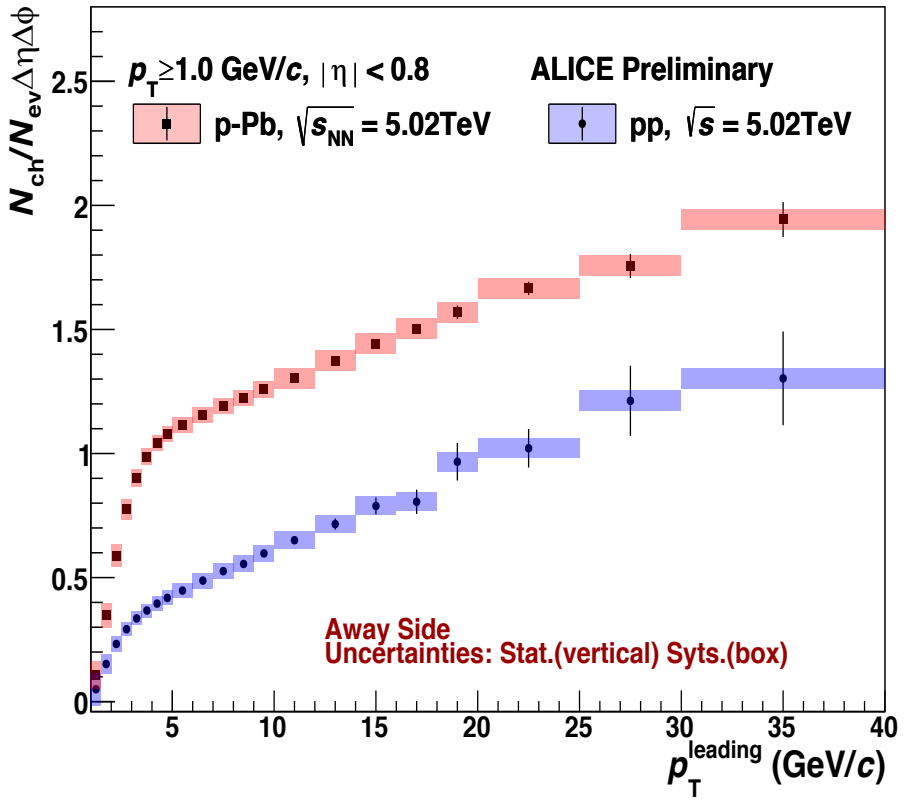
Number density and Sum p_T density for p_T cut >1.0 GeV/c

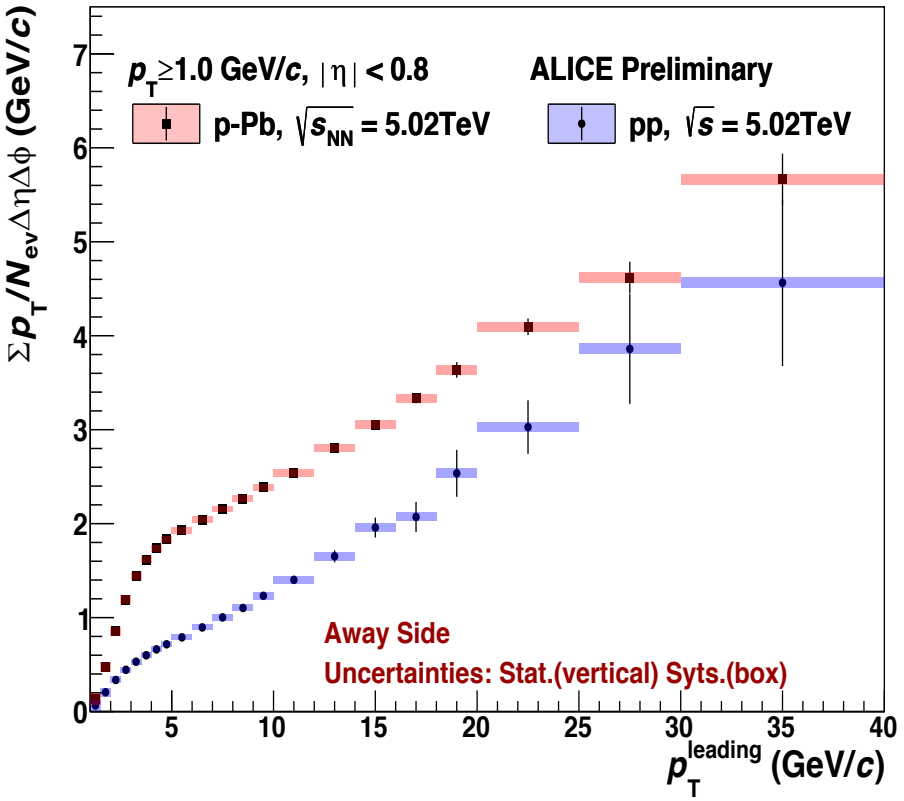




Number Density and Sum p_T Density in Near Side with Statistical and Systematics Uncertainty

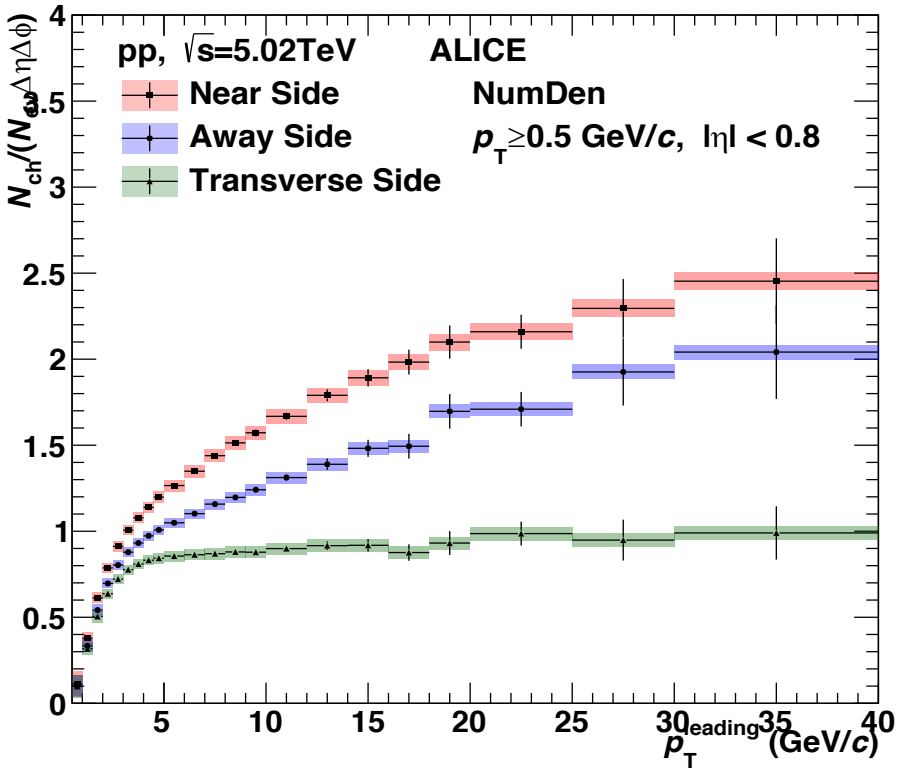
Number density and Sum p_T density for p_T cut >1.0 GeV/c

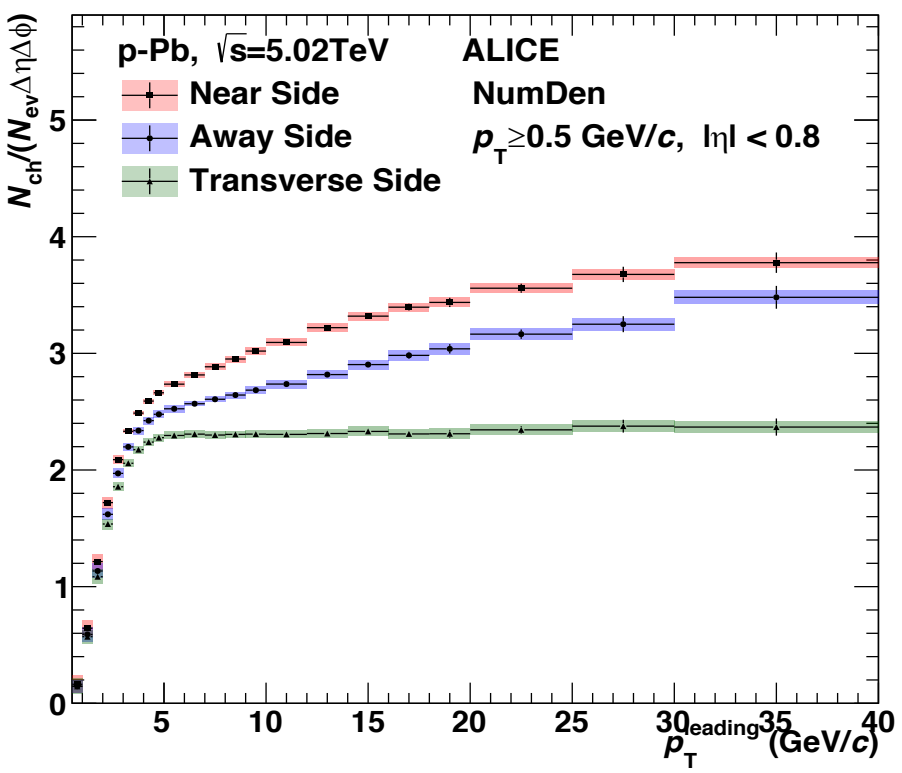




Number Density and Sum p_T Density in Away Side with Statistical and Systematics Uncertainty

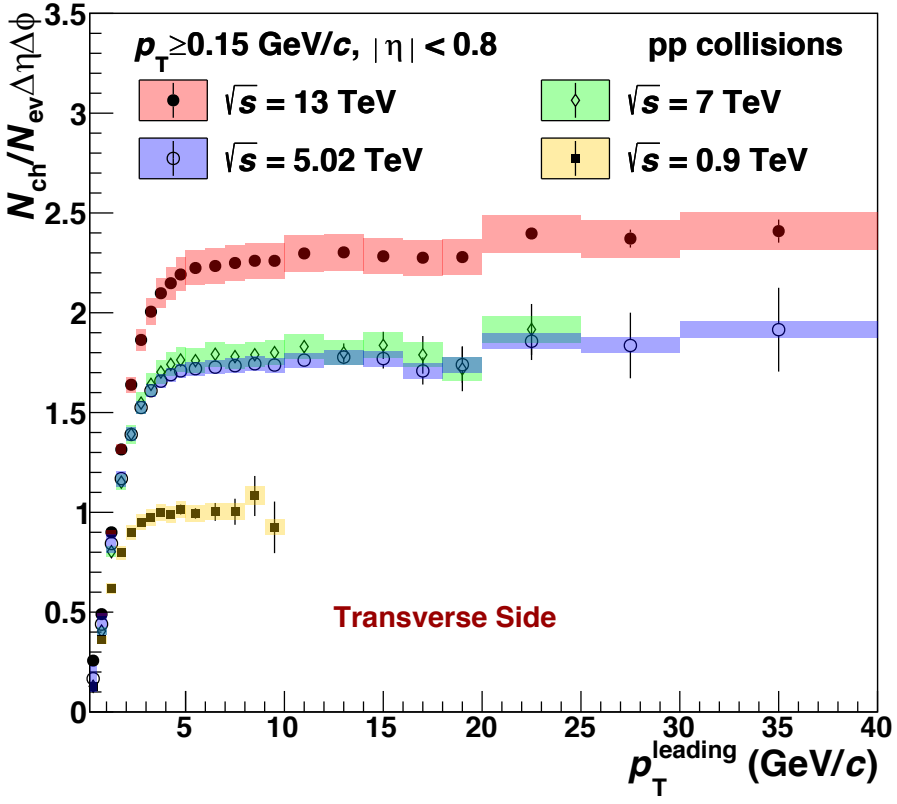
Number density for Transverse, near and away Sides for $p_{\mathrm{T}} \geq$ 0.5 GeV/c for pp and p-Pb @ 5.02TeV

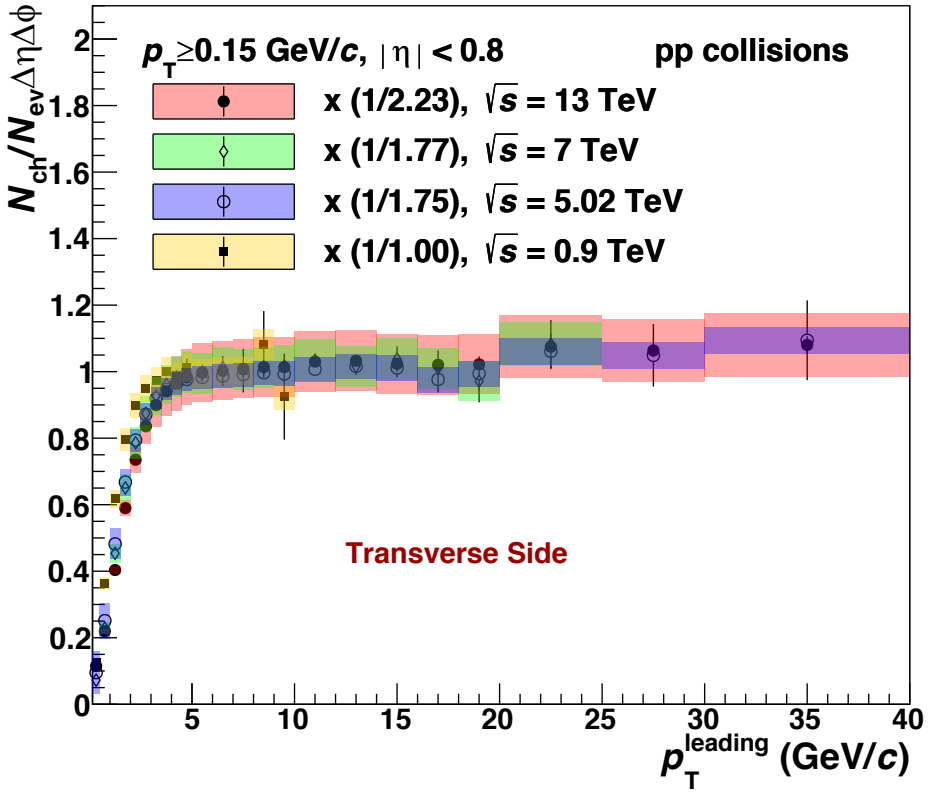




Histogram for paper publications

Number density for Transverse Sides for $p_{\mathrm{T}} \geq$ 0.15 GeV/c for all pp collisions @ 13,7,5.02 and 0.9 TeV





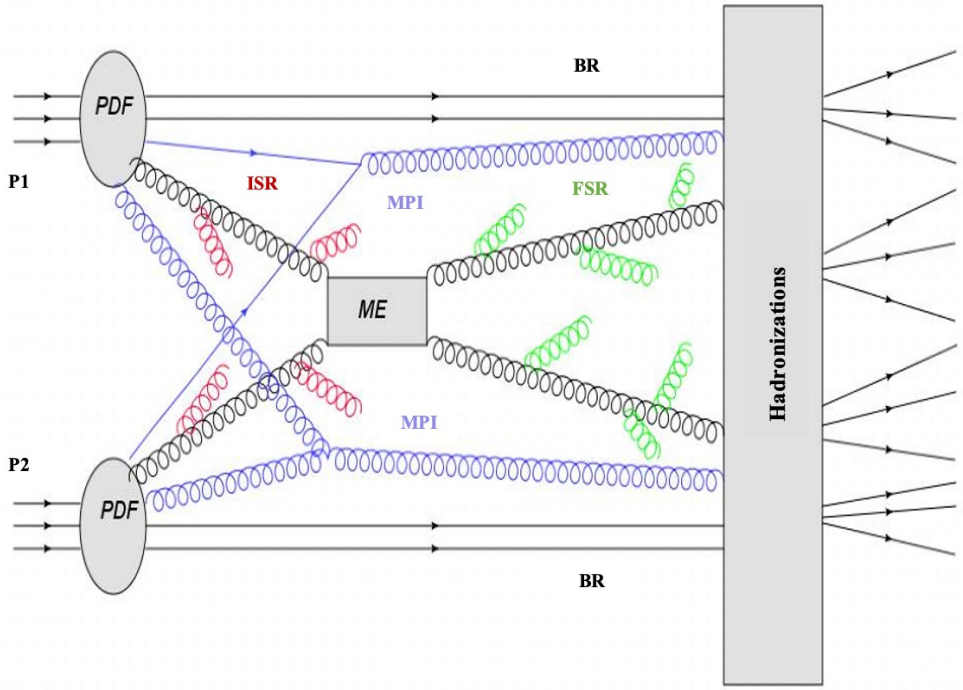
Histogram for paper publications

Summary

* The UE observables in pp and p-Pb collisions at 5.02 TeV are shown.
* Results indicate similarities in the UE observables measured in pp and p-Pb data.
* Calculated the the number density and sum p_{T} NS-TS and AS-TS.
* Showed mean p_{T} for near side and away side.
* Paper drift is almost ready.

backup

Introduction and Motivation



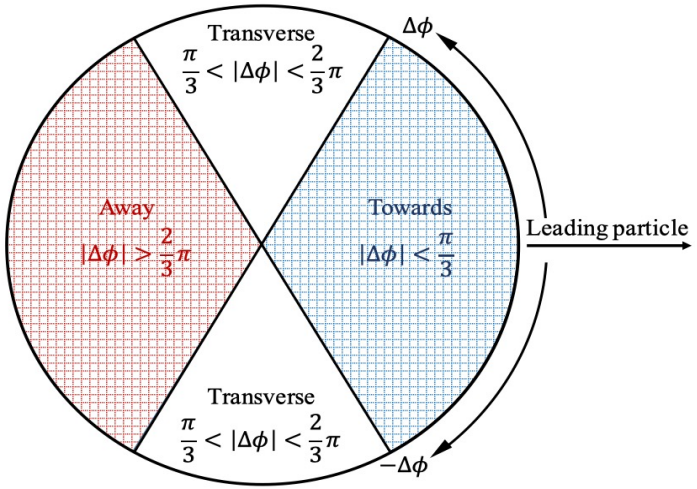
- A good description of the UE is needed to understand backgrounds to other observables in small systems.
- UE allows to access fundamental information on the hadron structure, a basic step of event characterization process.
- Provides a baseline for jet studies.
- Non-perturbative phenomenology in high energy hadronic collisions.
- In particular these studies serve as a powerful tool to tune Monte Carlo event generators.

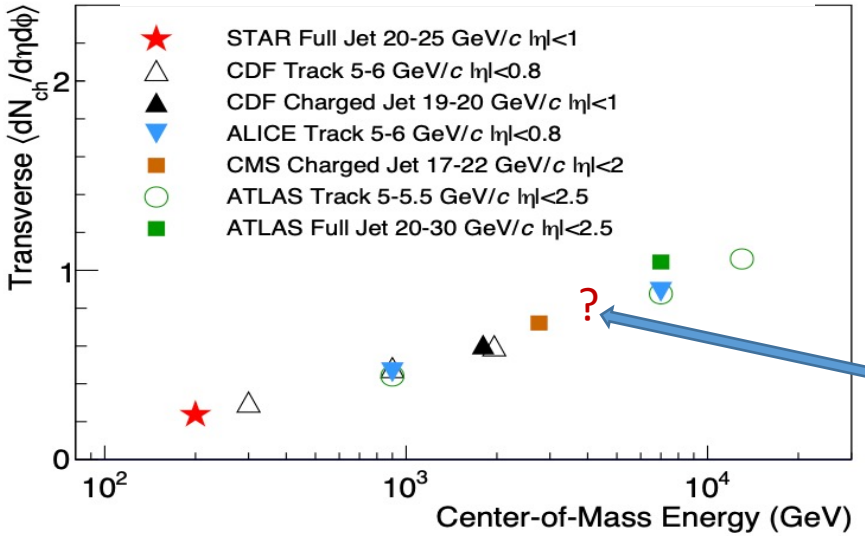
pp collision : hardest scattering → leading interaction

other scattering→ Underlying Event

(UE: Beam Remnants, Initial State Radiation, Final State Radiation, Multiple Partonic Interaction)

Introduction and Motivation





- The traditional UE analysis is based on the measurement of particle production in three distinct topological regions.

T. Martin, P. Skands and S. Farrington, Eur. Phys. J. C 2016 (26):299

Main observables:

Number Density $\frac{1}{\Delta\eta.\Delta\Phi}\frac{1}{N_{ev}(pT,LT)} N_{ch}(pT, LT)$

Energy Density $\frac{1}{\Delta\eta.\Delta\Phi}\frac{1}{N_{ev}(pT,LT)} \sum p_T\ (pT, LT)$

R. Field [CDF Collaboration], Int. J. Mod. Phys A 16S1A (2001) 250-254

- UE observables have been measured in pp collisions from RHIC to LHC energies

STAR Collaboration, Phys. Rev. D 101, 052004 (2020)

- pp data at 5.02 TeV are missing!
- This measurement would be important to confirm the scaling properties reported in

A. Ortiz and L. Valencia, Phys. Rev. D 96, 114019 (2017)

Introduction and Motivation

pp and p-Pb collisions exhibit collective-like behavior and strangeness enhancement, raising the question whether a small drop of Quark-Gluon Plasma is produced in small collision systems.
James L. Nagle, William Z. Zajc, Ann. Rev. Nucl. Part. Sci. 68 (2018) 211-235

The goal of our work is to perform for the first time the UE analysis in p-Pb collisions.

-We want to compare the UE observables (number density and the summed transverse momentum in the towards, away and transverse sides) in pp and p-Pb collisions for similar event classes (same p_{T} leading and same $\sqrt{s_{\mathrm{NN}}}$).

- The jet-like region is compared by subtracting the transverse side from the towards and away regions.

-Results is compared with QCD-inspired event generators. shown in preliminary approval's results

Data Analysis

Instituto de Ciencias Nucleares UNAM

Data Sample and Selection

In this presentation only results for pp and p-Pb collisions are shown.

Only good runs (according with DPG) were used:

pp (LHC15n pass4): 244340, 244343, 244351, 244355, 244359, 244364, 244377, 244411, 244416, 244418, 244421, 244453, 244456, 244480, 244481, 244482, 244483, 244484, 244531, 244540, 244542, 244617, 244618, 244619, 244626, 244627, 244628

MC production: LHC17e2 (Pythia 8 Monash)

p-Pb (LHC16q pass1 CENT wSDD): 265332, 265334, 265335, 265336, 265338, 265339, 265342, 265343, 265344, 265377, 265378, 265381, 265383, 265384, 265385, 265387, 265388, 265419, 265420, 265421, 265422, 265424, 265425, 265426, 265427, 265435, 265499, 265500, 265501, 265521, 265525, 265309

MC production: LHC17f2a_cent_fix (EPOS_LHC)

Data Sample and Selection

- Event selection
  - Minimum Bias Trigger (CINT7)
  - Standard Physics Selection (AliEventCuts): DAQ incomplete, SPD vertex reconstruction, Track vertex reconstruction.
  - Reject Pile up events
  - Vertex position within |Z| < 10 cm

Analysis task:
https://github.com/alisw/AliPhysics/tree/master/PWGMM/UE/UeKNO

- Track selection and Track cuts
  - StandardITSTPCTrackCuts2015PbPb
  - $p_T \geq$ 0.15,0.5,1.0 GeV/c, |η| < 0.8
  - MaxChi2PerClusterTPC(4)
  - MaxChi2TPCConstrainedGlobal(36)
  - MaxChi2PerClusterITS(36)
  - MaxFractionSharedTPCClusters(0.4)
  - MinRatioCrossedRowsOverFindableClustersTPC(0.8)
  - MaxDCAToVertexZ(2)
  - SetCutGeoNcrNcl(3., 130., 1.5, 0.85, 0.7)
  - SetMaxDCAToVertexXYPtDep("0.0182+0.0350/pt^1.01")
  - SetRequireSigmaToVertex(kFALSE)
  - SetAcceptKinkDaughters(kFALSE)
  - SetRequireTPCRefit(kTRUE)

Analysis Details

- The analysis starts from the extraction of the p_{T} spectra as a function of p_{T} leading. The p_{T} spectra are obtained for each topological region.
- The p_{T} spectrum associated to each p_{T} leading is corrected for efficiency and contamination from secondaries. For this we follow the standard strategy from PWG-LF.
- The p_{T} spectrum is normalized to the number of events in each p_{T} leading bin.
- The number density and average sum p_{T} density are both derived from the p_{T} spectra.
- Steps 1-4 give the number density and sum p_{T} as a function of p_{T} leading. This correlation is further corrected for the leading track misidentification and selection bias (vertex reconstruction).
- To see all the corrections factors see backup slides (slides 61-65).

Systematic Uncertainties

Systematics Uncertainties for Track/Event Selection Cuts

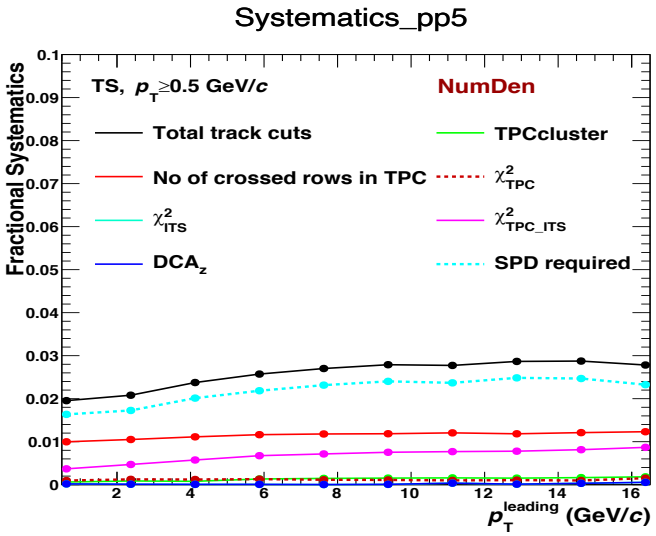
Vary Following Track/Event selection cuts

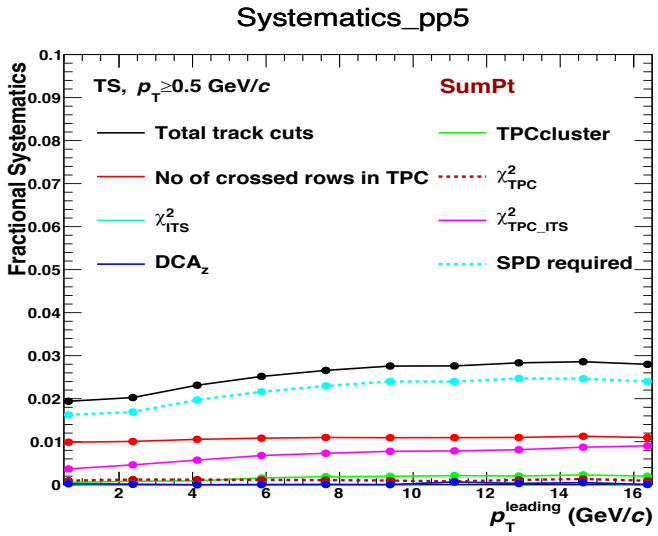
- MaxChi2PerClusterTPC(4) : 3 , 4(default), 5.
- MaxChi2TPCConstrainedGlobal(36) : 25 , 36(default), 49.
- MaxChi2PerClusterITS(36) : 25 , 36(default), 49.
- MaxFractionSharedTPCClusters(0.4) :0.2,0.4(default),1.0.
- MinRatioCrossedRowsOverFindableClustersTPC(0.8) : 0.7,0.8(default),0.9.
- MaxDCAToVertexZ(2) : 1 , 2(default), 5.
- SPD requirement (kTRUE).
- Vertex ZCut is also varied.

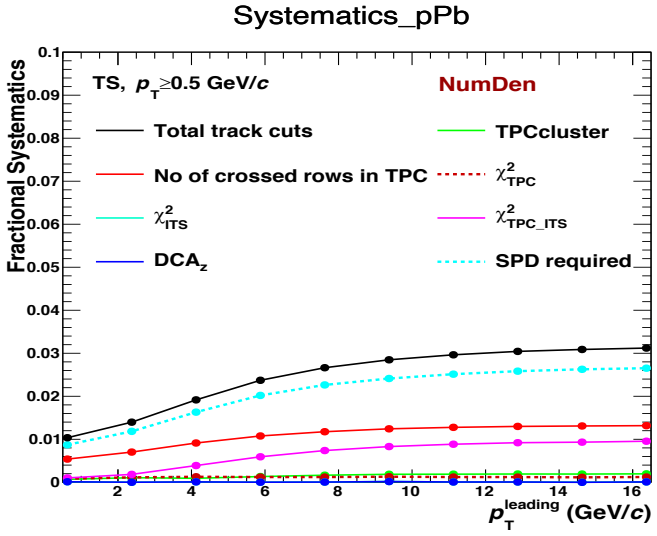
Systematic Uncertainties from Other Variations

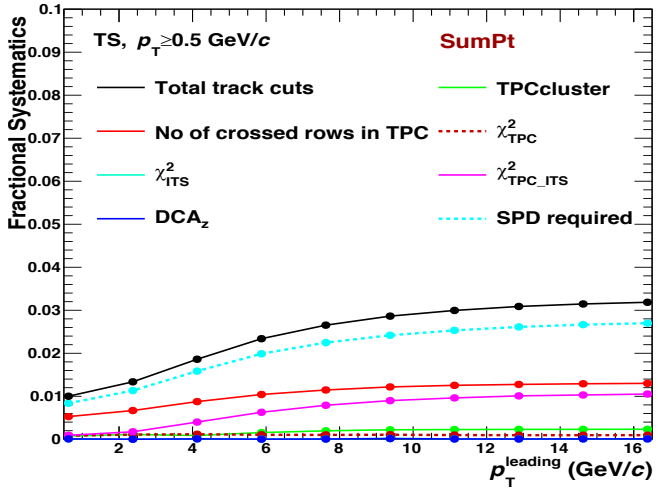
- Secondary Contamination: Varied the fit range for the MC template fit −1 to 1 and −2 to2. where as default interval is (−3 to 3). Maximum difference assigned as the systematic uncertainty.
- Misidentification Bias: Difference between Data driven and Monte-Carlo Method.
- Correction Method/MC closure: Difference between MC true and MC corrected in MC closure test
- For other p_{T} min cuts (0.15 and 1.0 GeV/c) see slides in backup (slides 67-76).

Systematics Uncertainty for Track Cuts TS(transverse side)









Systematics uncertainty for each cut

$$\text{Frac Uncertainty} = \left(\frac{|Y_{varied} - Y_{standard}|}{Y_{standard}}\right)$$

Total frac uncertainty for each cut

$$\delta z = \sqrt{\delta x^2 + \delta y^2}$$

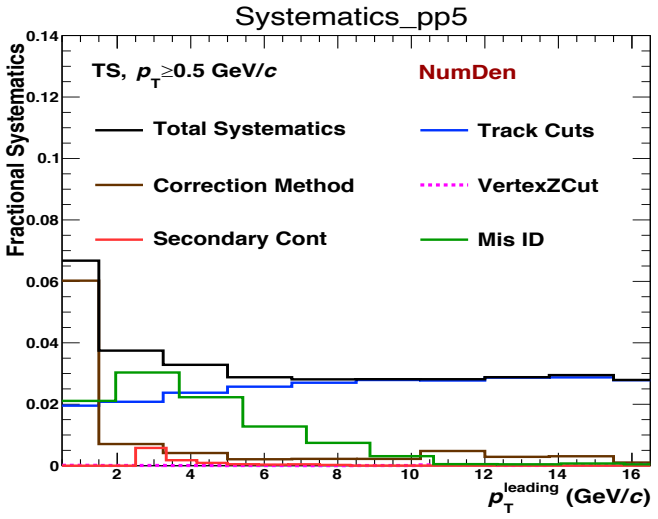
Total frac uncertainty

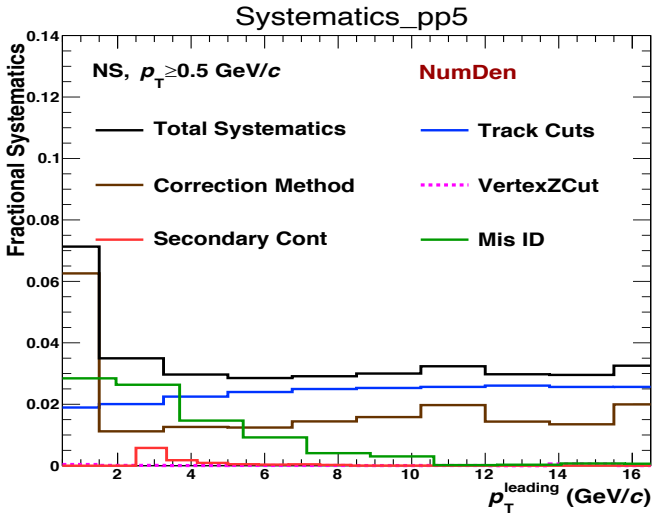
$$\delta t = \sqrt{\delta a^2 + \delta b^2 \ldots\ldots}$$

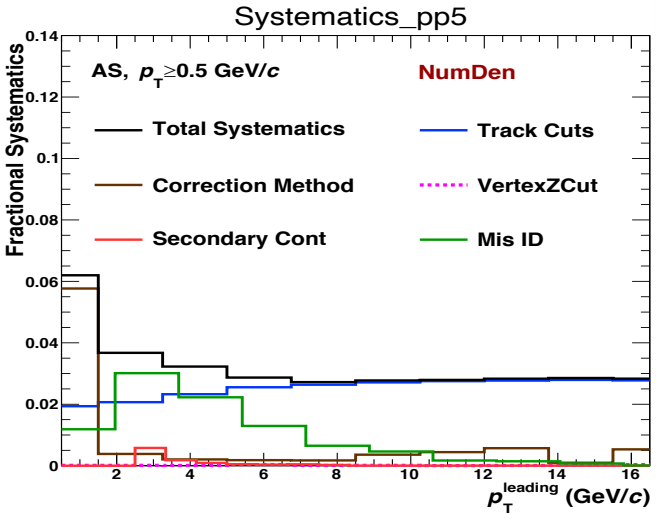
p.s p_T min cut $\geq$ 0.5

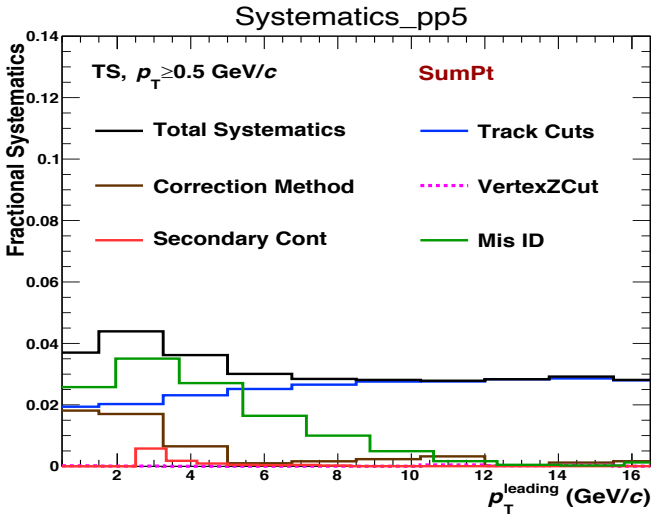
Total Systematics Uncertainties

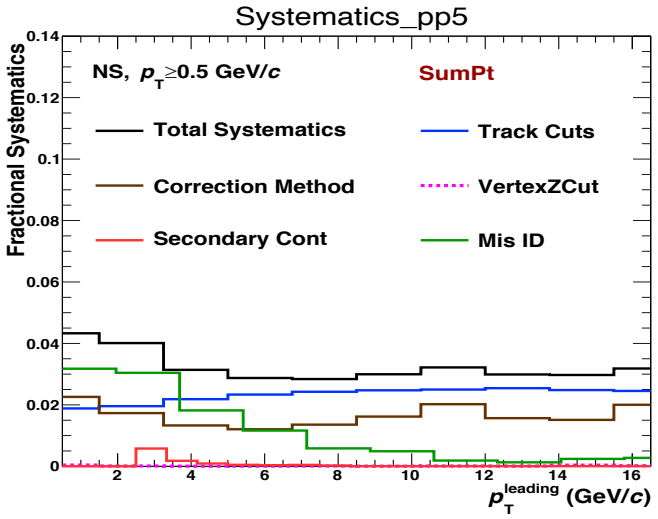
Number density and Sum p_{T} density in TS,NS and AS for $p_{\mathrm{T}} \geq$ 0.5 GeV/c for pp @ 5.02 TeV

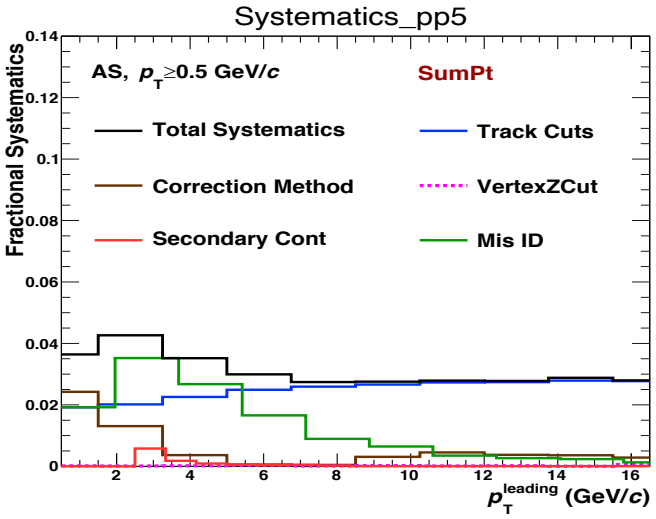






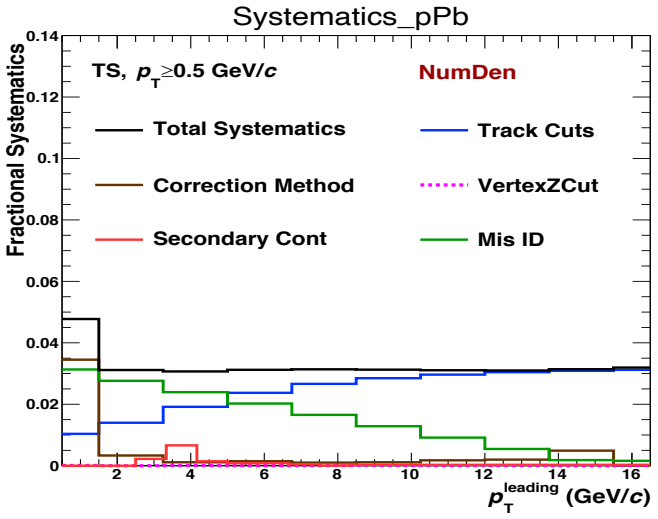


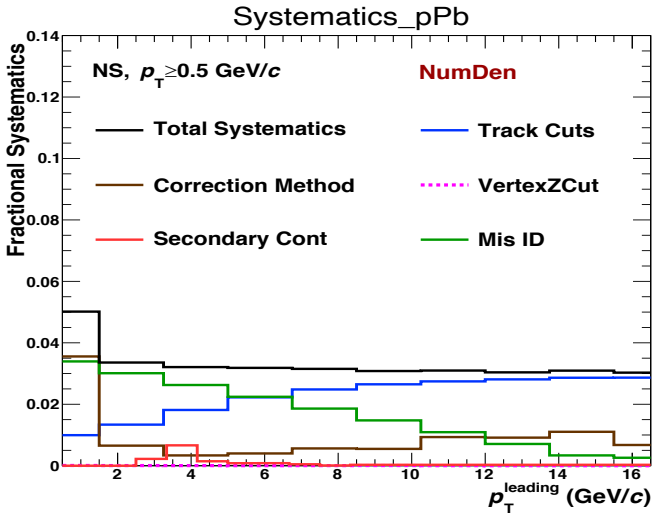


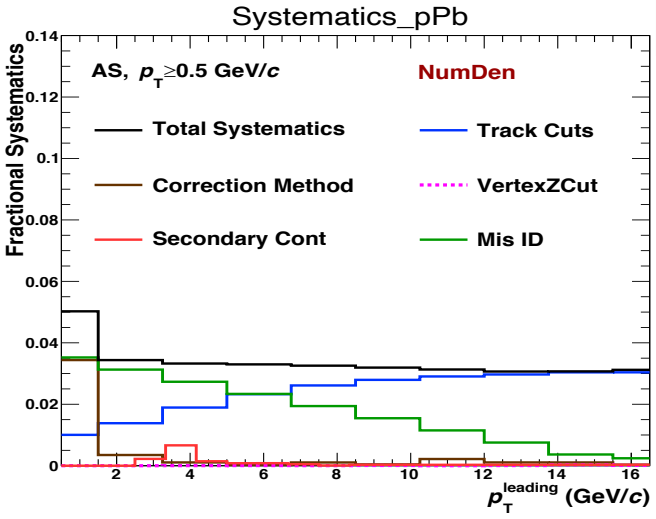


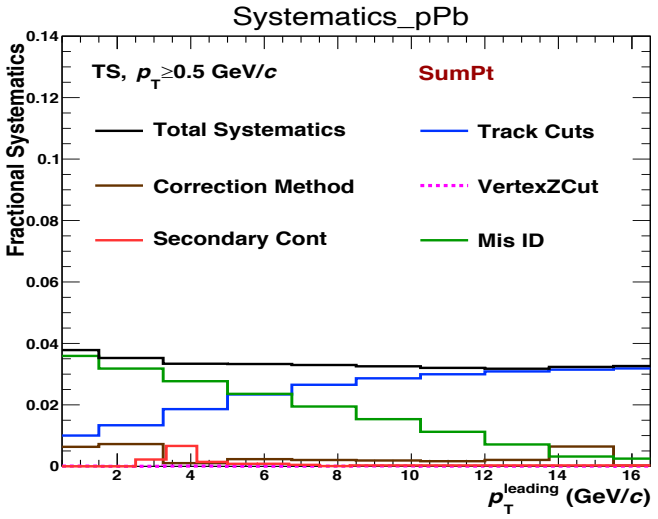
First row Number Density Second row SumPt Density

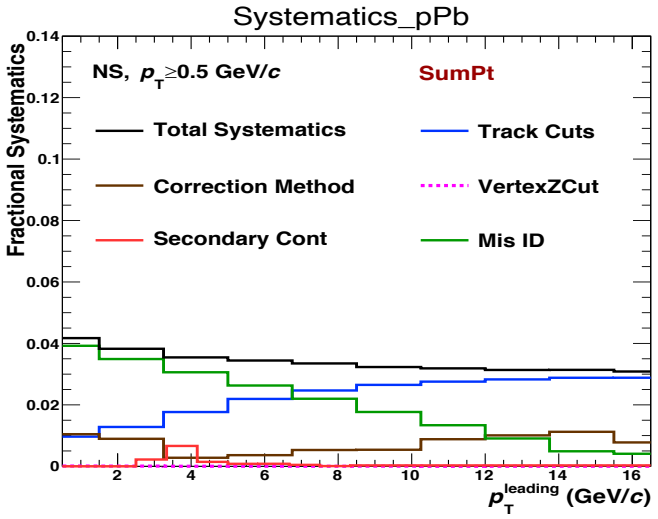
Number density and Sum p_{T} density in TS,NS and AS for $p_{\mathrm{T}} \geq$ 0.5 GeV/c for p-Pb @ 5.02 TeV

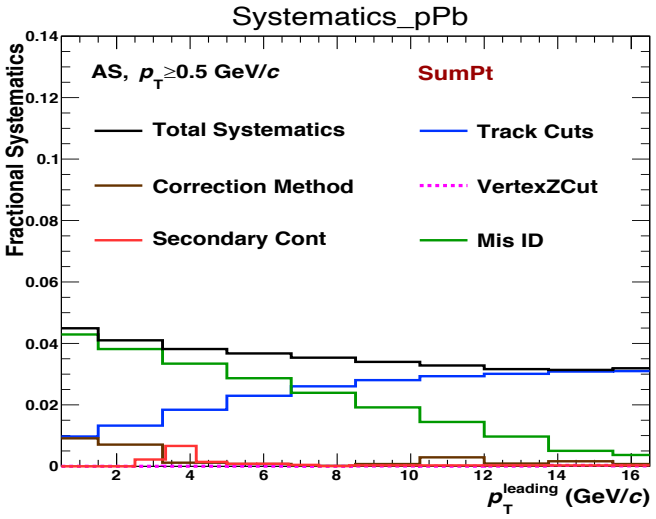












First row Number Density Second row SumPt Density