Particle production as a function of the UE activity in small and large systems and search for jet-like modifications

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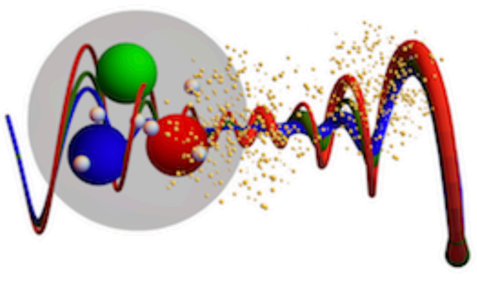
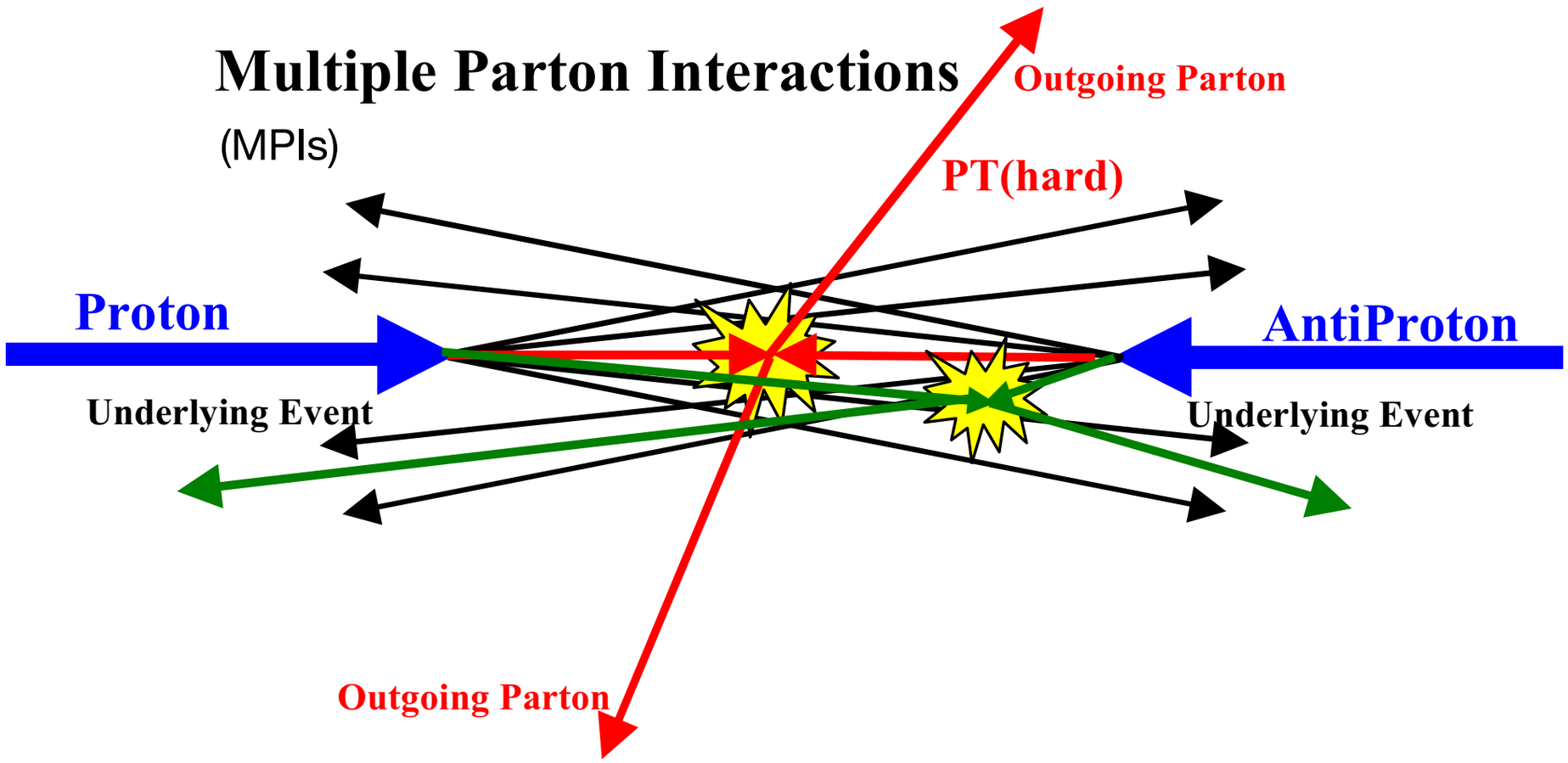


13th International workshop on Multiple Partonic Interactions at the LHC

The Underlying Event (UE)

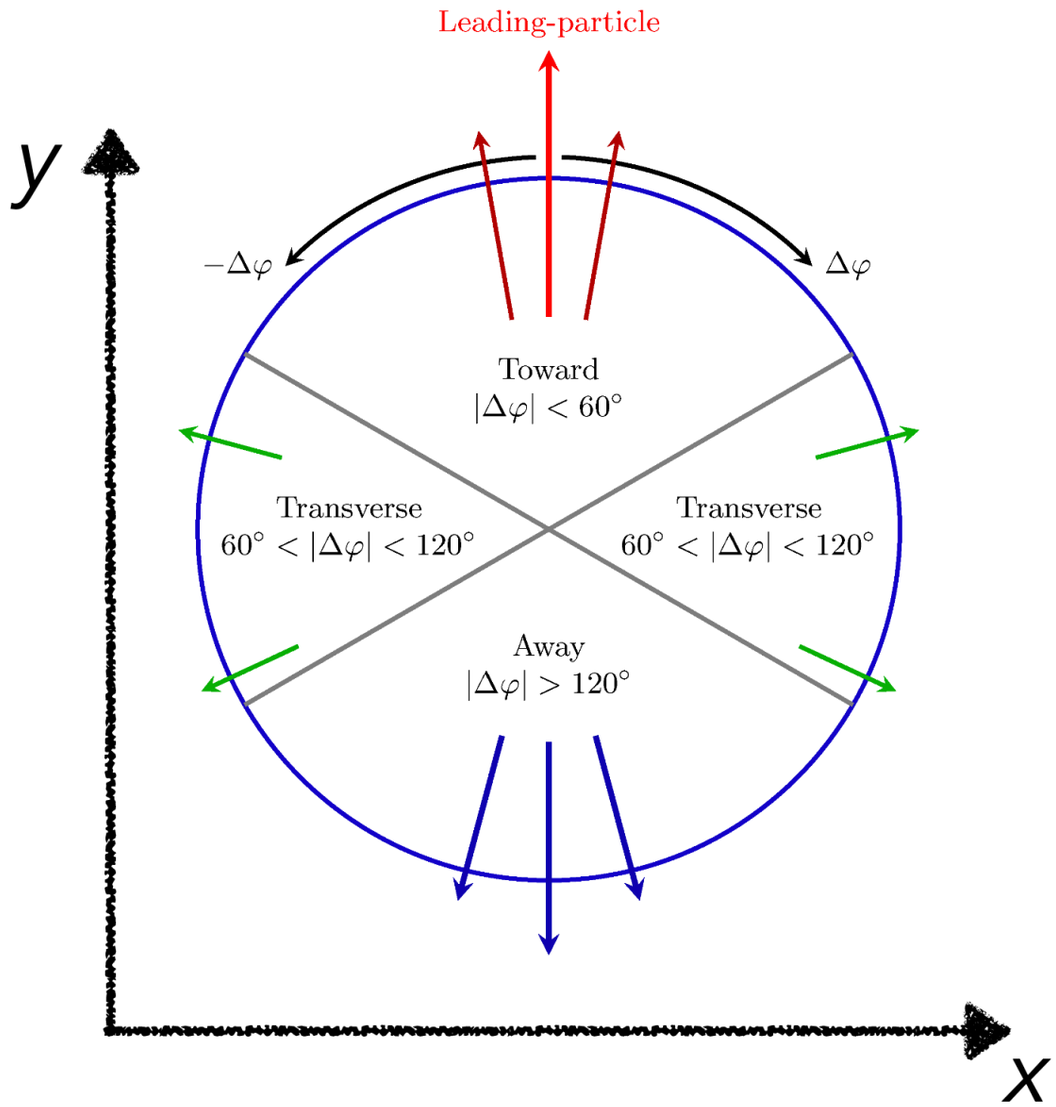


- The UE: the particles, which do not originate from the primary hard parton-parton scattering:
  - MPIs, initial- and final-state radiation (ISR/FSR), beam remnants.

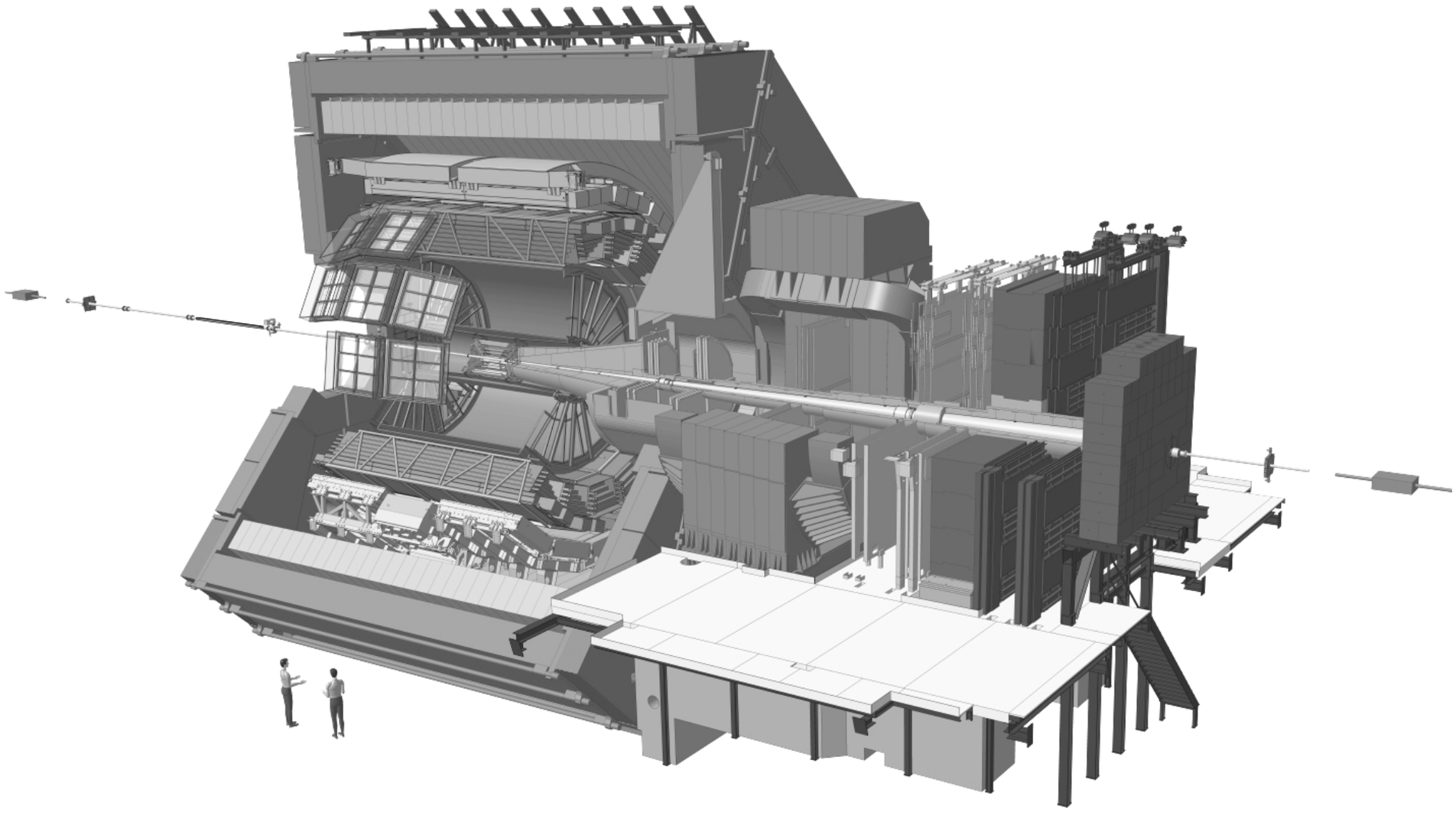
The UE observables

- Measured in events with leading charged particles.
- Defined in the angular region perpendicular to the leading charged particle.
- The UE is traditionally quantified by:
  - Particle number density: $N_{\mathrm{ch}} / \Delta\eta\Delta\varphi$
  - Summed transverse momentum density: $\sum p_{\mathrm{T}} / \Delta\eta\Delta\varphi$

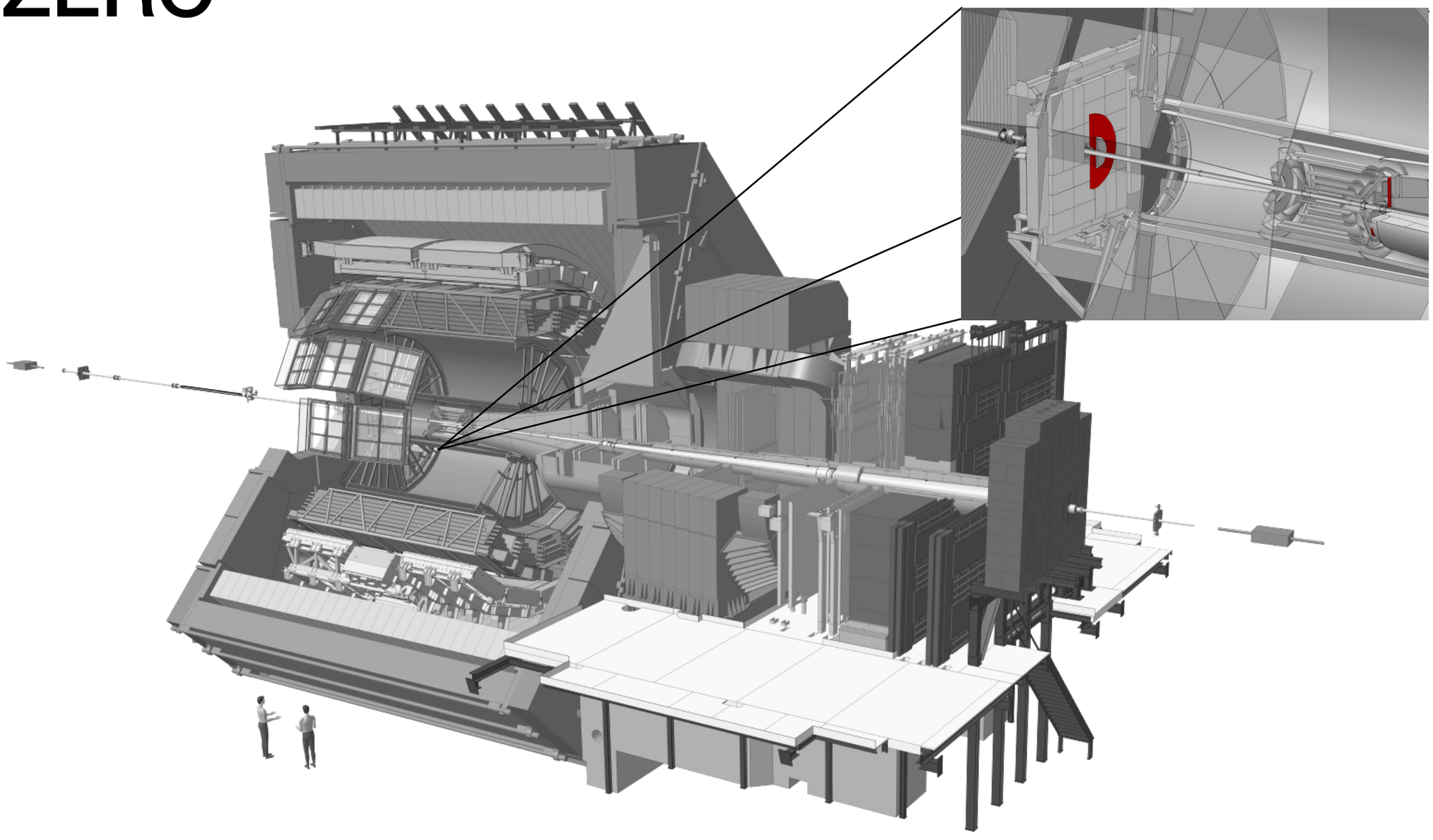
Particle spectra and ratios are studied as a function of multiplicity in the transverse region: N_{T}.



The ALICE apparatus in Run-1 and 2

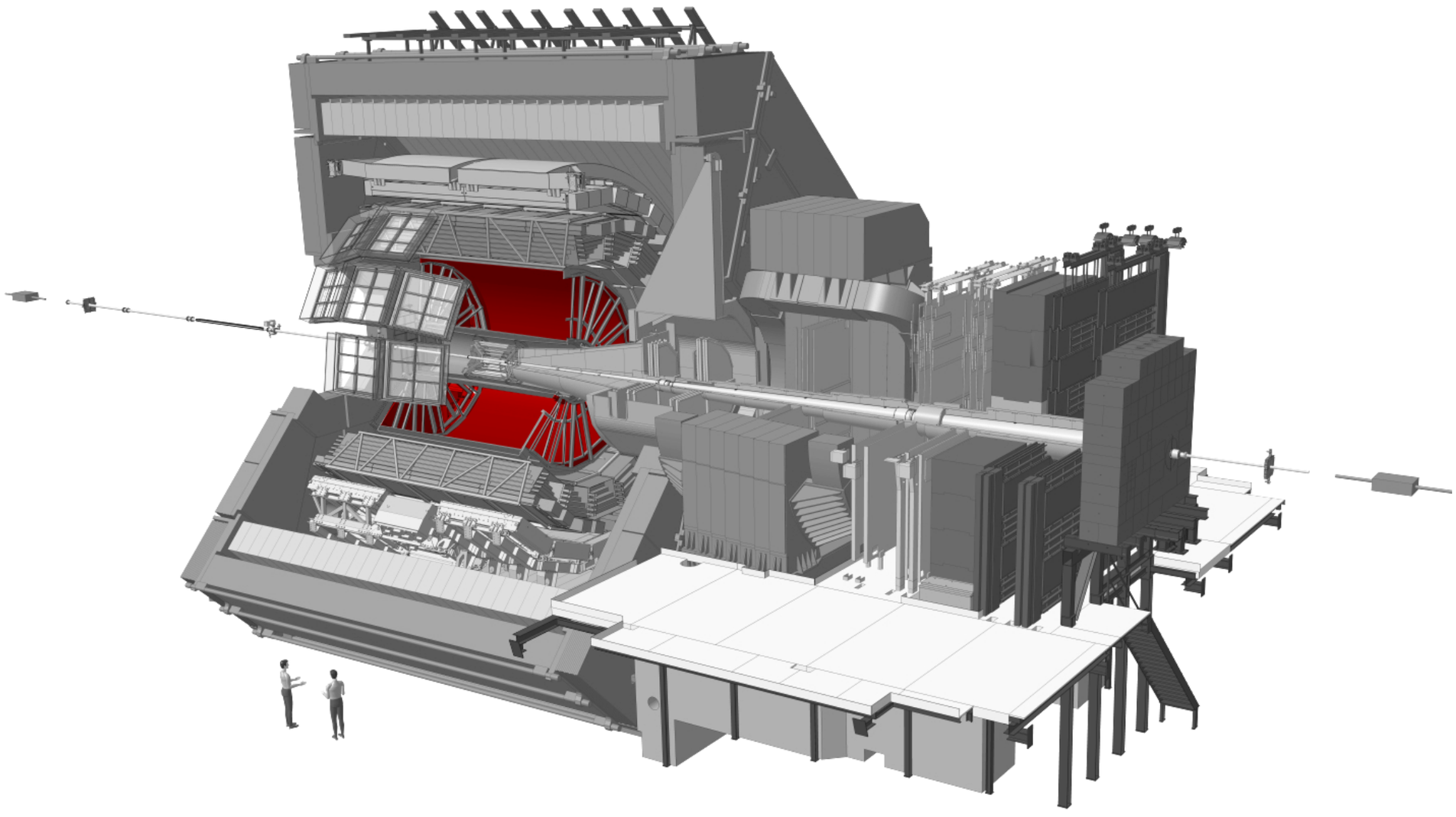


The VZERO



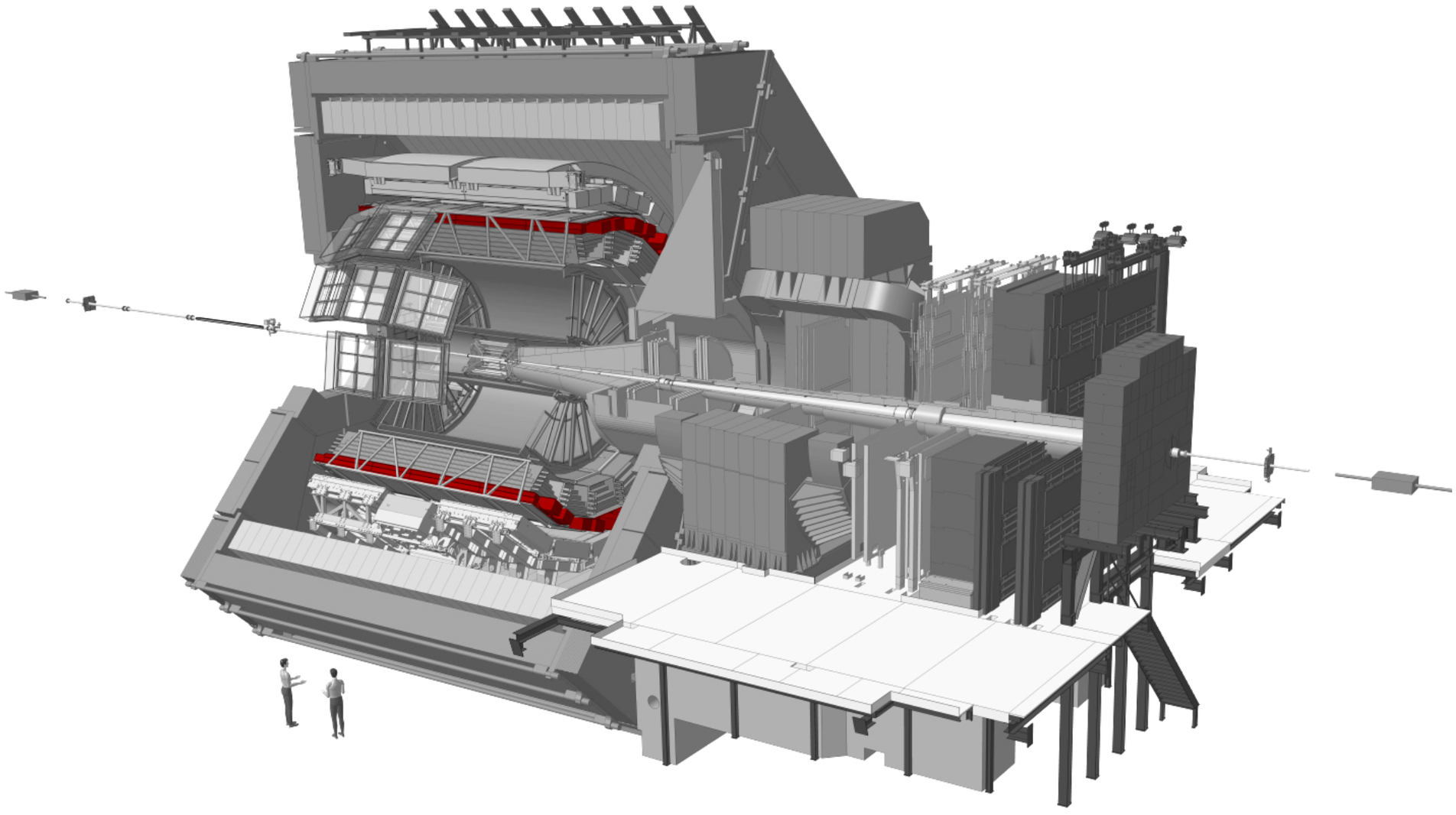
- V0: forward scintillator hodoscopes, V0A $(2.8 < \eta < 5.1)$ and V0C $(-3.7 < \eta < -1.7)$.
- Triggering, background suppression and multiplicity estimation.

The TPC



- $|\eta| < 0.8$ and full azimuthal angle coverage.
- Vertex reconstruction, tracking and particle identification.

The TOF

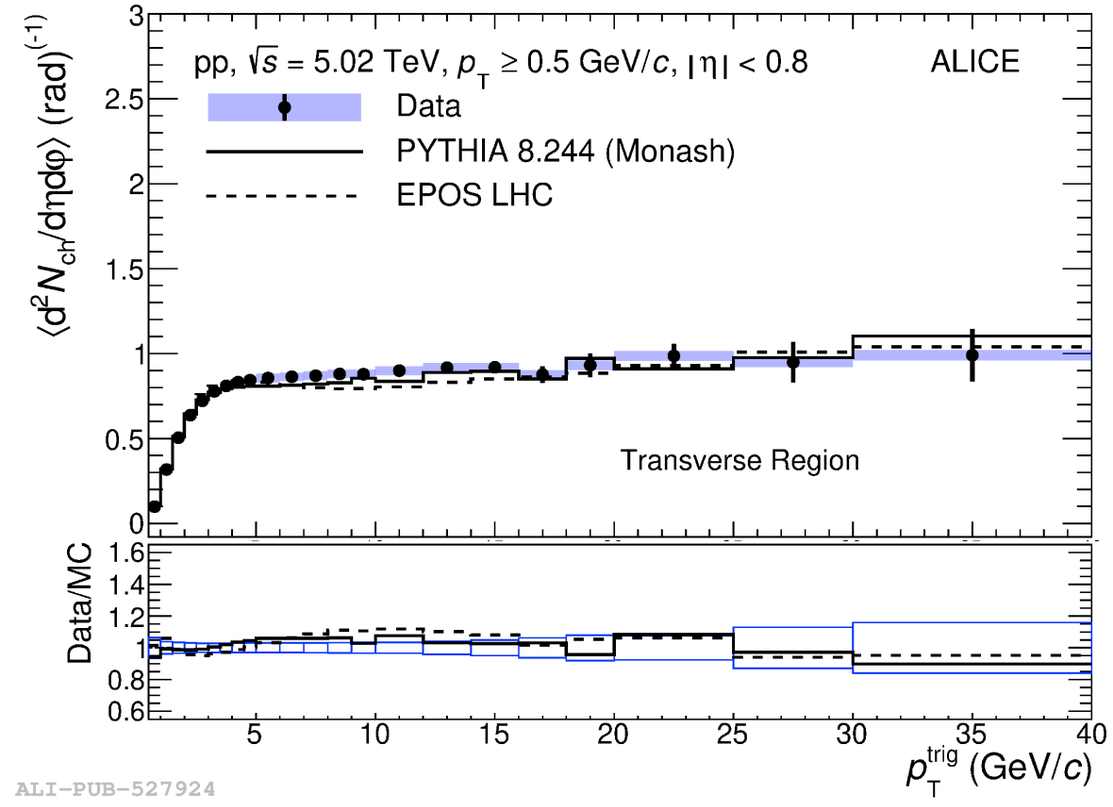


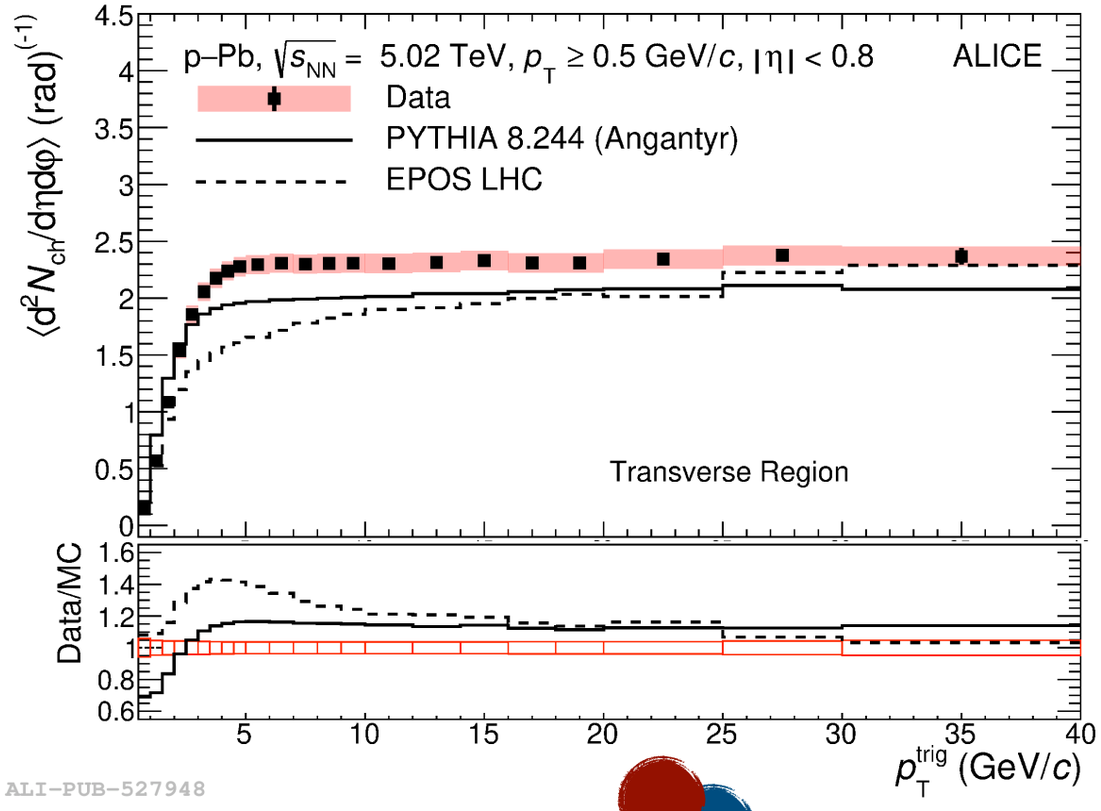
- $|\eta| < 0.8$ and full azimuthal angle coverage.
- Particle identification.

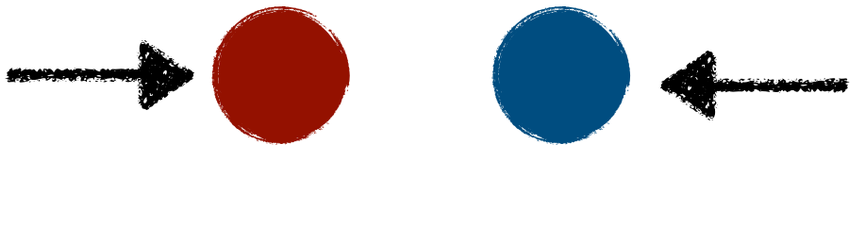
UE observables in pp and p–Pb collisions at 5.02 TeV

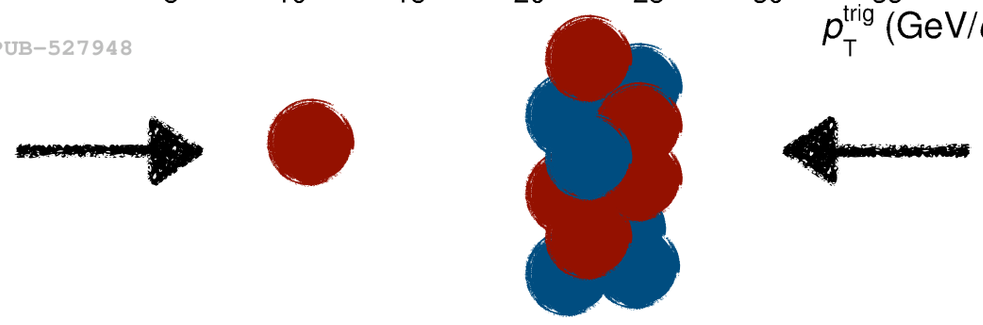
$\langle N_{\mathrm{ch}} / \Delta\eta\Delta\varphi \rangle$ in pp and p—Pb collisions

arXiv:2204.10389





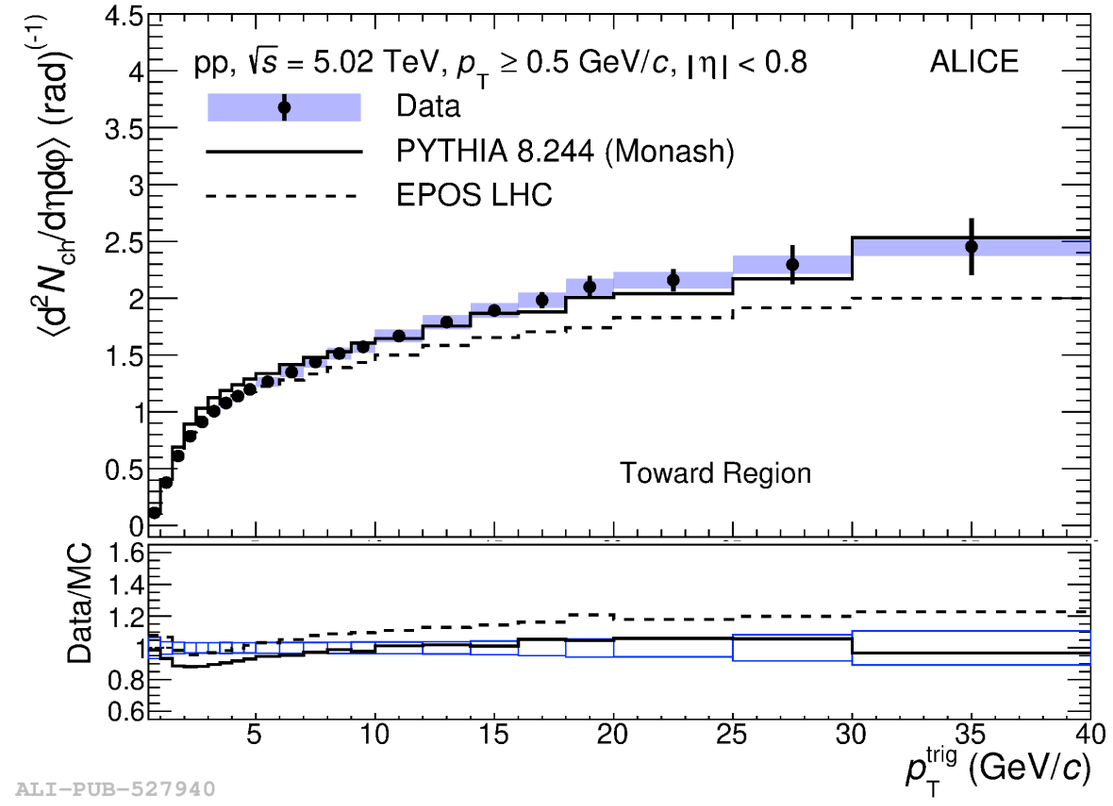


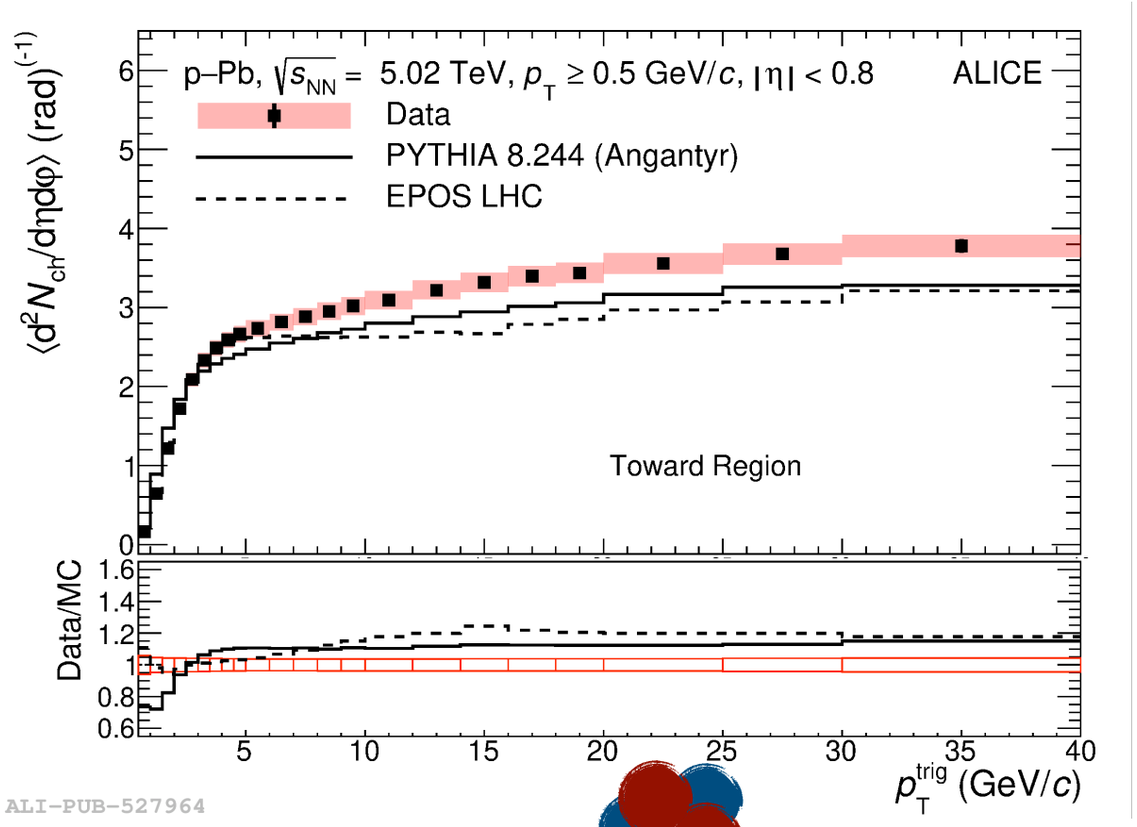


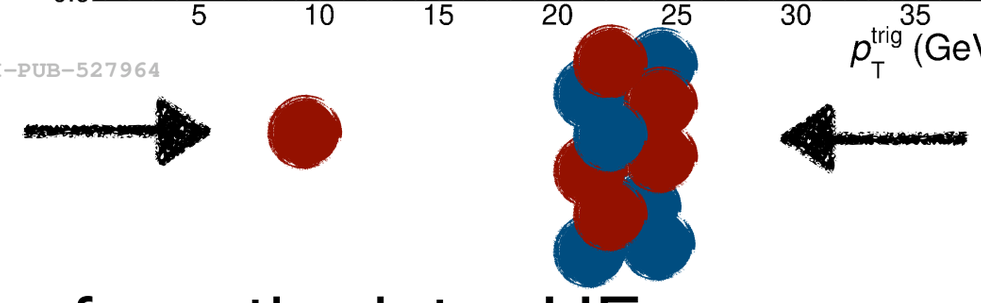
- Similar shape as a function of the $p_{\mathrm{T}}^{\mathrm{leading}}$ between both systems.
- The number density is independent of the leading particle for $p_{\mathrm{T}}^{\mathrm{leading}} \gtrsim 5$ GeV/c.

$\langle N_{\mathrm{ch}} / \Delta\eta\Delta\varphi \rangle$ in pp and p—Pb collisions

arXiv:2204.10389





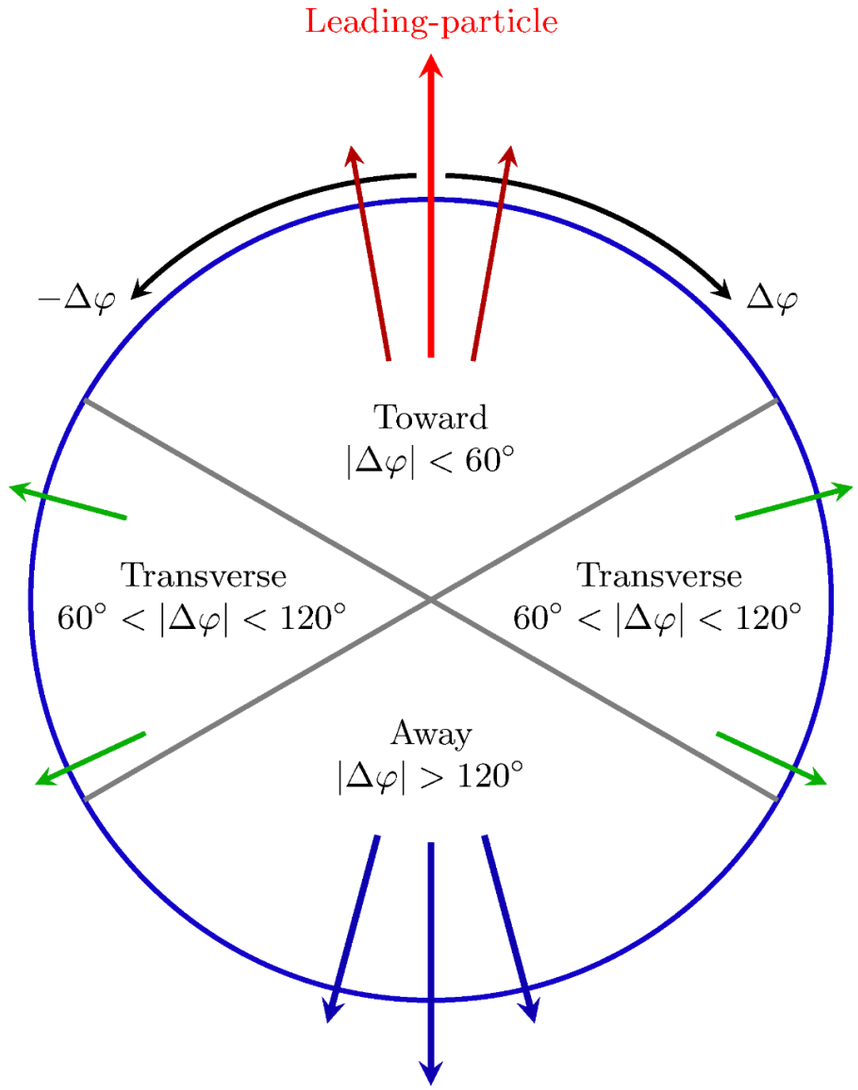


- The number density has contributions from the jet + UE.
- The number density as a function of the $p_{\mathrm{T}}^{\mathrm{leading}}$ in the toward region is similar between pp and p—Pb, however it increases faster in pp.
- PYTHIA and EPOS-LHC underestimate the number density in p—Pb.

Particle production across system size and searches for jet-like modifications in small systems at 5.02 TeV

Analysis strategy

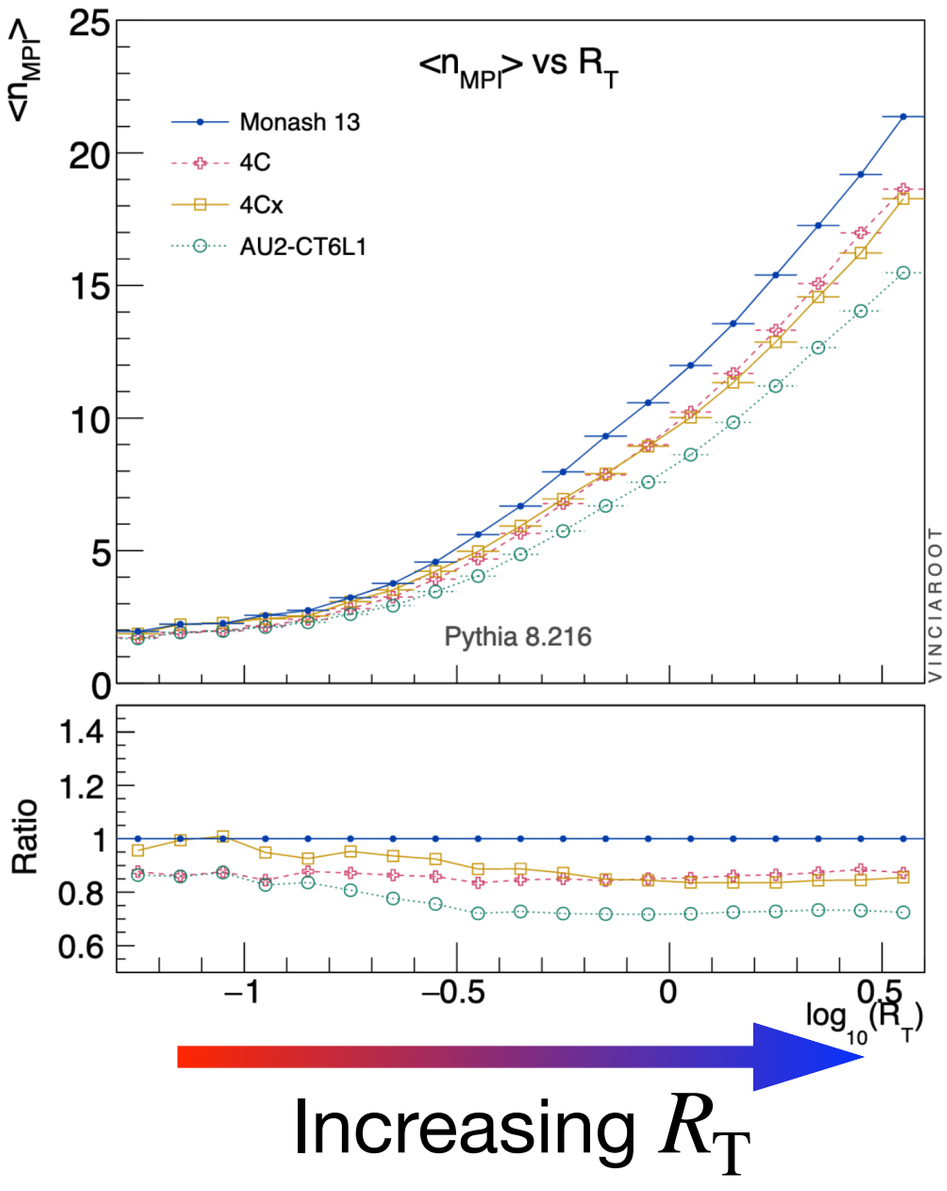
- Leading particle: $8 < p_{\mathrm{T}}^{\mathrm{leading}} < 15$ GeV/c and $|\eta| < 0.8$.



Analysis strategy

- Leading particle: $8 < p_{\mathrm{T}}^{\mathrm{leading}} < 15\ \mathrm{GeV}/c$ and $|\eta| < 0.8$.
- The p_{T} spectra is measured in each region as a function of the relative transverse activity, R_{T}.

$$R_{\mathrm{T}} = N_{\mathrm{T}}/\langle N_{\mathrm{T}} \rangle$$



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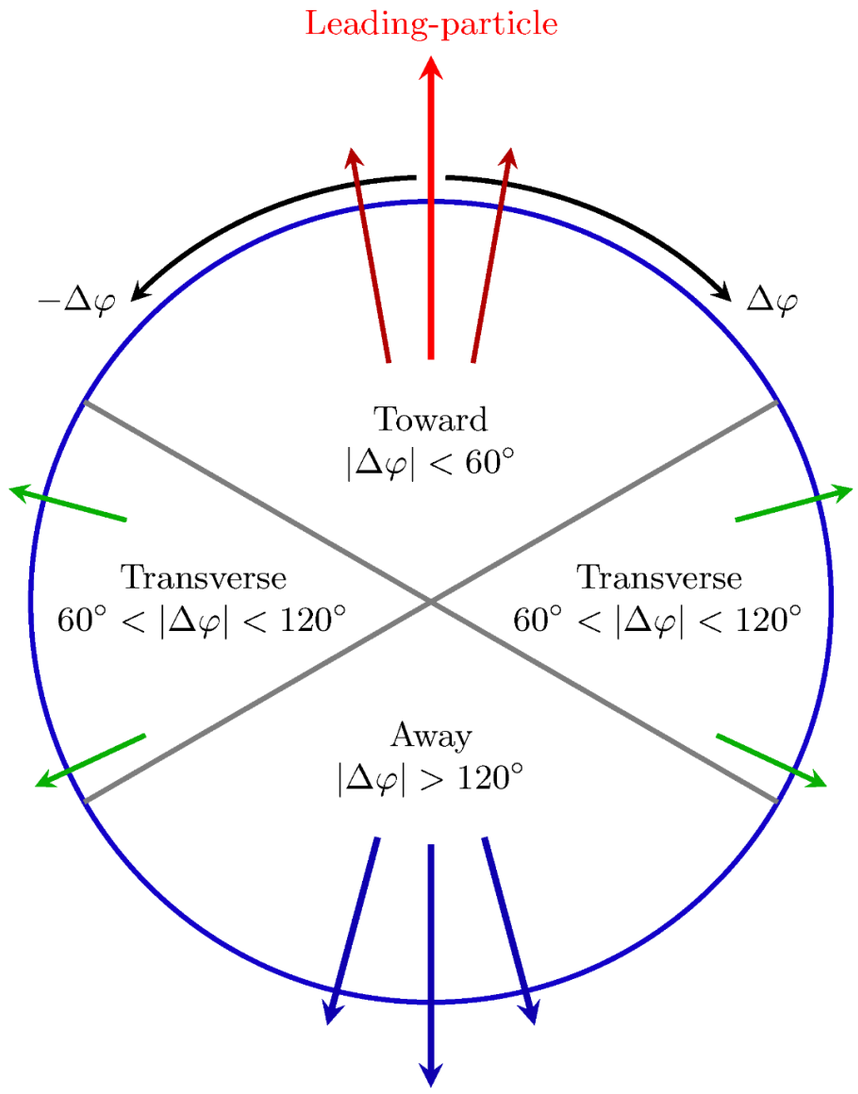
Phys. Rev. D 96, 114019

Analysis strategy

- Leading particle: $8 < p_{\mathrm{T}}^{\mathrm{leading}} < 15$ GeV/c and $|\eta| < 0.8$.
- The p_{T} spectra is measured in each region as a function of the relative transverse activity, R_{T}.

$$R_{\mathrm{T}} = N_{\mathrm{T}}/\langle N_{\mathrm{T}} \rangle$$

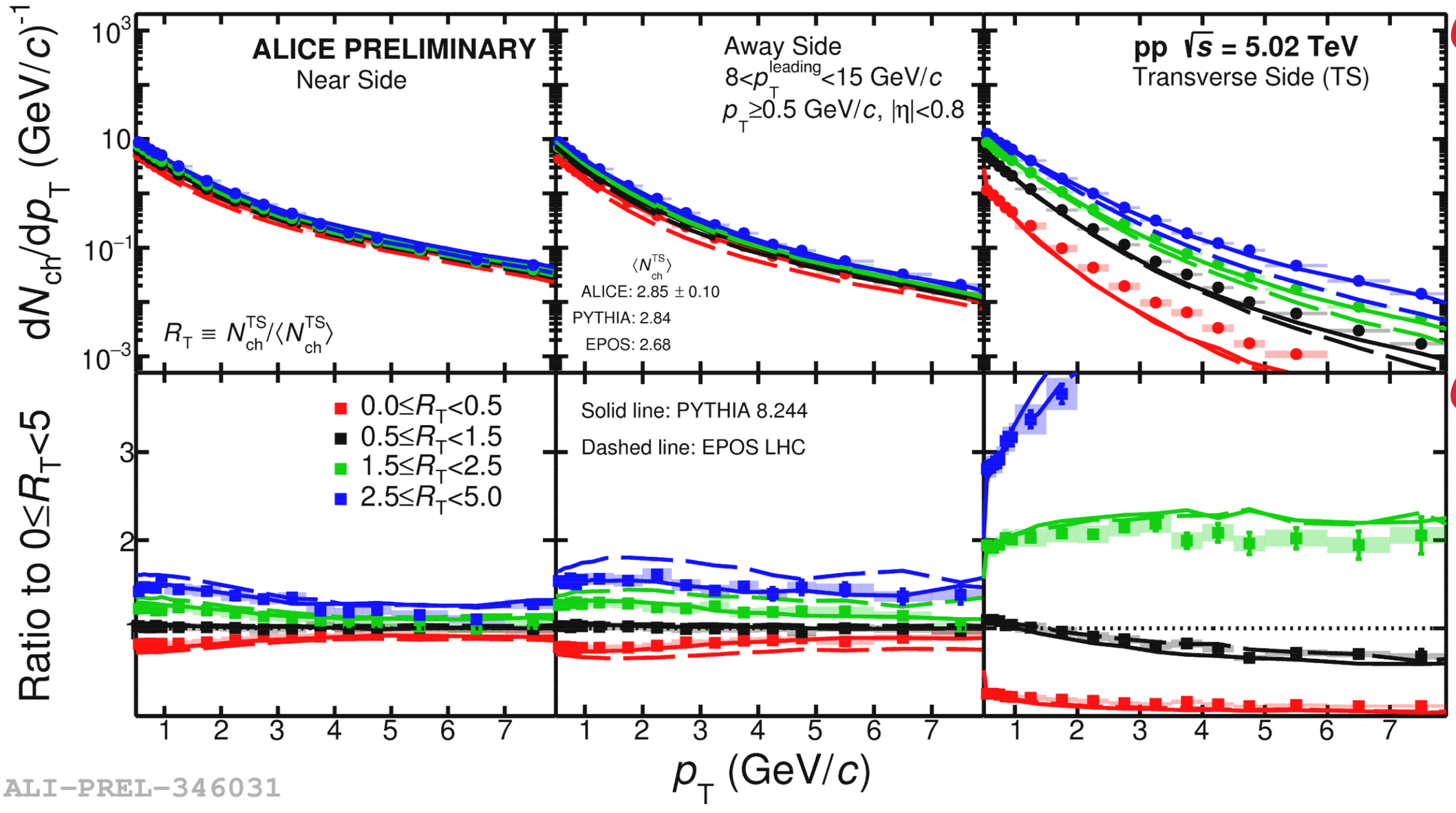
- The jet-like yields are quantified by I_X as a function of $\langle N_{\mathrm{T}} \rangle$ and multiplicity.
- Jet-like yields: the yield in the transverse region is subtracted from the toward and away (it is assumed that the UE is flat in $\Delta\varphi$).

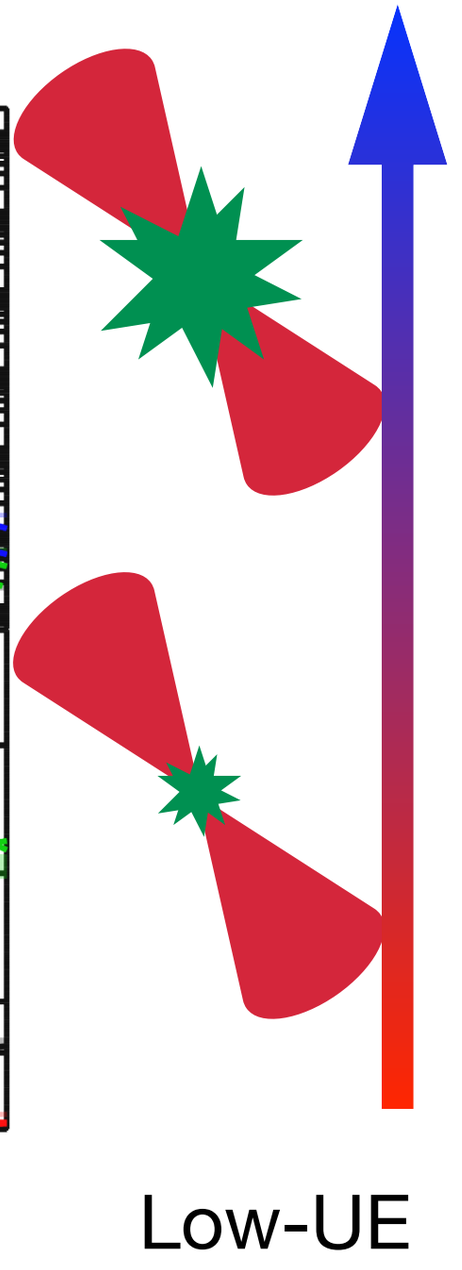


$$I_X = \frac{\left(\mathrm{d}N_{\mathrm{ch}}^{\mathrm{t,a}}/\mathrm{d}p_{\mathrm{T}} - \mathrm{d}N_{\mathrm{ch}}^{\mathrm{T}}/\mathrm{d}p_{\mathrm{T}}\right)|_X}{\left(\mathrm{d}N_{\mathrm{ch}}^{\mathrm{t,a}}/\mathrm{d}p_{\mathrm{T}} - \mathrm{d}N_{\mathrm{ch}}^{\mathrm{T}}/\mathrm{d}p_{\mathrm{T}}\right)|_{\mathrm{pp,MB}}}$$

X = pp, p—Pb and Pb—Pb

Charged particle production v.s. R_{T}





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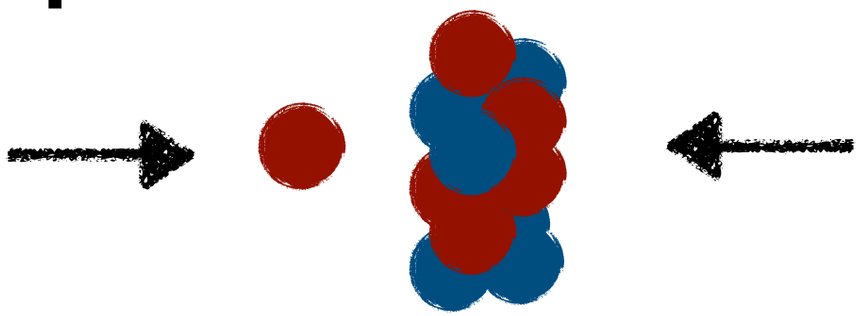
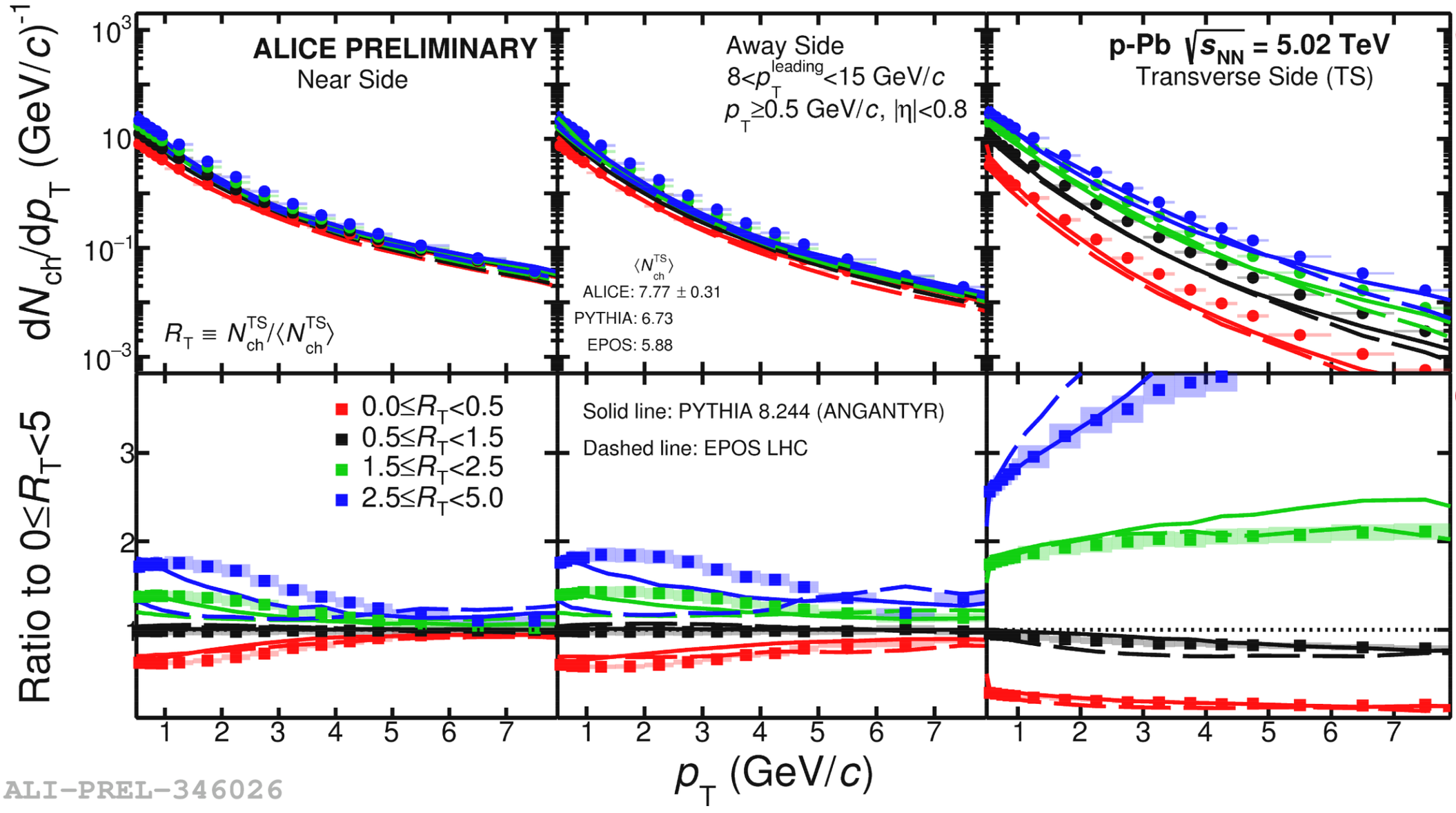
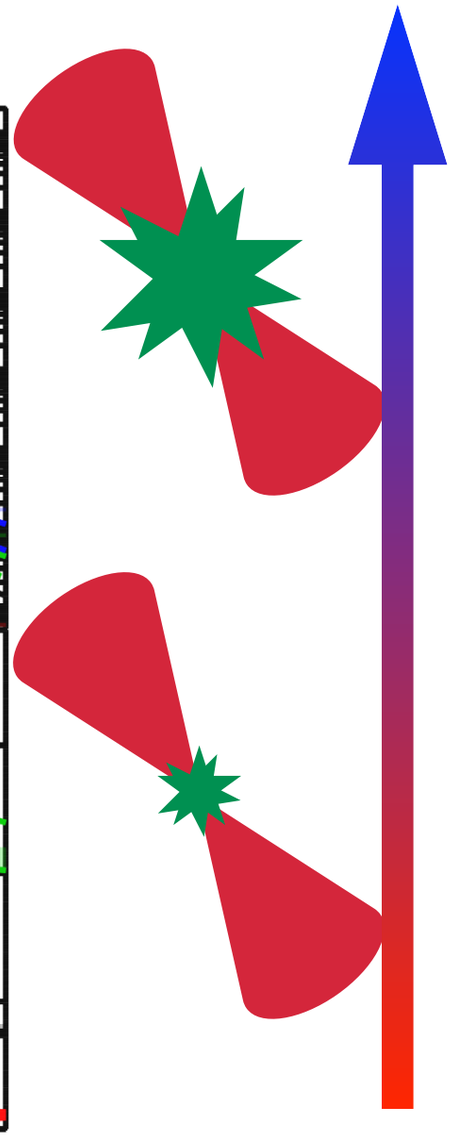
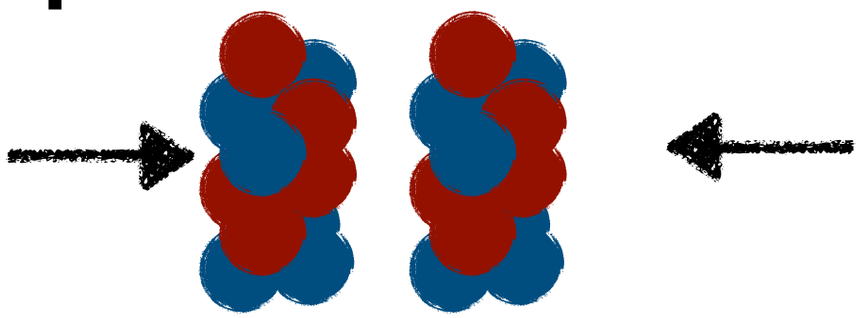
Charged particle production v.s. R_{T}

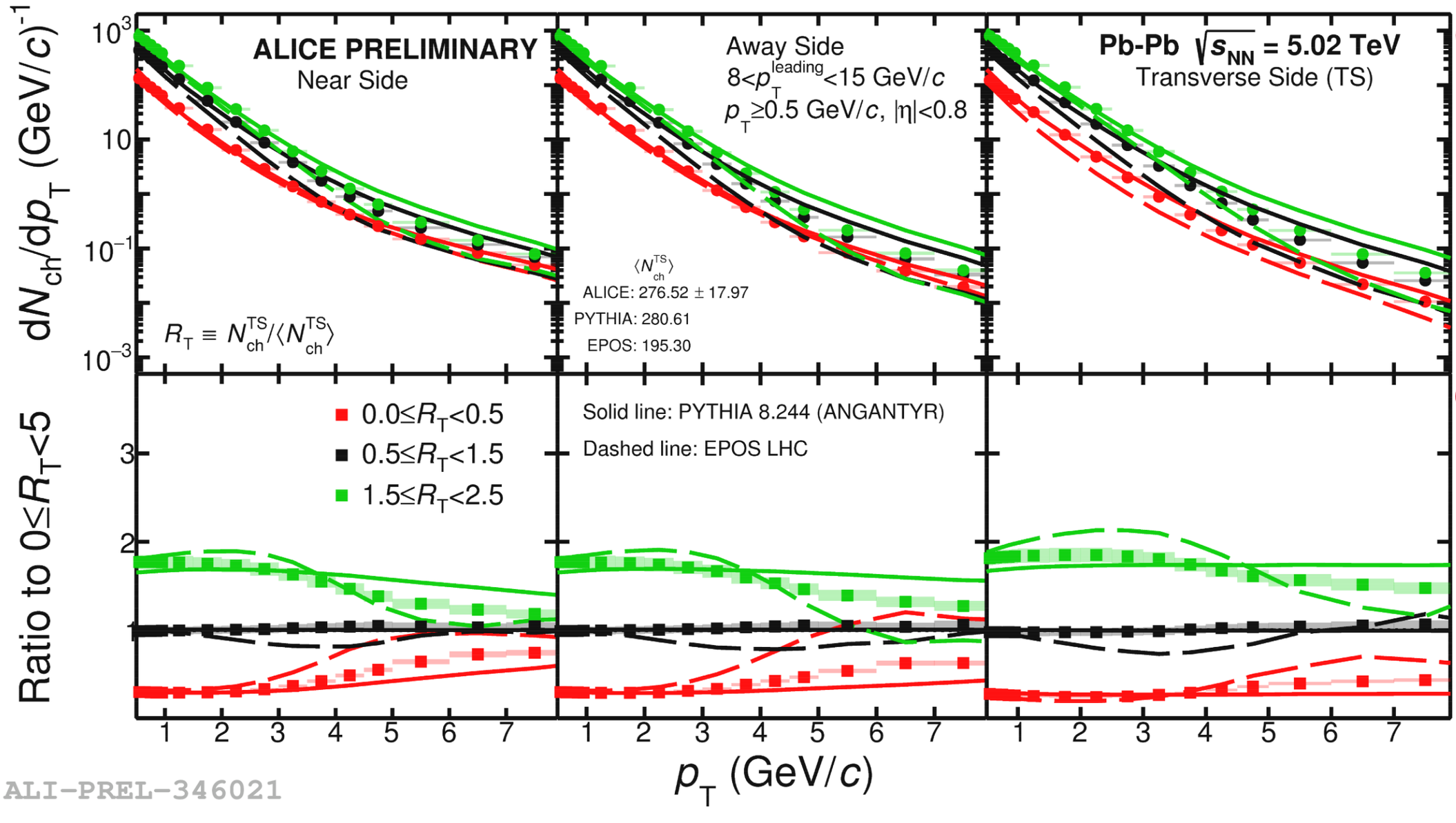


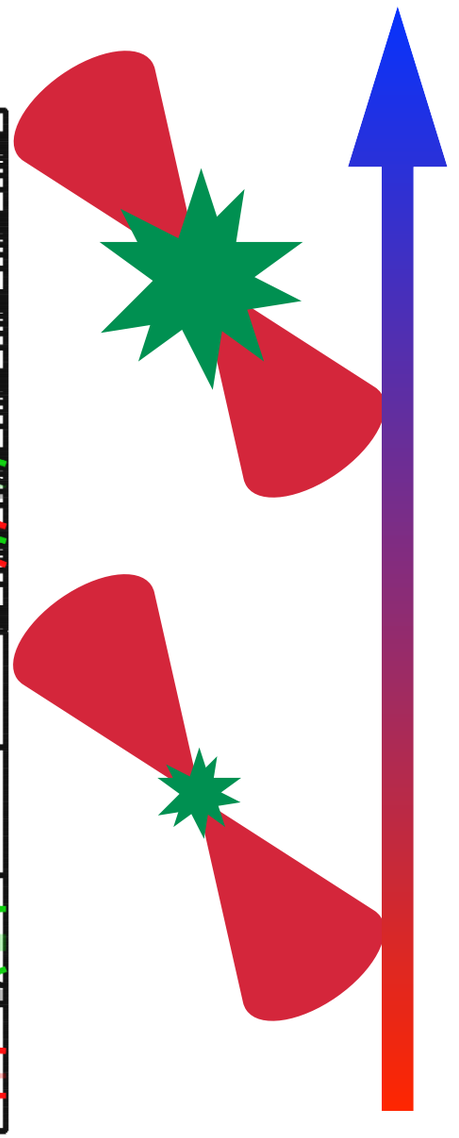




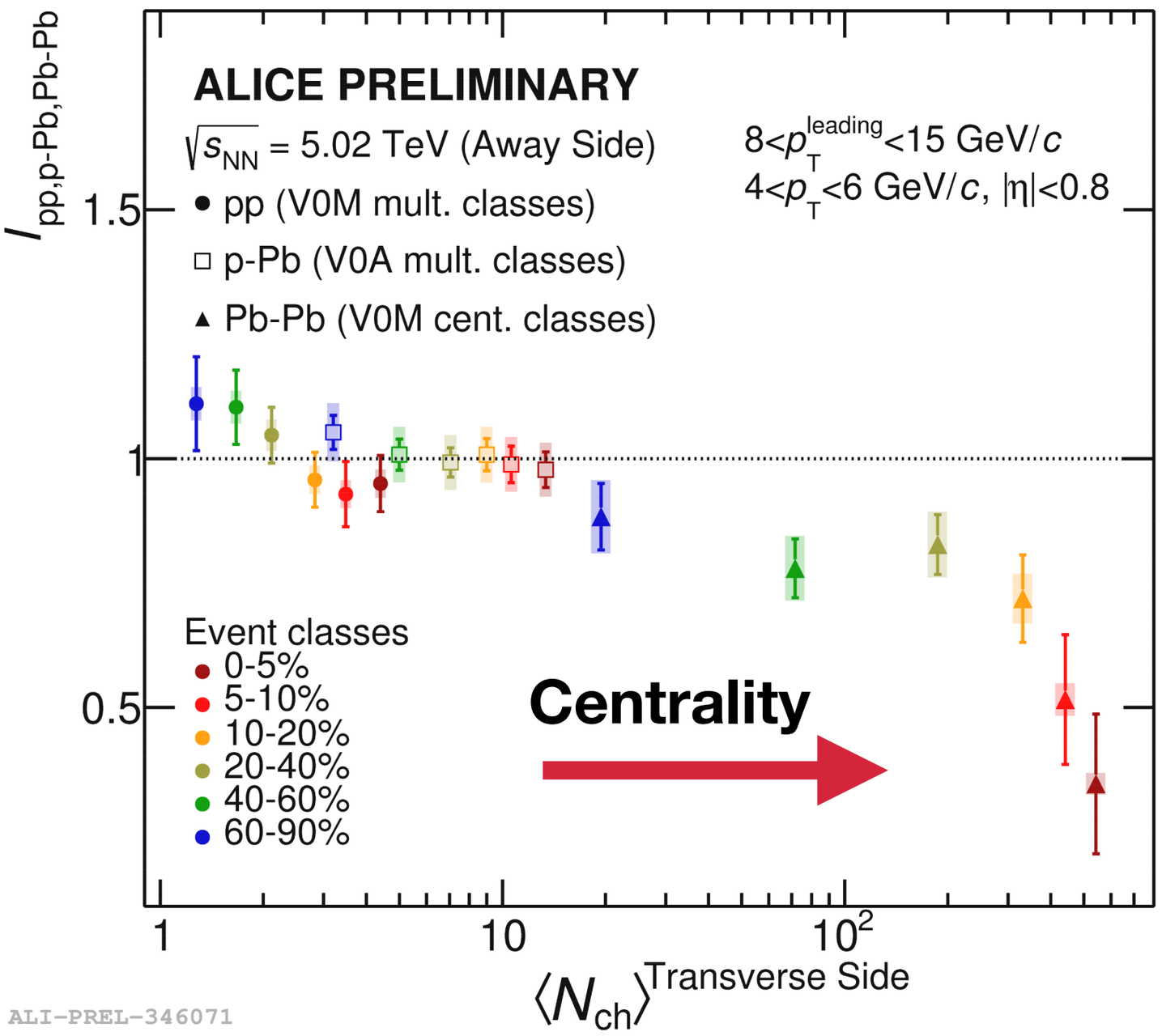
Charged particle production v.s. R_{T}







I_{X} as a function of $\langle N_{\mathrm{T}} \rangle$ (away region)

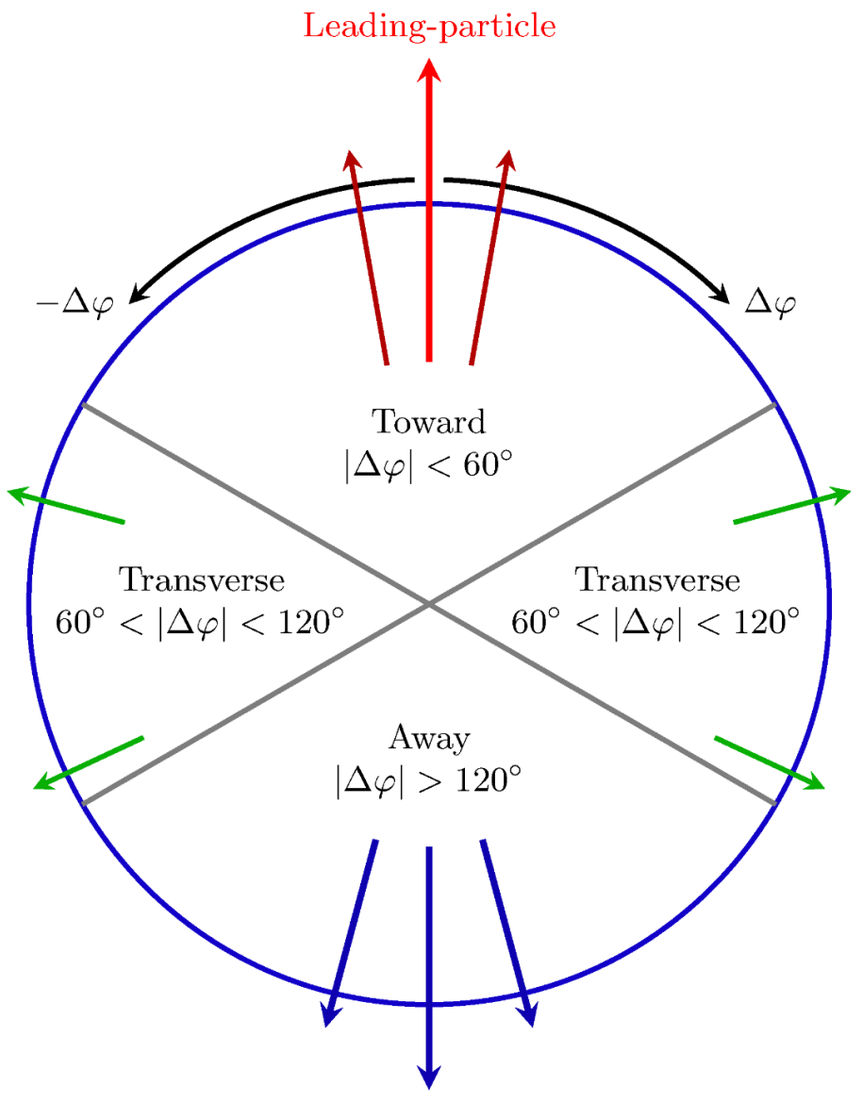


- Strong suppression of the jet-like yields with increasing centrality in Pb—Pb.
  - Medium effects: jet-quenching.
- The jet-like yields are consistent with unity in pp and p—Pb collisions.
  - No indication of jet-like modifications in small systems.

Identified particle production as a function of the event activity in pp collisions at 13 TeV

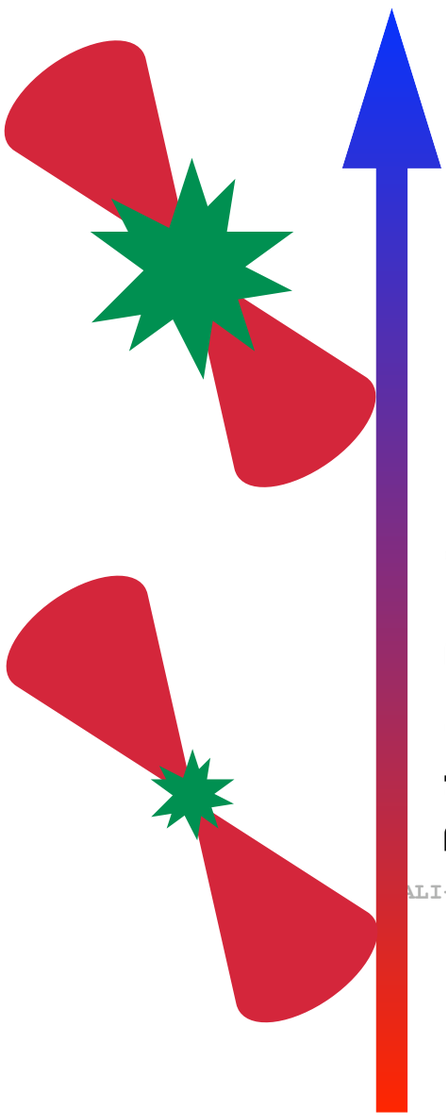
Analysis strategy

- Leading particle: $5 \leq p_{\mathrm{T}}^{\mathrm{leading}} < 40$ GeV/c and $|\eta| < 0.8$.
- The p_{T}-differential particle ratios are measured in each region at mid-pseudo rapidity.
- The particle ratios are reported as a function of R_{T}.

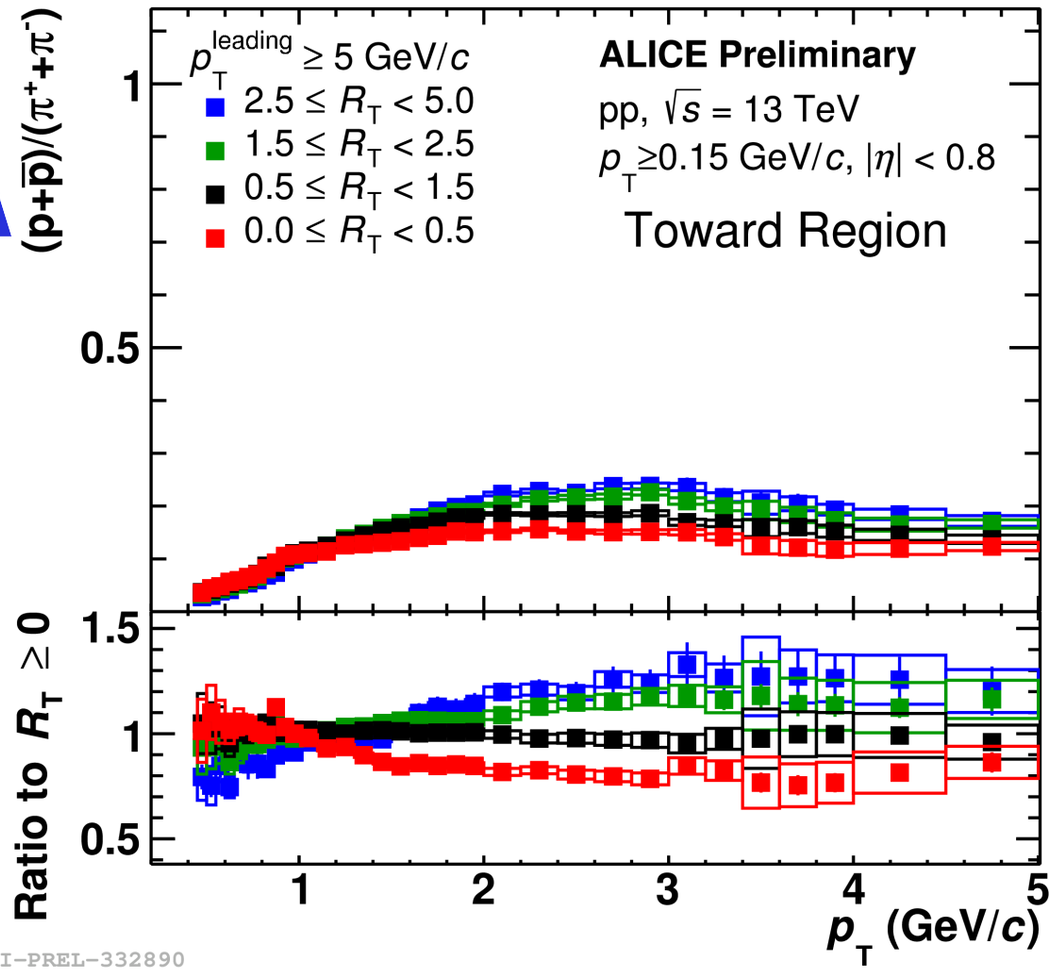


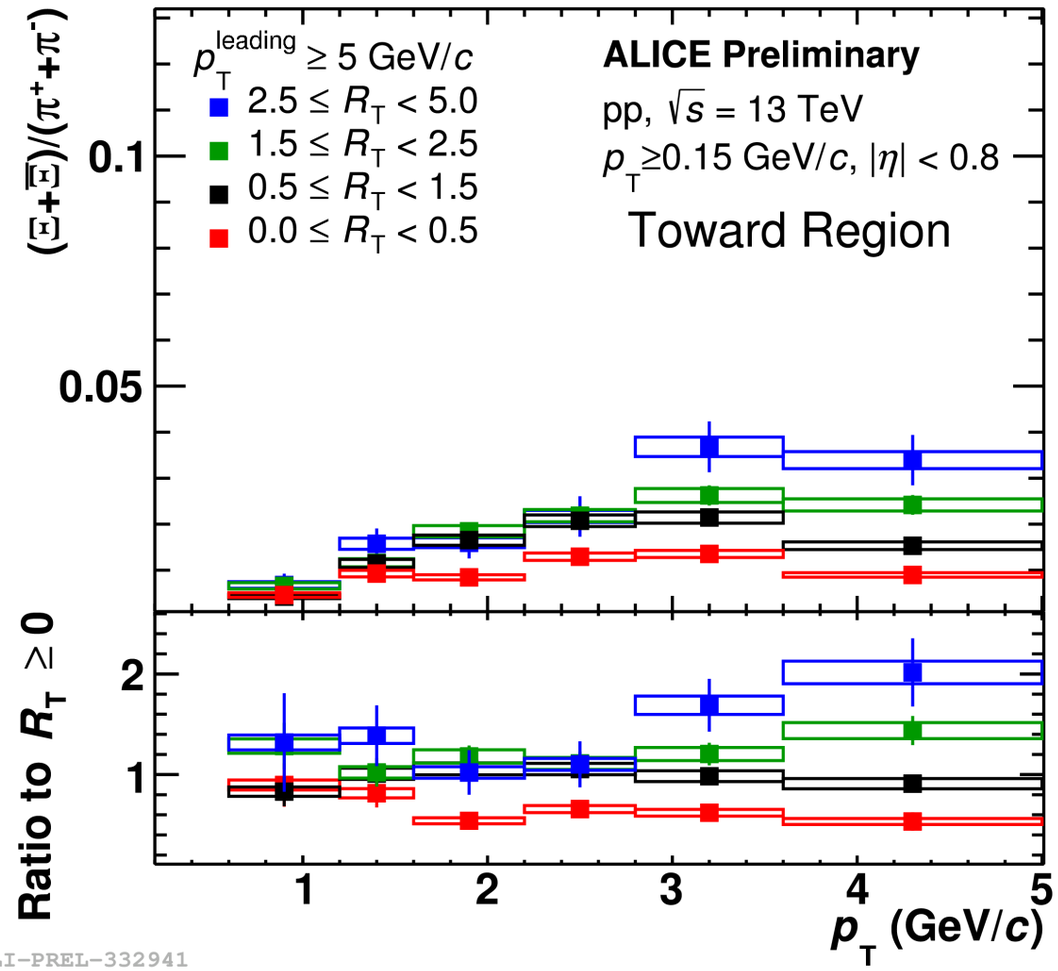
Particle ratios: toward region

High-UE



Low-UE

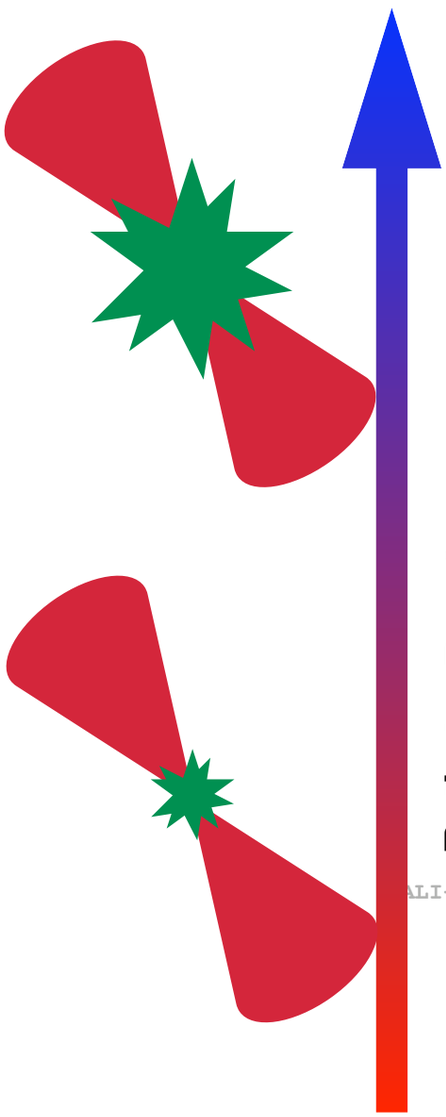




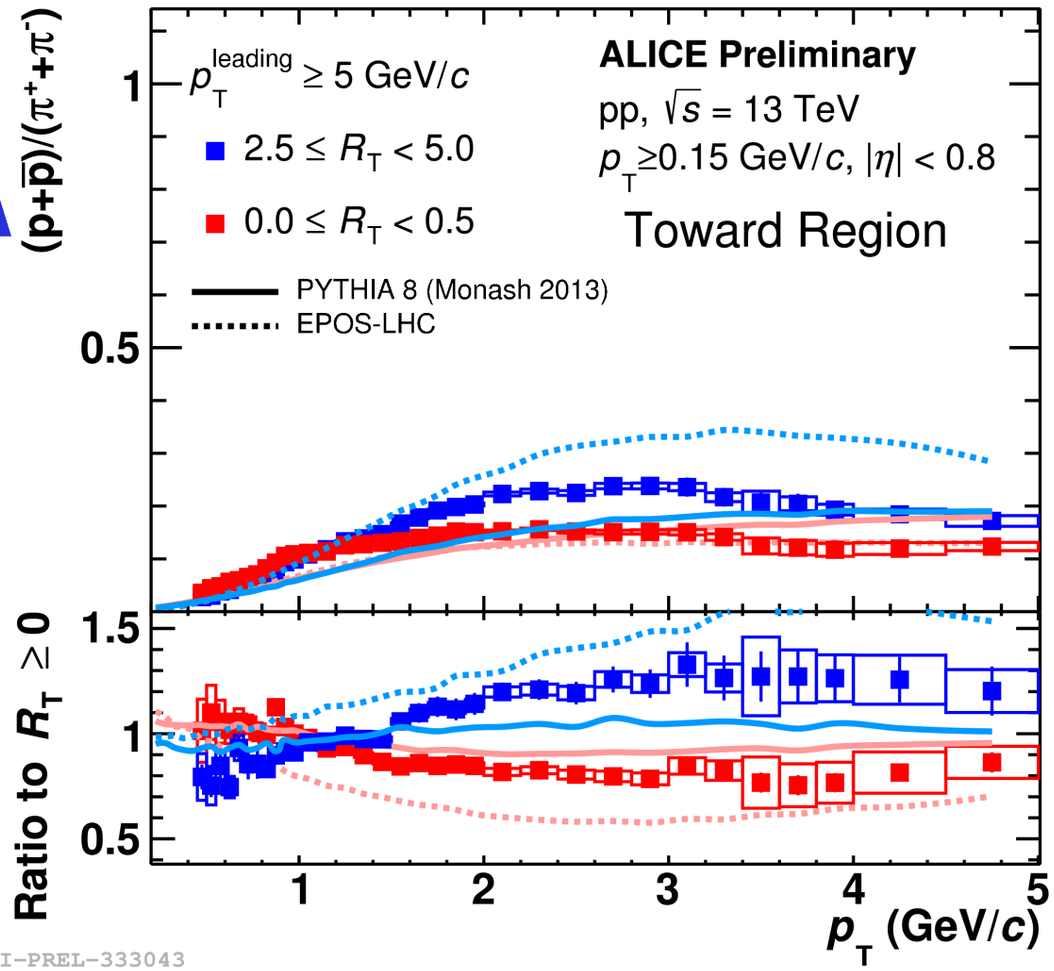
- Clear evolution of the p/π and Ξ/π ratios with R_{T}.
- The enhanced baryon-to-meson ratios can be attributed to radial flow effects.

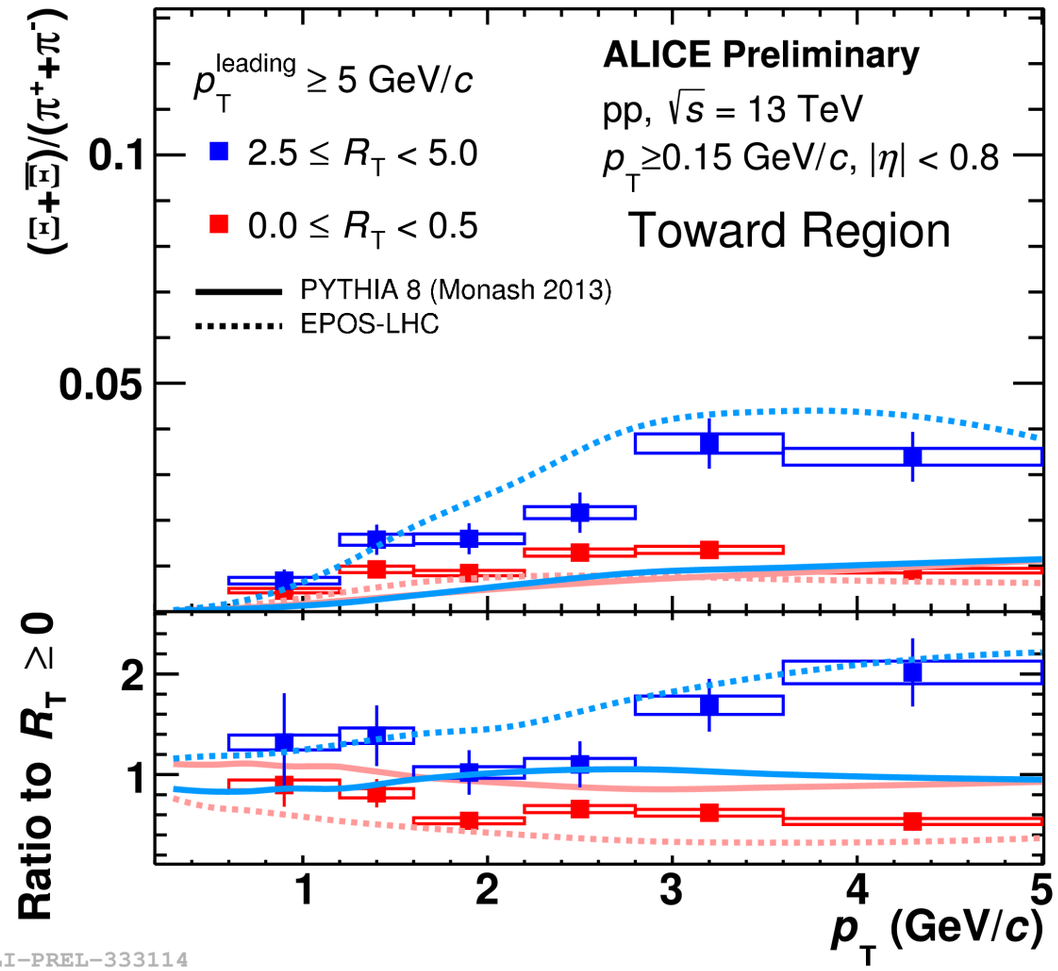
Particle ratios: toward region

High-UE



Low-UE

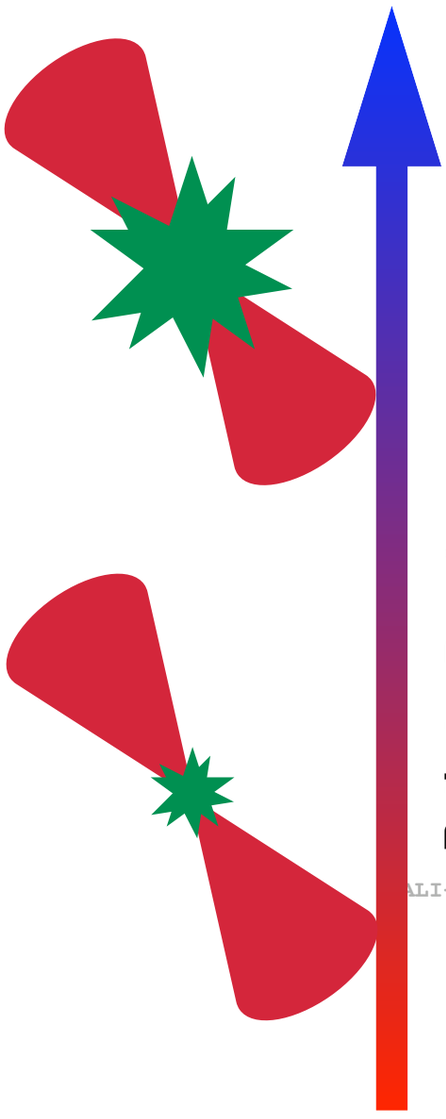




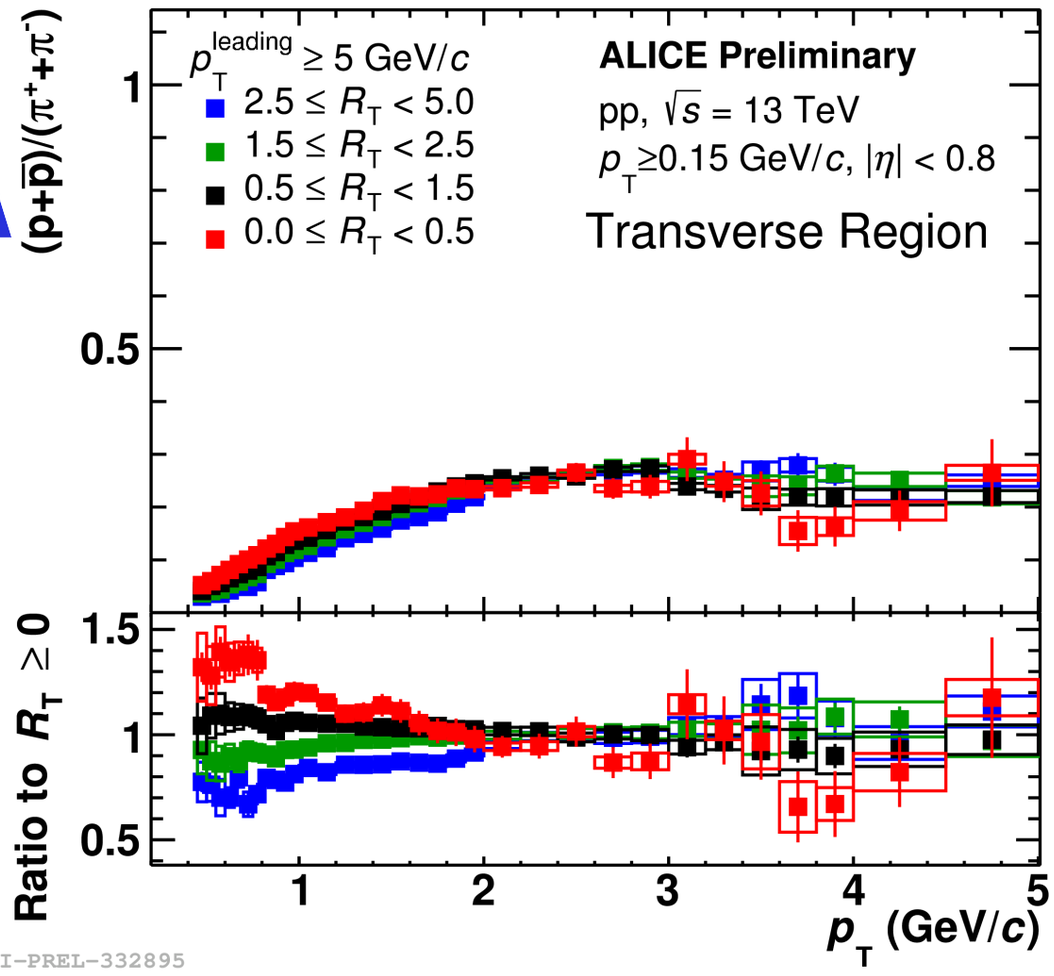
- PYTHIA and EPOS-LHC describe the low-UE events (expected since both models are tuned to e^+e^- data).
- It is clear what works in the models (hard processes) and what they fail at (UE).

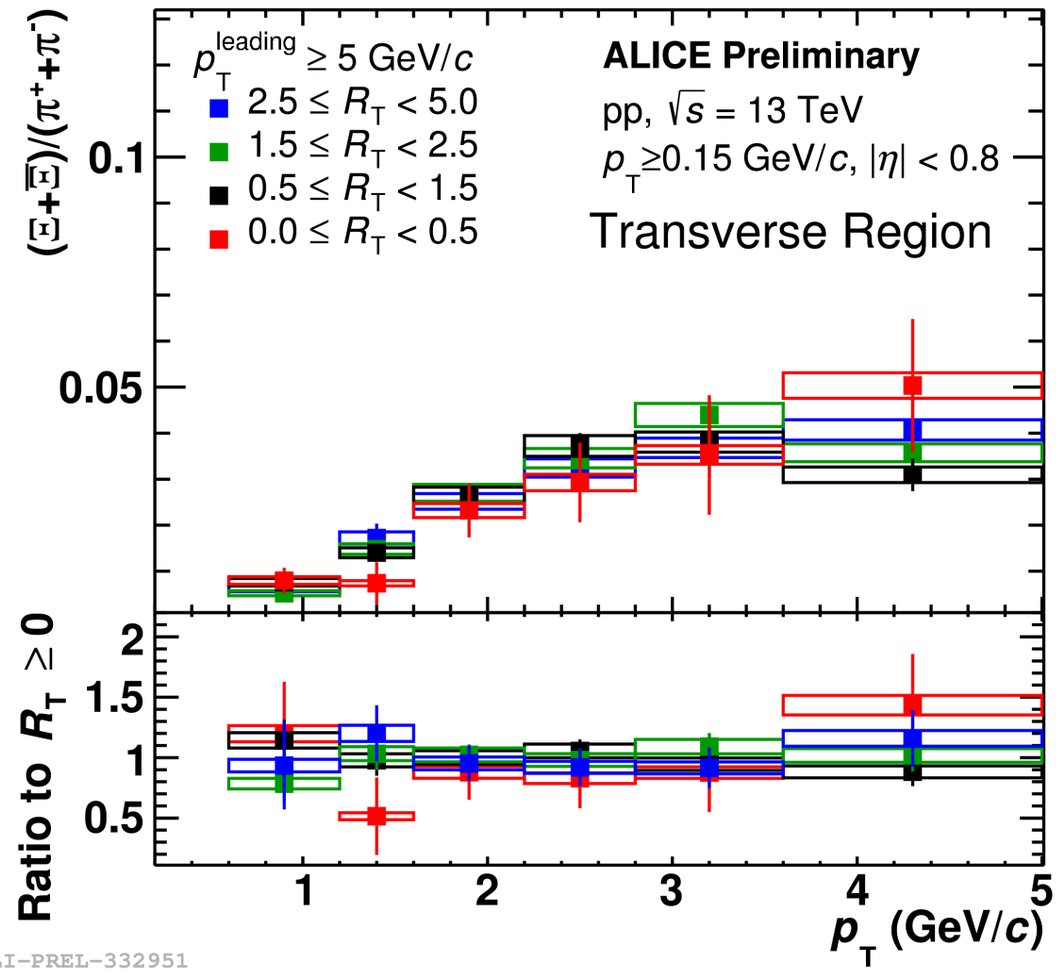
Particle ratios: transverse region

High-UE



Low-UE

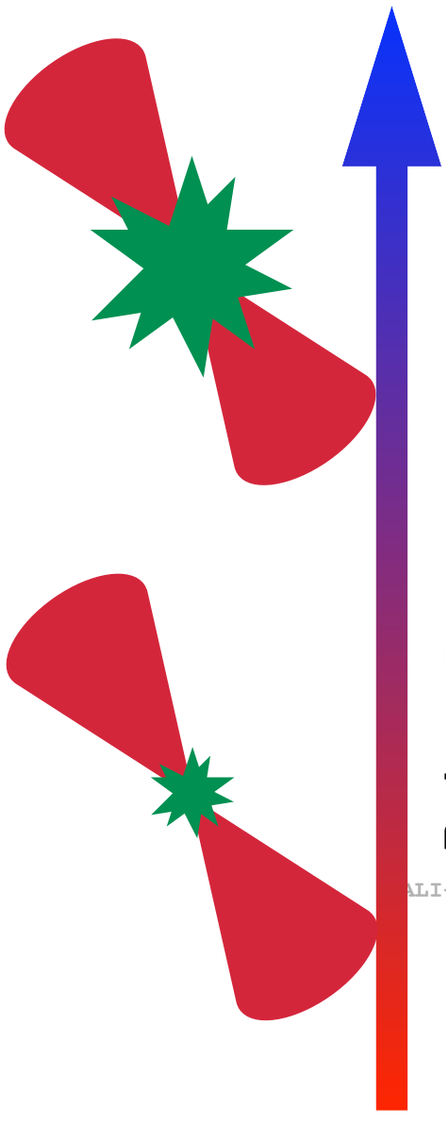




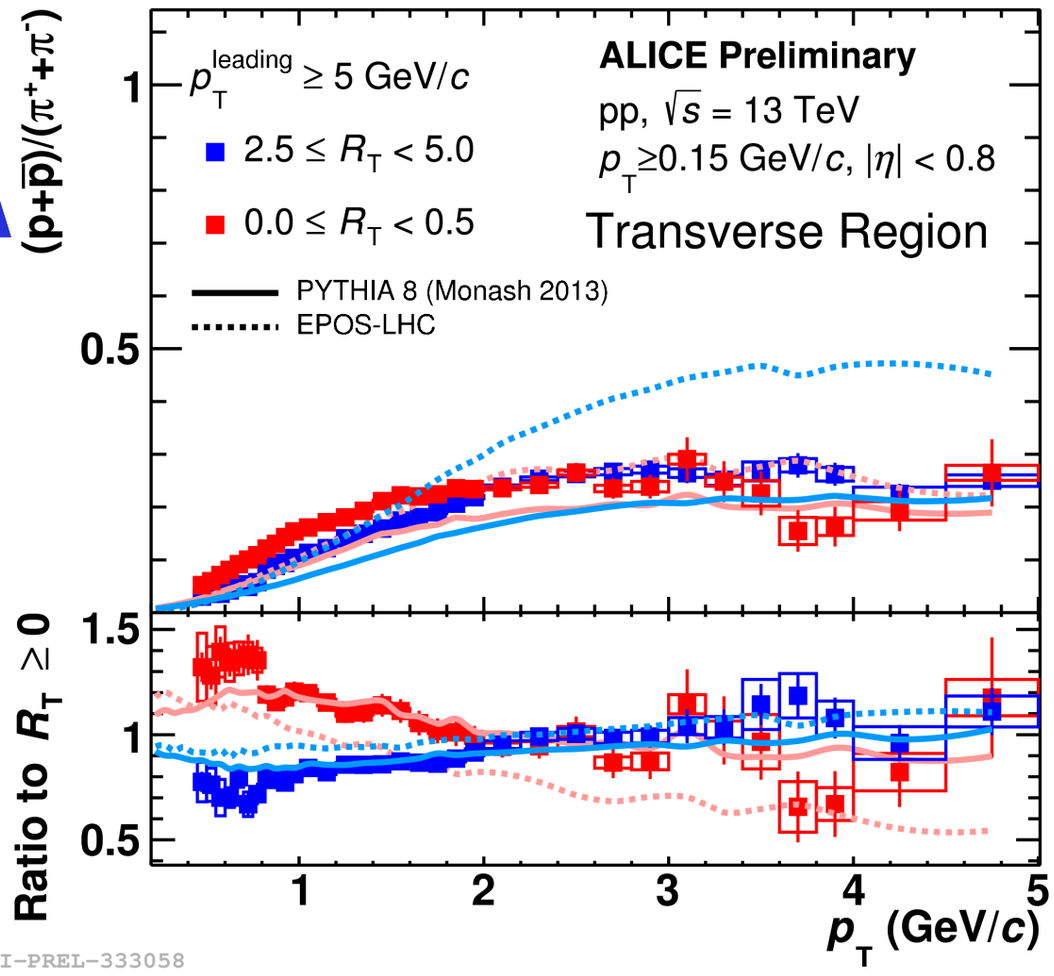
- The baryon-to-meson ratios have little dependence on R_{T}.
- Hint of suppression (enhancement) of the p/π ratio at low (high) p_{T}.

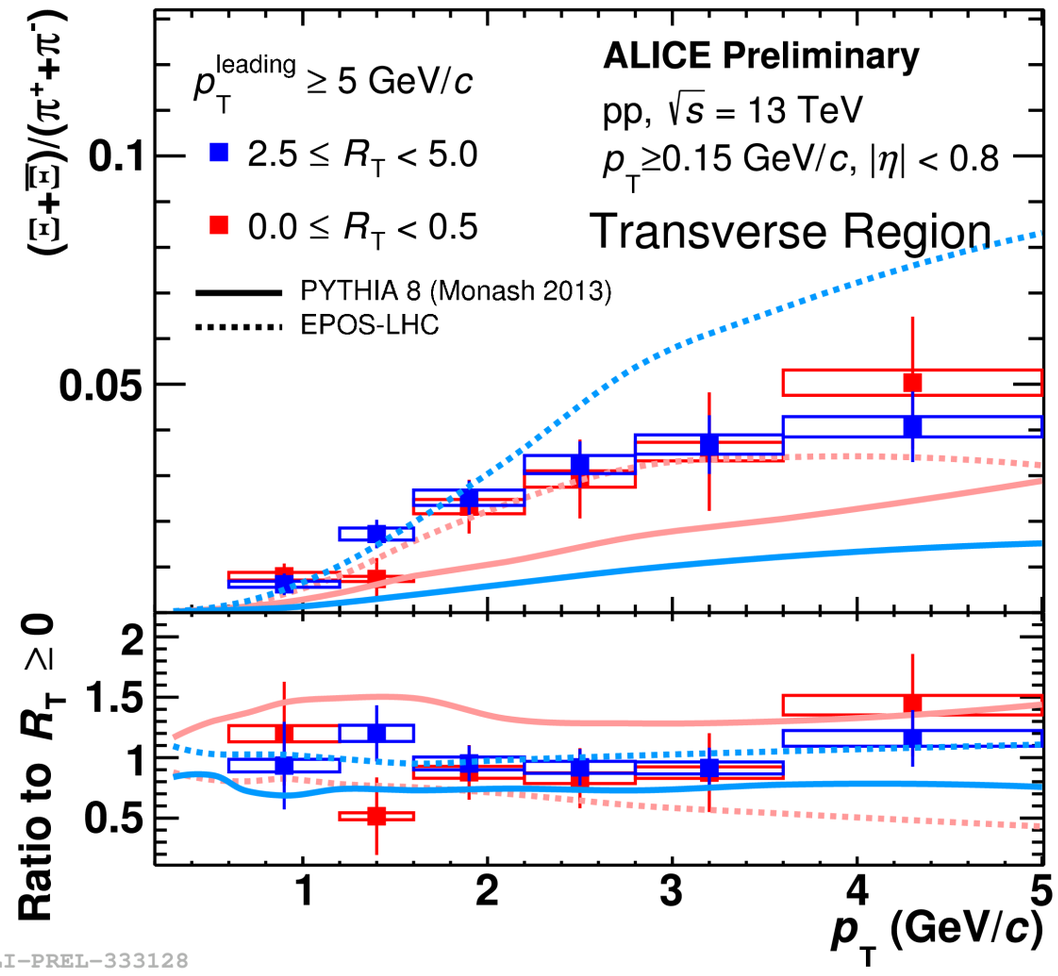
Particle ratios: transverse region

High-UE



Low-UE





- Both models describe the trend for the low-UE ratios.
- While PYTHIA describes the trends in the high-UE events, EPOS-LHC predicts a splitting that is not observed in data.

Summary

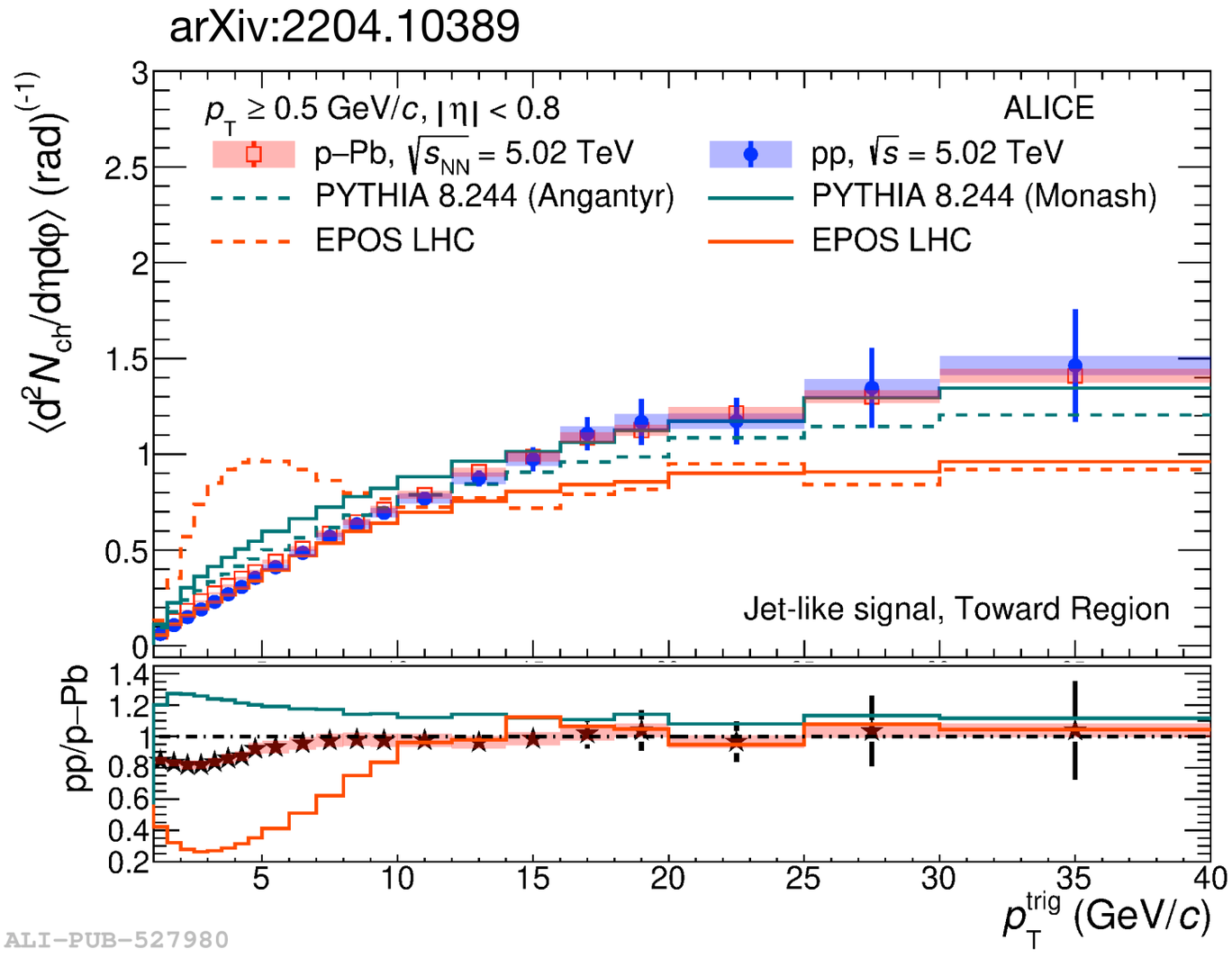
- The number density in the transverse region in pp and p—Pb collisions is independent of the scale of the hard probe for $p_{\mathrm{T}}^{\mathrm{leading}} \gtrsim 5$ GeV/c (UE plateau).

- Measurements of the I_X across system size show no indications of jet-like modifications in small systems.

- R_{T} allows to study the particle fractions in low-UE environments.
  - PYTHIA and EPOS-LHC describe reasonably the measurements.

Backup

$N_{\mathrm{ch}}/\Delta\eta\Delta\varphi$ in the jet-like signal



- The UE activity in the transverse region is subtracted from the toward region.
- The particle density in the jet-like signal increases in the entire $p_{\mathrm{T}}^{\mathrm{leading}}$ range.
- Remarkable similarity between pp and p—Pb for $p_{\mathrm{T}}^{\mathrm{leading}} \gtrsim 8$ GeV/c (fragmentation is not modified).