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

The 37th Winter Workshop on Nuclear Dynamics

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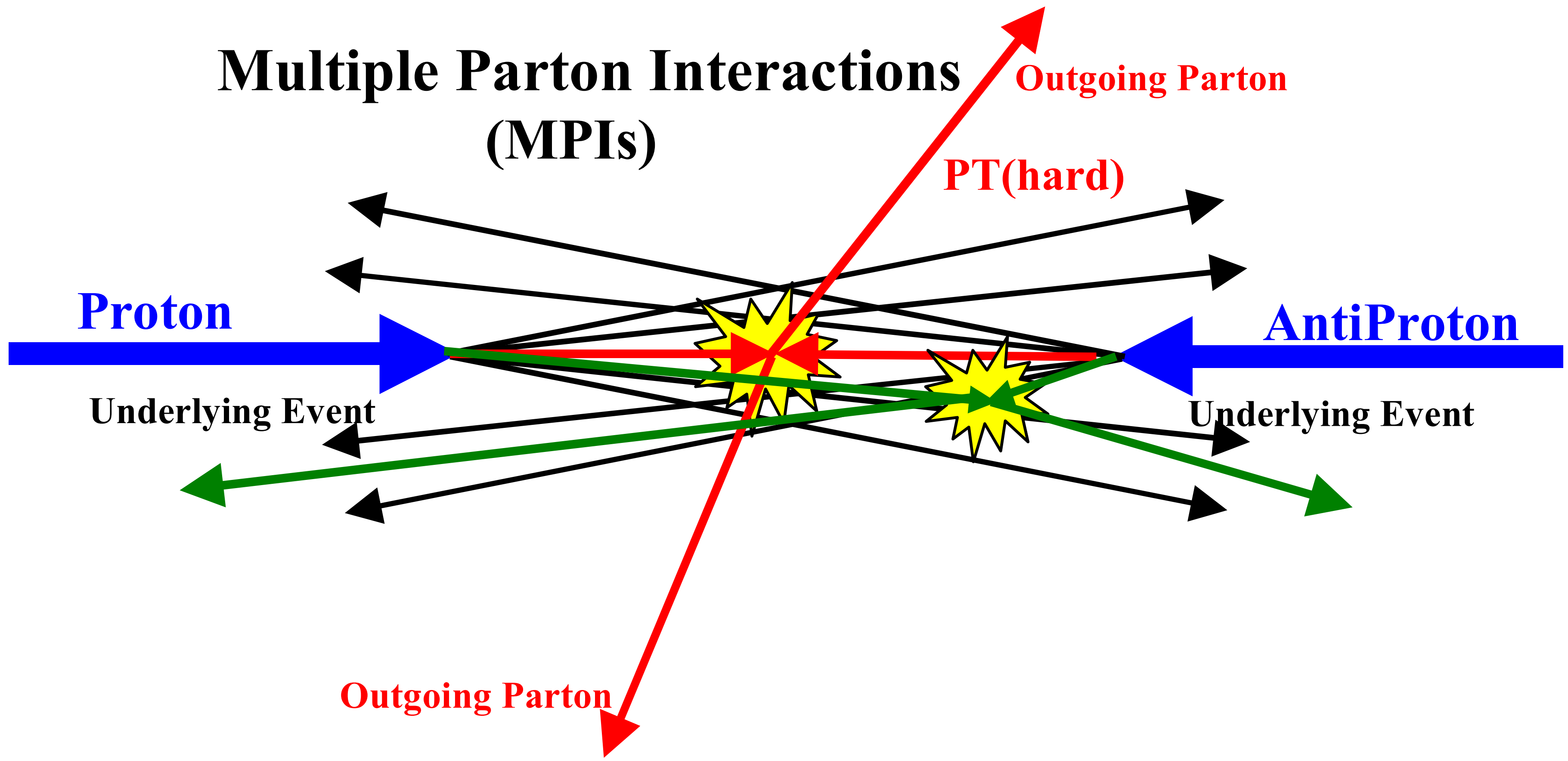
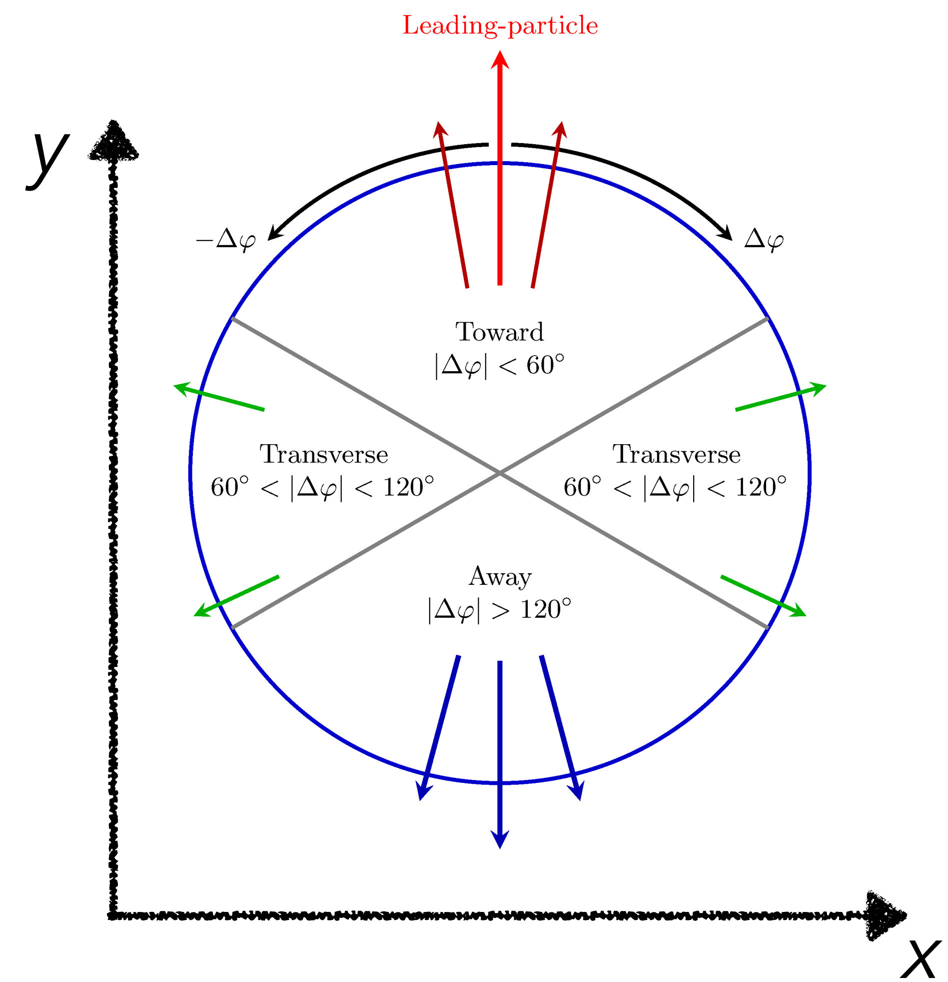
Omar Vazquez
for the ALICE Collaboration

The underlying event (UE)

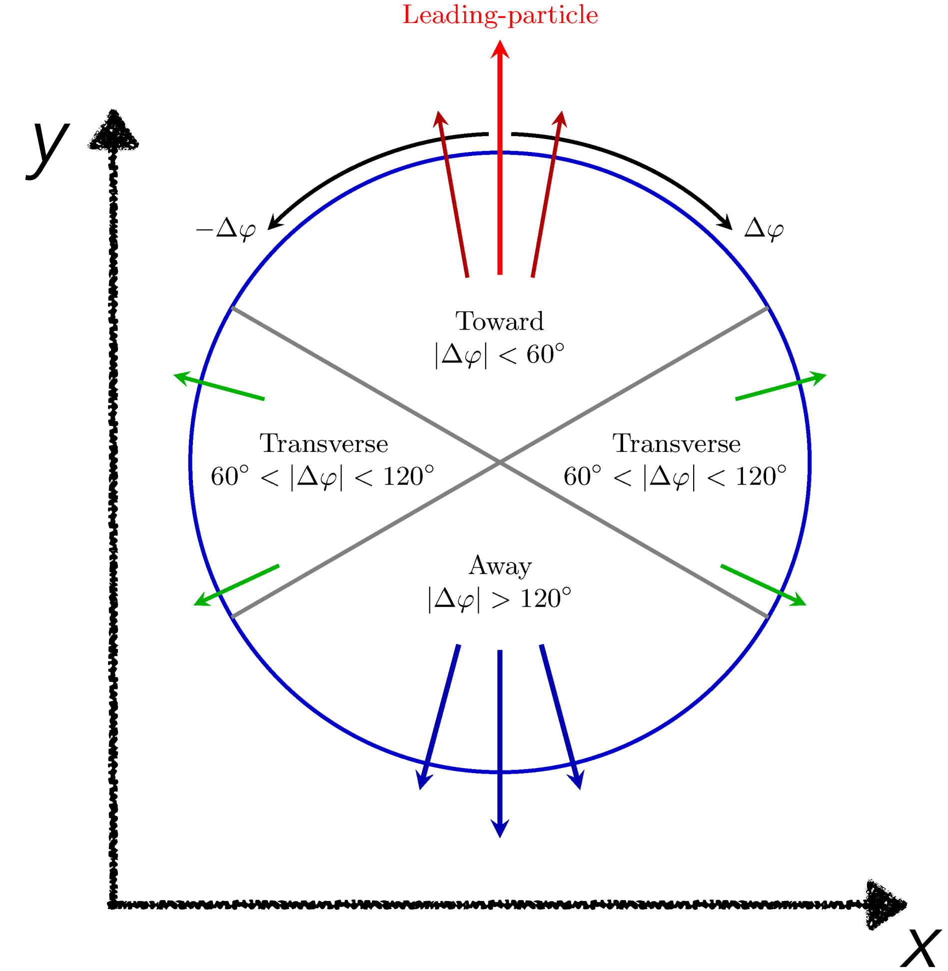


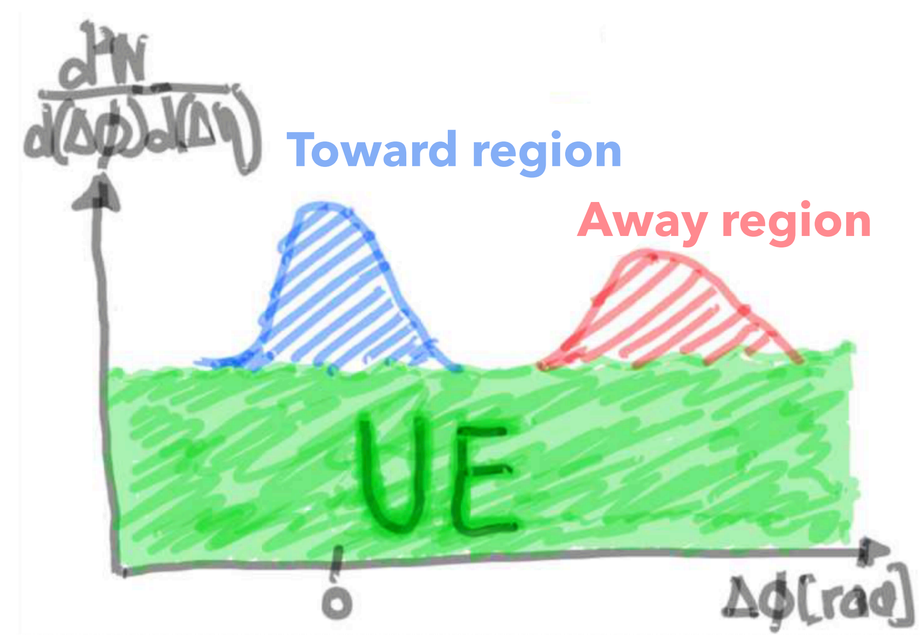
- The UE: the particles, which do not originate from the primary hard parton-parton scattering:
  - MPIs, initial- and final-state radiation (ISR/FSR), beam remnants.

The UE observables



The UE observables

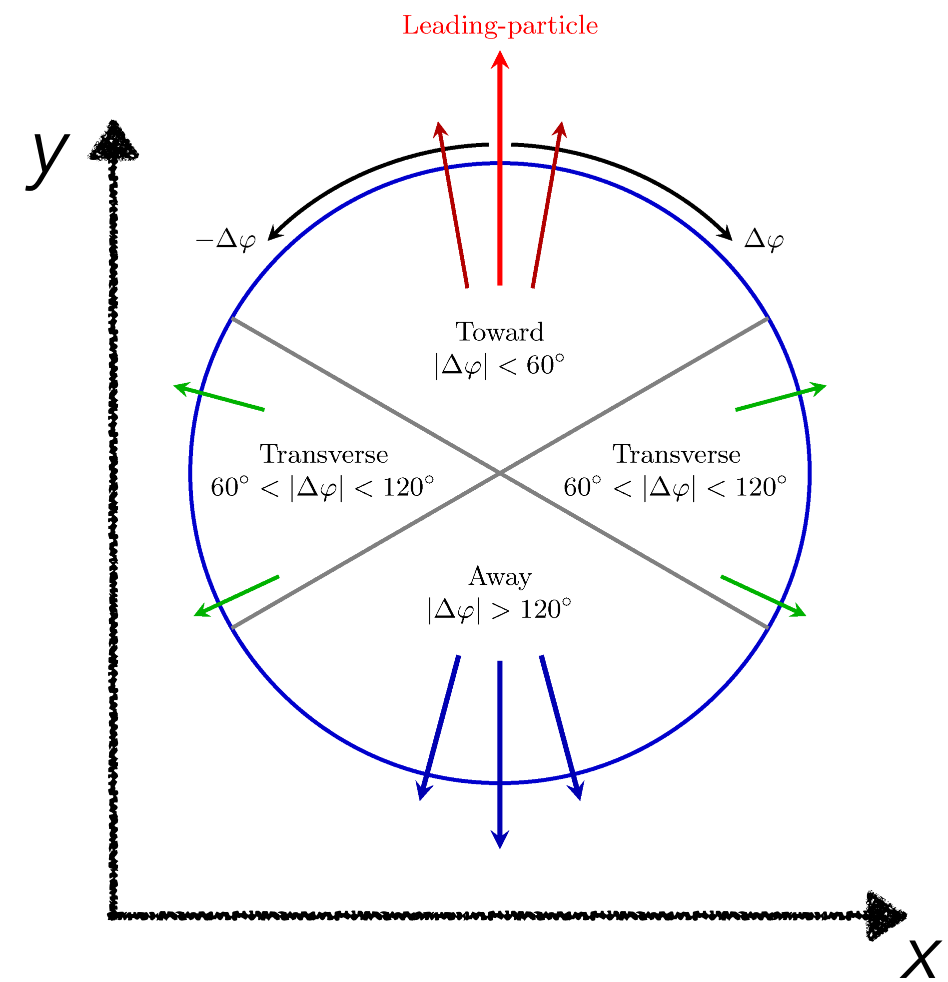


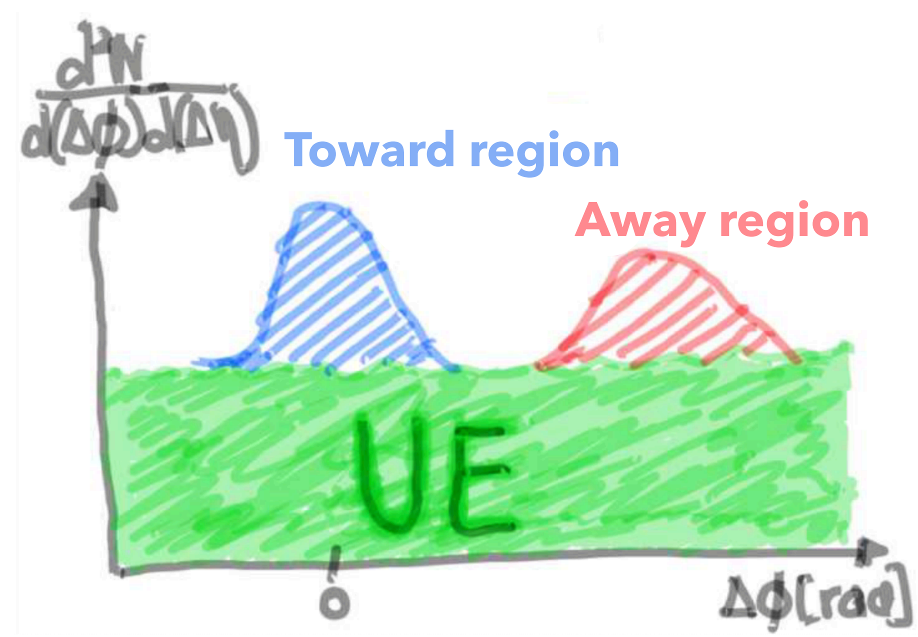


The UE observables

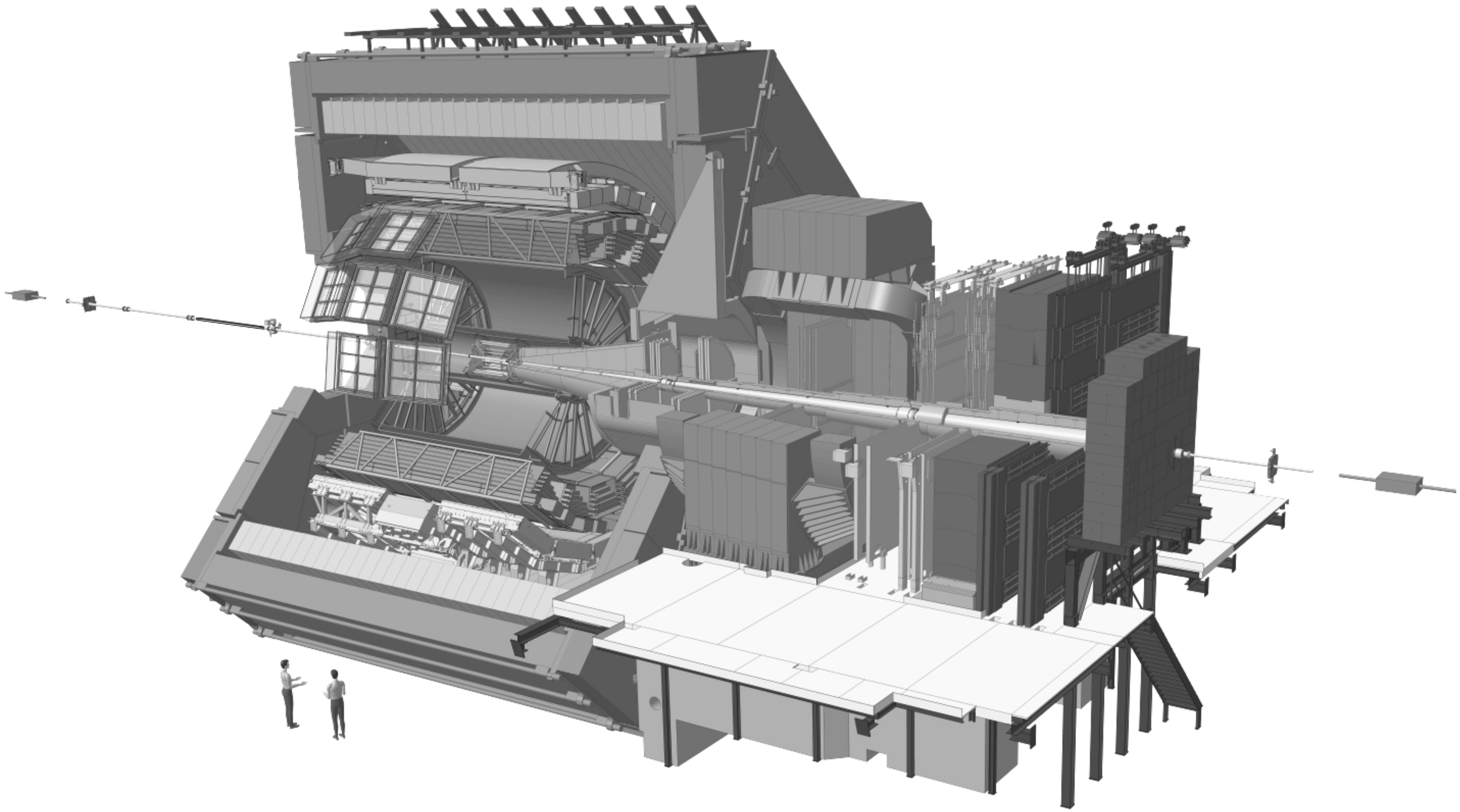
- Measured in events with leading charged particles.
- Defined in the angular region perpendicular to the leading charged particle.
- The UE is traditionally quantified by:
  - Particle number density: $N_{\mathrm{ch}}/\Delta\eta\Delta\varphi$.
  - Summed transverse momentum density: $\sum p_{\mathrm{T}}/\Delta\eta\Delta\varphi$

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

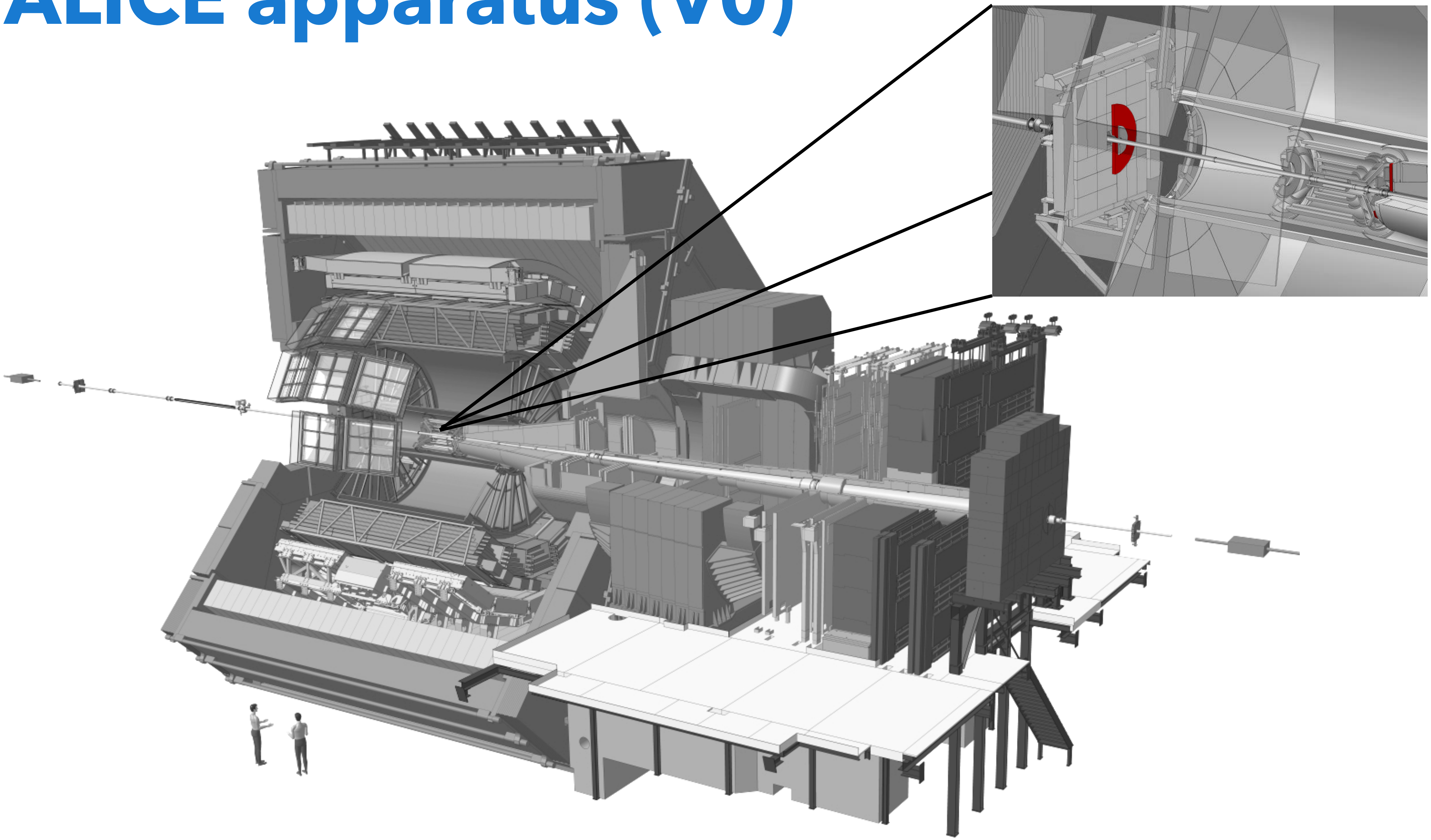




The ALICE apparatus

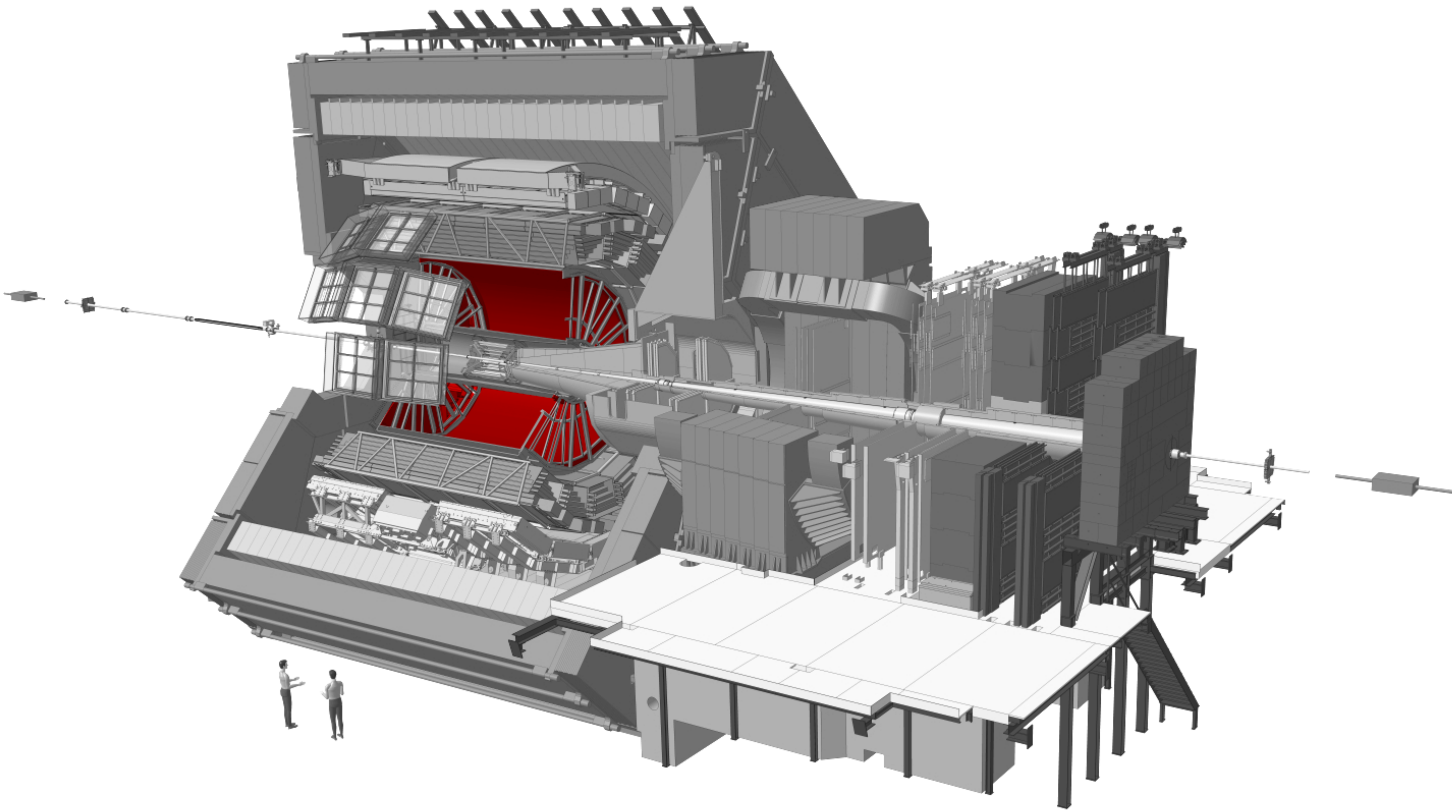


The ALICE apparatus (V0)



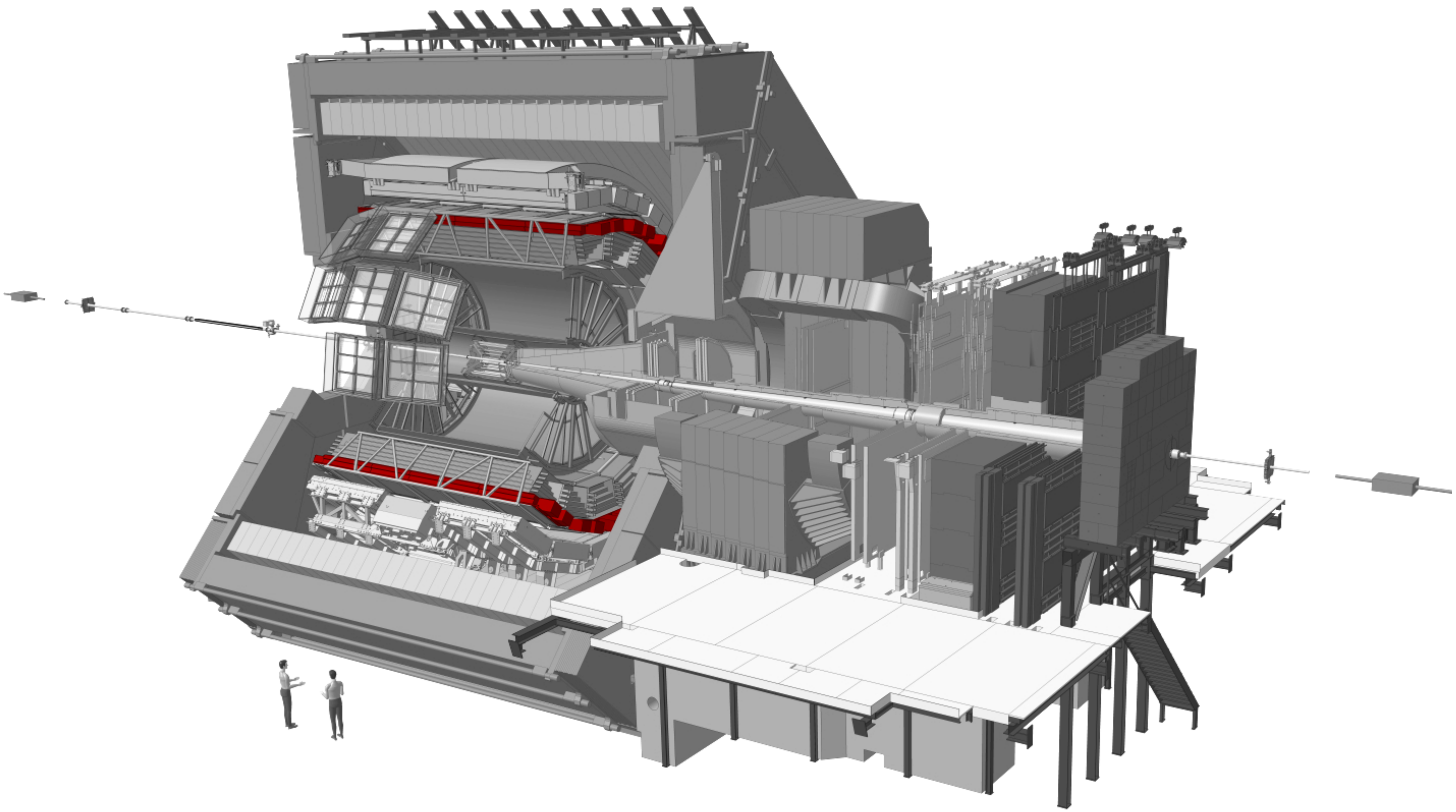
- V0: forward scintillator hodoscopes, V0A $(2.8 < \eta < 5.1)$ and V0C $(-3.7 < \eta < -1.7)$.
- Triggering, background suppression and multiplicity estimation.

The ALICE apparatus (TPC)



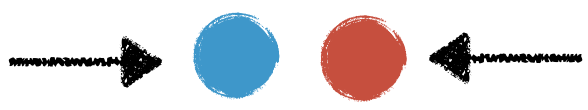
- $|\eta| < 0.8$ and full azimuthal angle coverage.
- Vertex reconstruction, tracking and PID.

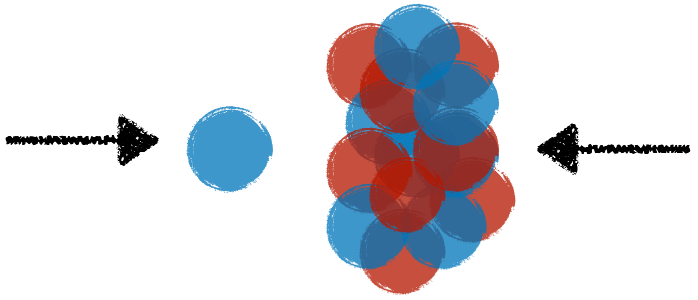
The ALICE apparatus (TOF)



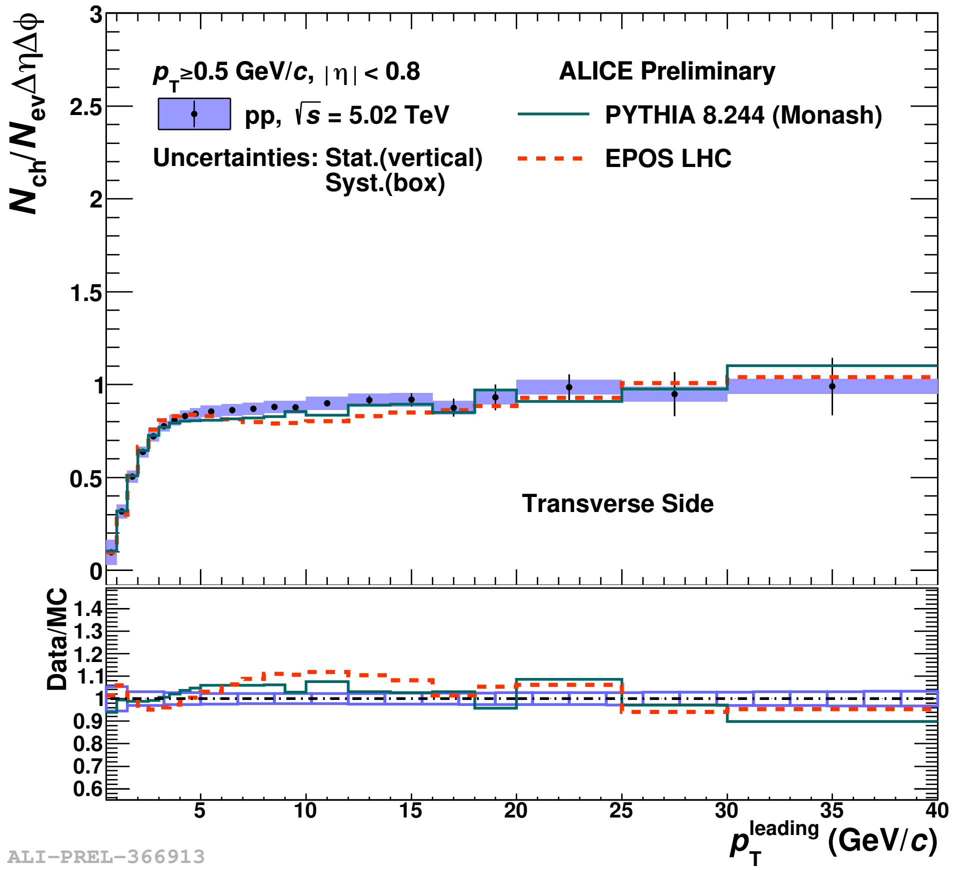
- $|\eta| < 0.8$ and full azimuthal angle coverage.
- PID.

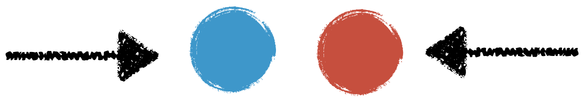
Underlying event observables in pp and p–Pb collisions at 5.02 TeV

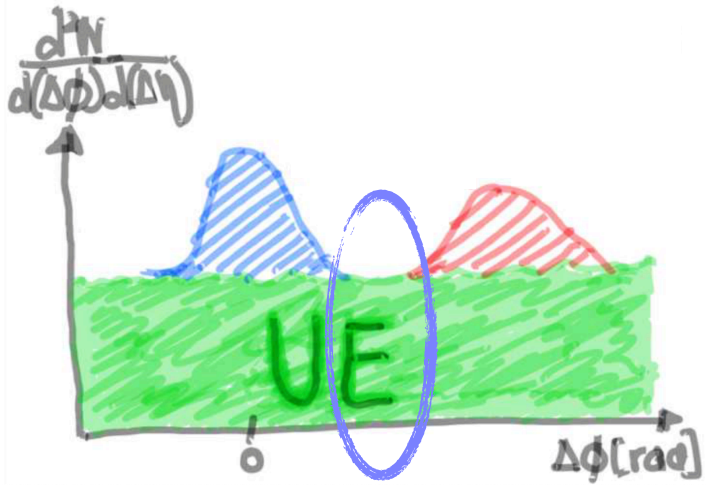




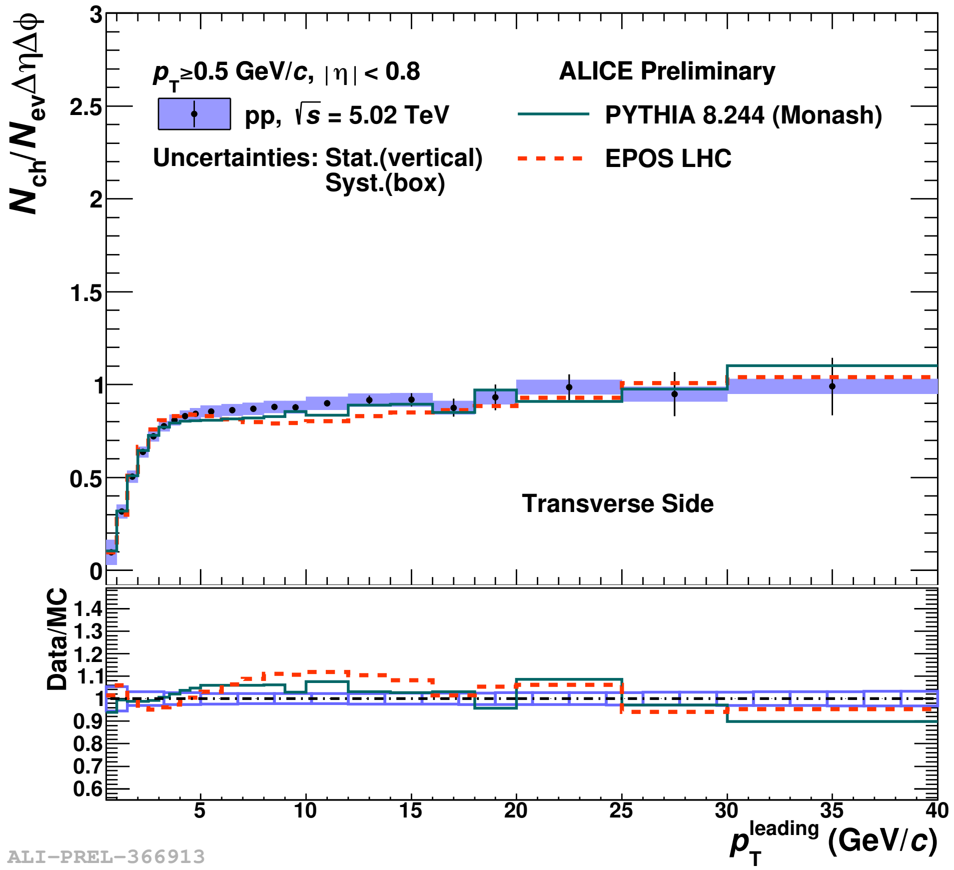
$N_{ch}/d\eta d\varphi$ in pp and p–Pb collisions at 5.02 TeV

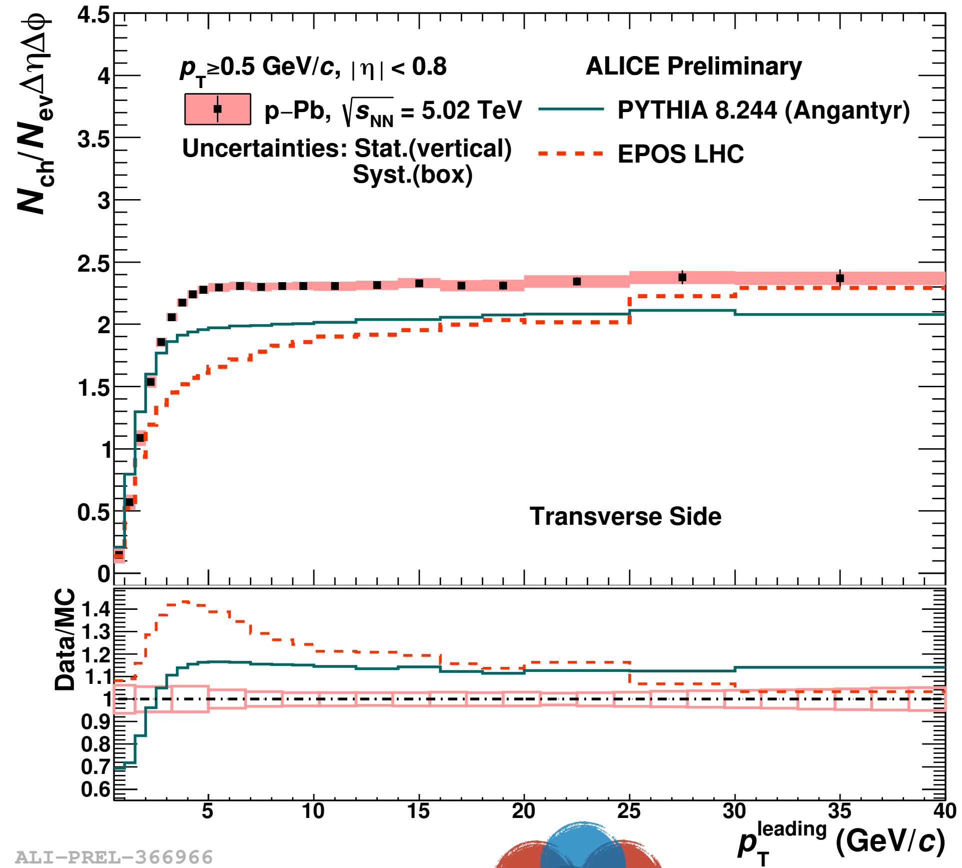


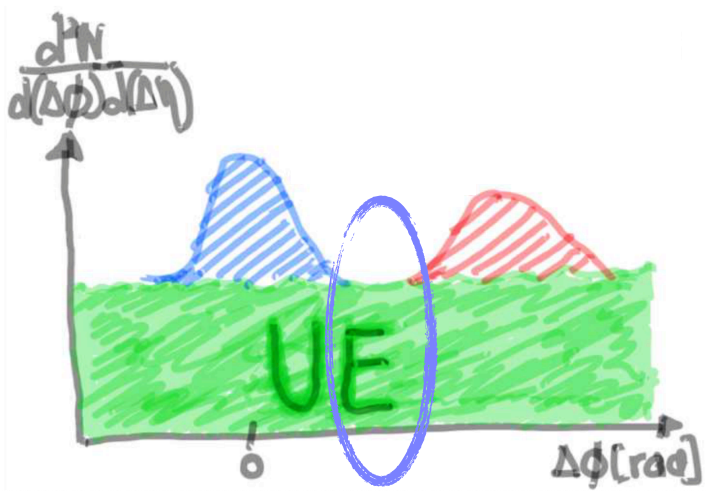


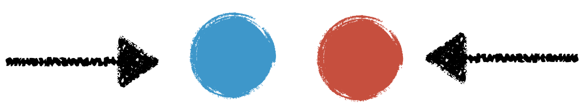


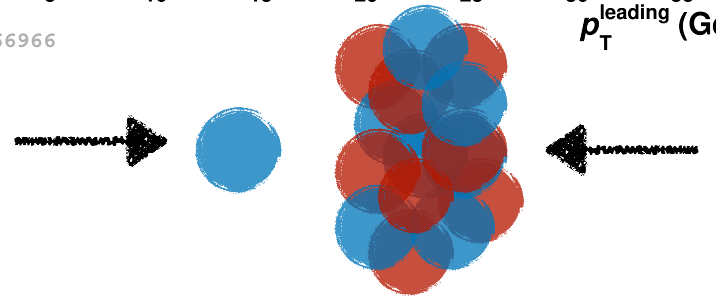
$N_{ch}/d\eta d\varphi$ in pp and p–Pb collisions at 5.02 TeV



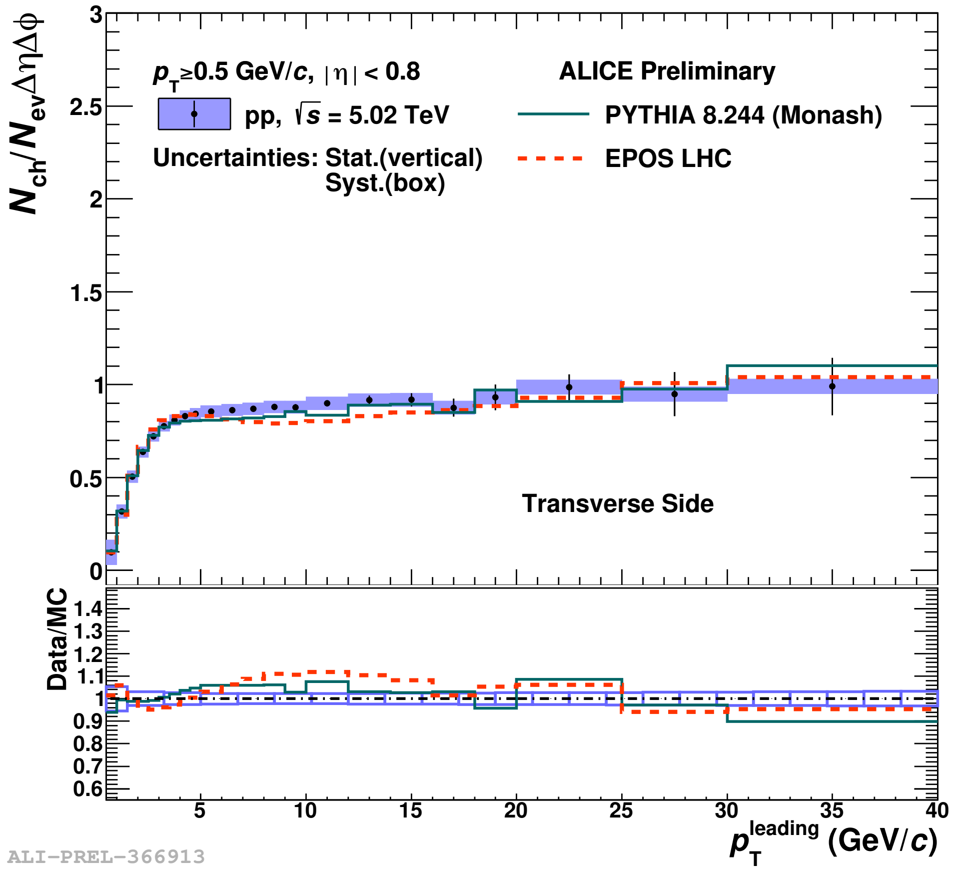


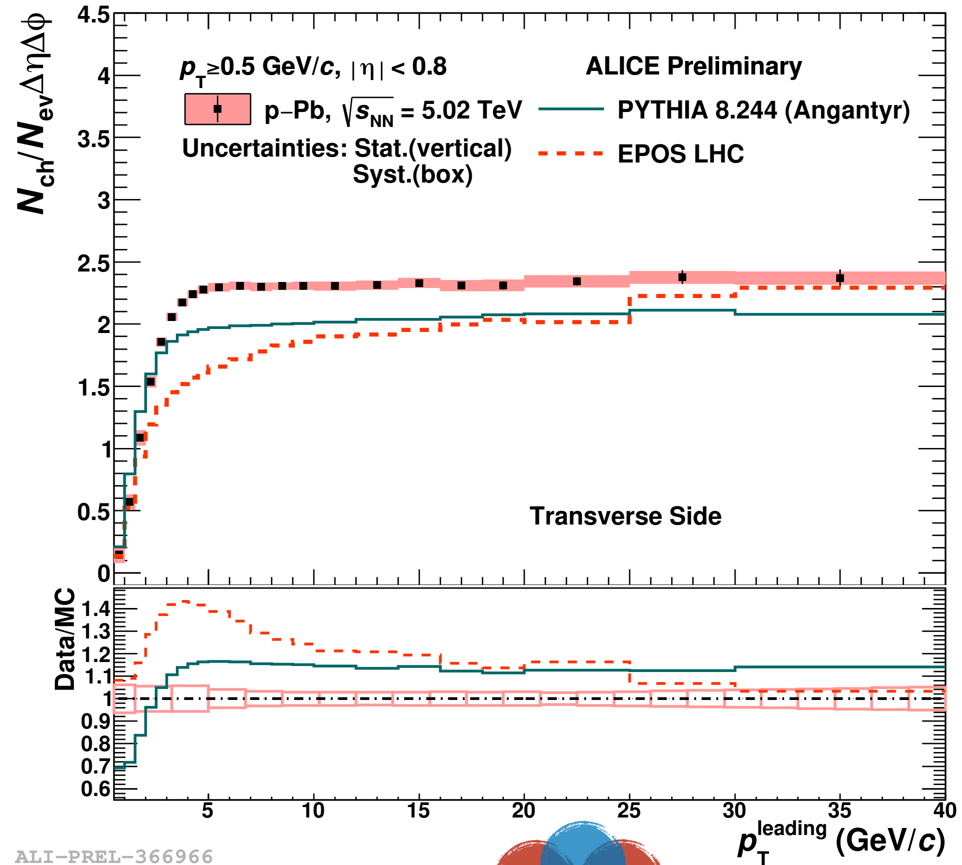


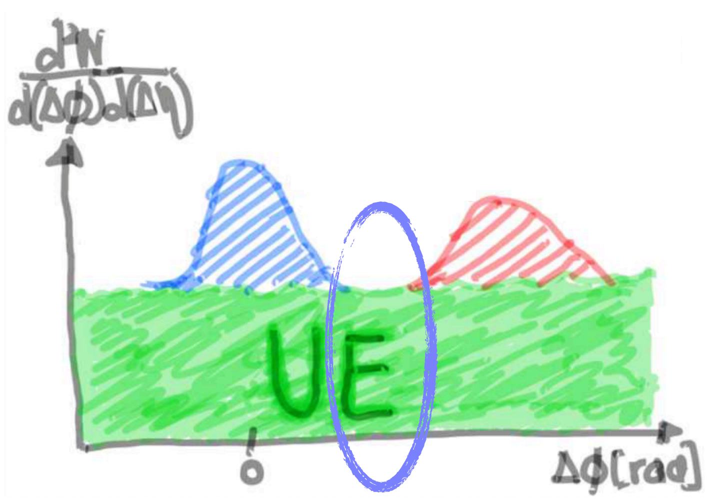


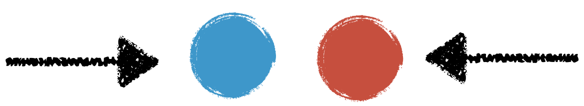


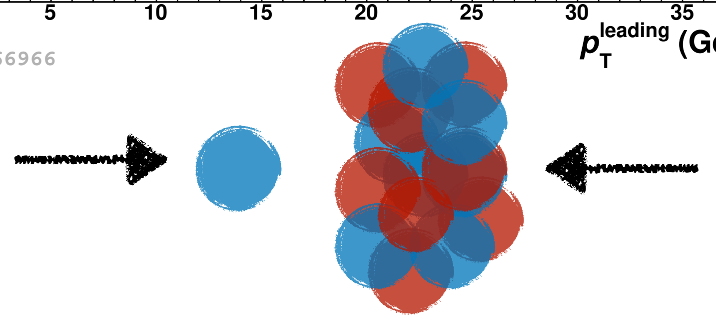
$N_{ch}/d\eta d\varphi$ in pp and p–Pb collisions at 5.02 TeV





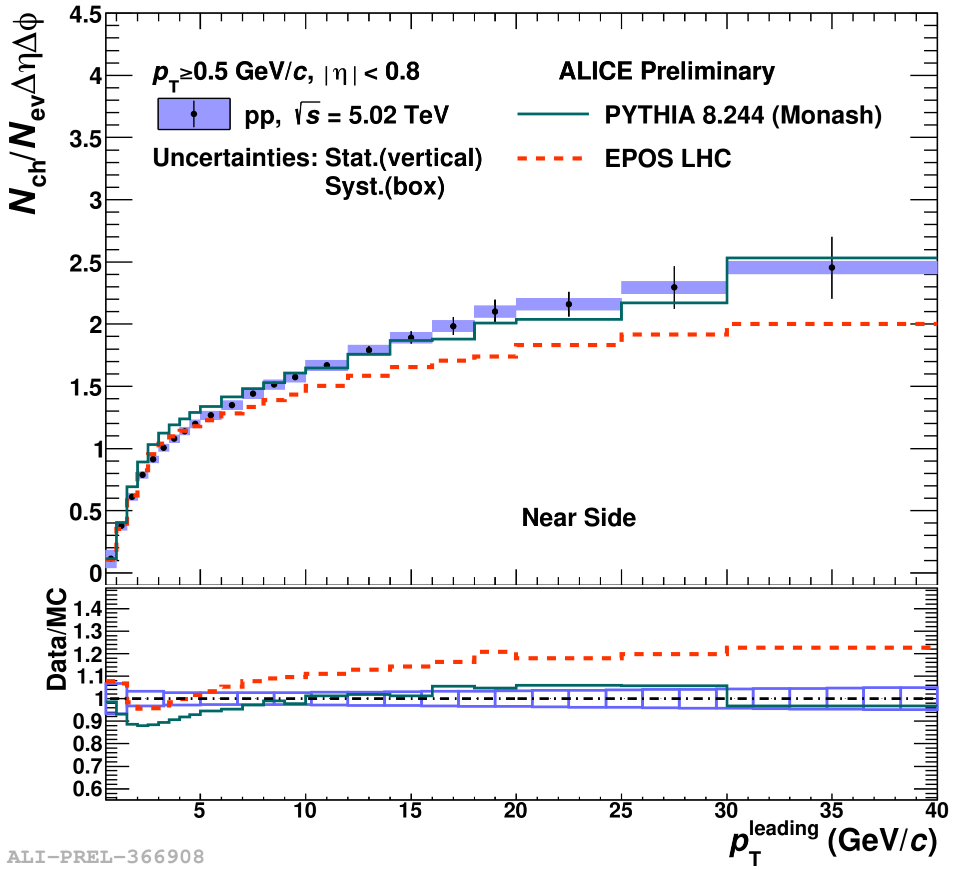


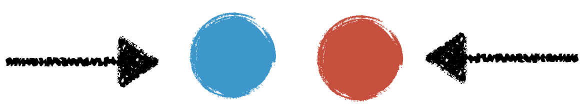


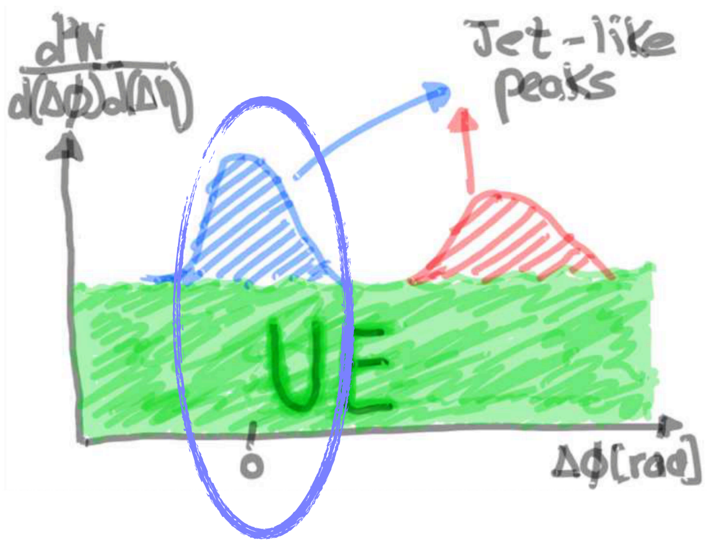


- Similar shape as a function of the $p_T^{leading}$ between both systems.
- The number density is independent of the leading particle for $p_T^{leading} \gtrsim 5$ GeV$/c$ (UE plateau).

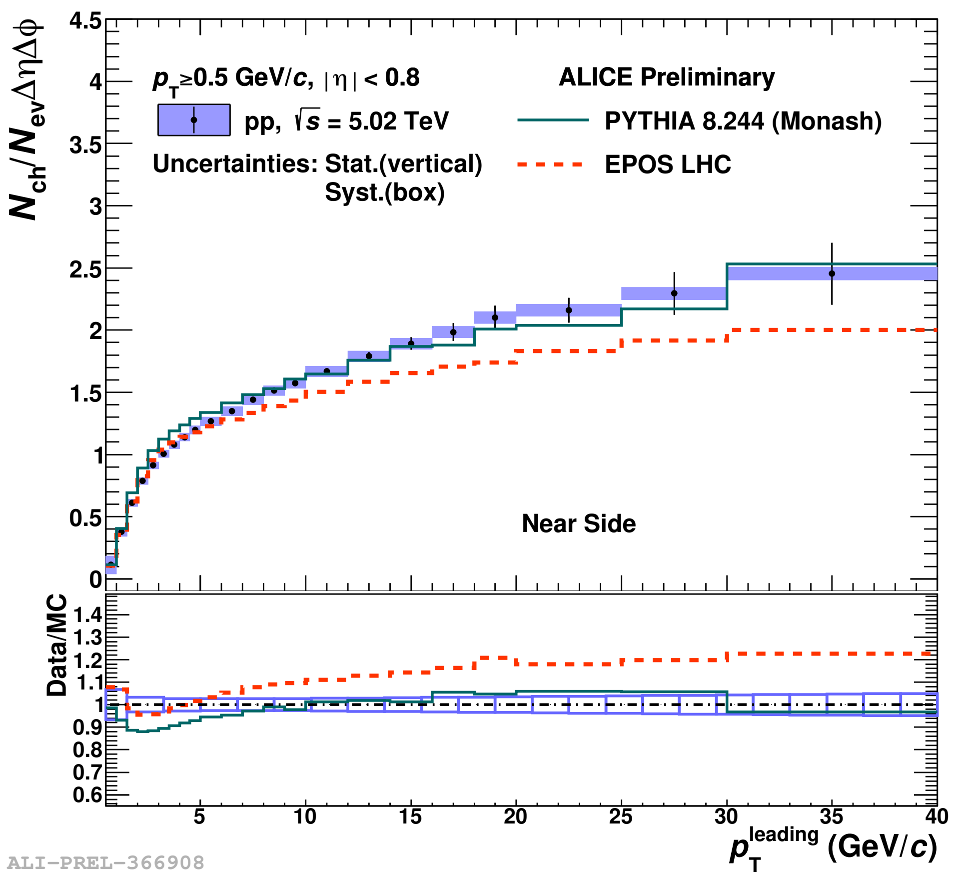
$N_{ch}/d\eta d\varphi$ in pp and p–Pb collisions at 5.02 TeV

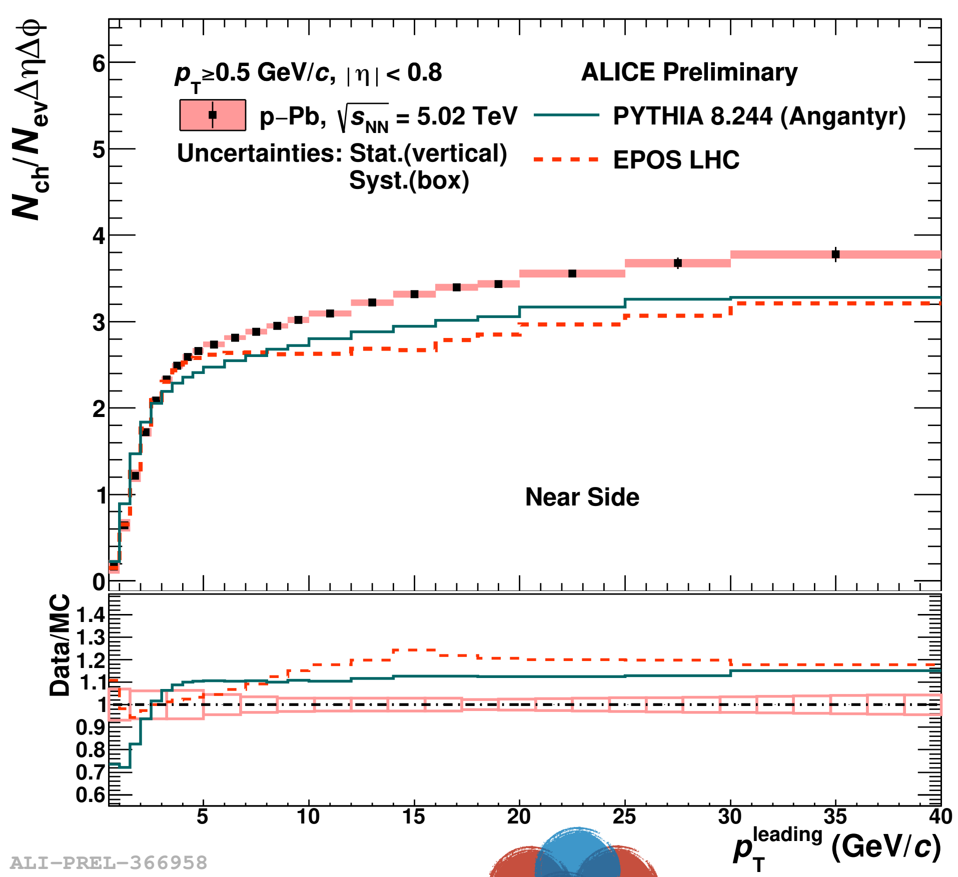


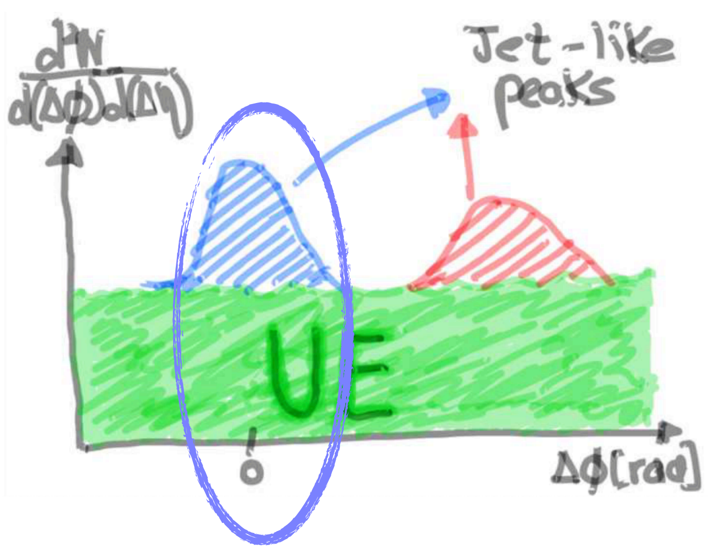


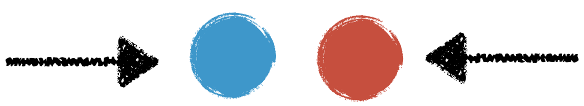


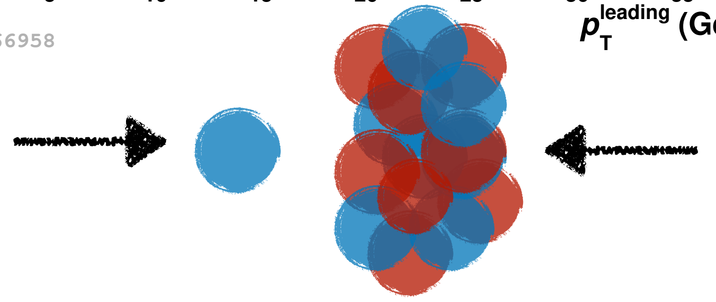
$N_{ch}/d\eta d\varphi$ in pp and p–Pb collisions at 5.02 TeV



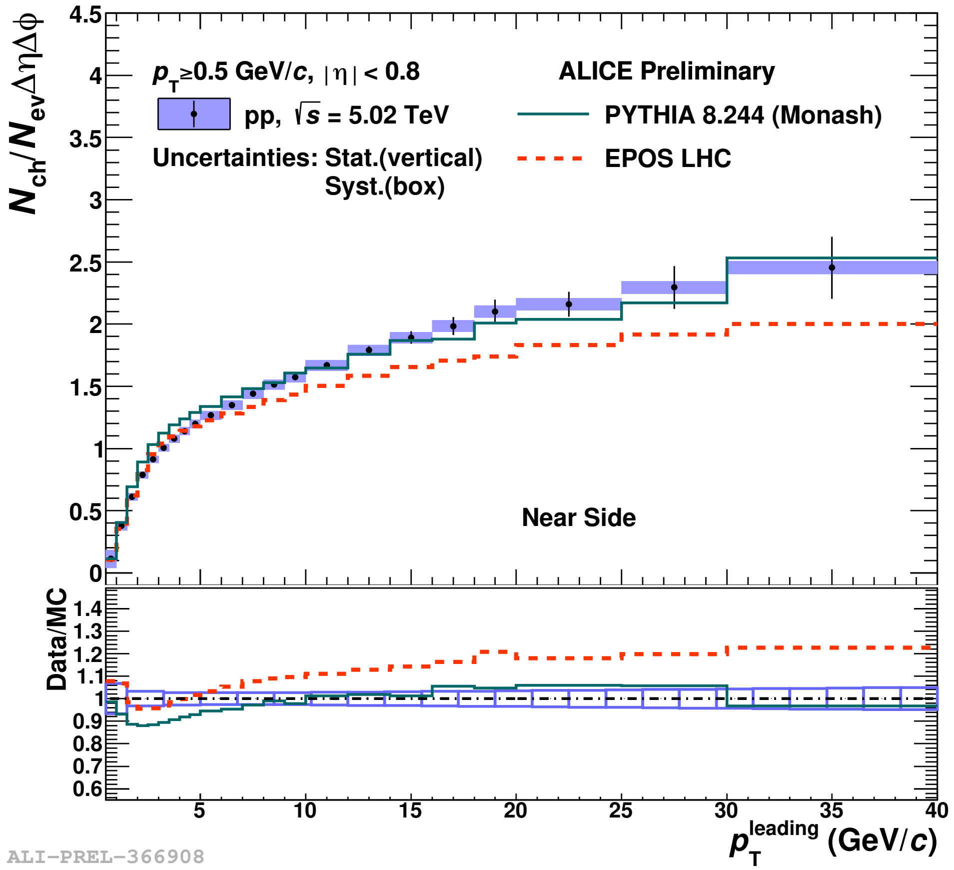


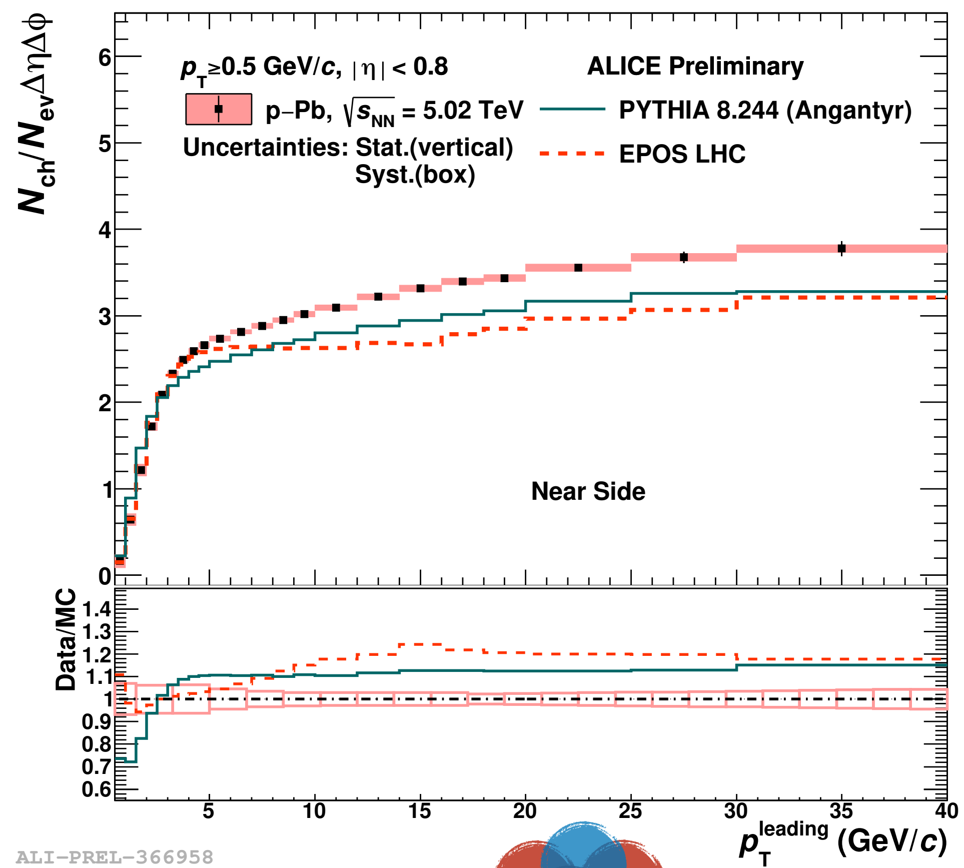


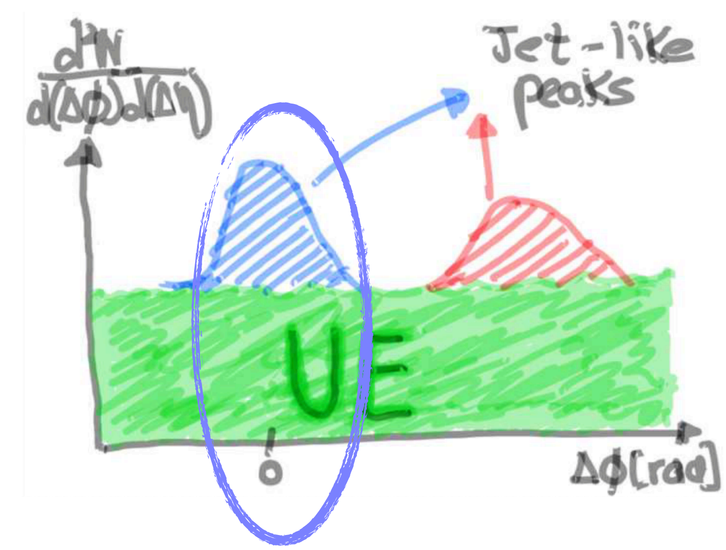


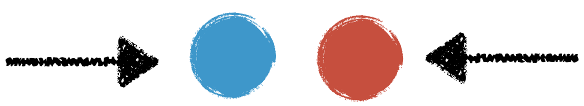


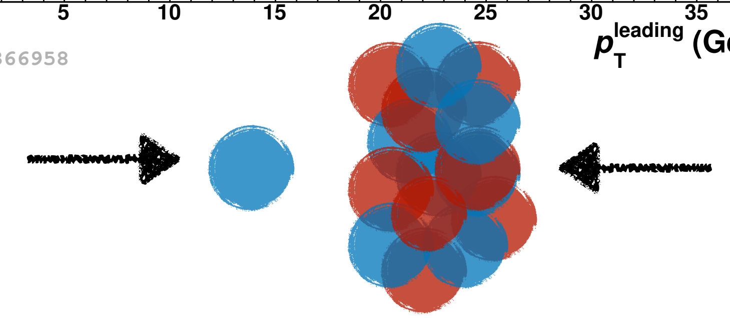
$N_{\mathrm{ch}} / \mathrm{d}\eta\mathrm{d}\varphi$ in pp and p–Pb collisions at 5.02 TeV





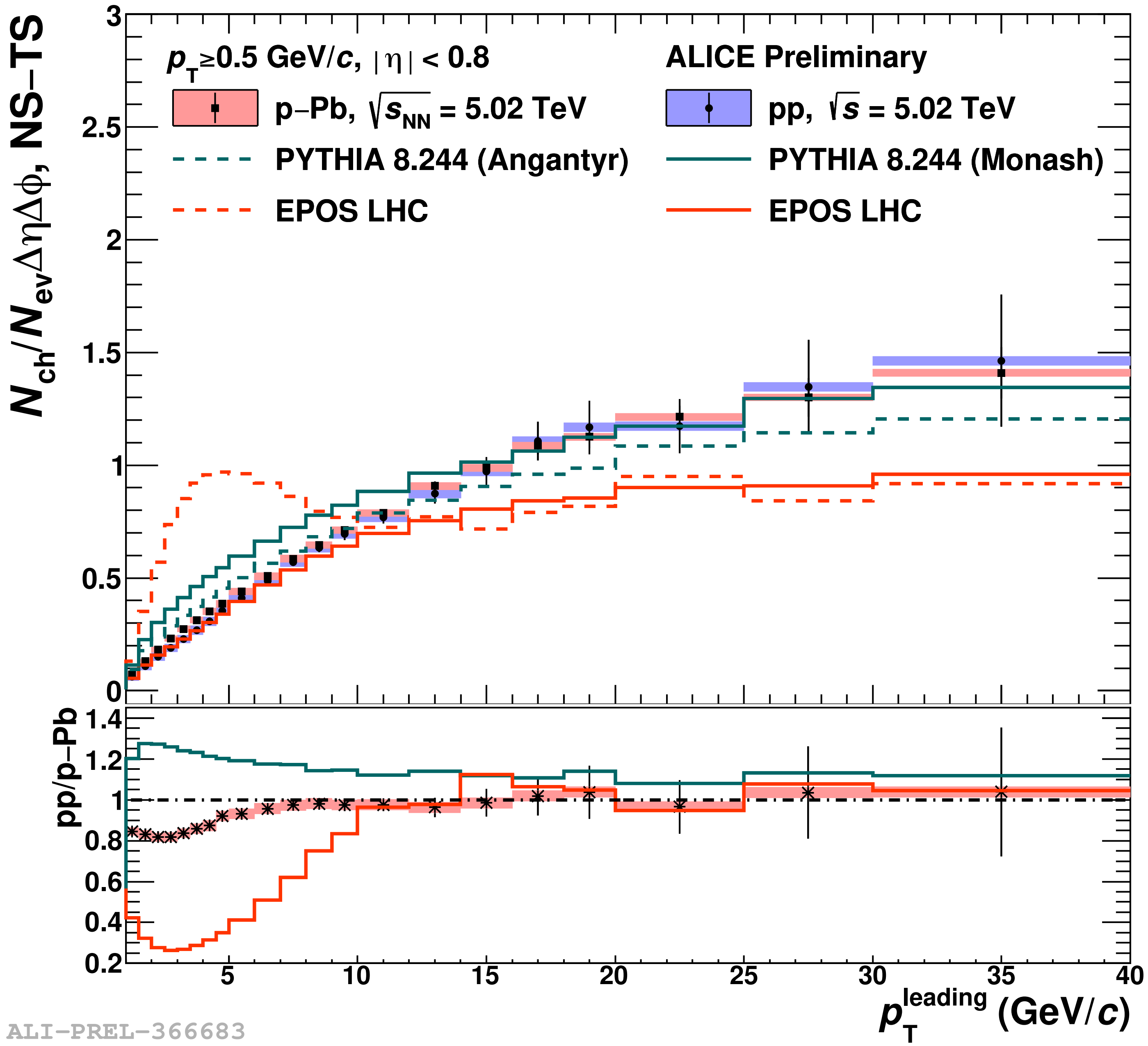




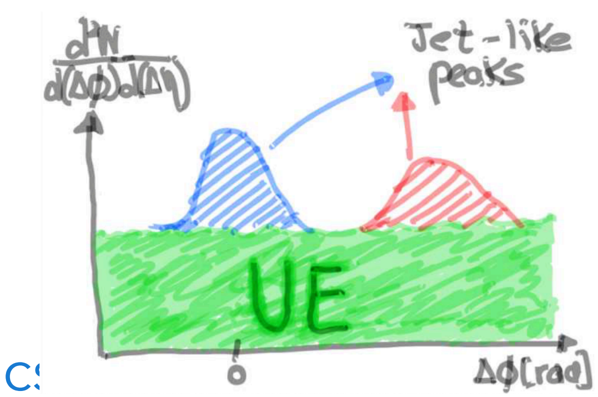


- The number density has contributions from the Jet + UE.
- The number density as a function of the p_T^{leading} in the toward region is similar between pp and p–Pb, however it increases faster in pp.
- PYTHIA and EPOS–LHC underestimate the number density in p–Pb.

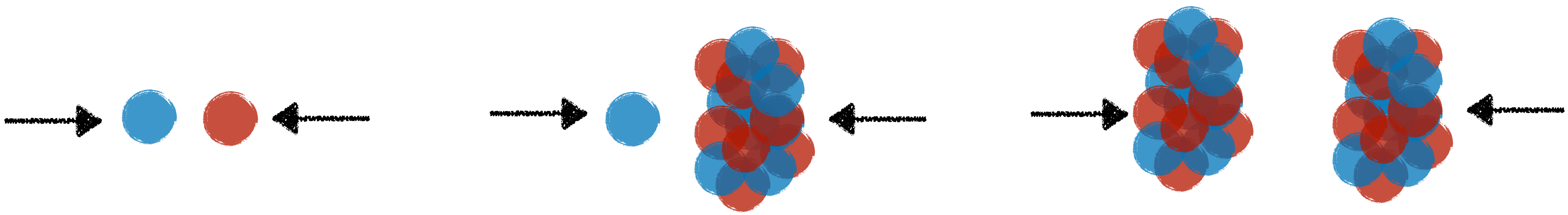
$N_{\mathrm{ch}}/\mathrm{d}\eta\mathrm{d}\varphi$ in the jet-like signal



- The event activity in the transverse region is subtracted from the toward (it is assumed that the UE is flat in $\Delta\varphi$).
- Increases in the entire $p_{\mathrm{T}}^{\mathrm{leading}}$ range.
- Remarkable similarity between pp and p–Pb for $p_{\mathrm{T}}^{\mathrm{leading}} \gtrsim 8\ \mathrm{GeV}/c$ (fragmentation is not modified)

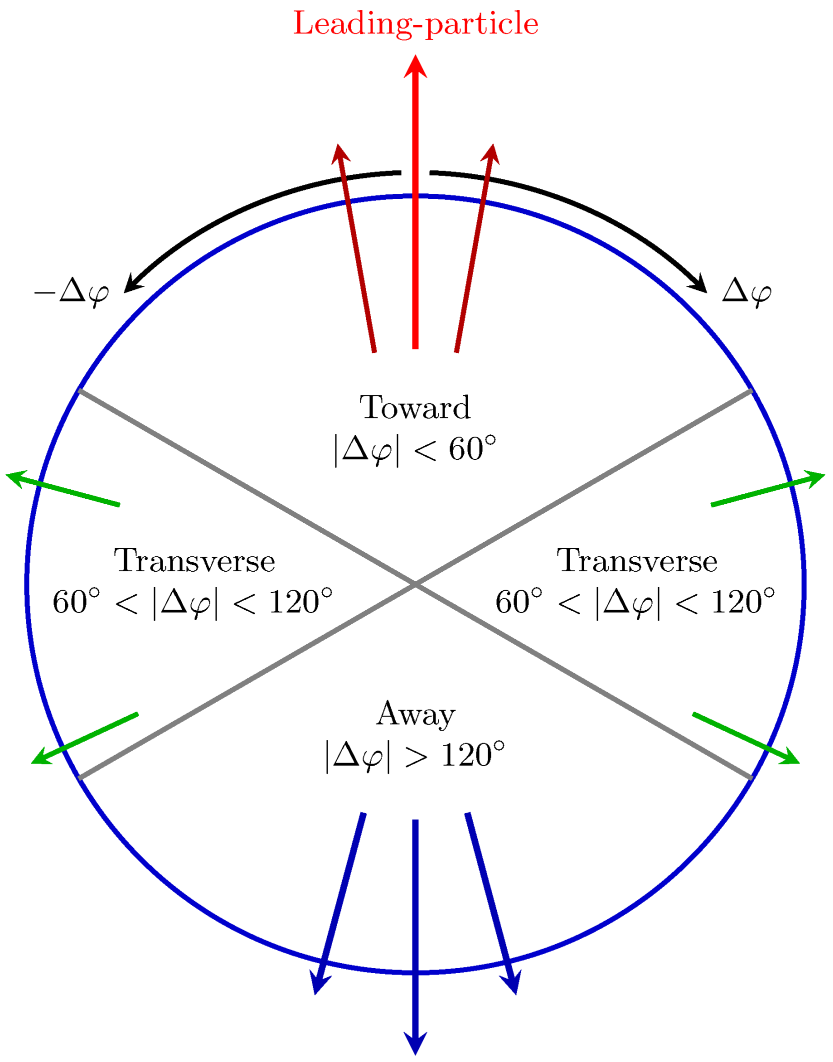


Particle production across system size and searches for jet-like modifications in small systems at 5.02 TeV



Analysis strategy

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



Analysis strategy

- Leading particle: $p_{\mathrm{T}}^{\mathrm{leading}}$, $8 - 15\ \mathrm{GeV}/c$, $|\eta| < 0.8$
- The p_{T} spectra of associated particles is measured in each region as a function of the Relative Transverse Activity, $R_{\mathrm{T}} = N_{\mathrm{T}} / \langle N_{\mathrm{T}} \rangle$ [1]

[1] Eur.Phys.J. C76 (2016) 299

Analysis strategy

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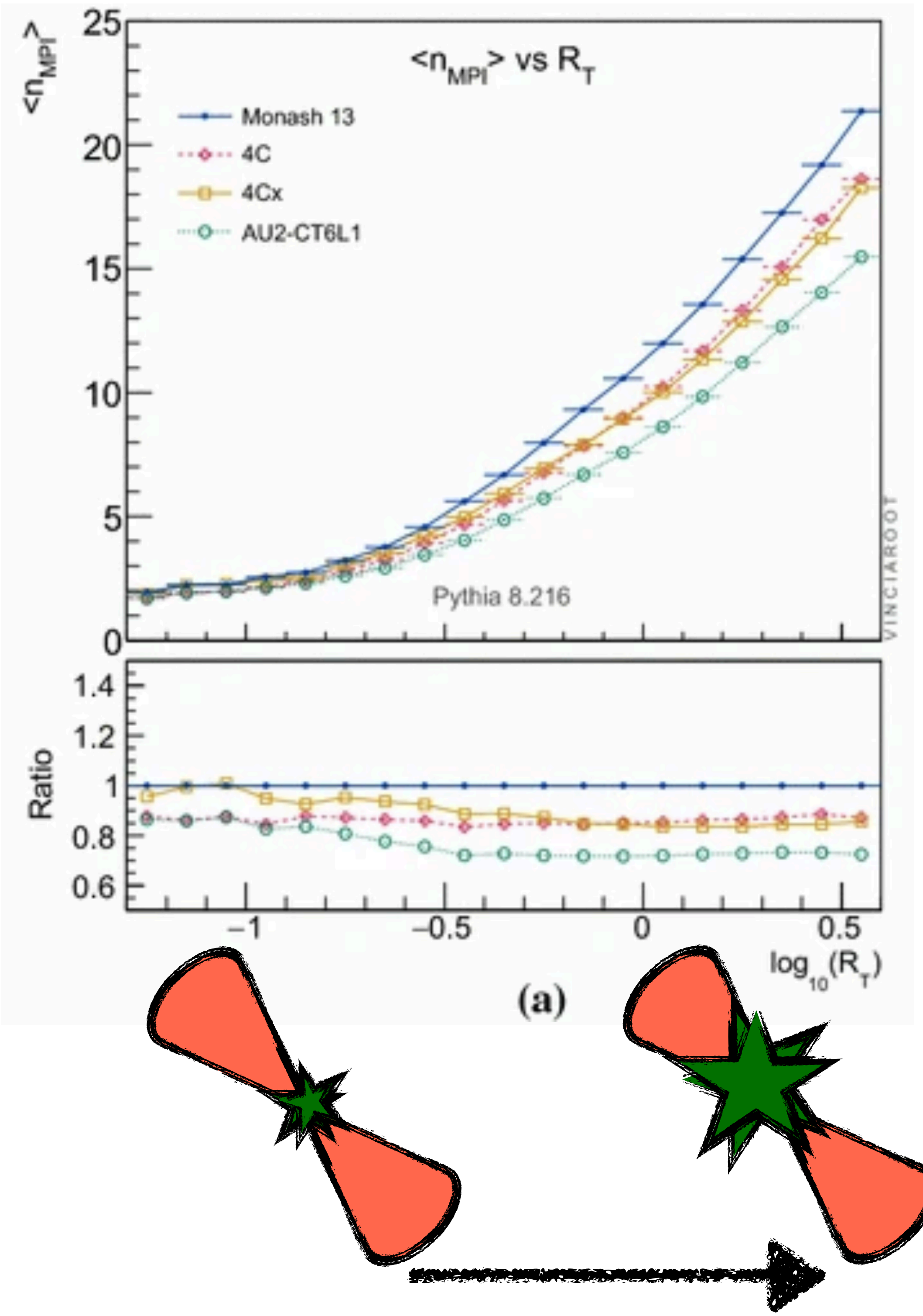


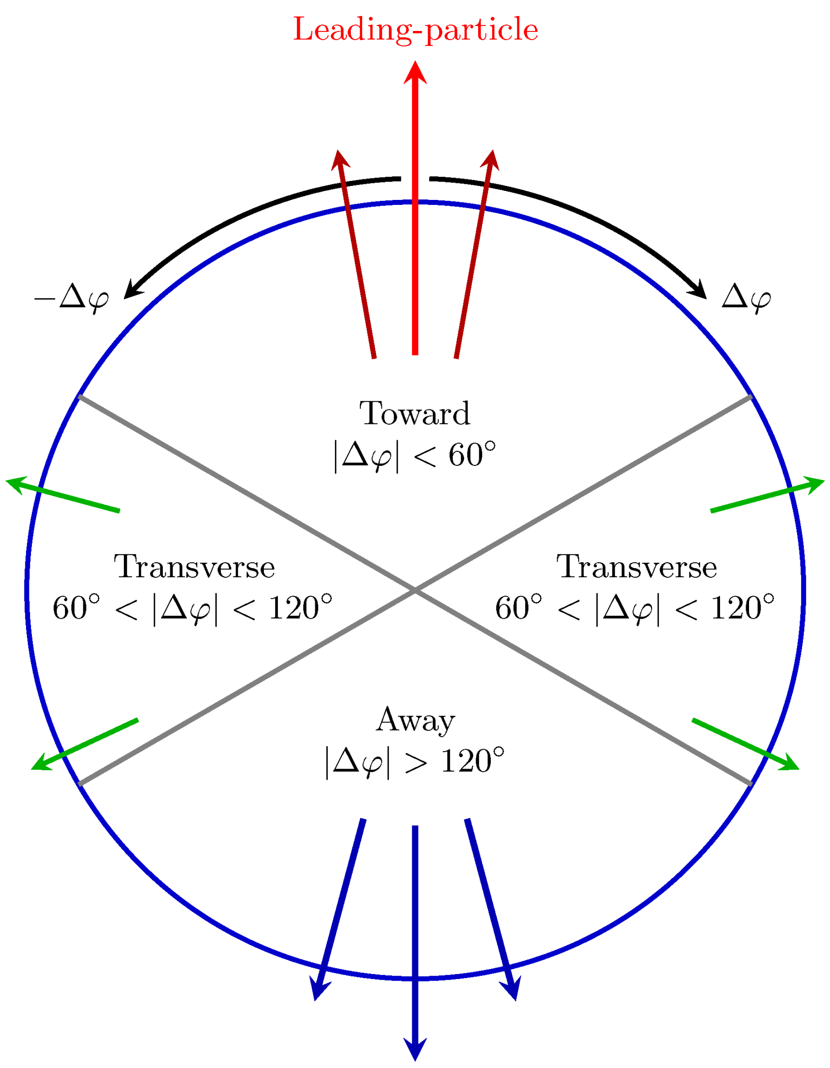
Increasing R_{T}

[1] Eur.Phys.J. C76 (2016) 299

Analysis strategy

- Leading particle: $p_{\mathrm{T}}^{\mathrm{leading}}$, $8 - 15\ \mathrm{GeV}/c$, $|\eta| < 0.8$
- The p_{T} spectra of associated particles is measured in each region as a function of the Relative Transverse Activity, $R_{\mathrm{T}} = N_{\mathrm{T}} / \langle N_{\mathrm{T}} \rangle$ [1]
- 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 $\Delta\varphi$).
- The jet-like yields are quantified by I_X as a function of $\langle N_{\mathrm{T}} \rangle$ and multiplicity.

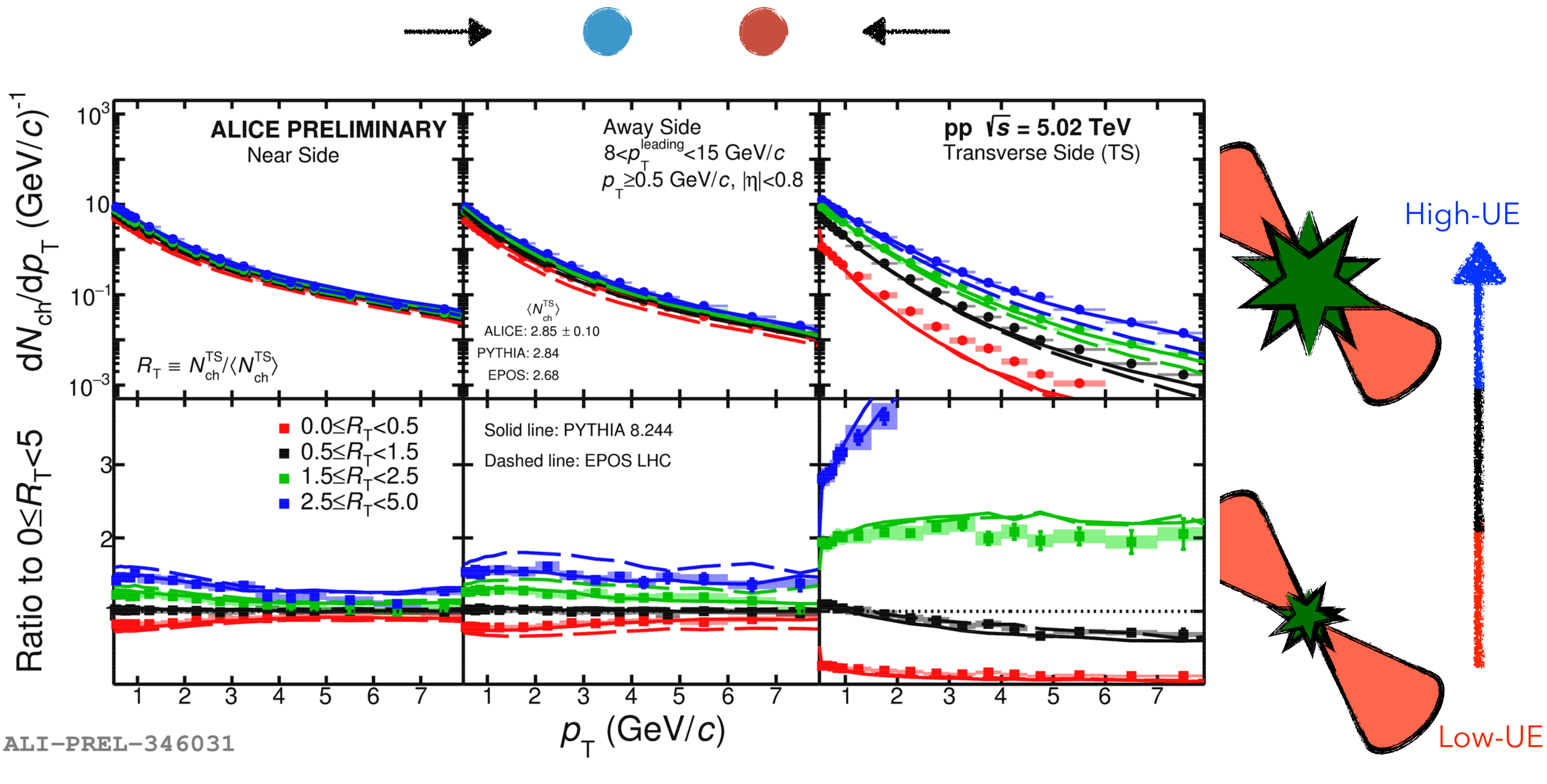
[1] Eur.Phys.J. C76 (2016) 299



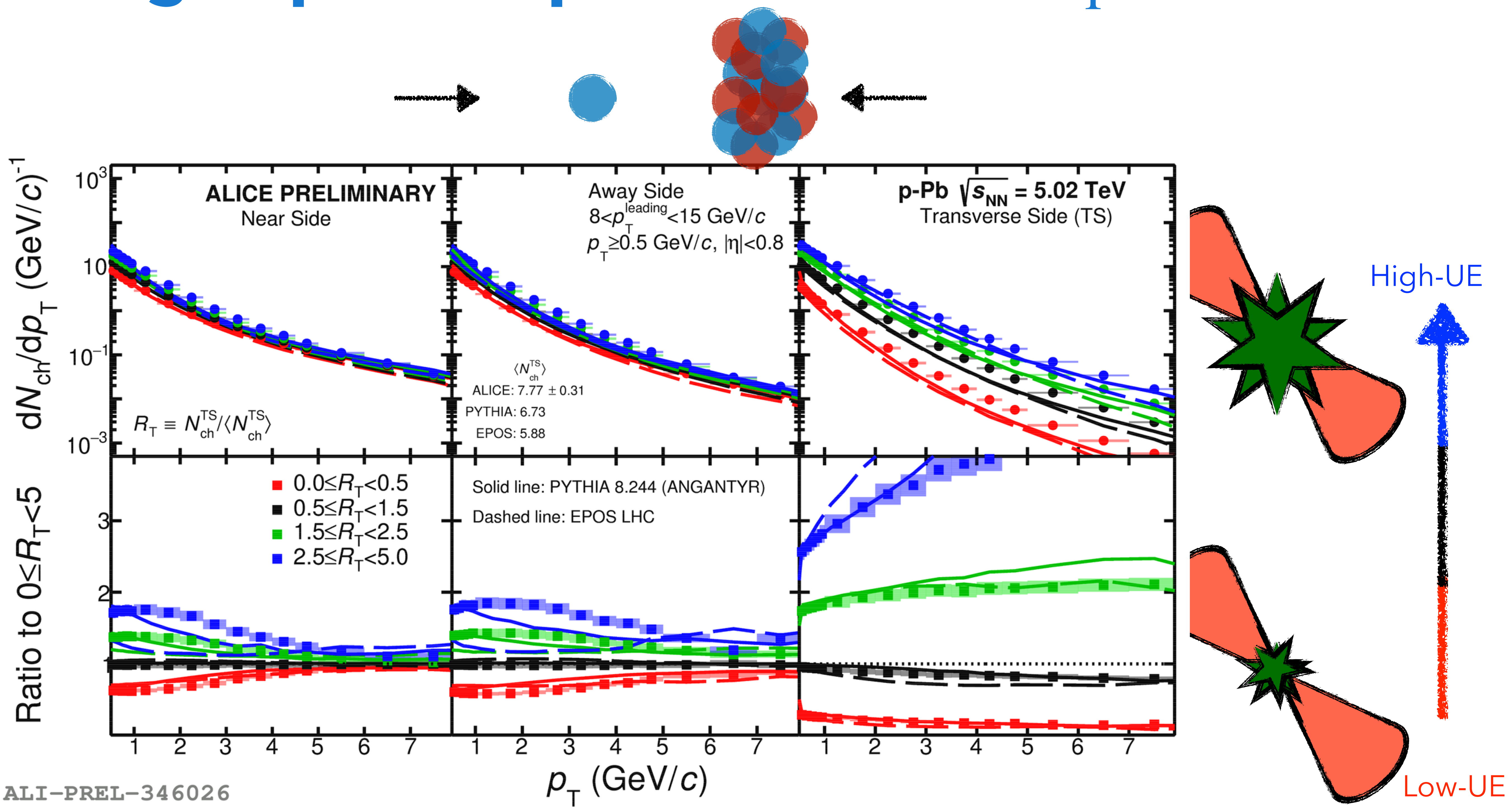
$$I_X = \frac{\left(\mathrm{d}N_{\mathrm{ch}}^{\mathrm{t,a}}/\mathrm{d}p_{\mathrm{T}} - \mathrm{d}N_{\mathrm{ch}}^{\mathrm{T}}/\mathrm{d}p_{\mathrm{T}}\right)|_X}{\left(\mathrm{d}N_{\mathrm{ch}}^{\mathrm{t,a}}/\mathrm{d}p_{\mathrm{T}} - \mathrm{d}N_{\mathrm{ch}}^{\mathrm{T}}/\mathrm{d}p_{\mathrm{T}}\right)|_{\mathrm{pp,MB}}}$$

X = pp, p-Pb, Pb-Pb

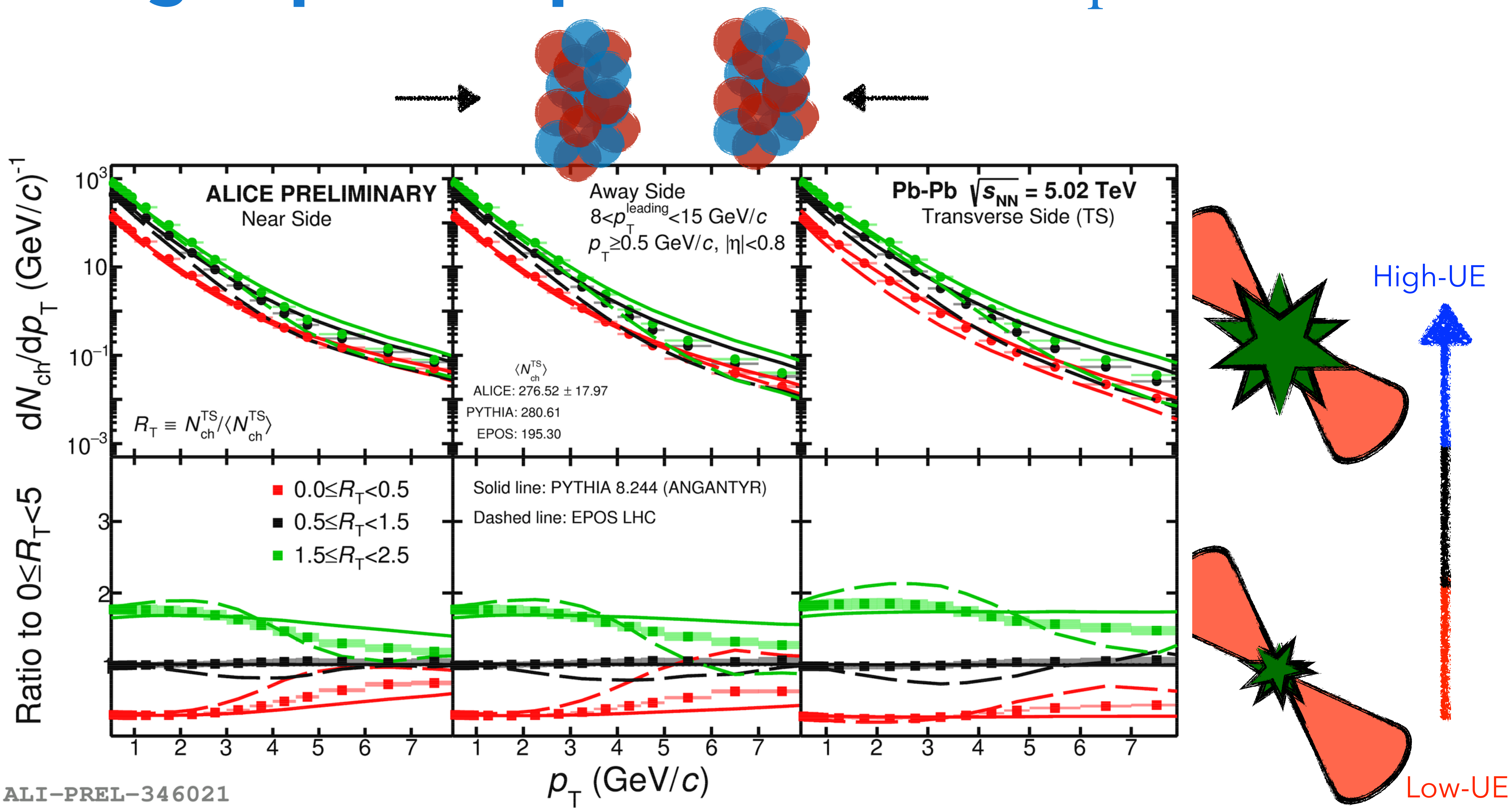
Charged particle production v.s. R_T



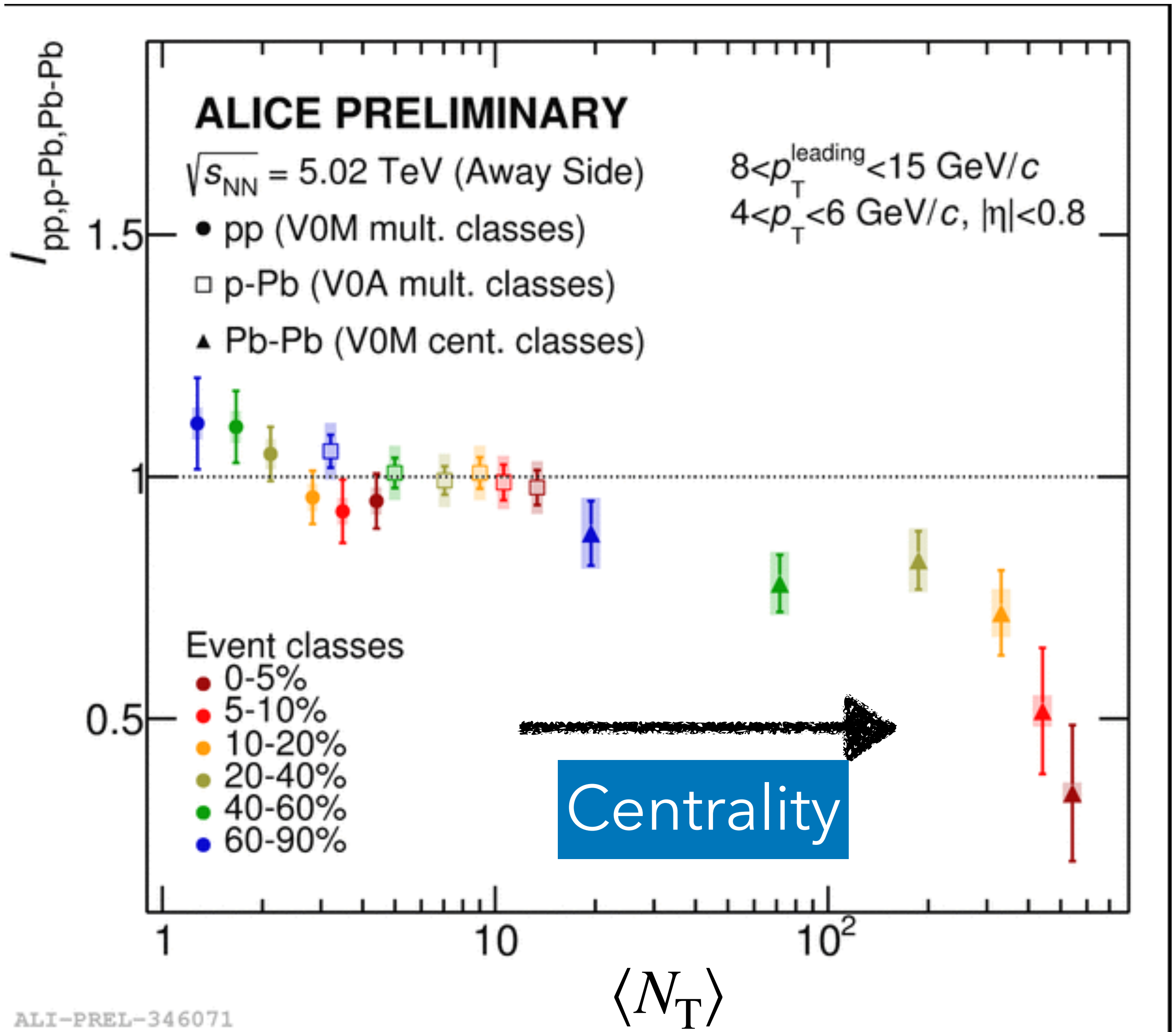
Charged particle production v.s. R_T



Charged particle production v.s. R_T

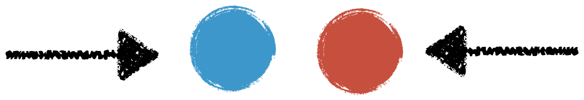


I_X as a function of $\langle N_T \rangle$ (away region)



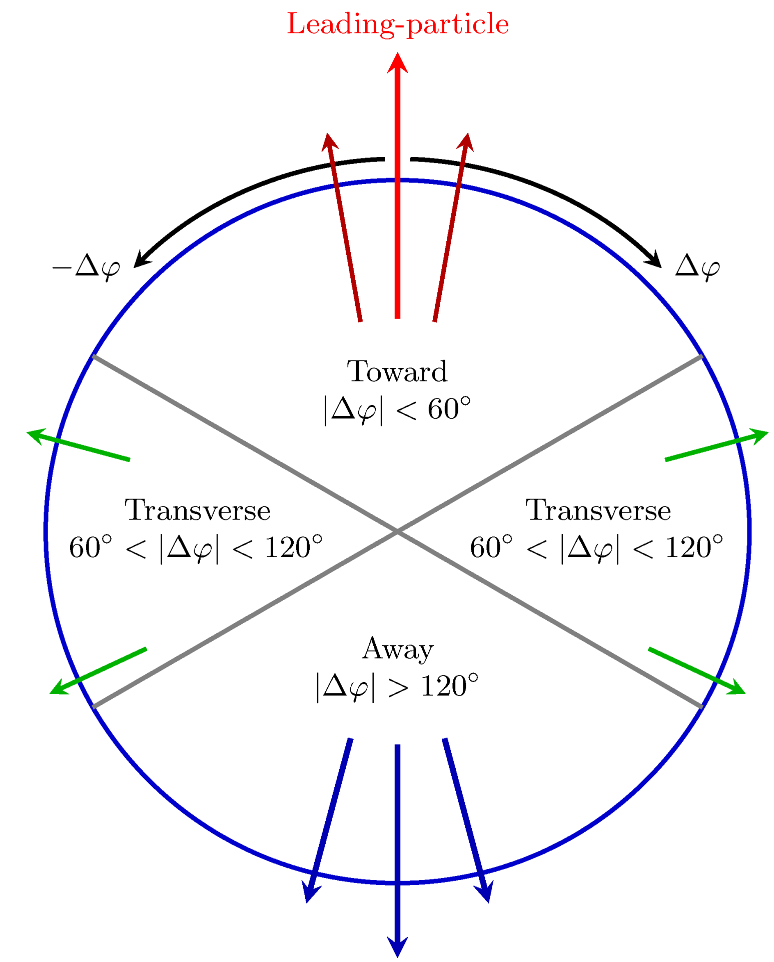
- Strong suppression of the yield with increasing centrality in Pb–Pb
  →medium effects: jet-quenching.
- Jet-like yields are consistent with unity in pp and p–Pb.
- No indication of jet-like modifications in small systems.

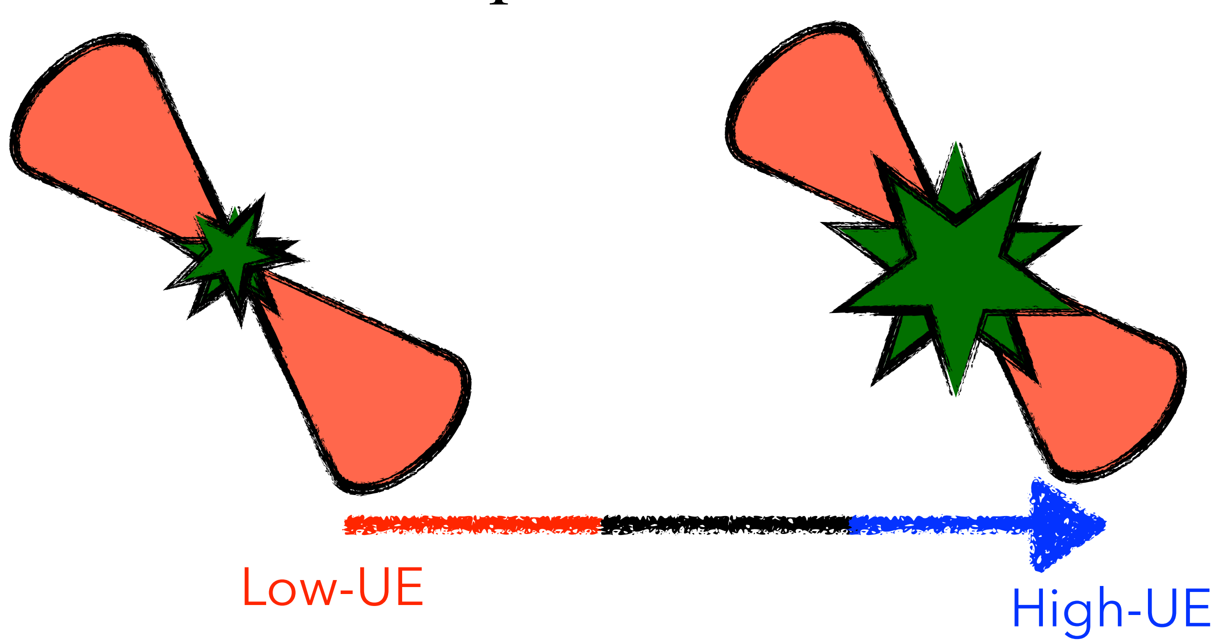
Identified particle production as a function of the event activity in pp @ 13 TeV

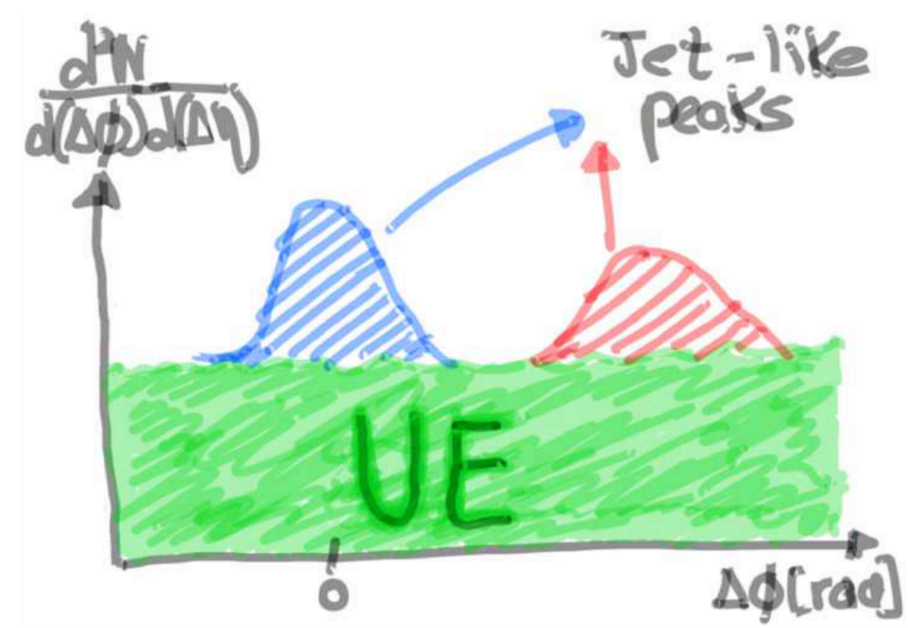


Analysis strategy

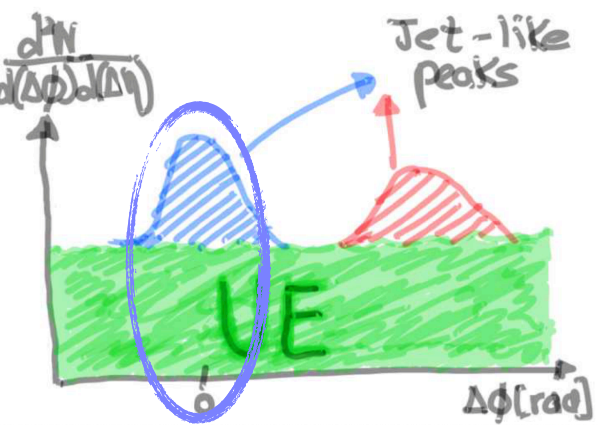
- Leading particle: $p_{\mathrm{T}}^{\mathrm{leading}}$, $5 - 40$ GeV/c, $|\eta| < 0.8$.
- The particle fractions are measured in each region at mid-rapidity.
- The particle ratios are reported as a function of R_{T}.

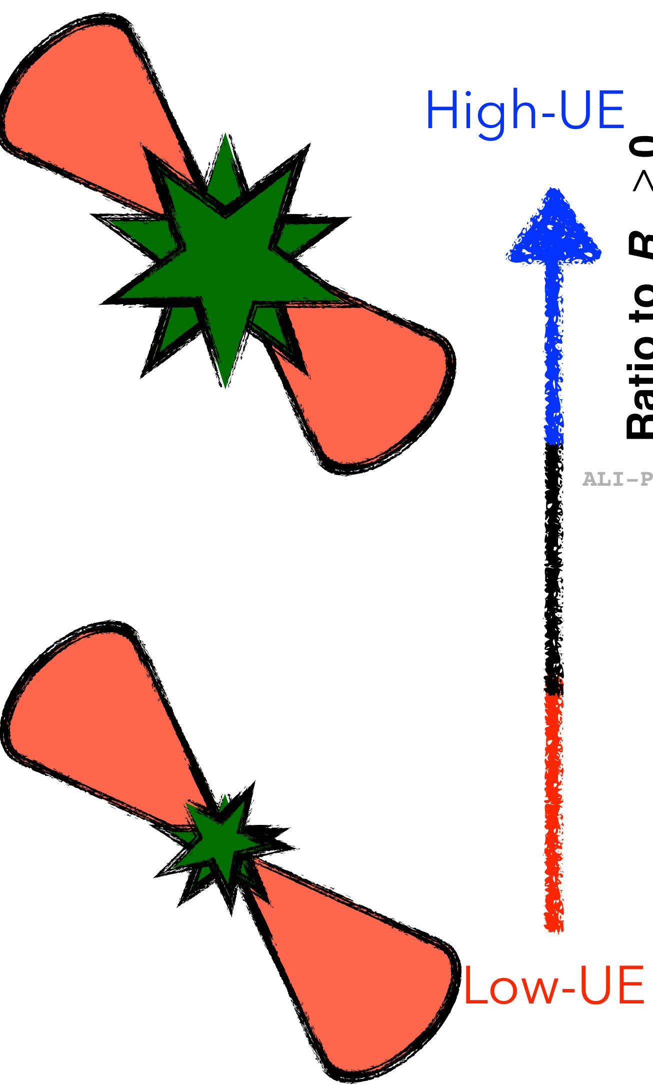


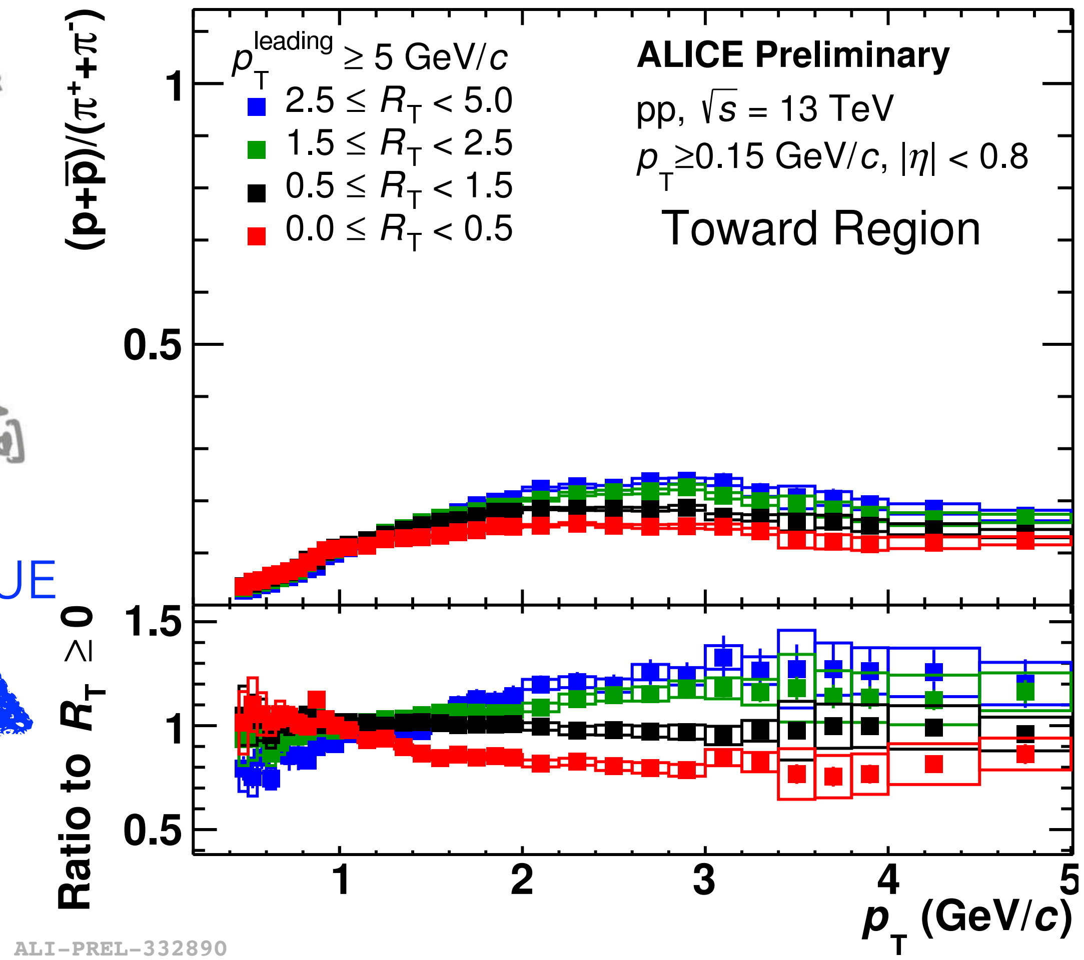


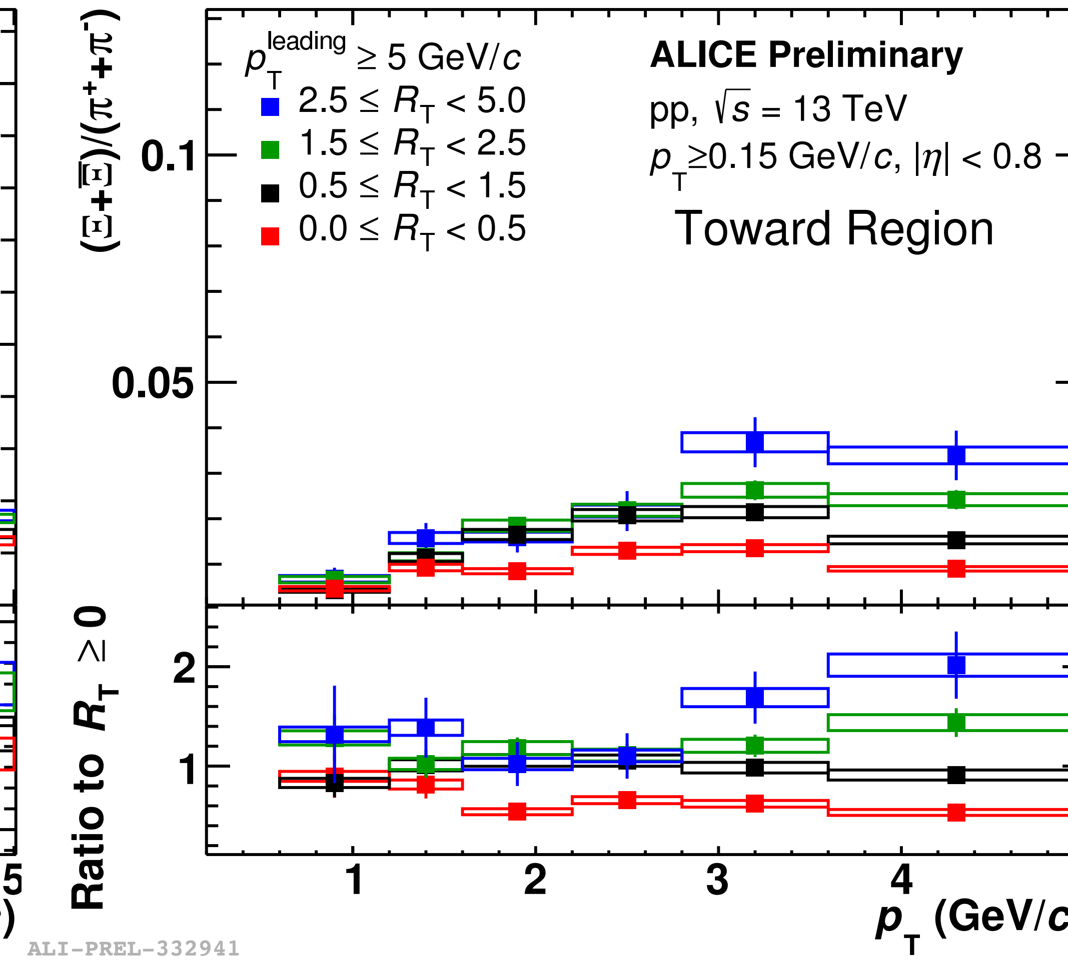


Particle ratios: Toward region



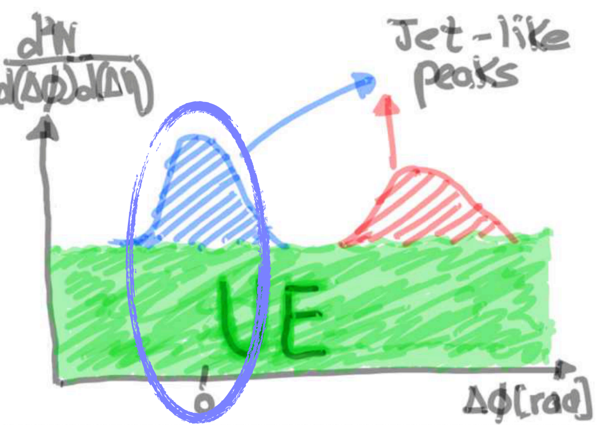


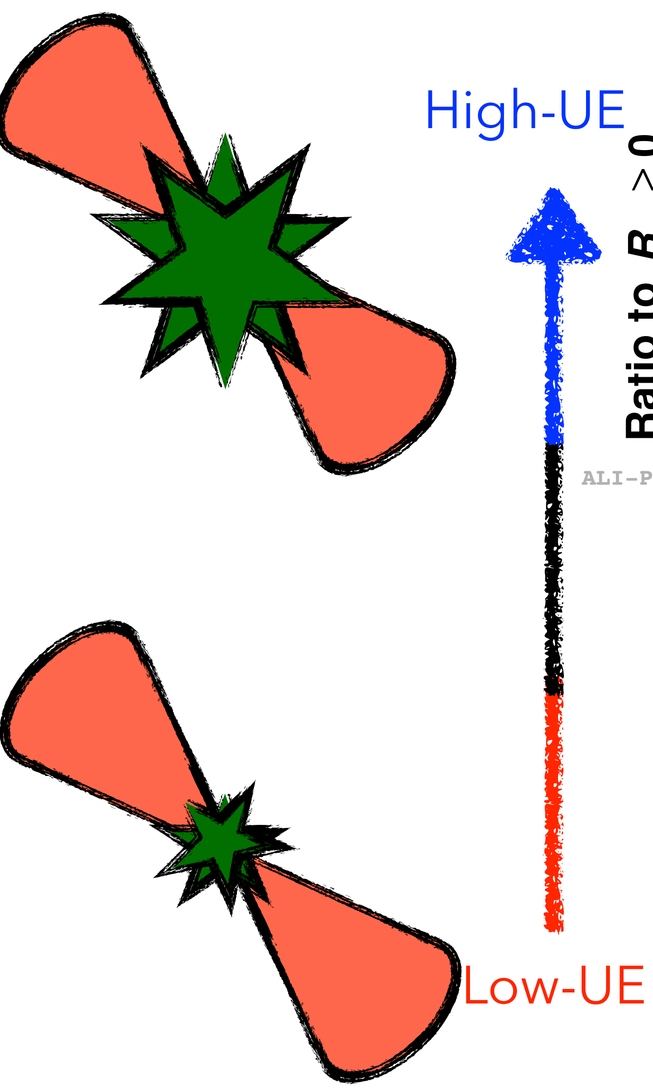


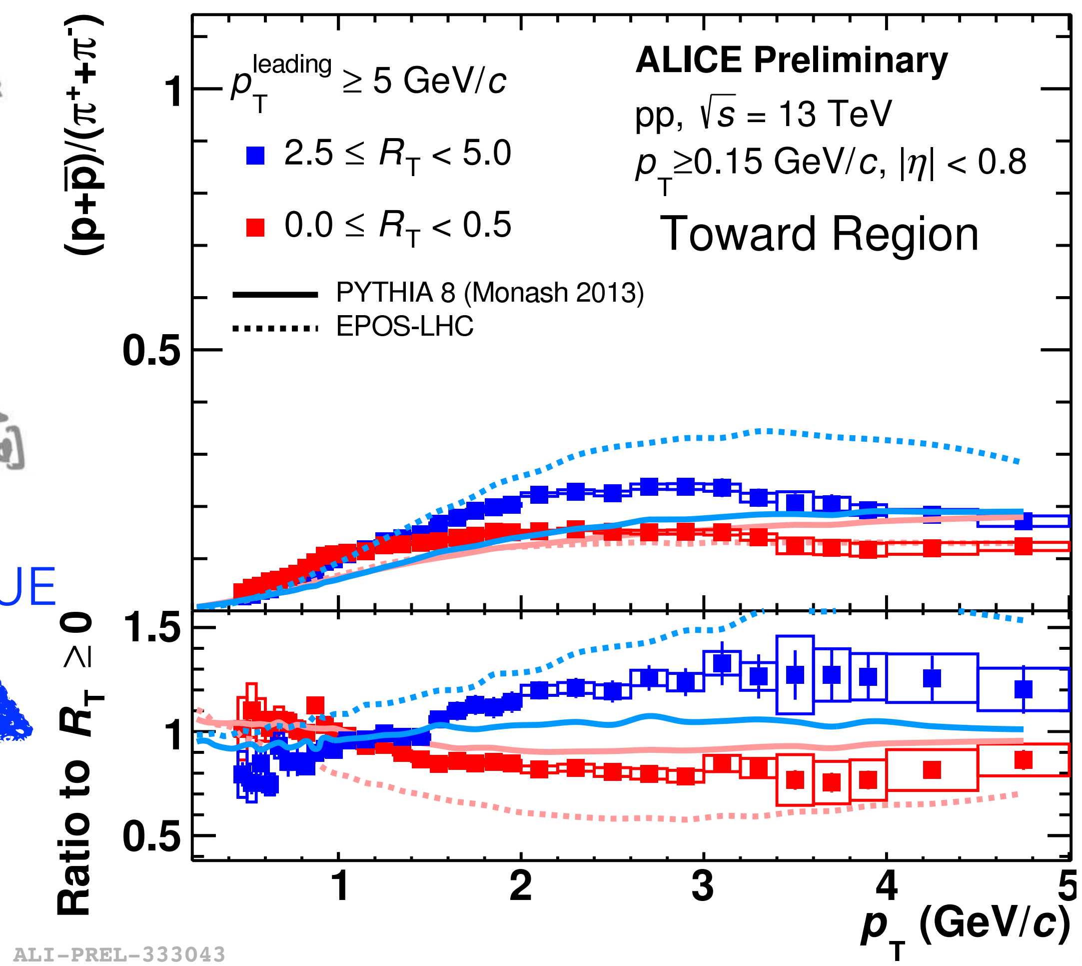


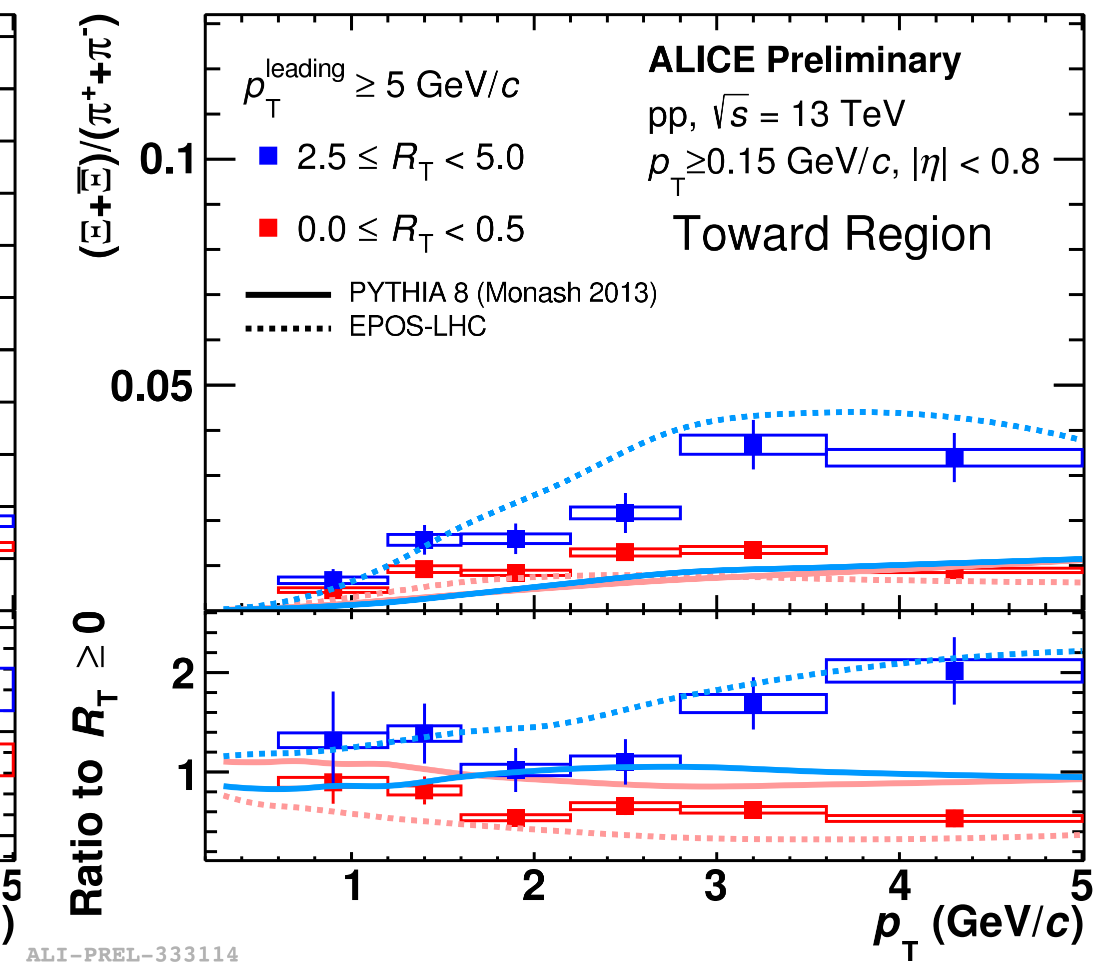
- Clear evolution of the p/π and Ξ/π ratios with R_T.
- The enhanced baryon-to-meson ratios can be attributed to radial flow effects.

Particle ratios: Toward region



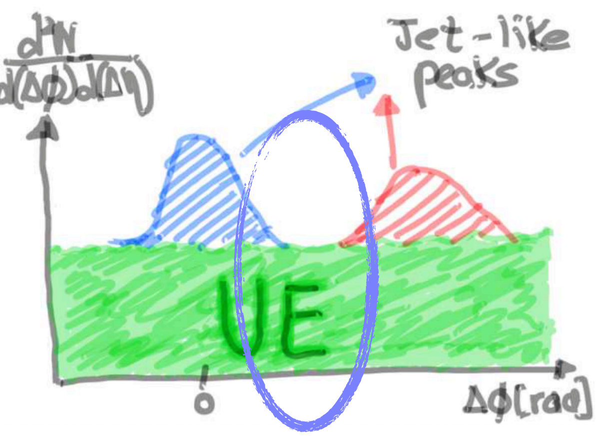


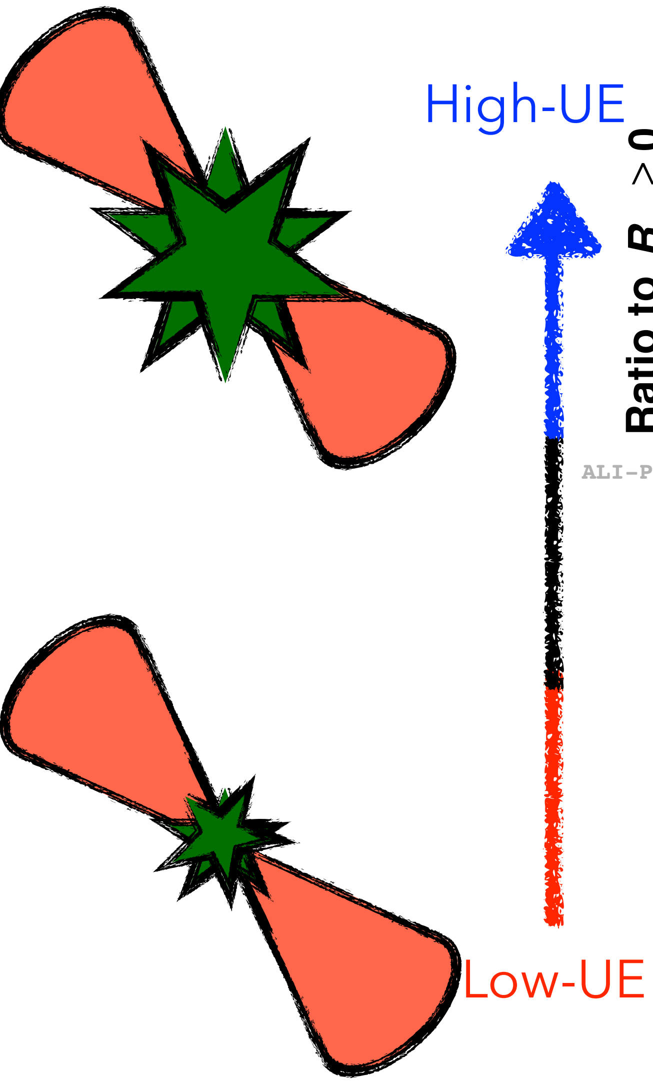


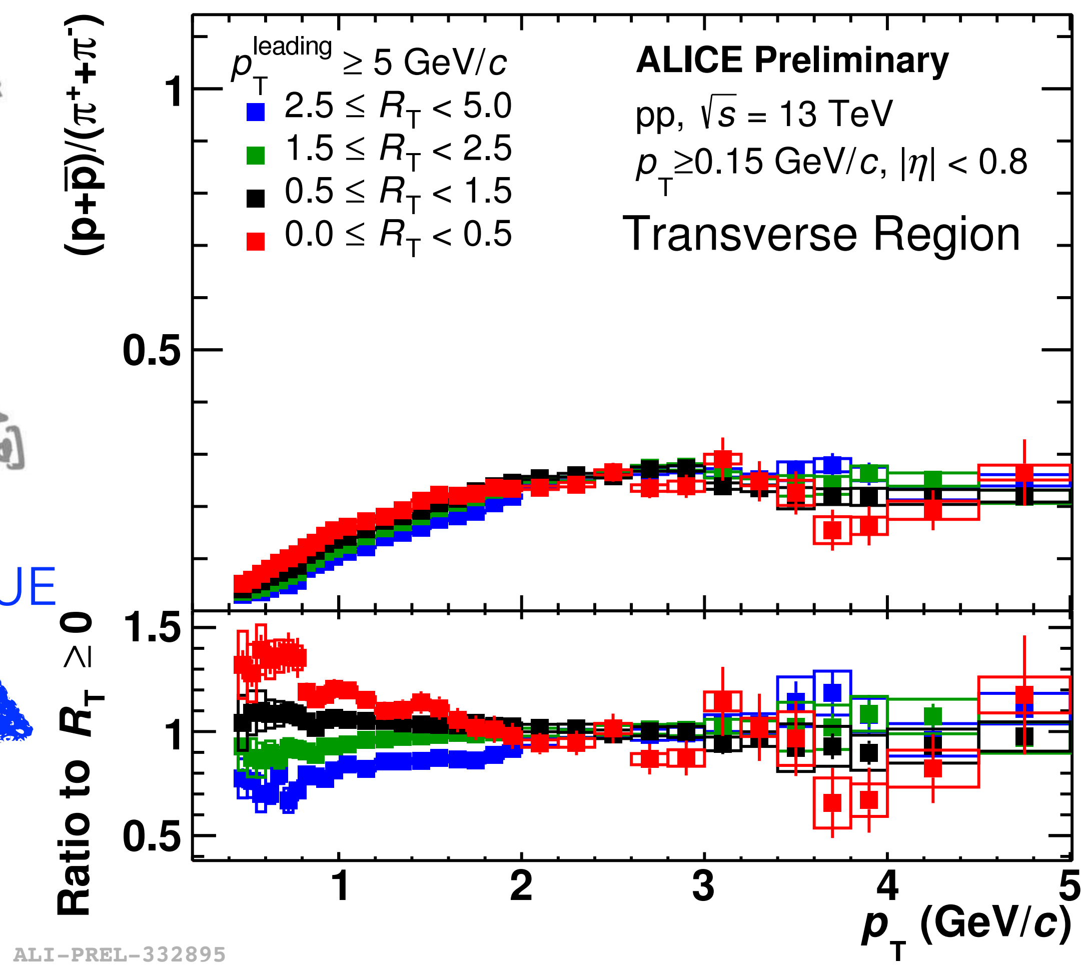


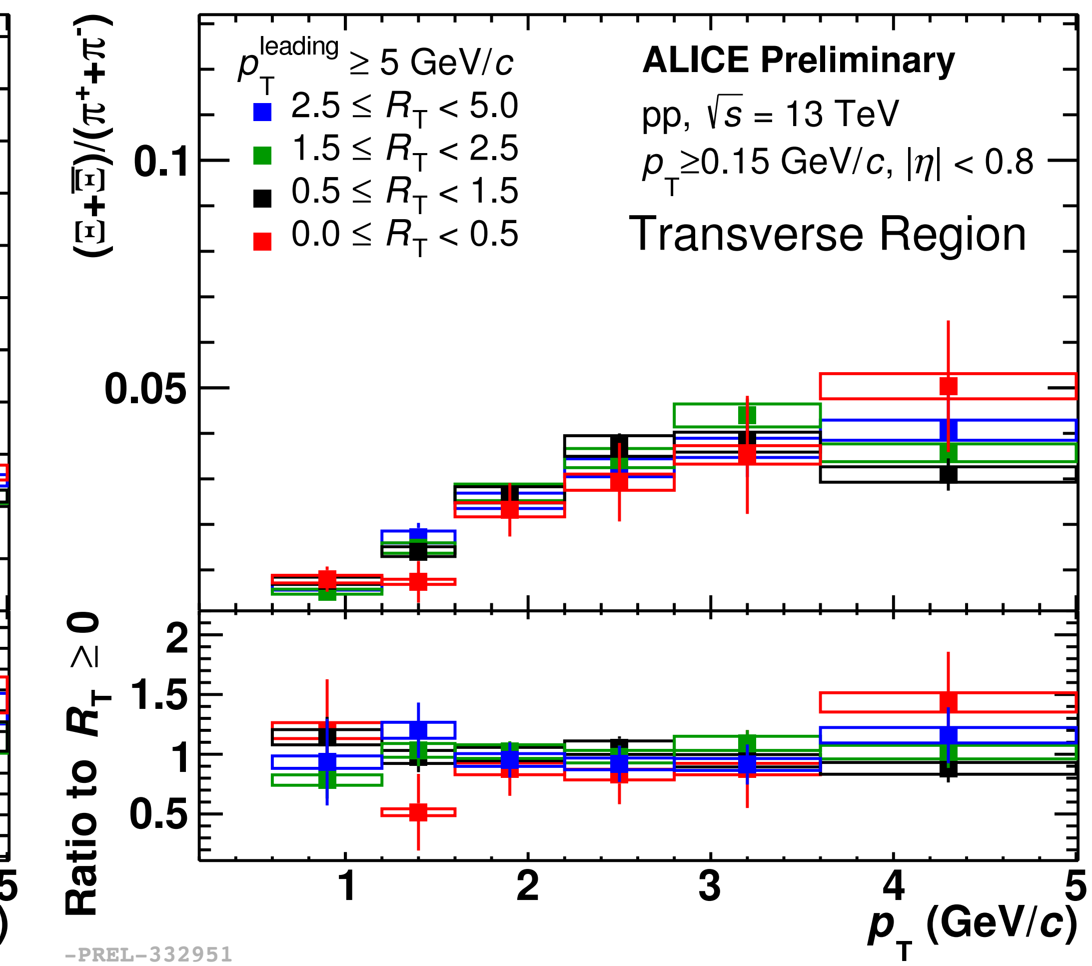
- PYTHIA and EPOS–LHC describe the low-UE events (expected since both models are tuned to e^+e^- data).
- It is clear what works in the models (hard processes) and what they fail at (UE).

Particle ratios: Transverse region



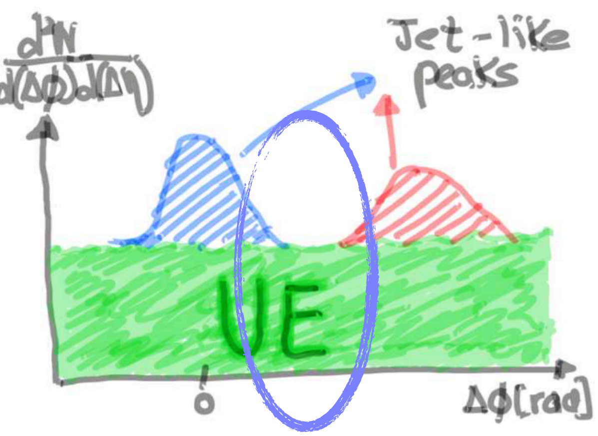


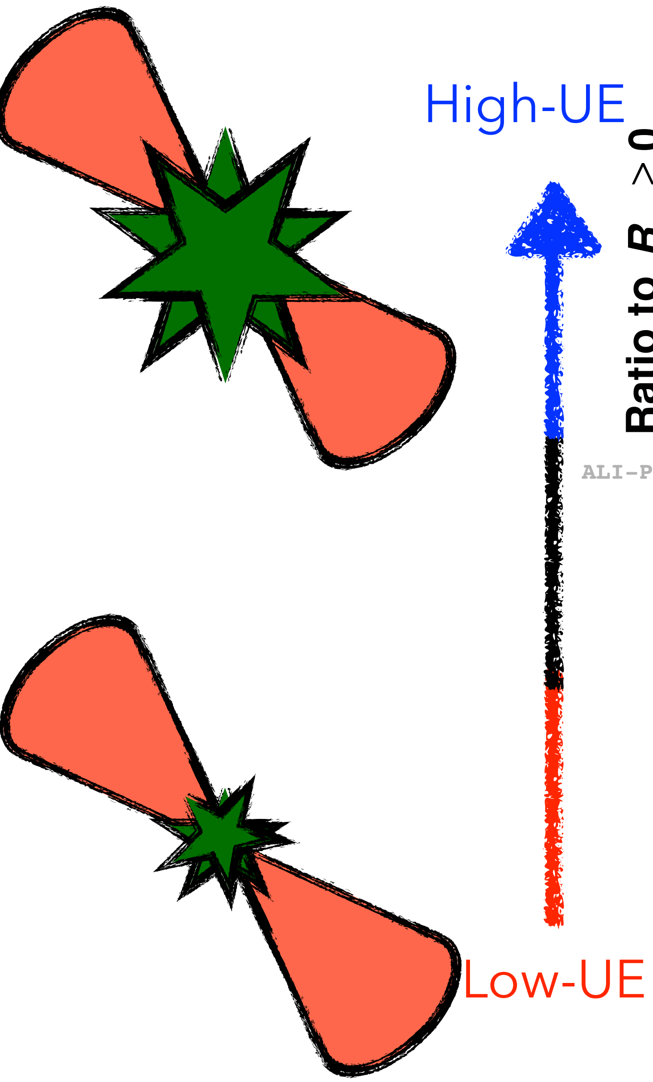


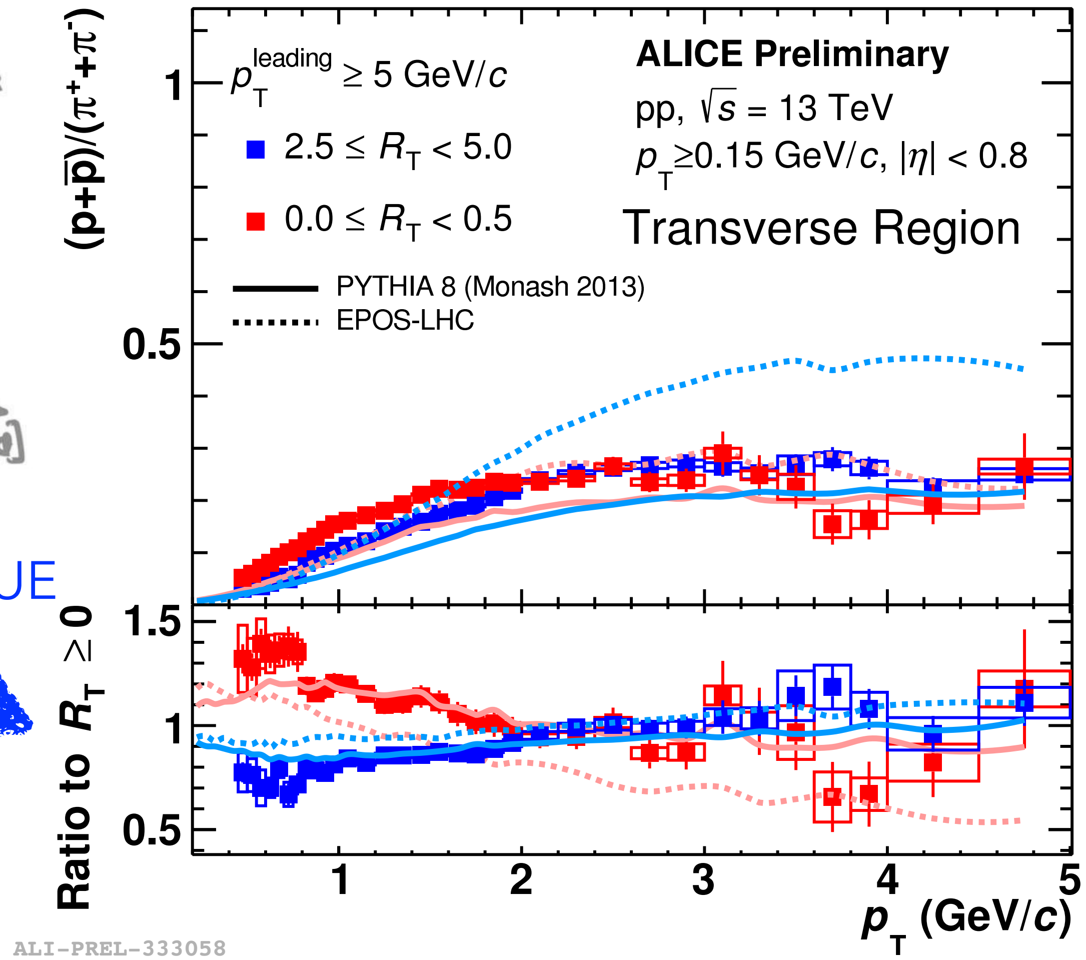


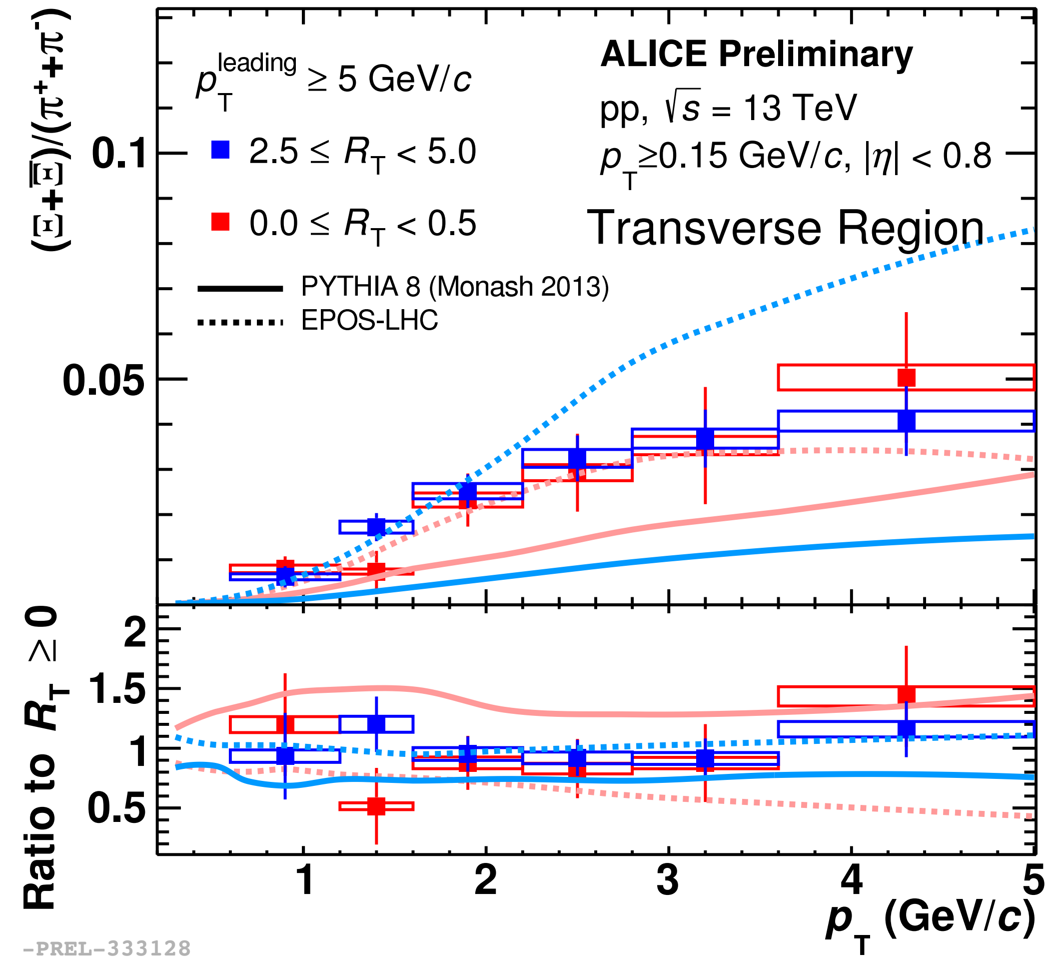
- The baryon-to-meson ratios have little dependence on R_T.
- Hint of suppression (enhancement) of the p/π ratio at low- (high)-p_T.

Particle ratios: Transverse region









- 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.

Conclusions

- The number density in the transverse region in pp and p–Pb collisions is independent of the scale of the hard probe for $p_{\mathrm{T}}^{\mathrm{leading}} \gtrsim 5\ \mathrm{GeV}/c$ (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 MPI-suppressed environments → PYTHIA and EPOS–LHC describe well these events.
- R_{T} allows to select events that exhibit signs of collective effects (radial flow).

Backup

I_X as a function of $\langle N_T \rangle$ (toward region)