Strangeness production (Λ, ϕ, K^0_S) in and out-of jets in pp and p–Pb collisions with ALICE at the LHC

Ryan Hannigan

The University of Texas at Austin
on behalf of the ALICE Collaboration

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TEXAS
The University of Texas at Austin

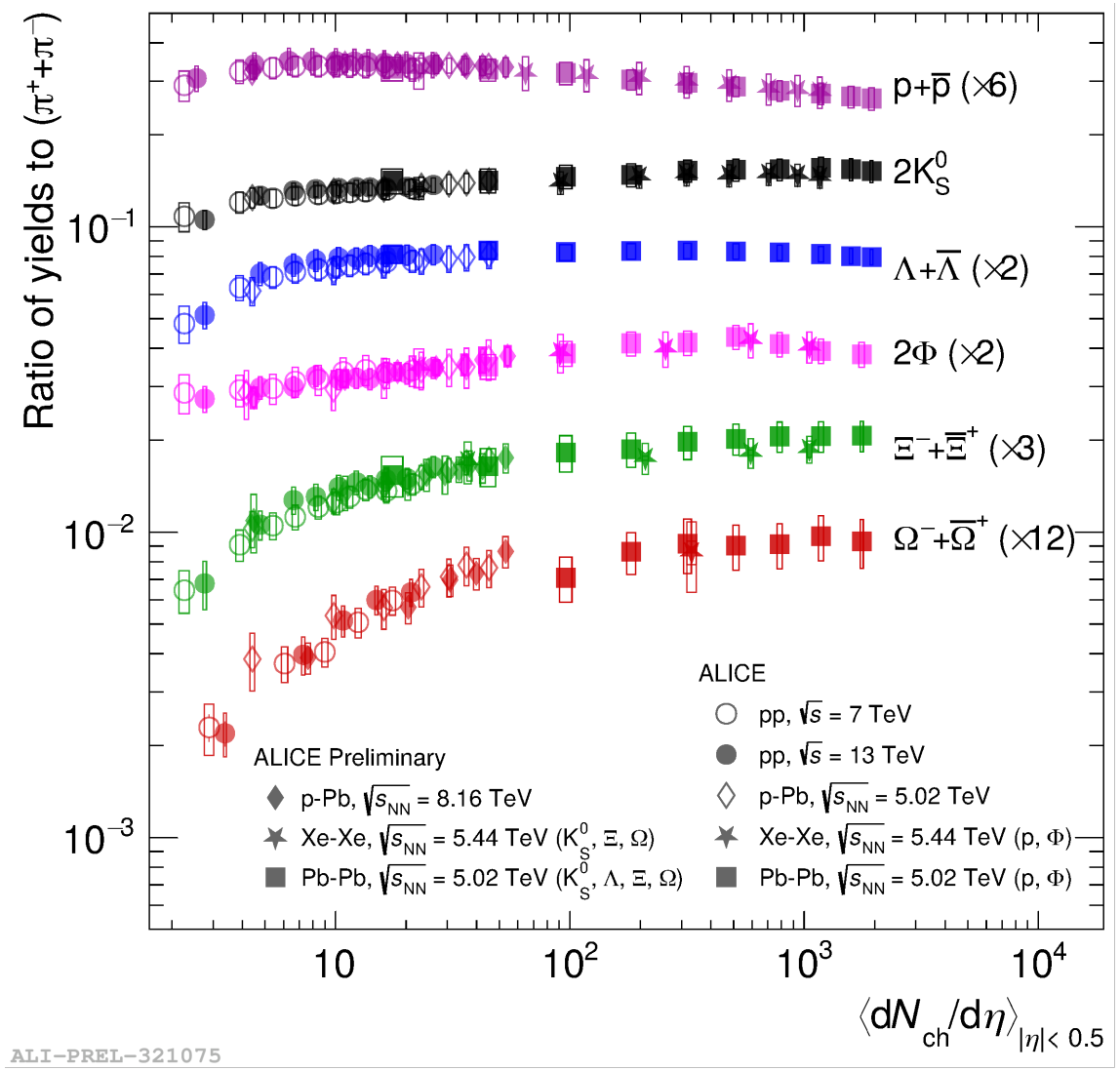
ALICE

CERN

Strangeness Enhancement

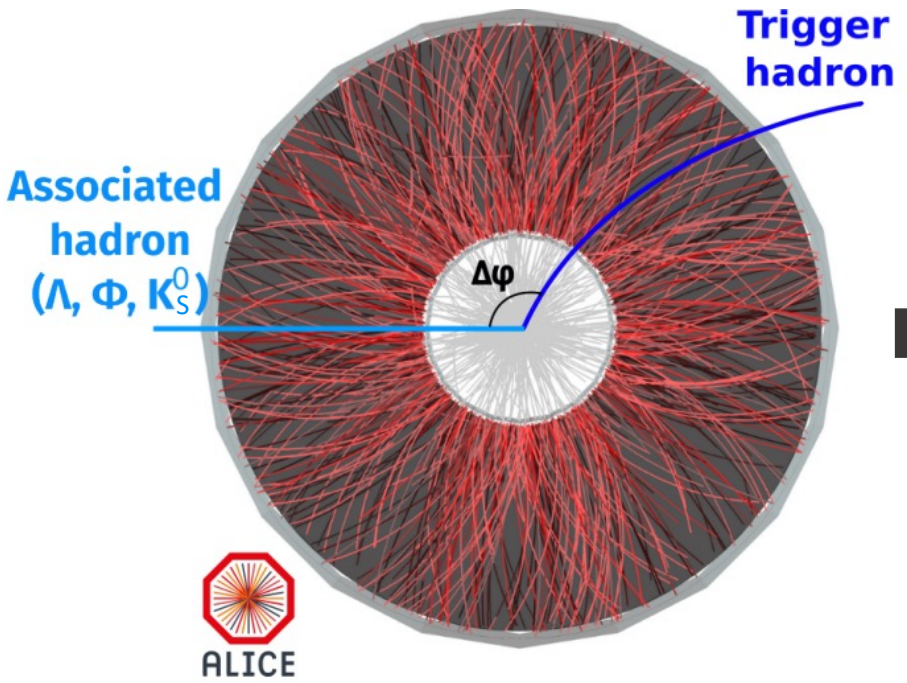
- Increase of strange/non-strange hadrons as a function of multiplicity
- K^0_S, Λ, and $\phi(1020)$ all undergo this enhancement
- Despite $|S| = 0$, the ϕ meson behaves like an open strange hadron

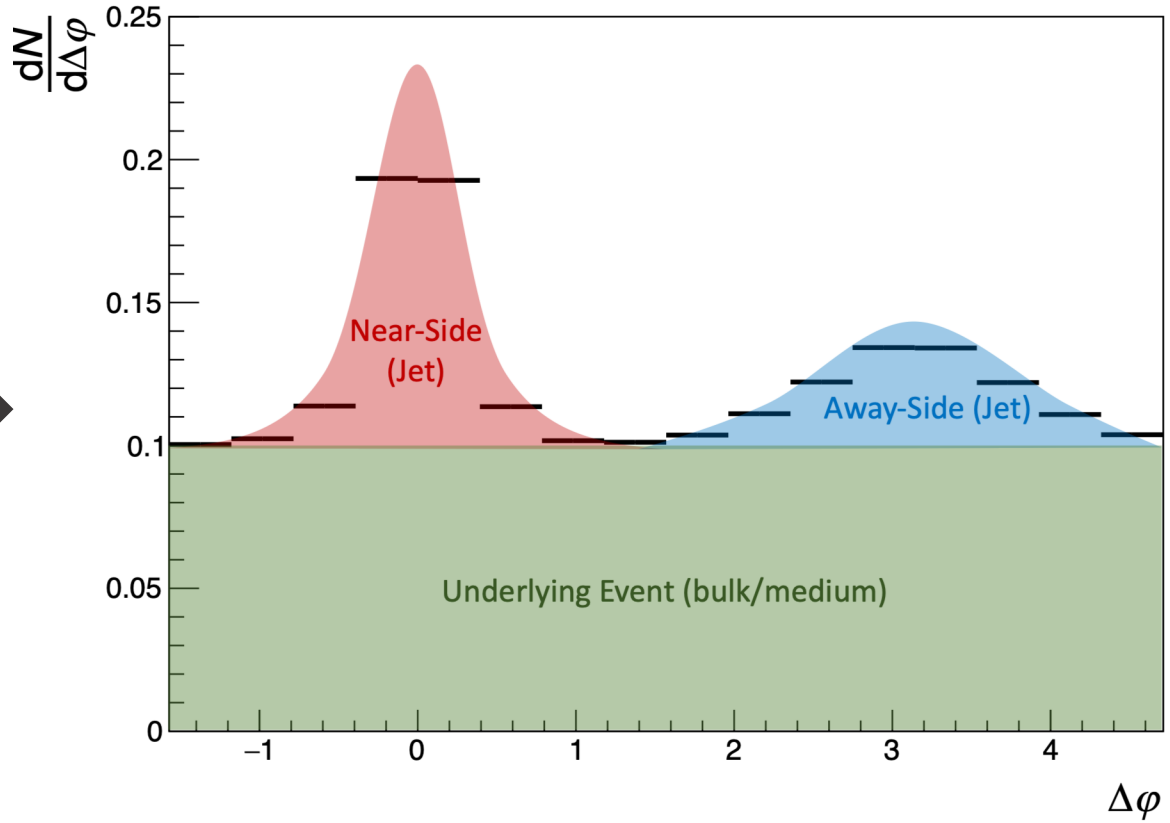
How much of this enhancement is coming from "jet"-like production?



Angular (Δφ) correlations with strange hadrons

Using Δφ correlations, separate pairwise yields into three kinematic regions:





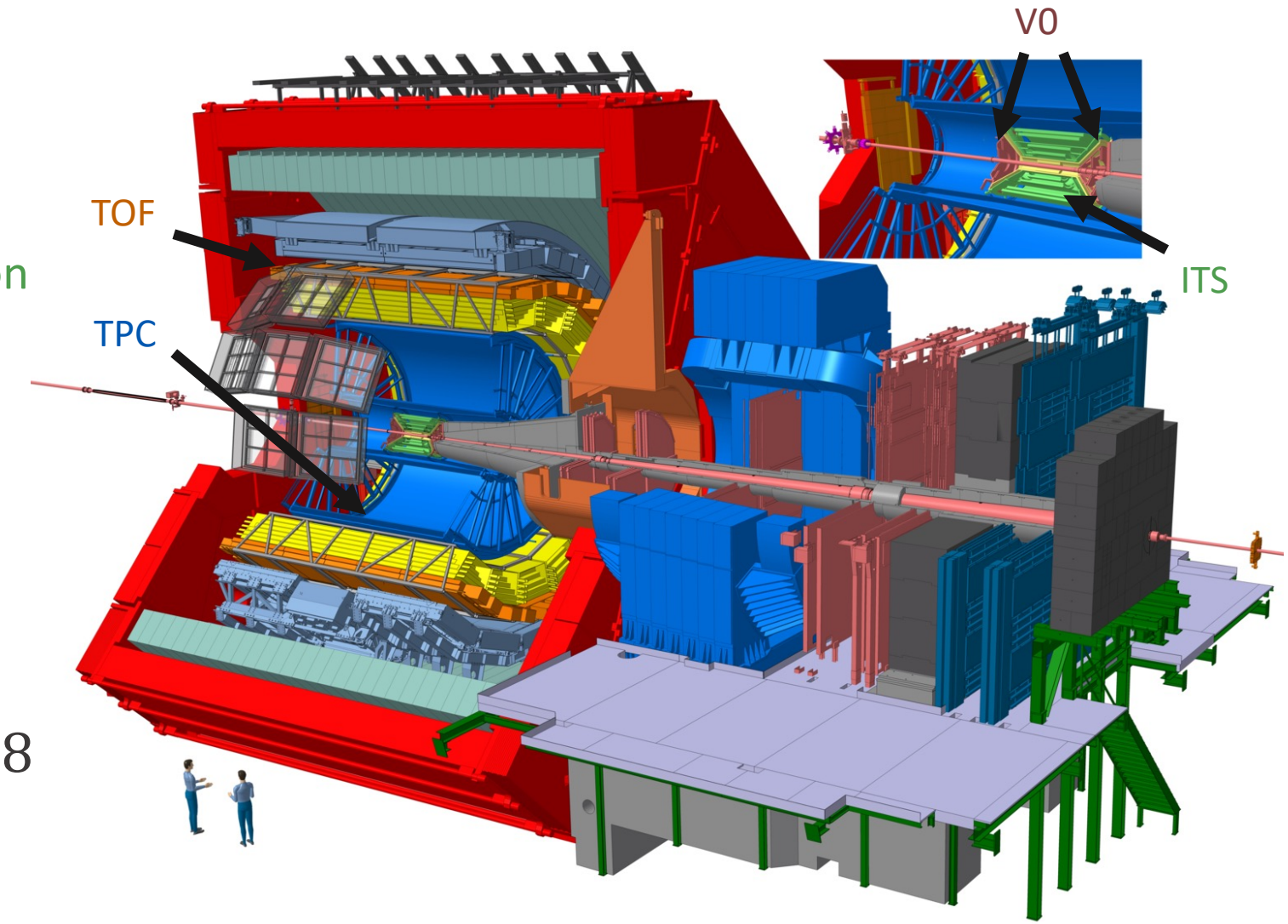
$$Y^{h-X}_{near} = \int_{-\pi/2}^{\pi/2} (\frac{dN}{d\Delta\varphi} - UE(\Delta\varphi)) d\Delta\varphi$$

$$Y^{h-X}_{UE} = \int_{-\pi/2}^{3\pi/2} UE(\Delta\varphi) d\Delta\varphi$$

How does the associated yield of Λ, ϕ, K^0_S in each of these regions depend on multiplicity in small systems?

The ALICE Detector

- 26m long, 16m high, and 16m wide
- Many subdetectors, most relevant for this analysis are:
  - ITS: Tracking, vertex reconstruction
  - TPC: Tracking, particle identification
  - TOF: Particle identification
  - V0: Multiplicity estimation in forwards (V0A) and backwards (V0C) directions
- All selected tracks have $|\eta| < 0.8$

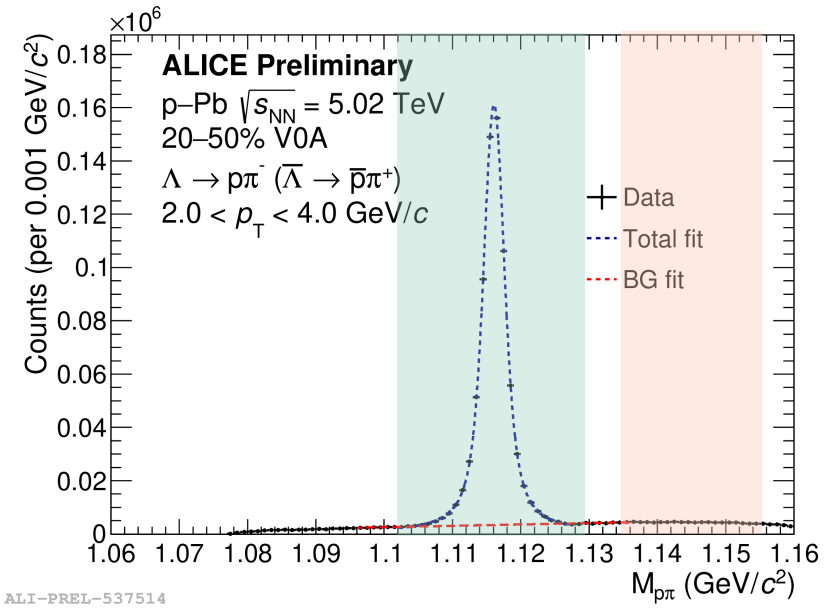


Λ, ϕ, and K^0_S reconstruction

Λ reconstructed via decay channel:

$$\Lambda \rightarrow p + \pi^-$$

BR ≈ 0.64



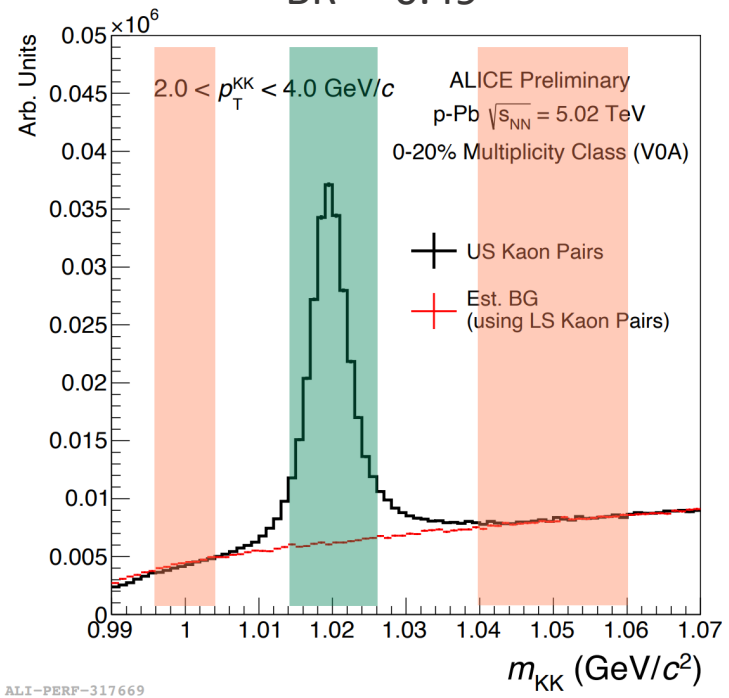
Signal region

Sideband region

ϕ reconstructed via decay channel:

$$\phi \rightarrow K^+ + K^-$$

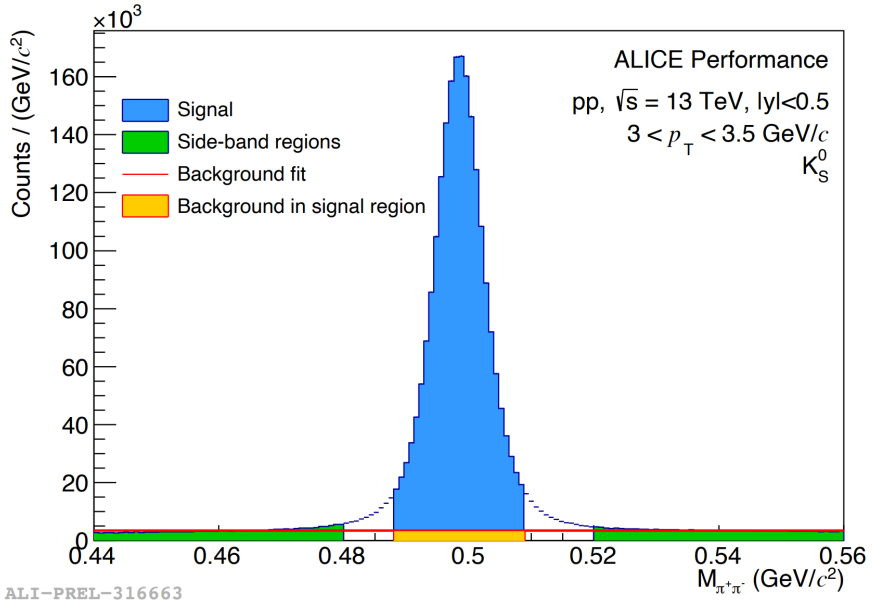
BR ≈ 0.49



K^0_S reconstructed via decay channel:

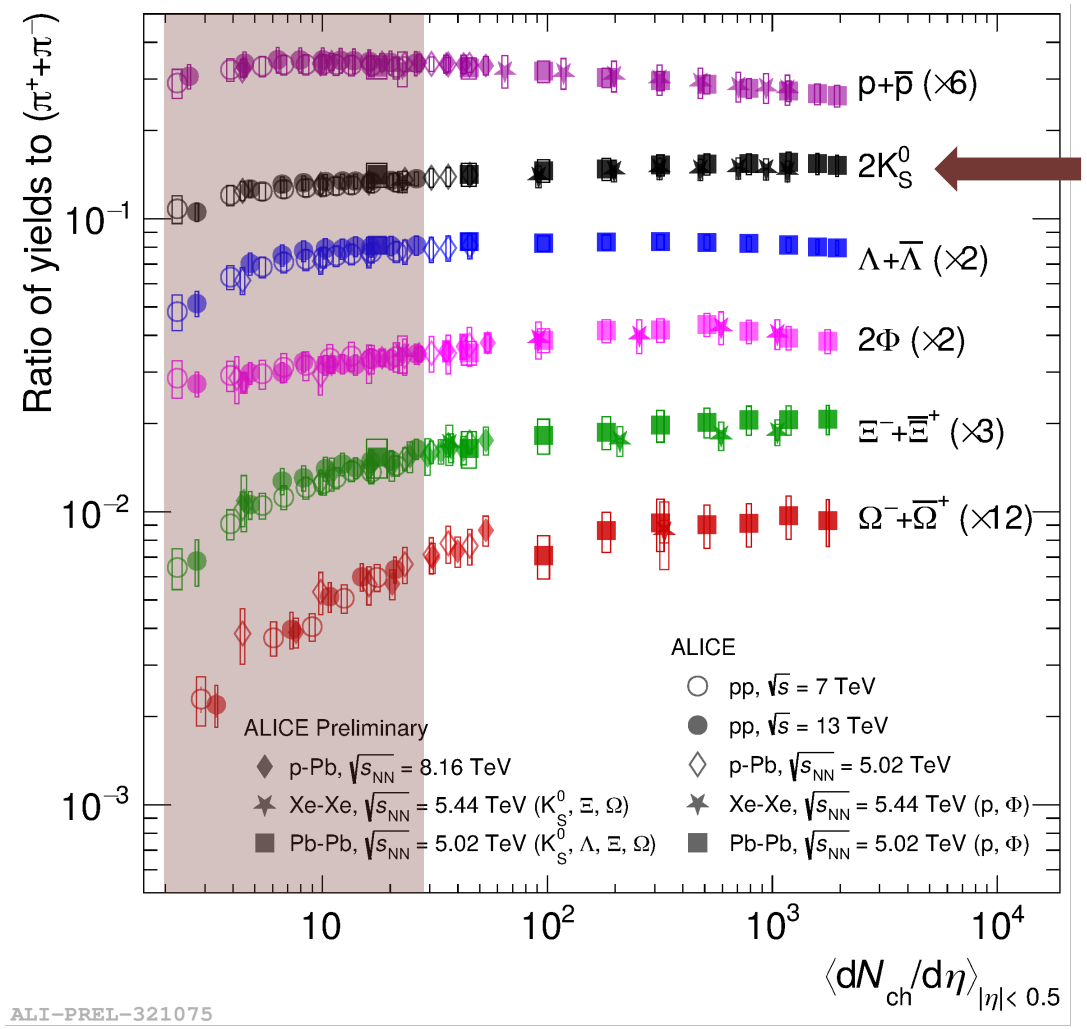
$$K^0_S \rightarrow \pi^+ + \pi^-$$

BR ≈ 0.69



Use correlation shape in sideband region to subtract off background in signal region!

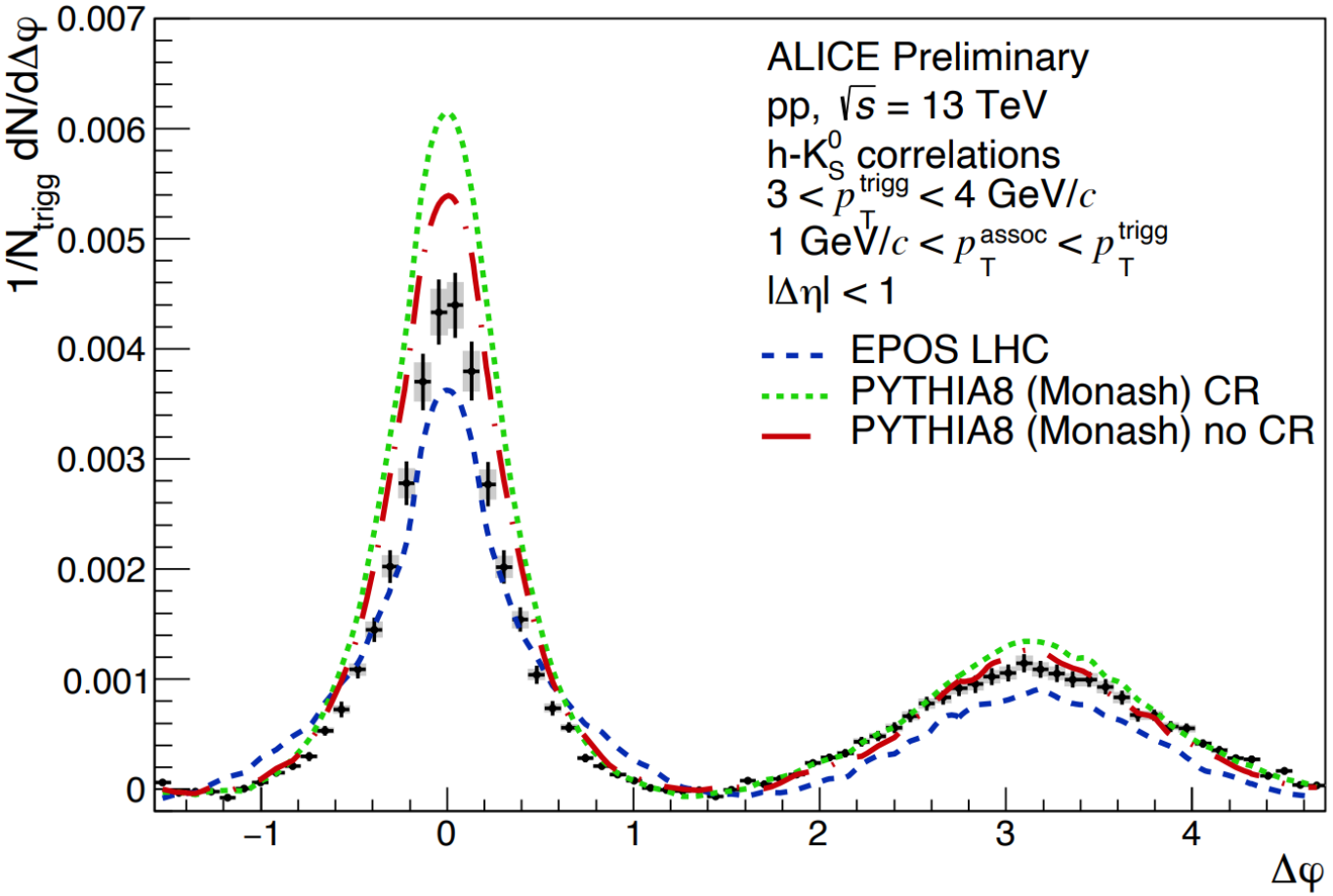
$\mathbf{h - K^0_S}$ and $\mathbf{h - h}$ correlations in pp collisions



$h - K^0_S$ $\Delta\varphi$ correlations

Collision system: pp, 13 TeV

$3 < p_T^{trigg} < 4$ GeV/c; $1 < p_T^{K^0_S} < p_T^{trigg}$ GeV/c

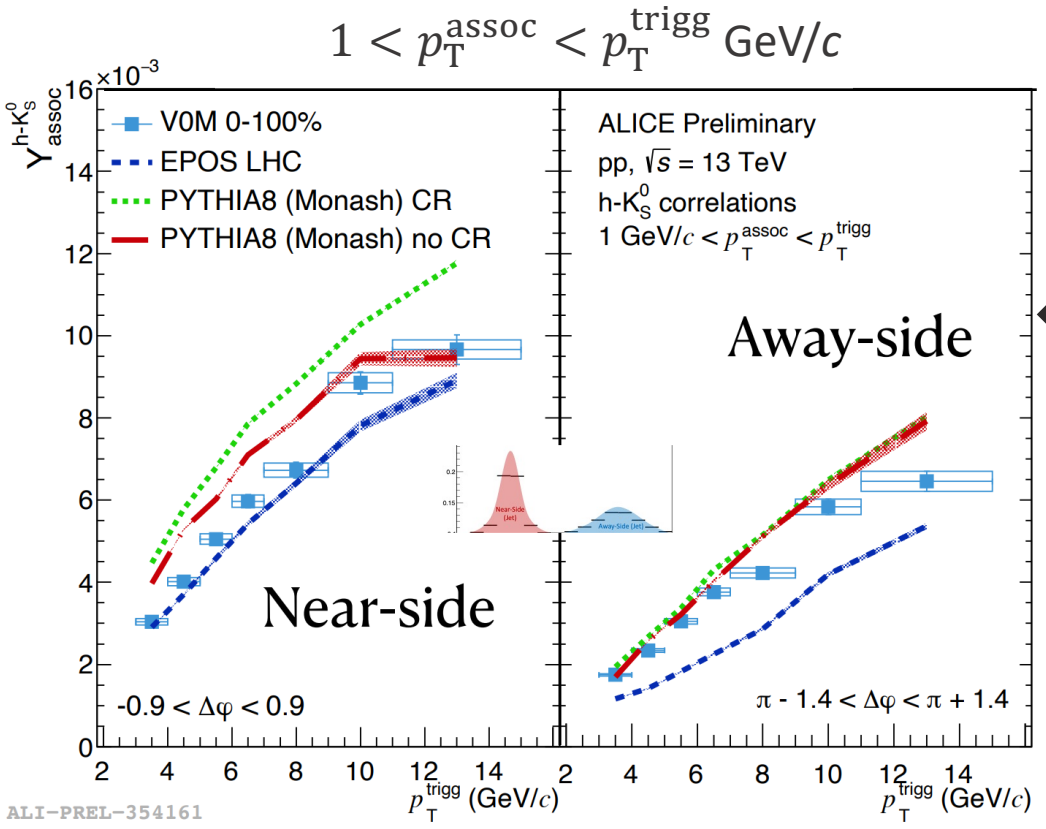


- No models are able to describe the overall shape of the correlation function
- PYTHIA8 overestimates jet-like peaks
- Disabling color reconnection (CR) moves PYTHIA8 closer to data
- EPOS underestimates jet-like peaks

What do the models say about the near and away-side yields?

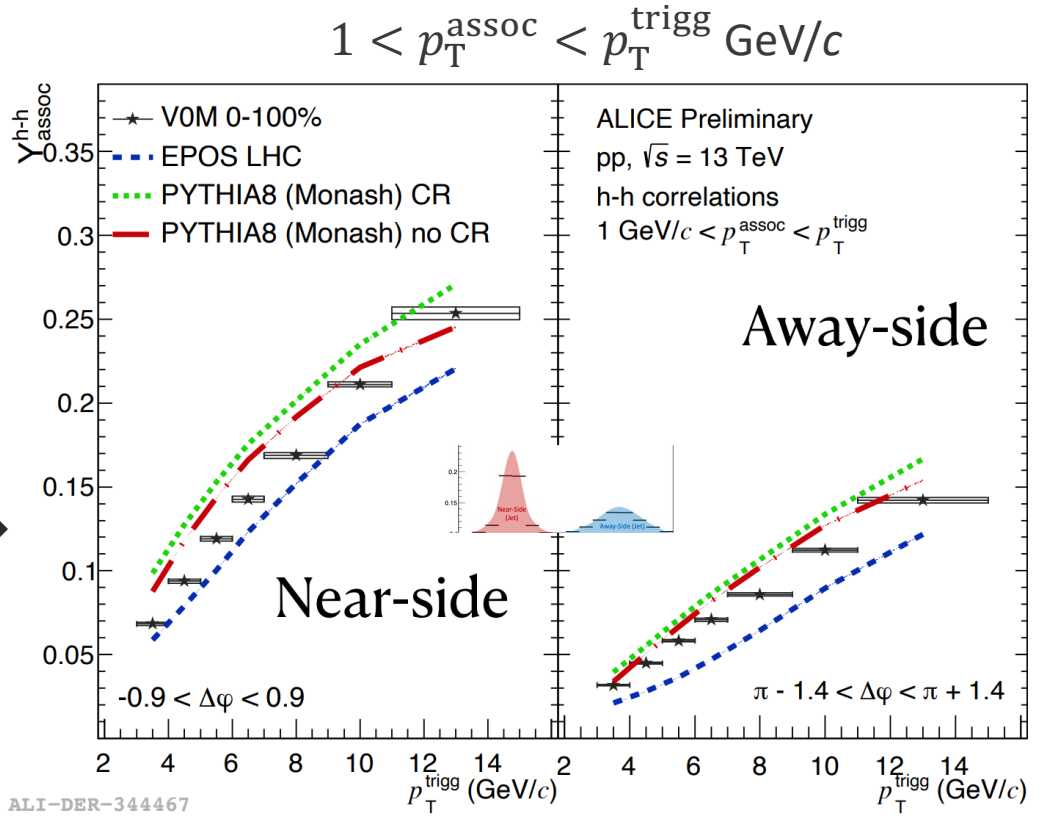
Per-trigger jet-like $h - K^0_S$, $h - h$ yields

Collision system: pp, 13 TeV



$h - K^0_S$

$h - h$

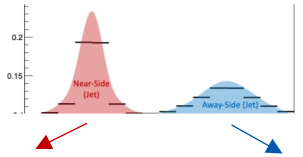


- The per-trigger near and away-side yields increase with p_T, with all models capturing this trend
- EPOS under-predicts the yields whereas both PYTHIA tunes over-predict the yields for both the $h - K^0_S$ and $h - h$

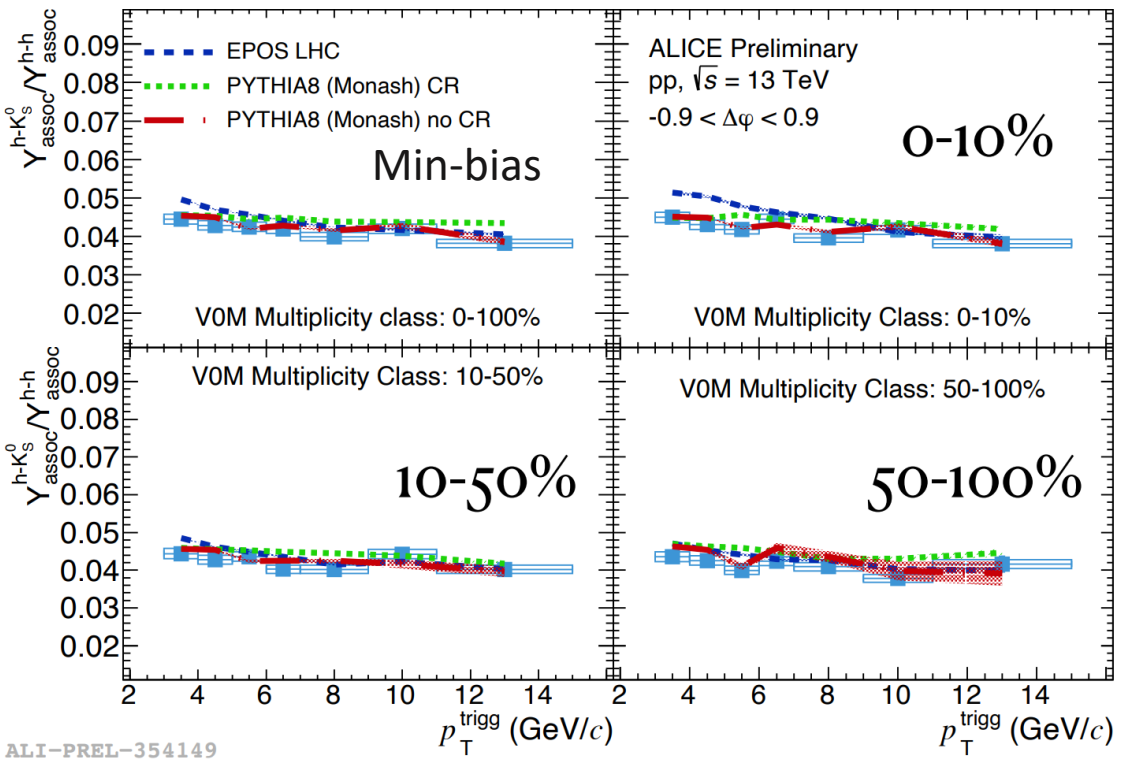
What about the $(h - K^0_S)/(h - h)$ yield ratios?

$(h - K^0_S)/(h - h)$ yield ratios vs. multiplicity

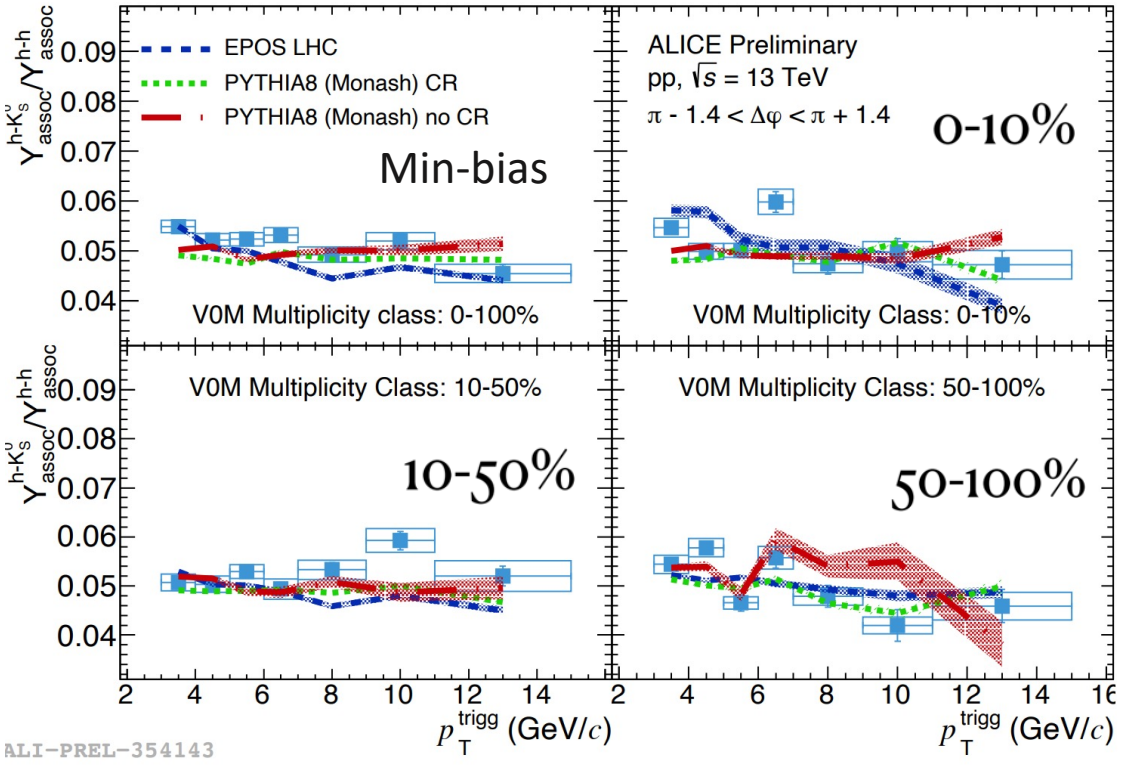
Collision system: pp, 13 TeV



Near-side yield ratios



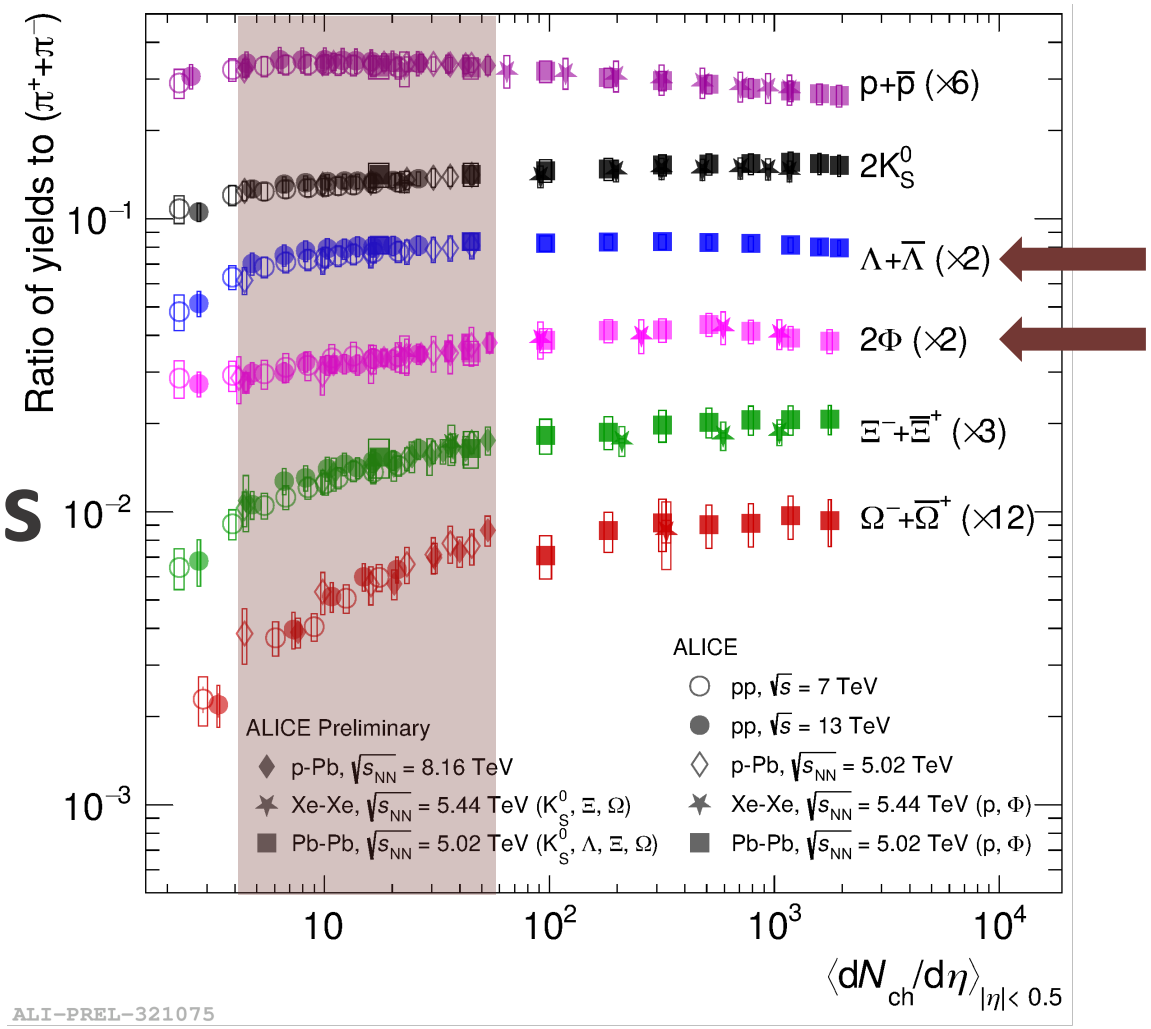
Away-side yield ratios



- Models appear to describe the near and away-side ratios
- **No observable multiplicity dependence** for both the near and away-side ratios

What about p–Pb with different strange hadrons?

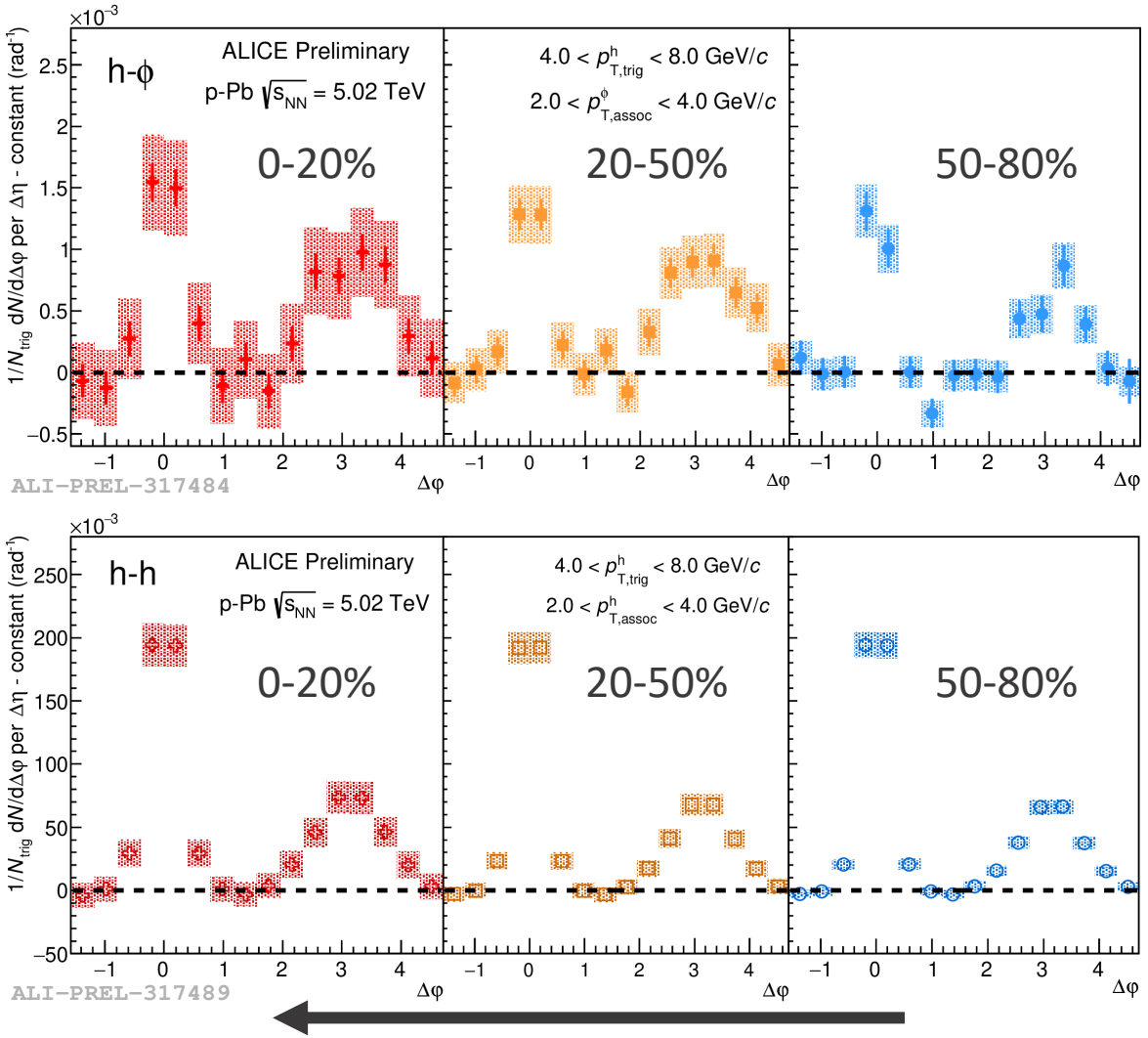
$h - \phi, \Lambda$ and $h - h$ correlations in p–Pb collisions



$h - \phi$ and $h - h$ $\Delta\varphi$ correlations

Collision system: p–Pb, 5 TeV

$4 < p_{\mathrm{T}}^{\mathrm{trigg}} < 8$ GeV/c; $2 < p_{\mathrm{T}}^{\mathrm{assoc}} < 4$ GeV/c



Increasing multiplicity

$h - \phi$

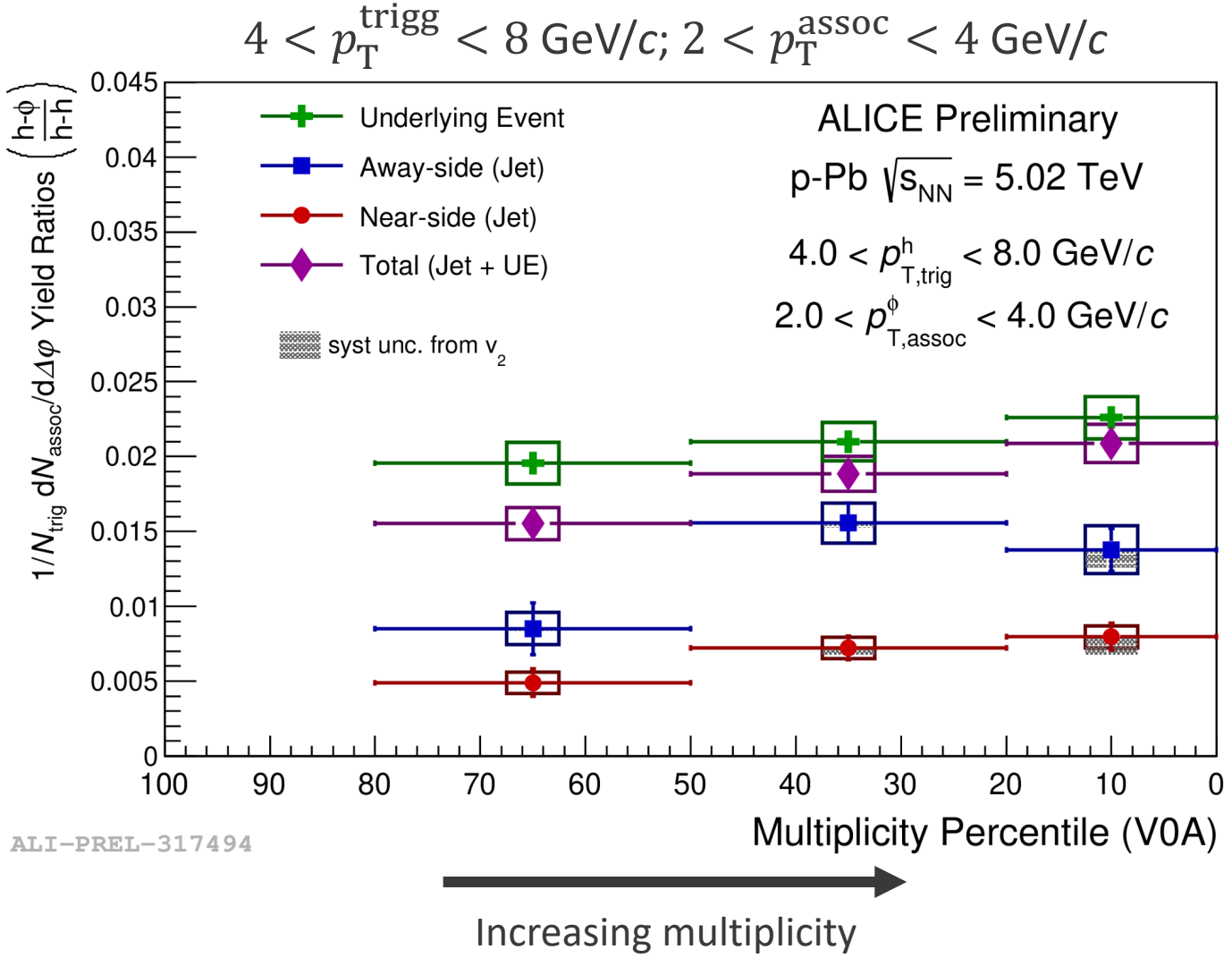
- Underlying event has been subtracted from correlation
- Correlation shape shows **little-to-no dependence on multiplicity** for both the $h - \phi$ and $h - h$ cases

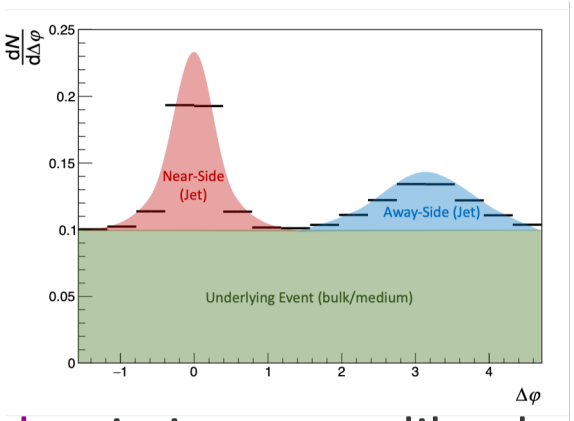
$h - h$

What about the $(h - \phi)/(h - h)$ yield ratios?

(h − ϕ)/(h − h) yield ratios vs. multiplicity

Collision system: p–Pb, 5 TeV





- The total ratio increases like the ϕ/π ratio shown on Slide 2
- Underlying event ratio is systematically higher for all multiplicity bins
- Jet-like production is lower than both the total and UE, with the away-side > near-side for all multiplicity bins
- Near and away-side ratios **clearly increase with multiplicity** (unlike K_S^0 in pp)

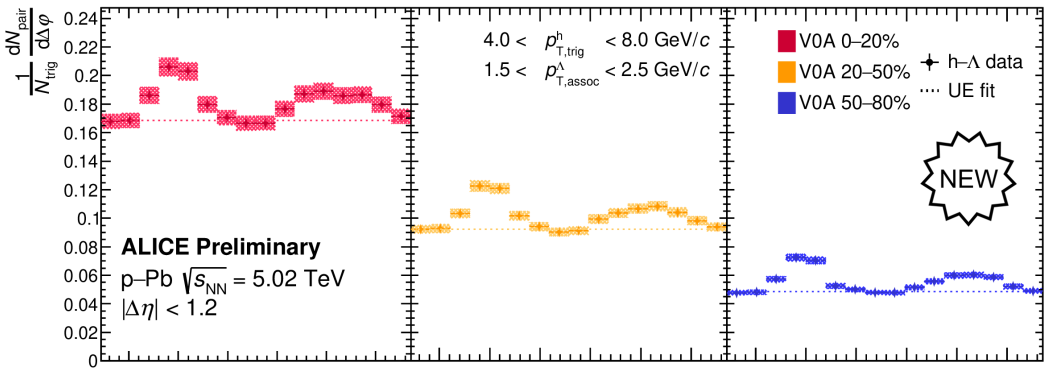
$h - \Lambda$ and $h - h$ $\Delta\varphi$ correlations

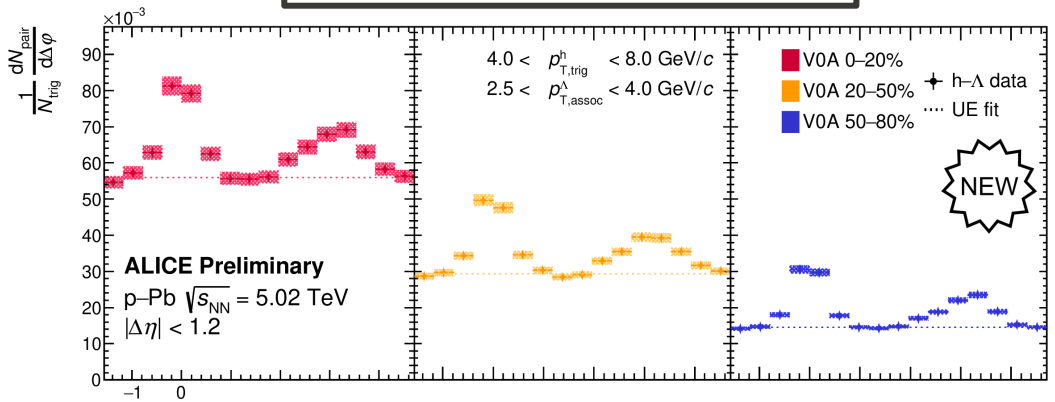
Collision system: p–Pb, 5 TeV

$4 < p_{\mathrm{T}}^{\mathrm{trigg}} < 8$ GeV/c

$1.5 < p_{\mathrm{T}}^{\mathrm{assoc}} < 2.5$ GeV/c

$2.5 < p_{\mathrm{T}}^{\mathrm{assoc}} < 4.0$ GeV/c

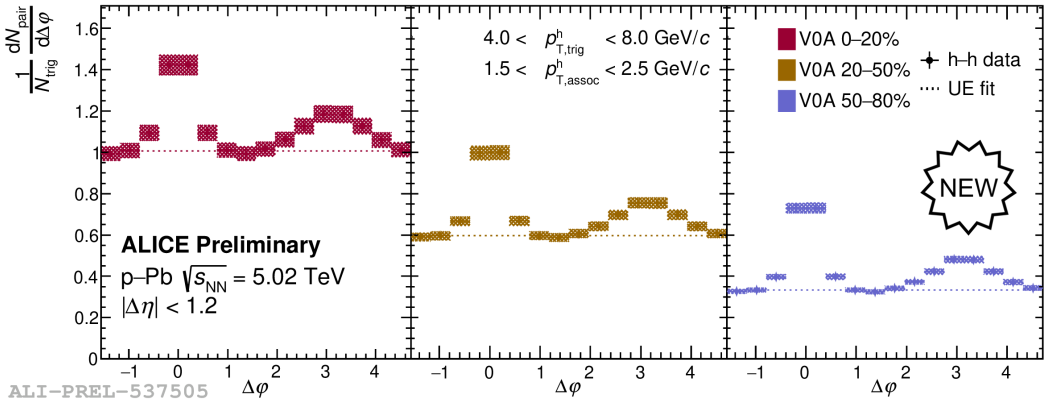


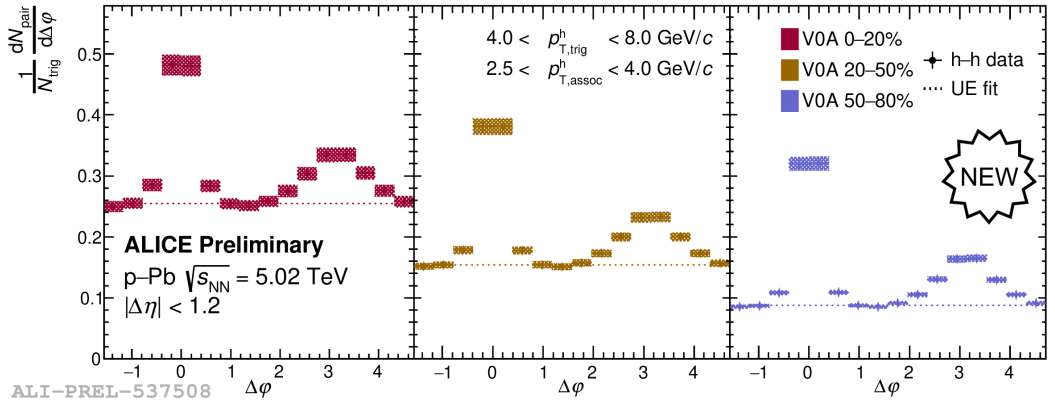


0-20% 20-50% 50-80%

$h - \Lambda$

$h - h$





- Underlying event **increases with multiplicity** and **decreases with associated p_{T}**
- Jet-component contribution **increases with associated p_{T}**

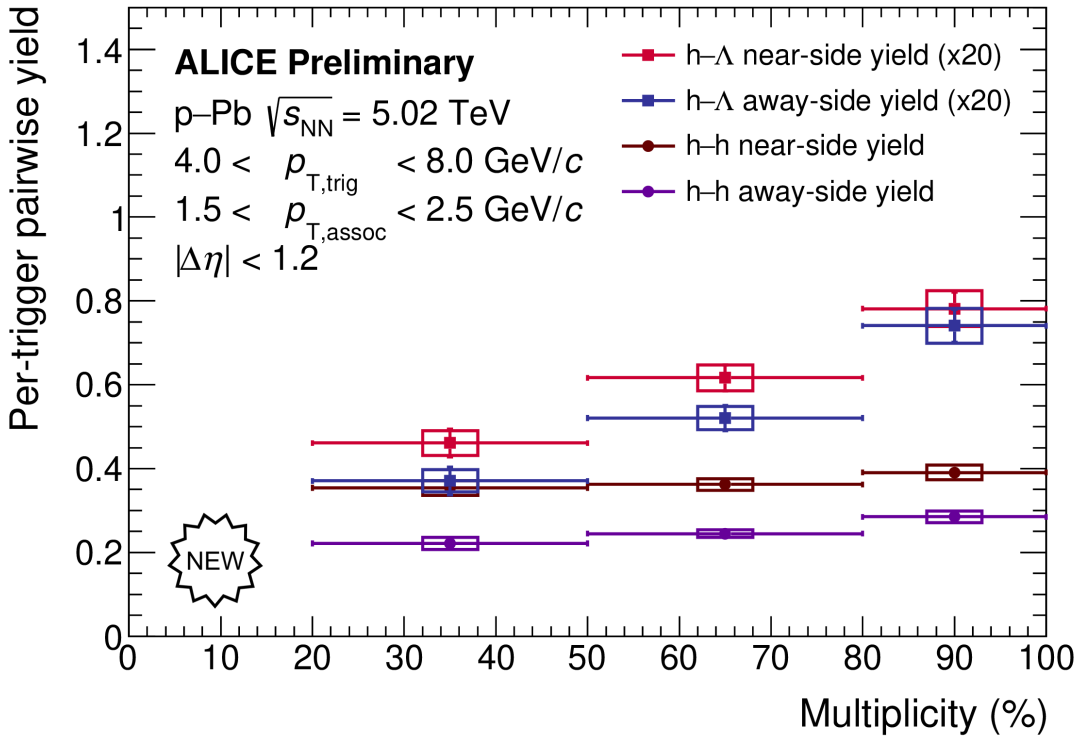
What about the $h - \Lambda$ and $h - h$ yields?

Per-trigger jet-like $\mathrm{h}-\Lambda$, $\mathrm{h}-\mathrm{h}$ yields

Collision system: p–Pb, 5 TeV

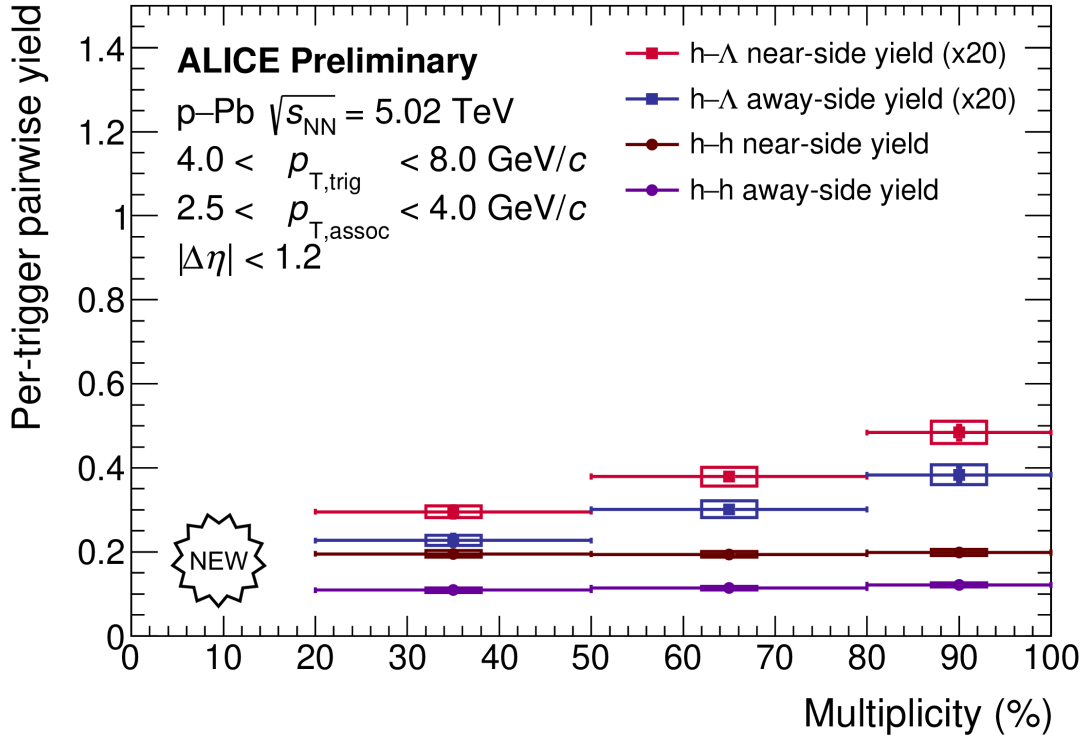
$4 < p_{\mathrm{T}}^{\mathrm{trigg}} < 8$ GeV/c

$1.5 < p_{\mathrm{T}}^{\mathrm{assoc}} < 2.5$ GeV/c



ALI-PREL-537455

$2.5 < p_{\mathrm{T}}^{\mathrm{assoc}} < 4.0$ GeV/c



ALI-PREL-537458

- **$\mathrm{h}-\Lambda$ jet-like yields see much larger increase than $\mathrm{h}-\mathrm{h}$ yields in both associated p_{T} bins** (~70% vs. ~10%)
- Overall increase is lower in the higher associated p_{T} bin for both $\mathrm{h}-\Lambda$ and $\mathrm{h}-\mathrm{h}$ (when compared with lower associated p_{T} bin)

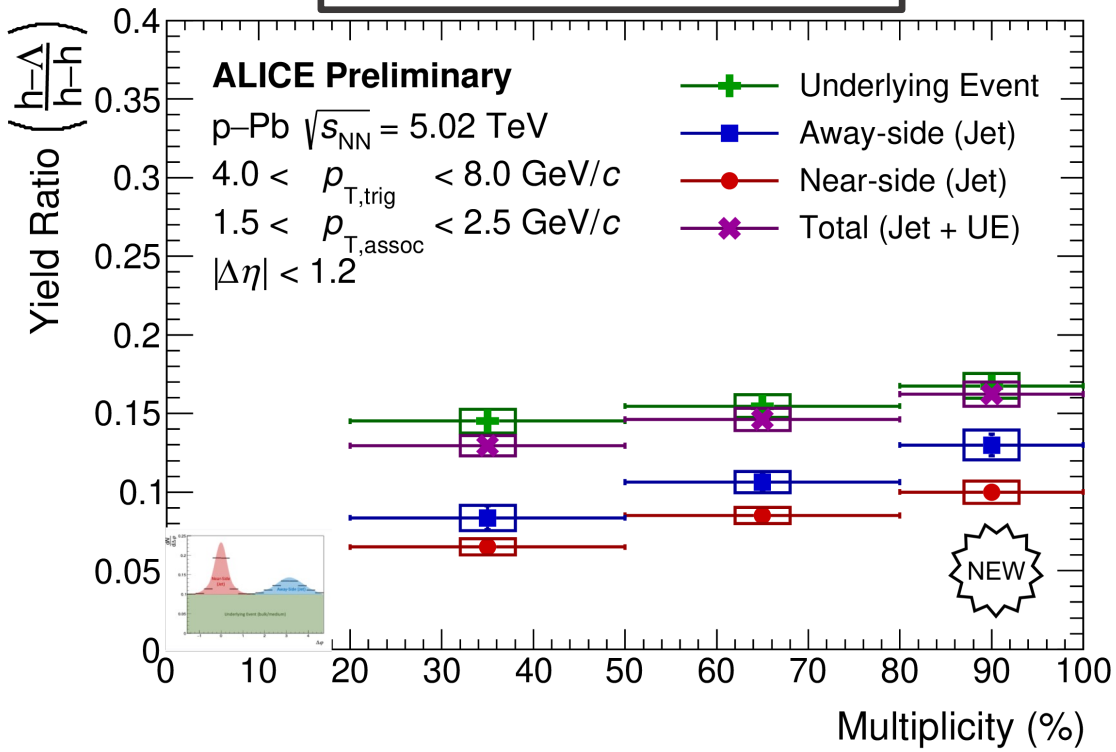
What about the $(\mathrm{h}-\Lambda)/(\mathrm{h}-\mathrm{h})$ yield ratios?

$(h - \Lambda)/(h - h)$ yield ratios vs. multiplicity

Collision system: p–Pb, 5 TeV

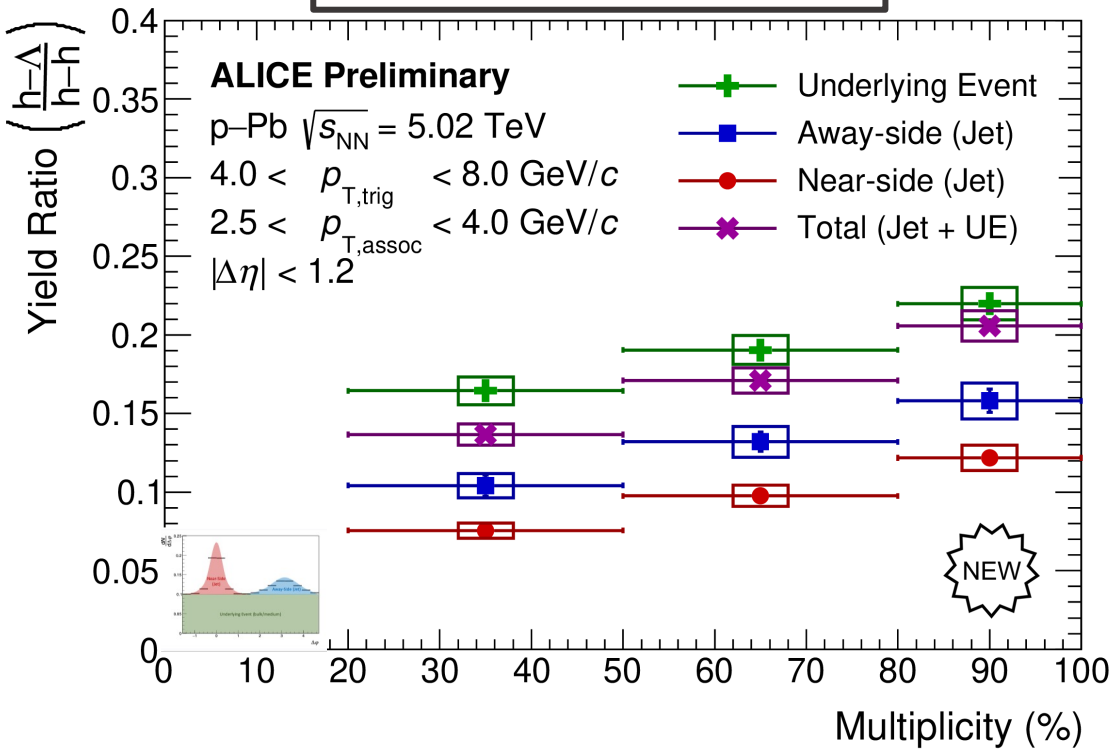
$4 < p_T^{trigg} < 8$ GeV/c

$1.5 < p_T^{assoc} < 2.5$ GeV/c



ALI-PREL-537473

$2.5 < p_T^{assoc} < 4.0$ GeV/c



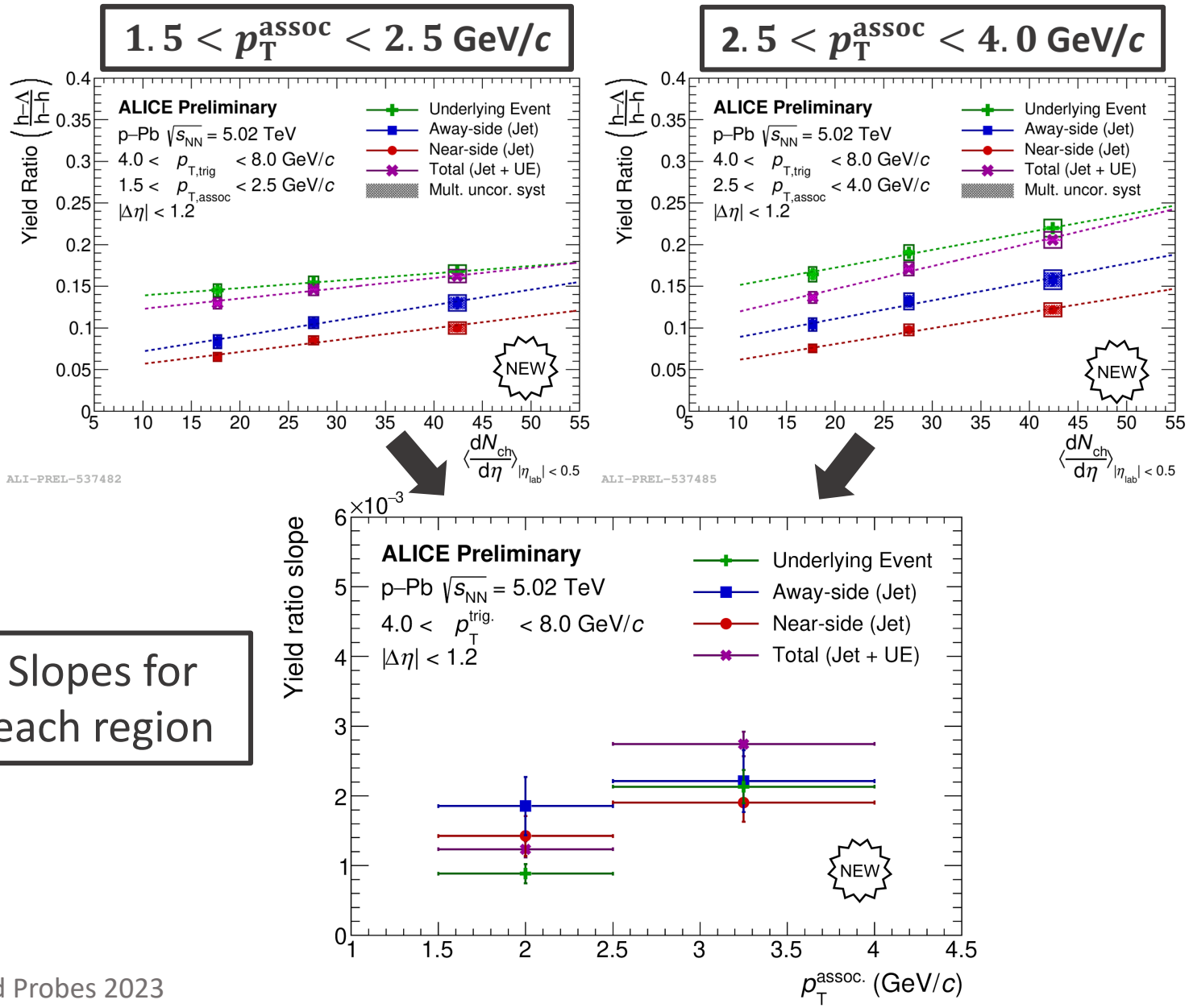
ALI-PREL-537476

- Very **similar trends as the $(h - \phi)/(h - h)$ measurement** (UE on top, jet-like ratios lower than UE & total, jet-like ratios increase)
- Larger enhancement at higher associated p_T

Can we quantify the enhancement in each region?

$(h - \Lambda)/(h - h)$ yield ratios vs. multiplicity

Collision system: p–Pb, 5 TeV



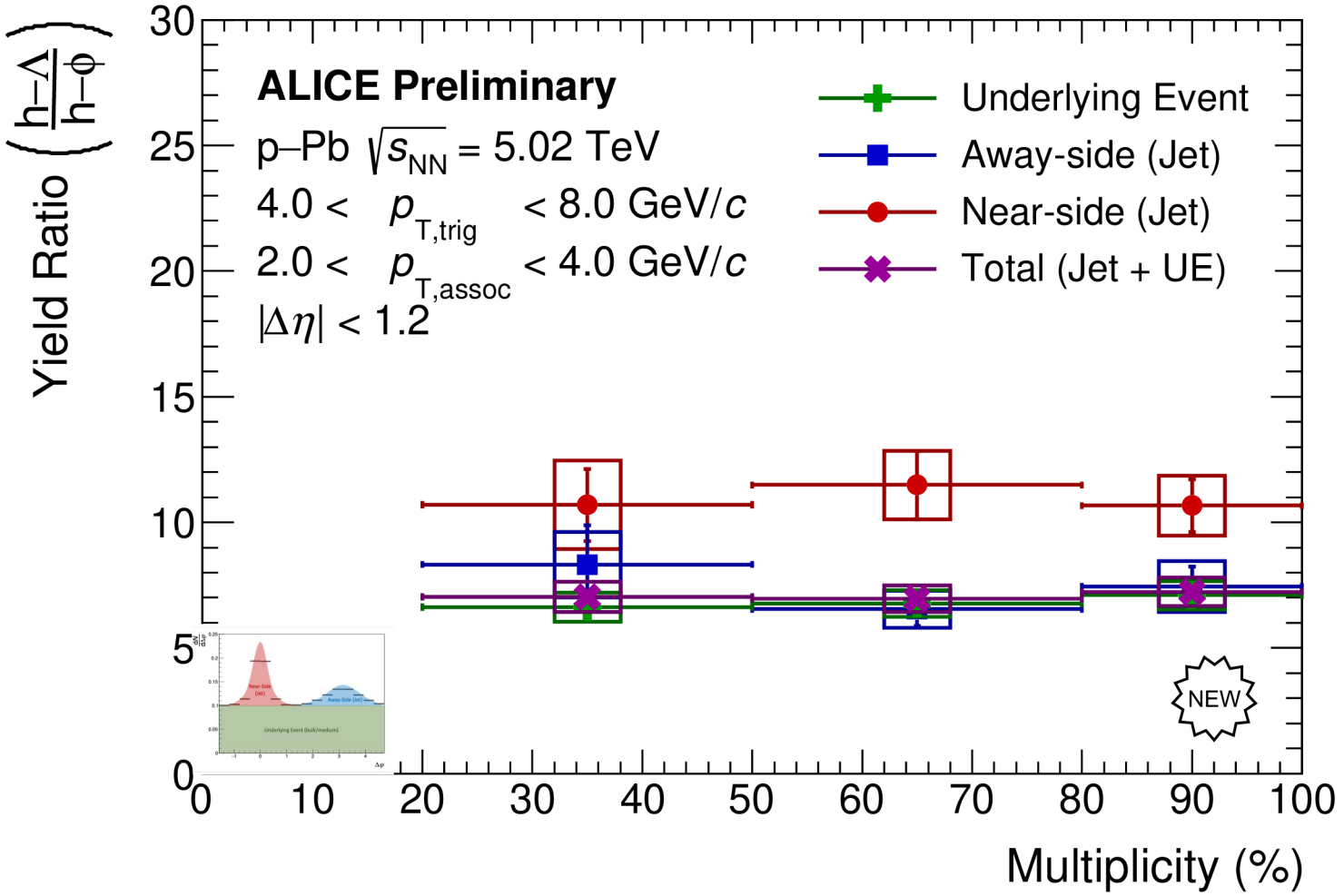
Slopes for each region

- **Slopes in the lower associated p_T bin are systematically lower** than those in the higher associated p_T bin
- **UE slope is much lower** when compared to the other regions **in the lower associated p_T bin**, whereas the higher associated p_T bin it is consistent with the jet-like regions

What about the $(h - \Lambda)/(h - \phi)$ ratios?

$(h-\Lambda)/(h-\phi)$ yield ratios vs. multiplicity

Collision system: p–Pb, 5 TeV



ALI-PREL-537490

- Ratios in each region are **constant as a function of multiplicity**
- The **near-side ratio is systematically higher** than the other regions
- Two competing effects? (s vs. $s\bar{s}$, baryon vs. meson)
- Need model comparisons to gain a better understanding!

Conclusions

In pp collisions…

- **No multiplicity dependence observed** for $(\mathbf{h} - \mathbf{K^0_S})/(\mathbf{h} - \mathbf{h})$ ratios in both the near- and away-side of the jet
- The investigated models are able to predict the $(\mathbf{h} - \mathbf{K^0_S})/(\mathbf{h} - \mathbf{h})$ ratios, despite failing to predict the individual pairwise yields

In p–Pb collisions…

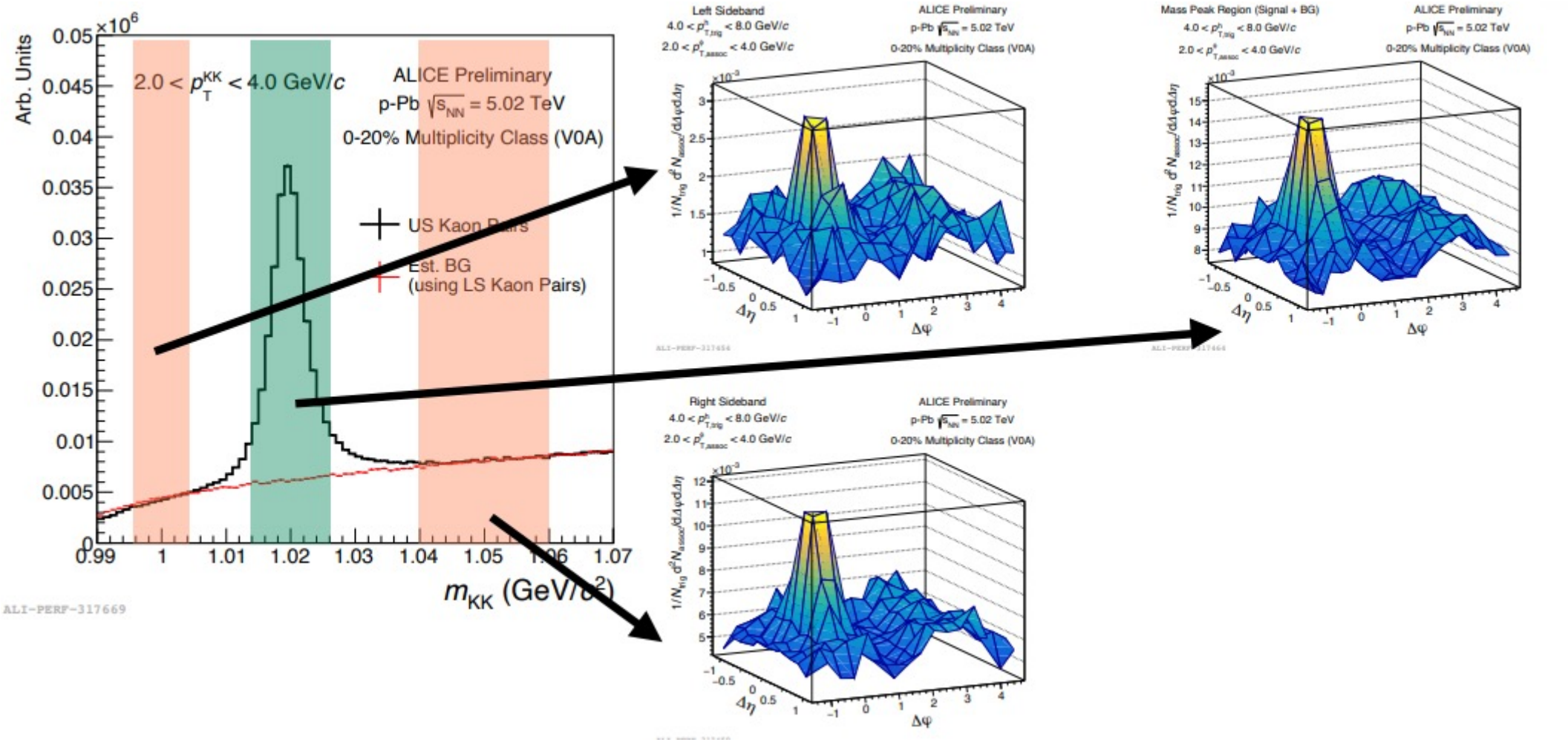
- Underlying event $(\mathbf{h} - \boldsymbol{\phi})/(\mathbf{h} - \mathbf{h})$ and $(\mathbf{h} - \boldsymbol{\Lambda})/(\mathbf{h} - \mathbf{h})$ ratios are higher than all other regions → **strangeness *production* mostly coming from UE**!
- Near and away-side jet $(\mathbf{h} - \boldsymbol{\phi})/(\mathbf{h} - \mathbf{h})$ and $(\mathbf{h} - \boldsymbol{\Lambda})/(\mathbf{h} - \mathbf{h})$ ratios increase with multiplicity → **strangeness *enhancement* in the jets**!

Looking forward: Model comparisons for the Λ, ϕ correlations in p–Pb!

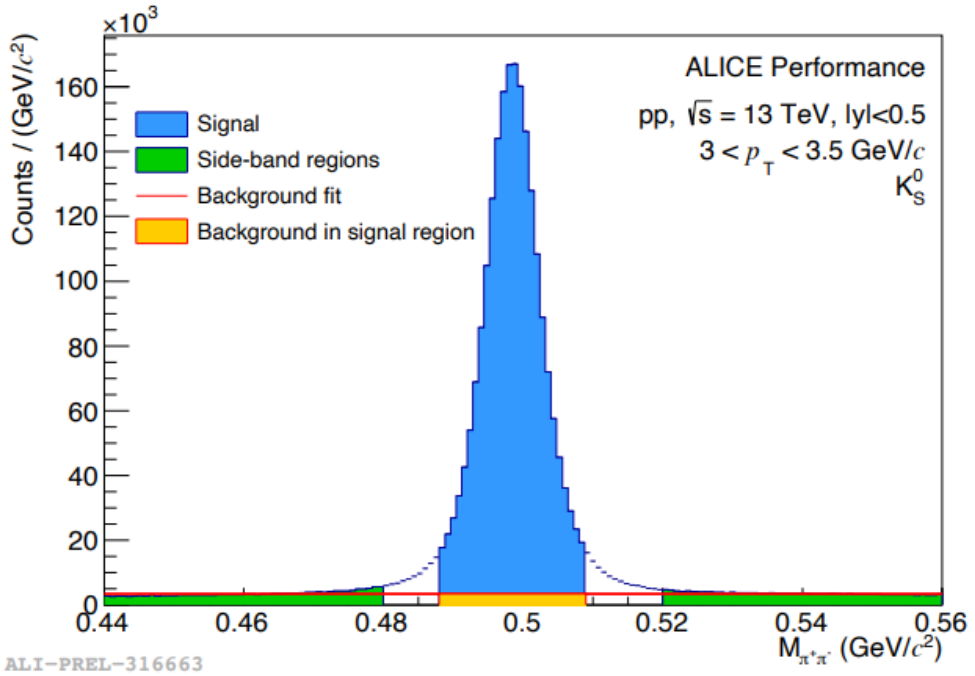
Questions?

BACKUP!!

Details: *Sideband subtraction for h-ϕ*



Details: *Sideband subtraction for h-K^0*



- Reconstruction via decay channel:
  $K^0_S \rightarrow \pi^+ + \pi^-$ (~69%)
- Selection criteria based on the decay topology
- Correction for remaining uncorrelated background

$$N^{\text{full corr}}_{\text{trigg}}(p_T^{\text{trigg}}) = \frac{sg}{sg + bg} N^{\epsilon\ \text{corr}}_{\text{trigg}}(p_T^{\text{trigg}})$$

$$\frac{dN^{\text{full corr}}_{\text{pair}}}{d\Delta\varphi}(\Delta\varphi, p_T^{\text{trigg}}) = \frac{1}{N^{\text{full corr}}_{\text{trigg}}}(p_T^{\text{trigg}}) \left(\frac{dN^{\text{corr}}_{\text{pair}\,sg}}{d\Delta\varphi}(\Delta\varphi, p_T^{\text{trigg}}) - \frac{bg}{sg - bg} \frac{sg}{sd} \frac{dN^{\text{corr}}_{\text{pair}\,sd}}{d\Delta\varphi}(\Delta\varphi, p_T^{\text{trigg}}) \right)$$

Technique: *Angular (Δφ) correlations with strange hadrons*