Looking for collective origin of strangeness enhancement in small collisions systems with ALICE at the LHC

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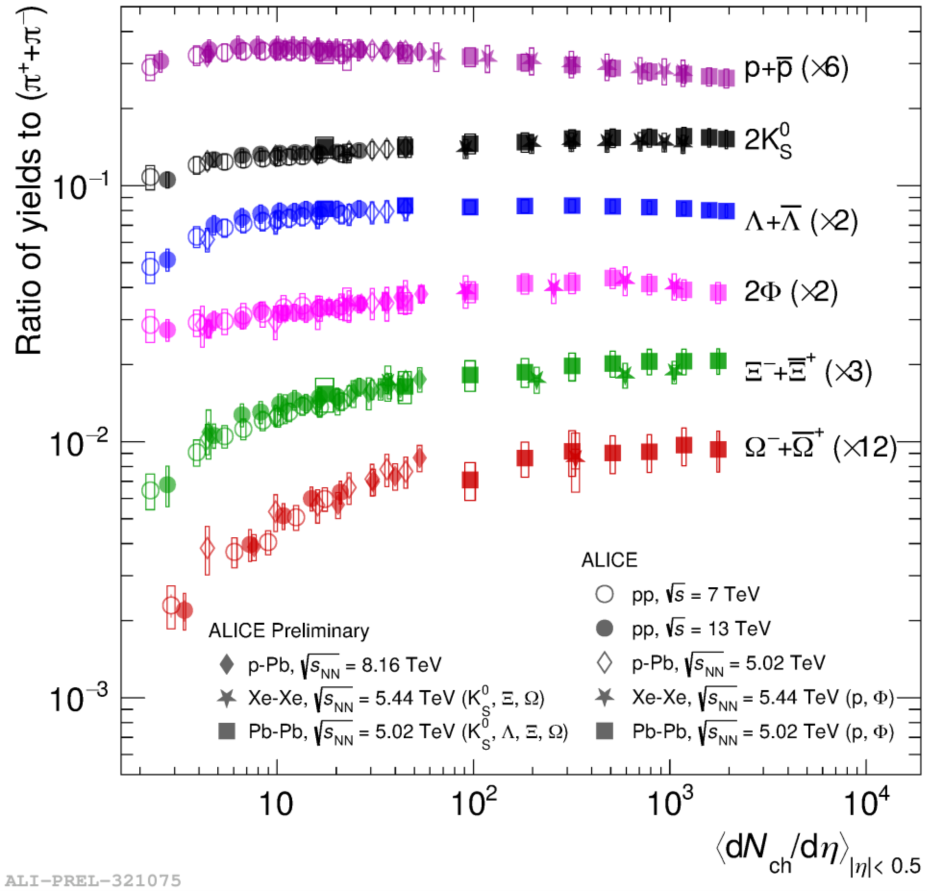
Strangeness enhancement in small collisions

ALICE

Strangeness enhancement in small collisions refers to an increasing ratio of strange hadron yields over pion yields as a function of multiplicity.

- Steady progression with charged particle multiplicity spanning multiple collision systems (pp, p-Pb & Pb-Pb)
- Independent of collision energy



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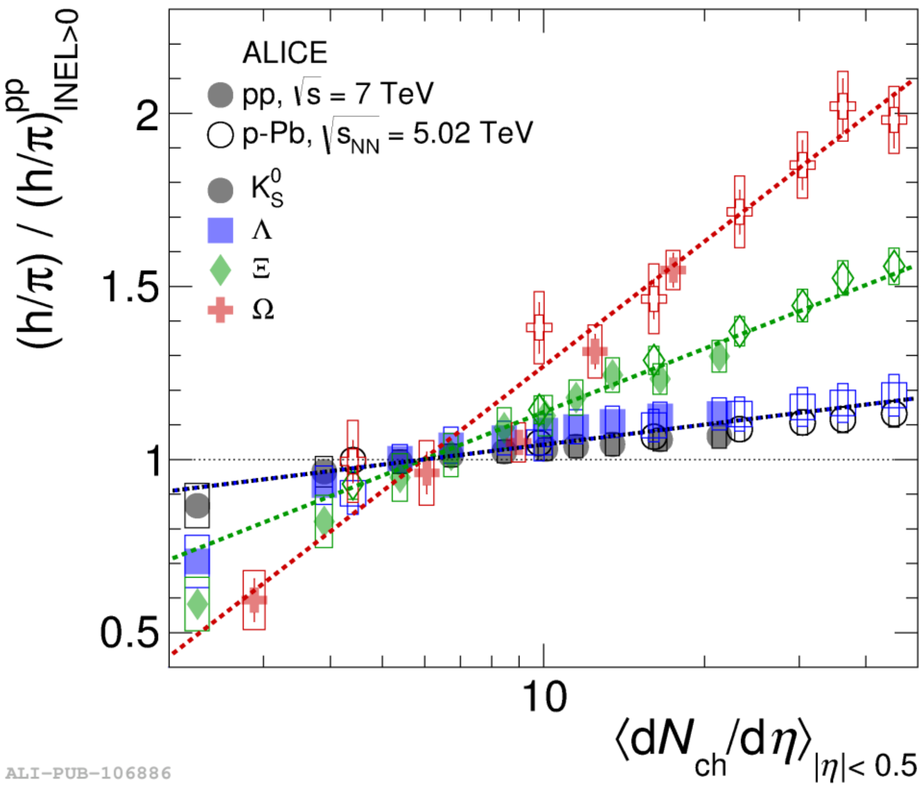

ALICE Collaboration, Nature Phys 13, 535–539 (2017)
ALICE Collaboration, Eur.Phys.J.C 80, 167 (2020)

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- Steady progression with charged particle multiplicity spanning multiple collision systems (pp, p-Pb & Pb-Pb)
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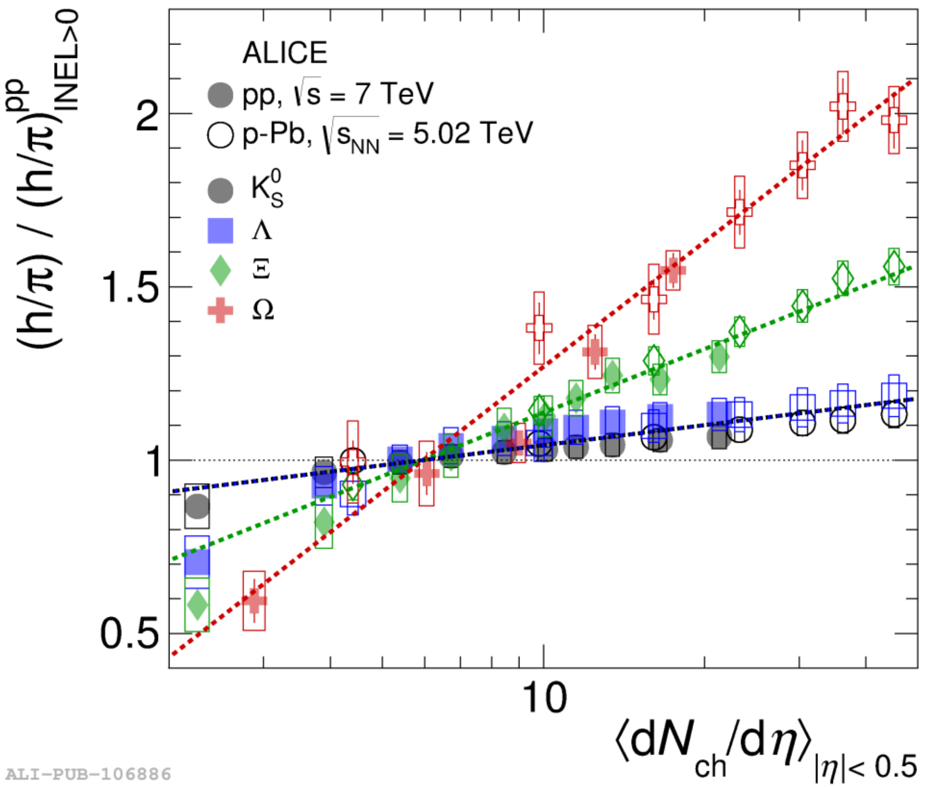
- Scales with particle strangeness content
- Relationship between strangeness enhancement and hard processes (jets) vs. soft (out-of-jet) processes?



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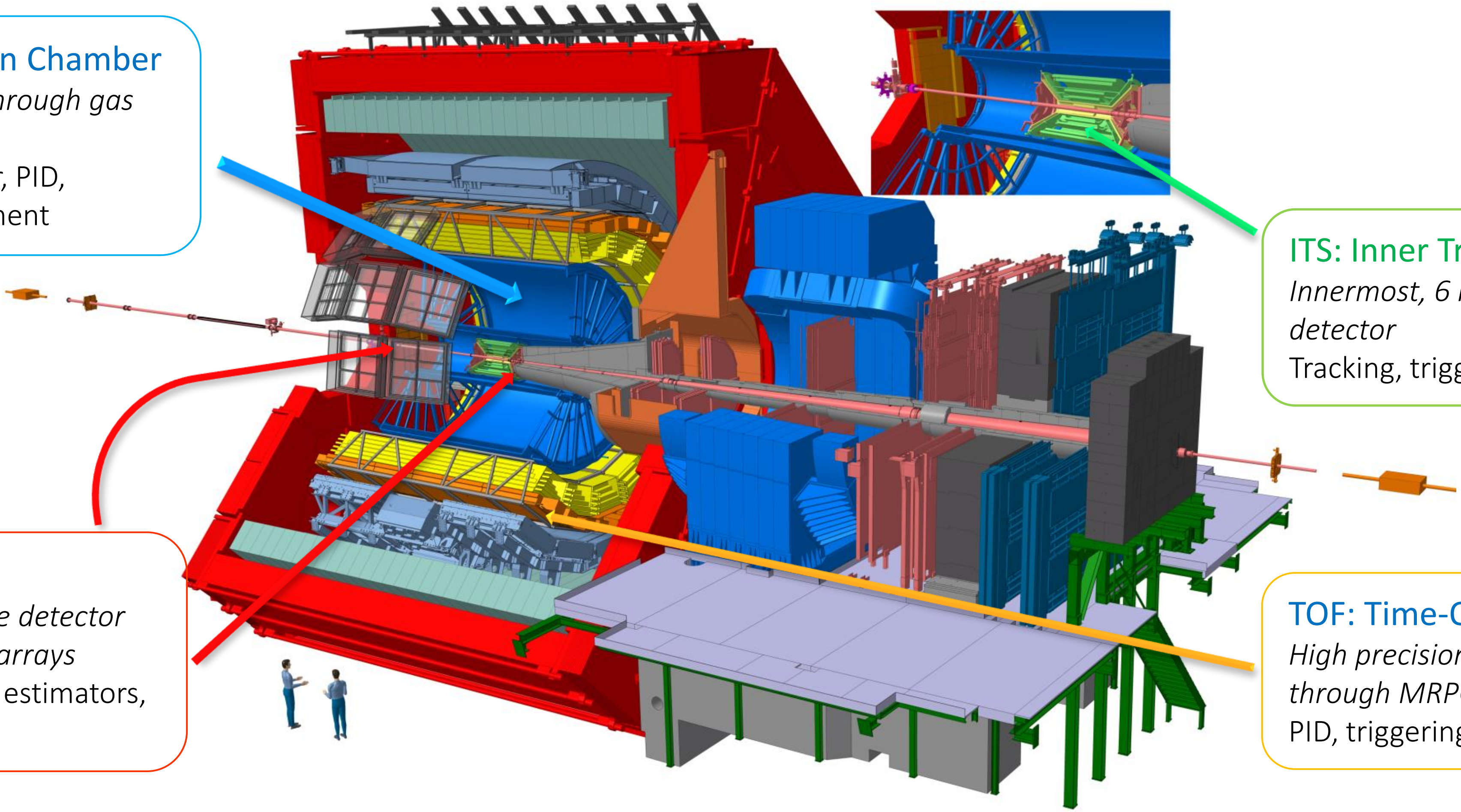
The ALICE detector

TPC: Time Projection Chamber
3-D particle tracking through gas ionisation
Main tracking detector, PID, momentum measurement



ITS: Inner Tracking System
Innermost, 6 layered silicone-based detector
Tracking, triggering, vertexing

V0 detector
V0A & V0C: small angle detector based on scintillators' arrays
Triggering, multiplicity estimators, background rejection

TOF: Time-Of-Flight detector
High precision time tracking through MRPCs
PID, triggering

Two-particle angular correlations

Method of studying strange hadron production w.r.t. jet axis: angular correlations $(\Delta\varphi, \Delta\eta)$ can be used to distinguish between hard (in-jet) and soft (out-of-jet) processes

1. Trigger particle (jet axis proxy) selection: highest p_{T} charged hadron with p_{T} > 3 GeV/c
2. Associated particles: identified strange hadrons
3. Angular correlation constructed using angular differences between trigger and associated particles:

$$\Delta\varphi = \varphi_{\text{trig}} - \varphi_{\text{assoc}}$$

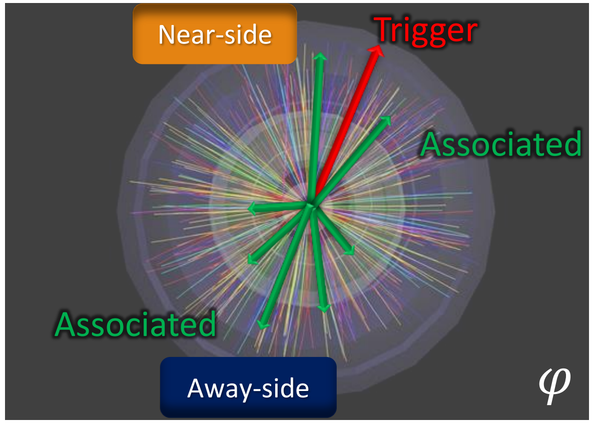
$$\Delta\eta = \eta_{\text{trig}} - \eta_{\text{assoc}}$$

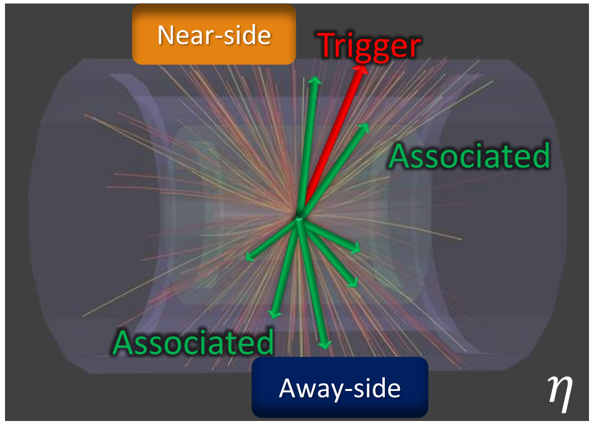
where φ : Azimuthal angle;

$\eta = -\ln(tan(\frac{\theta}{2}))$;

θ : Polar angle

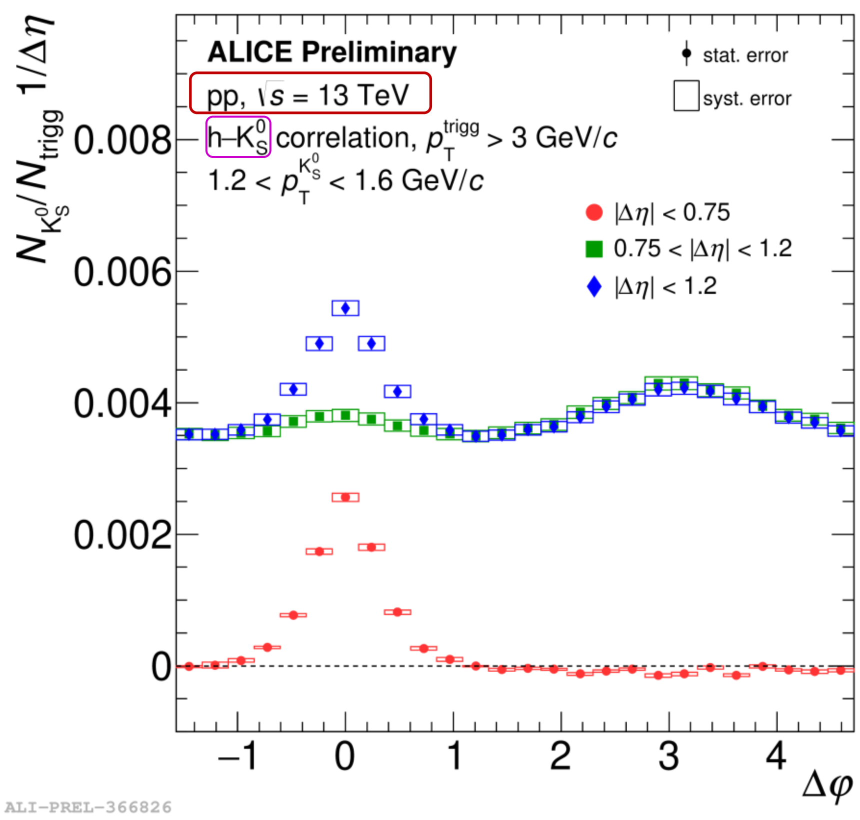
4. Per-trigger yield of associated particles corrected for trigger and associated particle reconstruction efficiencies, pair detector acceptance, contamination from non-primary particles, etc.



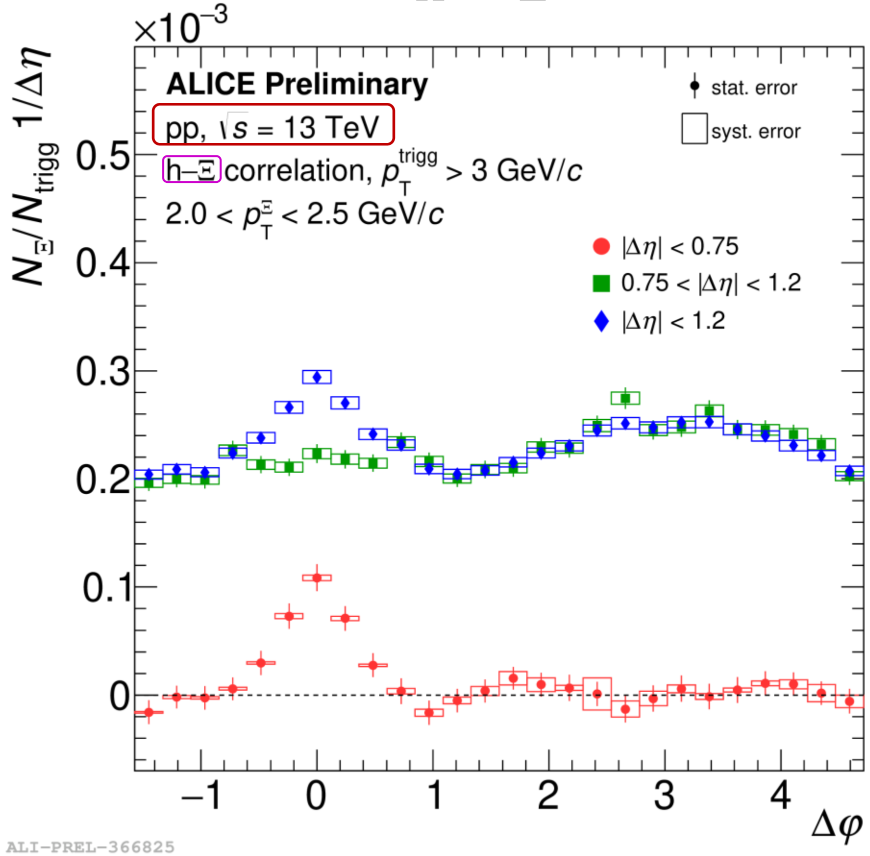


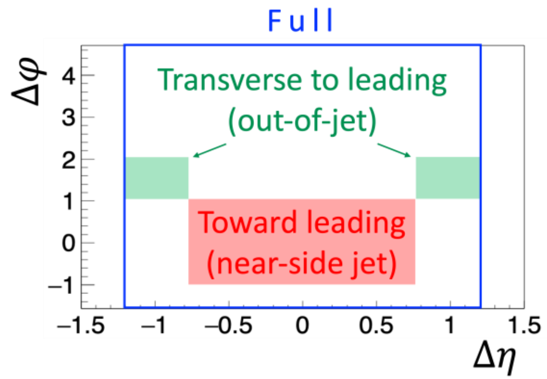
$h - K_S^0$ and $h - \Xi$ angular correlations

$h - K_S^0$



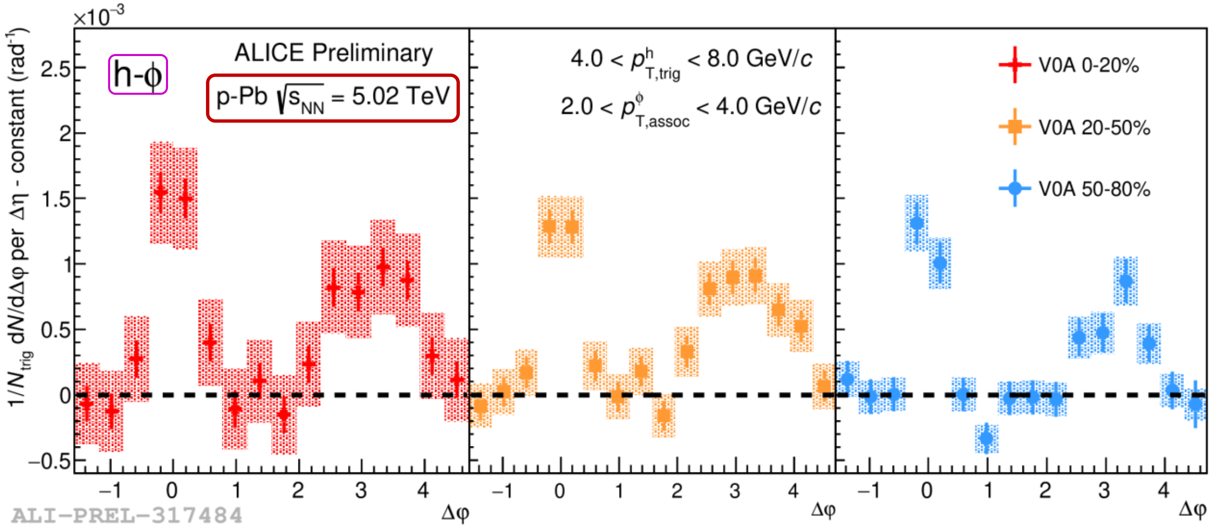
$h - \Xi$





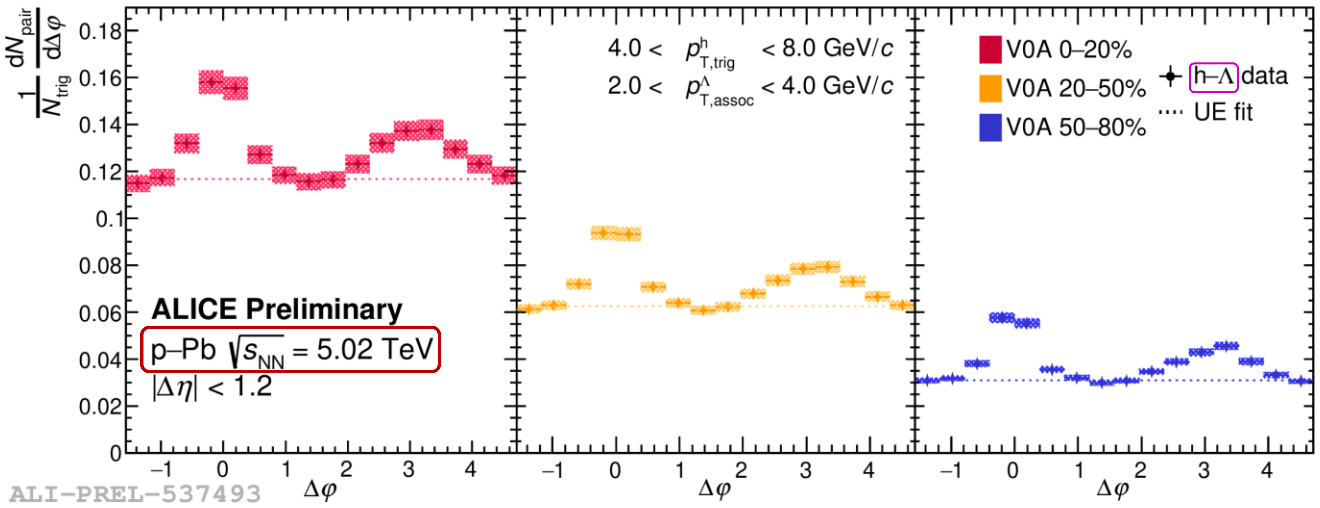
h − ϕ and h − Λ angular correlations

h − ϕ



h − Λ

New!



- $2.0 < p_{\mathrm{T,assoc}} < 4.0$ GeV/c
- Underlying event subtracted from correlation

- $2.0 < p_{\mathrm{T,assoc}} < 4.0$ GeV/c

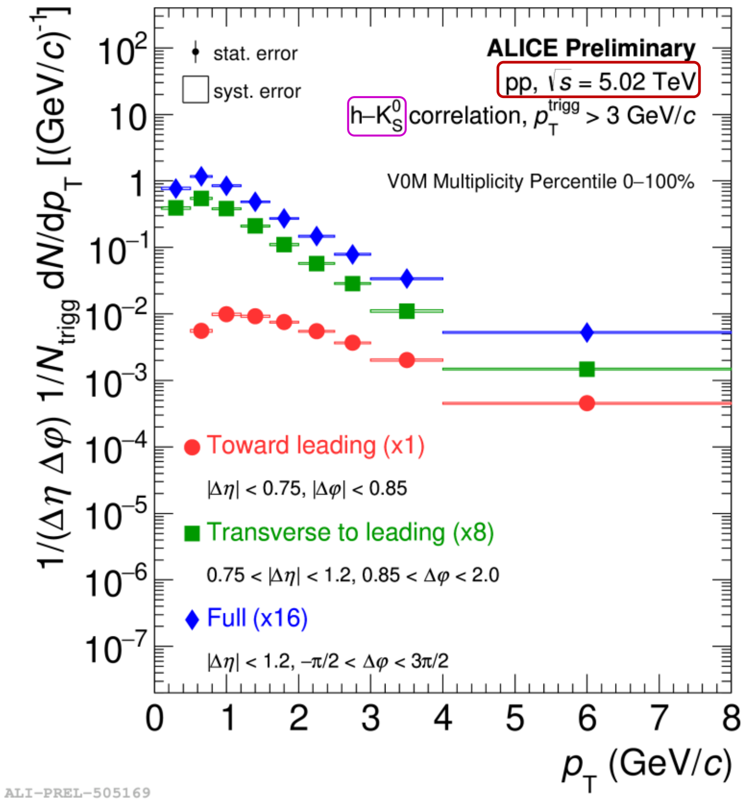
→ See also Ryan Hannigan's parallel talk (28 Mar 2023, 17:30, Parallel: High-Momentum Hadrons & Correlations)

Transverse momentum (p_T) spectra

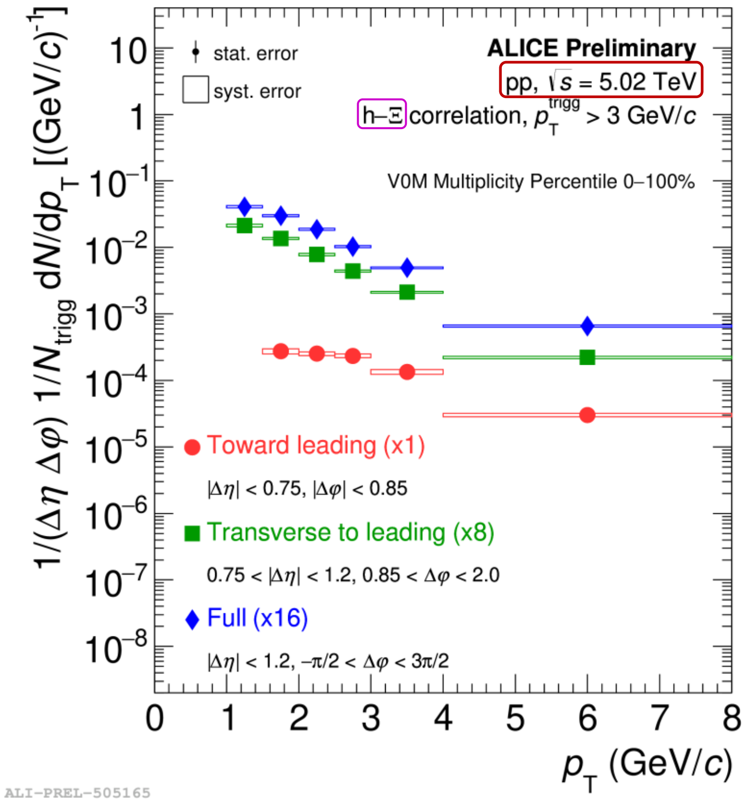
Strange hadrons: $K^0_S, \Xi^\pm$

- In-jet spectra **harder** than out-of-jet contribution
- Valid across different multiplicity classes and energies

$h - K^0_S$



$h - \Xi$



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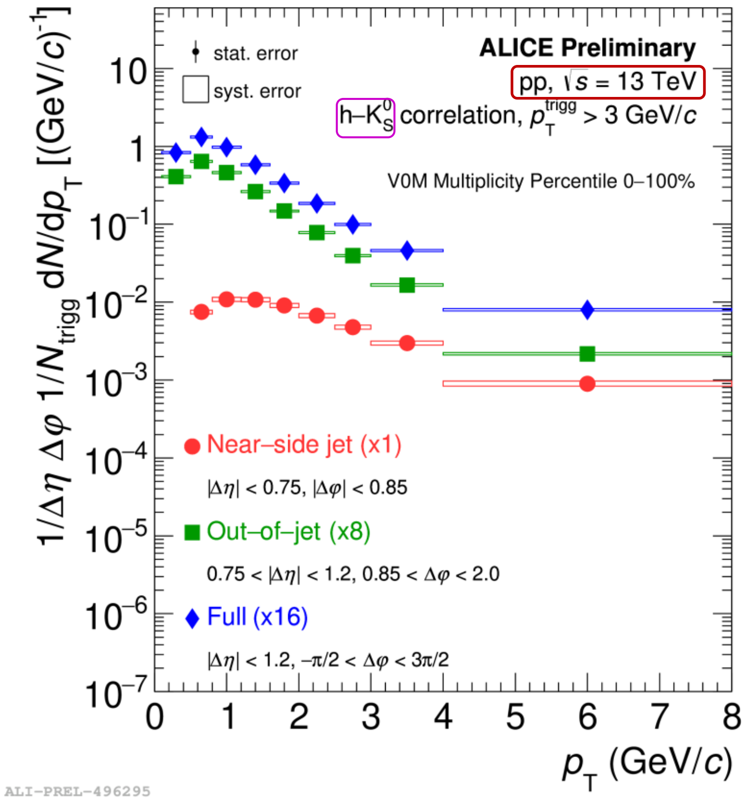
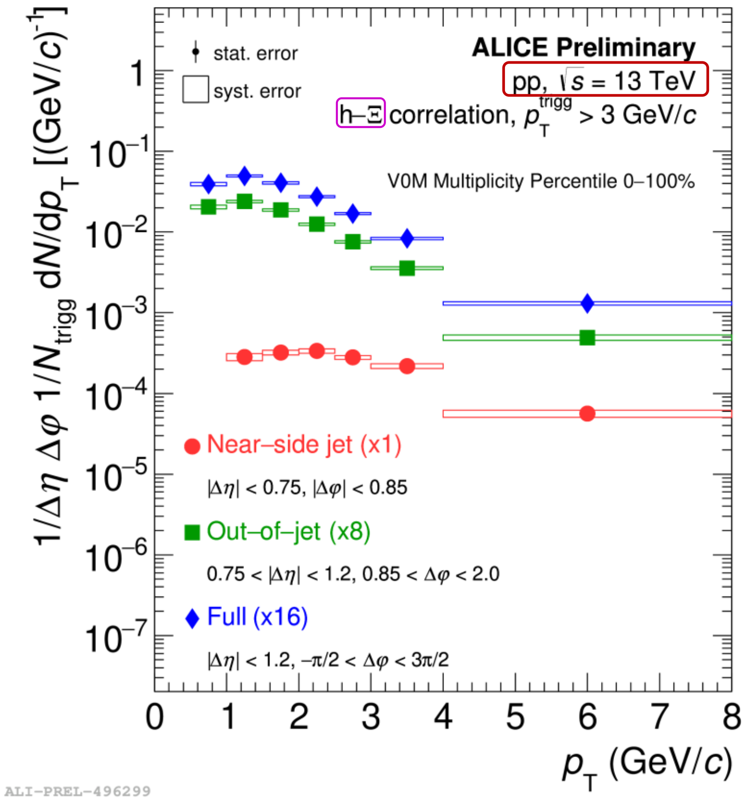


$h - \Xi$



Strange hadron yields vs. multiplicity

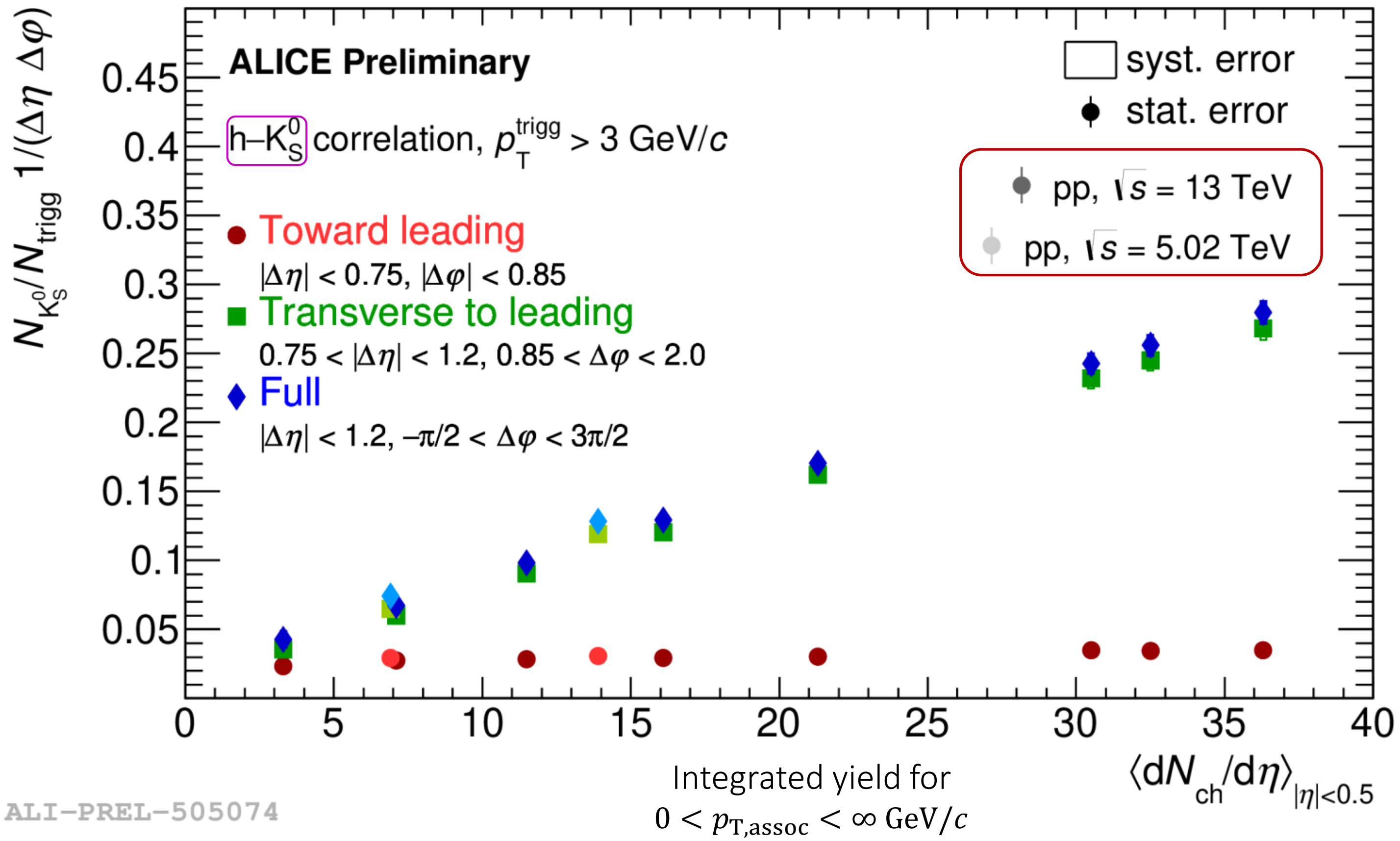
Strange hadron: K^0_S

- Near-side jet yield flatter
- Out-of-jet yield and full yield rise as a function of multiplicity ⇒ soft processes as a **dominant contributor** to the strangeness enhancement?

➢ Out-of-jet contribution relative to near-side jet increases with multiplicity

- Valid across different centre-of-mass energies

$N_{K^0_S}/N_{trigg}$



Integrated yield for
$0 < p_{T,assoc} < \infty$ GeV/c

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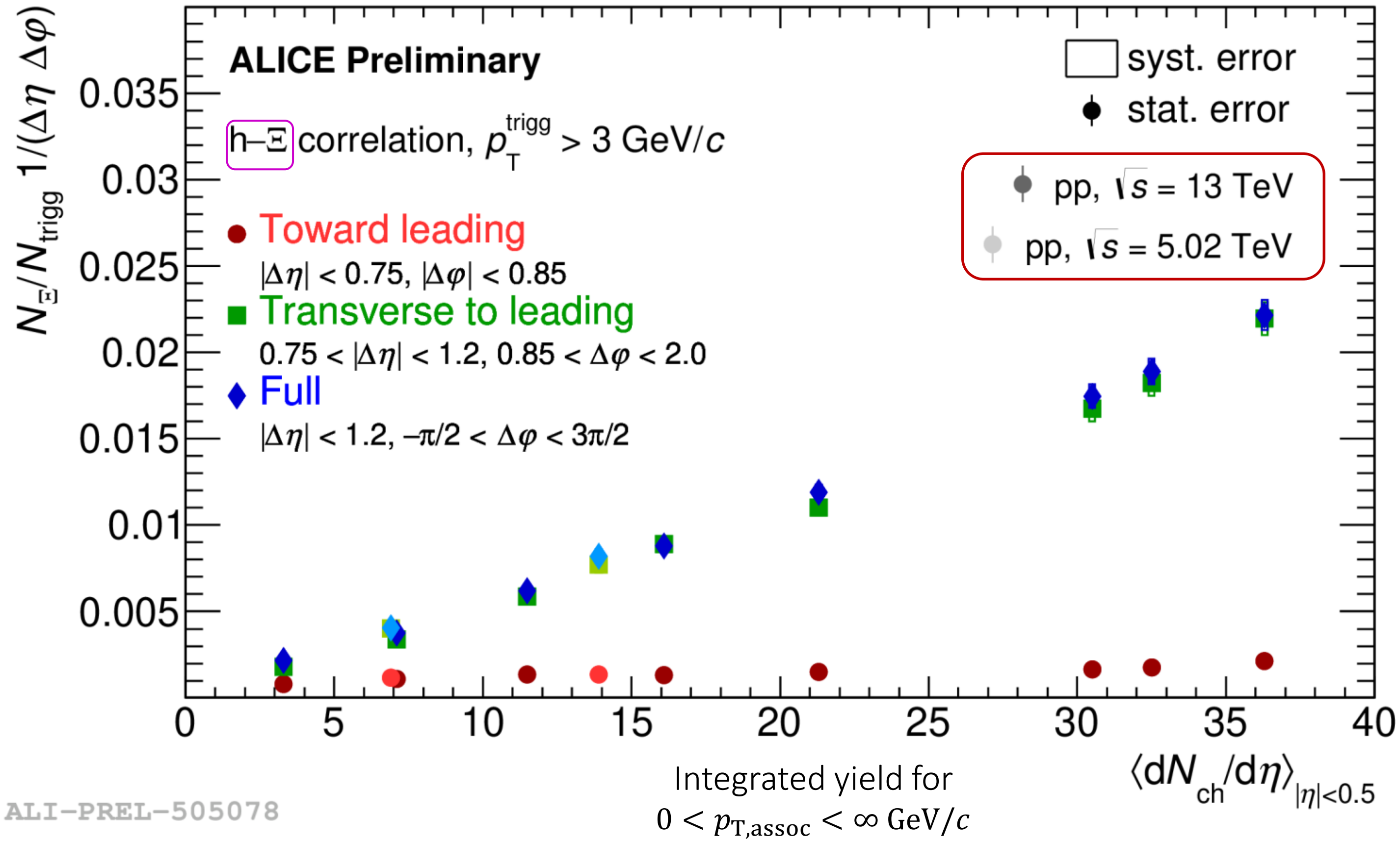

Integrated yield for
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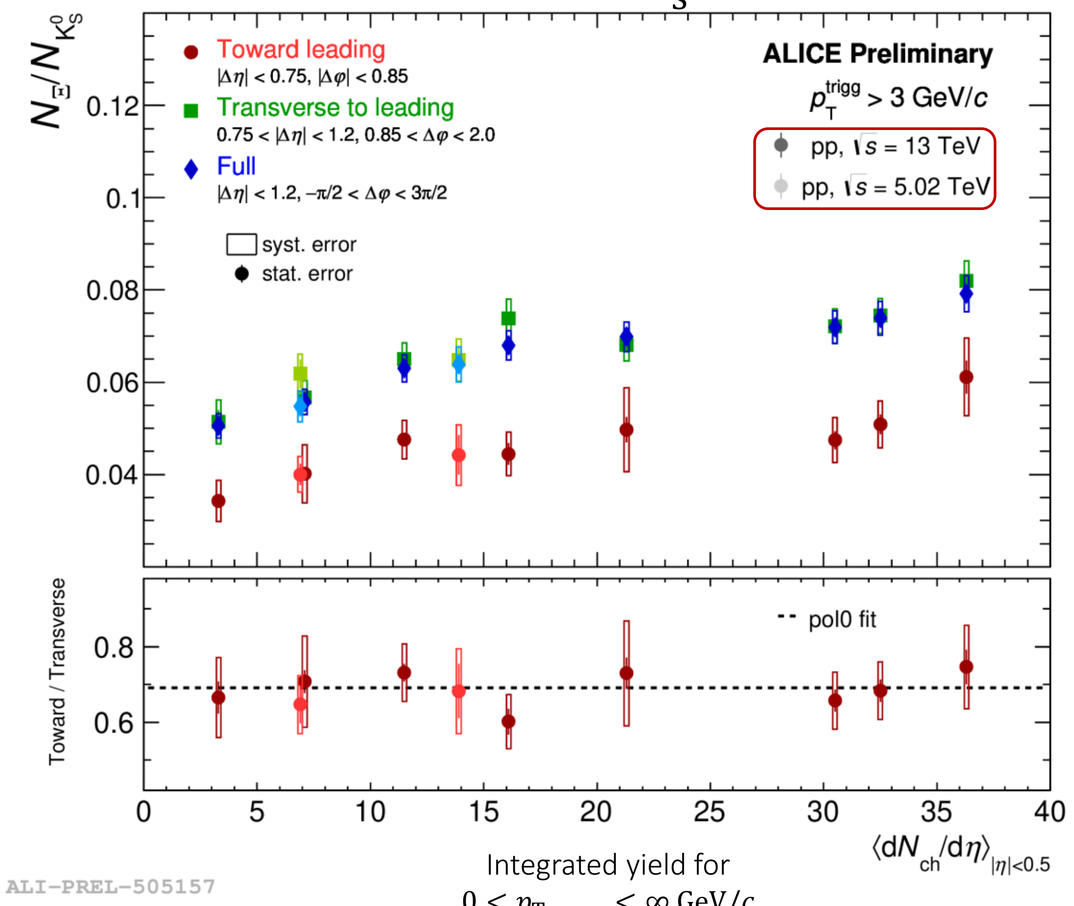
Per-trigger $\Xi^{\pm}/_{K^0_S}$ yield ratio vs. multiplicity

Per-trigger yield ratio: $\frac{N_{\Xi}}{N_{K^0_S}}$

- No centre-of-mass energy dependence
- Out-of-jet yield ratio and full yield ratio **increase with multiplicity**
- Near-side jet yield ratio also **increases** with multiplicity
- Near-side jet yield ratio **smaller** than out-of-jet yield ratio

$N_{\Xi}/N_{K^0_S}$



Integrated yield for
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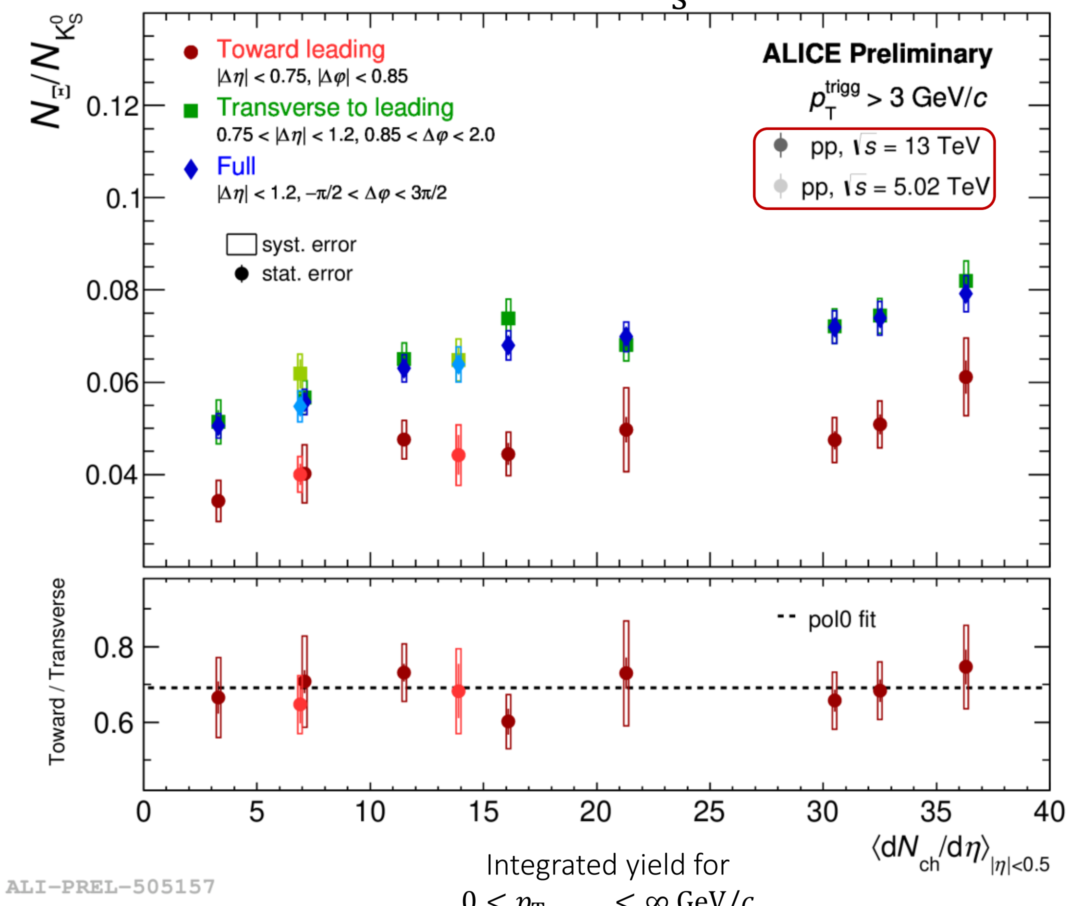
Per-trigger $\Xi^{\pm}/_{K^0_S}$ yield ratio vs. multiplicity

Per-trigger yield ratio: $\frac{N_{\Xi}}{N_{K^0_S}}$

- Higher values of out-of-jet yield ratio indicate a **dominant contribution** to the $\Xi^{\pm}/K^0_S$ full yield ratio
- Near-side jet yield ratio and out-of-jet yield ratio show a **compatible increase with multiplicity**

$N_{\Xi}/N_{K^0_S}$



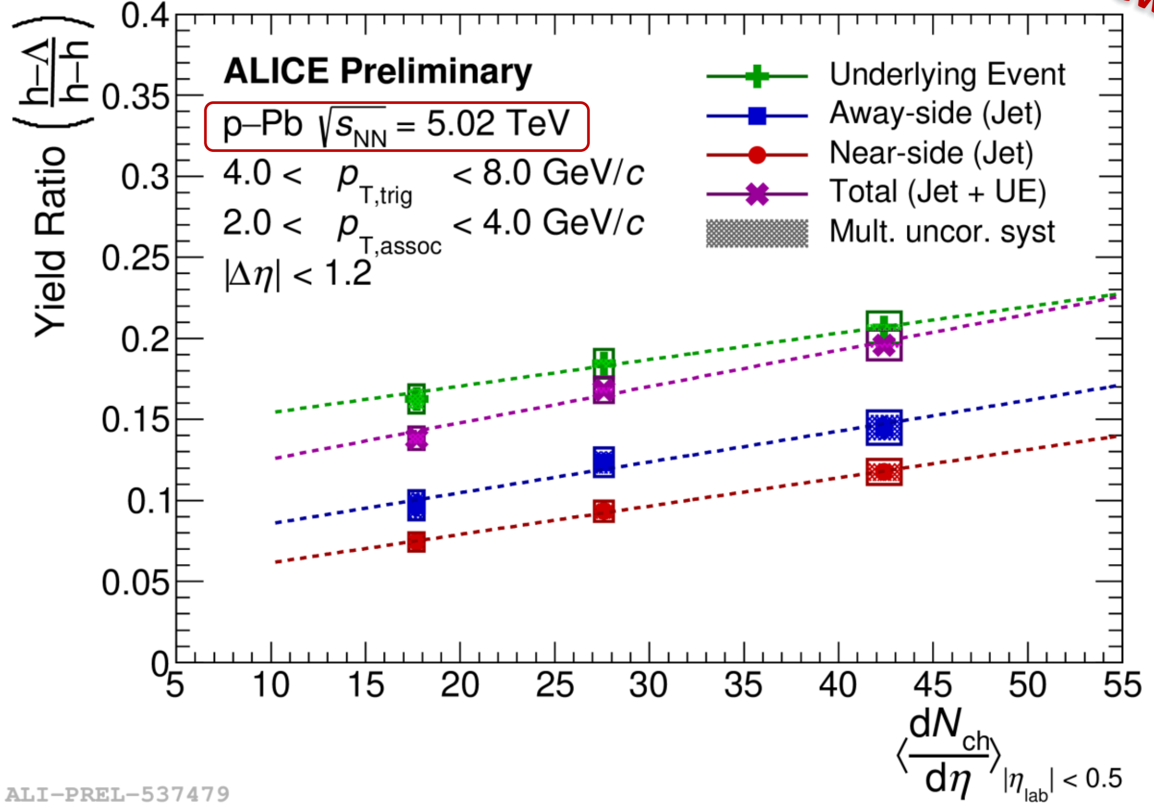
Integrated yield for
$0 < p_{\mathrm{T,assoc}} < \infty$ GeV/c

Per-trigger $\frac{h-\Lambda}{h-h}$ yield ratio vs. multiplicity

Per-trigger yield ratio: $\frac{h-\Lambda}{h-h}$

- Out-of-jet (UE) yield ratio and total yield ratio **increase with multiplicity**
- Near-side jet yield ratio also **increases** with multiplicity
- Near-side jet yield ratio **smaller** than out-of-jet (UE) yield ratio
- Higher values of out-of-jet (UE) yield ratio indicate a **dominant contribution** to the total (Jet + UE) yield ratio

New!



→ *See also Ryan Hannigan's parallel talk (28 Mar 2023, 17:30, Parallel: High-Momentum Hadrons & Correlations)*

Summary

- Harder p_{T} spectra for strange hadrons in jets than in out-of-jet events or full sample
- No centre-of-mass energy dependence or collision system dependence for strangeness enhancement studied via two-particle correlations
- Per-trigger yield ratios indicate strangeness enhancement dependent on charged particle multiplicity
- Hard (in-jet) and soft (out-of-jet) processes’ yield ratios show a compatible multiplicity dependence
- Soft (out-of-jet) processes have a dominant contribution towards strange particle production

Thank you for your attention!

BACKUP SLIDES

Per-trigger $\mathrm{h}-\Lambda$ and $\mathrm{h}-\mathrm{h}$ yields in p-Pb

- Multiplicity dependent $\mathrm{h}-\Lambda$ near-side jet yield
- Increased contribution as a function of increasing multiplicity, in contrast to di-hadron yield.