SQM2024

Measurement of strange baryon production in charged-particle jets in pp and p-Pb collisions with ALICE

Gijs van Weelden (Nikhef)
On behalf of the ALICE collaboration

ALICE

Nikhef

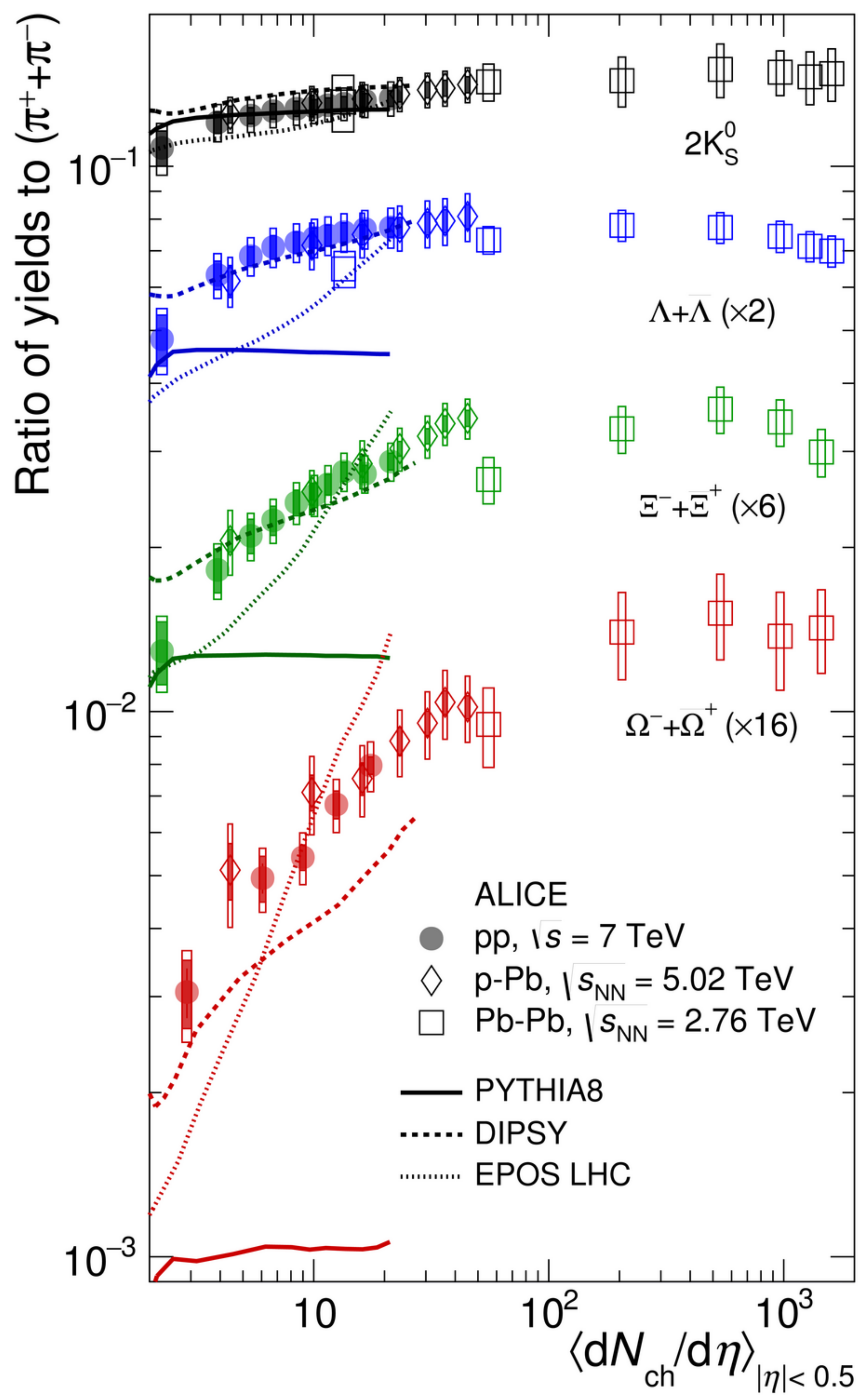
Utrecht University

Motivation

ALICE, Nature Phys. 13 (2017), 535-539

Strangeness yields across multiplicity

Enhancement increases with strangeness, rather than mass



Motivation

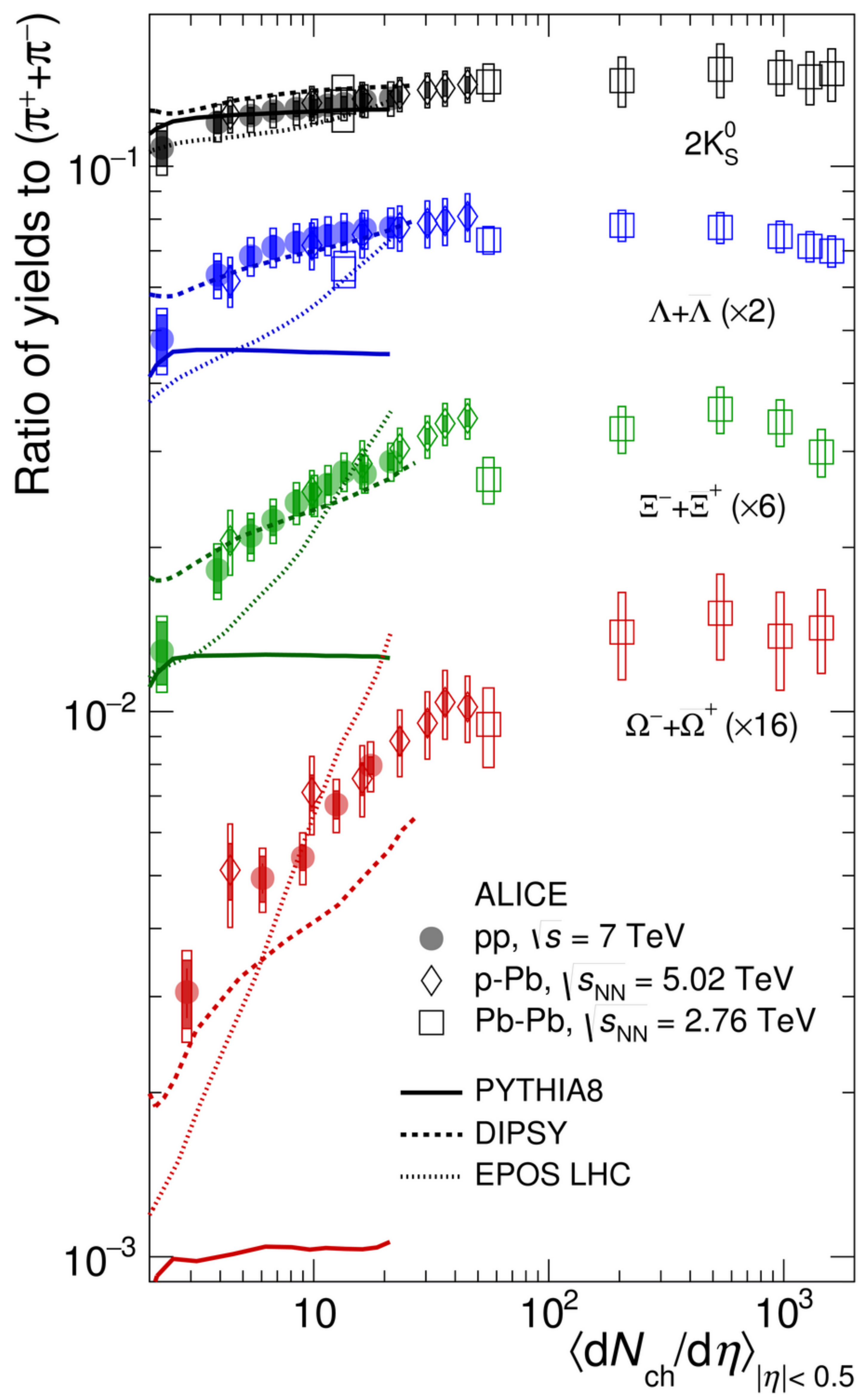
Strangeness yields across multiplicity

Enhancement increases with strangeness, rather than mass

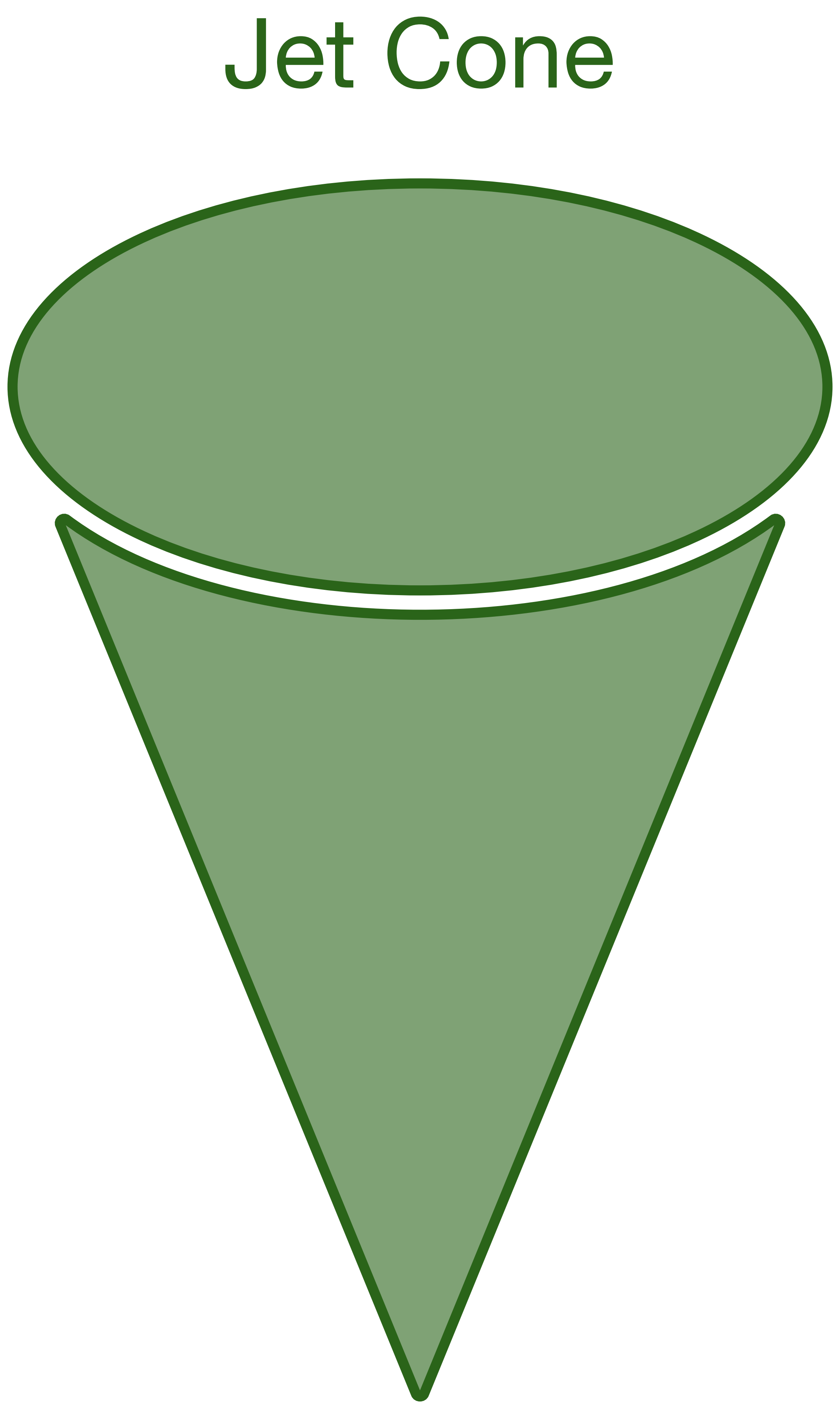
Disentangle strangeness production mechanisms in jets and in underlying event

- Run 2 published results (ALICE: JHEP 07 (2023), 136)
- Novel Run 3 jet analysis

ALICE, Nature Phys. 13 (2017), 535-539



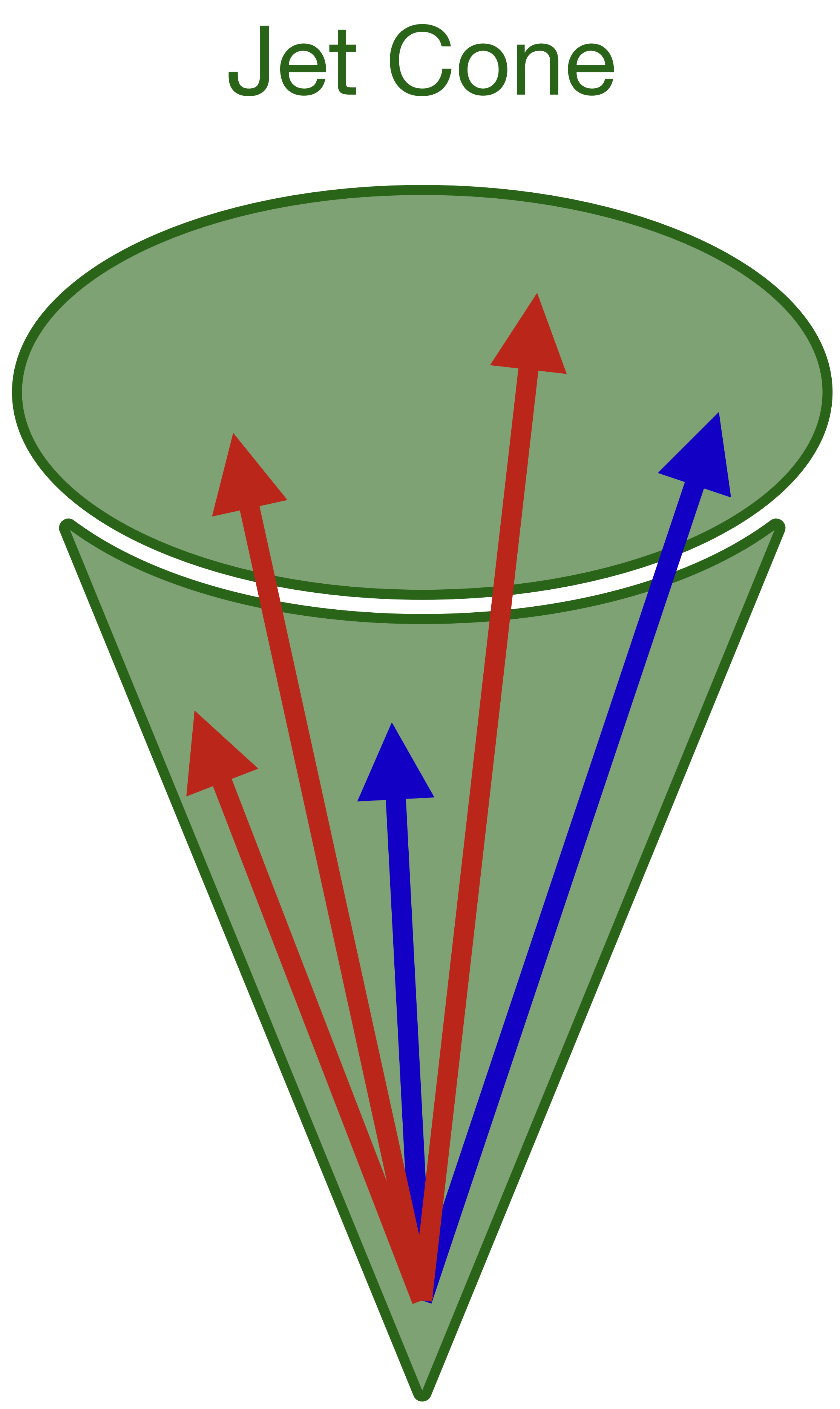
Yield in jets



Cluster jets with charged particles using anti-k_T algorithm

Reconstruct $\mathrm{K_S^0}, \Lambda, \Xi, \Omega$

Yield in jets



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Measure strange hadrons within jet cone

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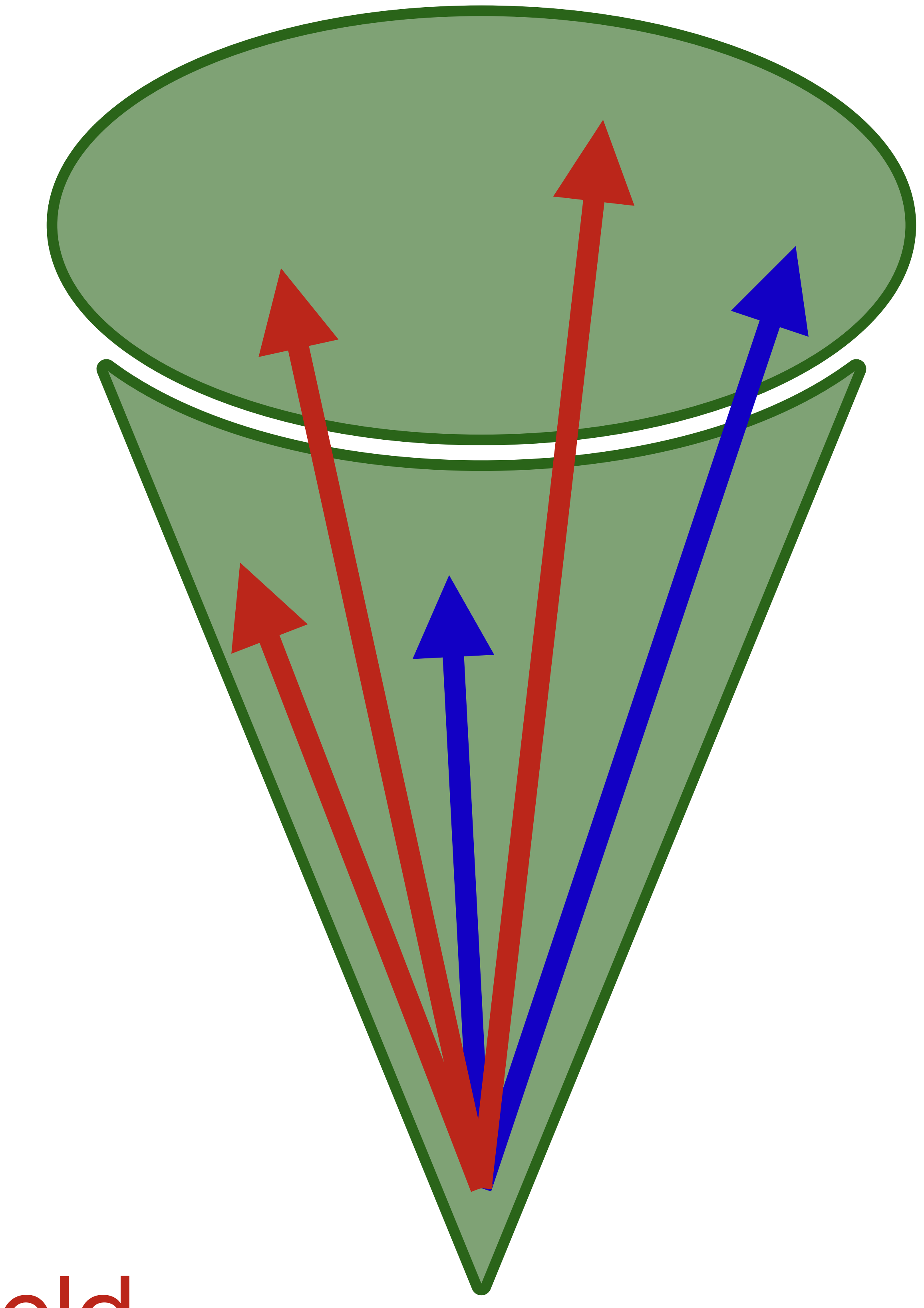


Cluster jets with charged particles using anti-k_T algorithm

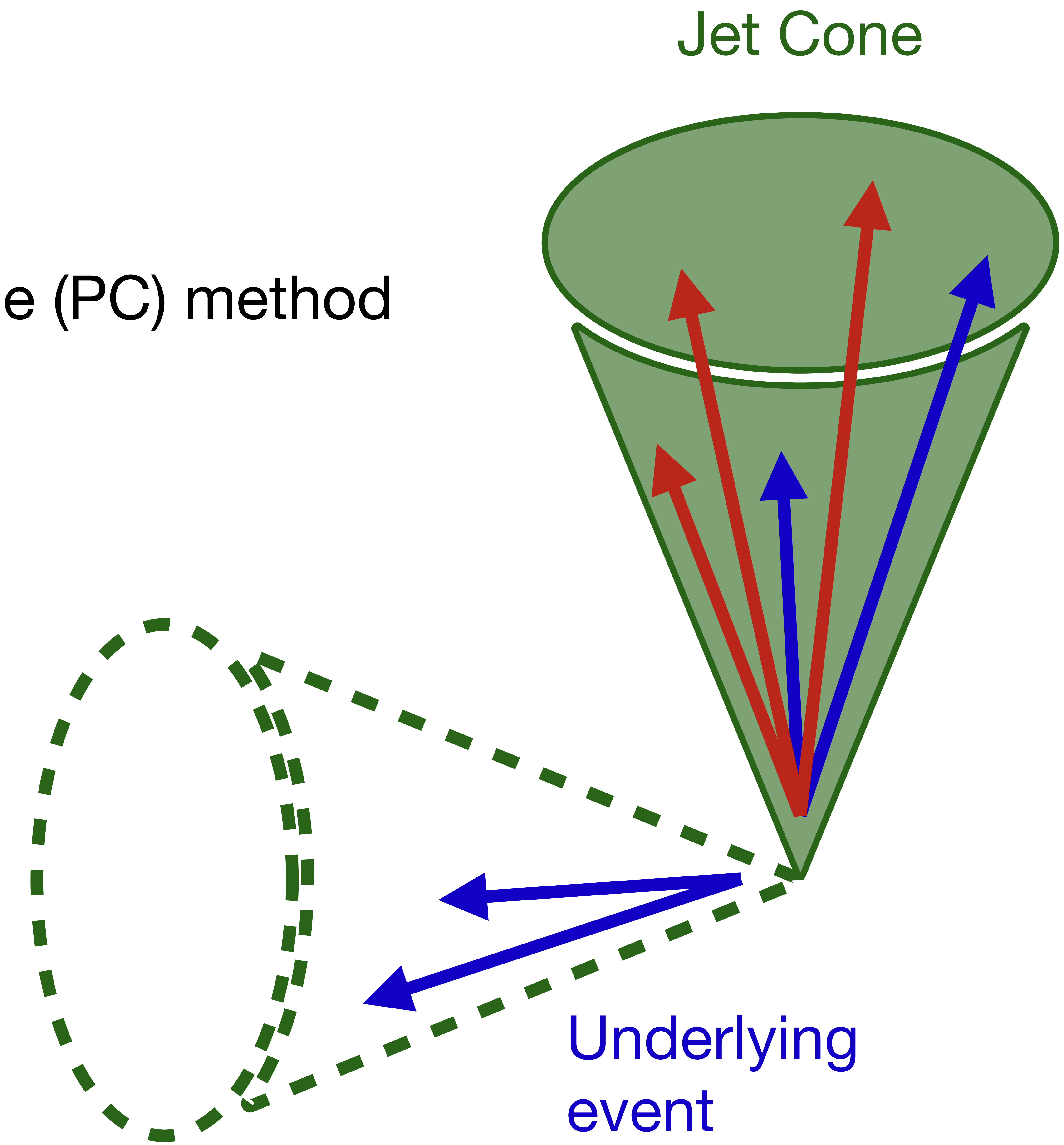
Reconstruct $K^0_S, \Lambda, \Xi, \Omega$

Measure strange hadrons within jet cone

Subtract underlying event (UE) contributions to find true jet yield

Yield in jets

Estimate UE yields with perpendicular cone (PC) method

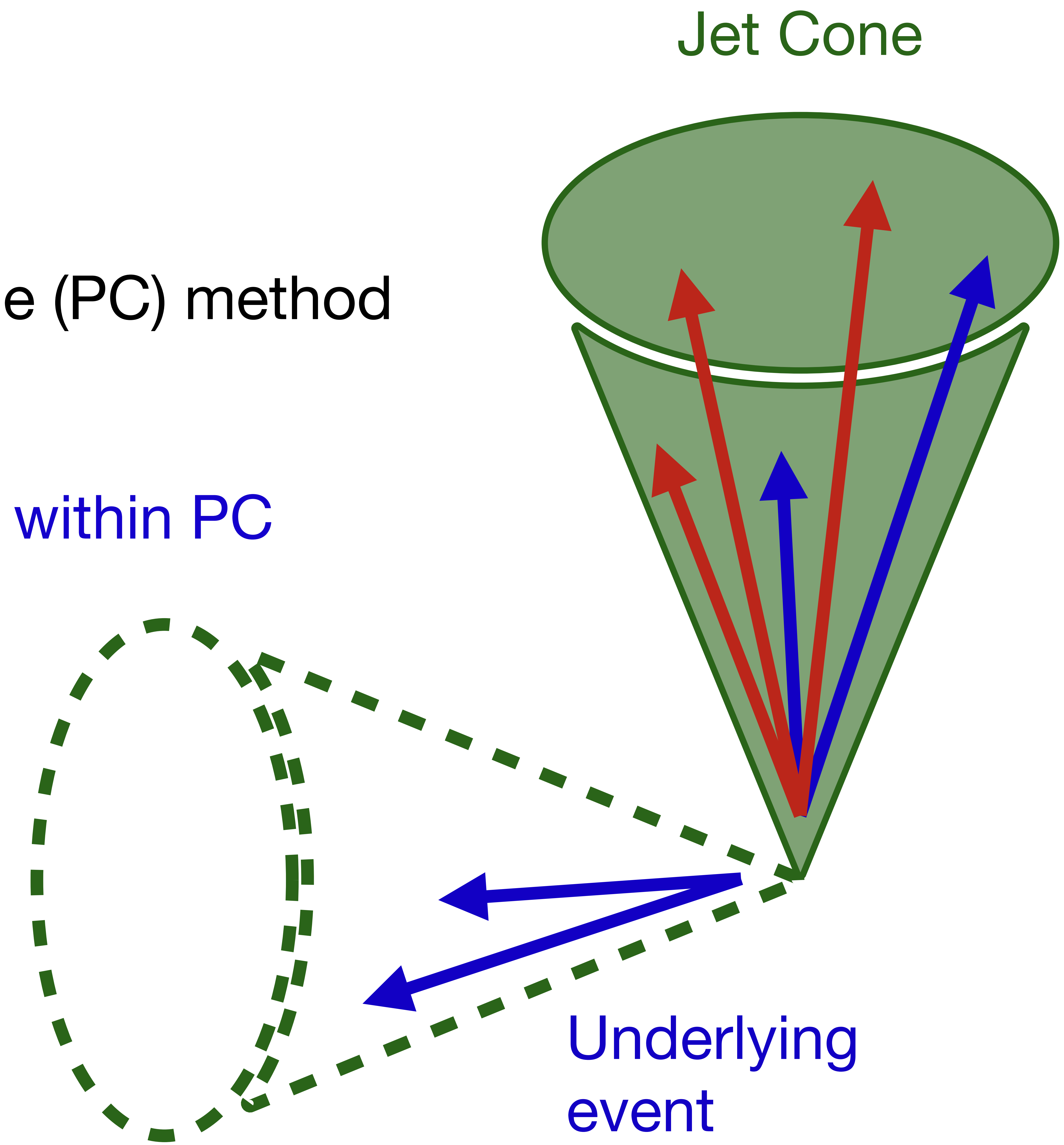


Yield in jets

Estimate UE yields with perpendicular cone (PC) method

Jet yield = yield within jet cone (JC) - yield within PC

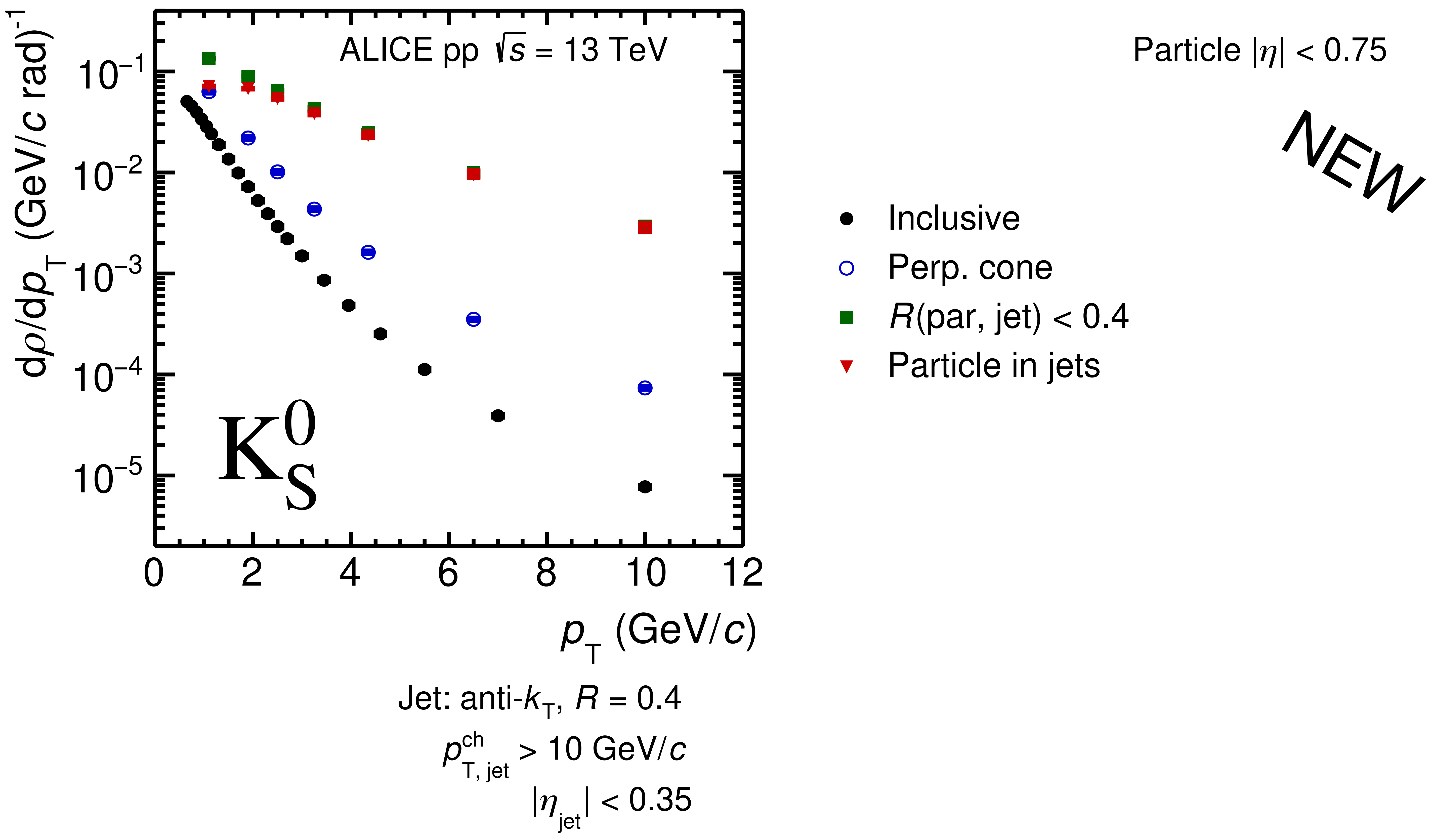
$$\frac{d\rho^{JE}}{dp_T} = \frac{d\rho^{JC}}{dp_T} - \frac{d\rho^{UE}}{dp_T}$$



pp Yields

Underlying event yield
has similar slope with p_T
as inclusive sample

High p_T is dominated
by jet fragmentation



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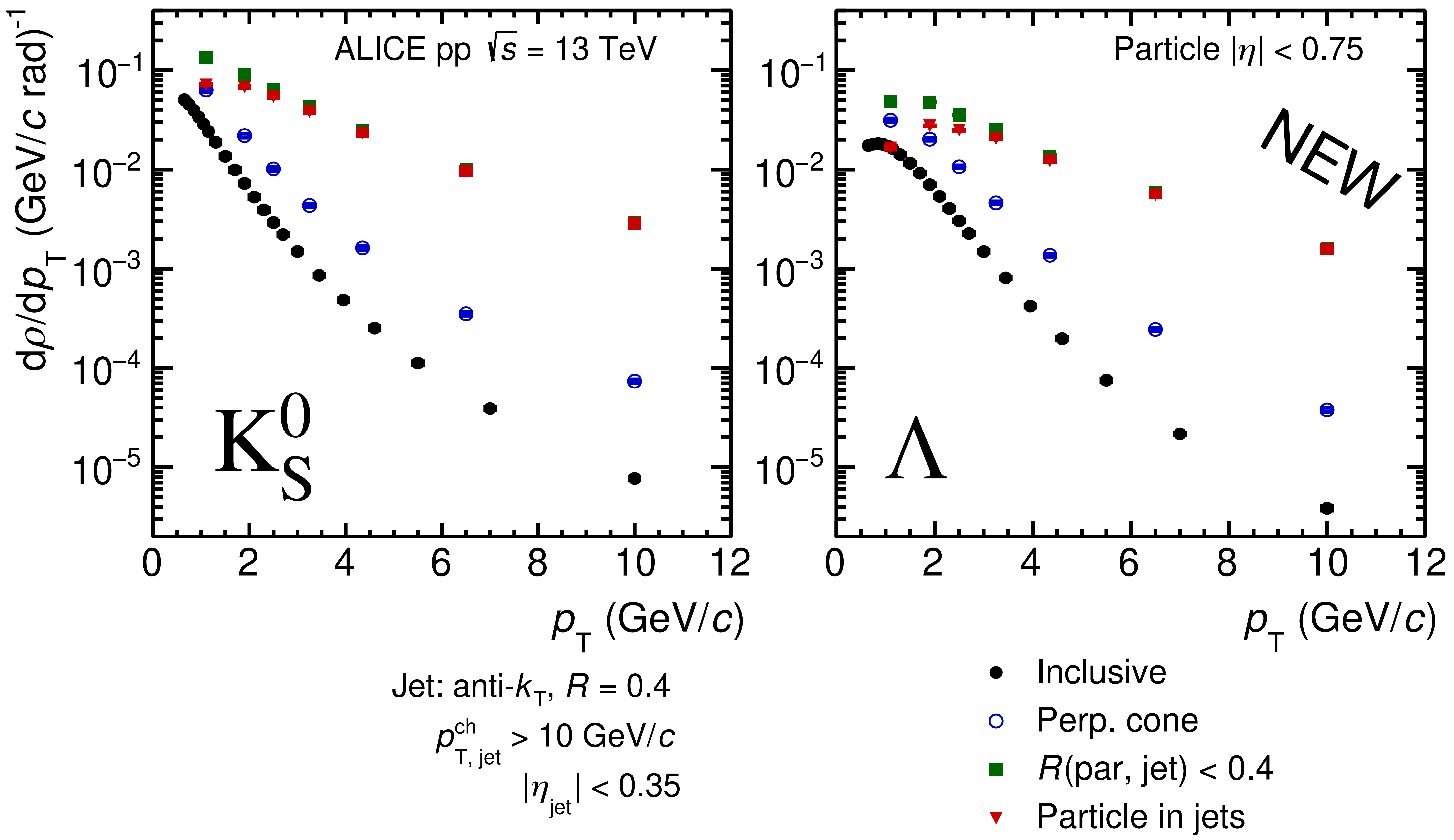

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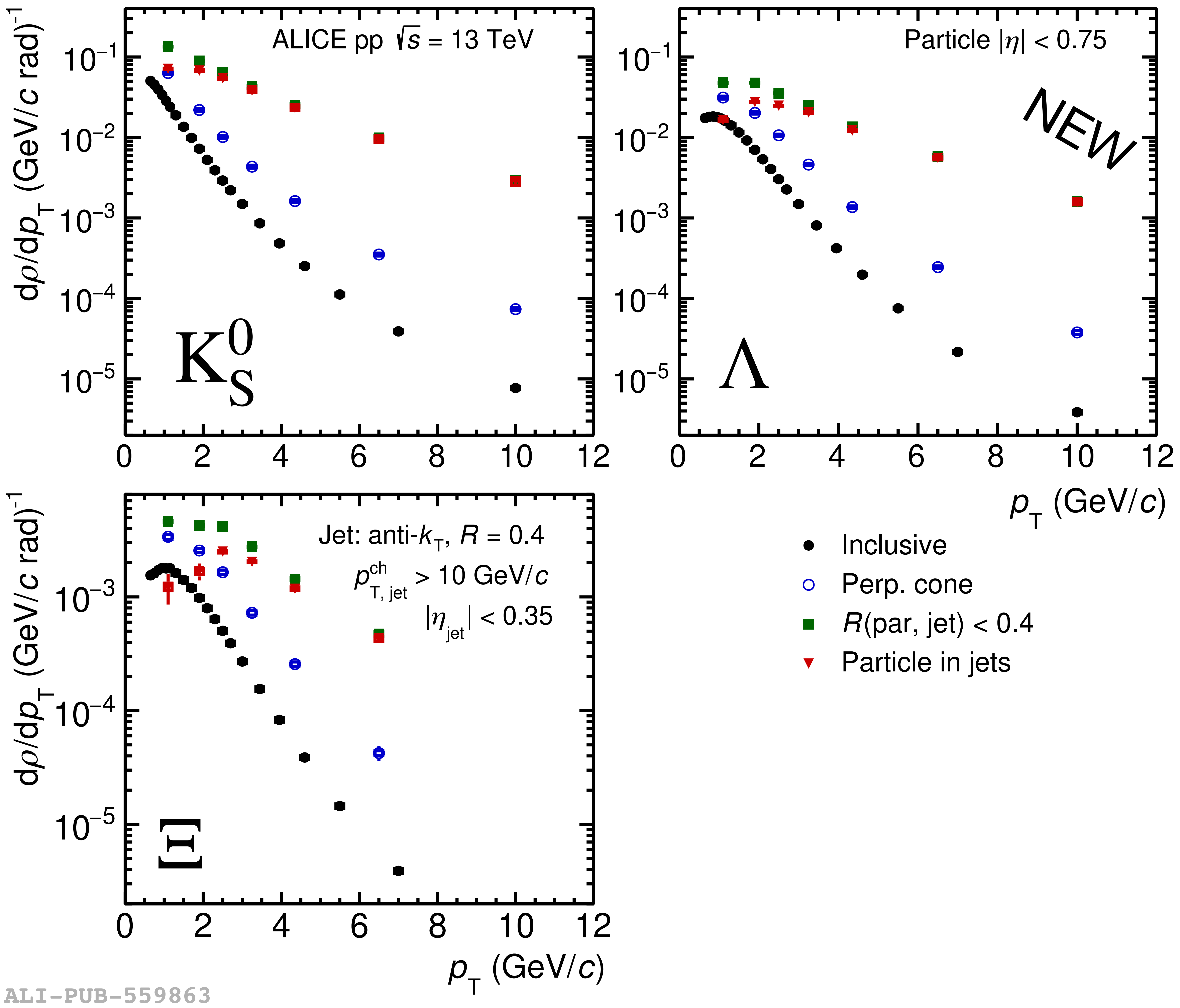
First measurement
of Ξ, Ω in jets



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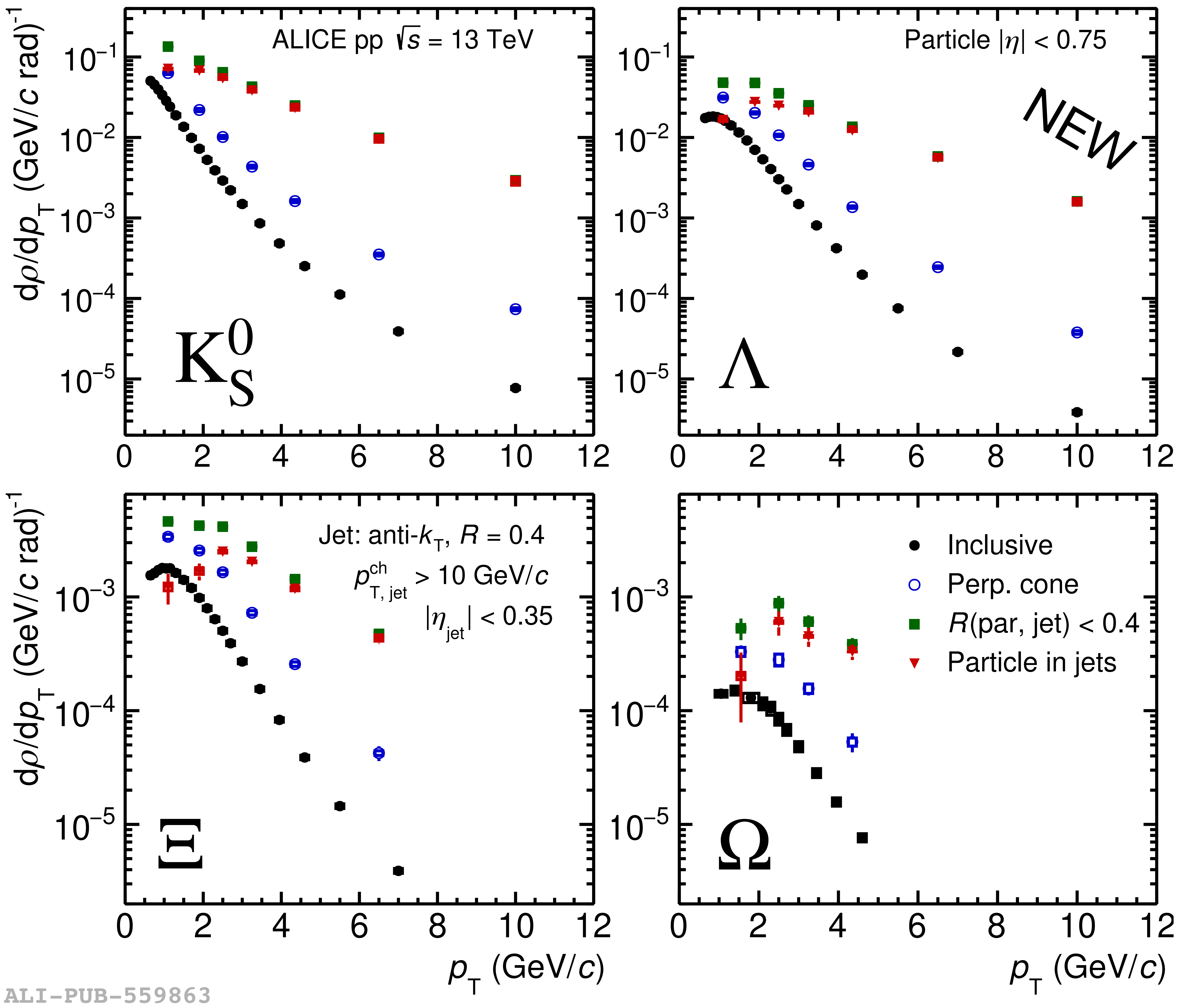
See posters by Jimun Lee
and Upasana Sharma



pp Yields: model comparison

NEW

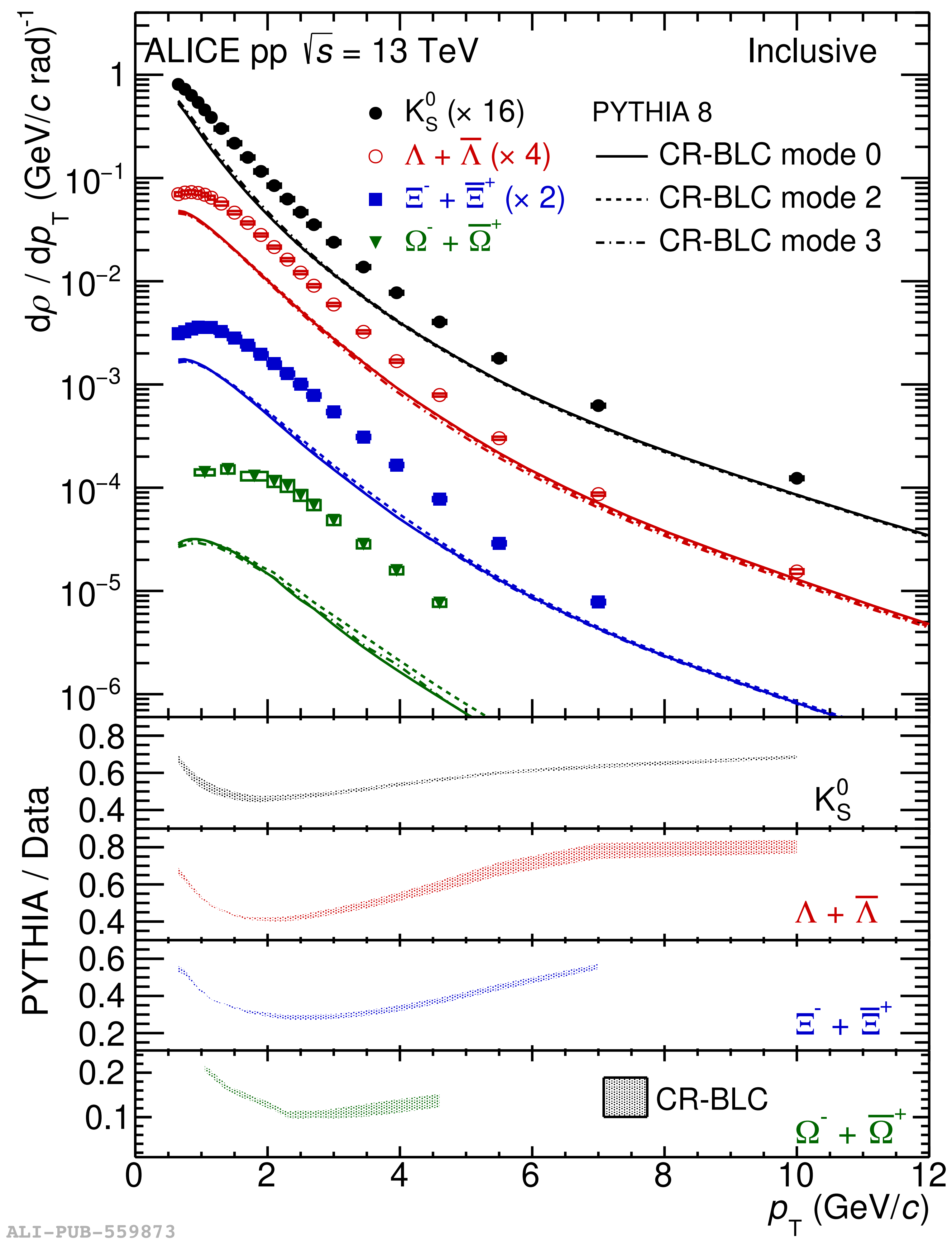
PYTHIA 8 with colour reconnection

Modes: time dilation constraints (none, strict, loose)

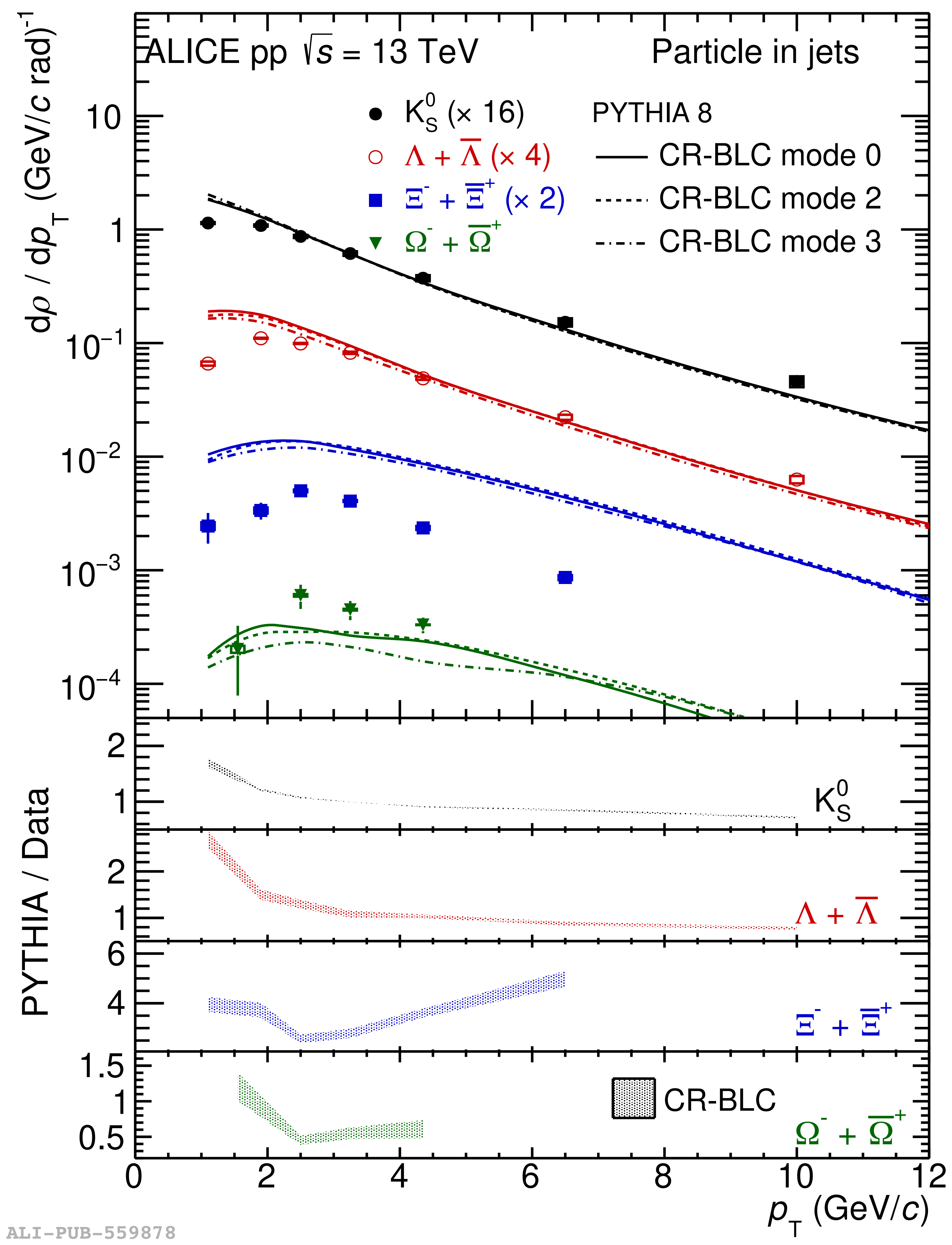
Only Λ and $\mathrm{K^0_S}$ in jets well-described for $p_{\mathrm{T}}^{\Lambda,\mathrm{K^0_S}} \gtrsim 2\ \mathrm{GeV}/c$

See talk by Chiara de Martin

Inclusive



In jets

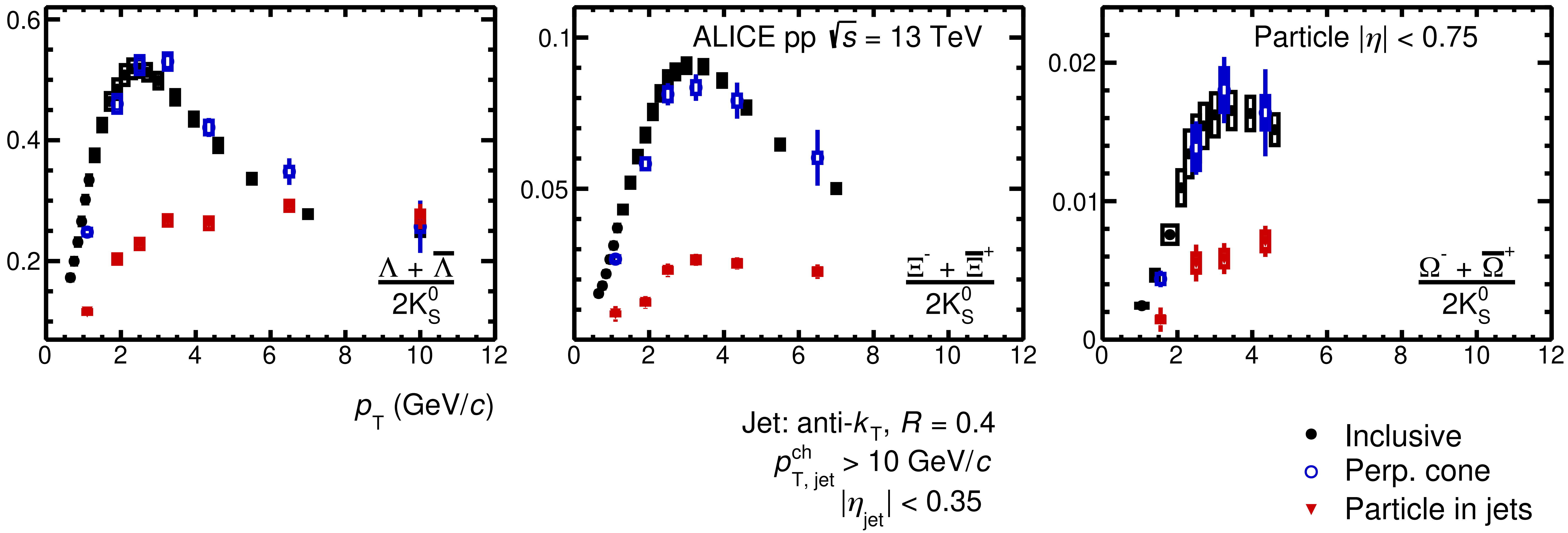


pp Yield ratios

NEW

$$\frac{\text{Baryon}}{\text{Meson}}$$

UE yield enhanced w.r.t. in-jet yield for $2 < p_T < 4$ GeV/c



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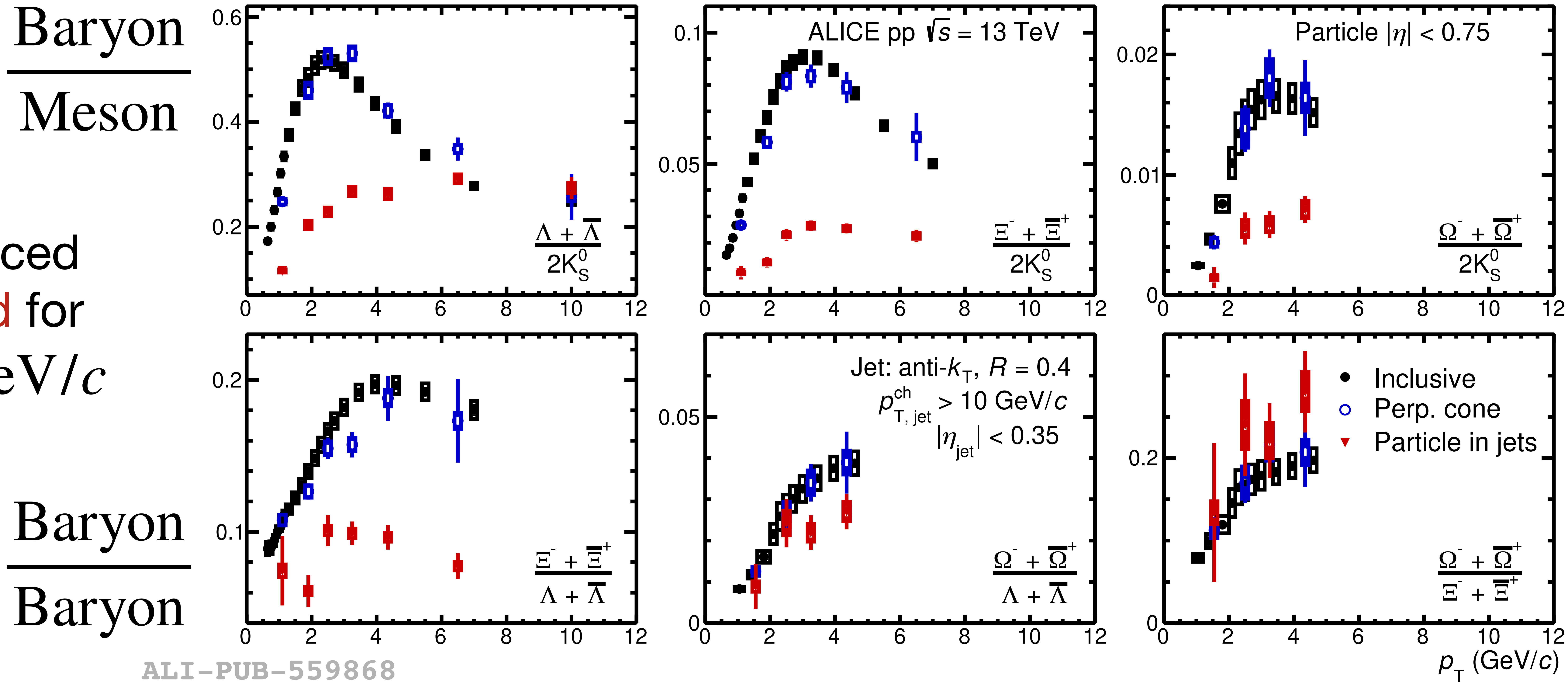


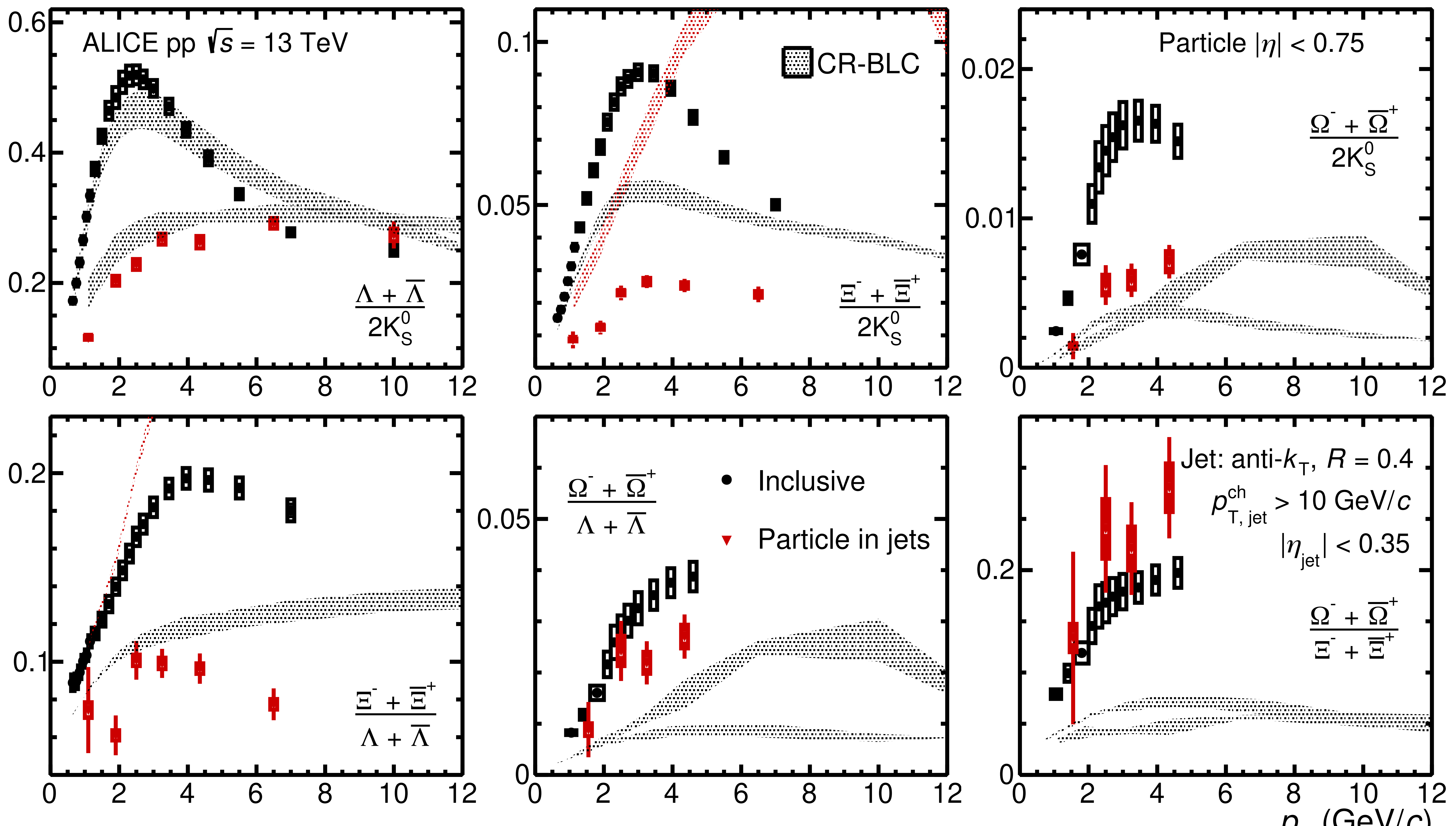
pp Yield ratios: model comparison

NEW

$\frac{\text{Baryon}}{\text{Meson}}$

Λ/K^0_S:
well-described by model both in jets and inclusive

$\frac{\text{Baryon}}{\text{Baryon}}$

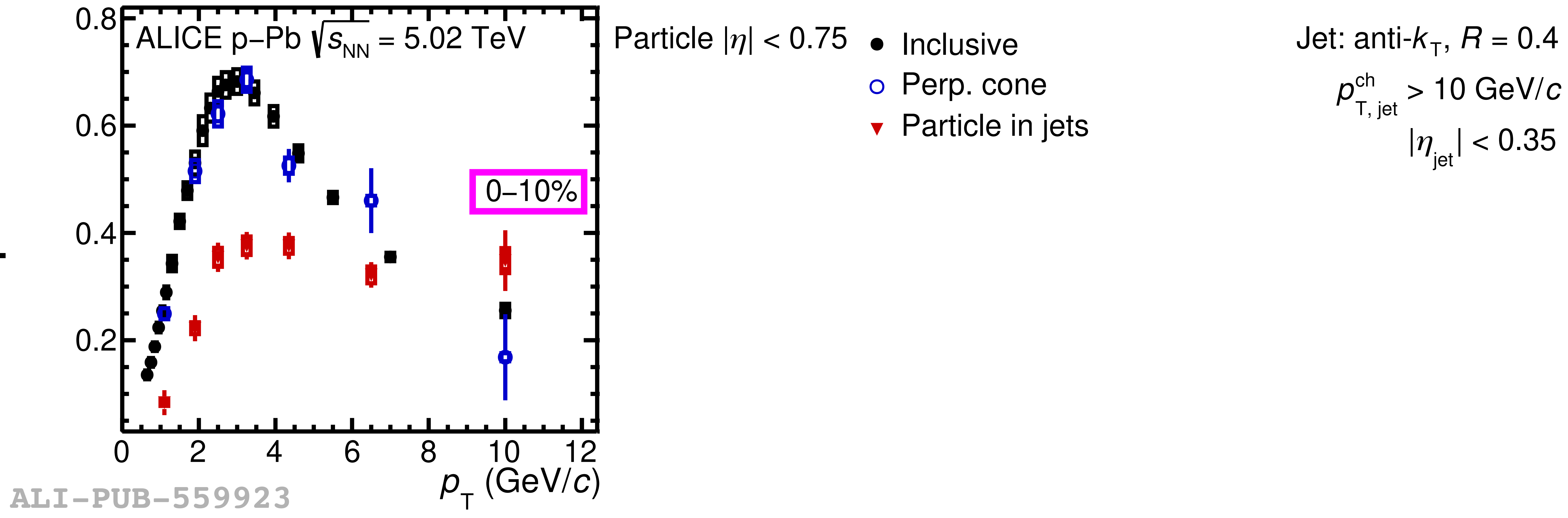


ALI-PUB-559883

p-Pb Yield ratios

NEW

$$\frac{\Lambda + \bar{\Lambda}}{2K^0_S}$$



UE yield is enhanced with centrality

In-jet yield not significantly enhanced

See talks by Roman Nepeivoda and Oliver Matonoha

p-Pb Yield ratios

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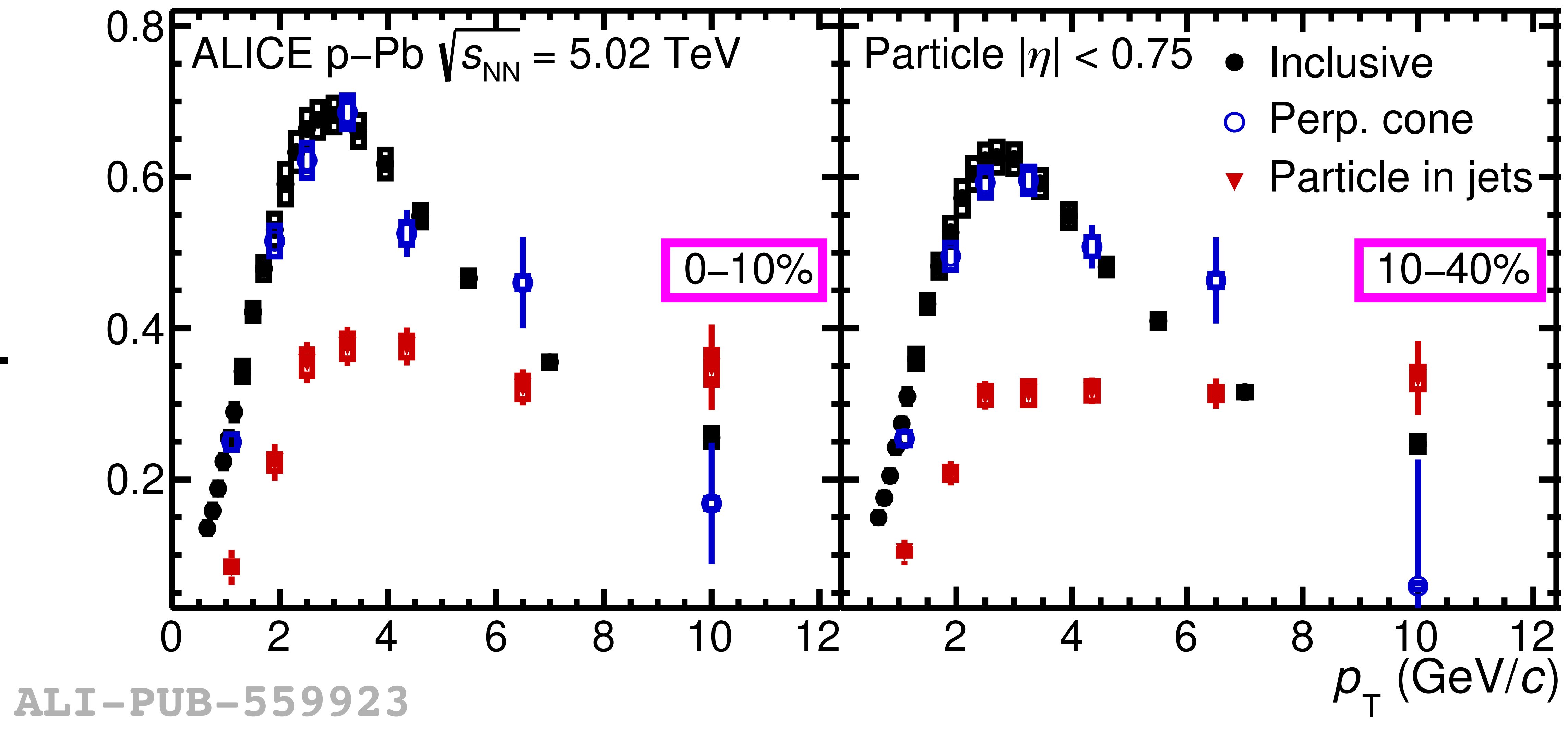

Jet: anti-k_T, R = 0.4
$p^{ch}_{T,jet}$ > 10 GeV/c
$|\eta_{jet}|$ < 0.35

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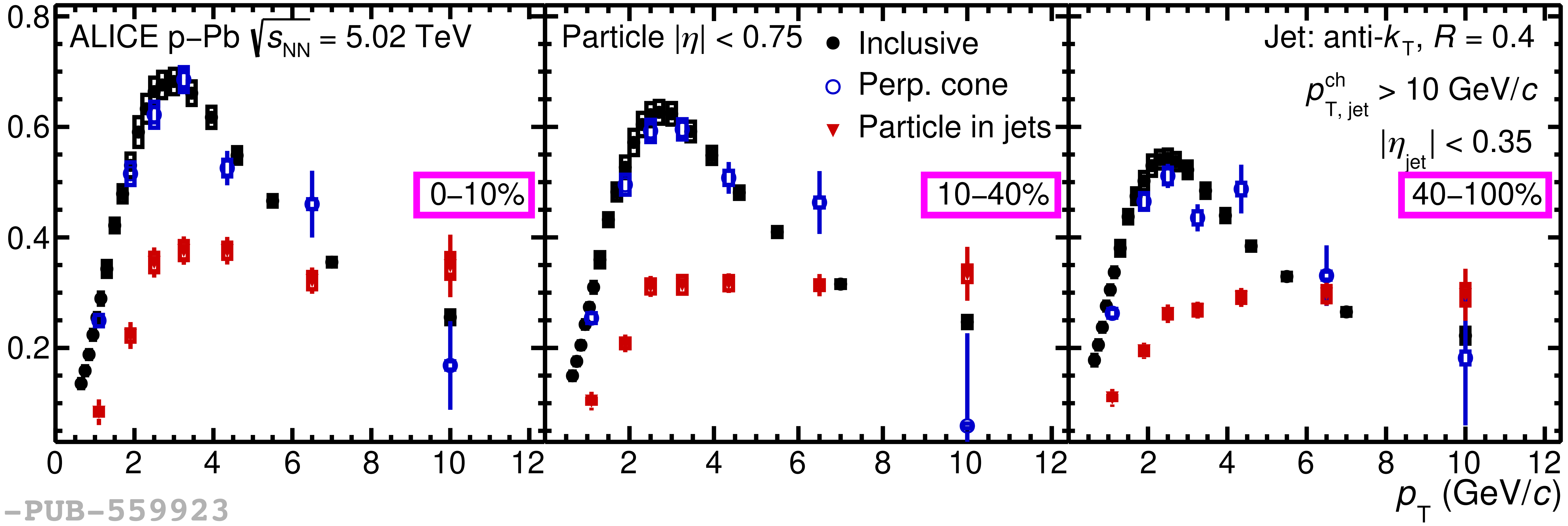

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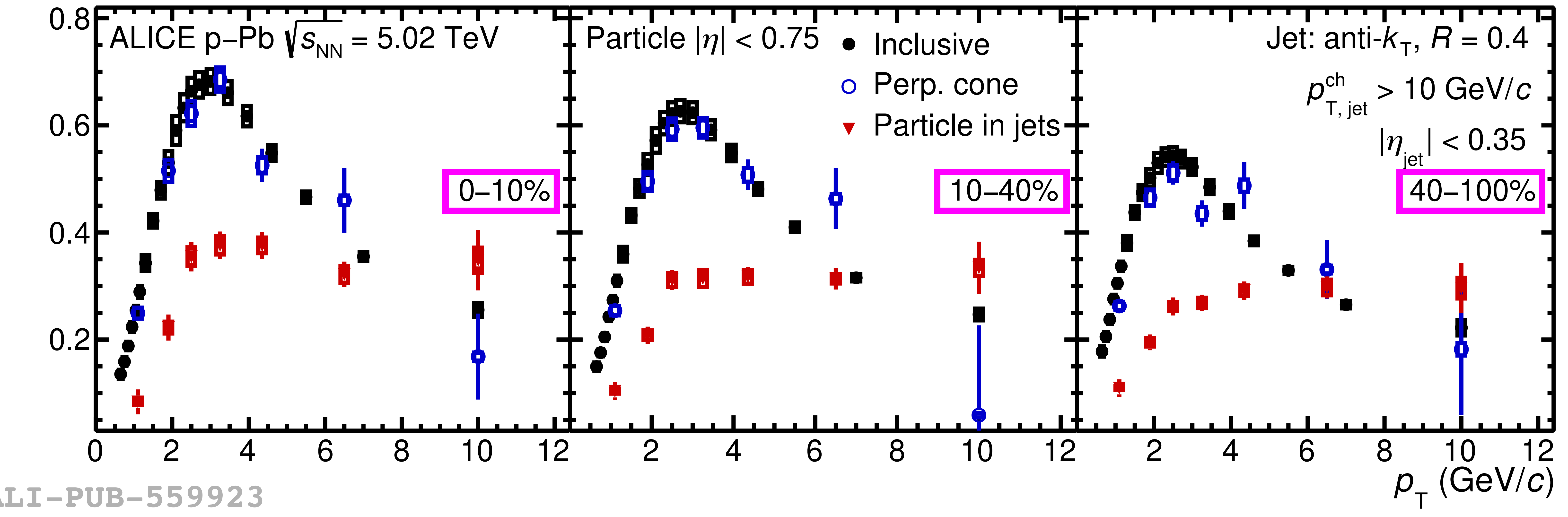

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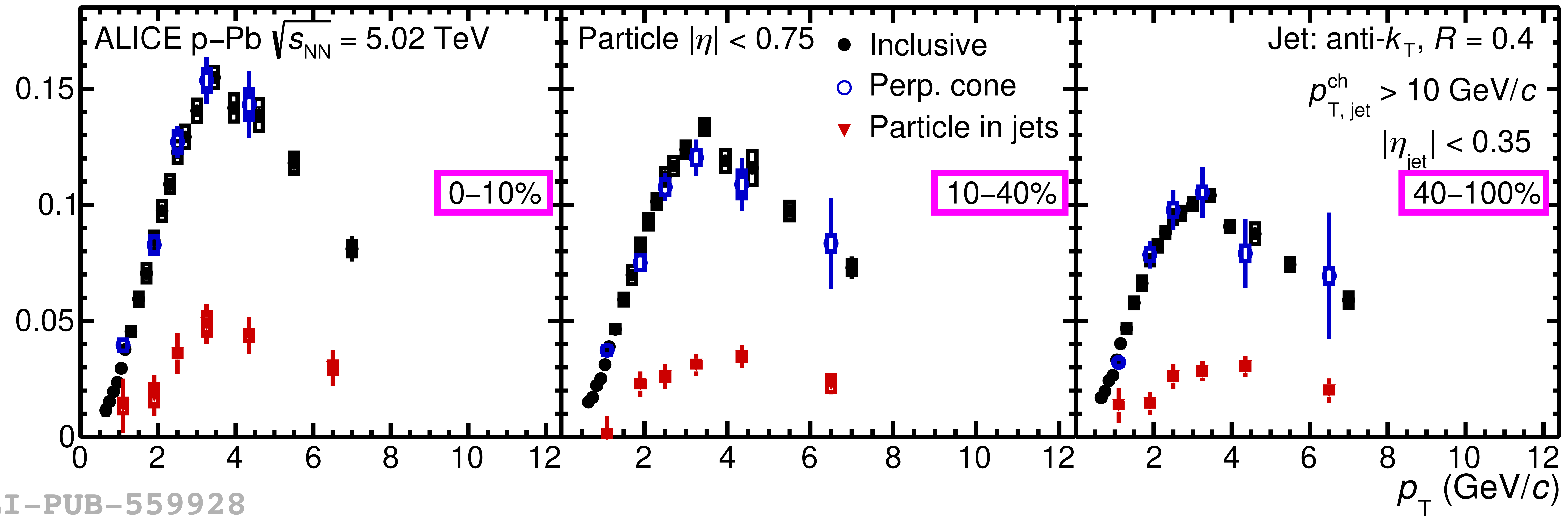
$$\frac{\Xi^- + \bar{\Xi}^+}{2K^0_S}$$



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p-Pb Yield ratios in jets

NEW

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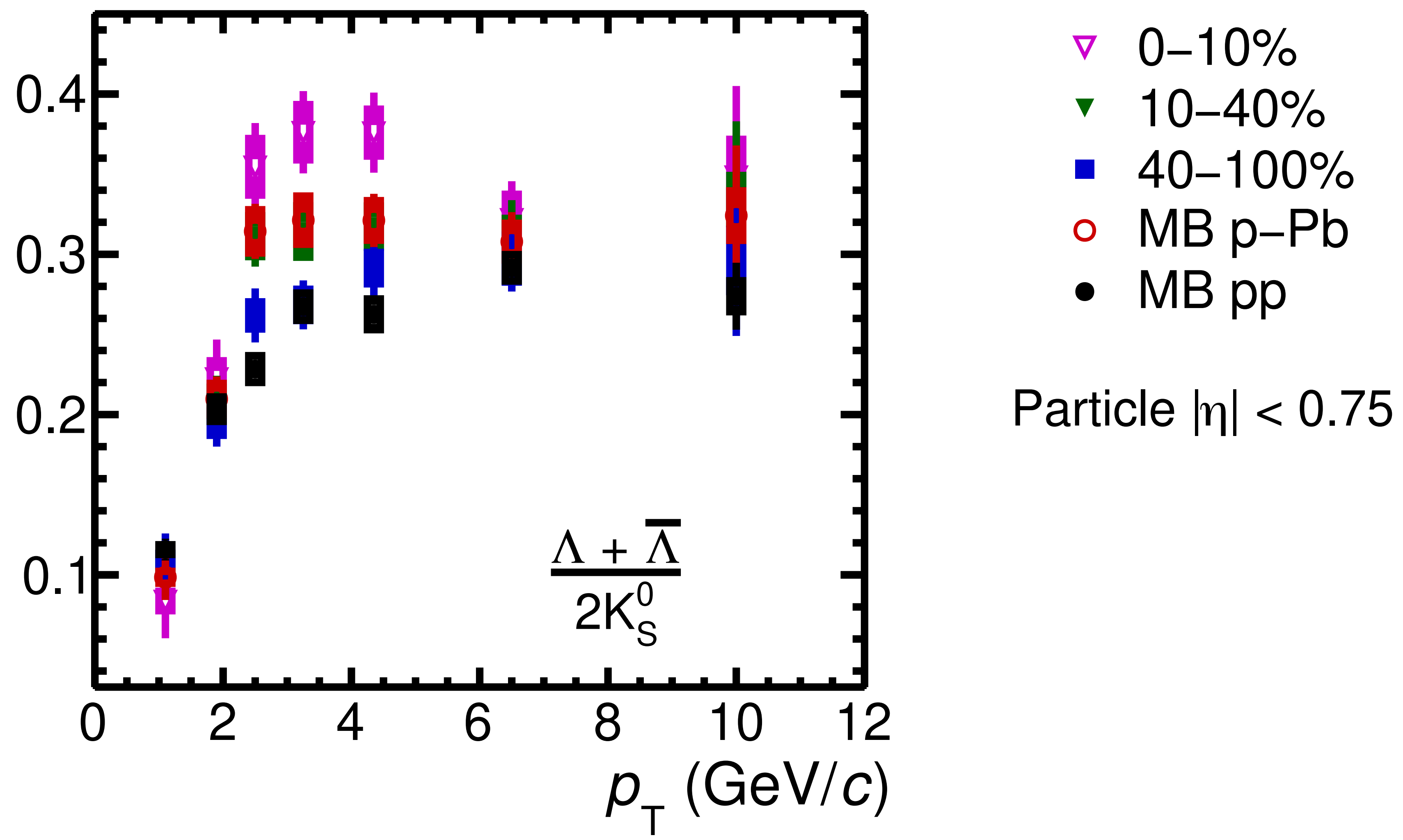
$$\frac{\text{Baryon}}{\text{Meson}}$$



$$\frac{\Lambda + \bar{\Lambda}}{2K^0_S}$$

ALI-PUB-559893

1σ enhancement of 0-10% over 40-100%

1σ enhancement of MB p-Pb over MB pp

p-Pb Yield ratios in jets

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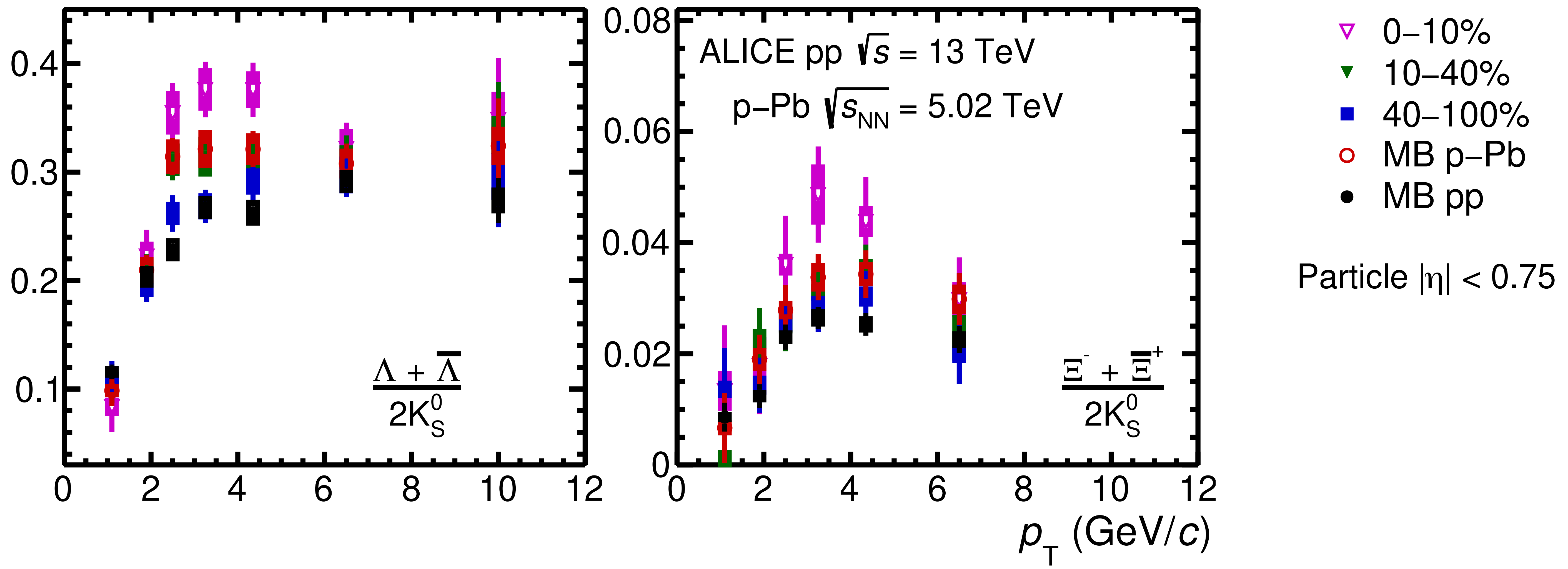

$$\frac{\Lambda + \bar{\Lambda}}{2K^0_S} \qquad \frac{\Xi^- + \bar{\Xi}^+}{2K^0_S}$$

ALI-PUB-559893

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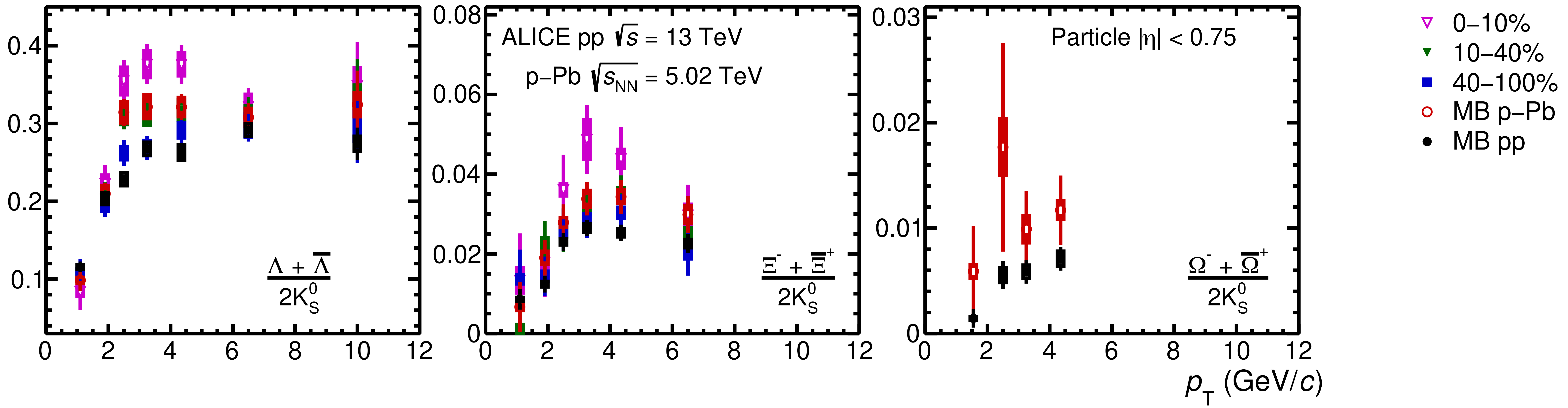


$$\frac{\Lambda + \bar{\Lambda}}{2K^0_S} \qquad \frac{\Xi^- + \bar{\Xi}^+}{2K^0_S} \qquad \frac{\Omega^- + \bar{\Omega}^+}{2K^0_S}$$

ALI-PUB-559893

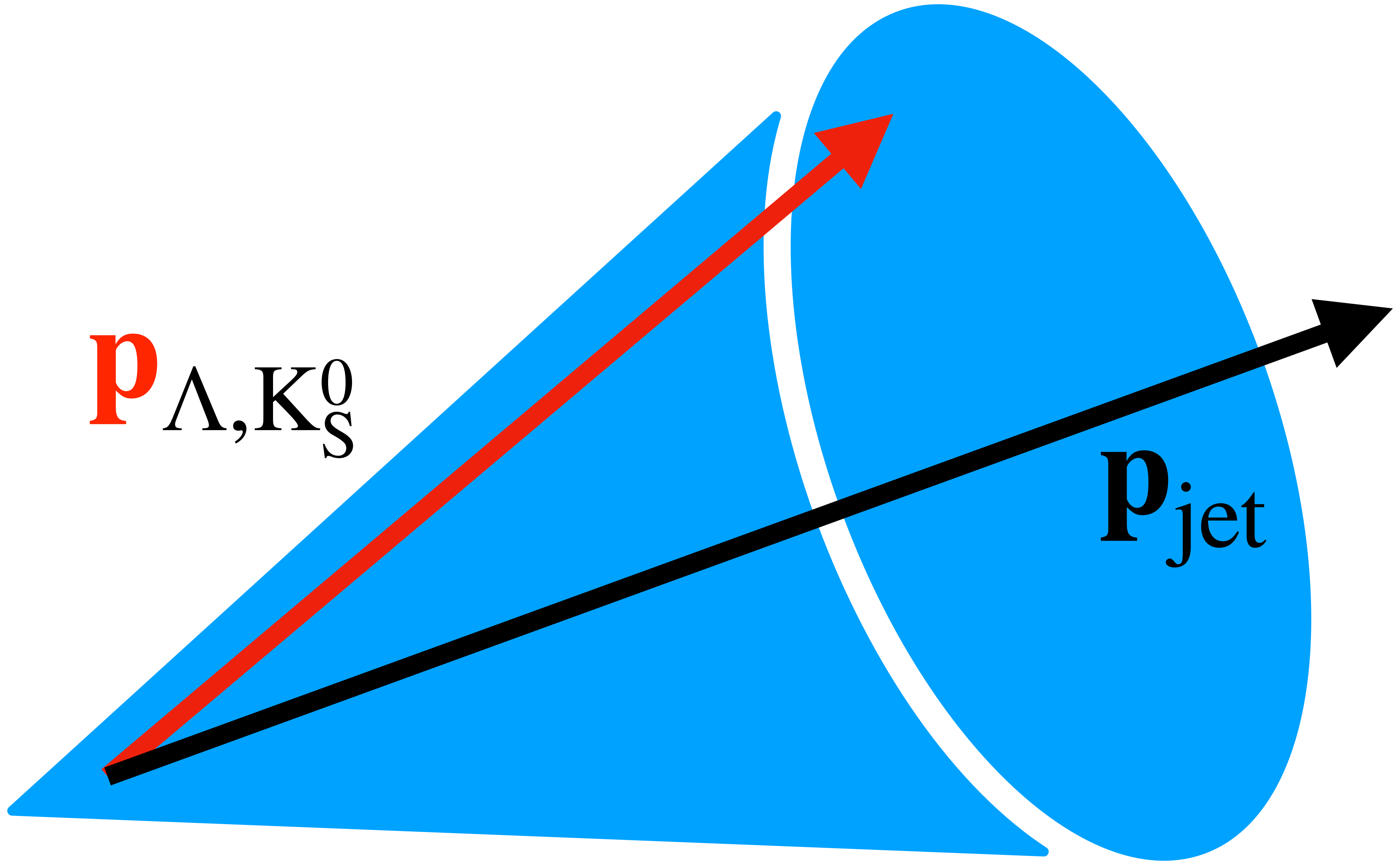
1σ enhancement of 0-10% over 40-100%

1σ enhancement of MB p-Pb over MB pp

Ω: insufficient statistics for centrality-differential analysis

Jet fragmentation

Jet fragmentation into Λ, K^0_S with Run 3



See talk by Joshua Koenig

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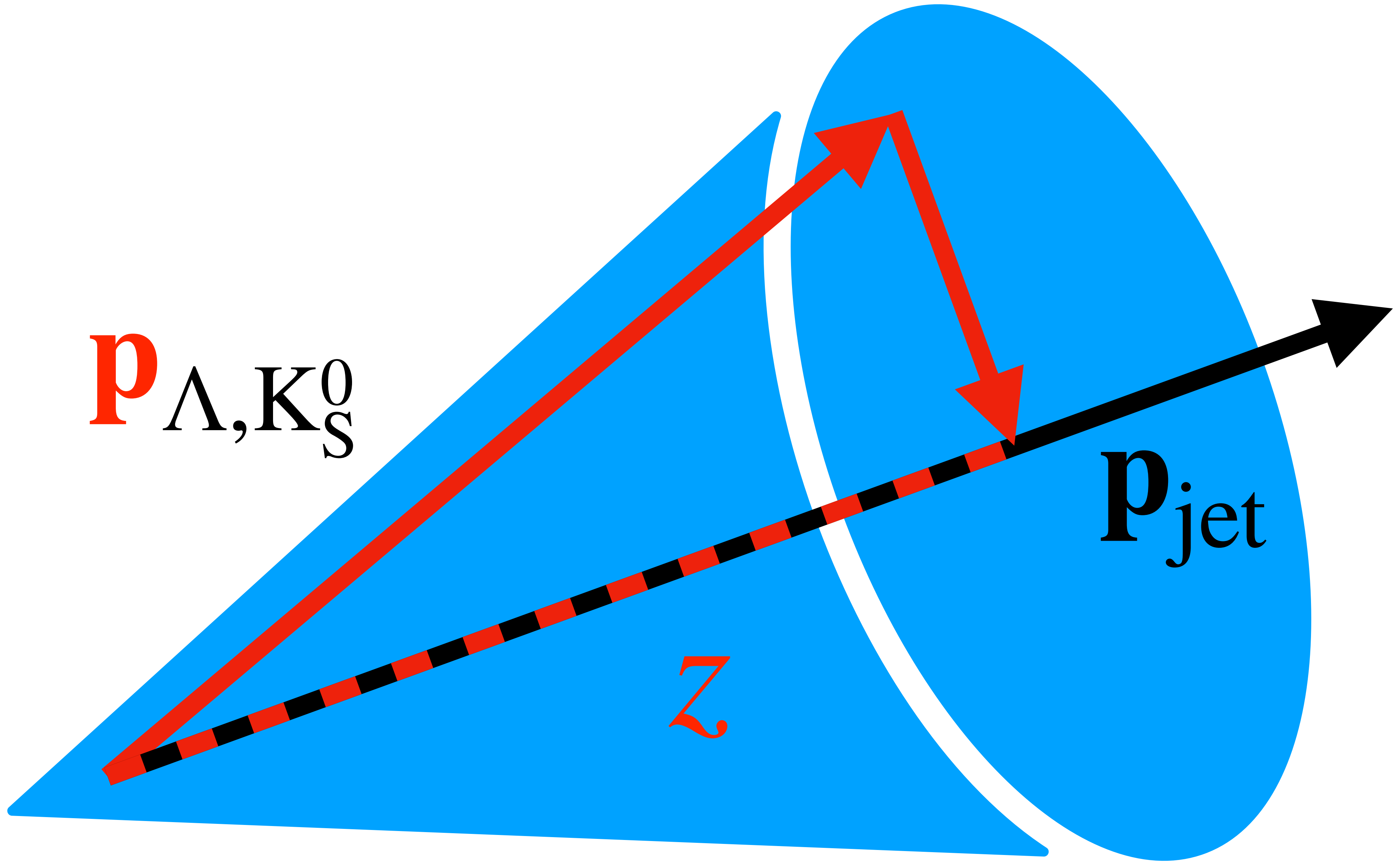

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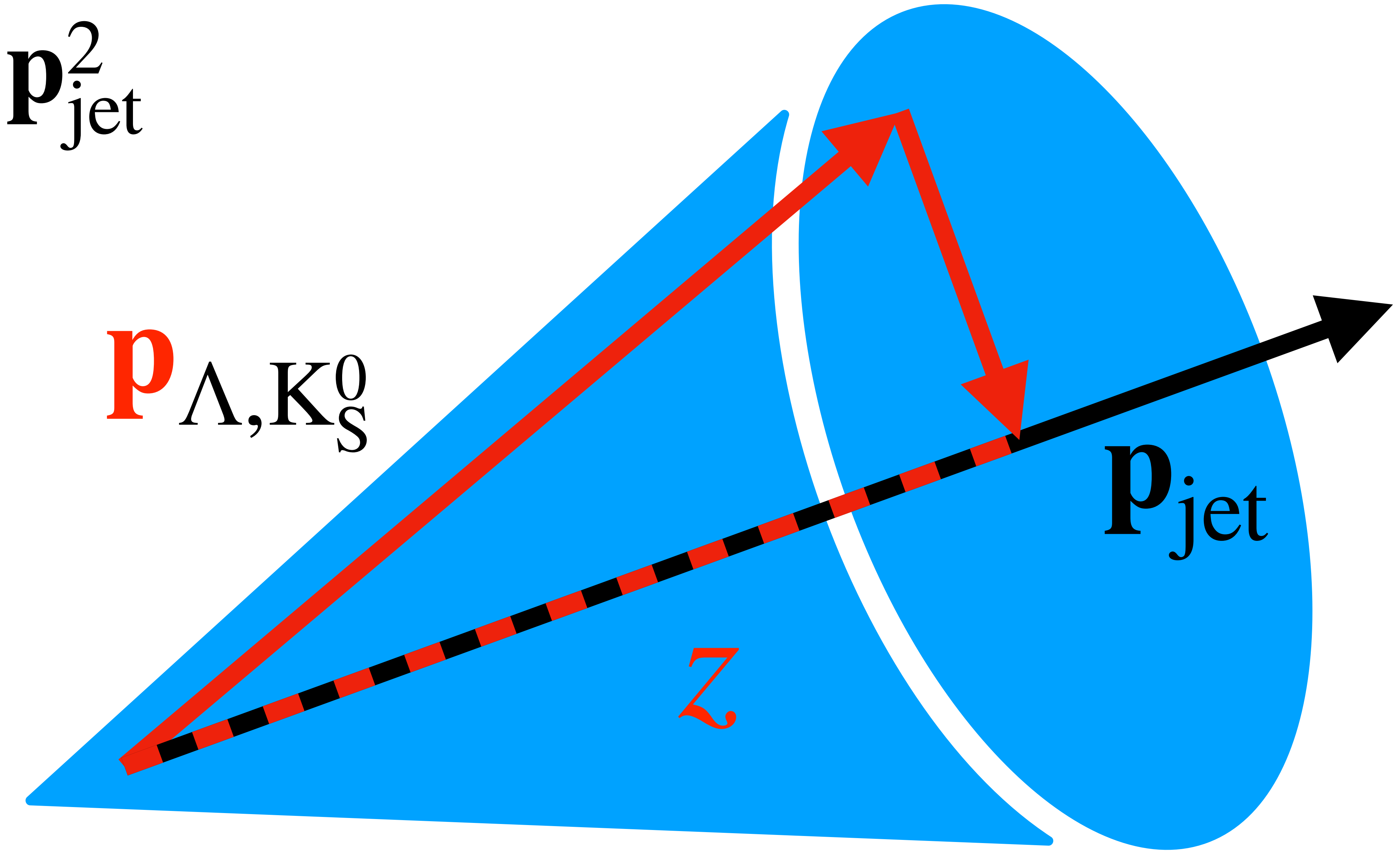
Jet fragmentation into $\Lambda, \mathrm{K^0_S}$ with Run 3

$$z_{\Lambda,\mathrm{K^0_S}} = \frac{\mathbf{p}_{\Lambda,\mathrm{K^0_S}} \cdot \mathbf{p}_{\mathrm{jet}}}{\mathbf{p}^2_{\mathrm{jet}}}$$



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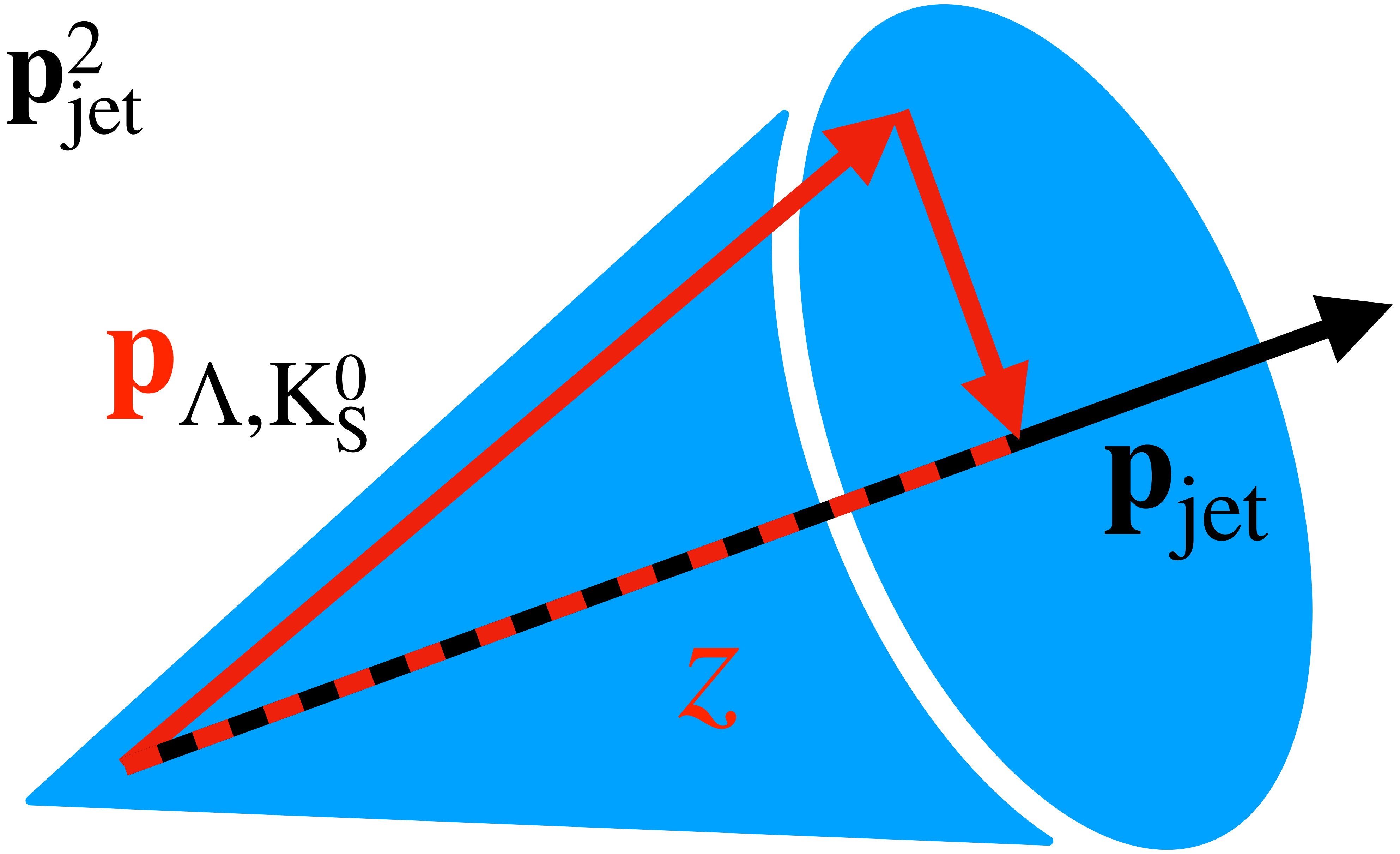
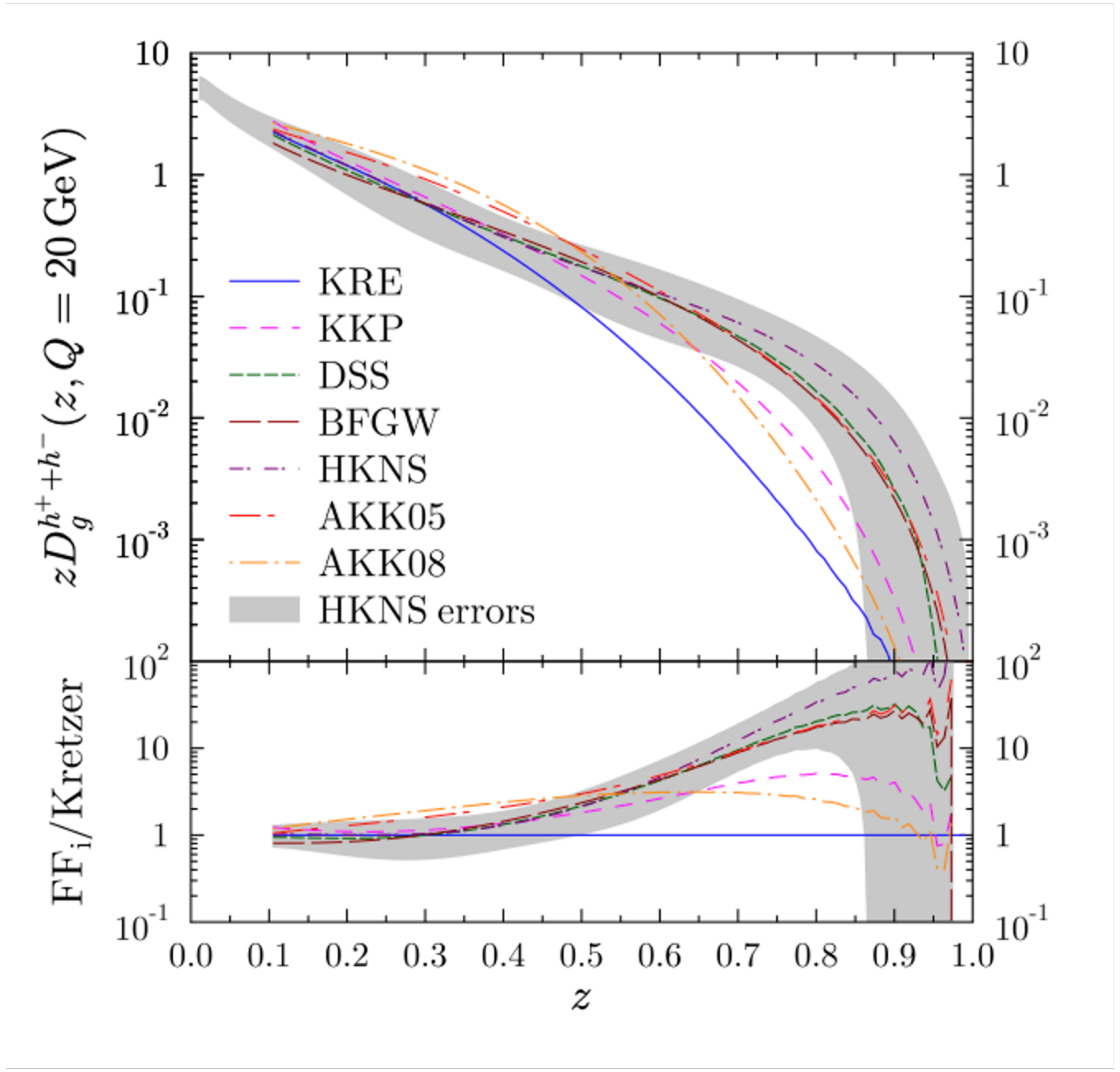


Gluon → charged hadrons



Describes how jets shower and hadronise

See talk by Joshua Koenig

d'Enterria et al.: Nucl.Phys.B 883 (2014) 615-628

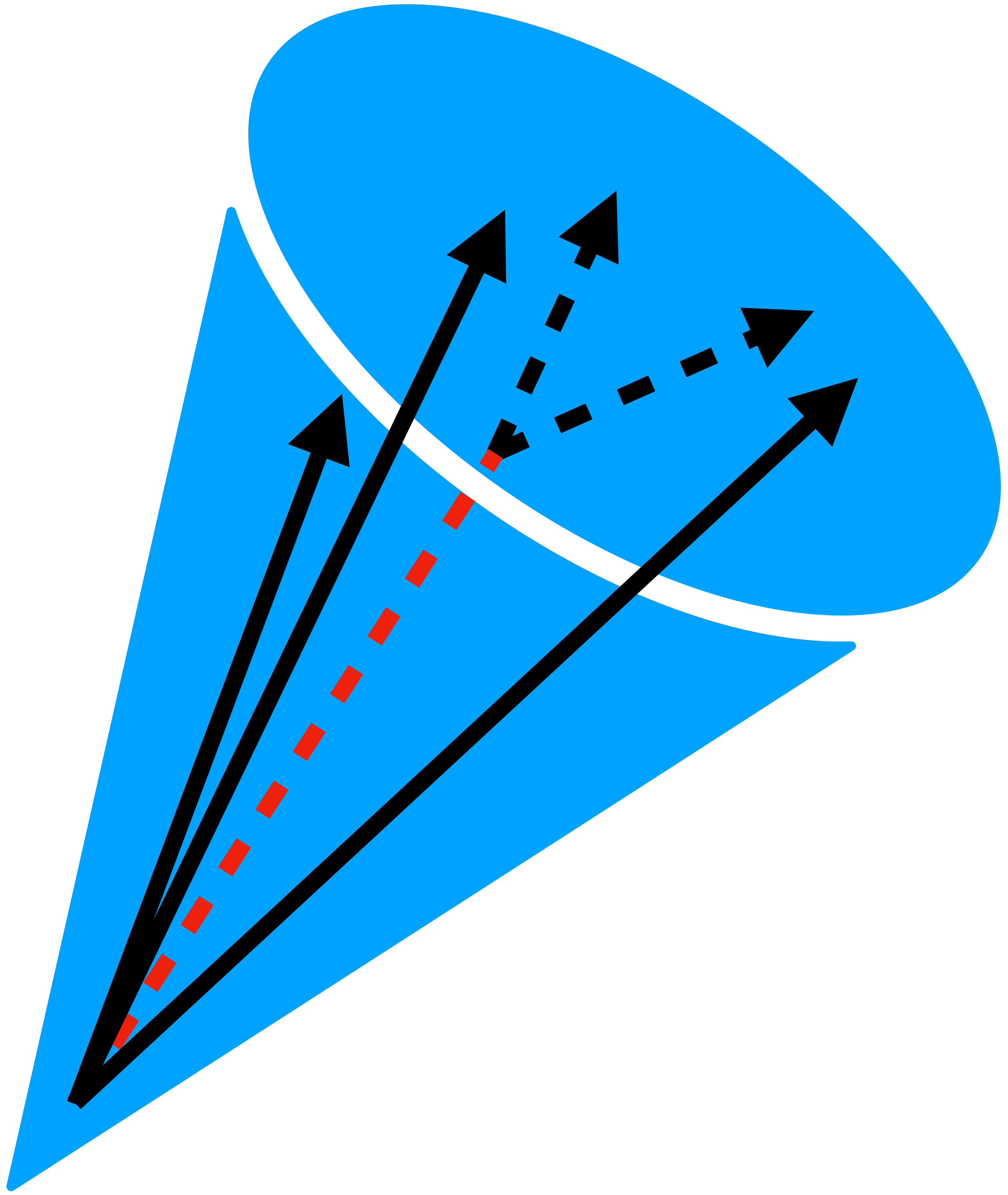
Jet fragmentation

Jet fragmentation into $\Lambda, \mathrm{K}^0_\mathrm{S}$ with Run 3

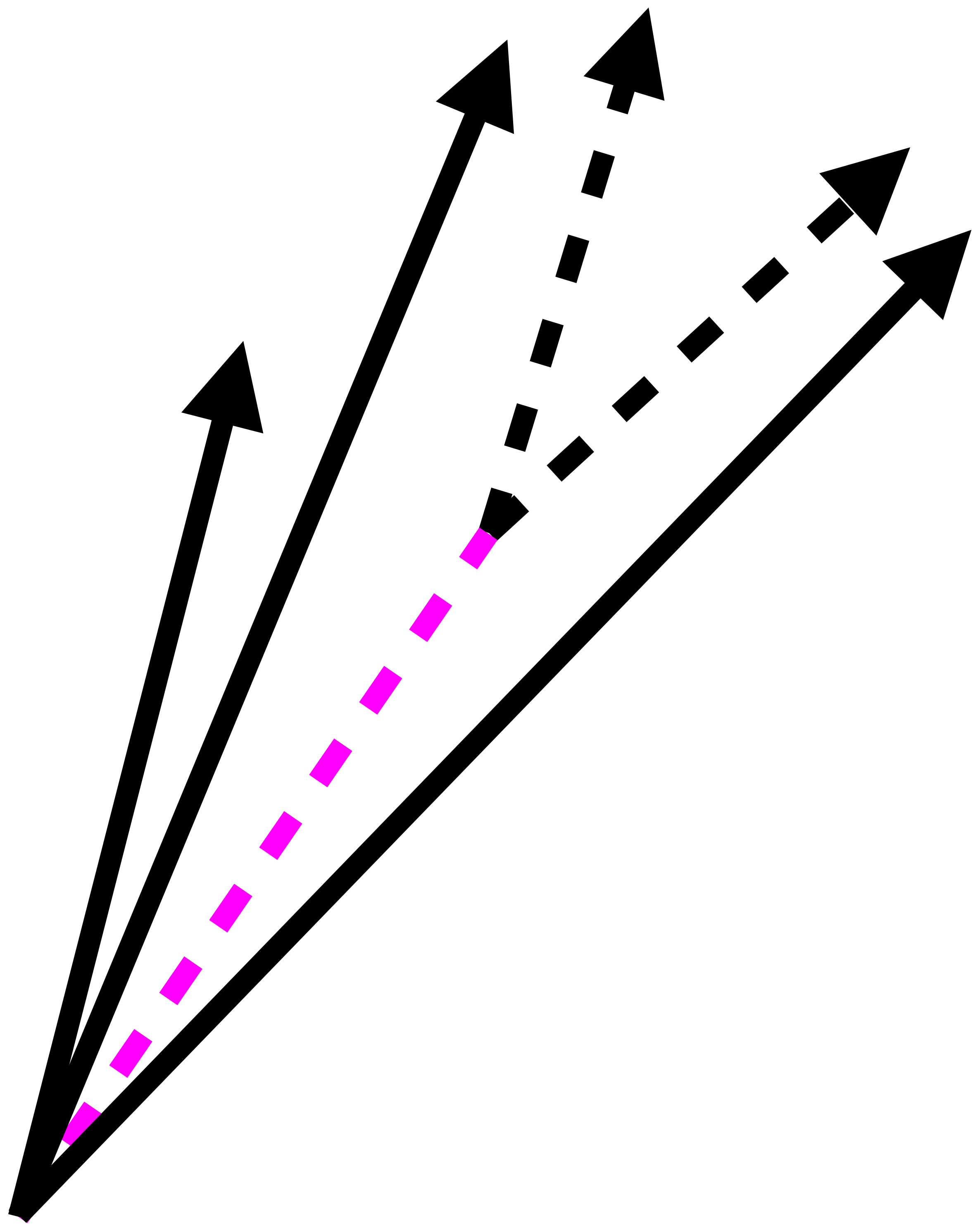
$$z_{\Lambda,\mathrm{K}^0_\mathrm{S}} = \frac{\mathbf{p}_{\Lambda,\mathrm{K}^0_\mathrm{S}} \cdot \mathbf{p}_\mathrm{jet}}{\mathbf{p}^2_\mathrm{jet}}$$

Not yield inside jet cone,
but $\Lambda, \mathrm{K}^0_\mathrm{S}$ candidates $(\mathrm{V0})$
included as input for jet clustering

Due to long lifetimes, $\Lambda, \mathrm{K}^0_\mathrm{S}$ decay
daughters are removed from jet clustering input



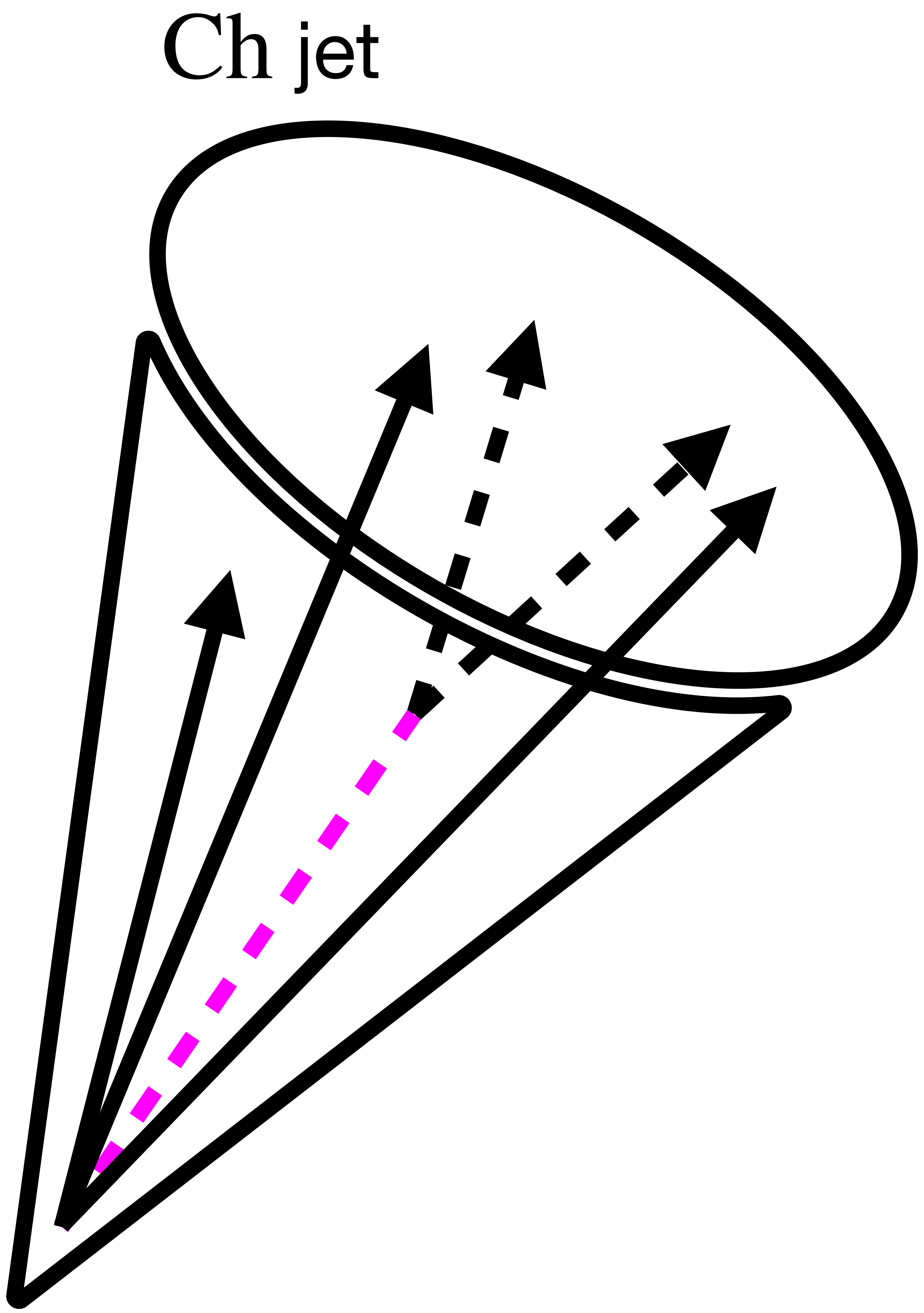
Jet fragmentation



Charged particles

V0 particle

Jet fragmentation



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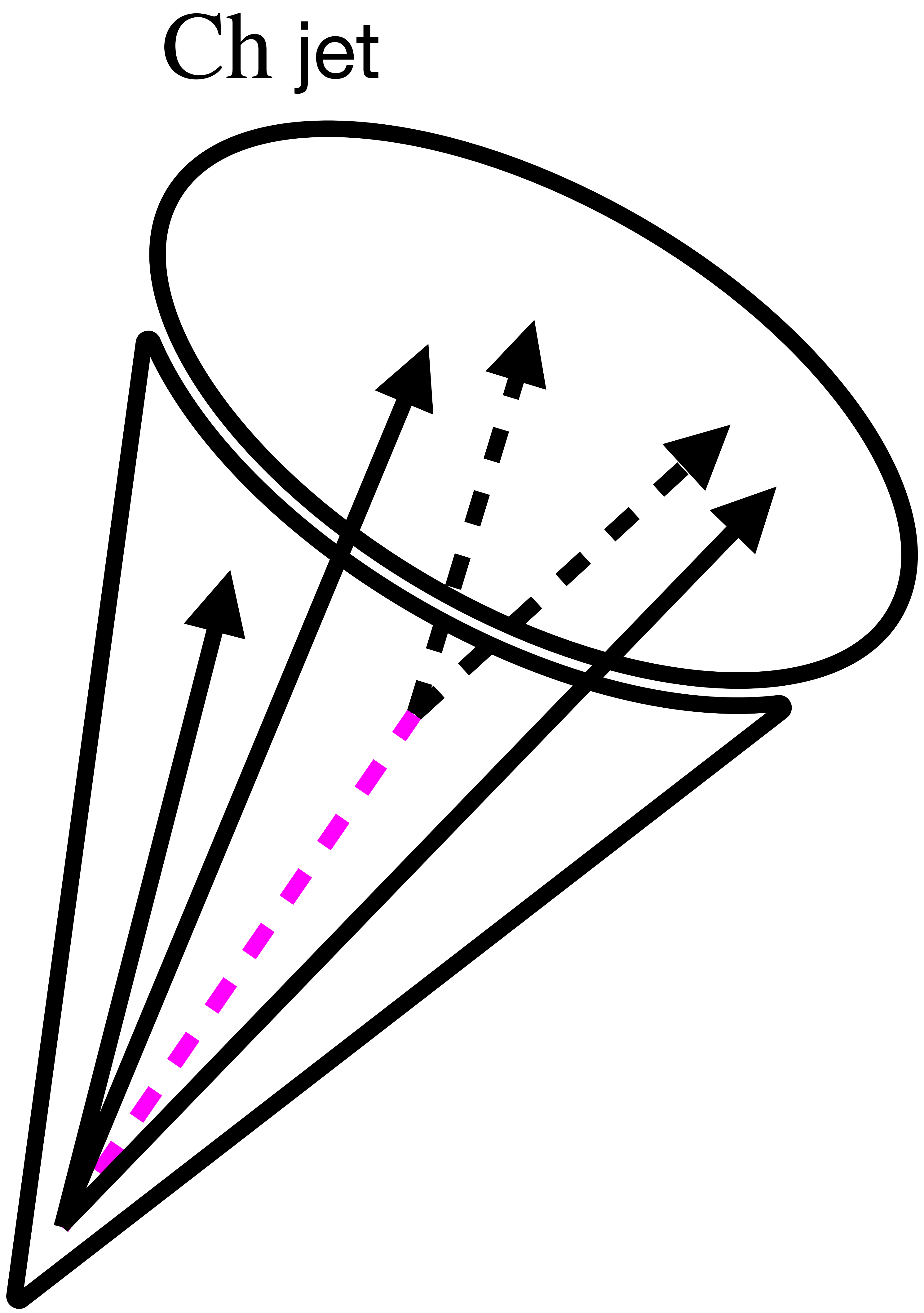
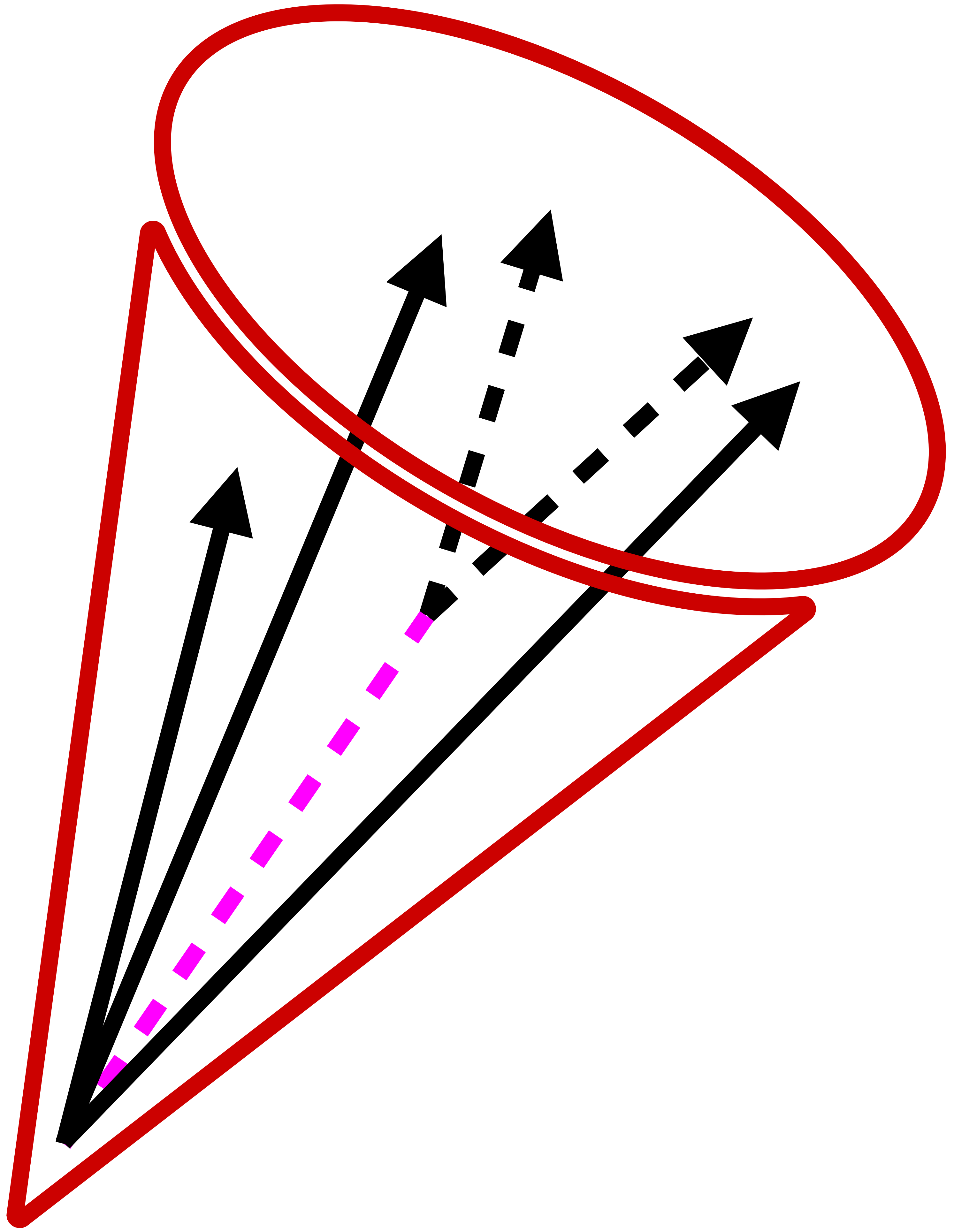
V0 particle

Jet fragmentation





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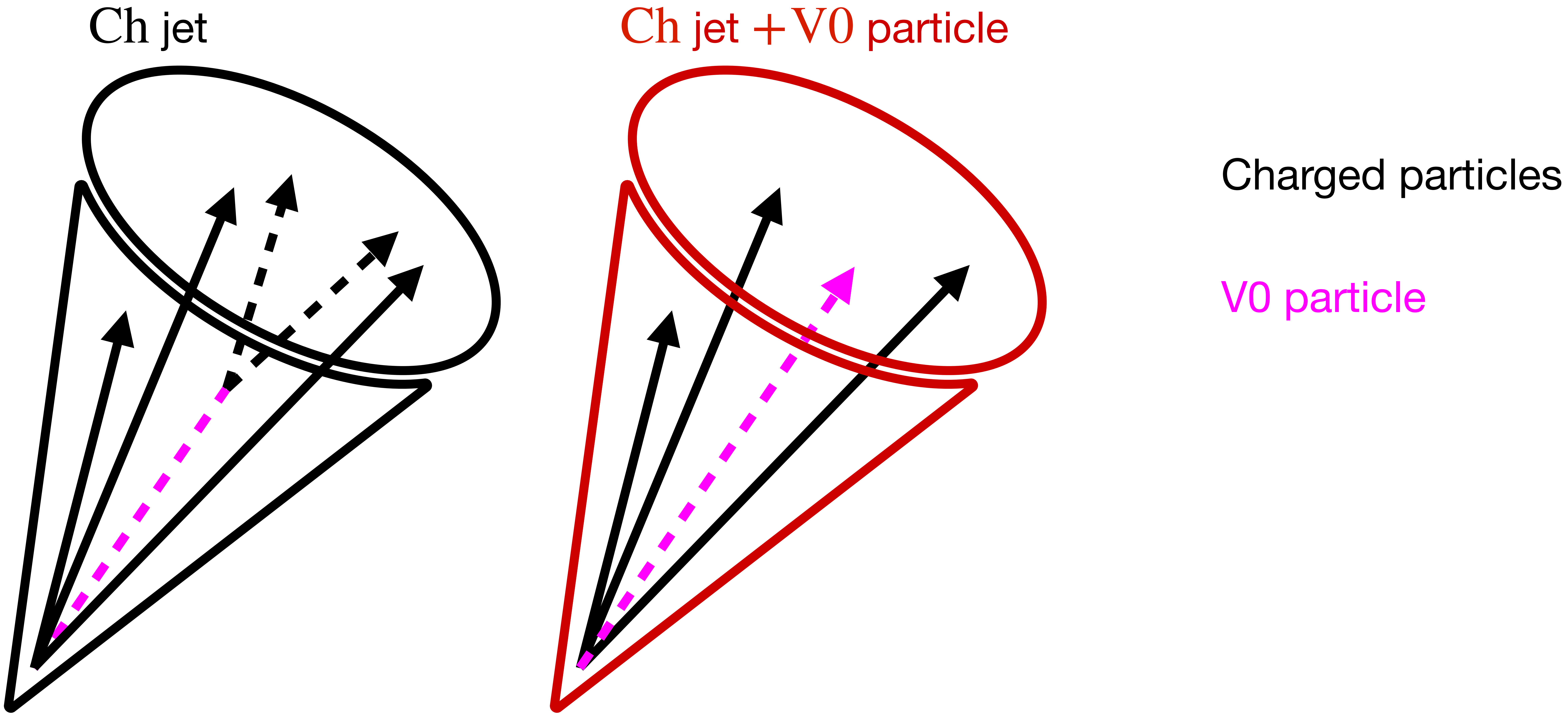

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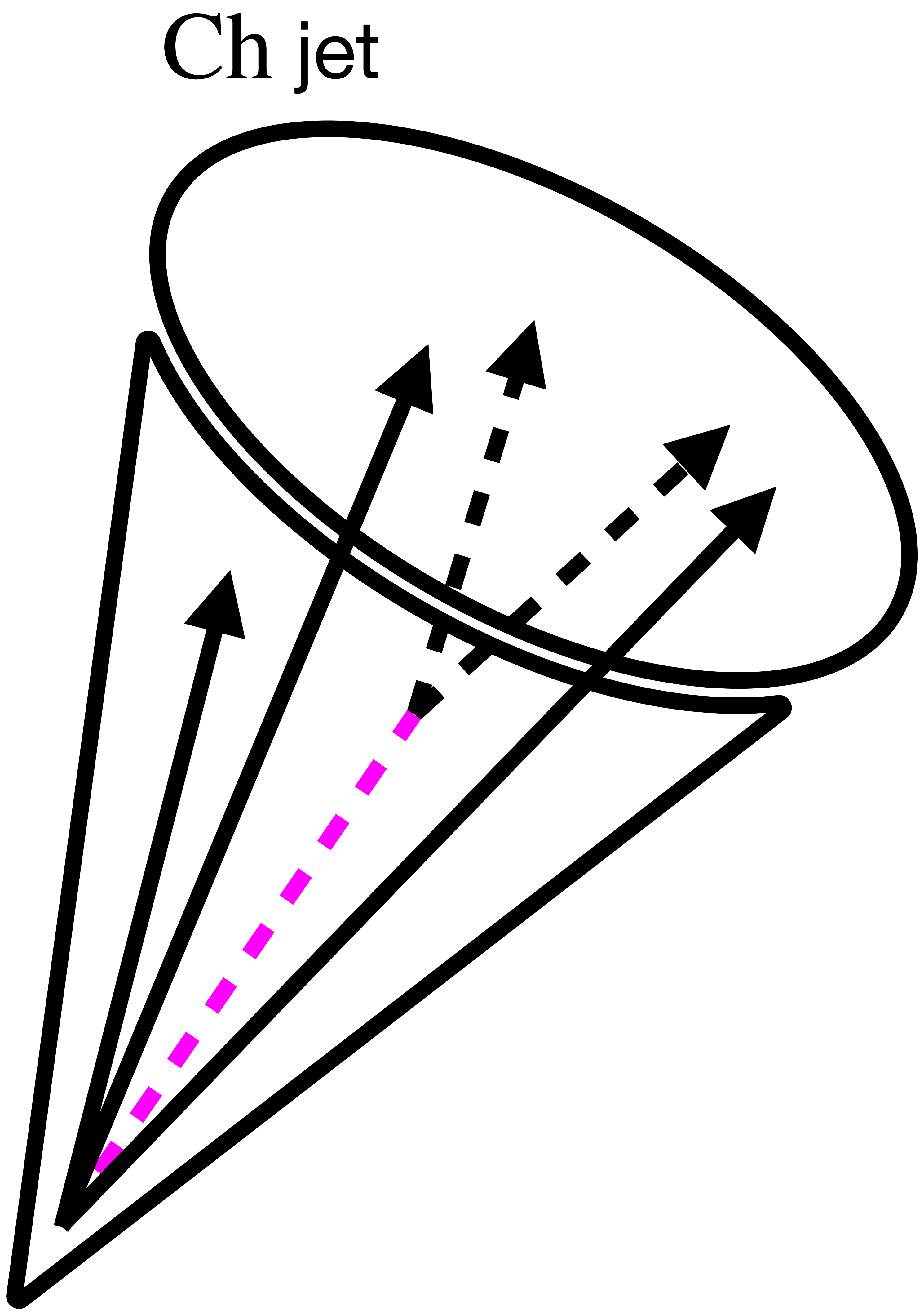

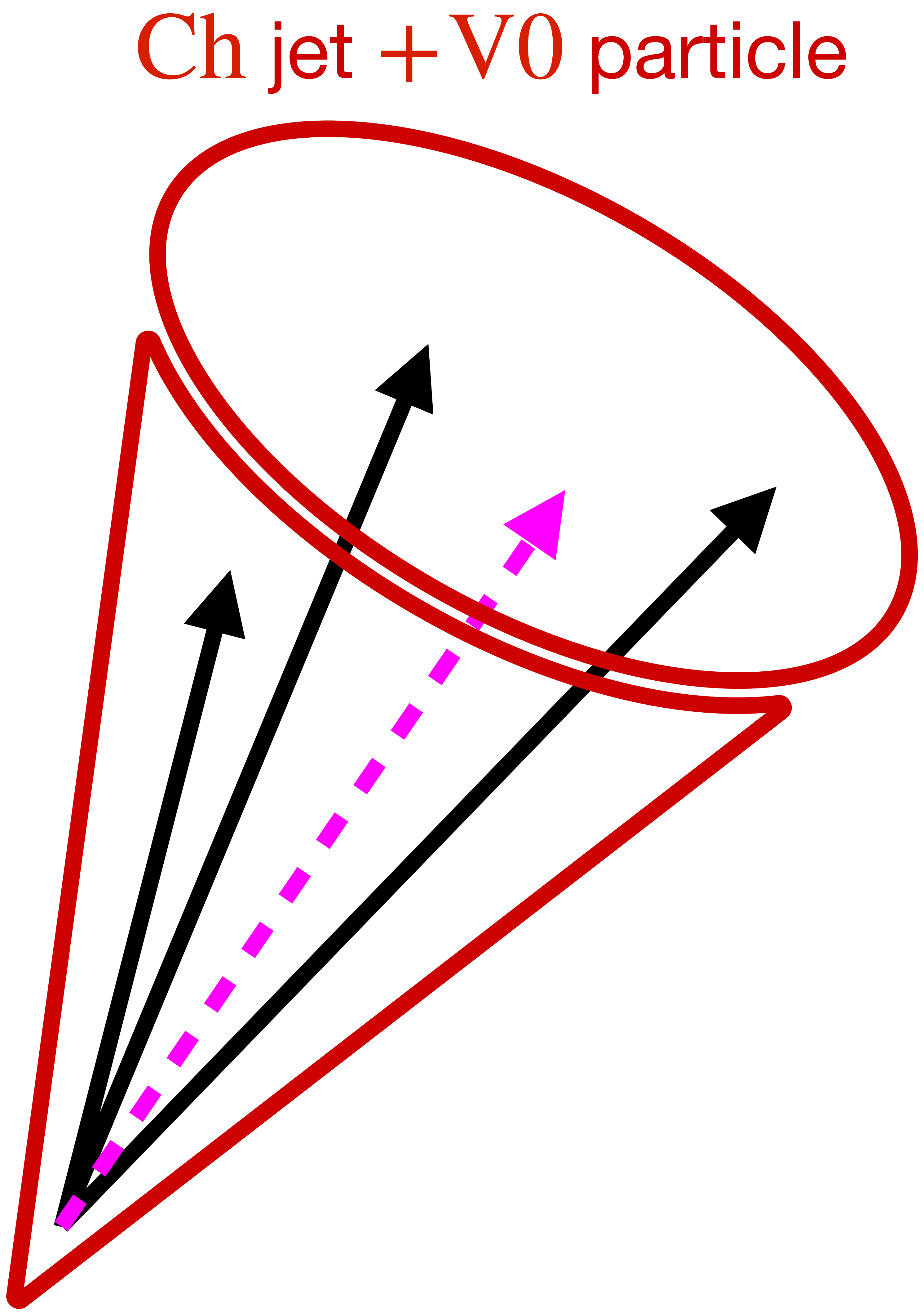

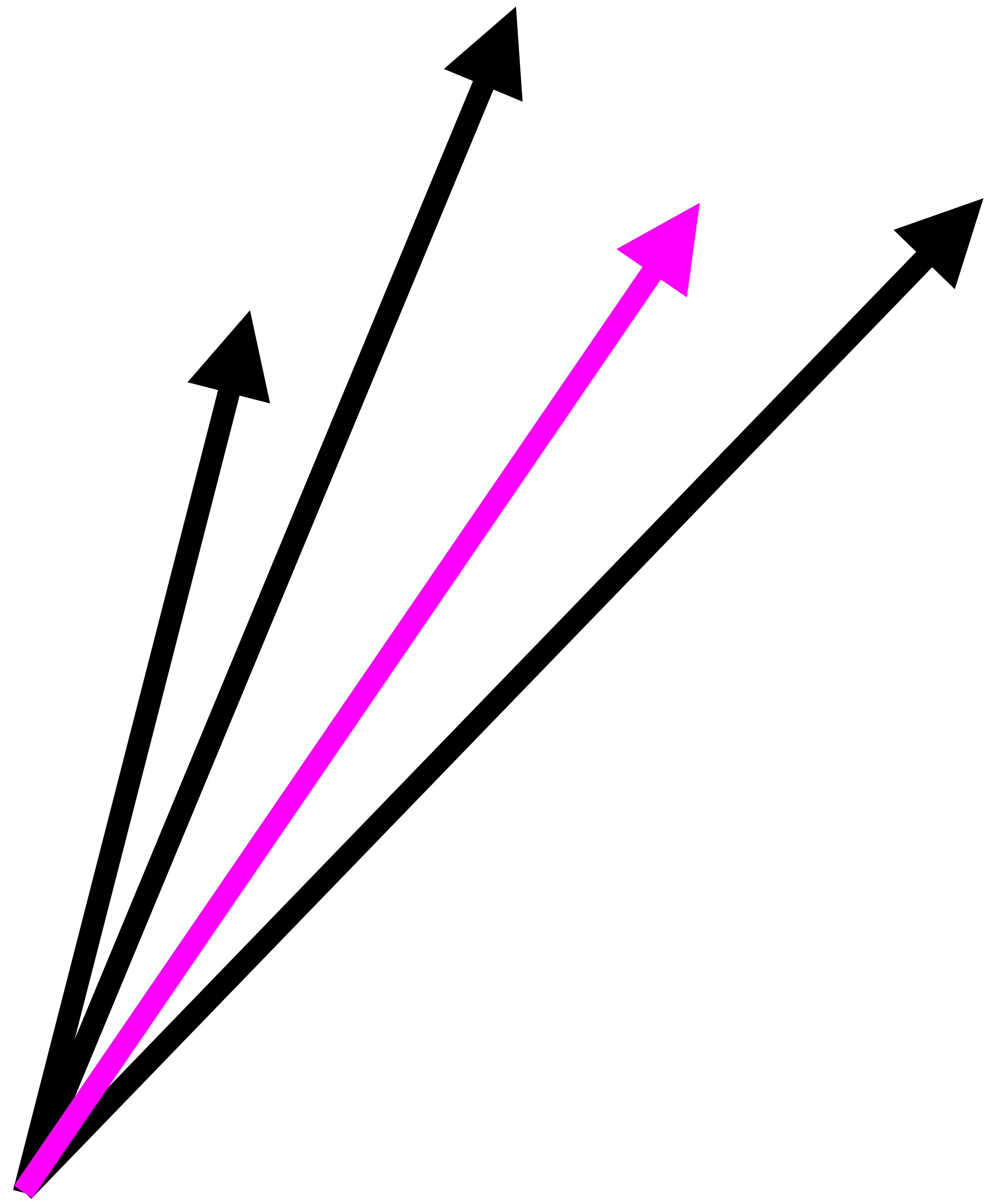

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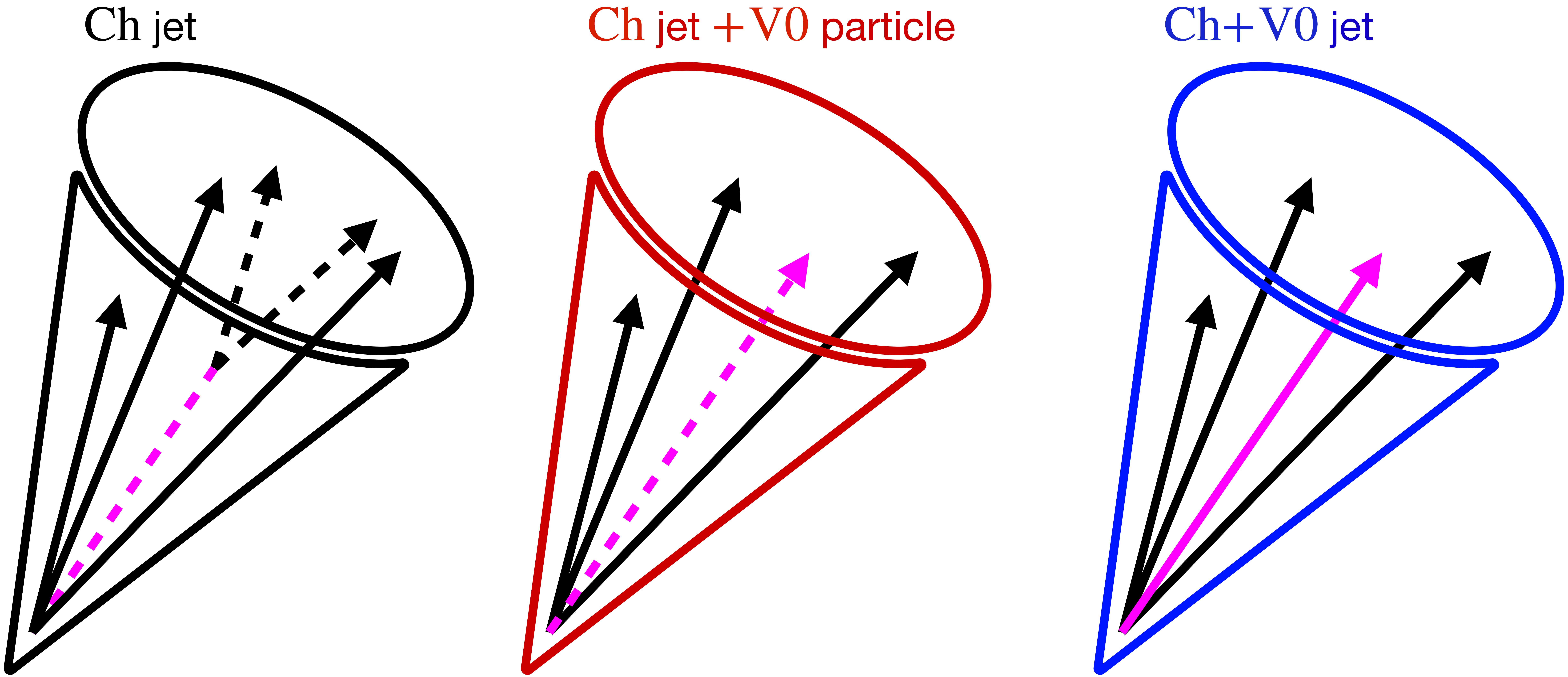
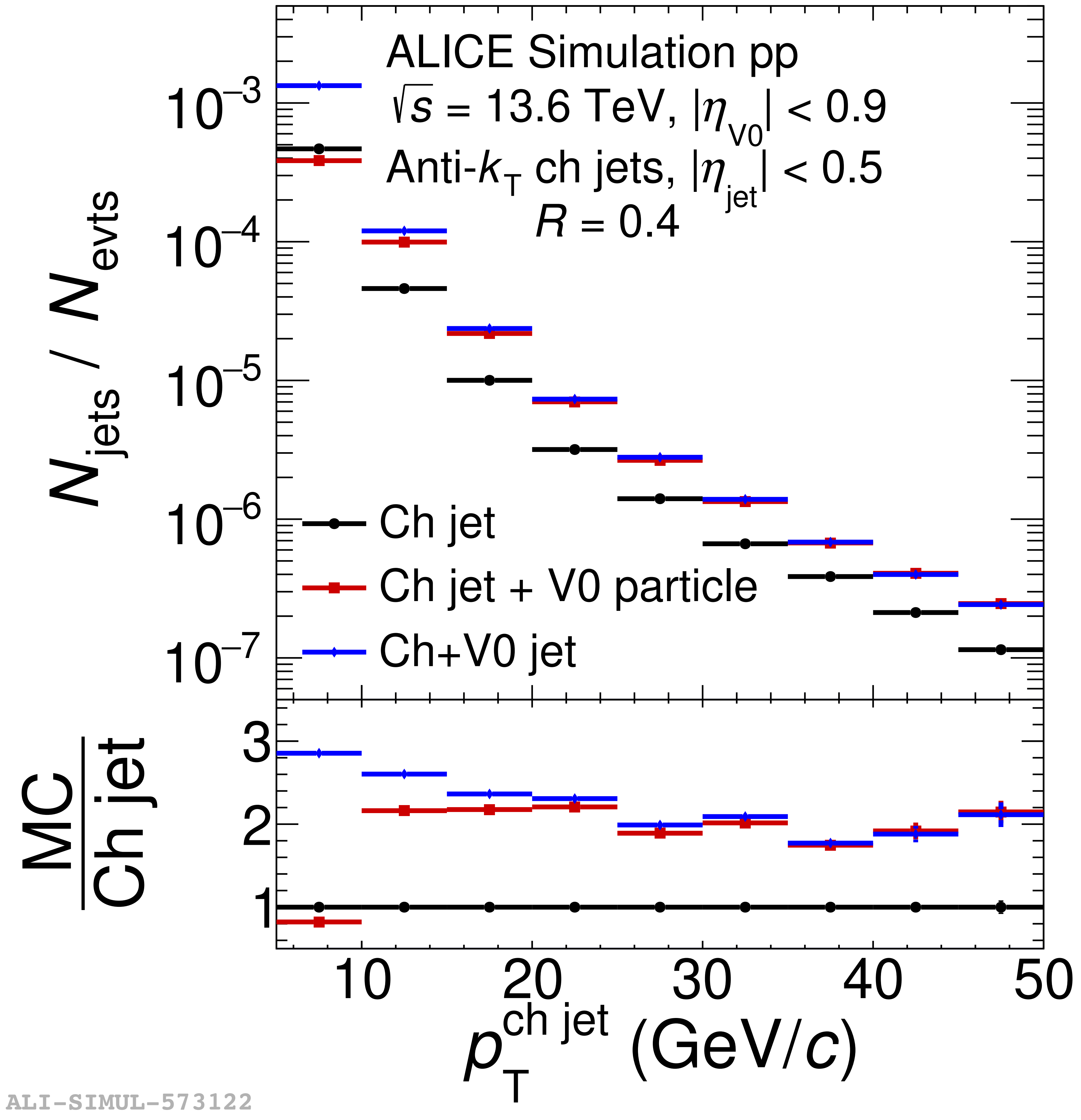


Ch + V0 jets

$V0 = \Lambda, K^0_S$ candidate

Increased statistics per event for Ch + V0 jets

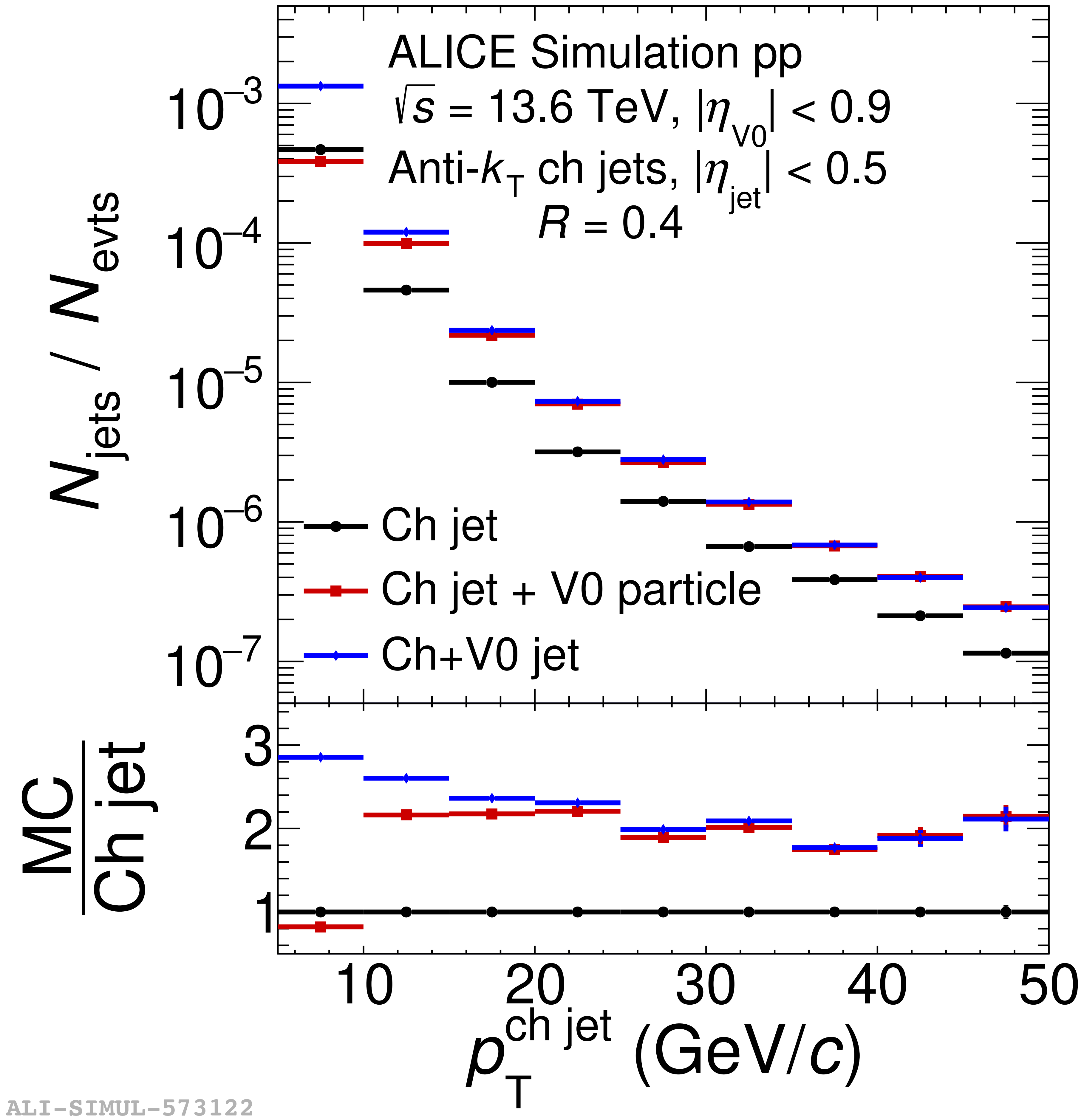


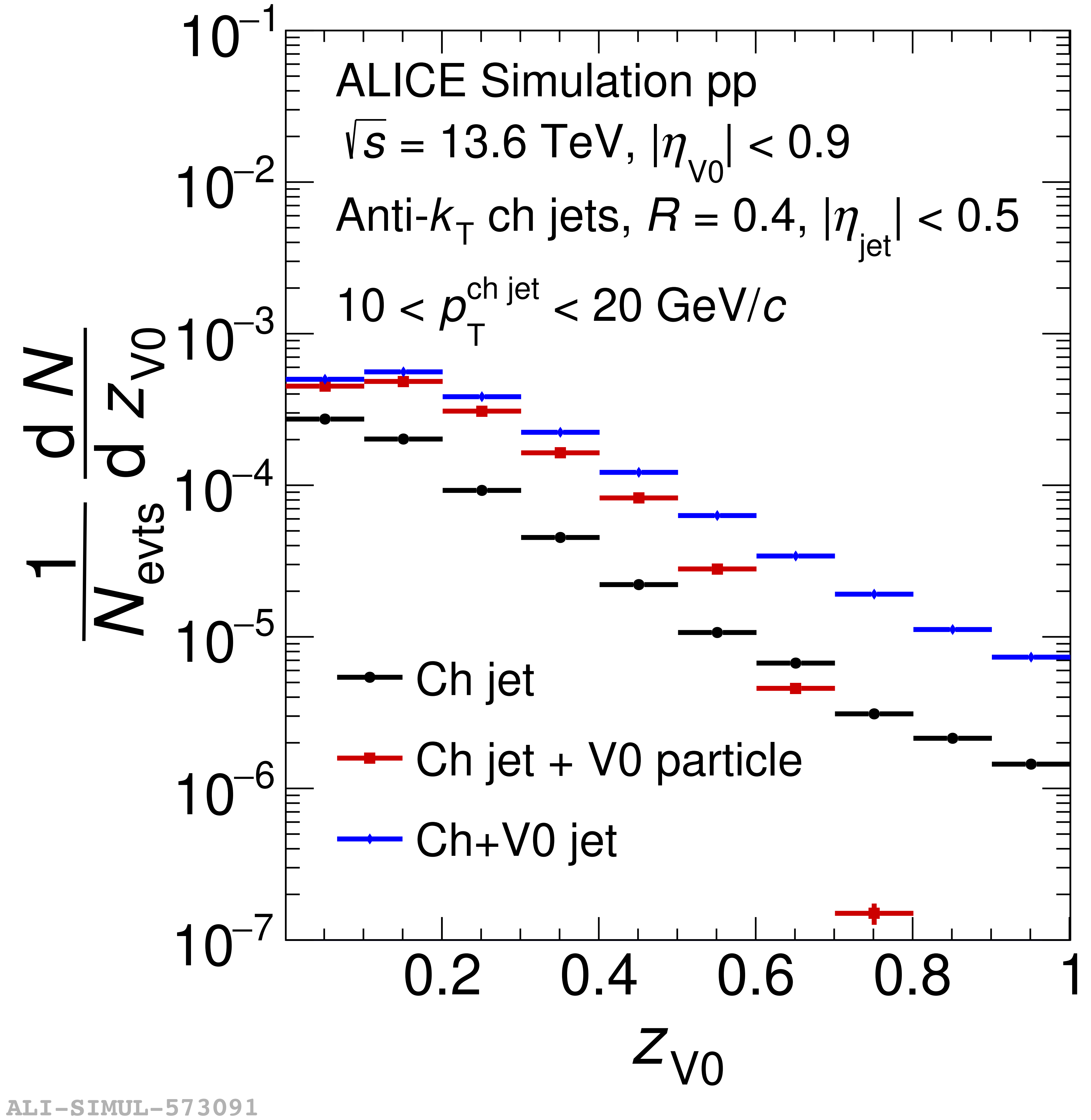
Ch + V0 jets

$\mathrm{V0} = \Lambda, \mathrm{K^0_S}$ candidate

Increased statistics per event for Ch + V0 jets

Increased sensitivity to jets with high $z_{\Lambda,\mathrm{K^0_S}}$

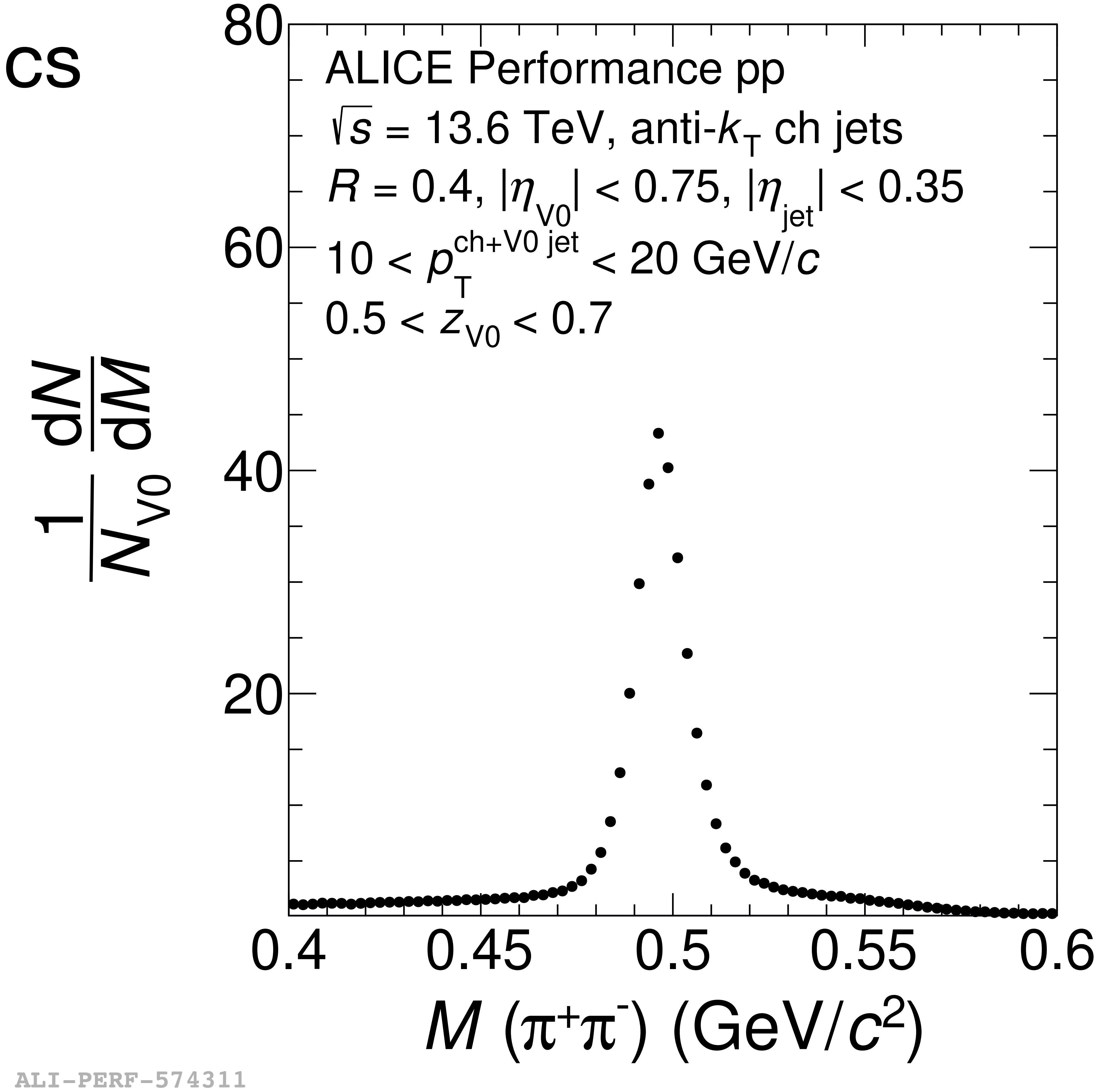


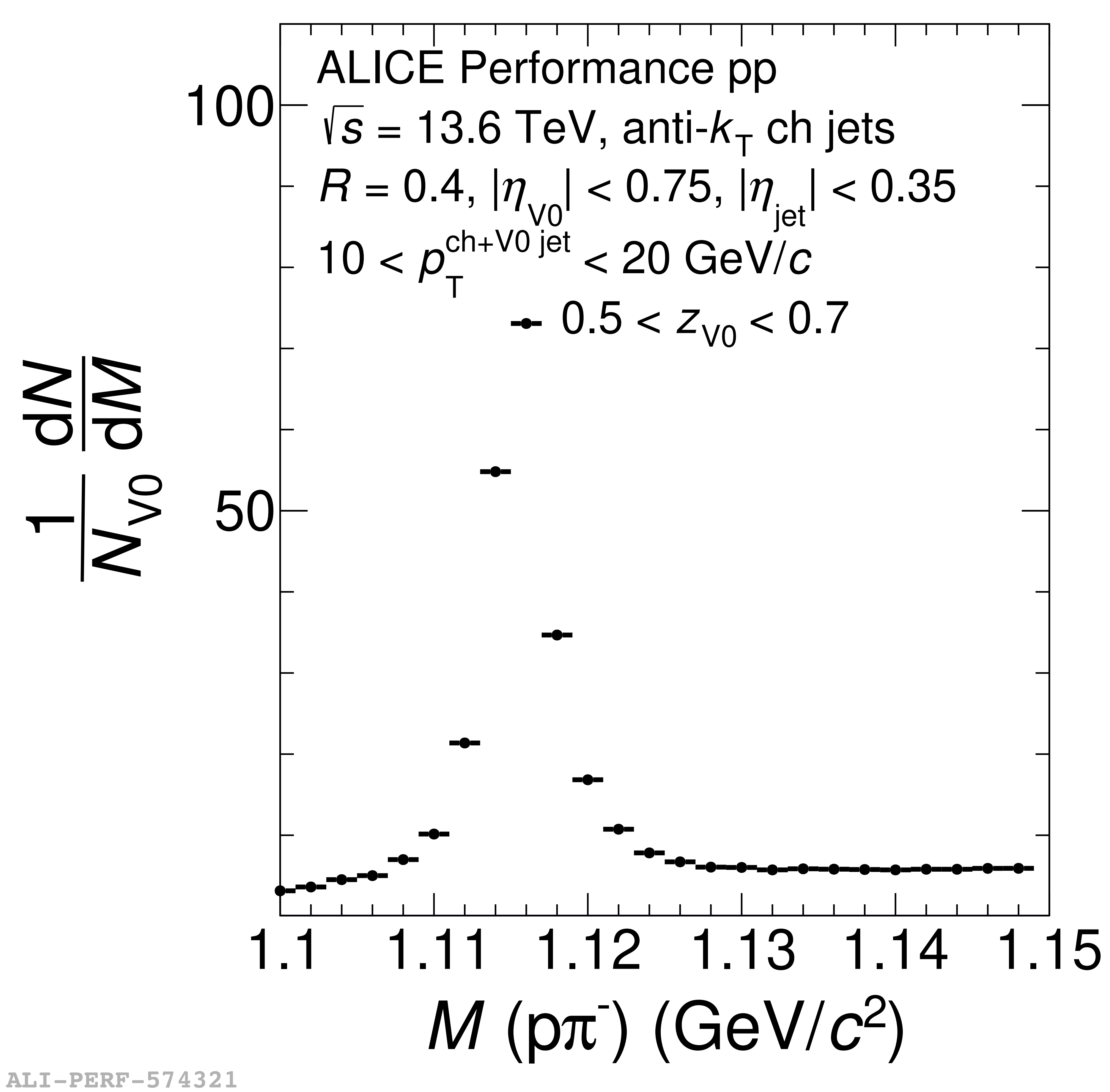


Λ, K^0_S in jets

$0.5 < z_{V0} < 0.7$: majority of jet momentum carried by V0

Run 3: enough statistics for $p_{T,\mathrm{jet}}$-differential analysis



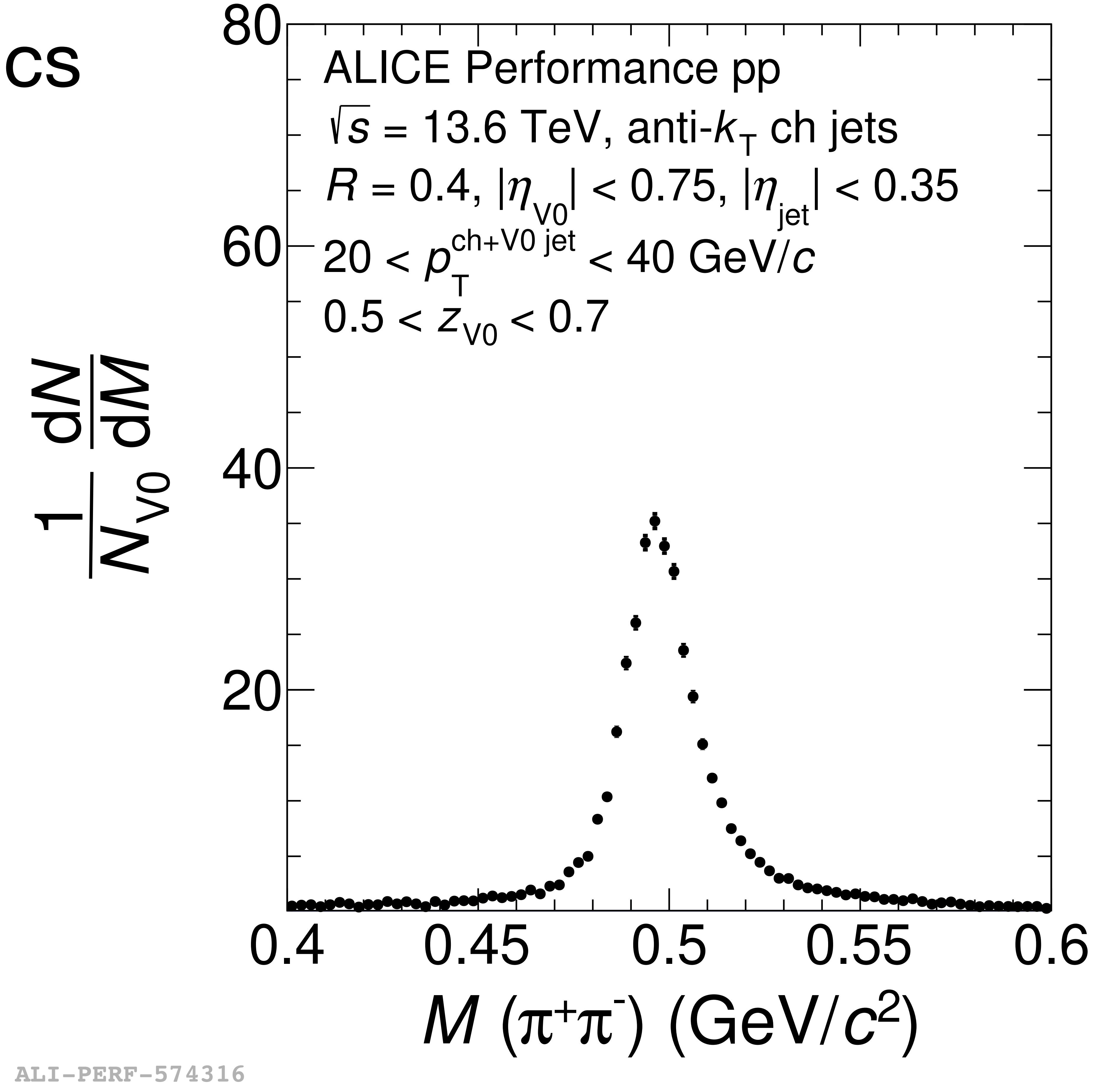


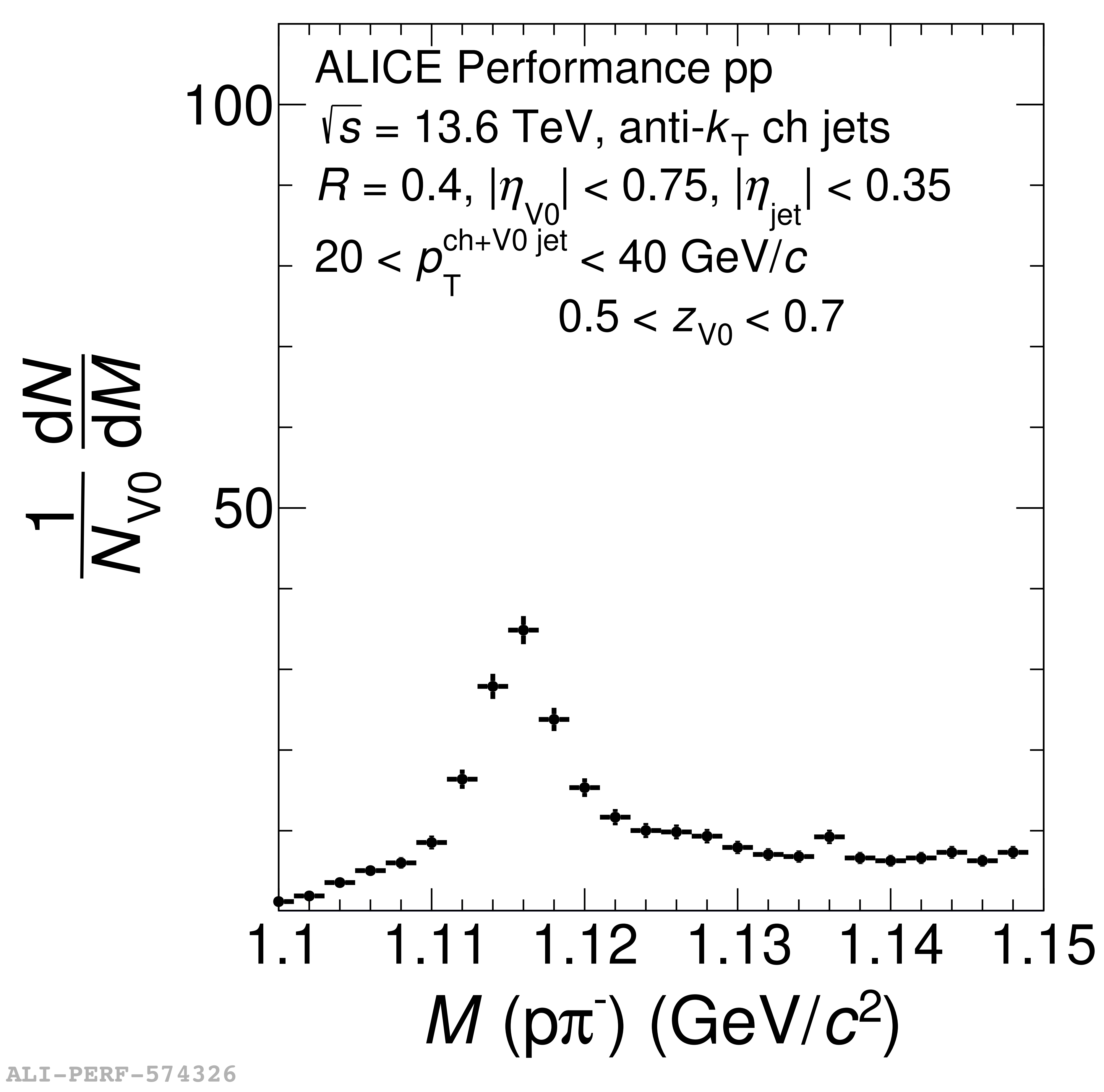
Λ, K^0_S in jets

$0.5 < z_{V0} < 0.7$: majority of jet momentum carried by V0

Run 3: enough statistics for $p_{T,jet}$-differential analysis

Capable of identifying Λ, K^0_S up to very high p_T

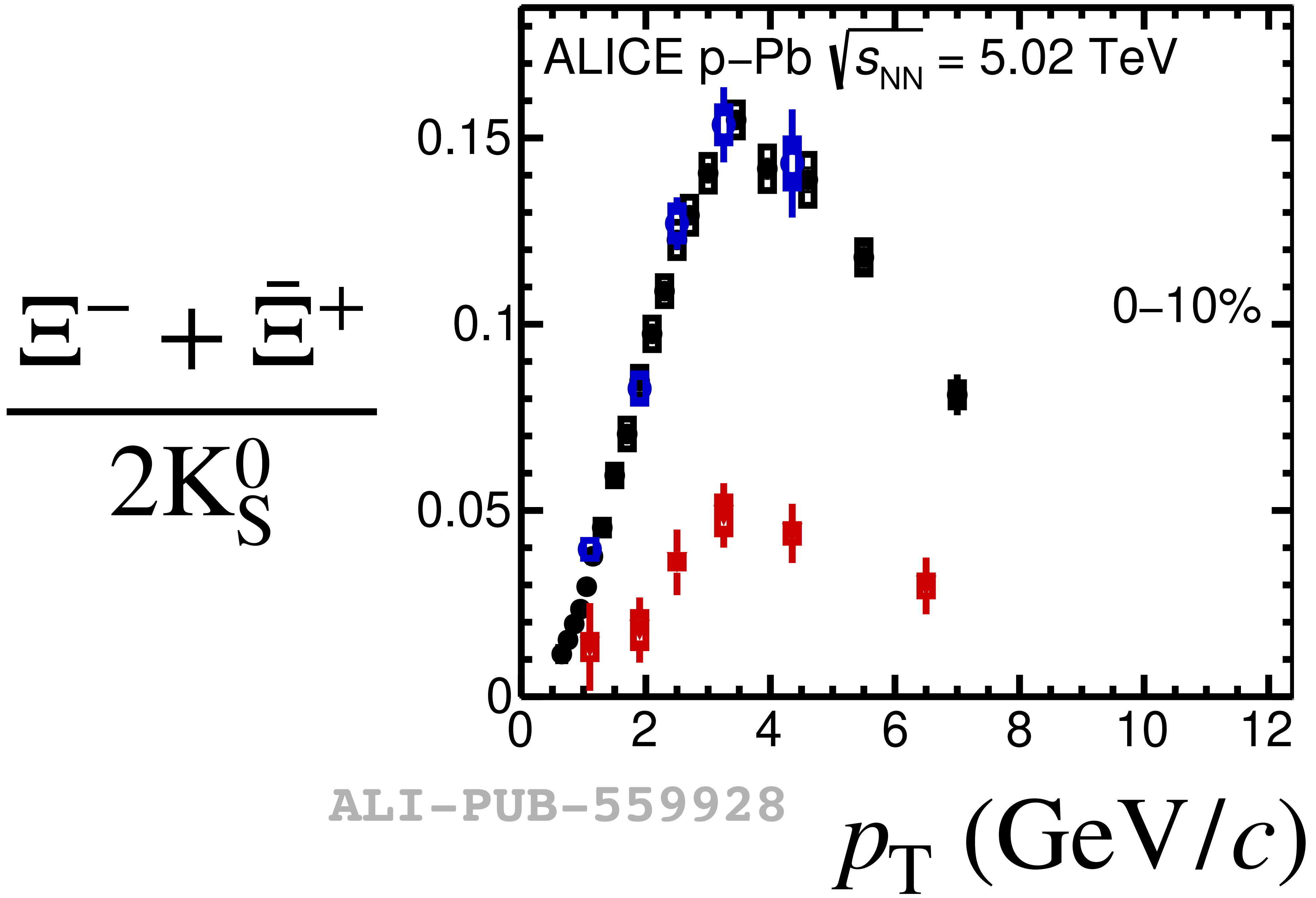




Summary

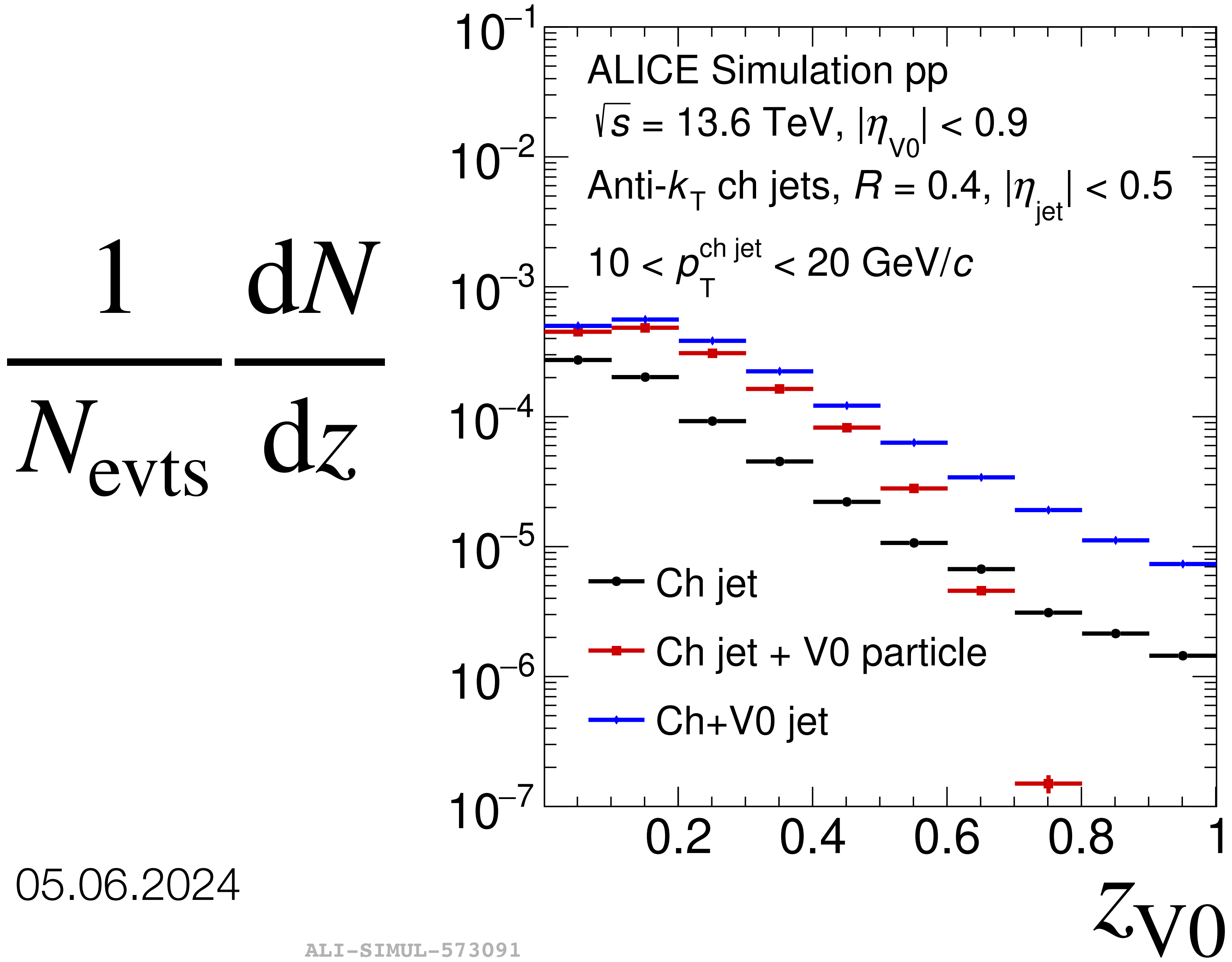
First measurement of Ξ, Ω yield in jets

$\frac{\text{Baryon}}{\text{Meson}}$ and $\frac{2\text{S}}{1\text{S}}$ yield ratios show enhancement with multiplicity in UE, but not in jets



First look at novel measurement of jet fragmentation into $\Lambda, \mathrm{K}^0_\mathrm{S}$ for Run 3 data

$\mathrm{Ch} + \mathrm{V0}$ jet clustering gives unprecedented access to high $z_{\Lambda,\mathrm{K}^0_\mathrm{S}}$



Backup

Jet correction

Correct jets for bkg: $p_{\mathrm{T,jet}}^{\mathrm{ch}} = p_{\mathrm{T,jet}}^{\mathrm{rec}} - \rho_{\mathrm{bkg}}^{\mathrm{ch}} \times A_{\mathrm{jet}}$

$$\rho_{\mathrm{bkg}}^{\mathrm{ch}} = \frac{\Sigma_i A_i}{A_{\mathrm{acc}}} \times \mathrm{median}\left\{ \frac{p_{\mathrm{T,jet}}^{\mathrm{rec}}}{A_{\mathrm{jet}}} \right\}$$

- A_i : area of k_{T} jets with at least one track

Decay channels

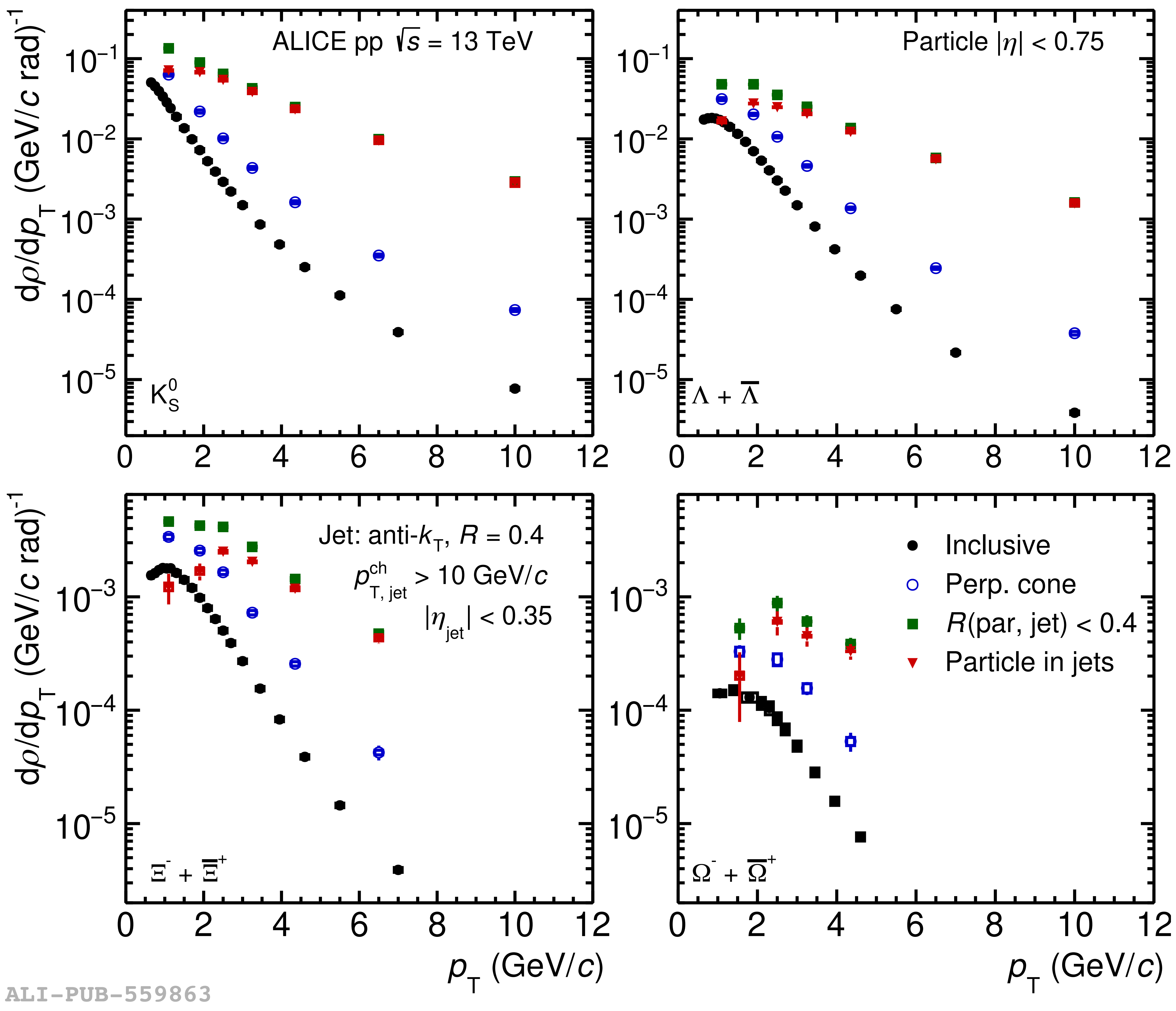
$$K^0_S \rightarrow \pi^+\pi^- \qquad (69.20 \pm 0.05)\,\%$$

$$\Lambda(\bar{\Lambda}) \rightarrow p(\bar{p}) + \pi^-(\pi^+) \qquad (63.9 \pm 0.5)\,\%$$

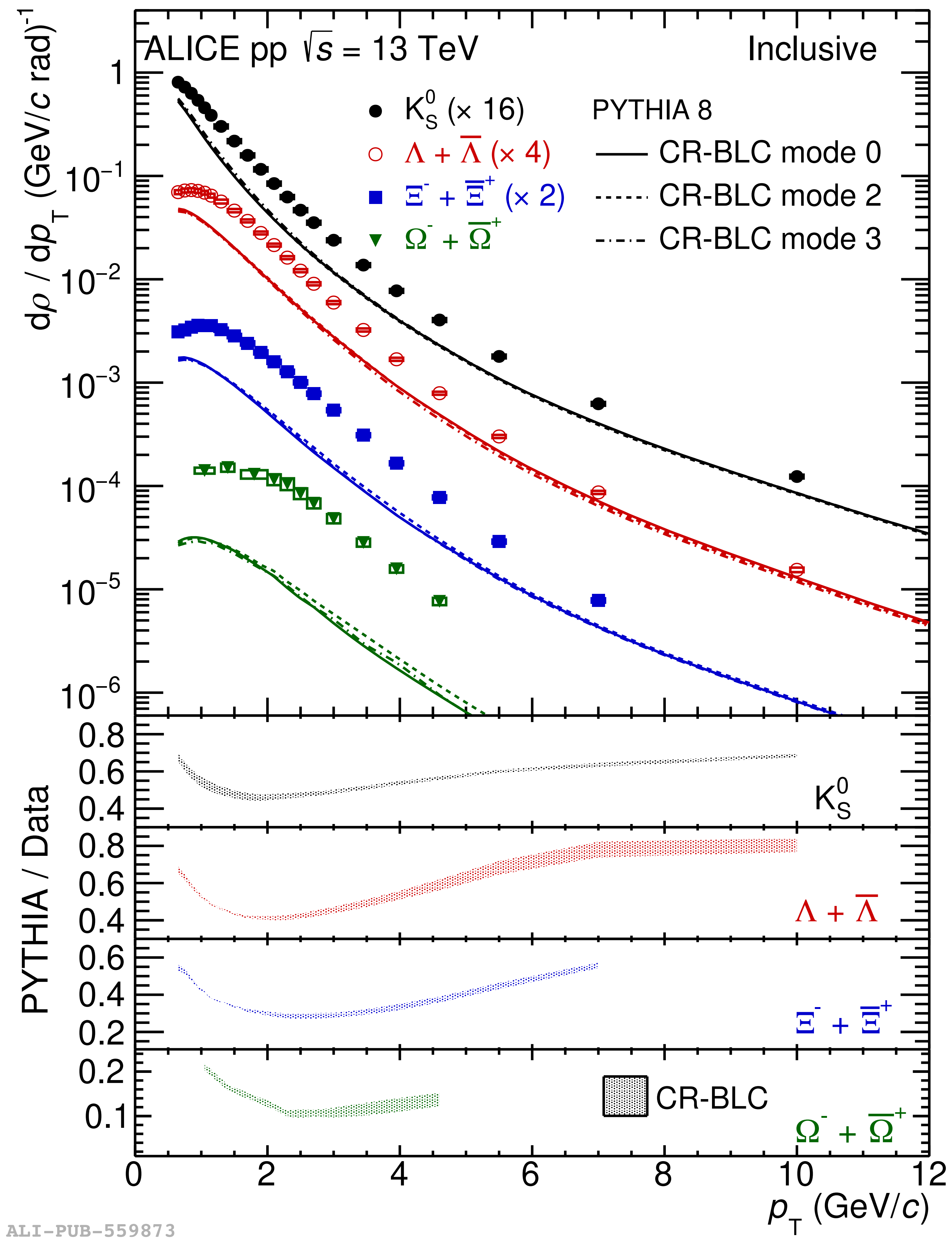
$$\Xi^-(\Xi^+) \rightarrow \Lambda(\bar{\Lambda}) + \pi^-(\pi^+) \qquad (99.887 \pm 0.035)\,\%$$

$$\Omega \rightarrow \Lambda(\bar{\Lambda}) + K^-(K^+) \qquad (67.8 \pm 0.7)\,\%$$

pp Yields

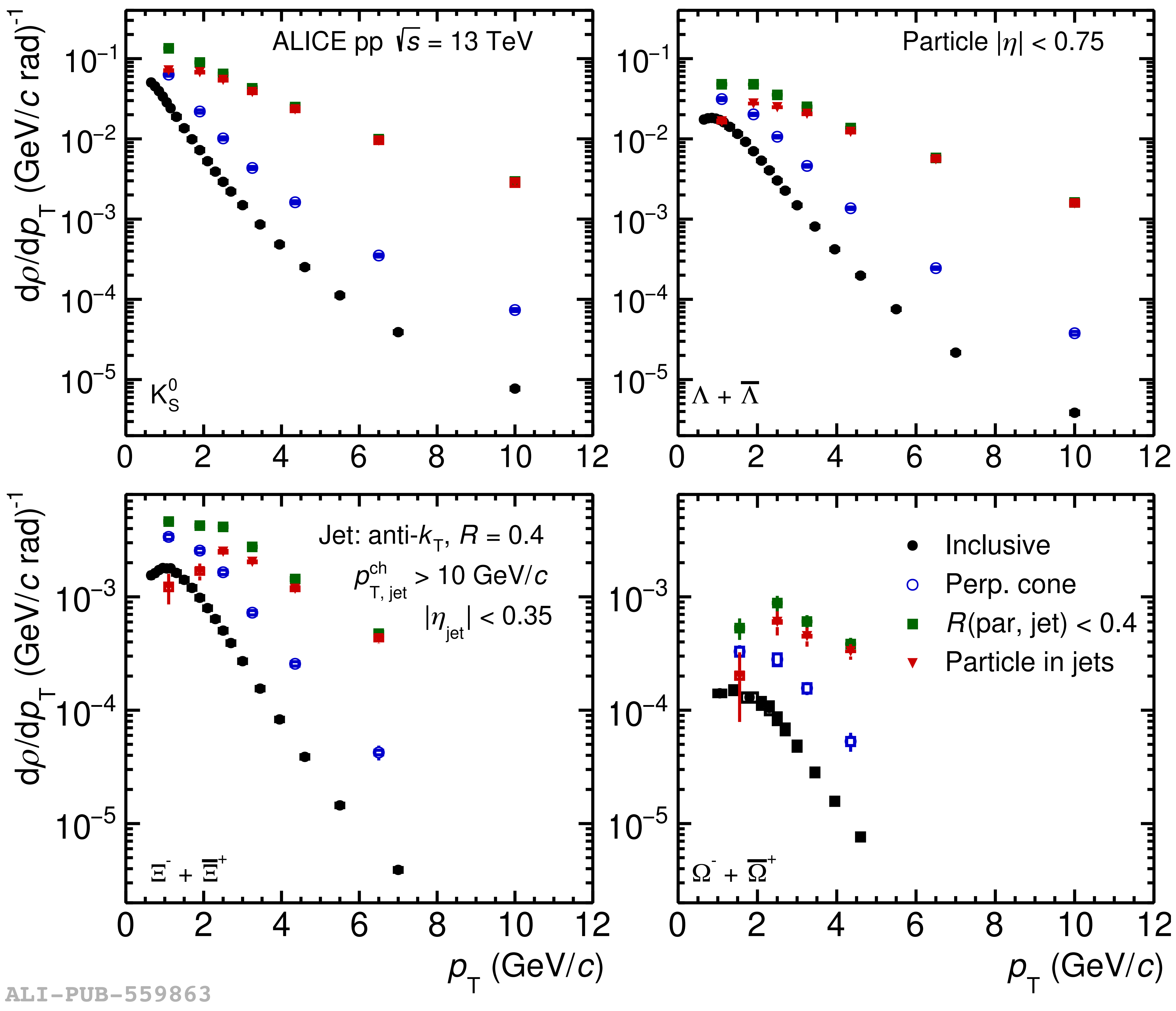


ALICE pp √s = 13 TeV
Particle |η| < 0.75
Jet: anti-k_T, R = 0.4
$p^{ch}_{T, jet}$ > 10 GeV/c
$|\eta_{jet}|$ < 0.35
Inclusive
Perp. cone
R(par, jet) < 0.4
Particle in jets
K^0_S
Λ + $\overline{\Lambda}$
Ξ^- + $\overline{\Xi}^+$
Ω^- + $\overline{\Omega}^+$
dρ/dp_T (GeV/c rad)$^{-1}$
p_T (GeV/c)
ALI-PUB-559863

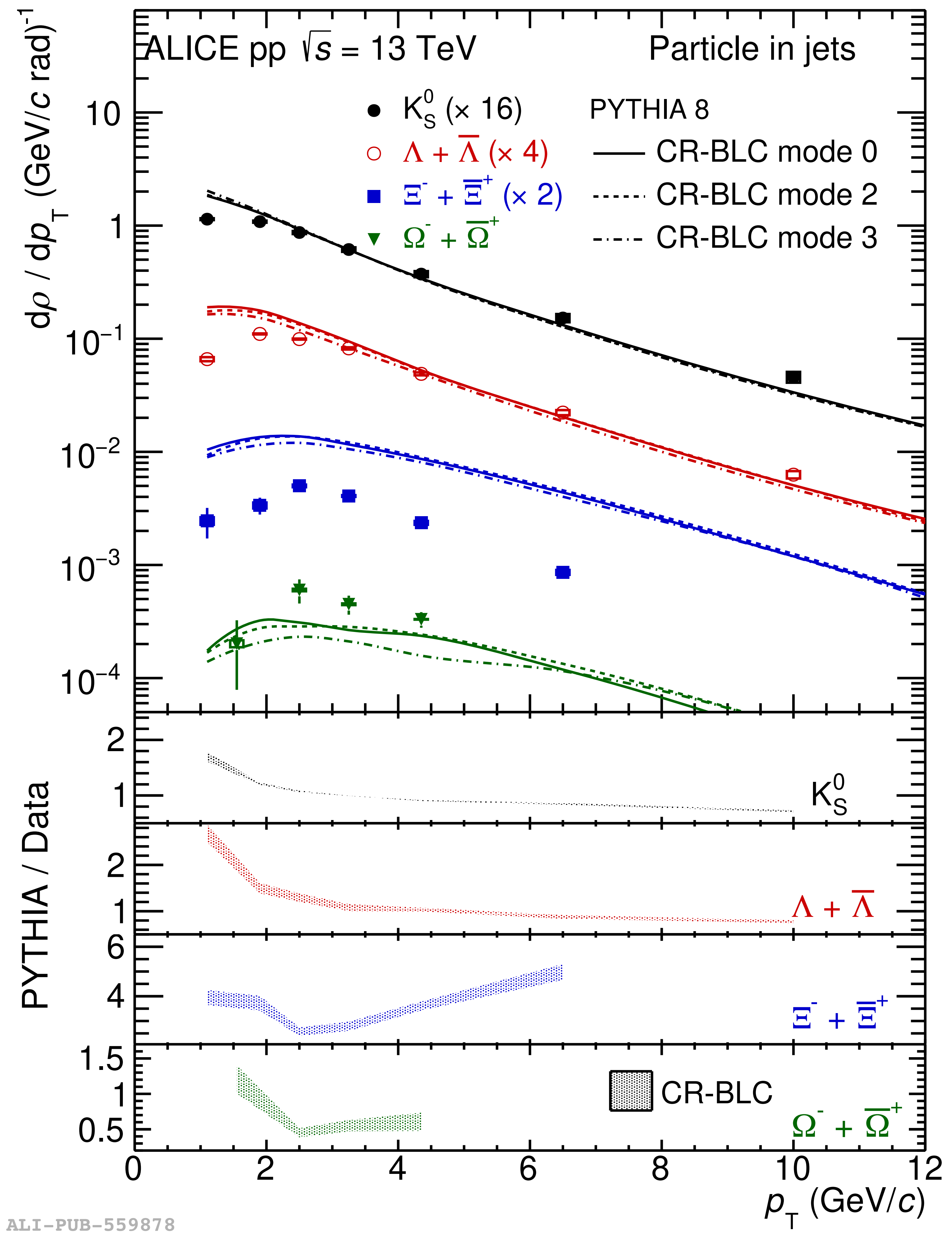


ALICE pp √s = 13 TeV
Inclusive
K^0_S (× 16)
Λ + $\overline{\Lambda}$ (× 4)
Ξ^- + $\overline{\Xi}^+$ (× 2)
Ω^- + $\overline{\Omega}^+$
PYTHIA 8
CR-BLC mode 0
CR-BLC mode 2
CR-BLC mode 3
dρ / dp_T (GeV/c rad)$^{-1}$
PYTHIA / Data
CR-BLC
p_T (GeV/c)
ALI-PUB-559873

pp Yields



ALICE pp √s = 13 TeV
Particle |η| < 0.75
Jet: anti-kT, R = 0.4
$p^{ch}_{T, jet}$ > 10 GeV/c
$|\eta_{jet}|$ < 0.35
Inclusive
Perp. cone
R(par, jet) < 0.4
Particle in jets
dρ/dpT (GeV/c rad)-1
pT (GeV/c)
ALI-PUB-559863

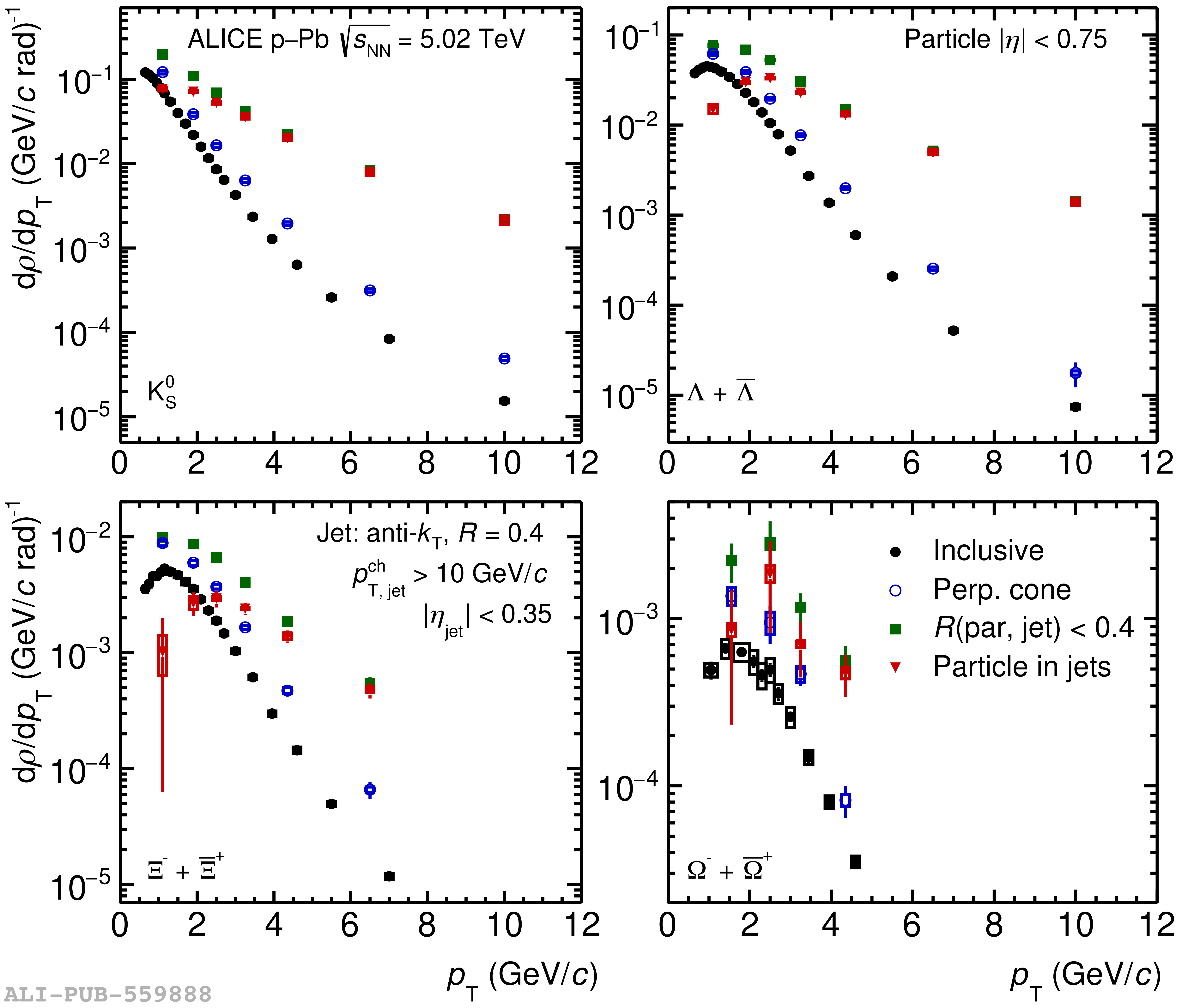


ALICE pp √s = 13 TeV
Particle in jets
PYTHIA 8
CR-BLC mode 0
CR-BLC mode 2
CR-BLC mode 3
CR-BLC
dρ / dpT (GeV/c rad)-1
PYTHIA / Data
pT (GeV/c)
ALI-PUB-559878

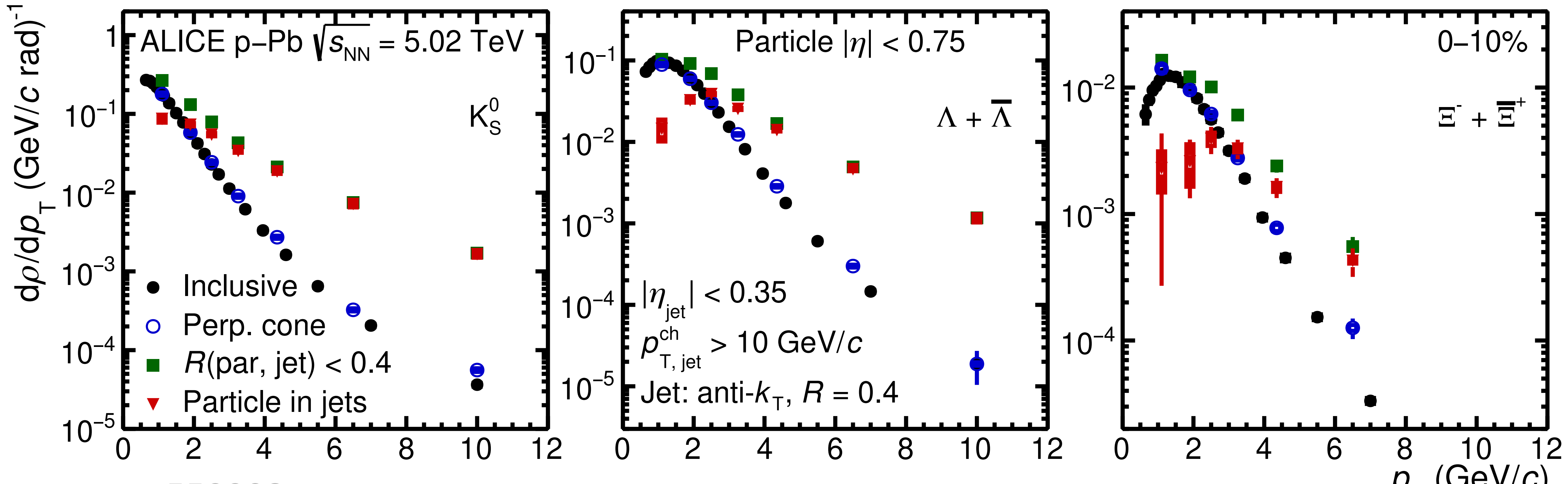
p-Pb Yields

Yields in p-Pb similar to pp

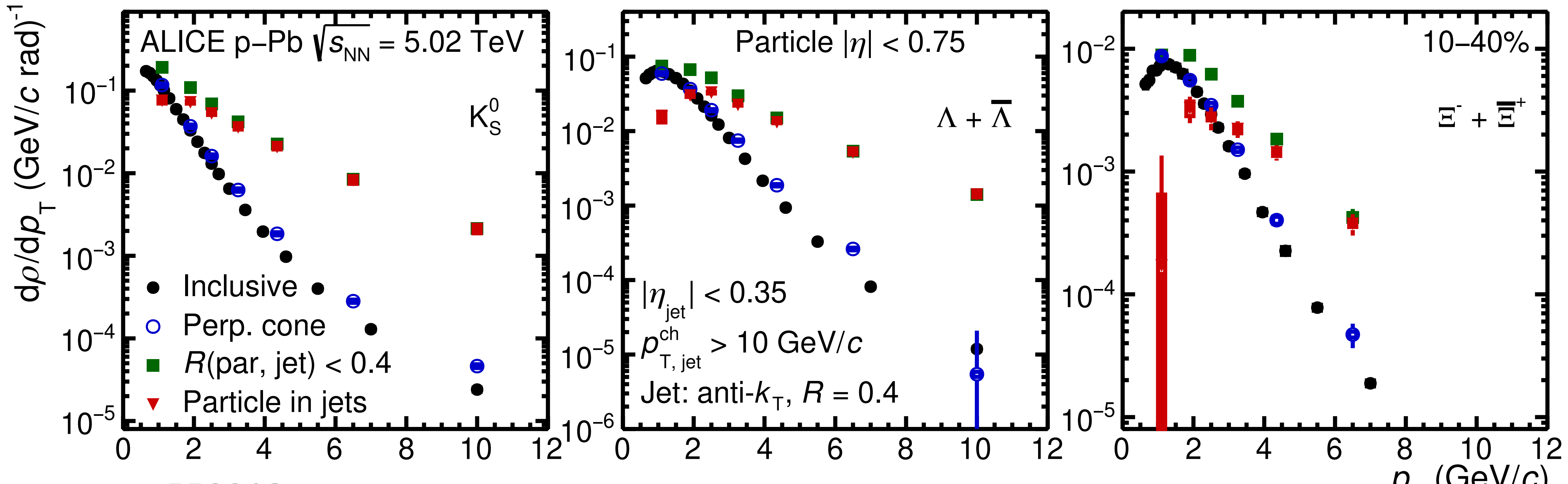
UE fraction pp → p-Pb increases $\sim 15\,\%$, except for Ω



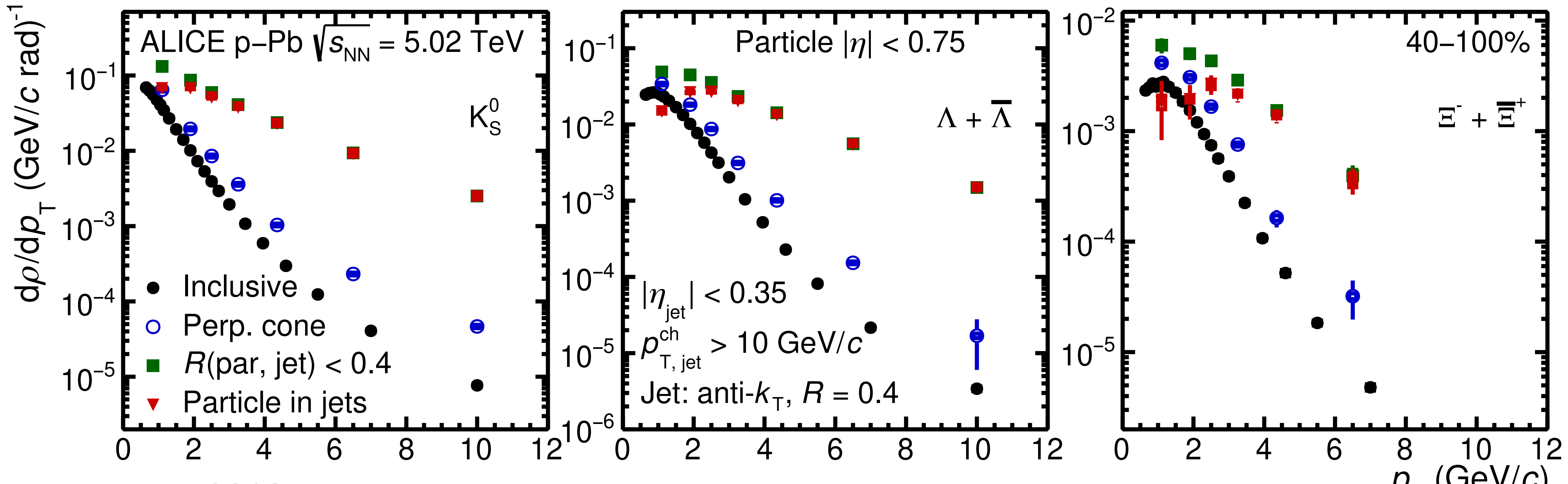
p-Pb Yields



ALI-PUB-559908



ALI-PUB-559913



ALI-PUB-559918