Study of strangeness enhancement in small systems through $\Xi-$hadron correlations in pp collisions at 13 TeV

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Introduction

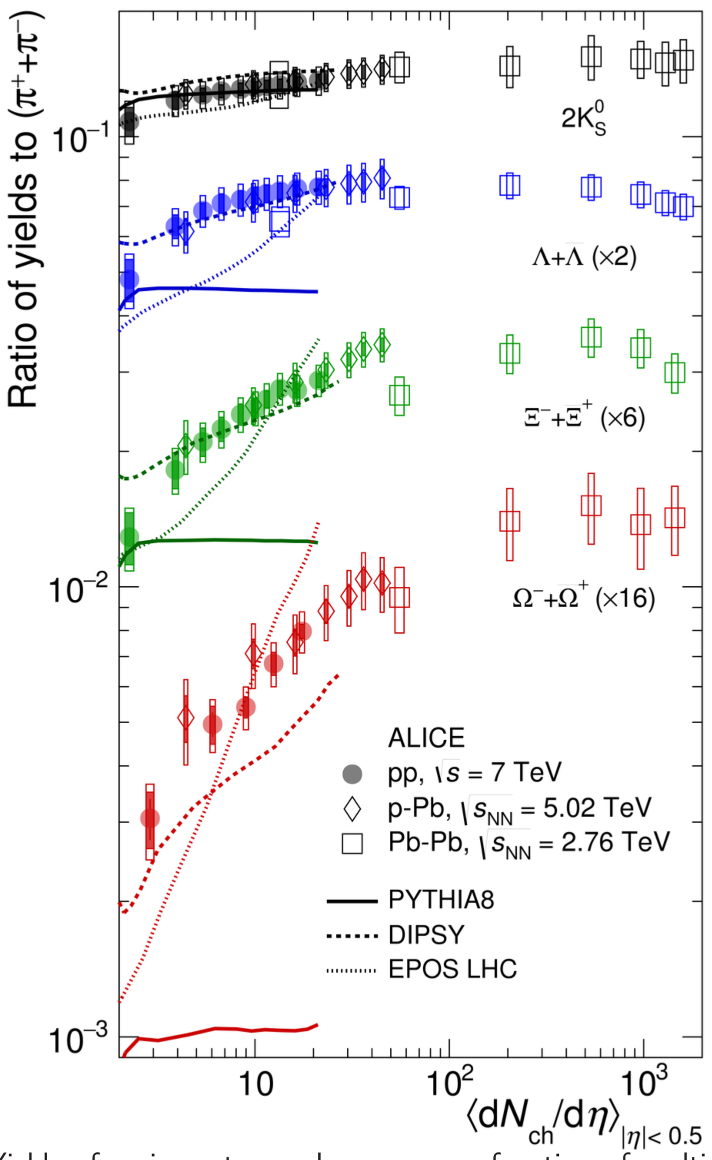
The aim of this analysis is to understand strangeness enhancement in small systems. This is studied through correlations between the Ξ baryon ($= ssd$) and other hadrons. Since strangeness is a conserved quantity in strong interactions, and the net strangeness of normal matter is zero, the formation of strange quarks must be balanced by antiquarks. In PYTHIA, this is achieved through string breakings, resulting in direct correlations with other strange hadrons, e.g.:

- kaons: $K^+ = \bar{s}u$, $K^- = s\bar{u}$, $K^0 =$ linear combinations of $\bar{s}d$ and $s\bar{d}$,
- ϕ mesons: $\phi^0 = s\bar{s}$,
- Λ baryons: $\Lambda^0 = uds$, $\overline{\Lambda}^0 = \bar{u}\bar{d}\bar{s}$,
- other Ξ baryons: $\Xi^- = ssd$, $\overline{\Xi}^+ = \bar{s}\bar{s}\bar{d}$, and
- Ω baryons: $\Omega^- = sss$, $\overline{\Omega}^+ = \bar{s}\bar{s}\bar{s}$,

but less so with non-strange hadrons, in particular:

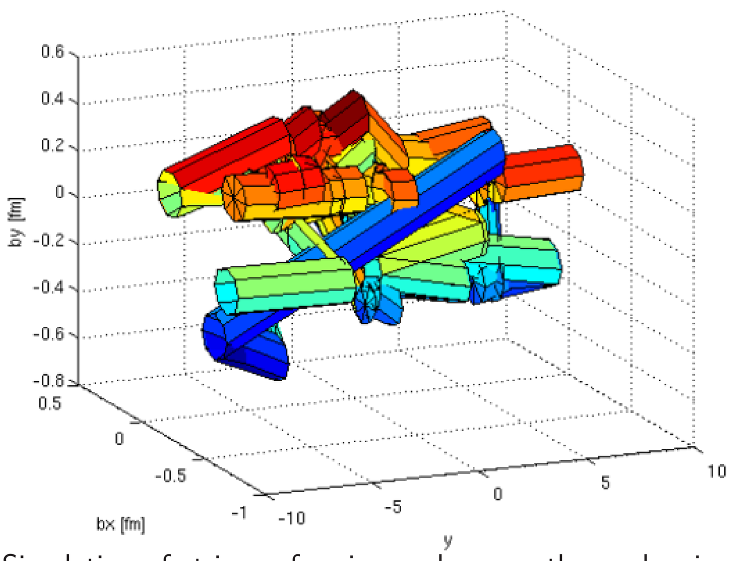
- pions: $\pi^+ = u\bar{d}$, $\pi^- = \bar{u}d$, $\pi^0 = (u\bar{u} + d\bar{d})/\sqrt{2}$, and
- protons: $p = uud$, $\overline{p} = \bar{u}\bar{u}\bar{d}$.

Any correlations with these should originate from the underlying event and be due to charge and baryon number conservation etc.



Yields of various strange baryons as a function of multiplicity, for different collision systems, along with theoretical predictions. DIPSY is based on rope hadronisation, and is used for the development of Angantyr. *ALICE Collaboration. Nature Phys. 13 (2017) 535-539.*

Since PYTHIA underestimates strangeness production, other models have been developed to solve this. One such approach is rope hadronisation, which is implemented in the Angantyr plugin to PYTHIA. Here, strings are clustered into ropes, forming multicolour states, which yields more multistrange hadrons.



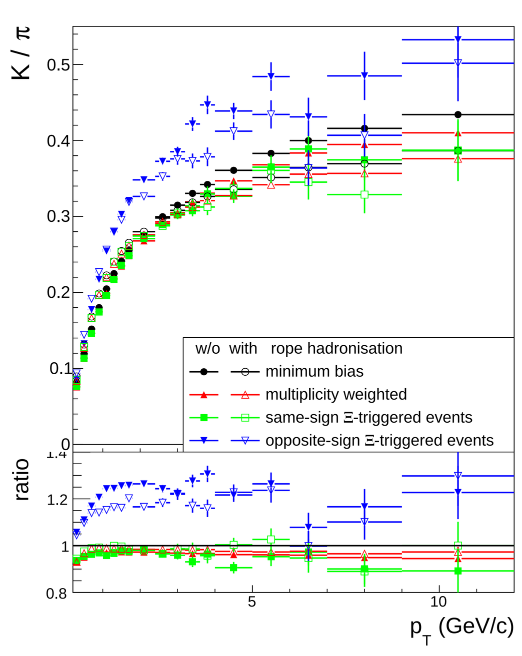
Simulation of strings of various colours partly overlapping in space, yielding more cofigurations of hadrons, and in particular multistrange ones. *C. Bierlich. QCD Challenges at the LHC: from pp to AA [conference presentation]. Taxco, Mexico. (2016).*

To study the strangeness production mechanism, one can either look at global (changes in spectra) or local correlations (direct correlations). In these poster, results from standard PYTHIA are compared with results where rope hadronisation is enabled.

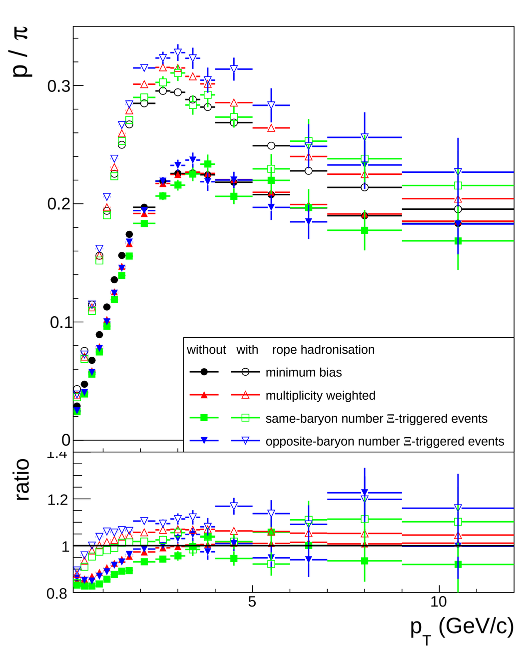
Global correlations

The plots below show how the spectra, relative to same-sign pions, change if triggering on a Ξ baryon. Since this changes the multiplicity of the event, the results are also compared to multiplicity-weighted minimum-bias spectra.

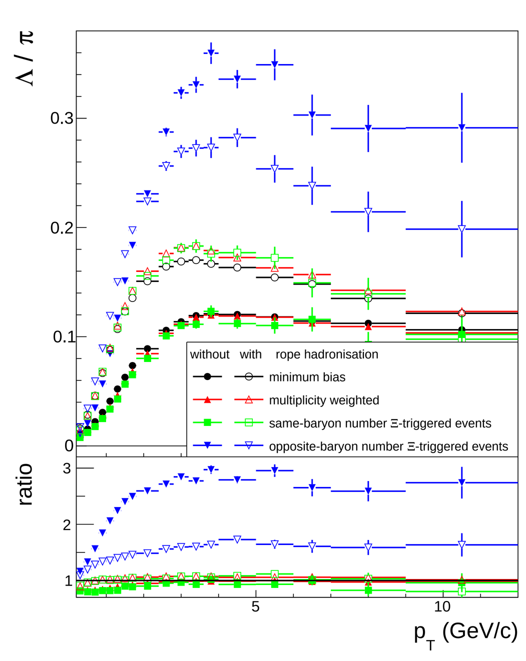
Kaons:



Protons:



Λ baryons:



Local correlations, method

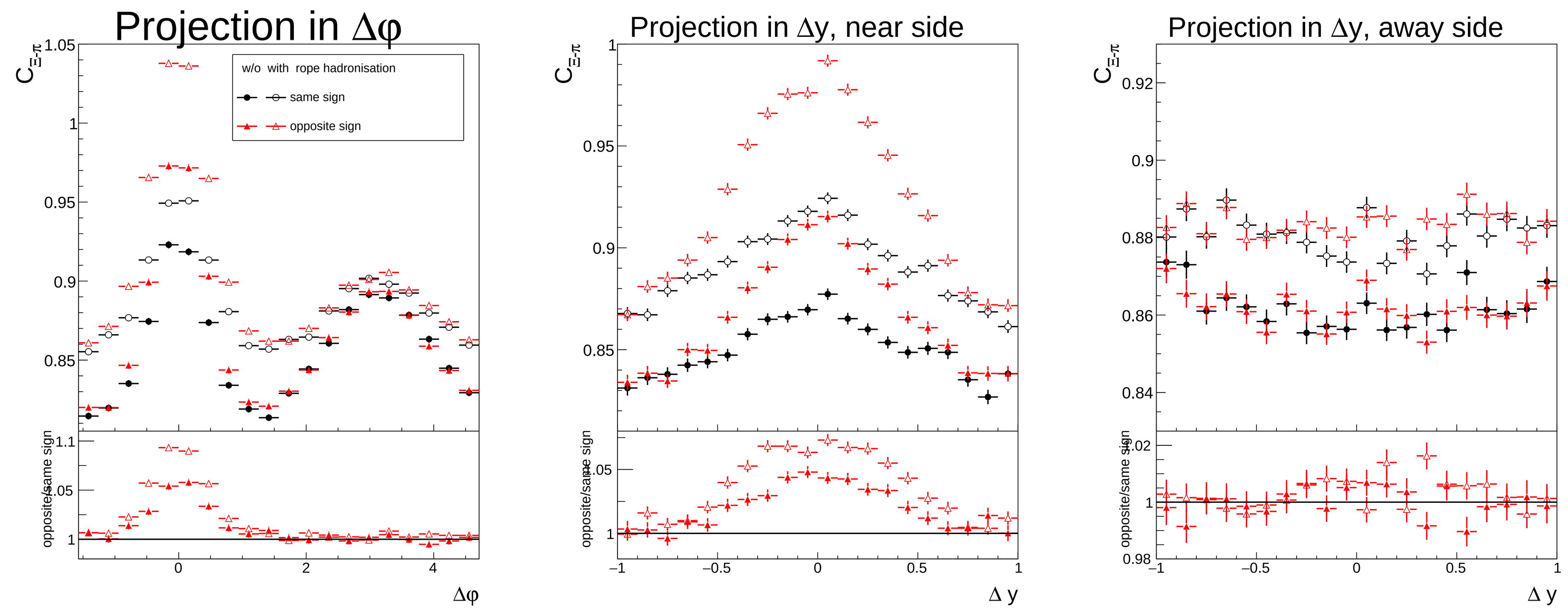
These are measured by calculating the correlation function between Ξ triggers and associated hadrons, which is defined as:

$$\mathbb{C}(\Delta y, \Delta\varphi) = \frac{\mathrm{d}^2 N}{\mathrm{d}\Delta\varphi \mathrm{d}\Delta y}.$$

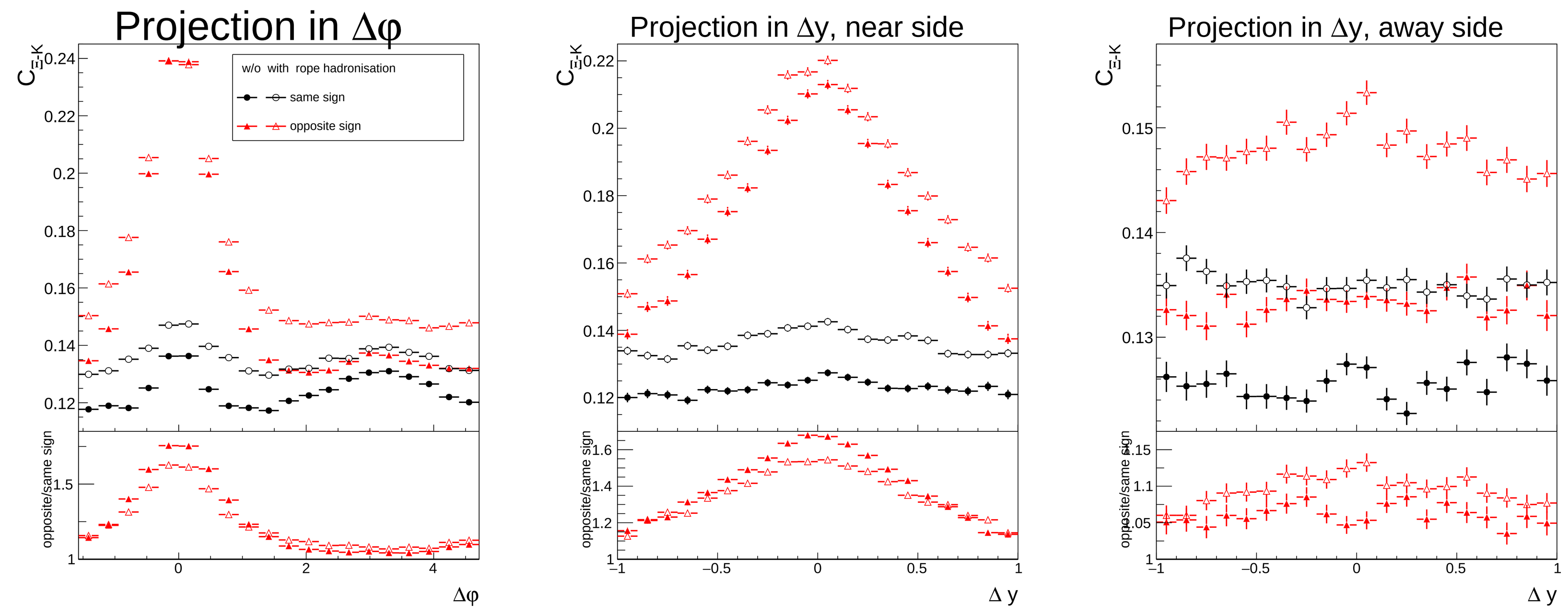
In this poster, projection onto $\Delta\varphi$ and Δy are shown, the latter both on the near side ($-\pi/2 < \Delta\varphi \leq \pi/2$) and the away side ($\pi/2 < \Delta\varphi \leq 3\pi/2$).

Local correlations, results

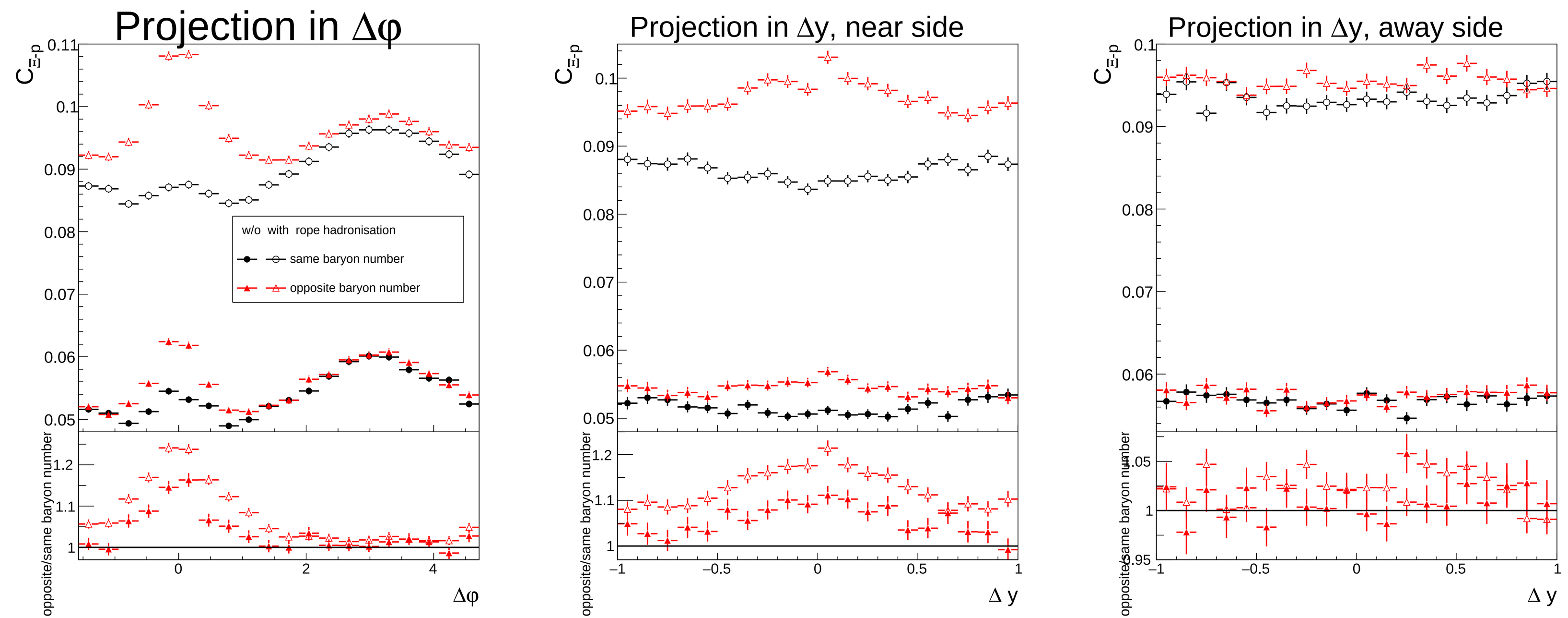
$\Xi - \pi$ correlations:



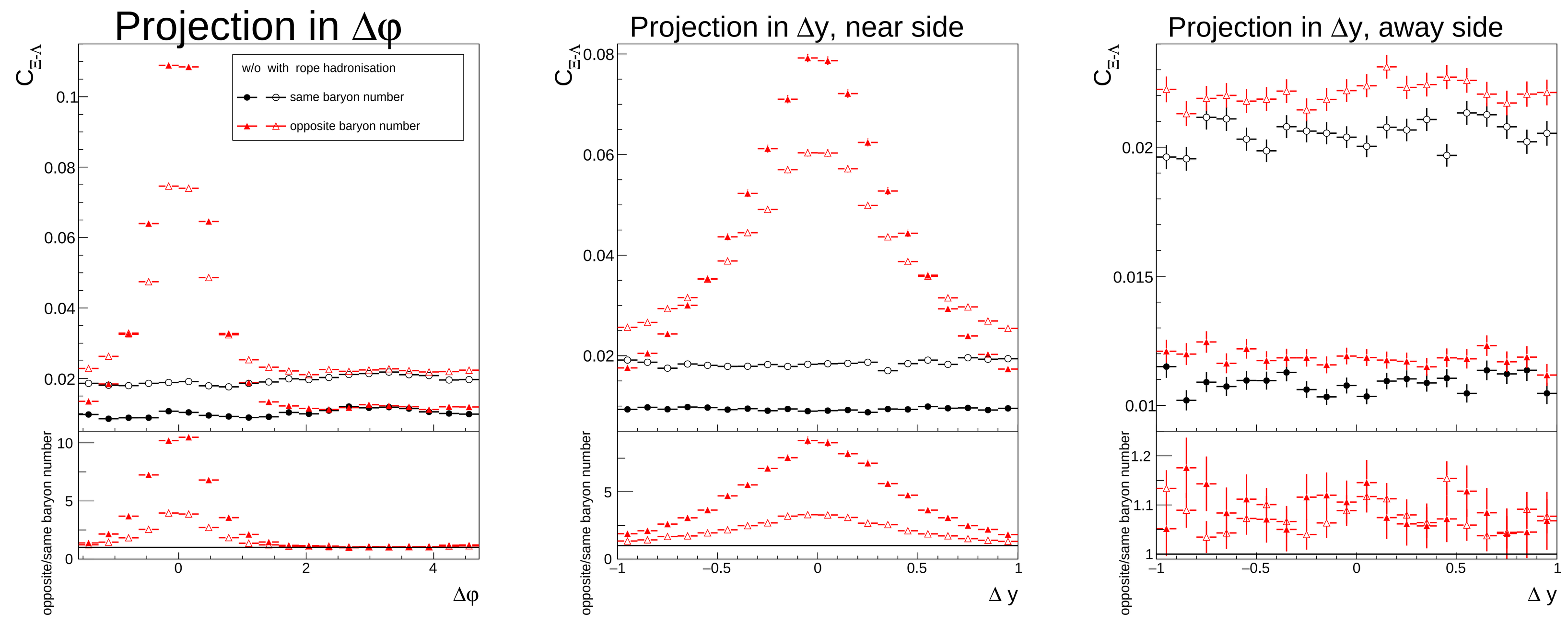
$\Xi - K$ correlations:



$\Xi - p$ correlations:

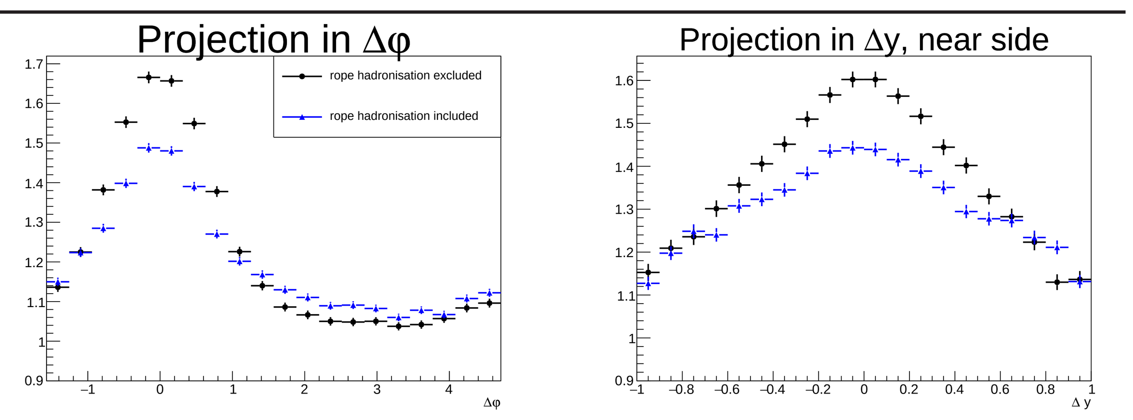


$\Xi - \Lambda$ correlations:



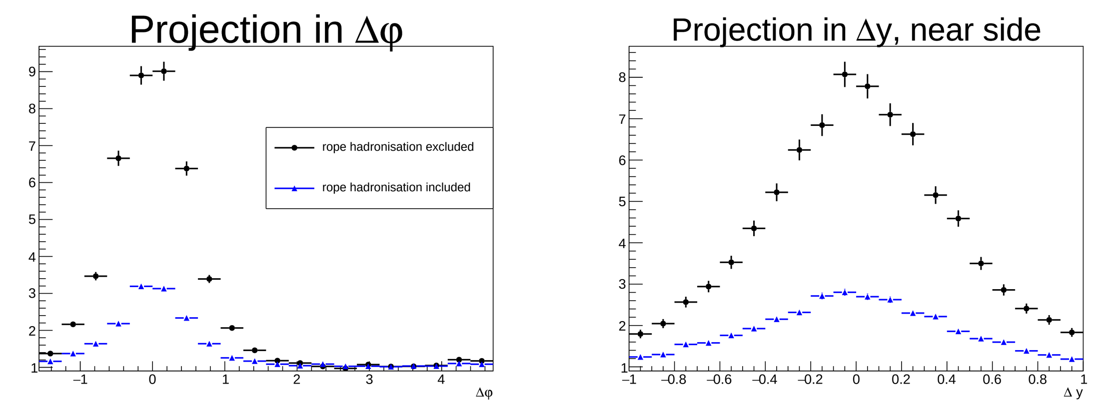
$$\frac{\mathbb{C}_{\Xi-K\,(\mathrm{OS})}/\mathbb{C}_{\Xi-K\,(\mathrm{SS})}}{\mathbb{C}_{\Xi-\pi\,(\mathrm{OS})}/\mathbb{C}_{\Xi-\pi\,(\mathrm{SS})}}$$

(to probe non-baryonic strangeness correlations):



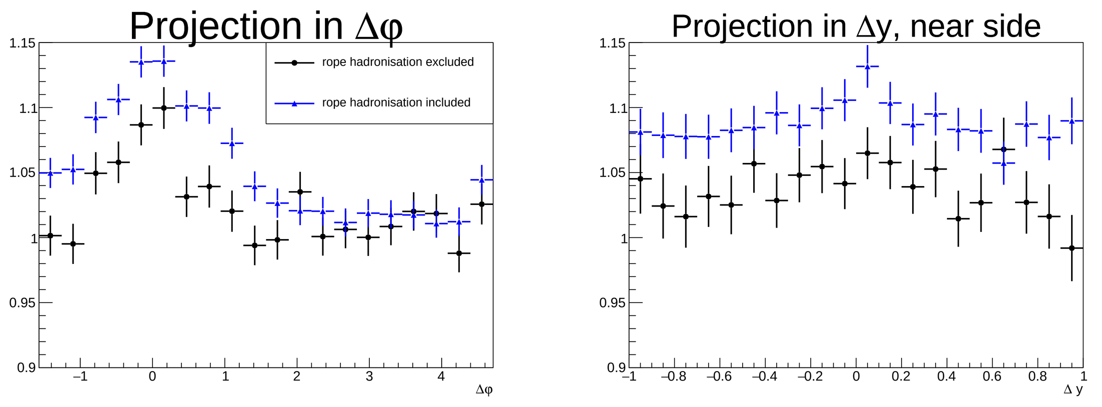
$$\frac{\mathbb{C}_{\Xi-\Lambda\,(\mathrm{OB})}/\mathbb{C}_{\Xi-\Lambda\,(\mathrm{SB})}}{\mathbb{C}_{\Xi-p\,(\mathrm{OB})}/\mathbb{C}_{\Xi-p\,(\mathrm{SB})}}$$

(to probe baryonic strangeness correlations):



$$\frac{\mathbb{C}_{\Xi-p\,(\mathrm{OB})}/\mathbb{C}_{\Xi-p\,(\mathrm{SB})}}{\mathbb{C}_{\Xi-\pi\,(\mathrm{OS})}/\mathbb{C}_{\Xi-\pi\,(\mathrm{SS})}}$$

(to probe baryon number correlations):



Summary and conclusions

Correlations between the Ξ baryon and other hadrons are compared between PYTHIA 8 with and without rope hadronisation enabled. Main features when including rope hadronisation:

- Larger overall strangeness yields.
- Λ spectra weaker in Ξ-triggered events.
- Weaker $\Xi - \Lambda$ correlations on the near side.
- Enhancement of opposite-sign $\Xi - K$ correlations on both sides of the event.
- Double ratio of $\Xi - K$ correlations compared to $\Xi - \pi$ weaker.
- Difference between opposite- and same-baryon number $\Xi - p$ correlations on the away side.