Investigating the influence of the mass on the baryon correlation puzzle using angular correlation functions at LHC energies

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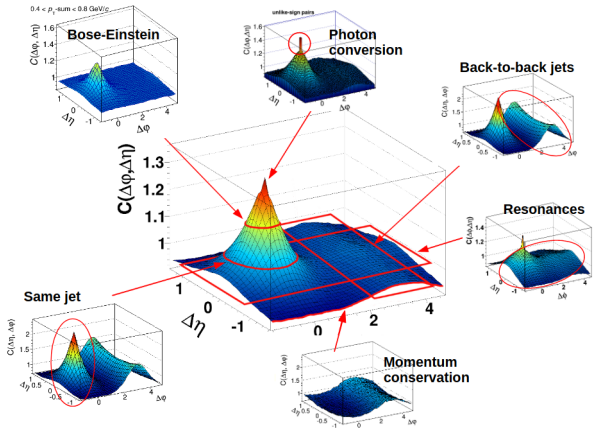
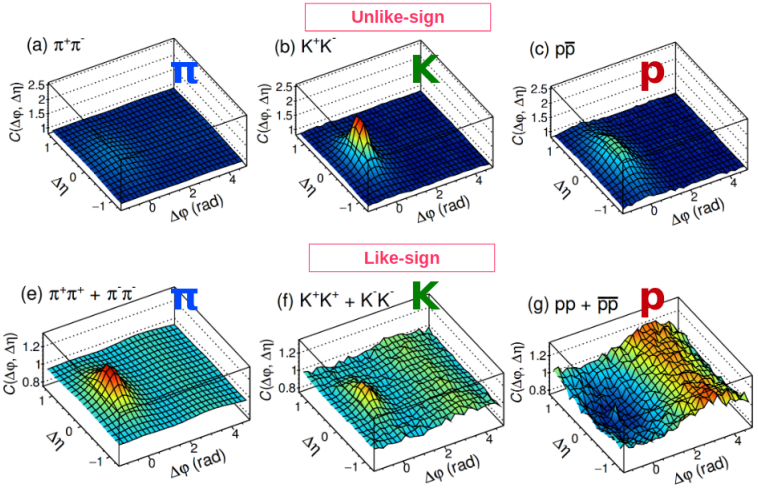
Introduction and general idea



Contributions from various sources to the angular correlation function C($\Delta\eta$, $\Delta\varphi$).

Ł. K. Graczykowski and M. A. Janik, *Unfolding the effects of final-state interactions and quantum statistics in two-particle angular correlations, Phys.Rev. C, vol. 104, no. 5, p. 054909, 2021.*

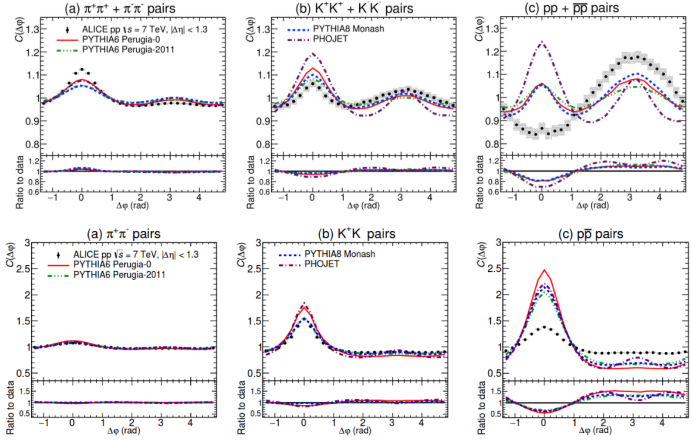
Baryon correlation puzzle



M. A. Janik, *"Insight into particle production mechanisms from angular correlations of identified particles in pp collisions measured by ALICE"*, EPJ Web Conf. 171 (2018) 19003

Baryon correlation puzzle

Comparing to the theoretical models



J. Adam et al., "*Insight into particle production mechanisms via angular correlations of identified particles in pp collisions at $\sqrt{s} = 7$ TeV*," Eur. Phys. J. C, vol. 77, no. 8, p. 569, 2017.

The baryon correlation puzzle

There are many possible explanations:

- too small range of p_{T},
- coulomb repulsion,
- other baryons,
- strong Final-State Interactions,
- Fermi-Dirac Quantum Statistics.

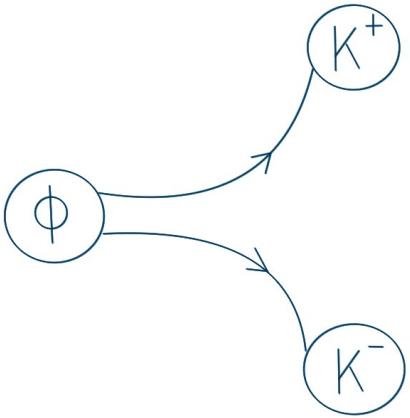
Influence of the mass on the baryon correlation puzzle

There are many possible explanations:

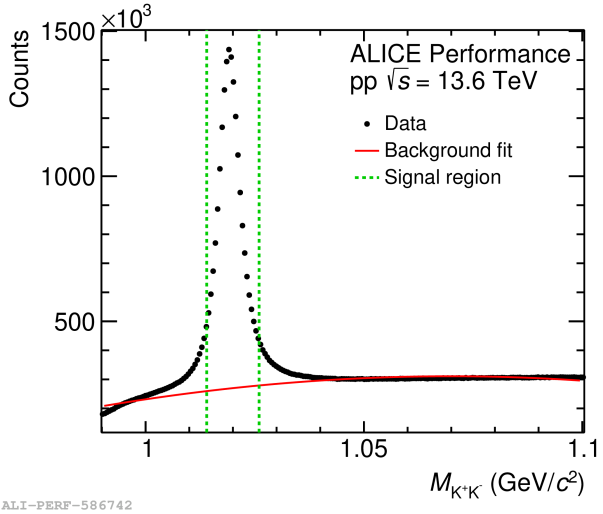
- too small range of p_{T},
- coulomb repulsion,
- other baryons,
- strong Final-State Interactions,
- Fermi-Dirac Quantum Statistics,
- **maybe mass plays a significant role?**

Why Φ mesons?

- Φ mesons have similar mass to protons but they are **not** baryons.
- By analysing correlation functions of Φ mesons there is a possibility to check whether this effect is purely baryonic.

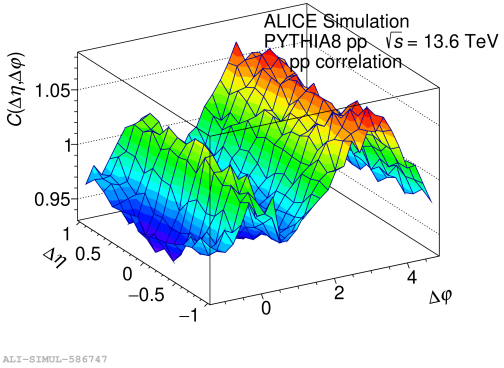


Influence of the mass on the baryon correlation puzzle

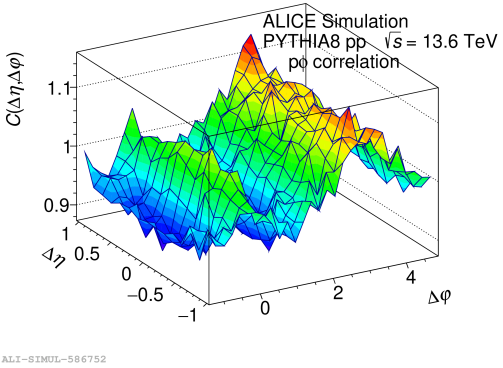


Invariant mass distribution for Φ meson candidates, ALICE p–p collisions at $\sqrt{s} = 13.6\,\mathrm{TeV}$.

Influence of the mass on the baryon correlation puzzle



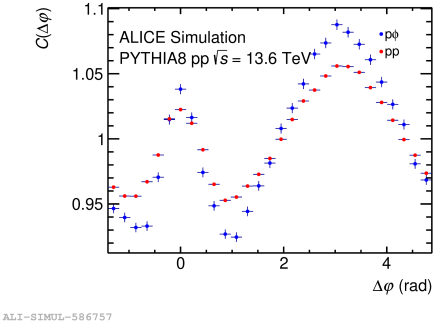
(a) pp



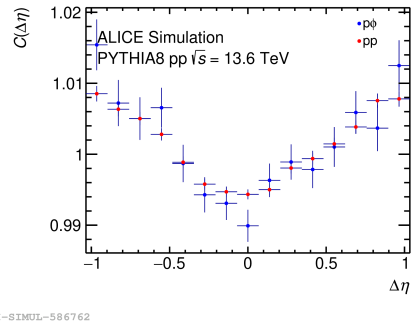
(b) pΦ

Angular correlation functions, PYTHIA p–p collisions at $\sqrt{s} = 13.6\,\mathrm{TeV}$.

Influence of the mass on the baryon correlation puzzle



(a) $\Delta\varphi$ projection

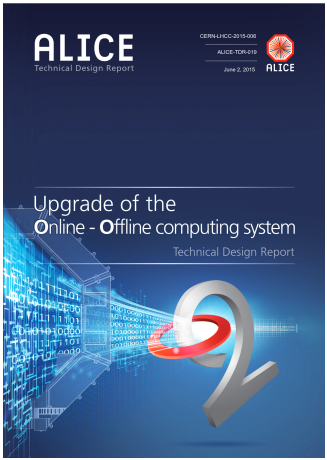


(b) $\Delta\eta$ projection

Projections of angular correlation function for pΦ and pp correlations, PYTHIA p–p collisions at $\sqrt{s} = 13.6\,\mathrm{TeV}$.

Tools that are used for the analysis of angular correlations in the ALICE experiment

The O^2 software



ALICE performs continuous data acquisition. New O^2 software introduces novel data format and processing method. It uses Apache Arrow flat arrays and is written in C++ 17.

The new software is more complex than the one used before and is still undergoing dynamic development. At the same time, the changes are so great that the existing analysis needs to be re-written.

P. Buncic, M. Krzewicki, and P. Vande Vyvre, "Technical Design Report for the Upgrade of the Online-Offline Computing System," tech. rep., 2015.

The O^2 software

New ALICE O^2 software:

- is based on the arrow tables https://arrow.apache.org/ (tables are split but linked),
- uses declarative programming.

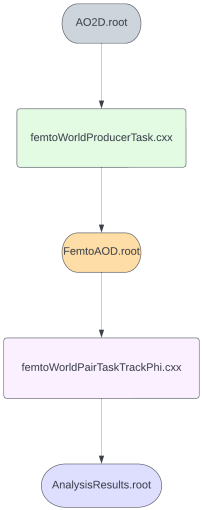
Track table	Collision index	pT	ϕ	η
Row 1	1	1.75	0.02	-0.51
Row 2	1	0.38	1.32	0.32
Row 3	2	0.92	-0.75	0.44
Row 4	2	2.63	0.66	-0.01
Row 5	2	1.65	-0.23	-0.14
Row 6	2	1.32	0.62	0.09
Row 7	3	0.21	1.43	0.30

FemtoUniverse

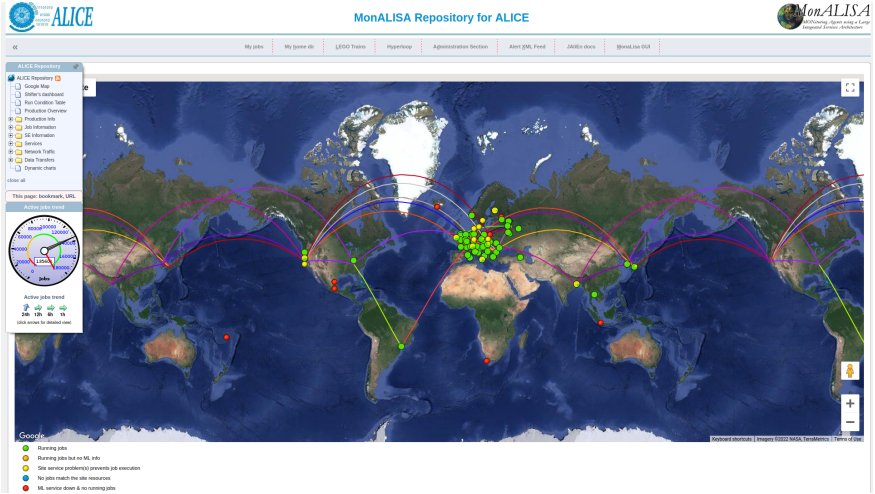
- Femtoscopic and/or angular correlations of
  - hadron $-\ \Phi$,
  - $p - \bar{p}$,
  - $\pi - \pi$,
  - hadron – V0,
  - and hadron – D0.
- Modular producer is used to select particles of interest to be saved/reconstructed.

Required steps for this analysis:

- reconstruct Φ meson candidates from K^+K^- pairs,
- correlate given Φ mesons candidates with identified hadrons.



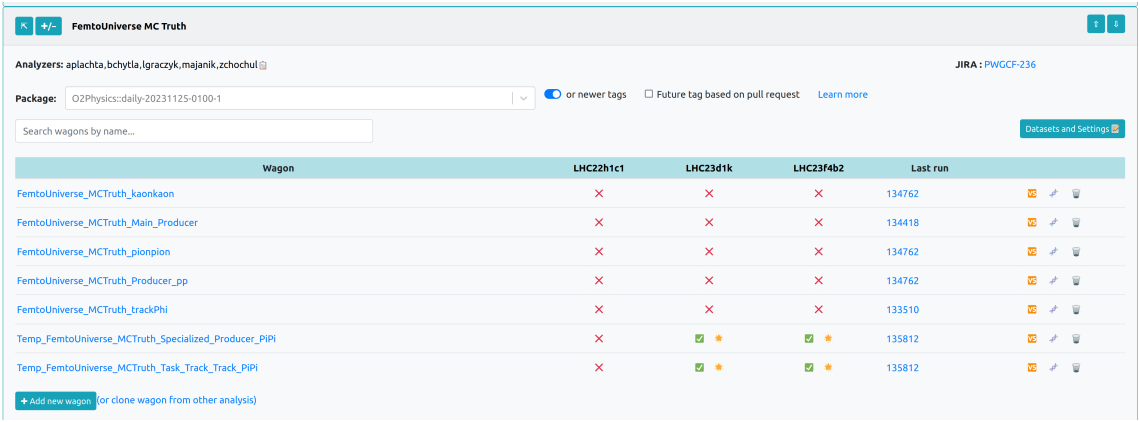
Each green dot indicate the site that is running jobs.



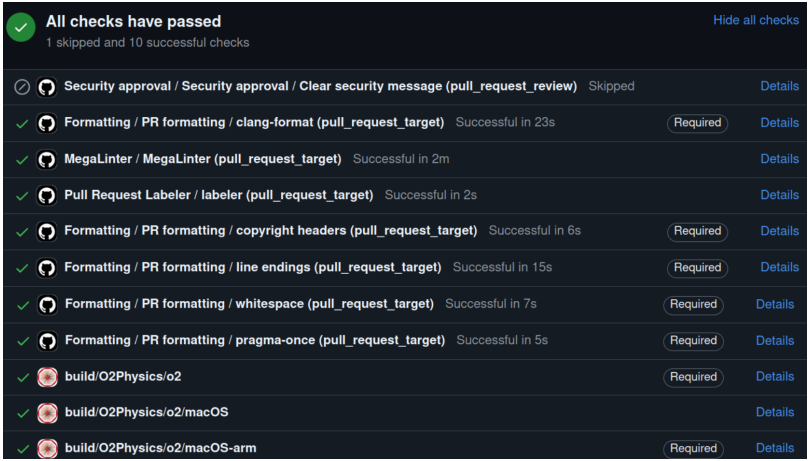
GRID sites map

Hyperloop

The Hyperloop train system is used to submit the analyses of multiple users to the GRID.



To add developed code to the official repository we use GitHub.

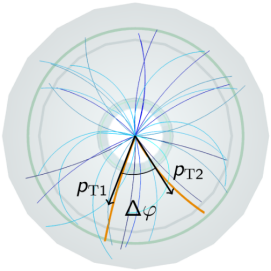


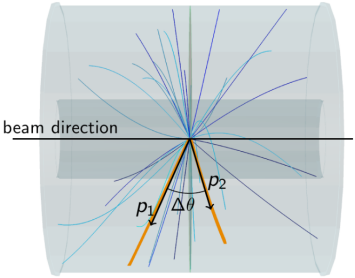
Summary and outlook

- **Summary:**
  - Baryon correlation puzzle remains unsolved still, but there are a lot of ongoing analyses trying to explain it.
  - From what can be seen in PYTHIA pp and pΦ angular correlation functions are quite similar.
- **Outlook:**
  - Future results of pΦ correlations from ALICE p–p collisions at $\sqrt{s} = 13.6\,\text{TeV}$ seam to be quite exciting!

Thank you for your attention!

Backup





p - particle momentum

θ - polar angle

η - pseudorapidity

p_{T} - transverse momentum

φ - azimuthal angle

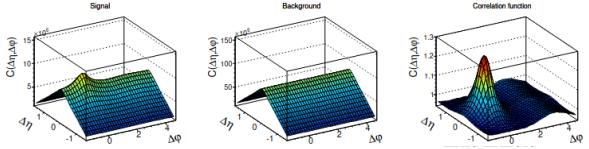
$\eta = -\ln\left(\tan\frac{\theta}{2}\right)$

Signal distribution:

$$S(\Delta\eta, \Delta\varphi) = \frac{d^2 N^{signal}}{d\Delta\eta\Delta\varphi}$$

Uncorrelated reference:

$$B(\Delta\eta, \Delta\varphi) = \frac{d^2 N^{mixed}}{d\Delta\eta\Delta\varphi}$$



Correlation function:

$$C(\Delta\eta, \Delta\varphi) = \frac{N^{\text{mixed pairs}}}{N^{\text{signal pairs}}} \frac{S(\Delta\eta, \Delta\varphi)}{B(\Delta\eta, \Delta\varphi)}$$

M. A. Janik, Ph.D. thesis, Warsaw U. of Tech., 2014