Prospects of angular correlation studies of identified hadrons in the LHC Run 3 with the ALICE experiment

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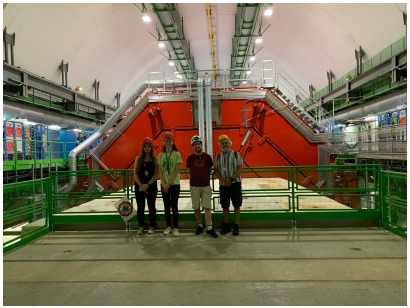
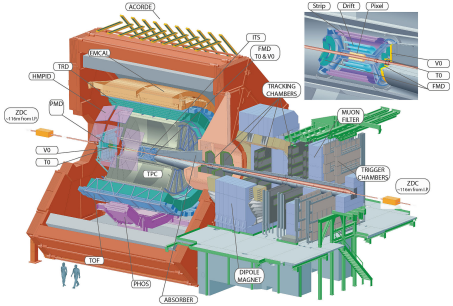
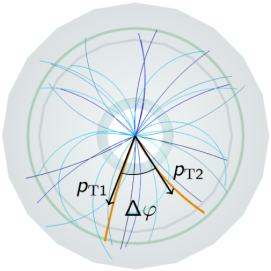
- Introduction and general idea
- Tools used for the analysis
- FemtoUniverse
- Summary

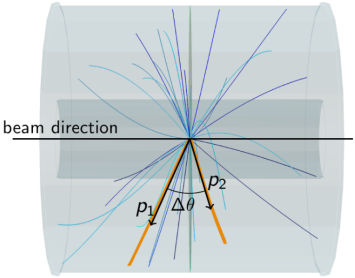


The cavern of the ALICE experiment.



The ALICE detector.





p - particle momentum

θ - polar angle

η - pseudorapidity

p_{T} - transverse momentum

φ - azimuthal angle

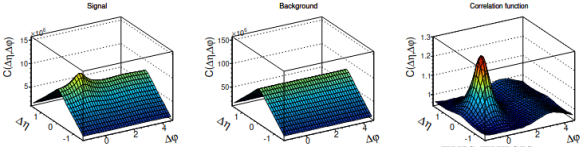
$\eta = -\ln\left(\tan\frac{\theta}{2}\right)$

Signal distribution:

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

Uncorrelated reference:

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

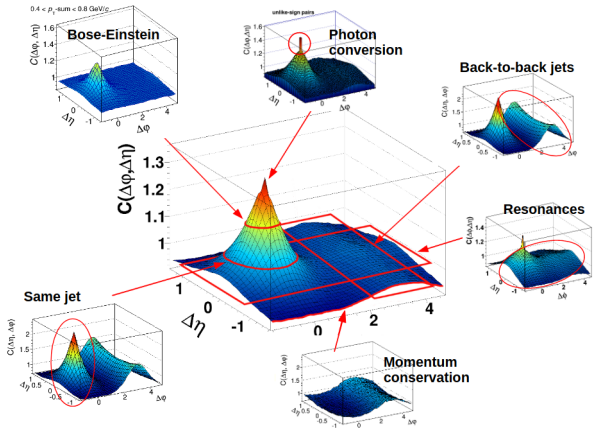


Correlation function:

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

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

Introduction and general idea



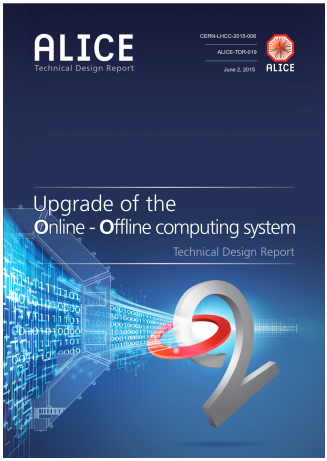
Contributions from various sources to the angular correlation function C(η, φ).

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.*

Tools used to analyze angular correlations in the ALICE experiment

Tools used in this analysis

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.

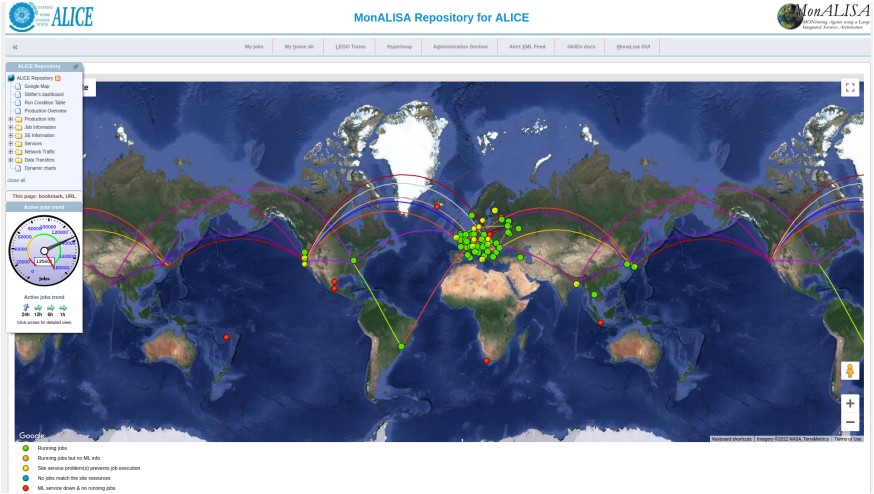
The O^2 software

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

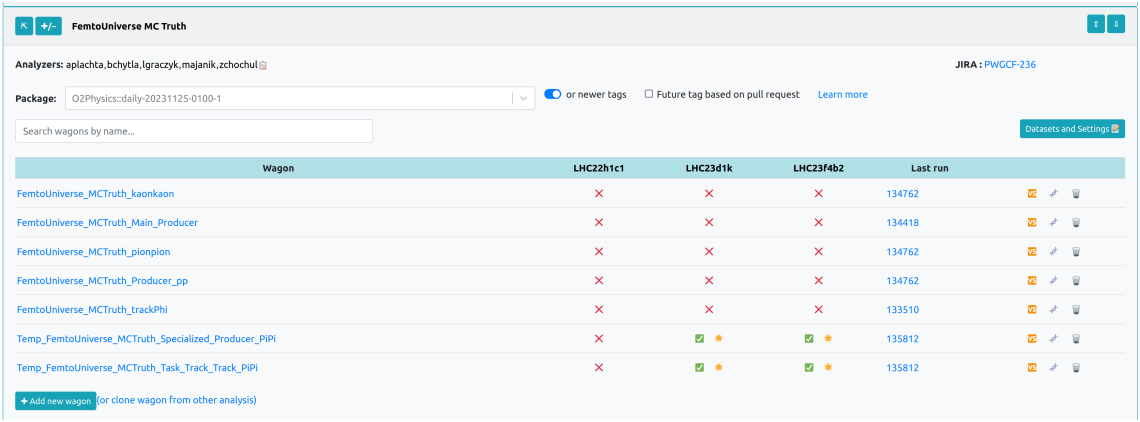
Each green dot indicate the site that is running jobs.



GRID sites map

Hyperloop

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

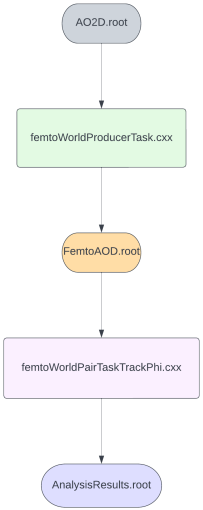


FemtoUniverse

- 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:

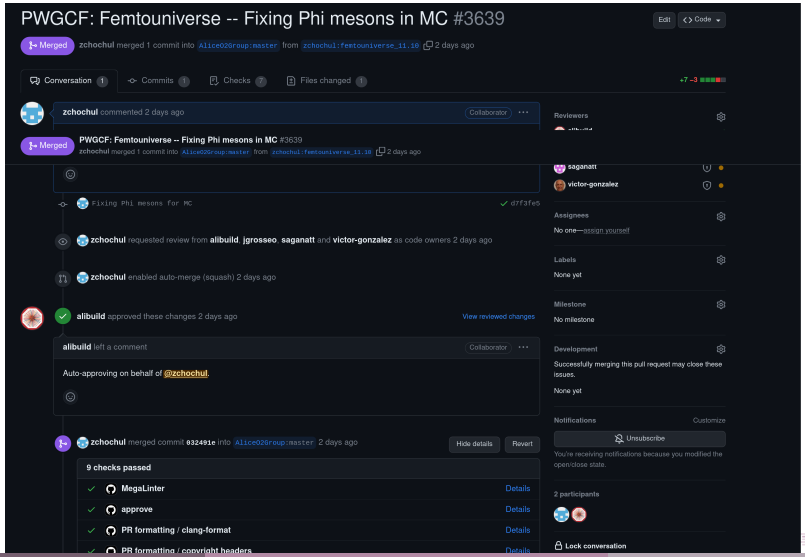
- reconstruct Φ meson candidates from K^+K^- pairs,
- correlate given Φ mesons candidates with identified hadrons.



Tools used in this analysis

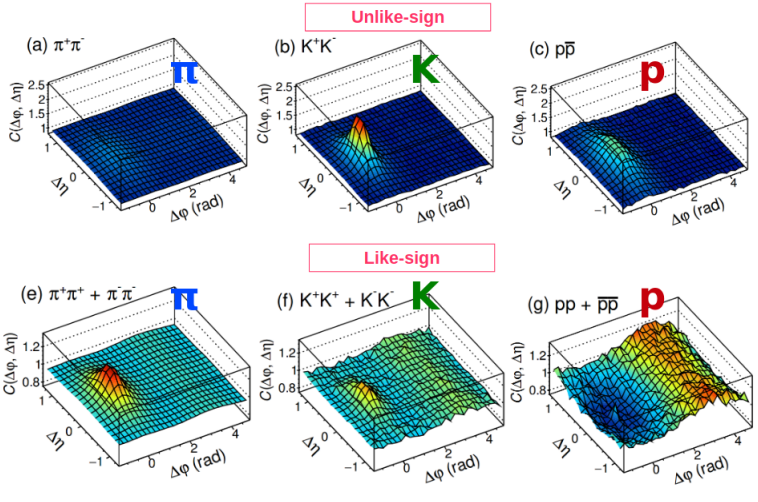
GitHub

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



My analysis in the FemtoUniverse

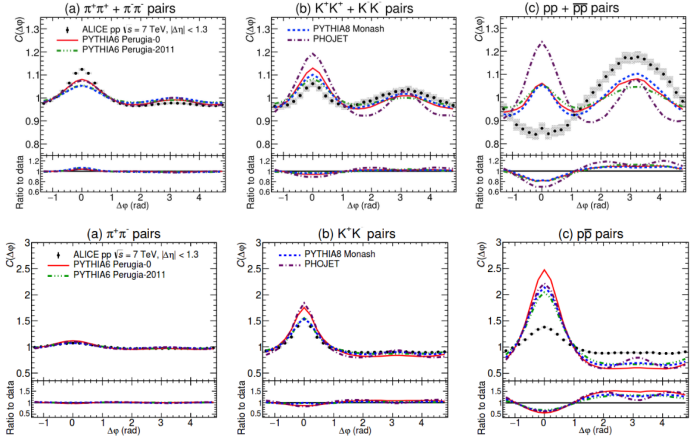
My analysis in the FemtoUniverse



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

My analysis in the FemtoUniverse

Comparing to the theoretical models



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

My analysis in the FemtoUniverse

There are many possible explanations:

- Too small range of p_{T}
- Coulomb repulsion
- Other baryons
- Strong Final-State Interactions
- Fermi-Dirac Quantum Statistics

My analysis in the FemtoUniverse

There are many possible explanations:

- Too small range of p_{T}
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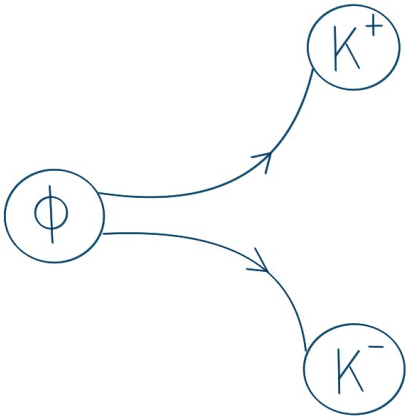
- Other baryons
- Strong Final-State Interactions
- Fermi-Dirac Quantum Statistics
- **Maybe mass plays a significant role?**

Why Φ mesons?

- Φ mesons have similar mass to protons but they are **not** baryons.
- By analysing correlation functions of Φ mesons we will be able to check whether this effect is purely baryonic.



Summary and outlook

- **Summary:**
  - The new FemtoUniverse package allows for the study of both angular and femtoscopic correlations.
  - The code is optimized within the O^2 framework and on the Hyperloop train system.
- **Outlook:**
  - The code still needs further testing and optimization, but the current performance and the preliminary results are promising.

Thank you for your attention!

Backup

Cuts	**globalTrack**
min number of crossed rows TPC	70
min ratio of crossed rows over findable clusters TPC	0.8
max chi2 per cluster TPC	4.0
max chi2 per cluster ITS	36.0
require TPC refit	true
require ITS refit	true
max DCA to vertex z	2.0
max DCA to vertex xy	0.0105*0.035/$p_T^{1.1}$
cluster requirement ITS	at least one hit in SPD
p_T range	0.1 - 1e10
η range	-0.8-0.8