

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

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WUT

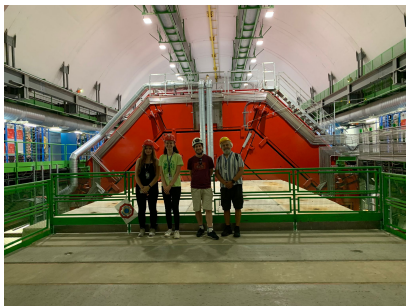


ALICE

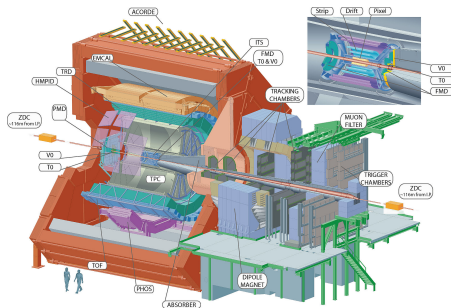
- Introduction and general idea
- Tools used for the analysis
- FemtoUniverse
- Summary

Introduction

ALICE CERN



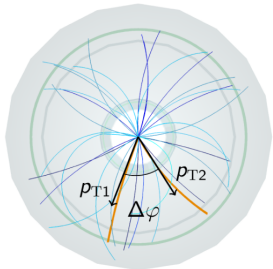
The cavern of the ALICE experiment.



The ALICE detector.

Introduction and general idea

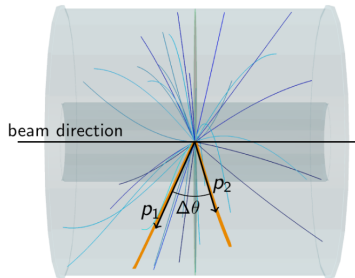
Observables



p - particle momentum

θ - polar angle

η - pseudorapidity



p_T - transverse momentum

φ - azimuthal angle

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

Introduction and general idea

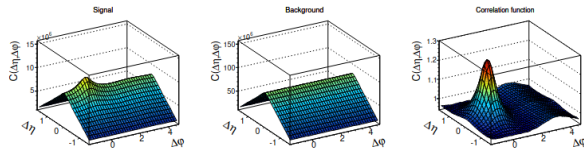
Angular correlations

Signal distribution:

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

Uncorrelated
reference:

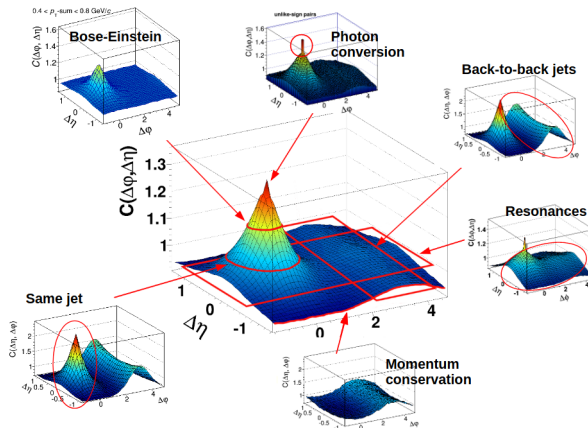
$$B(\Delta\eta, \Delta\varphi) = \frac{d^2 N^{mixed}}{d\Delta\eta d\Delta\varphi}$$



Correlation function:

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

Introduction and general idea



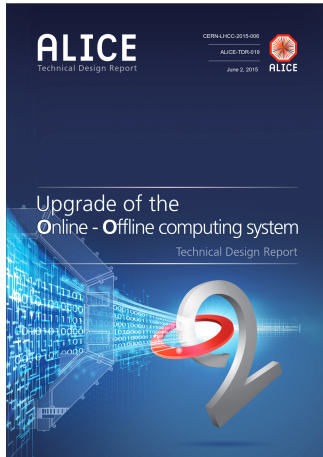
Contributions from various sources to the angular correlation function $C(\eta, \varphi)$.

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.

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.

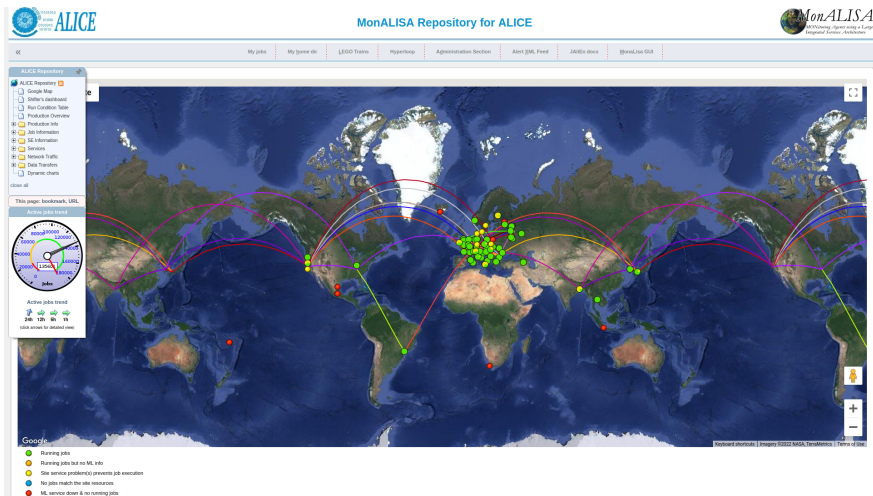
P. Buncic, M. Krzewicki, and P. Vande Vyvre, "Technical Design Report for the Upgrade of the Online-Offline Computing System," tech. rep., 2015.

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

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

FemtoUniverse MC Truth

Analyzers: aplachta,bchytla,lgraczyk,majanik,zchochul JIRA : PWGCF-236

Package: O2Physics:daily-20231125-0100-1 or newer tags Future tag based on pull request [Learn more](#)

Search wagons by name... Datasets and Settings

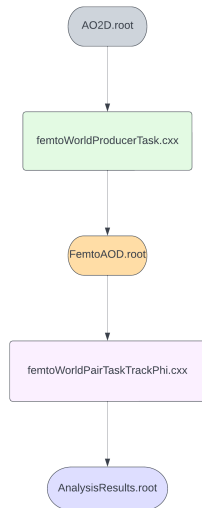
Wagon	LHC22h1c1	LHC23d1k	LHC23f4b2	Last run	
FemtoUniverse_MCTruth_kaonkaon	×	×	×	134762	
FemtoUniverse_MCTruth_Main_Producer	×	×	×	134418	
FemtoUniverse_MCTruth_pionpion	×	×	×	134762	
FemtoUniverse_MCTruth_Producer_pp	×	×	×	134762	
FemtoUniverse_MCTruth_trackPhi	×	×	×	133510	
Temp_FemtoUniverse_MCTruth_Specialized_Producer_PiPi	×	✓ *	✓ *	135812	
Temp_FemtoUniverse_MCTruth_Task_Track_Track_PiPi	×	✓ *	✓ *	135812	

+ Add new wagon (or clone wagon from other analysis)

- Femtoscopic and/or angular correlations of
 - hadron – Φ ,
 - p – \bar{p} ,
 - π – π ,
 - hadron – V_0 ,
 - and hadron – D_0 .
- 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

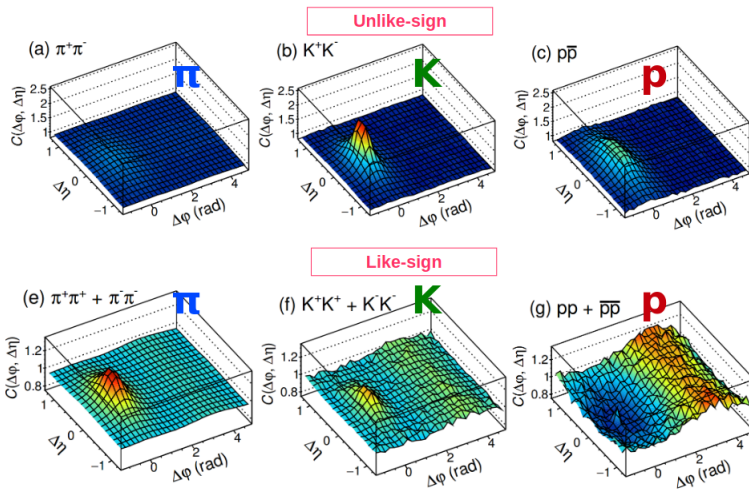
GitHub

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

The screenshot shows a GitHub pull request interface. At the top, the title is "PWGCF: Femtouniverse -- Fixing Phi mesons in MC #3639". A purple "Merged" badge indicates the pull request has been merged. Below the title, there are tabs for "Conversation", "Commits", "Checks", and "Files changed". The main content area shows a list of comments and actions: a comment by zchochul, a "Merged" notification, a commit "Fixing Phi mesons for MC" with a green checkmark, a request for review from alibuild, jgrosseo, saganatt, and victor-gonzalez, an auto-merge setting, and an approval from alibuild. A detailed comment from alibuild shows "Auto-approving on behalf of @zchochul". At the bottom, a "9 checks passed" section lists checks like MegaLinter, approve, PR formatting / clang-format, and PR formatting / copyright headers. On the right side, there are panels for "Reviewers" (saganatt, victor-gonzalez), "Assignees" (None), "Labels" (None), "Milestone" (None), "Development" (Successfully merging this pull request may close these issues), and "Notifications" (Unsubscribe).

My analysis in the FemtoUniverse

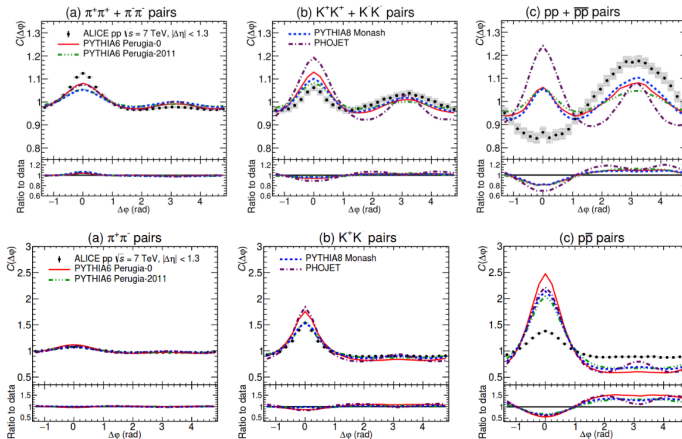
My analysis in the FemtoUniverse



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.

There are many possible explanations:

- Too small range of p_T
- Coulomb repulsion
- Other baryons
- Strong Final-State Interactions
- Fermi-Dirac Quantum Statistics

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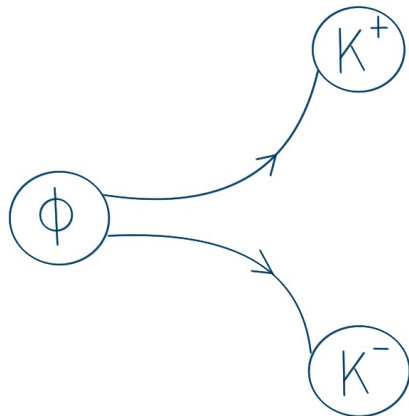
- Too small range of p_T
- Coulomb repulsion
- Other baryons
- Strong Final-State Interactions
- Fermi-Dirac Quantum Statistics
- Maybe mass plays a significant role?**

My analysis in the FemtoUniverse

Φ mesons

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:

- 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