Nuclei-hadron angular correlations (η, φ) in pp collisions

ALICE-ePIC Meeting - 21/02/2024

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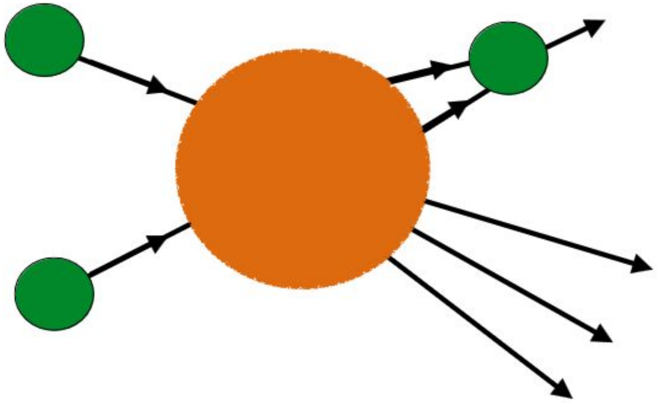
within the CosmicAntiNuclei Project

Physics motivation

Two phenomenological models for light nuclei formation:

Thermal statistical models → hadrons are produced by a thermally equilibrated source and their abundances are fixed at the chemical freeze-out



Coalescence approach → nucleons close in space, with similar velocities, and matching spin states can form a bound state

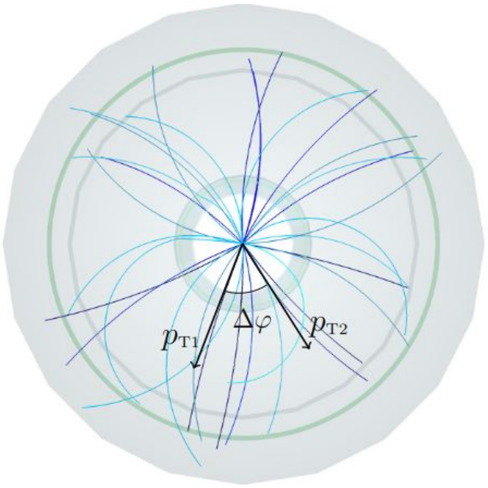
Small collision systems (as pp) particularly interesting

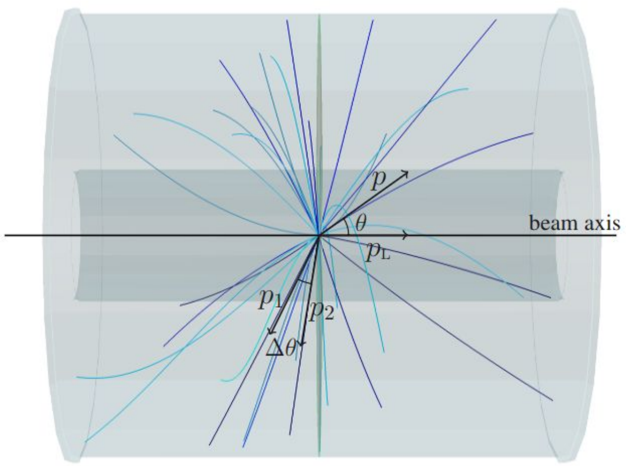
Analysis strategy

Angular correlation $(\Delta\eta, \Delta\varphi)$ distributions of the trigger (deuteron) and associated particle (proton) pairs → compare proton yields close with the deuteron in phase-space and uncorrelated to probe coalescence

$$
\begin{cases}
\Delta\eta = \eta^{d}_{trig} - \eta^{p}_{assoc} \\
\Delta\varphi = \varphi^{d}_{trig} - \varphi^{p}_{assoc}
\end{cases}
$$

φ: azimuthal angle
η = - ln (tan(θ/2))
θ: polar angle





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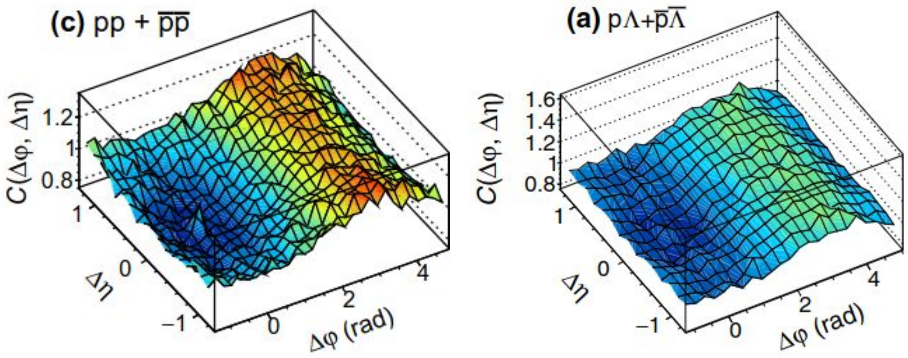
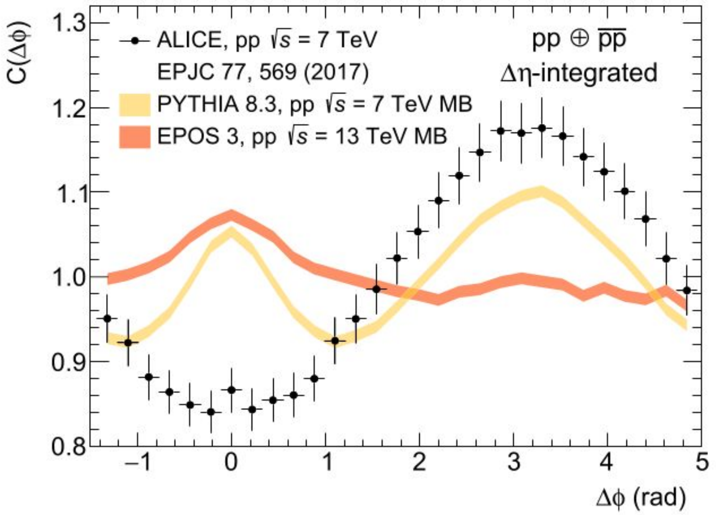
Baryon correlations

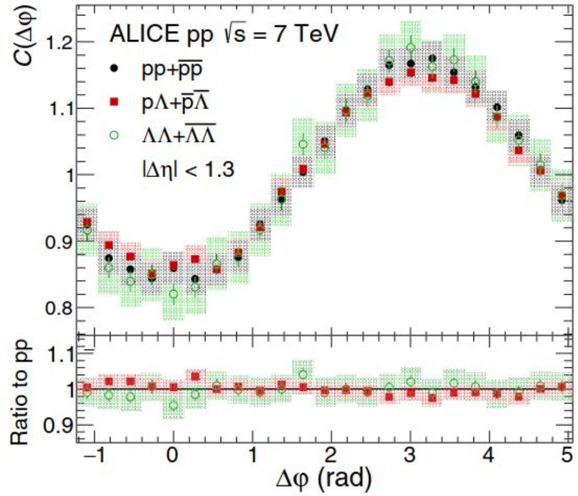
Near-side depression of the angular correlation functions for **like-sign baryon pairs**, not reproduced in PYTHIA/EPOS

Coalescence mechanism was considered

No results yet for d-p correlation!







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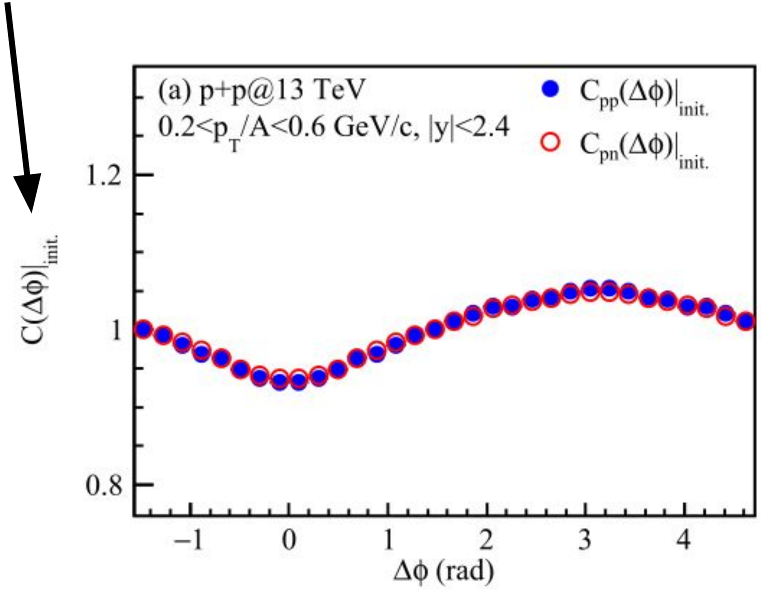
d-p correlations in the models

Azimuthal correlation functions of the ***initial*** protons and neutrons → emitted from the collision system at freeze-out



In this paper: AMPT model with a coalescence afterburner (hybrid model combining several sub-models)

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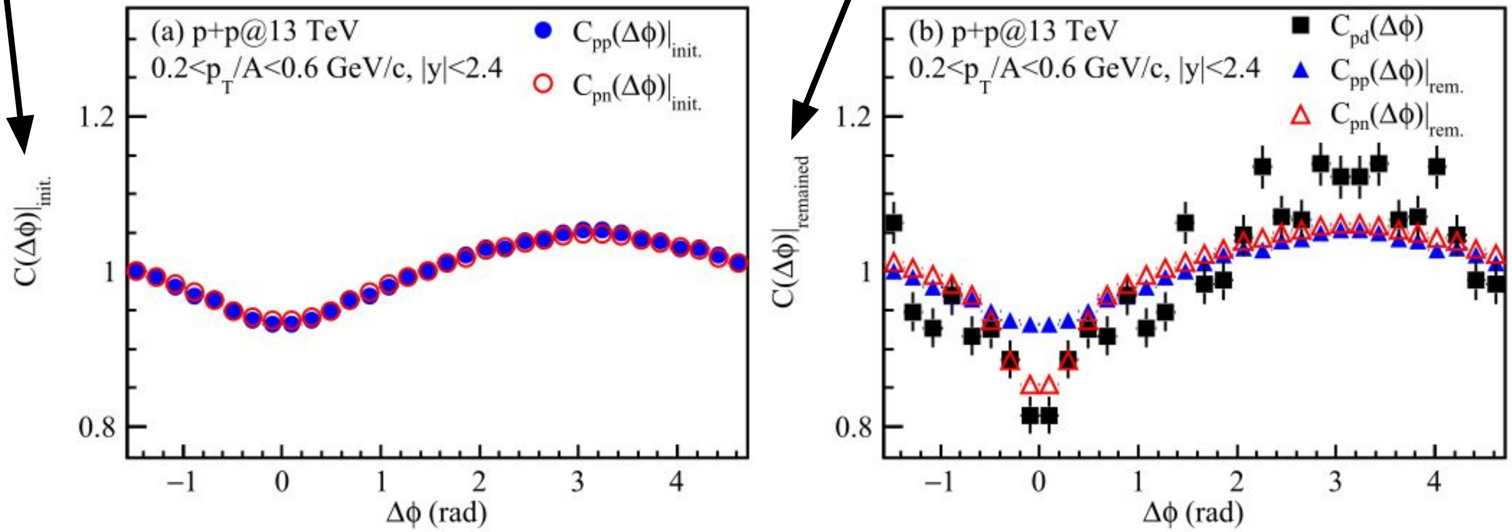
Part of the initial protons and neutrons coalesces into deuterons and the ***remaining*** nucleons construct the azimuthal correlation functions



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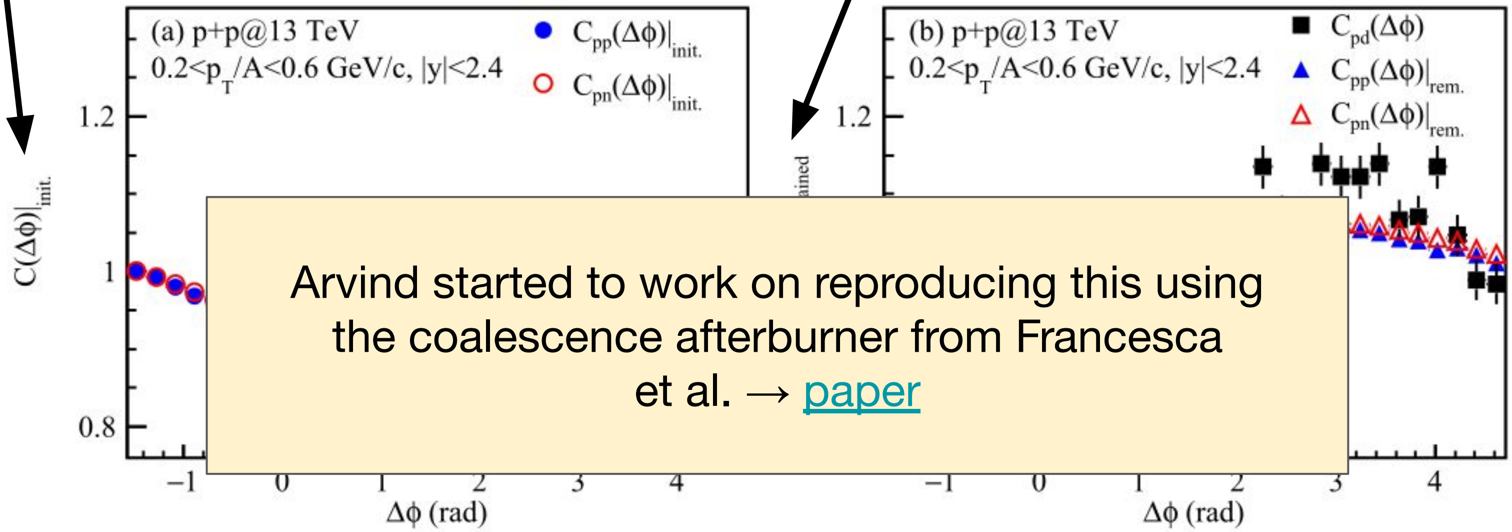


Arvind started to work on reproducing this using the coalescence afterburner from Francesca et al. → paper

In this paper: AMPT model with a coalescence afterburner (hybrid model combining several sub-models)

Analysis strategy

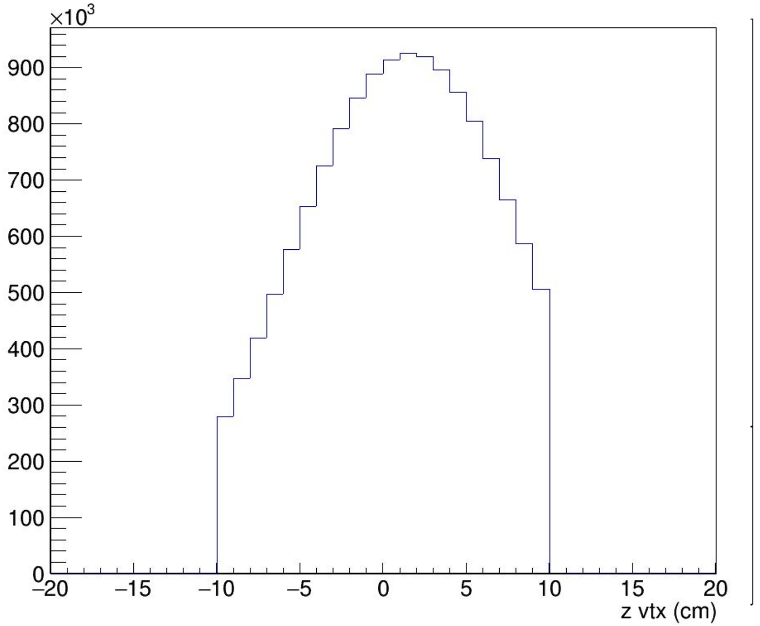
1. Event selection
2. Identification of deuterons (trigger particle)
3. Identification of associated protons
4. Calculation of the raw $(\Delta\eta, \Delta\varphi)$ angular correlation distribution between the trigger deuterons and associated protons
5. Correct the angular correlation distribution with:
   a. pair acceptance (Mixed Event) → to reject non physical correlations (**Data**)
   b. reconstruction efficiencies for deuterons and protons (p_T, η) (**MC**)
   c. corrections for secondaries (**MC**)

$$\frac{d^2N_{pair}}{d\Delta\varphi d\Delta\eta}(\Delta\varphi, \Delta\eta) = \frac{1}{N_{trigg}} \sum_{\eta_{trigg}} \sum_{\eta_{assoc}} \frac{1}{\varepsilon_{trigg}} \frac{1}{\varepsilon_{assoc}} \sum_{v_z} \frac{d^2N^{raw}_{pair}}{d\Delta\varphi d\Delta\eta}(\Delta\varphi, \Delta\eta) \frac{1}{\varepsilon_{pair}}$$

Event selection

- **Data**: LHC22cde apass4 → 80M events (Target → 13.6 TeV full apass4)
- **MC**: LHC22h1d1 → GP anchored to LHC22cde
- **Event selection**: sel8 + |zvtx|<10 cm

Data model: *singleTrackSelector* from femto team!



Track selection

For now TPC PID → $p_T < 1.2$ GeV/c

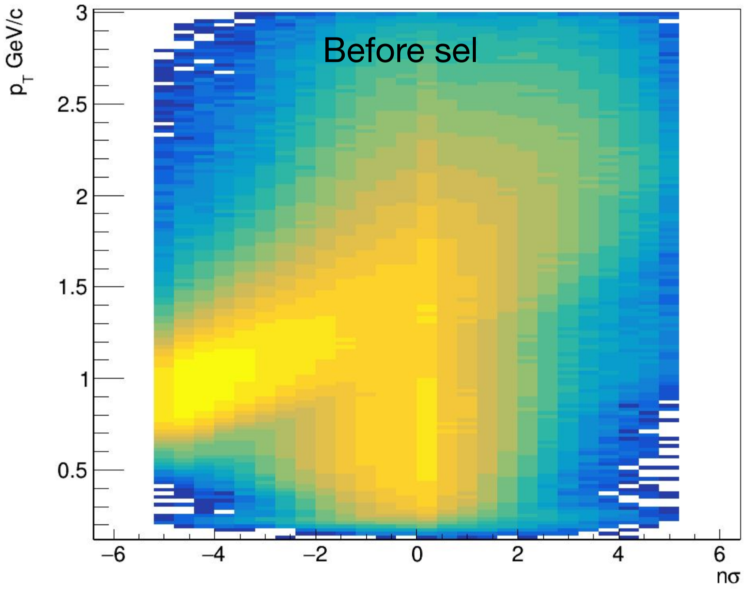
p_T bins:

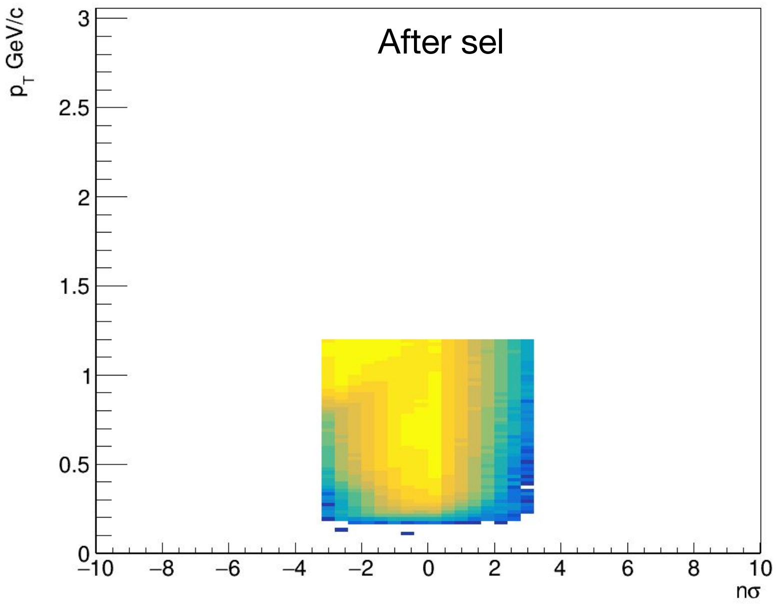
{0.2, 0.4, 0.5, 0.6, 0.7, 0.8, 1.0, 1.2}

Selection	Cut
hasITS	true
min N ITS clusters	1
hasTPC	true
TPC N cls found	80
TPC N crossed rows	70
ITS Chi2	36
TPC Chi2	4
p_T	> 0.2, < 1.0 GeV/c
DCA xy	0.14 cm
DCAz	0.1 cm

(Anti)proton identification (TPC)

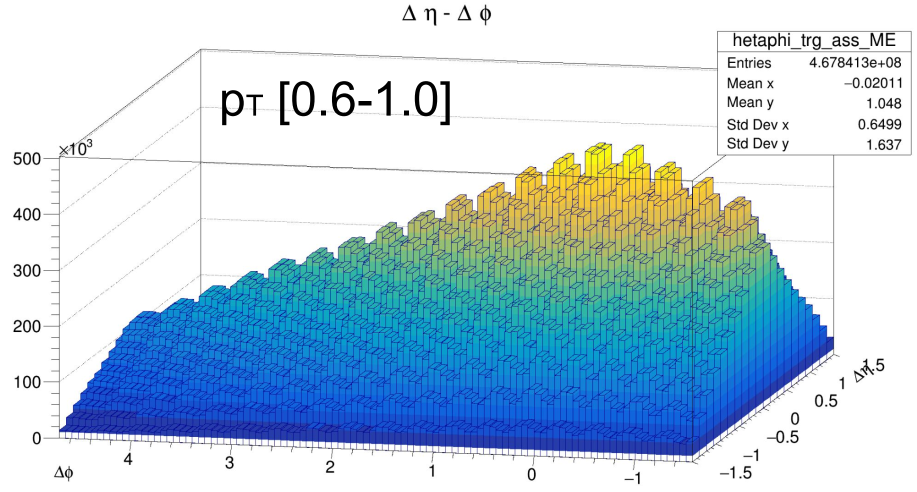
TPC 3σ (Pr) + $p_T < 1.2$ GeV/*c*





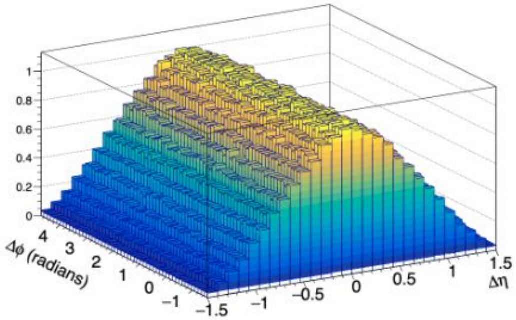
Mixed event implementation: $p\bar{p}$

1. Loop over tracks
2. Check PID of deu/pr
3. Map selected tracks to collision IDs
4. Loop over collisions
5. Define mixing bins in mult.+vertex bins (10x10)
6. mixing



First attempted using pr-antipr with AN 13 TeV as reference

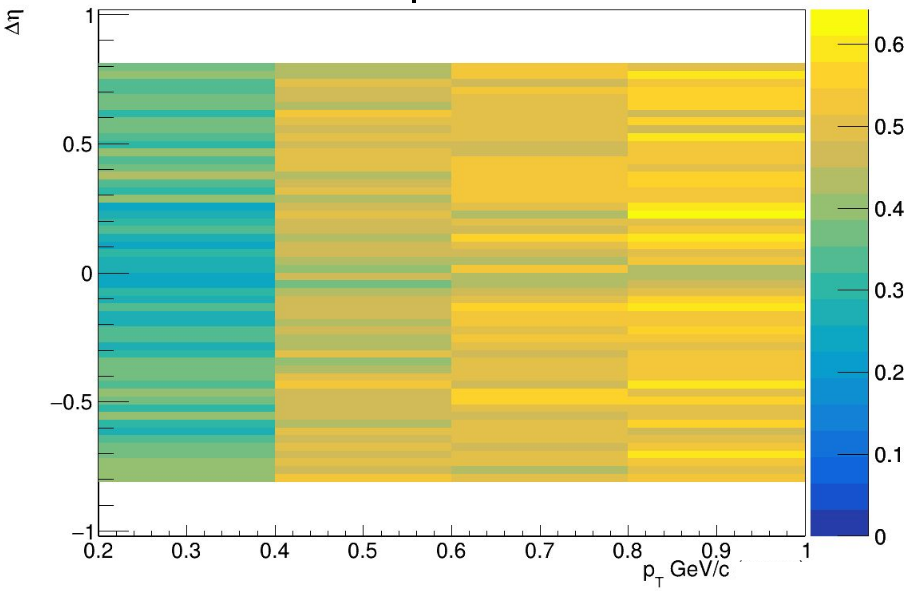
Not obtaining the correct distribution, i.e. → Under investigation

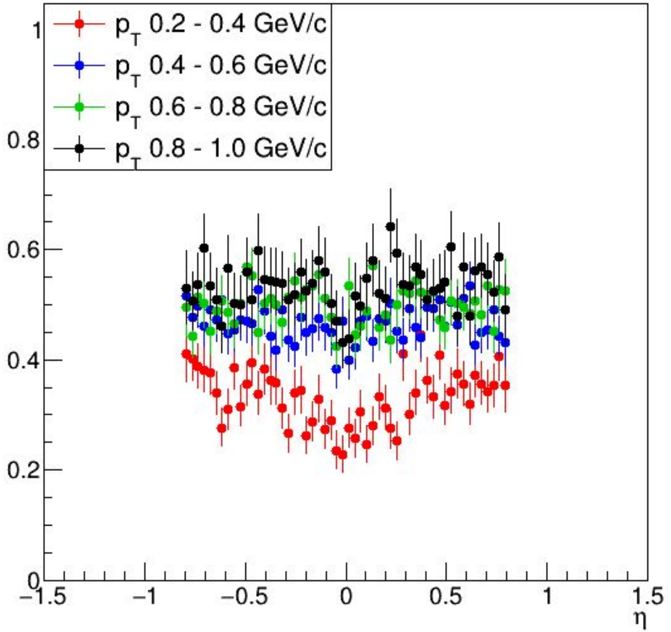


Efficiency calculation vs p_T, η

Tracking efficiency vs p_T, η (φ to do)

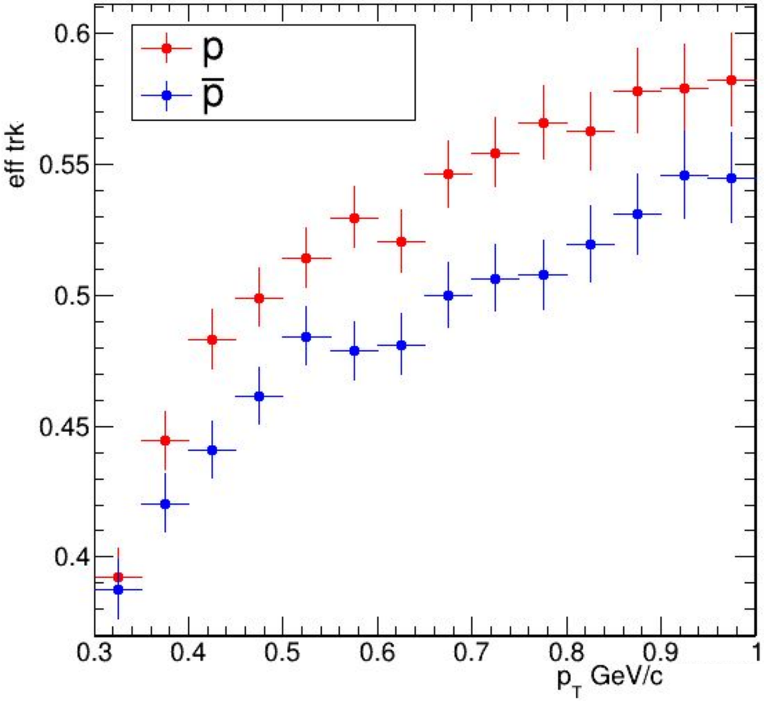
antiprotons





Efficiency calculation vs p_T, η

Tracking efficiency (anti-)protons vs p_T (on a subset of MC statistics!)



Outlook

New analysis on p-d angular correlation in p_T/A bins → data and simulation already being tackled !

Target datasets Run 3 data at 900 GeV and 13.6 TeV

Machinery being developed… more news soon!

Any idea/suggestion?