Angular correlations study of identified hadrons in the Au+Au collisions from $\sqrt{s_{NN}}$ = 7.7 – 62.4 GeV from STAR

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Abstract

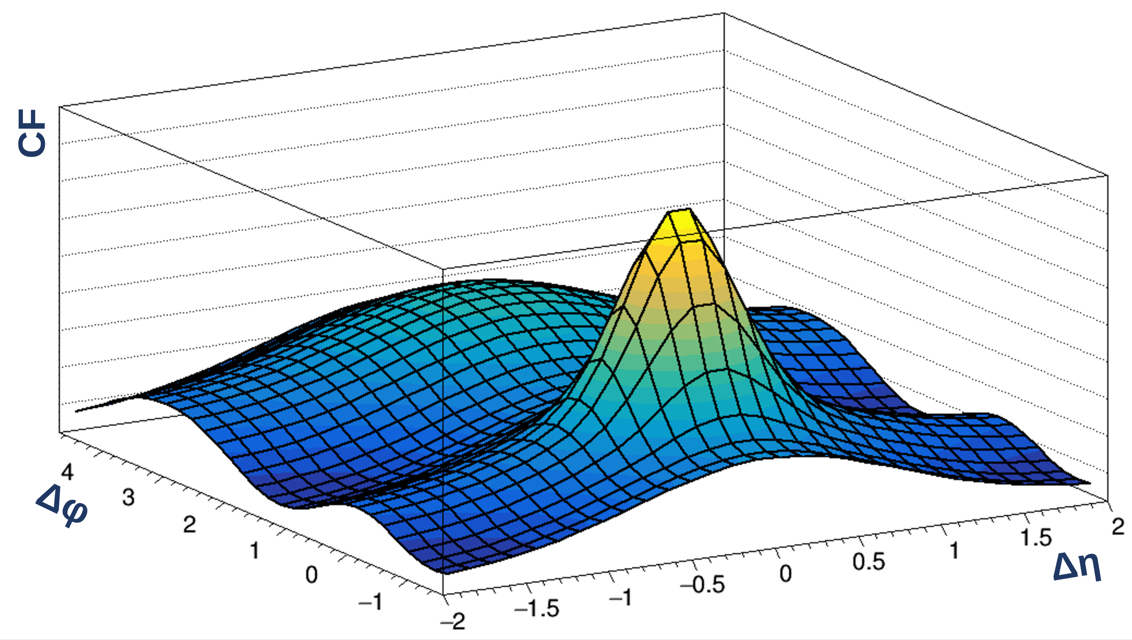
The angular correlation function (CF) refers to the correlation of particles in the pseudorapidity difference ($\Delta\eta = \eta_1 - \eta_2$) and azimuthal angle difference ($\Delta\varphi = \varphi_1 - \varphi_2$). CF is influenced by various physical phenomena such as conservation laws, collective particle flow, resonance decays, final state interactions, quantum statistics, or jets. CF analysis may allow to access the properties of system created during heavy ion collisions.

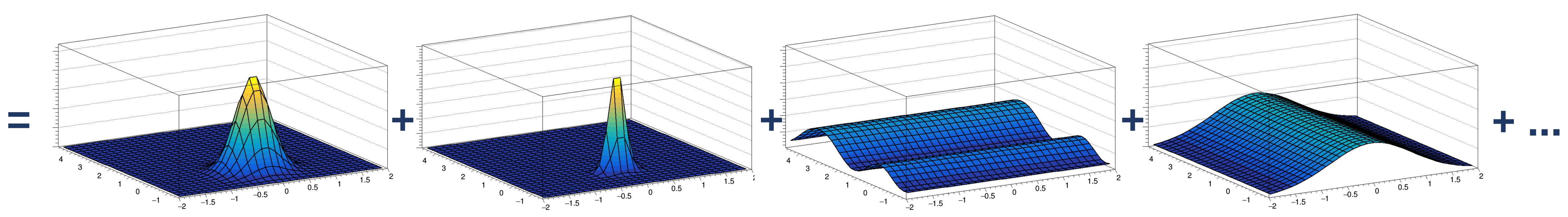
The STAR Beam Energy Scan data allows one to perform a detailed CF analysis to investigate the phase diagram of strongly interacting matter. This analysis covers data from seven Au+Au collision energies from $\sqrt{s_{NN}}$ = 7.7 to 62.4 GeV in 9 centrality classes. It is conducted with respect to charge combination and particle species. Such an extensive study provides constraints for theoretical models of heavy ion-collisions.

Note:
This is a STAR parallel analysis to that from [1]. Differences include: correlator definition, centrality selection, pseudorapidity acceptance, and the track crossing effect is not corrected

Goals and motivation

Model of 2D Correlation Function





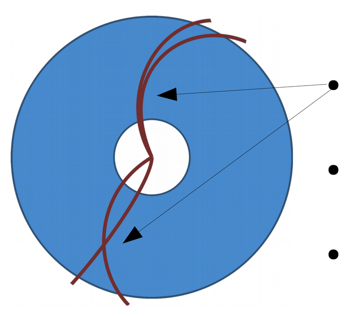
Short-range correlations: jets, final-state interactions, quantum statistics, ...

Long-range correlations: collective flow, string fragmentation, ...

- Exploration of data in search for signals of strongly interacting matter phase transition.
  - Different shapes of CF depending on a charge combination and a particle species:
  - Detailed study to provide constraints on theoretical models of heavy-ion collisions;
  - Unexplained pp correlations in small systems (p+p [2] and e^++e^- [3]) - what do we see in A+A?
- Disentanglement → study of contribution to CF from different mechanisms
  - study of collision energy dependence
  - study of centrality dependence

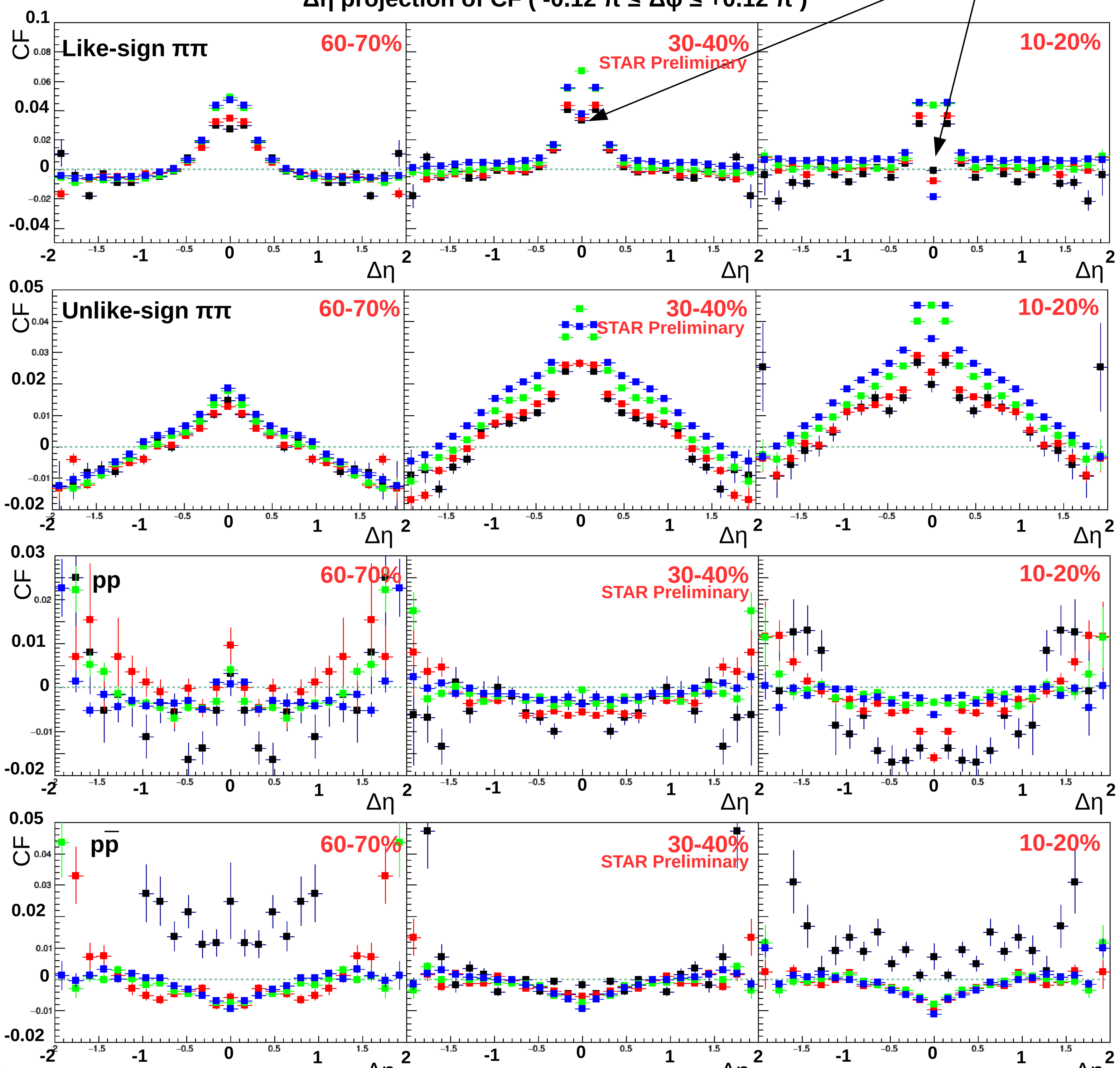
Results

Energy and centrality dependence of CF measured in Au + Au at:
$\sqrt{s_{NN}}$ = 7.7 GeV (black)
$\sqrt{s_{NN}}$ = 11.5 GeV (red)
$\sqrt{s_{NN}}$ = 19.6 GeV (blue)
$\sqrt{s_{NN}}$ = 39 GeV (green)
Uncertainties shown are only statistical



TPC hits merging:
- TPC hits from tracks close in space might be merged
- This results in pair losses in the nominator of CF
- This effect causes negative correlation at small Δη

Δη projection of CF (-0.12 π ≤ Δφ ≤ +0.12 π)



Analysis details

Definition of CF:

$$CF = \frac{\langle N_{ch} \rangle}{\Delta\eta\Delta\phi} \cdot \left(\frac{\rho_{sib}}{\rho_{ref}} - 1 \right)$$

where:
- ρ_{sib} is a single event pair density in a given Δη, Δφ bin;
- ρ_{ref} is a reference pair density in a given Δη, Δφ bin, obtained using **mixed events technique**;
- prefactor $\langle N_{ch} \rangle$ / ΔηΔφ is an average single-particle multiplicity divided by STAR angular acceptance (Δη = 2, Δφ = 2π).

Cuts and corrections:

- $0.2 \le p_T \le 0.8$ GeV/c
- $-1 \le \eta \le +1$
- PID ($e^\pm$, $\pi^\pm$, $K^\pm$, p and $\bar{p}$) using TPC dE/dx
  - $|n\sigma| < 2$ for each particle of interest
  - $|n\sigma| > 3$ for other particles
- Centrality based on N_{ch} in $|\eta| \le 1$
- Detector efficiency correction by mixing events in 50 N_{ch} and 2 cm wide V_z bins
- Pair reconstruction efficiency correction (influencing bin at Δη = 0) still pending

Conclusions

- CF in Au+Au at $\sqrt{s_{NN}}$ = 7.7, 11.5, 19.6 and 39 GeV have been measured for two-pion and two-proton pairs
- No non-monotonic behavior vs collision energy observed

Like-sign pion pairs:
- Strong short-range correlations are observed at all centralities and collision energies
- Peak amplitude grows with centrality and collision energy, assuming Gaussian or exponential shape

Unlike-sign pion pairs:
- Long-range correlation observed in all centralities and collision energies
- Long-range correlations overlaps with short-range correlation which resembles the one in LS pions

Like-sign (anti-)proton pairs:
- Long-range anti-correlation observed at all centralities and collision energies
- Weak centrality and collision energy dependence

Poton-anti-proton pairs:
- Short-range anti-correlation observed at all centralities and collision energies
- Weak centrality and collision energy dependence
- Limited due to small number of p$\bar{p}$ pairs in Au+Au @ 7.7 GeV

- Future work includes fine tuning of remaining corrections
- This analysis will continue with BES-II data

References
[1] A. Jowzaee for STAR, APS 2018 Columbus OH
[2] ALICE Coll., 2017 Eur. Phys. J. **C77** 569
[3] H. Aihara et al. 1986 Phys. Rev. Lett. **57** 3140

NATIONAL SCIENCE CENTRE POLAND
Project number: UMO-2016/21/N/ST2/00315

The STAR Collaboration
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