Femtoscopy Results in Au+Au collisions at $\sqrt{s_{NN}} = 3$ GeV at STAR

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Abstract: One of the main tasks of relativistic nuclear physics is the search for signs of formation, quantitative evaluation and description of nuclear matter properties under extreme conditions. Heavy-ion collision experiments provide a unique opportunity to investigate it in the laboratory. The characteristic of the system created as a result of heavy-ion collisions can be explored via spatial and temporal parameters obtained using the method of correlation femtoscopy. The results on the measurements of femtoscopic correlations are presented for proton-deuteron, deuteron-deuteron and identical pions pairs produced in Au+Au collisions at $\sqrt{s_{NN}} = 3$ GeV recorded by the STAR experiment at RHIC.

Motivation

Correlation femtoscopy of hadrons is widely used to study the spatio-temporal characteristics, shape and evolution of their sources created in heavy-ion collisions or other reactions involving hadrons.

Measurements of femtoscopic correlations of proton-proton, proton-deuteron, deuteron-deuteron and identical pions pairs produced in Au+Au collisions at $\sqrt{s_{NN}} = 3$ GeV recorded by the STAR experiment at RHIC provide important information (including parameters of strong interactions) about nuclear collisions at low energies.

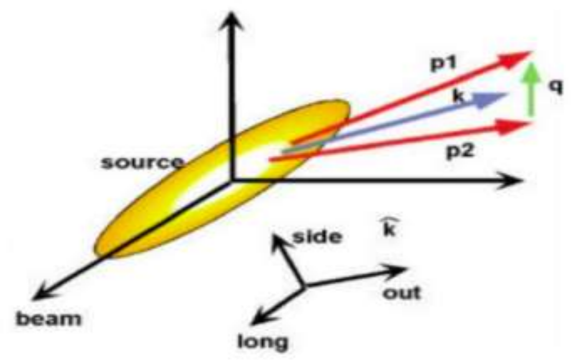
Correlation Femtoscopy Technique

Two-particle correlation function experimentally: $C(q) = \frac{A(q)}{B(q)}$, where

$A(q)$ - formed using pairs where both tracks are from the same event. It contains quantum-statistical correlations and final state interactions;

$B(q)$ - formed using pairs from different events (event-mixing technique).

q – relative momentum.

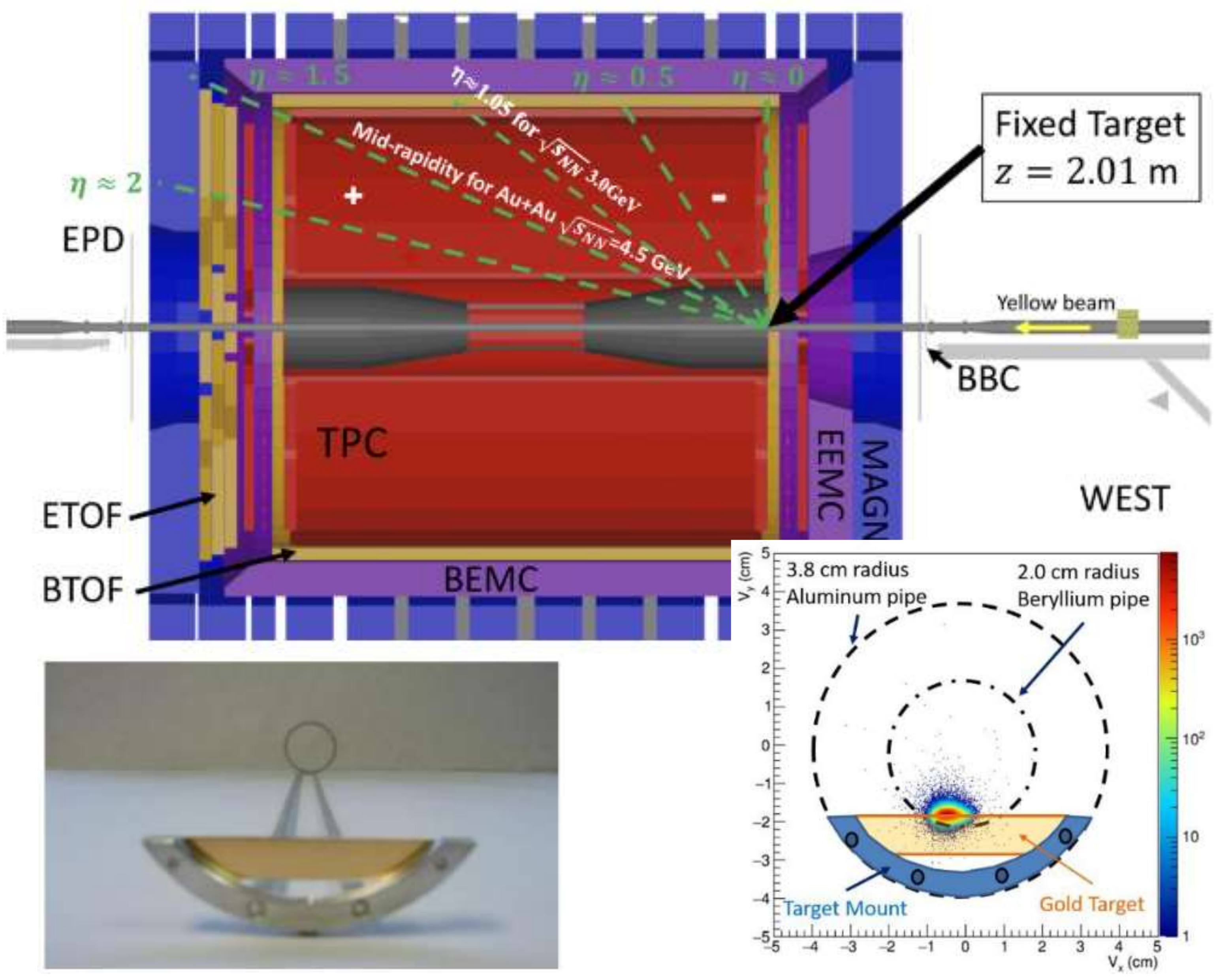


Femtoscopic radii are extracted by fitting C(q) with Bowler-Sinyukov [1-3]:

$$C(q) = N[(1-\lambda) + \lambda K(q)(1+G(q))]$$

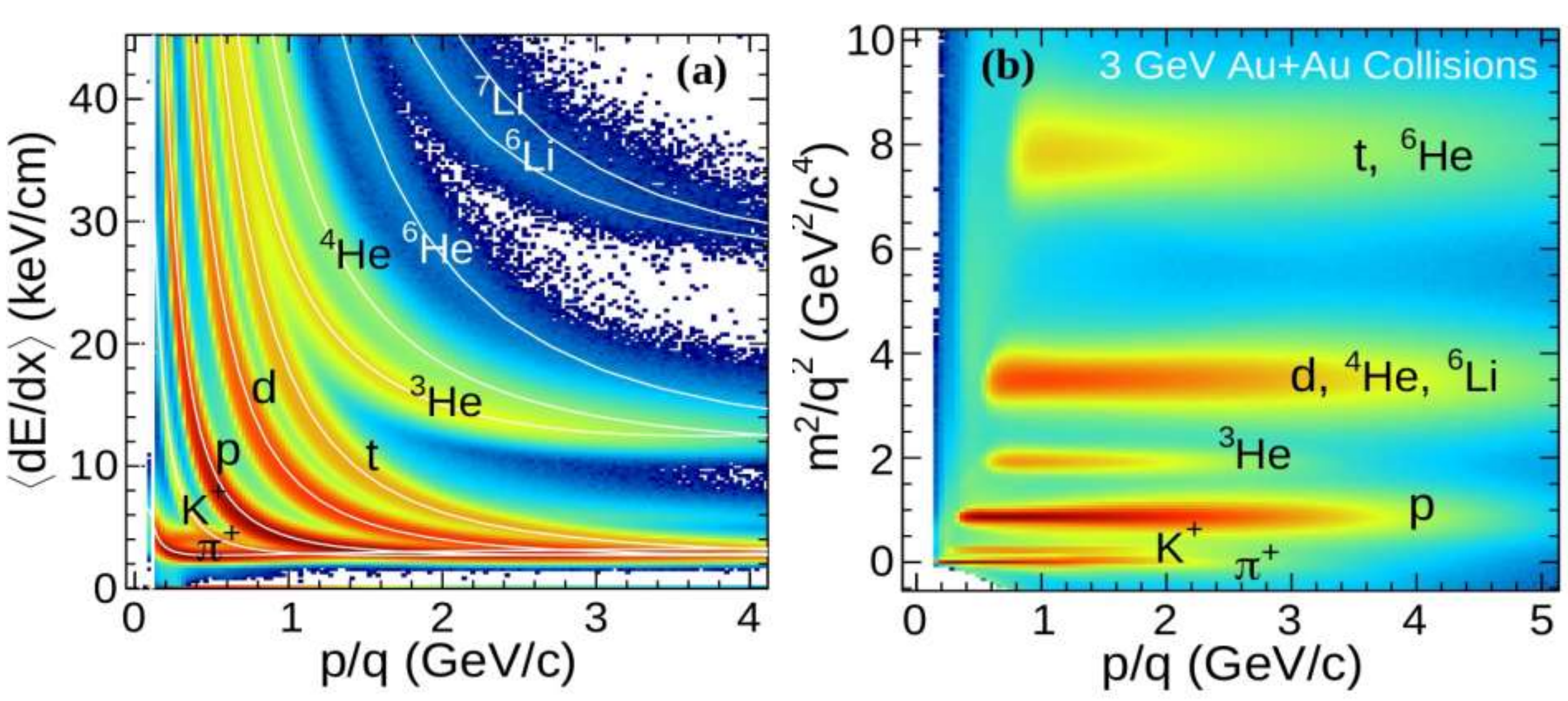
$$G(q) = exp(-q_o^2R_o^2 - q_s^2R_s^2 - q_l^2R_l^2 - 2q_oq_sR_{os}^2 - 2q_sq_lR_{sl}^2 - 2q_oq_lR_{ol}^2)$$

Fixed-Target (FXT) program at STAR



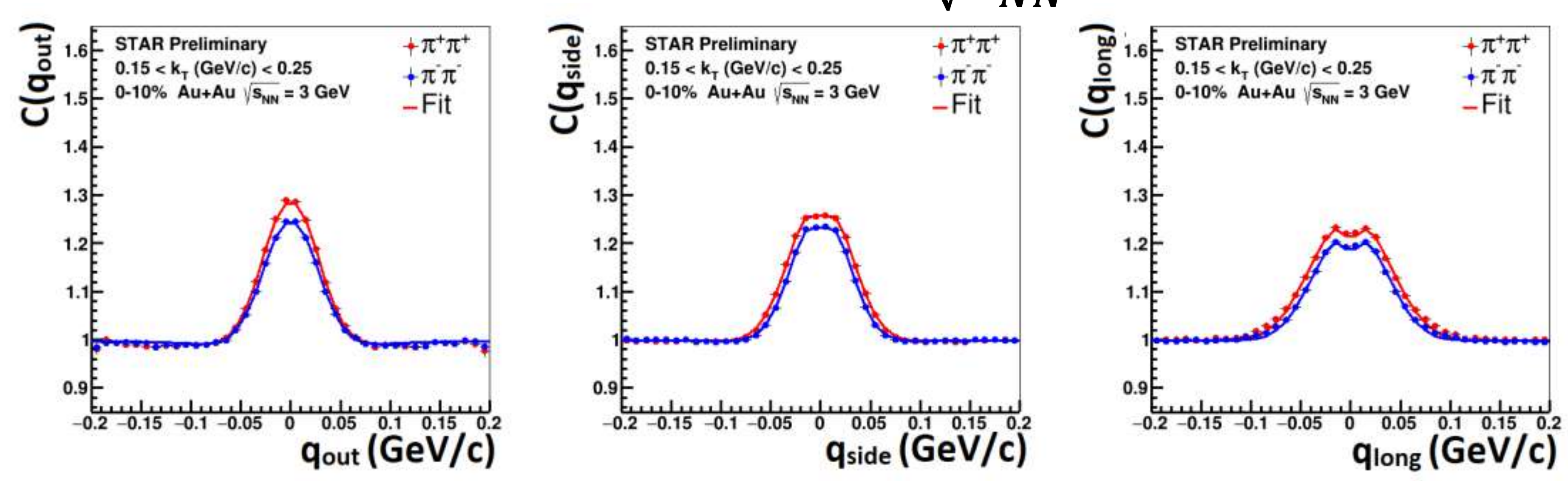
- Gold target of thickness 1.93 g/cm^2 (0.25 mm)
- Located 200.7 cm from the center of the Time Projection Chamber (TPC)
- Collision energies: $\sqrt{s_{NN}} = 3 - 13.7$ GeV

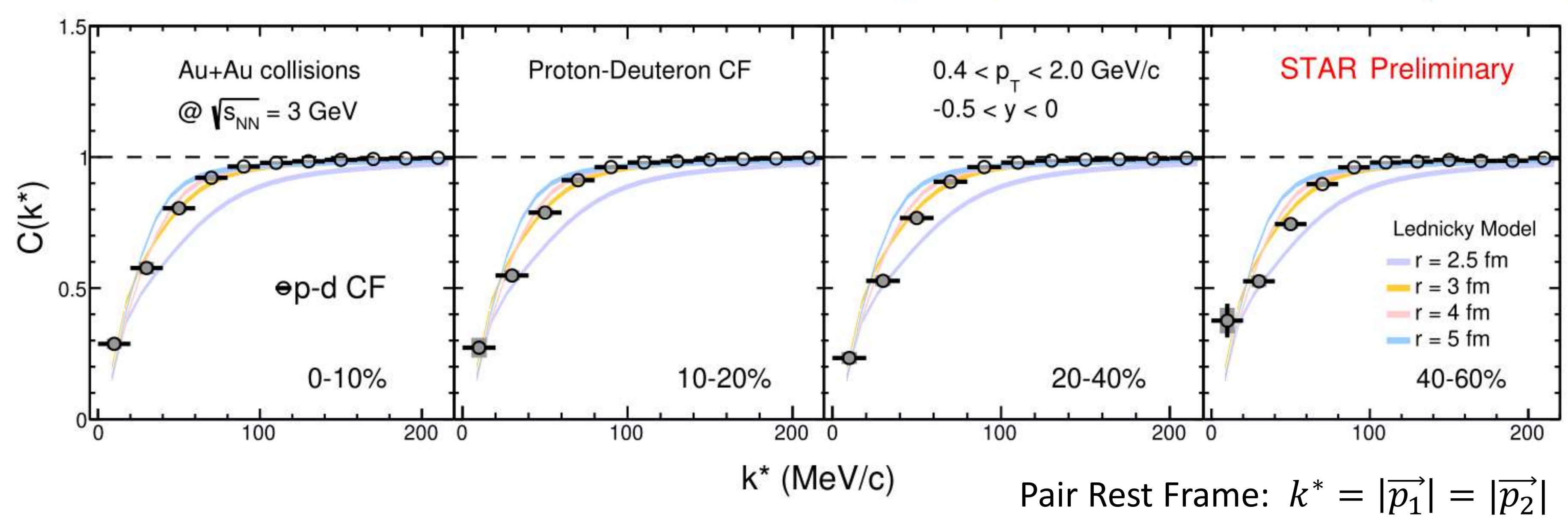
Particle Identification at $\sqrt{s_{NN}} = 3$ GeV

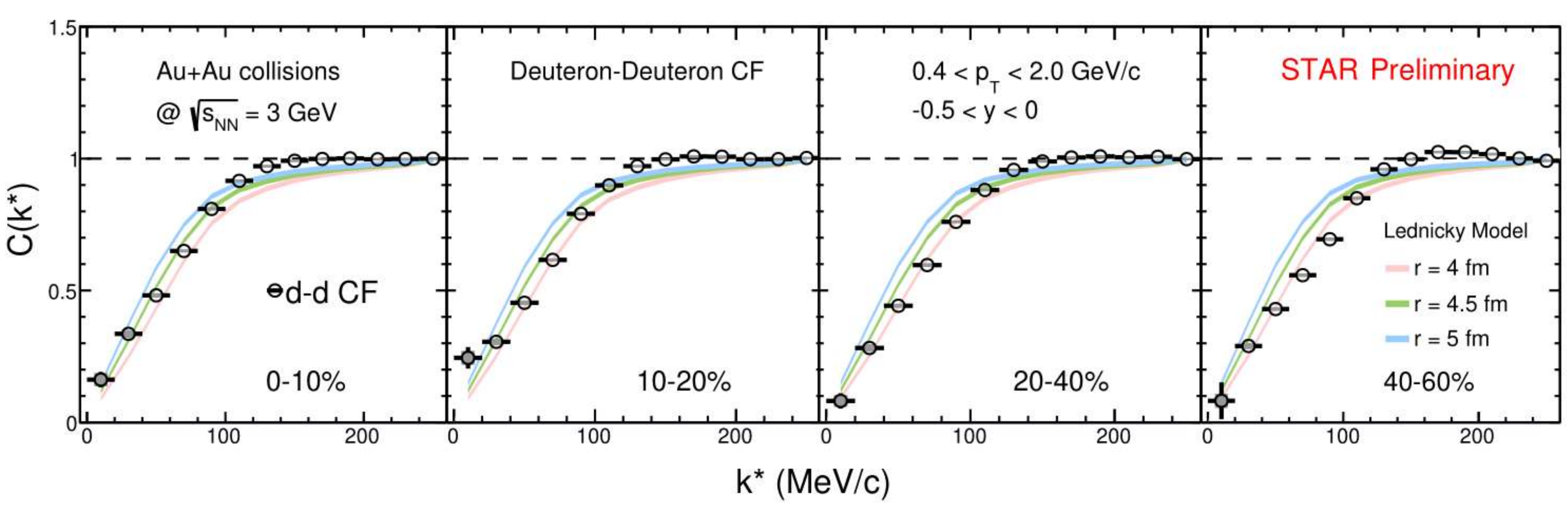


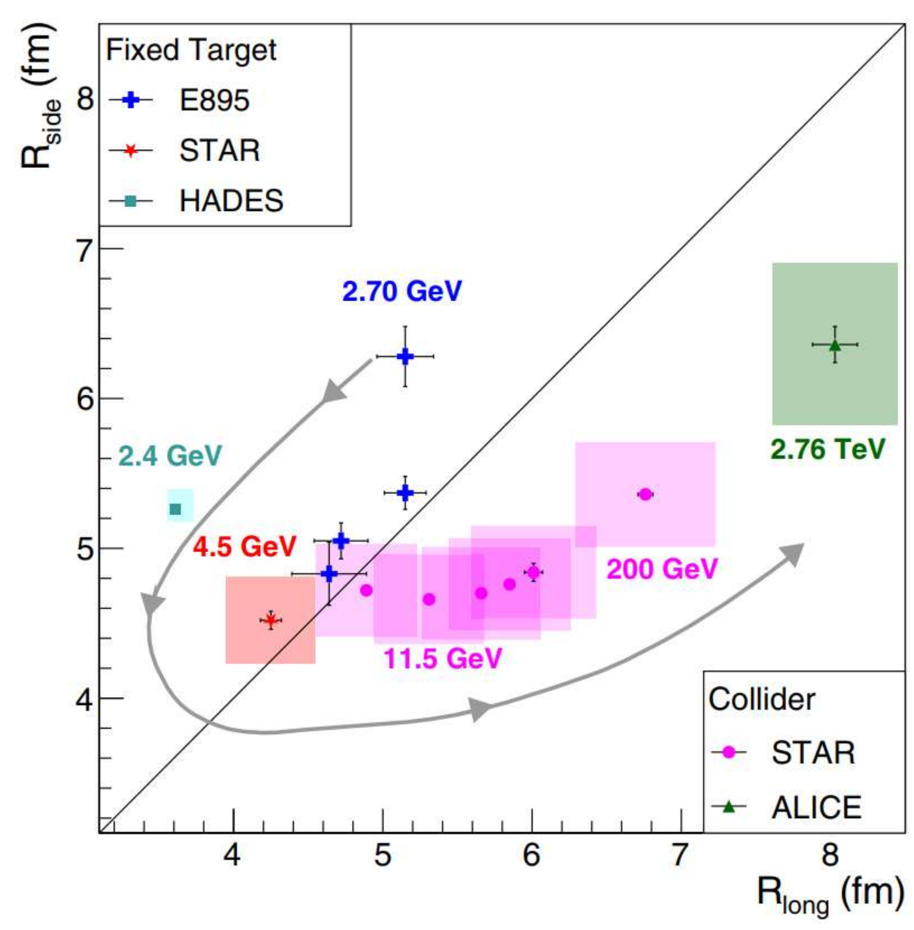
- Good particle identification using Time Projection Chamber (TPC) and Time-Of-Flight (TOF)
- TPC covers the pseudorapidity (η) of −2 < η < 0 in the laboratory frame

Results and Summary for Au+Au collisions at $\sqrt{s_{NN}} = 3$ GeV









- Fit of correlation functions of identical pions allows one to extract the radii of the emission region ($R_{out}, R_{side}, R_{long}$) and the correlation strength (λ).
- Lower energy collisions produce more oblate systems, and the shape of the emission region tends to become more prolate as the collision energy increases [4].
- Fit of correlation functions of *p-d*, *d-d* pairs provide information about strong interaction (scattering length and effective interaction range).

[1] Yu. Sinyukov et al. Phys. Lett. B 432, 248 (1998)
[2] M. Bowler Phys. Lett. B 270, 69 (1991)
[3] R. Lednicky and V. Lyuboshitz, Sov. J. Nucl. Phys. 35, 770 (1982)
[4] J. Adam et al. (STAR Collab.), Phys. Rev. C 103, 3 (2021)

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