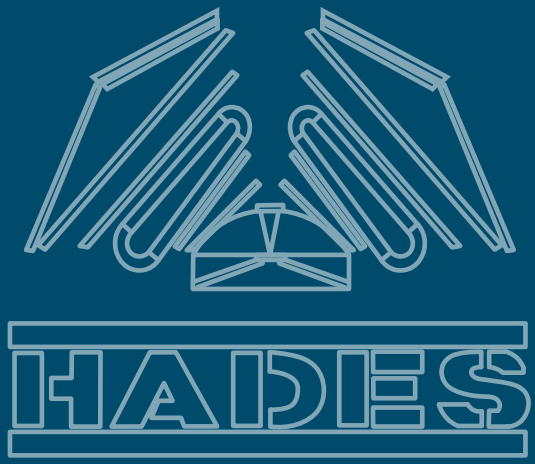
Faculty of Physics
Warsaw University of Technology

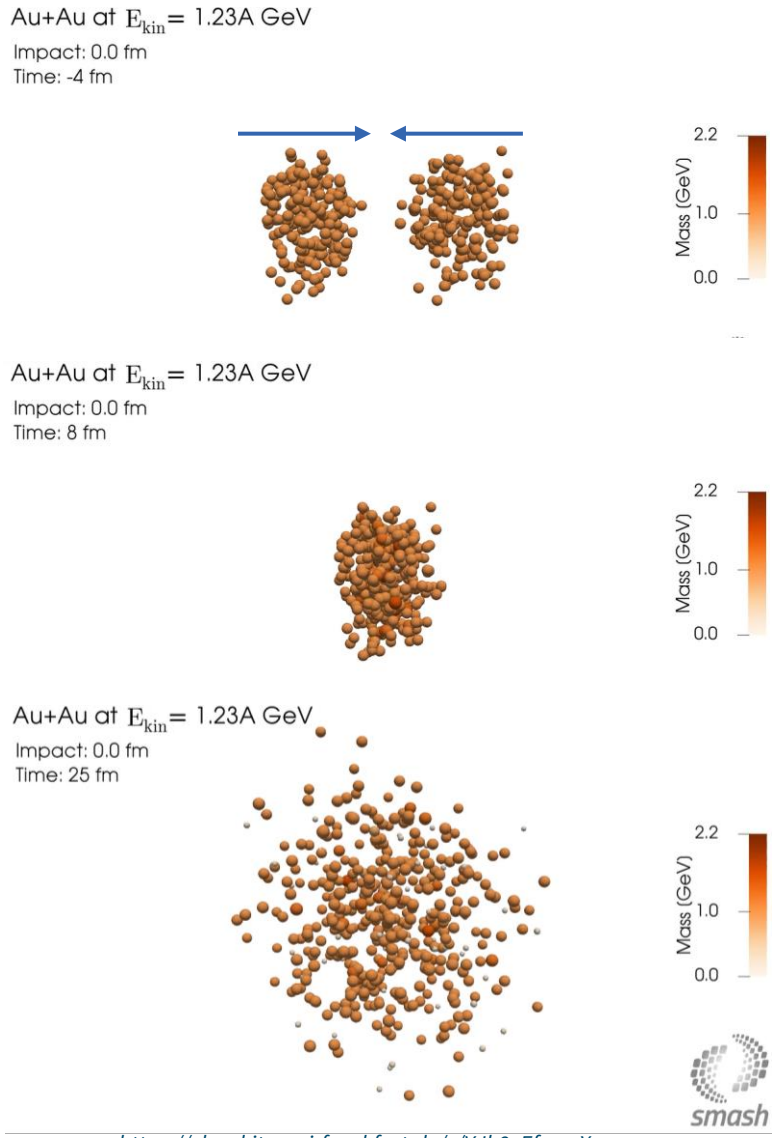
Proton Femtoscopy with 3D Source in Au+Au Collisions at $\sqrt{s_{NN}} = 2.4$ GeV

Jędrzej Kołaś
for the HADES Collaboration



High Net-Baryon Density Region

- Dynamics of heavy-ion collisions (HIC) at high net-baryon are unknown
- Protons → present throughout the whole duration
- Study of proton dynamics → a true study of HIC at high μ_B



https://cloud.itp.uni-frankfurt.de/s/YJb9zEfzwqXmwgp

Femtoscopic Correlations

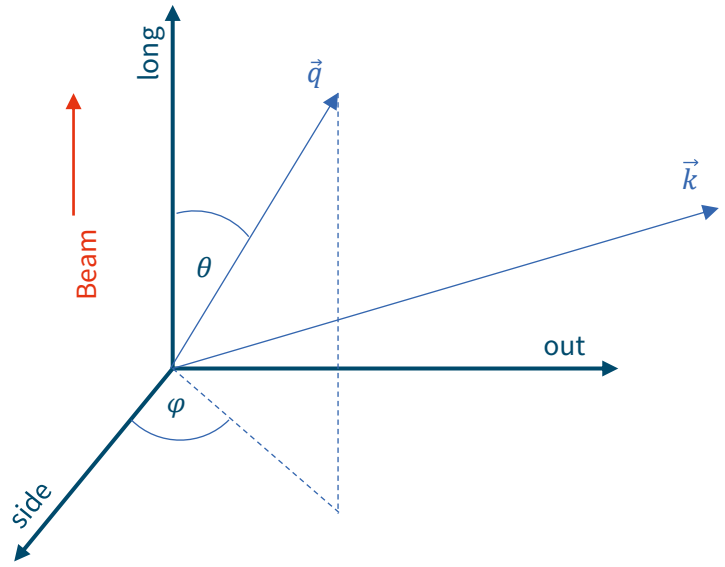
- **The Koonin-Pratt equation:**

$$C(\vec{q}) = \int d^3r\, S(\vec{r})|\psi(\vec{q},\vec{r})|^2$$

- Not much data on one-dimensional p-p source dynamics for baryon-rich region
- The three-dimensional p-p source dynamics have not been studied
- We know more about $S(\vec{r})$ → we know more about our collisions

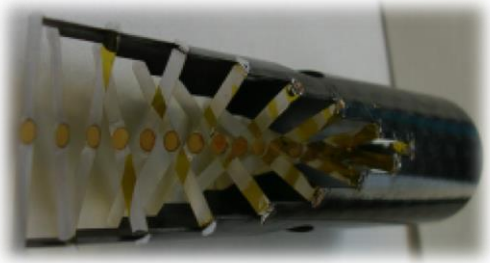
In this work:

- Longitudinal Co-Moving System (LCMS)
- 1D – q_{inv}
- 3D – Bertsch-Pratt Parametrisation (out-side-long)

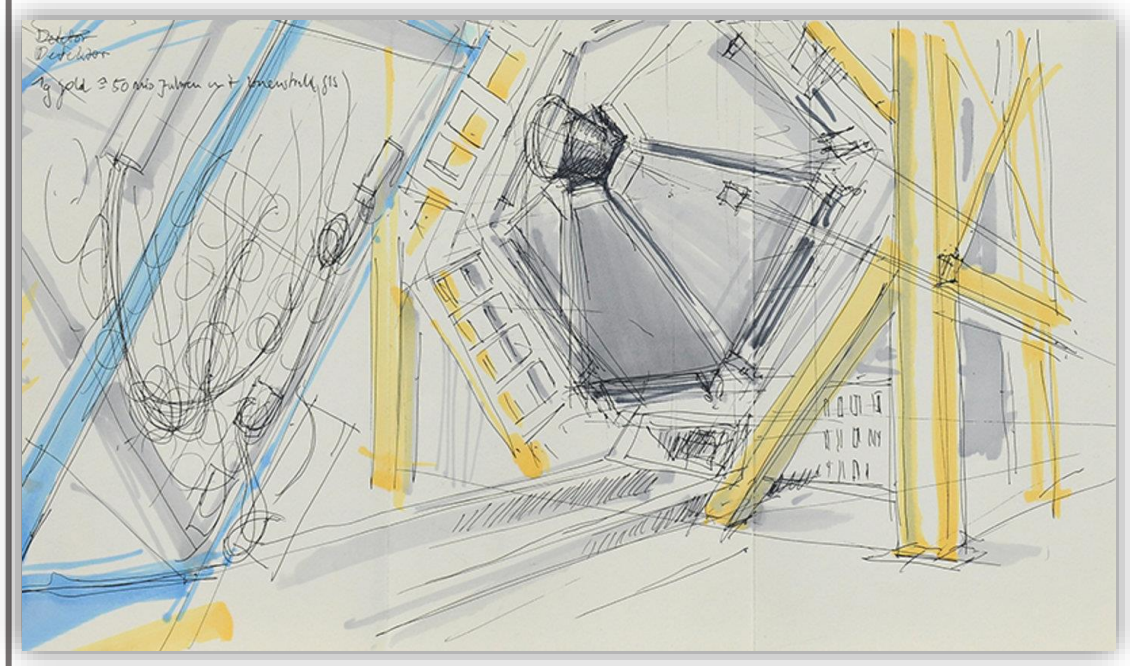


The HADES Detector

- Fixed target experiment at FAIR/GSI
- Large angular coverage:
  - $\theta \in (18^{\circ}, 85^{\circ})$
  - $\varphi \in (0^{\circ}, 360^{\circ})$
- Tracking detector with good momentum resolution
- Target – composition of multiple target plates:



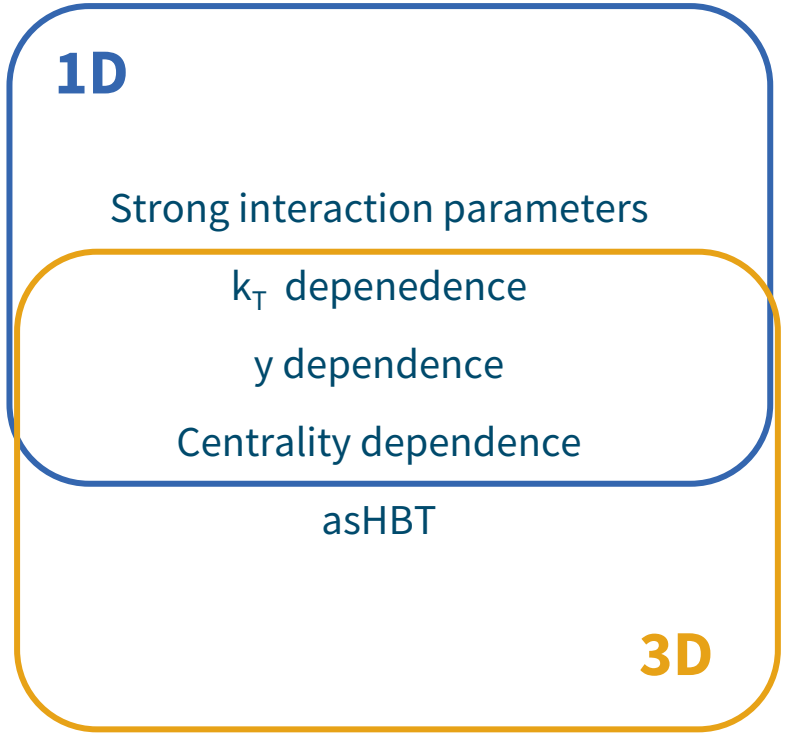
R. Greifenhagen „Two pion intensity-interferometry in collisions of Au+Au at $\sqrt{s_{NN}} = 2.4$ GeV measured with HADES", PhD Thesis



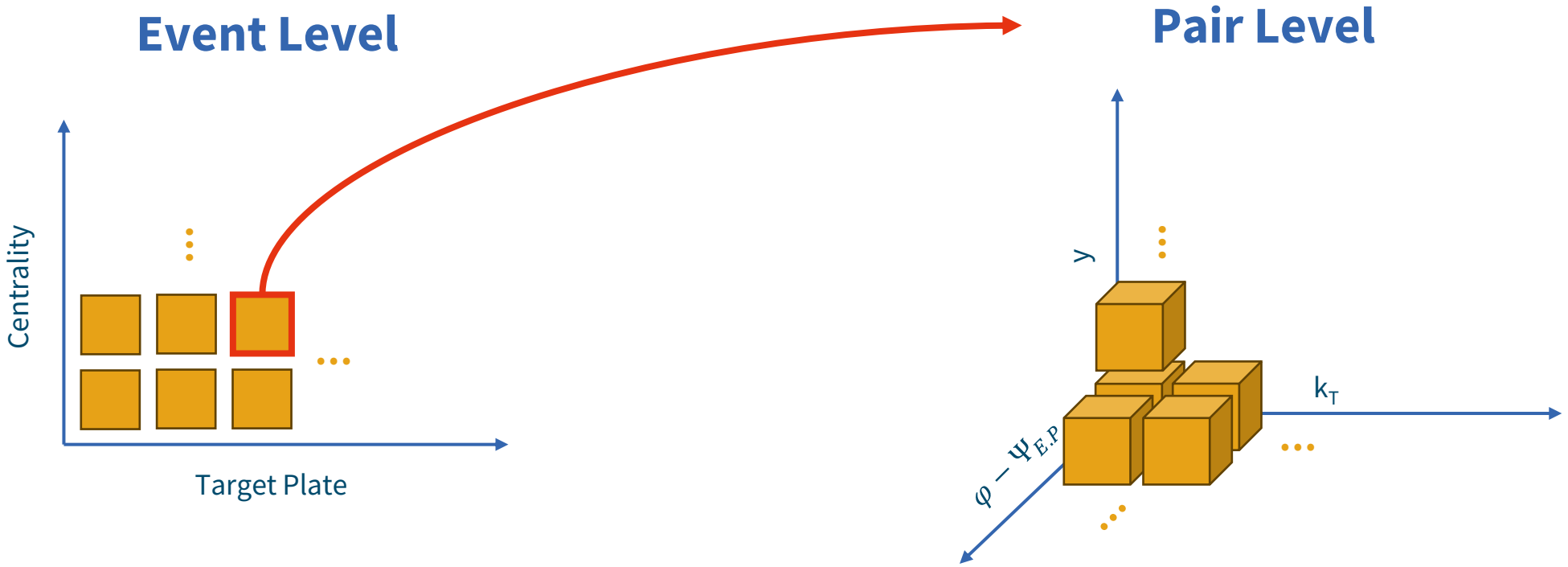
https://www.gsi.de/en/about_us/50_years_gsi/urban_sketchers_at_gsi_and_fair

Scientific Goal

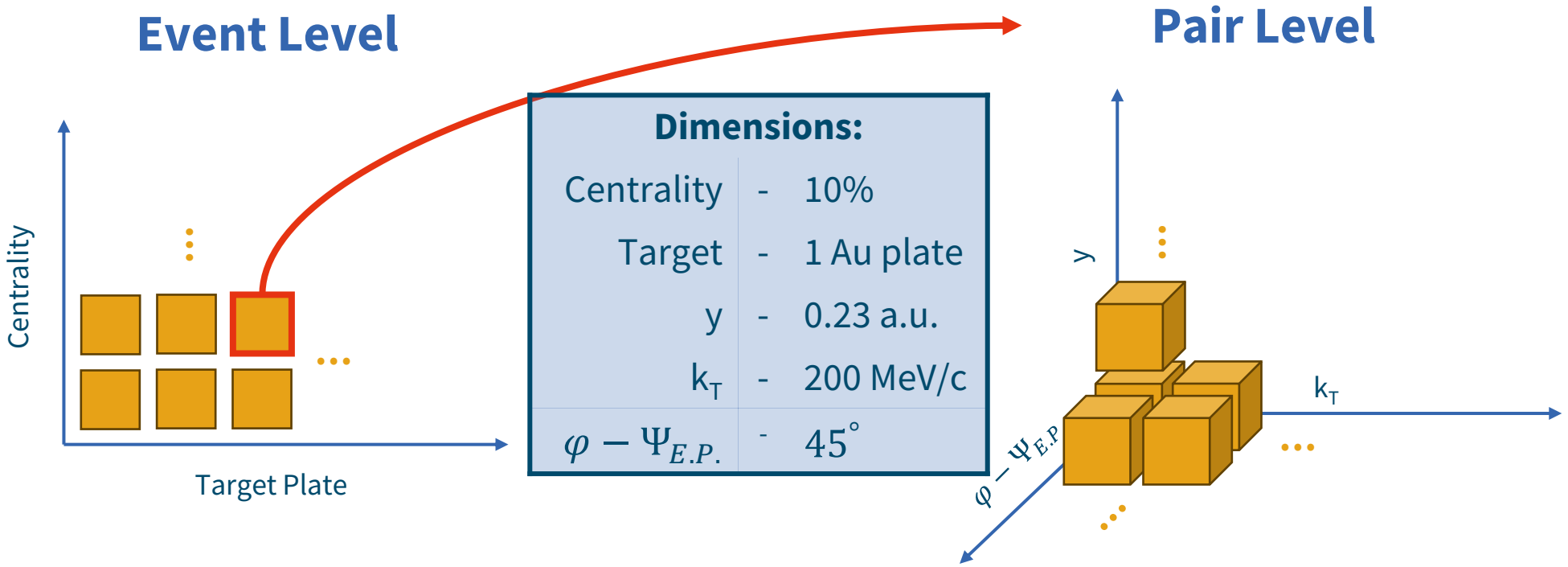
- **Multi-differential and multi-dimensional p-p analysis:**
  - Precise determination of p-p source
  - Dynamics of the p-p source
  - Comparison with models (which implement different EoS)
- **Dataset:**
  - Au+Au (big system)
  - $\sqrt{s_{NN}} = 2.4$ GeV (low energy)
  - HADES detector



Mixing

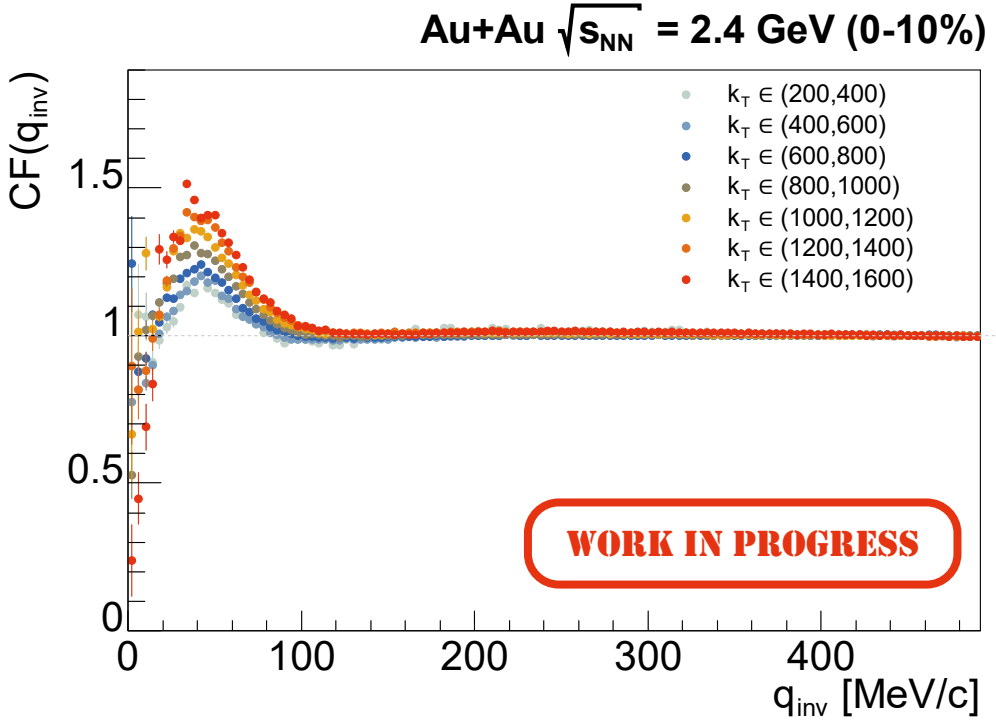

Event Level
Pair Level
Centrality
Target Plate
y
k_T
$\varphi - \Psi_{E.P}$

Mixing


Event Level
Pair Level
Centrality
Target Plate
Dimensions:
Centrality - 10%
Target - 1 Au plate
y - 0.23 a.u.
k_T - 200 MeV/c
$\varphi - \Psi_{E.P.}$ - 45°
y
k_T
$\varphi - \Psi_{E.P.}$

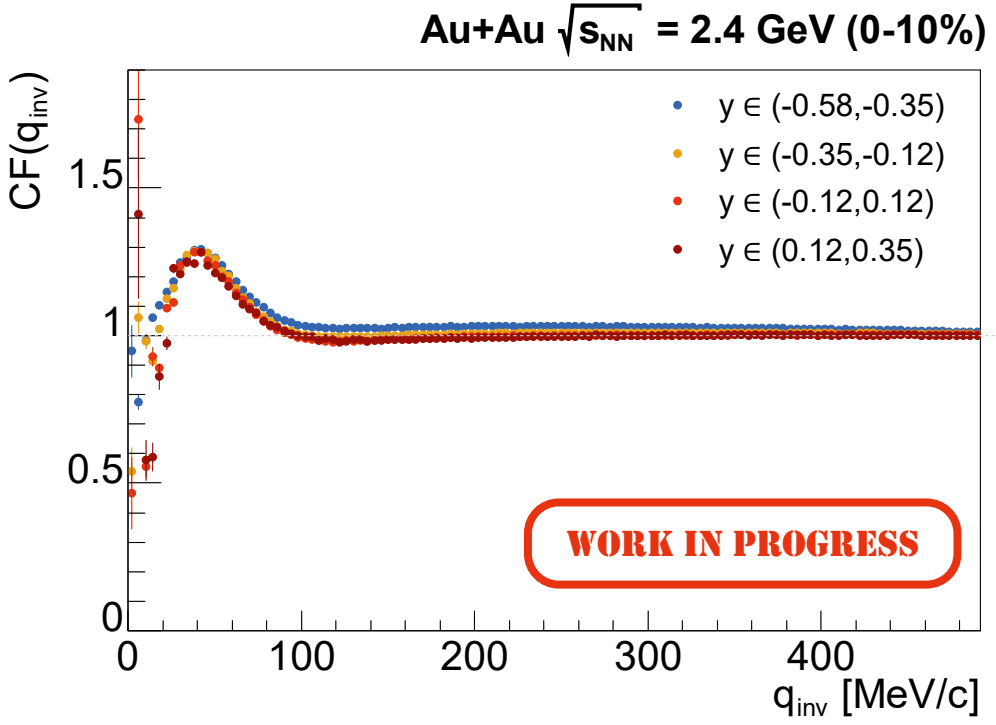
One-Dimensional Correlation Functions

- Raw results on 1D p-p correlation functions (most central)
- Other centralities are in the backup
- Visible k_T dependence
- Many points → great for fitting
- Not corrected for momentum resolution (yet)

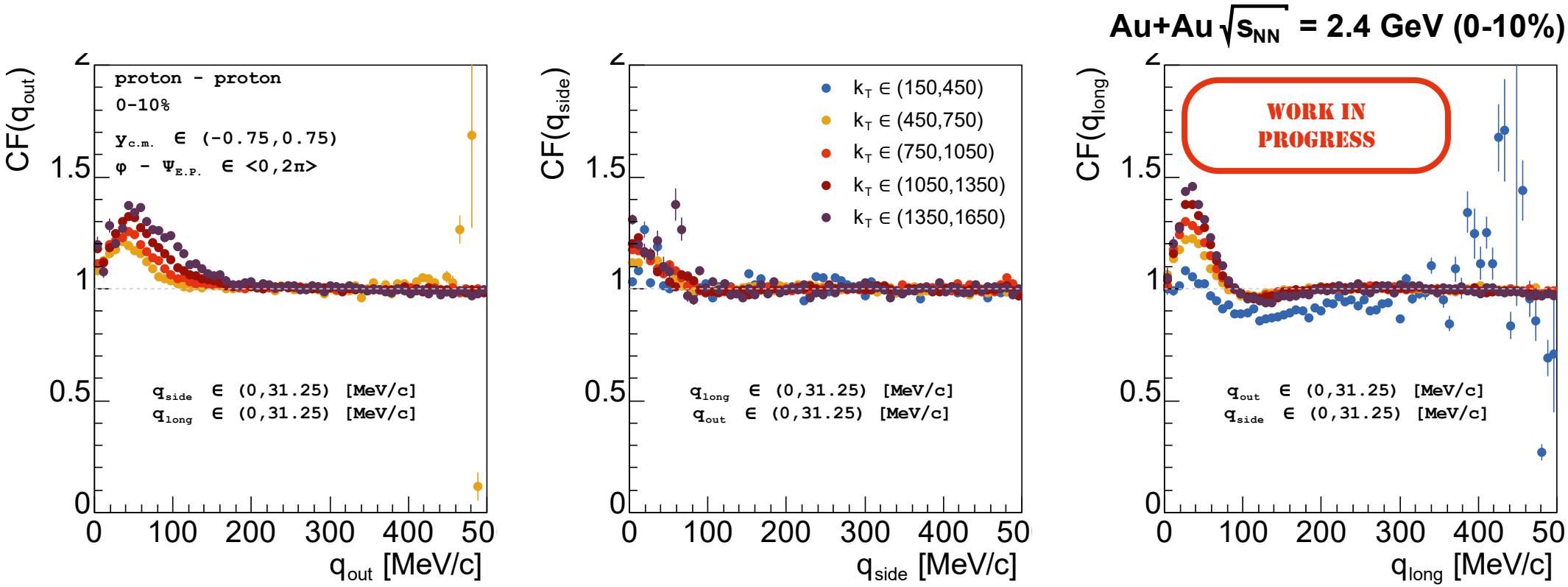


One-Dimensional Correlation Functions

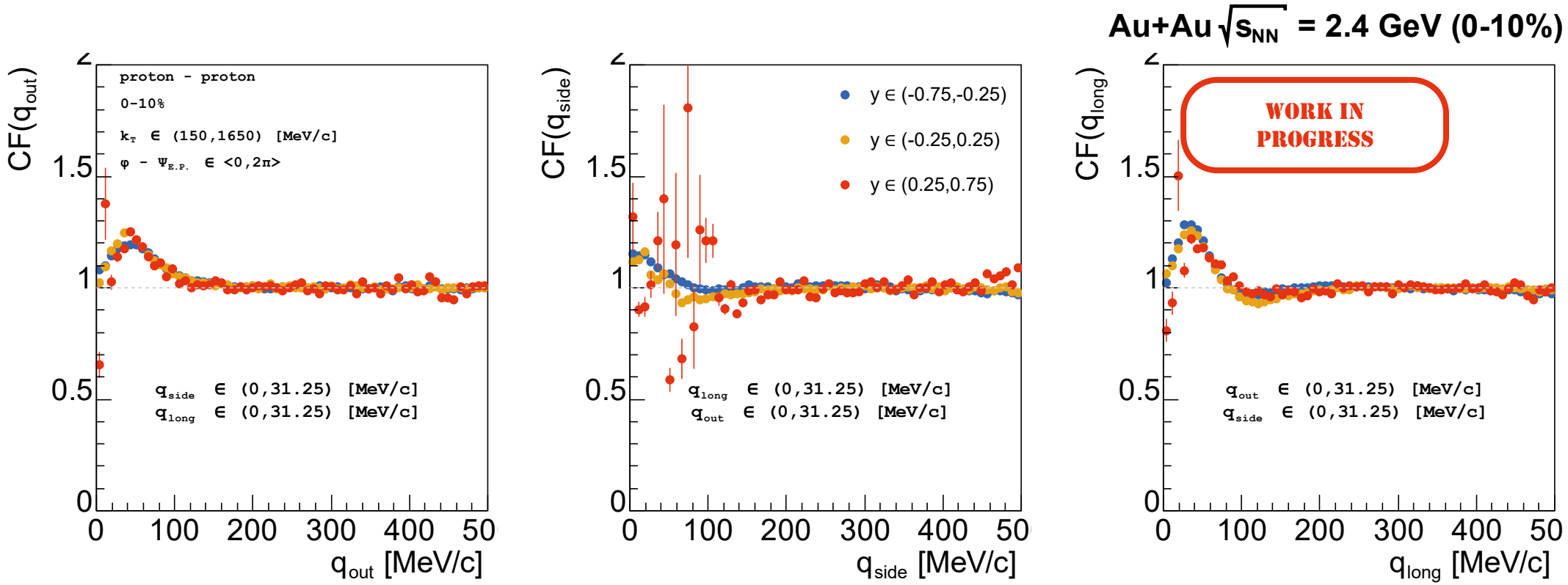
- Raw results on 1D p-p correlation functions (most central)
- Other centralities are in the backup
- Visible difference in radii → breaking boost-invariance
- Many points → great for fitting (again)
- Not corrected for momentum resolution (soon™)



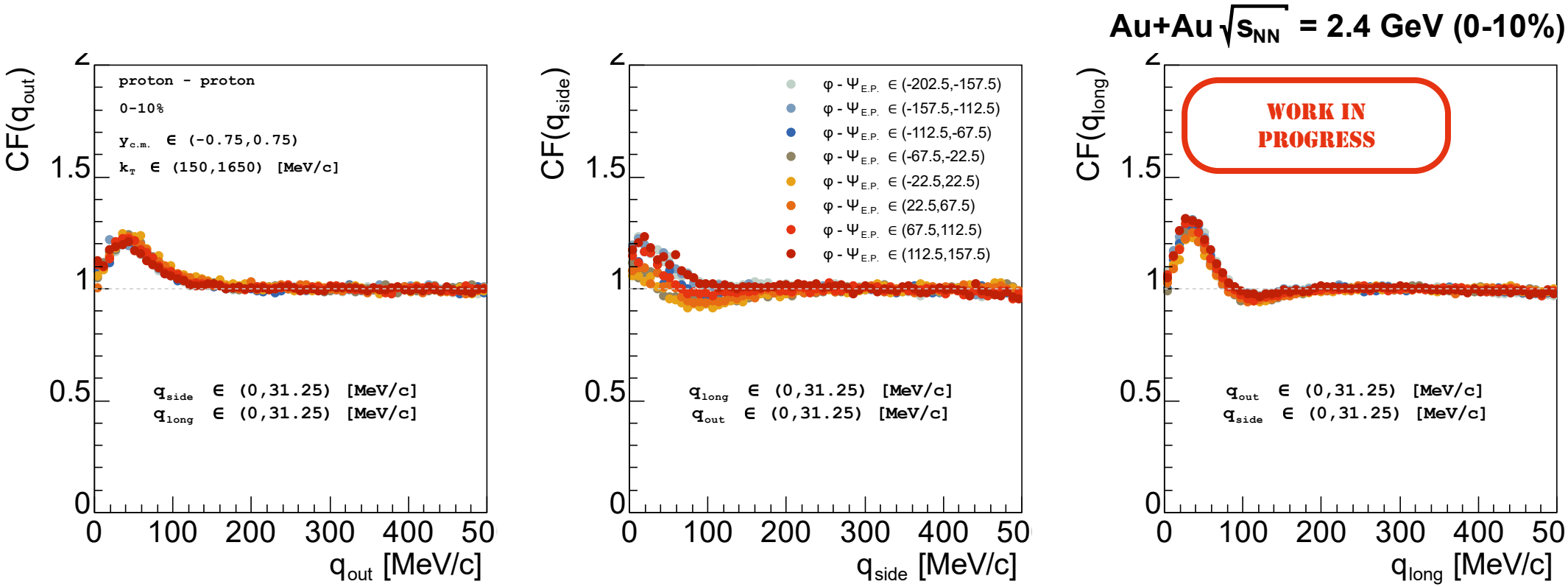
Three-Dimensional Correlation Functions



Three-Dimensional Correlation Functions



Three-Dimensional Correlation Functions



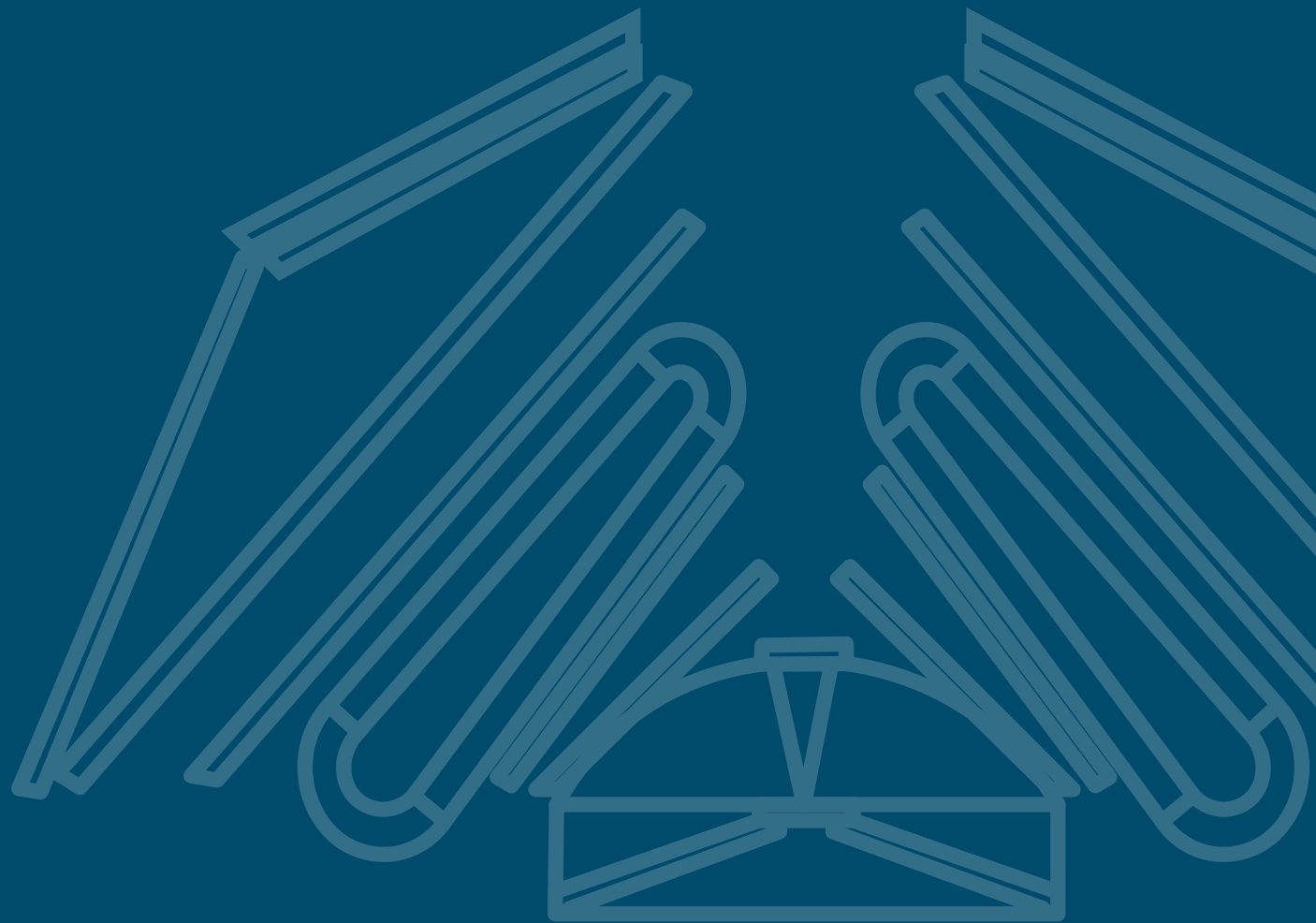
Summary & Outlook

- We intend to learn about the dynamics of high net-baryon density HIC
- Raw results on 1D and 3D p-p CFs are shown
- The results look promising w.r.t. the amount of observables which will be studied and their expected uncertainty

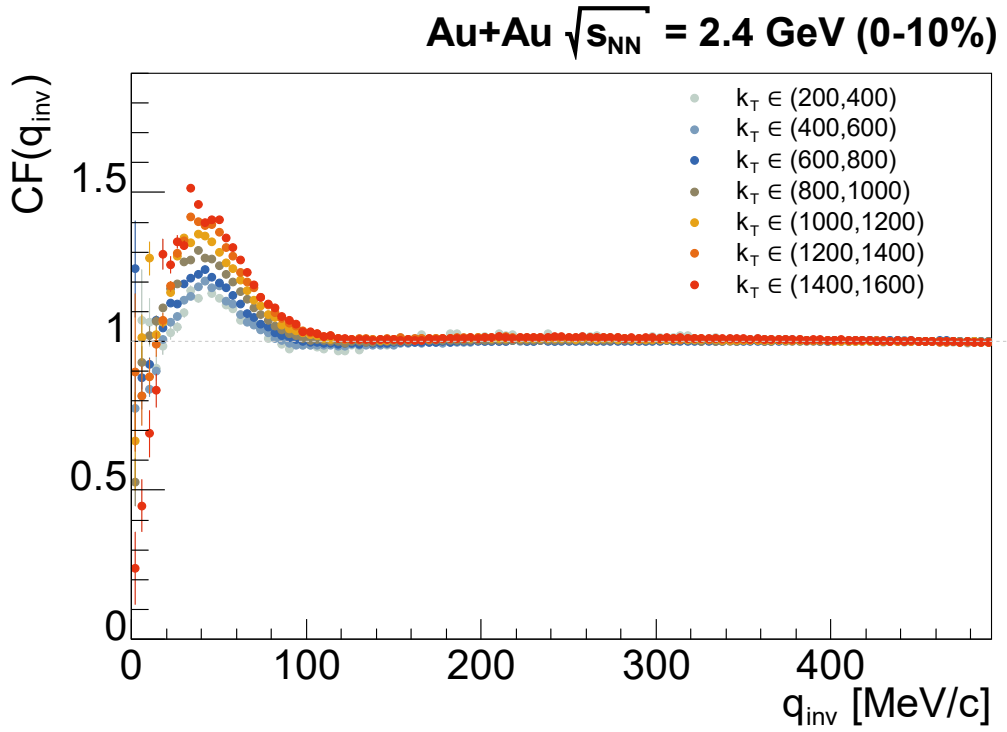
- With the momentum resolution correction in place, we will be able to learn about the p-p femtoscopic radii
- First time in 3D?
- In the future, we plan to compare the results with model predictions
- We also intend to measure the strong interaction (cross-check)

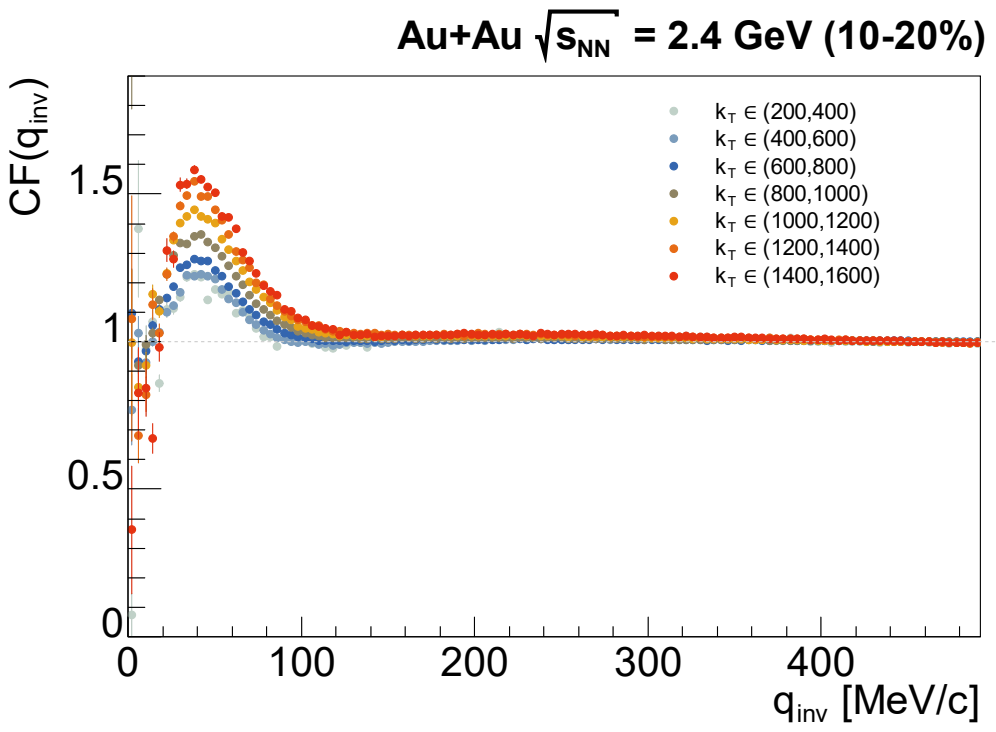
Thank you
for your attention

Backup



One-Dimensional Correlation Functions





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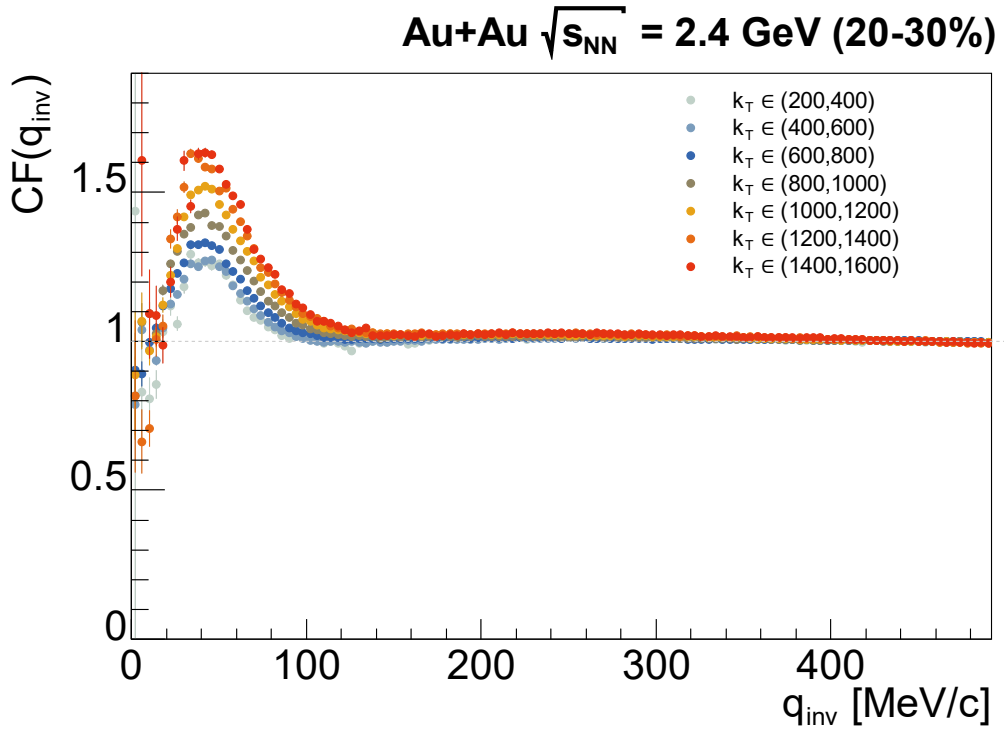

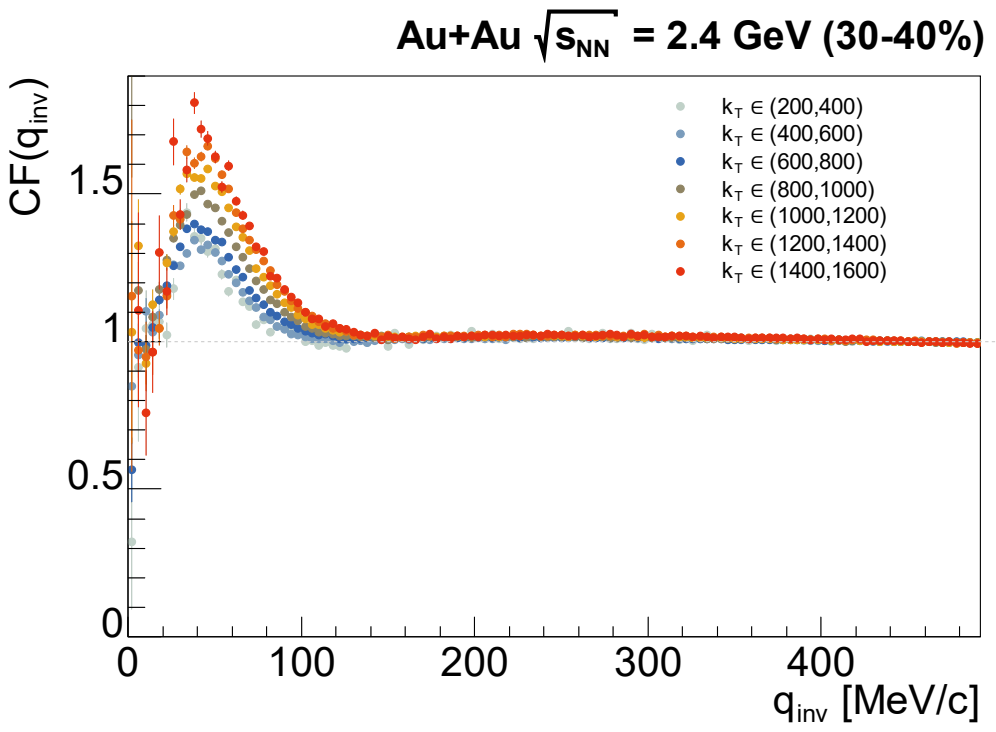

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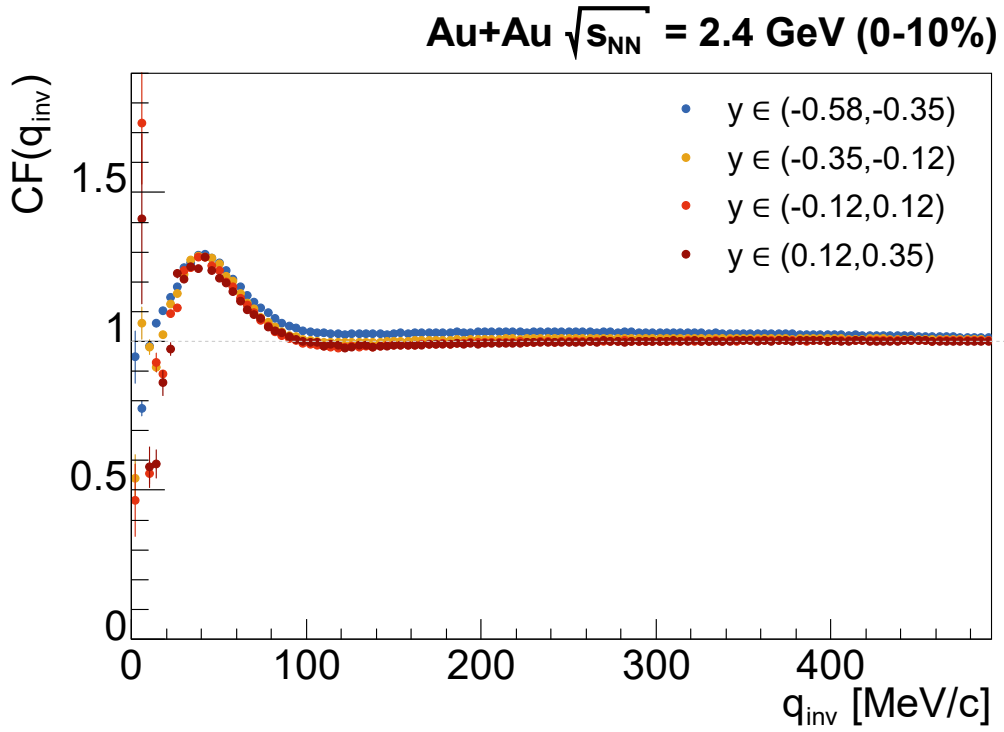

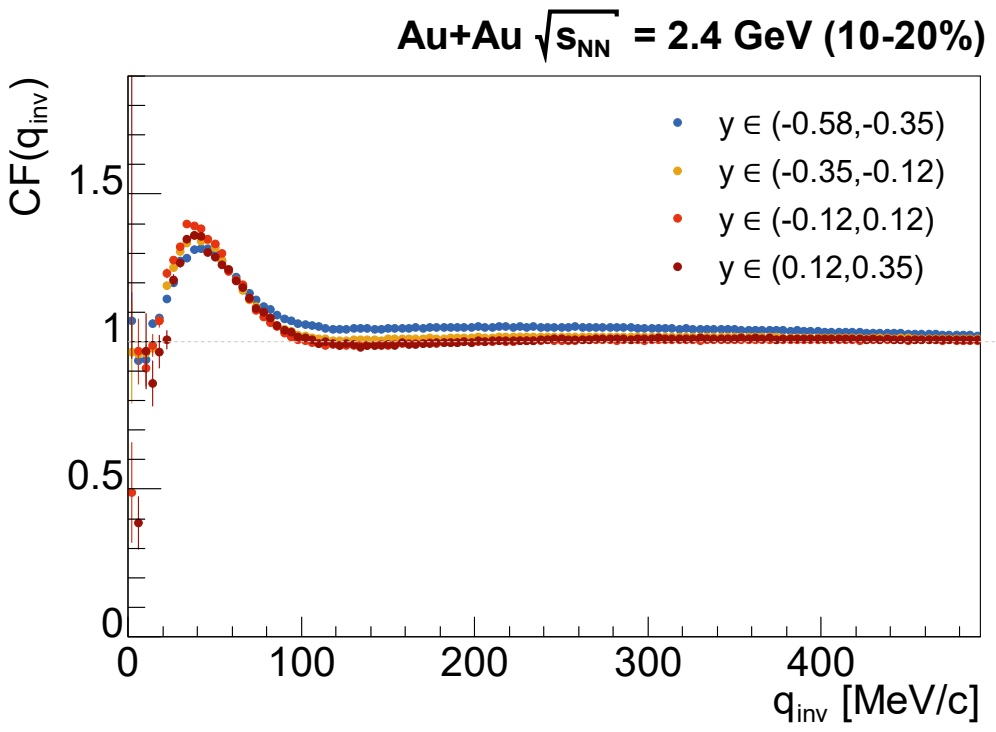

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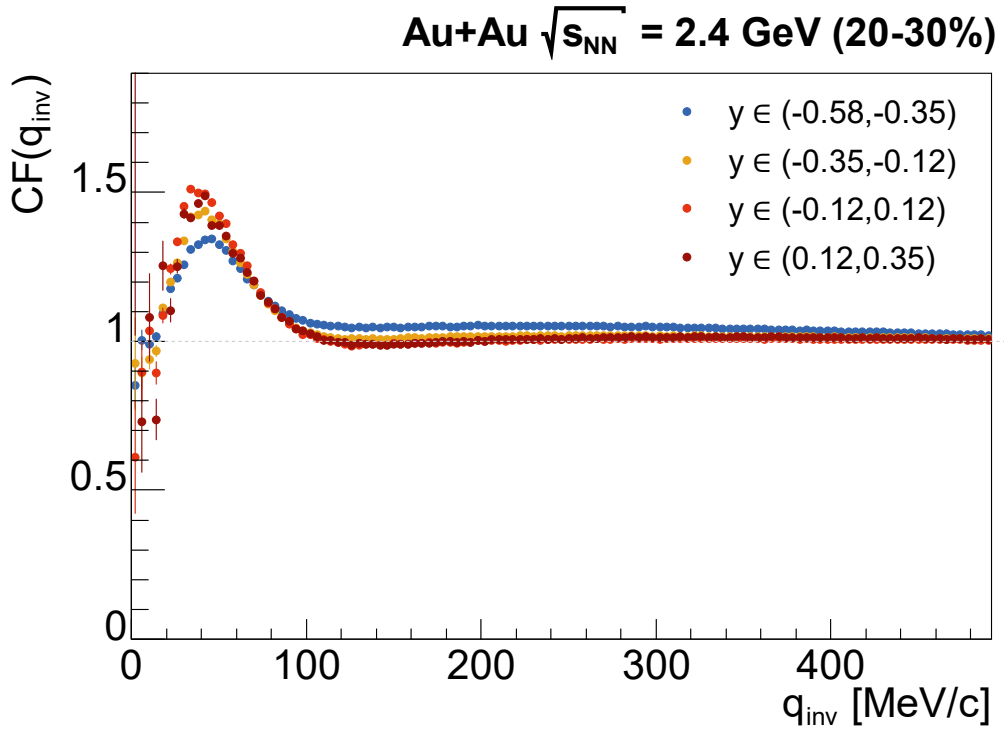
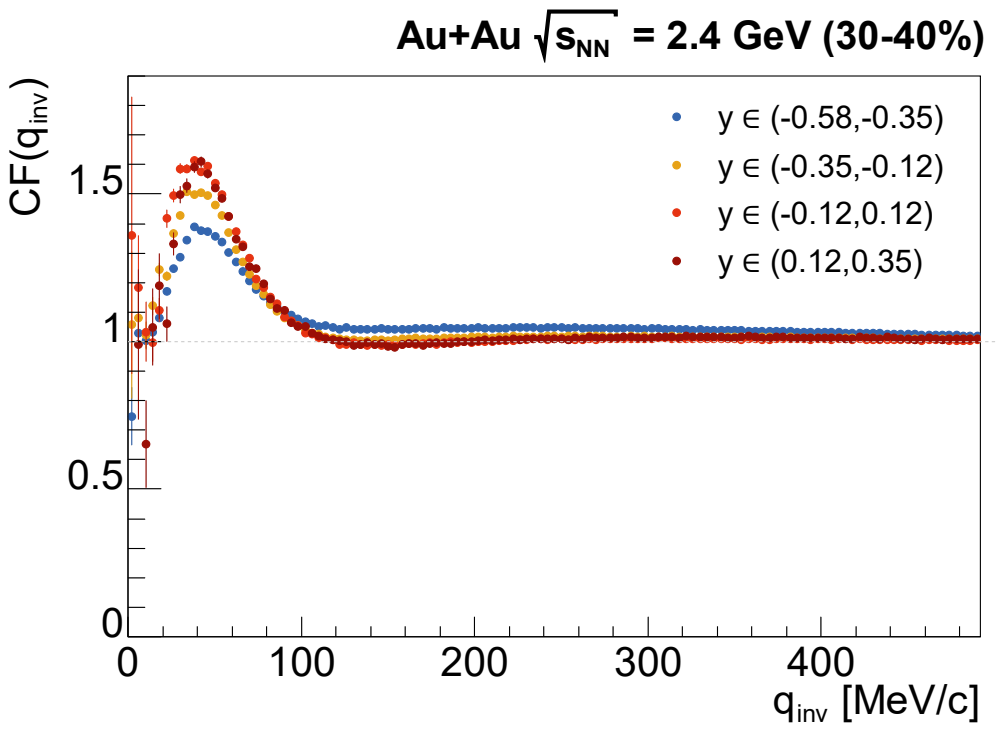
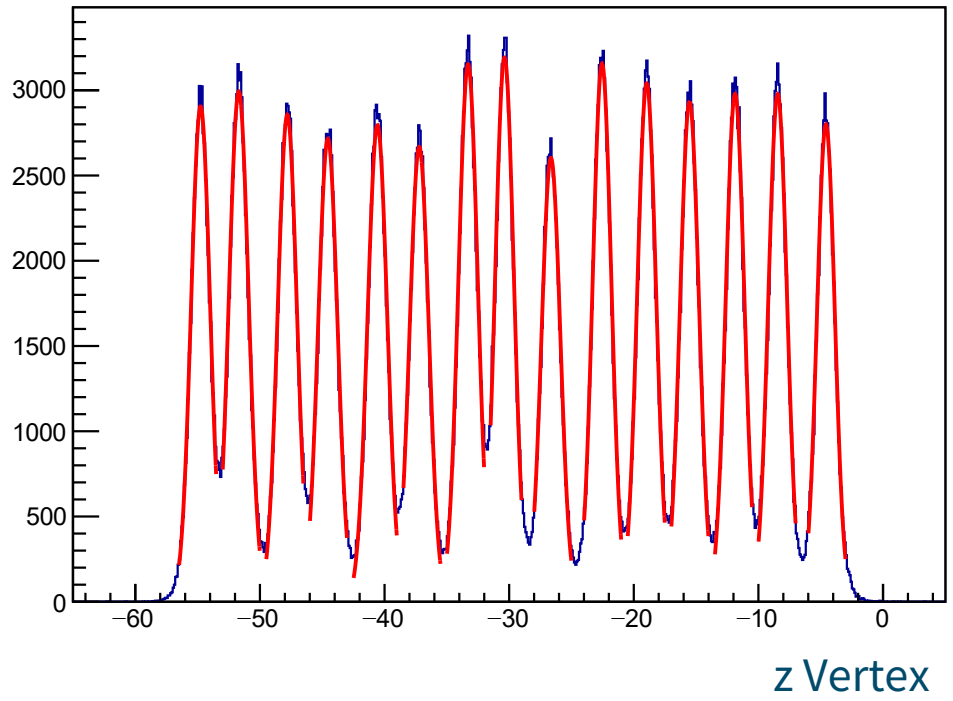




Cuts & Corrections

- **Dataset:**
  - Au + Au $\sqrt{s_{NN}} = 2.4$ GeV
- **Event:**
  - Target plate selection, X and Y vertex cut ($\mu \pm n\sigma$)
  - Must have EP reconstructed
  - Centrality 0-10%, 10-20%,… etc.
- **Track:**
  - Not at MDC edge
  - Beta-momentum cut
  - Bad layers < 2
- **Pair:**
  - Not the same ToF cell
  - Fraction of Close Hits = 70% (OneUnder)
- **Corrections:**
  - Energy-loss ✓
  - Purity ✓
  - Momentum resolution ✗

Target Vertex