

Femtoscopy of kaon-proton and kaon-deuteron from ALICE

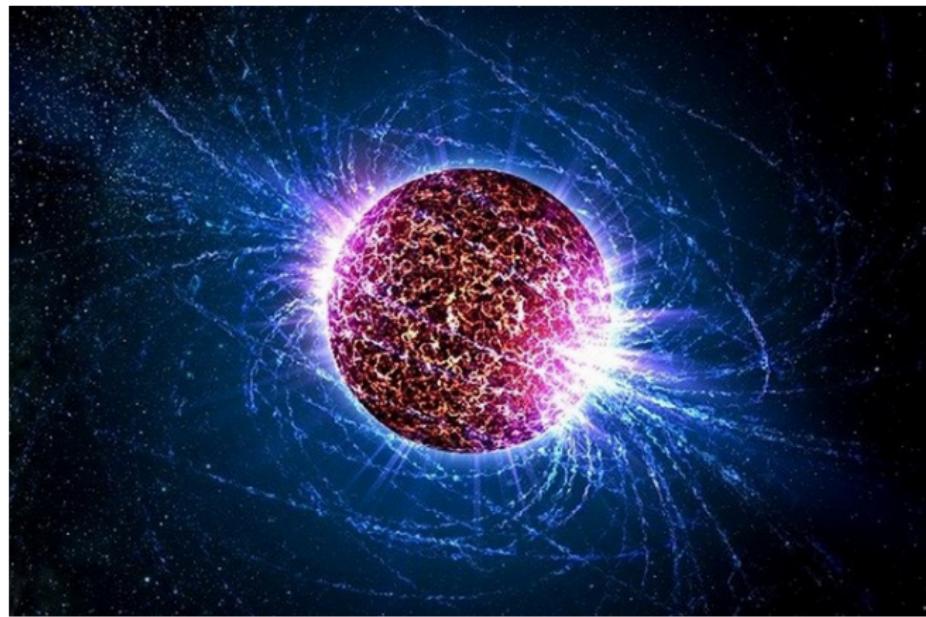


Wioleta Rzęsa, Georguy Kornakov
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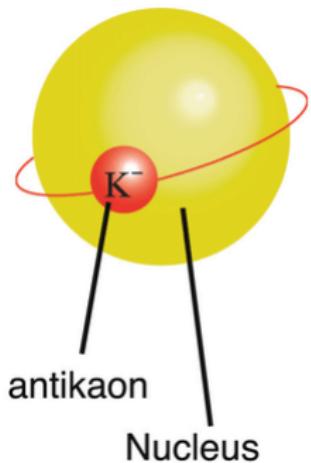


Motivation

Neutron stars



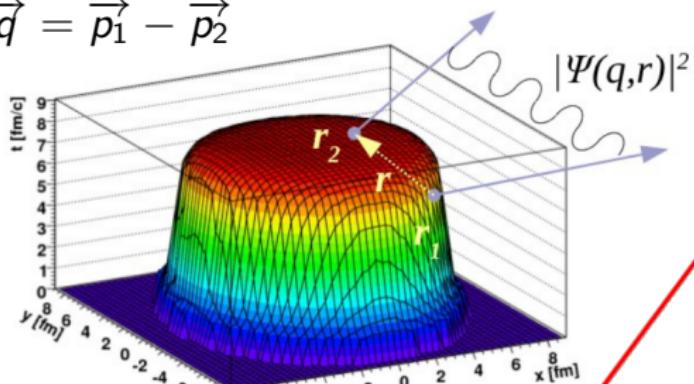
Kaonic atom



Femtoscopy

Theory: $C(\vec{q}) = \int S(\vec{r}) |\Psi(\vec{q}, \vec{r})|^2 d^4 r$

$$\vec{q} = \vec{p}_1 - \vec{p}_2$$



$|\Psi(\vec{q}, \vec{r})|$ – wave function
 $S(\vec{r})$ – source emission function

Experiment:

$$C(\vec{p}_1, \vec{p}_2) = \frac{P_2(\vec{p}_1, \vec{p}_2)}{P_1(\vec{p}_1)P_1(\vec{p}_2)}$$

$$C(\vec{k}^*) = \frac{A_{XY}(\vec{k}^*)}{B_{XY}(\vec{k}^*)} = \frac{\text{correlated pairs}}{\text{uncorrelated pairs}}$$

$$\vec{k}^* = \frac{\vec{p}_1 - \vec{p}_2}{2}$$

Femtoscopy: measure space-time characteristics of the source using particle correlations in momentum space.

Analysis details – datasets

- Both positive and negative magnetic fields – separately
- PbPb, 5.02 TeV data:
 - high interaction rate (highIR)
 - low interaction rate (lowIR)
- PbPb, 5.02 TeV simulation data:
 - HIJING Minimum Bias
 - dataset with injected light nuclei

Analysis details – selection criteria

■ Event selection criteria:

- trigger: Minimum Bias
- primary vertex: $|V_z| < 10\text{cm}$

■ Track selection criteria:

- global track, TPC only track
- pile-up rejection
- $|\eta| < 0.8$
- p_T ranges:
 - ▶ Kaons: $0.19 - 1.5 \text{ GeV}/c$
 - ▶ Protons: $0.7 - 4 \text{ GeV}/c$
 - ▶ Deuterons: $1 - 4 \text{ GeV}/c$

■ Particle identification:

- combination of TPC and TOF

Deuteron – PID criteria

■ Deuterons:

- $p > 1 \text{ GeV}/c \rightarrow \sqrt{N_{TPC\sigma}^2 + N_{TOF\sigma}^2} < 2$
- A cut on mass distribution obtained using the TOF signal

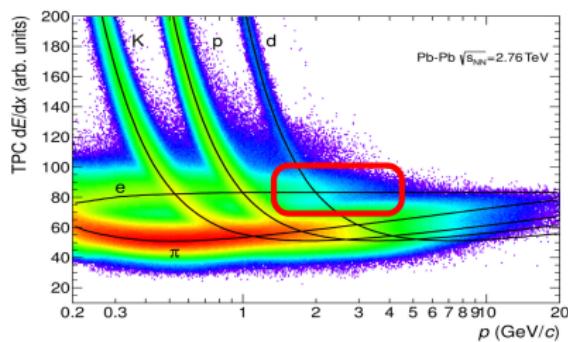
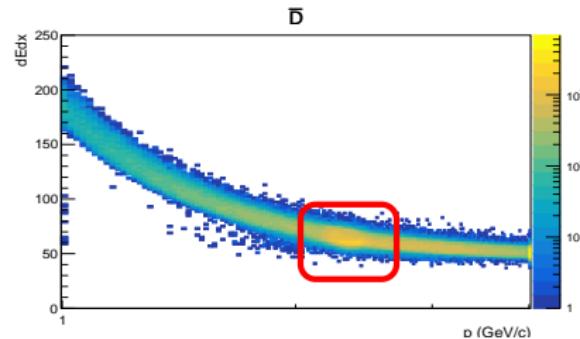
Not usual procedure in ALICE

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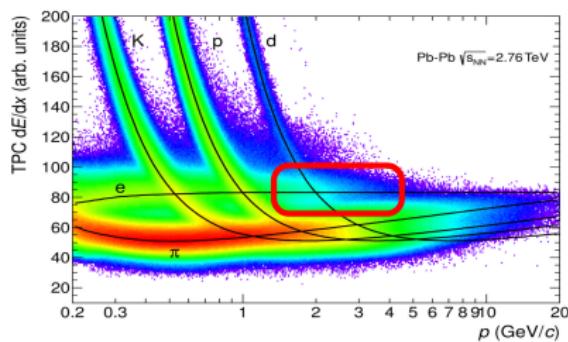
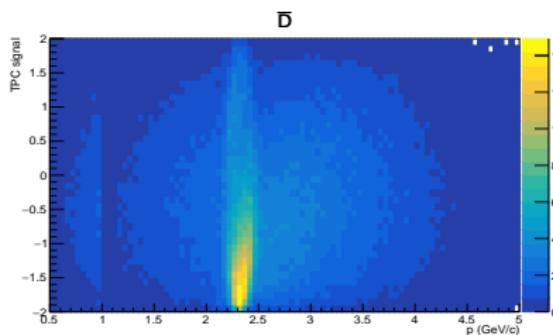
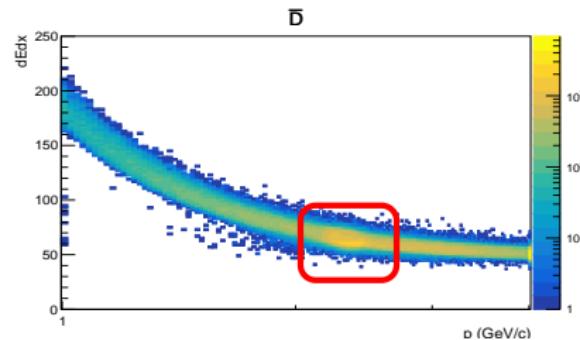


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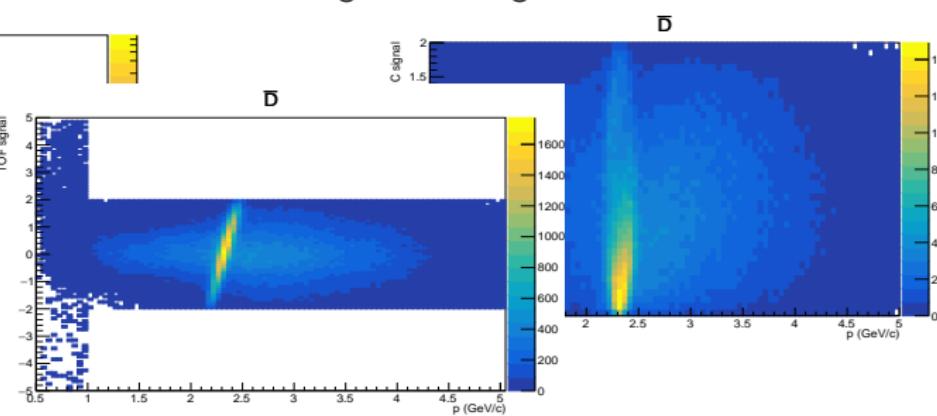
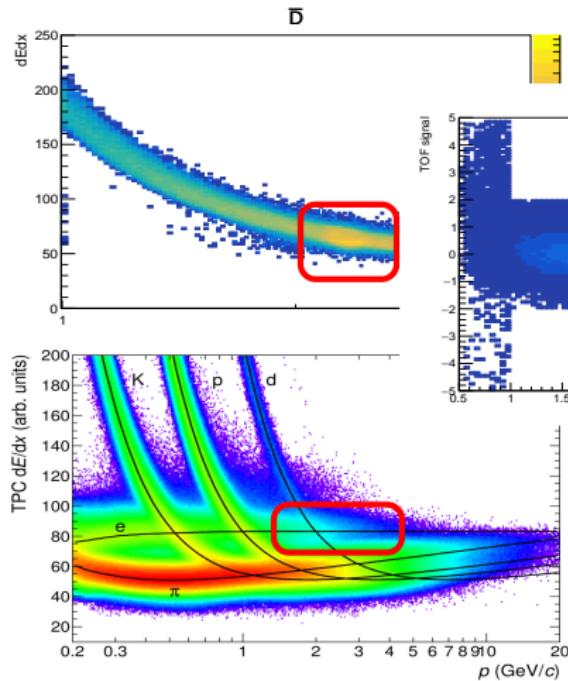


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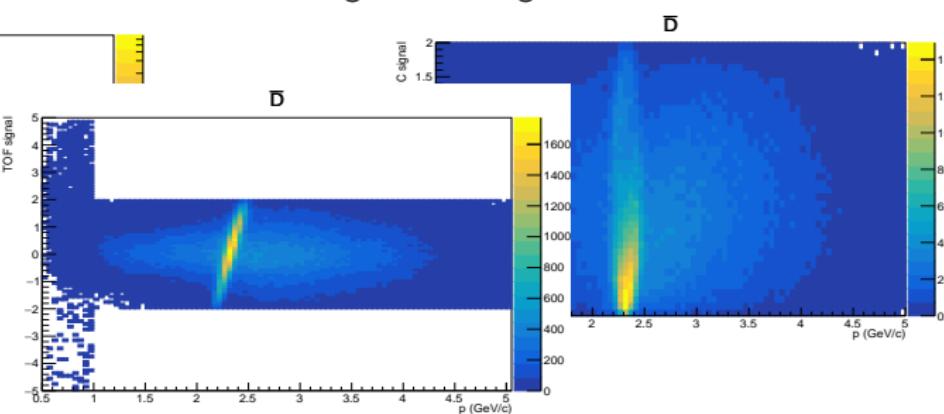
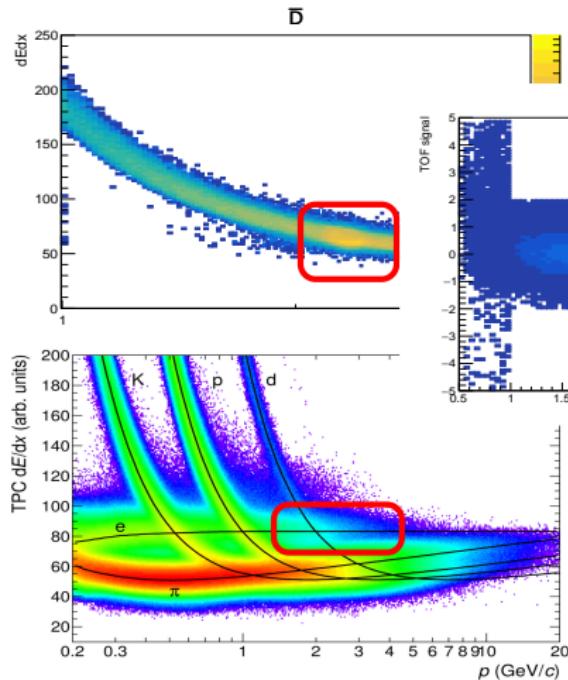


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$$m^2 = \frac{p^2}{c^2} \left(\frac{1}{\beta^2} - 1 \right)$$

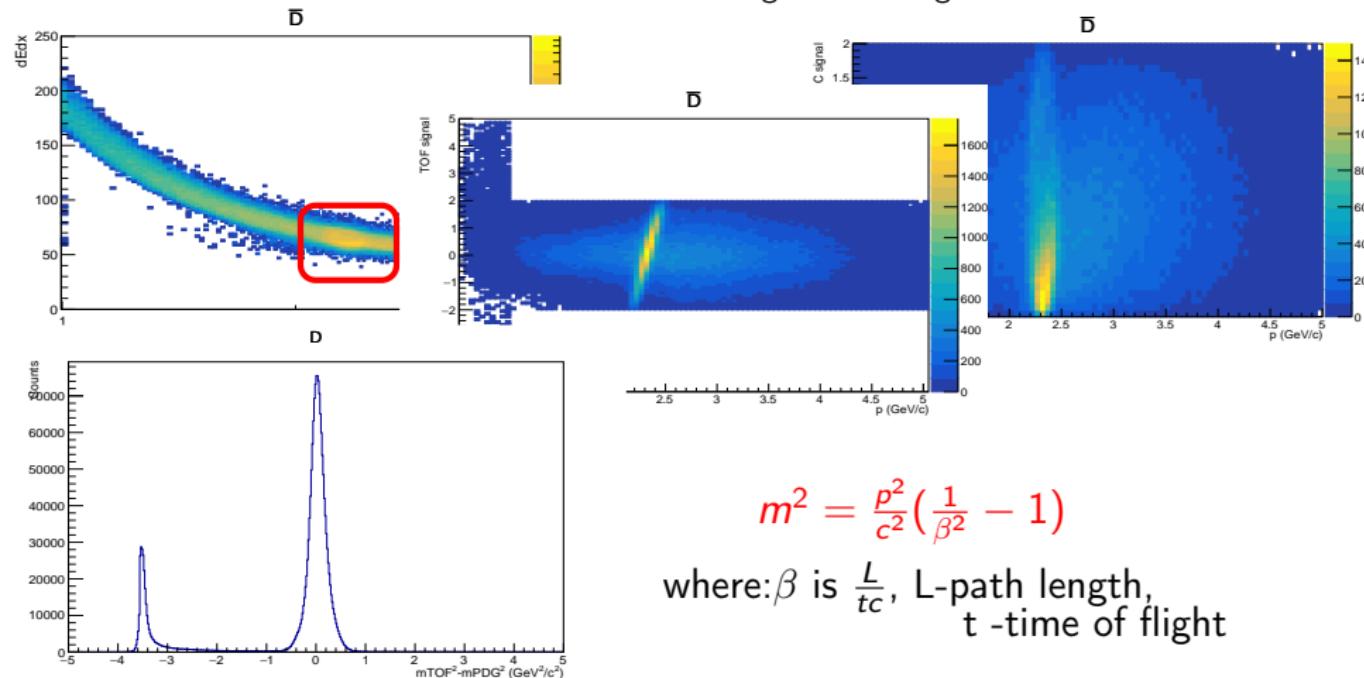
where: β is $\frac{L}{tc}$, L-path length,

Deuteron – PID criteria

■ Deuterons:

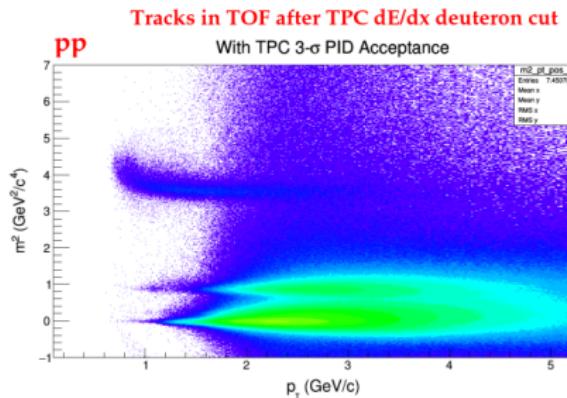
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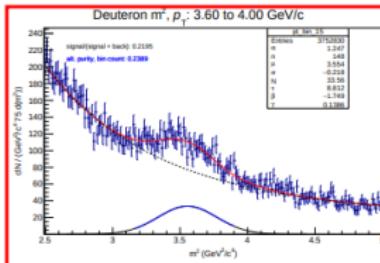
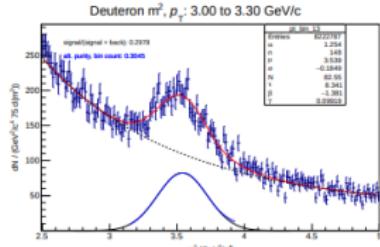
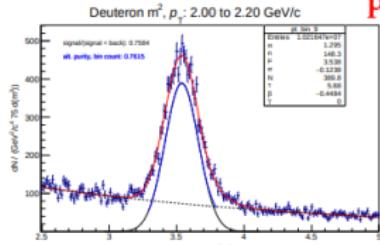
Deuteron - purity

pp

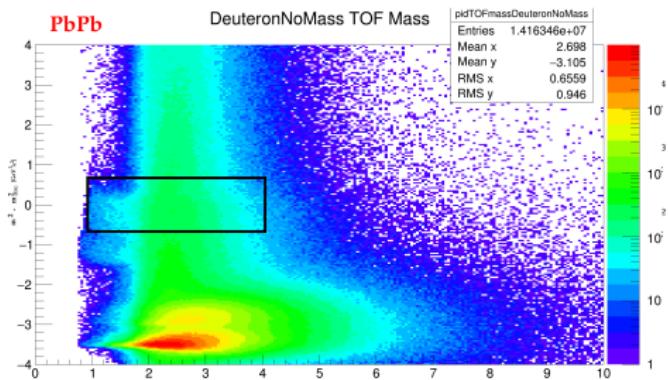


Deuteron purity estimates

pp



PbPb



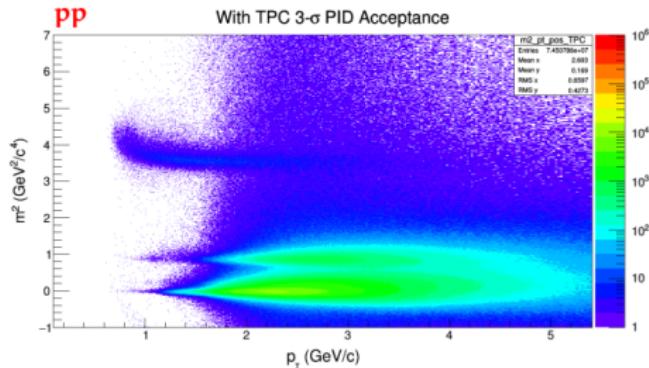
HIRG

WUT

Deuteron - purity

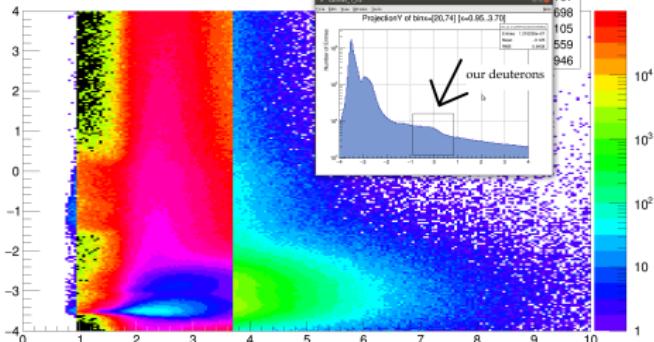
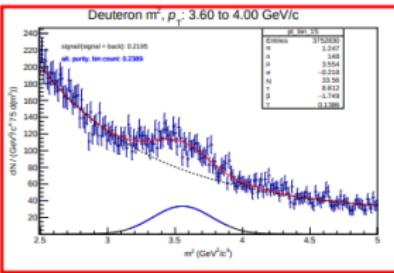
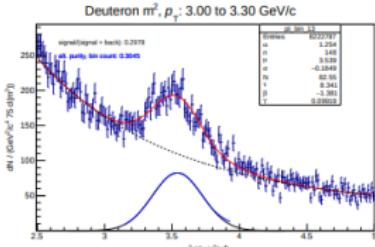
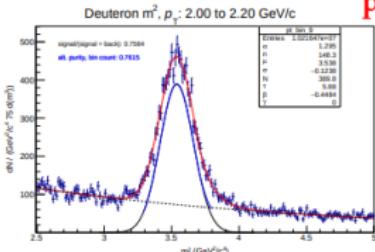
pp

Tracks in TOF after TPC dE/dx deuteron cut



Deuteron purity estimates

pp

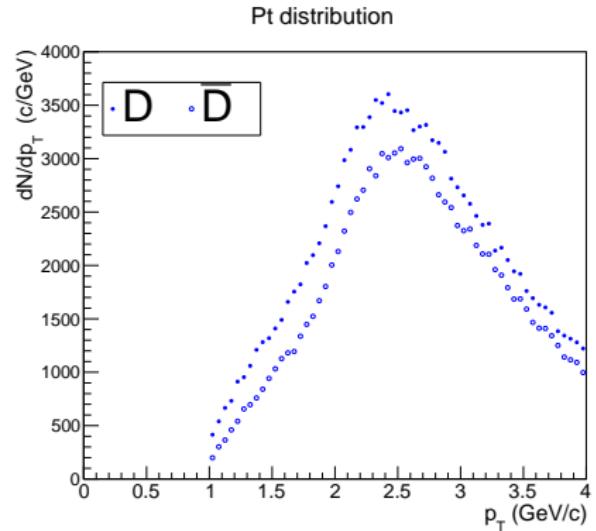
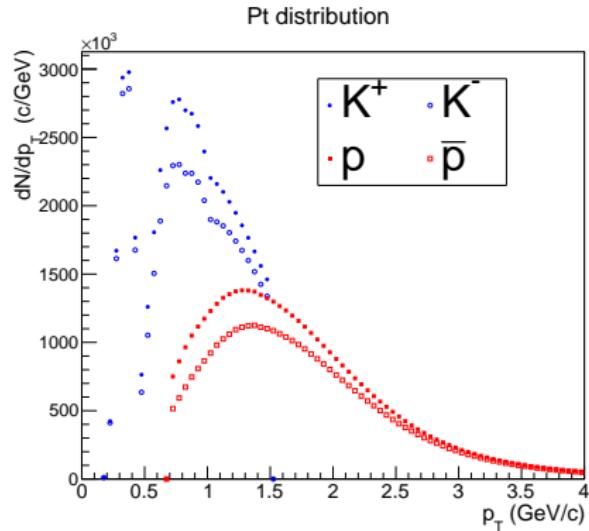


HIRG

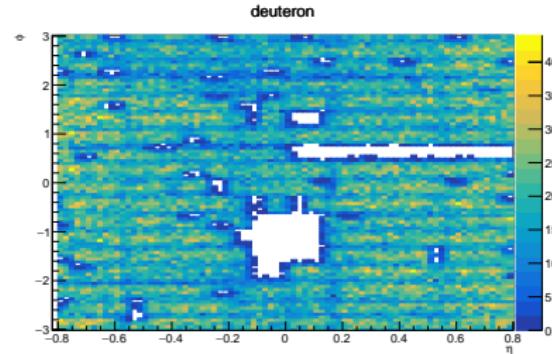
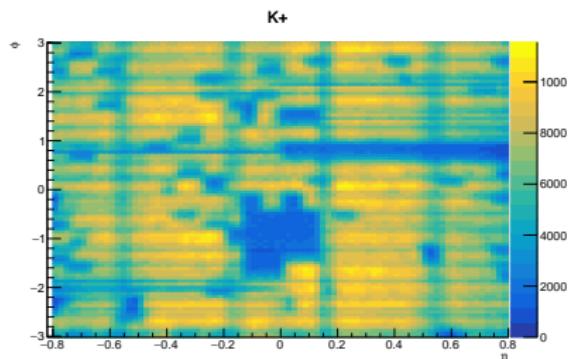
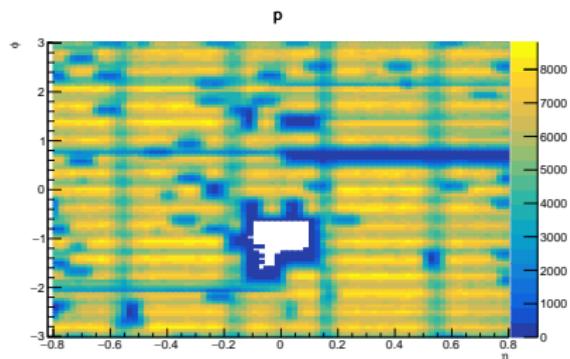
WUT

QA plots: p_T , highIR, cent 0-5%

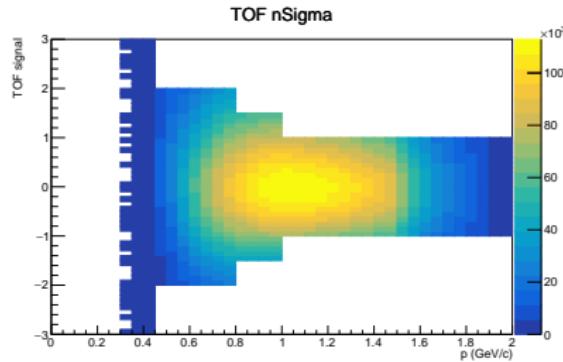
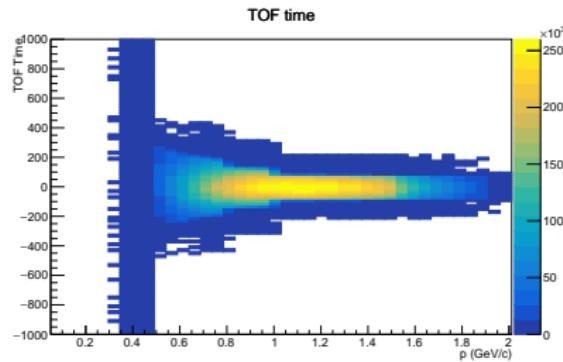
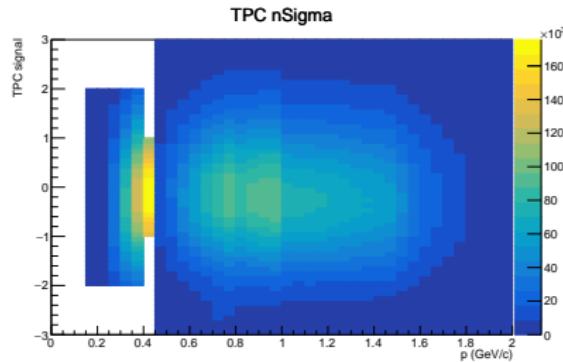
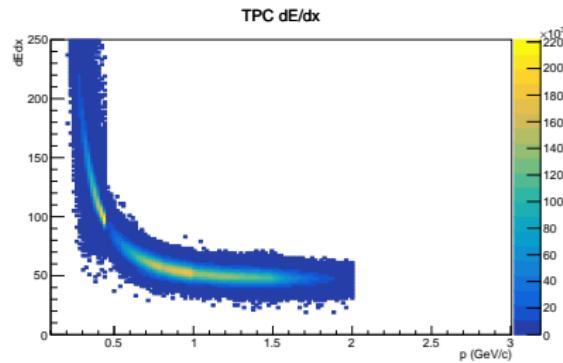
Negative magnetic field



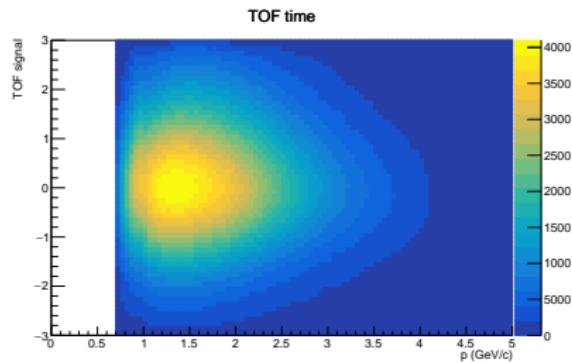
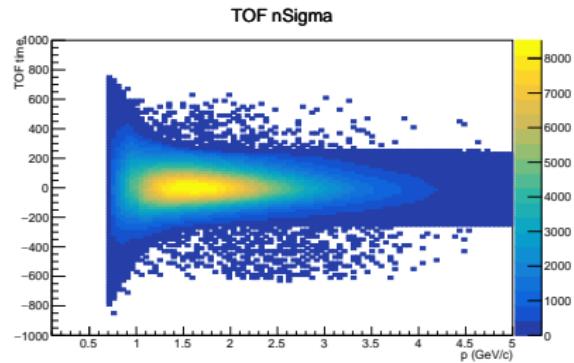
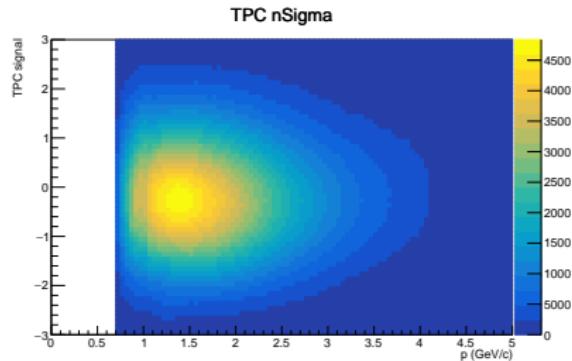
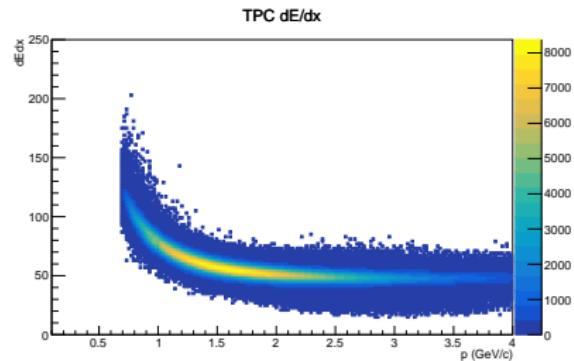
QA plots: eta-phi, highIR, cent 0-5%



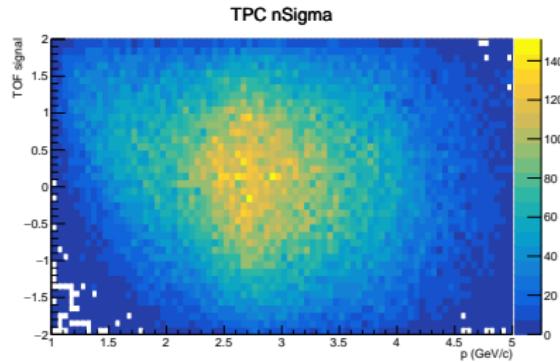
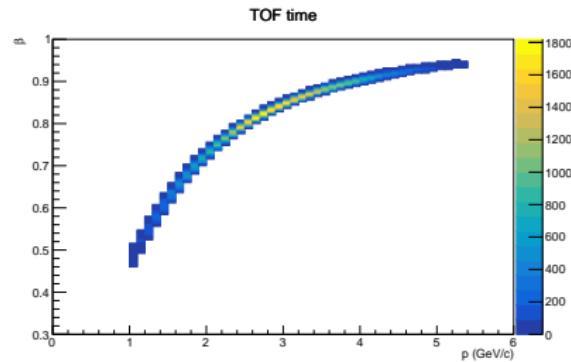
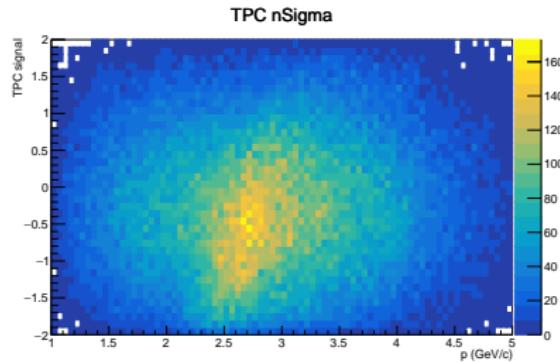
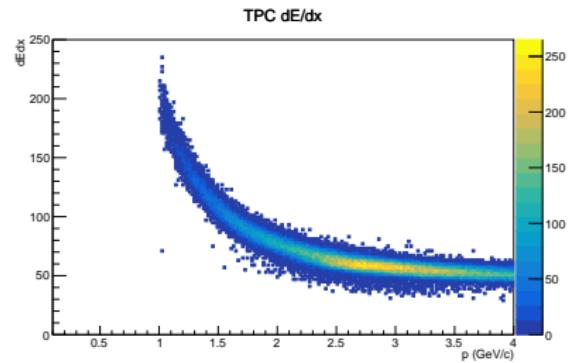
QA plots: kaon PID, highIR, cent 0-5%



QA plots: proton PID, highIR, cent 0-5%

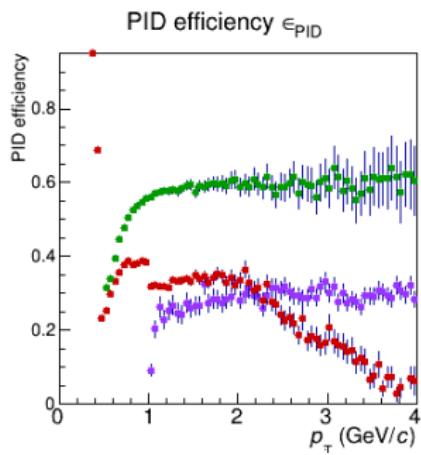
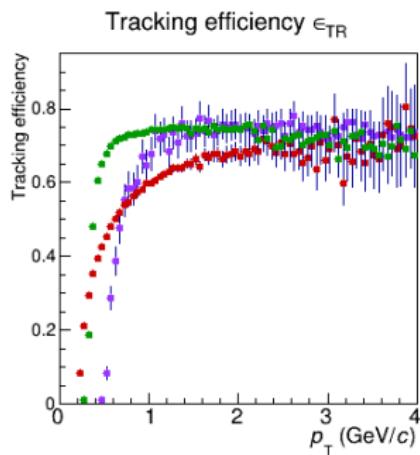
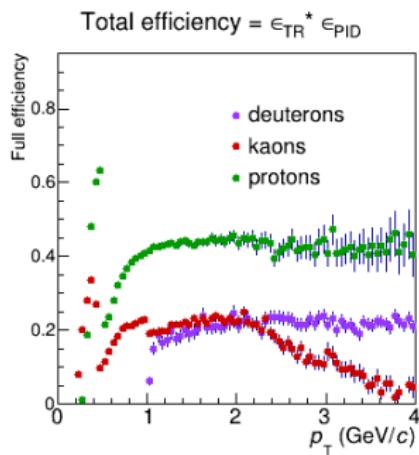


QA plots: deuteron PID, highIR, cent 0-5%

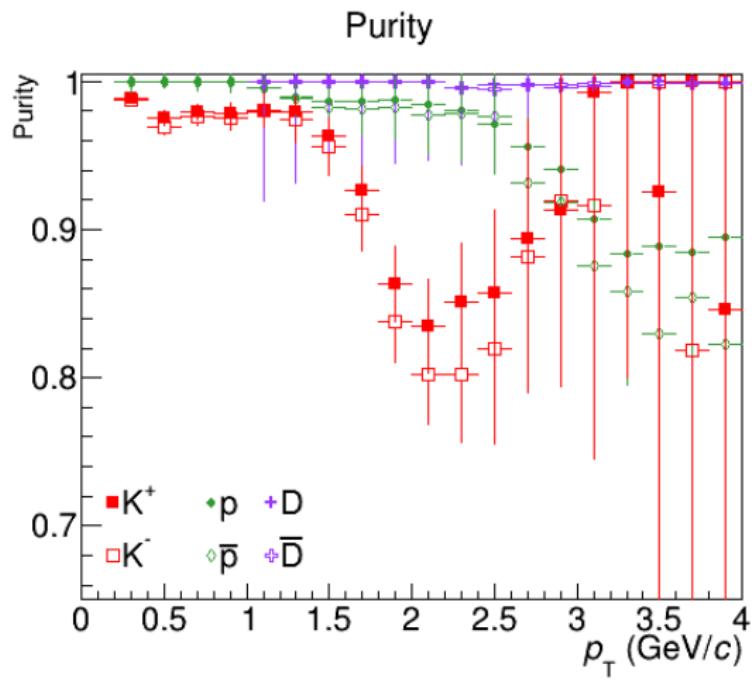


Efficiency

■ Injected Nuclei MC production (2.76 TeV)



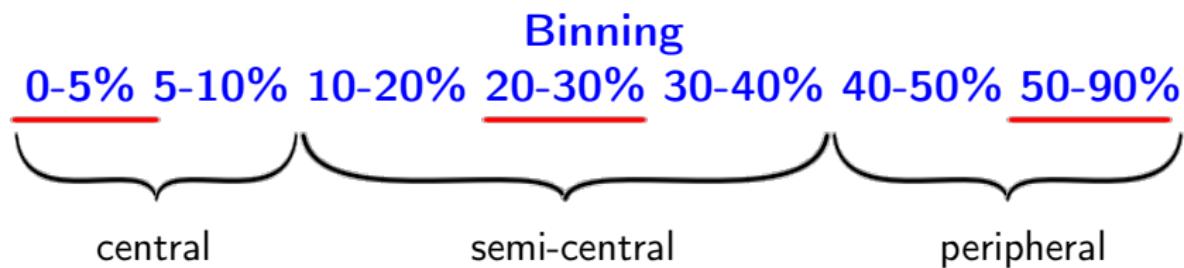
Purity



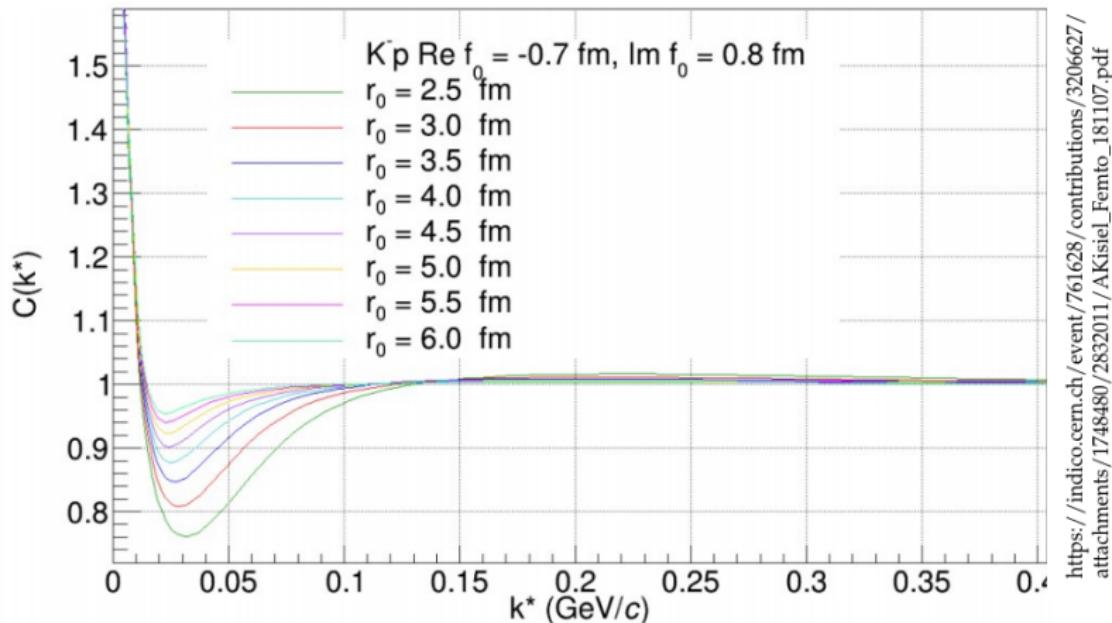
Both magnetic fields:

- – positive
- – negative

Correlation functions



Theoretical correlation functions: K-p

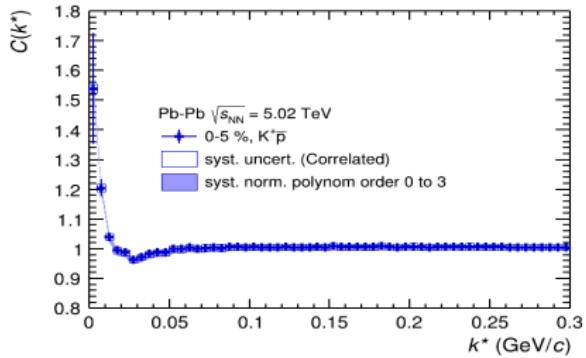
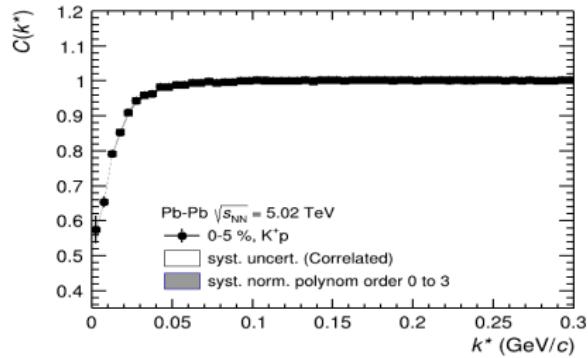
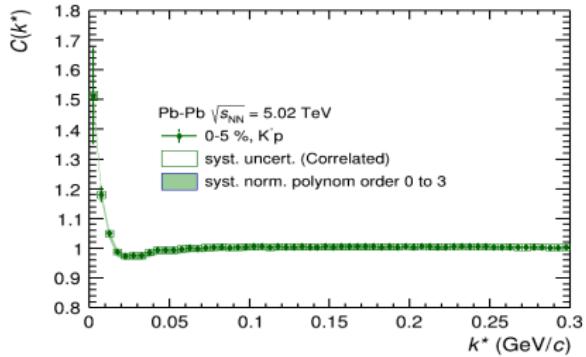
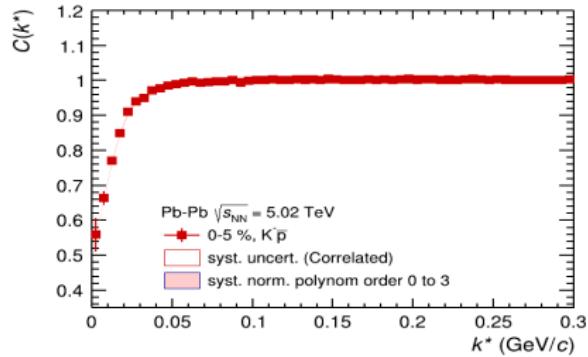


https://indico.cern.ch/event/761628/contributions/3206627/attachments/1748480/2832011/AKisiel_Femto_181107.pdf

Example numerical calculation: Prof. Adam Kisiel

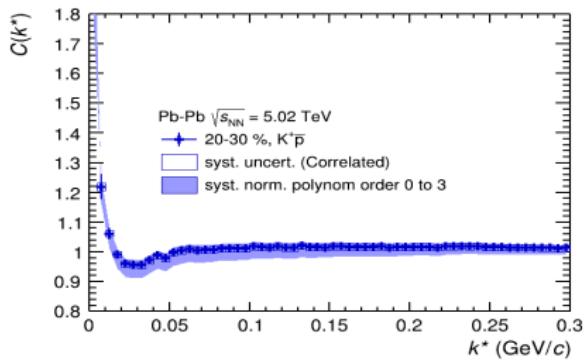
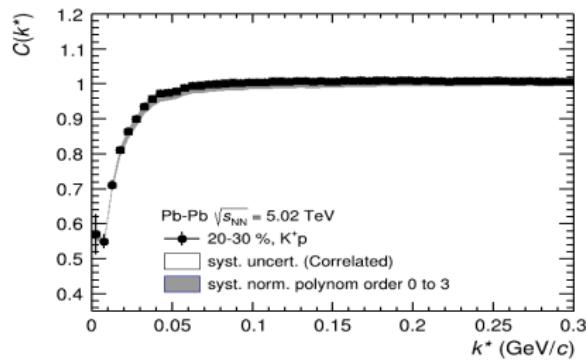
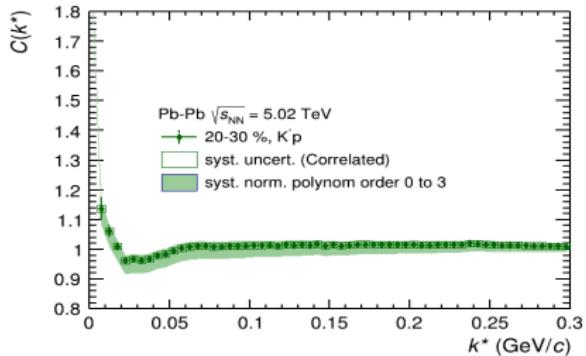
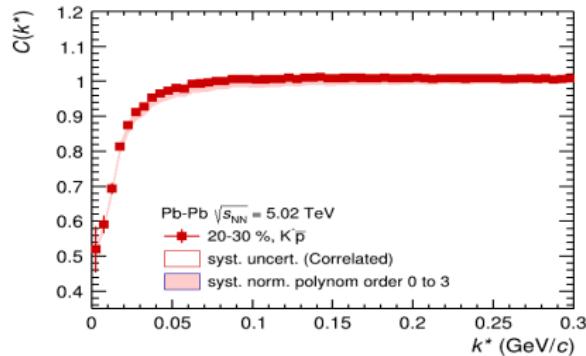
Kaon-proton CF

Merged fields and datasets, cent 0-5%



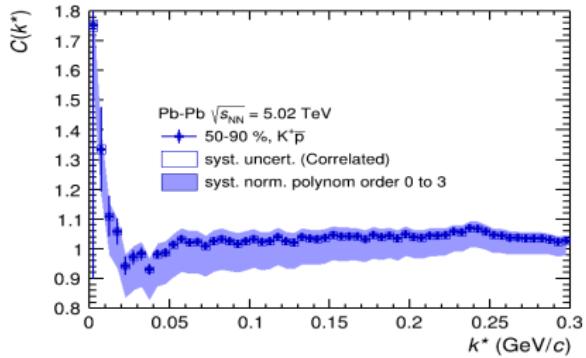
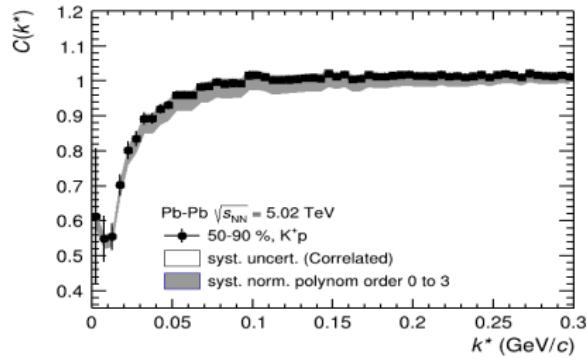
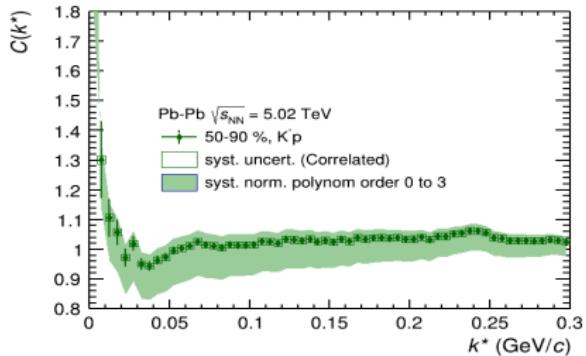
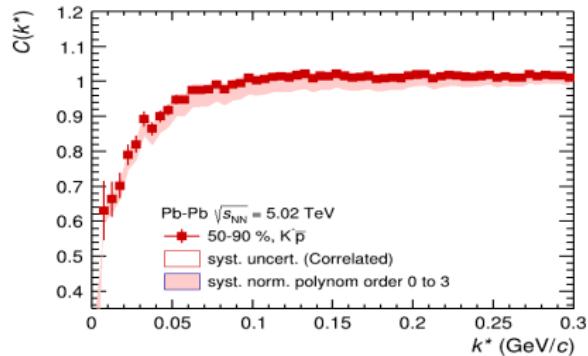
Kaon-proton CF

Merged fields and datasets, cent 20-30%



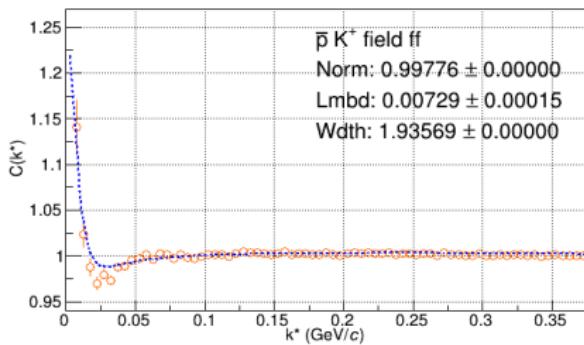
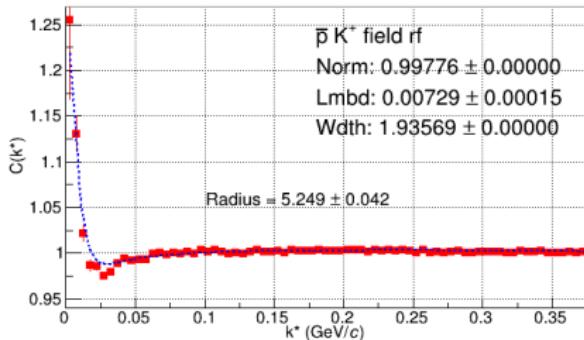
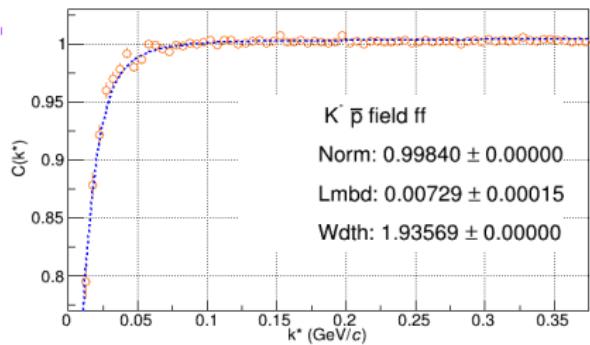
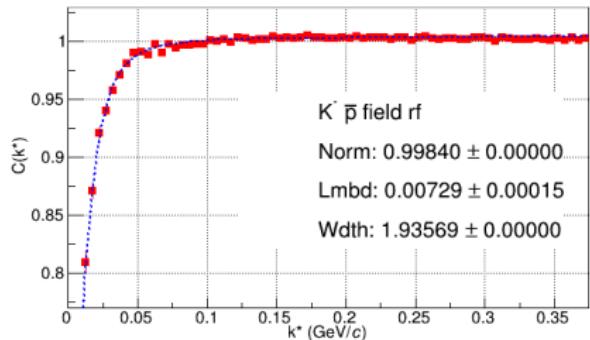
Kaon-proton CF

Merged fields and datasets, cent 50-90%



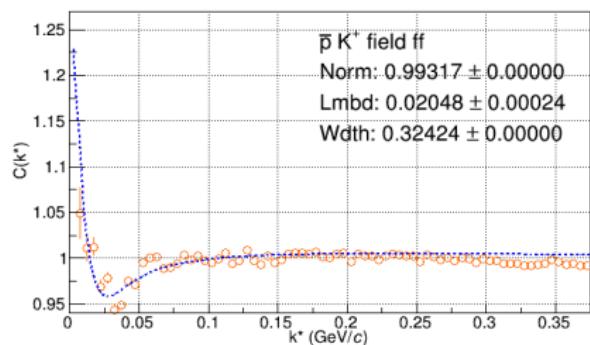
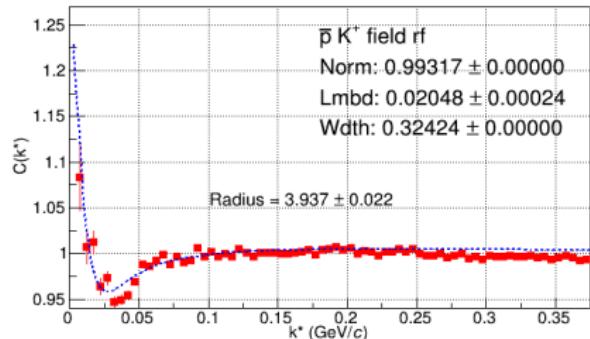
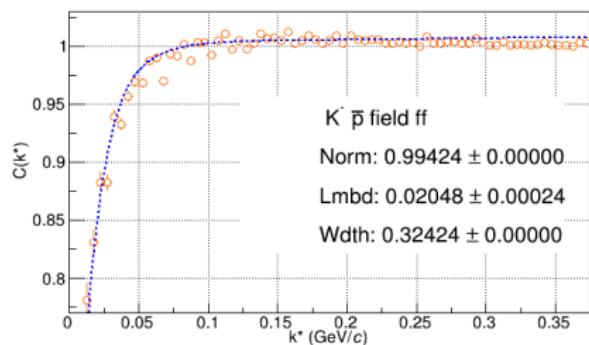
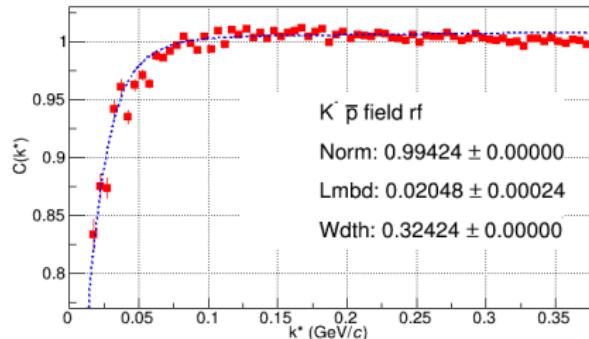
Fitting: kaon-proton CF

Negative magnetic field, cent 0-5%



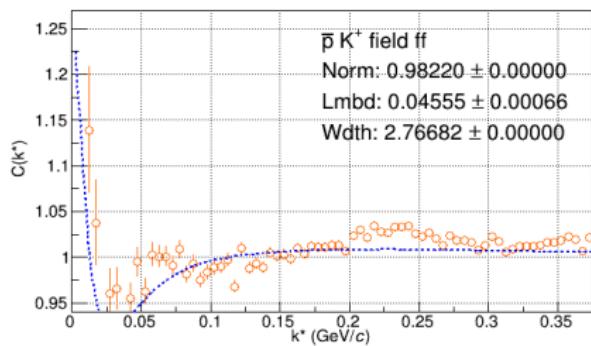
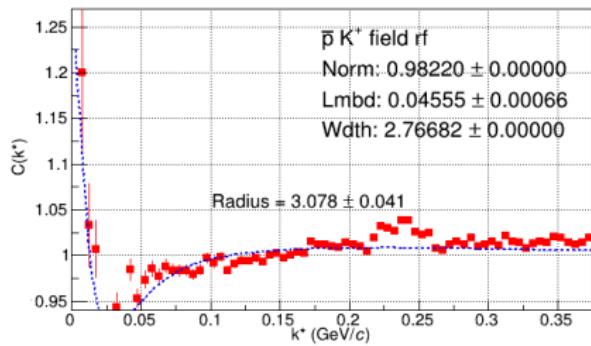
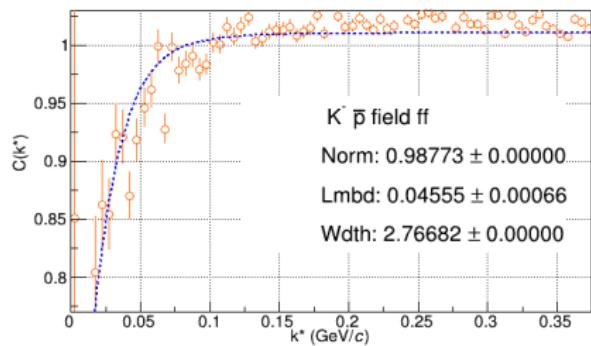
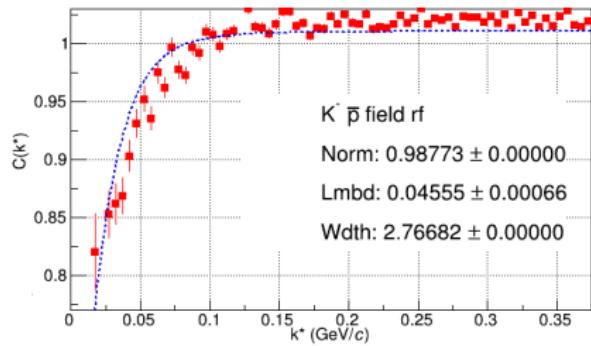
Fitting: kaon-proton CF

Negative magnetic field, cent 20-30%



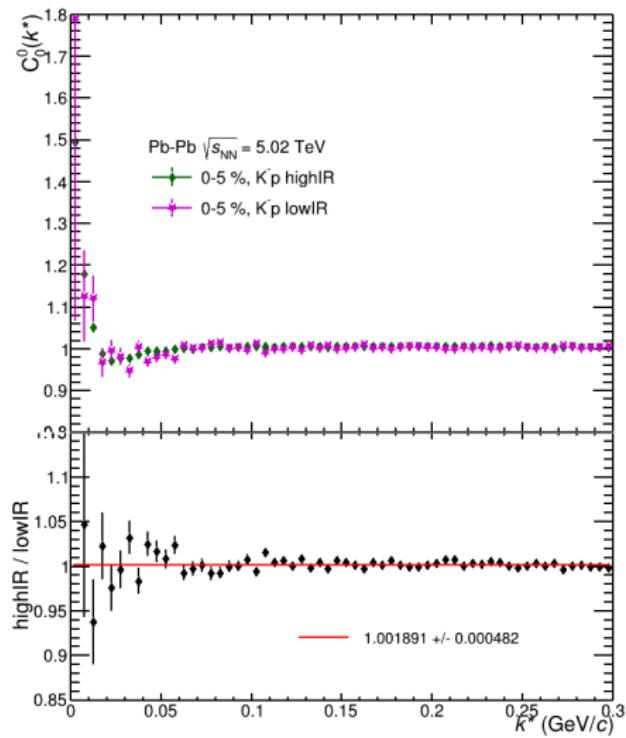
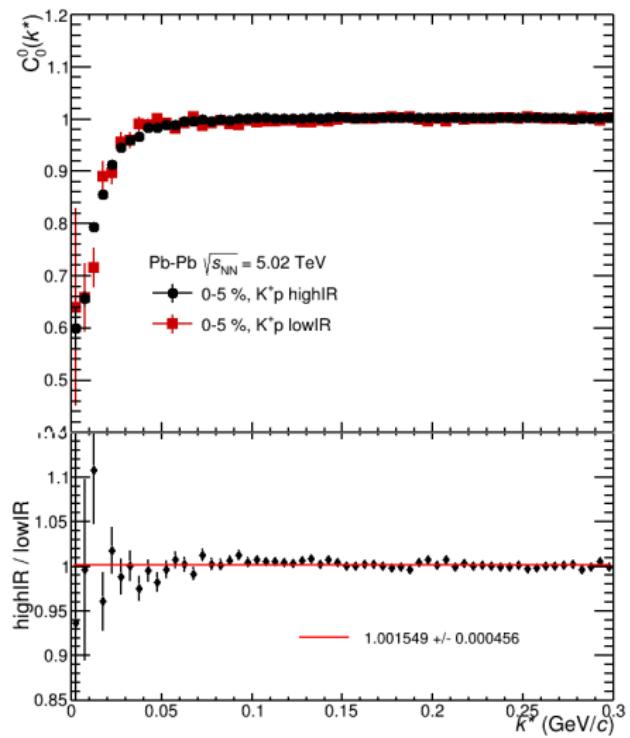
Fitting: kaon-proton CF

Negative magnetic field, cent 50-90%



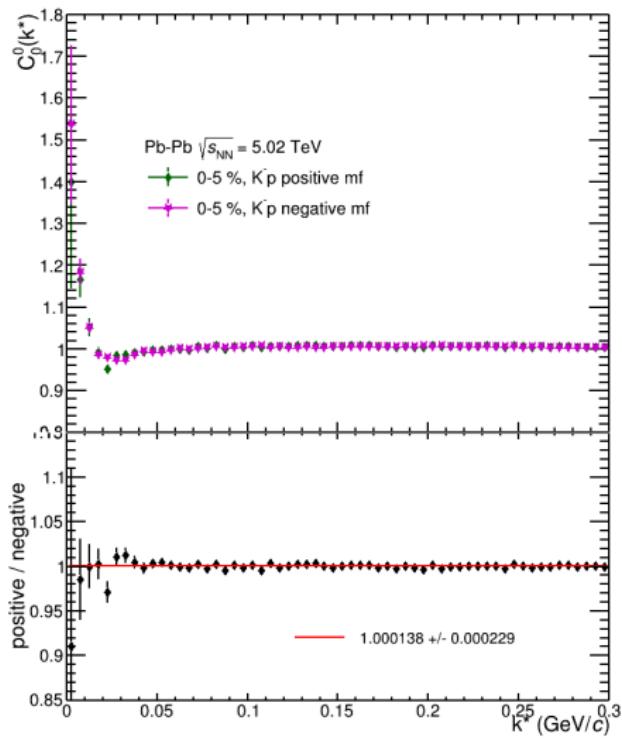
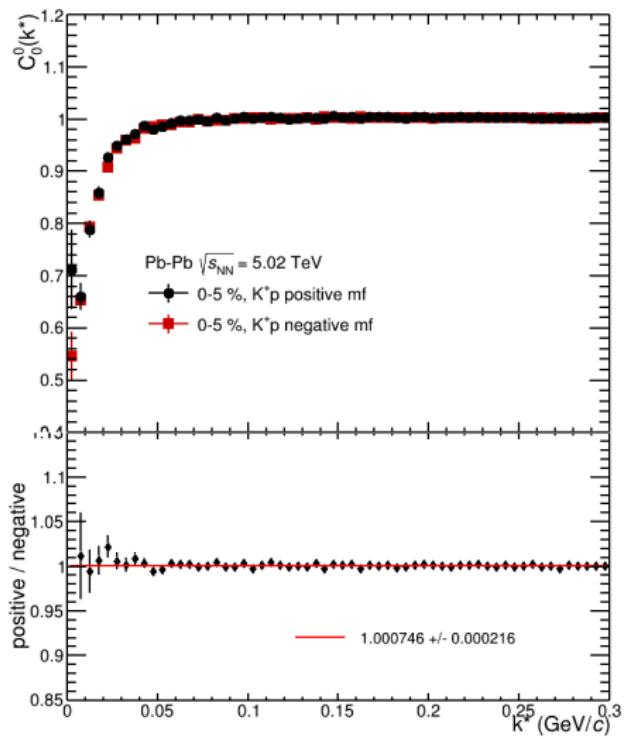
Comparison: lowIR and highIR

Merged fields, cent 0-5%



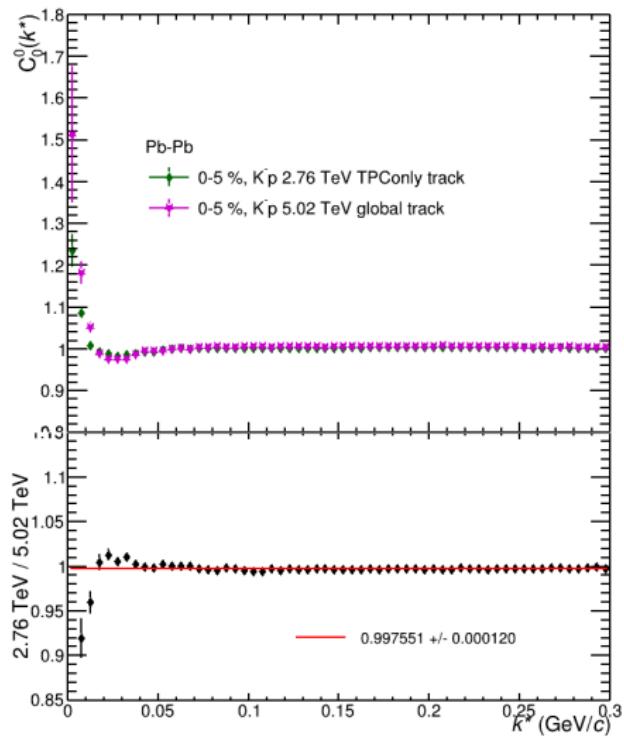
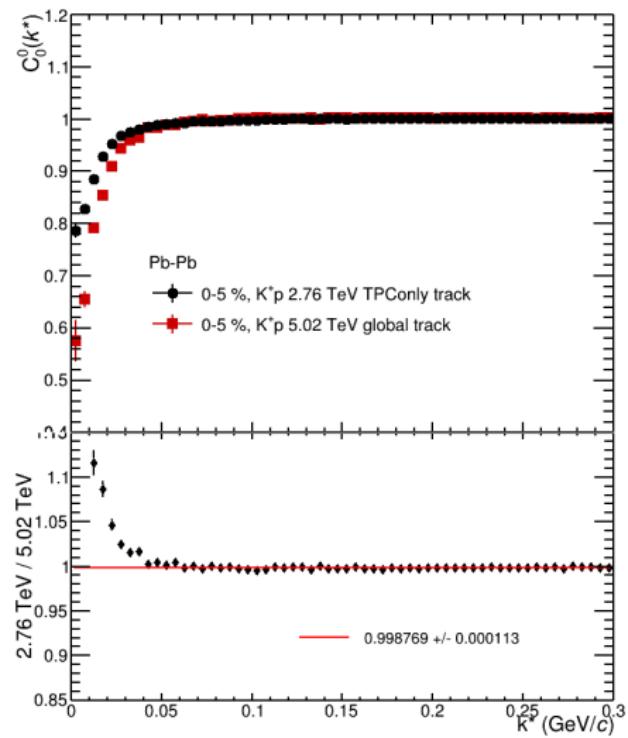
Comparison: magnetic fields

Merged datasets, cent 0-5%



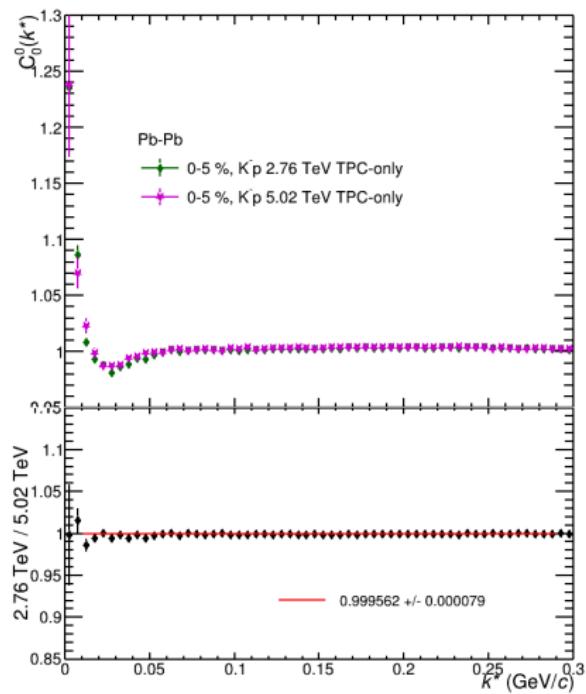
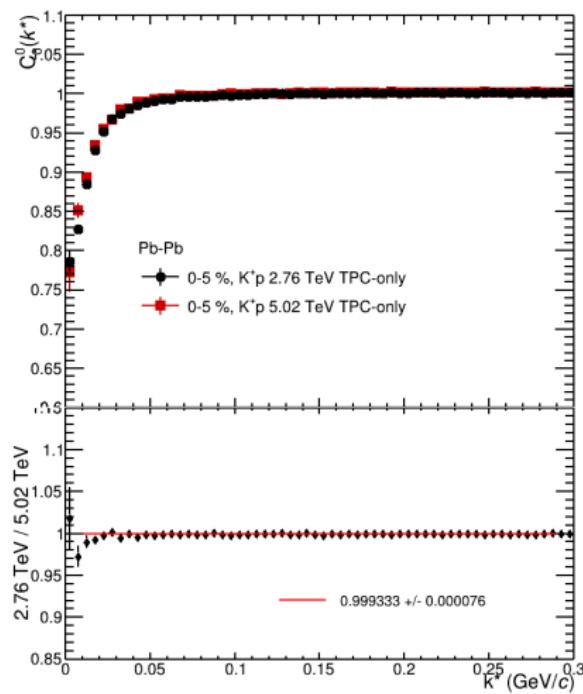
Comparison: energies

Merged fields and datasets, cent 0-5%



Comparison: energies

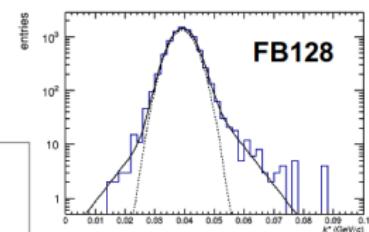
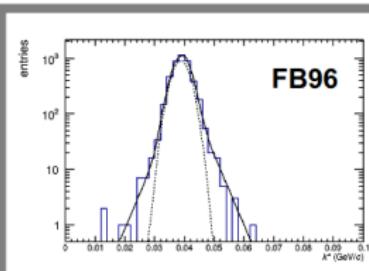
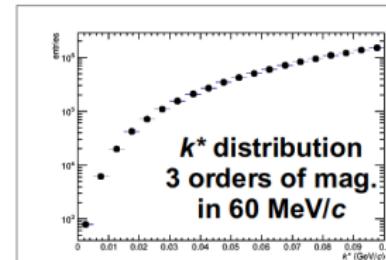
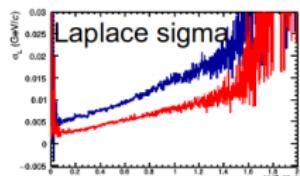
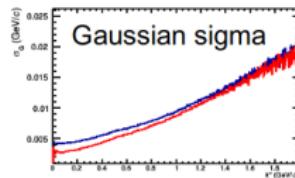
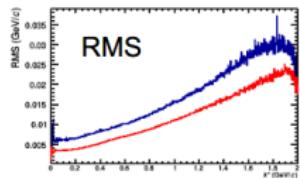
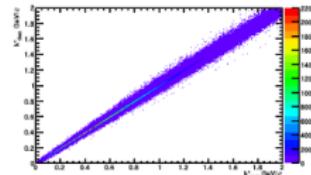
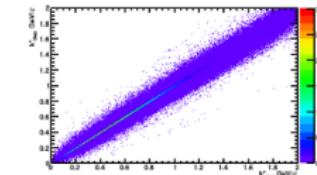
Merged fields and datasets, cent 0-5%



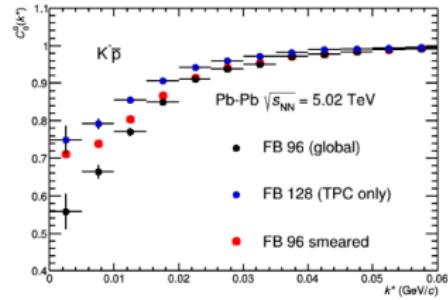
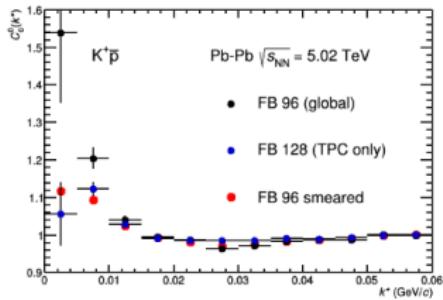
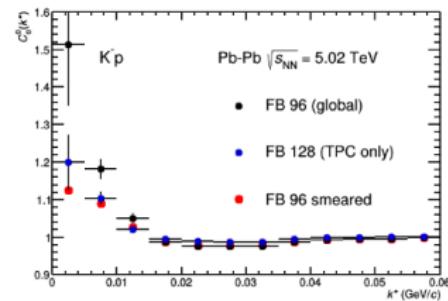
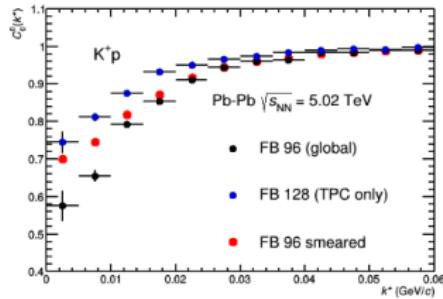
Filterbits

k^* resolution matrices for FB128 & FB96

Gaussian + Laplace for the tails

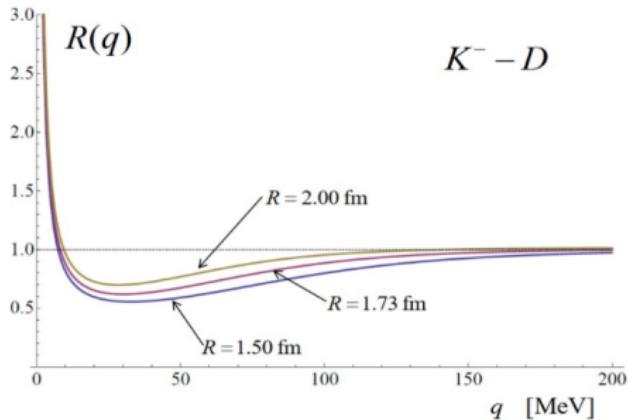


Smearing of FB96 → FB128



Theoretical correlation functions: K-D

K-D correlation functions



$$a = (1.46 - 1.08i) \text{ fm}$$

$$2.00 = \sqrt{\frac{4}{3}} 1.73 = \frac{4}{3} 1.50$$

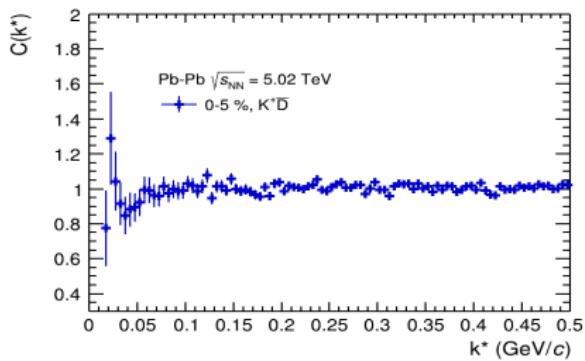
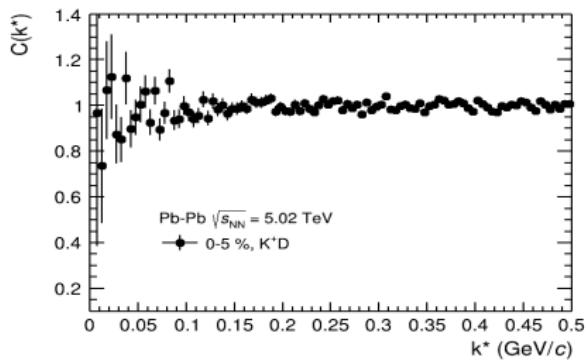
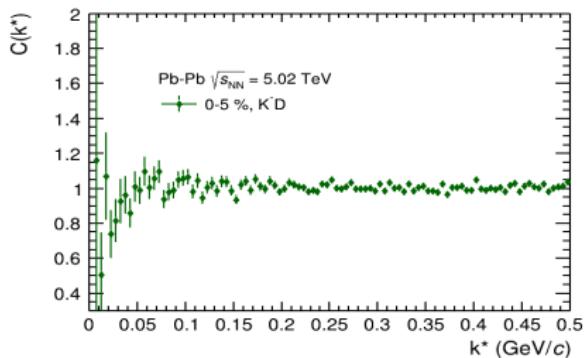
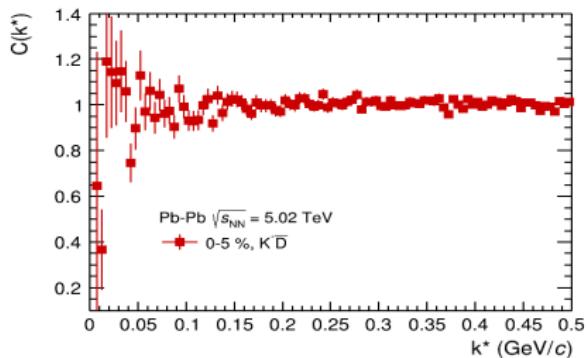
14

<https://indico.cern.ch/event/783416/contributions/3363952/attachments/1825402/2987278/Mrowczynski.pdf>

Prof. Stanisław Mrówczyński & Patrycja Słoń
Polish Workshop on Relativistic HIC

Kaon-deuteron CF

Negative magnetic field, merged datasets, cent 0-5%



SUMMARY



■ Done:

- implementation of the code for deuterons
- calculation of correlation functions for kaon-proton
- calculation of efficiency and purity
- calculation of kaon-proton CF uncertainties
- comparisons with different sets and analysis

■ In progress:

- fitting kaon-proton data
- understanding the discrepancy between results from different filterbits
- kaon-deuteron purity

■ In the near future:

- calculation of kaon-deuteron CF uncertainties
- fitting kaon-deuteron data

Thank you
for your attention

Backup slides

Analysis details – PID criteria

■ Kaons:

- $p < 0.4 \text{ GeV}/c \rightarrow N_{TPC\sigma} < 2$
- $0.4 < p < 0.45 \text{ GeV}/c \rightarrow N_{TPC\sigma} < 1$
- $0.45 < p < 0.8 \text{ GeV}/c \rightarrow N_{TPC\sigma} < 3 \text{ \& } N_{TOF\sigma} < 2$
- $0.8 < p < 1.0 \text{ GeV}/c \rightarrow N_{TPC\sigma} < 3 \text{ \& } N_{TOF\sigma} < 1.5$
- $p > 1.0 \text{ GeV}/c \rightarrow N_{TPC\sigma} < 3 \text{ \& } N_{TOF\sigma} < 1$

■ Protons:

- $p < 0.5 \text{ GeV}/c \rightarrow N_{TPC\sigma} < 3$
- $p > 0.5 \text{ GeV}/c \rightarrow \sqrt{N_{TPC\sigma}^2 + N_{TOF\sigma}^2} < 3$

■ Deuterons:

- $p > 1 \text{ GeV}/c \rightarrow \sqrt{N_{TPC\sigma}^2 + N_{TOF\sigma}^2} < 2$
- A cut on mass distribution obtained using the TOF signal