Like-sign kaon femtoscopy for the Beam Energy Scan at STAR

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for the STAR collaboration

Outline

- Introduction
- Event and track selections
- Results
  - k_T dependence
  - centrality dependence
  - beam energy dependence
- Summary

Motivation

- Femtoscopy provides information on space-time characteristics
- High Statistics needed $\Rightarrow$ π, K, p
- Unlike pions, most kaons are primary particles
- Strangeness $\Rightarrow$ Different production process if QGP is formed

Introduction

1D femtoscopic analysis of like-sign kaons

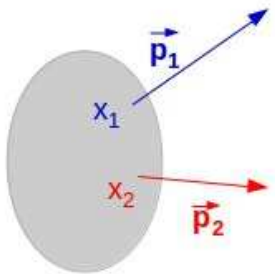
- 6 energies of BES at STAR: 7.7, 11.5, 14.5, 19.6, 27, 39 GeV
- 2 centrality bins: 0-30%, 30-80%
- 2 k_T bins: [0.2,0.4], [0.4,0.6] GeV/c

  $k_T = (\frac{p_1+p_2}{2})_T$

Femtoscopy

Correlation function

$$C(\vec{\mathbf{p_1}}, \vec{\mathbf{p_2}}) = \frac{P_2(\vec{\mathbf{p_1}}, \vec{\mathbf{p_2}})}{P_1(\vec{\mathbf{p_1}}) P_1(\vec{\mathbf{p_2}})}$$



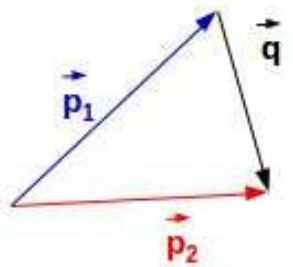
$P_2(\vec{\mathbf{p_1}}, \vec{\mathbf{p_2}})$: probability to observe in one event two particles with momenta $\vec{\mathbf{p_1}}$ and $\vec{\mathbf{p_2}}$

$P_1(\vec{\mathbf{p_1}})$: probability to observe in one event one particle with momentum $\vec{\mathbf{p_1}}$
$P_1(\vec{\mathbf{p_2}})$: probability to observe in one event one particle with momentum $\vec{\mathbf{p_2}}$

Femtoscopy

Event-mixing procedure

$$C(q_{inv}) = \frac{A(q_{inv})}{B(q_{inv})}$$



$$q_{inv} = |\vec{\mathbf{p_2}} - \vec{\mathbf{p_1}}|$$

$A(q_{inv})$: Real pairs from same event
$B(q_{inv})$: Mixed pairs from different events with similar vertex z-position (bins of 5 cm) and multiplicity (10 bins)

Femtoscopy

Sources of correlations

- Quantum Statistics: Bose-Einstein Correlation
- Final State Interaction
  - Strong
  - Coulomb

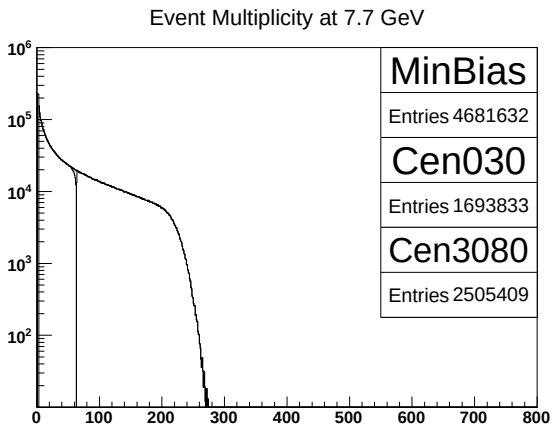
Selection of Events and Tracks

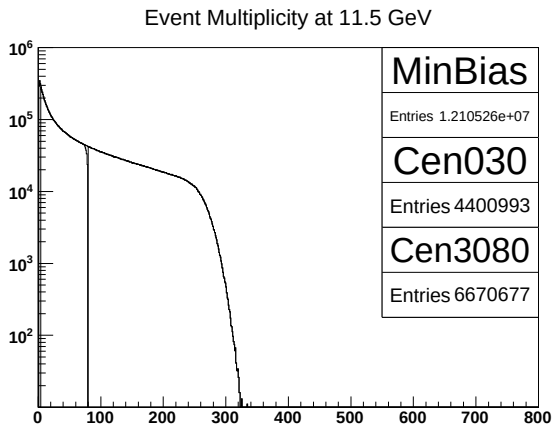
$\sqrt{s_{NN}}$ [GeV]	z_{Vert} [cm]	R_{Vert} [cm]	N_{Events}
7.7	[-70,70]	[0,2]	4.7M
11.5	[-50,50]	[0,2]	12.1M
14.5	[-30,30]	[0,1]	8.7M
19.6	[-30,30]	[0,2]	17.2M
27	[-30,30]	[0,2]	68.7M
39	[-30,30]	[0,2]	75.1M

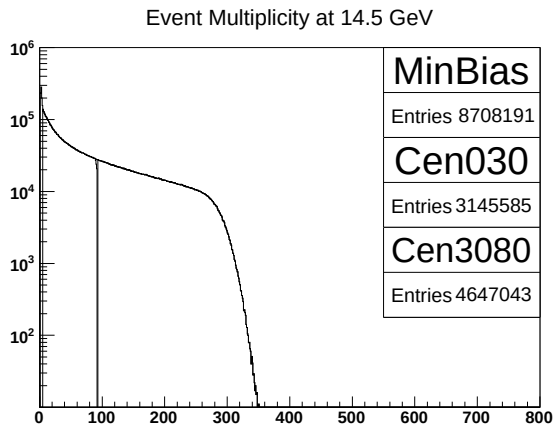
z_{Vert} and R_{Vert}: cylindrical coordinates of the collision vertex

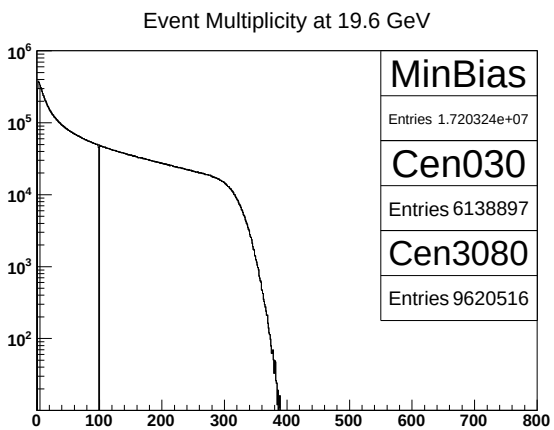
NHits in TPC > 15
Distance of closest approach (DCA) < 3 cm
Momentum p $\in$ [0.2,1.6] GeV/c
$|\eta| < 0.5$

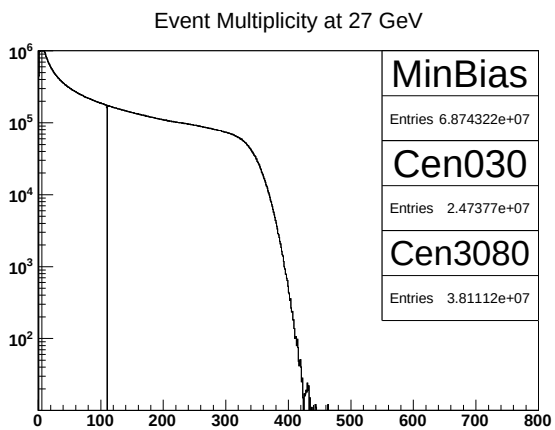
Event Multiplicity

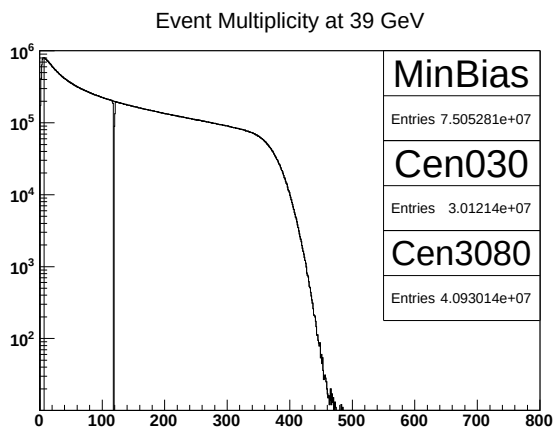












Centrality selection based on MC Glauber calculation

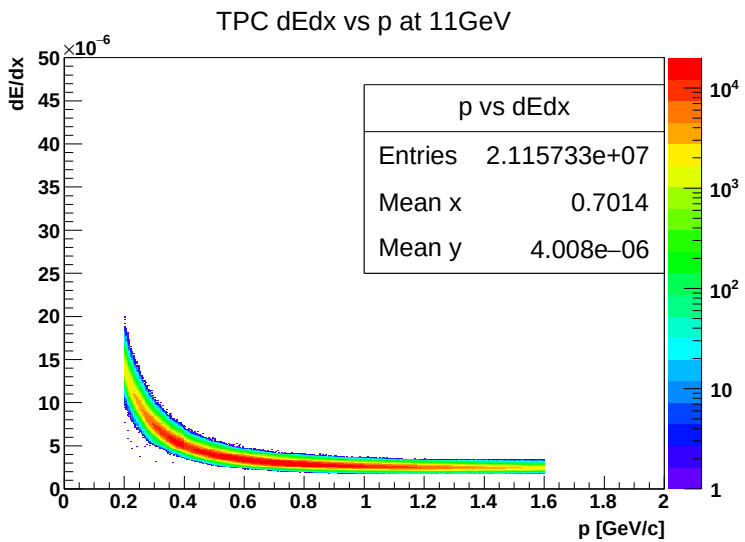
PID: TPC/TPC+TOF

for p $<$ 0.4 GeV/c

info from ToF? No $\Rightarrow$ TPC Only

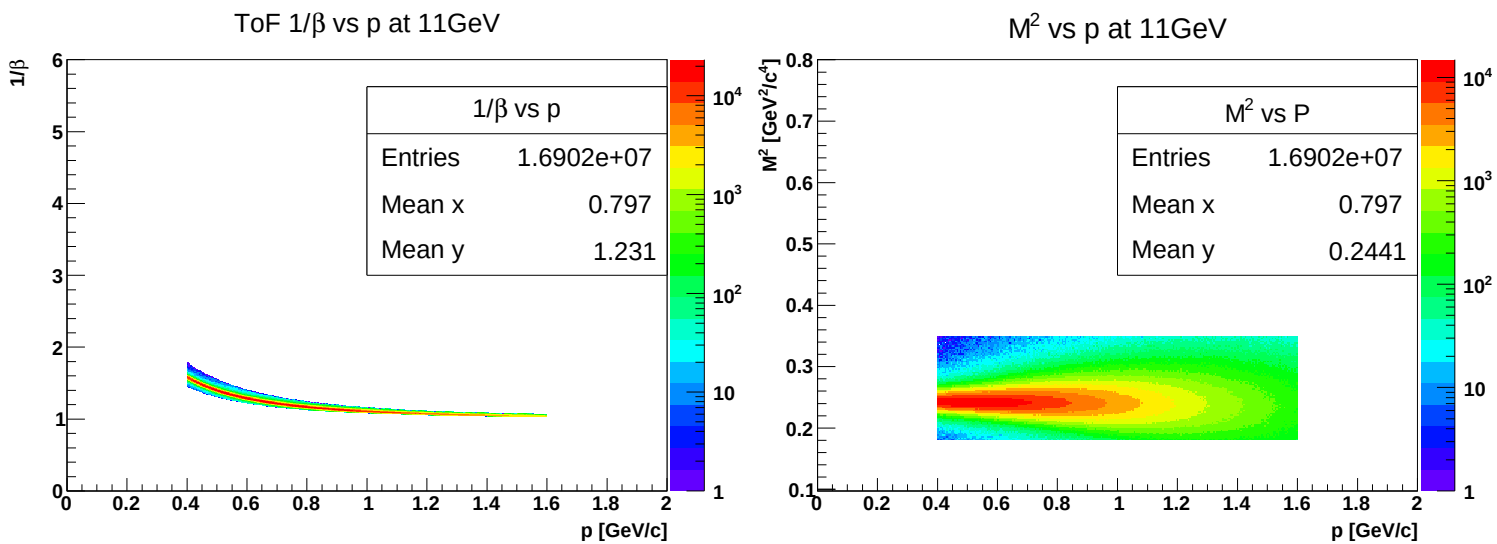
Yes $\Rightarrow$ TPC+ToF

for p $>$ 0.4 GeV/c $\Rightarrow$ TPC+ToF



$|N_{\sigma,K}| < 2$ $|N_{\sigma,pi}| > 2$ $|N_{\sigma,p}| > 2$

PID: TPC/TPC+TOF



$$0.18 < M^2 < 0.35\ GeV^2/c^4$$

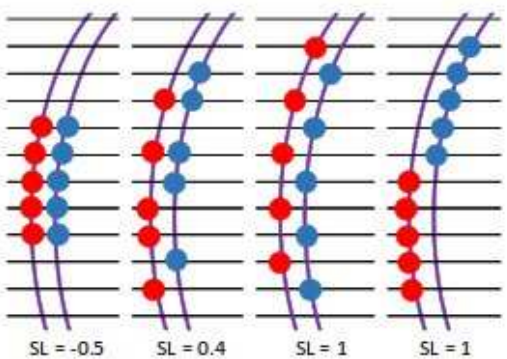
Pair Cuts

Remove merging (2 tracks mistaken as 1):

Fraction of merged hits $< 10\%$
Average Separation between tracks > 5cm

Remove splitting (1 track mistaken as 2):

split level $\in$ [-0.5,0.6]



$$\text{split level} = \frac{NPads_{1hit} - NPads_{2hits}}{N_{hits}}$$

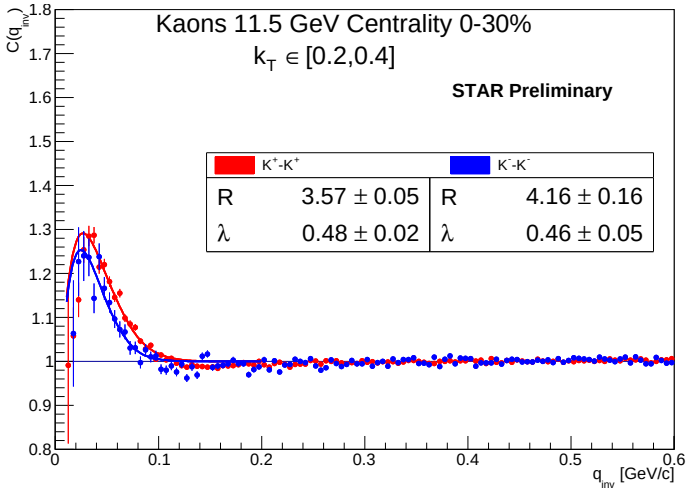
Fitting procedure

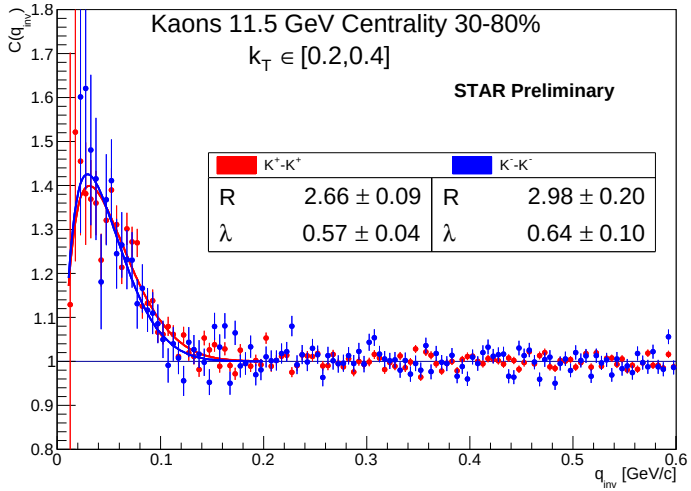
Bowler-Sinyukov

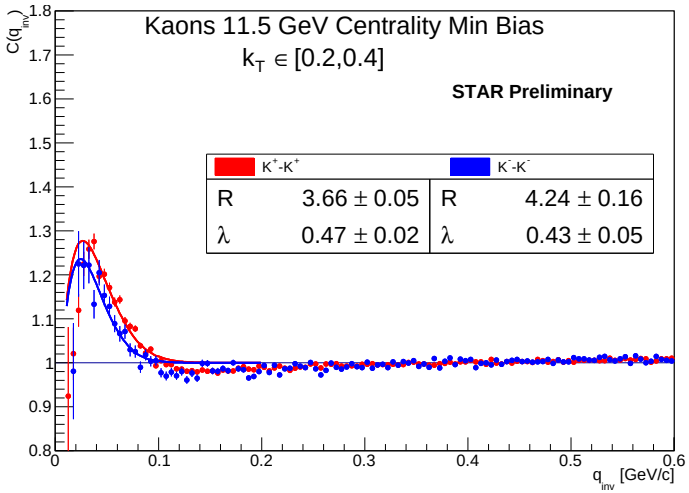
$$C(q_{inv}) = 1 - \lambda + \lambda K(q_{inv})(1 + e^{-q_{inv}^2 R^2})$$

Fit Range: [0,0.2] GeV/c
Normalization Range: [0.2,0.3] GeV/c

11.5 GeV
$k_T \in [0.2,0.4]$ GeV/c

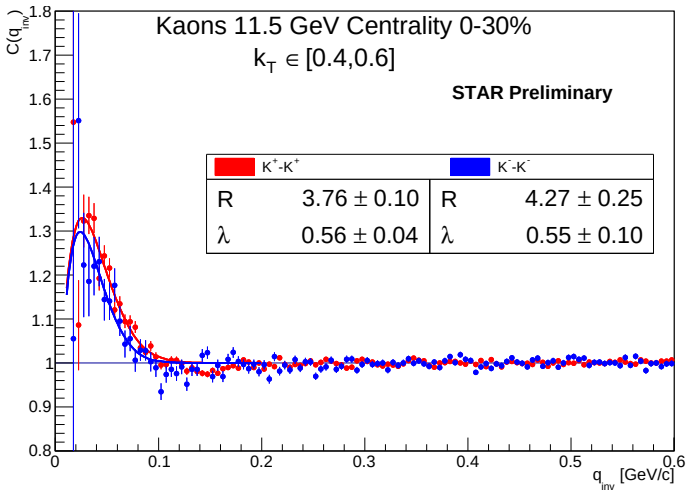


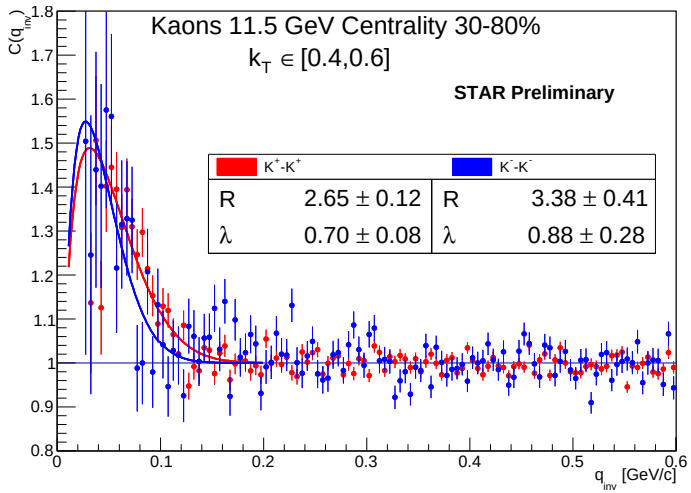


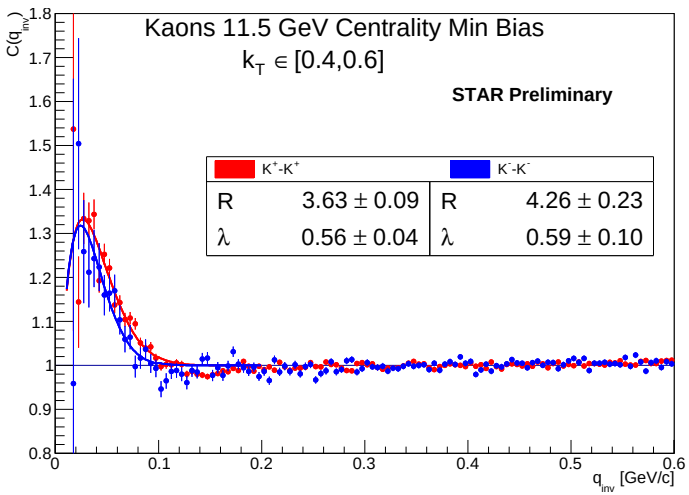


For central collisions larger correlation for $K^+ \Rightarrow$ Smaller R

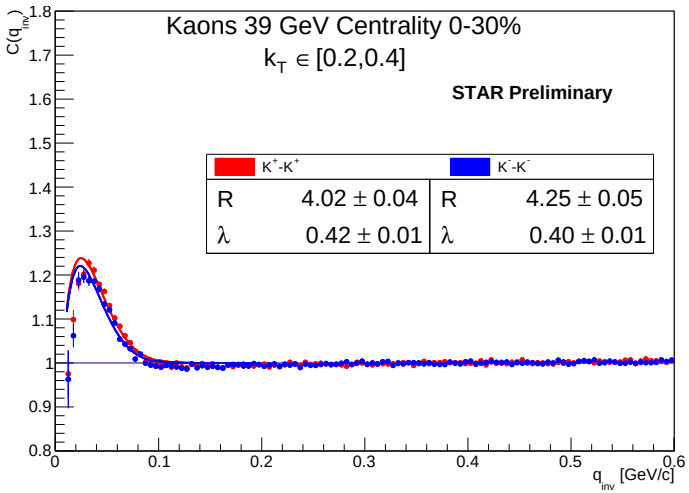
11.5 GeV
$k_T \in [0.4,0.6]$ GeV/c

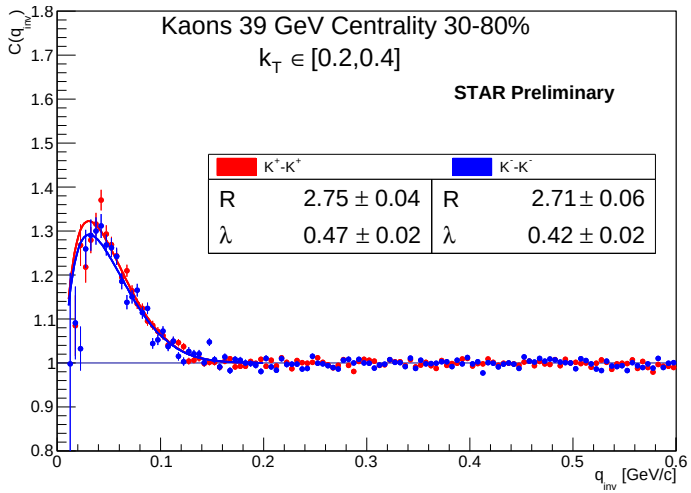


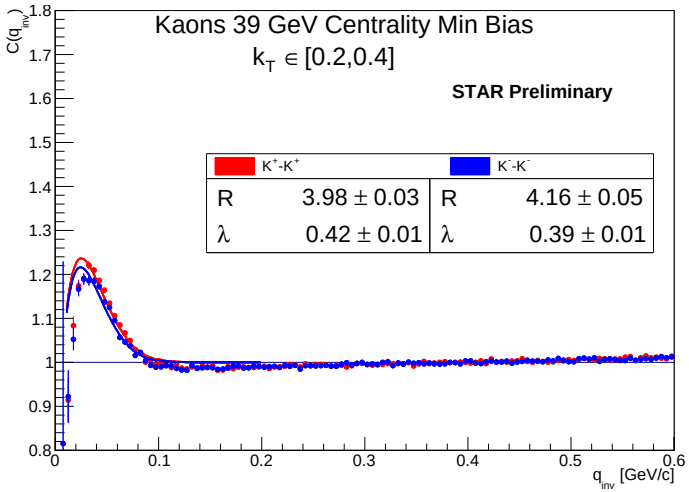




39 GeV
$k_T \in [0.2,0.4]$ GeV/c

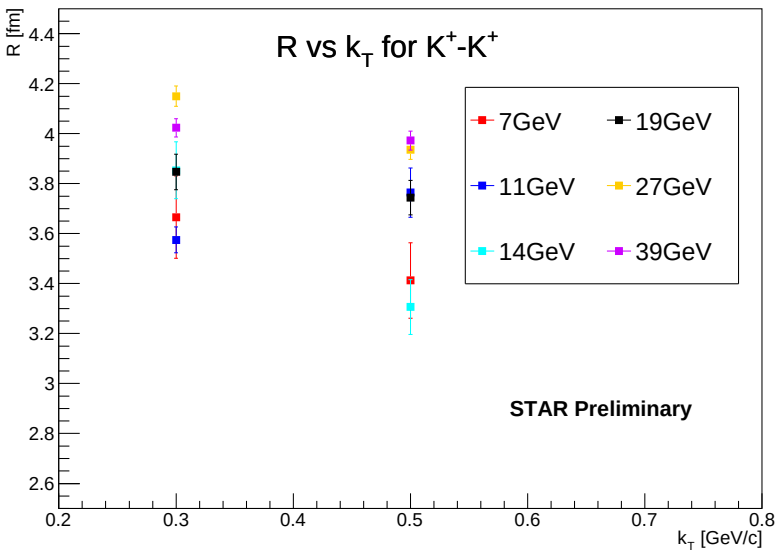


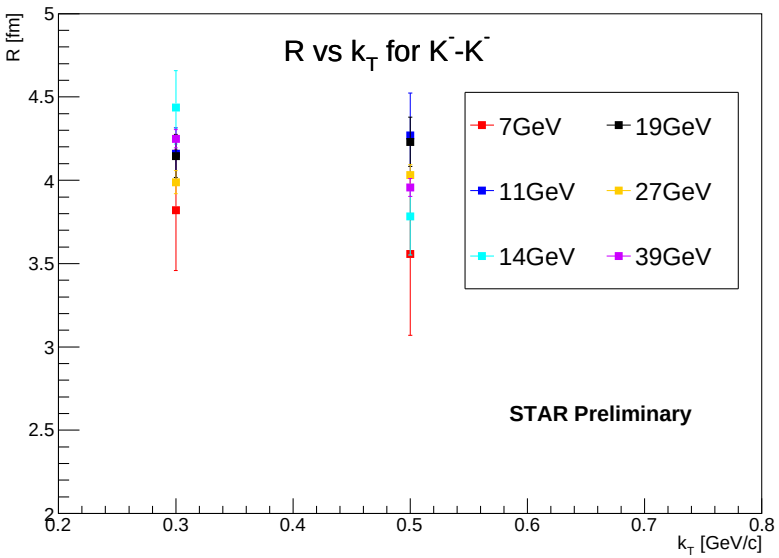




Smaller differences between K^+ and K^- than for 11 GeV

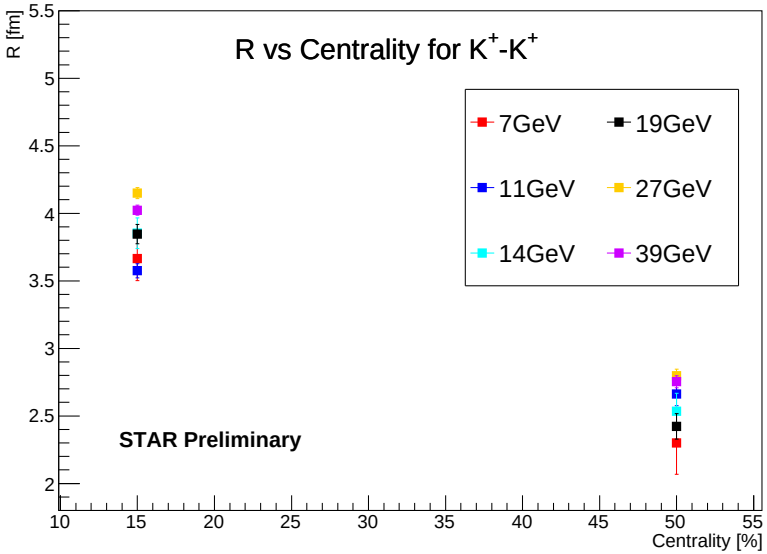
k_T dependence
Centrality 0-30%

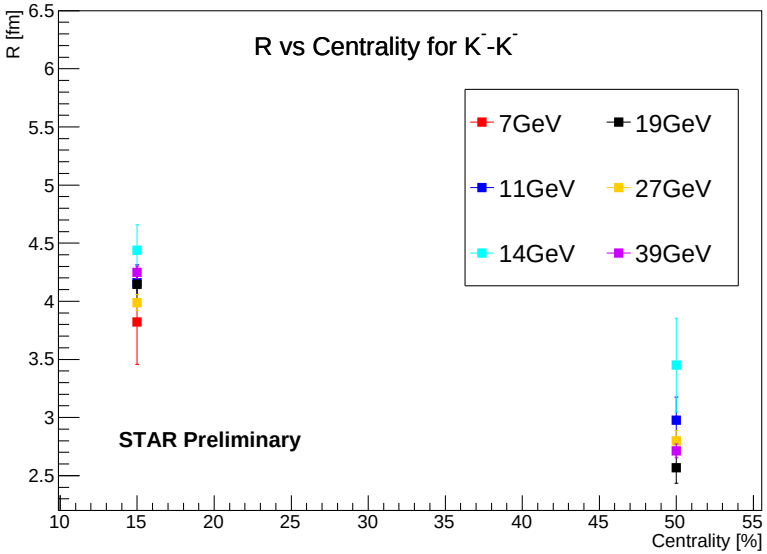




Small decrease of R for higher k_T

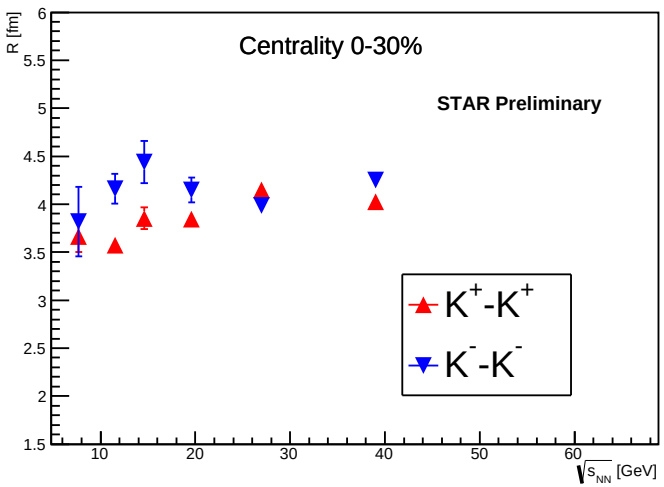
Centrality dependence
$k_T \in [0.2,0.4]$ GeV/c

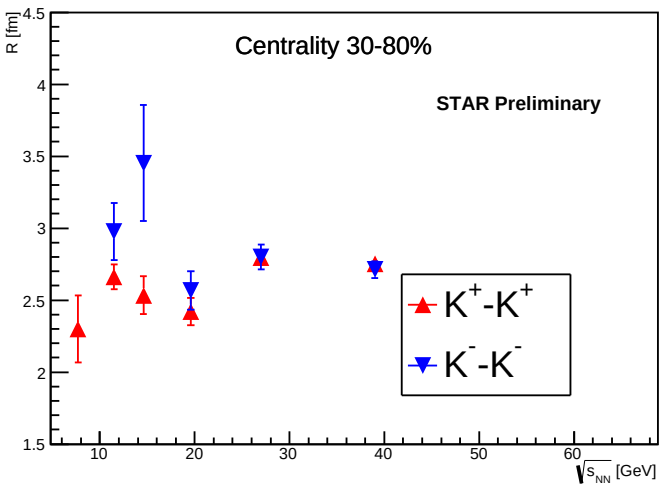


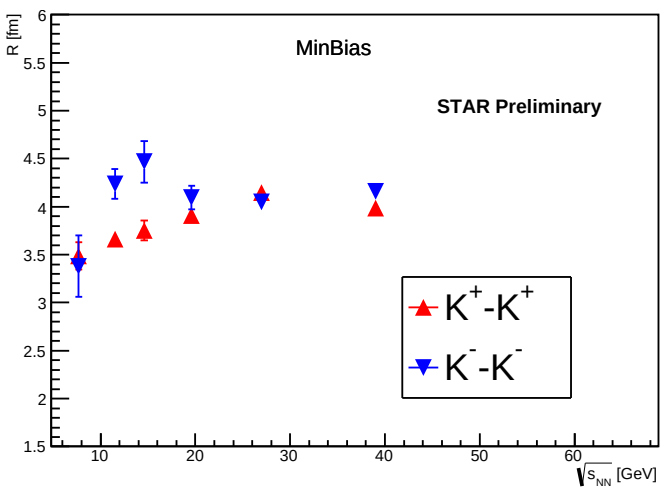


R is increasing for more central collisions

Beam energy dependence
$k_T \in [0.2,0.4]$ GeV/c



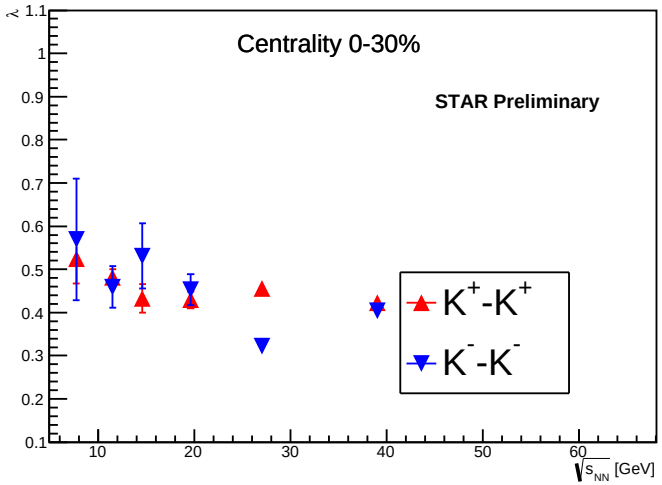


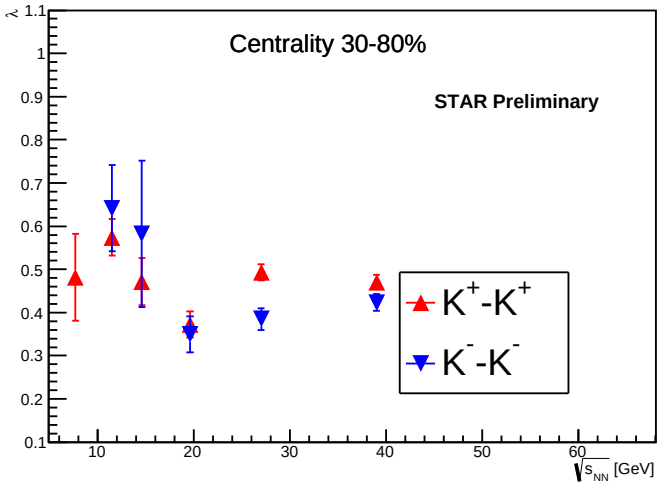


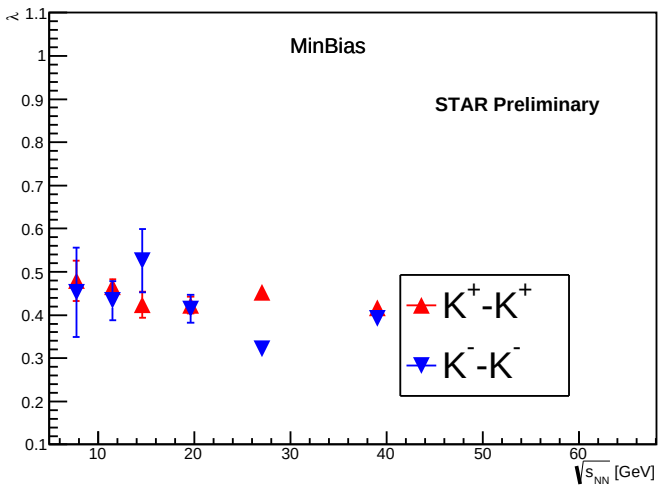
No clear beam energy dependence visible

Different behaviour for K^+ and K^- for beam energy 10-20 GeV in central collisions?

λ for $k_T \in [0.2,0.4]$ GeV/c

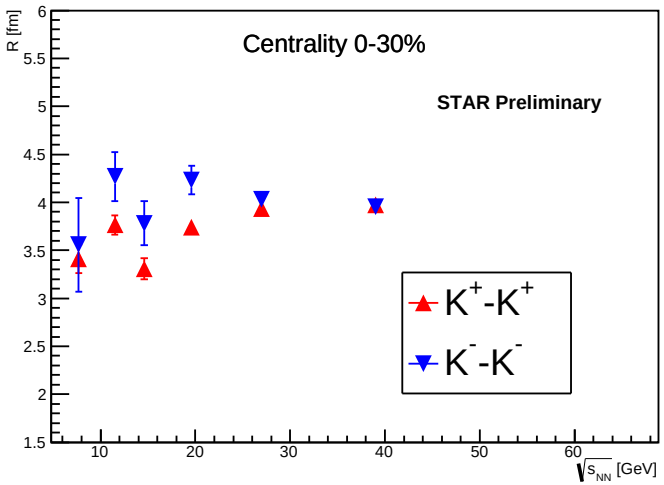


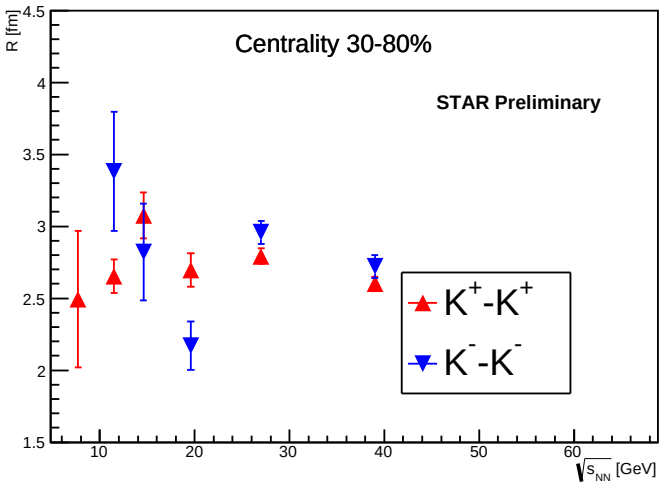


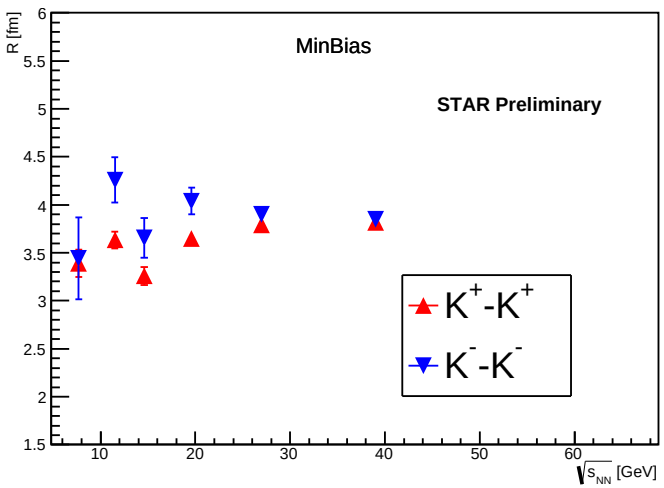


$\lambda \sim$ 0.4-0.5

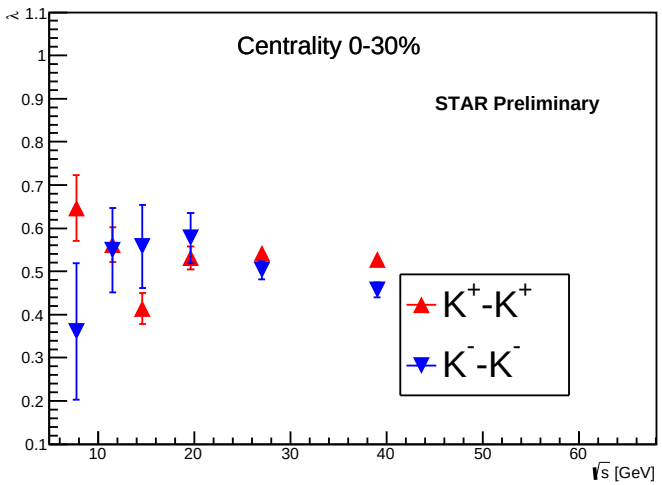
Beam energy dependence
$k_T \in [0.4,0.6]$ GeV/c

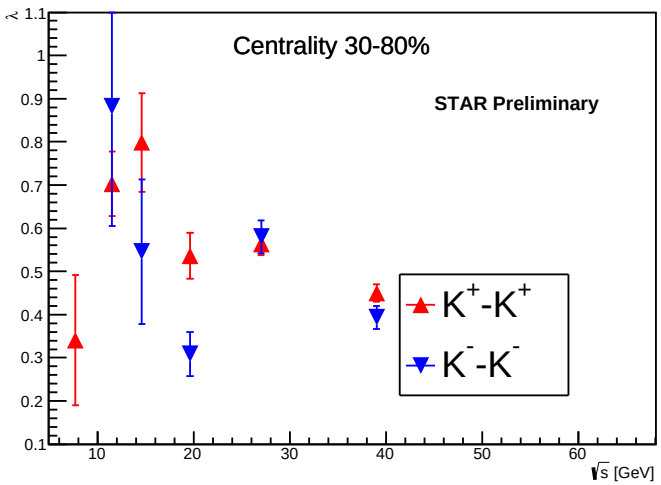


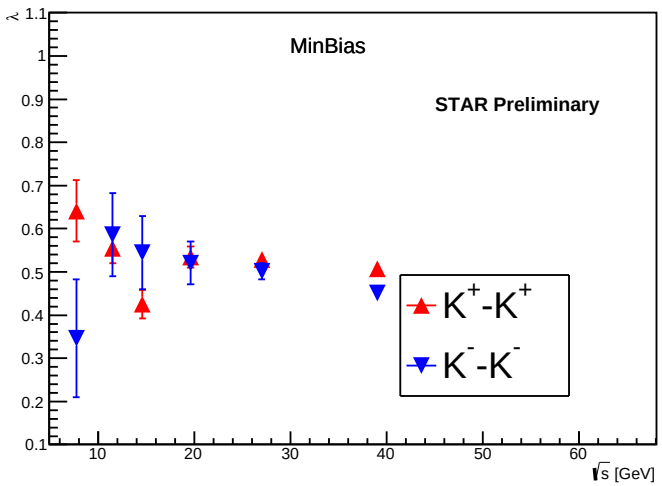




λ for $k_T \in [0.4,0.6]$ GeV/c







Summary

- k_T, centrality and beam energy dependence for like-sign kaon femtoscopy were presented
- Small decrease of R for higher k_T
- R increases for more central collisions
- No clear beam energy dependence

  - TO BE DONE

- Momentum resolution corrections

THANK YOU FOR YOUR ATTENTION!!