Transverse mass dependence of kaon Bose-Einstein correlations in p+p collisions at 200 and 510 GeV

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Motivation

- Kaons can serve as a cleaner probe of the studied system than pions as they are less affected by resonance decays
- Kaons contain strange quarks and have smaller cross-section with hadronic matter than pions so measurements with kaons can be sensitive to earlier collisions stages
- Study the dynamics of the collision evolution via measurement of the transverse mass dependence of the correlation function.
- Measurement of the spatial and temporal characteristics of the emission source

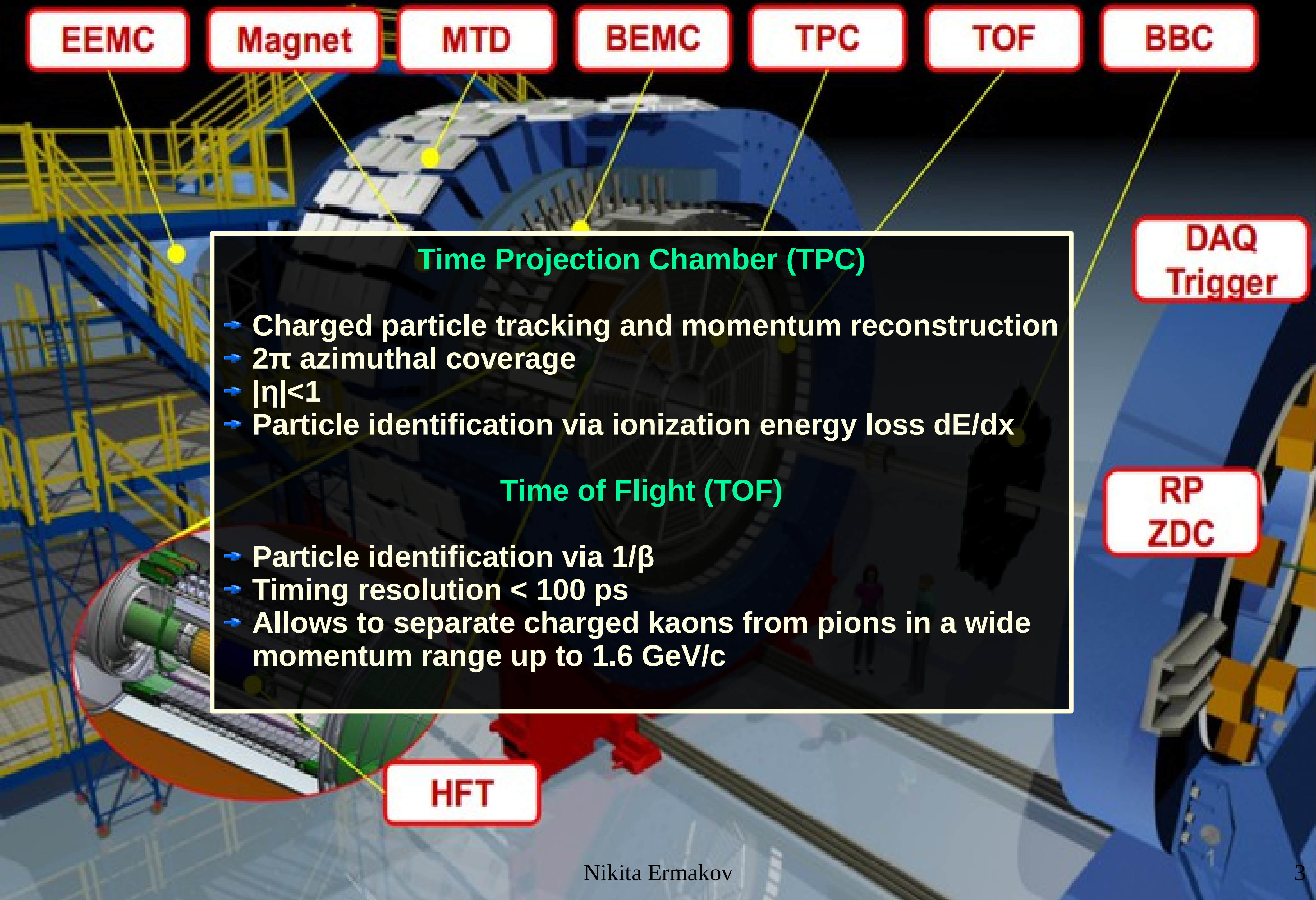
Pair transverse momentum:

$$\vec{k}_T = \frac{\vec{p}_{1T} + \vec{p}_{2T}}{2}$$

Transverse mass of the pair:

$$m_T = \sqrt{k_T^2 + m_{K^{ch}}^2}$$

STAR experiment



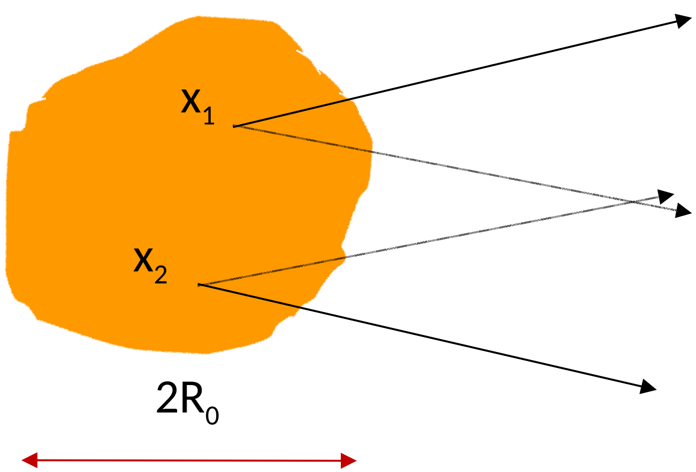
Time Projection Chamber (TPC)

- Charged particle tracking and momentum reconstruction
- 2π azimuthal coverage
- $|\eta|<1$
- Particle identification via ionization energy loss dE/dx

Time of Flight (TOF)

- Particle identification via $1/\beta$
- Timing resolution < 100 ps
- Allows to separate charged kaons from pions in a wide momentum range up to 1.6 GeV/c

Correlation femtoscopy



Experiment correlation function:

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

A — relative 4-momentum distribution of the particles in the same event
B — relative 4-momentum distribution of the particles from different events (not correlated) — event mixing technique

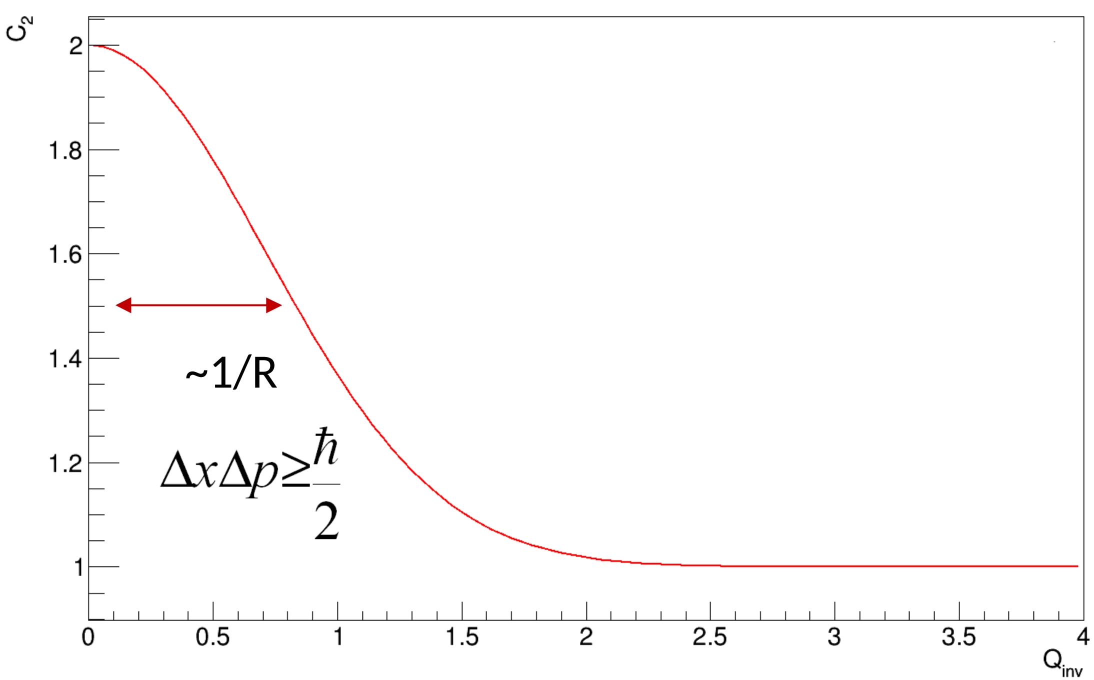
In current analysis 10 events are used for the event mixing.

Assuming a Gaussian-shape emitting source, the one-dimensional correlation functions can be parameterized with the form:

$$C_2(Q_{inv}) = 1 + \lambda e^{-Q_{inv}^2 R_{inv}^2}$$

where relative 4-momentum of the pair:

$$Q_{inv} = \sqrt{(\vec{p_1} - \vec{p_2})^2 - (E_1 - E_2)^2}$$



Dataset sample:

- *Systems (minimum bias triggers)*: p+p 510 GeV and p+p 200 GeV

Event selection:

- $|V_Z| < 30$ cm
- $|VpdV_Z — V_Z| < 5$ cm
- $V_R < 2$ cm

Track selection:

- 0.15 < p (GeV/c) < 1.55
- Nhits > 15 (of 45 possible)
- $|\eta| < 1$
- DCA < 2 cm

Pair selection:

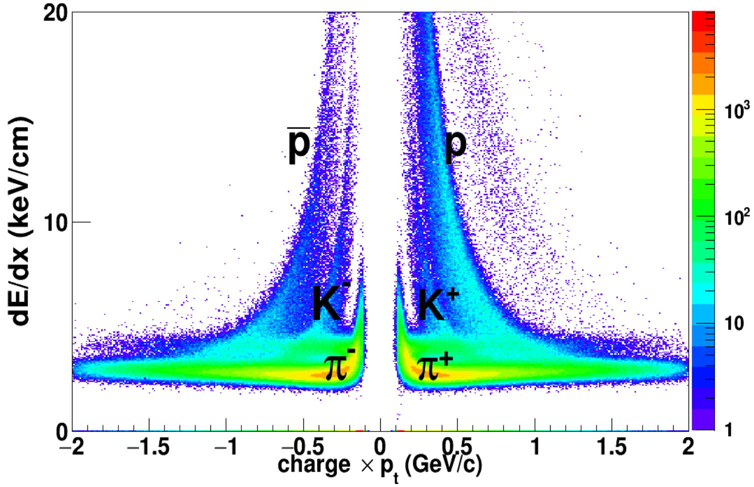
- Fraction of merged hits not more than 10%
- -0.5 < splitting level < 0.6

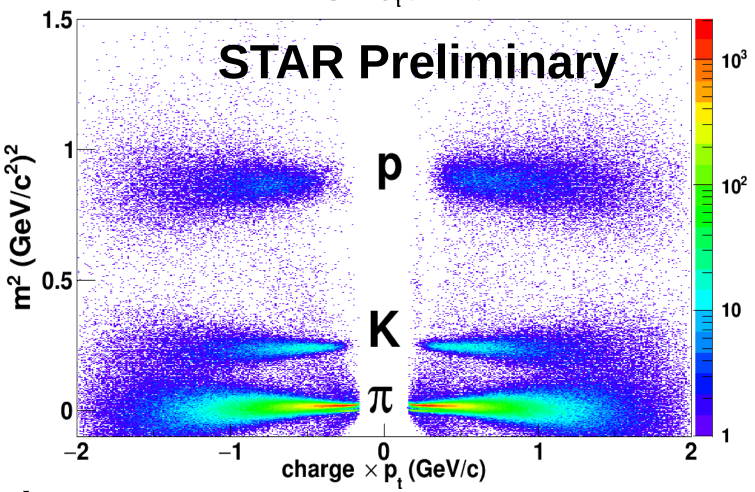
STAR Collaboration PhysRev C71:044906,2005

Particle identification:

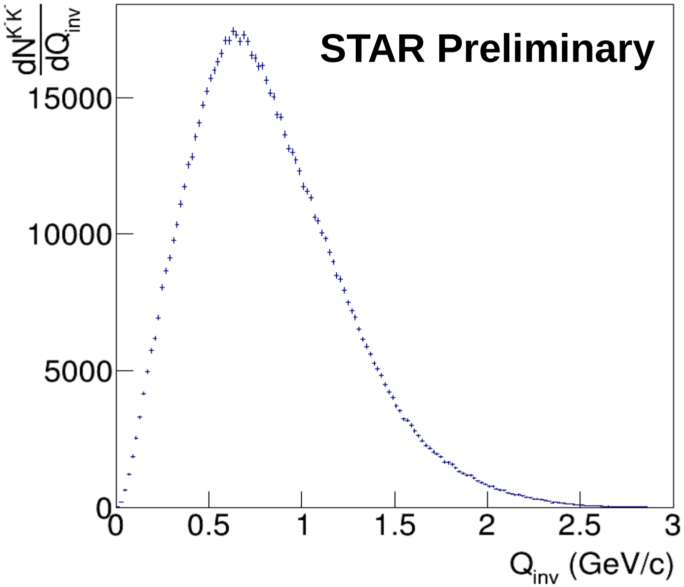
- TPC
  - 0.15 < p (GeV/c) < 0.55
  - $|n\sigma(K)| < 2$
- TOF
  - 0.15 < p (GeV/c) < 1.45
  - $0.2 < m^2 (GeV/c^2)^2 < 0.32$

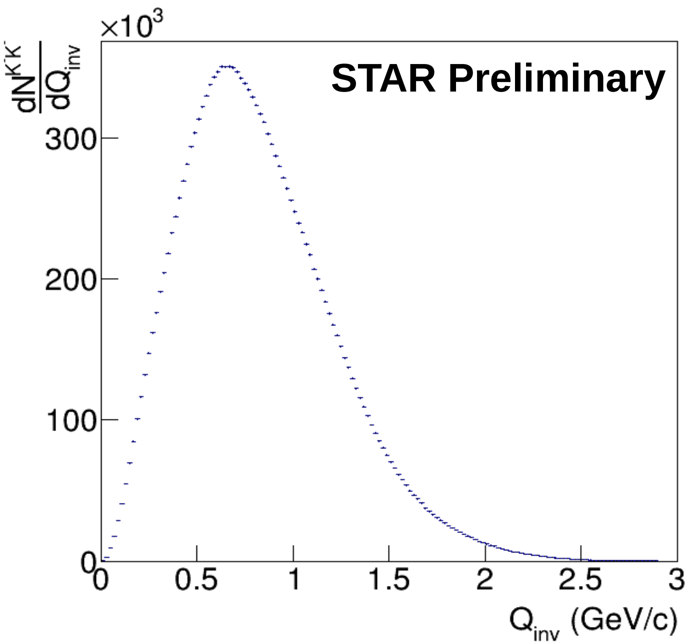
$$m^2 = p^2 c^2 \left(\frac{1}{\beta^2} - 1\right)$$

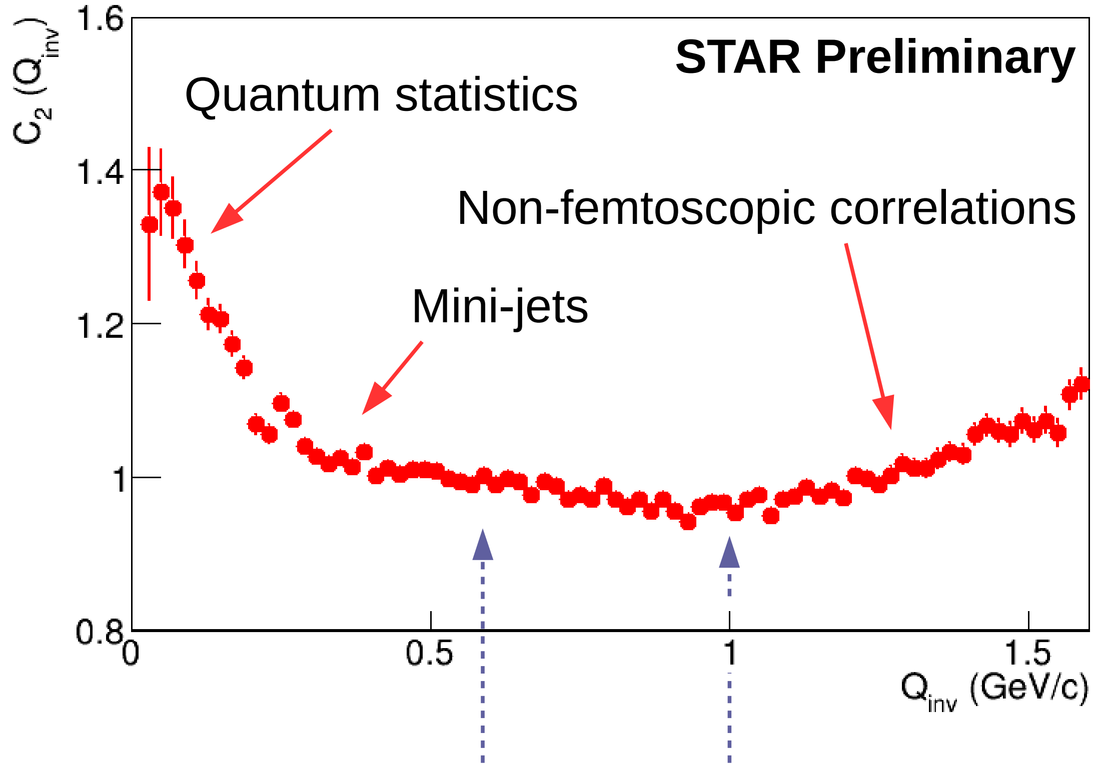




Experimental correlation function of negative kaon pairs for p+p collisions at energy 200 GeV



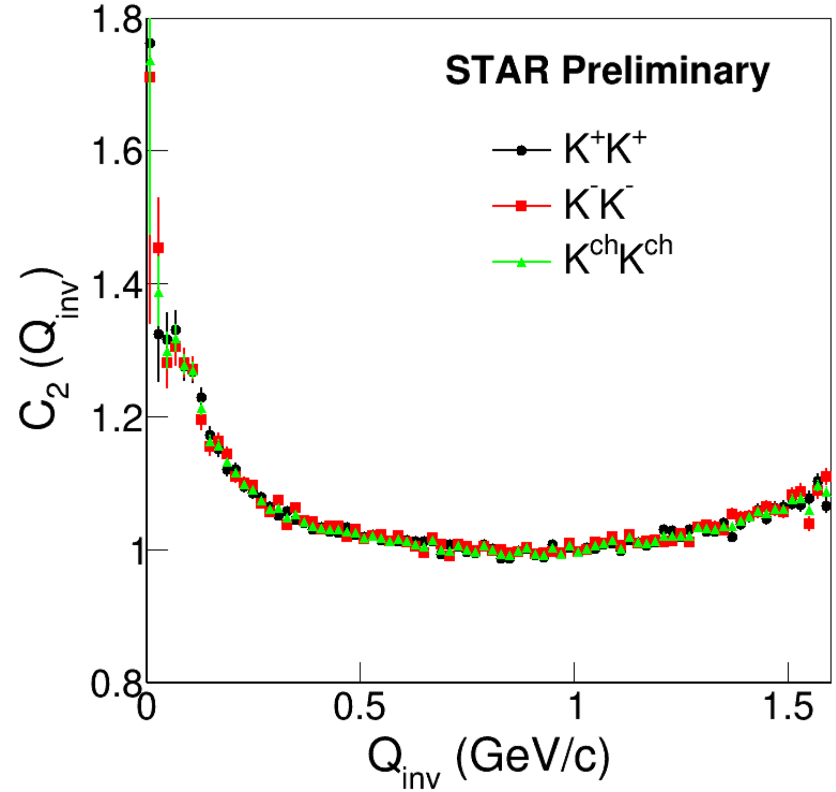




Normalization in range from 0.6 to 1.0 GeV/c due to small non-femtoscopic correlations at low (mini-jets contribution) and large Q_{inv} (energy-momentum conservation induced correlations).

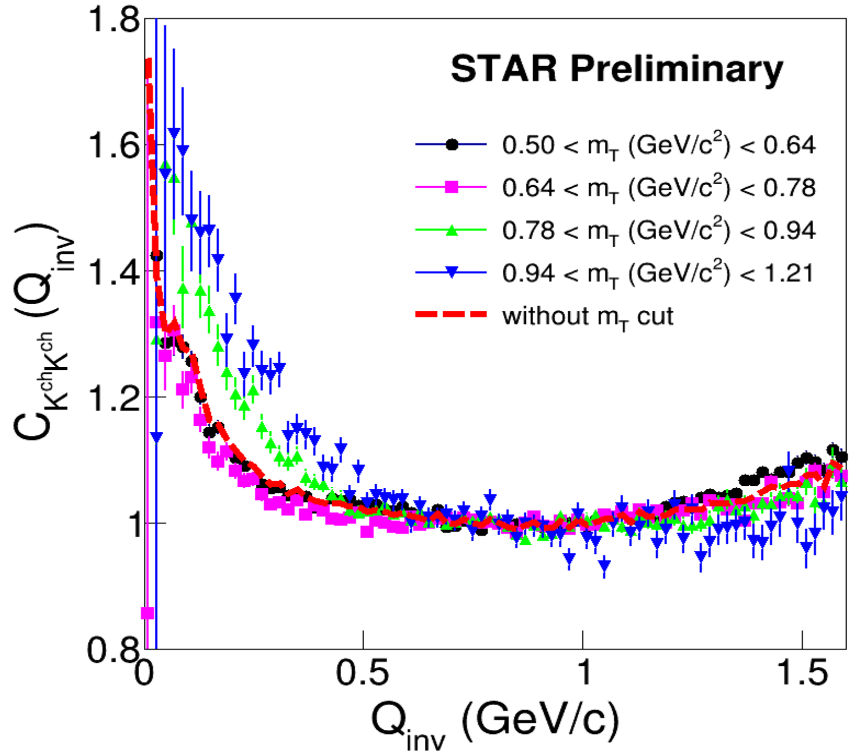
In the future work, different normalization ranges will be checked to estimate the systematic uncertainties.

Like-sign kaon (K^+K^+ and K^-K^-) correlation functions for p+p at 510 GeV



- No charge difference, so positive and negative kaon pairs can be summed:

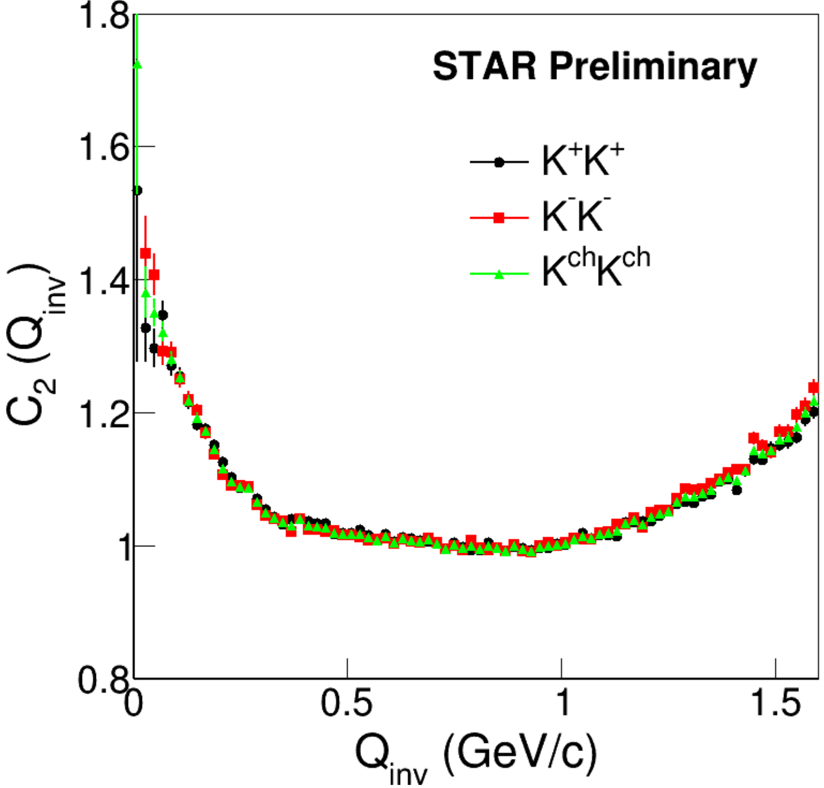
$$C_{K^{ch}K^{ch}}(Q_{inv}) = \frac{\frac{dN^{same\ event}_{K^+K^+}}{dQ_{inv}} + \frac{dN^{same\ event}_{K^-K^-}}{dQ_{inv}}}{\frac{dN^{mixed\ events}_{K^+K^+}}{dQ_{inv}} + \frac{dN^{mixed\ events}_{K^-K^-}}{dQ_{inv}}}$$



- Qualitativly the emission source radius decreases with increasing transverse mass.

For the correlation functions only statistical uncertainties are shown

Like-sign kaon (K^+K^+ and K^-K^-) correlation functions for p+p at 200 GeV



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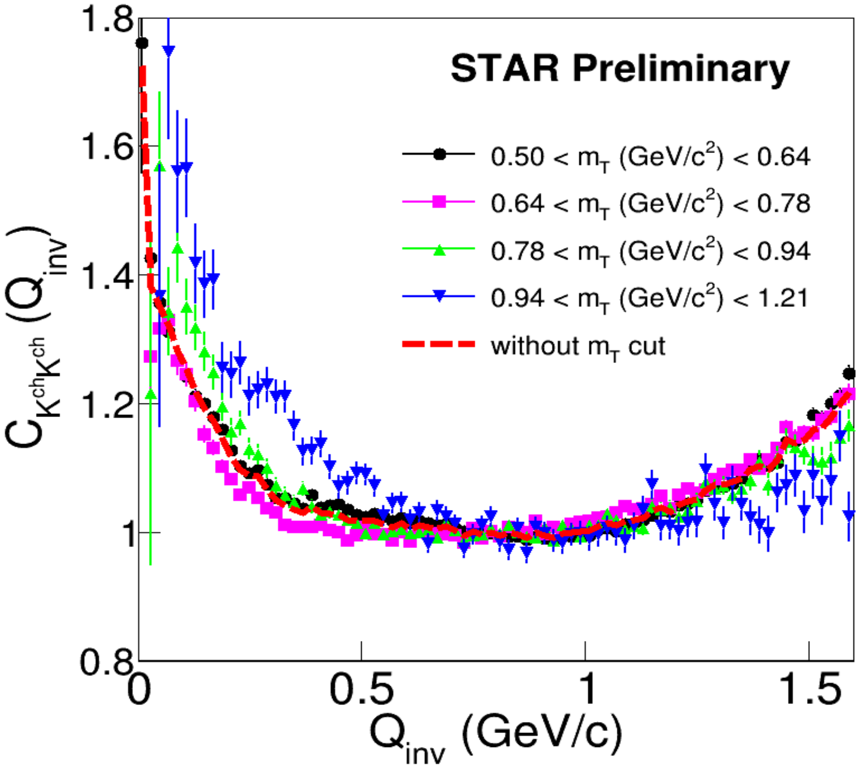

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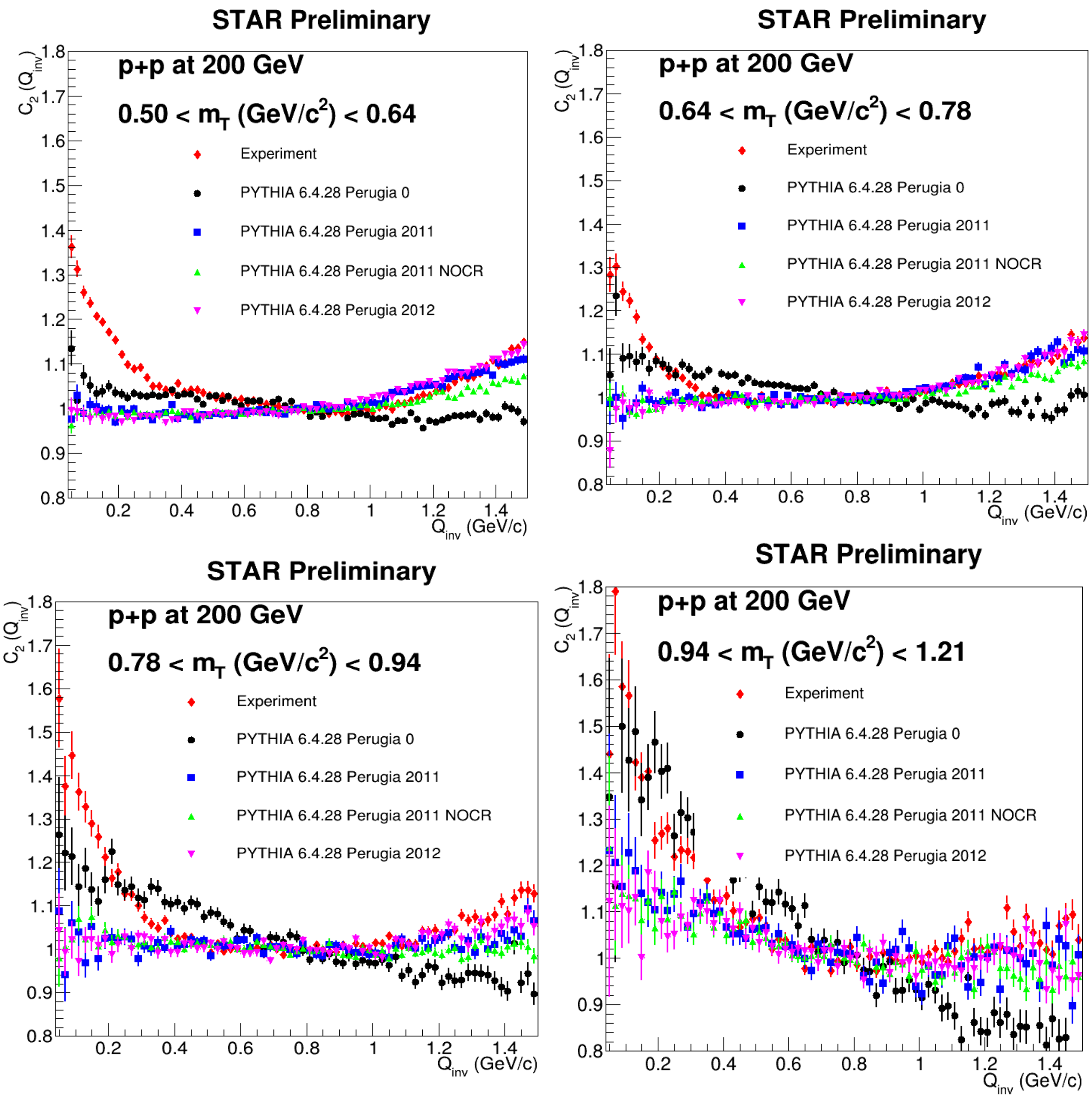
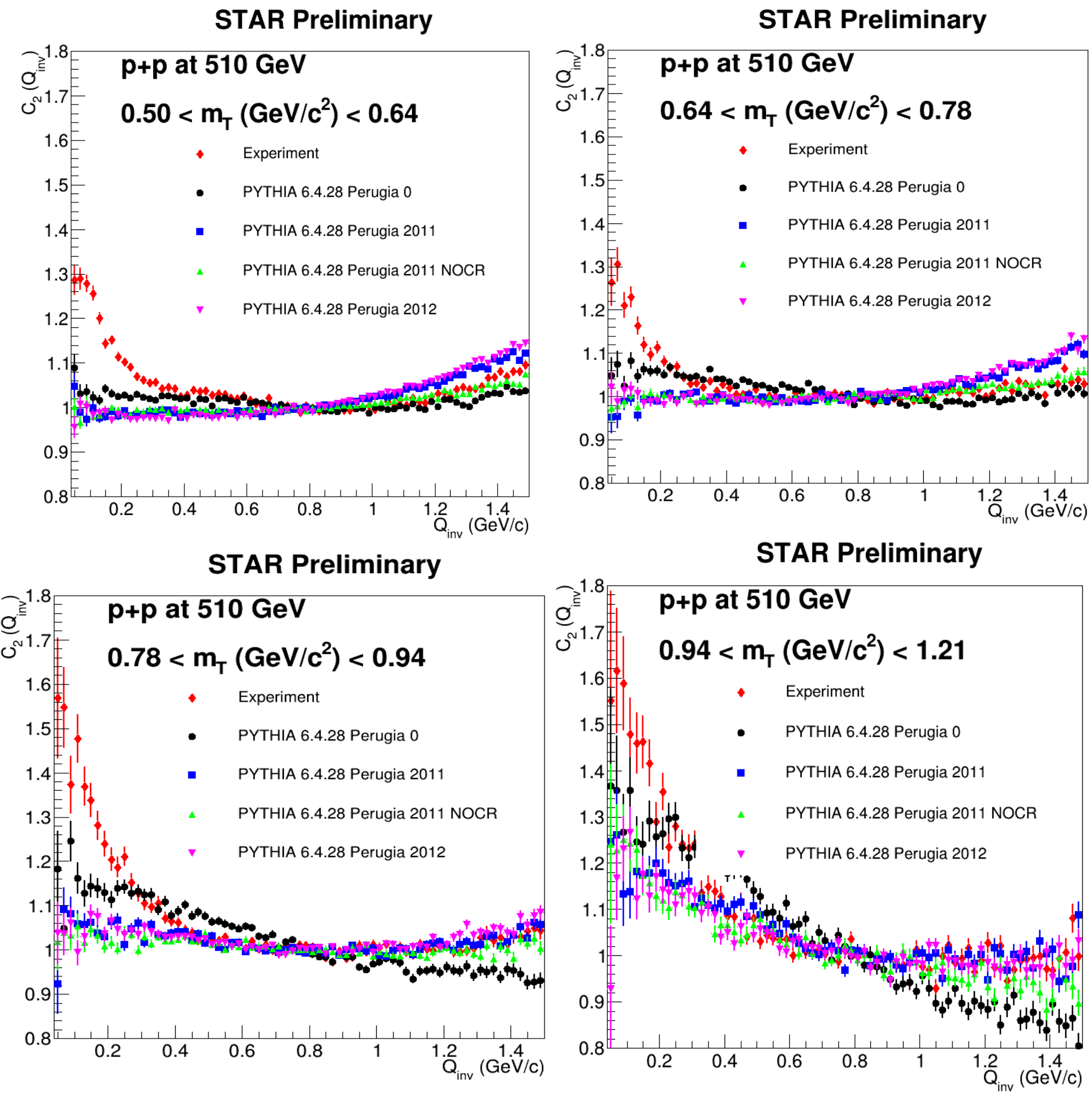
Like-sign kaon (K^+K^+ and K^-K^-) correlation functions for p+p at 200 GeV



- Non-unity behavior of the correlation functions at low Q_{inv} in simulation data may be induced by the mini-jets and resonance decays.
- At large Q_{inv} the correlation functions are strongly affected by the non-femtoscopic correlations.
  Deviation from unity at large Q_{inv} is due to the energy-momentum conservation induced correlations
- Generally the Perugia 2011 without color reconnection and Perugia 2012 tunes for PYTHIA 6.4.28 describes the experimental data at large Q_{inv}. More investigation is needed.

For the correlation functions only statisticaluncertainties are shown

Like-sign kaon (K^+K^+ and K^-K^-) correlation functions for p+p at 510 GeV



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Summary

- In 200 GeV and 510 GeV p+p collision no difference is observed in the correlation function between positive and negative kaon pairs. Thus positive and negative kaon pairs are combined.

- Transverse mass dependece of the two-kaon correlation functions for 200 GeV and 510 GeV p+p collisions is measured. Qualitatively the emission source radius decreases with increasing transverse mass.

- Different Monte Carlo tunes are compared to the experimental data. Generally the Perugia 2011 tune without color reconnection for PYTHIA 6.4.28 describes the experimental data at large Q_{inv}.

Outlook

- Check different methods of the Q_{inv} distrubtion construction without quantum-statistics correlations.

- Take into account non-femtoscopic effects using Monte Carlo and perform estimation of the emission source parameters.

Thanks for your attention!