

Abstract

We report on the results of charged kaon femtoscopy analysis of the 7 TeV pp collisions at the LHC in the ALICE experiment. KK correlation functions are constructed in 3 multiplicity and 4 k_T bins. The KK source parameters are extracted by fitting the correlation functions with a Gaussian, describing the source. The contributions to the systematic errors from the baseline choice have been studied. The weak increase of the KK R_{inv} with multiplicity and some evidence on the decrease with k_T were observed in k_T range (0.2-0.8) GeV/c. For the k_T dependence, the charged kaons are found to be complementary to the neutral ones in their coverage, of a larger range in k_T (0.2-2.0) GeV/c and a decrease in the R_{inv} is observed for increasing k_T as it is also seen in identical two-pion correlations for these collisions [1].

Kaon femtoscopy in pp. Physics motivation.

- Perform the first measurements of the charged kaon source size in pp collisions by Bose-Einstein correlations (femtoscopy). These are the first measurements of KK correlations in pp collisions, only in AA, because of insufficient statistics at lower energies and/or problems with particle identification (PID). Good ALICE PID capabilities and the availability of the large statistics 7 TeV data sets allow one to perform KK femtoscopy analysis in pp.

- Look for collective behavior by studying the source size dependence on the particle transverse momentum and mass. In heavy-ion collisions the strong decrease of the correlation radii with increasing pair transverse momentum (p_T) and transverse-mass (m_T) are usually considered as a manifestation of the collective behavior of matter created in such collisions. Event multiplicities reached in the 7 TeV pp collisions at the LHC are comparable to those registered for peripheral AuAu collisions at RHIC. Do we observe the same physics in pp and AA? Kaon femtoscopy together with the pion one provides an additional test of this assumption.

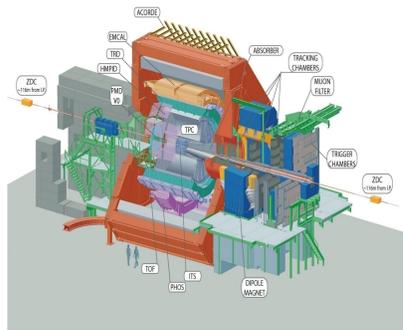
- Using charged KK & $K_s^0 K_s^0$ increases available k_T range

ALICE

ALICE provides excellent tracking capabilities and particle identification.

In the present analysis:

- Time Projection Chamber (TPC) main tracking device PID (energy loss)
- Inner Tracking System (ITS) tracking PID (energy loss)
- TOF (Time of Flight) PID (time-of-flight) especially important for kaons



Charged kaon identification pp @ 7 TeV Combined PID: dE/dx vs p and p vs β (TOF)

pp @ 7 TeV data

Simulations
PYTHIA (PERUGIA-0)

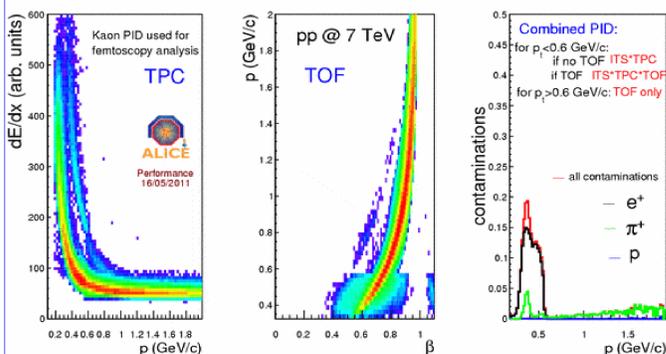


Fig.1: The first two panels represent the charged kaon selection by the combined PID method. The first panel shows TPC energy loss (dE/dx) versus momentum for the selected kaons; the second one shows momentum versus velocity of selected kaons measured by TOF; the third one represents PYTHIA (PERUGIA-0) simulations of the contaminations by different particle species. The most important contamination comes from electrons in the momentum range (0.2-0.4) GeV/c and is about 15%.

The combined PID method [2]:

The Bayesian approach for combined Particle Identification [2] was used. The probabilities to be a particle of i -type ($i = e, \mu, \pi, K, p$) were calculated. At $p_T < 0.6$ GeV/c: if there is no TOF signal the combined probabilities are calculated using ITS and TPC; if there is a TOF signal, a combined probabilities with ITS, TPC and TOF are calculated. At $p_T > 0.6$ GeV/c, if there is a TOF signal, then the combined probabilities are calculated using only TOF; if there is no TOF signal then the track is just skipped. The particles with the maximum probability of being kaons are selected.

Details of Analysis

General analysis conditions:

- 3 bins in uncorrected charged particle multiplicity for $|\eta| < 0$: $M < 20$, $20 < M < 40$, $M < 40$.
- 4 bins in k_T (0.2-0.35) (0.35-0.5) (0.5-0.7) (0.7-1.0) GeV/c.

Event selection:

- Only events with minimum bias trigger were selected.
- Reconstructed vertex must be within 10 cm of the center of the TPC along the beam direction.
- At least one particle must be reconstructed and identified as a kaon.

Single track cuts:

- $|\eta| < 1.0$ & $0.15 < p_T < 2.0$ GeV/c.
- Only well reconstructed tracks are accepted: at least 70 out of maximum 159 points in the TPC.
- Distance of particle trajectory to the primary vertex. in the transverse plane < 0.2 cm and in the beam direction < 0.25 cm.

Double track cuts:

- pairs which share more than 5% of clusters in the TPC were removed - anti-splitting cut;
 - pairs that are separated by less than 3 cm at the entrance of the TPC were removed - anti-merging cut.
- Pair cuts were applied in exactly the same way for same (signal) and mixed (background) pairs.

Fitting strategy & discussion of the possible sources of systematic errors.

Stronger Coulomb FSI & smaller purity make the correlation peak less pronounced than in $\pi\pi$ and $K_s^0 K_s^0$ cases so the relative role of the non-femtoscopic background increases.

- 1) The CFs were corrected for Coulomb interactions: divided by K_{coul} - Coulomb function integrated over a spherical source of size 1 fm (1.2, 0.8 fm were used for the systematic errors estimation \rightarrow effect negligible).
- 2) To take into account the long range correlations due to energy-momentum conservation, the CF were fitted with $P_2 = 1 + a Q_{inv} + b Q_{inv}^2$ in the range where the correlation effect is absent.
- 3) The assumption that P_2 at low Q_{inv} still follows the shape fitted at large Q_{inv} was used and the CFs were divided on P_2 . **Main source of the systematic errors!** Different models e.g. PYTHIA, PHOJET, QGSM, EPOS predict different behaviors for the baseline at small Q_{inv} . However the present tunes of e.g. PYTHIA do not describe well the kaon spectra, so the hypothesis of a flat extrapolation of P_2 was used.
- 4) The fit was performed with $CF = N(1 + \lambda \exp(-R^2 Q_{inv}^2))$. Different Q_{inv} ranges (a,b) were used: $a = 0, 0.03, 0.06$ GeV/c - to study the influence of the splitting effects on radii ($< 10\%$ difference) and $b = 1.0, 1.5$ GeV/c (no difference was observed).

Charged kaon correlation functions

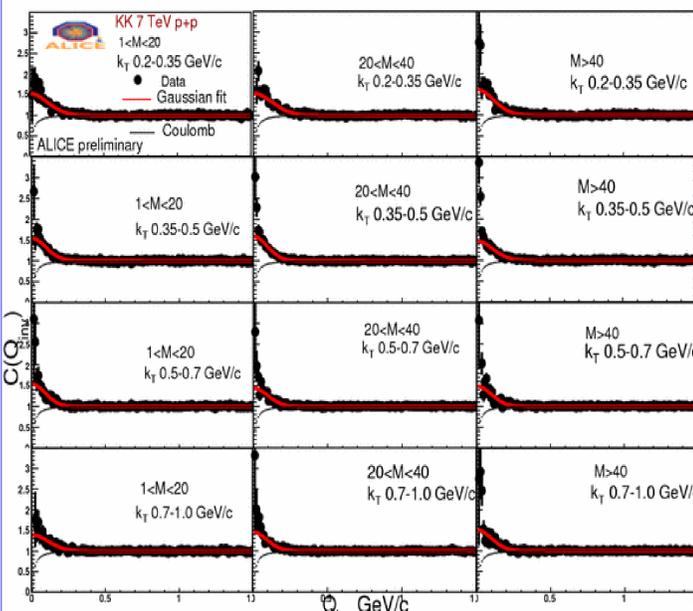


Fig. 2: The correlation functions of charged kaons with Coulomb correction, normalized on $P_2 = 1 + a Q_{inv} + b Q_{inv}^2$ polynomial baseline. Fit is performed with simple Gaussian $CF = N(1 + \lambda \exp(-R^2 Q_{inv}^2))$ in the range $Q_{inv} = (0-1.5)$ GeV/c.

k_T -dependence of charged kaon correlation radii in small multiplicity bin ($M < 20$)

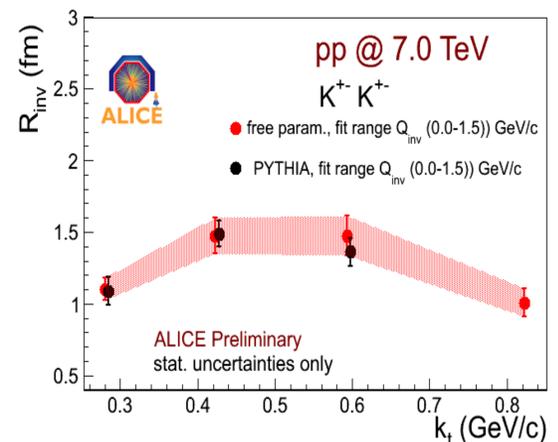


Fig. 3: The transverse momentum dependence of the charge kaon correlation radii calculated with a free-polynomial baseline assumption (red points) and a PYTHIA one (black points).

k_T -dependence of R_{inv} of KK versus $K_s^0 K_s^0$

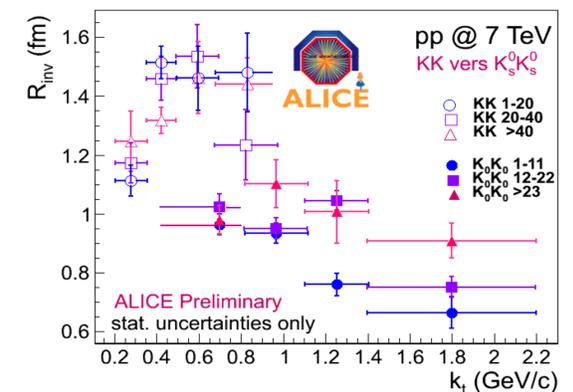


Fig. 4: The transverse momentum dependence of the charge kaons (open symbols) and the neutral kaons (solid symbols) [3] correlation radii for three multiplicity bins.

Conclusions

- Measured charged kaon radii are larger than pion [2] and K_s^0 [3] ones;
- A weak increase of the KK R_{inv} with multiplicity is observed;
- Some evidence of a decrease with k_T is observed in the k_T range (0.2-0.8) GeV/c;
- Charged kaons are found to be complementary to the neutral ones with a larger range in k_T (0.2-2.0) GeV/c and a decrease in the R_{inv} is observed for increasing k_T
- In the kinematic range $k_T < 0.7$ GeV/c & $M < 20$ PYTHIA describes reasonably the kaon spectra and so it can be used for the baseline calculation. In this range the values of R_{inv} obtained using the polynomial extrapolation of the baseline to small Q_{inv} and PYTHIA baseline fit are close.
- Detailed systematic error studies are foreseen.

[1] K. Aamodt et al. (ALICE Collaboration); "Two-pion Bose-Einstein correlations in pp collisions at $\sqrt{s}=900$ GeV"; Phys. Rev. D82 (2010) 052001; arXiv: 1007.0516 [hep-th]; K. Aamodt et al. (ALICE Collaboration); "Femtoscopy of pp collisions at $\sqrt{s}=0.9$ and 7 TeV at the LHC with two-pion Bose-Einstein correlations"; arXiv: 1101.3665 [hep-ex]

[2] ALICE Collaboration (M Cinausero et al.) J. Phys. G30:1517,2004

[3] talk of T. Humanic in QM2011