Feasibility study of pions and kaons femtoscopy correlations for 9.0 GeV Bi-Bi with UrQMD

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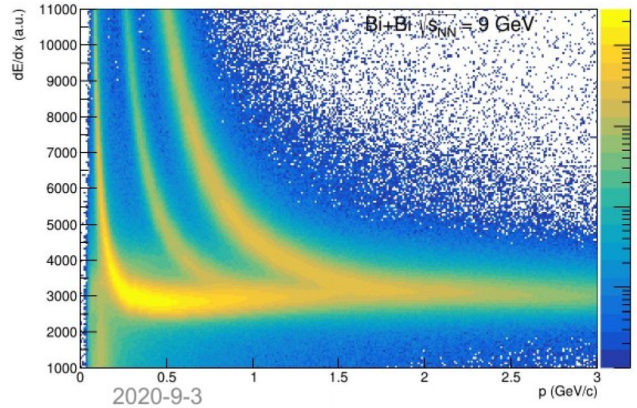
19.11.2020

Details of analysis (pions & kaons)

- Dataset (reconstructed in MPD tracks) production: /eos/nica/mpd/sim/data/MiniDst/dst-BiBi-09GeV-mp07-20-pwg3-250ev/BiBi/09.0GeV-0-14fm/UrQMD/'
- - 10 mln
  UrQMD Minimal Bias events
  BiBi 9 GeV
  - Mini Dst format



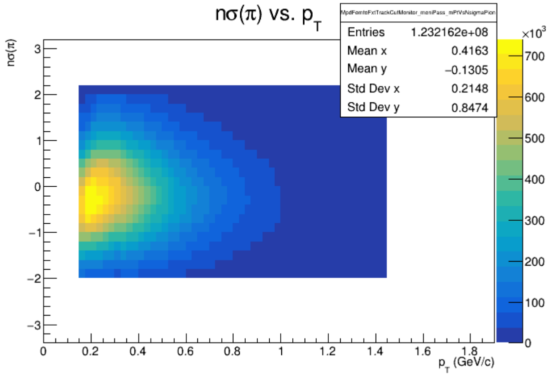
Dedx histo Range ????

- Kinematic conditions for pions
  pT (0.15-1.45) GeV/c
  |eta|<1.0

- - Nhits TPC > 15
  - DCA < 3 cm
  - |VertexZ| < 75
  - PID :
  - Nsigma for pion and kaons in TPC & TOF = 2
  - for pions: m2 (-0.05, 0.08)
  - for kaons: m2 (0.1, 0.4)

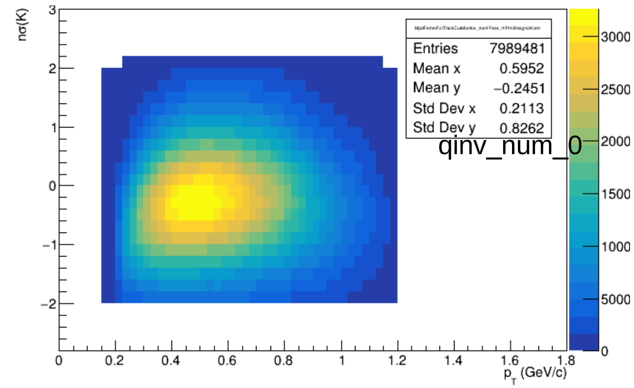
- Average Separtion > 5cm

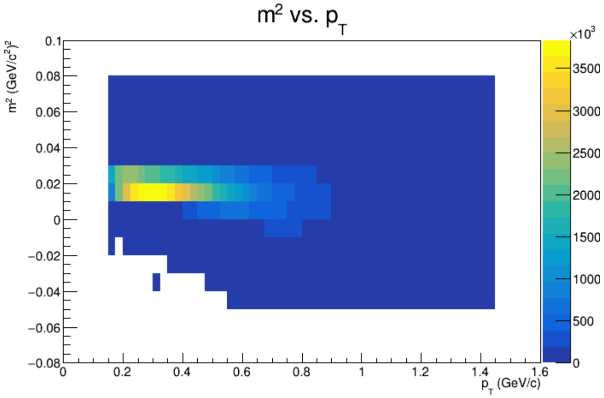
Pions: $1.2 \cdot 10^8$

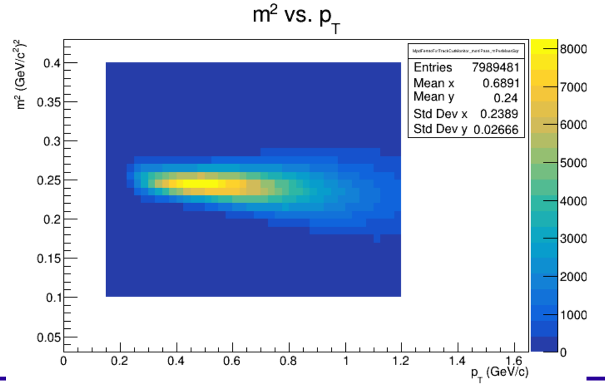


Kaons: $0.08 \cdot 10^8$

All primary ?





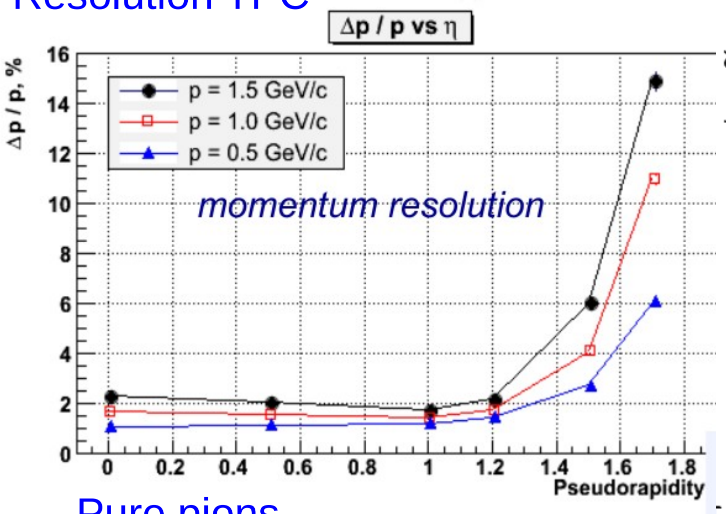


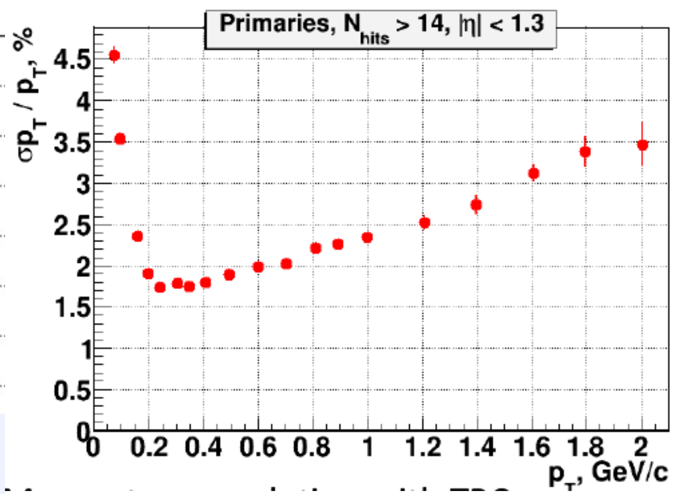
Test of class for resolution: pion QS+Coulomb

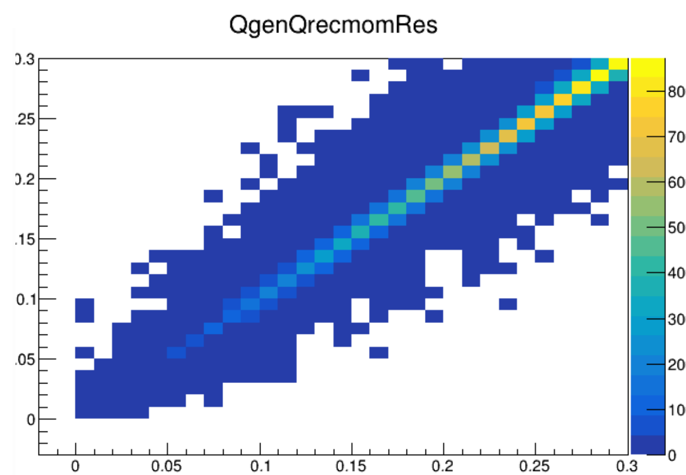
Calculations with class MpdFemtoModelCorrFctnMomResolution
Rosl = 5 fm; QS+Coulomb,   PURE pions by pdg
pairCut→ pairCut->setKt(0.15, 0.35);

ALL registered as pions by pdg

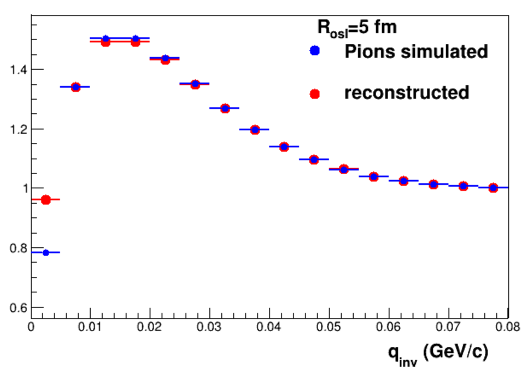
Resolution TPC

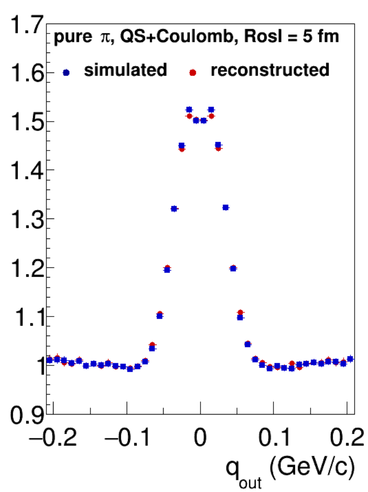


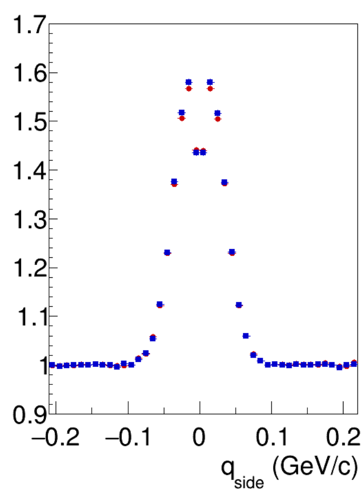


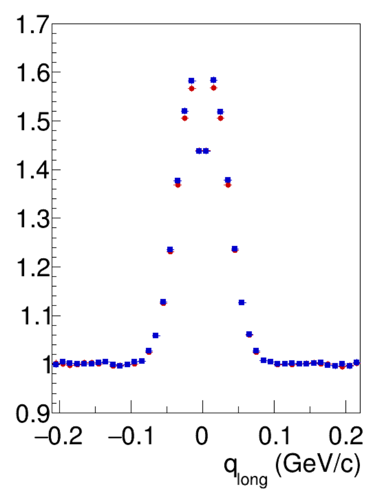


Pure pions









kT: (0.15-0.25) GeV/c; QS <~2%

Ideal CF: Ro = 4.96 +/- 0.01 Rs = 4.97 +/- 0.01 Rl = 4.97 +/- 0.01 lambda = 0.99 +/- 0.003

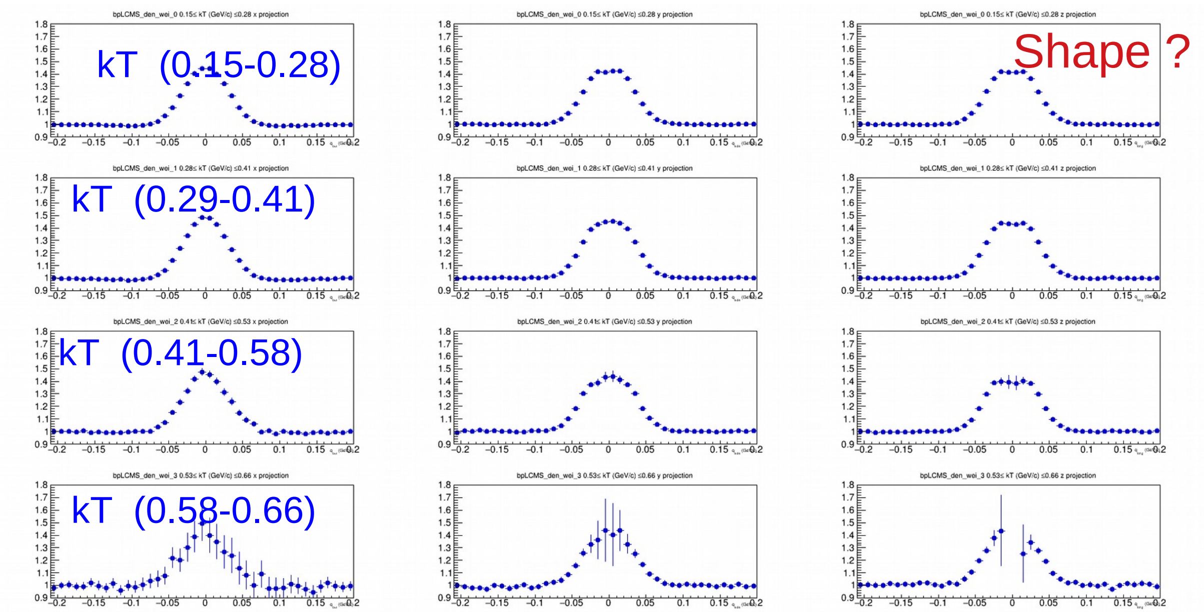
Reconstructed: : Ro = 4.86 +/- 0.01   Rs = 4.94 +/- 0.01 Rl = 4.94 +/- 0.01   lambda = 0.96 +/- 0.003

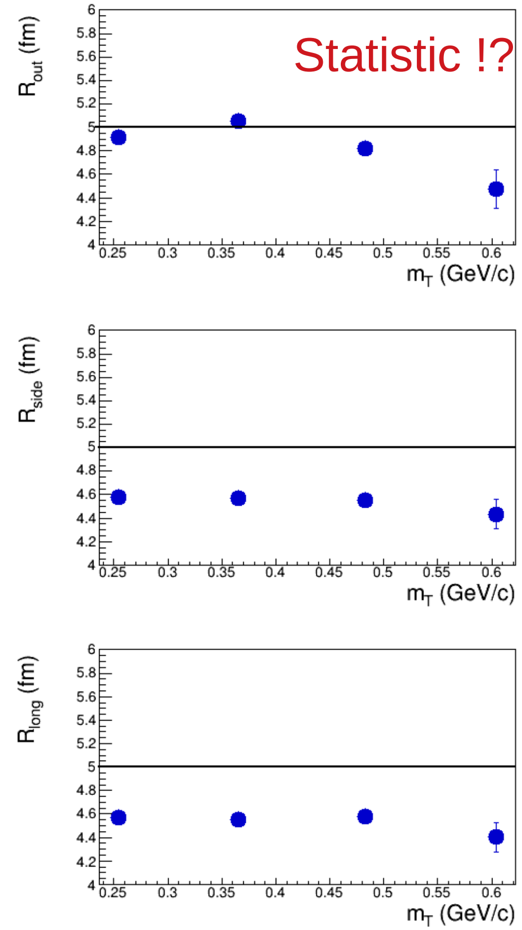
3D CF for pions : resolution / non-purity

MpdFemtoModelBPLCMS3DCorrFctnKt class:

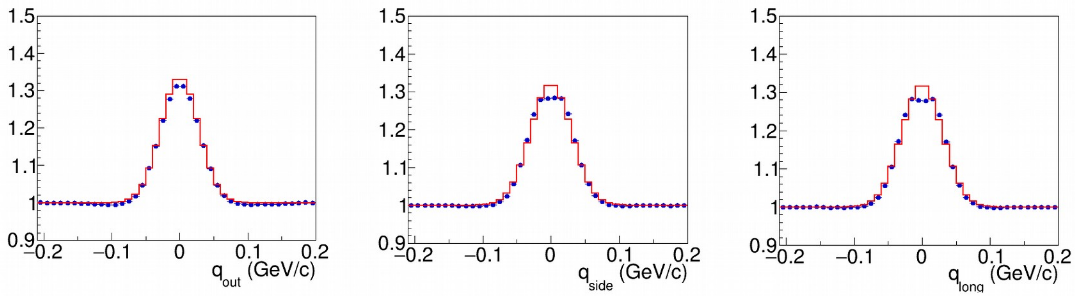
Test Rosl = 5 fm ; 10 mln MB events

kT (0.15-0.65) GeV/c & 4 kT bins – CF = (Dmixed, weight=QS)/ Dmixed





Example of fit: kT (0.15-0.35) GeV/c;



It looks like we shell use Loglikelihood method not chi2

kT (0.15-0.65) GeV/c , 2 kT bins

-kT (0.15-0.40) Ro = 4.83 +/- 0.01 Rs = 4.94+/- 0.007 Rl = 4.93 +/- 0.008 lambda = 0.79+/- 0.001

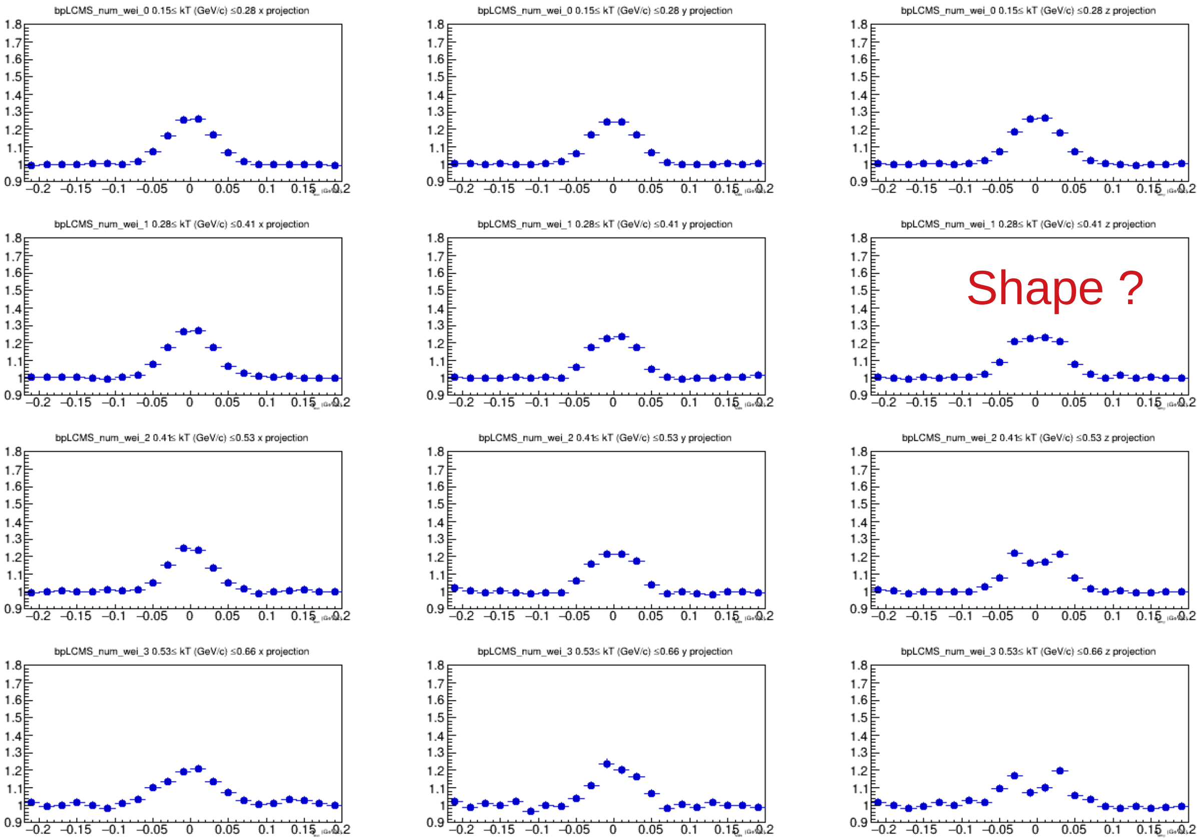
KT (0.4-0.65) Ro = 4.68 +/- 0.04 Rs = 4.87 +/- 0.03 Rl = 4.87 +/- 0.03 lambda = 0.80 +/- 0.01

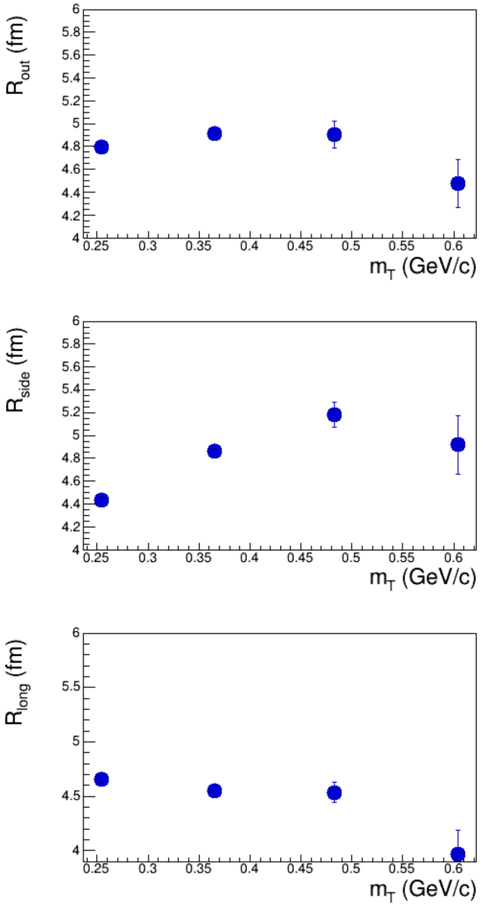
3D CF for pions : resolution / non-purity / TTC

MpdFemtoModelBPLCMS3DCorrFctnKt class:

Test Rosl = 5 fm ; 10 mln MB events

kT (0.15-0.65) GeV/c & 4 kT bins – CF = (Nsame, weight=QS)/ Dmixed





Statistic !!!

-kT (0.15-0.40) Ro = 4.64 +/- 0.02 Rs = 4.81+/- 0.02 Rl = 4.87 +/- 0.02 lambda = 0.77+/- 0.03

KT (0.40-0.65) Ro = 4.59 +/- 0.1 Rs = 5.24 +/- 0.09 Rl = 4.60 +/- 0.07 lambda = 0.77 +/- 0.03

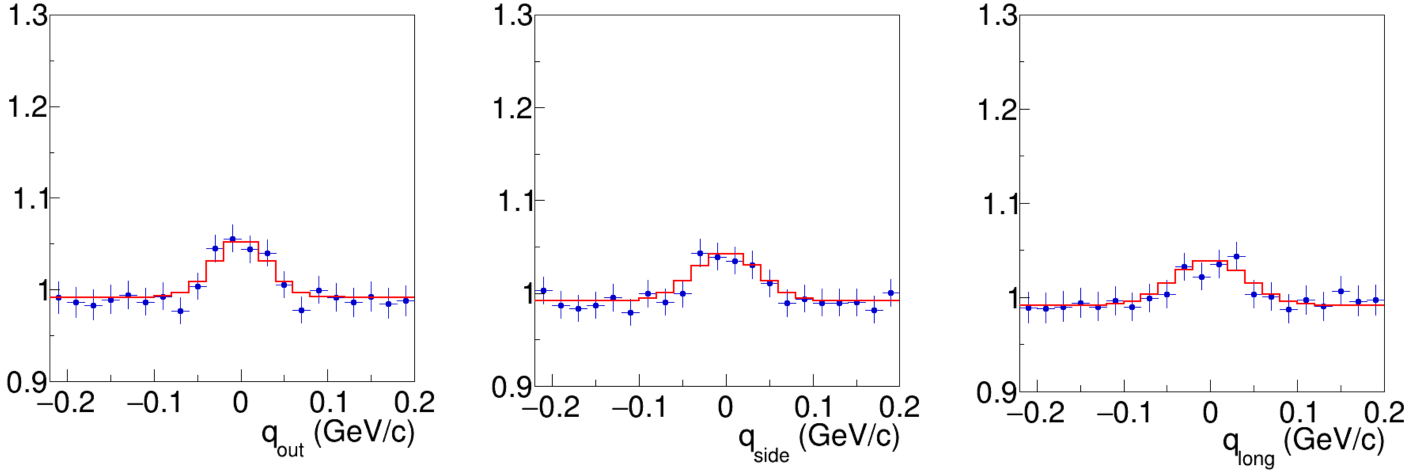
3D CF for kaons with QS weights : resolution / TTC

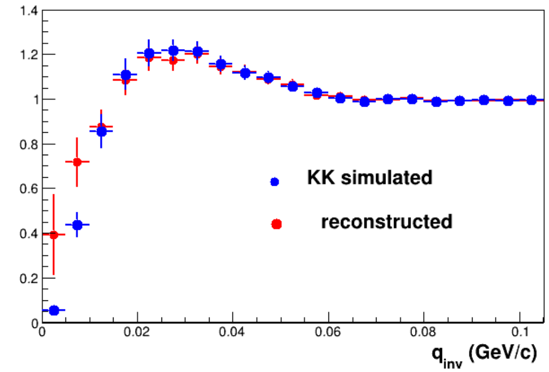
MpdFemtoModelBPLCMS3DCorrFctnKt class:
Test Rosl = 5 fm ; 10 mln MB events
kT (0.15-1.2) GeV/c & 1 kT bin

All
primary ?

CF = (Dmixed, weight=QS)/ Dmixed

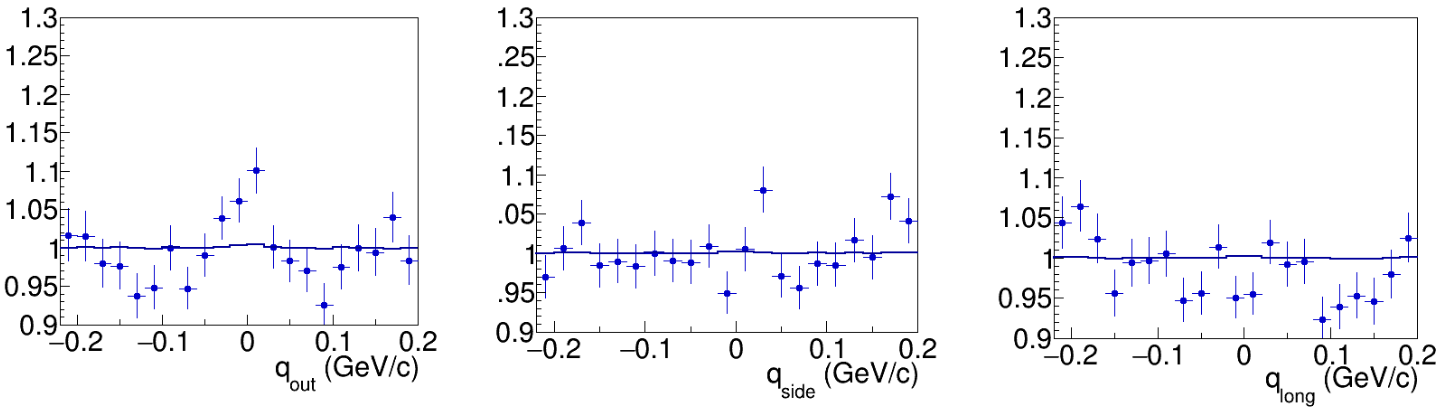
Resolution for kaons:





Ro = 4.22 +/- 0.26   Rs = 4.84 +/- 0.29 Rl = 4.86 +/- 0.29   lambda = 0.83 +/- 0.06

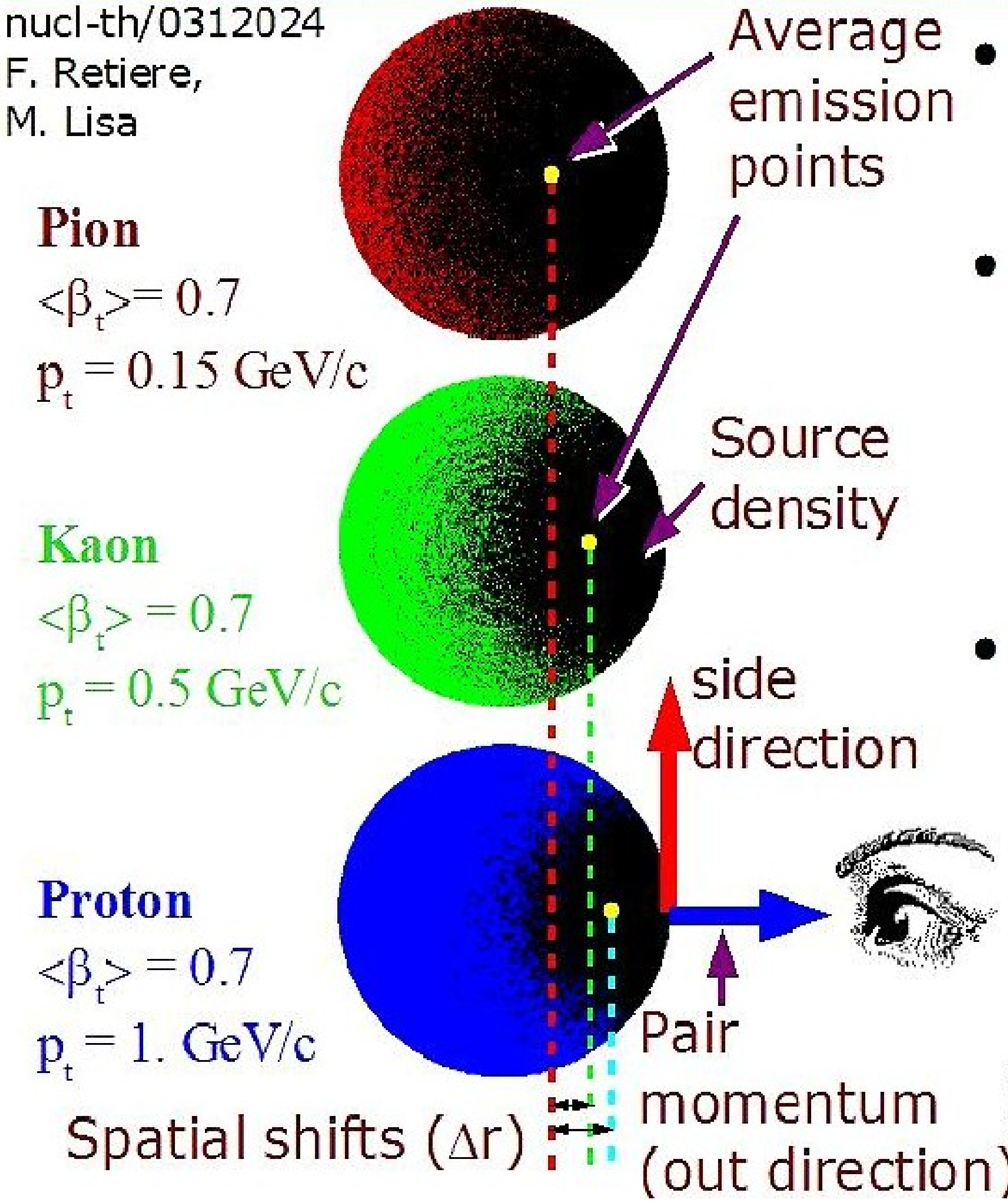
CF = (Nsame, weight=QS)/ Dmixed



Statistic !!!

Some remarks about asymmetries

Flow in the transverse plane



- Flow produces emission asymmetries in space Δr
- Observed asymmetry r* can come from emission time difference Δt too

$$\langle r^* \rangle = \gamma(\langle \Delta r \rangle - \beta_T \langle \Delta t \rangle)$$

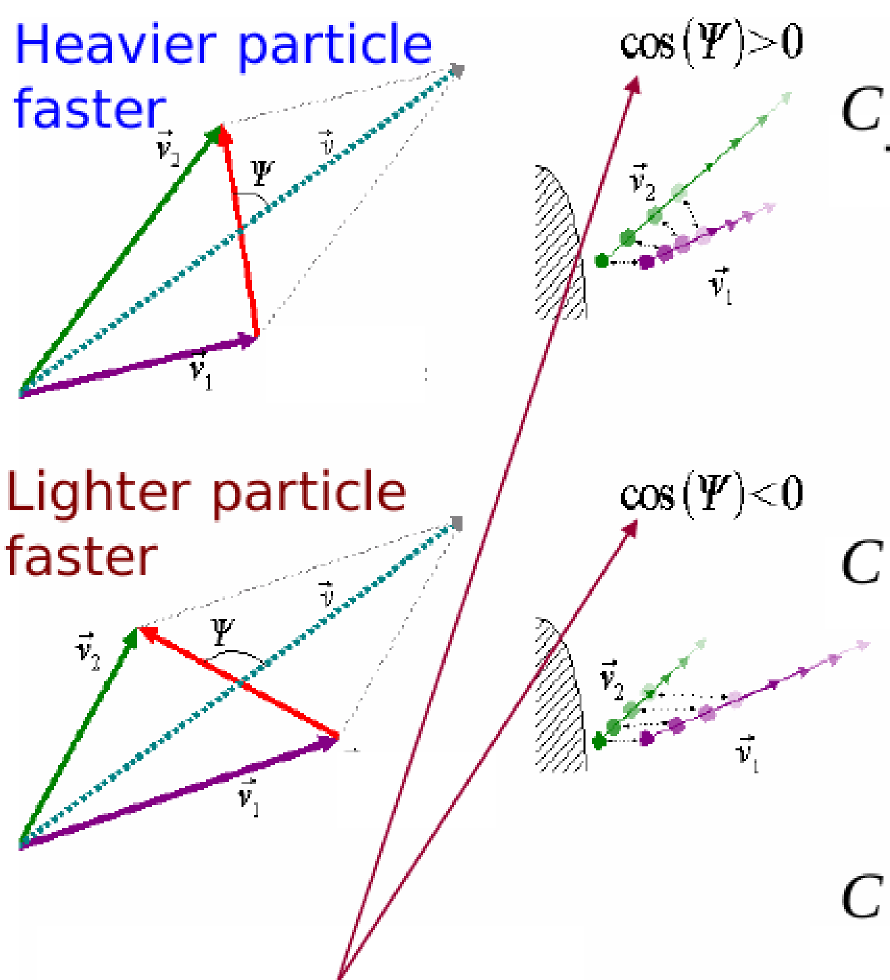
- We expect asymmetry in "out" direction, but not in "side", due to symmetry

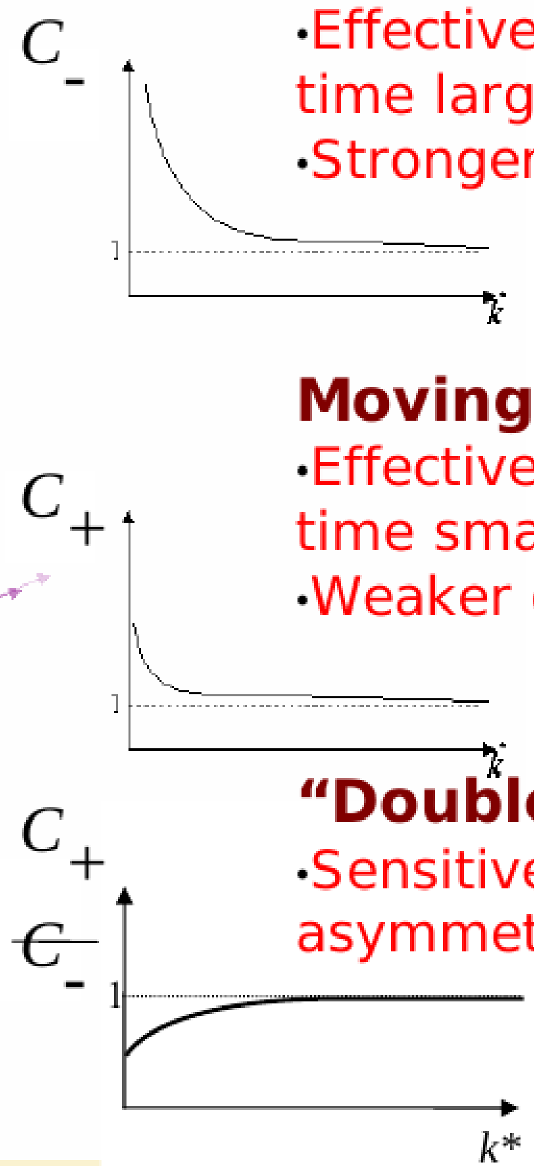
S.Voloshin, R.Lednicky, S. Panitkin, N.Xu, Phys.Rev.Lett.**79**(1997)30

R. Lednicky, nucl-th/0305027

Adam Kisiel,
Fabrice Retiere

Nonidentical particle correlations – the asymmetry analysis





Kinematics selection along some direction
e.g. k_{Out}, k_{Side}, cos(v,k)

Catching up
- Effective interaction time larger
- Stronger correlation

Moving away
- Effective Interaction time smaller
- Weaker correlation

“Double” ratio
- Sensitive to the space-time asymmetry in the emission process

R.Lednicky, V. L.Lyuboshitz, B.Erazmus, D.Nouais, Phys.Lett. B373 (1996) 30.

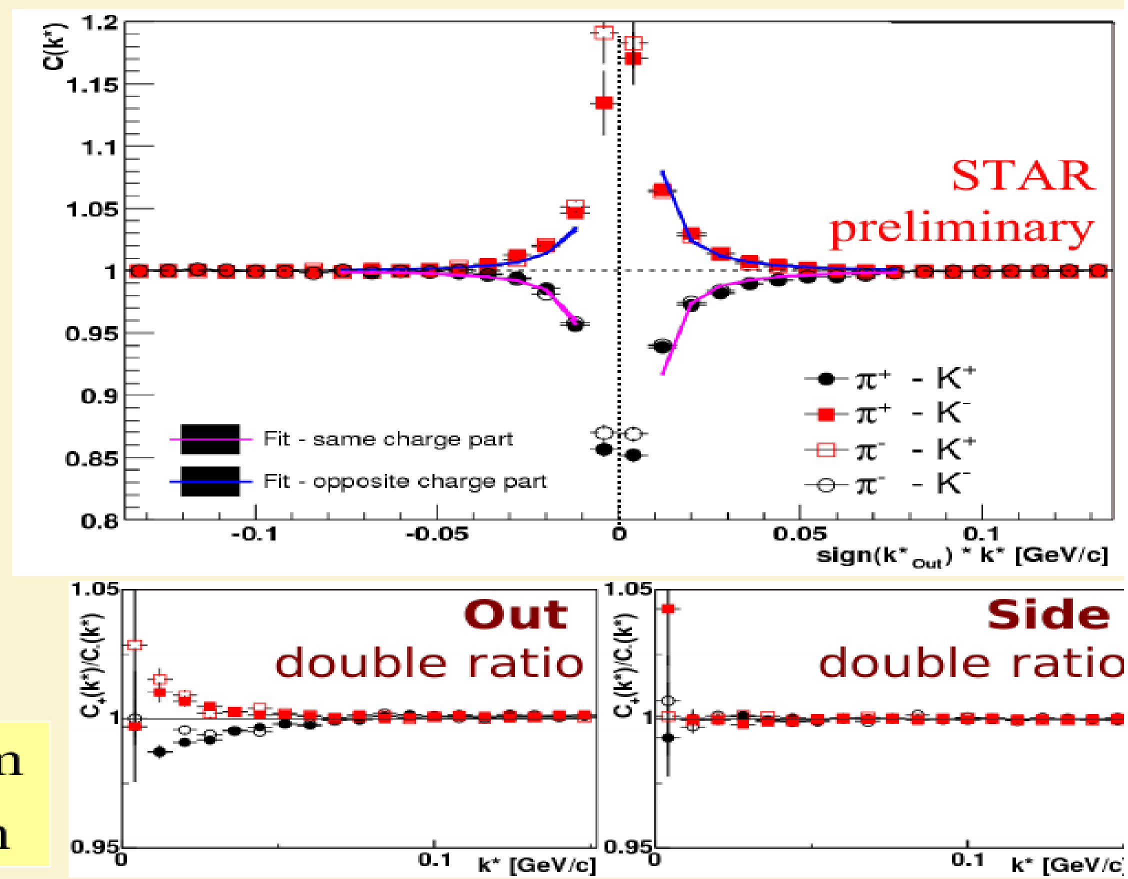
Femtoscopy with non-identical particles: average space-time differences

In experiment the information about space-time asymmetries **$\langle\Delta x^*\rangle = \gamma_t(\Delta x - v_t\Delta t)$** was extracted using method **:$CF_{+x}/CF_{-x} \rightarrow 1+2\langle\Delta x^*\rangle/a$** suggested in

Lednicky, Lyuboshitz et al. PLB 373 (1996) 30

Pion-Kaon at 200 AGeV

- **Clear emission asymmetry signal**



Sigma: **17.3 ± 0.8** $^{+0.9\text{ syst.}}_{-1.6\text{ syst.}}$ fm

Mean: **-7.0 ± 1.2** $^{+6.1\text{ syst.}}_{-4.0\text{ syst.}}$ fm

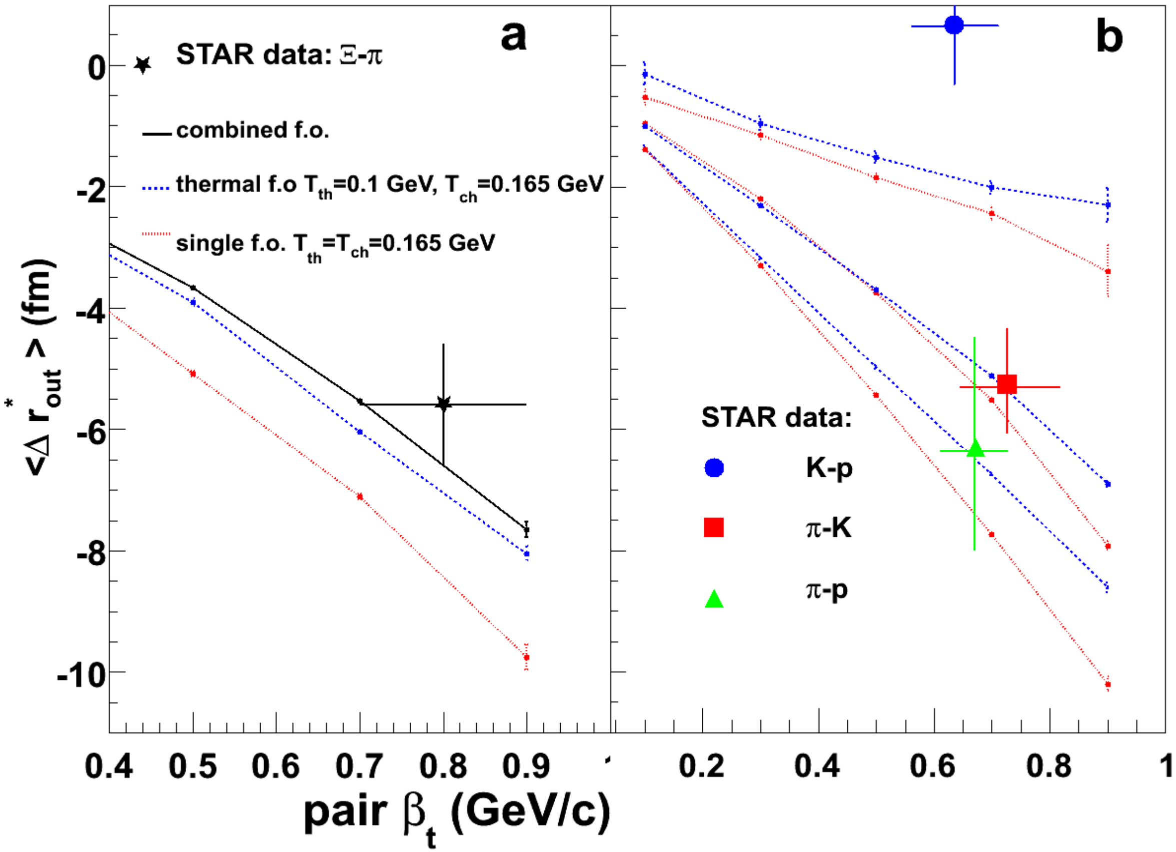
Space-Time shifts in PRF: πΞ, πK, πp, Kp

As particle mass (or p_T) grows, average emission point moves more “outwards” - origin of the effect the same as m_T scaling:

due to collective transverse flow & higher thermal velocity of lighter particles

Consistent with hydrodynamic model predictions, strong evidence against competing explanations

HYDJET++ model calculations



STAR, J.Phys. G30 (2004) S1059-S1064

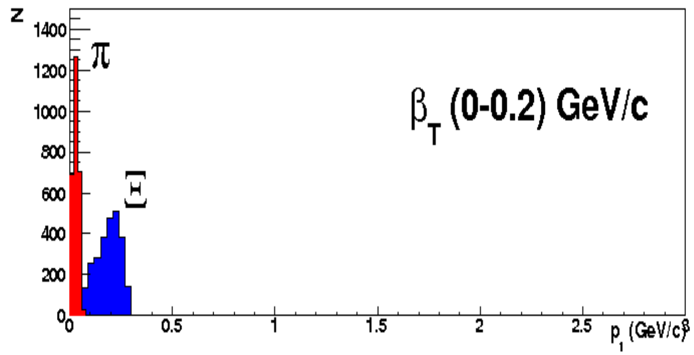
Good review of non-ident particle femtoscopy: A. Kisiel, Phys.Rev. C81 (2010) 064906

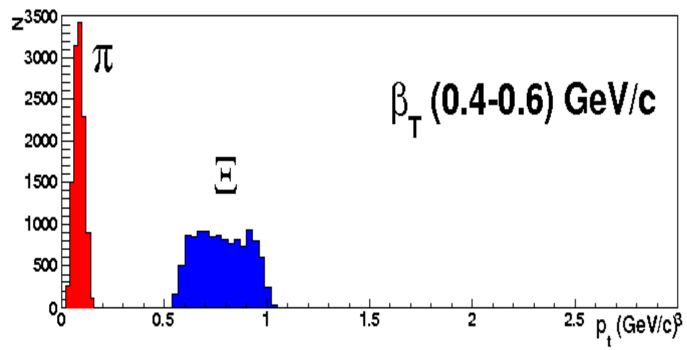
Femtoscopy with non-identical particles: average space-time differences

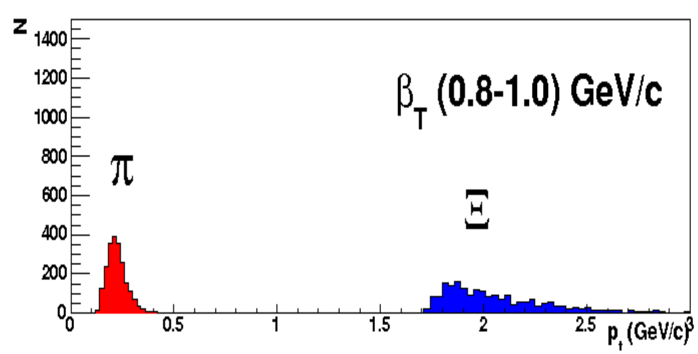
HYDJET++ model calculations

Spectacular example: π Ξ

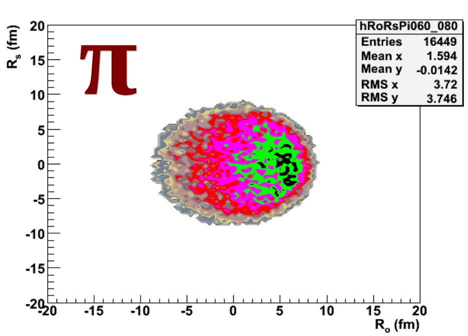
Particles interact if they are close in the phase space in the PRF --> relative momentum in pair rest frame is small. It means that in laboratory rest frame they have close velocities. But for the particles with such a different masses the corresponding momenta will be very different: to large Ξ momentum corresponds the small π momentum

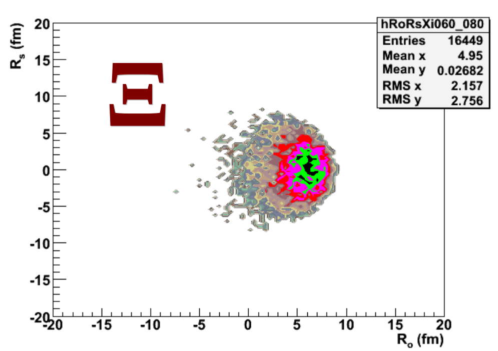






Random smearing is maximal for particle with low mass and momentum--> the system region emitting particles with given momentum shrinks and moves to edge of the system as mass/momentum increases





Some interesting articles related with average space-time differences

SEARCH FOR PRODUCTION OF
STRANGELETS IN QUARK MATTER USING
PARTICLE CORRELATIONS, arXiv:hep-ph/9706256 1997
S. Soff, D. Ardouin, C. Spieles, S. A. Bass, H. St¨ocker, ...R.Lednisky, V.Lyuboshitz

Unlike Particle Correlations and the Strange Quark Matter
Distillation Process, arXiv:nucl-th/0203030v1 2002
D. Ardouin, Sven Soff, C. Spieles, S. A. Bass, H. St¨ocker, ...R.Lednisky, V.Lyuboshitz

The possibility to create strangelets or droplets of metastable cold strange quark matter. A mechanism of separation of
strangeness from anti-strangeness (distillation process) has been proposed
during hadronization of a system at finite baryon densities. This scenario, which assumes a first order phase transition, predicts a relative time delay between the production of strange and
anti-strange particles.
K^+K^- pairs