Nonfemtoscopic correlations study with EPOS model.

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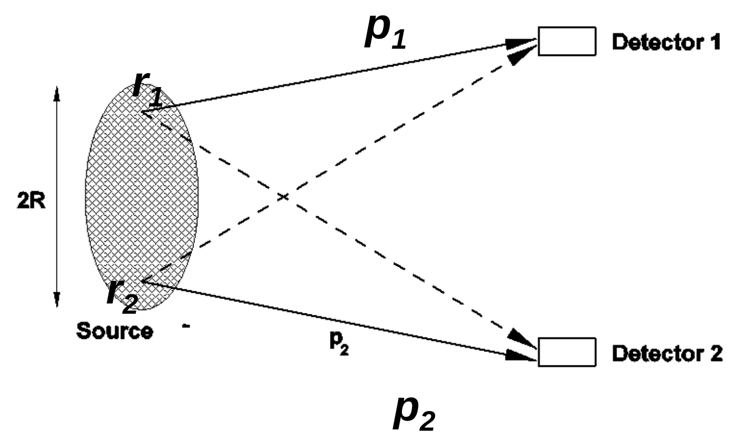
Motivation.

1. Correlations at small relative velosities due to identical particle interferometry, strong and Coulomb FSI effects are sensitive to space-time characteristics of the process under investigation and well known as femtoscopy. The width of these effects relatively small but not negligible, especially for small source size and correlations between baryons and antibaryons. On the other hand, nonfemtoscopic background for such a study visible experimentally, even for high energy experiments, especially for pp collisions. It means, that nonfemtoscopic correlations could be the source of remarkable systematic errors for femtoscopy measurements.
2. The process of high energy heavy ion interactions is very complicated one due to evolution of the created system from one state of matter to another. All visible effects in high energy heavy ion interactions should be used as a source of information about the nature of the process. Up to now nonfemtoscopic correlations does not provide any information because the nature of this effects was not clear.
3. We used EPOS model for the study of nonfemtoscopic correlations because of this model includes all stages of interactions and describe experimental data rather well.

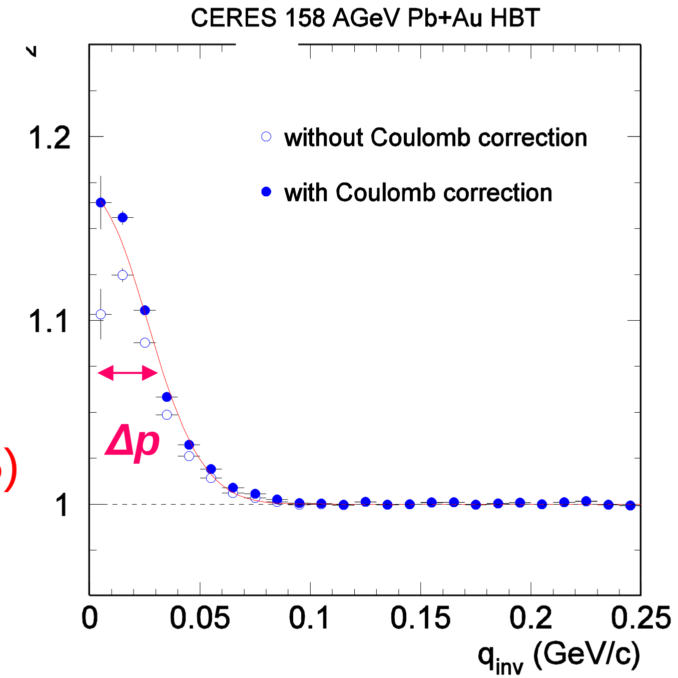
Femtoscopy correlations

Bose-Einstein statistics of identical bosons leads to short-range correlations in momentum space

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



First application with photons: size of stars (R. Hanbury-Brown, R.Q. Twiss, 1956)



In elementary particles physics and heavy-ion reactions: pions, photons,kaons, baryons…
Bose-Einstain or Fermi-Dirac statistics,
Strong and Coulomb final state interactions
also sensitive to space-time parameters.
Theoretical basis: G.I.Kopylov&M.I.Podgoretsky(71-75)

$$\Delta r = \frac{\hbar c}{\Delta p} = \frac{197\ \mathrm{MeV/c}}{\Delta p}\ \mathrm{fm}$$

Correlation femtoscopy : measurement of space-time characteristics R, cτ ~fm of particle production using particle correlations due to the effects of QS and FSI

Ideal background for femtoscopy-all correlations except femtoscopy one
Mixing- no correlations at all ! - not ideal, but very simple and effective (single particle acceptance is taken into account automatically)!

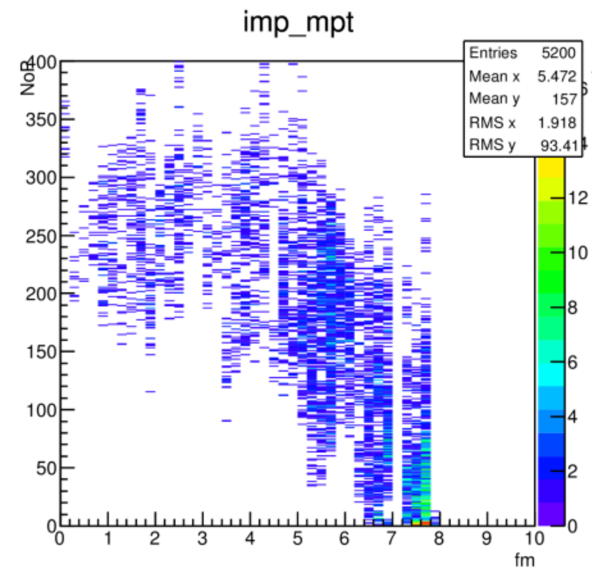
Fit by :

$$CF=N(1-\lambda+\lambda K_{cou1}(1+\exp(-R^2Q_{inv}^{\ 2})))P_2$$

$P_2 = 1 + a\, Q_{inv} + bQ_{inv}^{\ 2}$ - baseline

Event sample: EPOS (3076)
p-Pb collisions $\sqrt{s_{NN}}$=5,02 TeV, 5200 events

Selection criteria:
$\pi^{\pm}$, p_t : 0.12 – 4.0 GeV/c , η : -0.8 – 0.8
“Central collisions”: impact paremeter 0.0 – 2.0 fm
“Peripheric collisions”: impact parameter 6.0 – 8.0 fm



Correlation function: normalized ratio of the
same event distribution to mixing one

$\sum_{i=1}^{n} \mathbf{p}_i = 0$ (momentum conservation)

$\sum_{i=2}^{n} \mathbf{p}_i = -\mathbf{p}_1$; $< \mathbf{p}_{i\neq1} > = \frac{-\mathbf{p}_1}{n-1}$

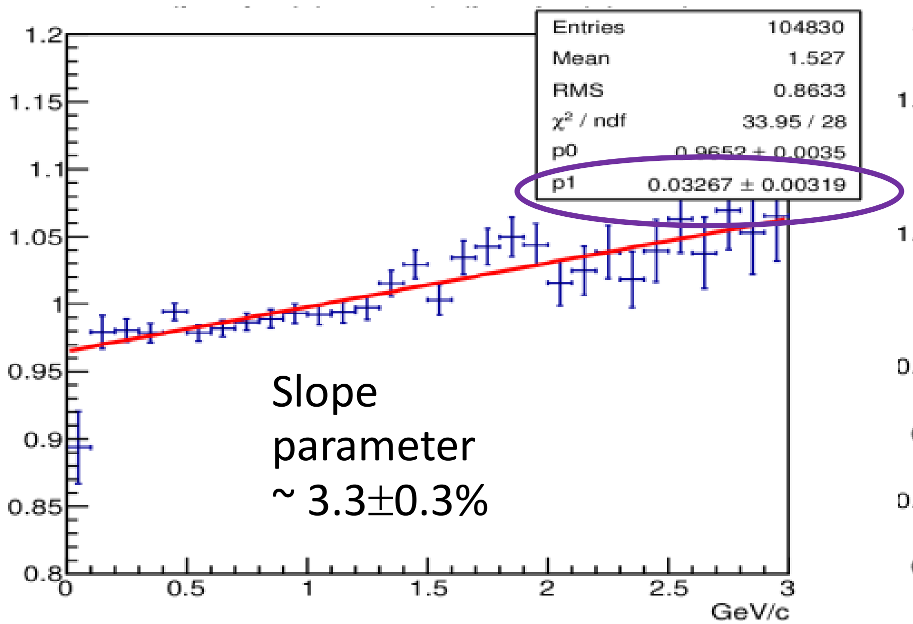
$< \mathbf{p}_1 - \mathbf{p}_{i\neq1} > = \mathbf{p}_1 (1+ \frac{1}{n-1}) > \mathbf{p}_1$

but

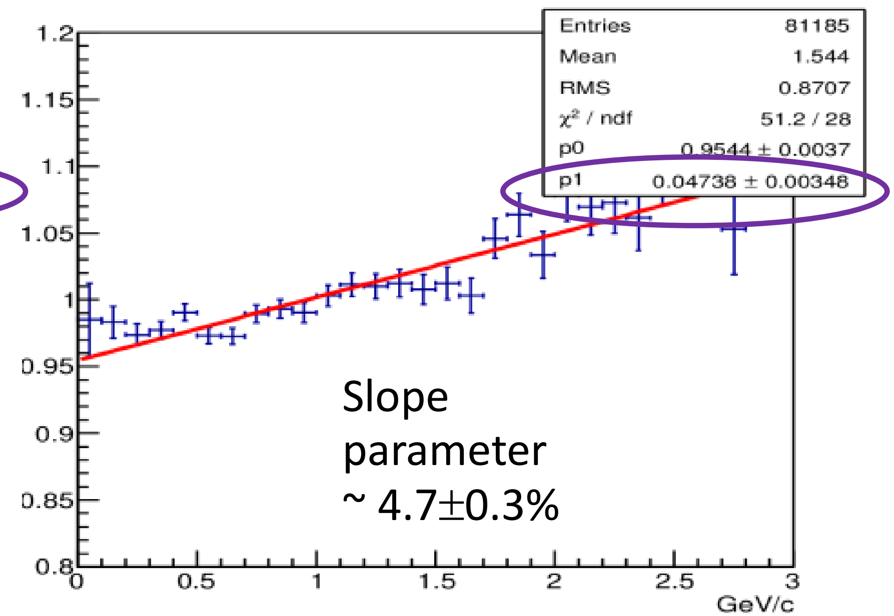
$< \mathbf{p}_1 + \mathbf{p}_{i\neq1} > = \mathbf{p}_1 (1- \frac{1}{n-1}) < \mathbf{p}_1$

Momentum conservation ?

$R(\mathbf{q}) = N(\mathbf{q})/N_{mix}(\mathbf{q})$



Central collisions



Peripheral collisions

$\mathbf{q} = \vec{p}_1 - \vec{p}_2$, ; events without multiplicity cuts

$\sum_{i=1}^{n} \mathbf{p}_i = 0$ (momentum conservation)

$\sum_{i=2}^{n} \mathbf{p}_i = -\mathbf{p}_1 \; ; \langle \mathbf{p}_{i\neq 1} \rangle = \frac{-\mathbf{p}_1}{n-1}$

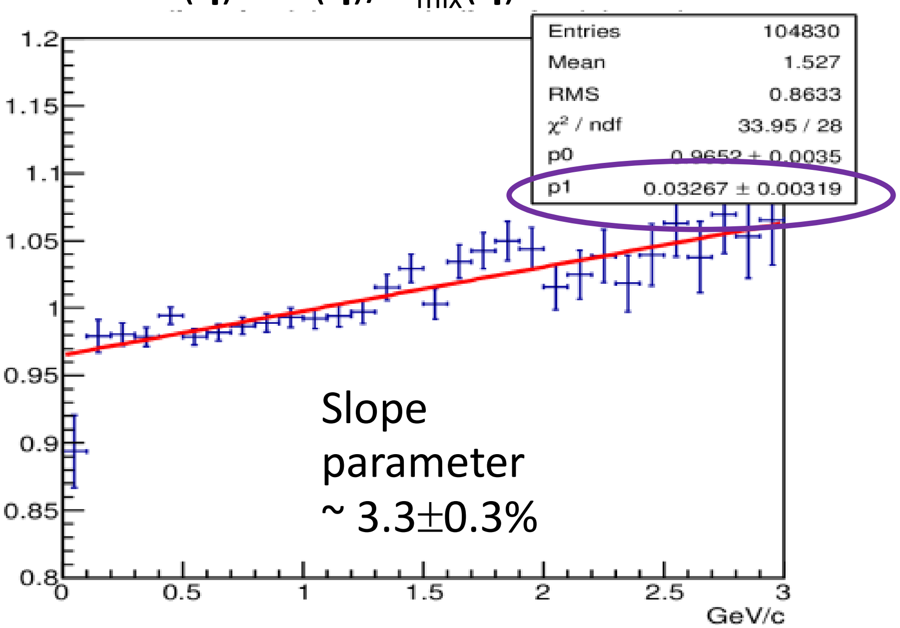
$\langle \mathbf{p}_1 - \mathbf{p}_{i\neq 1} \rangle = \mathbf{p}_1 (1 + \frac{1}{n-1}) > \mathbf{p}_1$

but

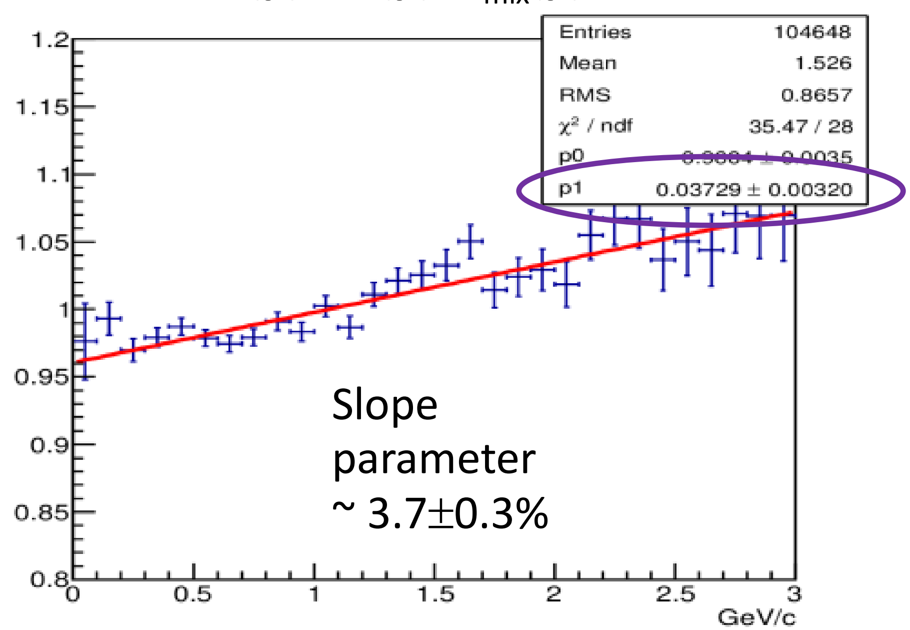
$\langle \mathbf{p}_1 + \mathbf{p}_{i\neq 1} \rangle = \mathbf{p}_1 (1 - \frac{1}{n-1}) < \mathbf{p}_1$

~~Momentum conservation~~

R(**q**) = N(**q**)/N_{mix}(**q**)

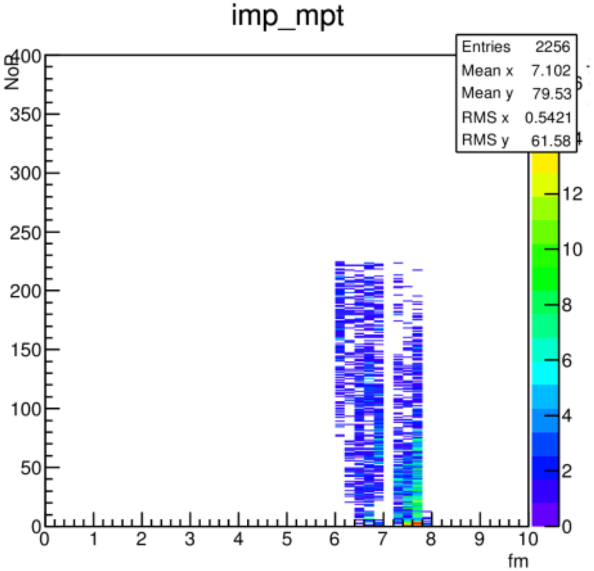


R(**p**) = N(**p**)/N_{mix}(**p**)

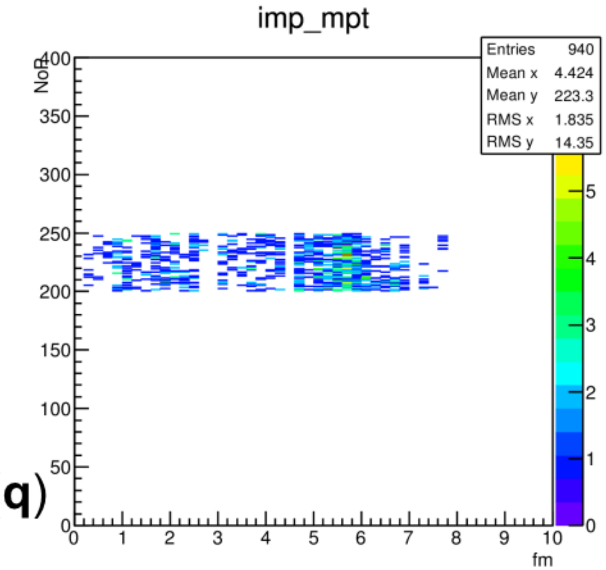


$\vec{\mathbf{q}} = \vec{p}_1 - \vec{p}_2$, $\vec{\mathbf{p}} = \vec{p}_1 + \vec{p}_2$; Central events without multiplicity cuts

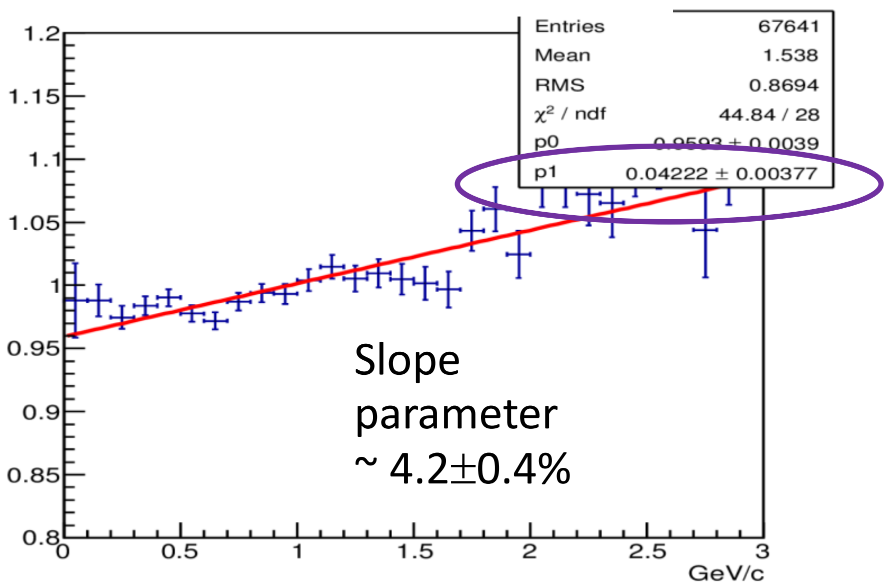
Peripheral events (6-8 fm)
without (realy) multiplicity cut
(n_π:0-225)

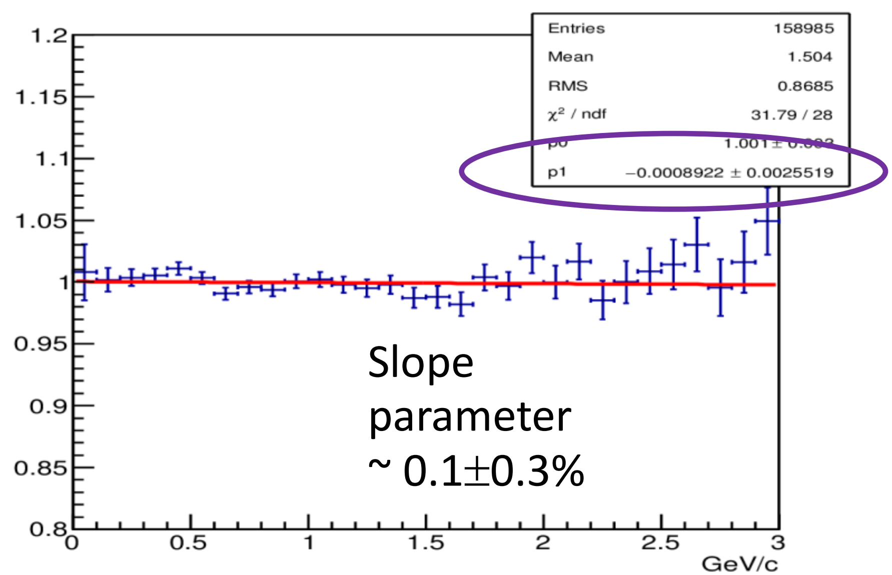


All centralities
with multiplicity cut
(n_π:200-250)



$$R(\mathbf{q}) = N(\mathbf{q})/N_{mix}(\mathbf{q})$$





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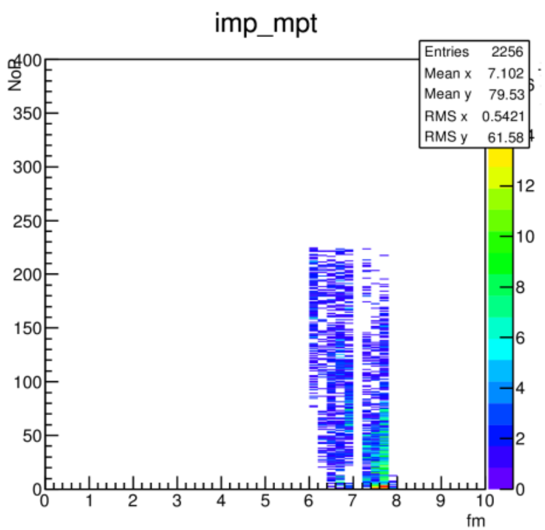
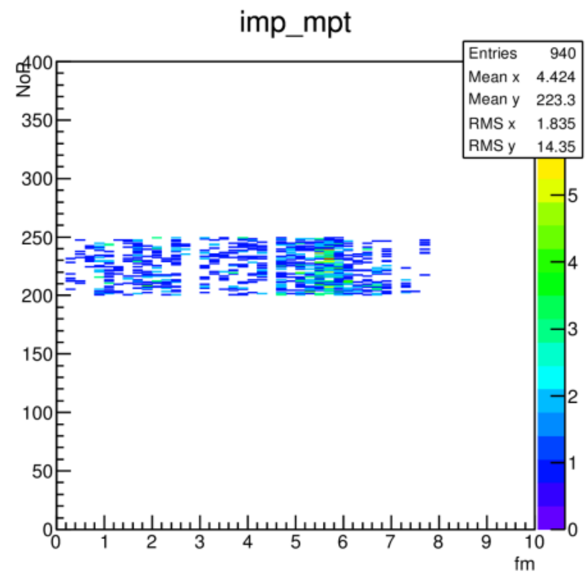
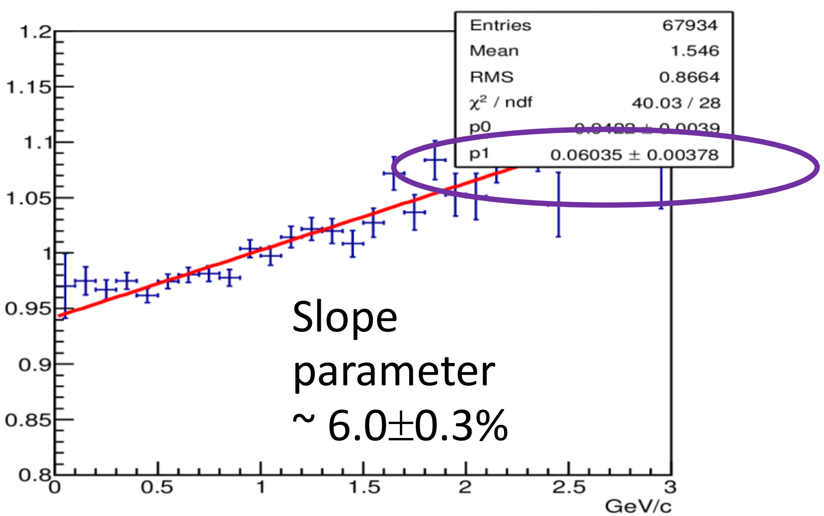
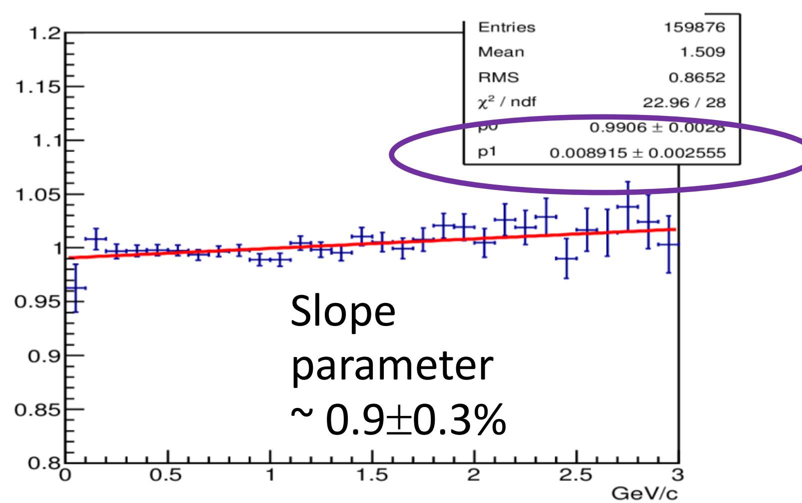
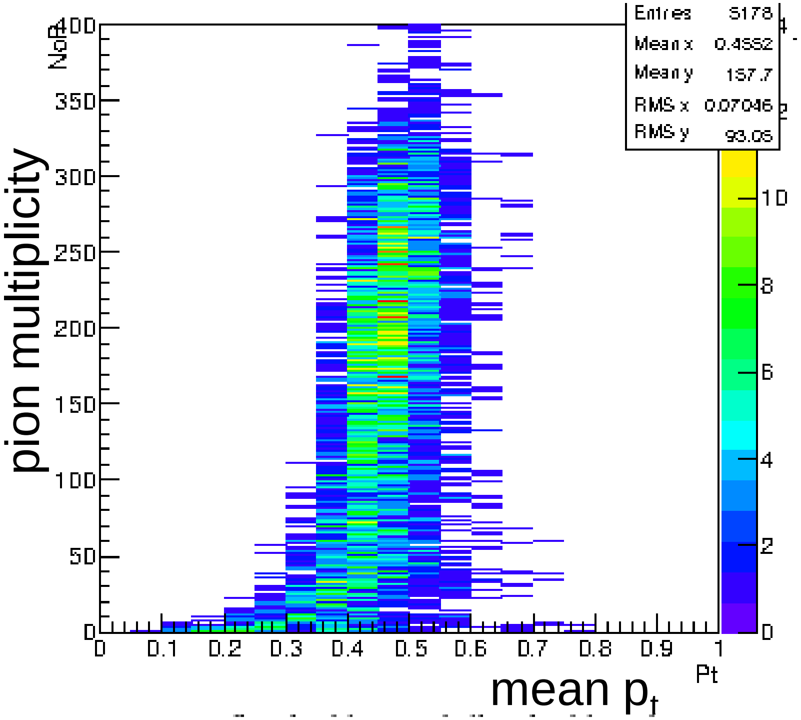




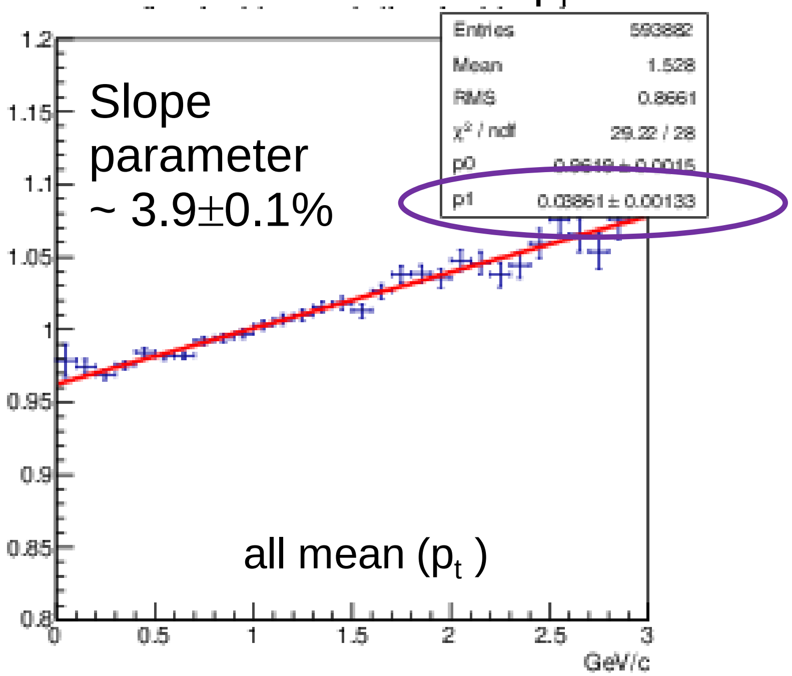
$R(\mathbf{p}) = N(\mathbf{p})/N_{mix}(\mathbf{p})$

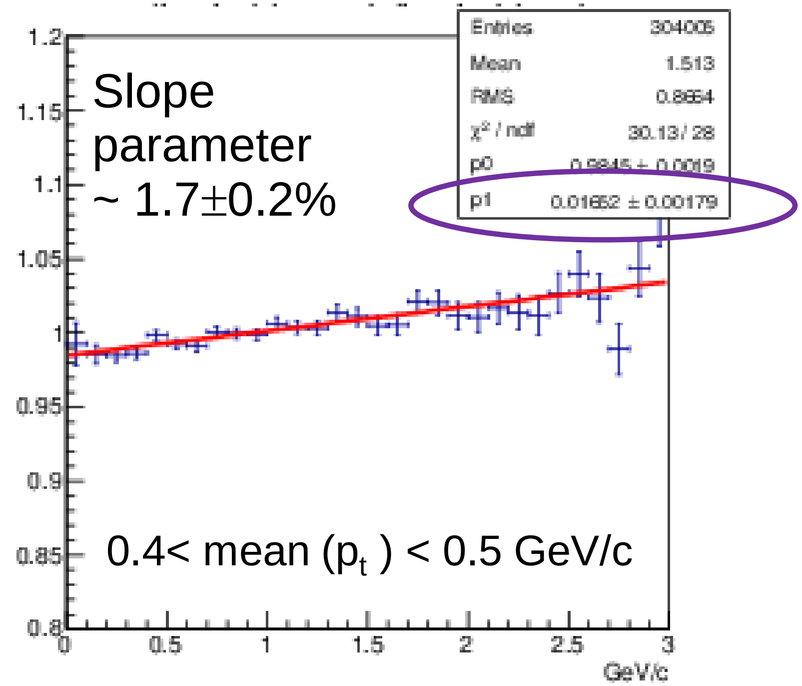


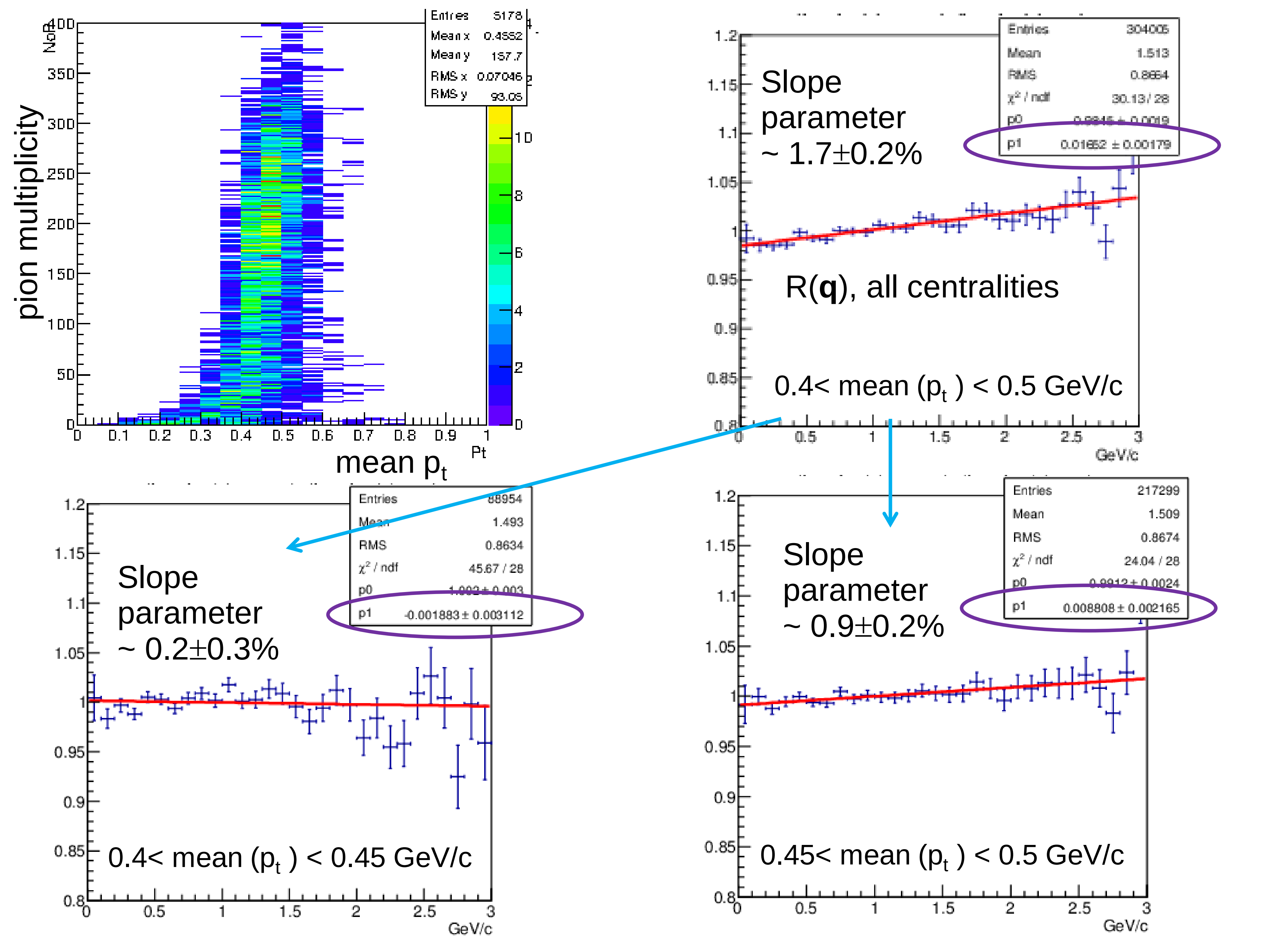




R(**q**), all centralities

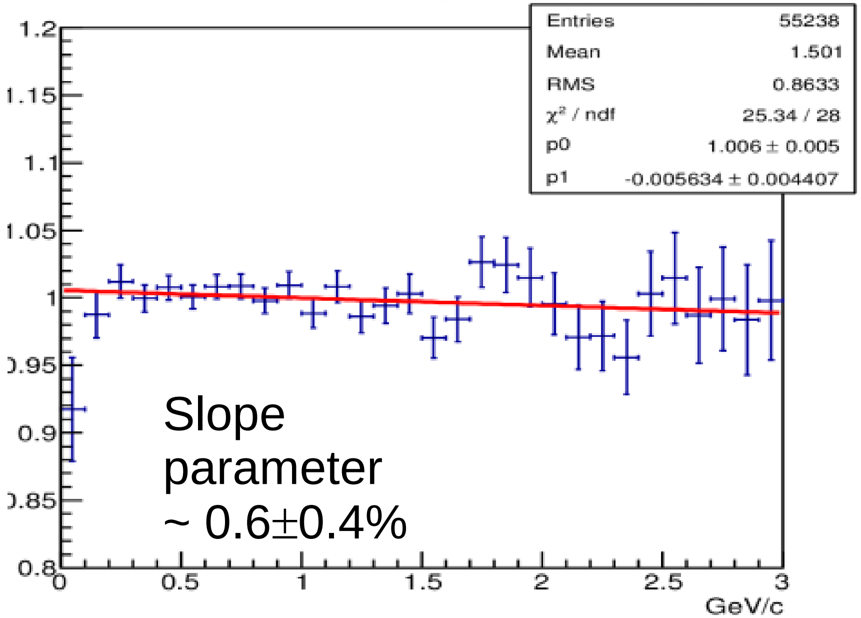






Entries 5178
Mean x 0.4552
Mean y 157.7
RMS x 0.07046
RMS y 93.08
NoP
pion multiplicity
Pt
mean p_t
Entries 304005
Mean 1.513
RMS 0.8654
χ^2 / ndf 30.13 / 28
p1 0.01652 ± 0.00179
Slope parameter ~ 1.7±0.2%
R(**q**), all centralities
0.4< mean (p_t) < 0.5 GeV/c
GeV/c
Entries 88954
Mean 1.493
RMS 0.8634
χ^2 / ndf 45.67 / 28
p0 1.002 ± 0.003
p1 -0.001883 ± 0.003112
Slope parameter ~ 0.2±0.3%
0.4< mean (p_t) < 0.45 GeV/c
GeV/c
Entries 217299
Mean 1.509
RMS 0.8674
χ^2 / ndf 24.04 / 28
p0 0.9912 ± 0.0024
p1 0.008808 ± 0.002165
Slope parameter ~ 0.9±0.2%
0.45< mean (p_t) < 0.5 GeV/c
GeV/c

$R^{*}=N(\mathbf{q})/N(\mathbf{p})$,
central events



A. Stavinskiy et al., Nucleonika 2004; 49(supplemented): S23-S25

Conclusions

1) Nonfemtoscopic correlations seen within EPOS model both for R(**q**) and R(**p**)
2) Effect can be reduced by multiplicity cut or by mean p_t cut
3) R(**p**) can be used as background distribution for femtoscopy