Status of KK femtoscopy in ALICE

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Outline

- Physics Motivation of KK femtoscopy
- Existing data
- Distortions of K+K+ correlation function:
  - PID's of Kaons
  - Resonances ($v\tau \geq$ source size): K*, Φ
  - Residual correlations
- First results for K+K-
- Conclusion

Physics motivation

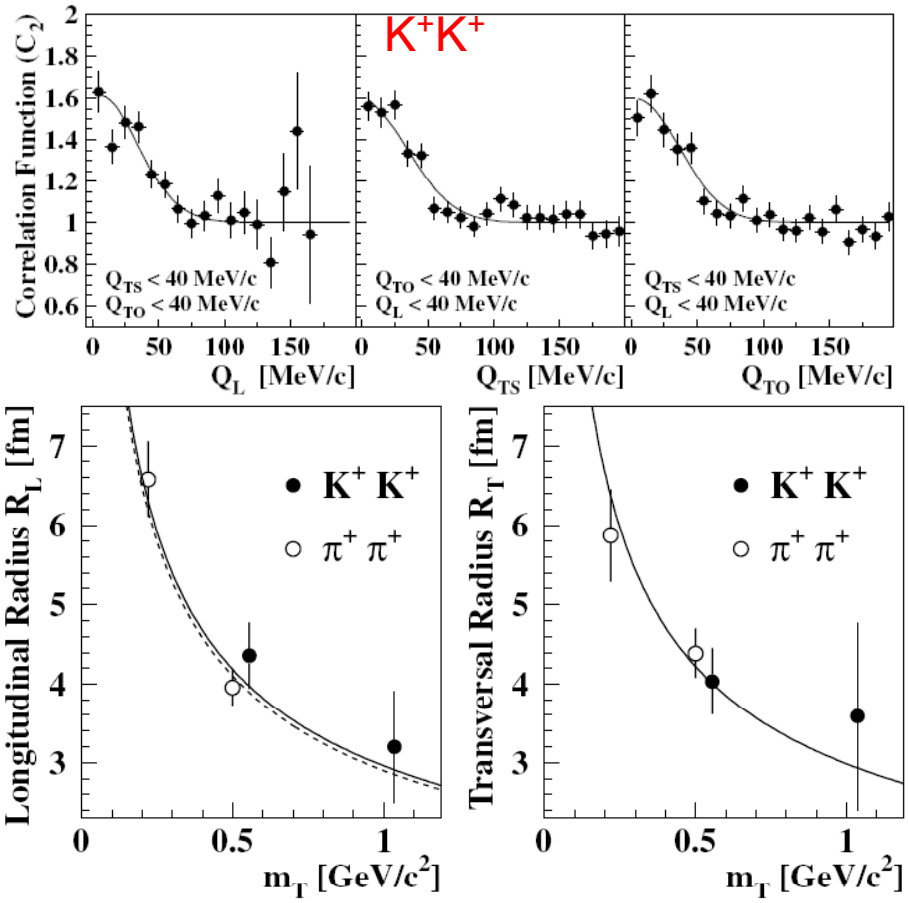
- Physics:
  - Strangeness enhancement is one of the signatures of QGP
  - The strangeness distillation mechanism could lead to strong temporal emission asymmetries between kaons and anti-kaons *[S.Soff et al., J.Phys.G23,2095(1997);D.Ardouin et al.,Phys.Lett.B446,191(1999)].*
  - Kaons is more penetrating particles than pions
  - The mT dependence: $m_T(K) > m_T(\pi)$.

- Methodics:
  - Kaon femtoscopy signal is more pure than pion femtoscopy signal since kaons are less affected by resonance decay.
  - Since the highest branching ratio of φ meson is $\varphi \rightarrow KK$ and decay momentum relatively small (~100MeV/c) the $\varphi\varphi$ residual correlations could be seen from KK correlation function.

Experimental data

CERN-SPS: Pb+Pb at 158 AGeV/c

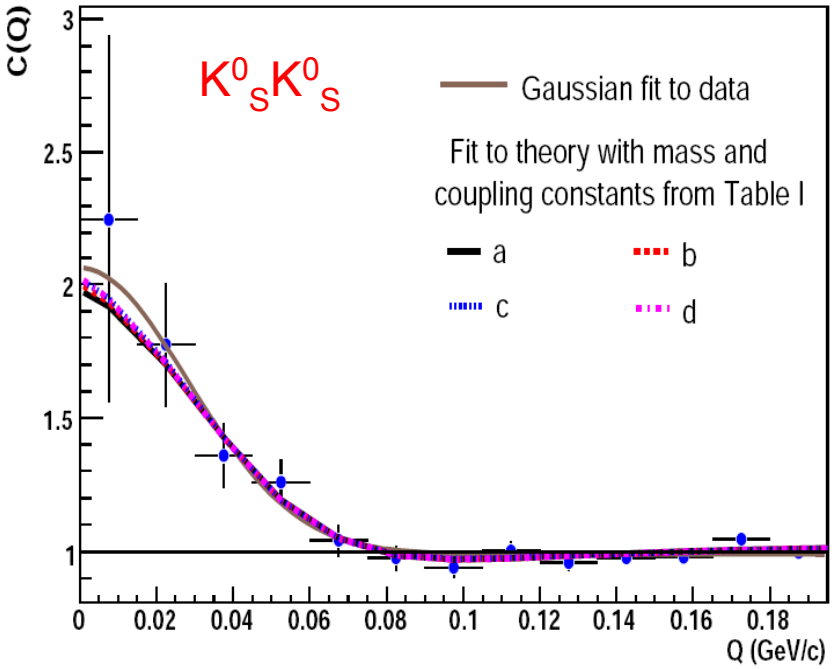
[PRL,87(2001)112301]



The duration time
$\Delta\tau=\sqrt{(r^2_{out}-r^2_{side})}/\beta=$
2.2± 5.2(stat.) ± 5.1(sys) fm

RHIC-STAR: Au+Au sqrt(S_{NN})=200GeV

[Phys.Rev.C 74 (2006),054902]

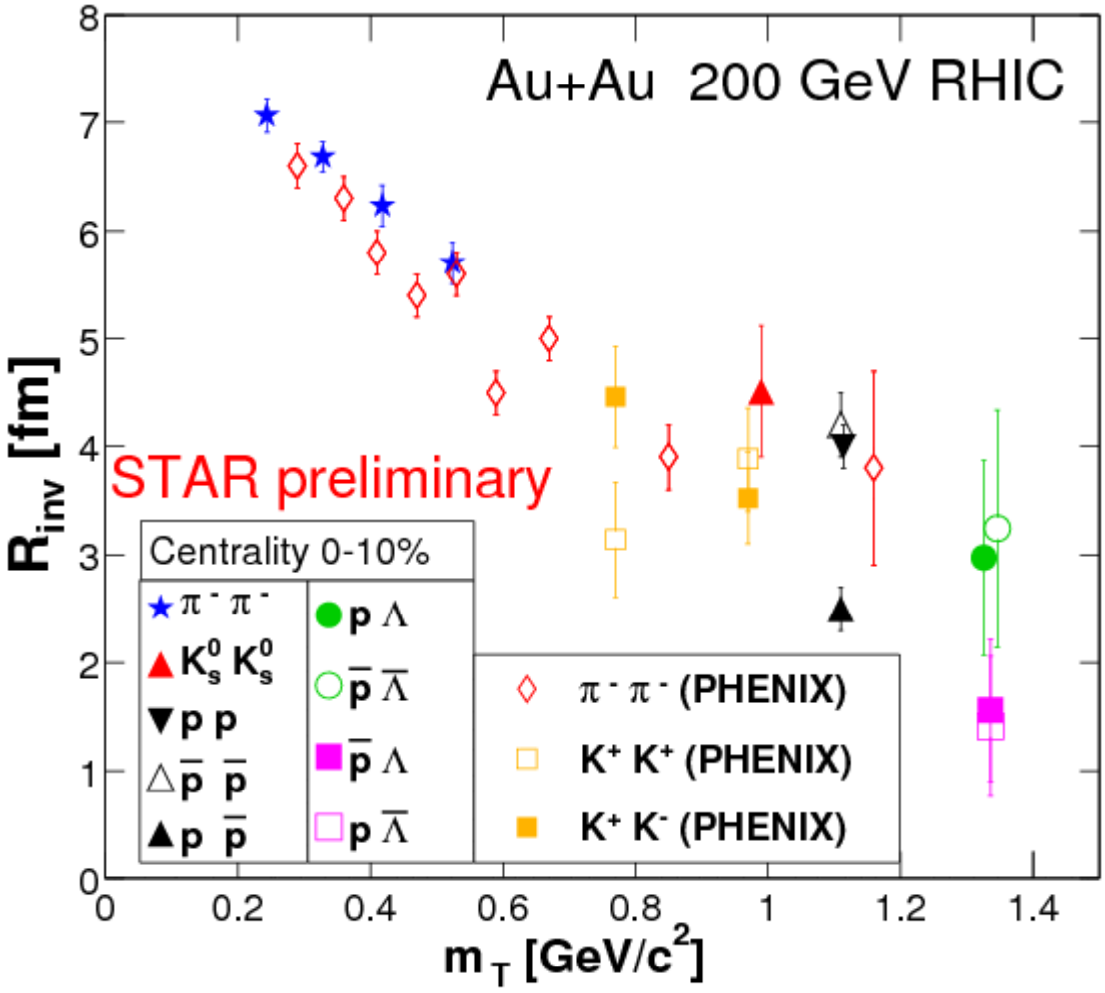


R = 4.09 ± 0.46(stat.) ± 0.31(sys) fm and
λ = 0.92±0.23(stat)±0.13(sys) at the mean transversemass $\langle m_T \rangle$ = 1.07 GeV.

Experimental data

RHIC-PHENIX: Au+Au sqrt(S_{NN})=200GeV

[M. Heffner J., Phys. G 30 (2004) S1043-S1047], [nucl-ex/0510014]

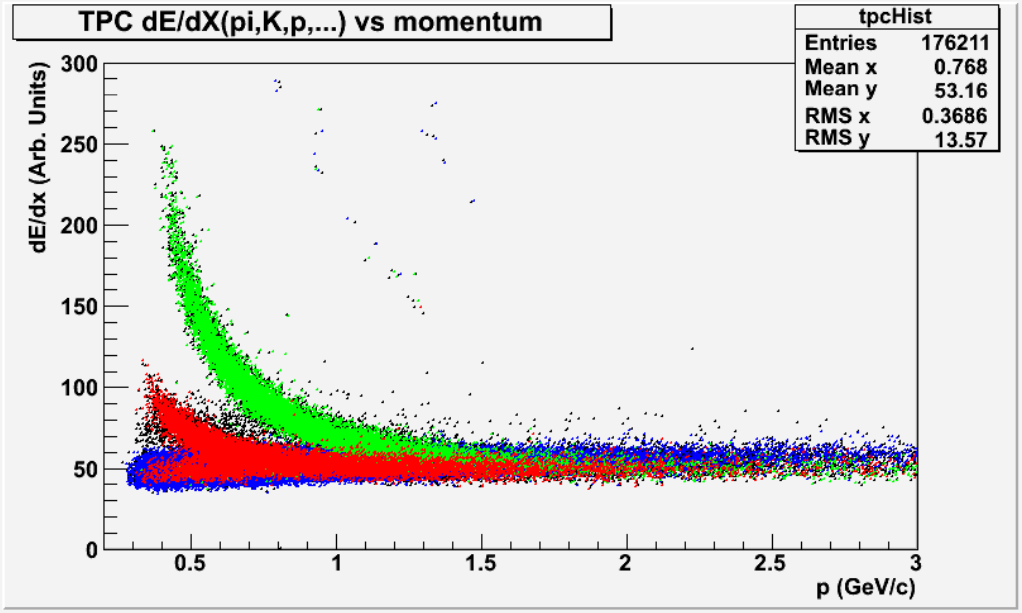


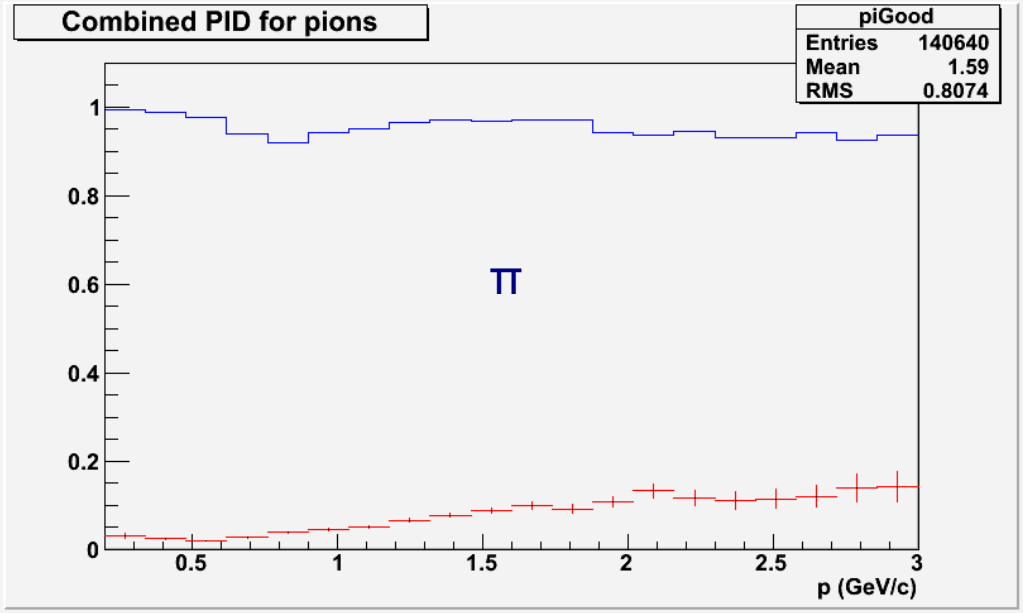
- an approximately "universal" m_T dependence is usually attributed to collective flow
- KK one dimensional radius 3-5 fm

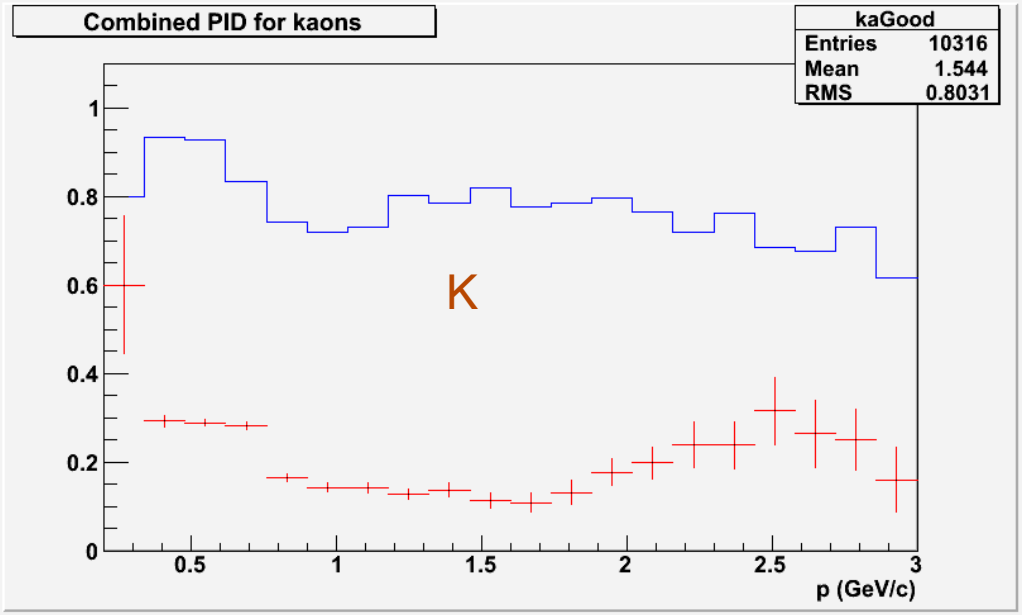
ALICE Software and input

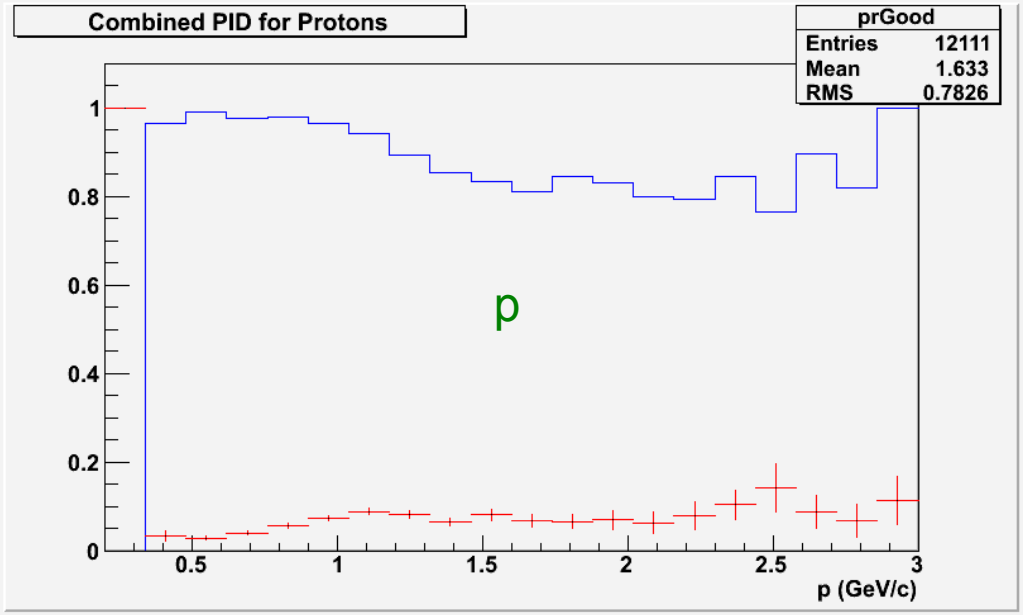
- Aliroot (with AliFemto) v4-12-Rev-02
- Local analysis of 3K events
  PDC2007: HIJING PbPb 5.5 TeV
  (dN_{ch}/dy~6500)
- 1D KK correlations
  - 0.1 < P_T < 1.0 GeV/c
  - Anti-splitting cut
  - Gaussian distr.: $d^3N/d^3\mathbf{r}^* \sim \exp(-\mathbf{r}^{*2}/(4r_0^2))$
    KK r_0: 2 and 5 fm
  - Source size for kaons from K* decay was corrected on $v_{K^*}\tau_{K^*}$: $r'_0=\mathrm{sqrt}(r_0^2+(v_{K^*}\tau_{K^*})^2)$

PID

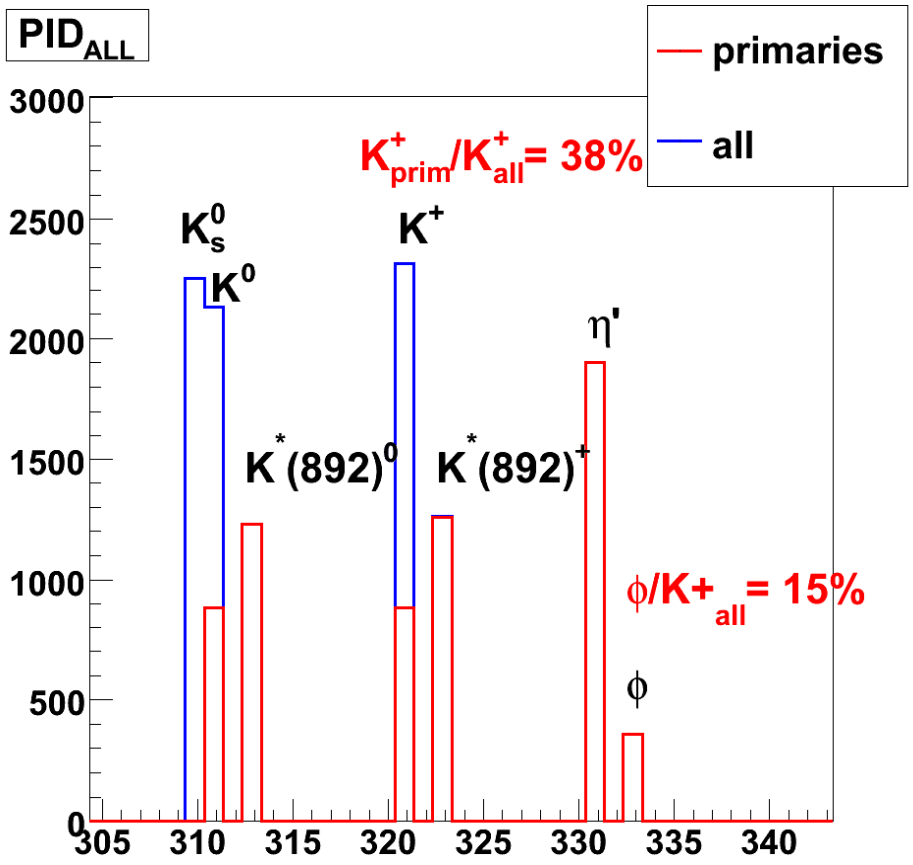

TPC dE/dX(pi,K,p,...) vs momentum
tpcHist
Entries 176211
Mean x 0.768
Mean y 53.16
RMS x 0.3686
RMS y 13.57
dE/dx (Arb. Units)
p (GeV/c)

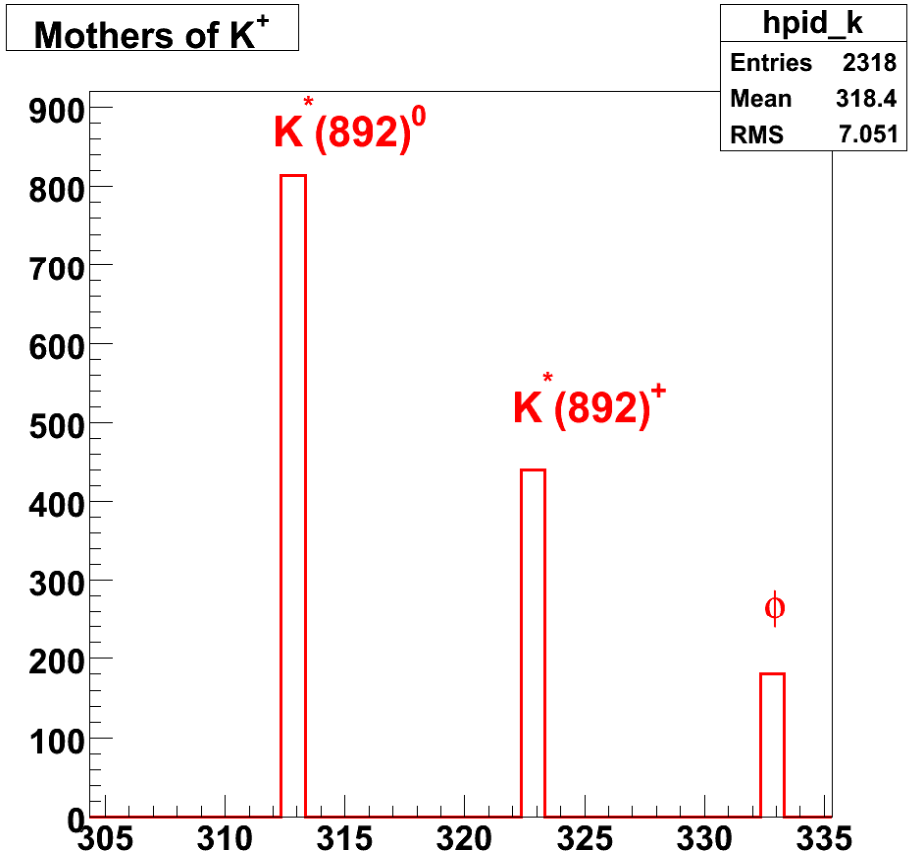

Combined PID for pions
piGood
Entries 140640
Mean 1.59
RMS 0.8074
π
p (GeV/c)


Combined PID for kaons
kaGood
Entries 10316
Mean 1.544
RMS 0.8031
K
p (GeV/c)


Combined PID for Protons
prGood
Entries 12111
Mean 1.633
RMS 0.7826
p
p (GeV/c)

K+ Mothers

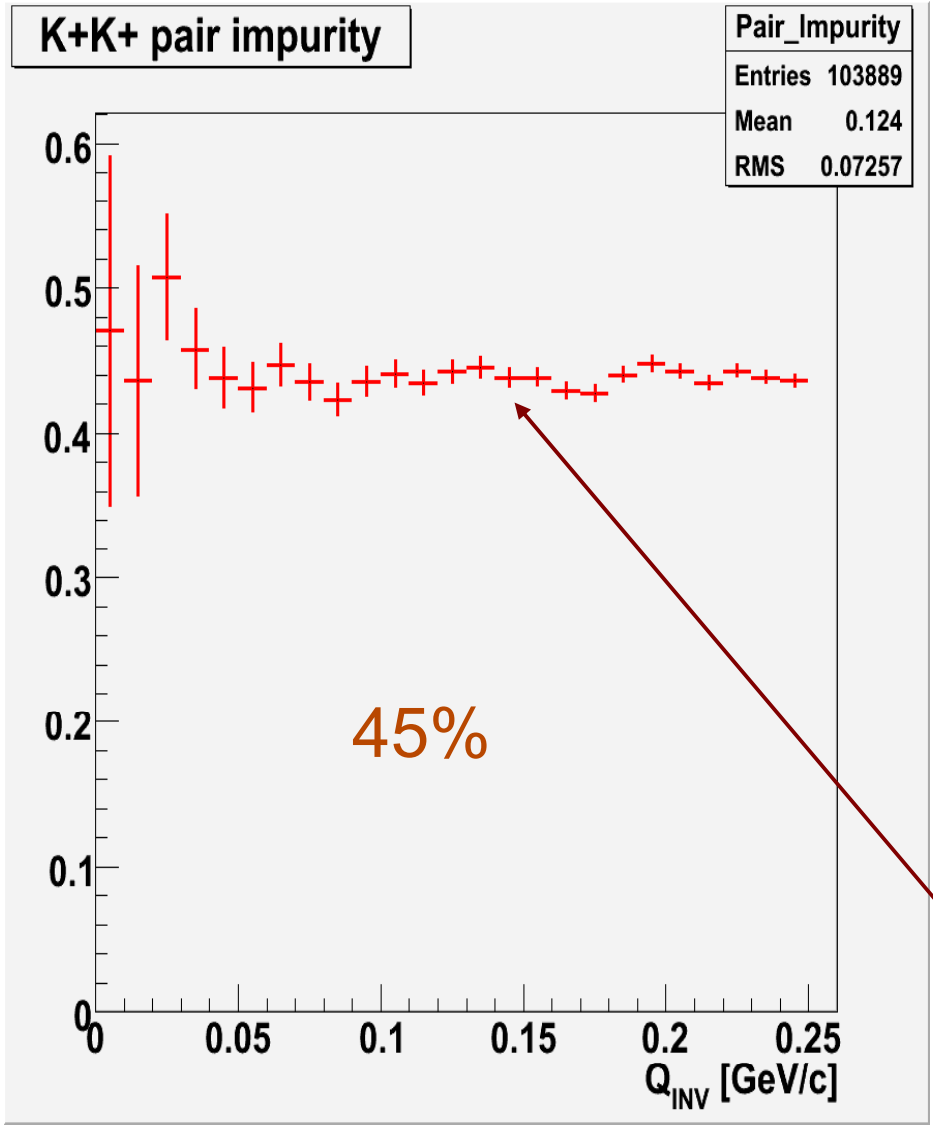




K^+_{direct} 38% $K_{K^*(892)0}$ 35% $K_{K^*(892)+}$ 19% K_{Φ} 8%,
it is two times better than π+ (π^+_{prim}/π^+_{all} =19%)

Pair PID

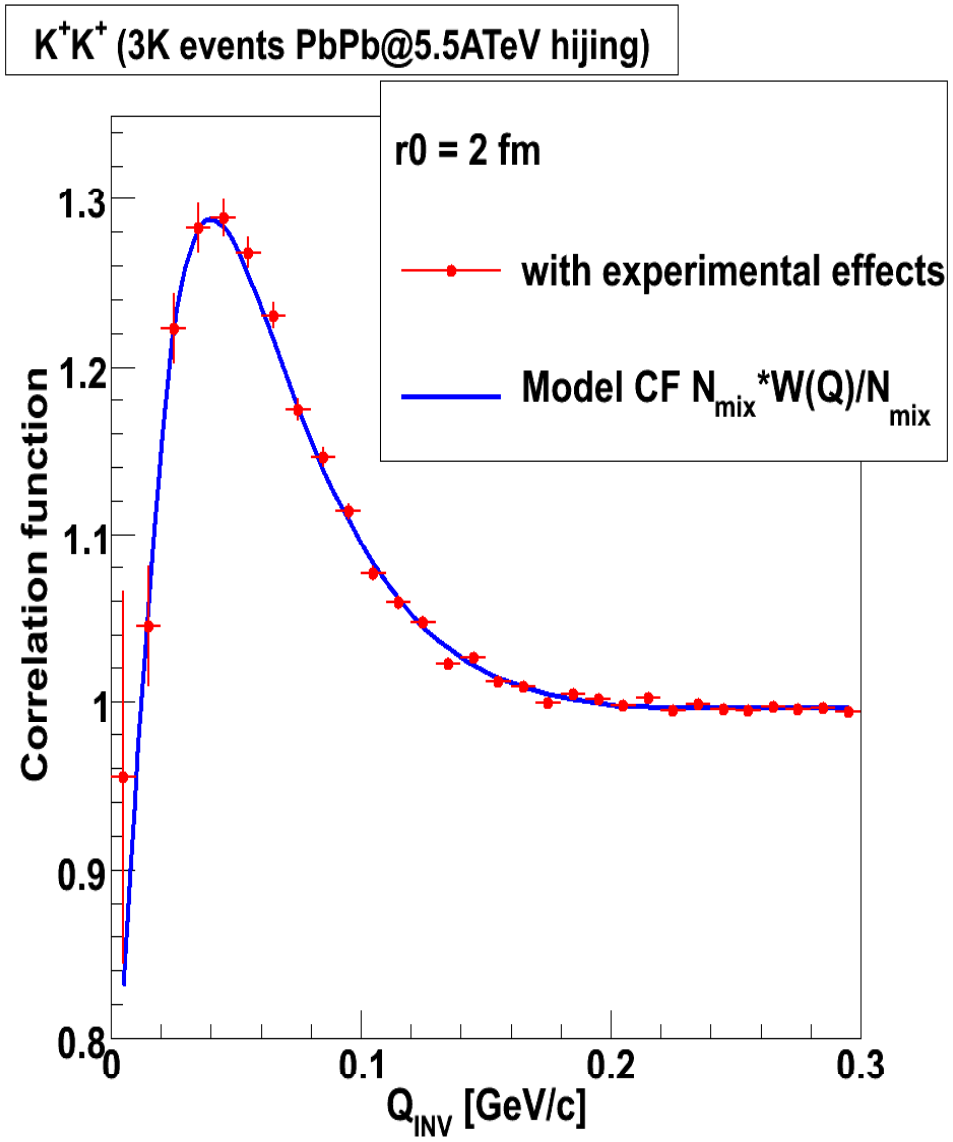
100 events PbPb@5.5 TeV HIJING Q_{INV}<0.25GeV/c

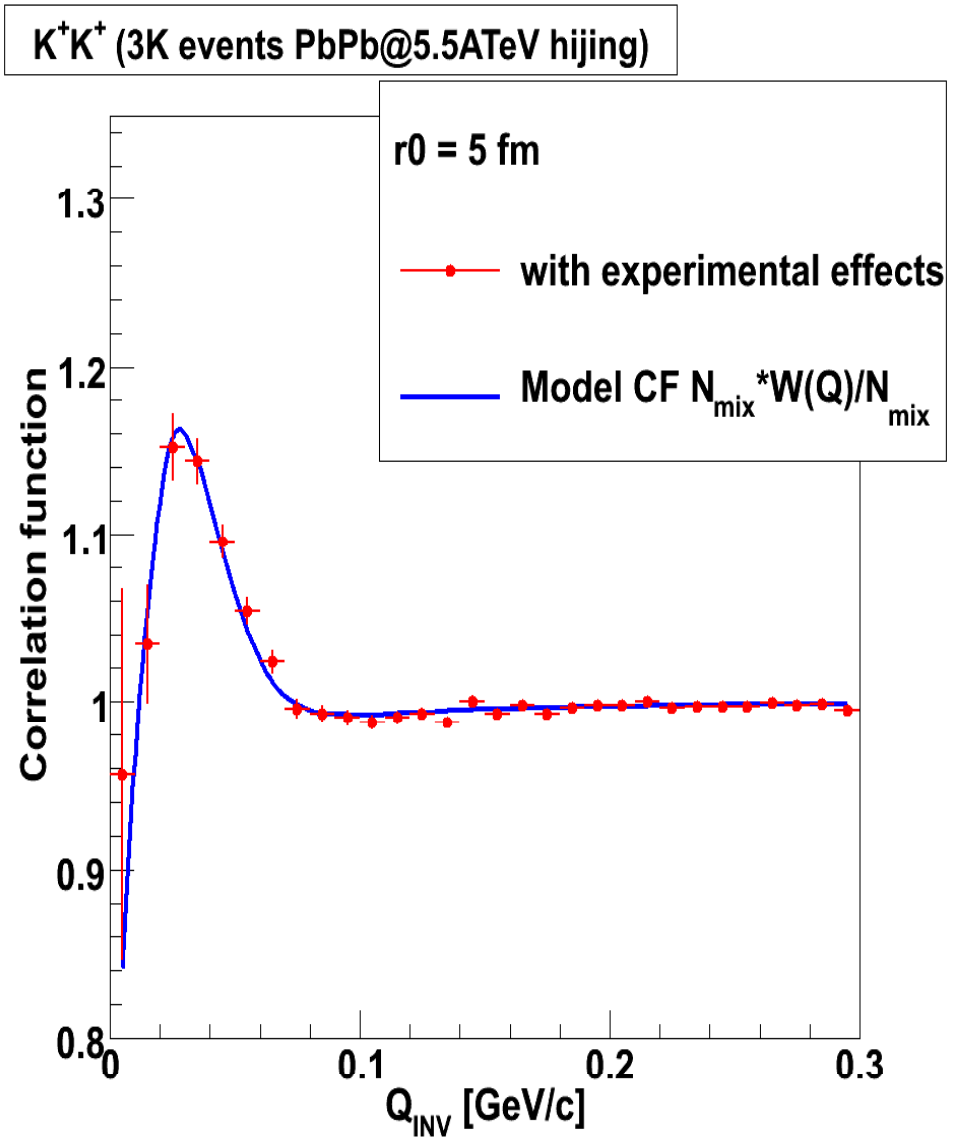


$K_{dir}K_{dir}$	*7%*	7222(6.95165%)
$K_{dir}K_{K^{*0}}$		15298(14.7253%)
$K_{dir}K_{K^{*+}}$		7652(7.36555%)
$K_{K^{*0}}K_{K^{*+}}$	*39%*	8181(7.87475%)
$K_{K^{*+}}$ $K_{K^{*+}}$		2067(1.98962%)
$K_{K^{*0}}$ $K_{K^{*0}}$		8077(7.77464%)
$K_{dir}K_{\Phi}$		3129(3.01187%)
$K_{\Phi}K_{\Phi}$		345(0.332085%)
$K_{K^{*0}}(K_{K^{*+}})K_{\Phi}$		5022(4.83401%)
Other exotic ($K_{dir}K_{D0}$,...)		1352(1.30139%)
$(KK)_{fake}$		46896(45.1405%)
Total		103889 (100%)

K+K+:Model&"Experiment"

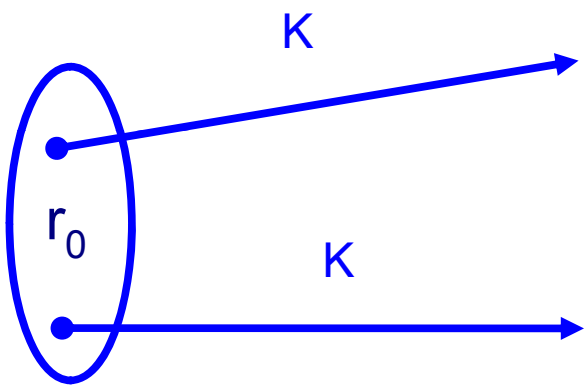
Splitting cut was applied



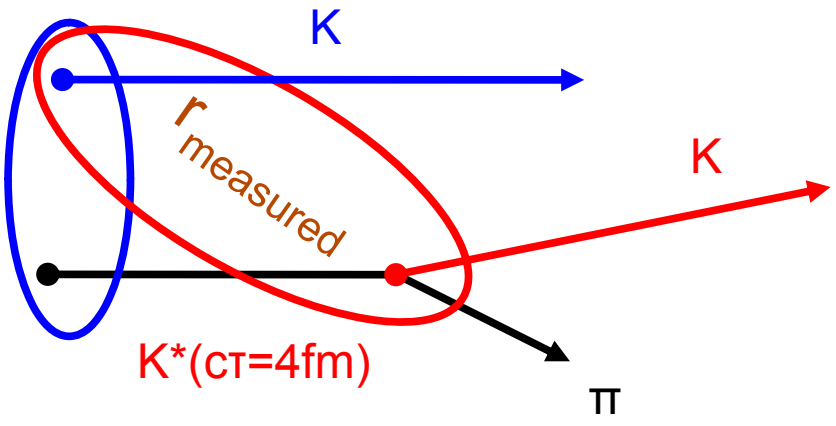


Source “expansion” due to K*

Both K are direct



One K is direct and the other one from K* decay



- $K_{dir}K_{dir}$ source size is smaller than $K_{dir}K_{K^*}$ due to K* decay length
- Assume K* source size the same as $K_{dir}K_{dir}$ (r_0)
- Measured source in second case:

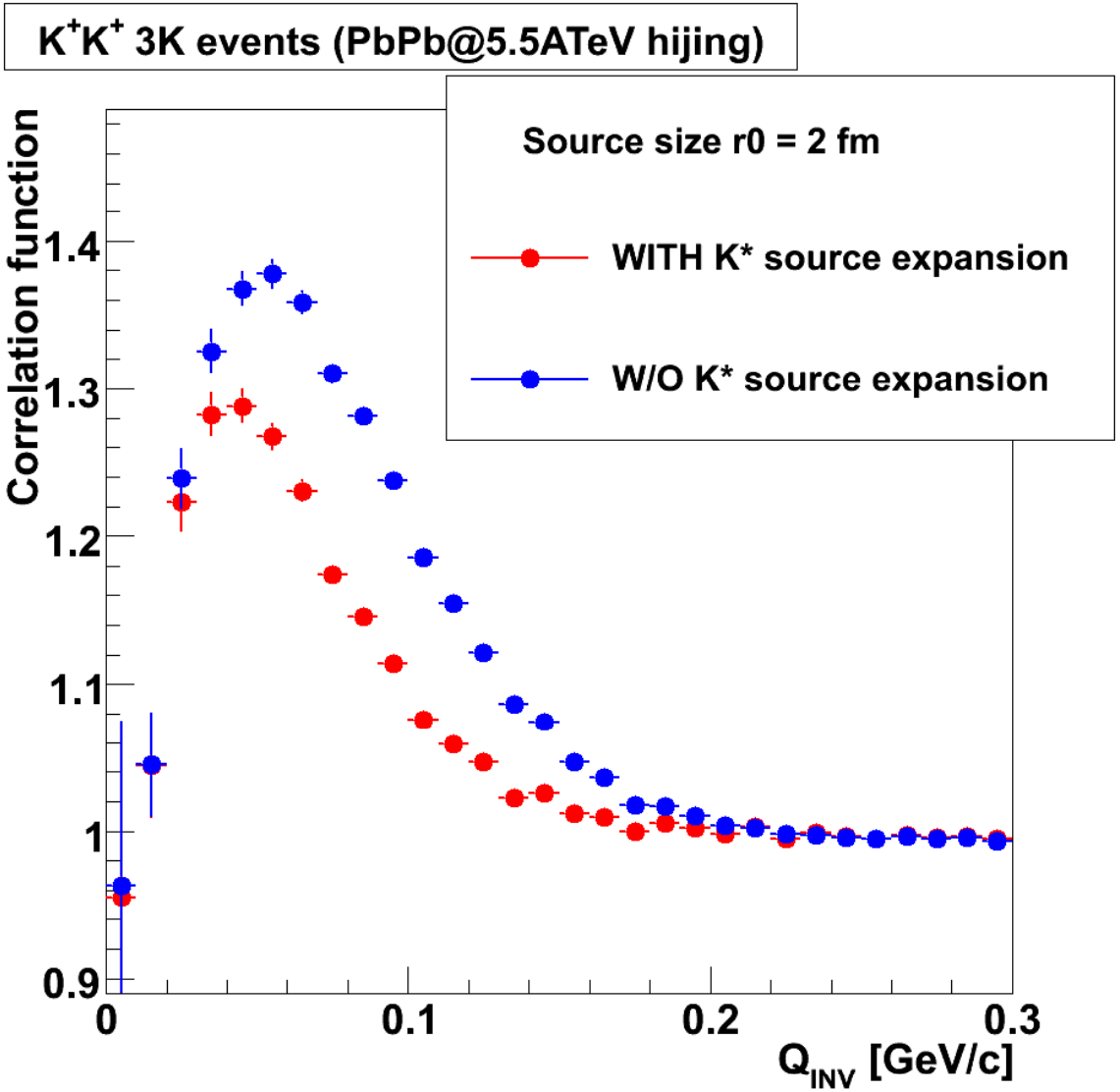
$r'_0 = \mathrm{sqrt}(r_0^2+(v\tau)^2)$ $[K_{dir}K_{K^*}]$ or

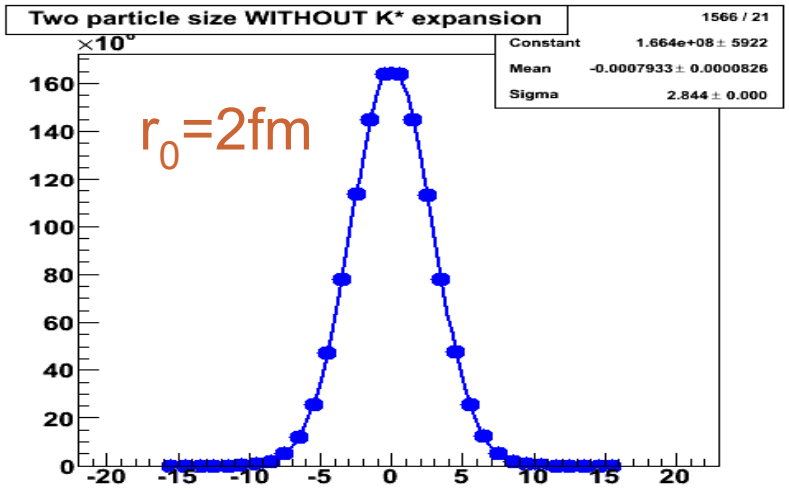
$r'_0 = \mathrm{sqrt}(r_0^2+(v_1\tau_1)^2+(v_2\tau_2)^2)[K_{K^*}K_{K^*}]$

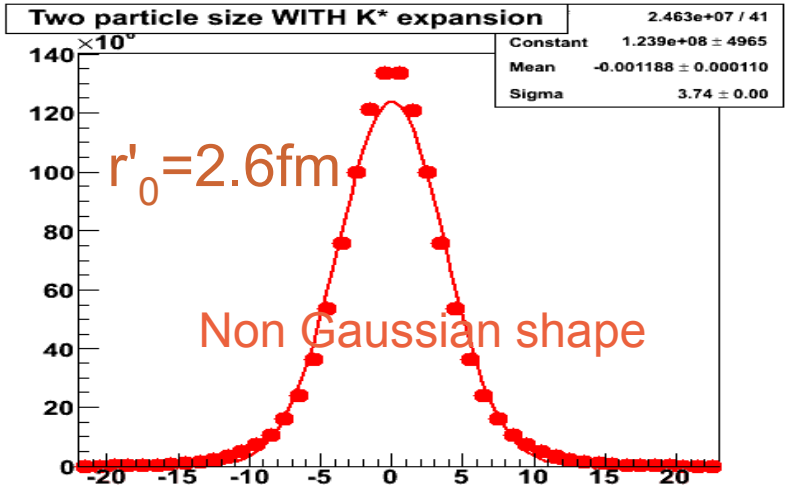
- Get v of K* from generator ($v\tau$~2.6 fm)

K+K+: K* source “expansion”(2fm)

Source “expansion” due to K* decay (r_0=2fm, K* vτ ~ 2.6fm)

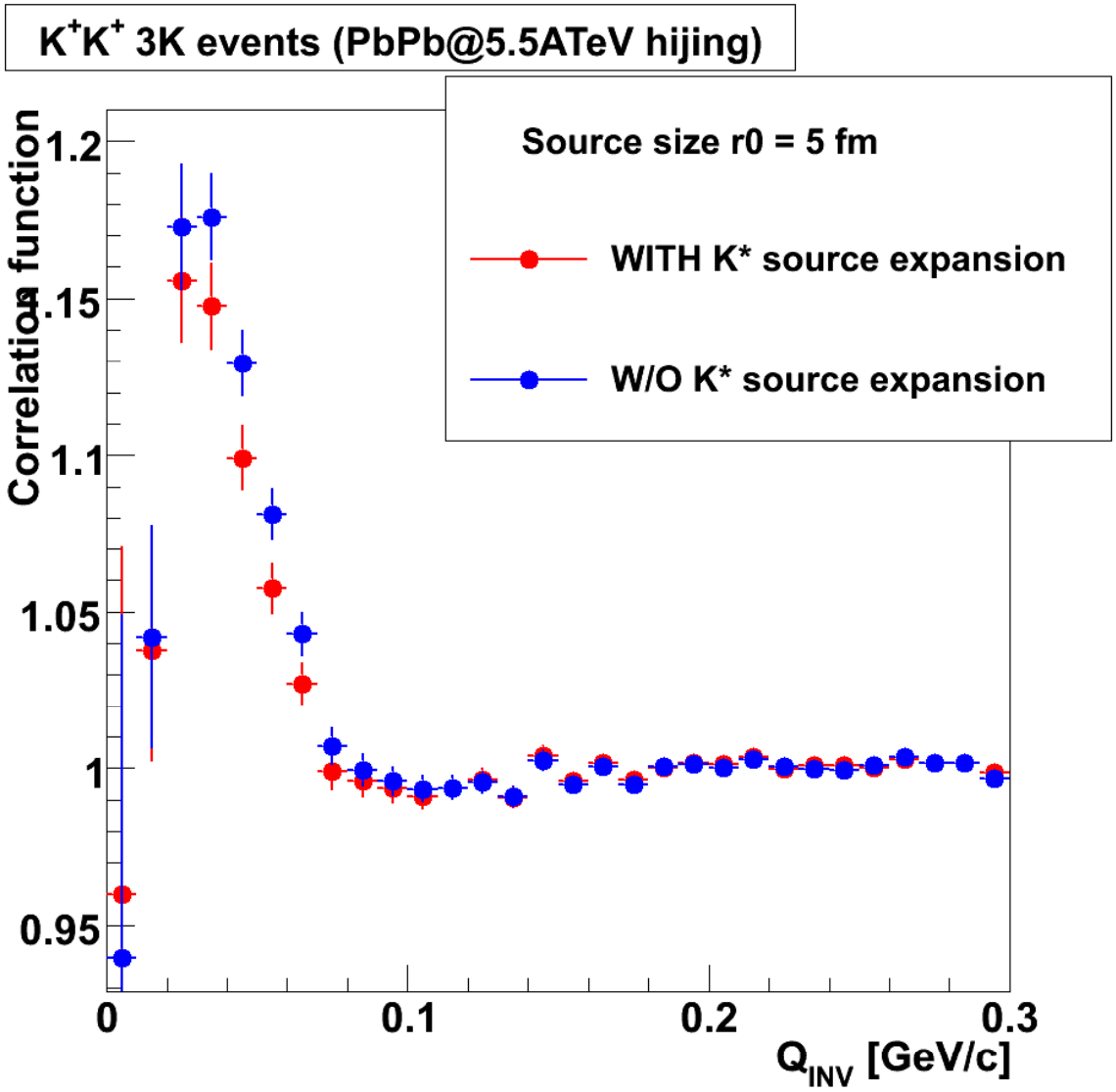


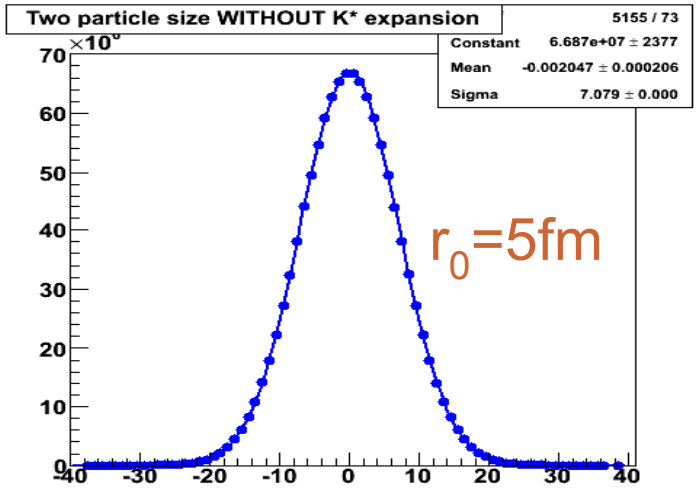


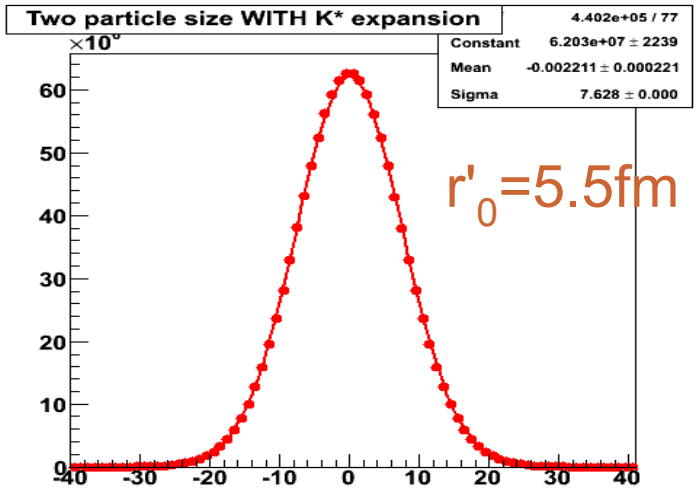


K^+K^+: K* "expansion" (5fm)

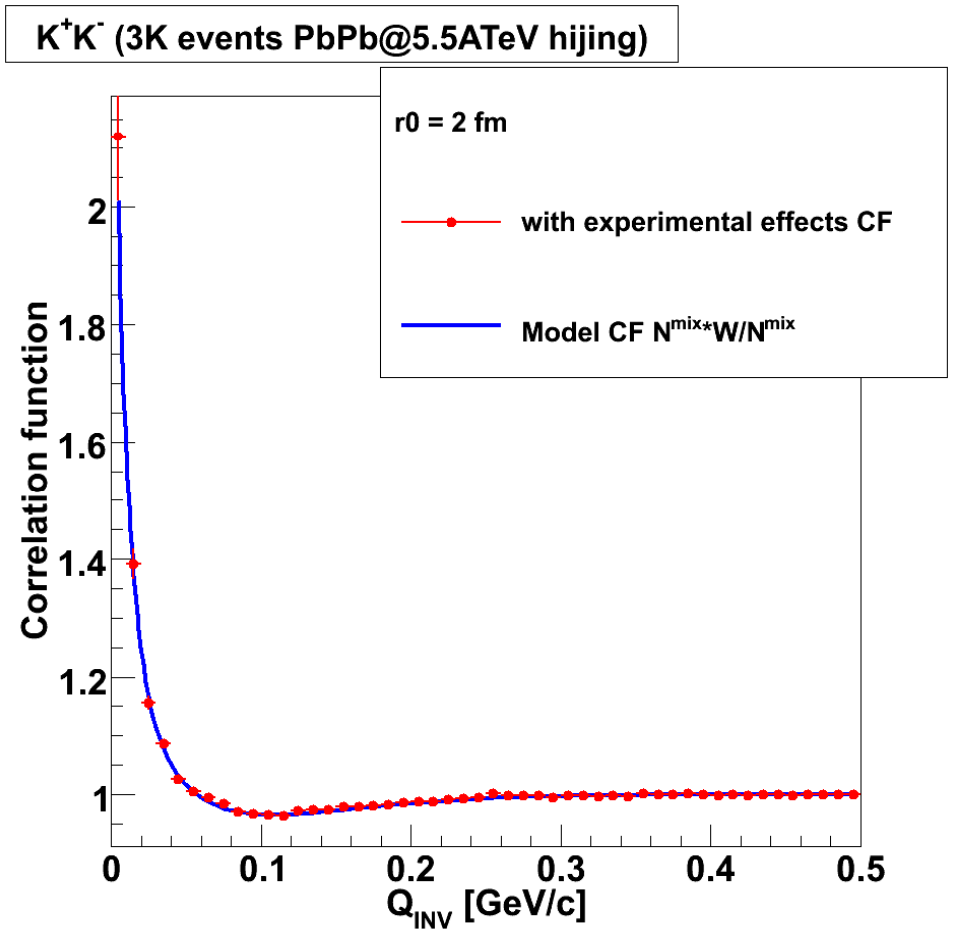
Source "expansion" due to K* decay (r_0=5fm, K* vτ ~ 2.6fm)

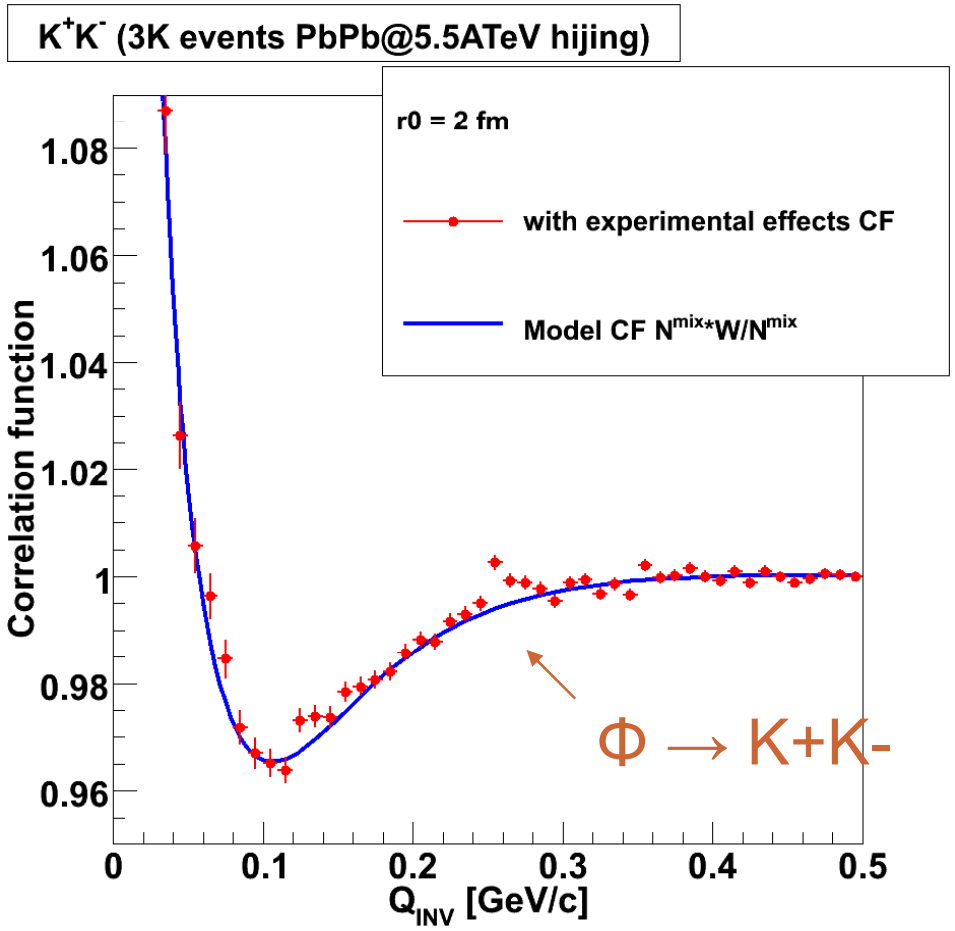




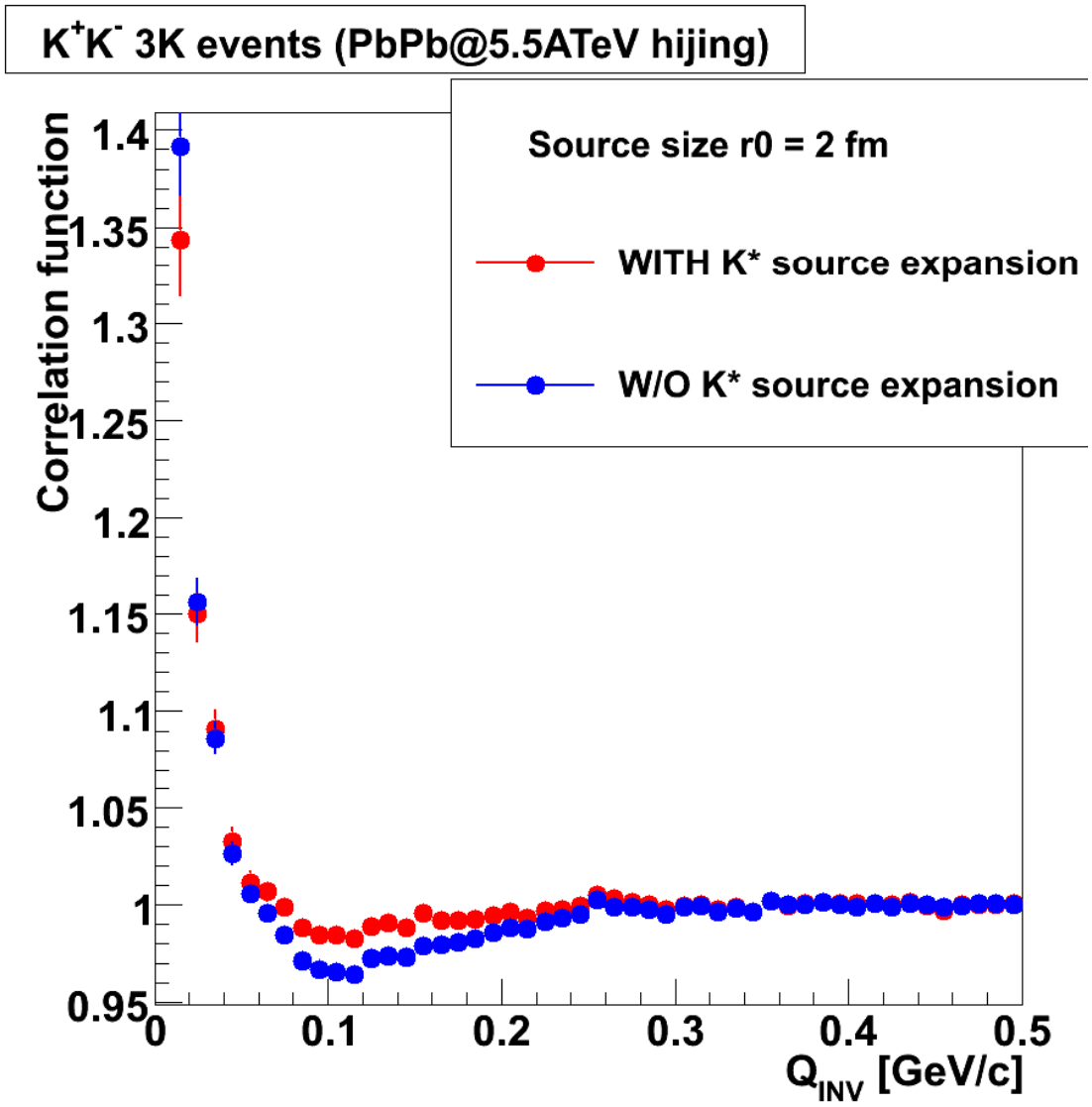


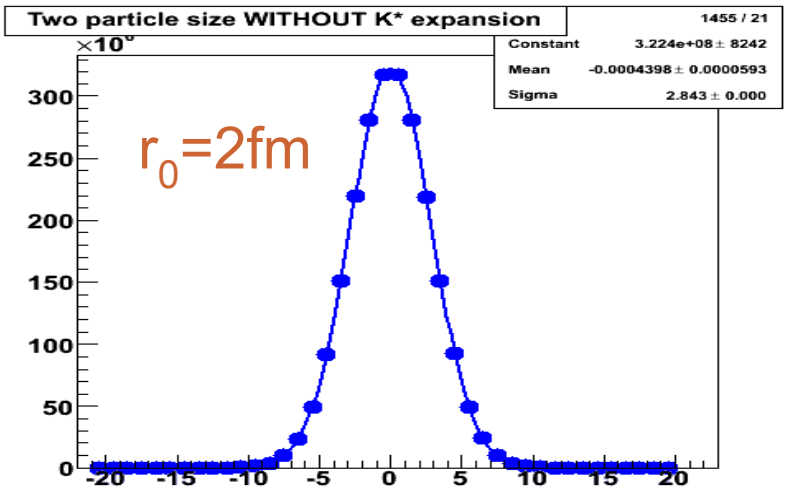
K+K-: Model&"Experiment"

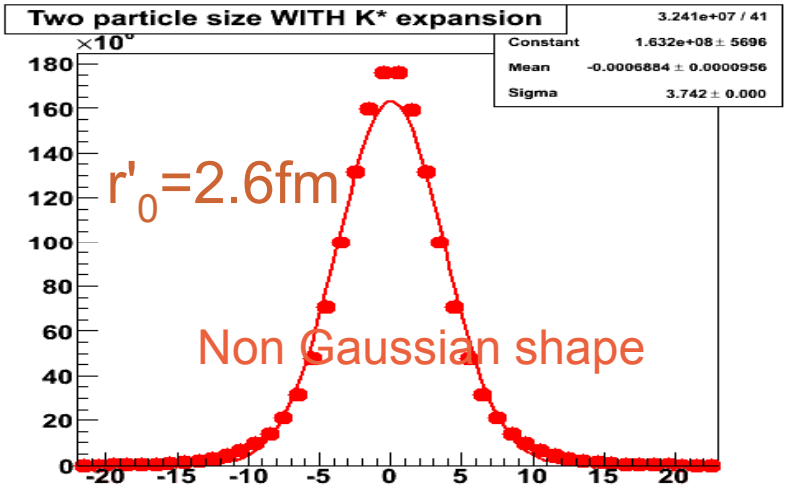




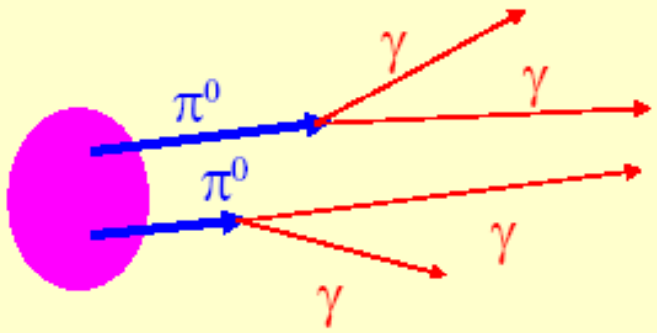
K+K-: K* “expansion”(2fm)







Example of residual correlations



} residual correlation

Distance between $\gamma_{\pi 0}$ ~10^7 fm

No γγ interference , but correlation due to π^0 π^0 interference

The correlation function of γγ-pair:

$$C(\gamma\gamma) = N_{real} * C(\pi\pi)/N_{mixed},$$

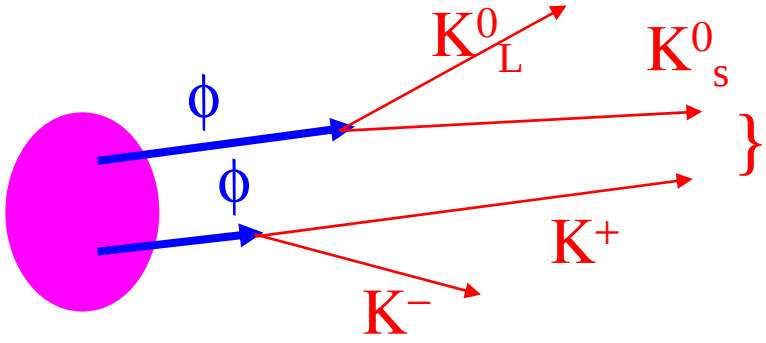
where $C(\pi\pi)$ is the correlation function of $\pi^0\pi^0$, N_{real} - the pair distribution for particle-pairs from the same event, and N_{mixed} is the corresponding distribution for pairs of particles taken from different events.

$C(\pi\pi)$ usually parametrized:

$$C(\pi\pi) = 1+\lambda_{\pi\pi}\exp(-Q_{\pi\pi}{}^2 r_{0\pi\pi}{}^2),$$

$\lambda_{\pi\pi}$ - correlation strength, $Q_{\pi\pi}$ - invariant relative momentum, $r_{0\pi\pi}$ - source size

residual correlations for kaons



} residual correlation

✔*Distance between* $K^0_s K^+$ *~20 fm*

No interference , no Coulomb

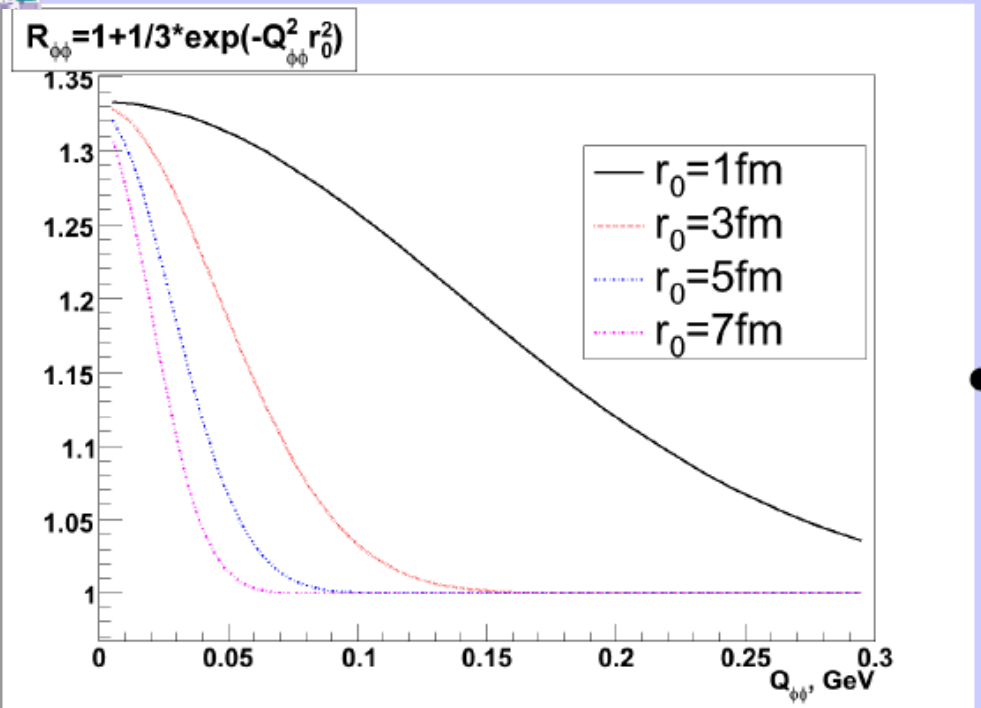
but correlation due to ϕϕ *interference*

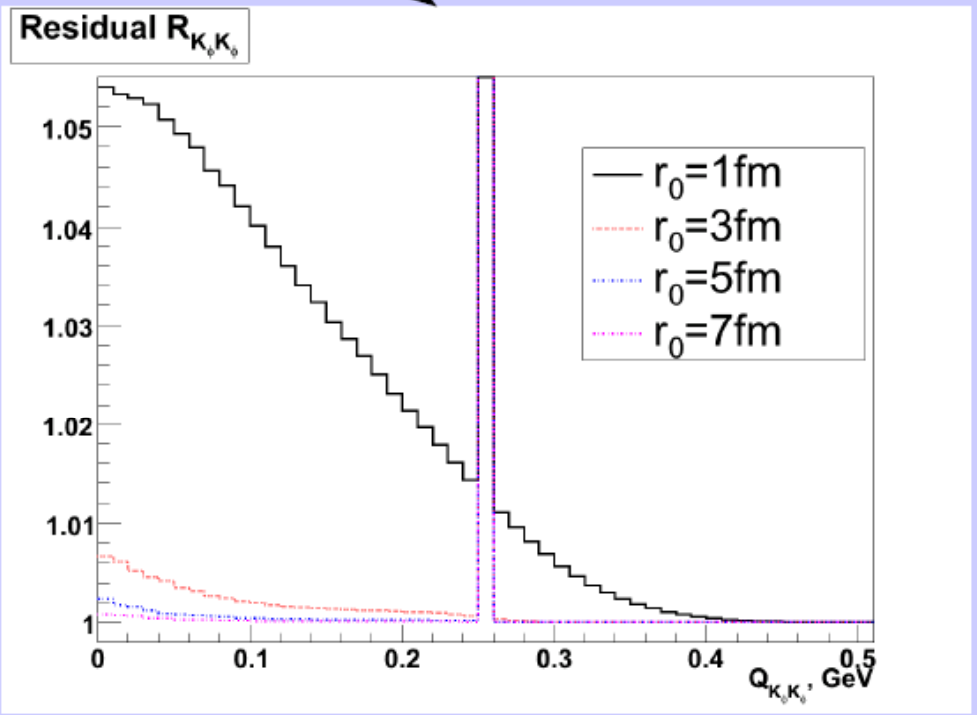
with the width corresponding

relatively small $r_{\phi\phi}$ *distance*

smearing by decay momentum

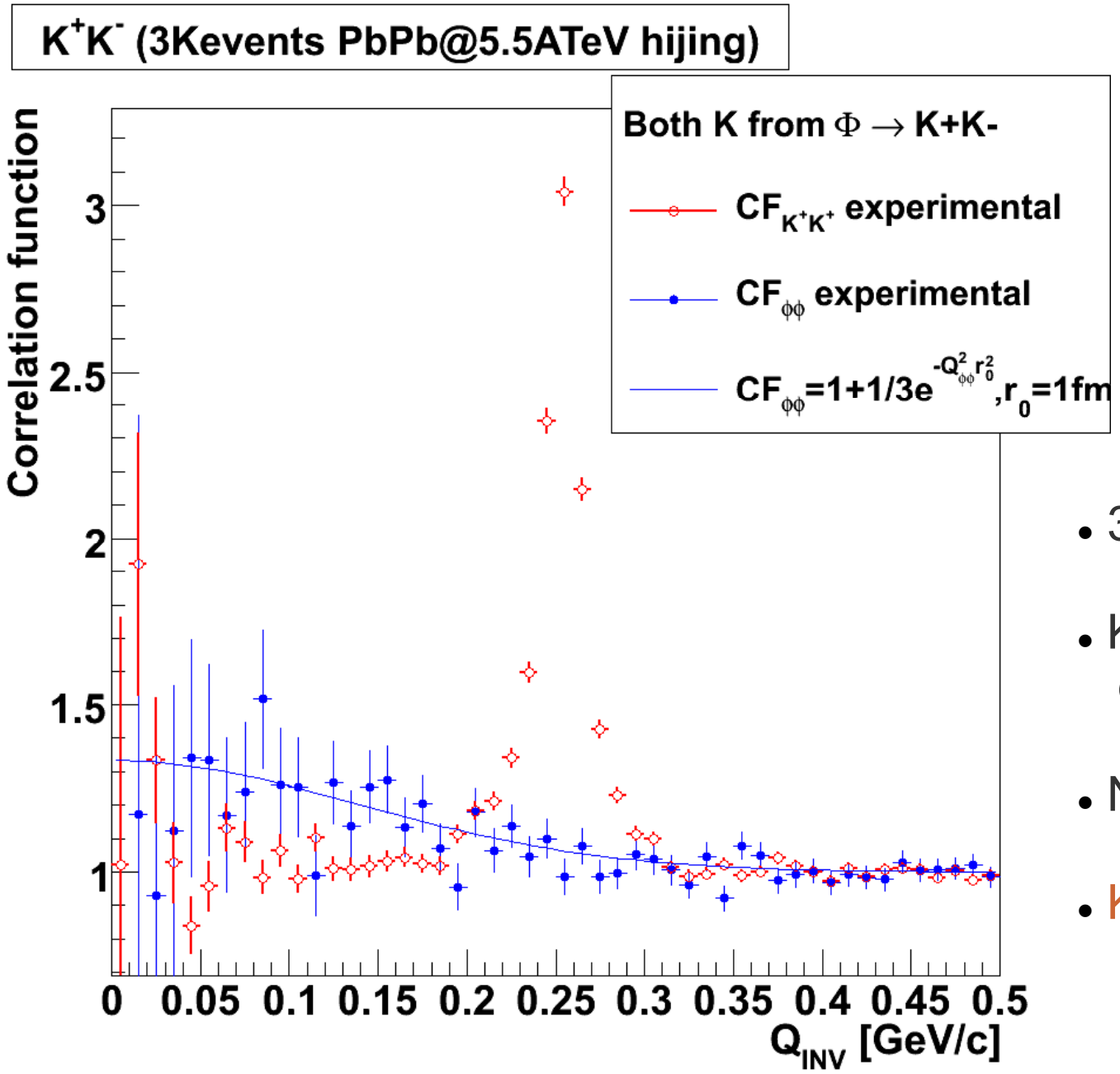
Residual correlations for $\phi\phi$ correlations





Residual correlations could be sensitive to small fraction of droplets.

ΦΦ residual CF in K+K-



- 3000 PbPb events
- Kaons only from K* decay
- Need More statistics
- $K^0K^{(+/-)}$ is better

Conclusion

1. There are several sources of the KK correlation function “distortion”:

   Single Kaon impurity, Resonances,Pair impurity, Splitting-merging,

   Residual correlations

2. K* expansion could be important for KK

3. Study of correlated background to be continued

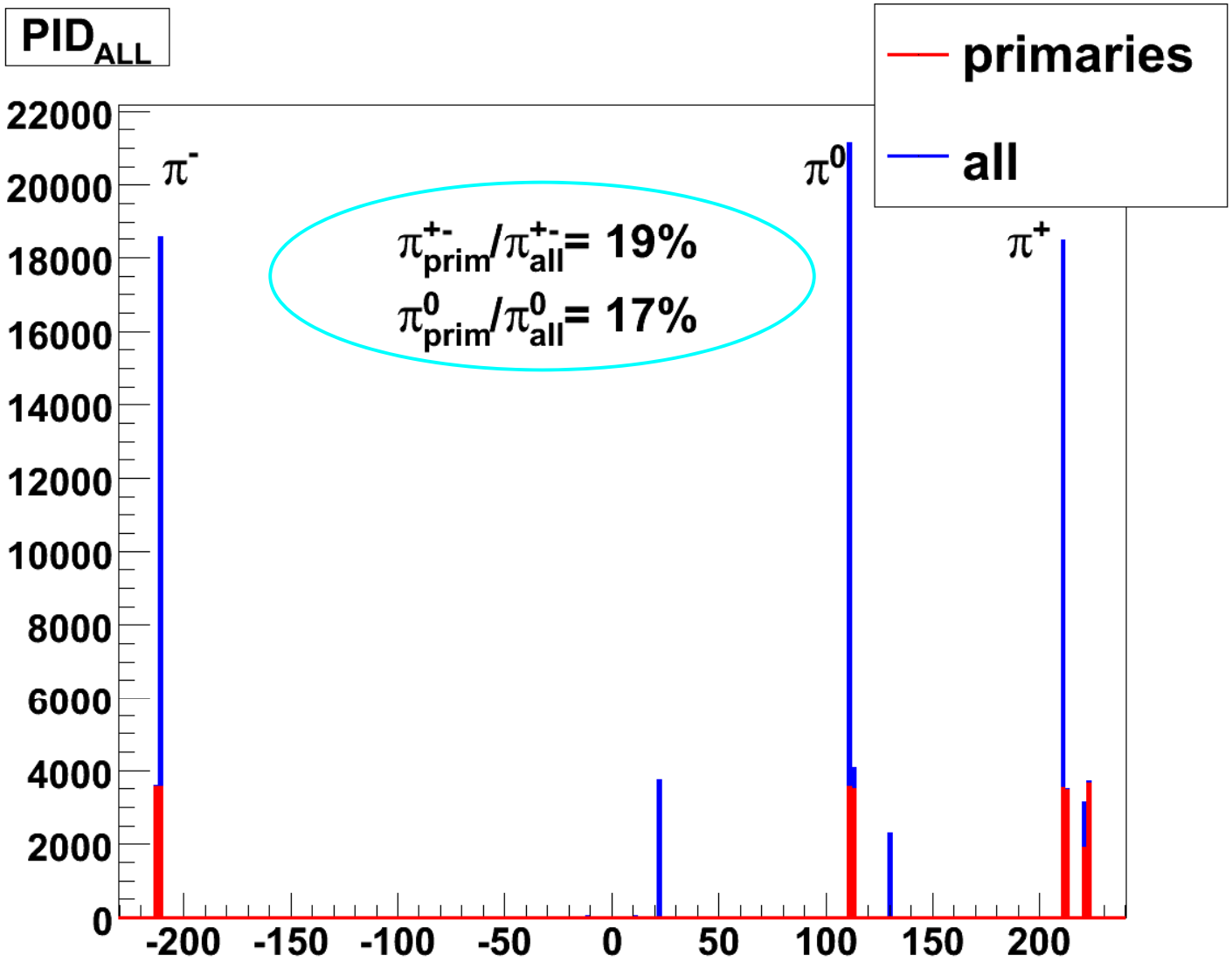
   (fake pairs!)

4. $K^0_S K^{+(-)}$ is for ΦΦ residual correlations?

Thank you for your attention!

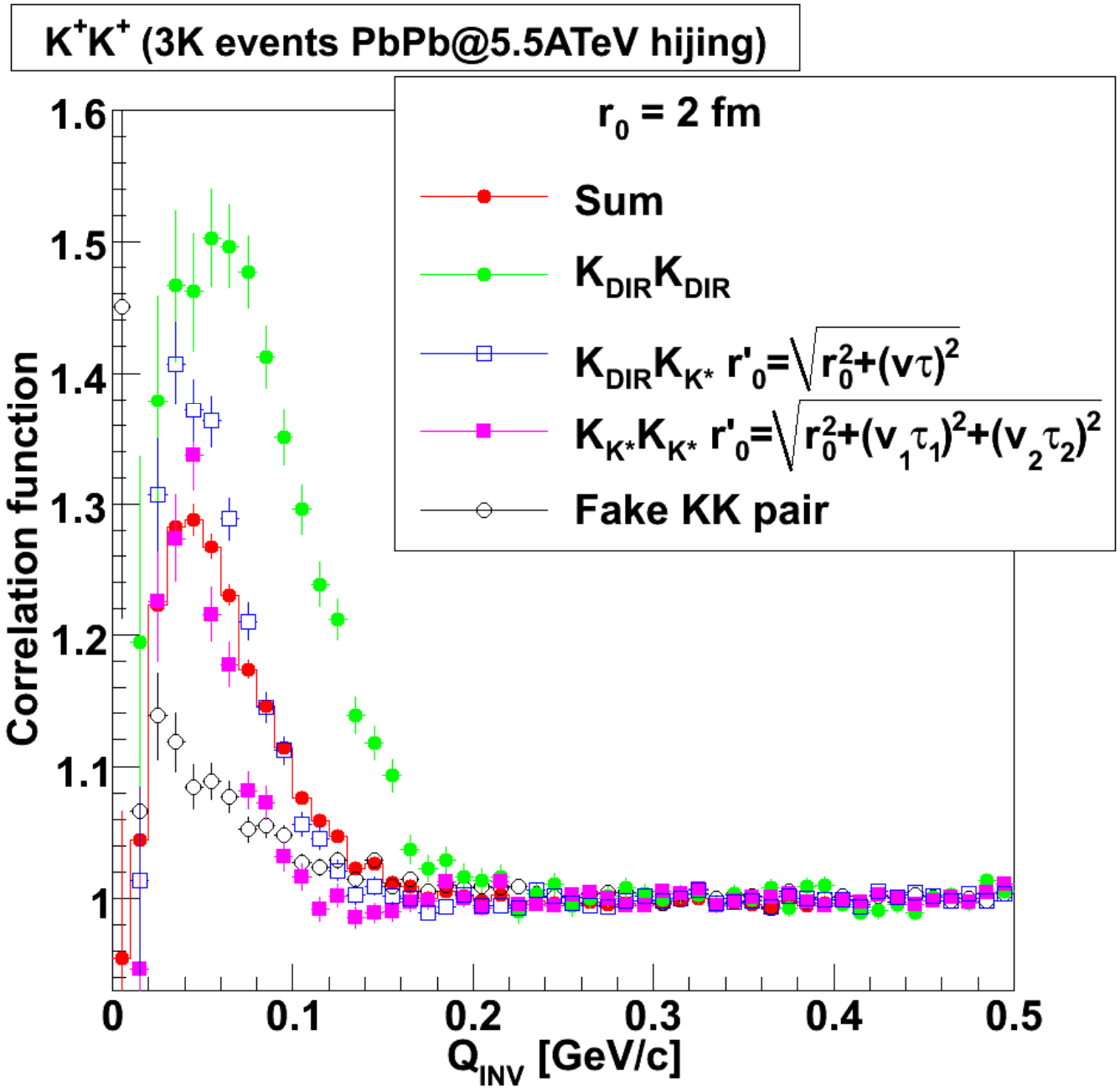
Extra Slides

π Mothers

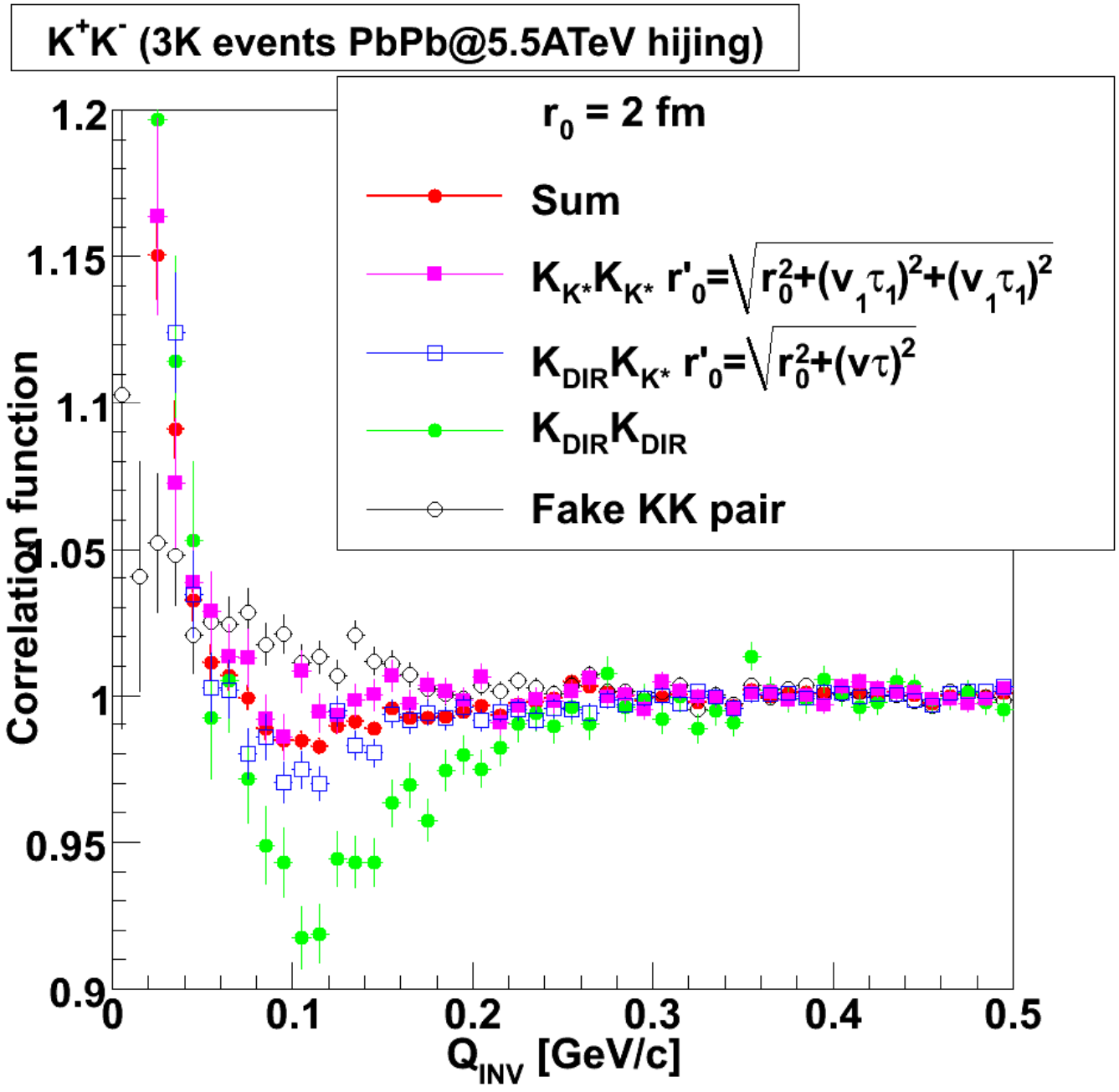


Resonances can play significant role for ππ correlations

K+K+:Different contribution



K+K-: Different contribution



- With K*
- Correlated background!!!

Extra Slides

Fake contribution to K+K+
Good KK: 57.9429
Fake KK : 42.0571
pi+K+ : 27.2202
pi+pi+ : 3.57522
pK+ : 3.3108
e+K+ : 4.3075
mu+K+ : 1.12317
pi+e+ : 0.999998
ppi+ : 0.71421
others : 0.733494