宇宙史実習最終報告

2013 . 9. 27

Naoto Tanaka

HBT(Femtoscopy)

- **HBT(Hanbury Brown & Twiss effect)**
  - we can see the source size by measuring intensity of interference between two identical particles .

Wave function $$\psi = \frac{1}{\sqrt{2}}(e^{ip_1(x_1-r_1)}e^{ip_2(x_1-r_2)} \pm e^{ip_1(x_1-r_2)}e^{ip_2(x_2-r_1)})$$

Correlation function $$C_2 = \frac{P_{12}(p_1,p_2)}{P_1(p_1)P_2(p_2)}$$

$$= 1 + |\tilde{\rho}(q)|$$

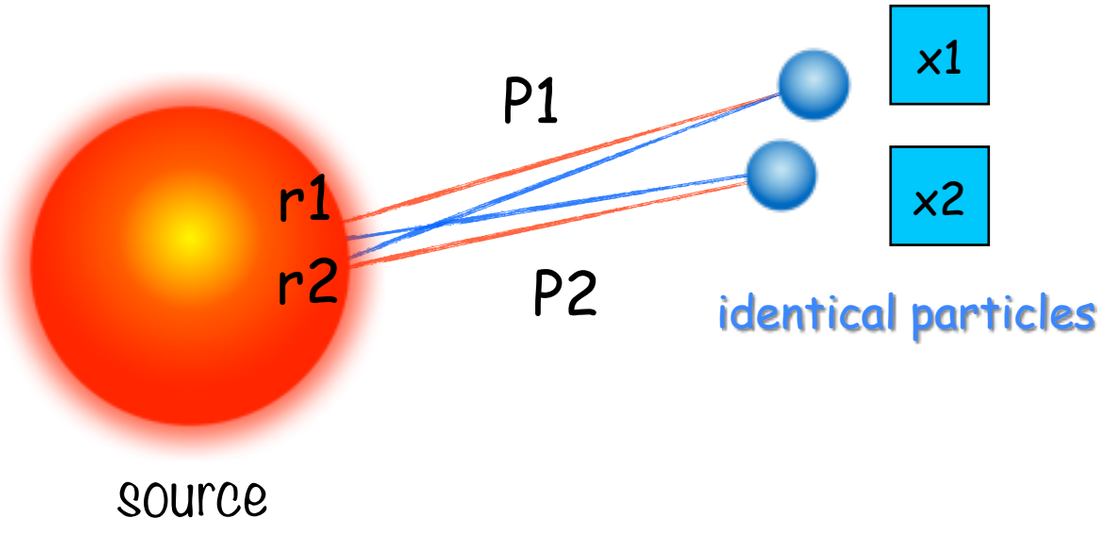
$\tilde{\rho}$: Fourier transform ρ : density

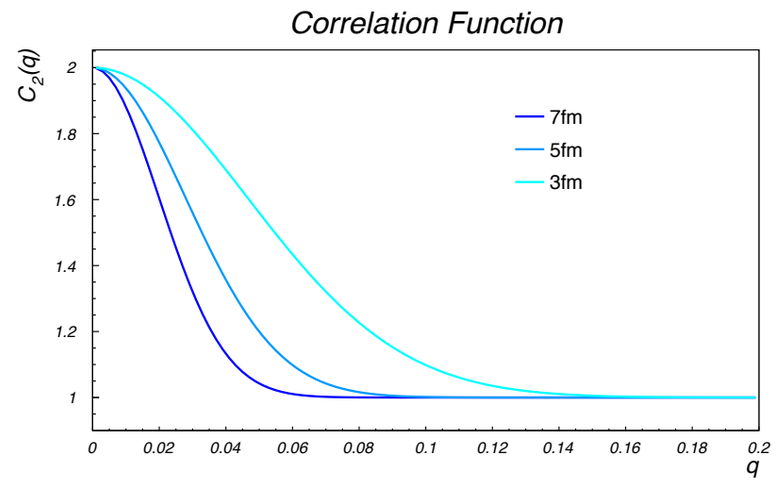
Assuming Gaussian Source

$$C_2(q) = 1 + \lambda \exp(-R^2 q^2)$$

R : Source Size

λ : Chaoticity parameter



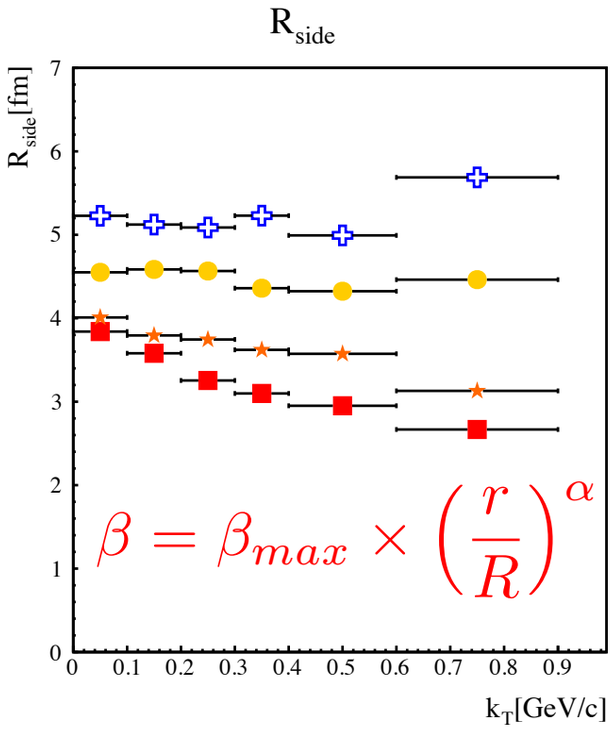


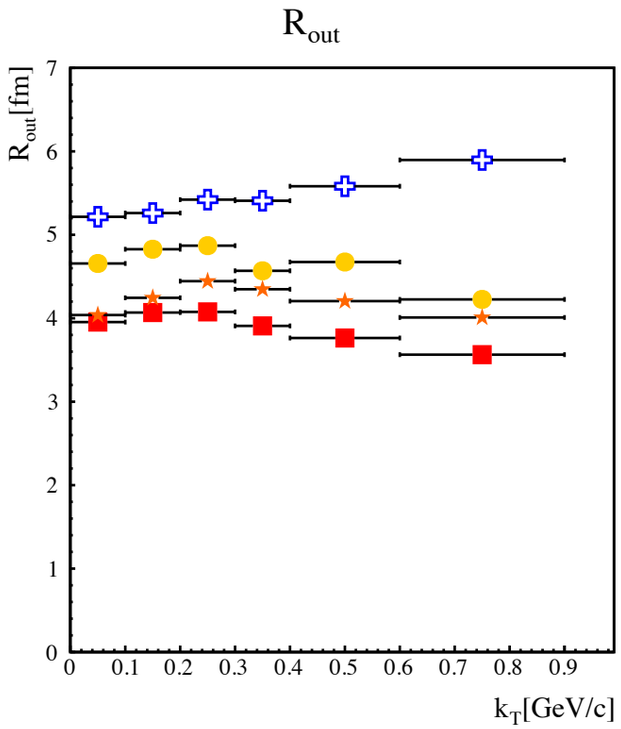
kT dependence

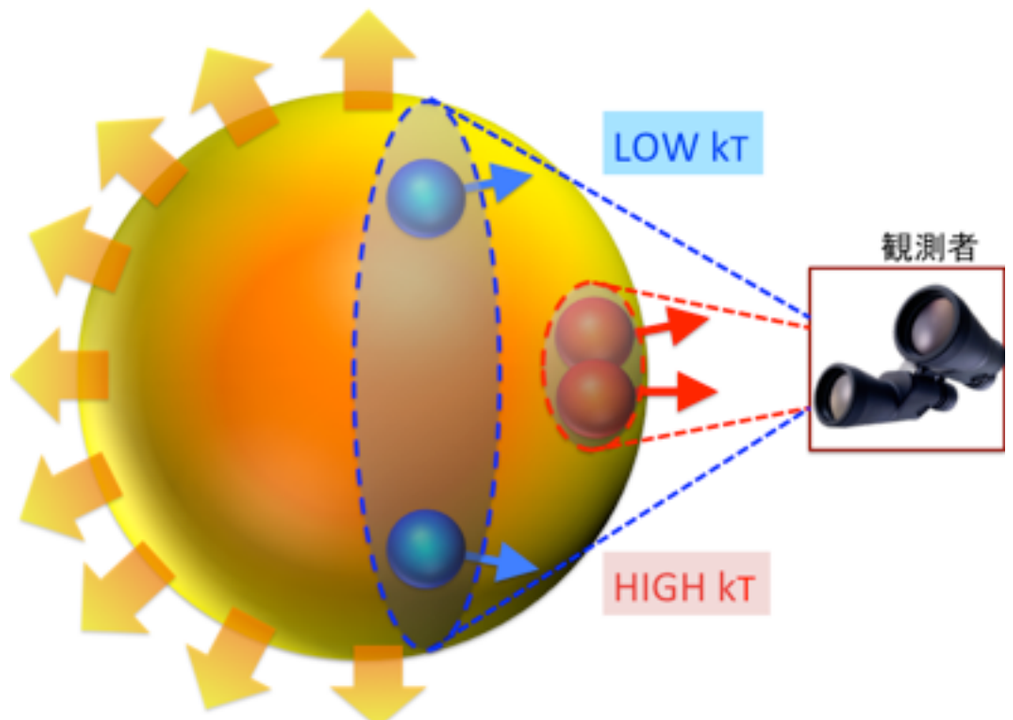
- HBT in expanding source?

$$\overrightarrow{k_T} = \frac{\overrightarrow{p_{T_1}} + \overrightarrow{p_{T_2}}}{2}$$

  - static source : HBT radius = Full source size
  - expanding source : HBT radius ≠ Full source size
  - Radial flow effect : β = βmax (r/R)

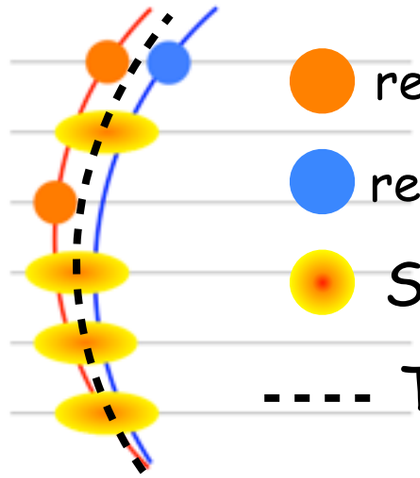






Two track resolution

- **Track splitting**
  - One track is falsely reconstructed as two tracks that are spatially close.



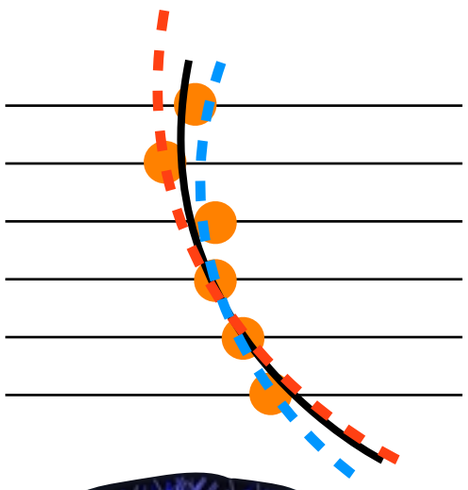
reconstruction point as particle 1

reconstruction point as particle 2

Shared TPC pad

---- True track

- **Track merging**
  - Two tracks that are spatially very close are falsely reconstructed as one



—— Reconstructed track

---- True track 1

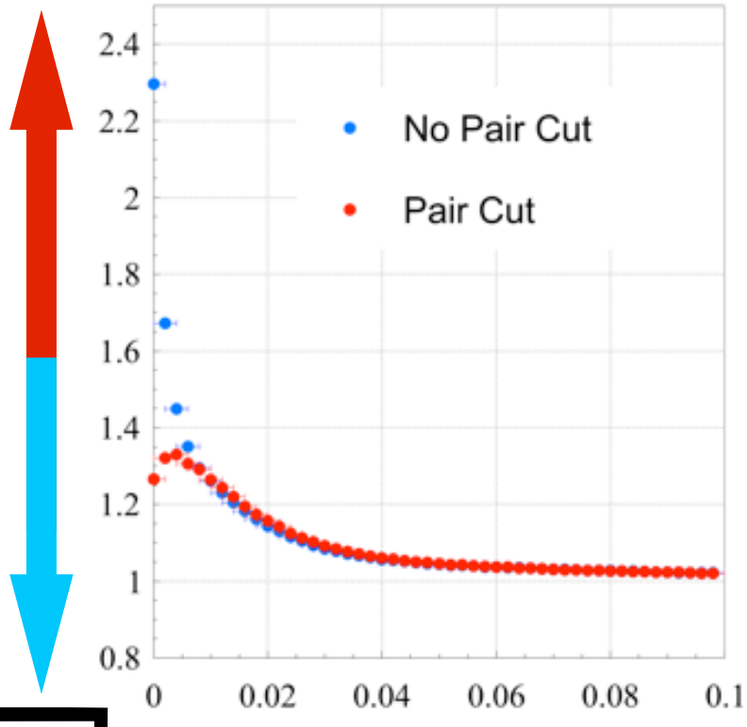
---- True track 2

enhance

- cased by splitting

suppress

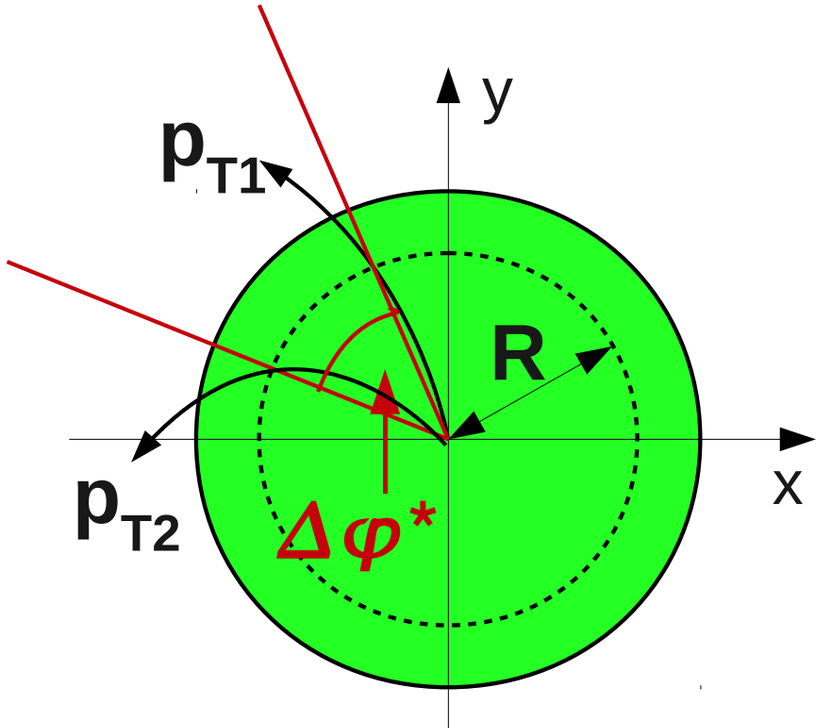
- cased by merging



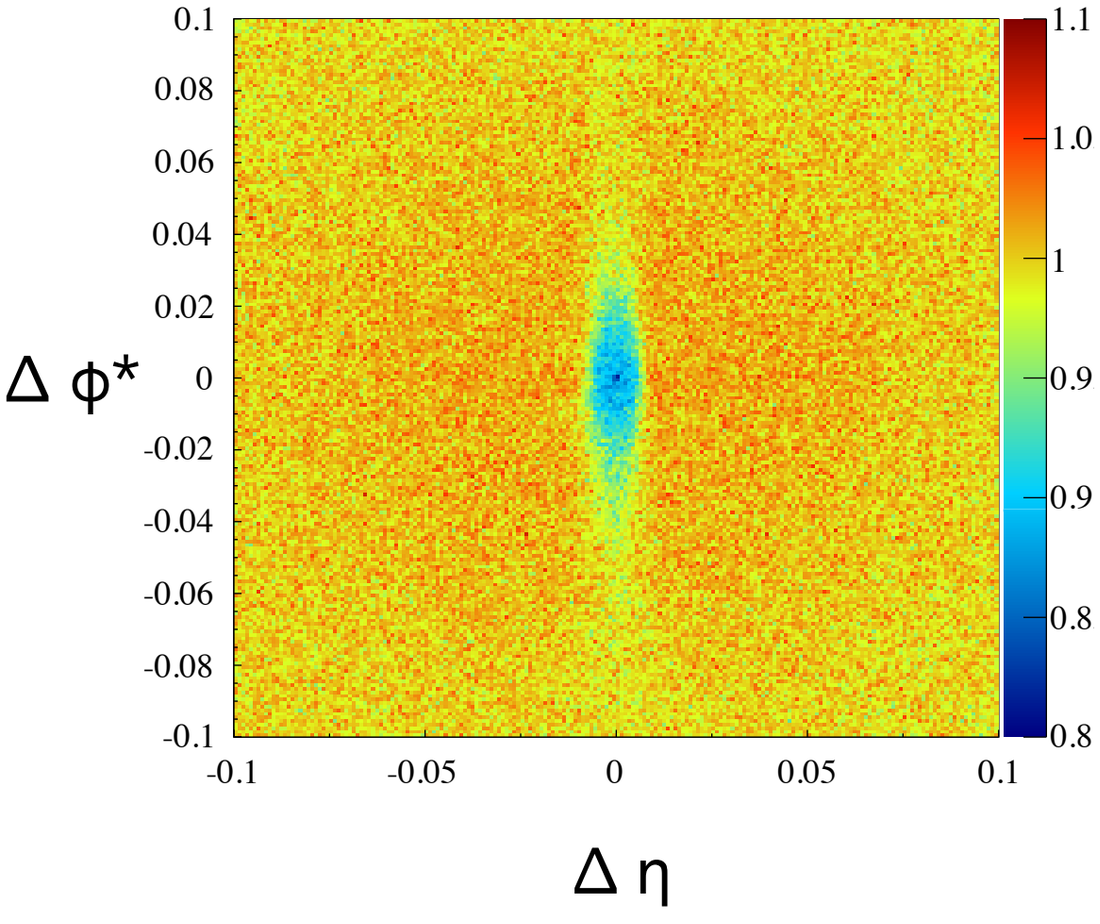
- Δφ*Δη distribution
- Fraction of Shared TPC clusters
- Quality factor

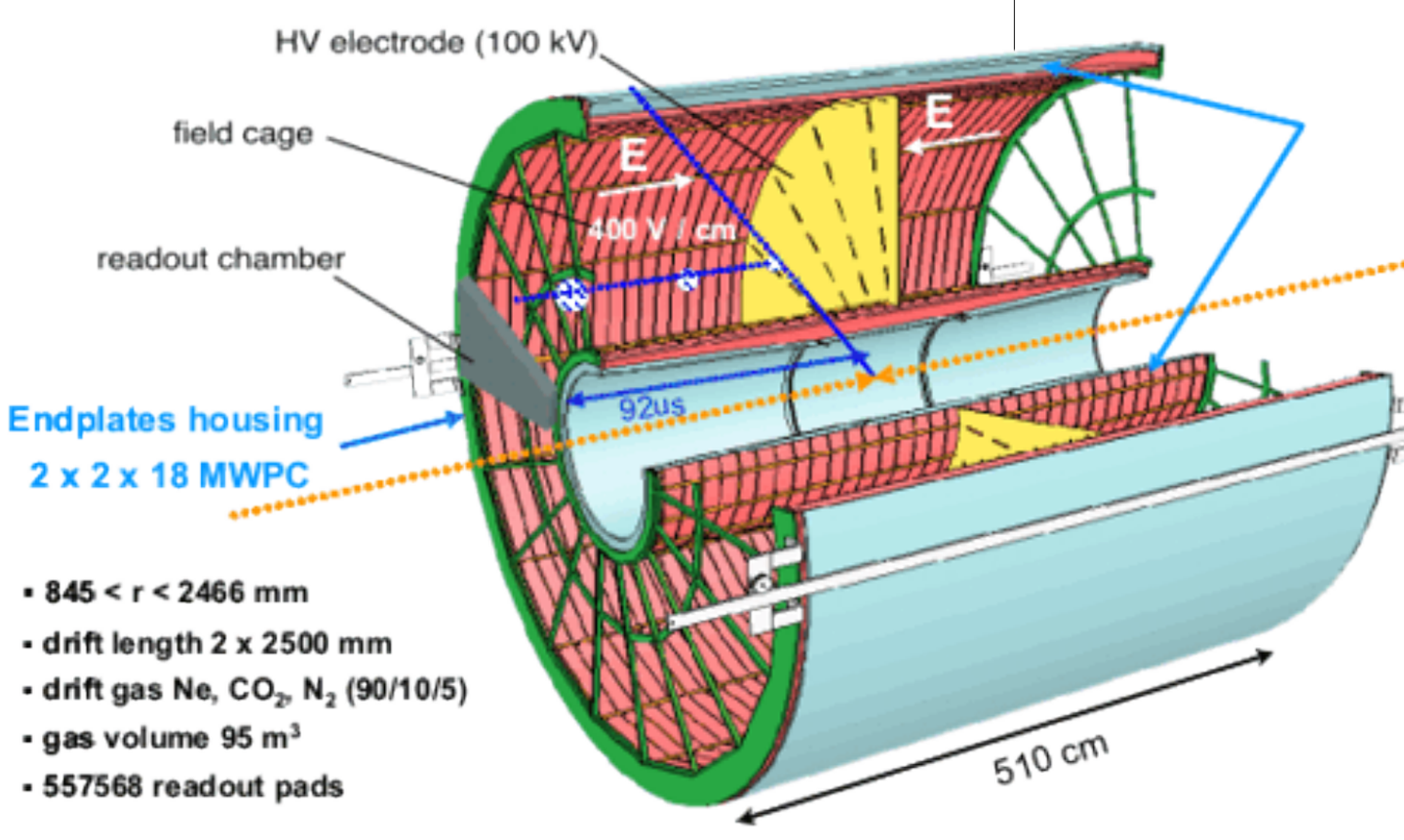
Δφ* v.s. Δη in various Angular Distance inside TPC

$$\Delta\phi* = \phi 1 - \phi 2 + \sin^{-1}\left(\frac{Z_e \cdot B_z \cdot R}{2p_{T1}}\right) + \sin^{-1}\left(\frac{Z_e \cdot B_z \cdot R}{2p_{T2}}\right)$$



- kT Dependence
- Angular distance Dependence

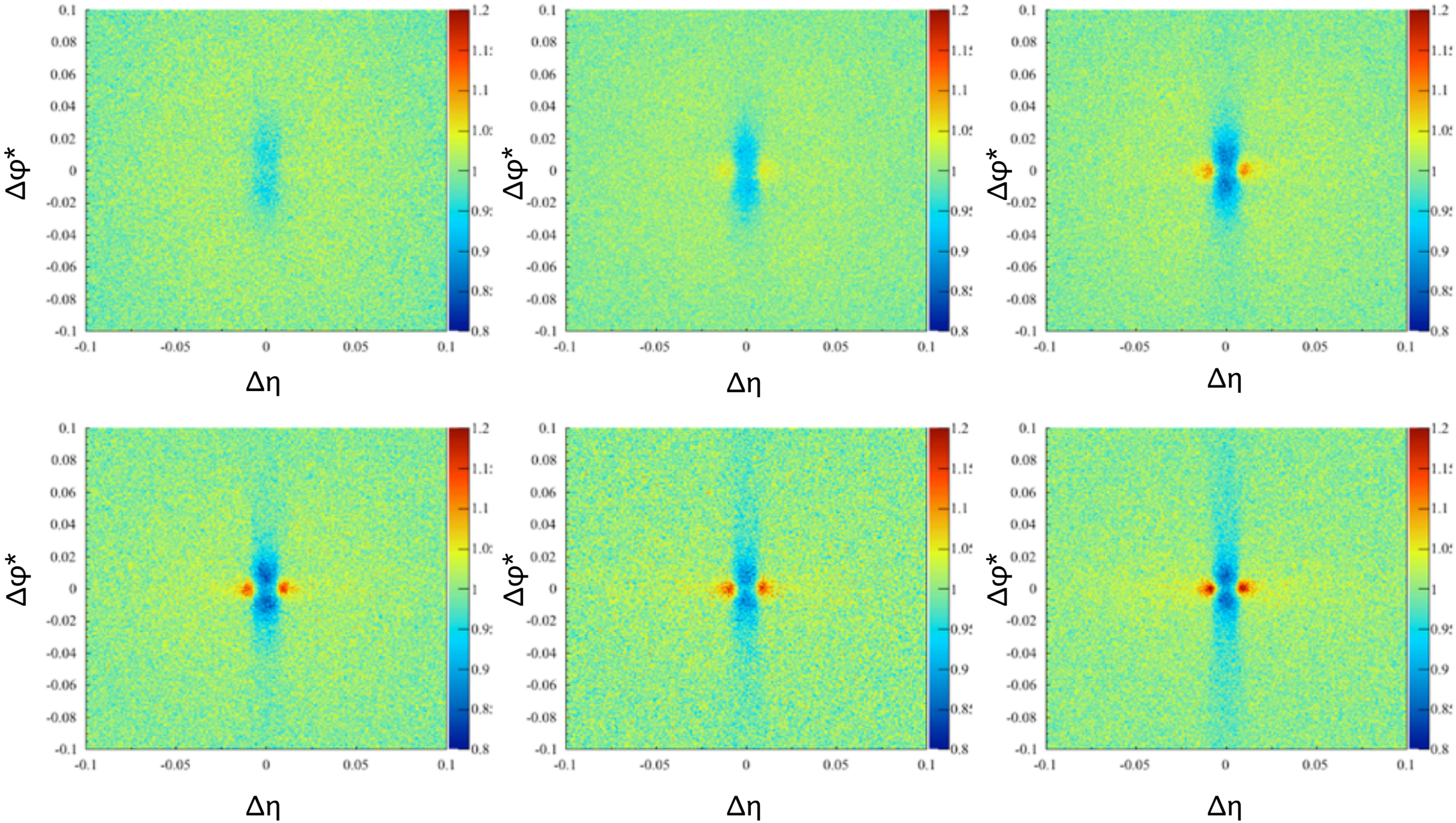




Δφ* v.s. Δη in Angular Distance 1.1m

- kT Dependence
- Angular distance Dependence

- R = 1.1 [m]



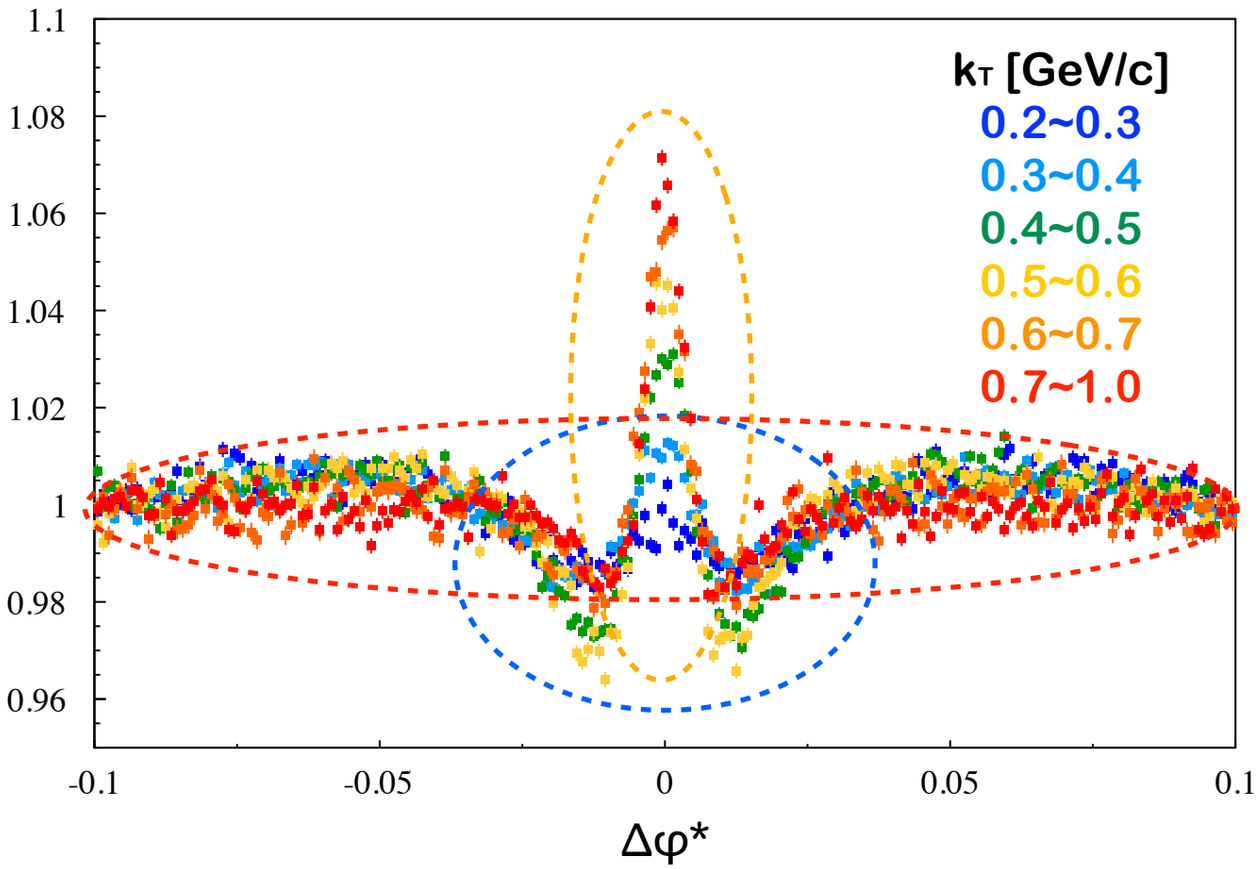
Δφ* v.s. Δη in Angular Distance 1.1m

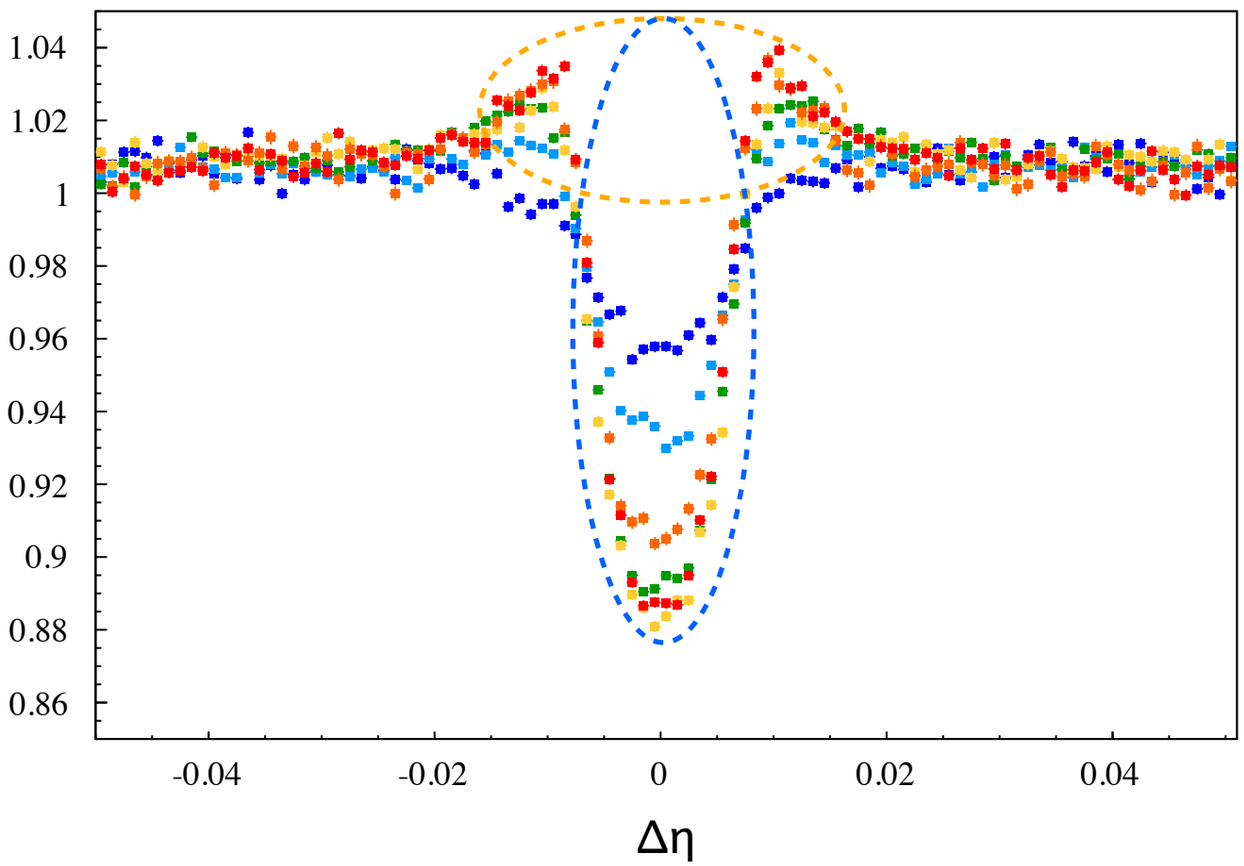
- kT Dependence
- Angular distance Dependence

- R = 1.1 [m]

Ghost track + Track merging + Physics effect (something like Jet)

- Pair cut
  - -|Δφ*| < 0.1 && |Δη| < 0.03 ??
  - -Optimization of Paircut



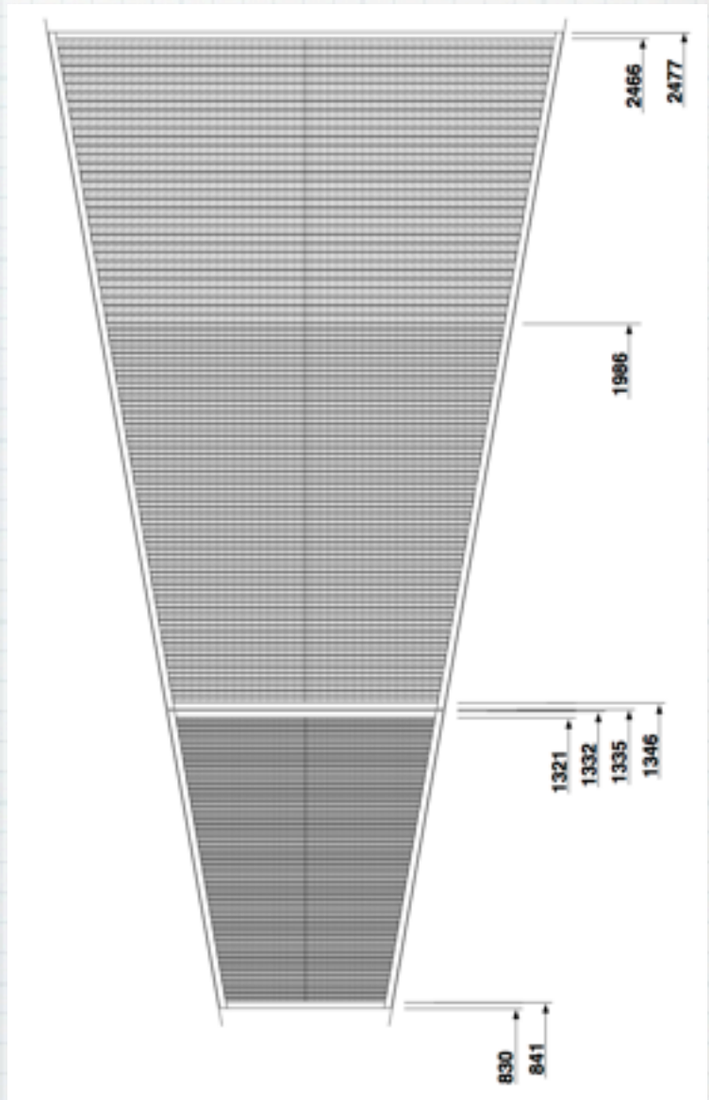


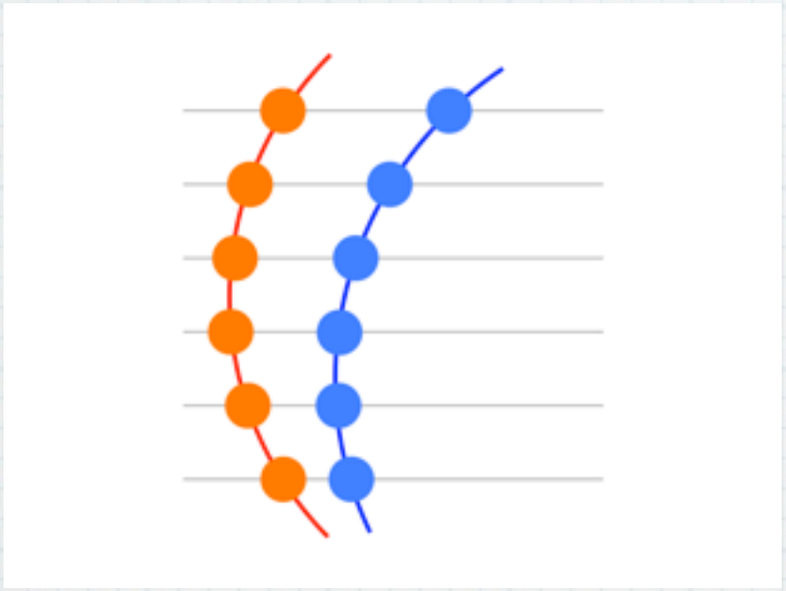
Fraction of Shared TPC Cluster

* **two track quality factor**

$$Sharity = \frac{\Sigma sh_i}{N_{hits}}$$

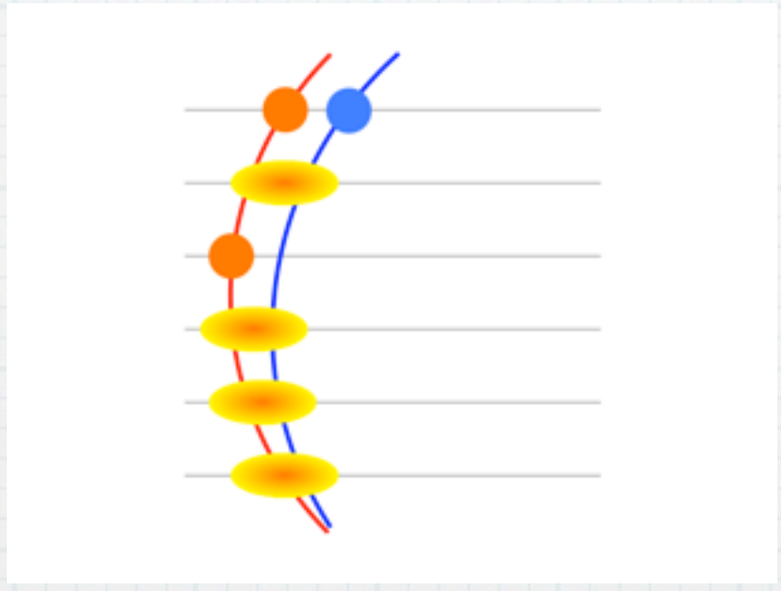
TPC
- 3D track reconstruction
- 18 Segment × 150 rows
- Precise PID via dE/dx
- Measure momentum





Separate tracks

Sharity = 0.0



Probably split track

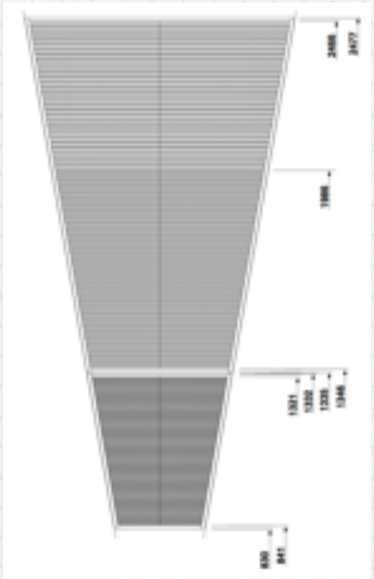
Sharity = +0.73

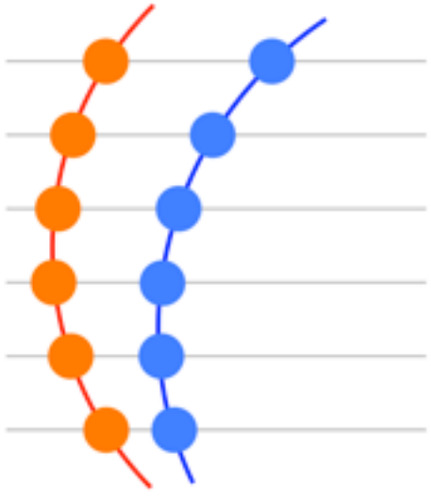
Qfactor

$$Quality = \frac{\Sigma q_i}{N_{hits}}$$

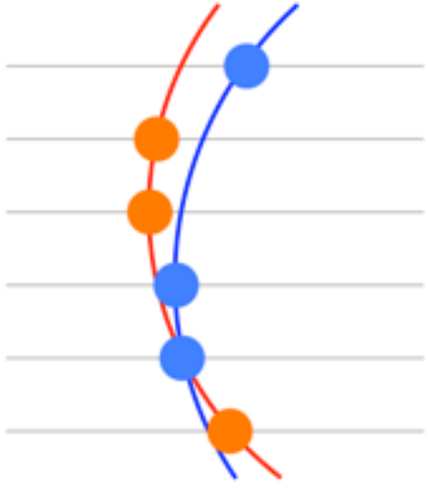
* Qfactor(two track quality factor)

q_i = -1 if both tracks have a hit in padrow
0 if none of the tracks have a hit in padrow
+1 if only one track has a hit in padrow or a hit is shared

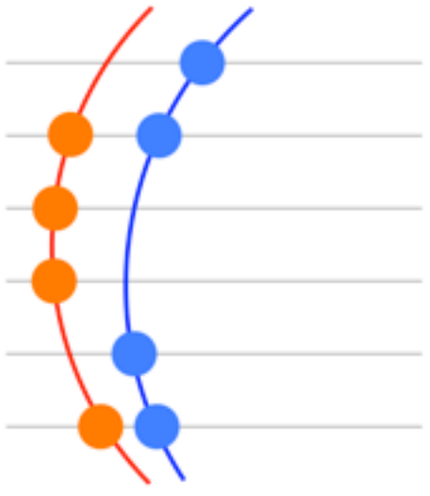




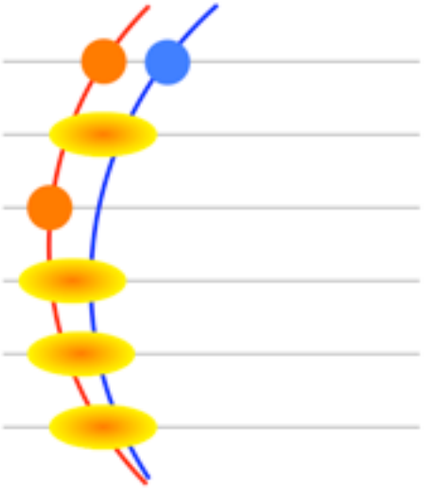
Separate tracks
Quality = -0.5



Probably split track
Quality = +1.0

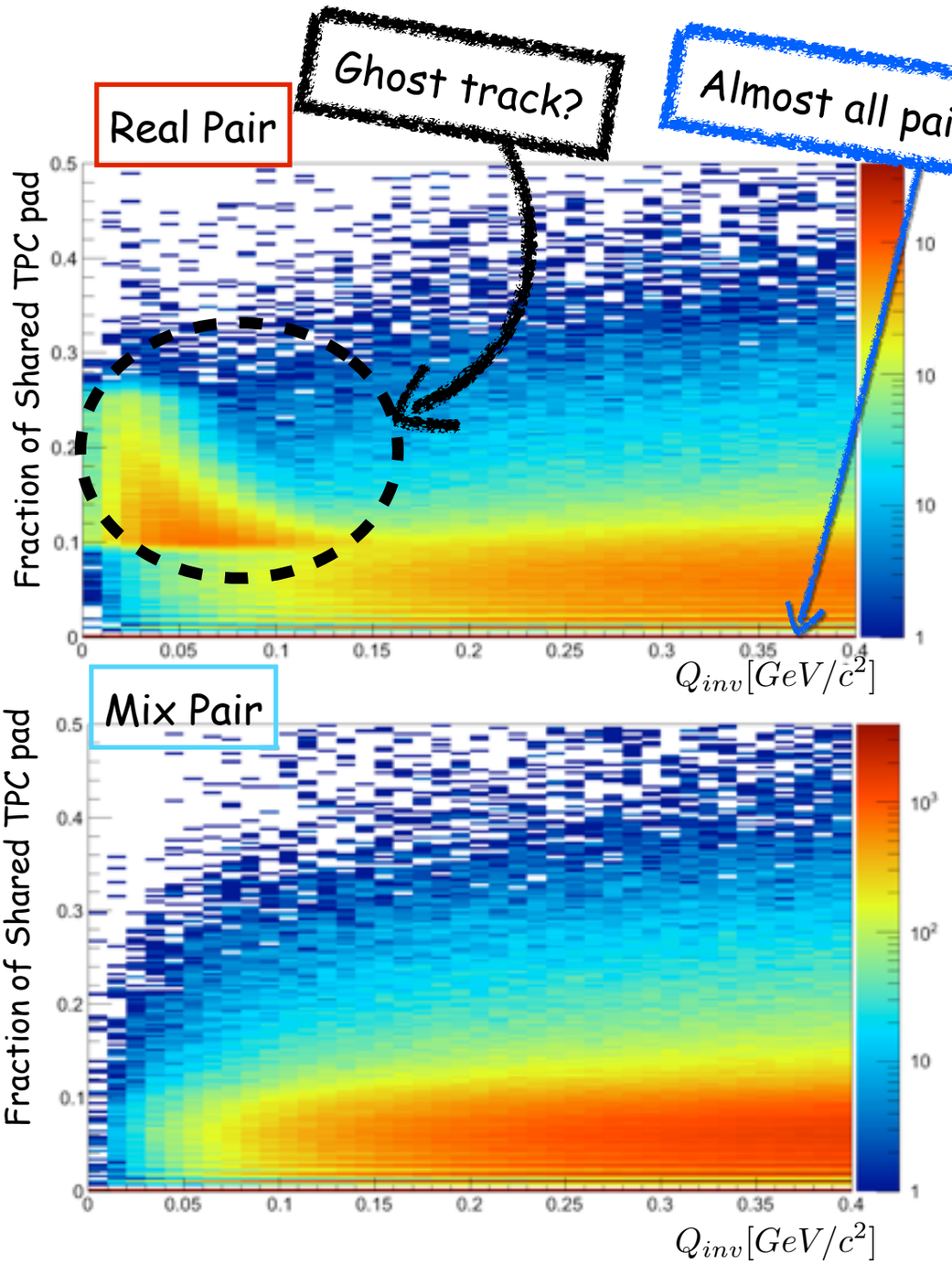


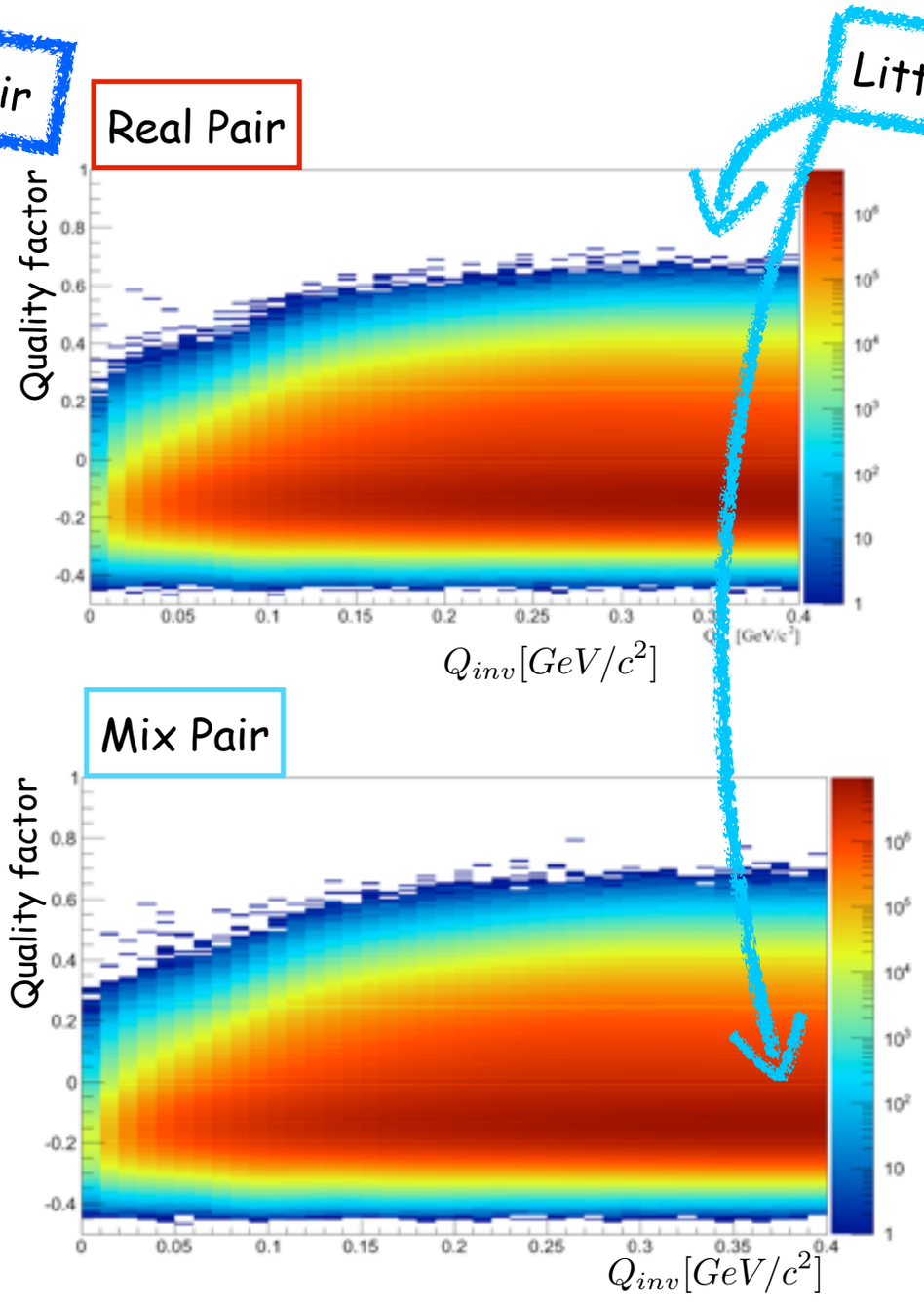
Probably separate track
Quality = -0.125



Probably split track
Quality = +0.36

Two track resolution



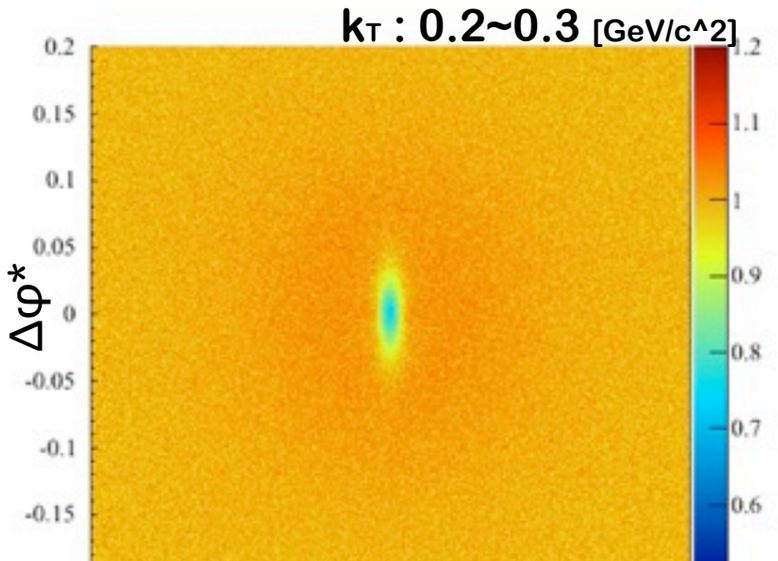


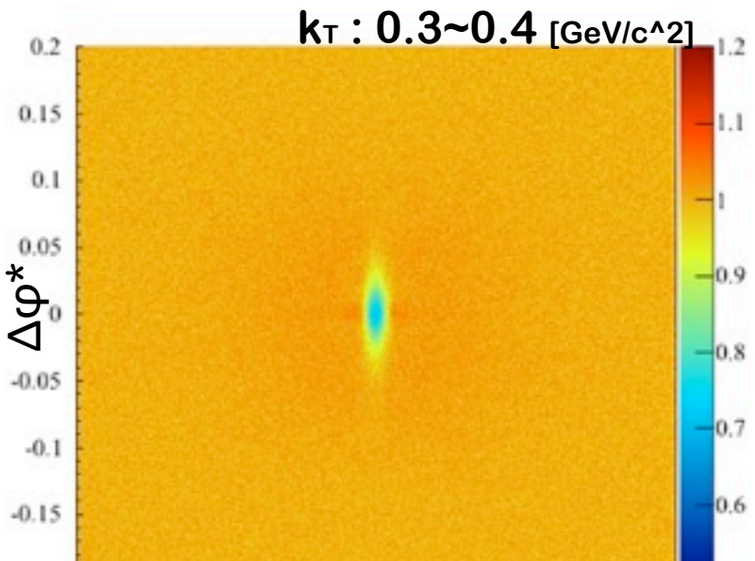
- Fraction of Shared TPC cluster < 0.05
- Quality factor < 0.5

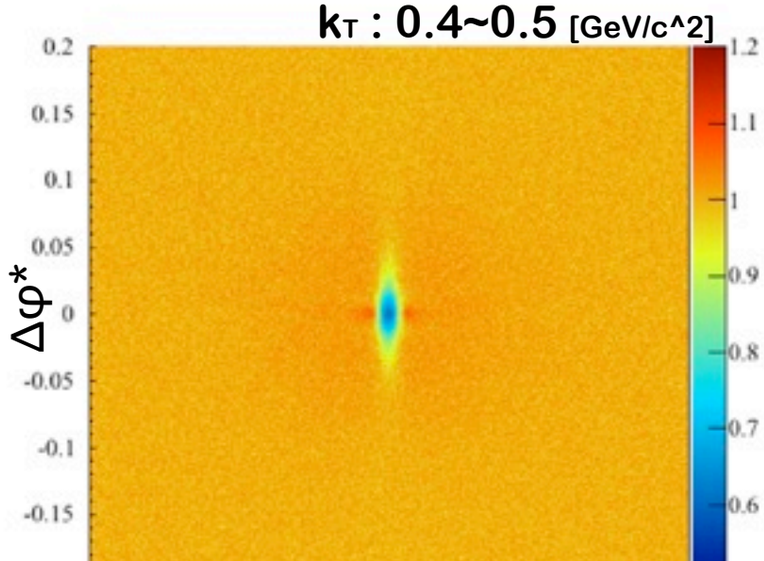
Δφ* v.s. Δη in Angular Distance 1.1m

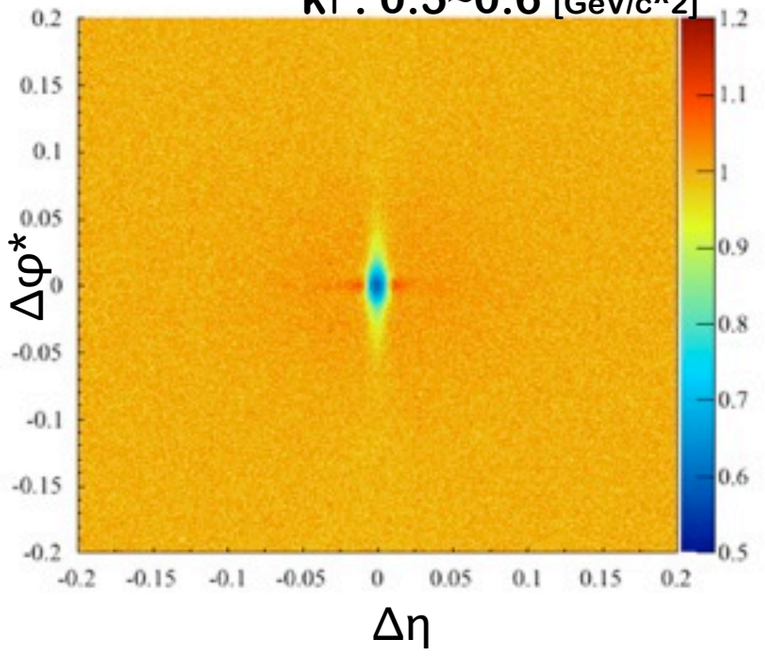
- kT Dependence
- Angular distance Dependence

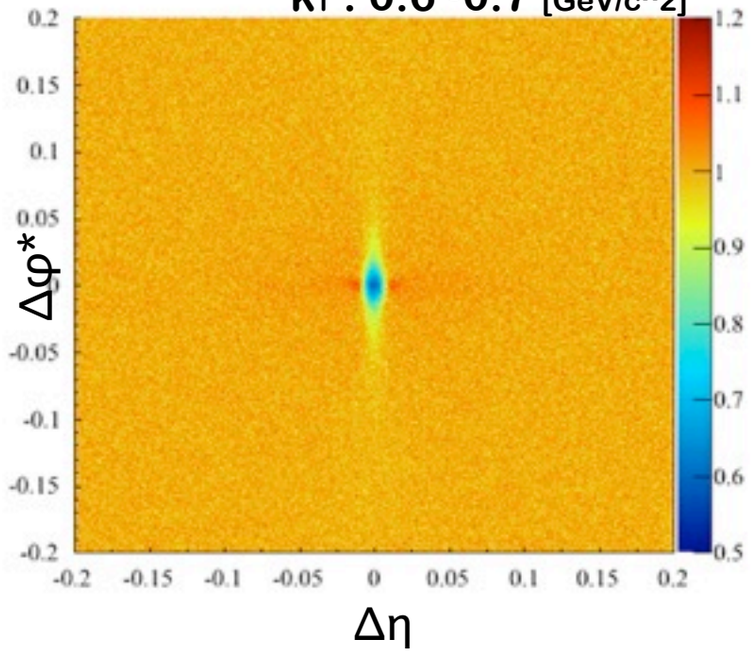
- After Qfactor and Sharity cut
- R = 1.1 [m]

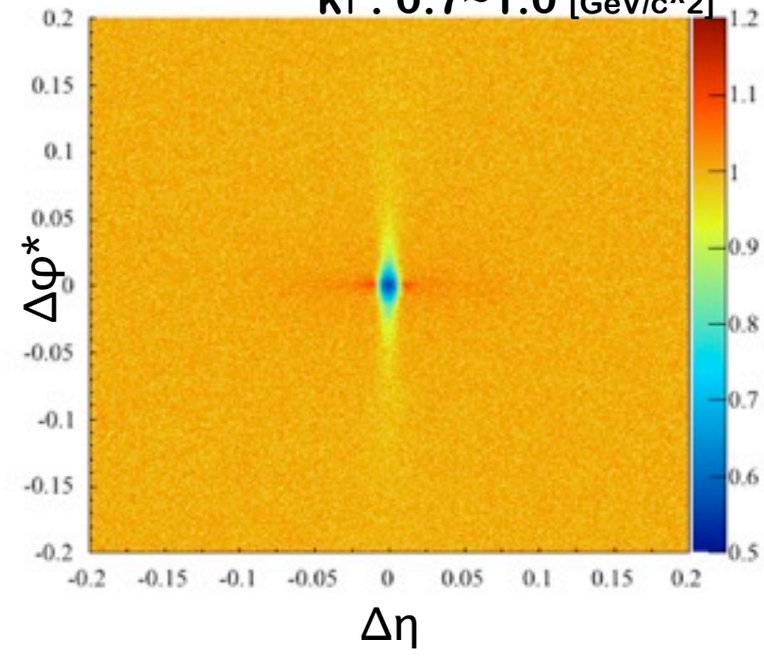




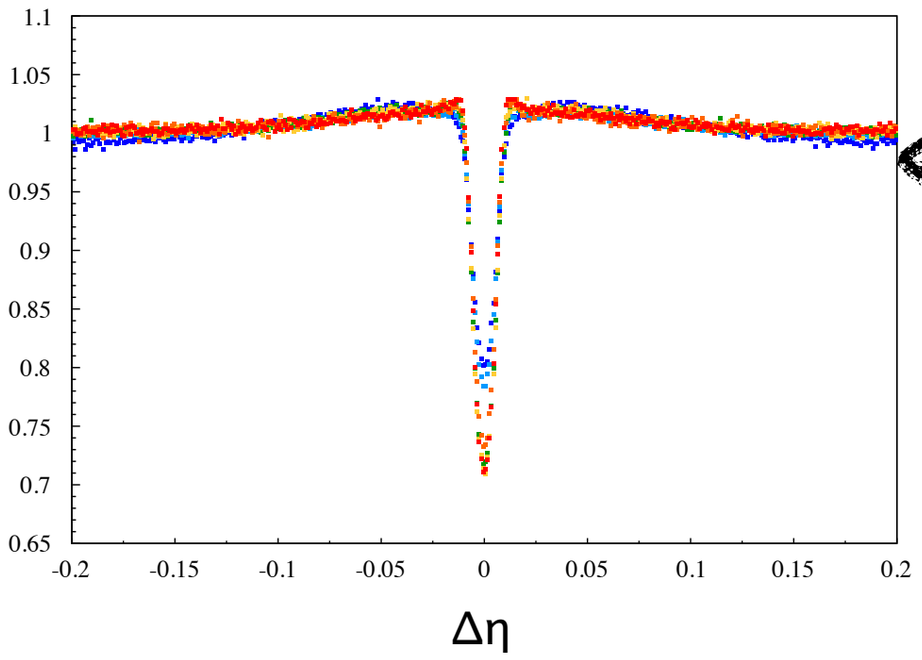




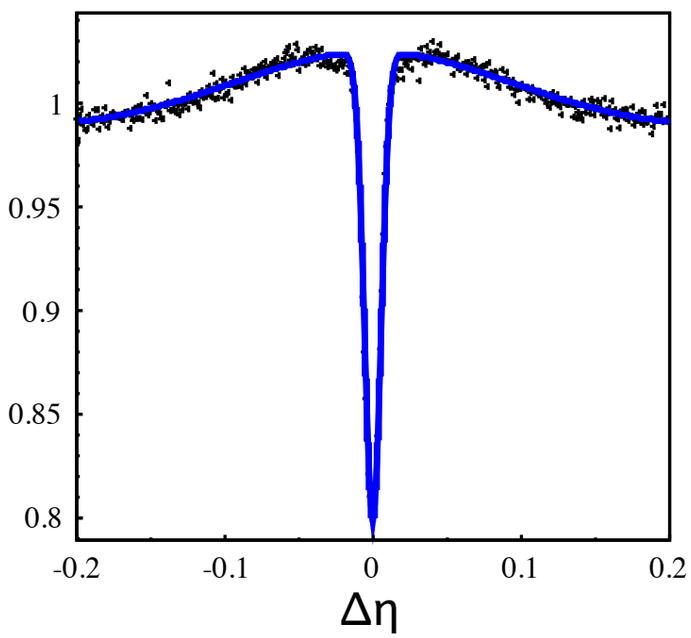




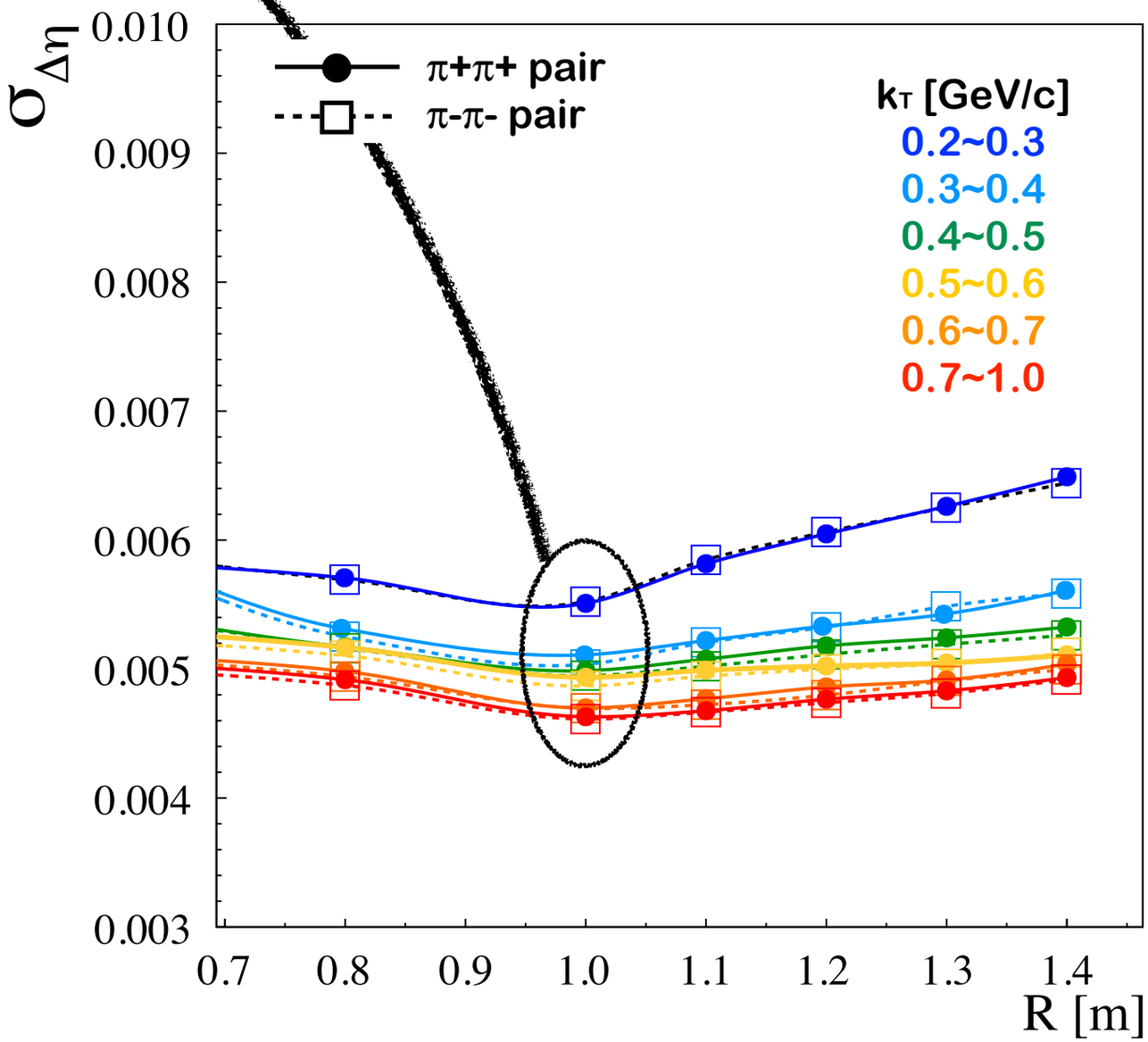
Δφ* v.s. Δη in various Angular Distance inside TPC



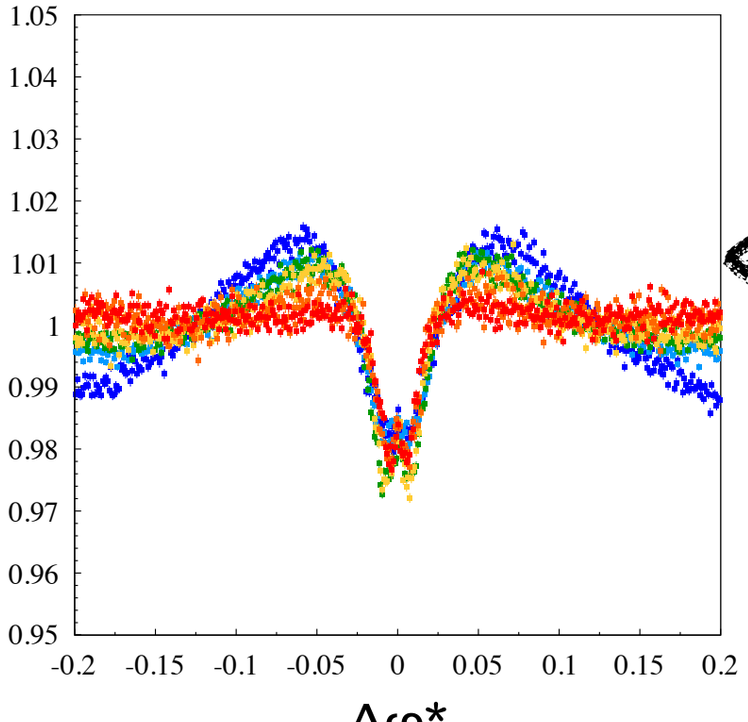
- Projection φ* : -0.02 ~ 0.02
- Double gaussian fit



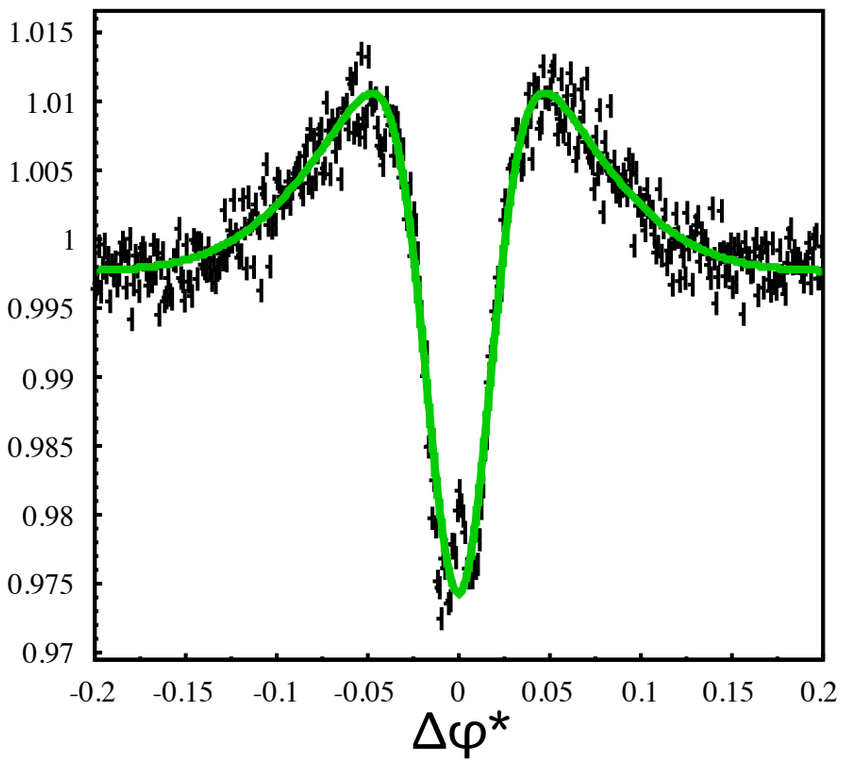
- Double gauss analysis
  - -positive gauss has Physics message I think
    - kT dependence is weak, of course
  - -negative gauss cased by track merging



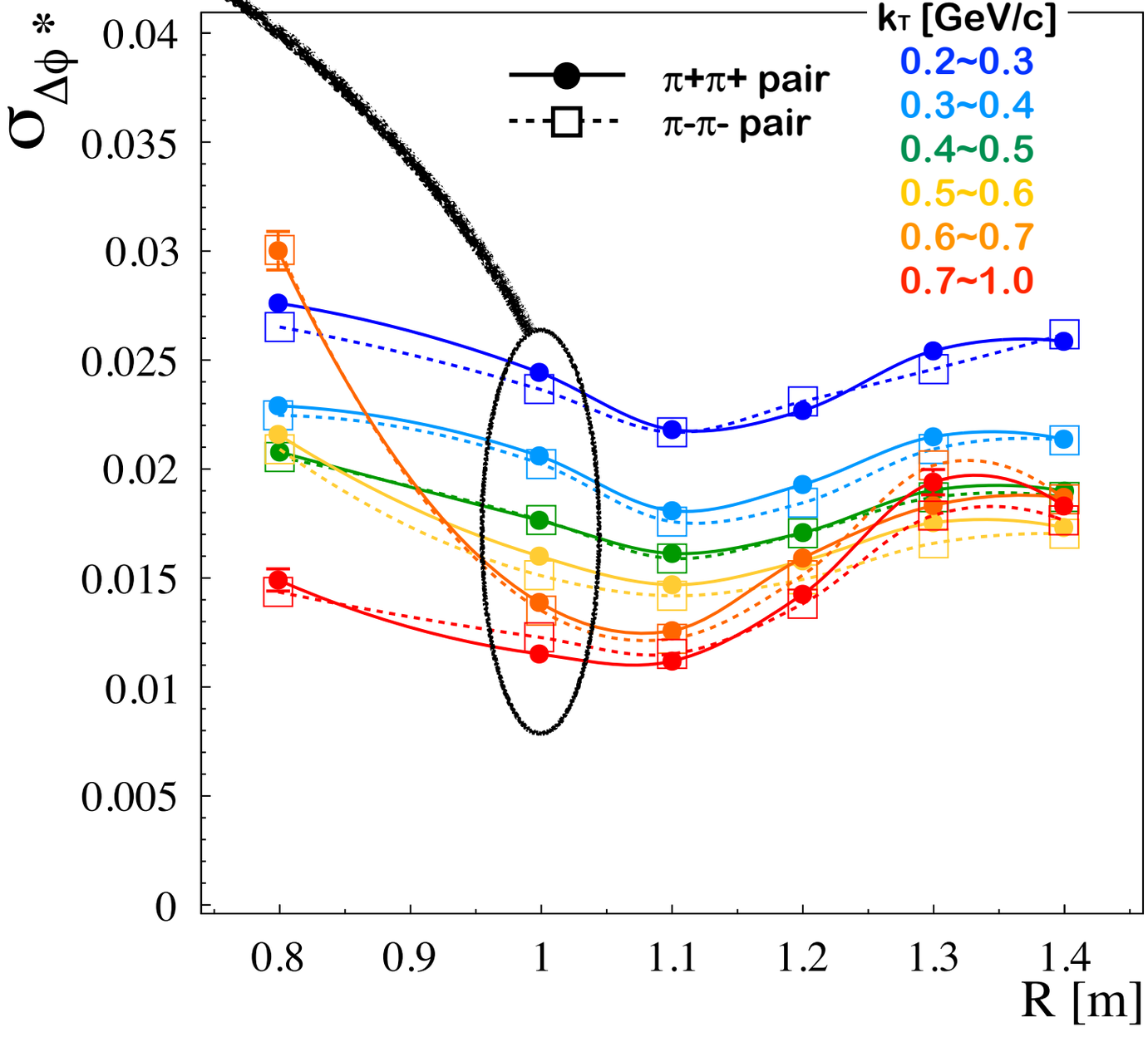
Δφ* v.s. Δη in various Angular Distance inside TPC



- Projection η : -0.02 ~ 0.02
- Double gaussian fit

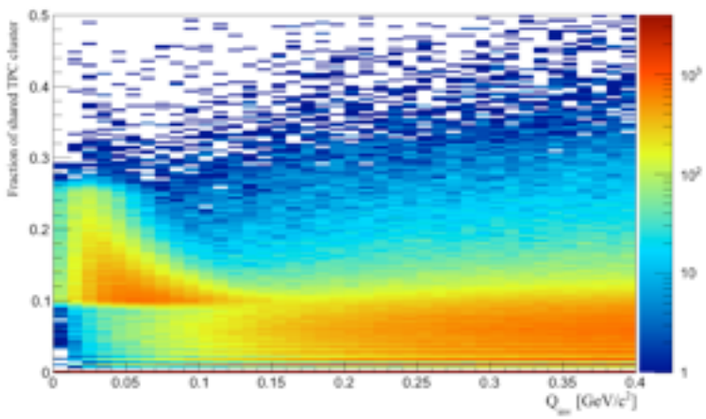


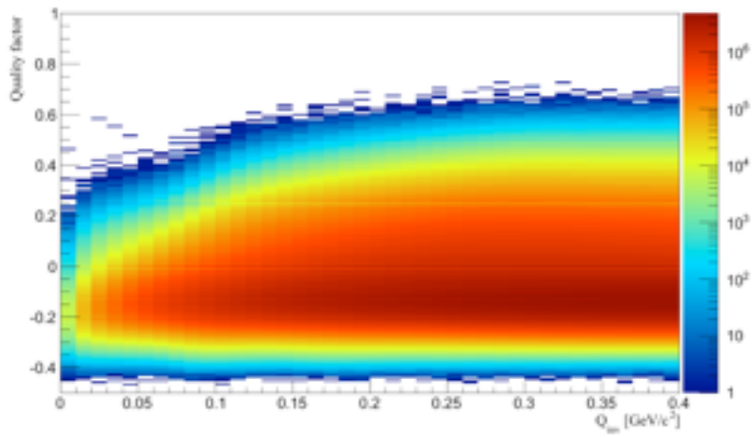
- Double gauss analysis
  - -positive gauss has strong kT dependence
  - -negative gauss cased by track merging

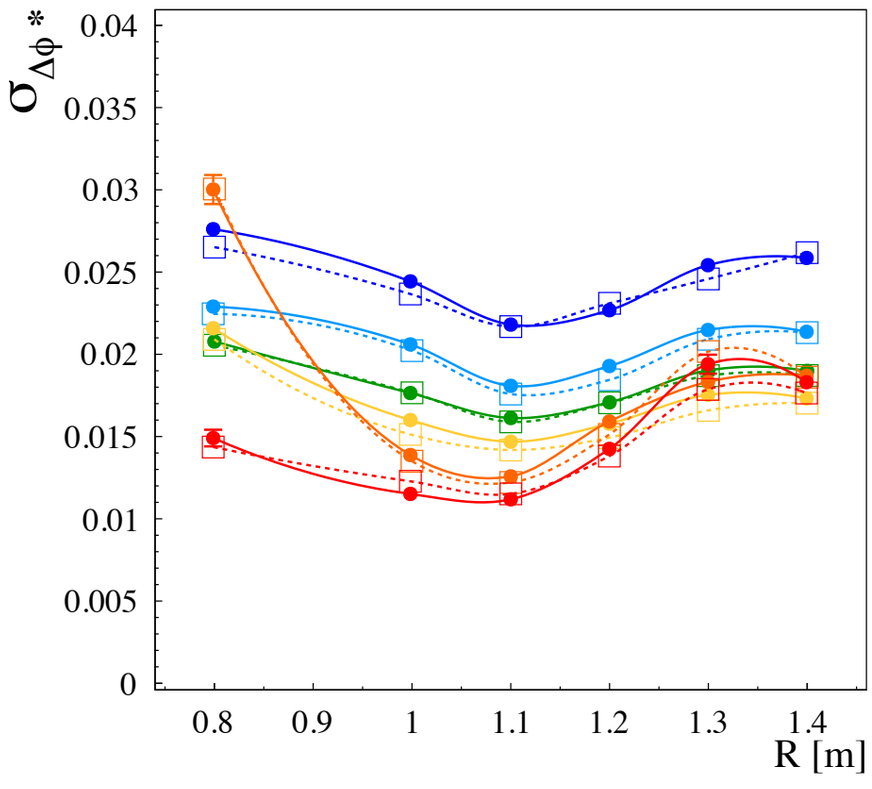


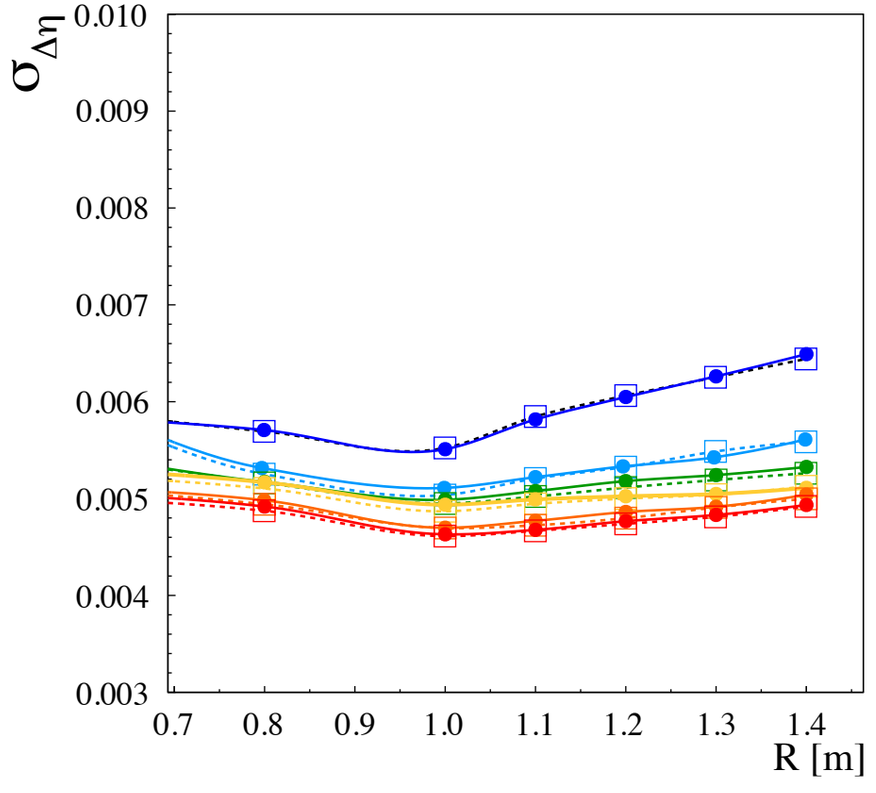
Conclusion

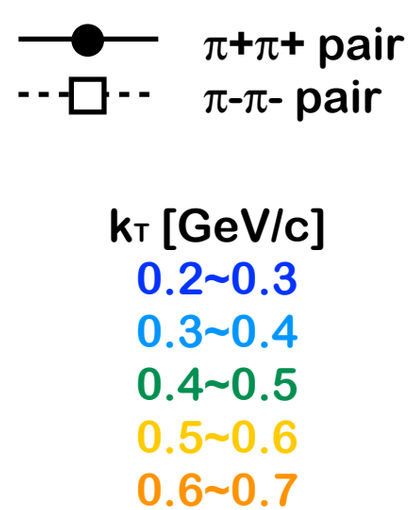
- **Optimized Pair cut**
  - Fraction of Shared TPC clusters < 0.05
  - Quality factor < 0.5
  - Δφ*, Δη cut @ R = 1.1 [m]
    - 3σ of gaussian cut
    - |Δφ*| < 0.066 && |Δη| < 0.018







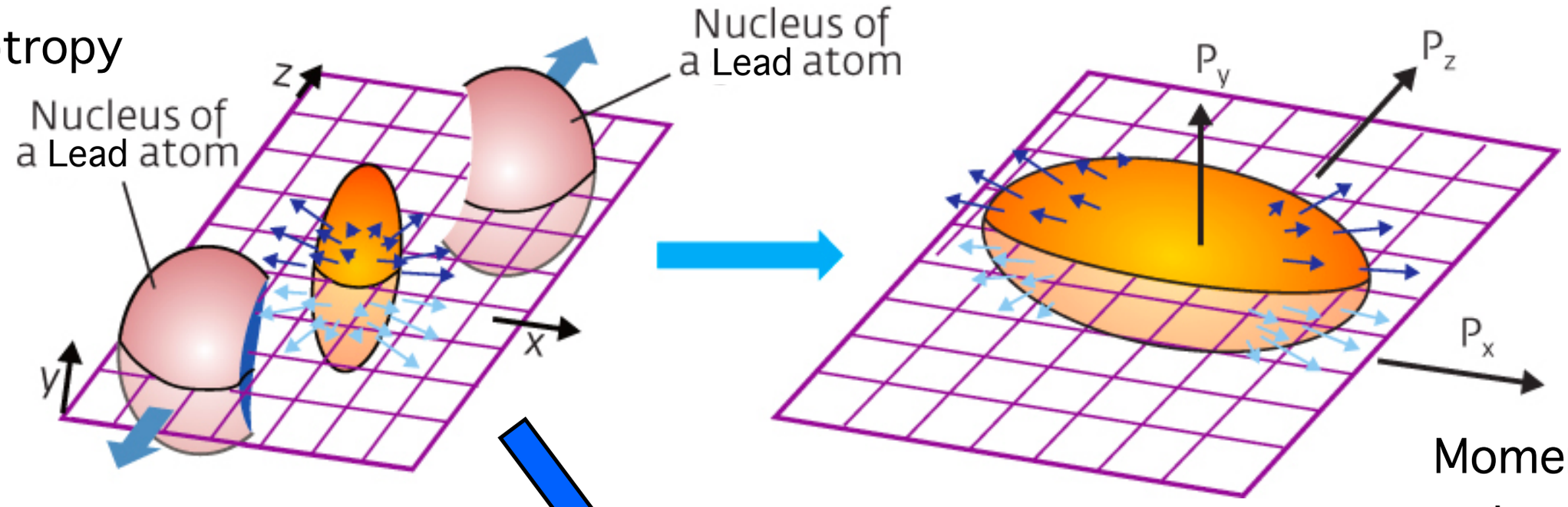




Back up

Azimuthal sensitive HBT

Geometrical anisotropy

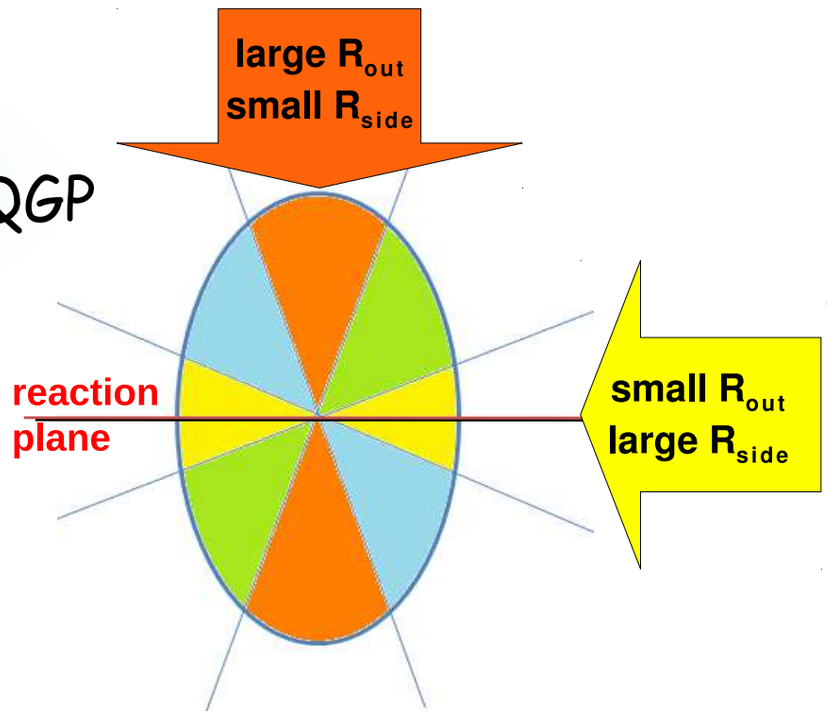


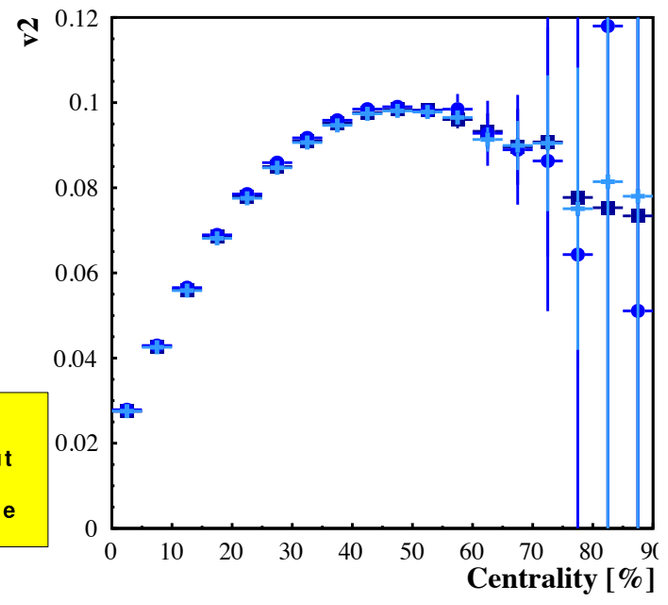
Momentum anisotropy

- Small mean free pass
- Thermalization
- Pressure gradient

Study goal

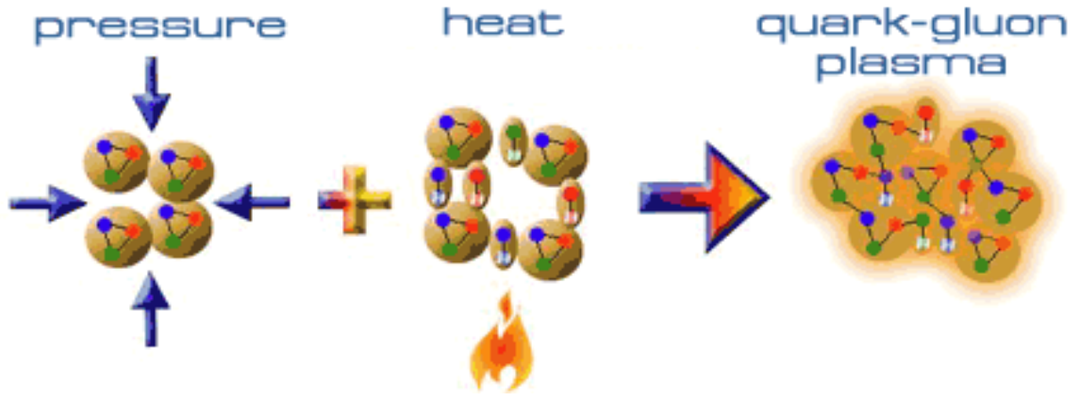
- study space-time characteristics of QGP with respect to the Psi2 & Psi3





QGP

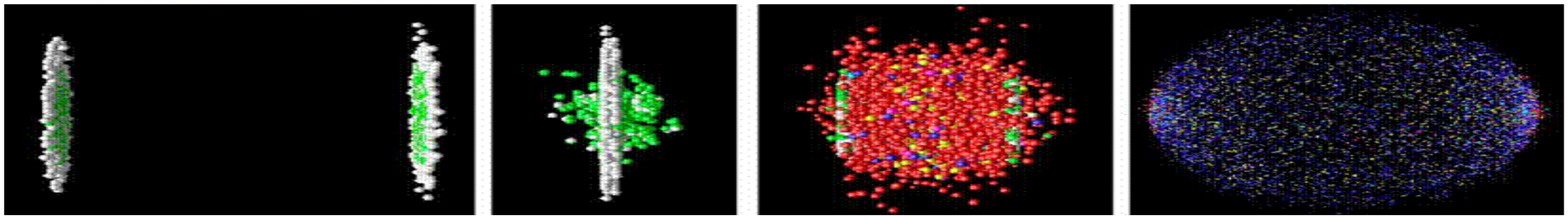
Quark Gluon Plasma : QGP
超高温・高密度状態に達成する物質状態



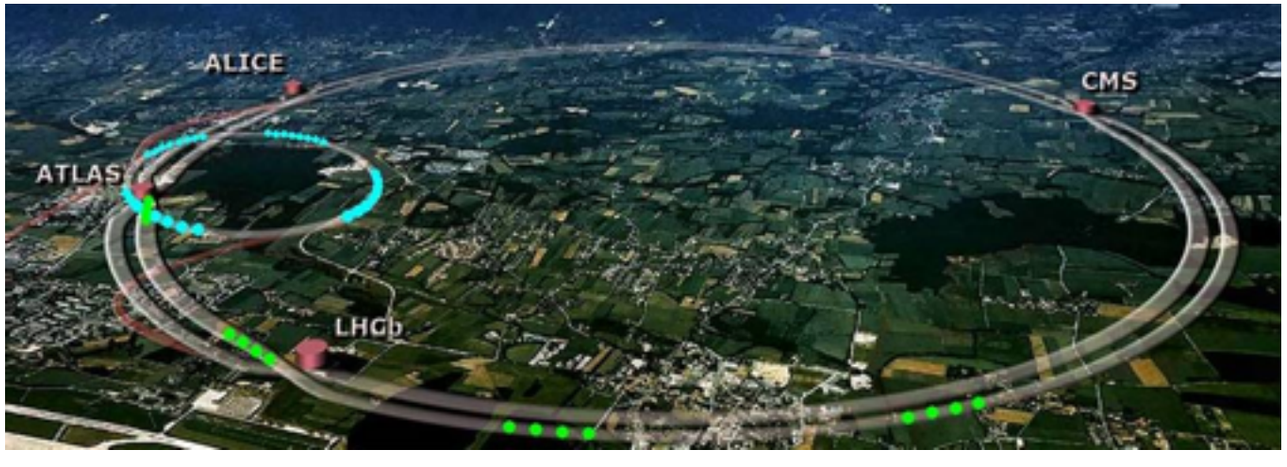
通常では強い相互作用により核子内に
閉じ込められているクォークやグルーオンが
比較的大きな体積内を自由に飛び回る状態

Big　Bang後、数μ秒の初期宇宙

中性子星の内部に存在

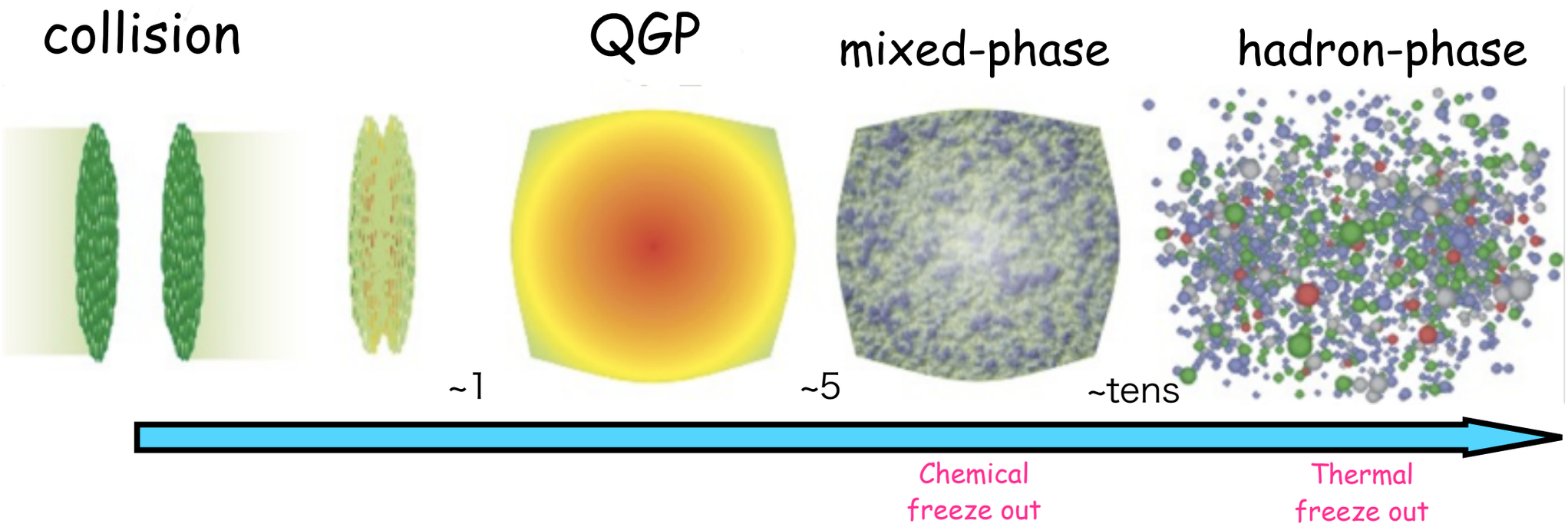


高エネルギー原子核実験により再現



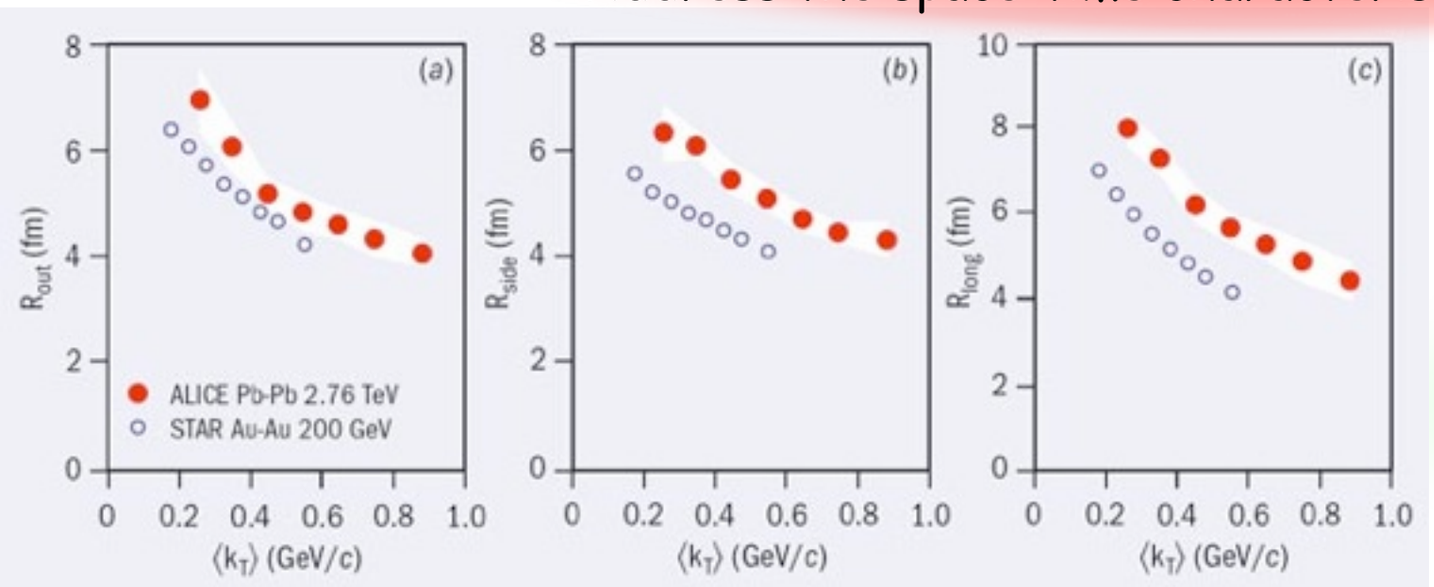
ALICE実験

Space-time characteristics



HBT

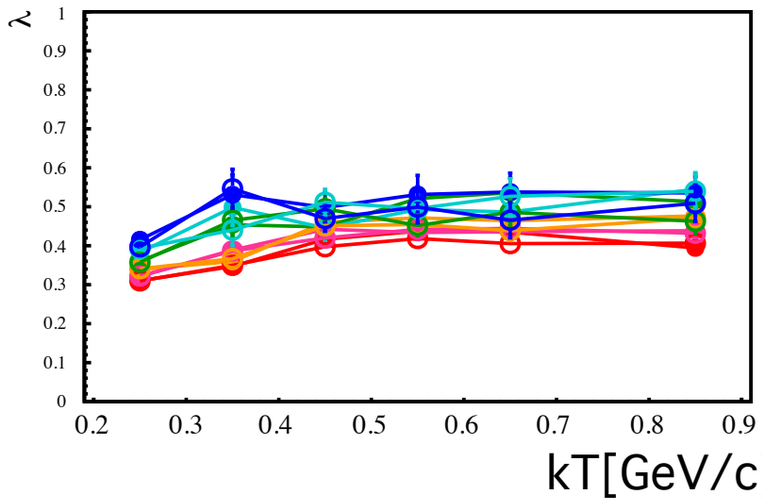
- Address the space-time characteristics of emitting source

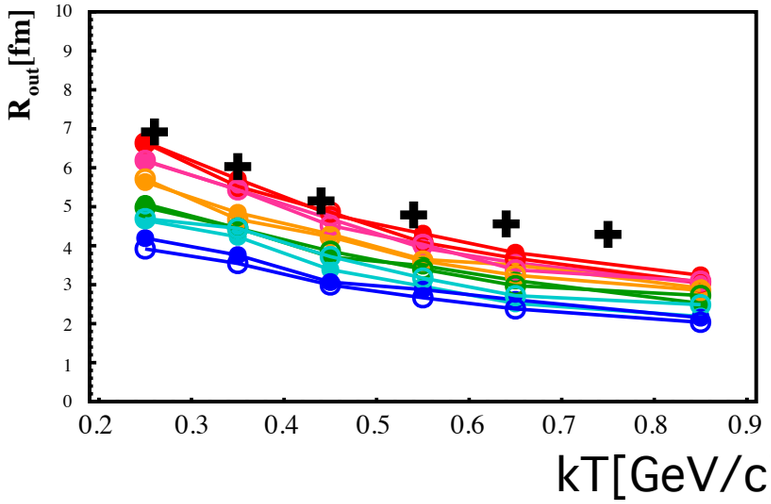


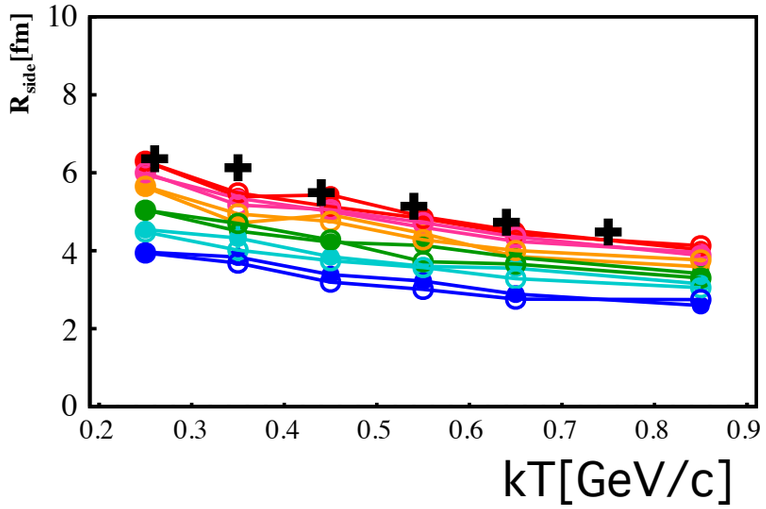
Motivation

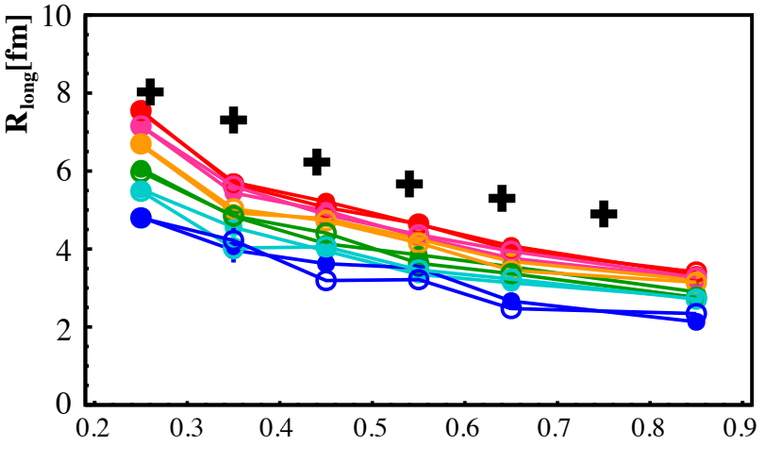
- study space-time characteristics of QGP
  - Though various Femtoscopy parameter dependence

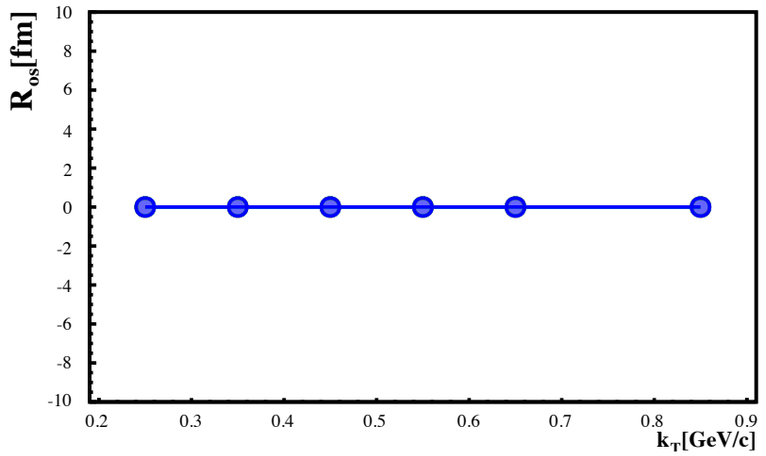
kT Dependence

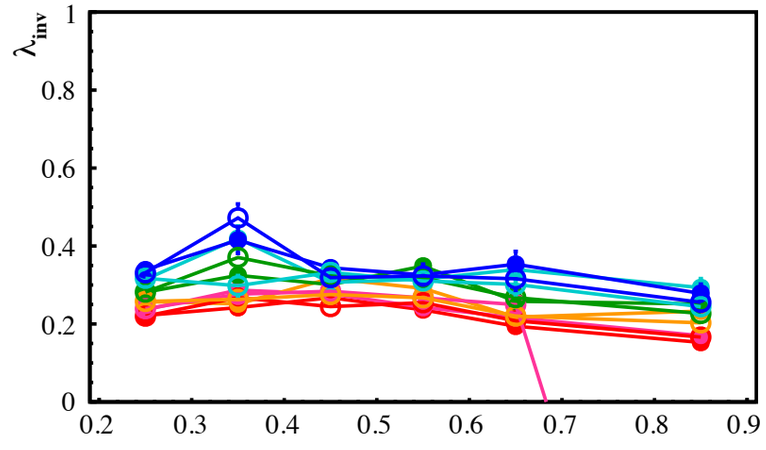


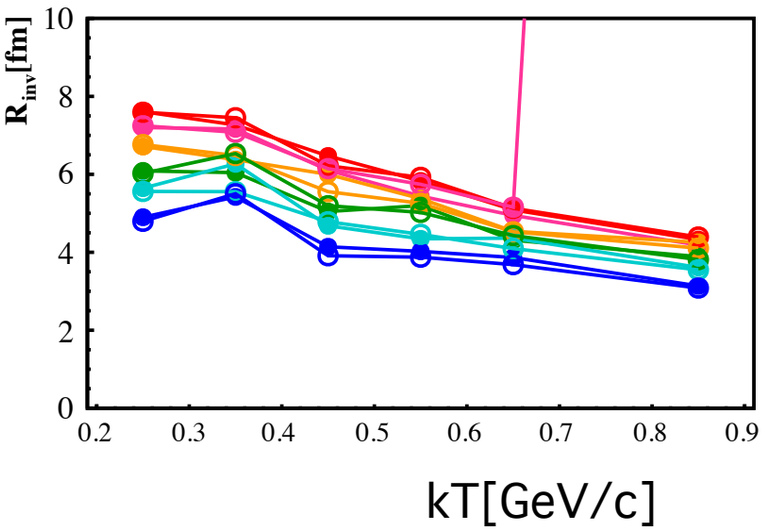












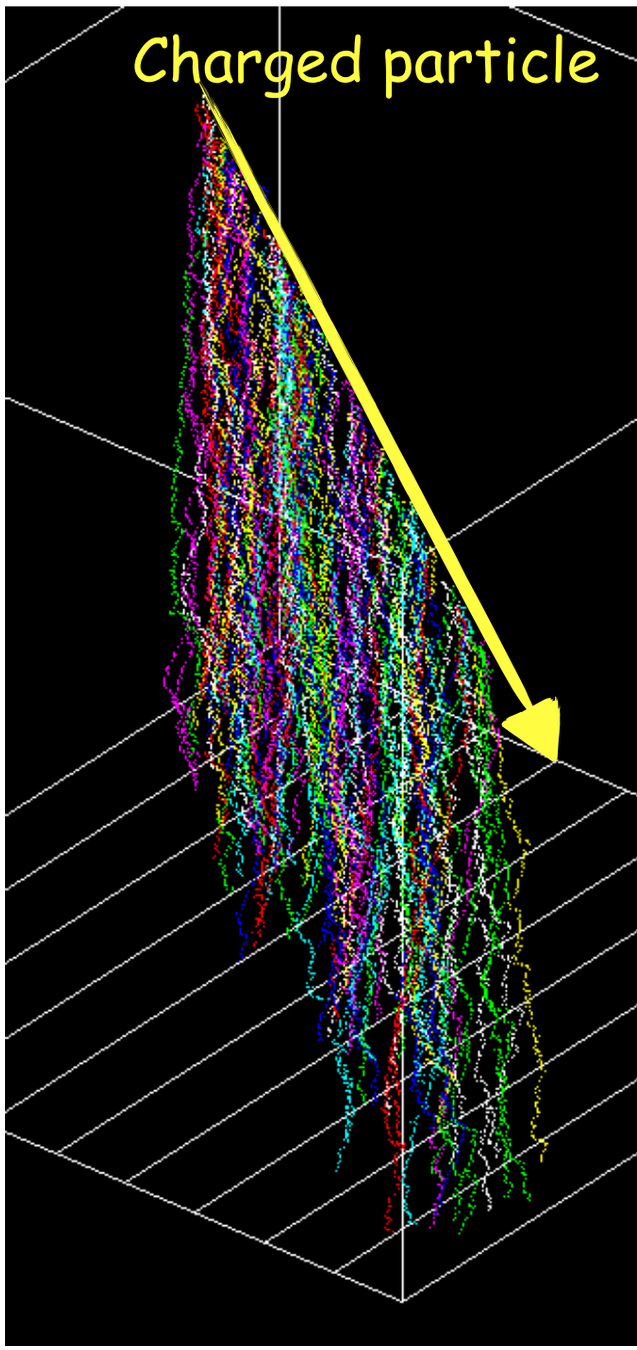
- π+π+0~5%
- π+π+5~10%
- π+π+10~20%
- π+π+20~30%
- π+π+30~40%
- π+π+40~50%
- π+π+50%~

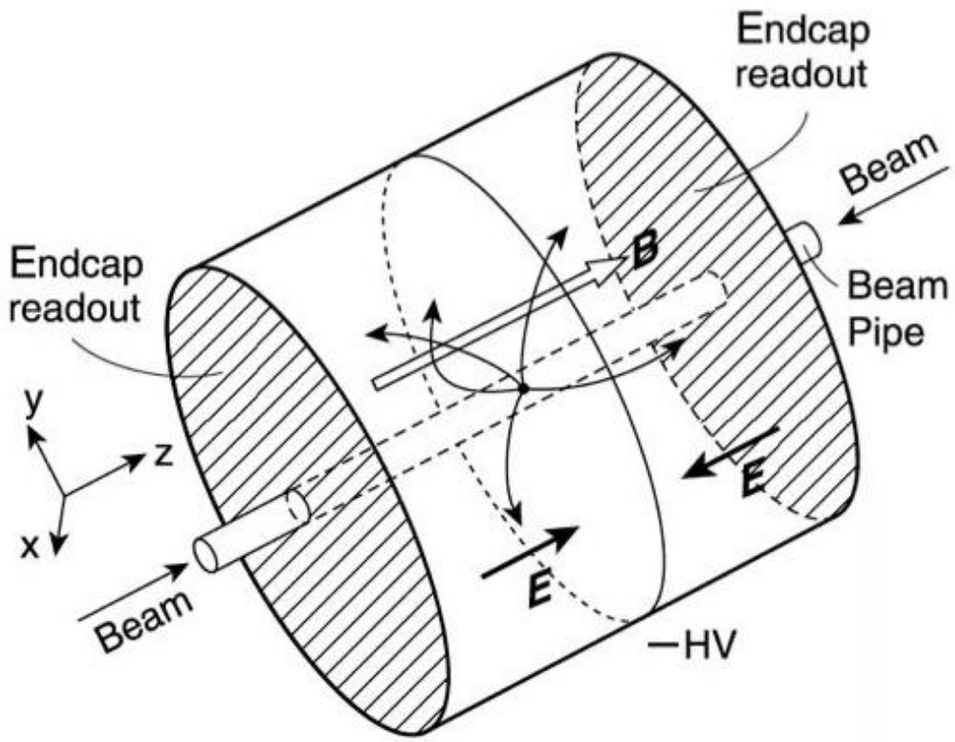
- π-π-0~5%
- π-π-5~10%
- π-π-10~20%
- π-π-20~30%
- π-π-30~40%
- π-π-40~50%
- π-π-50%~

TPC

TPC (Time Projection Chamber)

- 3D track reconstruction
- 18 Segment × 150 rows
- Global tracking
- Precise PID via dE/dx
- Measure momentum





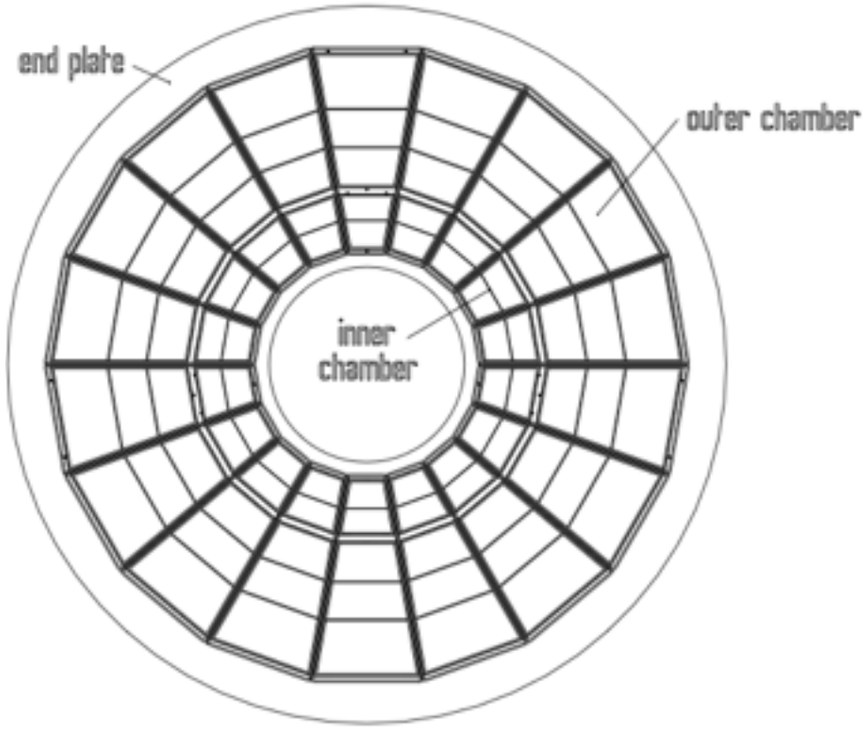
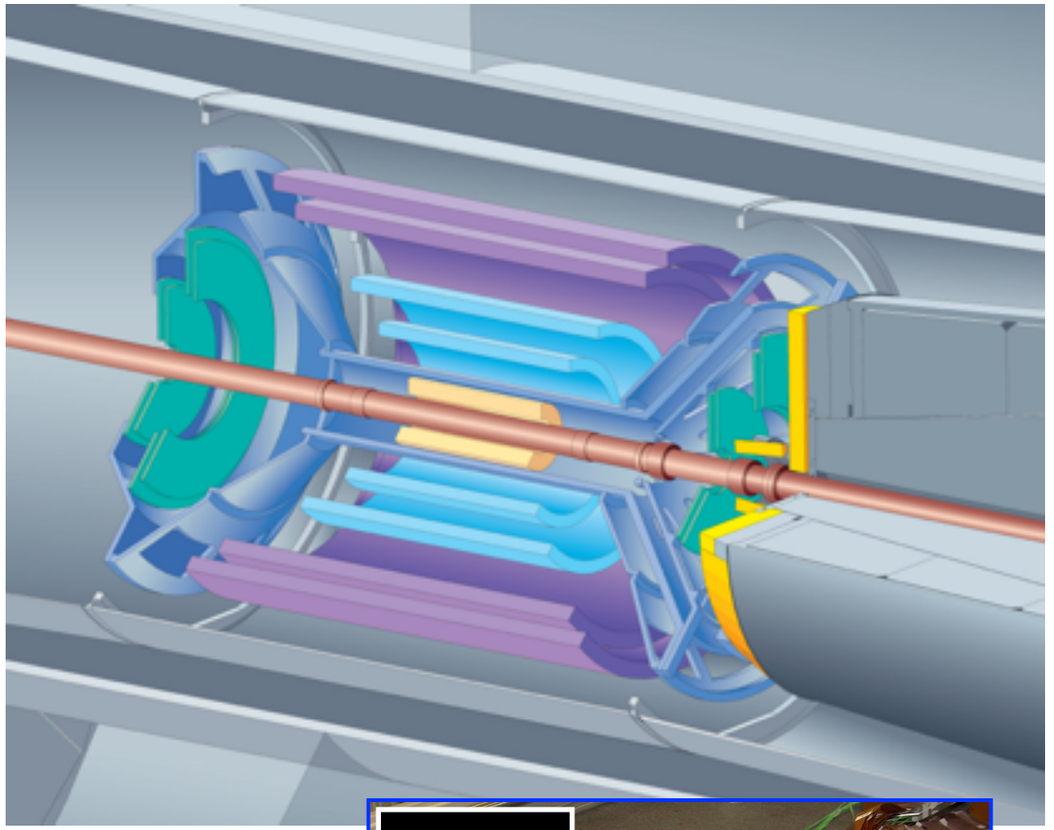


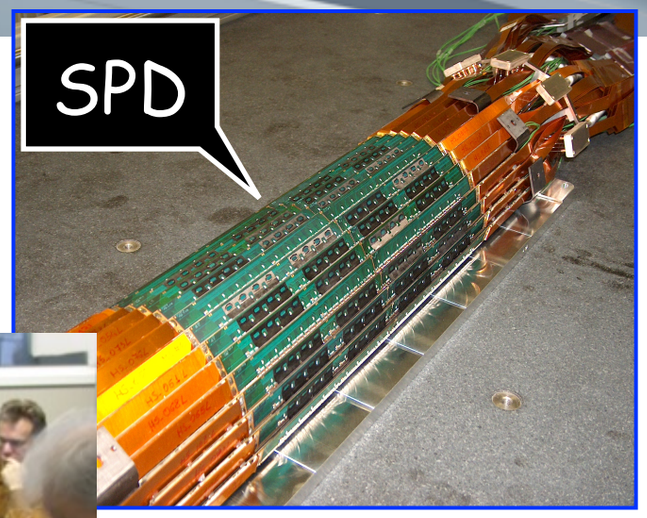
Figure 4.1: Segmentation of the readout plane.

ITS

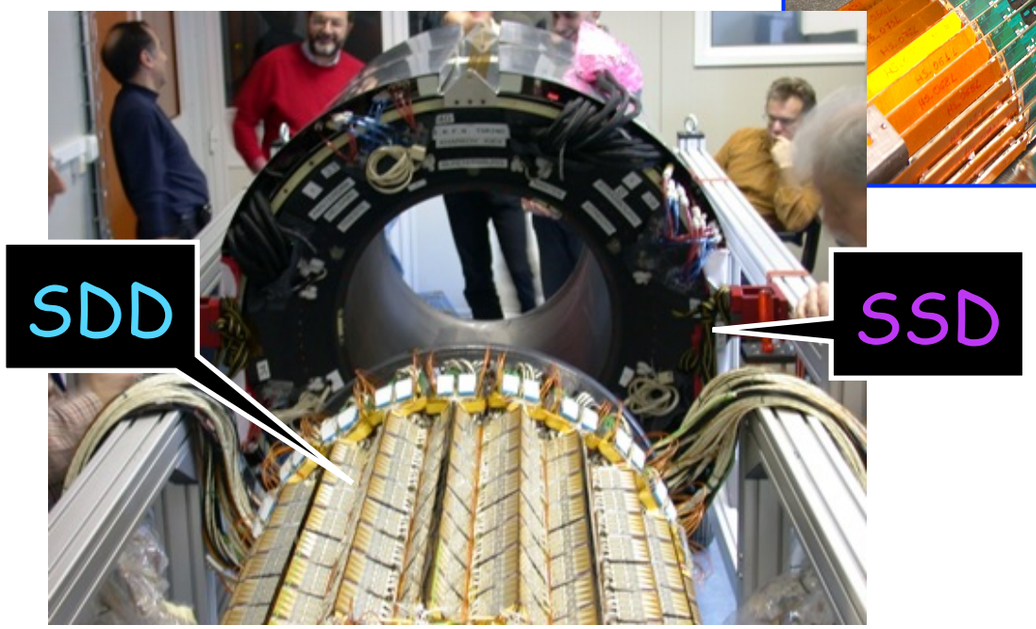
ITS (Inner Tracking System)

- 6 layers of Silicon detectors
- 2 SPD (Silicon Pixel Detector)
- 2 SDD (Silicon Drift Detector)
- 2 SSD (Silicon Strip Detector)





- Reconstruction of primary and secondary vertices
- Contributes to the global tracking
- PID via dE/dx measurement very low p_T 35 MeV ~)
- Event trigger & Multiplicity



Optimization of the pair cut