

Research report

@CERN

Naoto Tanaka

INDEX

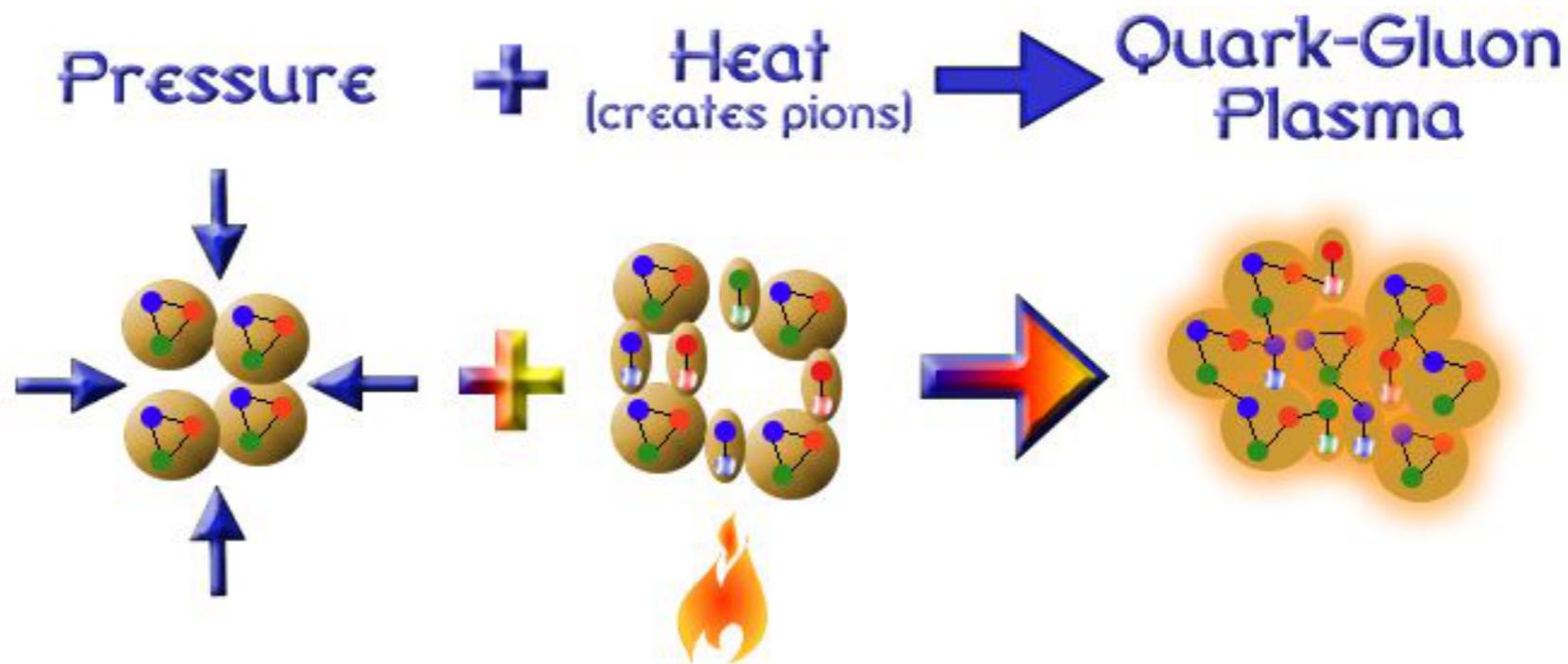
- *QGP*
- *CERN, LHC*
- *ALICE experiment*
- *HBT*
 - ◆ *HBT*
 - ◆ *HBT in Data analysis*
 - ◆ *kt dependence*
- *Data set*
- *Result*

QGP

Quark Gluon Plasma

- クォークは通常強い束縛状態にあり単体で取り出すことができない
- 高温・高密度状態になるとクォークとグルーオンが自由に動き回れるようになる

→ QGP状態



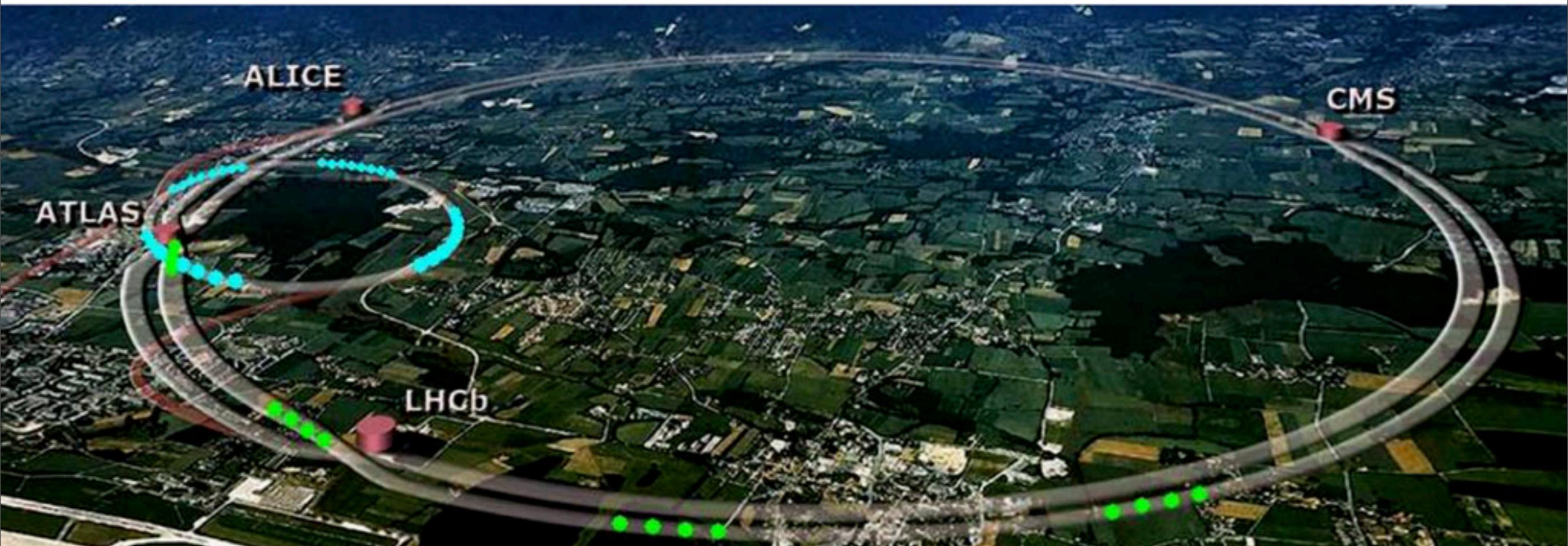
- *Big bang*数 μ 秒後の極初期宇宙
- QGPの研究はクォーク・グルーオンの性質の理解とともに宇宙の誕生や進化の解明にもつながる研究課題

QGPを人工的に生み出す方法 → 高エネルギー原子核衝突実験

CERN LHC

Conseil Européen pour la Recherche Nucléaire
(European Organization for Nuclear Research)

- *LHC : world's largest accelerator @Switzerland and France*
 - *colliding-beam circular accelerator*
 - *$p+p$ Max $\sqrt{s} = 14$ TeV, $Pb+Pb$ Max $\sqrt{s_{NN}} = 5.5$ TeV*
 - *2010, 2011 $Pb+Pb$ $\sqrt{s_{NN}} = 2.76$ TeV*



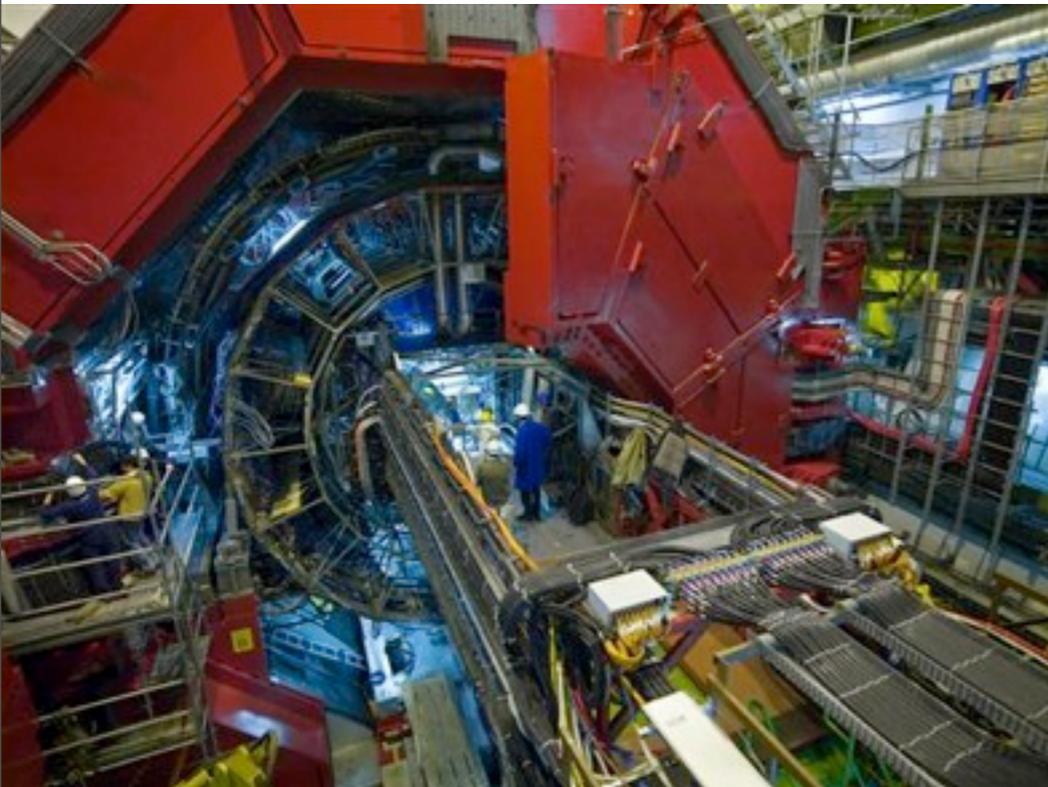
ALICE

A Large Ion Collider Experiment

- Search QGP from Heavy Ion collision

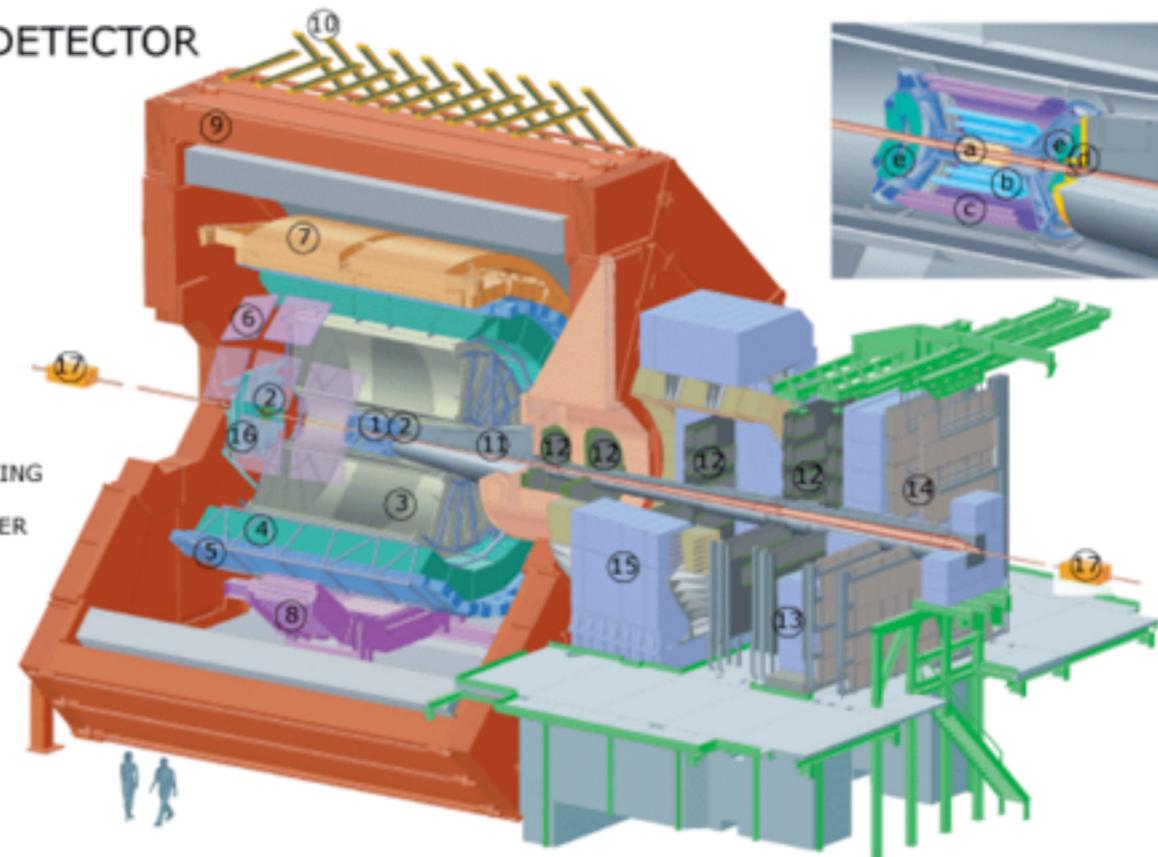
ALICE Detector

- TPC : measure the 3D track of charged particles
charge · momentum · Energy loss(dE/dx)



THE ALICE DETECTOR

1. ITS
2. FMD , T0, V0
3. TPC
4. TRD
5. TOF
6. HMPID
7. EMCAL
8. PHOS CPV
9. MAGNET
10. ACORDE
11. ABSORBER
12. MUON TRACKING
13. MUON WALL
14. MUON TRIGGER
15. DIPOLE
16. PMD
17. ZDC



- a. ITS SPD Pixel
- b. ITS SDD Drift
- c. ITS SSD Strip
- d. V0 and T0
- e. FMD

HBT

HBT interference effect

■ What is HBT ?

◆ quantum interference effect

between the two homogeneity particles

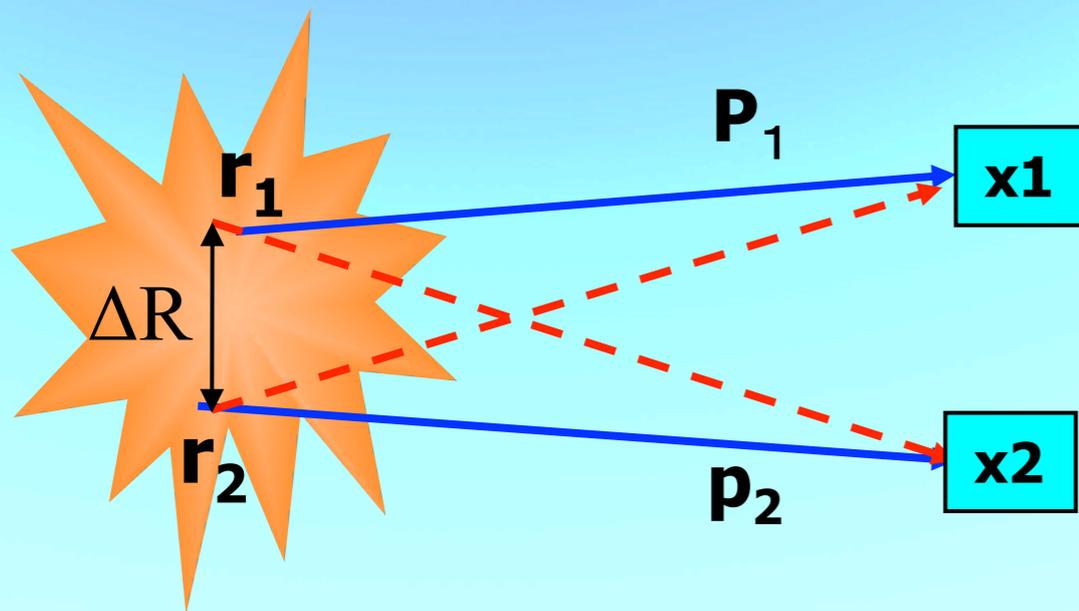
$$\psi = \frac{1}{\sqrt{2}} (e^{ip_1(x_1-r_1)} e^{ip_2(x_2-r_2)} \pm e^{ip_1(x_1-r_2)} e^{ip_2(x_2-r_1)})$$

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

$$= 1 + |\tilde{\rho}(q)|^2$$

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

$\tilde{\rho}$: ρ のフーリエ変換



$$q_{inv} = \sqrt{q_x^2 + q_y^2 + q_z^2 - q_0^2}$$

$$q_0 = \sqrt{p^2 + m^2}$$

R_{inv}

HBT in Data Analysis

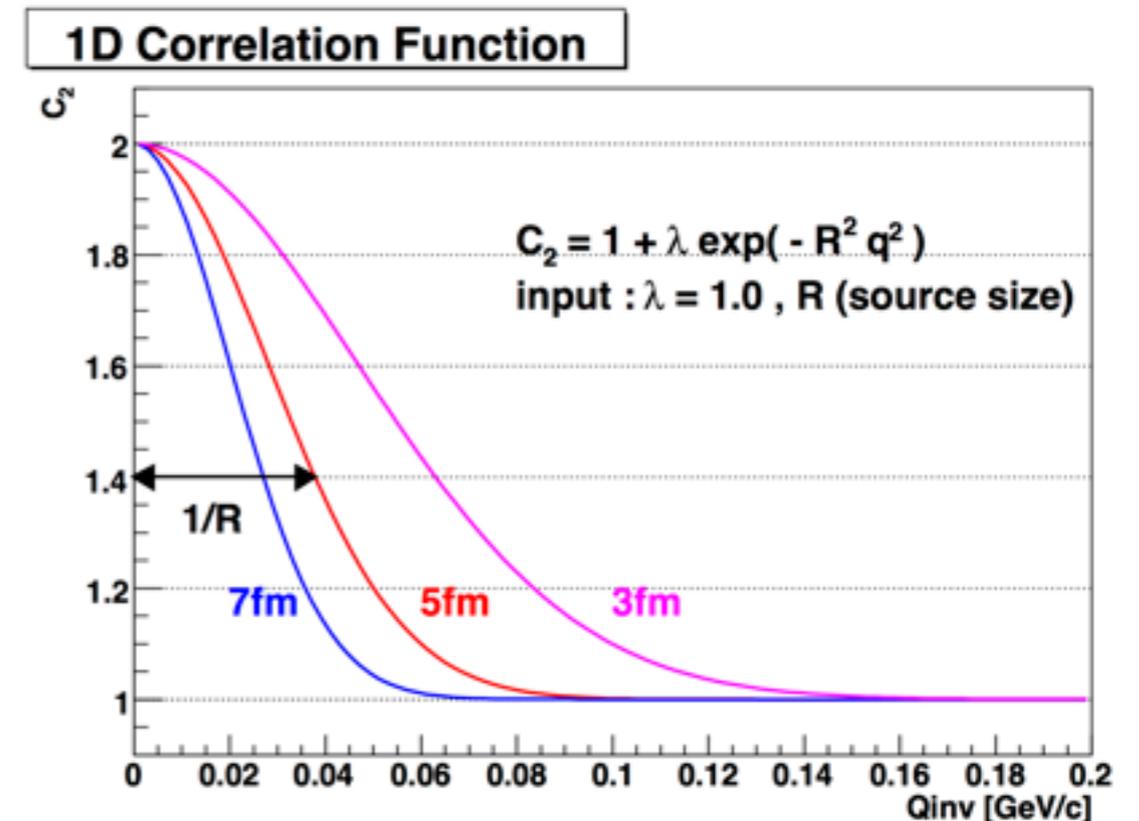
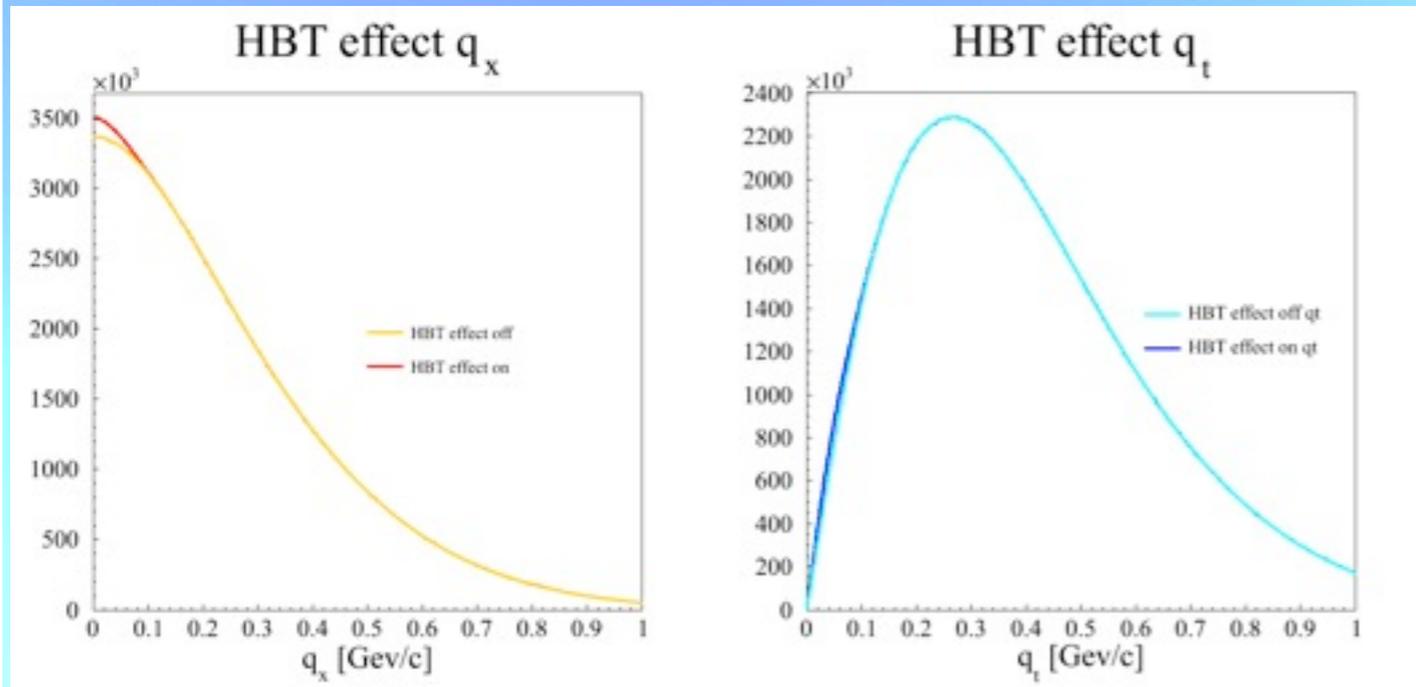
$$C_2 = \frac{A(q)}{B(q)}$$

$A(q)$: two pair from *same* event
 $B(q)$: two pair from *difference* event

$$C_2 = 1 + \lambda \exp(-R^2 q^2) \quad : \text{Fitting function}$$

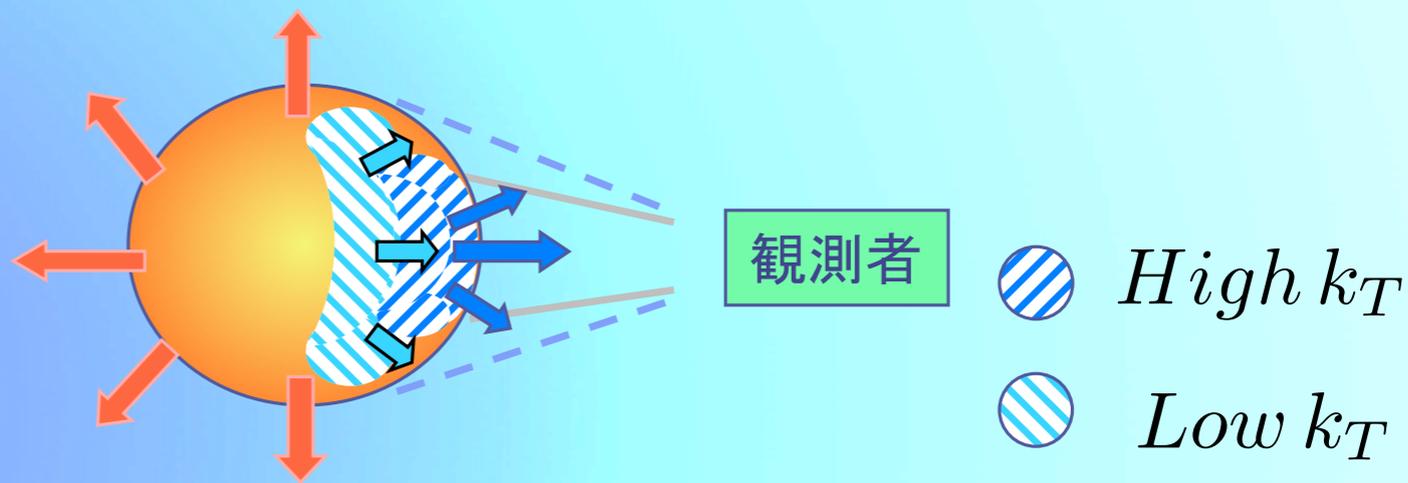
getting R, λ parameter

R : source size
 λ : chaoticity

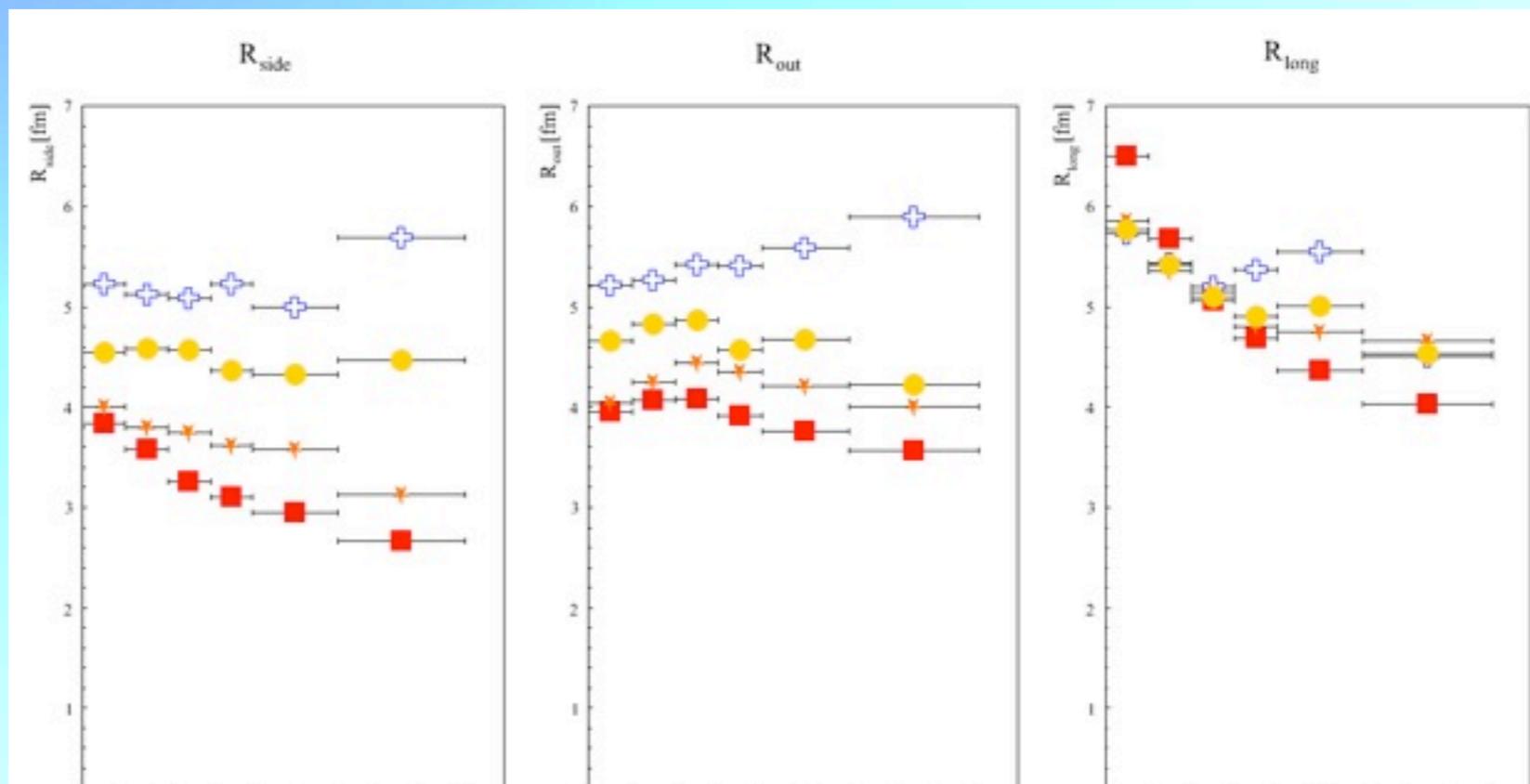


kt Dependence

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



- 粒子源が静的であるならば HBT で測定される大きさは粒子源全体の大きさに対応する
- 位置と運動量に相関があるような膨張をしている粒子源では、HBT で測定される大きさというのは全体の大きさではなく、ある運動量を持った粒子が分布する領域を測っているということになる



Data Analysis

■ LHC ALICE experiment $p+p$ 2.76TeV(LHC11a)

◆ Event number : 28,564,881

■ Track cuts

◆ `AcceptKinkDaughters(kFALSE)`

◆ `MinNClustersTPC(80)`

◆ `MinNClustersITS(2)`

◆ `MaxChi2PerClusterTPC(4)`

◆ `MaxDCAToVertexXY(3)`

◆ `MaxDCAToVertexZ(3)`

◆ `EtaRange(-1.2, 1.2)`

◆ `RequireTPCRefit(kTRUE)`

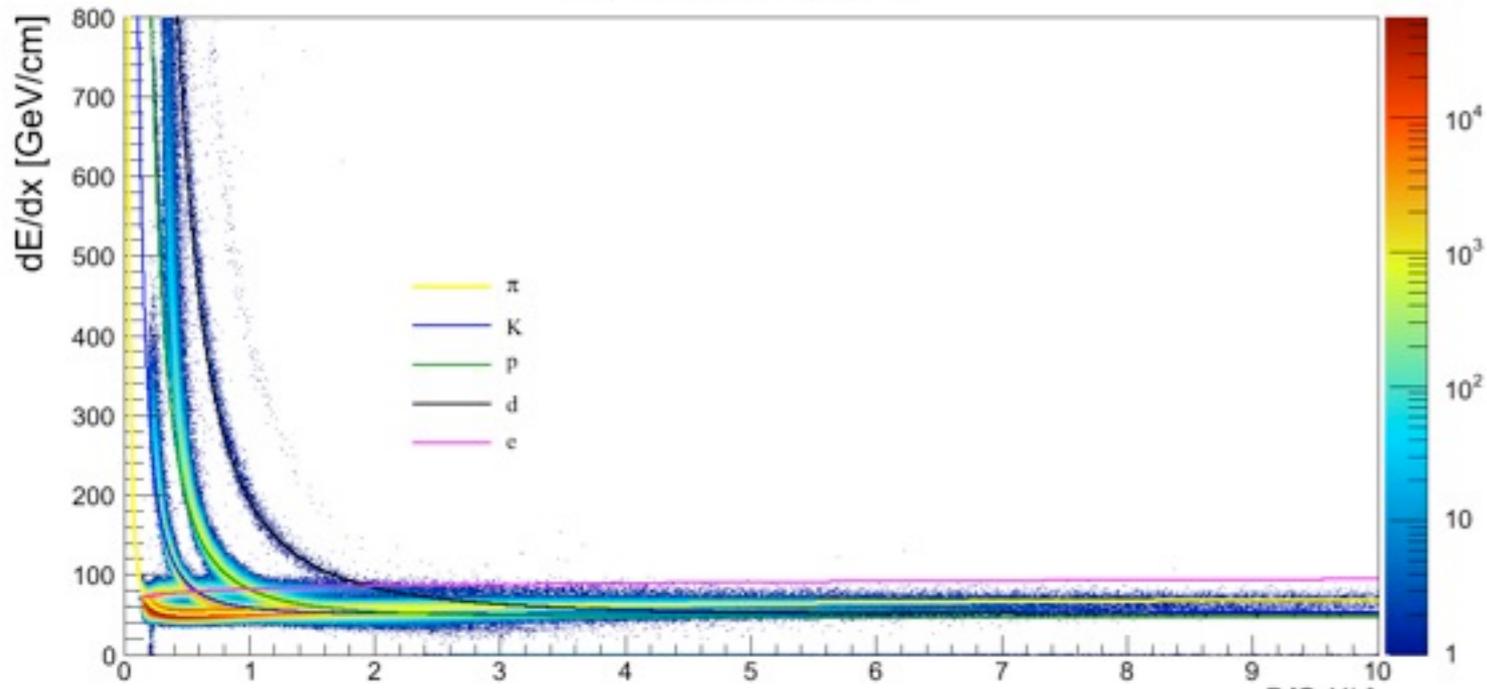
◆ `RequireITSRefit(kTRUE)`

◆ `ClusterRequirementITS`

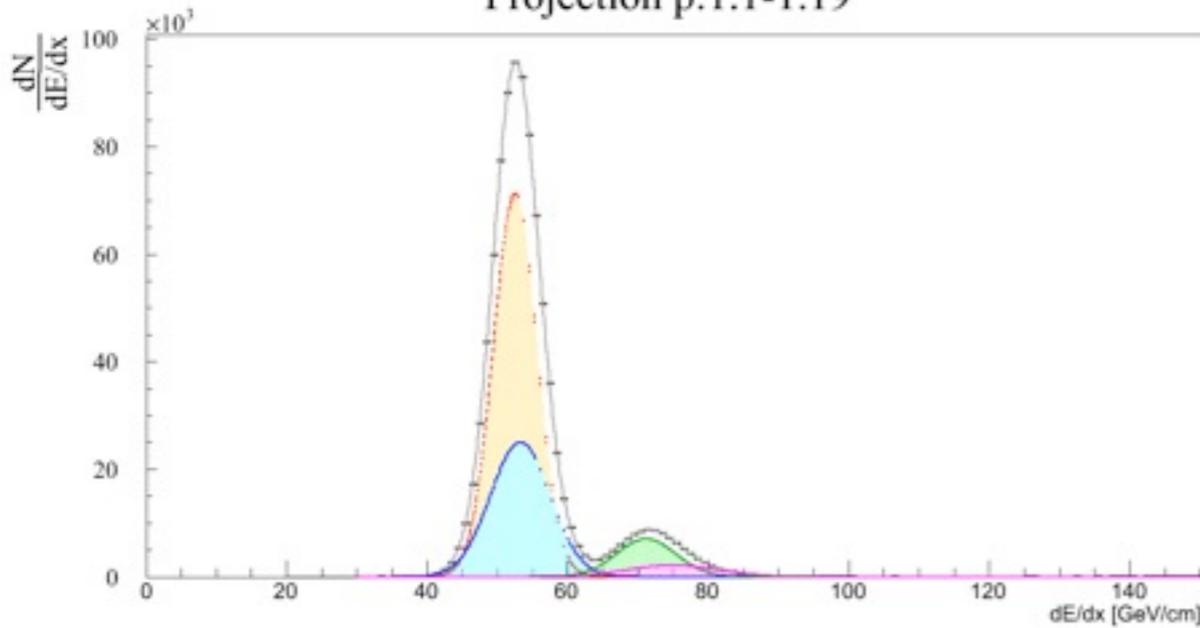
`(AliESDtrackCuts::kSPD,
AliESDtrackCuts::kAny)`

PID

dE/dx distribution

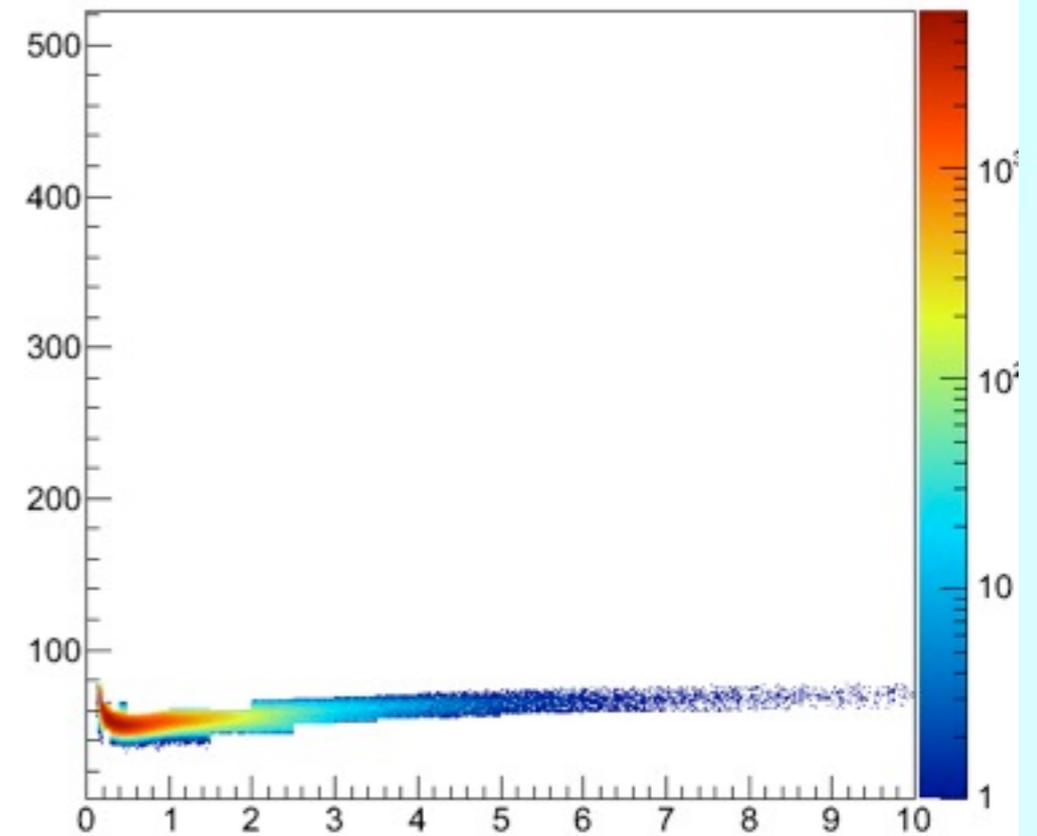


Projection p: 1.1-1.19



■ Pion selection

dE/dx distribution pion select

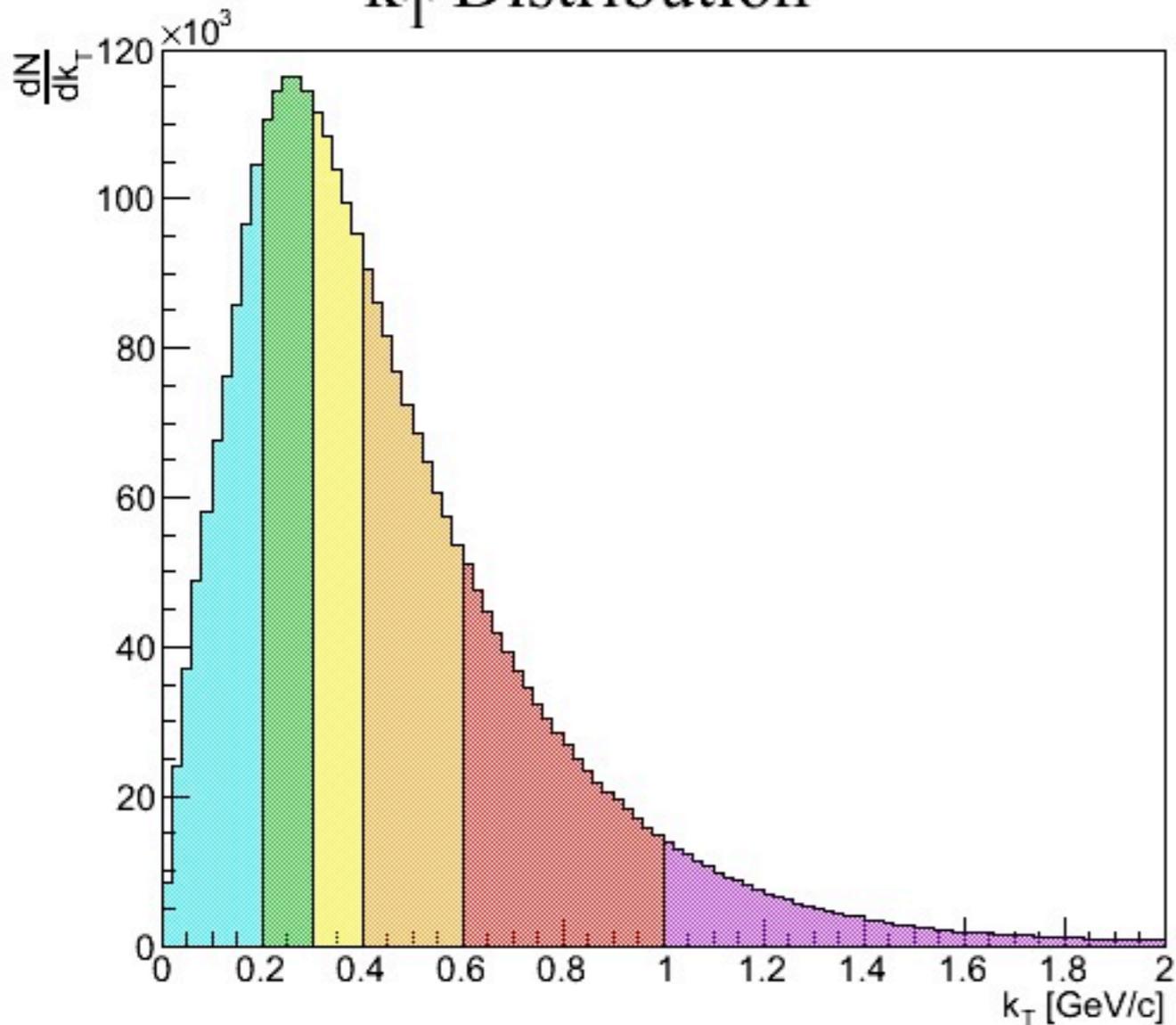


$$-\frac{dE}{dx} = 2\pi N_a r_e^2 m_e c^2 \rho \frac{Z}{A} \frac{z^2}{\beta^2} \left(\ln \left(\frac{2m_e \gamma^2 v^2 W_{max}}{I^2} \right) - 2\beta^2 - \delta - 2\frac{C}{Z} \right)$$

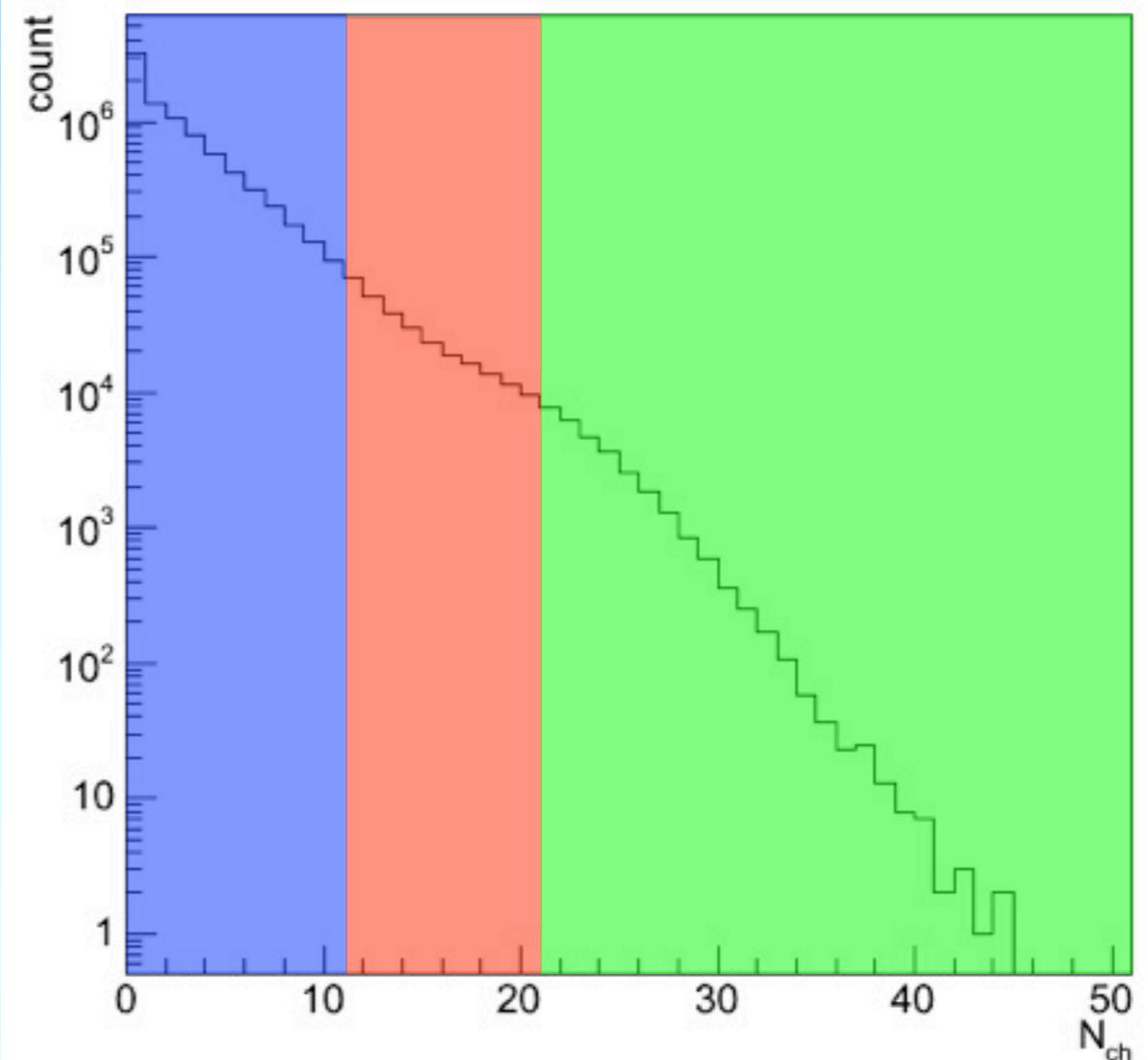
Mixing Class

kt : 0.0-0.2[GeV/c]	Multiplicity : Nch: 1 -11
0.2-0.3[GeV/c]	12 - 22
0.3-0.4[GeV/c]	22 -
0.4-0.6[GeV/c]	
0.6-1.0[GeV/c]	
1.0-[GeV/c]	

k_T Distribution



Number of Tracks



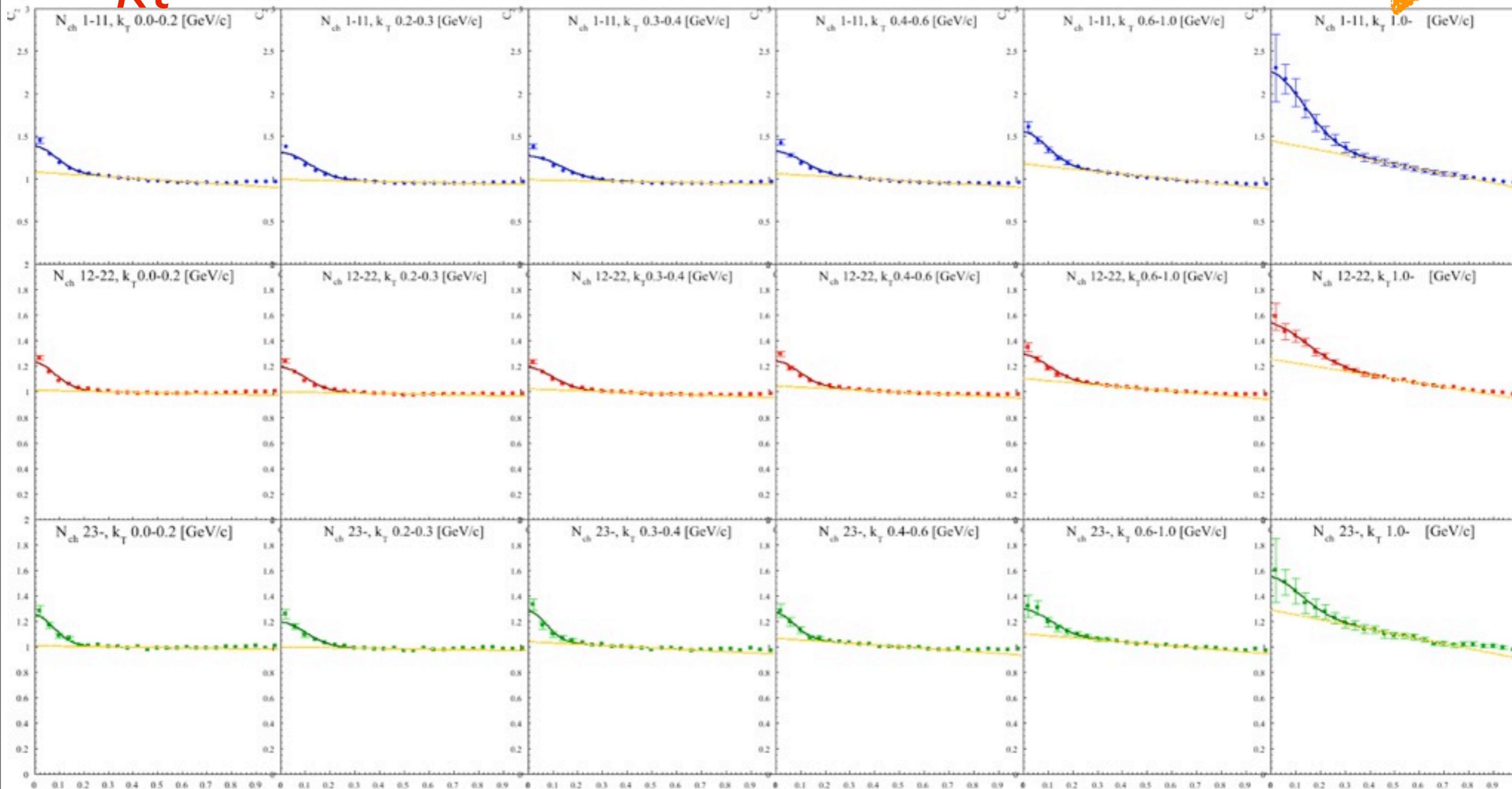
π^+ correlation

Nch: 1 - 11
12 - 22
23 -

$$C(q_{inv}) = [1 + \lambda \exp(-R_{inv} q_{inv})] * [p_0 + p_1 q_{inv}]$$

$q_{inv} : 0-1 [\text{GeV}/c]$ *BaseLine*

kt



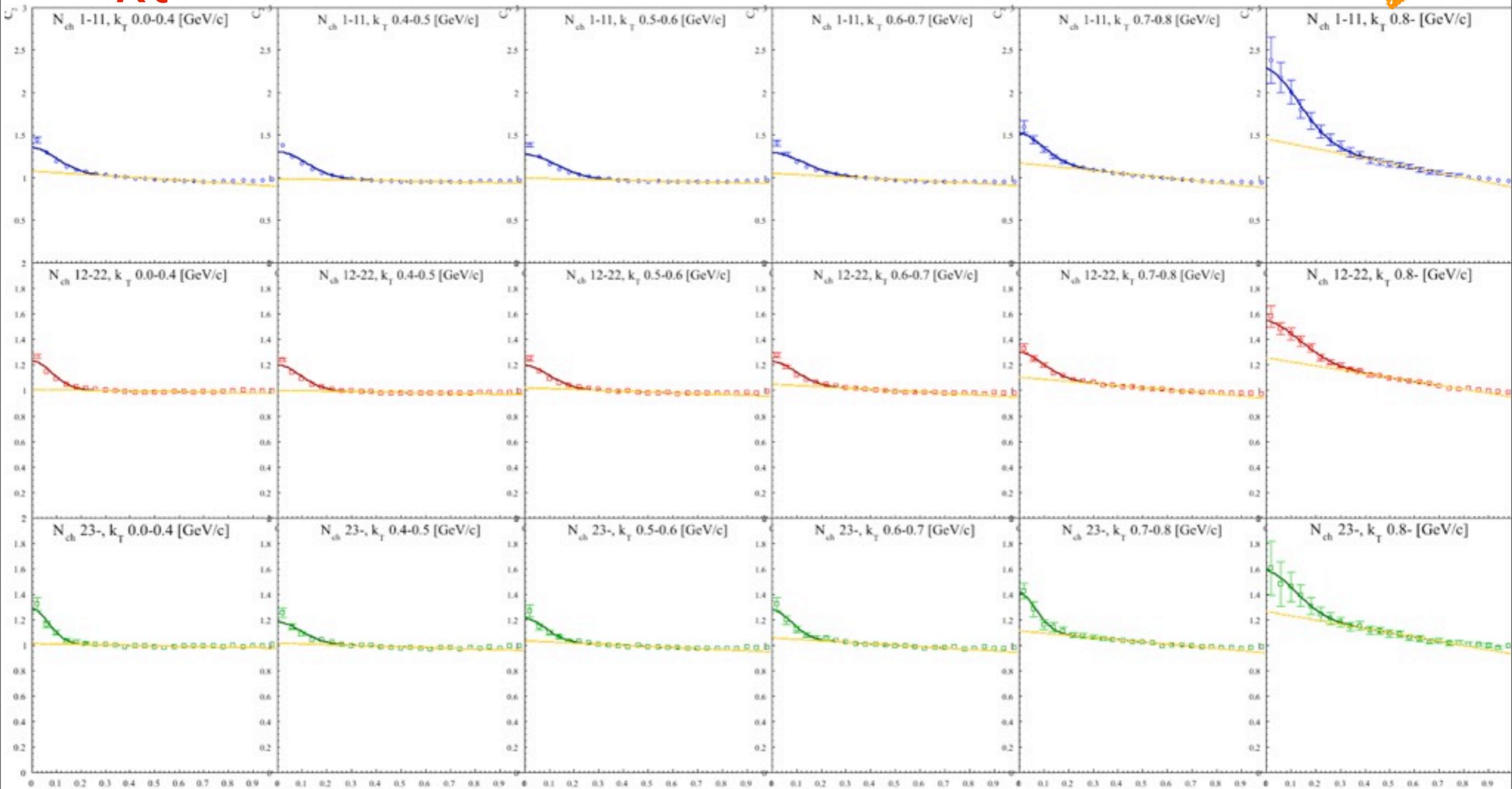
π^- correlation

Nch: 1 - 11
12 - 22
23 -

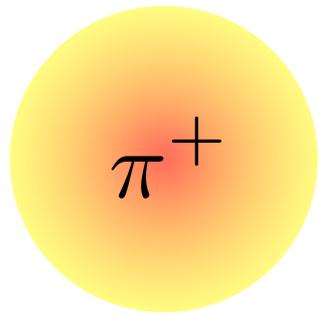
$$C(q_{inv}) = [1 + \lambda \exp(-R_{inv} q_{inv})] * [p_0 + p_1 q_{inv}]$$

$q_{inv} : 0-1 [\text{GeV}/c]$ *BaseLine*

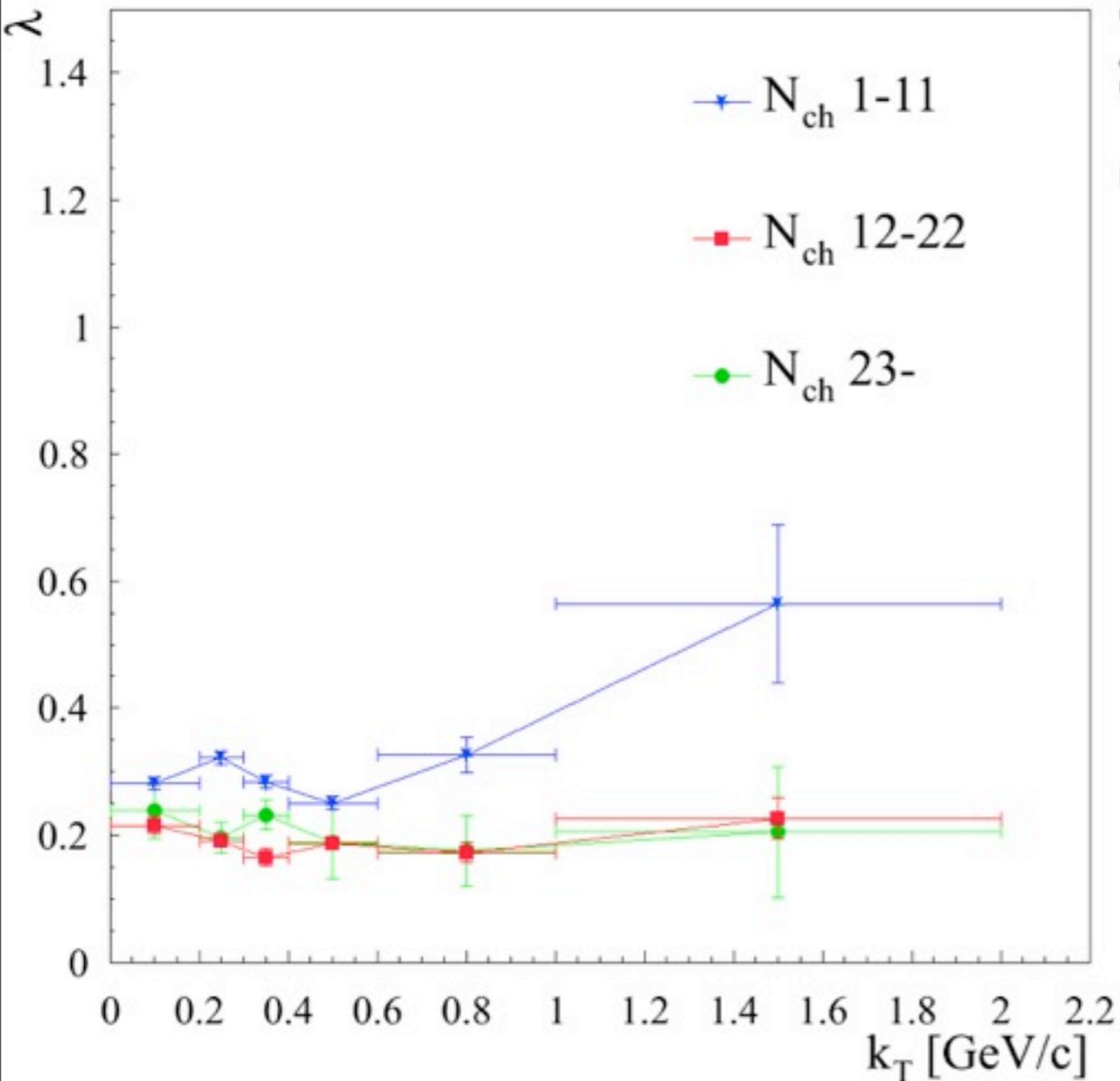
kt



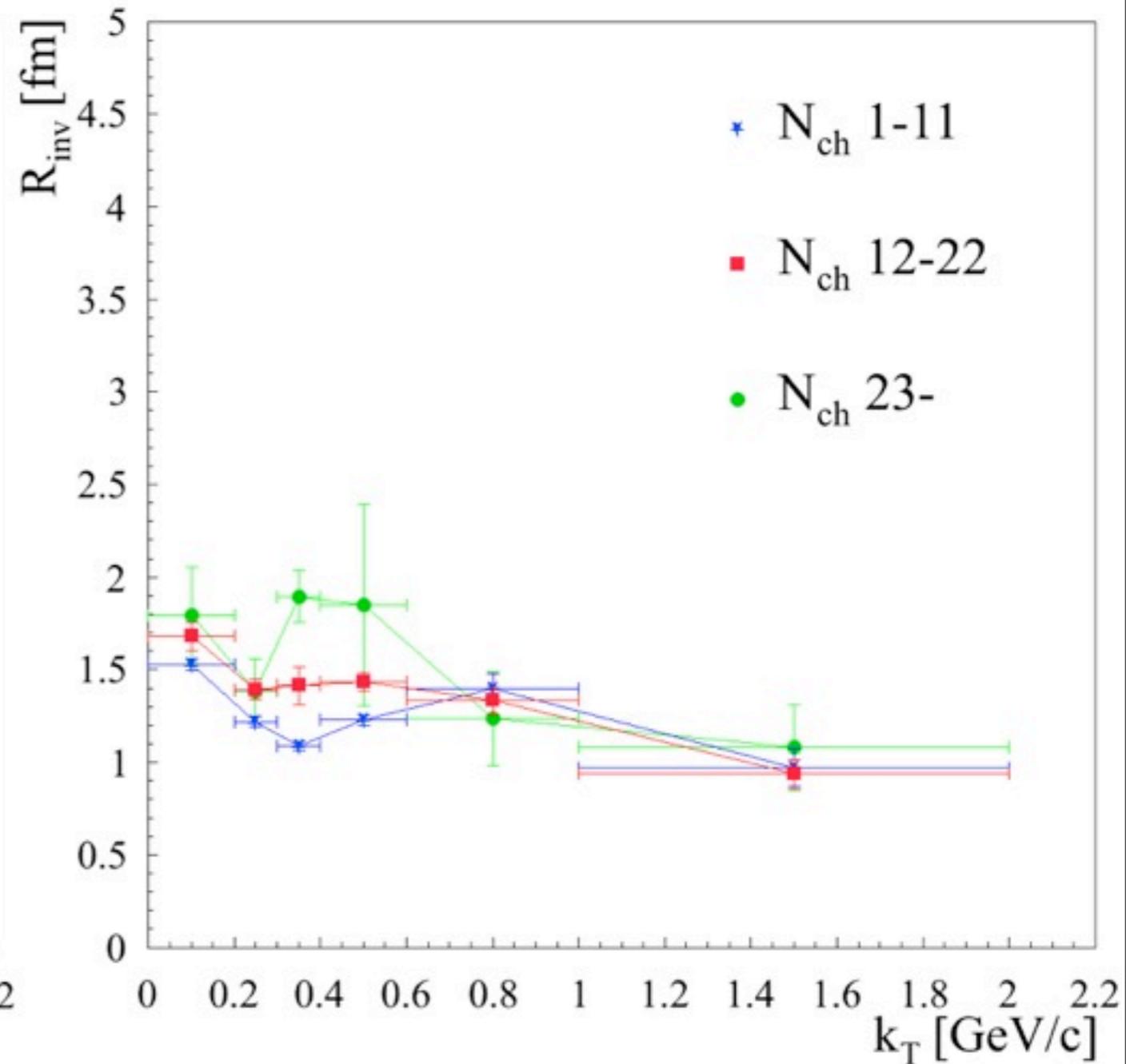
kt dependence of HBT Radius



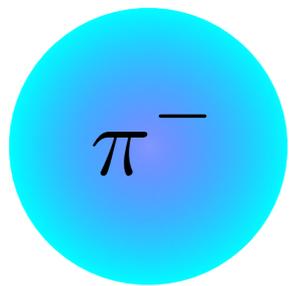
λ



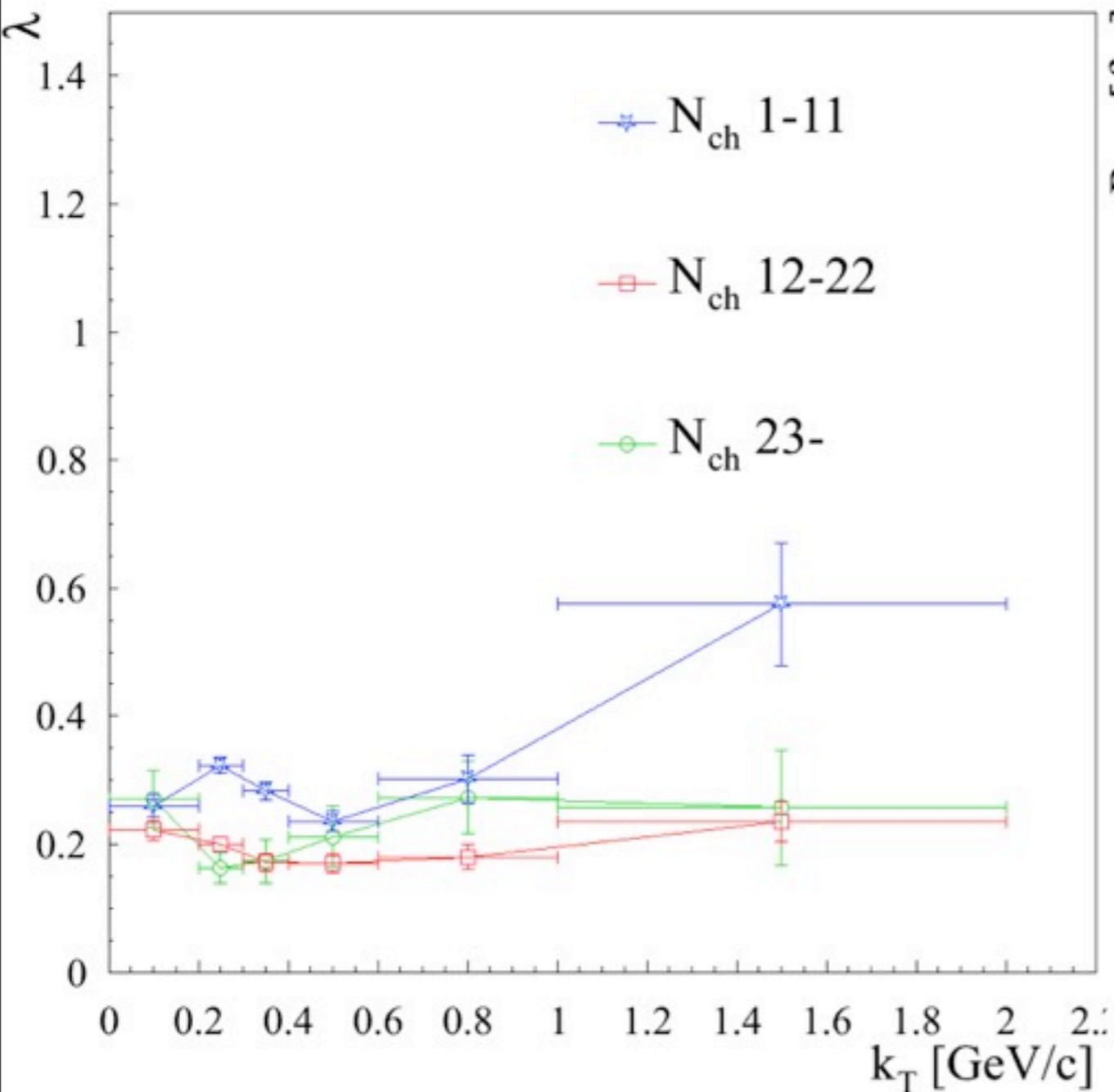
R_{inv}



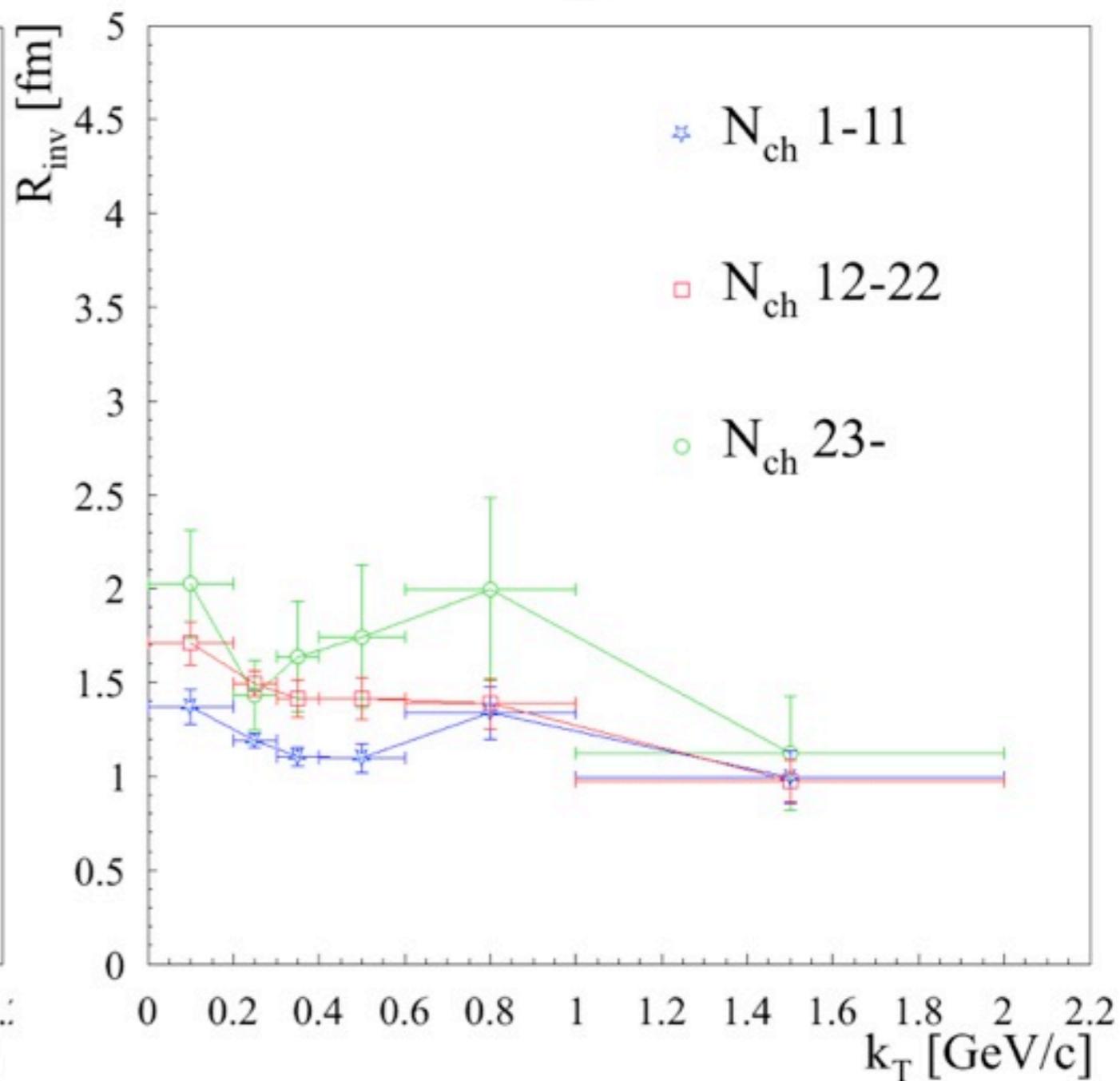
kt dependence of HBT Radius



λ



R_{inv}



解析におけるご指導いただいた江角さん
スイスでの生活とCERNでの手続きなどなど
様々な面で助けていただいた中條さん、坂田さん
渡邊くん



Atlasのcontrol roomなど案内していただいた
原先生、空港でのトラブルで助けていただいた
永井さん



みなさまありがとうございました！



Back Up

Slice P : 0-1 [GeV/c] Fit 4 Gaus

