Joint Institute for Nuclear Research

Feasibility of hyperon elliptic flow study at MPD@NICA

Nikolay Geraksiev for the MPD Collaboration

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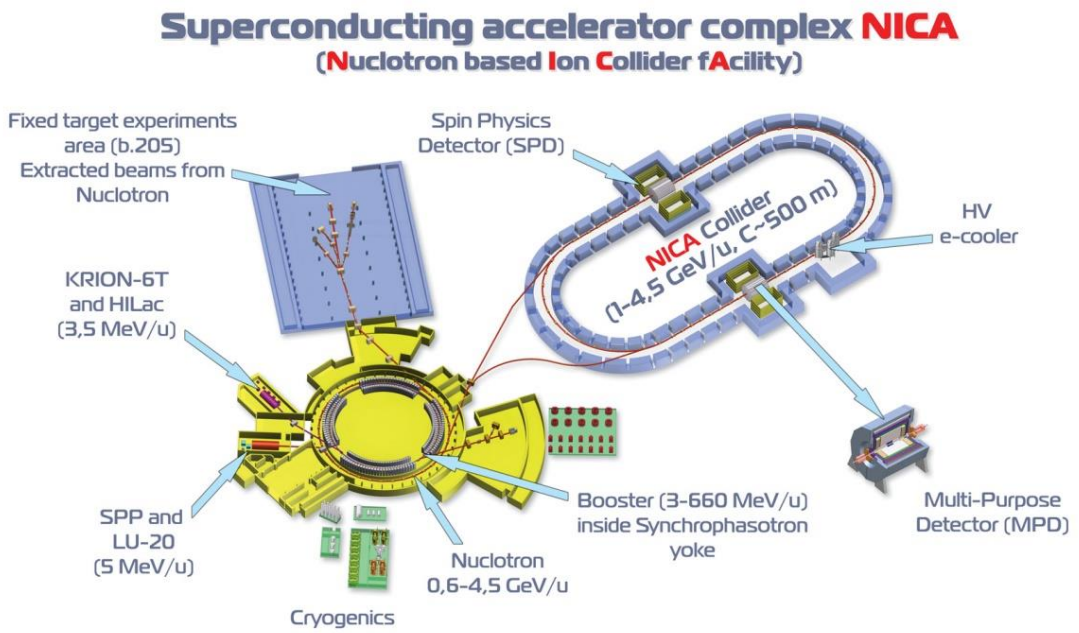
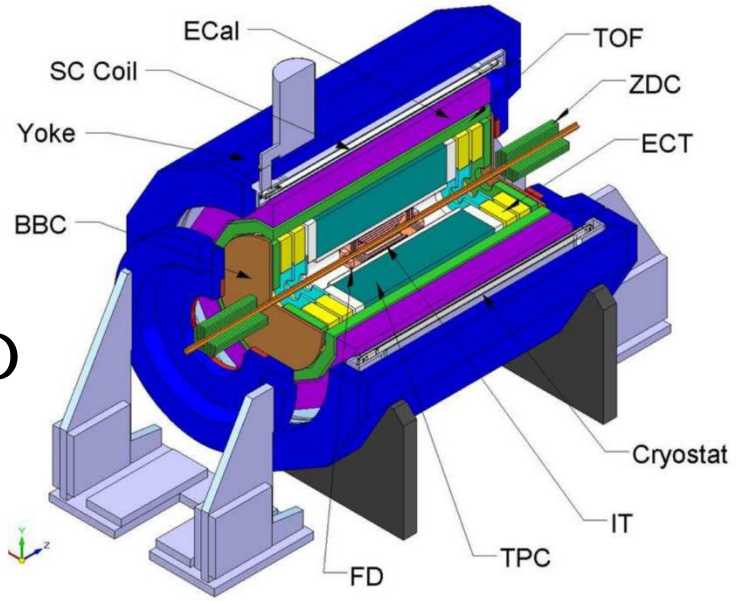
MPD@NICA



- $\sqrt{s_{AuAu}}$ = 11 GeV,
- $L_{AuAu} = 10^{27}\,\mathrm{cm^{-2}s^{-1}}$
- $\sqrt{s_{pp}}$ = 27 GeV
- $L_{pp} = 10^{32}\,\mathrm{cm^{-2}s^{-1}}$

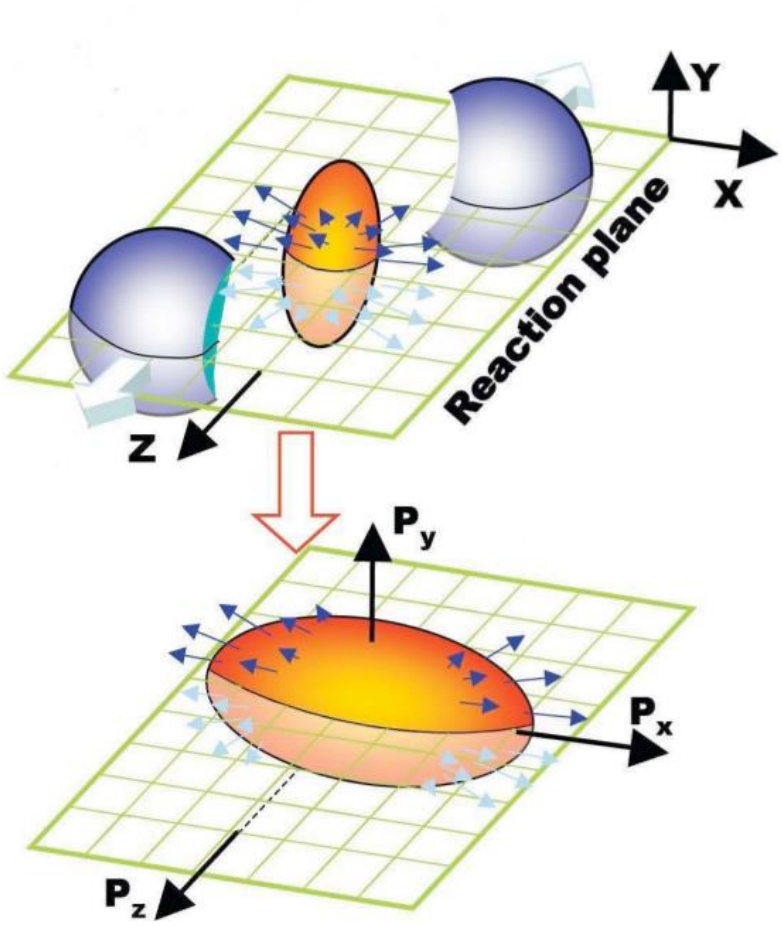


- 1st stage of MPD:

TPC, TOF, ZDC, ECAL, FFD

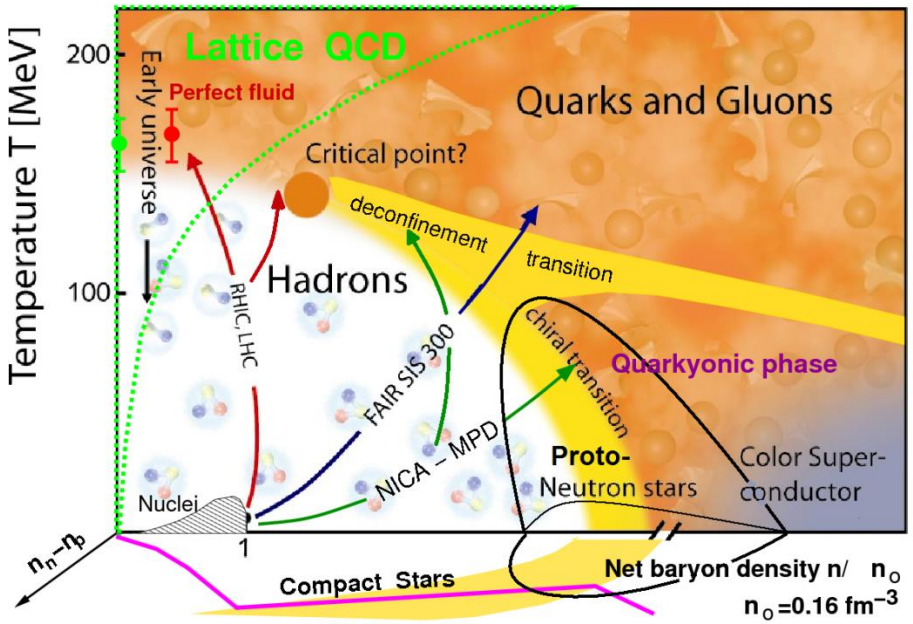
For details:
http://nica.jinr.ru/files/NICA_CDR.pdf
http://nica.jinr.ru/files/MPD_CDR_en.pdf

Anisotropic Flow



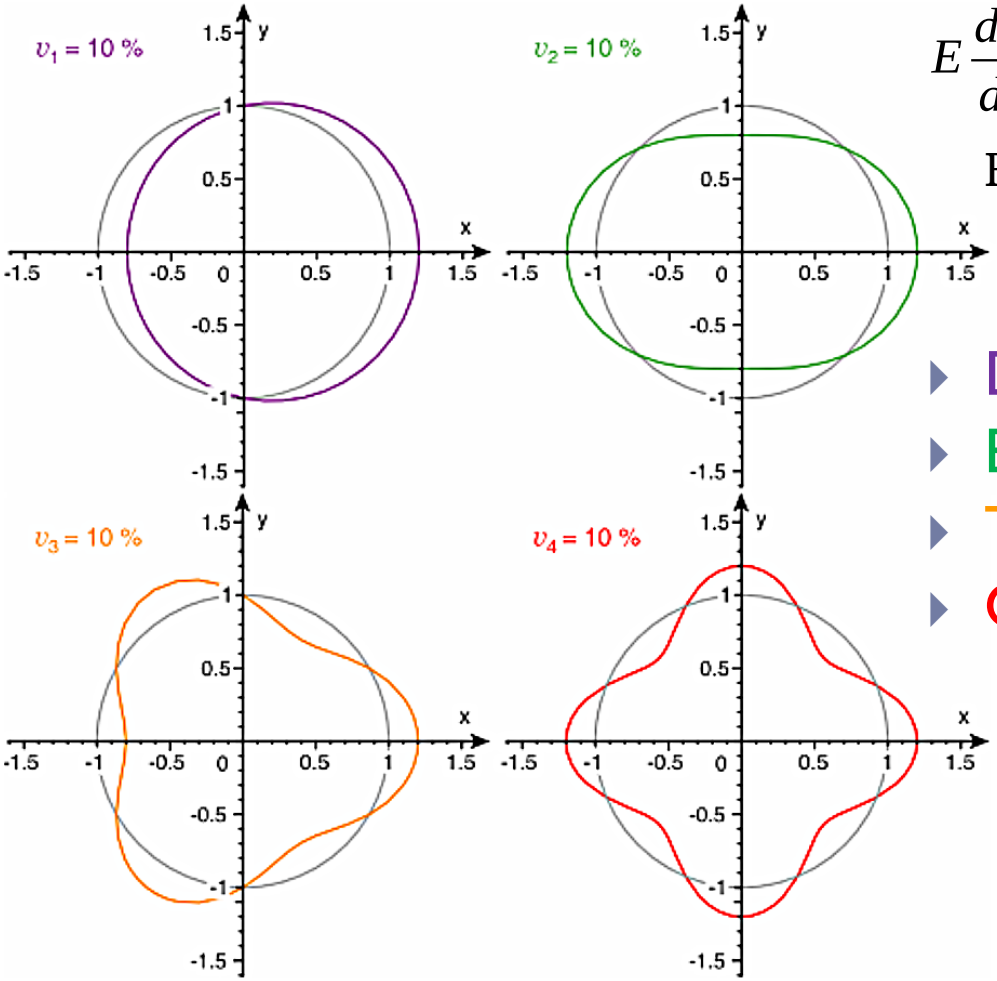
- ***Non-zero impact parameter***
- ***Spatial anisotropy -*** coordinate space configuration anisotropic (almond shape) however, initial momentum distribution isotropic
- ***Pressure gradient -*** interacting constituents generate a pressure gradient, which transforms the initial space anisotropy into a momentum space anisotropy
- ***Momentum anisotropy***

Motivation



- ***Equation of State***
- ***Phase transition / degree of thermalization***
- ***Flow of hyperons*** - less sensitive to freeze-out temp and more directly reflects conditions of the early stages of collision than the flow of lighter particles.

Flow Harmonics

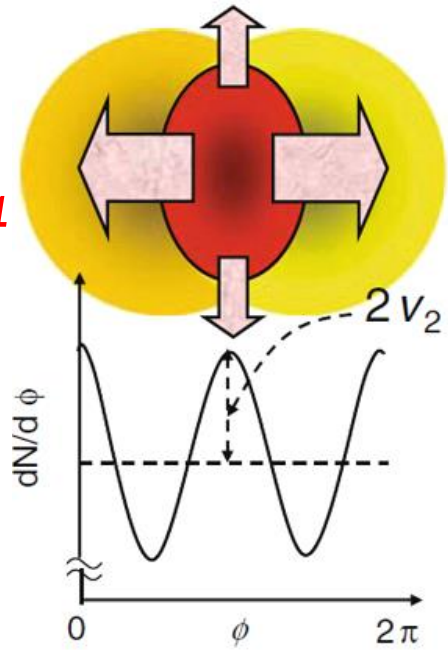


$$E\frac{d^3N}{d^3p} = \frac{1}{2\pi}\frac{d^2N}{p_t dp_t dy}\left(1+\sum_{n=1}^{\infty}2v_n\cos\left(n\left(\phi-\Psi_r\right)\right)\right)$$

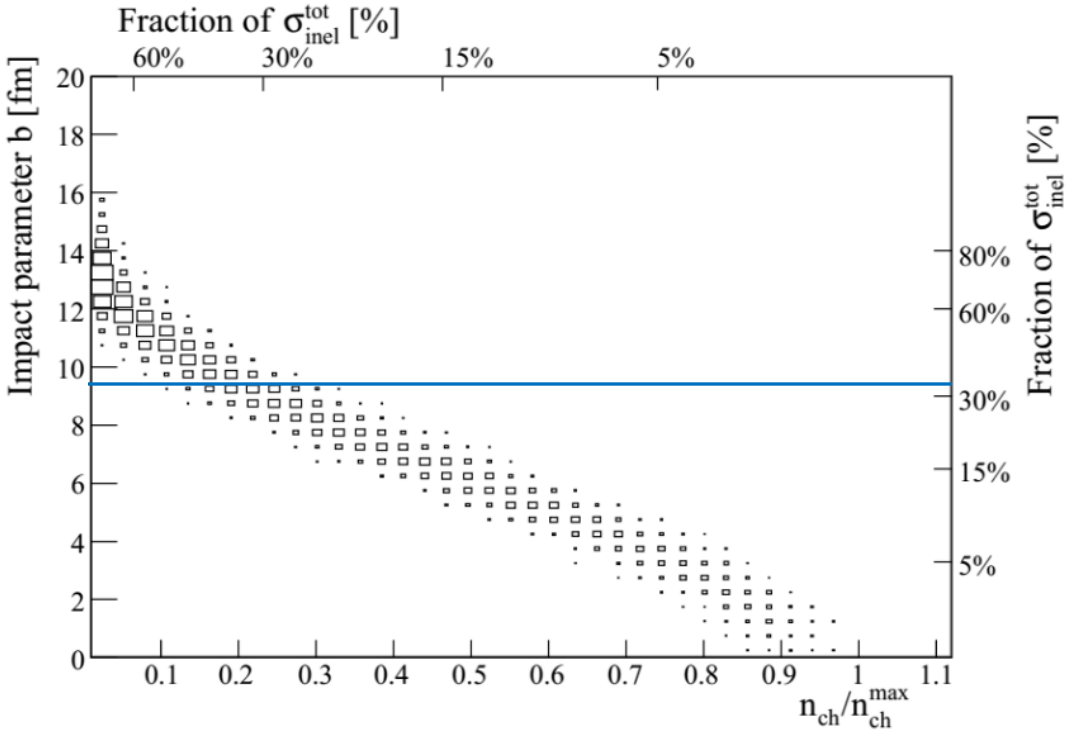
Fourier expansion with coefficients v_n

$$v_n = \langle\cos(n(\varphi - \Psi_{EP}))\rangle$$

- Directed *v1*
- Elliptic *v2*
- Triangular *v3*
- Quadrangular *v4*

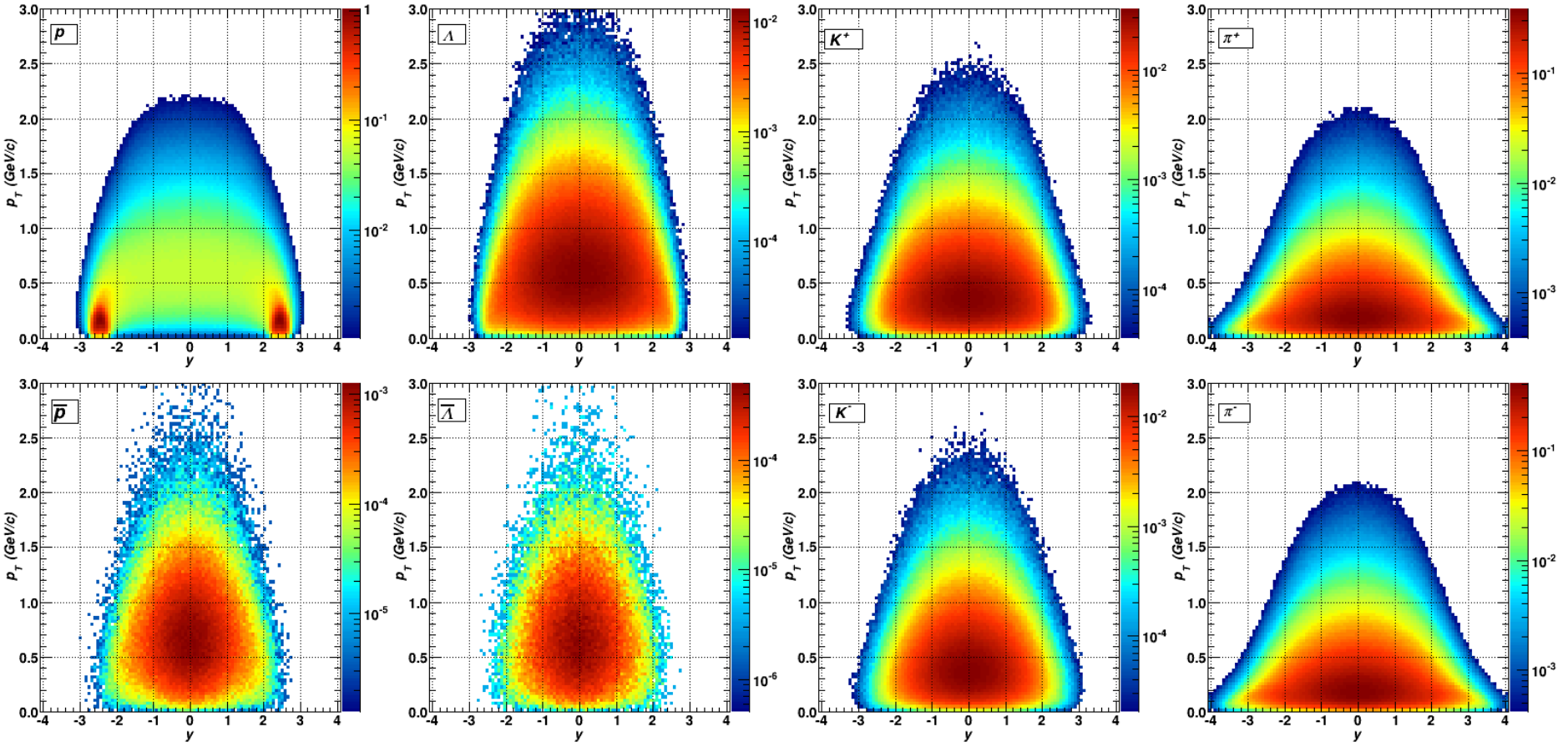


Data Set

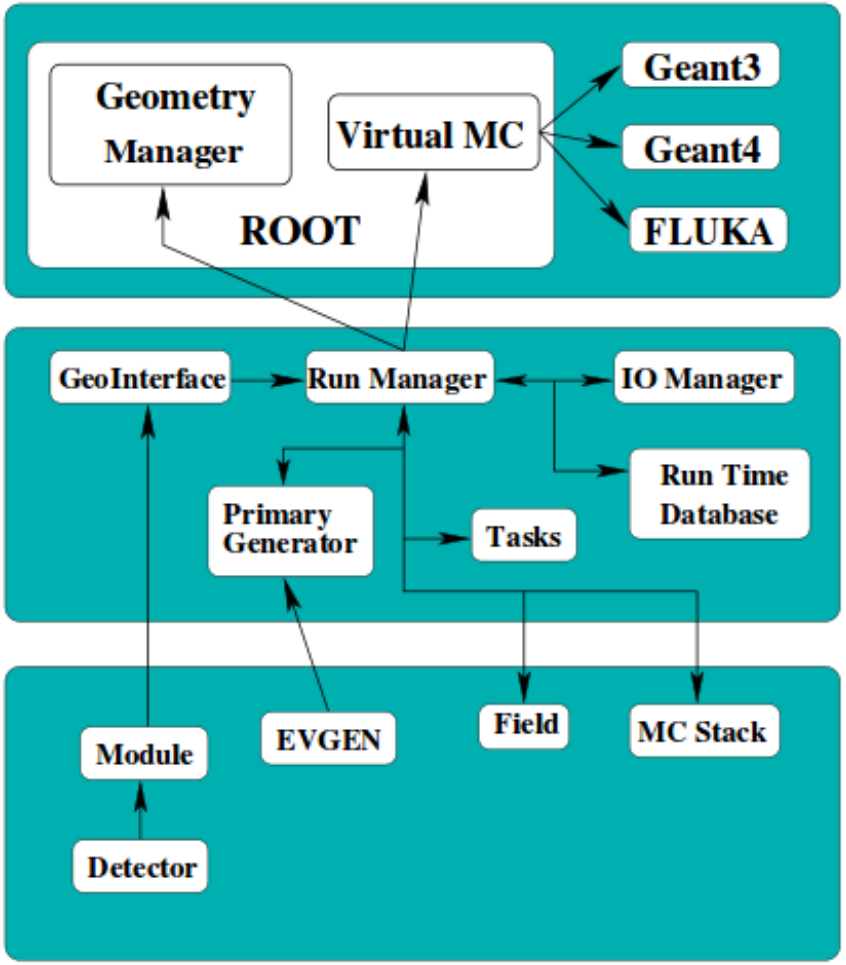


- ***UrQMD 3.3***
- $\sqrt{s_{AuAu}}$ = 11 GeV
- b = 0..9 fm ~ cent=0..30%
- 300k events
- **Transport model** – treat non-equilibrium processes directly.
- Includes **non-flow correlations** naturally during the system evolution
- **Event by event model** – contains the event by event flow fluctuations.
- Underpredicts elliptic flow

UrQMD Phase Space



Analysis Procedure

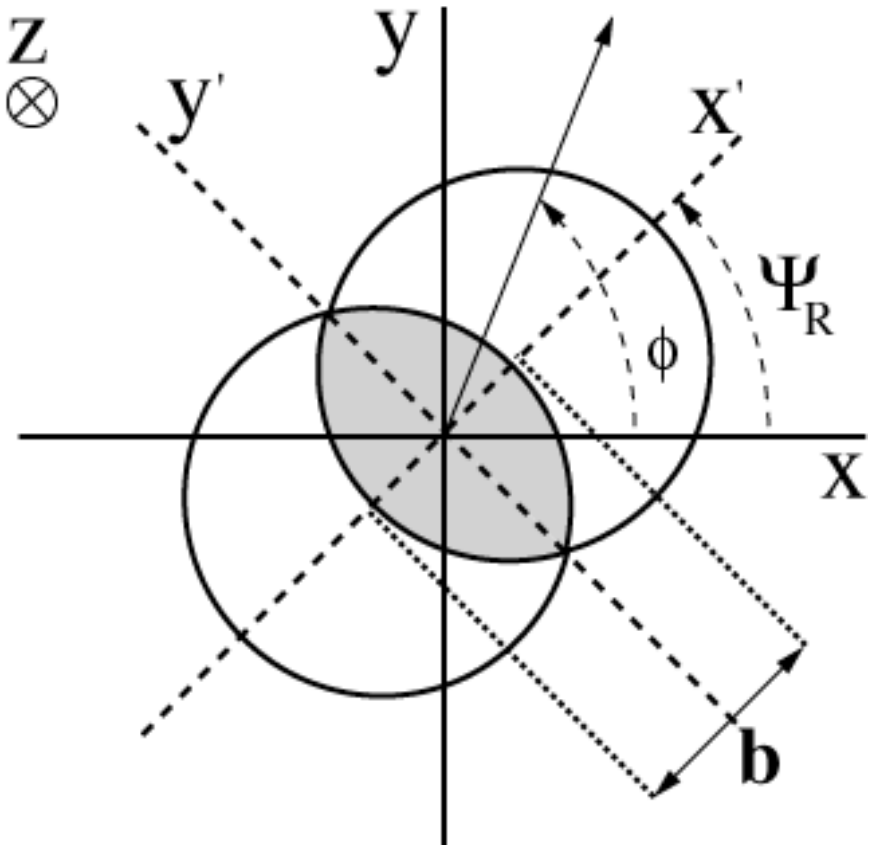


- UrQMD
- Geant3
- Reconstruction

TPC and TOF with:

- $|\eta| < 1.5$
- $p_T < 2$ GeV/c
- $N_{TPChits} > 10$

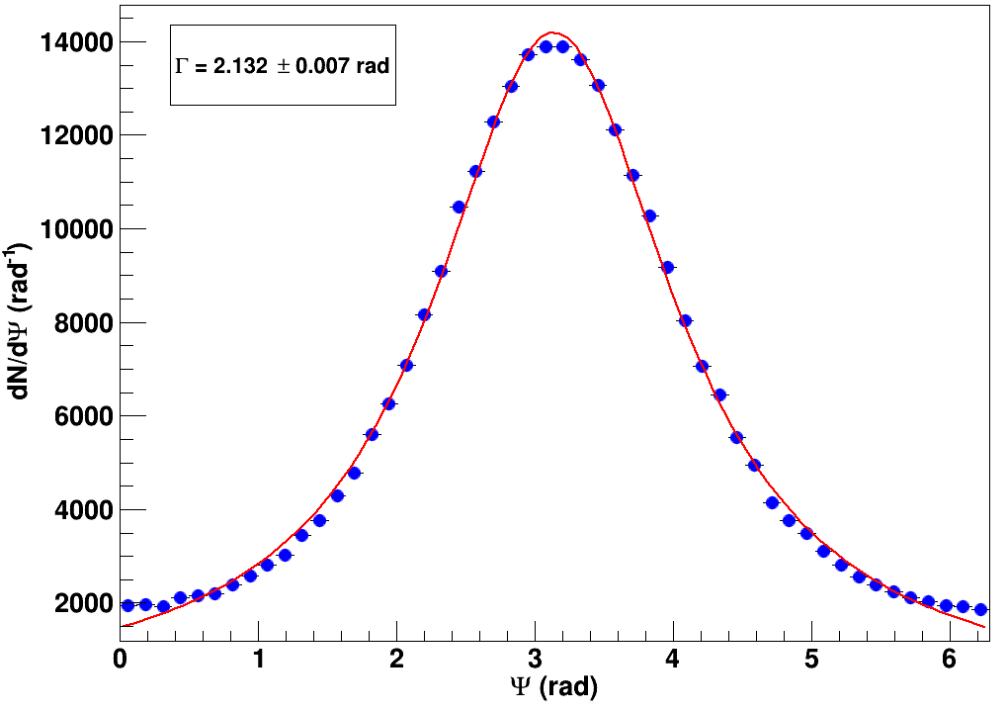
Event Plane Method

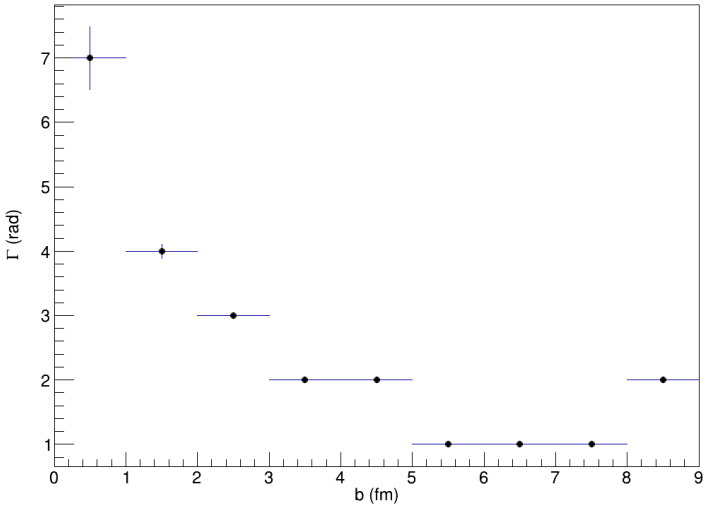


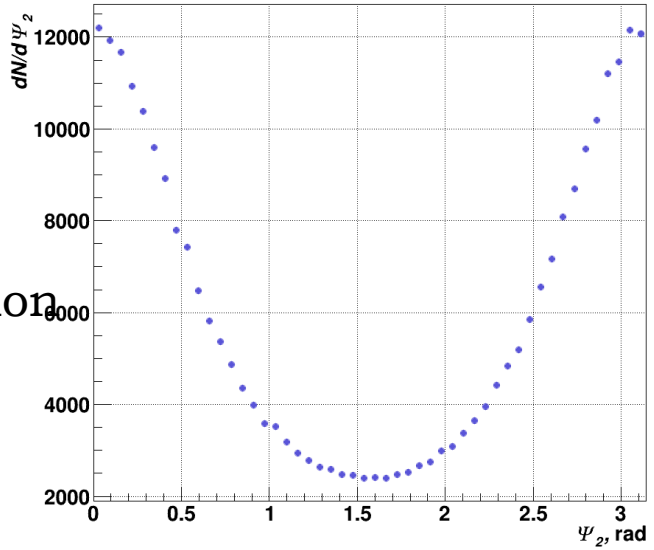
S. Voloshin and Y. Zhang,
Z. Phys. C 70, p. 665 (1996)

- Event selection (e.g. cent)
- Track selection (e.g. pid, pt)
- Flattening $dN/d\varphi$
- Build Q vector:
- $Q_{n,x} = \sum_i w_i \cos n\varphi_i$
- $Q_{n,y} = \sum_i w_i \sin n\varphi_i$
- Event Plane Angle:
- $\Psi_n = \frac{1}{n} arctan(Q_{n,y}/Q_{n,x})$
- Negative values are shifted by adding $2\pi/n$
- Resolution by sub-events
- $R_n = \sqrt{2\langle\cos[n(\Psi_n^A - \Psi_n^B)]\rangle}$
- Correlate particle with EP and calculate flow:
- $\upsilon_n^{obs} = \langle\cos[n(\varphi - \Psi_n)]\rangle$
- $\upsilon_n = \upsilon_n^{obs}/R_n$

Event Plane Angle







EP angle is reconstructed with TPC tracks

The distribution is fit with Breit-Wigner function

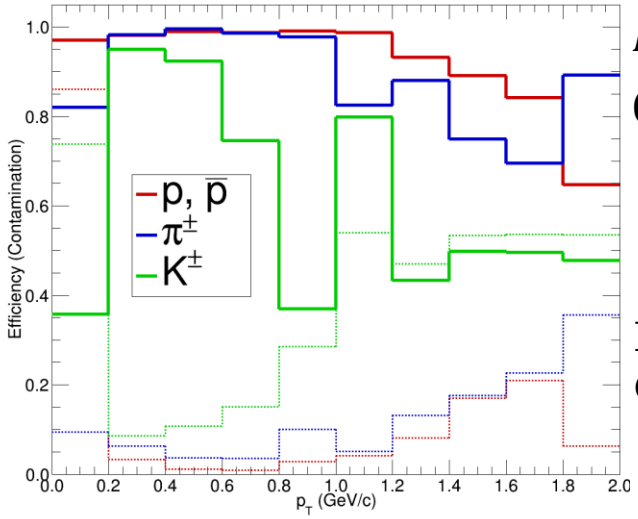
Sub-event resolution is:

R_1 = 0.661 ± 0.001

R_2 = 0.493 ± 0.002

Integrated for all particles v_2= (2.66 ± 0.03)%

Particle Identification



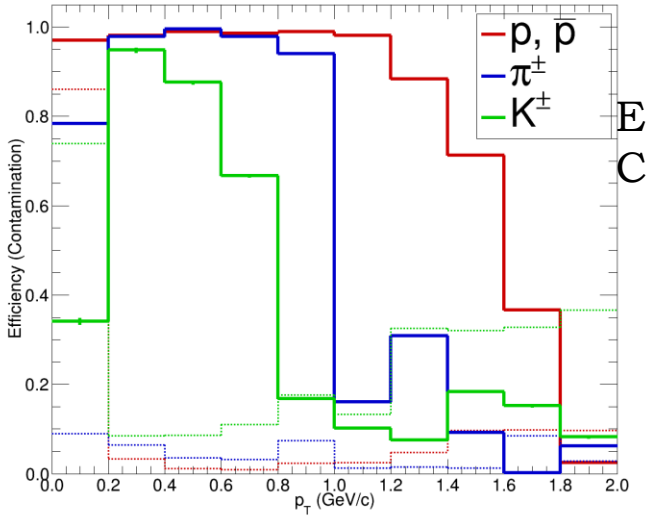
$E = N_{corr}/N_{ana}$

$C = N_{incorr}/N_{corr+incorr}$

$P_{trust} > 0$

E p = 0.95 π = 0.95 K = 0.71

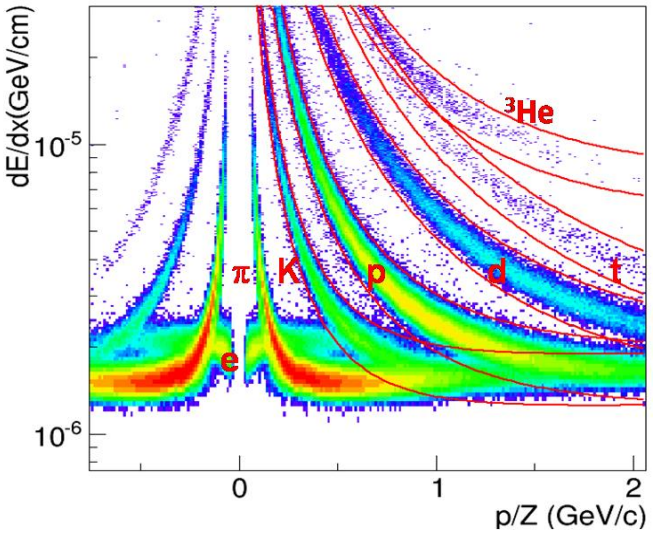
C p = 0.17 π = 0.07 K = 0.29

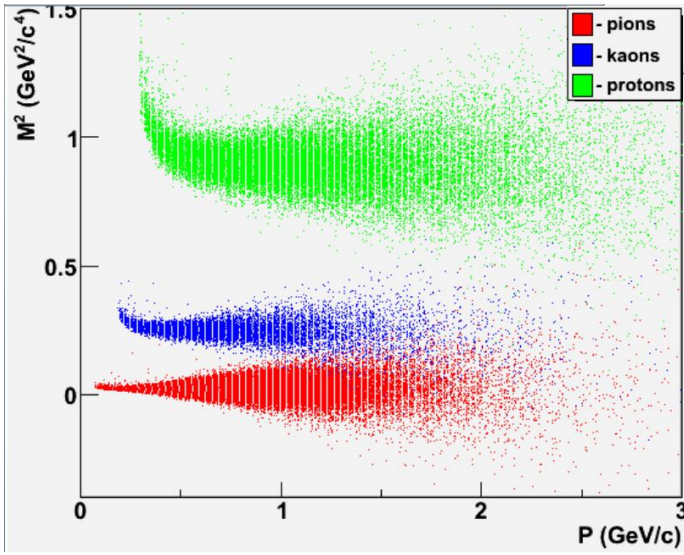


$P_{trust} > 0.6$

E p = 0.87 π = 0.88 K = 0.52

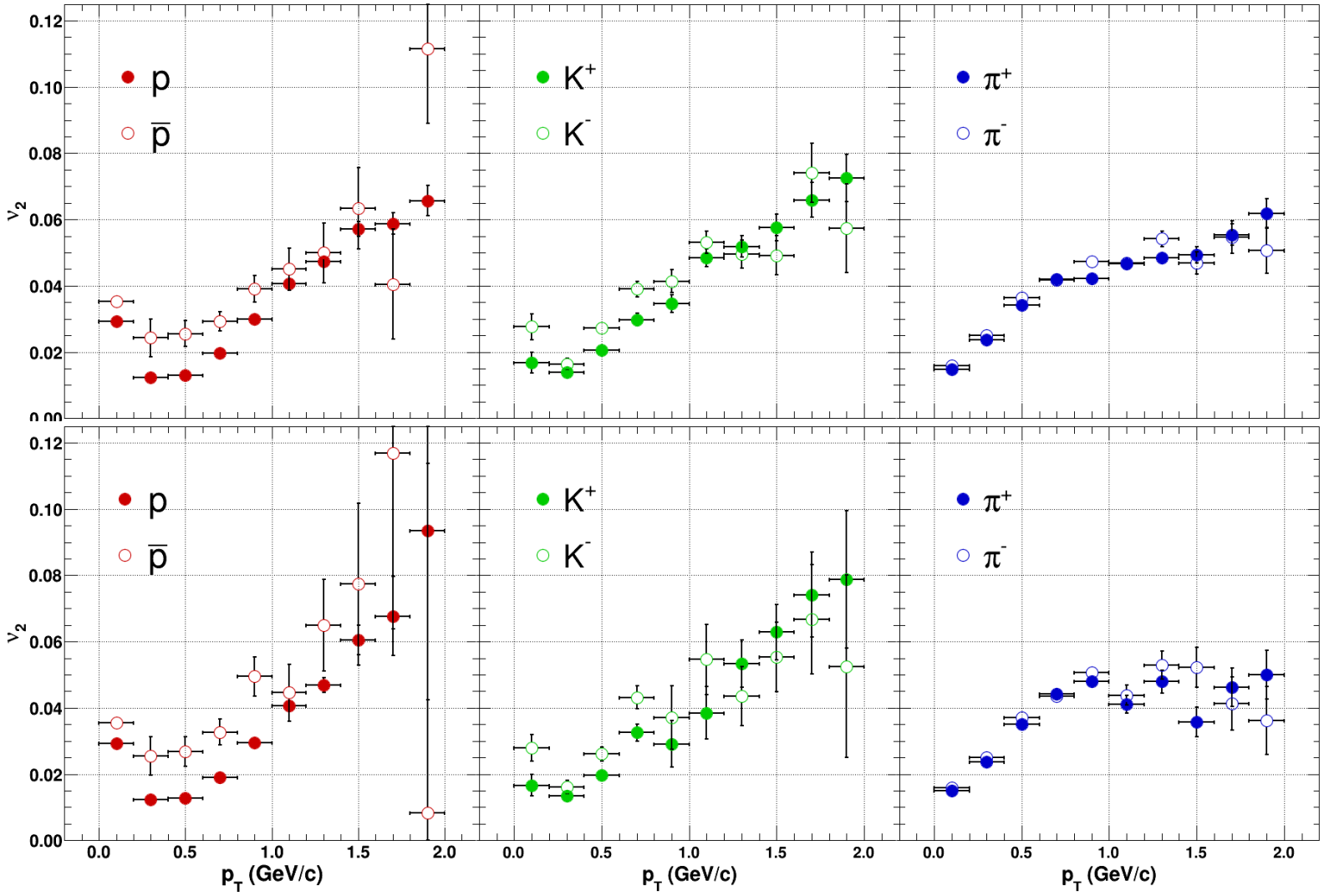
C p = 0.16 π = 0.06 K = 0.14





For Details: S.P. Merts et al.,Matem. Mod. 12, p. 102 (2012)

Identified Particles' Elliptic Flow



$P_{trust} > 0$

Int v_2

p = 2.52

p_{bar} = 3.45

K^+ = 2.68

K^- = 3.13

π^+ = 2.76

π^- = 2.79

$P_{trust} > 0.6$

Int v_2

p = 2.23

p_{bar} = 3.53

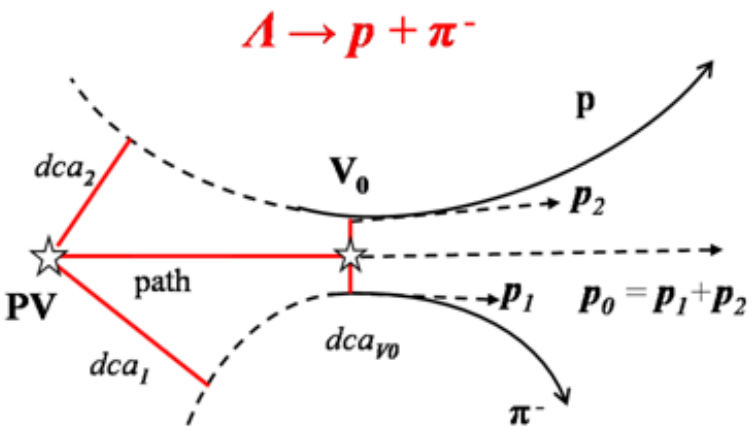
K^+ = 2.04

K^- = 2.59

π^+ = 2.64

π^- = 2.71

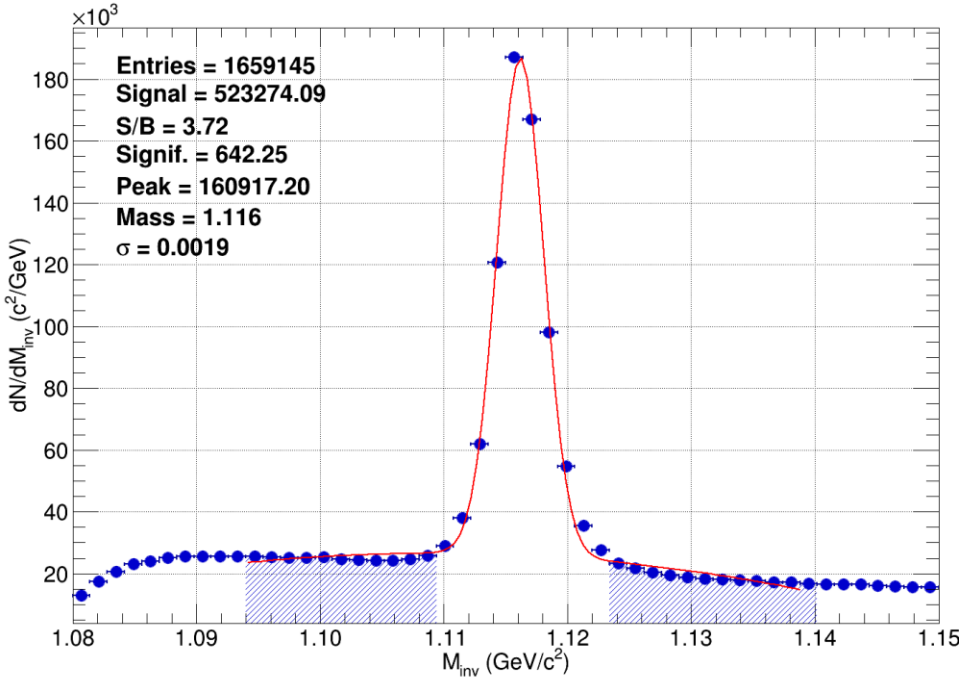
Λ Reconstruction



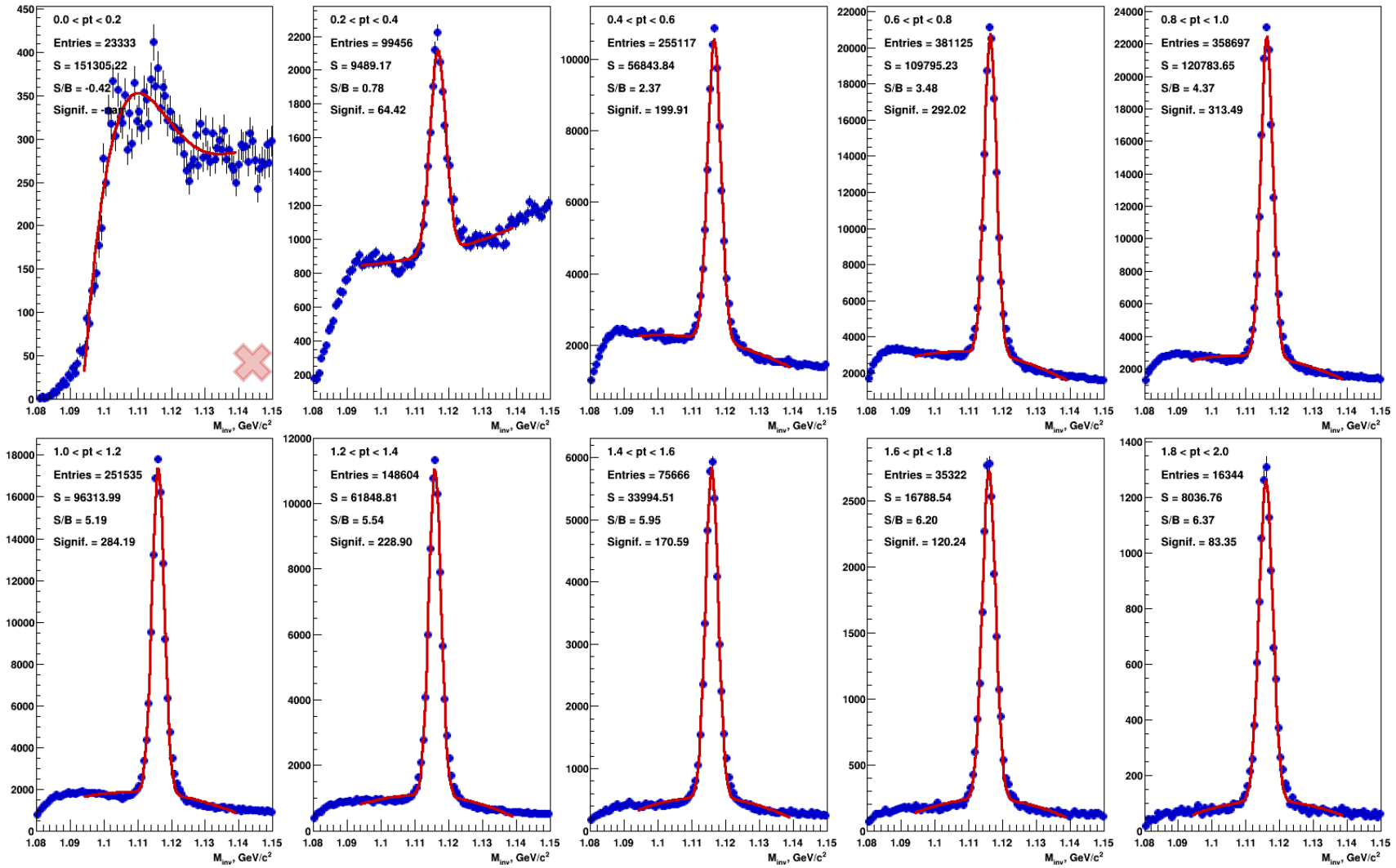
- Reconstructed Λ are correlated with the event plane angle
- Daughter autocorrelation is avoided
- Sidebands method is used to remove background contribution

PV – primary vertex
V0 – vertex of Λ decay
dca – distance of the closest approach
path – decay length
$|\eta| < 2$

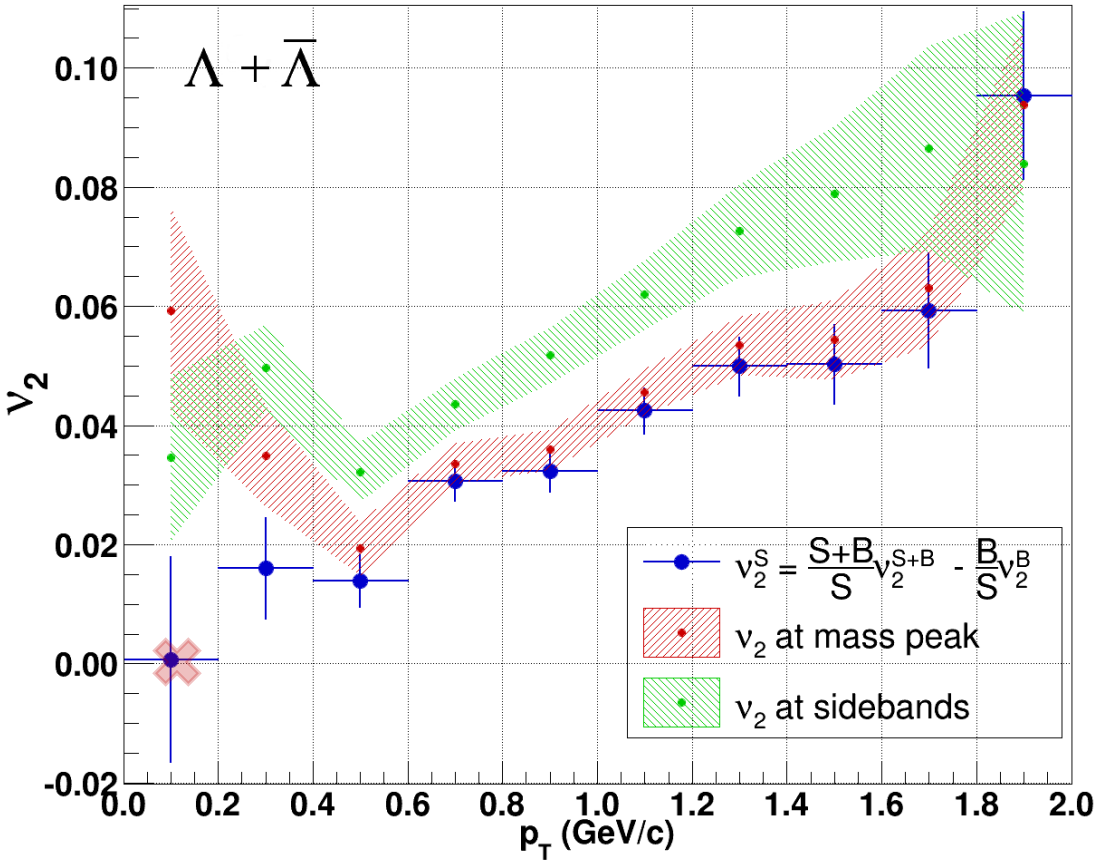
$P_{trust} > 0$



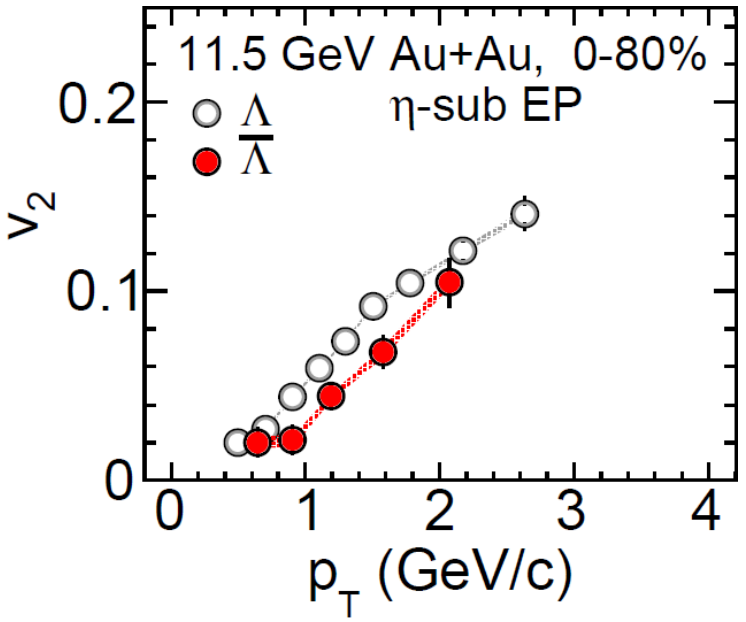
Λ Reconstruction in bins of p_T



Λ Elliptic Flow



RHIC: BES arXiv:1301.2348v1



Summary

- Study of hyperon flow is very interesting and important for the upcoming MPD@NICA project
- The present study was conducted using the UrQMD event generator and utilizing the MpdRoot software chain
- Elliptic flow of reconstructed hadrons has been estimated, with special attention to lambda hyperons and the results are promising…

Thank you for your attention!