CZECH PARTICIPATION AT FACILITY

FOR ANTIPROTON AND ION RESEARCH (FAIR)

Simulation study of effects induced by final granularity of detector in particle flow

Alexandr Prozorov
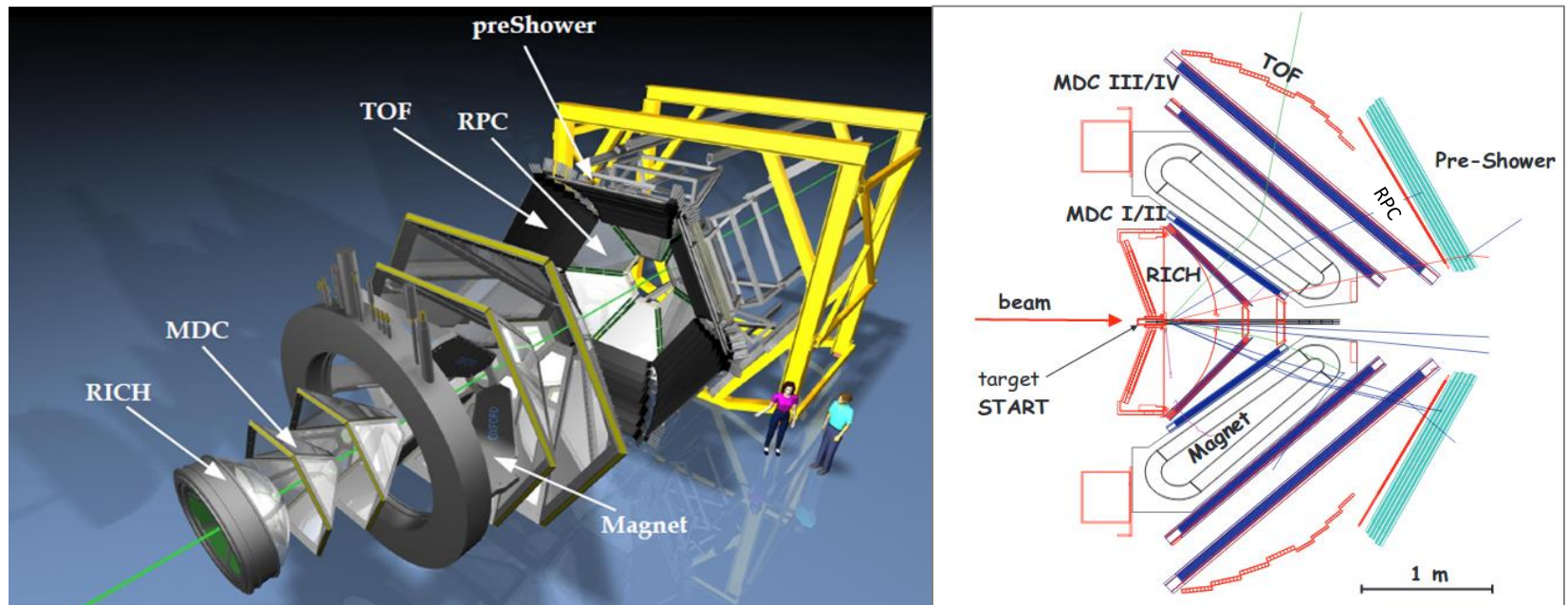
Nuclear Physics Institute
of the Czech Academy of Sciences

Outline

- Model of registration for a different cell size for IQMD model data
- Efficiency of registration and its effects

- Correction matrix that takes into account unregistered particles
- Comparison of the corrected model data to the original data
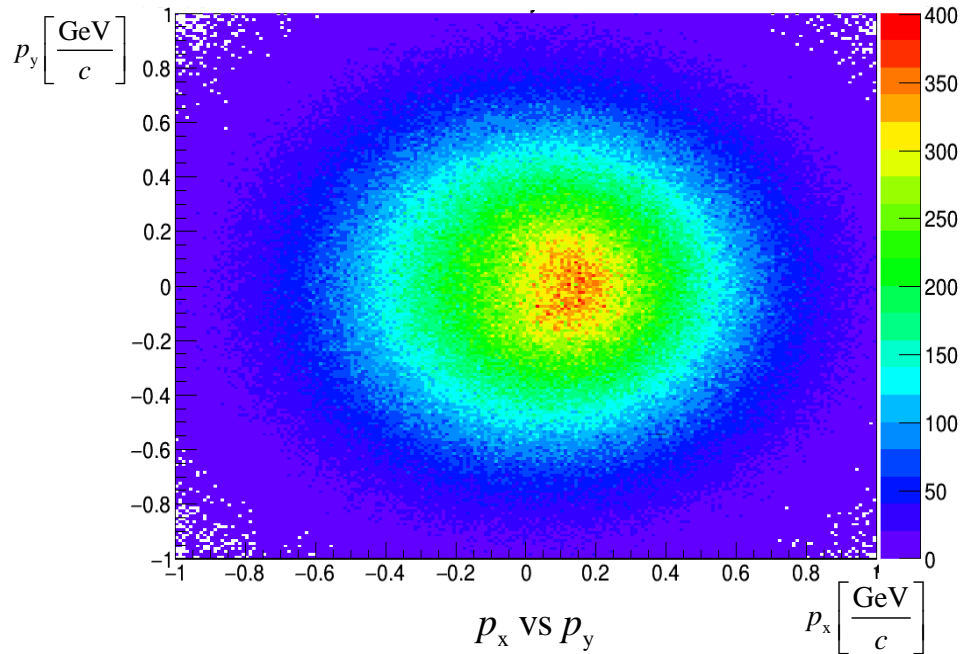
Experiment HADES

Description of spectrometer and tracking system

Study of particles distribution

$$\frac{dN}{d\varphi} \sim 1 + 2\sum_n v_n \cos n(\varphi - \Phi_{RP}), \quad \Phi_{RP} = 0 \text{ for generators itself}$$
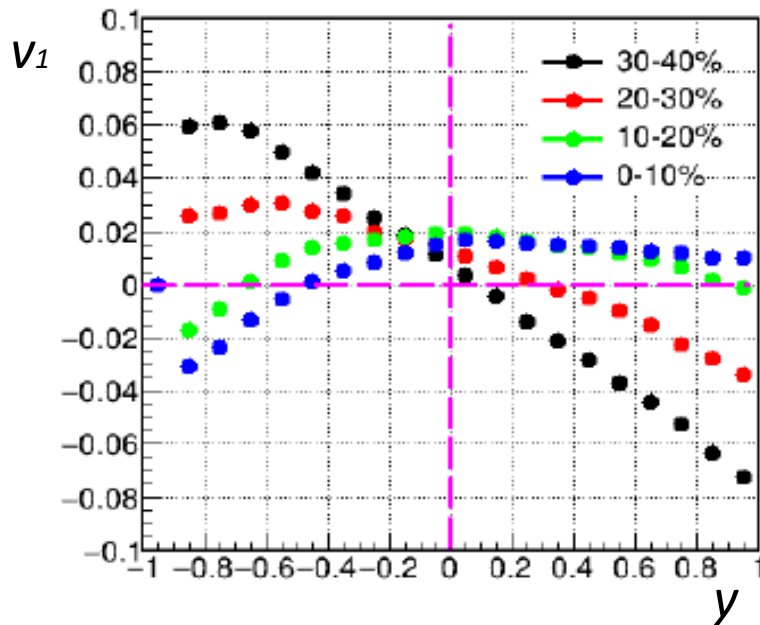
Protons at forward rapidity Au+Au 1.23AGeV

p_x vs p_y

Directed flow:

$$v_1 = \left\langle \frac{p_x}{p_t} \right\rangle = \left\langle \cos(\varphi') \right\rangle, \, p_t = \sqrt{p_x^2 + p_y^2}$$
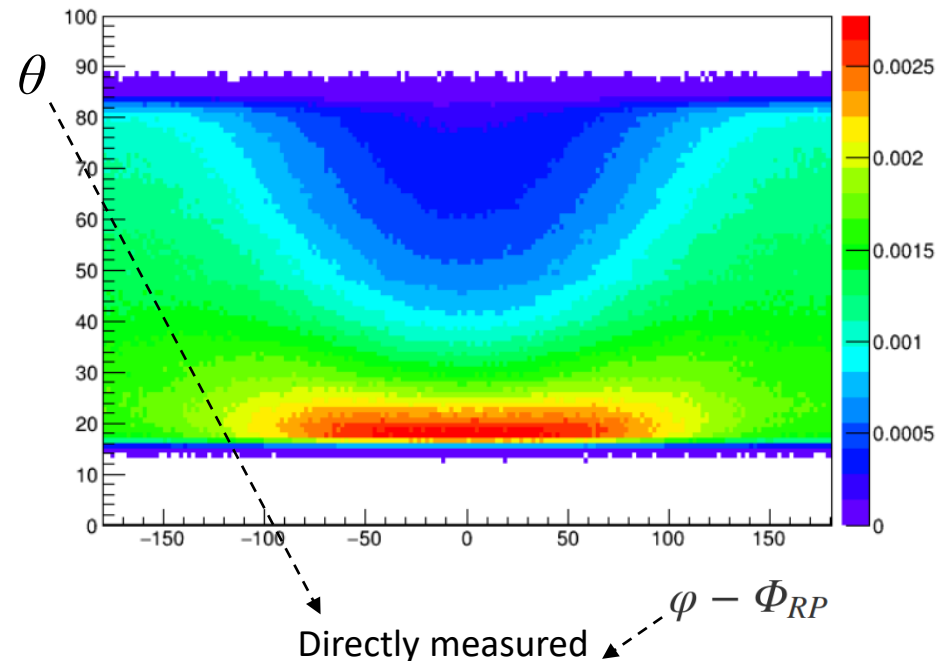
Experimental data Au+Au 1.23AGeV @HADES

Preliminary*

π^-

Raw data, not corrected on detection efficiency.
Analysis under progress

Preliminary*

All particles distribution

Directly measured $\quad \varphi - \Phi_{RP}$
Not like in Nucl.Phys. A781 (2007) 459, page. 491-492

*See talk of M. Gumberidze on HADES analysis meeting
https://indico.gsi.de/event/5389/contribution/1/material/slides/0.pdf

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Detection model

- Calculation and remembering angles of all particles in one event

- Cycle through cells (-180° ≤ φ < 180° & 18° ≤ θ < 85°). Division of all space (as they are normally distributed spherically) into cells with the same area d$\cos\theta$ dφ (for example - a sphere is divided with d$\cos\theta$ = 0.1, dφ = 10°)

- If a cell contains more than one particle, only one is selected and written into the final data file

- Finally, the directed flow is calculated for different types, centralities and rapidity ranges using the final data file
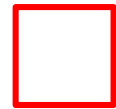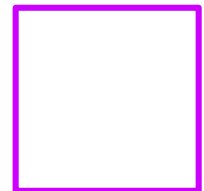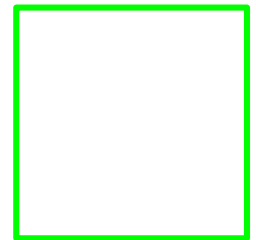
Simulation results for IQMD model

V_1 for π^- for 0-10% centrality

Legend:
- 2x2[deg]
- 5x5[deg]
- 6x6[deg]
- 8x8[deg]
- 10x10[deg]
- original
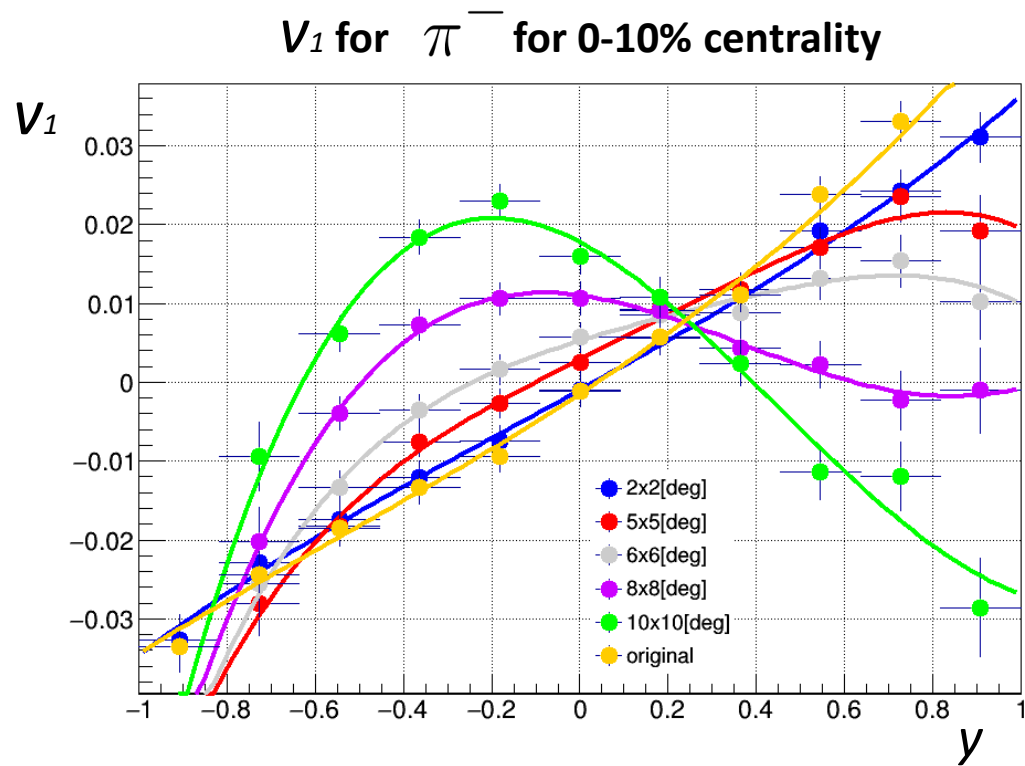
2°x2°

5°x5°

6°x6°

8°x8°

10°x10°

Comparison

Raw data, not corrected on
detection efficiency

Best fit qualitatively 6°x 6°
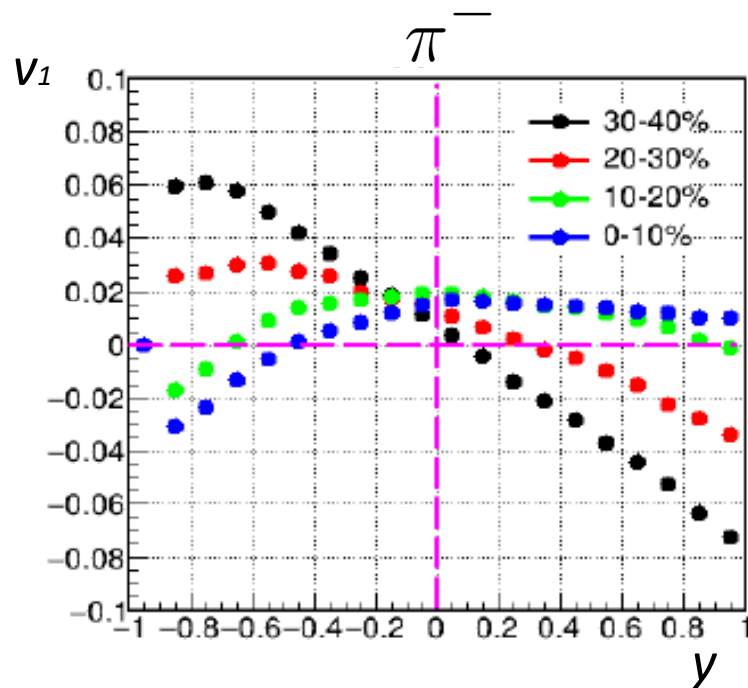detection model

Comparison

Experiment (preliminary)

Model for cellsize 6°x 6°
(IQMD generator)

Raw data, not corrected on
detection efficiency

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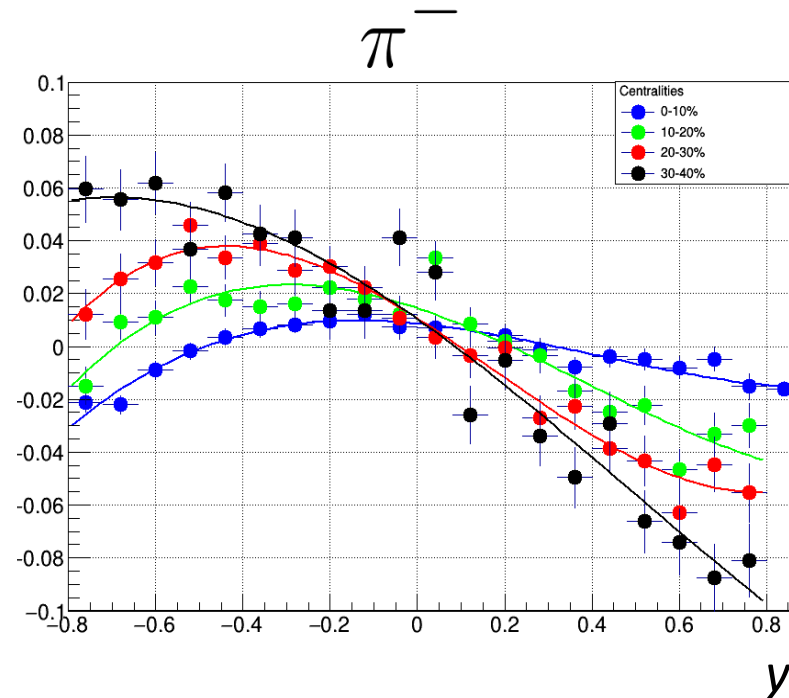
Proton flow
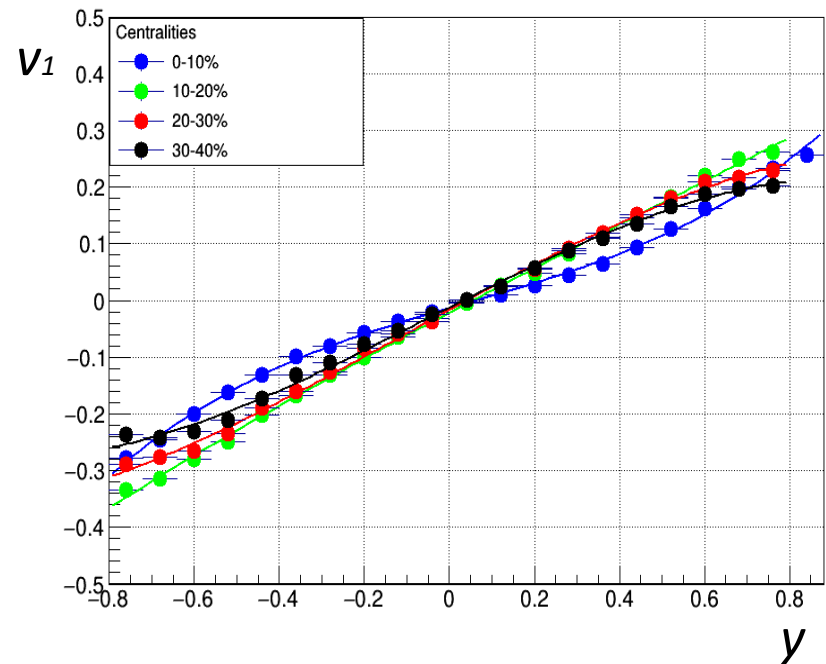

Experiment*

V₁ for protons
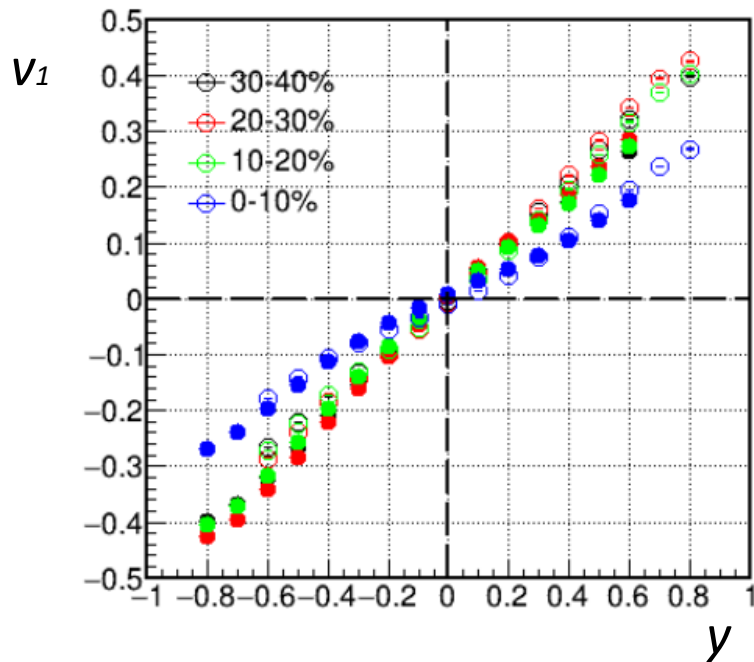
Model for cellsize 6°x 6° (IQMD generator)

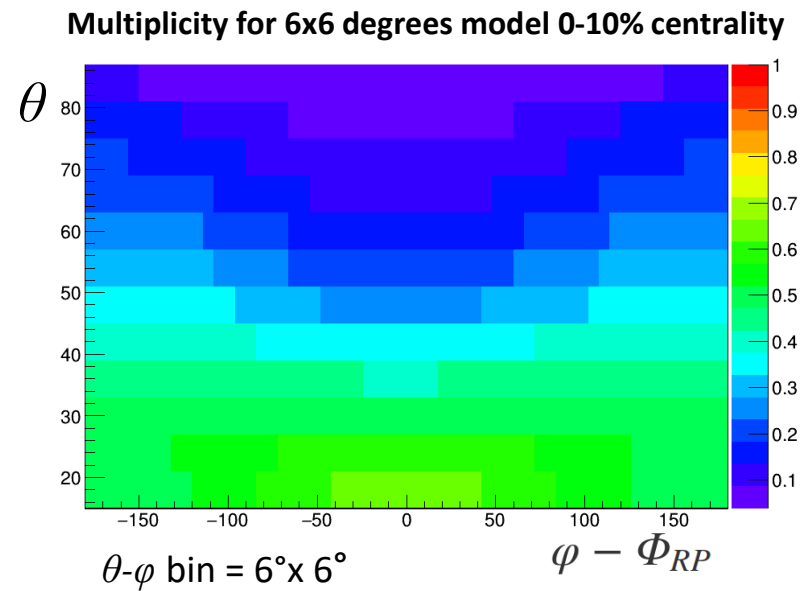**V₁ for protons**

*Behruz Kardan, QM18

Proposed method

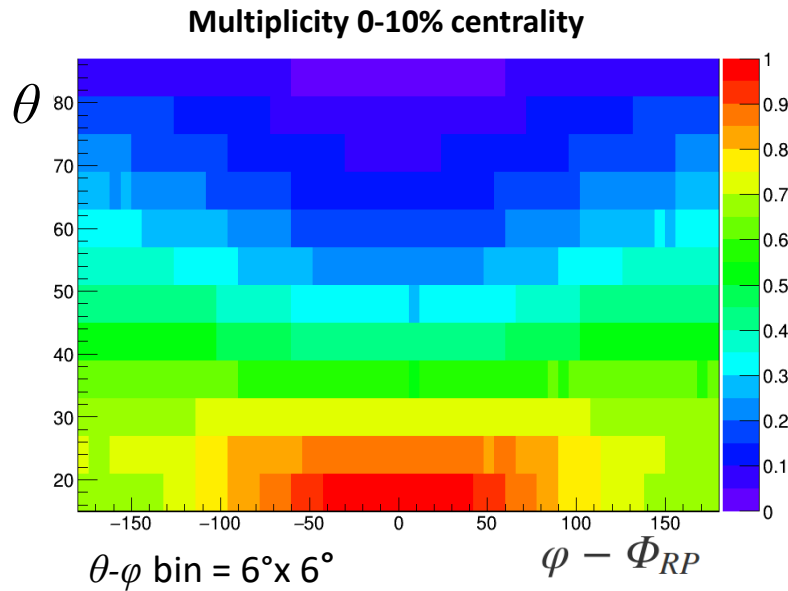- Express efficiency of registration as a linear function of the mean multiplicity of particles

$$\varepsilon = 1 - k * \langle mult \rangle$$

- Construct a correction matrix in the azimuthal and polar angles

- Record the histogram information about the flow taking into account the correction matrix

- Select the parameter *k* such that the directed flows are symmetric and pass through the zero point

Multiplicities

Multiplicity 0-10% centrality

Multiplicity for 6x6 degrees model 0-10% centrality

θ-φ bin = 6°x 6°

$\varphi - \Phi_{RP}$
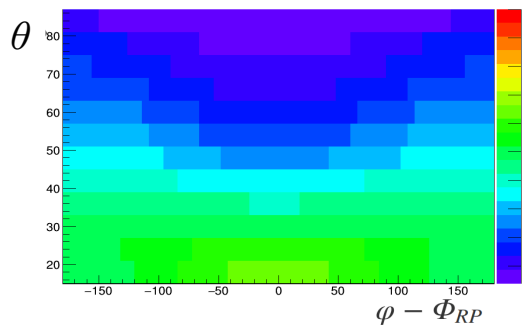
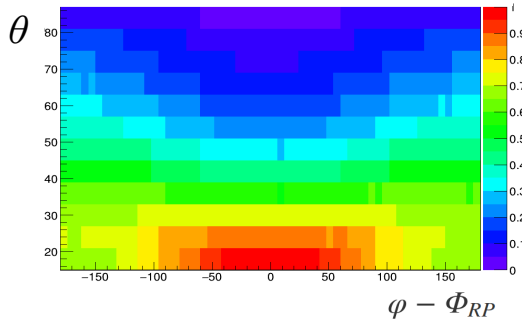θ-φ bin = 6°x 6°

$\varphi - \Phi_{RP}$

Multiplicity – average number of particles that hit
a theta-phi bin during one event

Efficiency of registration
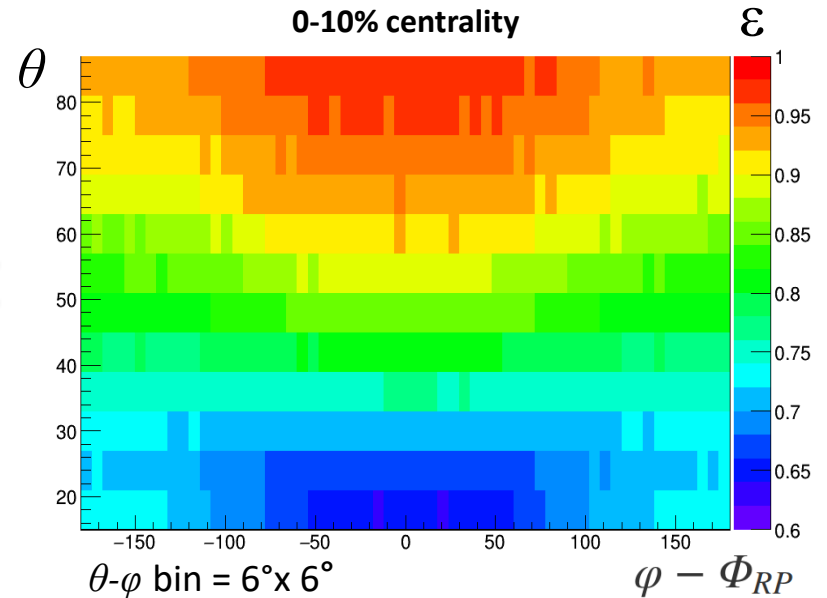
Multiplicity for 6x6 degrees model 0-10% centrality

Multiplicity 0-10% centrality

A ratio between multiplicity for
registered and for all particles

bin by bin

**True efficiency for 6x6 degrees model
0-10% centrality**

θ-φ bin = 6°x 6°
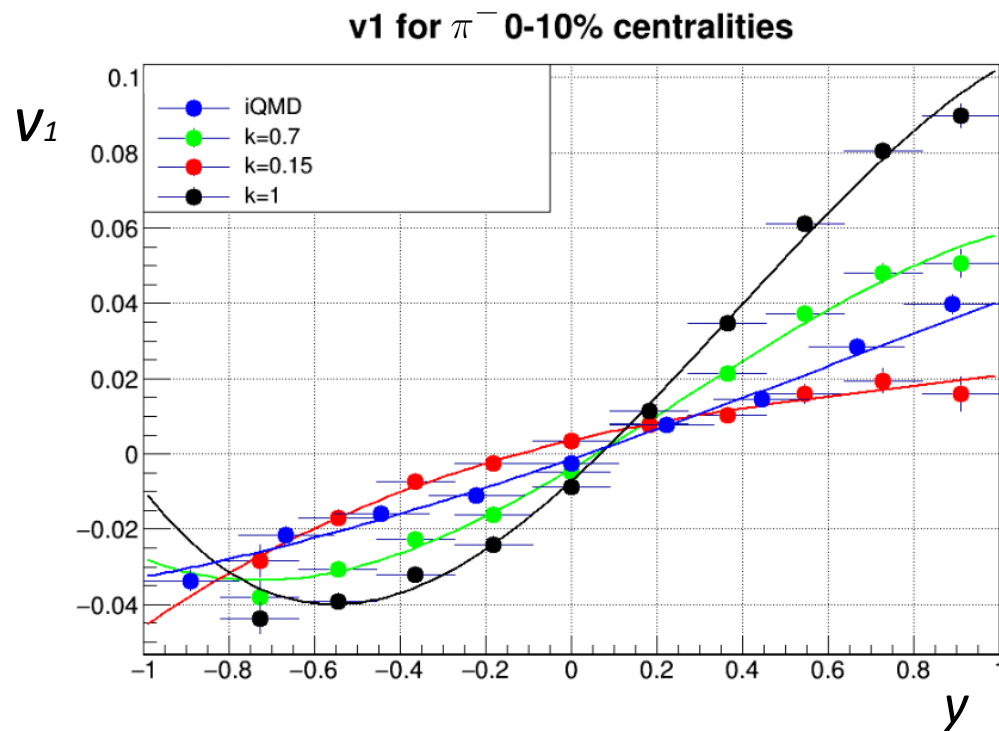
Efficiency of registration is a number
between 0 and 1 showing which part
of all particles was registered

Efficiency vs Multiplicity

$k = 0.42$

True efficiency vs Multiplicity

Efficiency for all types

Multiplicity for registered particles

True efficiency vs Multiplicity

Efficiency for π^-

π^-

Multiplicity for registered particles
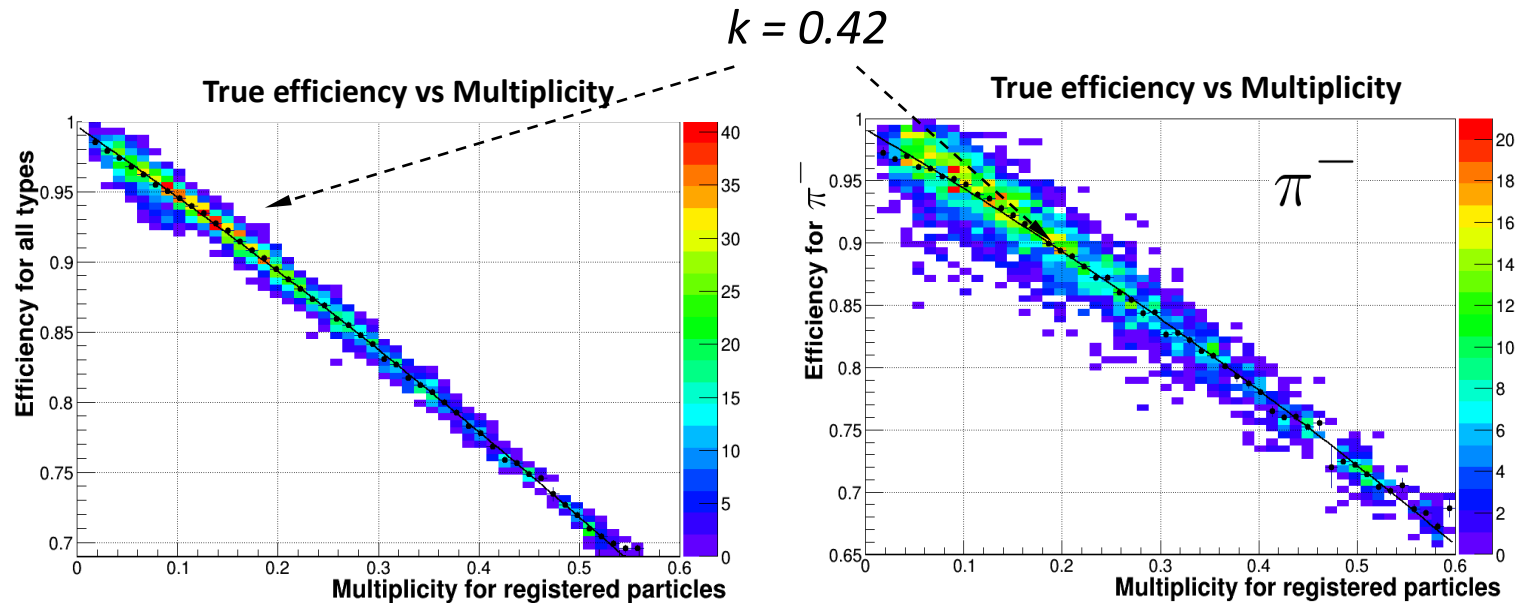
$$\varepsilon = 1 - k * \langle mult \rangle$$
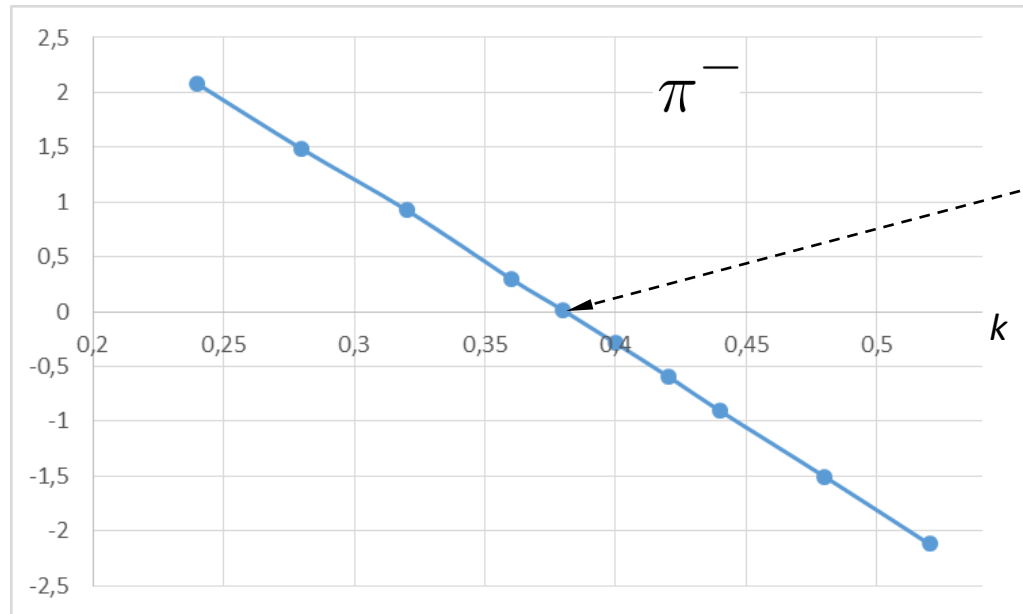
Different slopes

Flow dependence on different efficiency of registration

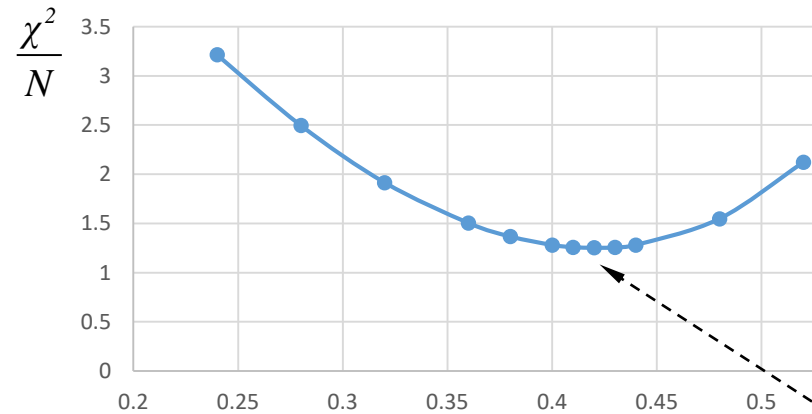# Experimental way for finding *k*

V_1 at midrapidity for 0-10% centrality π^-

$V_1 x\ 10^3$
($y = 0$)

π^-

$k = 0.38$

k

Chi-square minimum

$\dfrac{\chi^2}{N}$ dependence on k

N = 10 points

Data points   Model expectation

$$\chi^2 = \sum_{i=1}^{N} \frac{(x_i - e_i)^2}{\sigma_i^2}$$

Uncertainty

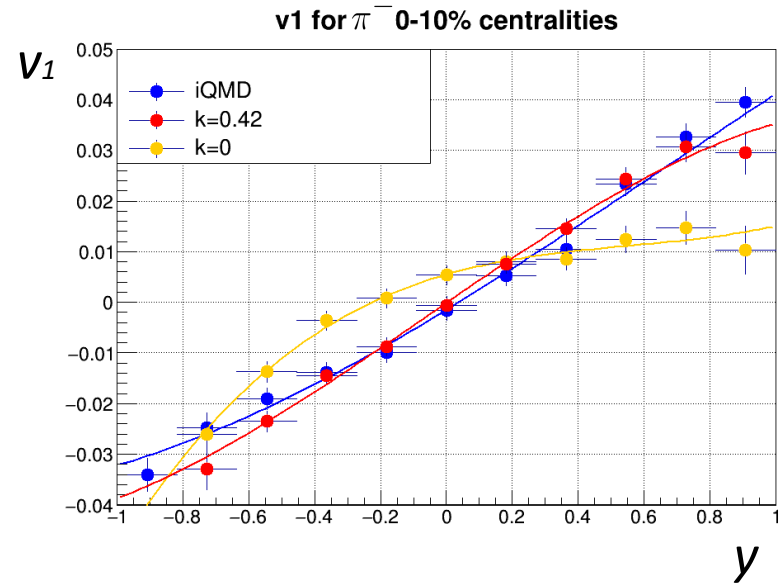$\dfrac{\chi^2_{\min}}{N} = 1.25$ at $k{=}0.42$

Corrected directed flows

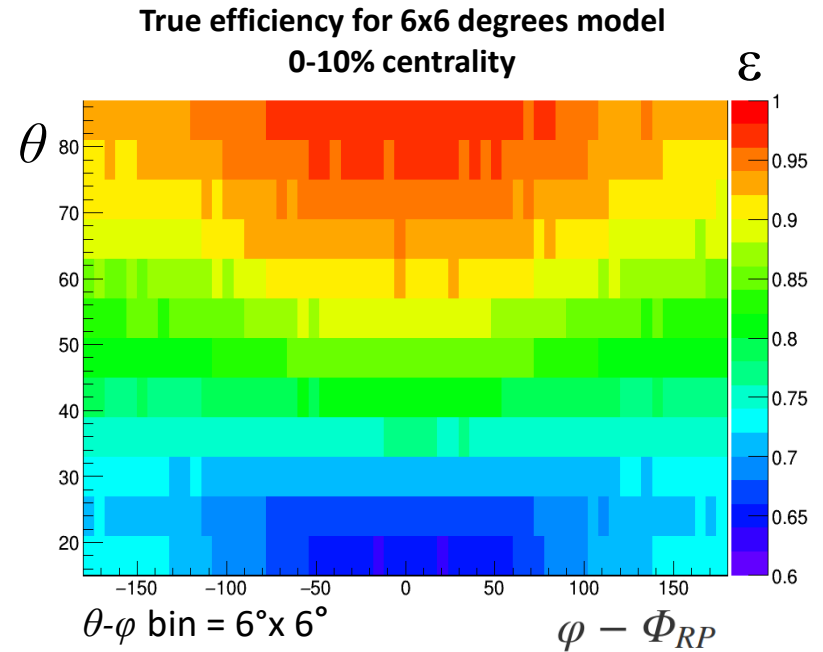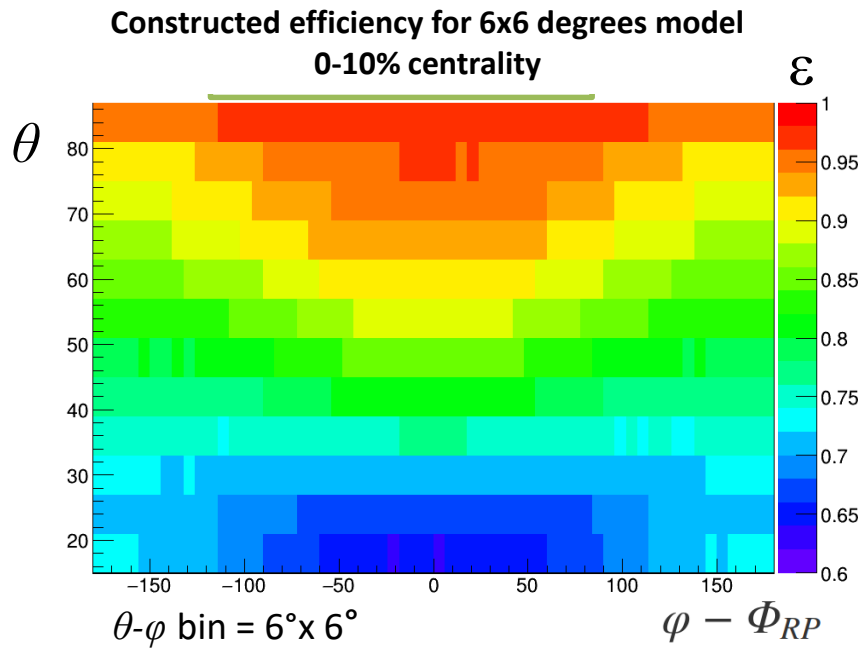v1 for π^- 0-10% centralities
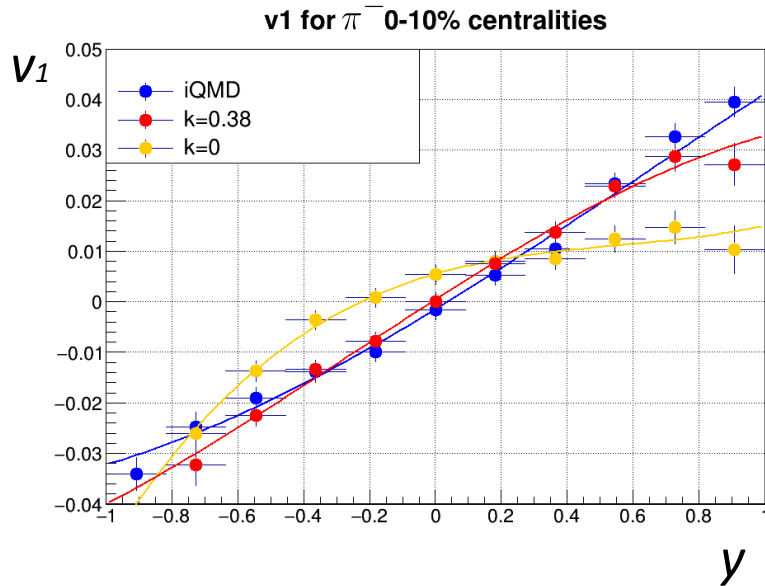
Experimental way for v_1 = 0 at midrapidity

$$\frac{\chi^2}{N} = 1,366$$

Chi square minimum

$$\frac{\chi^2}{N} = 1,25$$

Comparison for Efficiency

Constructed efficiency for 6x6 degrees model
0-10% centrality

ε

θ

$\varphi - \Phi_{RP}$

θ-φ bin = 6°x 6°

True efficiency for 6x6 degrees model
0-10% centrality

ε

θ

$\varphi - \Phi_{RP}$

θ-φ bin = 6°x 6°

Constructed efficiency of registration
for k = 0.42

Results and conclusions

- A particle detection model similar to the Au+Au at 1.23 A GeV experiment was made

- The dependence of efficiency of registration on the size of cells was investigated

- Proposed by HADES group method of correction was justified

Thank you for attention

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