Simulation study of effects induced by final granularity of detector in particle flow deduced from experimental data in relativistic heavy ion collisions for HADES experiment

Speaker: Alexandr Prozorov

Supervisor: Dr. Andrej Kugler

27th of February 2017

TPU – NPI

Monthly seminar

Presentation layout

- Brief introduction to QGP in relativistic heavy-ion collision
- HADES experiment
- Collision characterization
- Goals and plans for diploma thesis
- First results

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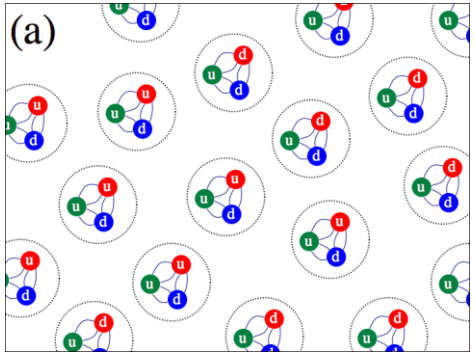
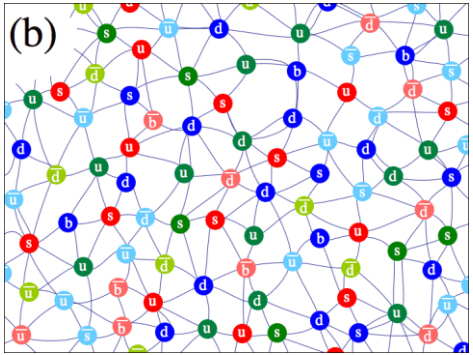
Defined as: free movement of quarks and gluons - no longer confined to hadrons (e.g. protons, neutrons)

Normal Nuclear Matter



Quark Gluon Plasma



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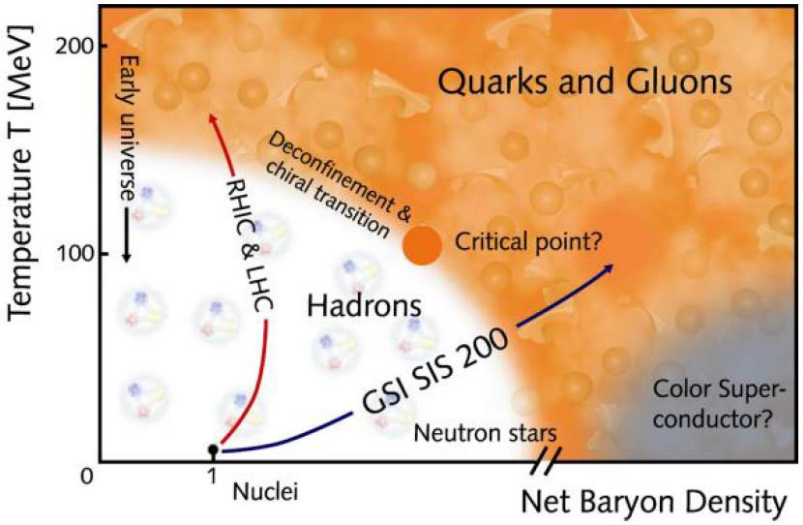
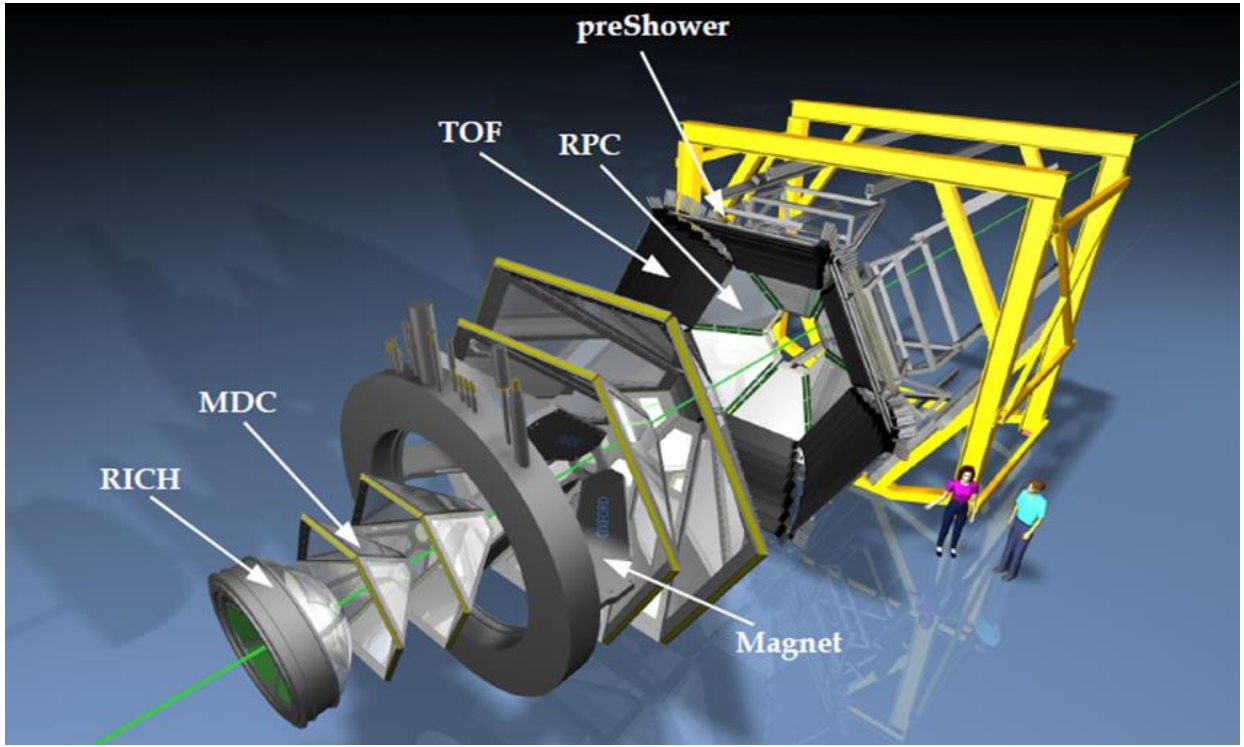


Phase diagram of matter in Temperature-Baryon Density plane.
The two distinct phases of normal hadronic matter and QGP are indicated

Setup of HADES experiment



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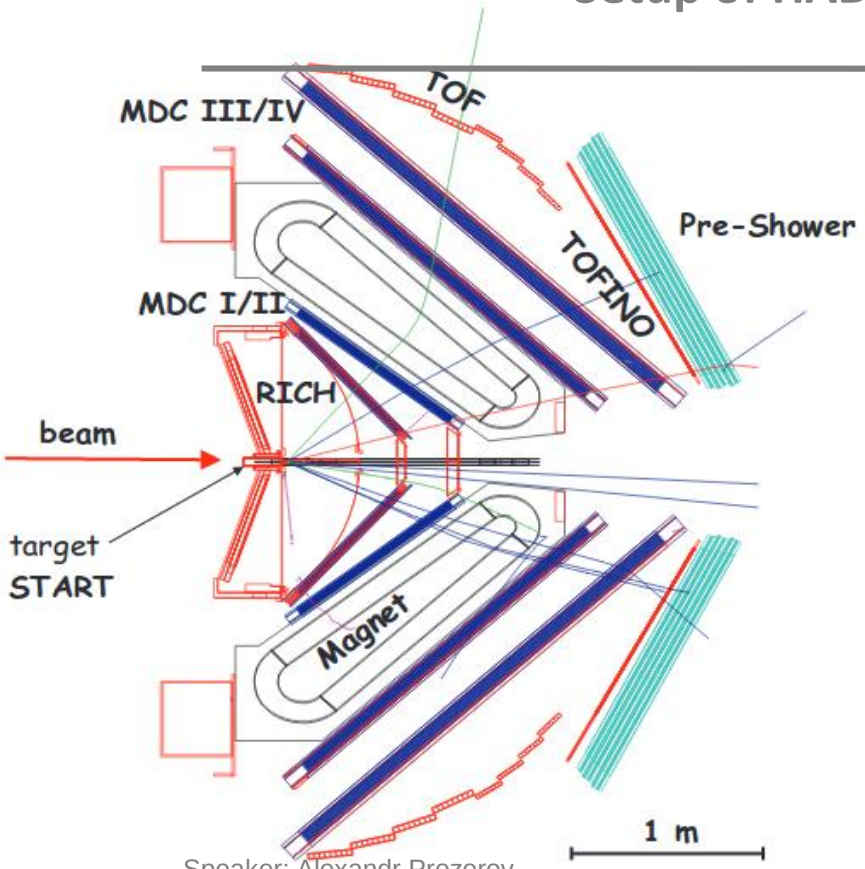
Setup of HADES experiment



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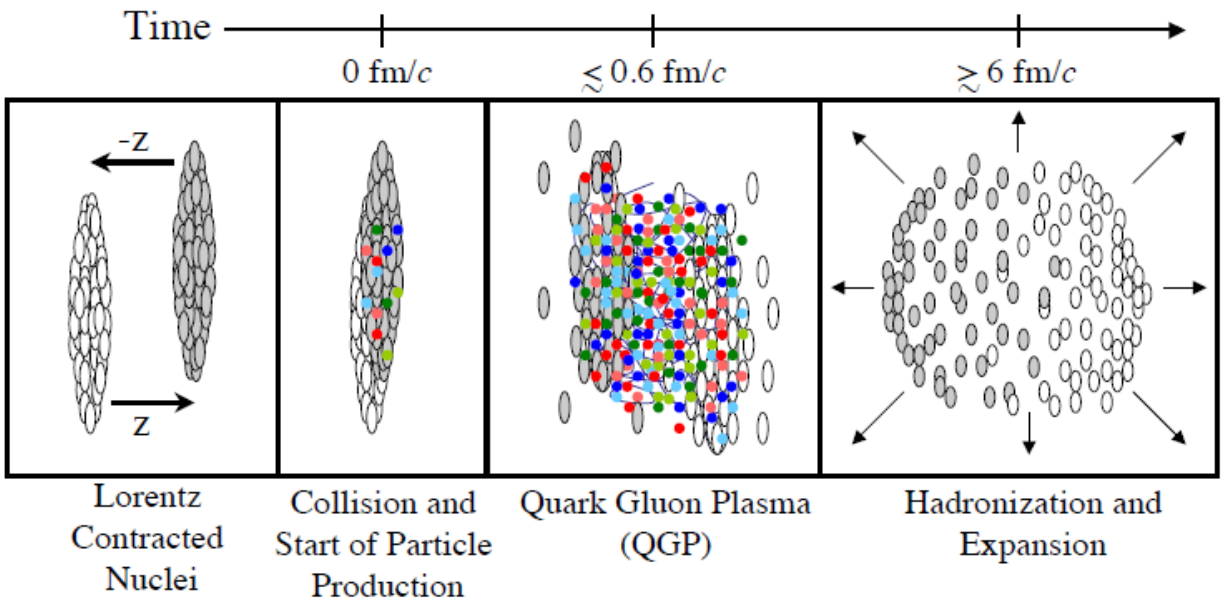
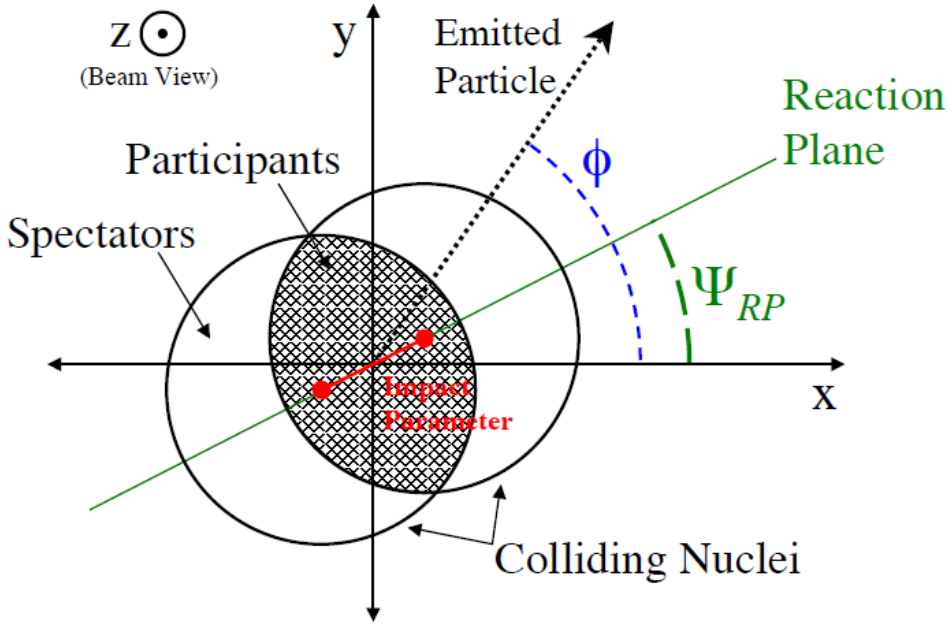
Au+Au collision



Event characterization in the heavy-ion collisions



- Different approaches and one of them is to use flow

In non-central collisions flow of particles is usually described by Fourier decomposition with respect to reaction plane:

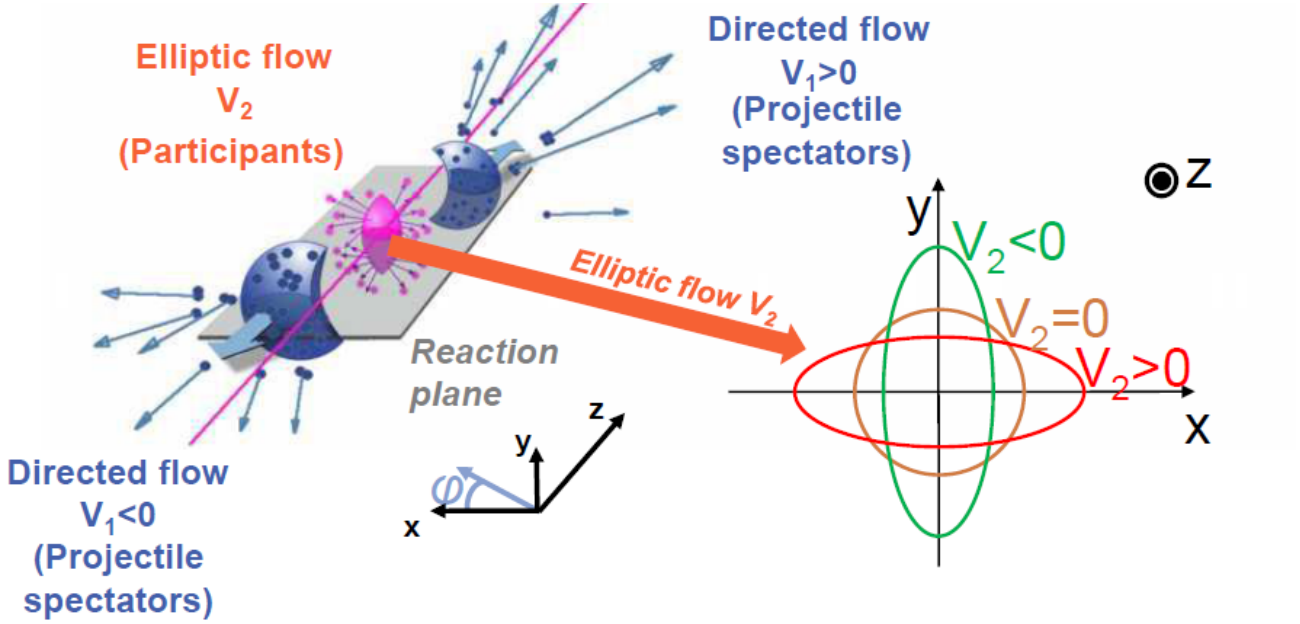
$$\frac{dN}{d\varphi} \sim 1 + 2\sum_{n} v_n \cos n(\varphi - \Phi_{RP}), \quad \Phi_{RP} = 0 \text{ for generators itself}$$

Directed flow

My purpose $$v_1 = \left\langle \frac{p_x}{p_t} \right\rangle = \langle \cos(\varphi') \rangle$$

My purpose is to confirm experimental results

Event characterization in the heavy-ion collisions



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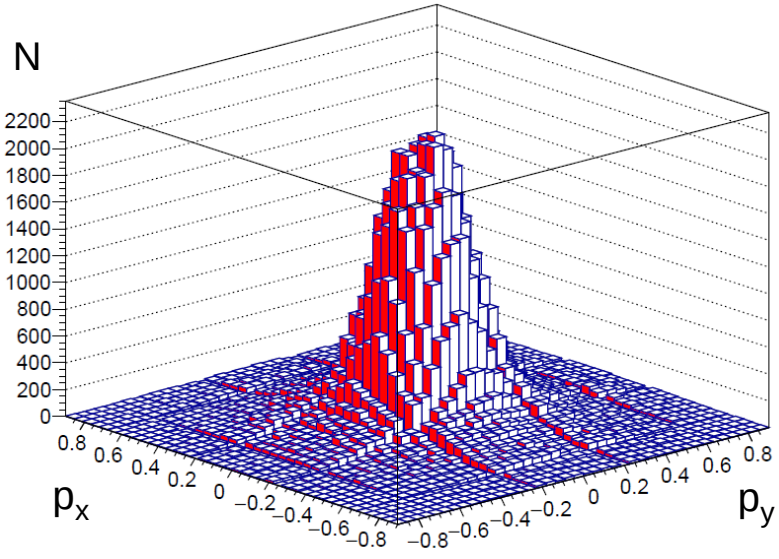
Rapidity is a smart way to characterize longitudinal momentum in the beam-direction.

Rapidity is defined a $$y = \frac{1}{2} \ln \left(\frac{E + p_z}{E - p_z} \right)$$

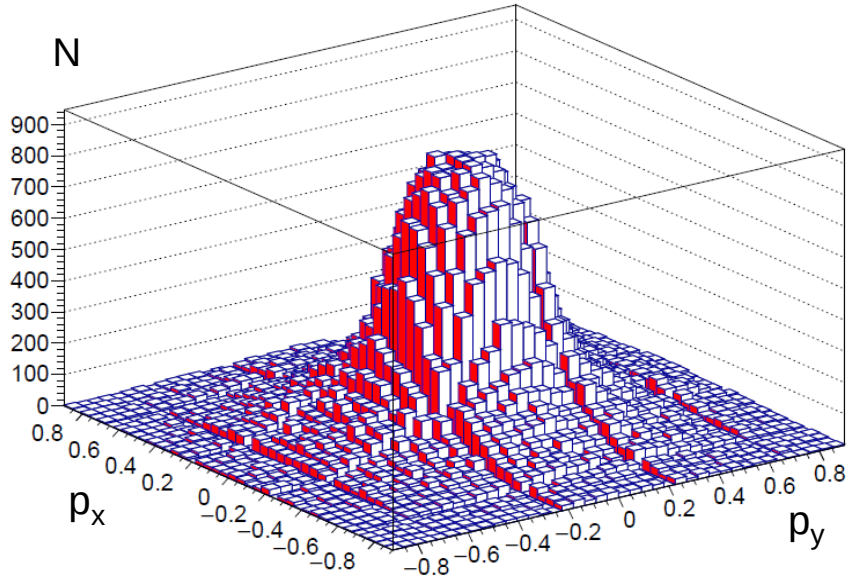
- Create a model of detector to see the dependence between direct flow and different granularity using QMD data Au+Au collisions at 1.23 AGev
  - read QMD input data
  - calculate momenta in **CM** system
  - study close track pairs
  - study of effects
- Simulate a model using Hgeant software
  - Check current status of the flow
  - Modify granularity

```
UQMD   version:       20030   1000  20030  output_file  14
projectile:  (mass, char)  197  79   target:  (mass, char)  197  79
transformation betas (NN,lab,pro)      0.0000000  0.6292914 -0.6292914
impact_parameter_real/min/max(fm):    6.91  0.00 10.00  total_cross_section(mbarn):    3141.59
equation_of_state:    0  E_lab(GeV/u): 0.1230E+01  sqrt(s)(GeV): 0.2414E+01  p_lab(GeV/u): 0.1955E+01
event#         1 random seed:  1391164247 (auto)   total_time(fm/c):      100 Delta(t)_O(fm/c):      100.000
op  0    0    0    0    1    0    0    0    0    0    0    0    0    0    0
op  0    0    0    0    0    0    1    0    1 *  0    0    0    0    2    1
op  0    0    0    1    1    0    0    0    0    0    0    0    0    1    0
pa 0.1000E+01   0.5200E+00   0.2000E+01   0.3000E+00   0.0000E+00   0.3700E+00   0.0000E+00   0.9300E-01   0.3500E+00   0.2500E+00   0.0000E+00   0.5000E+00
pa 0.2700E+00   0.4900E+00   0.2700E+00   0.1000E+01   0.1600E+01   0.8500E+00   0.1550E+01   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
pa 0.9000E+00   0.5000E+02   0.1000E+01   0.1000E+01   0.1000E+01   0.1500E+01   0.1600E+01   0.0000E+00   0.2500E+01   0.1000E+00   0.3000E+01   0.2750E+00
pa 0.4200E+00   0.1080E+01   0.8000E+00   0.5000E+00   0.0000E+00   0.5500E+00   0.5000E+01   0.8000E+00   0.5000E+00   0.8000E+06   0.1000E+01   0.2000E+01
pvec: r0              rx             ry             rz             p0             px             py             pz             m          ityp 2i3 chg lcl#  ncl or
        413          100
     1090     700     358      32     149     333       0       0
  0.10000000E+03  0.35757397E+02 -0.41143918E+02 -0.16112840E+02  0.12371926E+01  0.54036063E+00 -0.55732684E+00 -0.21954213E+00  0.93800002E+00          1 -1  0      144    8  20
  0.10000000E+03  0.15706573E+02 -0.88087713E+00  0.46554875E+02  0.11187586E+01  0.16583027E+00  0.56313856E-02  0.58672426E+00  0.93800002E+00          1  1  1       50    6   0
  0.10000000E+03  0.90143089E+01  0.12774686E+02  0.52122105E+02  0.12287586E+01  0.63365622E-01  0.14817800E+00  0.77719473E+00  0.93800002E+00          1  1  1      147    2   0
  0.10000000E+03  0.55012064E+02  0.65522958E+01  0.49560385E+02  0.17112913E+01  0.10170827E+01  0.14052449E+00  0.99723100E+00  0.93800002E+00          1 -1  0       45   10  30
  0.10000000E+03 -0.25736357E+02 -0.60444285E+01 -0.39453144E+02  0.11270308E+01 -0.33350919E+00 -0.67291011E-01 -0.52402102E+00  0.93800002E+00          1 -1  0      224   20  20
  0.10000000E+03  0.10563890E+02  0.53008522E+00  0.56782218E+02  0.13021491E+01 -0.12434127E+00 -0.17935447E+00  0.91681236E+00  0.89856478E+00          1  1  1        0    0   0
  0.10000000E+03 -0.32419850E+02  0.21271454E+02 -0.97317388E+01  0.10811268E+01 -0.42509219E+00  0.28666268E+00 -0.16159265E+00  0.93800002E+00          1 -1  0      218    8  30
  0.10000000E+03  0.13218519E+02 -0.40923778E+01  0.57102001E+02  0.13019747E+01  0.12456687E+00 -0.70983521E-01  0.89148103E+00  0.93800002E+00          1  1  1        2    7   0
```

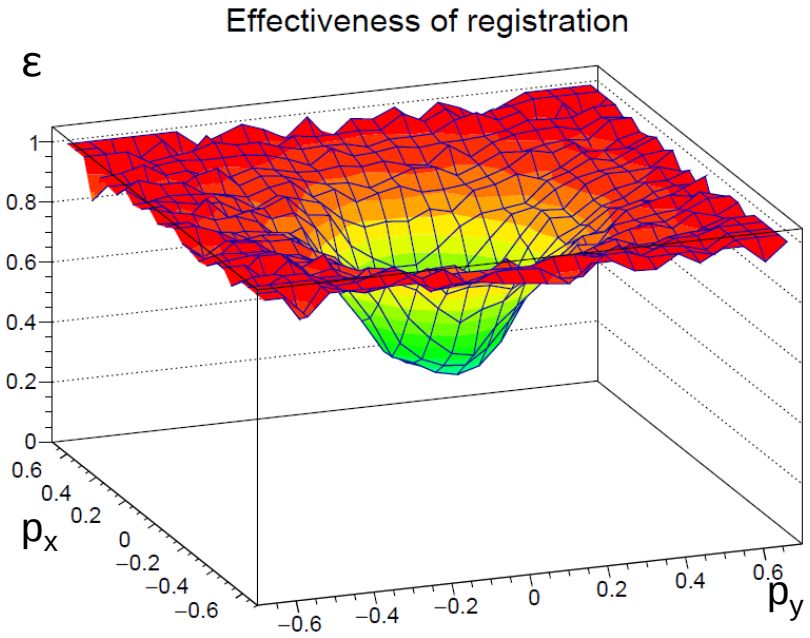
UrQMD input data

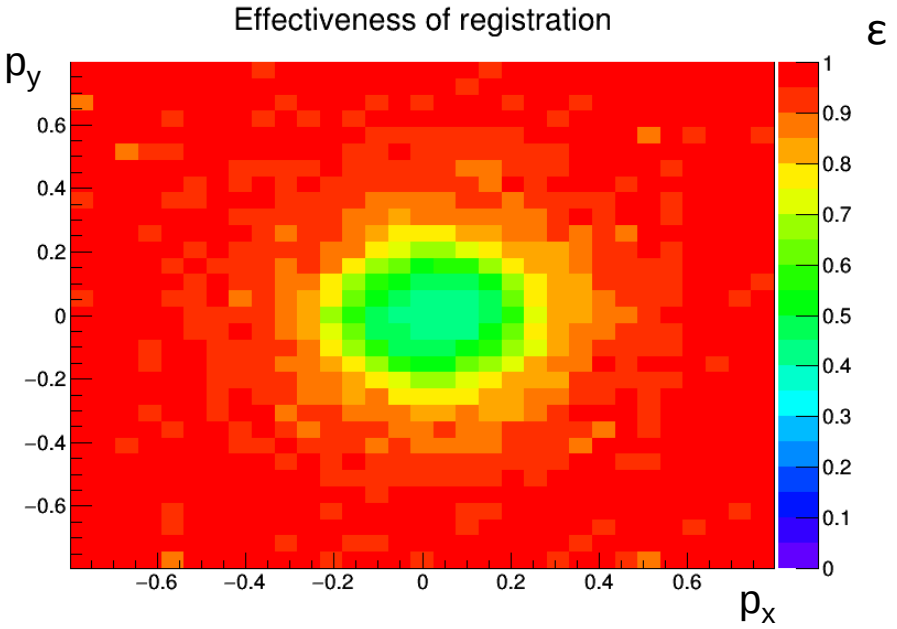


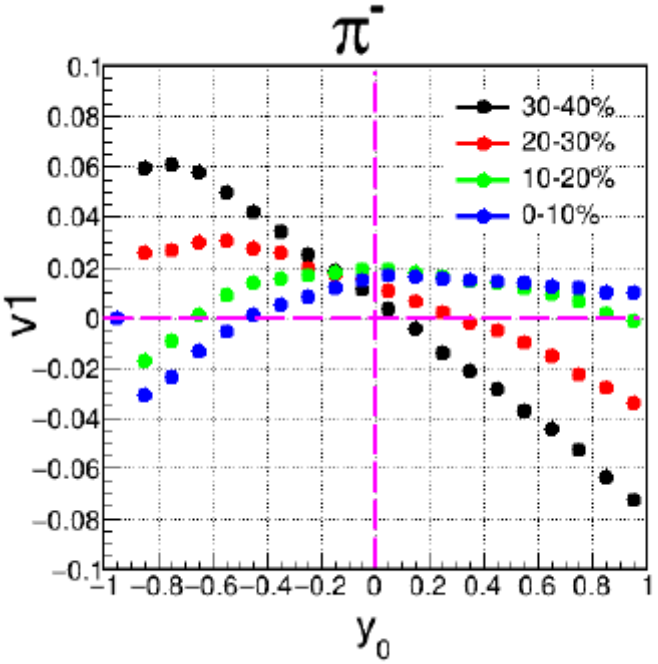
Distribution of particles per cell of detector no close track rejection

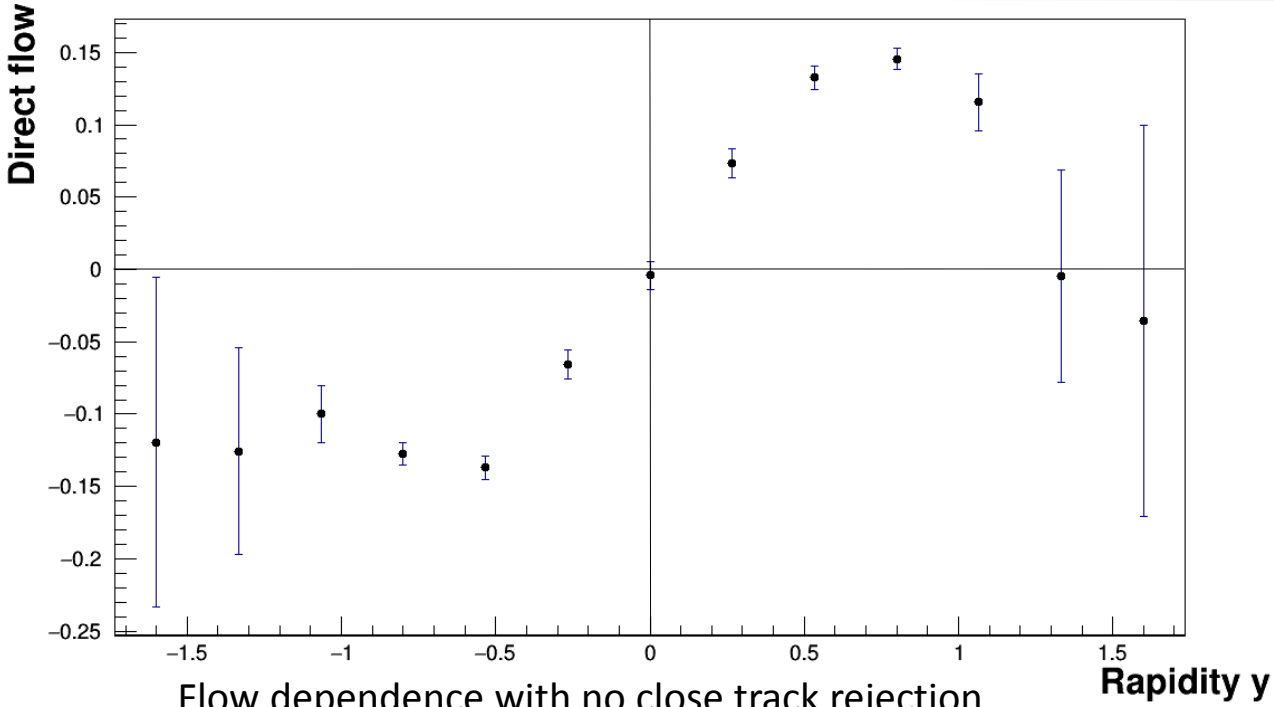


Distribution of particles per cell of detector with final granularity

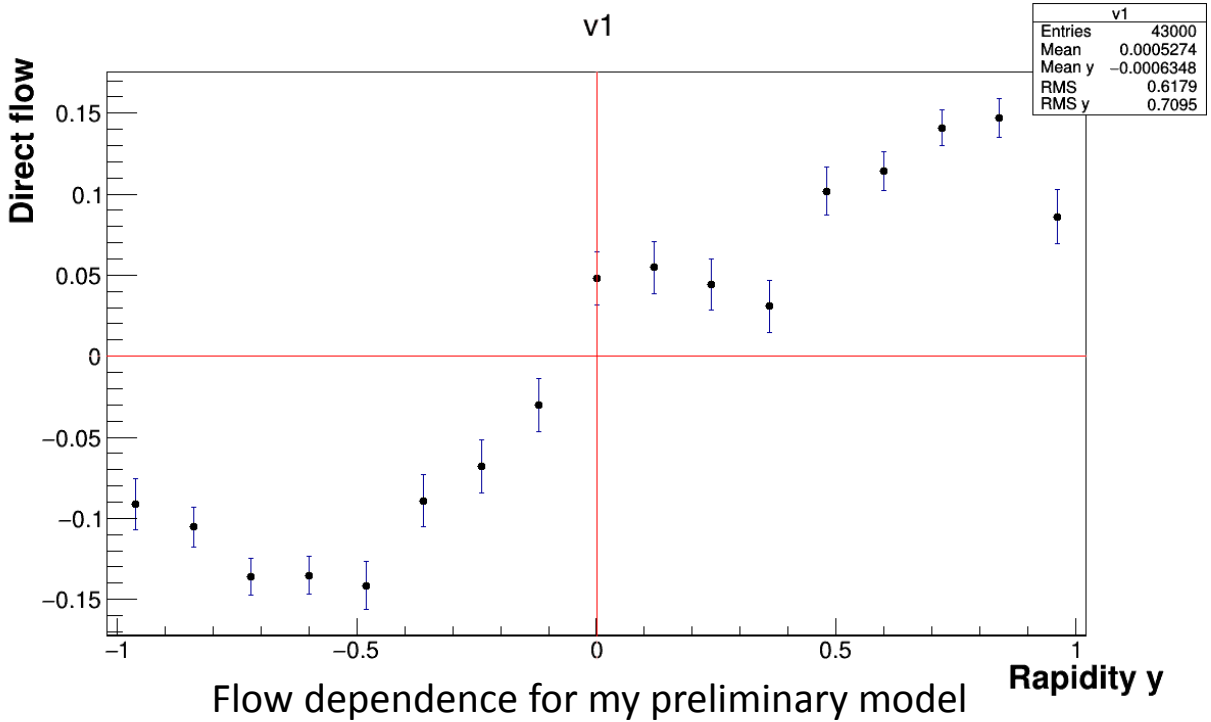

Effectiveness of registration
ε
1
0.8
0.6
0.4
0.2
0
0.6
0.4
0.2
0
−0.2
−0.4
−0.6
p_x
−0.6
−0.4
−0.2
0
0.2
0.4
0.6
p_y


Effectiveness of registration
ε
p_y
0.6
0.4
0.2
0
−0.2
−0.4
−0.6
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
−0.6
−0.4
−0.2
0
0.2
0.4
0.6
p_x

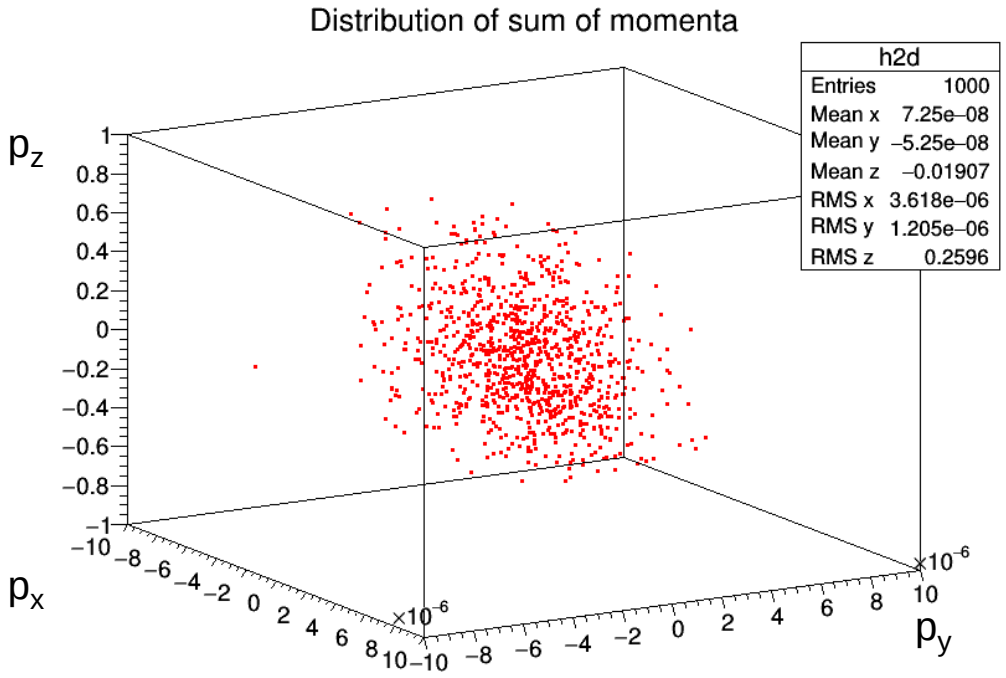

π⁻
v1
y0
30-40%
20-30%
10-20%
0-10%
0.1
0.08
0.06
0.04
0.02
0
−0.02
−0.04
−0.06
−0.08
−0.1
−1
−0.8
−0.6
−0.4
−0.2
0
0.2
0.4
0.6
0.8
1



Flow dependence with no close track rejection from UrQMD data



Flow dependence for my preliminary model


Distribution of sum of momenta
h2d
Entries 1000
Mean x 7.25e–08
Mean y –5.25e–08
Mean z –0.01907
RMS x 3.618e–06
RMS y 1.205e–06
RMS z 0.2596
p_z
p_x
p_y
$\times 10^{-6}$
$\times 10^{-6}$

From 2 to 25 Feb.

- A model of detector was created to see the dependence direct flow on granularity
  -used Ubuntu 16/04 OS and root package 5.34/34
  - read UrQMD input data
  - study close track pairs
  - study of effeciency

Next steps:

- Improve model using more input data
- Compare with experimental data
- Monte Carlo model using Hgeant 2.4-9
  -solve problem of installation

Thank you for your attention