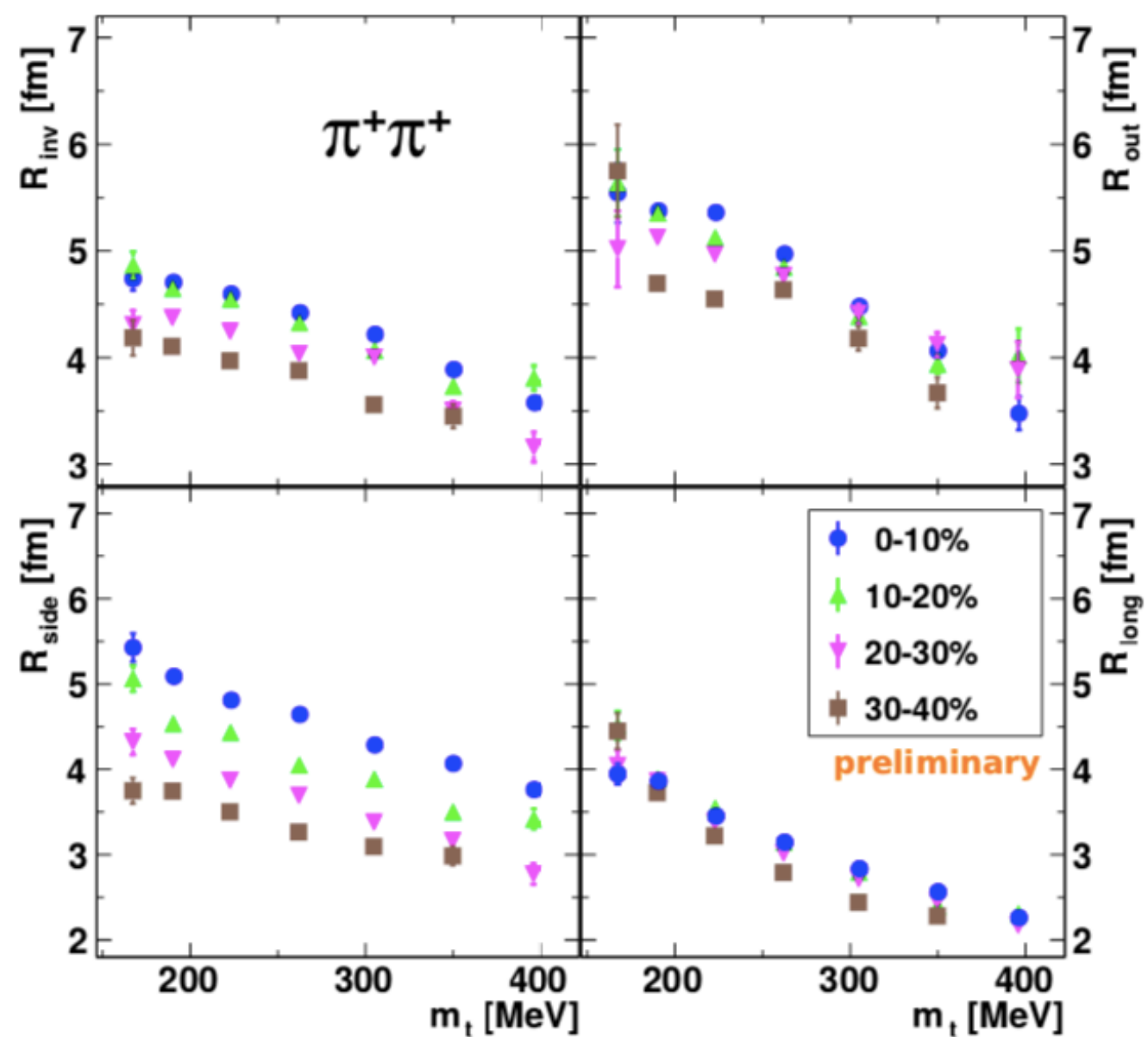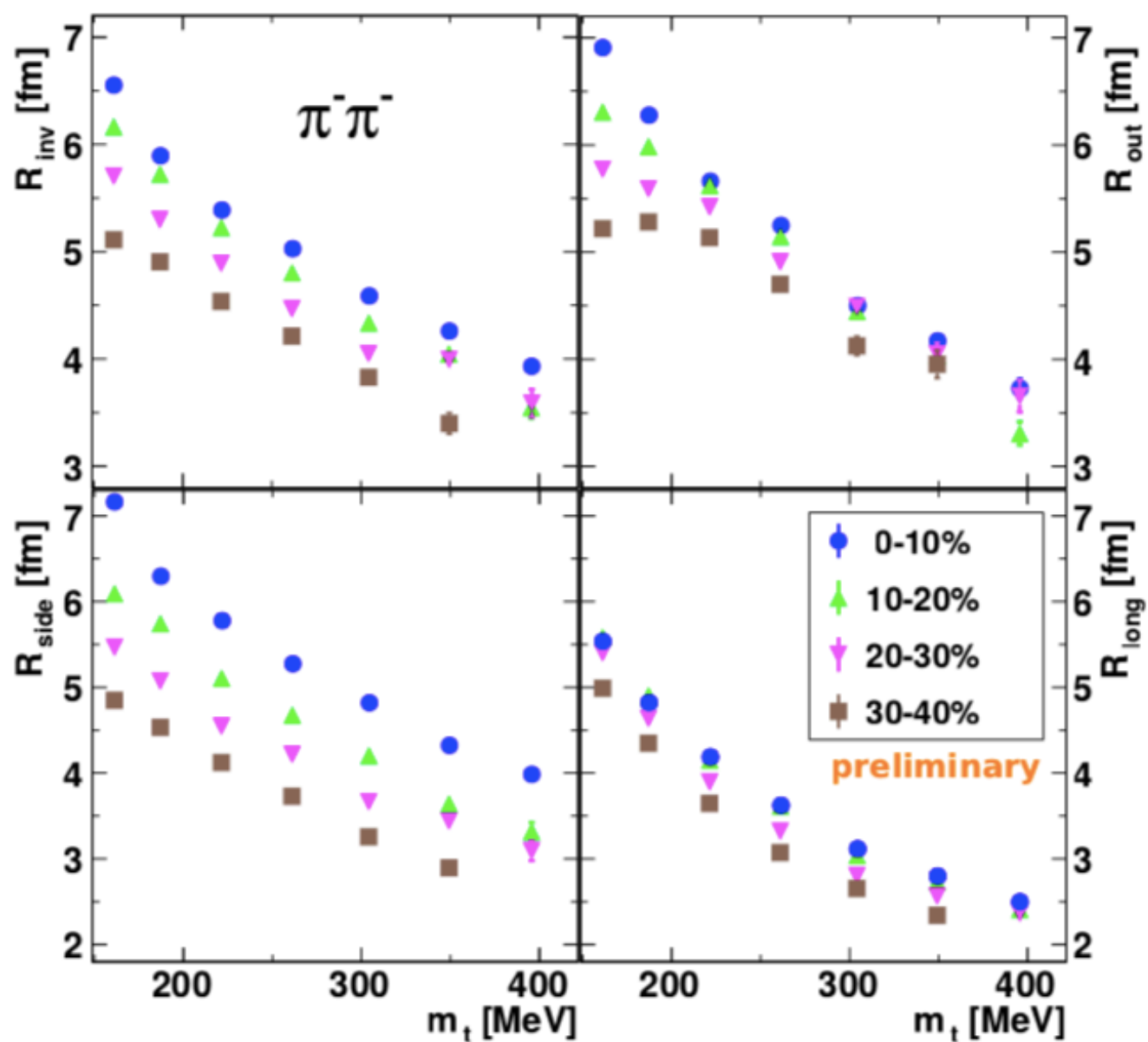# Aplikace femtoskopie ve srážkach těžkých iontů
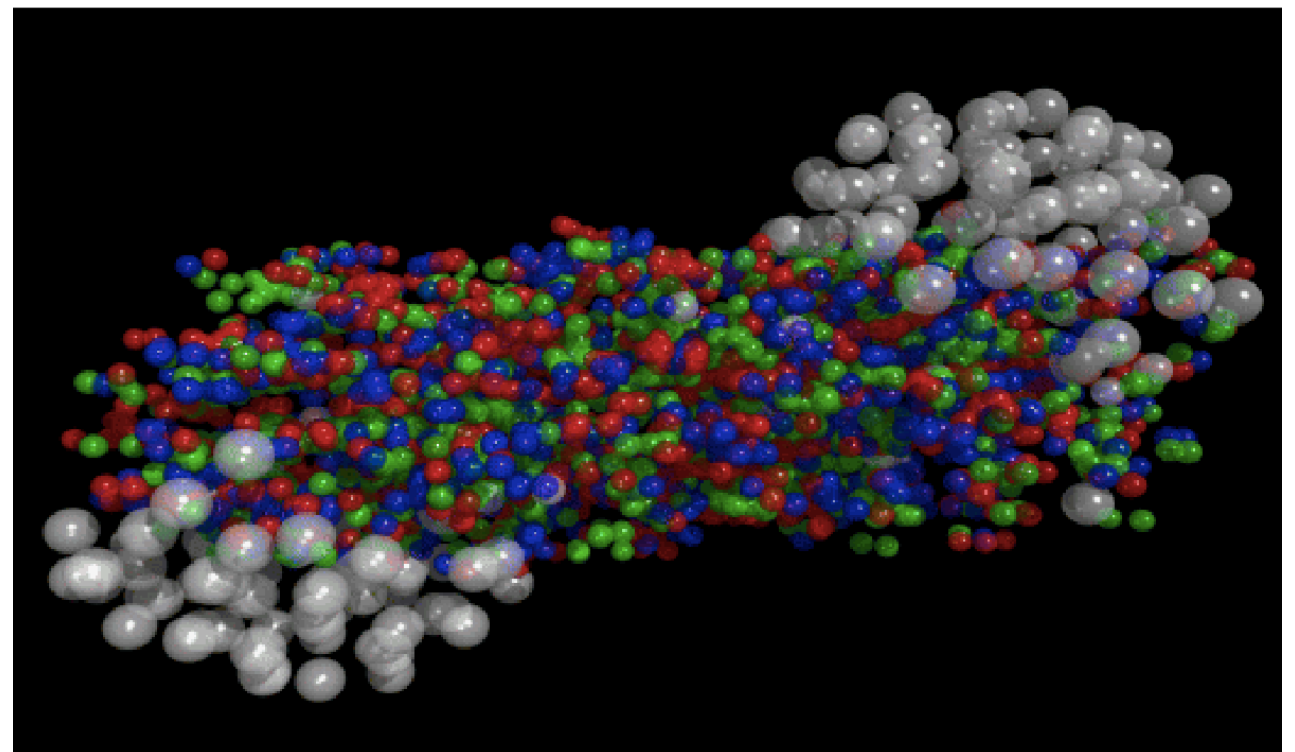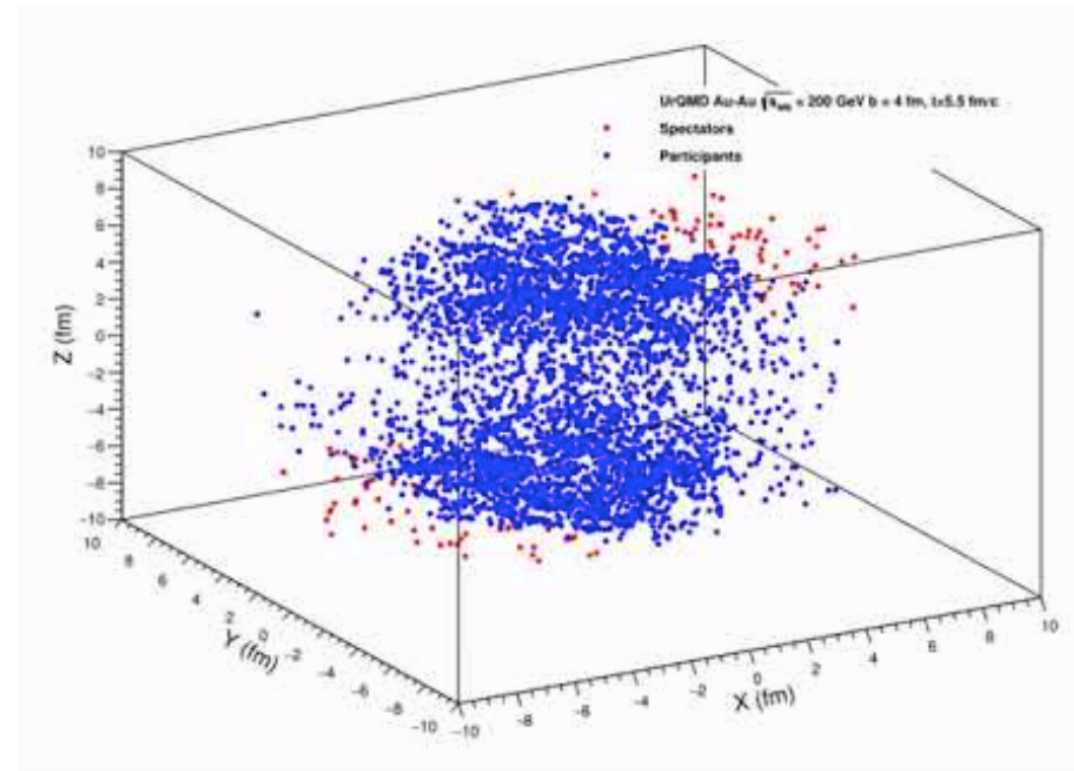
Jakub Štěrba, ČVUT FJFI

HADES

- Au+Au

- 1,23A GeV

UrQMD simulace
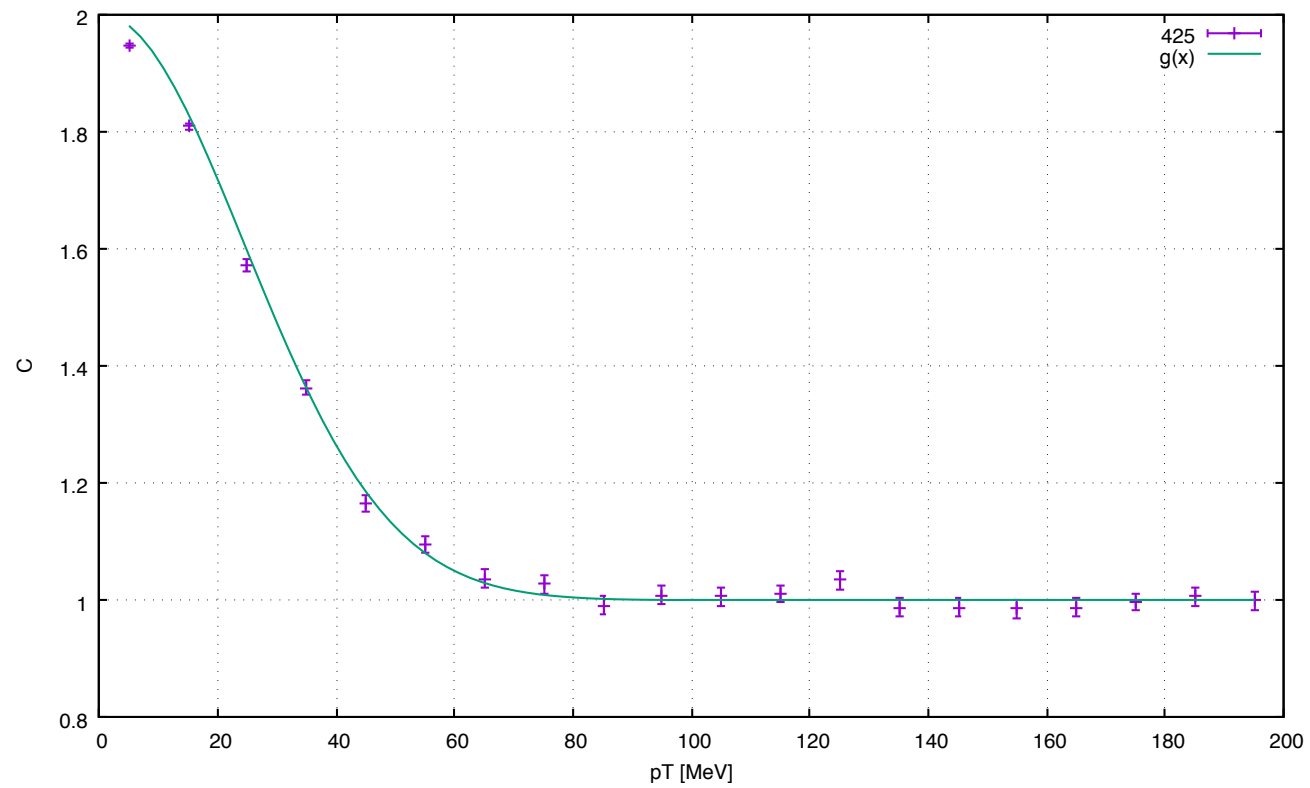
- Monte Carlo simulace

- (ultra)relativisticé srážky
  těžkých iontů v rozmezí energií
  $\sqrt{s} = 2 - 200$ GeV

- Skyrmeho stavové rovnice

- Yukawův a Coulombický
  potenciál

CRAB

```
:1   31   0   0
    1   -211    0.34969830E-01 -0.11119143E+00 -0.37379596E-01 0.18446587E+00 0.13800000E+00 0.26830083E+01 -0.27953229E+01 0.22223369E+01 0.48832862E+01
    2    211   -0.10746664E+00 0.55999636E-01 -0.41699120E-01 0.18832911E+00 0.13800000E+00 -0.14119077E+01 0.49002976E+01 -0.12819779E+01 0.86257559E+01
    3    211    0.68231445E-01 -0.21896024E-01 0.16587386E+00 0.22736117E+00 0.13800000E+00 0.39421025E+01 0.38283112E+01 0.20526071E+01 0.96298346E+01
    4   -211   -0.13215831E+00 0.19163140E+00 0.34321242E+00 0.43706656E+00 0.13800000E+00 0.30810640E+01 0.42935947E+01 0.31959821E+01 0.10352486E+02
    5   -211   -0.78211127E-01 -0.19416405E-01 0.32114877E+00 0.35871230E+00 0.13800000E+00 0.44134040E+01 -0.57466409E+01 0.15776365E+01 0.11322703E+02
    6   -211    0.80783297E-01 0.27591481E+00 0.15870505E+00 0.35621091E+00 0.13800000E+00 0.58778641E+01 0.45688107E+01 0.29819371E+01 0.11936351E+02
    7   -211   -0.10077651E+00 -0.50898750E-02 -0.19493737E+00 0.25928052E+00 0.13800000E+00 -0.21326087E+01 0.44821993E+01 -0.35567726E+01 0.12077005E+02
    8    211   -0.15290236E-01 0.81630171E-01 0.64466471E-01 0.17348545E+00 0.13800000E+00 0.52109653E+01 0.48023898E+01 -0.18959214E+01 0.13562070E+02
    9    211   -0.11890525E+00 0.32585867E-02 0.25555470E-01 0.18397326E+00 0.13800000E+00 -0.32881556E+01 0.41360162E+00 0.14728769E+01 0.13941031E+02
   10   -211   -0.34786977E-01 -0.62265315E-01 -0.13519261E-01 0.15592906E+00 0.13800000E+00 0.14211724E+01 0.69329153E+01 -0.54329366E+01 0.14565593E+02
   11   -211   -0.10218481E+00 -0.65997854E-01 0.10961207E+00 0.21414074E+00 0.13800000E+00 -0.40163902E+01 -0.13665497E+01 0.14424969E+01 0.14877039E+02
   12   -211   -0.24042014E+00 0.70092061E-02 0.19394090E+00 0.33839037E+00 0.13800000E+00 0.19448289E+01 -0.53068550E+01 0.40532910E+01 0.15256941E+02
   13    211    0.99229955E-01 0.79532606E-01 0.27567332E-01 0.18967334E+00 0.13800000E+00 0.68223319E+01 0.34572313E+01 0.42141202E+01 0.16086612E+02
   14   -211    0.15018152E-01 -0.79874729E-01 0.58732011E-01 0.17058419E+00 0.13800000E+00 0.90097386E+00 -0.48521995E+00 0.20697021E+01 0.16605189E+02
   15   -211    0.84617912E-02 0.13914343E+00 -0.86595306E-01 0.21441838E+00 0.13800000E+00 -0.26087248E+01 0.67451625E+01 -0.23209172E+01 0.16785292E+02
   16   -211    0.58881835E-01 -0.22247639E+00 0.27492469E+00 0.38417496E+00 0.13800000E+00 0.46555011E+00 0.38952758E+00 0.54807979E+01 0.17068181E+02
   17   -211   -0.22787125E+00 -0.17417942E+00 0.84606006E-01 0.32934169E+00 0.13800000E+00 -0.42133444E+01 -0.50251725E+01 -0.87260890E+00 0.17744555E+02
   18   -211    0.16055344E+00 0.42852990E-01 0.88641800E-01 0.23348480E+00 0.13800000E+00 0.17887174E+00 -0.34735790E+00 0.21349374E+01 0.17760034E+02
   19    211    0.27169309E+00 -0.49280173E-01 0.38595154E+00 0.49421479E+00 0.13800000E+00 0.71634673E+01 0.67348349E+01 0.63935066E+01 0.17890682E+02
   20   -211    0.36349990E-01 0.12645813E+00 0.15481196E+00 0.24560888E+00 0.13800000E+00 -0.33029593E+01 0.52848831E+01 -0.10713904E+01 0.18062292E+02
   21   -211    0.60077649E-01 0.27704086E+00 -0.24347414E+00 0.39835238E+00 0.13800000E+00 0.30948848E+01 0.43371602E+01 -0.83038763E+00 0.18231876E+02
   22    211   -0.80467900E-01 0.21085718E+00 -0.23756038E+00 0.35554854E+00 0.13800000E+00 0.14321883E+01 0.89550138E+01 -0.35396004E+01 0.18590467E+02
   23   -211    0.53303462E-01 -0.25408406E-01 -0.10507277E+00 0.18322427E+00 0.13800000E+00 -0.30201514E+00 0.15625888E+01 -0.47530001E+00 0.19252486E+02
   24    211   -0.14022316E+00 0.25252766E+00 0.24610357E+00 0.40378673E+00 0.13800000E+00 -0.67299730E+01 0.11389347E+02 -0.22951061E+00 0.19975842E+02
   25   -211    0.20989890E+00 -0.13289353E-01 0.11976765E+00 0.27860805E+00 0.13800000E+00 0.70968436E+01 0.60768038E+01 0.22313091E+01 0.20184941E+02
   26   -211    0.64361718E-01 0.13662446E-01 0.69741961E-01 0.16803879E+00 0.13800000E+00 -0.41713414E+01 0.80045513E+01 -0.32483792E+01 0.20559938E+02
   27   -211    0.20088585E+00 0.37129765E-02 -0.10489571E-01 0.24397324E+00 0.13800000E+00 0.66081057E+01 -0.16664647E+01 0.33687237E+01 0.23382986E+02
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   29   -211    0.15842287E+00 -0.26680239E+00 -0.79849820E-01 0.34885716E+00 0.13800000E+00 -0.55165975E+01 -0.71721789E+01 -0.21746286E+01 0.24957602E+02
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   31    211   -0.12075755E-01 -0.19754154E+00 0.78248713E-01 0.25364413E+00 0.13800000E+00 0.53923355E+01 -0.54952080E+01 0.14083651E+02 0.35174129E+02
2   16   0   0
    1    211    0.73210382E-01 0.19478067E+00 -0.10540465E-01 0.24990872E+00 0.13800000E+00 0.38191328E+01 0.59574701E+01 0.68968592E-01 0.95645290E+01
    2    211    0.22115852E+00 -0.19413358E+00 0.46861460E+00 0.57030043E+00 0.13800000E+00 0.16498953E+01 -0.65538141E+01 0.23635323E+01 0.10071821E+02
    3    211    0.42878355E-01 0.73890131E-01 -0.78583573E-02 0.16249325E+00 0.13800000E+00 0.56541393E+01 -0.31190738E+01 0.35419211E+01 0.13687122E+02
    4   -211    0.98591611E-01 0.21474029E+00 0.28555537E+00 0.39549913E+00 0.13800000E+00 0.39816612E+01 0.59049529E+01 0.40418525E+01 0.17303665E+02
    5   -211   -0.20890810E+00 -0.42839238E-01 0.32679644E+00 0.41390543E+00 0.13800000E+00 -0.25628603E+00 -0.88437557E+01 0.13674245E+01 0.17749745E+02
    6    211    0.37578803E+00 -0.24982916E+00 0.54688113E-01 0.47504320E+00 0.13800000E+00 0.85427164E+01 -0.40684722E+01 0.62141197E+01 0.18589569E+02
    7   -211    0.94390524E-01 0.11892746E+00 -0.17570311E+00 0.27012755E+00 0.13800000E+00 -0.21171663E+01 0.45869594E+01 -0.38354999E+01 0.18707552E+02
    8    211    0.19621707E+00 -0.10858014E+00 -0.26957828E+00 0.37683847E+00 0.13800000E+00 0.83418044E+01 0.64046570E+01 -0.90215940E+00 0.19767547E+02
    9    211    0.14335526E+00 0.20003746E+00 0.12936864E+00 0.31039645E+00 0.13800000E+00 0.35641178E+01 0.12691452E+01 -0.13667841E+01 0.20258744E+02
   10    211    0.61260142E-02 0.28257859E+00 0.52343174E-01 0.31886046E+00 0.13800000E+00 -0.22206743E+01 0.50063529E+01 -0.12443209E+01 0.20853589E+02
   11    211   -0.32687166E-01 -0.77896172E-01 0.12745230E+00 0.20597173E+00 0.13800000E+00 -0.44852258E+00 0.73100769E+01 0.65787797E+01 0.26281745E+02
   12   -211    0.23146309E-01 0.20282380E+00 0.12281738E+00 0.27532046E+00 0.13800000E+00 -0.10004440E+02 0.10449294E+02 0.18387184E+01 0.28847319E+02
   13   -211    0.48132171E-01 0.14188446E+00 -0.12979162E-01 0.20410870E+00 0.13800000E+00 0.78211939E+01 0.42071252E+00 -0.63274438E+00 0.29278909E+02
   14   -211   -0.38382154E-01 -0.20526678E+00 0.46663300E-02 0.25034659E+00 0.13800000E+00 -0.11959263E+02 -0.74969224E+01 0.74186545E+00 0.29559662E+02
   15   -211   -0.86045915E-01 0.88055462E-01 0.24724915E-01 0.18658238E+00 0.13800000E+00 0.90669248E+01 0.60159915E+01 0.87463382E+01 0.30789588E+02
   16    211    0.29581761E+00 0.18587431E+00 -0.92702568E-01 0.38690448E+00 0.13800000E+00 0.10110091E+02 0.49526902E+01 0.76836983E+01 0.30950193E+02
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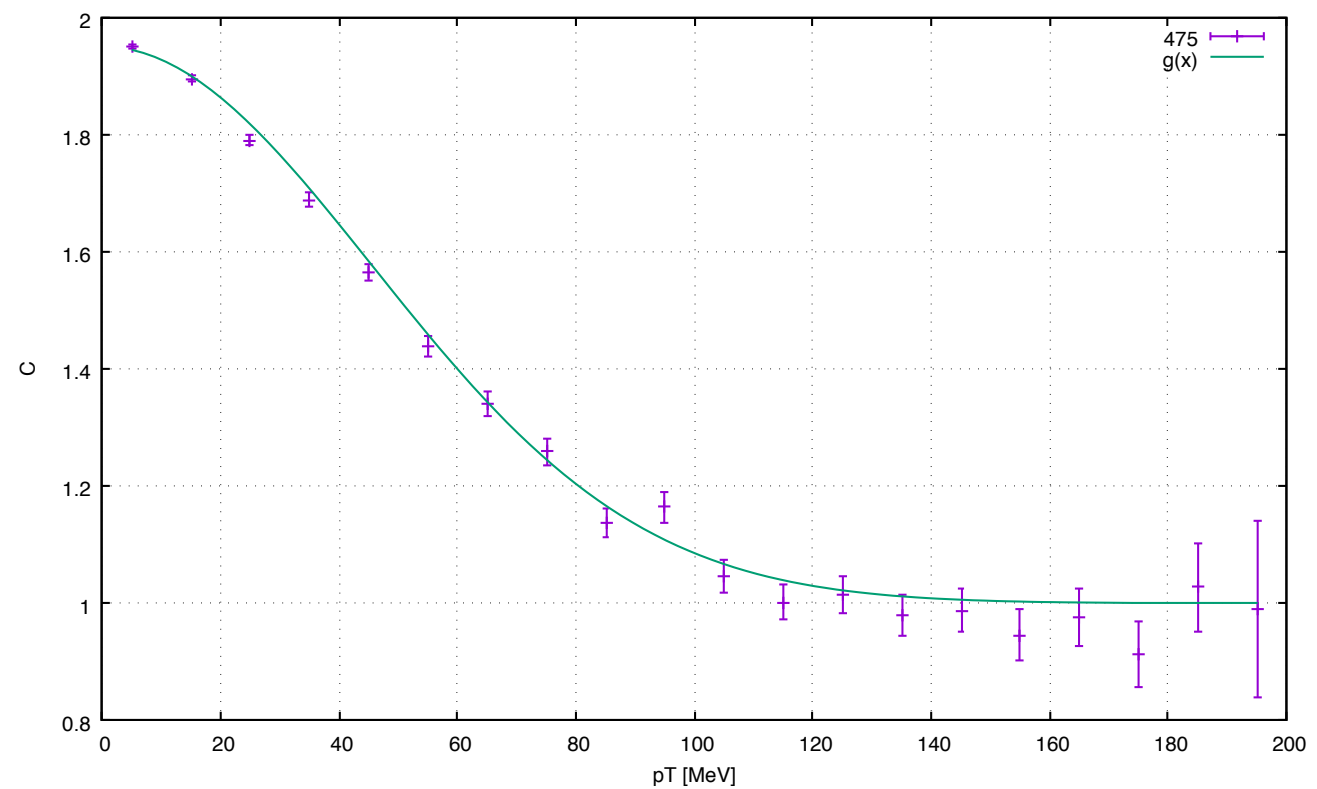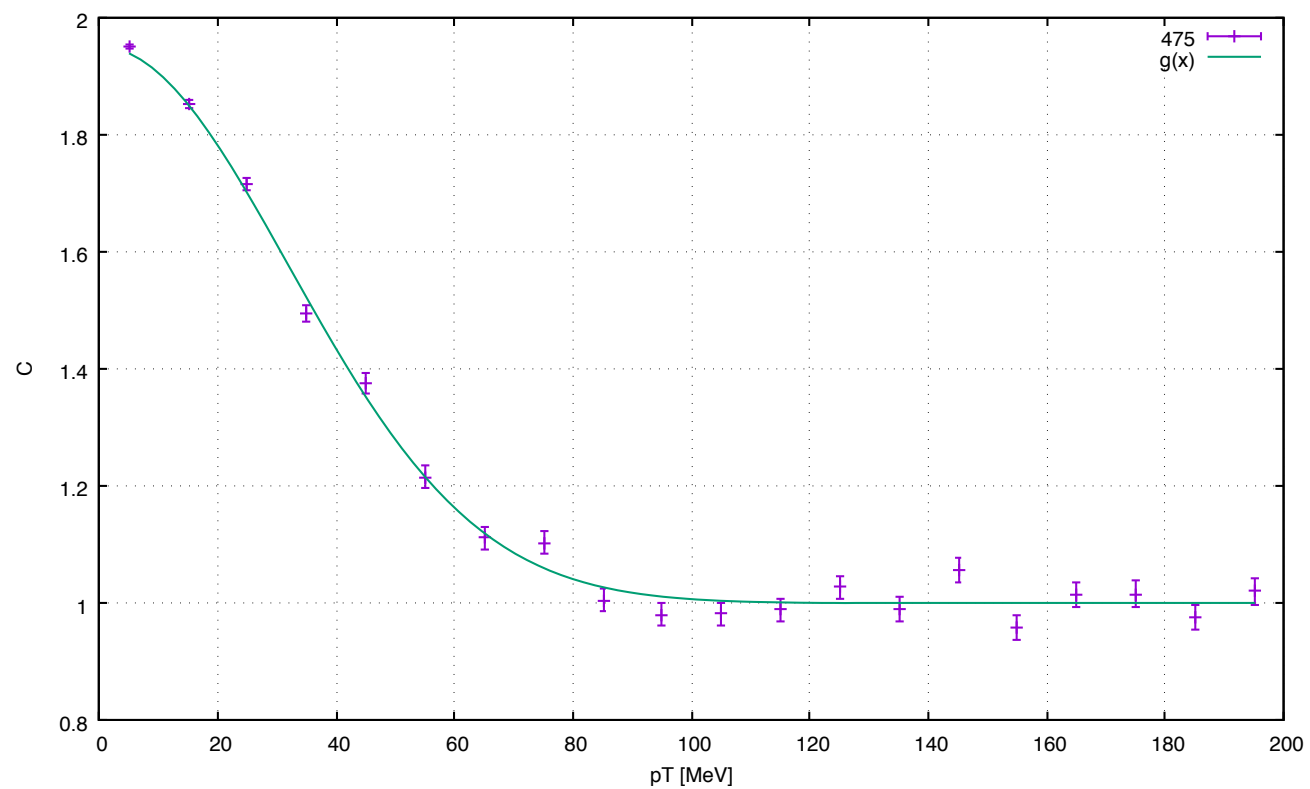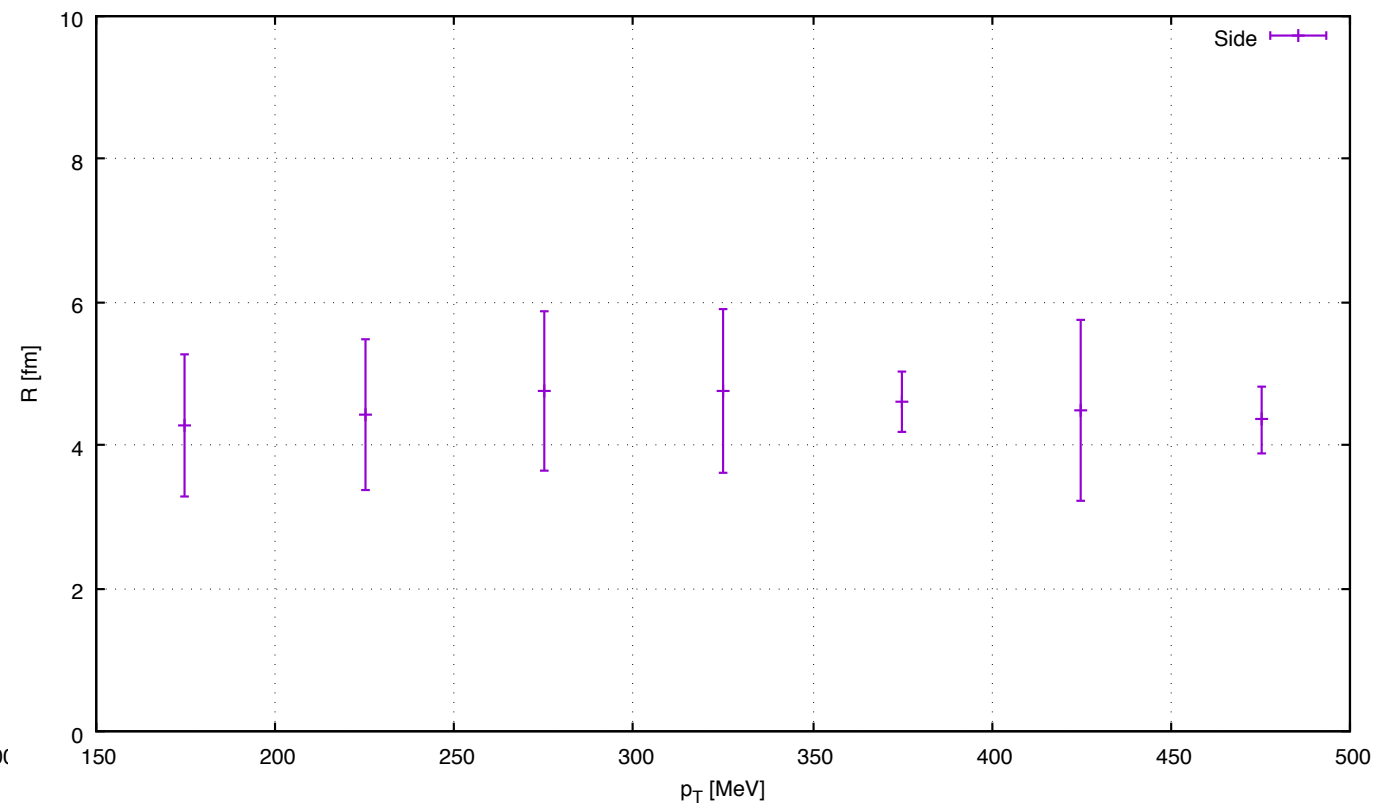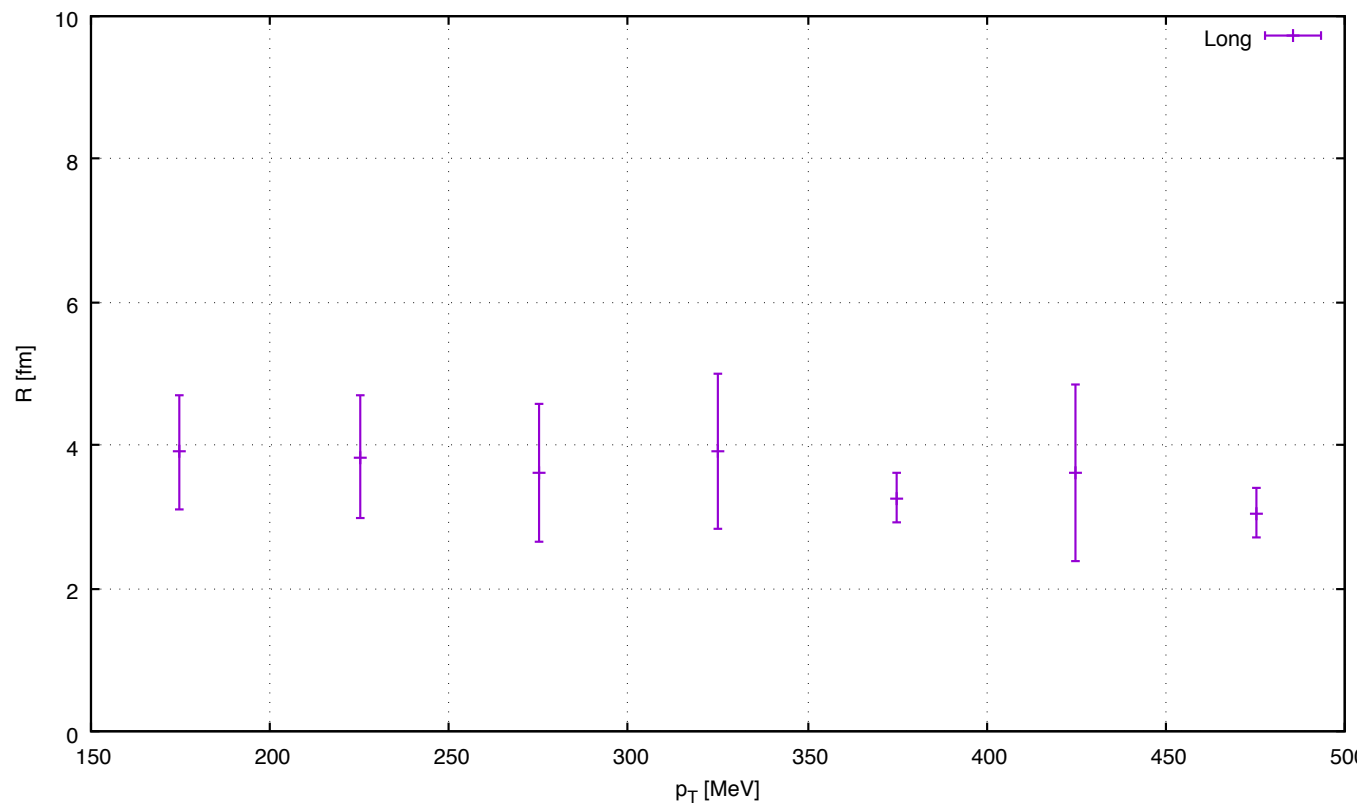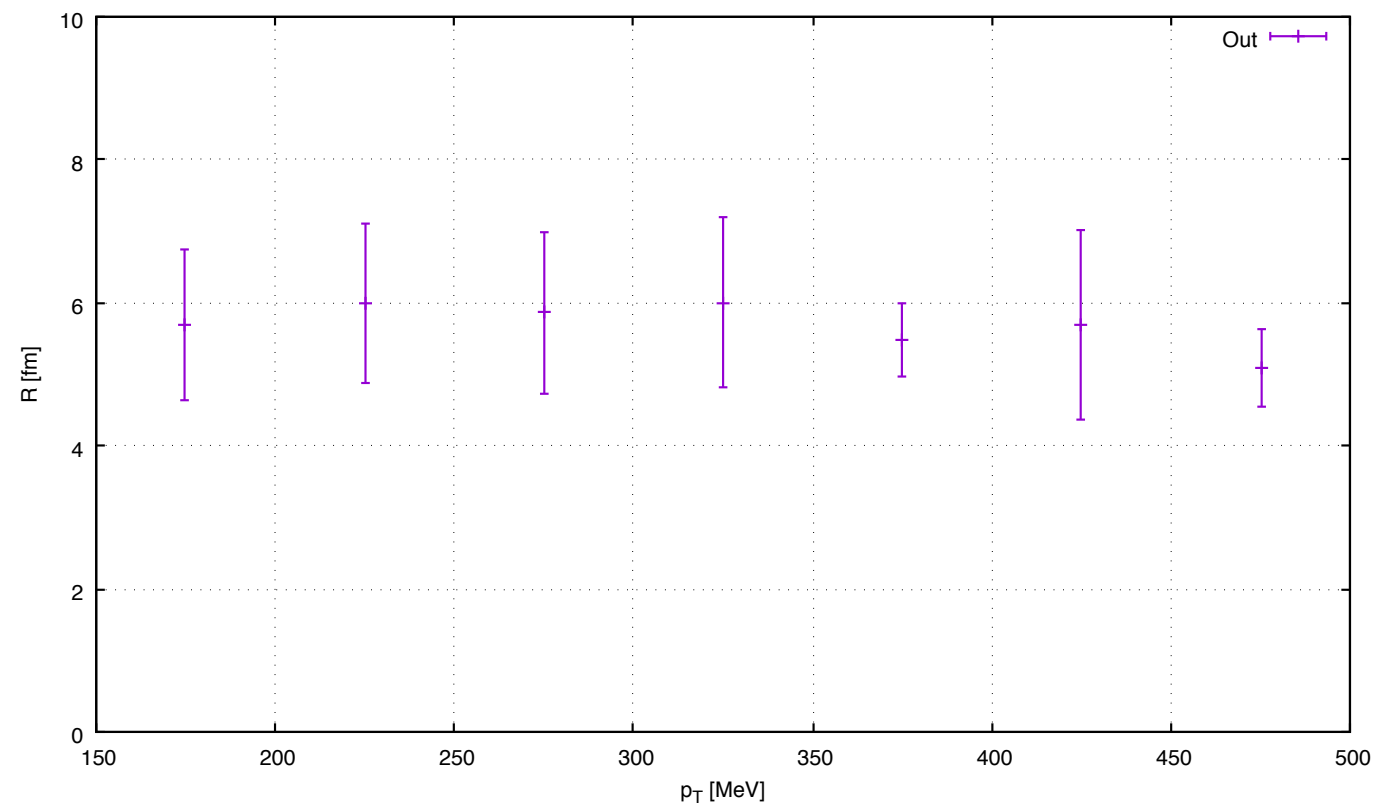
CRAB

- korelace nabitých pionů

- $C = Ae^{-(R_{out}^2 q_{out}^2 + R_{side}^2 q_{side}^2 + R_{long}^2 q_{long}^2)} + 1$
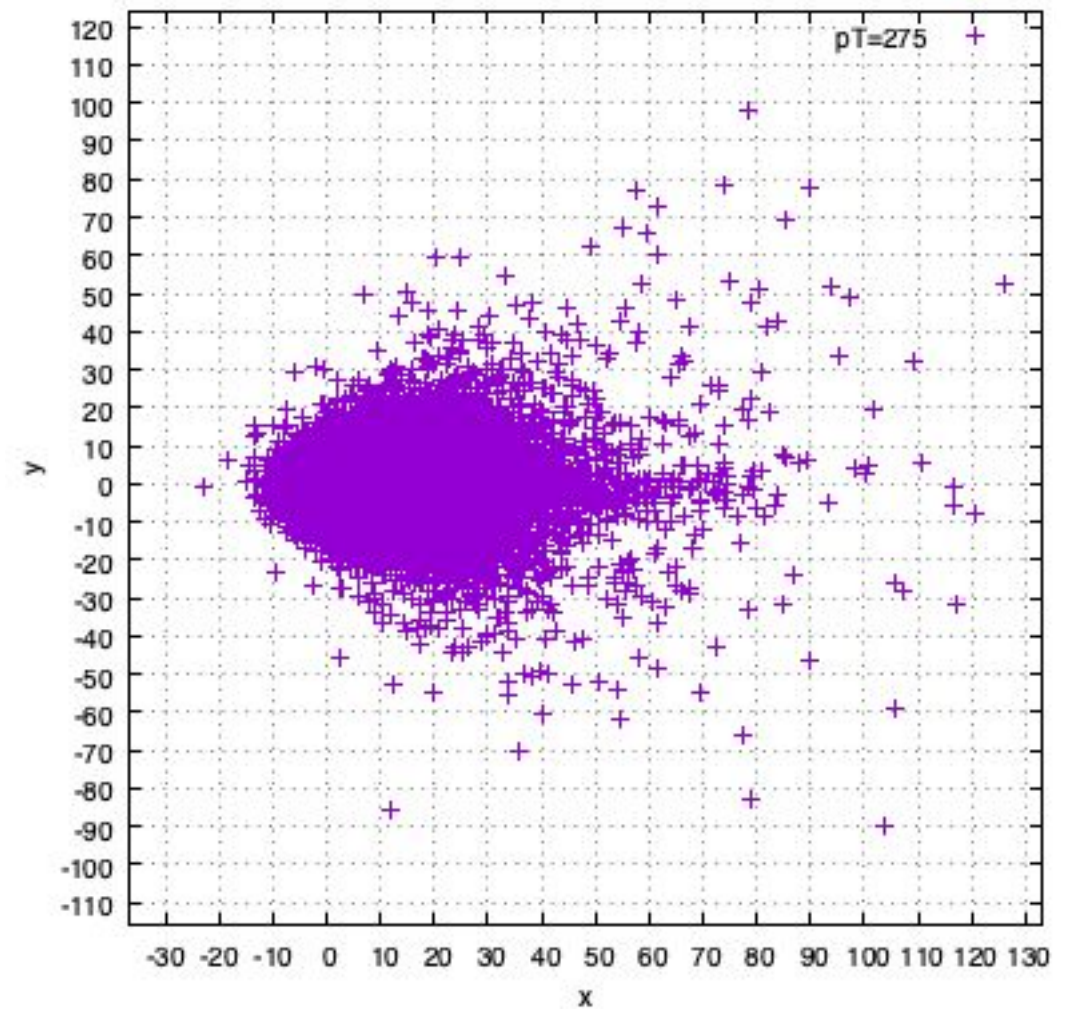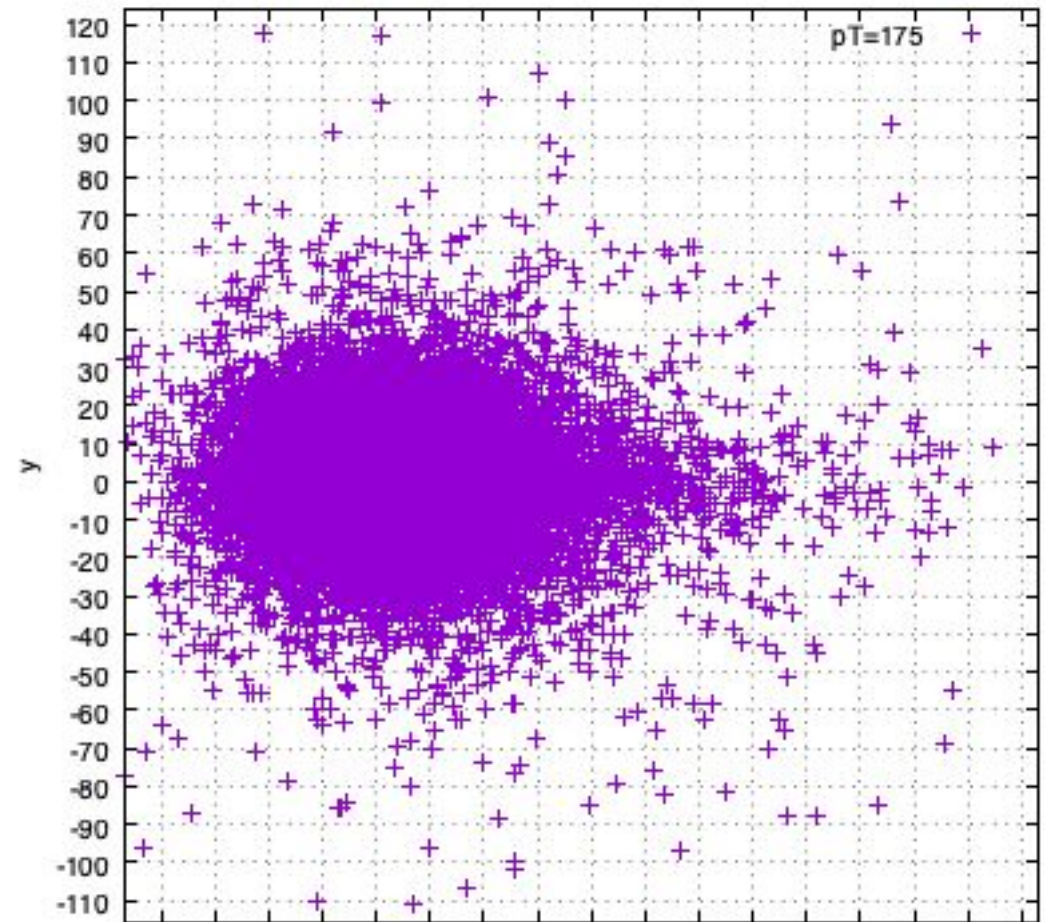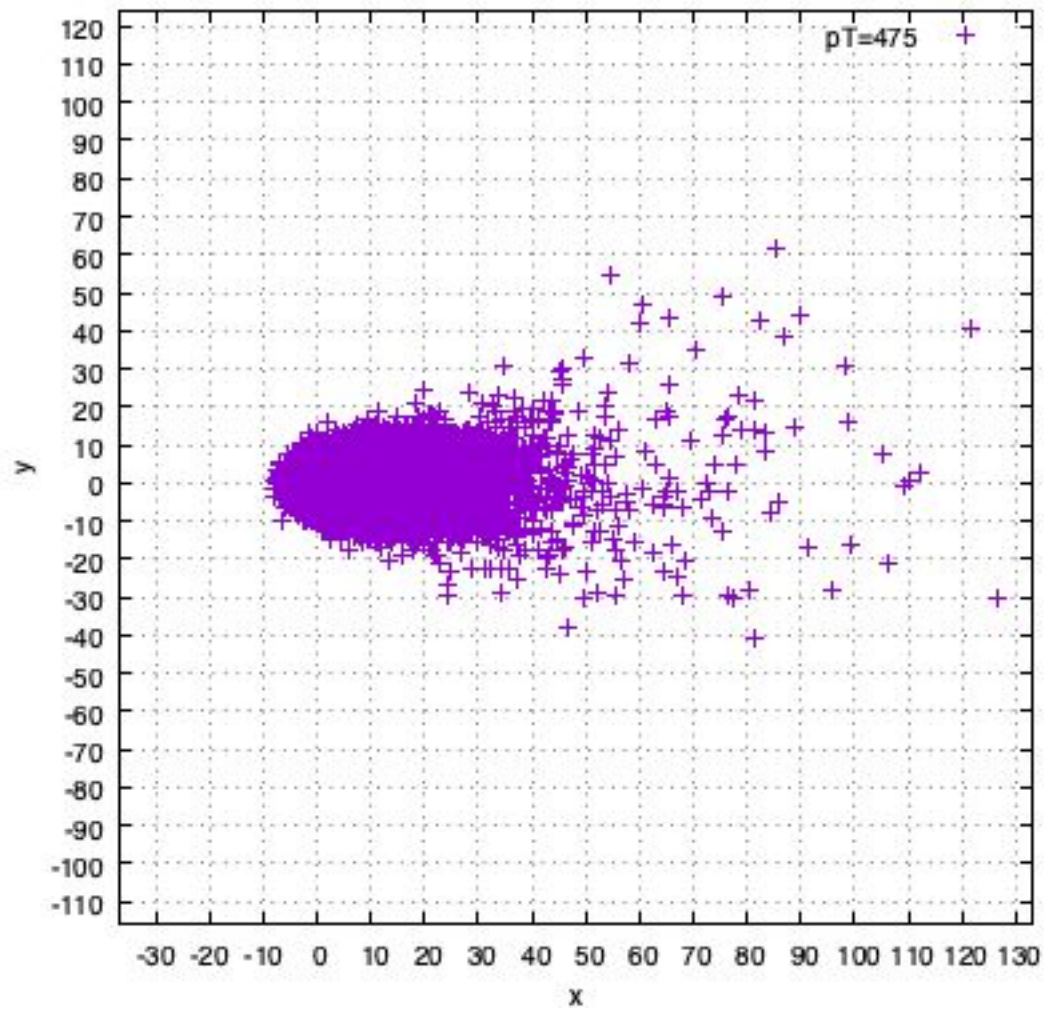
- $|y| < 0.35$

HBT

- konstantní?

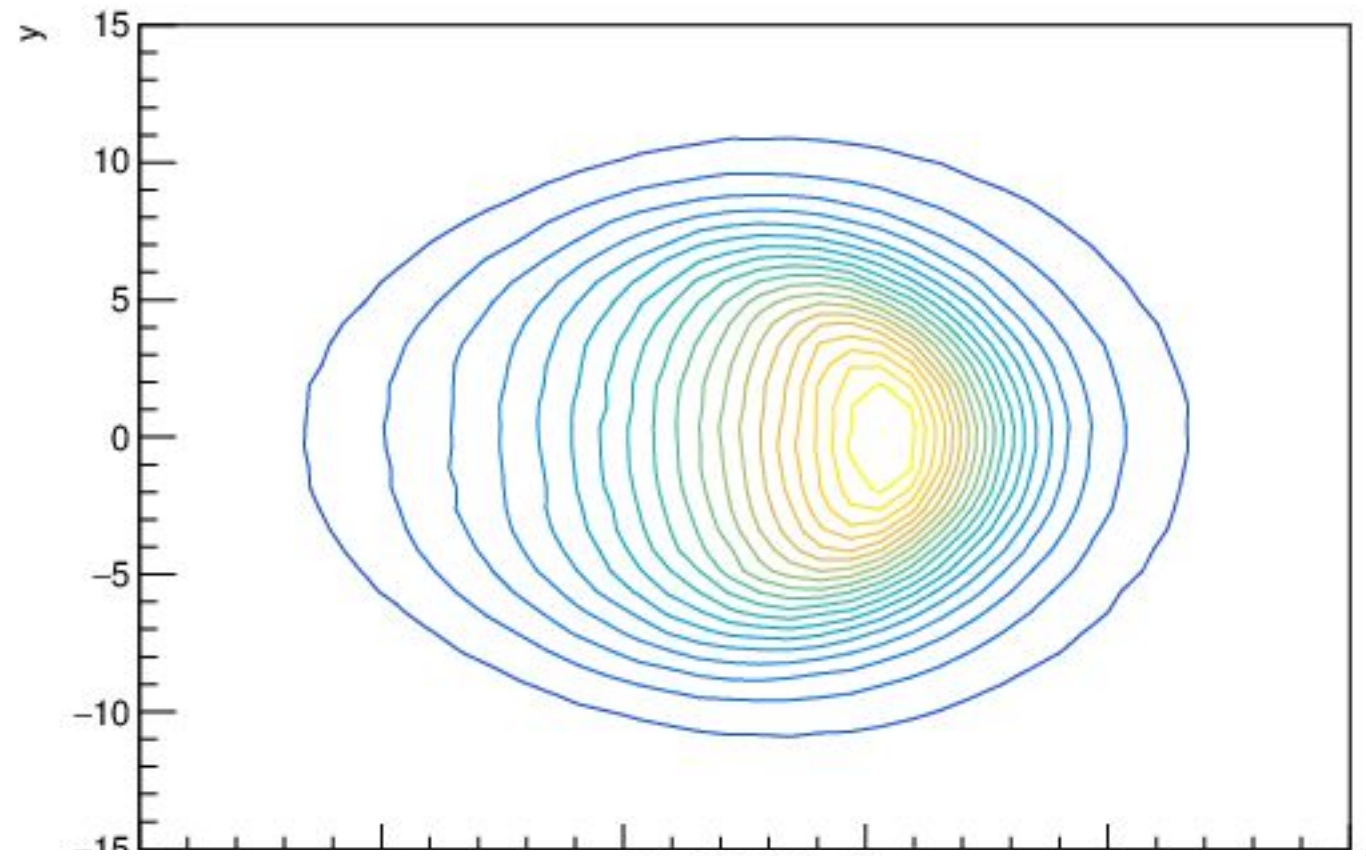- jiný pohled

Scatter plot

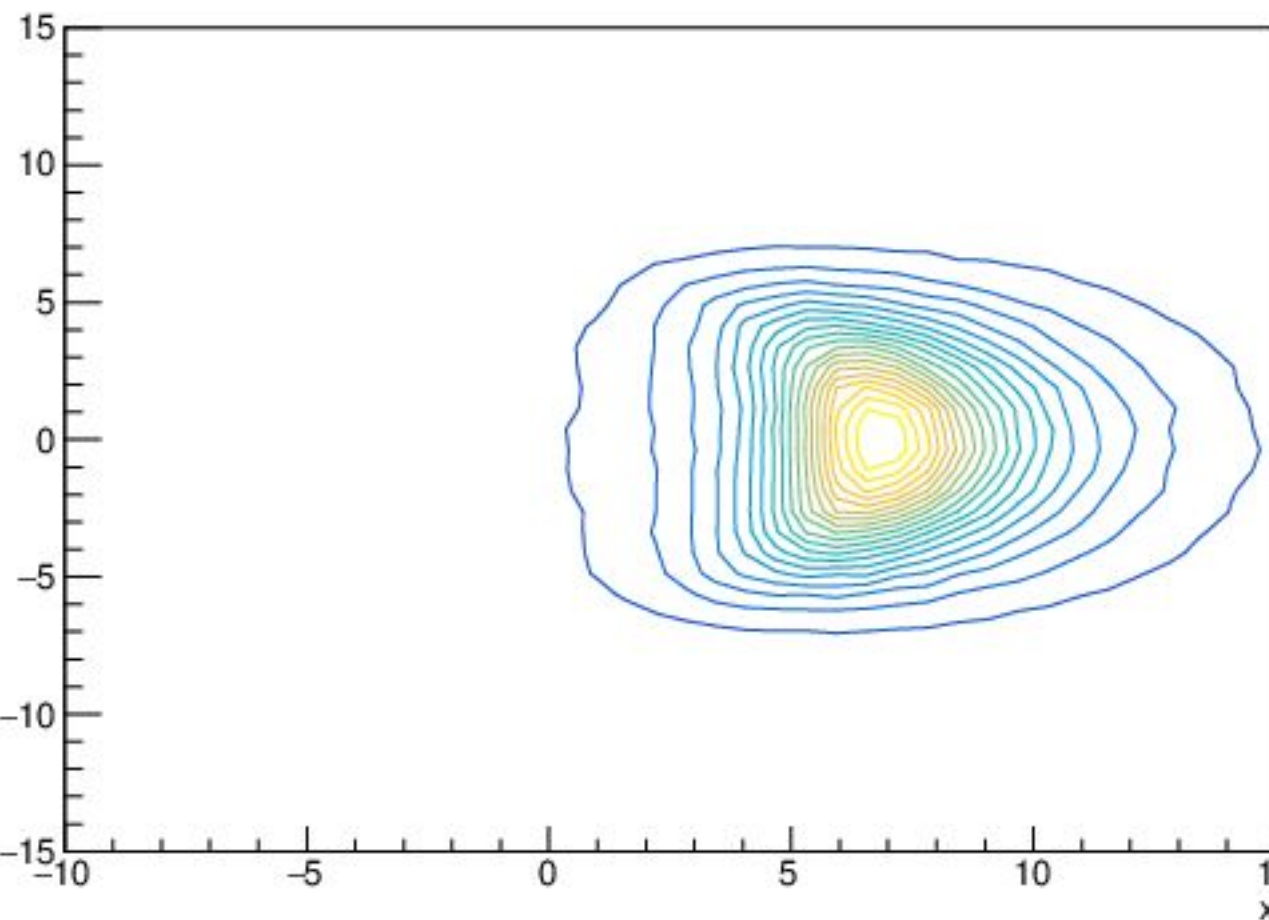- rotace hybnosti do směru x

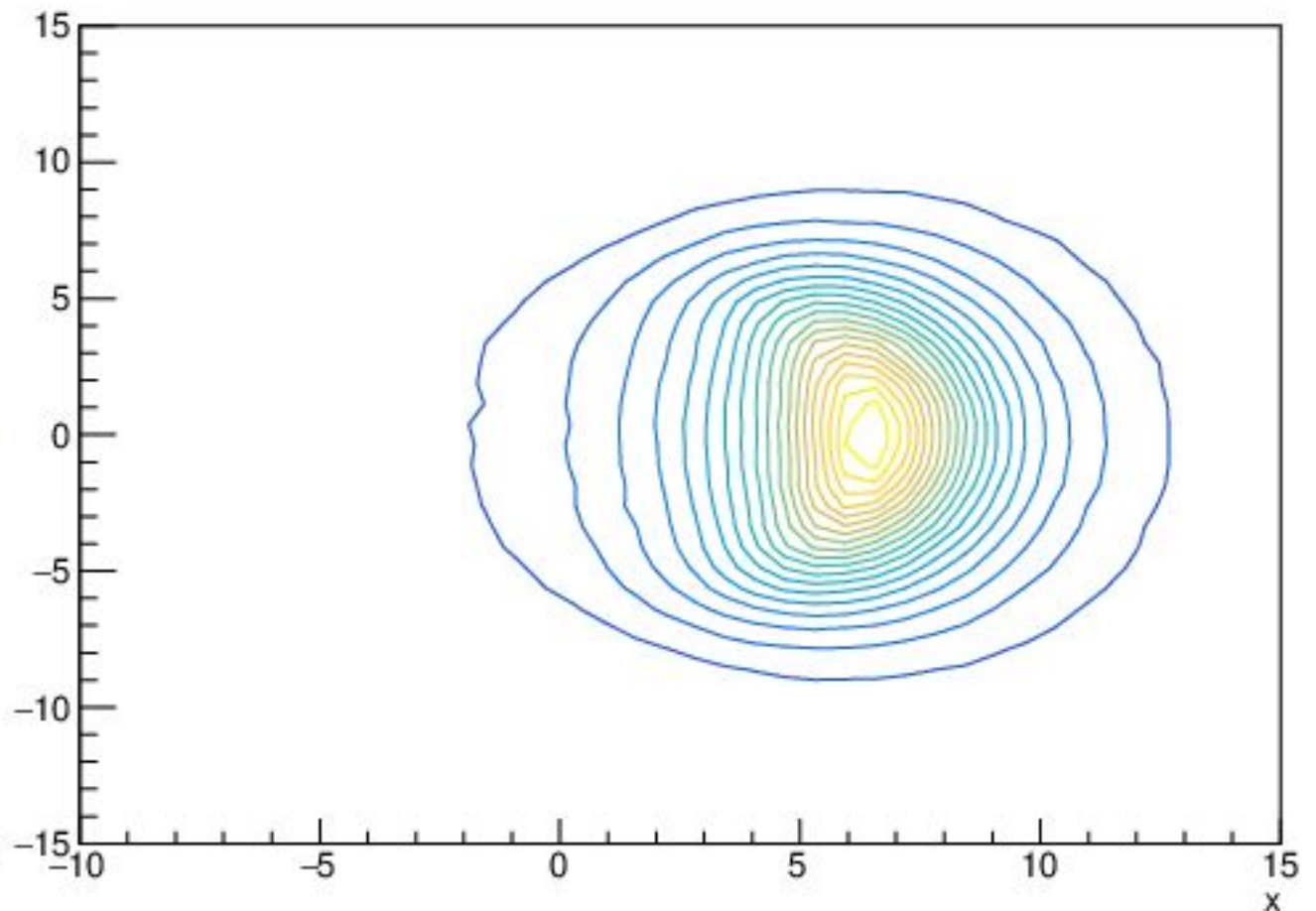# Scatter plot

- rotace hybnosti do směru x

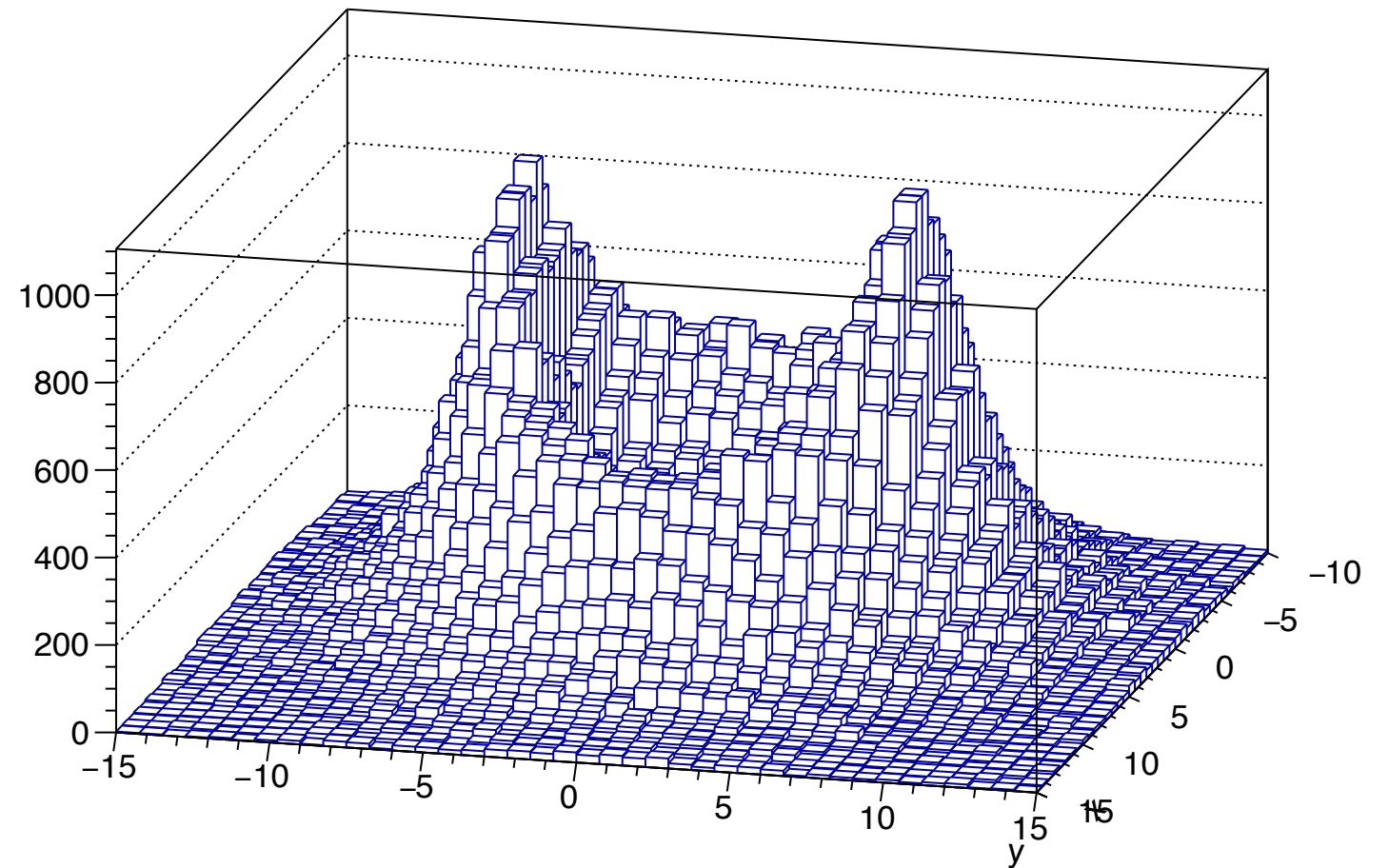- hlubší pohled

pT=175 MeV

pT=475 MeV

pT=275 MeV

Závěr

- při zpracování dat pro π^+ nebylo možné pozorovat podobnost s daty HADES

- π^-?

- jiný model?

Reference

- [1] Relativistic Hadron-Hadron Collisions and the Ultra-Relativistic Quantum Molecular Dynam- ics Model (UrQMD)
  M. Bleicher, E. Zabrodin, C. Spieles, S.A. Bass, C. Ernst, S. Soff, H. Weber, H. Stöcker and W. Greiner.
  J. Phys. G25 (1999) 1859–1896.

- [2] *Microscopic Models for Ultrarelativistic Heavy Ion Collisions*
  S. A. Bass, M. Belkacem, M. Bleicher, M. Brandstetter, L. Bravina, C. Ernst, L. Gerland, M. Hofmann, S. Hofmann, J. Konopka, G. Mao, L. Neise, S. Soff, C. Spieles, H. Weber, L. A. Winckelmann, H. Sto¨cker, W. Greiner, C. Hartnack, J. Aichelin and N. Amelin.
  Prog. Part. Nucl. Phys. 41 (1998) 225–370.

- [3] http://theor.jinr.ru/~wpcf2019/files/talks/06/14.talk_Dubna_060619.pdf [3.12. 2019]

- [4] https://www.fias.science/en/theoretical-physics/research-groups/marcus-bleicher/ [3.12. 2019]

„The LHC accelerates
the protons and the lead,
and the things that it discovers
will rock you in the head.“

Katherine McAlpine in her Large Hadron Collider Rap