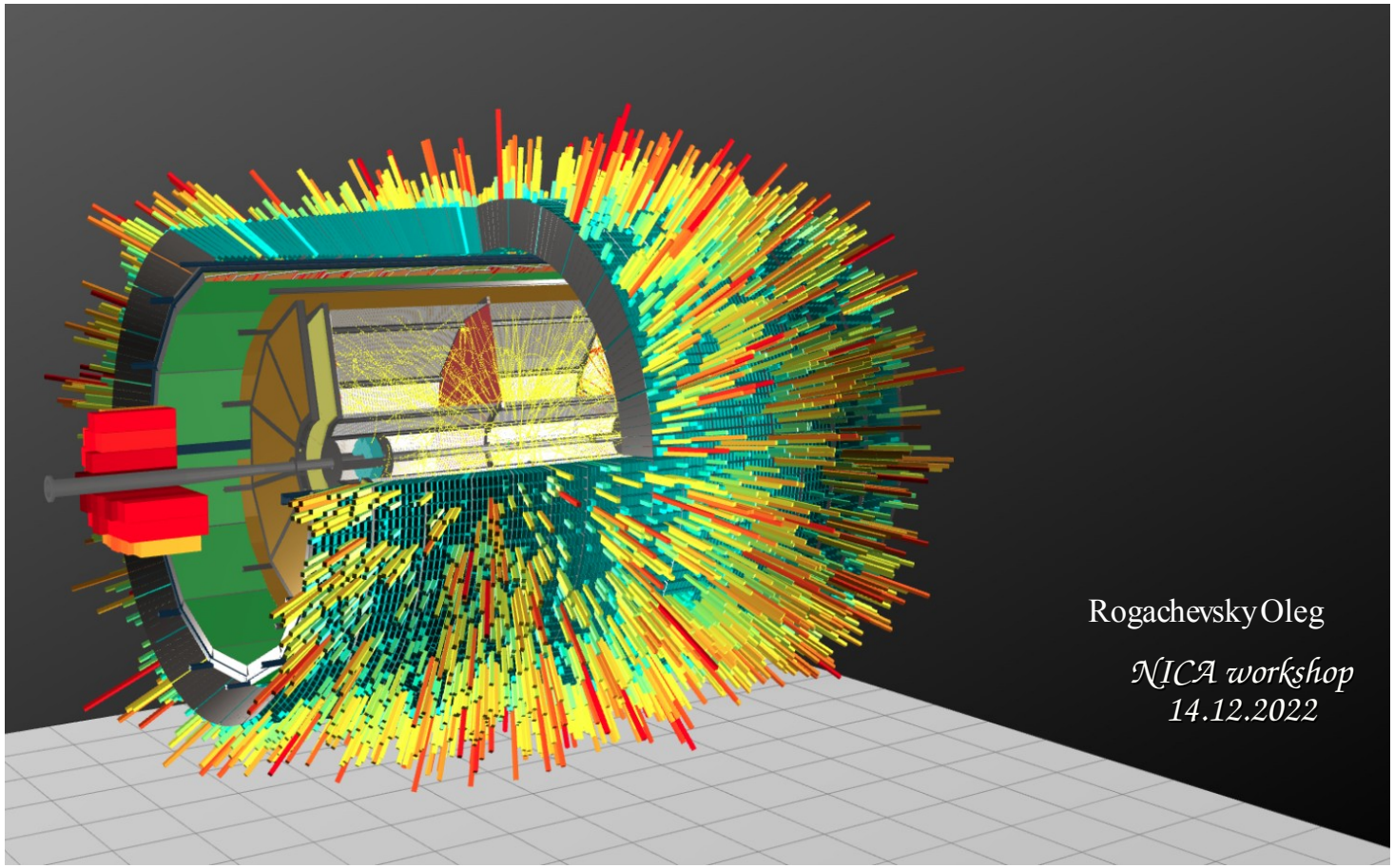
Two particles correlations & events structure in heavy ion collisions at NICA energies



Rogachevsky Oleg

NICA workshop
14.12.2022

Particles correlation

2-particle correlations:

$$\frac{d^2N}{d\Delta\phi d\Delta\eta}(\Delta\phi,\Delta\eta) = \frac{1}{N_{trig}}\frac{1}{\epsilon(\phi,\eta,\Delta\phi,\Delta\eta)}\frac{d^2N_{raw}}{\Delta\phi\Delta\eta}$$

within some p_T range

Jet quenching, femtoscopy, ridge, ...

Multiparticle correlations:

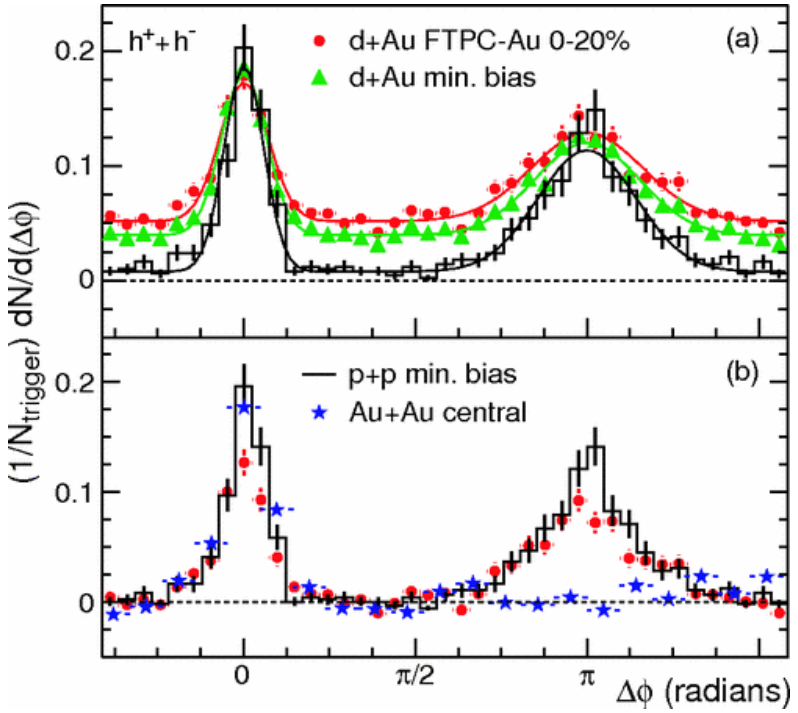
- Flow,
- Intermittency
- fractal moments
- Fractal analyses
- ...

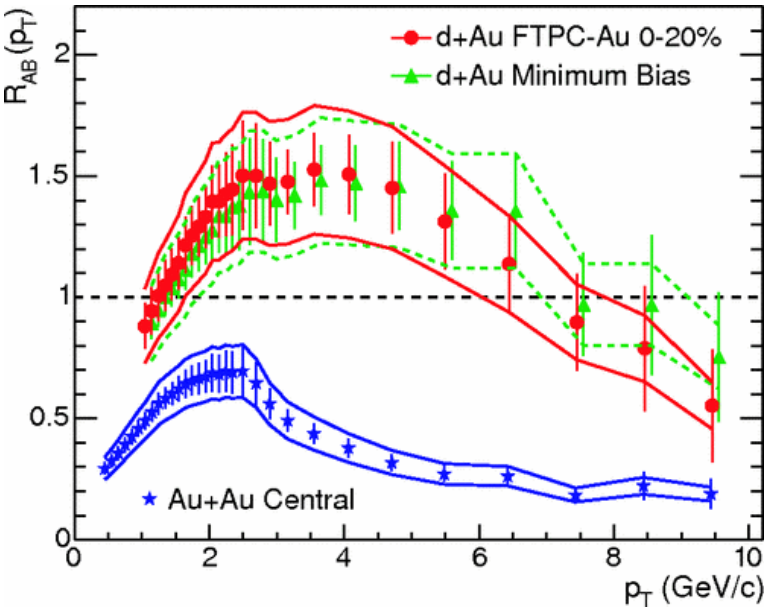
$$\frac{\mathrm{d}^3N}{\mathrm{d}^3\mathbf{p}} = \frac{1}{2\pi}\frac{\mathrm{d}^2N}{p_\mathrm{t}\mathrm{d}p_\mathrm{t}\mathrm{d}y}\left(1+2\sum_{n=1}^{\infty}v_n\cos[n(\varphi-\Psi_\mathrm{RP})]\right)$$

$$F_q(M) = \frac{<\frac{1}{M^D}\sum_{i=1}^{M^D} n_i(n_i-1)\dots(n_i-q+1)>}{<\frac{1}{M^D}\sum_{i=1}^{M^D} n_i>^q}$$

Jet quenching

Phys.Rev.Lett. 91 072304, 2003



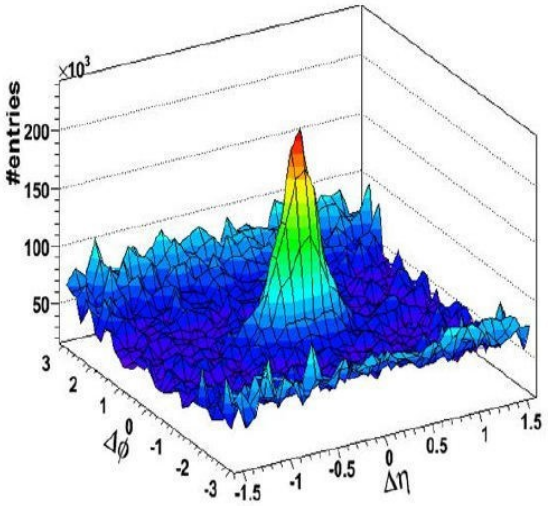


4 GeV/c < p_T^{trig} < 6 GeV/c
2 GeV/c < p_T^{assoc} < p_T^{trig}

Ridges@ RHIC

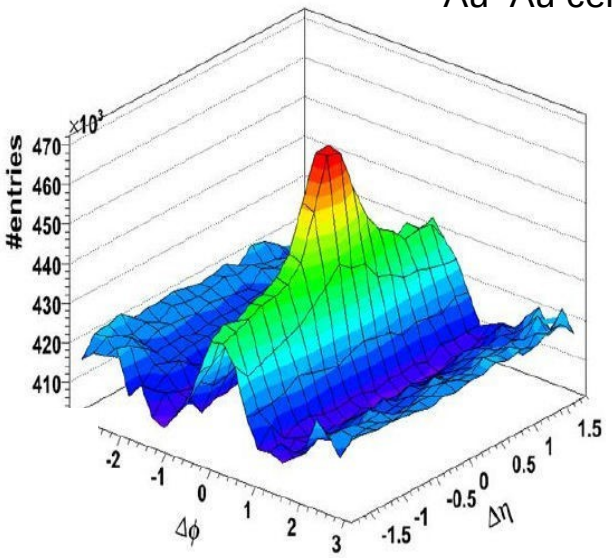
B. Abelev et al., Phys. Rev. C80, 064912 (2009).

d–Au

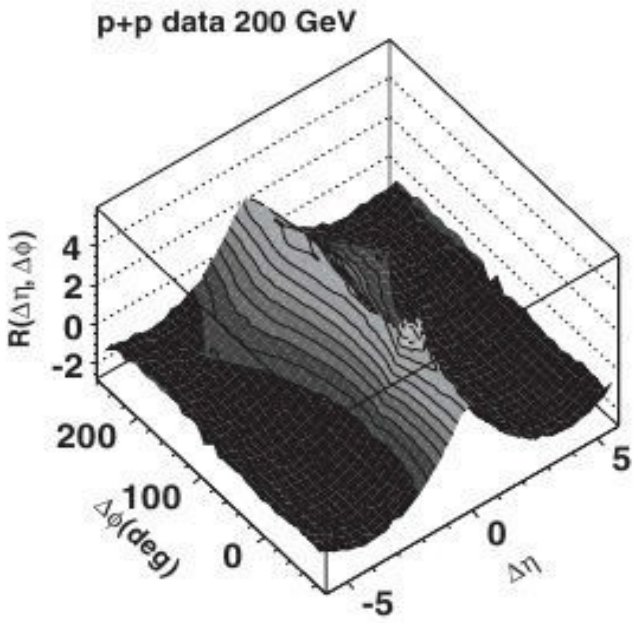


Two particle correlation function at 200 GeV/N from STAR experiment

Au–Au central



PHYSICAL REVIEW C 75, 054913 (2007)

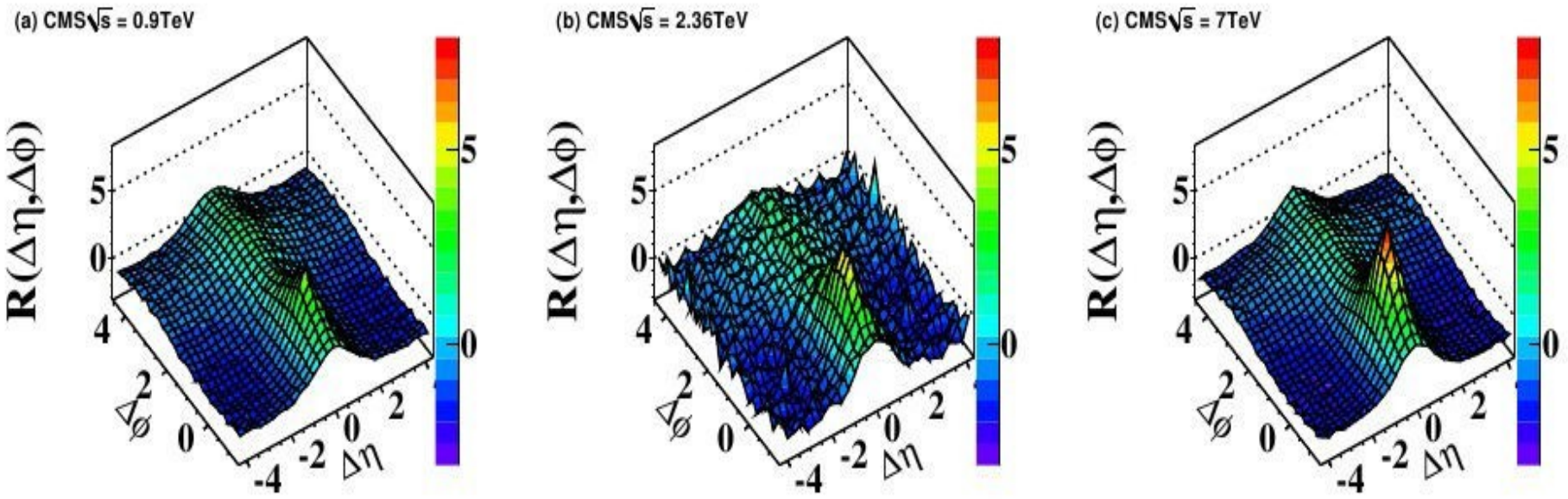


Cover an acceptance
of $3 < |\eta| < 4.5$ and
$-180^\circ < \varphi < 180^\circ$
5×10^5 200-GeV Au+Au
8×10^5 410 GeV p+p
$|z_{vtx}| < 10$ cm

$3\ \text{GeV/c} < p_T^{\text{trig}} < 4\ \text{GeV/c}$
$2\ \text{GeV/c} < p_T^{\text{assoc}} < p_T^{\text{trig}}$

Ridge at LHC (CMS)

arXiv:1009.4122



Two-particle correlation functions versus Δη and Δφ in pp collisions

Interpretations: theory

- Jet quenching
  David d'Enterria arXiv:0902.2011 (2009)
- Colour Glass Condensate effective theory
  K. Dusling et al., Nucl. Phys. A836, 159 (2010).
- Hydrodynamical expansion and many flux tubes
  K. Werner et al., Phys. Rev. Lett. 106, 122004 (2011)
- Effect of an elliptic flow manifestation.
  P. Bozek, Eur. Phys. J. C71, 1530 (2011)
- Int workshop "The Ridge" May, 2012
- Momentum kick model
  C. Y. Wong, Phys. Rev. C 76, 054908 (2007)
- Jet Quenching in Heavy-Ion Collisions The Transition Era from RHIC to LHC
  Barbara Betz arXiv:1211.5897, (2012)
- Jet quenching in high-energy heavy-ion collisions
  Guang-you Qin and Xin-Nian Wang, arXiv:1511.00790 (2015)
- Jet quenching and medium response in high-energy heavy-ion collisions: a review
  Shanshan Cao and Xin-Nian Wang, arXiv:2002.04028 (2020)
- From hydro to jet quenching, coalescence and hadron cascade
  W. Zhao, W. Ke, W. Chen, T. Luo and X. N.Wang, Phys.Rev.Lett. 128 (2022) 2, 022302.
- Conference "Jet Quenching In The Quark-Gluon Plasma" Jun 13 – 17, 2022 ECT

…

So far there is no consensus on the origin of the effects and various explanations of the these phenomena were proposed

P_T cuts does matter

Ridge

RHIC AuAu

$3\ \text{GeV/c} < p_T^{trig} < 4\ \text{GeV/c}$

$2\ \text{GeV/c} < p_T^{assoc} < p_T^{trig}$

LHC pp

$0.1\ \text{GeV/c} < \ldots < p_T < \ldots < 5.\ \text{GeV/c}$

Multiplicity N > 110

Jet Quenching

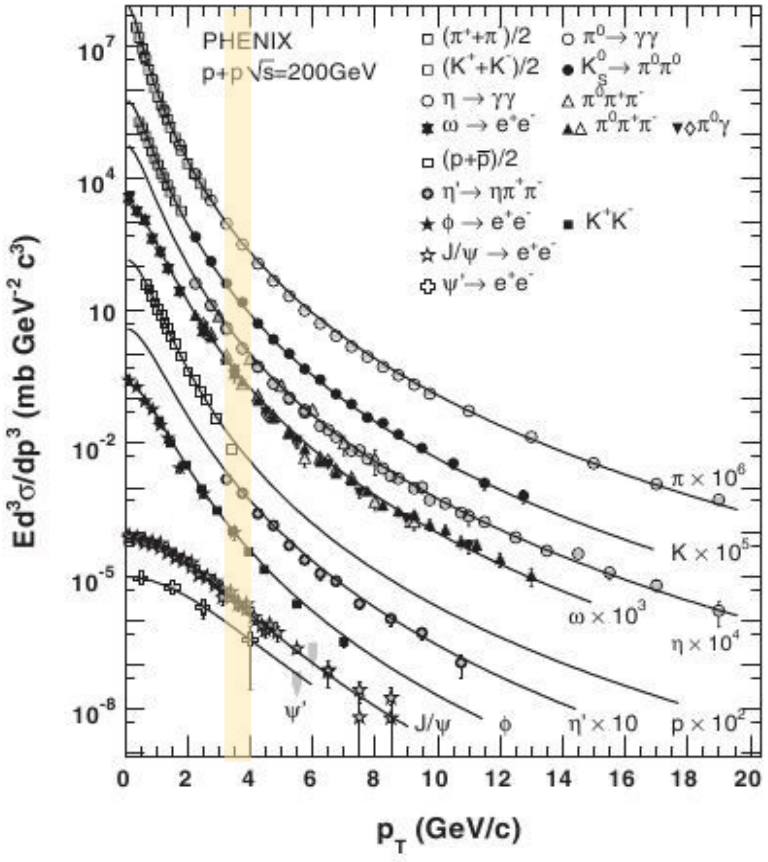
RHIC AuAu

$4\ \text{GeV/c} < p_T^{trig} < 6\ \text{GeV/c}$

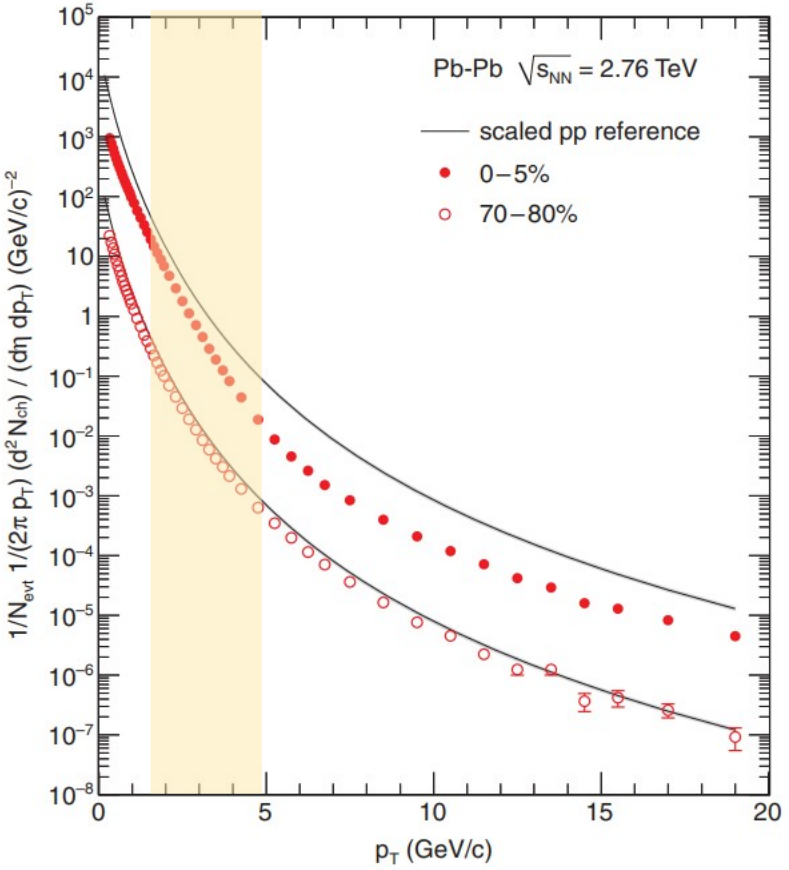
$2\ \text{GeV/c} < p_T^{assoc} < p_T^{trig}$

P_T inclusive particles spectra

PHENIX P.R. D 83, 052004 (2011)
+ Tsallis fitting

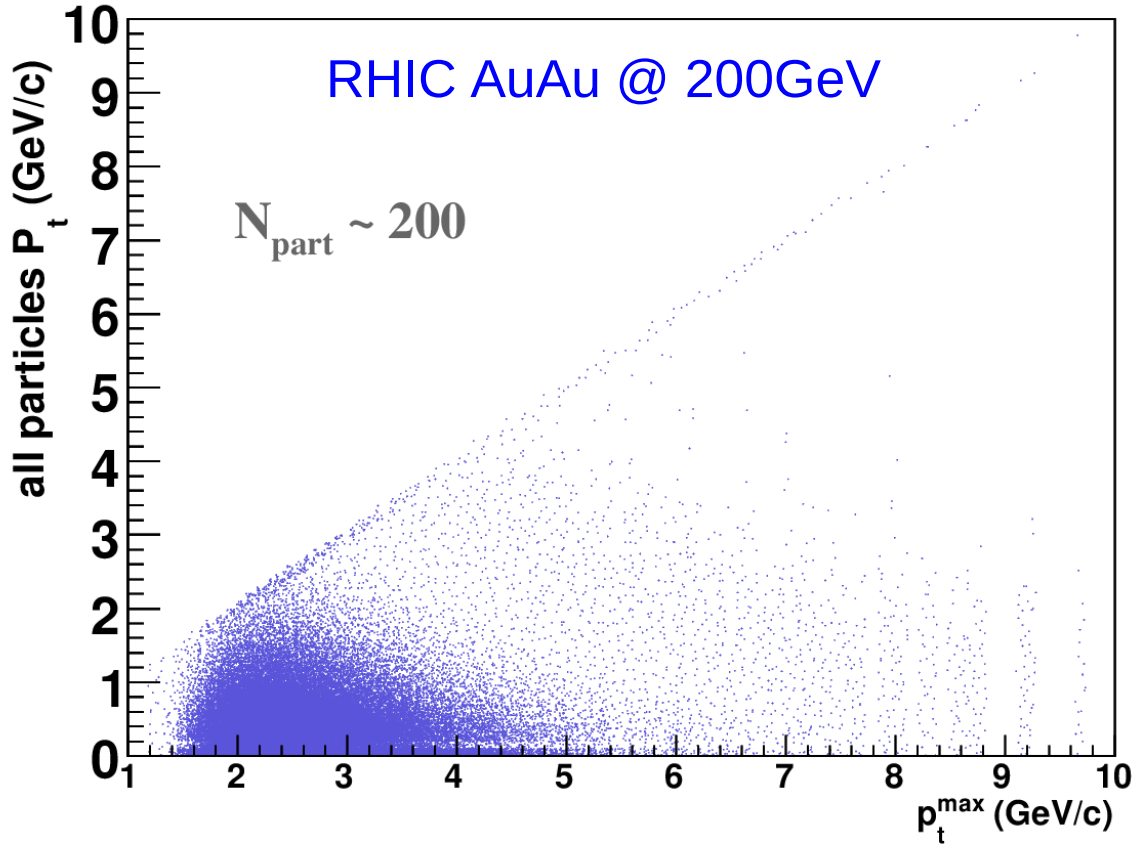


LHC



Universal events structure with p_T^{max}

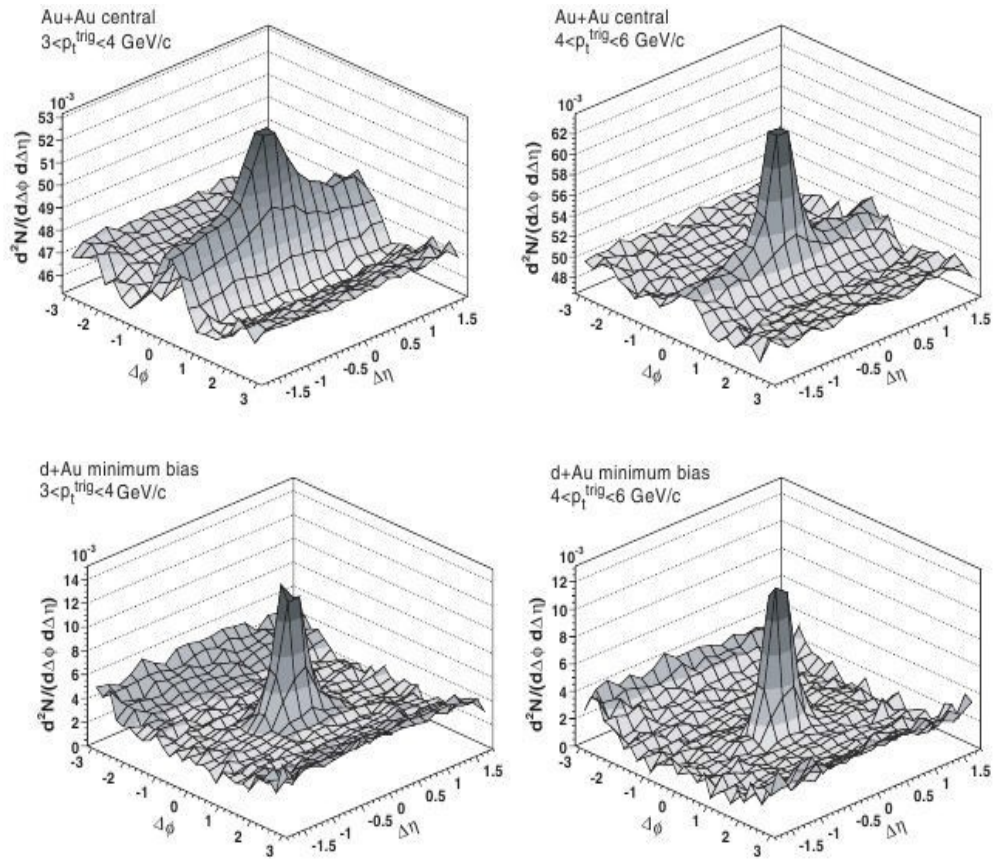
R.O. ICHEP 2006 v.2 p.443-446
Scale dependent (fractal) analysis approach for STAR events



Does not depend on:

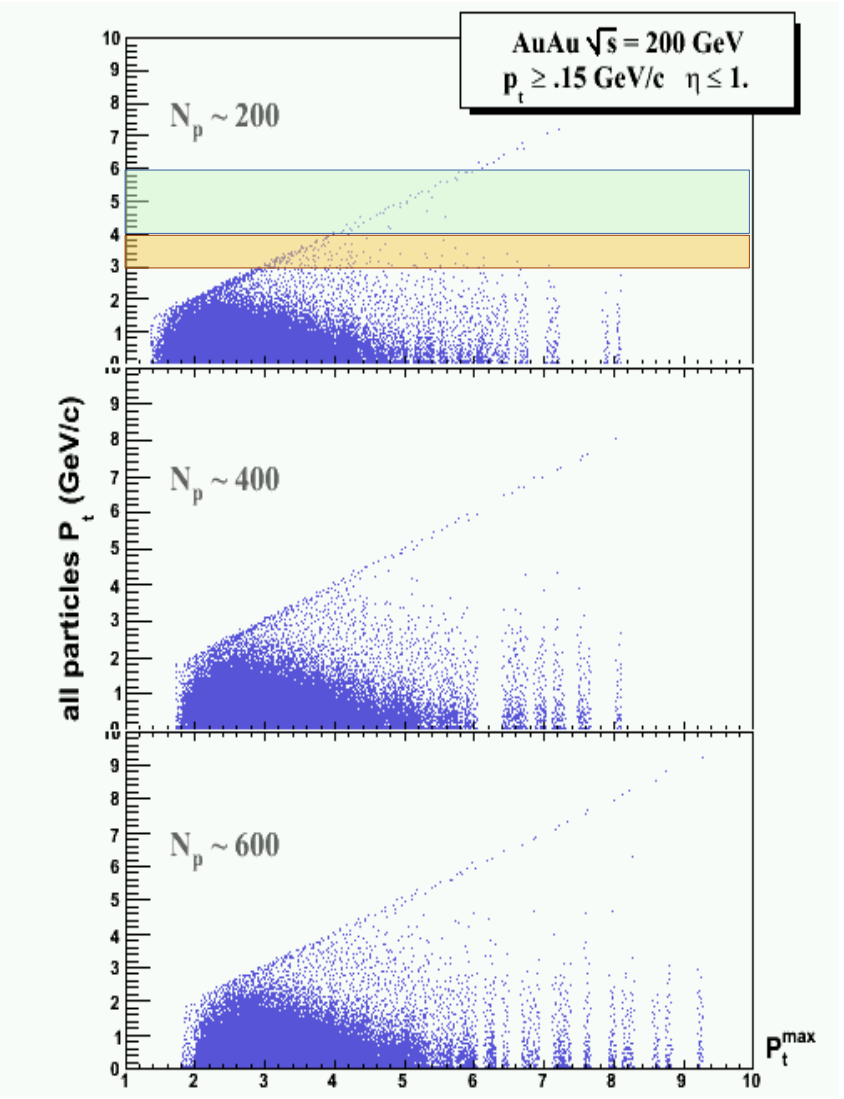
- Multiplicity
- Collision energy
- Colliding particles
- Type of produced particles

Ridge @ STAR



$2\ \text{GeV/c} < p_T^{\text{assoc}} < p_T^{\text{trig}}$

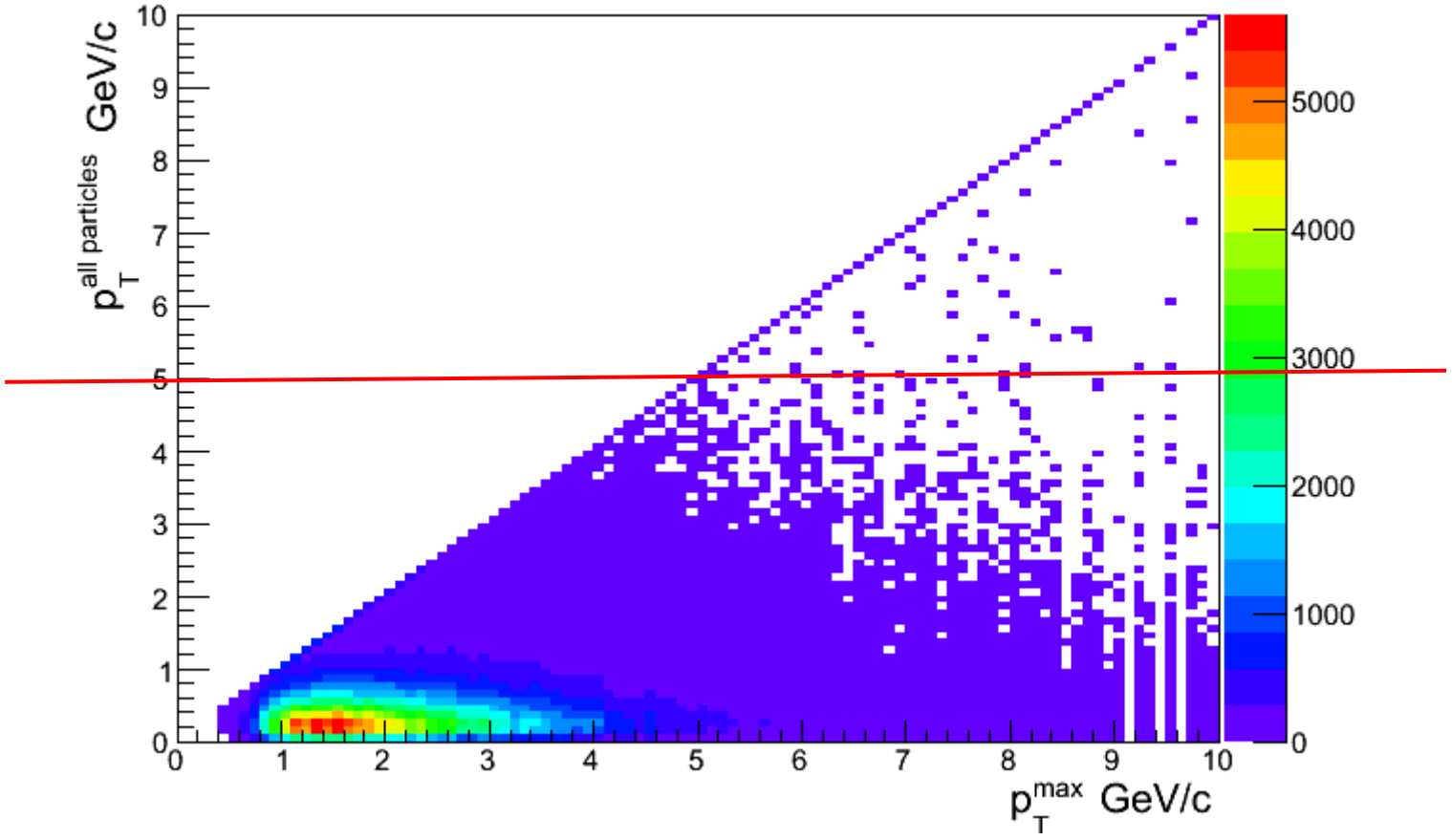
R.O. STAR events



pp @ √s = 7 TeV

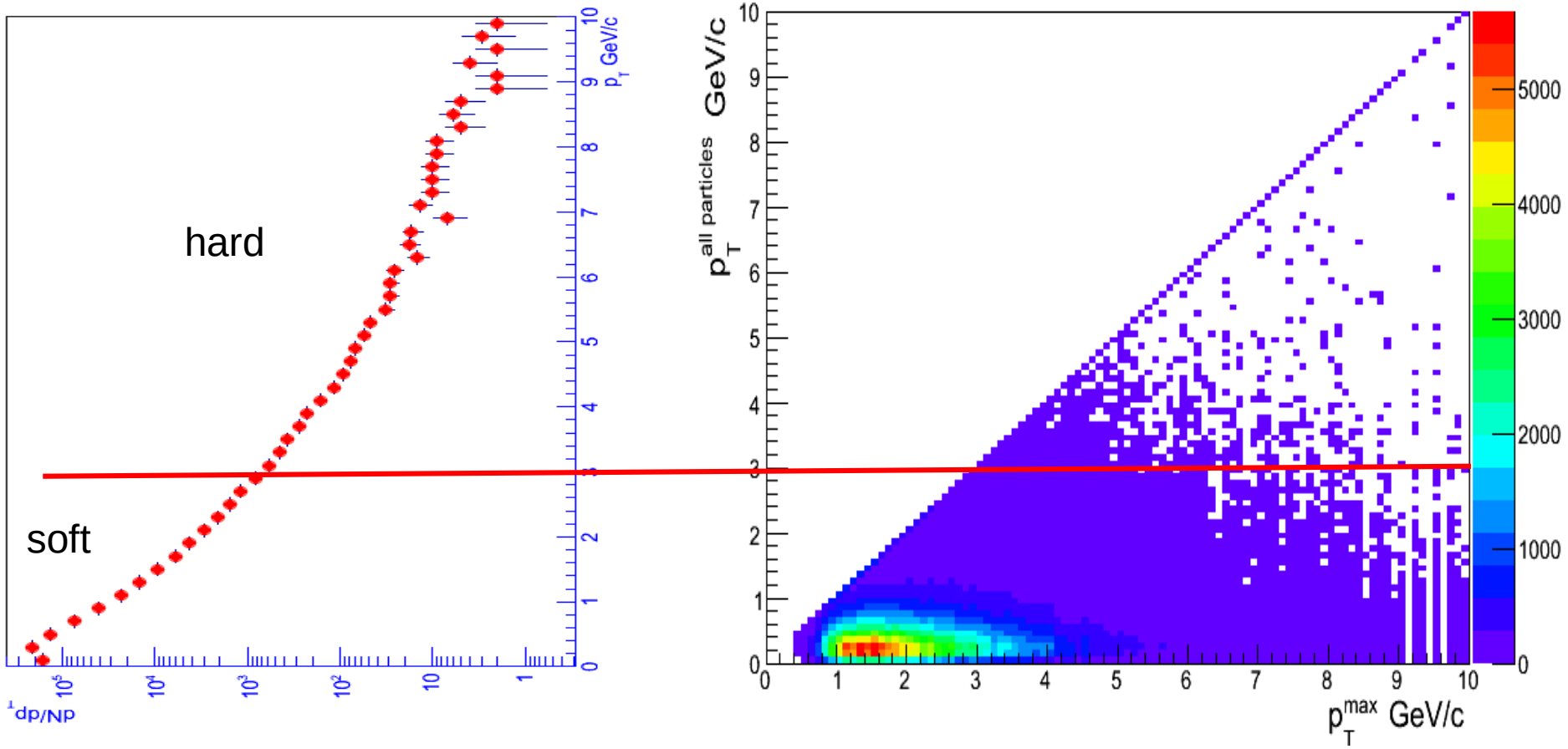
Pythia v.6 - 424

All charged particles



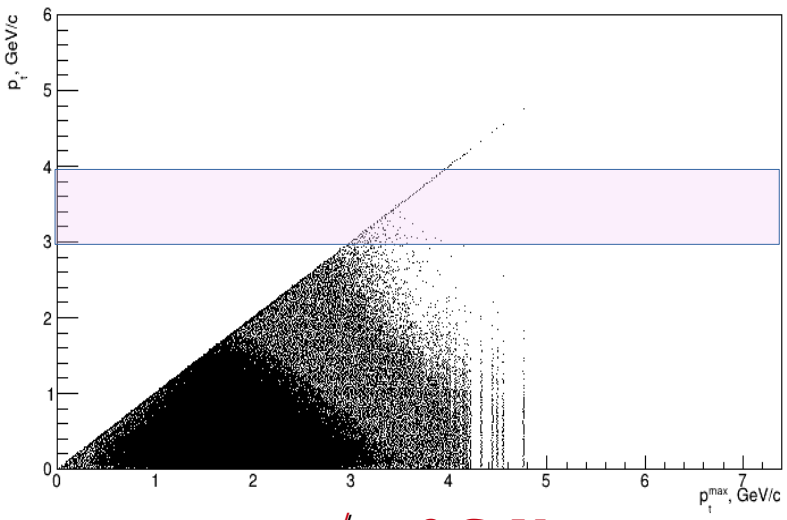
pp @ √s = 7 TeV

Pythia v.6-424 10K events
All charged particles

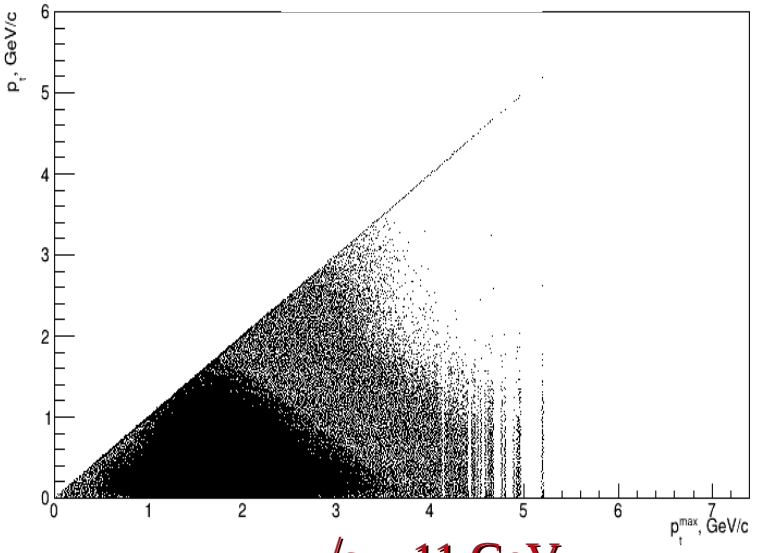


p_T^{max} distribution for NICA energies

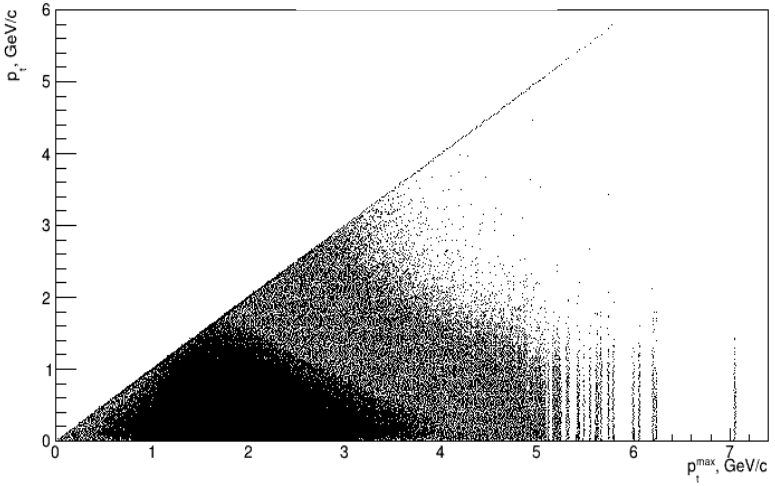
√s = 4 GeV



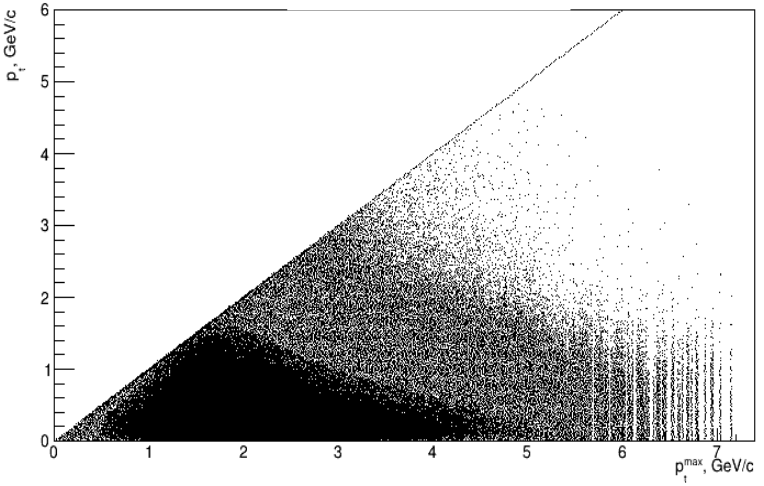
√s = 7 GeV



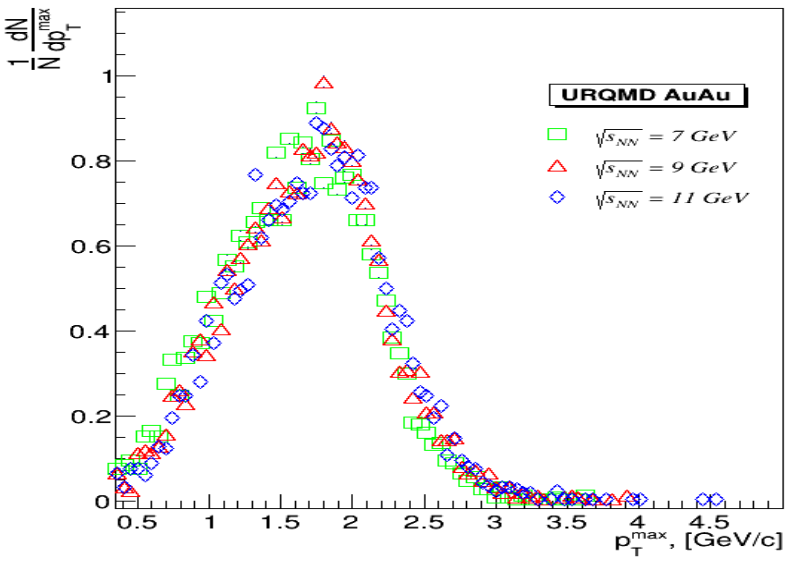
√s = 9 GeV

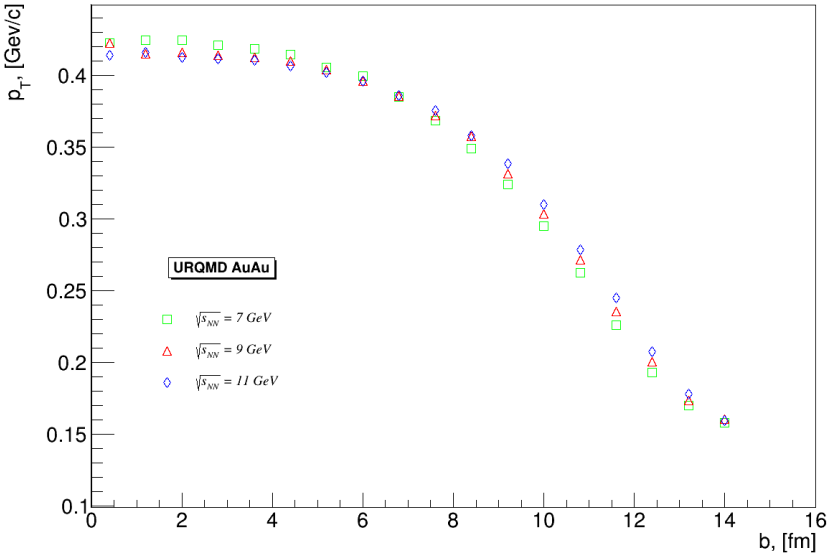


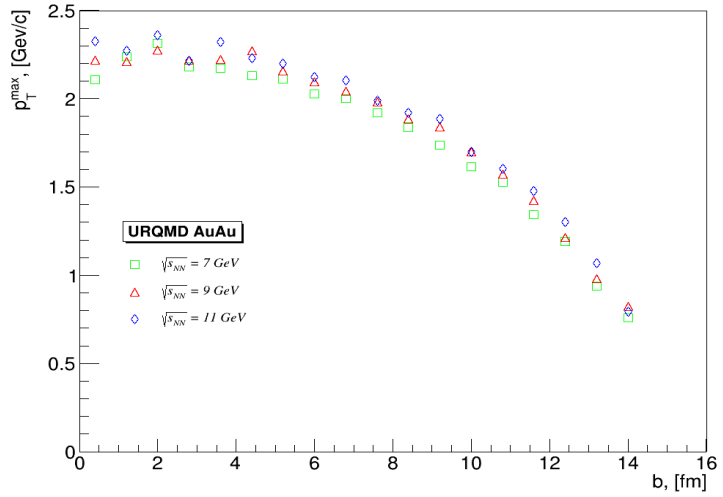
√s = 11 GeV

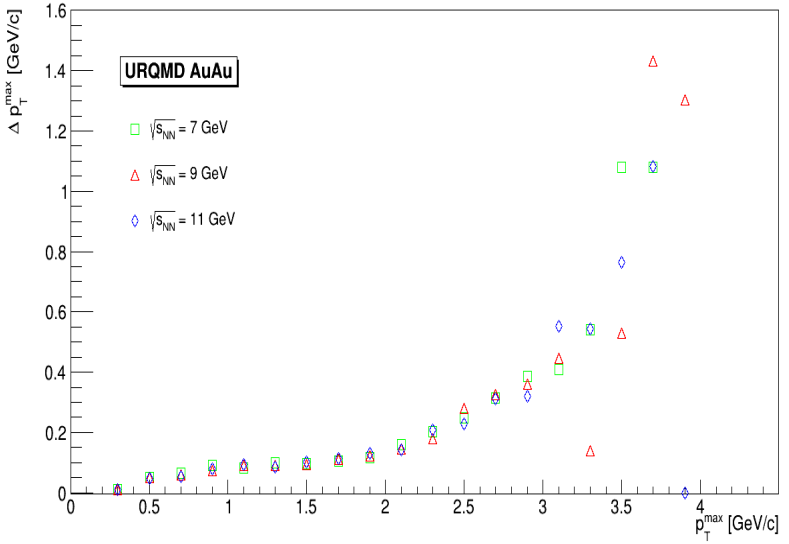


P_T^{max} study @ NICA energies: UrQMD

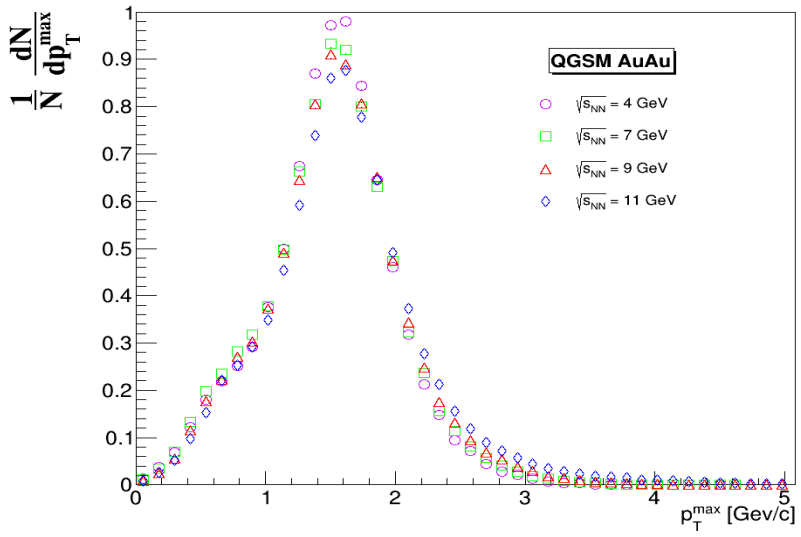


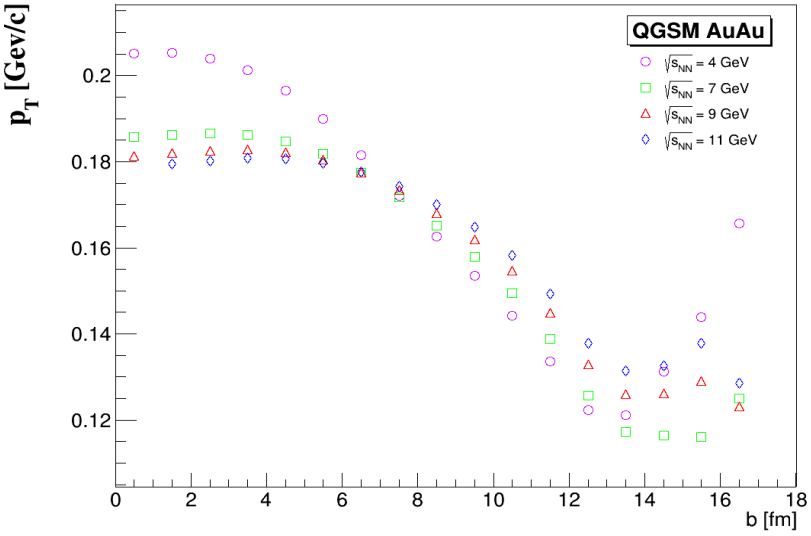


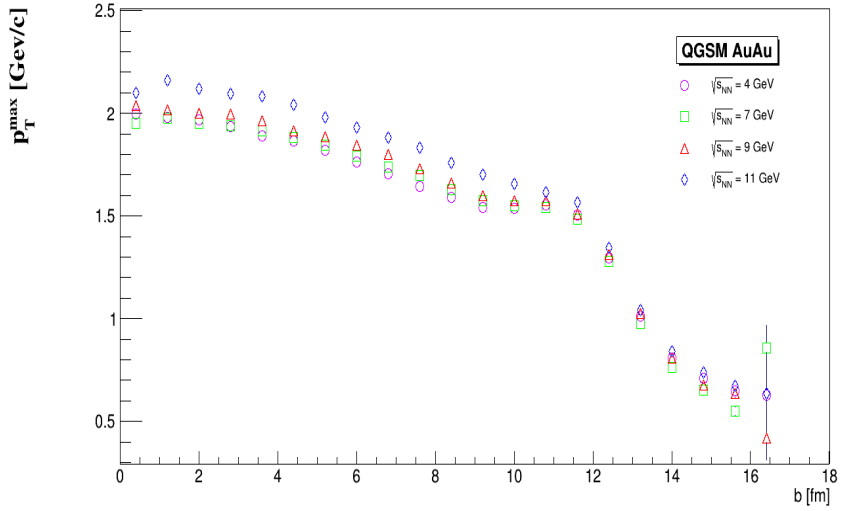


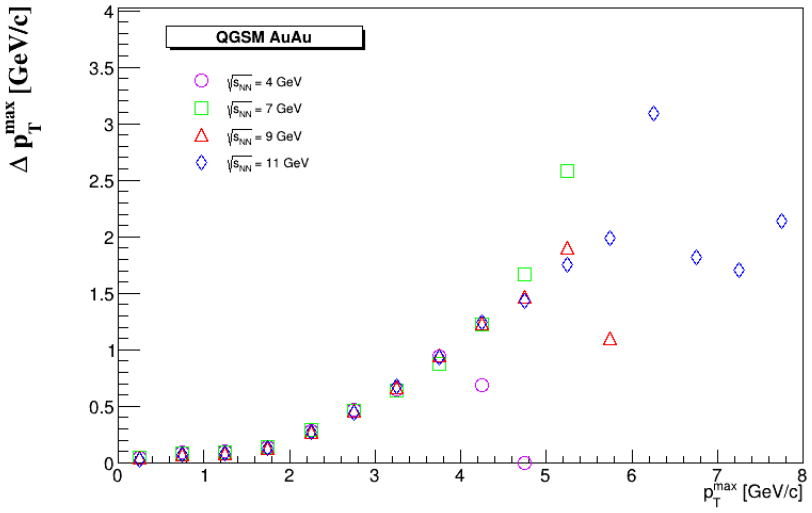


P_T^{max} study @ NICA energies: QGSM

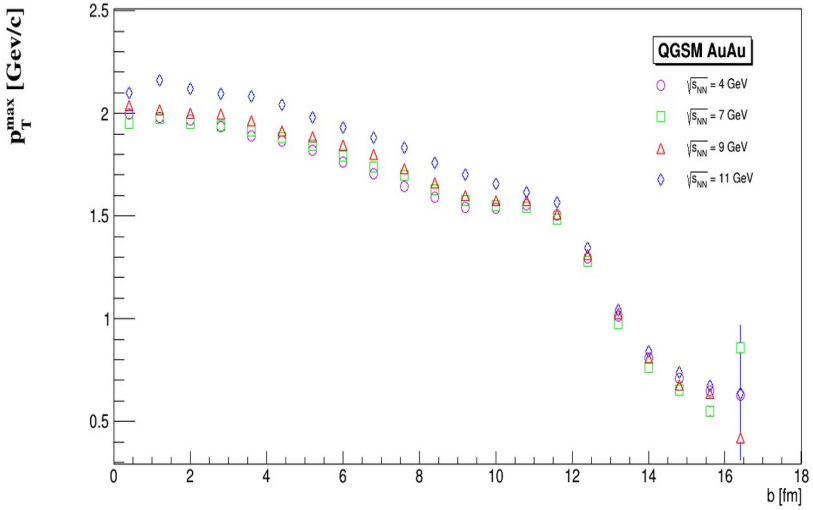


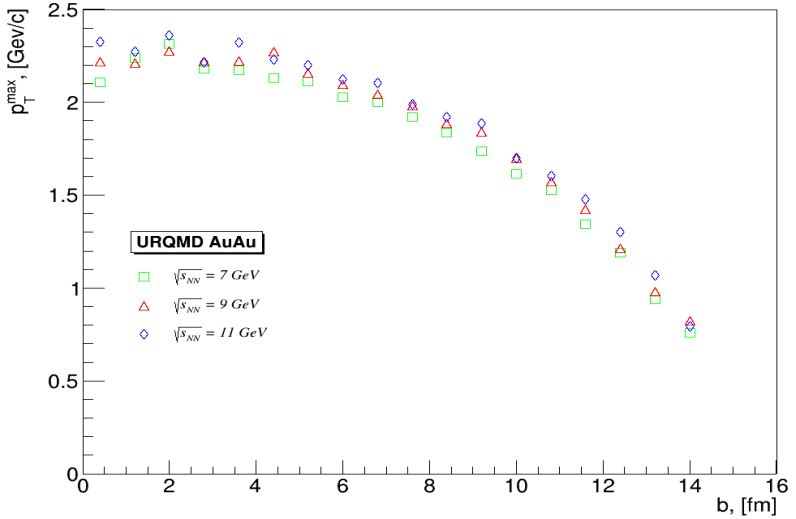


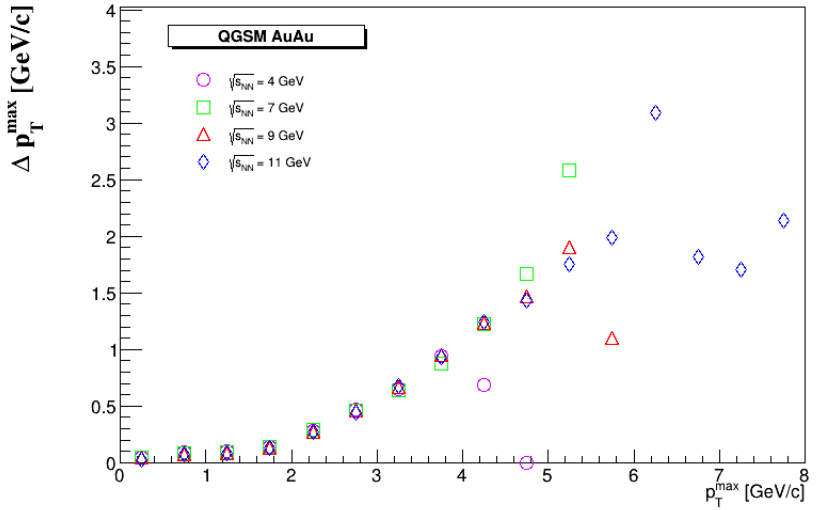


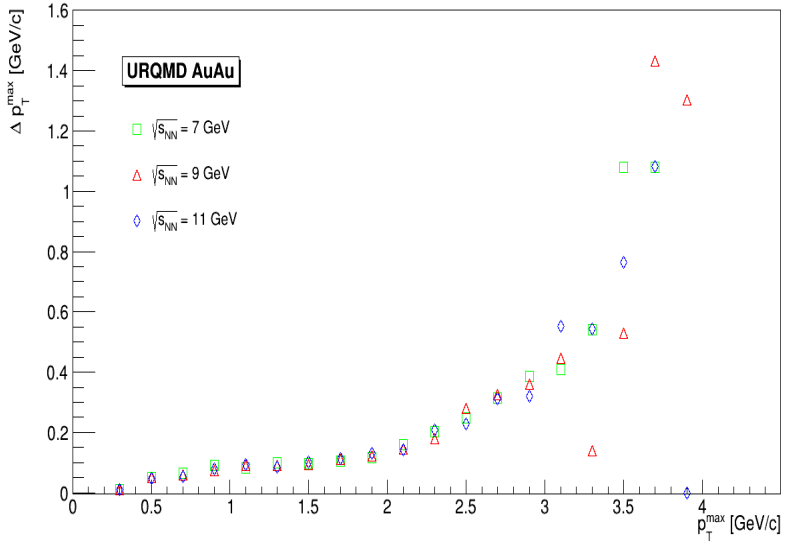


P_T^{max} @ NICA : QGSM vs UrQMD

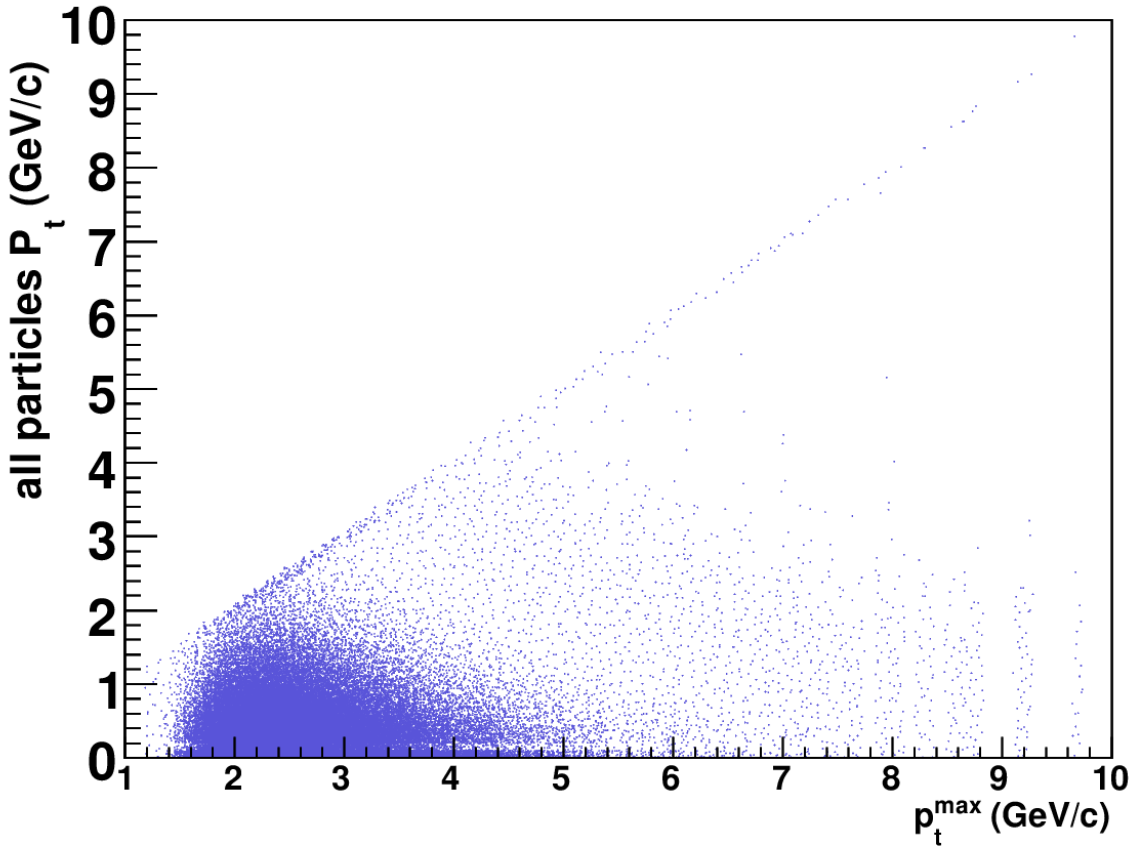








Other correlation analyses could be sensitive to the events structure




Thanks for your attention