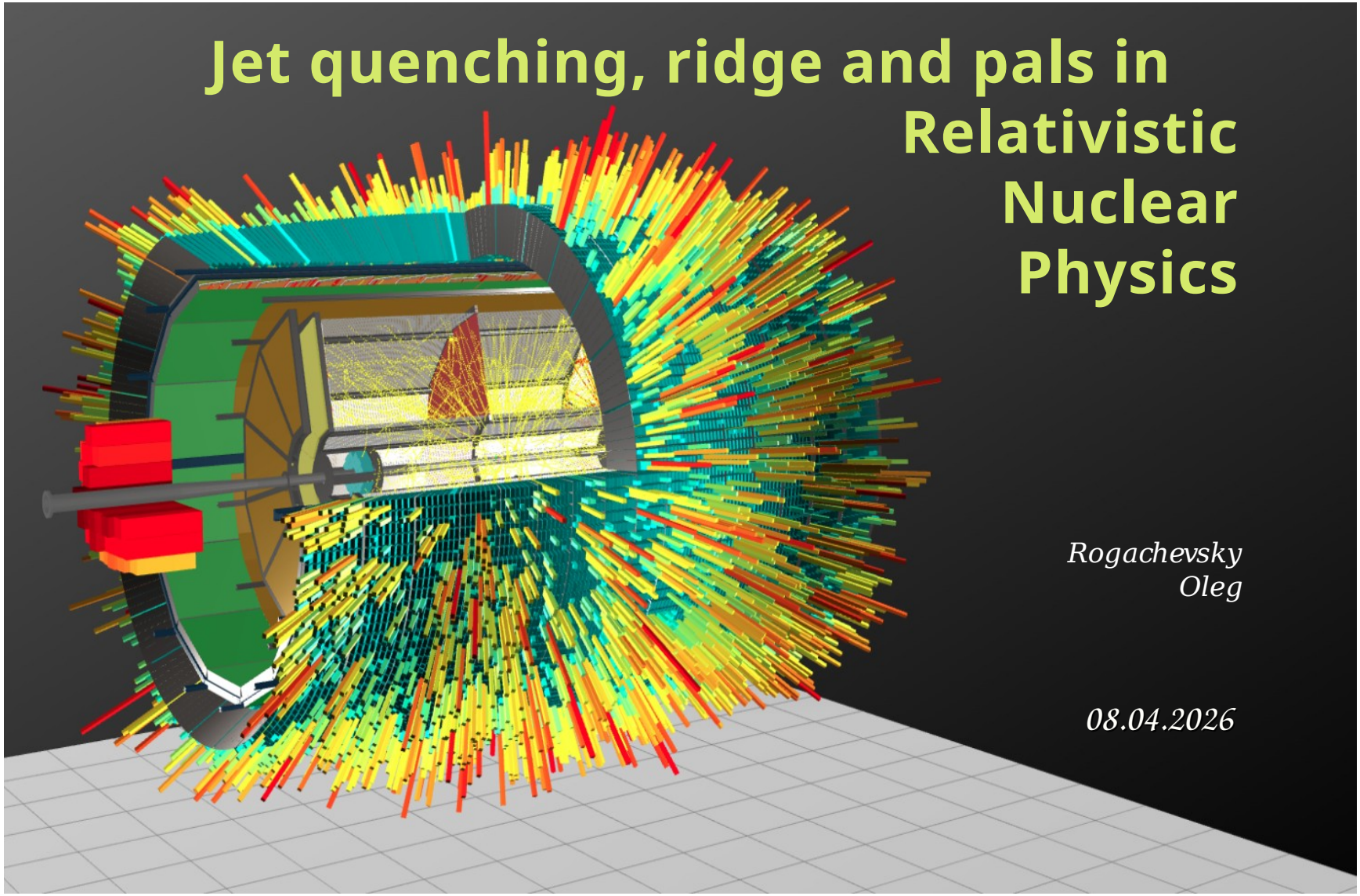
Jet quenching, ridge and pals in Relativistic Nuclear Physics



Rogachevsky Oleg

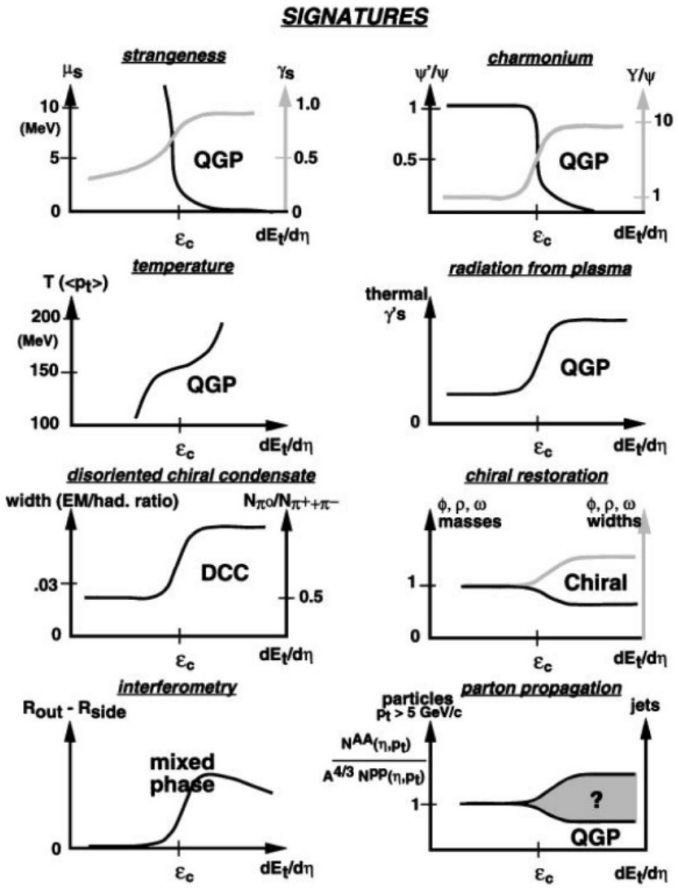
08.04.2026

QGP signatures from theory

arXiv:9602235 Feb 1996

John W. Harris and Berndt Müller

THE SEARCH FOR THE QUARK-GLUON PLASMA



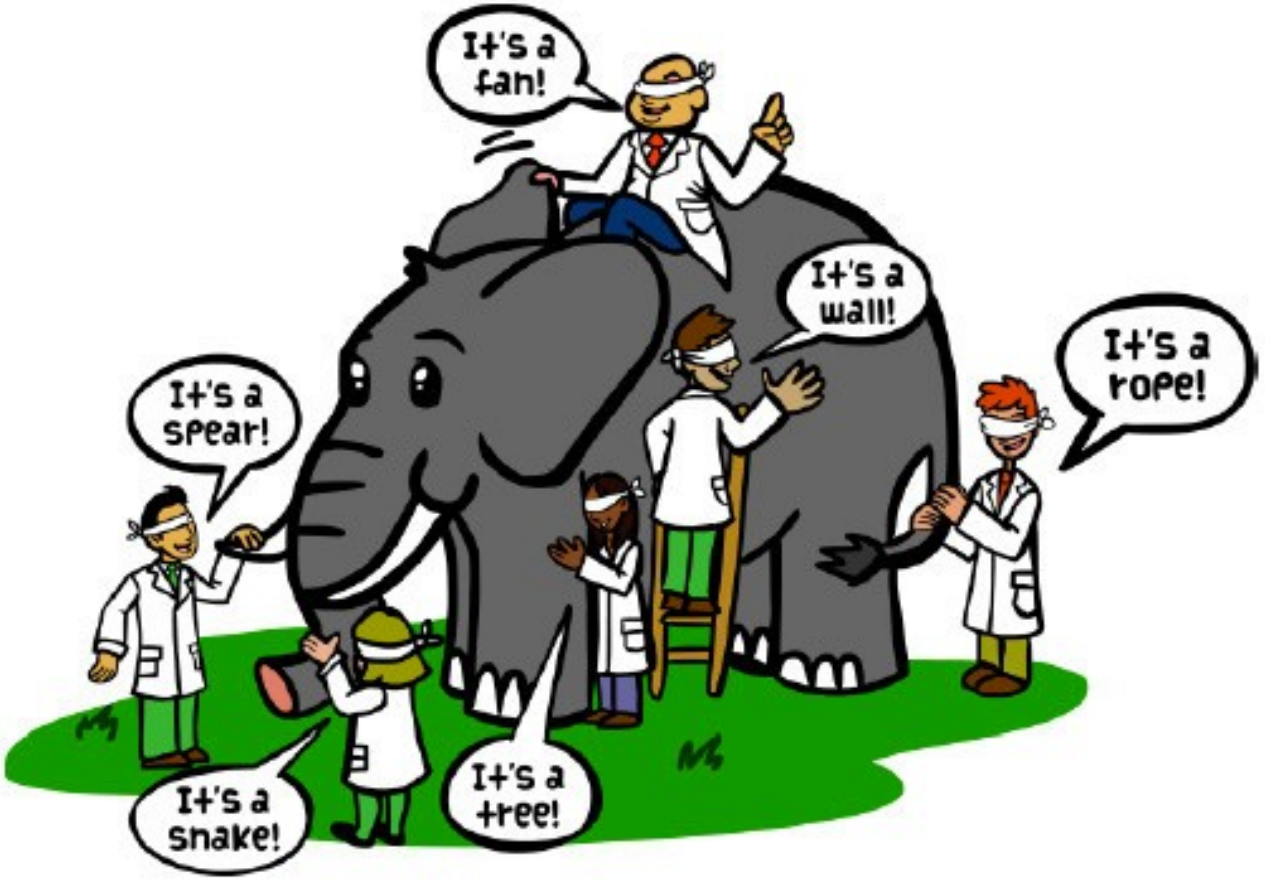
Summary and Outlook

Nearly three decades of experimental and theoretical research have affirmed the scientific strategy aimed at the discovery and characterization of the quark-gluon plasma that was described in 1996. Extensive measurements have converted the qualitative expectations for the quark-gluon plasma signatures summarized in Fig. 1 into quantitative knowledge. As with any preconceived strategy, adjustments were made in reaction to new insights gathered along the way. Some signatures have been found to be less useful or more difficult to measure than originally thought. Others have proven to be immensely valuable including several that were unanticipated or some that were known in principle but underappreciated.

arXiv:2308.05743 Feb 2024

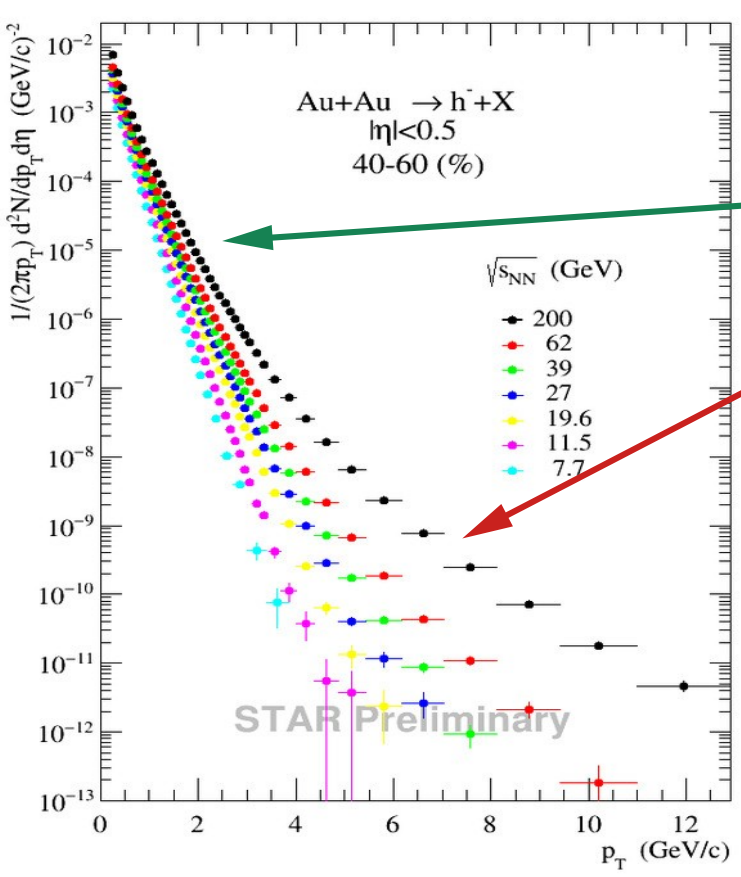
"QGP Signatures" Revisited

What is the elephant (QGP) ?



P_T spectra @ STAR

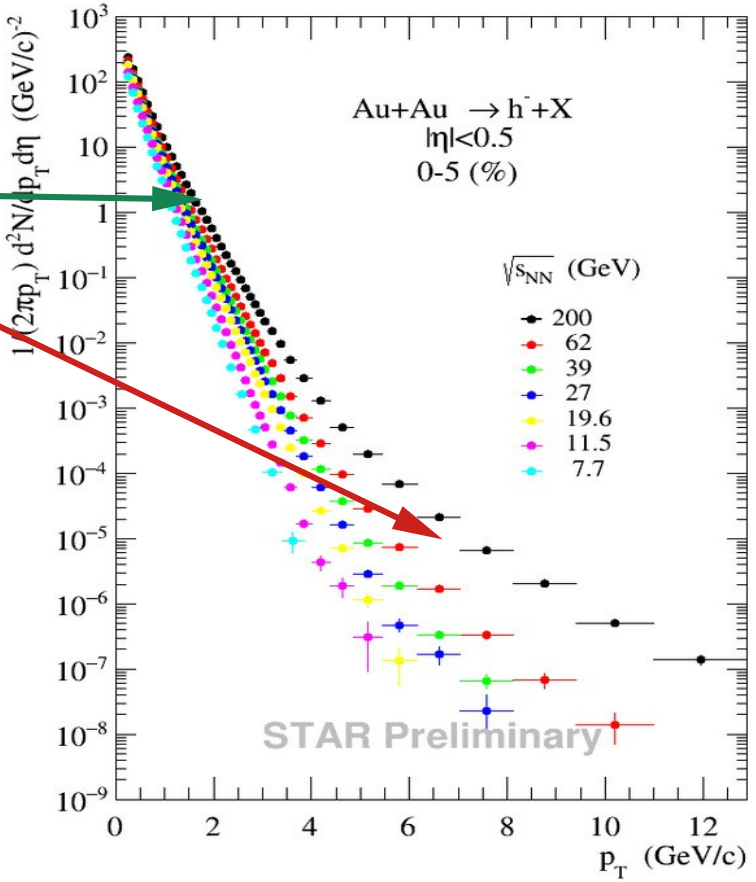
M.Tokarev et al.,
"Self-similarity of negative particle production from the Beam Energy Scan Program at STAR,"
Int. J. Mod. Phys. Conf. Ser. 39, 1560103 (2015)



Soft

Hard

EbyE

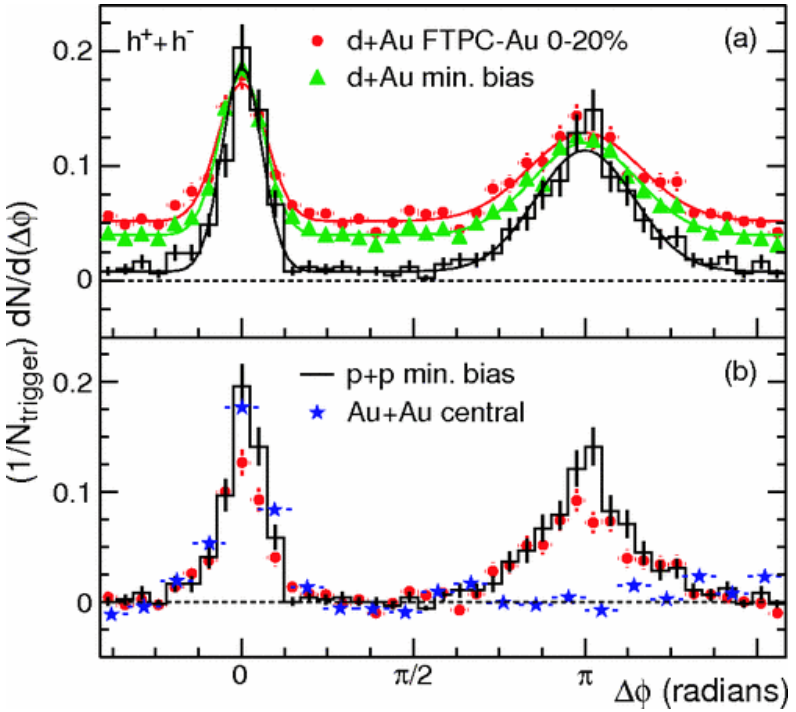


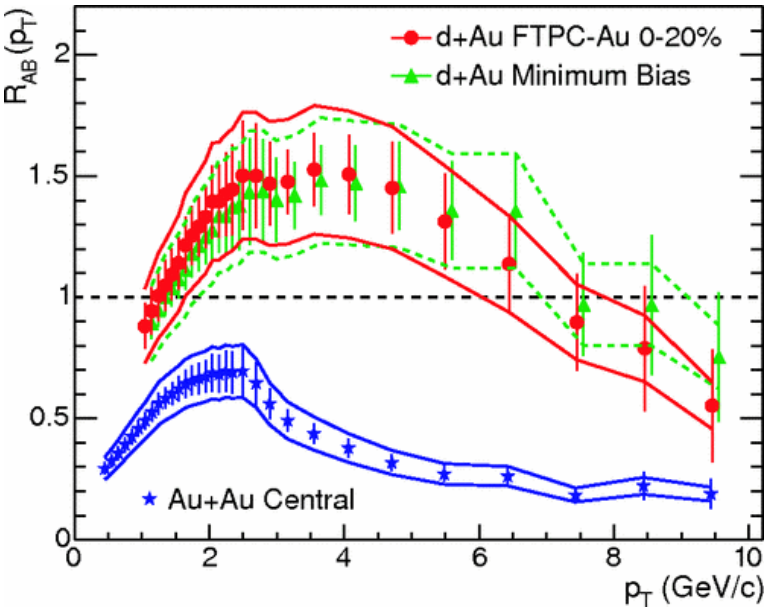
The dependence of the spectra of negatively charged particles produced in the central and minbias Au+Au collisions at energies √s = 7.7, 11.5, 19.6, 27, 39, 62.4, and 200 GeV in the range η < 0.5 on the transverse momentum

Jet quenching

Evidence from d+Au Measurements for Final-State Suppression of High-p_T Hadrons in Au+Au Collisions at RHIC

Phys.Rev.Lett. 91 072304, 2003



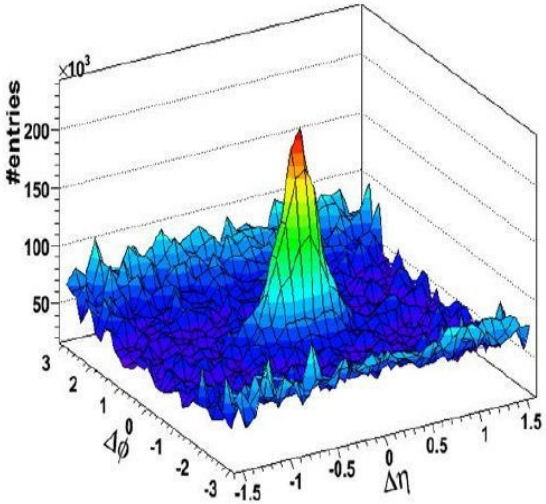


Ridge @ RHIC

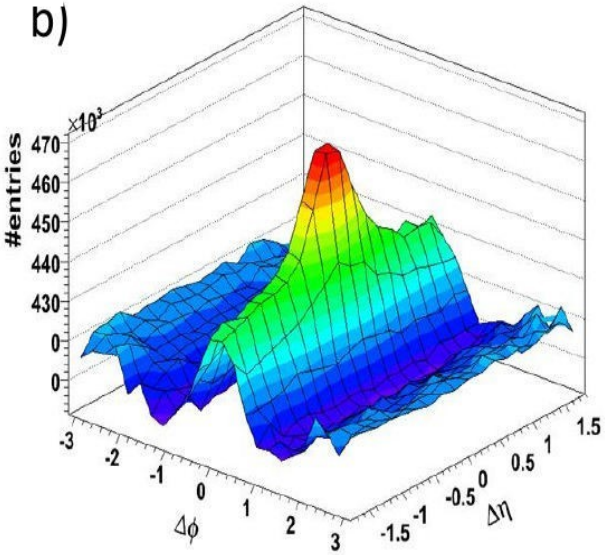
Long range rapidity correlations and jet production in high energy nuclear collisions

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

d–Au

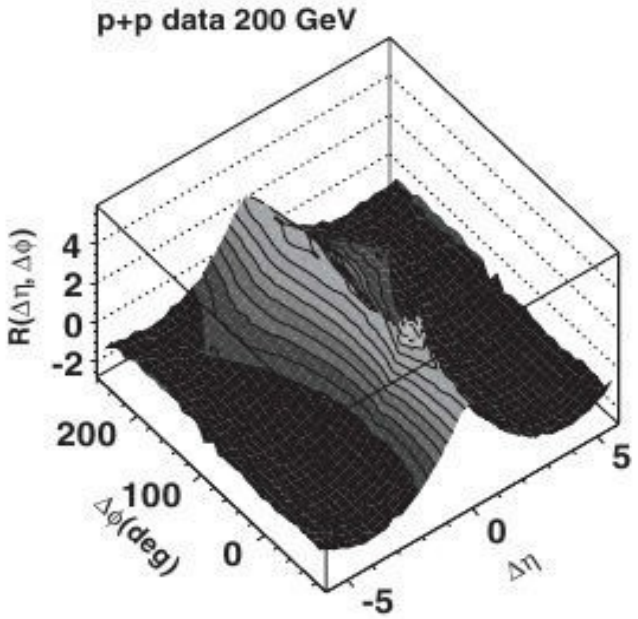


Au–Au central



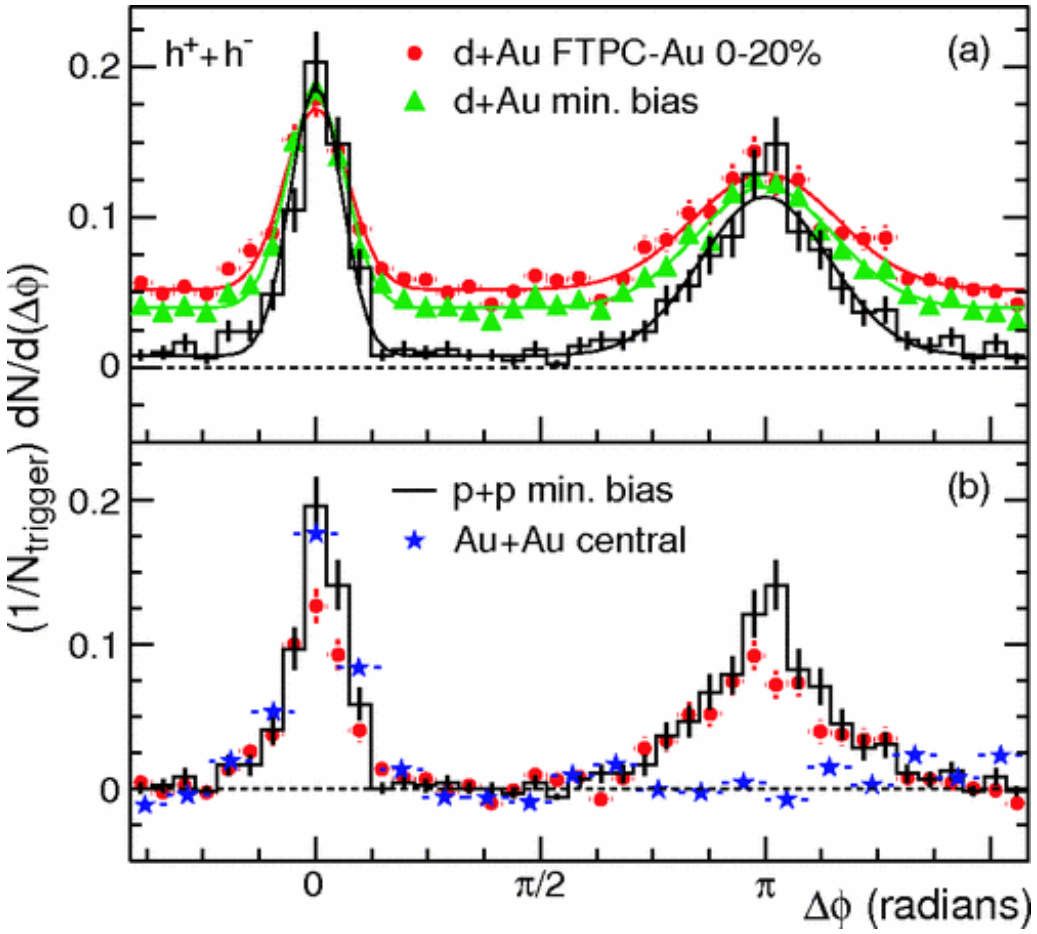
Two particle correlation function at 200 GeV from STAR experiment

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

P_T cuts for jet quenching



Jet Quenching

RHIC AuAu

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

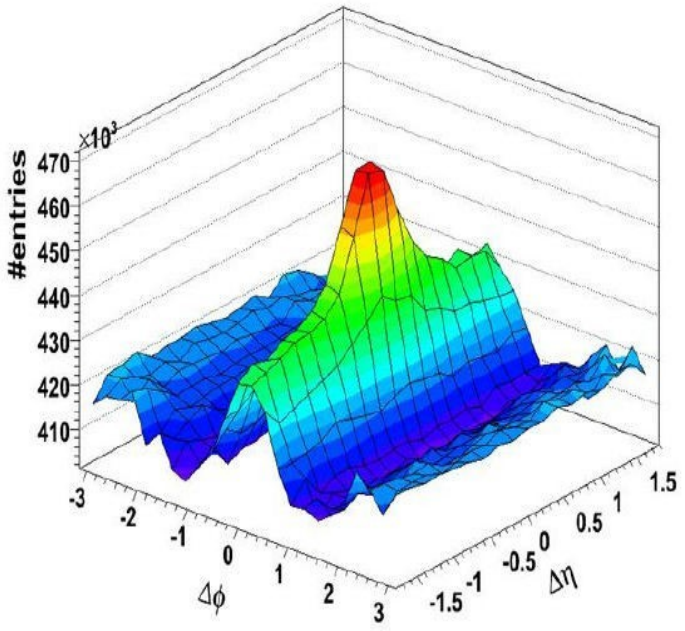
2 GeV/c < p_T^{assoc} < p_T^{trig}

P_T cuts for ridge at $\sqrt{s_{NN}}$ = 200 GeV

Long range rapidity correlations and jet production in high energy nuclear collisions

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

Ridge at RHIC AuAu

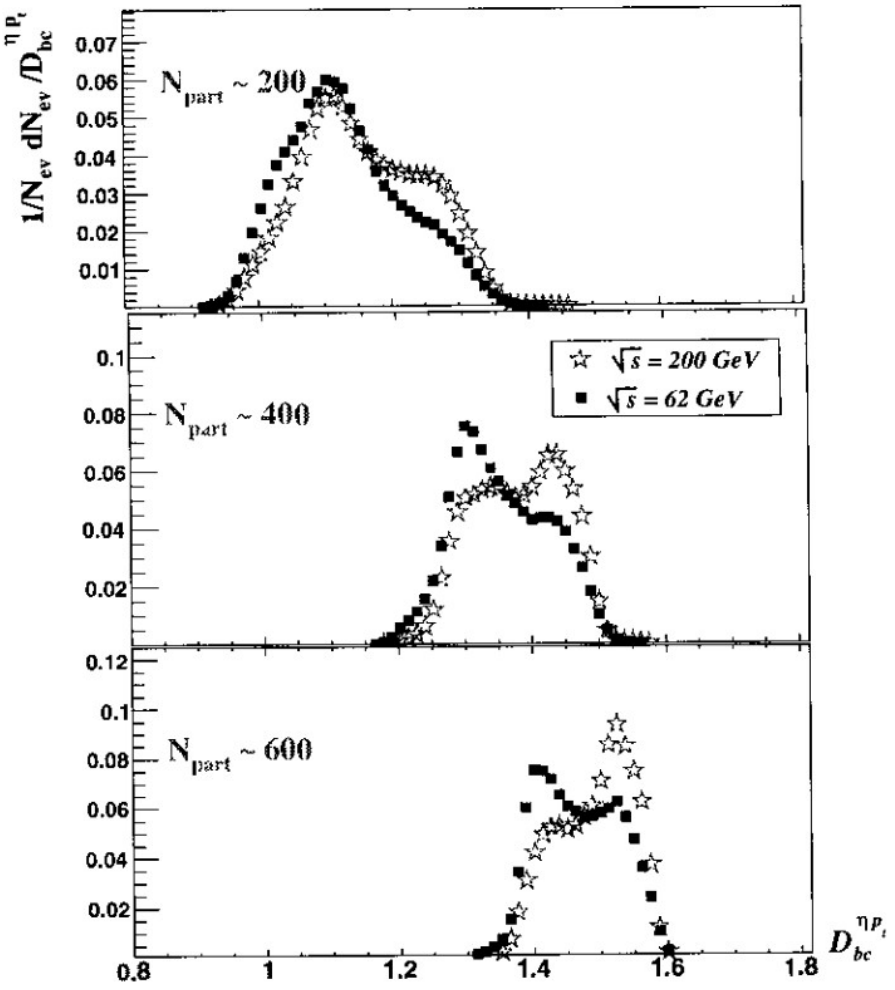


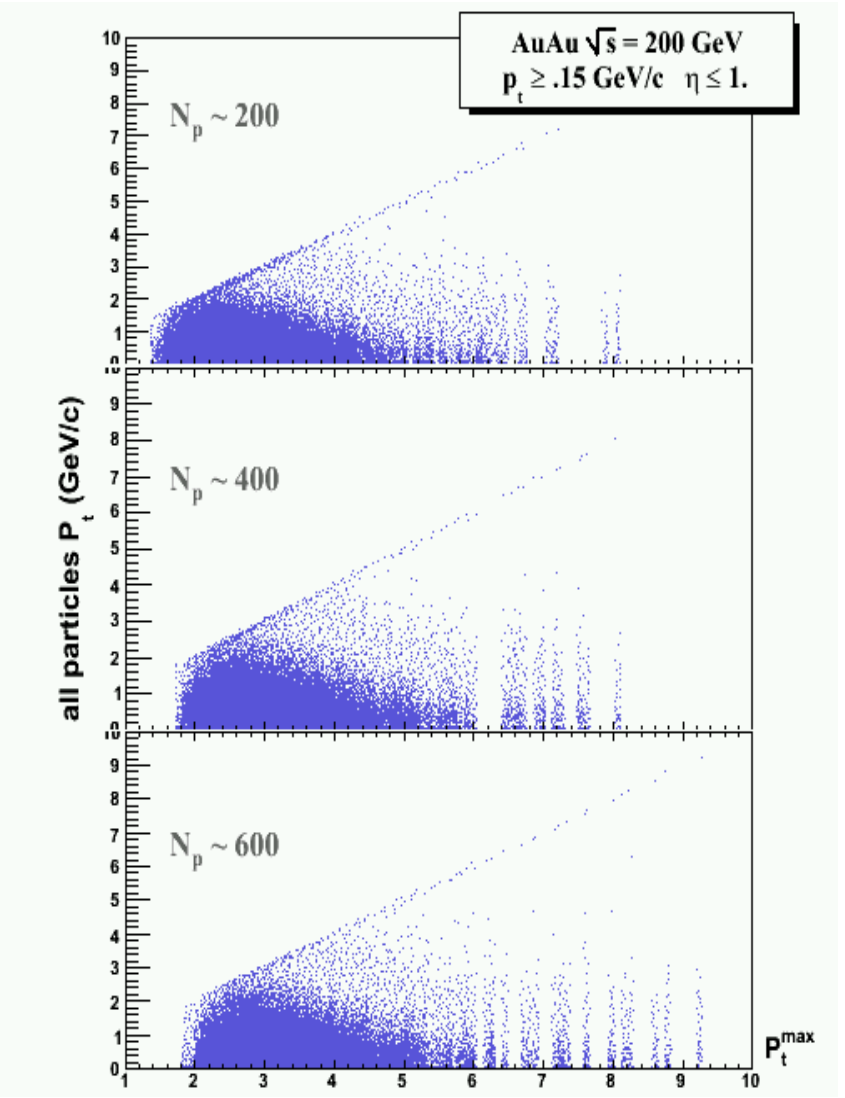
3 GeV/c < p_T^{trig} < 4 GeV/c

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

Universal events structure with p_T^{max}

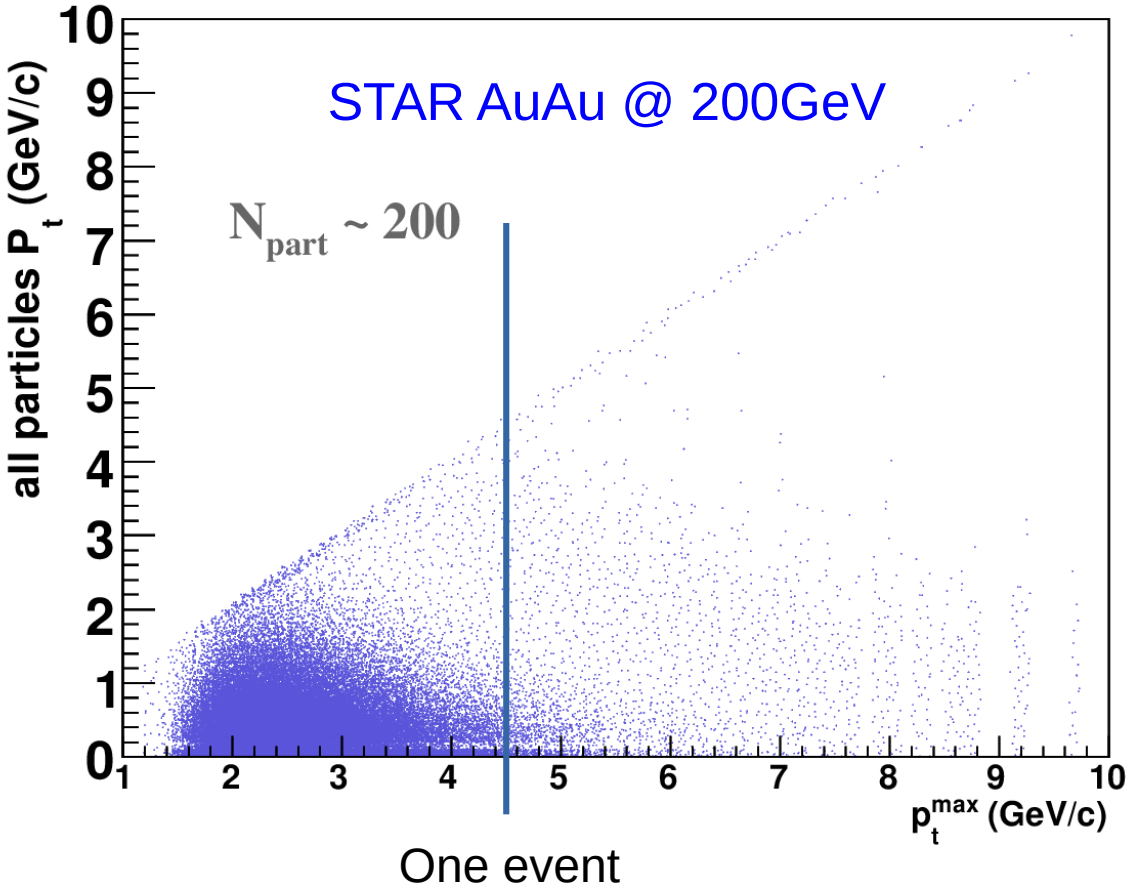
Scale dependent analysis approach for STAR events. R.O. ICHEP 2006 v.2 p.443





Universal events structure with p_T^{max}

~$2 \cdot 10^6$ event



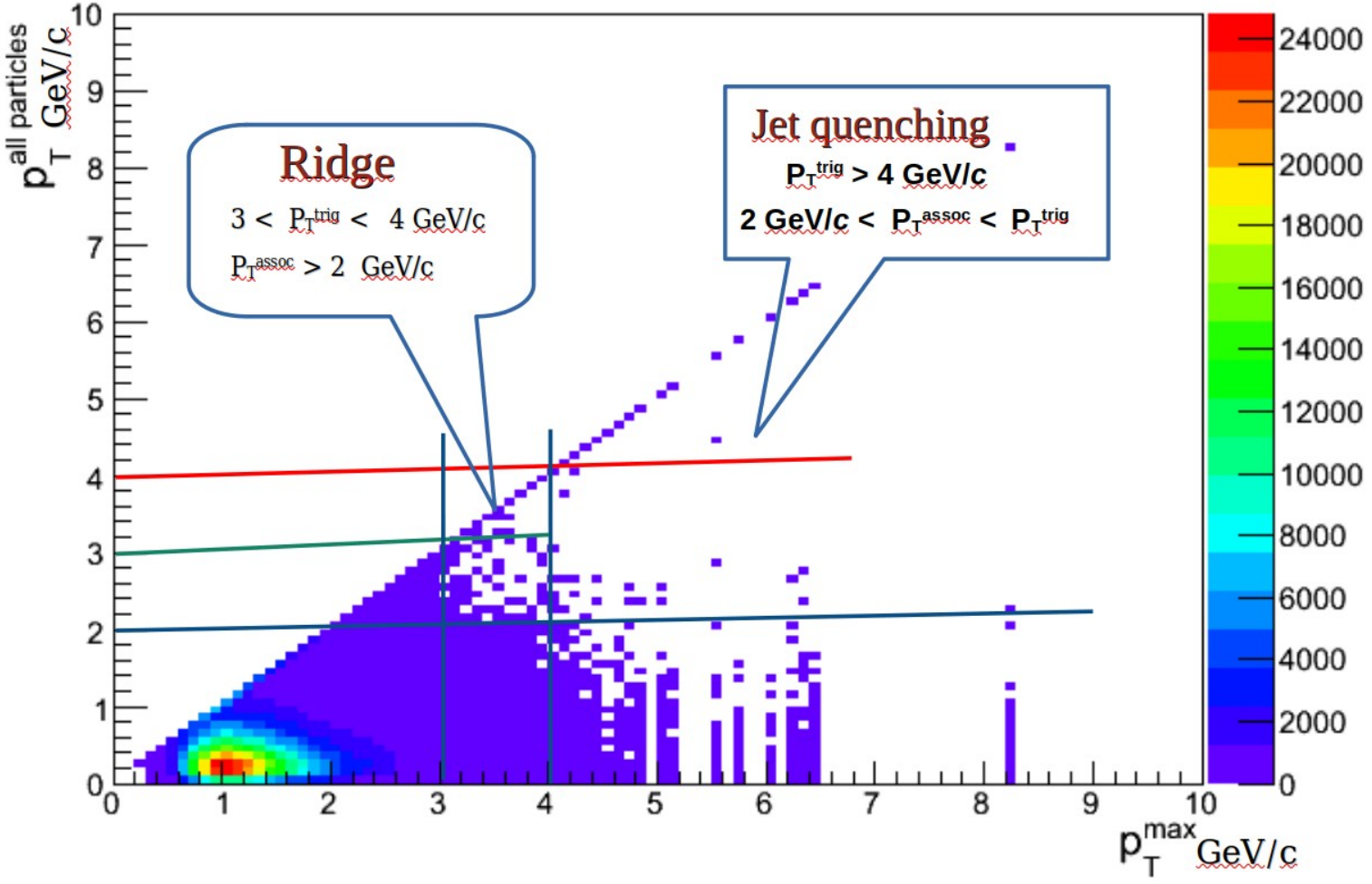
One event

Structure does not depend on:

- Multiplicity
- Collision energy
- Colliding particles
- Produced particles

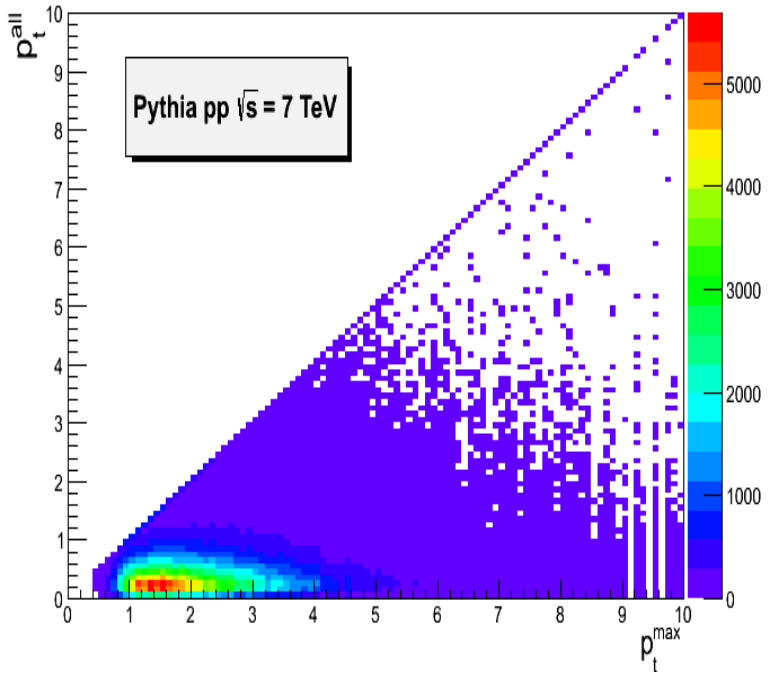
P_t^{max} event distributions

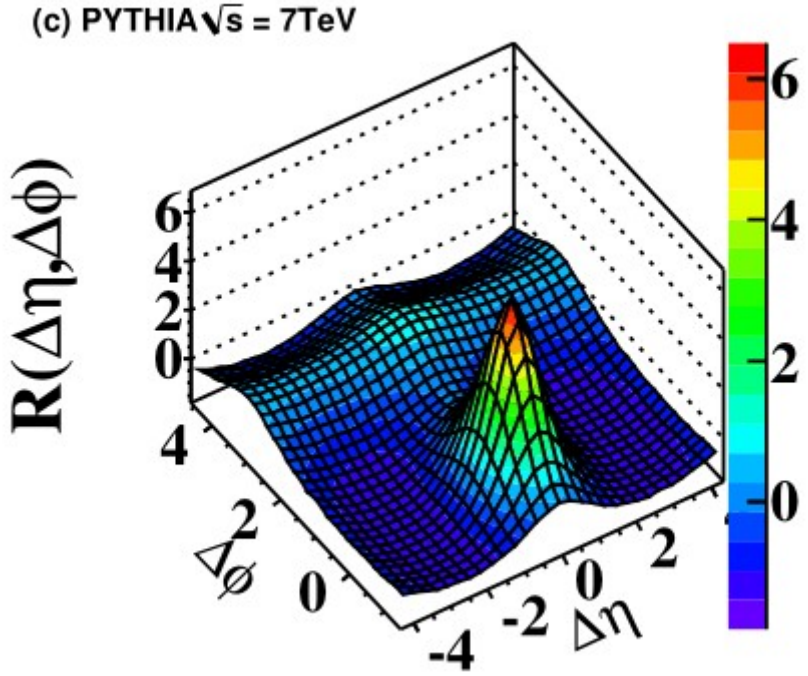
STAR AuAu $\sqrt{s_{NN}}$ =200 GeV



Event structure @ high energy collisions

Pythia pp $\sqrt{s_{NN}}$ = 7 TeV all charged particles



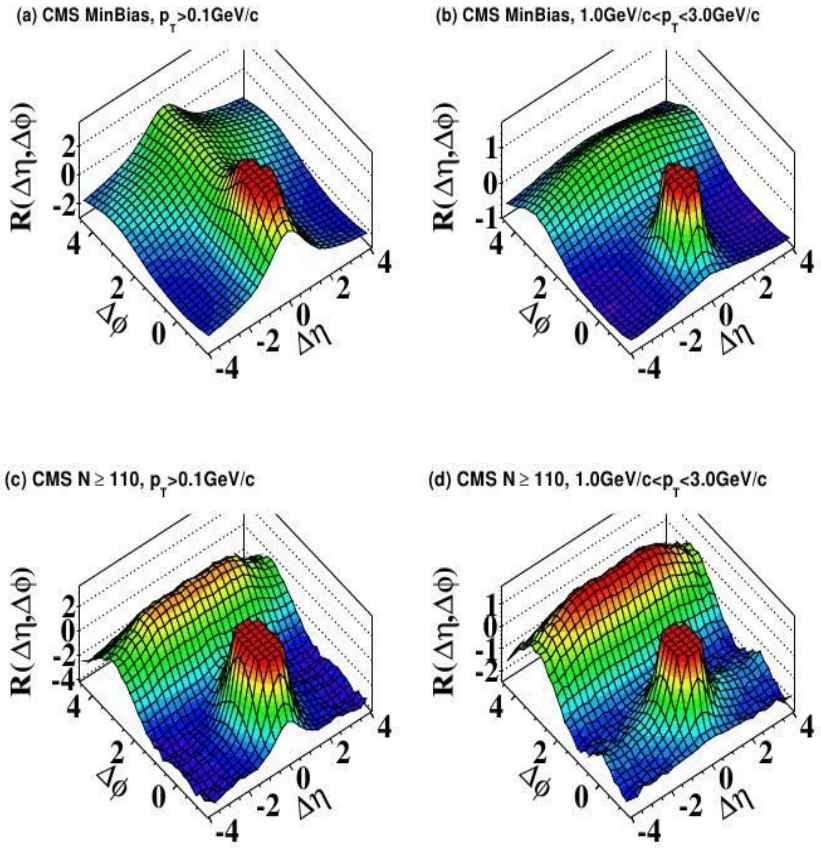


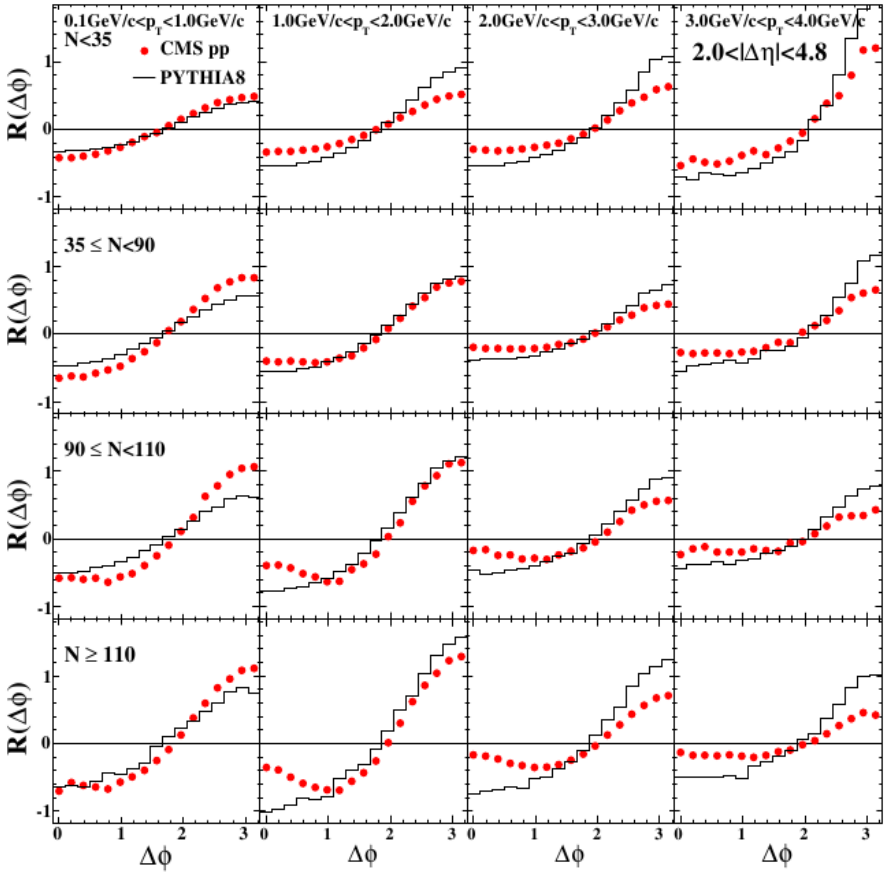
0.1 GeV/c < … < p_T < … < 5. GeV/c

Multiplicity N > 110

CMS vs Pythia

pp @ 7 TeV

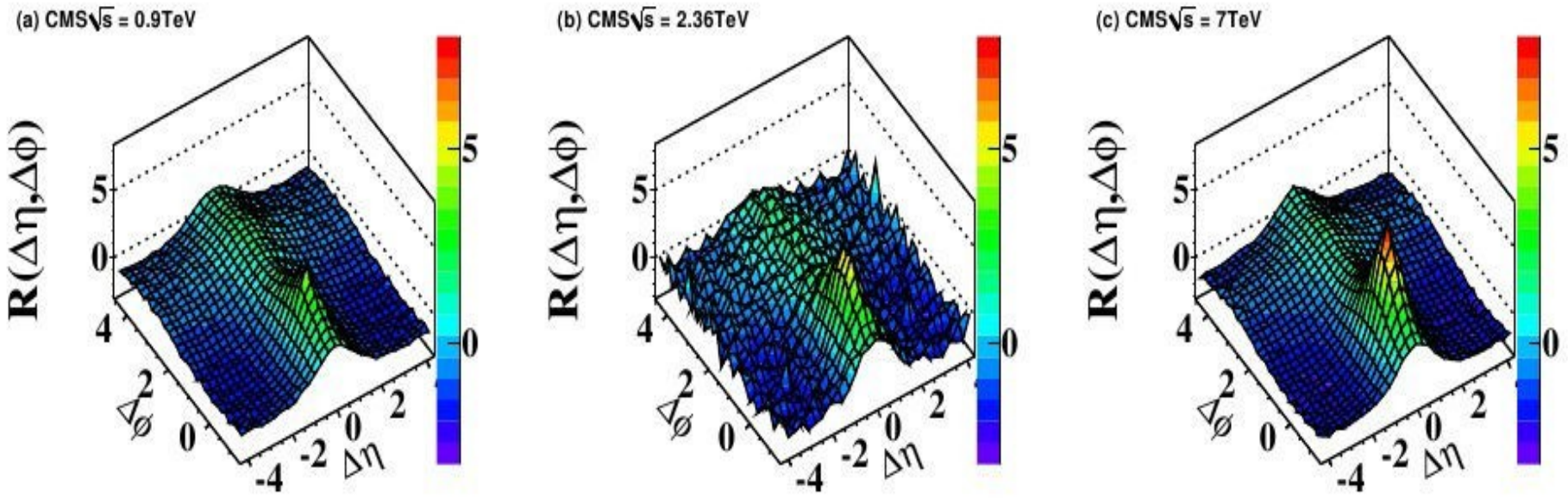




P_T cuts for ridge at LHC

CMS arXiv:1009.4122 2010

Observation of Long-Range, Near-Side Angular Correlations in Proton-Proton Collisions at the LHC



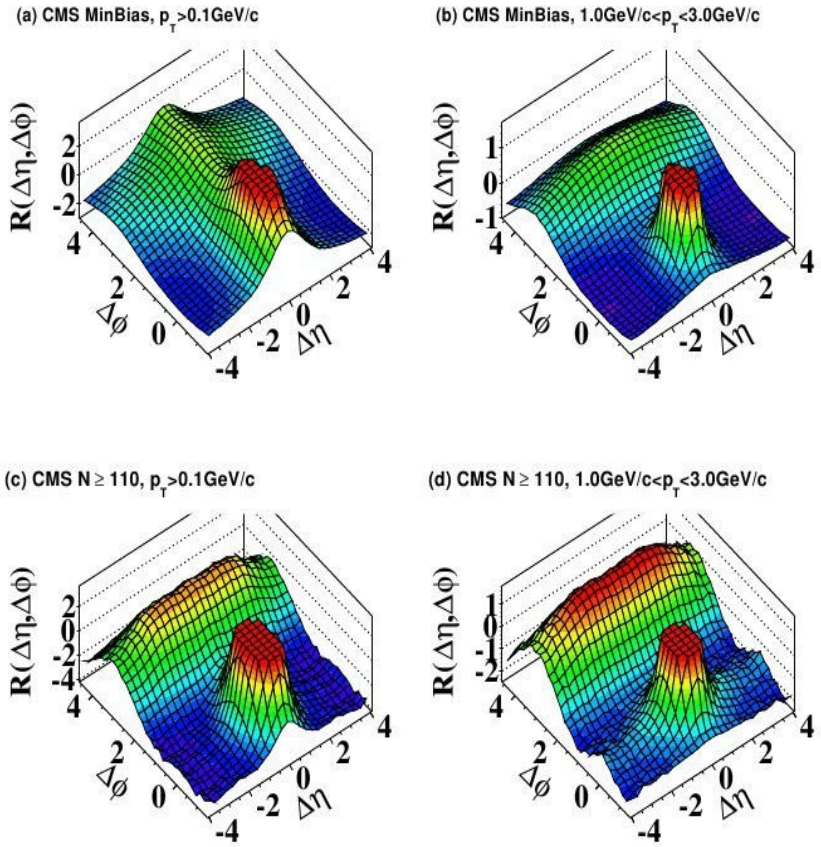
Two-particle correlation functions versus Δη and Δφ in pp collisions

The complex two-dimensional (2-D) correlation structure shown in Fig. 2 is dominated by three prominent components: a narrow peak at (Δη,Δφ)≈(0,0) which can be understood as the contribution from higher p_T clusters (e.g., hard processes like jets); a ridge at Δφ ≈ π spread over a broad range in Δη, interpreted as due to away-side jets or more generally momentum conservation; and an approximately Gaussian ridge at Δη ≈0 extending over the whole range of Δφ, becoming broader toward larger Δφ values, which arises from the decay of clusters with lower p_T (e.g., soft QCD string fragmentation).

CMS ridge

pp @ 7 TeV

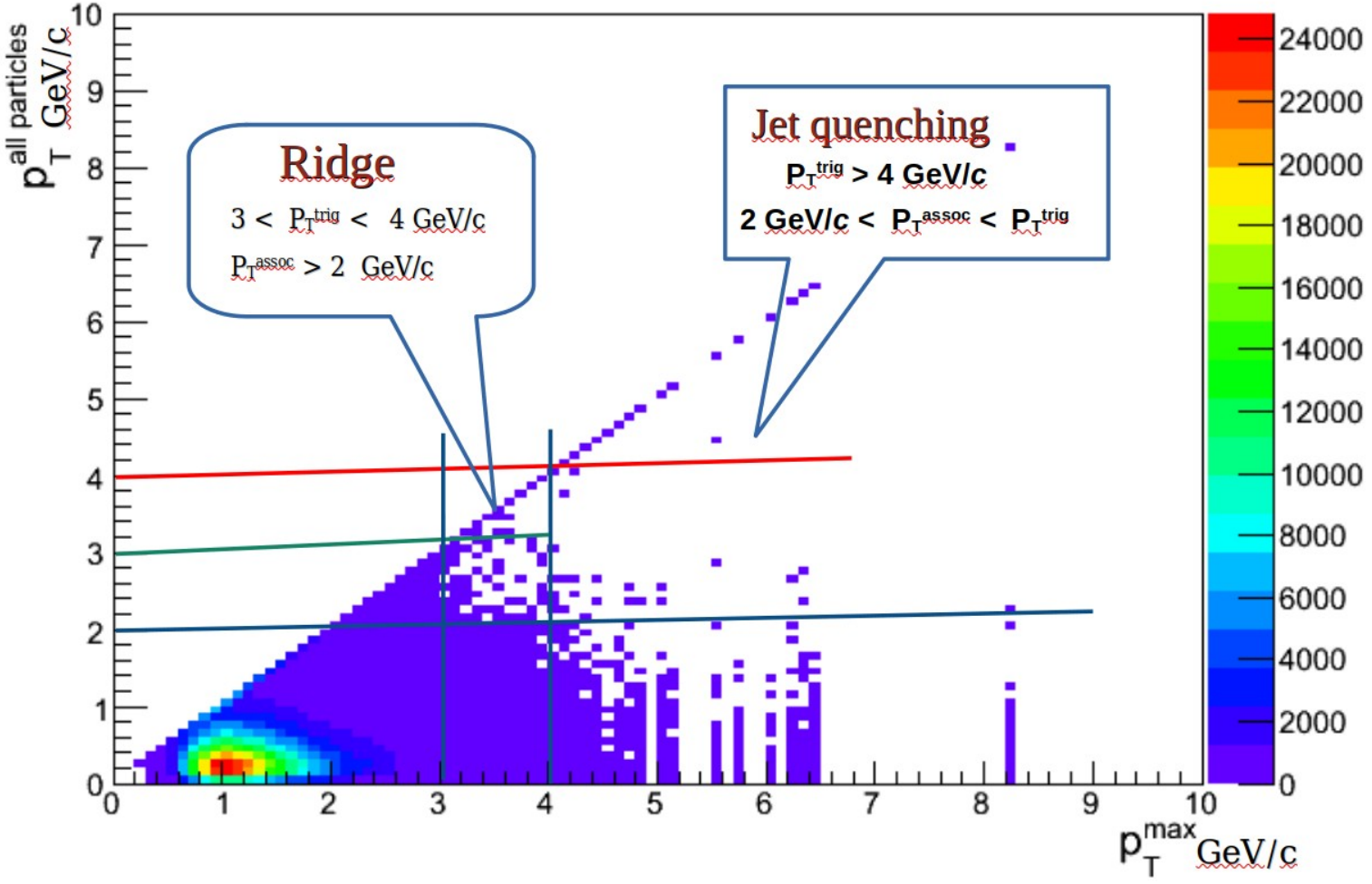
CMS arXiv:1009.4122 2010



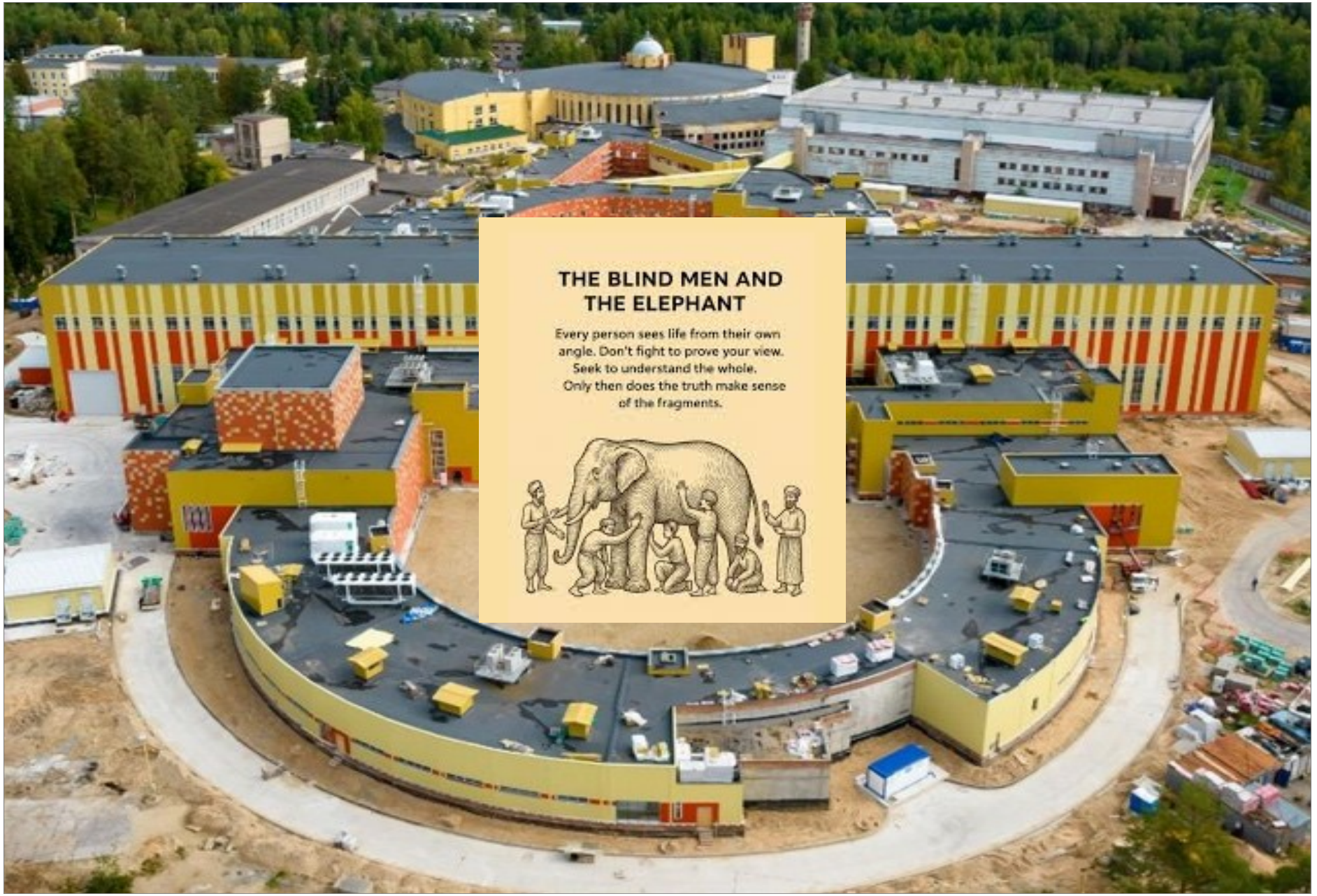
Moving to the intermediate p_T range in high multiplicity events shown in Fig. (d), an unexpected effect is observed in the data. A clear and significant "ridge"-like structure emerges at $\Delta\varphi \approx 0$ extending to $|\Delta\eta|$ of at least 4 units. This is a novel feature of the data which has never been seen in two-particle correlation functions in pp or $p\bar{p}$ collisions. Simulations using MC models do not predict such an effect

P_t^{max} event distributions

STAR AuAu $\sqrt{s_{NN}}$ =200 GeV



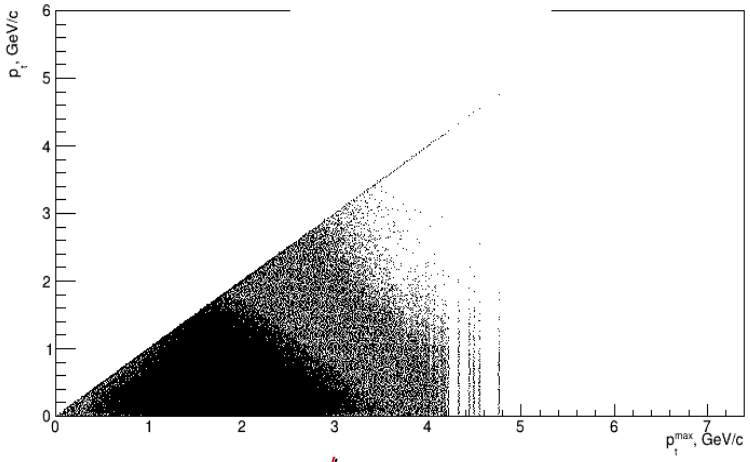
Thanks for your attention



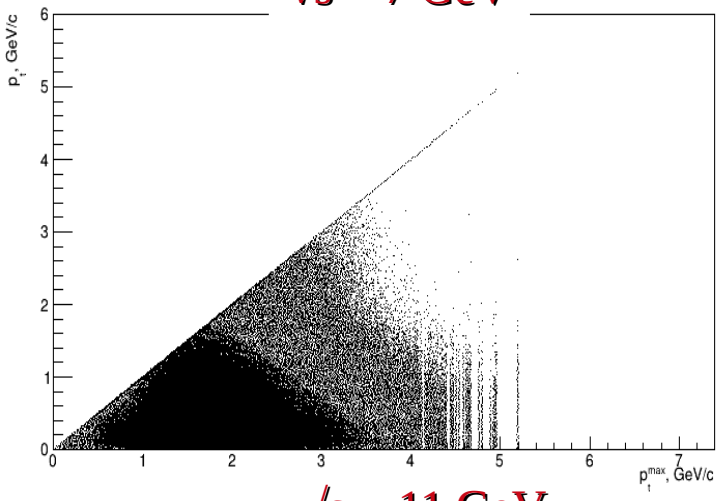
Events structure for NICA energies

UrQMD

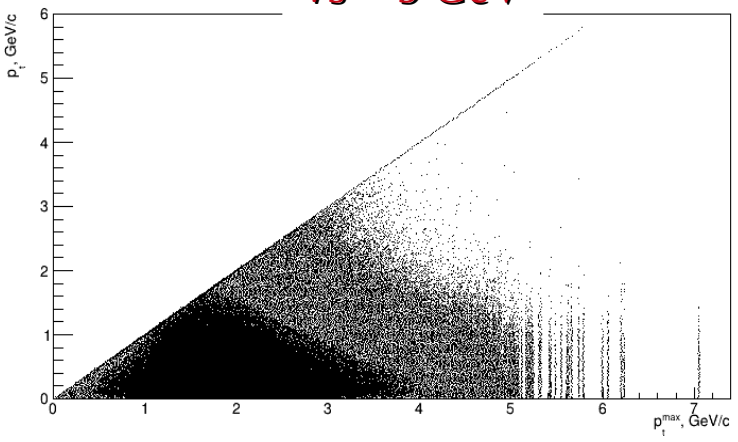
√s = 4 GeV



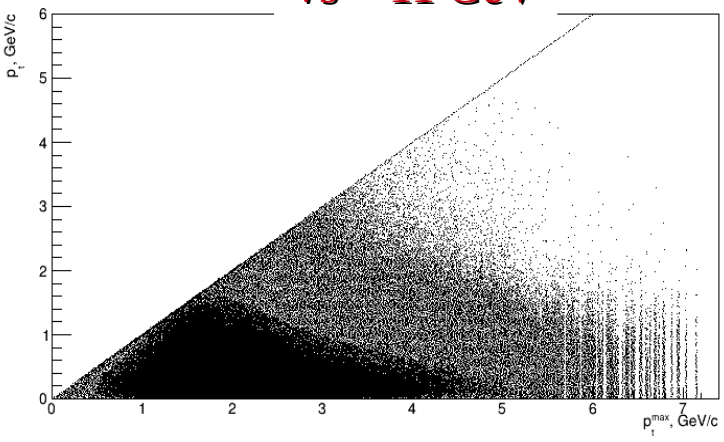
√s = 7 GeV



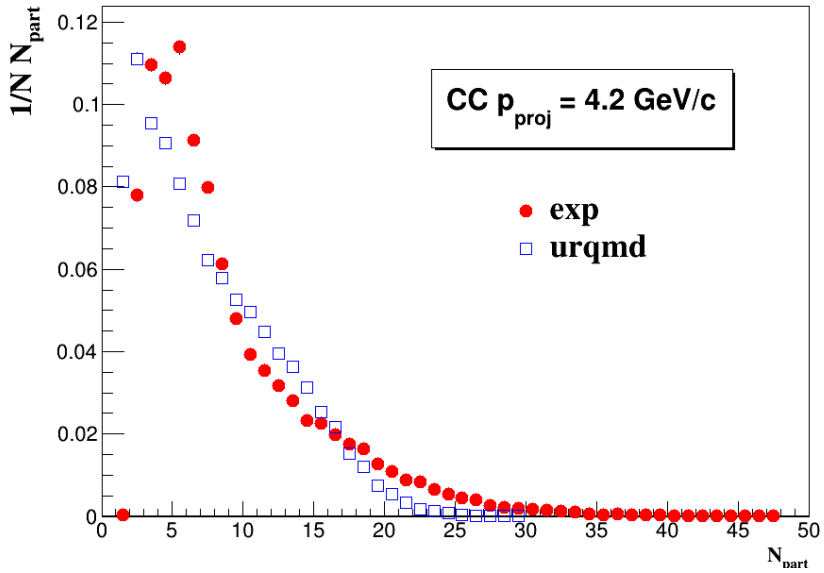
√s = 9 GeV

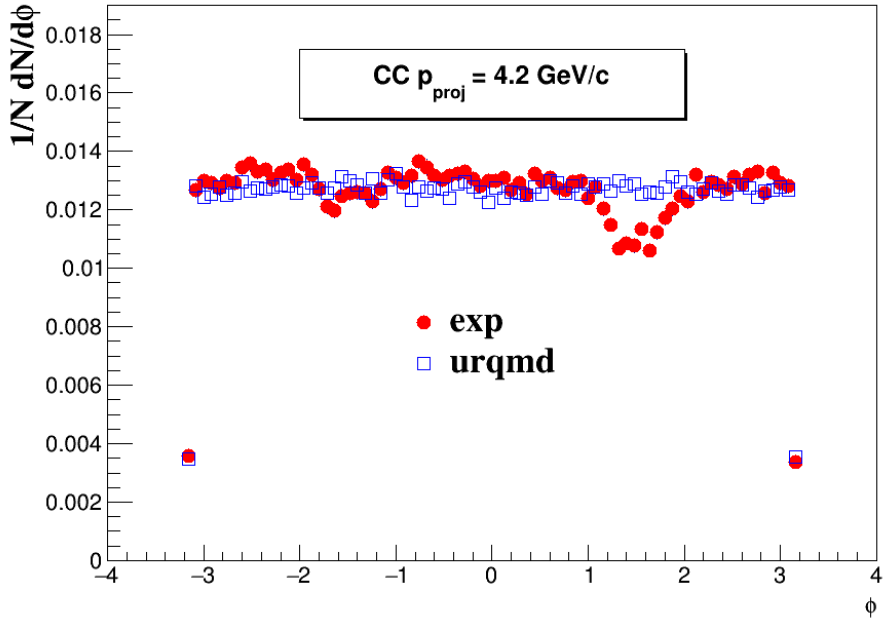


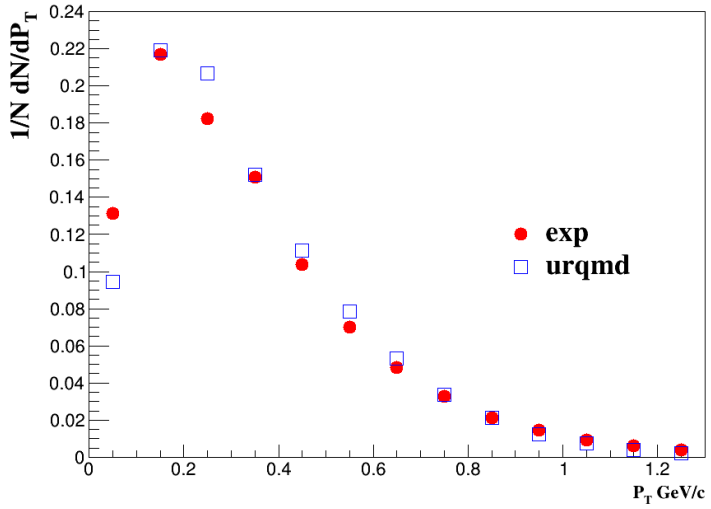
√s = 11 GeV



CC exp. vs UrQMD

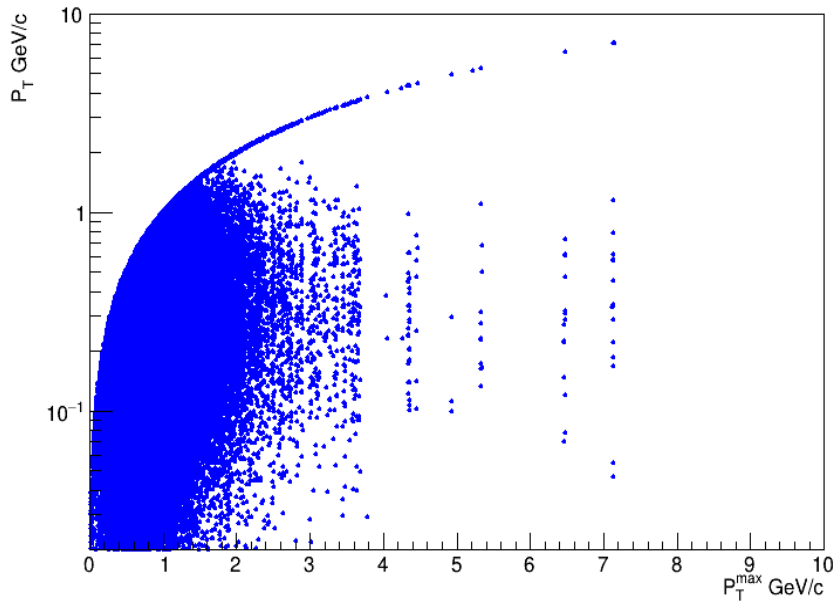




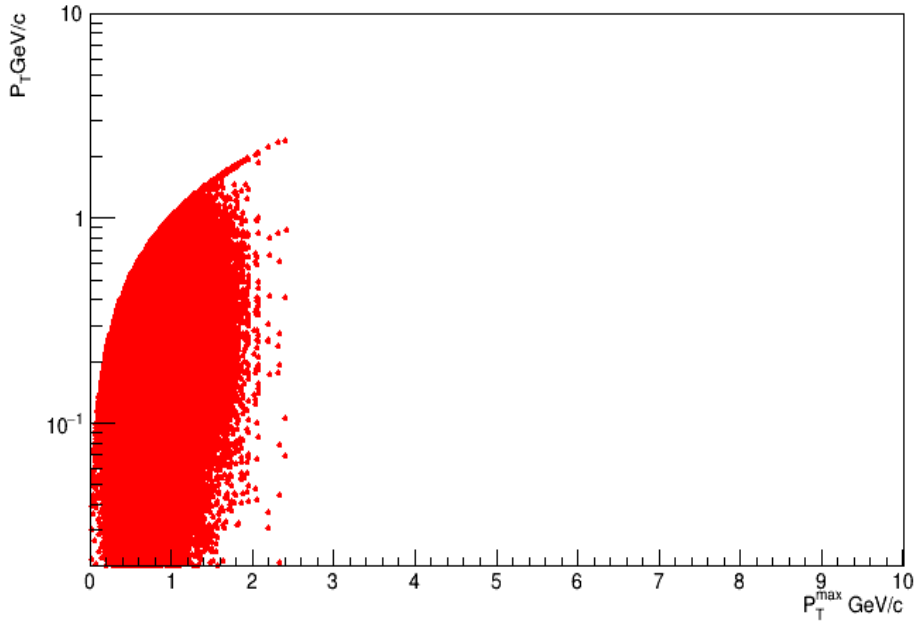


CC @ 4.2 GeV/c

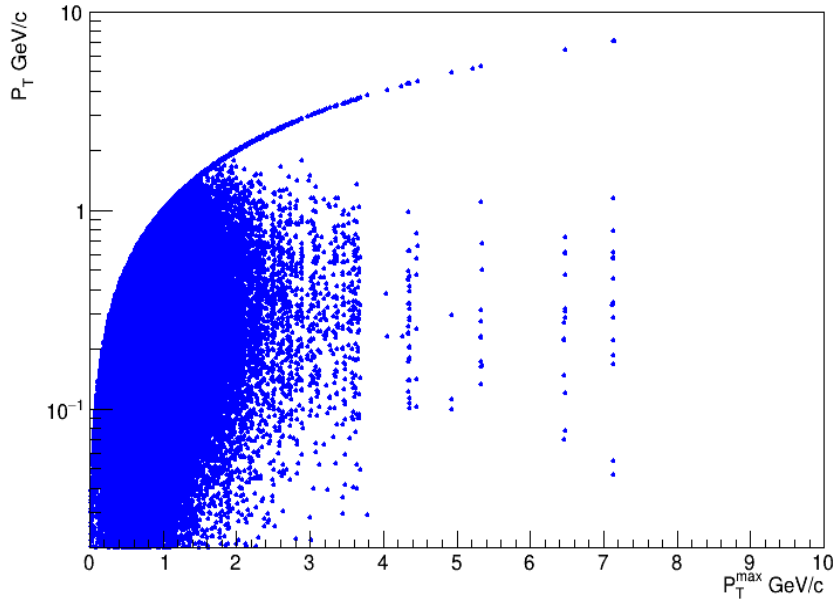
2-m propan bubble chamber

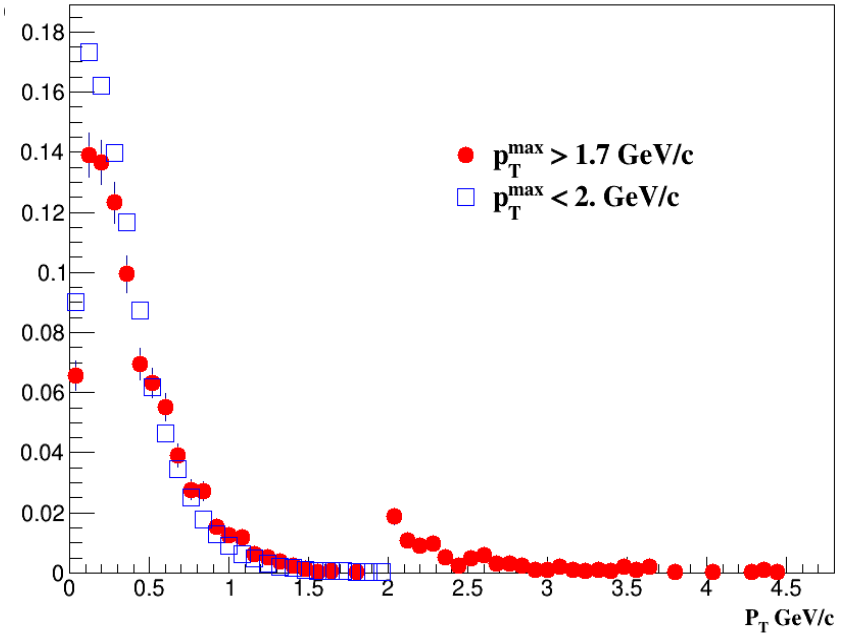


UrQMD

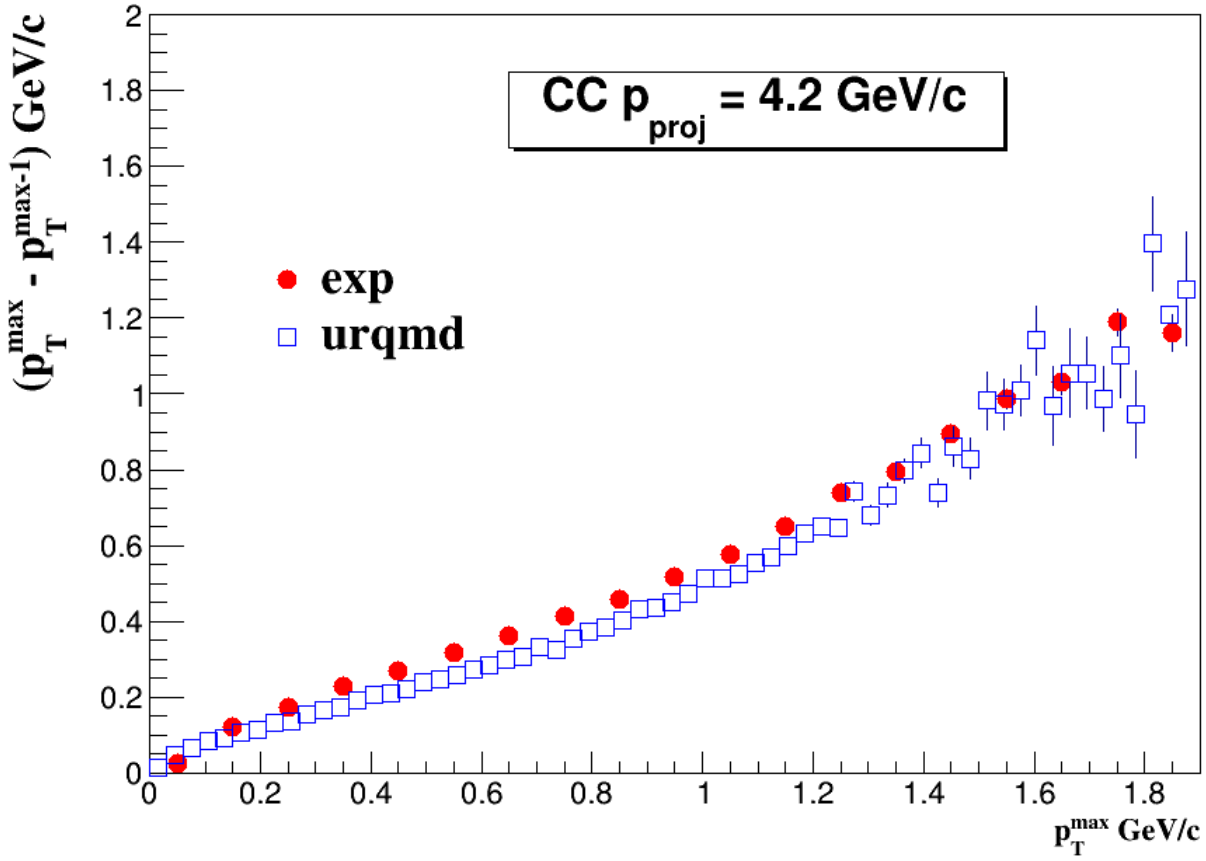


Jet & flow events

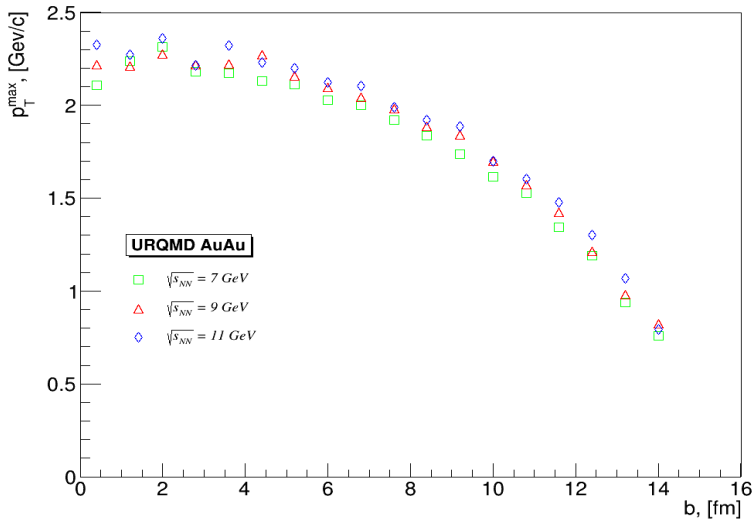


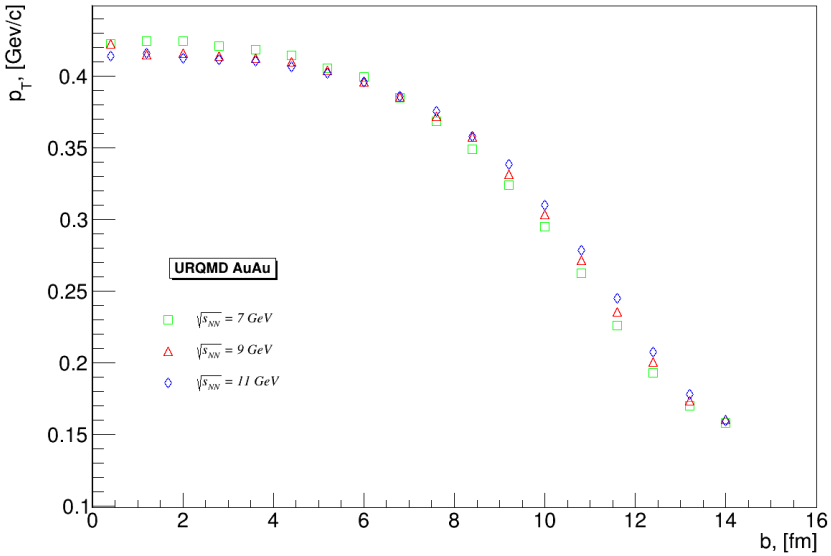


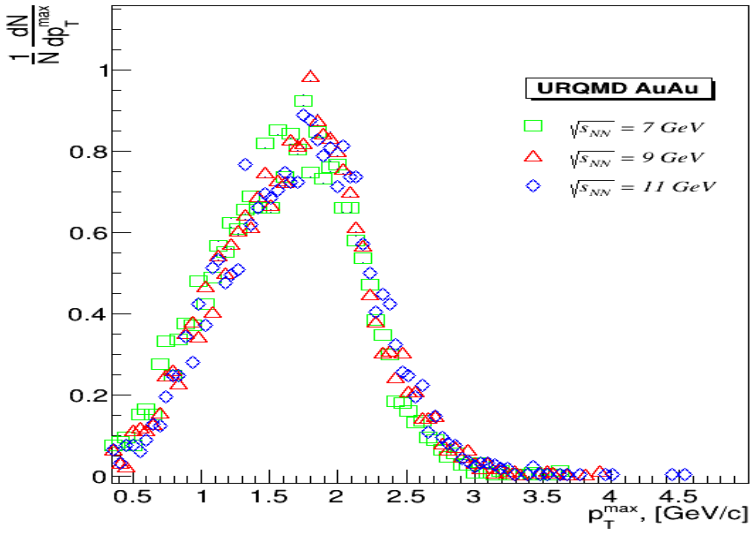
How the gap in p_T increases

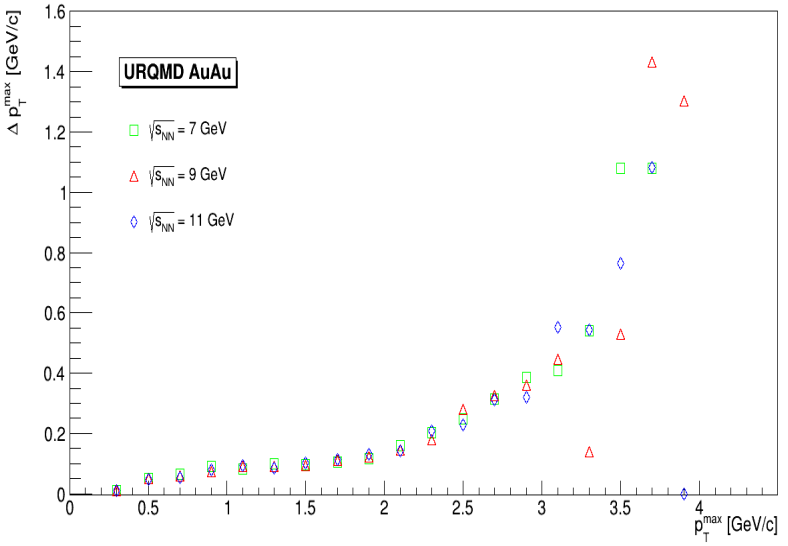


Centrality dependence (UrQMD)

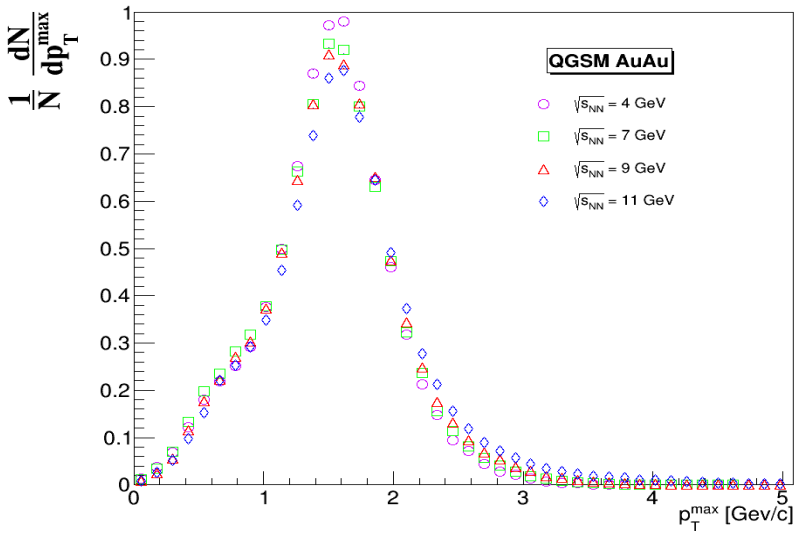


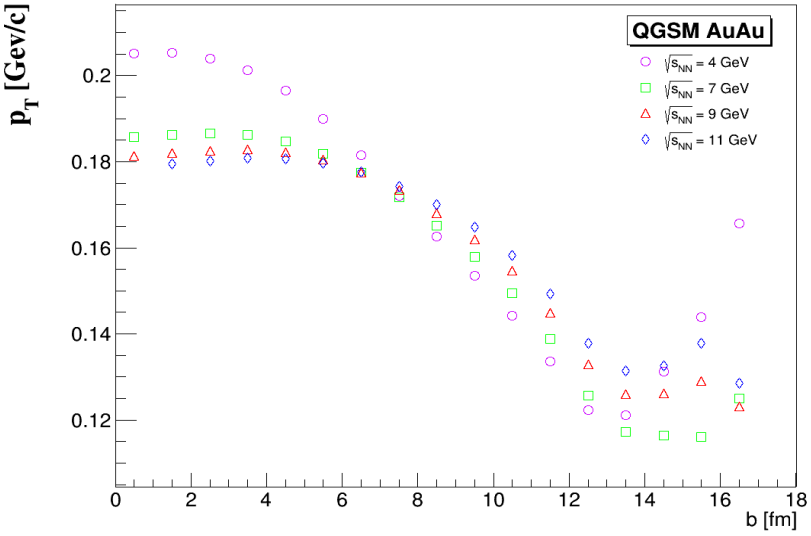


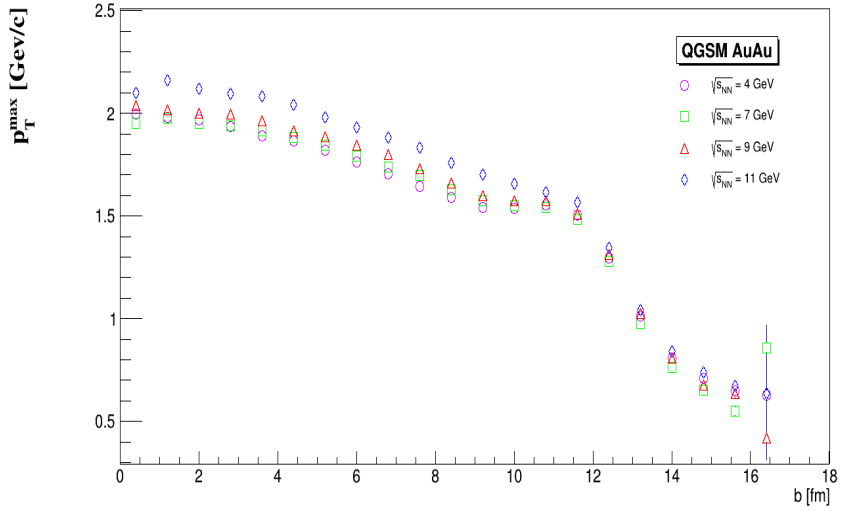


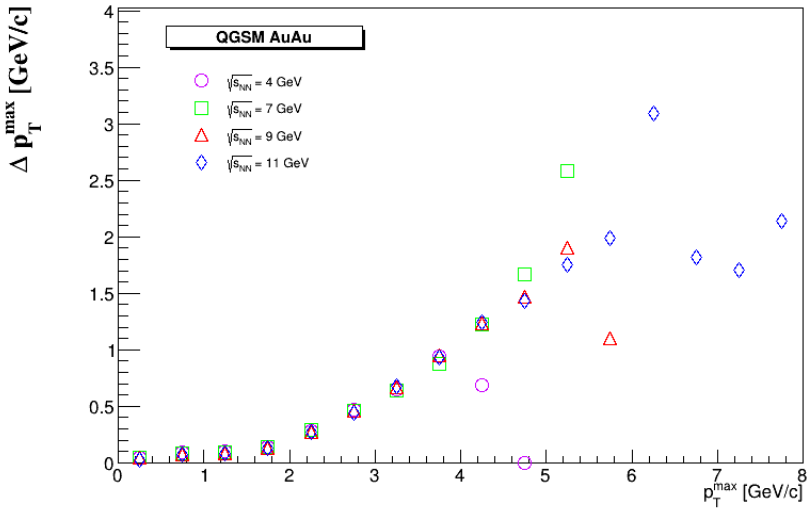


NICA energies: QGSM









NICA energies

QGSM

UrQMD

