Latest RHIC results

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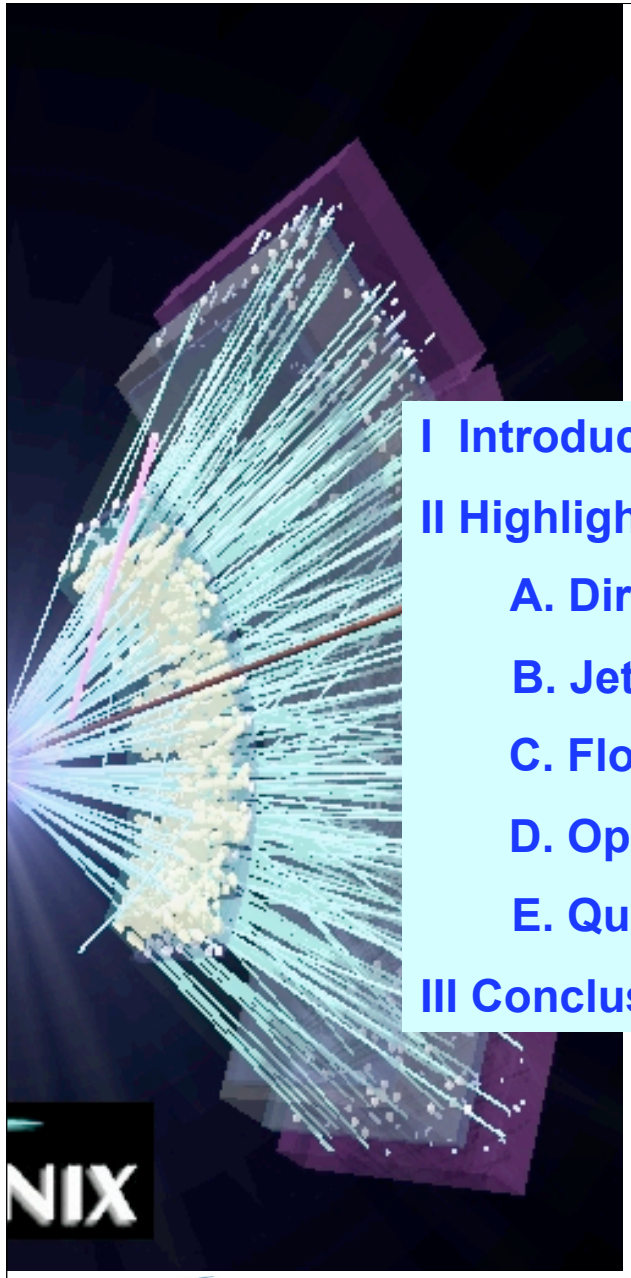
Rencontres QGP-France, 25-27 September 2012, Etretat, France



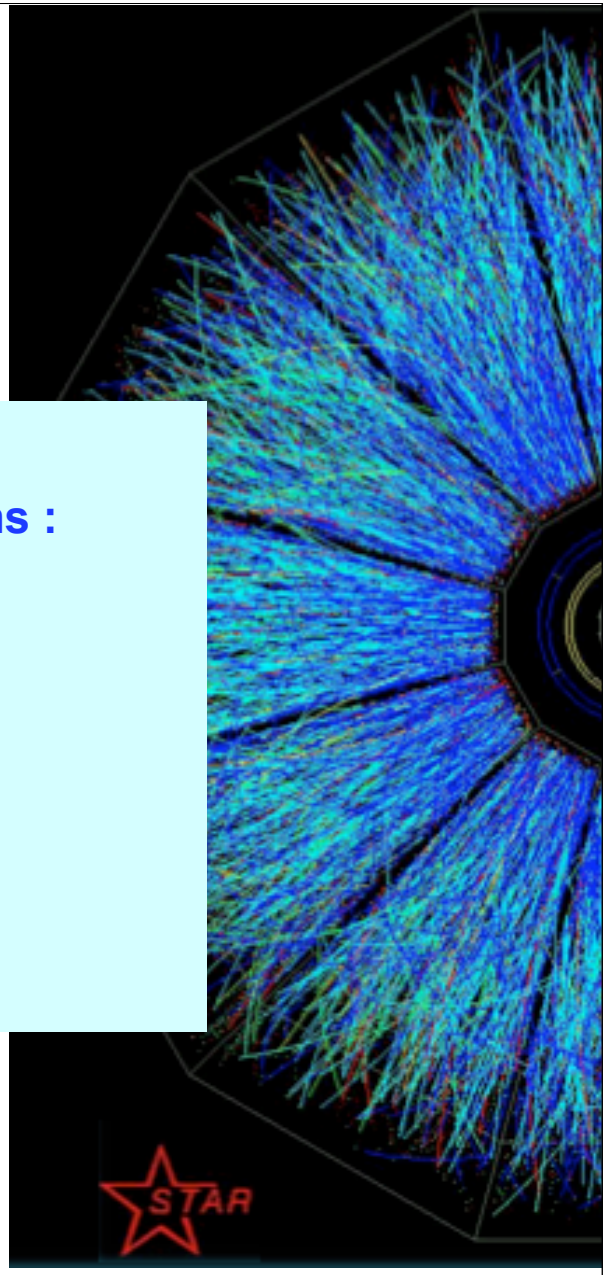
Outline

I Introduction

II Highlights on selected physics items :

- A. Direct photons
- B. Jet quenching
- C. Flow
- D. Open heavy flavour
- E. Quarkonia

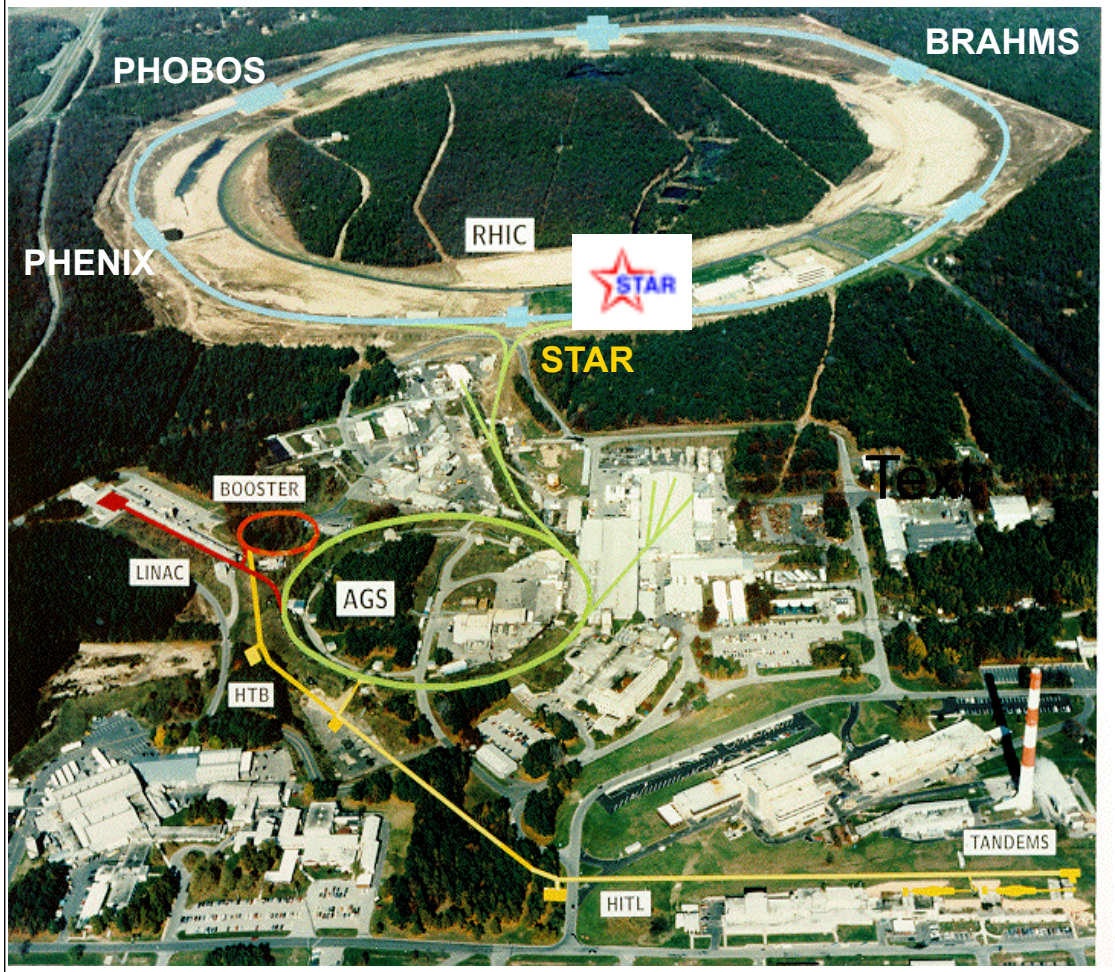
III Conclusions and Outlook



I Introduction

Relativistic Heavy Ion Collider

RHIC site in BNL on Long Island, USA



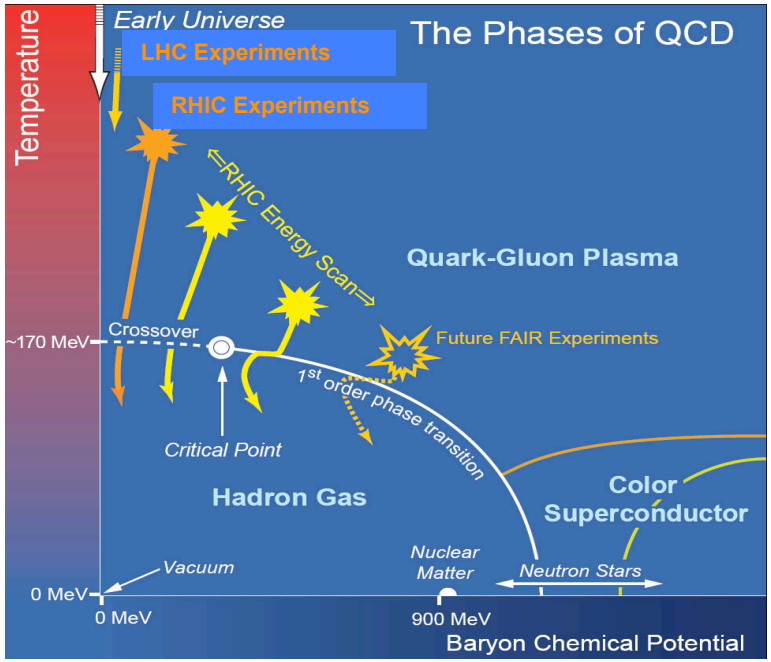
RHIC has been exploring nuclear matter at extreme conditions over the last decade 2000-2011

4 experiments:
STAR PHENIX
BRAHMS PHOBOS

Colliding systems:
p↑+p↑, d+Au, Cu+Cu, Au+Au
Energies A+A :
$\sqrt{s_{NN}}$ = 62, 130, 200 GeV
and low energy scan
7.7, 11.5, 19.6, 22.4, 27, 39 GeV

News from RHIC:
U+U, Cu+Au and higher luminosity (2012)

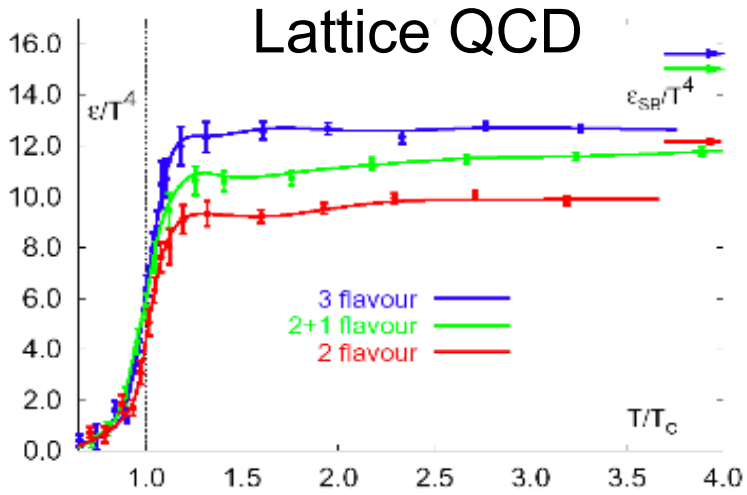
Physics goals: Mapping out the phases of QCD



Experimental program of Heavy Ion Collisions of last ~25 years aims to :

Study QCD matter under extreme conditions of densities and Temperatures

Reproduce a phase transition of the early universe at 10^{-6} sec after the Big Bang, between hadrons and quarks and gluons (Quark-Gluon-Plasma)



This plot illustrates propositions and is not proven by measurement.

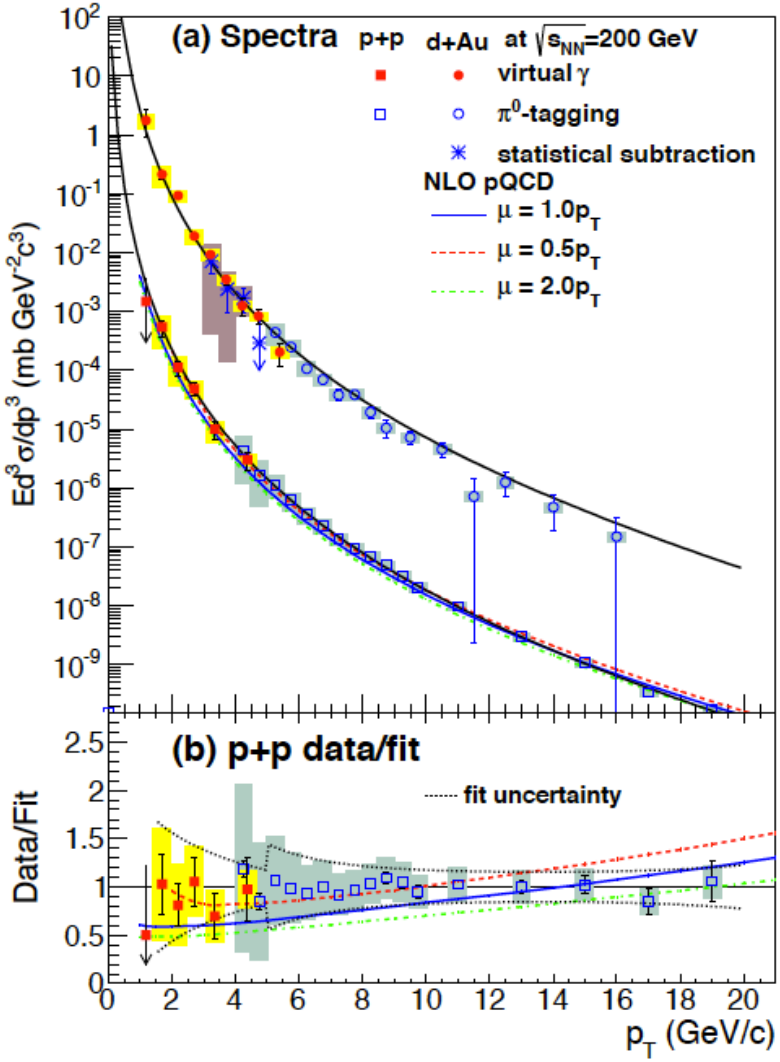
QCD on the lattice predicts a cross over at zero net baryon density and T(characteristic) of ~160-180 MeV energy density ~0.6-1GeV/fm^3

An energy scan from below Tc up to well above Tc can reveal the nature of the phase diagram of QCD

II Highlights on selected physics items :

A. Direct photons

Direct photons in d+Au from PHENIX

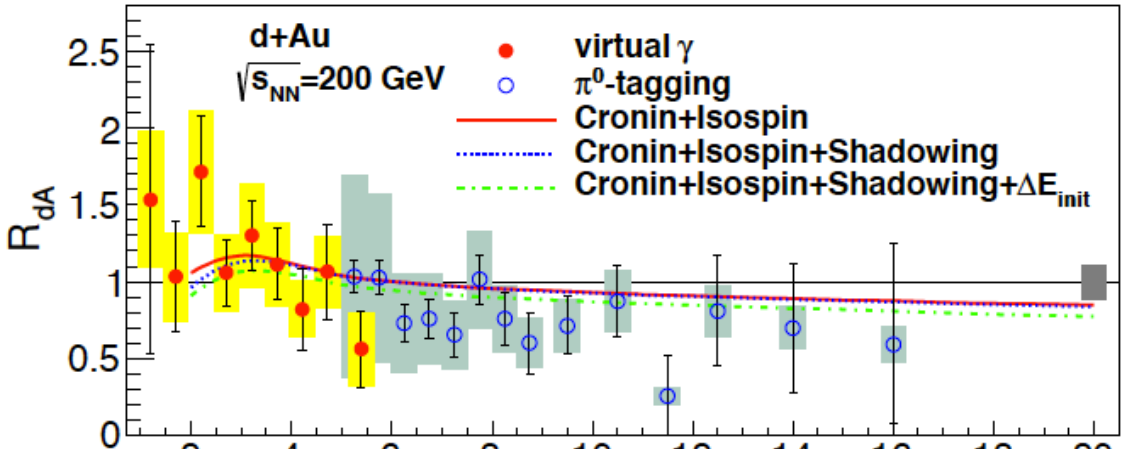


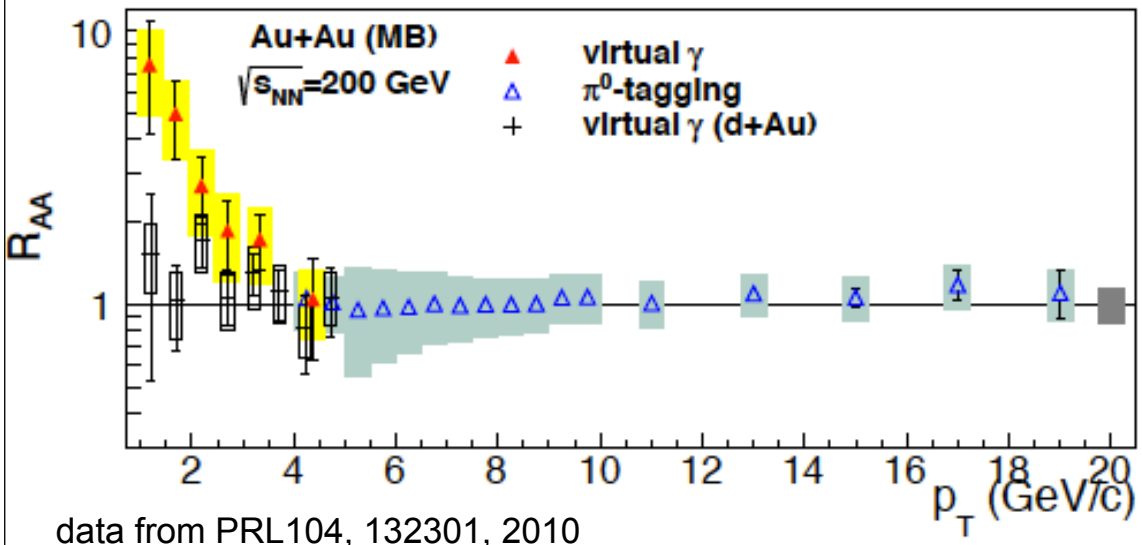
PHENIX 1208.1234

- Agreement between 3 different methods to extract the direct photons in dAu

- Higher statistics for direct photons in p+p

Direct photons in d+Au from PHENIX





data from PRL104, 132301, 2010

PHENIX 1208.1234

- RdAu direct photons pT=1-16 GeV consistent with unity

- Standard cold-nuclear-matter effects describe the RdAu data at all pts

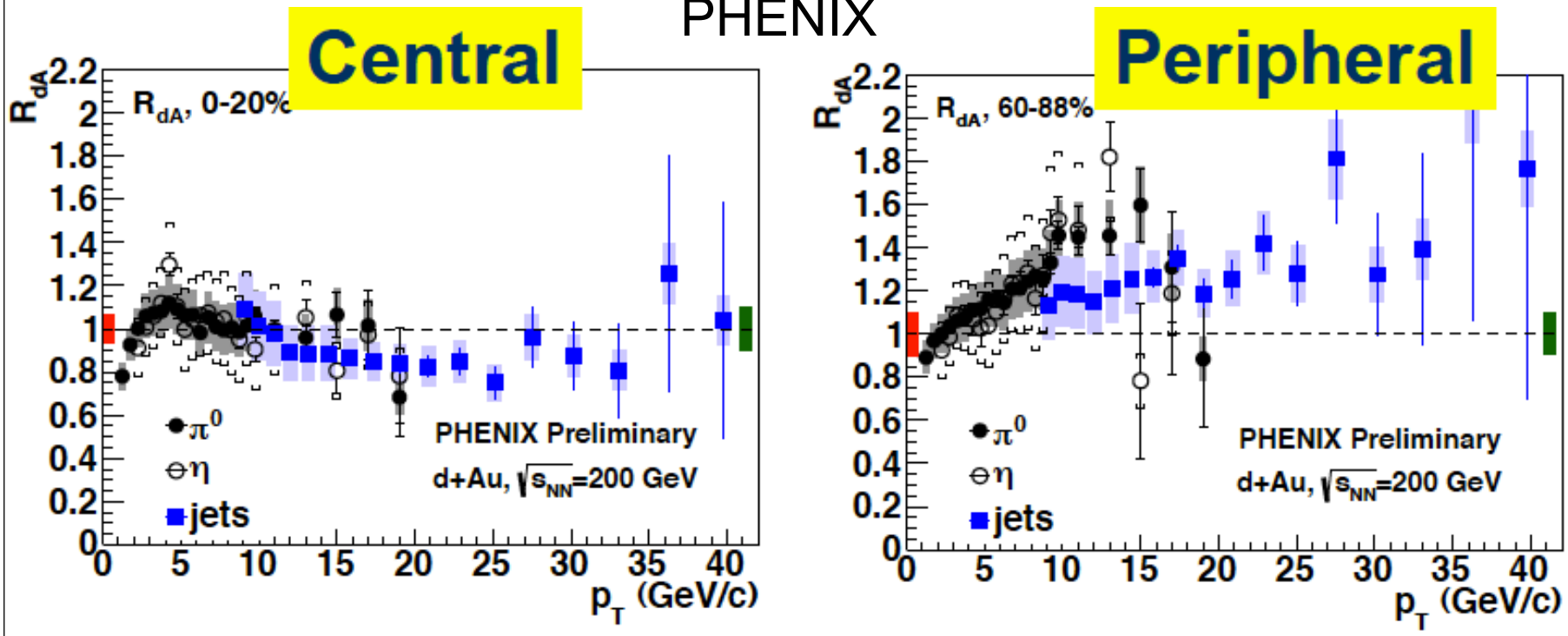
- RAuAu consistent with unity at high pt, while it shows large enhancement below pt=2 GeV compared to d+Au

- dAu data indicate that the RAuAu enhancement is due to a source other than the initial state nuclear effects.

B. Jet quenching

Jet reconstruction in d+Au 200 GeV

PHENIX



M Wysocki, B Sahlmueller,PHENIX, QM2012

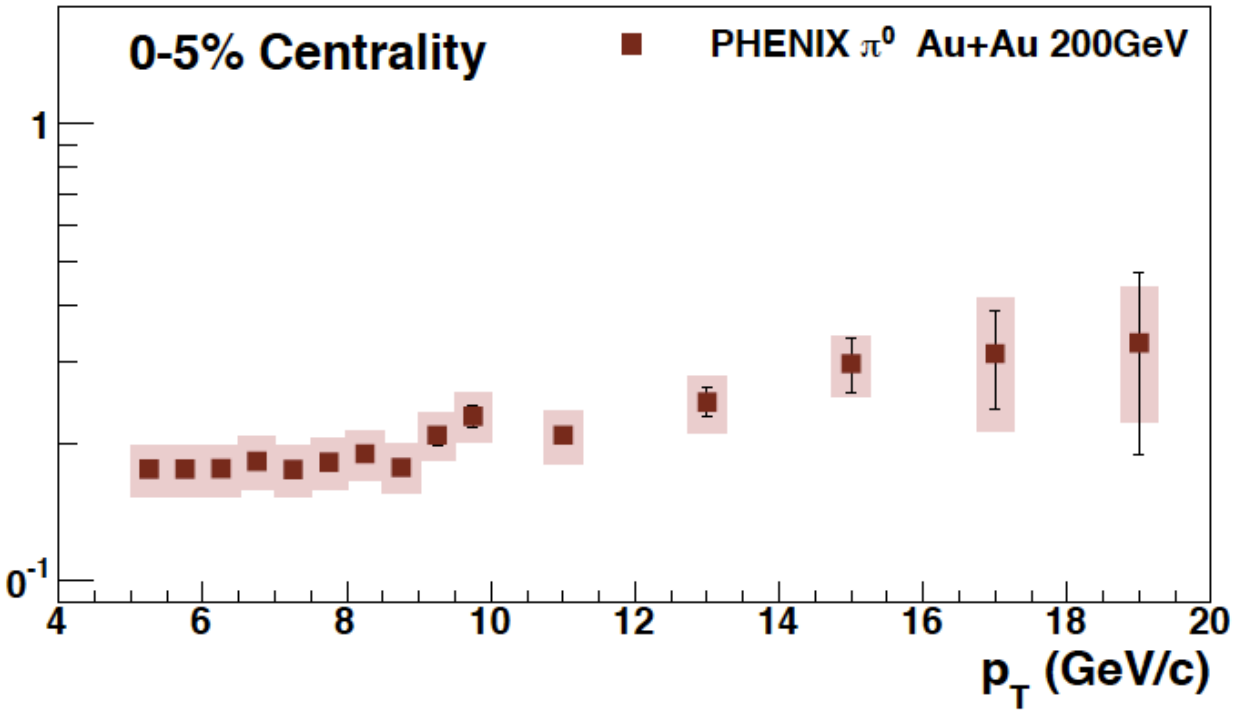
Jets are reconstructed at midrapidity in d+Au up to pT=40 GeV

RdAu increases for more peripheral collisions at high pT

RAA of pi0 in Au+Au 200 GeV

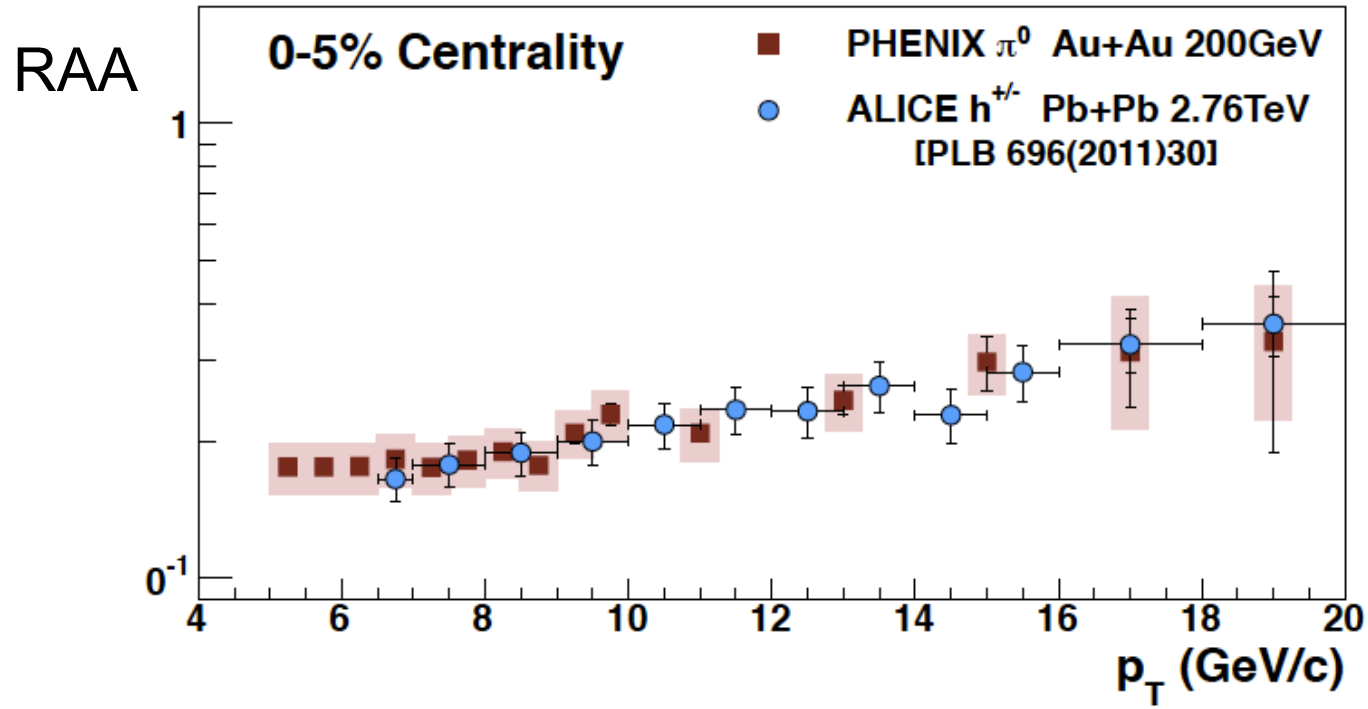
Sakaguchi, PHENIX, QM2012

RAA



RAA of pi0 in Au+Au 200 GeV compared to ALICE

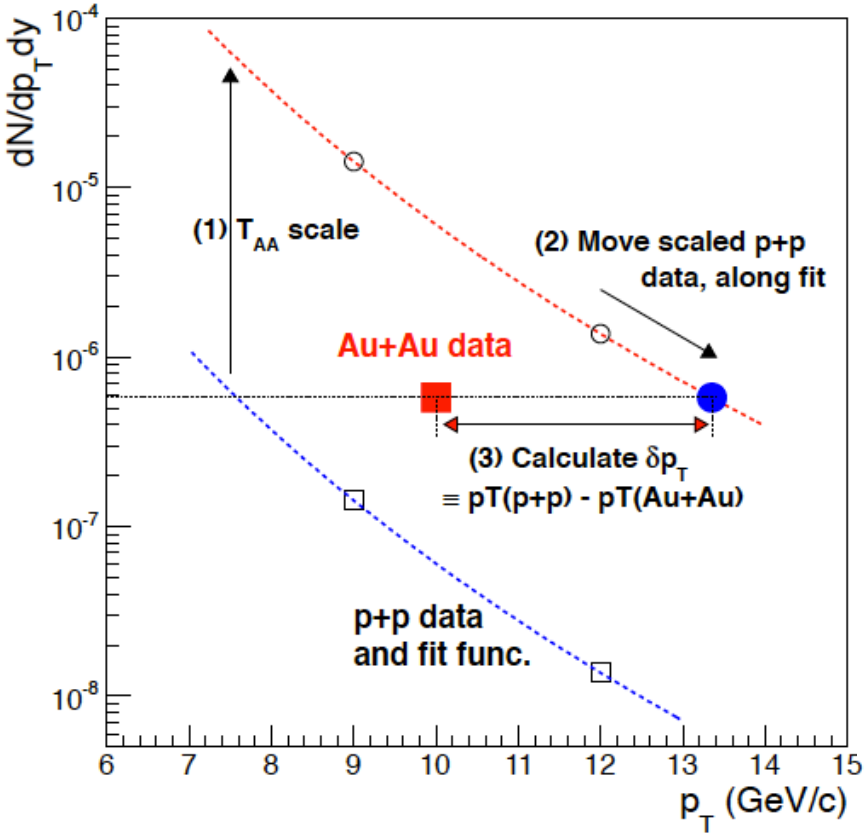
Sakaguchi, PHENIX, QM2012



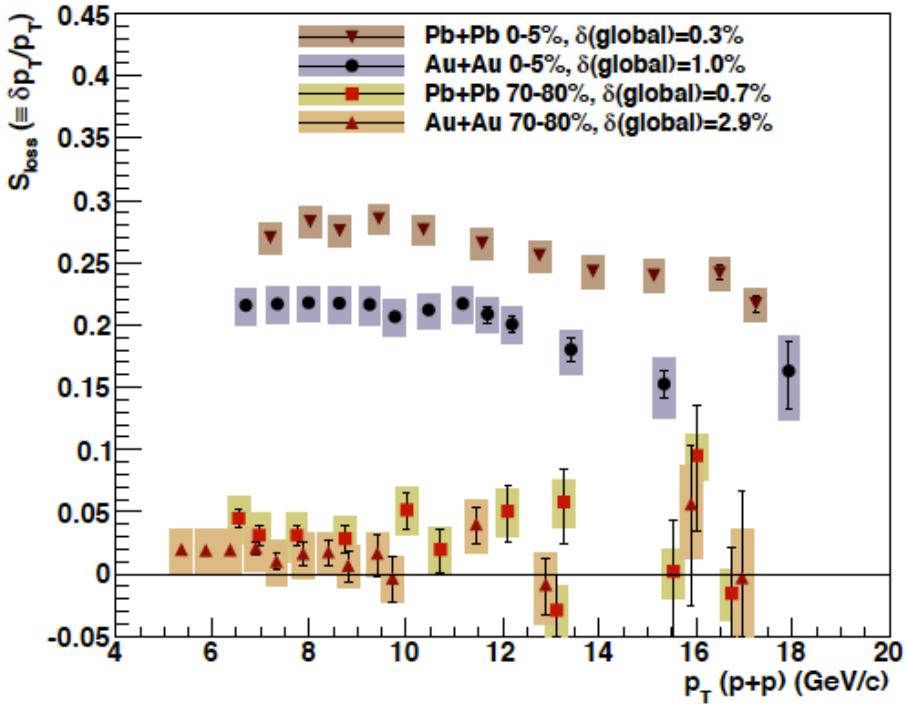
PHENIX pi0 in Au+Au 200 GeV and charged hadrons in Pb+Pb 2.76 TeV 0-5% look very similar

Fractional momentum loss from PHENIX

arXiv:1208.2254

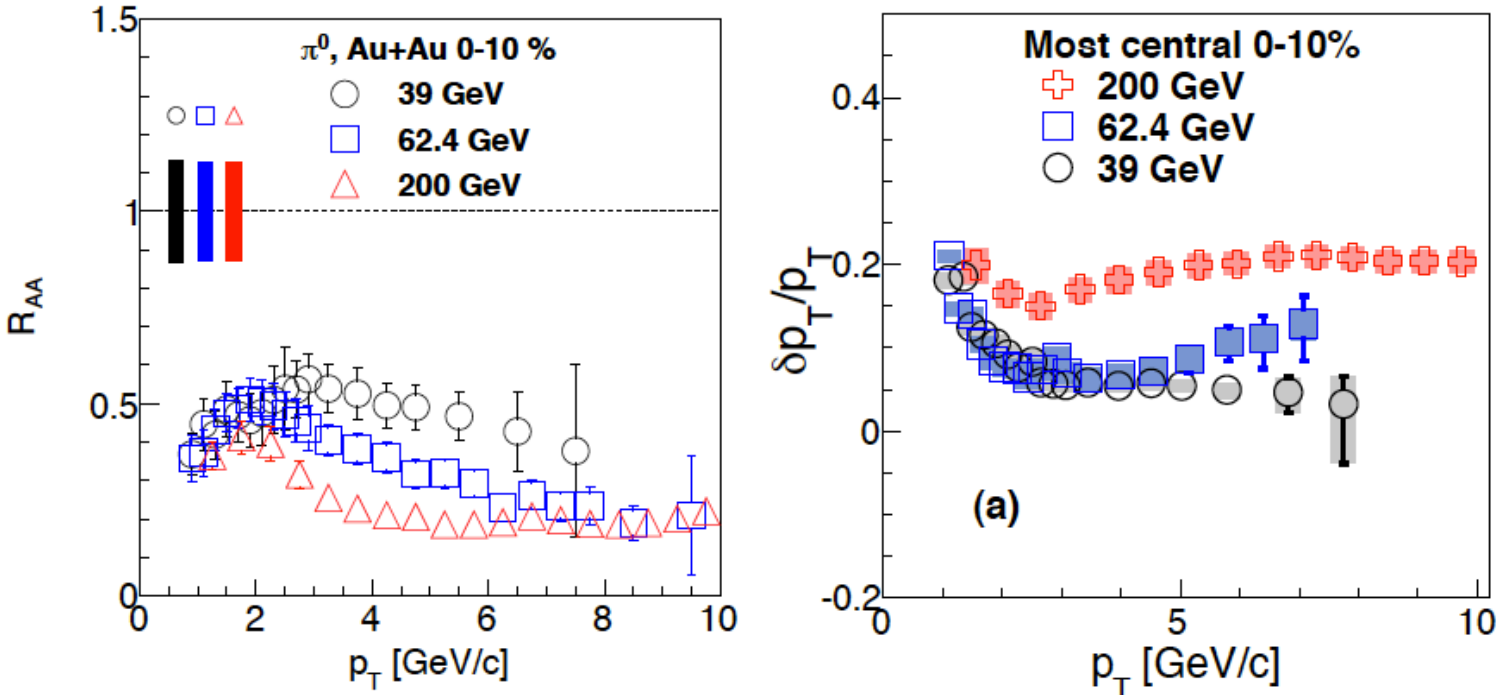


Measure fractional momentum loss instead of RAA



- Different dpT/pt for RHIC and LHC, for same RAA
- dpt/pt is 25% higher for ALICE
- dpt/pt decreases slightly with increasing pt (where rise of RAA occurs)

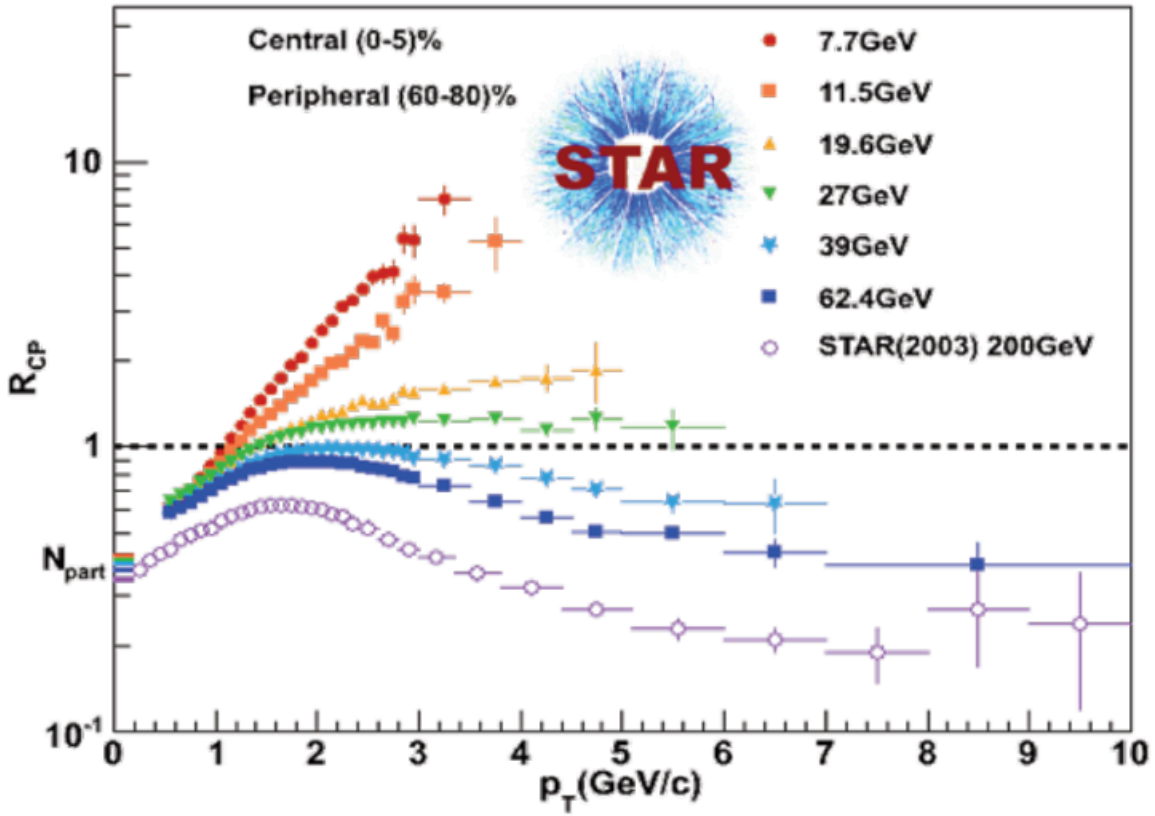
RHIC BES: Energy dependence of dpt/pt from PHENIX



PHENIX 1204.1526, O'Brien, PHENIX QM2012

dpt/pt decreases significantly from 200 GeV to 62.4 and 39 GeV

RHIC BES: Collision energy dependence of “jet quenching” : at which energy is it “switched off” ?

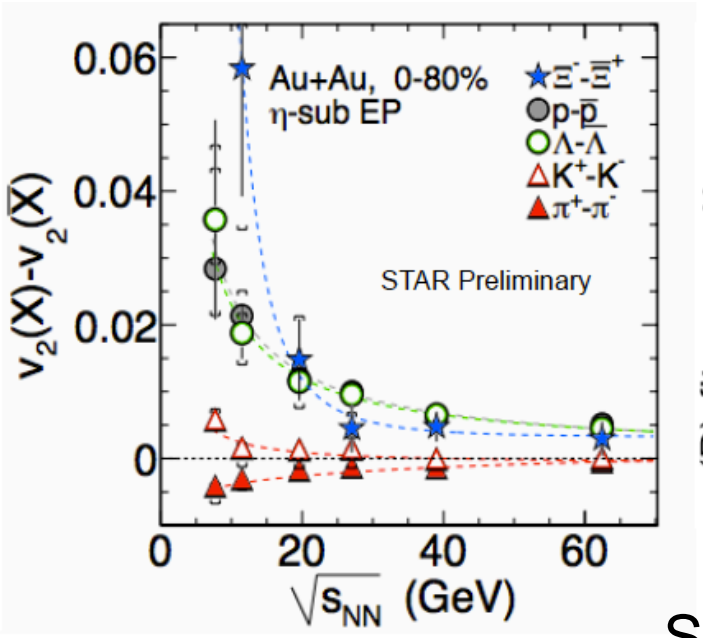


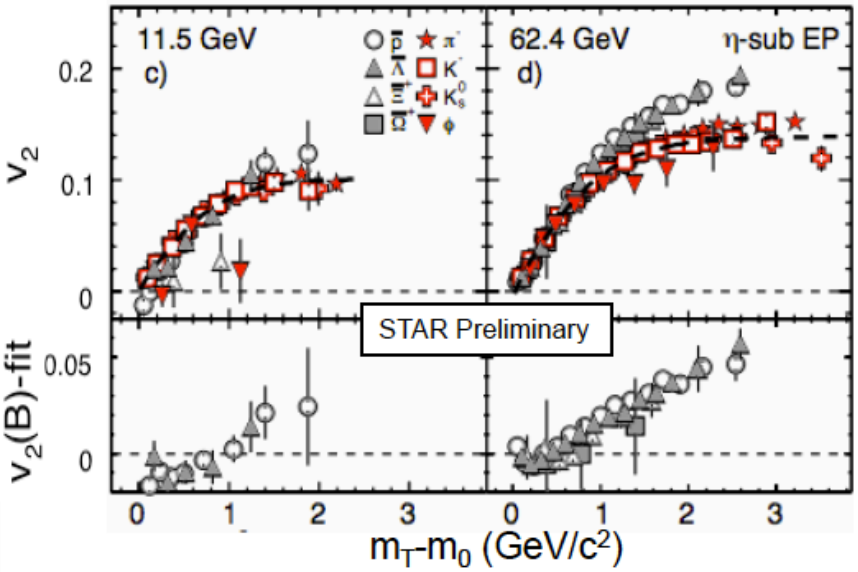
S. Milov, J. Solana, STAR, BES, QM2012

Disappearance of RCP suppression below 39 GeV

C. Flow

Breakdown of NCQ-scaling
STAR Beam Energy Scan





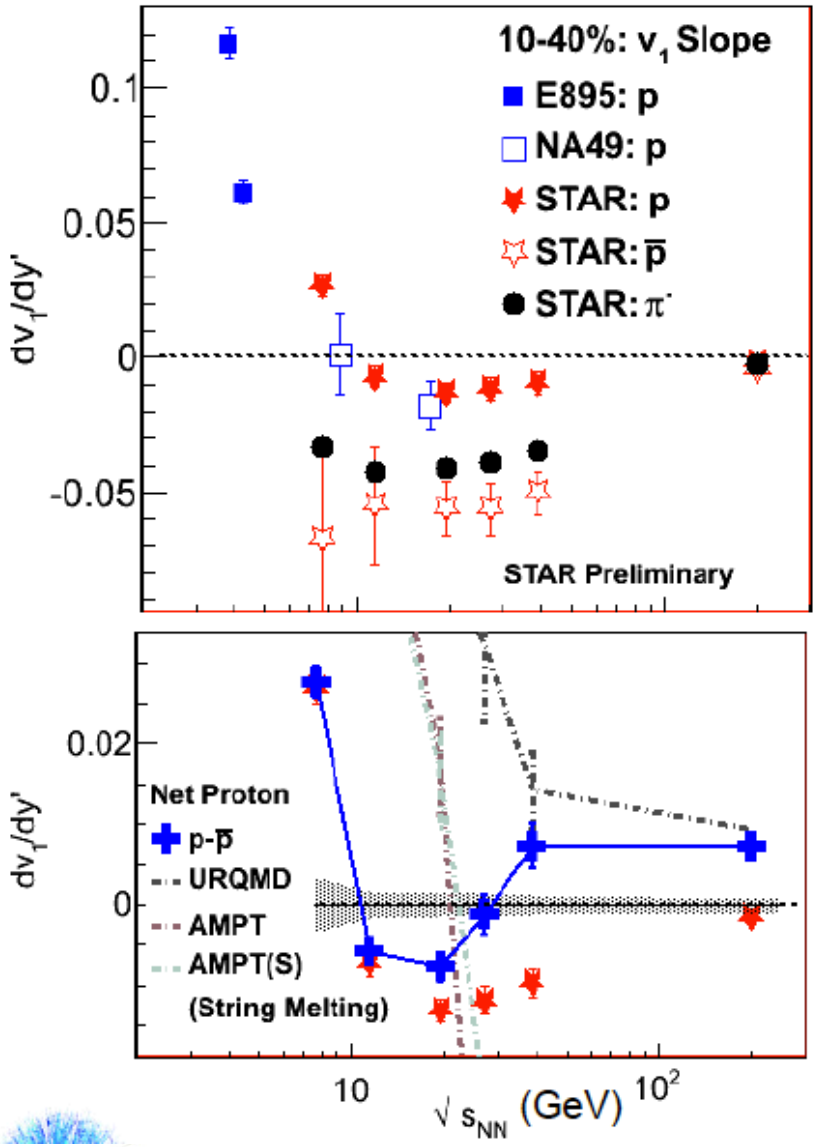
Shi, Schmah, STAR QM2012

Significant difference between baryon-antibaryon v2 at low energies

Changes in v2 for energies<= 11.5 GeV

NCQ scaling broken at low energies

Directed flow of protons



Y Pandit, STAR, QM2012

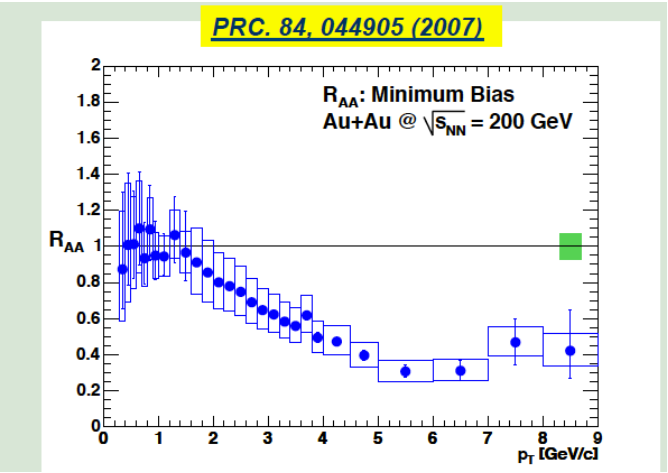
Proton v1 slope changes sign from + to - between 7.7 and 11.5 GeV and remains small and negative up to 200 GeV

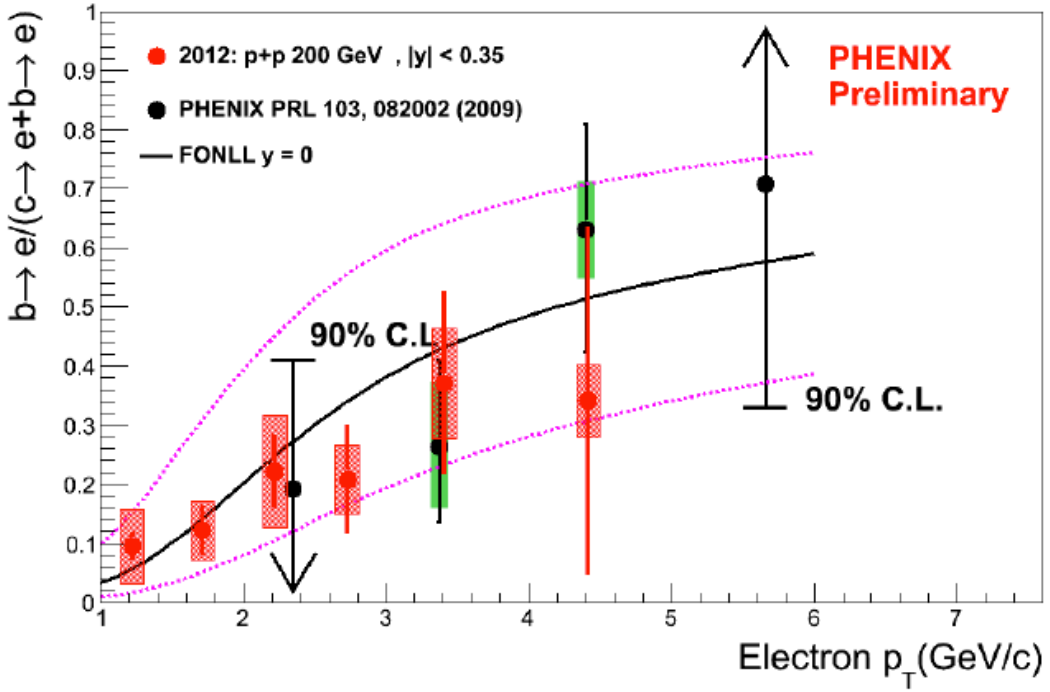
v1 slopes of other particles are negative

Net-proton v1 slope shows a minimum around 11.5-19.6 GeV

Open Heavy Flavour

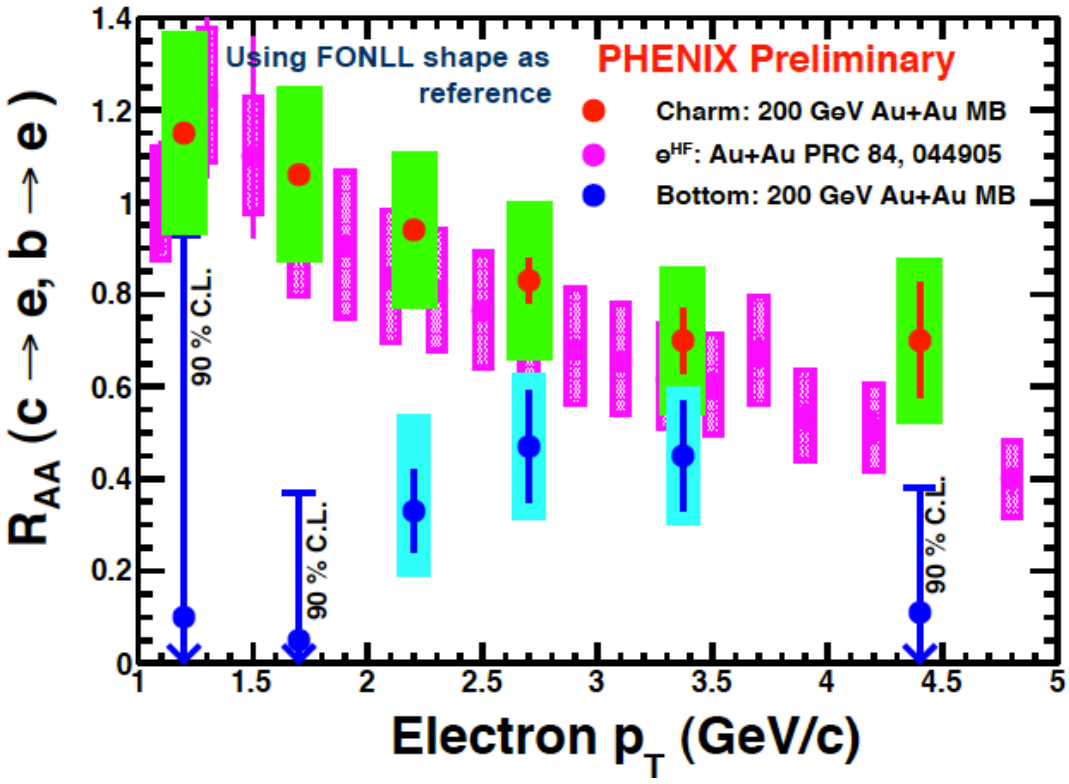
Open Heavy Flavour in PHENIX





- First direct c/b decomposition in p+p 200 GeV using the new vertex detector
- New direct measurement of beauty fraction agrees with FONLL (M Rosati, R Nouicer QM2012)

First RAA for charm and beauty measured in MinBias Au+Au from PHENIX



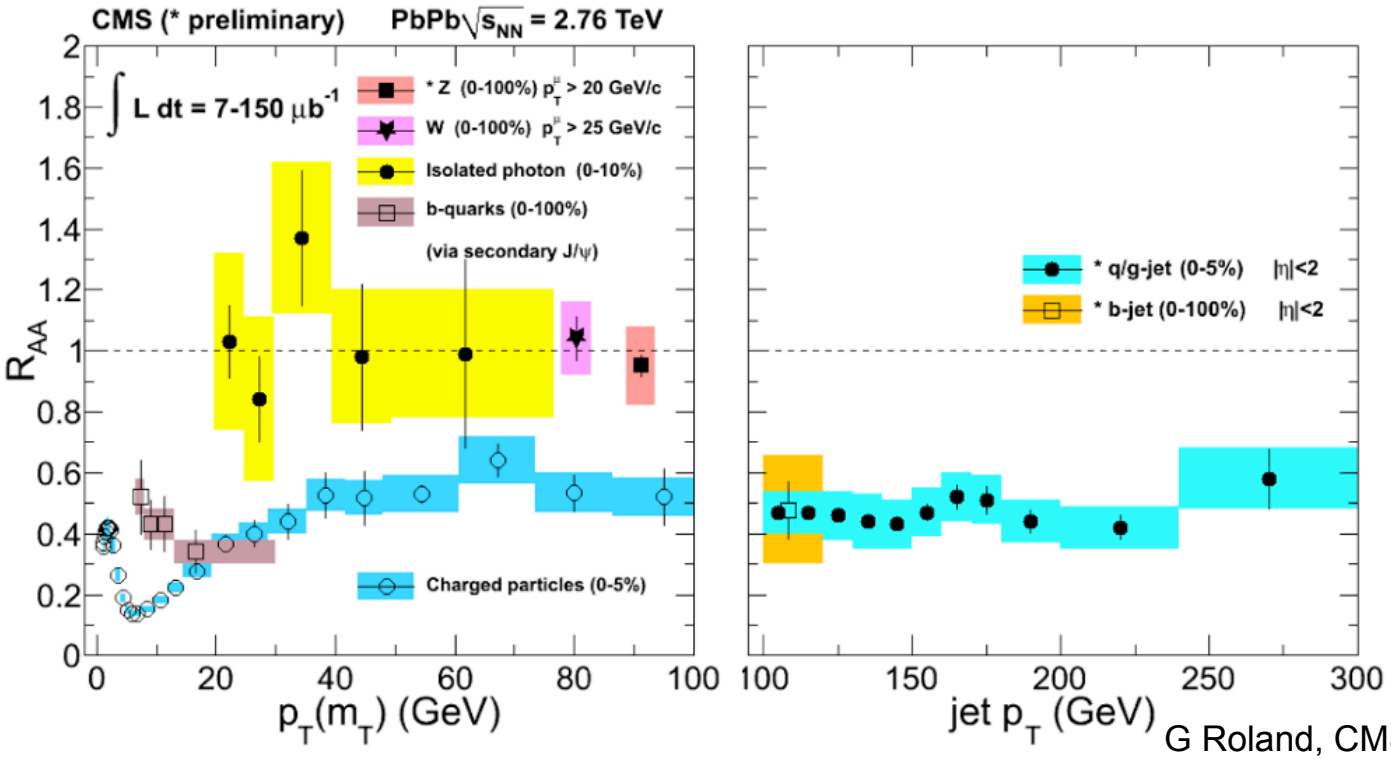
M Rosati,R Nouicer, QM2012

Beauty->e is strongly suppressed

Charm->e is less suppressed

RAA for c->e is consistent with RAA for heavy flavour -> e

Beauty suppression :at the LHC



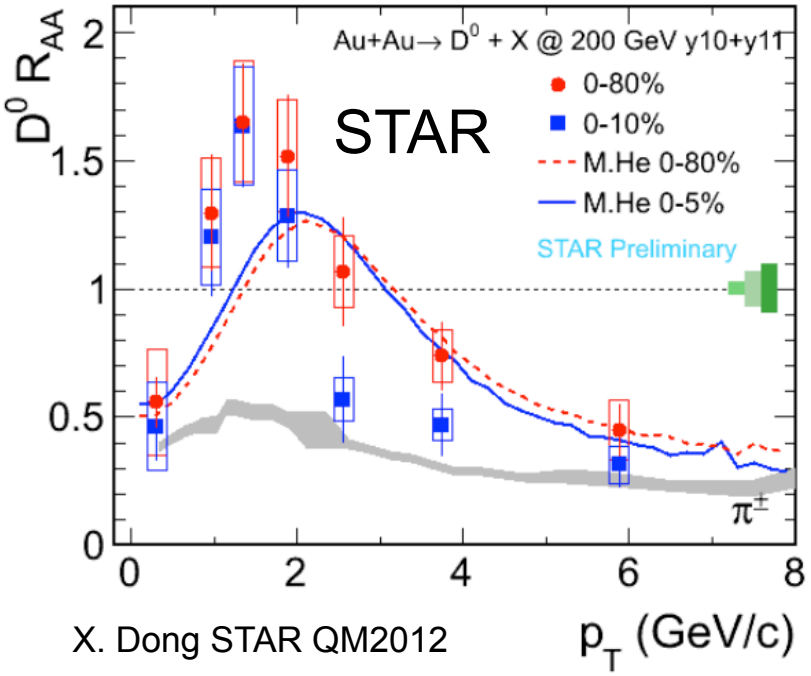
G Roland, CMS, QM2012

b-quark suppression in Pb+Pb

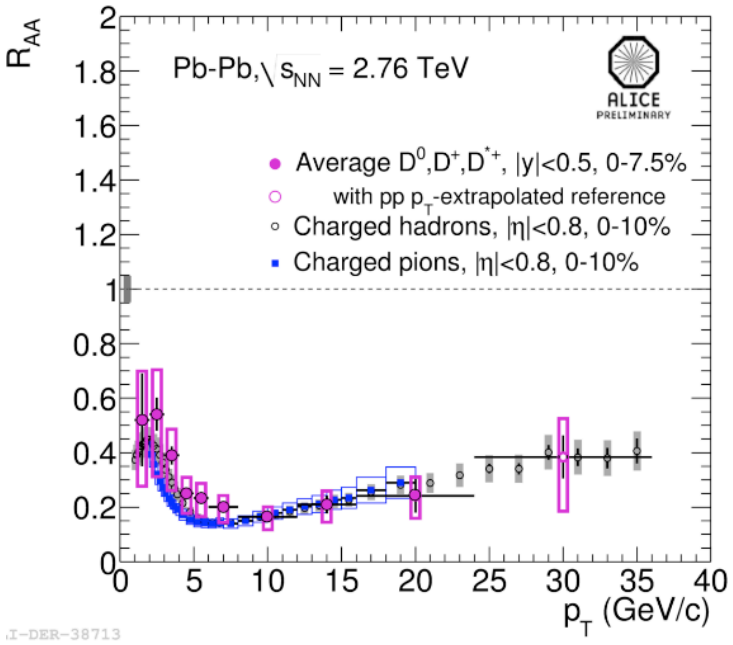
First observation of b-jet suppression at high pT

RHIC vs LHC: Quenching of open charm

The RAA of Charm and Beauty are both suppressed at RHIC and LHC.



X. Dong STAR QM2012



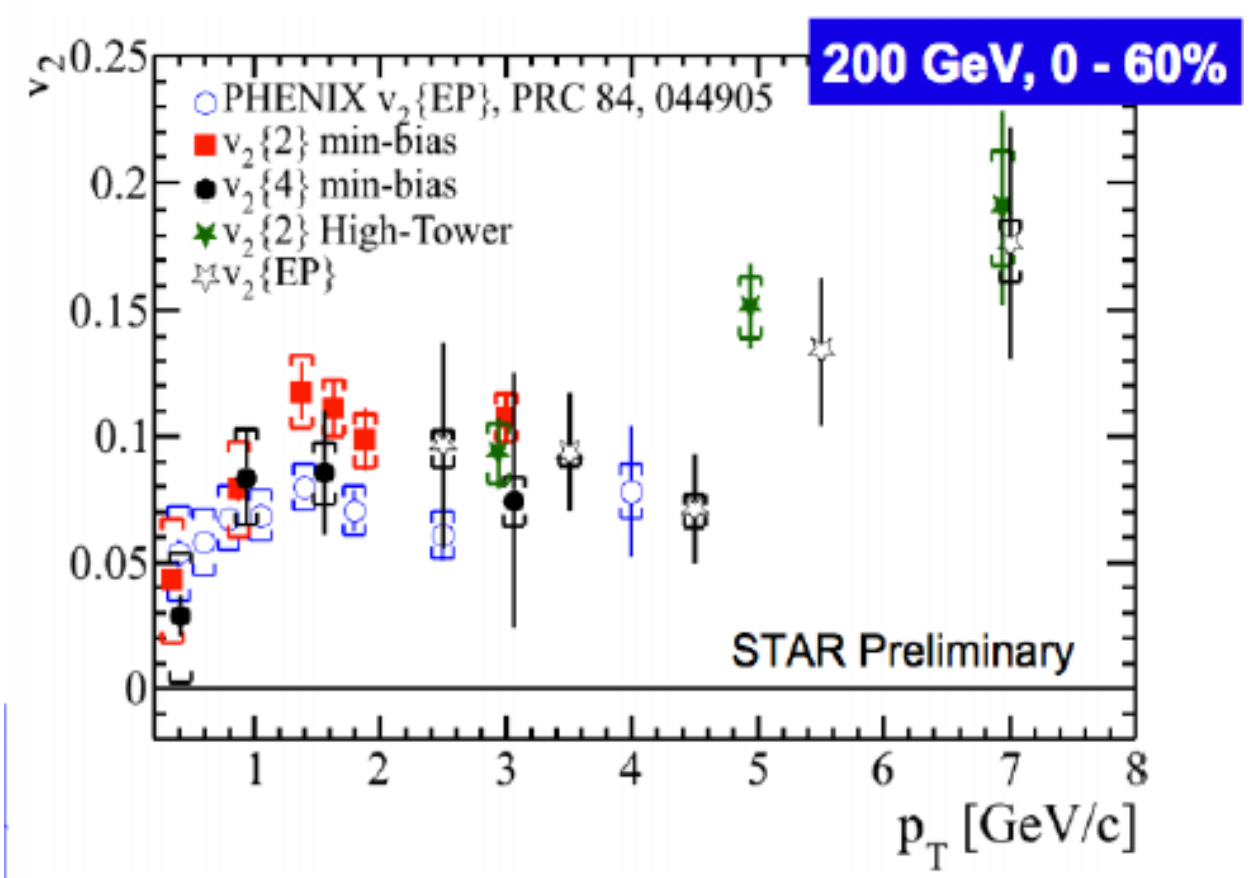
K Safarik, ALICE, QM2012

* **The RAA of D0 at RHIC (STAR) is suppressed after pT=3 GeV, and is similar to the RAA of charged hadrons at pT~6 GeV.**

* **The RAA of D0 at LHC (ALICE) is suppressed and is similar to the RAA of charged hadrons at high pT.**

v2 of Non Photonic Electrons from STAR

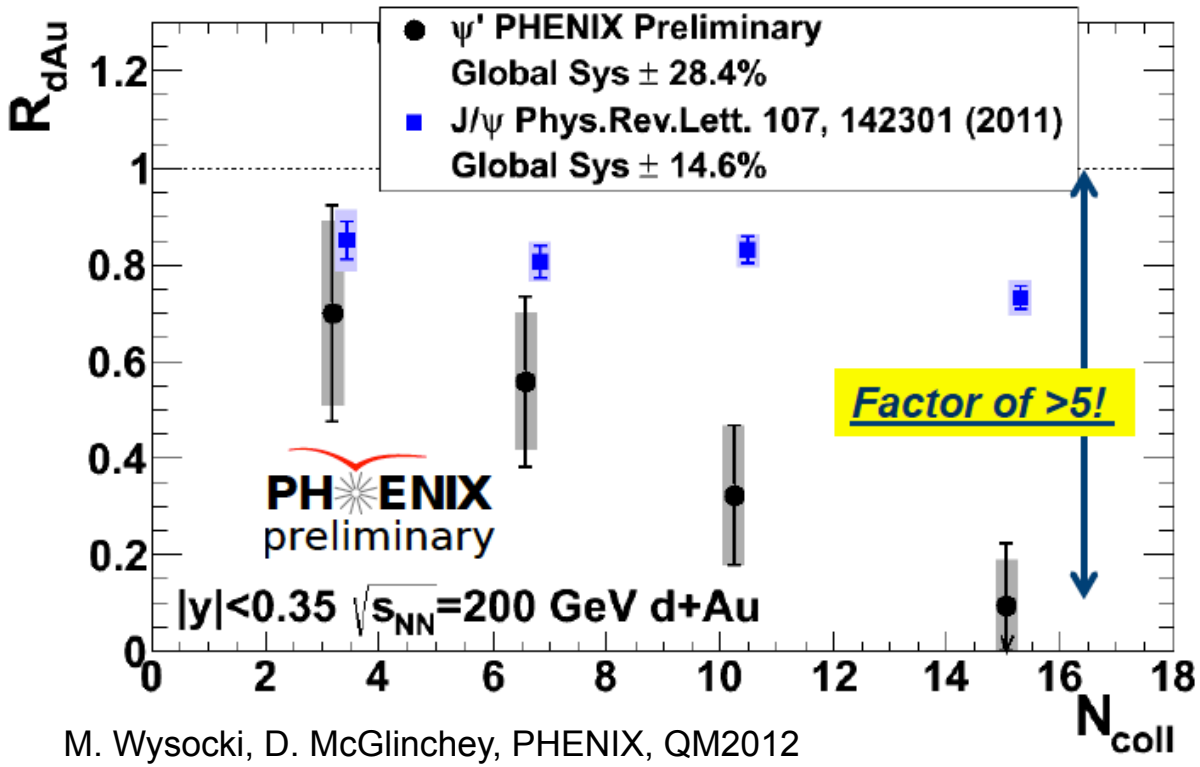
X. Dong, STAR, QM2012



Finite NPE v2 in Au+Au at 200 GeV 0-60% centrality

E. Quarkonia

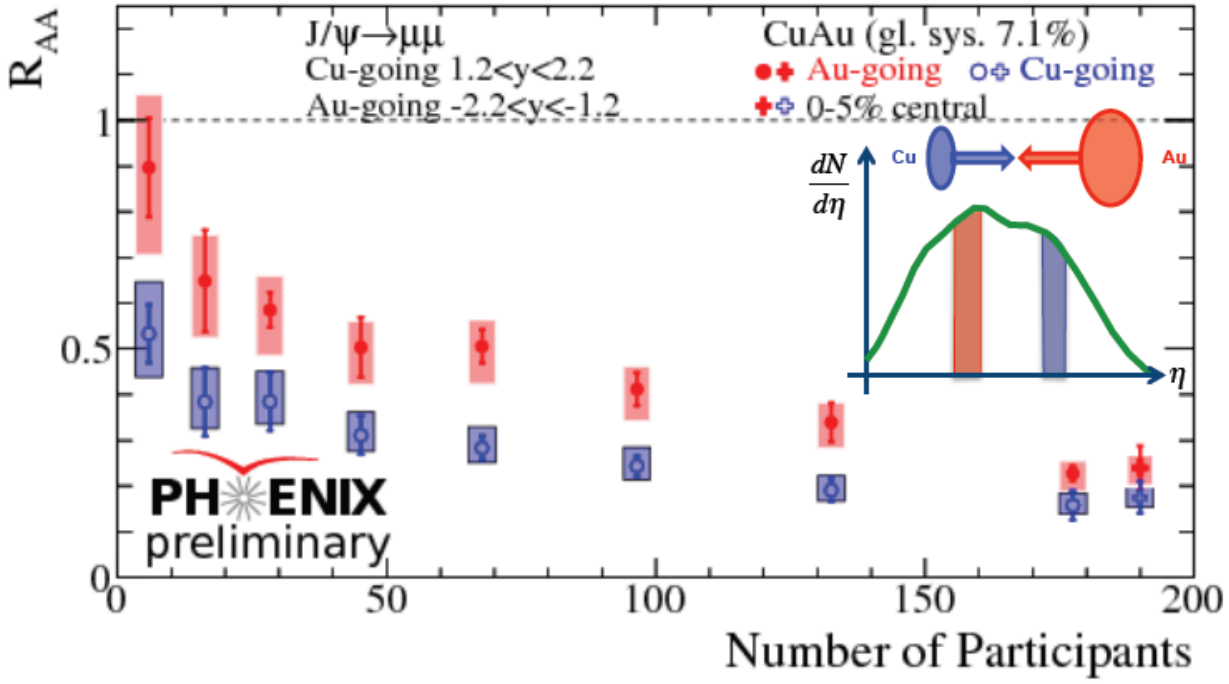
First measurement of Psi prime in d+Au from PHENIX



M. Wysocki, D. McGlinchey, PHENIX, QM2012

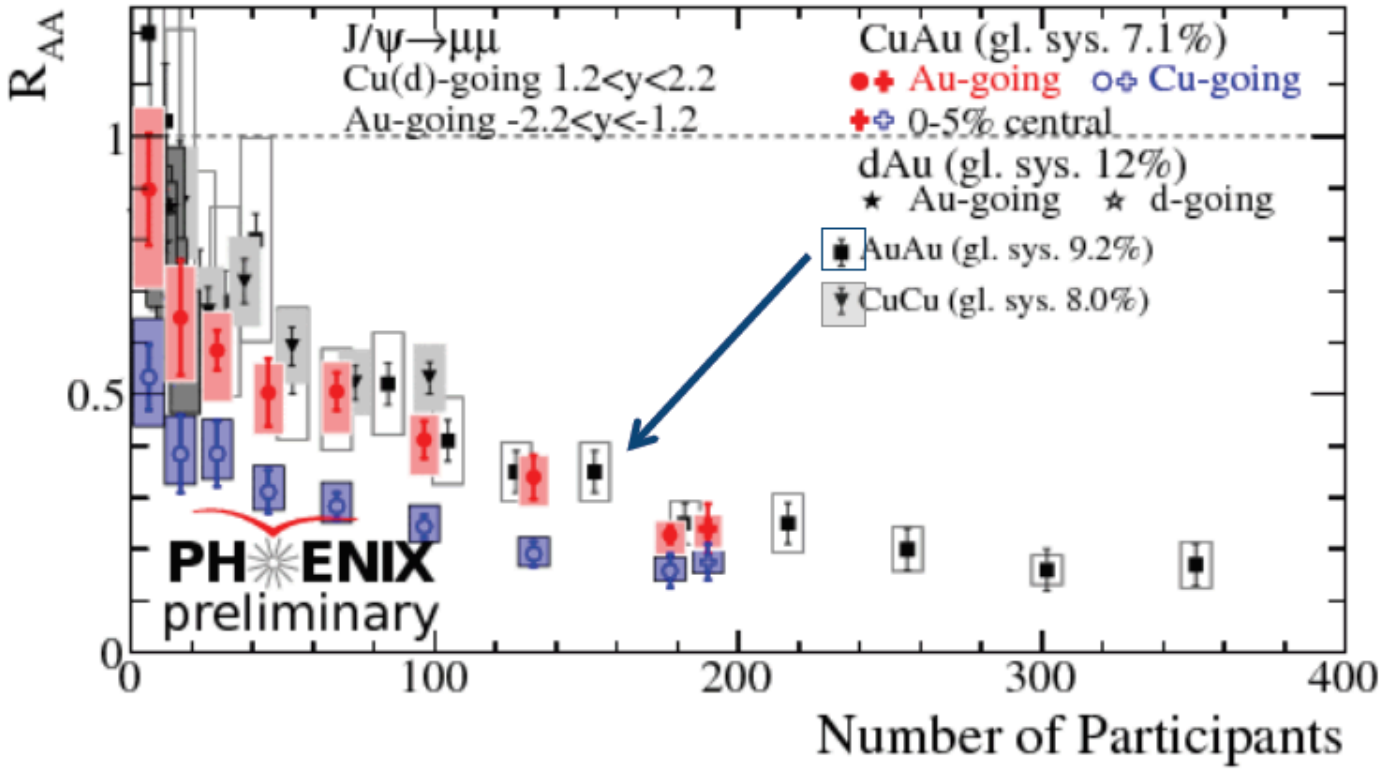
Psi prime is strongly suppressed in d+Au

J/Psi in Cu+Au 200 GeV from PHENIX



J/Psi in Cu+Au is more suppressed in the Cu going direction as compared to Au going direction

J/Psi in Cu+Au and Au+Au from PHENIX

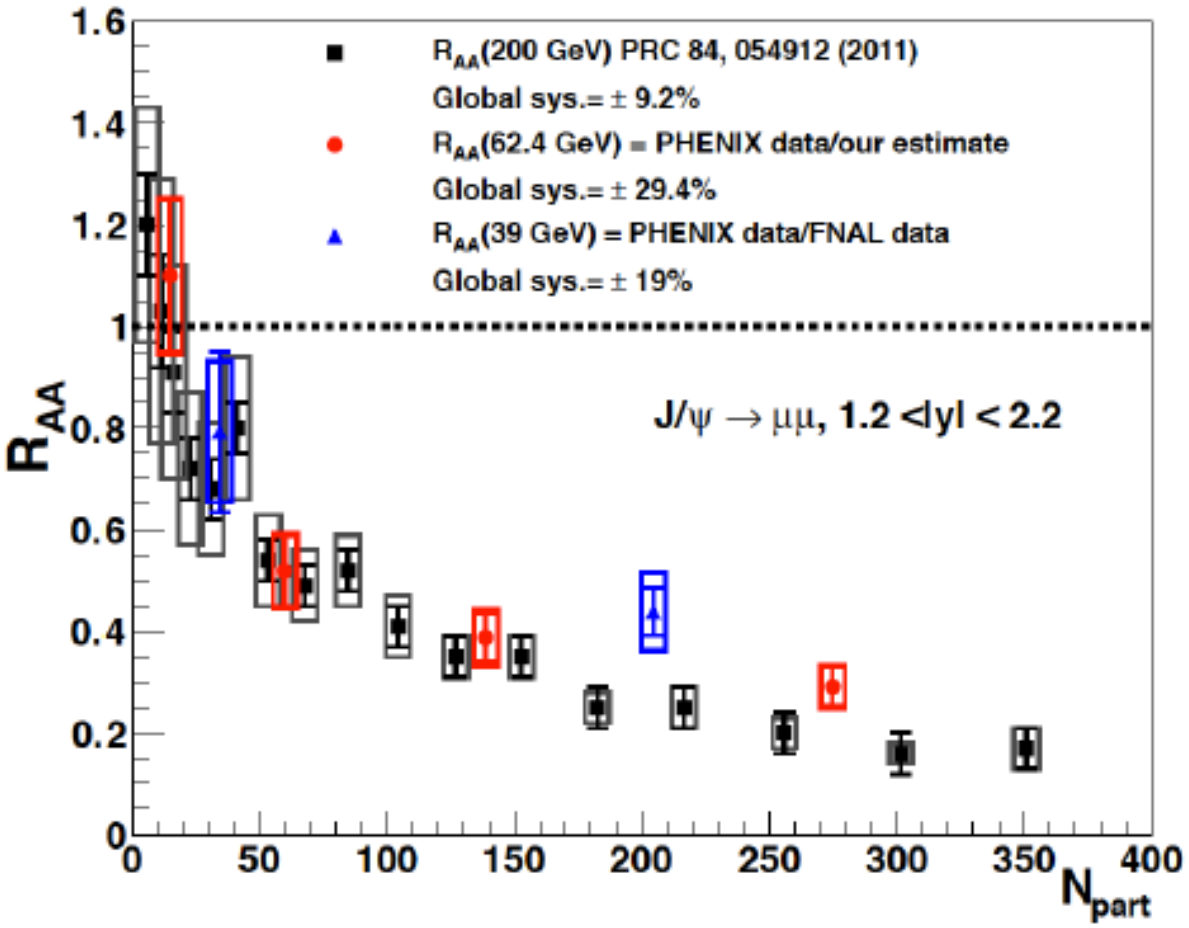


M Rosati, R Hollis, PHENIX, QM2012

J/Psi suppression in Au-going direction is the same as Au+Au

Cu-going direction shows stronger suppression than in Au+Au

RHIC Energy scan: J/Psi PHENIX

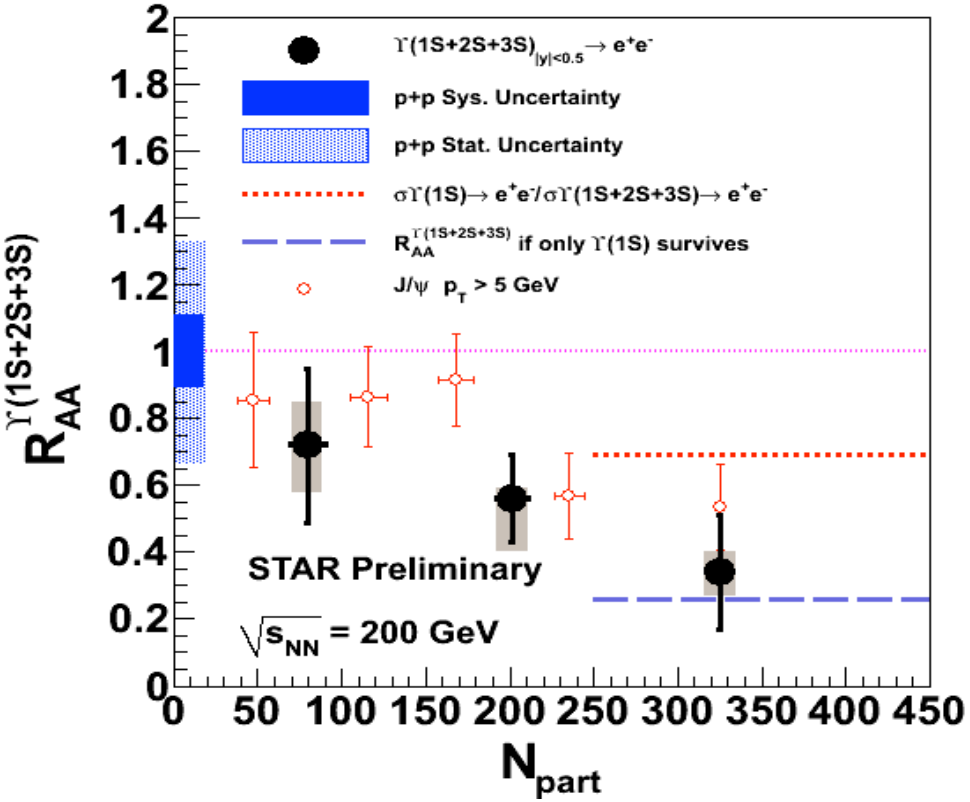


Frawley, PHENIX, 1209.1159

First measure of Y suppression in Au+Au at 200 GeV from STAR

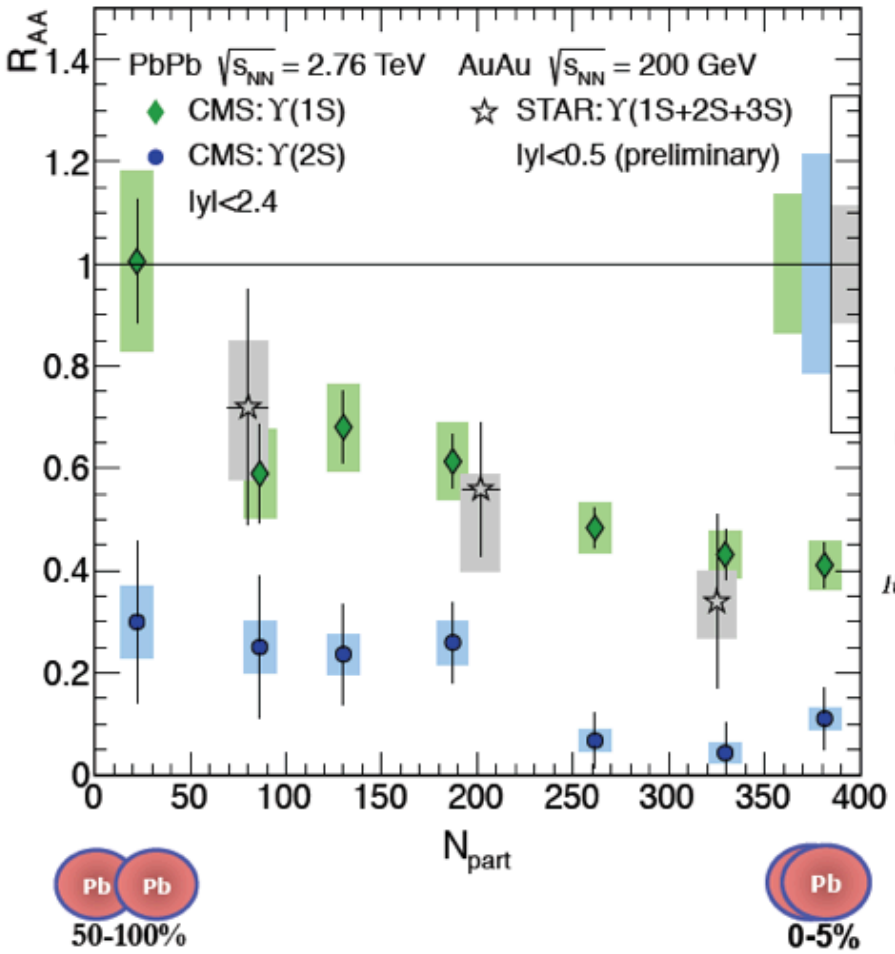
Rosi Reed, STAR, flash talk, poster QM2011

state	$J/\psi(1S)$	$\chi_c(1P)$	$\psi'(2S)$	$\Upsilon(1S)$	$\chi_b(1P)$	$\Upsilon(2S)$	$\chi_b(2P)$	$\Upsilon(3S)$
T_d/T_c	2.10	1.16	1.12	> 4.0	1.76	1.60	1.19	1.17



- Υ(1S+2S+3S) suppression at central collisions
  - -Similar suppression with high p_T J/ψ
- First measurement of Υ suppression at RHIC
- RAA at most central point is in agreement with only Y(1S) surviving
- CMS Y(1S) suppression in agreement with suppression of only excited states

STAR-CMS comparison of Y suppression



G Breto Rangel, CMS, QM2012

✓STAR measured R_{AA} of Υ(1S+2S+3S) combined

$$R_{AA}(\Upsilon(1S+2S+3S)) = 0.56 + 0.21^{+0.08}_{0.16}$$

(arXiv:1109.3891v1)

✓CMS: separate R_{AA} for Υ(1S) and Υ(2S) can calculate R_{AA} of Υ(1S+2S+3S):

$$R_{AA}(\Upsilon(1S+2S+3S)) = R_{AA}(\Upsilon(1S)) \times \frac{1 + \Upsilon(2S+3S)/\Upsilon(1S)|_{PbPb}}{1 + \Upsilon(2S+3S)/\Upsilon(1S)|_{pp}}$$

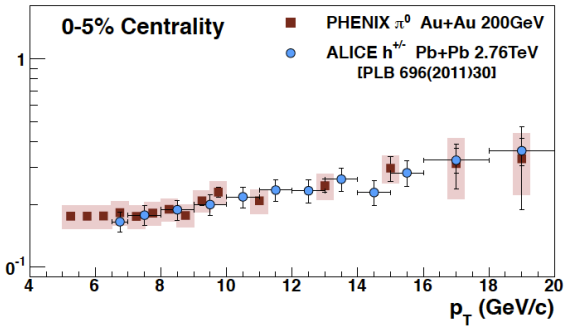
$$R_{AA}\ (\Upsilon(1S+2S+3S)) \sim 0.32$$

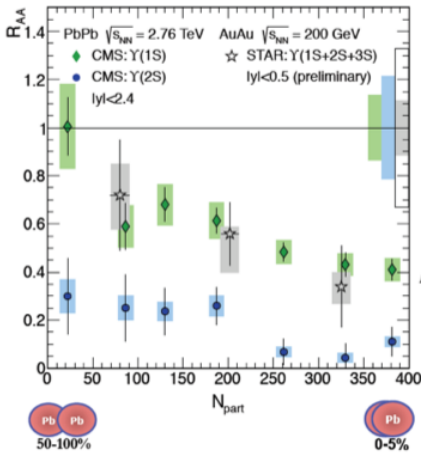
✓Similar Suppression Pattern

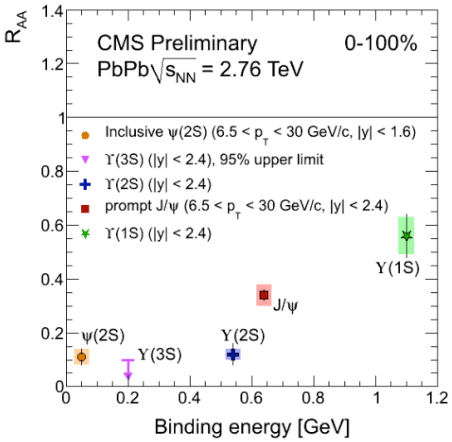
III Conclusions and outlook

Conclusions and outlook

- After 25 years of searches for the QGP we arrived at a culmination point with long awaited results.
- RHIC BES: Several key sQGP signatures not seen at low energies.
- RHIC experiments STAR and PHENIX enter a new era of high precision measurements with major upgrades







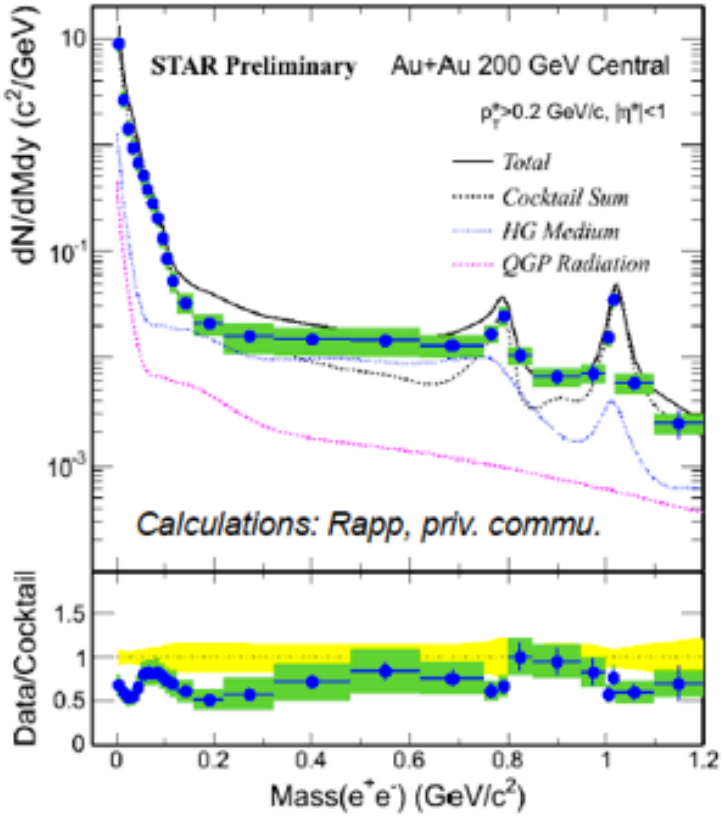
In the next few years new data will allow to establish these results and add to them possible new discoveries at:

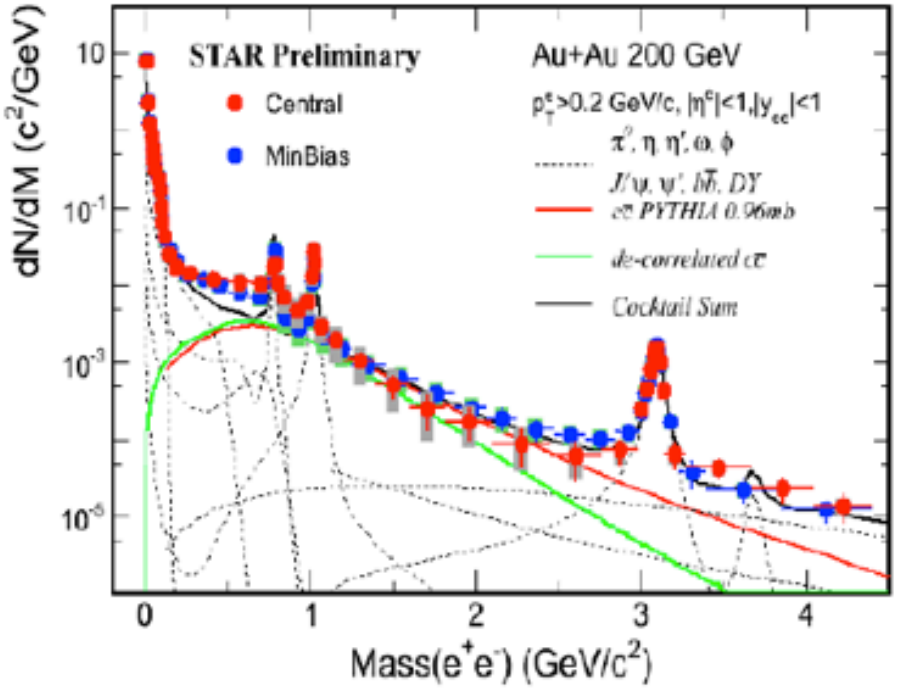
* high energy and low muB
* low energy and high muB (Beam Energy Scan)

to map out the QCD phase diagram

Thank you very much

Dielectrons at Au+Au 200 GeV



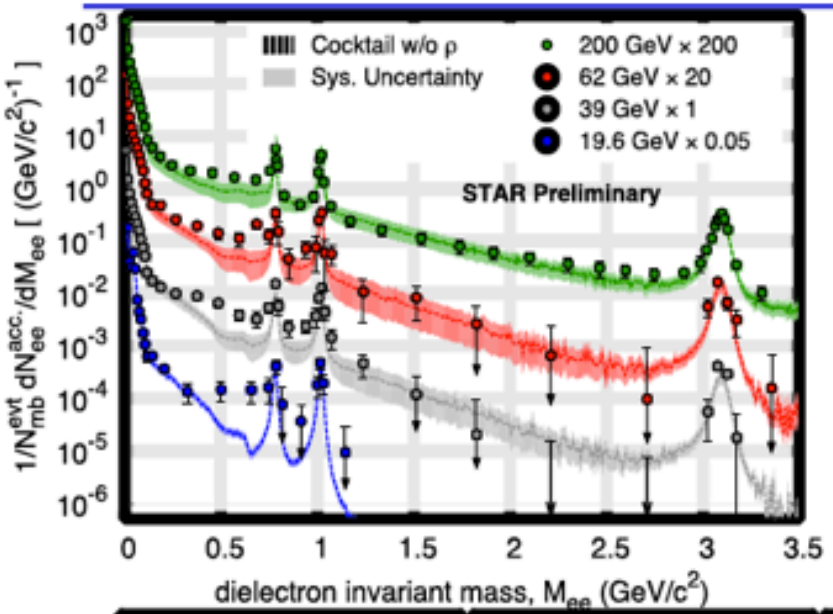


Geurts, IV, Thu.; Huang, 3C, Wed.

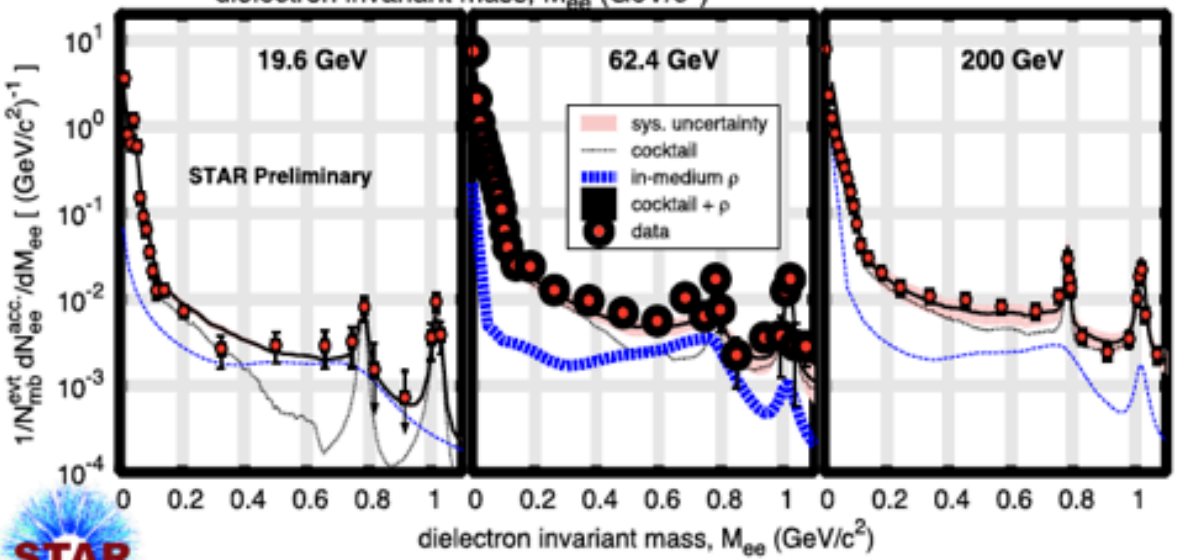
- Low mass enhancement in Au+Au 200 GeV is accounted for by theoretical calculations of in-medium ρ broadening.
- Data in central/minbias show hints of charm modifications/other sources in IMR.
- Systematic studies on dielectron production:
  - p_T and centrality dependence at 200 GeV
  - elliptic flow measurements

Zhao, poster #153
Cui, poster #322

Energy Dependent Dielectron Production



- Systematic measurements of dielectron mass spectra over a broad energy range.
- LMR enhancement persists down to 19.6 GeV.
- Theoretical calculations of in-medium ρ broadening with similar baryon densities from 19.6 - 200 GeV reproduce LMR excesses well.

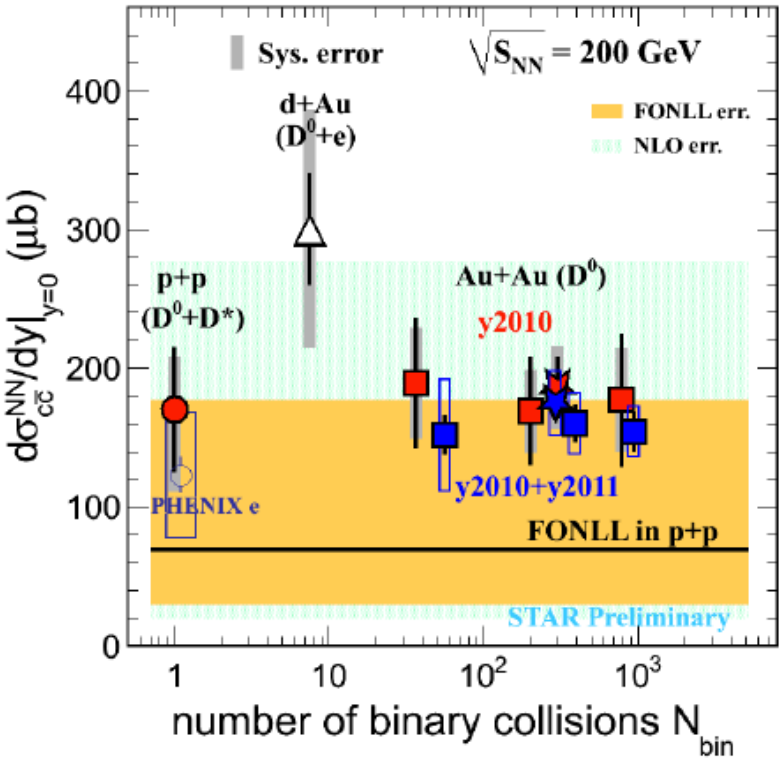


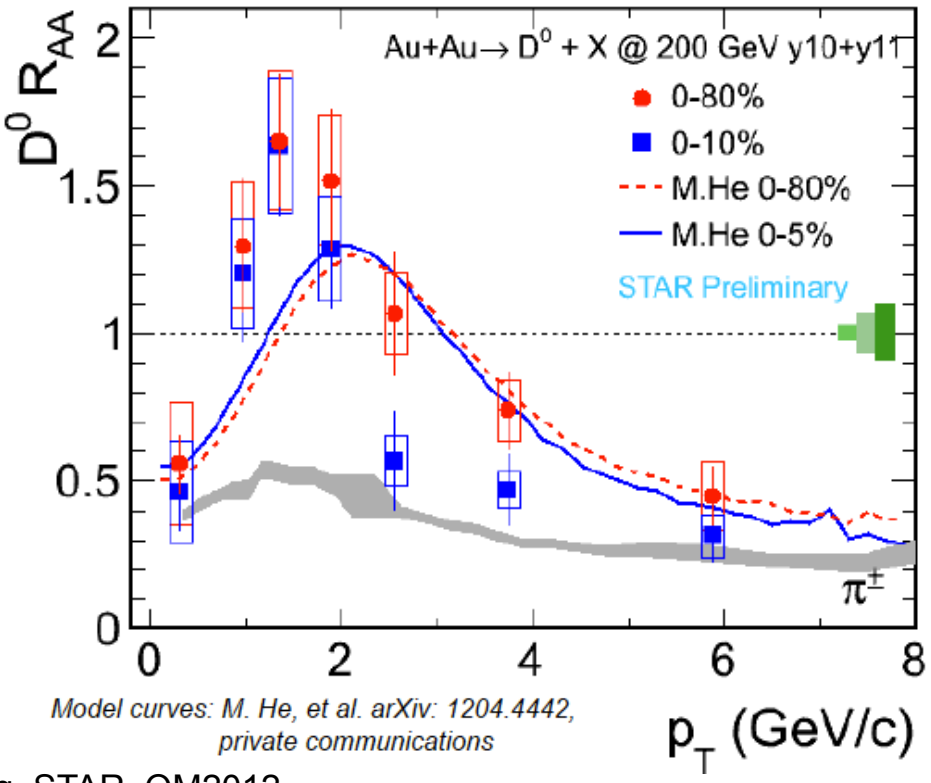
In-medium ρ broadening
R. Rapp: private communications

Geurts, IV, Thu.
Huang, 3C, Wed.

Huck, Huang,
poster #113, 269

RAA of identified charm from STAR

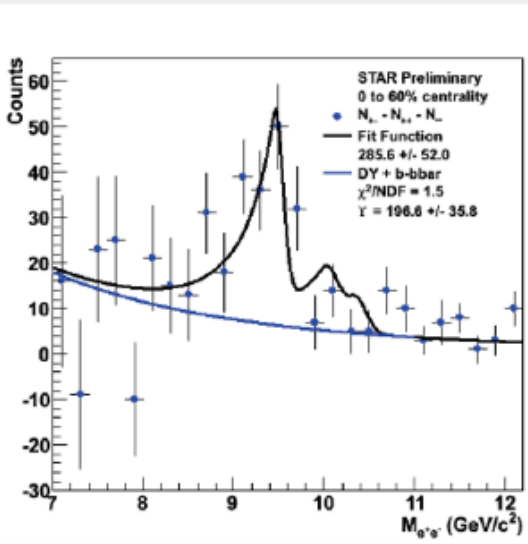




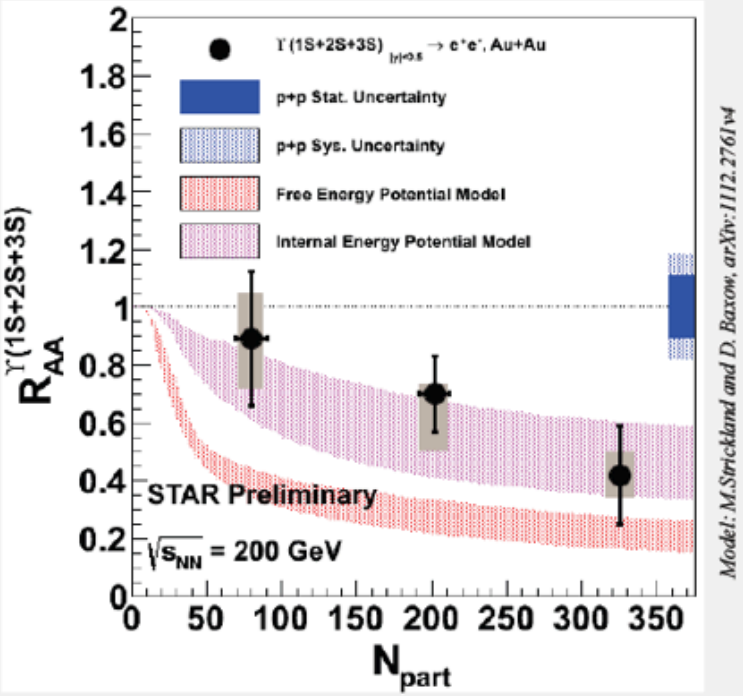
X. Dong, STAR, QM2012

- Charm production cross section follows Nbin scaling (2010+2011 data)
- RAA D0 in Au+Au suppressed at pT>3 GeV

Y in Au+Au 200 GeV from STAR



Raw yield of $\Upsilon \rightarrow e^+e^-$ with $|y|<0.5 = 197 \pm 36$



- ✓ Comparison with dynamic model with fireball expansion and quarkonium feed-down, calculation included variation of initial η/S and T_0
- ✓ Results are consistent with complete melting of 3S and very strong suppression of 2S in central collisions in this model

B Trzeciak, STAR QM2012