Recent Results from PHENIX

Heavy Ions

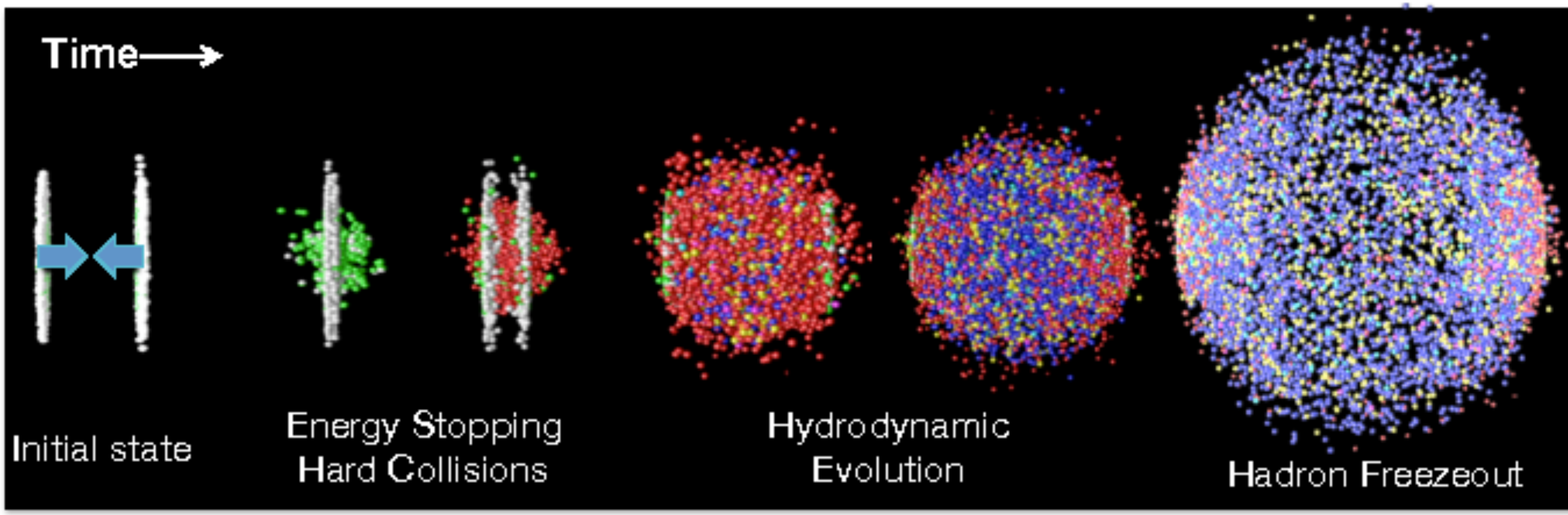
Talk by Sasha B. on Spin

Stefan Bathe

Baruch College, CUNY

for the PHENIX collaboration

Time evolution of heavy ion collision



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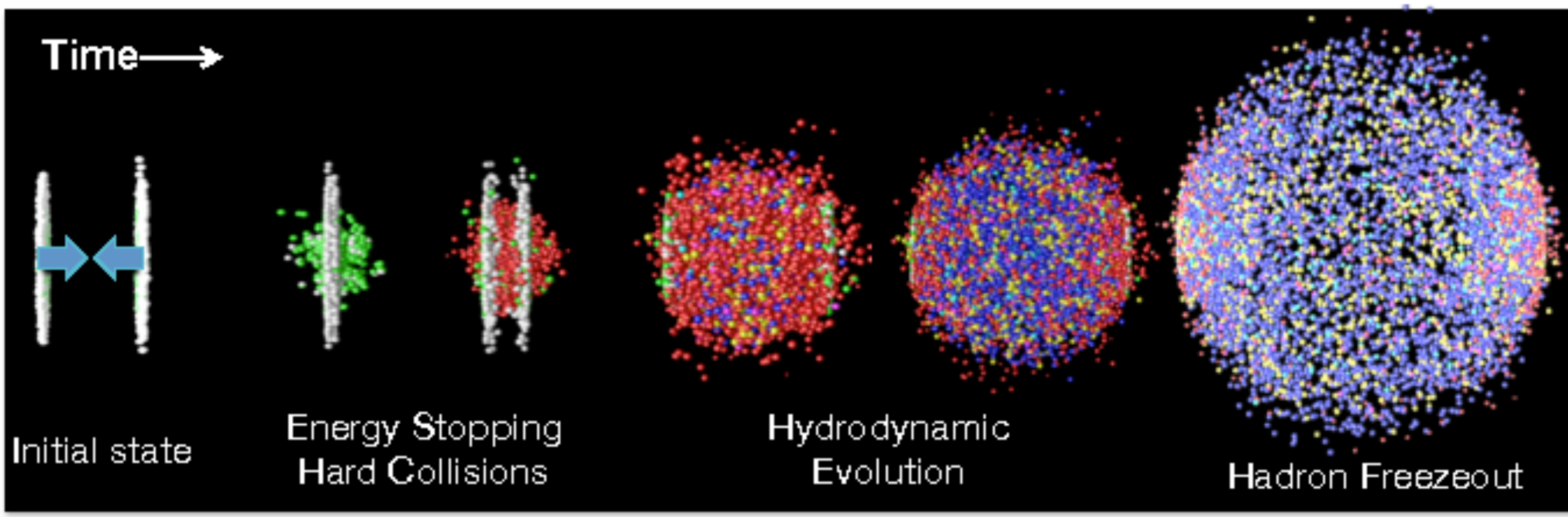
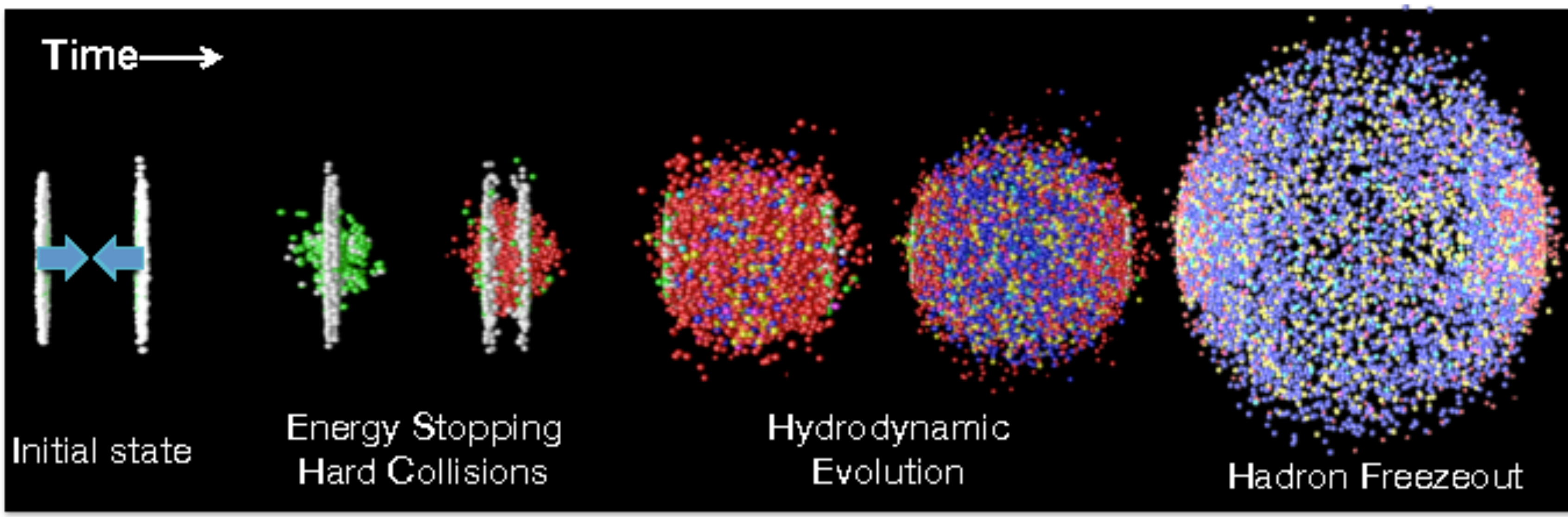


small systems

smallest QGP droplet, equilibration, initial state, viscosity

Time evolution of heavy ion collision



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Direct photon spectra and flow

Space-time evolution

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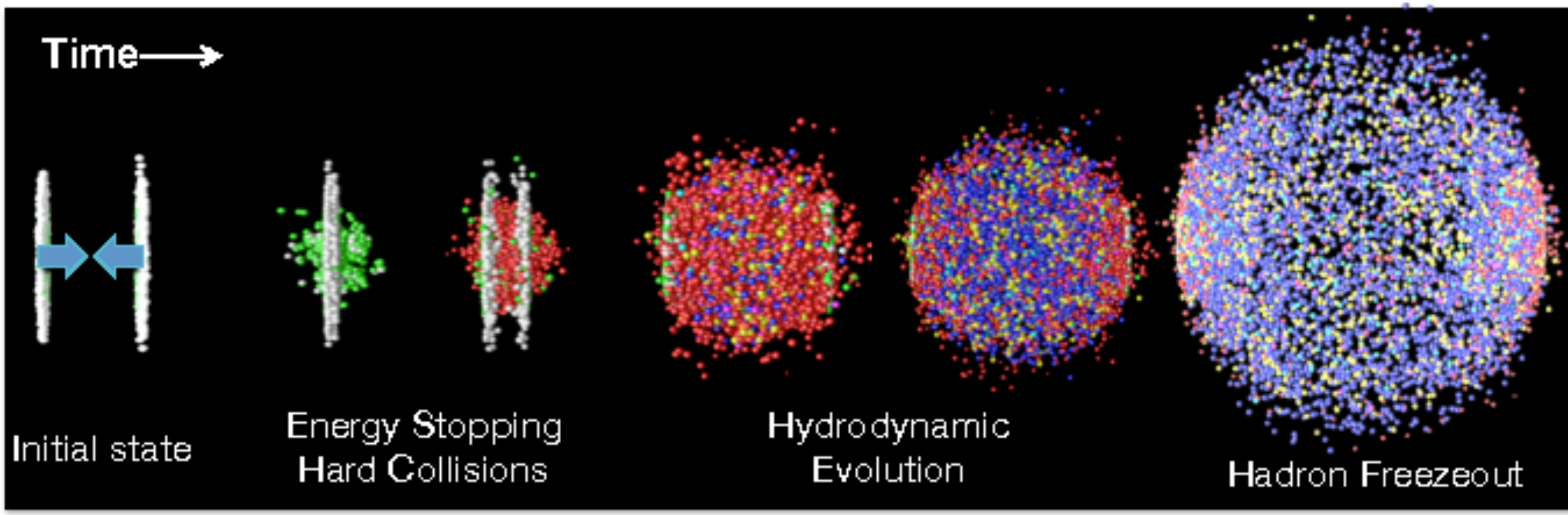

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Heavy flavor energy loss
QGP transport coefficient

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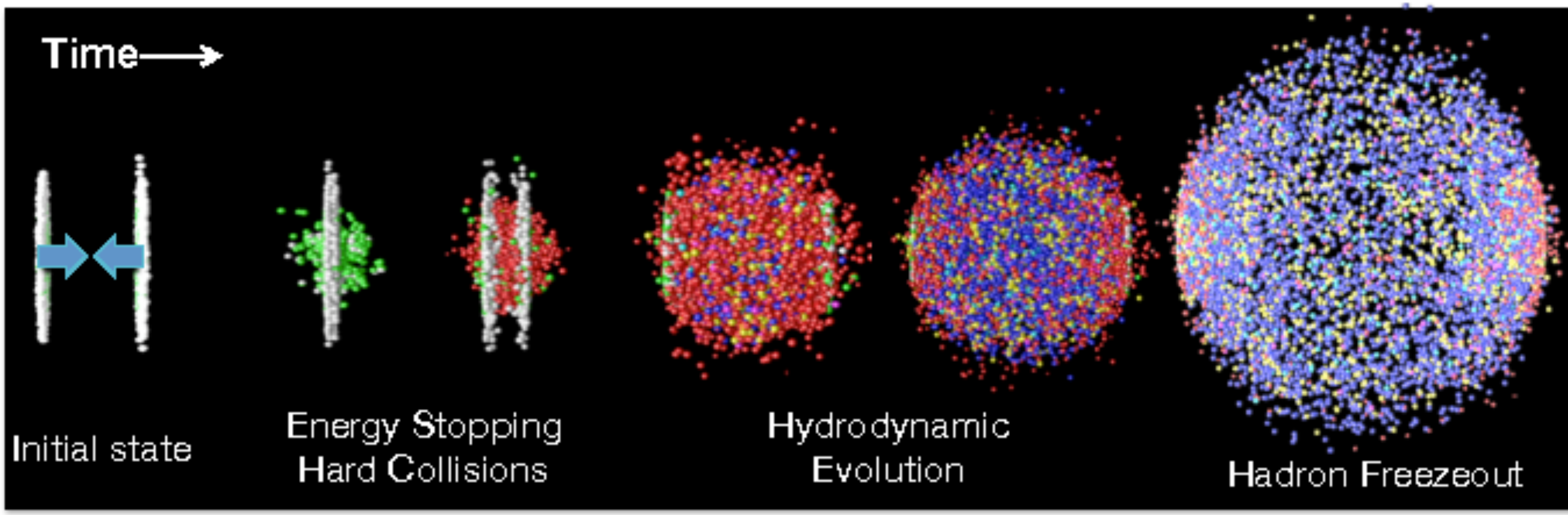

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Hadronization, chiral symmetry restoration

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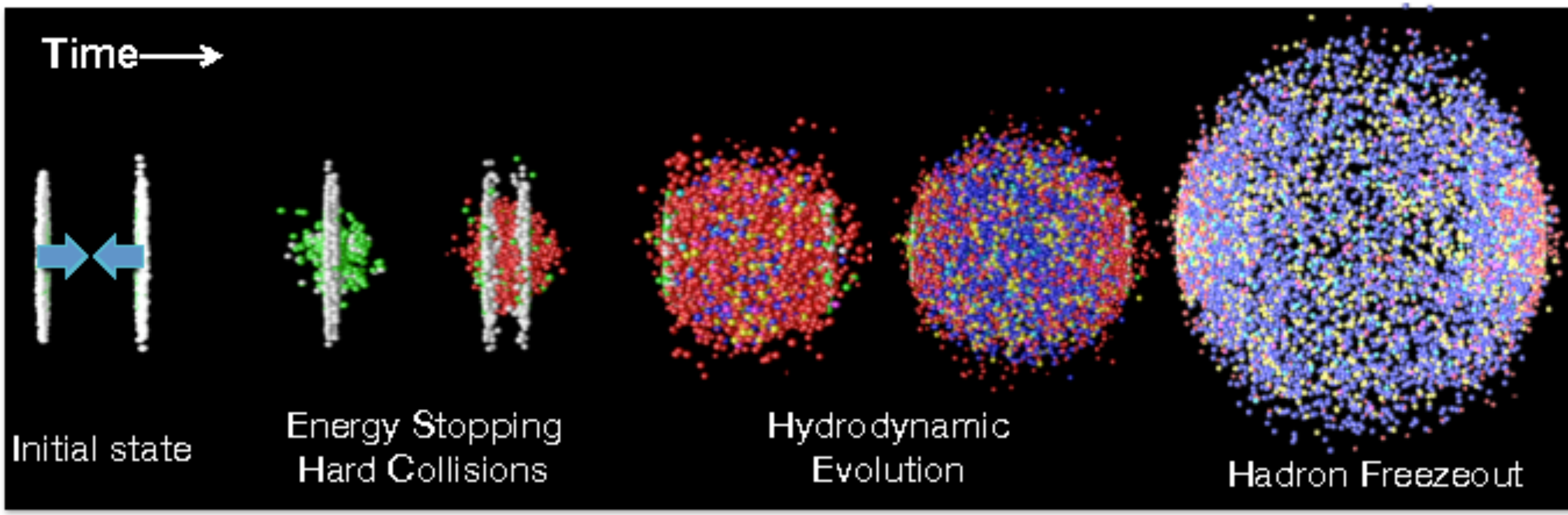

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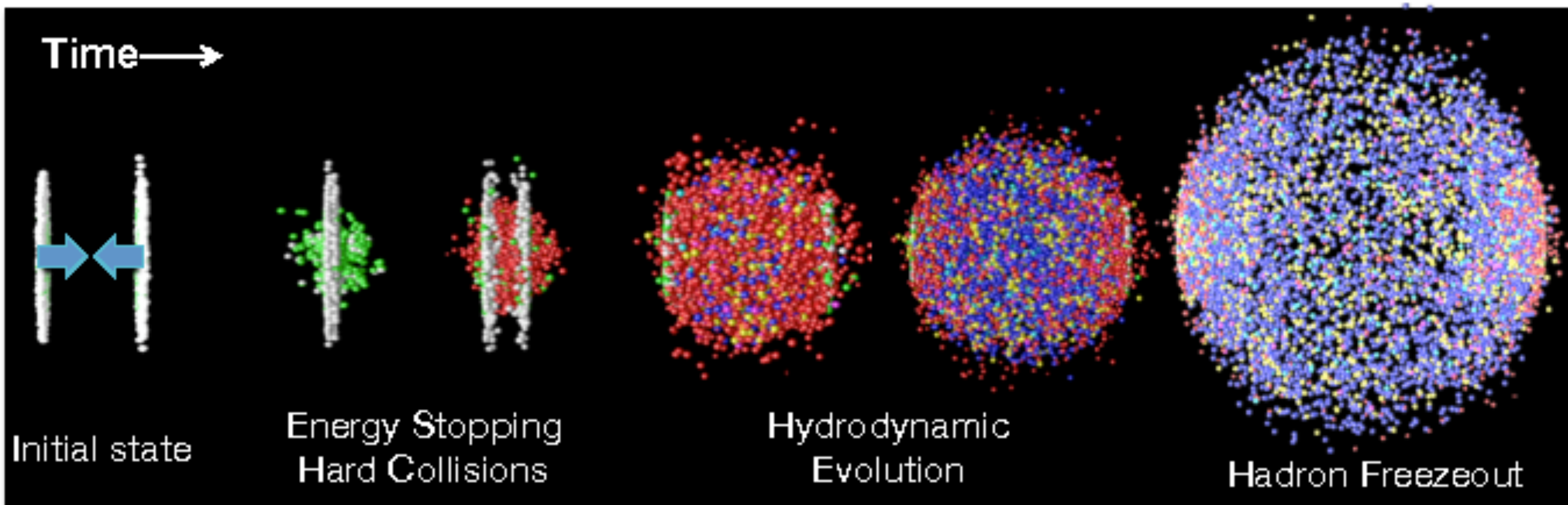

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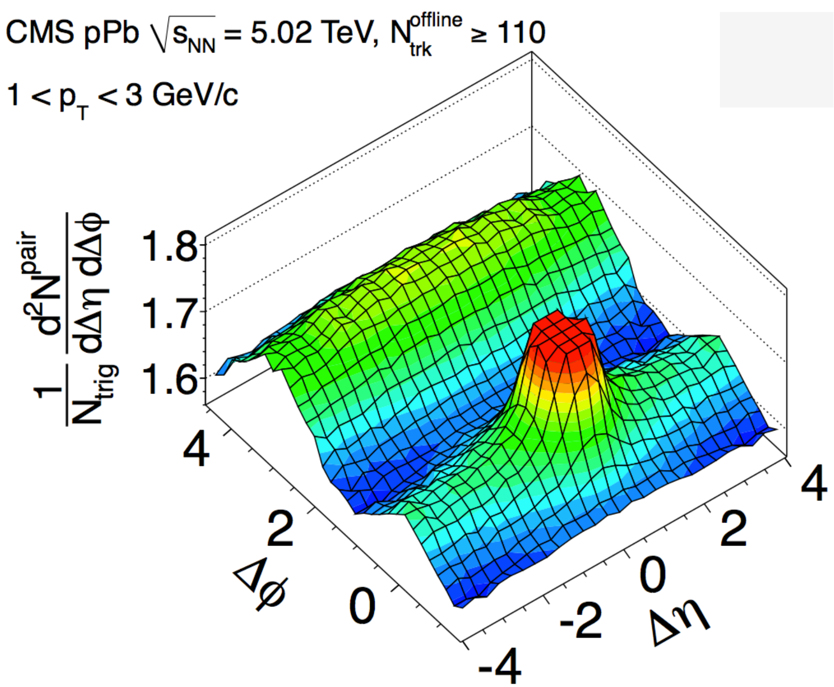
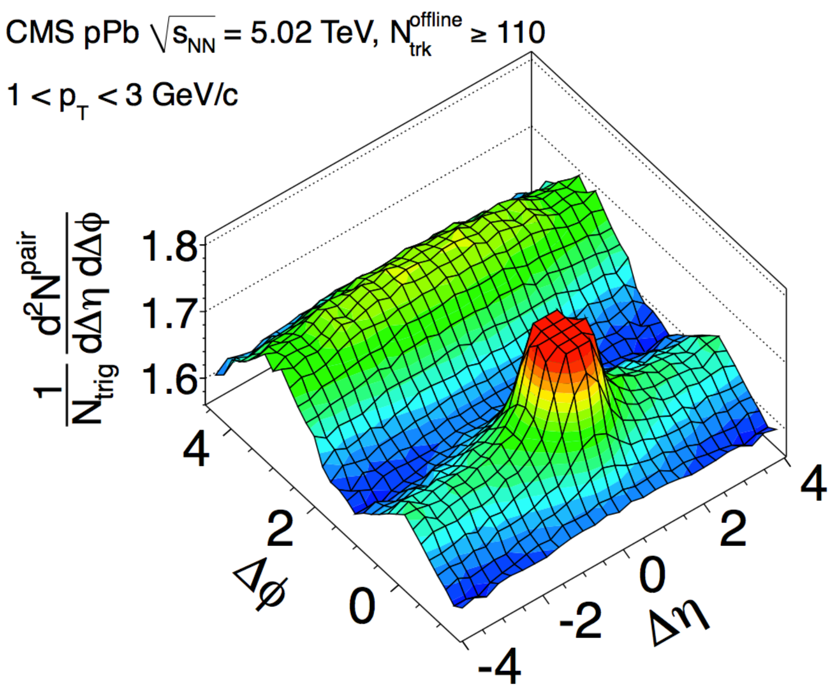


PLB718 (2013) 795-814

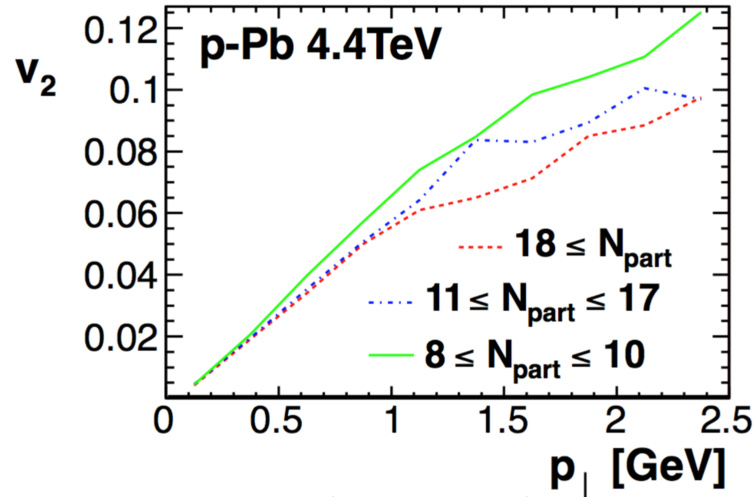
What is the origin of the ridge in p+A?

Smallest QGP droplet

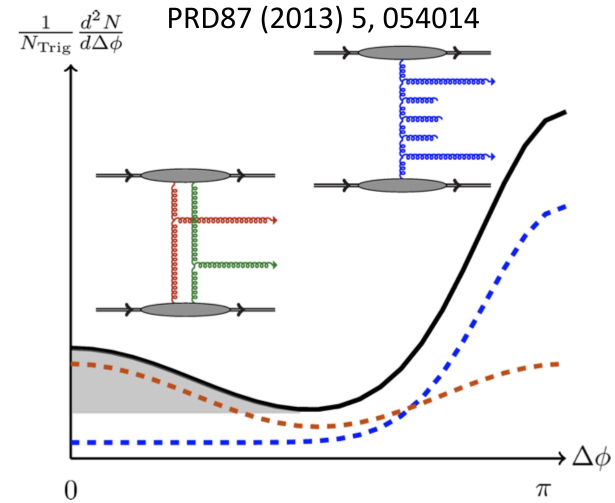


PLB718 (2013) 795-814

Bozek, PRC85 (2012) 014911



Dusling, Venugopalan, PRD87 (2013) 5, 054014



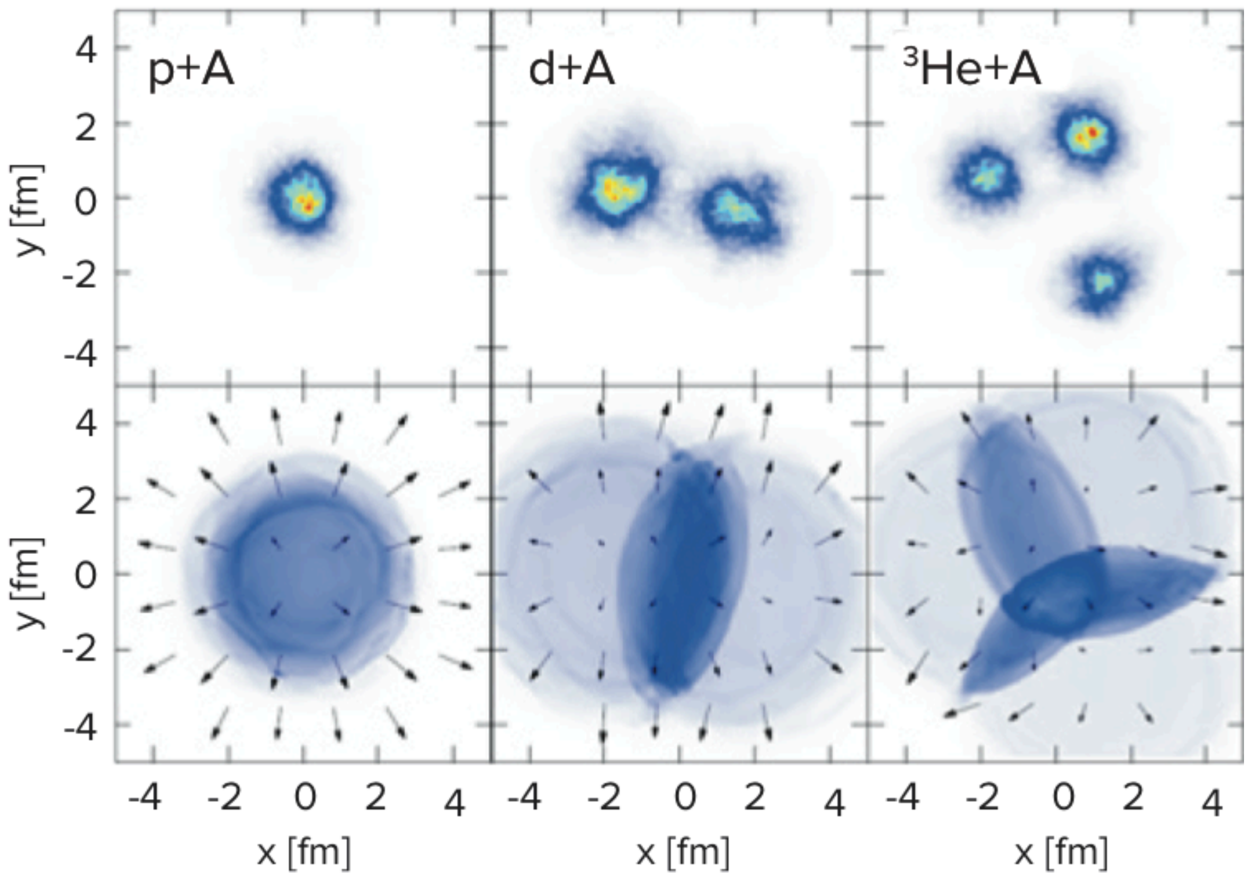
What is the origin of the ridge in p+A?

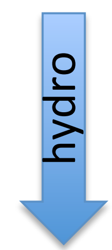
Smallest QGP droplet?

Disentangle initial state from viscosity

Geometry Engineering

p+Au(2015) d+Au(2008) ^{3}He+Au(2014)

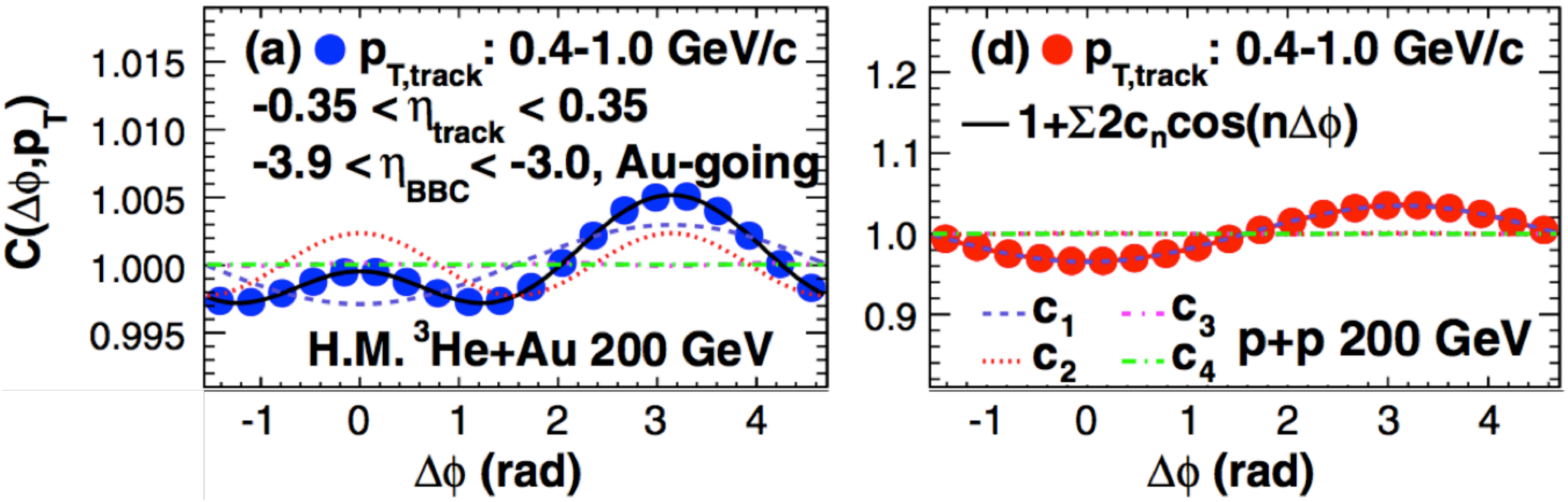




Nagle et al., PRL 113, 112301 (2014),
figure: Bjoern Schenke, NSAC Long Range Plan, 9/2015

Ridge in high-multiplicity ^{3}He+Au

PRL 115, 142301 (2015)



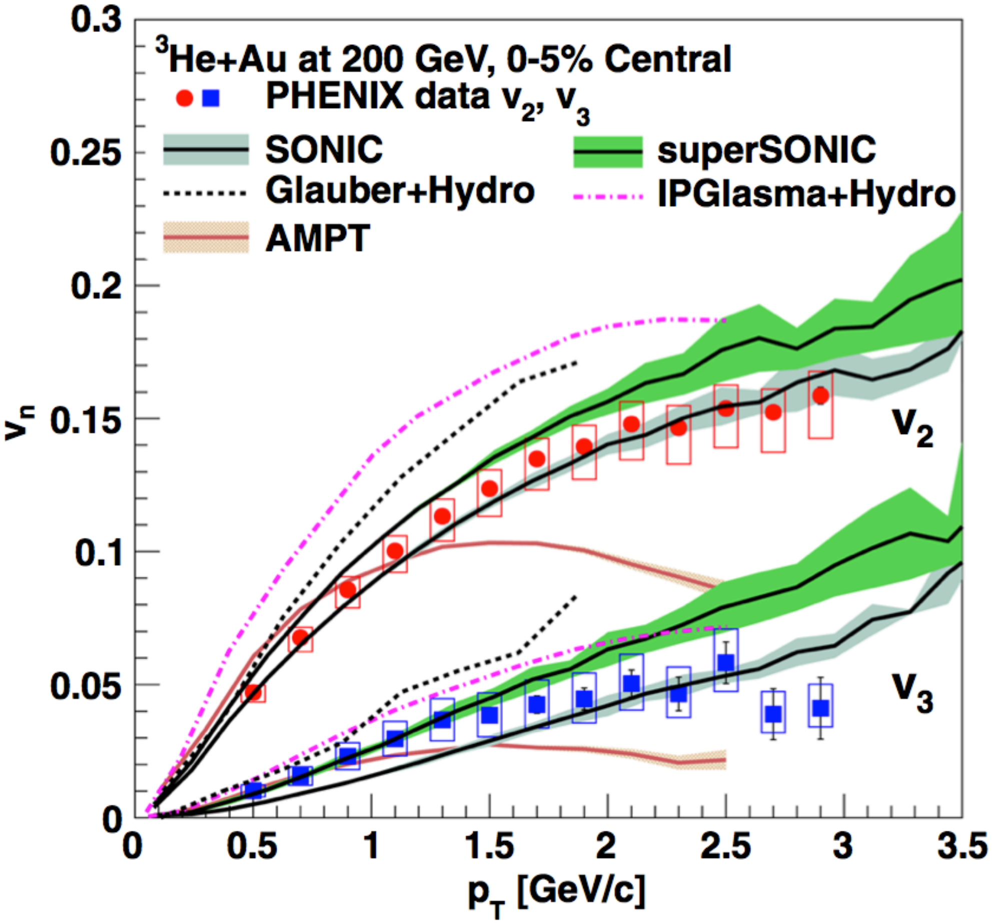
2-particle correlation between mid-rapidity track and backward (Au-going) charge separated by 3 units in pseudo-rapidity

$$S(\Delta\phi, p_T) = \frac{d(w_{\rm PMT} N^{{\rm track}(p_T)\text{-PMT}}_{\rm Same\ event})}{d\Delta\phi},$$

$$C(\Delta\phi, p_T) = \frac{S(\Delta\phi, p_T)}{M(\Delta\phi, p_T)} \frac{\int_0^{2\pi} M(\Delta\phi, p_T) d\Delta\phi}{\int_0^{2\pi} S(\Delta\phi, p_T) d\Delta\phi}$$

v_2, v_3 theory comparison

PRL 115, 142301 (2015)



Event-plane method
mid-rapidity track, FVTX: $-3<\eta<-1$)

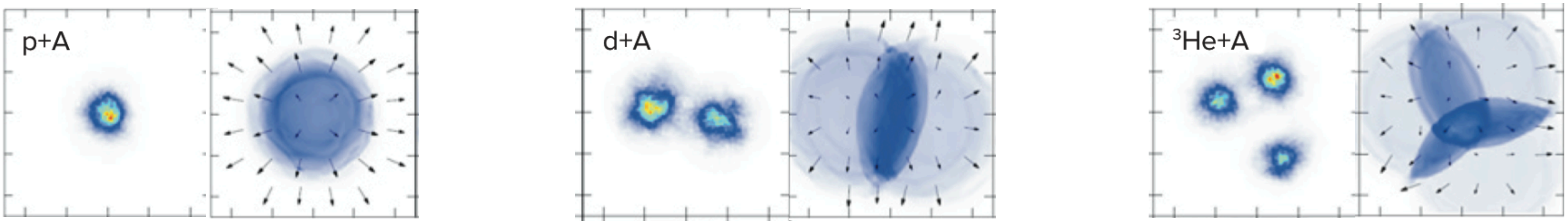
AMPT (A Multi-Phase Transport Model), incoherent elastic parton-parton scatterings, underpredicts data at high p_T

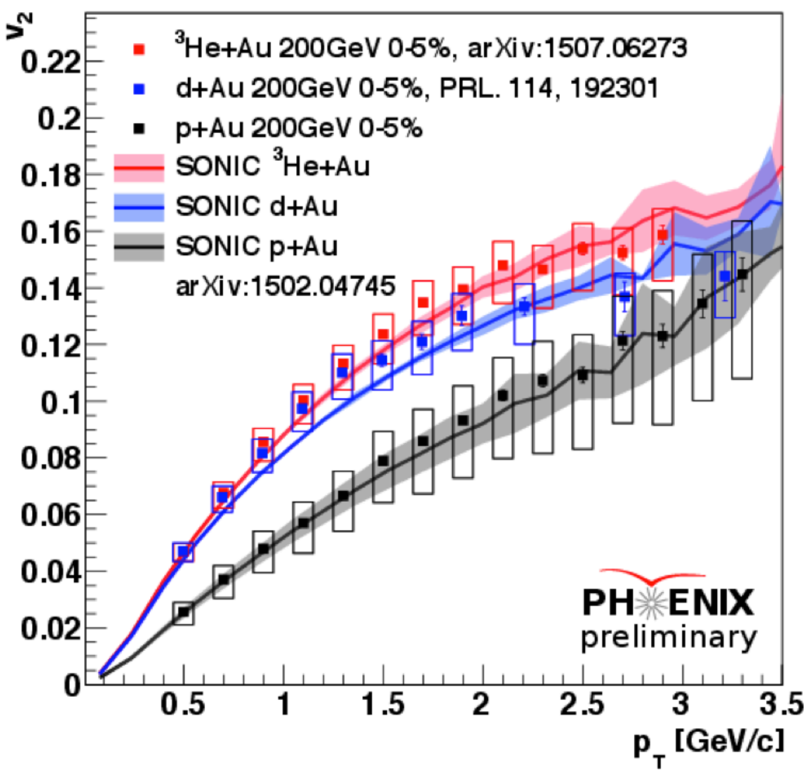
Glauber+Hydro and IP Glasma+Hydro overpredict

Best description with (super)SONIC: Glauber, viscous hydro, hadronic afterburner, (pre-flow)

AMPT: arXiv:1501.06880
SONIC: arXiv:1502.04745
IP+Hydro:arXiv:1407:7557

v_2 system and theory comparison



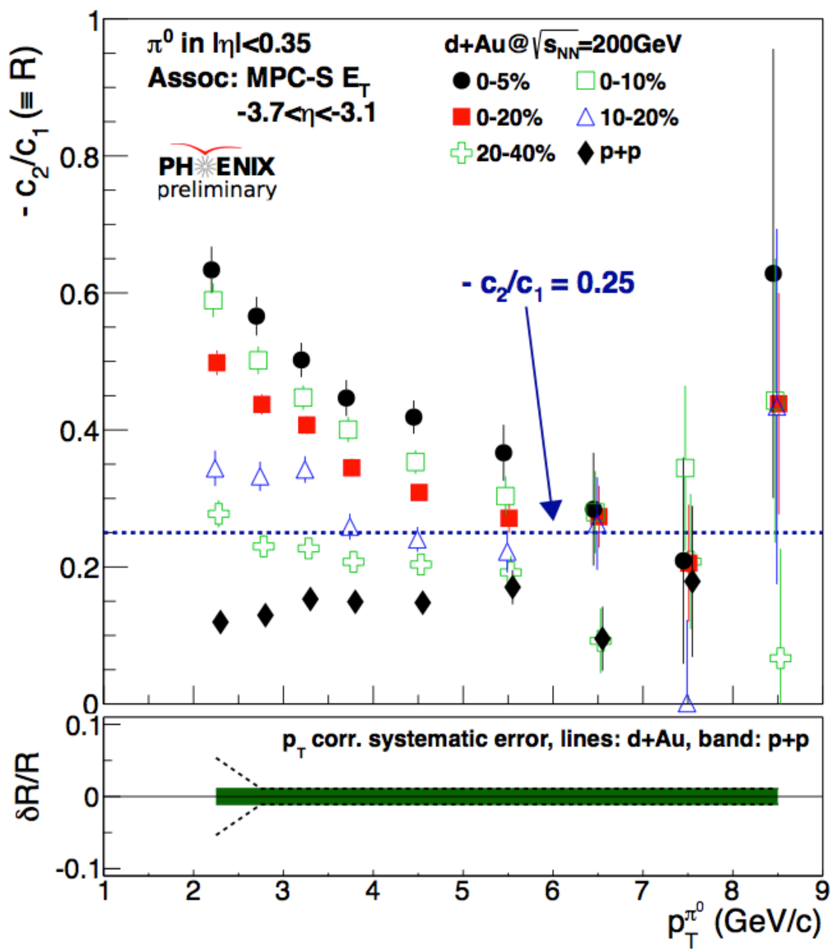


Good description with SONIC (Glauber, viscous hydro, hadronic afterburner) for all three systems

d+Au energy scan coming up this spring!

Talk by Vicki G. on flow in Cu+Au

Energy loss in small systems?



Extend previous analysis in d+Au to higher p_T by substituting mid-rapidity tracks with π^0s

Normalize c_2 by c_1 as proxy for primordial multiplicity-related effects

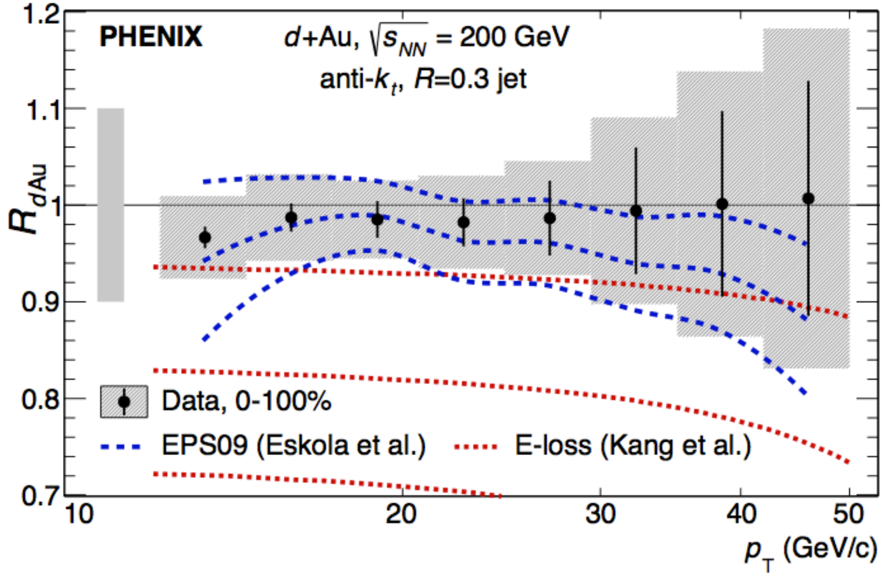
$-c_2/c_1$ { > 0.25: crest in CF; < 0.25: trough in CF }

Crest extends to p_T = 6 GeV/c in central d+Au

Similar to high p_T v_2 behavior in Au+Au

Jets in d+Au

arXiv:1509.04657



$$R_{dAu} = \frac{dY^{\pi^0}_{d+Au}\Big|_f / dp_T}{\langle T_{d+Au}\rangle\Big|_f \, d\sigma^{\pi^0}_{p+p} / dp_T}$$

minimum bias jets show no energy loss

Jets in d+Au

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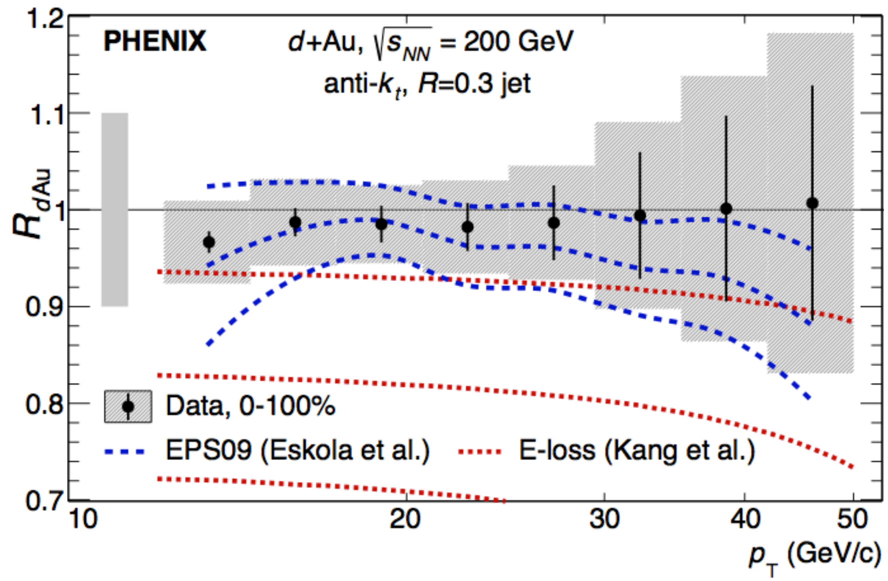
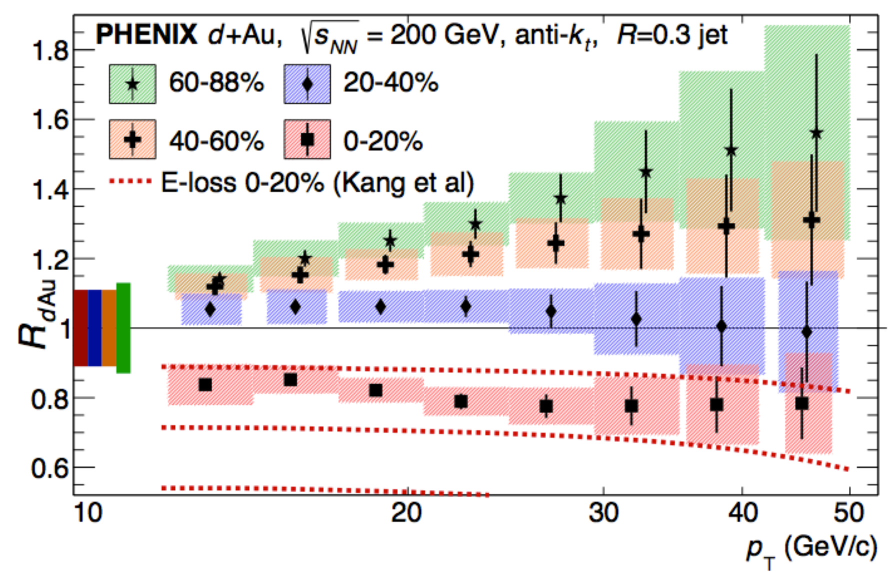




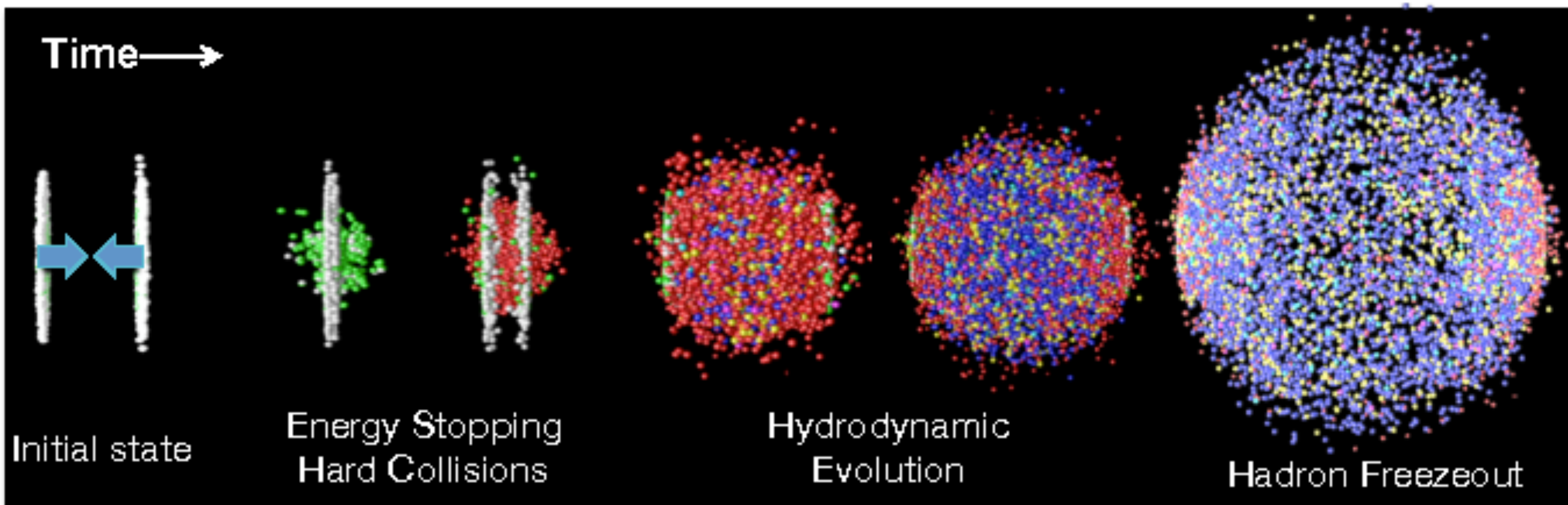
minimum bias jets show no energy loss

Strong centrality dependence

But different from that in Au+Au

Explanation would be anti-correlation between hard and soft particle production

Time evolution of heavy ion collision



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Dileptons
Hadronization, chiral symmetry restoration

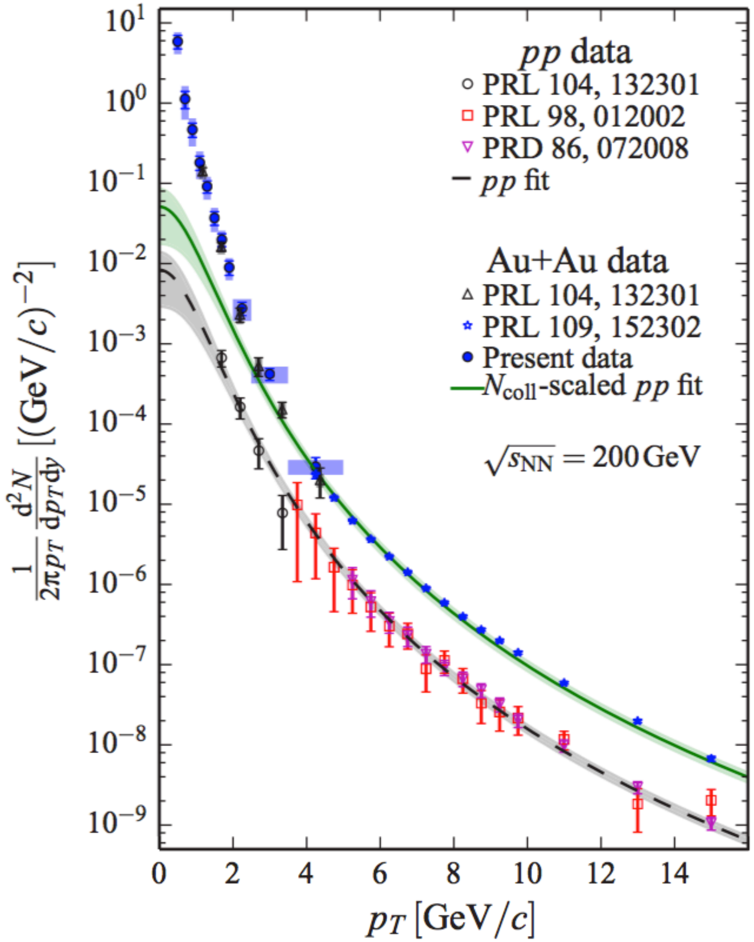
Direct photon spectra and flow
Space-time evolution

Beam Energy Scan
Critical point

Heavy flavor energy loss
QGP transport coefficient

Direct photon spectrum

PRC 91, 064904 (2015)



Photons do not interact strongly

Carry information from entire space-time history

External conversion method

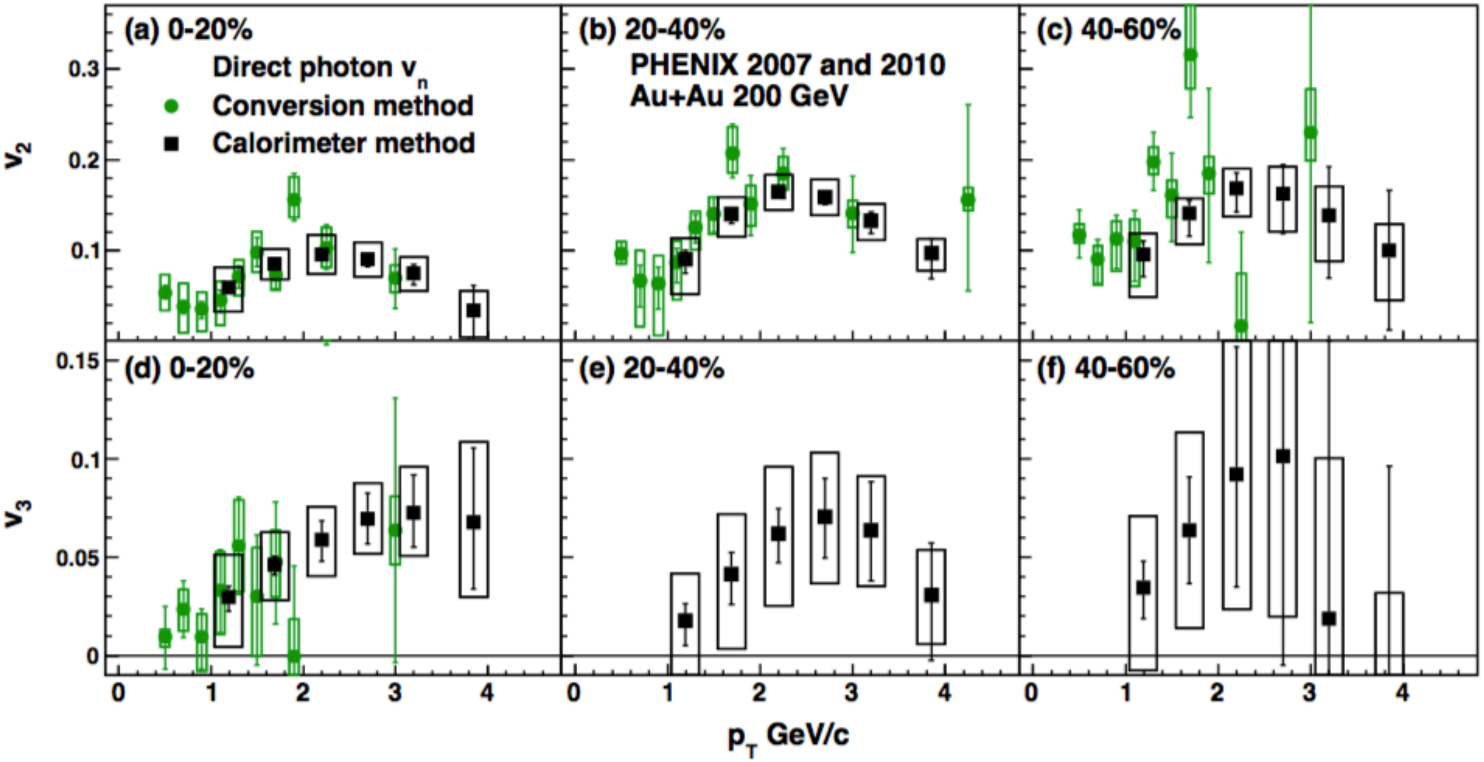
Extends previous measurement to lower p_T

Large exponential excess above pQCD photons

Inverse slope of excess: $T_{eff} \approx 240$ MeV

Direct photon flow

arXiv:1509.07758

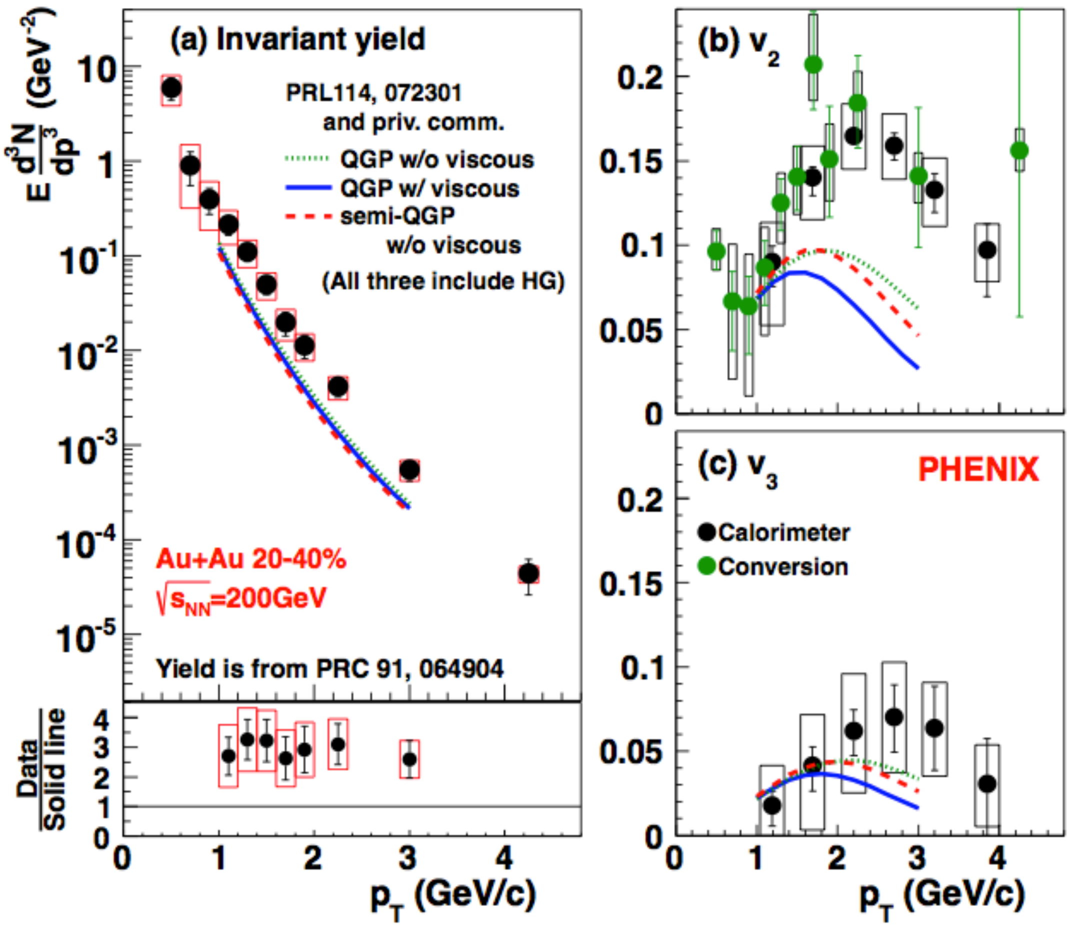


Large direct photon v_2 observed (similar to hadrons)

Large v_3 observed, no significant centrality dependence (similar to hadrons)

Example model comparison

arXiv:1509.07758



Paquet, Shen, Denicol, Luzum, Schenke, Jeon, Gale, arXiv:1509.06738
Shen, Paquet, Heinz, Gale, PRCC 91, 014908 (2015)
Gale, Hidaka, Jeon, Lin, Paquet, Pisarski, Satow, Skokov, Vujanovic, PRL 114, 072301 (2015)

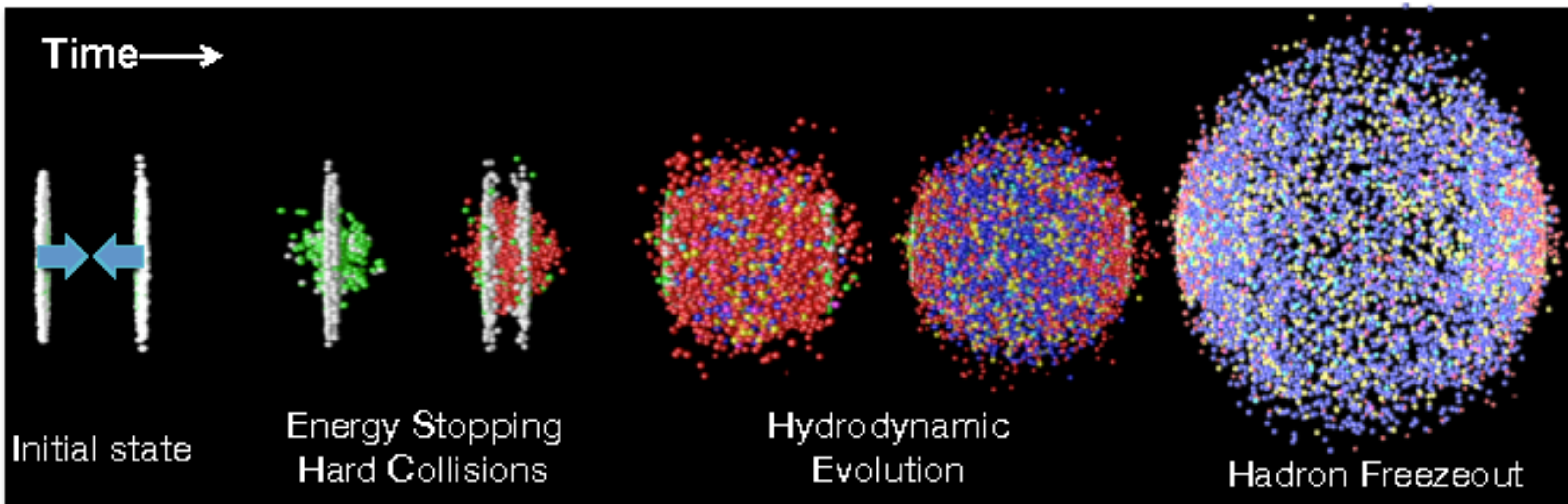
Simultaneous description of large yield and large flow difficult

Late emission important

Shining sQGP

Talk by Edward K. on leptonic probes at RHIC

Time evolution of heavy ion collision



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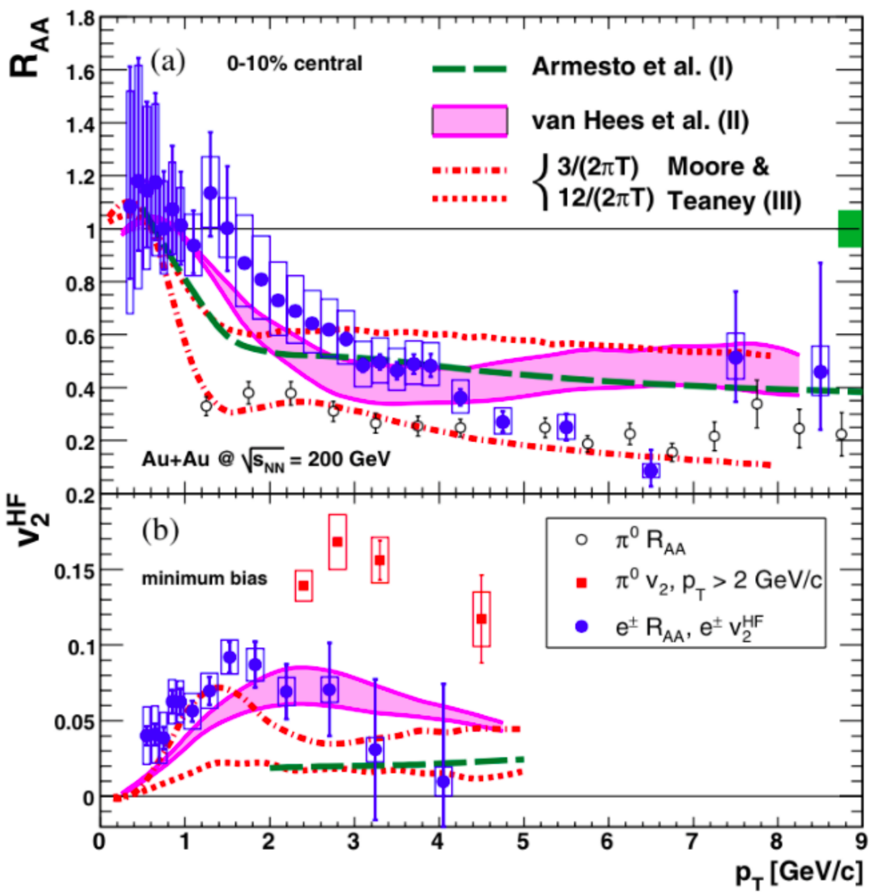
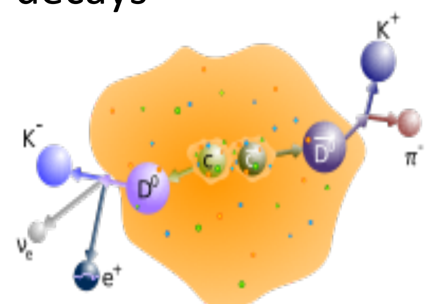
PHENIX heavy flavor suppression

PRC84, 044905 (2011)



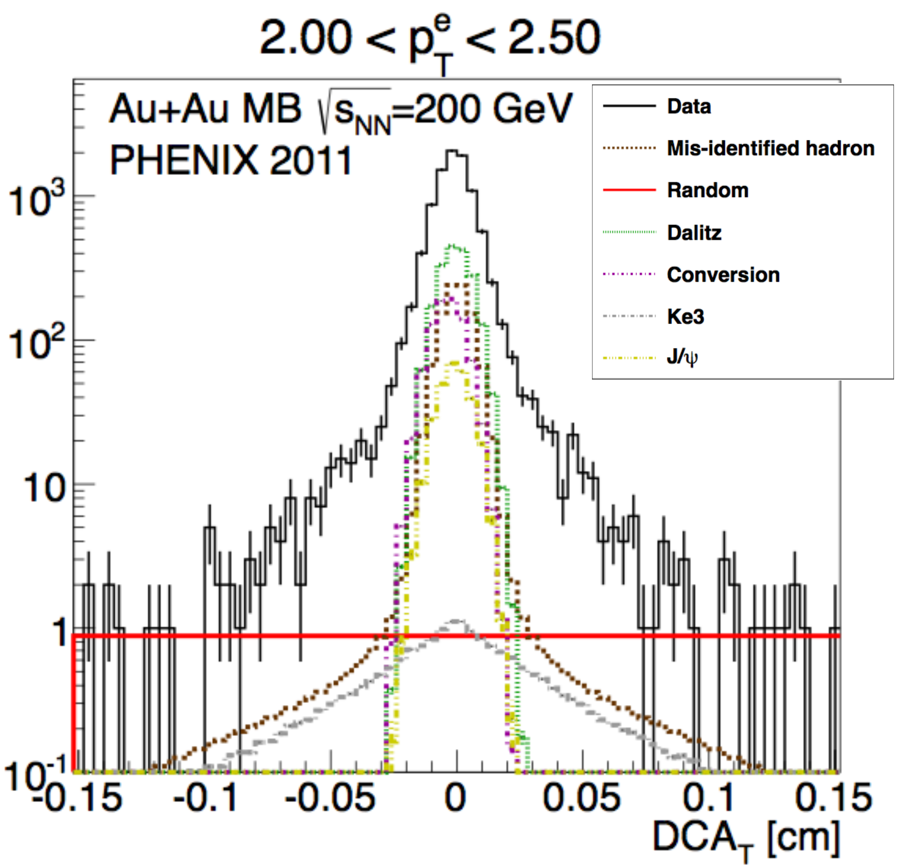
Discovery of large suppression and elliptic flow of single electrons from heavy flavor decays



Expect less bottom suppression (dead cone effect)

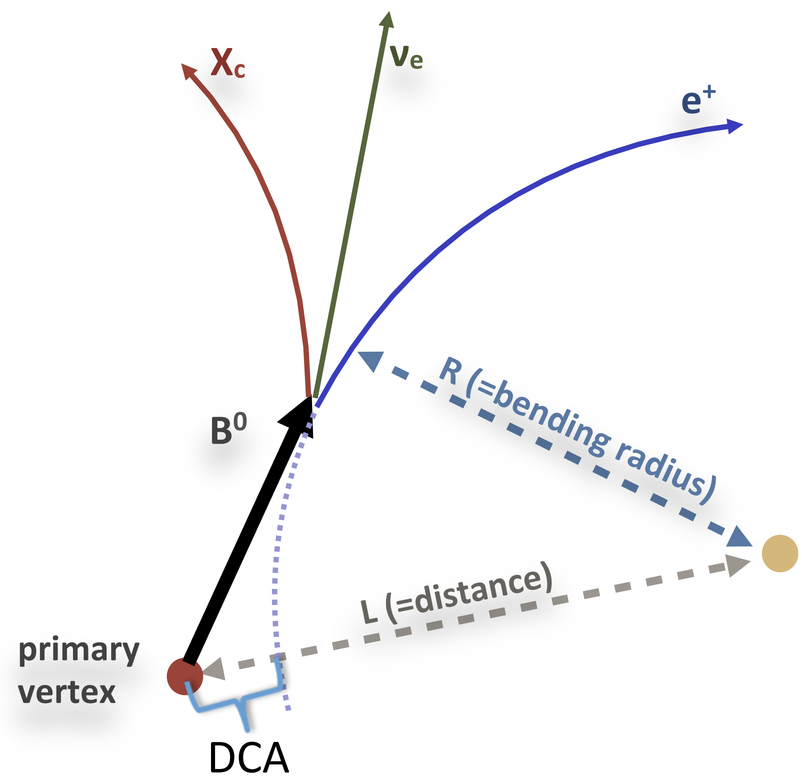
Separate charm and bottom!

Barrel Silicon Vertex Detector



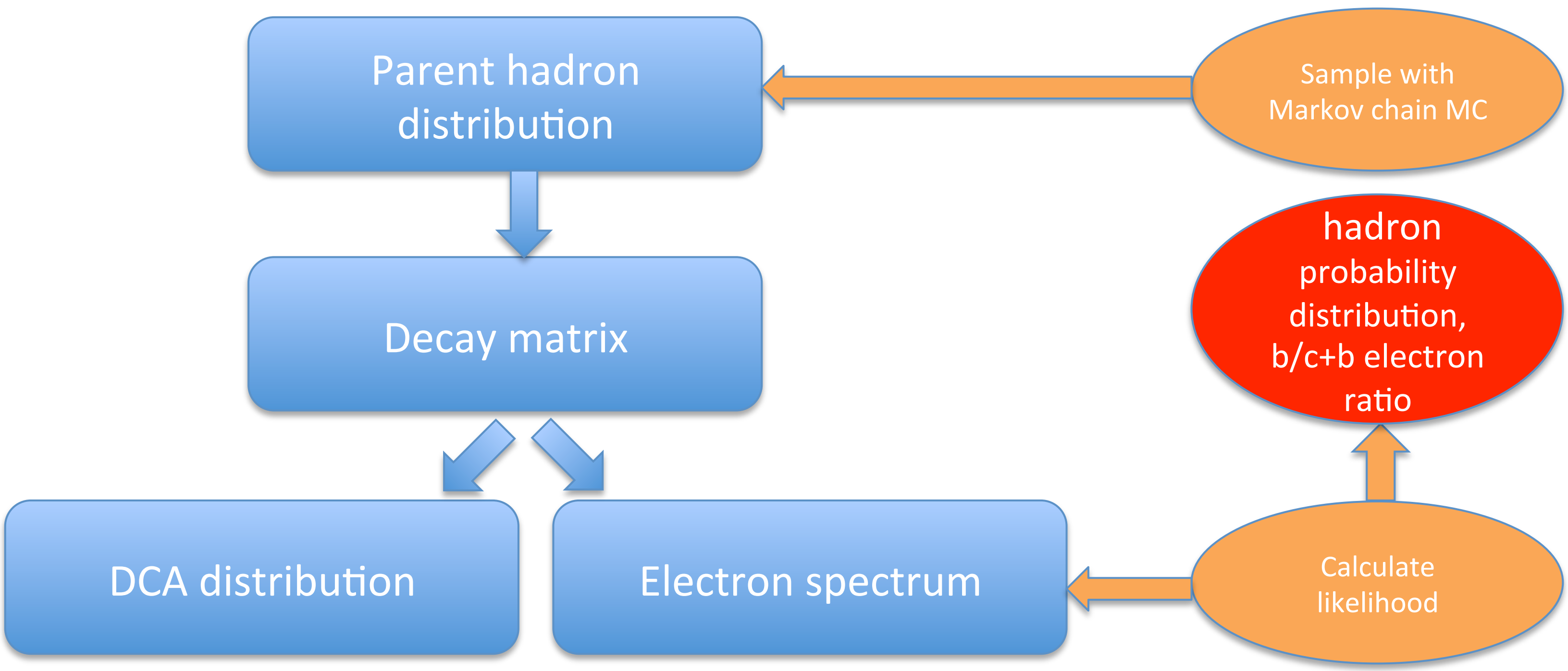
DCA resolution < 75 μm

Silicon Vertex Detector provides precision measurement of Secondary decay vertex: Distance of Closest Approach (DCA)



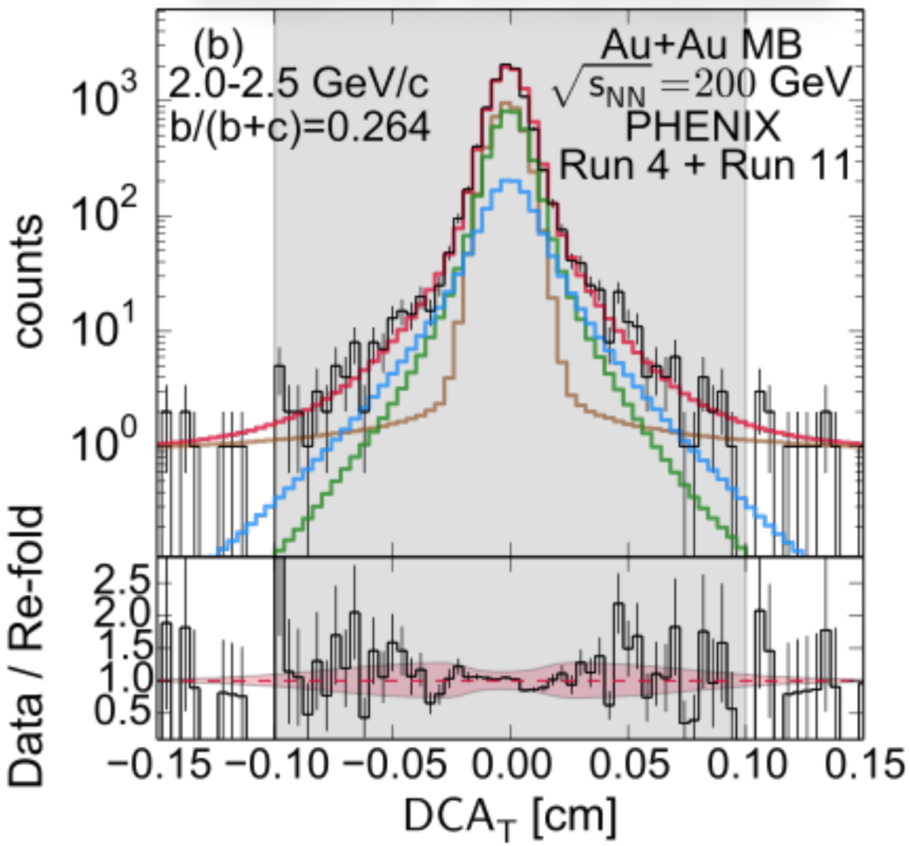
Unfolding

Electron DCA and spectrum depends on hadron distribution, which is not known *a priori:*
requires unfolding
(Bayesian inference technique)



Data comparison

Accepted in PRC, arXiv:1509.04662 (2015)



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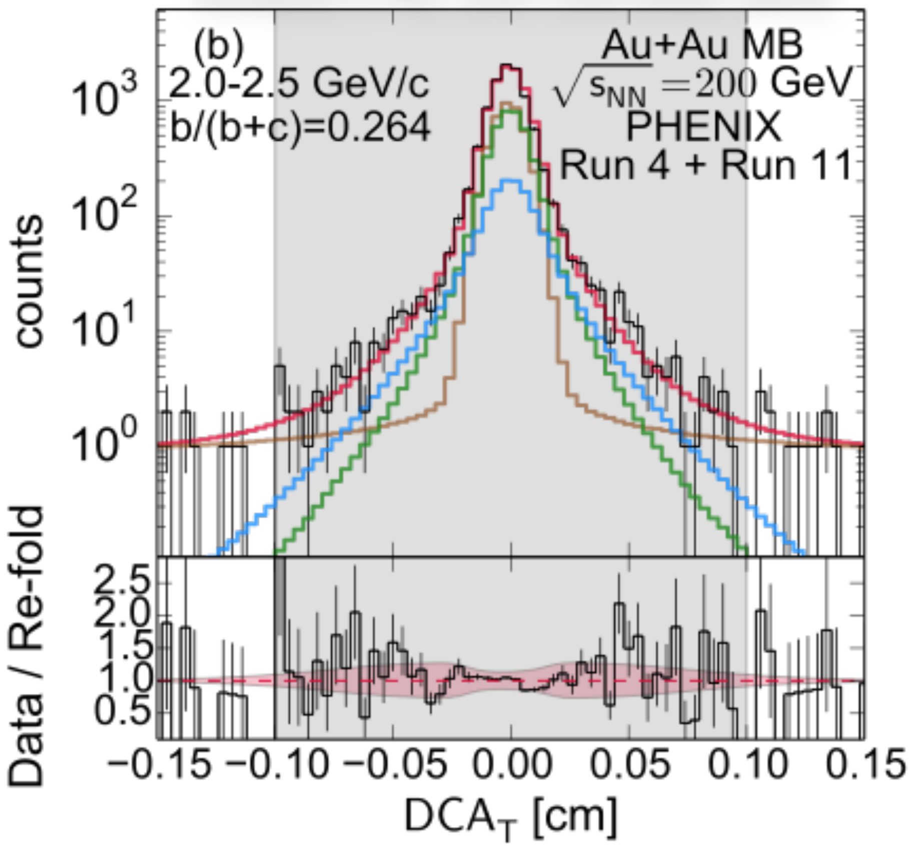

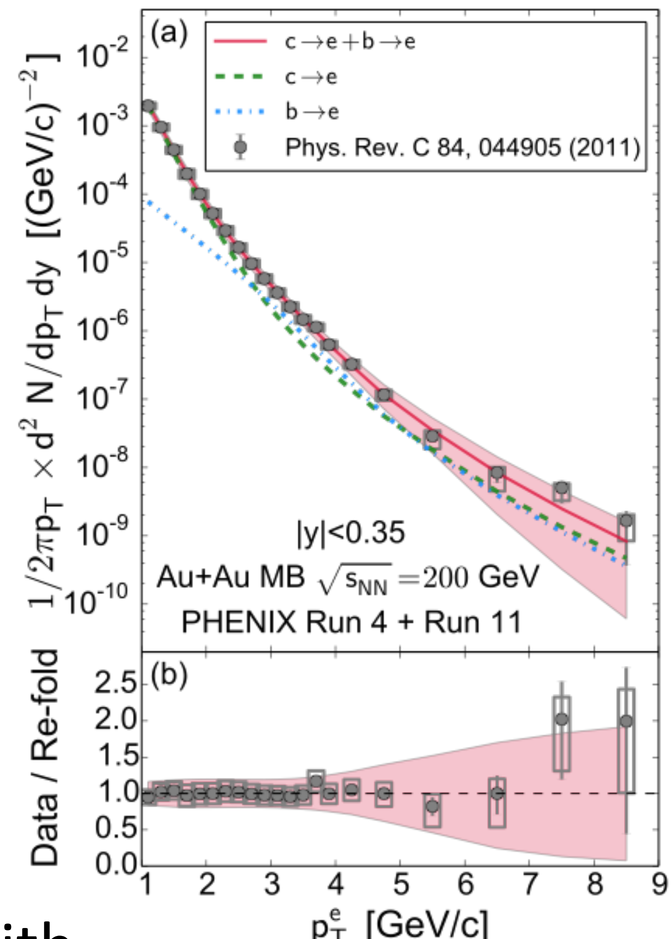

Unfold gives good consistency with DCA_T and electron invariant yield

Unfolded hadron yields

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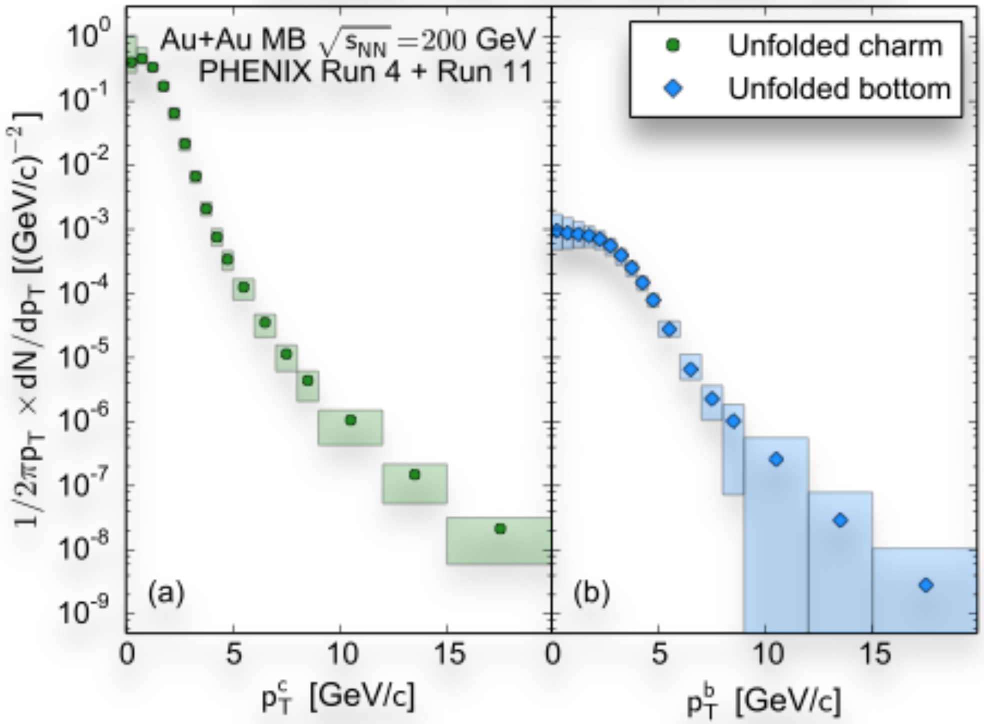

Result of unfolding procedure is invariant yield of charm and bottom

Unfolded hadron yields

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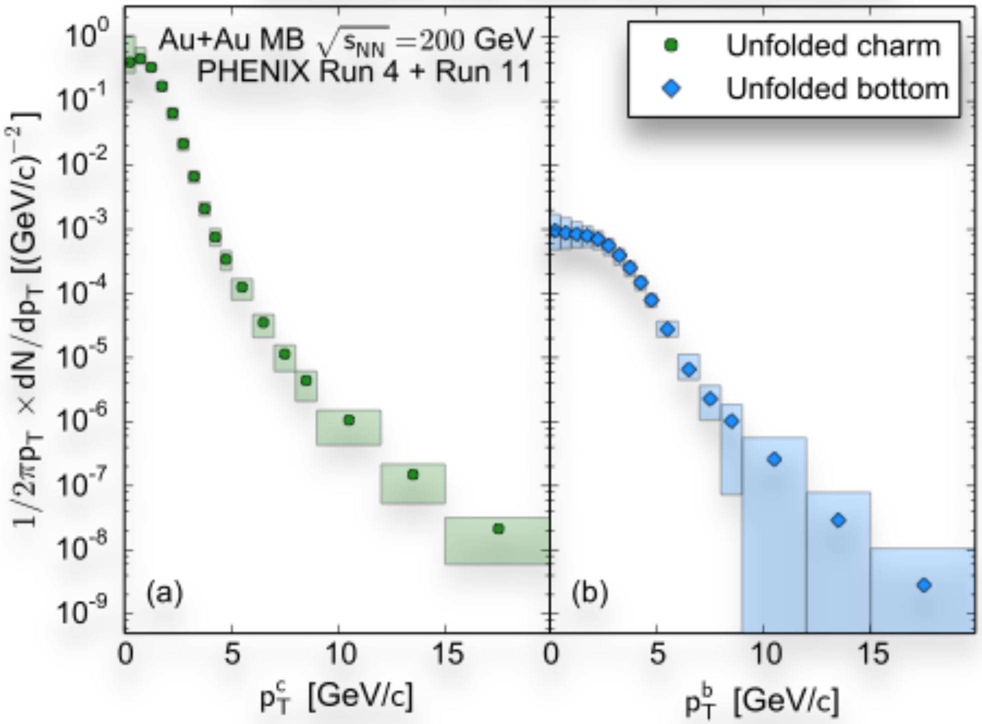
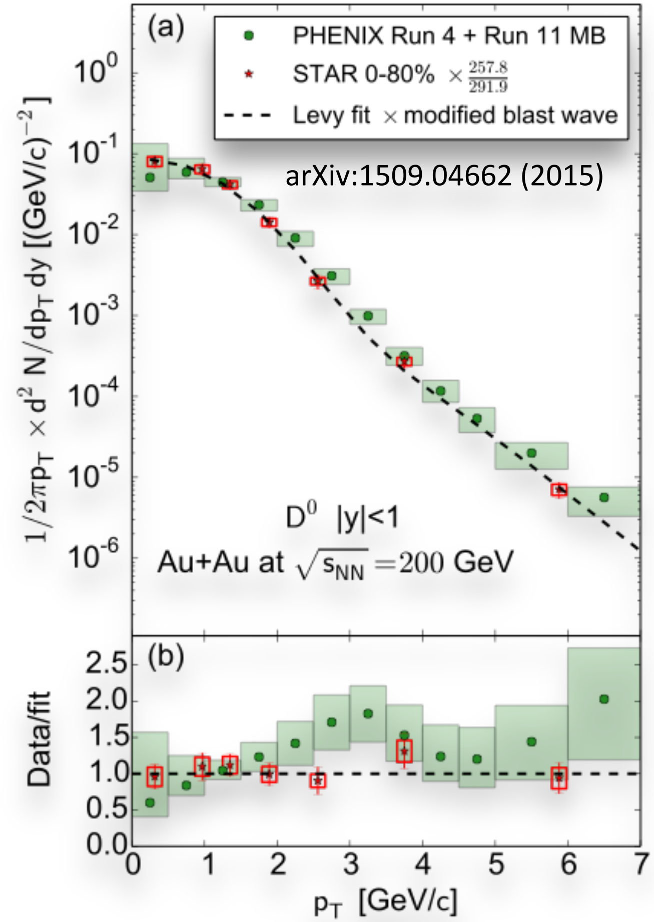
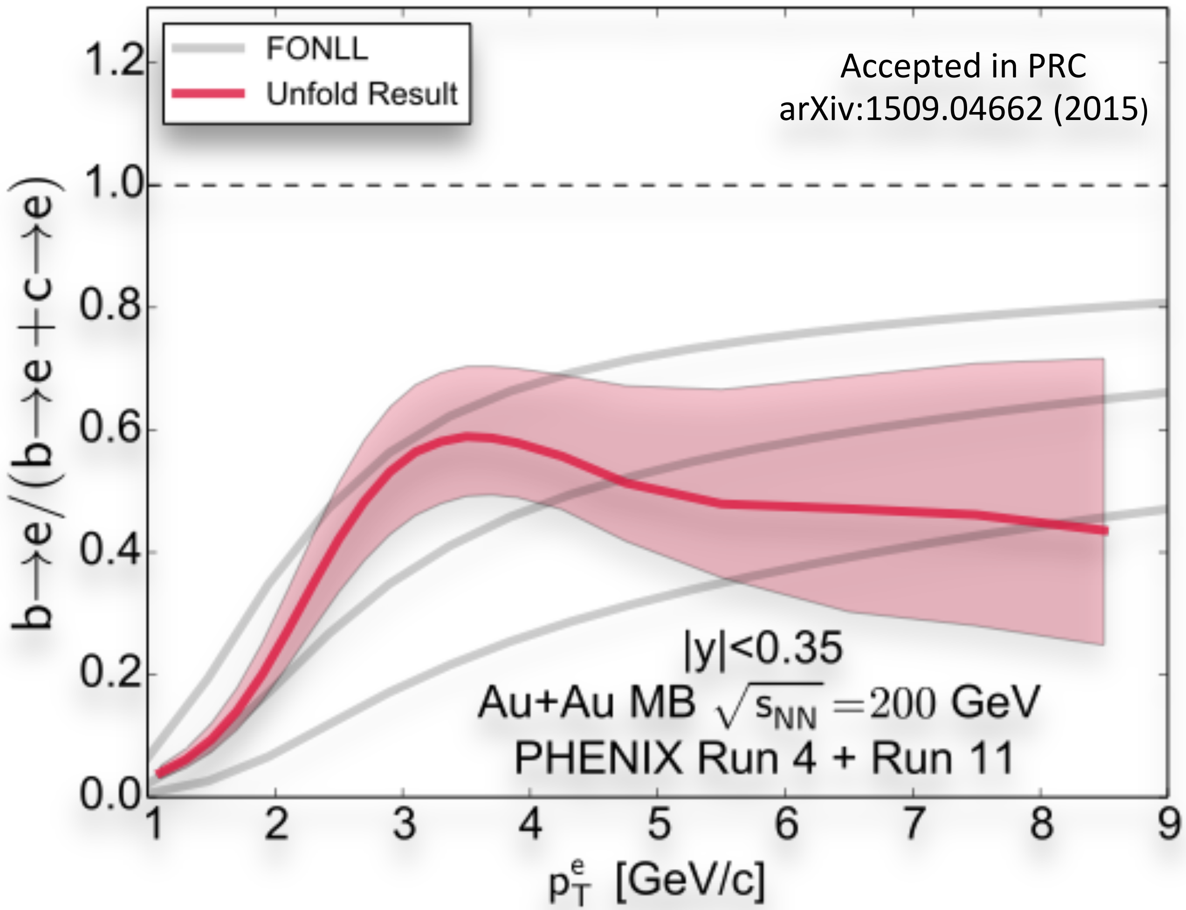




Result of unfolding procedure is invariant yield of charm and bottom

Good agreement with STAR D^0

Bottom electron fraction



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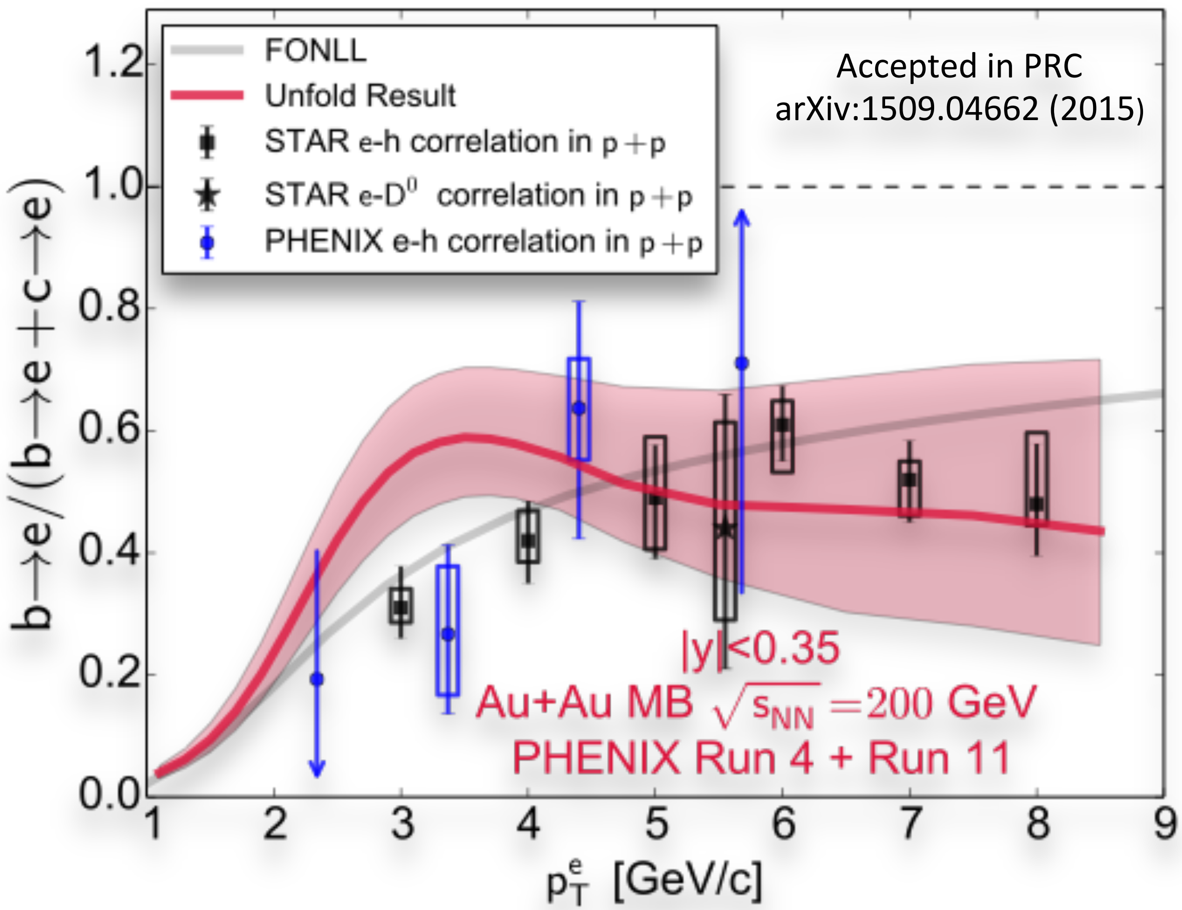
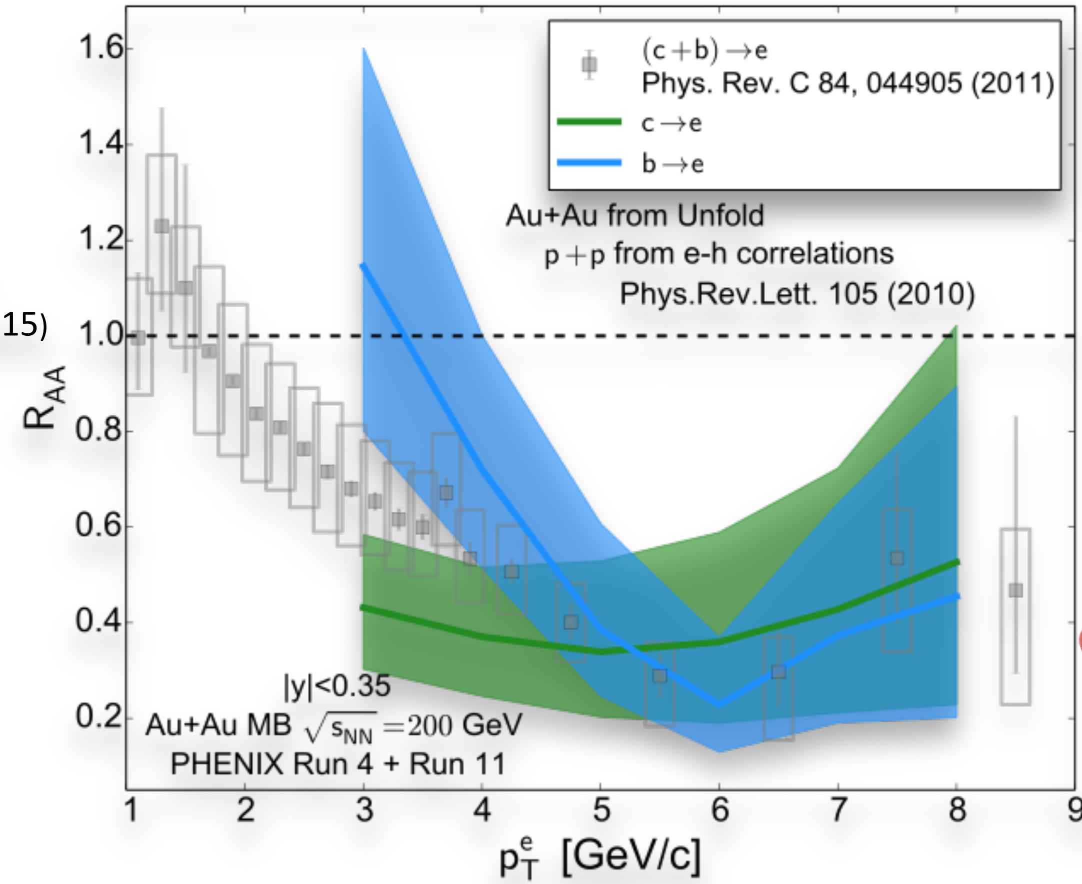


Enhancement above p+p measurements and FONLL at p_T = 3-4 GeV/c

Heavy Flavor R_{AA}

Accepted in PRC
arXiv:1509.04662 (2015)



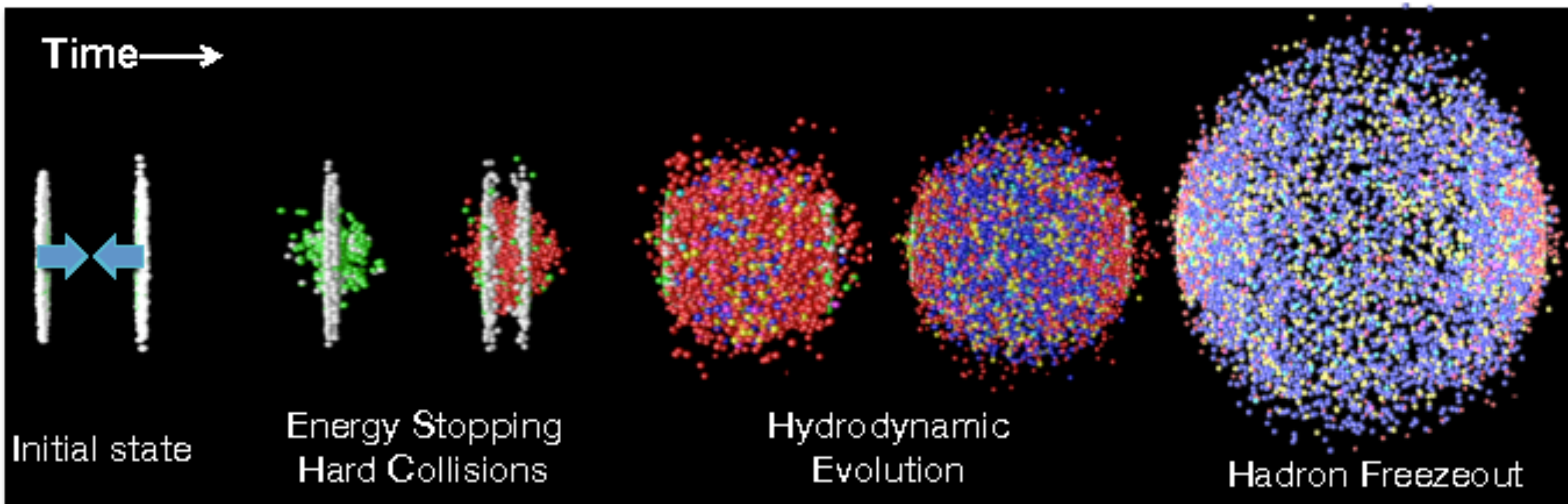
Looking forward to 10 x statistics from 2014 run

Talk by Hidemitsu A.

Electrons from bottom less suppressed than those from charm for p_T < 4 GeV/c
Similarly suppressed for p_T > 4 GeV/c

See talk by Hidemitsu Asano

Time evolution of heavy ion collision



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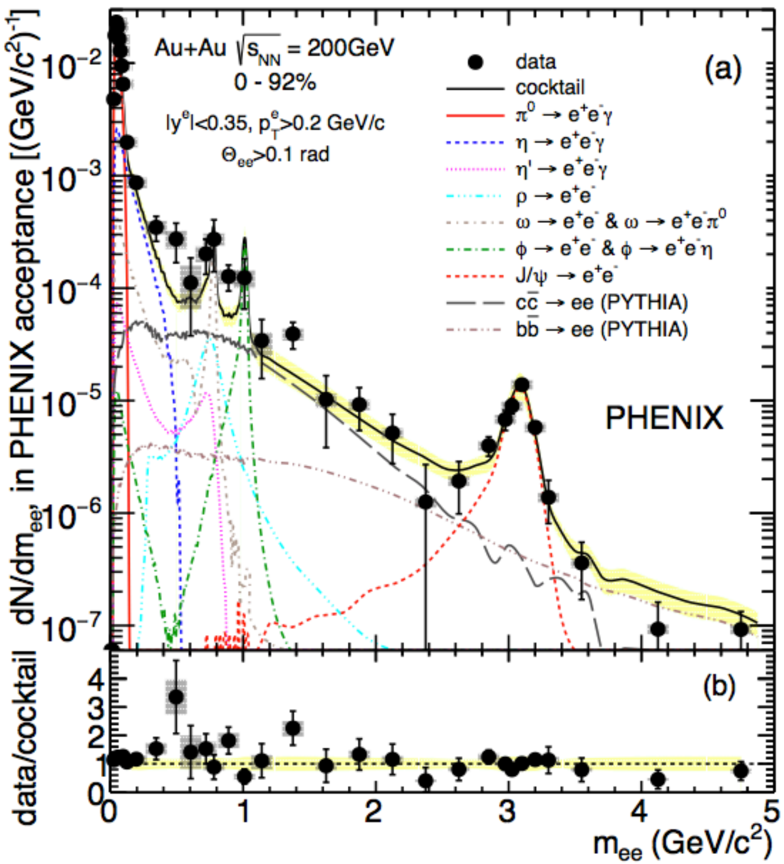
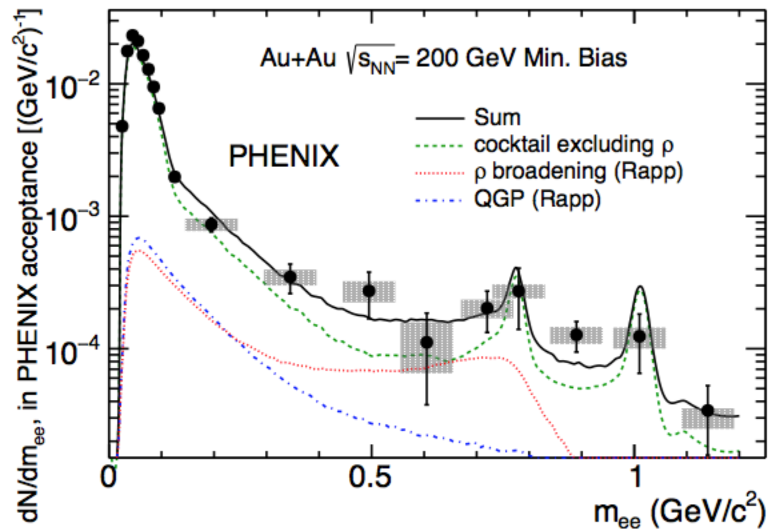
Dileptons

Accepted in PRC, arXiv:1509.04667 (2015)





Moderate enhancement in low mass region

Smaller than previous PHENIX result

Consistent with STAR

Consistent with ρ broadening

Accepted for publication in PRC

New measurement with Hadron Blind Detector

Sub-percent understanding of background

Neural networks for PID

Talk by Edward K. on leptonic probes at RHIC

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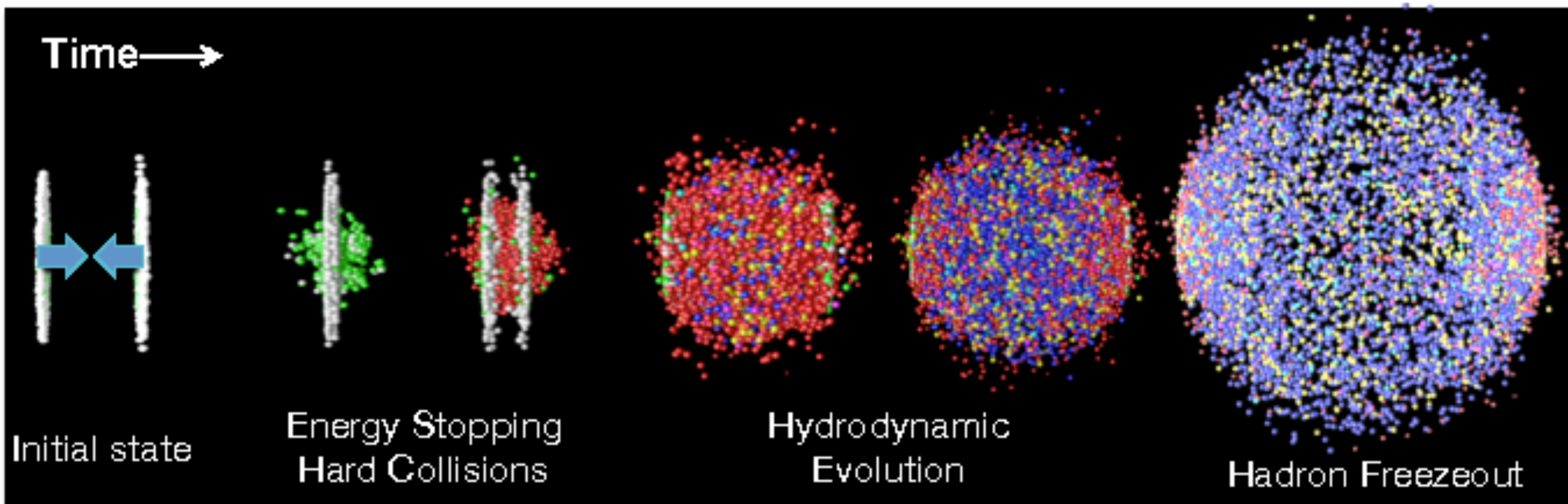

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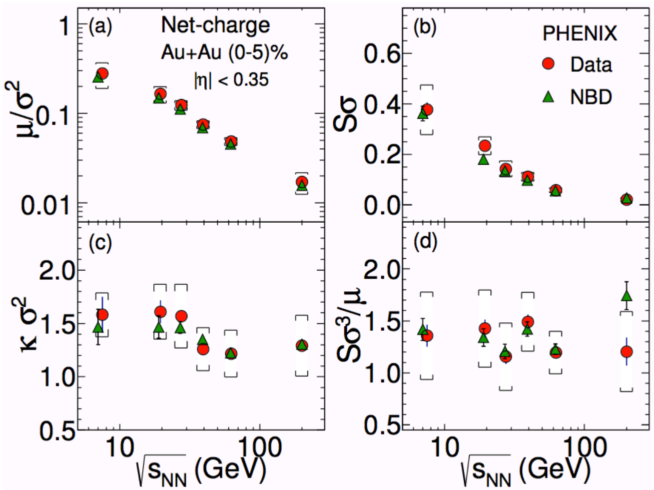
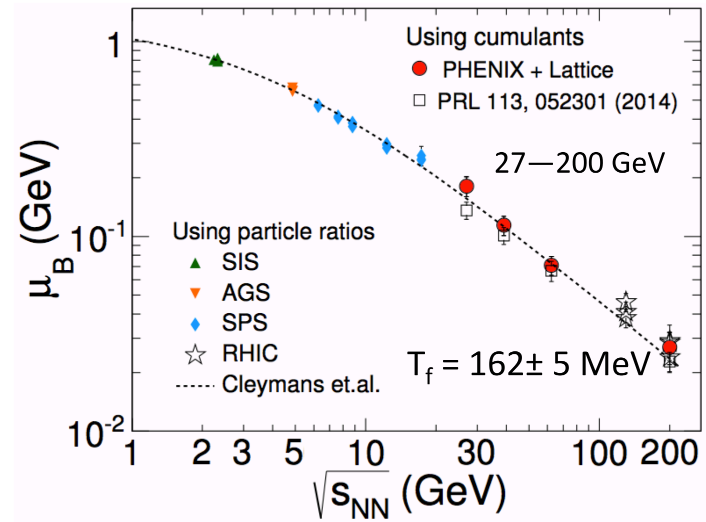
arXiv:1506.07834



Cumulants of net charge distribution

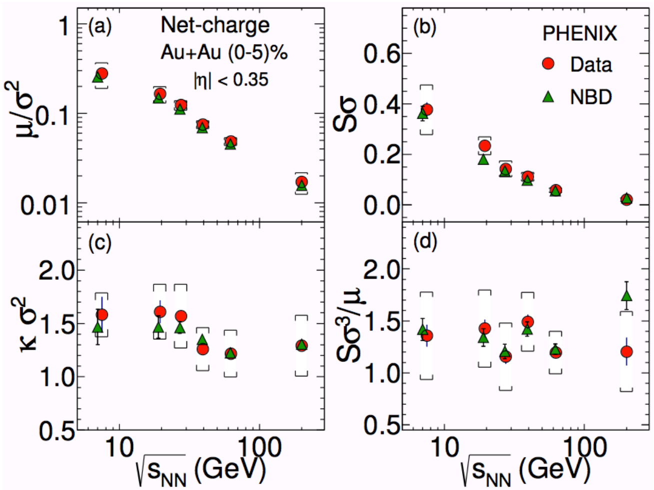
Lattice



Monotonic change of μ_b at constant T_f

Beam Energy Scan

arXiv:1506.07834



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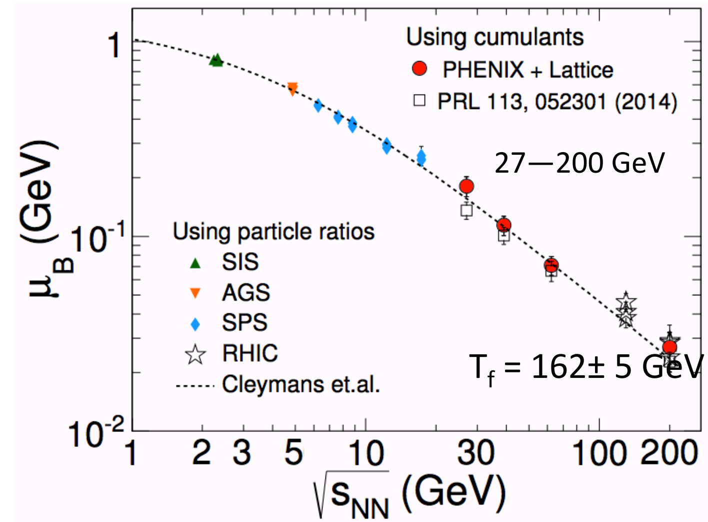

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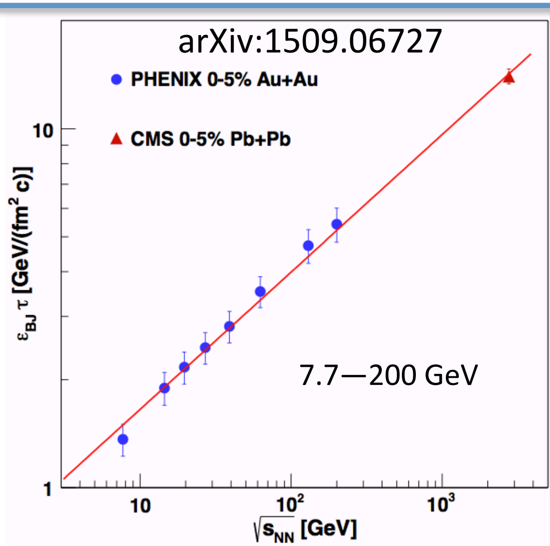
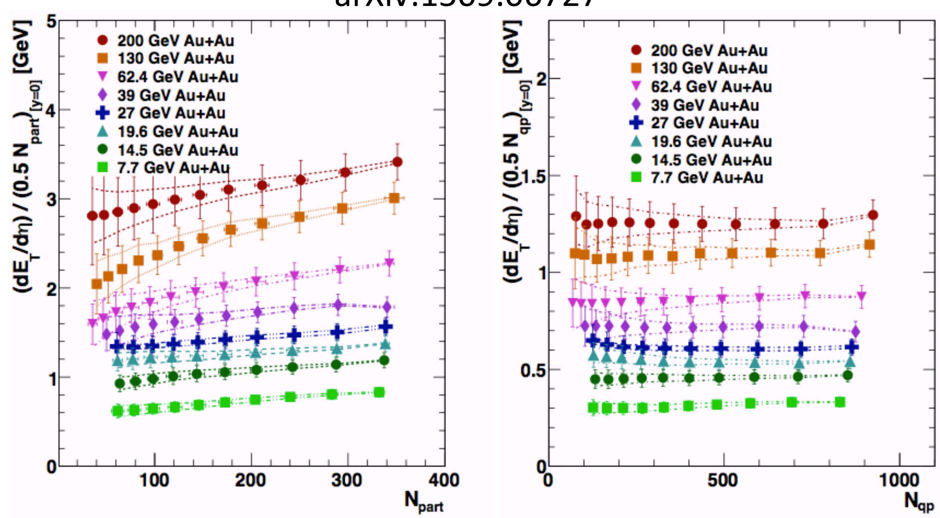


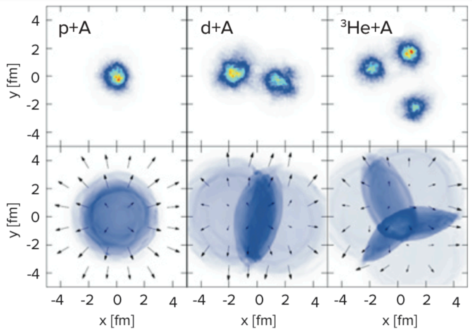
Energy density shows power law dependence on beam energy

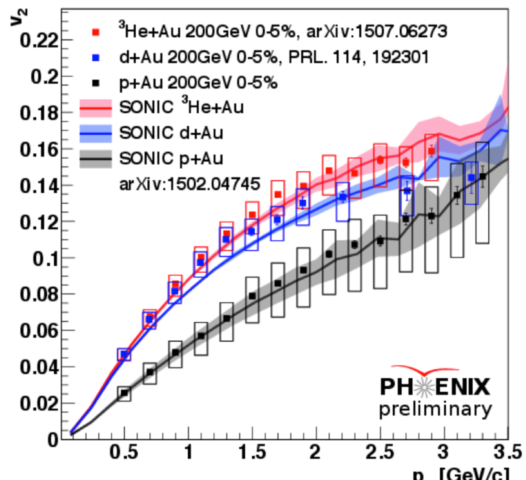
arXiv:1509.06727



E_T scales better with N_{QP} than with $_N$part

Summary and Outlook

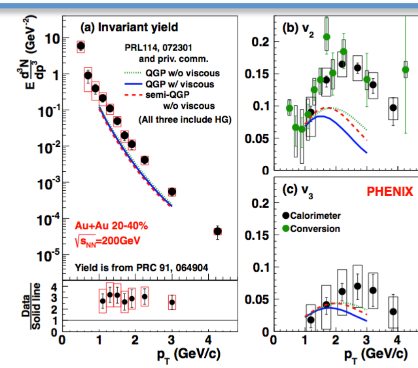




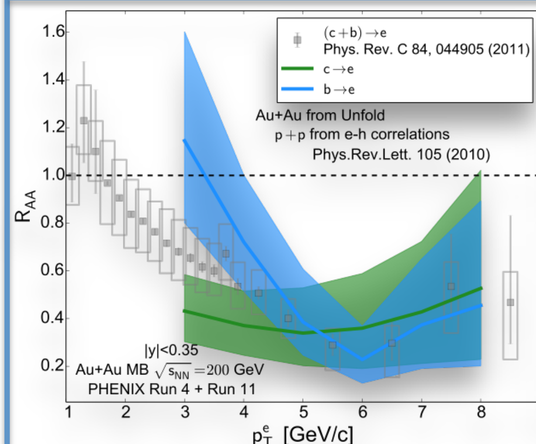
Strong evidence for collective motion in light-heavy ion collisions

Constraints on initial state versus viscosity

d+Au energy scan coming up



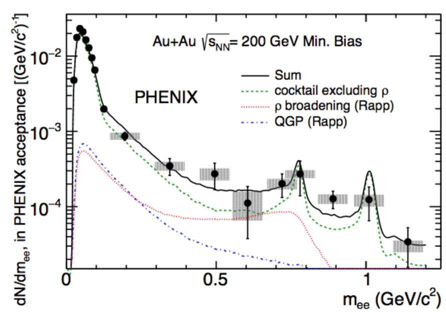
Direct photons strongly constrain space-time evolution



First measurement of bottom energy loss

Bottom less suppressed than charm at 3—4 GeV/c

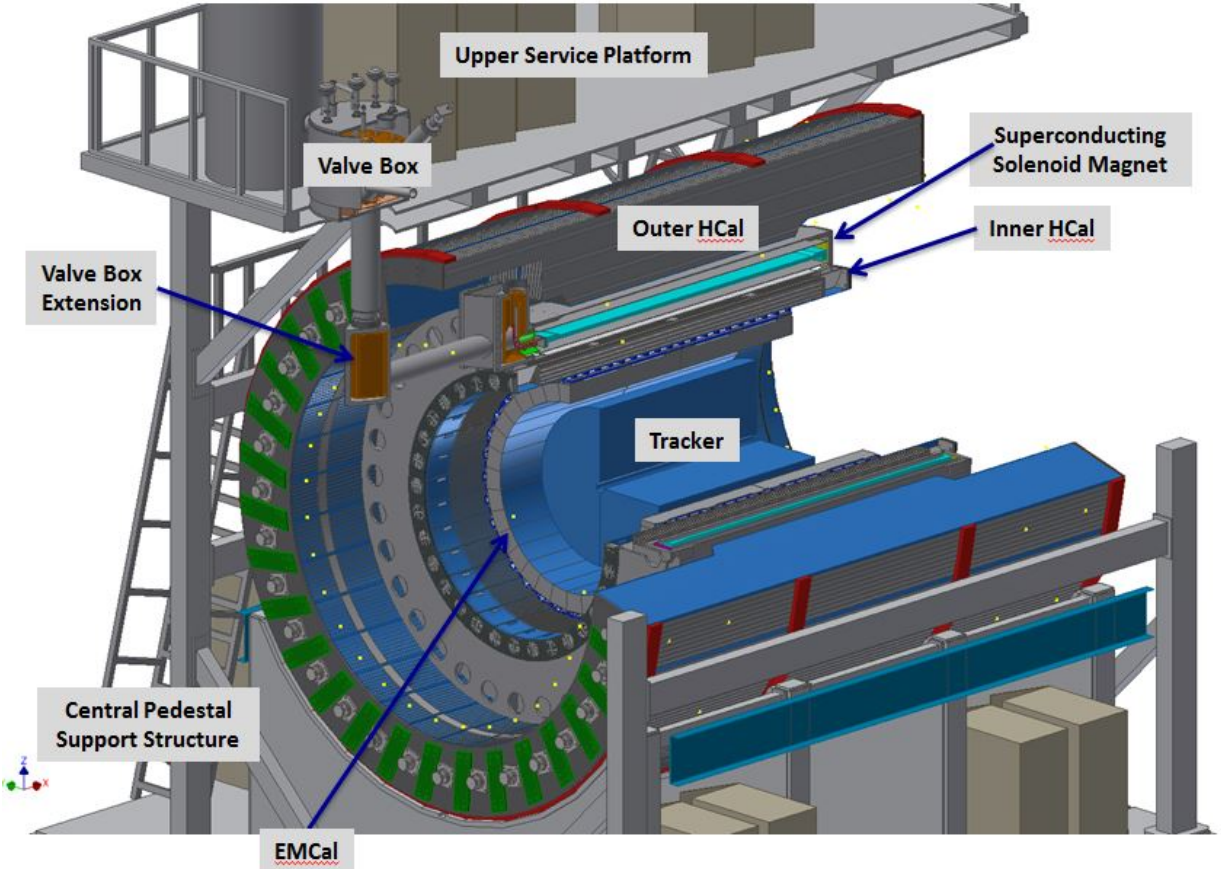
Upcoming analysis of high statistics run



Final HBD dilepton measurement

Consistent with ρ broadening

A Large-Acceptance Jet and Y Detector for RHIC (sPHENIX)



Talk by Rosi Reed

Science case endorsed through Department of Energy review
First constitutional collaboration meeting December 10-12, 2015, at Rutgers University