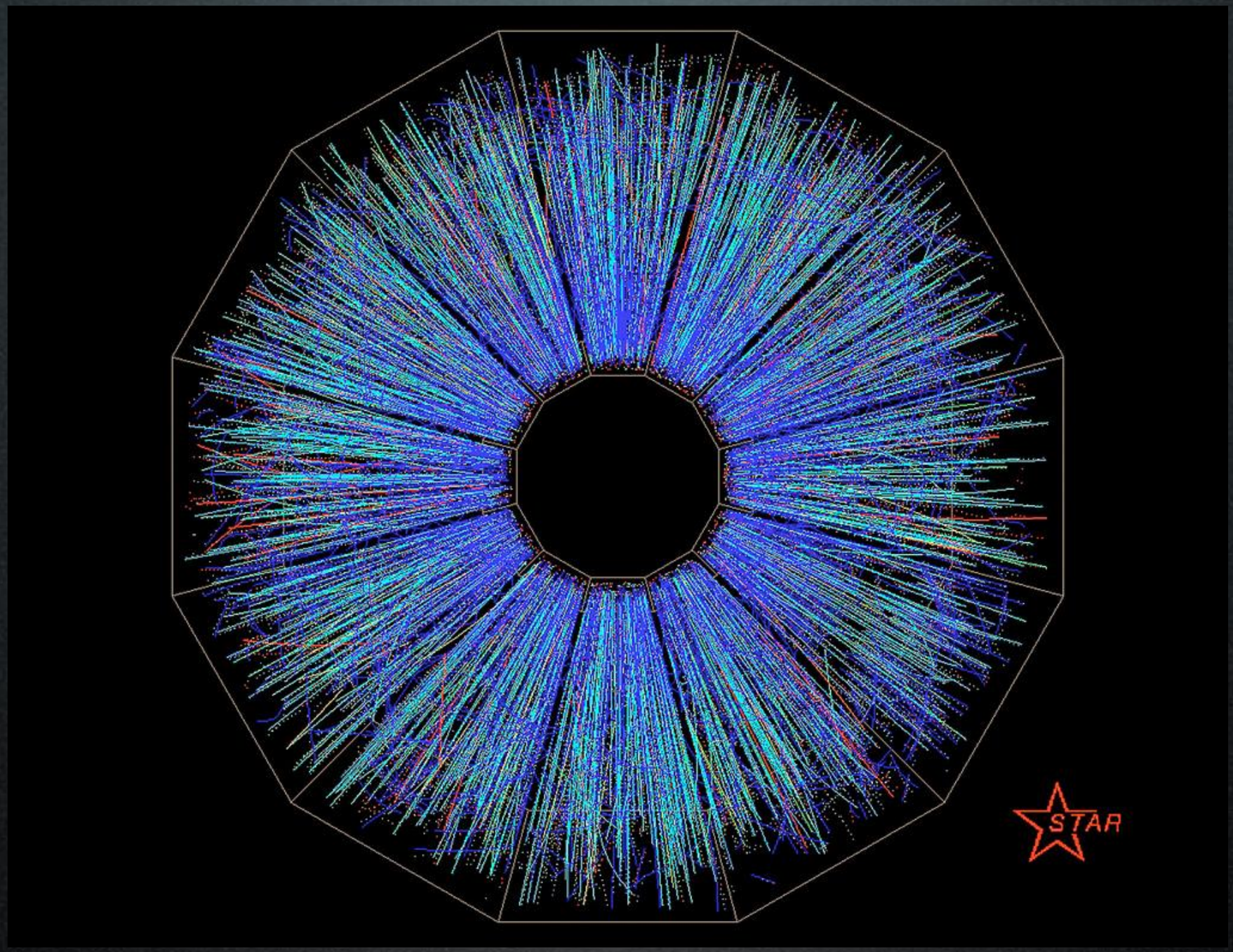


Solenoidal Tracker At Rhic (STAR) with recent Results

Outline

- Relativistic Heavy Ion Collision
- STAR Experiment at RHIC(ollider) in BNL
- Recent Highlights (some updates of QM2011)
- A Large Ion Collider Exp. @ LHC

Brookhaven National Lab. (BNL)

★ First collision: 2000

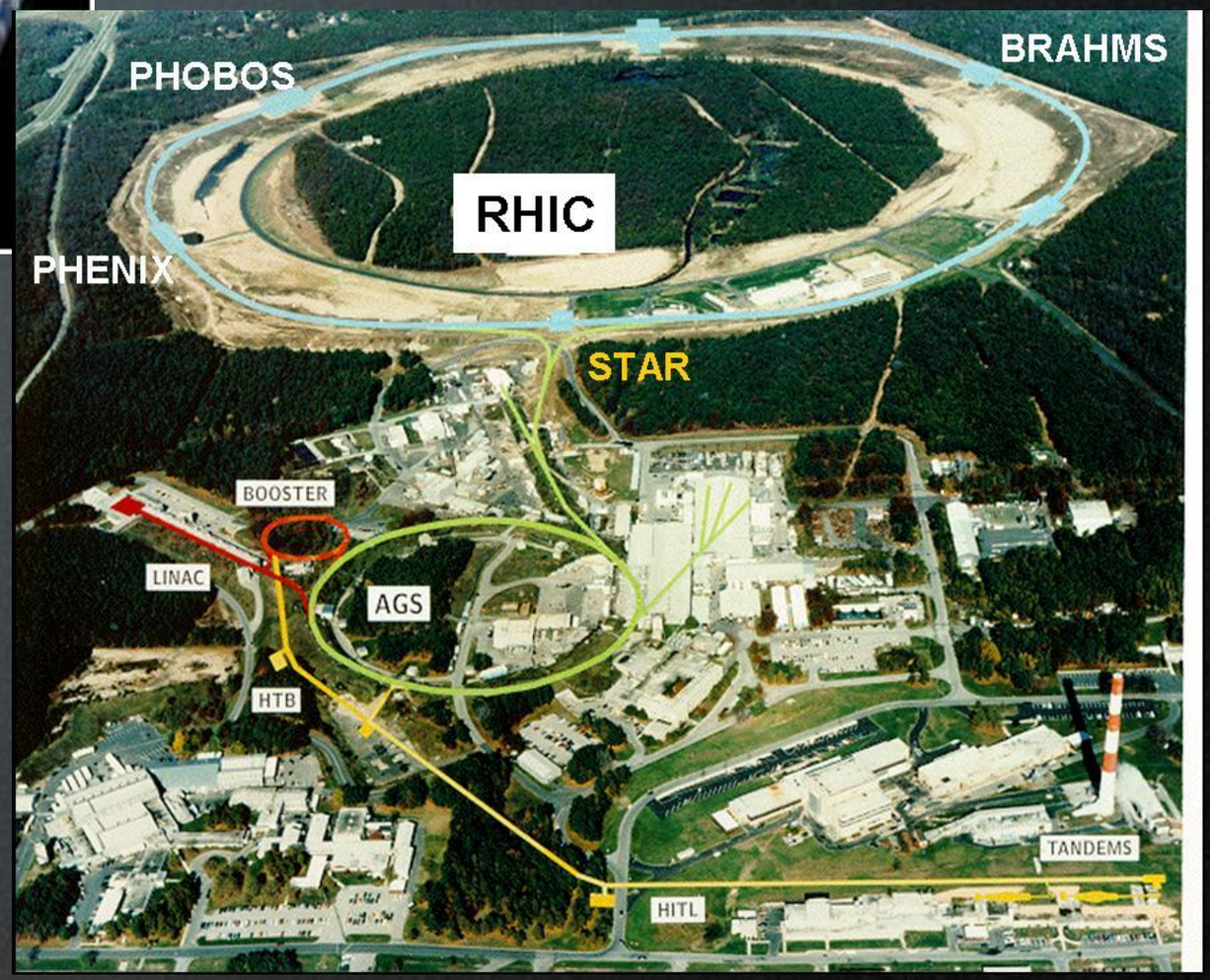
★ 100A GeV Au+Au($2X10^{26}/cm^2/s$)

★ 250 GeV p + p ($2X10^{32}/cm^2/s$)

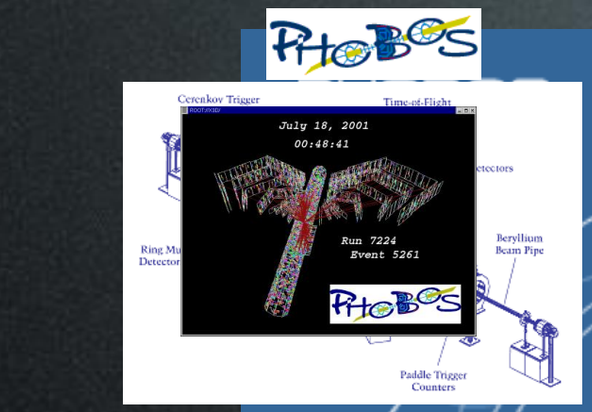
★ AuAu @ 19.6, 62, 130, 200 AGeV/u

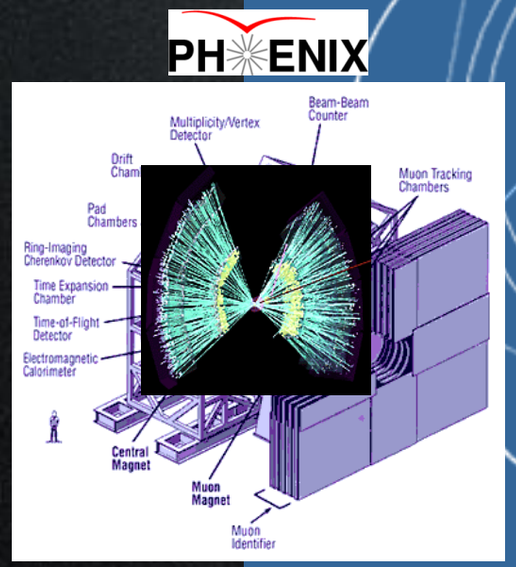
★ CuCu @ 200 AGeV/u

★ dAu @ 200 AGeV/u

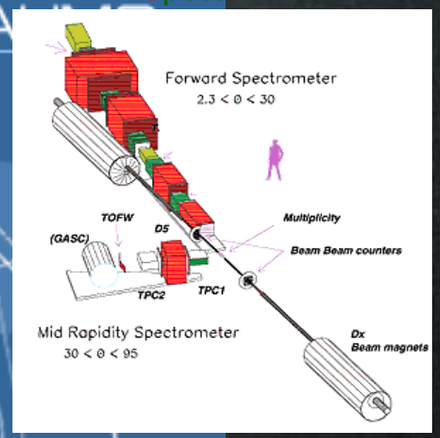


Detectors @ RHIC



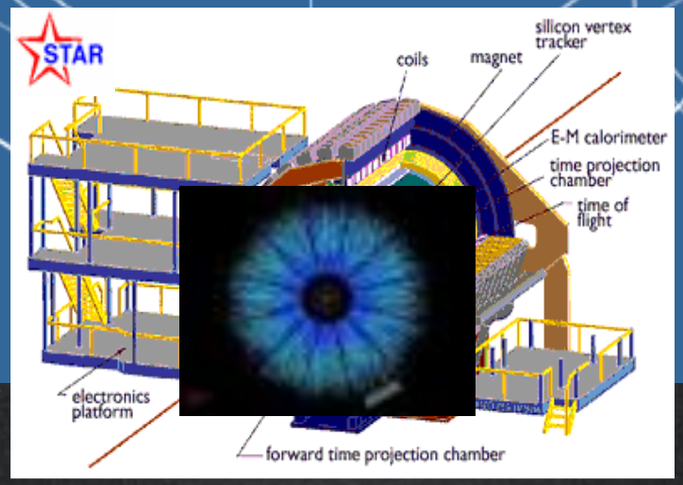


the Broad Range Hadron Magnetic Spectrometer

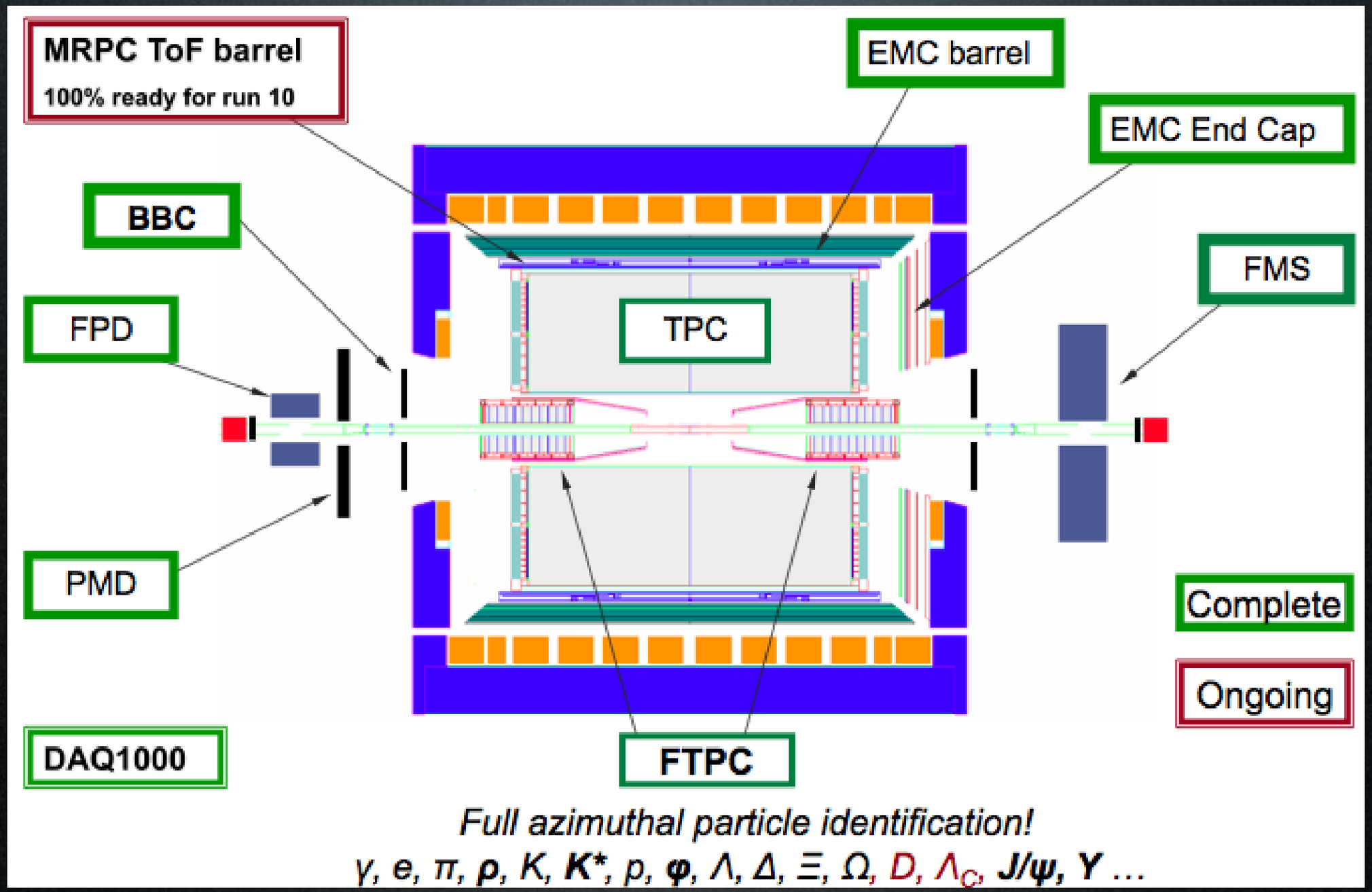


STAR

The Solenoidal Tracker at RHIC (STAR)



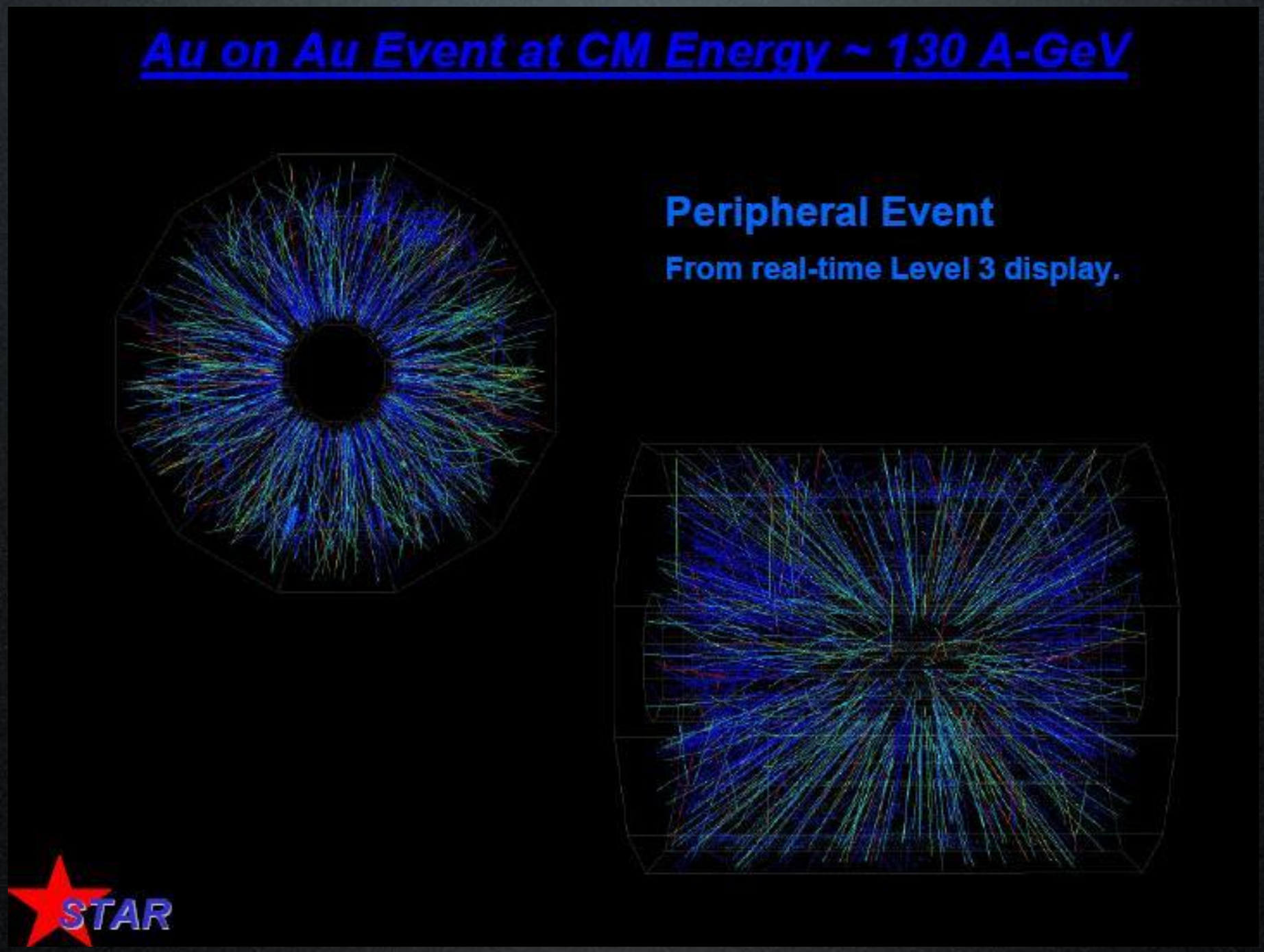
STAR Detector



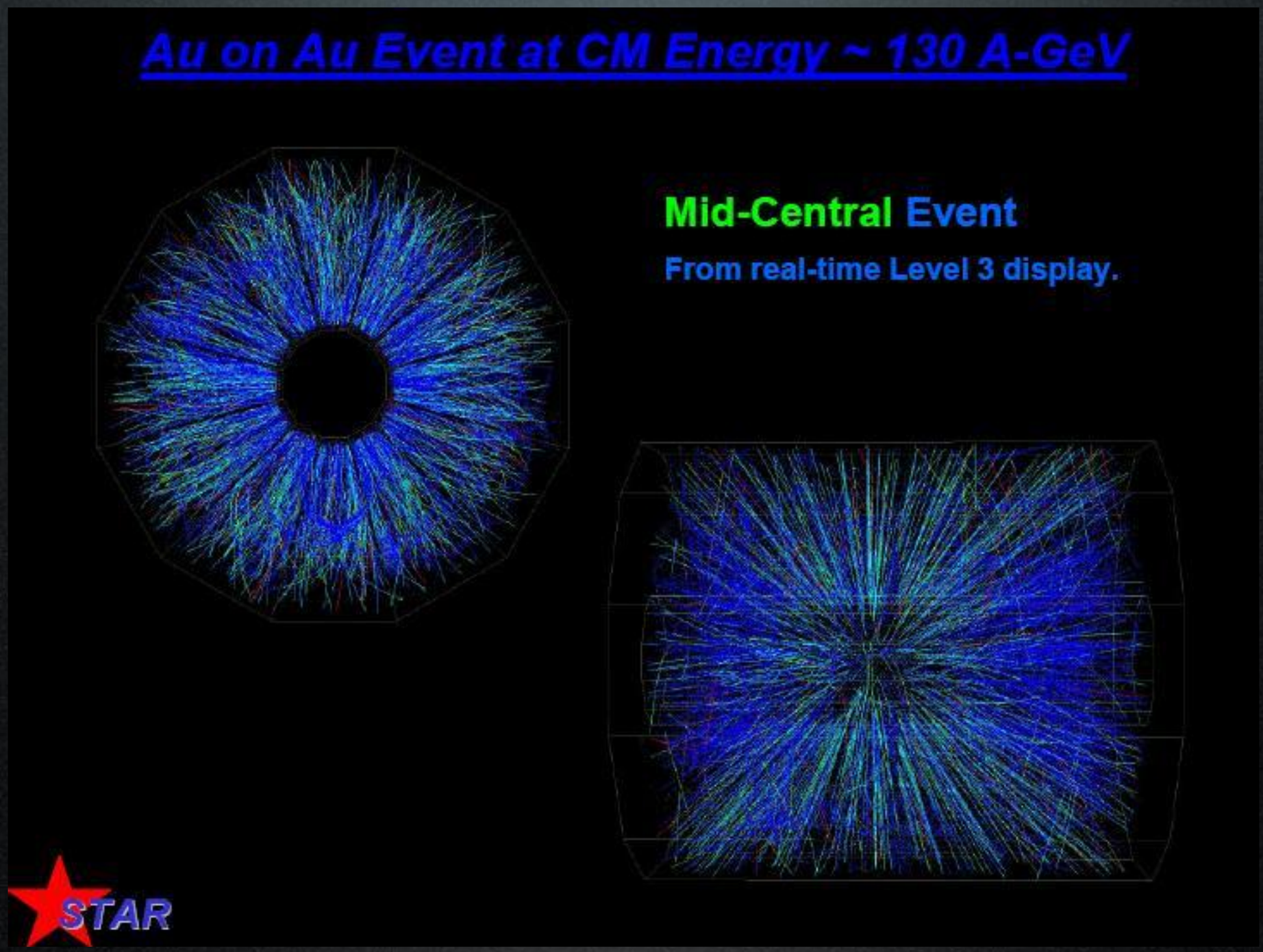
Full azimuthal particle identification!

γ, e, π, ρ, K, K^*, p, φ, Λ, Δ, Ξ, Ω, D, Λ_c, J/ψ, Υ …

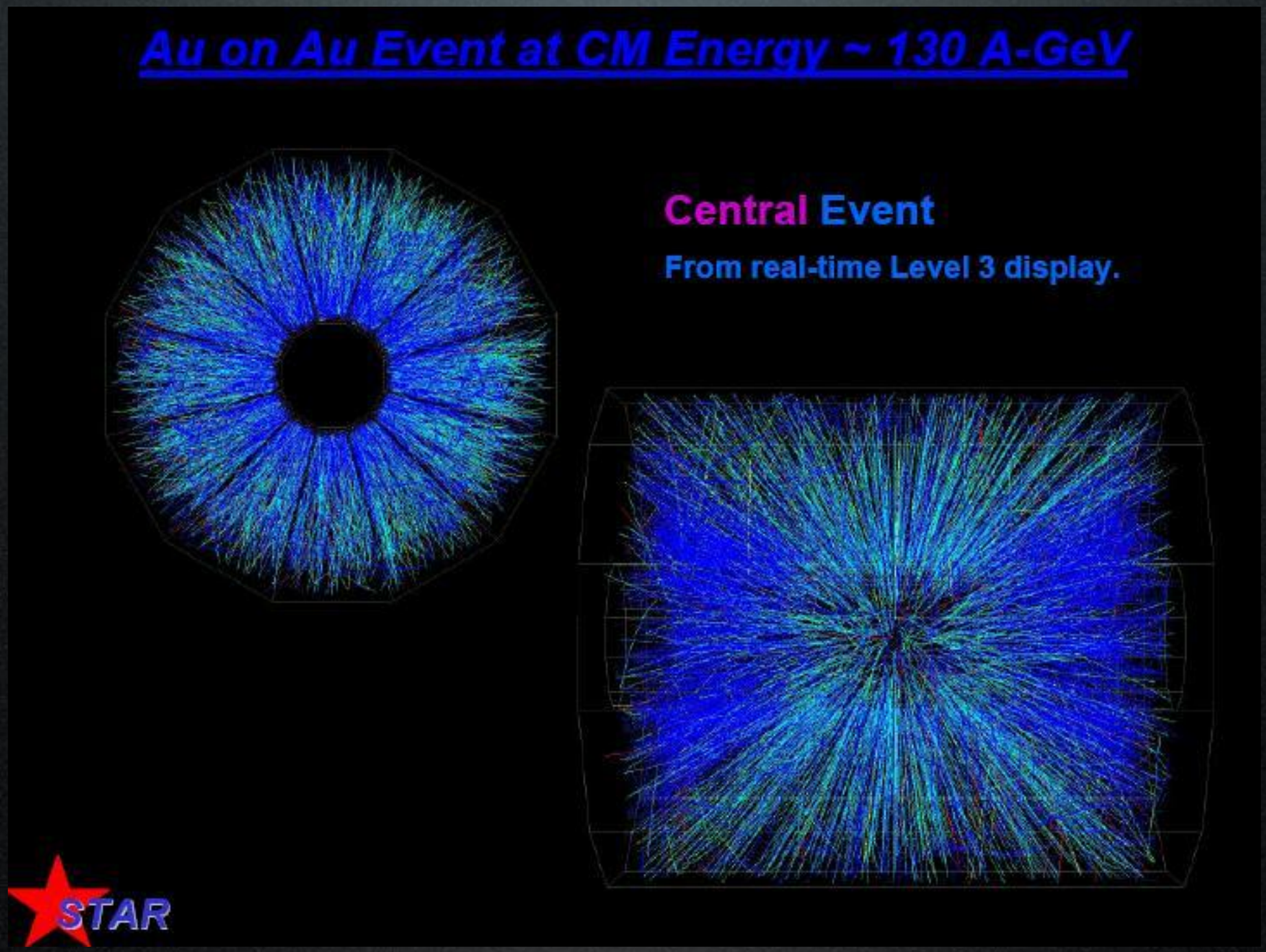
AuAu Collisions @ 130 AGeV



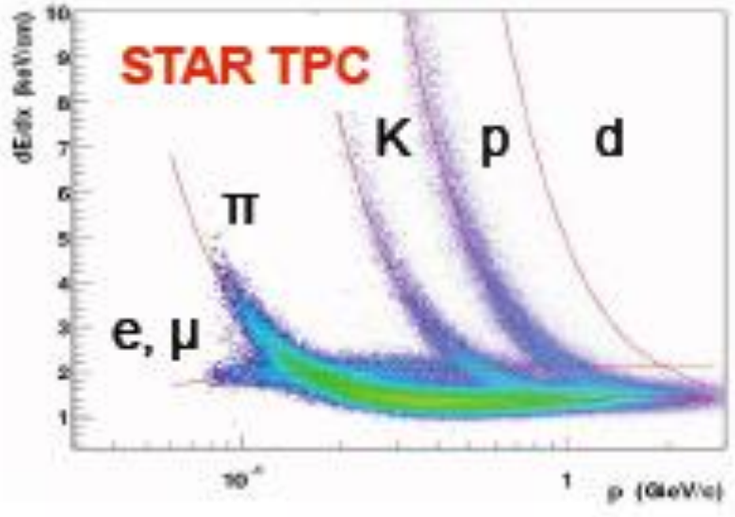
AuAu Collisions @ 130 AGeV

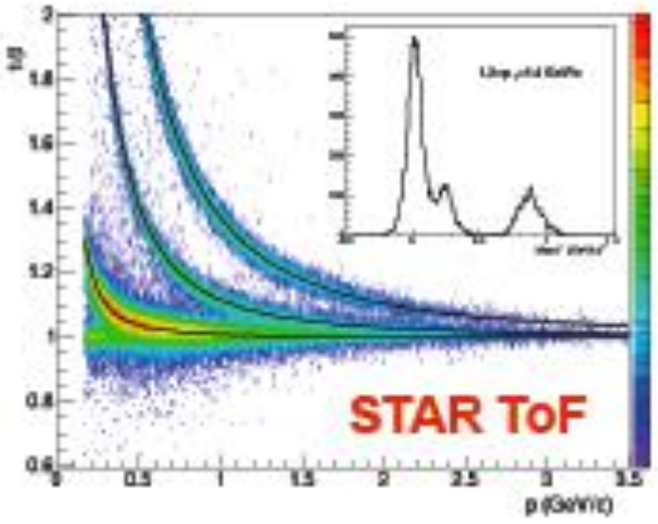


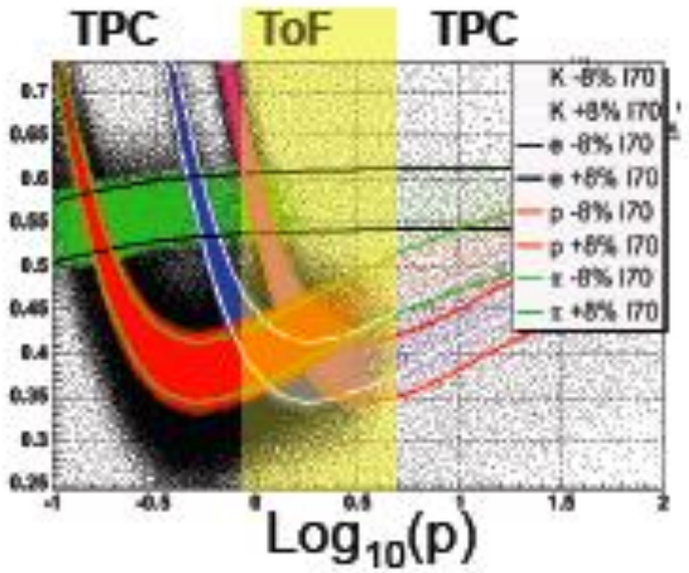
AuAu Collisions @ 130 AGeV

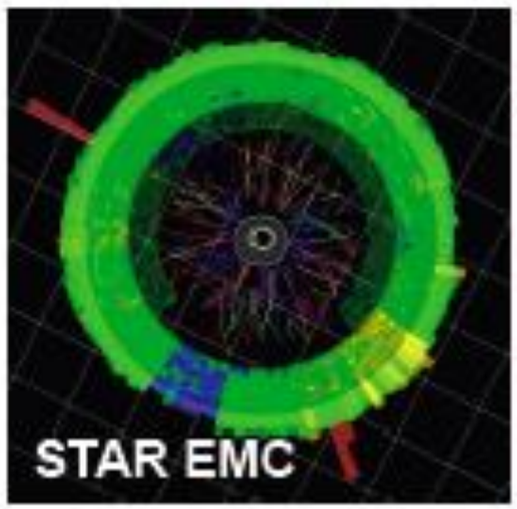


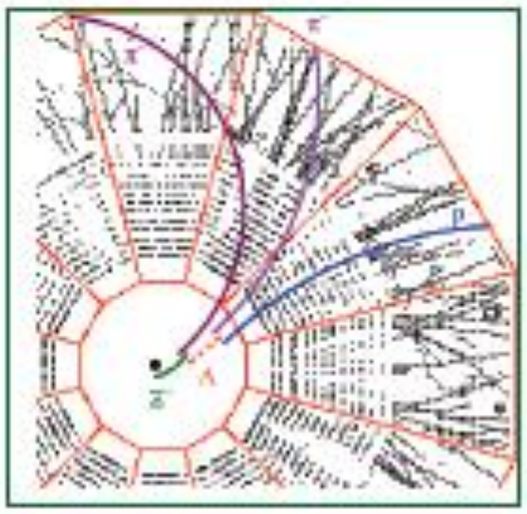
Particle ID @ STAR

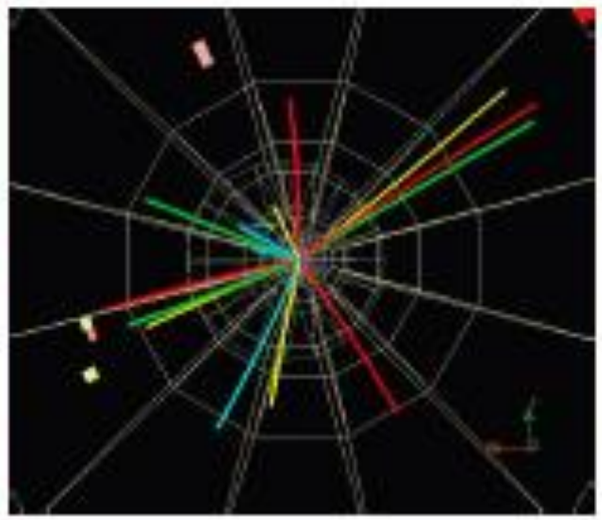


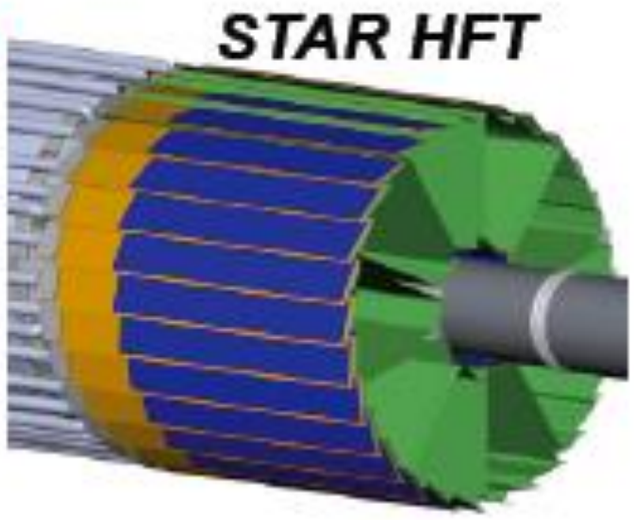






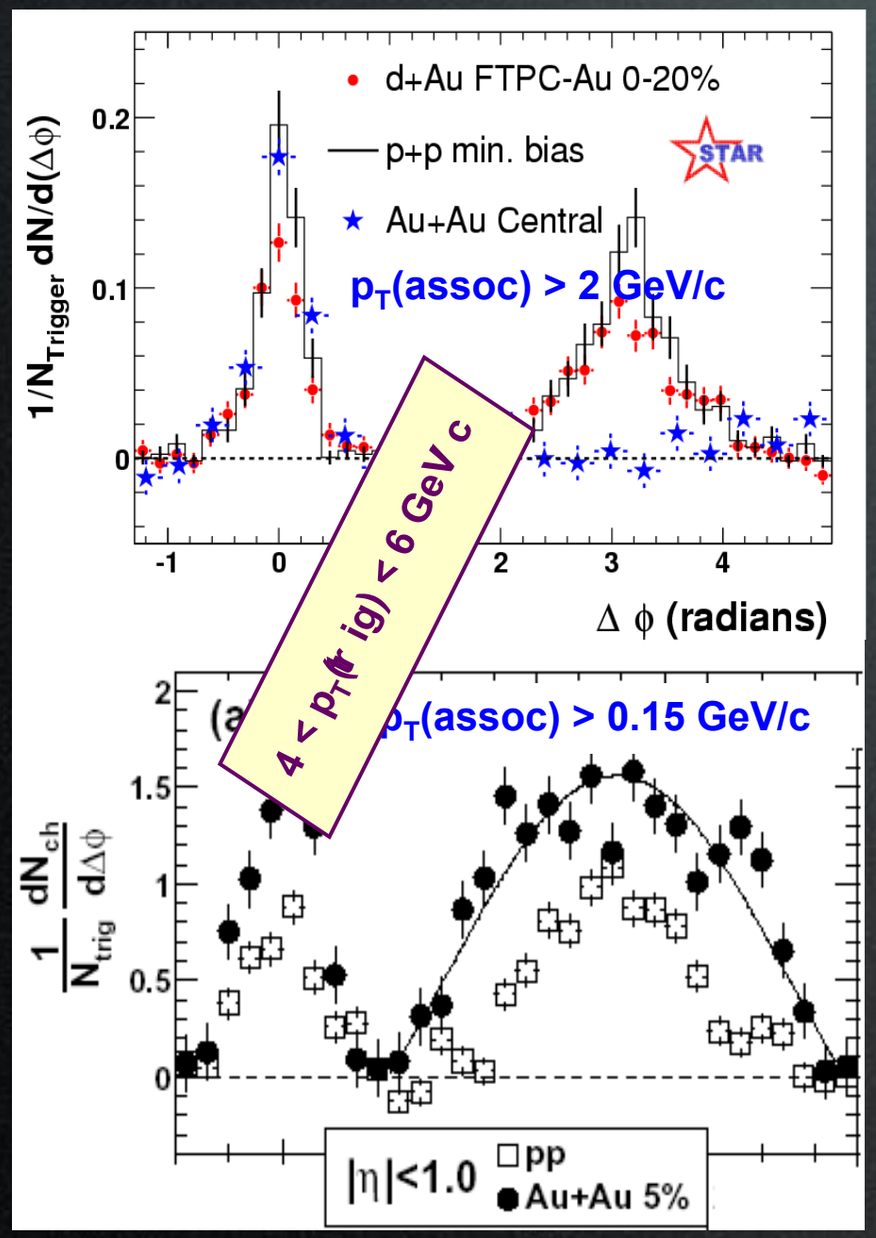




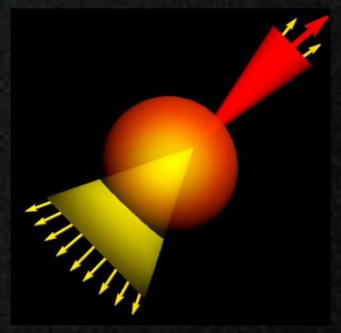


Neutral particles **Strange hyperons** **Jets** **Heavy Quark Hadrons**

Jet Quenching @STAR

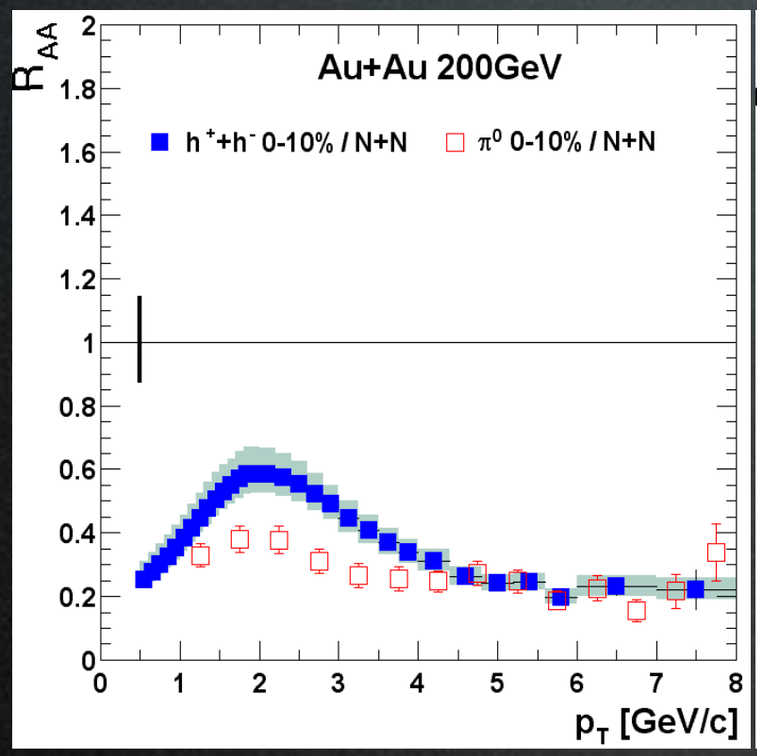


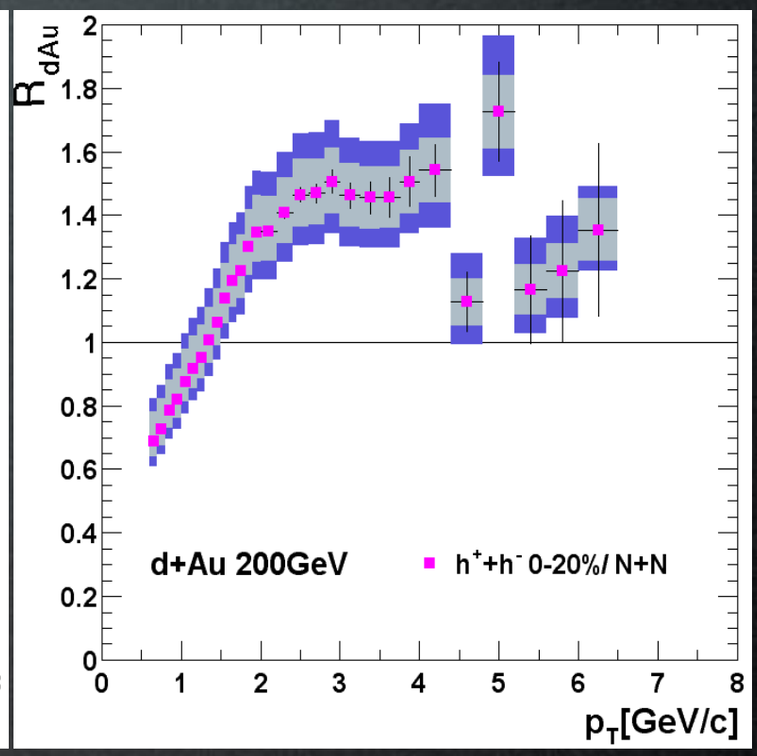
Hard associated particles → suppression



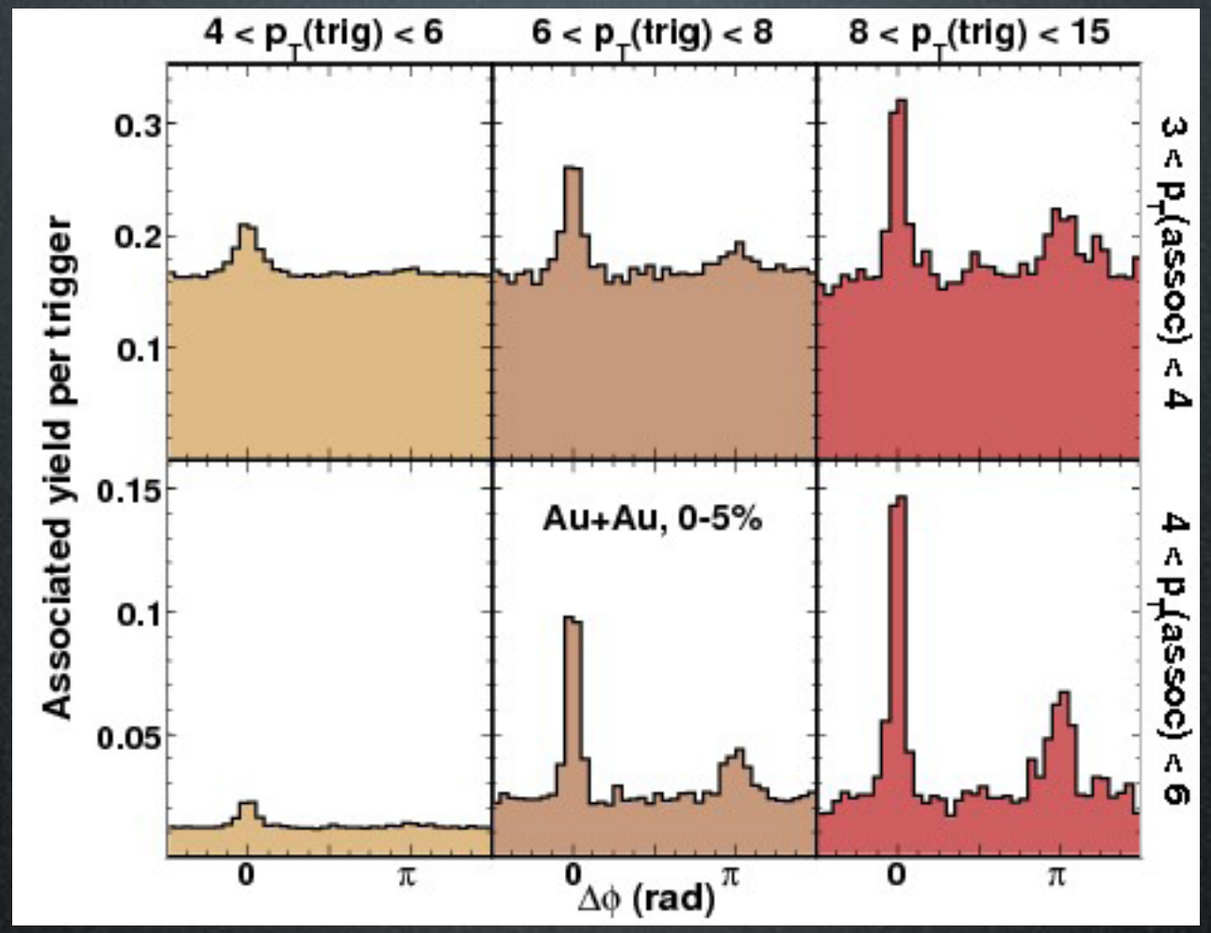
Soft associated particles → enhancement

Jet Quenching @ PHENIX



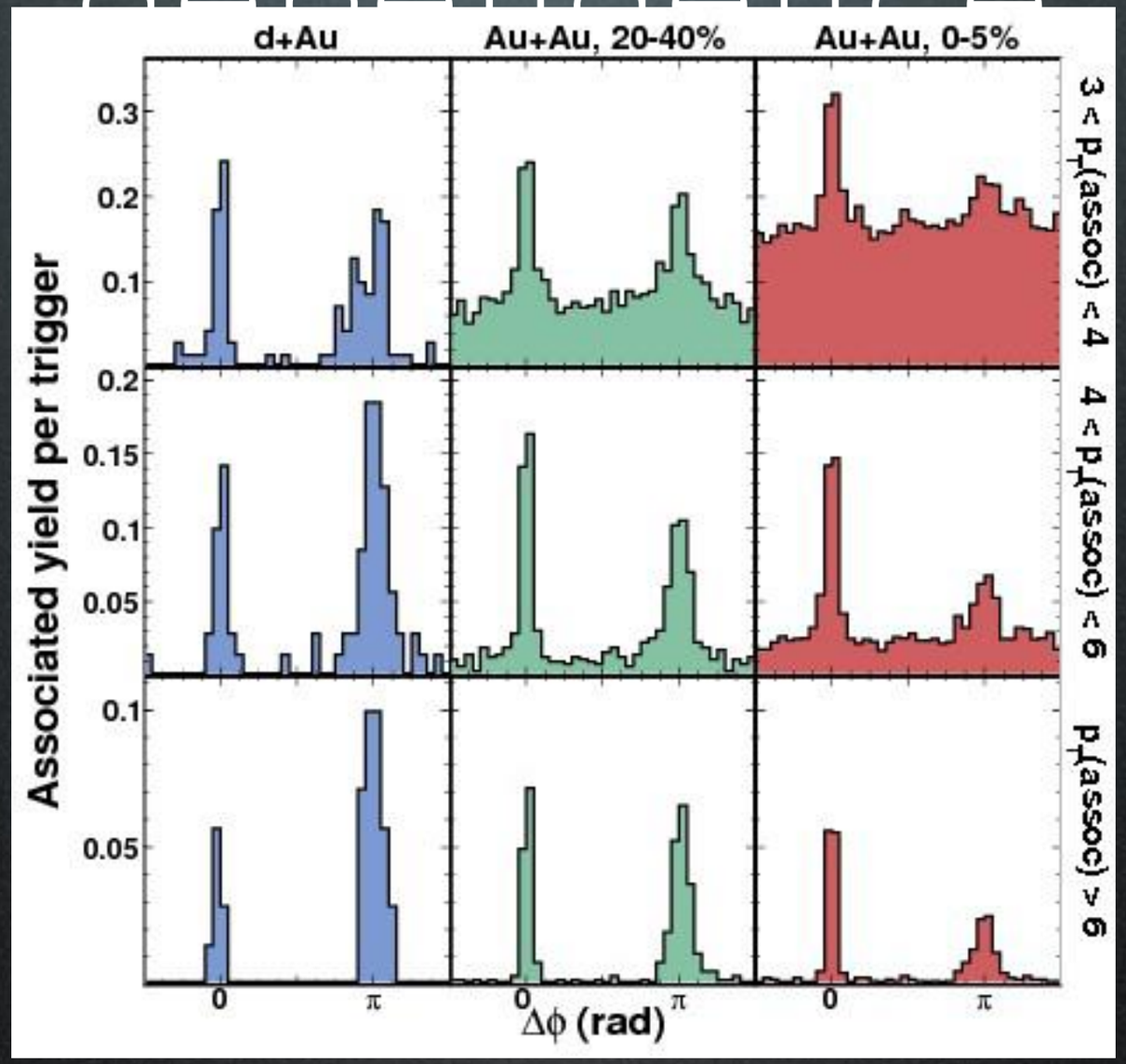


Monojet ? or Dijet?



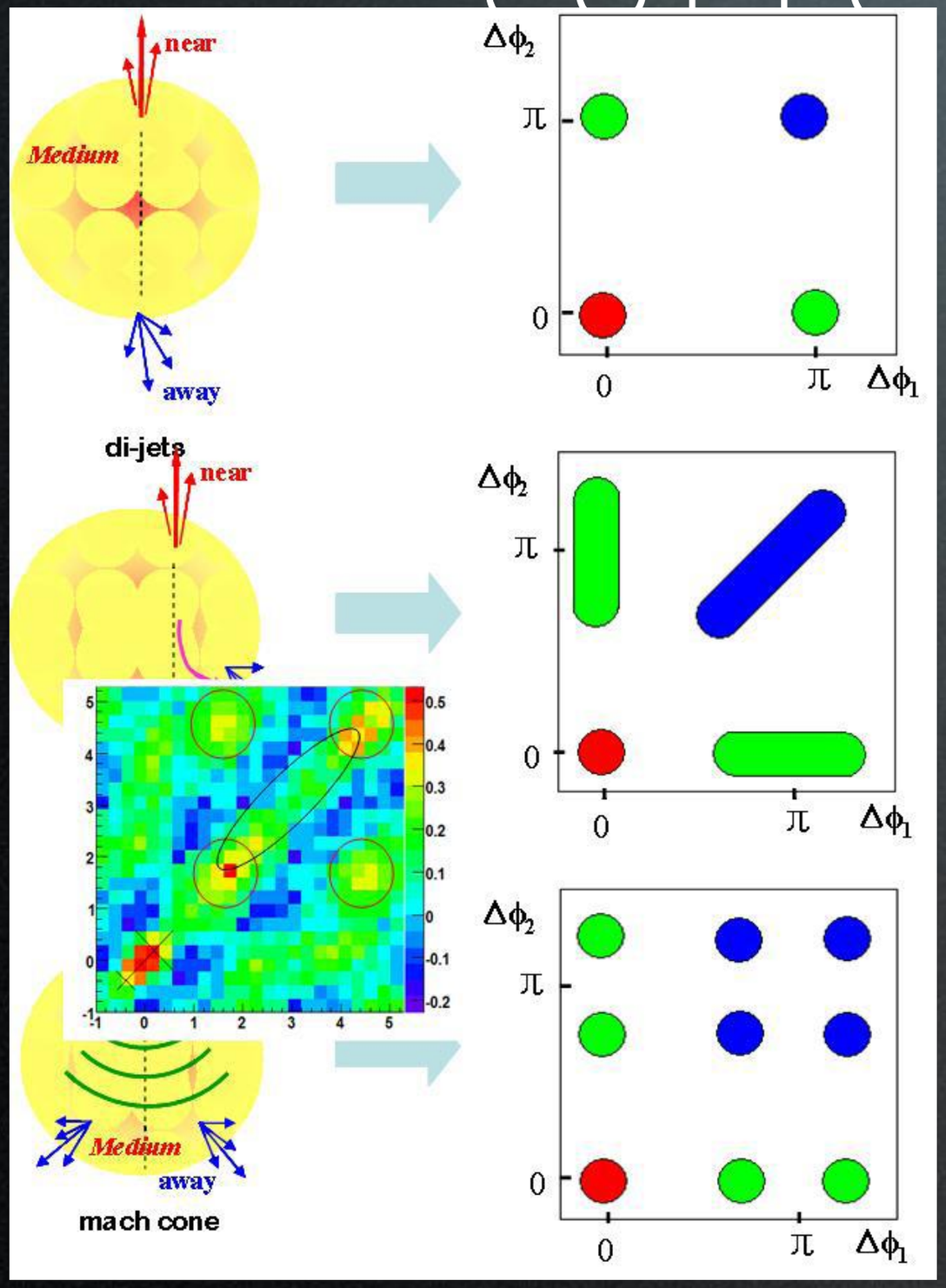
- With increasing the jet energy, back-to-back peaks in central AuAu collisions are reappearing

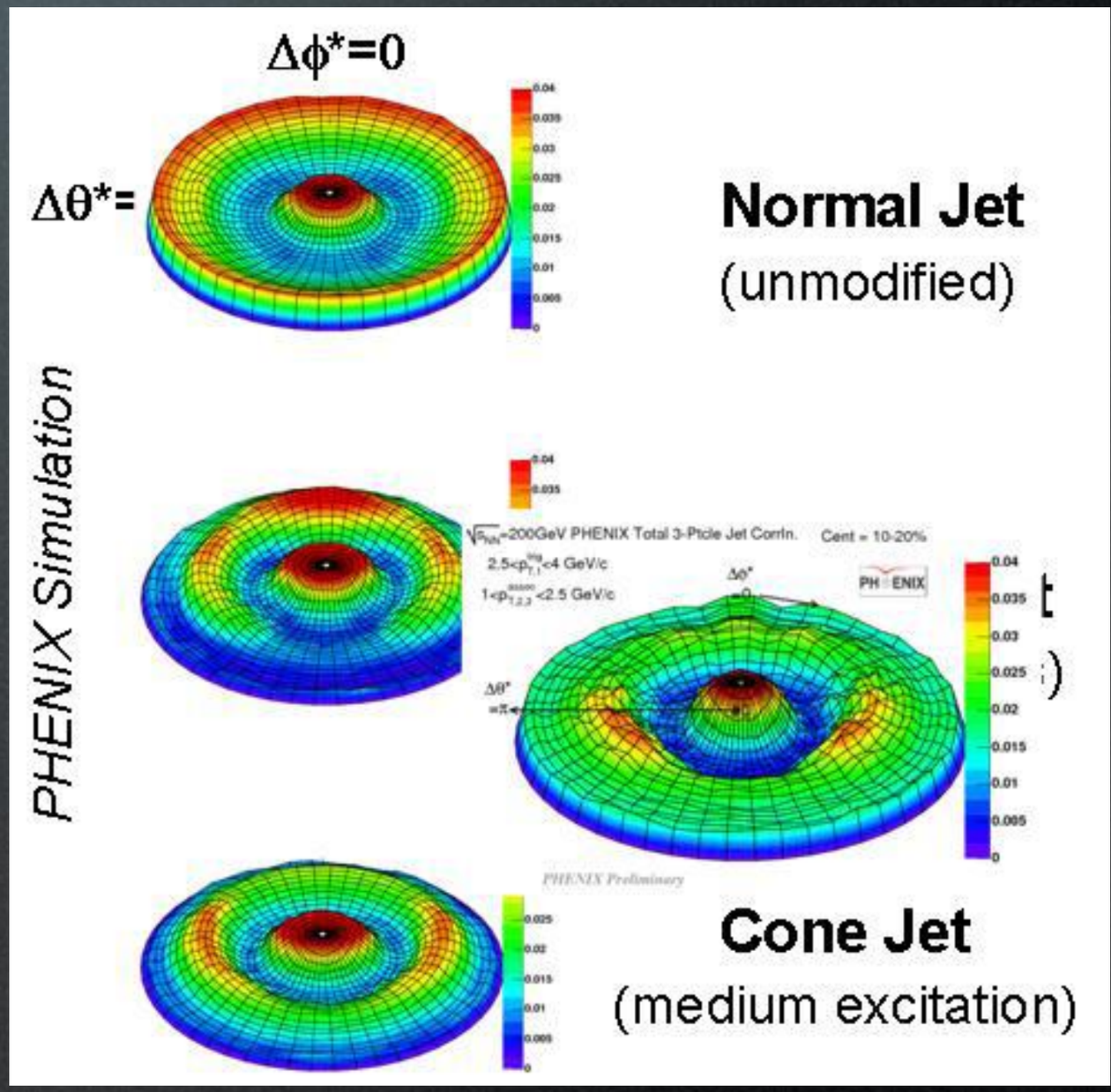
System-size dependence



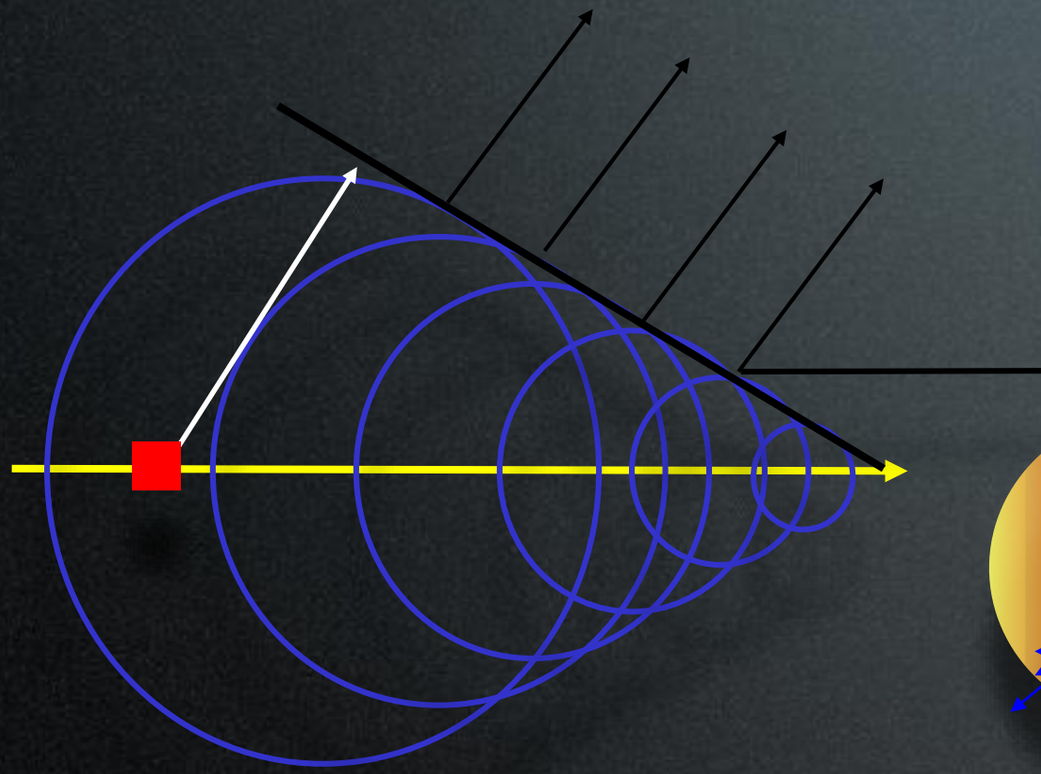
- With increasing system-size, back-to-back peaks are suppressed.

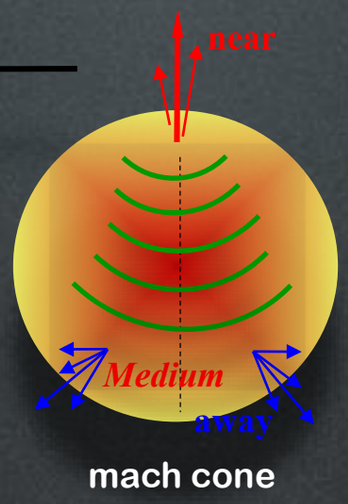
3 particle correlations

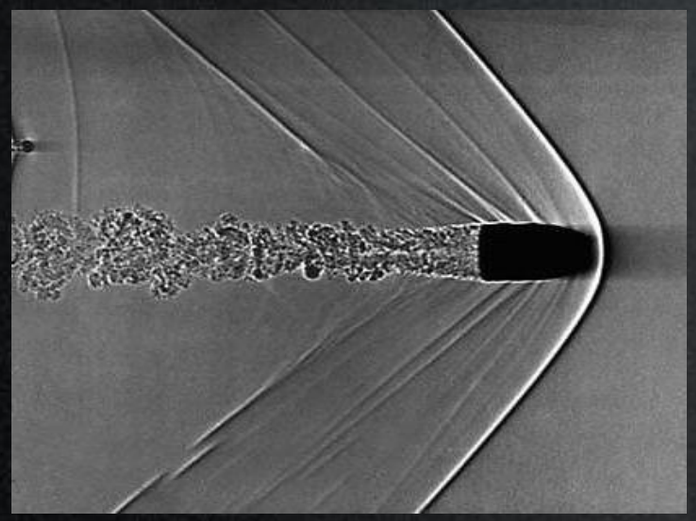




Mach-like Shock Wave





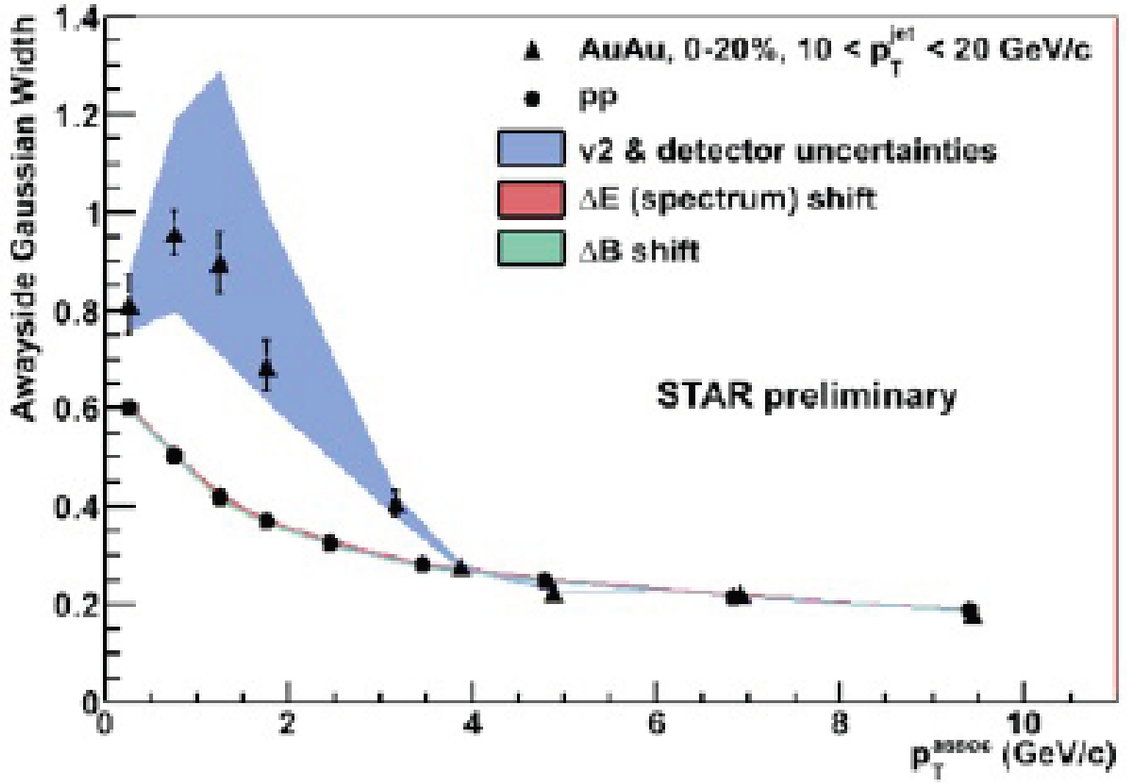


A fast thermalization through dispersing energy into collective modes of shock waves.

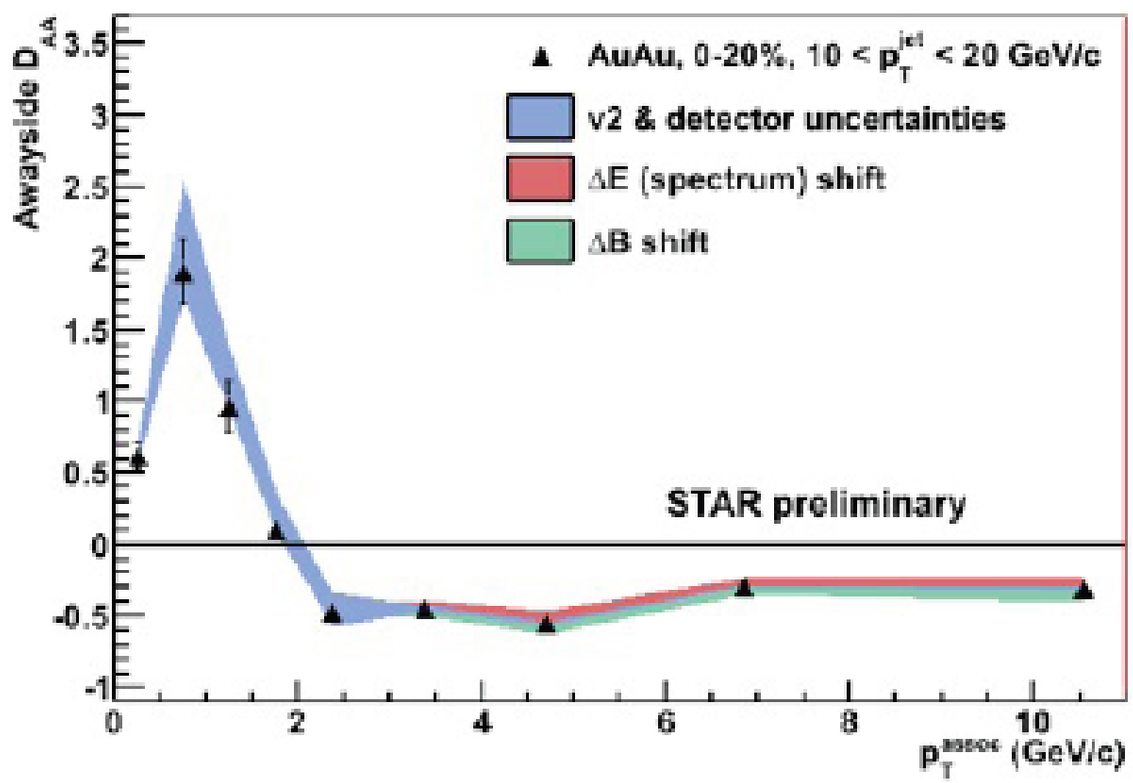
Jet-hadron correlation

Alice Ohlson, Fri/27 18:10

Away side Gaussian width



Away side energy balance

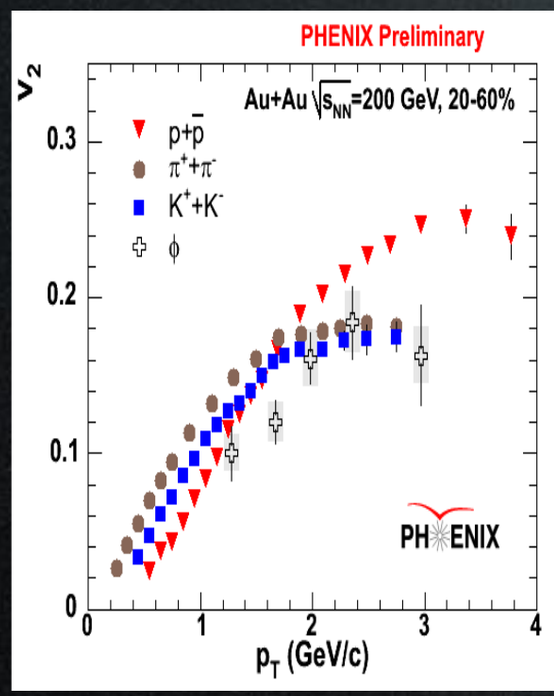


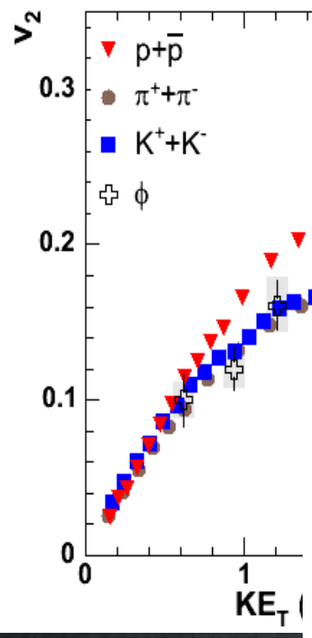
$$D_{AA}(p_T^{assoc}) = Y_{AA}(p_T^{assoc}) \cdot p_T^{assoc} - Y_{pp}(p_T^{assoc}) \cdot p_T^{assoc}$$

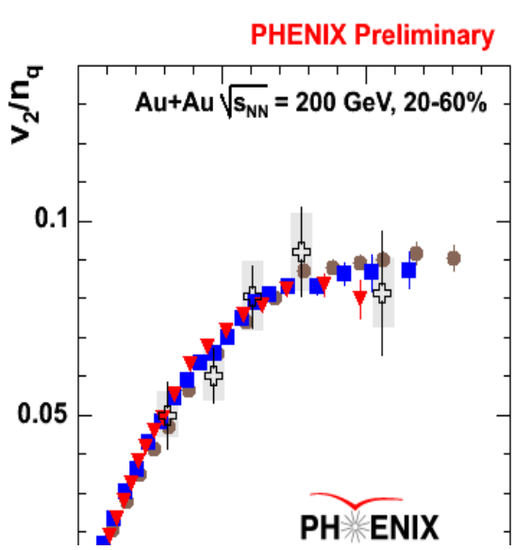
- Significant broadening and softening of jets in Au + Au
- High p_T suppression largely balanced at low p_T enhancement

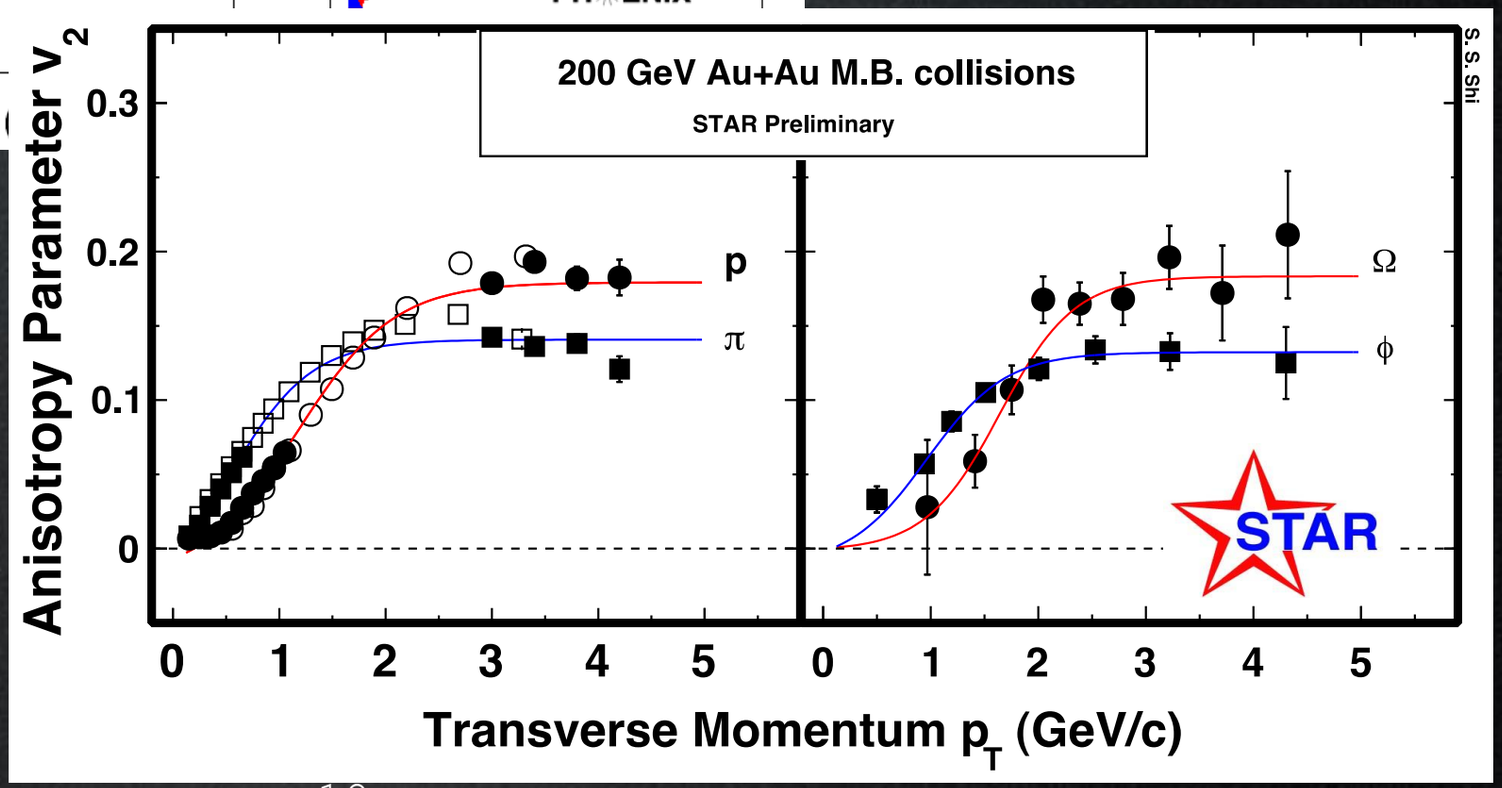
➡ Seems to consistent with radiative energy loss picture

Coalescence @ RHIC





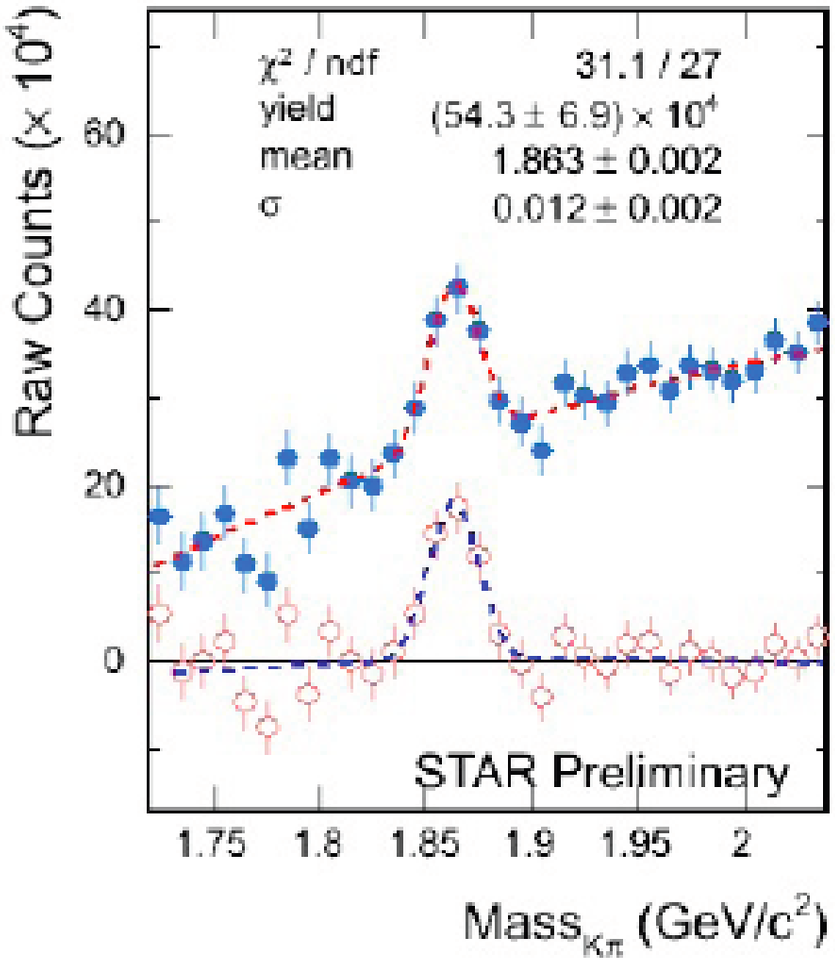




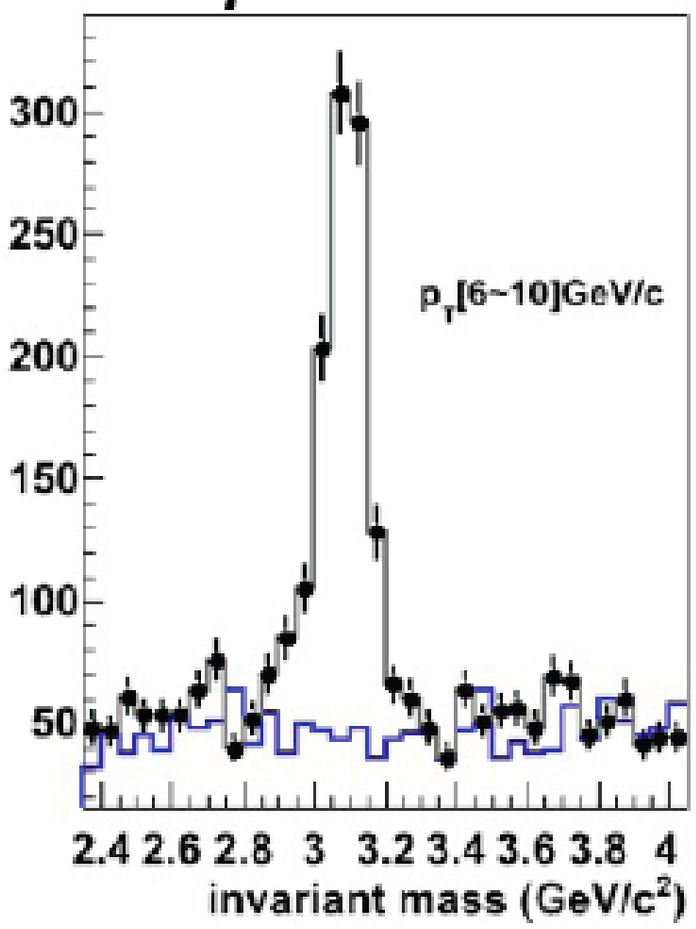
Liquid-like Early Universe

STAR capability for heavy flavors

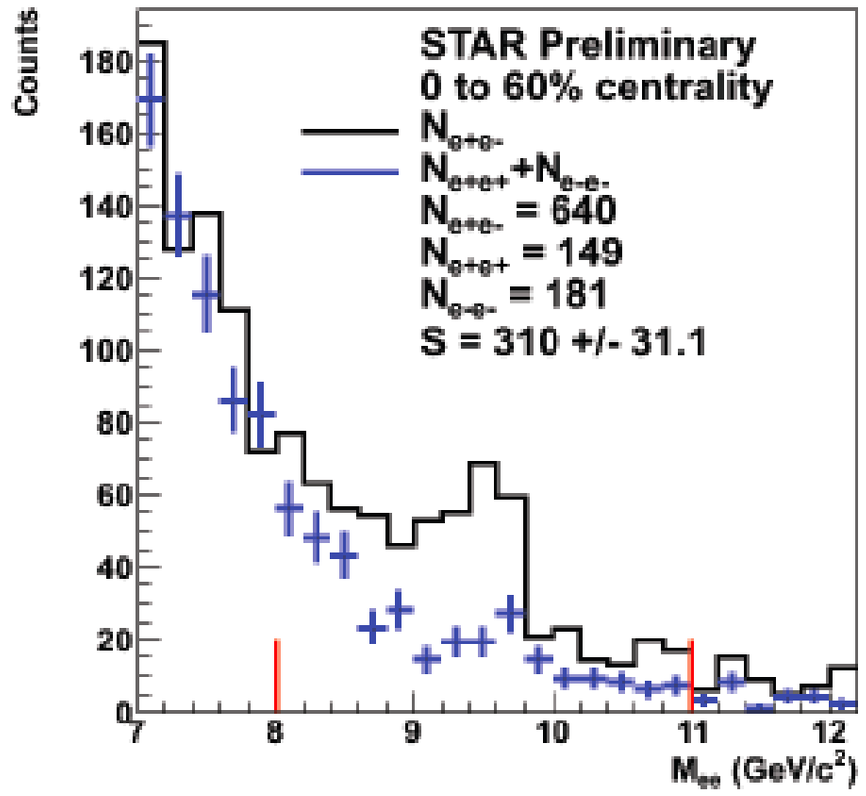
$D^0 \rightarrow K^-\pi^+$



$J/\psi \rightarrow e^+e^-$



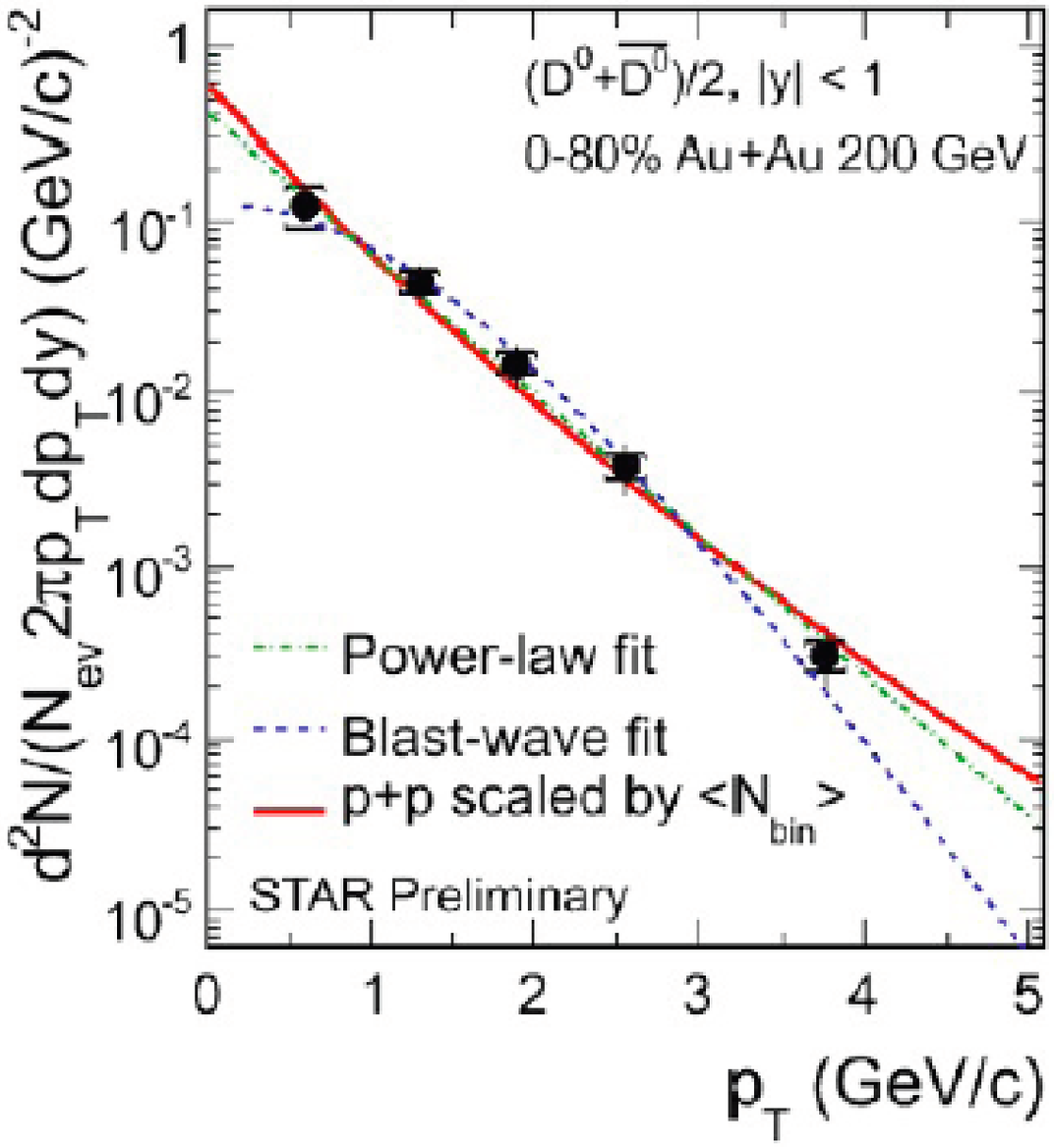
$\Upsilon \rightarrow e^+e^-$

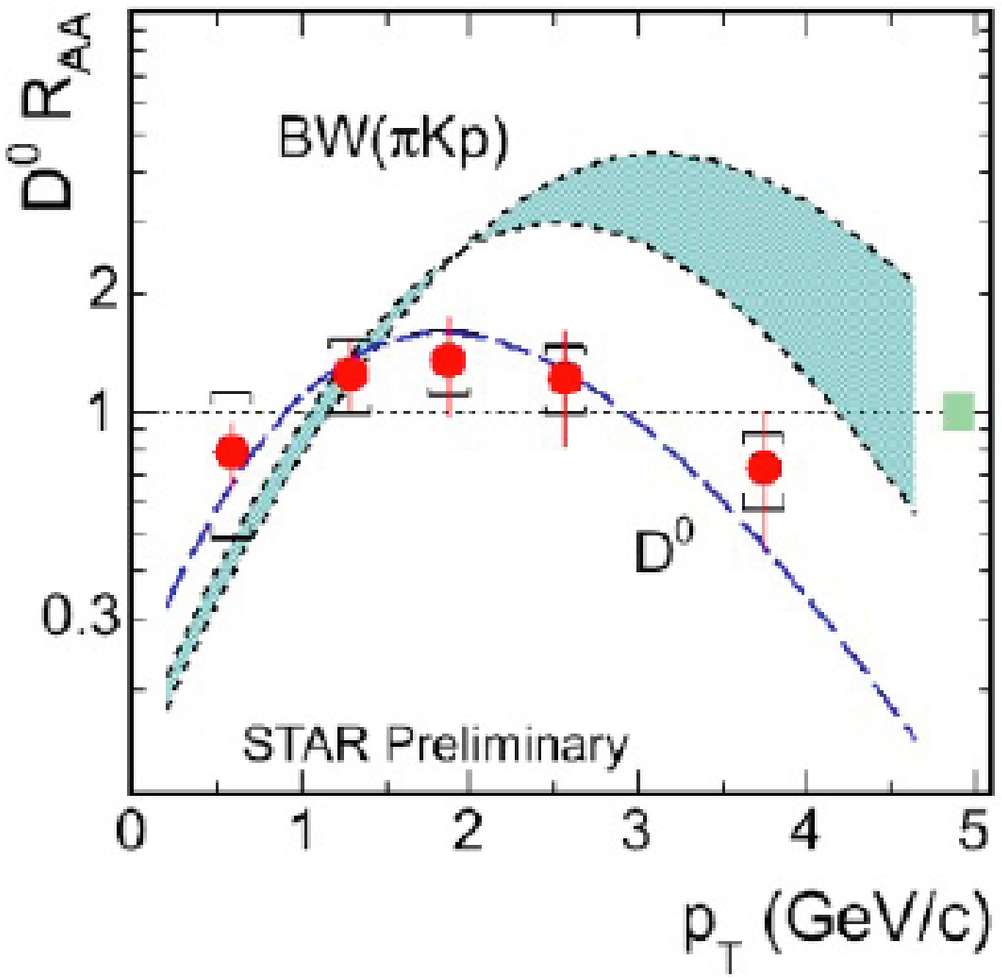


- Clear signal for D^0 mesons, J/ψ and Υ in Au + Au collisions

D^0 R_{AA}

Yifei Zhang, Fri/27 16:00





*BW(πKp) Blast-wave fit results, STAR, **PRC79**, 034909 (2009)*

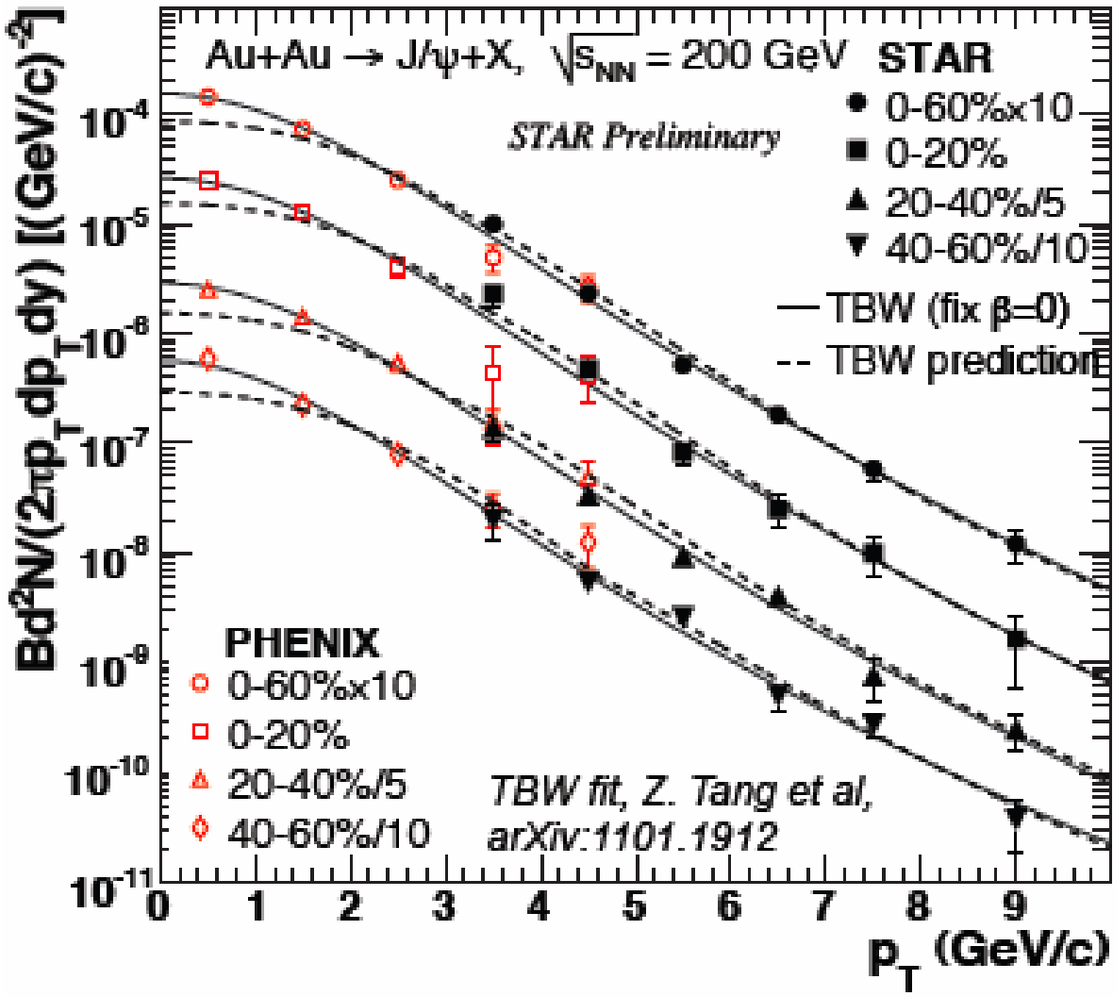
- First measurement of D^0 R_{AA}, R_{AA} ~ 1 in p_T < 3 GeV/c
- Blast-wave fit favors higher T_{kin}, smaller β_T for D^0 than light hadrons

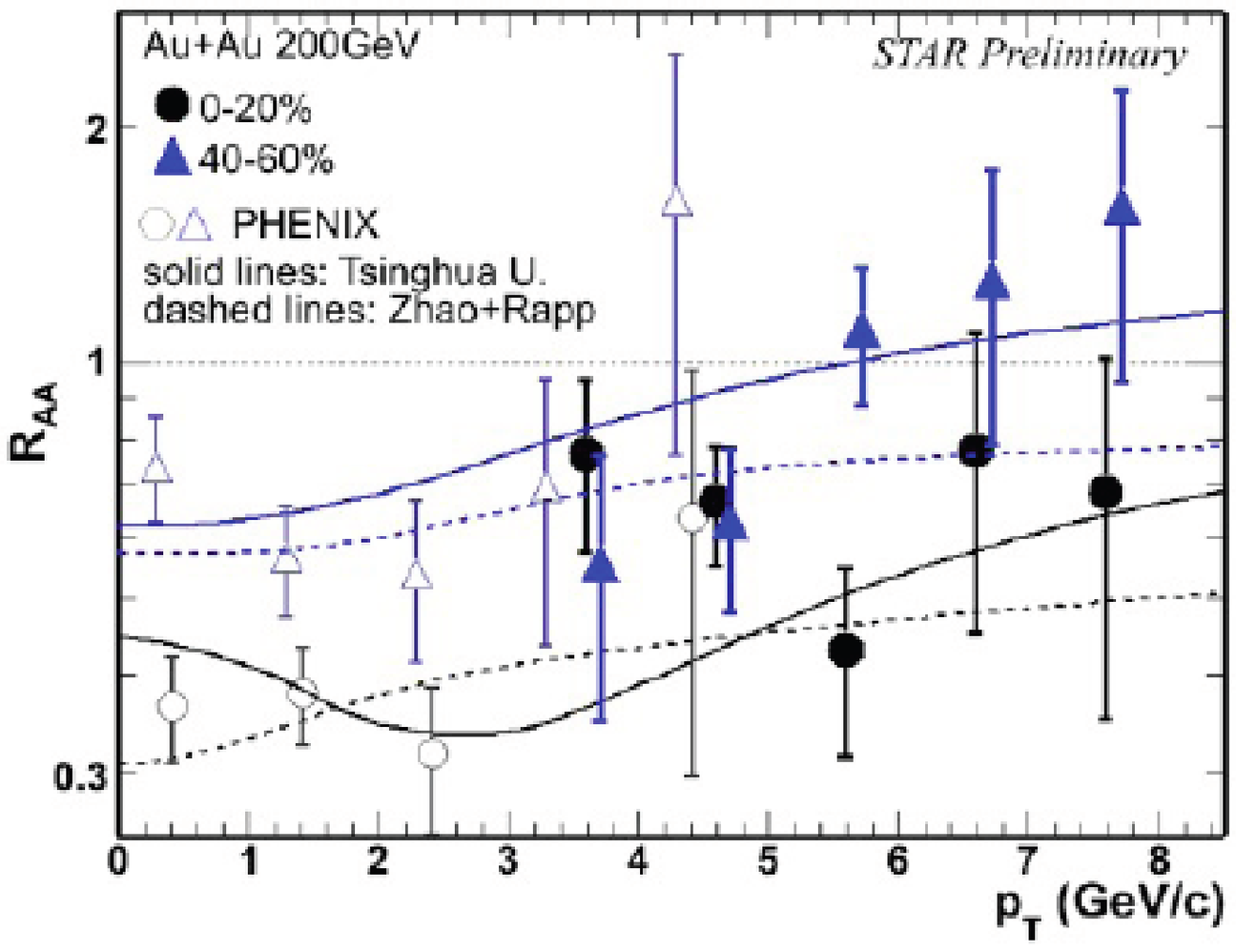
➡ D^0 freeze-out earlier than light hadrons

J/ψ spectra & R_{AA}

Zebo Tang, Tue/24 15:40

*STAR CuCu: **PRC80**, 041902(R) (2009), PHENIX: **PRL98**, 232301 (2007)*
*Y. Liu et al, **PLB678**, 72 (2009) and private comminication*
*X. Zhao and R. Rapp, **PRC82**, 064905(2010) and private communication*

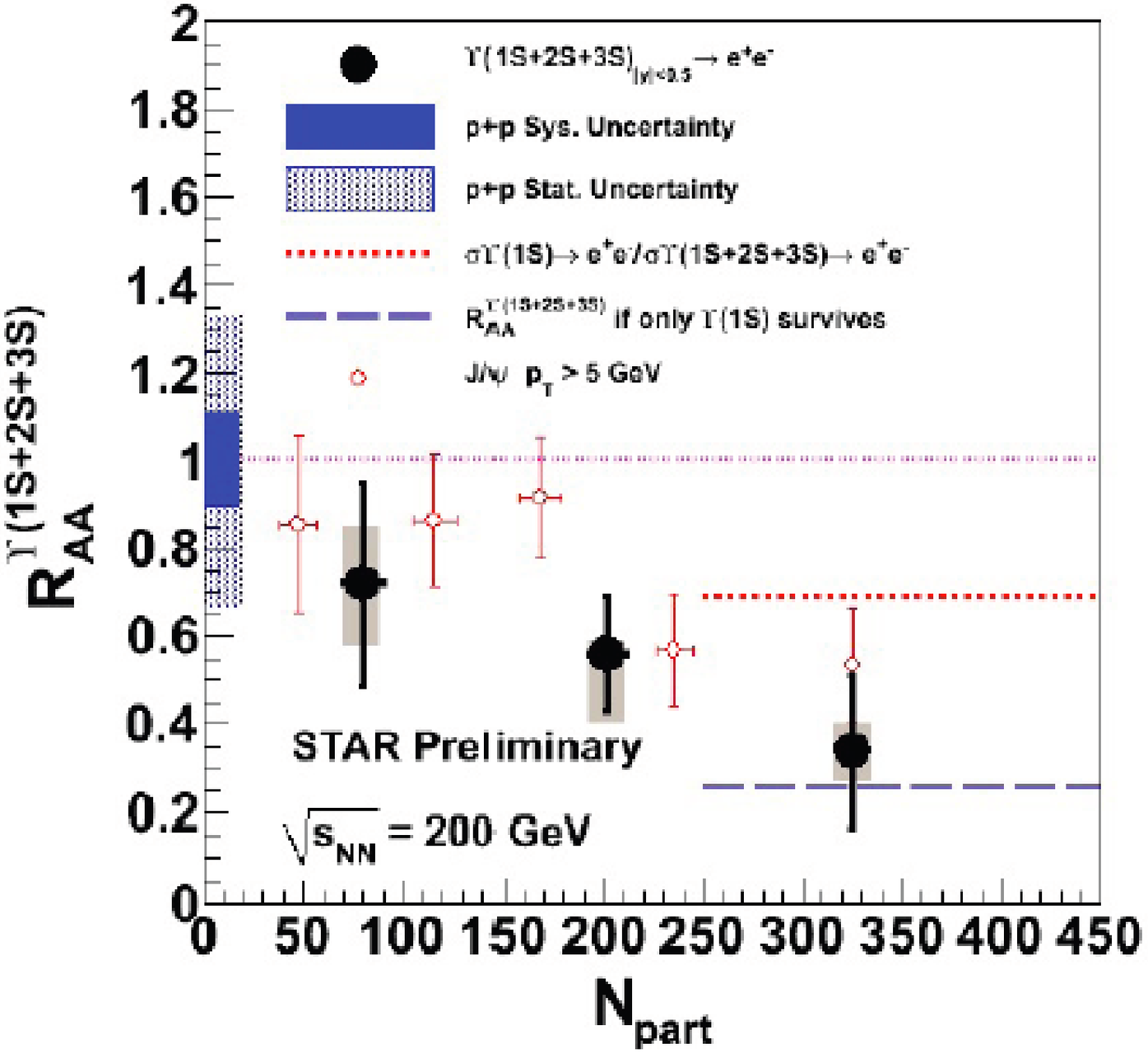




- Extend J/ψ spectra up to 10 GeV/c
- High p_T (p_T > 5 GeV/c) J/ψ suppression at central collisions

Υ R_{AA}

Rosi Reed, poster board 48, Thu/26



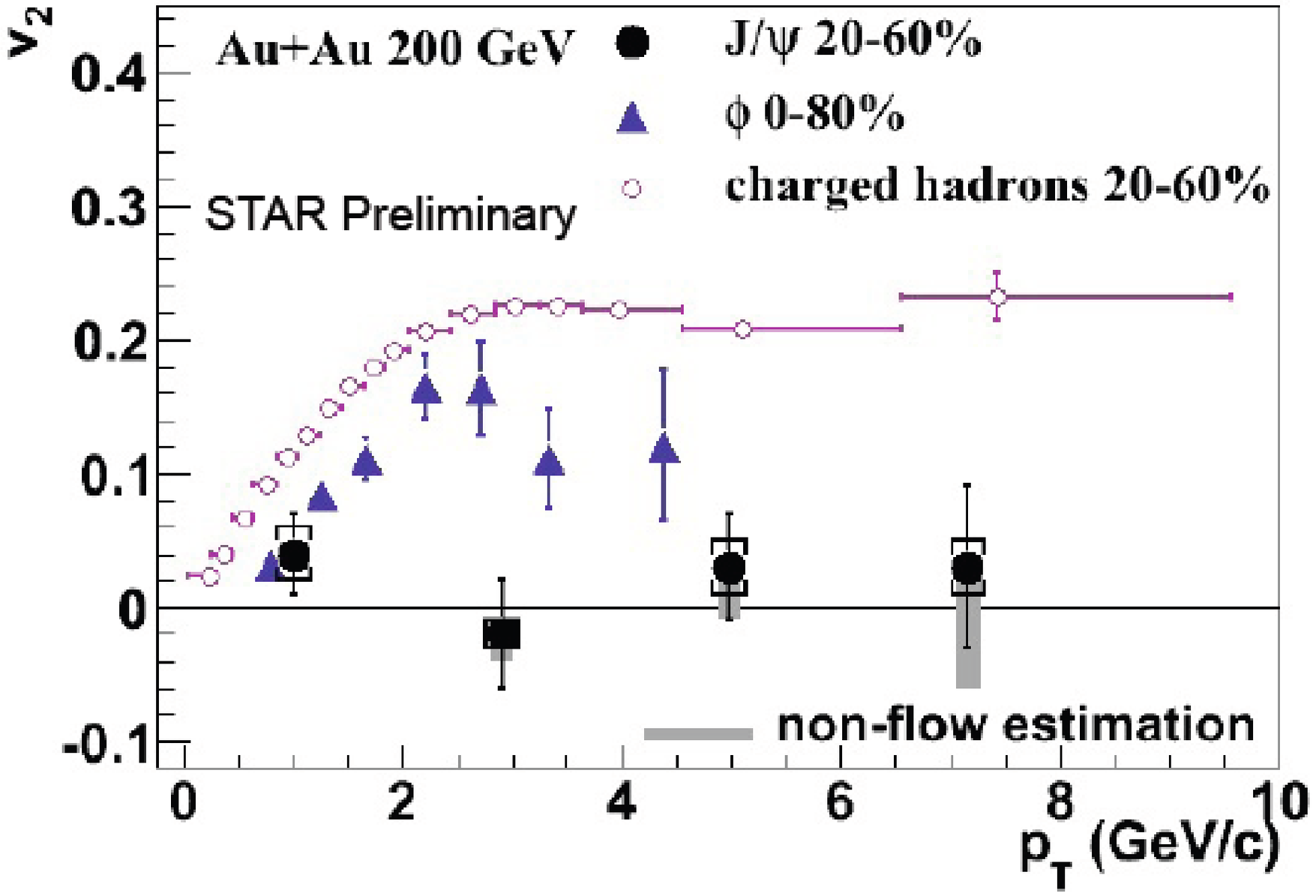
- $\Upsilon(1S+2S+3S)$ suppression at central collisions
  - Similar suppression with high p_T J/ψ
- First measurement of Υ suppression
- Statistical uncertainty will be improved by more than a factor of 2
  - × 3 in p+p 2009
  - × 2 in Au+Au 2011

J/Ψ v_2

Hao Qiu, poster board 60, Thu/26

Zebo Tang, Tue/24 15:40

*charged hadrons, STAR, **PRL93**, 252301 (2004)*
*φ, STAR, **PRL99**, 112301 (2007)*

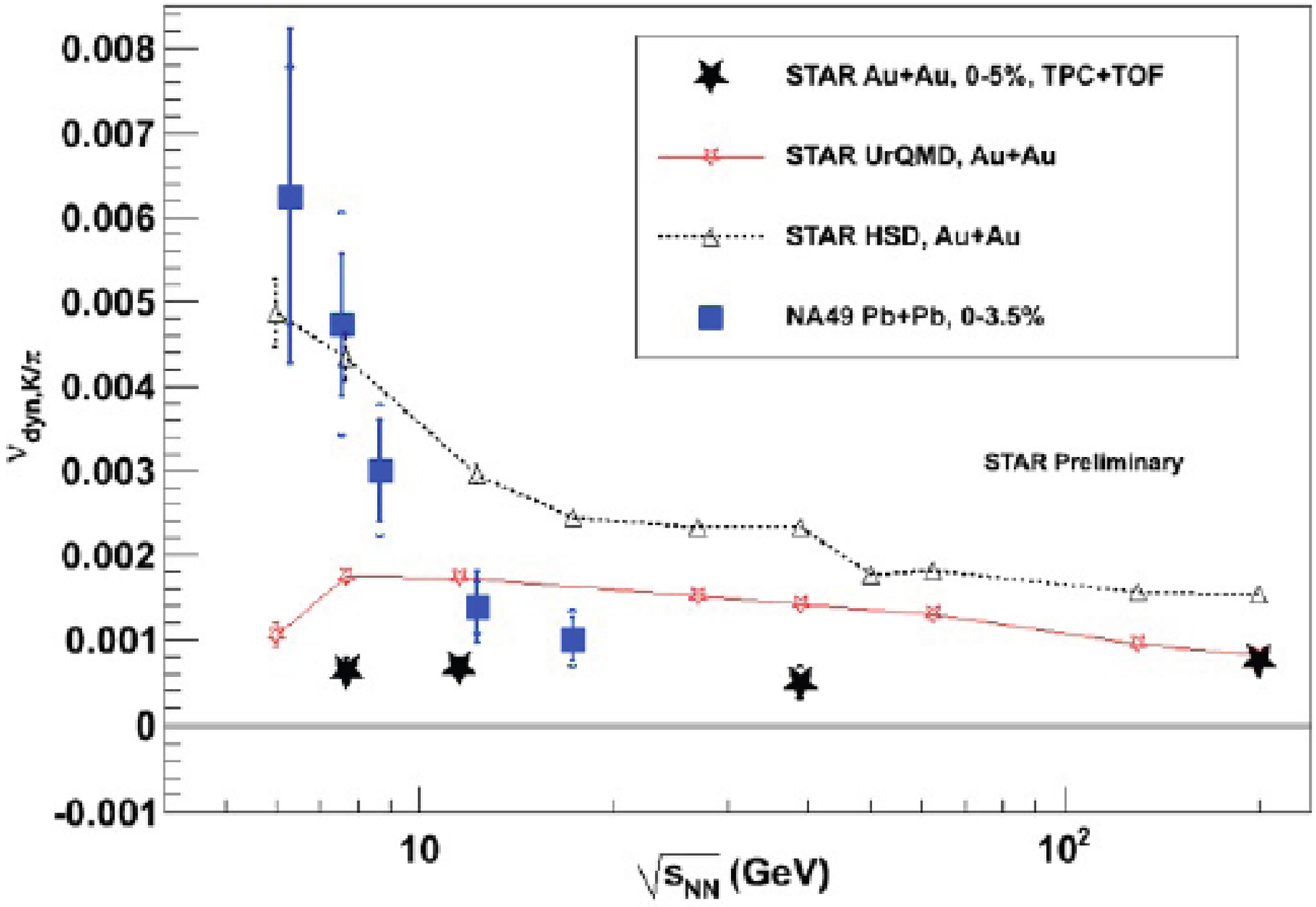


- *J/ψ* v_2 ~ 0 up to p_T ~ 8 GeV/c in mid-central 20-60%

➡ Disfavors coalescence from thermalized charm quarks

Particle ratio fluctuations

Terence Tarnowsky, Mon/23 16:00



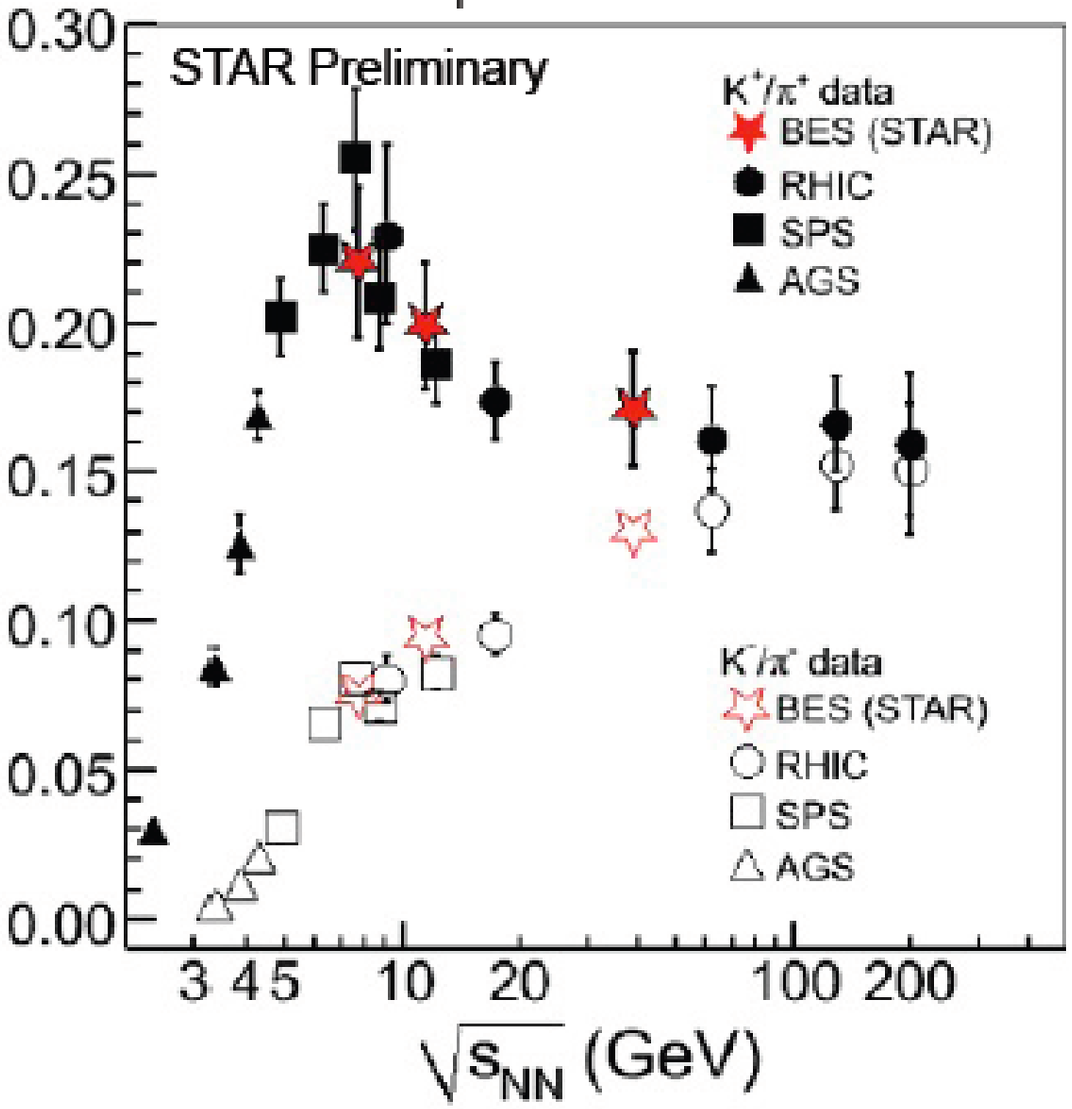
STAR TPC+TOF
π: $0.2 < p_T < 1.4$ GeV/c
K; $0.2 < p_T < 1.4$ GeV/c

Year	$\sqrt{s_{NN}}$ (GeV)	# of good events
2010	7.7	~5M
	11.5	~11M
	39	~170M
2011	19.6	~17M
2011	5	-
2012	27	-

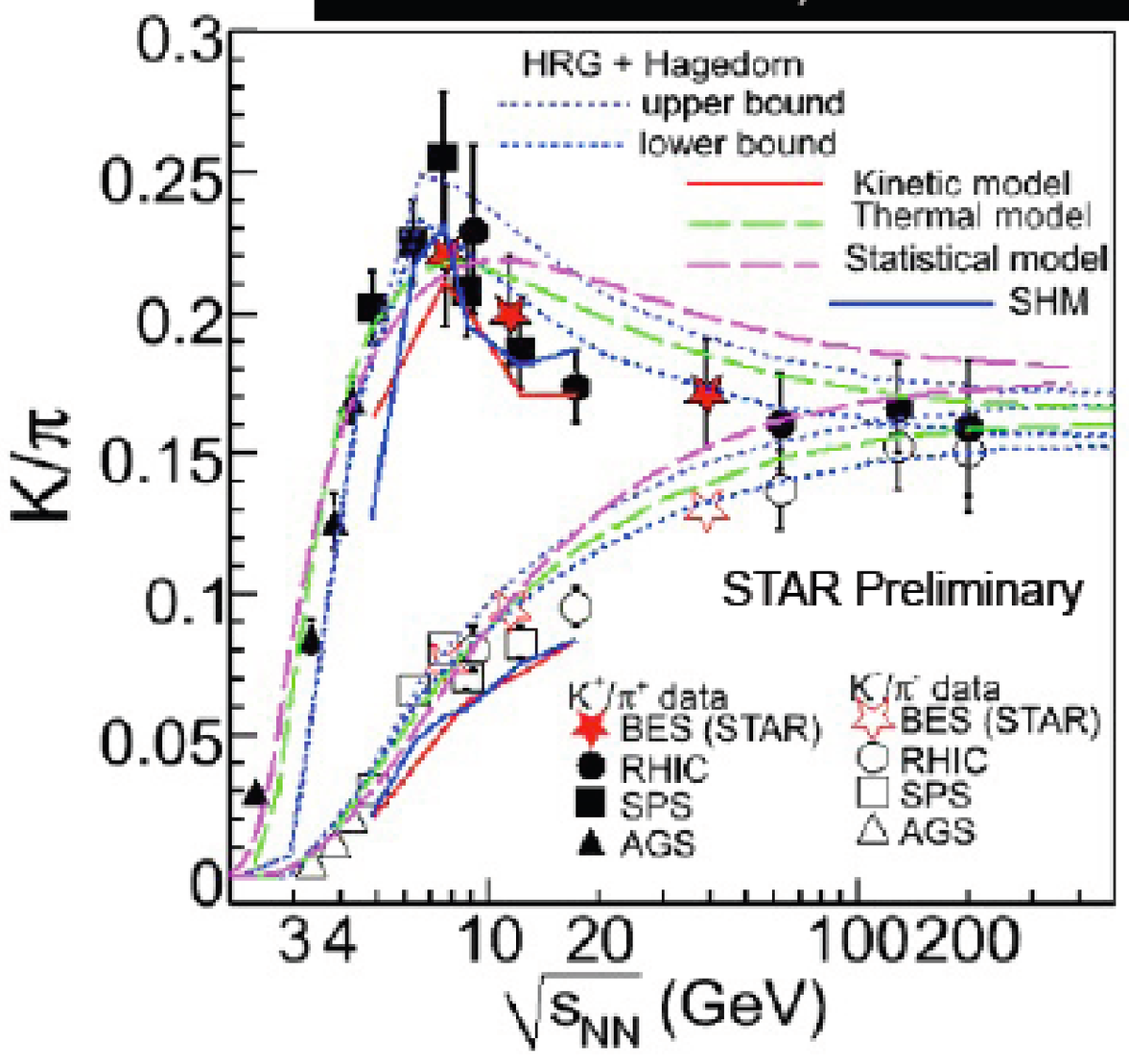
- No strong energy dependence of K/π fluctuations in central 0-5% Au + Au collisions from STAR data

K/π ratio

Statistical and systematic error added in quadrature

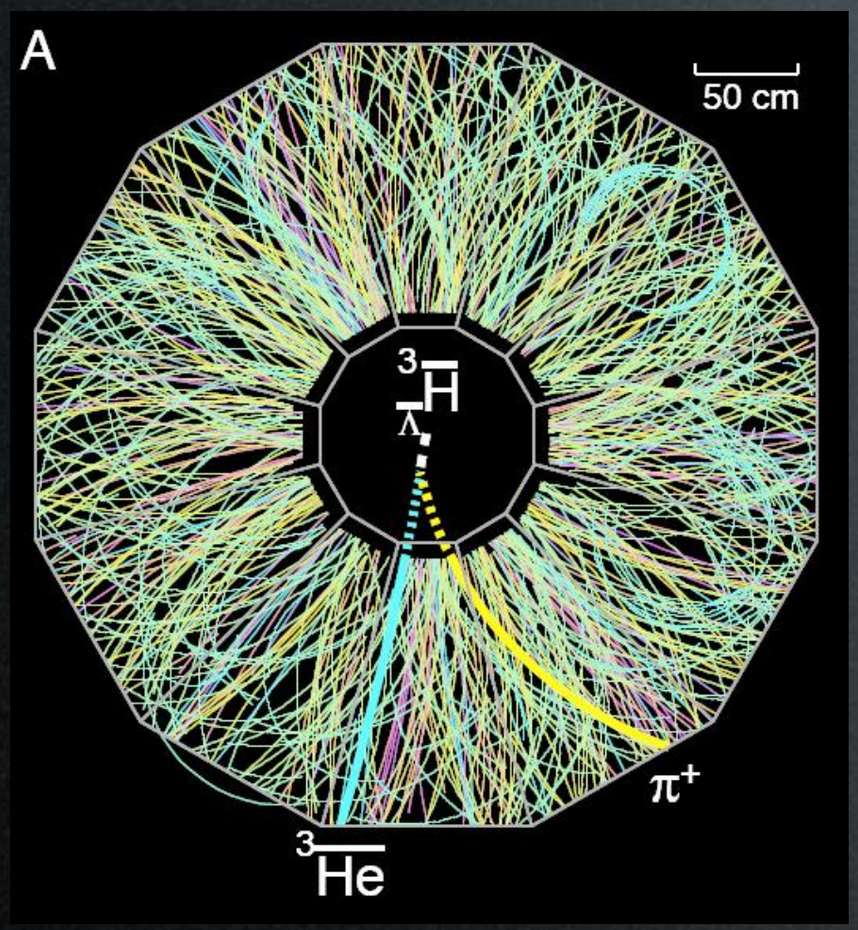


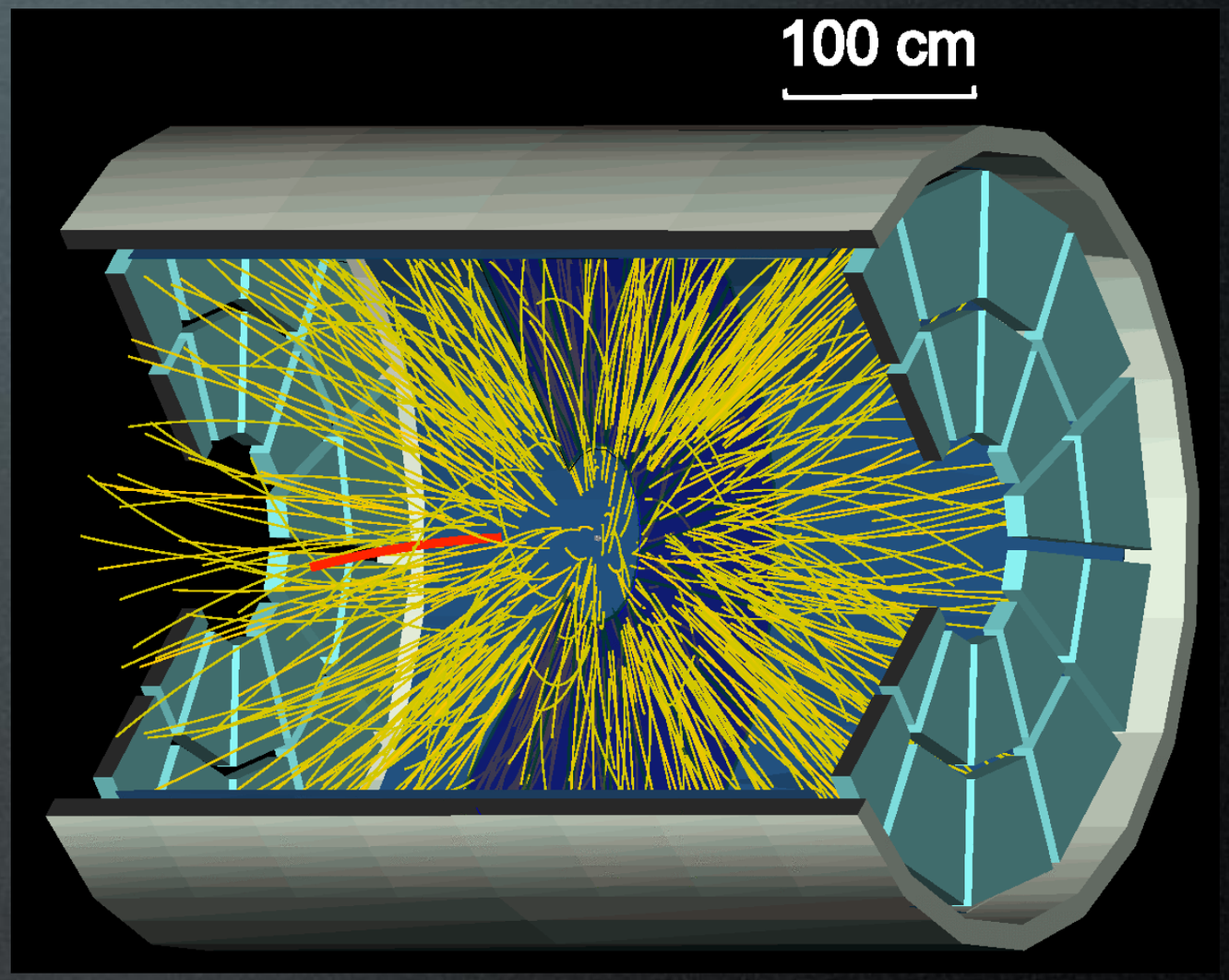
Lokesh Kumar, Fri/27 15:00



- K/π consistent with published results → strangeness enhancement
- K^+/π^+ is best explained by HRG + Hagedorn model

RHIC as Exotic/Antimatter Machine





Science

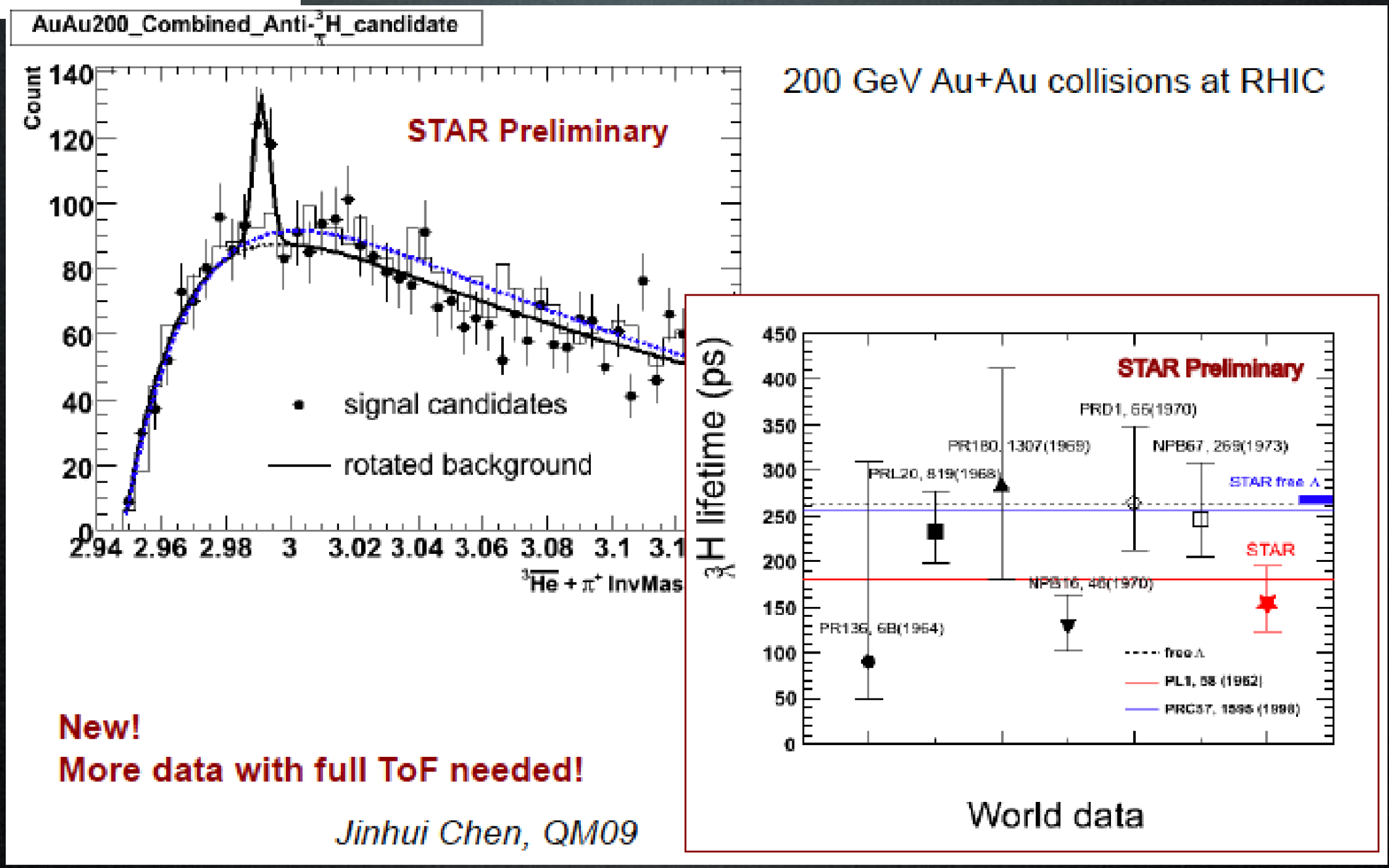
Science 328, 58 (2010)

nature

Nature 473, 353 (2011)

Antimatter Hyper Triton

$$\overline{{}^{3}_{\Lambda}H} \rightarrow \overline{{}^{3}He} + \pi^{+}$$

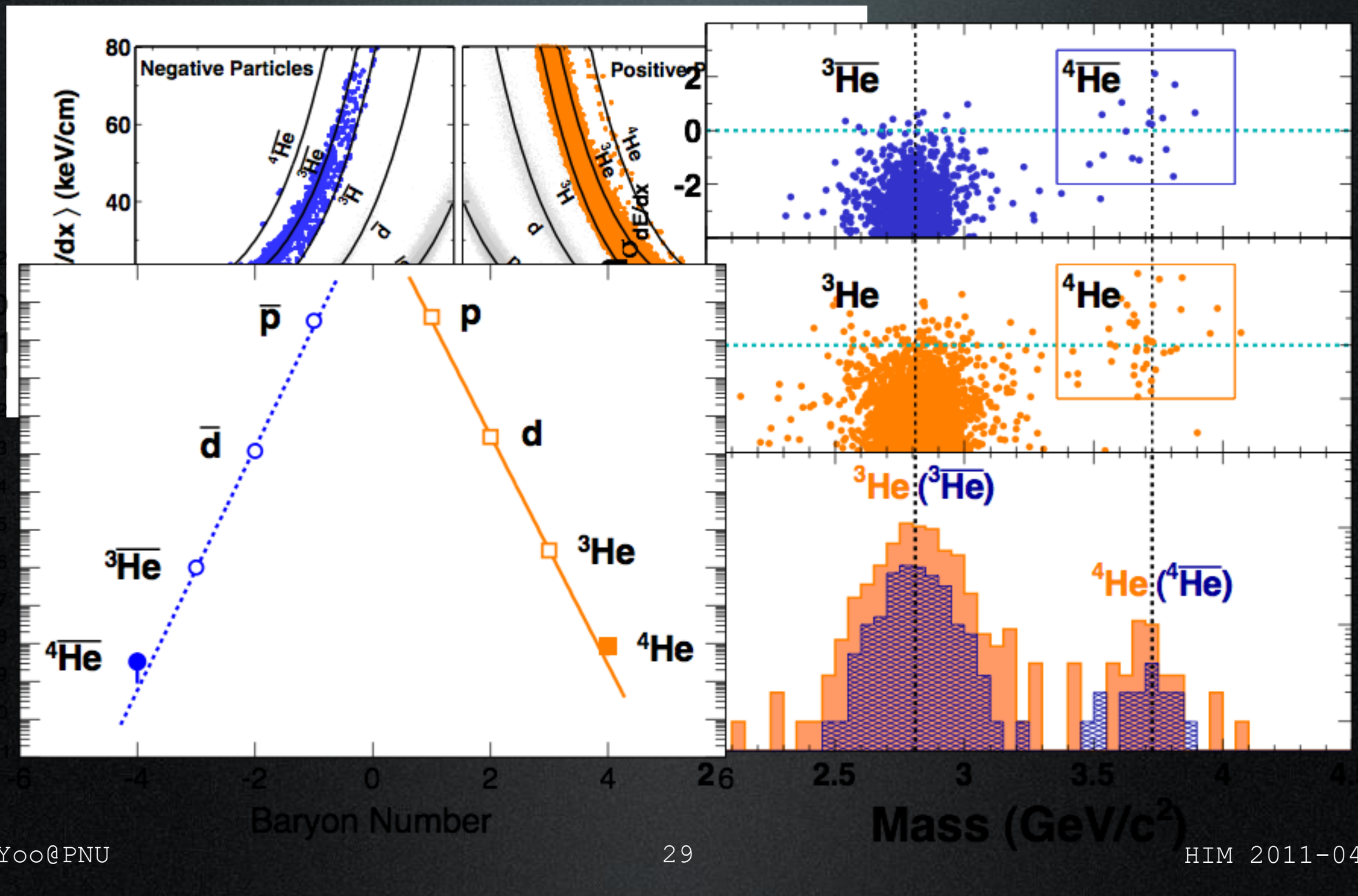


New!

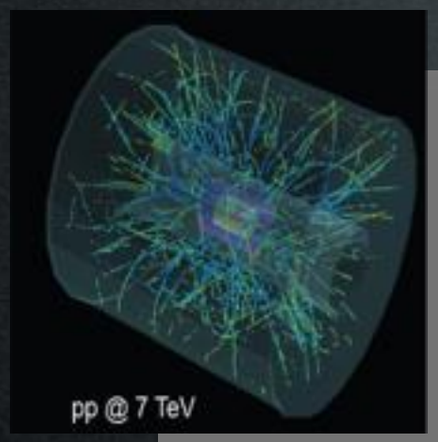
More data with full ToF needed!

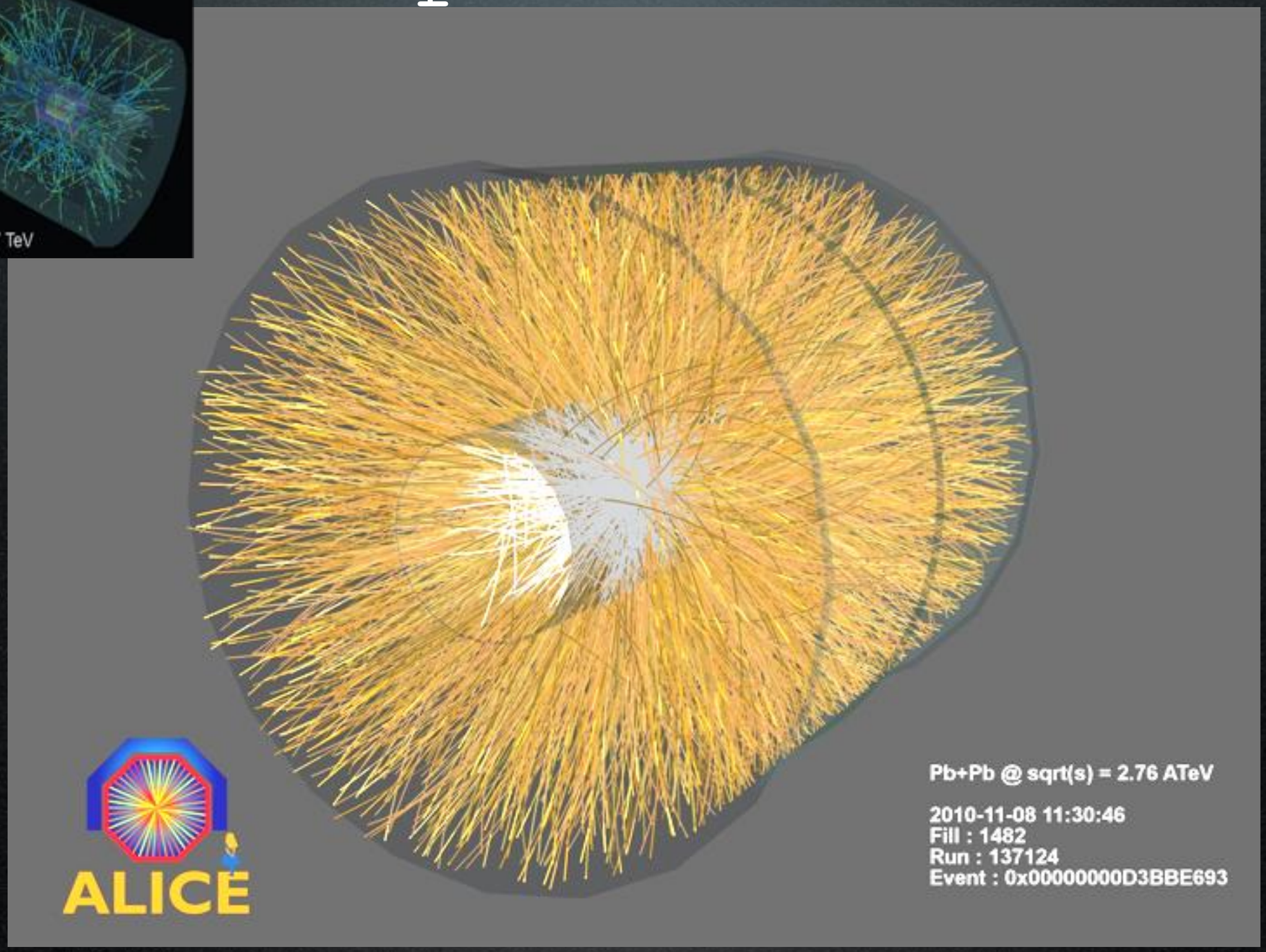
Jinhui Chen, QM09

Antimatter Helium



A Large Ion Collider Exp. @ LHC





A Large Ion Collider Exp. PbPb@ 2.76TeV

Energy density from $dN_{ch}/d\eta$

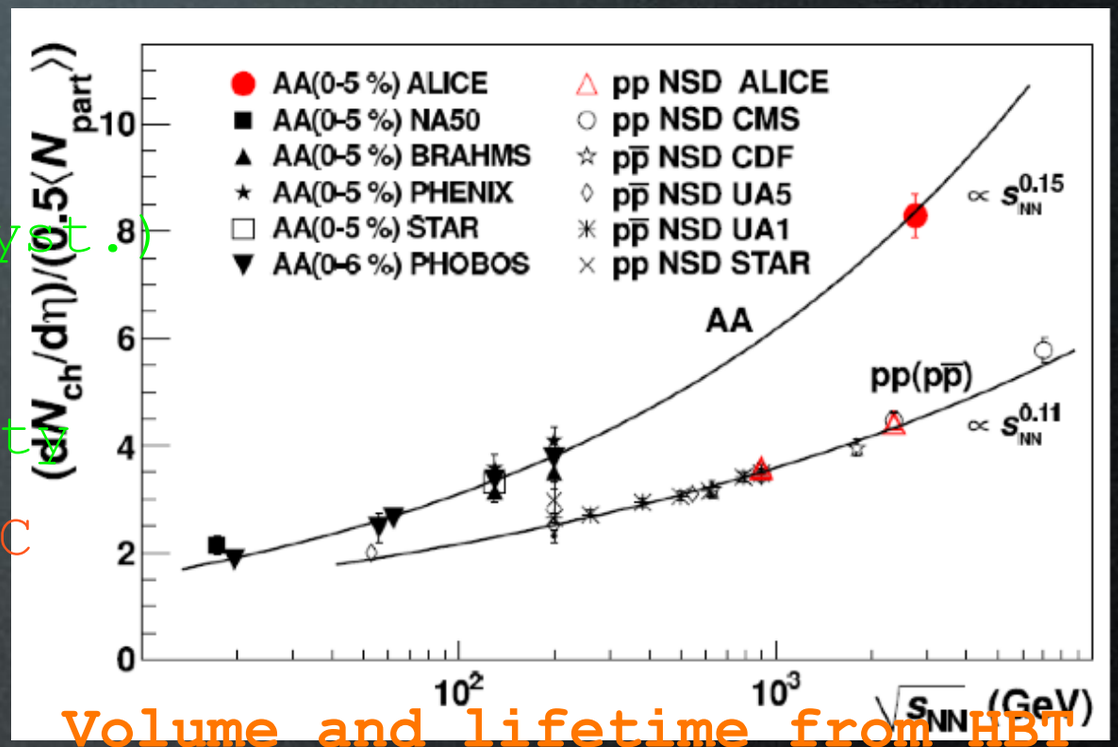
$dN_{ch}/d\eta$ = 1599 ± 4 (stat.) ± 80 (syst.)

constrains / rules out models

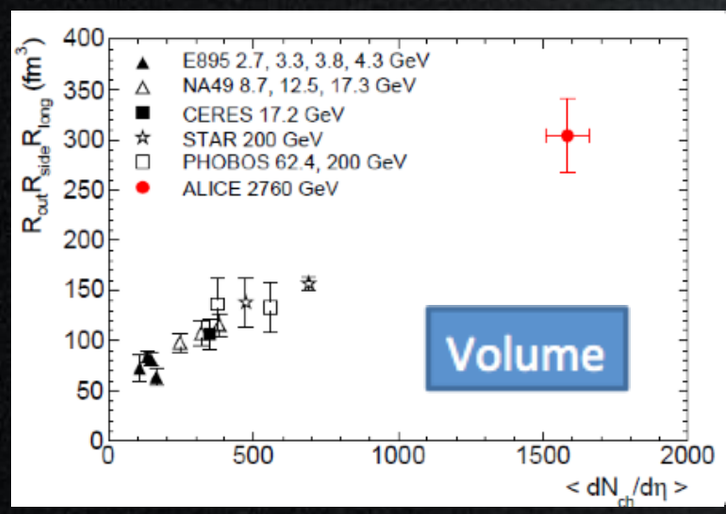
100 times cold nuclear matter density

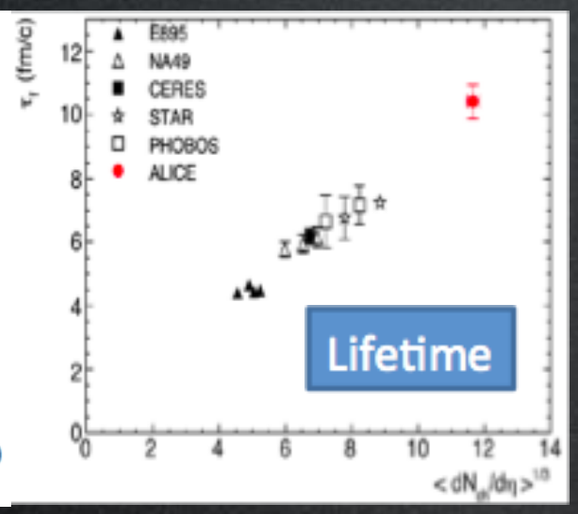
~3 times the density reached at RHIC

($\varepsilon \approx 15$ GeV/fm^3)



Volume and lifetime from HBT





Freeze-out volume ~ 300 fm^3

~ 2 times the volume measured at RHIC (AuAu@200 GeV)

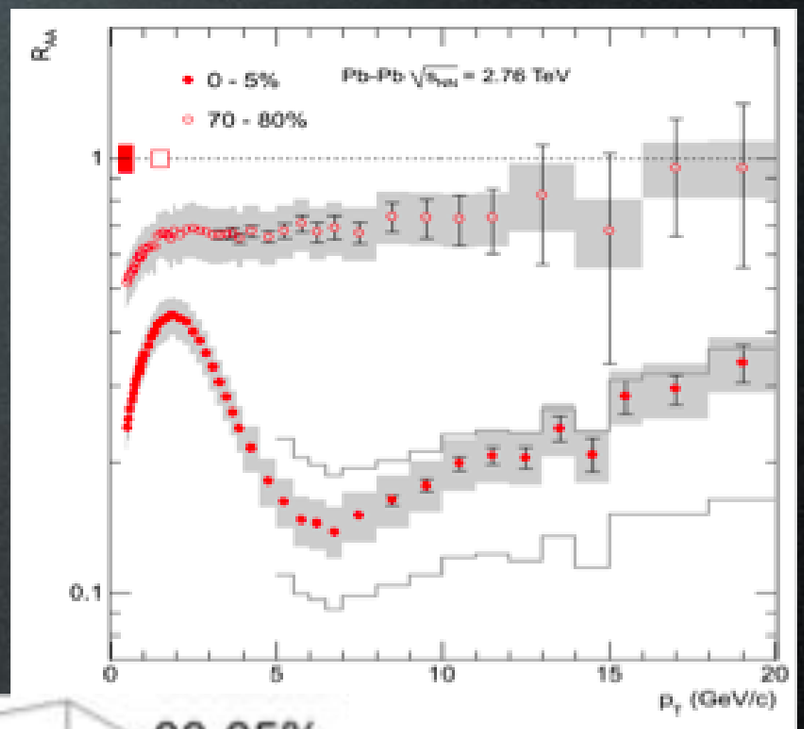
Lifetime until freeze-out ~ 10 fm/c

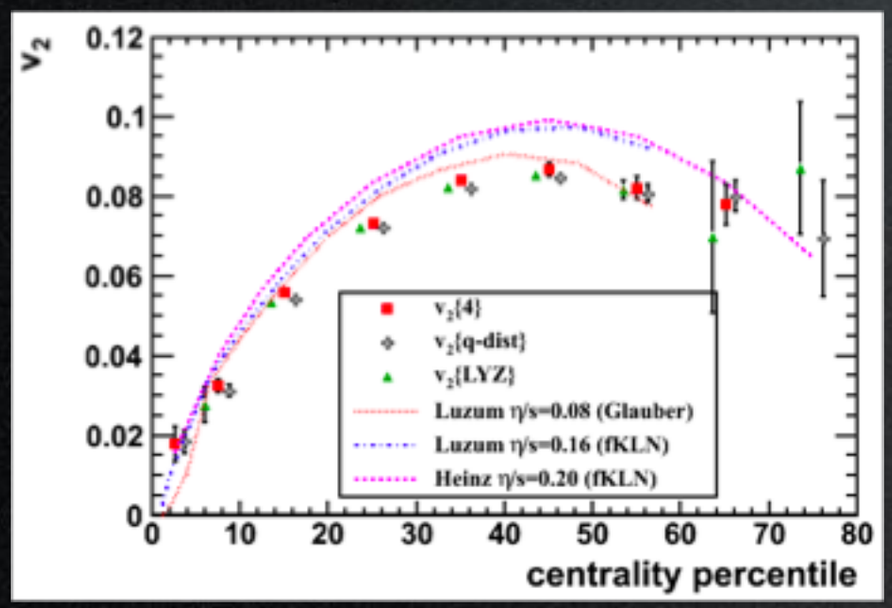
A Large Ion Collider Exp. PbPb@ 2.76TeV

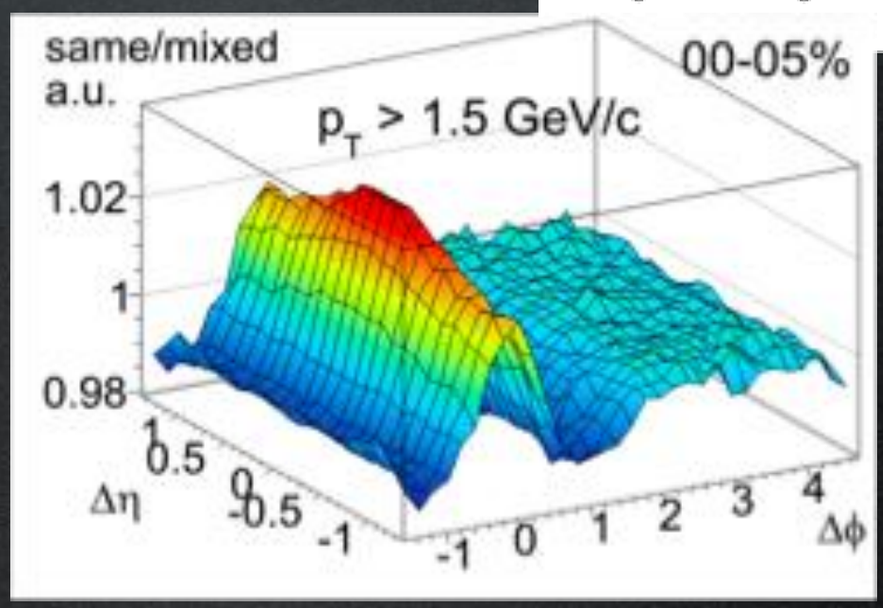
Strong energy loss in hot and dense medium

Quantified by nuclear suppression factor R_{AA}

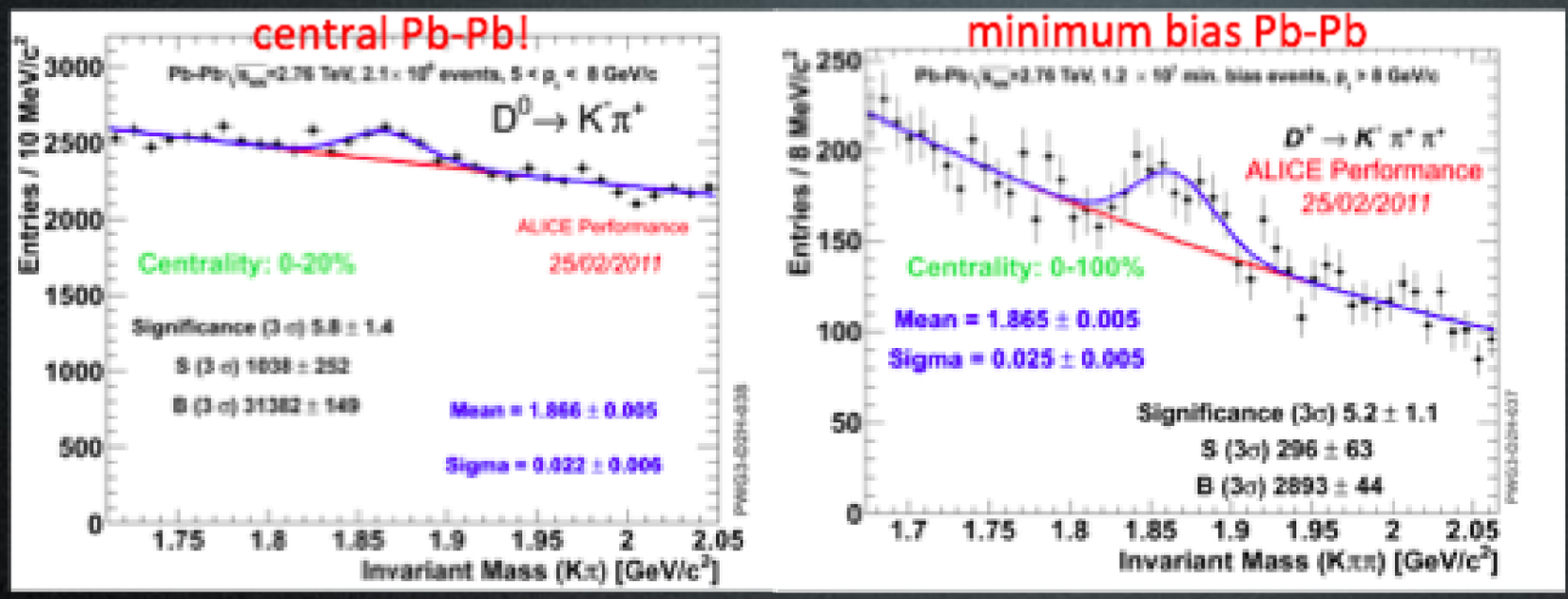
Maximum suppression R_{AA} ~ 1.5 - 2 x stronger than at RHIC

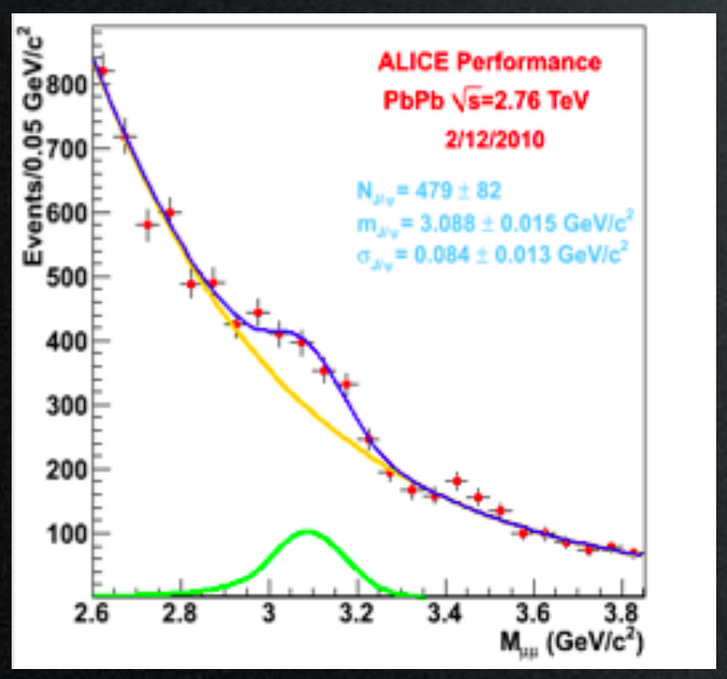


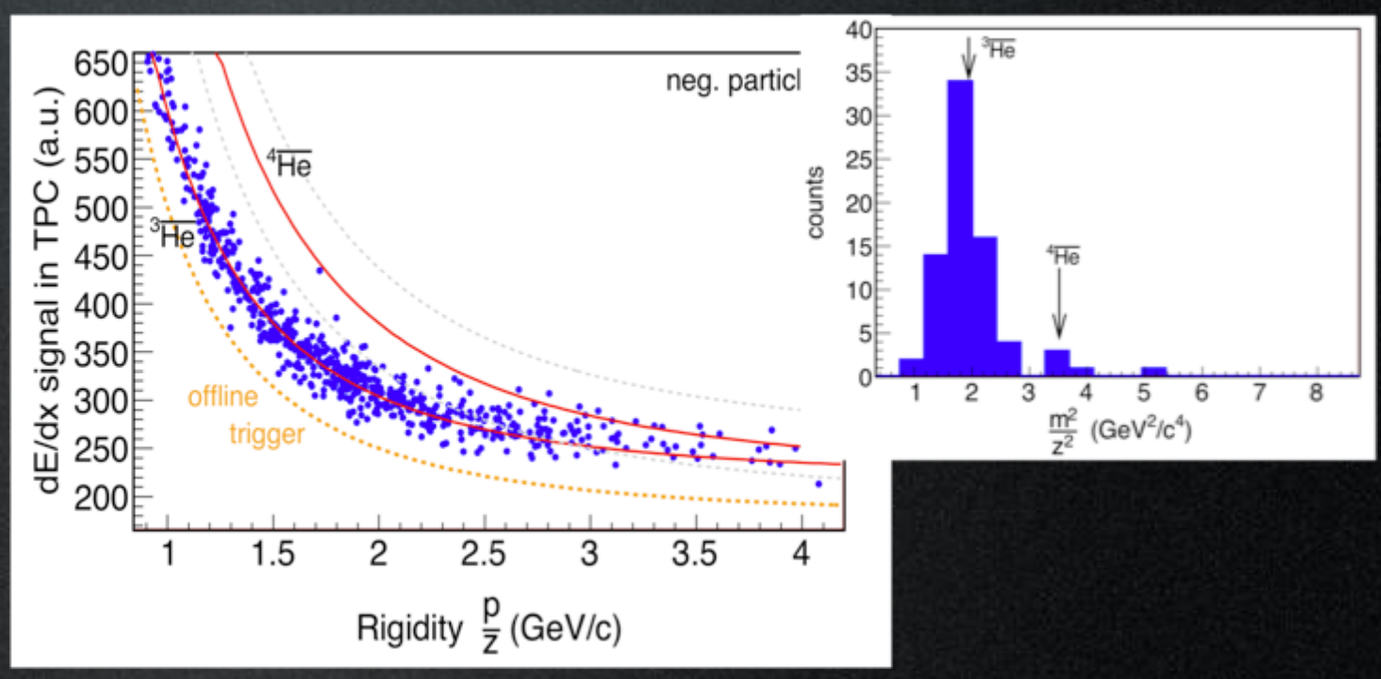




A Large Ion Collider Exp. PbPb@ 2.76TeV







Thanks!

- 35 Heavy Ion Meetings since 2004-12
- 290 Talks / avrg. 35 participants
- 101 foreign invitees
- Asian Triangle HI Conferences (ATHIC)
- GREAT APPRECIATION TO PROF.SHIM