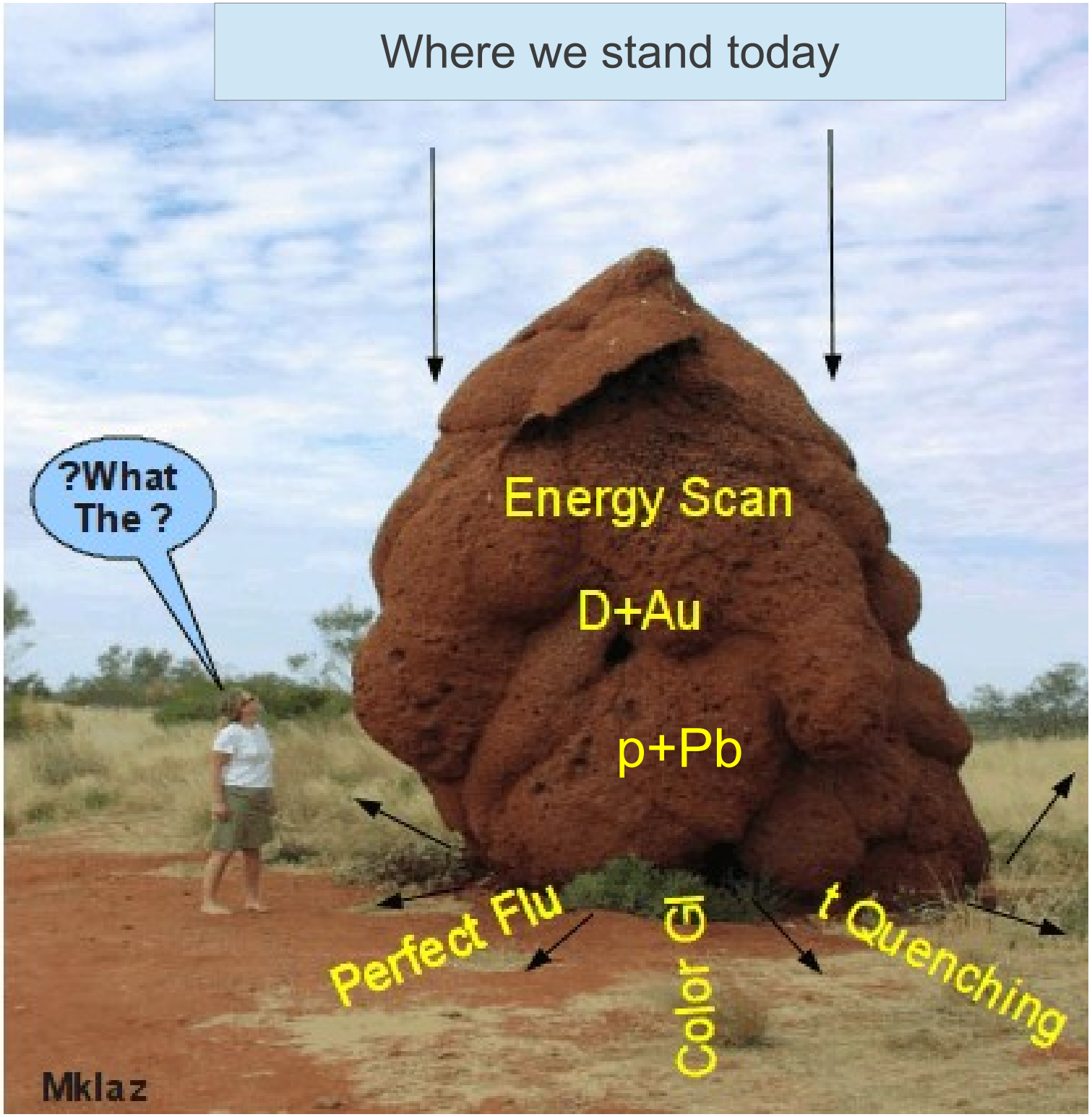
"The Revenge of Wit 2013"

Will the Au Pillars of QGP and CGC 2003 be left Standing after the pA and DA and BES ?

Me,Looking for the Ag Lining in the ashes of pA DA and BES

Where we stand today



Part 1: The Good Old Days : Triangles

Part 2: Building the Au Pillars of QGP and CGC at RHIC

Part 3: Reinforcing with Pb the Au Pillars at LHC

Part 4: The Revenge PA and DA and BES > 2012

Part 5: Heresy

Concluding remarks

pA data has, and continues to surprise us

- lack of cascading in the 1950' and 1960's
- long range correlations and simplicity of participant scaling in the 1970's
- "Cronin effect" in the the 1970's
- strong quenching of forward particles in the 1970's and 1980's
- "flow-like" behavior in the 2010's

pA is like a litmus test. Until we understand pA from our understanding of pp and AA, we cannot claim to have a deep understanding of pp and AA.

Concluding remarks

Formation Time: tform ~ E/mT^2

Feinberg, LPM

Color flux tubes
q-qbar and q-qq

BGK 77, Lund , DPM

pA data has, and continues to surprise us

- lack of cascading in the 1950' and 1960's
- long range correlations and simplicity of participant scaling in the 1970's
- "Cronin effect" in the the 1970's

Cold nuclear (Moliere) scattering of partons

Kuhn, Lev 76

- strong quenching of forward particles in the 1970's and 1980's

(Baryon Stopping)

- "flow-like" behavior in the 2010's

Woopps ?? Shock and Awe ! Could this be the Glasma Quantum INTERFERENCE smoking gun??

Was

pA is like a litmus test. Until we understand pA ~~from our understanding of pp and AA~~, we cannot claim to have a deep understanding of pp and AA.

MG Corollary 1: If PA DA is weird , AA remains un-controlled
MG Corollary 2: "If it ain't got that pA DA swing, it don't mean a thing !"

Recalling BGK p+A "Rapidity Triangle"

- Multiple independent wee parton dx/x collisions produce ~uniform in rapidity color charges between valence p and valence wounded A.
- Color neutralizes via pair production between wee and valence partons
-
- Leaves a stack of
- $A^{1/3}$ ~ 10 Target beam jets
- For rare Nch~300 maybe 30 Pb nucleons line up
- There is just 1 Proj beam jet
-
- Y *Slope* δ = Ntr / log(s)
- RHIC δ ~ 2 x LHC δ

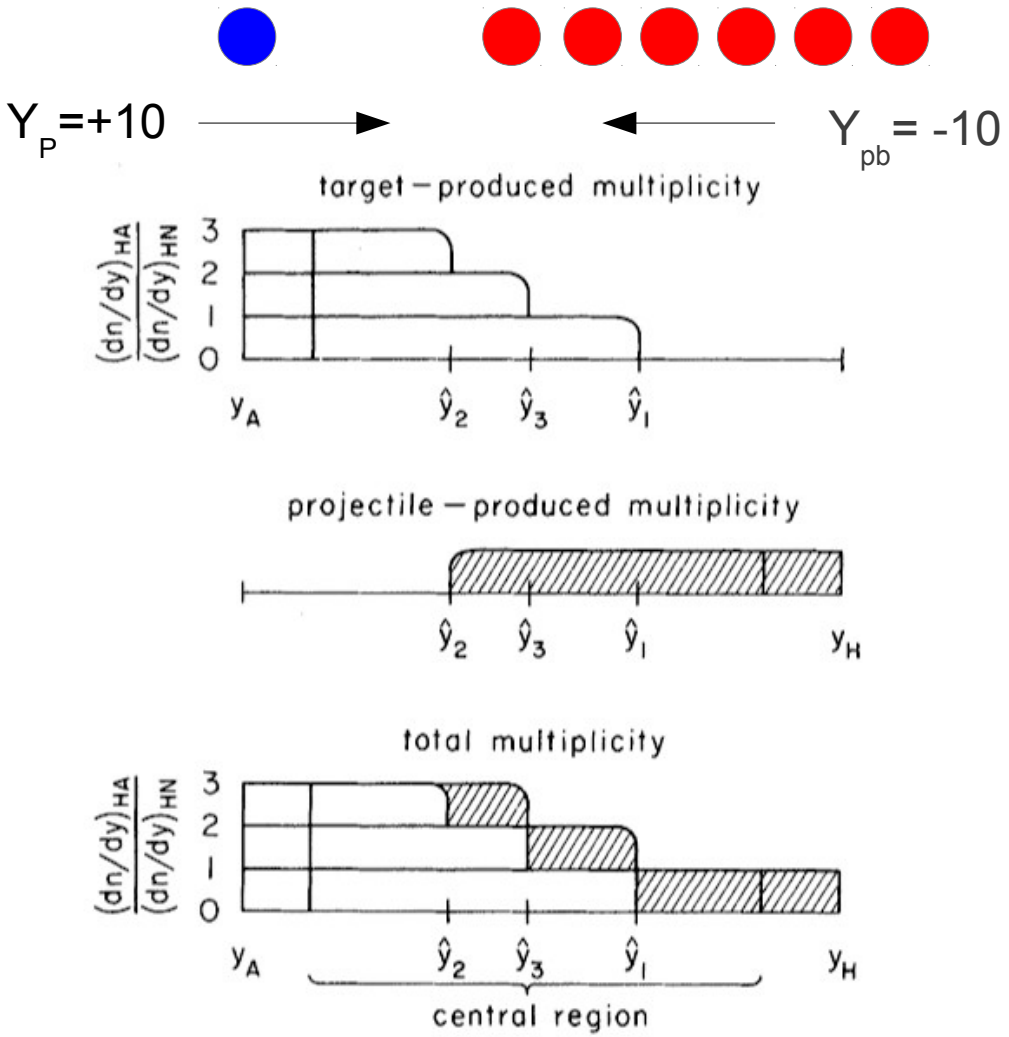
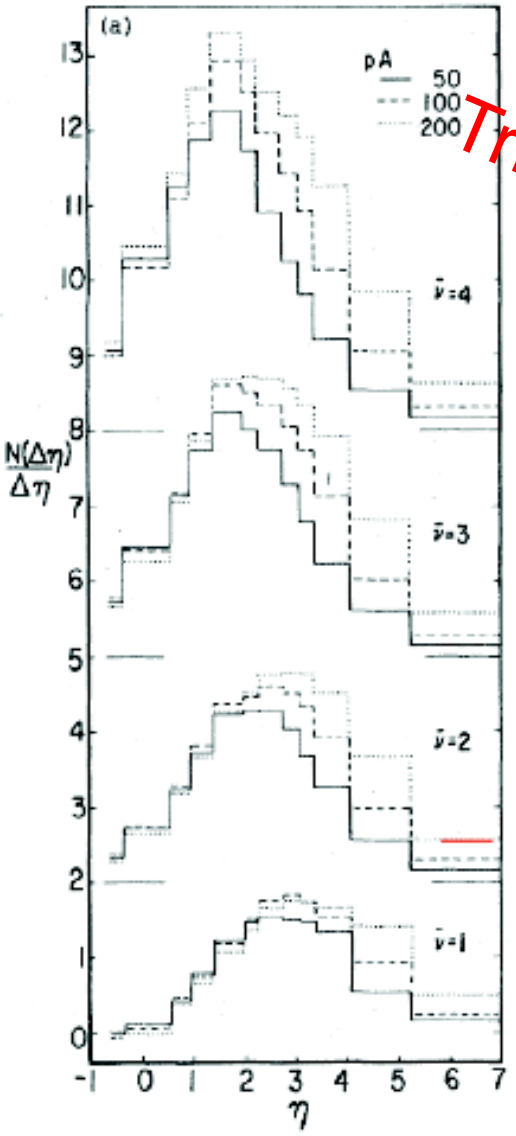
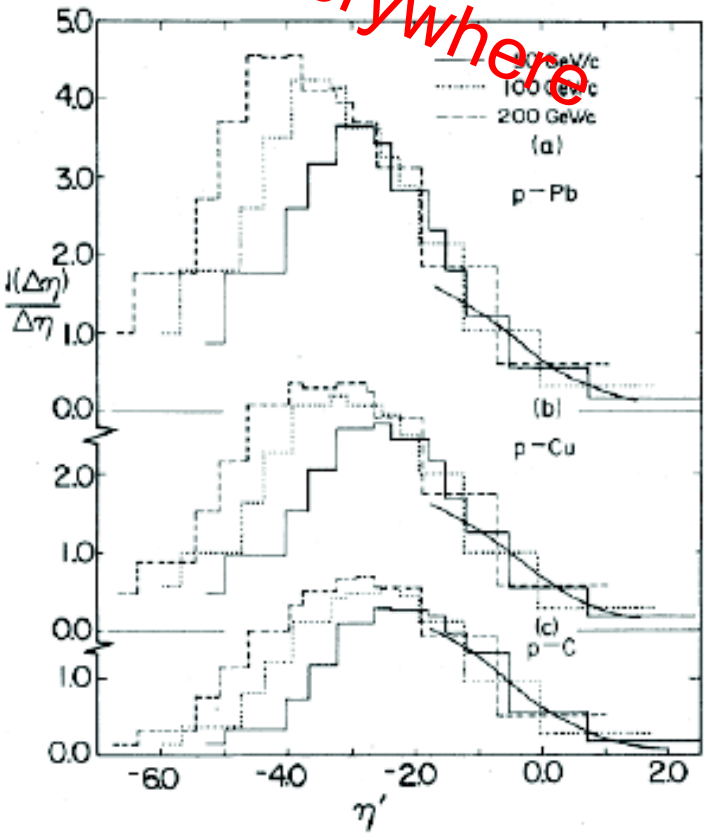


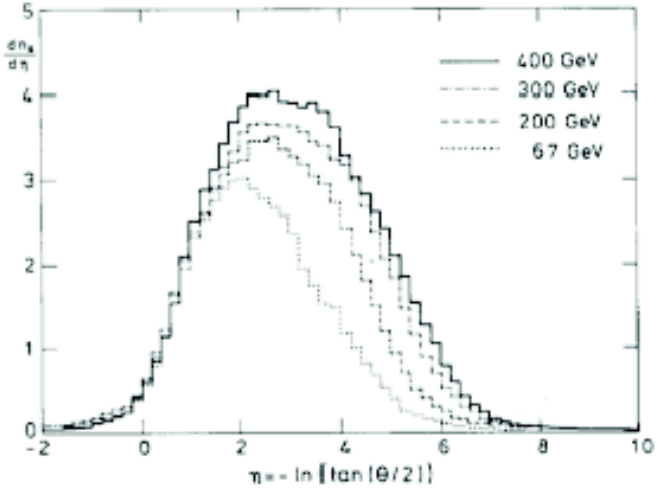
Figure from Brodsky, Gunion, Kuhn 1977

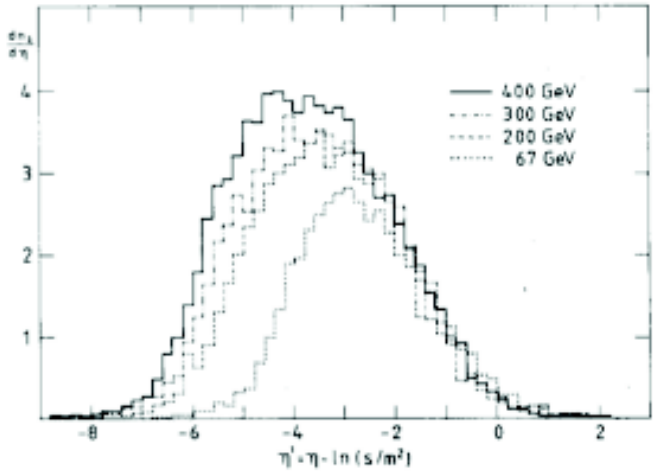
Extended Longitudinal Scaling in E178 Data for $\sqrt{s_{NN}}$ 10 - 20 GeV



Triangles Everywhere







Nucleus rest frame

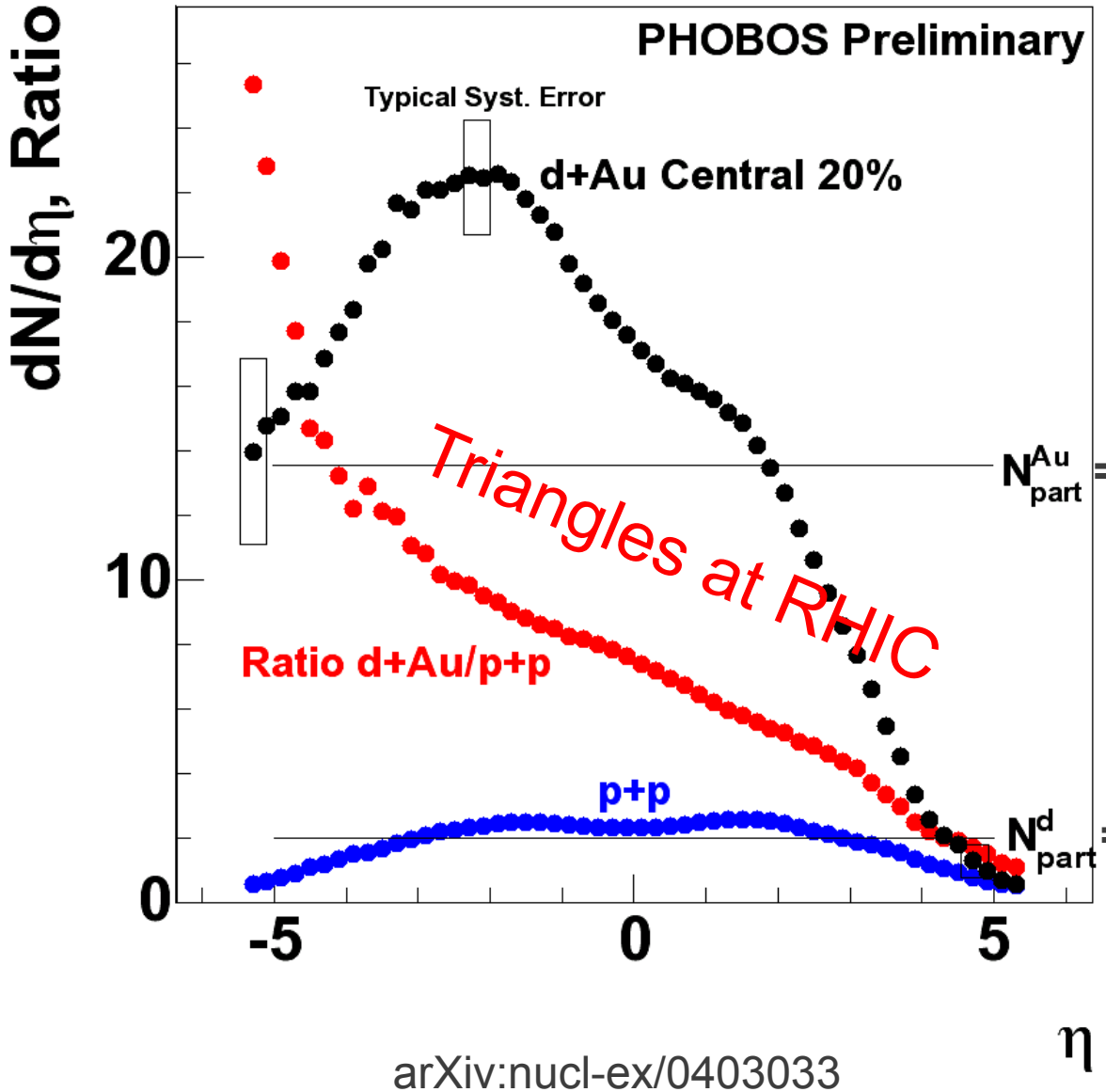
Projectile rest frame

J. Elias et al., (E178) PR D22 (1980)13

pEmulsion data (Otterlund et al., compilation NP B142 (1978) 445

N_{part} scaling for asymmetric collisions at RHIC:

W.Busza, RBRC 4/15/2004



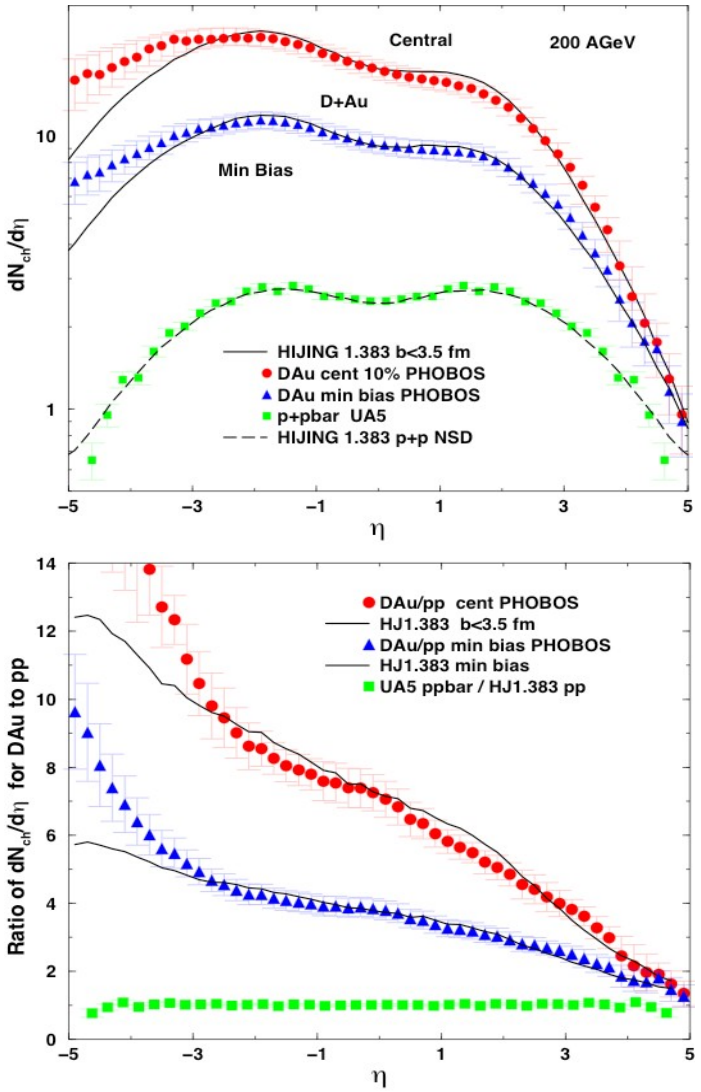
arXiv:nucl-ex/0403033

Triangles “Explained” via HIJING/Lund/BGK

- Lund model T+P ***beam jets*** =flux tubes in HIJING account well for PHOBOS data and reproduced the basic BGK77 triangle form of the ratio p+A/p+p, as well as the absolute magnitude dNch/deta

- Except in Au frag region y< -3

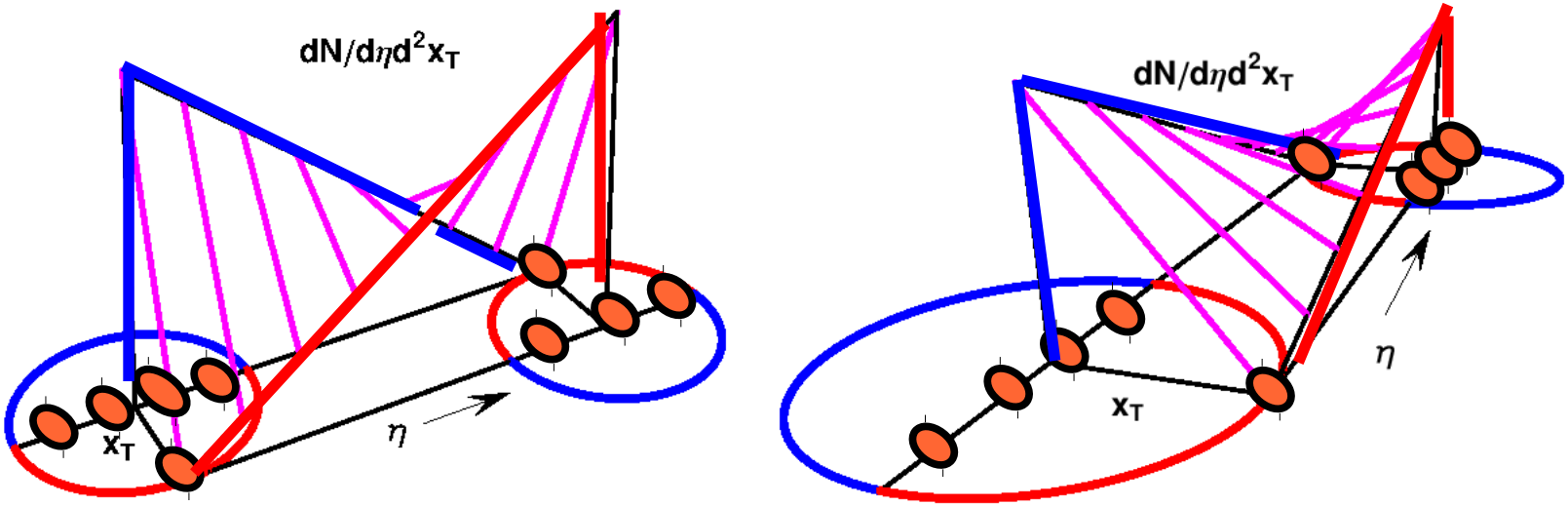
  where cascading missing in HIJING enhances y< -3 Nch yields



A.Adil, MG, PRC 72 (2005) 034907

3D jet tomography and the twisted color glass condensate
A. Adil, M. Gyulassy, T. Hirano , Nucl.Phys. A774 (2006) 593

$$A+A = (p+A^{1/3}) + (A^{1/3}+p) + \text{Symmetric Stuff}(A-A^{1/3} + A-A^{1/3})$$



AA b>0 has 2 Rapidity Triangle p+A edges

But total dN/dy integrated over xT is completely flat & constant!

Symmteric AA is *NOT* boost invariant *locally* at fixed xT

Part 1: The Good Old Days Triangles

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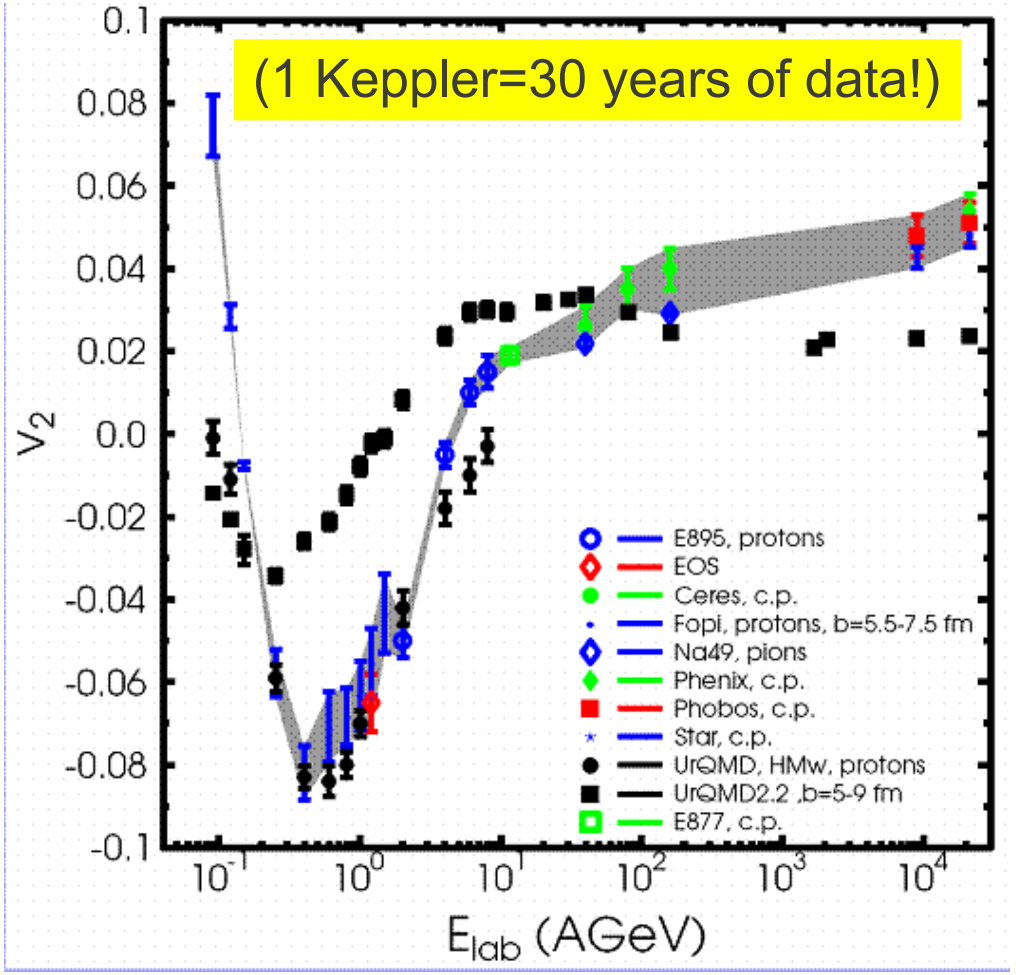
Perfect Fluidity was not seen before below RHIC energies

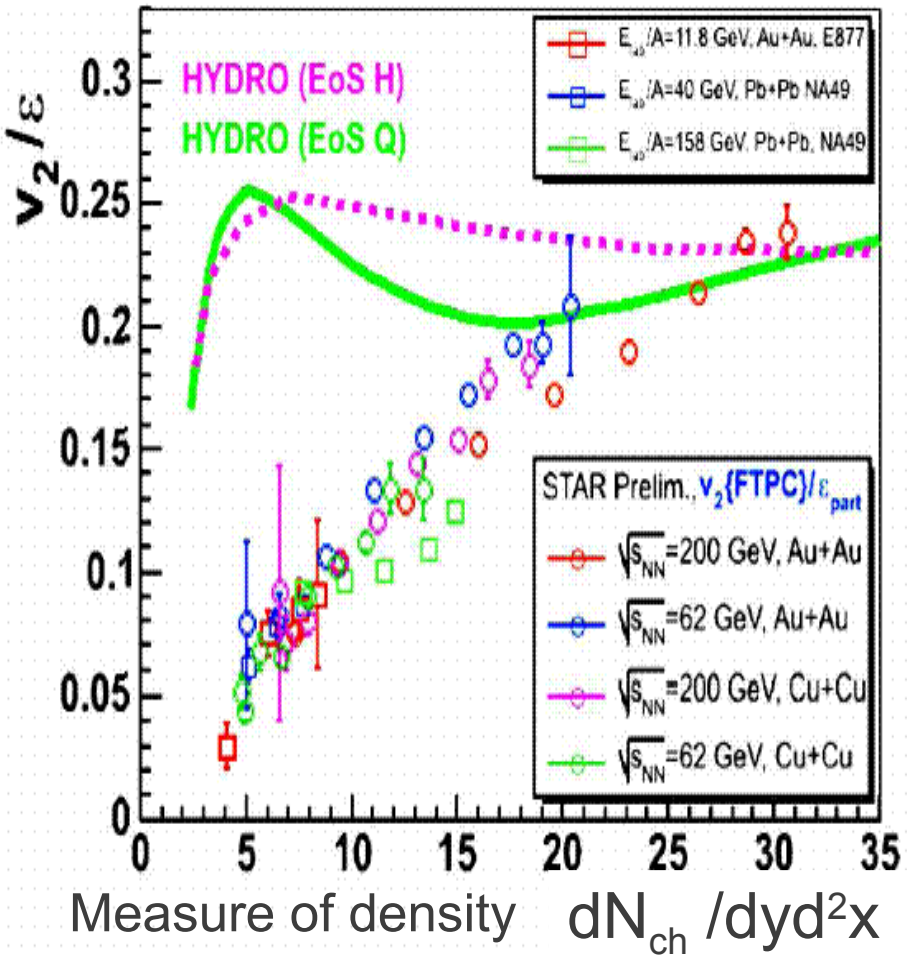
Elliptic flow is ubiquitous

M. Bleichert, et al UrQMD, Transport



But perfect fluid elliptic flow is not

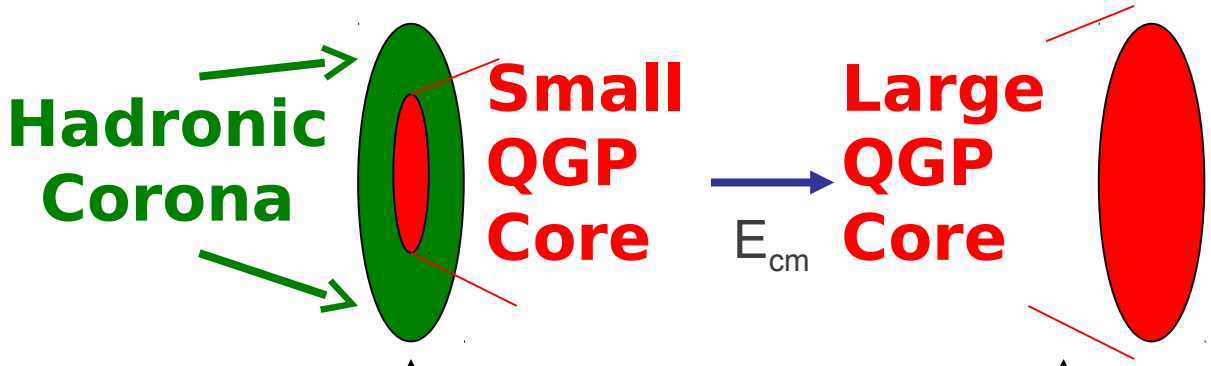
Kolb, Heinz: Euler Hydrodynamics



Ordinary nuclear matter and hadron resonance matter is
an imperfect viscous fluid with large deviation from perfect fluidity
The quark soup appears to be nearly perfect

At lower energies Perfect Fluidity is Obscured
the highly dissipative Hadron Kinetic Corona

Bass, Dumitru,…
Teaney, Shuryak
Hirano, Nara



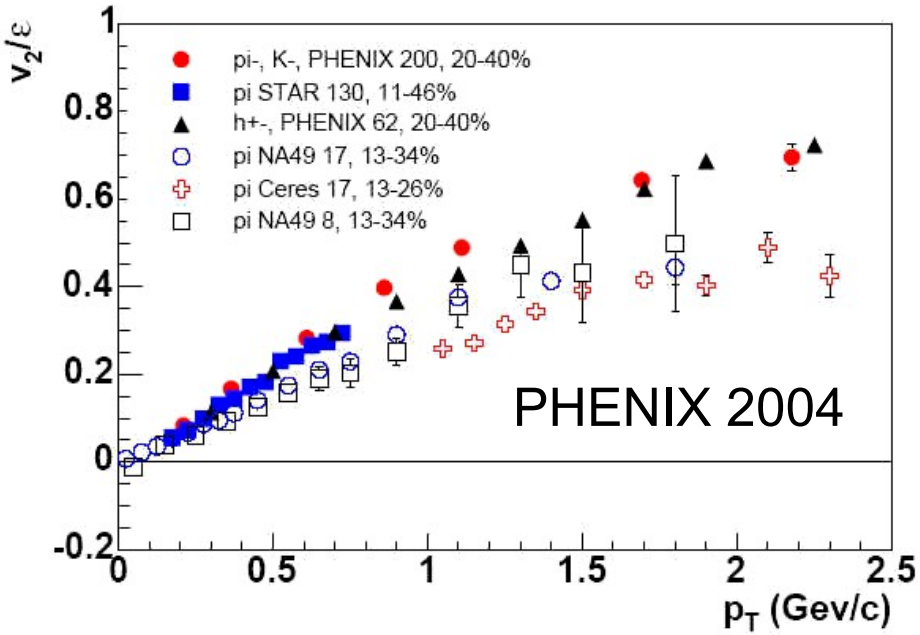


FIG. 16: $v_2(p_T)/\varepsilon$ versus p_T for mid-central collisions at RHIC (filled symbols) and SPS (open symbols). Dividing by eccentricity removes to first order the effect of different centrality selections across the experiments.

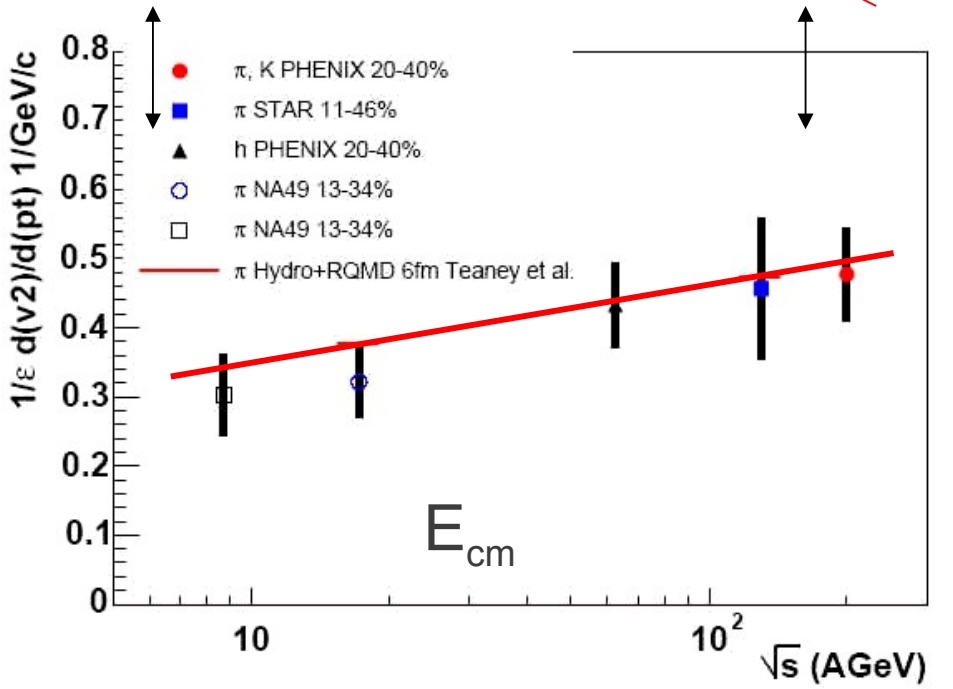
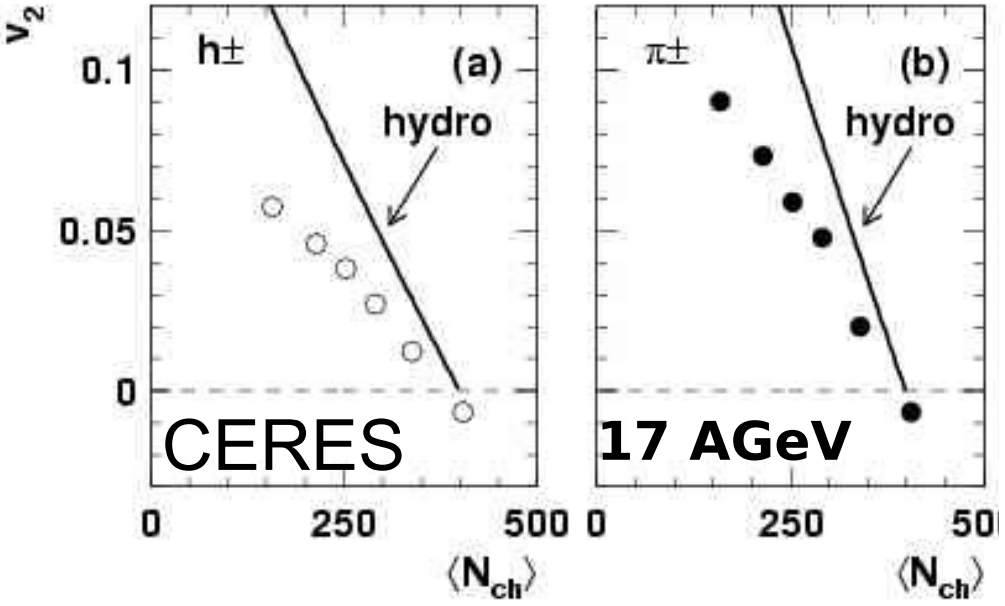
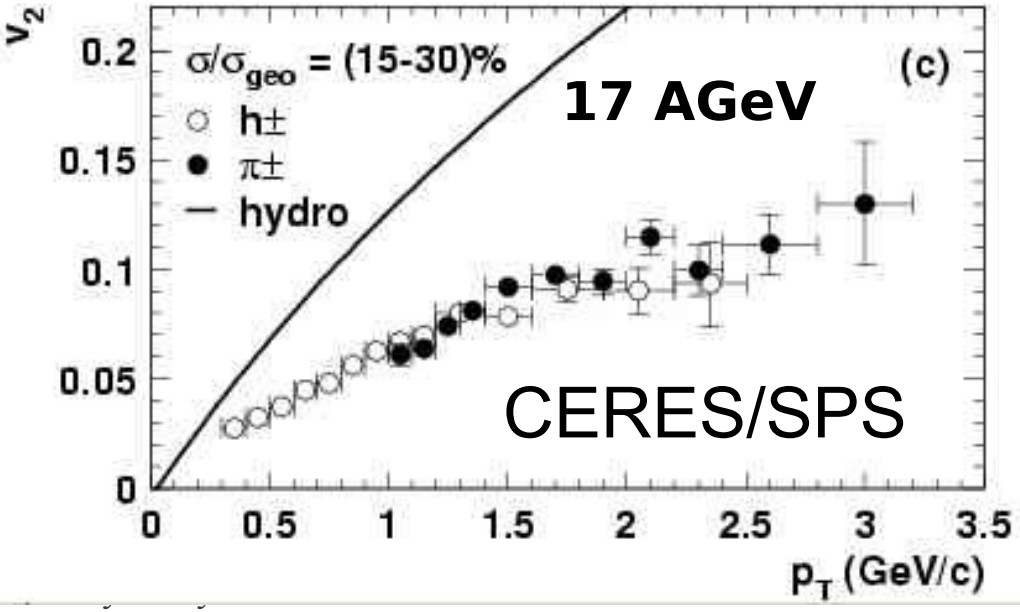


FIG. 17: The slope of the scaled elliptic flow, $(dv_2/dp_T)/\varepsilon$, for mid-central collisions at RHIC (filled symbols) and the SPS (open symbols). The slope is calculated for the data $p_T < 1$ GeV/c. The solid error bars are the systematic errors that include the systematic error on v_2 and ε.

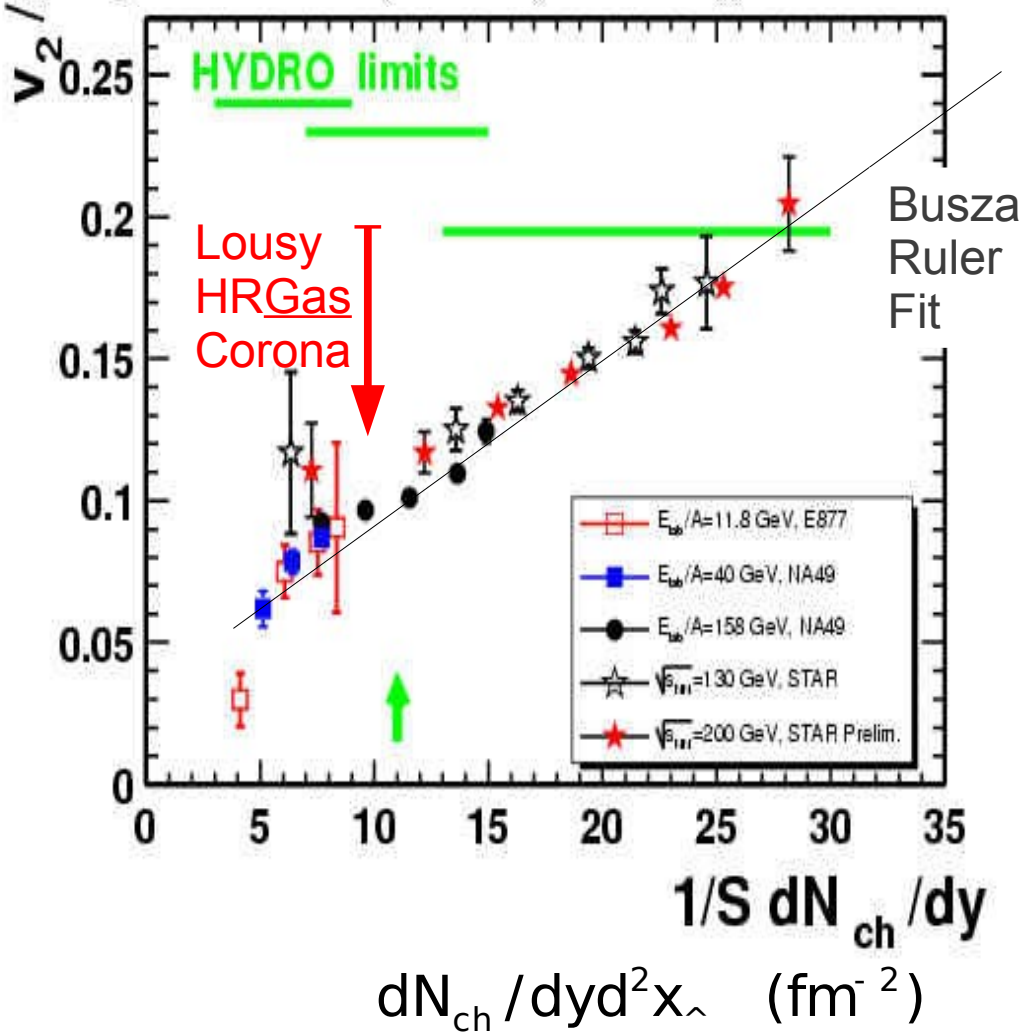
Below RHIC energies, QCD hydro failed elliptic flow!

"Perfect fluid" hydro worked for first time at RHIC
Because lousy HRGas Corona was finally small enough

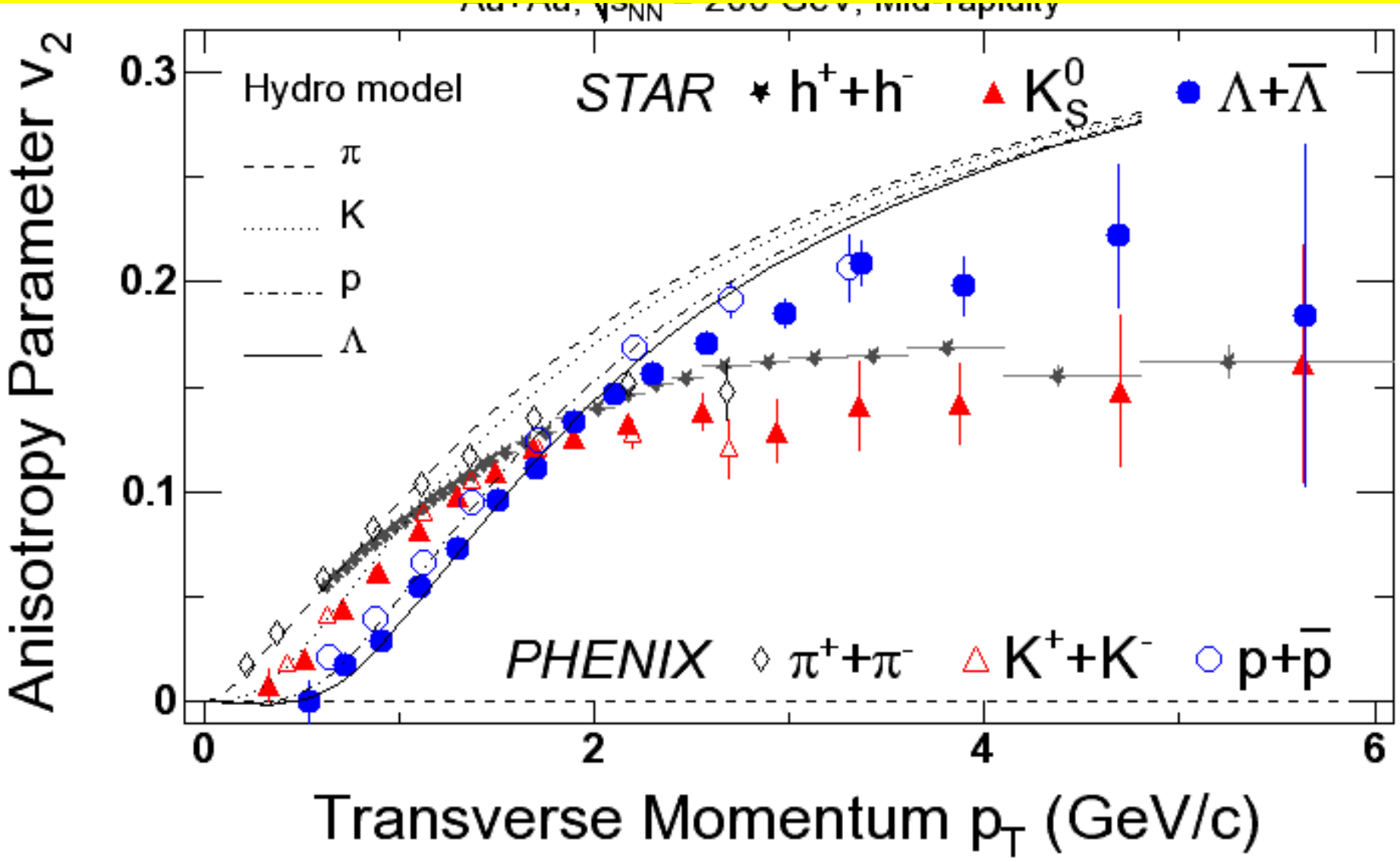




2) DIRECTED AND ELLIPTIC FLOW OF CHARGED PIONS AND PROTONS IN PB + PB COLLISIONS AT 40-A-GEV AND 158-A-GEV.
By NA49 Collaboration (C. Alt *et al.*). Mar 2003. 35pp.



The QGP Fingerprint at RHIC = Fine Structure of collective flow $P_{QCD}(T)$



Bulk P_{QCD} Hydro

pQCD Jets

qqq Coalescence

High-p_T Tomography of d + Au and Au + Au at SPS, RHIC, and LHC

Ivan Vitev[1,2] and Miklos Gyulassy[1]

Initial State
Shadow+CroninControl

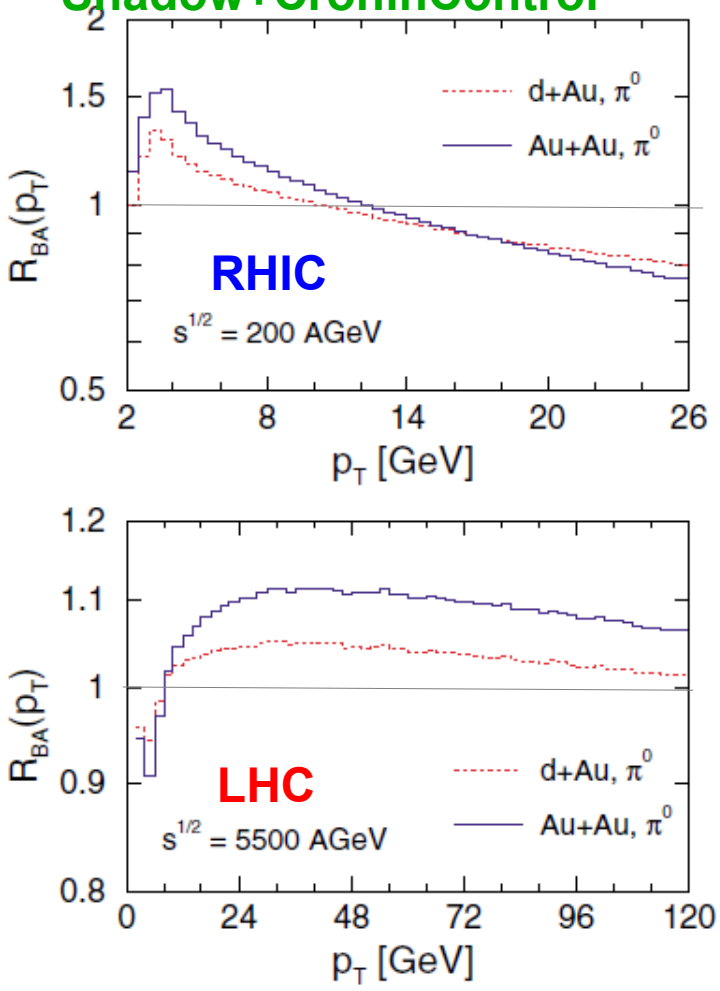
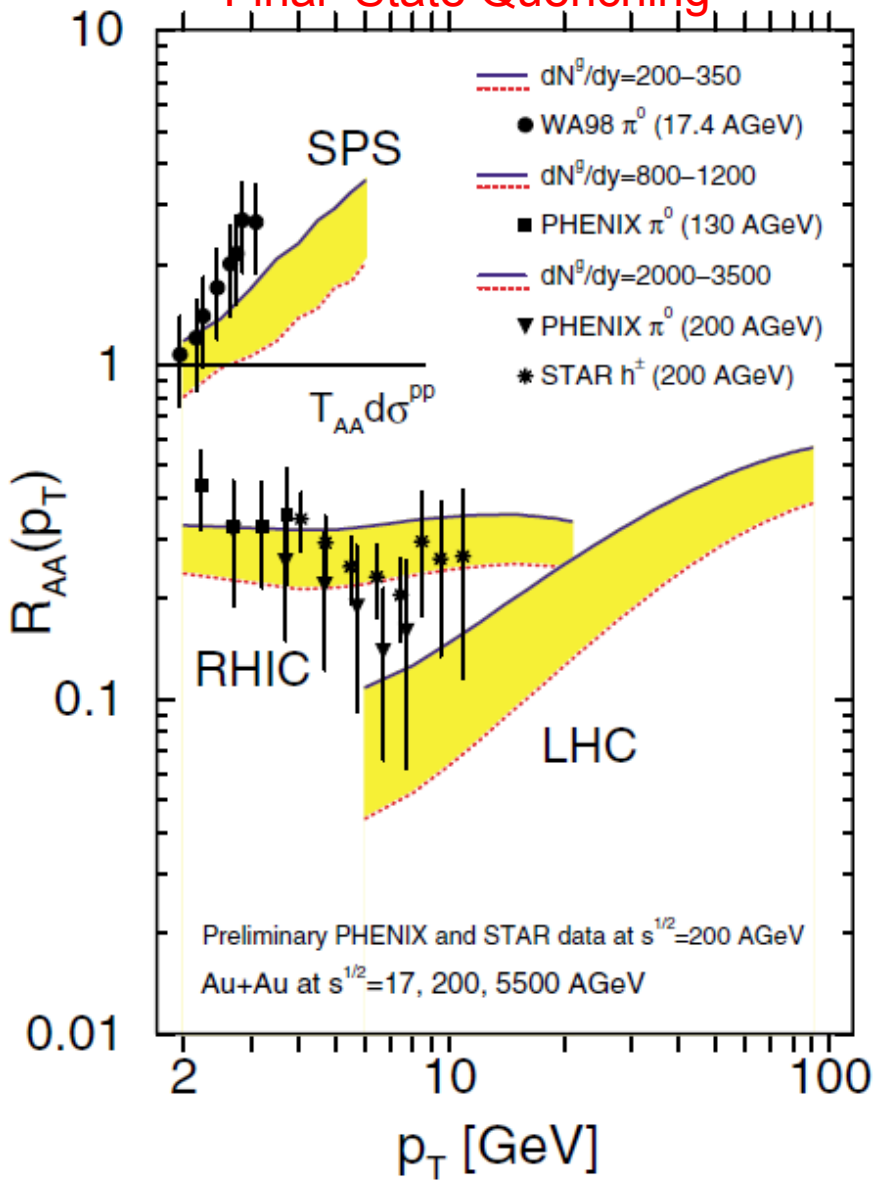


FIG. 2 (color online). The nuclear modification $R_{BA}(p_T)$ due to Cronin effect and shadowing (but not energy loss) for π^0 in d + Au ($B = d, A =$ Au) and central Au + Au ($B = A =$ Au) reactions at $\sqrt{s_{NN}} = 17$, 200, and 5500 GeV.

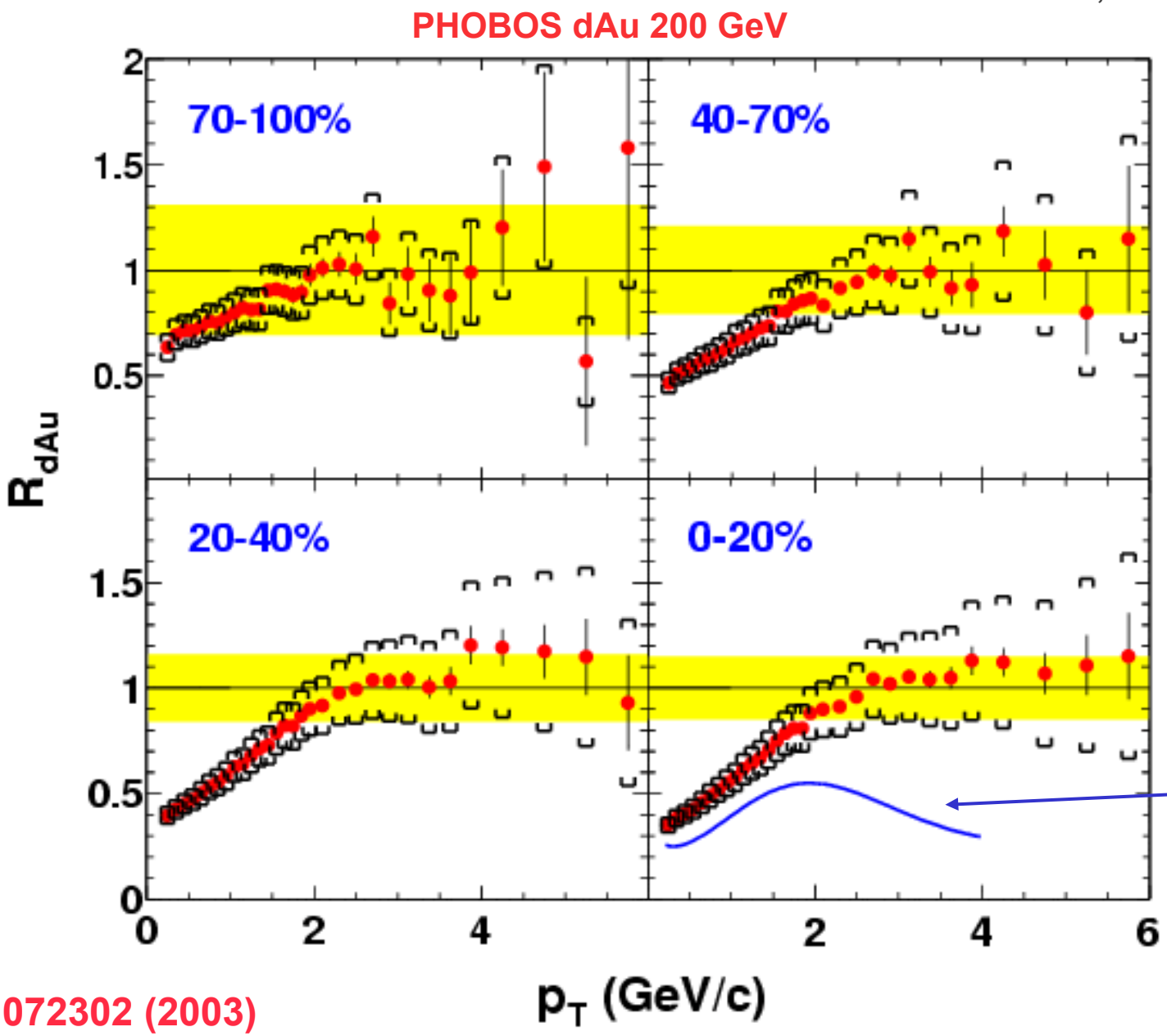
Final State Quenching



Evidence from the suppression of high-p_T particles:

[in central AA but not in D+A]

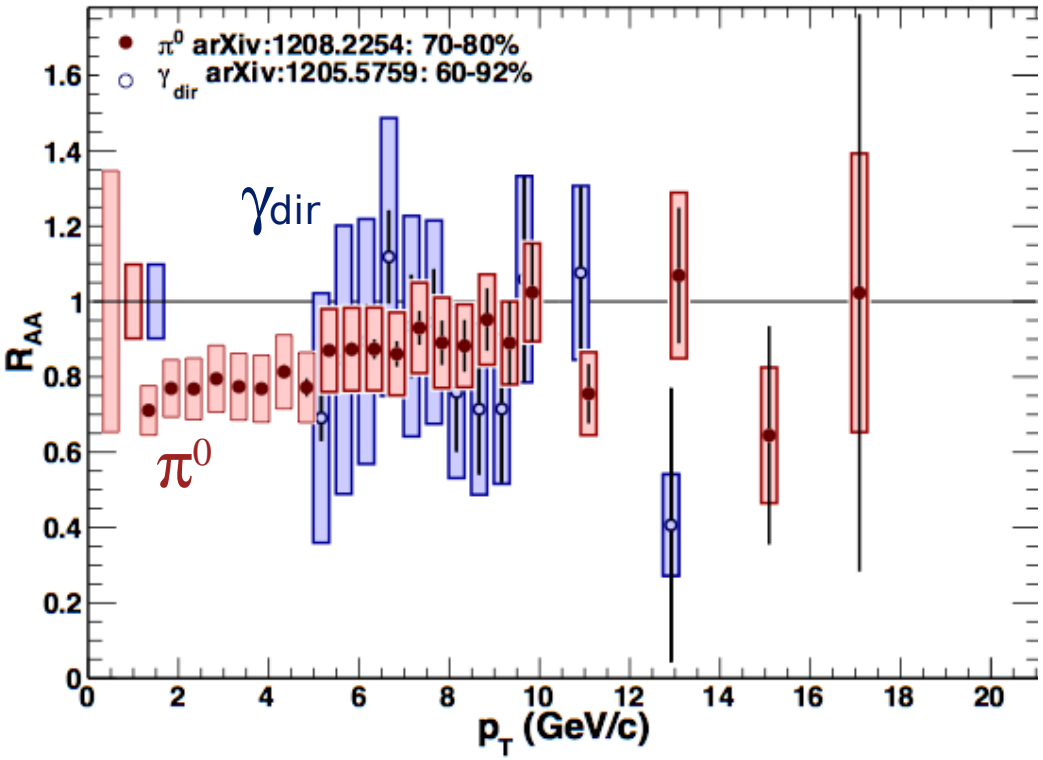
W.Busza, RBRC 4/15/2004

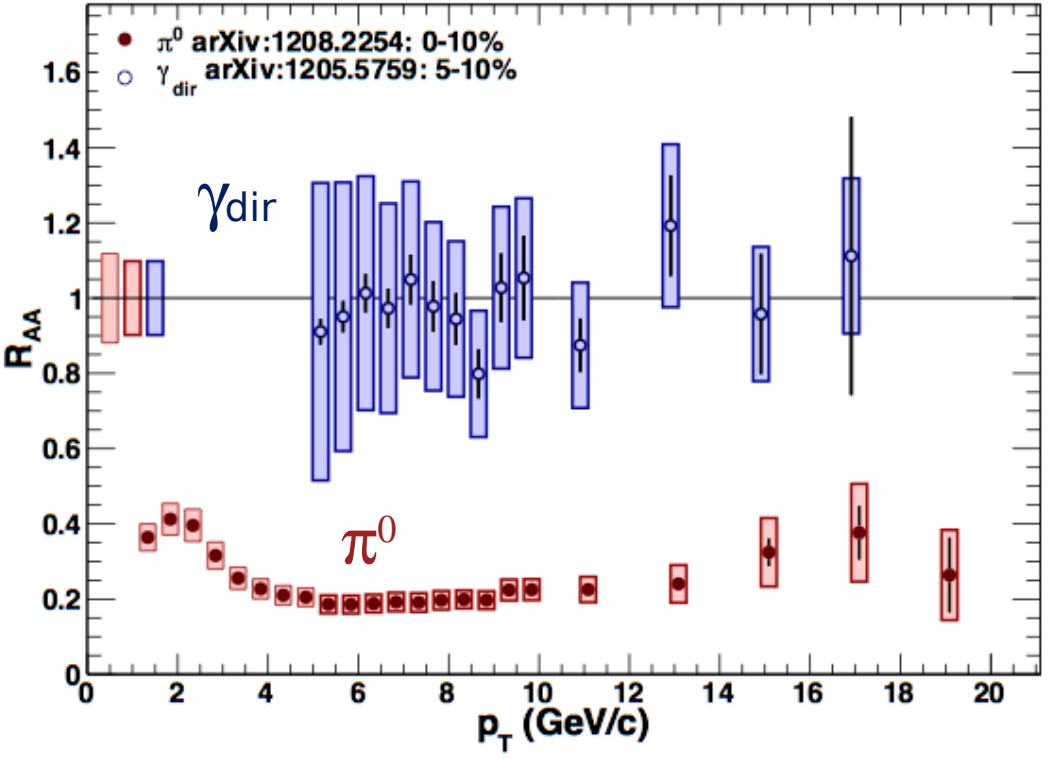


PRL 91, 072302 (2003)

2012 PHENIX direct photon control data at RHIC confirms That Q^2 > 25 GeV^2 ***Initial State*** nuclear shadowing is small

And hence the observed factor **5** suppression of pions pT> 5 GeV In Au+Au is due to the high opacity of ***Final State*** QGP



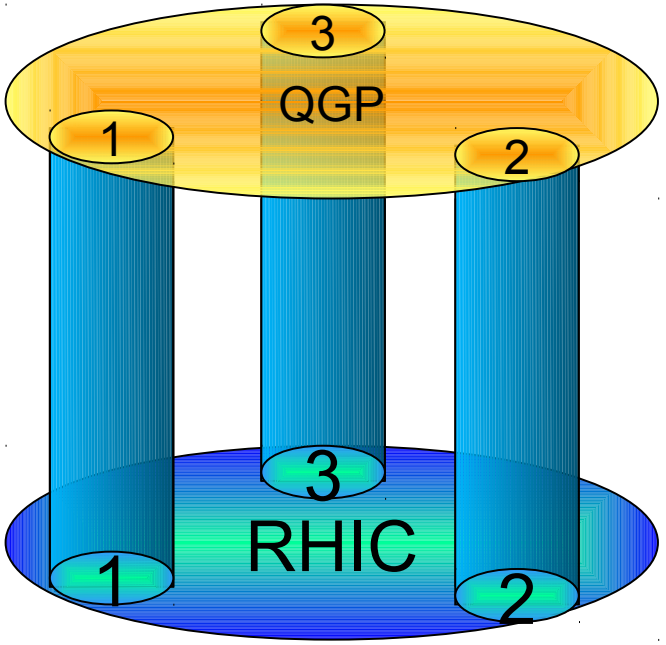


In 2003 Three Lines of Data ***Seemed*** to Converged to QGP at RHIC

Null Control

Three Pillars Stable even if unequal

Bulk P_{QCD}



Parton pQCD

1. Bulk P_{QCD} Collective Elliptic Flow v2 √
2. Parton pQCD Jet Quenching RAA √
3. p+p Calibration and **d+A Null Control** √ √

QGP = P_{QCD} + pQCD + dA = v_2 + (R_{AA}+I_{AA}) + R_{dA}

(MG,Nato School, Kemer, Turkey 5/23/03)

Part 1: The Good Old Days : Triangles

Part 2: Building the Au Pillars of QGP and CGC at RHIC

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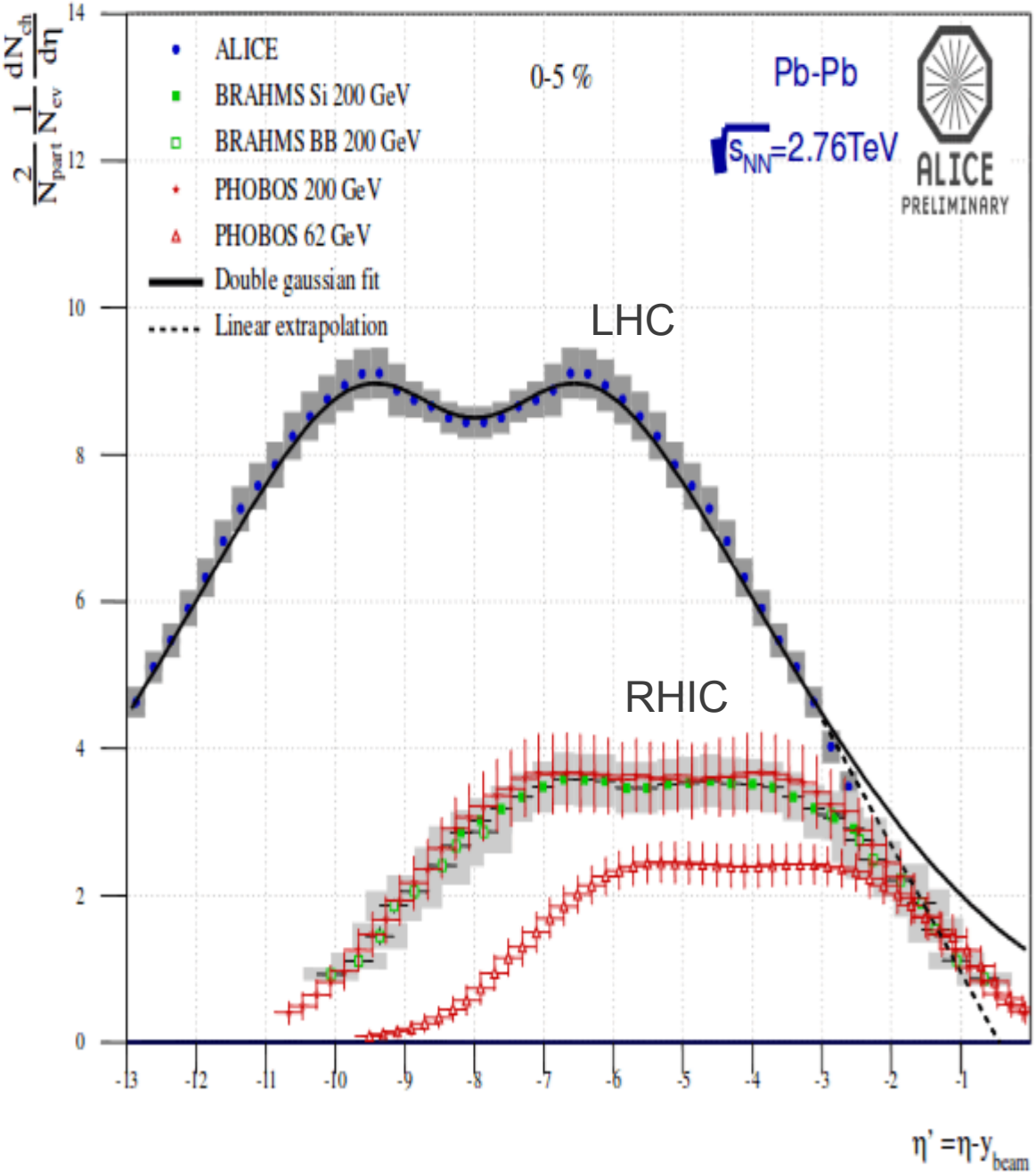
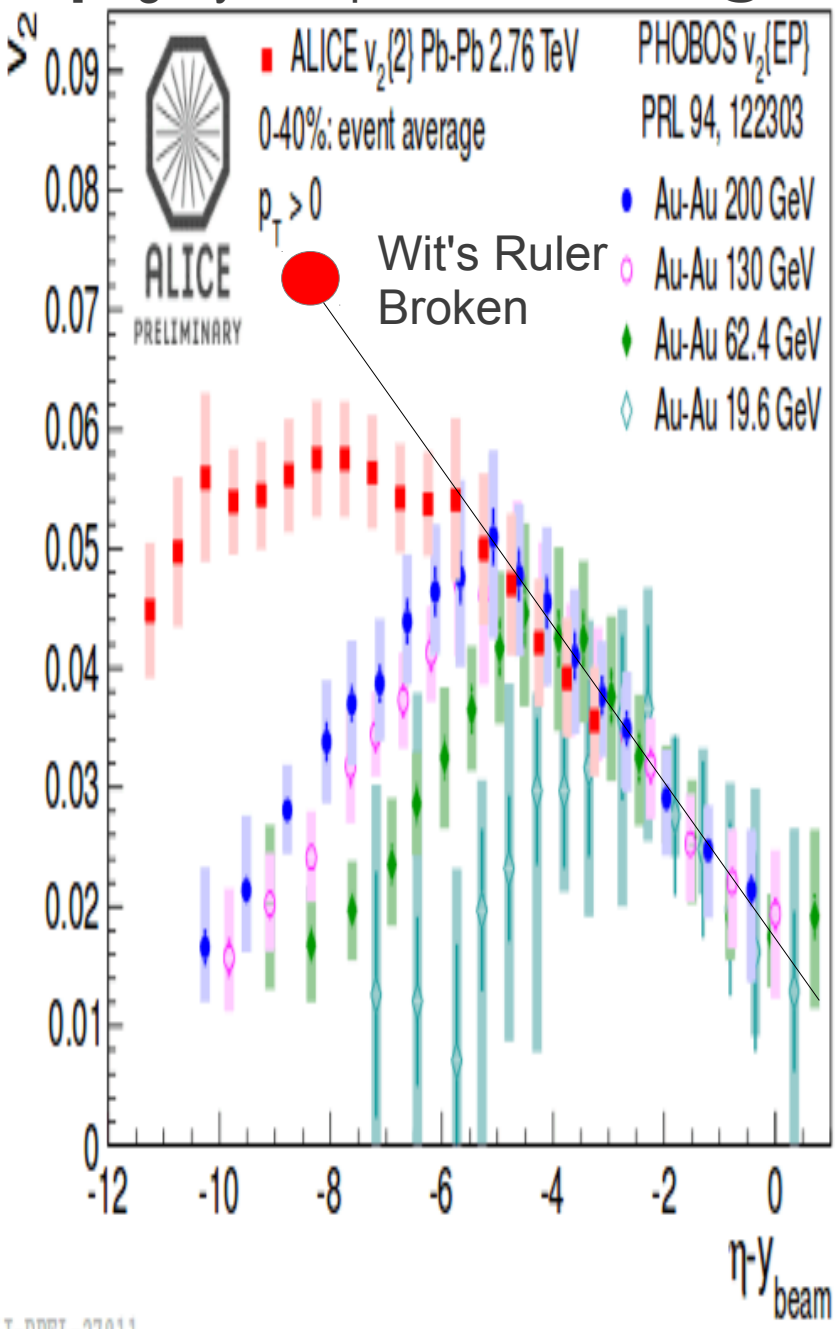
Part 4: The Revenge PA and DA > 2012

Part 5: Heresy

The BIG picture today 2013: The view from Mt. LHC on the RHIC and SPS foothills

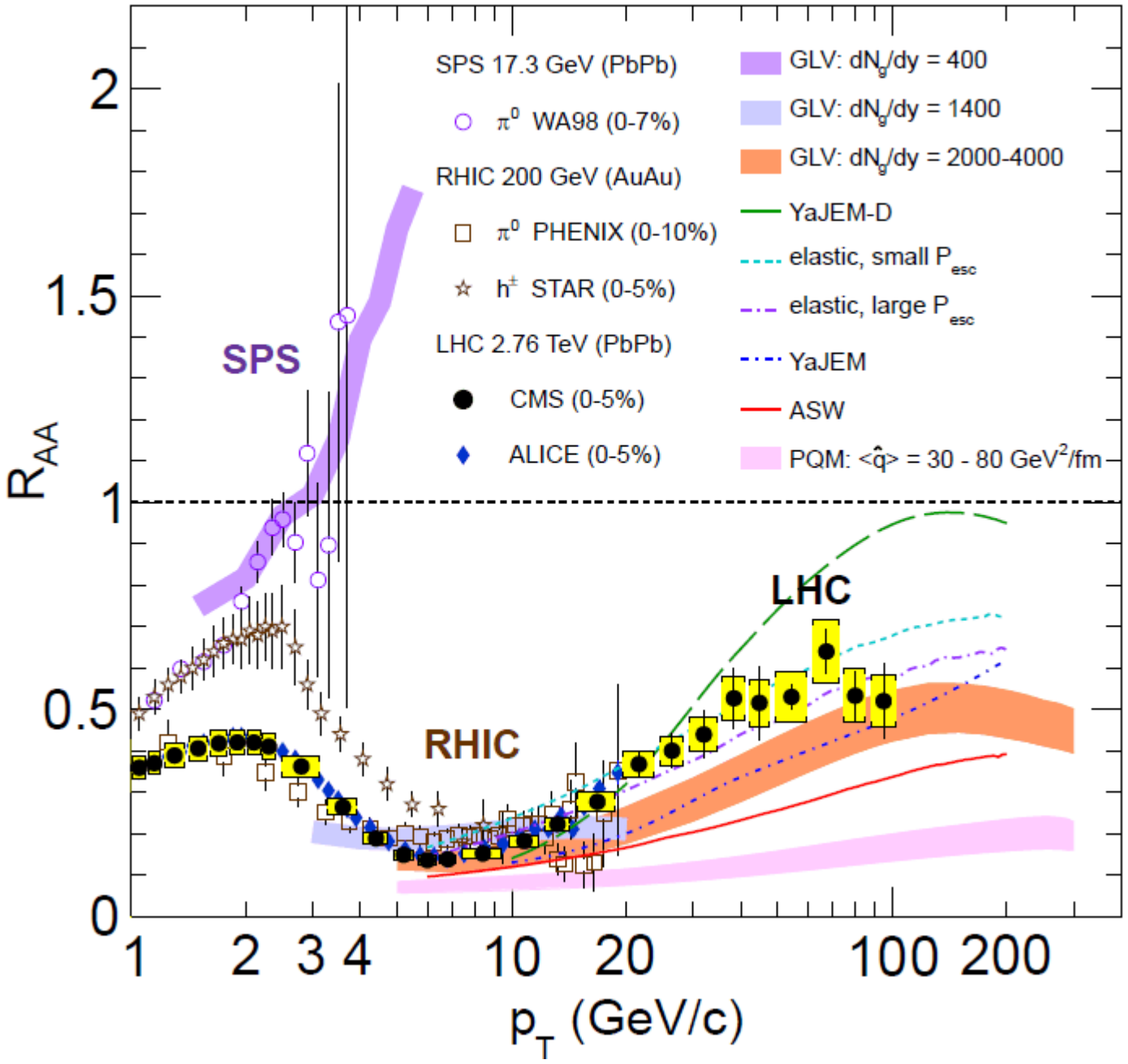
[Slightly less perfect flow than @RHIC]





Mt. LHC is even smaller than expected with HIJING = More evidence for CGC

CMS arXiv:1202.5022 "Big Picture" of Nuclear modification of jets SPS- RHIC-LHC

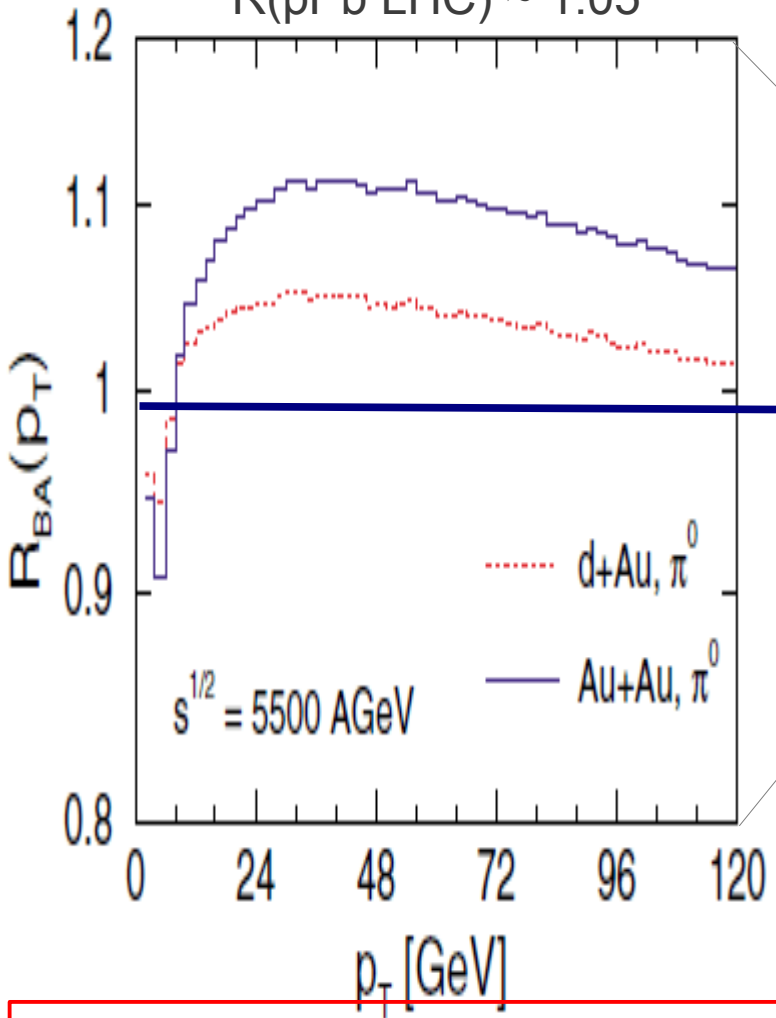


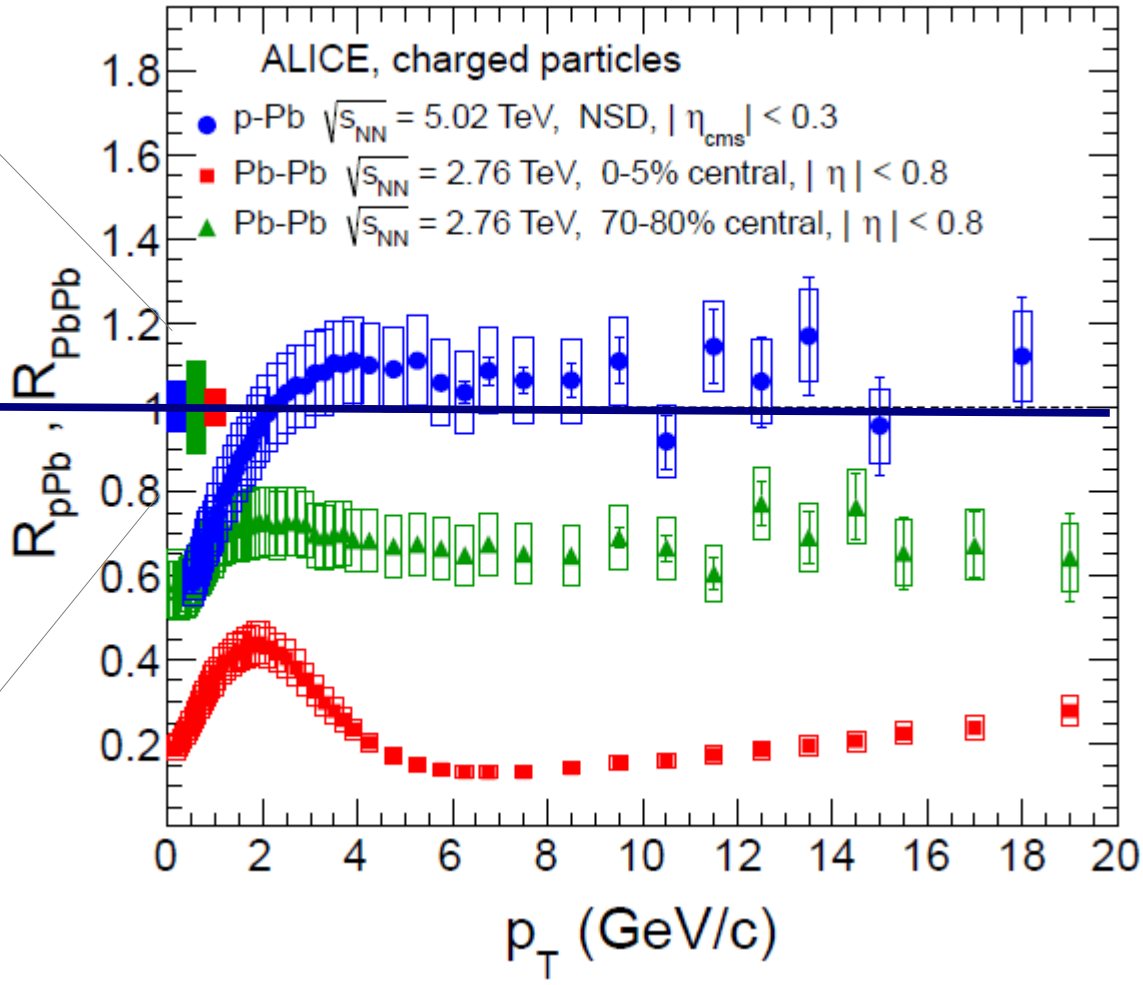
High-p_T Tomography of d + Au and Au + Au at SPS, RHIC, and LHC

Ivan Vitev[1,2] and Miklos Gyulassy[1]

ALICE 2012 pPb 1210.4520v1
Initial State modifications r
small ~10% at y=0 even at 5 ATeV

Predicted Cronin+ EKS98
R(pPb LHC) ~ 1.05





We can safely calculate RPbPb(y=0, pT>4, LHC) *neglecting* initial state interactions

Part 1: The Good Old Days

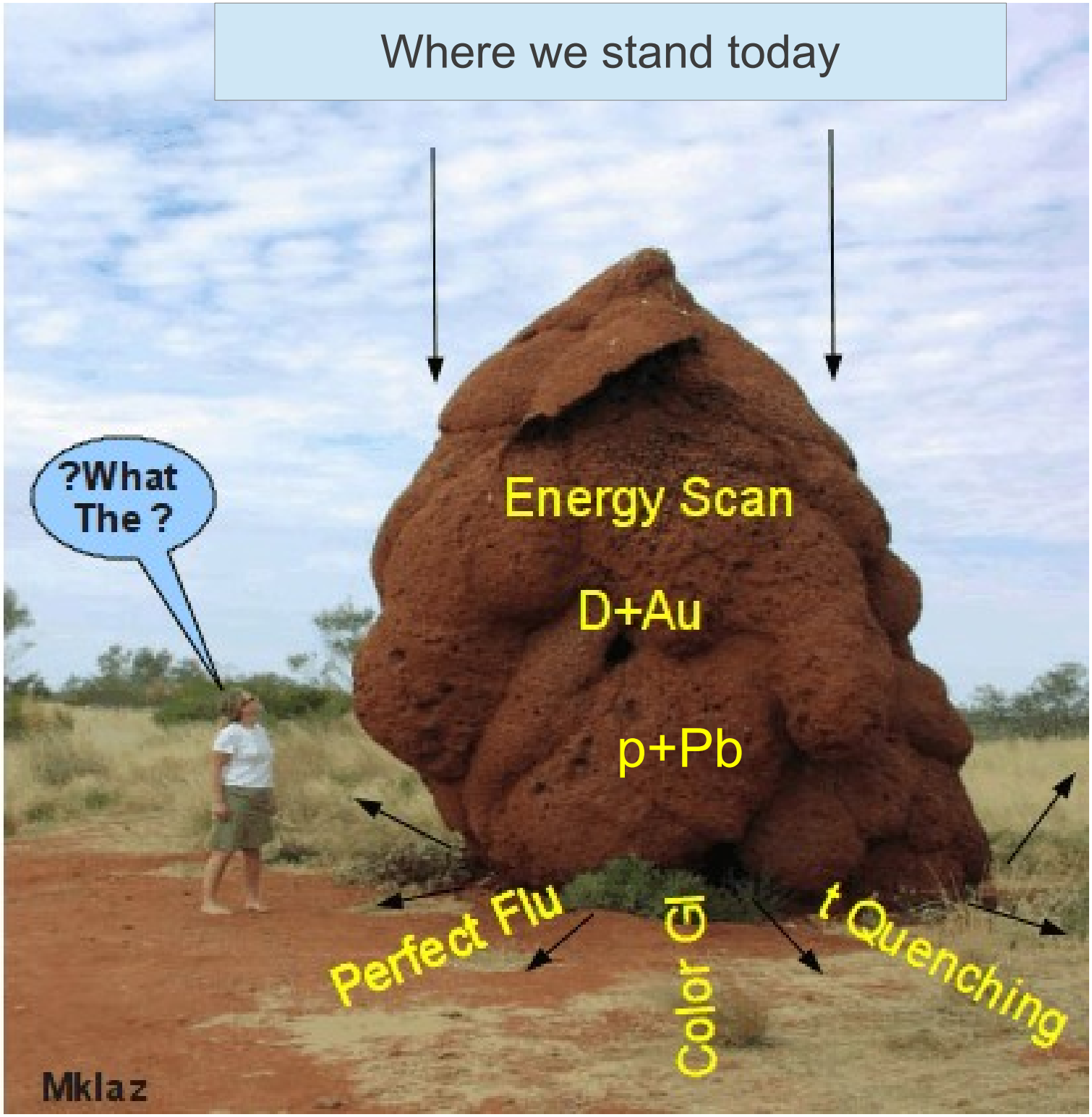
Part 2: Building the Au Pillars of QGP and CGC at RHIC

Part 3: Reinforcing the Au Pillars with Pb at LHC

Part 4: Wit's Last Stand: PA DA and BES > 2012

Part 5: Heresy

Where we stand today

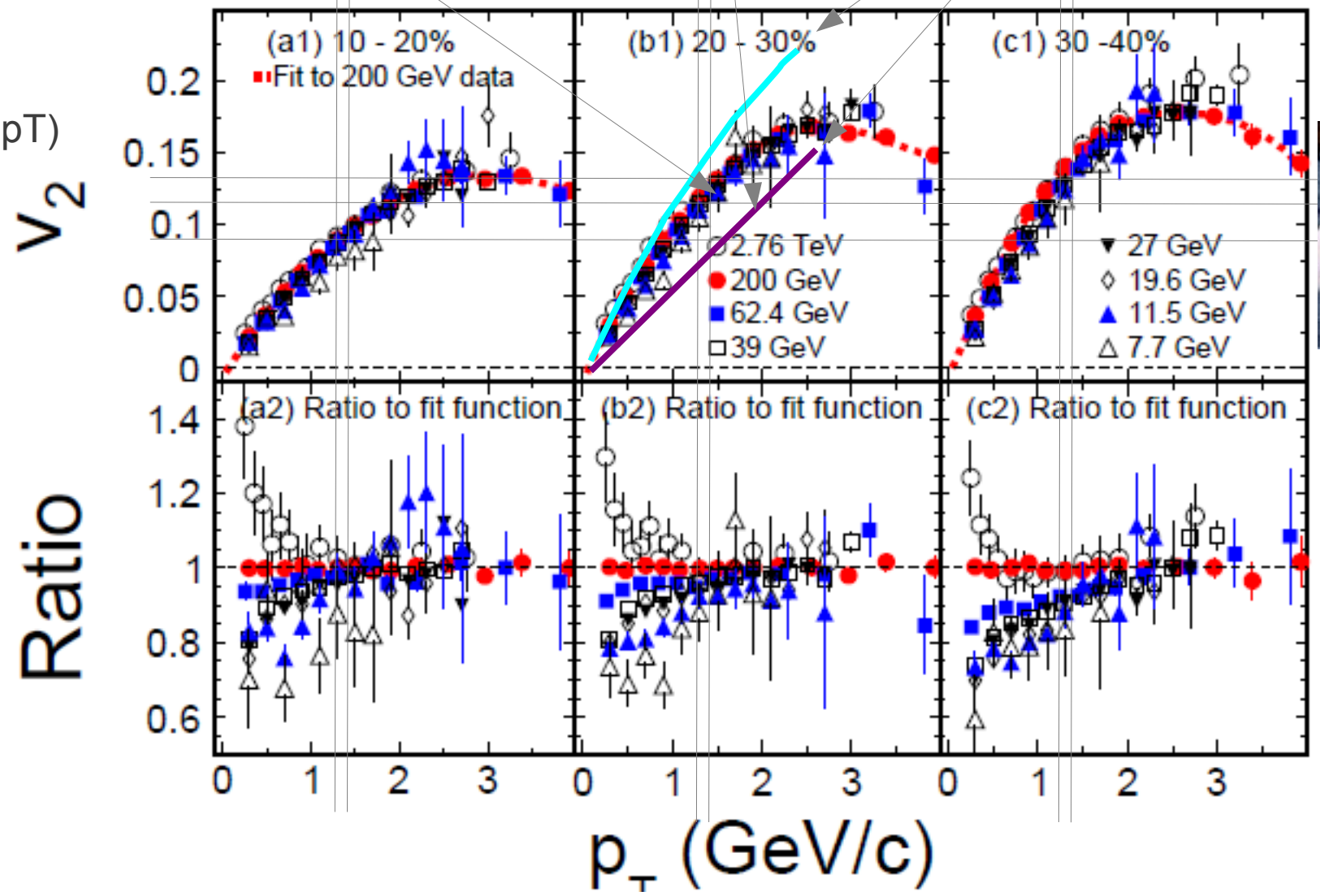


Beam Energy Scan QM12, ***FALSIFIED*** CERES data and our HRG dissipative corona story!!

STAR data 19.6 contradicts CERES 17.2

Ideal Hydro 17.2GeV: Huovinen
Tf=120 MeV
Tf=160 MeV

v2{4}(pT)



Does "ideal hydro" now works EVERYWHERE?

Why does perfect fluidity not TURN-OFF as HRG Corona dominates at Ecm< 20 AGeV?

Could "perfect fluidity" be an illusion ? ?

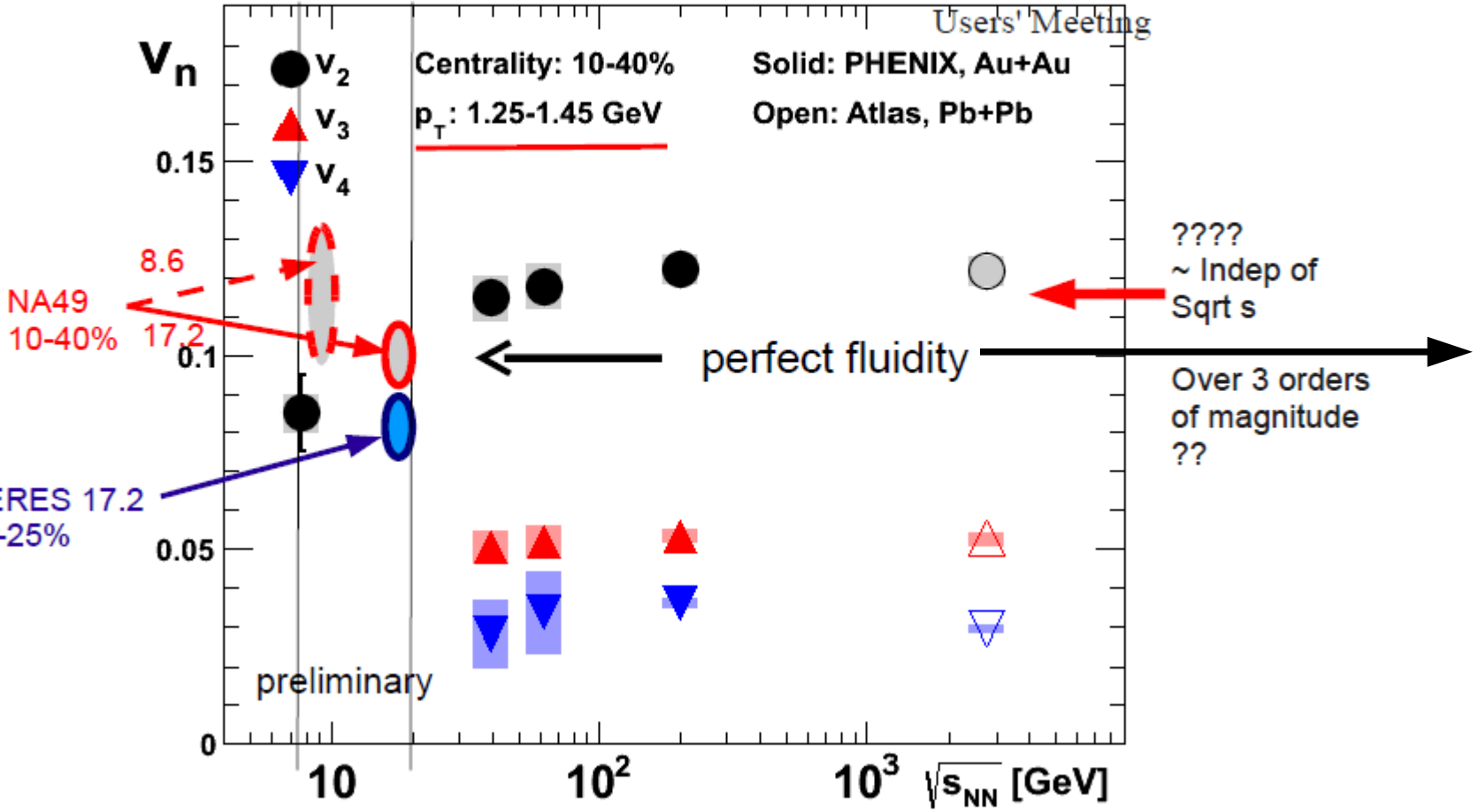
M.Cyd

Independence

QM12 PHENIX story: (same as STAR BES story)

Ecm dependence of vn{Ψn} for charged hadrons

R.Pack, 2012 RHIC & AGS Annual Users' Meeting



Null control of Pillar 1 At low Ecm Is Down!

The (AGS, SPS, RHIC) Perfect Fluid QGP Core + Lousy HRG Corona DIED a cruel death

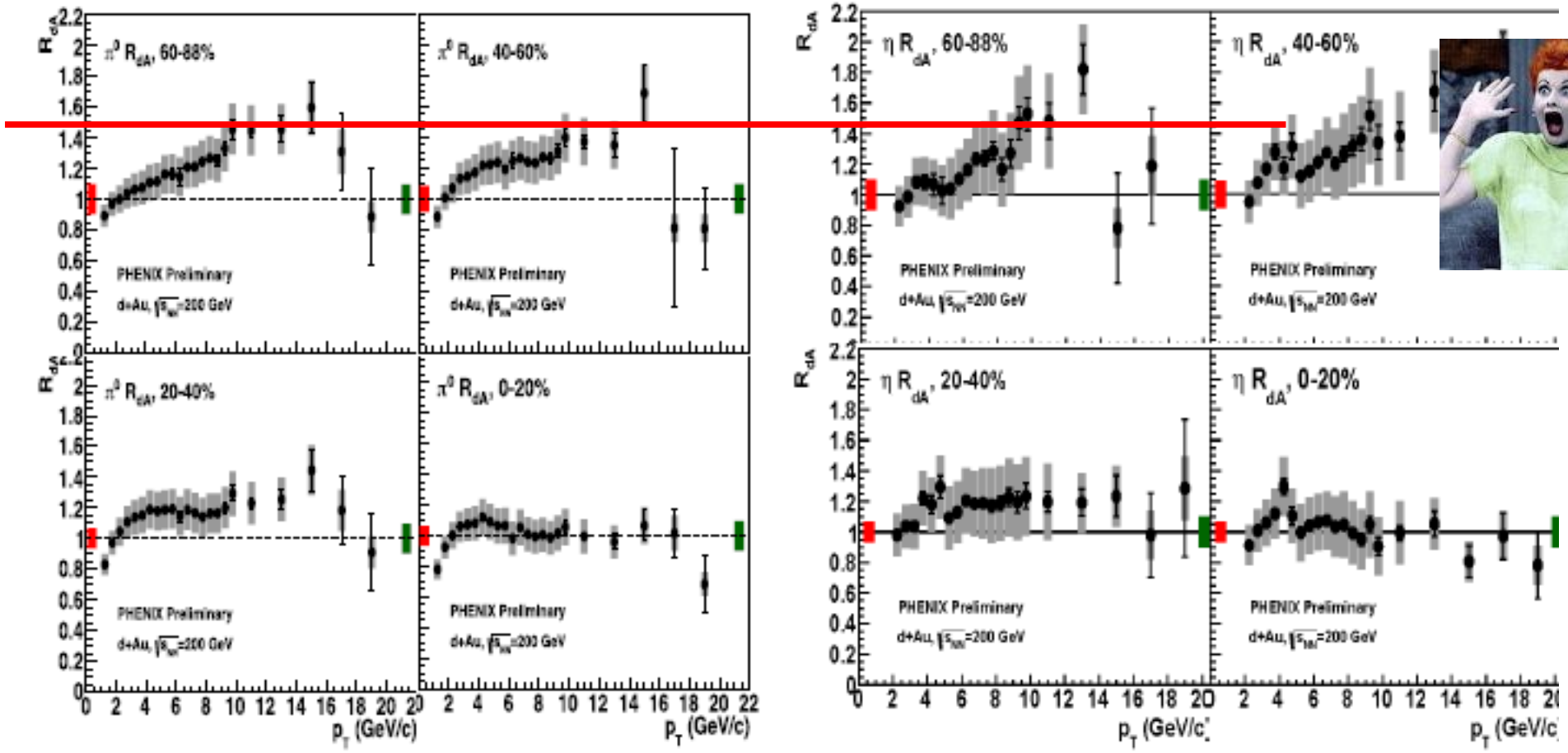
?? Where is the HRG Corona ??

more

Now some results to lose sleep over

PHENIX preliminary, QM'12

2008 (high) statistics d+Au data, nuclear modification factors vs centrality

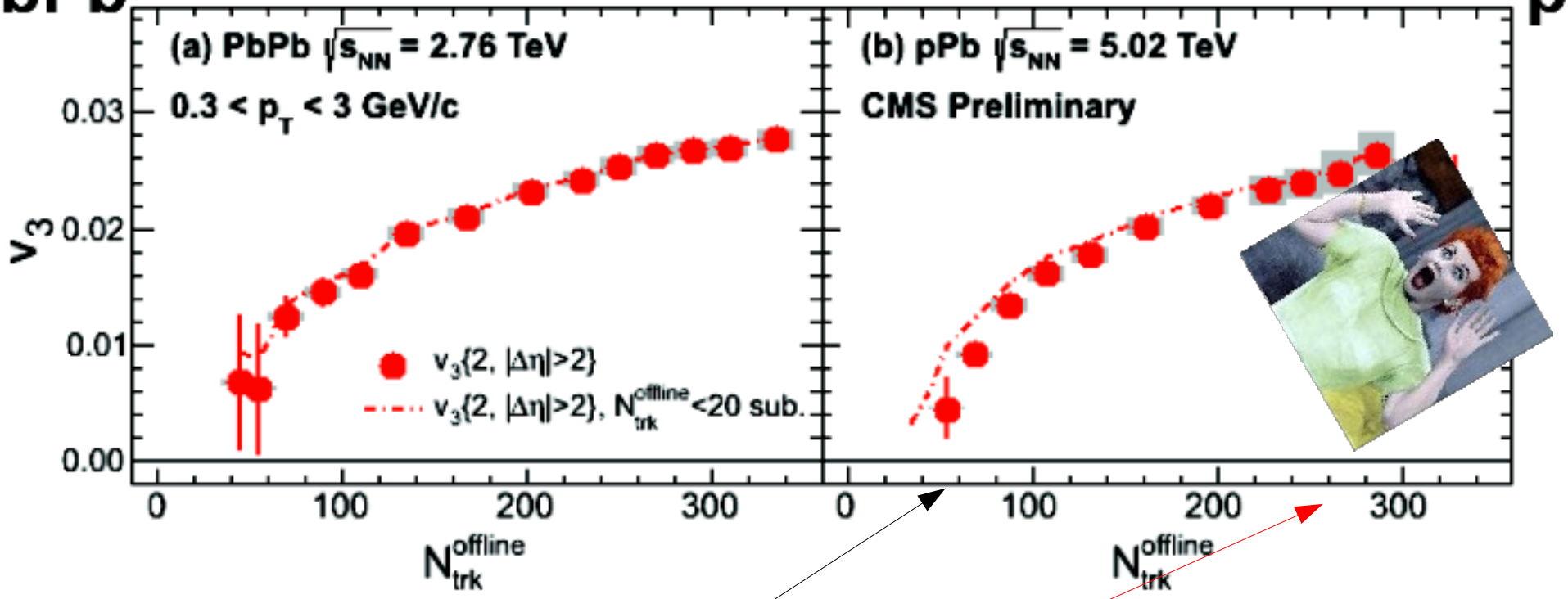


Is it possible that π_0, η production at high p_T in peripherals is enhanced???

v_3 in pPb and PbPb

RBRC13 CMS SHOCK waves from super central pPb @ LHC

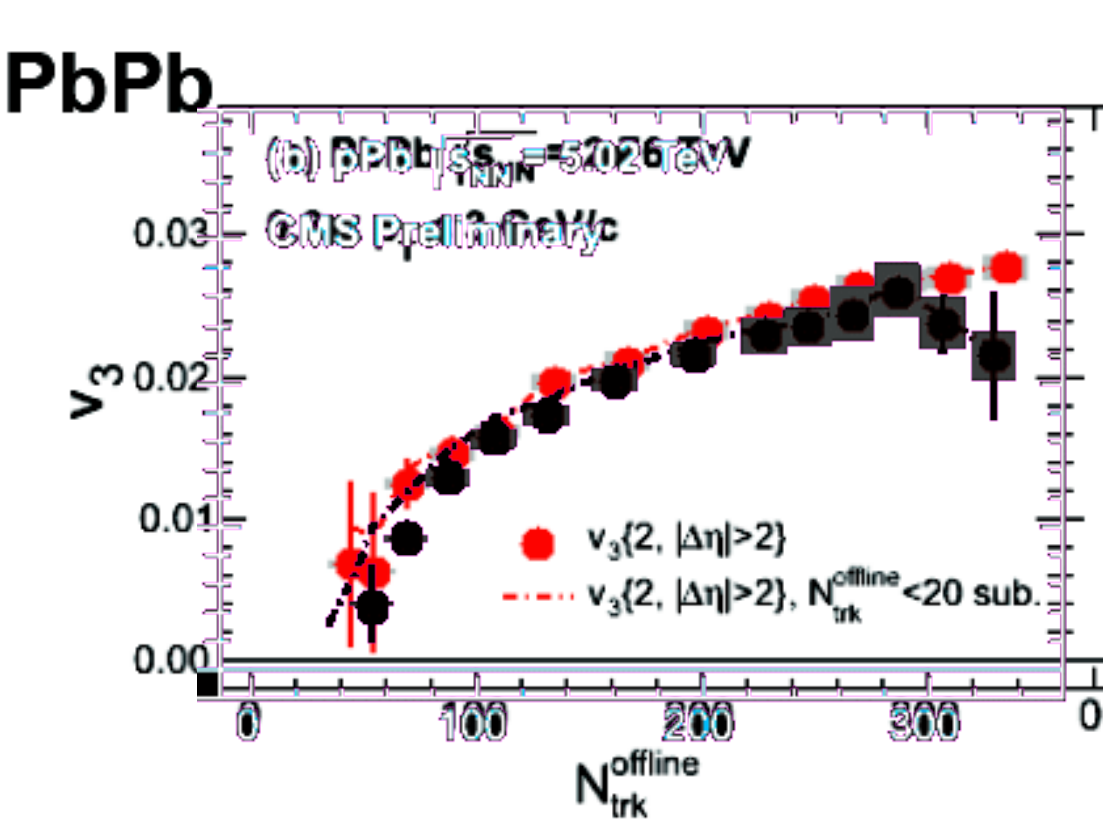
PbPb pPb

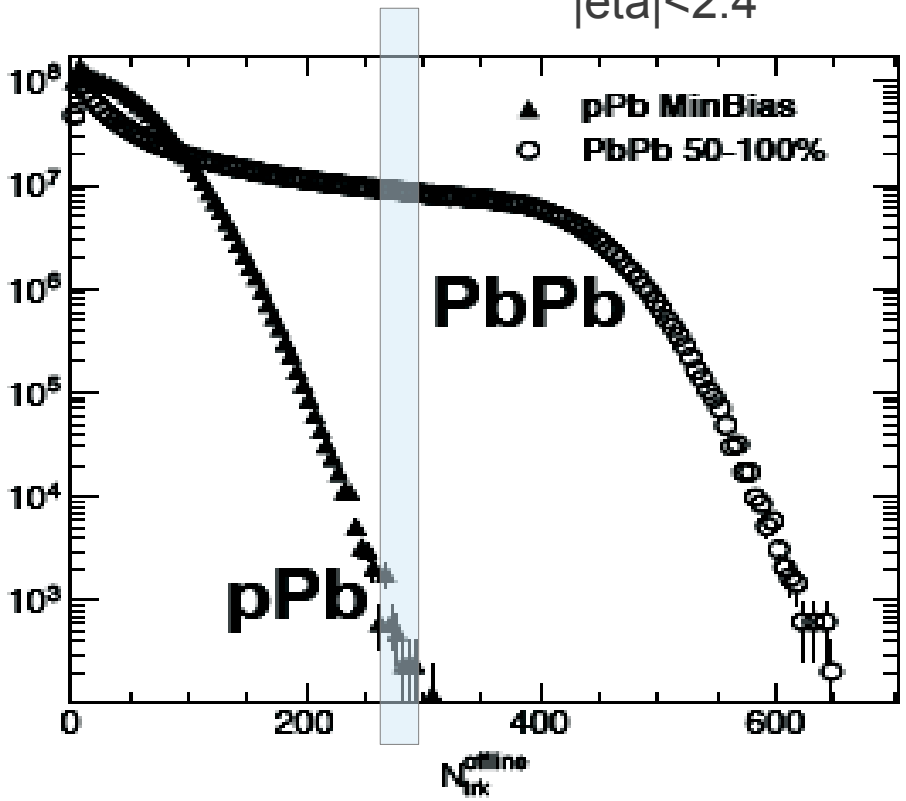


v_3 shows similar shape in pPb and PbPb; magnitude comparable

In both central and very rare fluctuation events

v_3 in pPb and PbPb





v_3 shows ~~similar~~ shape in pPb and PbPb; magnitude ~~comparable~~

same ***same***

Data falsify "Apples ≠ Oranges" Theorem

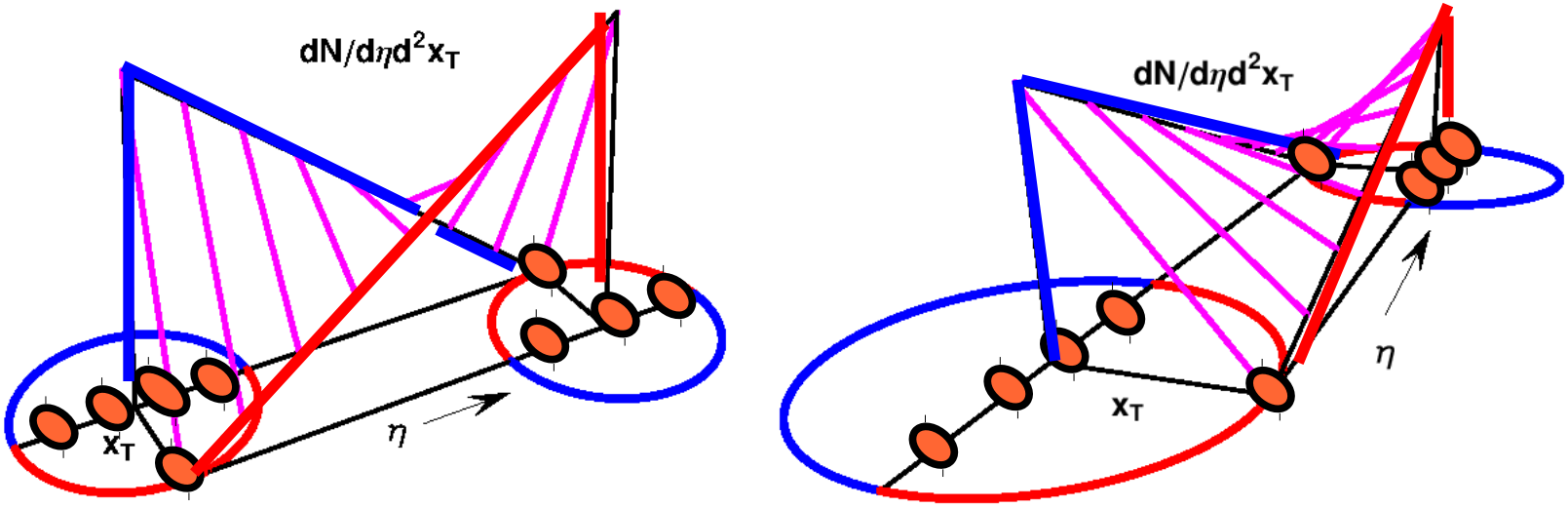
What is going on?

Could the Triangles in PbPb Be the missing link?

pPb

3D jet tomography and the twisted color glass condensate
A. Adil, M. Gyulassy, T. Hirano , Nucl.Phys. A774 (2006) 593

$A+A = (p+A^{1/3}) + (A^{1/3}+p) + \text{Symmetric Stuff}(A-A^{1/3} + A-A^{1/3})$



AA b>0 has multiple Rapidity Triangle p+A edges

What *IF* there is No Hydro , No v_n Flow from bulk ??

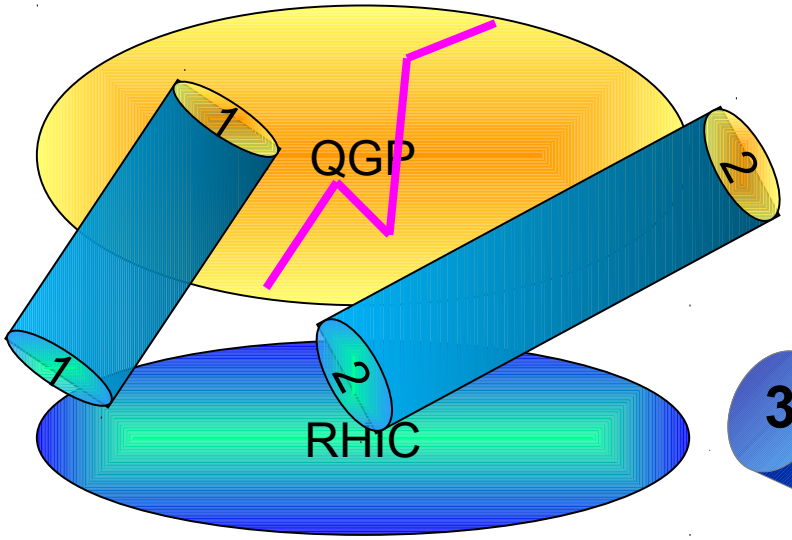
But instead only "Glasma" Interference Phenomena at p+A and A+p edges ???

Can sQGP perfect fluid survive the BES, D+Au and p+Pb tsunami?

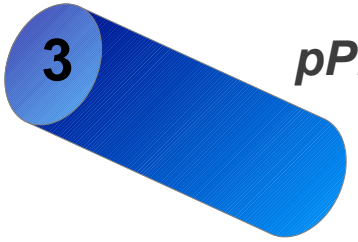
BES , D+Au and p+Pb uncalibrated our v2 Barometer of sQGP
D+Au (and ? p+Pb) uncalibrated our RAA opacity meter

No Legged Tables *Fall*

BES +
DAu
Broke
P_{QCD}
Flow?

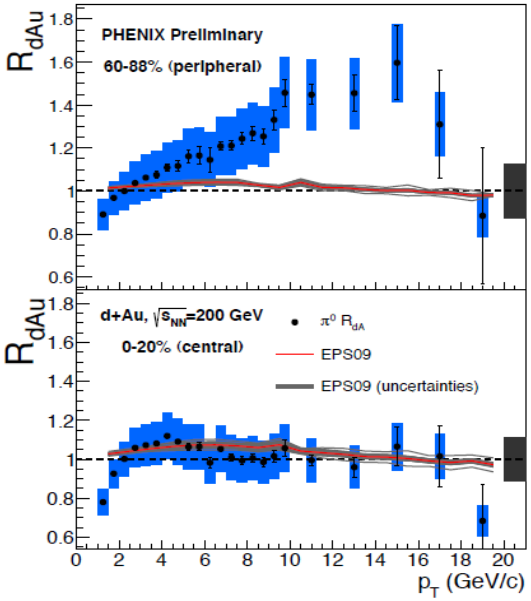


DAu Broke
pQCD
Quench control?

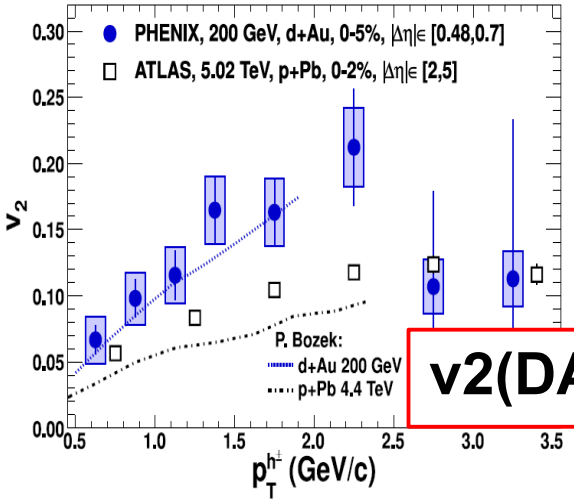


pPb is Not Null !

R(DAu) ≠ 1 ??



v2(DAu) = v2(AuAu) ??



v2(DAu) = 2 v2(pAu) ??

We have lost our
PA DA BES
Null Controls !

Part 1: The Good Old Days

Part 2: Building the Au Pillars of QGP and CGC at RHIC

Part 3: Reinforcing the Au Pillars with Pb at LHC

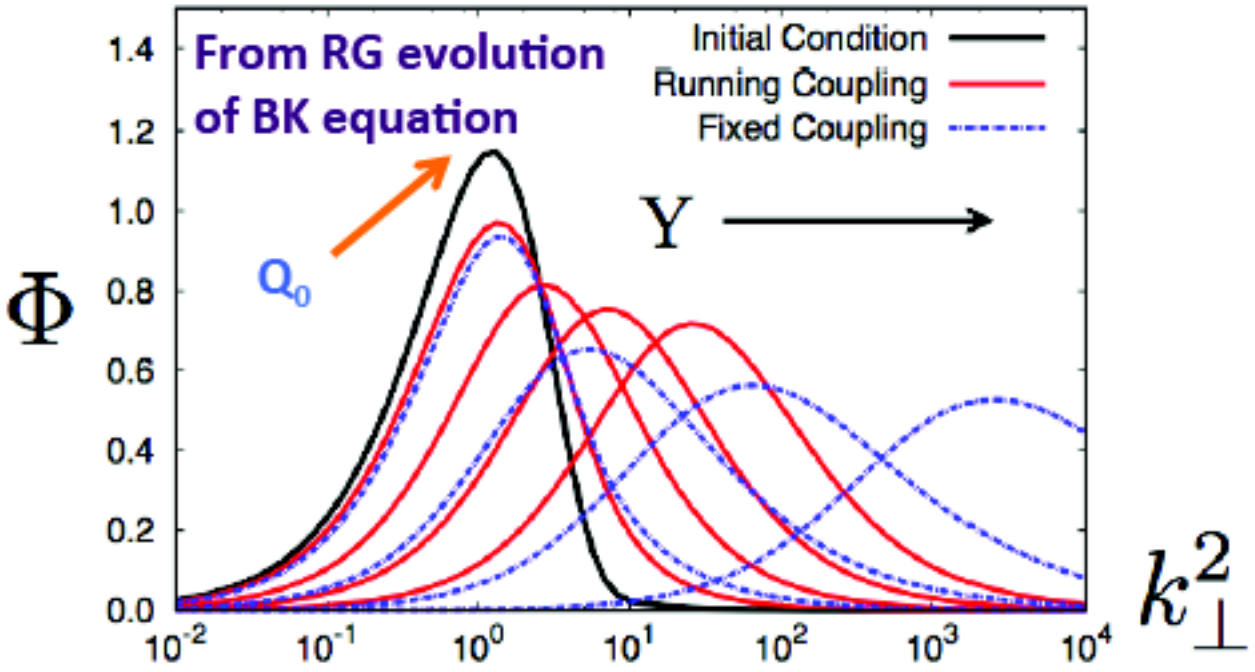
Part 4: Wit's Last Stand: PA DA and BES > 2012

Part 5: Heresy (Warning: PG60)
Is it time to be radical?

See Raju et al slide 25

Are we **Collimated yield ?**

$$C(\mathbf{p},\mathbf{q}) \propto \frac{g^4}{\mathbf{p}_\perp^2\mathbf{q}_\perp^2}\int \mathrm{d}^2\mathbf{k}_{1\perp}\,\Phi^2_{A_1}(y_p,\mathbf{k}_{1\perp})\Phi_{A_2}(y_p,\mathbf{p}_\perp-\mathbf{k}_{1\perp})\Phi_{A_2}(y_q,\mathbf{q}_\perp-\mathbf{k}_{1\perp}) + \text{permutations}$$

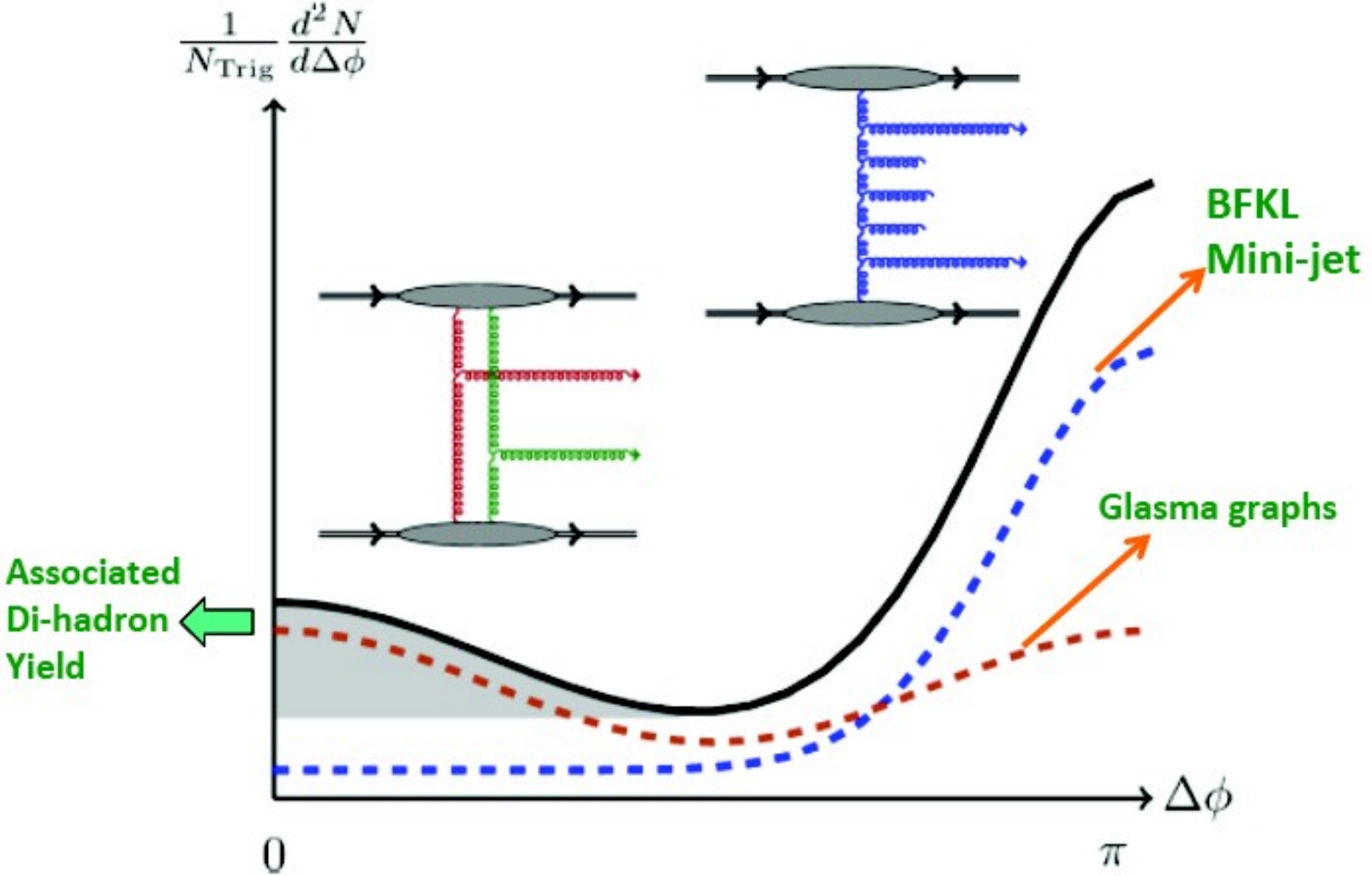


Dominant contribution from $|p_T\text{-}k_T| \sim |q_T\text{-}k_T| \sim |k_T| \sim Q_s$

This gives a collimation for $\Delta\Phi \approx 0$ and π

See Raju et al slide 57

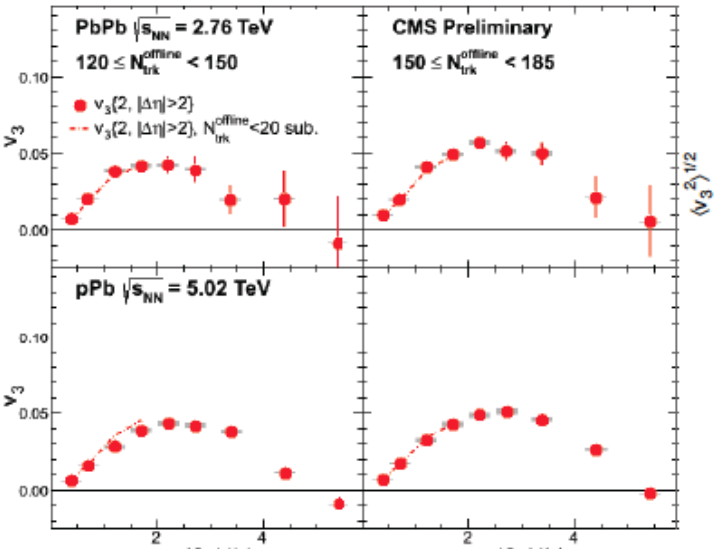
Anatomy of long range collimation yields

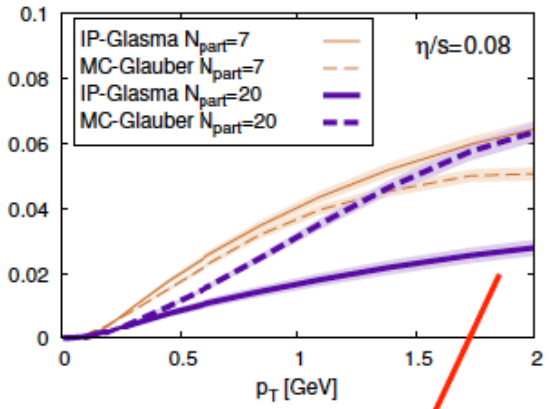


See Raju et al slide 60,61

Flow in p+A

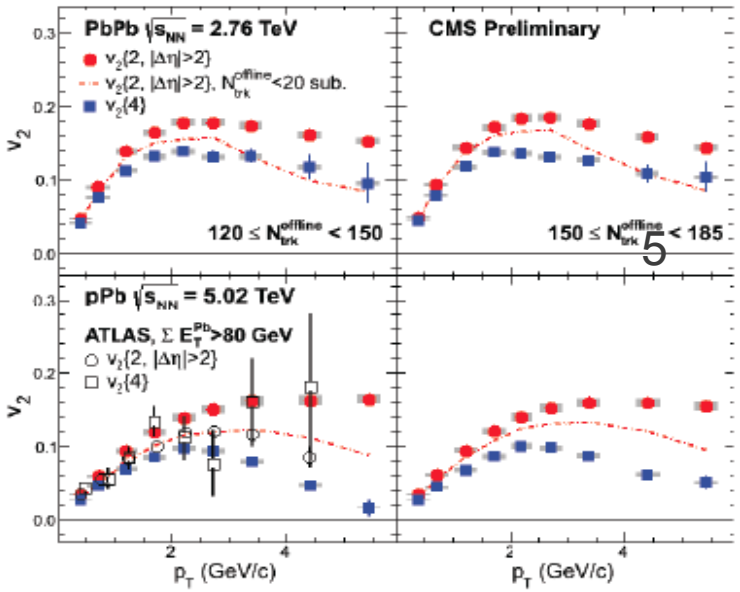
V_3



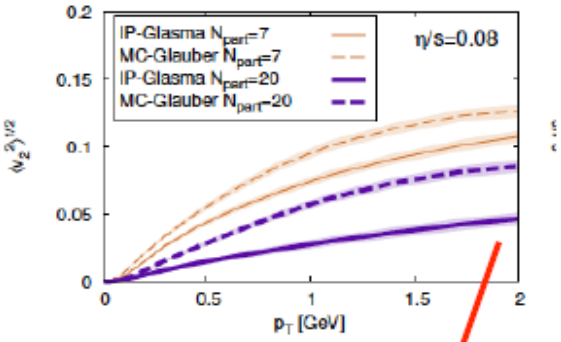


IP-Glasma result
2 times smaller than

Flow in p+A



5



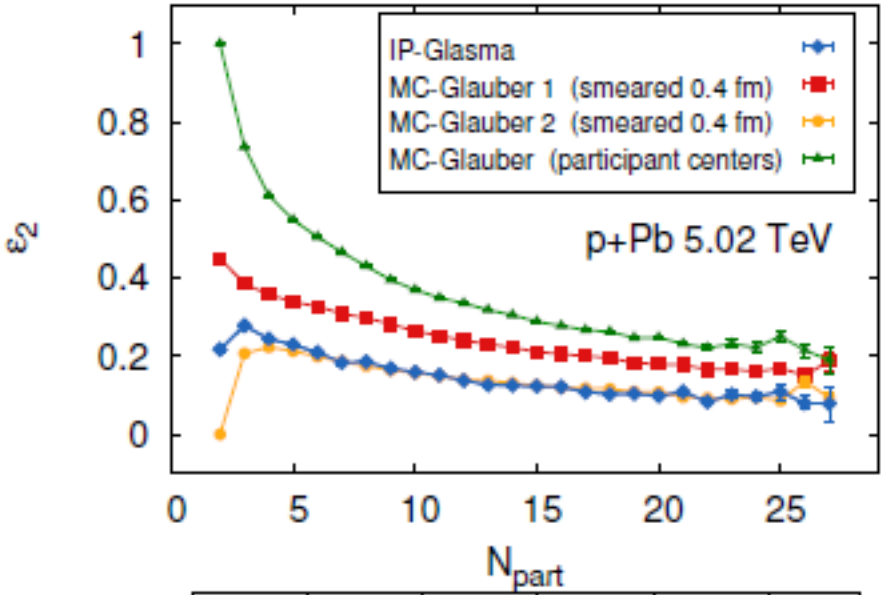
IP-Glasma result
2 times smaller than
data for η/s=0.08

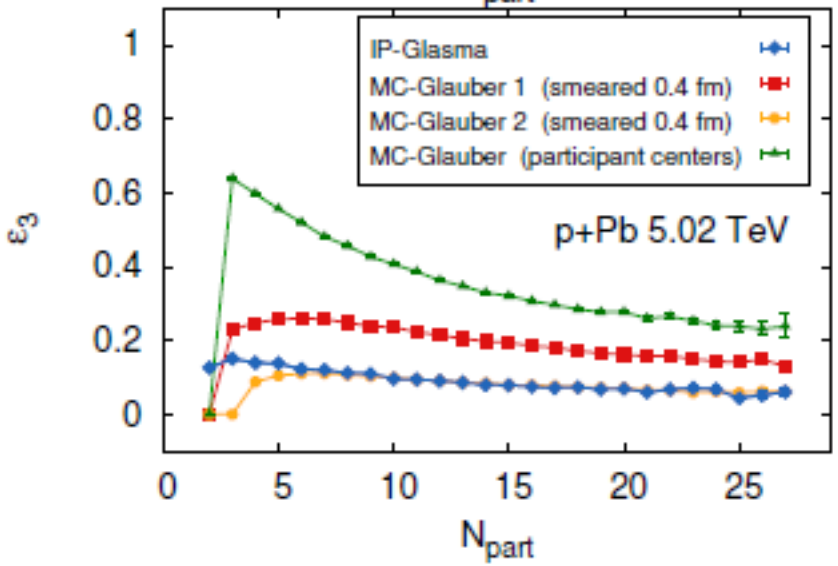
But
Hydro makes
No sense in sub
Fm p+A

Maybe Current
Glasma
Interference
Models are
still too crude?

There is 0 control of hydro Initial Conditions in p+A

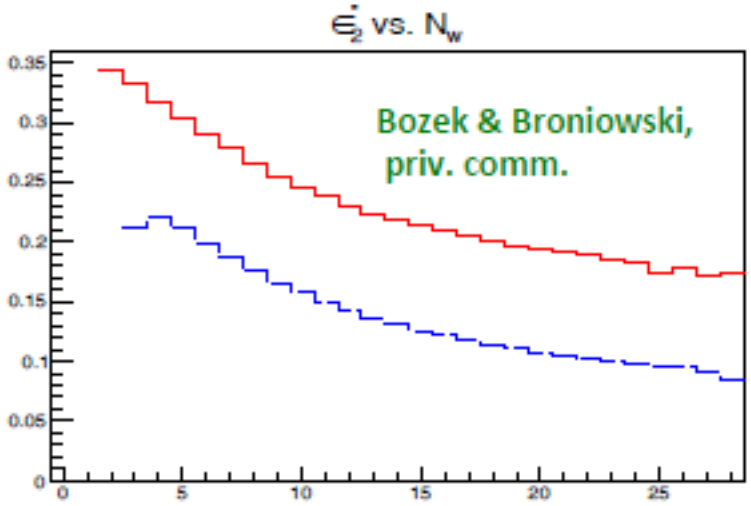
Initial conditions in p+A: IP-Glasma vs "Glauber"





Bzdak,Schenke,Tribedy,RV:1304.3403

MC-Glauber 1 MC-Glauber 2



In MC Glauber 1, big differences in hard sphere & Gaussian smearing

Exp fact 2013: v2(DAu , 5%) = v2(AuAu, 30%) = 2 X v2(p Au , 5%)
RHIC RHIC LHC

What if both DAu and AuAu vn are controlled by glasma like quantum interference involving just 2 separate p+A triangles
While pA vn are controled by just 1 quantum interfering triangle !

Exp fact 2: BES vn(AA,pT) is ~same over 3 orders variation of energies!

v2(AuAu, 7 AGeV) ~ v2(AuAu,200 AGeV) ~ v2(PbPb,2800 AGeV)

MAYBE BES reflects basic quantum interference correlation phenomenon involving high energy multiparticle production Involving multi
p+A like asymmetric in rapidity fluctuating Color charge antenna ??

PA BA and BES do call for radical re-evaluation of our past paradigms.

Wit's P+A is no longer a null litmus test, but could be the missing link Needed to resolve 2013 BES and DA and pA anomalies

Needed@RHIC future BES of p+A and D+Au : Is v2(DA)=v2(AA)= 2 v2(pA) at all cm energies ?