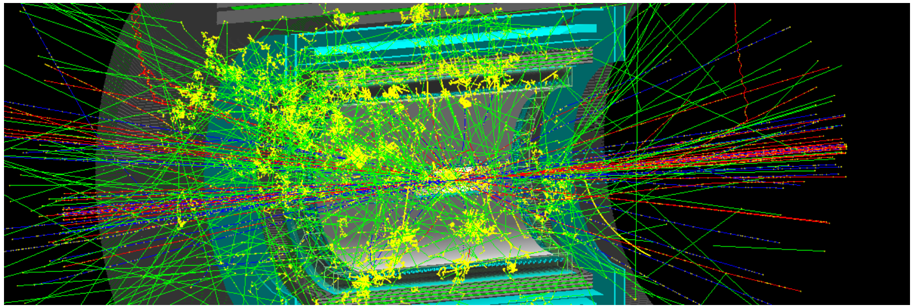
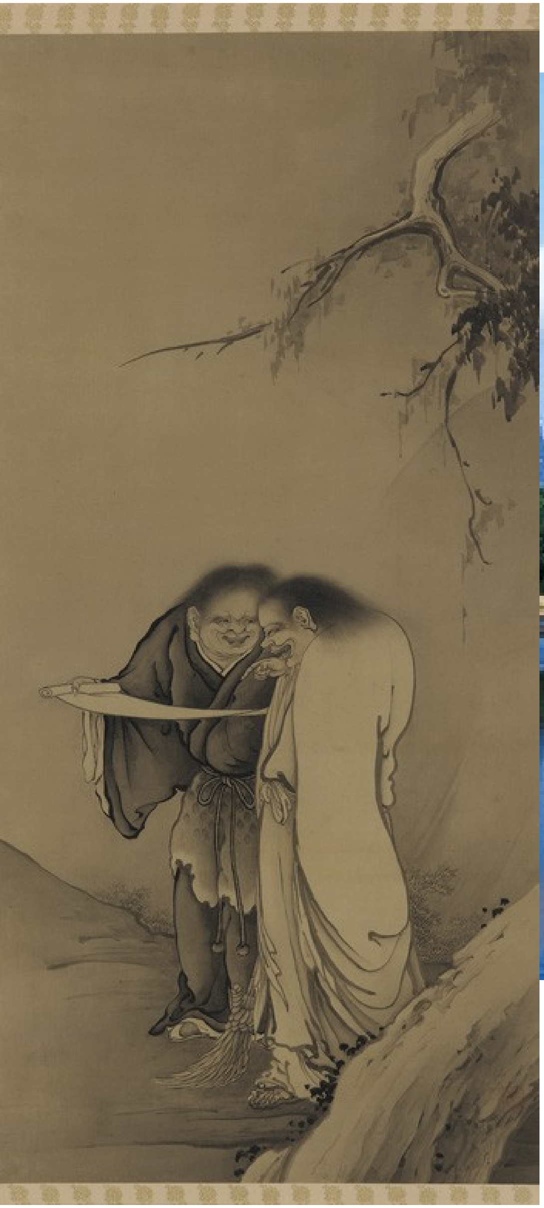
The Jet Energy-loss Tomography with a Statistically and Computationally Advanced Program Envelope (JETSCAPE) collaboration is an NSF funded multi-institutional effort to design the next generation of event generators to simulate the physics of ultra-relativistic A+B collisions.



on the “Tao” with Xin Nian towards New States of Matter

XN shows me his code



On occasion of his 60th birthday

Karsk Jetscape

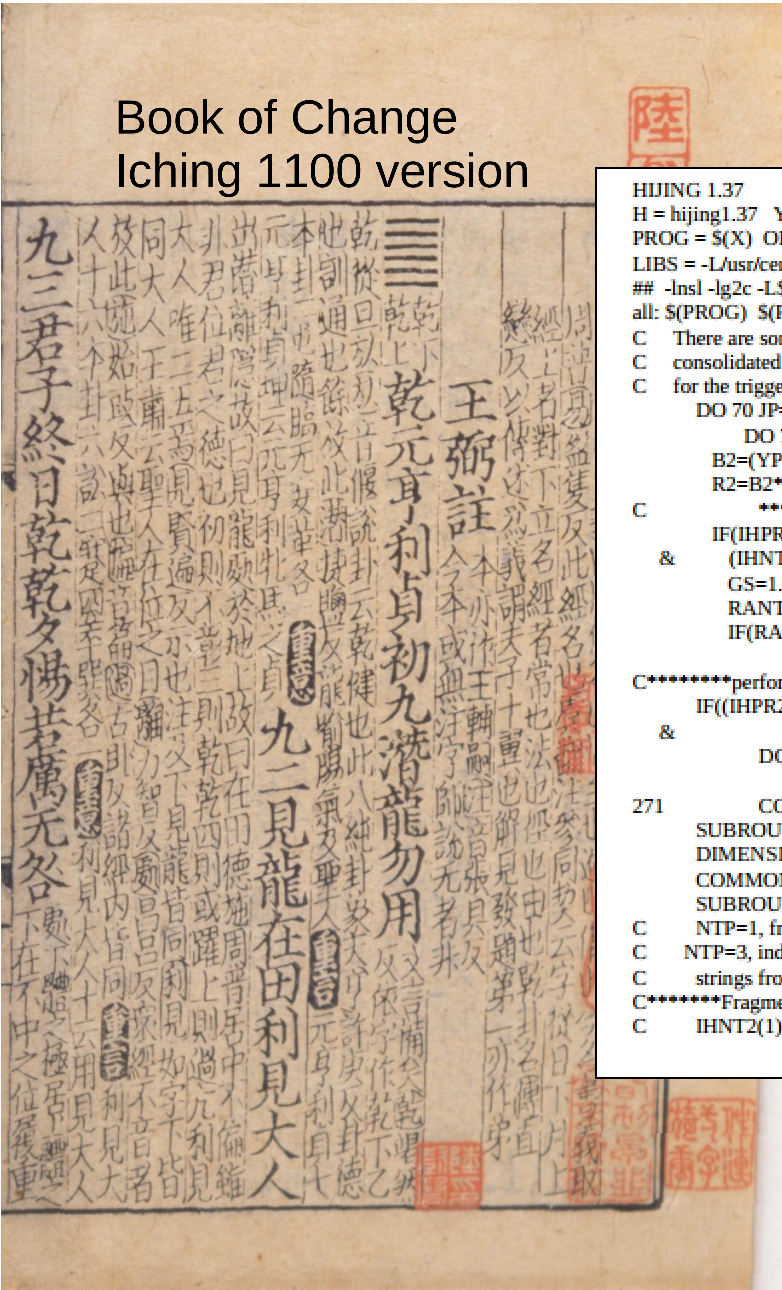
32 years ago XinNian took me for
a great long scenic ride !

Perfect Fluid Li

谢谢 = Kőszőnőm

Our Tao via Hijing and Jet Quenching toward sQGP

Book of Change
Iching 1100 version



Hijing 1991 version

```
HIJING 1.37
H = hijing1.37   Y = hipyset1.35   X = xhj135
PROG = $(X)  OBJ = $(H).o $(X).o $(Y).o FC = f77  -O
LIBS = -L/usr/cern/97a/lib -lpacklib  -lkernlib
##  -lnsl -lg2c -L$(CERN_ROOT)/lib -lpacklib -lpawlib -lkernlib
all: $(PROG)  $(PROG): $(OBJ)      $(FC) -o $@ $(OBJ) $(LIBS)
C     There are some changes in the program: subroutine HARDJET is now
C     consolidated with HIJHRD. HARDJET is used to re-initiate PYTHIA
C     for the triggered hard processes.
        DO 70 JP=1,IHNT2(1)
              DO 70 JT=1,IHNT2(3)
          B2=(YP(1,JP)+BBX-YT(1,JT))**2+(YP(2,JP)+BBY-YT(2,JT))**2
          R2=B2*HIPR1(40)/HIPR1(31)/0.1
C                *********mb=0.1*fm, YP is in fm,HIPR1(31) is in mb
          IF(IHPR2(14).EQ.0.OR.
     &      (IHNT2(1).EQ.1.AND.IHNT2(3).EQ.1)) THEN
            GS=1.0-EXP(-(HIPR1(30)+HINT1(18))*ROMG(R2)/HIPR1(31))
            RANTOT=RAN0(NSEED)
            IF(RANTOT.GT.GS) GO TO 70

C*********perform jet quenching for jets with PT>HIPR1(11)**
        IF((IHPR2(8).NE.0.OR.IHPR2(3).NE.0).AND.IHPR2(4).GT.0.AND.
     &                IHNT2(1).GT.1.AND.IHNT2(3).GT.1) THEN
                DO 271 I=1,IHNT2(1)
                        IF(NFP(I,7).EQ.1) CALL QUENCH(I,1)
271             CONTINUE
        SUBROUTINE QUENCH(JPJT,NTP)
        DIMENSION RDP(300),LQP(300),RDT(300),LQT(300)
        COMMON/HIJCRDN/YP(3,300),YT(3,300)
        SUBROUTINE HIJFRG(JTP,NTP,IERROR)
C       NTP=1, fragment proj string, NTP=2, targ string,
C      NTP=3, independent
C       strings from jets.  JTP is the line number of the string
C*******Fragment all leading strings of proj and targ***************
C       IHNT2(1)=atomic #, IHNT2(2)=proton #(=-1 if anti-proton)  *
```

JET Collab 2015 version

ntitative Jet and Electromagnetic Tomography (JET)
Extreme Phases of Matter in Heavy-ion Collisions

JET Collaboration

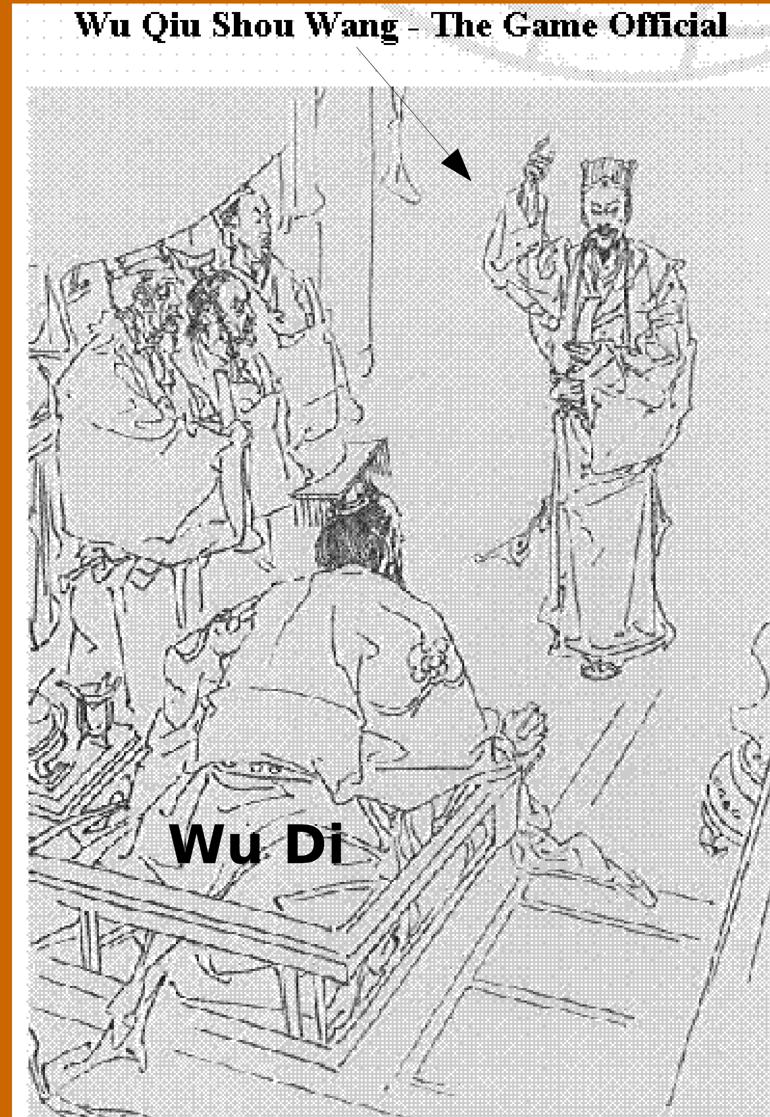
(in alphabetical order of institutions)
Miklos Gyulassy (Columbia University)
Paul Romatschke (University of Colorado, Boulder)
Steffen Bass and Berndt Müller (Duke University)
Michael Strickland (Kent State University)
Xin-Nian Wang (Lawrence Berkeley National Laboratory)
Ramona Vogt (Lawrence Livermore National Laboratory)
Ivan Vitev (Los Alamos National Laboratory)
Charles Gale and Sangyong Jeon (McGill University)
Ulrich Heinz (Ohio State University)
Denes Molnar (Purdue University)
Rainer Fries and Che-Ming Ko (Texas A&M University)
Abhijit Majumder (Wayne State University)

Co-Spokespersons:
Heinz (2013-15), Berndt Müller (2010-13) and Xin-Nian Wang (2010-15)

Principal Investigator:
Xin-Nian Wang
Nucle... R0319,
Lawrence Berkeley National Laboratory, Berkeley, CA 94720
Tel: (510) 486-5239   Email: xnwang@lbl.gov

August 31, 2015

Ancient Hun-Han History



As the Chinese saying goes, 'Serving the King is like attending a tiger', the Game Official was a tough position. If you lose to the king, he will consider you a lousy player and fire you. However, if you beat the king, he is not going to be happy, because no one likes to lose. Thus Wu Qiu Shou Wang was soon fired by the king. He begged Wu Di to let him stay in the palace and take care of the royal horses, but Wu Di turned him down. He eventually asked for permission to join the army in fighting the Huns (Humgarians), and Wu Di accepted his request.

Fortunately for me, Wu Wang did not succeed to wipe out the Huns

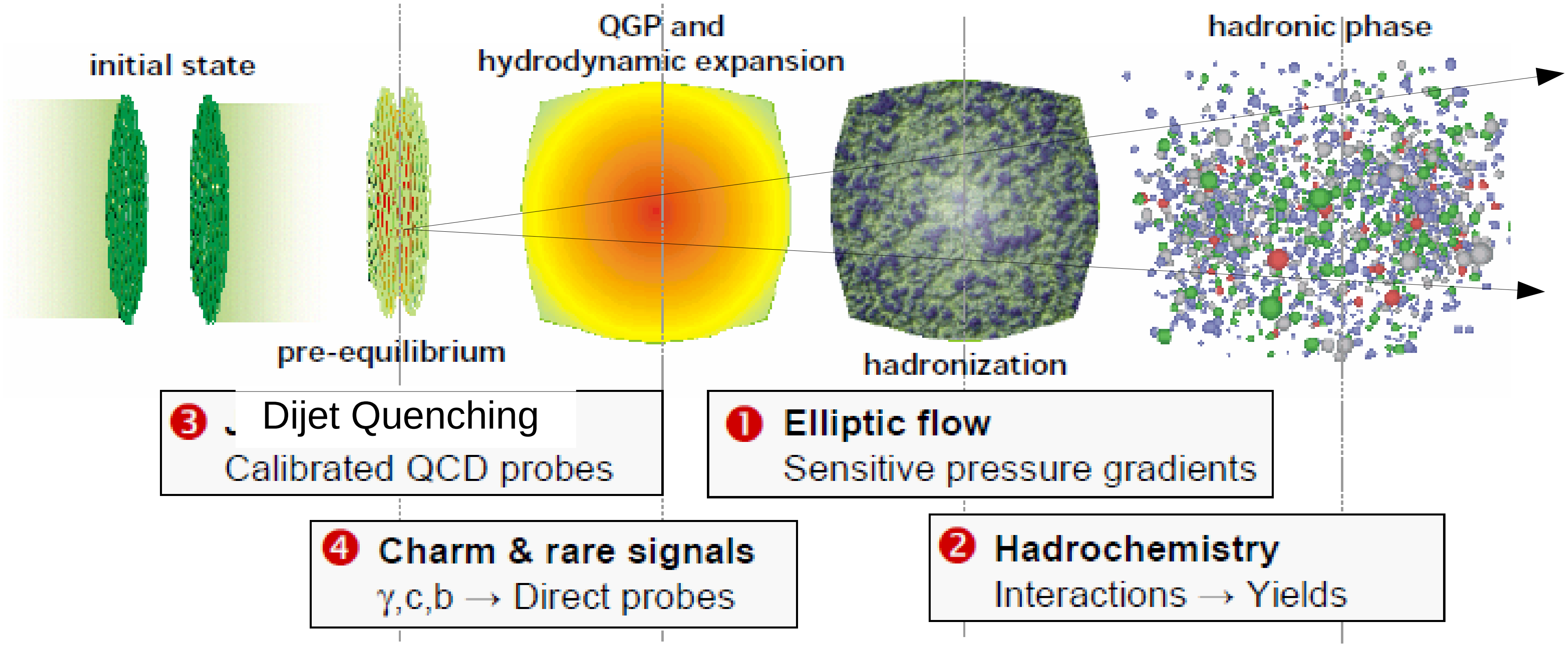
This talk is a nostalgic random walk of physics topics I studied with XinNian

For more serious professional talks, please zoom to other talks at this workshop

The harrowing task since 1974 :

Multiple Physics components that must be theoretically and exp controlled to enable unambiguous interpretation of high energy A+A data

S.Bass's Iconic Cartoon



- Each has benefitted from RHIC's *and LHC's* evolving experimental programs
  - Increased Au+Au statistics → Rare probes, higher p_T
  - New collision systems → Reference data, initial conditions
  - New collision energies → Initial conditions, evolution of QGP signatures

But how do systematic theoretical uncertainties propagate after each step?
Can we de-convolute the tsunami of data at RHIC and LHC to distinguish and test each step?

The Good Old Days at LBL 1991

Lunches in theory lounge were fun

The Good New Days 30 years later on my porch

The Good New Days 2021, 30 years later, With our better halves

Celebrating

HIJING@30

Celebrating
The 30 th
Birthday of HIJING:

Heavy **I**on **J**et
INteraction
Generator

Phys.Rev.D 44 (1991) 3501

Phy.Rev.Lett. 68 (1992) 1480

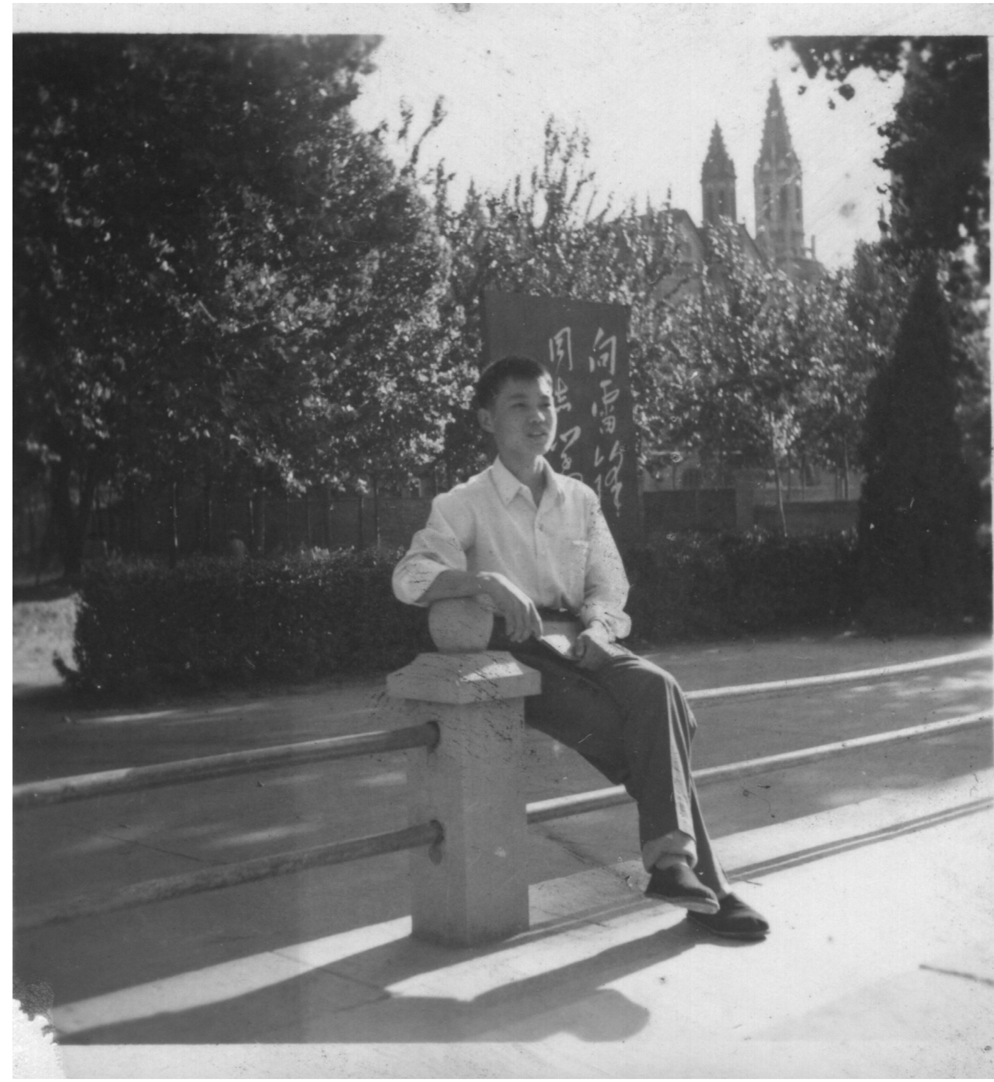
Comp.Phys.Com. 83 (1994) 307


HIJING @ 30
Party 12/10/21
Today we
celebrate
XNW @ 60

XN @ 6 1968

Born shortly after the Big Famine of 1960 referred to as Mao's "The Great Leap"

XN @ 17 1979



Sophmore at Shandong Uni in Jinan

XN @ 20 1982

Grad school at IHEP Beijing
TDLee started CUSPEA program

XN @ 23 1985

Went to U. Oregon to work on PhD
with Rudy Hwa on transverse momentum
In high energy A+A

XN @ 27 1989

Defended PhD with Rudy Hwa on geometric branching models and AA multiplicity

Greatly worried about Tiananmen

XN @ 28 1990

Celebrated two babies while PostDoc at LBL

1) daughter Cynthia and 2) HIJING1.0 code

XN @ 29 1991

PostDoc 2 at Duke

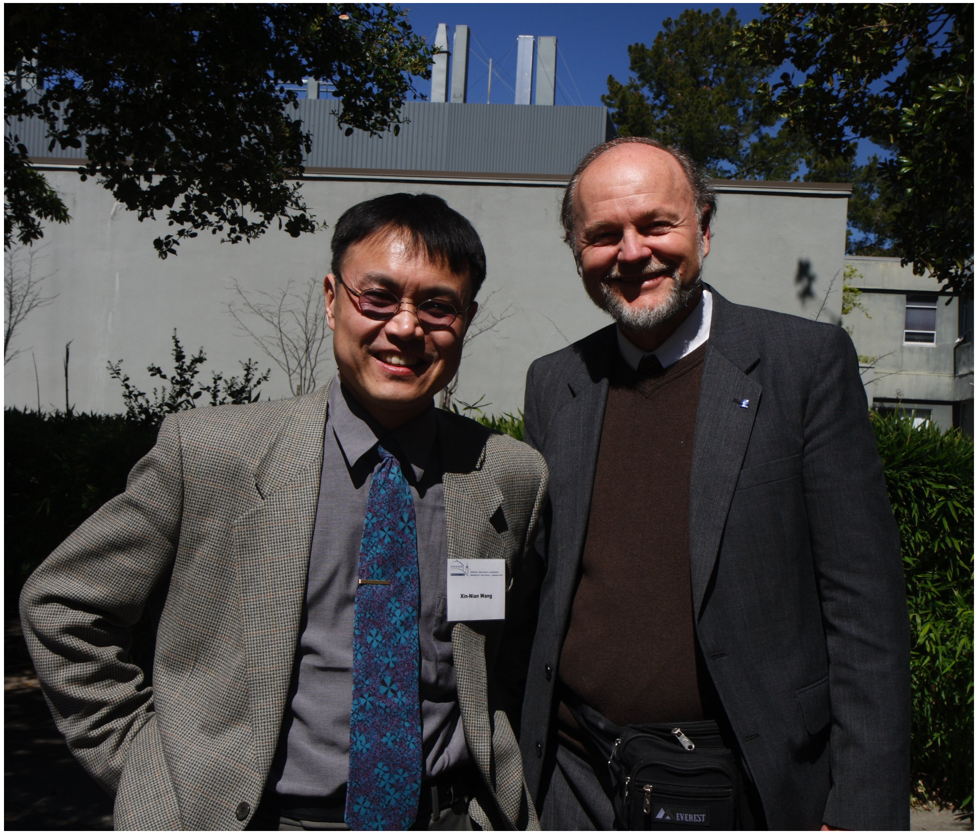
XN @ 39 2001

Hawaiian Luau in Maui at DNP meeting

XN @ 40 2002

XN organized a Wuhan Heavy Ion Workshop. We visited Guiyuan Temple.
From 2015 to 2019 I had the pleasure to work at CCNU as visiting prof

XN @ 47 2009



Organized MG@60 party at LBL

XN @ 47 2009

XN began experimental studies of quenching in
The perfect fluids of Hawaii DNP 2009

Back to the future 2009 when we were all 13 years younger.

Coupling hard jet dE/dx path integrals with soft Hydro T(x,t) & u(x,t) exp constrained fluid fields

2010-2015

Proposal for a Topical Collaboration on

Quantitative Jet and Electromagnetic Tomography (JET) of Extreme Phases of Matter in Heavy-ion Collisions

for the period of
May 1, 2010 – April 30, 2015

(in alphabetical order of institutions)
Miklos Gyulassy (Columbia University)
Steffen Bass and Berndt Mueller (Duke University)
Volker Koch, Xin-Nian Wang and Feng Yuan (Lawrence Berkeley National Laboratory)
Ramona Vogt (Lawrence Livermore National Laboratory)
Ivan Vitev (Los Alamos National Laboratory)
Charles Gale and Sangyong Jeon (McGill University)
Ulrich Heinz and Abhijit Majumder (Ohio State University)
Denes Molnar (Purdue University)
Rainer Fries and Che-Ming Ko (Texas A & M University)

Co-Spokespersons: Berndt Mueller (Duke University) and Xin-Nian Wang (LBNL)

Principal Investigator:
Xin-Nian Wang
Nuclear Science Division, MS70R0319,
Lawrence Berkeley National Laboratory, Berkeley, CA 94720
Tel: (510) 486-5239 Email: xnwang@lbl.gov

Columbia University Progress Report on CUJET2.0 from

M.Gyulassy 8/22/13 JET collab meeting

1) Review of **CUJET1.0** = running coupling DGLV + Bj(no transverse)
Alessandro Buzzatti

2) Recent progress with **CUJET2.0** = rcDGLV+ VISHNU 2+1 hydro
Jiechen Xu

G.Torrieri (Frankfurt)

M.Mia
AdS/CFT

A.Ficnar
AdS/CFT

XN @ 57   Quark Matter   2019   MG @70

QM19 was last time 1000 heavy ioners met in person before the pandemic shut down the world.

Is this “Great Reset” of 2022 a repeat of the tragic “Great Leap Forward” in 1962 ?

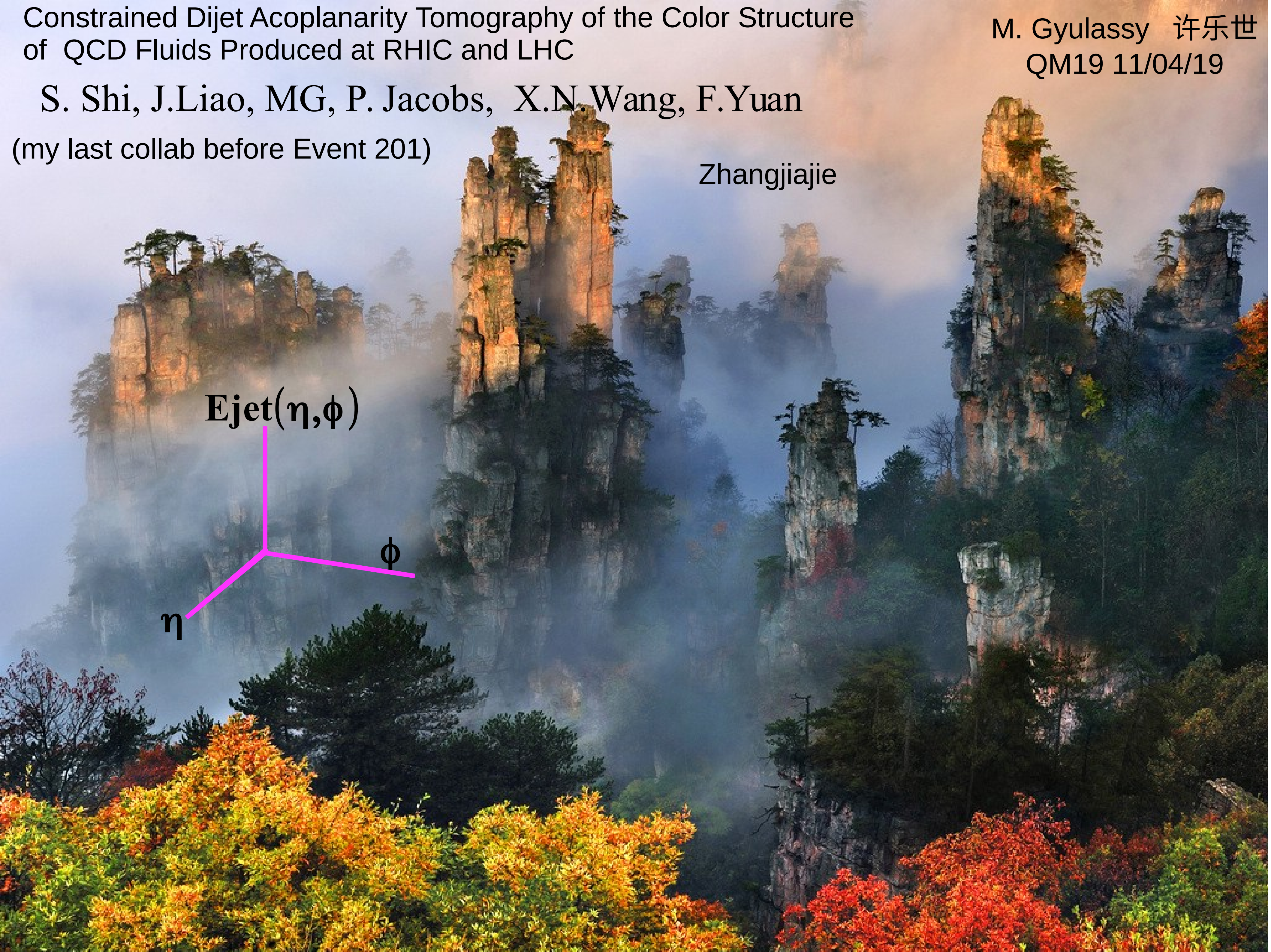
I certainly hope not. This JETSCAPE workshop and QM22 provides some hope.

Constrained Dijet Acoplanarity Tomography of the Color Structure of QCD Fluids Produced at RHIC and LHC

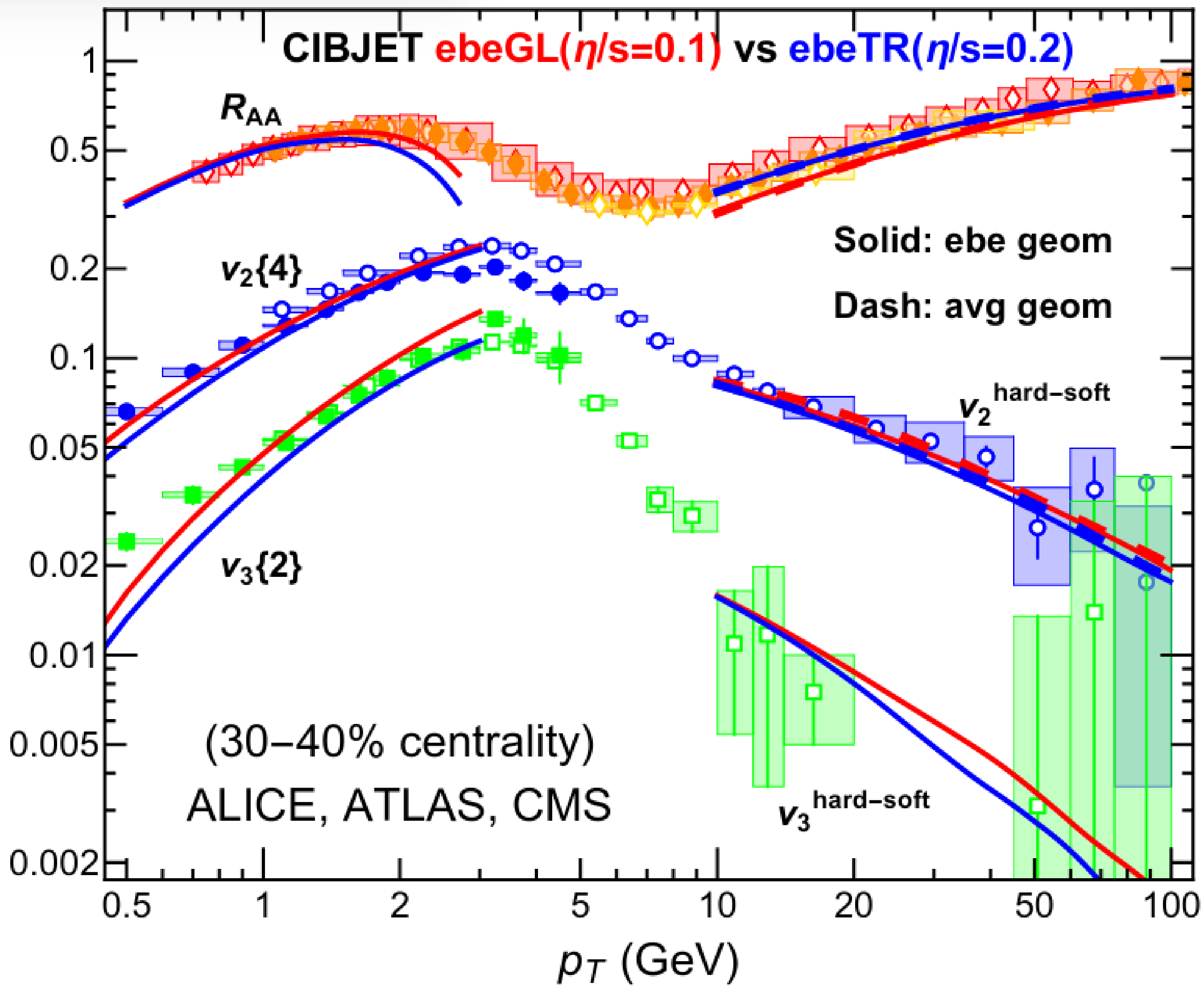
M. Gyulassy 许乐世
QM19 11/04/19

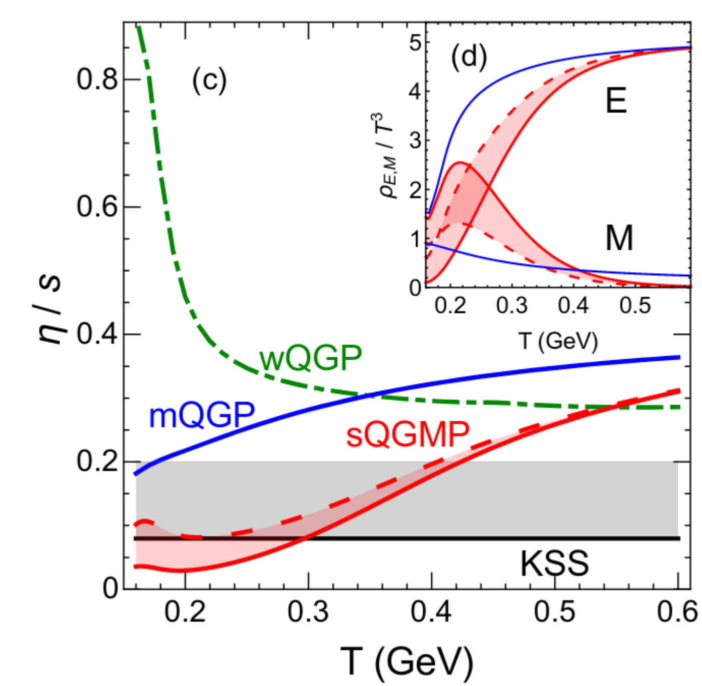
S. Shi, J.Liao, MG, P. Jacobs, X.N.Wang, F.Yuan

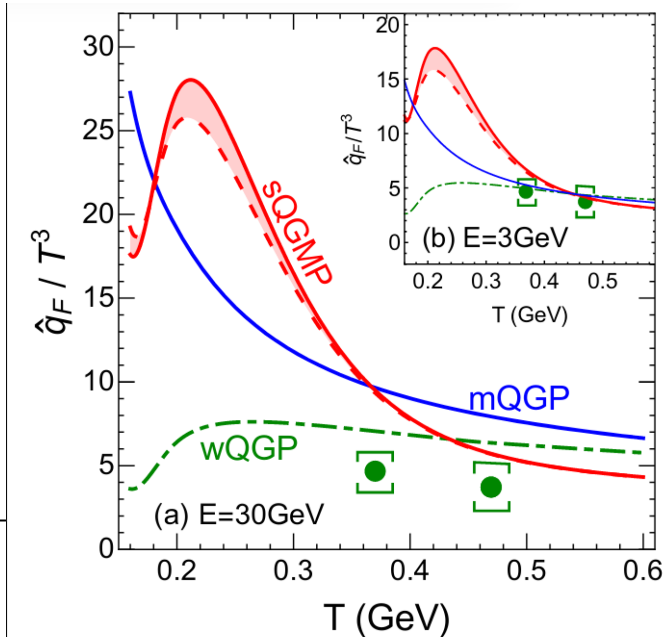
(my last collab before Event 201)



Probing the Color Structure of the Perfect QCD Fluids via Soft-Hard-Event-by-Event Azimuthal Correlations







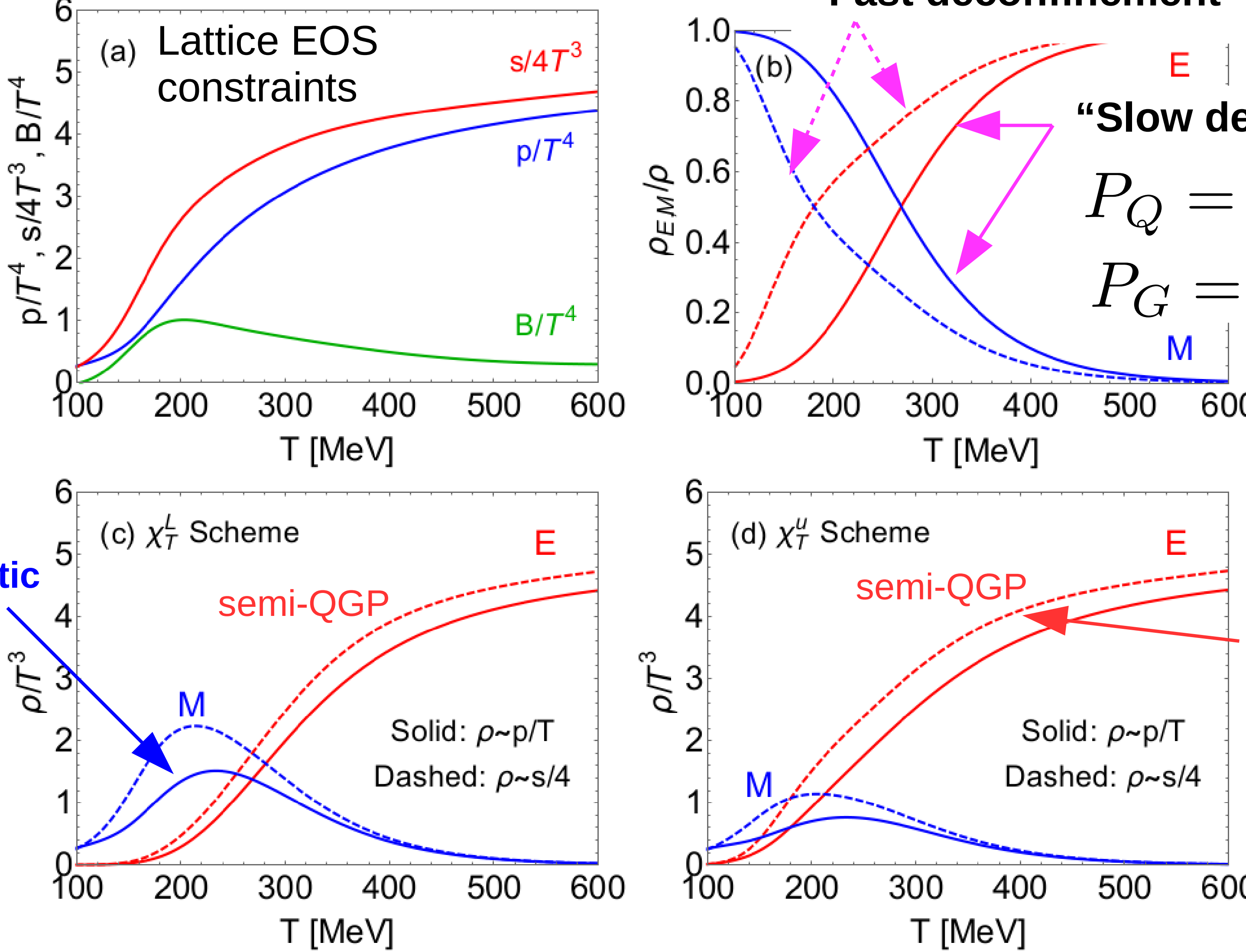
S.Shi, J.Liao. MG, Chin.Phys.C 42 (2018) 10, 104104

CUJET3 **sQGMP** composition constrained by Lattice QCD thermo P(T), L(T), $\chi^u(T)$, $\mu_E(T)$, $\mu_M(T)$

"Fast deconfinement"

"Slow deconfinement"

$$P_Q = P_Q^{SB} L(T)$$
$$P_G = P_G^{SB} L^2(T)$$



Emergent Color Magnetic Monopole d.o.f.
Shuryak, Liao (2007)

Suppressed Color Electric "semi-QGP"
Hidaka,Pisarski

sQGMP is a lattice QCD constrained model of the 1974 suggestion by **t'Hooft, Polyakov and Mandelstam** that emergent color magnetic monopole d.o.f. may play an important role in confining color electric q and g d.o.f. at T=0

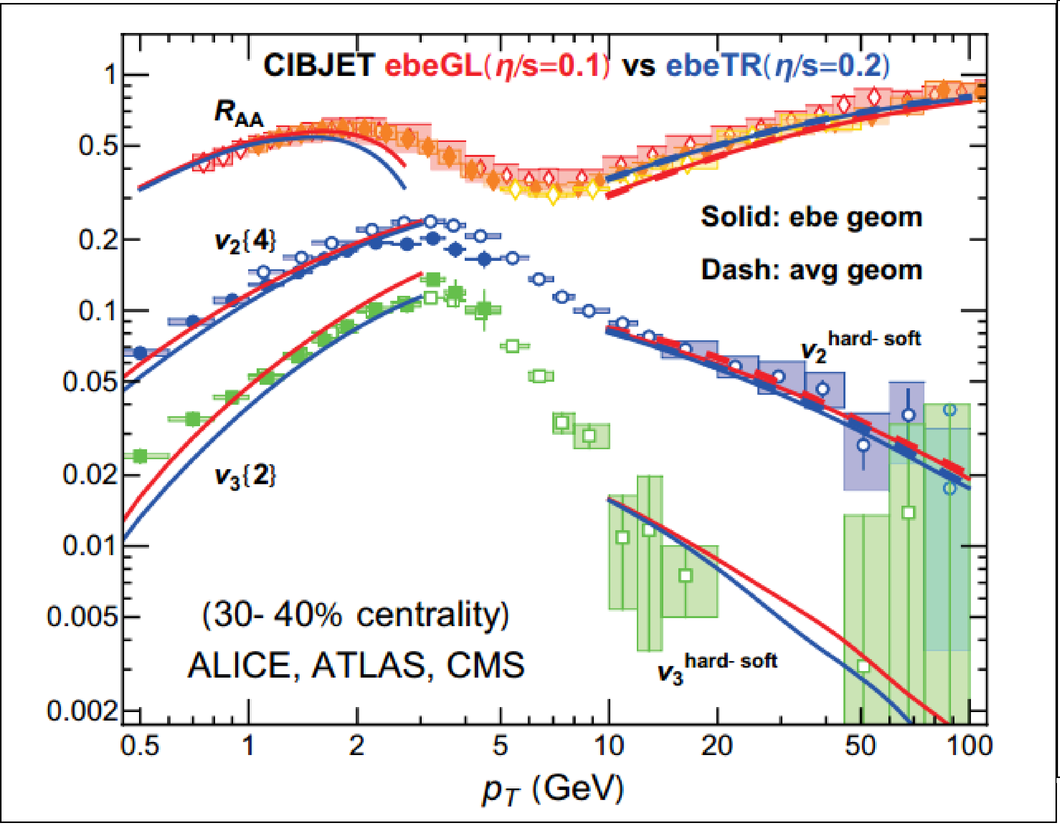
(See also B.Zakharov:1412.6287; Ramamurti, Shuryak, Zahed, 1802.10509)

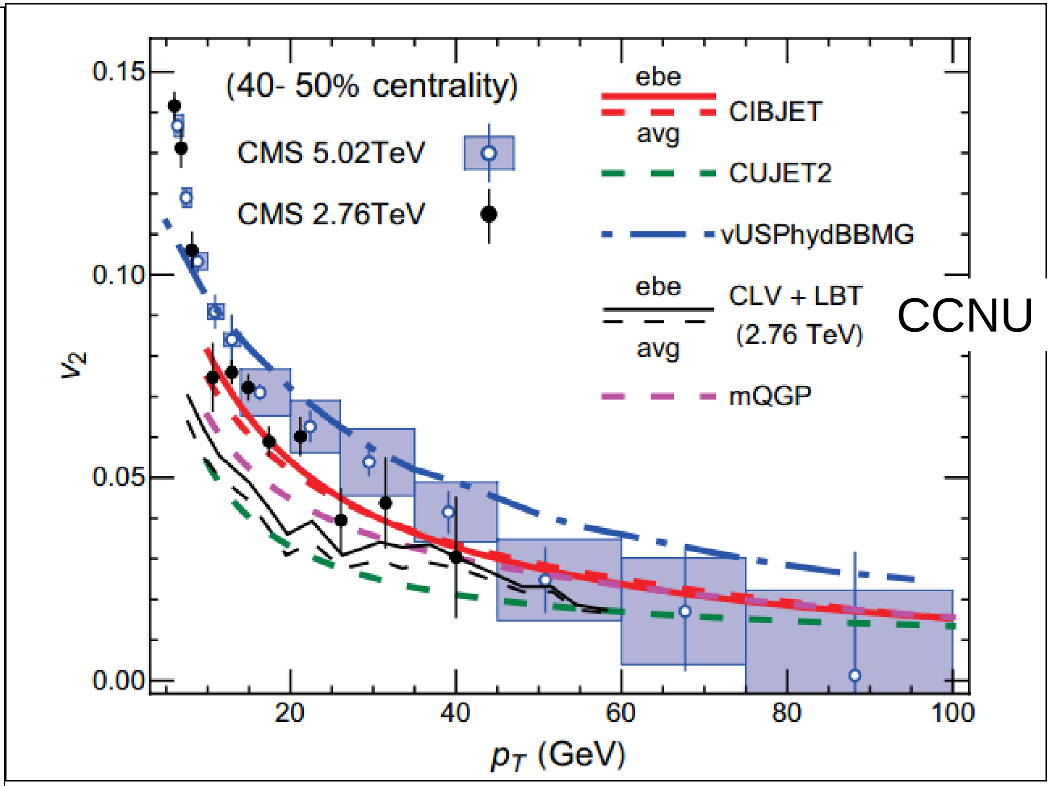
施舒哲 廖劲峰 许乐世

(S Shi, J Liao, MG)

Chinese Physics C Vol. 42, No. 10 (2018) 104104

CIBJET (sQGMP) provides a $\chi^2/dof < 2$ solution to all RAA, v2, v3 data at RHIC and LHC





CCNU

However other globally consistent RHIC+LHC RAA&v2 solutions also exist:

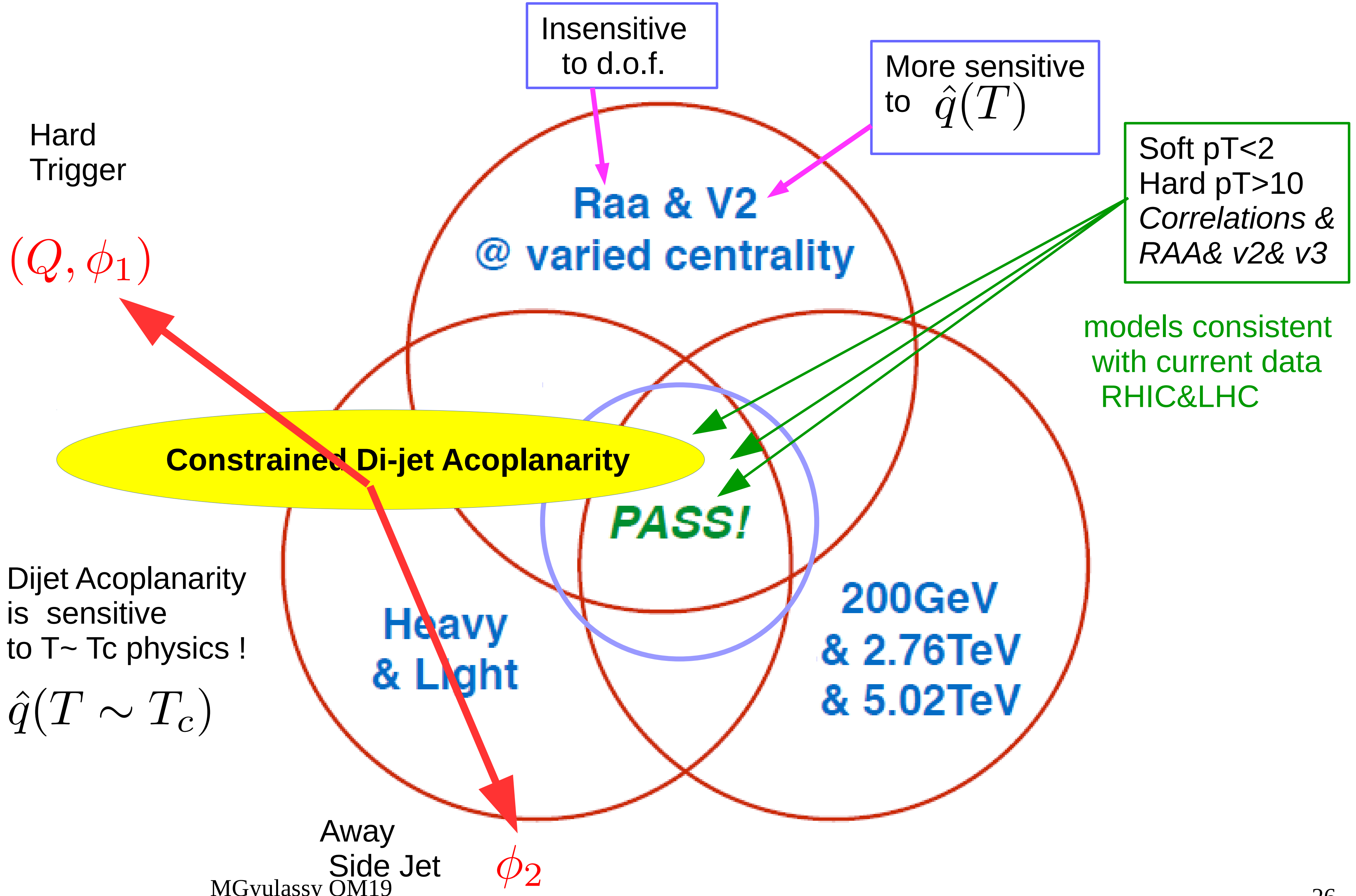
1. J. Noronha Hostler et al, PRL116,252301 (2016)
   "Event-by-Event Hydro +Jet Energy Loss: A Solution to the RAA⊗v2 Puzzle"

2. C. Andres et al, PoS HardProbes2018 (2019) 070
   "Constraining energy loss from high-T azimuthal asymmetries"

→ **We need other observables to break theoretical degeneracies !**
***Constrained* Dijet AcoplanarityTomography can help**

Summary Cartoon of the Task ahead for youngsters like XinNian

RAA&v2 *Constrained* Dijet Acoplanarity Tomography can help to falsify competing models of the color d.o.f. in perfect QCD fluids produced at RHIC and LHC



OK, Back to the Future ~ 1992

again

Lessons from P0(Ecm, A) and CGC

Rewind Back to 1992 XN@30 Our first 3 *Predictions* with HIJING XN Wang, MG

VOLUME 68, NUMBER 10 PHYSICAL REVIEW LETTERS 9 MARCH 1992

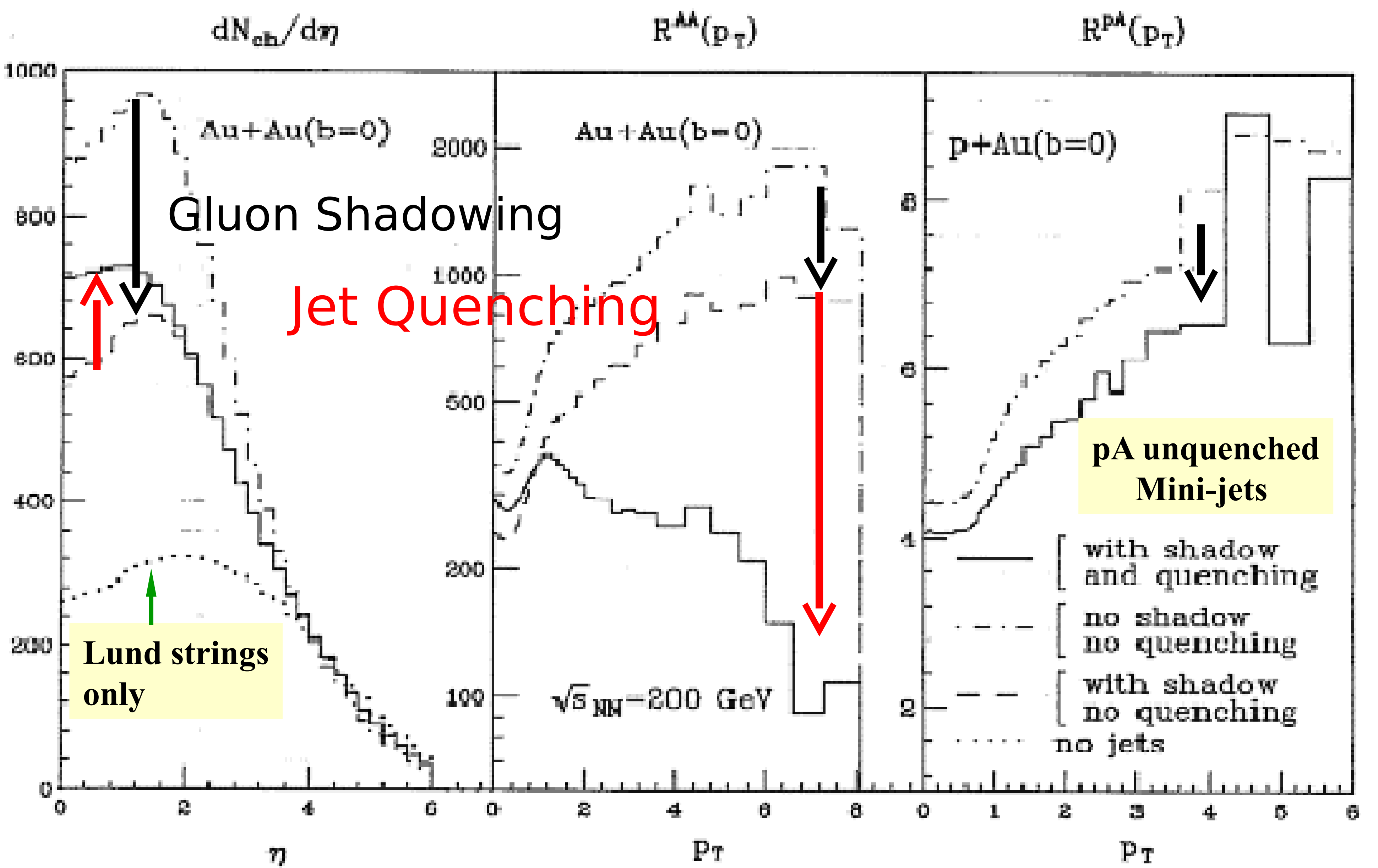


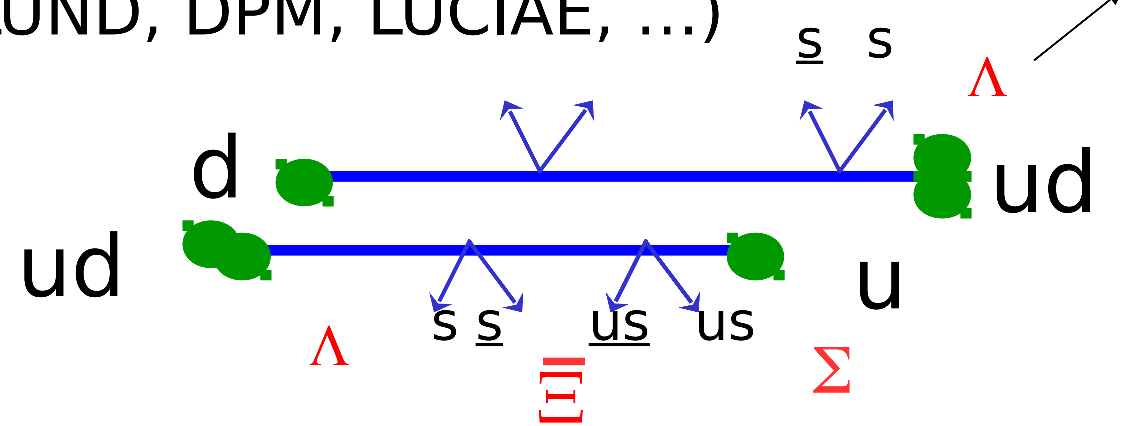
FIG. 1. Results of HIJING on the dependence of the inclusive charged-hadron spectra in central Au+Au and $p+$Au collisions on minijet production (dash-dotted line), gluon shadowing (dashed line), and jet quenching (solid line) assuming that gluon shadowing is identical to that of quarks and $dE/dl = 2$ GeV/fm with $\lambda_s = 1$ fm. $R^{AB}(p_T)$ is the ratio of the inclusive p_T spectrum of charged hadrons in $A+B$ collisions to that of $p+p$.

HIJING: Multi Strings+pQCD Framework

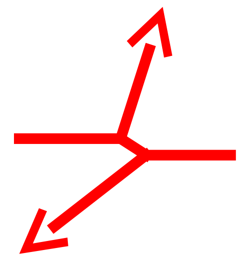
1) Soft Beam Jet Fragmentation

(LUND, DPM, LUCIAE, ...)

$N_{part}(b)$



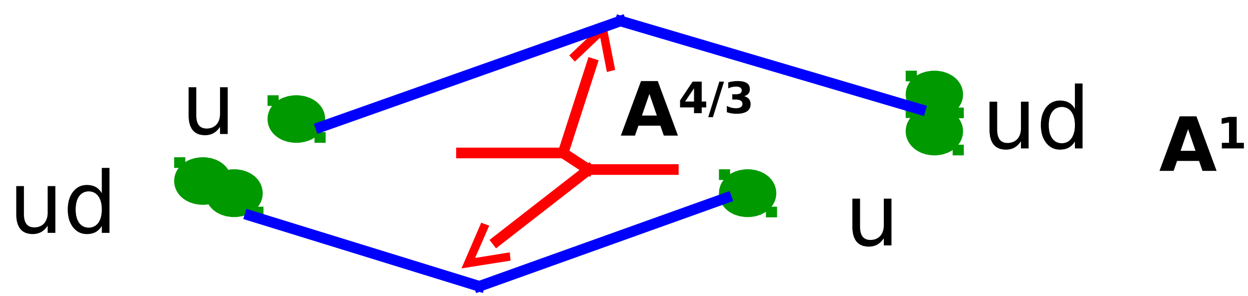
2) Hard pQCD $p_T > P_0$ (Pythia)



x T_{AB}(b)

3)=1+2 Hard pQCD Hadronized by Strings

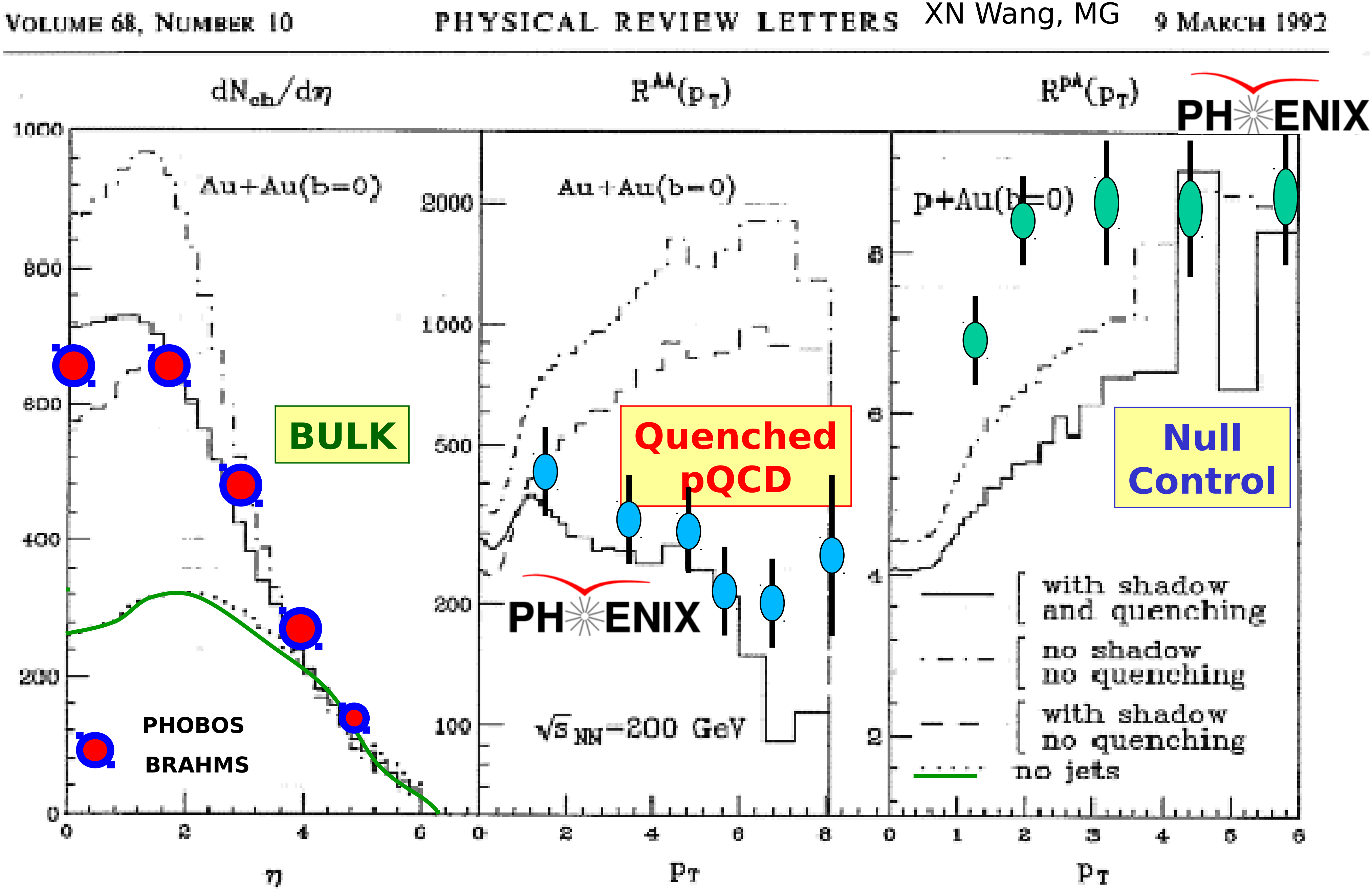
(Hijing,Fritiof)



+Later Generalizations: Color Ropes, Baryon Junctions, Saturation $P_0(N_{part}, E_{cm})$

OUR FIRST HOMERUN around the three bases in 2003

XN Wang, MG



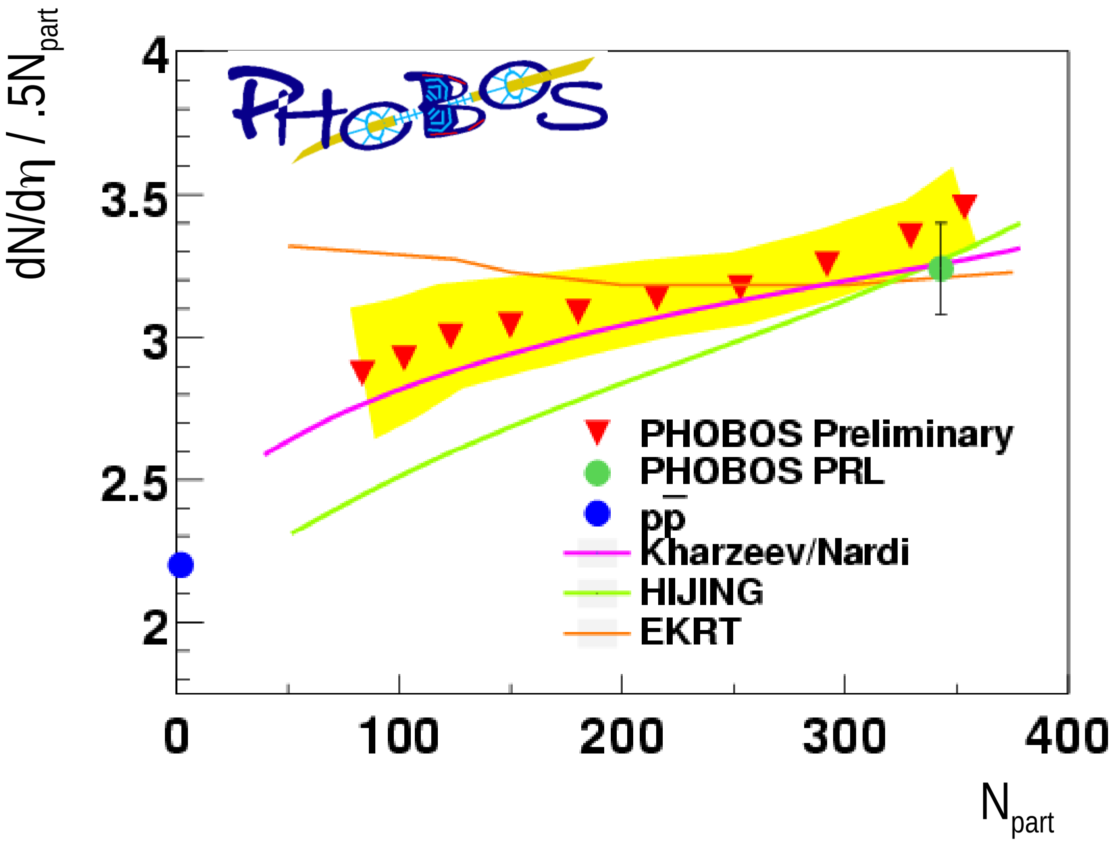
2003 RHIC data compared to our 1992 HIJING PRL68 predictions

Intersections between HIJING and Gluon Saturation Models and exp Npart dependence

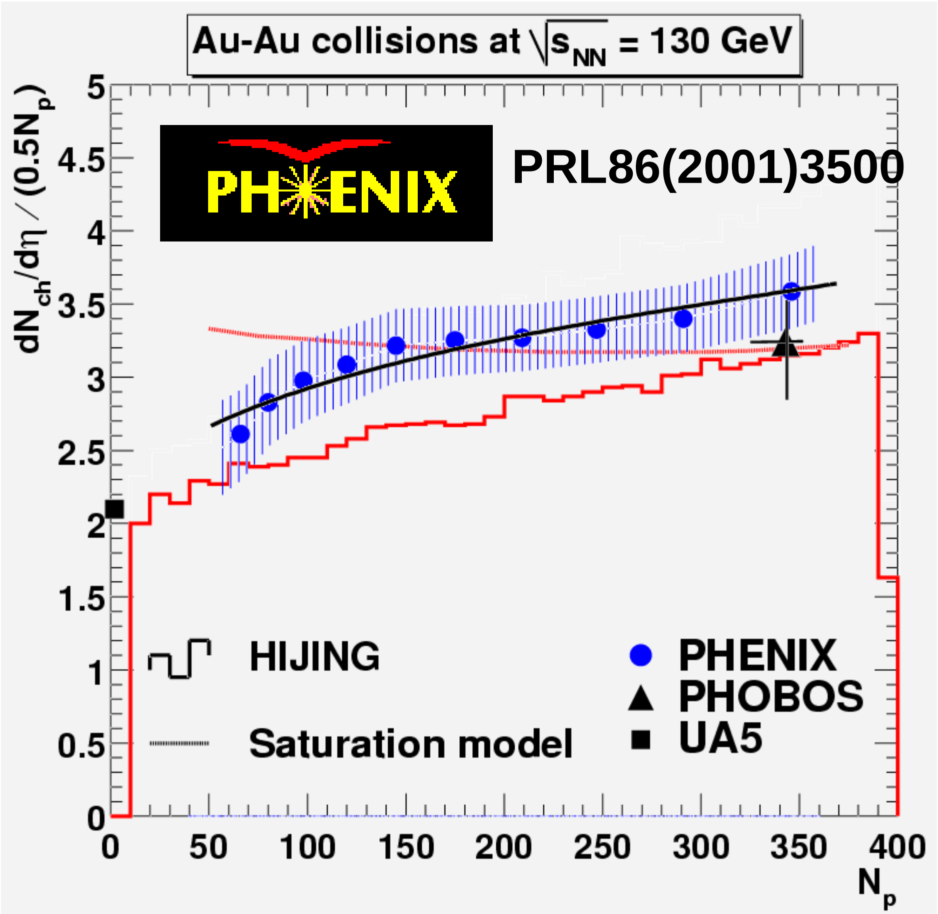
First exp hint that mini jet scale P_0 must evolve with centrality and Ecm

Centrality Dependence of $dN_{ch}/d\eta$

P. Steinberg QM01



XW,MG , PRL86 (2001) 3496



Centrality N_{part} and s_{NN} dependence of $dN_{ch}/dy/N_{part}$ favors CGC saturation

AA Pizza pie area πR_A^2 fully **saturated** when number N_s of pepperonis of area $\pi\alpha(Qs^2)/Qs^2$

exceeds

$$N_s \sim \frac{1}{\alpha_s(Q_s^2)}\, Q_s^2 R_A^2 \sim N_A \sim A. \quad \longrightarrow \quad Q_s^2 \sim \alpha_s(Q_s^2)\,\frac{N_A}{R_A^2} \sim A^{1/3}$$

Kharzeev,Nardi, PLB 507 (2001) 121
Blaizot, Mueller, NPB B289 (1987) 847

L McLerran, R Venugopalan, (1994) , ...

Computing quark and gluon distribution functions for very large nuclei (Classical YangMills)

Mueller, Qui (1986), Blaizot, A Mueller, (1987)

THE EARLY STAGE OF ULTRA-RELATIVISTIC HEAVY ION COLLISIONS

considers gluons with smaller p_T overlapping configurations become more common. When $xG_A(x, p_T^2) \gtrsim p_T^2 R^2$ different gluons must begin to occupy the same spatial region. Since $xG_A(x, p_T^2) \simeq AxG(x, p_T^2)$ one sees that this dense configuration is enhanced in large nuclei with strong interactions expected between the quanta when $p_T^2 \sim \alpha A/R^2$. (The factor of α, to be derived below, reflects the fact that the overlapping gluons interact (recombine) with strength α.) Thus, the actual transition from a low density to a high density gluonic system occurs at $xG_A(x, p_T^2) \gtrsim p_T^2 R^2/\alpha$.

$$p_T^2 \frac{\partial}{\partial p_T^2} xG_A(x, p_T^2) = \frac{\alpha C_A}{\pi} \int_x^1 \frac{dx_1}{x_1} x_1 G_A(x_1, p_T^2)$$

Altarelli Parisi g->gg

$$- \left(\frac{\alpha C_A}{\pi}\right)^2 \frac{\pi^3}{2 p_T^2} \int_x^1 \frac{dx_1}{x_1} x_1^2 G_A^{(2)}(x_1, p_T^2)$$

Higher Twist gg->g

LHS = 0 when

$$AxG(x, p_T^2) = \frac{16}{9\pi} \frac{p_T^2 R^2}{\alpha C_A}$$

$$p_T^2 = \tfrac{9}{16} \pi \alpha C_A \frac{AxG}{R^2}$$

CGC Saturation Scale Q_s^2

Motivated by Mueller,Qiu (1986) and Blaizot,Mueller (1987) and Dima's CGC model
the emerging A and Ecm data systematics forced
XinNian to generalize HIJING to

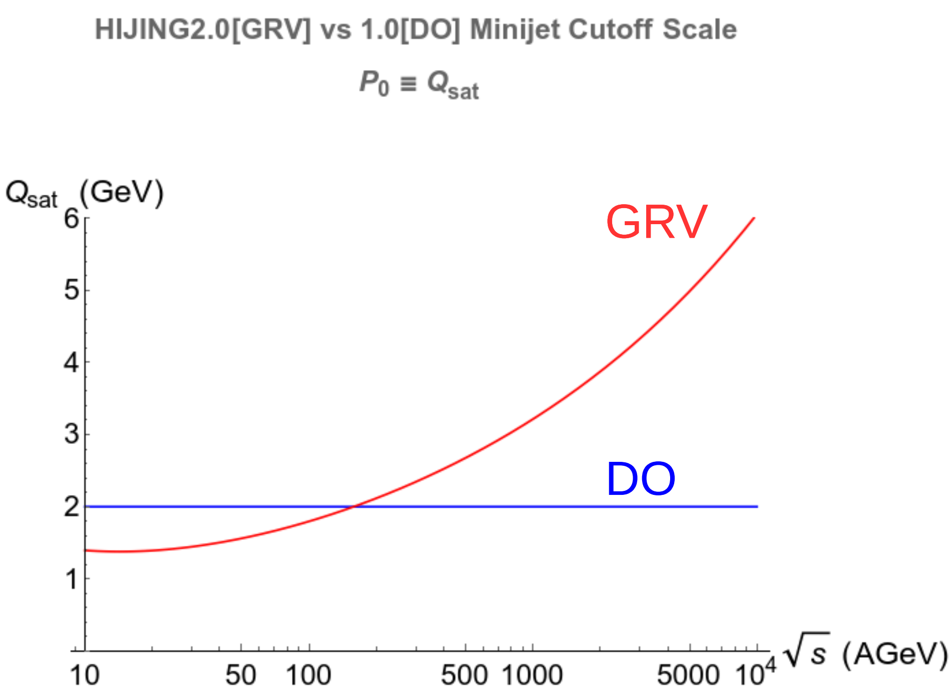
Hadron production with the HIJING 2.0 model = GRV + phenom Qs(√s,A)
WT Deng, XN Wang, R Xu, Phys.Rev.C 83 (2011) 014915

Furthermore, with a constant transverse momentum cut-off $p_0 = 2$ GeV/c in HIJING 1.0, the total number of min-jets per unit transverse area could exceed the limit

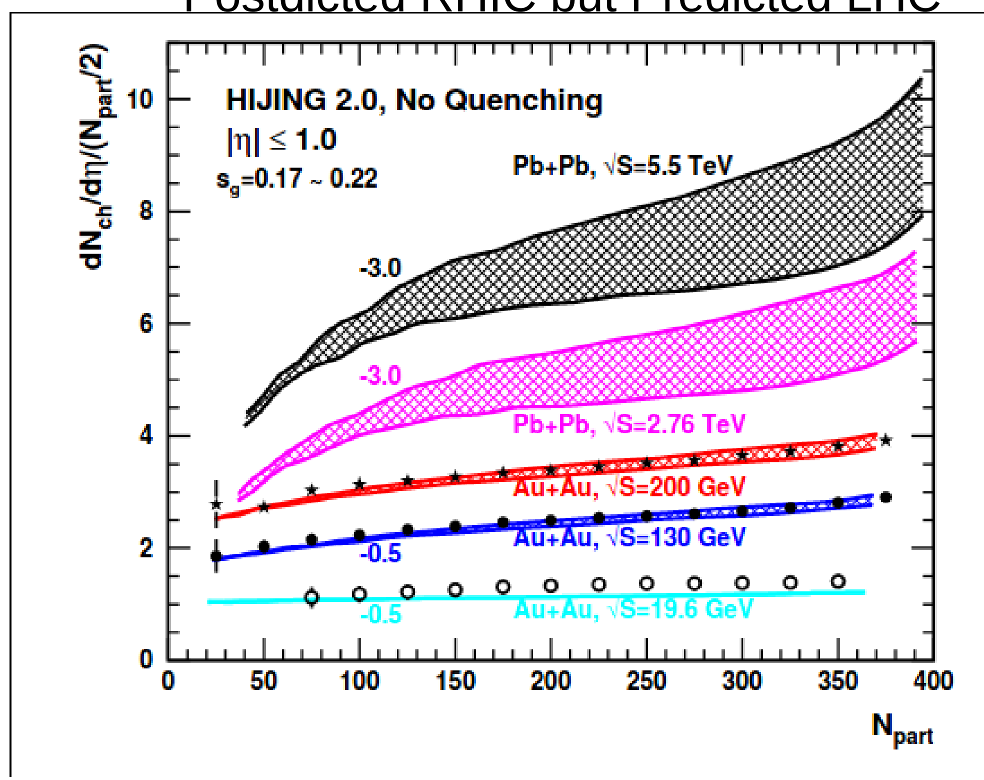
$$\frac{T_{AA}(b)\sigma_{jet}}{\pi R_A^2} \leq \frac{p_0^2}{\pi} \qquad (9)$$

Because of the large gluon density at small x<<1 in the GRV

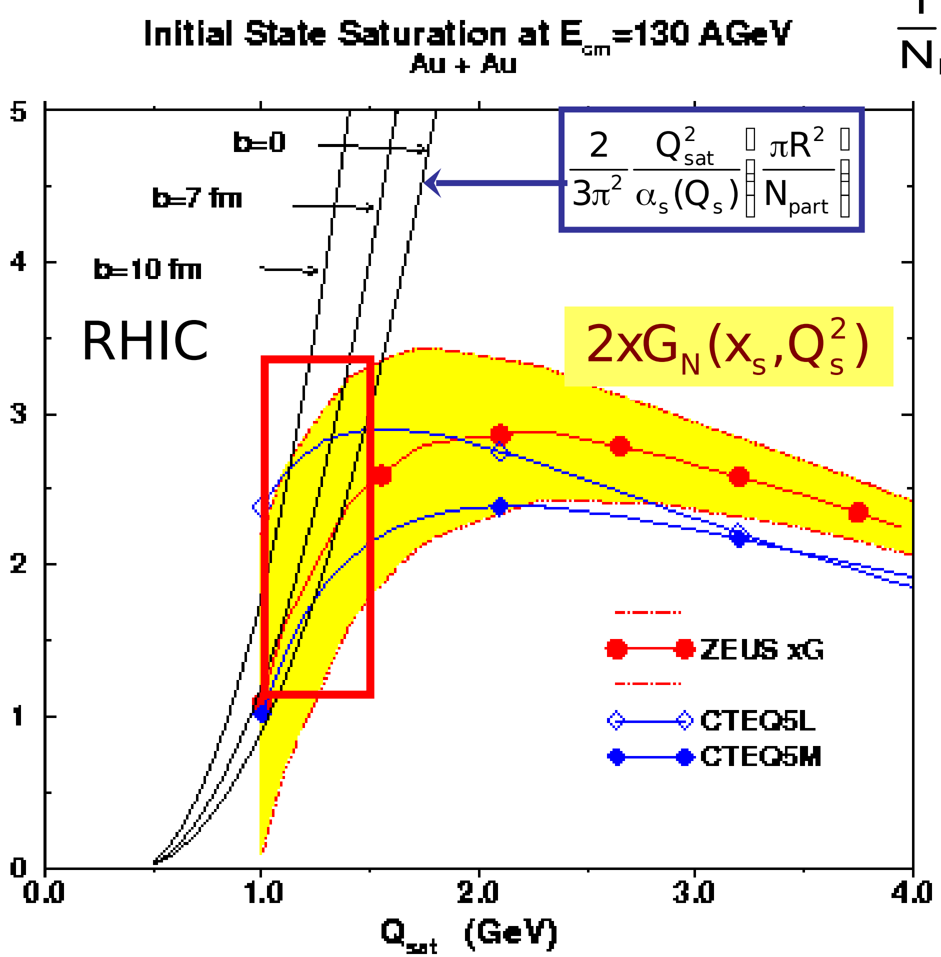
XN had to introduce a Ecm and A dependent Mini jet cutoff P_0

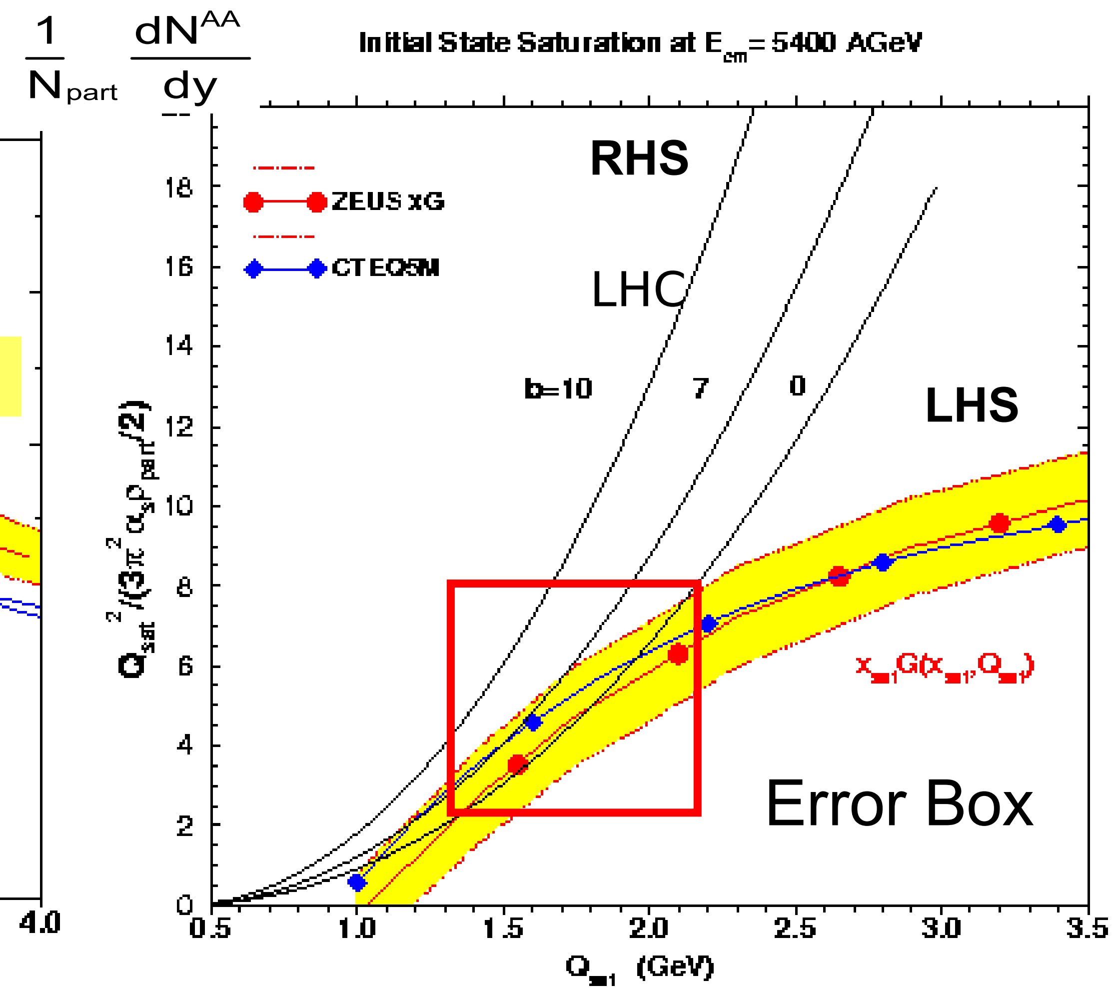


Postdicted RHIC but Predicted LHC



Systematic Errors of $P_0=Q_{sat}$ prediction based on measured $xG_{g/p}(x,Q^2)$ are unfortunately large . Can this sys error be reduce ?





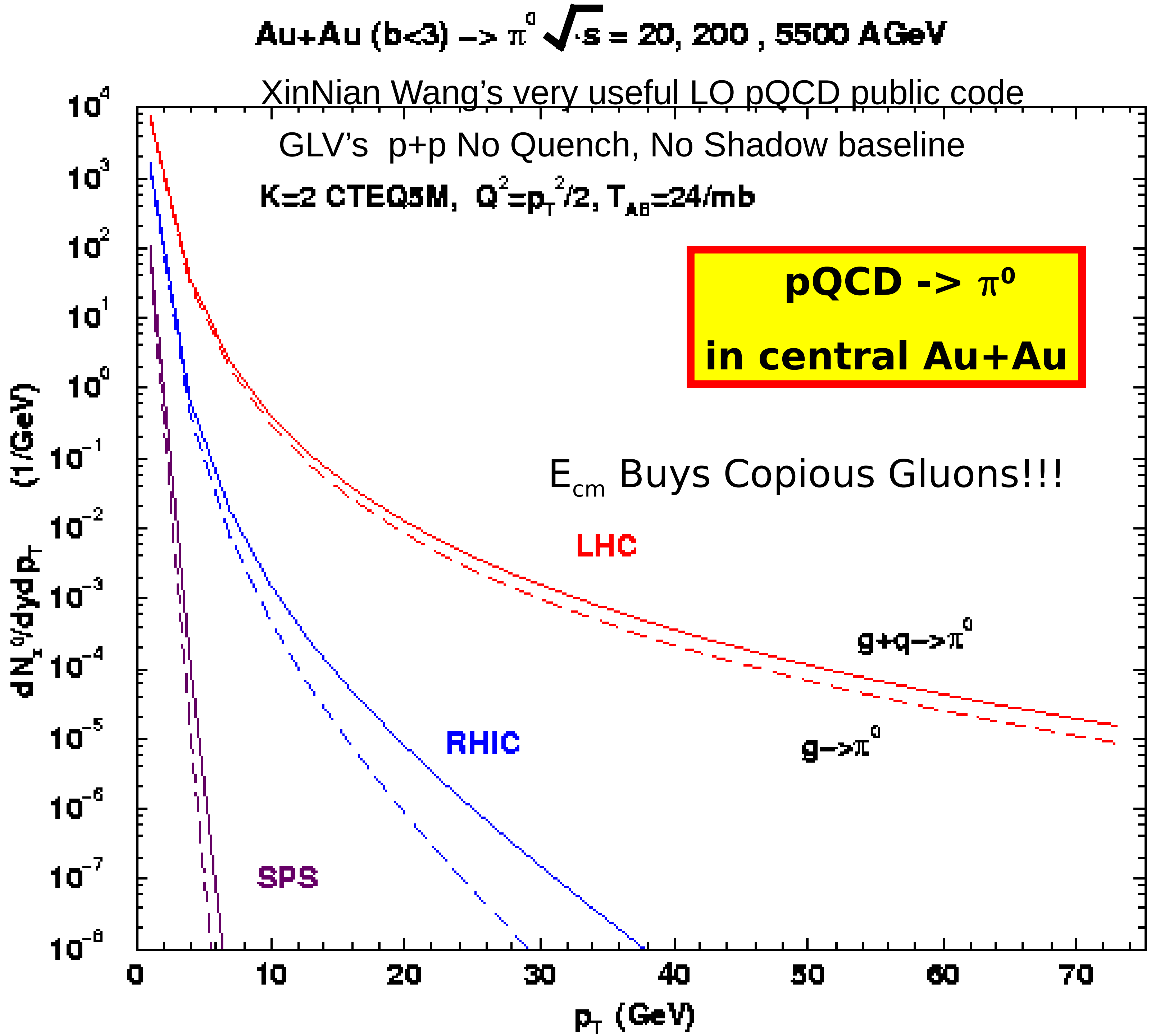
$$2xG_A\left(x=\frac{2Q_{sat}}{\sqrt{s}},Q_{sat}^2\right)=\frac{2c}{3\pi^2}\,\frac{Q_{sat}^2R^2}{\alpha_s(Q_s)}$$

$$2xG_p\left(x=\frac{2Q_{sat}}{\sqrt{s}},Q_{sat}^2\right)=\frac{2c}{3\pi^2}\,\frac{Q_{sat}^2}{\alpha_s(Q_s)}\left(\frac{\pi R^2}{N_{part}}\right)$$

$$\frac{dN^{LHC}}{dy}\approx 1000-3000$$

Jet Quenching and Tomography after 2000 RHIC

Quick overview from a GLV perspective



Au+Au (b<3) -> π⁰ √s = 20, 200 , 5500 AGeV
XinNian Wang's very useful LO pQCD public code
GLV's p+p No Quench, No Shadow baseline
K=2 CTEQ5M, Q²=p_T²/2, T_AB=24/mb
pQCD -> π⁰
in central Au+Au
E_cm Buys Copious Gluons!!!
LHC
g+q->π⁰
g->π⁰
RHIC
SPS
dN_π⁰/dydp_T (1/GeV)
p_T (GeV)

Run 2002/2003 d-Au $\sqrt{s}$ = 200 GeV:

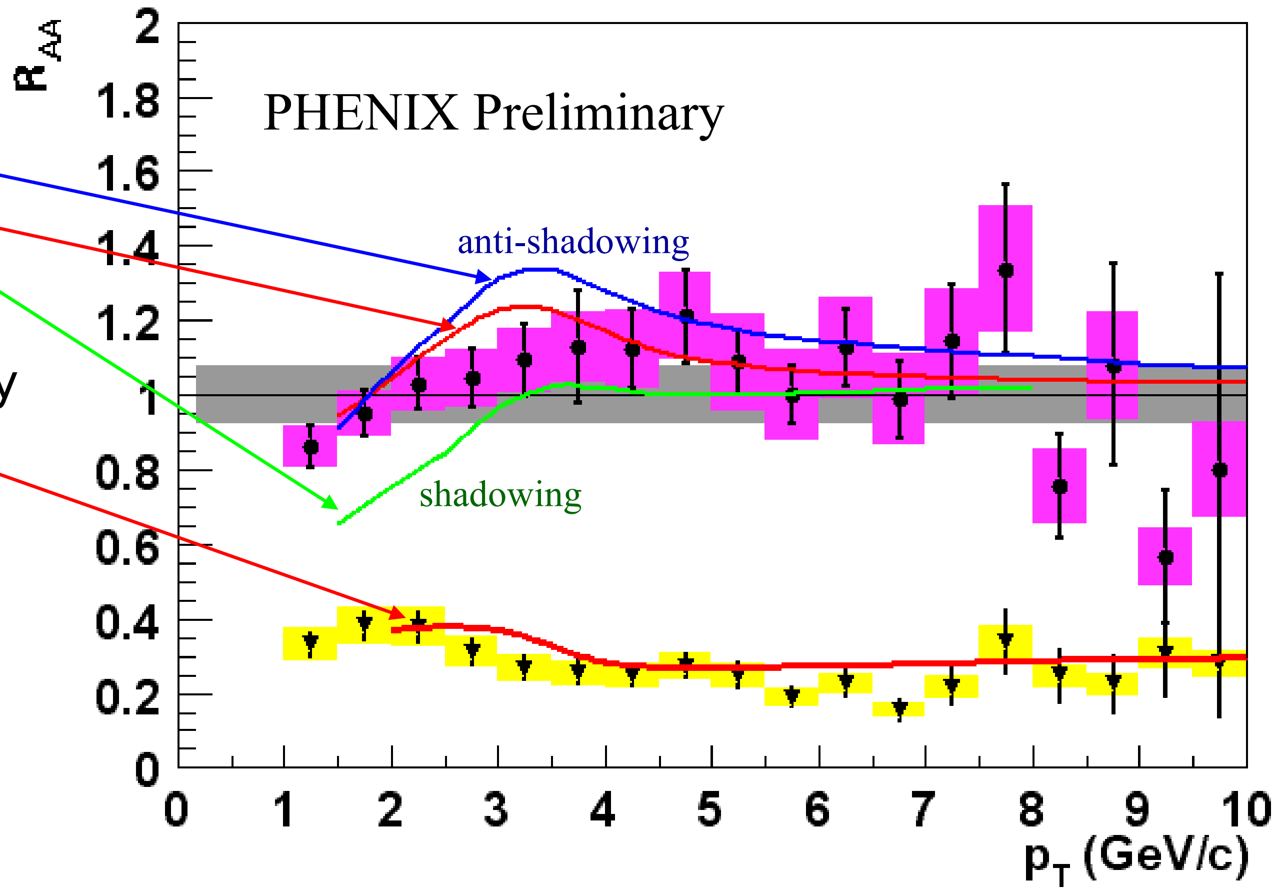
π^0 R_{AA} Theory vs Experiment for central Au+Au versus d+Au collisions

d+Au: I. Vitev, PLB562(2003)

Au+Au: I. Vitev, MG, PRL89 (2002)

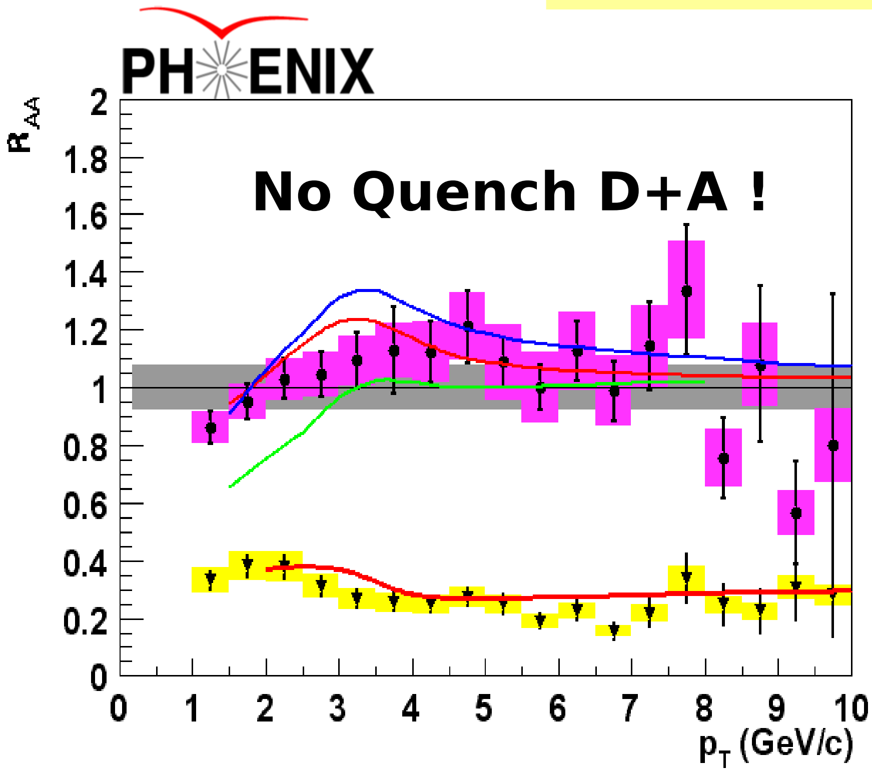
Using the GLV jet quench opacity series formalism

MG, P. Levai,I. Vitev, NPB 594, (2001), PRL 85 (2000).

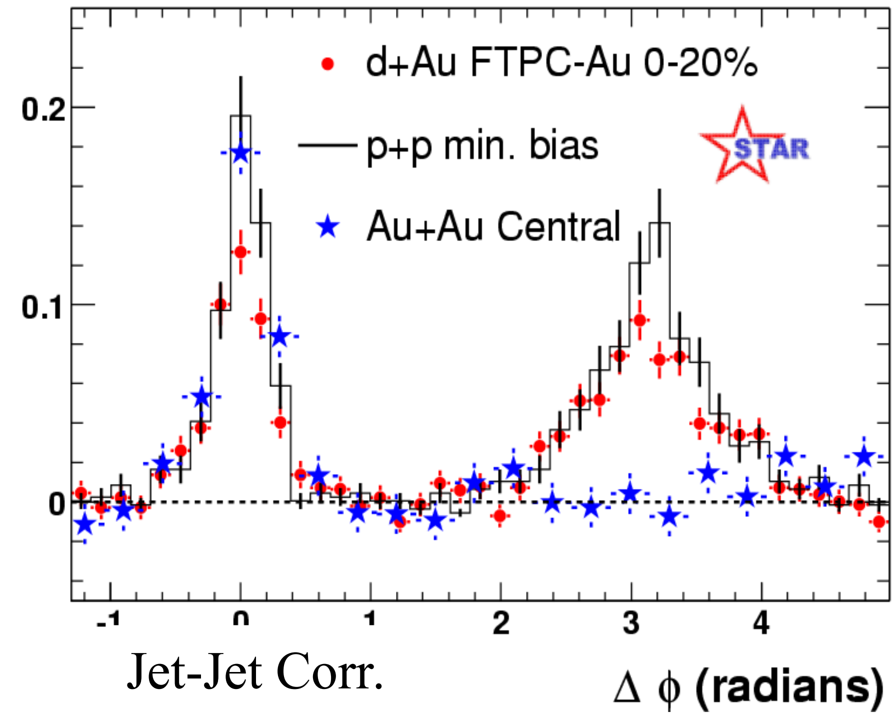


MG: CPANP2003

" Return of the Jeti "



Strong Quench A+A



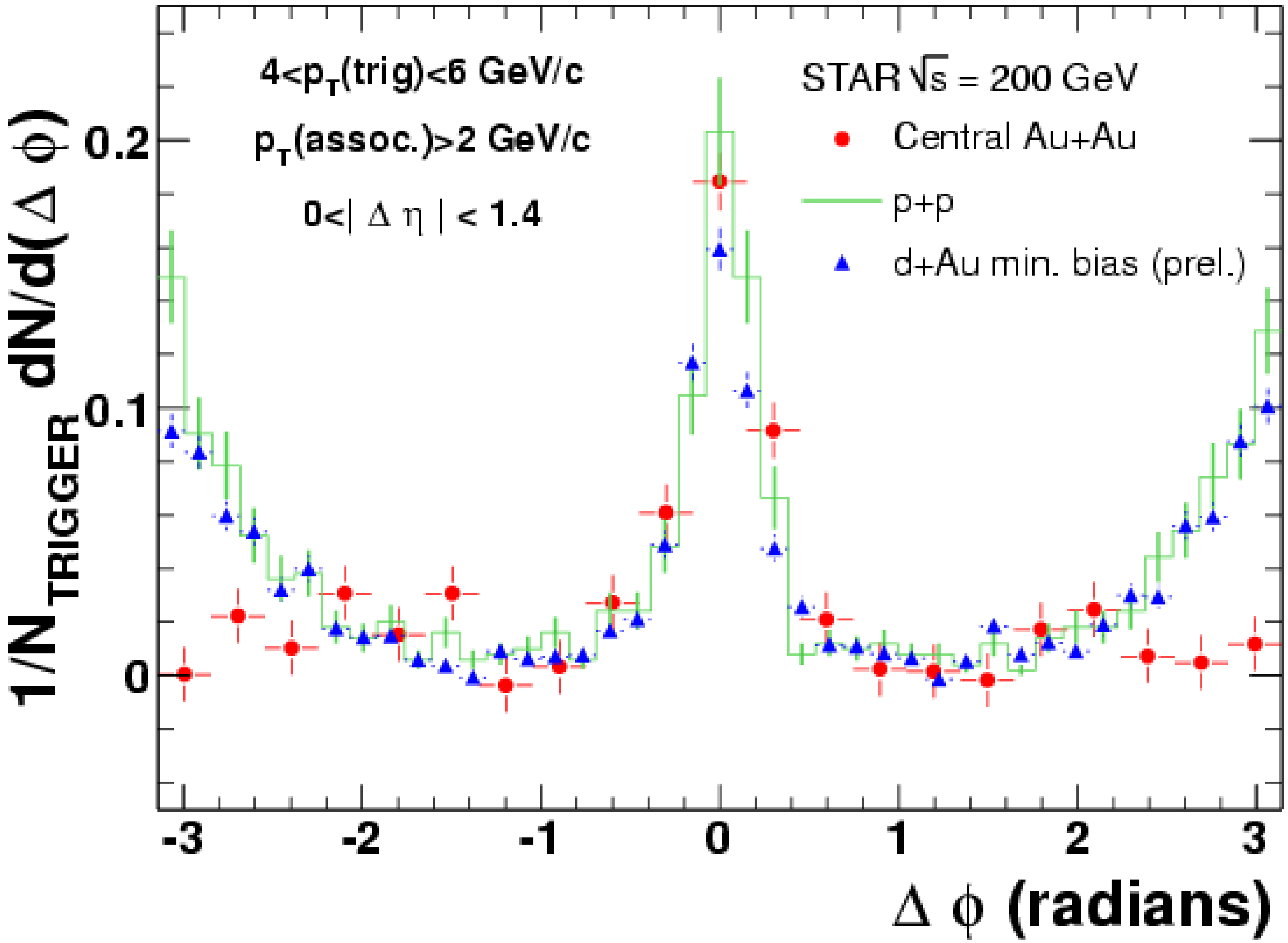
Jet-Jet Corr.

Jet and Dijet Quenching turns ***OFF*** in small systems

dA=Critical Control Experiment

"Return of the Jeti" in d+Au

$$d + Au \rightarrow h_1(p_T^{trig}, \phi^{trig}) + h_2(p_T^{assoc}, \phi^{trig} + \Delta\phi) + X$$



STAR data

d+Au dijet correlations are similar to p+p dijets

* But dijets in Au+Au are strongly quenched !

HIJING predicted NULL quenching pT>2 in d+Au was confirmed !

MG: CPANP2003

In contrast, bulk collective flow v2 (pT) observables in d+A and A+A are similar at similar dNch/dy centrality events and not strongly dependent on beam energy!

Perfect Fluidity of sQGP?

Good old days before BES

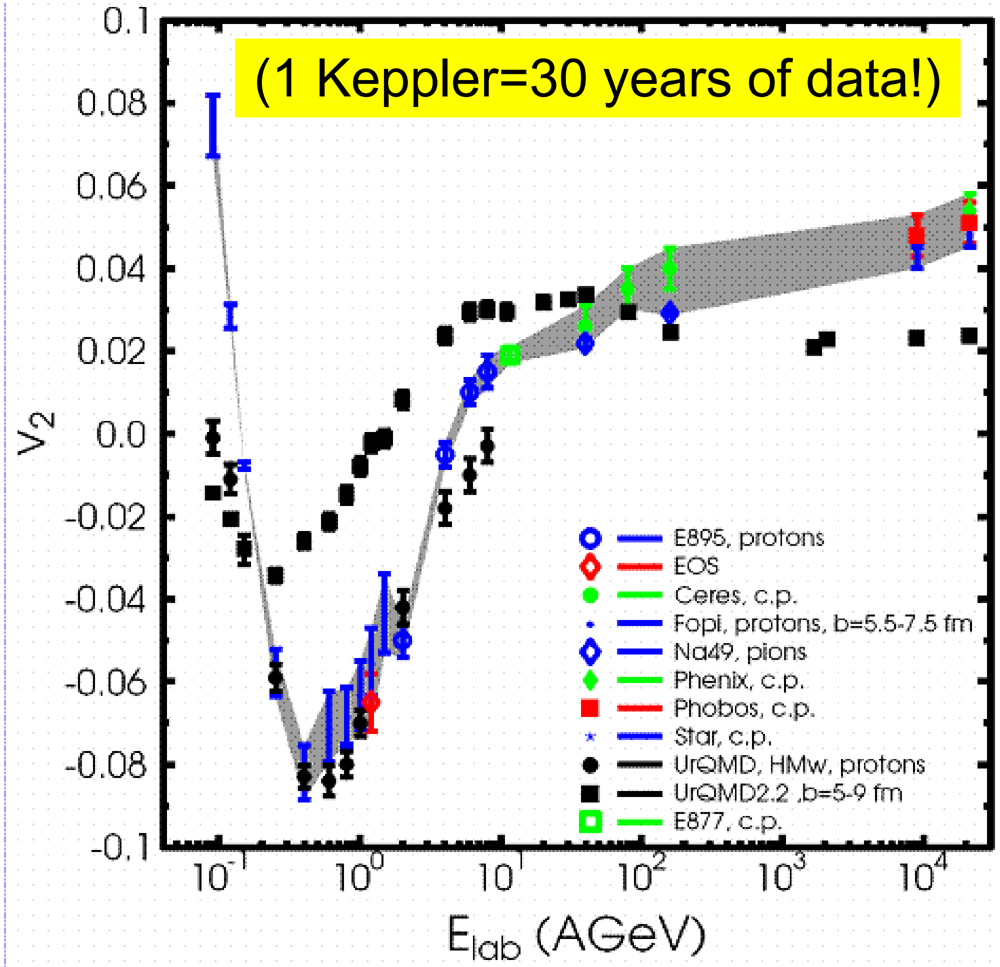
New Puzzles for XinNian

and JETSCAPE

In the good old days Perfect Fluidity was only found at RHIC energies

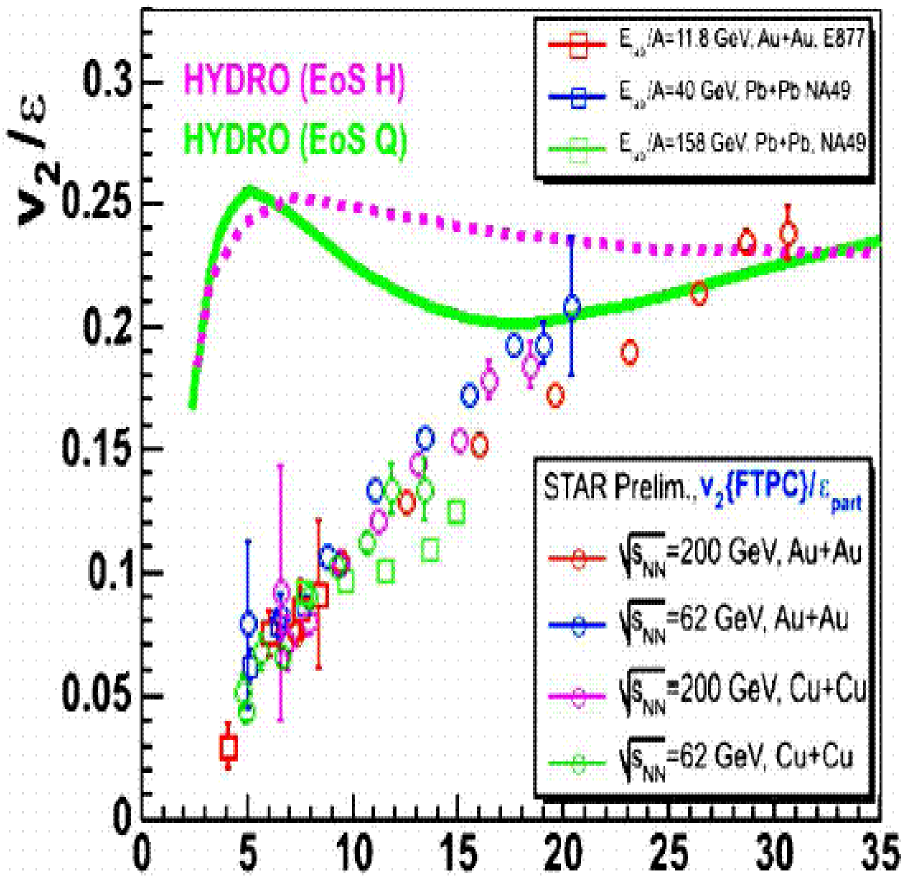
Elliptic flow is ubiquitous

M. Bleichert, et al UrQMD, Transport



But perfect fluid elliptic flow was not

Kolb, Heinz: Euler Hydrodynamics

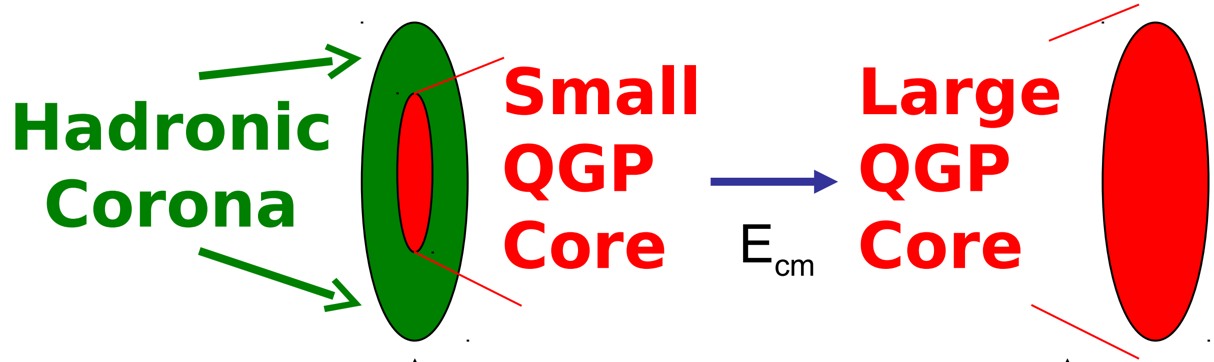


Measure of density dN_{ch}/dyd^2x

Ordinary nuclear matter and hadron resonance matter is
an imperfect viscous fluid with large deviation from perfect fluidity
while the sQGP appears to be nearly perfect

At lower energies Perfect Fluid Core was Obscured by the highly dissipative Hadron Resonance Corona

Kolb, Heinz
Bass, Dumitru,…
Teaney, Shuryak
Hirano, Nara



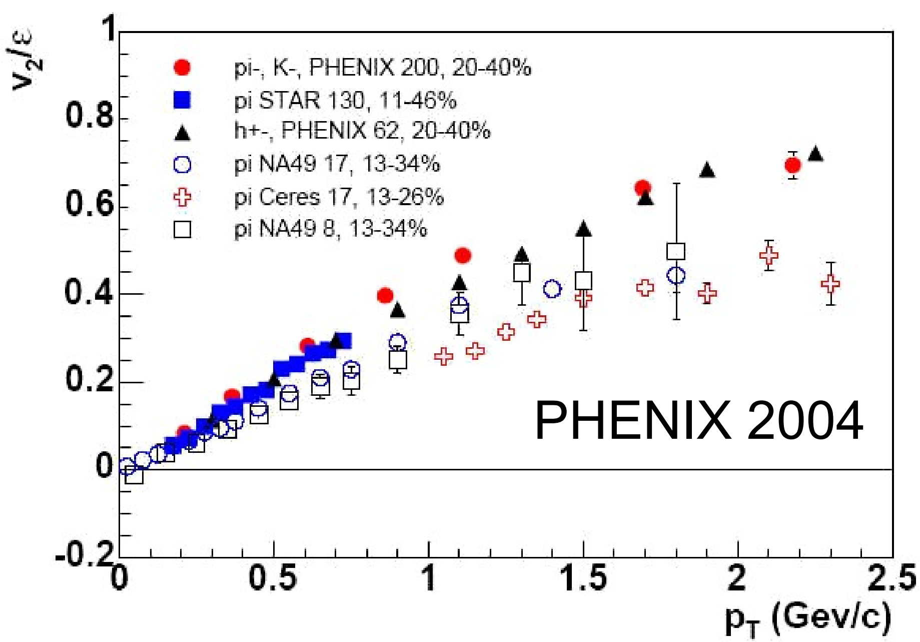


FIG. 16: $v_2(p_T)/\varepsilon$ versus p_T for mid-central collisions at RHIC (filled symbols) and SPS (open symbols). Dividing by eccentricity removes to first order the effect of different centrality selections across the experiments.

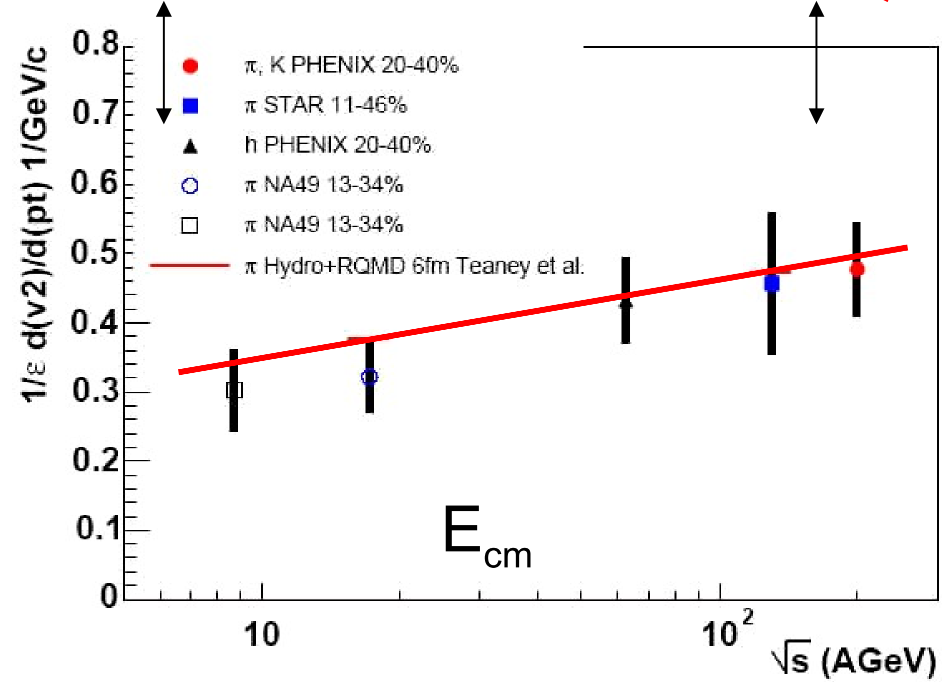


FIG. 17: The slope of the scaled elliptic flow, $(dv_2/dp_T)/\varepsilon$, for mid-central collisions at RHIC (filled symbols) and the SPS (open symbols). The slope is calculated for the data $p_T < 1$ … lid error bars are the systematic errors that … ematic error on v_2 and ε.

This was the critical SPS Null control SPS data that Larry and I emphasized in 2004 RBRC report

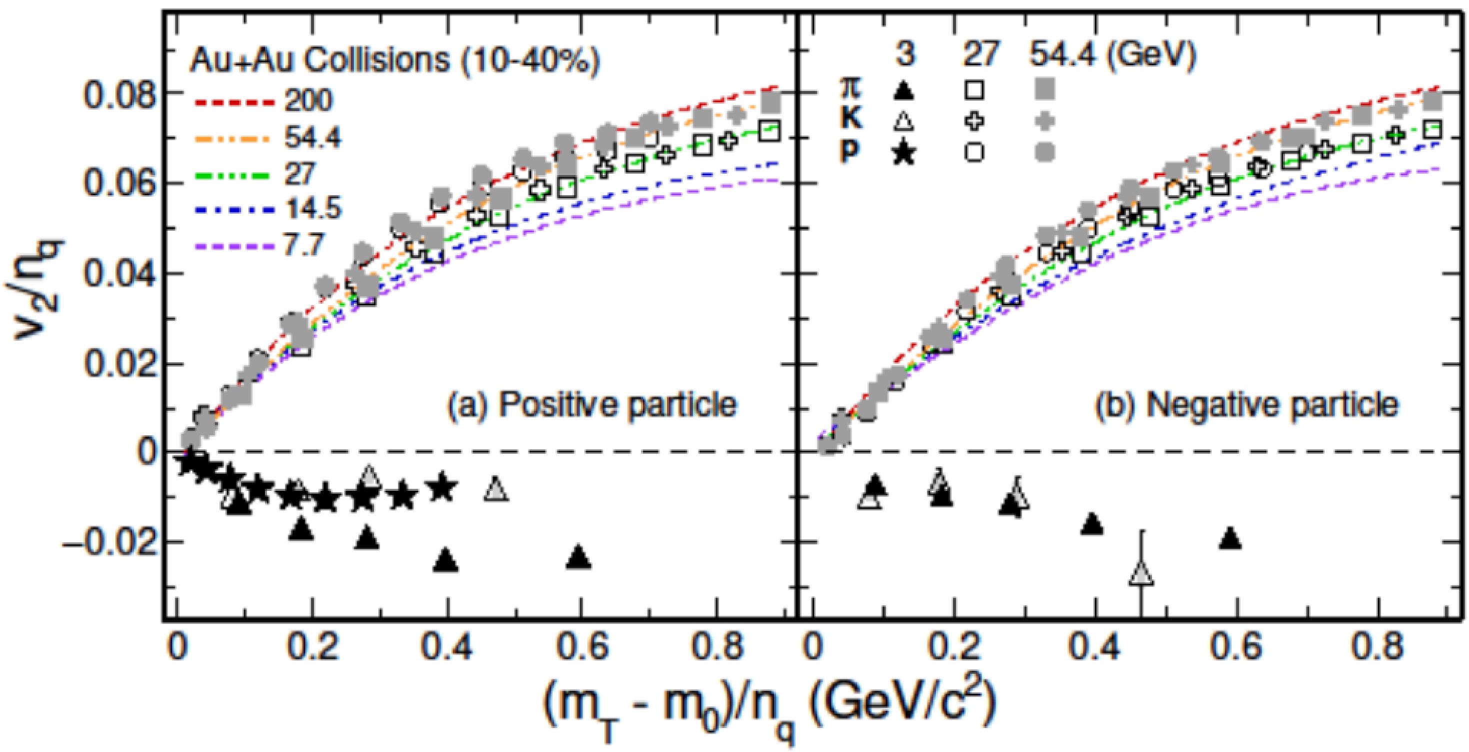
Daniel Cebra 6/9/2022 RHIC-AGS Annual Users Meeting

Does 2022 BES challenge to the *uniqueness* of Flow signatures of sQGP ??

Disappearance of partonic collectivity in 3 GeV Au+Au collisions at RHIC

Submitted Nov. 24, 2021 , Published Mar. 10, 2022, Phys. Lett. B **827** (2022) 137003

- Elliptic flow is negative (squeeze-out) at 3 GeV, as expected from the previous AGS data.
- The quark number scaling (n_q) has been used at higher energies as a signature of the QGP. At 3 Gev, the scaling has broken down ➔ hadronic gas (not QGP).
- First midrapdity pion and kaon results.



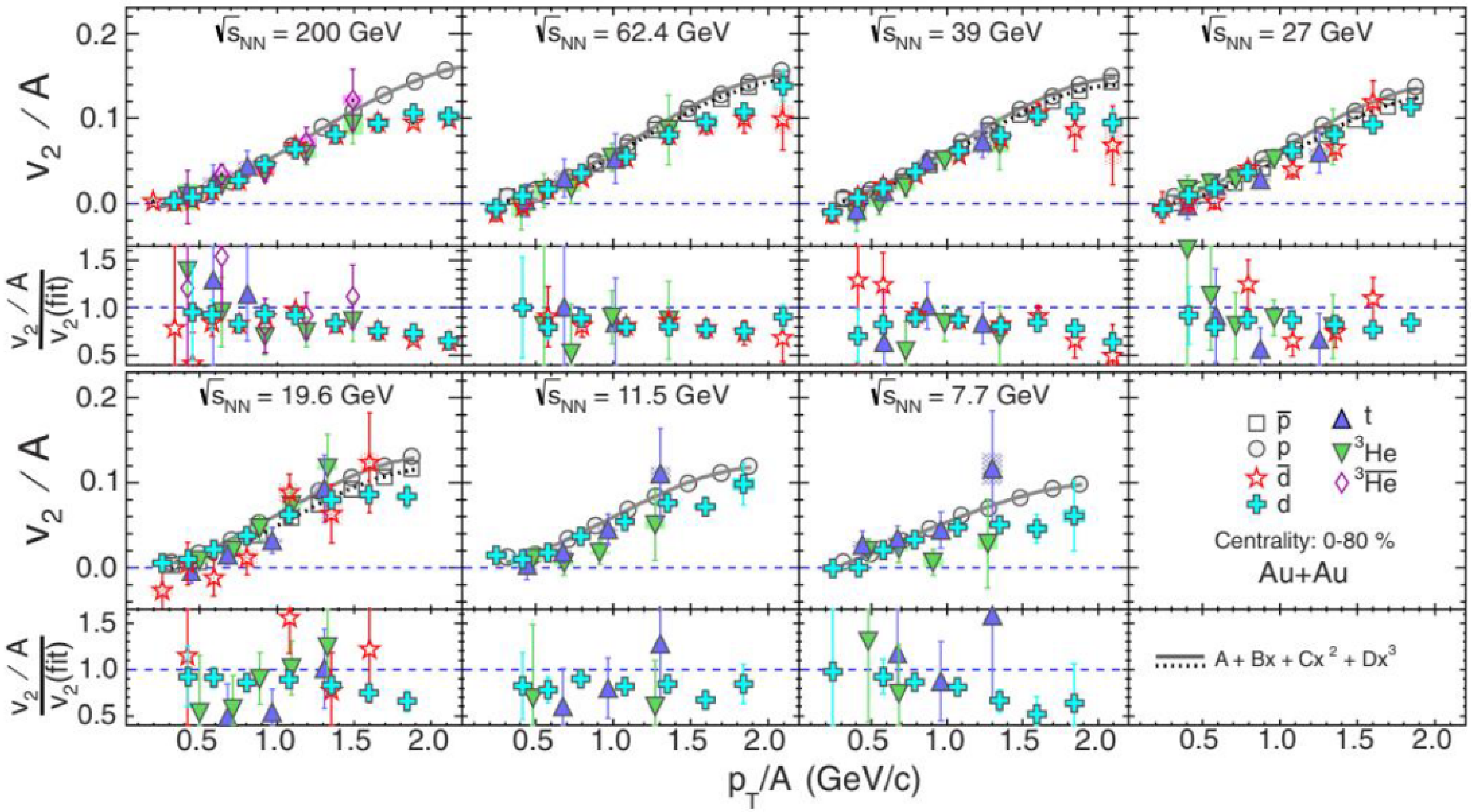
Is there an inconsistency between old SPS data and current BES RHIC data?

Universality of Berndt's constituent quark scaling down to Bevalac ????

Does 2022 BES a challenge to the ***uniqueness*** of Flow signatures of sQGP ??

Light Nuclei v_2 from BES-I

Physics Review C 94, 034908 (2016)



For $\sqrt{s_{NN}}$>7.7 GeV, the light nucleus v_2 follow A scaling of at low p_T.
→ coalescence production

Is there any room left for an ONSET of the sQGP perfect fluid core ???

Creation of quark–gluon plasma droplets with three distinct geometries
But near identical v2(pT) and v3(pT) "flow" !

PHENIX Collab, Nature Physics | VOL 15 | MARCH 2019 | 214–220 |

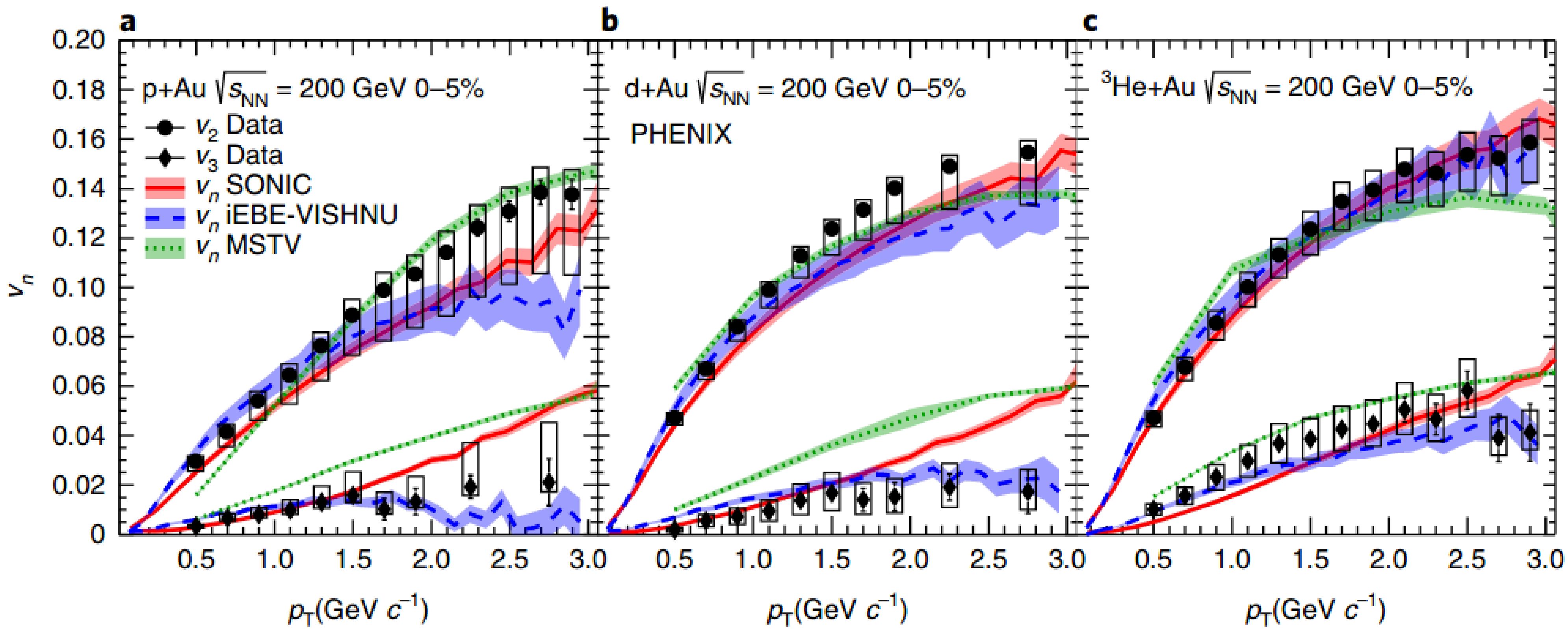


Fig. 3 | Measured $v_n(p_T)$ in three collision systems compared with models. a, Measured $v_n(p_T)$ in the 0–5% most central p+Au collisions compared with models. **b**, Measured $v_n(p_T)$ in the 0–5% most central d+Au collisions compared with models. **c**, Measured $v_n(p_T)$ in the 0–5% most central ^{3}He+Au compared with models. Each point in **a**–**c** represents an average over p_T bins of width 0.2 GeV c^{-1} to 0.5 GeV c^{-1}; black circles are $v_2(p_T)$, black diamonds are $v_3(p_T)$. The vertical lines (boxes) represent one standard deviation statistical (systematic) uncertainties. The solid red (dashed blue) curves represent

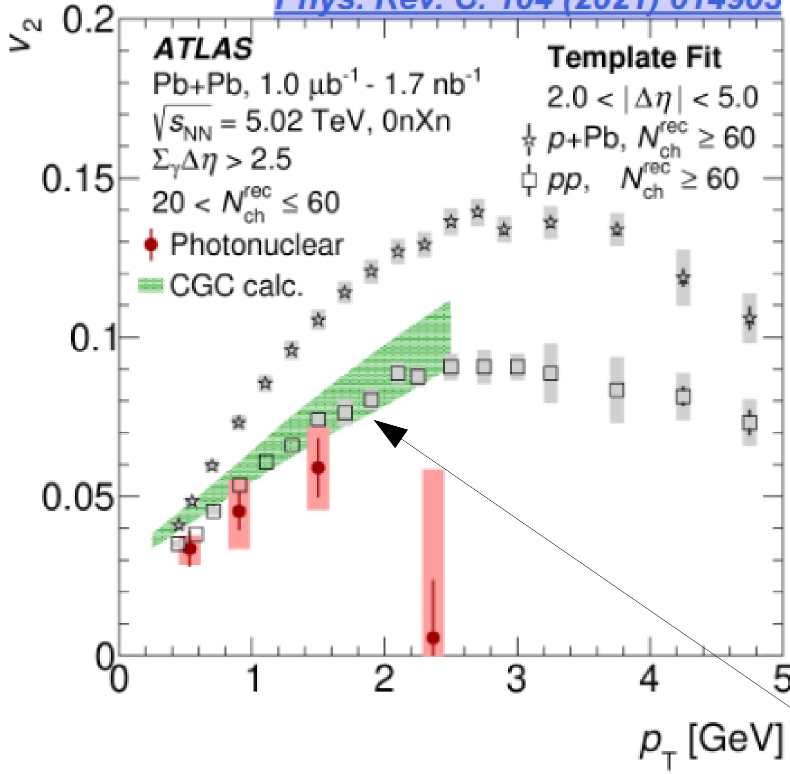
MG: Puzzling weakdependence of vn system size in pp, pA, DA, HeA … PbPb and beam energy

A >> 1 flow "signatures" cannot be turned off with A → 1 ???

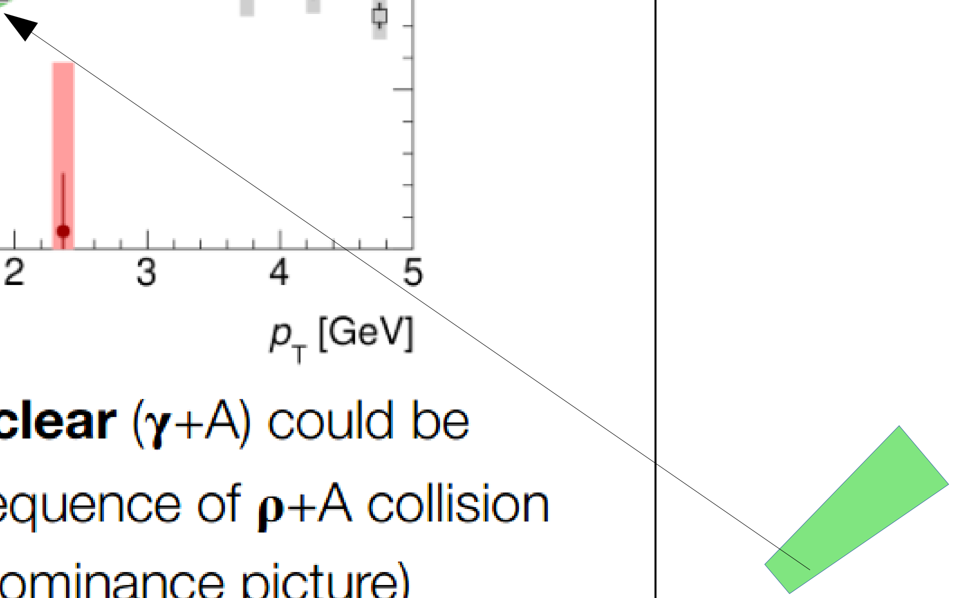
Will even eRIC e+p "flow" ???

Flow in photo-nuclear events (system event smaller than pp)

Phys. Rev. C. 104 (2021) 014903



Flow in photo-nuclear (γ+A) could be understood as a consequence of ρ+A collision (Vector Meson Dominance picture)

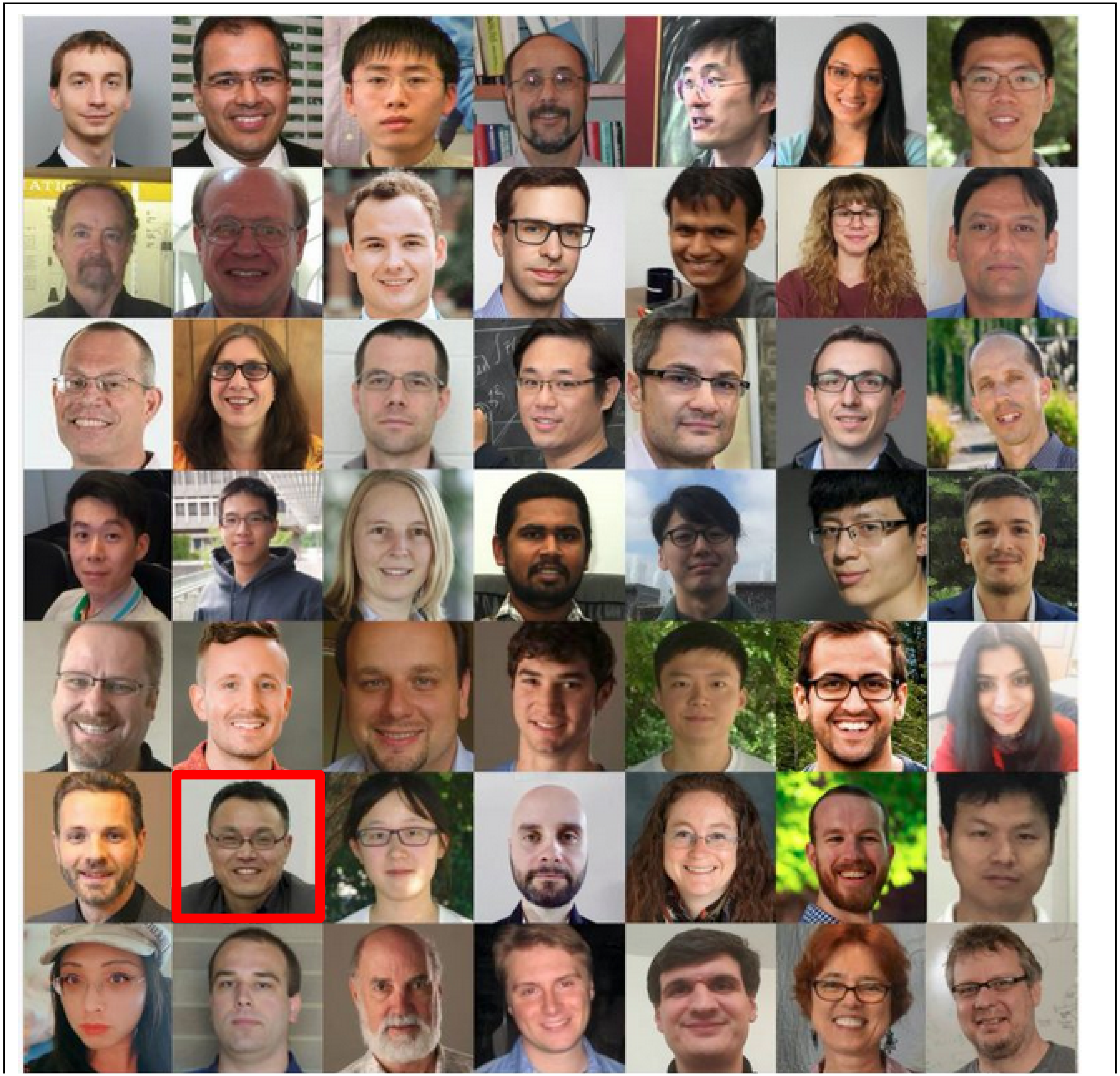


CGC calc ?

Y. Shi, L Wang, SY Wei, BW Xiao, and L. Zheng, **Collective phenomena at the EIC**, PRD103, 054017 (2021)

Why is there is **No Null Control** OFF switch for vn(pT) observables?

The JETSCAPE choir sings “Happy Bday to You, Happy Bday 2 U Dear XN@60 ...”



We all wish Xin Nian a happy birthday and wish you continued great physics into the far furure