Plenary Session XII: Summaries - **Qing-Chuan Hall (16:00-17:50)**

-Conveners: Andreas Morsch

time	[id] title	presenter
16:00	[247] Experimental Summary (30 minutes)	CAINES, Helen
16:30	[248] Theory summary (30 minutes)	JEON, Sangyong
17:00	[249] What are missing? (30 minutes)	GYULASSY, Miklos
17:30	[250] Closing (20 minutes)	

Miklos Gyulassy

Nuclear Science Division, Lawrence Berkeley National Laboratory, Berkeley, CA 94720, USA
Pupin Lab MS-5202, Department of Physics, Columbia University, New York, NY 10027, USA and
Institute of Particle Physics, Central China Normal University, Wuhan, China

MTA Wigner Research Centre for Physics, RMI, Budapest, Hungary

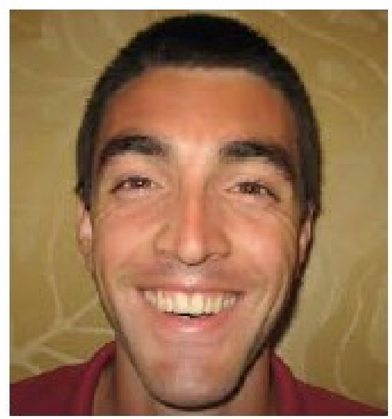
Special thanks to many talented young collaborators

Jiechen Xu

Jinfeng Liao

Jorge Noronha

Jaki Noronha-Hostler



Alessandro Buzzatti

Andrej Ficnar

Barbara Betz

And to many senior collaborators X.N.Wang, I.Vitev, P.Levai, T. Biro, G.Papp, G. Barnafoldi, ...

I asked my guru, “What Are Missing ? At the end of HP16”

What Does the Future Hold for Hard Probes?

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What Does the Future Hold for Hard Probes?

He said:

“The Past is easier to Postdict. Predictions for Hard Probes are harder”

What Is/Are Missing at end of HP16 ? **The answers to many open questions such as**

[My HP16 guesses]

Which future data could best discriminate between competing A+A models ? **[SHEE]**

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Can we devise effective microscopic dynamical models that can interpolate between long wavelength "perfect fluidity" (large qhat near Tc) and short wavelength high pT perturbative QCD (small qhat at high pT) ? **[? sQGDP Semi-Quark-Gluon-Dion-Pasmas]**

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$P(T)$, $S(T)$, $\eta/s(T)$, $\xi/s(T)$, $m_E(T)$, $m_M(T)$, $\alpha(r,T)$, $L(T)$, $\chi(T)$?

Thermodynamics — **Chromo eletric and magnetic dynamics**

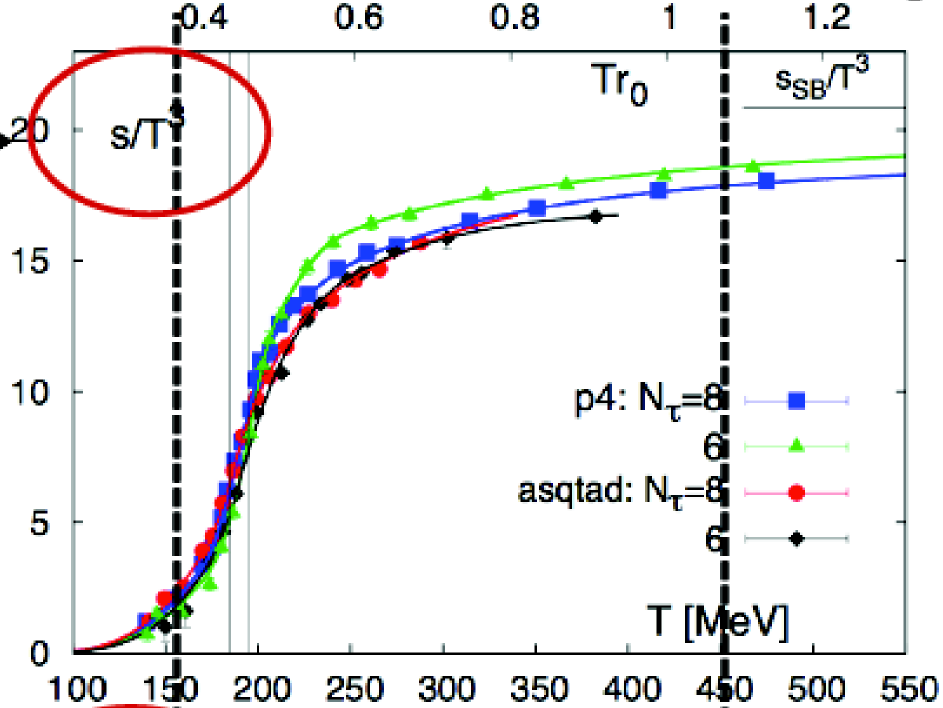
Soft Probes — **Hard Probes**

[so far only η/s with soft vn(pT<2), maybe $\alpha(r,T)$ with RAA&vn(pT>10)]

The nonperturbative medium near T_c from lattice

Thermal

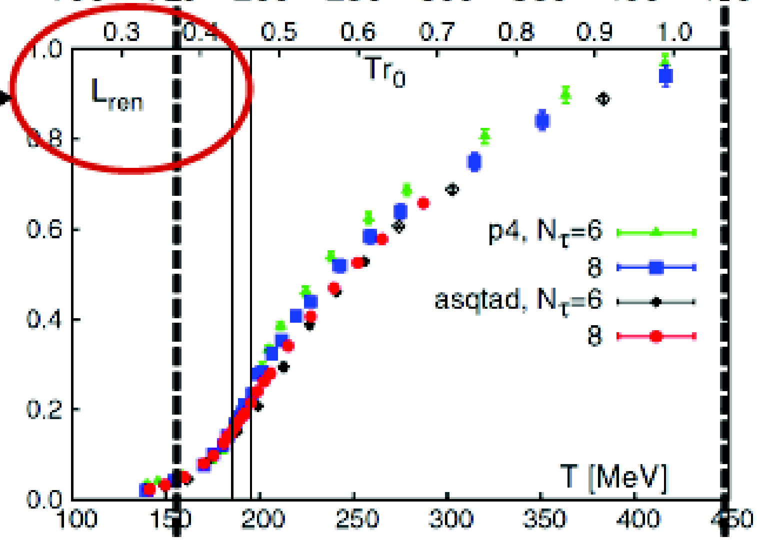
Local
Thermo-***statics***
Equation of State
Entropy density s(T)



HotQCD Lattice
F.Karsh et al

Chromo

Measure
Of free energy
Of heavy quark



Bazavov et al PRD 2009

$$L(\mathbf{x}) = \frac{1}{N_c} \mathrm{tr}\mathcal{P}\exp\left[ig\int_0^{1/T} A_4(\tau,\mathbf{x})d\tau\right]$$

$$\langle L \rangle \propto e^{-F_Q/T}$$

$$\langle L \rangle \begin{cases} = 0, & \text{confined } (T < T_c) \\ \neq 0, & \text{deconfined } (T > T_c) \end{cases}$$

- What would be a lattice compatible, microscopic description of the near Tc matter?
  - Does this help reconciling the “soft” vs “hard” transport inconsistency?

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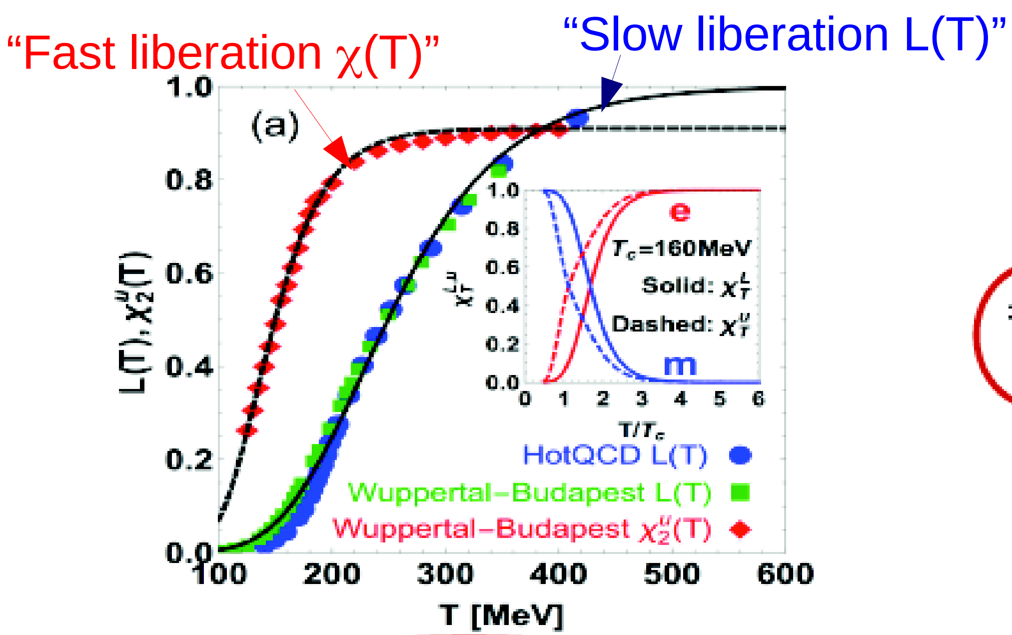
What can A+A teach us about *THE* unsolved HARD problem since 1974 about the mechanisms in QCD that confine all color electric and magnetic degrees of freedom T<Tc ? [We need to keep trying to develop new Soft+Hard tools. Soft-Hard correlations over pT and y are most powerful tool at hand.]

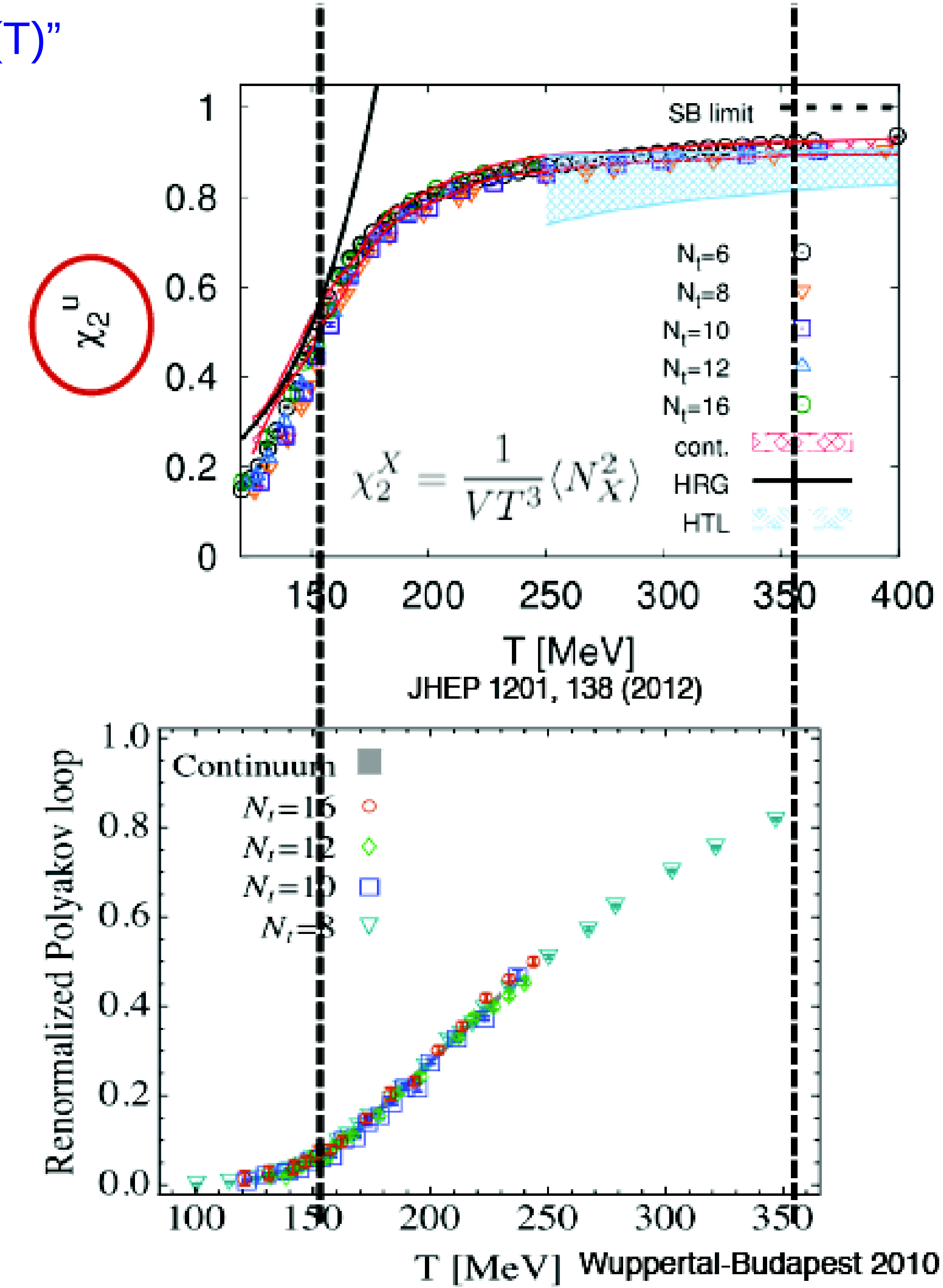
Deconfinement: Quark number susceptibility vs Polyakov loop



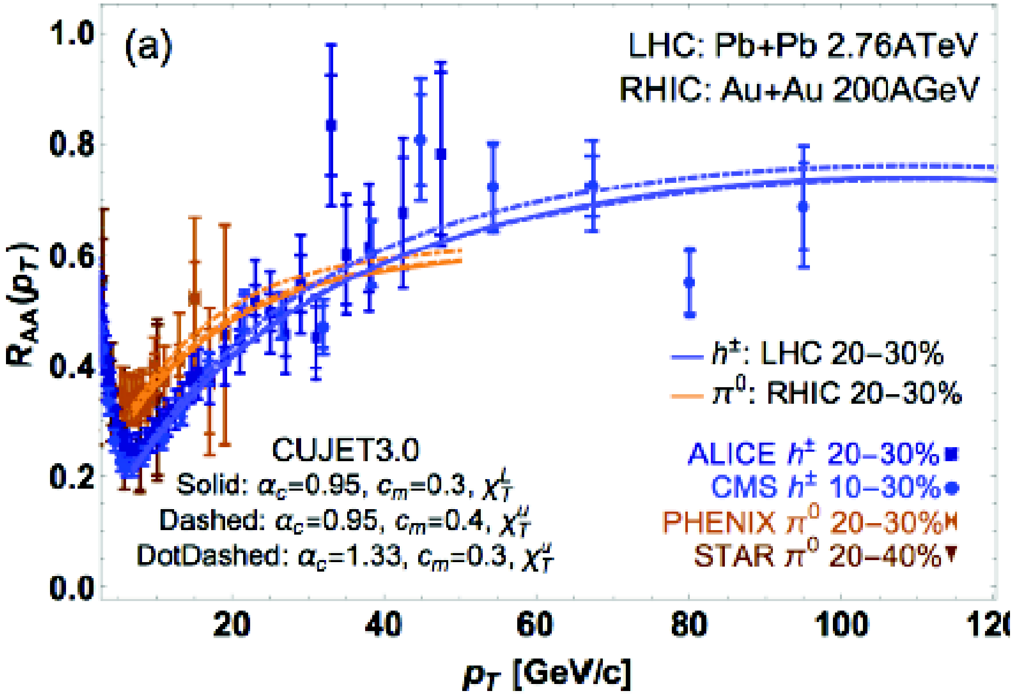
$$\chi_T(T) = c_q\, L(T) + c_g\, L^2(T)$$
$$\chi_T^u = c_q\, \tilde{\chi}_2^u + c_g\, L^2$$

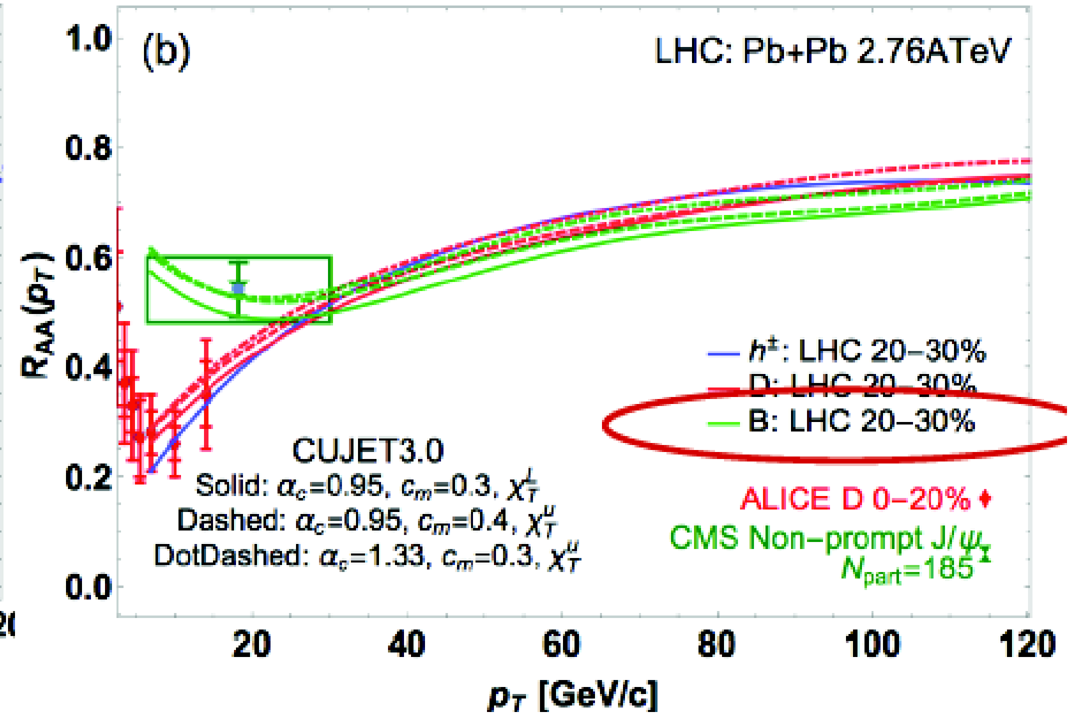
JX, Liao, Gyulassy, arXiv:1508.00552

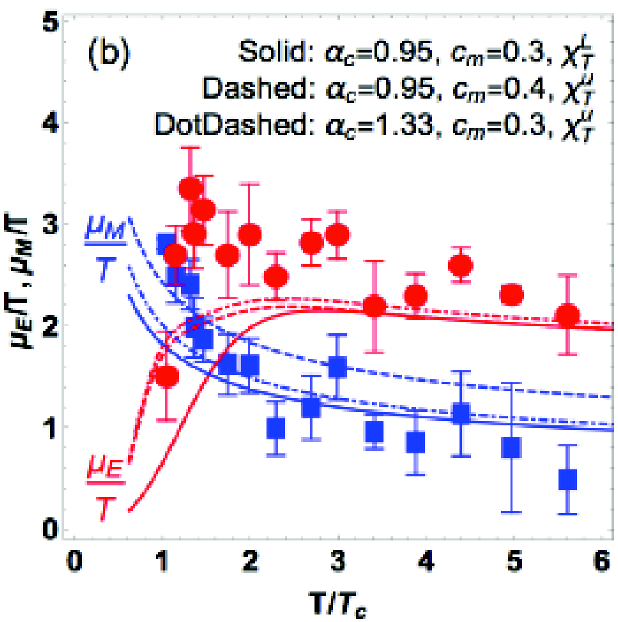
- Quark DOFs are dynamic and almost massless rather than static and massive
- Use normalized quark number susceptibility instead of Polyakov loop for the deconfinement rate of quarks near T_c



Light hadron and open heavy flavor R_{AA} with "fast deconfinement"







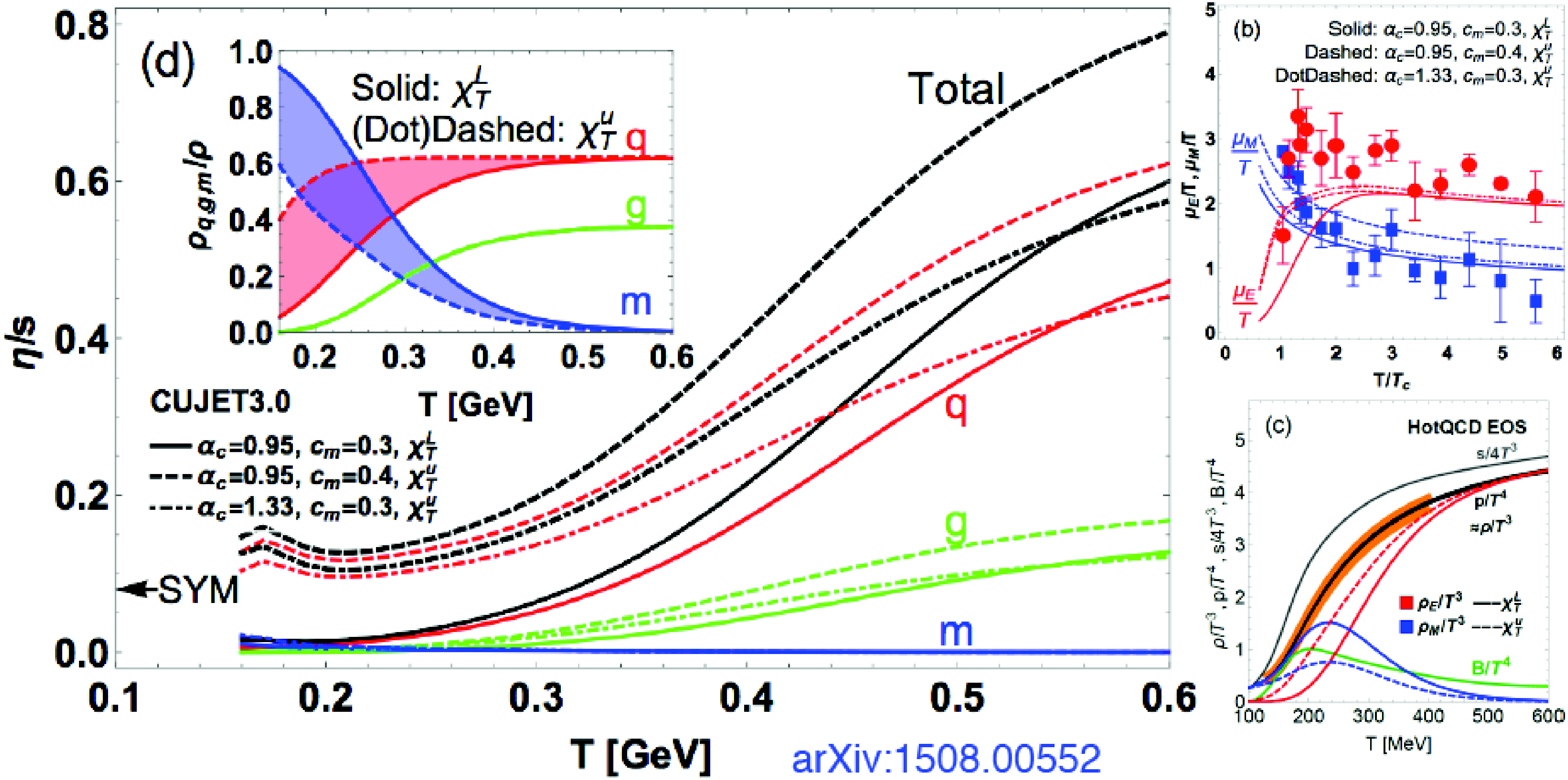
JX, Liao, Gyulassy, arXiv:1508.00552

- ❖ The parameter is adjusted to fit to LHC charged hadron R_{AA} at p_T=12.5GeV
- ❖ The beauty R_{AA} distinguishes the different liberation schemes
- ❖ The combination of light hadron and open heavy flavor R_{AA} may be used as a measure of deconfinement

CUJET3 = smooth GL IC X VISH2+1 X sQGMP dE/dx

The shear viscosity with "fast deconfinement"

Compared to "slow deconfinement"



arXiv:1508.00552

- The shear viscosity minimum is sensitive to how rapidly quark DOFs are deconfined
- The slope of η/s(T) is affected mainly by the temperature dependence of E and M screening masses

Fast Confinement sQGMP does not violate KSS bound below T<300

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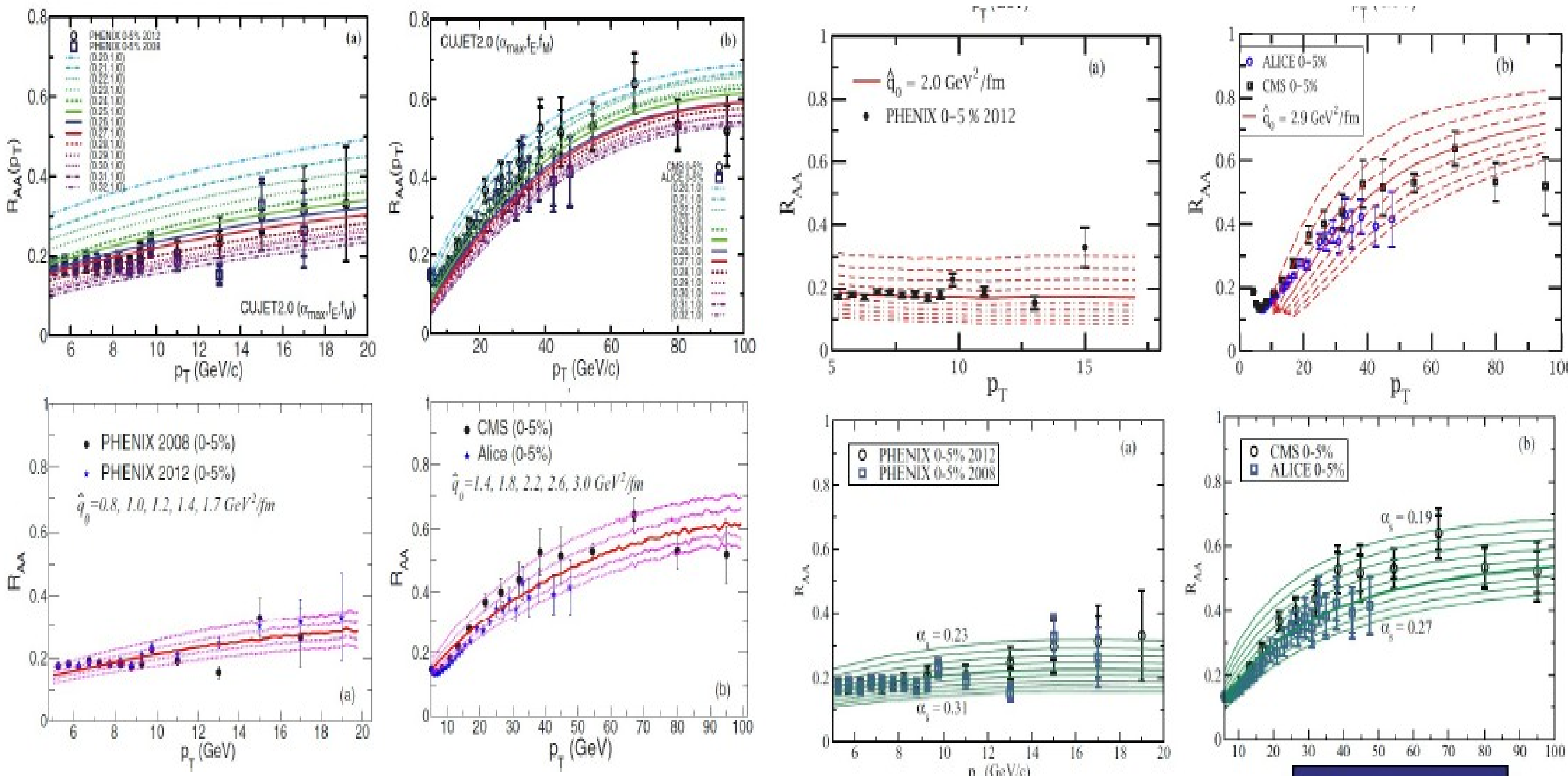
Can the huge volume of the space of 3+1D A+A models 3D IC ⊗ vHydro 3+1D ⊗ dE/dx(E,T) be constrained to reduce the ambiguities & nonuniqueness of current data interpretations?
[Yes, many models falsified at HP16; Many more will vanish in the course of SHEE pp,pA,AA]

JET collaboration : 5 pQCD based quenching models fit RAA*(RHIC+LHC) well but
All failed to get high pT jet elliptic anisotropy v2(pT>10 GeV) without extra parameters



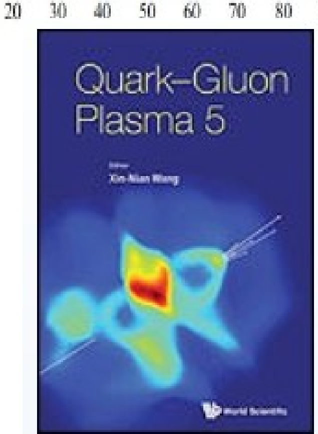
arXiv:1511.00790 [pdf, other]

Jet quenching in high-energy heavy-ion collisions

Guang-You Qin, Xin-Nian Wang

Comments: review for QGP5, 68 pages, 34 figures

March 2016
$161



Before HP16 CUJET3 and Majumder's HT extentions of HTL dEdx could
Post-dict hard RAA & v2 . At HP16 J.Noronha-Hostler et al solved v2 puzzle within HTL!

What solved the puzzle?

With Event-by-Event 2+1D viscous hydro + dEdx~LT ^{3} Soft-Hard Correlation ***predictions***

- Used the scalar product (like the experiment)

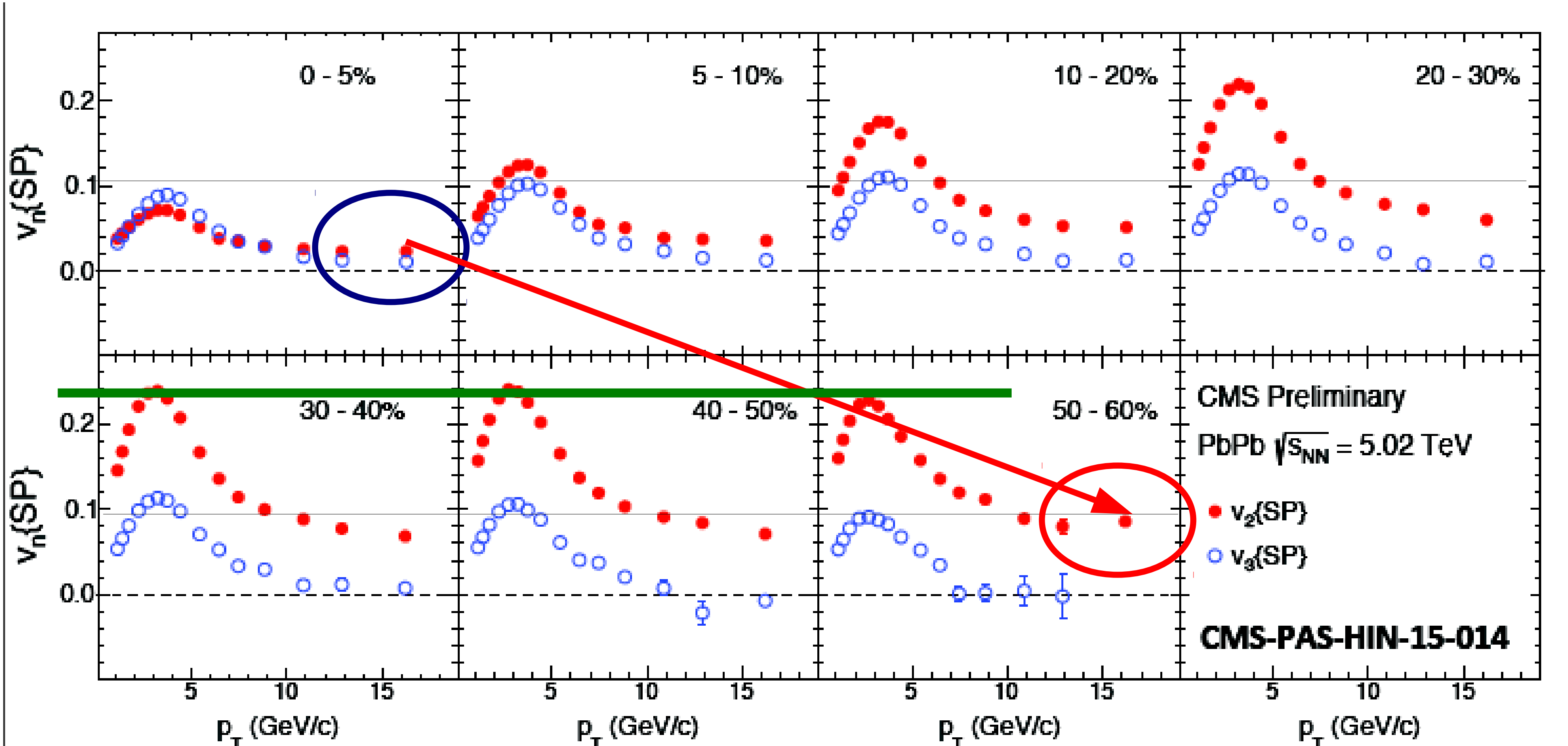
$$v_n\{2\}(p_T) = \frac{\langle v_n^{soft}\, v_n^{hard}(p_T)\cos\left(n\left[\psi_n^{soft} - \psi_n^{hard}(p_T)\right]\right)\rangle}{\sqrt{\left\langle \left(v_n^{soft}\right)^2 \right\rangle}}$$

- For smooth backgrounds $v_2\{2\}(p_T) \to v_2^{hard}(p_T)$, Was not what was measured!!
- Initial geometry strongly affects $v_n\{2\}(p_T)$ pT>10 GeV MCGlauber≠MCKLN
- **Predictions needed to confirm across energies**

(Consistency RHIC&LHC , light and heavy, and with Event Class Engineering)

New 5ATeV PbPb data presented at HP16

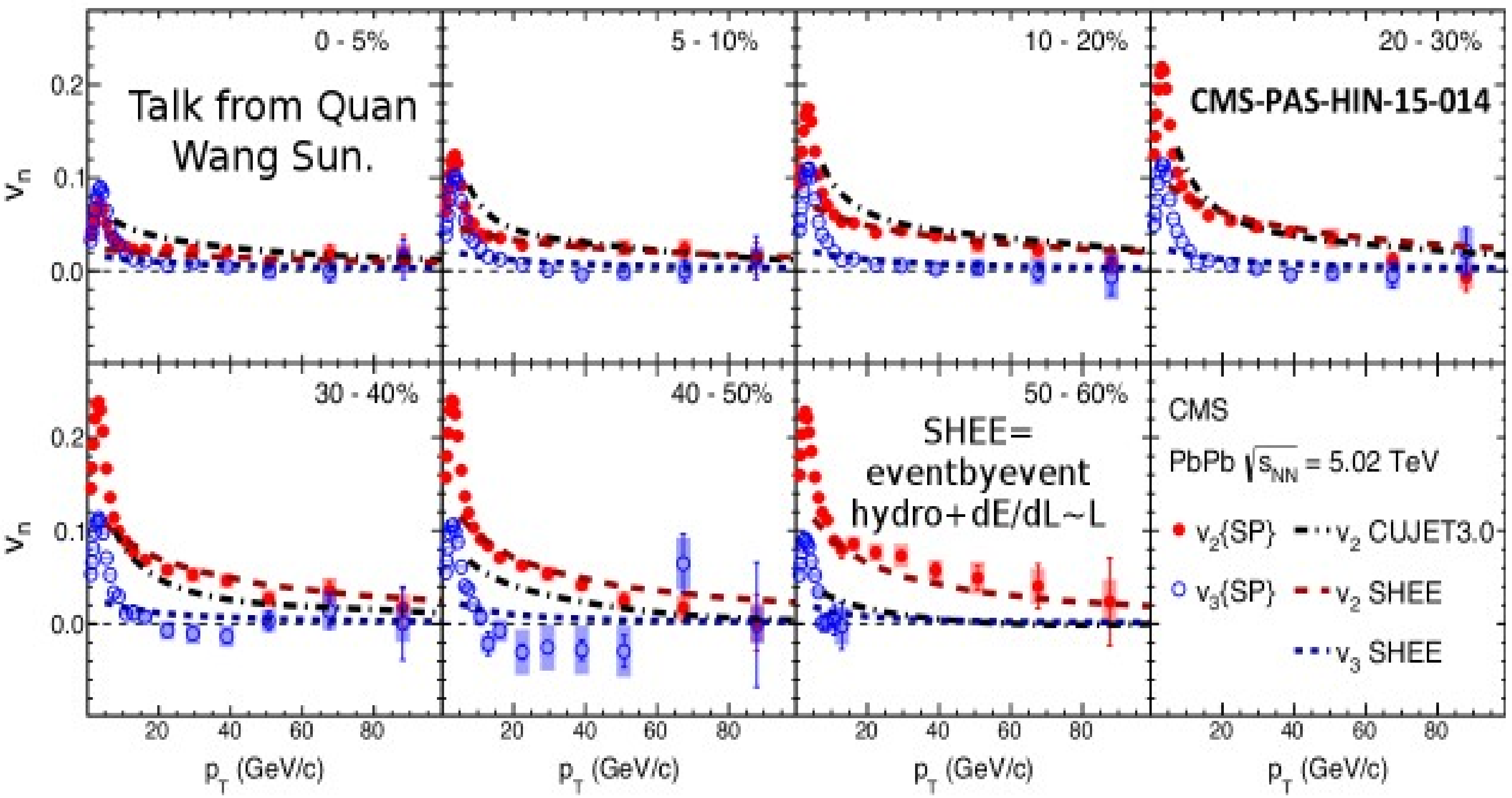
In overlap region 0< pT< 25 GeV with ATLAS (see K.Burka), CMS and ATLAS agree well



Hard v2(~15GeV) continues to grow with impact parameter out to 75% centrality

While Soft v2(pT<3) ~ 0.22 saturates with centrality above 20% centrality !

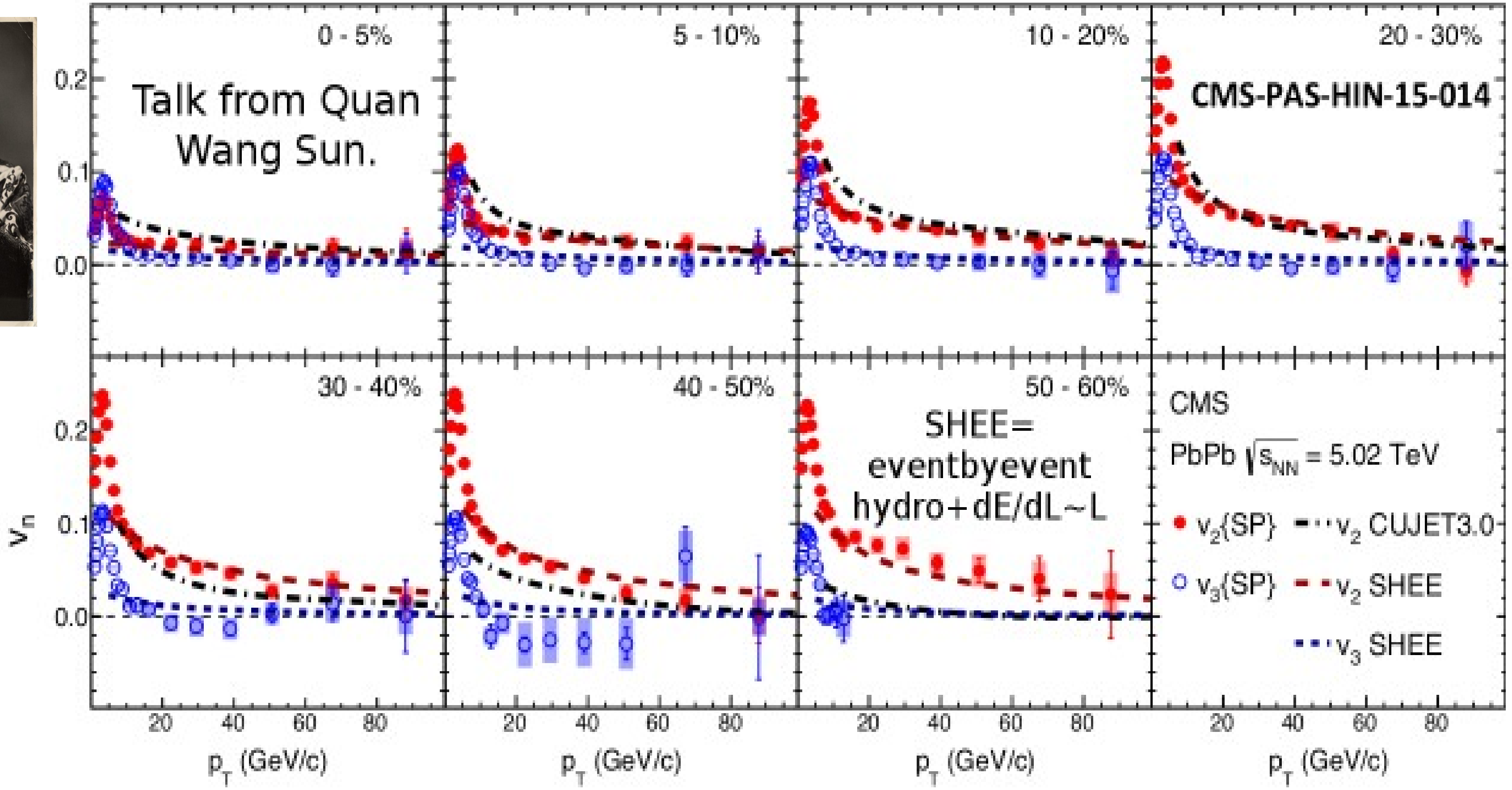
New CMS data at HP16 on centrality dependence of vn(pT) out to 100 GeV
Confirmed ebe-vHydro+dEdx J.Norohna-Hostler_etal PRL(2016) ***predictions,***
and falsified event ave IC CUJET3 ***predictions*** at large impact parameters



- Predictions (SHEE) match data well with $dE/dL \sim L$
- Remaining question: why is v_3 SMALL at high p_T?
- η/s effects very small (not shown, see Betz et al, arXiv:1609.05171)

New CMS data at HP16 on centrality dependence of vnhard out to 100 GeV
Confirmed (ebe-vHydro+dEdx) J.Norohna-Hostler ***predictions,***

(but my guru warned me, beware of future “improved” post-dictions)



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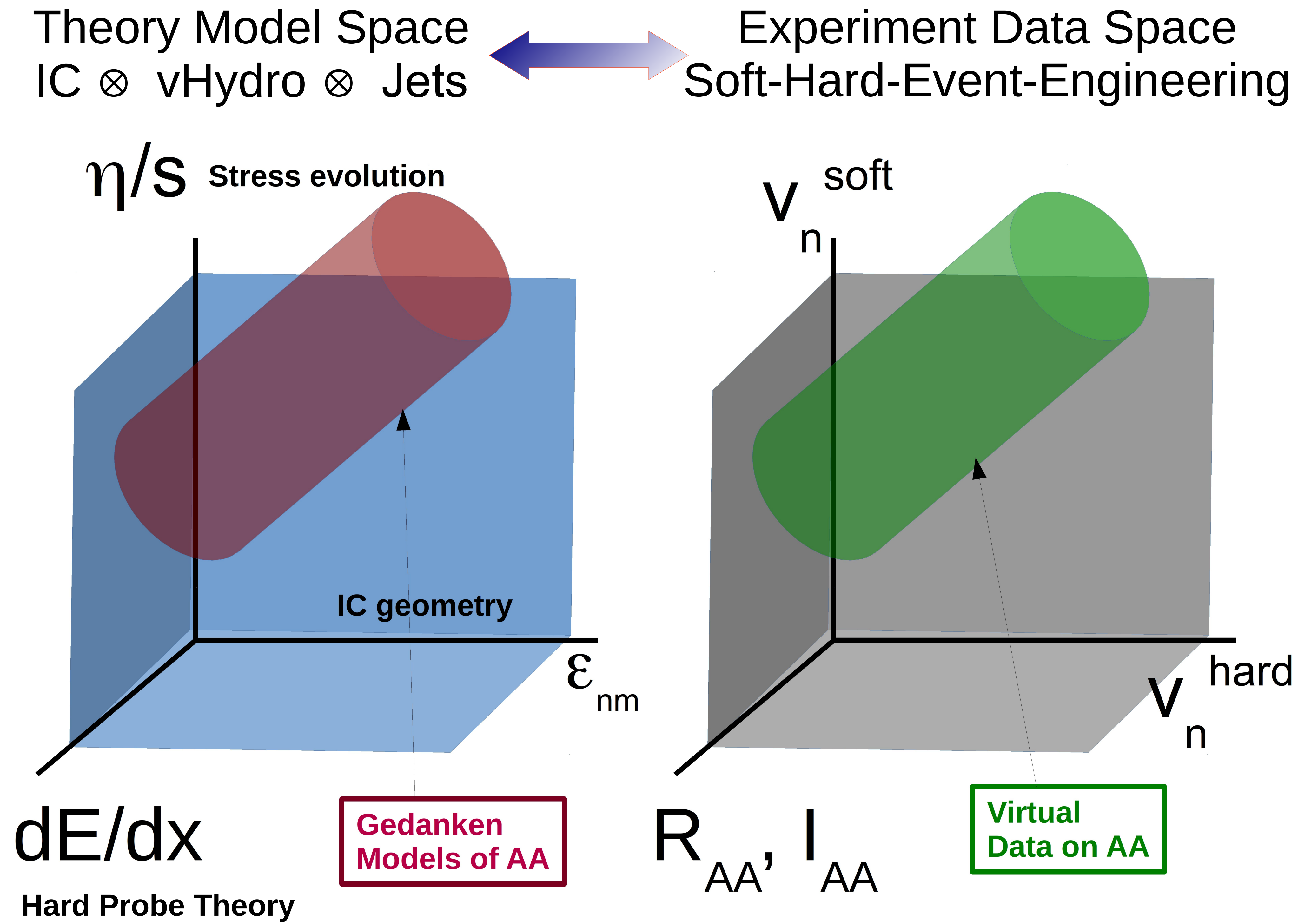
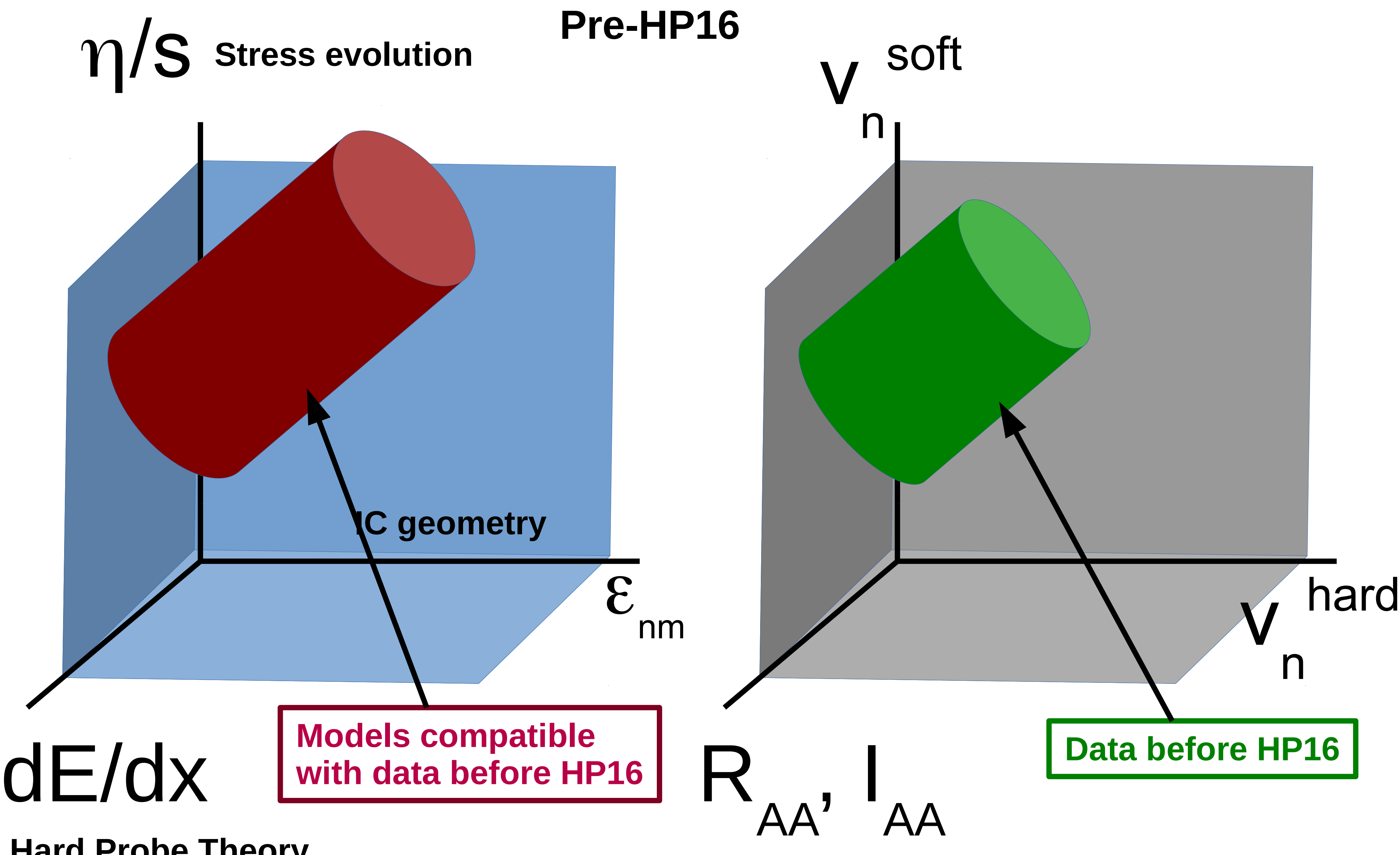

Theory Model Space
IC ⊗ vHydro ⊗ Jets
Experiment Data Space
Soft-Hard-Event-Engineering
η/s
Stress evolution
IC geometry
ε nm
dE/dx
Hard Probe Theory
Gedanken
Models of AA
v n soft
v n hard
R AA, I AA
Virtual
Data on AA

Theory Model Space ⟷ Experiment Data Space

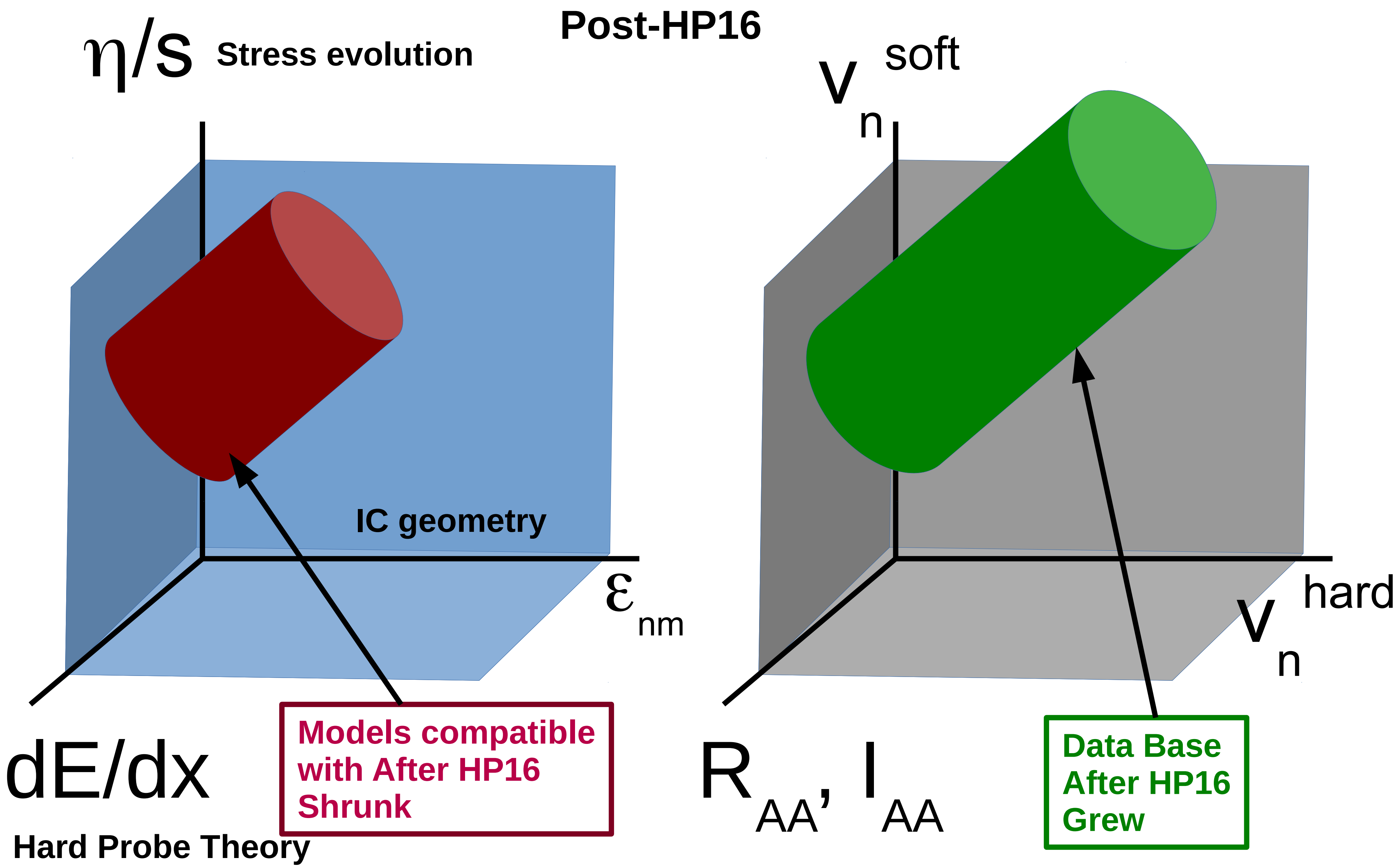
IC ⊗ vHydro ⊗ Jets ⟷ Soft-Hard-Event-Engineering



Before HP16 Vol(Theory) > Vol(Data)

Theory Model Space
IC ⊗ vHydro ⊗ Jets

Experiment Data Space
Soft-Hard-Event-Engineering



After HP16 Vol(Theory) < Vol(Data)

Complications of **Volumetric Jet Tomography** of A+A

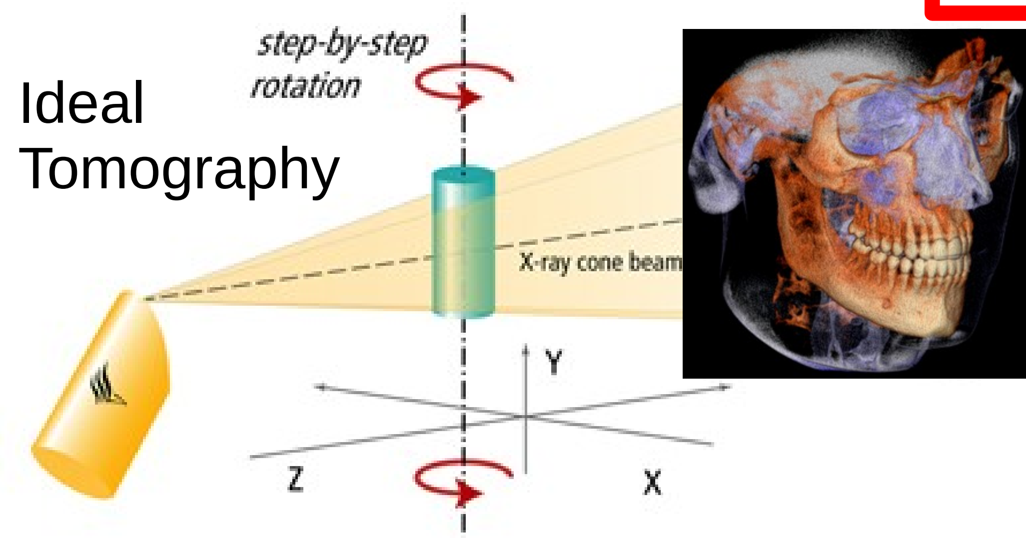
√ 1) Well known initial flux of ***penetrating probes*** — **OK, via pQCD and p+p**

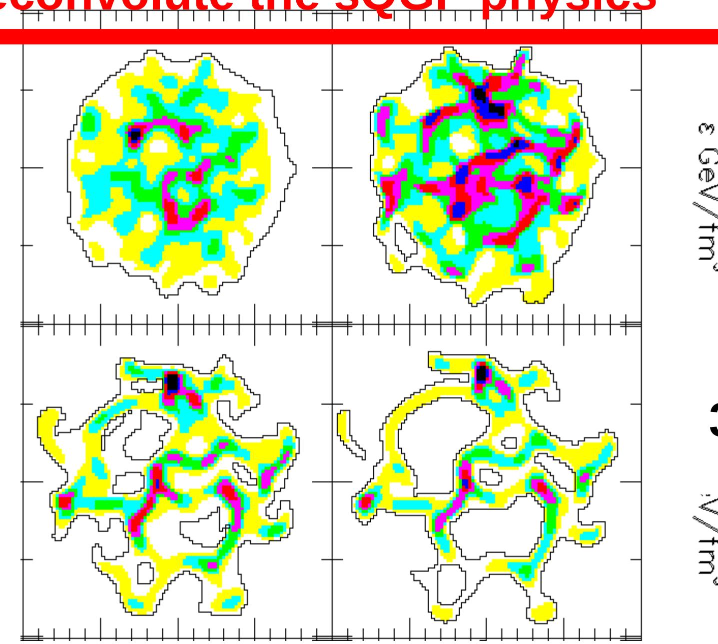
? 2) Theory of ***density dependent energy loss*** — **BDMS, DGLV,HT,AMY CUJET, AdS/BH, SLTc, ...**

X 3) **Cooperative, Static Patient**

NO! **we must simultaneously develop theory of dEdx AND Initial Conditions AND Viscous evolution AND hadronization to deconvolute the sQGP physics**

Ideal Tomography





Actual A+A case

"Turbulent Inhomo 3+1DFluid"

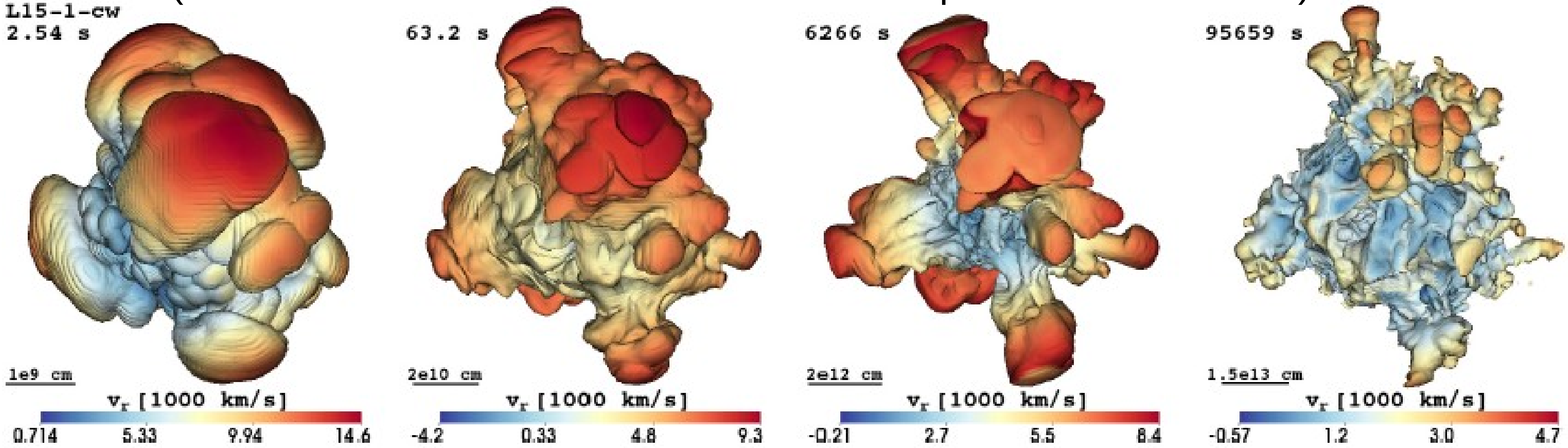
(HIJING+Hydro (1997) Rischke,Zhang, MG)

Nuclear modification of Jet quenching in A+A *cannot be understood* without Simultaneous understanding of fluctuations of Hard AND Soft probe physics

Soft-Hard-Event-Engineering is a powerful tool to unfold Fluctuating Hard from Fluctuating Soft Physics (J.NoronhaHostler et al, PRL 2016)

Analogous need for full 3+1D Multi Component theory of 3+1D Core Collapse Supernova

(General rel. + nuclear chem + neutrino transport + 3D instabilities)



A. Wongwathanarat et al.: 3D CCSN simulations A&A 577, A48 (2015)

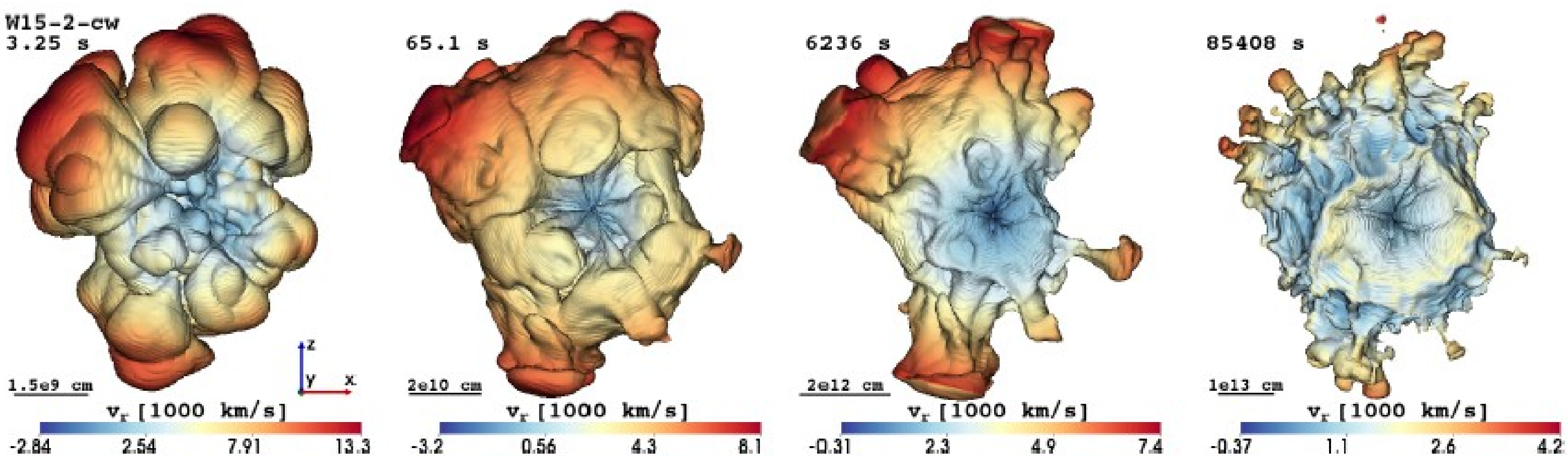


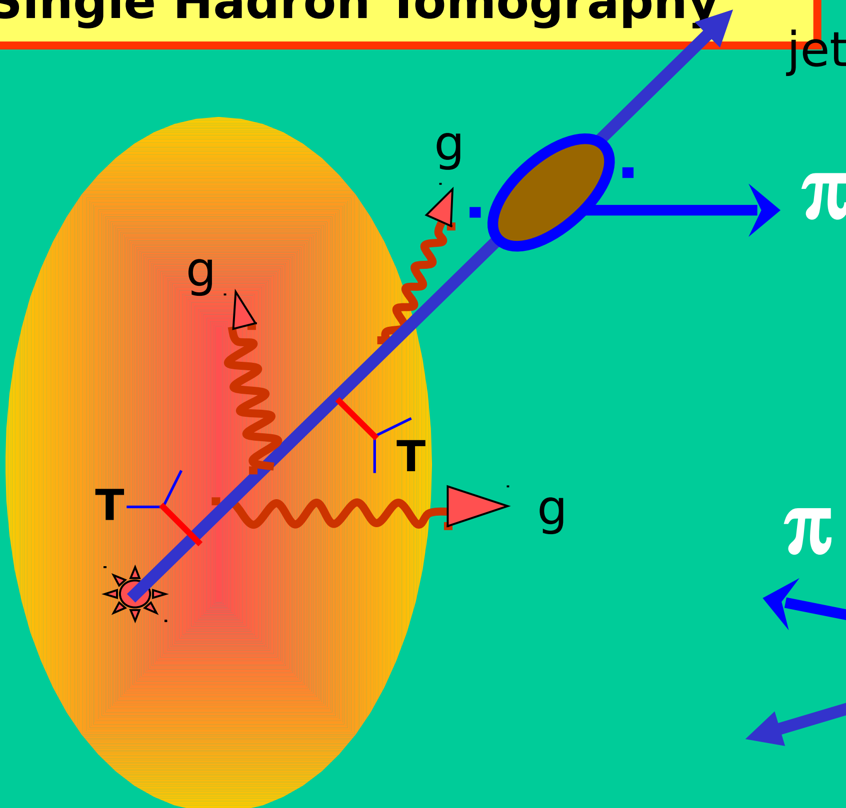
Fig. 7. Snapshots displaying isosurfaces where the mass fraction of ^{56}Ni plus n-rich tracer X equals 3% for model W15-2-cw (*top row*), L15-1-cw (*second row*), N20-4-cw (*third row*), and B15-1-pw (*bottom row*). The isosurfaces, which roughly coincide with the outermost edge of the neutrino-heated ejecta, are shown at four different epochs starting from shortly before the SN shock crosses the C+O/He composition interface in the progenitor star until the shock breakout time. The colors give the radial velocity (in units of km s^{-1}) on the isosurface, with the color coding

Ideal Elliptic Jet Quenching and Tomography

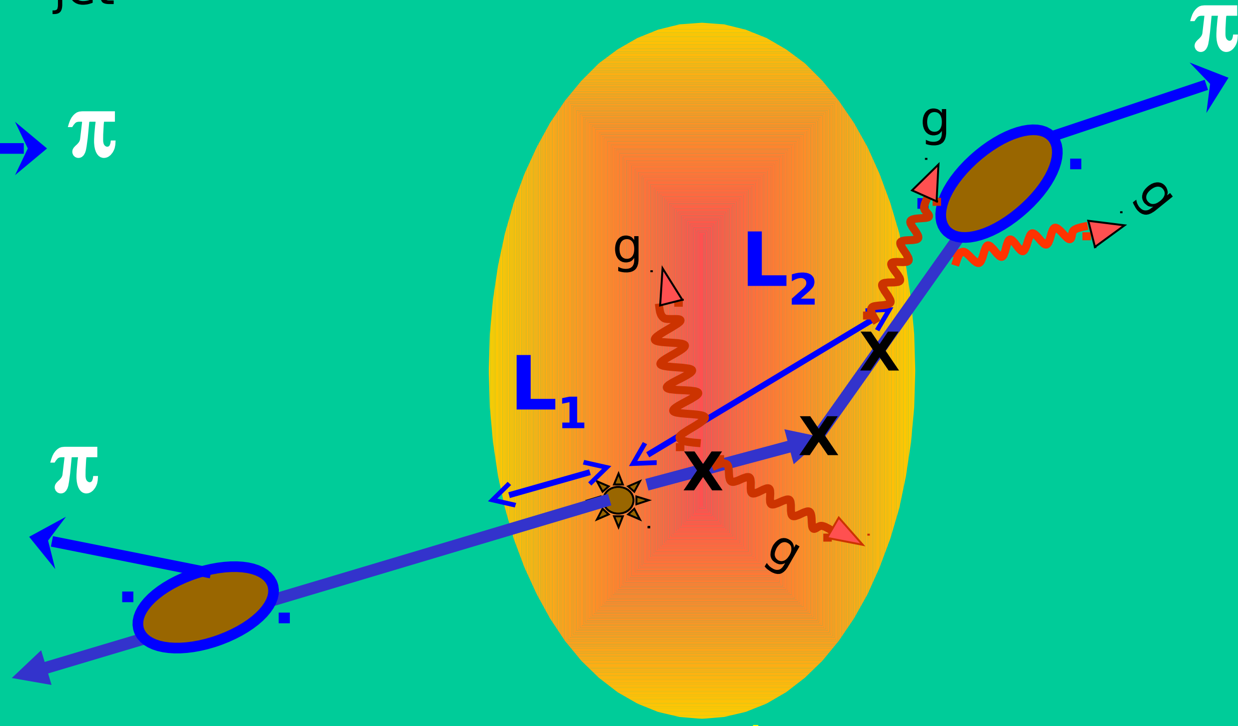
Ivan Vitev, Peter Levai, Xin-Nian Wang, MG

Review in nucl-th/0302077

Single Hadron Tomography



Di-Hadron Tomography



$$L(f)\quad \frac{1}{pR^2}\frac{dN}{dy}$$

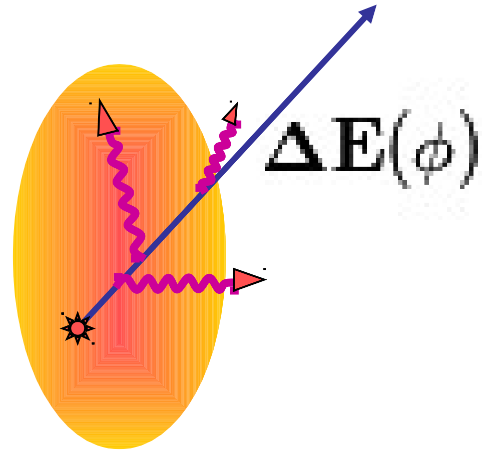
$$\Delta E_{GLV} : C_{Jet} C_T \alpha_s^3 \; \ln\frac{p_T}{\mu^2 L} \int d\tau\, \tau\, \rho\big(\tau, r(\tau)\big)$$

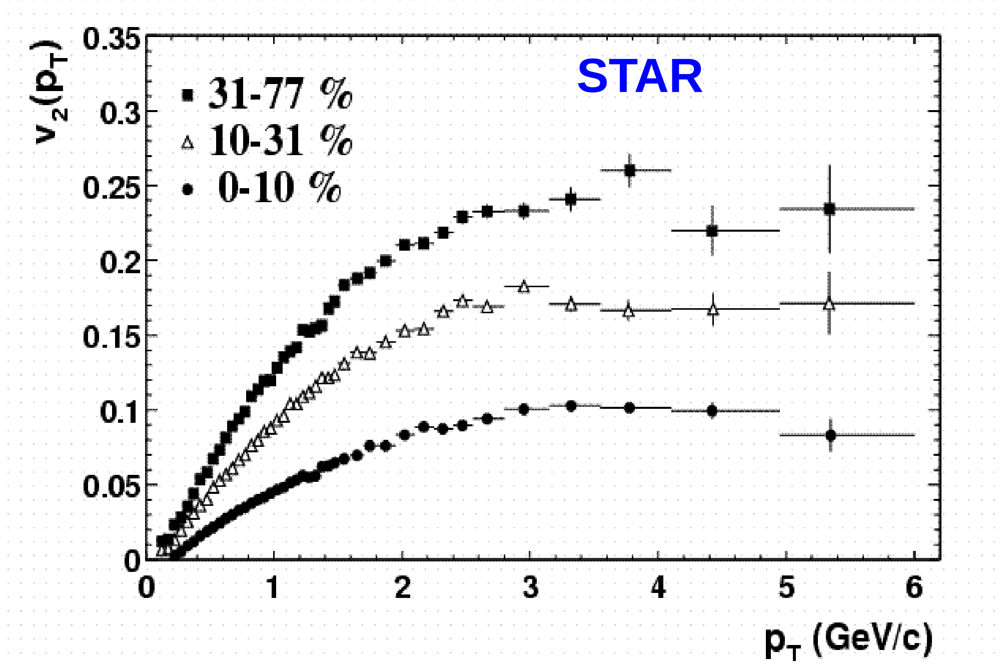
ideal <u>*Elliptic*</u> Jet Tomography

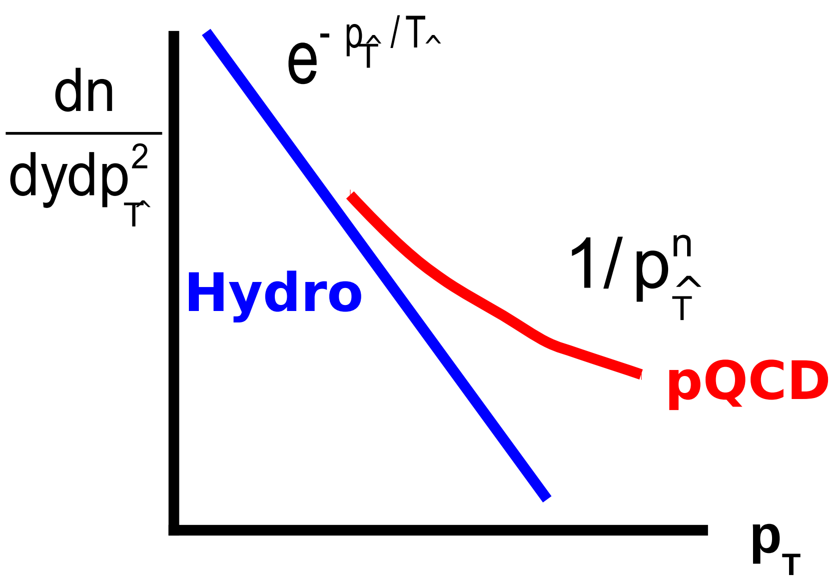
MG, I. Vitev and X.N. Wang, PRL86(01)

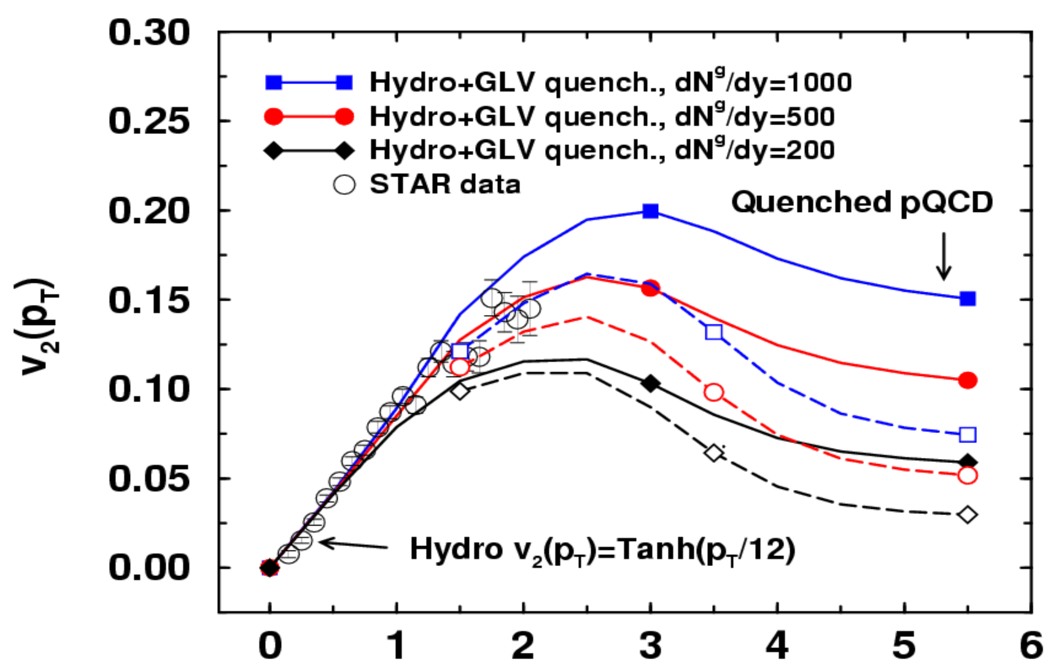
"Elliptic Cow Approx"

$$\rho_{QGP}(\tau, x_0 + \hat{n}\tau)$$









Until very recently RAA *<u>and</u>* v2 data
<u>*could not be simultaneously fit*</u>. One solution to this problem
was nonperturbative **sQGMP** (CUJET3: J.Xu, J. Liao, MG, CPL32 , 2015)

The nuclear modification factor of high transverse momentum hadron, h, fragments in $A+B \to h+X$ and centrality class $\mathcal{C}$ used to probe the short wavelength dynamics in an sQGP is defined as

$$R^h_{AB}(y,\vec{p}_T;\sqrt{s},\mathcal{C}) = \frac{dN^{A+B\to h}(y,\vec{p}_T,\sqrt{s},\mathcal{C})/dyd^2\vec{p}_T}{T_{AB}(\mathcal{C})d\sigma^{p+p\to h}(\sqrt{s})/dyd^2\vec{p}_T} \; .$$

For a fixed $\sqrt{s}$ center of mass (cm) energy (per nucleon pair) and nucleon-nucleon (NN) inelastic cross section $\sigma^{in}_{NN}(\sqrt{s})$ the mean number of elementary binary NN collisions in centrality class $\mathcal{C}$ is given by $\sigma^{in}_{NN}T_{AA}$

SHEE (Soft-Hard Event Engineering) generalizes this idea to the study of R in Sub-classes of events specified not only by centrality, but also by soft (low pT<2) azimuthal harmonics

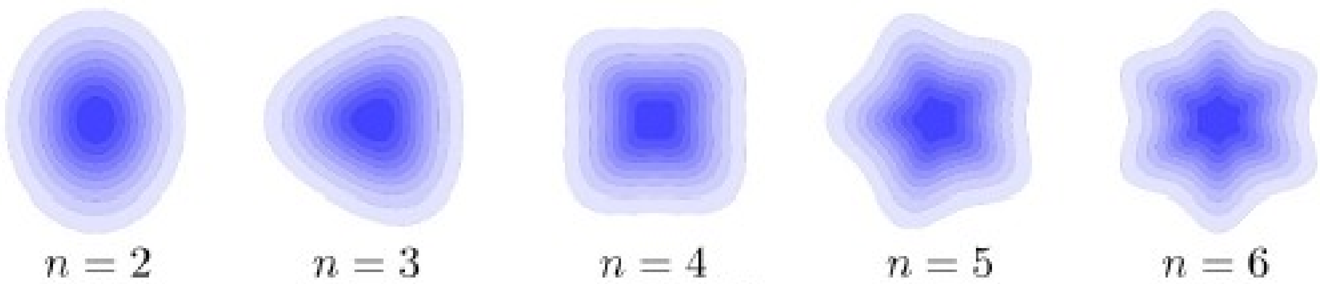
$$\mathcal{C} = \mathcal{C}_{cent} \otimes \mathcal{C}[\{v_2^{soft}, v_3^{soft}, \cdots\}]$$

The distribution of particles can be written as a Fourier series

$$E\frac{d^3N}{d^3p} = \frac{1}{2\pi}\frac{d^2N}{p_T\,dp_T\,dy}\left[1 + \sum_n 2v_n \cos\left[n\left(\phi - \psi_n\right)\right]\right]$$

$$v_n^{\text{"theory"}}(p_T) = \frac{\int_0^{2\pi} d\phi \frac{dN}{p_T\,dp_T\,d\phi}\cos\left[n\left(\phi - \Psi_n\right)\right]}{\int_0^{2\pi} d\phi \frac{dN}{p_T\,dp_T\,d\phi}}$$

where $\Psi_n = \frac{1}{n}\arctan\frac{\langle sin[(n\phi)]\rangle}{\langle cos[(n\phi)]\rangle}$



Example of an exotic SHEE class of events with given centrality but specific soft geometry

$$\mathcal{C}_{triang} = \mathcal{C}_{cent}(dNdy = 200) \otimes \mathcal{C}[\{v_2^{soft} = 0.05, v_3^{soft} = 0.2\}]$$

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Wuhan HP2016

High p_T spectra and anisotropy of light and heavy hadrons

P. Christiansen (Lund University)

- The work done to constrain the energy loss in a data driven way
  - Using elliptic flow to fix path length and vary the medium density (Phys. Rev. C 89, 034912, 2014)
    - Together with Vytautas Vislavicius and Konrad Tywoniuk
  - Using Event Shape Engineering to keep the medium density fixed while varying the path length
    - PC, J. Phys. Conf. Ser. 736 (2016) no.1, 012023
- I will interleave some questions and comments
- Jacquelyn Noronha-Hostler will give a theory driven discussion of this in the afternoon J.Noronha-Hostler et al, PRL 116 (2016) 252301 ; and arXiv:1609.05171

- Work in a similar spirit: R. A. Lacey, N. N. Ajitanand, J. M. Alexander, X. Gong, J. Jia, A. Taranenko, and R. Wei, Phys. Rev. C 80, 051901, 2009. (+ arXiv:1202.5537, arXiv:1203.3605).

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Which future data could best discriminate between competing A+A models ? **[SHEE]**

What theory advances will be required to move beyond current spherical cow approximations to address consistently and simultaneously **Soft Bulk pT<2 GeV *AND* Hard "Jet" pT>10 GeV** observables? **[full 3+1 D !]**

Can we devise effective microscopic dynamical models that can interpolate between long wavelength "perfect fluidity" (large qhat near Tc) and short wavelength high pT perturbative QCD (small qhat at high pT) ? **[sQGDP]**

Can we test quantitatively via A+A the ab initio Lattice QCD 2+1 flavor **predictions** for sQGP **P(T), S(T), η/s(T), ξ/s(T), m_E(T), m_M(T), α(r,T), L(T), χ(T)** ? **[so far only η/s with pT<2]**

What can A+A teach us about *THE* unsolved HARD problem since 1974 about the mechanisms in QCD that confine all color electric and magnetic degrees of freedom T<Tc ? [We need to keep trying to develop new Soft+Hard tools. Soft-Hard correlations over pT and y are most powerful tool at hand.]

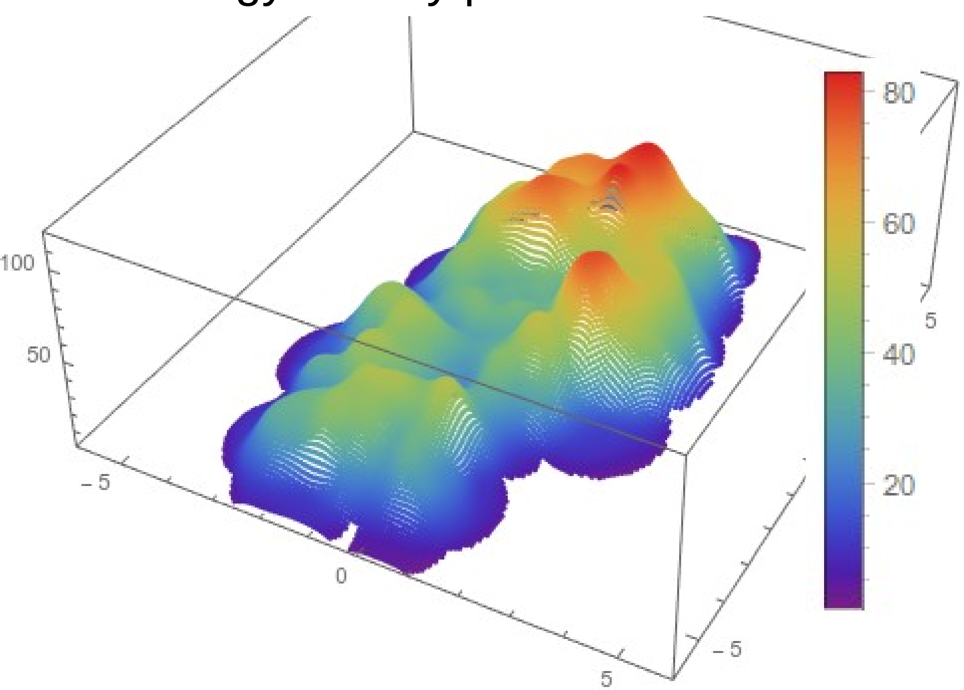
Can the huge volume of the space of 3+1D A+A models 3D IC ⊗ vHydro 3+1D ⊗ dE/dx(E,T) be constrained to reduce the ambiguities & nonuniqueness of current data interpretations?
[Yes, many models falsified at HP16; Many more will vanish in the course of SHEE pp,pA,AA]

How do soft bulk asymmetric rapidity fluctuations a_n and transverse fluctuations v_n evolve in AA and how will they modify Hard Probe observables? [??, my guru blanked out]

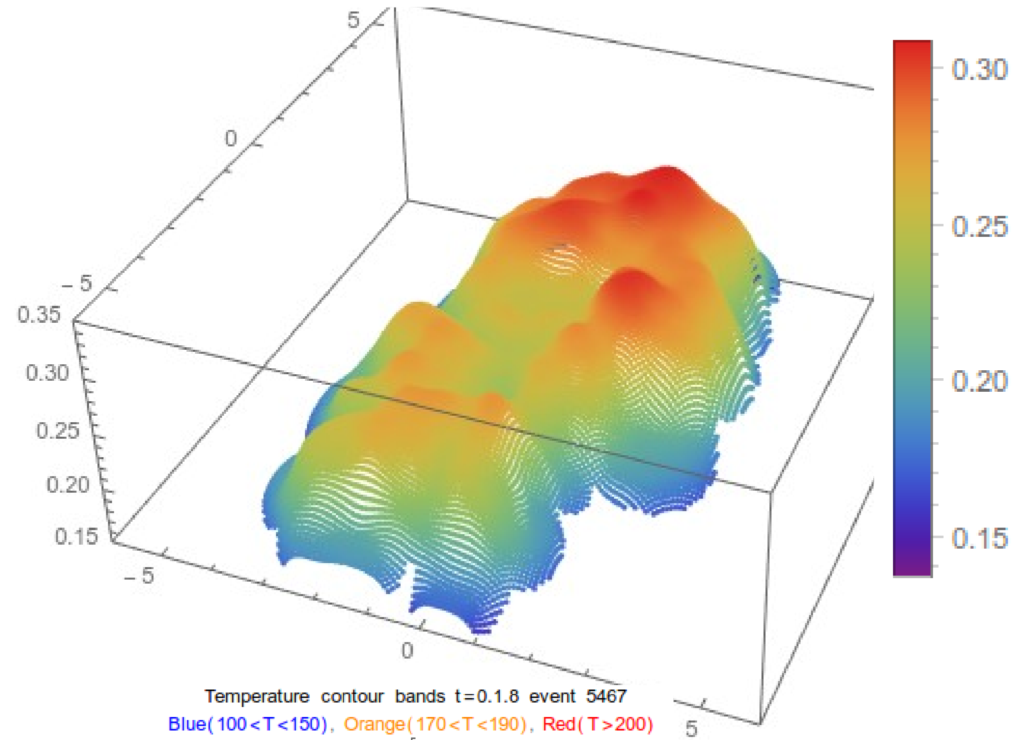
Jacquelyn Noronha-Hostler, et al PbPb2.76 20-30% inhomogeneous MCKLN vUSPHY hydro

Example of a typical lumpy 2+1D vHydro evolution with **disconnected isotherm surfaces !**

Energy density profile event 5467



Temperature profile event 5467

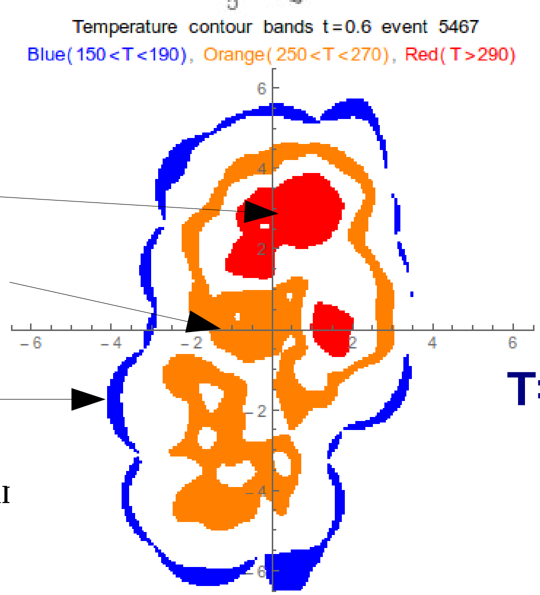


t=0.6

T > 290

T=170-220

T=150-190

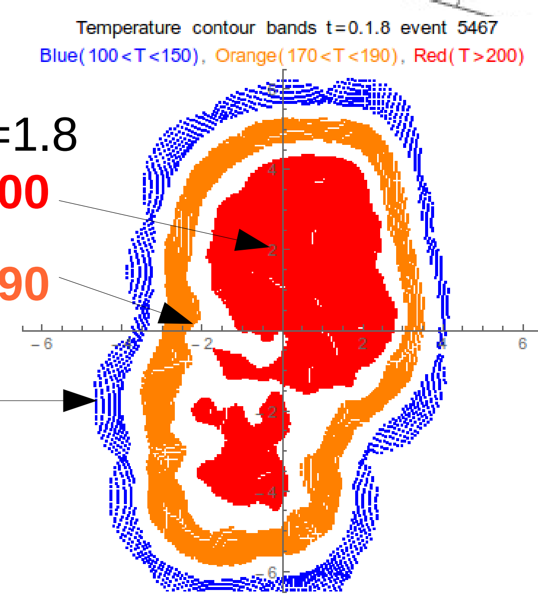


t=1.8

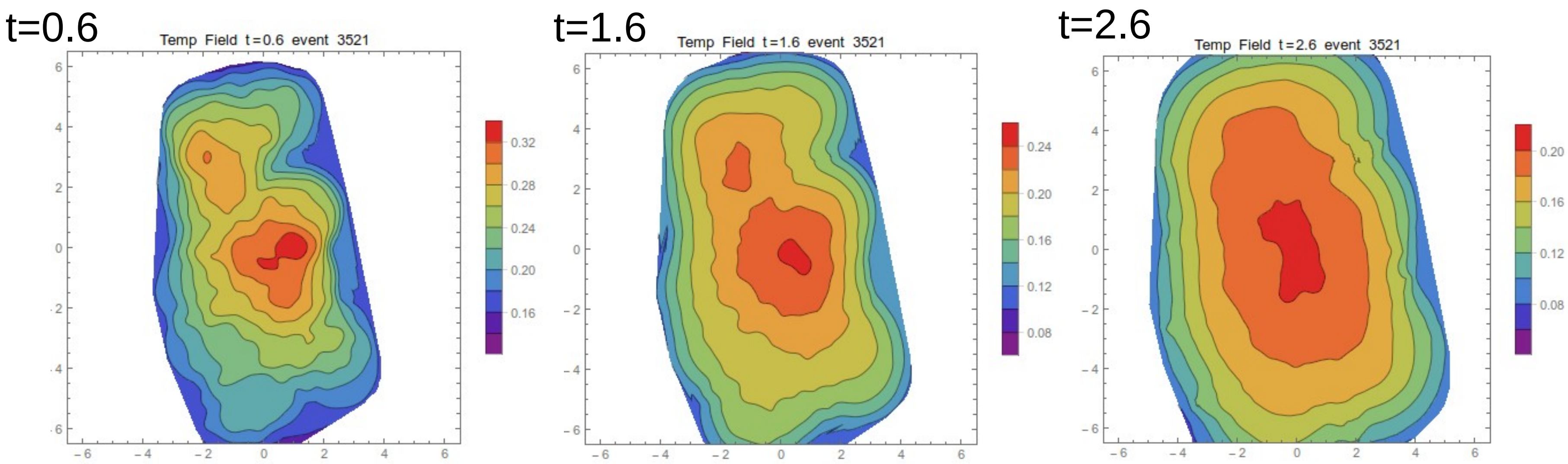
T > 200

T=170-190

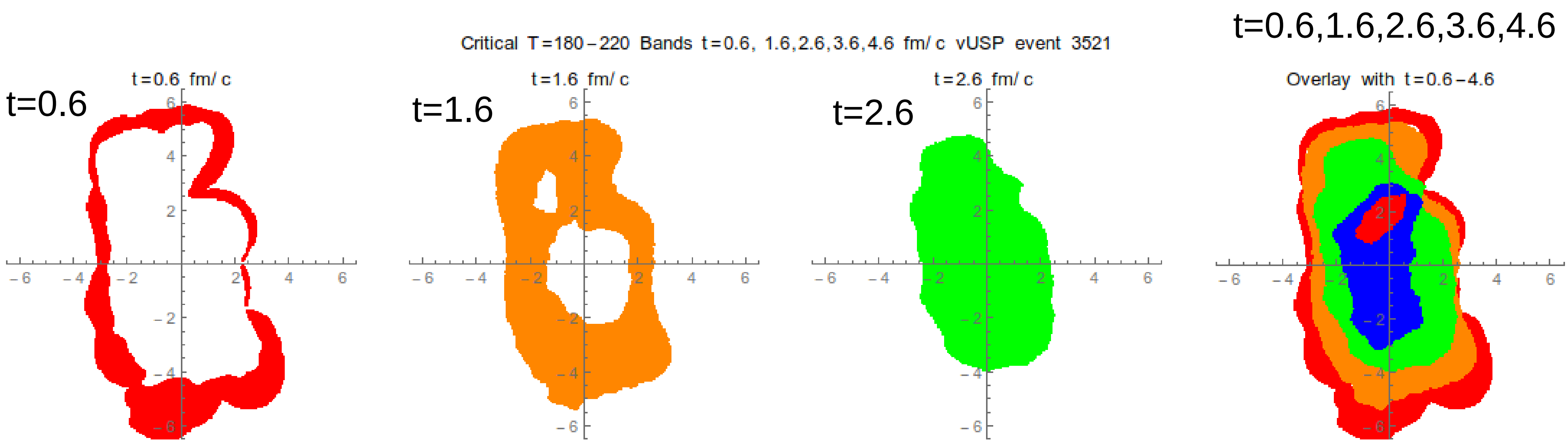
T=100-150



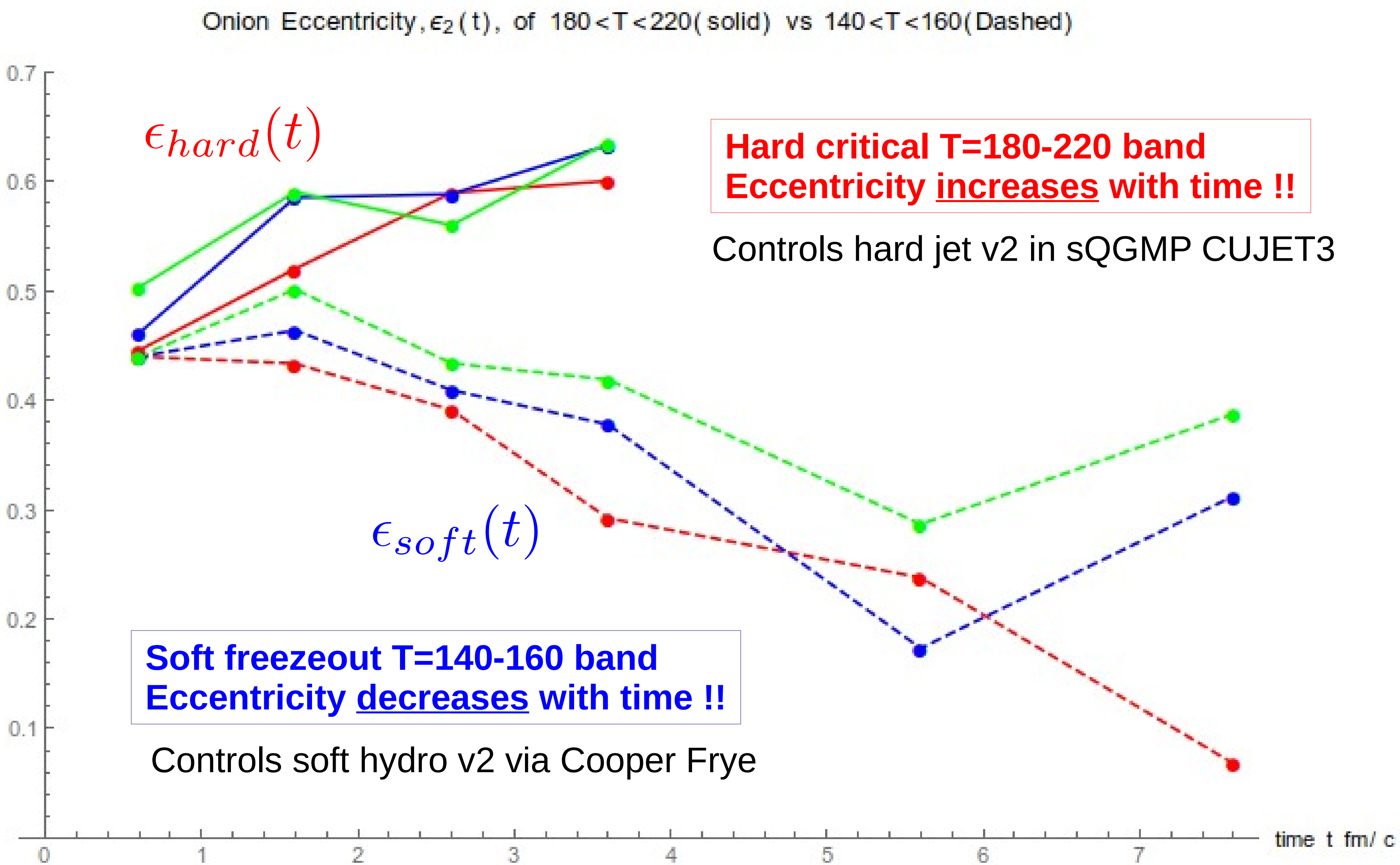
Example of Evolution of T(x,t) Temperature Field n 1 Events LHC vSPH 20-30% centrality



Evolution of T-180-220 Transition Isotherm Band vs time



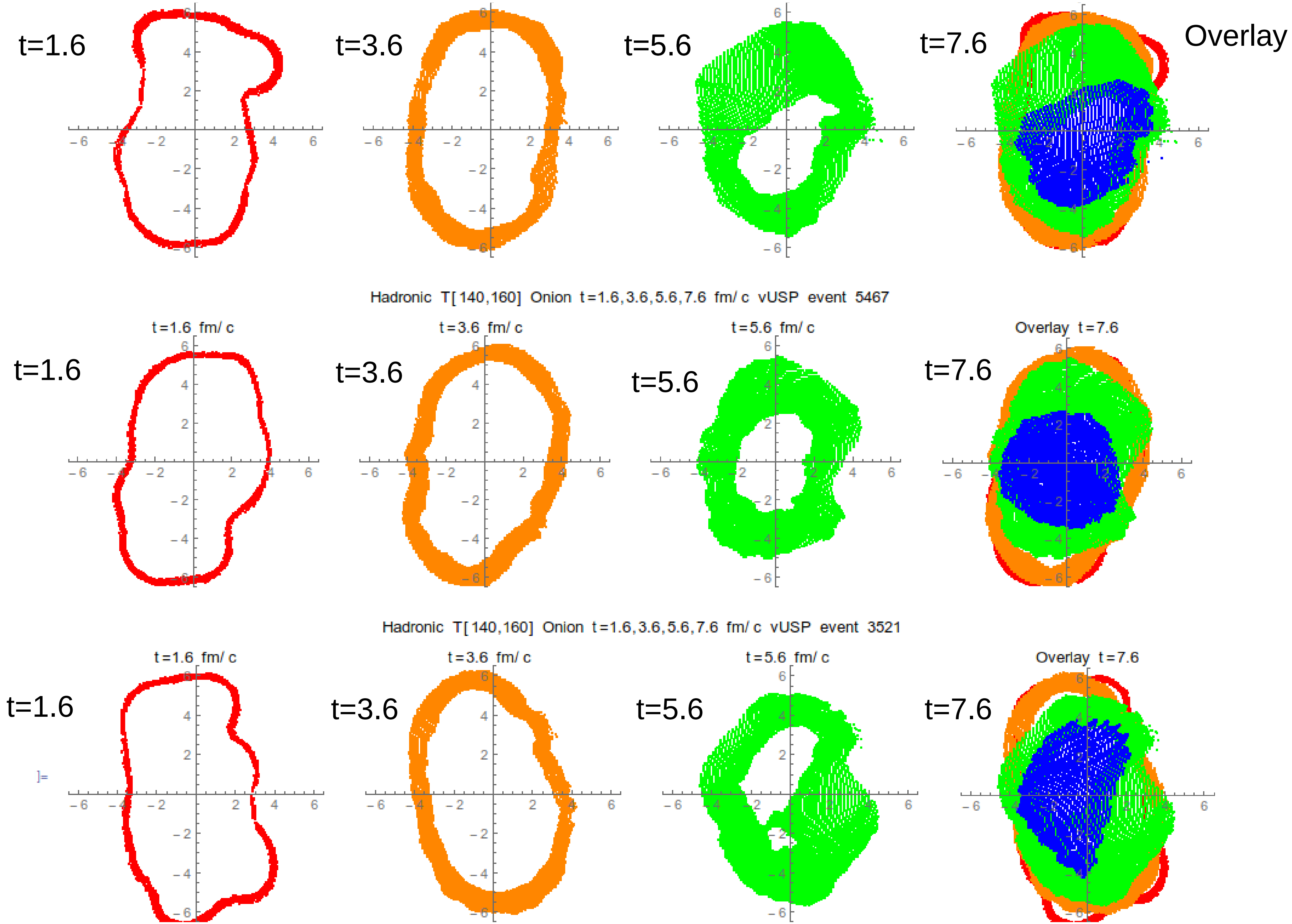
Evolution of Isotherm band **eccentricity** in three typical vSPH LHC2.76 20-30% events



Shape and orientation of inner and outer "onion" bands initially causally disconnected

=> cannot expect simple linear response between hard and soft v2 and geom ecc.

Examples of Evolution of T-140-160 Freezeout Isotherm in 3 Events LHC vSPH 20-30% centrality



Sensitivity of EbE jet tomography to path length $dE/dx \sim L^b$

Unlike event averaged smooth jet tomography ebe tomography has enhance sensitivity

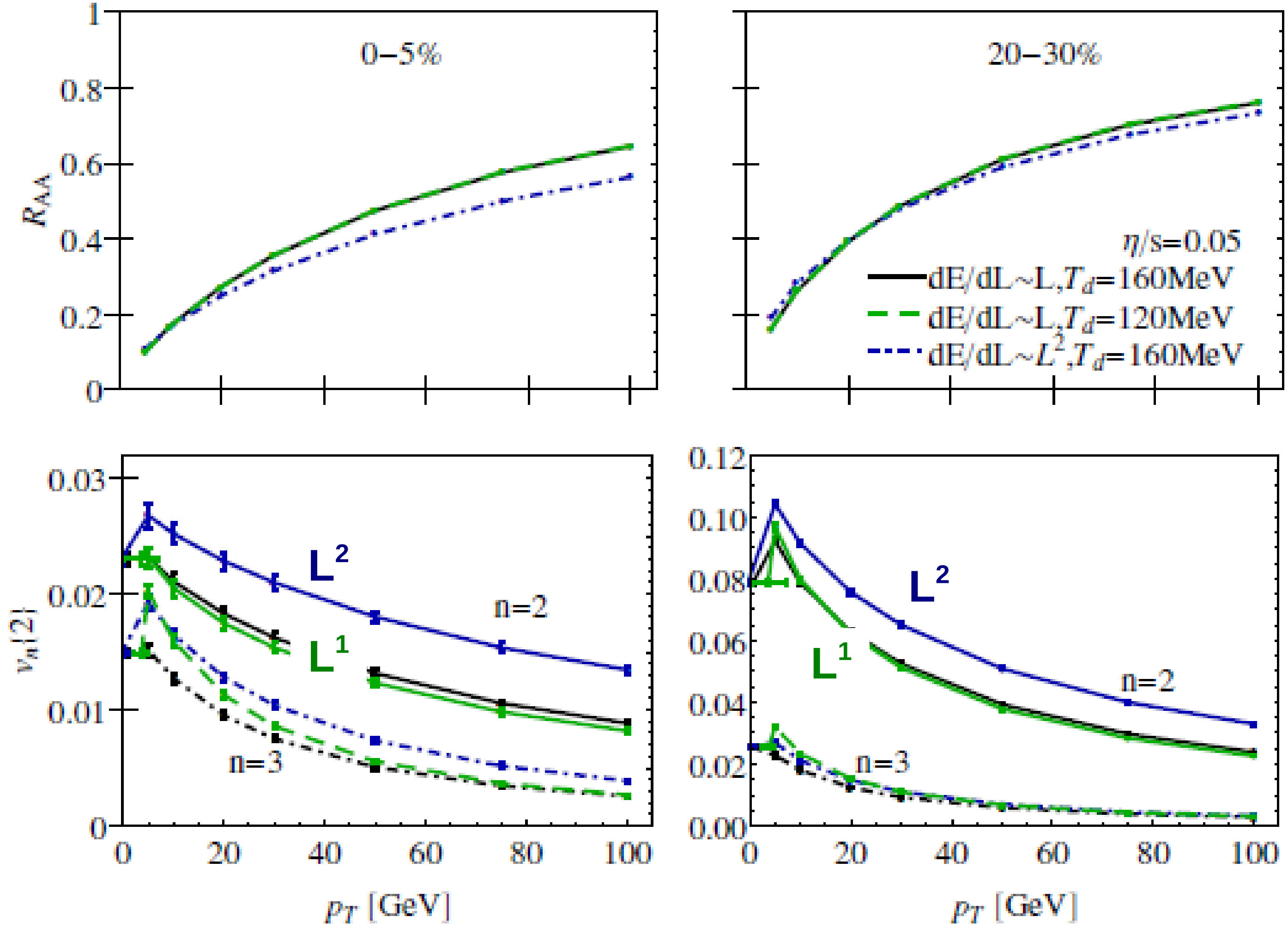


FIG. 9. (Color online) Variation of $R_{AA}(p_T)$, $v_2\{2\}(p_T)$, and $v_3\{2\}(p_T)$ with the path length dependence $dE/dL \propto L$ vs. $dE/dL \propto L^2$ and the jet-medium decoupling temperature $T_d = 160$ MeV vs. $T_d = 120$ MeV, keeping $\eta/s = 0.05$. Only $0-5\%$ and $20-30\%$ centralities are shown. All values are calculated for PbPb LHC collisions at $\sqrt{s_{NN}} = 5.02$ TeV.

Soft-Hard-Event Engineering will strongly reduce the Volume of Hard Probe Theory space

Overtime Part ? :

Toward full 3+1 D jet tomography of A+A in the future

“Ah, oh, I am getting dizzy”

3D jet tomography of twisted strongly coupled quark gluon plasmas
A. Adil, M. Gyulassy PRC72 (2005) 034907

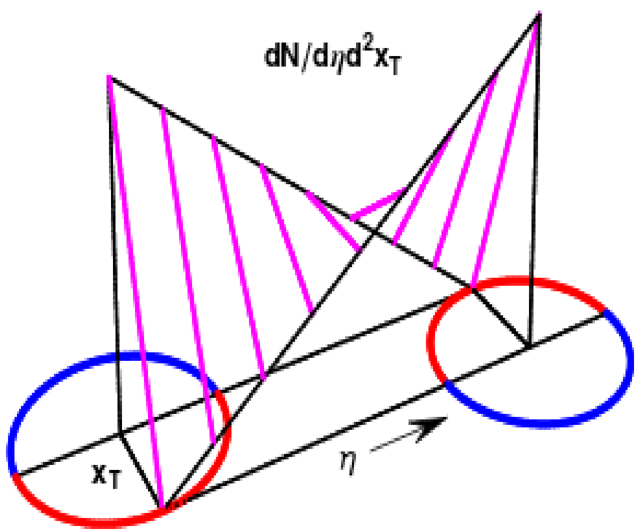


FIG. 3: Schematic illustration of how local trapezoidal nuclear enhancements of the rapidity distributions in the reaction plane $(x, \eta, y = 0)$ twist the bulk initial density about the normal in non central $A + A$ collisions. (see eqs.(3,8)) (In

Forward-backward eccentricity and participant-plane angle fluctuations
J.Jia, P.Huo, PRC90 (2014)

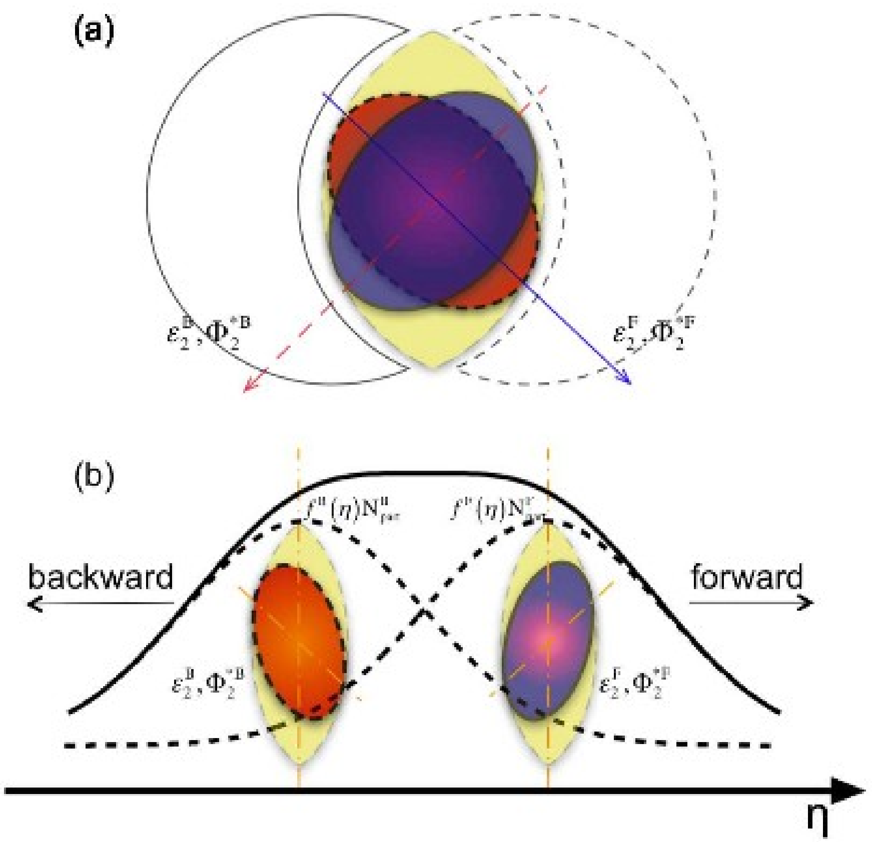
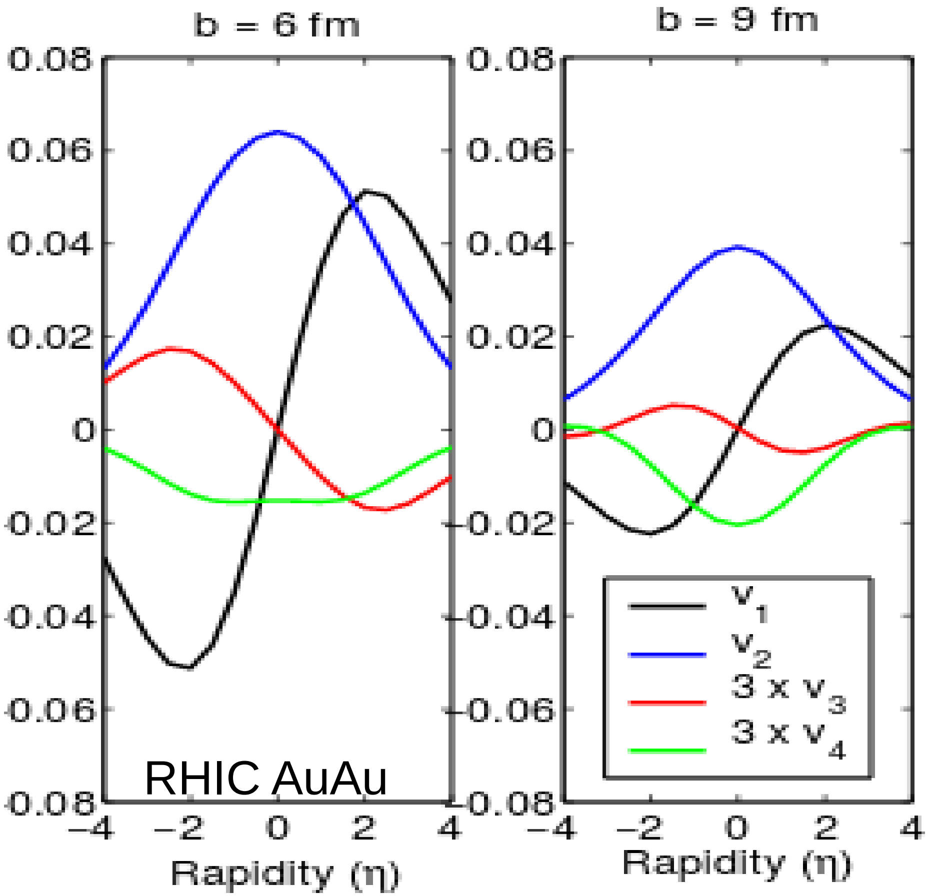


FIG. 1: Schematic illustration of the forward-backward fluctuation of second-order eccentricity and participant plane, in transverse plane (a) and along rapidity direction (b) in A+A collisions. The dashed-lines indicate the particle production profiles for forward-going and backward-going participants, $f^{\mathrm{F}}(\eta)N^{\mathrm{F}}_{\mathrm{part}}$ and $f^{\mathrm{B}}(\eta)N^{\mathrm{B}}_{\mathrm{part}}$, respectively.

Rapidity dependence of high pT vn from

$$R_{AA}(\eta,\phi;b)=\frac{1}{N_{\rm Bin}}\int d^2\mathbf{x}_0\,\frac{dN_{\rm Bin}}{d^2x}(\mathbf{x}_0,b)e^{-\kappa\chi(\mathbf{x}_0,\eta,\phi,b)}$$



Rapidity odd v1, v3

A. Adil, M. Gyulassy PRC72 (2005)

Twisted Forward Backward rapidity gap Di-jets due to

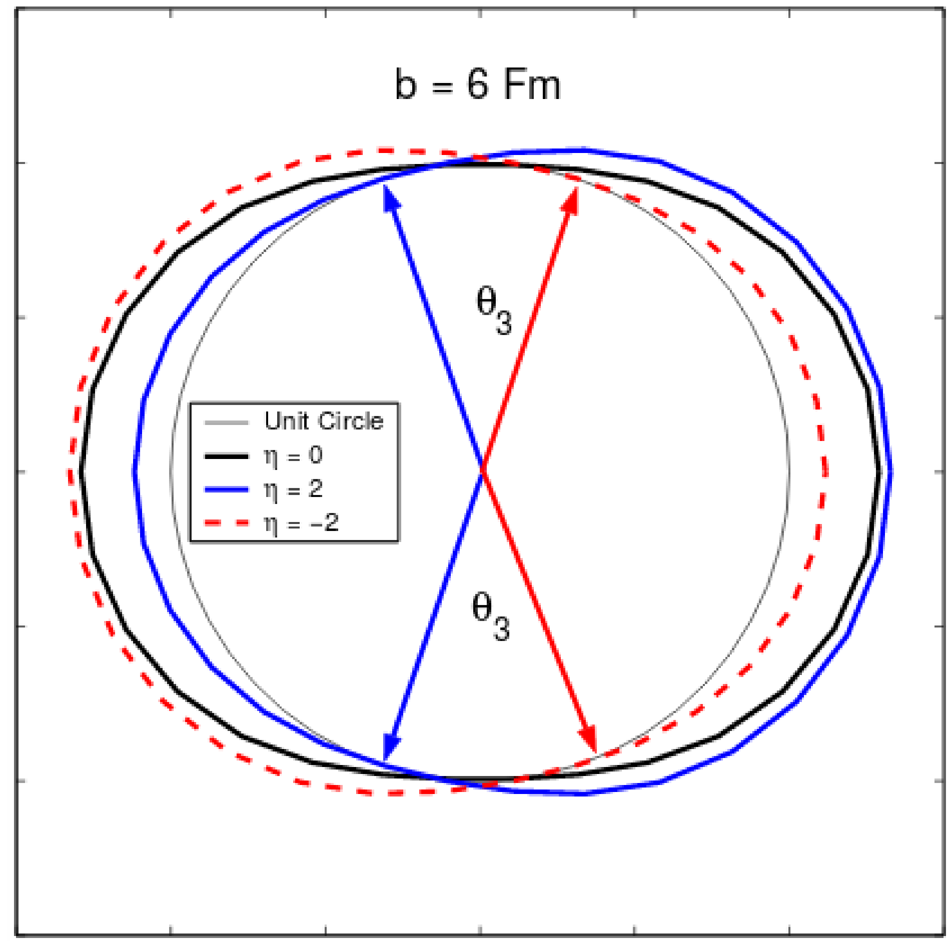


FIG. 13: A polar plot of the relatively normalized R_{AA}/R_{AA}^{min} for $b = 6$ comparing two $\eta = \pm 2$ slices (blue solid, dashed red) to the unit circle corresponding to $b = 0$ (thin black). For $b =$

.

Longitudinal fluctuations of the fireball density in heavy-ion collisions

Adam Bzdak, Derek Teaney Phys.Rev. C87 (2013) no.2, 024906

$$\rho(y;a_0,a_1,...)=\rho(y)\left[1+\sum\nolimits_{i=0}a_iT_i\left(y/Y\right)\right]$$

Assuming that at a given $a_0, a_1, ...$ there are no other large sources of long-range rapidity correlations, the two-particle rapidity distribution is

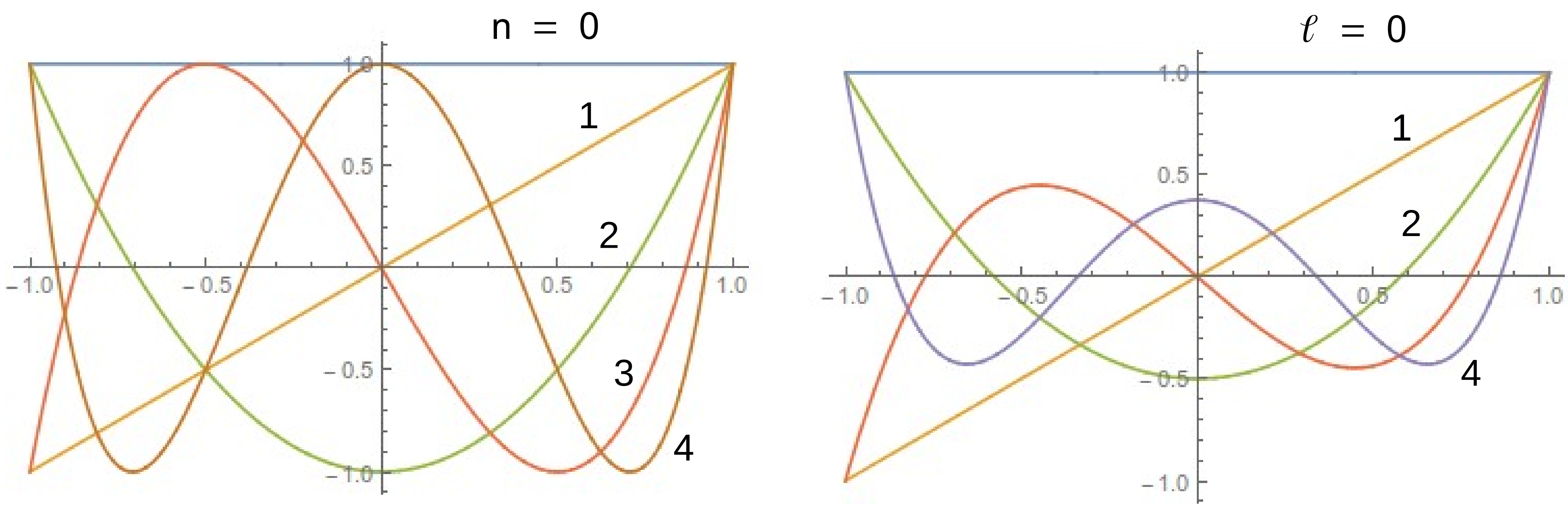
$$\rho_2(y_1,y_2;a_0,a_1,...)=\rho(y_1;a_0,a_1,...)\rho(y_2;a_0,a_1,...)\,. \tag{3.2}$$

Taking an average over a_i and subtracting $\rho(y_1)\rho(y_2)$, we obtain the two-particle rapidity correlation function

$$C(y_1,y_2)=\rho(y_1)\rho(y_2)\left[\sum\nolimits_{i,k=0}\langle a_ia_k\rangle\,T_i\left(y_1/Y\right)T_k\left(y_2/Y\right)\right]\,. \tag{3.3}$$

$$\langle a_ia_k\rangle=\frac{1}{c_ic_k}\int_{-Y}^{Y}\frac{C(y_1,y_2)}{\rho(y_1)\rho(y_2)}\frac{T_i(y_1/Y)T_k(y_2/Y)}{\left[1-(y_1/Y)^2\right]^{1/2}\left[1-(y_2/Y)^2\right]^{1/2}}\frac{dy_1dy_2}{Y^2}$$

Chebeshev Poly $T_n(x)$ More Convenient than Legendre Poly $P_\ell(x)$ basis for expanding Radidity density fluctuations

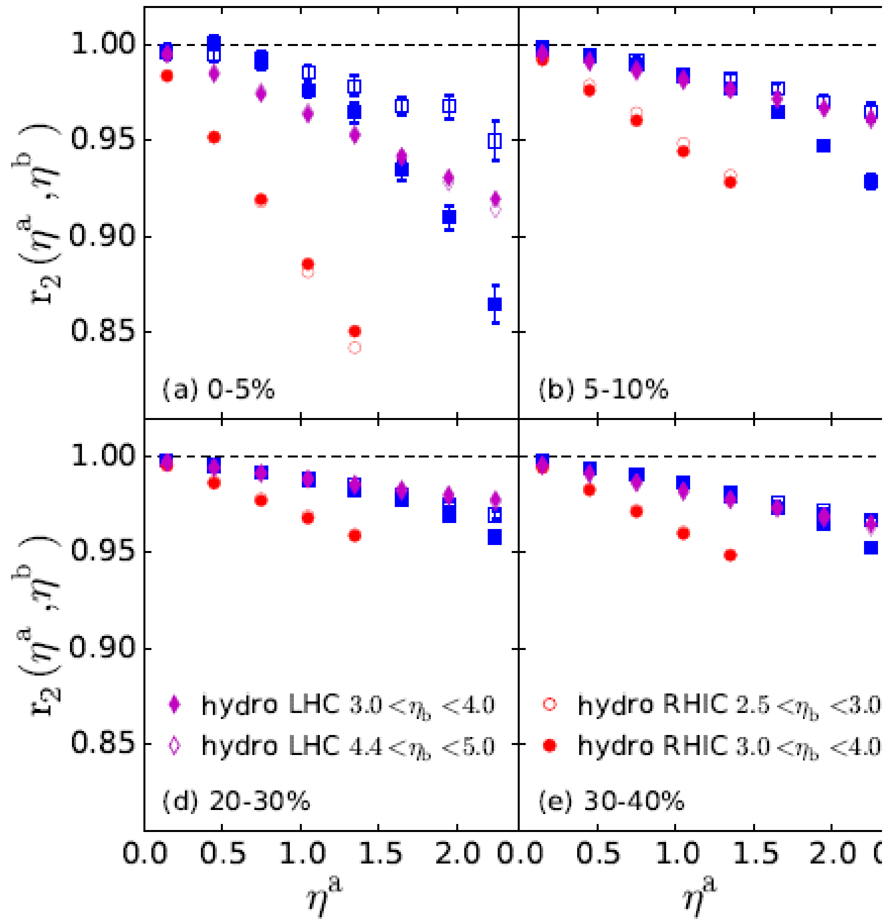


L.G.Pang, H.Petersen, G.Y.Qin, V.Roy and X.N.Wang,
``Decorrelation of anisotropic flow along the longitudinal direction,''
Eur.Phys.J.A52 (2016)

A (3+1)D ideal hydrodynamical model [20, 41] is employed to study the decorrelation of anisotropic flows in different rapidity windows in Pb+Pb 2:76 TeV and Au+Au 200 GeV with fluctuating initial conditions from AMPT that initializes with Hijing

$$\vec{Q}_n \equiv Q_n e^{in\Phi_n} = \frac{1}{N}\sum_{i=1}^{N} e^{in\phi_j}$$

$$r_n(\eta_a,\eta_b) = \frac{\left\langle \vec{Q}_n(-\eta_a)\vec{Q}_n^*(\eta_b)\right\rangle}{\left\langle \vec{Q}_n(\eta_a)\vec{Q}_n^*(\eta_b)\right\rangle}$$



First predictions of
Rapidity decorrelations
Of azimuthal harmonics

Era of 3+1D
Chebeshev-Fourier
Harmonics has begun

Non-boost-invariant dissipative hydrodynamics

For non-boost invariant 1+1D generalized Bjorken viscous hydro

Wojciech Florkowski,[1] Radoslaw Ryblewski,[1] Michael Strickland,[2] and Leonardo Tinti[3]

QCD EOS **Bulk and Shear Stress**

$$\partial_\mu T^{\mu\nu}(x) = 0,$$

$$T^{\mu\nu} = \mathcal{E}\, U^\mu U^\nu - \left(\mathcal{P} + \Pi\right) \Delta^{\mu\nu} + \pi^{\mu\nu}, \qquad (3)$$

where Π is the bulk pressure, $\pi^{\mu\nu}$ is the shear stress tensor (the space-like, symmetric, and traceless part of $T^{\mu\nu}$),

$$U^\mu = \left(\cosh(\eta+\theta_\parallel), 0, 0, \sinh(\eta+\theta_\parallel)\right) \qquad Z^\mu = \left(\sinh(\eta+\theta_\parallel), 0, 0, \cosh(\eta+\theta_\parallel)\right)$$

$$\pi^{\mu\nu} = \frac{\pi_s(\tau,\eta)}{2}\left(X^\mu X^\nu + Y^\mu Y^\nu\right) - \pi_s(\tau,\eta)\, Z^\mu Z^\nu$$

Positive Transverse Pressure correction

Negative Longitudinal Pressure correction !

Isreal-Stewart Relaxation Ansatz

$$D\pi_s + \frac{\pi_s}{\tau_\pi} = \frac{4}{3}\beta_\pi \theta - \pi_s \frac{T\beta_\pi}{2}\partial_\mu\left(\frac{1}{T\beta_\pi}U^\mu\right)$$

$$\beta_\pi = \eta/\tau_\pi$$

ANISOTROPIC HYDRODYNAMICS

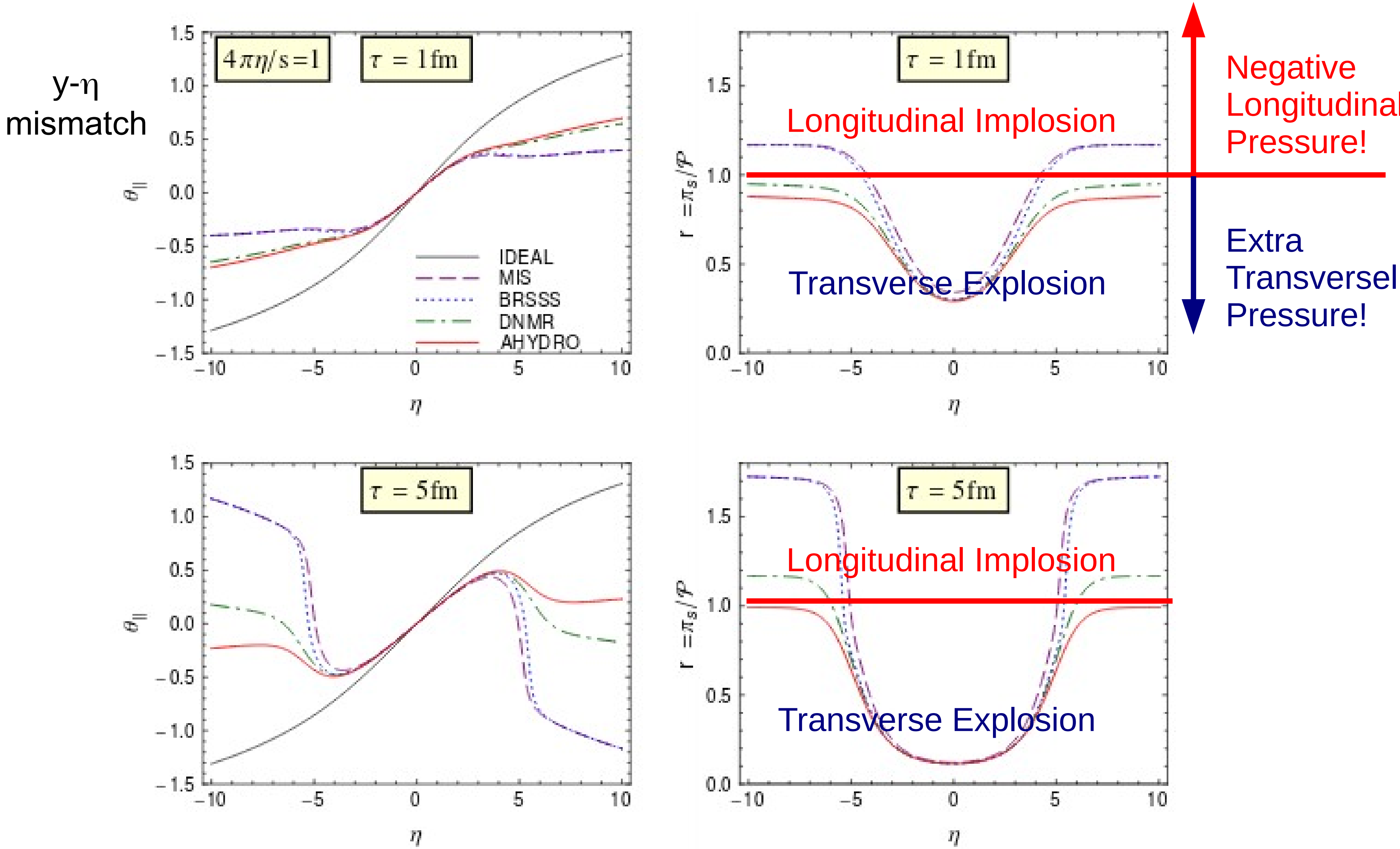
$$\mathcal{P}_L = \mathcal{P}_{\rm eq}(\Lambda)\mathcal{R}_L(\xi),$$
$$\mathcal{P}_T = \mathcal{P}_{\rm eq}(\Lambda)\mathcal{R}_T(\xi)$$

ξ is the anisotropy parameter.

$$\pi_s = 2(\mathcal{P}_T - \mathcal{P}_L)/3$$

For non-boost invariant 1+1D generalized Bjorken viscous hydro arXiv:1609.06293

All IsrealStewart like 2^{nd} order isotropic viscous models unstable in fragmentation regions



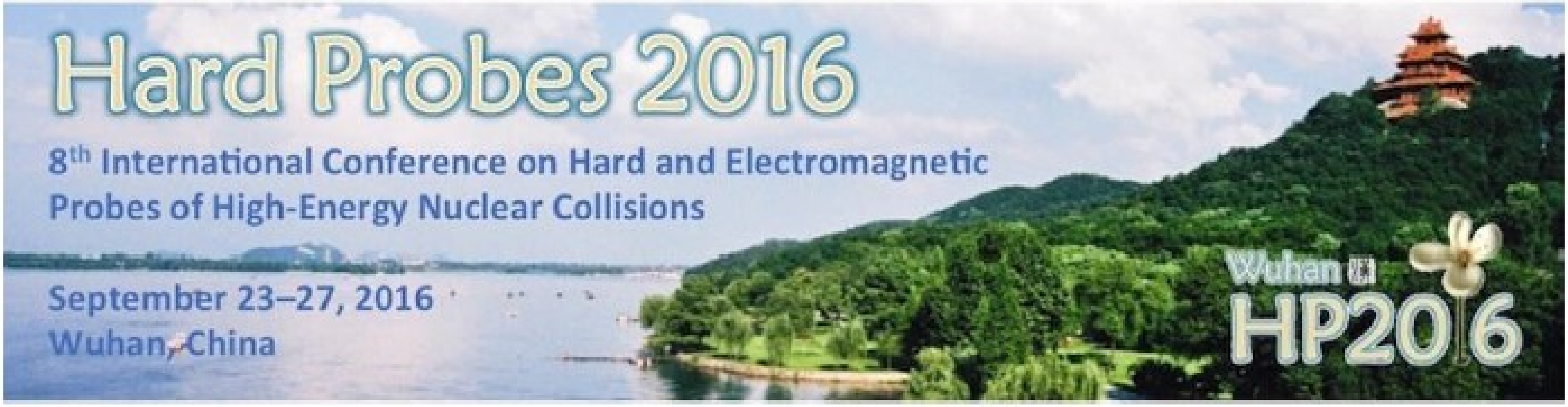
Asymmetric Hydro ansatz (Strickland et alArXiv:1609.06293) remains stable

Experimentally the Baryon rich AA fragmentation regions are fundamentally interesting

MG and Laszlo Csernai, NPA460 (1986) 723

There is no summary of a summary

But only grate gratitude from all participant here
To the organizers of HP16 for a wonderful venue and program
In Wuhan



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