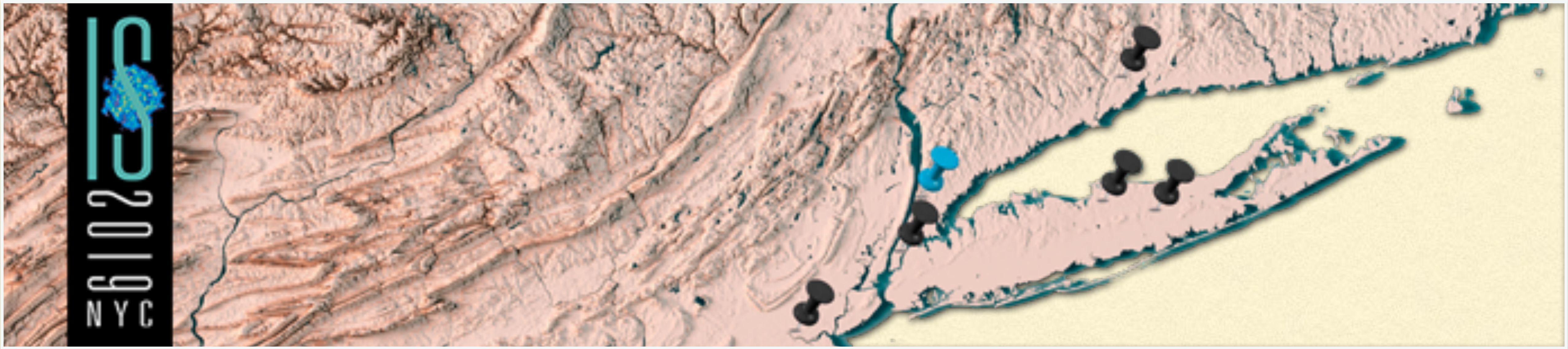
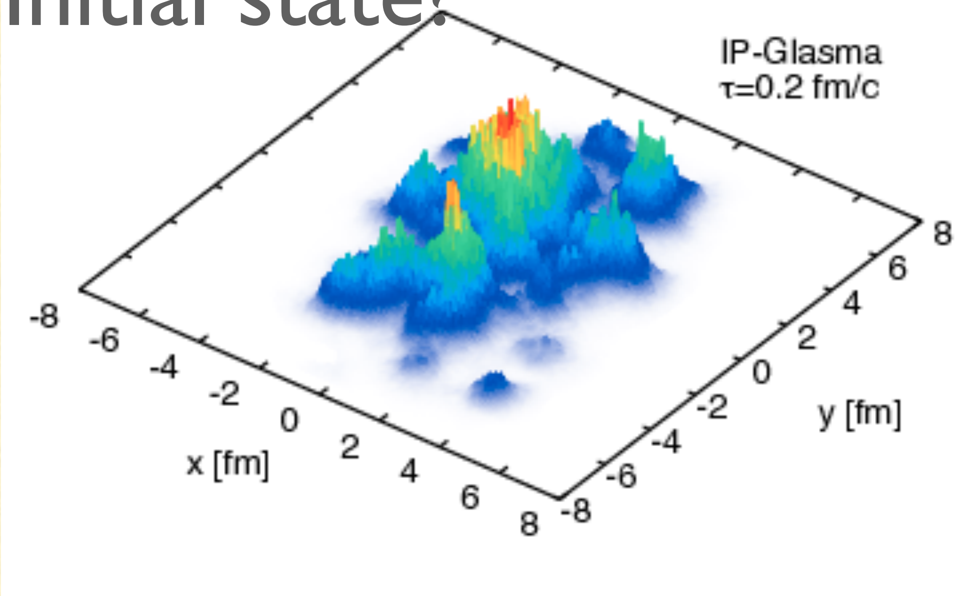


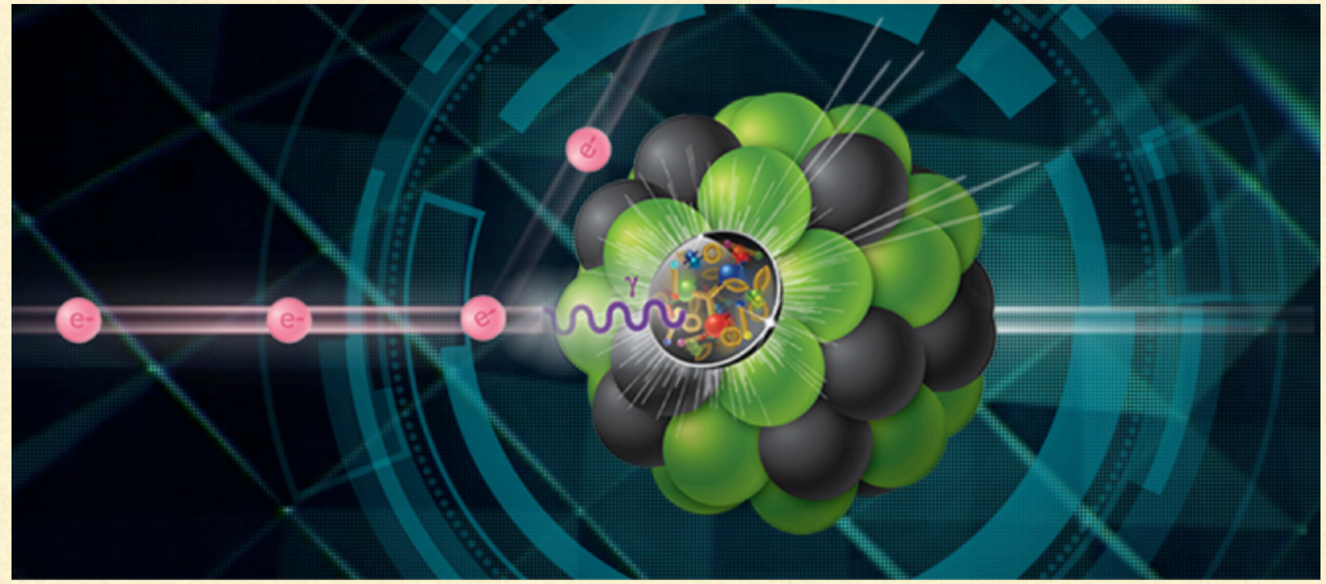
CONFERENCE SUMMARY

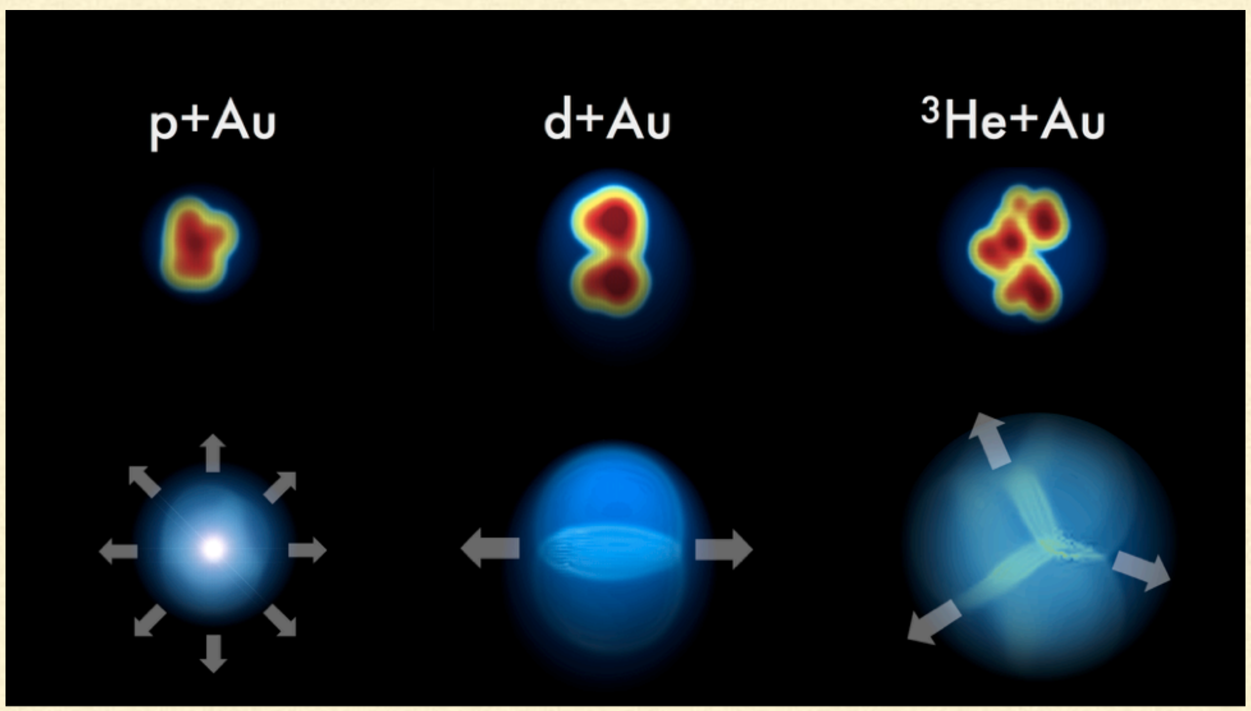
Jacquelyn Noronha-Hostler
Rutgers University

Prospects at the Electron Ion Collider

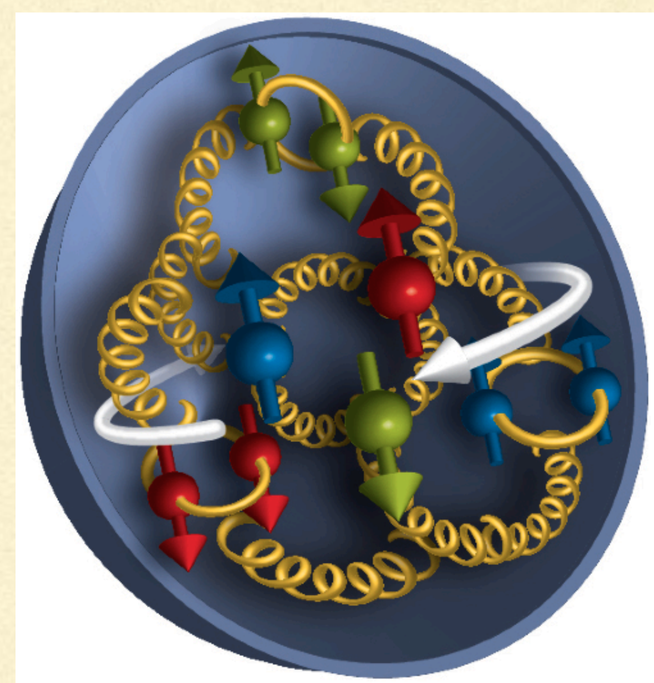
Initial state?





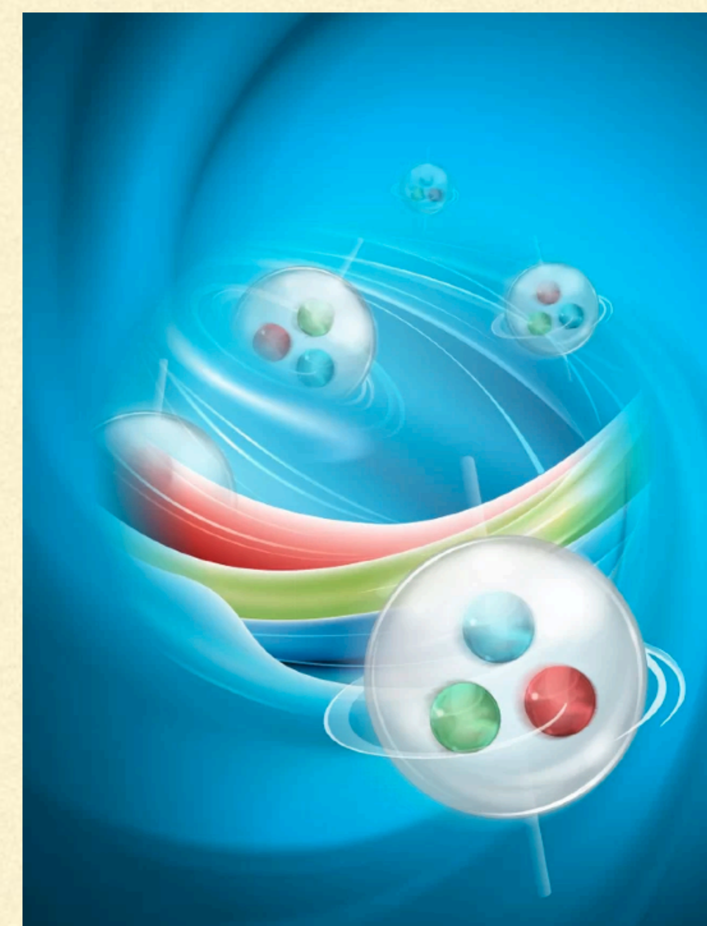


What is the smallest droplet of QGP? When is hydro applicable?



Origin of proton spin?

CME/vorticity



What are we missing?

I’m looking at myself here too…

What problems do we need to stop ignoring?

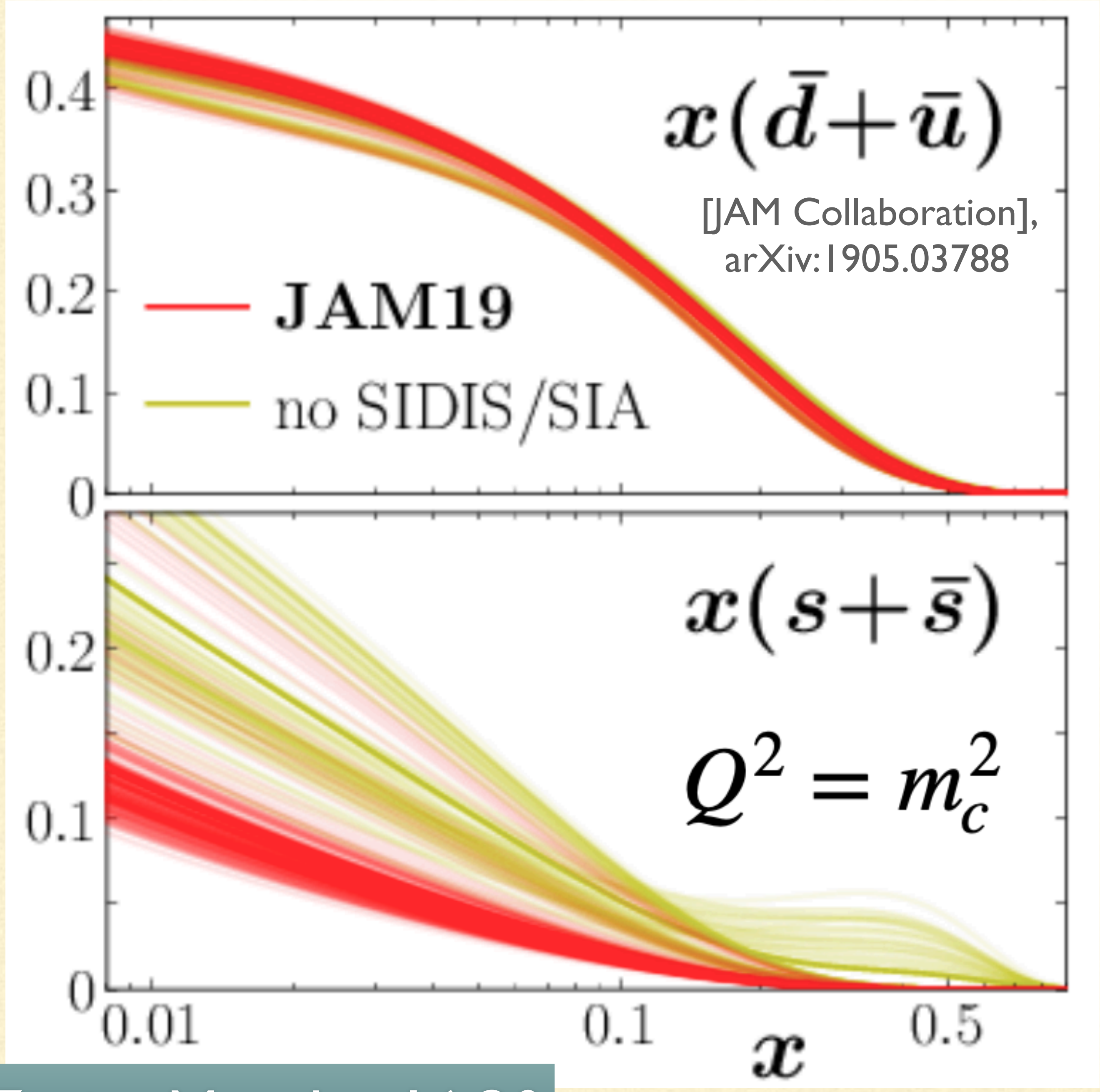
If I was given infinite resources, we would tackle…

- Beyond simple initial conditions: full $T^{\mu\nu}$, finite baryon densities, spin/chirality/magnetic fields
  - Proton/neutron structure and how does this relate to initial conditions?
- Control on NLO saturation physics calculations
- Is hydro (γ^*Pb) =hydro (pp) = hydro (pA) = hydro (AA)?
  - We really shouldn't forget about hadrochemistry/strangeness
- What is happening to jets/heavy flavor in small systems?

BEYOND SIMPLE INITIAL CONDITIONS

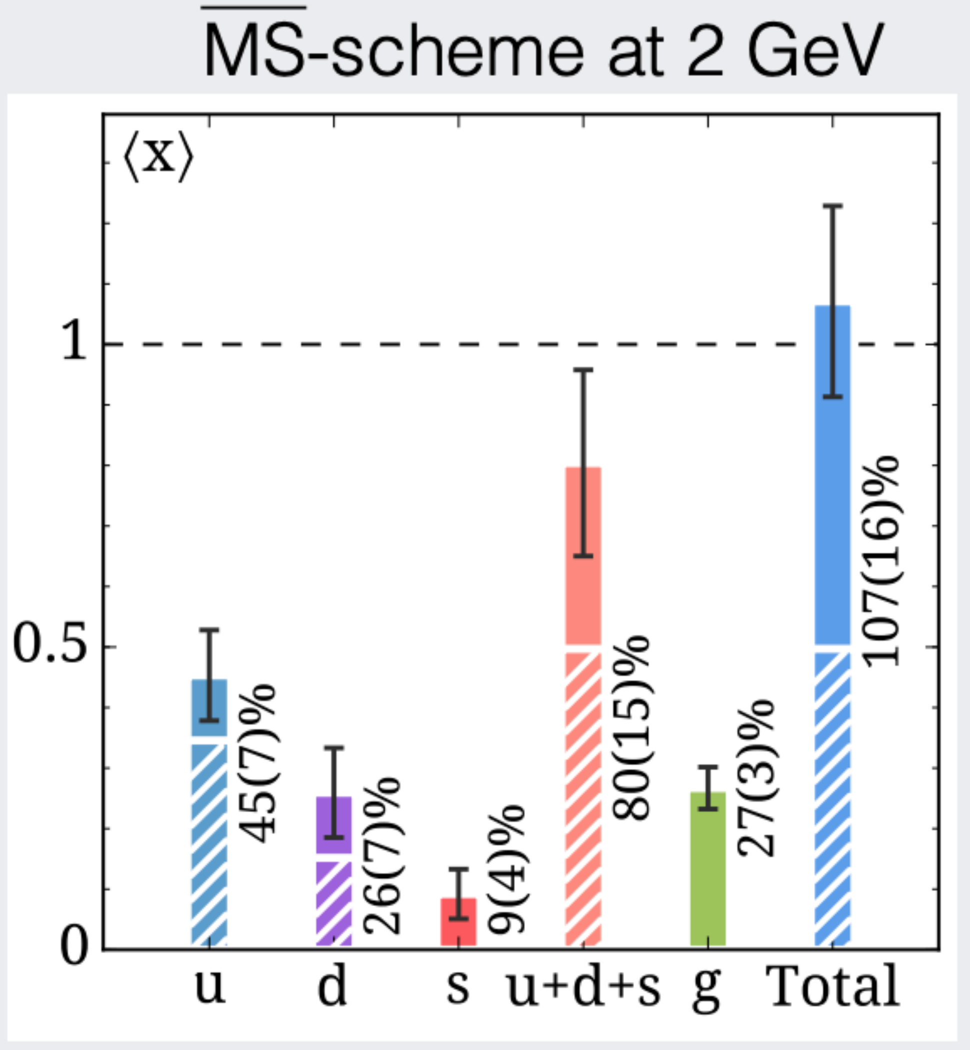
Learning from proton/nucleus structure

How strange is a proton?



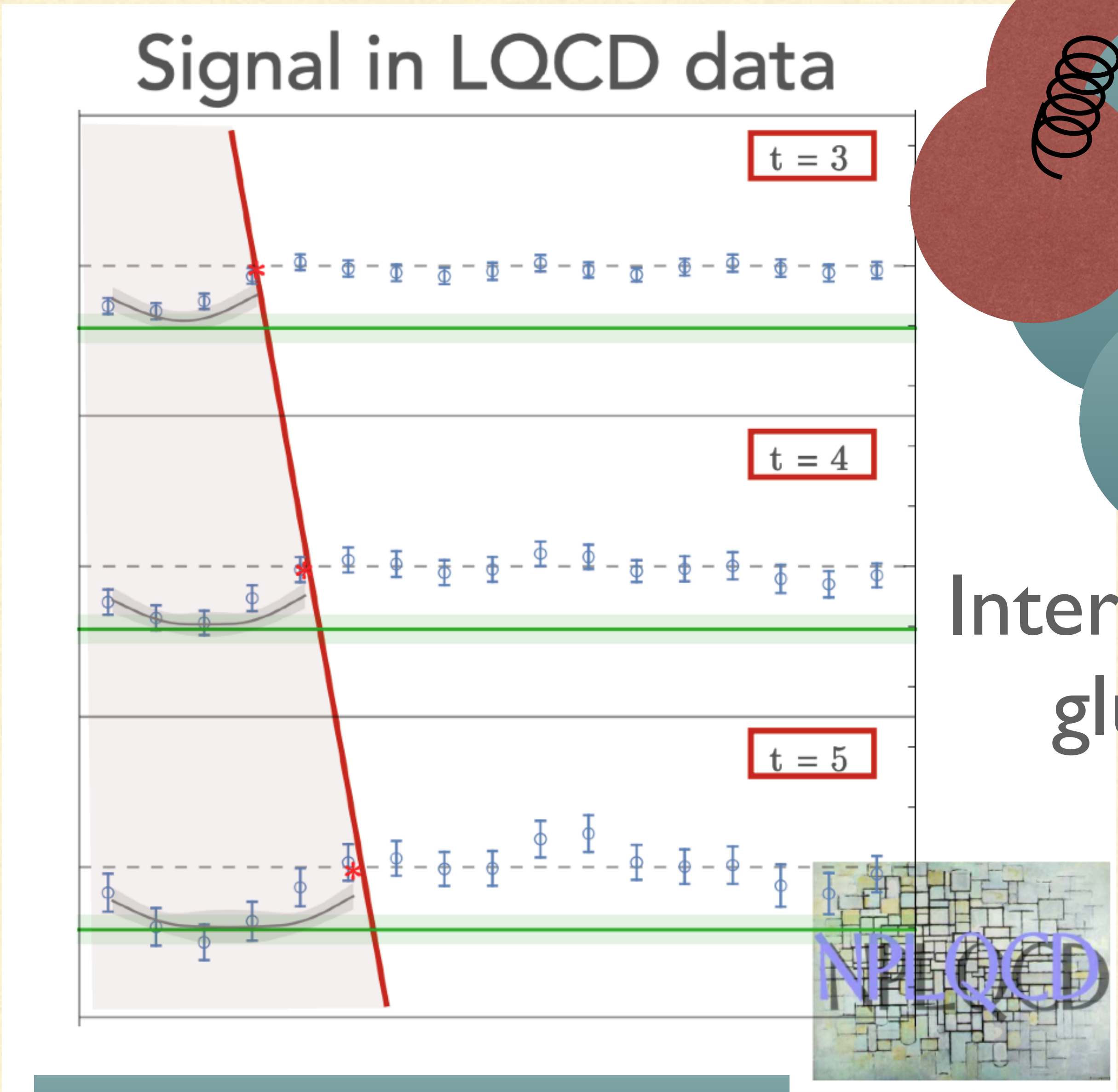
Zurita Monday 16:30

Proton momentum distribution from Lattice QCD

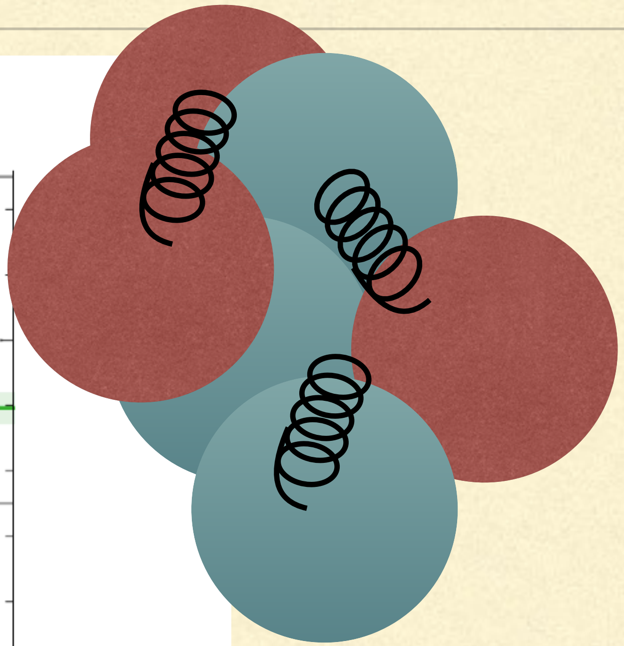


[C. Alexandrou et al., PRL 119 (2017)]

Nucleons $\neq$ Nucleus

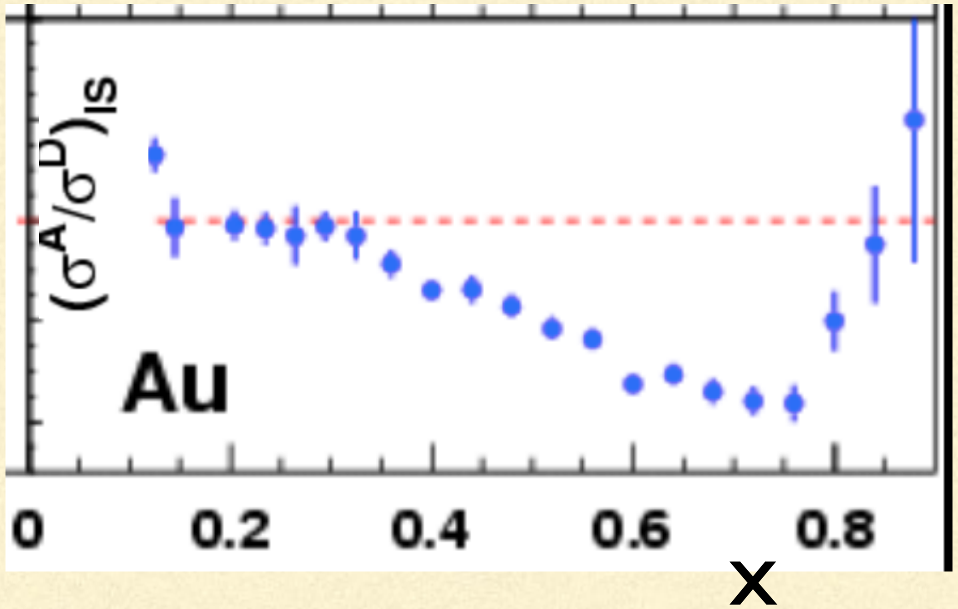


Shanahan Monday 17:00



Internucleus gluons

EMC effect- depletion of high x quarks

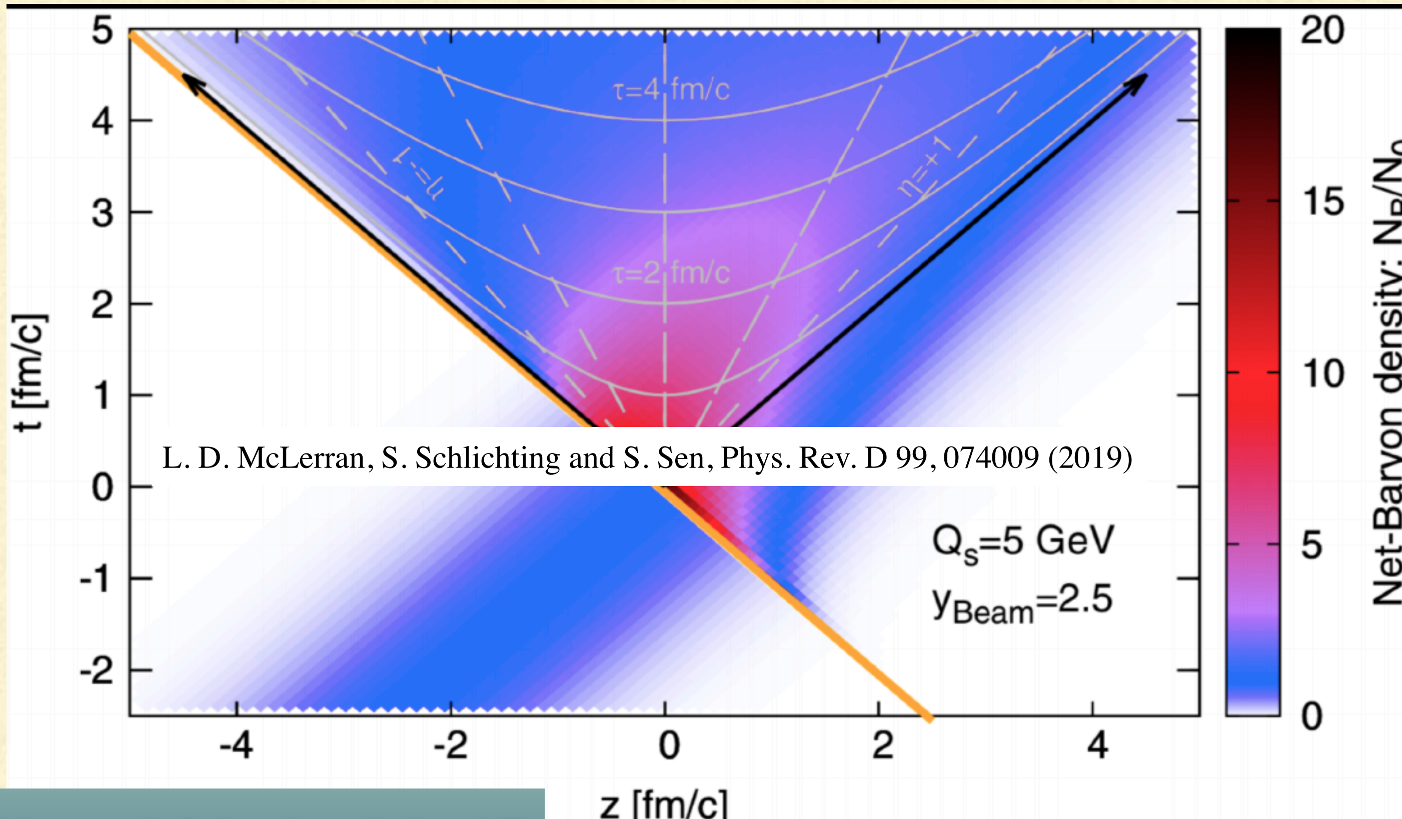


Fomin Weds 10:45

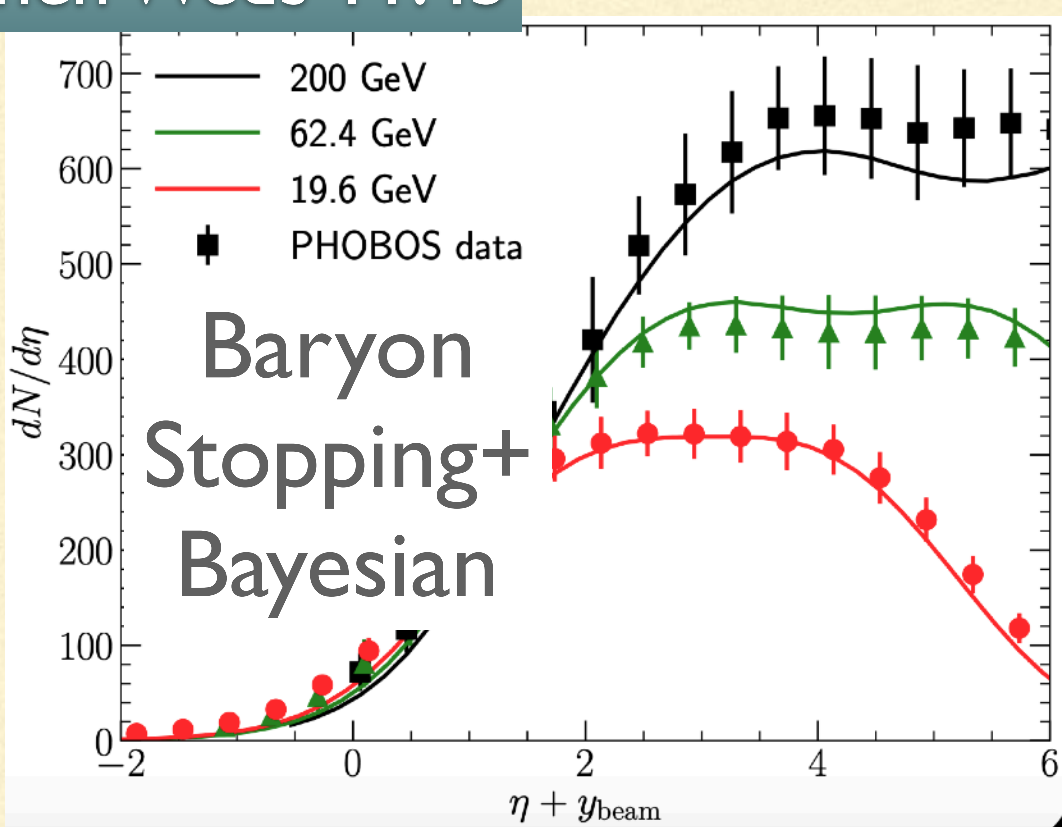
What does this mean for initial conditions in heavy ions??

INITIAL STATE+ BARYONS STRANGENESS ELECTRIC CHARGE

CGC+finite μ_B

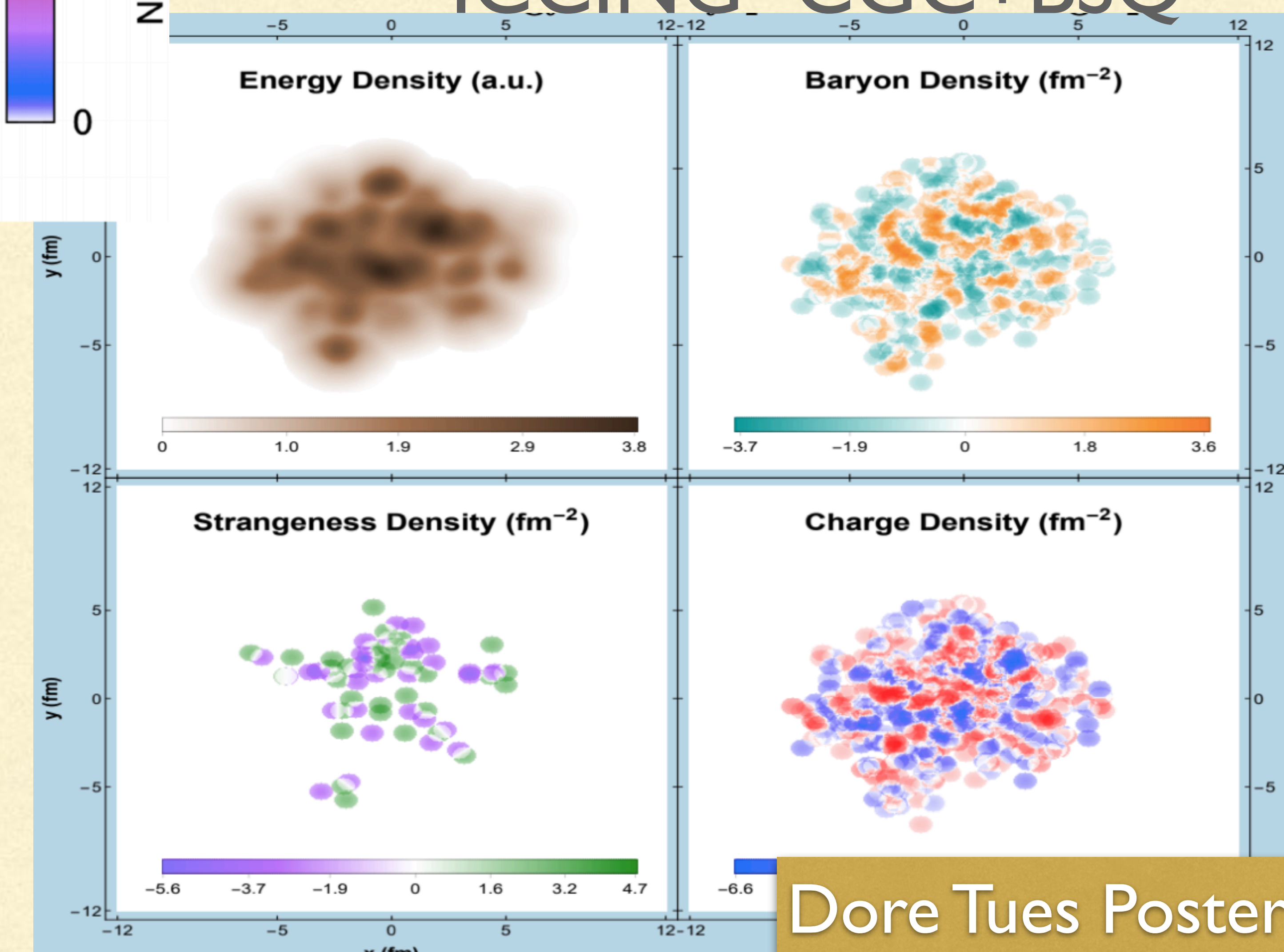


Shen Weds 11:45



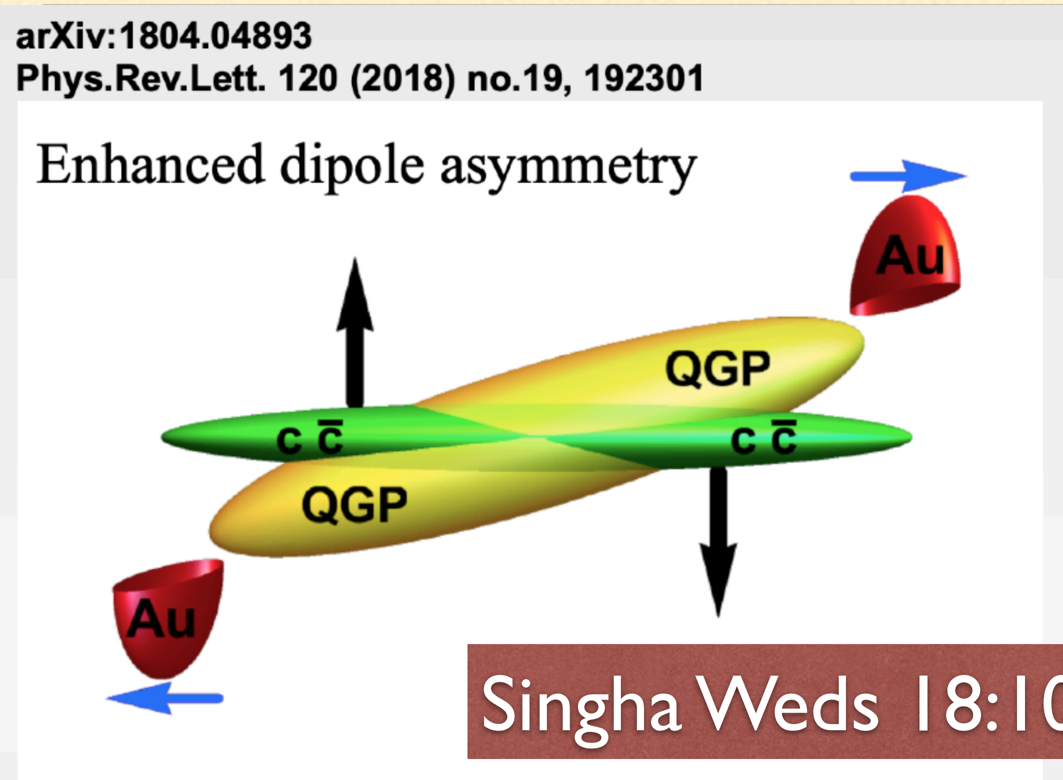
Baryon Stopping+ Bayesian

ICCING=CGC+BSQ

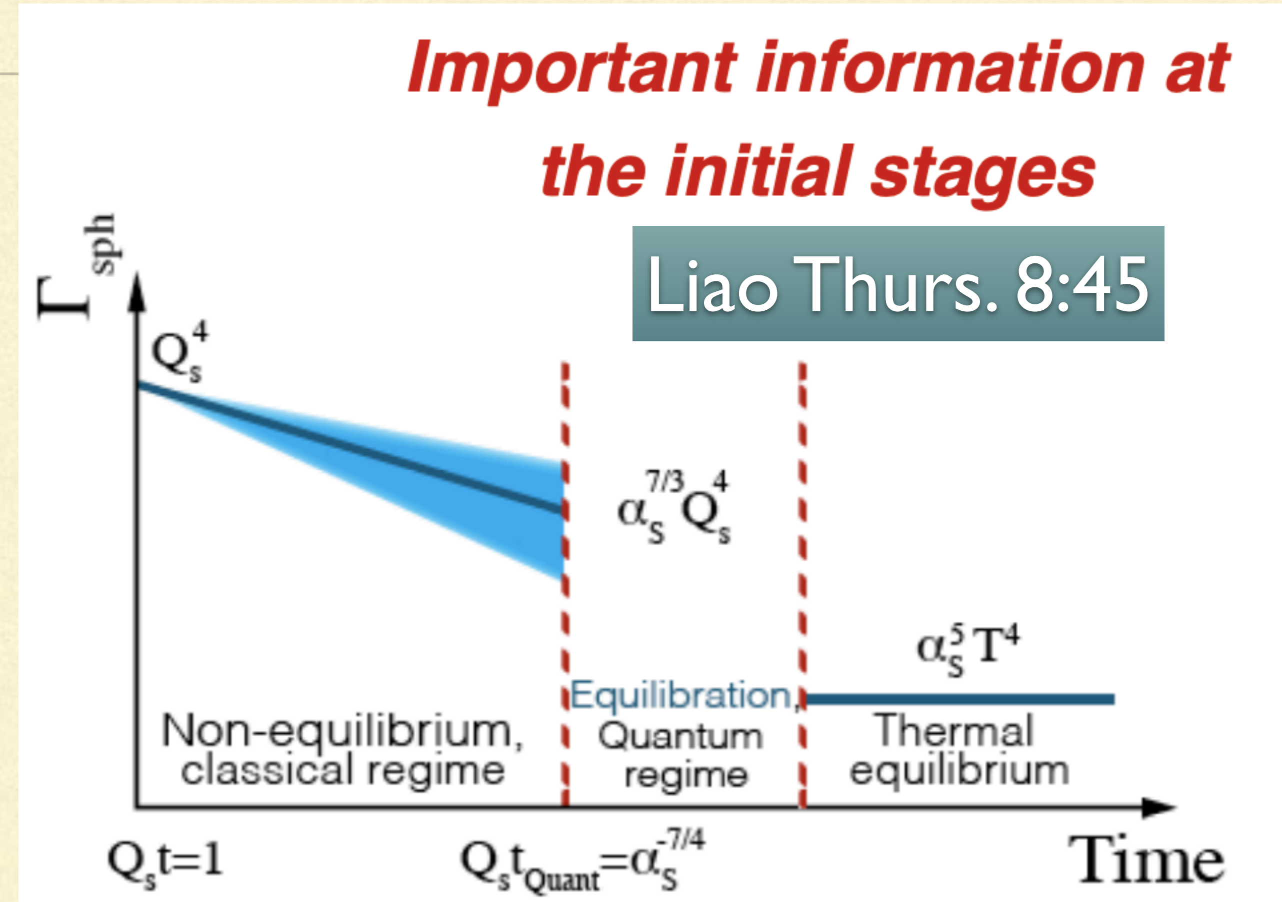


Dore Tues Poster

Magnetic fields/chirality/spin

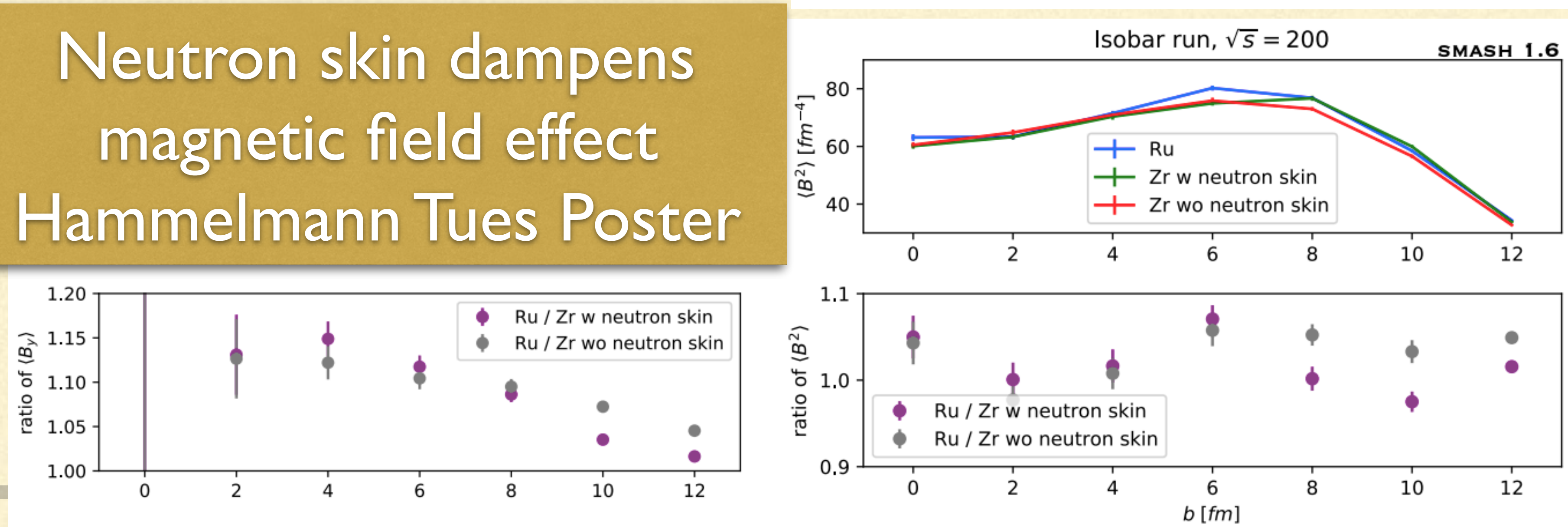


Singha Weds 18:10



Liao Thurs. 8:45

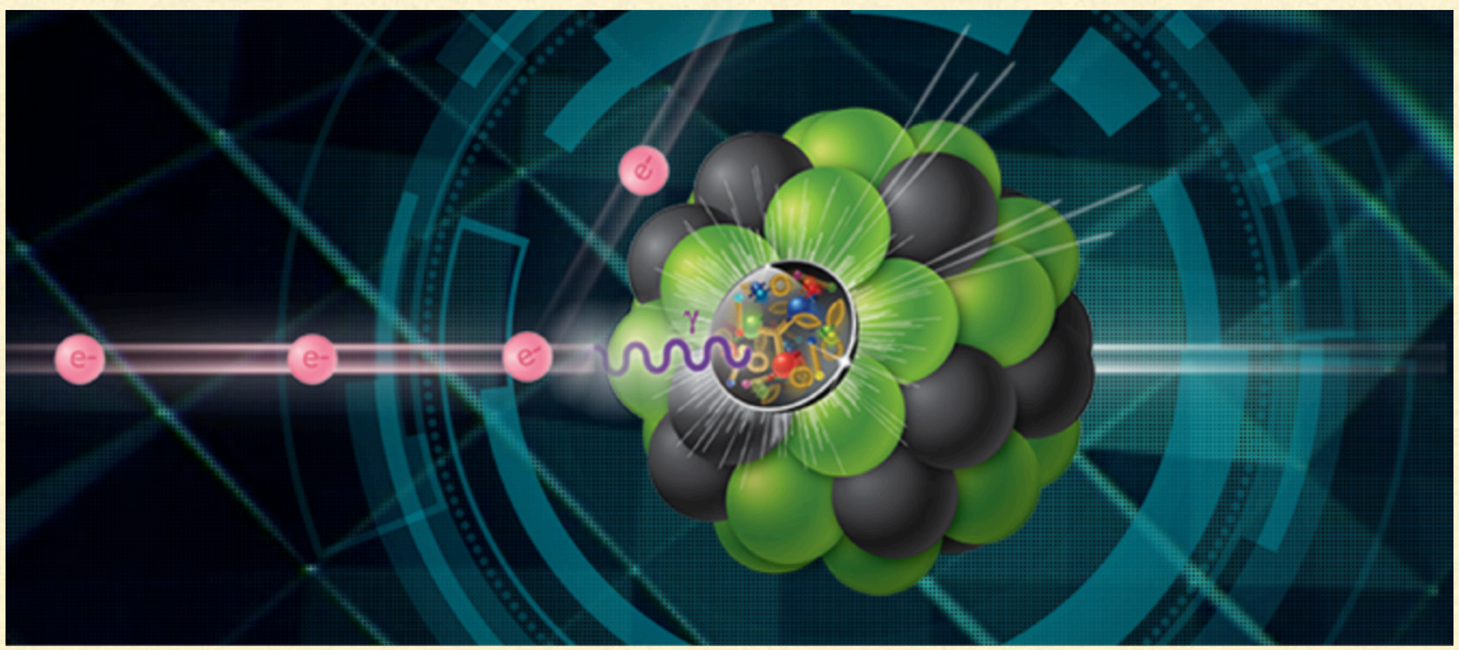
Neutron skin dampens magnetic field effect
Hammelmann Tues Poster

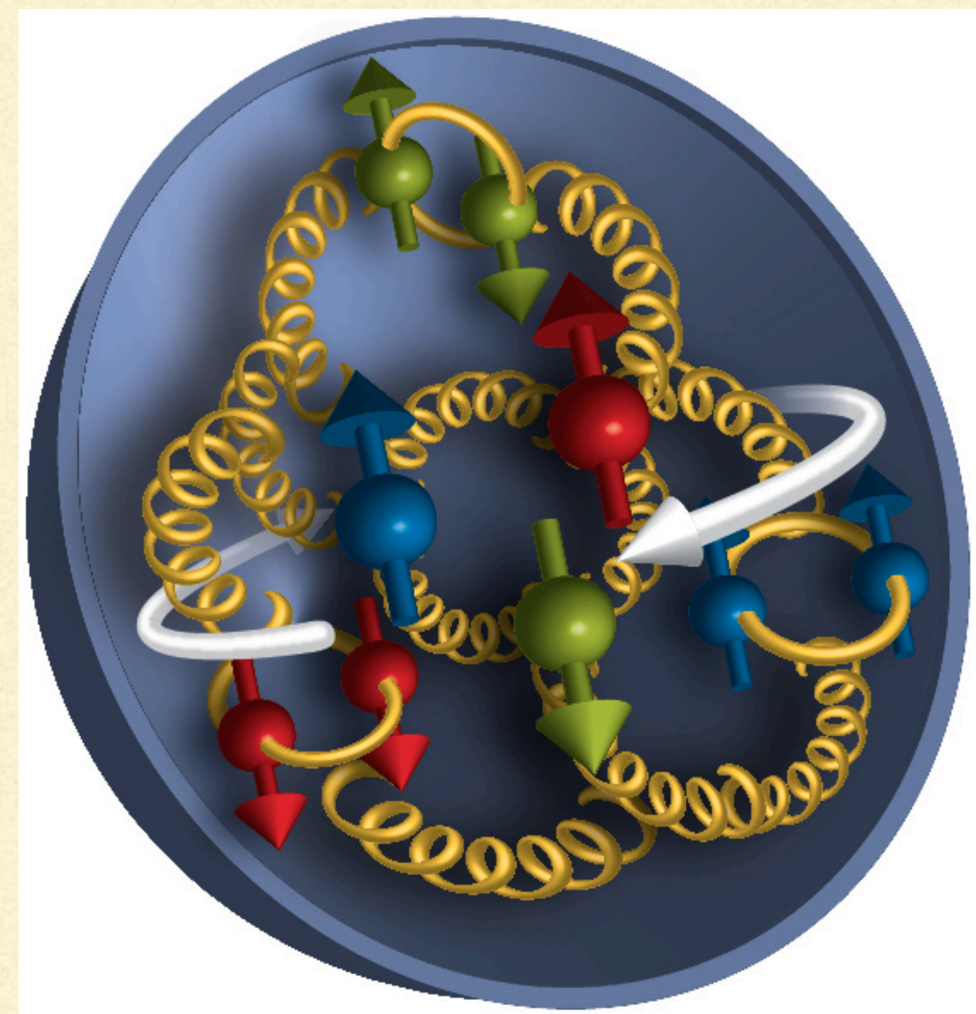


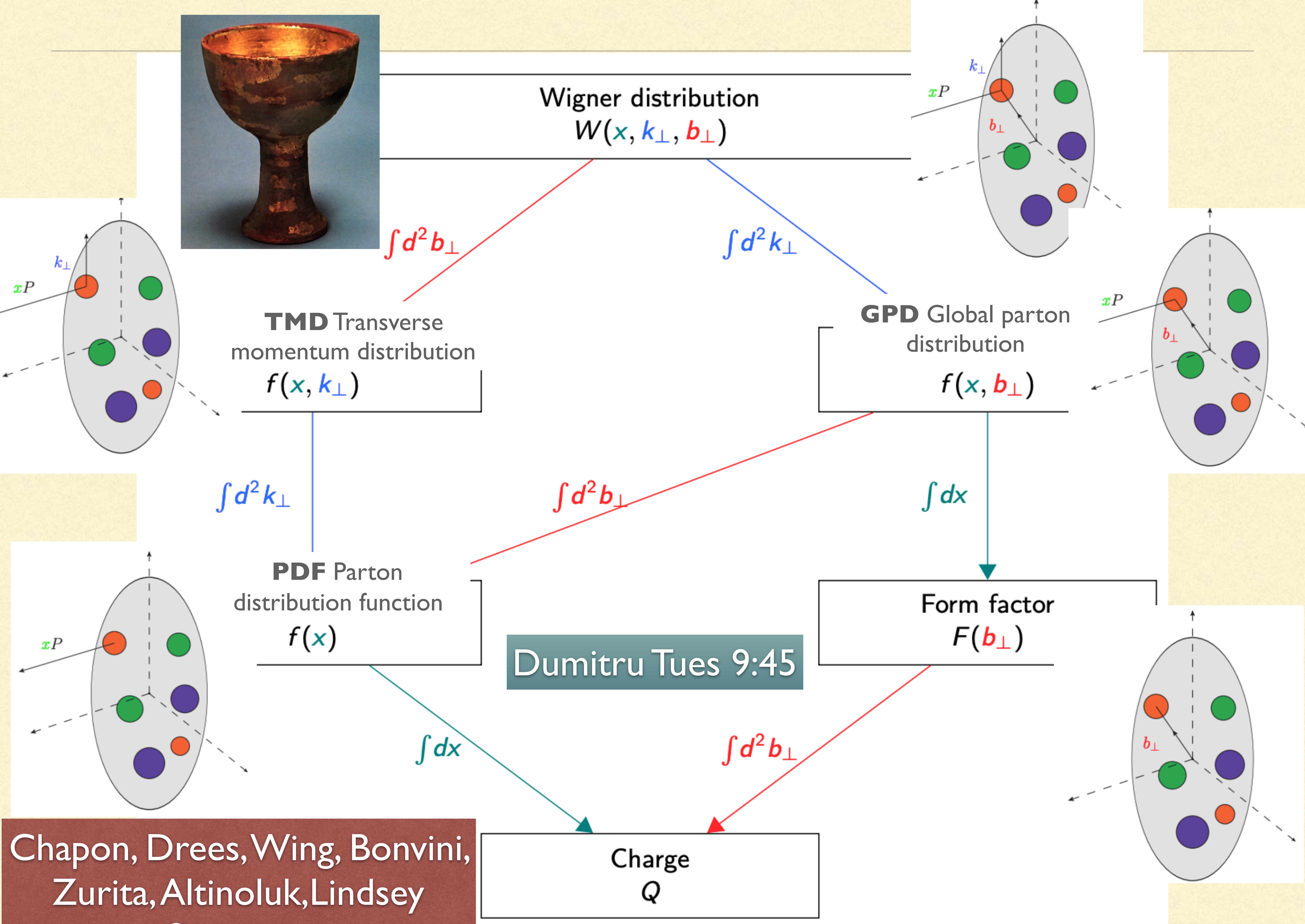
Honest question, what all is needed?

Magnetic fields+initial angular momentum+BSQ conserved charges+full $T^{\mu\nu}$+input from PDFs+nuclear structure

The guts of the proton



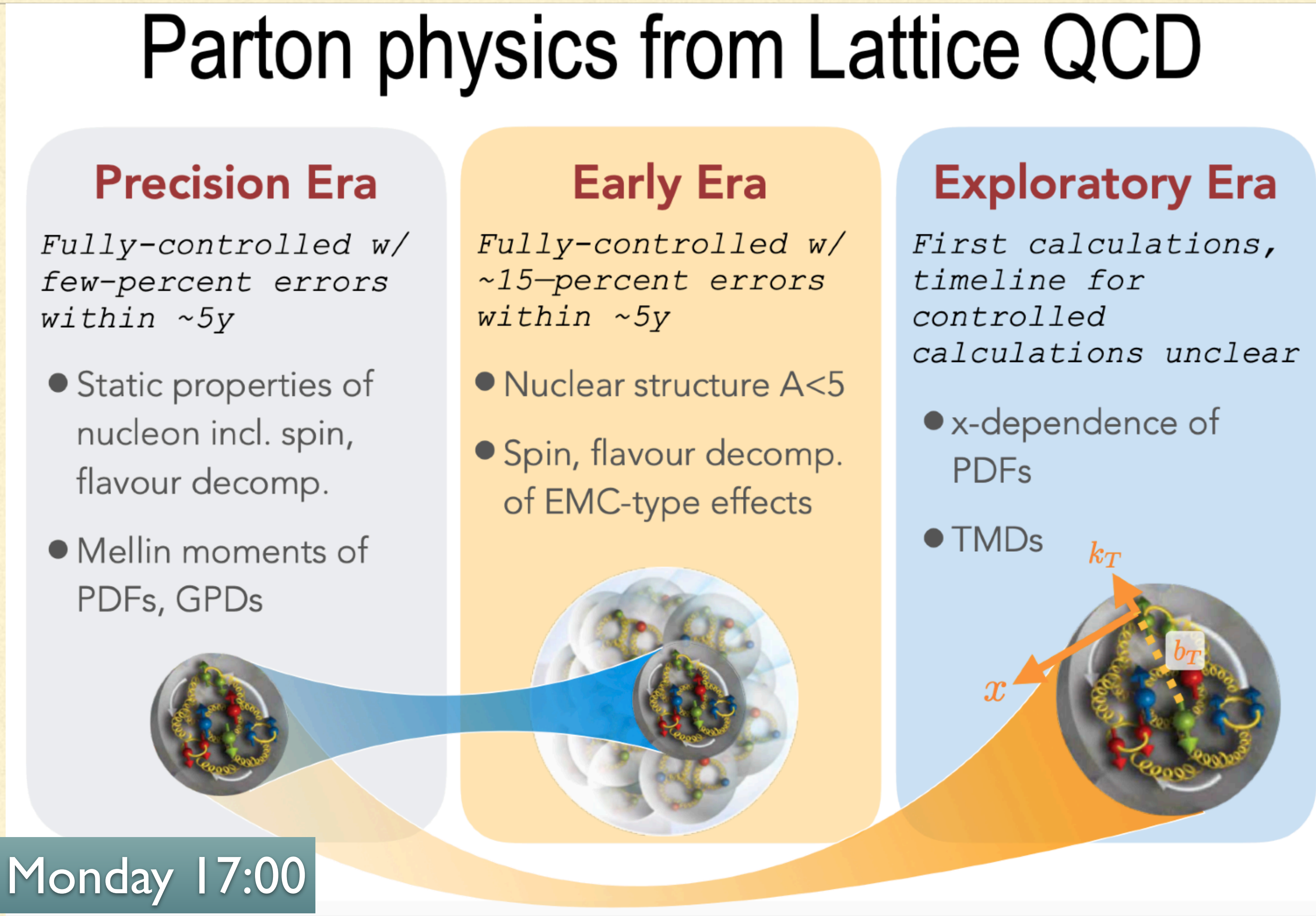




Dumitru Tues 9:45

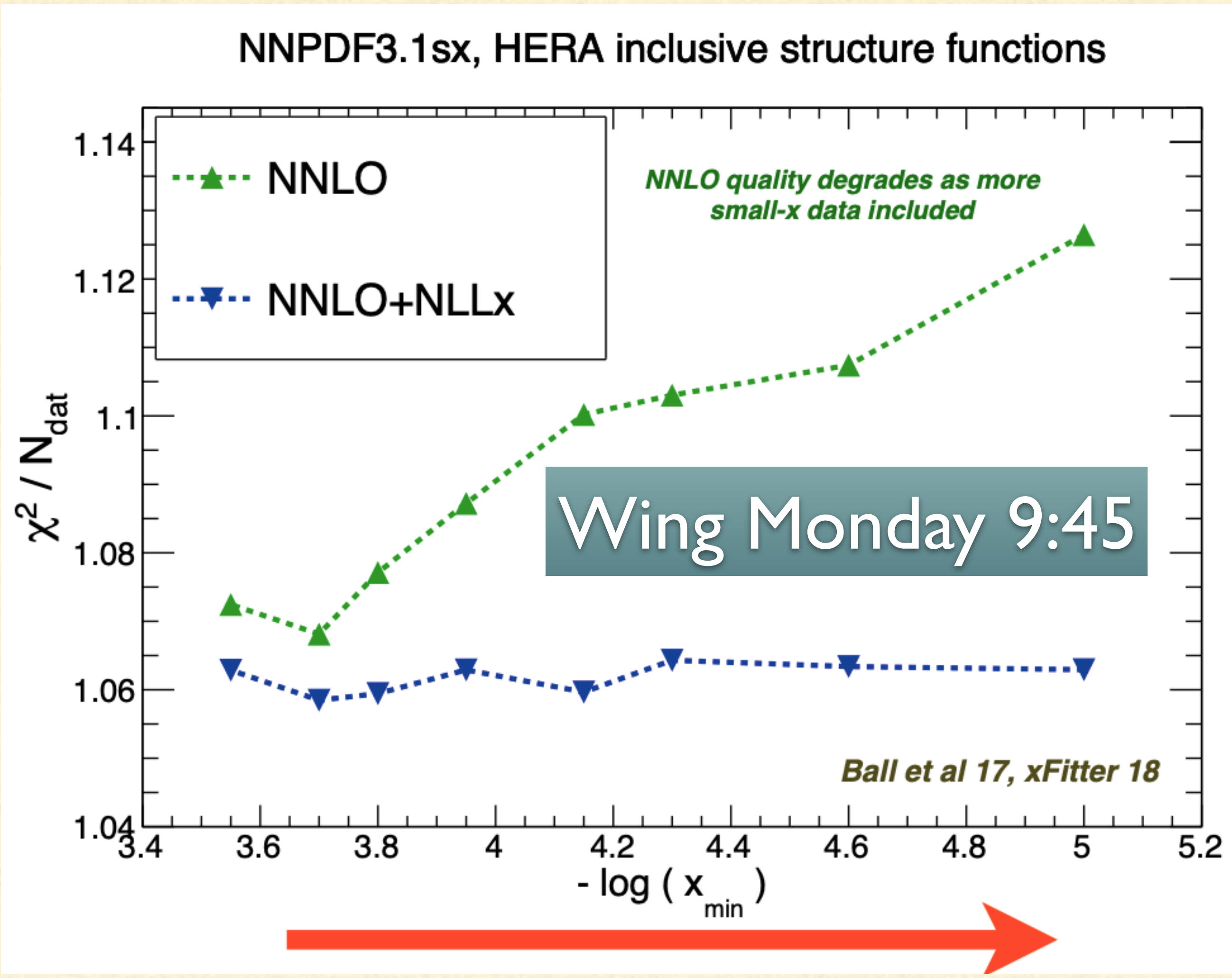
Chapon, Drees, Wing, Bonvini, Zurita, Altinoluk, Lindsey Sievert…

Structure from Lattice QCD

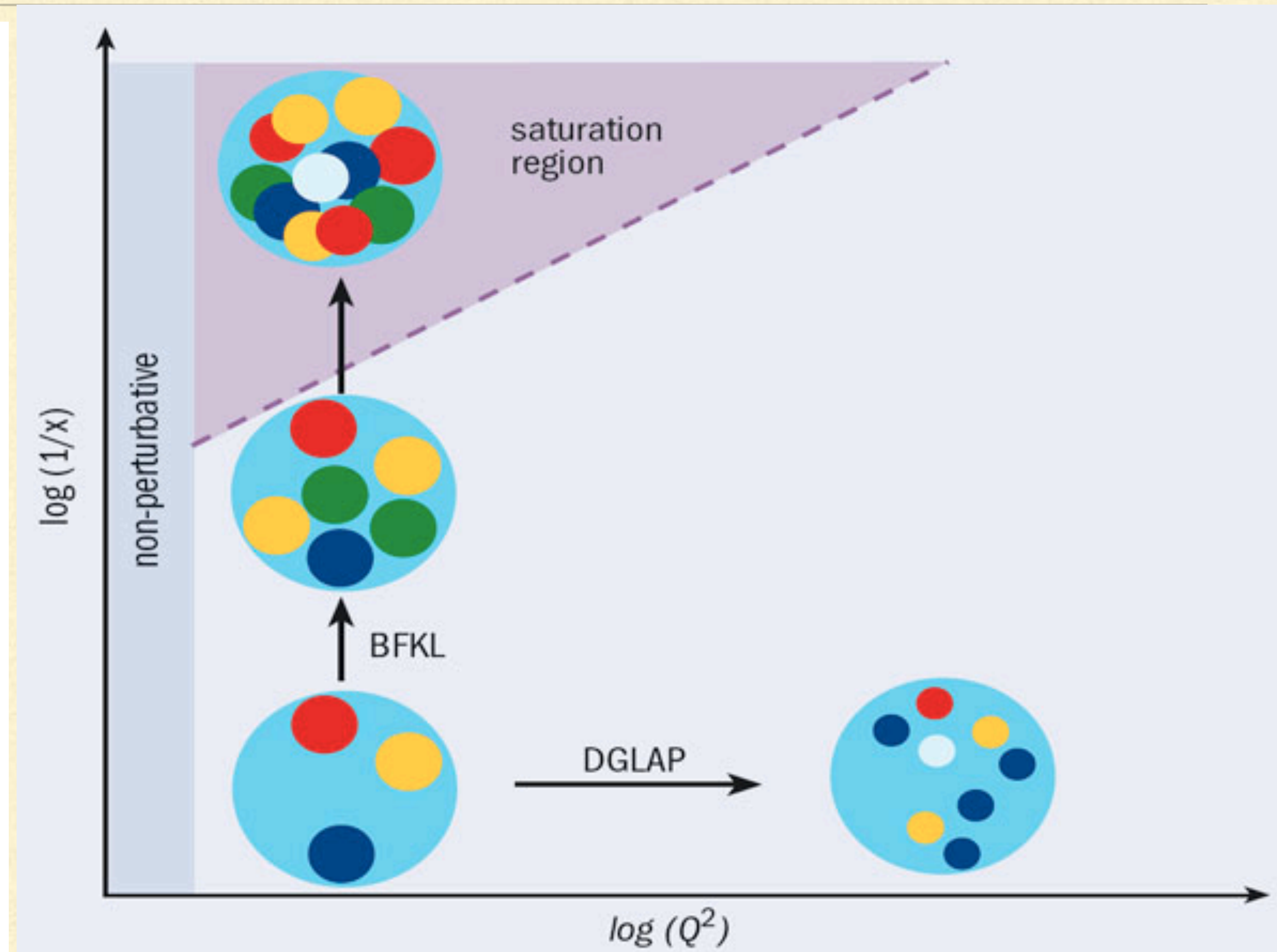


Shanahan Monday 17:00

Hints of small-x physics



Wing Monday 9:45



However, many non-trivial considerations when studying NLO small-x physics (especially once things like spin or finite μ_B need to be considered!).
Sievert Friday 9:30 and Altinoluk Monday 17:30

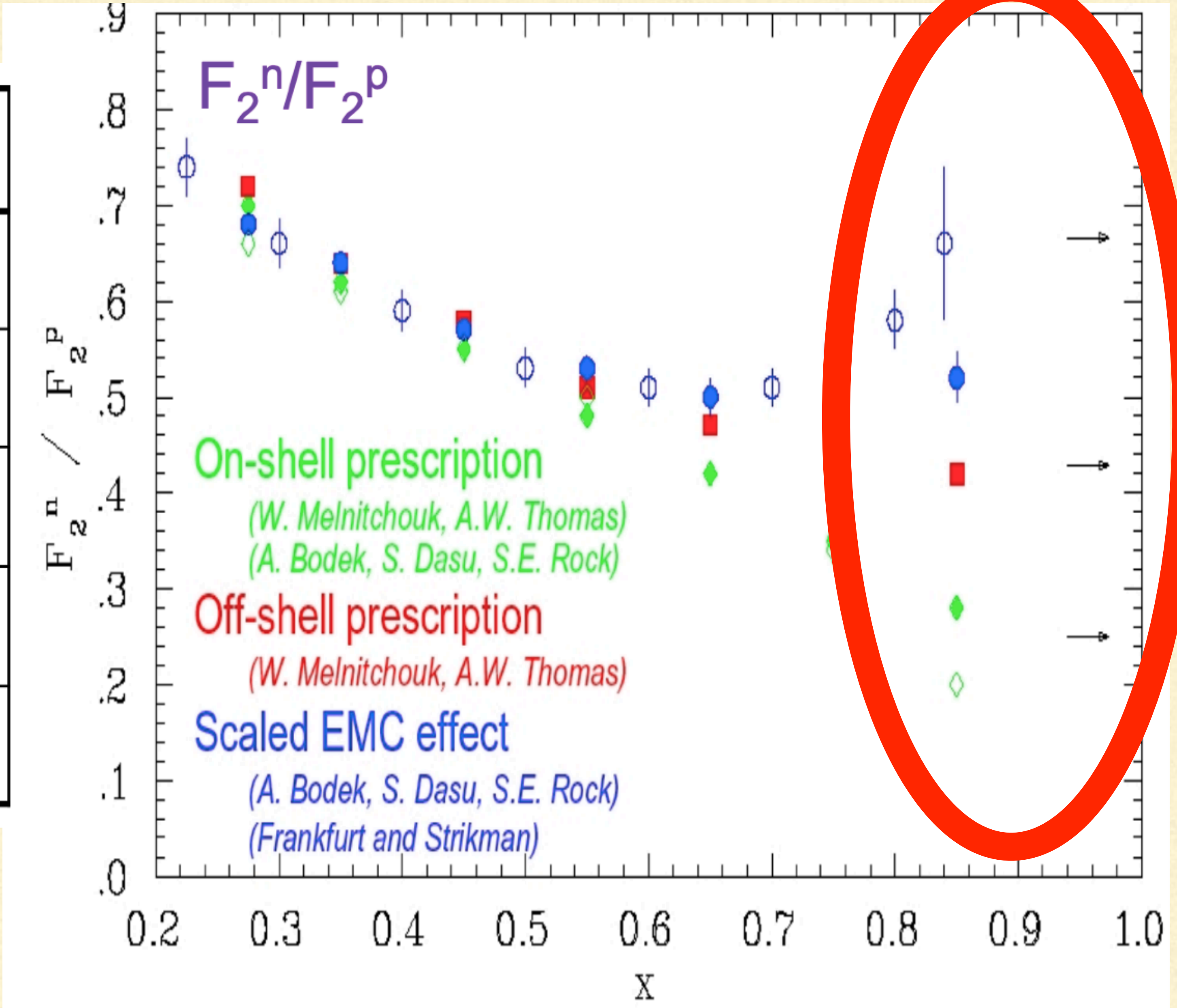
How is the momentum distributed inside a neutron at large x?

Theory

Nucleon Model	F_2^n/F_2^p	d/u
SU(6)	2/3	1/2
Valence Quark	1/4	0
DSE contact interaction	0.41	0.18
DSE realistic interaction	0.49	0.28
pQCD	3/7	1/5

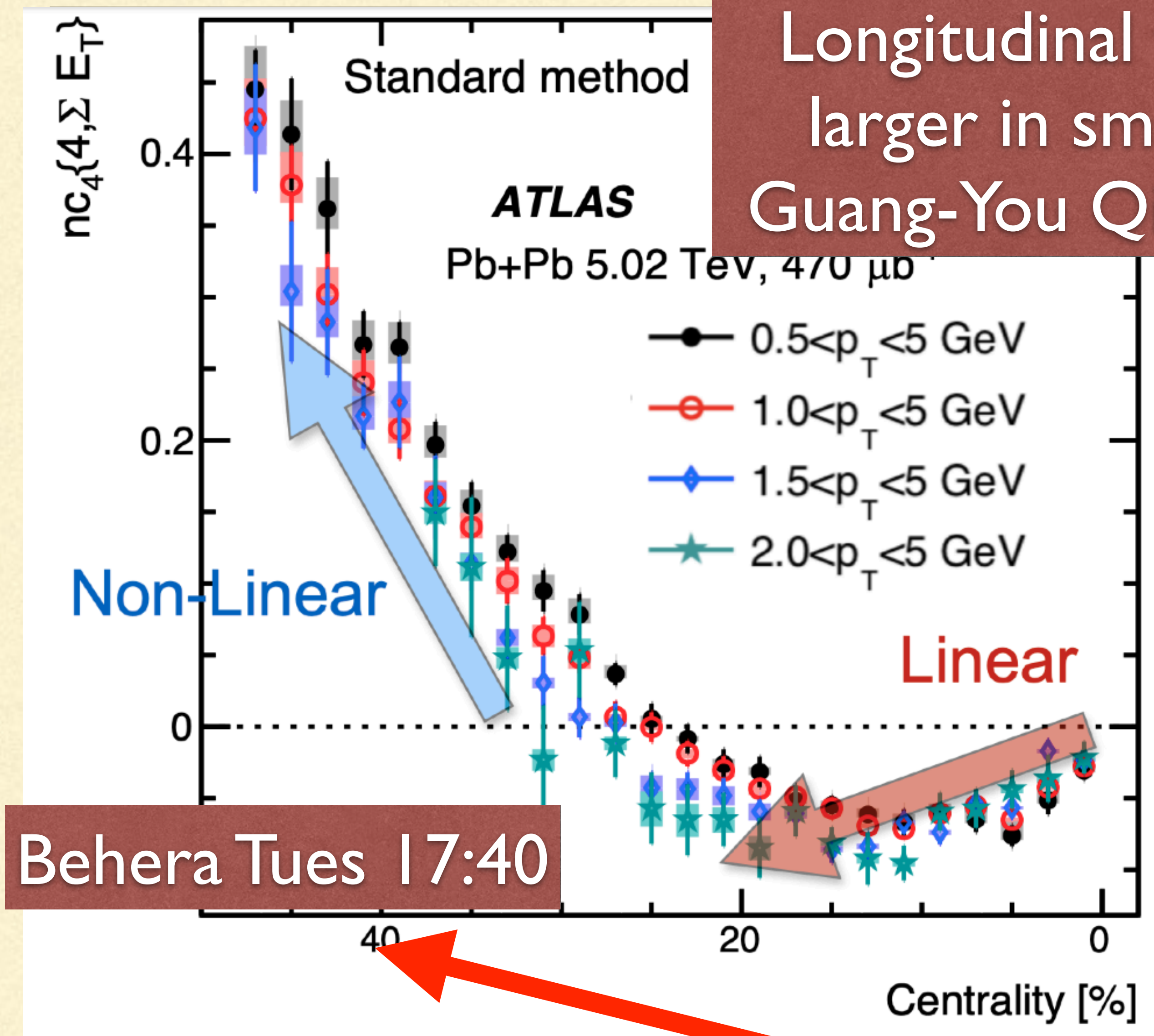
JLab progress
Keppel Tues 8:45

Experiment



Questions remaining in large heavy-ion systems

IC+hydrodynamics puzzles

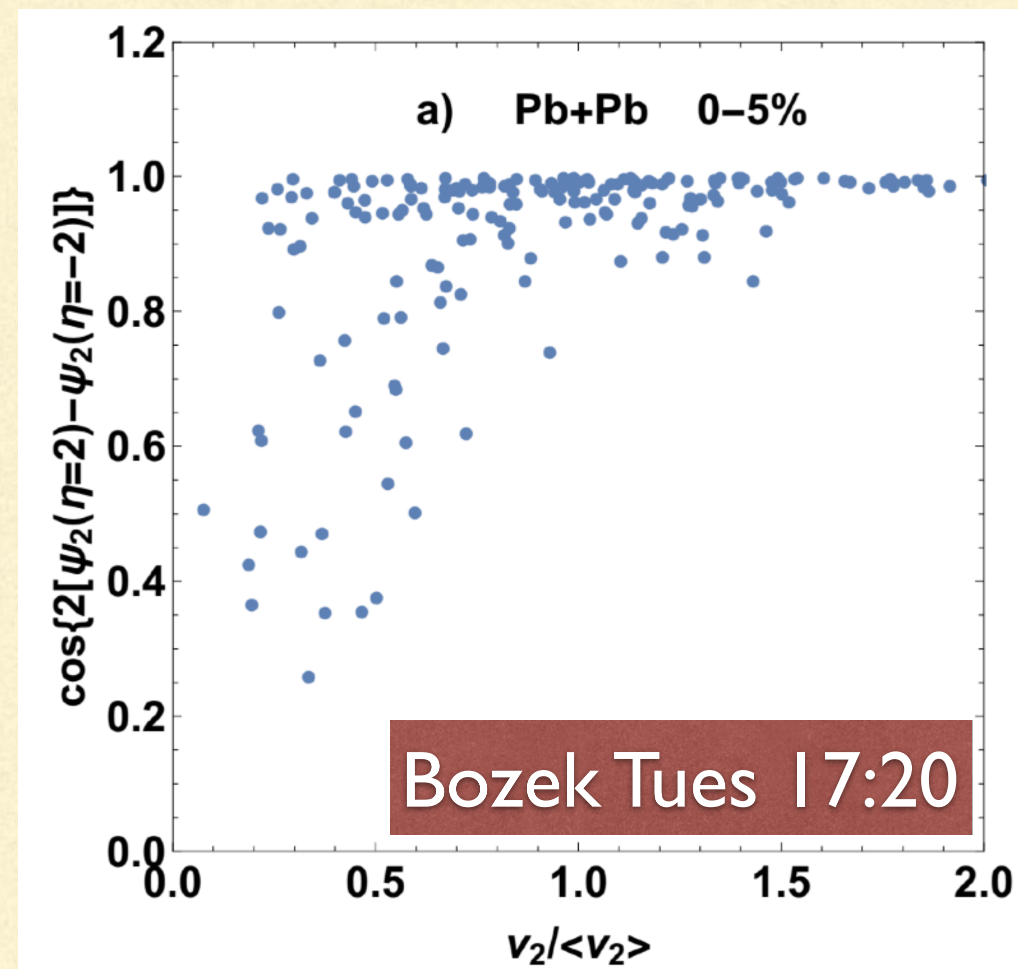


Longitudinal fluctuations larger in small systems
Guang-You Qin Tues 18:00

Behera Tues 17:40

Twisting angle large for small v2

η in ICs important

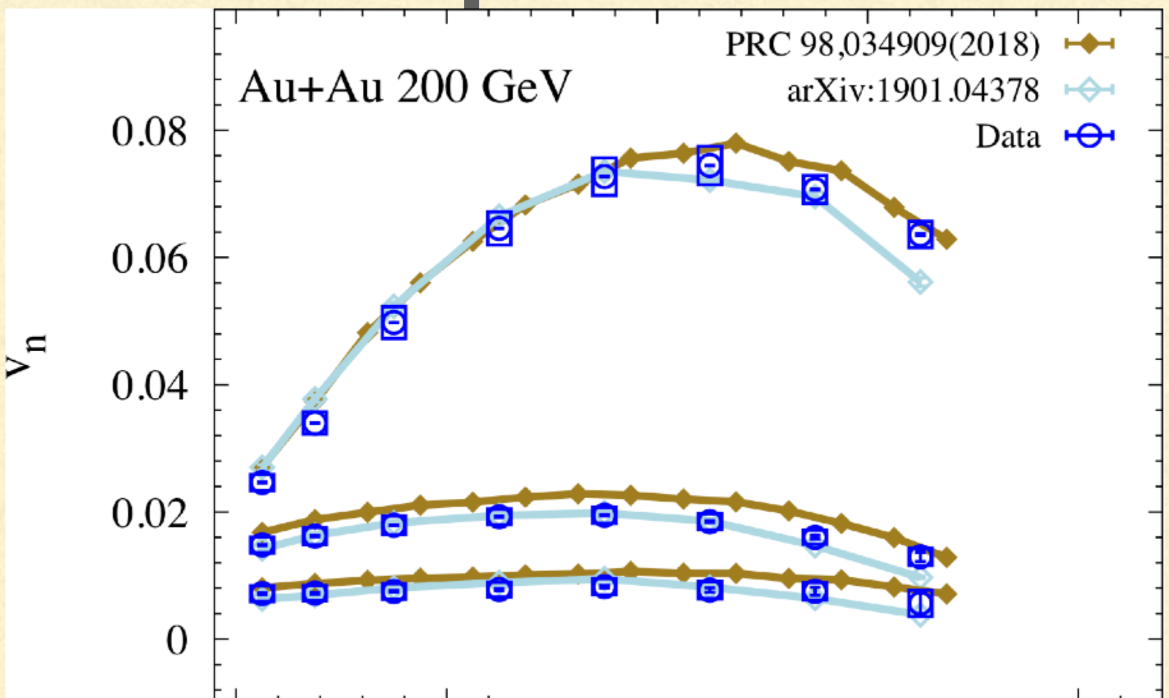


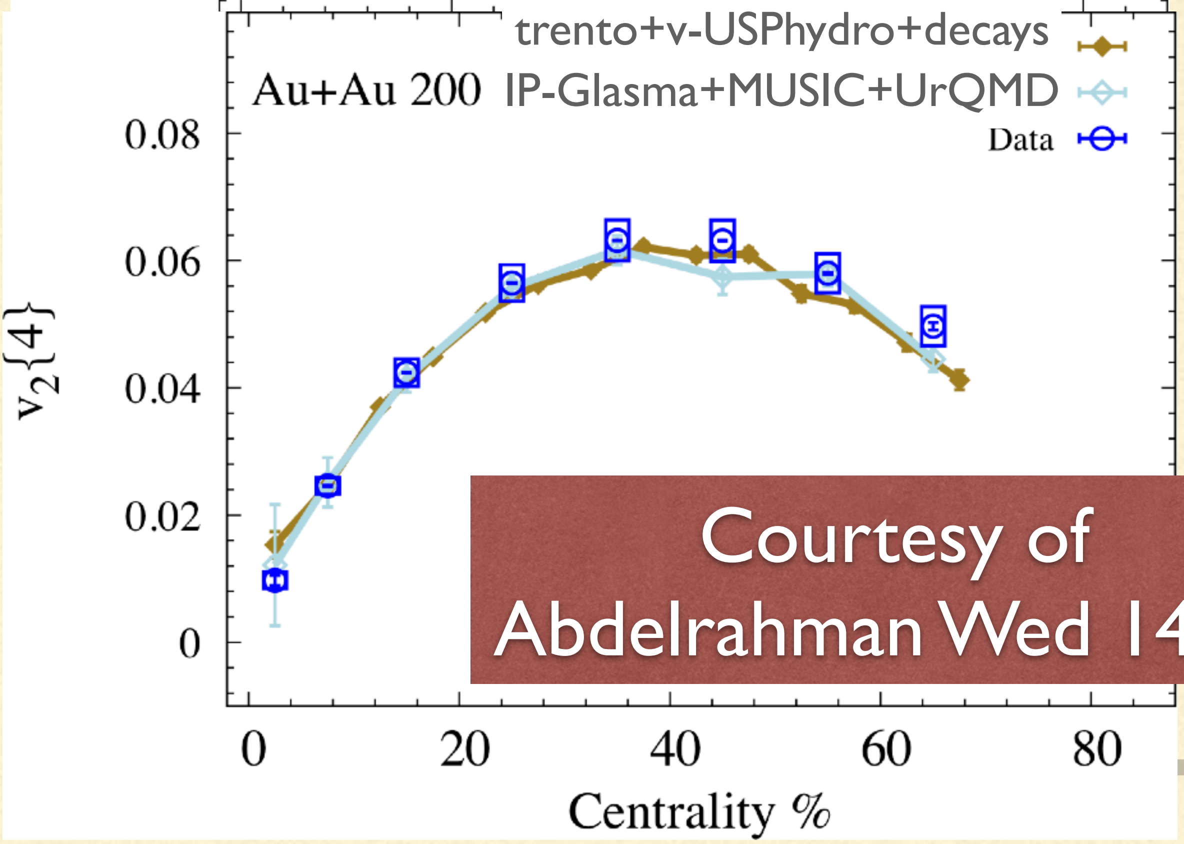
Bozek Tues 17:20

Hydro switches at ~40%

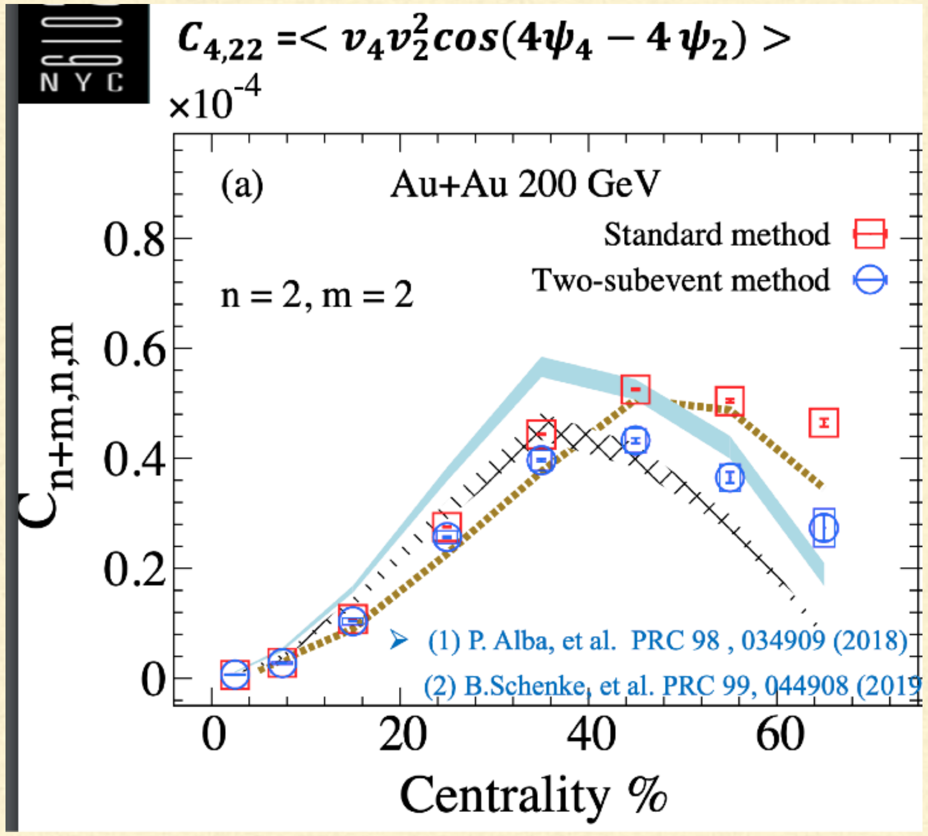
Giacalone et al, J.Phys.Conf.Ser. 779 (2017) no.1, 012064
Alba et al, Phys.Rev. C98 (2018) no.3, 034909

Discriminating observables for transport coefficients





Courtesy of Abdelrahman Wed 14:40

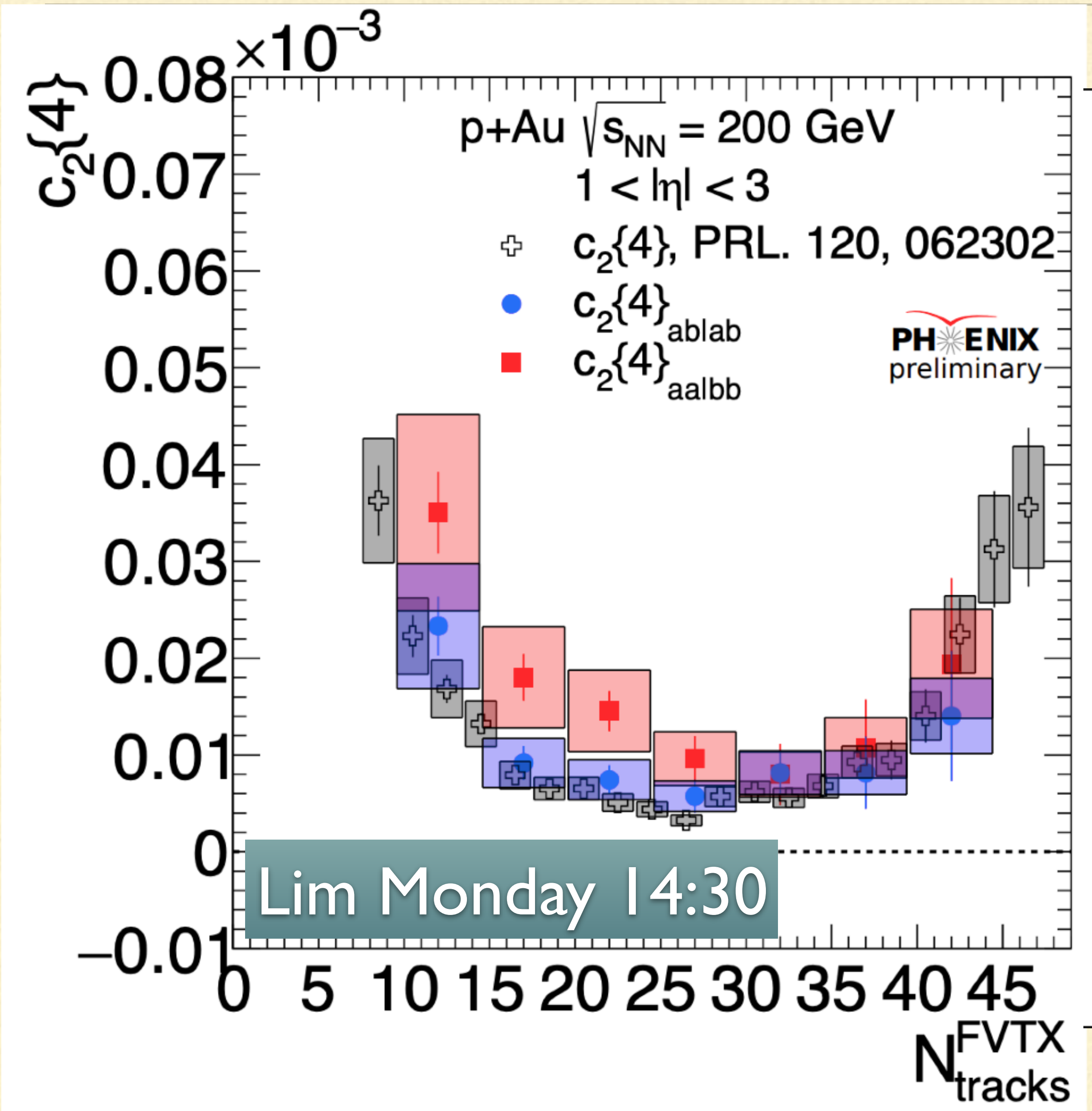


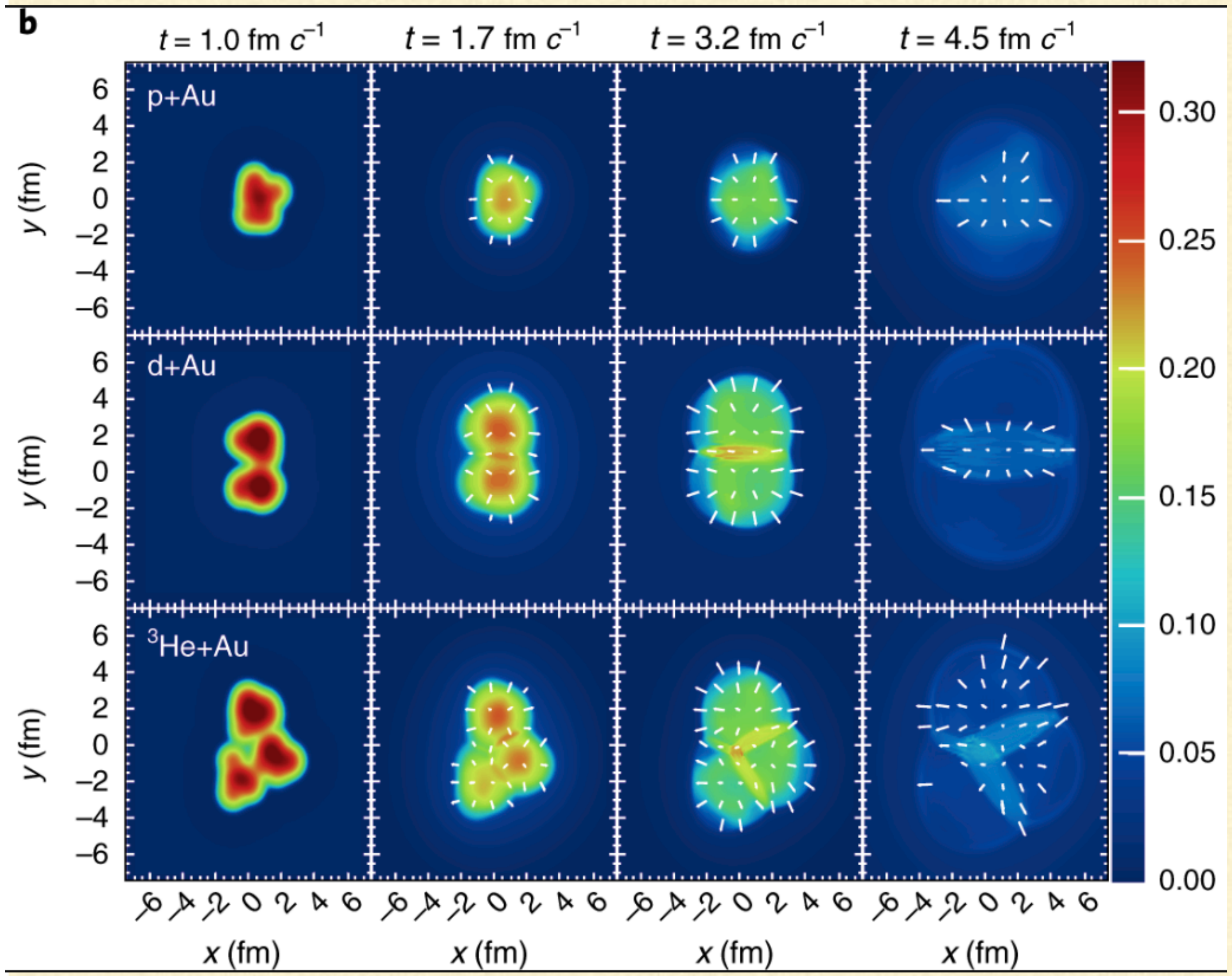
Event plane correlations distinguish transport coefficients

Niemi et al, Phys.Rev. C93 (2016) no.2, 024907

Do we have any hope of understanding small systems?

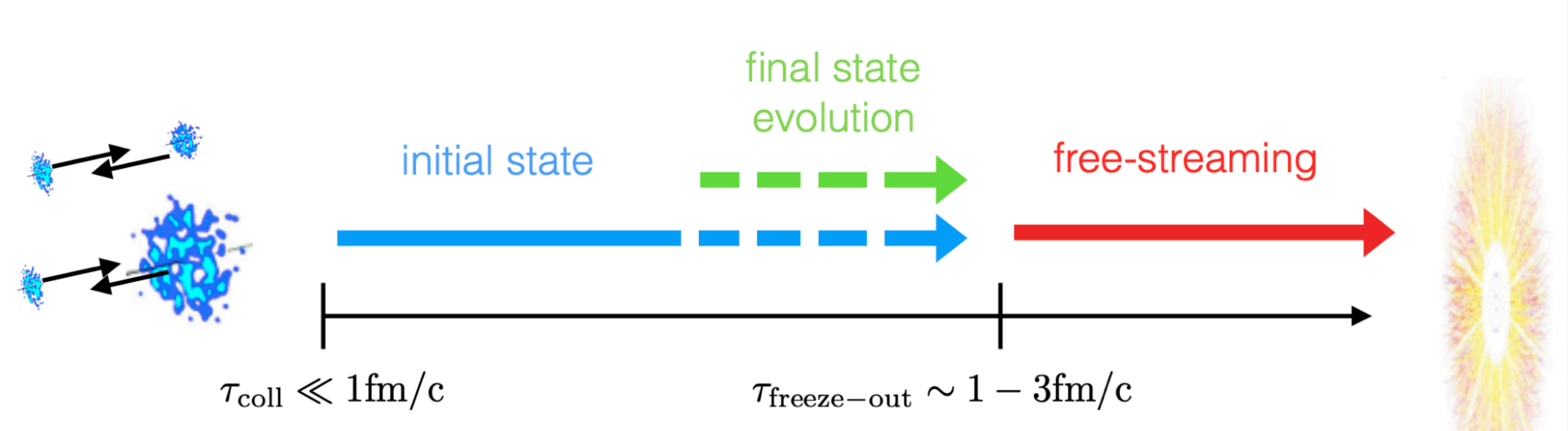
PHENIX sub-events (signal holds)





Initial vs. Final State in small systems

We should always compare **Initial Conditions**+Hydrodynamics vs. CGC (or your other favorite model)

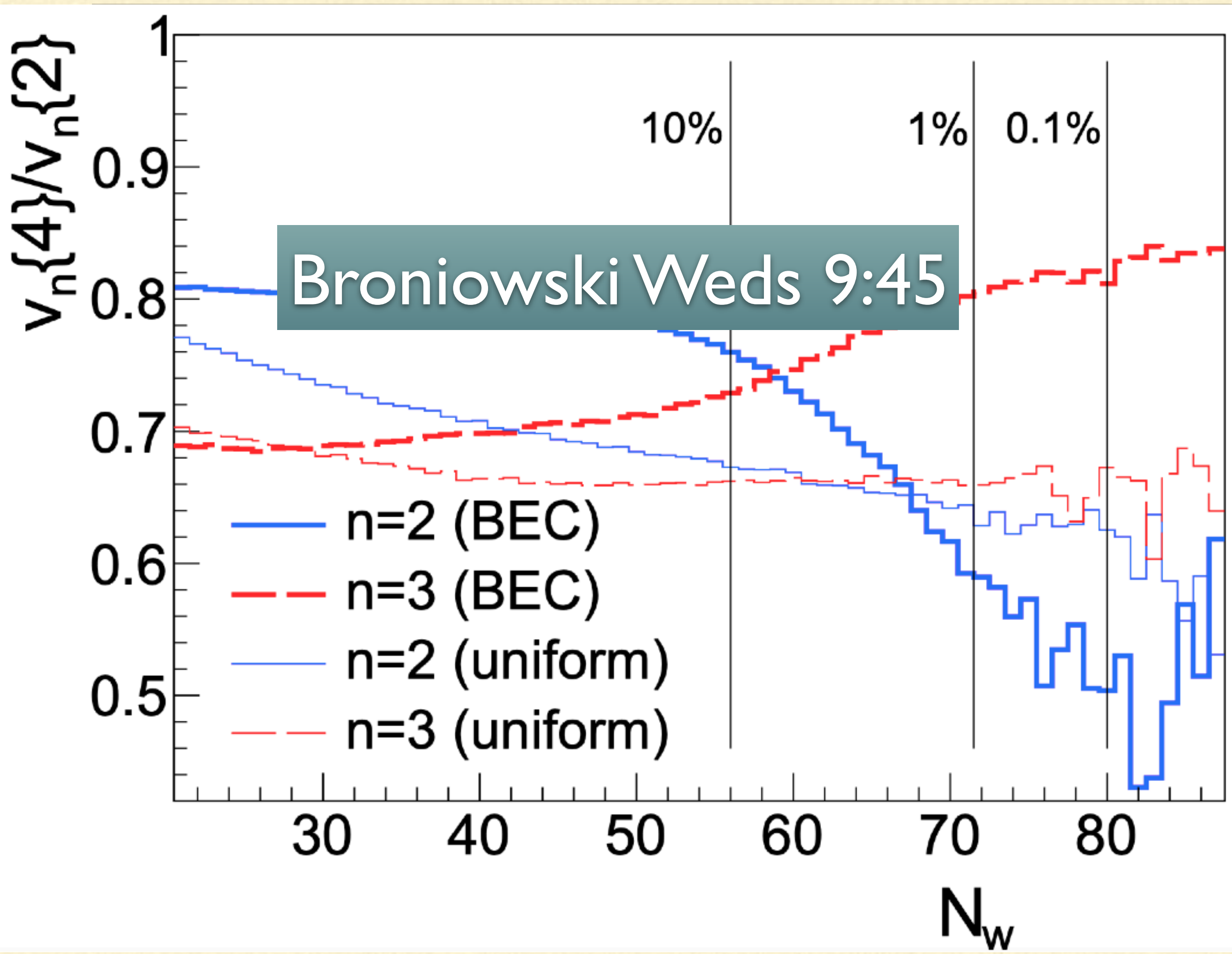


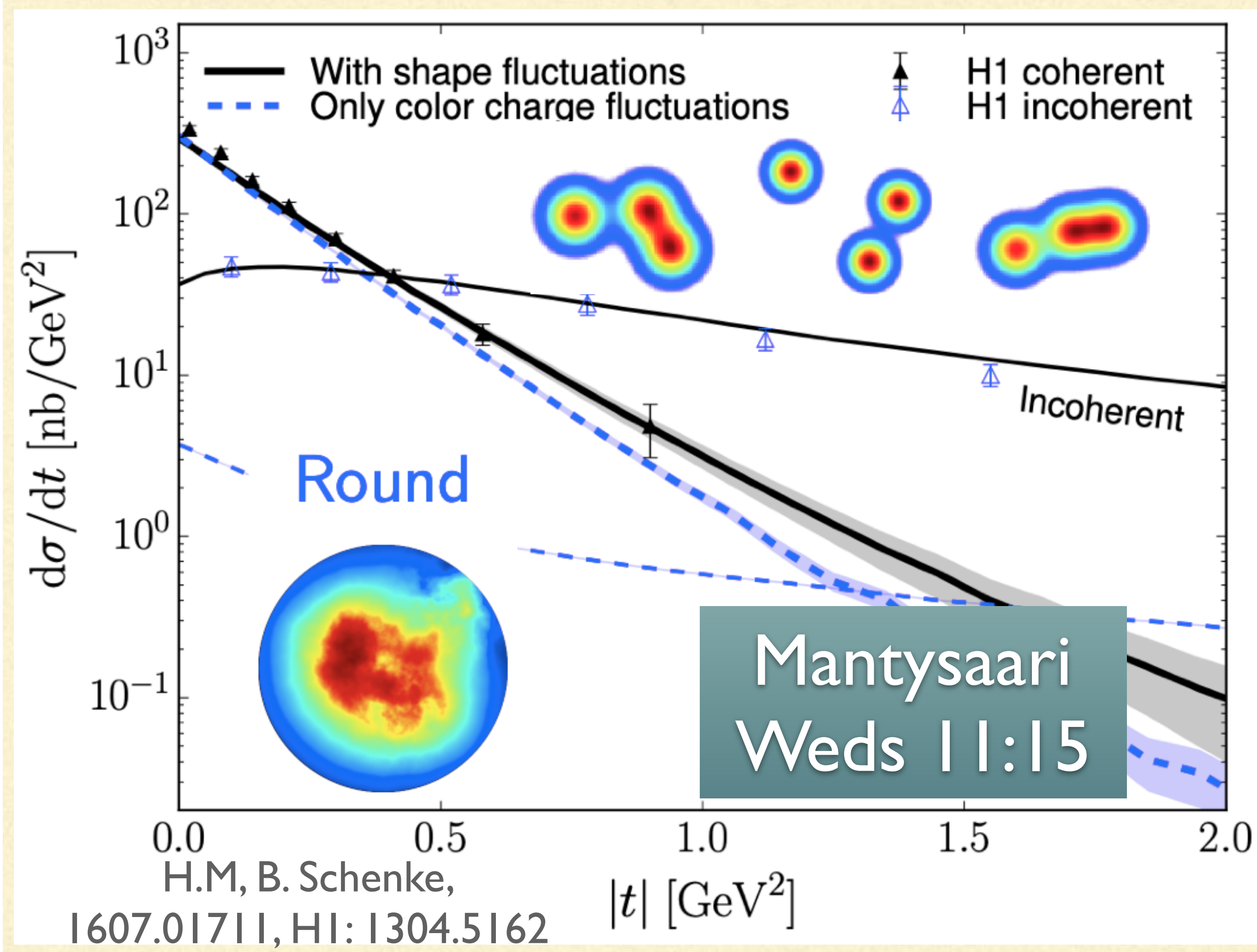
Schlichting Mon 8:45

In fact, small systems provide an **opportunity** to learn about microscopic physics

Mapping of full $T^{\mu\nu}$
Luzum Poster

Constraining initial conditions in small systems





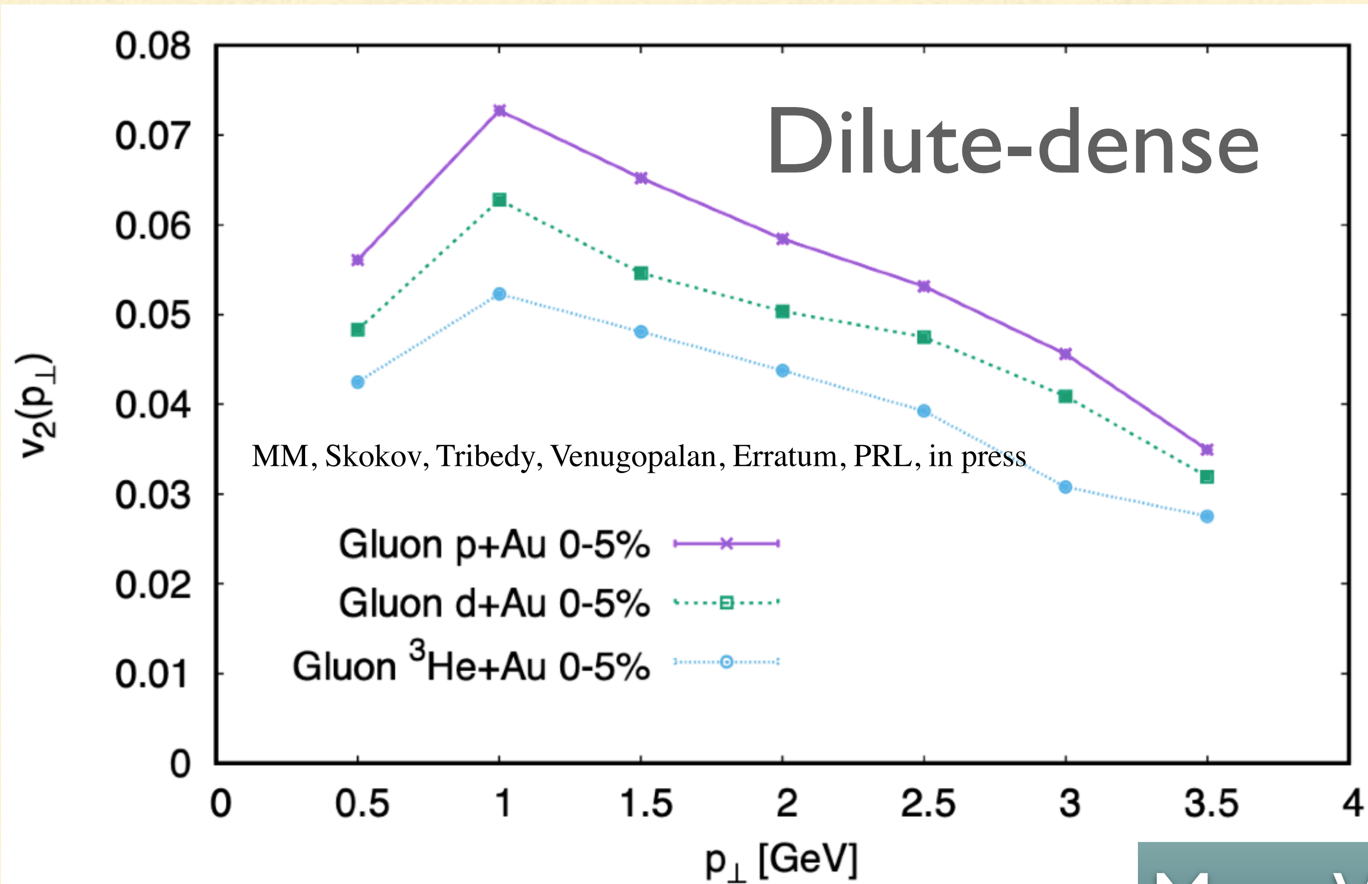
Use $\frac{v_n\{4\}}{v_n\{2\}} \sim \frac{\varepsilon_n\{4\}}{\varepsilon_n\{2\}}$ to constrain ICs

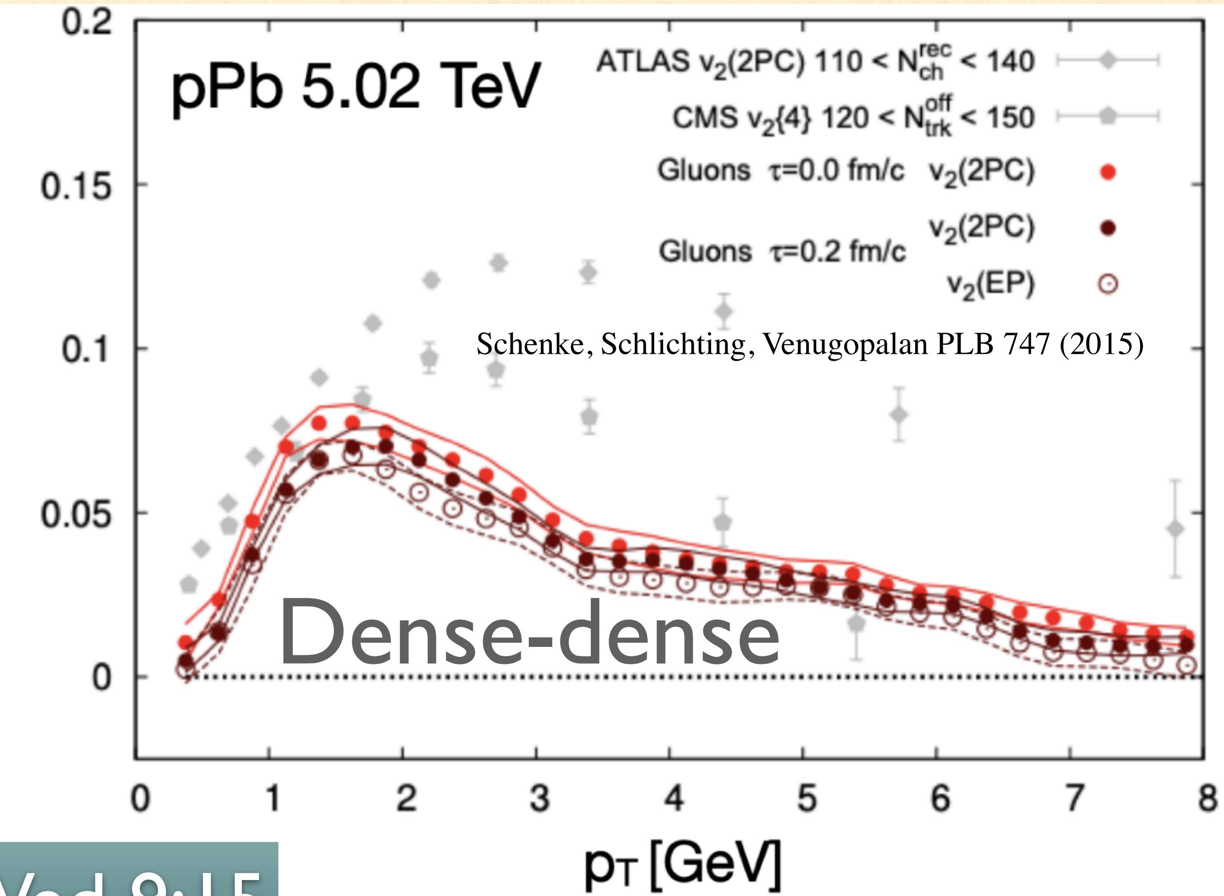
Giacalone et al, Phys.Rev. C95 (2017) no.5, 054910
Sievert & JNH arXiv:1901.01319

Symmetric cumulant questions as well

Behera, Gajdosova, Mohapatra, Pacik,Alba

Dilute-dense vs. dense-dense

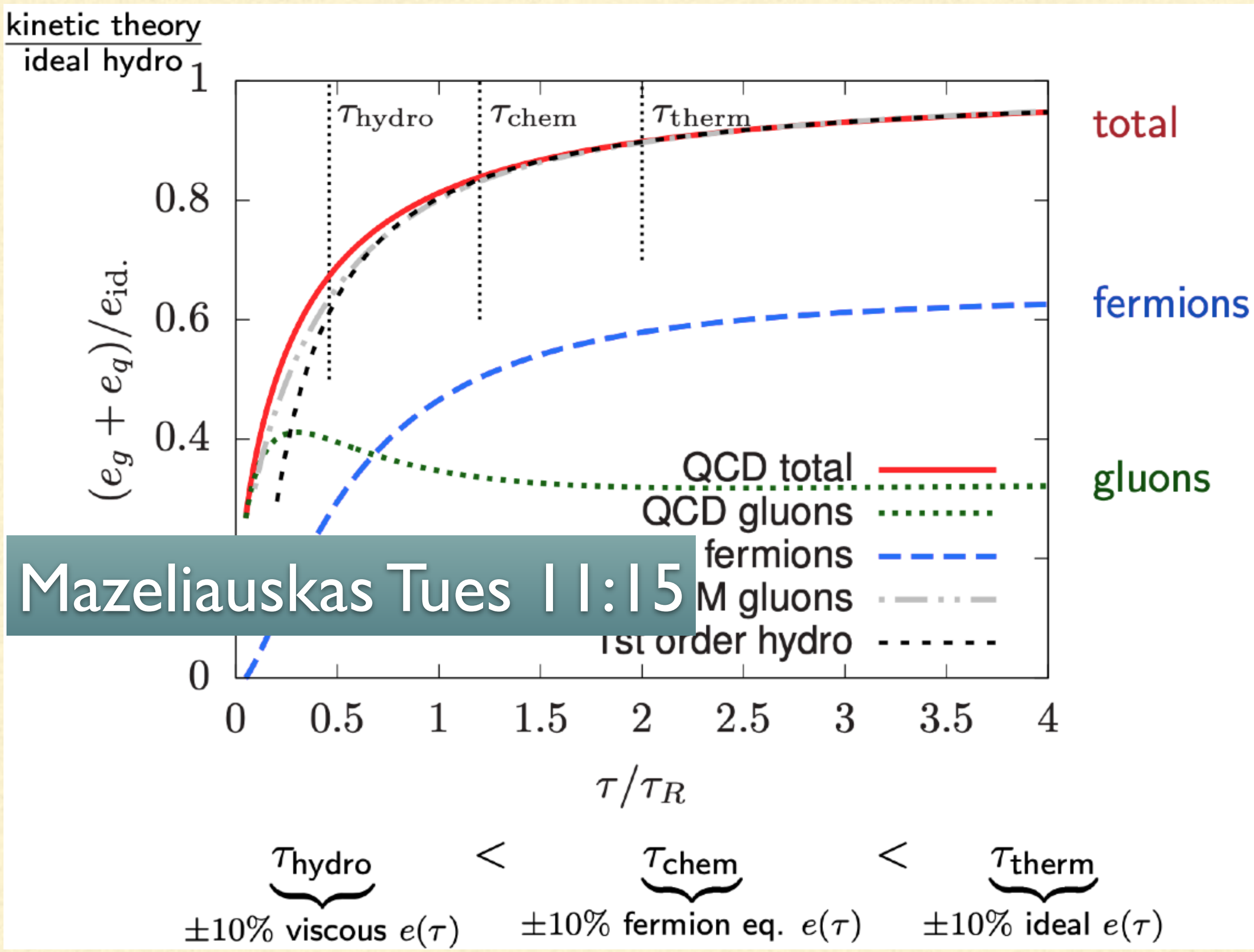




Mace Wed 9:15

Other observables? Hopefully more to come by next Initial Stages

Can we understand early time scales?

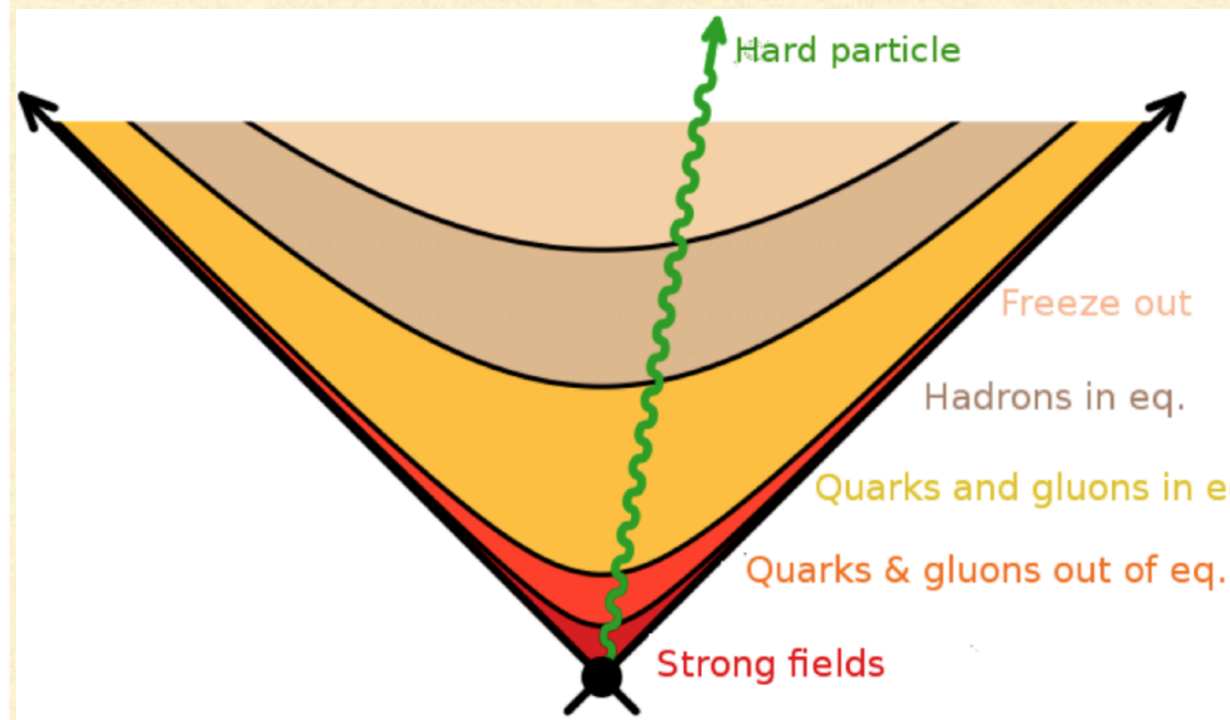


Mazeliauskas Tues 11:15

Andres Thurs 14:00

No energy loss before

$$\tau_{therm} \gtrapprox 0.6\ fm$$



Schlichting (Mon), Berges (Tues), Heller (Tues), Noronha (Tues), Martinez (Tues), Denicol (Tues),

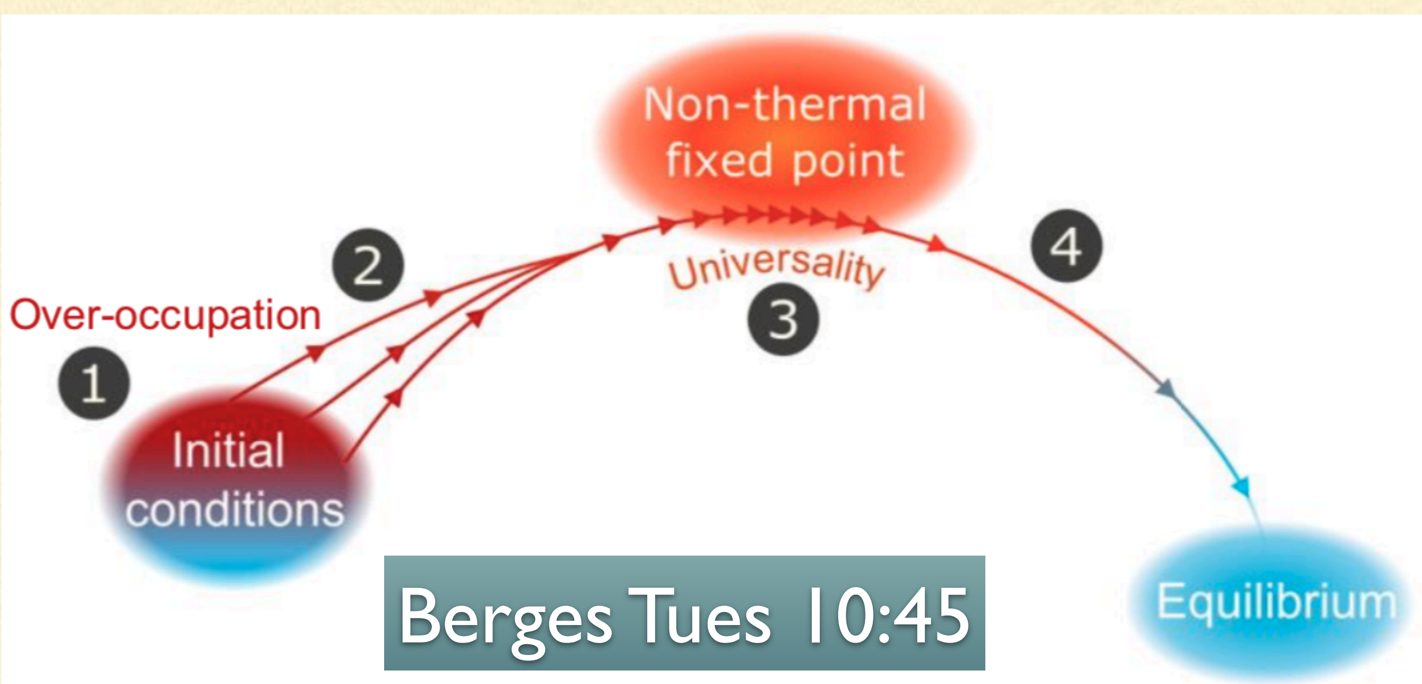
Non-thermal attractors

gluon distribution function

(pre-)scaling exponents

$$\boxed{f_g(p_\perp, p_z, \tau) = \tau^{\alpha(\tau)} f_S\left(\tau^{\beta(\tau)} p_\perp, \tau^{\gamma(\tau)} p_z\right)}$$

universal fixed-point distribution



Signals in small systems or hard/heavy probes?

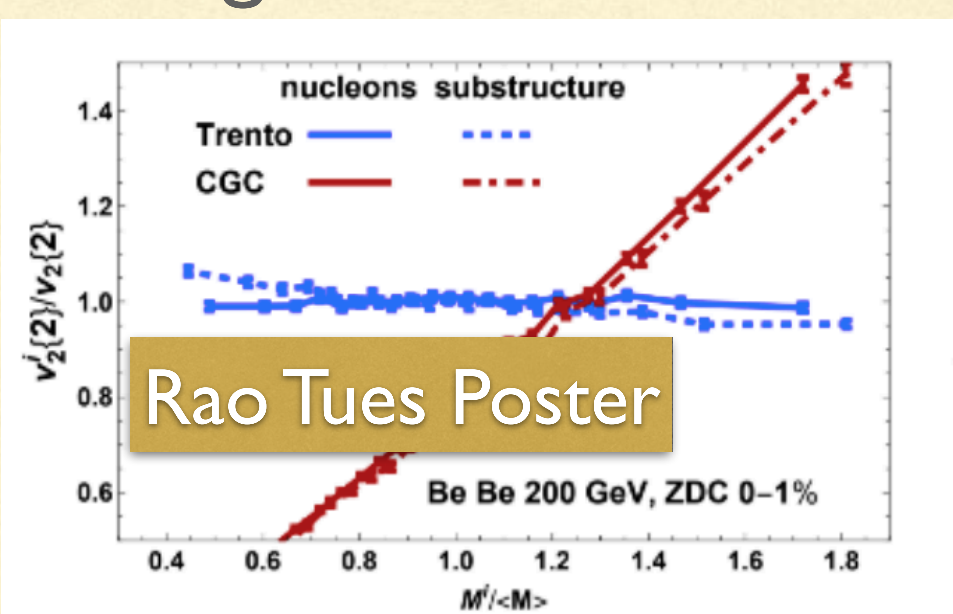
Initial vs. Final State in small systems

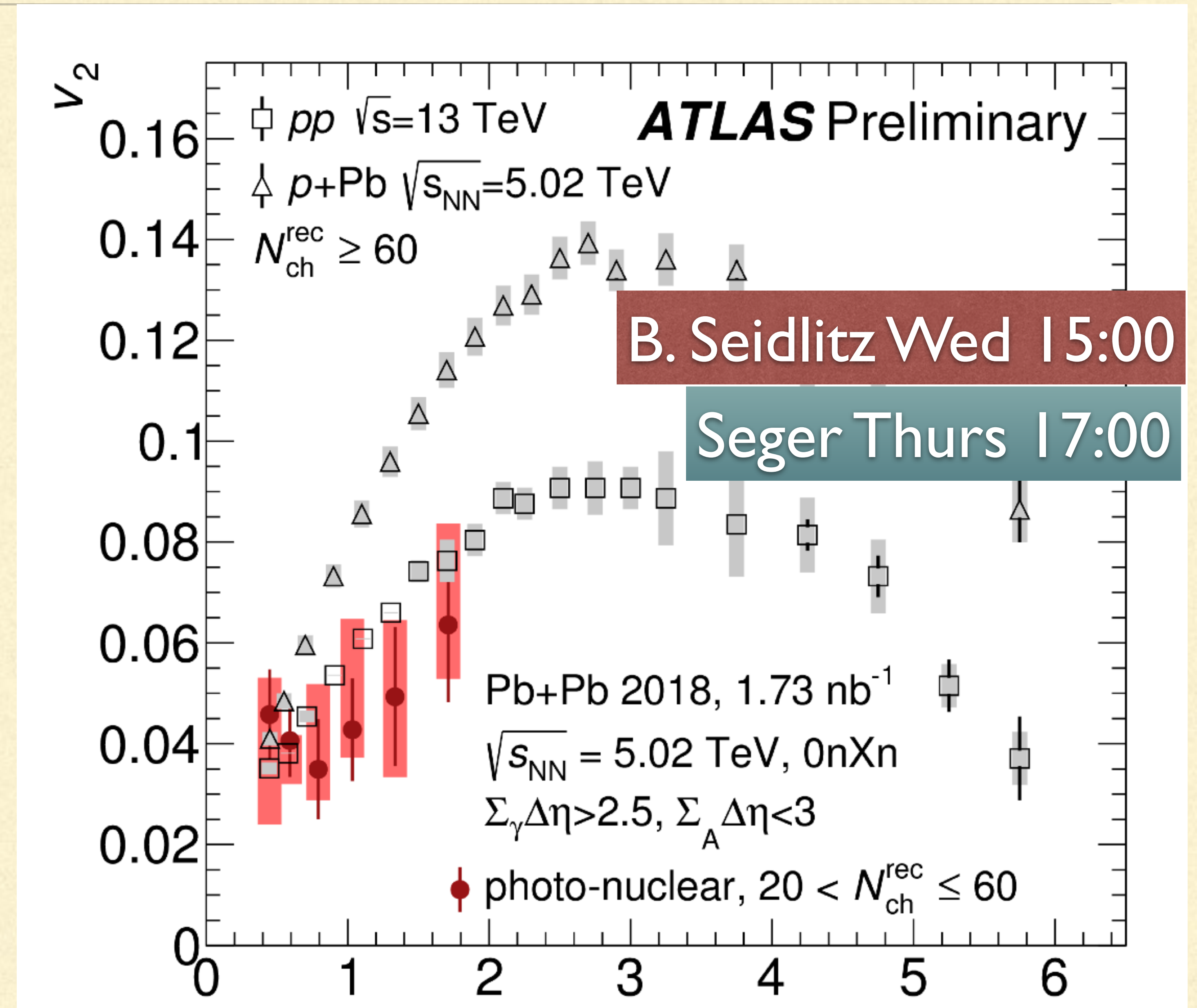
VAR recall of IS from Schenke

5 IS : FS 5

CGC vs. hydro
Gajdosova, Mace, Zajc

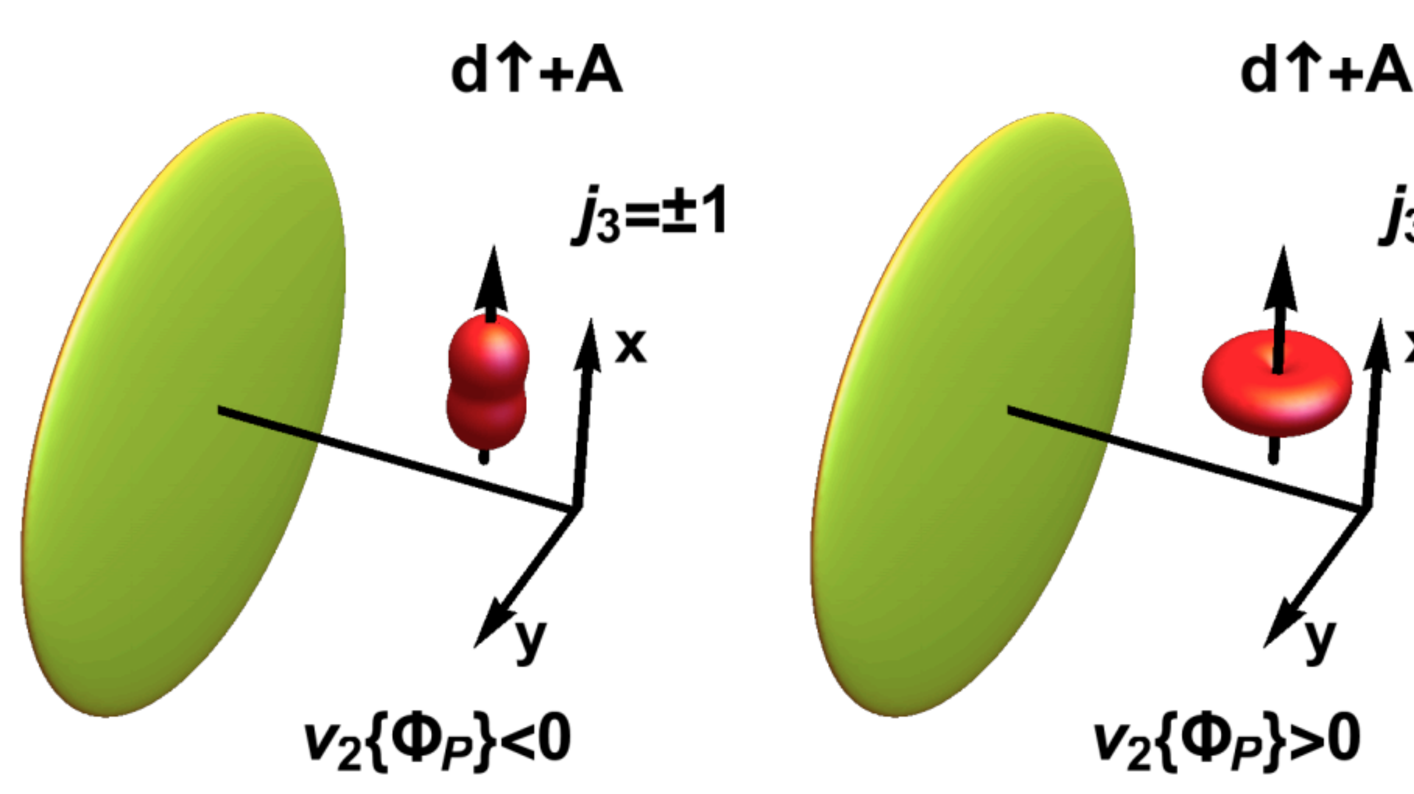
Small deformed collisions distinguish CGC vs. IC+Hydro





Intriguing implications for EIC!

Polarized beams of deformed ions



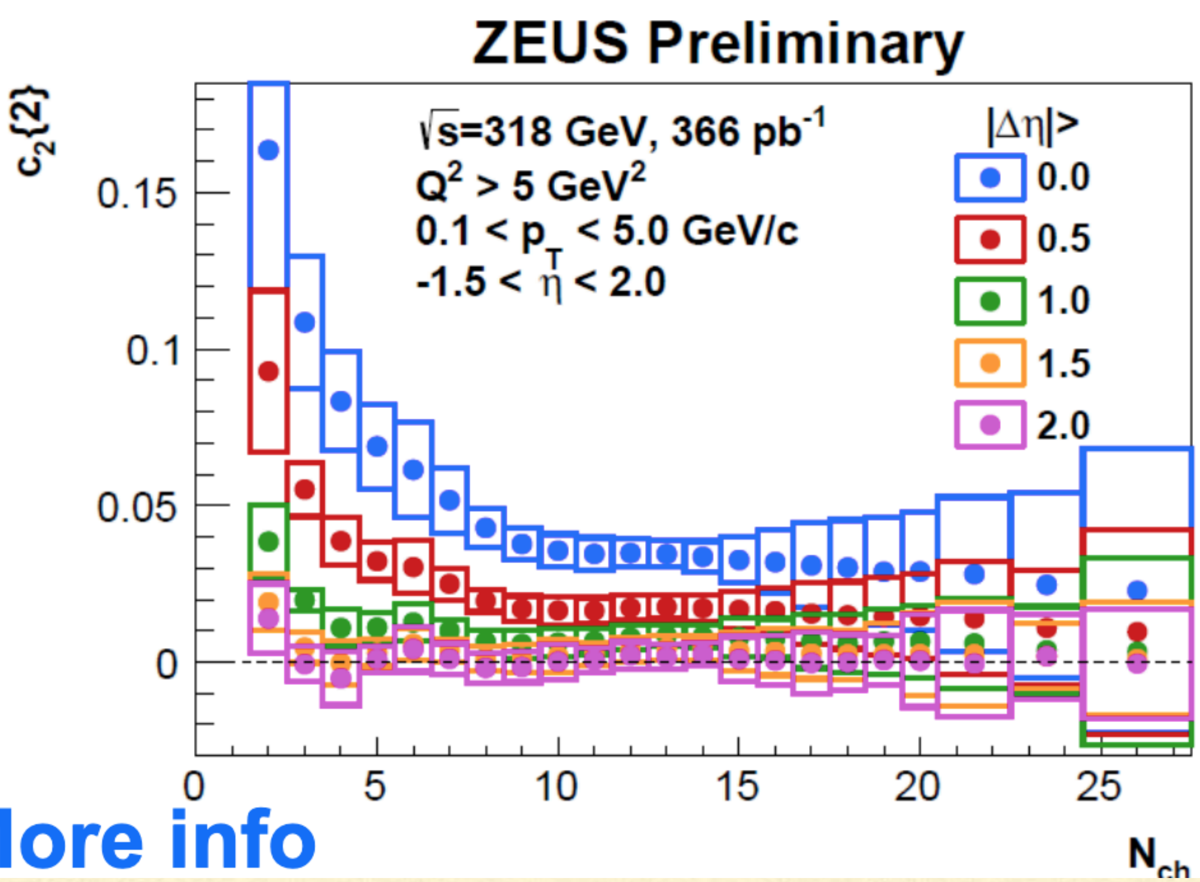
[PB, WB, PRL 121 (2018) 202301]

Broniowski Weds 9:45

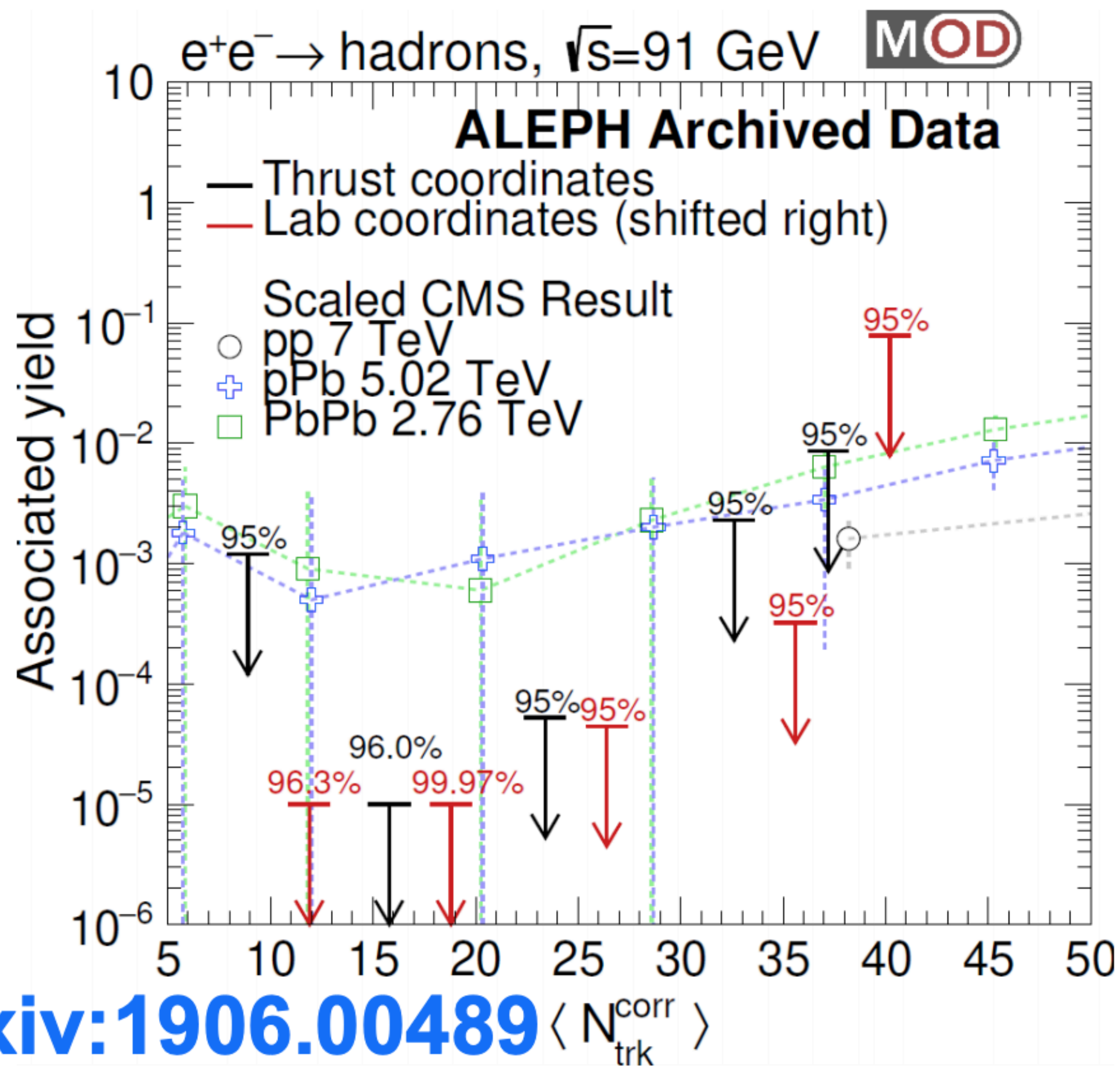
Maybe we need to go into extra time to finalize the score?

Can we shut off elliptical flow?

Baty Thurs 16:30



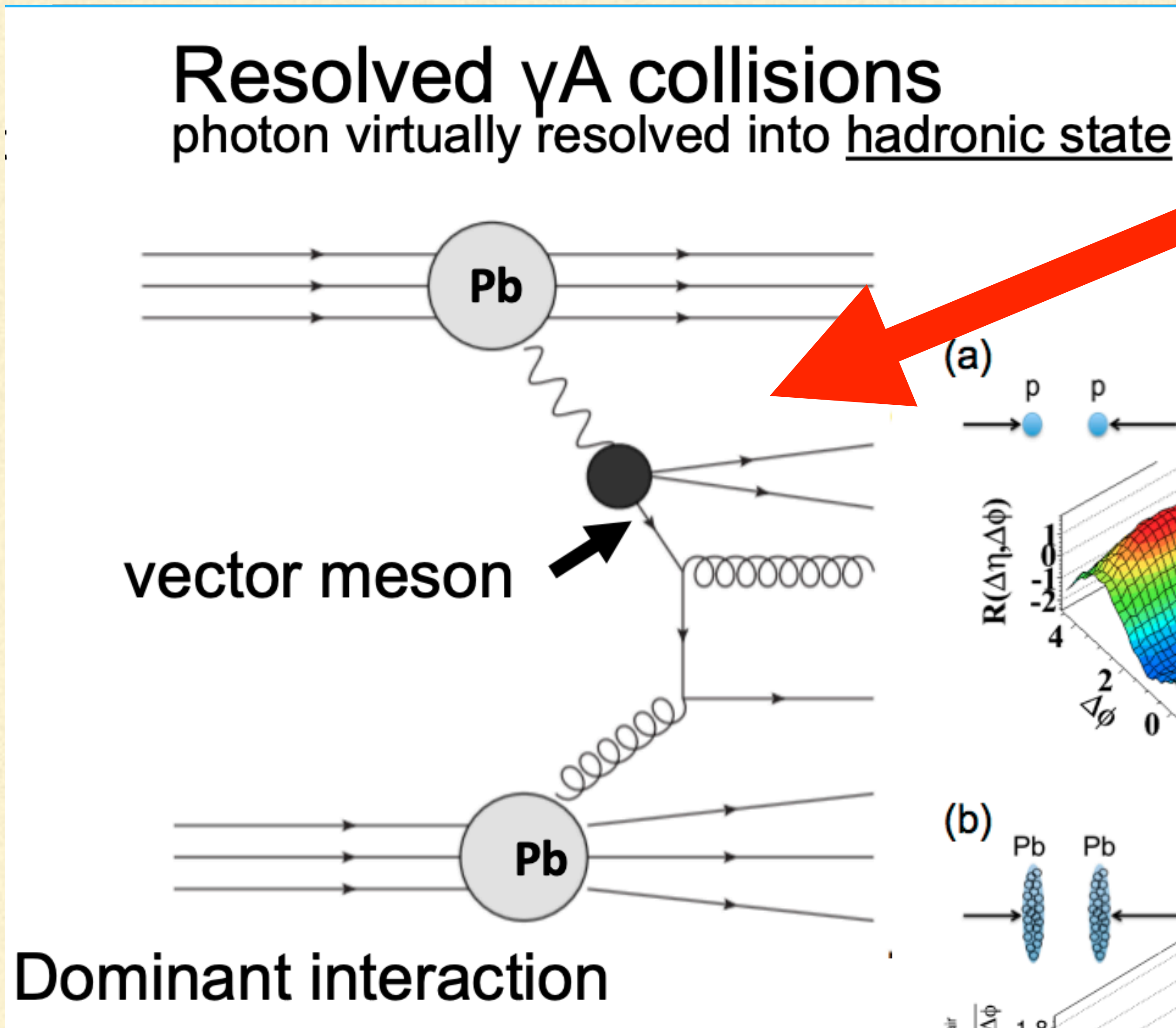
More info



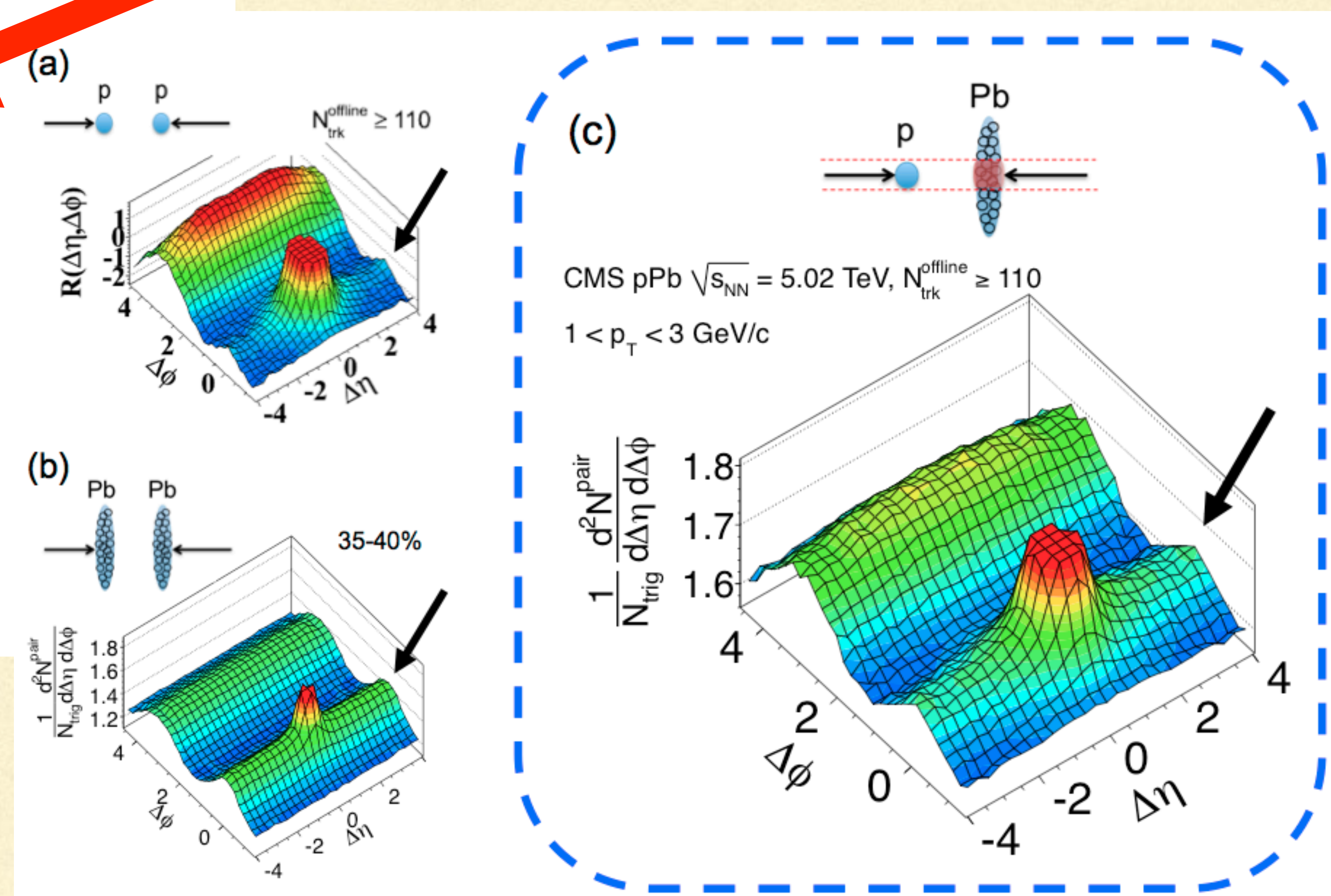
Arxiv:1906.00489

Thankfully, it looks like we can in e^+e^- data

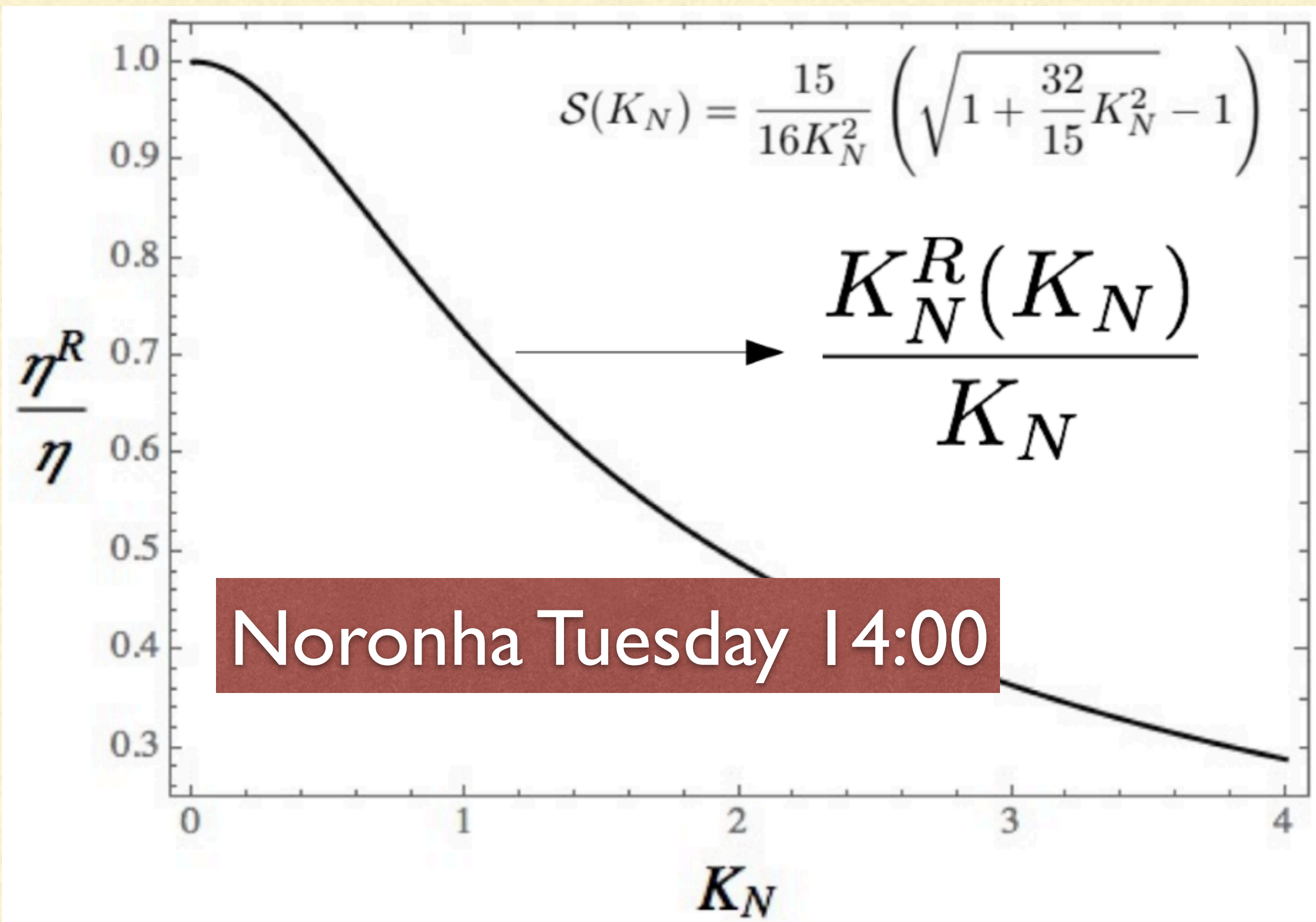
Is hydro (γ*Pb) =hydro (pp) = hydro (pPb) = hydro (PbPb)?



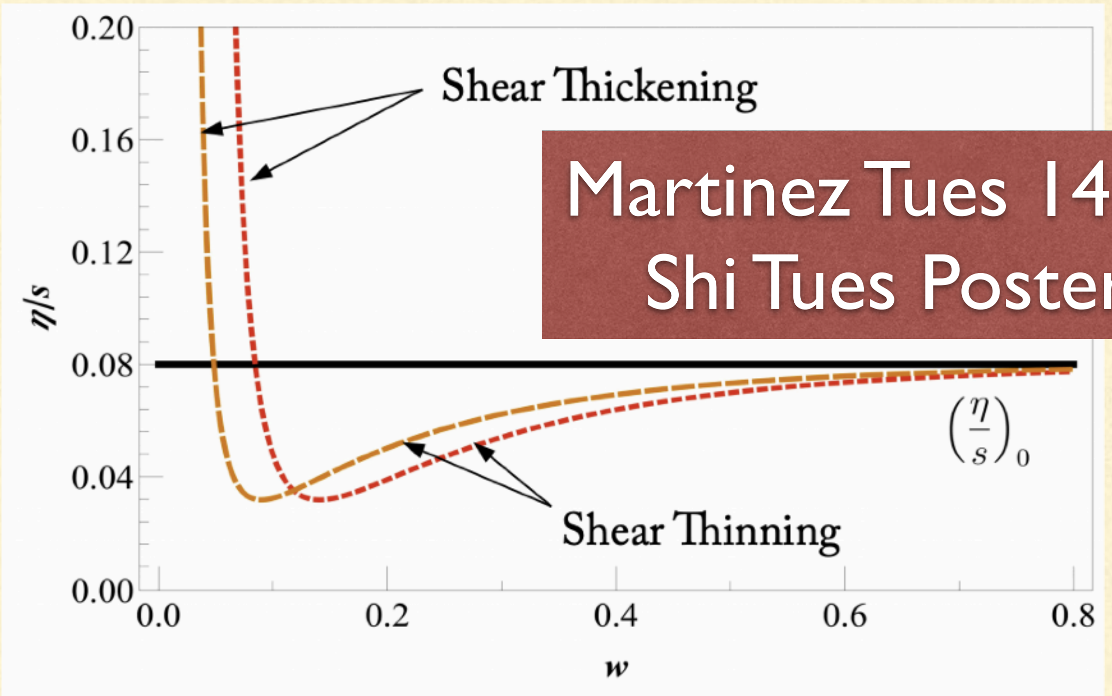
Hopefully next IS we'll have more thoughts on this!



Far-from-equilibrium and $\eta/s(T)$



Noronha Tuesday 14:00



Martinez Tues 14:20
Shi Tues Poster

Change in the collision kernel affects transport coefficients

Almaalol Tuesday 15:40

$$p^\mu \partial_\mu f_p = C[f_p]$$

Hydro Equations of Motion identical in and out of equilibrium!

We recover the usual equation for the shear stress:

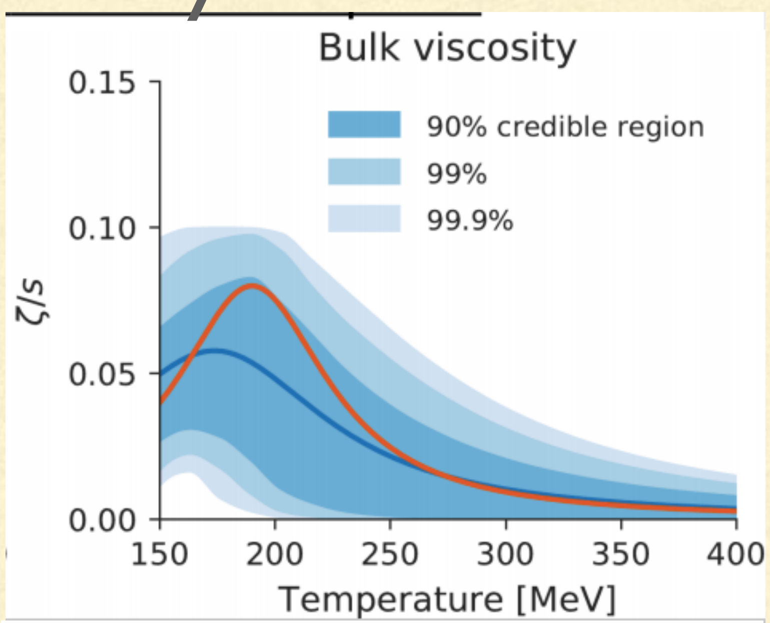
$$\dot{\pi}^{\langle\mu\nu\rangle} + \frac{\pi^{\mu\nu}}{\tau_\pi} - \frac{2I_{40}}{3I_{50}}\sigma\pi^{\lambda\langle\mu}\pi_\lambda^{\nu\rangle} = 2\frac{\eta}{\tau_\pi}\sigma^{\mu\nu} - 2\sigma_\lambda^{\langle\mu}\pi^{\nu\rangle\lambda} - \frac{4}{3}\pi^{\mu\nu}\theta$$

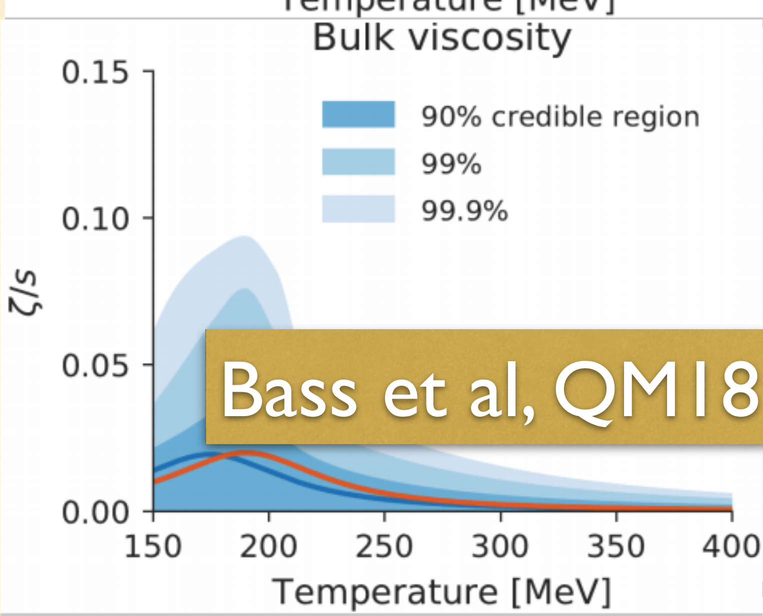
$f_{0\mathbf{k}}$	$\lambda\exp\left(-E_{\mathbf{k}}/\Lambda\right)$	$\lambda\Theta\left(\Lambda - E_{\mathbf{k}}\right)$	$\lambda\delta\left(E_{\mathbf{k}} - \Lambda\right)$
τ_π	$\frac{9}{5}\ell_{\mathrm{mfp}}$	$\frac{18}{13}\ell_{\mathrm{mfp}}$	$\frac{9}{7}\ell_{\mathrm{mfp}}$
η	$\frac{6}{5}\frac{T}{\sigma_T}$	$\frac{84}{65}\frac{T}{\sigma_T}$	$\frac{9}{7}\frac{T}{\sigma_T}$

Denicol Tues 17:00

Small systems+transport coefficients

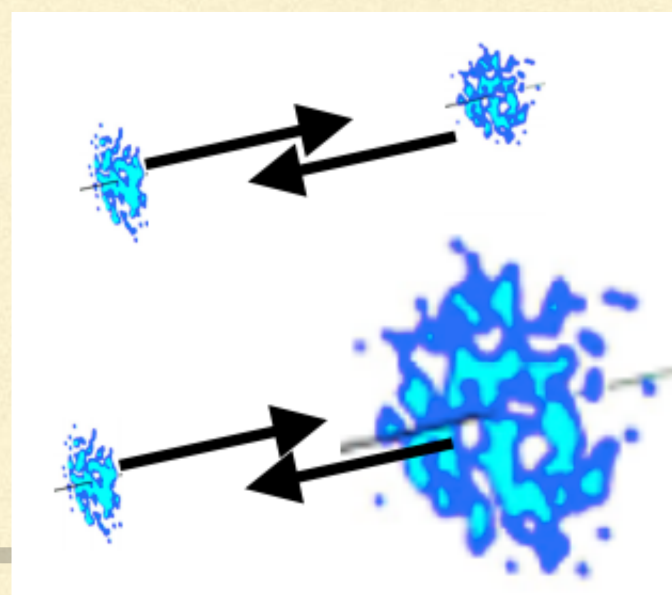
Bulk viscosity doesn't pass Bayesian closure test



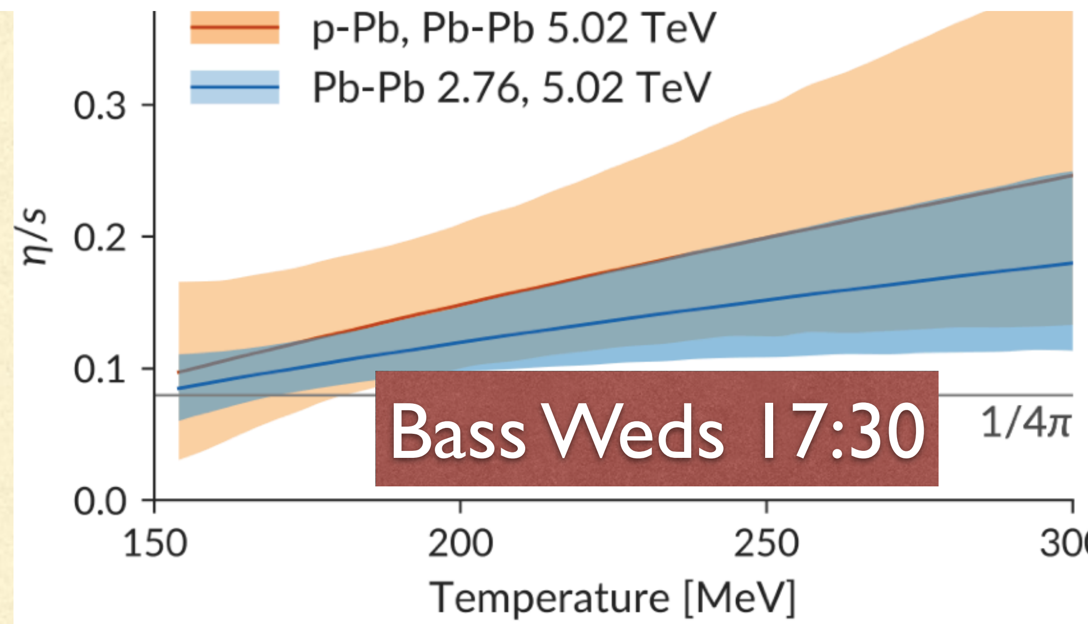


Bass et al, QM18

We still don't understand δf_{bulk}, I was complaining about this at IS14!



But what about each system separately?

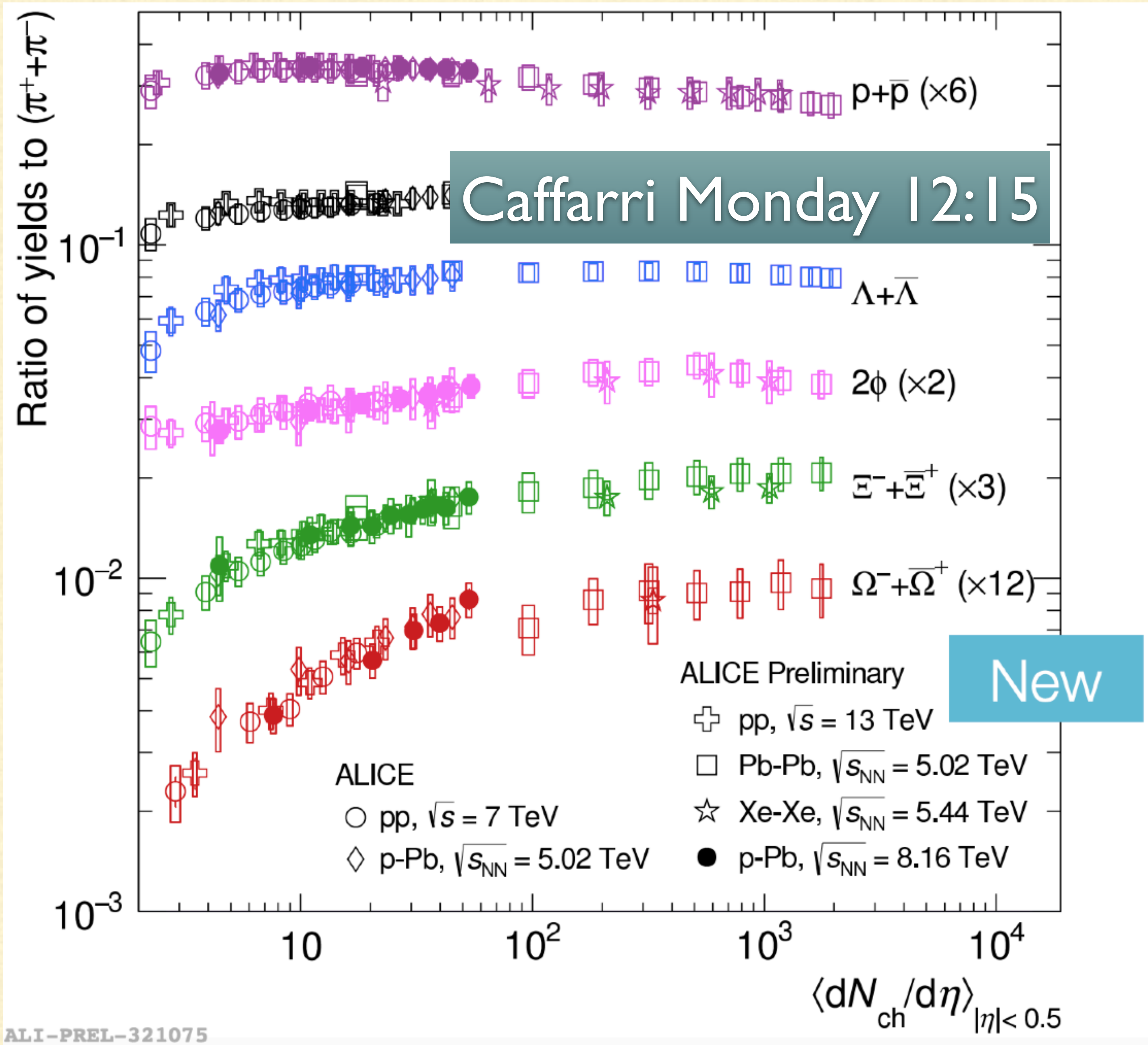


Bass Weds 17:30

Small systems constrain higher order transport coefficients?

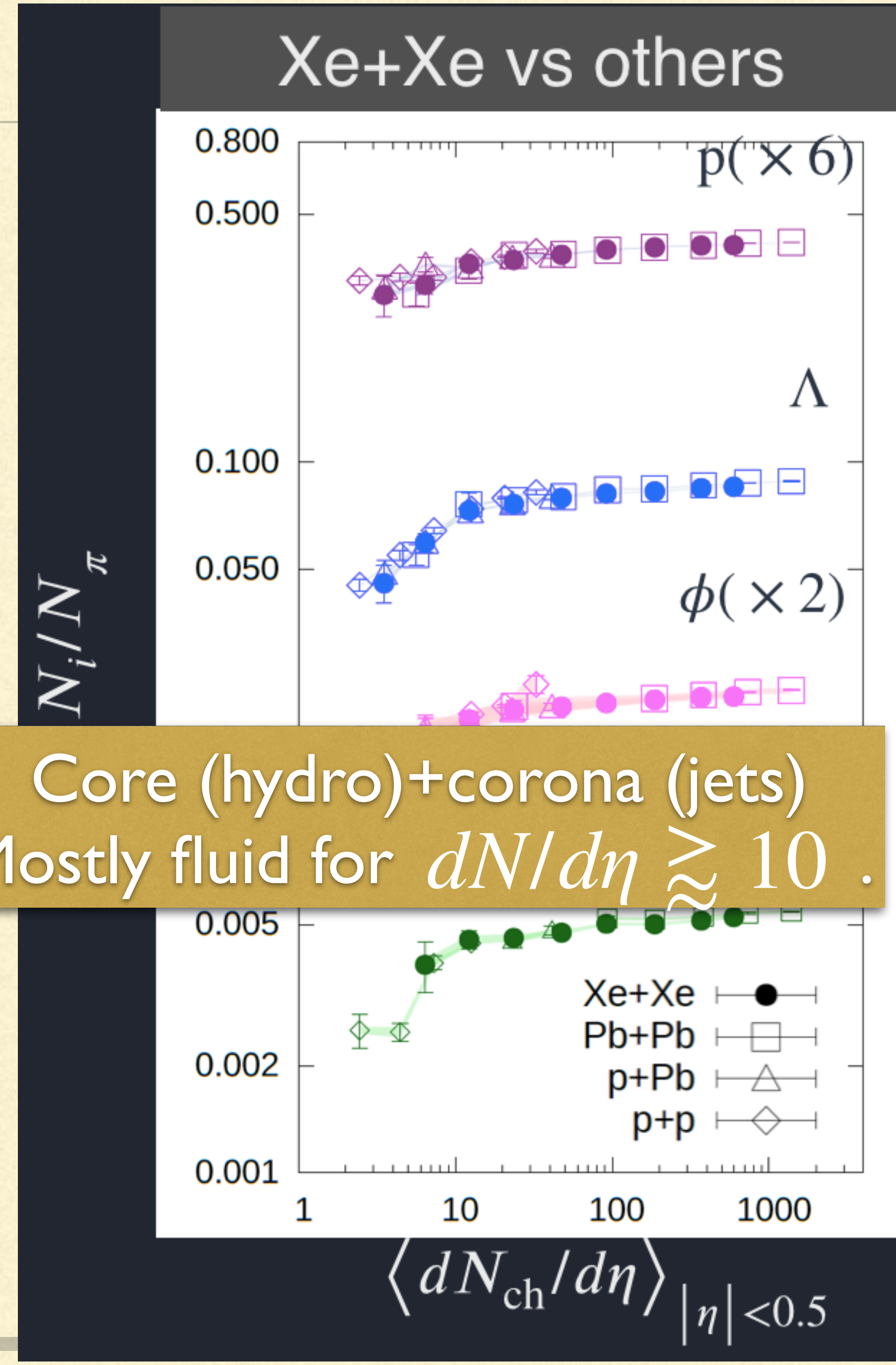
Mon Schlichting
Thurs: Grozdanov & Wu

STRANGENESS: CORE+CORONA



ALICE Coll. Nature Physics 13 (2017) 535-539

Kanakubo et al PTEP 2018 (2018) no.12, 121D01

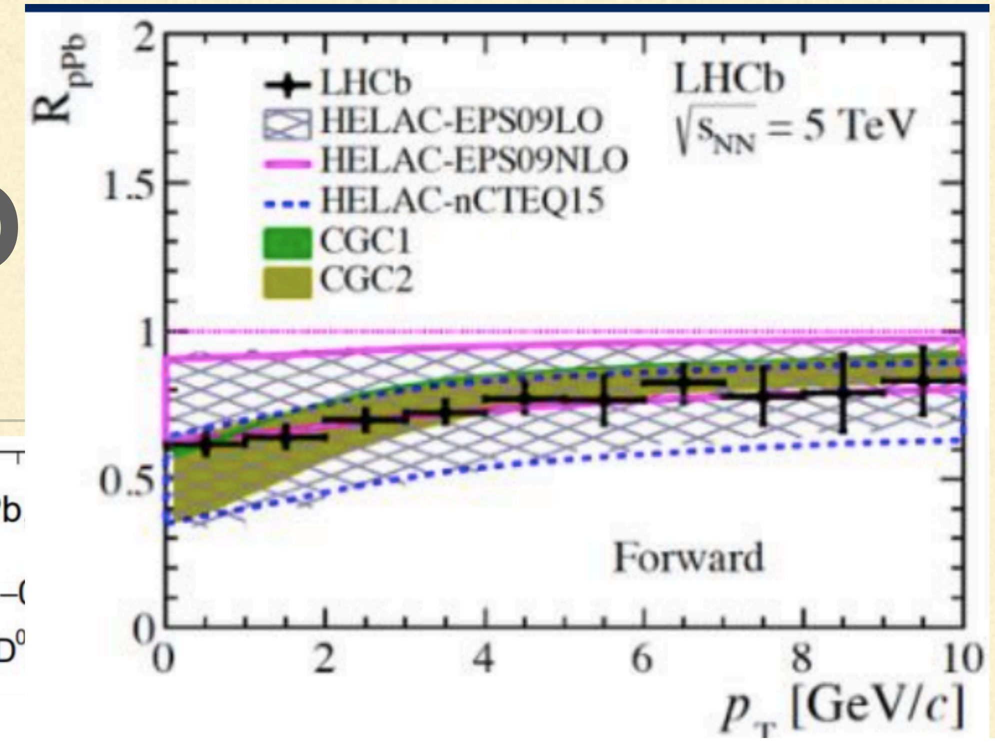


Core (hydro)+corona (jets)

Mostly fluid for $dN/d\eta \gtrsim 10$.

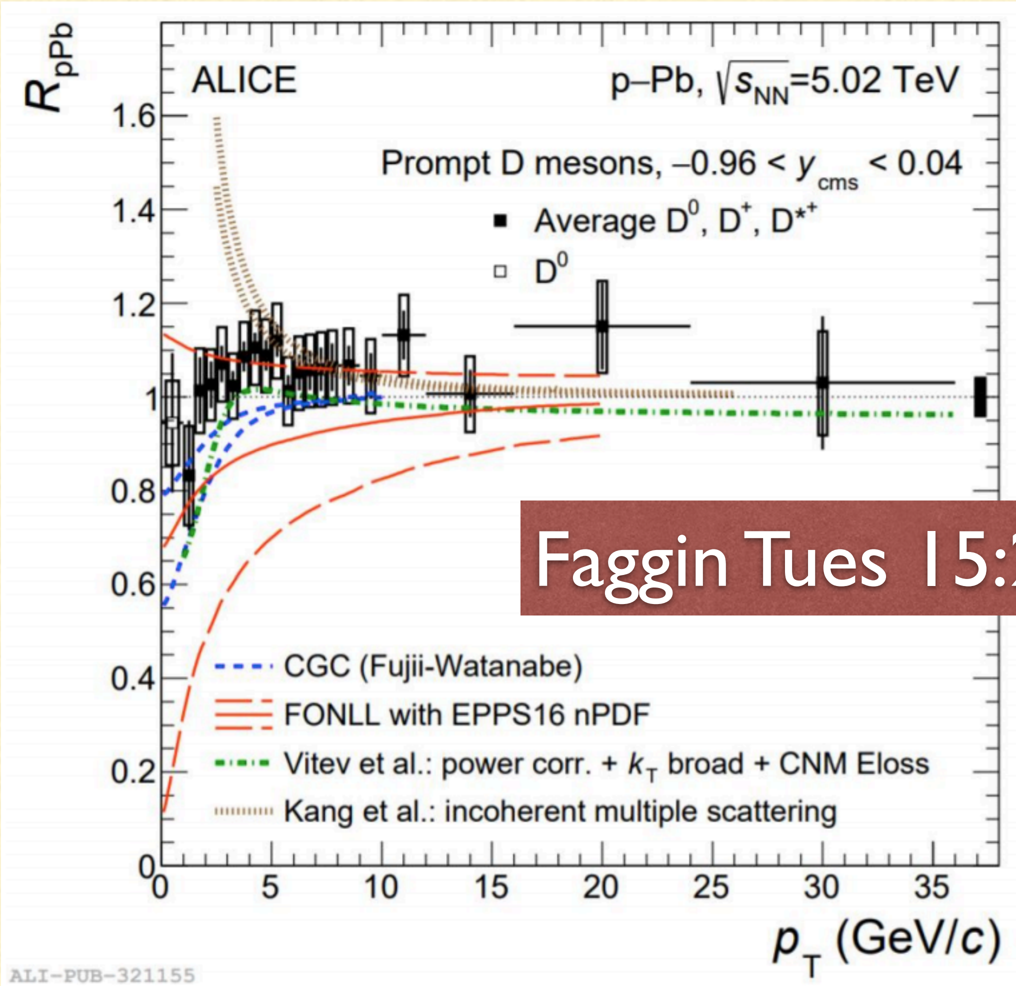
Heavy flavor

D mesons R_{pA} in pPb

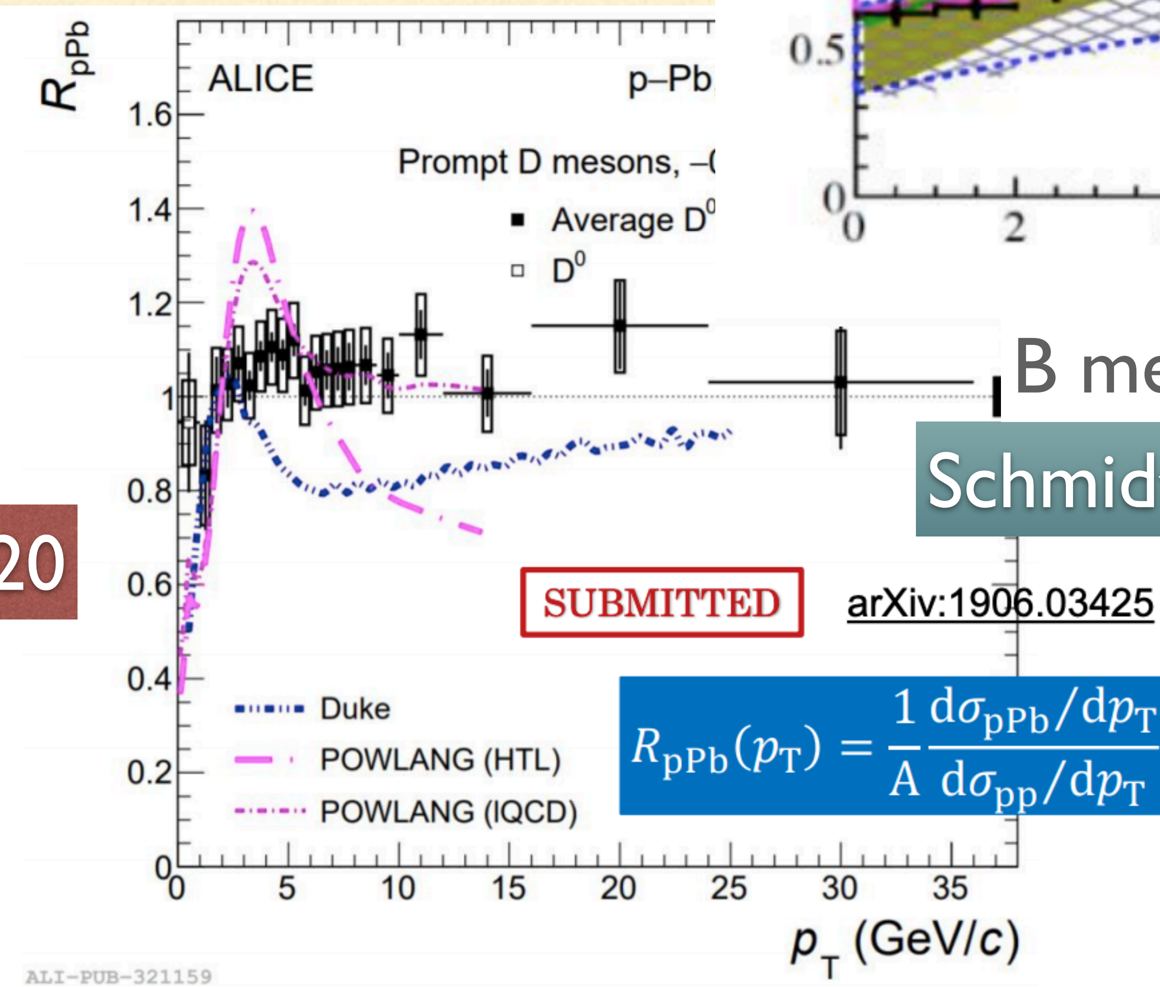


B mesons consistent

Schmidt Monday 11:45



Faggin Tues 15:20



SUBMITTED

arXiv:1906.03425

$$R_{\mathrm{pPb}}(p_T) = \frac{1}{A}\frac{d\sigma_{\mathrm{pPb}}/dp_T}{d\sigma_{\mathrm{pp}}/dp_T}$$

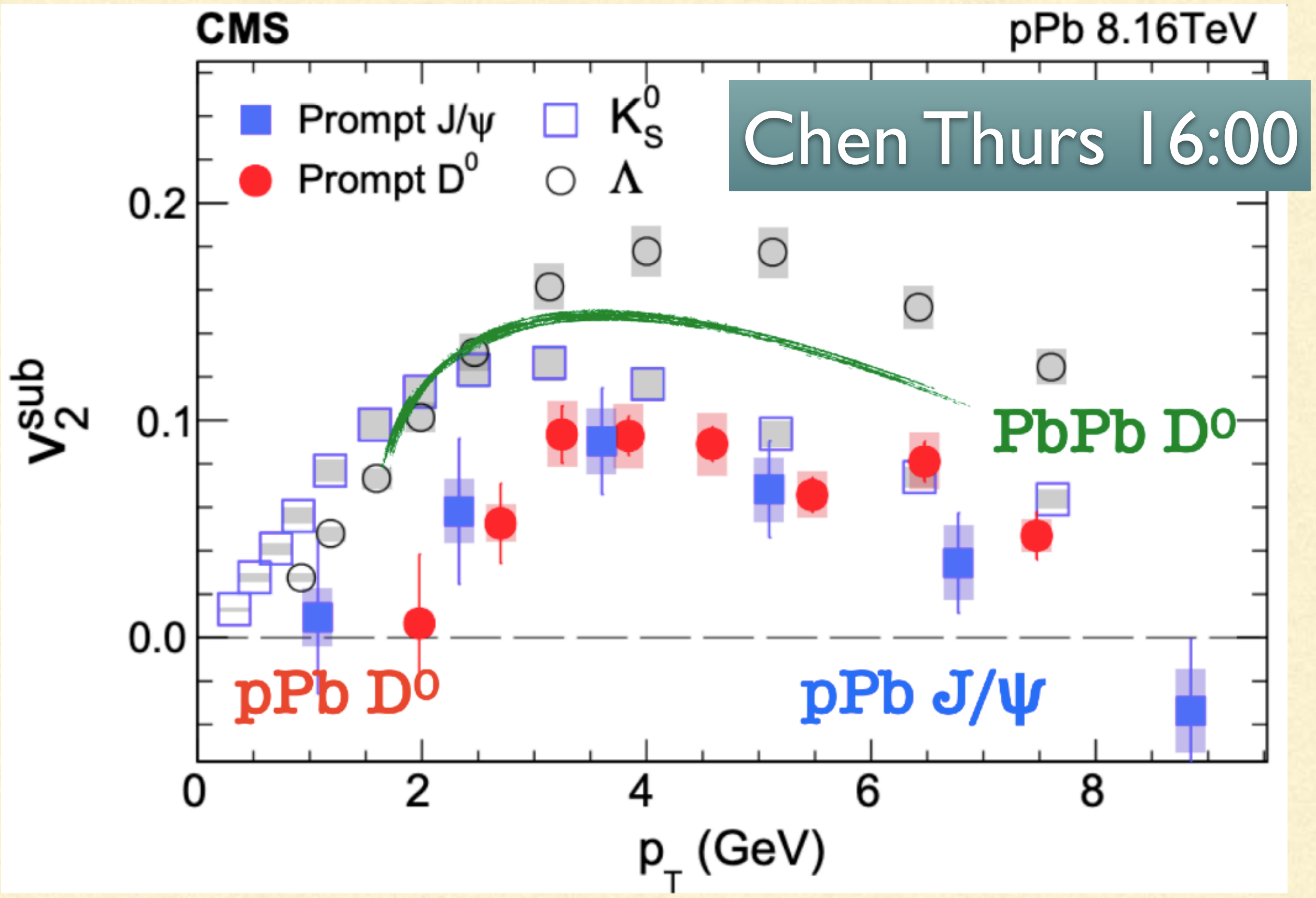
arXiv:1706.06728 [hep-ph]
JHEP 1210 (2012) 137, Eur. Phys. J. C77 no. 3, (2017) 163
Phys. Lett. B740 (2015) 23–29

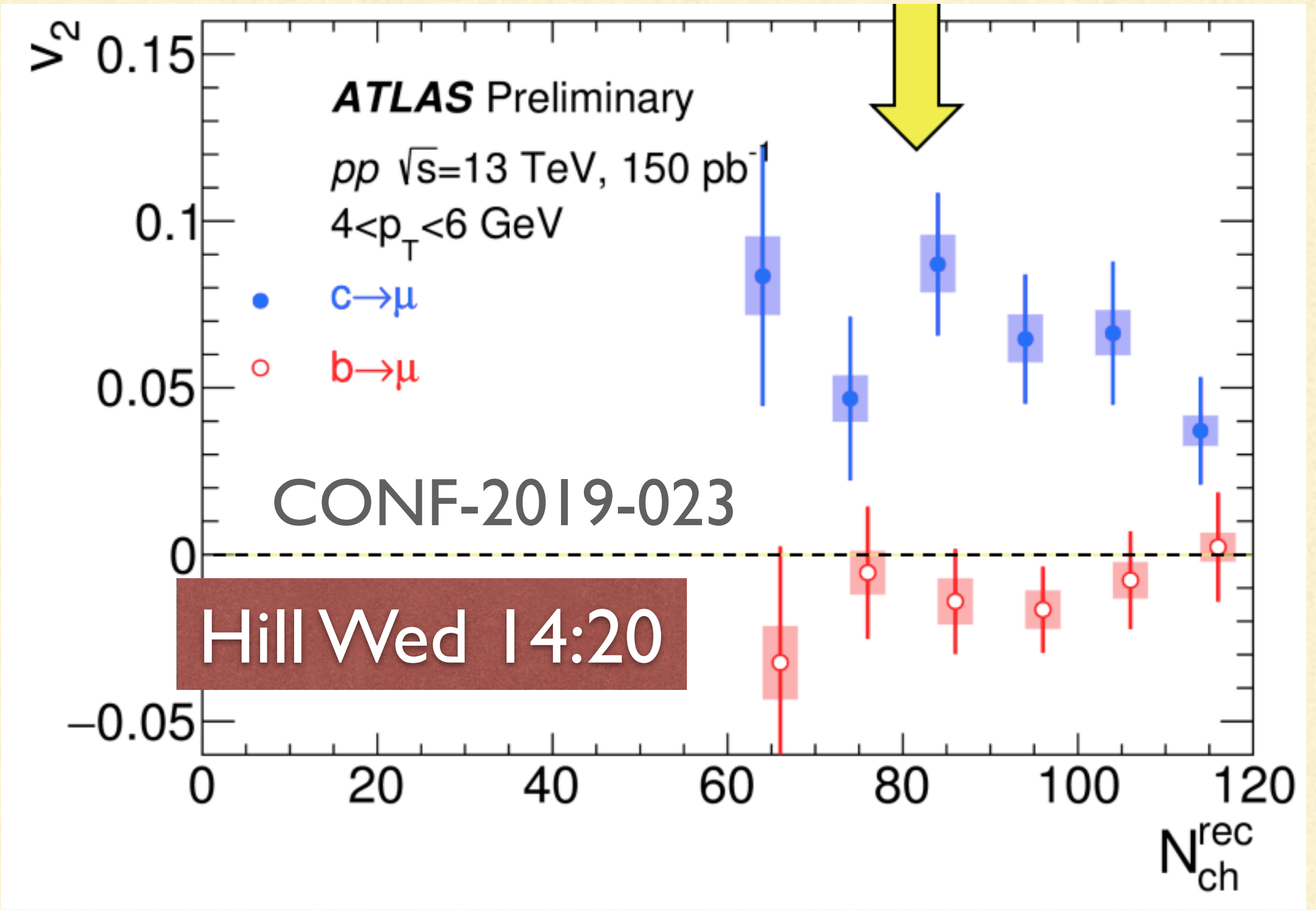
Phys.Rev. C80 (2009) 054902
Nucl. Part. Phys. Proc. 276-278 (2016) 225–228
JHEP 03 (2016) 123

Bottomonia
Kim Wed 14:20

CGC models reproduce RAA better than hydro+heavy quarks

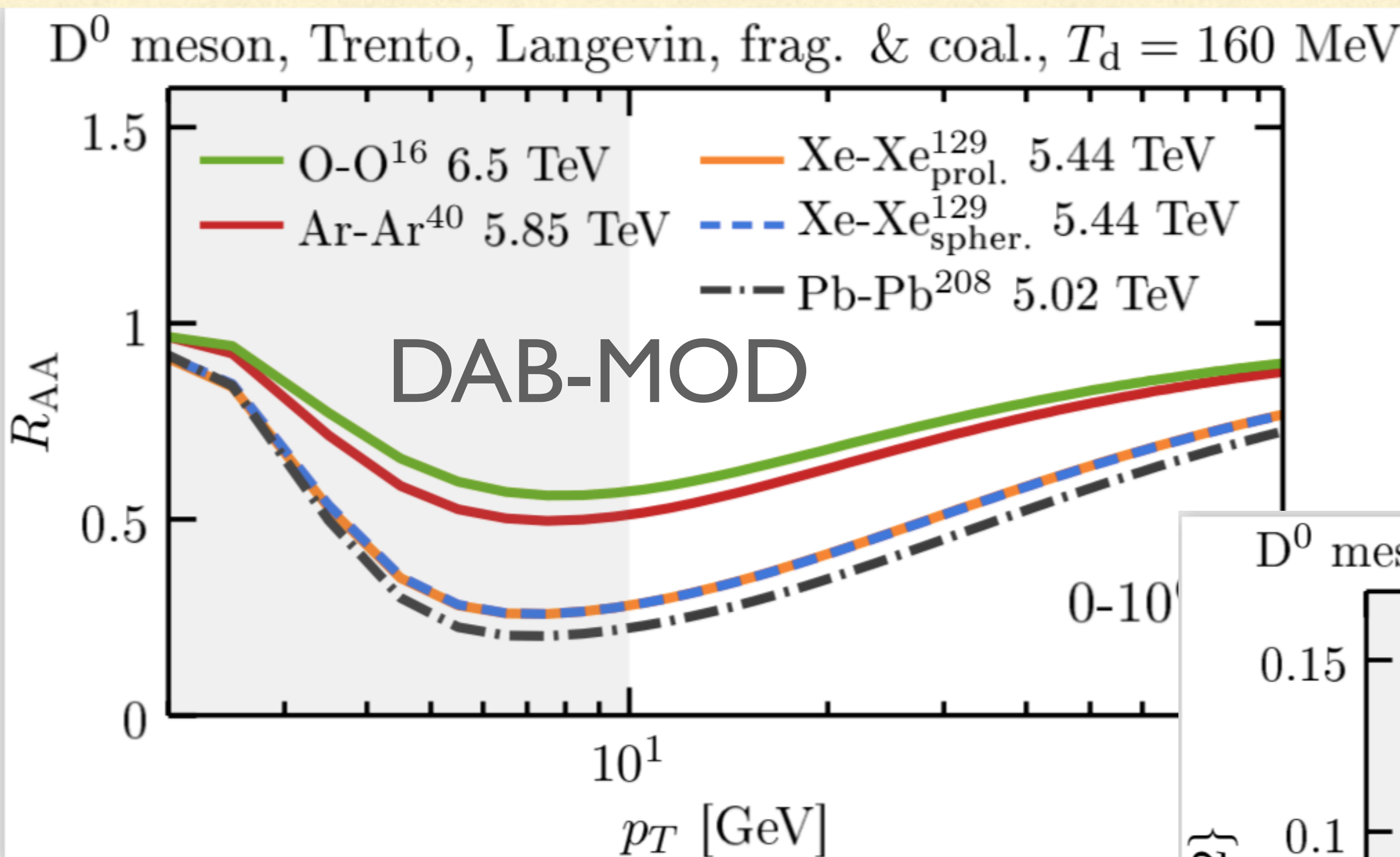
D mesons/μ's v_2 in pPb and pp





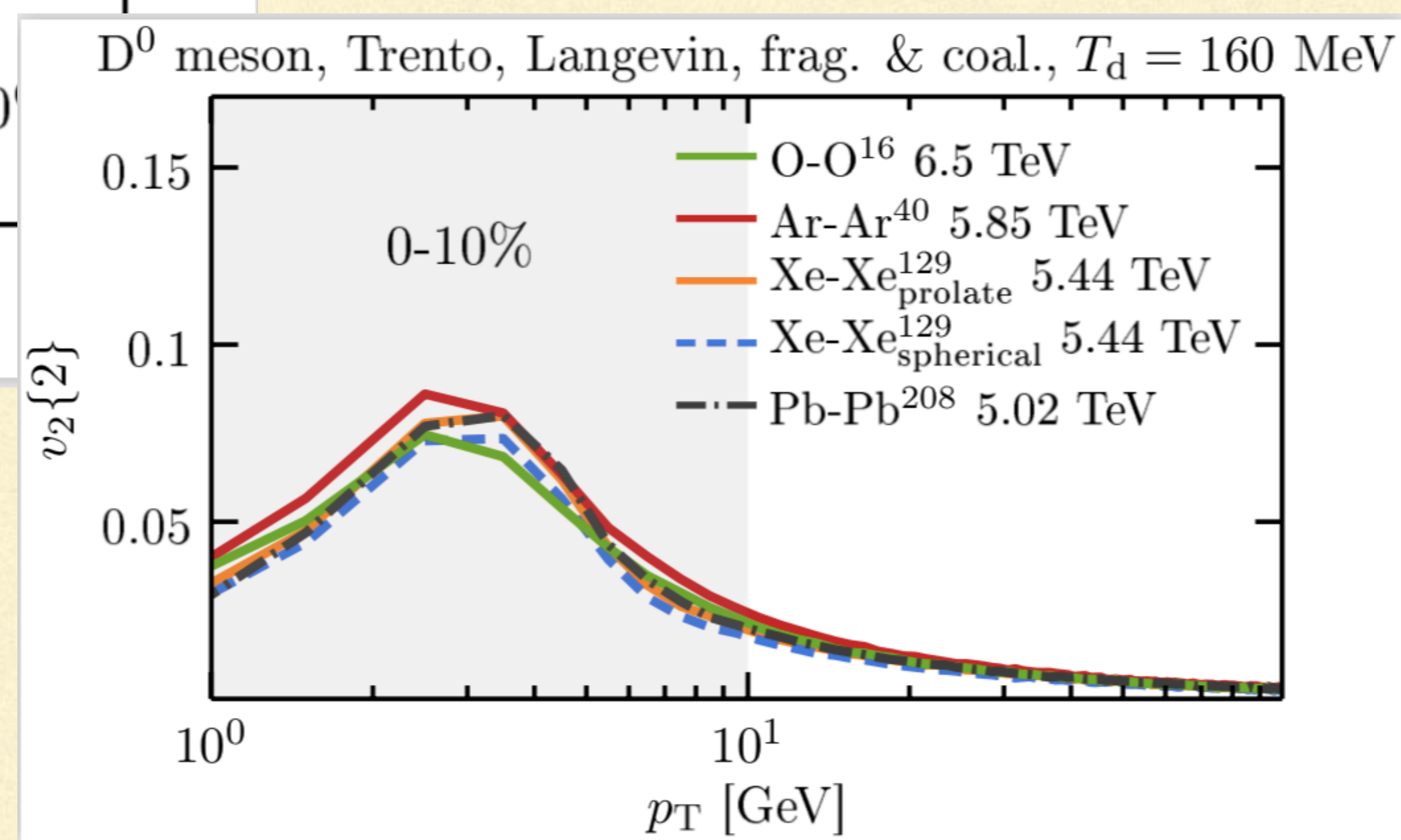
D meson v_2 is significant (but somewhat suppressed) in pPb
How do we understand these pp μ results?

Langevin in ArAr, OO, XeXe, PbPb



$v_2 \sim const$ with system size

Complicated interplay between size and eccentricities

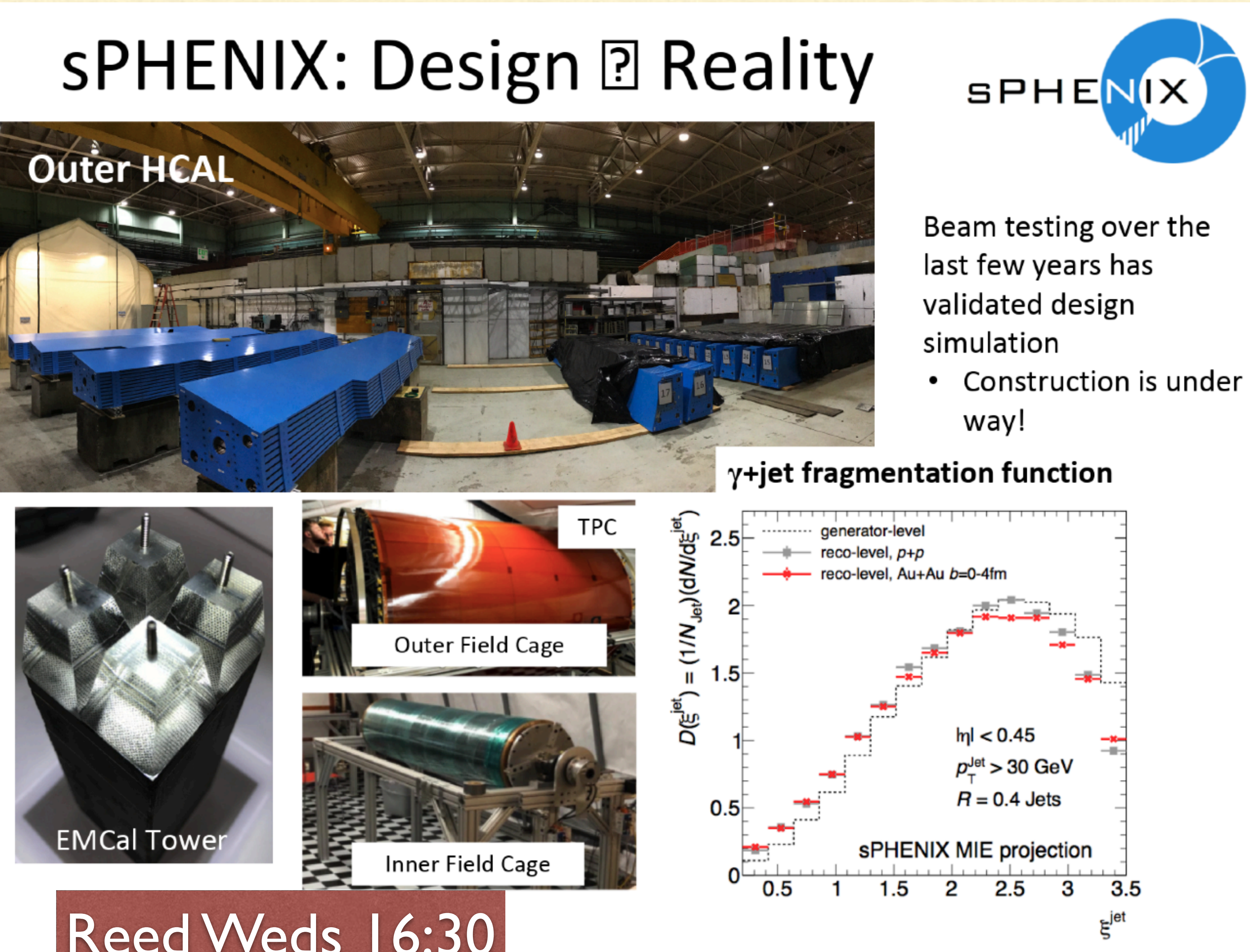


As system size decreases,

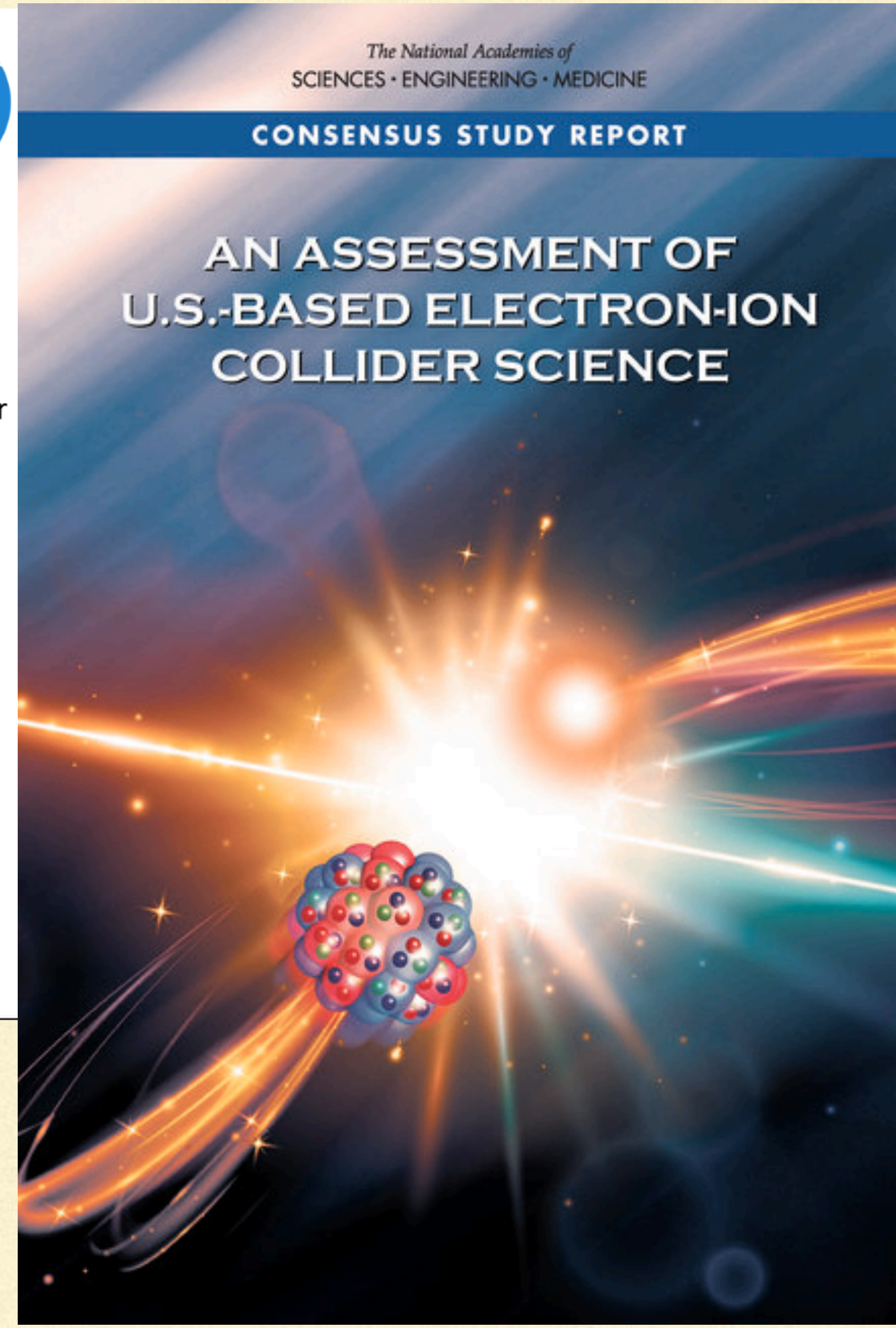
$R_{AA} \to 1$

Roland Katz SQM19

Future insight with sPHENIX and EIC



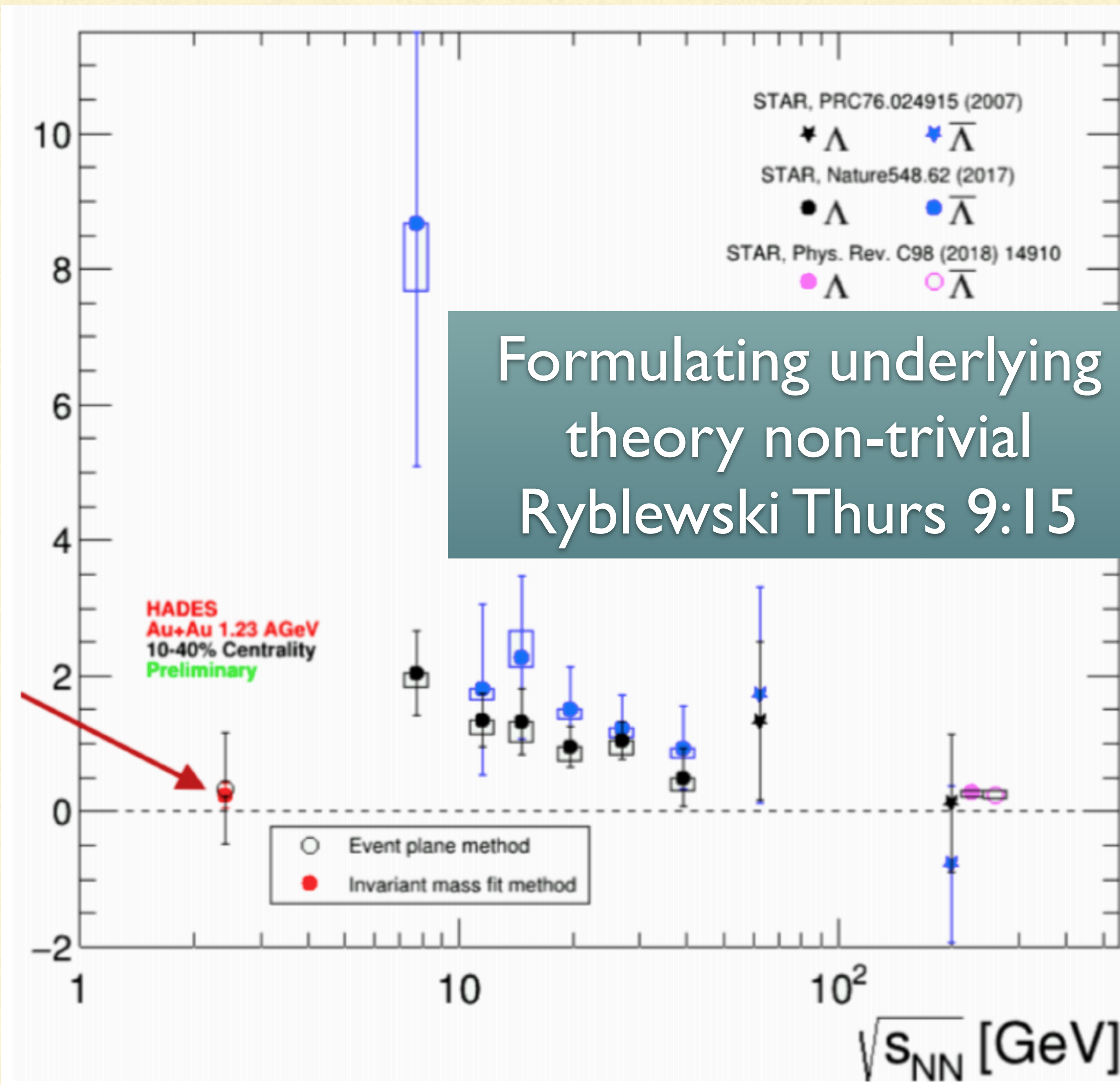
Reed Weds 16:30



Other possible experiments
Wing Monday 9:45

+THE KITCHEN SINK

Vorticity disappearing at fixed target (low beam energy)!!!



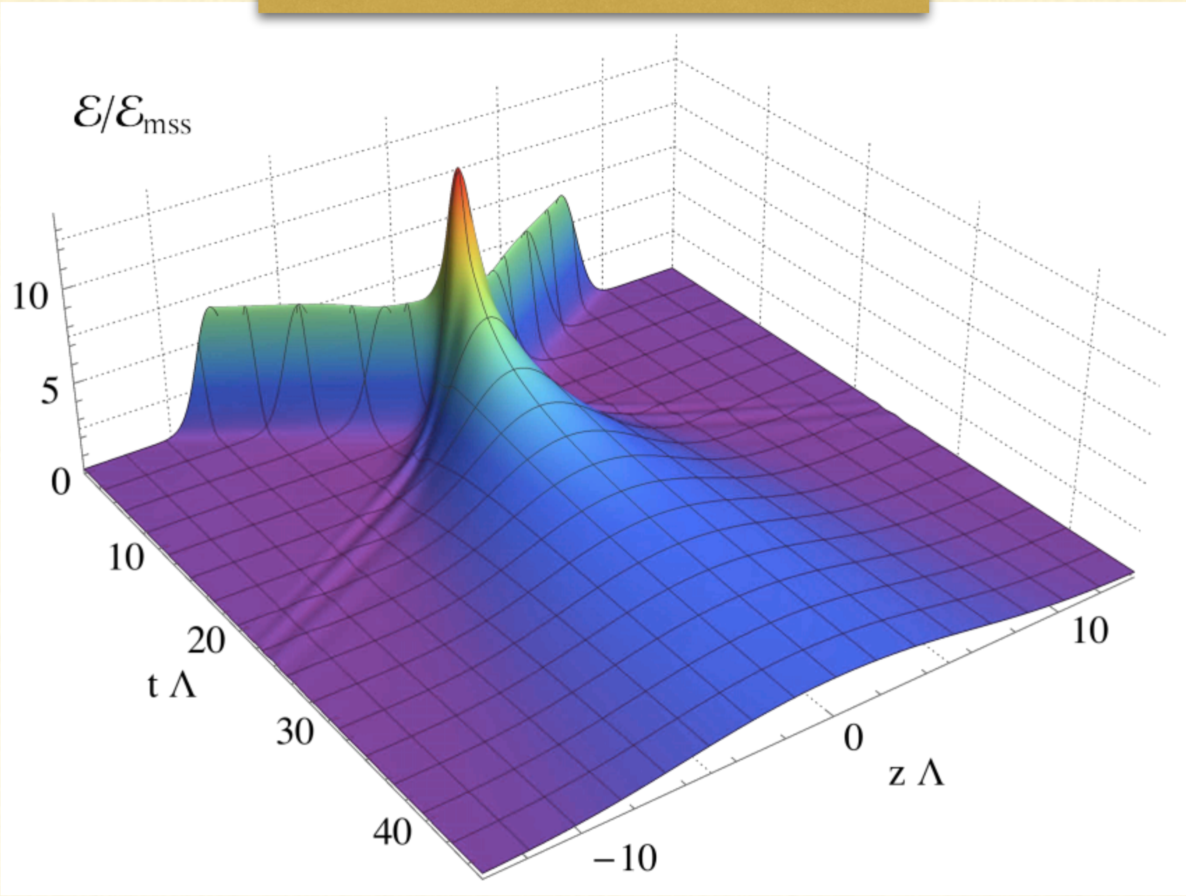
Formulating underlying theory non-trivial
Ryblewski Thurs 9:15

So many questions:

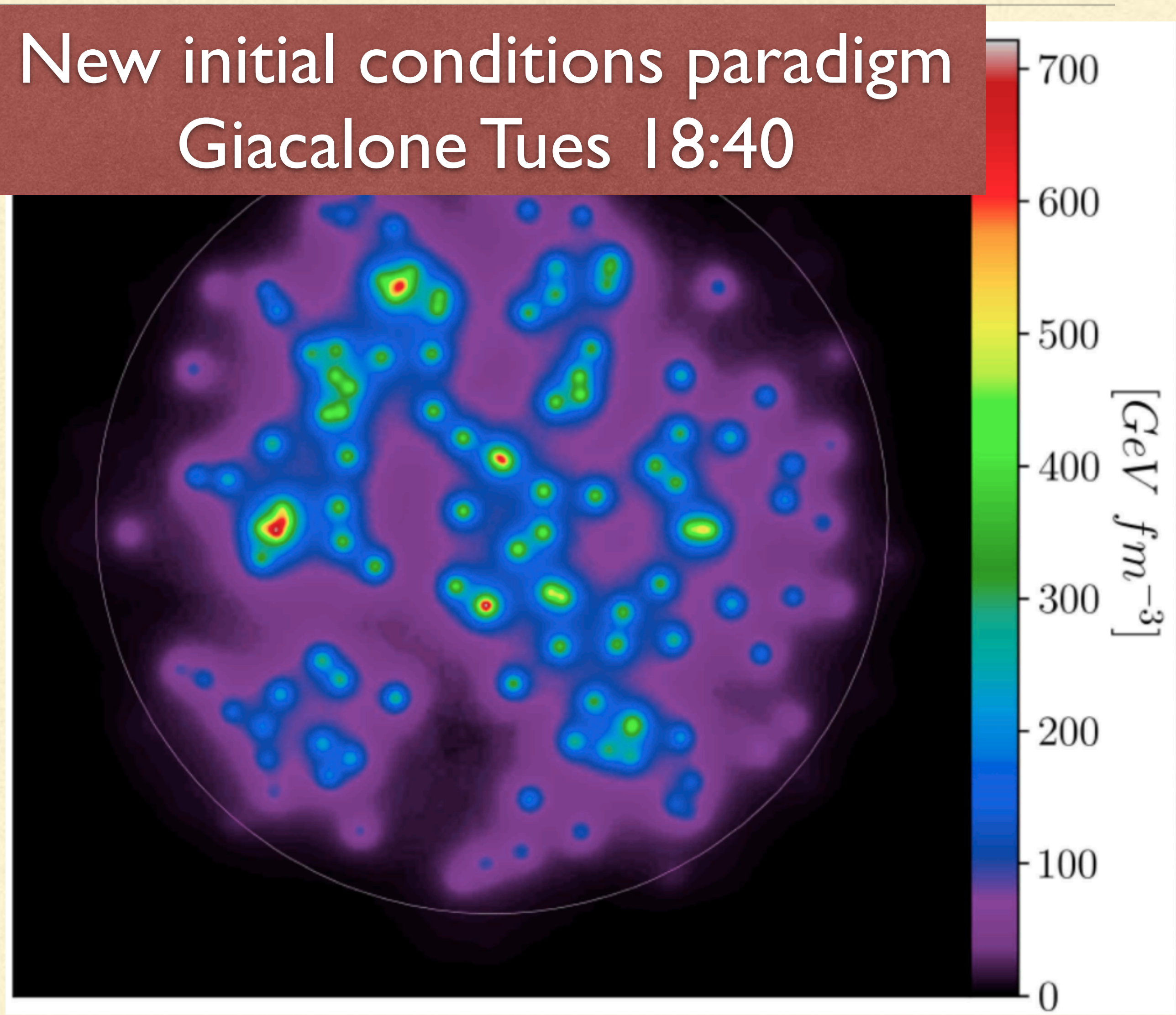
- Sign of Critical Point?
- HADES too low of T?
- Collider vs. fixed target?
- Detector effects?
- HADES, only in the HRG phase? Not a really QGP?

More interesting results

Shockwaves at the critical point
Attems Tues Poster



New initial conditions paradigm
Giacalone Tues 18:40

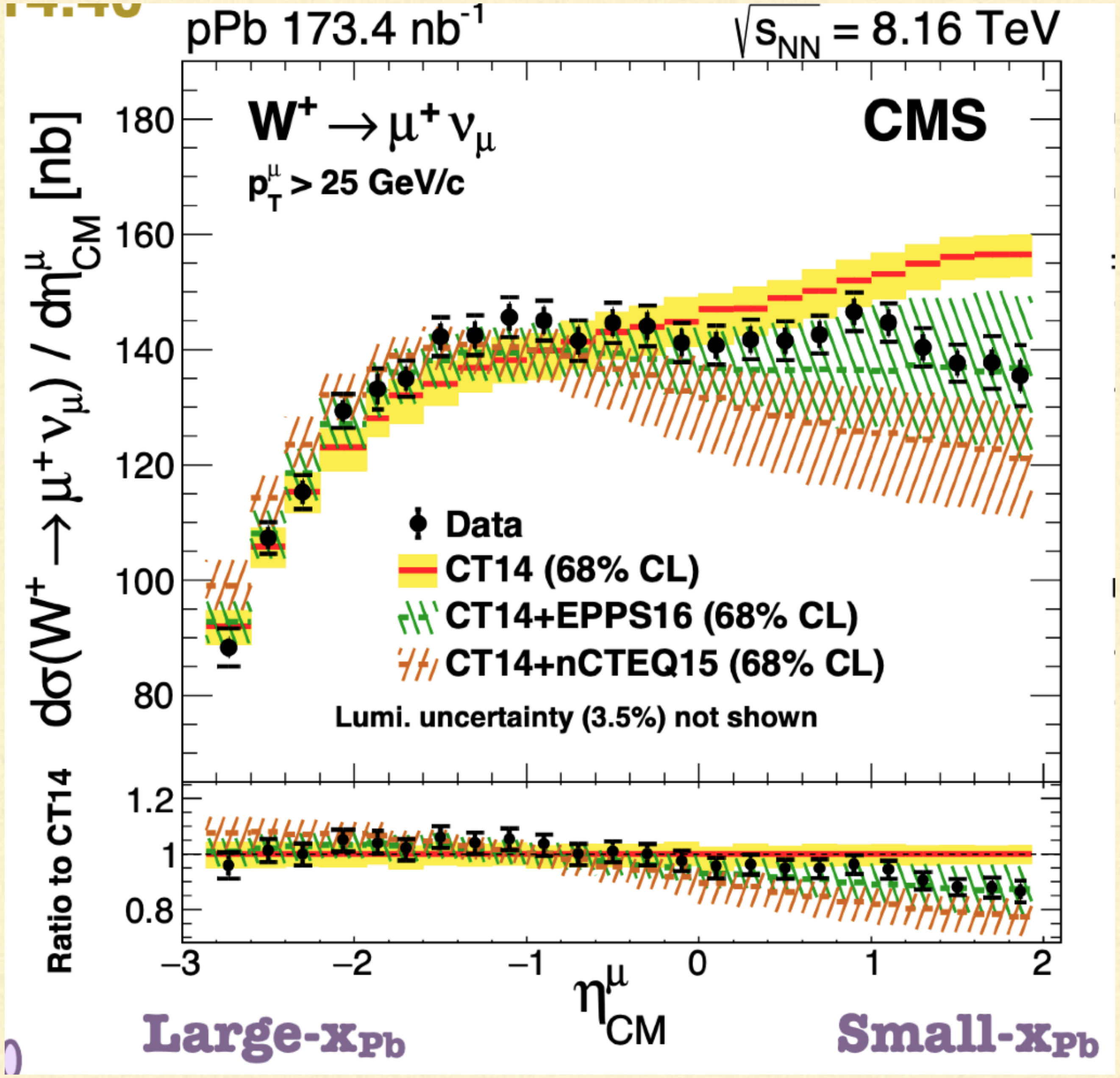


Hard probes to constrain initial state
Djordjevic Thurs 15:00

Summary of the summary of summaries

BACKUP

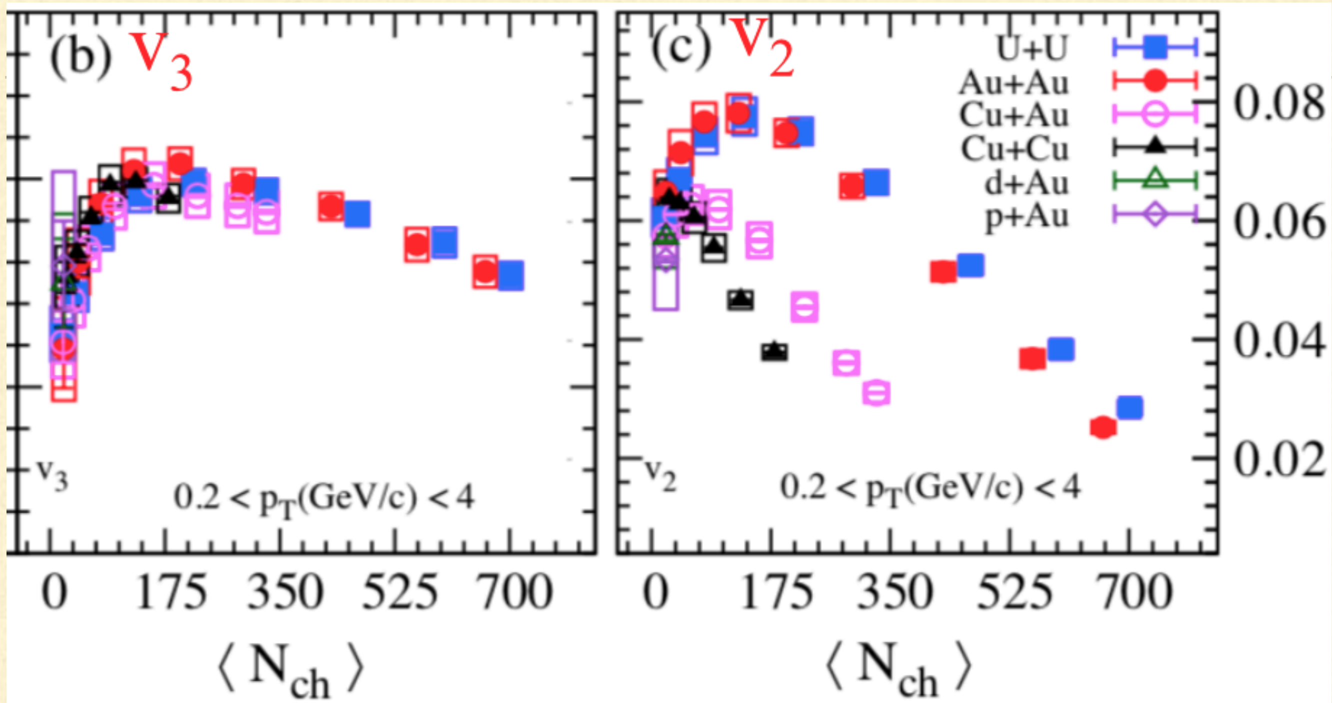
Shadowing at small-x



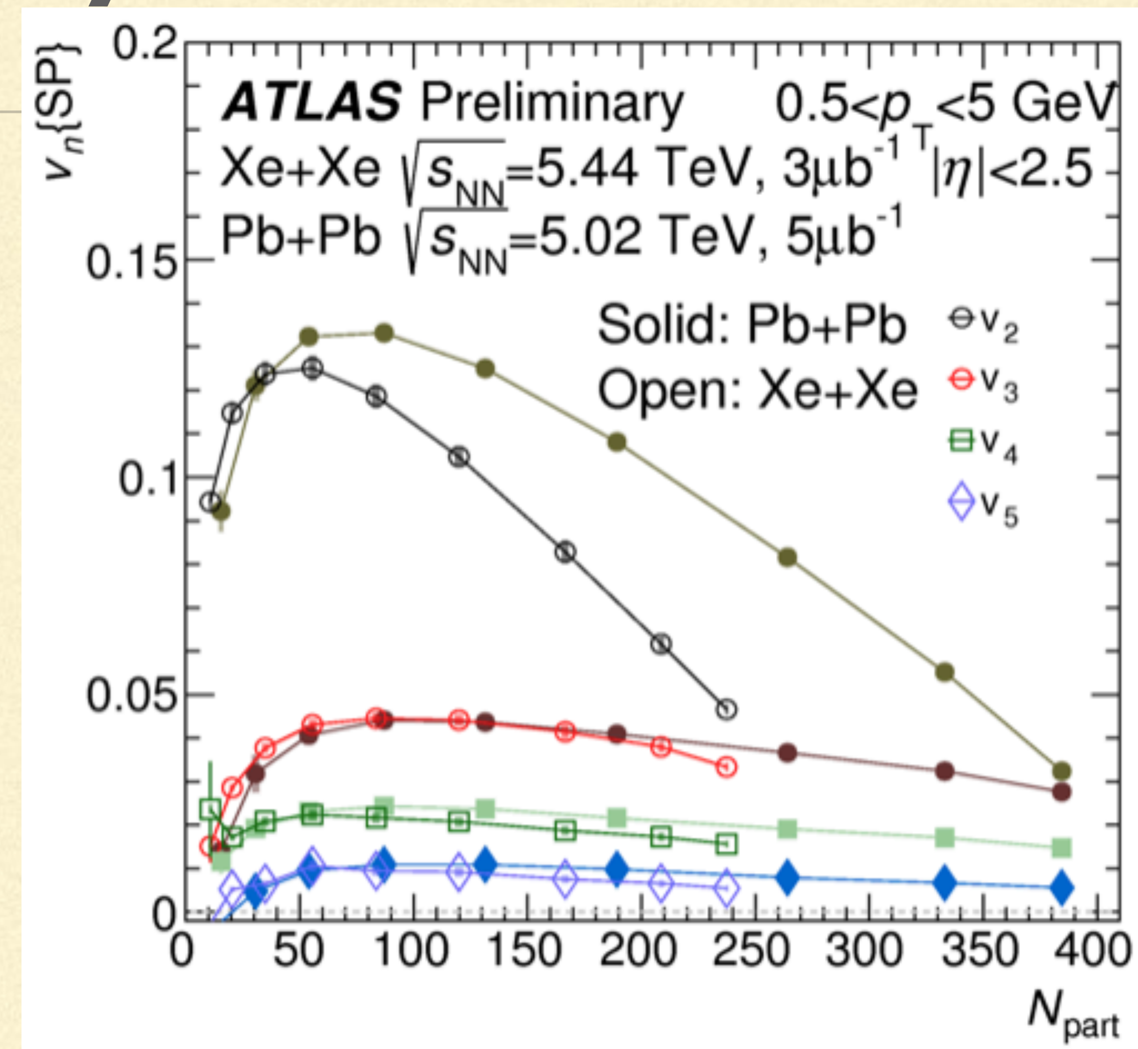
significant shadowing at $x \sim 10^{-3}$

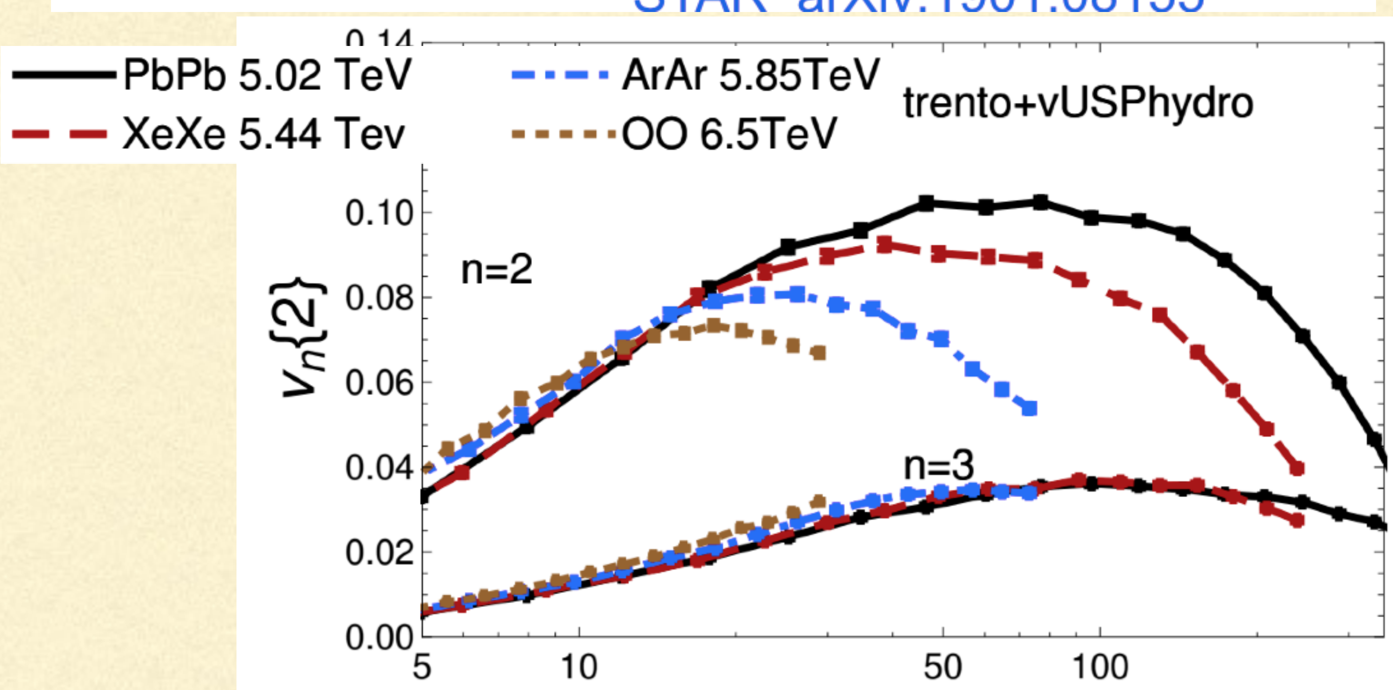
Wang Monday 10:45

Vn scaling across system size



STAR arXiv:1901.08155





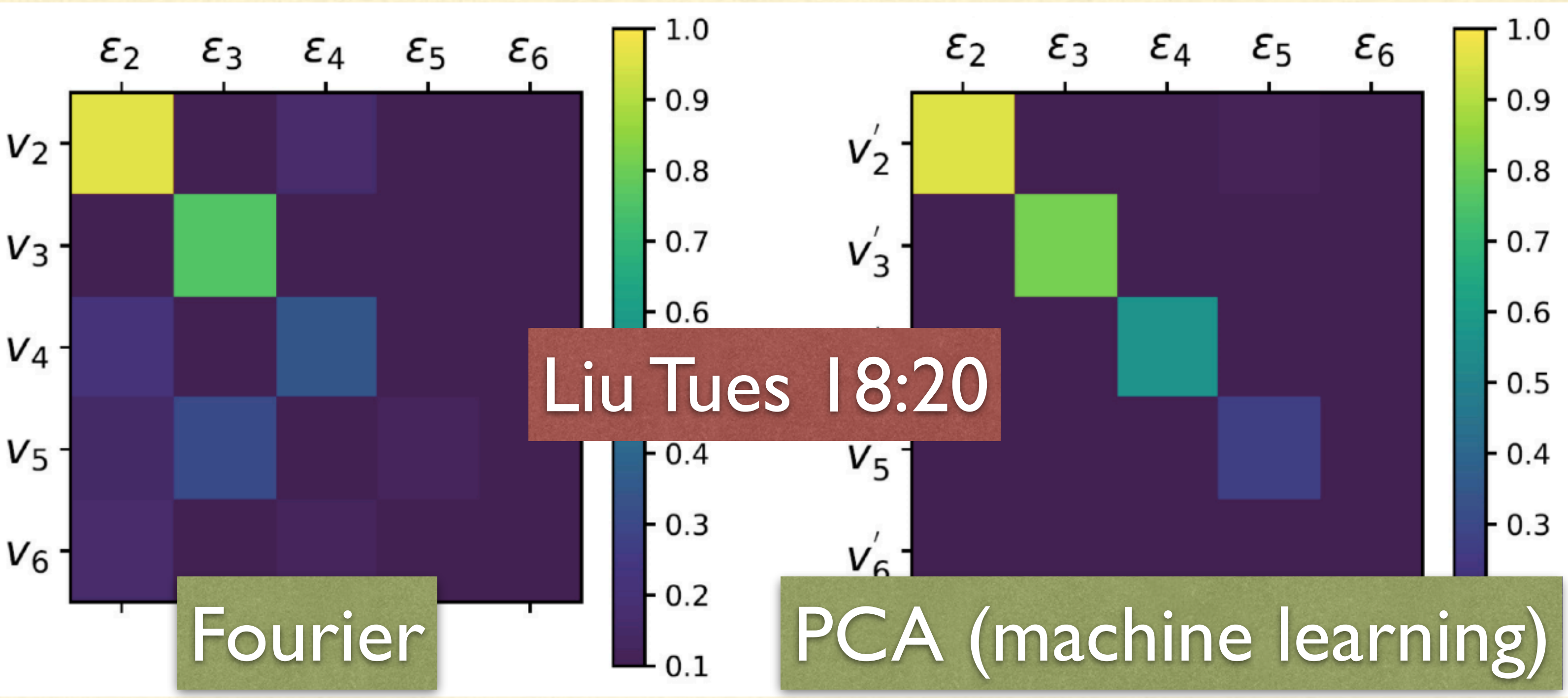
1901.01319

Seen both at RHIC and LHC, v2 hierarchy, v3 universal scaling

Mohapatra Monday 9:15

Principle Components Analysis

New v_n' closer to $\varepsilon_{n\geq4}$



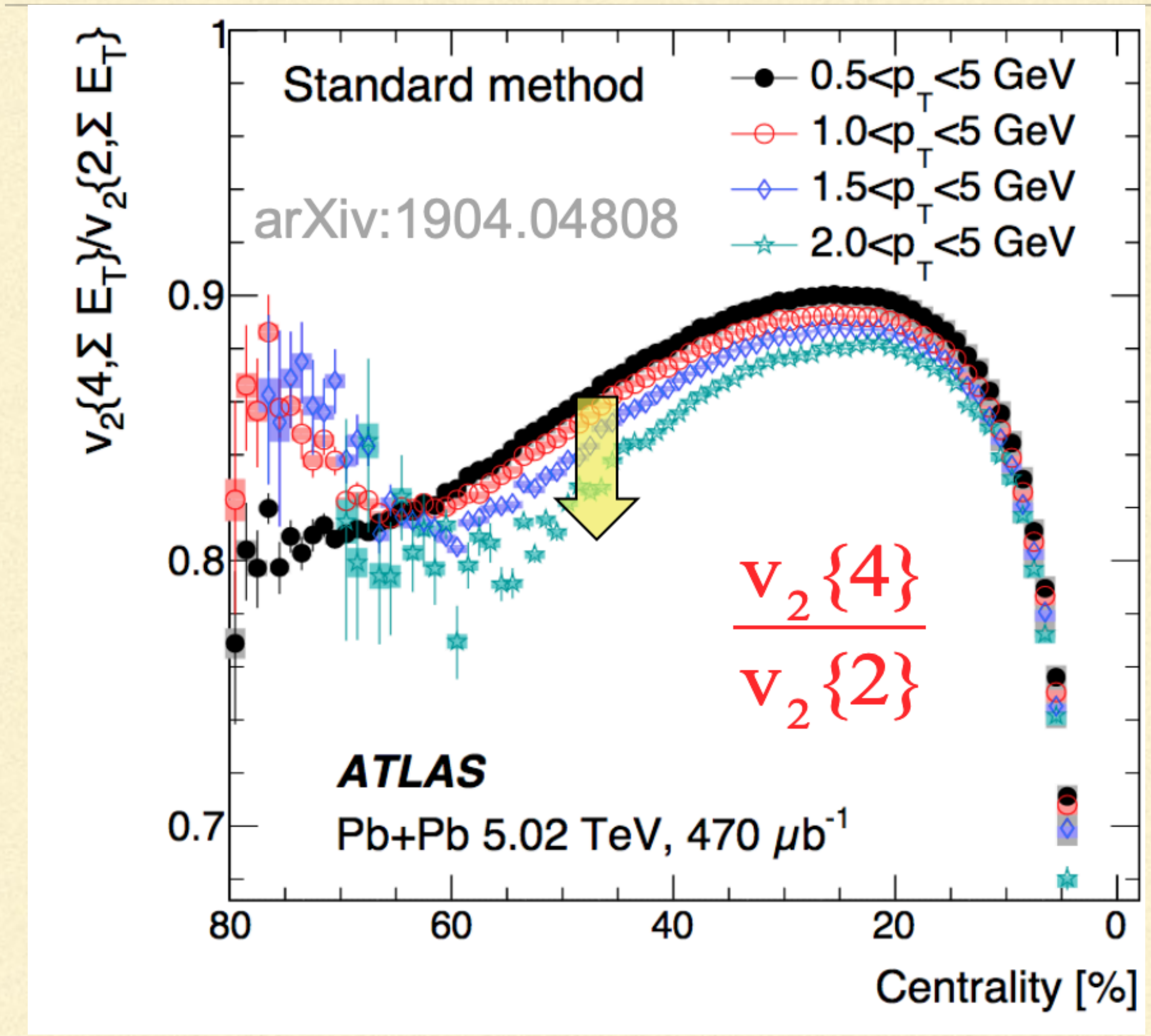
Liu Tues 18:20

Fourier

PCA (machine learning)

Posters: Luzum, Hippert

Linear vs. cubic response



Comparing PDFs to data

Bonvini Monday 16:00