Macroscopic QGP properties experimental considerations

✦Temperature ✦ Vorticity ✦ 3D dynamics

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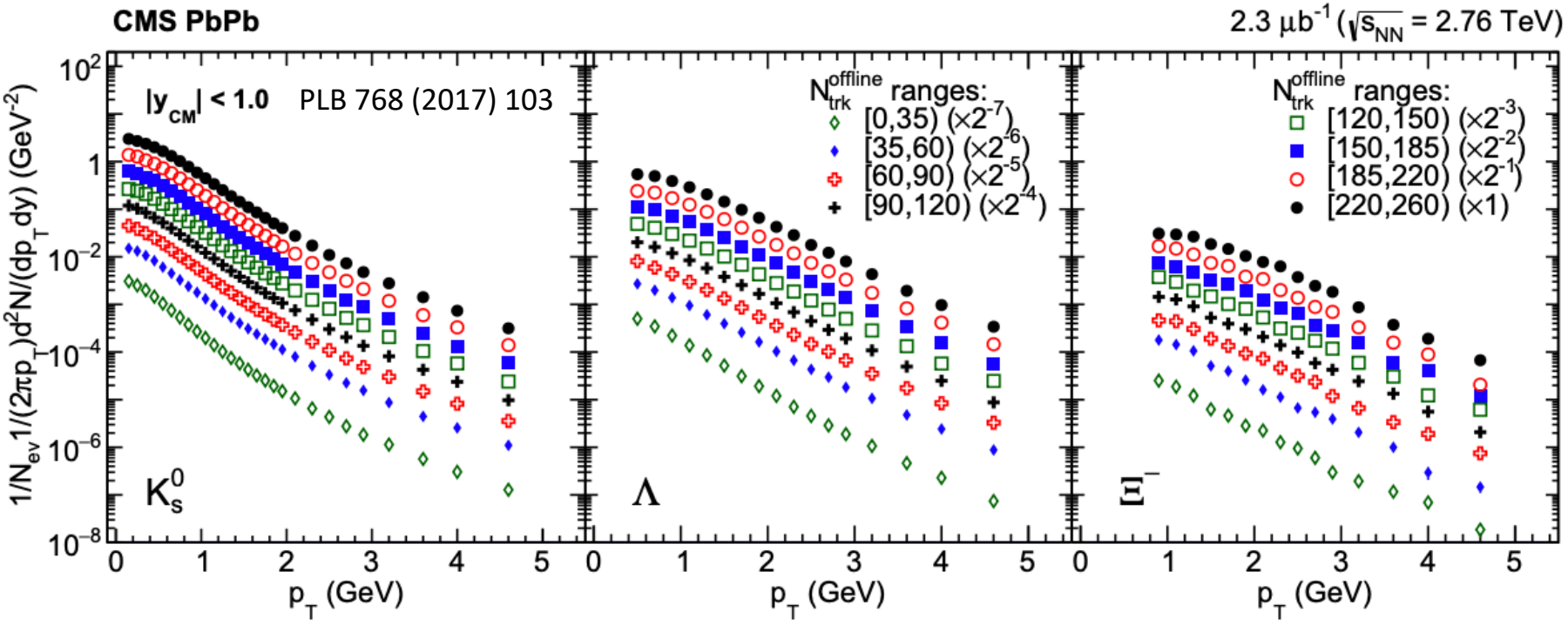
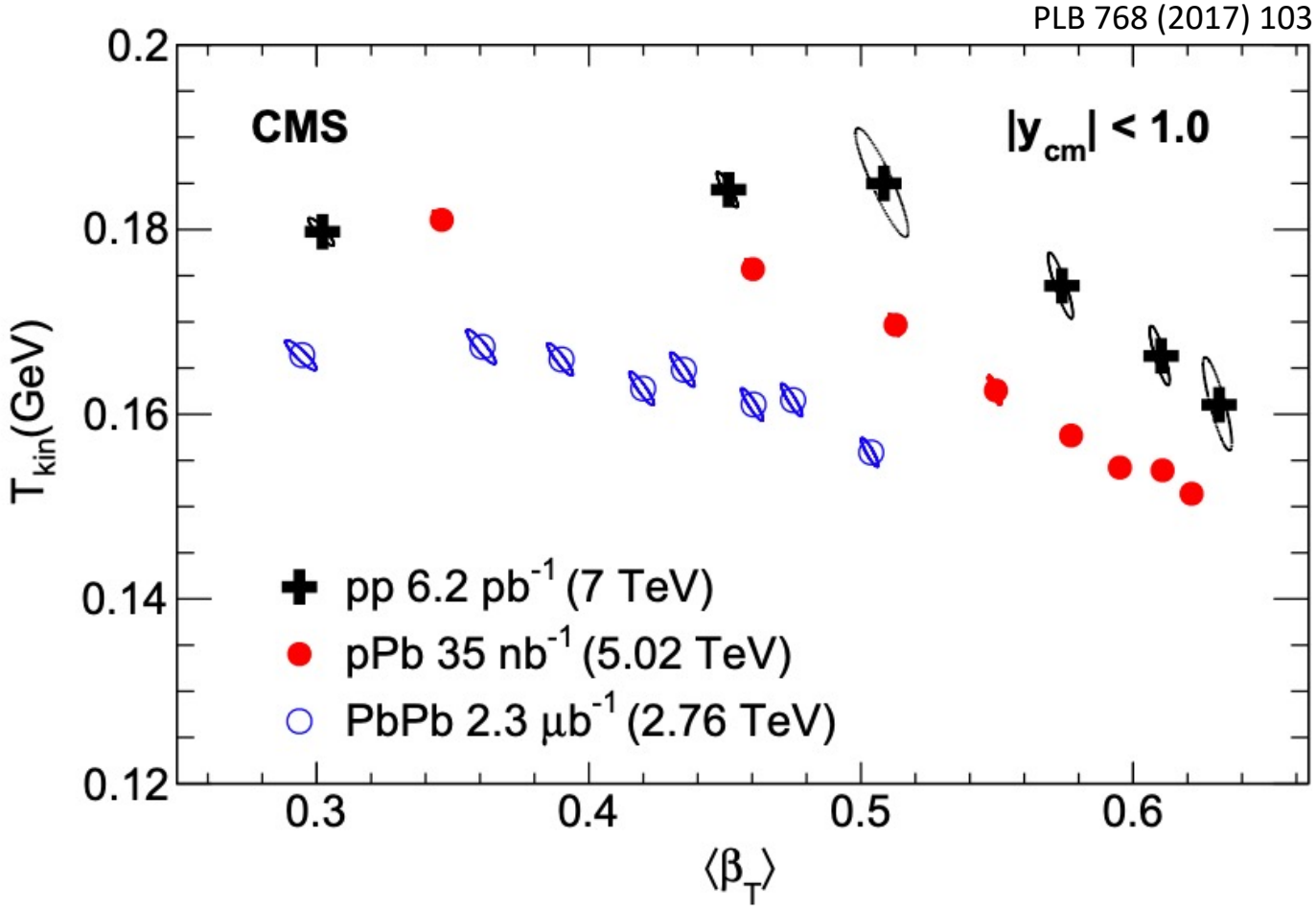
Temperature: PID spectra



Particle spectra provide a simple way to extract system temperature

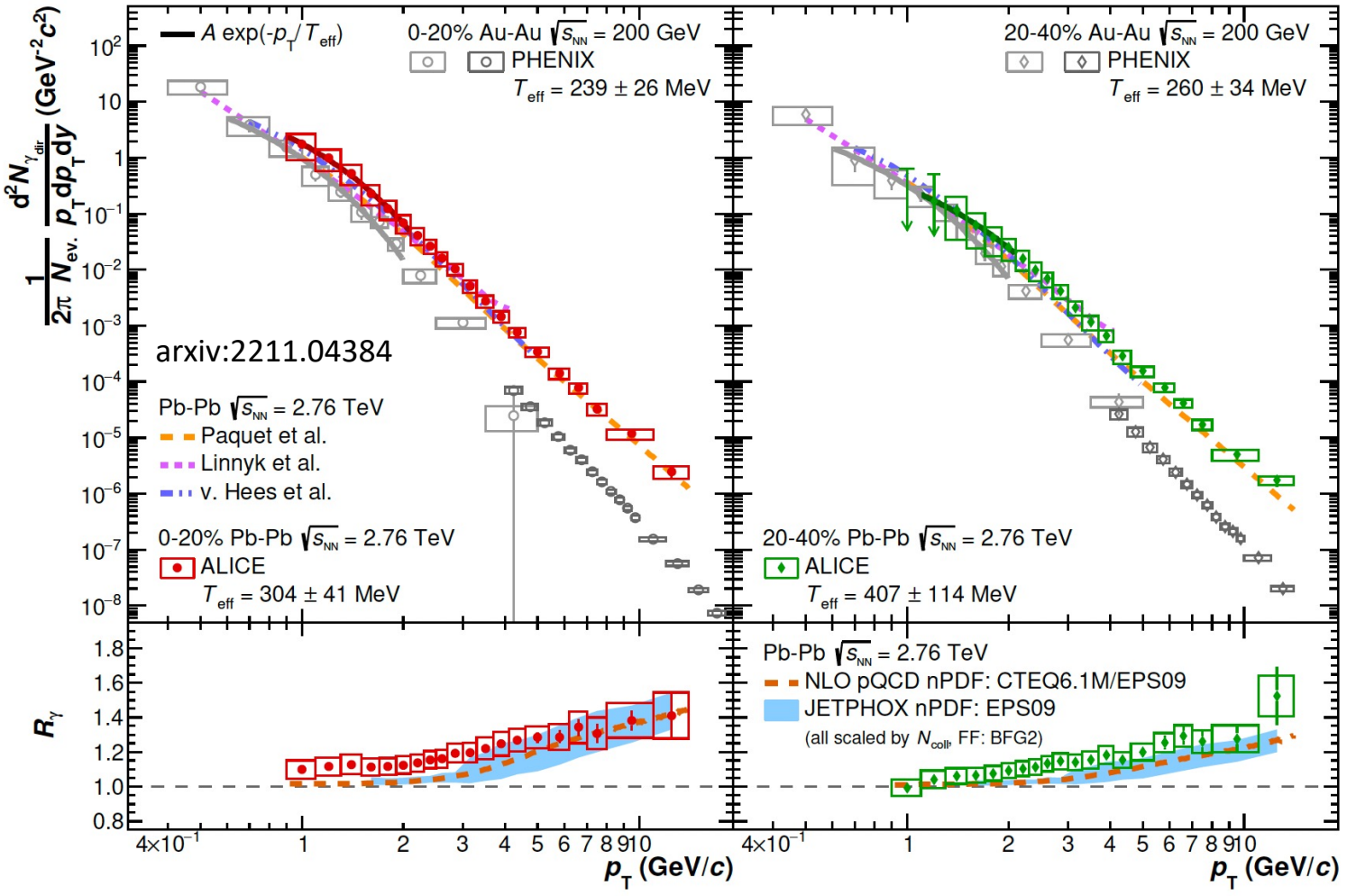
Temperature: PID spectra



Particle spectra provide a simple way to extract system temperature

Can get T_{kin} but not earlier temperature

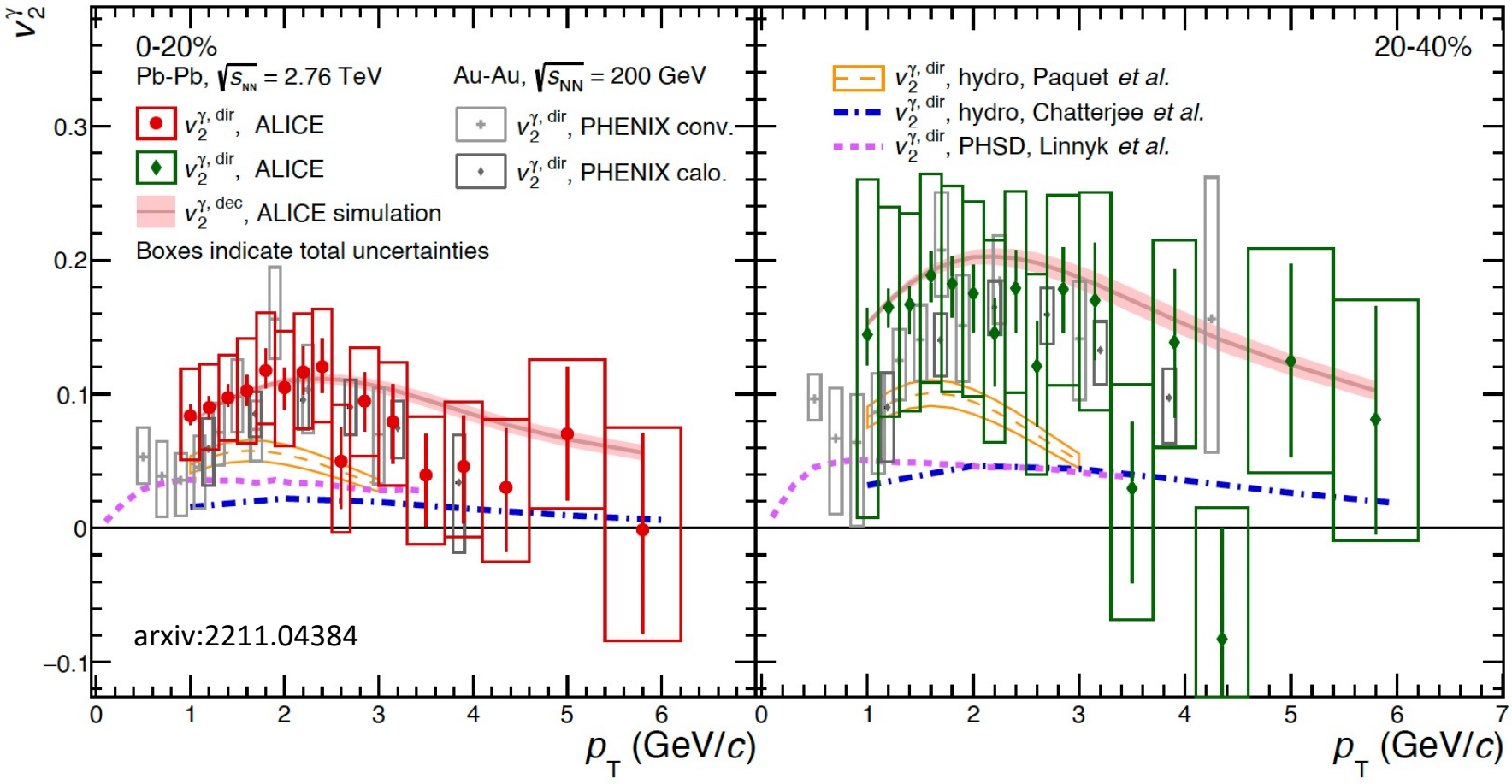
Temperature: direct photon



Direct photon spectra indicate T_{eff} through the whole evolution

T_{eff} increases from RHIC to LHC

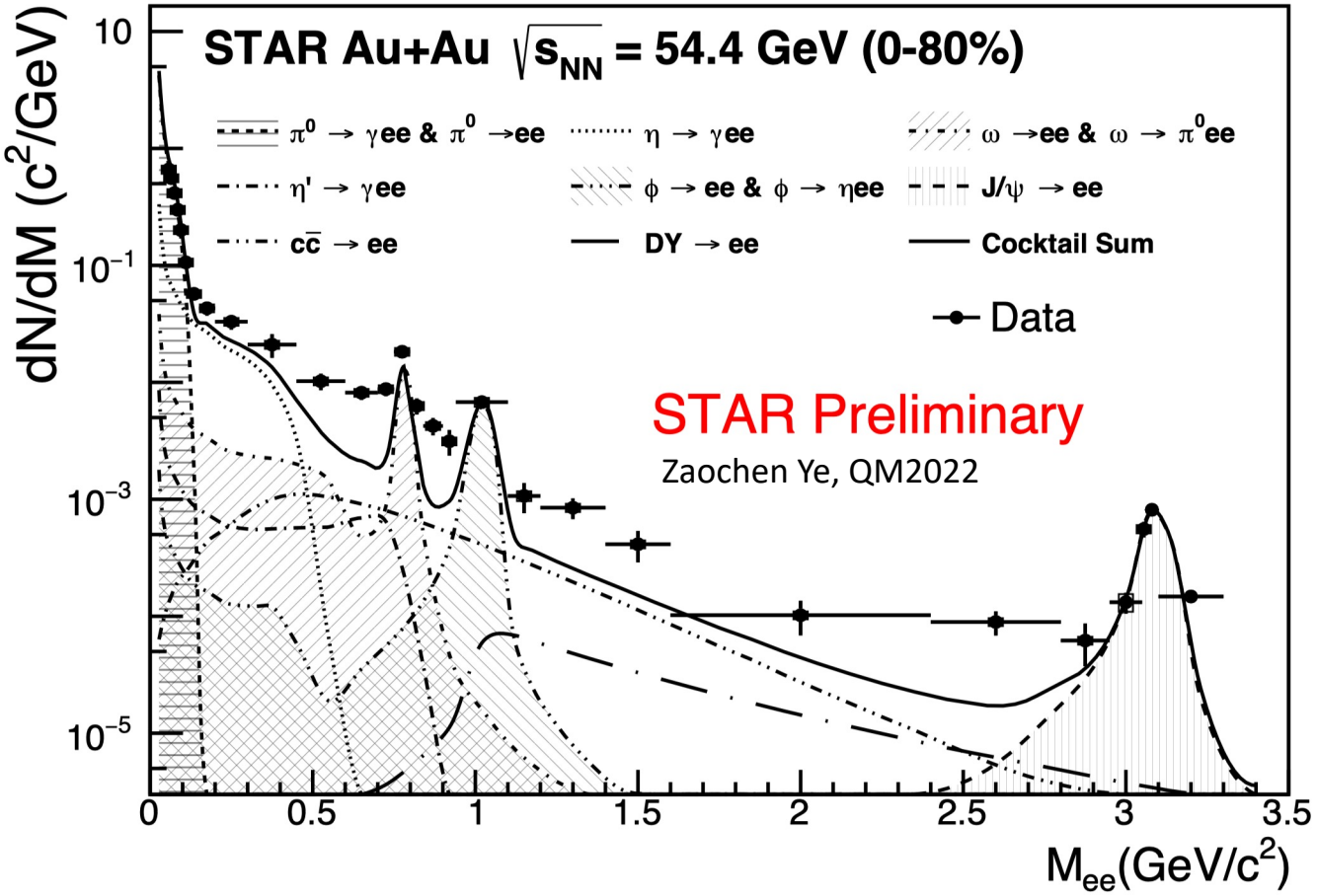
Temperature: direct photon



Measured direct photon v_2 larger than hydro calculation

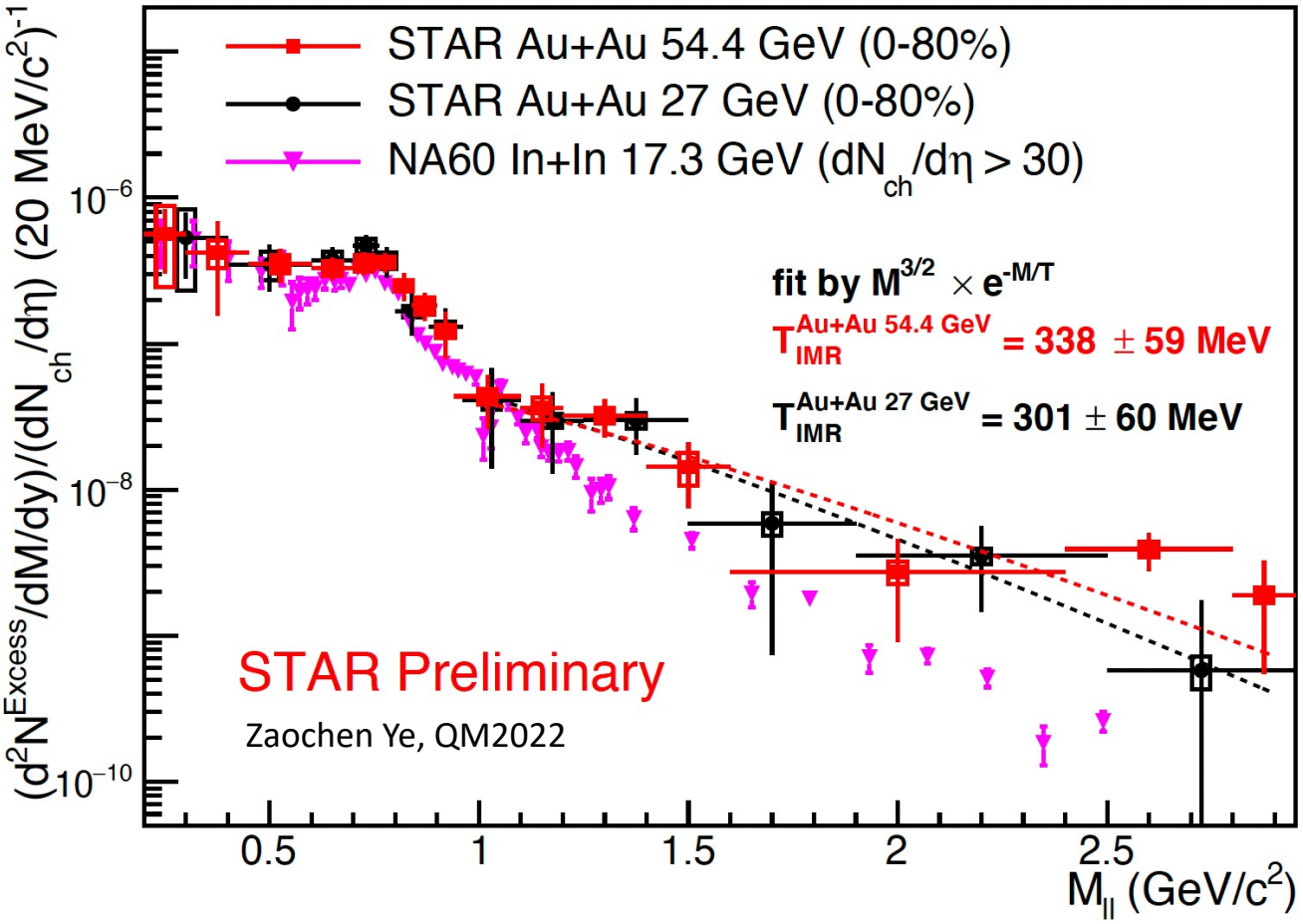
"Direct photon puzzle": how to describe spectra and v_2 together

Temperature: thermal dilepton



No blue shift effects: direct extraction of temperature

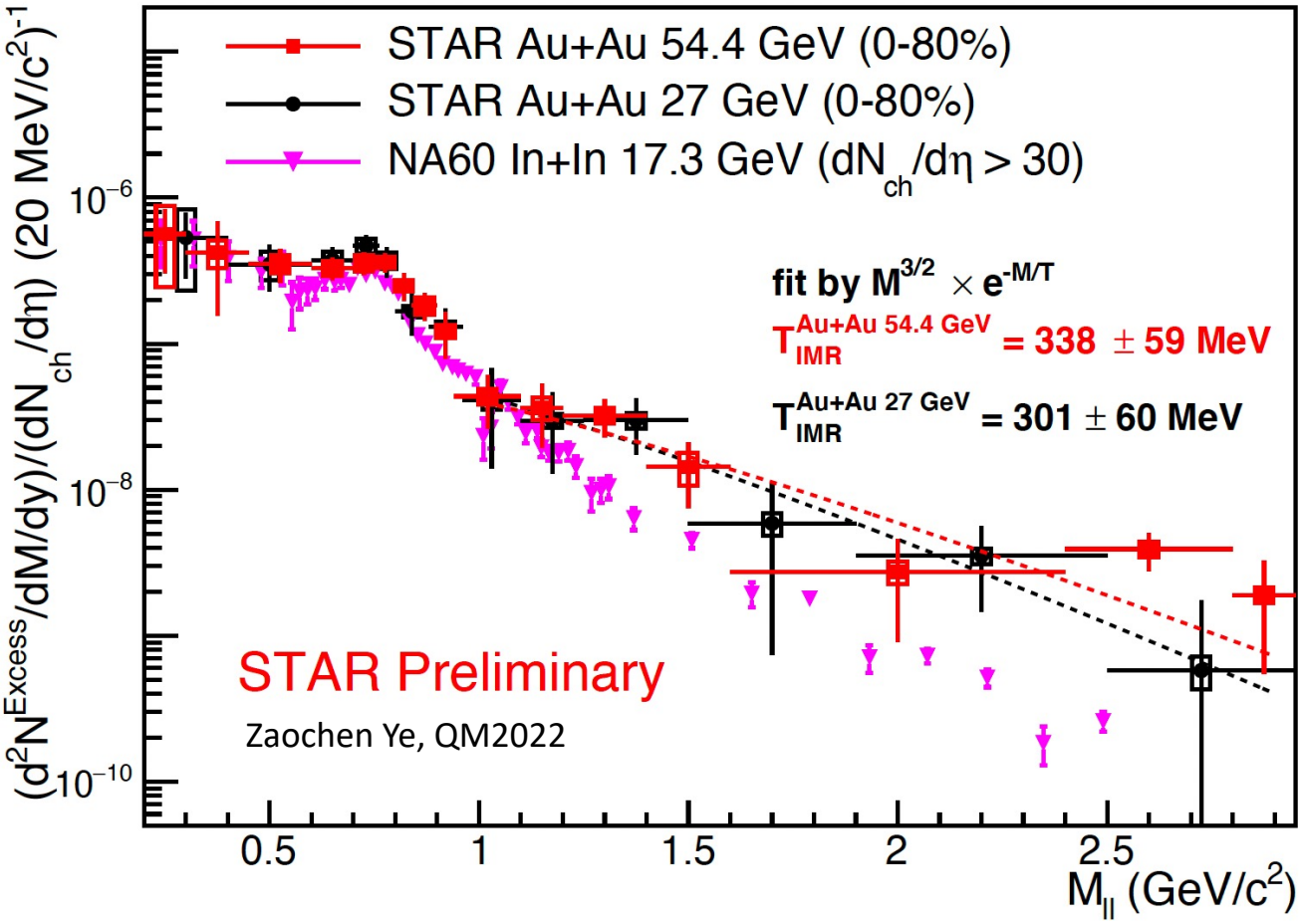
Temperature: thermal dilepton



No blue shift effects: direct extraction of temperature

QGP at RHIC hotter than SPS (205+/-12 MeV)

Temperature: thermal dilepton

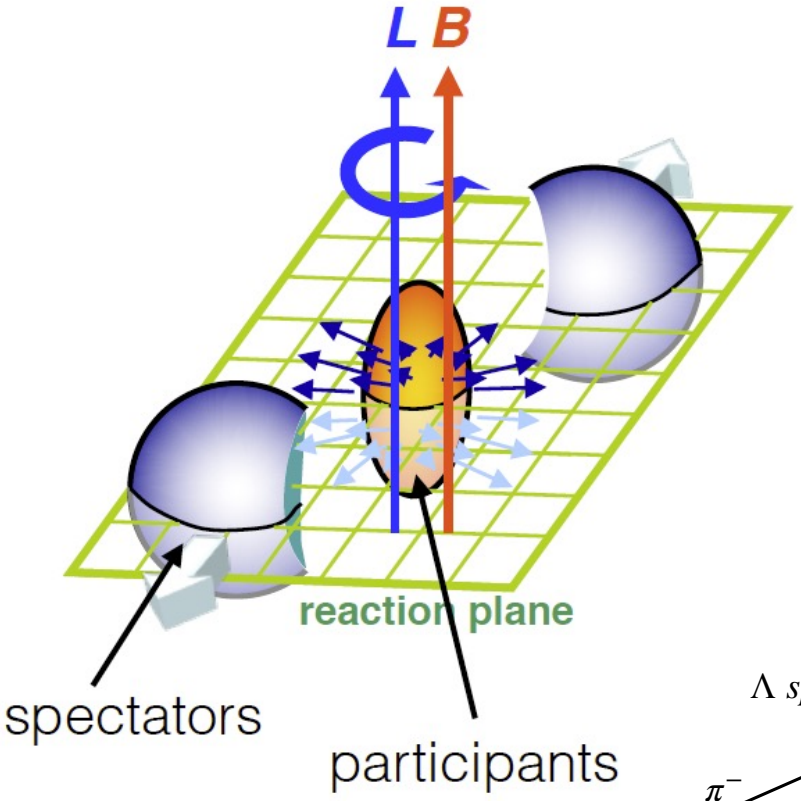


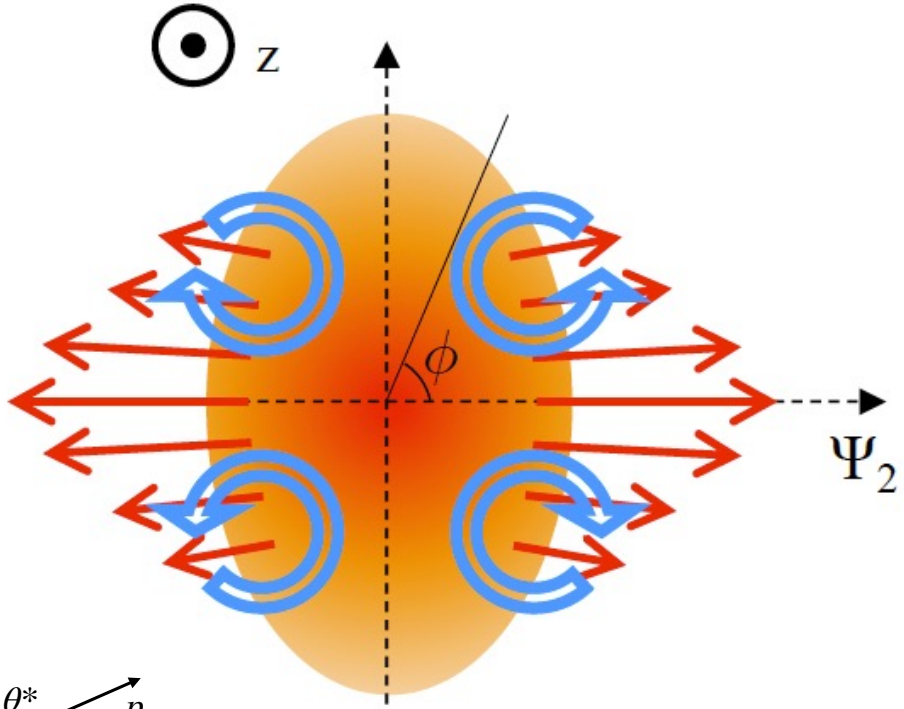
No blue shift effects: direct extraction of temperature

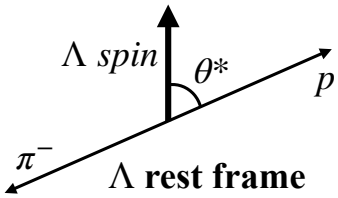
QGP at RHIC hotter than SPS (205+/-12 MeV)

Stay tuned for more results at different energies

Vorticity: hyperon polarization





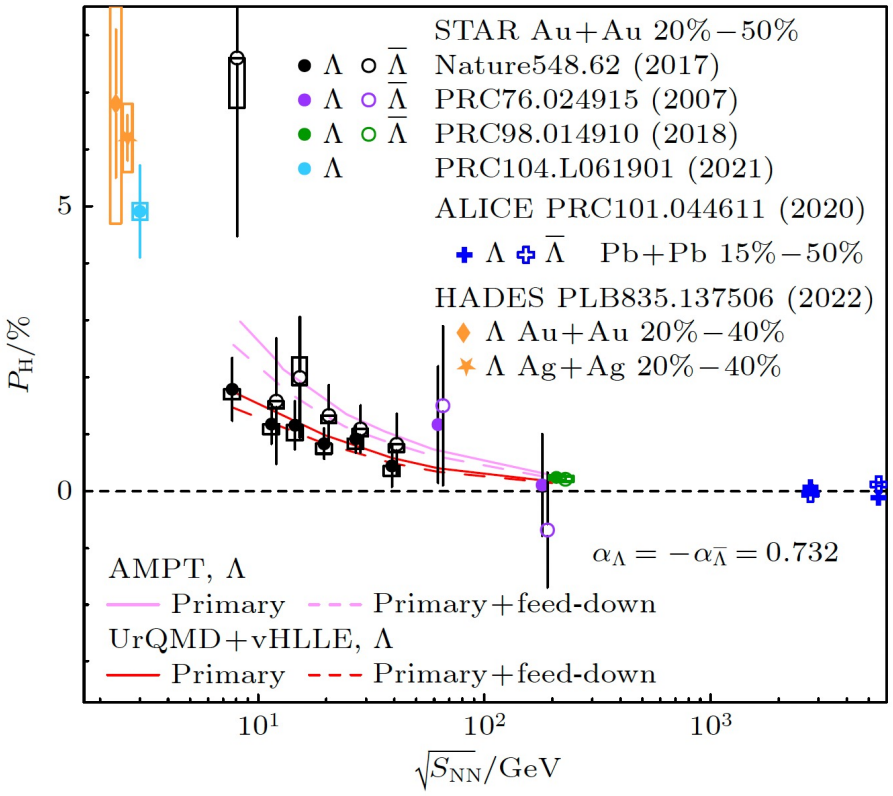


Vorticities provide unique constraints on QGP properties

Easily measurable via hyperon weak decay

Vorticity: hyperon polarization

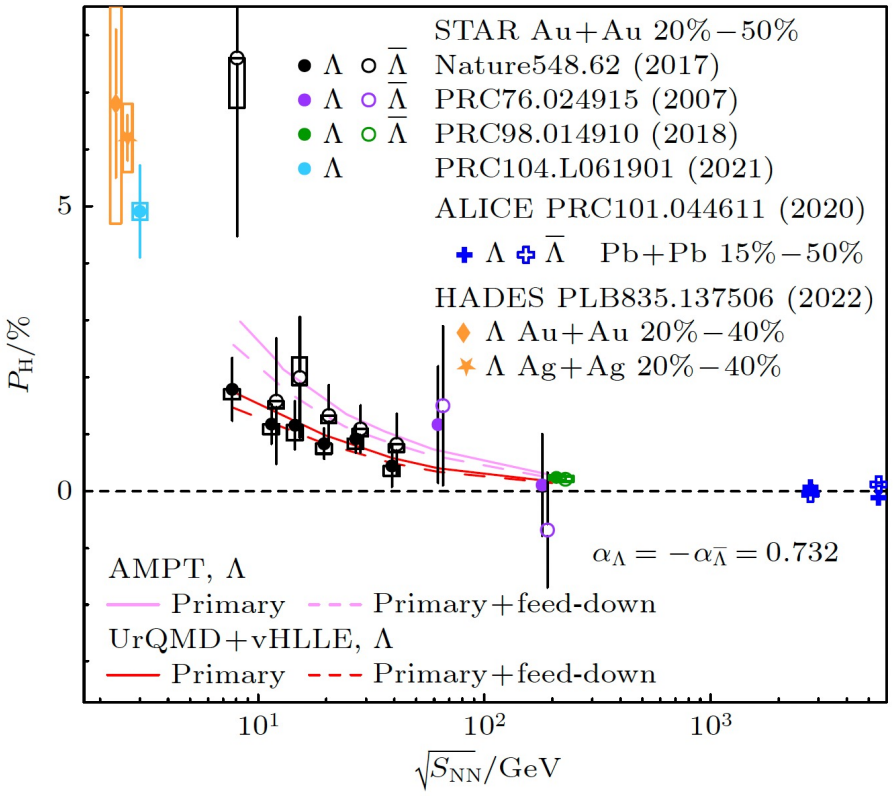
物理学报. Vol. 72, No. 7(2023) 072401

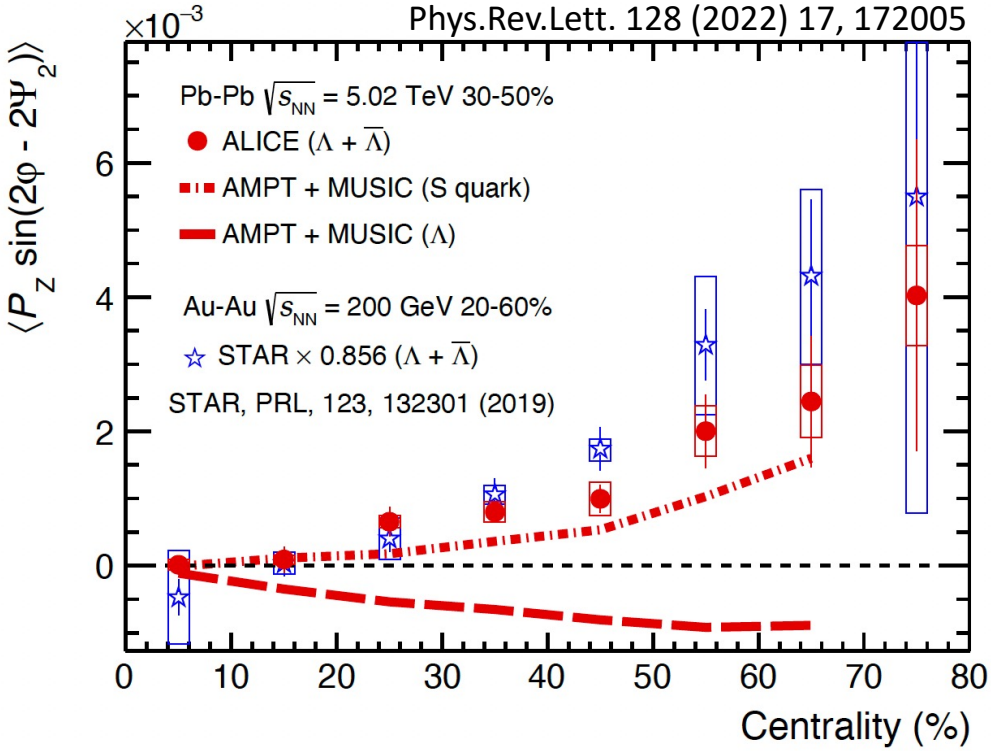


Global polarization consistent with 0 as expected

Vorticity: hyperon polarization

物理学报. Vol. 72, No. 7(2023) 072401



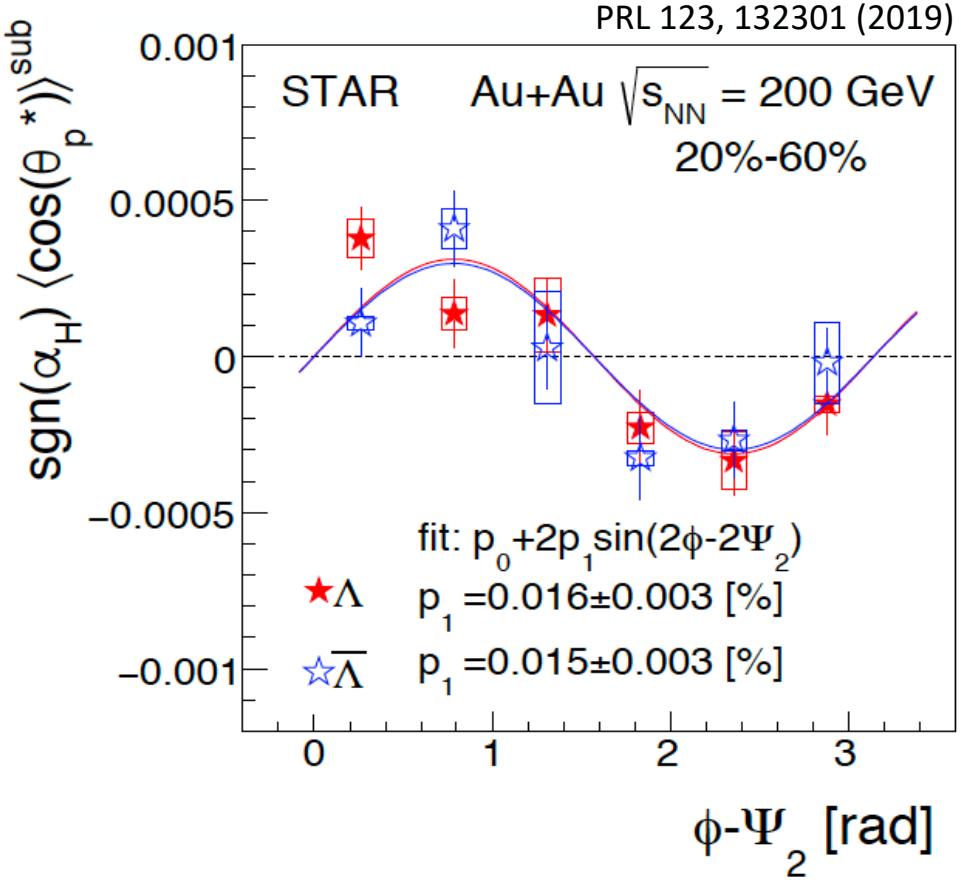


Global polarization consistent with 0 as expected

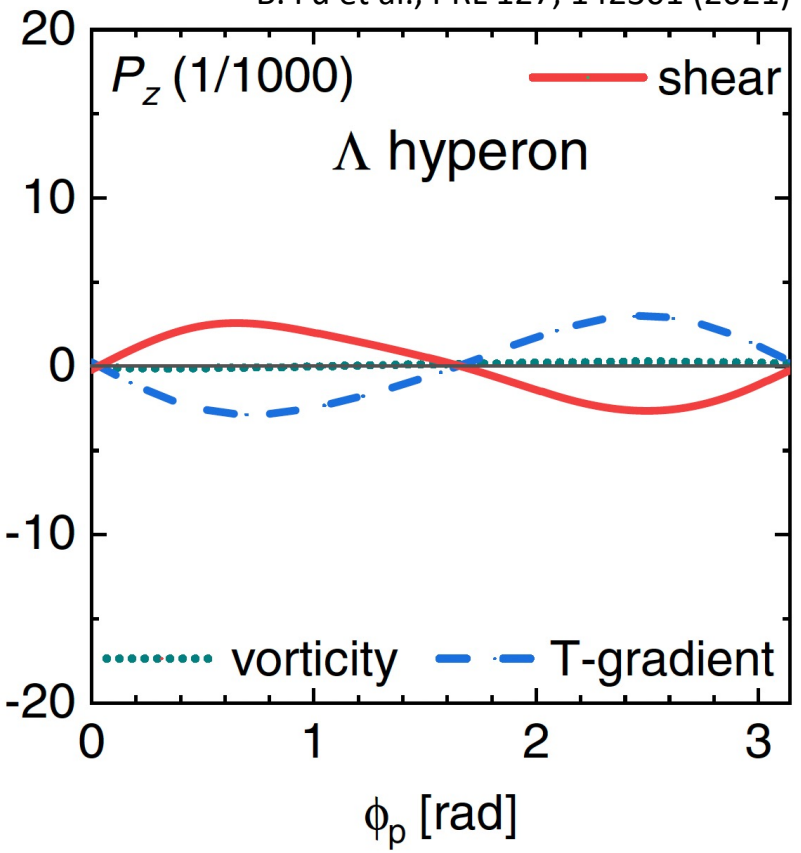
Significant polarization along beam direction

Vorticity: local polarization P_z

PRL 123, 132301 (2019)



B. Fu et al., PRL 127, 142301 (2021)

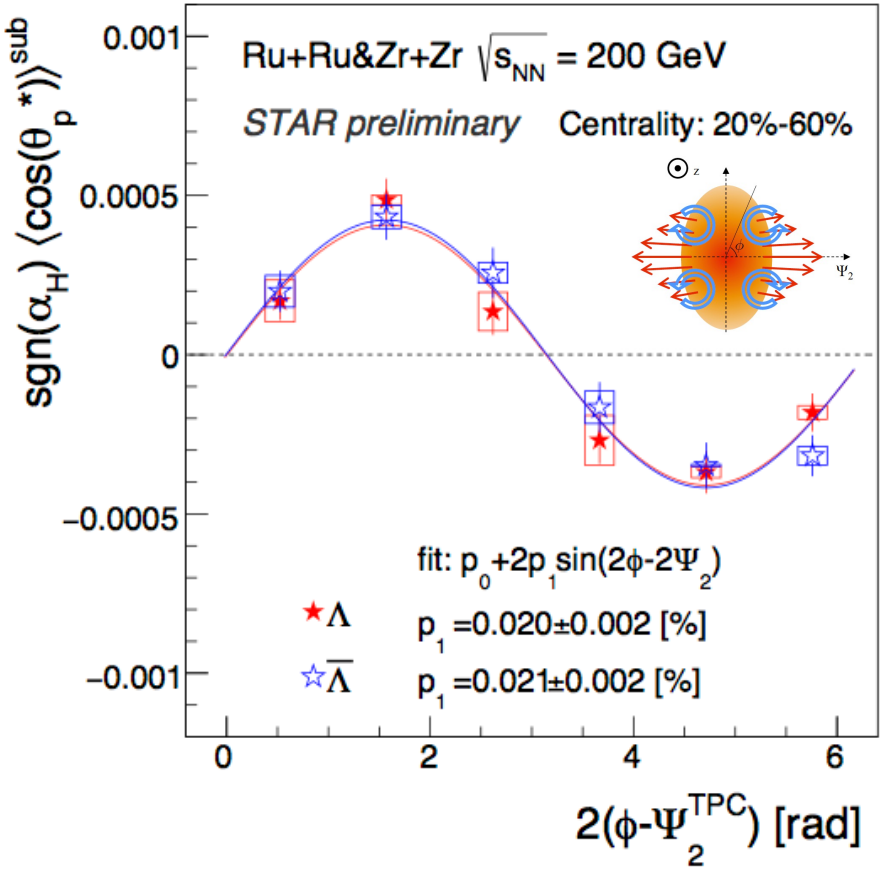


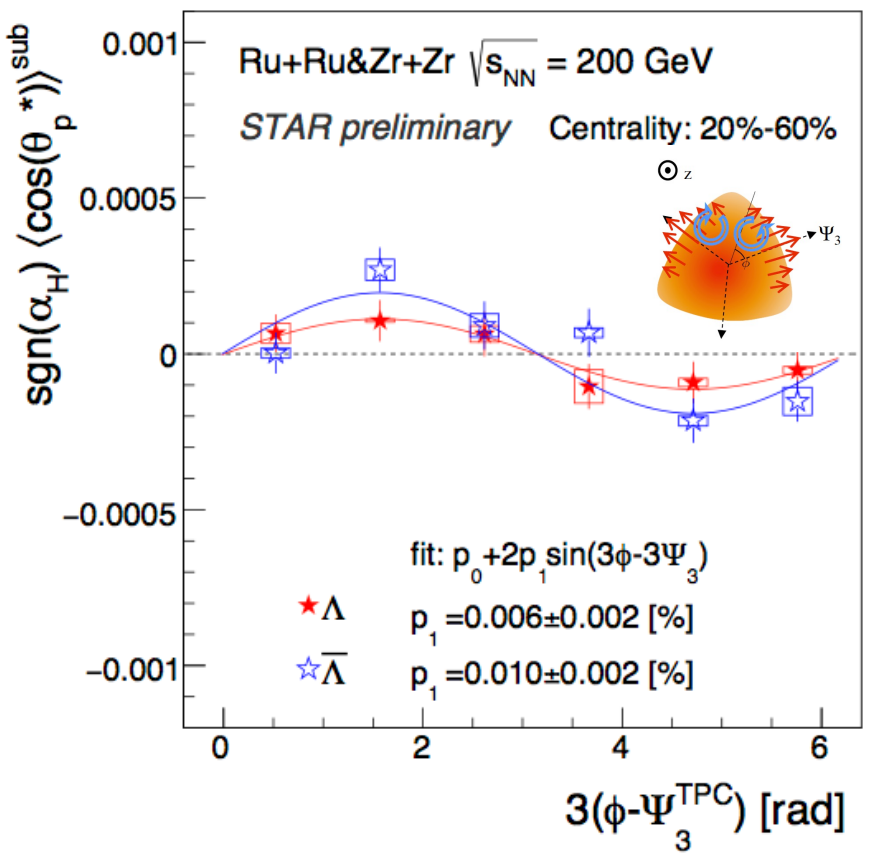
Multiple components needed to explain data

Fraction of each contribution provide unique constrain for hydro

Vorticity: local polarization P_z

arXiv:2303.09074

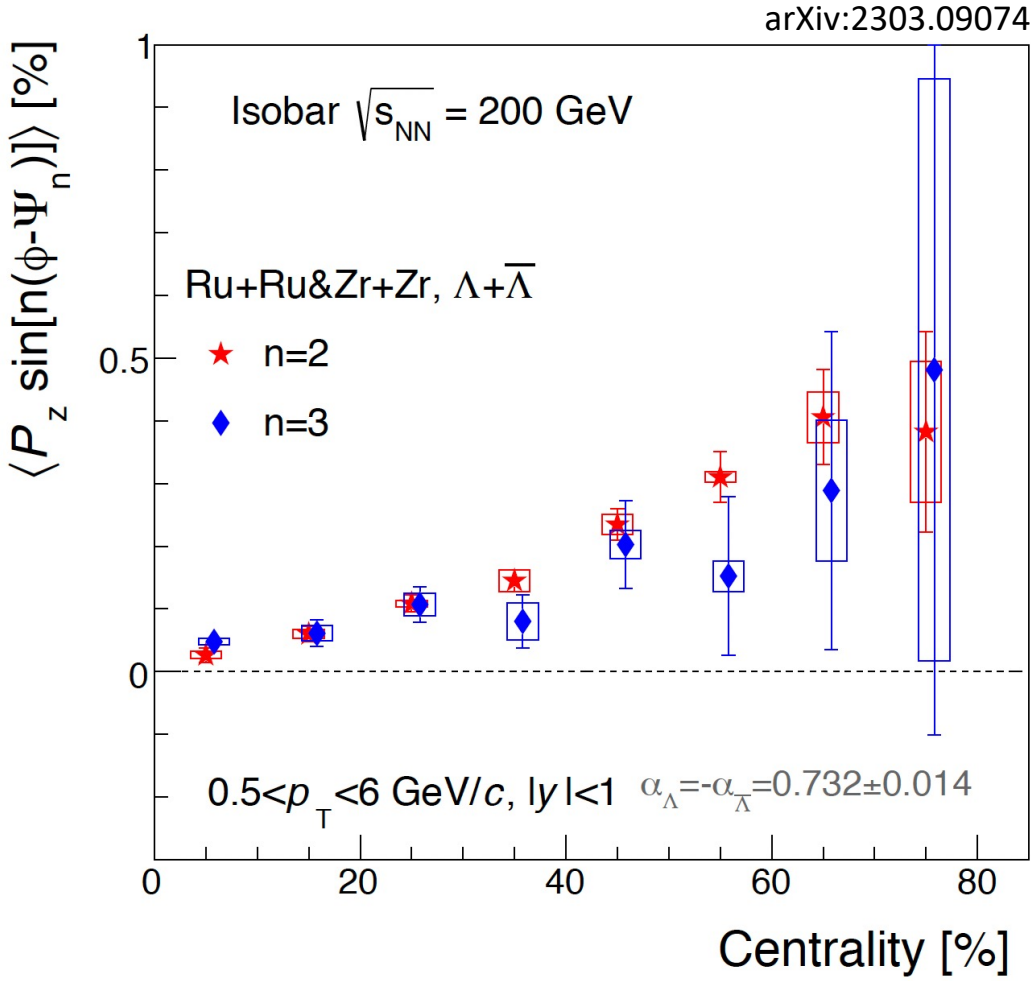




STAR measures local polarization to third order

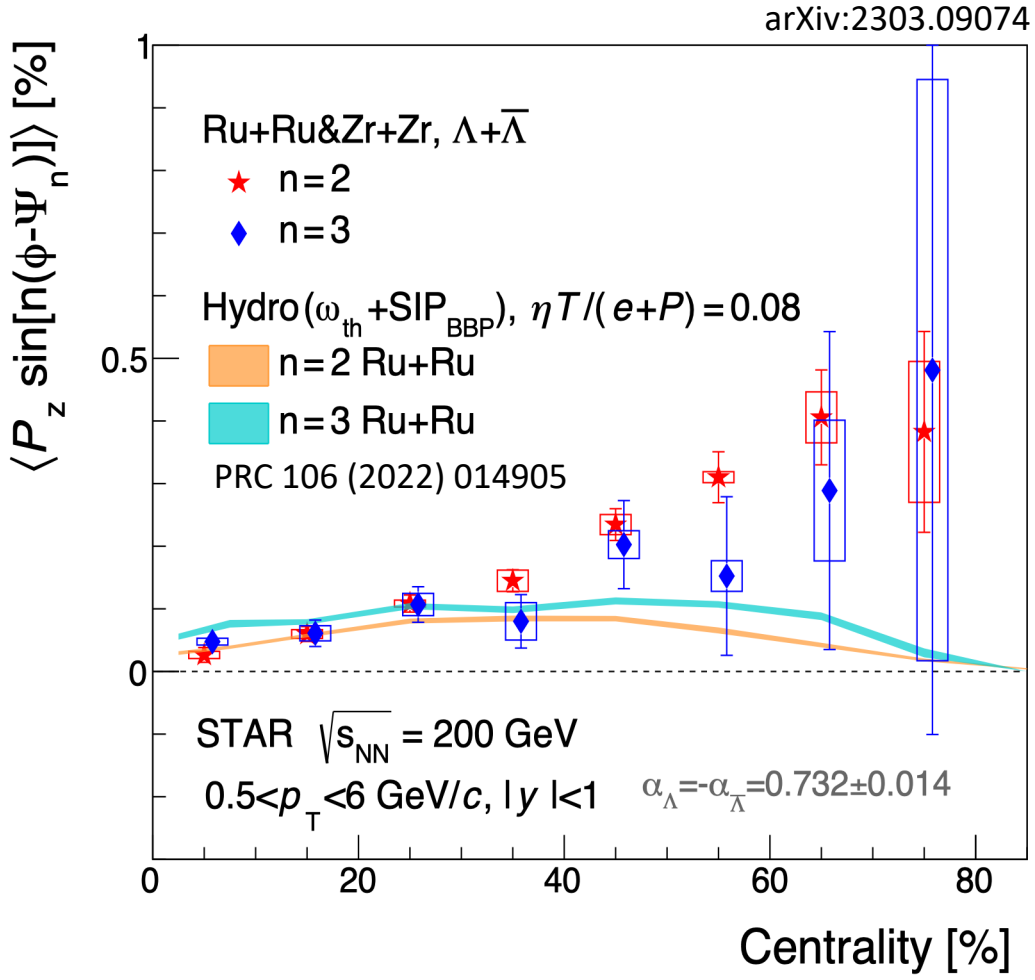
Indication of direct link between flow and polarization

Vorticity: P_z vs centrality



Comparable polarization signal wrt second and third order event plane

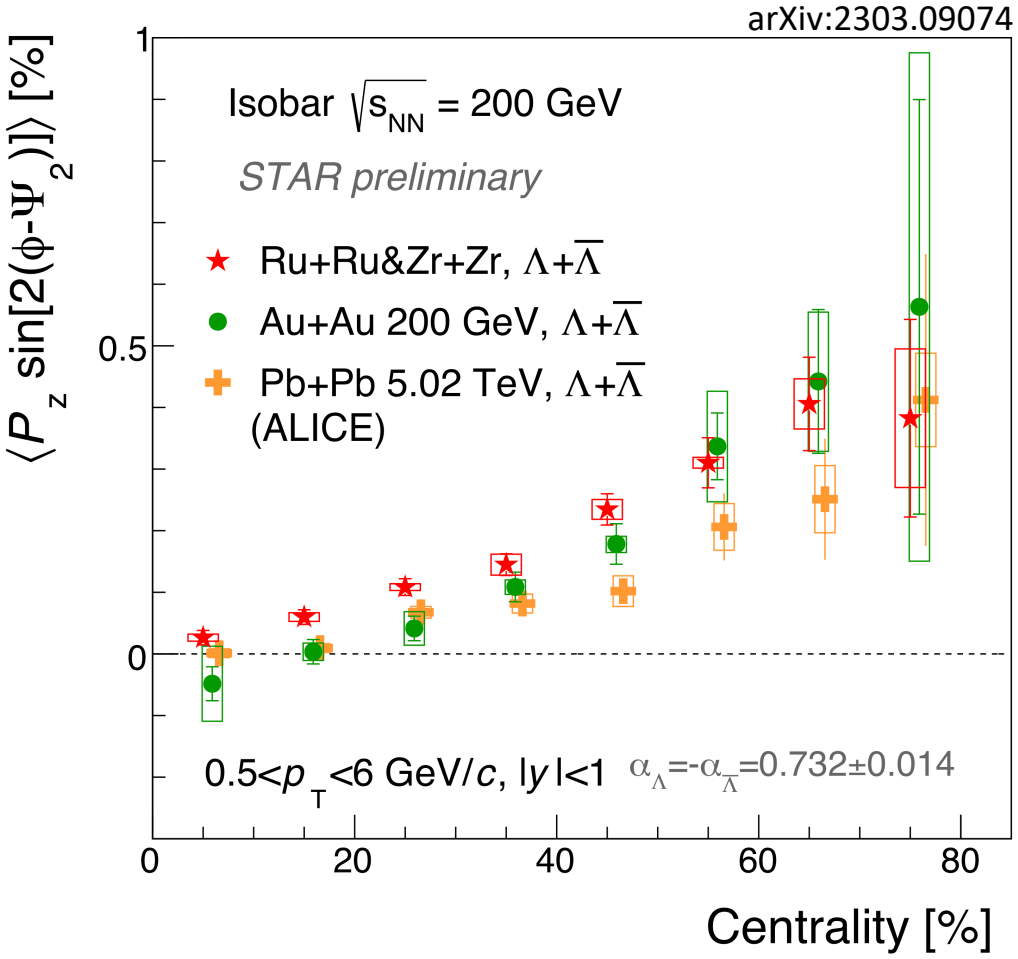
Vorticity: P_z vs centrality



Comparable polarization signal wrt second and third order event plane

Reasonably reproduced by hydro calculations except peripheral

Vorticity: P_z vs energy & system size

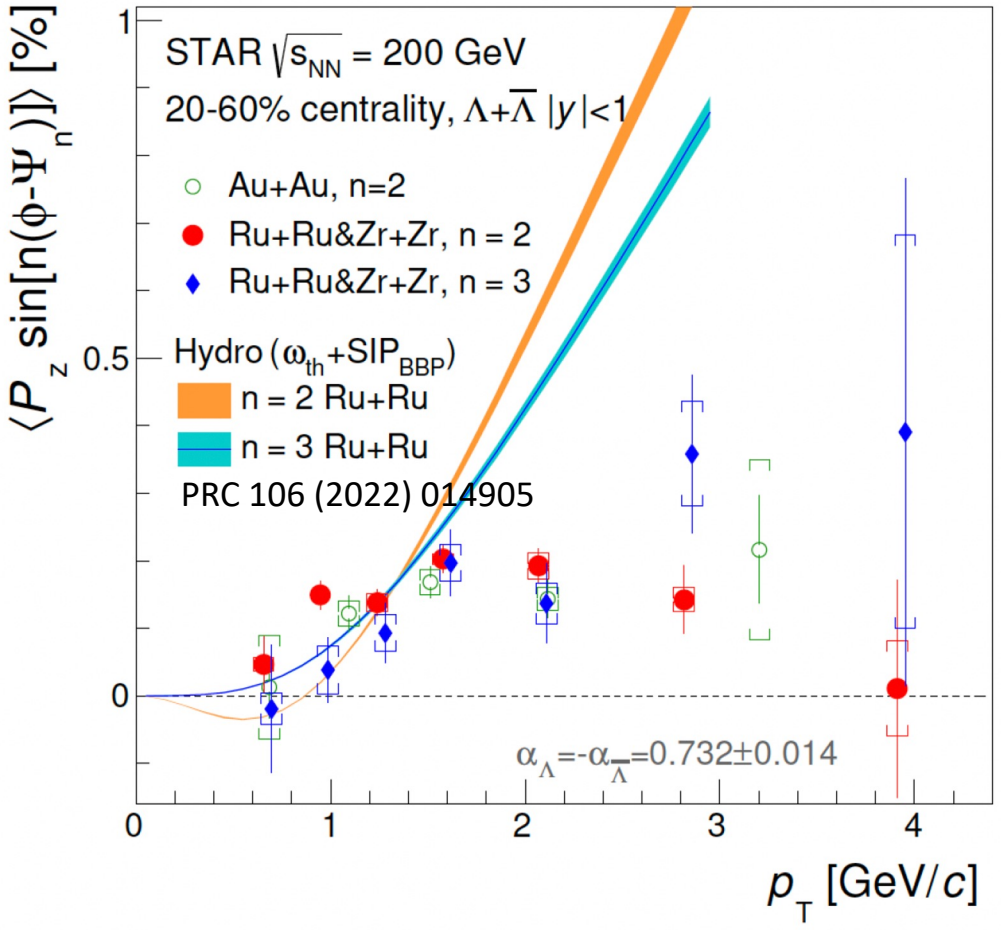


Hint of system size dependence between isobar & Au

No obvious energy dependence between RHIC & LHC

Vorticity: P_z vs p_T

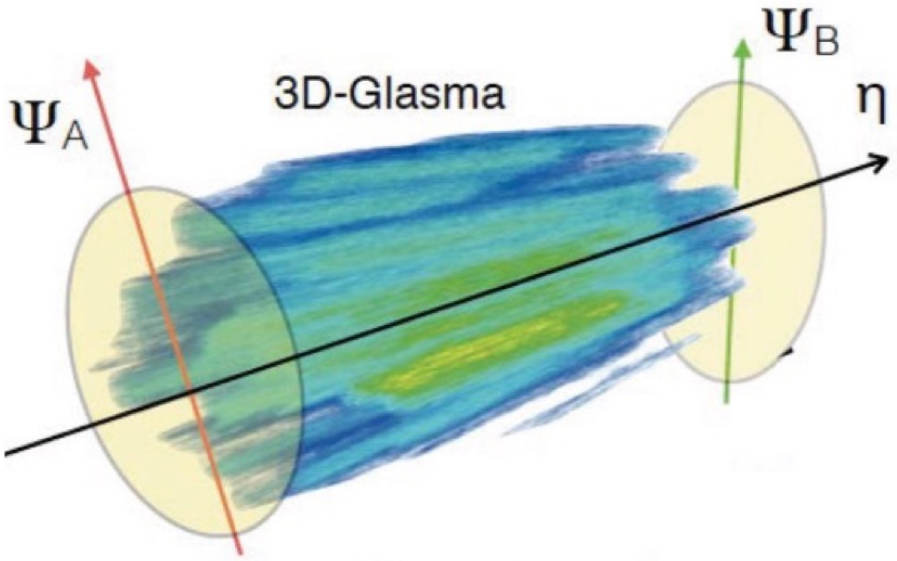
arXiv:2303.09074



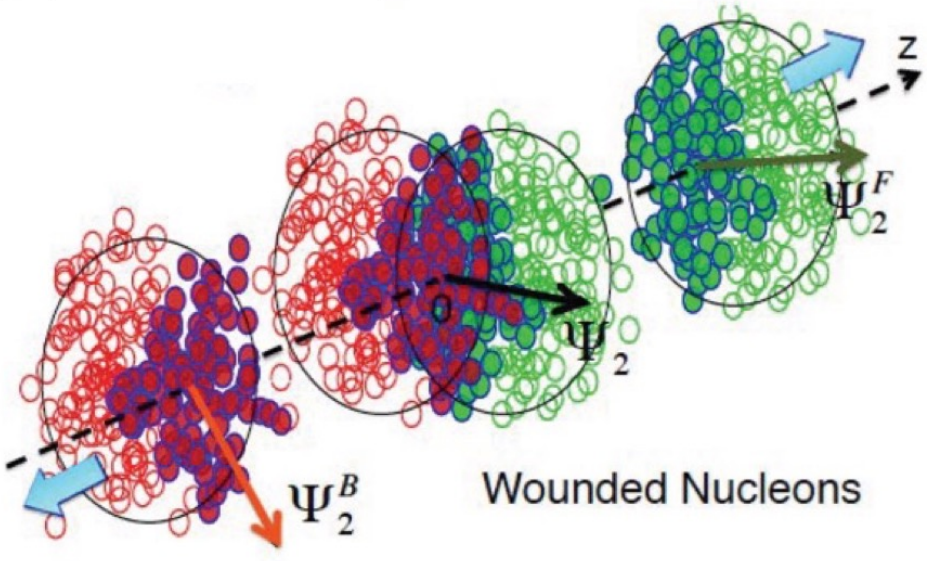
Slightly larger $P_{z,2}$ than $P_{z,3}$

Decreasing towards high p_T

3D dynamics: longitudinal decorrelation



Bjorn Schenke, Soren Schlichting
Phys. Rev. C 94 (2016) 4, 044907



Jiangyong Jia, Peng Huo
Phys. Rev. C 90 (2014) 034905

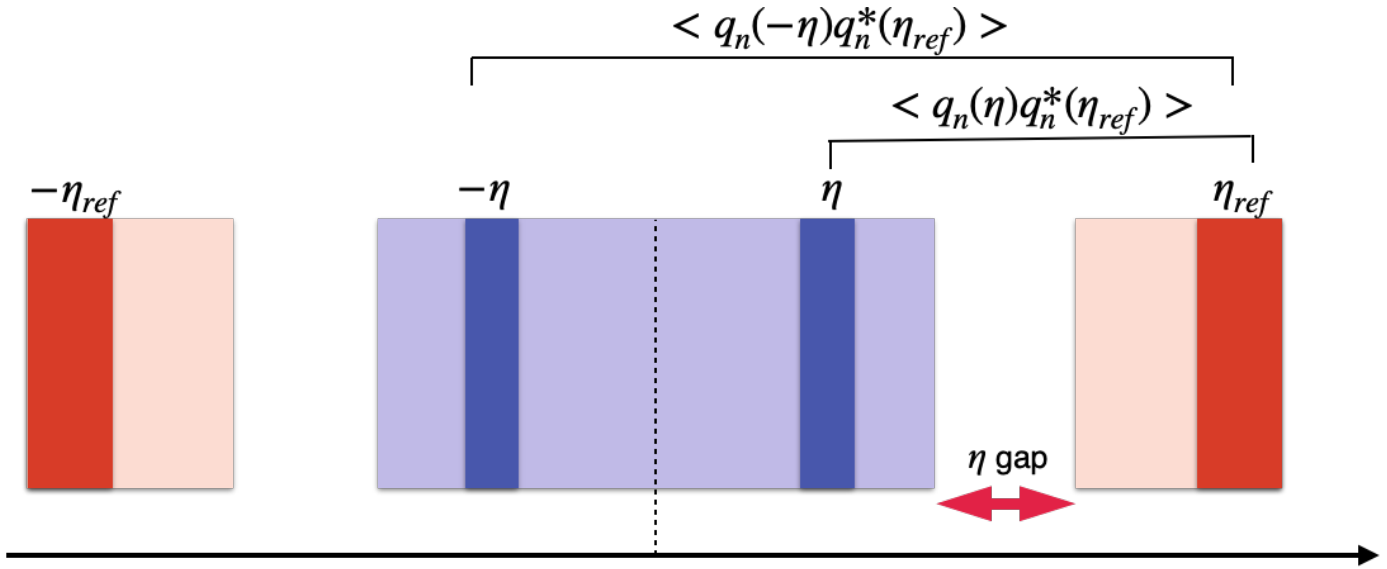
Decorrelation measurements probe 3D initial state

and dynamical evolution of QGP

Play a key role in flow measurements in smaller systems

3D dynamics: longitudinal decorrelation

$$r_n(\eta) = \frac{< q_n(-\eta) q_n^*(\eta_{ref}) >}{< q_n(+\eta) q_n^*(\eta_{ref}) >} = \frac{< v_n(-\eta) v_n(\eta_{ref}) cos\{n[\psi_n(-\eta) - \psi_n(\eta_{ref})]\}) >}{< v_n(+\eta) v_n(\eta_{ref}) cos\{n[\psi_n(+\eta) - \psi_n(\eta_{ref})]\}) >}$$



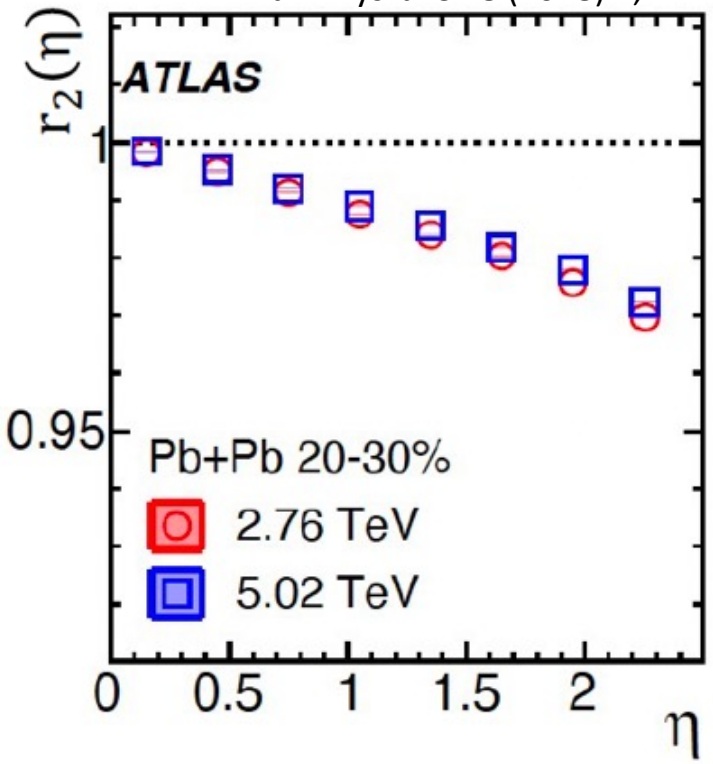
Decorrelation measurements probe 3D initial state and dynamical evolution of QGP

Play a key role in flow measurements in smaller systems

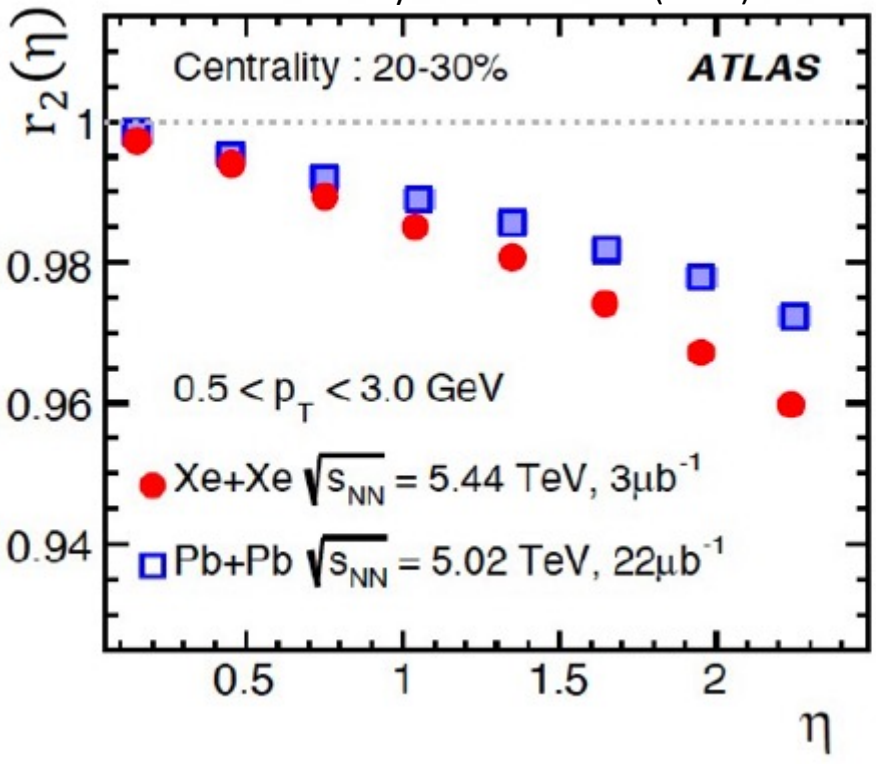
Measurable by factorization breakdown ration r_n

3D dynamics: longitudinal decorrelation

Eur. Phys. J. C 78 (2018) 2, 142



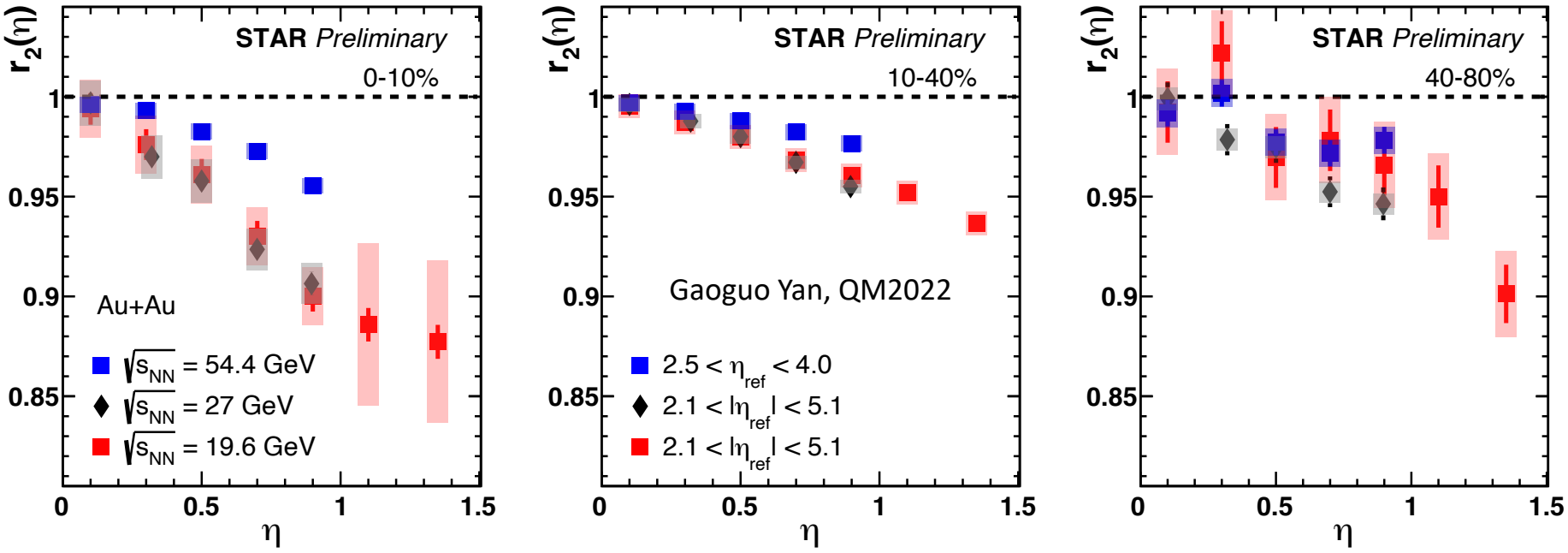
Phys. Rev. Lett. 126 (2021) 122301



Fruitful results at LHC

Collision energy dependence & system dependence studies can be extended at RHIC

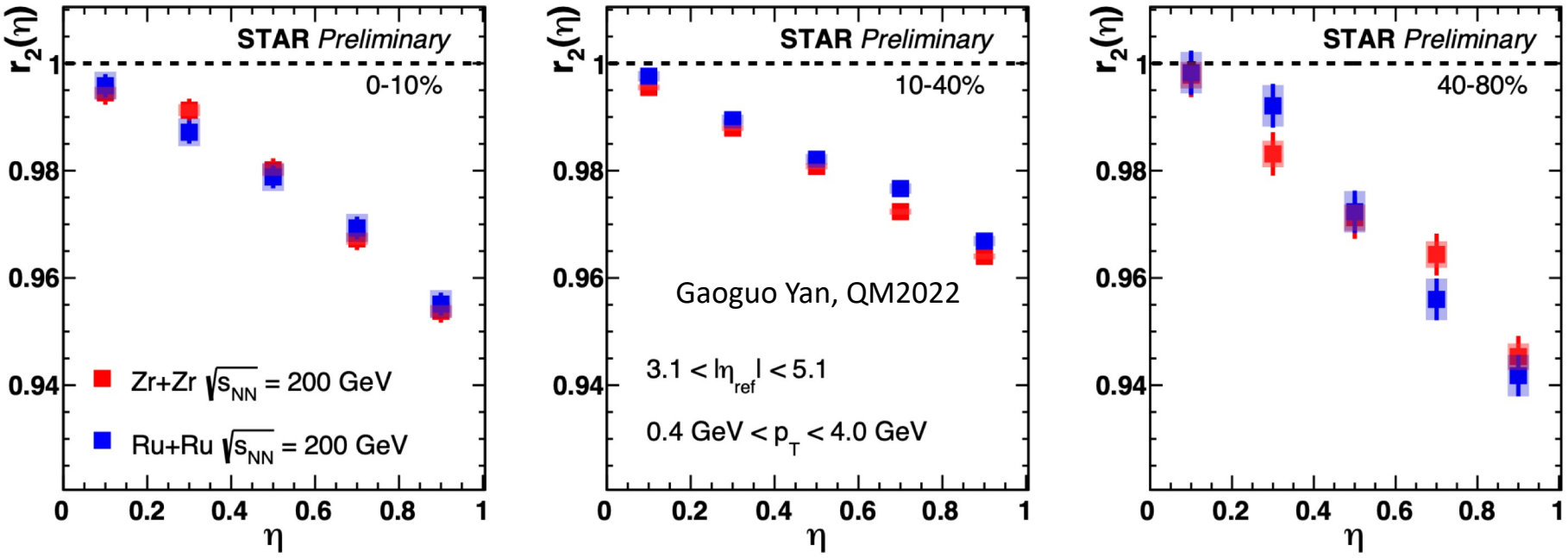
3D dynamics: longitudinal decorrelation



Clear energy dependence between 54 and 27 GeV

Hint of non-linear energy dependence at lower energy?

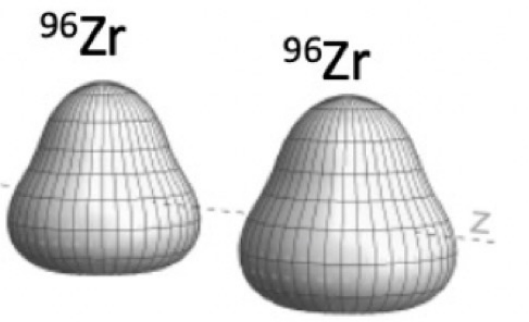
3D dynamics: longitudinal decorrelation



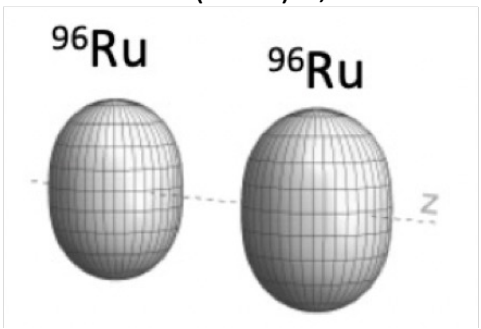
No obvious difference between Ru & Zr

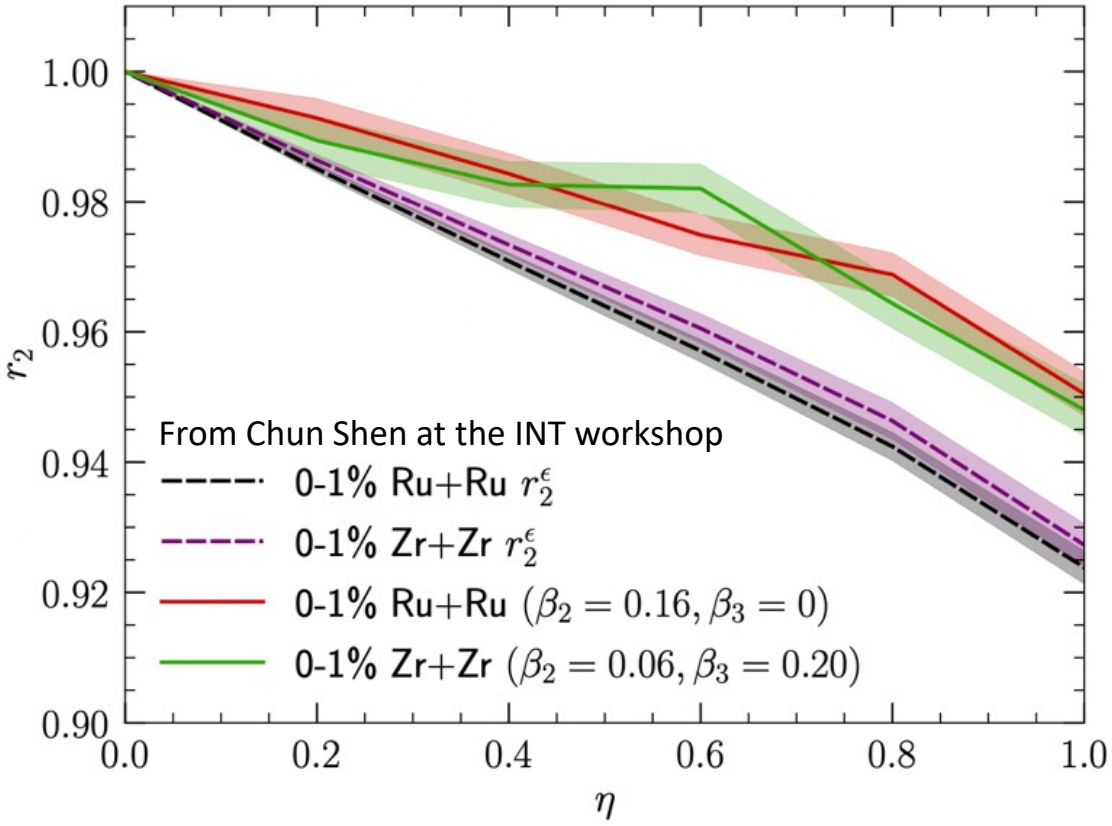
Observable not sensitive to nuclear shape deformation?

3D dynamics: longitudinal decorrelation



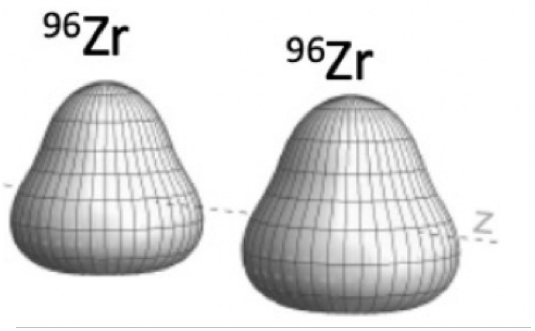
PRL 128 (2022) 2, 022301





Deformation has little impact on r_2

3D dynamics: longitudinal decorrelation



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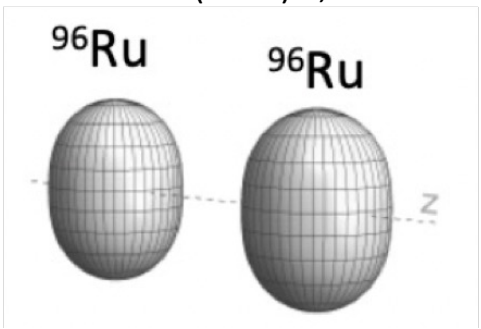
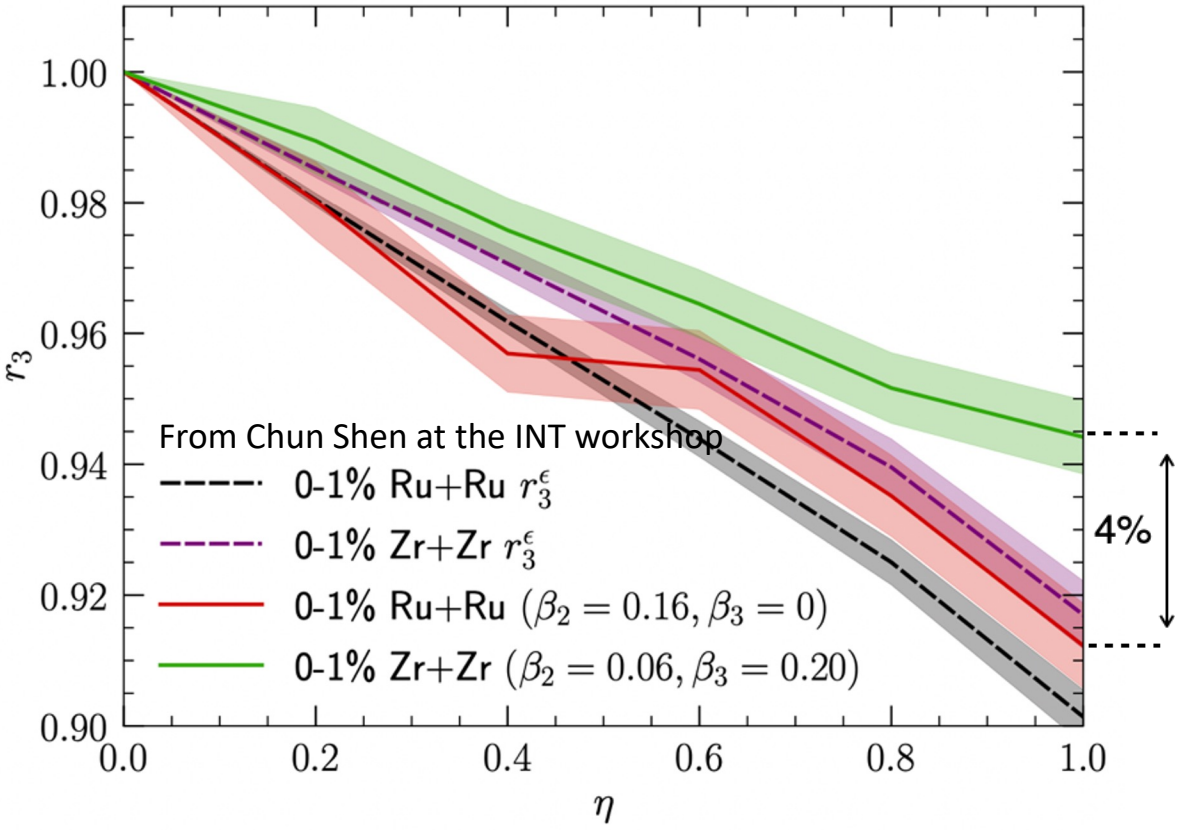




Deformation has little impact on r_2

Noticeable and measurable effects on r3

Works ongoing at STAR

Where to go?

QGP temperature

- "Direct photon puzzle" also at LHC?
- Possible thermal dilepton results from Run3&4?

QGP vorticity

- Local polarization for Xi, Omega at LHC
- v_n-$P_{z,n}$ correlation
- System size dependence (XeXe, OO…)

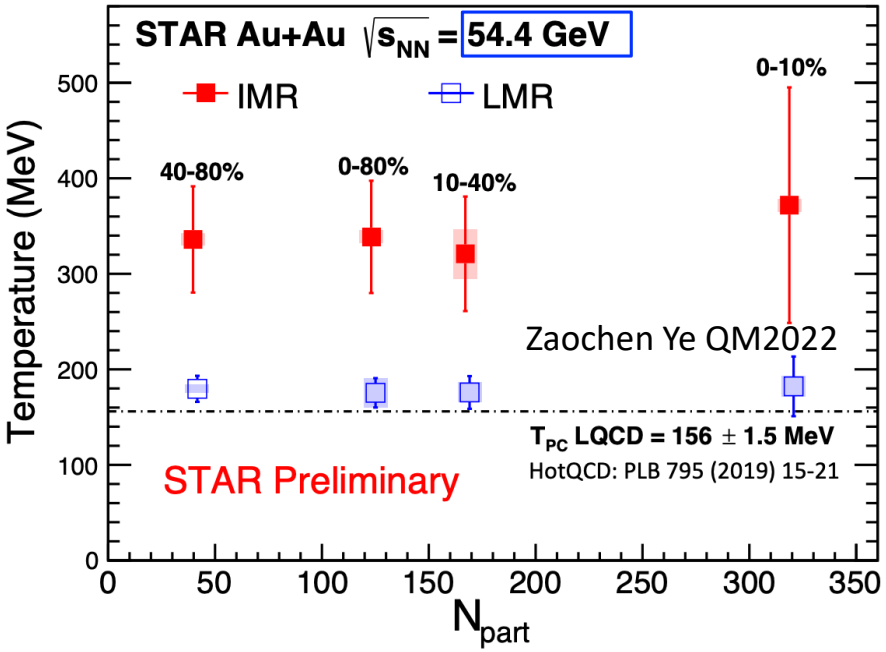
QGP longitudinal decorrelation

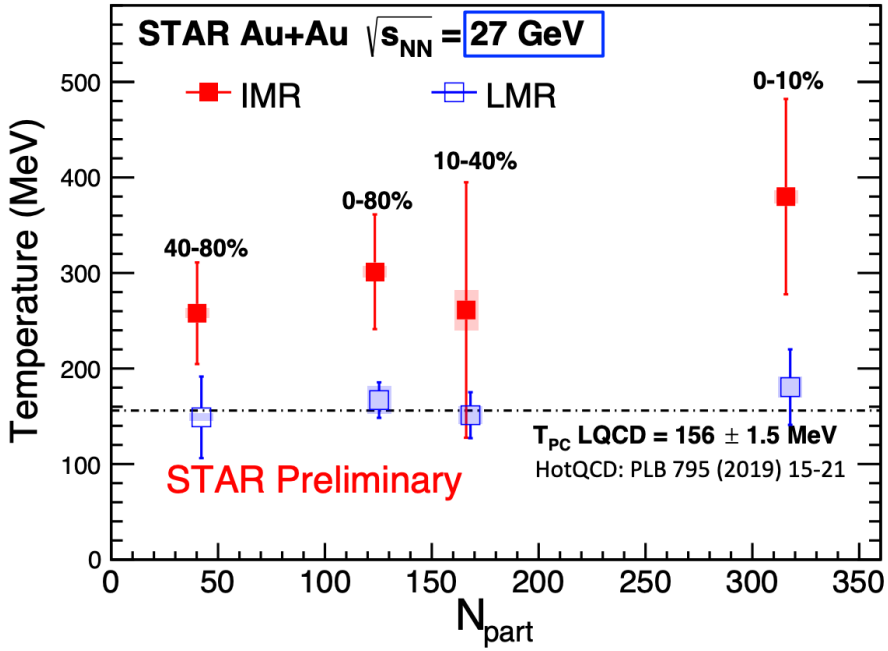
- Extend studies to bridge small and large system, e.g. OO
- Possible PID studies? What do we learn from it?

And much more…

Back up

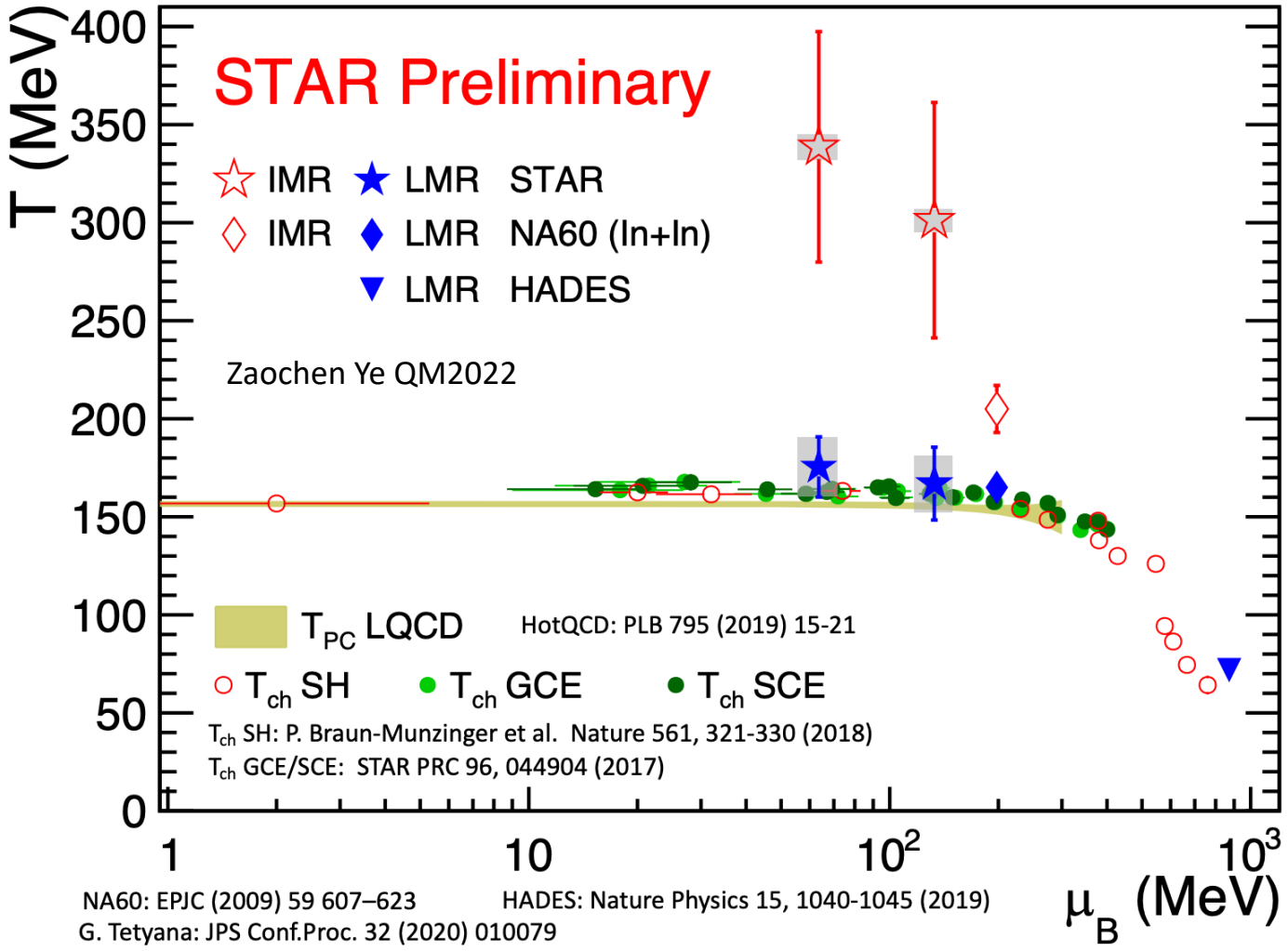
QGP temperature: thermal dilepton





No clear centrality dependence

QGP temperature: thermal dilepton



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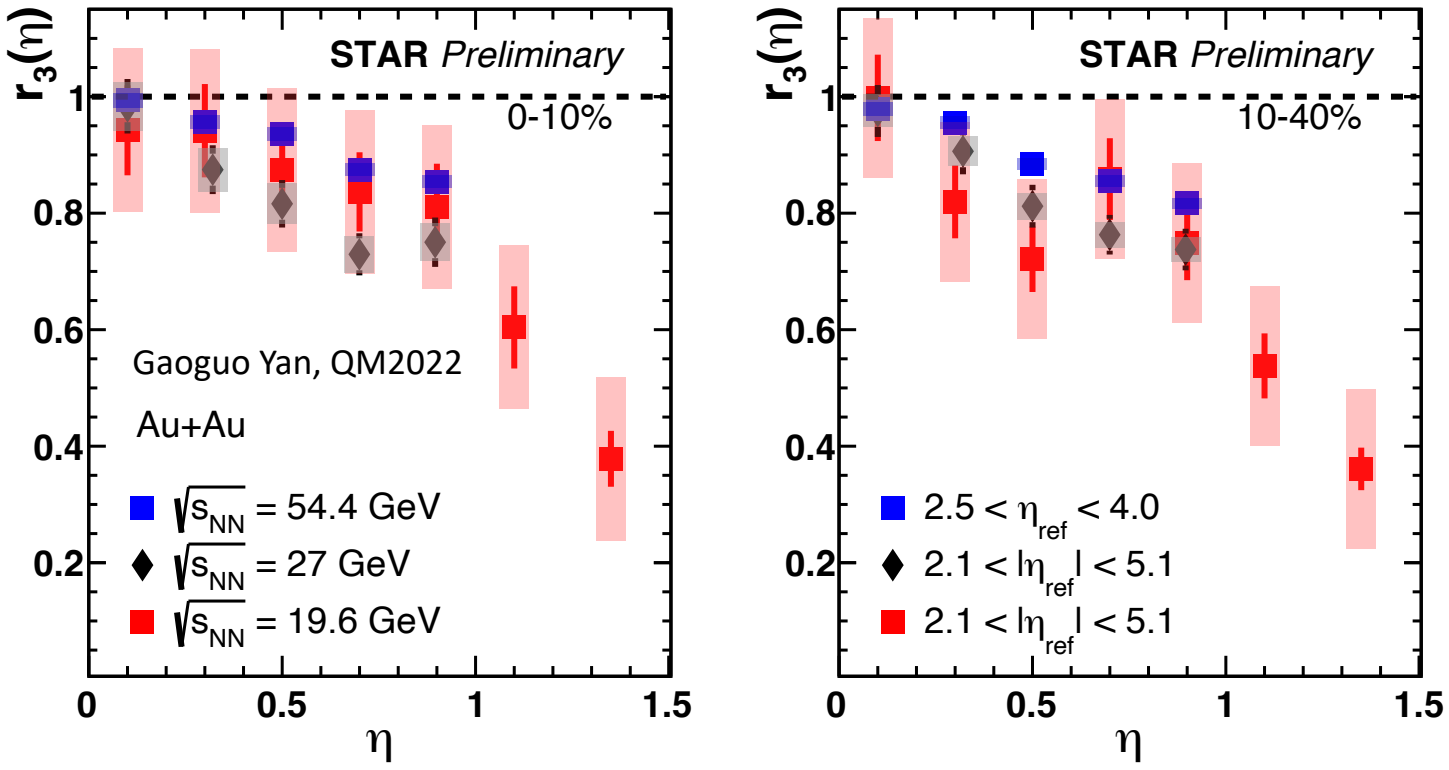

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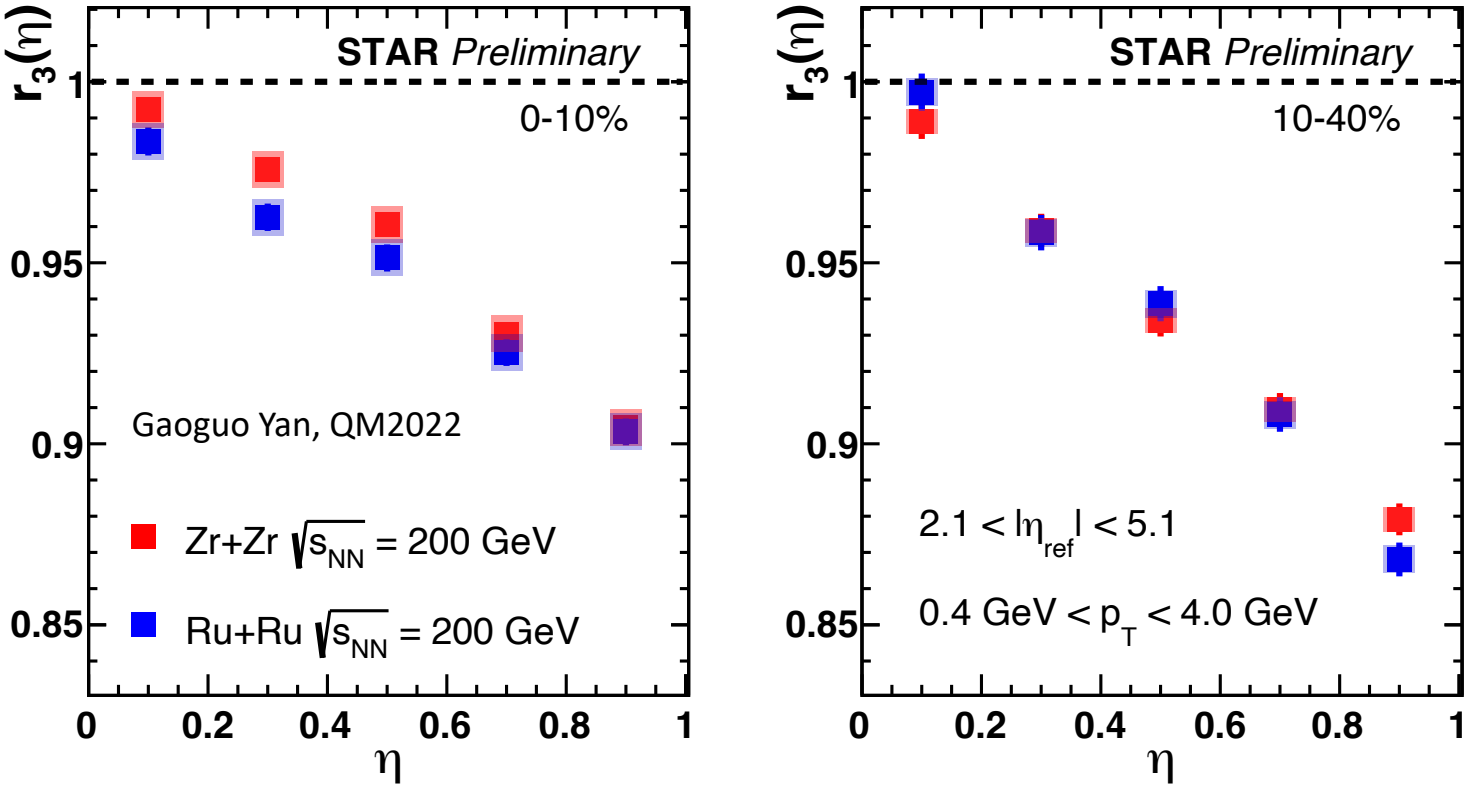

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