

**California EIC Consortium  
Collaboration Meeting**



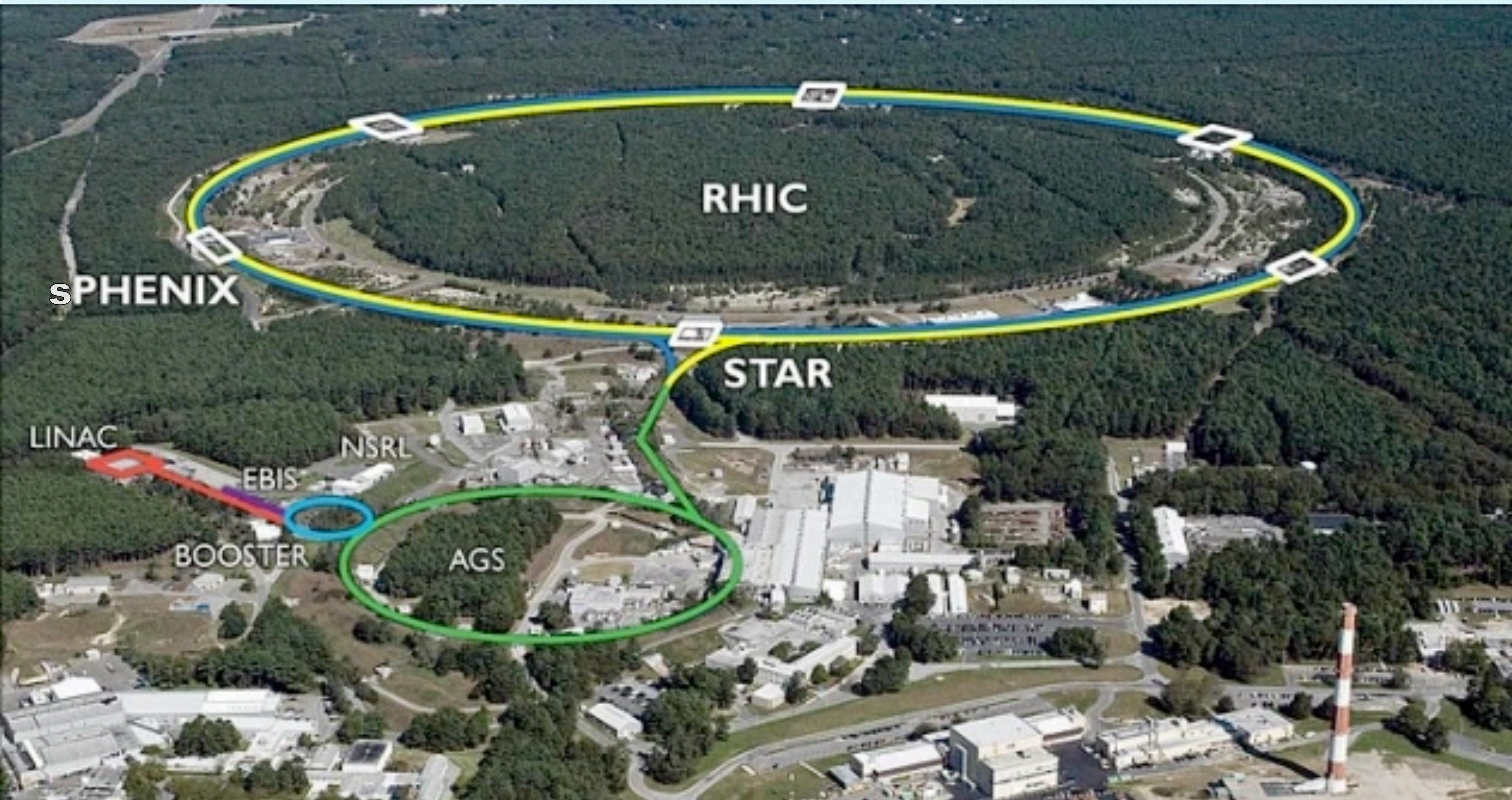
**UCLA**

# **Neutron Rich effect on flow measurements in EIC**

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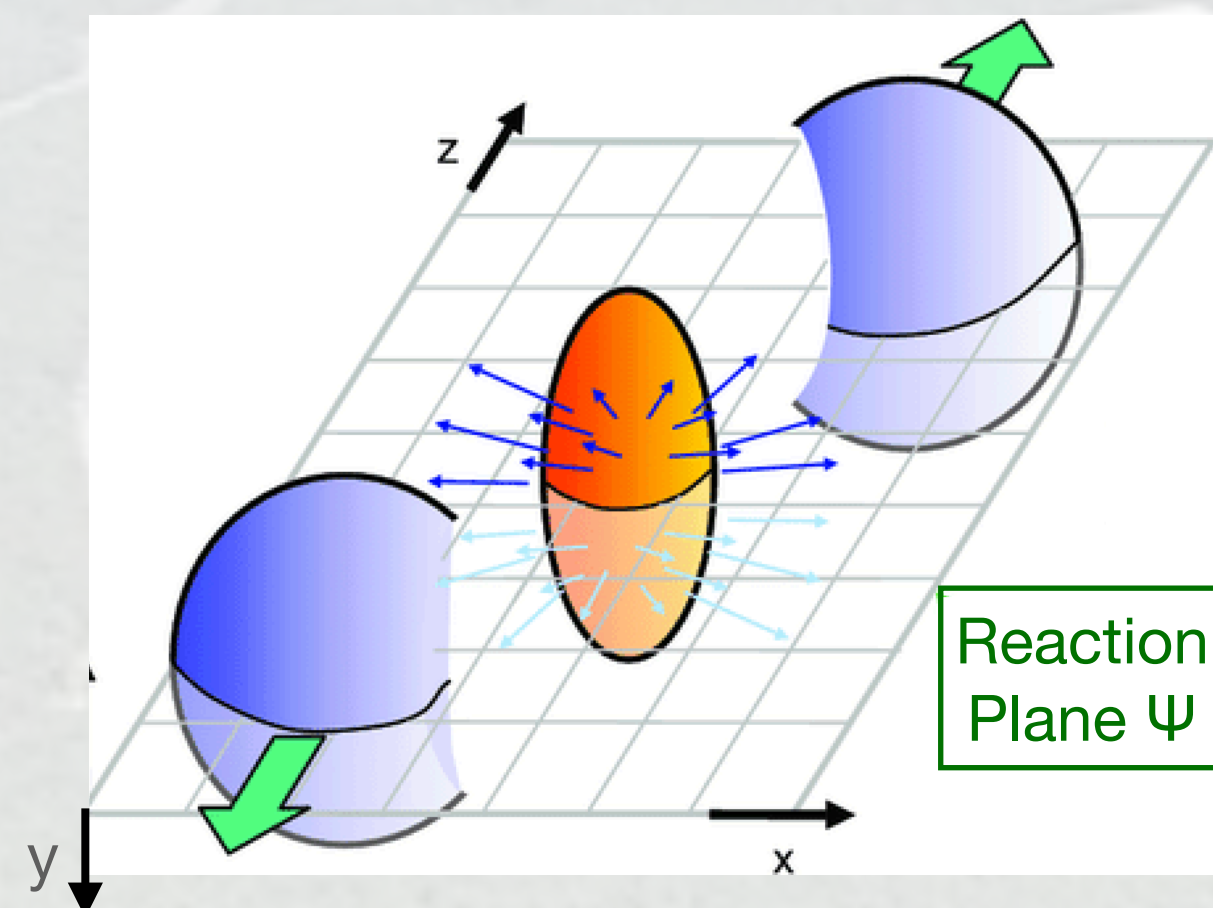


# Collective motion at high-energy

So far, the most successful achievement of RHIC.

Evidence of parton collectivity:  $N_{cq}$  scaling of  $v_2$  in A+A Collisions.

Initial spacial anisotropy turns into final momentum space anisotropy

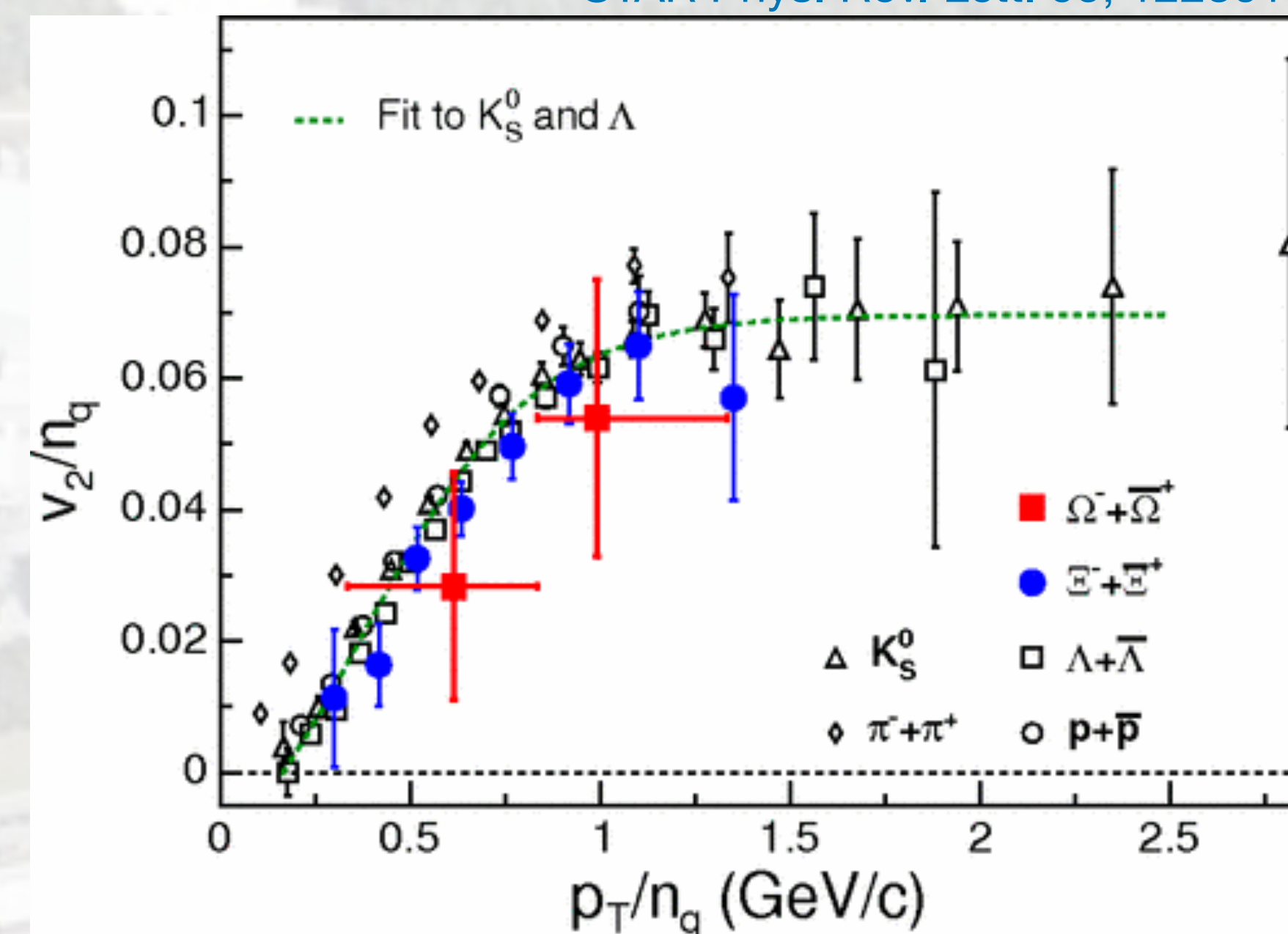
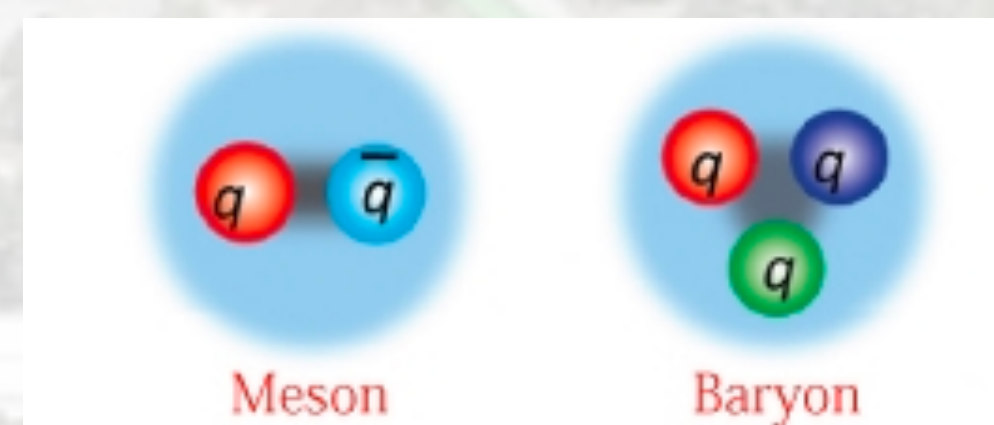


$$\frac{dN_{\pm}}{d\varphi} \propto 1 + 2v_1 \cos(\varphi - \Psi_{RP}) + 2a_1^{\pm} \sin(\varphi - \Psi_{RP}) + \boxed{2v_2} \cos(2\varphi - 2\Psi_{RP}) + \dots$$

STAR Phys. Rev. Lett. 95, 122301

## Coalescence sum rule.

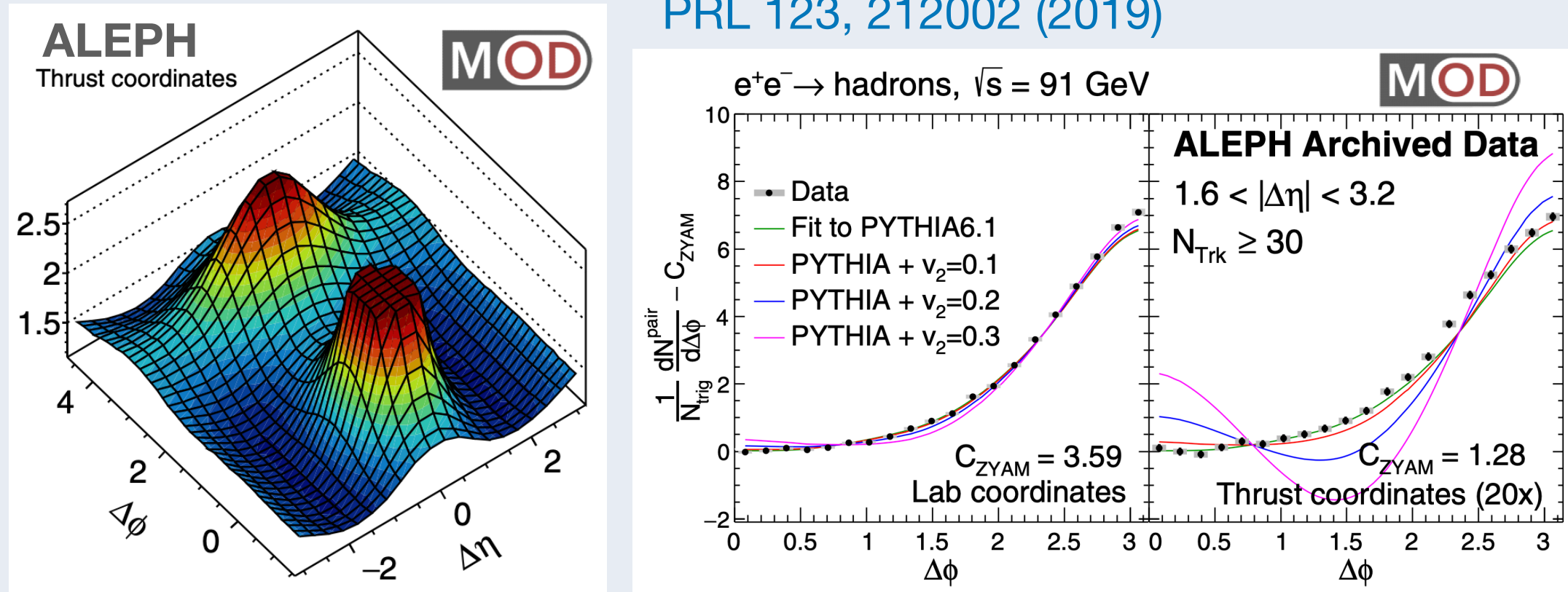
- constituent quarks recombine into a hadron
- $v_2$  of hadron = sum of quarks  $v_2$



# Collective motion at high-energy

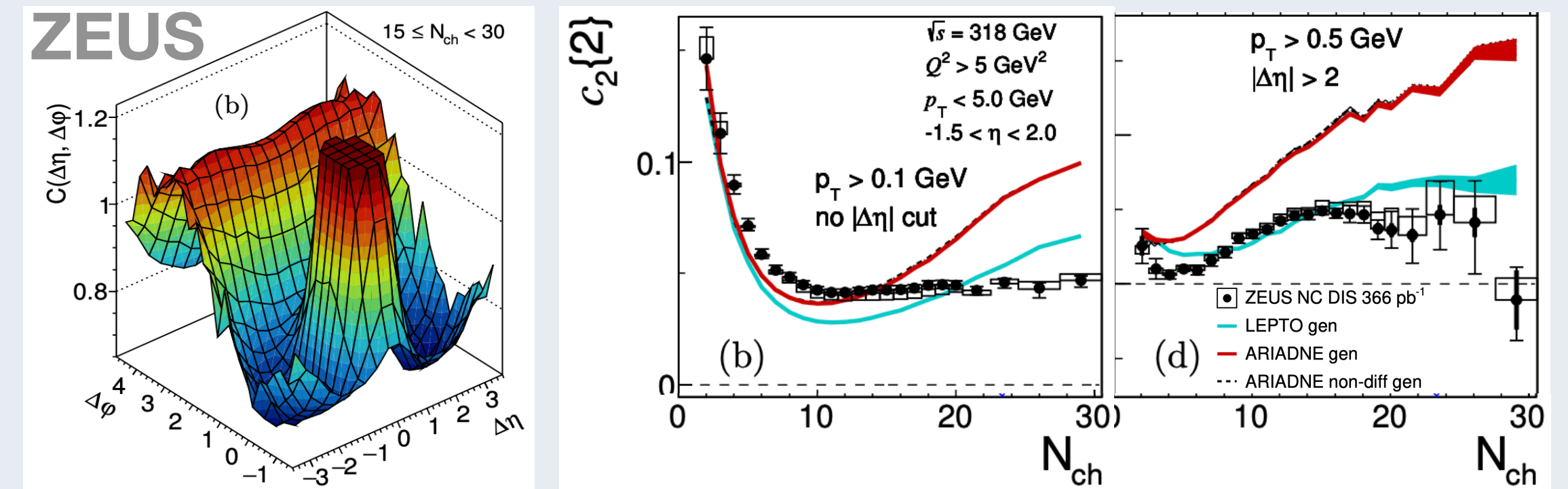
**e+e: no 2nd-order two-particle correlations**

PRL 123, 212002 (2019)

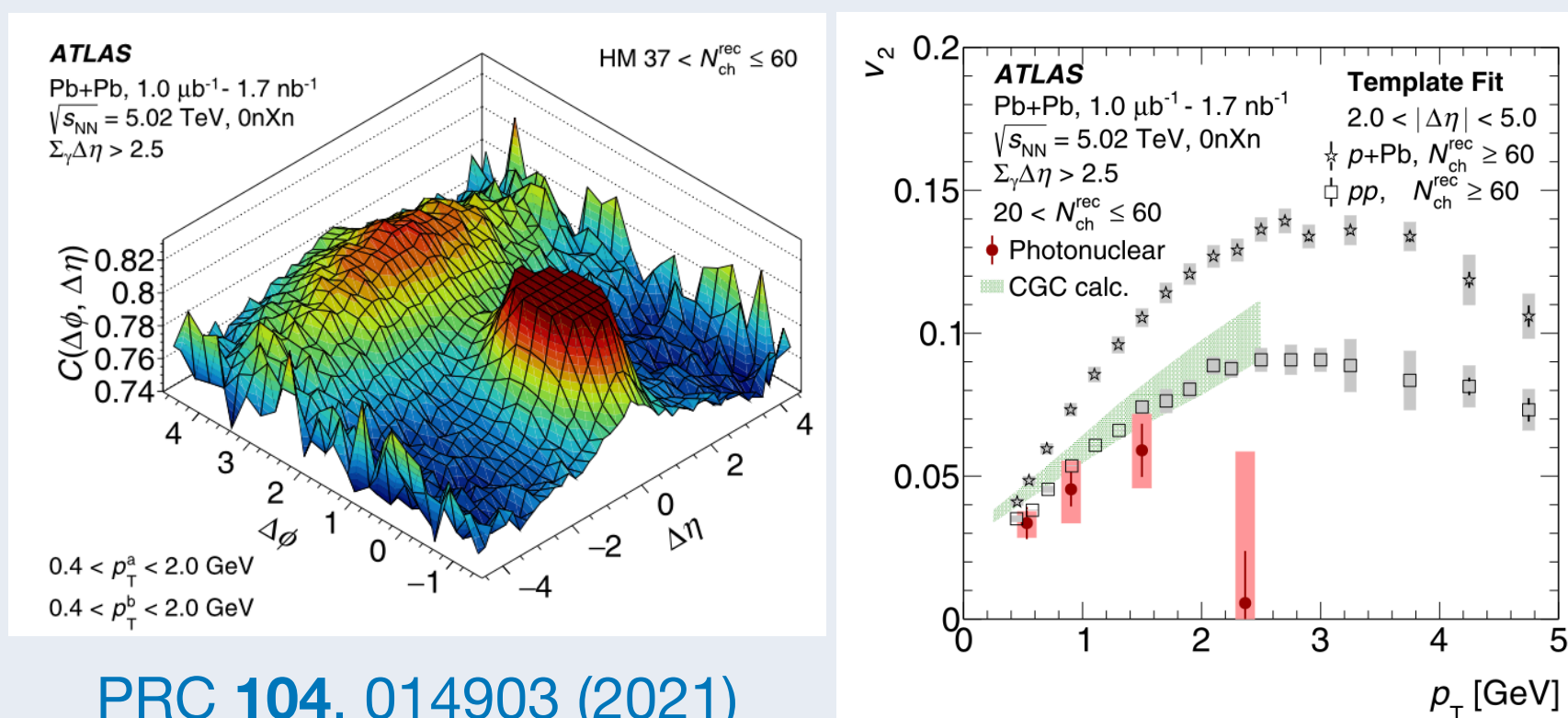


**e+p: hard processes dominated (jets).  
No global collective behavior.**

JHEP04(2020)070

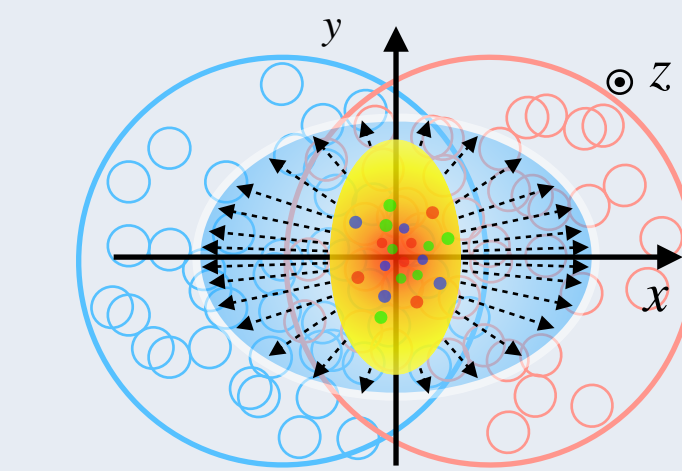


**γ+A (UPC): hard processes dominated (jets).  
Some flow collective behavior.**

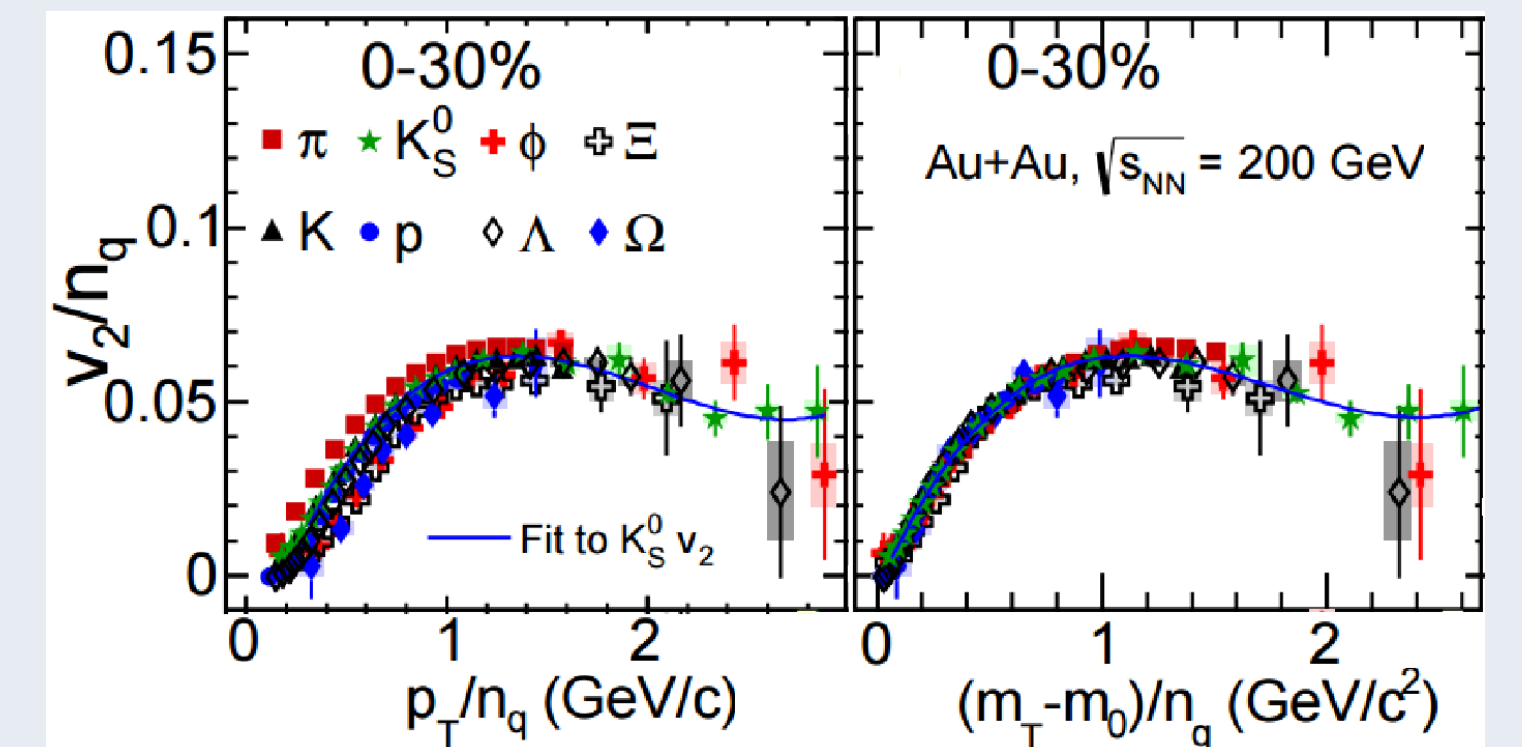


PRC 104, 014903 (2021)

**A+A: Flow (parton collectivity) dominated**

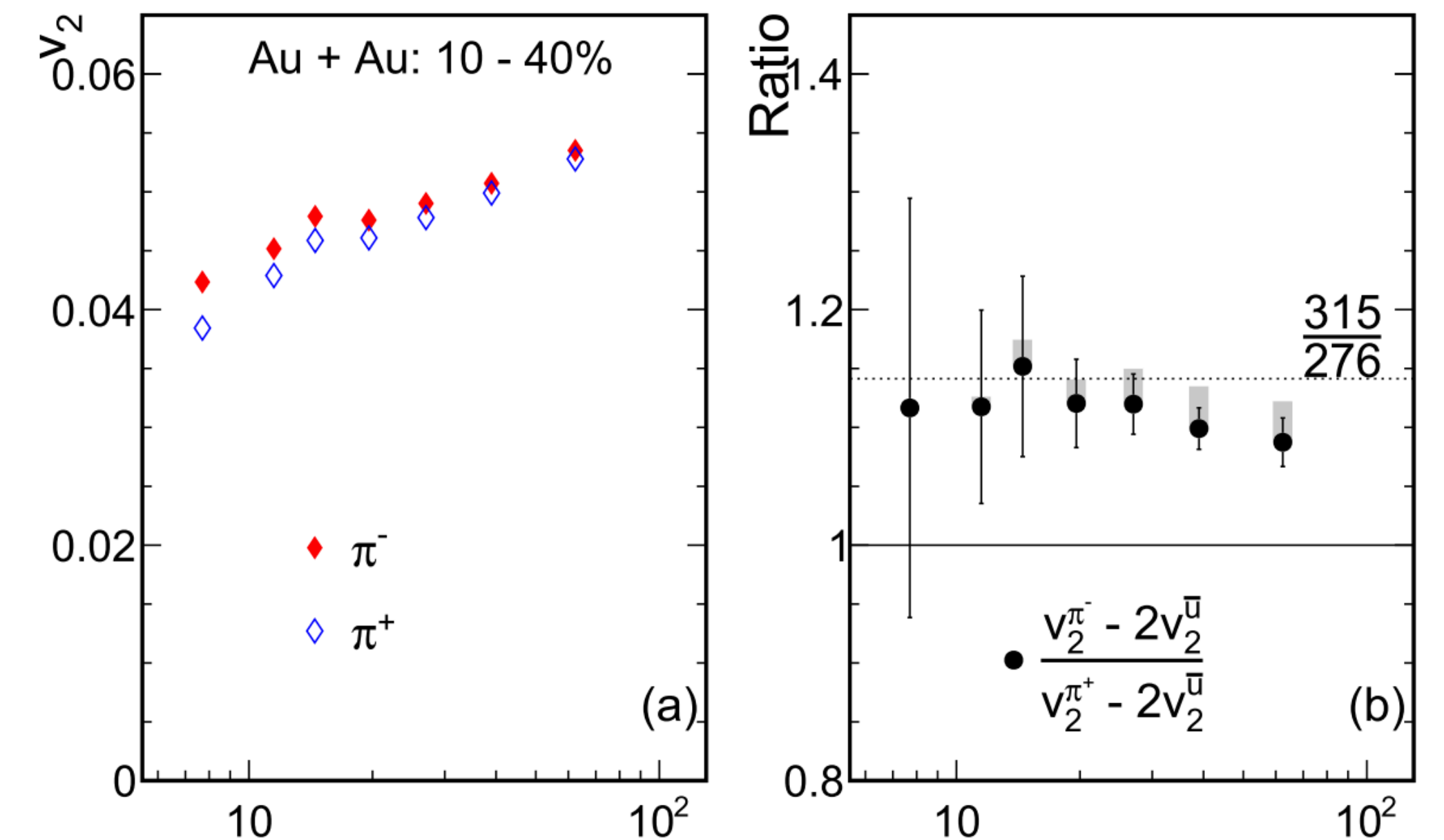
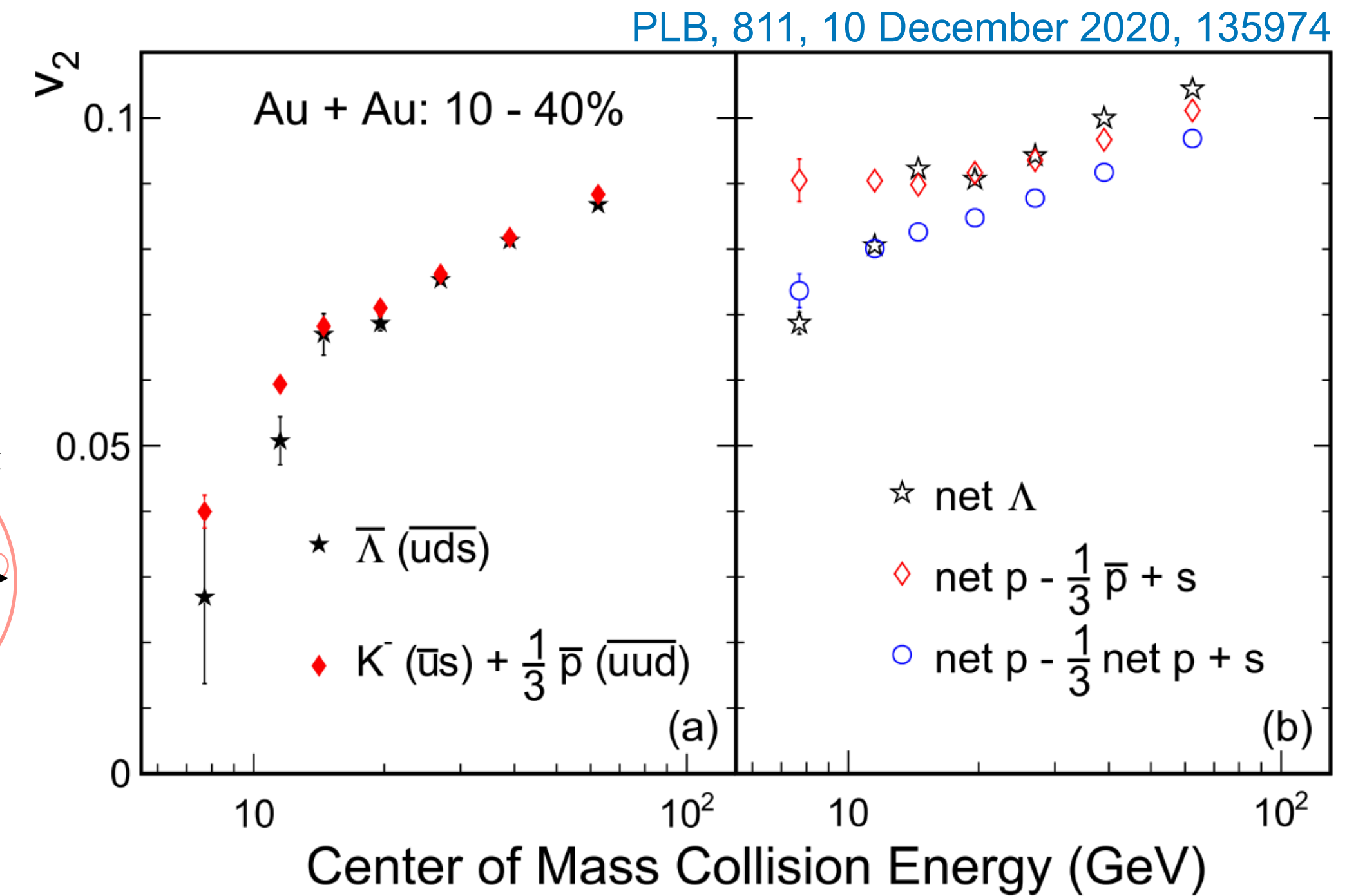
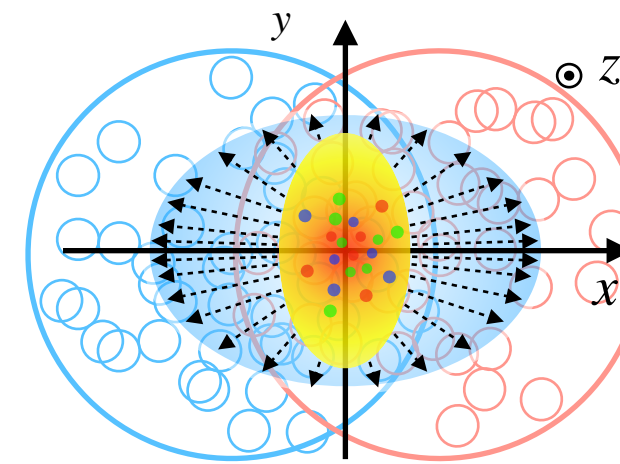


**A prove of the  
coalescence  
framework.**



# Flow: the Parton Collectivity

- Coalescence sum rule works for  $p_T$ -integrated  $v_2$  at different beam energy
  - Produced quark (u/d/s)
  - Transport quark
- Neutron Rich effect cause d/u ratio.
- Neutron Skin will further modify the d/u ratio at peripheral collision, leading to a centrality dependence.



$$v_2^{\pi^-} = N_{\text{trans}.d}^{\pi^-} \cdot v_2^{\text{trans}.d} + (2 - N_{\text{trans}.d}^{\pi^-})v_2^{\bar{u}}$$

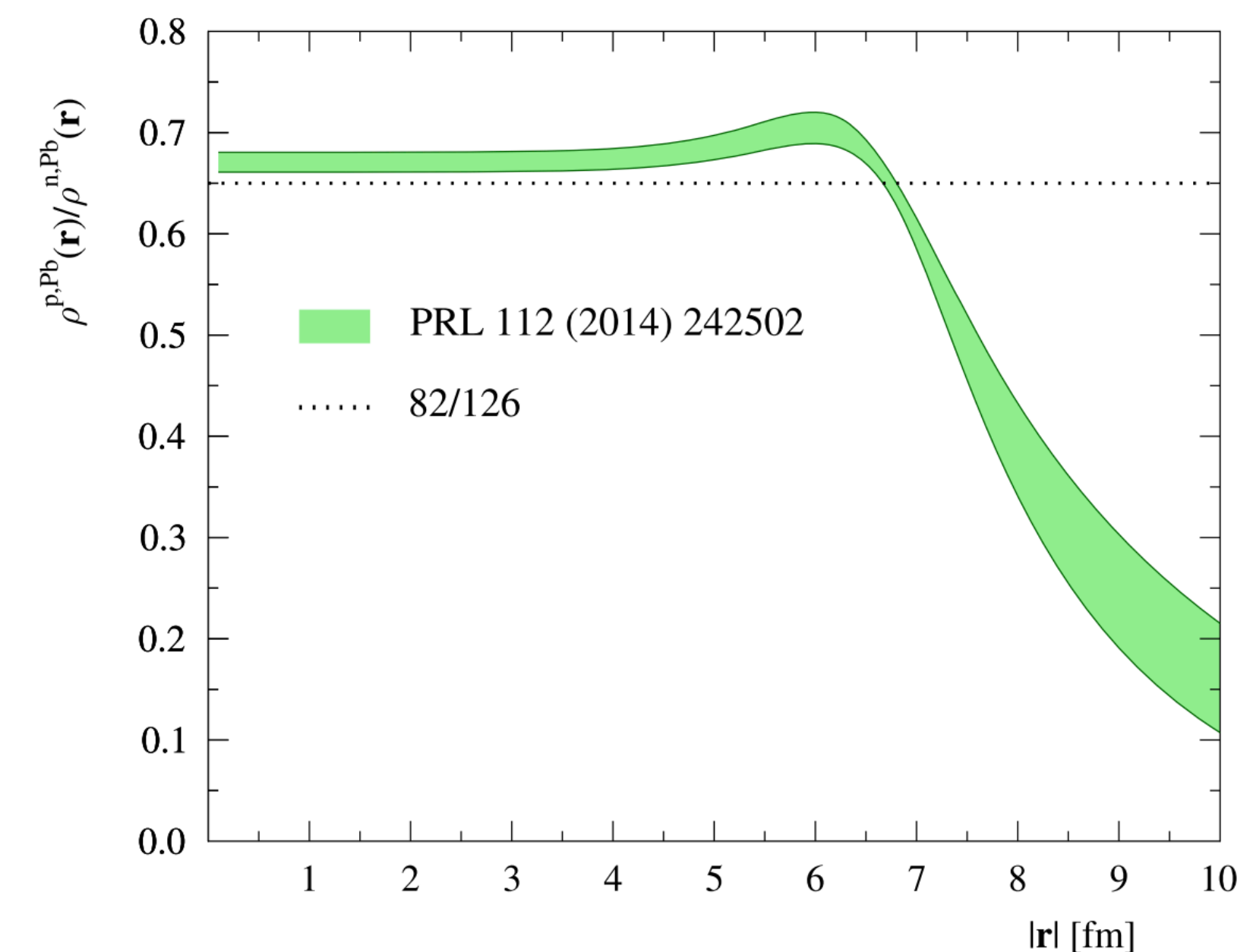
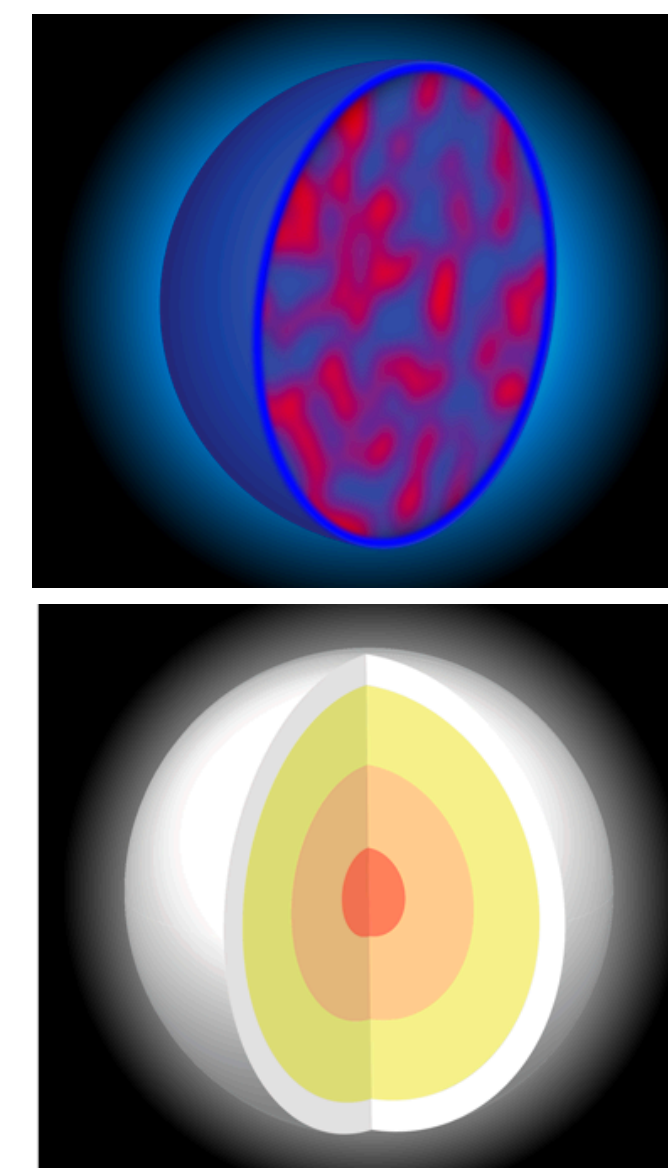
$$v_2^{\pi^+} = N_{\text{trans}.u}^{\pi^+} \cdot v_2^{\text{trans}.u} + (2 - N_{\text{trans}.u}^{\pi^+})v_2^{\bar{d}}$$

$$\frac{N_{\text{trans}.d}^{\pi^-}}{N_{\text{trans}.u}^{\pi^+}} = \frac{v_2^{\pi^-} - 2v_2^{\bar{u}}}{v_2^{\pi^+} - 2v_2^{\bar{u}}} = \frac{v_2\{\pi^-\} - \frac{2}{3}v_2\{\bar{p}\}}{v_2\{\pi^+\} - \frac{2}{3}v_2\{\bar{p}\}}$$

# Neutron Skin: higher-order effect

Neutron Skin (NS) is due to the excess of neutron over proton in a nuclei.

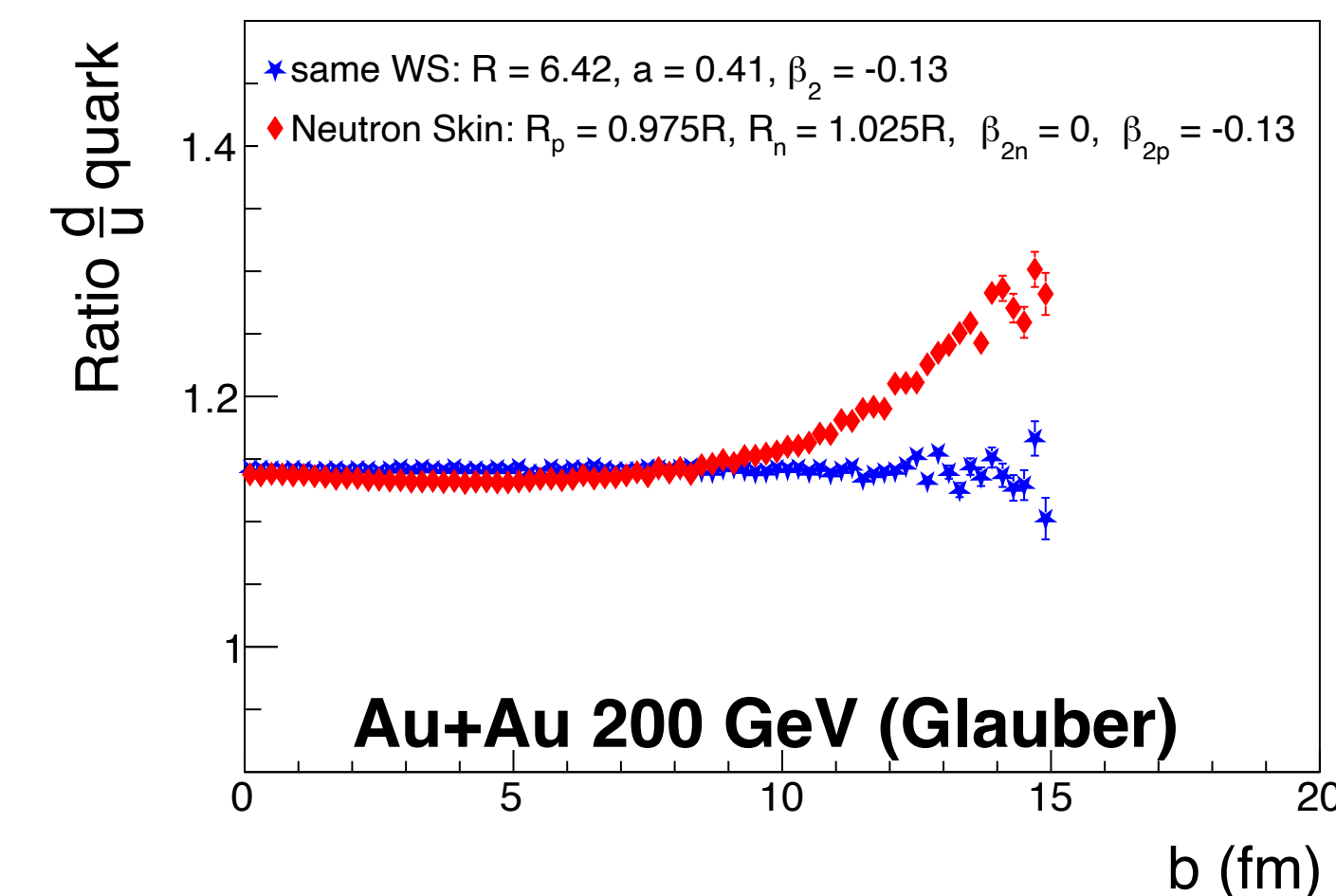
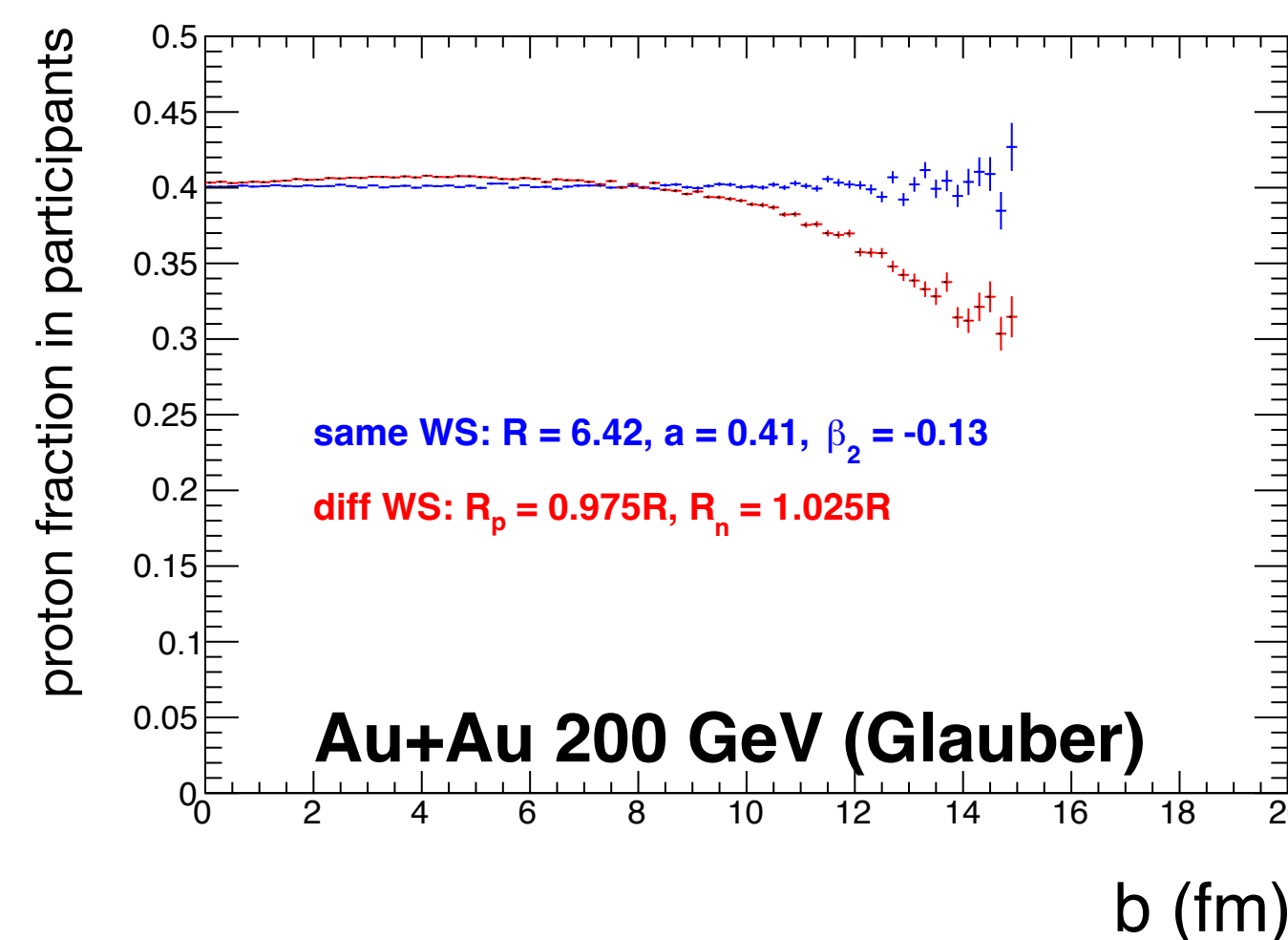
- Polarized e+Pb elastic scattering PREX-I and PREX-II  
[Phys. Rev. C 85, 032501\(R\) \(2012\).](#)  
[PhysRevLett.126, 172502 \(2021\)](#)



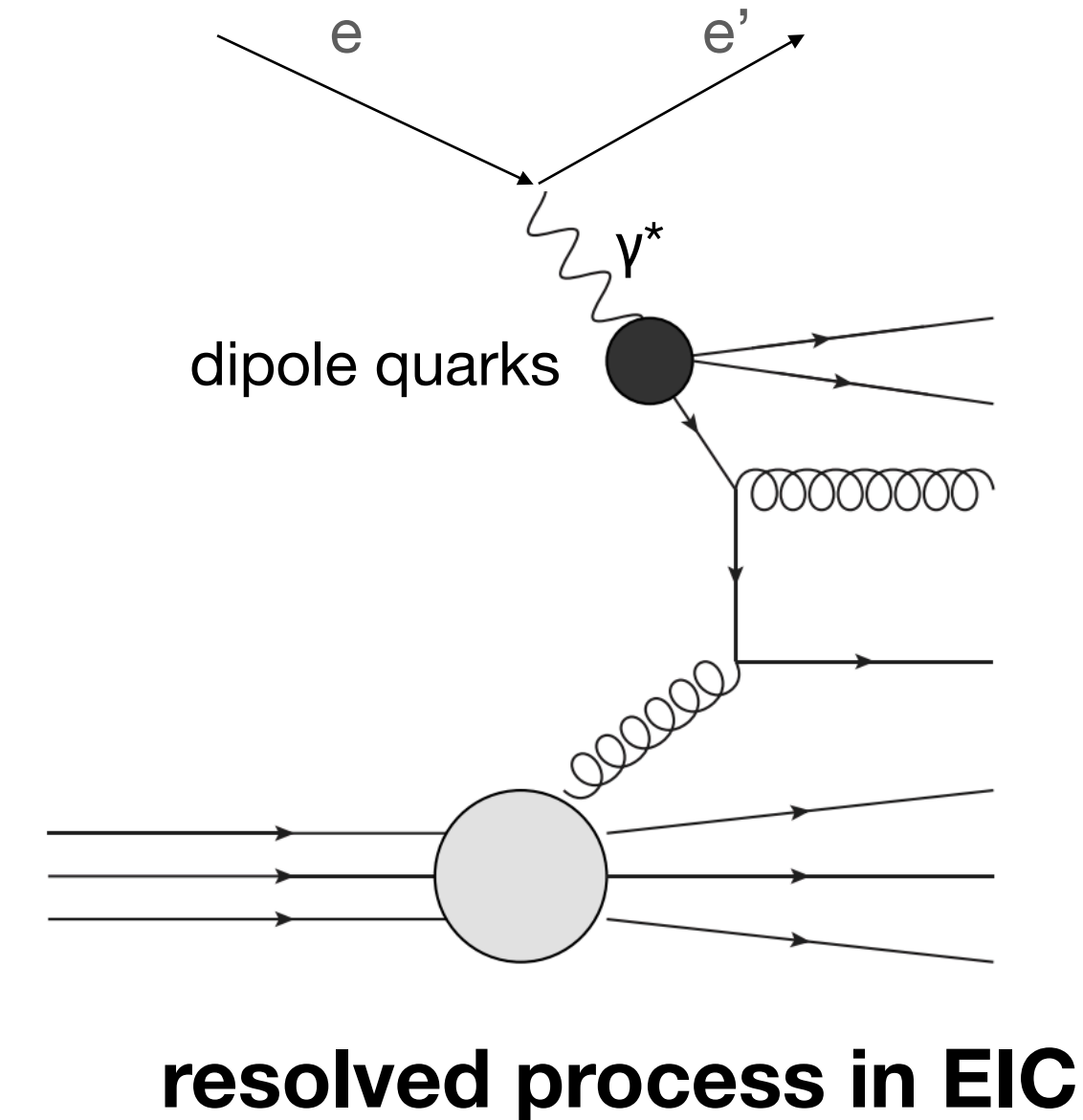
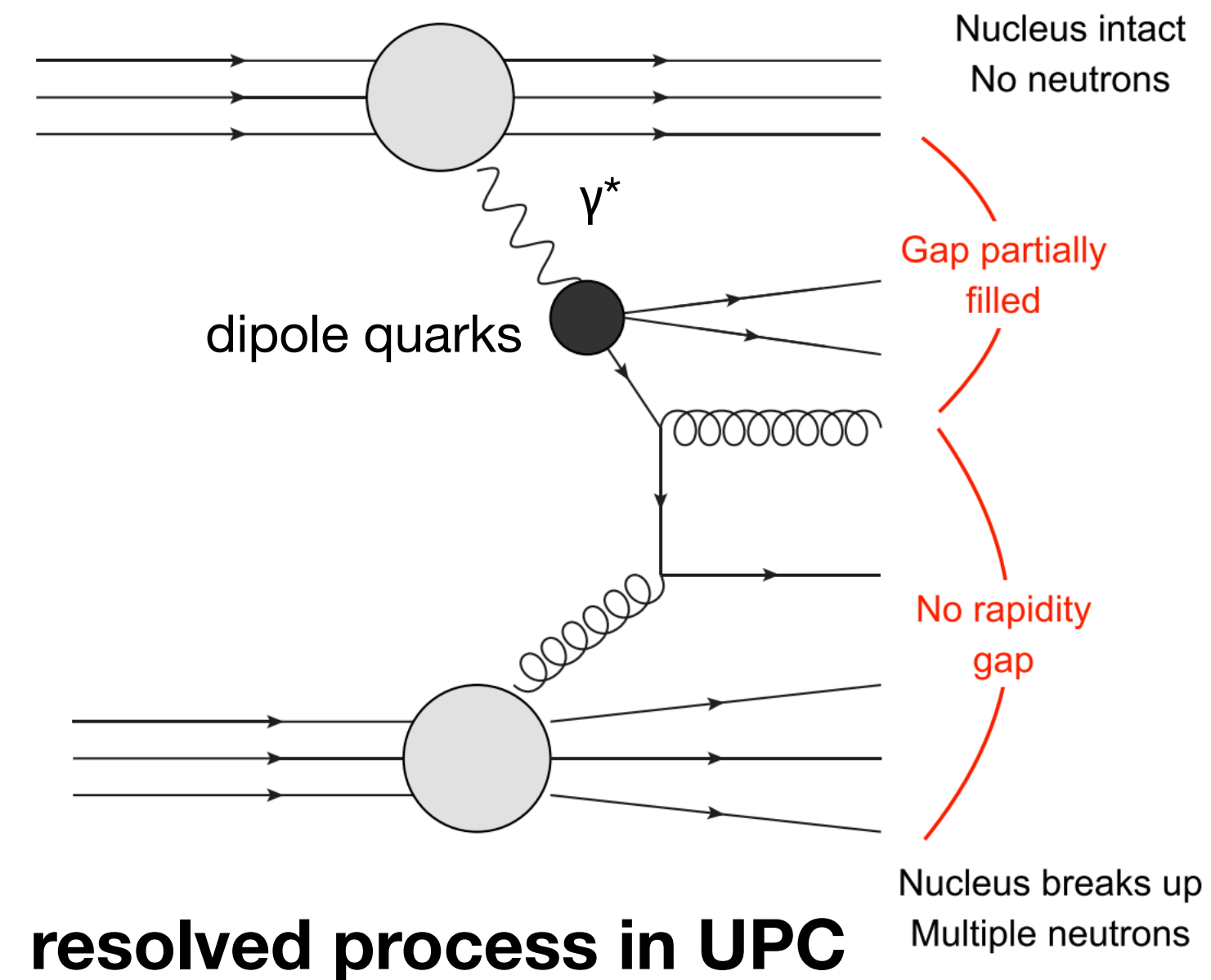
NS affects the transport d/u ratio in heavy-ion flow measurement:

- provides a high-order test for **parton collectivity**, the **coalescence picture**.

$$R = \frac{v_2\{\pi^-\} - \frac{2}{3}v_2\{\bar{p}\}}{v_2\{\pi^+\} - \frac{2}{3}v_2\{\bar{p}\}}$$



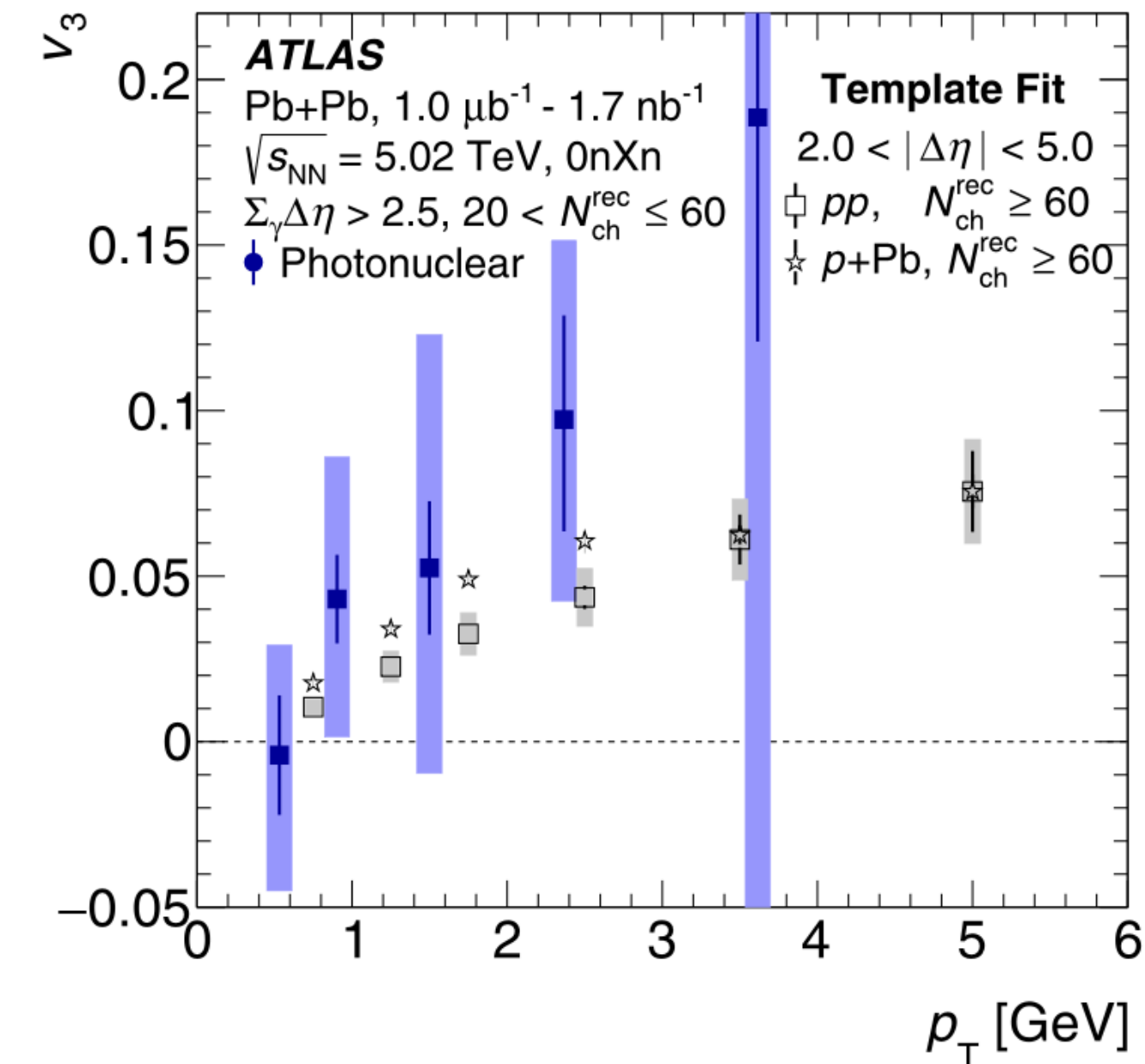
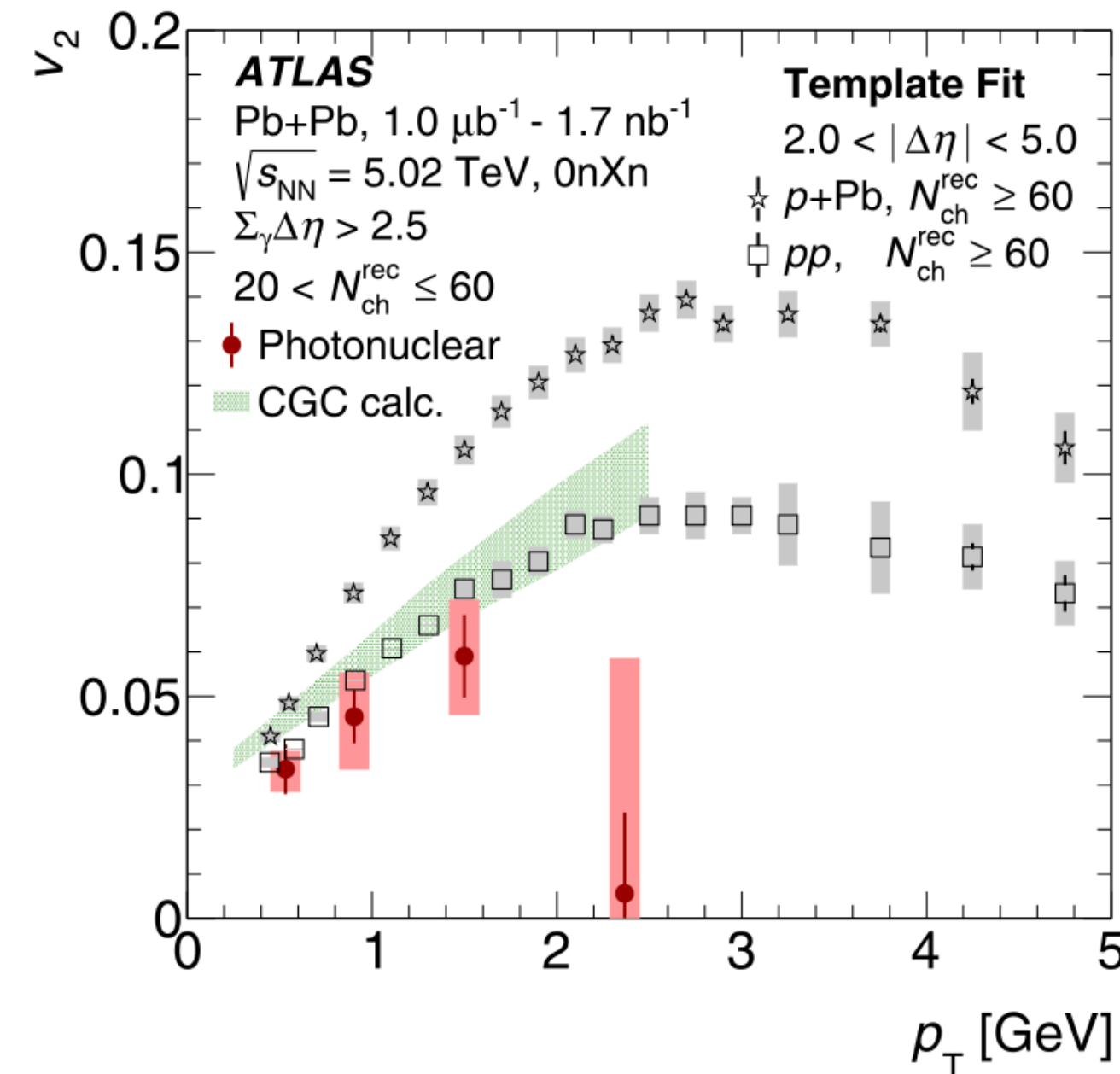
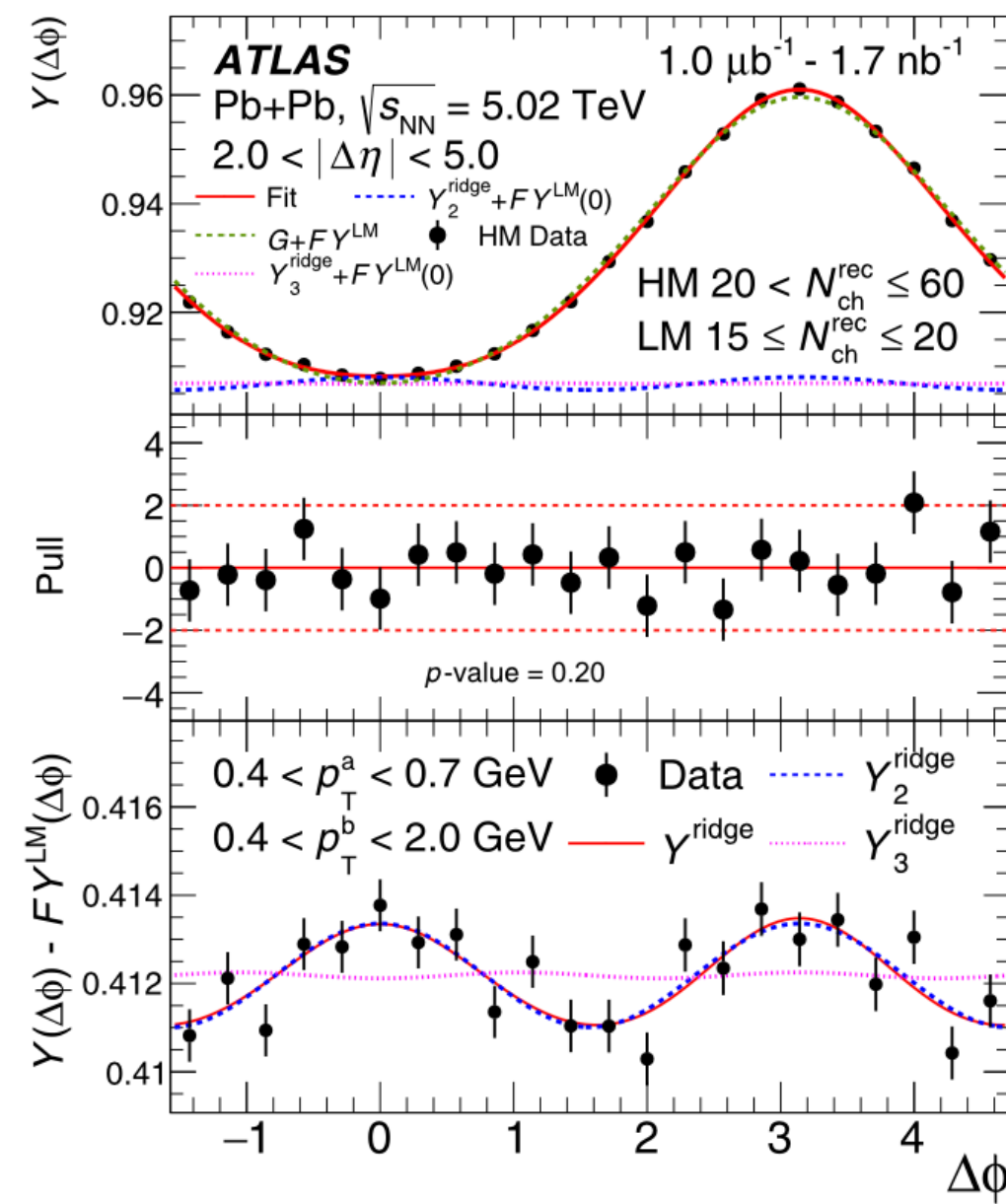
# Ultra-peripheral collision and eA at EIC



- The photonuclear interaction in **UPC** is similar to **EIC**.
- 2 types of photonuclear collisions: direct process and resolved process ( $\gamma^* \rightarrow$  hadronic states)
- Vector meson - ion interaction entails a nontrivial initial transverse geometry, which can be computed by MC Glauber model.

# UPC flow measurement at ATLAS

PHYSICAL REVIEW C 104, 014903 (2021)

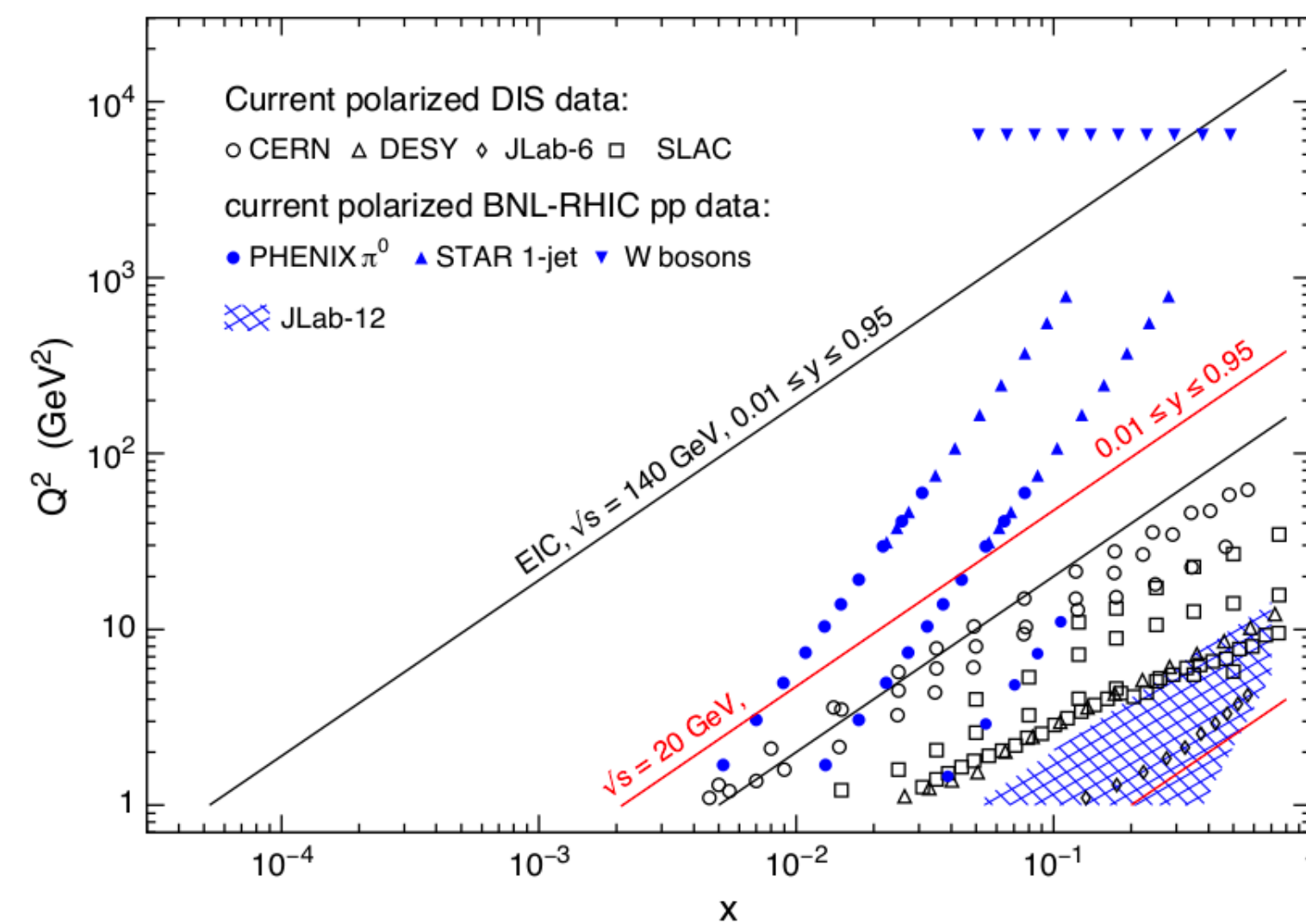


- In UPC: ATLAS reported the  $v_2$  (non-flow subtracted) smaller than in pp/pPb collision, and  $v_3$  on the same scale.
  - Currently no hydrodynamic/transport predictions in photonuclear collisions.
  - In agreement with the color glass condensate (CGC) calculation of color dipole + Pb.
  - Glauber model over-estimate the size of 2nd-order eccentricity.
- EIC may also have a chance
  - if flow exists and coalescence picture holds (first order effect)
  - Neutron Rich effect and NS will affect the centrality dependence (higher order effect)



# Advantage at EIC

- **Electron-Ion provides a cleaner picture than UPC.**
- **Precise kinematics reconstruction by a hermetic detector.**



*Thank you for the attention.  
 Questions are warmly welcomed!*

