



Hyperon polarization along the beam direction relative to the second and third order event planes in isobar collisions from STAR

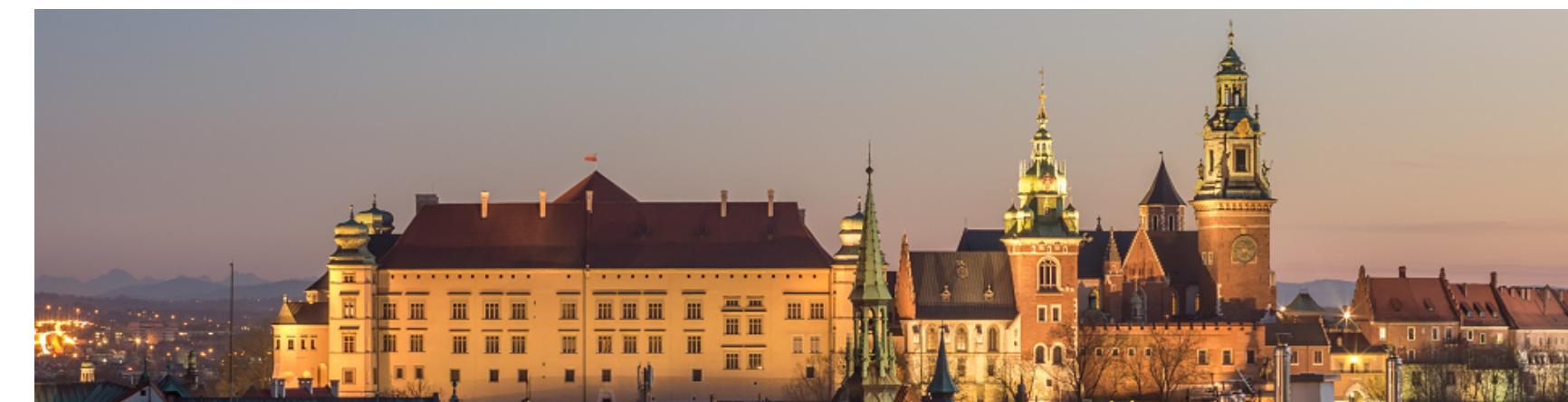
Takafumi Niida
for the STAR Collaboration



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Local vorticity and polarization

- Local vorticity induced by anisotropic flow results in polarization along the beam direction, P_z
- Models based on thermal vorticity cannot explain the data ("spin puzzle" in heavy-ion collisions)
- Recently, inclusion of a shear term might explain the P_z measurement qualitatively

B. Fu et al., PRL127, 142301 (2021)
 F. Becattini et al., PRL127, 272302 (2021)

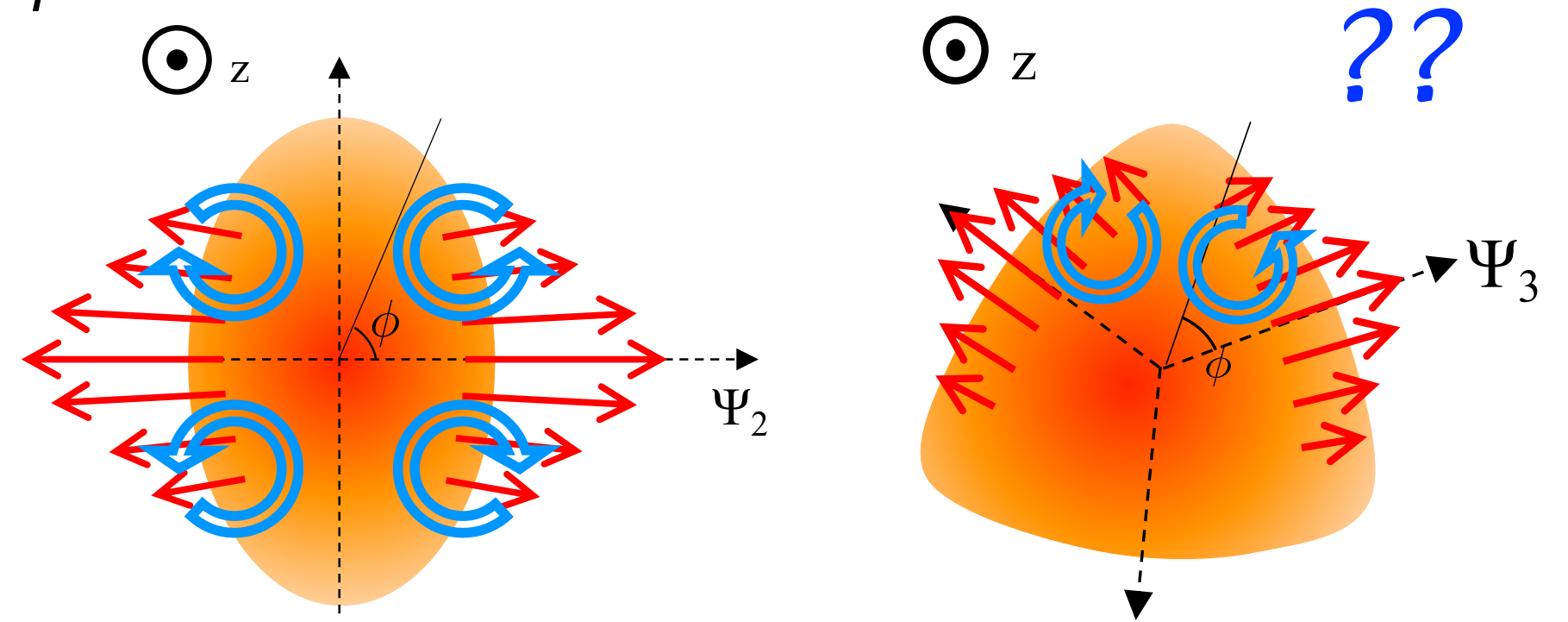
$$\text{vorticity: } \omega_{\rho\sigma} = \frac{1}{2} (\partial_\sigma u_\rho - \partial_\rho u_\sigma)$$

$$\text{shear: } \Xi_{\rho\sigma} = \frac{1}{2} (\partial_\sigma u_\rho + \partial_\rho u_\sigma)$$

Similar polarization is expected due to higher harmonic flow

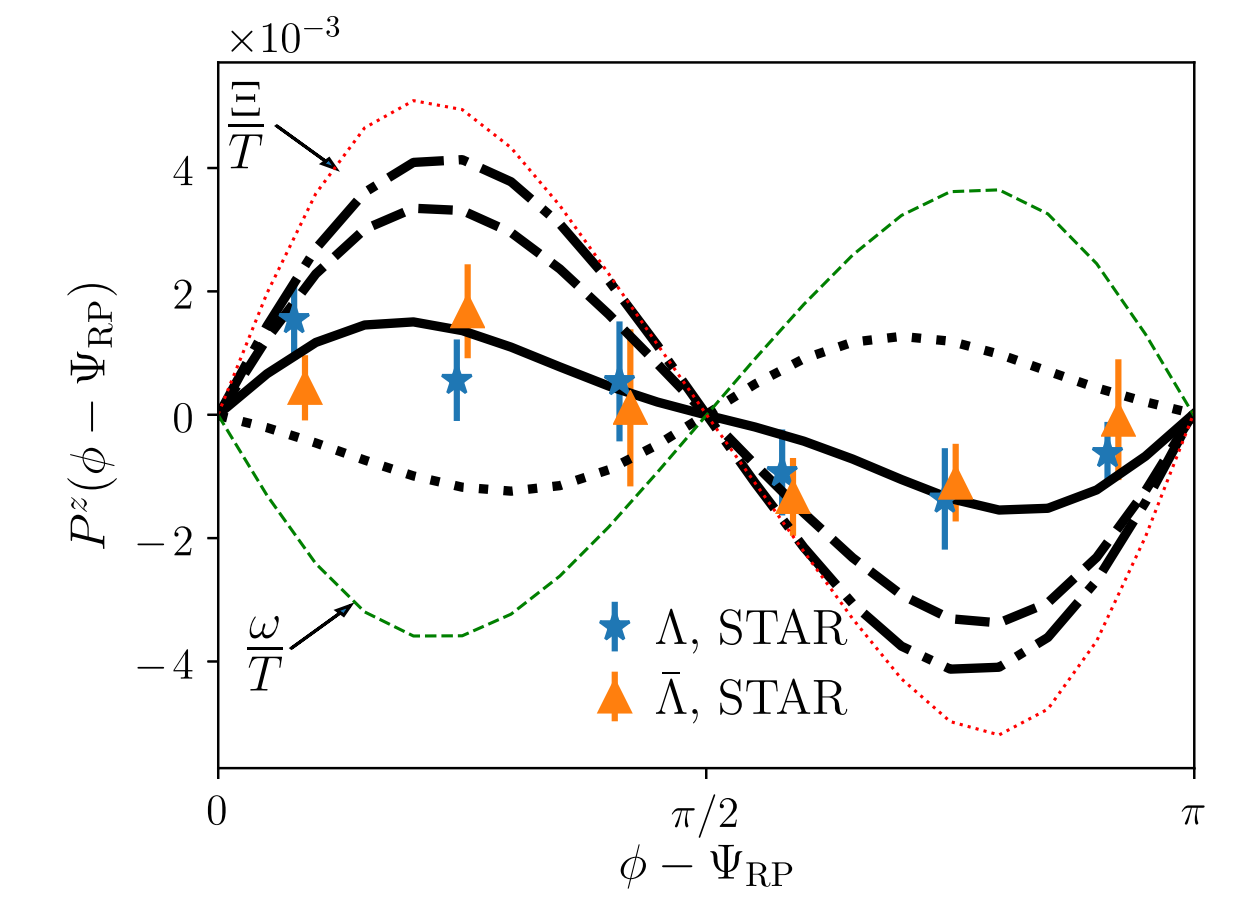
► *new insights into polarization phenomena*

S. Voloshin, EPJ Web Conf.171, 07002 (2018)

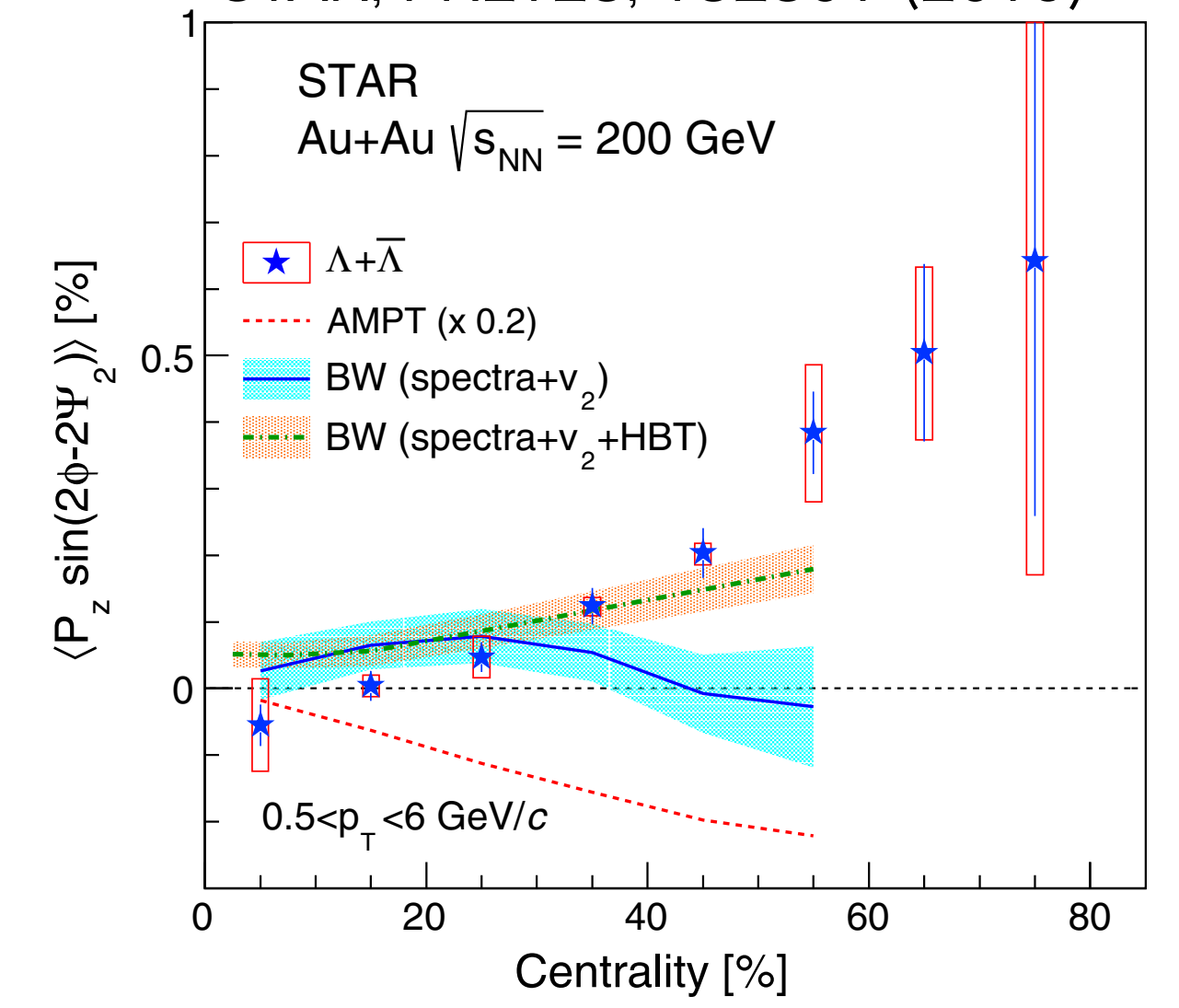


F. Becattini et al., PRL127, 272302 (2021)

* sign of anti- Λ is flipped for comparison

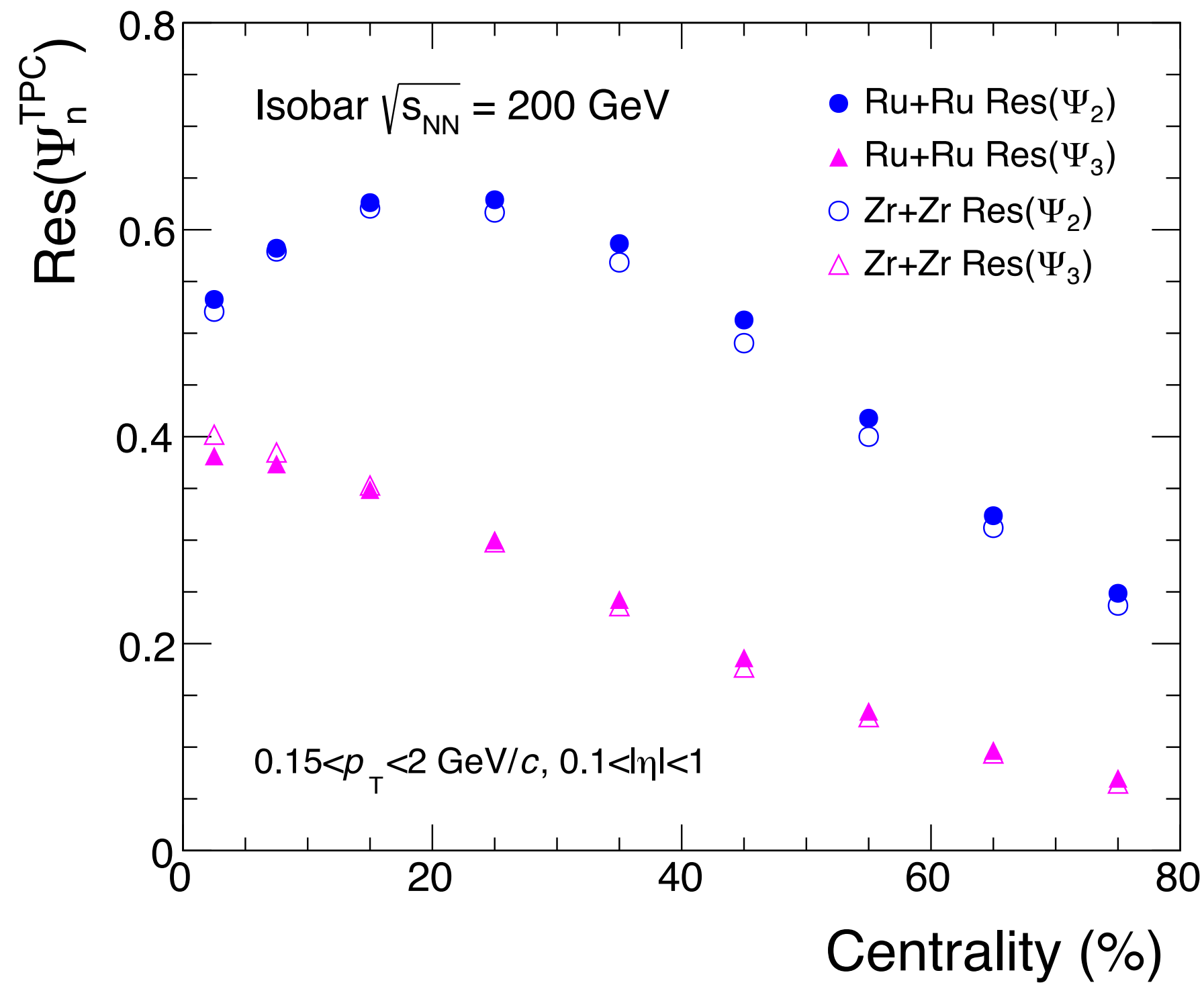


STAR, PRL123, 132301 (2019)

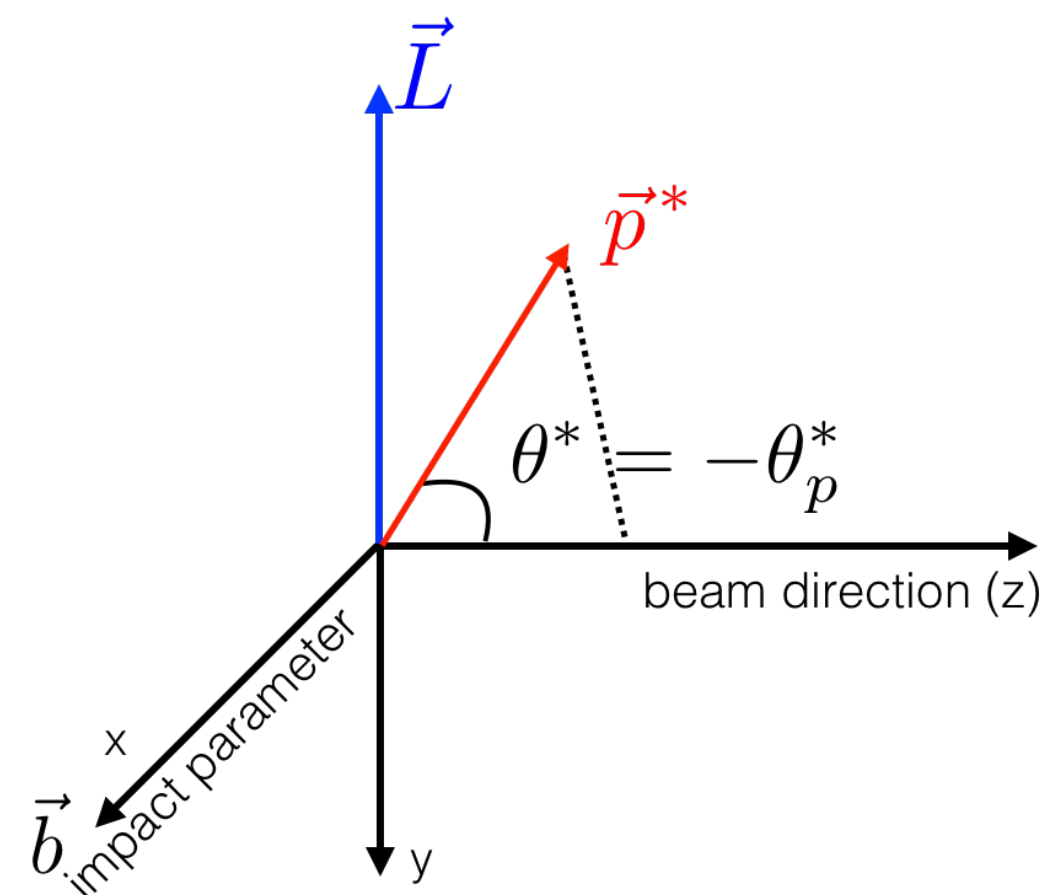




Local polarization measurement



STAR, PRL123, 132301 (2019)



$$\frac{dN}{d\Omega^*} = \frac{1}{4\pi} (1 + \alpha_H \mathbf{P}_H \cdot \mathbf{p}_p^*)$$

$$\langle \cos \theta_p^* \rangle = \int \frac{dN}{d\Omega^*} \cos \theta_p^* d\Omega^*$$

$$= \alpha_H P_z \langle (\cos \theta_p^*)^2 \rangle$$

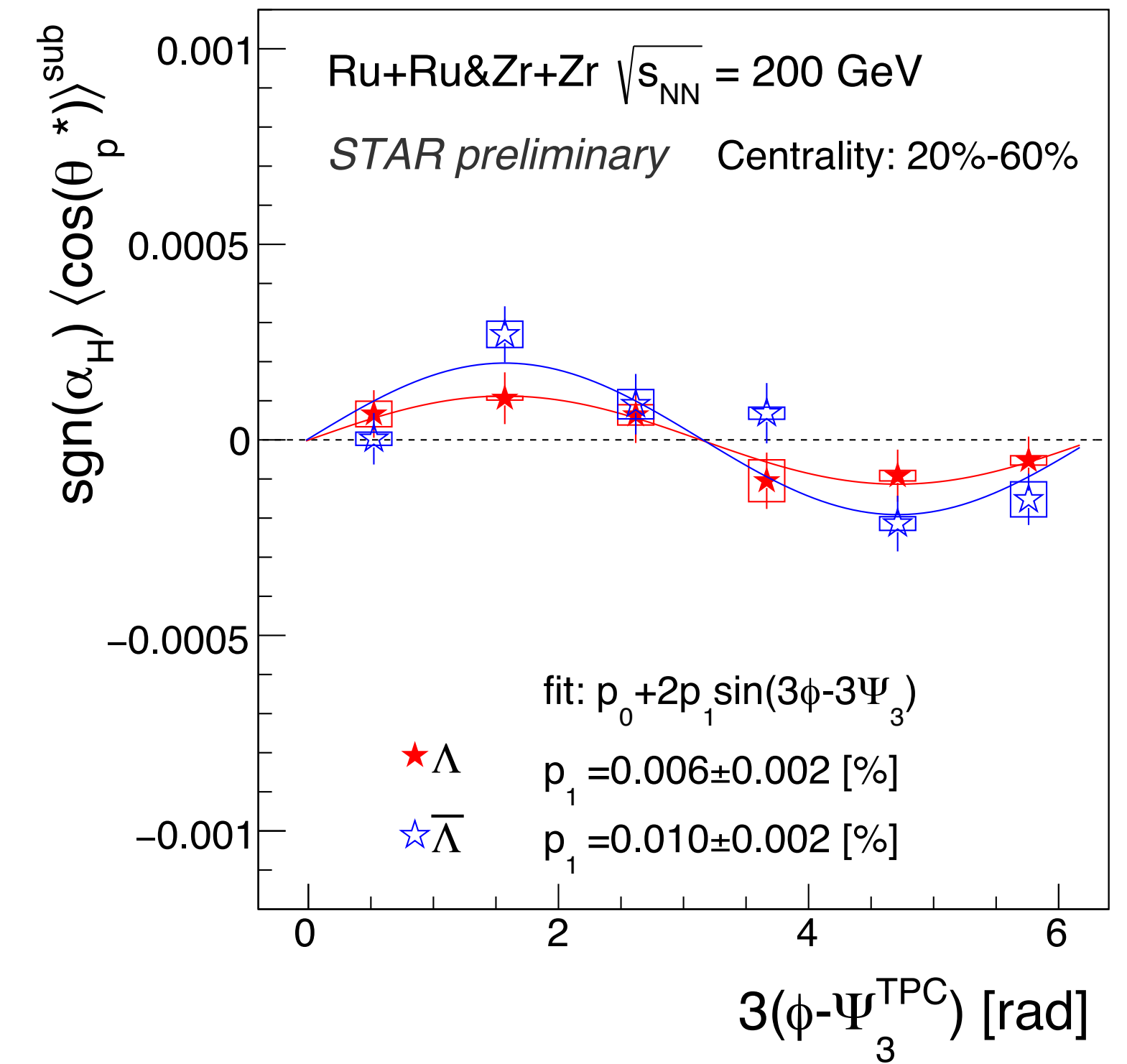
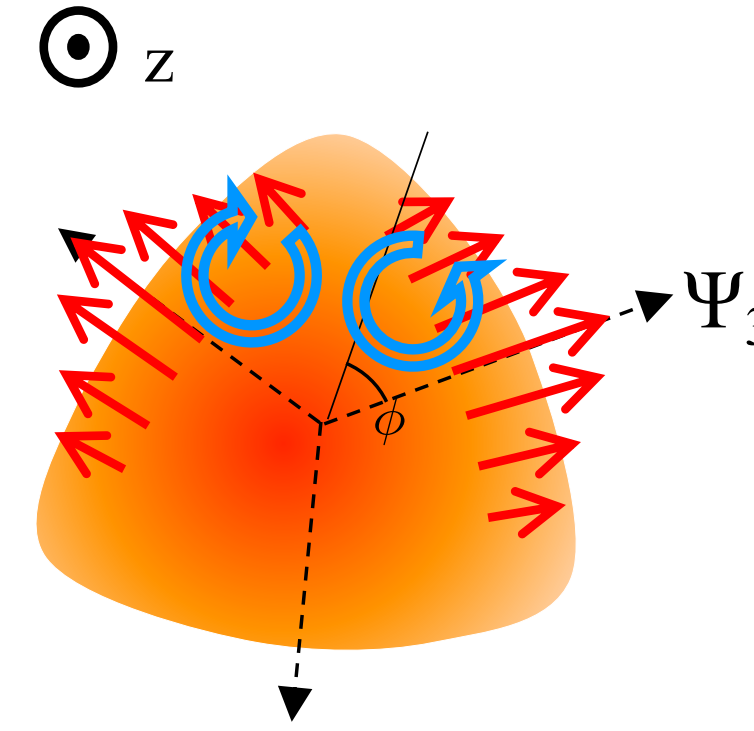
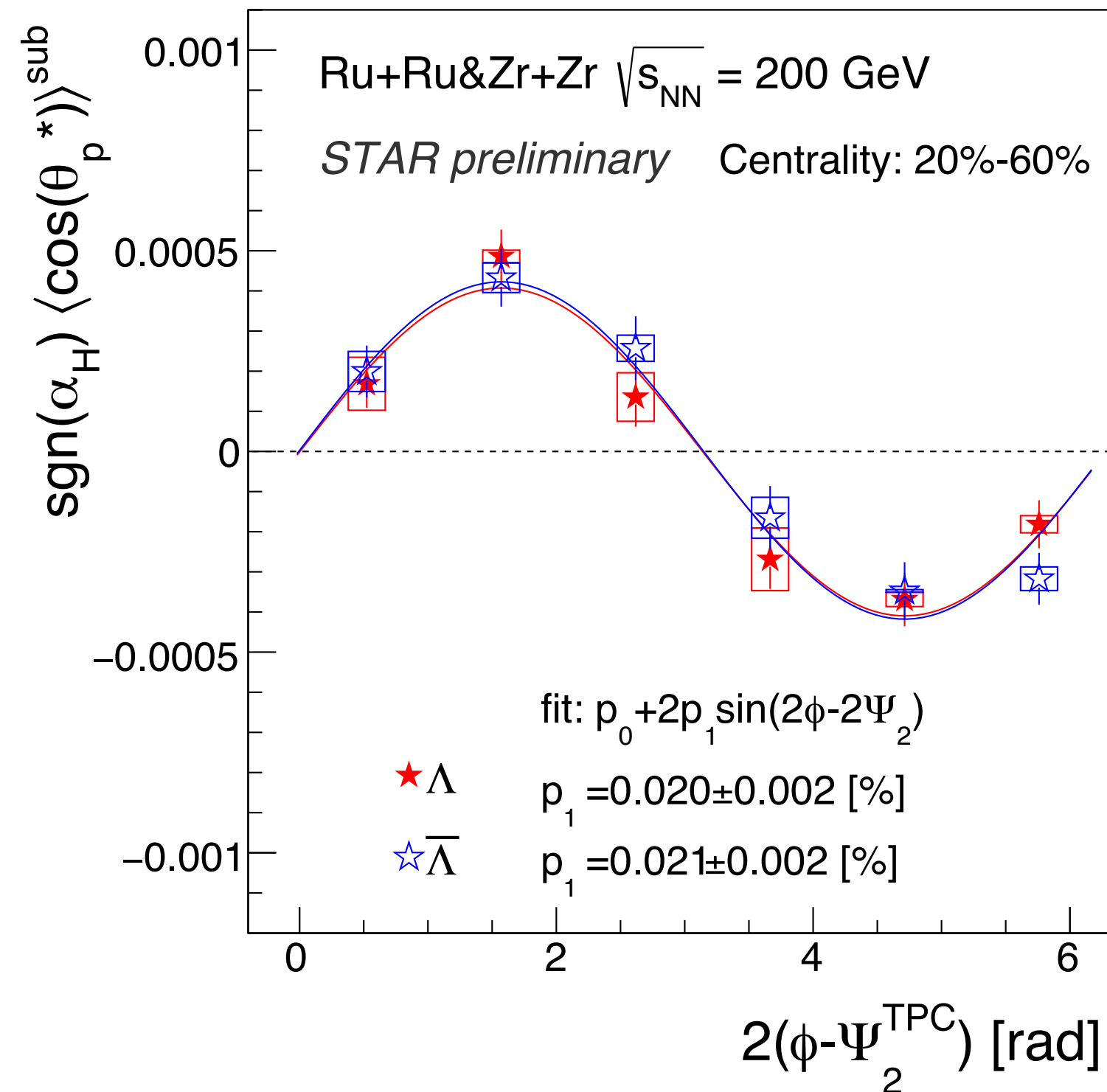
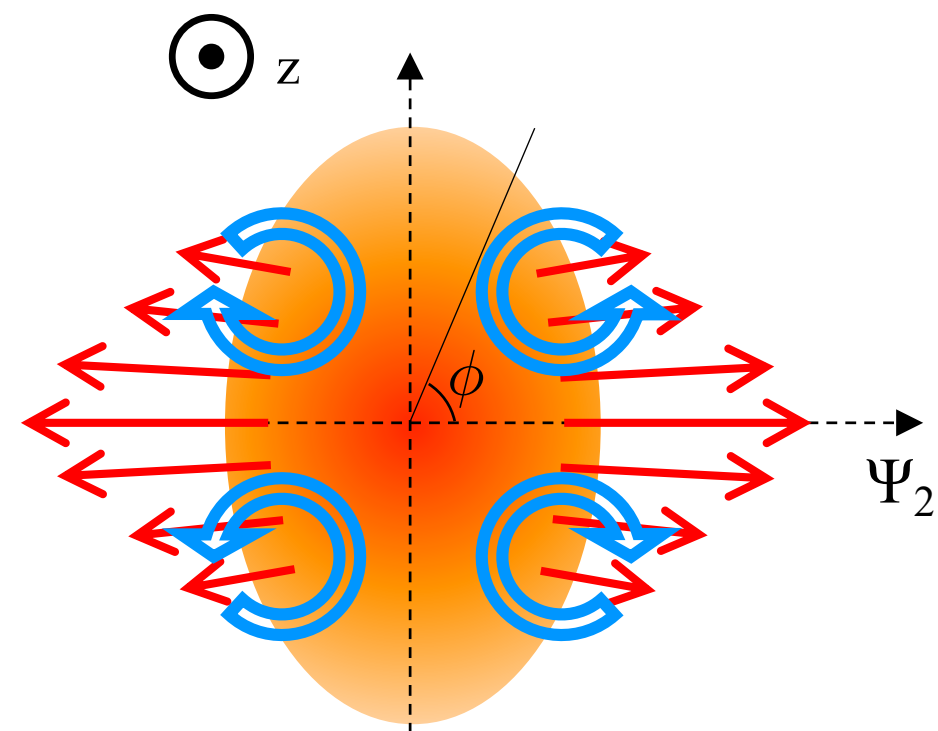
$$\therefore P_z = \frac{\langle \cos \theta_p^* \rangle}{\alpha_H \langle (\cos \theta_p^*)^2 \rangle}$$

decay parameter $\alpha_\Lambda = -\alpha_{\bar{\Lambda}} = 0.732$

accounts for acceptance effect (close to 1/3)

- Ru+Ru and Zr+Zr collisions at $\sqrt{s_{NN}} = 200$ GeV (~3.8B events in total)
- Event planes determined by tracks from TPC
- Λ hyperons reconstructed via decay topology
- Polarization measurement utilizing Λ weak decay

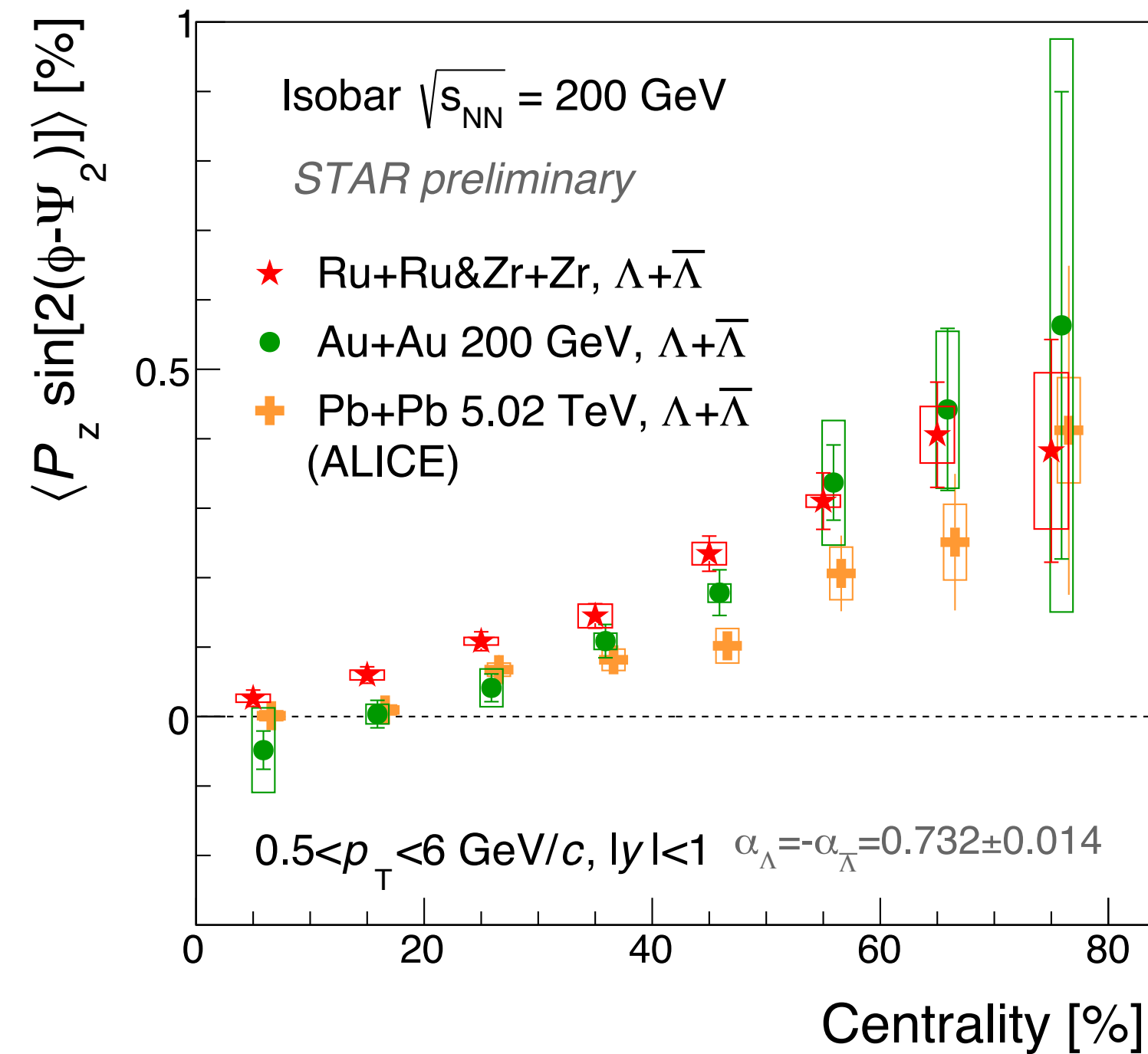
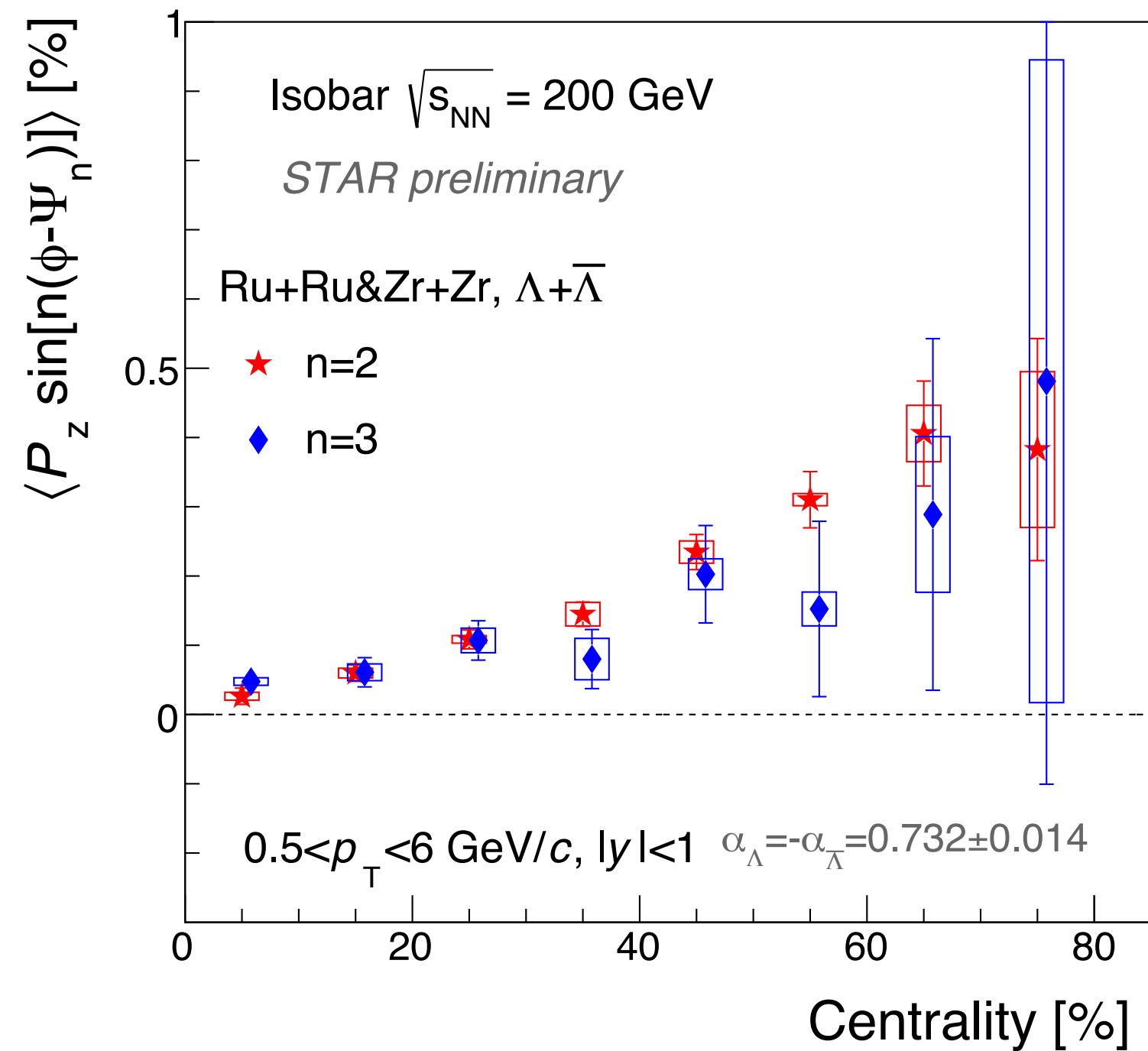
*Not accounted for EP resolution and decay parameter



- Clear Ψ_2 dependence as seen in Au+Au at 200 GeV
- **First measurement relative to the 3rd-order event plane Ψ_3 !**
 - ▶ Similar pattern to the 2nd-order, as expected from triangular flow



Centrality dependence of P_z modulation



- Comparable 2nd and 3rd order sine coefficients of P_z
 - ▶ Especially in most central events
 - ▶ Can models describe the data with correct sign?
- P_z from Isobar data comparable to Au+Au and Pb+Pb
 - ▶ A hint of system size dependence rather than energy dependence

Summary

- ▶ First measurements of longitudinal polarization relative to 2nd and 3rd order event planes in isobar collisions
- ▶ Longitudinal polarization driven by triangular flow is clearly observed with similar magnitude to the 2nd order, indicating a complex local vortical structure in heavy-ion collisions
- ▶ Study on p_T dependence is also ongoing