



**SQM2022**

The 20th International Conference on Strangeness in Quark Matter  
13-17 June 2022 Busan, Republic of Korea

# Differential study of $\Lambda$ -hyperon polarization in a few-GeV regime within transport model approach

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# $\Lambda$ -hyperon polarization in transport model (UrQMD)

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In the assumption of local thermal equilibrium one can find expression for spin 4-vector: [PRC 95, 054902 (2017)]

$$S^\mu(p, x) \approx -\frac{1}{8m} \epsilon^{\mu\nu\rho\sigma} p_\nu \varpi_{\rho\sigma}(x), \quad \varpi^{\mu\nu} = \frac{1}{2} \left( \partial^\nu \frac{u^\mu}{T} - \partial^\mu \frac{u^\nu}{T} \right)$$

From this one can find  $\Lambda$  polarization:

$$\vec{S}^*(x, p) = \vec{S} - \frac{(\vec{p} \cdot \vec{S})}{E(m + E)} \vec{p}, \quad \langle \vec{S} \rangle = \frac{1}{N} \sum \vec{S}_i^*(x_i, p_i), \quad P_\Lambda = 2 \langle \vec{S} \rangle \cdot \vec{n}$$

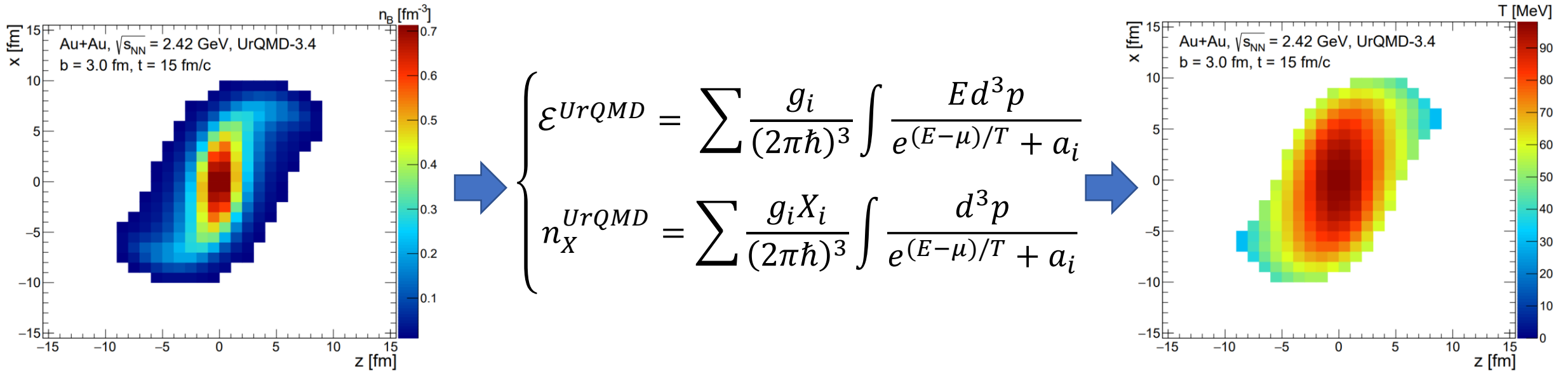
**How to calculate it in the transport model?**

Solution: Coarse-graining approach + HRG Model

[PLB 803, 135298 (2020)]

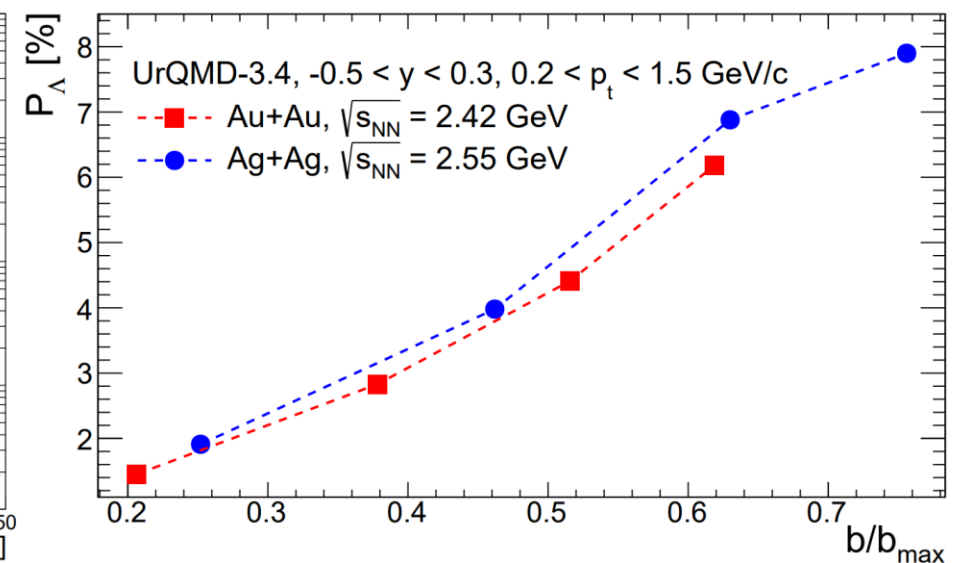
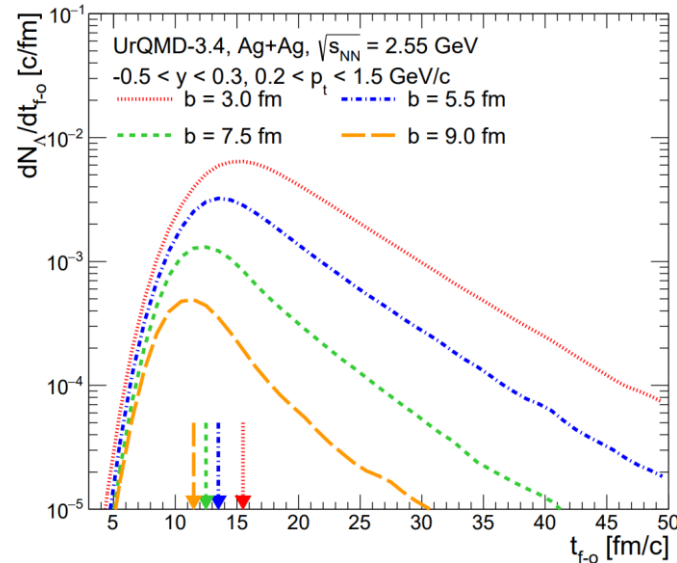
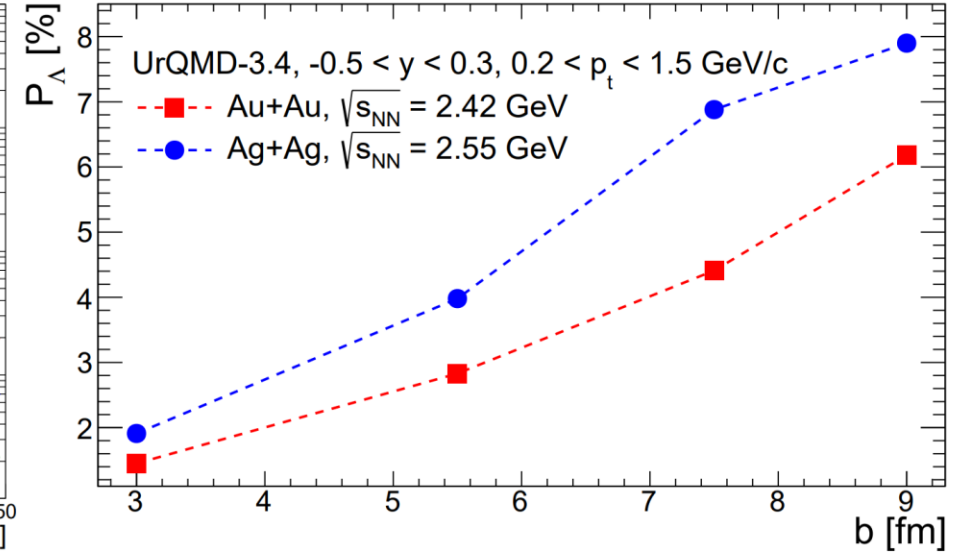
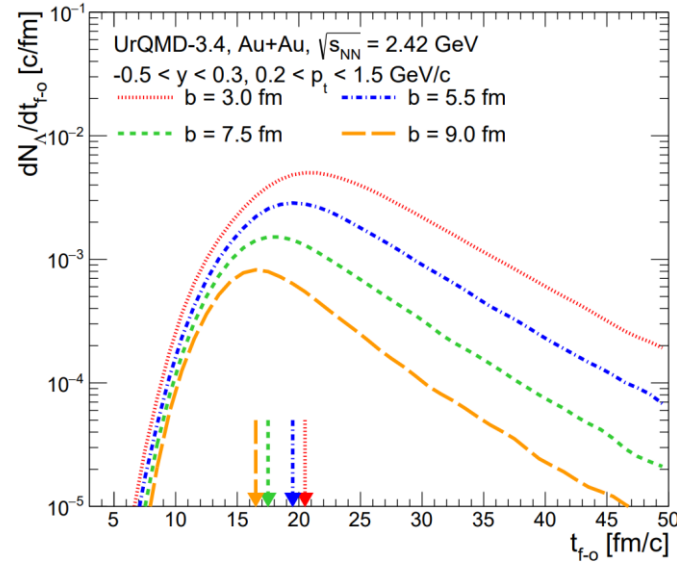
# $\Lambda$ -hyperon polarization in transport model (UrQMD)

1. Data generated with timestep  $\Delta t = 1 \text{ fm}/c$
2. For each timestep, whole space was subdivided into cubic cells with volume  $V = 1 \text{ fm}^3$
3. Collective velocity as well as  $\varepsilon, n_B, n_S, n_Q$  in the rest frame of each cell were calculated
4. Temperature field extracted with the help of HRG Model
5. With 4-velocity and  $T$  fields thermal vorticity field was obtained
6. For each  $\Lambda$ -hyperon we found spin 4-vector at its freeze-out position at its freeze-out time
7. Finally, global polarization and other observables were calculated



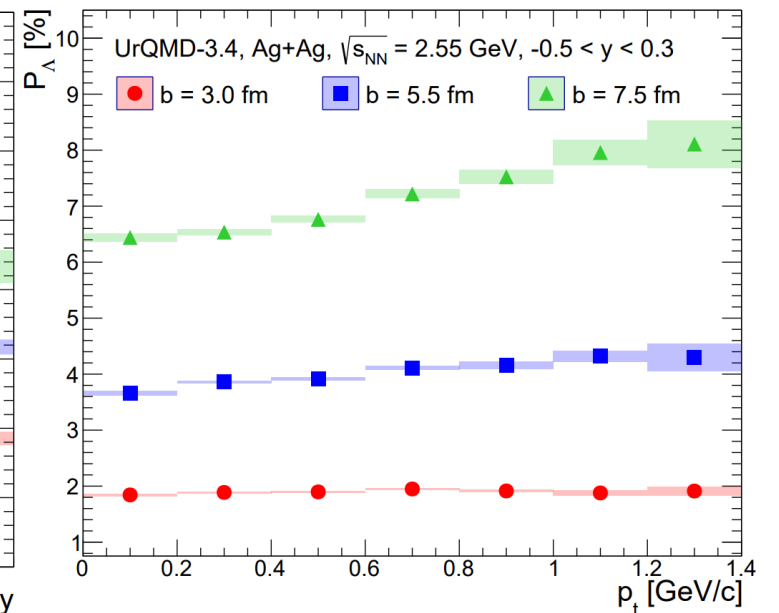
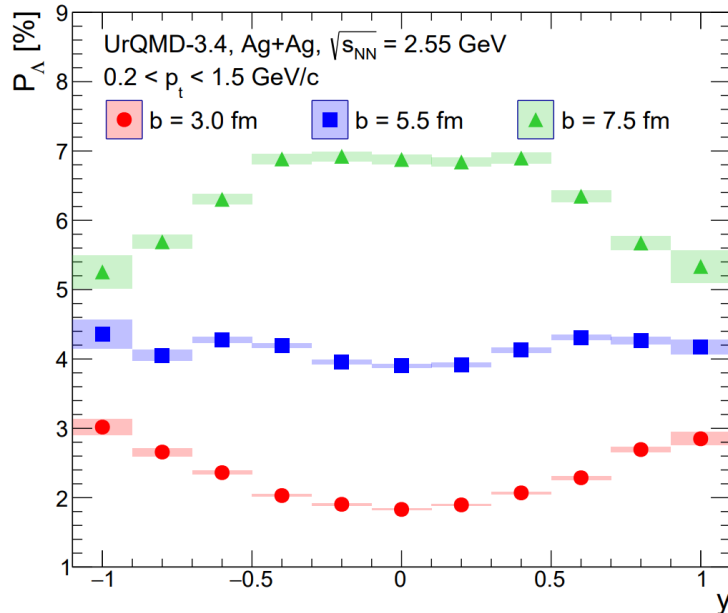
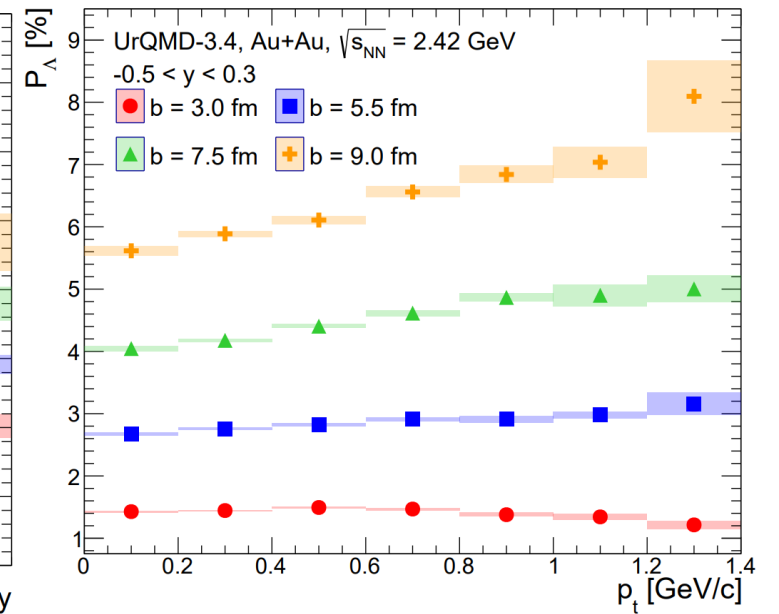
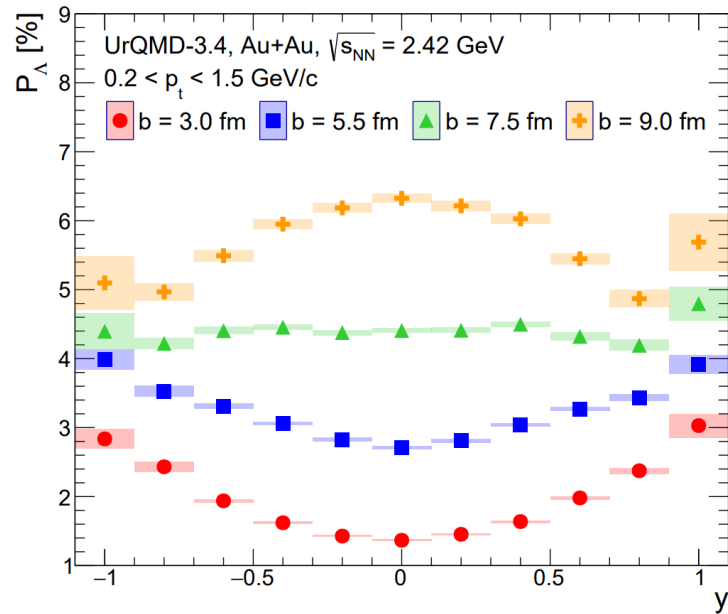
# Freeze-out of $\Lambda$ and Centrality Dependence of $P_\Lambda$

- Although the main amounts of both hyperons are emitted within 10-30 fm/c, there is continuous radiation of  $\Lambda$  up to the very late stage of system evolution.
- The time of maximum emission is decreasing with increasing impact parameter  $\Rightarrow$  Radiation from regions with higher vorticity  $\Rightarrow$  Higher polarization
- Polarization increases with impact parameter  $\Rightarrow$  Match qualitative explanations that the vorticity and angular momentum are also increasing towards more peripheral collisions.



# Study of $p_t$ and $y$ dependence

- Polarization is a linearly increasing function of  $p_t$  except of most central events where behaviour is more non-trivial.
- Non-trivial behaviour of polarization as function of rapidity and centrality
- Polarization distribution as a function of rapidity changes shape from concave to convex with increasing impact parameter



# Global polarization & Conclusions

Global polarization values are in agreement with HADES preliminary data (for Au+Au  $P_{\Lambda}[\%] = 4.609 \pm 0.966(stat.) \pm 1.22(sys.)$ ), while for the Ag+Ag run a value of is  $P_{\Lambda}[\%] = 3.174 \pm 0.294(stat.) \pm 0.319(sys.)$

## Conclusions:

- $\Lambda$ -hyperon polarization at HADES energies is studied in the UrQMD model within a coarse-graining approach in combination with the HRG model
- Differential studies show a non-trivial behaviour of  $\Lambda$  polarization as a function of transverse momenta, rapidity and impact parameter
- Obtained results are in agreement with the preliminary HADES data

