Global and local Λ polarization from 27 to 200 GeV from a 3D viscous hydrodynamic model

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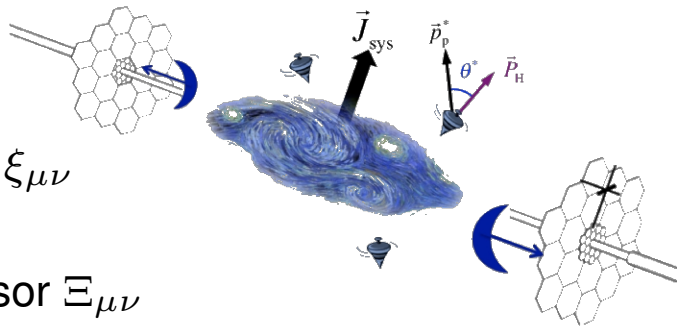
- Spin polarization in relativistic non-central heavy-ion collisions
  - Caused by strong angular momentum $\vec{J}$ perpendicular to the reaction plane
- Polarization of quarks is transfered to hadrons
- It leads to a non-zero mean global polarization along the direction of $\vec{J}$
- Cooper-Frye formula extended to the spin of particles
- Spin four-vector S^μ
  - Thermal vorticity tensor $\varpi_{\mu\nu}$ and thermal shear tensor $\xi_{\mu\nu}$
- One can assume Isothermal Local Equilibrium (ILE)
  - Kinematic vorticity tensor $\omega_{\mu\nu}$ and kinematic shear tensor $\Xi_{\mu\nu}$



Hydrodynamic model and Λ polarization

$$S^{\mu}_{\varpi}(p) = -\frac{1}{8m}\frac{\int_{\Sigma} \mathrm{d}\Sigma_{\lambda} p^{\lambda} f(x,p)\left[1-f(x,p)\right]\varepsilon^{\mu\nu\rho\sigma}p_{\sigma}\varpi_{\nu\rho}}{\int_{\Sigma} \mathrm{d}\Sigma_{\lambda} p^{\lambda} f(x,p)}$$

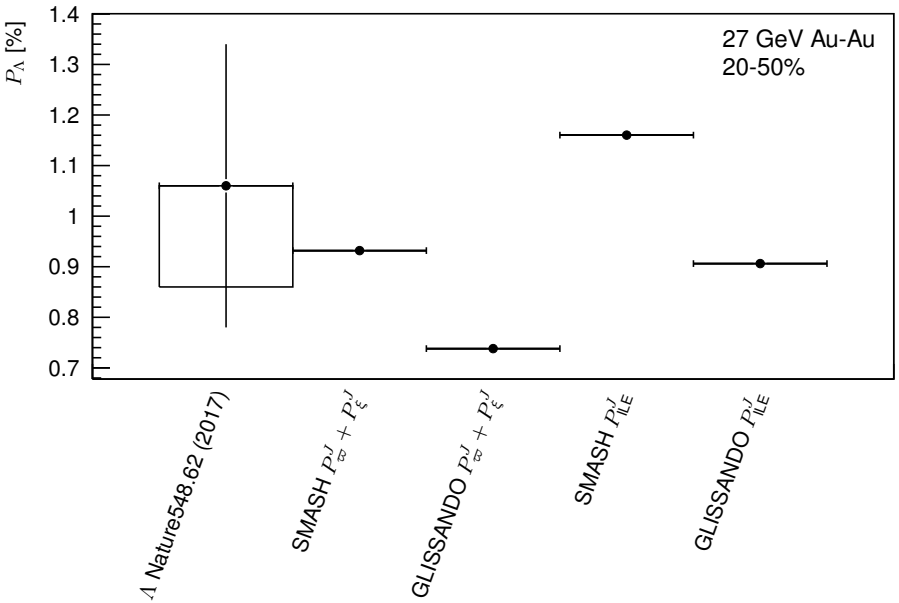
$$S^{\mu}_{\xi}(p) = -\frac{1}{4m}\varepsilon^{\mu\rho\sigma\tau}\frac{p_{\tau}p^{\lambda}}{\epsilon}\frac{\int_{\Sigma} \mathrm{d}\Sigma_{\lambda} p^{\lambda} f(x,p)\left[1-f(x,p)\right]\hat{t}_{\rho}\xi_{\sigma\lambda}}{\int_{\Sigma} \mathrm{d}\Sigma_{\lambda} p^{\lambda} f(x,p)}$$

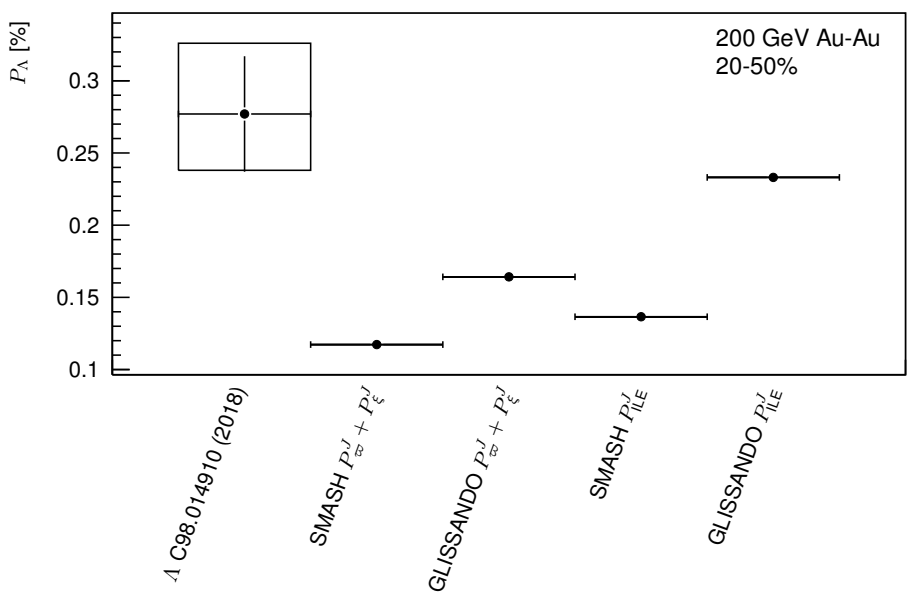
$$S^{\mu}_{\mathrm{ILE}}(p) = -\varepsilon^{\mu\rho\sigma\tau}p_{\tau}\frac{\int_{\Sigma} \mathrm{d}\Sigma_{\lambda} p^{\lambda} f(x,p)(1-f(x,p))\left[\omega_{\rho\sigma}+2\hat{t}_{\rho}\frac{p^{\lambda}}{\epsilon}\Xi_{\lambda\sigma}\right]}{8mT_{\mathrm{dec}}\int_{\Sigma} \mathrm{d}\Sigma_{\lambda} p^{\lambda} f(x,p)}$$

- Rest frame polarization: $P = 2S^{*}$
- Two different averaged initial states:
  - SMASH (Relativistic hadronic transport model)[1]
  - GLISSANDO (Monte Carlo Glauber model)[2]
- Hydrodynamic:
  - vHLLE (3+1D viscous hydrodynamic code in the Israel-Stewart formalism)[3]
- A-A collisions, 20-50%

[1] *https://smash-transport.github.io/*
[2] *Comput. Phys. Commun. 185 (2014) 1759-1772*
[3] *Comput. Phys. Commun. 185 (2014) 3016-3027*

Global polarization at mid-rapidity



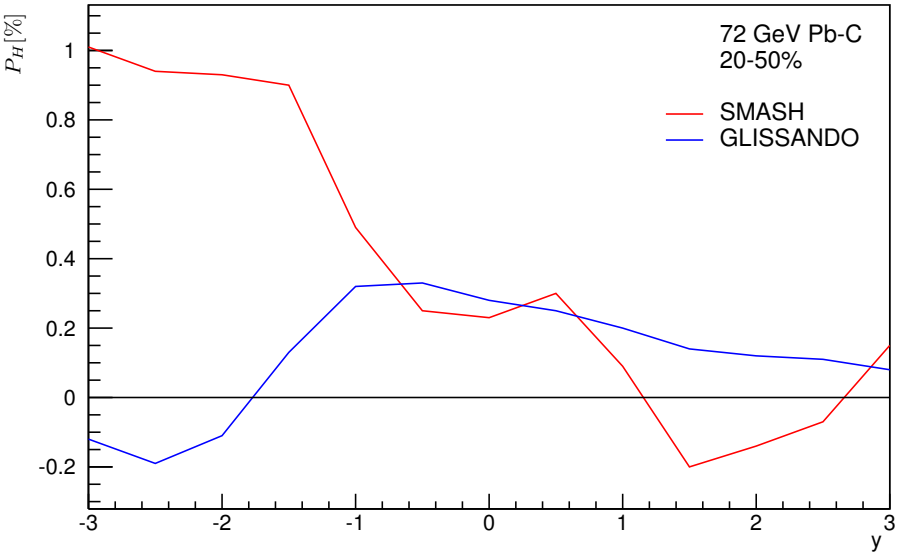


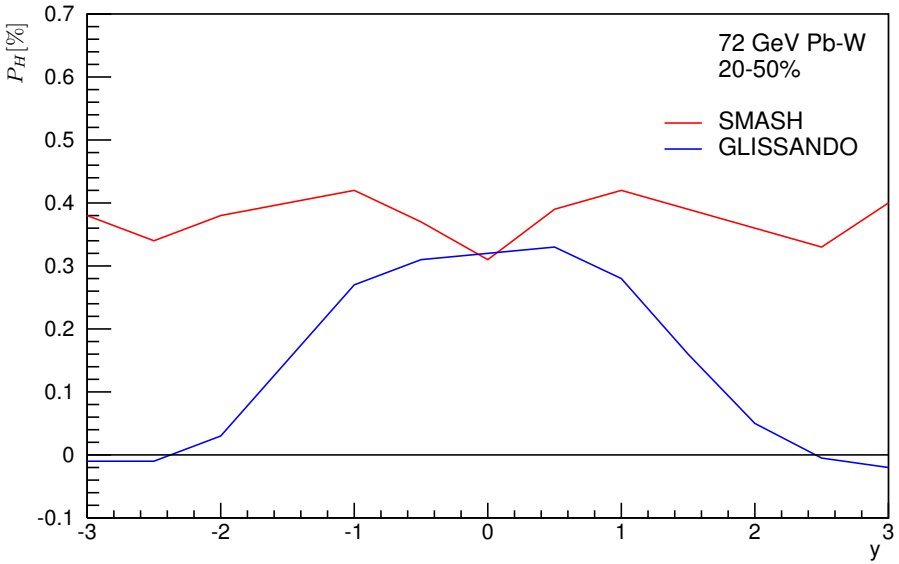
- Symmetric collision system Au-Au
- Region of mid-rapidity (y=0)
- 27 GeV - consistent results of Λ polarization with published data[4]
  - For both initial states and $P^J_\varpi + P^J_\xi$ and $P^J_{\rm ILE}$
- 200 GeV - small underestimation of Λ polarization w.r.t published data[5]
  - Except for GLISSANDO IS with ILE assumption $P^J_{\rm ILE}$

[4] *Nature 548 (2017) 62-65*

[5] *Phys. Rev. C 98 (2018) 014910*

Polarization rapidity dependence and FXT experiment

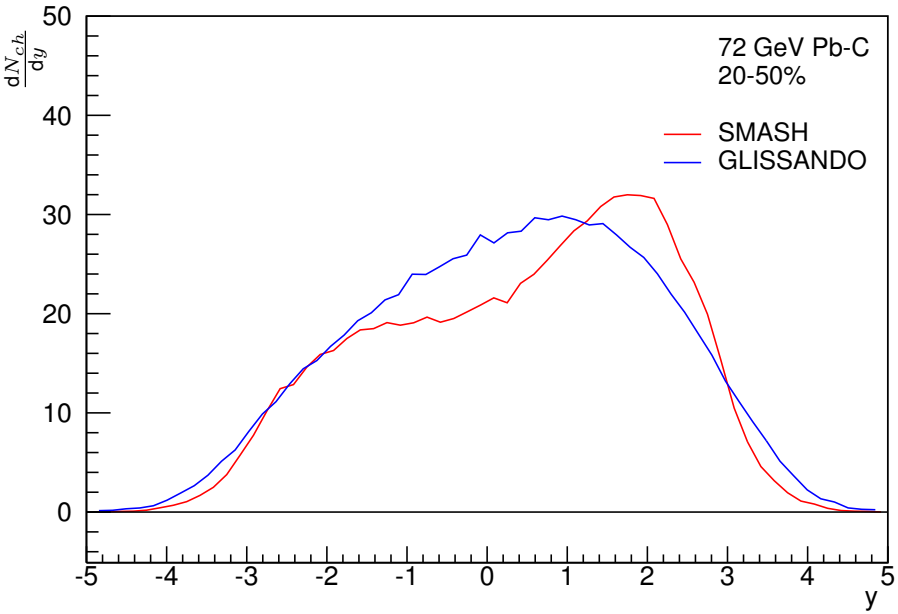


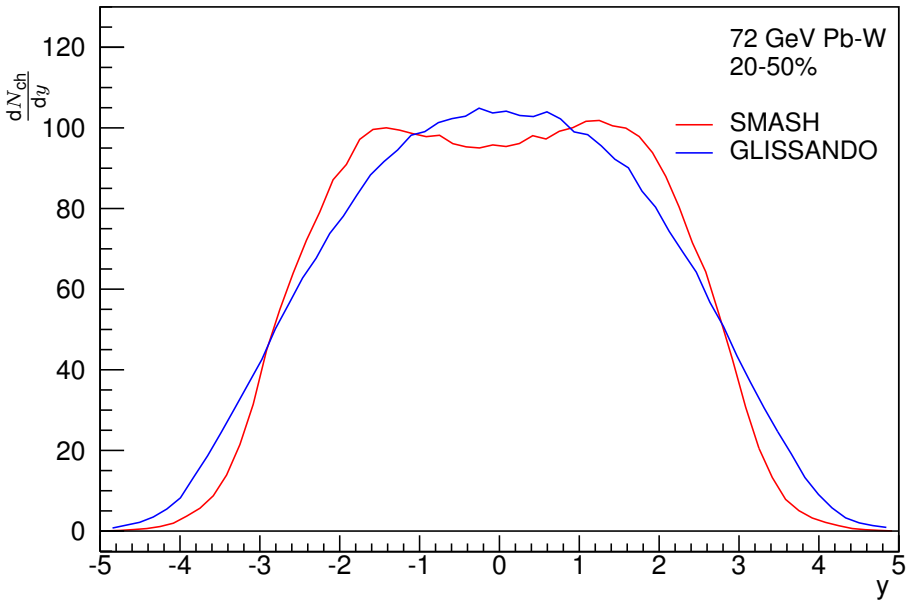


- Fixed-target physics program (AFTER@LHC)[6]
  - Backward rapidity coverage
- Non-central (20-50%) asymmetric collision systems at 72 GeV (Pb-C, Pb-W)
- Polarization dependence on rapidity y
  - Discrepancy between different initial states
  - SMASH and GLISSANDO predict different sign of polarization at $y \in (-3; -2)$

[6] *Phys. Rept. 911 (2021) 1-83*

Charged-particle multiplicity and FXT experiment





- Rapidity dependence of charged-particle multiplicity
  - Small shape discrepancies
  - Consistent at $y \in (-3; -2)$
  - The difference emerges where the dN/dy is not small, therefore it is not due to corona effects