The Λ spin polarization in heavy-ion collisions

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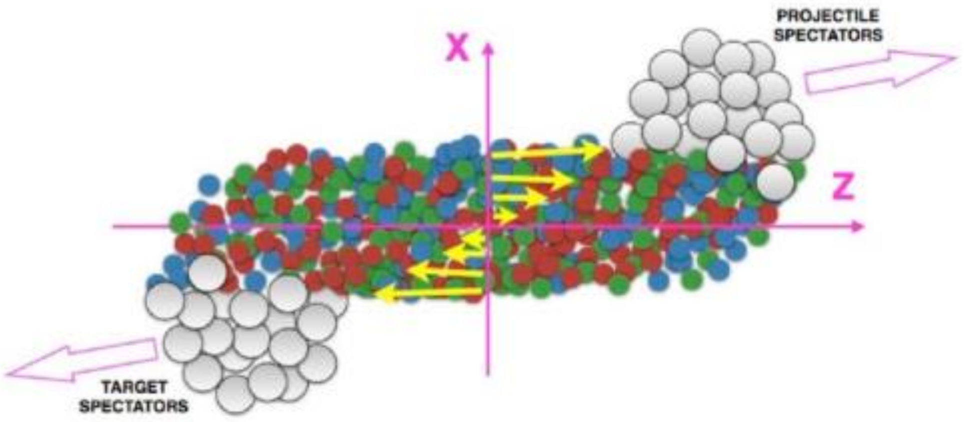
Theoretical study of particle spin polarization in heavy ion collisions

- Parton scattering is shown to polarize quarks along the same direction due to spin-orbital coupling
- quark recombination is the dominant hadronization mechanism

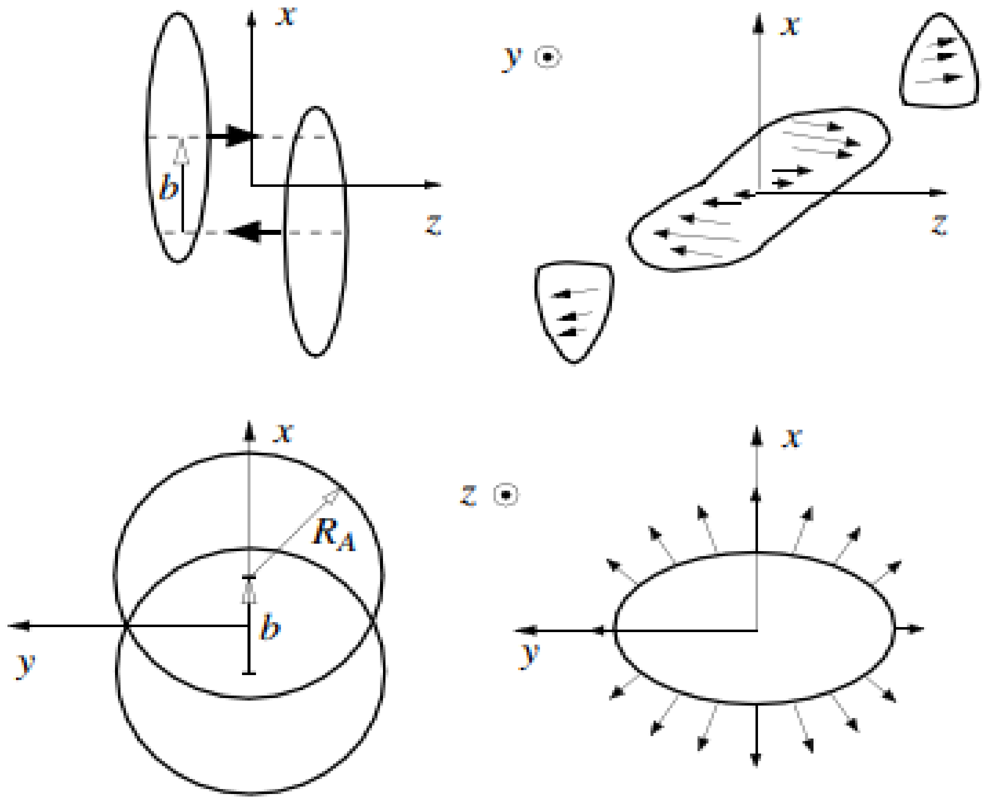


Schematic view of the collision. Taken from

[1] BECATTINI F, KARPENKO I, LISA M A, et al. Phys. Rev.C, 2017, 95:054902.

- polarized cross section

$$\frac{d\Delta\sigma}{d^2x_T} = -\mu\frac{\vec{p}\cdot(\hat{x}_T\times\vec{n}_b)}{E(E+m_q)}4C_T\alpha_s^2K_0(\mu x_T)K_1(\mu x_T),$$

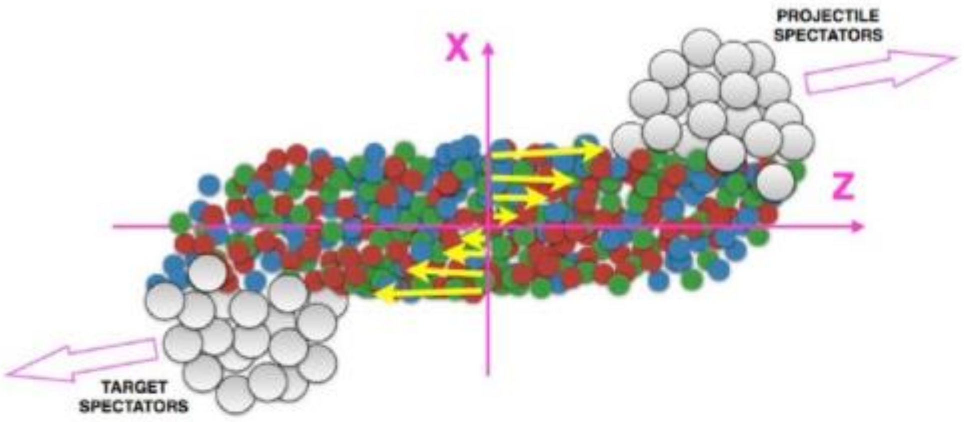


Taken from

[2] LIANG Z T, WANG X N. Phys. Rev. Lett., 2005, 94:102301.

Theoretical study of particle spin polarization in heavy ion collisions

Because of the strong magnetic field of the heavy-ion collisions, the particle will have a spin polarization which is different to that is caused by the velocity field. The magnetic field will cause the spin polarization splitting in particle or anti-particle.



Schematic view of the collision. Arrows indicate the flow velocity field, the +y direction points out of the page, and both the orbital angular momentum and the magnetic field point into the page. Taken from

[1] BECATTINI F, KARPENKO I, LISA M A, et al. Phys. Rev.C, 2017, 95:054902.

Only a fraction of all detected Λ and $\bar{\Lambda}$ hyperons are produced directly at the hadronization stage and are thus primary. Decays of heavier particles will emit some hyperons. The effect of feed-down has an important effort to result of spin polarization

$$\mathbf{S}_D^* = C\mathbf{S}_P^*,$$

Decay	C
Parity conserving: $1/2^+ \to 1/2^+ \; 0^-$	$-1/3$
Parity conserving: $1/2^- \to 1/2^+ \; 0^-$	1
Parity conserving: $3/2^+ \to 1/2^+ \; 0^-$	$1/3$
Parity-conserving: $3/2^- \to 1/2^+ \; 0^-$	$-1/5$
$\Xi^0 \to \Lambda + \pi^0$	$+0.900$
$\Xi^- \to \Lambda + \pi^-$	$+0.927$
$\Sigma^0 \to \Lambda + \gamma$	$-1/3$

Taken from

[1] BECATTINI F, KARPENKO I, LISA M A, et al. Phys. Rev.C, 2017, 95:054902.

Experiment of polarization in nuclear collisions

2007: 62.4 and 200 GeV

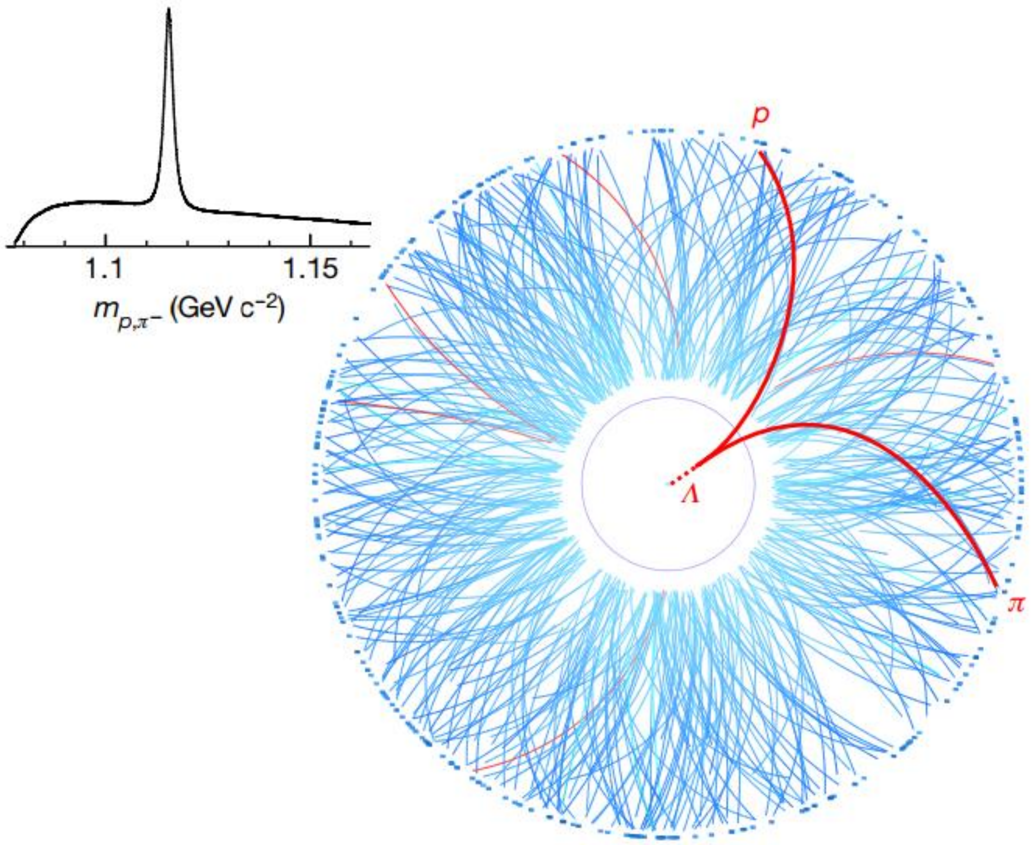
2017: < 62.4 GeV

2018: 62.4 and 200 GeV

Λ hyperons can 'self-analysing' by Λ → p + π

average projection of the polarization $$P_H = \frac{-8}{\pi\alpha_H}\frac{\langle sin(\phi_p^* - \Psi_{EP}^{(1)})\rangle}{R_{EP}^{(1)}}$$

Experiment of polarization in nuclear collisions

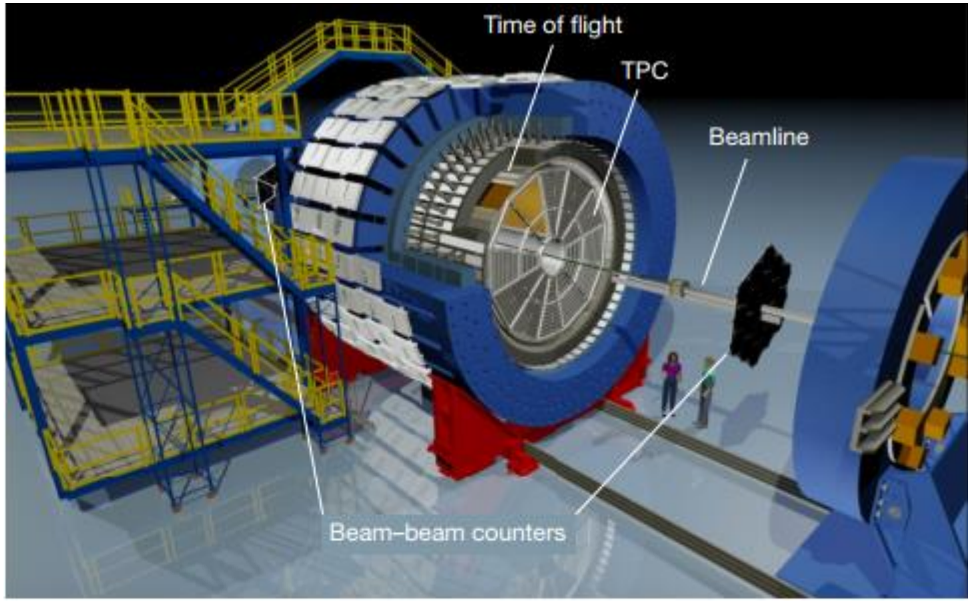


A single Au + Au collision in the STAR TPC. Charged particles from a collision ionize the gas in the TPC, forming tracks that curve in the magnetic field of the detector.

Taken from

[3] L. ADAMCZYK E A, J. K. Adkins. Global Λ hyperon polarization in nuclear collisions [J/OL]. Nature, 2017, 548:62-65

Experiment of polarization in nuclear collisions

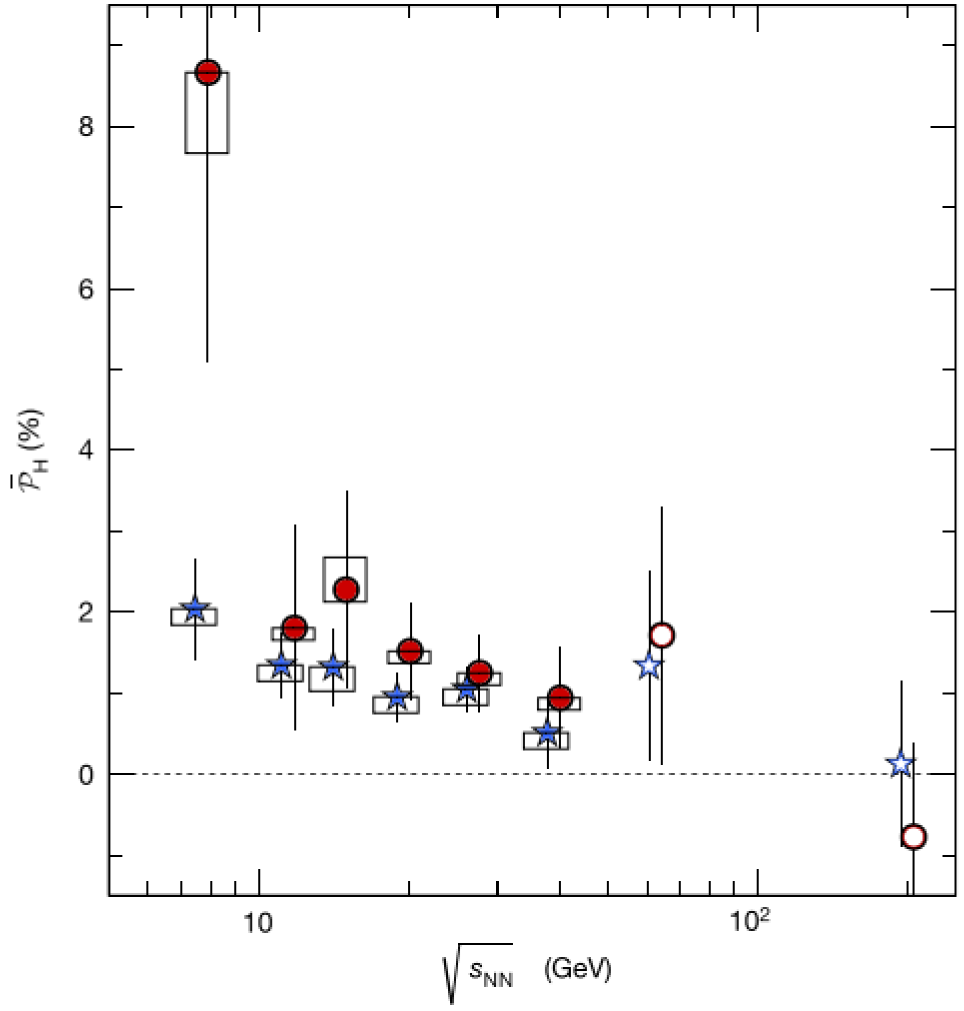


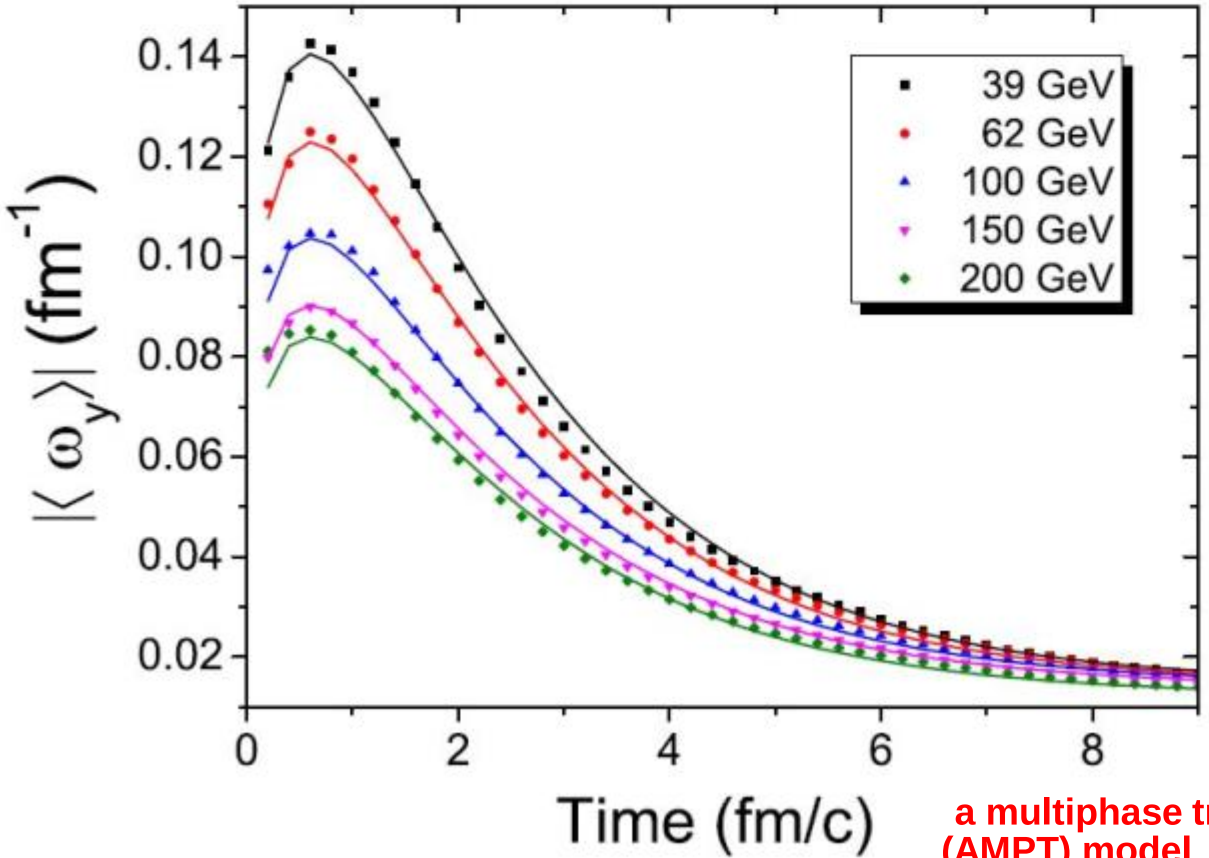
The rendering of the STAR detector system. Gold nuclei travelling at nearly the speed of light travel along the beamline and collide in the centre of the detector system. Charged particles are measured in the TPC and time-of-flight (TOF)detectors.
Forward- and backward- going beam fragments are detected in the beam-beam counters.

Taken from

[3] L. ADAMCZYK E A, J. K. Adkins. Global Λ hyperon polarization in nuclear collisions [J/OL]. Nature, 2017, 548:62-65

Results of polarization in nuclear collisions





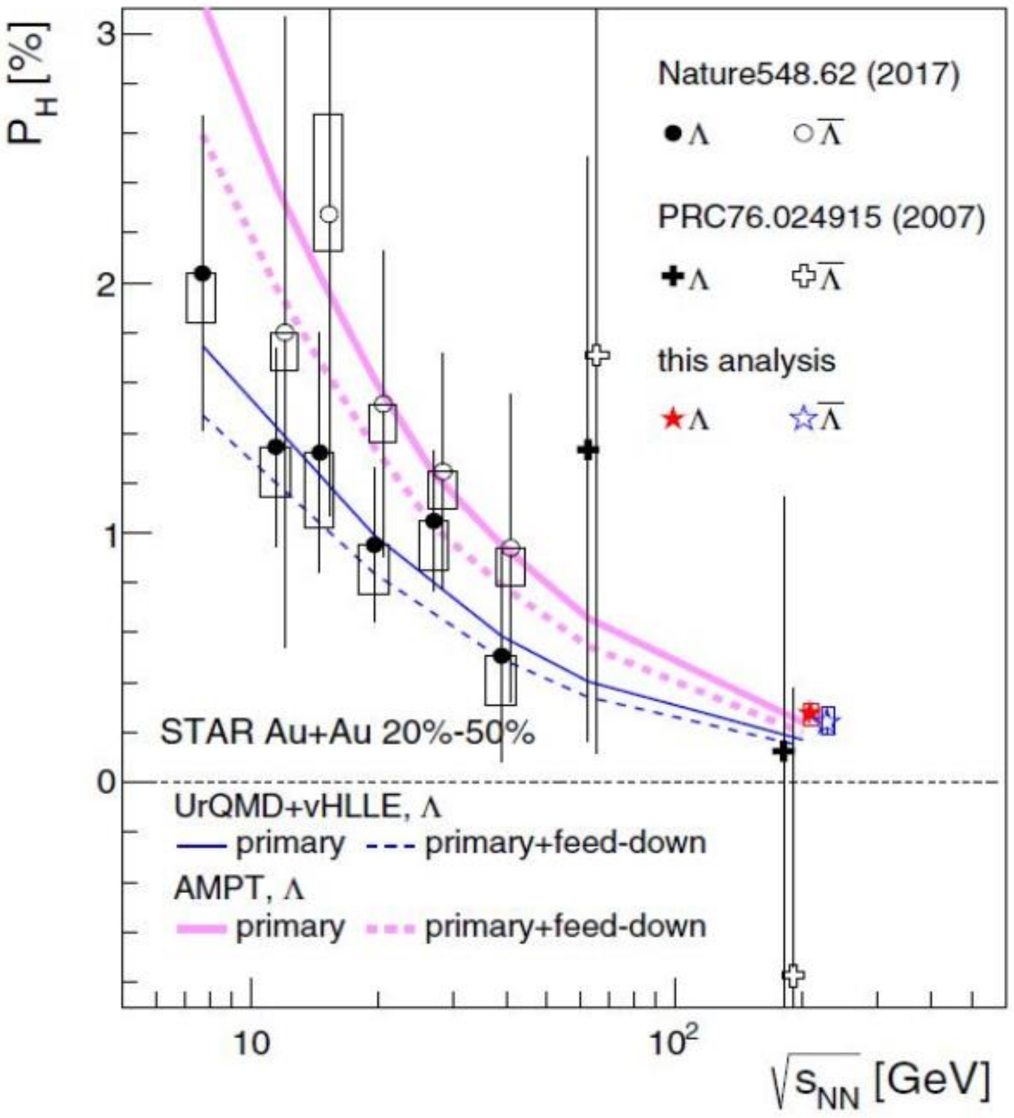
a multiphase transport (AMPT) model

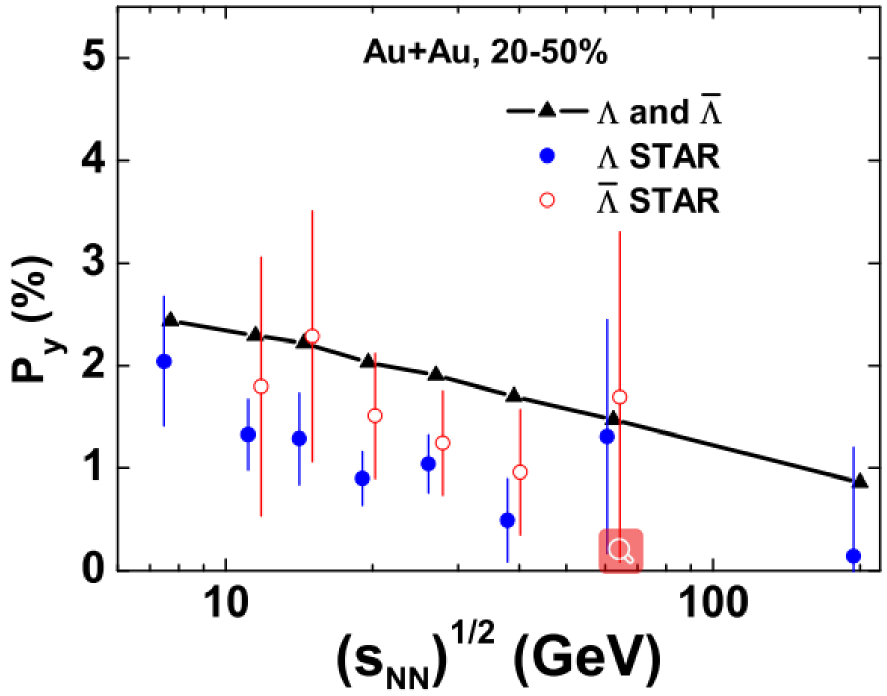
Taken from

[3] L. ADAMCZYK E A, J. K. Adkins. Global Λ hyperon polarization in nuclear collisions [J/OL]. Nature, 2017, 548:62-65

[4] JIANG Y, LIN Z W, LIAO J. Rotating quark-gluon plasma in relativistic heavy-ion collisions[J/OL]. Phys. Rev. C, 2016, 94:044910.

Results of polarization in nuclear collisions





[5] ADAM J, ADAMCZYK L, et al. Global polarization of Λ hyperons in Au + Au collisions *at* $\sqrt{s_{NN}}$= 200 GeV[J/OL]. Phys. Rev. C, 2018, 98:014910.
[6]SUN Y F, KO C M. Λ hyperon polarization in relativistic heavy ion collisions from a chiral kinetic approach[J/OL]. Phys. Rev. C, 2017, 96:024906.

SUMMARY

1. The degree of spin polarization of the hyperon seems to decrease with the increase of collision energy.
2. The spin polarization of Λ hyperon and $\bar{\Lambda}$ hyperon will split because of the strong magnetic field.