Global spin polarization of Λ hyperons in fixed target Au+Au collisions in STAR experiment at RHIC

Tan LU (lut@impcas.ac.cn) for the STAR collaboration
Institute of Modern Physics, Chinese Academy of Sciences

Supported in part by
**ENERGY** Office of Science
U.S. DEPARTMENT OF

Introduction

In non-central heavy ion collisions, large angular momentum is generated, leading to the creation of significant vorticity and subsequent spin polarization of particles with finite spin. The global polarization of Λ hyperons (P_Λ) measured along the direction of global angular momentum can serve as an effective probe of vorticity as well as spin degrees of freedom. Recently, global Λ polarization has been measured over a wide collision energy range. The Fixed-Target program at the STAR experiment at RHIC provides a unique opportunity to study P_Λ in regions of high baryon density.

Global Λ polarization measurement technique in heavy ion collisions[1]
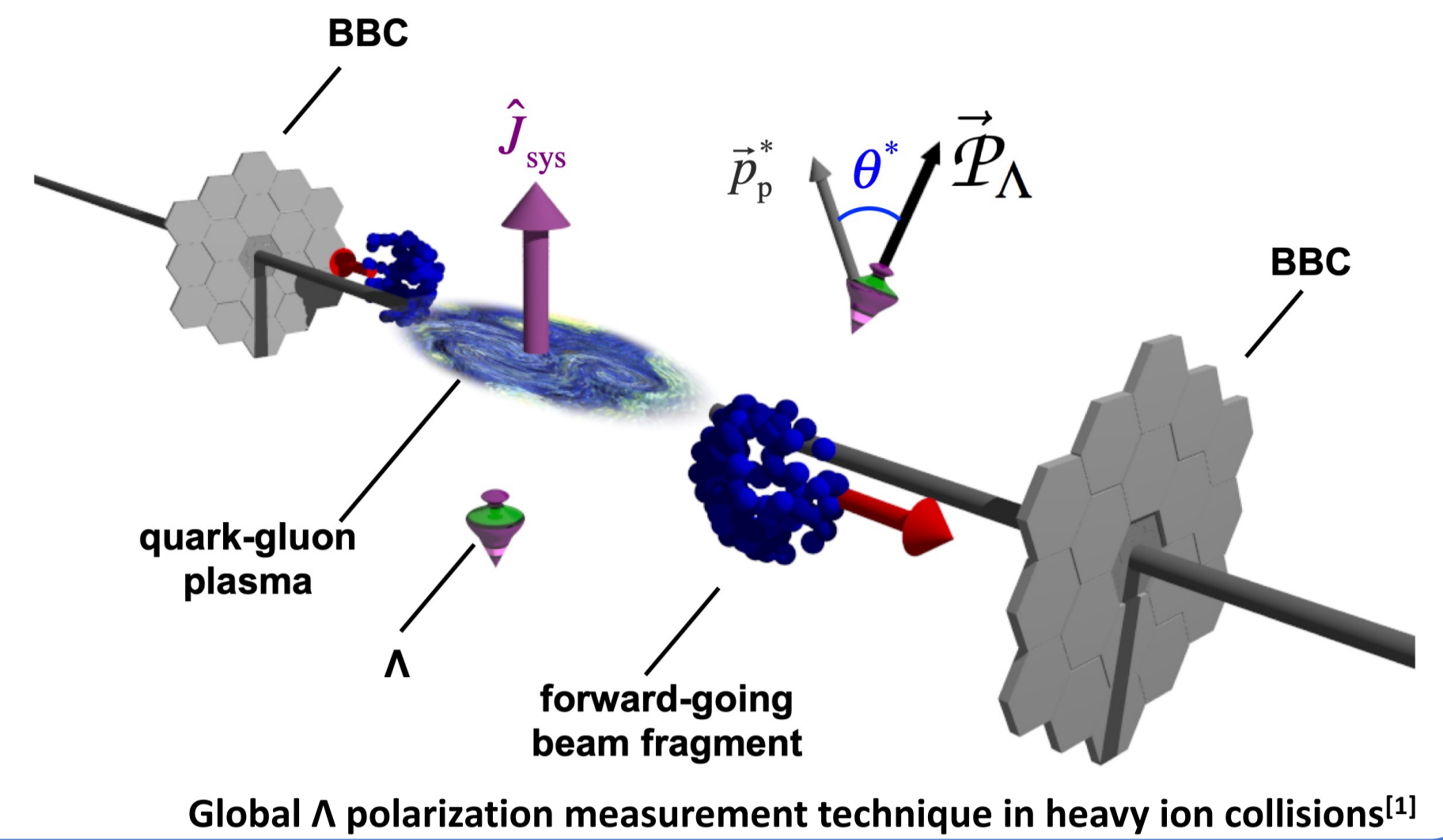
Motivation

- Global spin polarization is the probe of vorticity and spin degree of freedom.
- Measurement P_Λ of at high baryon density region can be sensitive to Equation-of-State of the medium.

Dataset and Λ acceptance

- STAR fixed-target dataset at $\sqrt{s_{NN}}$ = 3.0, 3.2, 3.5, 3.9, 4.5 GeV datasets are used in this analysis.
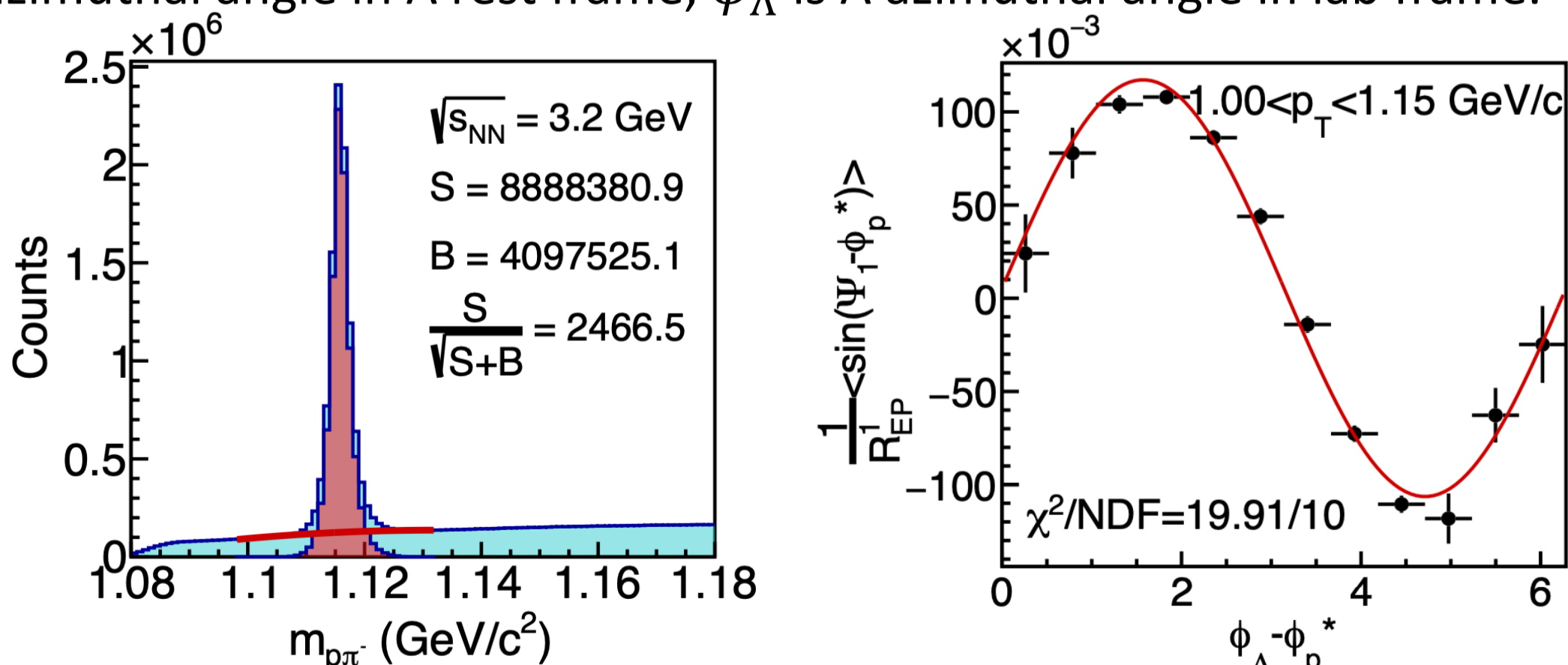
STAR Fixed-target
Au+Au collisions
Λ acceptance
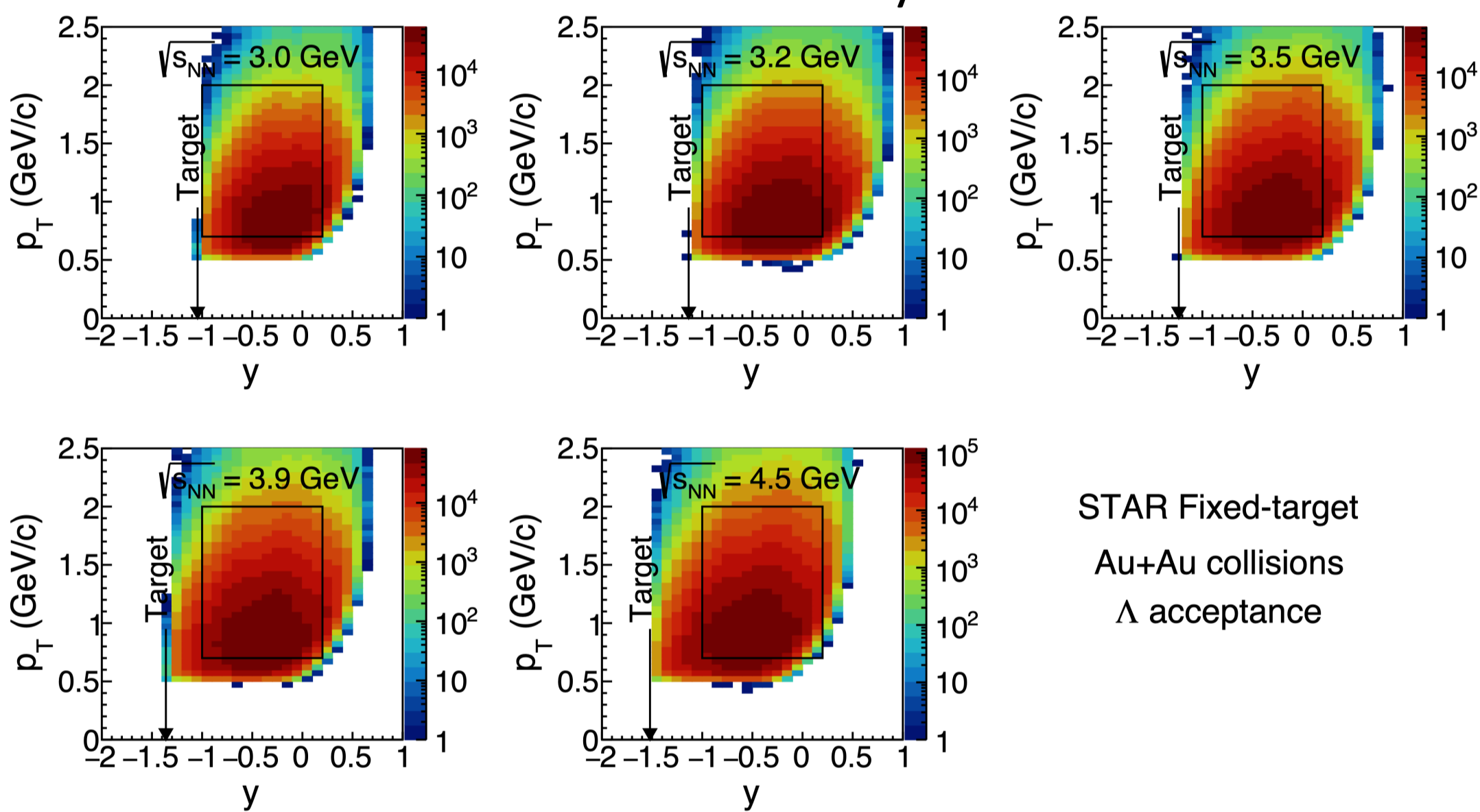
Analysis procedure

Generalized invariant mass method[2] is used to extract the P_Λ.

$$\frac{8}{\pi\alpha_\Lambda}\frac{1}{R_{EP,1}}<\sin(\Psi_1 - \phi_p^*)> = \overline{P}_\Lambda + c\sin(\phi_\Lambda - \phi_p^*)$$

α_Λ is the decay parameter, Ψ_1 is 1st order event plane from Event Plane Detector (EPD), $R_{EP,1}$ is 1st order event plane resolution, ϕ_p^* is proton azimuthal angle in Λ rest frame, ϕ_Λ is Λ azimuthal angle in lab frame.

$\sqrt{s_{NN}}$ = 3.2 GeV
S = 8888380.9
B = 4097525.1
$\frac{S}{\sqrt{S+B}}$ = 2466.5
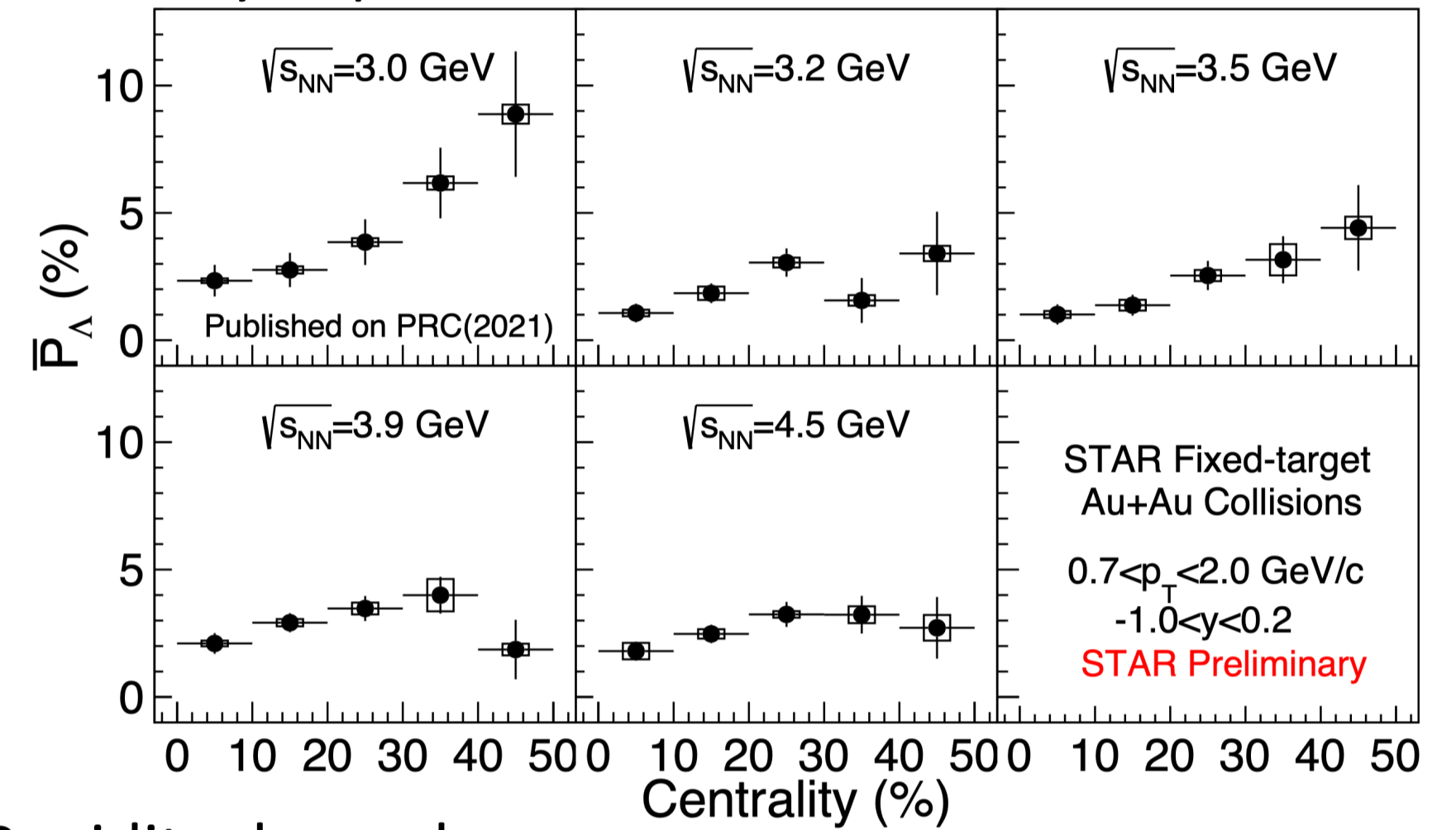
$1.00 < p_T < 1.15$ GeV/c
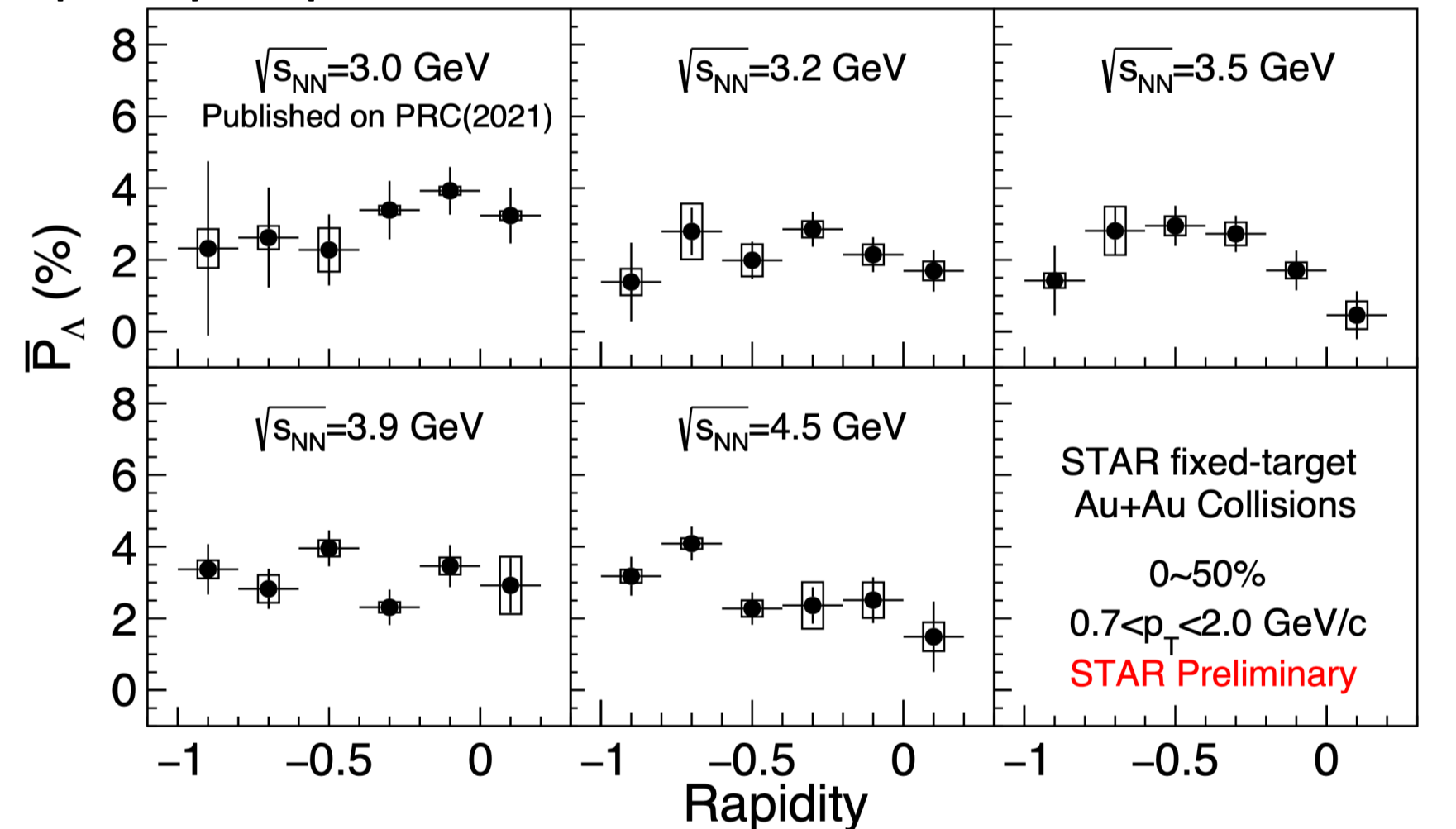χ^2/NDF=19.91/10

Summary

- Differential measurement for P_Λ is obtained for Au+Au collisions at $\sqrt{s_{NN}}$ = 3.0 - 4.5 GeV at STAR@RHIC.
- Clear p_T and centrality dependence is observed.
- No strong rapidity dependence is observed within y∈[-1.0,0].
- P_Λ shows collision energy dependence, models can't explain data between $\sqrt{s_{NN}}$ =3.2 - 4.5 GeV.
- Analysis of new 3 GeV dataset (2 billion events) is underway.
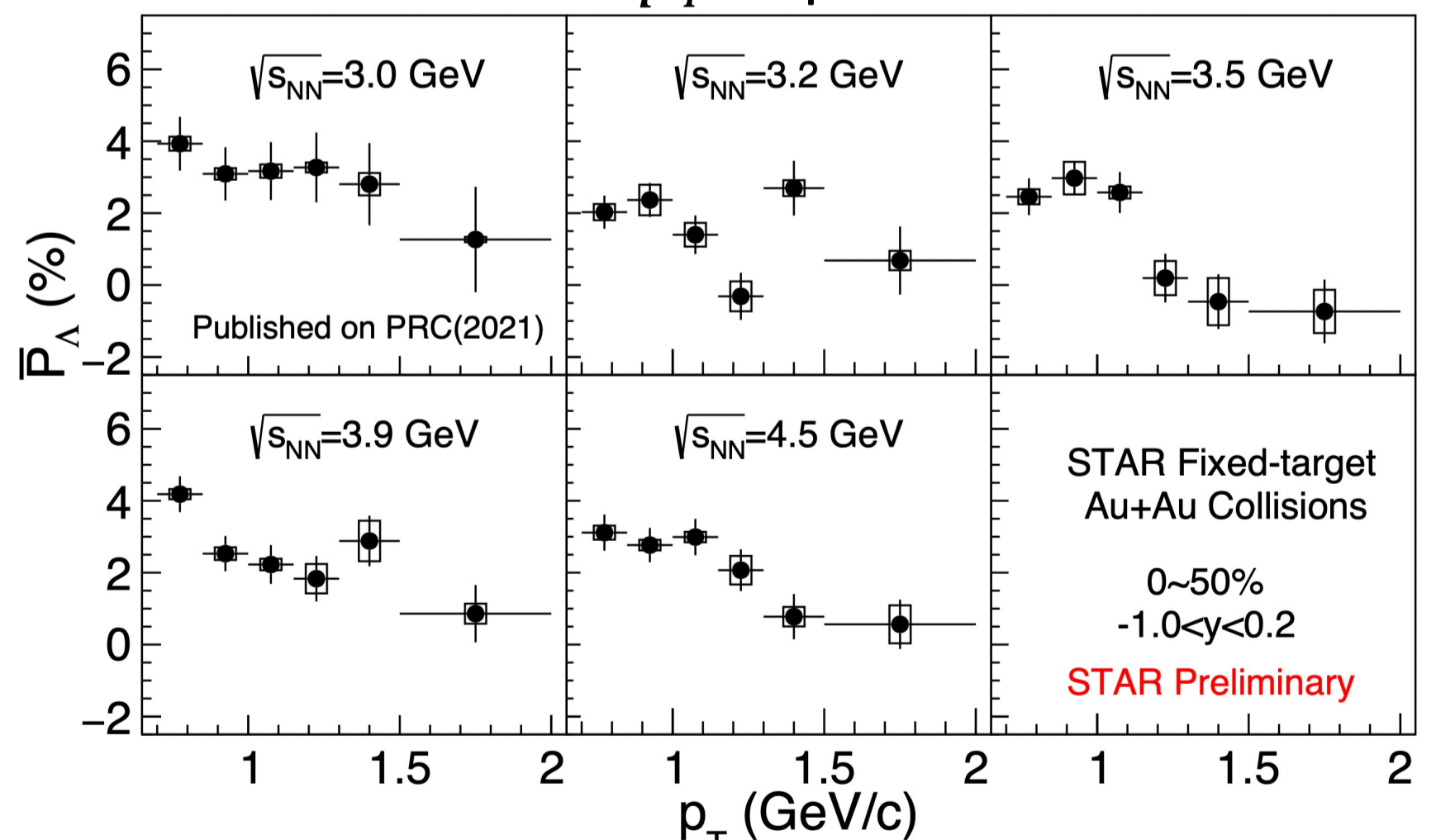
Global Λ polarization results

• Centrality dependence

$\sqrt{s_{NN}}$=3.0 GeV | $\sqrt{s_{NN}}$=3.2 GeV | $\sqrt{s_{NN}}$=3.5 GeV
Published on PRC(2021)
$\sqrt{s_{NN}}$=3.9 GeV | $\sqrt{s_{NN}}$=4.5 GeV

STAR Fixed-target
Au+Au Collisions
$0.7 < p_T < 2.0$ GeV/c
$-1.0 < y < 0.2$
STAR Preliminary

• Rapidity dependence

$\sqrt{s_{NN}}$=3.0 GeV | $\sqrt{s_{NN}}$=3.2 GeV | $\sqrt{s_{NN}}$=3.5 GeV
Published on PRC(2021)
$\sqrt{s_{NN}}$=3.9 GeV | $\sqrt{s_{NN}}$=4.5 GeV

STAR fixed-target
Au+Au Collisions
0~50%
$0.7 < p_T < 2.0$ GeV/c
STAR Preliminary

• Transverse momentum p_T dependence

$\sqrt{s_{NN}}$=3.0 GeV | $\sqrt{s_{NN}}$=3.2 GeV | $\sqrt{s_{NN}}$=3.5 GeV
Published on PRC(2021)
$\sqrt{s_{NN}}$=3.9 GeV | $\sqrt{s_{NN}}$=4.5 GeV

STAR Fixed-target
Au+Au Collisions
0~50%
$-1.0 < y < 0.2$
STAR Preliminary

• Collision energy dependence

STAR 20-50%, Λ
★ This analysis
□ EPJ(2022),preli.
◇ Nature(2017)
○ PRC(2021)
HADES 20-40%, Λ
△ AuAu PLB(2022)
▽ AgAg

STAR Preliminary

Model calculation
AMPT, b=8fm, |y|<1.0, $p_T \in [0.4,3.0]$GeV/c
3FD, b=8fm, |y|<0.8
- - - 1PT EoS
- · - CrossOver EoS
- · - Hadronic EoS

Reference: [1] (STAR collaboration), Nature 548, 62 (2017); [2] (STAR collaboration), Phys. Rev. C 104 (2021) L061901