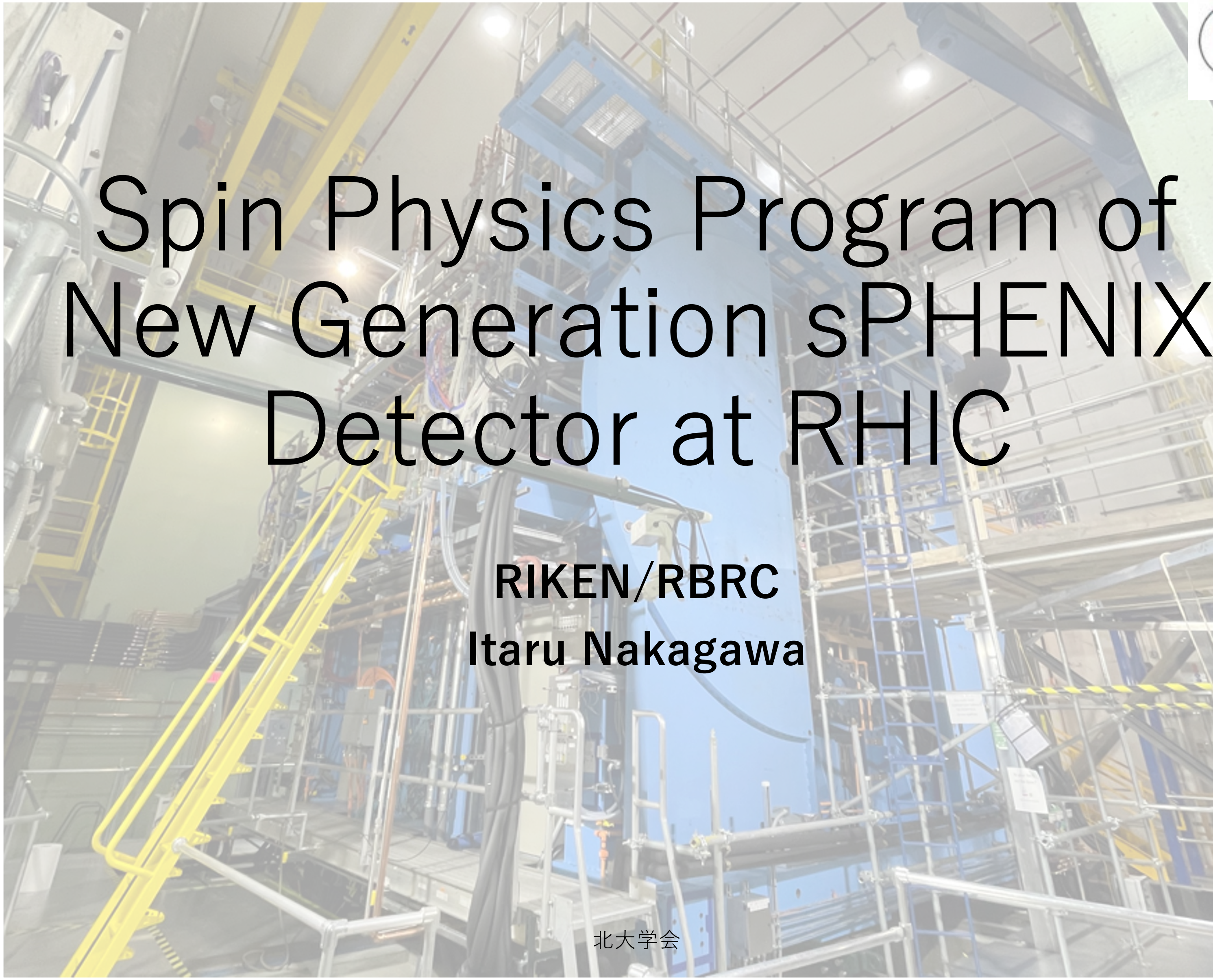
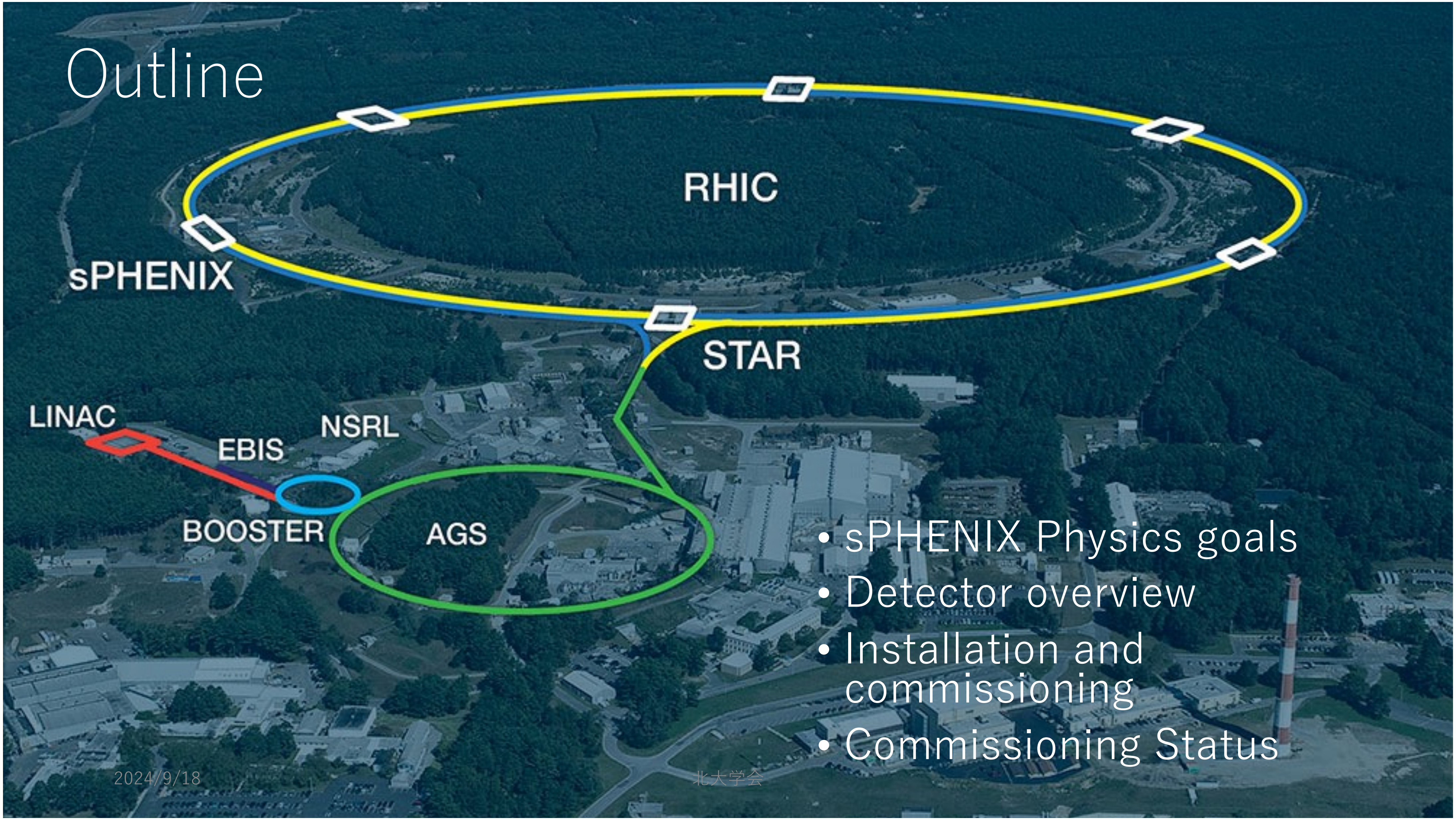


Spin Physics Program of New Generation sPHENIX Detector at RHIC

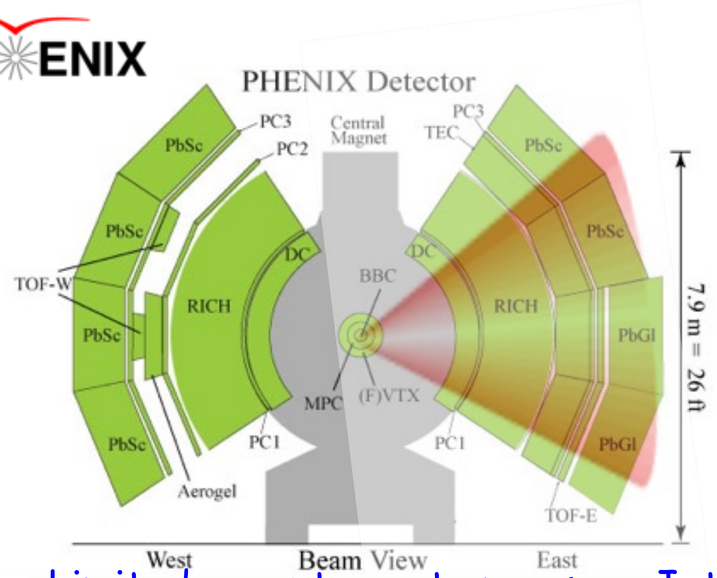
RIKEN/RBRC
Itaru Nakagawa

Outline

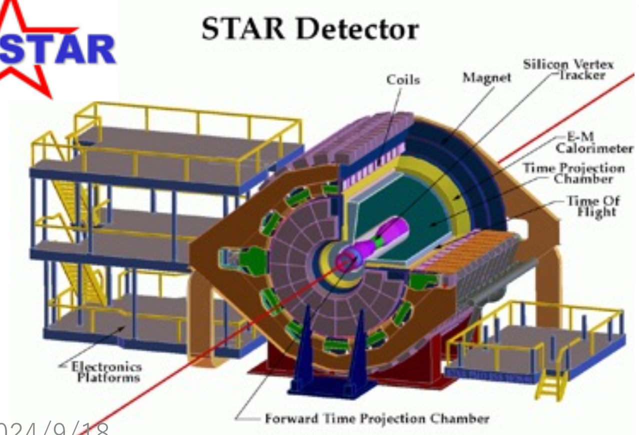


- sPHENIX Physics goals
- Detector overview
- Installation and commissioning
- Commissioning Status

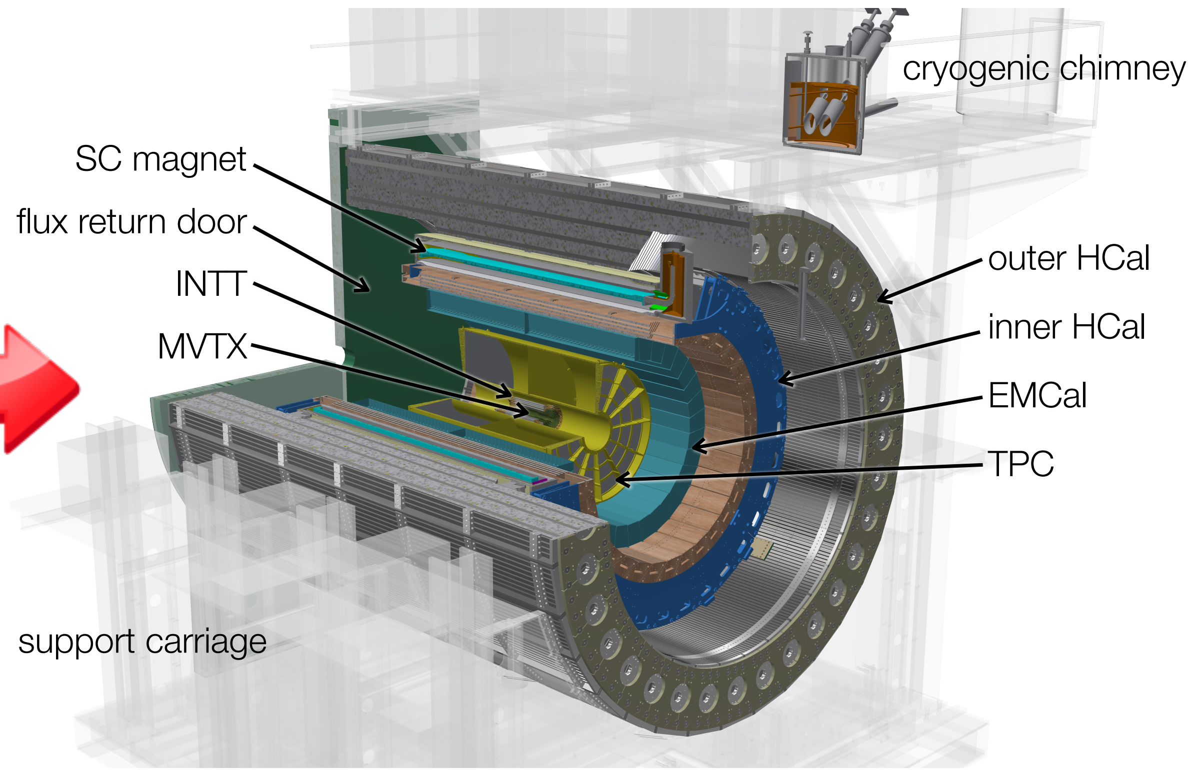
What's new about sPHENIX



Limited acceptance to measure Jet.



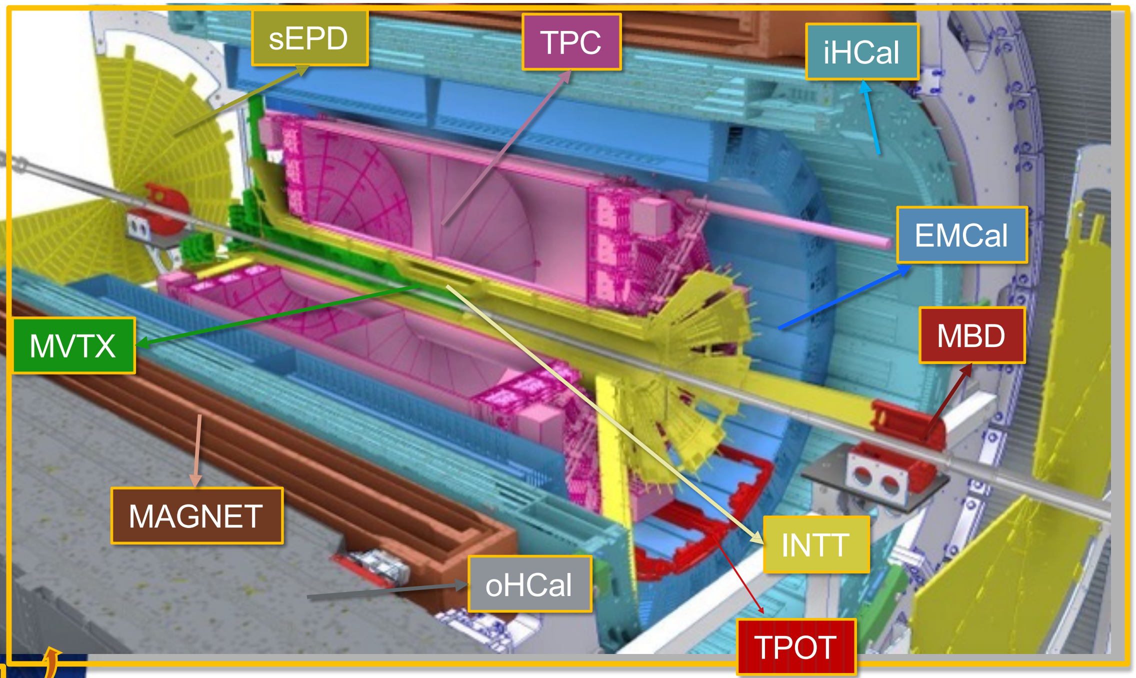
4π, but incomplete for jet without HCAL

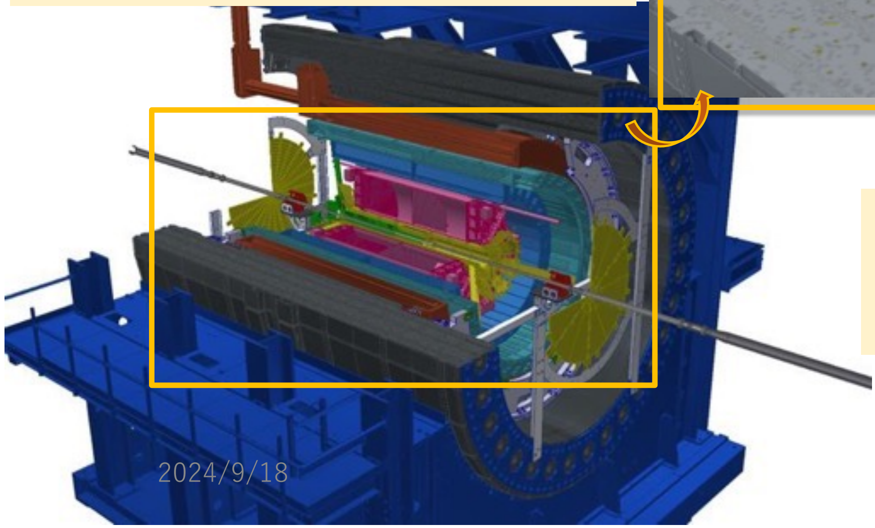


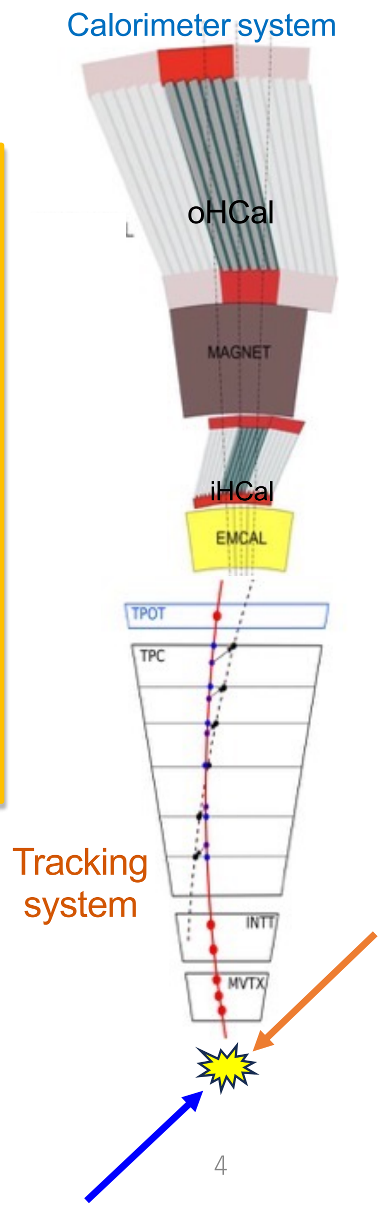
4π & $-1<\eta<1$ with HCAL
Designed to be ideal detector for Jet

sPHENIX Detector

- 1.4T Solenoid from BaBar
- Hermetic coverage: |η|<1.1, 2π in φ
- Large-acceptance EM+H calorimeters: brings first full jet reconstruction & b-jet tagging at RHIC!!
- High data rates: 15 kHz for all subdetectors
- Precise tracking with tracking system in stream readout





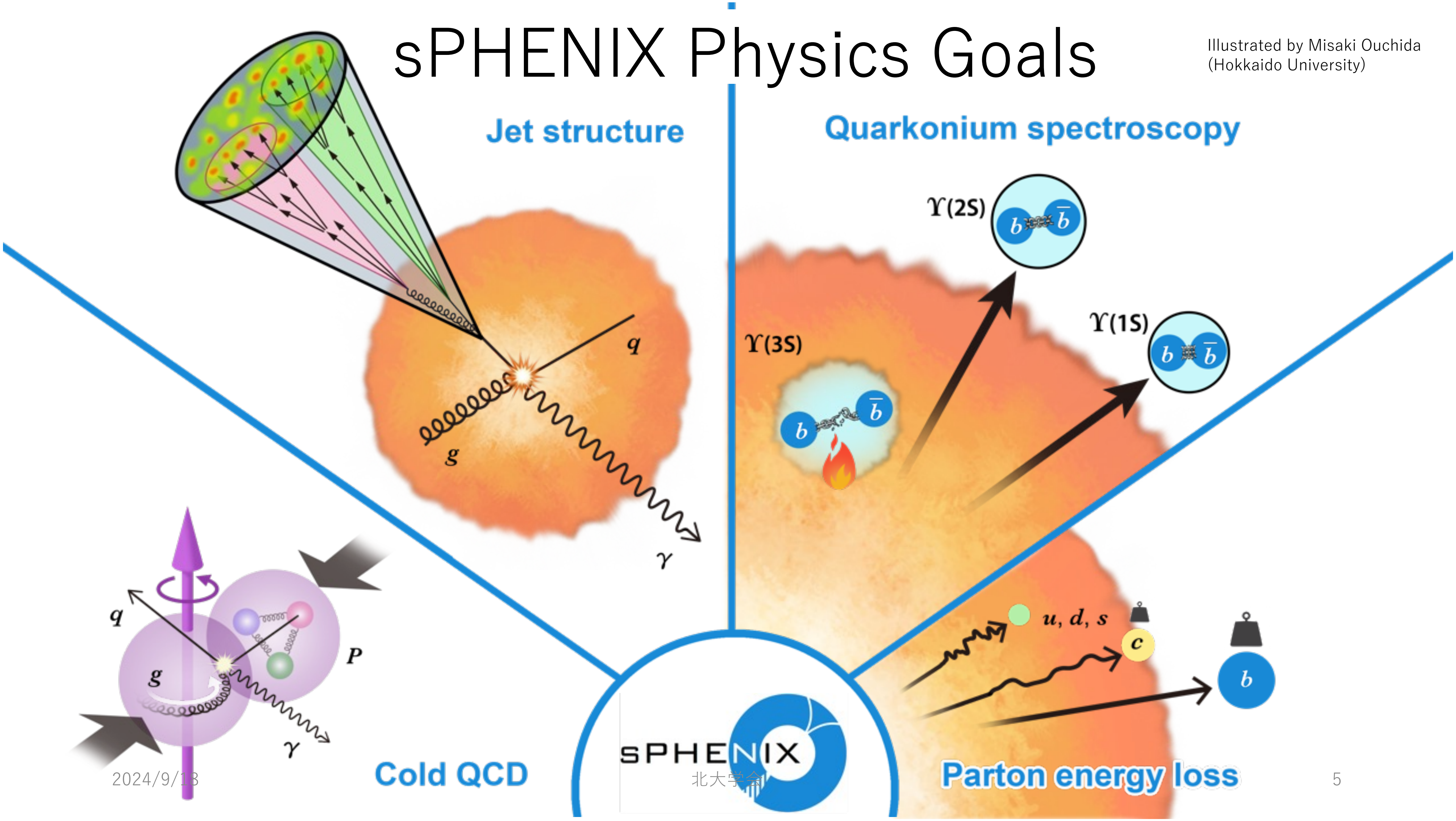


2023 : Commissioning Au+Au
2024 : p+p, Au+Au
2025 : Au+Au … p+A?

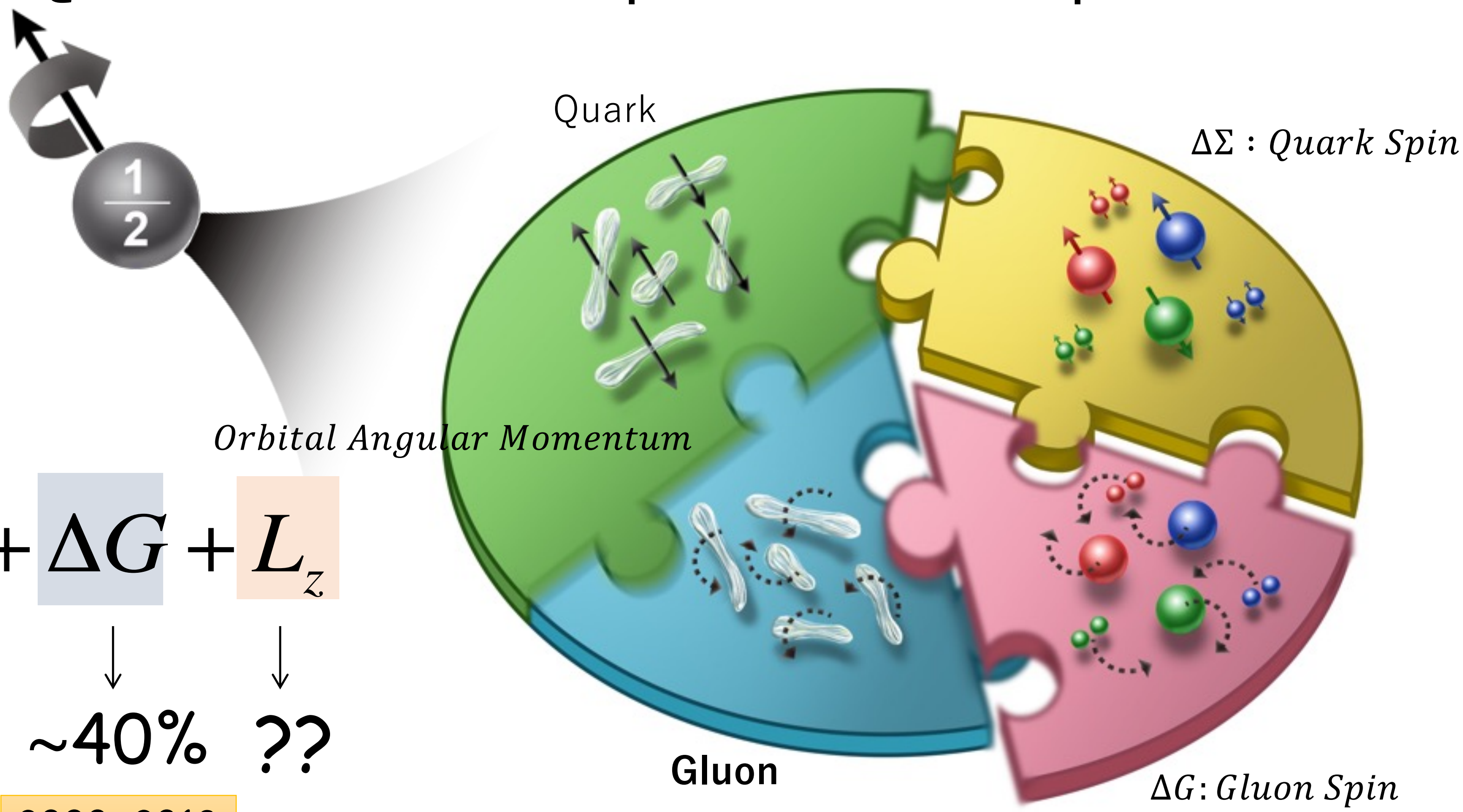
$\sqrt{s}$ =200GeV

sPHENIX Physics Goals

Illustrated by Misaki Ouchida
(Hokkaido University)



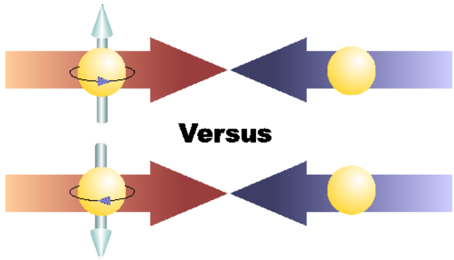
Cold-QCD: Proton Spin Decomposition



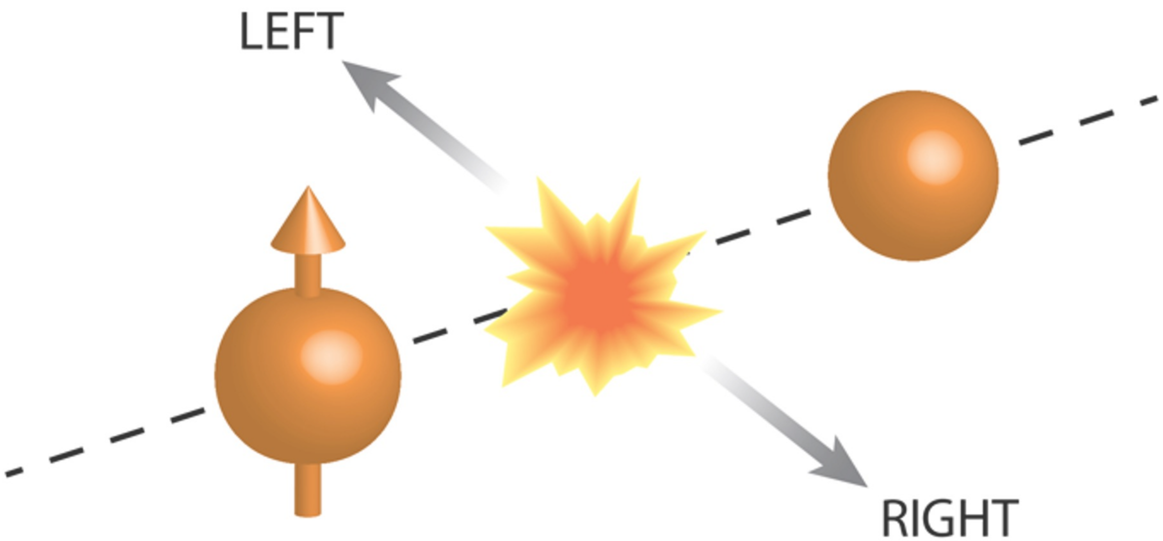
$$S_z = \frac{1}{2}\Delta\Sigma + \Delta G + L_z$$

$\frac{1}{2}\Delta\Sigma$	ΔG	L_z
~25%	~40%	??
1980's	2000~2018	

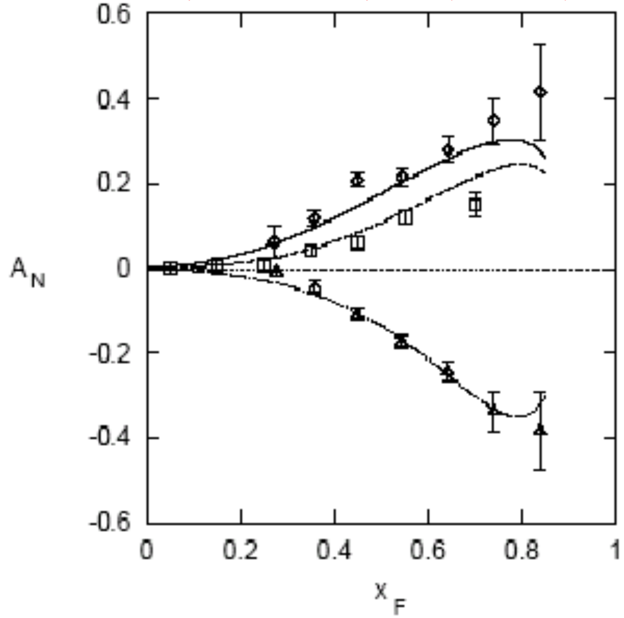
Transverse Single Spin Asymmetry



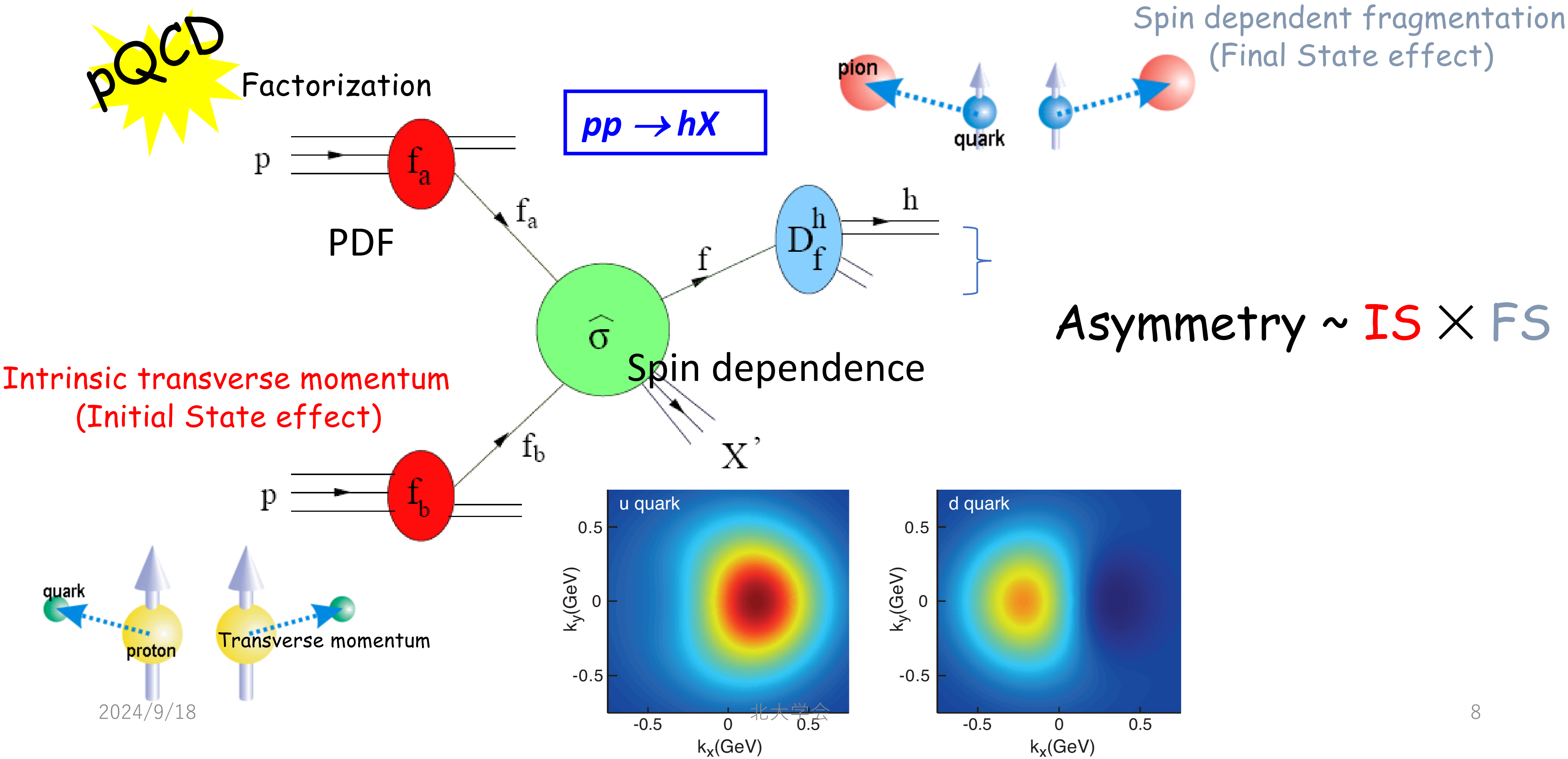
$$A_N = \frac{1}{P} \frac{\sigma_L^\pi - \sigma_R^\pi}{\sigma_L^\pi + \sigma_R^\pi}$$



E704: pion single spin asymmetry A_N



Origin of Left-Right Asymmetry



Hadron and EM Calorimeters

Outer HCal Installation

Inner HCal Installation

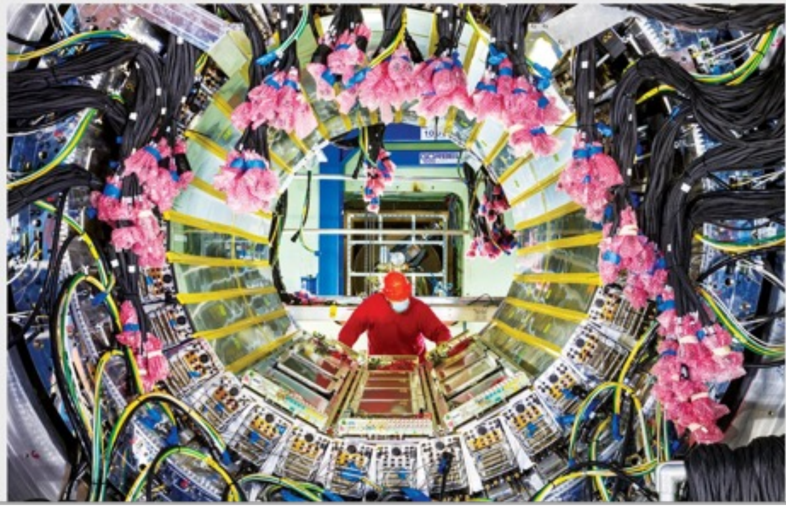
Tiny Bubbles of Primordial Soup Re-create Early Universe

MARCH 1, 2023 | 11 MIN READ

Tiny Bubbles of Primordial Soup Re-create Early Universe

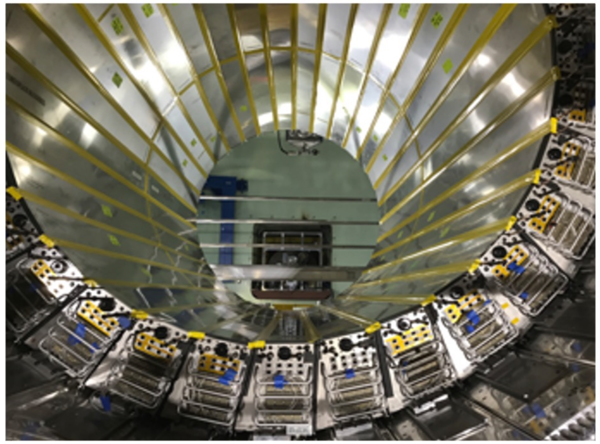
New experiments can re-create the young cosmos, when it was a mash of fundamental particles, more precisely than ever before

BY CLARA MOSKOWITZ



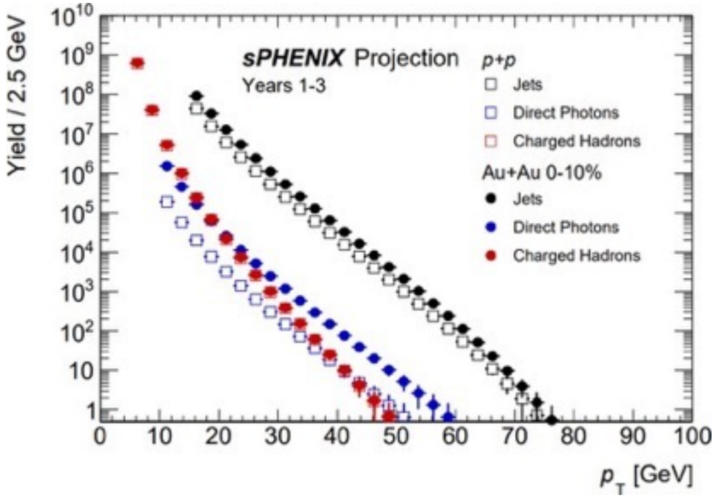
Scientific America, March 2023

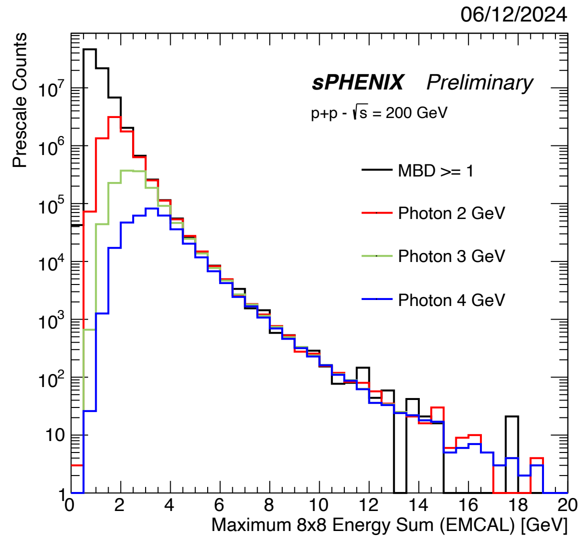
EMCal in position

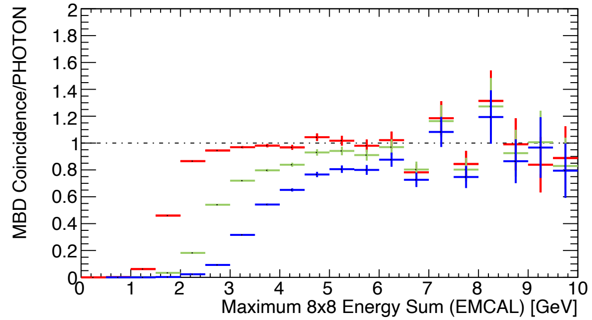


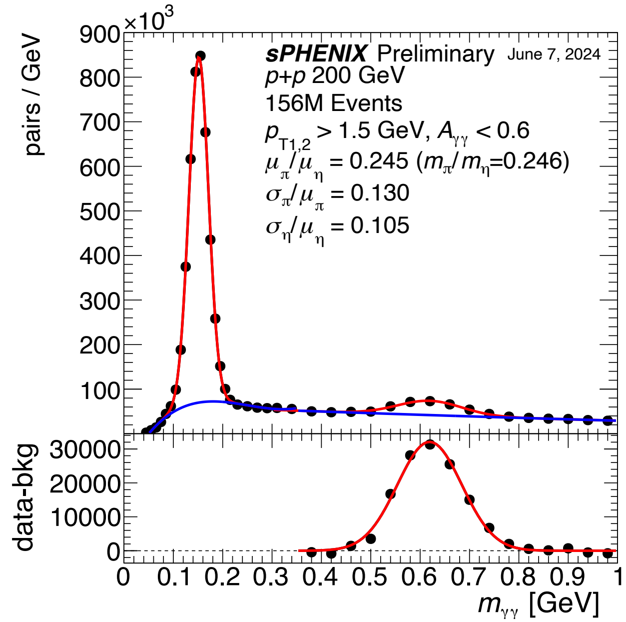
Photon and Jet Data Taking in Run24 p+p

sPHENIX Simulation









- sPHENIX will have kinematic reach out to ~ 70 GeV for jets, kinematic overlap with the LHC.
- Sampled 82 pb^{-1} w/ g/jet trigger so far (Goal ~ 62 pb^{-1}).

π^0 reconstruction using EM Calorimeter

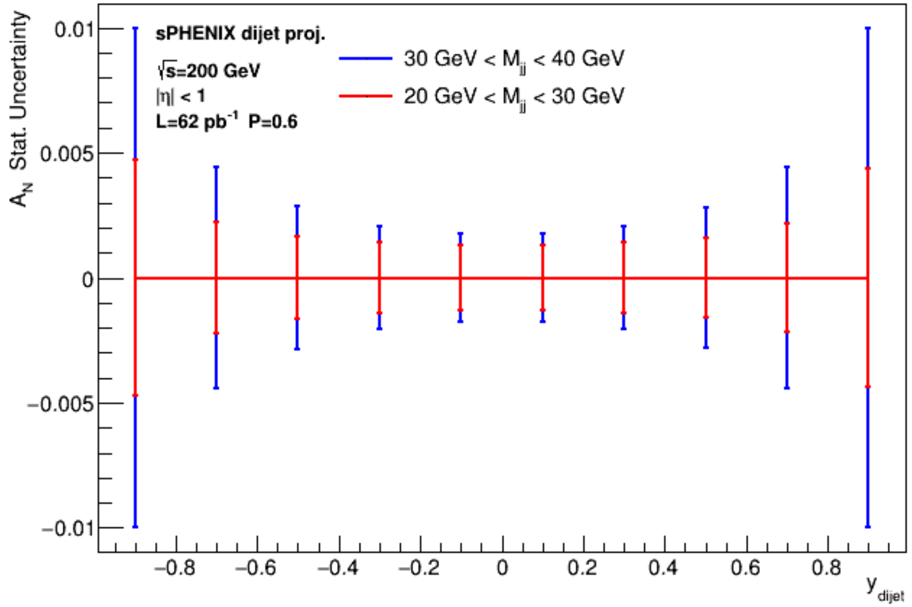
Asymmetry Measurement of Jet(s)

Inclusive Jet $p^{\uparrow} + p \rightarrow jet + X$

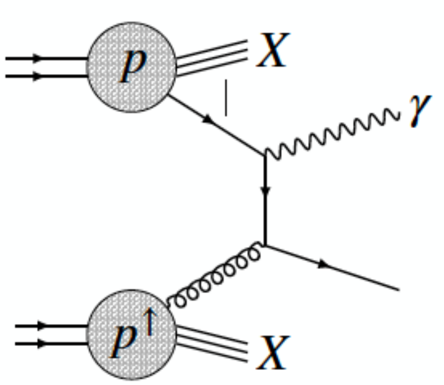
- Transverse single spin asymmetry without final state effect (Spin dependent fragmentation)
- Possible flavor separation by tagging leading hadron charge.

Dijets $p^{\uparrow} + p \rightarrow jet + jet + X$

- Kinematical advantage. Direct access to intrinsic transverse momentum of partons.
- Statistics is challenging as a trade off

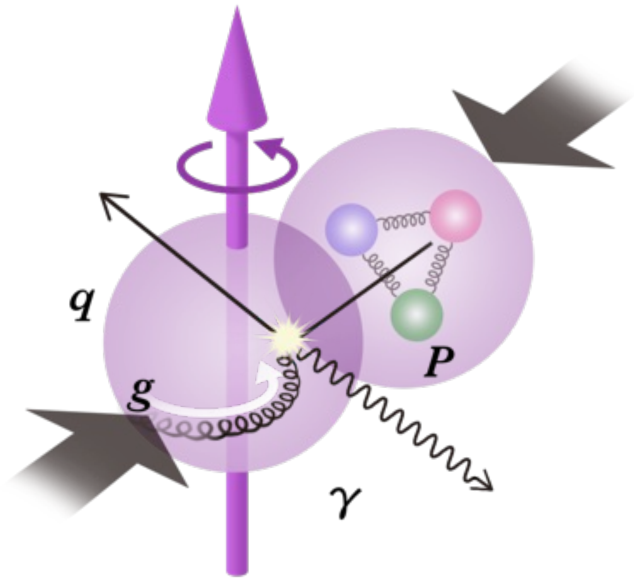


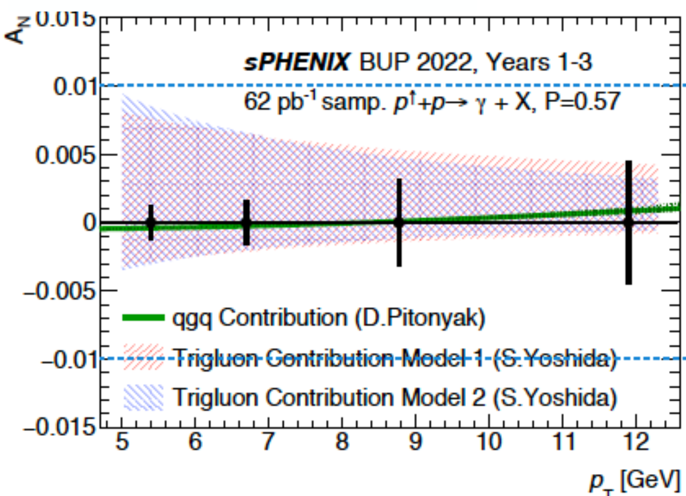
Gluon TMD by Direct-γ

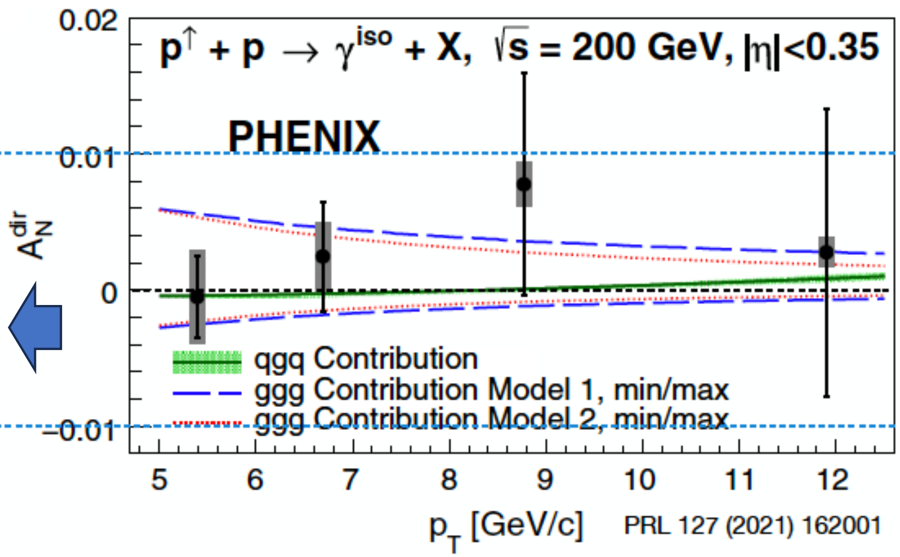


TMD: Transverse Momentum Dependence
Sensitive to Gluon orbital mortion

$$p^{\uparrow} + p \rightarrow \gamma + X$$

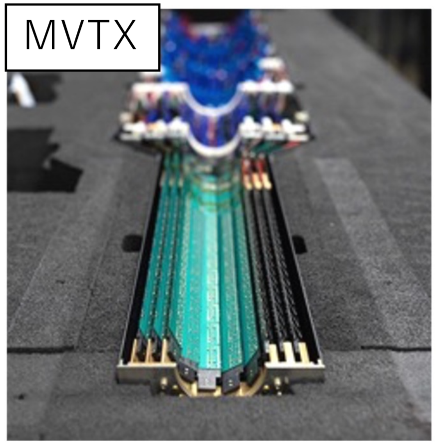


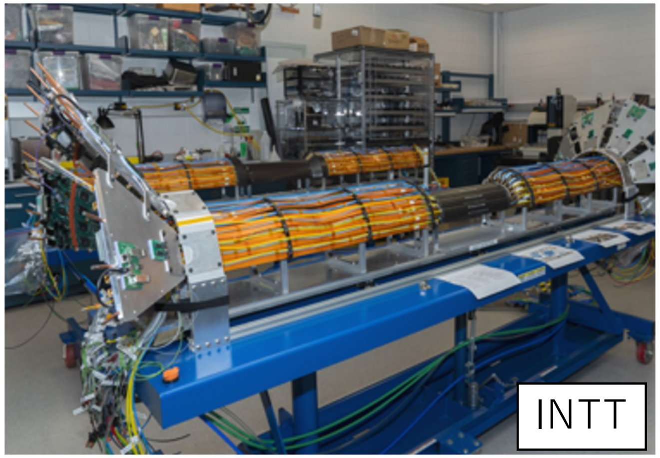


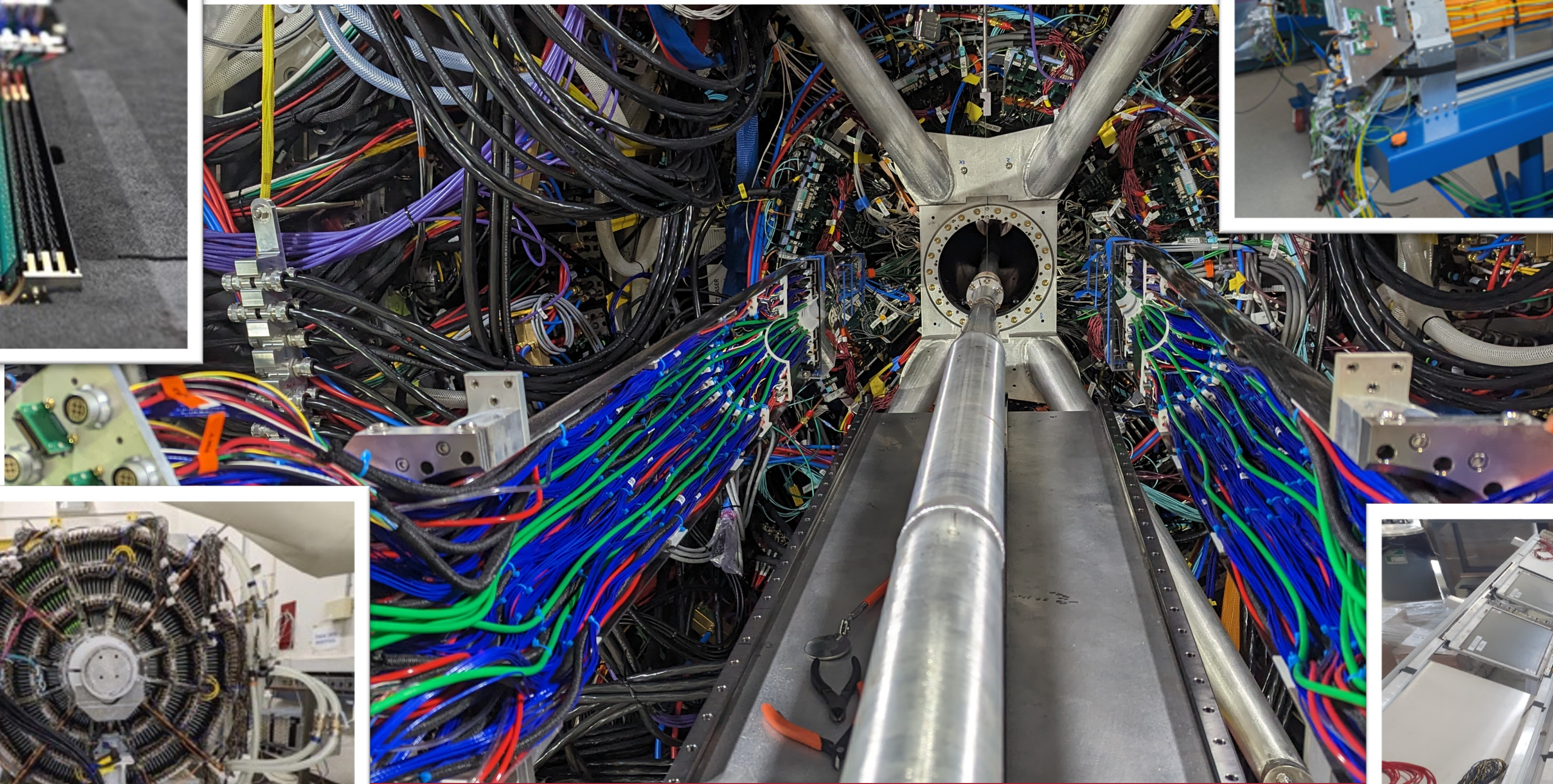


Much improved direct photon TSSA -> gluon TMD

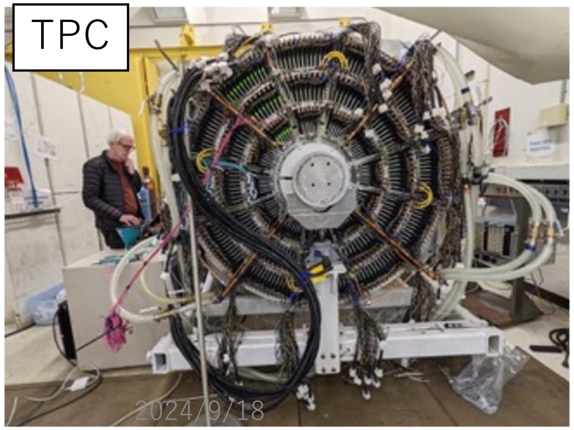
Tracking Detectors

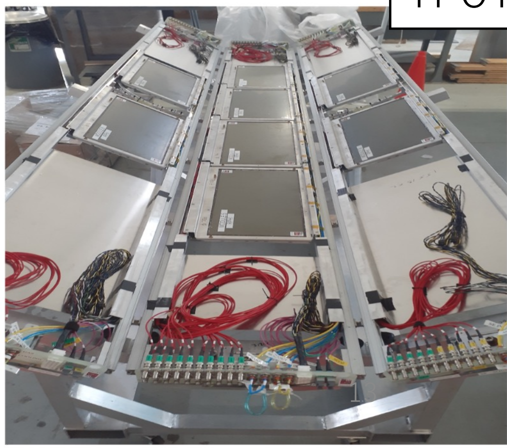






All Trackers installed in Position (March 30th, 2023)





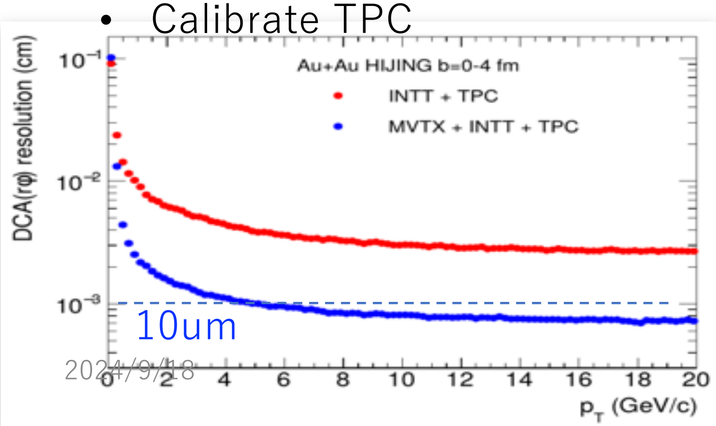
Tracking System

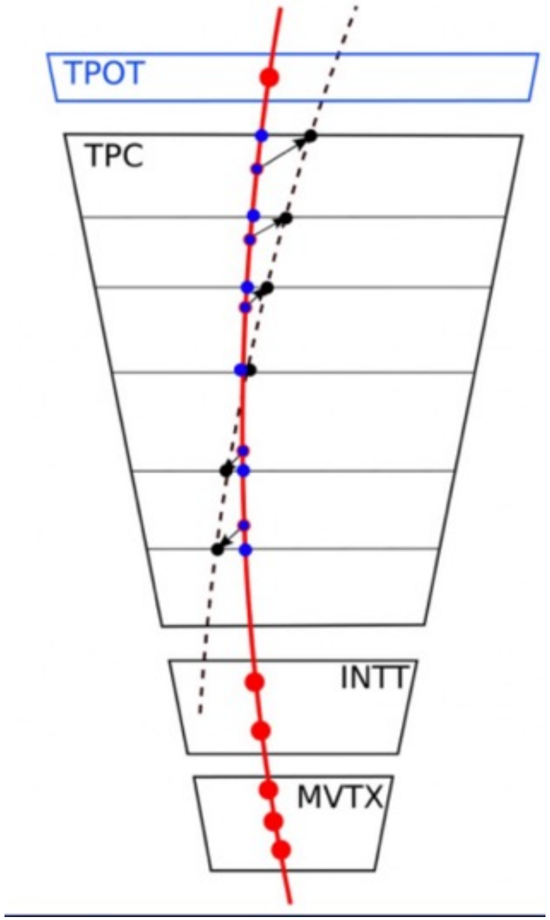
Silicon pixel detector (MVTX)
- 29 um x 27 um, pixels
- 2.5 cm < R < 4.5cm
- 20 BLCK integration time

Silicon strip detector (INTT)
- 78um, strip sensors
- 7cm < R < 11cm
- 1 BCLK timing resolution

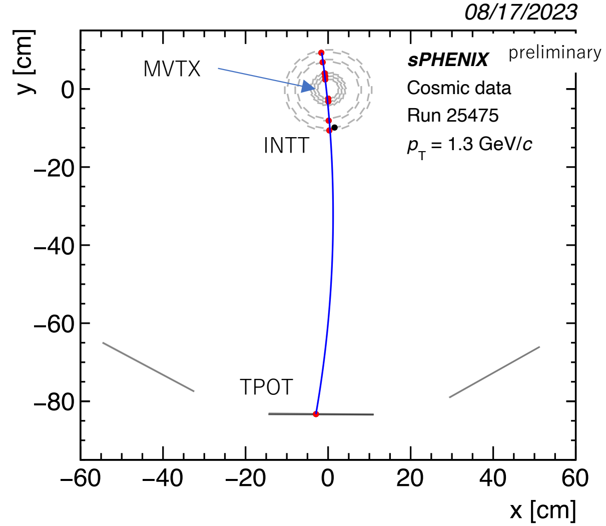
Time projection Chamber (TPC)
- 20cm < R < 78cm
- Spatial resolution, ~100um
- Long drift time, ~13us

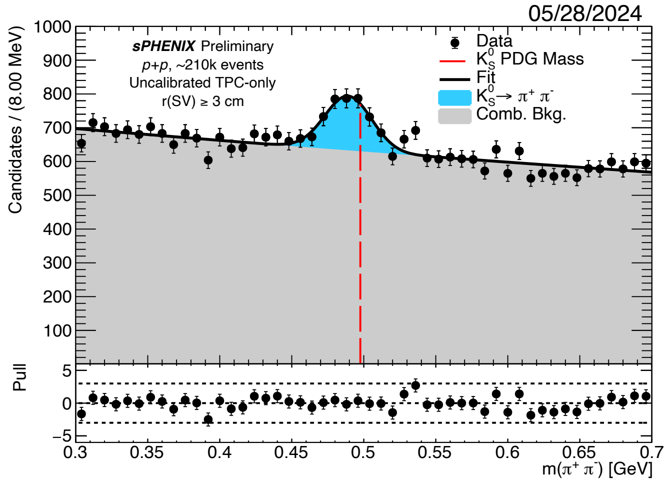
TPC Outer Tracker (TPOT)
- Calibrate TPC





Cosmic Ray Track Reconstruction





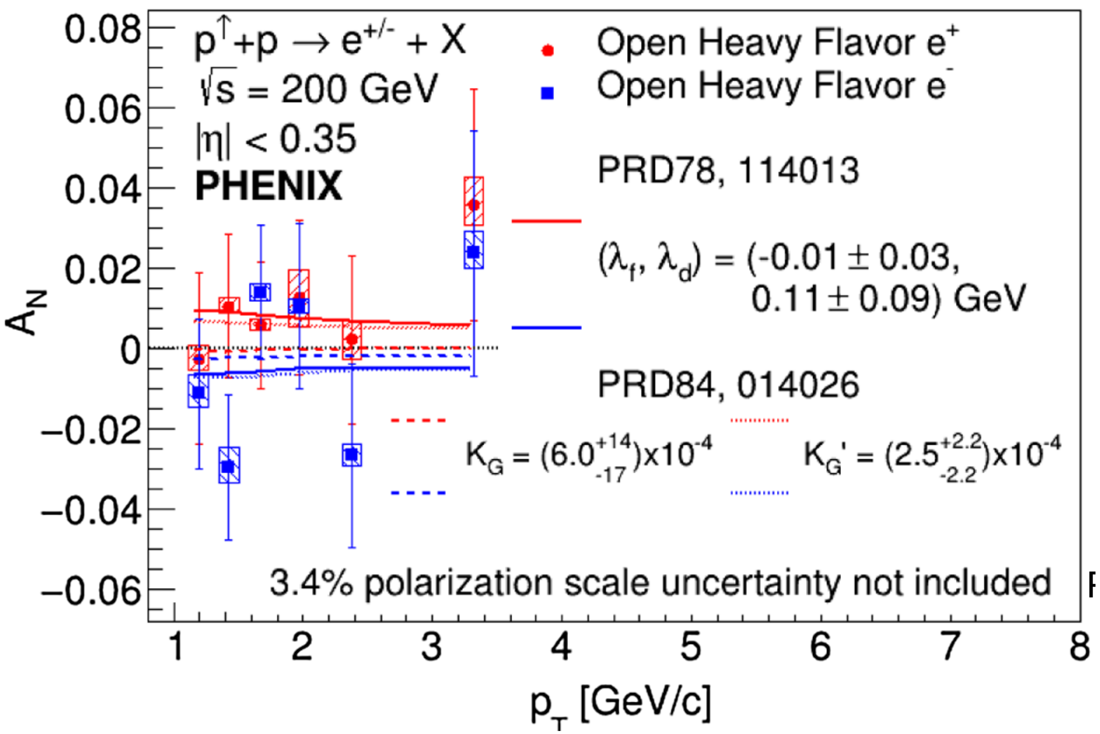
Heavy Flavor Meson

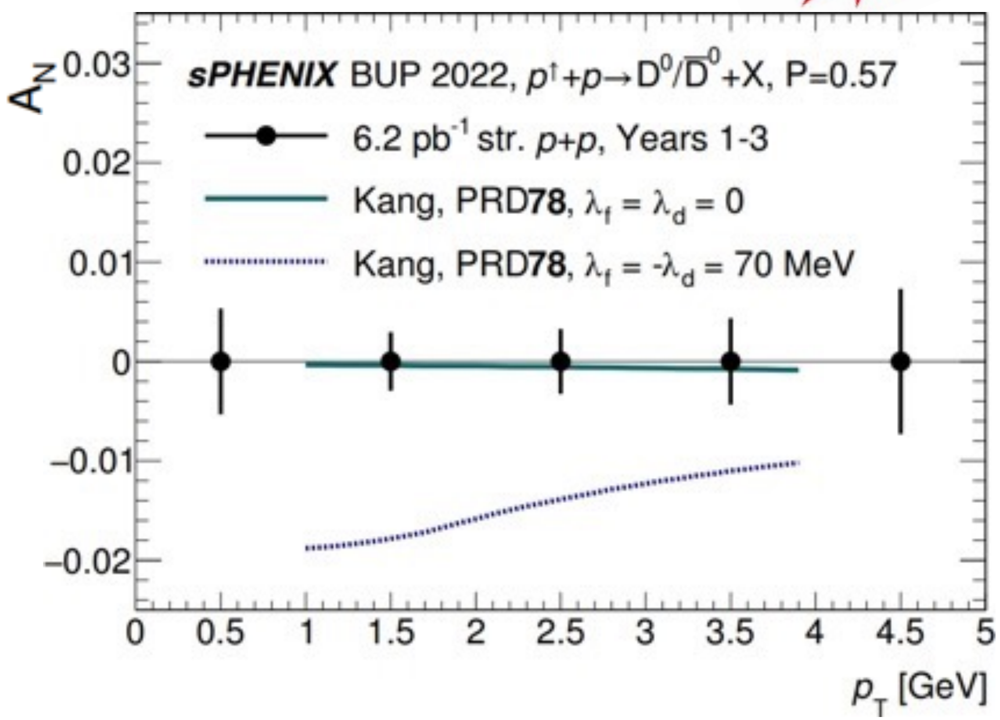
Sensitive to gluon Sivers TMD function via
3-gluon correlation function of Single Spin Asymmetry.

Statistics Hungry Measurement

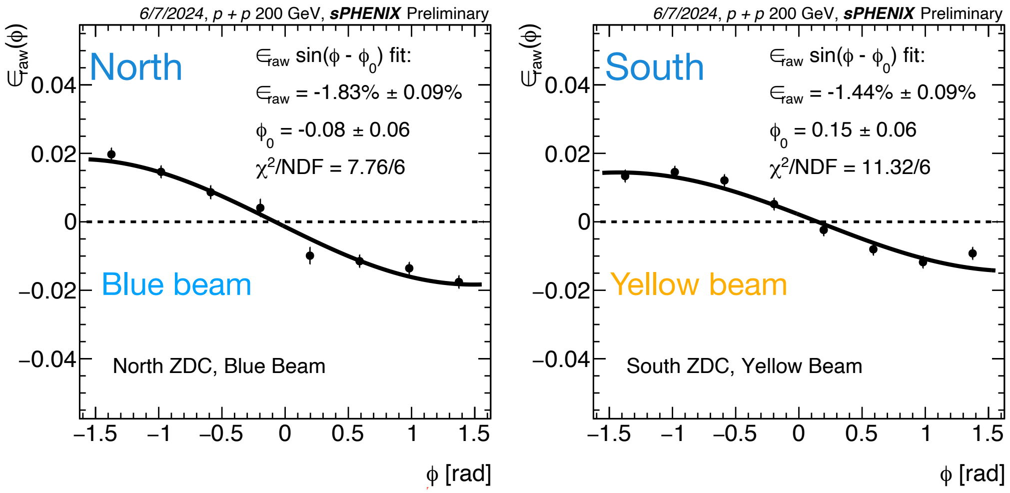
⬇

Streaming readout of tracking detector





Zero Degrees Forward Neutron Asymmetries



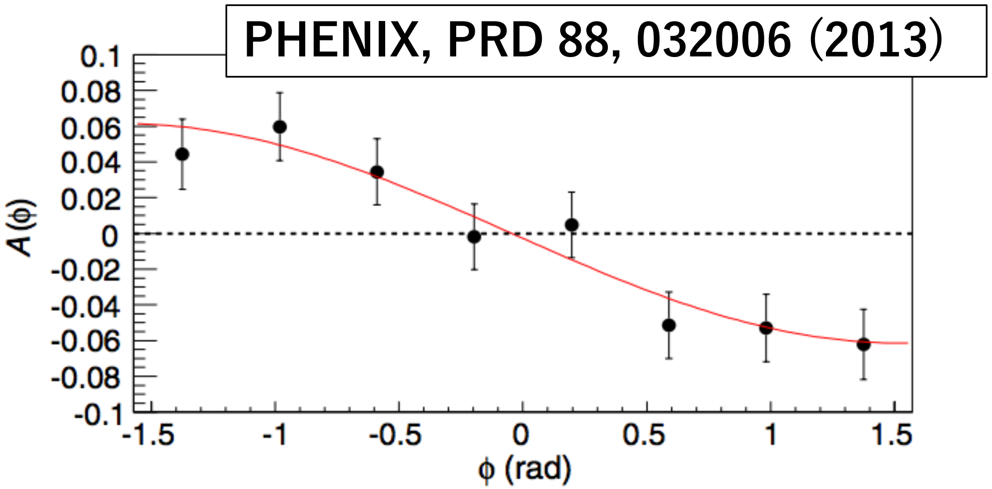
$$A_N = \frac{e_N(\phi)}{\sin(\phi - \phi_0)} \frac{1}{P}$$

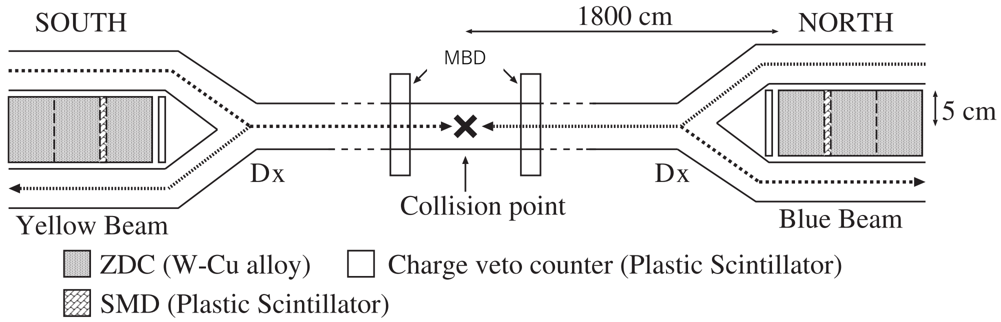
0 rad.

~33%

$$A_N = \frac{1.83}{0.33} \sim 0.054$$

Consistent!

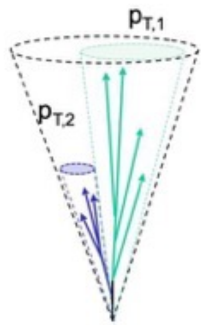




Confirmed the spin vector is pointing vertical in 1008 and observed asymmetries are consistent with published data.

sPHENIX Summary

- Large and hermetic EM and hadronic calorimetry.
- Highly precise tracking.
- 15kHz trigger rate and stream readout for trackers.
- Wide range of physics covered in sPHENIX
- Run24 p+p at $\sqrt{s}$ =200GeV is ongoing. Taking 10 years of worthy data for high energy pQCD field until the EIC launches in 2032 at BNL.



Jet Physics

Quarkonium spectroscopy