Readiness for physics data taking of sPHENIX experiment at RHIC

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Conclusion

• No Physics Yet
Conclusion

• sPHENIX is new Jet and heavy flavor Detector at RHIC for QGP and cold-QCD.
• Commissioning ongoing.
• Some detectors are ready to take physics, while some needs are not yet.
Outline

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

Jet physics
- Vary momentum & angular scale of probe

Quarkonium spectroscopy
- Vary size of probe

Cold QCD
- Vary temperature of QCD matter
  - Study proton spin, transverse-momentum, and cold nuclear effects

Parton energy loss
- Vary mass & momentum of probe
  - Photon, gluon
Cold-QCD: Proton Spin Decomposition

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

- \( \Delta \Sigma \): Quark Spin
- \( \Delta G \): Gluon Spin

Orbital Angular Momentum

\[ \sim 25\% \quad \sim 40\% \quad ?? \]

- 1980's
- 2000~2018
1.4T Solenoid from BaBar
- Hermetic coverage: $|\eta|<1.1$, $2\pi$ in $\phi$
- 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
2025: Au+Au

$\sqrt{s} = 200\text{GeV}$
sPHENIX Detector

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$\sqrt{s} = 200$ GeV
sPHENIX will have kinematic reach out to ~70 GeV for jets, kinematic overlap with the LHC.
Gluon TMD by Direct-$\gamma$

TMD: Transverse Momentum Dependence

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

Much improved direct photon TSSA $\rightarrow$ 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 < 4.5 cm
- 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

- Preliminary

08/17/2023

sPHENIX
Cosmic data
Run 25475
p_T = 1.3 GeV/c

08/17/2023

sPHENIX
preliminary

Cosmic data
Run 25475

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• TPC Event Display in Au+Au @ 200GeV
• Multiplicity correlations between MBD-INTT-TPOT
• MVTX correlation between different layers
• More correlation hits in Zhaozhong Shi’s talk on Thursday 08/24

Clear separation between 2S and 3S states
Vertex Reconstruction & Centrality

**INTT-MBD Z-vertex Reconstruction**

*August 18, 2023*

- **sPHENIX Preliminary**
  - Au+Au \( \sqrt{S_{NN}} = 200 \text{ GeV} \)

**MBD-ZDC Centrality**

*7/21/2023*

- **sPHENIX Preliminary**
  - Au+Au \( \sqrt{S_{NN}} = 200 \text{ GeV} \)
  - ZDC trigger

**Published Centrality plot in PHENIX**

*Phys. Rev. C 71, 034908 (2005)*

Confirmed fairly consistent z-vertex reconstruction between two independent detectors.
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
- A lot of progress in 2023 commissioning with Au+Au Collision at $\sqrt{s} = 200$GeV and getting ready for 2024 Run.
- Will address on cold QCD in 2024!
Backup Slides
Jet Physics

Probing the QGP with precise jet, direct photon, and hadron measurements

- High data rates & hermetic EMCal+HCal offer wide $p_T$ range for jet reconstruction.
- sPHENIX can precisely measure the low $p_T$ region, which is challenging at the LHC.
- sPHENIX will have kinematic reach out to $\sim 70$ GeV for jets, kinematic overlap with the LHC.
Heavy Flavor

- Cleanly separate open bottom via DCA.
- Study mass dependence of energy loss and collectivity.
- Bottom quarks and light quarks are expected to be different for $R_{AA}$ and $v_2$ for $p_T \lesssim 15$ GeV.

Explores gluon spin contribution to proton spin.
Cold QCD: Gluon TMD with Direct photons

\[ p^\uparrow + p \rightarrow \gamma + X \]

Much improved direct photon TSSA -> gluon TMD
First Data from Commissioning: EMCal

- Clear π0 peak seen in the di-photon invariant mass spectrum
Heavy Flavor

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Explores gluon spin contribution to proton spin
Suppression with clear distinction of three Upsilon states. Color dipoles probing the QGP at three length scales.

The centrality dependence and particularly the $p_T$ dependence are critical measurements for comparison between RHIC and the LHC.

Signal enhancement with ML tools (BDT) is expected.