



Readiness for physics data taking of sPHENIX experiment at RHIC

RIKEN/RBRC
Itaru Nakagawa

Conclusion

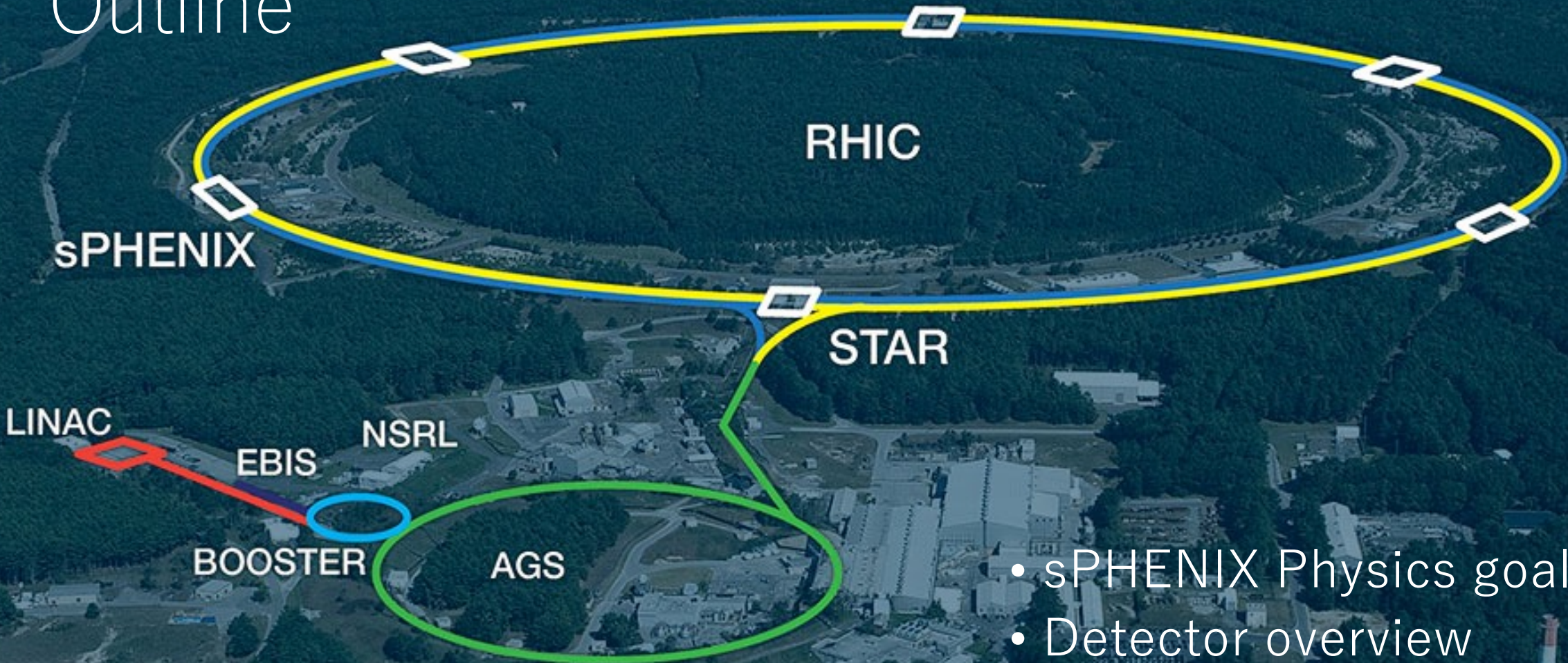
- No Physics Yet

STAY
TUNED

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.

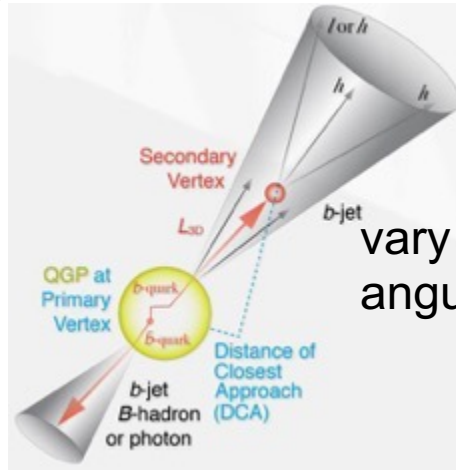
Outline



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

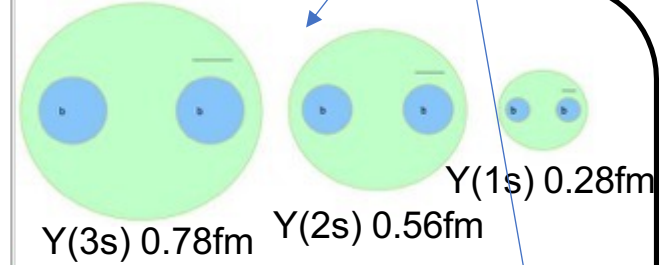
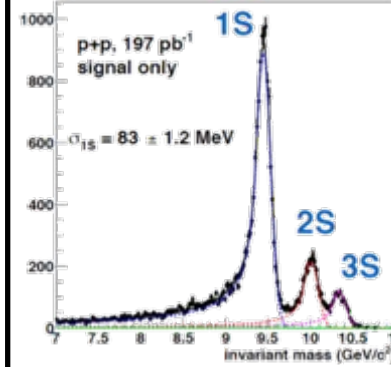
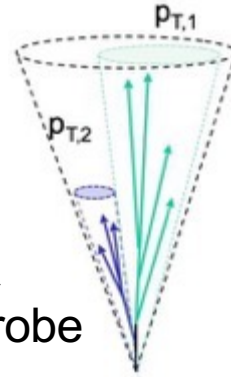
sPHENIX Physics Program

Zhaozhong Shi's talk on Thursday 08/24



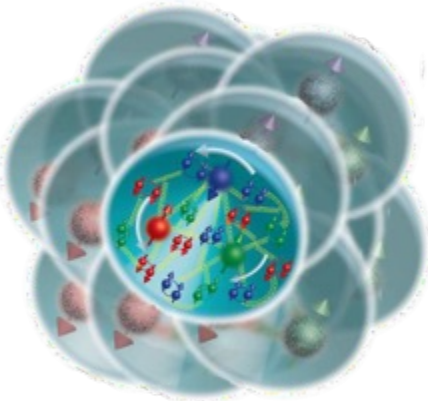
vary momentum & angular scale of probe

Jet physics



vary size of probe

Quarkonium spectroscopy



Cold QCD

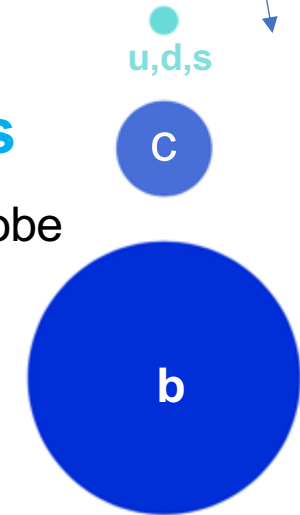
vary temperature of QCD matter

study proton spin, transverse-momentum, and cold nuclear effects

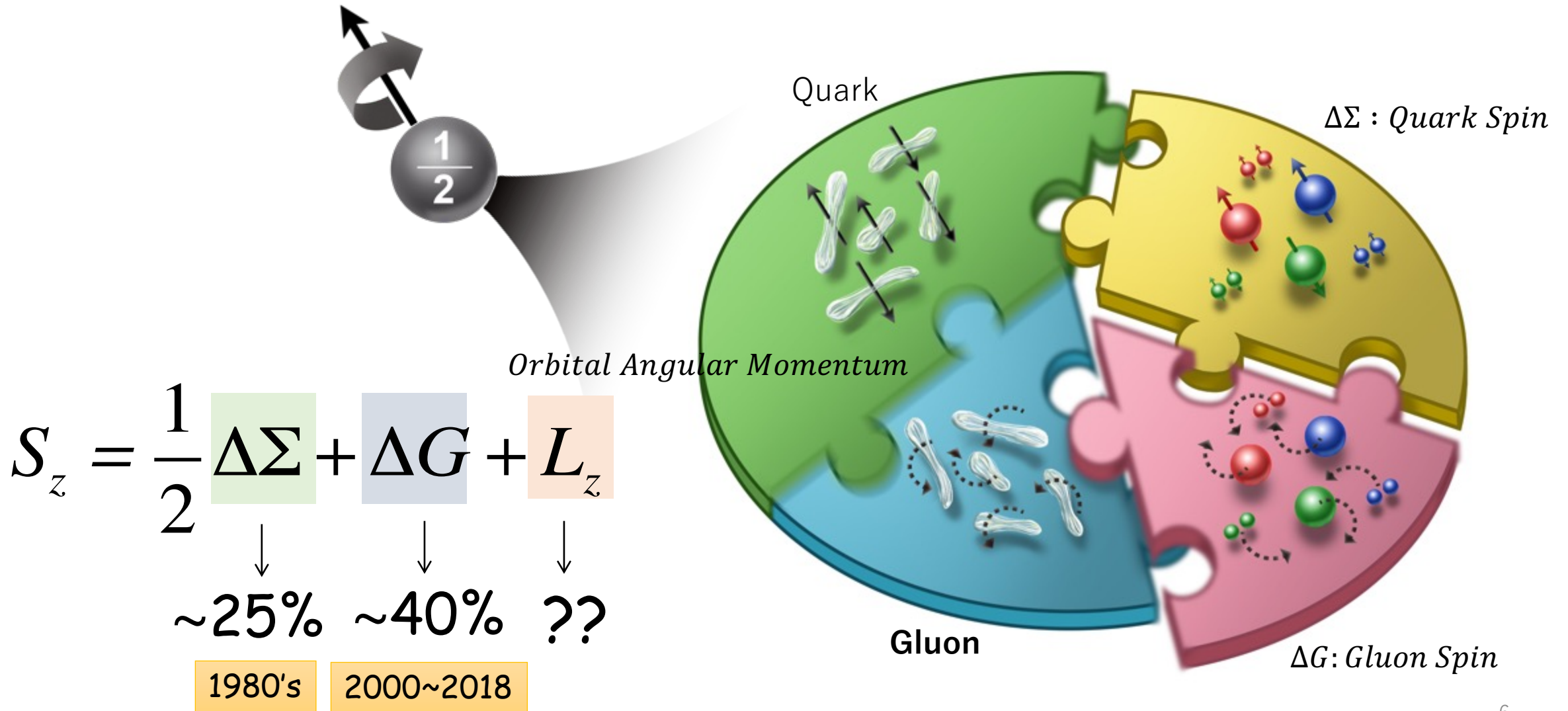
Parton energy loss

vary mass & momentum of probe

photon
gluon



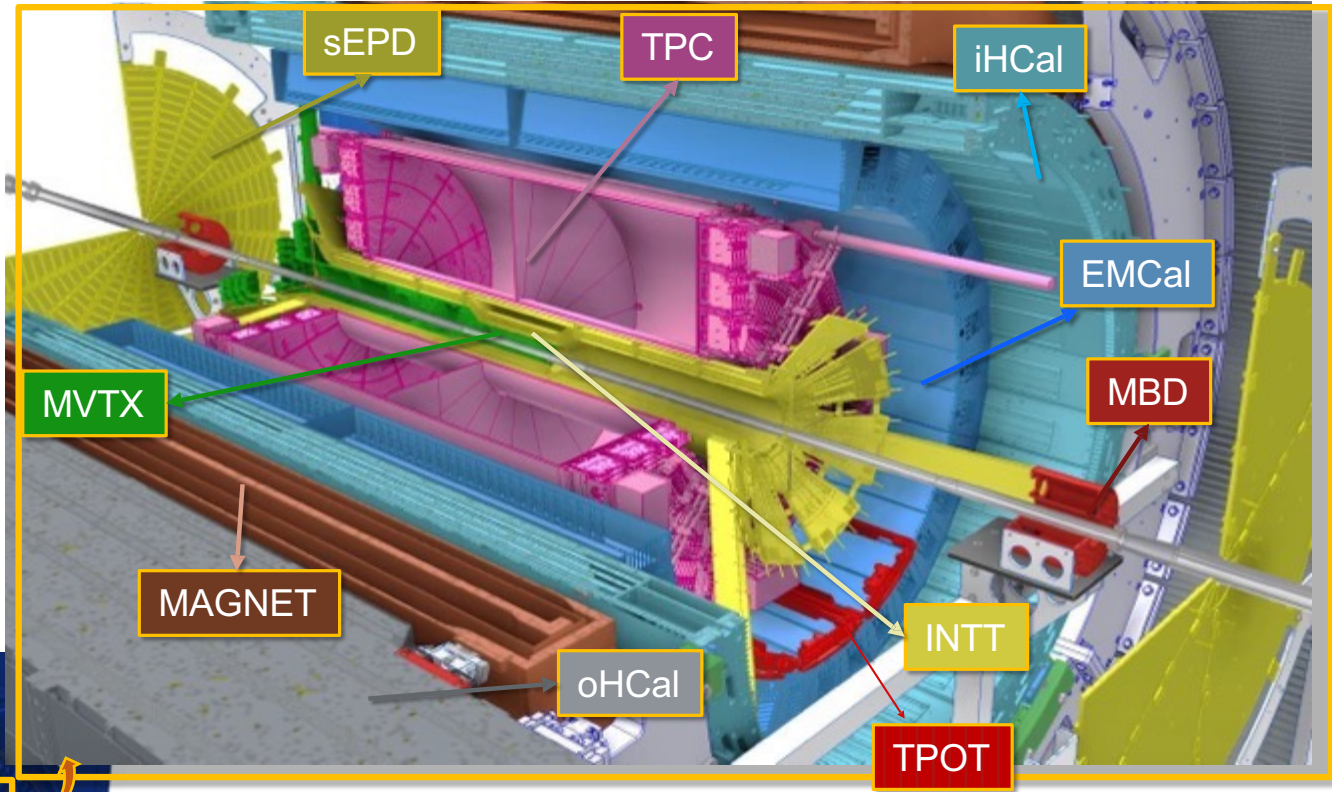
Cold-QCD: Proton Spin Decomposition



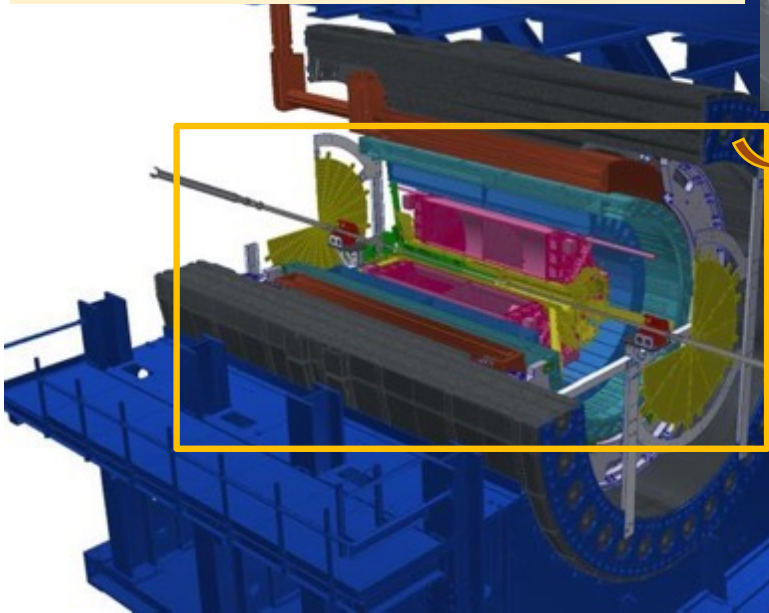
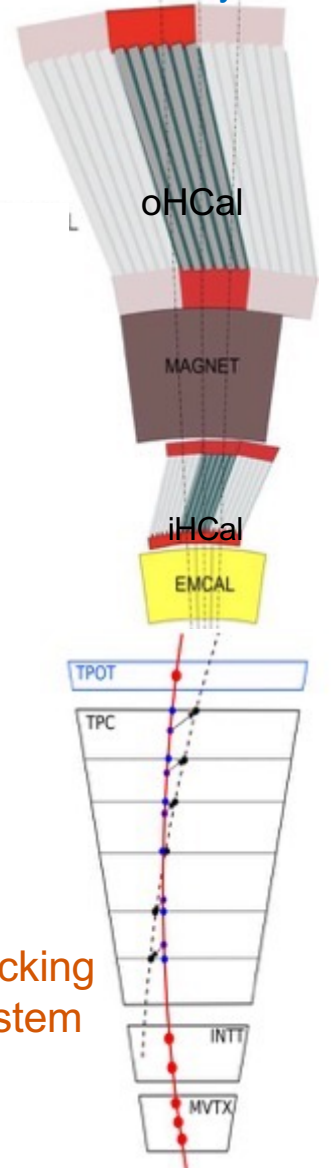


sPHENIX Detector

- 1.4T Solenoid from BaBar
- Hermetic coverage: $|\eta| < 1.1, 2\pi$ 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



Calorimeter system



2023 : Commissioning Au+Au
 2024 : p+p
 2025 : Au+Au

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

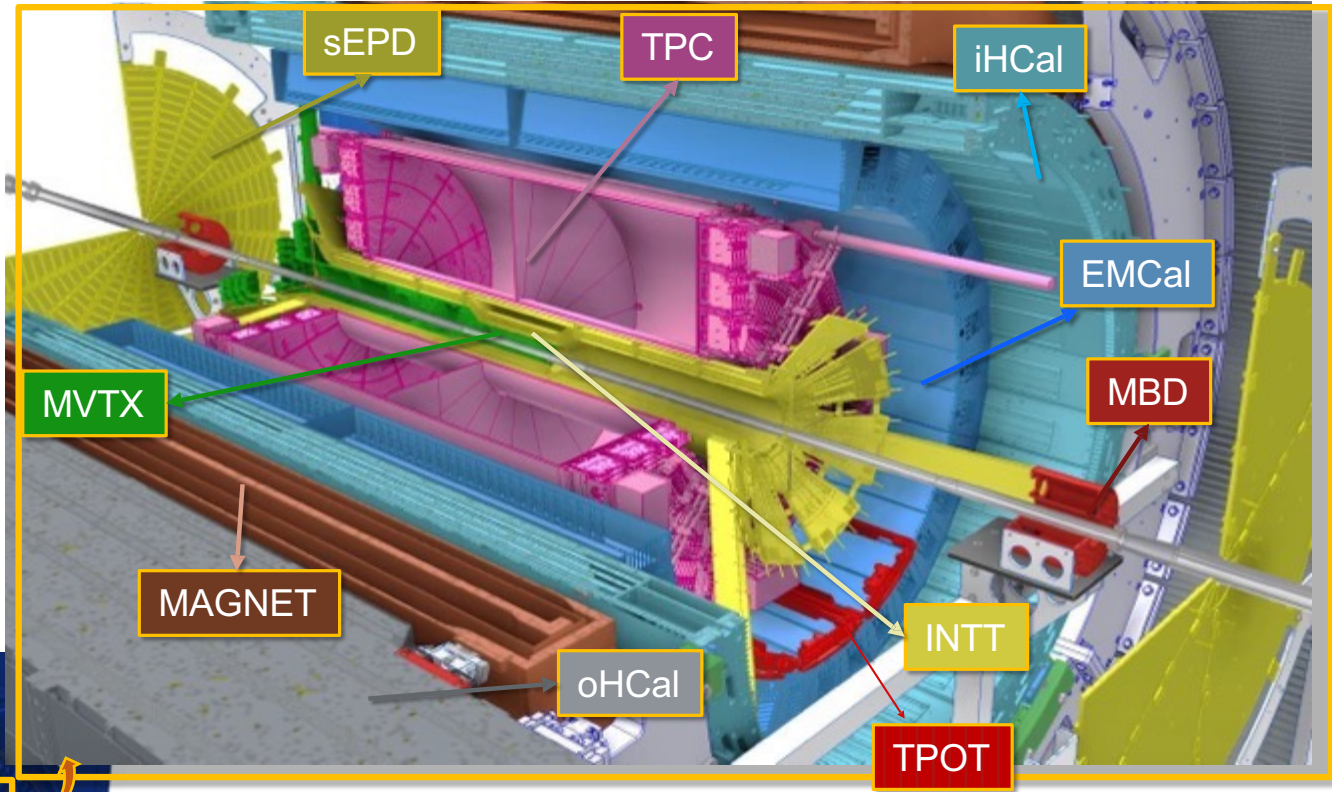


Tracking system

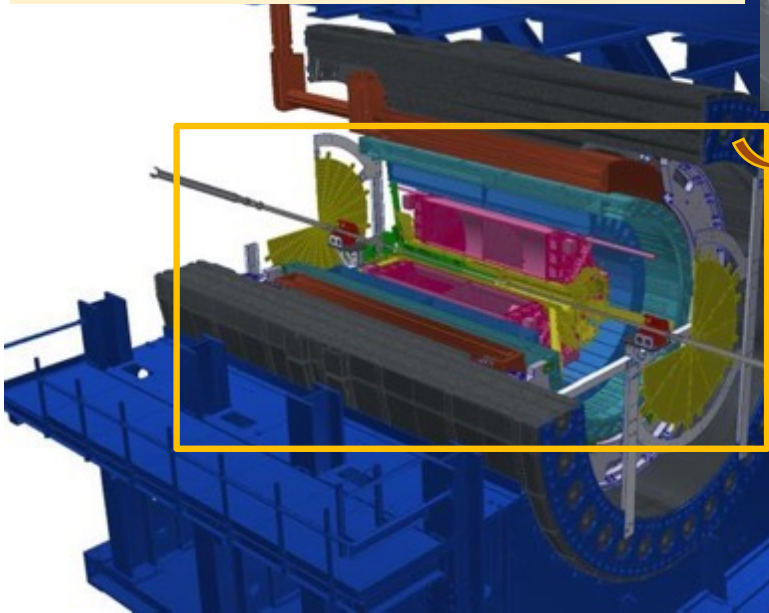
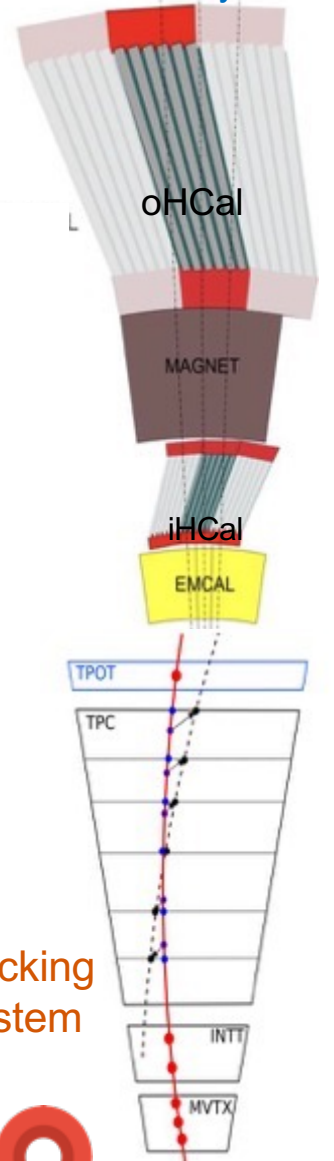


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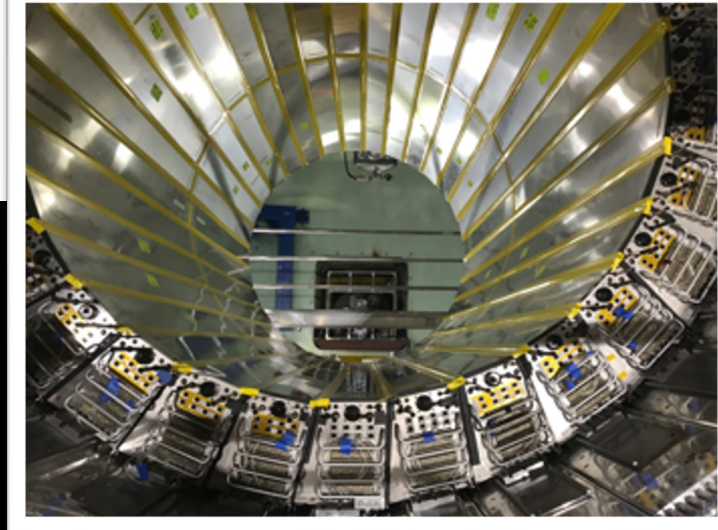
$\sqrt{s} = 200\text{GeV}$



Tracking system

Hadron and EM Calorimeters

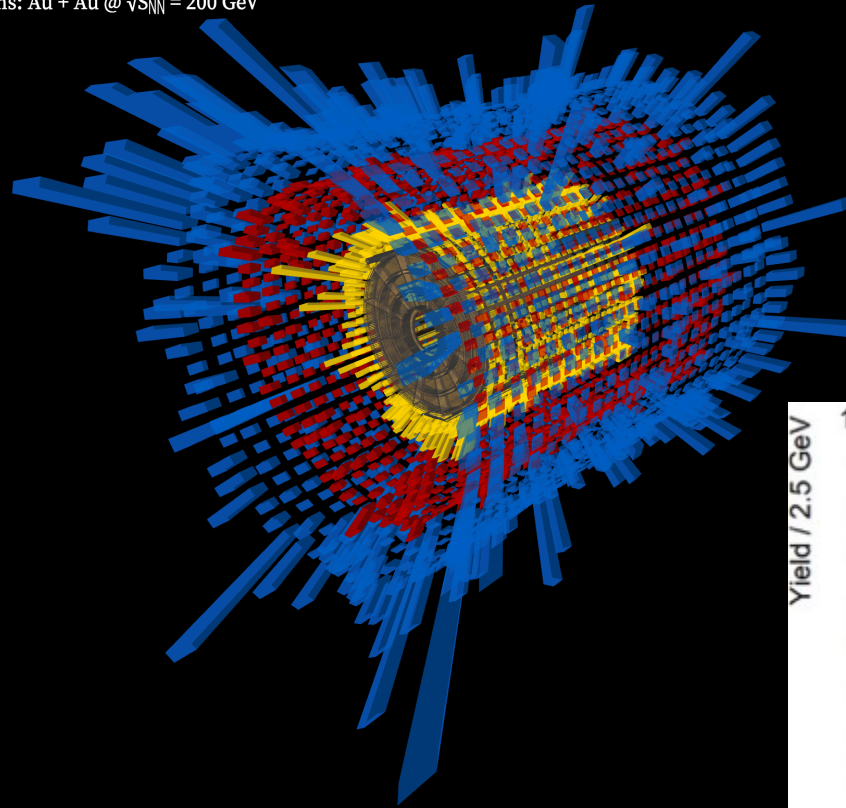
EMCal in position



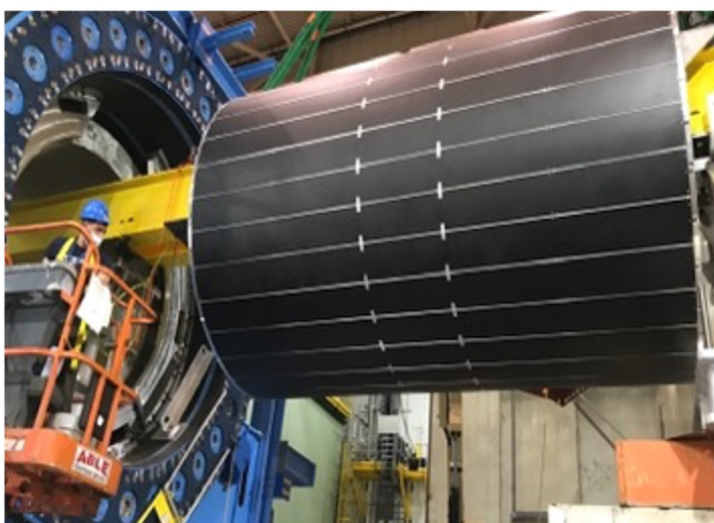
Outer HCal Installation



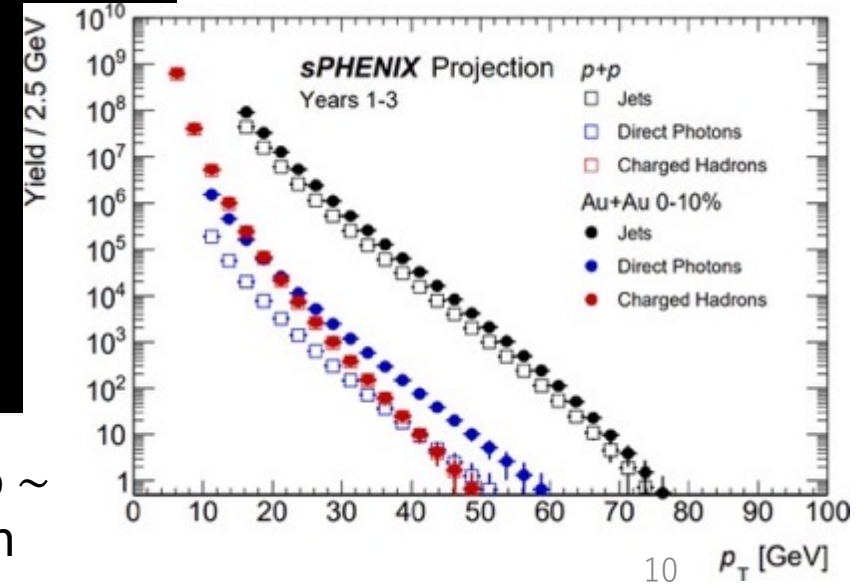
sPHENIX Experiment at RHIC
 Data recorded: 2023-07-16 00:54:00 EST
 Run / Event: 21707 / 3194
 Collisions: Au + Au @ $\sqrt{s_{NN}} = 200$ GeV



Inner HCal Installation

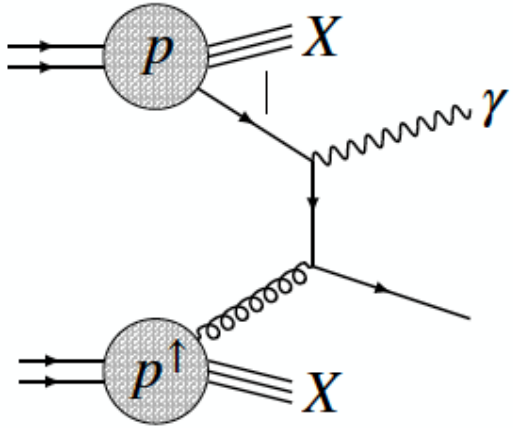


sPHENIX Simulation



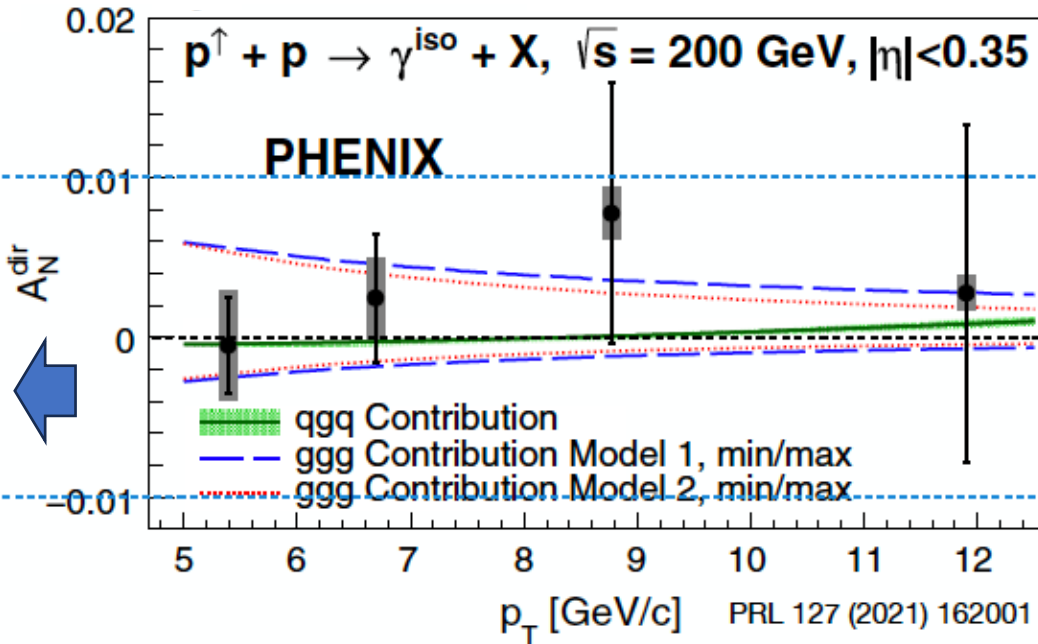
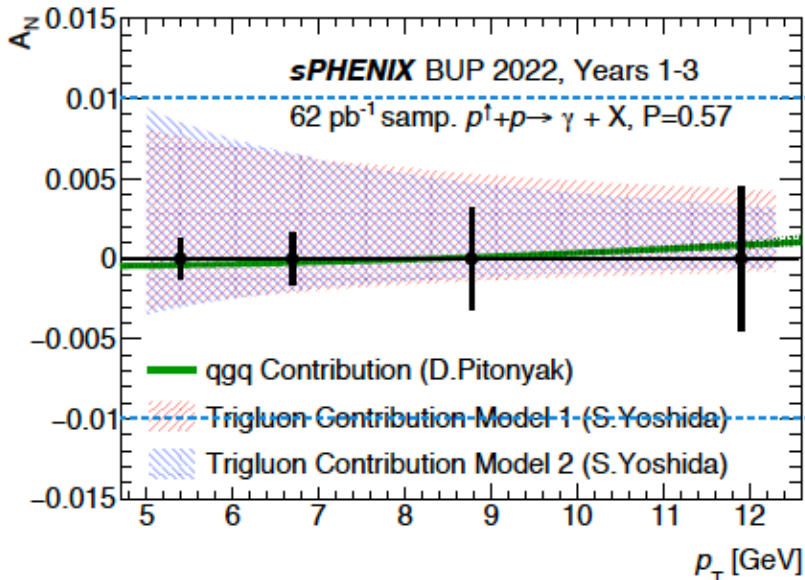
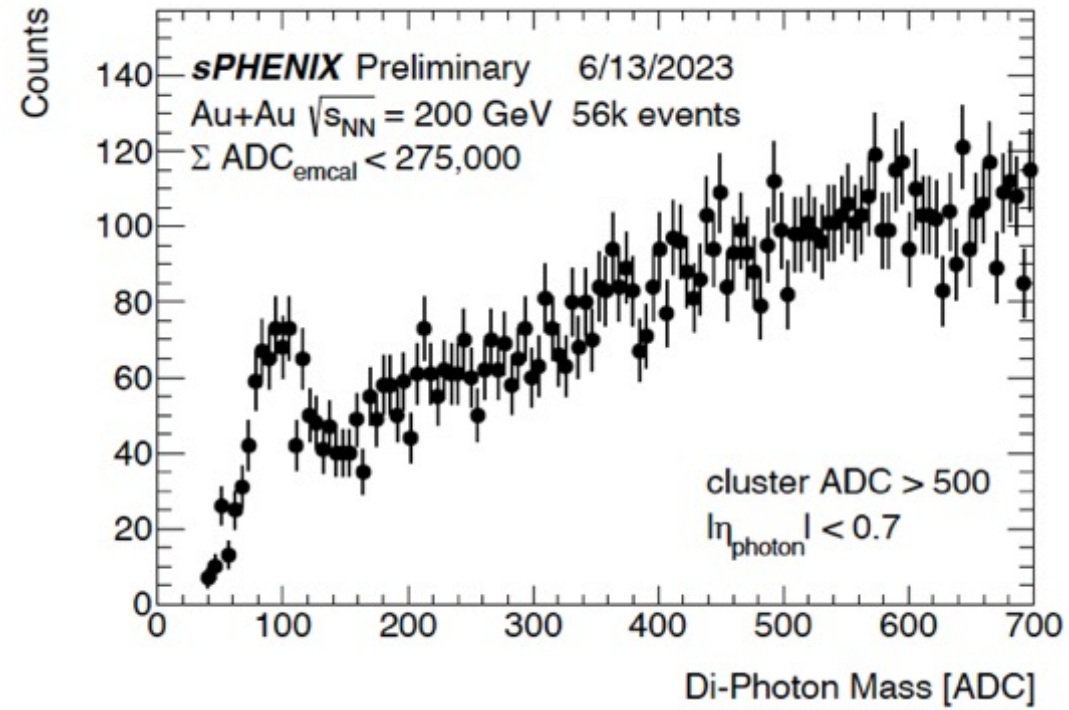
sPHENIX will have kinematic reach out to ~ 70 GeV for jets, kinematic overlap with the LHC.

Gluon TMD by Direct- γ



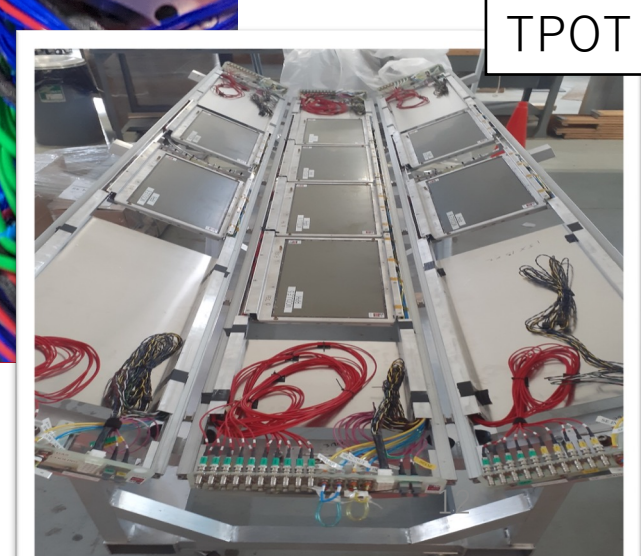
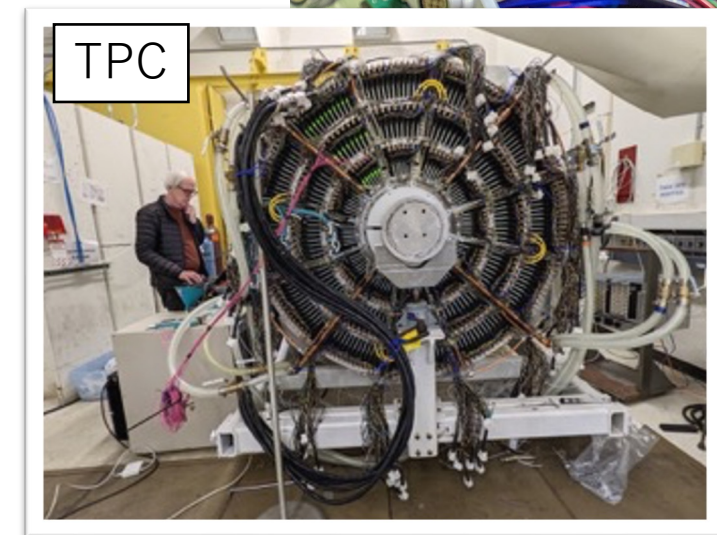
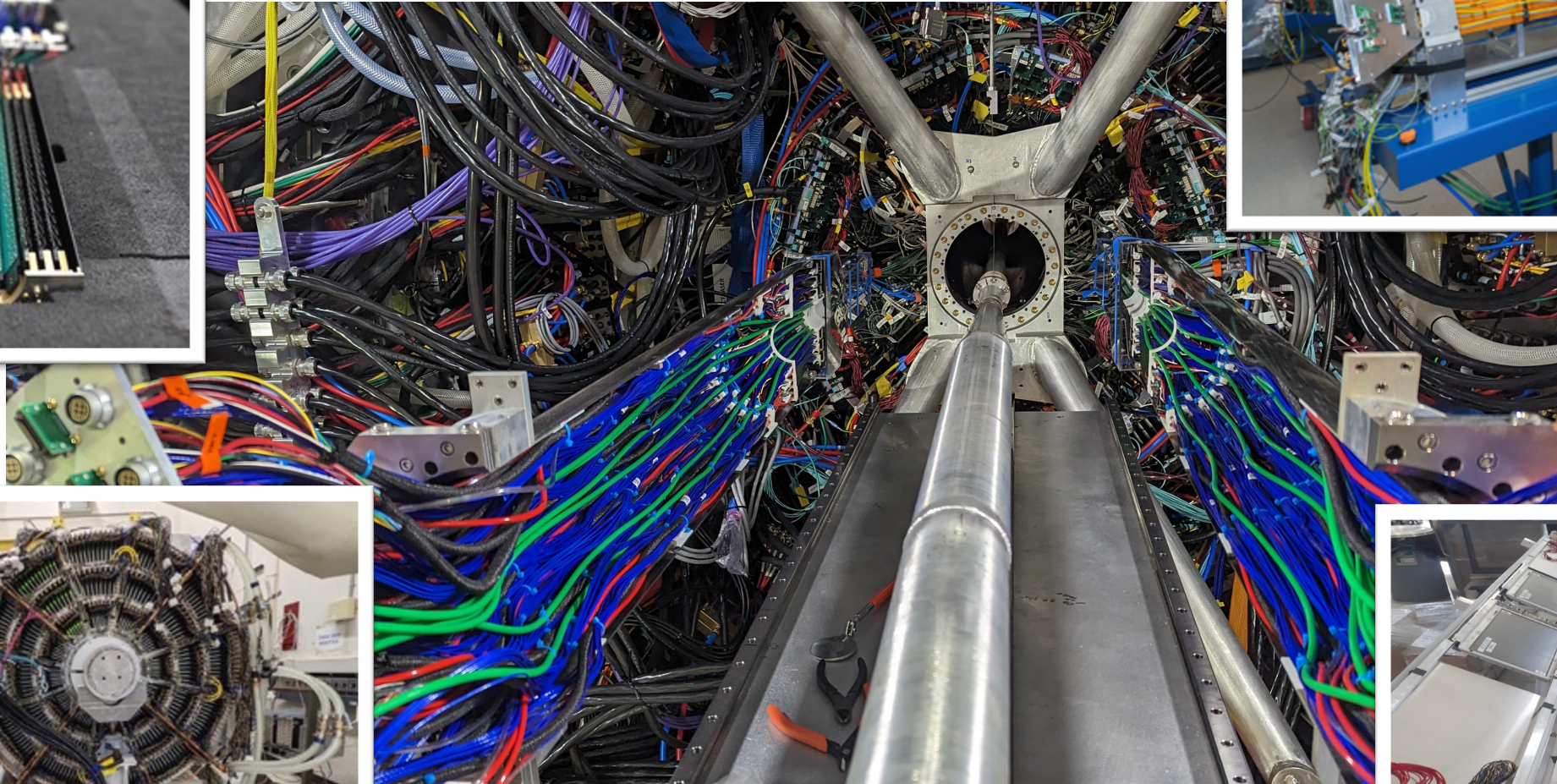
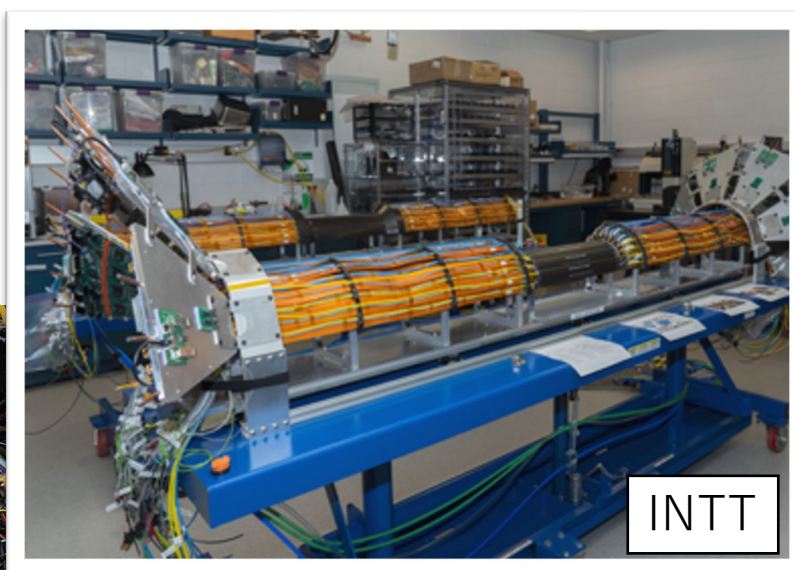
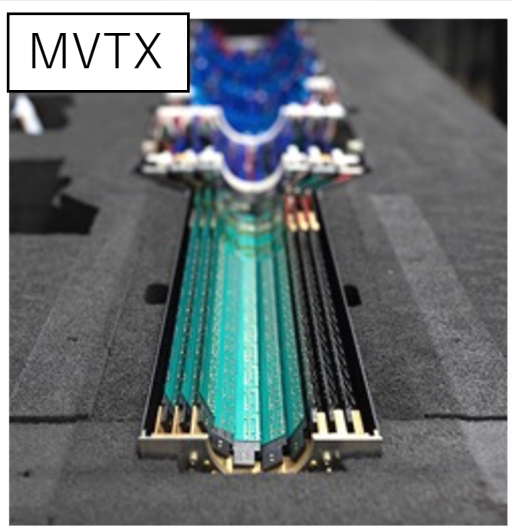
TMD: Transverse Momentum Dependence

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



Much improved direct photon TSSA -> gluon TMD

Tracking Detectors



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

Silicon pixel detector (MVTX)

- 29 μm x 27 μm , pixels
- $2.5\text{ cm} < R < 4.5\text{ cm}$
- 20 BCLK integration time

Silicon strip detector (INTT)

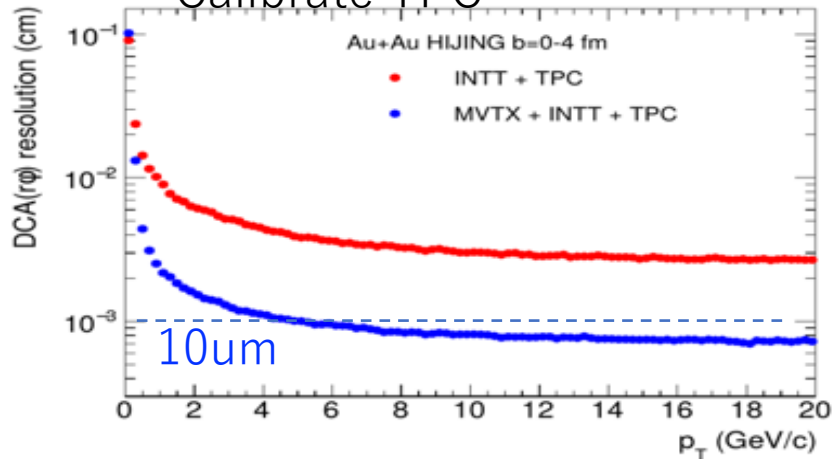
- 78 μm , strip sensors
- $7\text{ cm} < R < 11\text{ cm}$
- 1 BCLK timing resolution

Time projection Chamber (TPC)

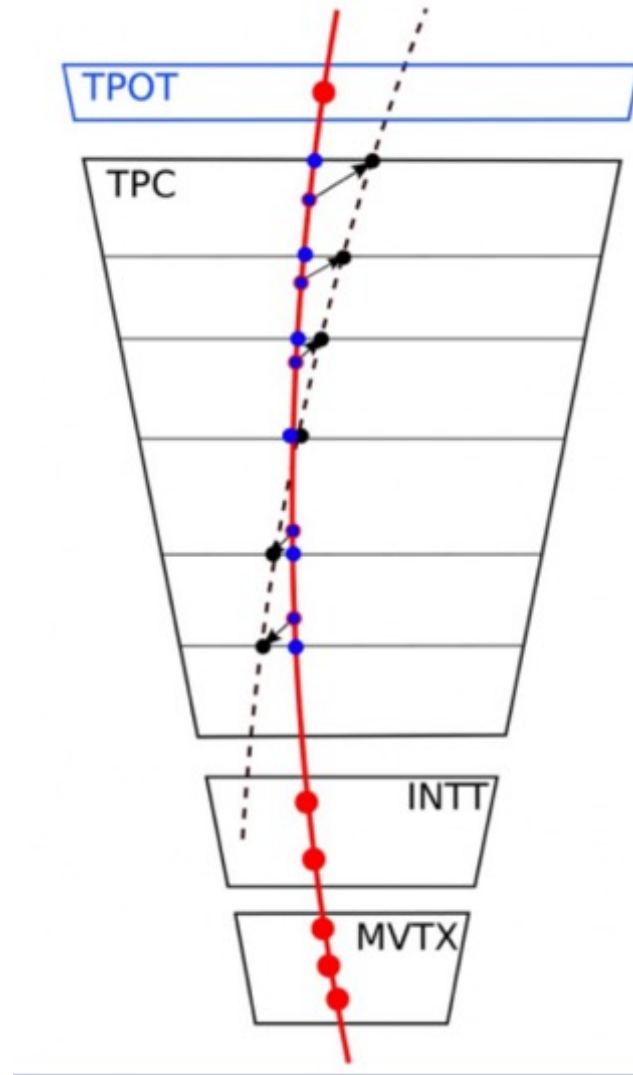
- $20\text{ cm} < R < 78\text{ cm}$
- Spatial resolution, $\sim 100\mu\text{m}$
- Long drift time, $\sim 13\mu\text{s}$

TPC Outer Tracker (TPOT)

- Calibrate TPC

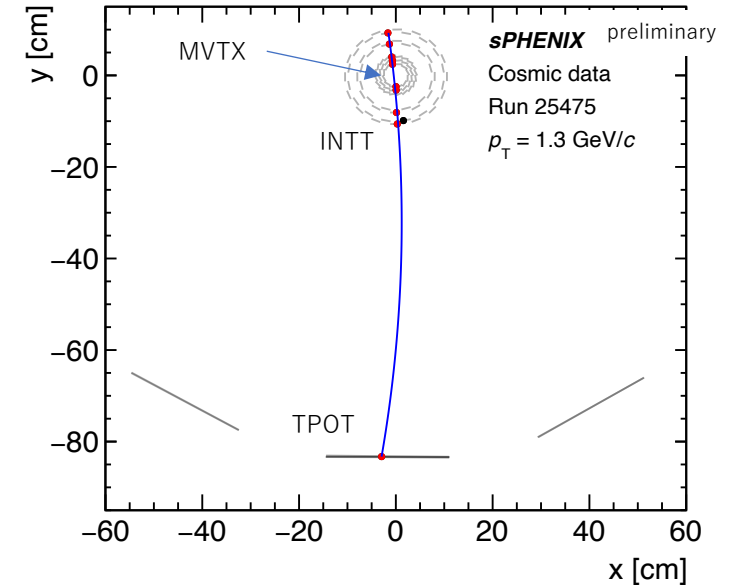


Tracking System

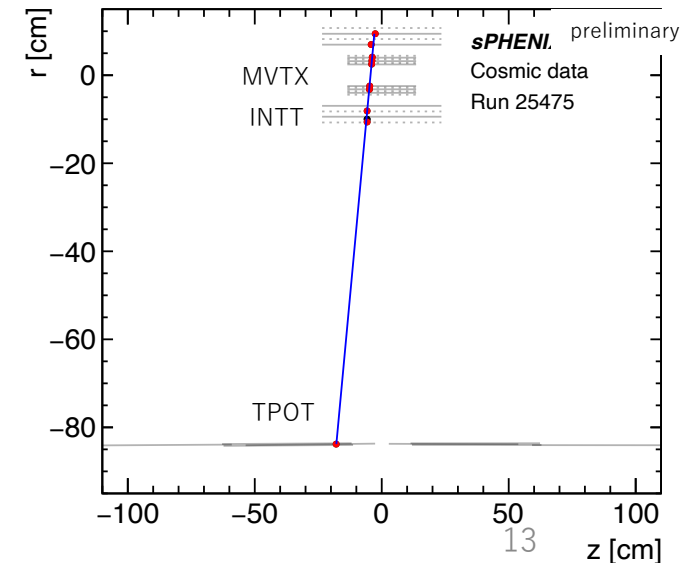


Cosmic Ray Track Reconstruction

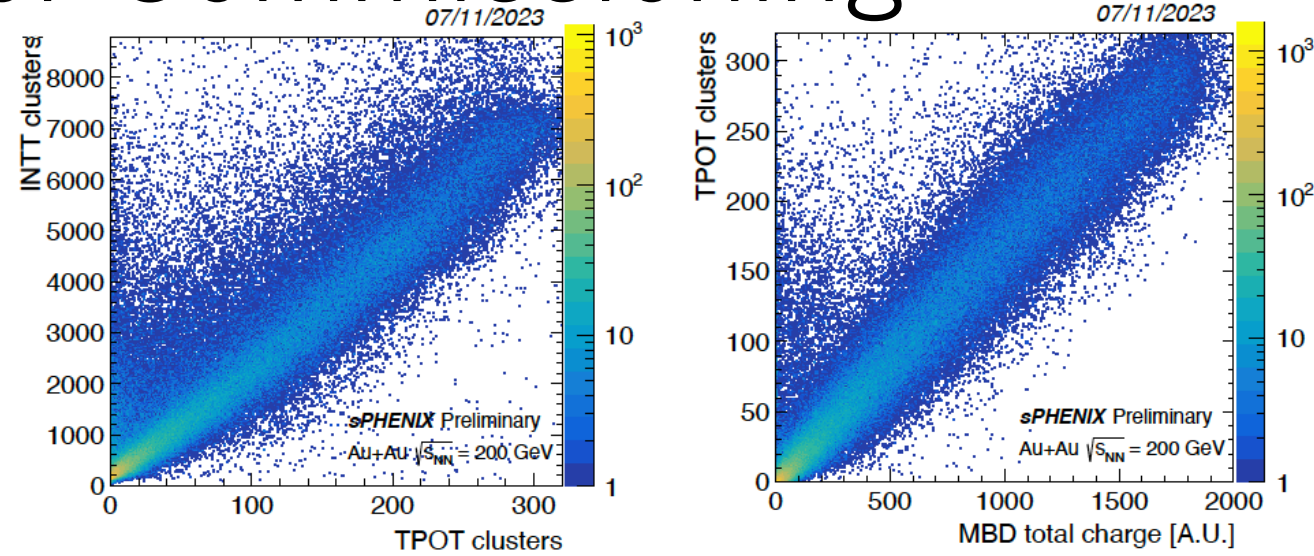
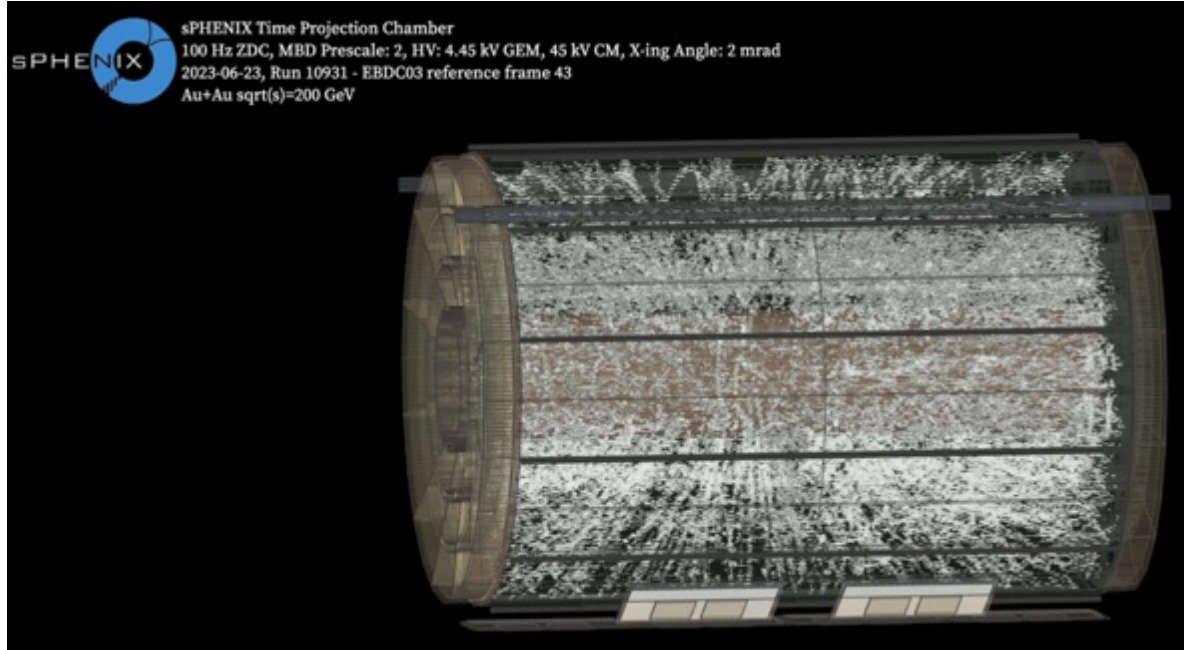
08/17/2023



08/17/2023

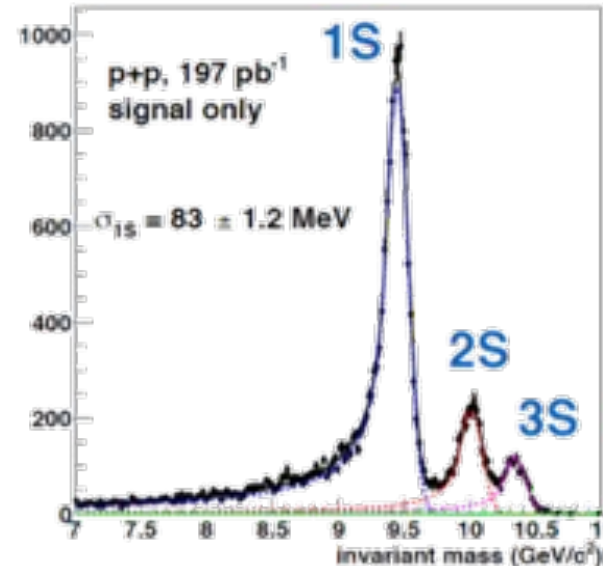


Tracking Detector Commissioning



- 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

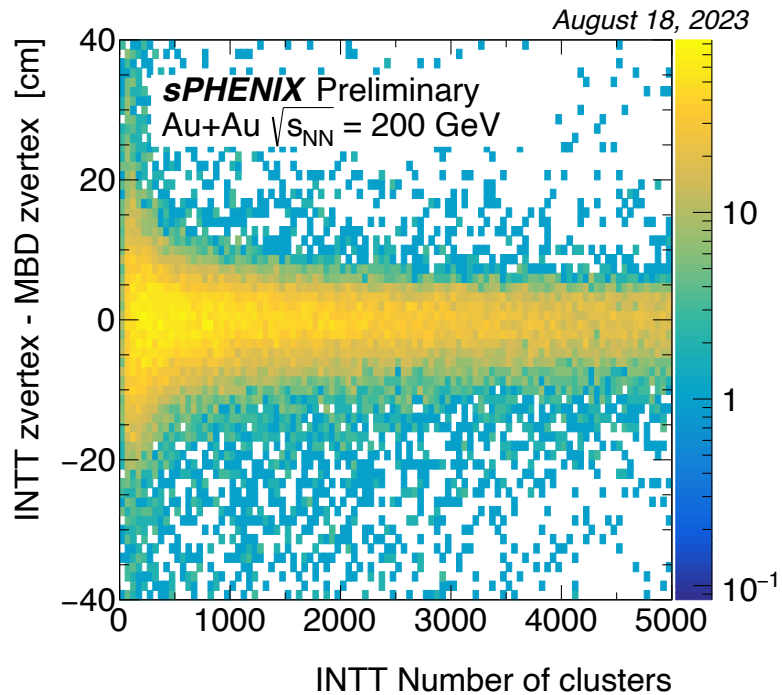
sPHENIX Simulation



Clear separation between 2S and 3S states

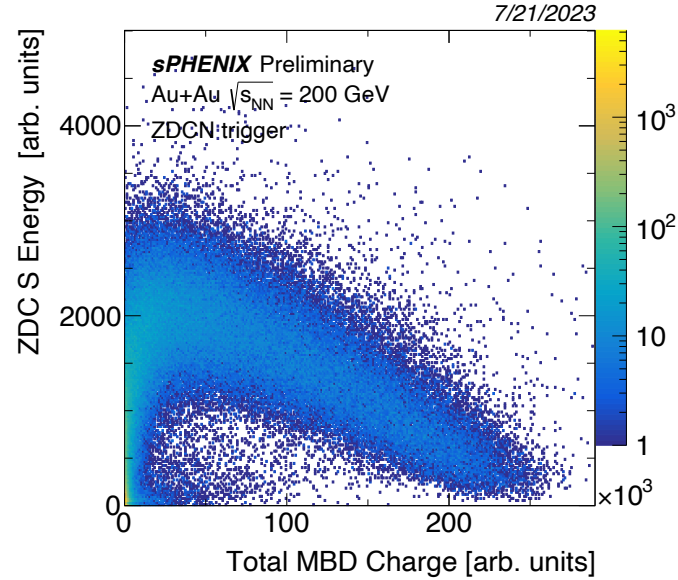
Vertex Reconstruction & Centrality sPHENIX Simulation

INTT-MBD Z-vertex Reconstruction

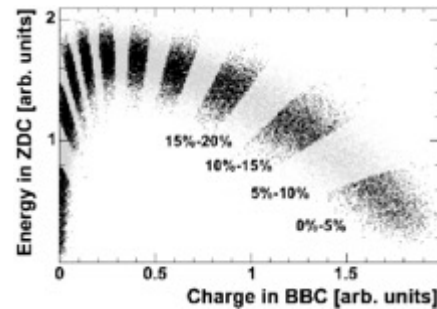


Confirmed fairly consistent z-vertex reconstruction between two independent detectors

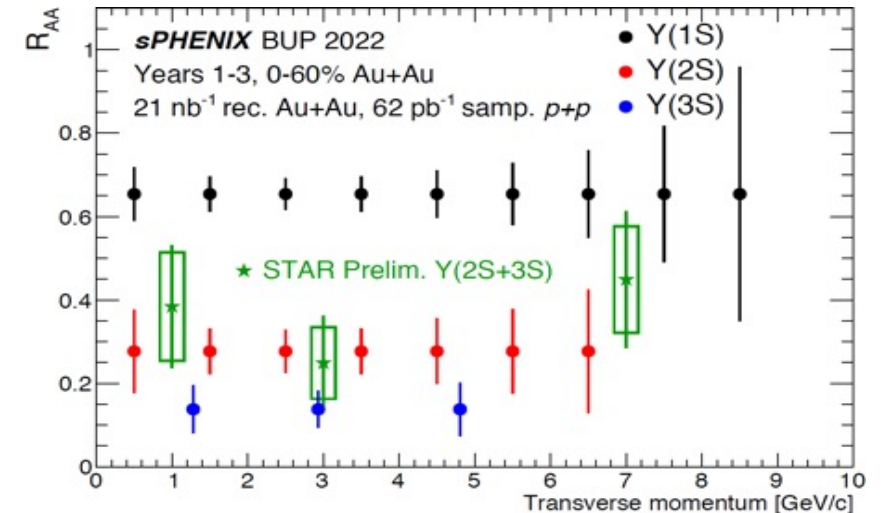
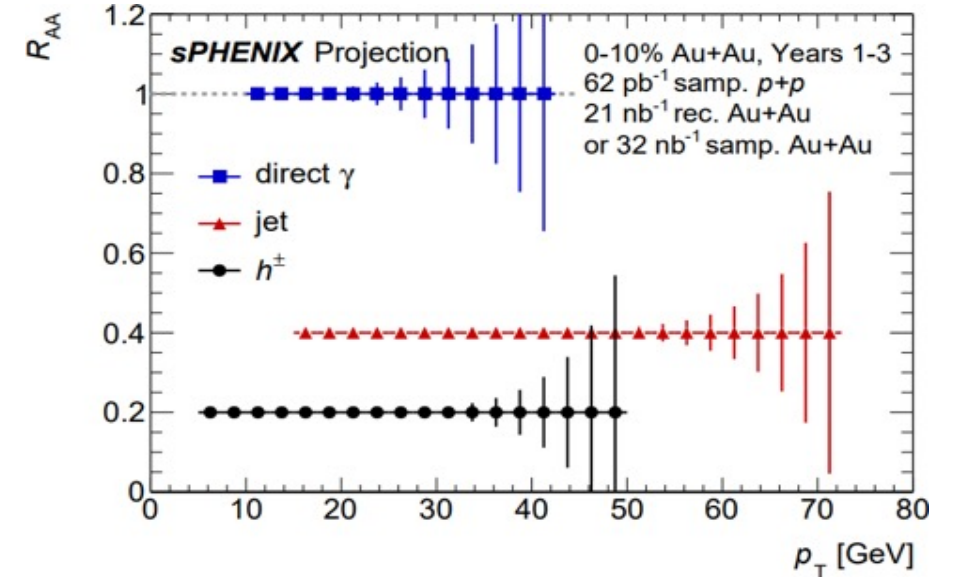
MBD-ZDC Centrality



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

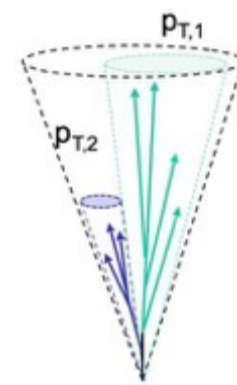


Published Centrality plot in PHENIX



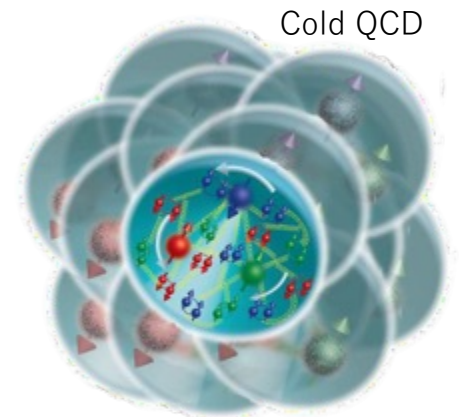
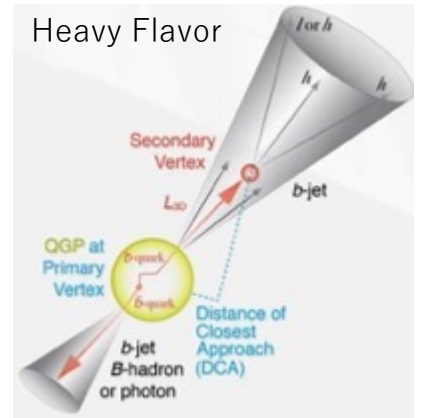
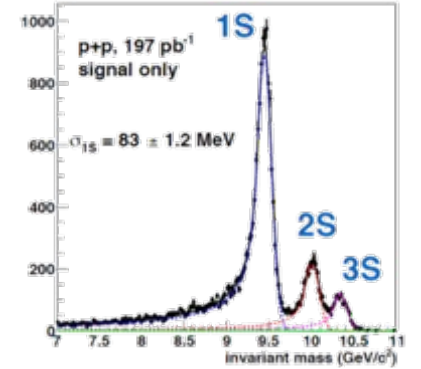
sPHENIX Summary

- 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 $\sqrt{s} = 200\text{GeV}$ and getting ready for 2024 Run.
- Will address on cold QCD in 2024!



Jet Physics

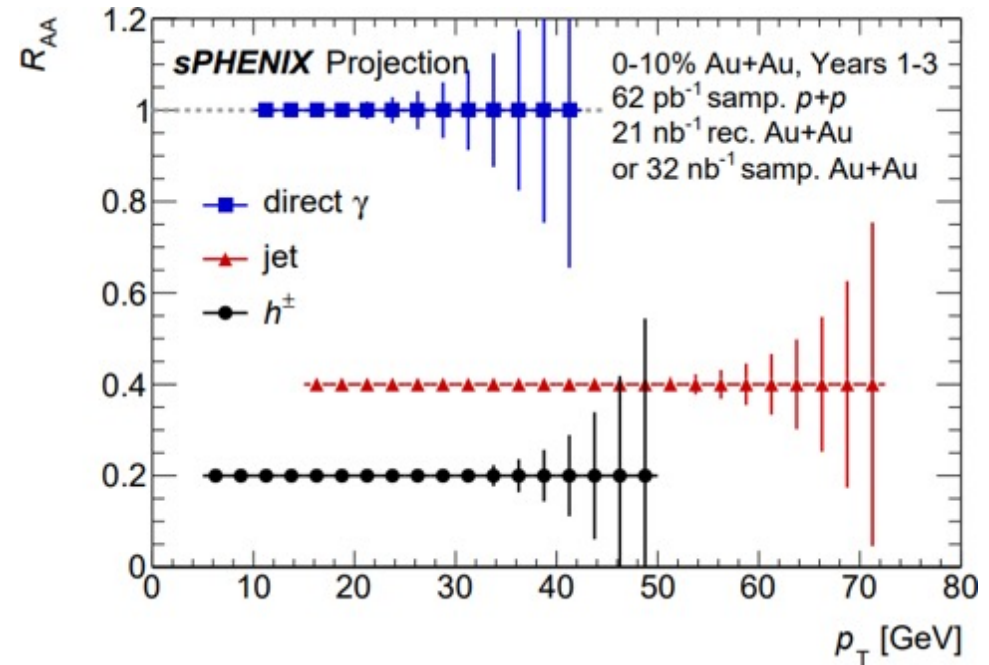
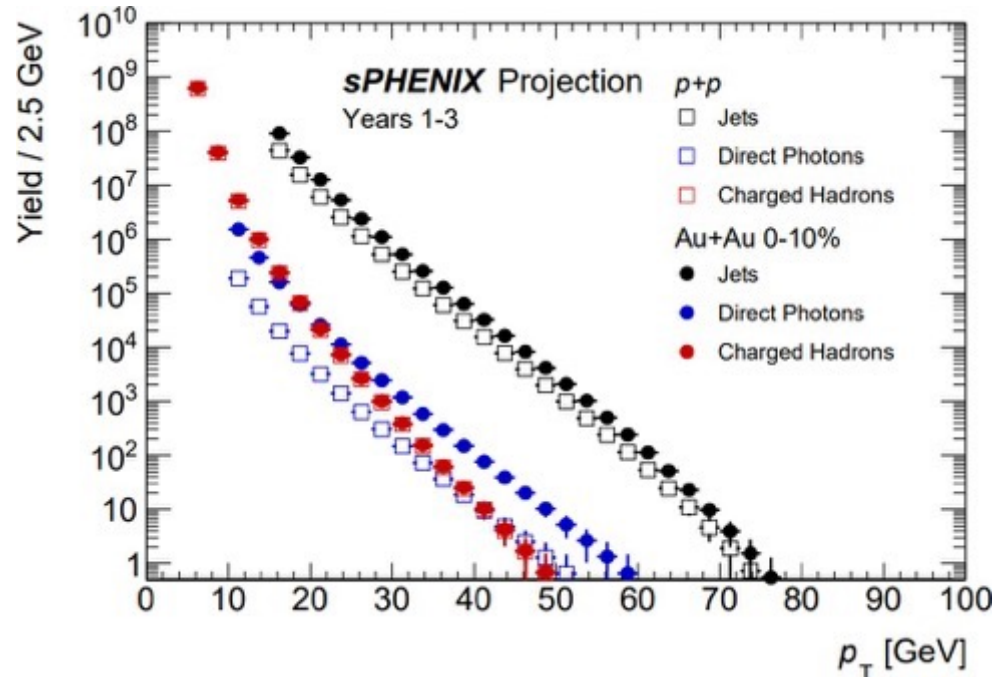
Quarkonium spectroscopy



Backup Slides

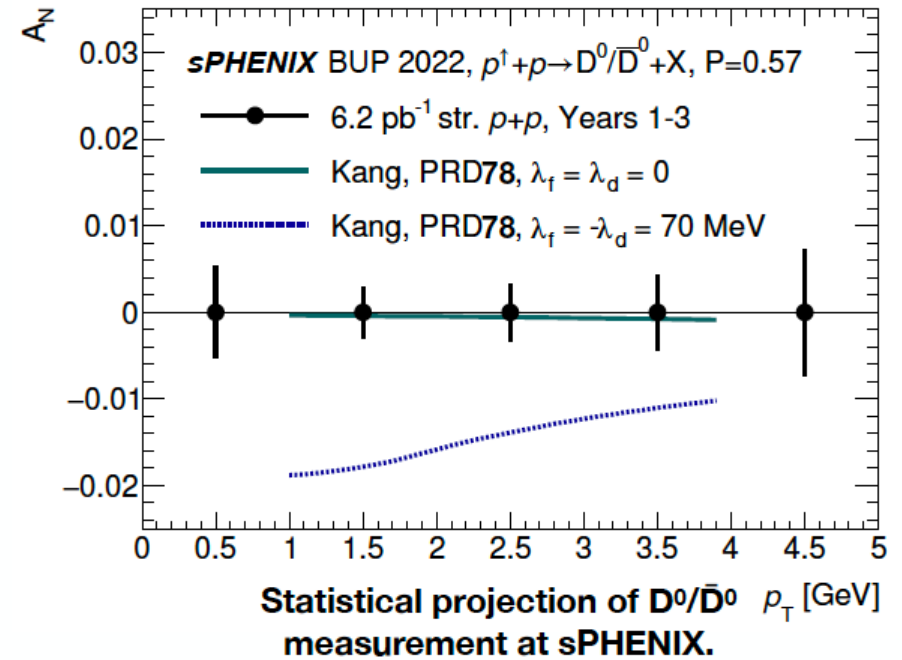
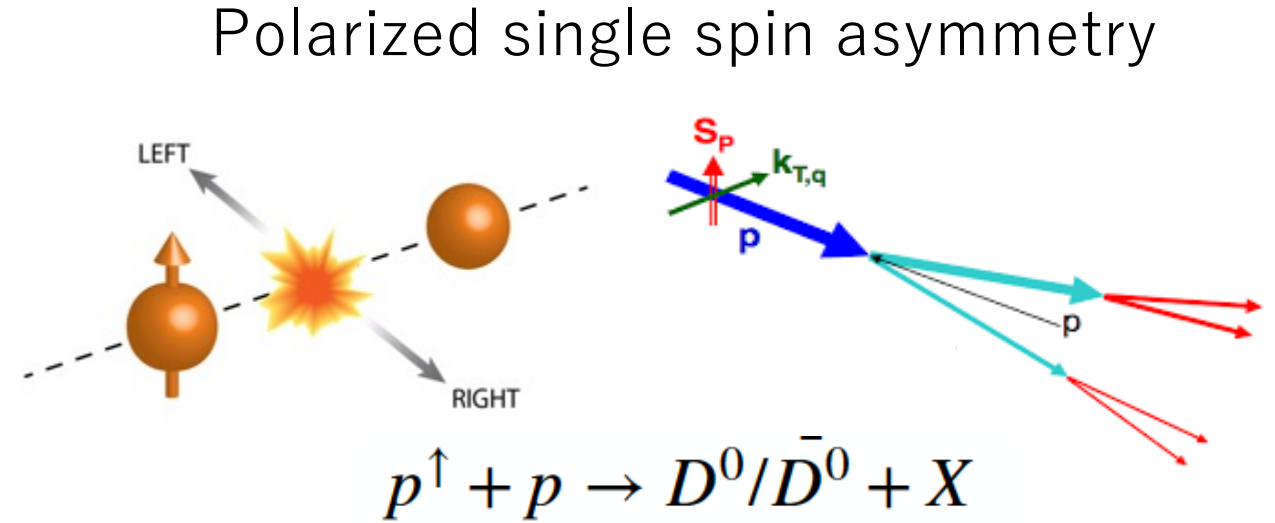
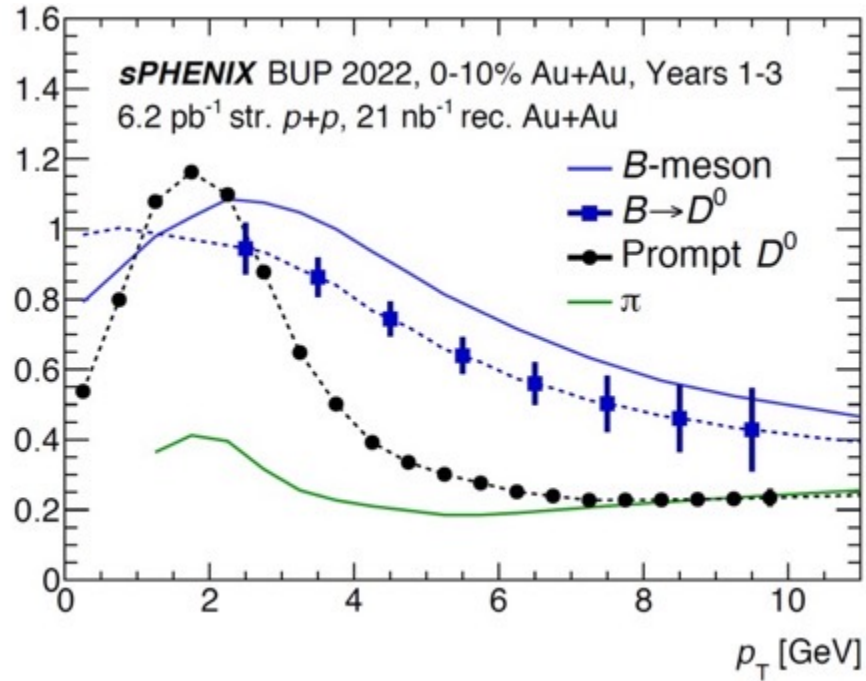
Jet Physics

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 ~ 70 GeV for jets, kinematic overlap with the LHC.

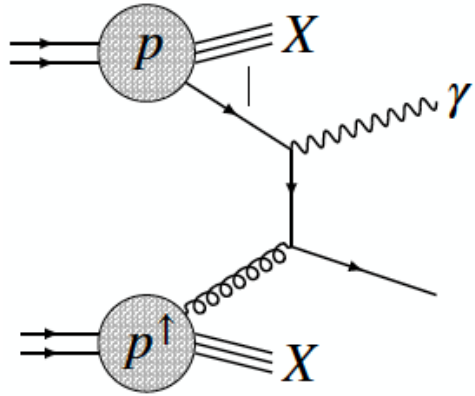
Heavy Flavor



- ✓ 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.

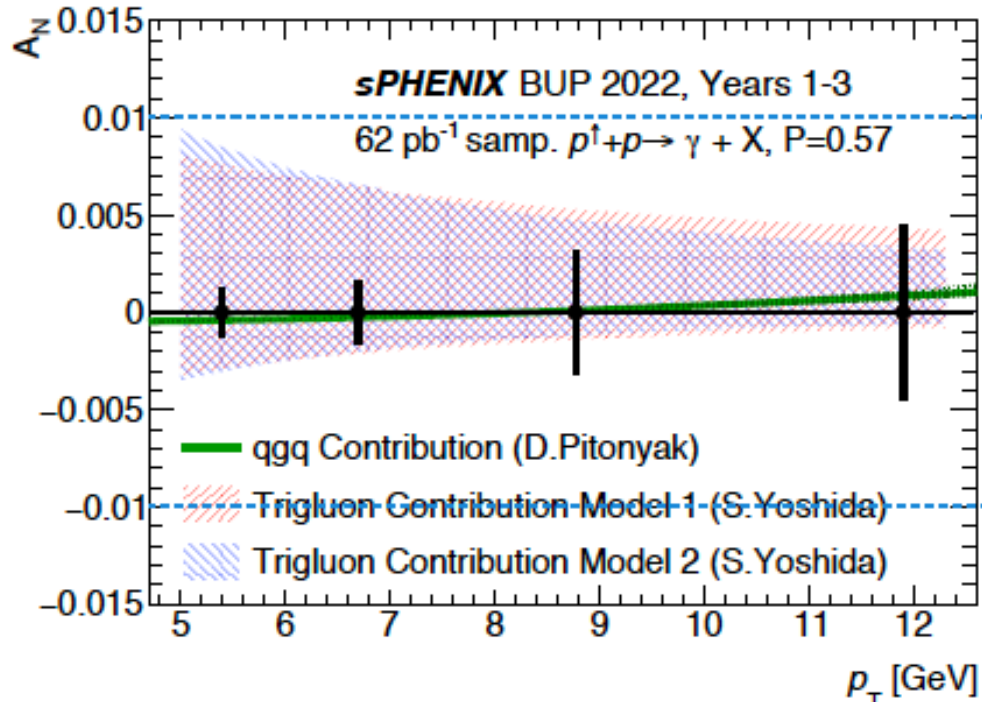
Explores gluon spin contribution to proton spin

Cold QCD : Gluon TMD with Direct photons

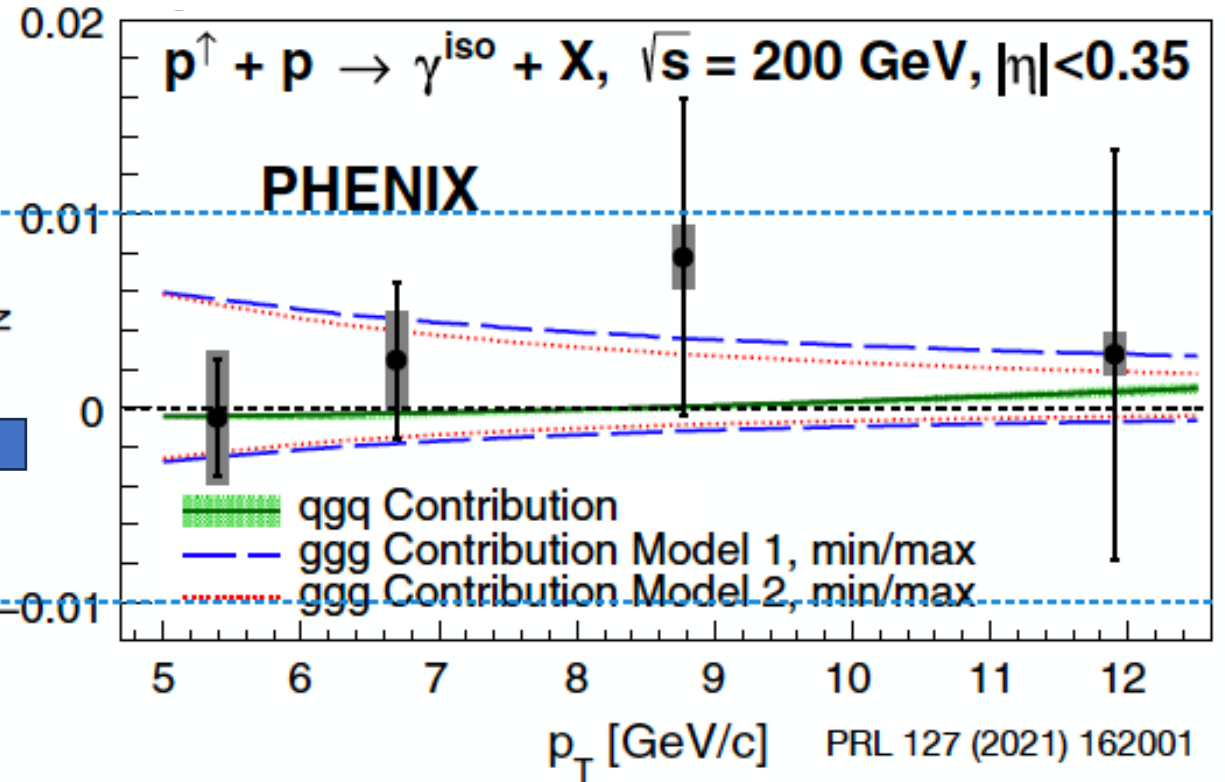


$$p^\uparrow + p \rightarrow \gamma + X$$

Much improved direct photon TSSA -> gluon TMD

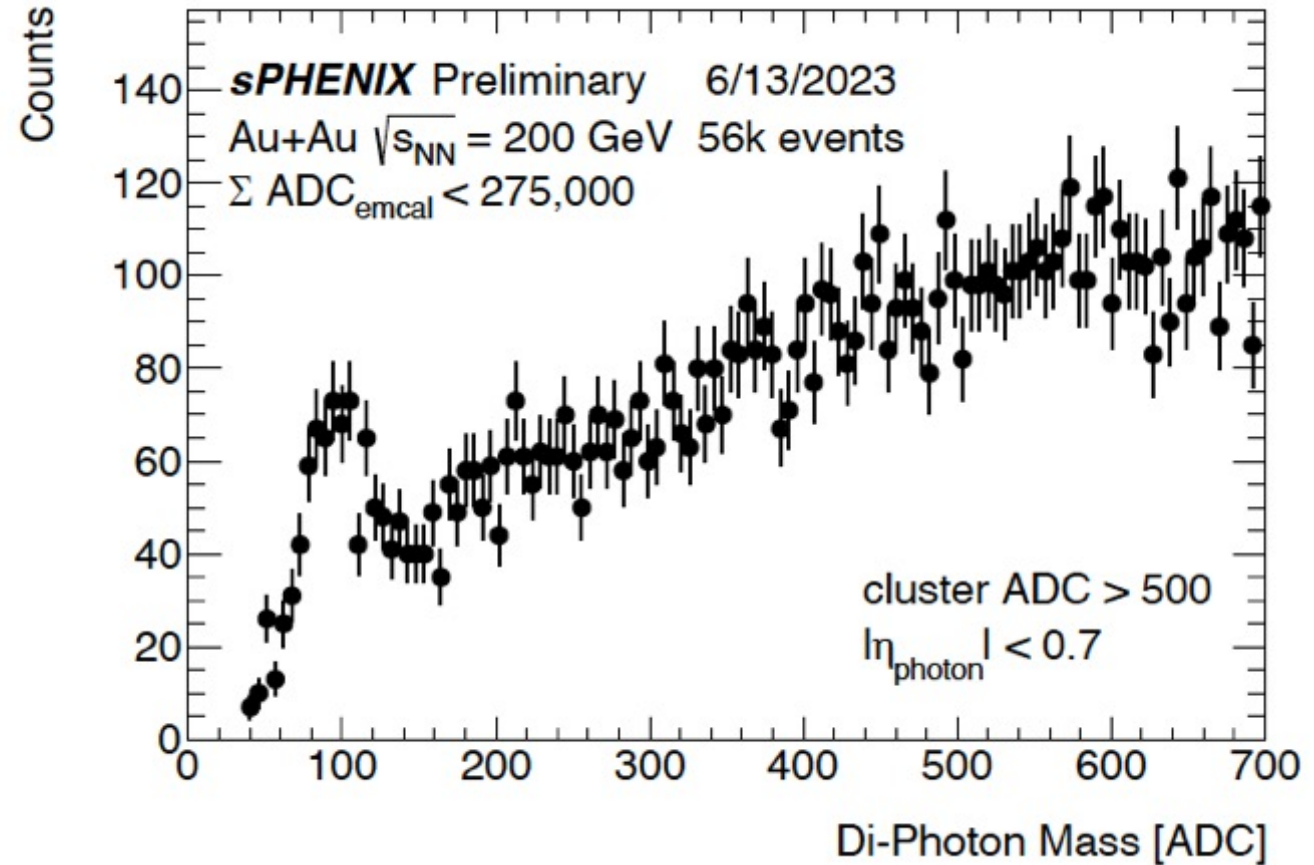
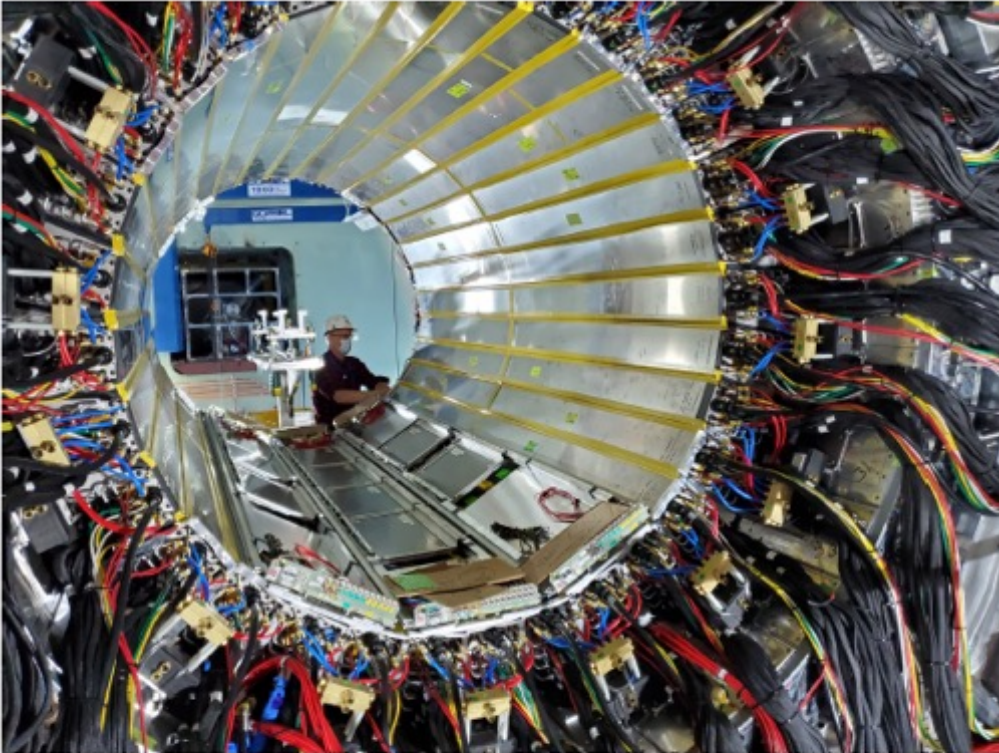


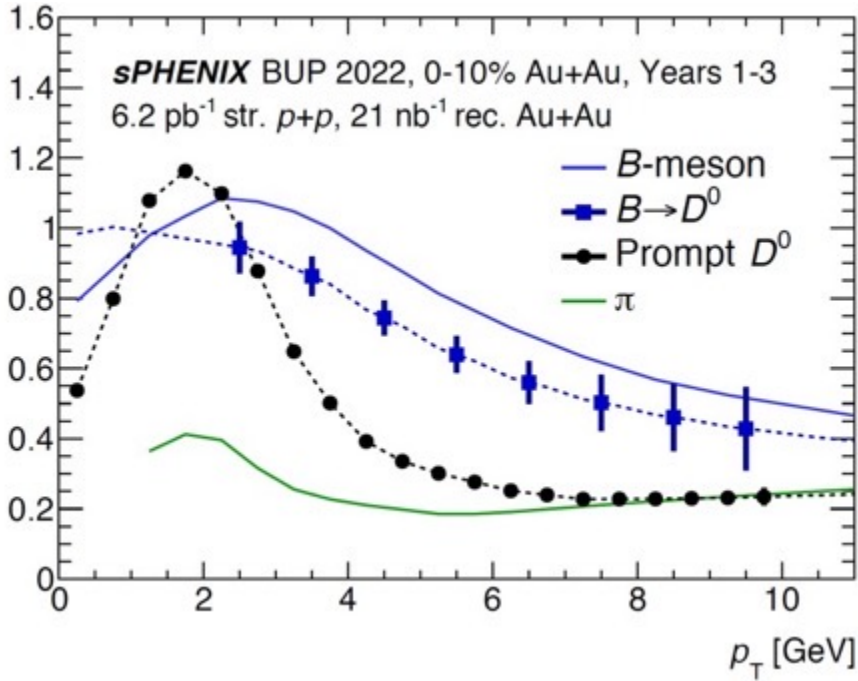
A_N^{dir}



First Data from Commissioning: EMCal

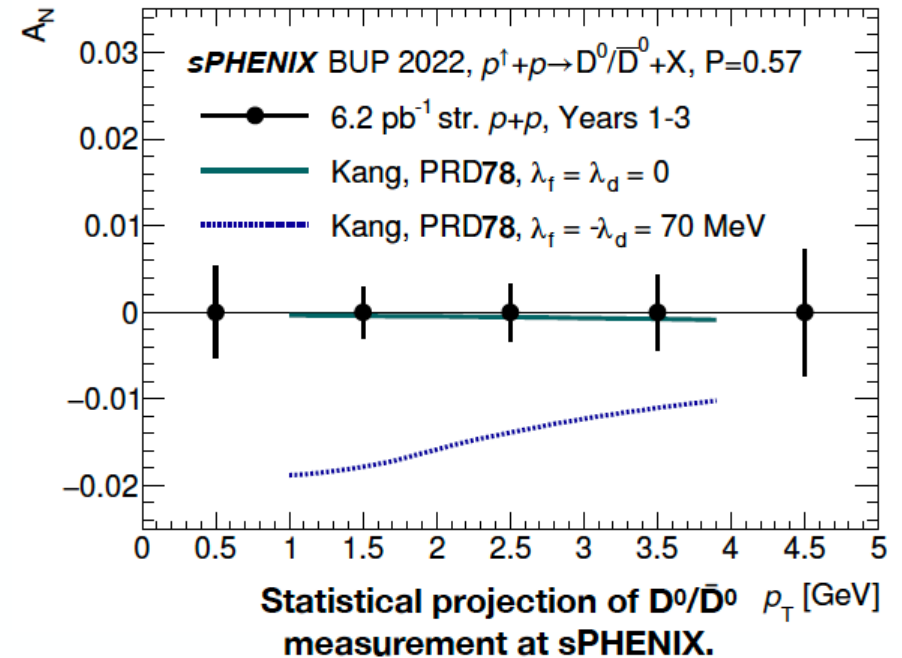
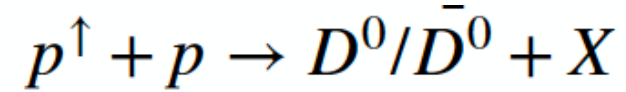
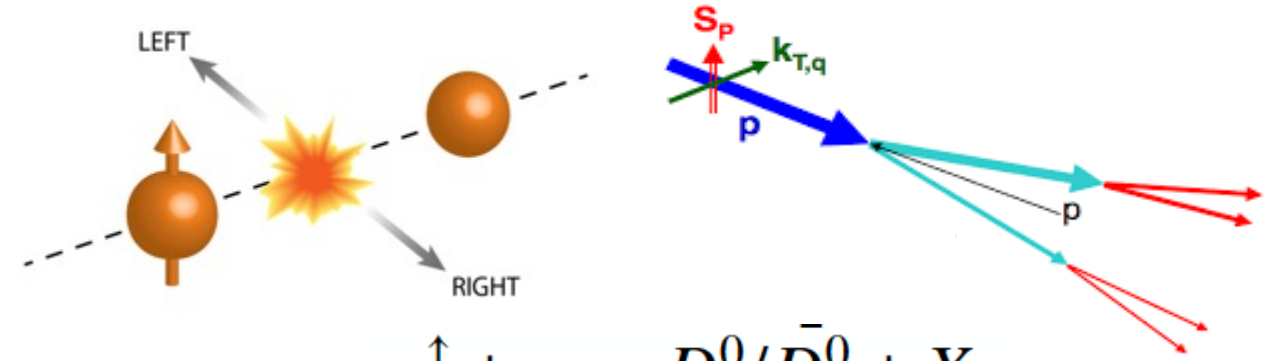
- Clear π^0 peak seen in the di-photon invariant mass spectrum





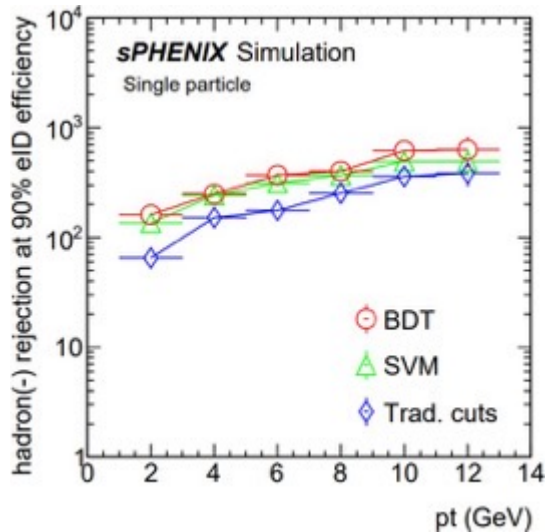
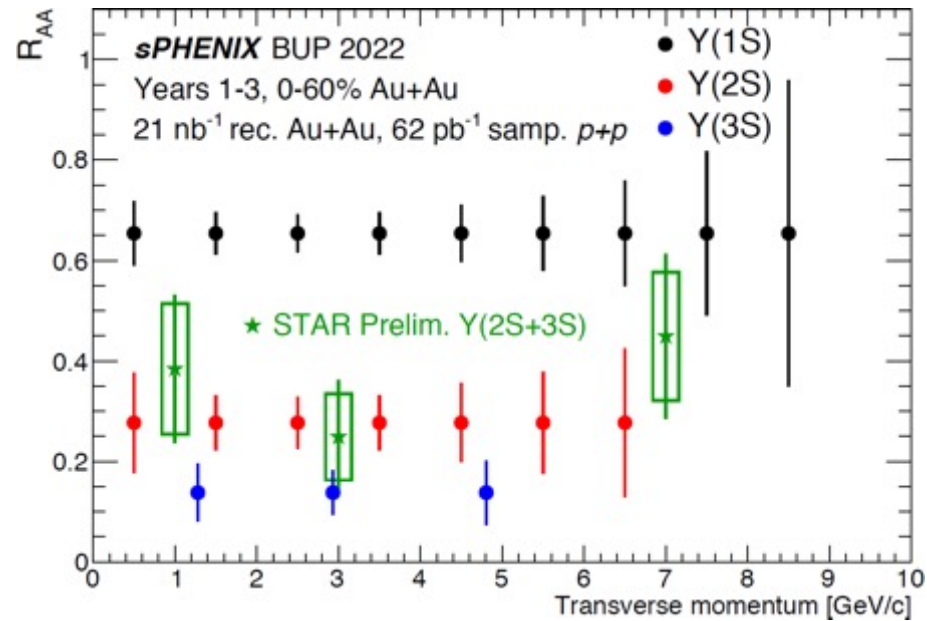
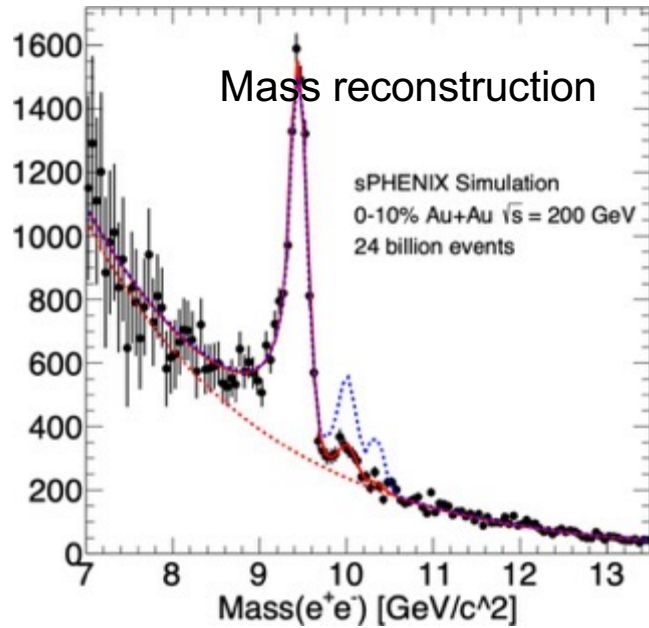
- ✓ Cleanly separate open bottom via DCA.
- ✓ Study mass dependence of energy loss and collectivity.
- ✓ Bottom quarks and light quarks are expected to be different for R_{AA} and v₂ for p_T ≲ 15 GeV.

Polarized single spin asymmetry



Explores gluon spin contribution to proton spin

Quarkonium spectroscopy



- ✓ 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.