Readiness for physics data taking of sPHENIX experiment at RHIC

RIKEN/RBRC

Itaru Nakagawa

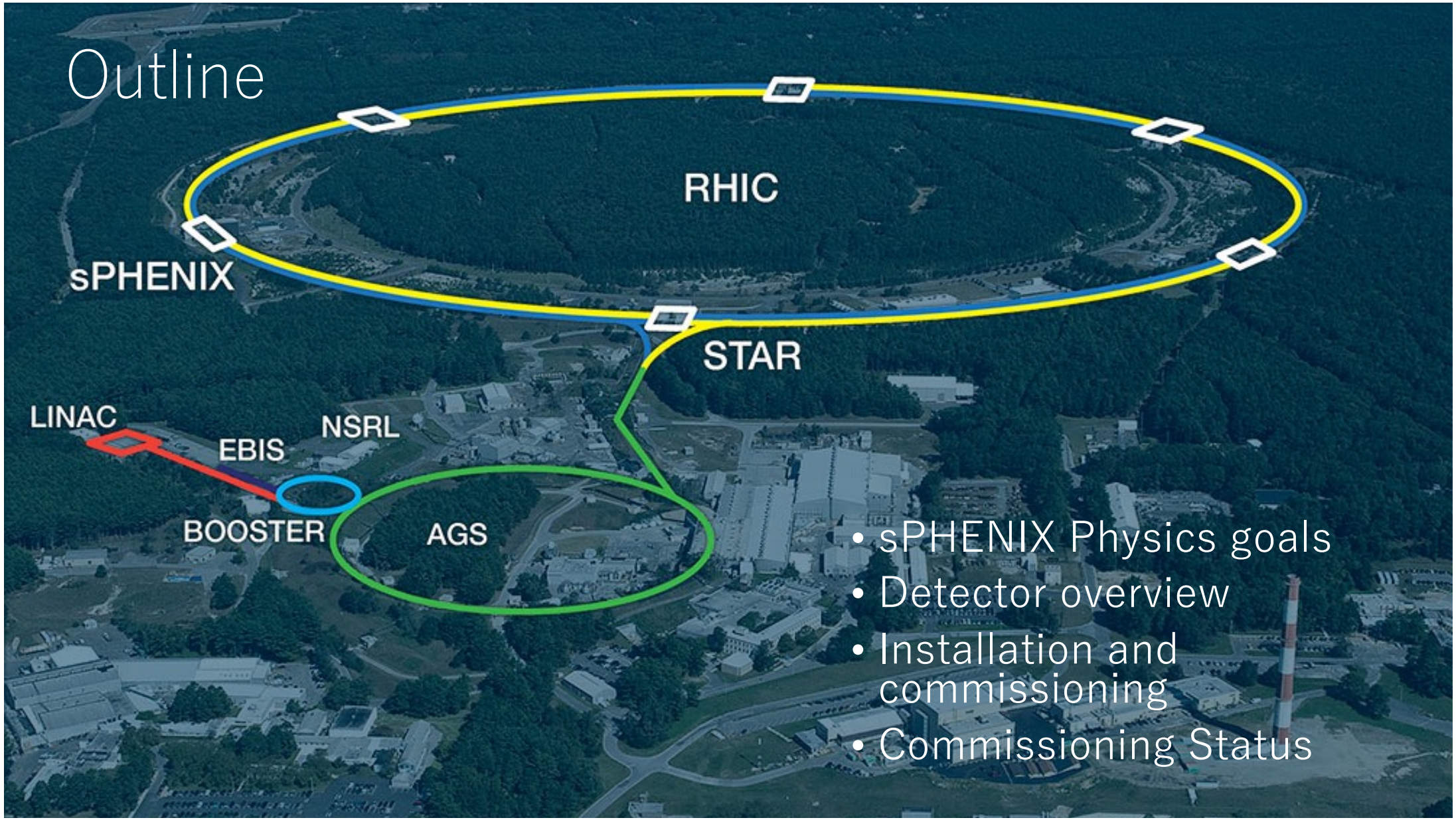
Conclusion

- 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.

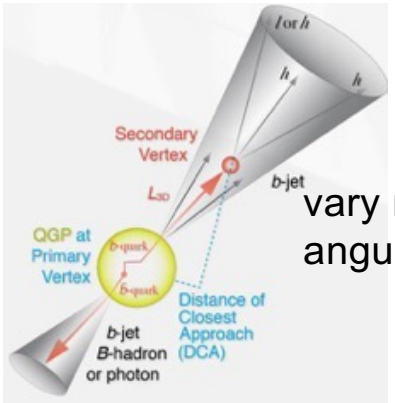
Outline



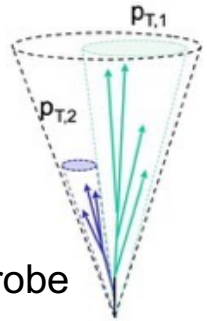
- sPHENIX Physics goals
- Detector overview
- Installation and commissioning
- Commissioning Status

sPHENIX Physics Program

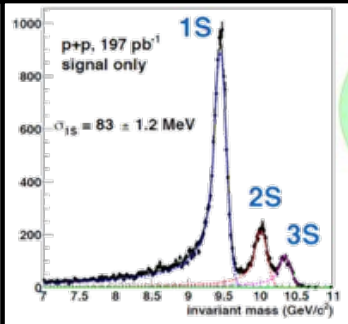
Zhaozhong Shi's talk on Thursday 08/24

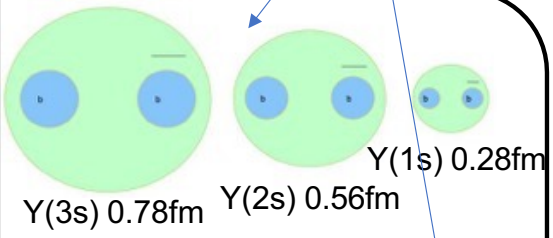


vary momentum & angular scale of probe



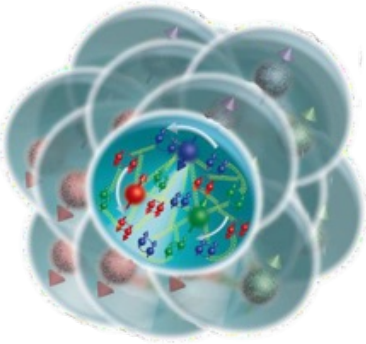
Jet physics





vary size of probe

Quarkonium spectroscopy



Cold QCD

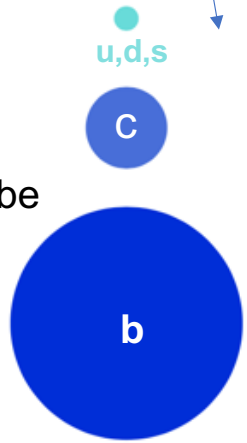
vary temperature of QCD matter

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

Parton energy loss

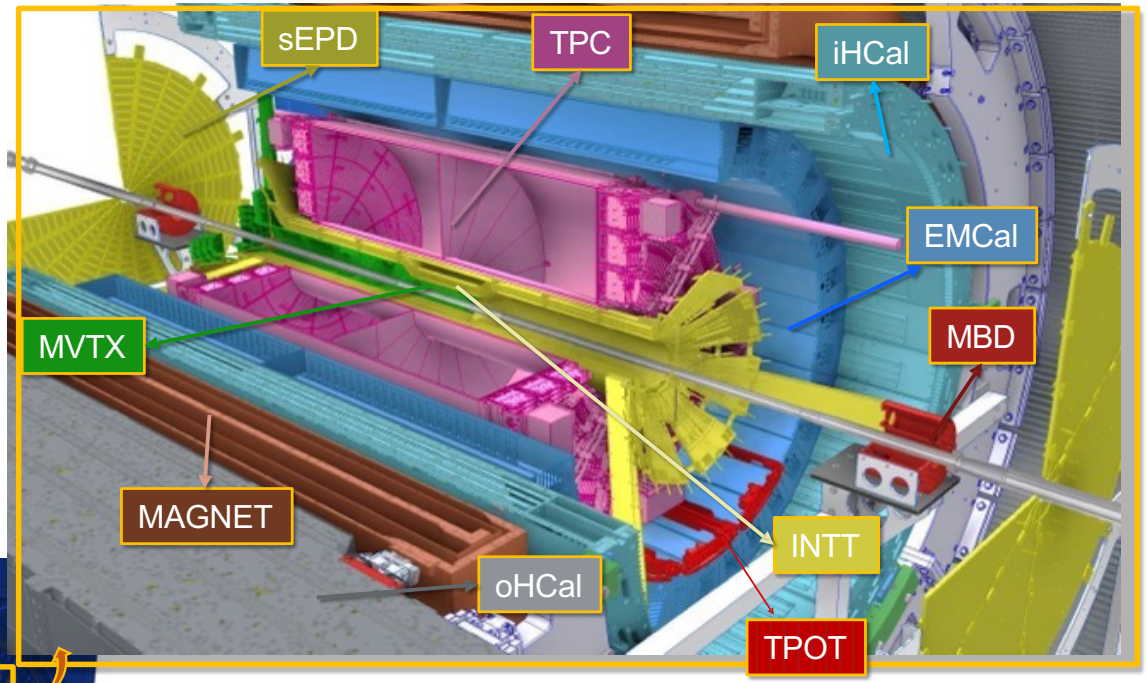
vary mass & momentum of probe

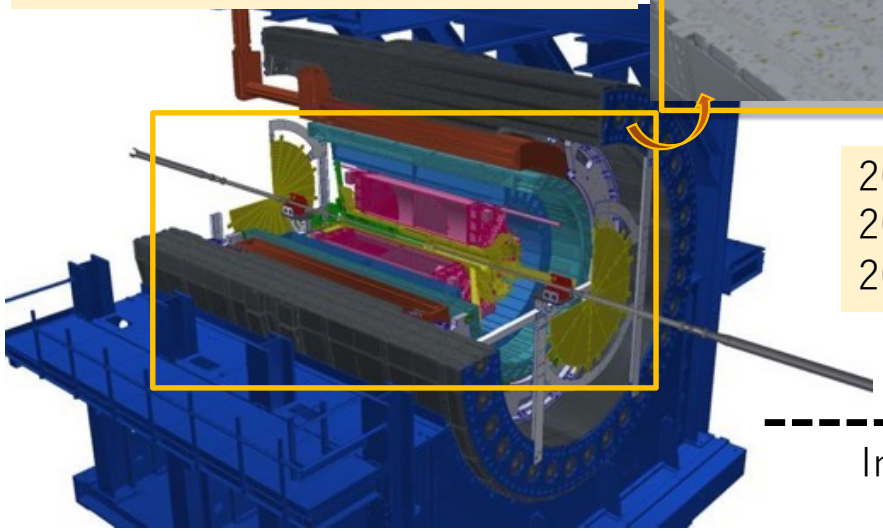
photon
gluon



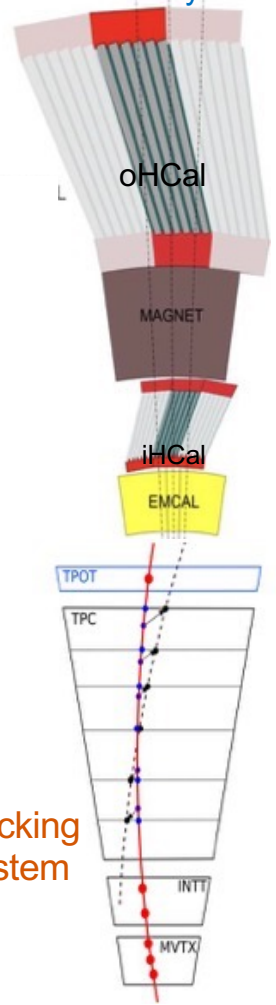
sPHENIX Detector

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





Calorimeter system



Tracking system

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

$\sqrt{s}$ =200GeV

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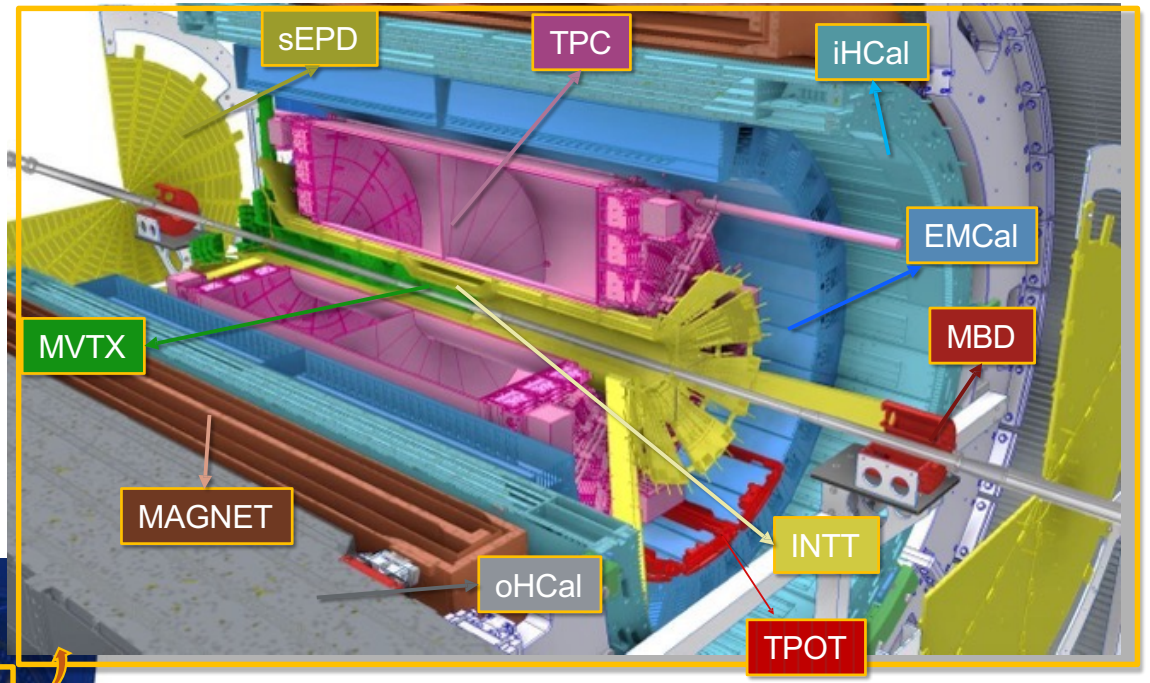

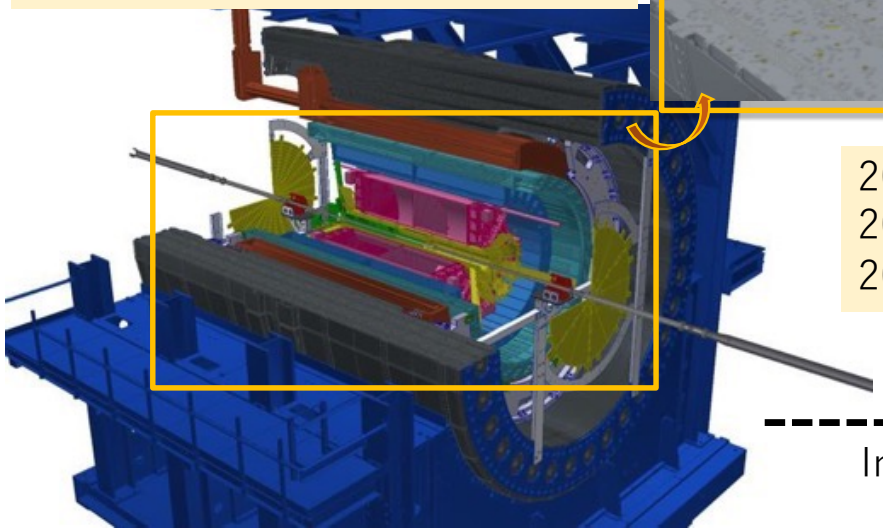

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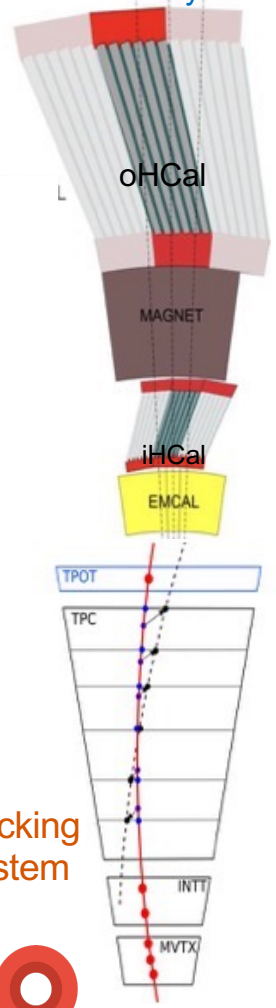

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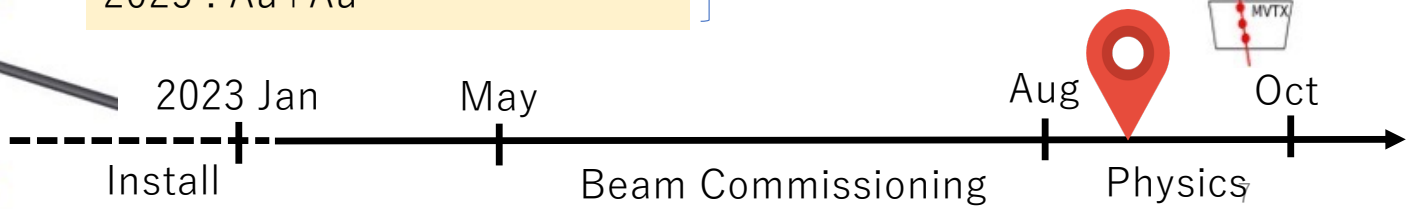

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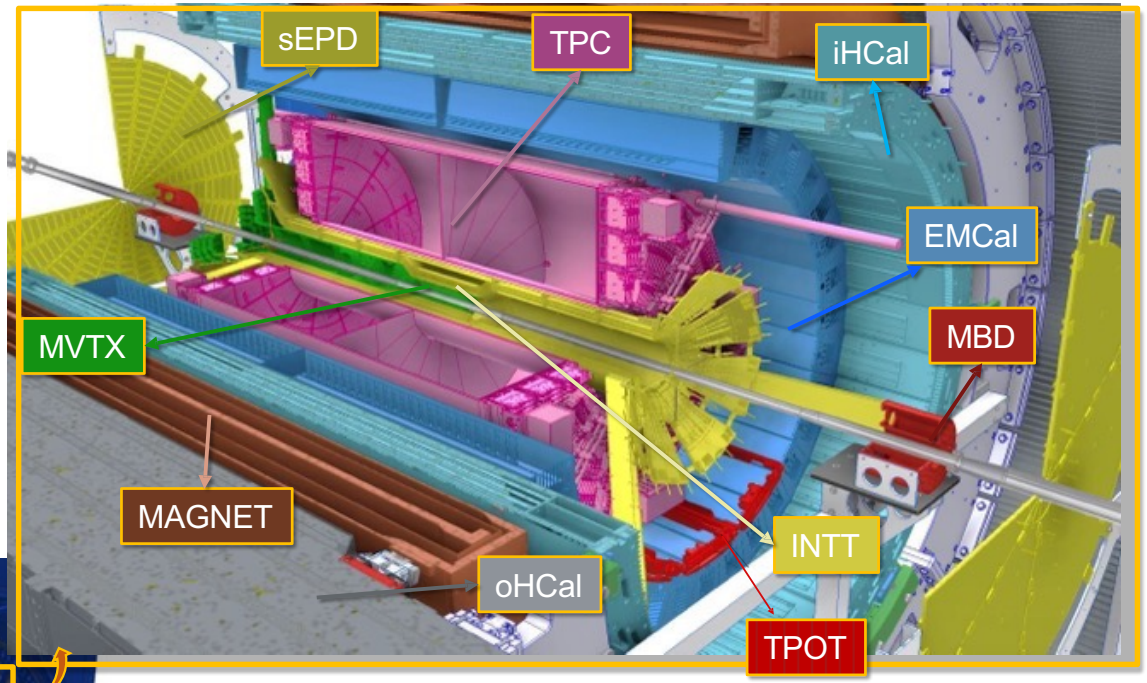

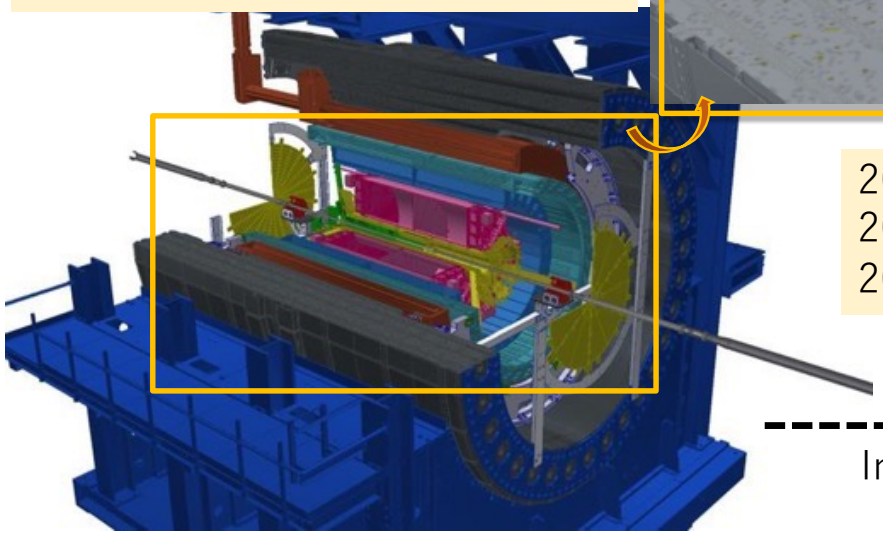

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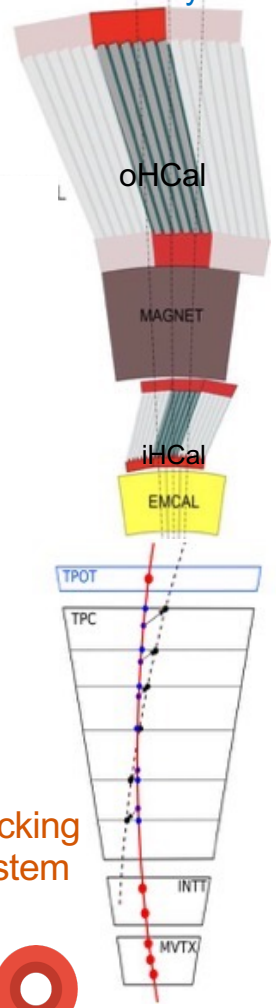

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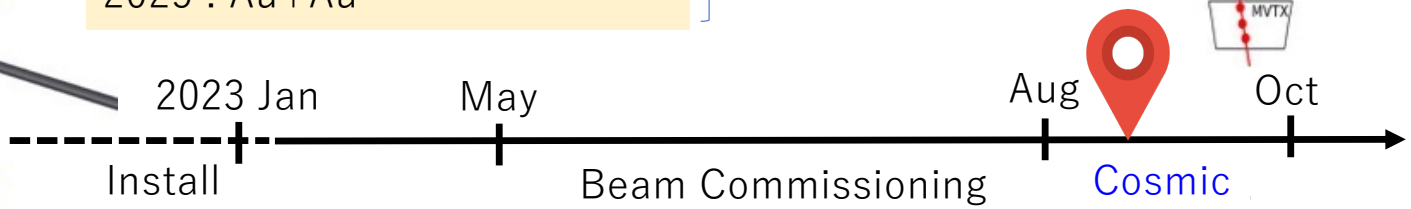
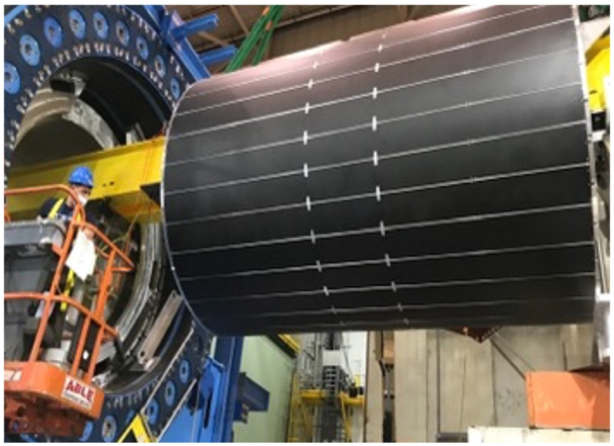
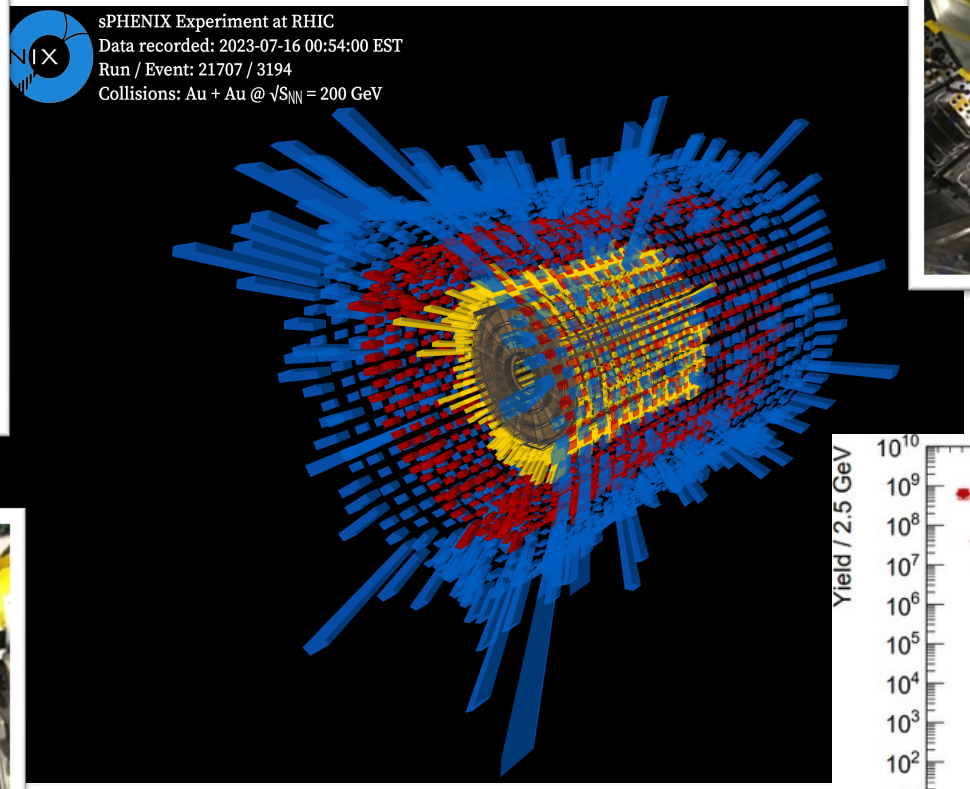


Hadron and EM Calorimeters

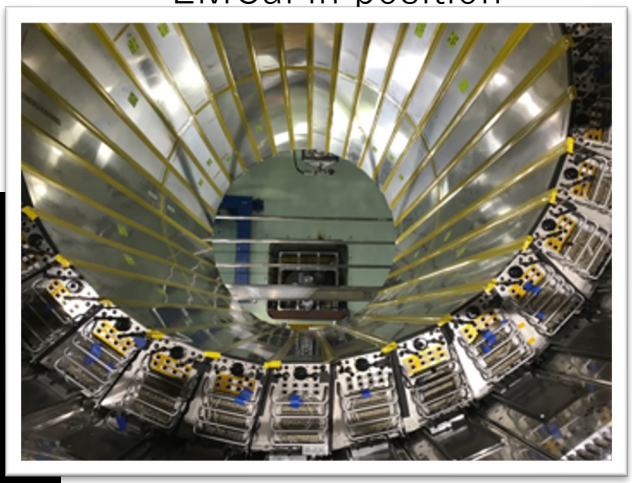
Outer HCal Installation

Inner HCal Installation

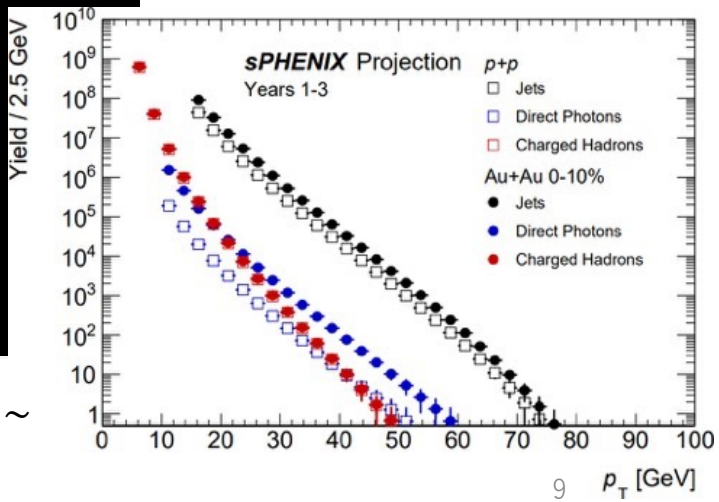




EMCal in position

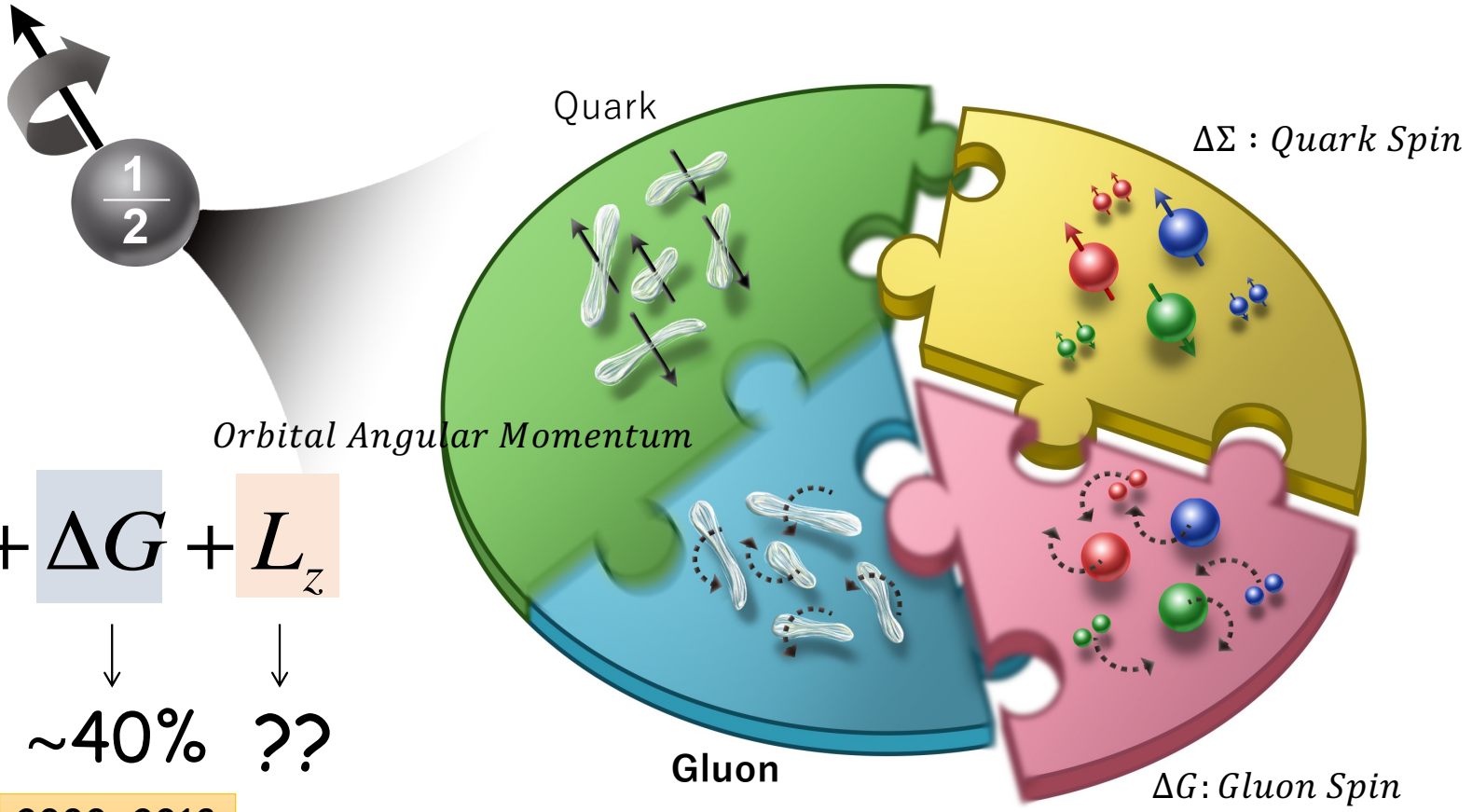


sPHENIX Simulation



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

Cold-QCD: Proton Spin Decomposition

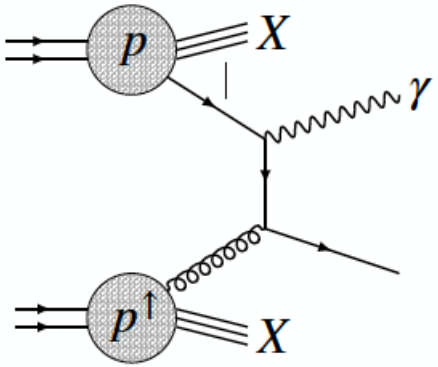


$$S_z = \frac{1}{2}\Delta\Sigma + \Delta G + L_z$$

~25% ~40% ??

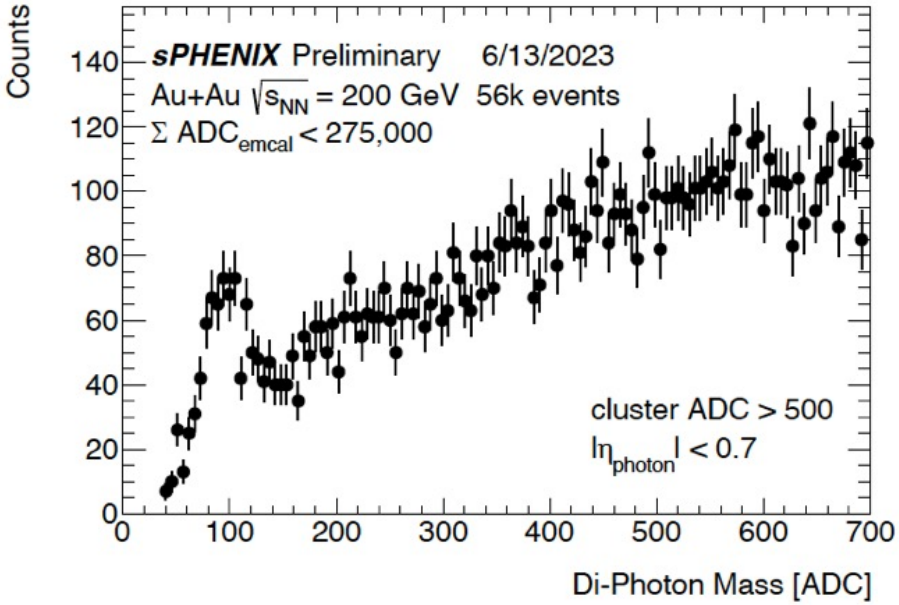
1980's 2000~2018

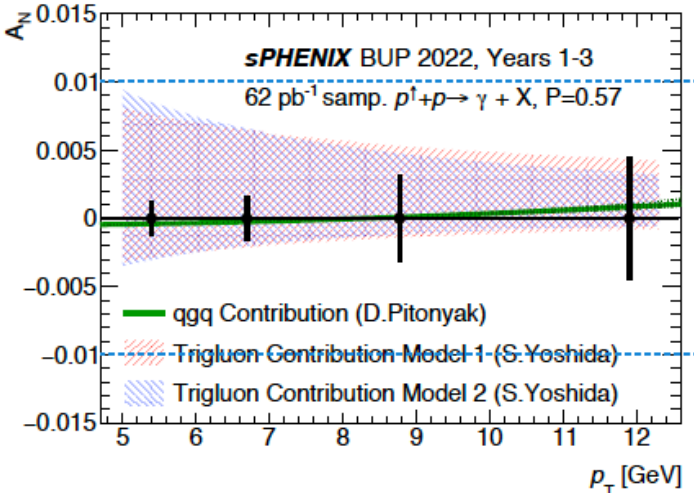
Gluon TMD by Direct-γ

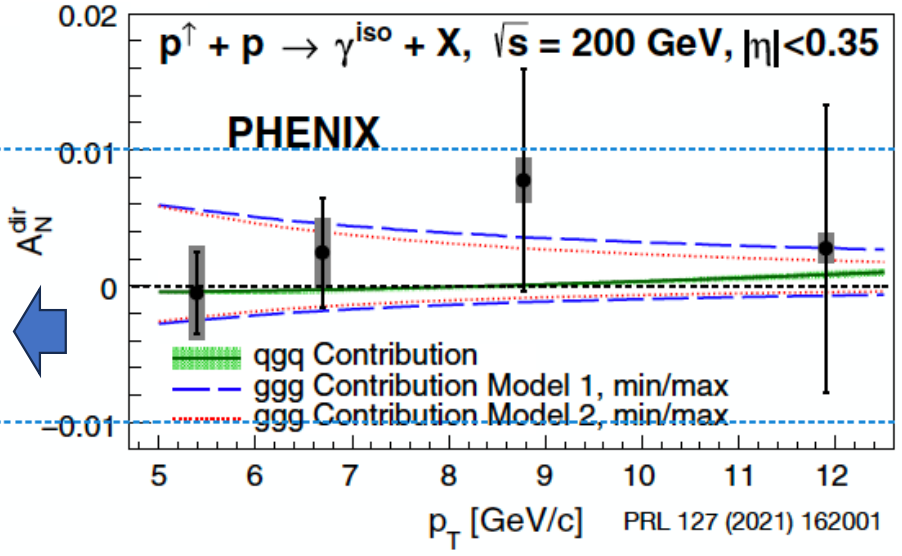


TMD: Transverse Momentum Dependence

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

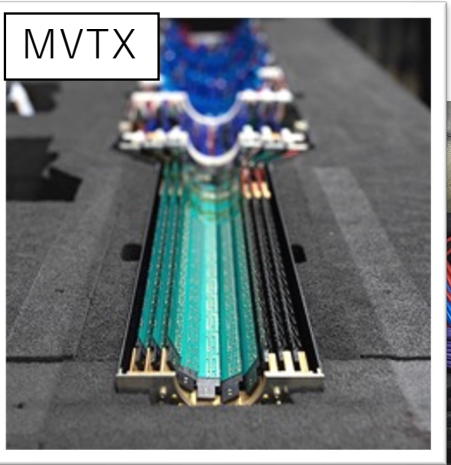


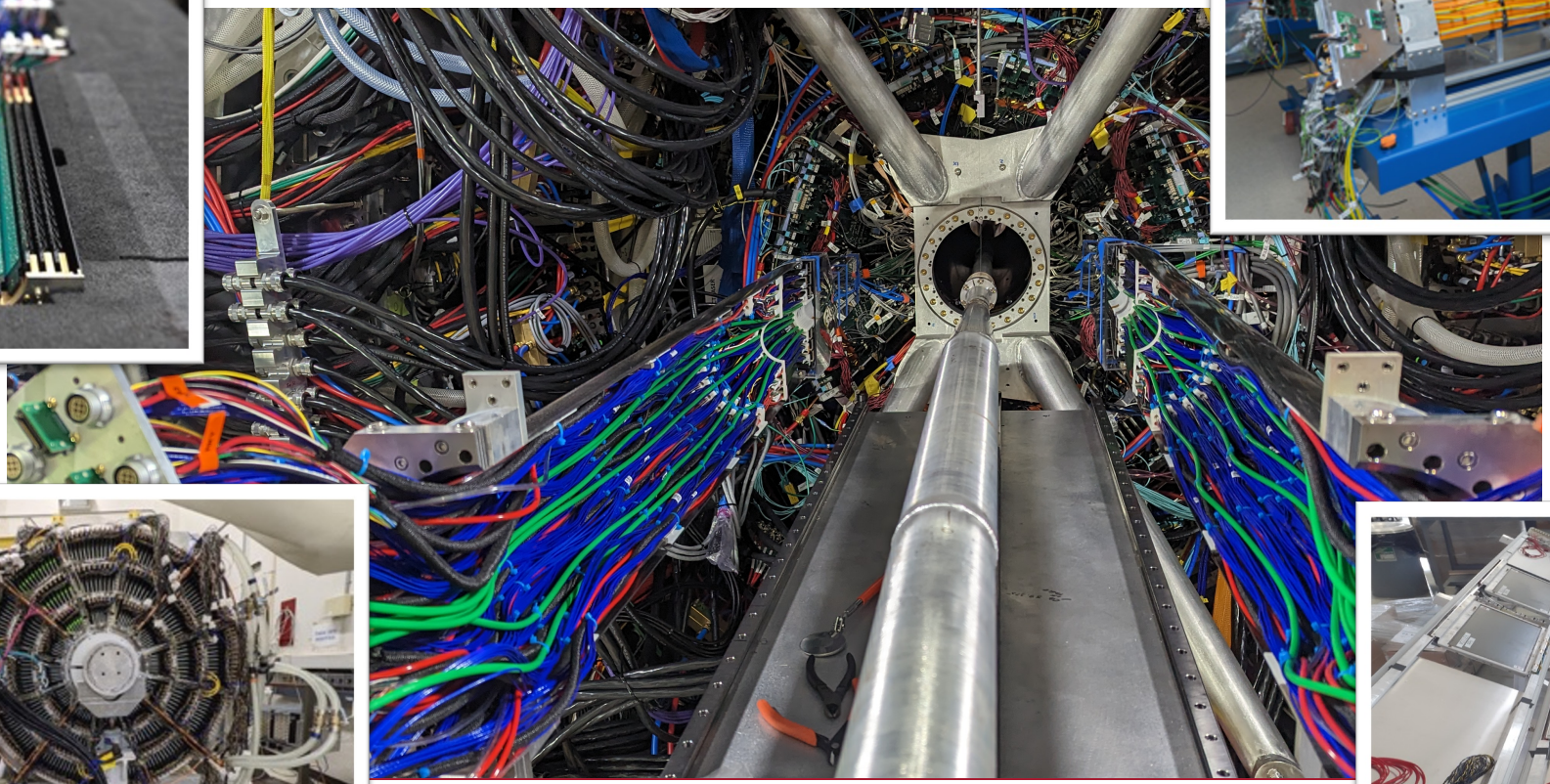




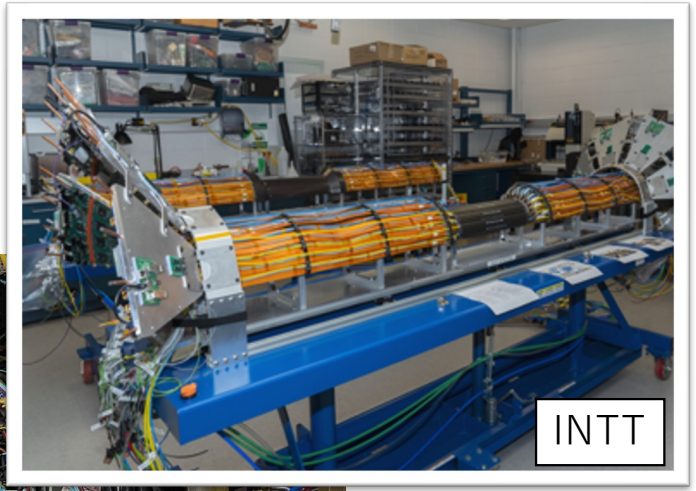
Much improved direct photon TSSA -> gluon TMD

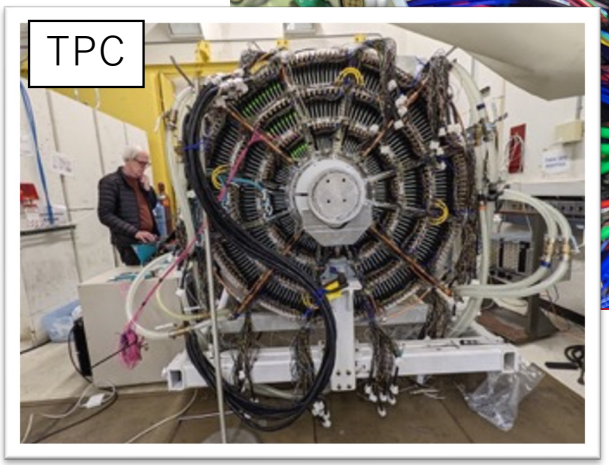
Tracking Detectors

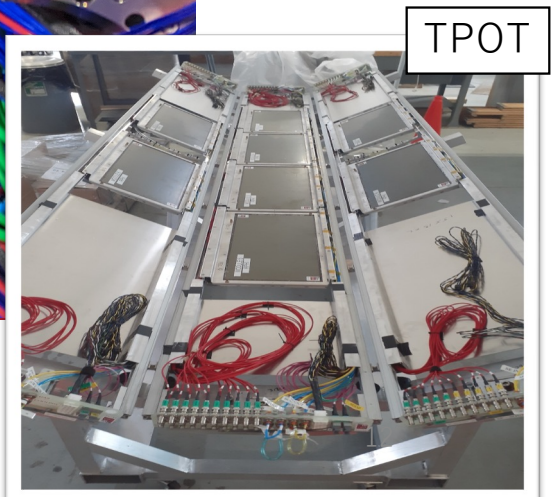




All Trackers installed in Position (March 30th, 2023)







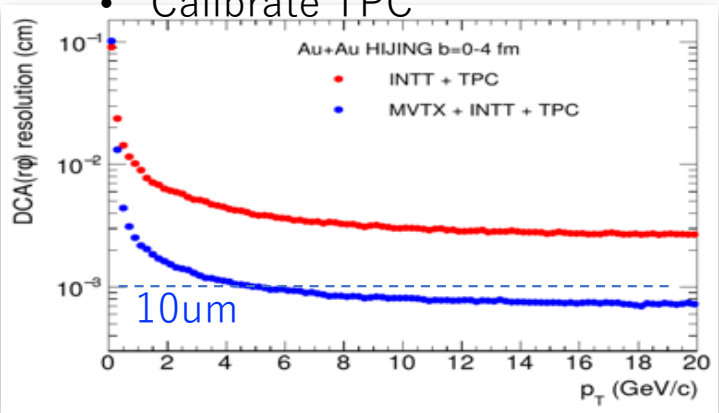
Tracking System

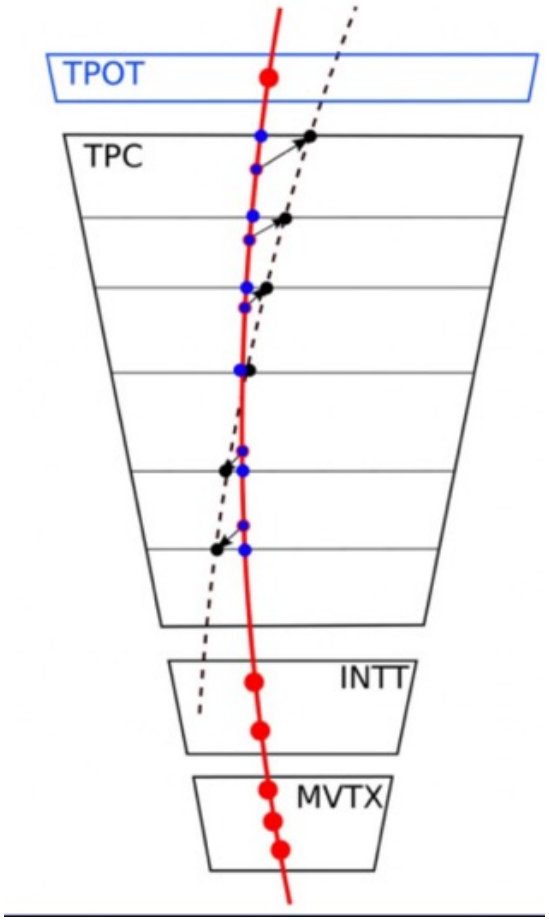
Silicon pixel detector (MVTX)
- 29 um x 27 um, pixels
- 2.5 cm < R < 4.5cm
- 20 BLCK integration time

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

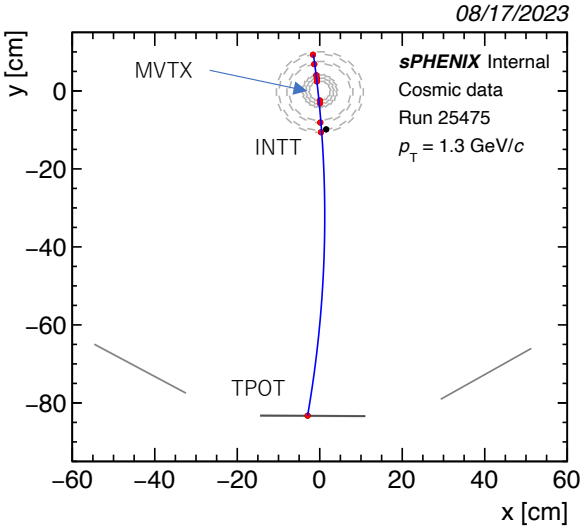
Time projection Chamber (TPC)
- 20cm < R < 78cm
- Spatial resolution, ~100um
- Long drift time, ~13us

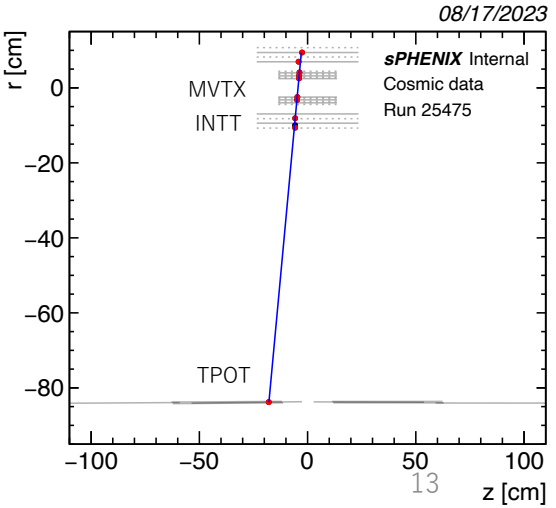
TPC Outer Tracker (TPOT)
- Calibrate TPC



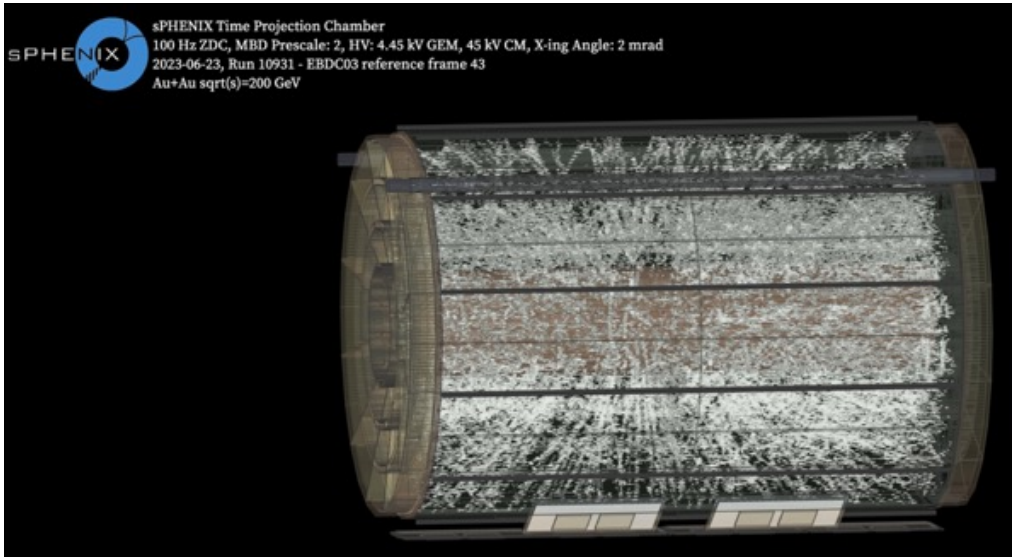


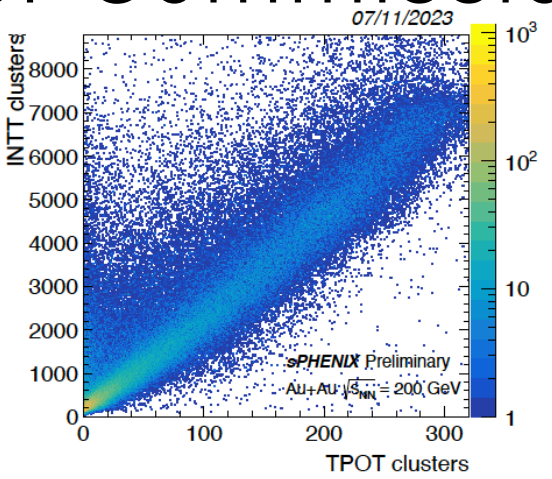
Cosmic Ray Track Reconstruction

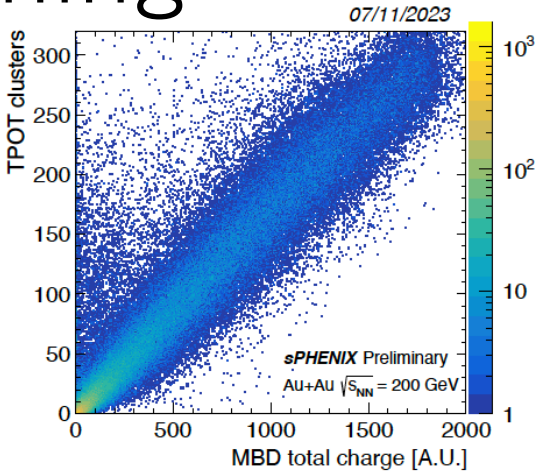




Tracking Detector Commissioning

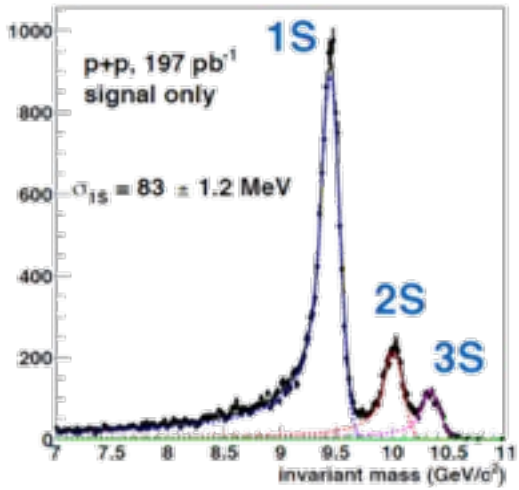






- TPC Event Display in Au+Au @ 200GeV
- Multiplicity correlations between MBD-INTT-TPOT
- MVTX correlation between different layers
- More correlation hits in Zhaozhong Shi's talk on Thursday 08/24

sPHENIX Simulation

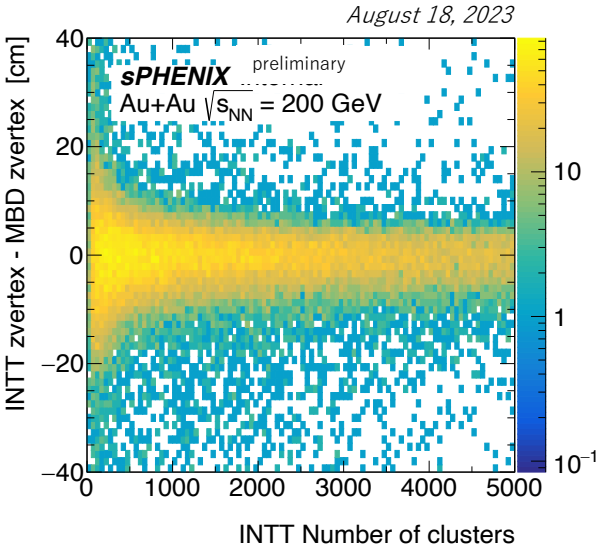


Clear separation between 2S and 3S states

Vertex Reconstruction & Centrality

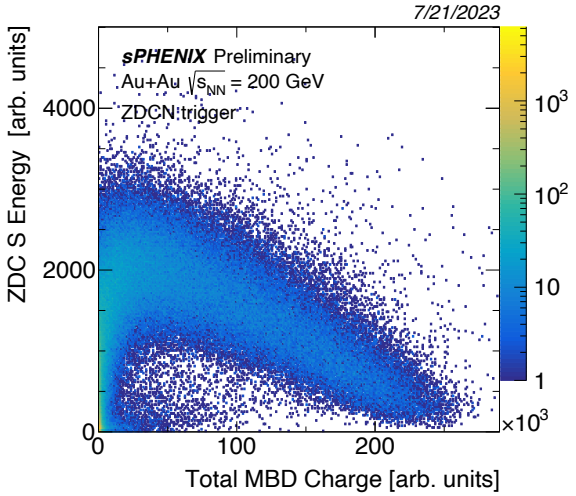
sPHENIX Simulation

INTT-MBD Z-vertex Reconstruction

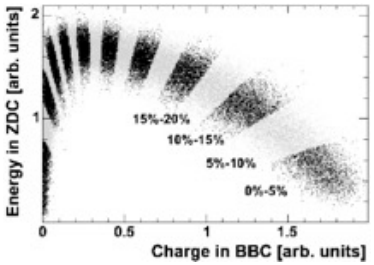


Confirmed fairly consistent z-vertex reconstruction between two independent detectors

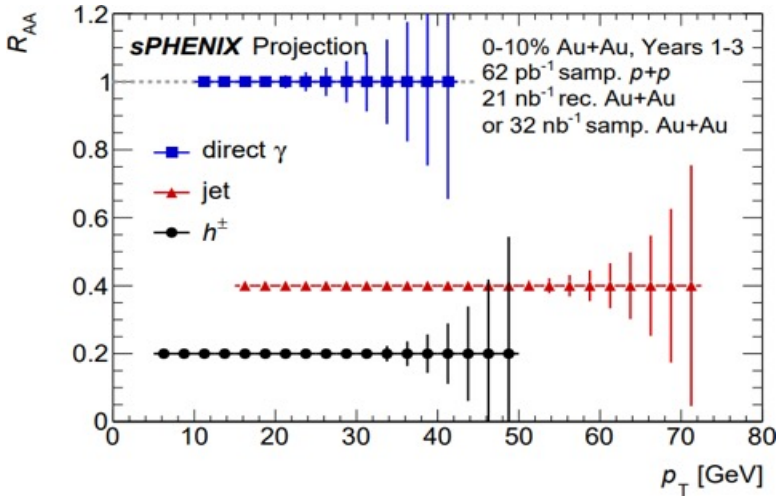
MBD-ZDC Centrality

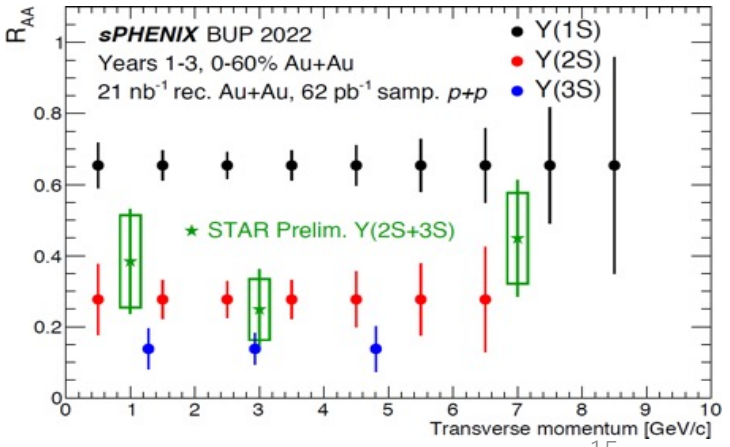


Phys. Rev. C **71**, 034908 (2005)

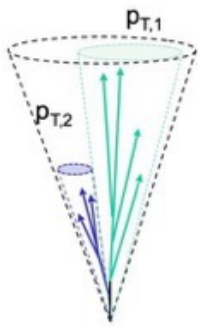


Published Centrality plot in PHENIX



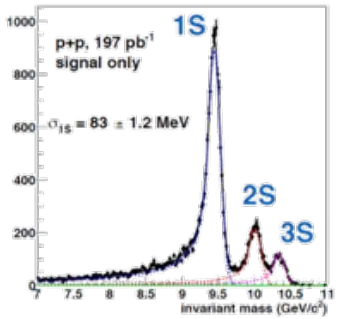


sPHENIX Summary



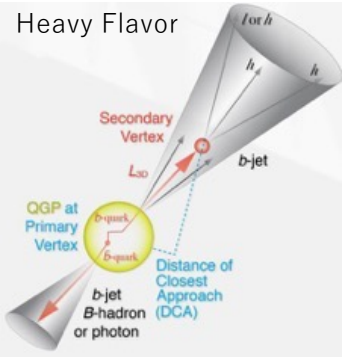
Jet Physics

Quarkonium spectroscopy



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

Heavy Flavor

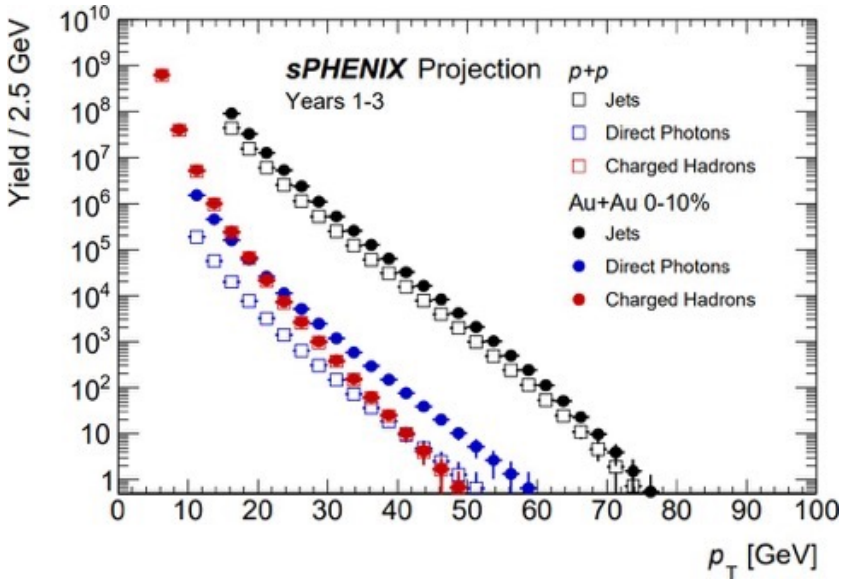


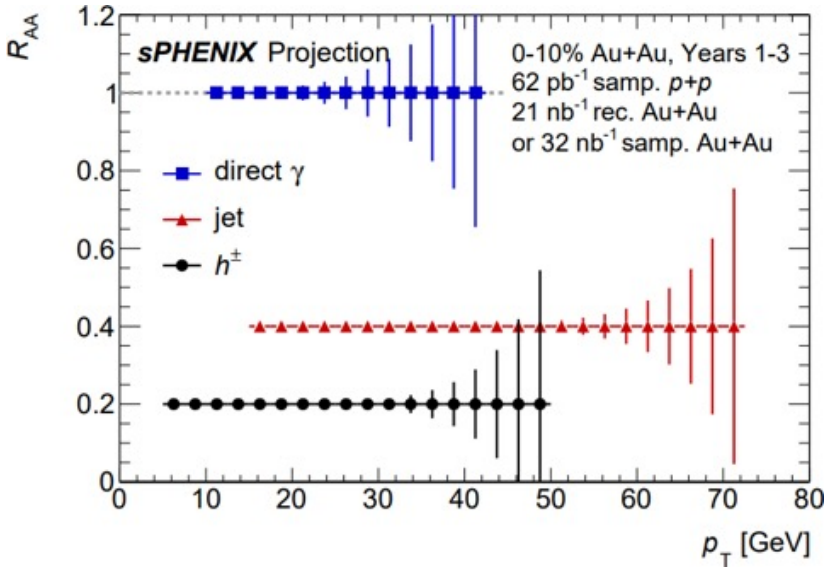
Cold QCD

Backup Slides

Jet Physics

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



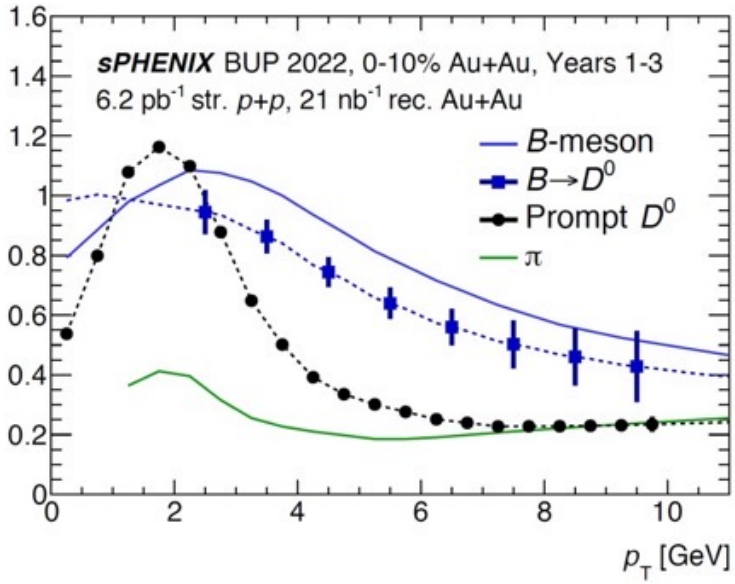


✓High data rates & hermetic EMCal+HCal offer wide p_T range for jet reconstruction.

✓sPHENIX can precisely measure the low p_T region, which is challenging at the LHC.

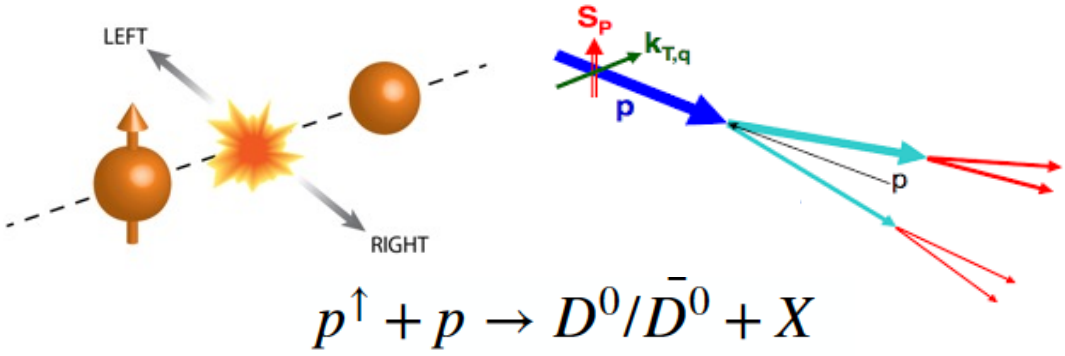
✓sPHENIX will have kinematic reach out to ~ 70 GeV for jets, kinematic overlap with the LHC.

Heavy Flavor

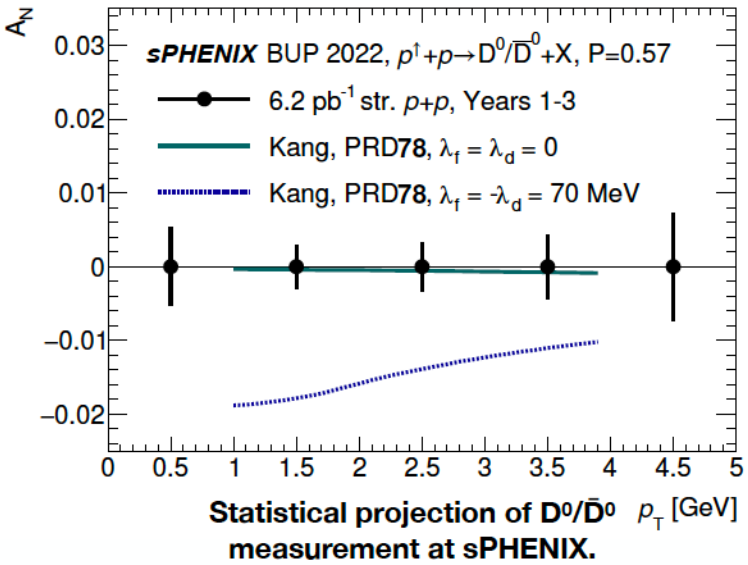


- ✓ Cleanly separate open bottom via DCA.
- ✓ Study mass dependence of energy loss and collectivity.
- ✓ Bottom quarks and light quarks are expected to be different for R_{AA} and v_2 for $p_T \lesssim 15$ GeV.

Polarized single spin asymmetry

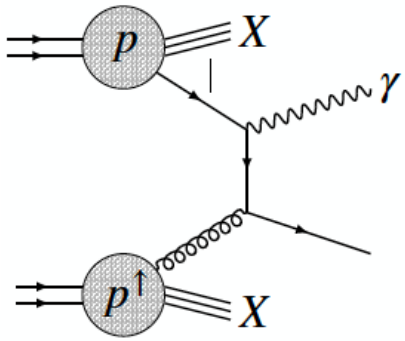


$$p^{\uparrow} + p \rightarrow D^0/\bar{D}^0 + X$$



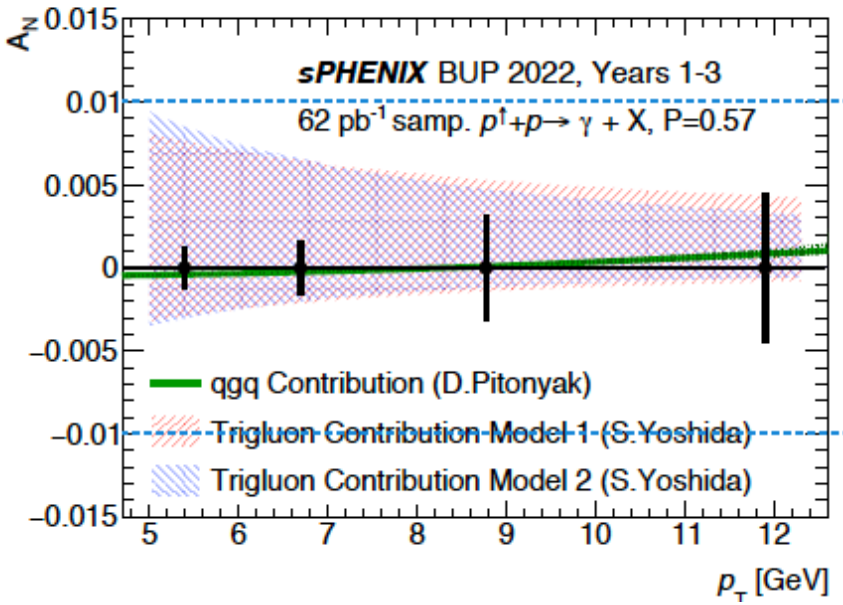
Explores gluon spin contribution to proton spin

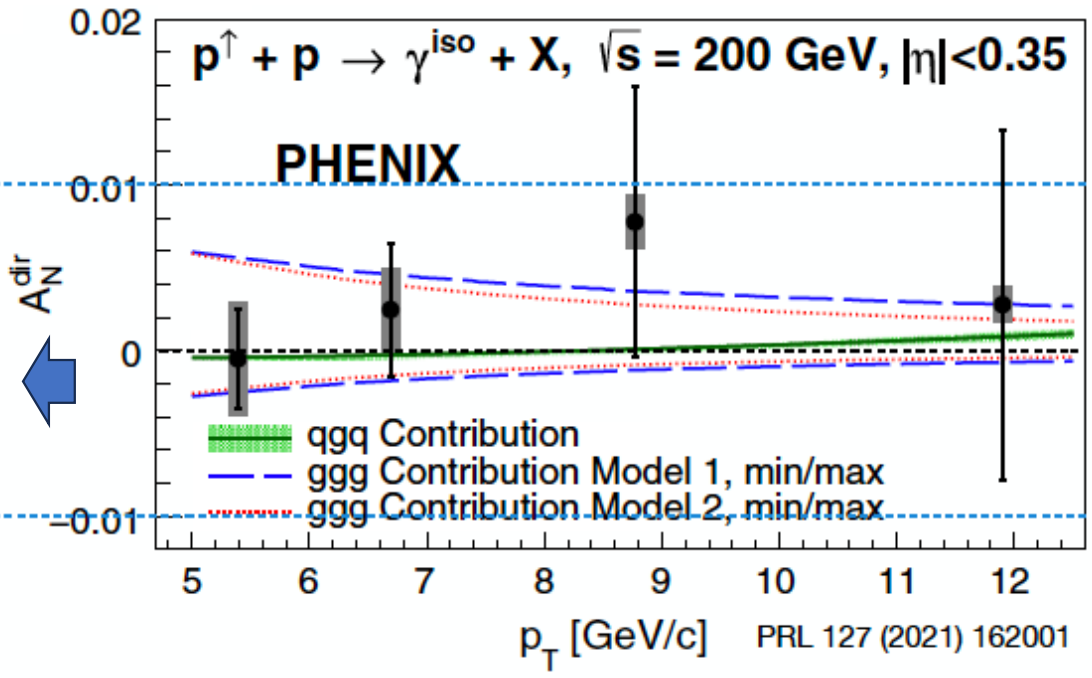
Cold QCD : Gluon TMD with Direct photons



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

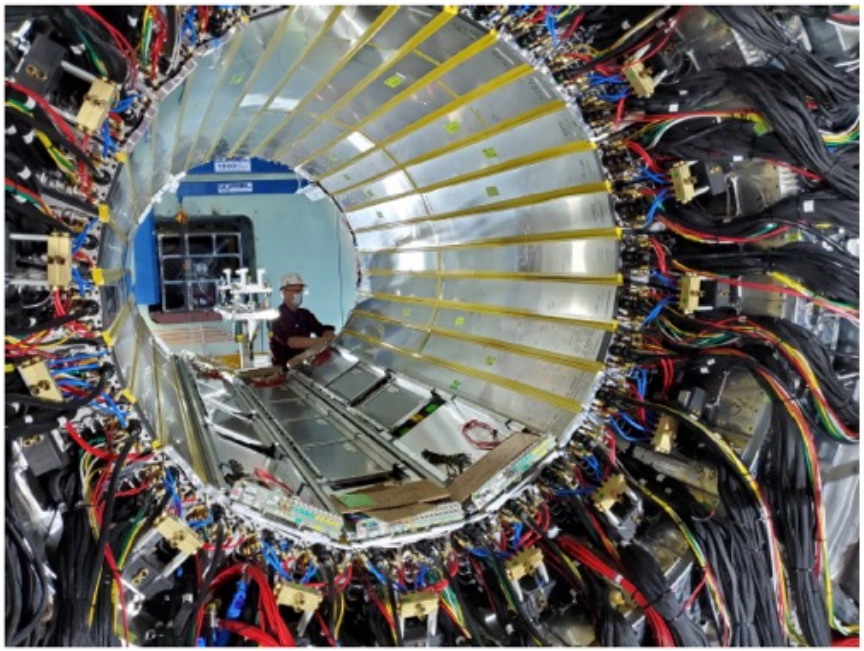
Much improved direct photon TSSA -> gluon TMD

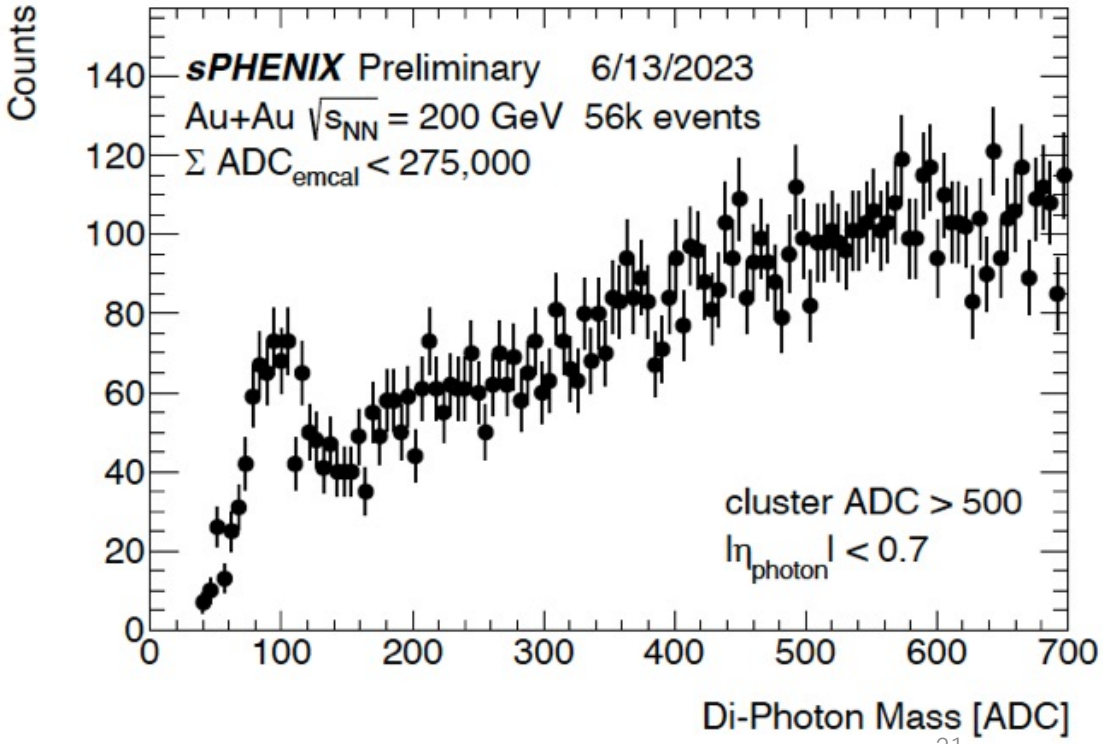




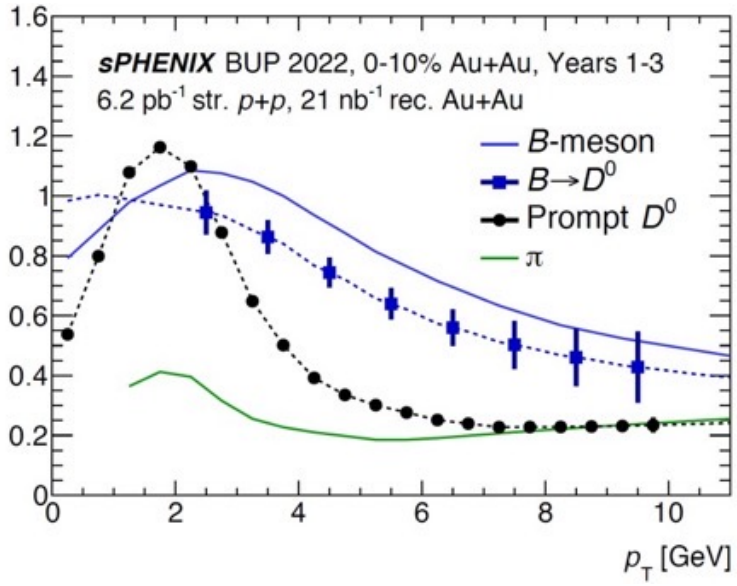
First Data from Commissioning: EMCal

- Clear **pi0 peak seen in the di-photon invariant mass spectrum**



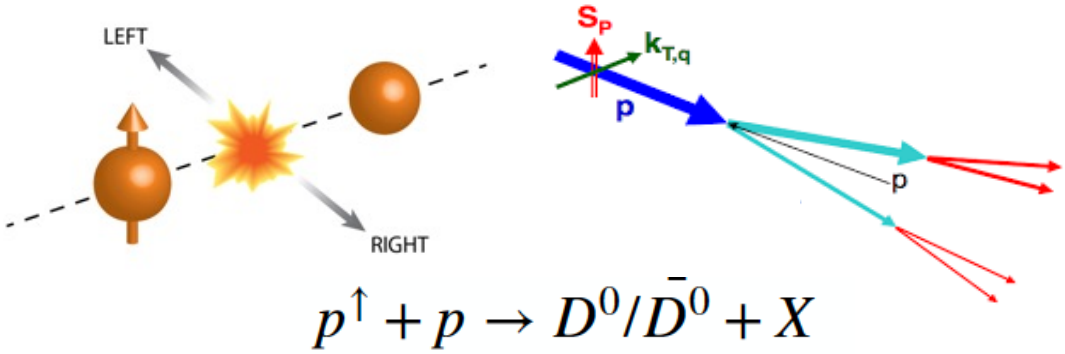


Heavy Flavor

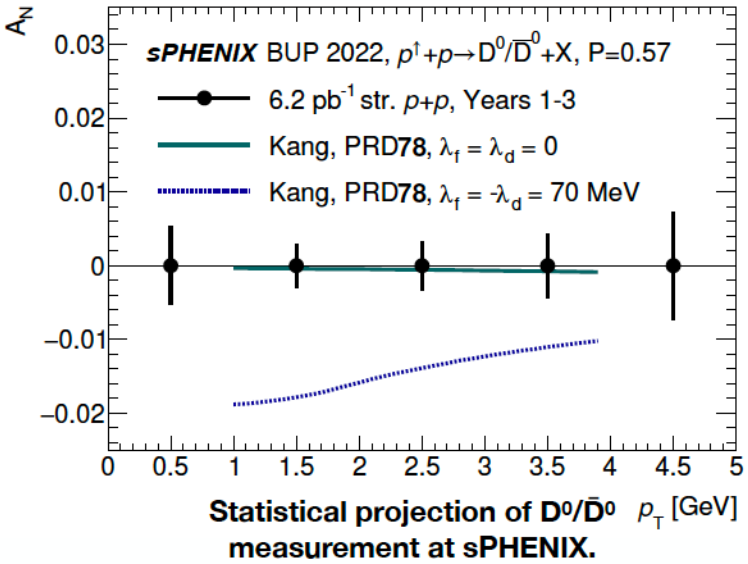


- ✓ Cleanly separate open bottom via DCA.
- ✓ Study mass dependence of energy loss and collectivity.
- ✓ Bottom quarks and light quarks are expected to be different for R_{AA} and v_2 for $p_T \lesssim 15$ GeV.

Polarized single spin asymmetry



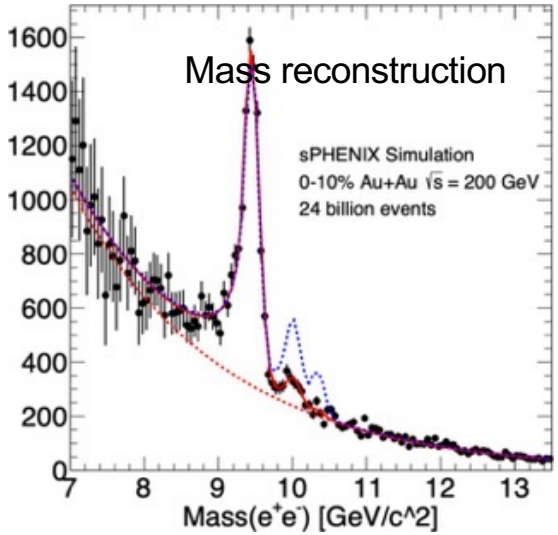
$$p^{\uparrow} + p \rightarrow D^0/\bar{D}^0 + X$$

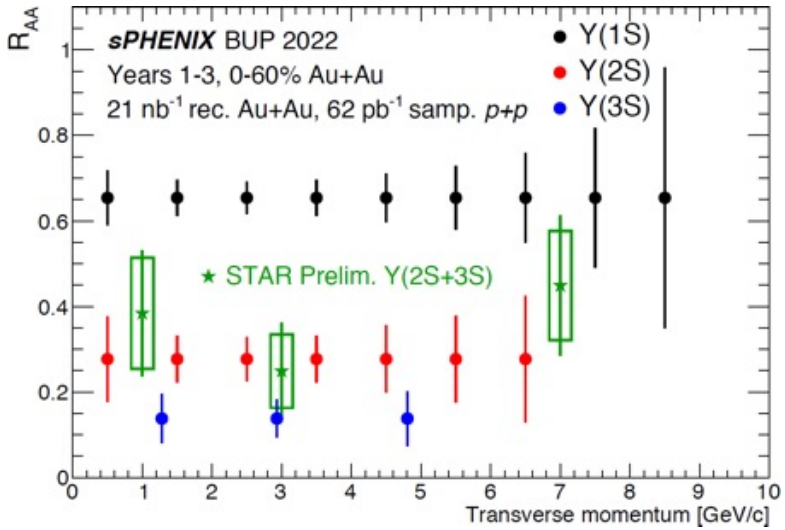


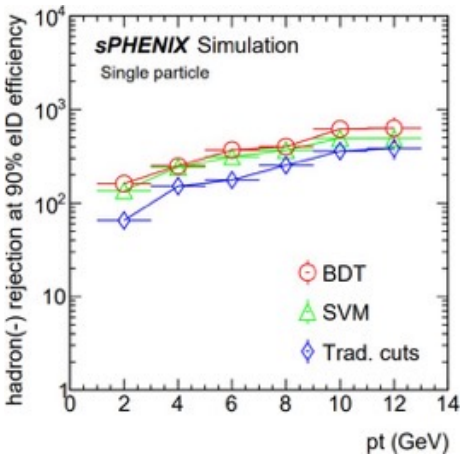
Statistical projection of $D^0/\bar{D}^0$ measurement at sPHENIX.

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.