

The sPHENIX Open and Close Heavy Flavor Program

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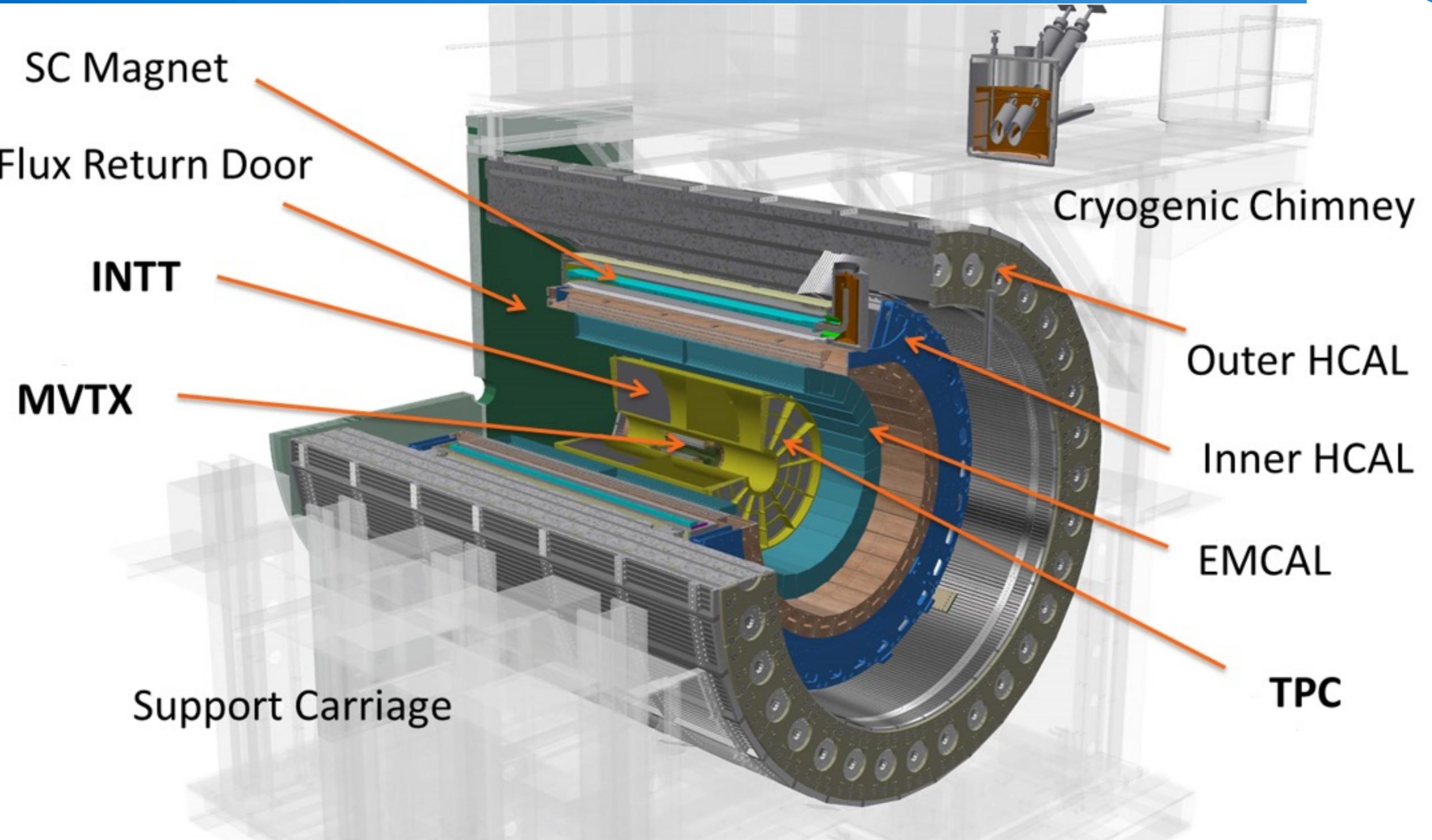
on behalf of the sPHENIX collaboration

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**QNP2022 - The 9th International Conference on Quarks
and Nuclear Physics**

5-9 September 2022, Tallahassee, Florida, USA (Virtual)

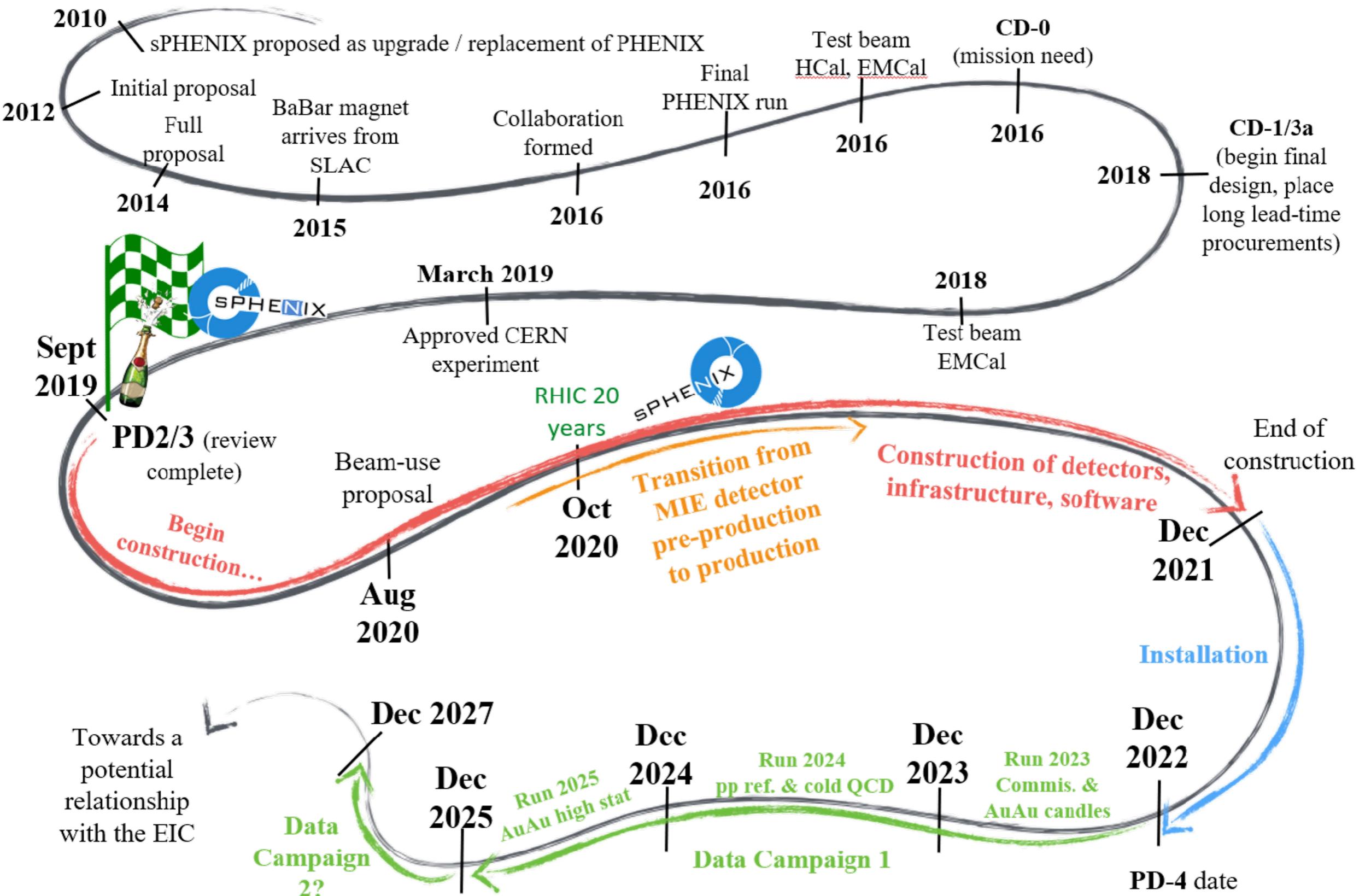
The sPHENIX Experiment at RHIC



2015 NSAC Long range Plan for Nuclear Science: sPHENIX experiment at RHIC

- Probe the inner workings of QGP by resolving its properties at shorter and shorter length scales
- Complementary to LHC experiments

Overall sPHENIX Timeline



- Collective efforts of international collaboration from countries over two decades

sPHENIX Detector Commissioning



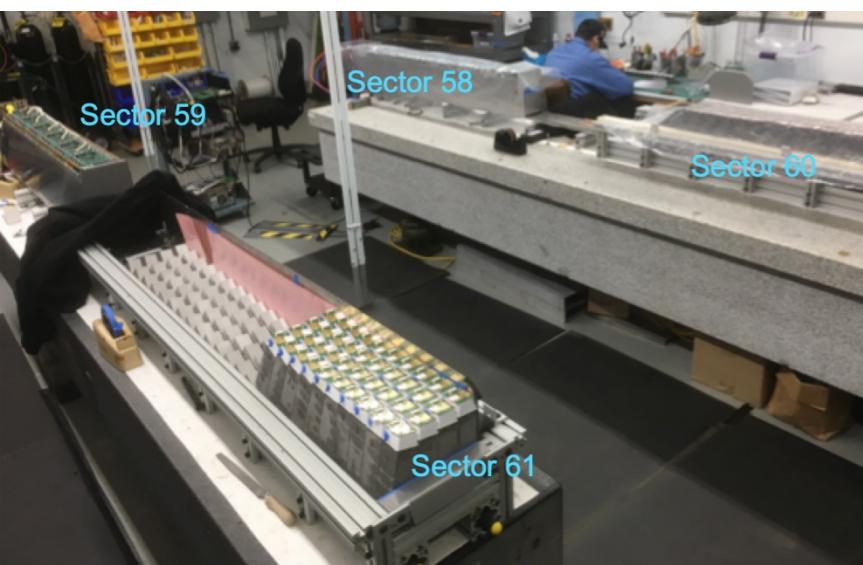
TPC commissioning at Stony Brook University



TPOT Effort By
LANL/Stony Brook



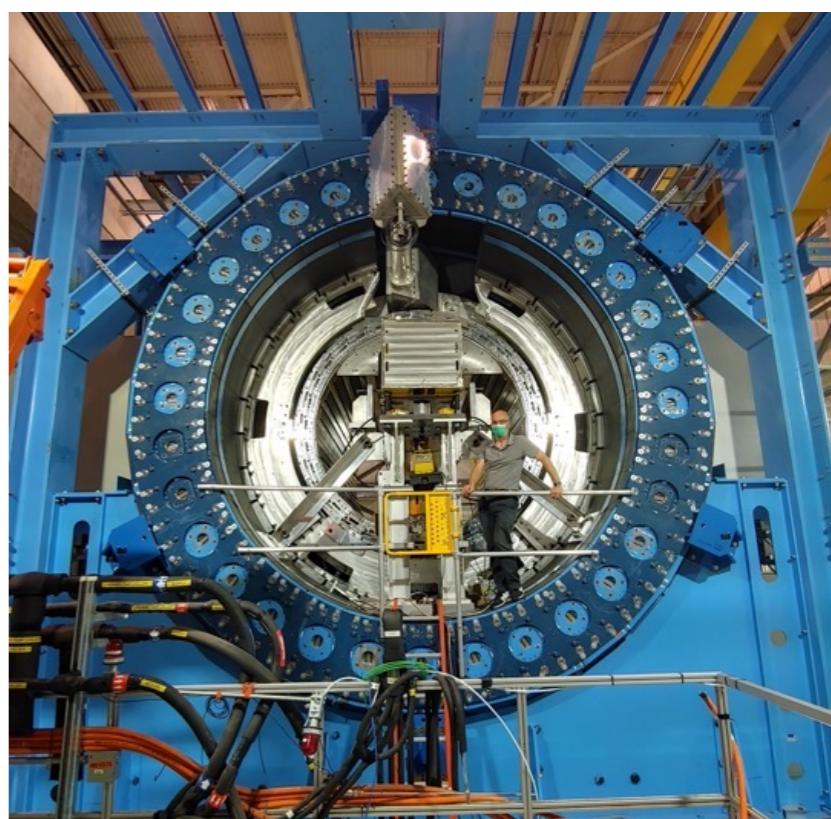
INTT stave completed, carbon fiber parts at BNL



EMCAL assembly at BNL



Commissioning Task Force



sPHENIX detector with
HCAL in the PHENIX hall

- Lots of commissioning activities of detectors ongoing in many places
- Collaborative and diverse workforce of students, postdocs, staff, and faculty
- Install the sPHENIX detector from outermost to innermost in the PHENIX hall at BNL

MVTX Commissioning Status

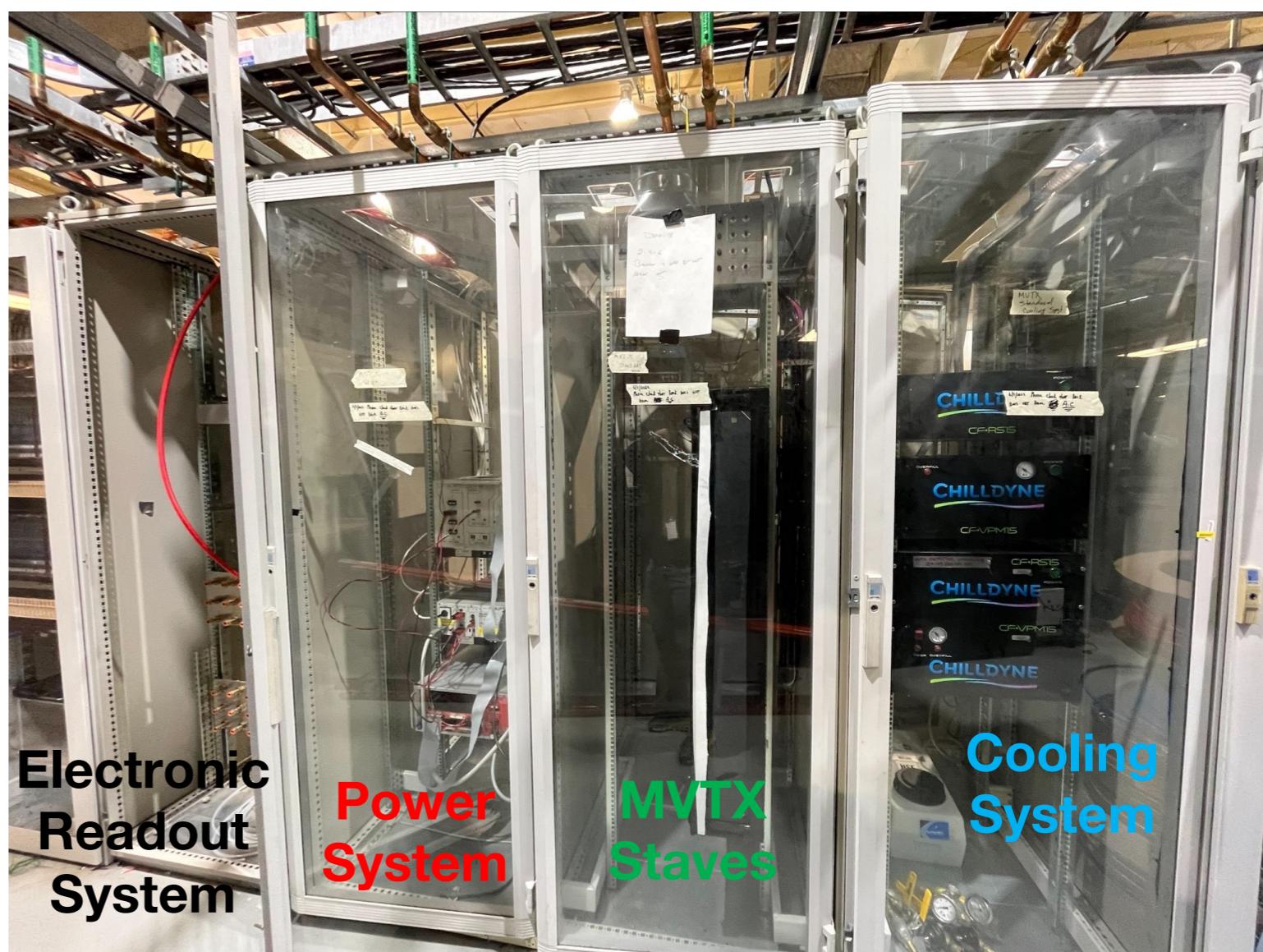


LBNL Assembly

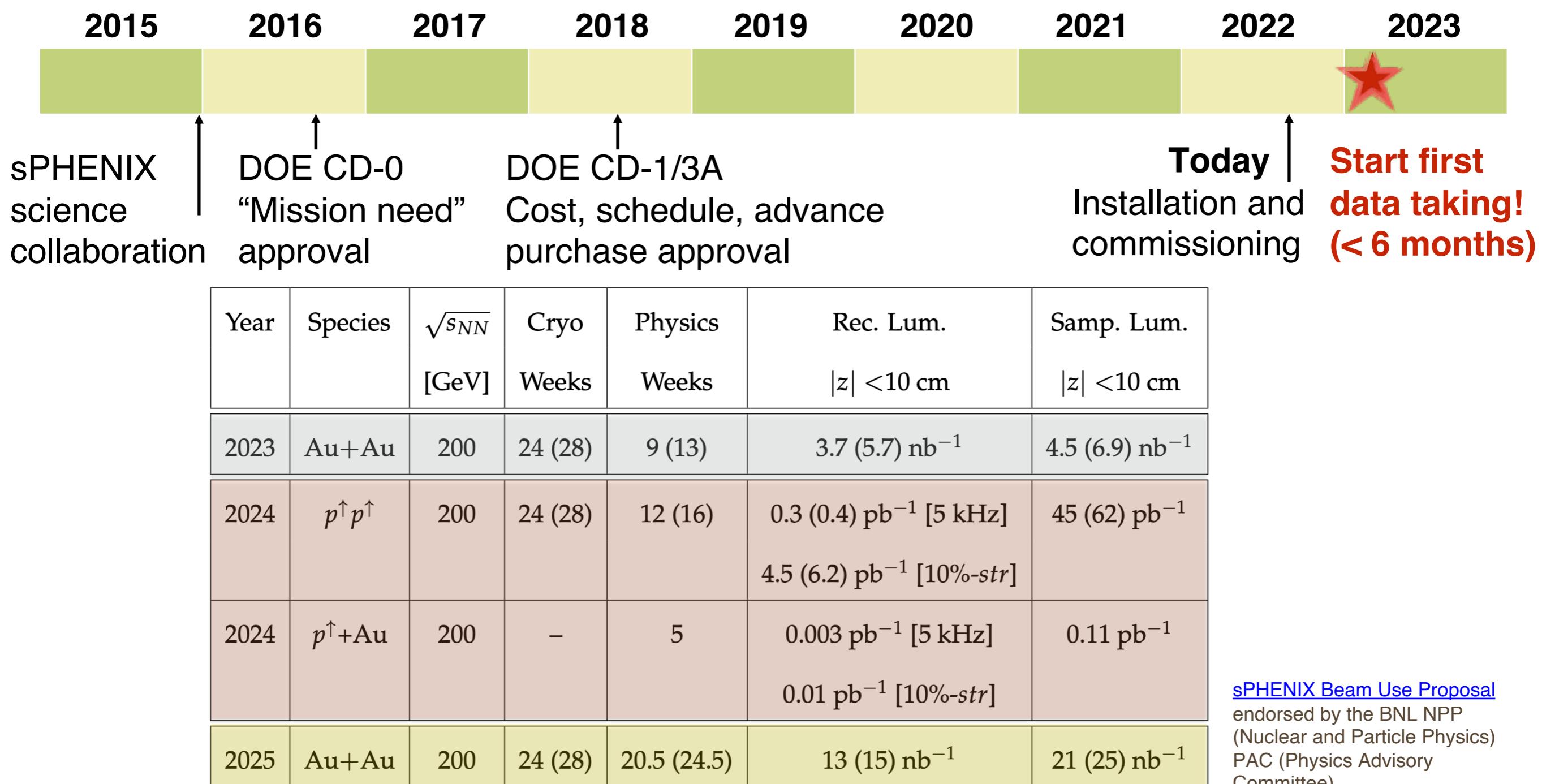
- Half detector assembly: stave gluing to carbon structure
- Precision alignment with machine CMM
- MVTX CAEN power system and cabling

BNL Commissioning

- Clean tent setup
 - MOSAIC system to test the functionality of the staves
- 8-stave MVTX telescope setup
 - Readout chain test
 - Detector alignment
 - Ensure high quality data taking

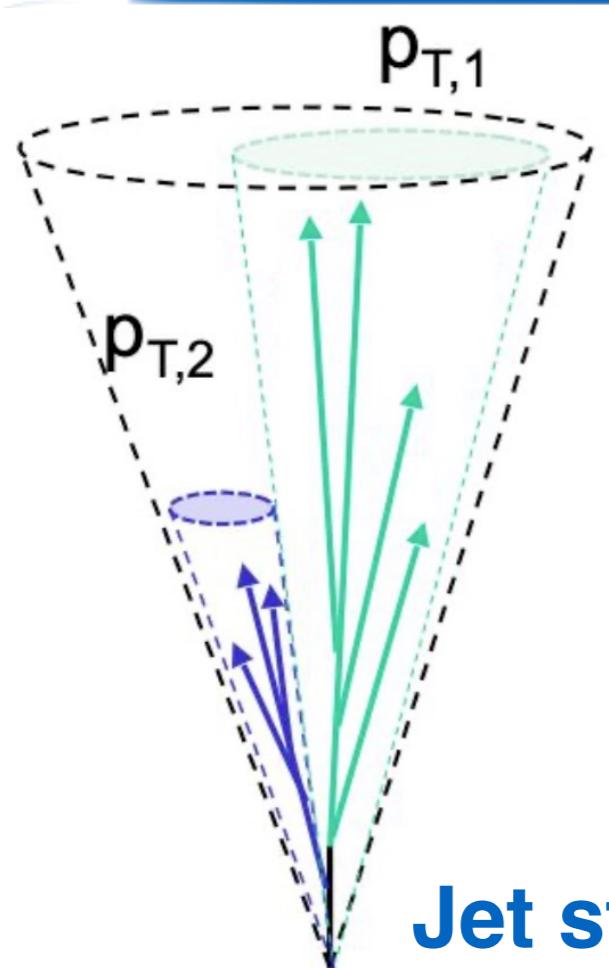


Proposed Run Plan

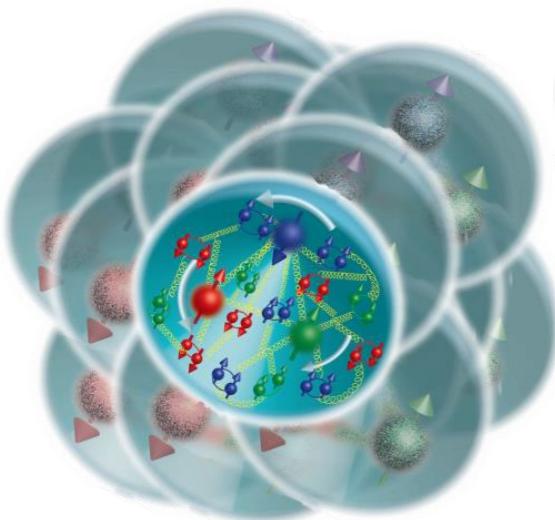


- Extensive **3-year** data taking starting in < 6 months
 - Year-1:** commissioning and first physics in Au+Au
 - Year-2:** p+p and p+Au runs for heavy-ion reference and cold QCD physics
 - Year-3:** very large Au+Au dataset (145B events in total)

The sPHENIX Physics Program



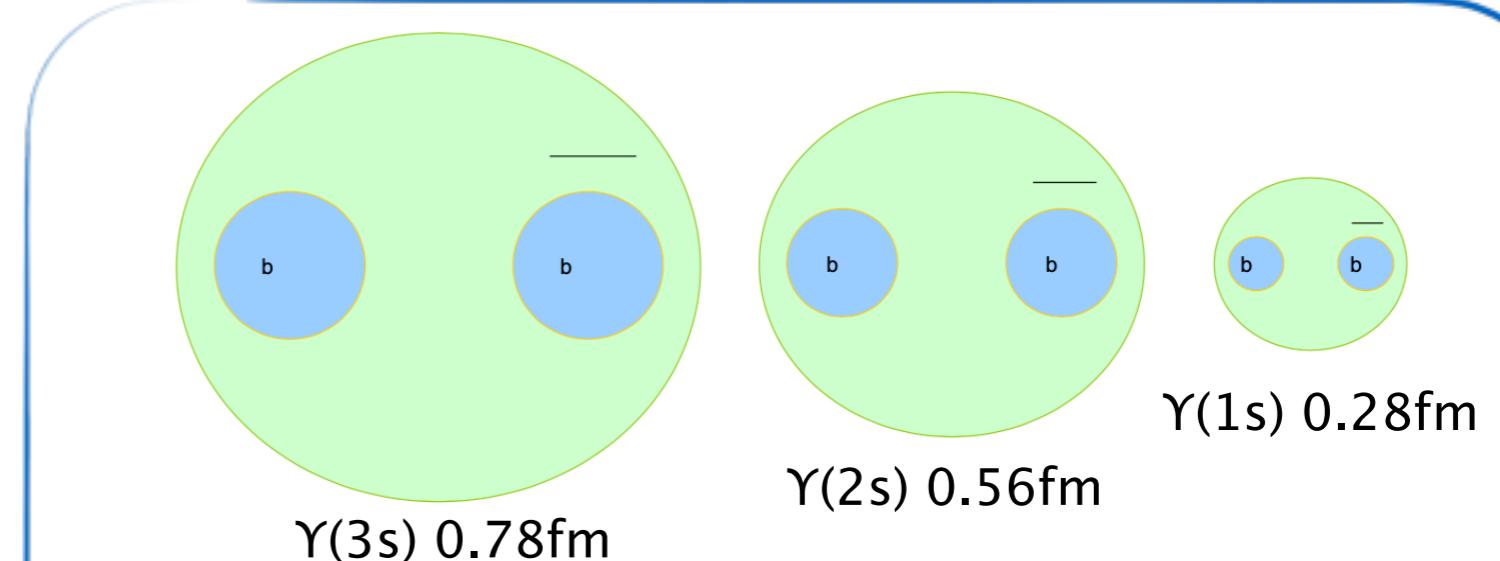
Jet structure
vary momentum/angular scale of probe



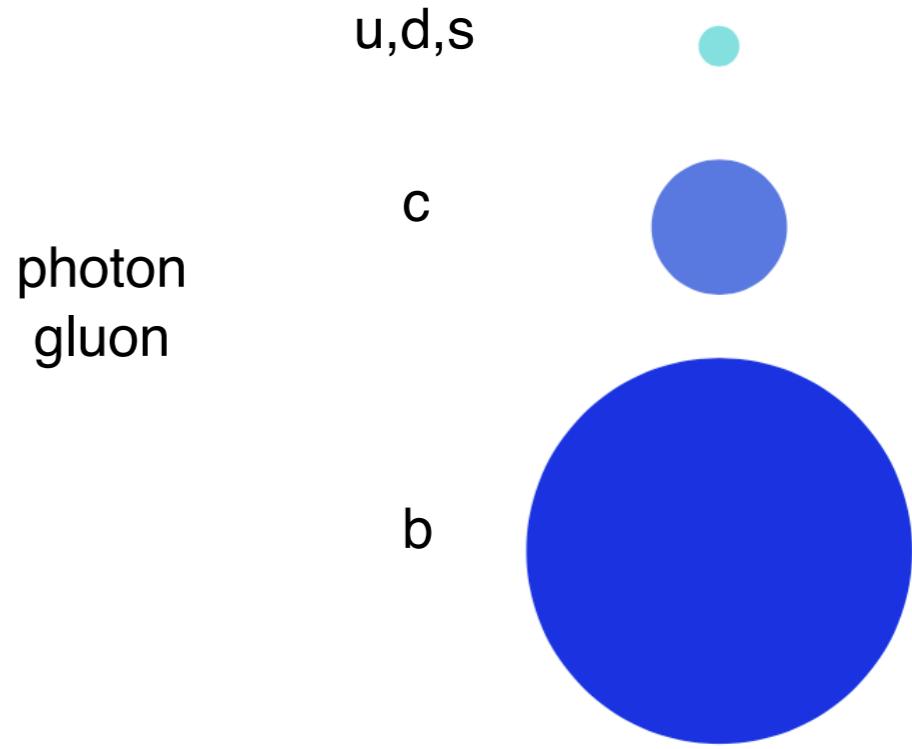
Cold QCD
study proton spin,
transverse-momentum,
and cold nuclear effects



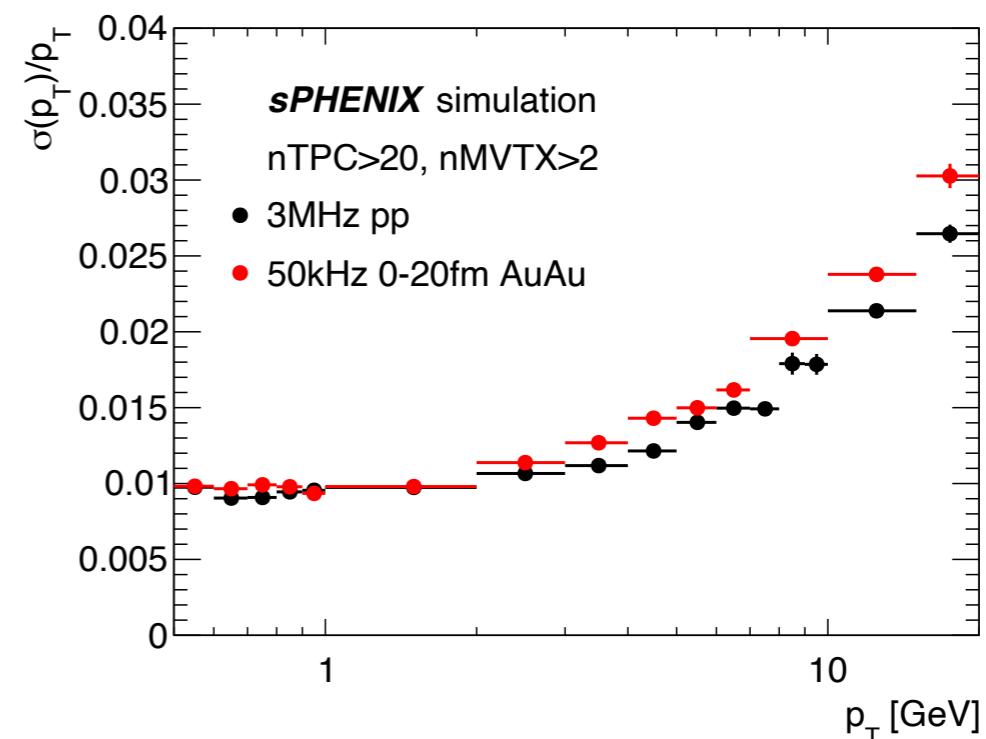
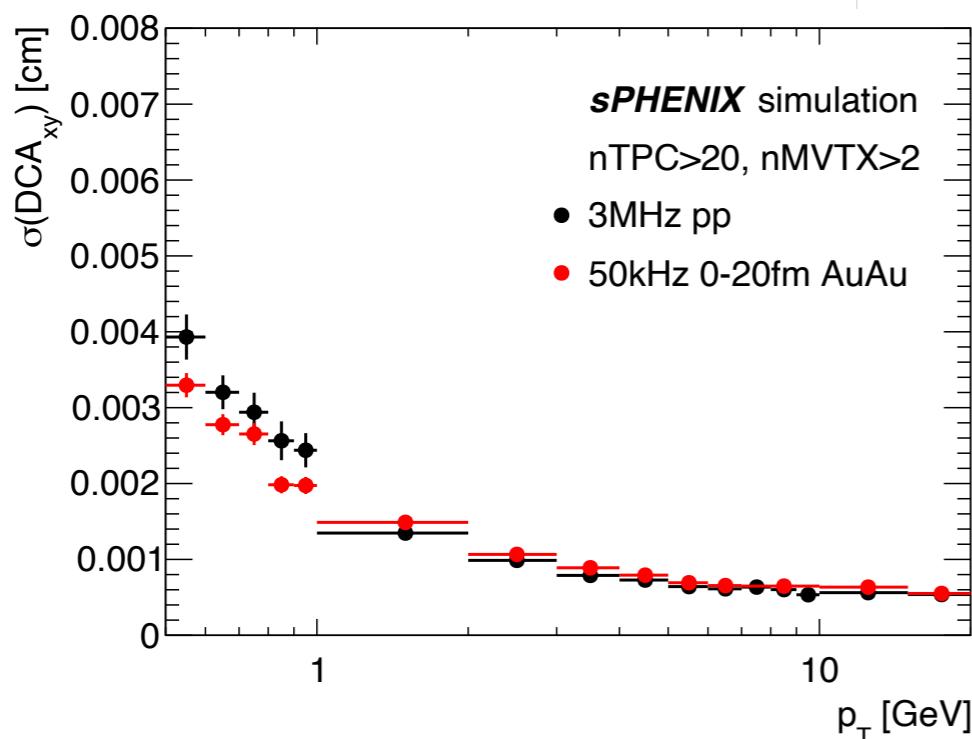
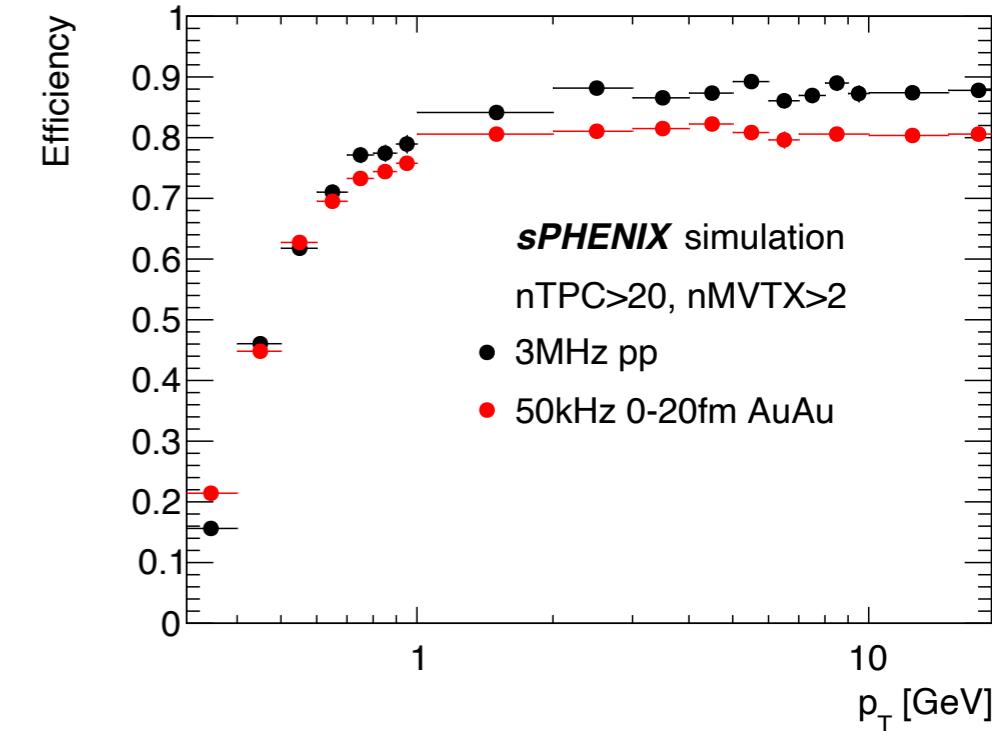
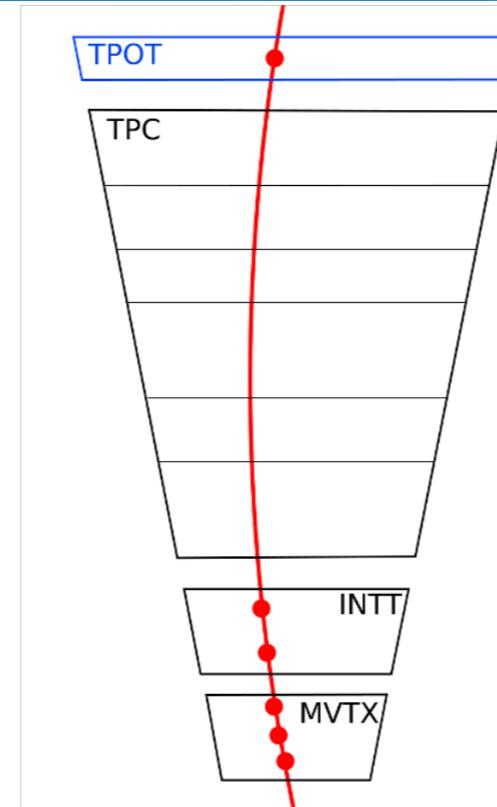
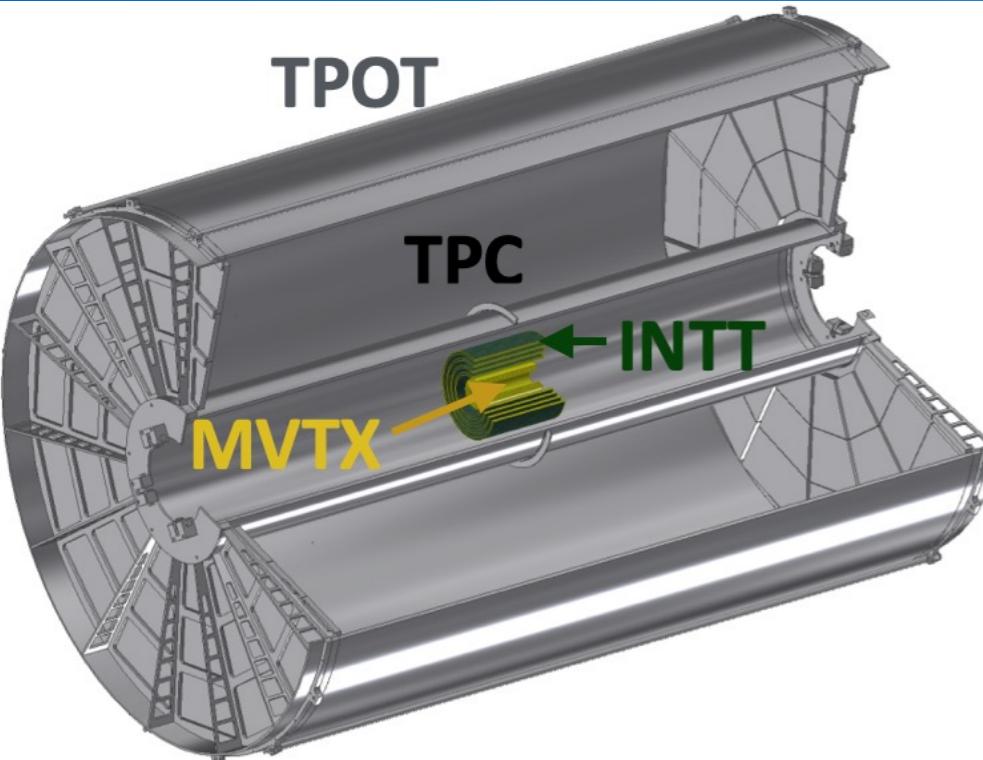
Quarkonium spectroscopy
vary size of probe



Parton energy loss
vary mass/momentum of probe
u,d,s

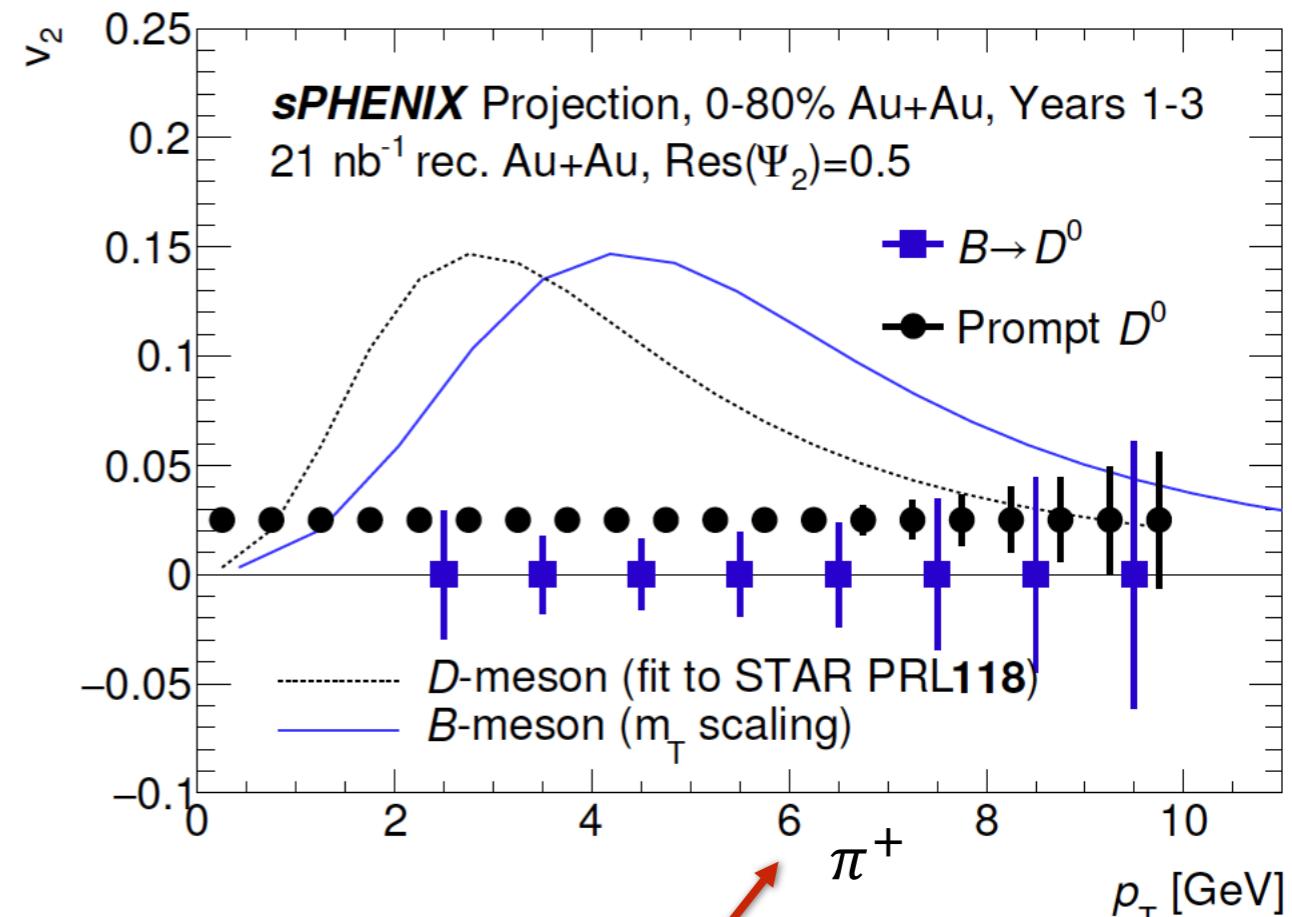
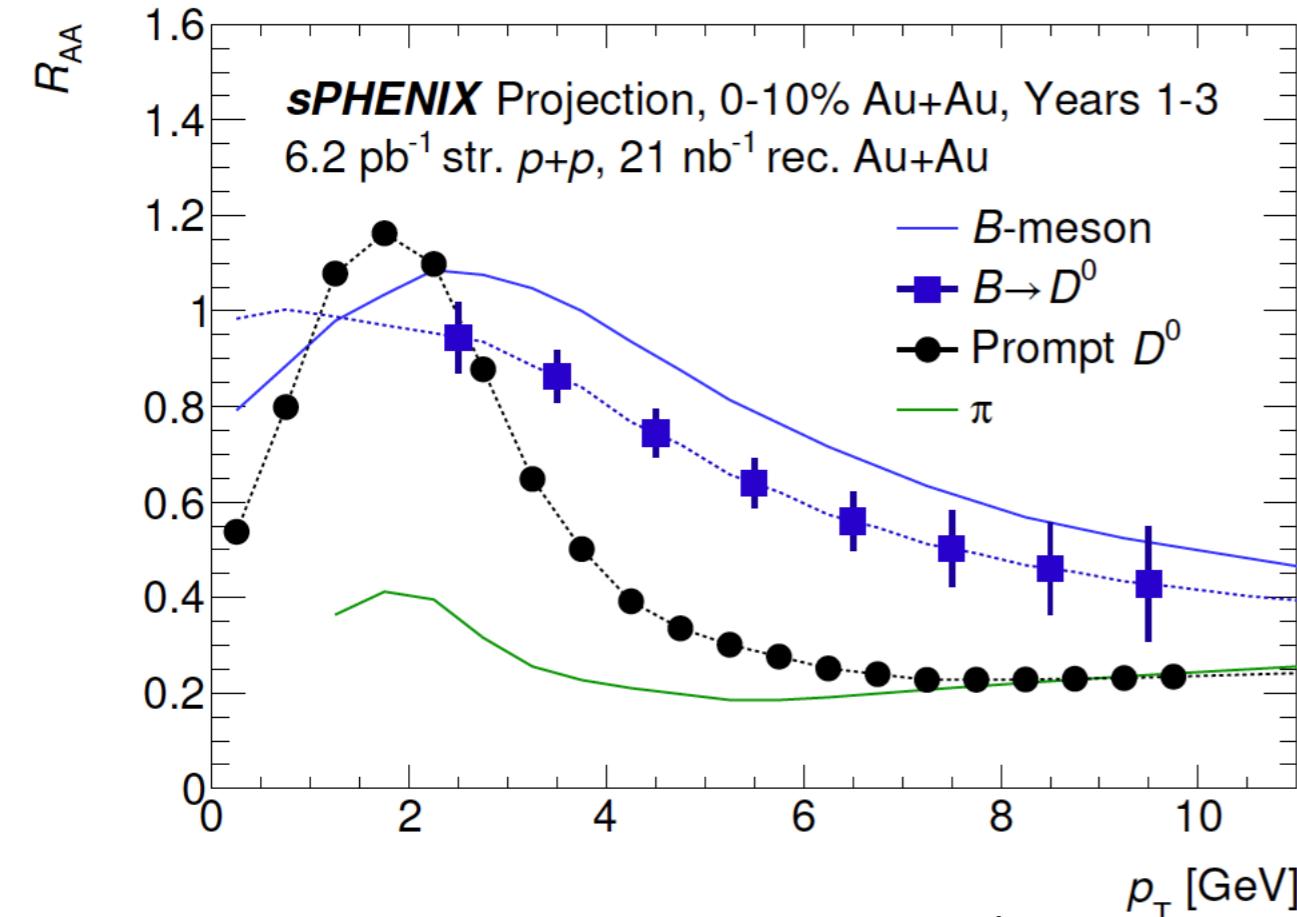


Tracking System and Performance

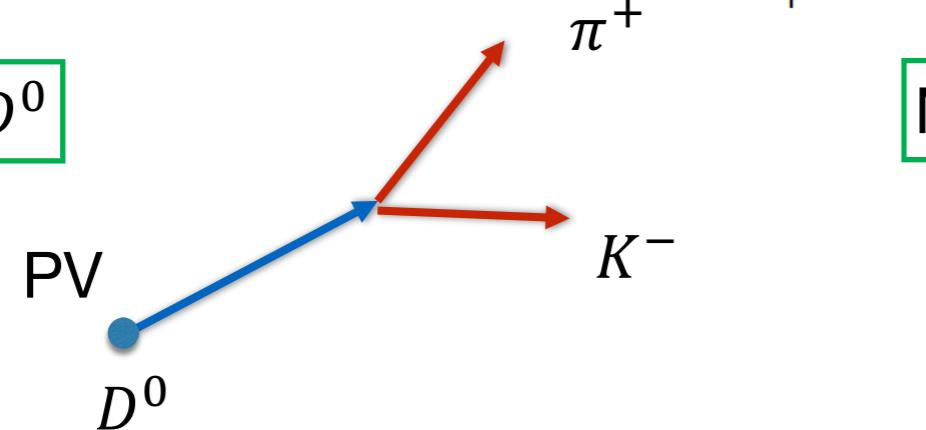


- MVTX and INTT operating in continuous streaming readout mode with fast electronics
- TPC + TPOT for main for outer tracking
- Excellent tracking reconstruction and vertexing performance for HF physics studies

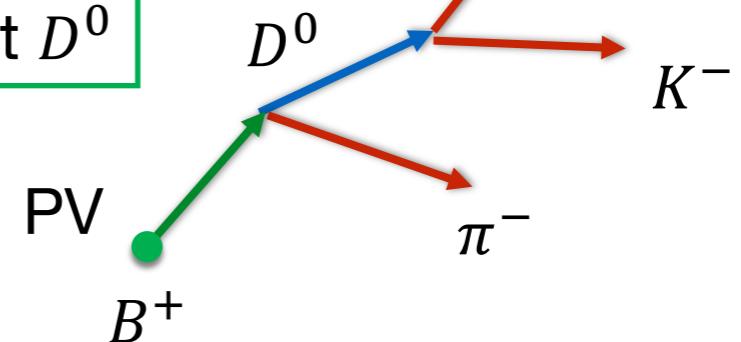
Fully reconstructed D^0 mesons



Prompt D^0

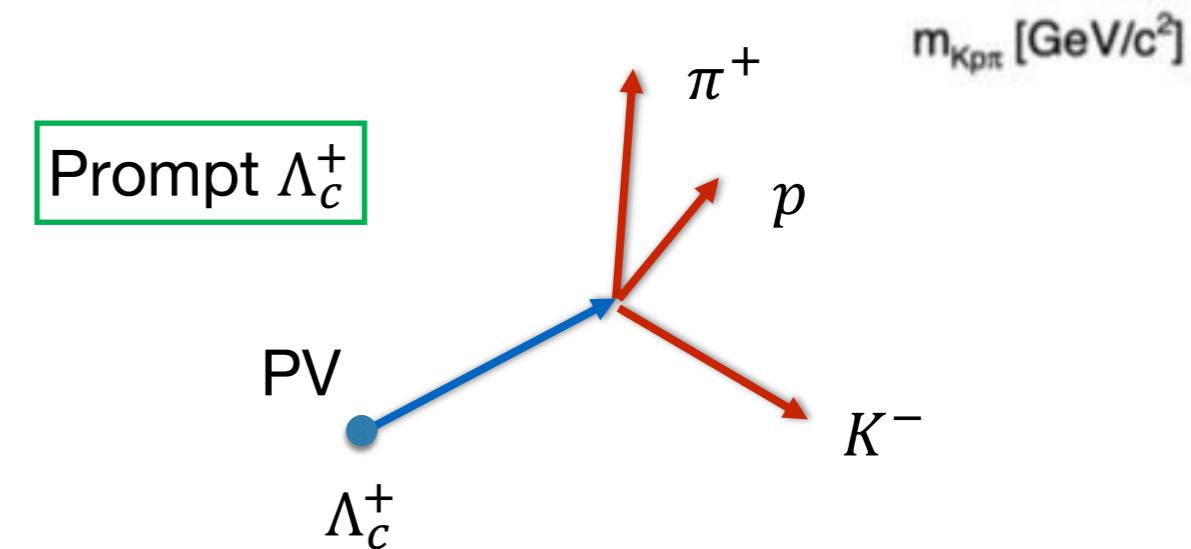
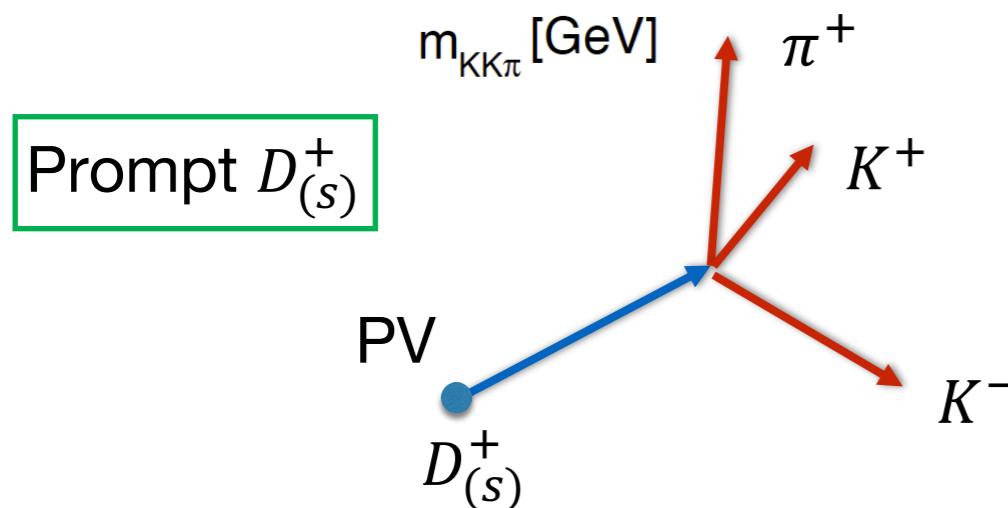
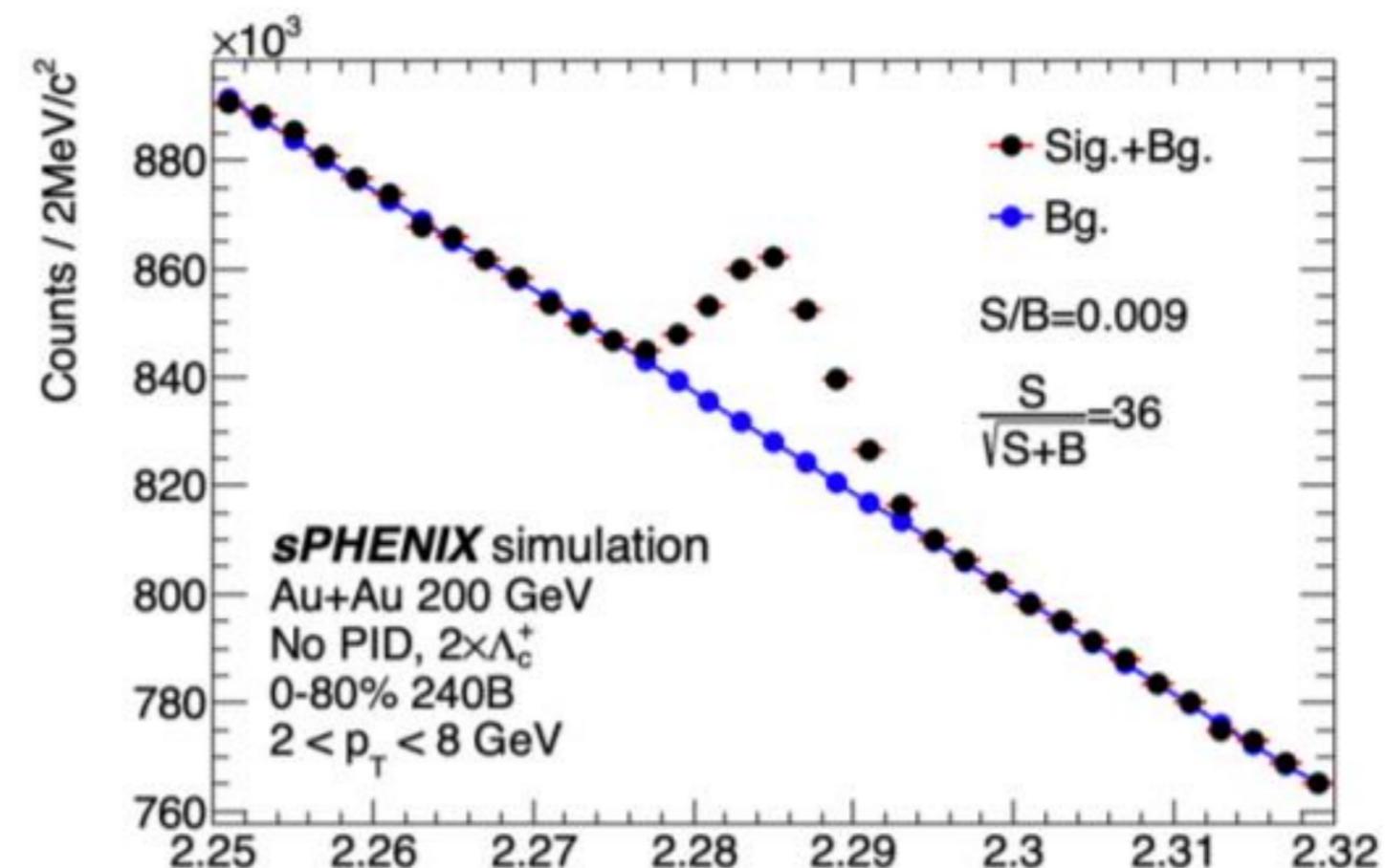
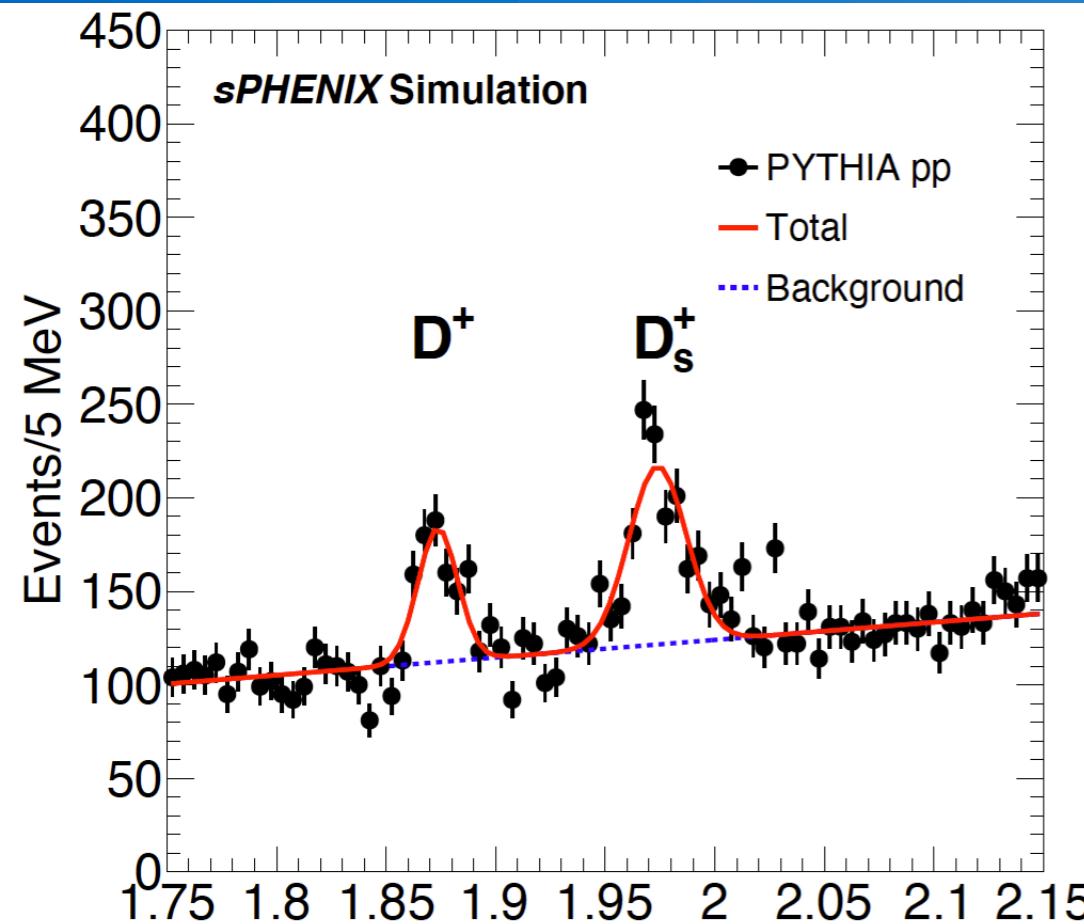


Non-Prompt D^0



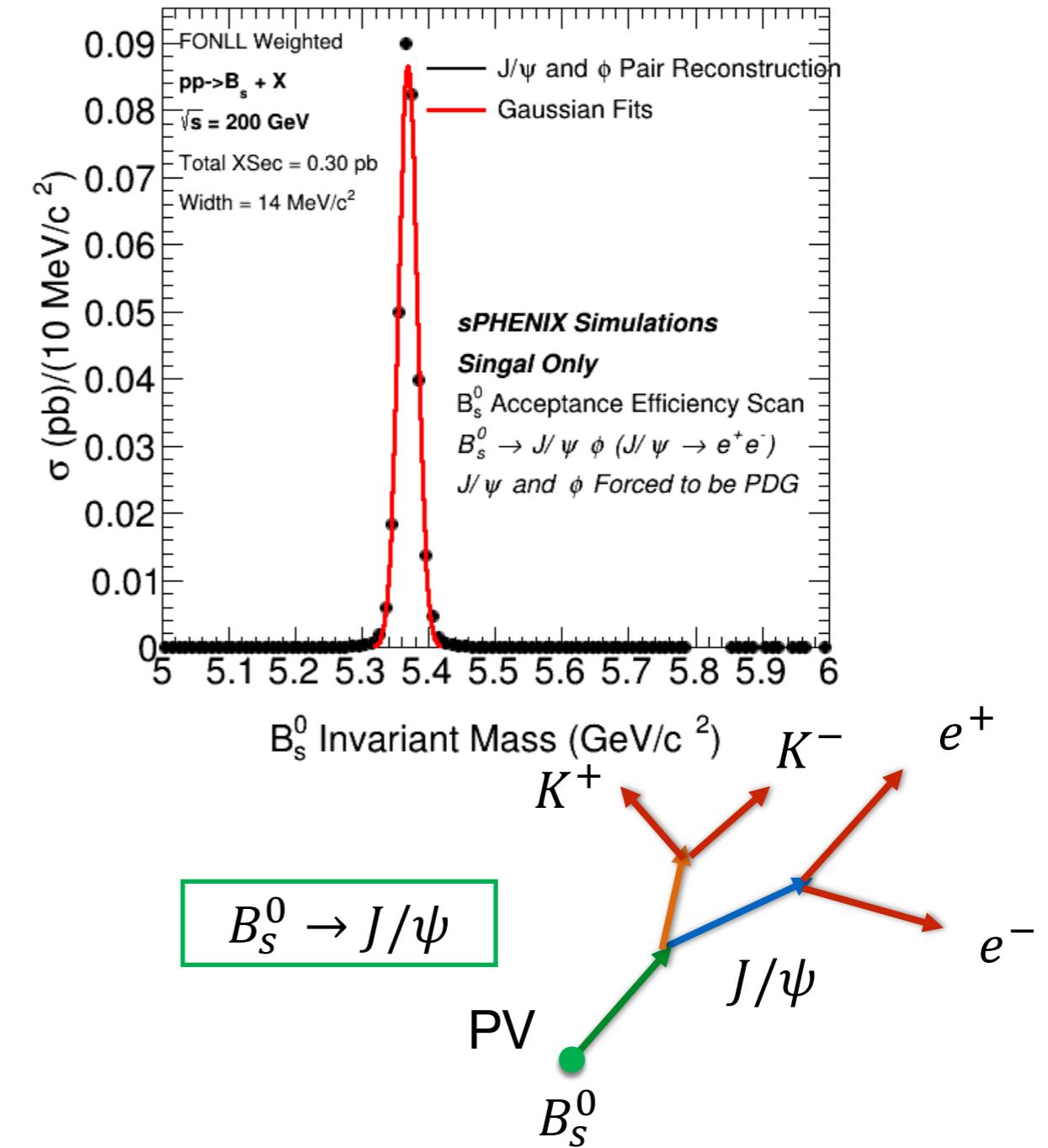
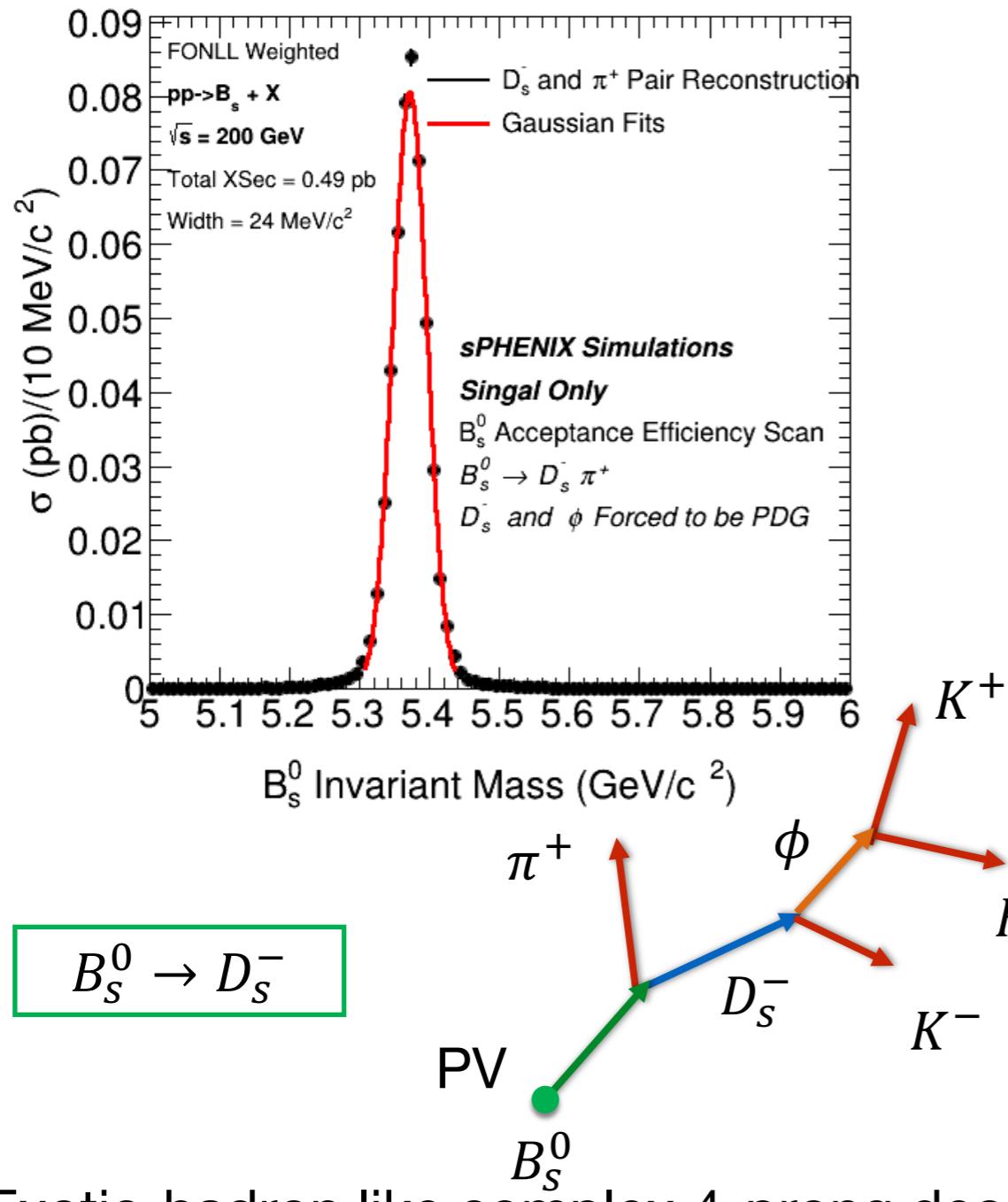
- Fully reconstructed D^0 via $D^0 \rightarrow K^- \pi^+$ without hadronic PID
- Charm quark energy loss mechanism to probe the internal structure of QGP
- Diffusion coefficient for charm quarks in QGP at RHIC energy
- Data-driven method to separate of prompt and non-prompt D^0 with DCA
- $D^0 v_2$: candidate measurement for Year 1 Heavy Flavor Physics

Charm Hadronization



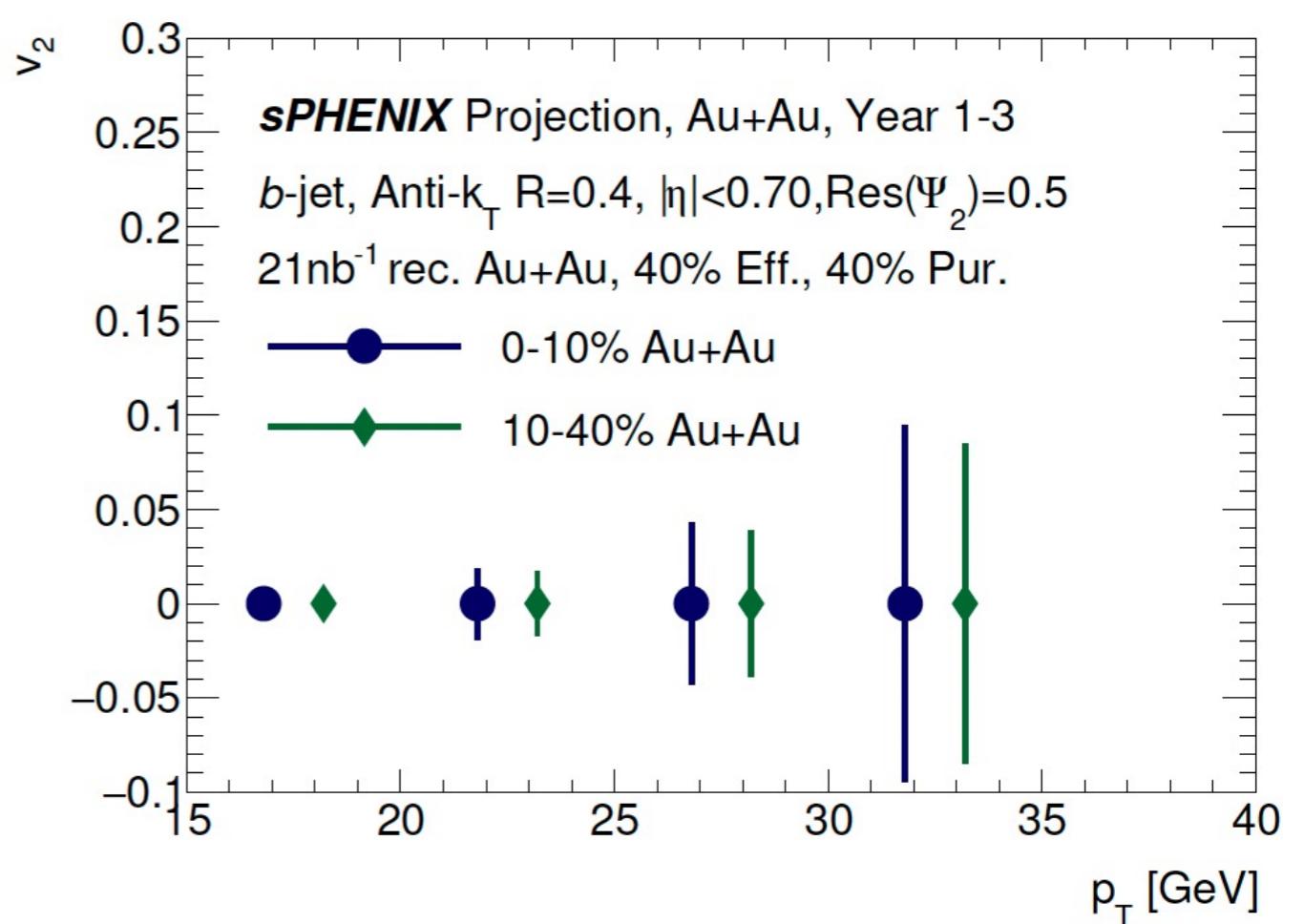
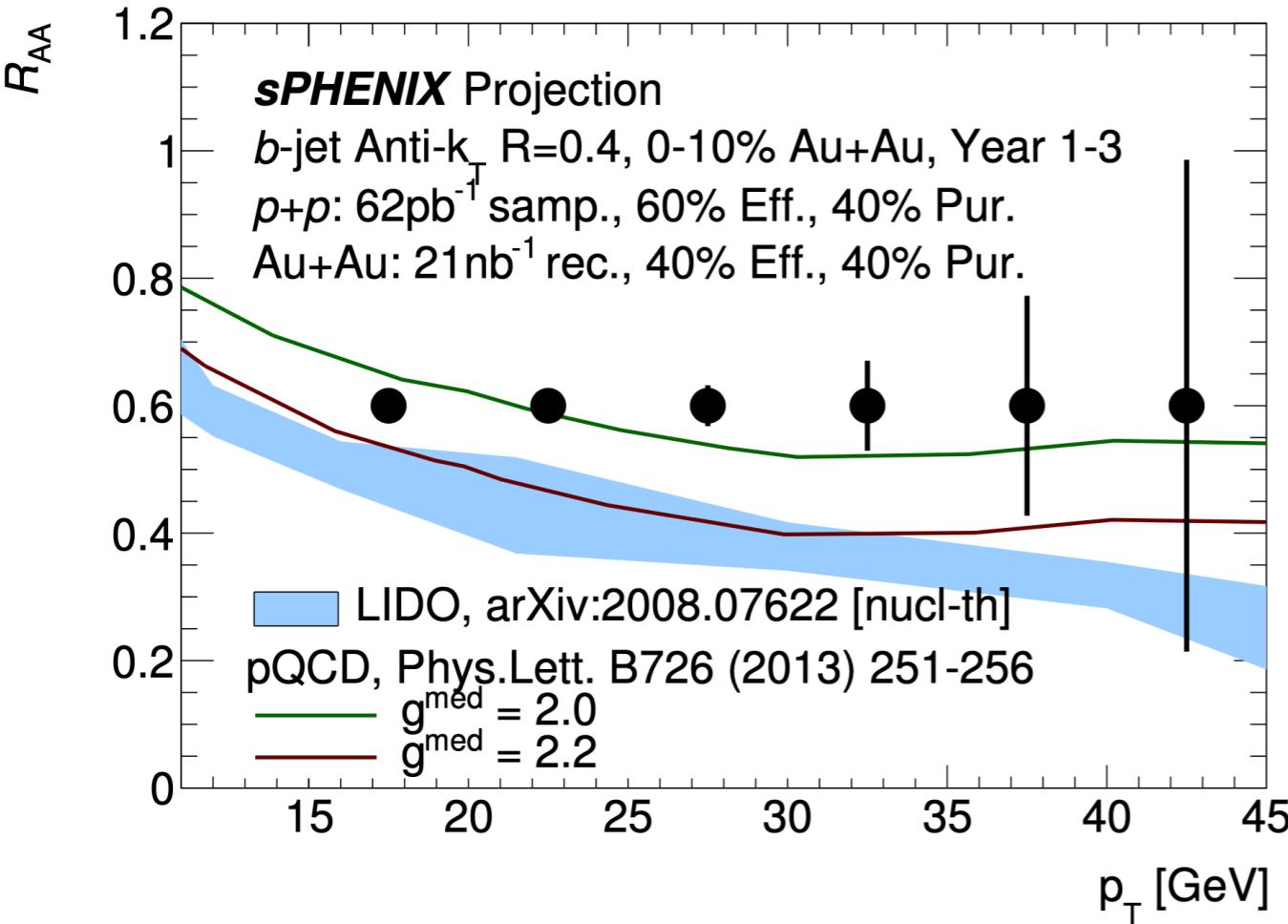
- More complex 3-prong decays
- High precision measurement thanks to streaming readout data taking and tracking
- Study charm hadronization from vacuum to QGP via the measurements of D_s^+/D^+ and Λ_c^+/D^0 as a function of event multiplicity

Fully Reconstructed B_s^0 Meson

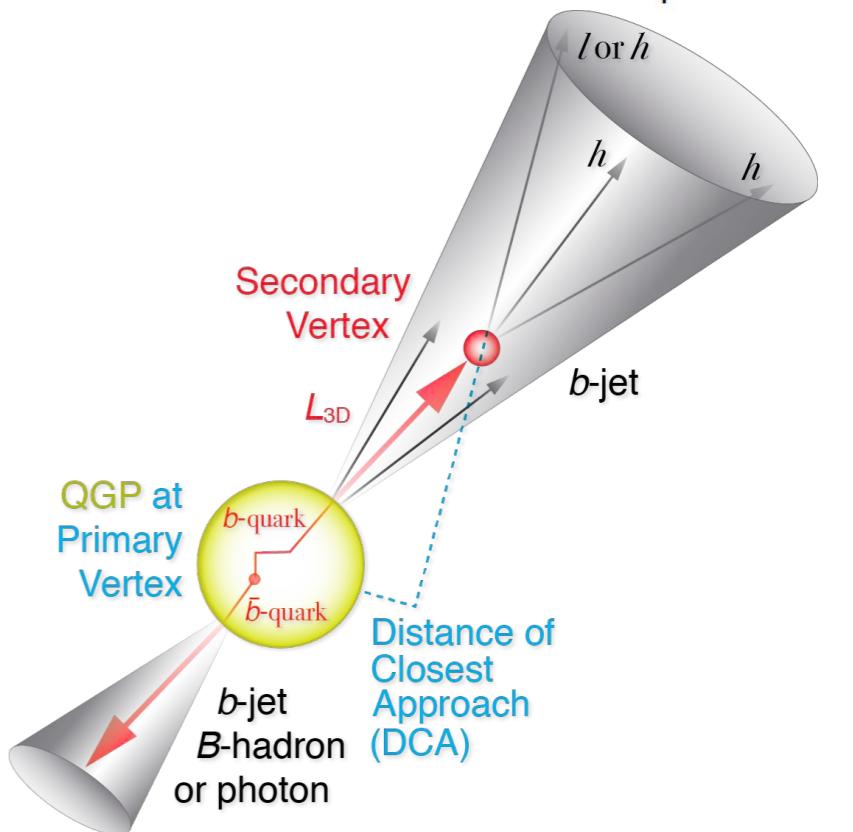


- Exotic-hadron like complex 4-prong decays
- FONLL weight B_s^0 in GEANT simulation for signal only prediction
- First observation of fully reconstructed B-meson in nuclear collisions at RHIC
- Study beauty quark hadronization mechanism with B_s^0/B^+ ratio
- Test QCD factorization theorem at RHIC energy in the beauty sector

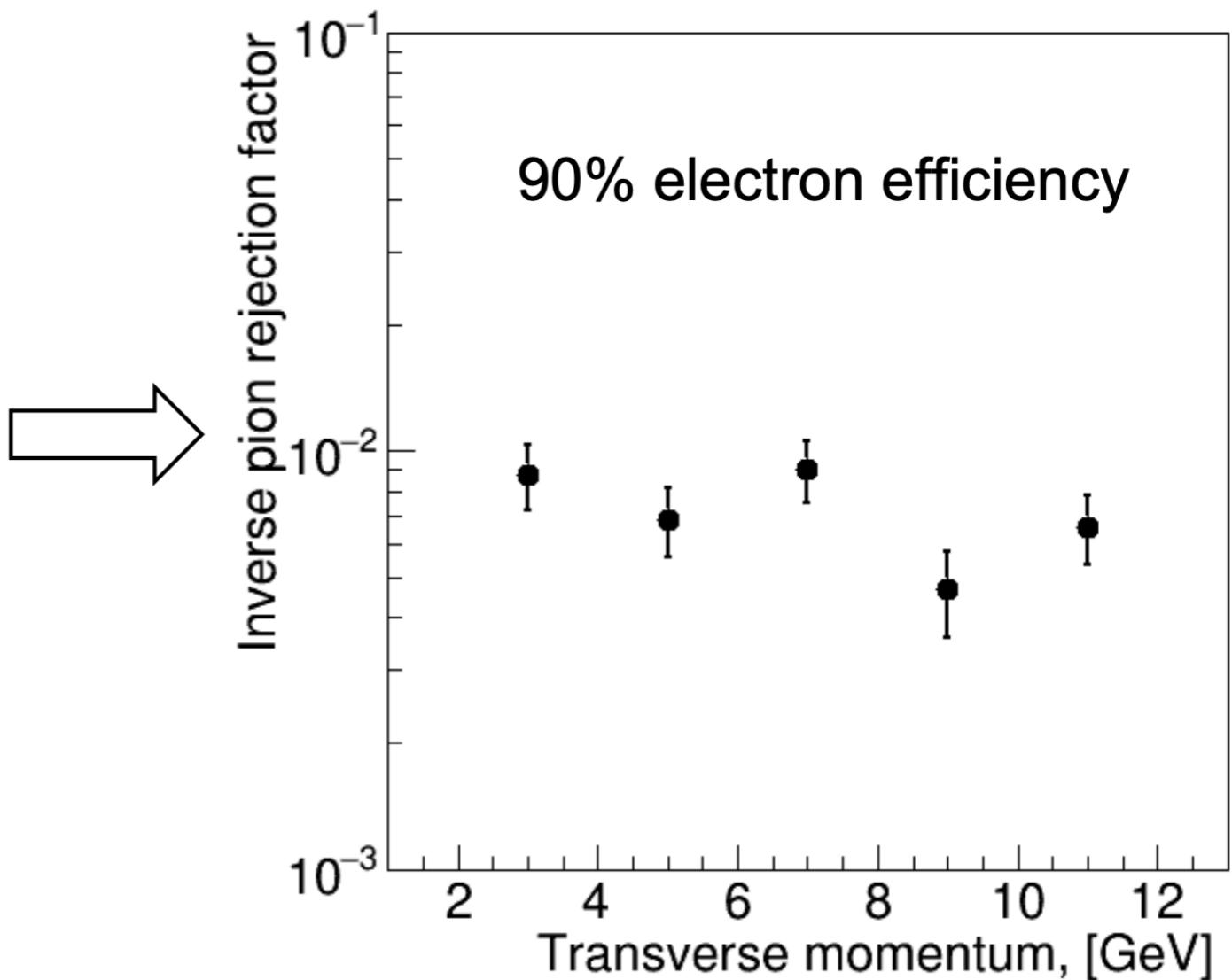
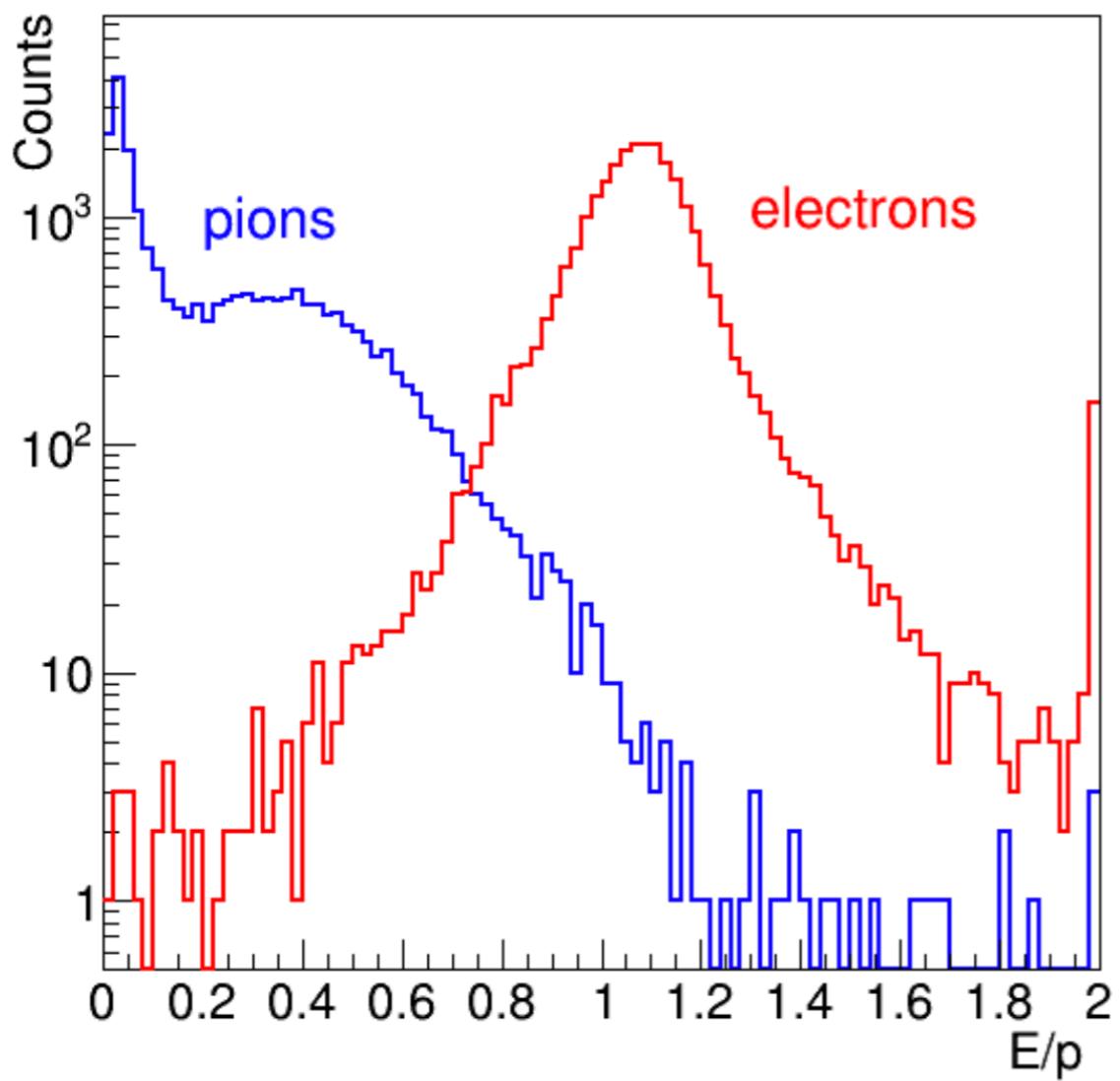
b-jet R_{AA} and v_2 Measurement



- Utilization of MVTX to reconstruct secondary vertex within the jet cone
 - Jets with displaced vertex to tag the b quarks
 - Inclusive measurement with better statistics
- First b-jet measurement at RHIC
- Sensitive to heavy-quark collisional and radiative in-medium energy loss
- Constrain beauty quark diffusion coefficient at RHIC energy
- Complementary to LHC with better measurements at lower p_T

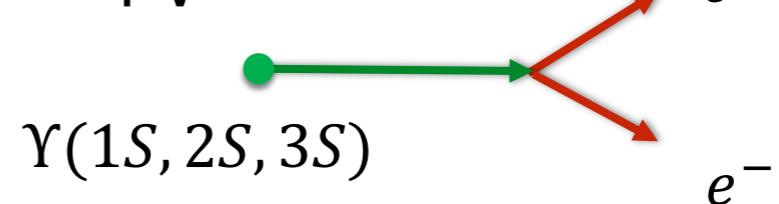
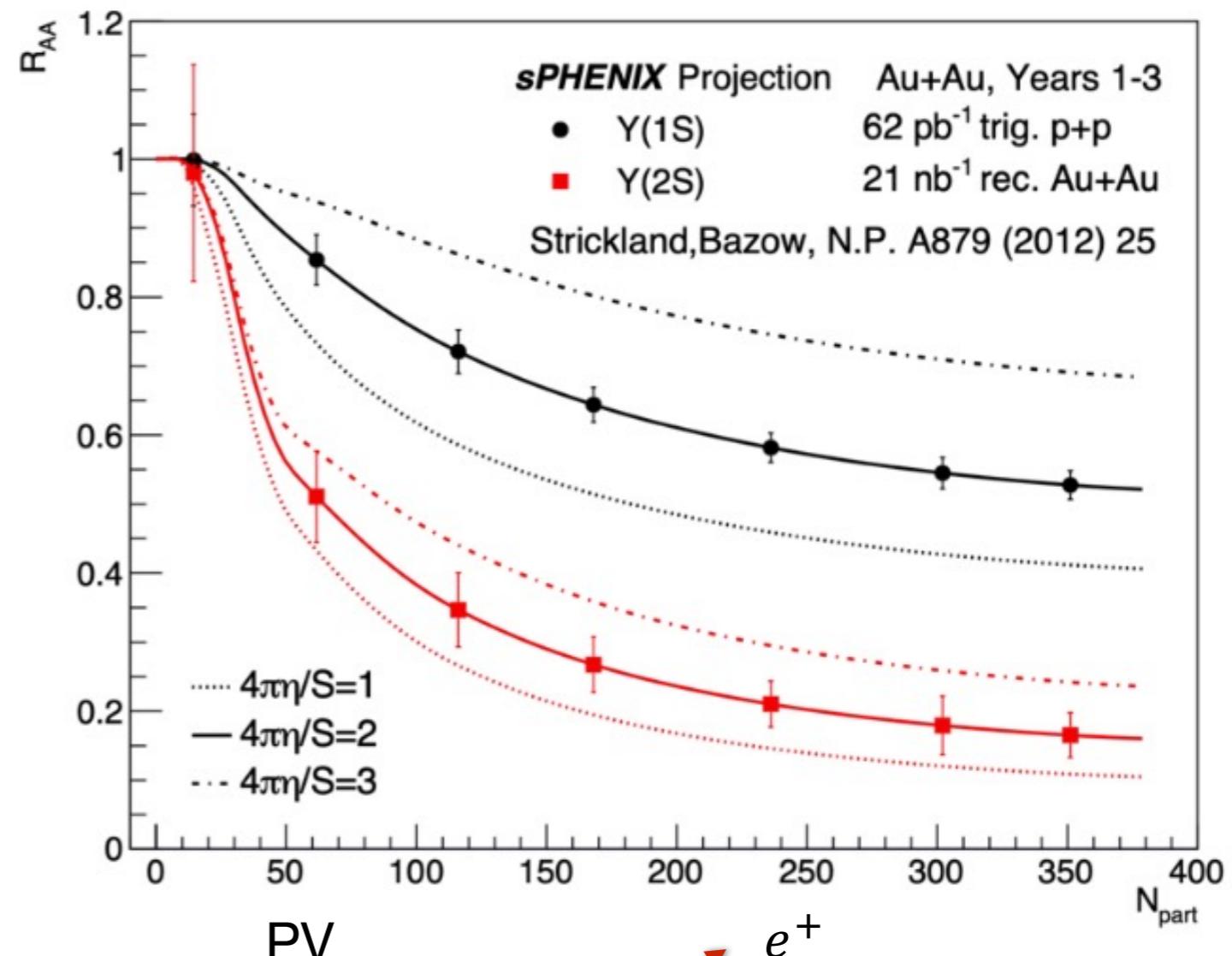
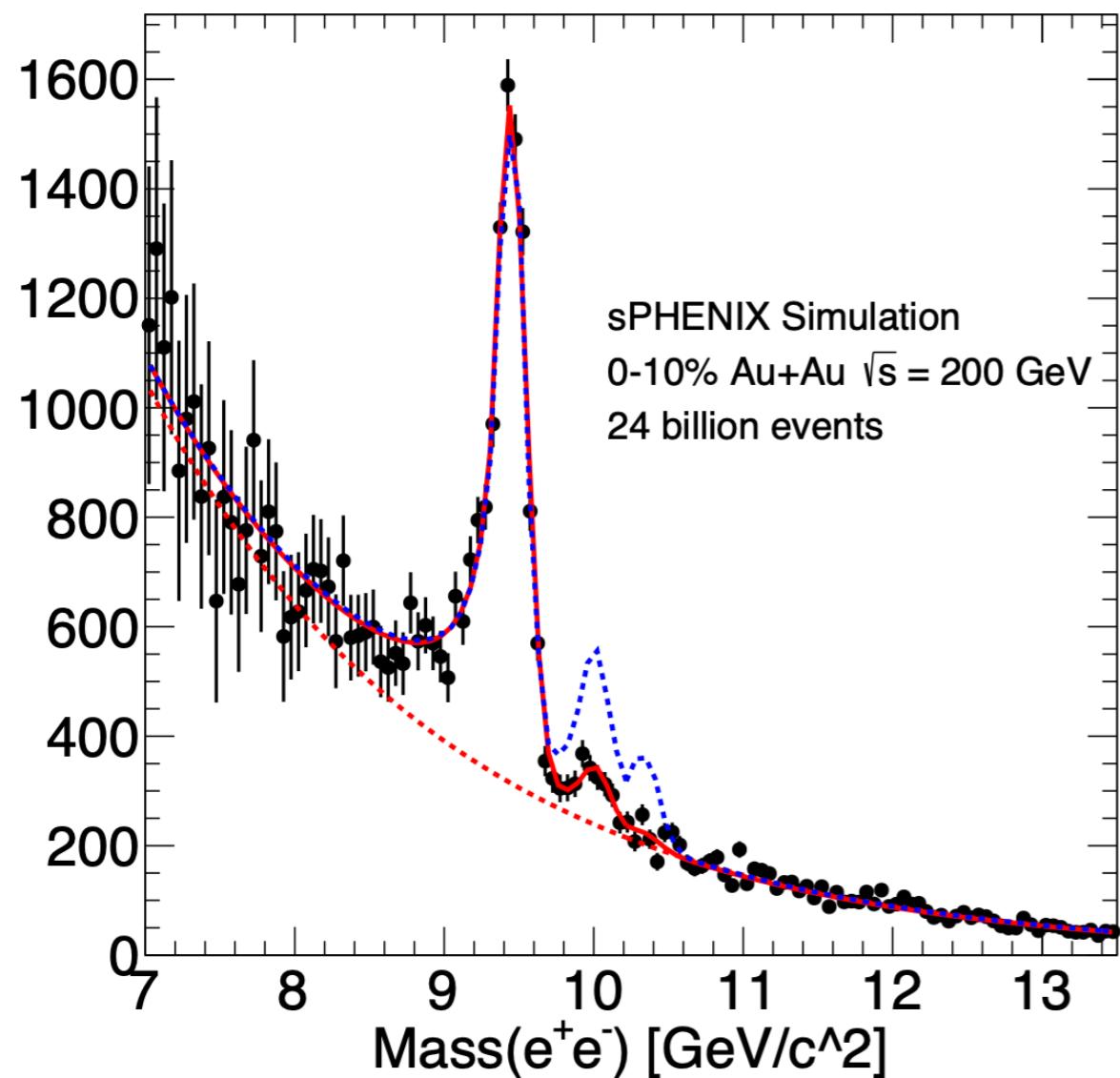


Electron Identification Capabilities

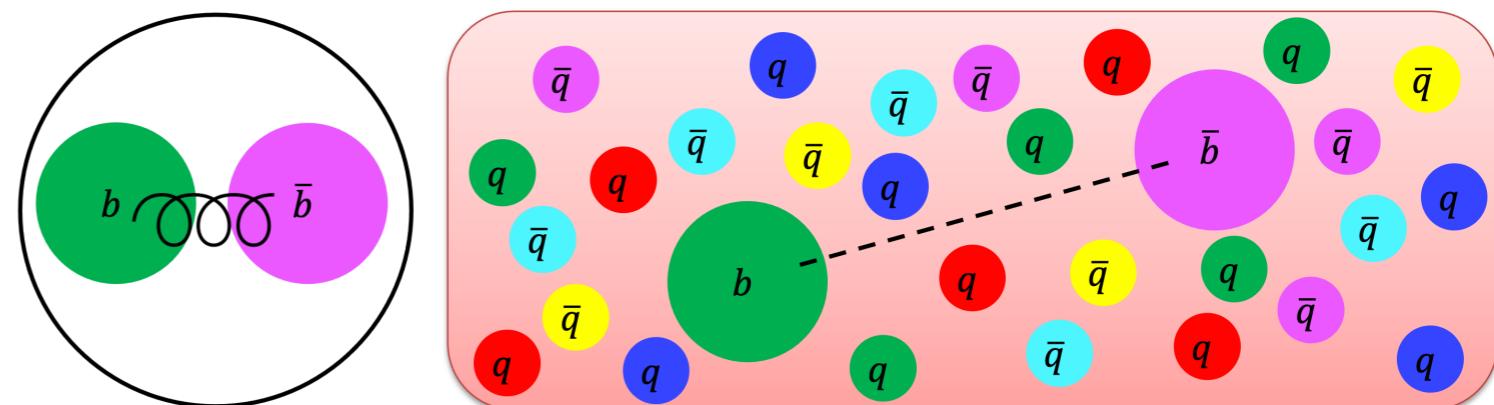


- Use shower core energy information from central EMCAL and HCAL for e/h separation
- Working point: EMCAL/ $p > 0.9$ and iHCAL/EMCAL < 0.2 to maintain 90% electron efficiency
- Excellent electron identification capabilities for quarkonia background rejection
- Improvement with machine learning techniques in development
- Ongoing muons identification studies with machine learning techniques

Upsilon Spectroscopy



- Measuring QGP temperature via color screening effect
- Excellent mass resolution dielectronic decay channel
- R_{AA} measurement with high precision
- Potential observation of $\Upsilon(3S)$ at RHIC



Summary

The sPHENIX Experiment at RHIC

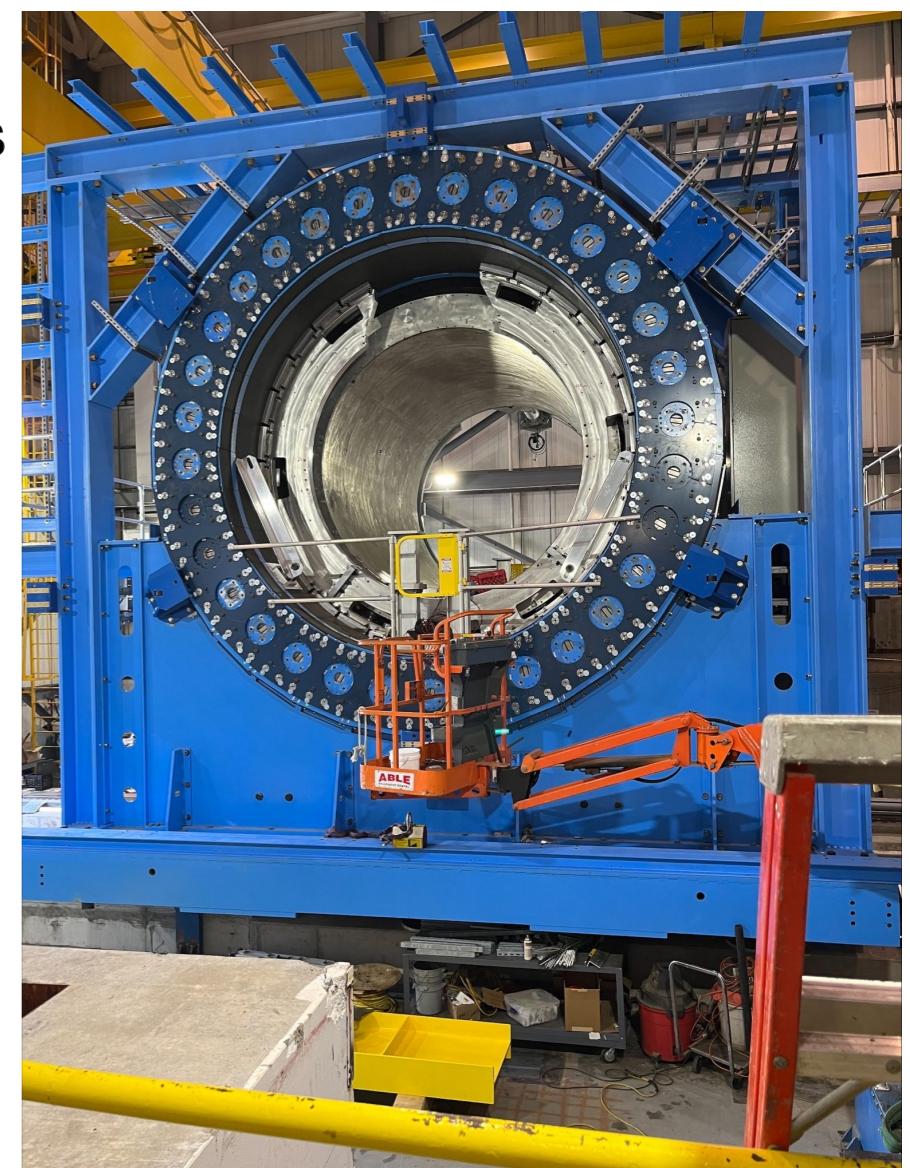
- Physics program: jet, **open heavy flavor, quarkonia**, cold QCD
- Detector commissioning: lots of activities are ongoing right now

Detector Performance

- Excellent tracking and vertexing capabilities for heavy flavor physics measurements
- Good electron identification performance for quarkonia background rejection

Open Heavy Flavor Physics Program

- Fully reconstructed charm and beauty hadron measurements
 - Heavy quark energy loss
 - Heavy quark diffusion
 - Heavy quark hadronization
- First inclusive b-jet measurements
 - Complementary to LHC experiments
 - Precision measurements at low p_T



Hidden heavy flavor Physics Program

- Upsilon Spectroscopy
 - measure the temperature of QGP
 - Potential observation of $\Upsilon(3S)$ at RHIC

 **First data taking starts in around 02/2023: STAY TUNE!**



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- **Thank you very much for your attention!**



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