sPHENIX: The next generation heavy ion experiment at RHIC

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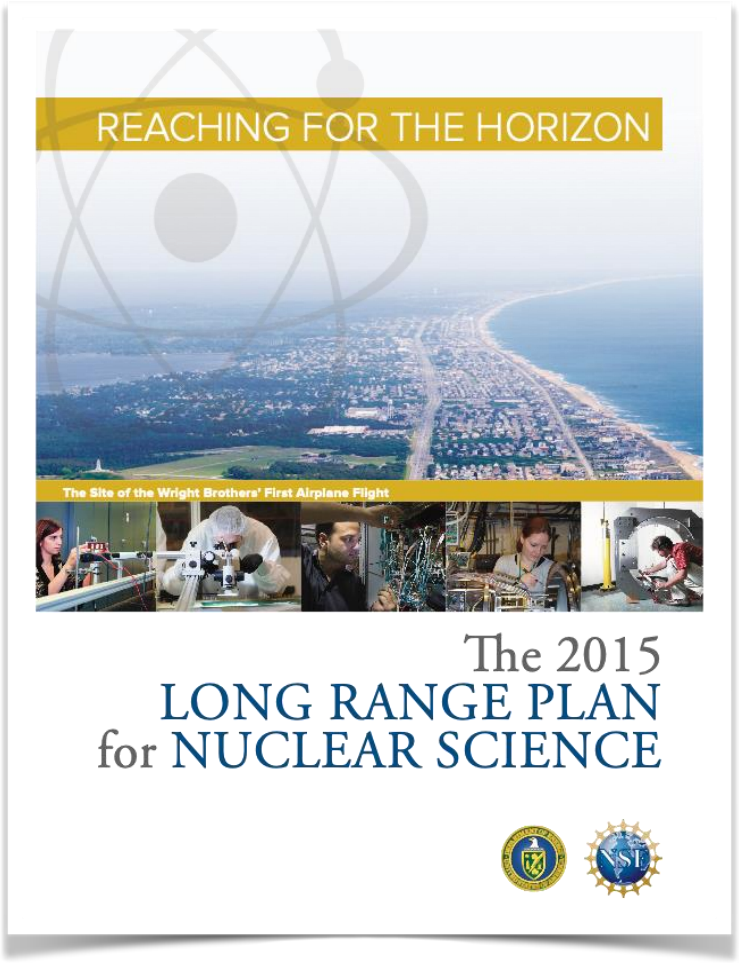
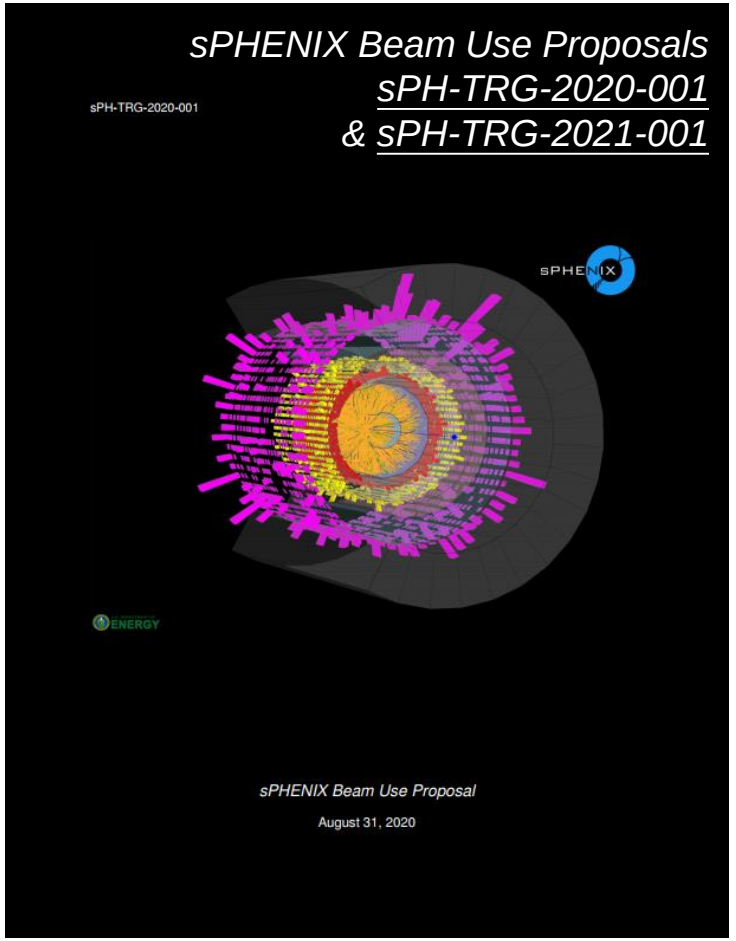
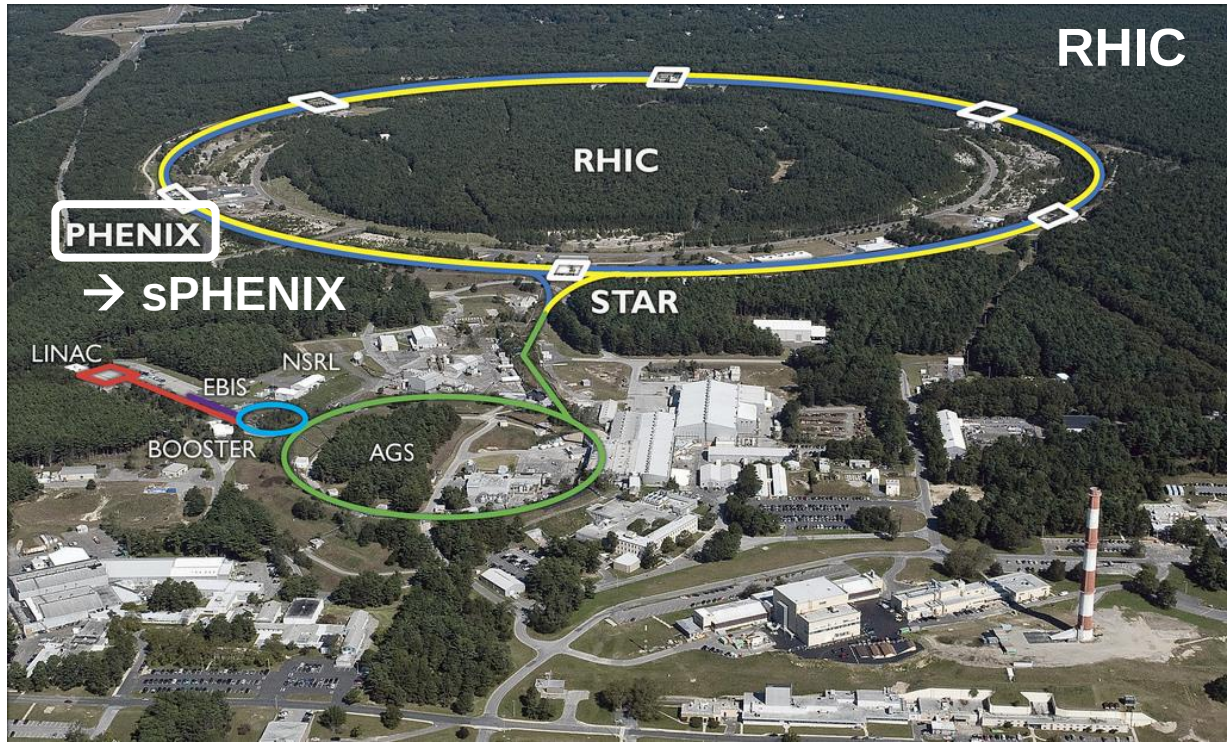
sPHENIX Mission





- **A state-of-the-art jet detector; the first new detector at RHIC in >20 years.**
- Completing the scientific mission of RHIC.
- **Complementarity to LHC.**
- Beam Use Proposals (BUP) in 2020 & 2021.
- sPHENIX as the highest priority for Runs 2023-2025 (PAC Report, Sep. 2020)

sPHENIX Collaboration



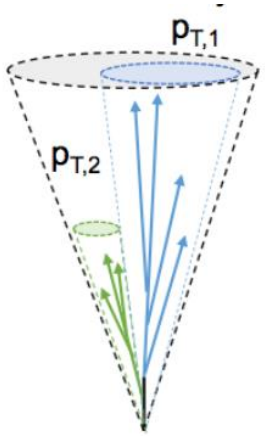
Asian regional meetings were held annually during the pre-pandemic days (at Fudan in 2019)

Spokespersons: Gunther Roland (MIT), Dave Morrison (BNL)

- Upgrade of PHENIX; proposed in 2010 & collaboration formed in 2016.
- More than 320 members from 84 institutions in 14 countries (as of early 2021)
- **9 institutes from China (复旦, 北大, 华中师范, 近代物理所, 科大, 上海应物所, 清华, 原子能院, 中山)**

4 Core Physics Programs @ sPHENIX

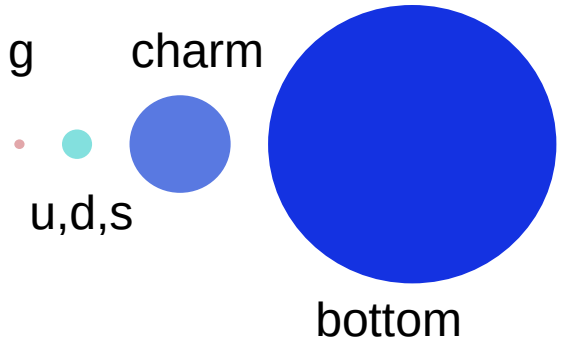
Jet Structure



Vary momentum & angular scale of probe

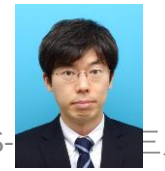
Co-convenors:
Dennis Perepelitsa (Colorado)
Rosi Reed (Lehigh)

Open Heavy Flavors

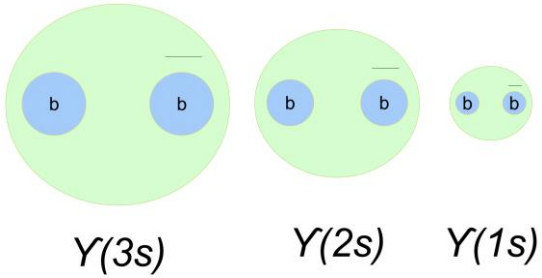


Vary mass & momentum of probe

Co-convenors:
黄进 (BNL)
大川英希 (复旦)



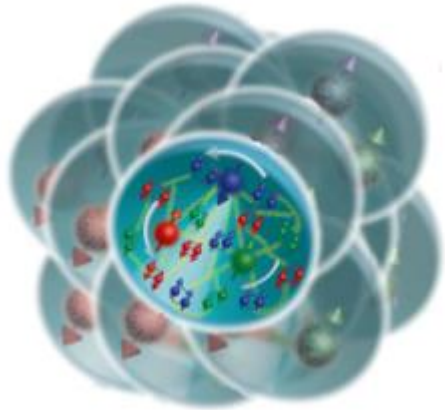
Upsilon Spetroscopy
"Closed Heavy Flavors"



Vary size of probe

Co-convenors:
Anthony Frawley (FSU)
Marzia Rosati (ISU)

Cold QCD



Vary temperature of QCD matter

Co-convenors:
Alexander Bazilevsky (BNL)
Ralf Seidl (RIKEN)

Run Plan (2023-2025)

Year	Species	$\sqrt{s_{NN}}$ [GeV]	Cryo Weeks	Physics Weeks	Rec. Lum. $\lvert z\rvert$ <10 cm	Samp. Lum. $\lvert z\rvert$ <10 cm
2023	Au+Au	200	24 (28)	9 (13)	3.7 (5.7) nb^{-1}	4.5 (6.9) nb^{-1}
2024	$p^{\uparrow}p^{\uparrow}$	200	24 (28)	12 (16)	0.3 (0.4) pb^{-1} [5 kHz] 4.5 (6.2) pb^{-1} [10%-*str*]	45 (62) pb^{-1}
2024	$p^{\uparrow}$+Au	200	–	5	0.003 pb^{-1} [5 kHz] 0.01 pb^{-1} [10%-*str*]	0.11 pb^{-1}
2025	Au+Au	200	24 (28)	20.5 (24.5)	13 (15) nb^{-1}	21 (25) nb^{-1}

Year-1 (Au+Au): Commissioning, calibration, HI standard candle

Year-2 (pp & pAu): Reference for HI measurements & cold QCD measurements

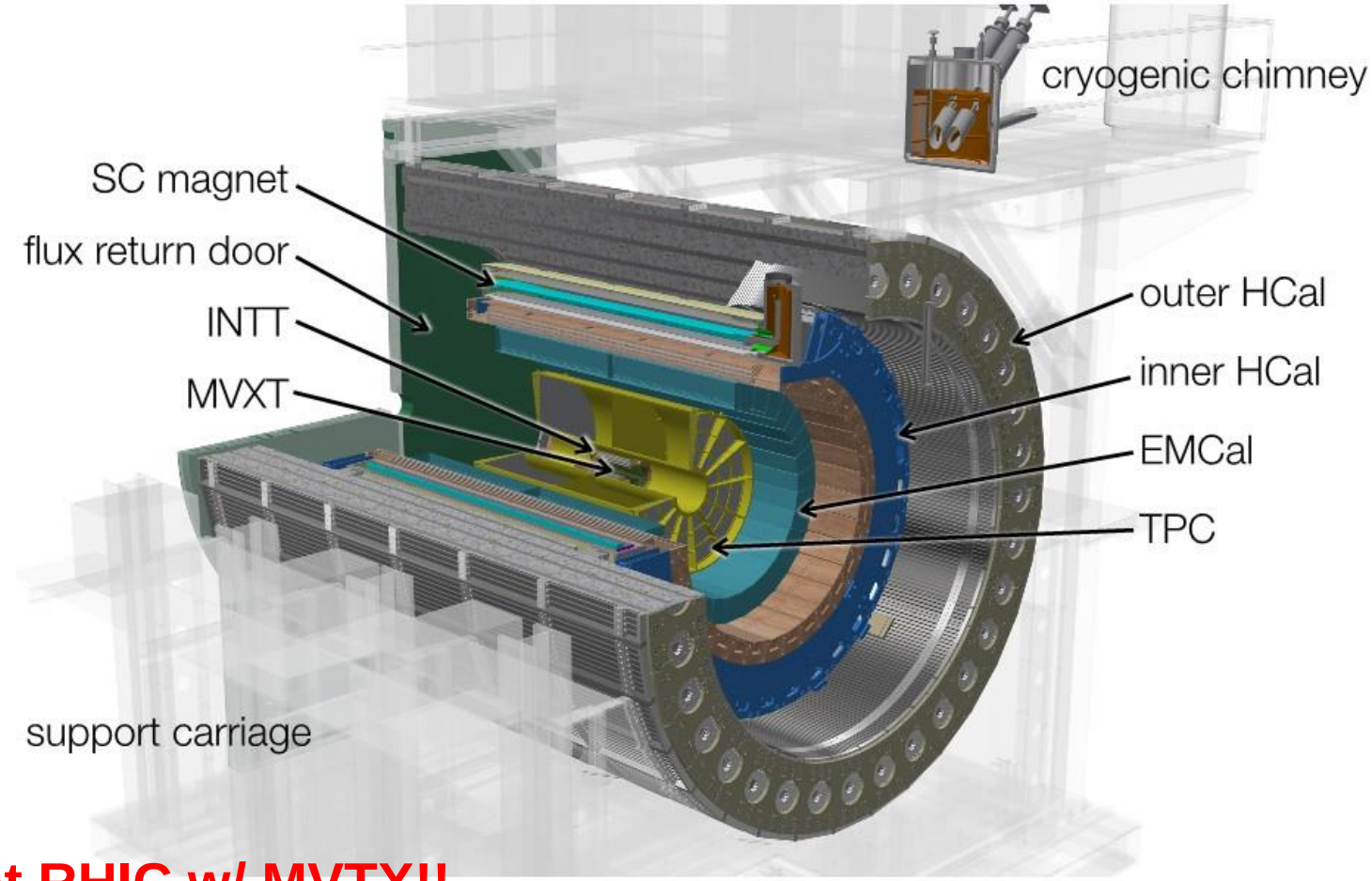
Year-3 (Au+Au): High statistics HI

- **Scientific mission of sPHENIX can be achieved with 3 years of running.**
- Consistent with the currently envisioned **Electron Ion Collider (EIC) schedule.**
- If opportunity arises, additional runs can fully utilize the potential of the detector.

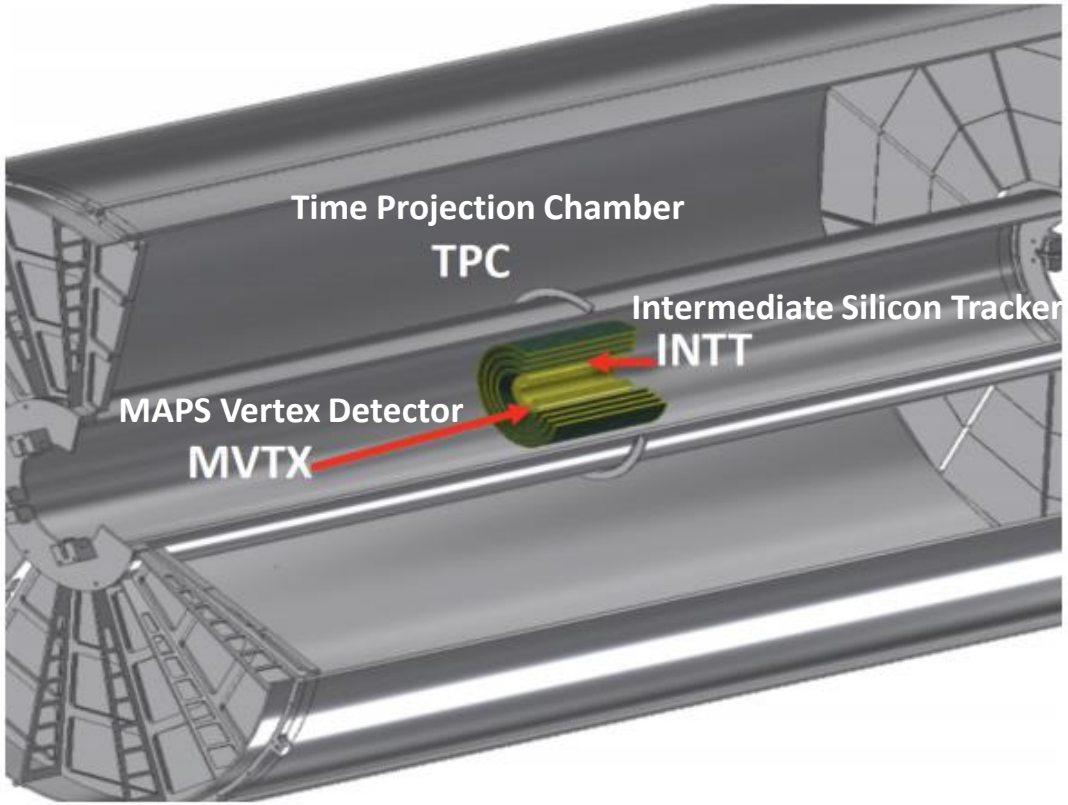
sPHENIX Detector

- High data rates: 15 kHz for all subdetectors
- 1.4 T Solenoid from BaBar
- Hermetic coverage: |η|<1.1
- Trigger capability also with streaming readout
- **High resolution vertexing with MAPS Vertex detector (MVTX)**
- **Large acceptance hadronic calorimetry for jets**

→ brings first b-jet tagging at RHIC w/ MVTX!!



sPHENIX Tracking Detectors



1/30 of ALICE TPC Volume

MVTX (2.3 < r < 3.9 cm): precision vertexing

- 3 layers Monolithic Active Pixel Sensors using ALICE ALPIDE. 30μm pitch.
- Nearest to collision point.
- **MAPS chip & stave test (华中师范,科大), simulation (科大,中山)**

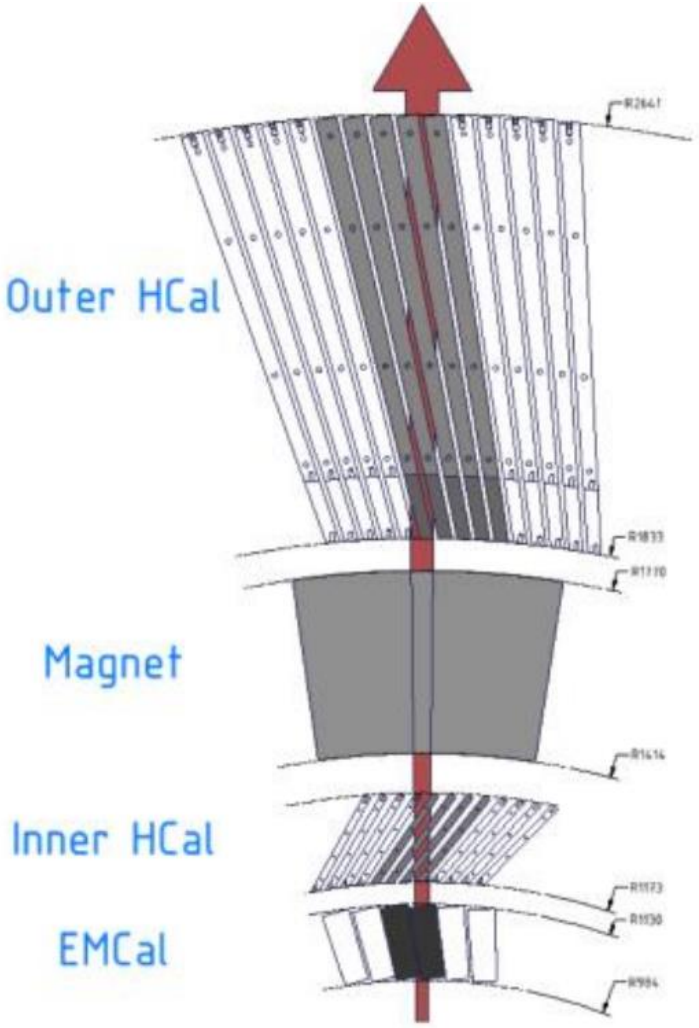
INTT (6 < r < 12 cm): pileup separation

- 2 layers of silicon strips (86μm pitch)
- Fast integration time. Can resolve one beam crossing

TPC (20 < r < 78 cm): momentum measurement

- Very compact GEM-based TPC: 48 layers with gateless and continuous readout.

sPHENIX Calorimeters



Full Electromagnetic and Hadronic calorimeter system

- Large Acceptance: $|\eta| < 1.1$ and full 2π azimuthal coverage
- SiPM used for light collection & readout

EMCal

- Tungsten-scintillating fiber sampling calorimeter (SPACAL type). 18 X_0, 1 λ. Tower size: Δη x Δϕ=0.025x0.025. Resolution ~ 16%/√E ⊕5%.
- **1248 blocks (|η|>0.85) will be made by 复旦/北大/原子能院.**

Inner HCal

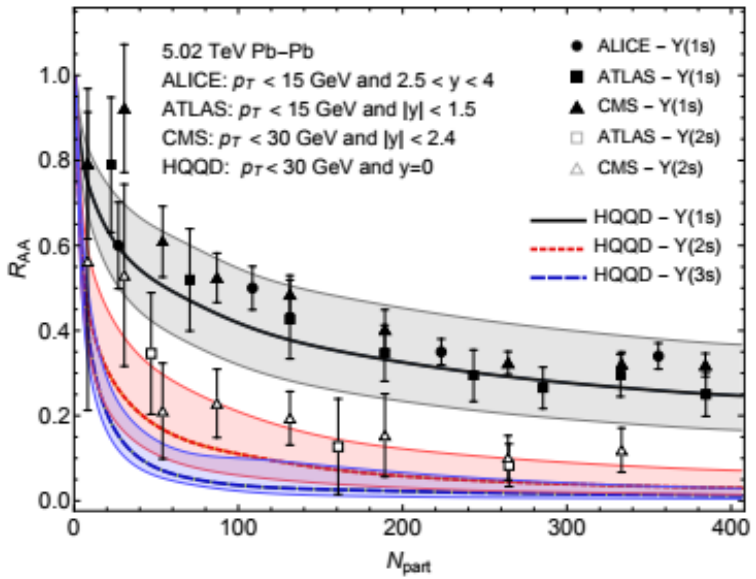
- Aluminum absorber plates and scintillating tiles with embedded WLS fibers

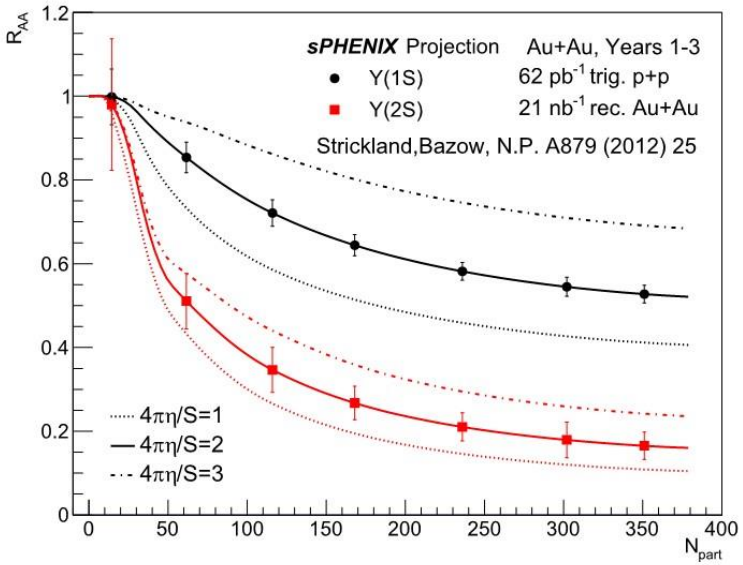
Outer HCal

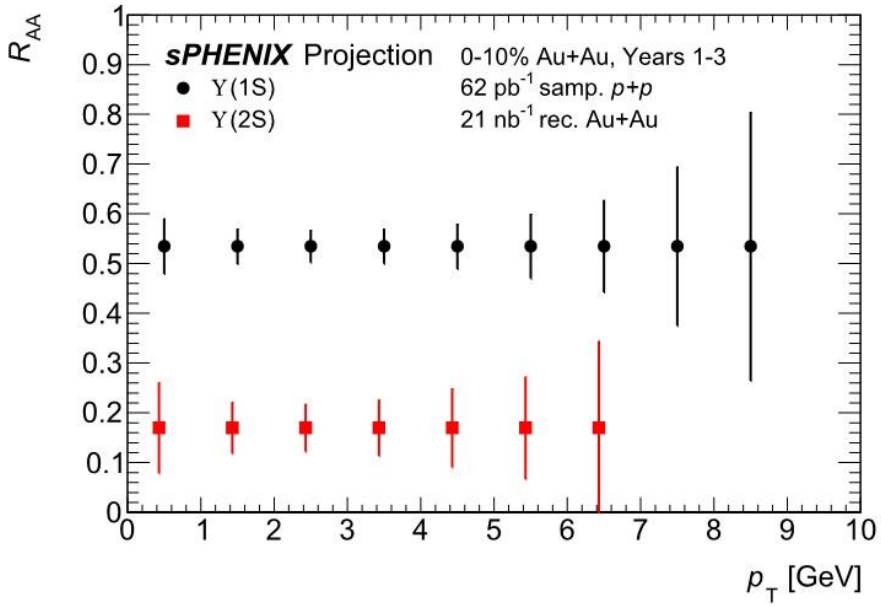
- Steel absorber plates and scintillating tiles with embedded WLS fibers
- $\sigma_E/E < 100\%/\sqrt{E}$ (single particle) for overall HCal.

Upsilon R_{AA}

LHC *A. Islam, M. Strickland, JHEP 03 (2021) 235*

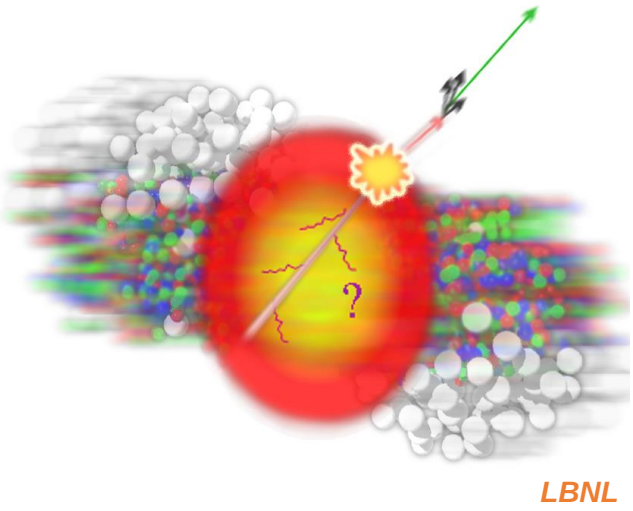


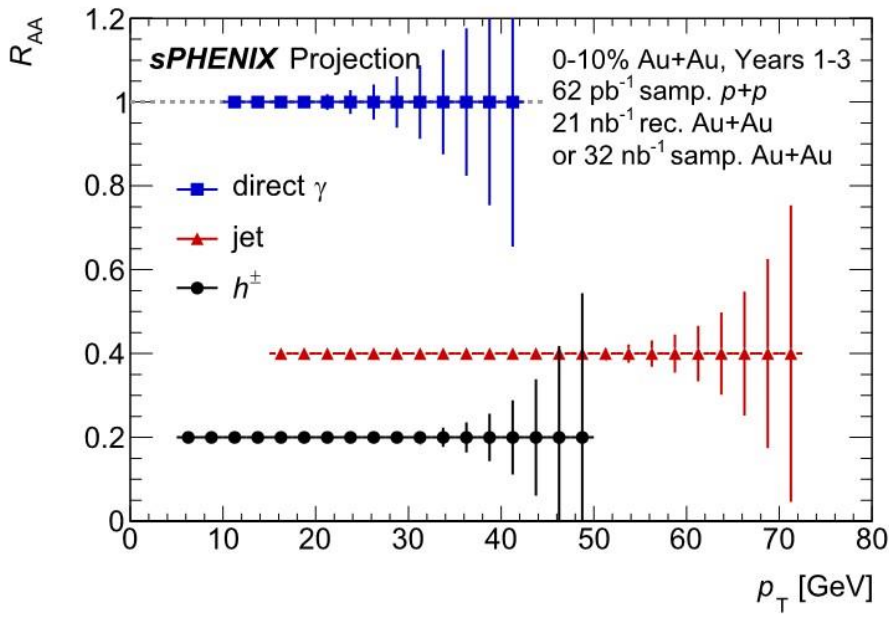


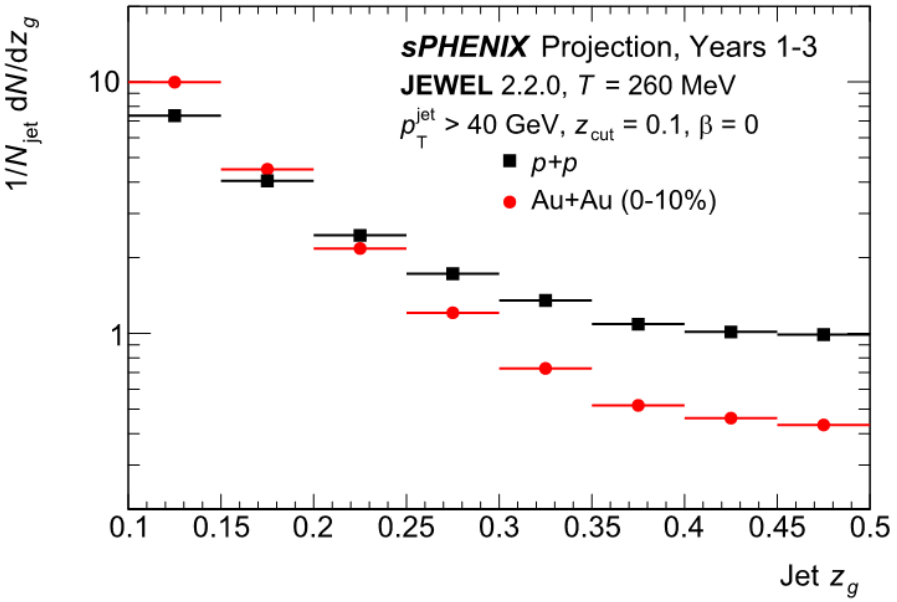


- Measuring centrality & p_T dependence of R_{AA} is critical to compare with LHC. sPHENIX will be able provide measurement overlapping with the LHC kinematic regions.
- Measuring Y(3S) modification will be challenging due to the large suppression. Feasibility checks ongoing for Y(3S) modification.

Jets & Photons

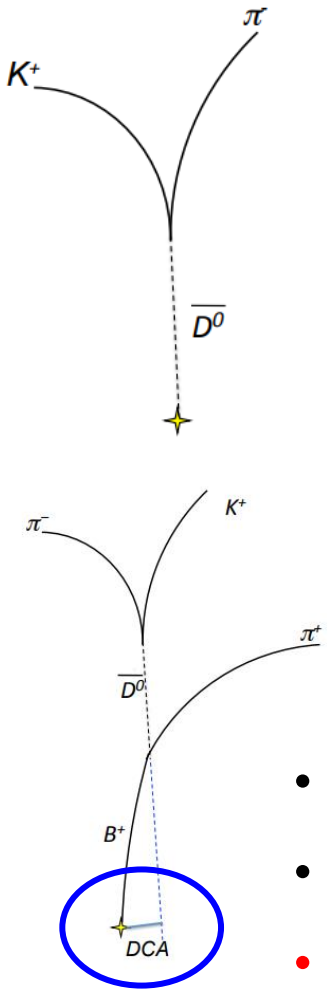


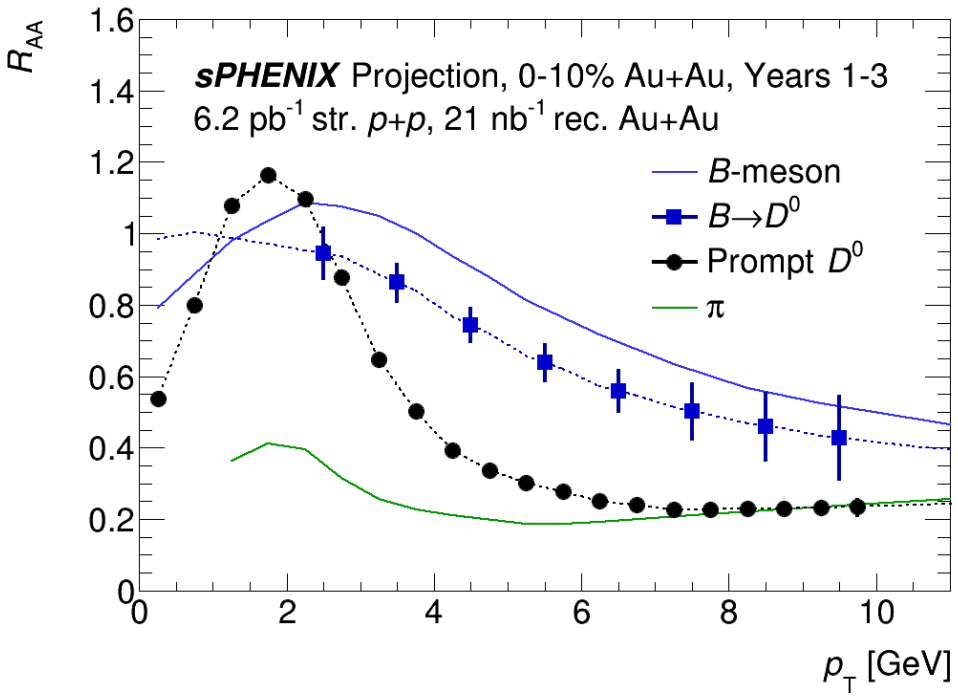


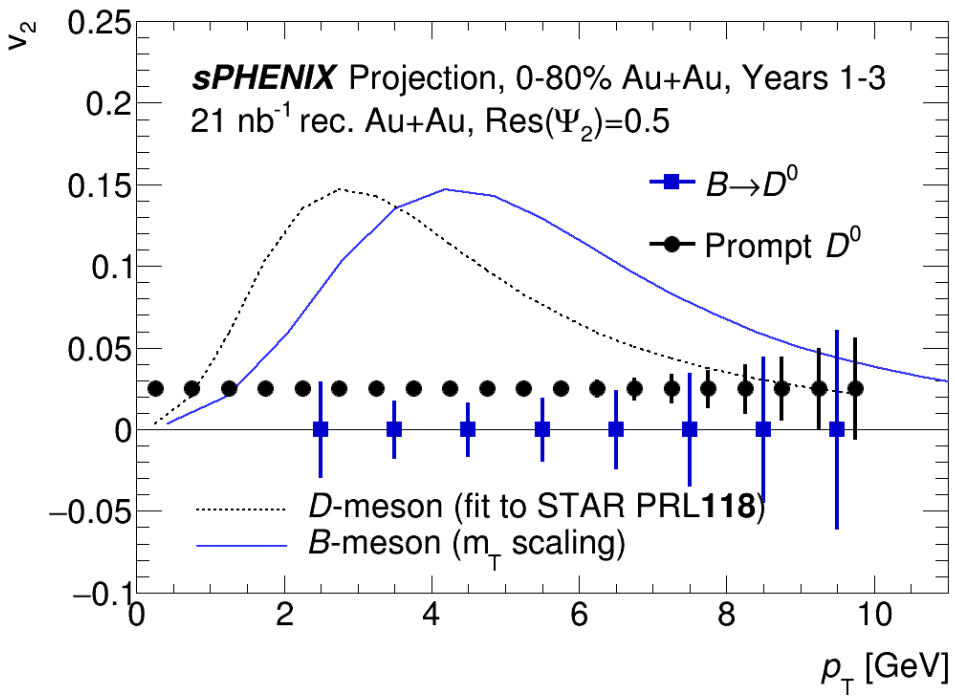


- **High data rates & hermetic EMCal+HCal offer wide p_T range of jet recontruction.**
- Precise measurements in low p_T as well as overlap with the LHC in high p_T region.
- Jet substructure as a probe for the QGP properties & connection to fundamental QCD.

Heavy Flavor R_{AA} & Flow

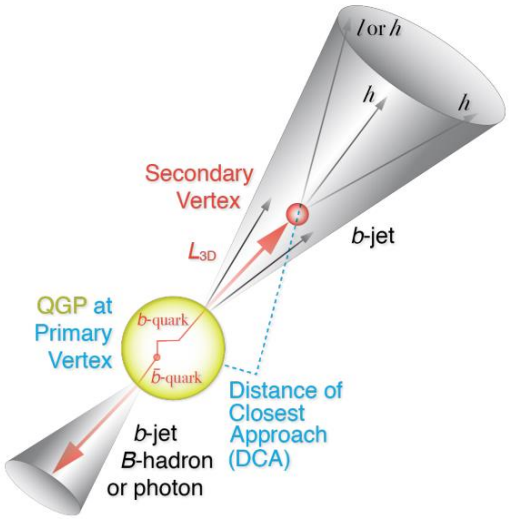


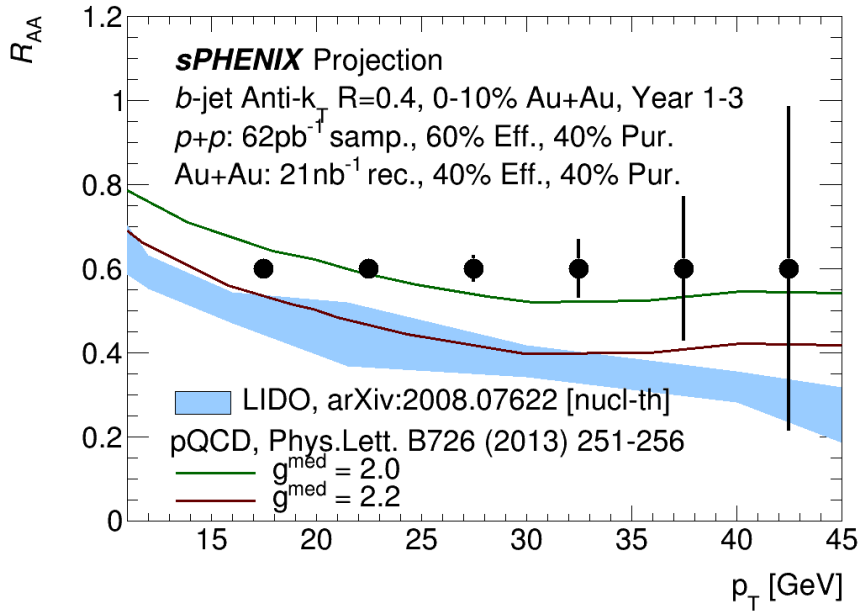


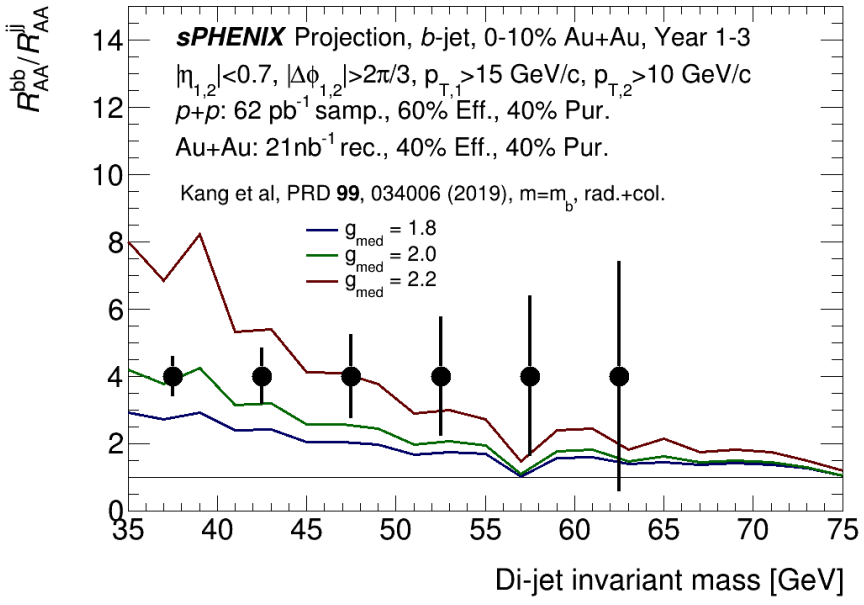


- Streaming readout allows us to measure R_{AA}.
- Precise measurement of non-prompt-D^0 suppression thanks to MVTX performance.
- **Determine b-quark R_{AA} & v_2 → clean access to diffusion at RHIC**

Heavy Flavor Jet R_{AA}

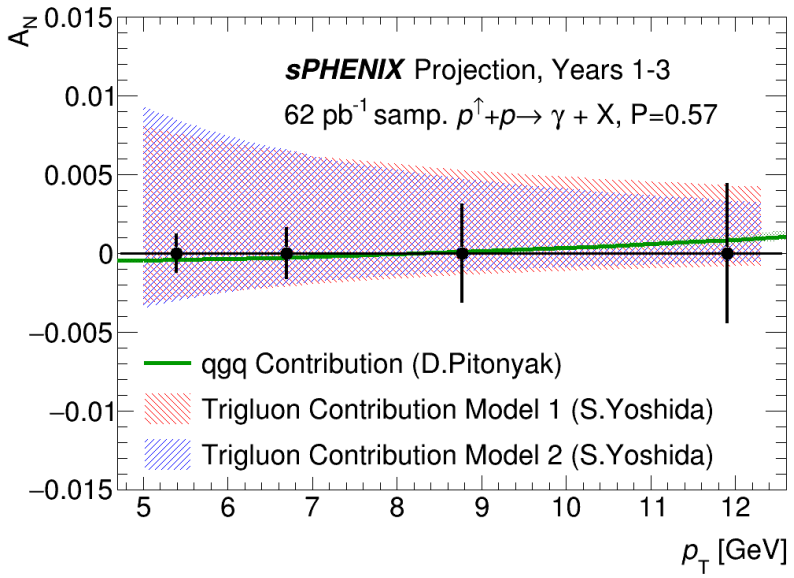


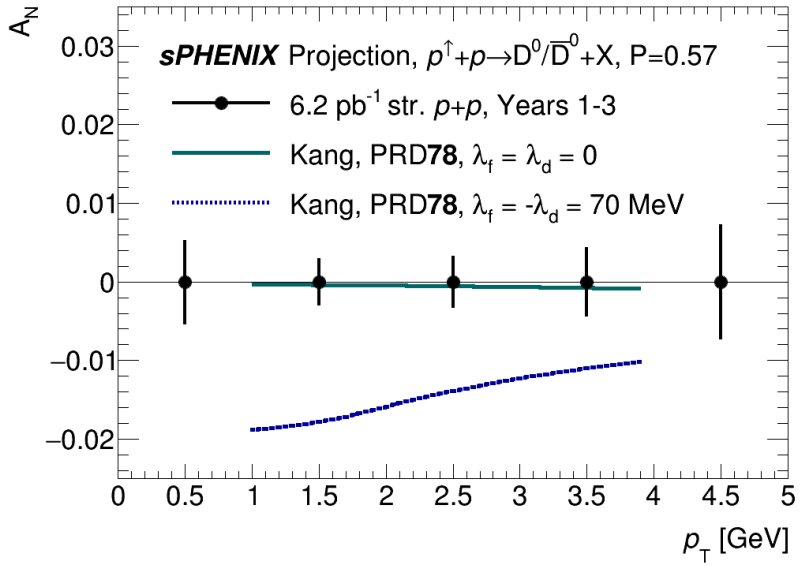


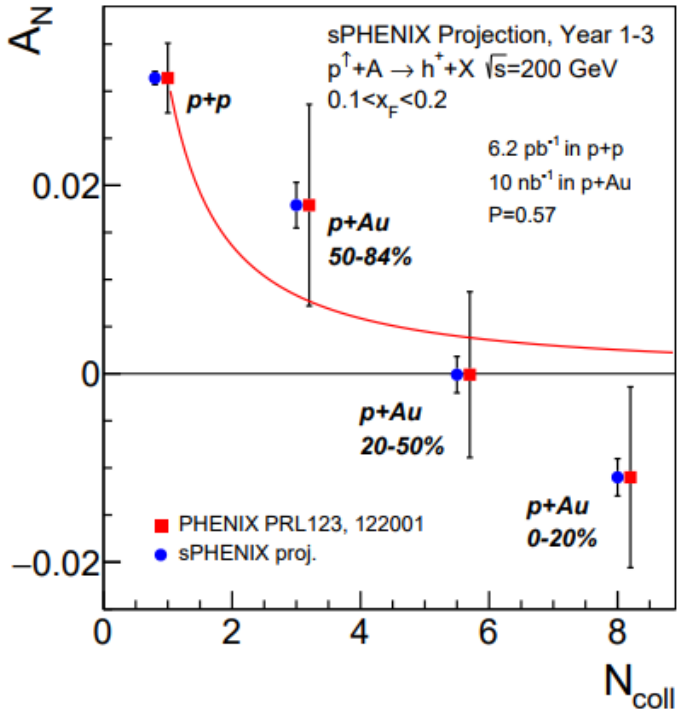


- **First b-tagging at RHIC thanks to MVTX & full calorimeter implementation.** b-tag performance compatible to CMS.
- RHIC will have much less background (i.e. g→bb) than LHC.
- Outstanding precision in low-p_T region. **Enhanced sensitivity with dijet mass.**

Cold QCD



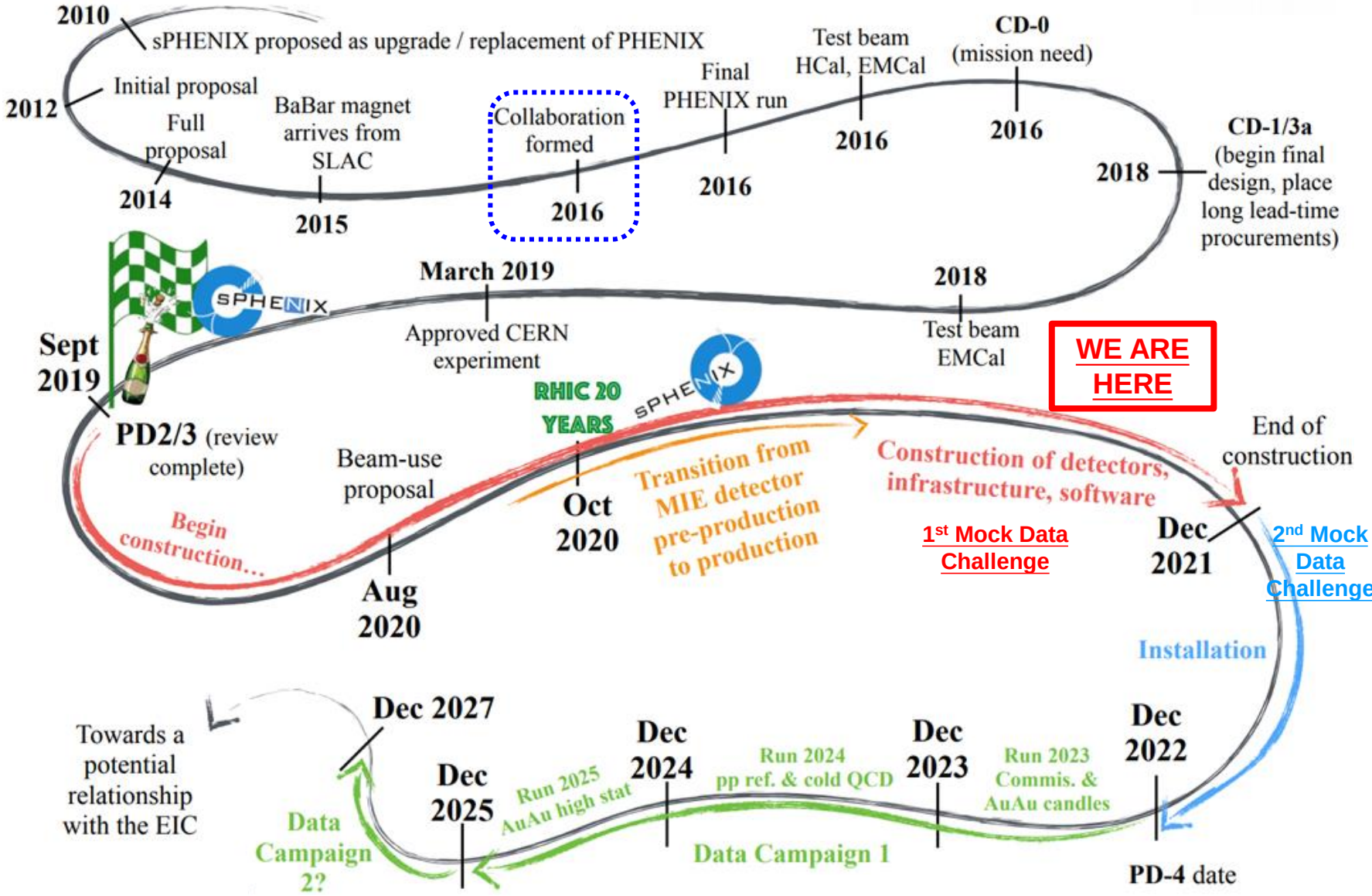




- Access to transverse single spin asymmetry (TSSA) via prompt photon & D^0.
  → gluon dynamics in transversely polarized nucleons.
- In pAu, measuring nuclear dependence of TSSA will offer insight to its origin (much improved precision from PHENIX).

Schedule

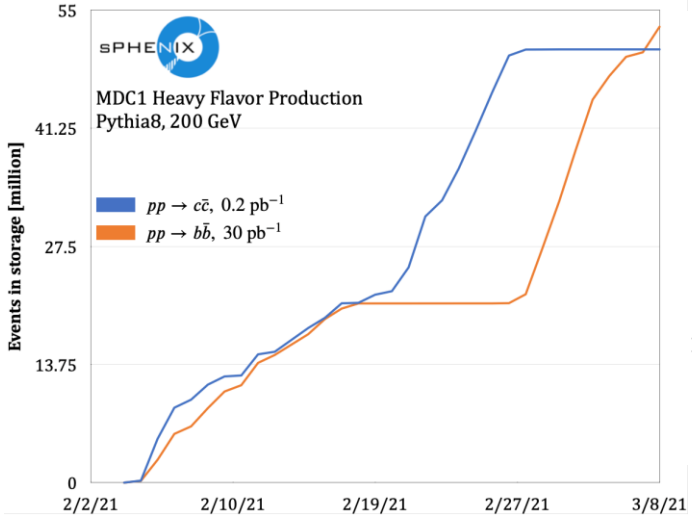
- **At the last stage of detector construction (by the end of 2021).**
- **1st Mock Data Challenge (2021) for software development & validation.**
- Detector installation & 2nd Mock Data Challenge in 2022.
- **Data taking from 2023!**

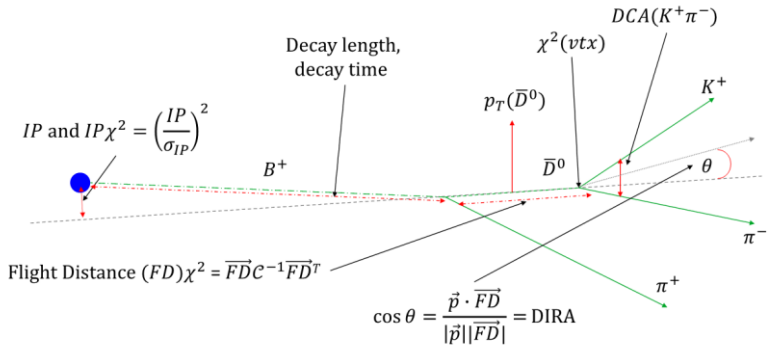


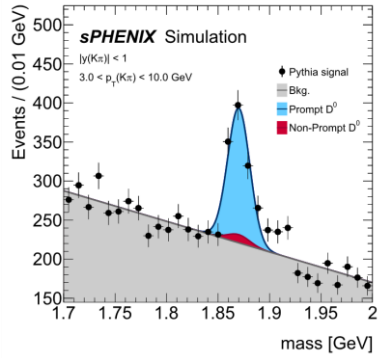
From Caroline Riedl

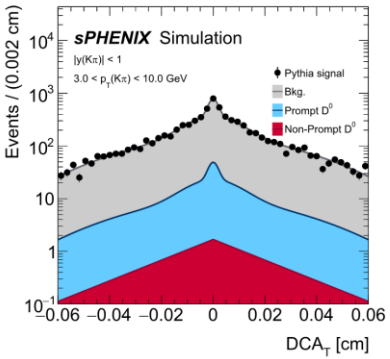
Toward the First Data Taking

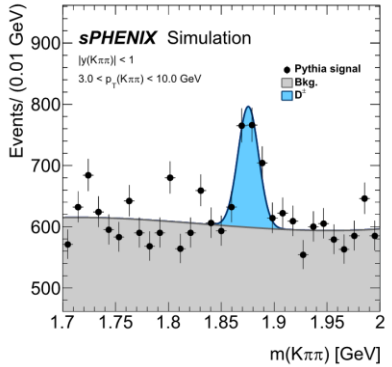
sPHENIX Note sPH-HF-2021-001

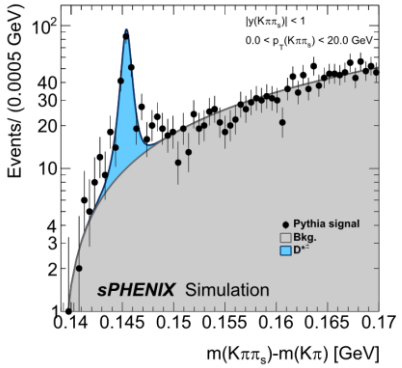


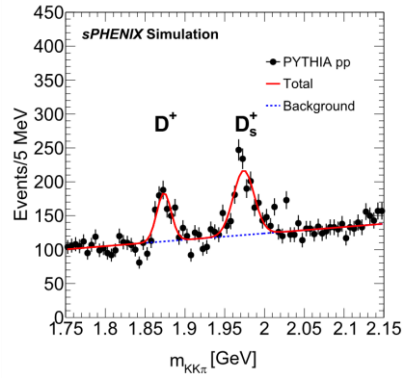


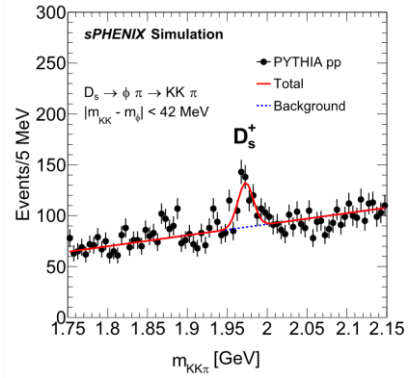












- Currently going through **1st Mock Data Challenge (MDC1)** to test the full chain of generation→ G4 simulation → reconstruction (including KFParticle) → analysis
- Will have another set of production later this year for Minbias & HF jet studies.
- 2nd Mock Data Challenge (MDC2) will follow next year.

Summary

- sPHENIX is a state-of-the-art jet detector, the first new detector at RHIC in >20 years.
- sPHENIX brings high statistics measurements to jet production, jet substructure and open/hidden heavy flavors over unprecedented kinematic range at RHIC.
- sPHENIX will complete the scientific mission of RHIC along with STAR.
- 1st Mock Data Challenge has been successful to validate the full analysis framework. More production expected this year & preparing for 2nd Mock Data Challenge next year.
- Detector construction by end of this year (**on schedule!**) & installation next year.
- **Preparing for the first data taking in 2023!** Stay tuned!

Thank you for your attention! 谢谢大家！