Heavy Flavor Capabilities of the sPHENIX Experiment

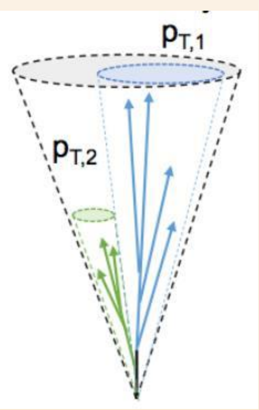
Zhaozhong Shi (Massachusetts Institute of Technology), *for the sPHENIX Collaboration*

Abstract

The sPHENIX detector at BNL's Relativistic Heavy Ion Collider (RHIC) will measure a suite of unique jet and Upsilon observables with unprecedented statistics and kinematic reach at RHIC energies. The projected Au + Au events collected by sPHENIX is about 200 billion. A MAPS-based vertex detector upgrade to sPHENIX inner tracking system, the MVTX, will provide a precise determination of the impact parameter of tracks relative to the primary vertex in high multiplicity heavy ion collisions. These new capabilities will enable precision measurements of open heavy flavor observables, covering an unexplored kinematic regime at RHIC. The physics program, its potential impact, and recent detector development will be discussed in this poster.

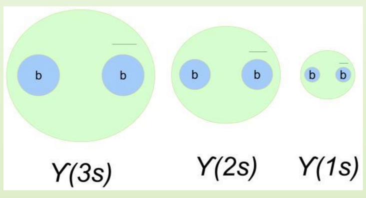
sPHENIX Physics Program

Jet and Photon



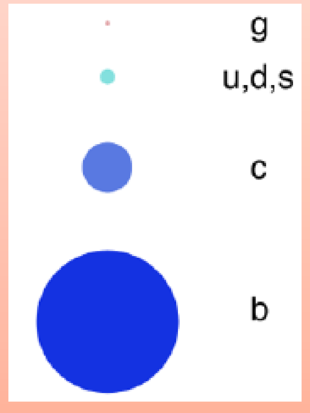
Vary the moment & angular scale of the probes

Upsilon



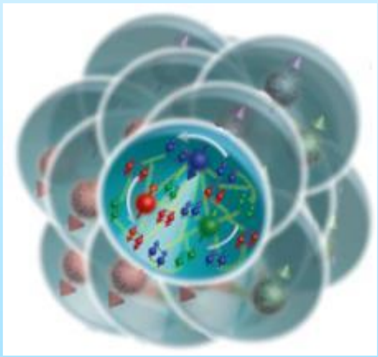
Vary the size of the probe

Open Heavy Flavor



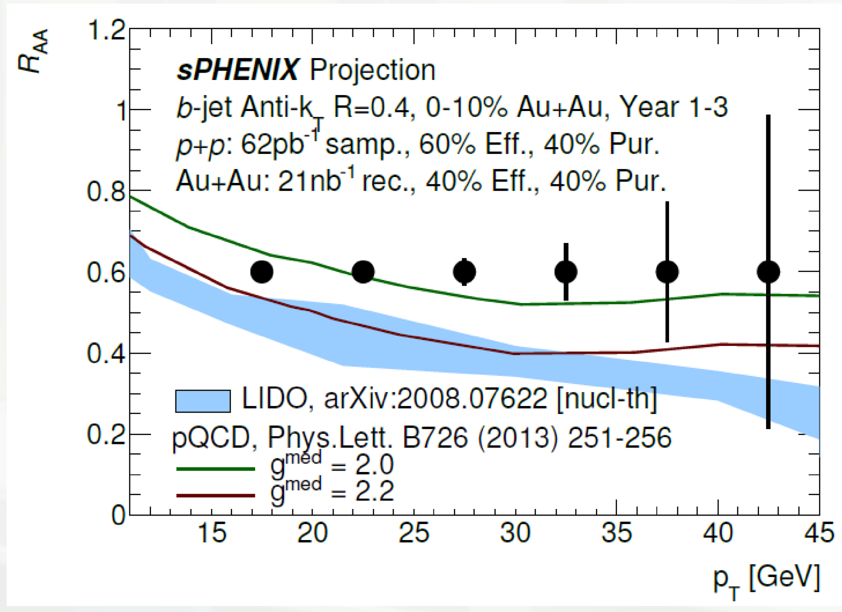
Vary the mass & momentum of the probe

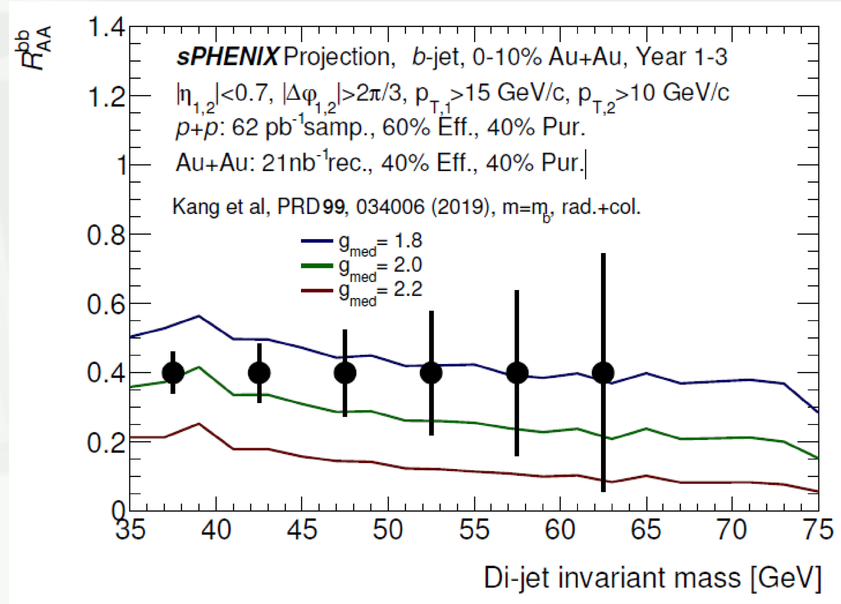
Cold QCD



Vary the temperature of QCD matter

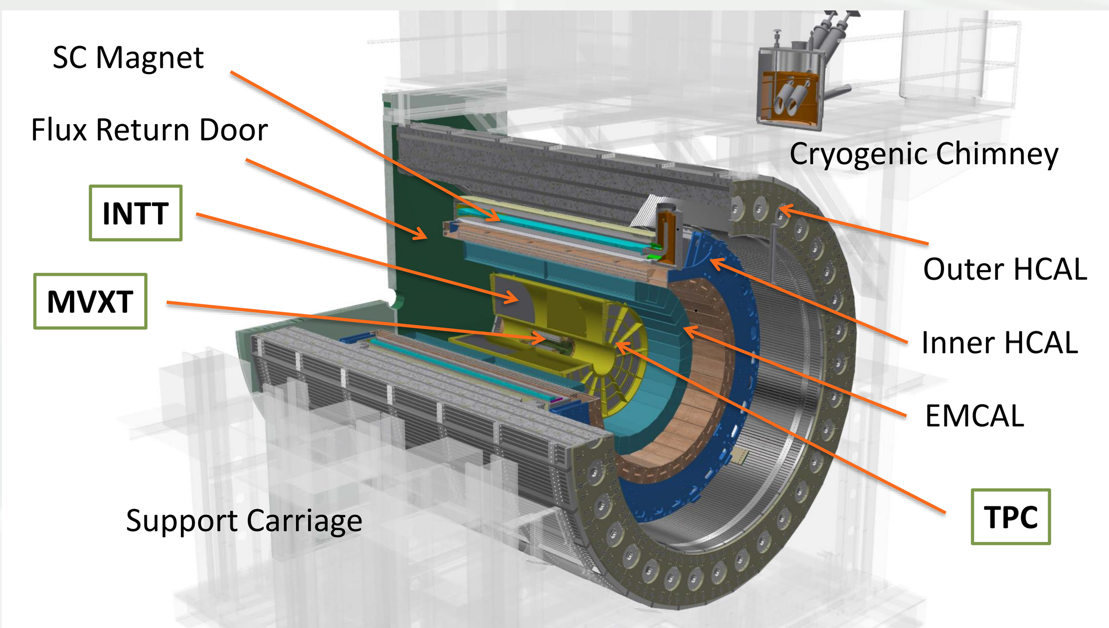
b-jet Physics





- Test the pQCD calculations at RHIC energy
- Study energy loss mechanisms with the QGP medium
- Understand flavor dependence of energy loss (potentially due to dead cone effect)

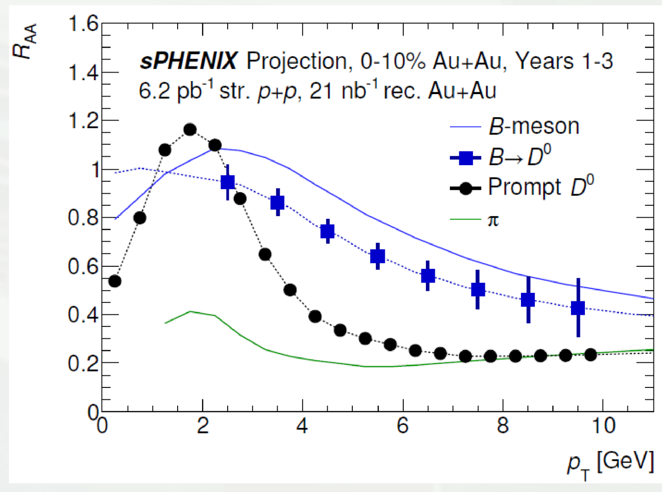
sPHENIX Detector

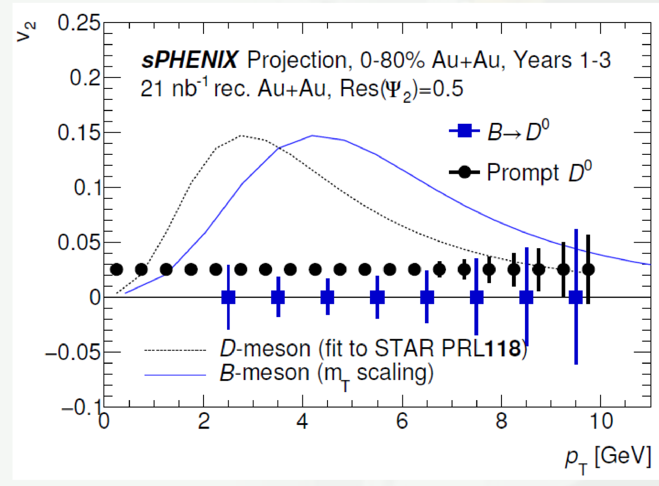


- An upgrade of the PHENIX experiment, state-of-the-art jet detector at RHIC
- Study the inner workings of QGP with hard probes at a broad range of length scale
- Complementary to LHC experiments at different temperature and baryon chemical potential
- Enabling precision bottom quark physics studies at RHIC

Open Heavy Flavor Measurements

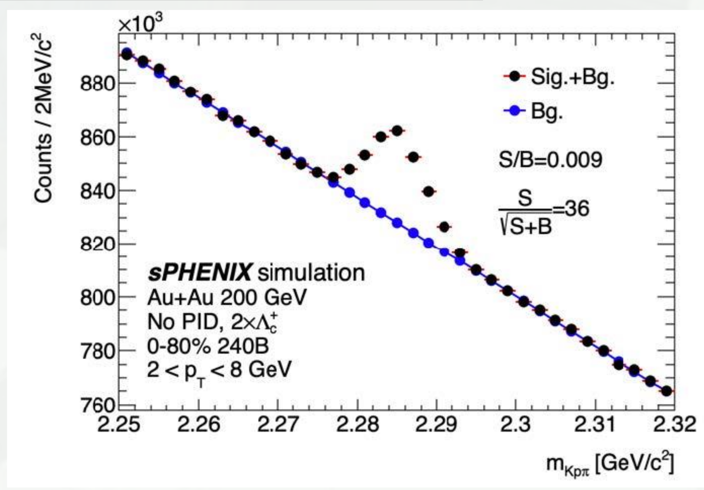
D^0 Meson Measurements

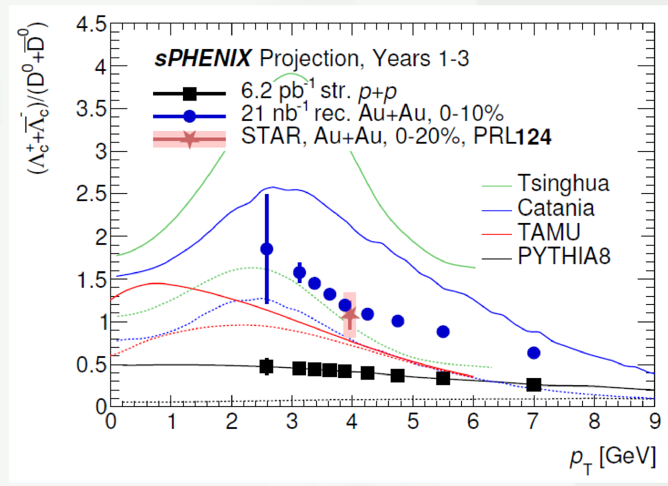




- Precise R_{AA} and v_2 measurements → experimental constraints to theoretical models
- Precision study of the charm and bottom diffusion and energy loss mechanism in the QGP medium
- Understand flavor dependence of energy loss

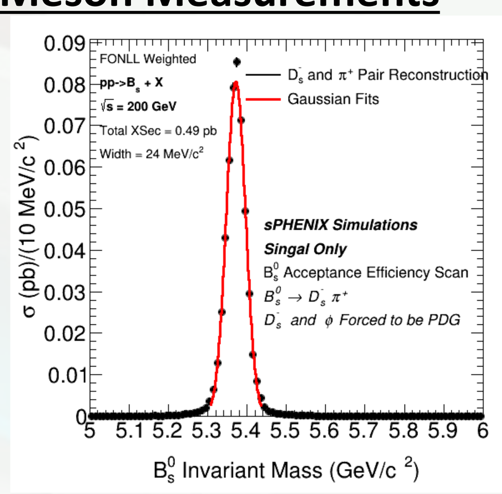
Λ_c^+/D^0 Meson Measurements

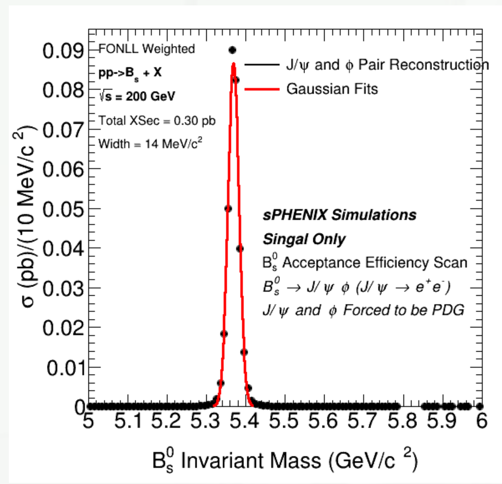


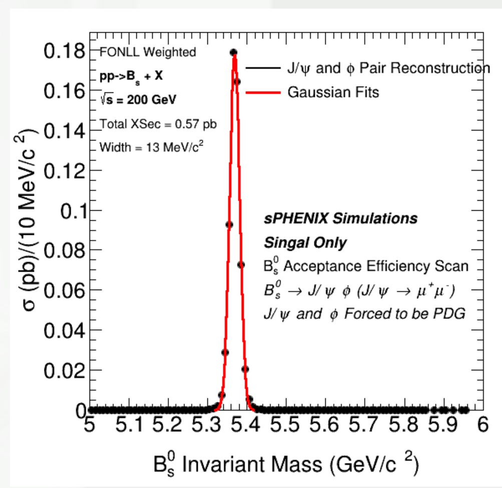


- Study hadronization mechanism of charm quarks
- Constrain various hadronization models such as statistical, fragmentation, and coalescence

B_s^0 Meson Measurements





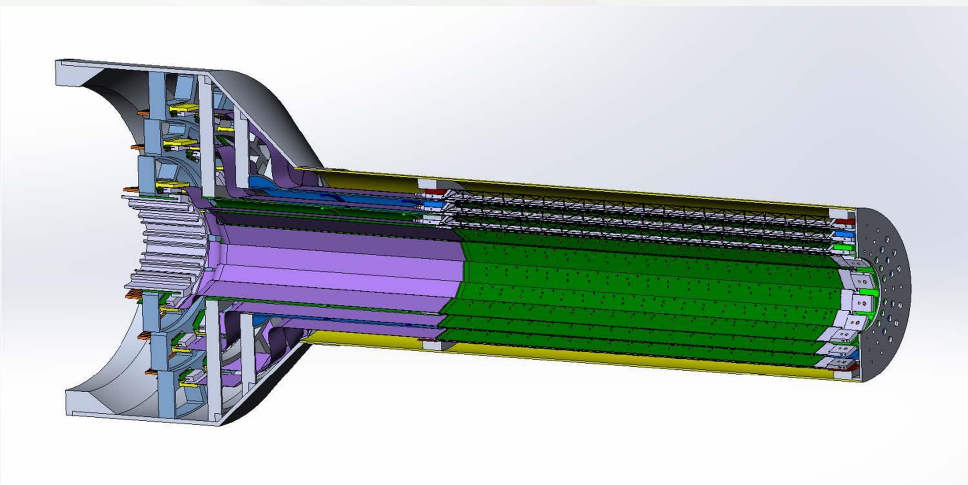


- Full detector simulation of the signal only. The study of background is still ongoing
- Exploring the possibility of B_s^0 measurement at RHIC energy
- Potential B_s^0 p_T differential measurements down to $p_T = 0$
- Study hadronization mechanism of bottom quarks

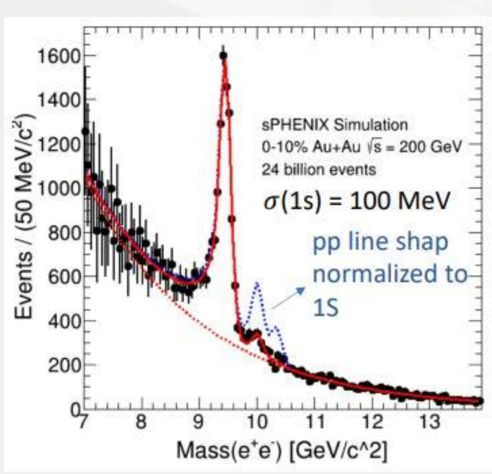
MVTX Detector and Vertexing Capabilities

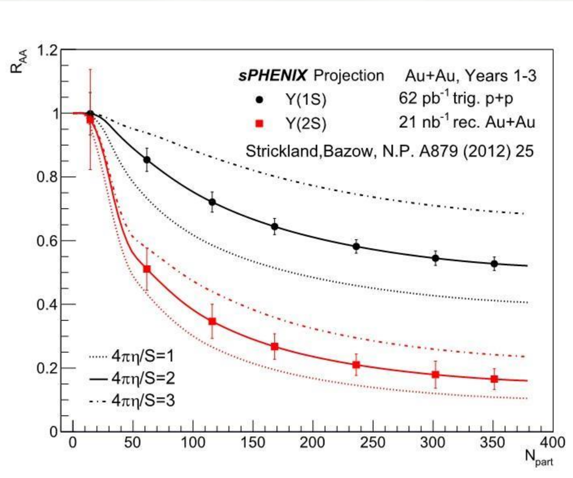
MVTX

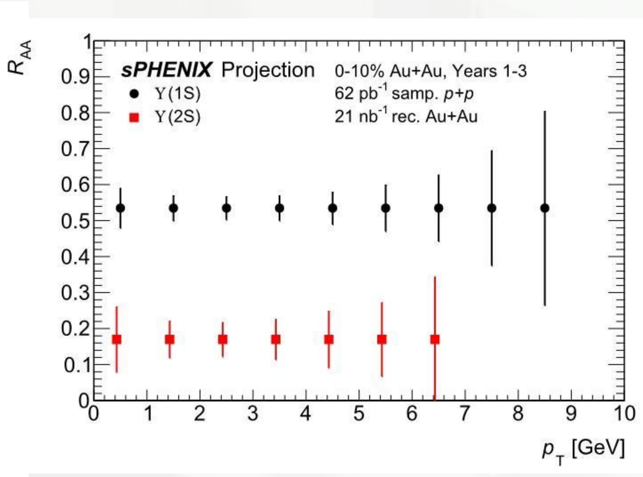
- **MVTX:** Monolithic Active Pixel Sensor (MAPS)-based-vertex detector
- Adapting the inner barrel of ALICE inner tracking system (3 layers)
- Placed nearest the collision point
- High granularity of pixel pitches
- Track vertex displacement resolution < 30 μm for p_T > 1 GeV/c
- Precise vertexing and enables the b-jet and open heavy flavor physics programs



Upsilon Spectroscopy







- Measurement of the Υ(1S, 2S, 3S) states with precise invariant mass resolution
- Sufficient accuracy for clear separation of the Υ(1S, 2S, 3S) states
- Feasibility check of first measurement of Υ(3S) state in Au + Au collisions ongoing
- Sequential melting of Υ(1S, 2S, 3S) states: suppression due to color screening effect with the presence of the QGP medium

Summary

- Rich and comprehensive heavy flavor physics program
- MVTX provides precise vertexing, crucial for heavy flavor hadron reconstruction
- Large statistics and excellent tracking for precise heavy flavor measurements down to low p_T
- Probe the inner workings and temperature QGP with heavy flavor quarks
- Provide experimental constraints for theoretical model predictions

References

- sPHENIX Collaboration, A. Adare et. al., arXiv: 1501.01697
- sPHENIX Beam Use Proposal, https://indico.bnl.gov/event/9301/attachments/30172/47155/sPH-TRG-2020-001.pdf Aug 2020

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