Heavy Flavor Capabilities of the sPHENIX Experiment

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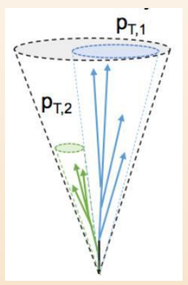
Abstract

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. A MAPS-based vertex detector upgrade to sPHENIX, 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 talk.

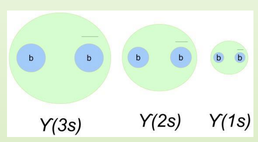
sPHENIX Physics Program

Jet and Photon



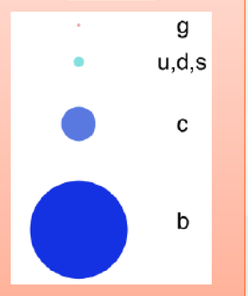
Vary the moment & angular scale of the probes

Upsilon



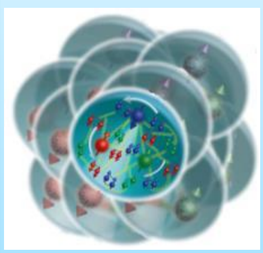
Vary the size of the probe

Open Heavy Flavor



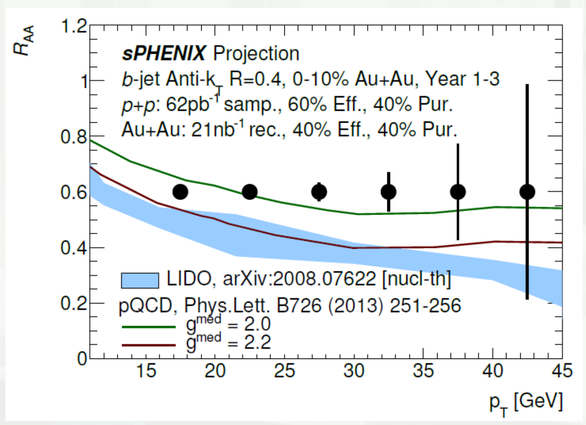
Vary the mass & momentum of the probe

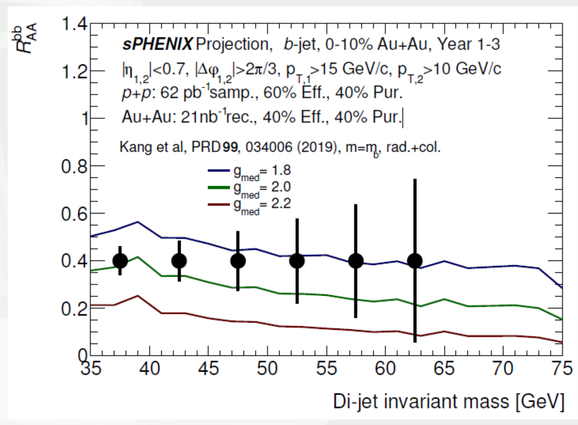
Cold QCD



Vary the temperature of QCD matter

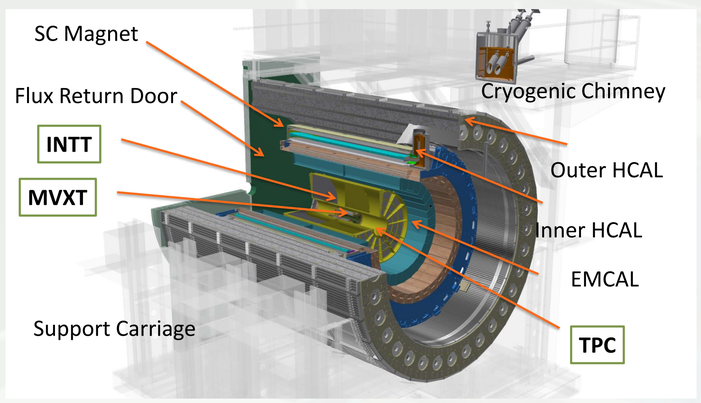
b-jet Physics





- 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)
- Constrain bottom quark diffusion transport parameters

sPHENIX Detector

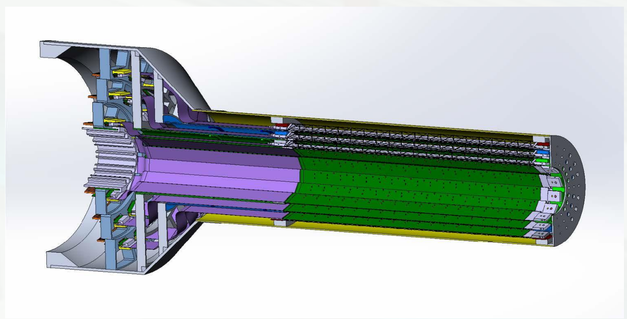


- An upgrade of the PHENIX experiment, state-of-the-art jet detector at RHIC
- Probing the inner workings of QGP by resolving its properties at shorter and shorter length scale
- Complementary to LHC experiments at different temperature and baryon chemical potential
- Larger datasets and higher precision measurements for bottom quark physics studies

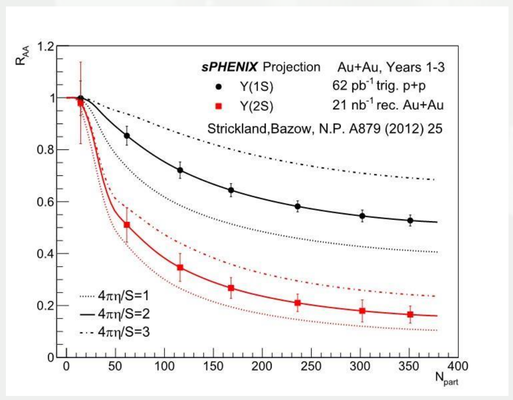
MVTX Detector and Vertexing Capabilities

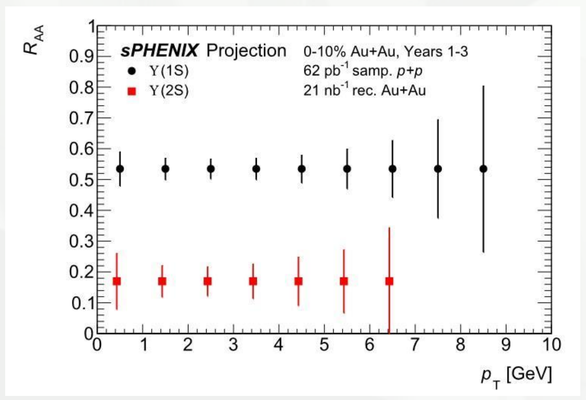
MVTX

- **MVTX:** Monolithic Active Pixel Sensor (MAPS)-based-vertex detector
- Copy of the inner barrel of ALICE inner tracking system (3 layers)
- Placed nearest the collision point
- High granularity of pixel pitches
- Vertex resolution ~5 μm for p_T > 1 GeV/c
- Precise vertexing and enables the b-jet and open heavy flavor physics programs



Upsilon Spectroscopy

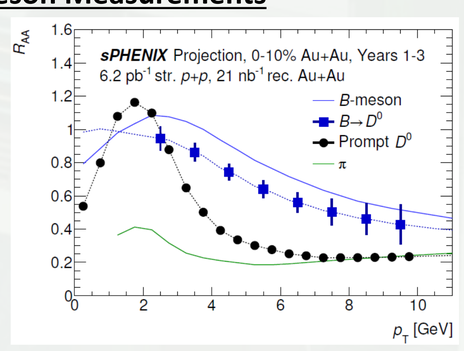


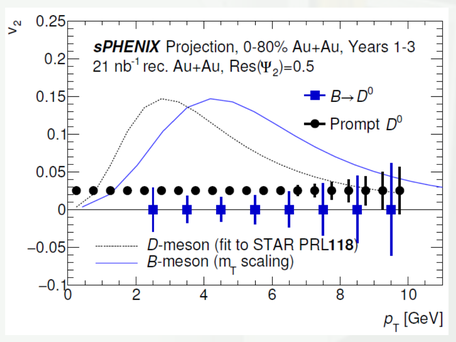


- Sufficient accuracy for clear separation of the Υ(1S, 2S, 3S) states
- Sequential melting of Υ(1S, 2S, 3S) states: suppression due to color screening effect with the presence of the QGP medium
- Comparison between the sPHENIX with LHC experiments on centrality and p_T dependences

Open Heavy Flavor Measurements

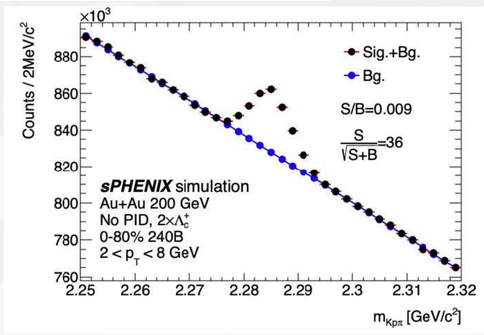
D^0 Meson Measurements

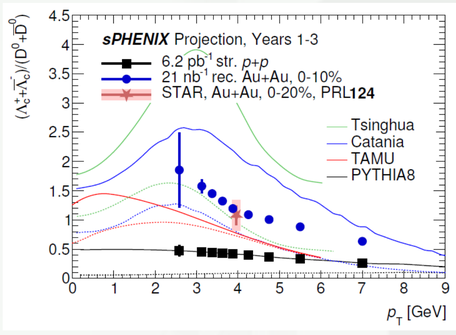




- Precise R_{AA} and v_2 measurements → experimental constraints to theoretical models
- Study charm diffusion and energy loss mechanism in the QGP medium
- Understand flavor dependence of energy loss

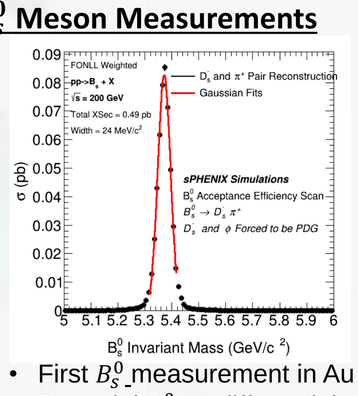
Λ_c^+/D^0 Meson Measurements

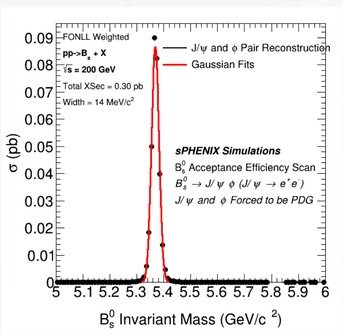


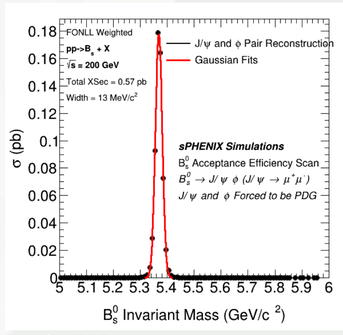


- Study hadronization mechanism of charm quarks
- Constrain various hadronization models such as statistical, fragmentation, and coalescence

B_s^0 Meson Measurements







- First B_s^0 measurement in Au + Au collision at RHIC energy with leptonic PID
- Potential B_s^0 p_T differential measurements down to $p_T = 0$
- Study hadronization mechanism of bottom quarks

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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