sPHENIX tracking detector highlight and related physics studies

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Iowa State University

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2nd workshop on advancing the understanding of non-perturbative QCD using energy flow

Stony Brook University

Outline

sPHENIX Overview

sPHENIX Tracking Detectors

- MVTX
- INTT
- TPC
- TPOT

sPHENIX Physics

- Jets
- Heavy Flavor/Quarkonia

sPHENIX Overview

Tracking Detectors

- MVTX
- INTT
- TPC
- TPOT

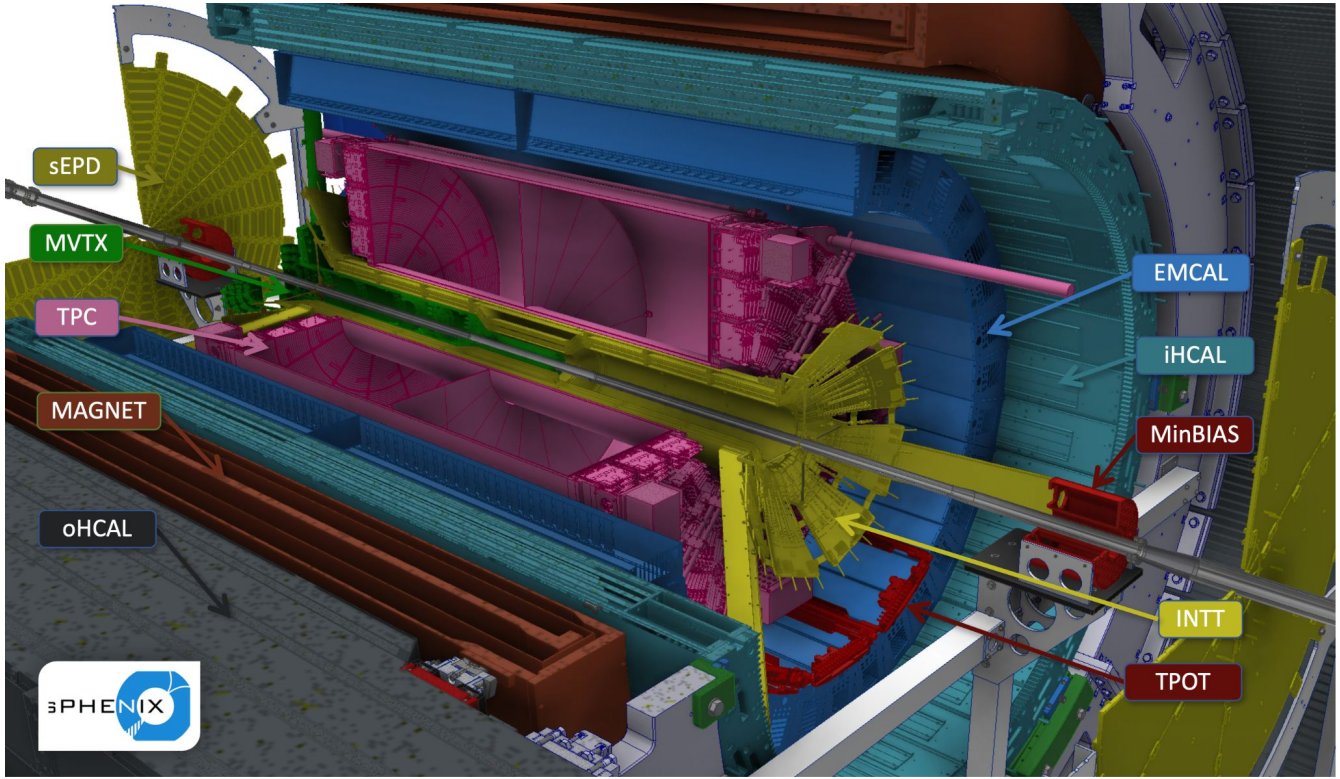
Calorimetry

- EMCAL
- HCAL (inner/outer)

Magnet

Forward Detectors

- sEPD
- MBD (minBIAS)



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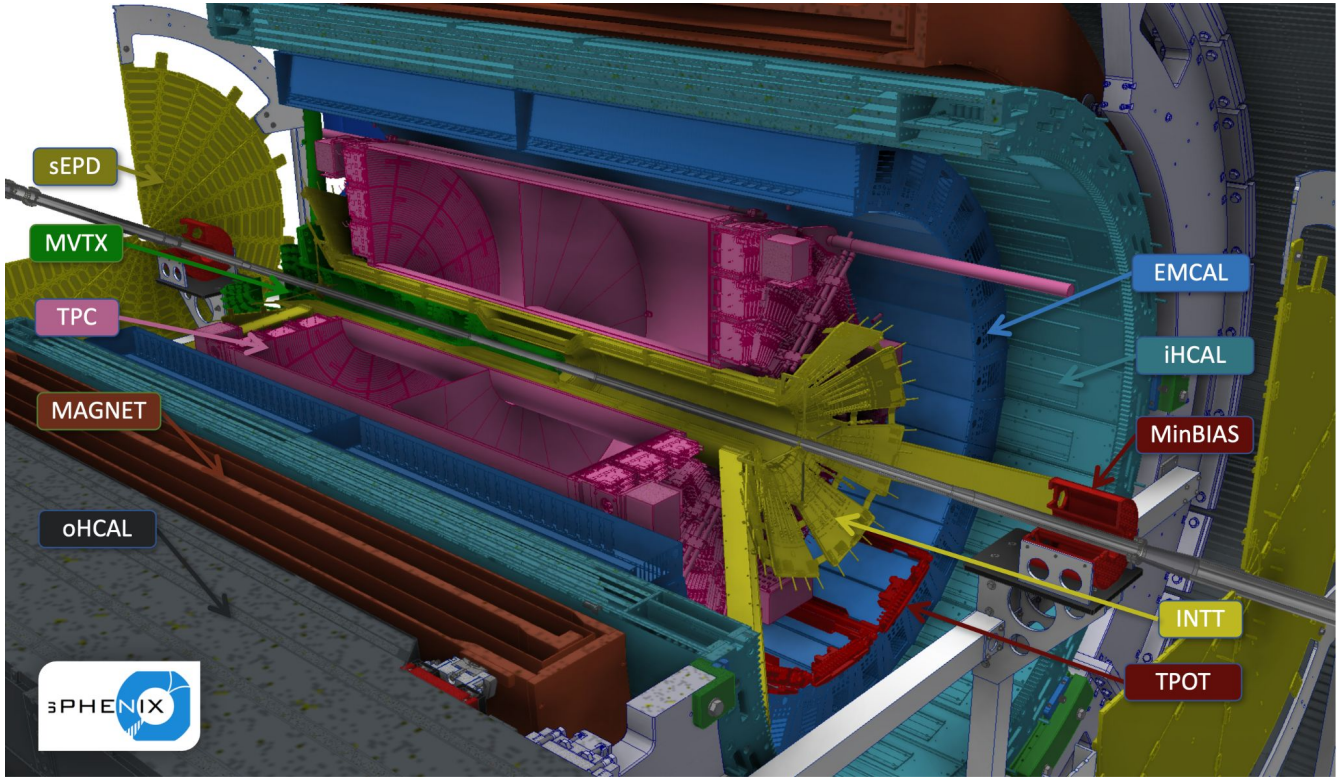
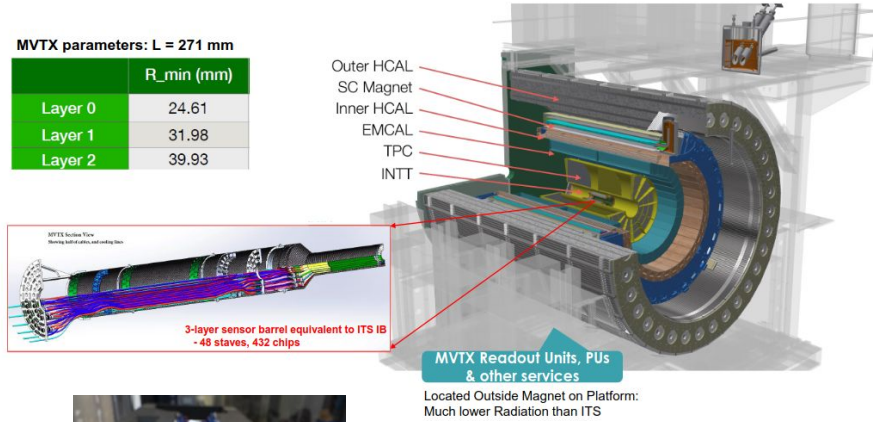


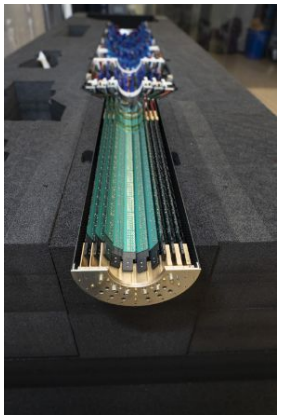
MVTX - Maps-based VerTeX detector

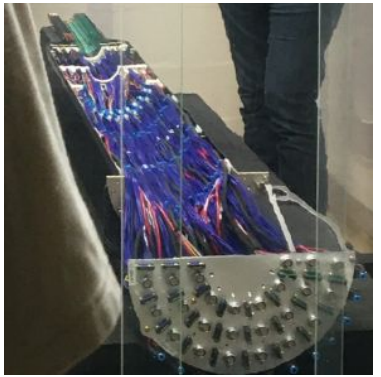
- MAPS: Monolithic Active Pixel Sensors
  - ALPIDE CMOS Pixel
  - 29 x 27 μm
- 48 staves/3 layers
  - 9 ALPIDE chips/stave
  - 2.4 < r < 4 cm, |η| < 1.1, full φ
- Identifies collision vertex position
  - O(1 - 10 μm) vertex position resolution
  - O(1 μs) timing

MVTX parameters: L = 271 mm

	R_min (mm)
Layer 0	24.61
Layer 1	31.98
Layer 2	39.93





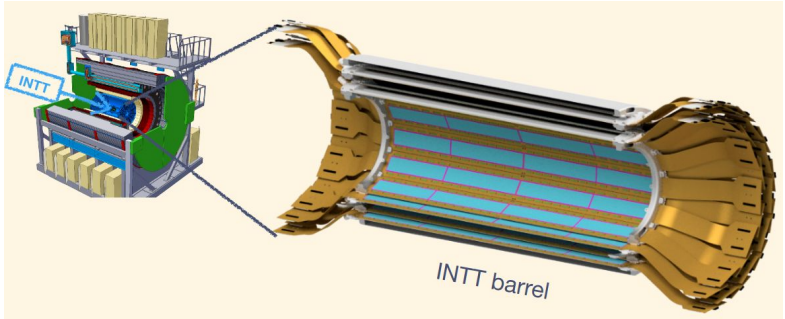


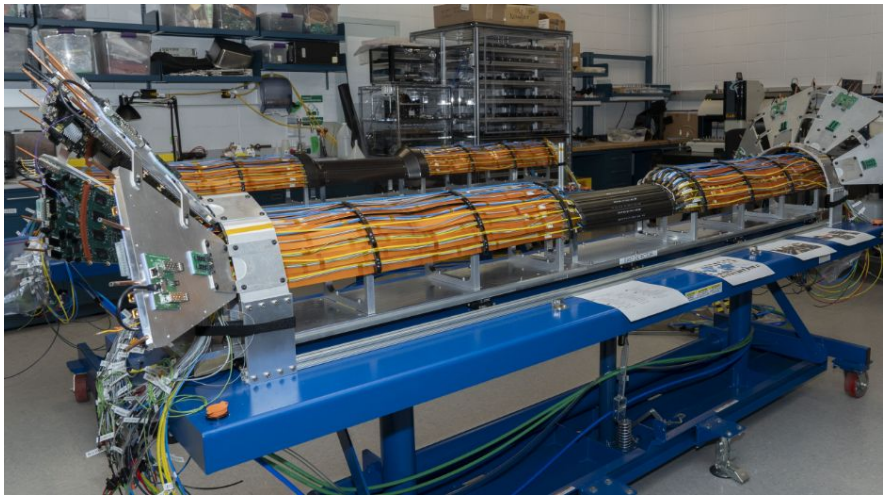
INTT - INTermediate silicon Tracker

- Silicon Semiconductor Strip Detectors
  - 2 kinds of Hamamatsu silicon modules
  - 78 μm x 16 or 20 mm

- 56 staves/2 layers
  - 32+20 chips/stave
  - 7 < r < 11 cm, |η| < 1.1, full φ

- Precision Timing + Hit Interpolation
  - O(100 ns) - similar to bunch x-ing
  - O(10 μm) resolution in rφ
  - O(1 cm) resolution in z



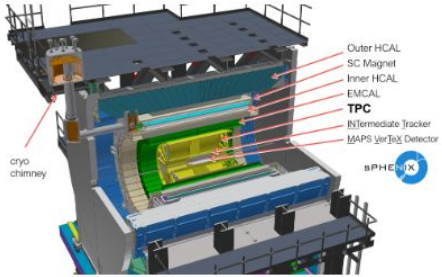


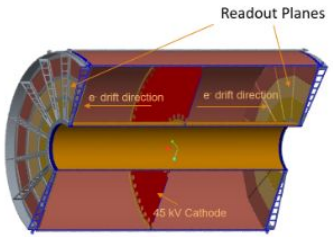
TPC - Time Projection Chamber

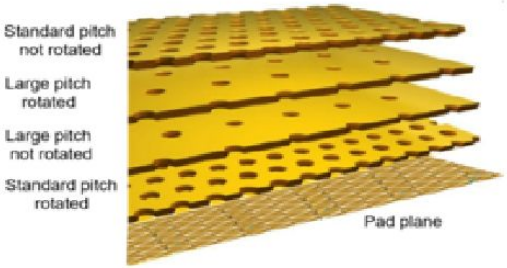
- Gaseous Drift Detector
  - Ar/CF_4 60/40 % drift gas
    - O(13 μs) drift time
  - GEM (Gaseous Electron Multiplier) amplification
    - 4 Kapton + Copper GEMs / module
  - Zig/Zag segmented copper sensor pads

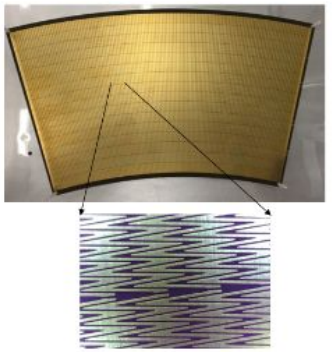
- 72 GEM modules/2 sides
  - 36 modules / full φ
  - 3 modules / full r
  - 20 < r < 78 cm, |η| < 1.1, full φ

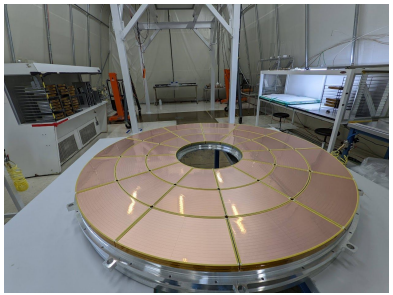
- Measures Momentum
  - Target momentum resolution:
    - Δp/p = 0.02 * p for p ~ 5 GeV
  - O(150 μm) spatial resolution

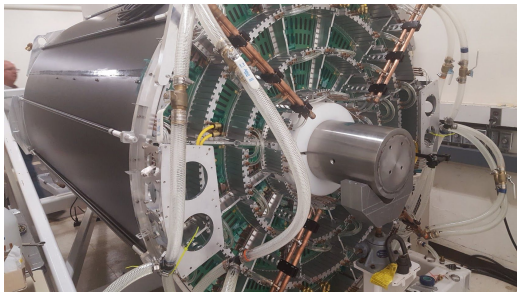










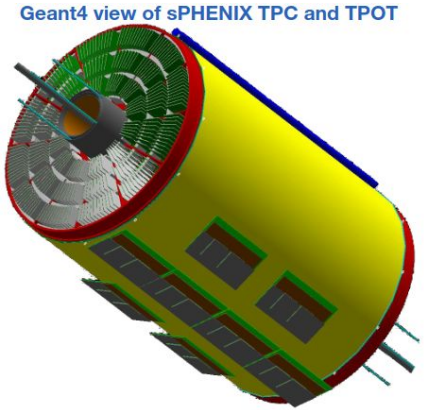


TPOT - Time Projection chamber Outer Tracker

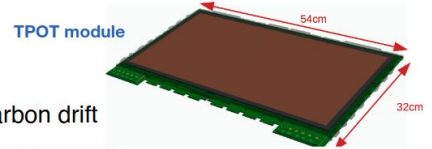
- Gaseous Drift Detector
  - Ar/HC$(CH_3)_3$ 95/5 % drift gas
    - 3 mm drift length
  - Micromegas amplification
  - Resistive layer w/ strips for readout

- 8 modules/bottom of TPC
  - Partial coverage

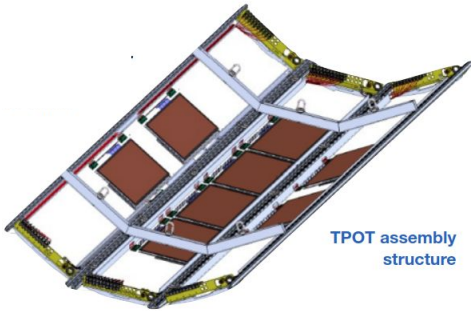
- Provides reference for TPC
  - O(100 μm) spatial resolution
  - Correction of average distortions



Each module = **2 bulk, resistive 1D-Micromegas detectors (back-to-back)**

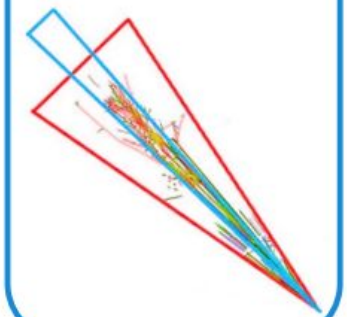


- Carbon drift
- 1mm/2mm pitch
- Ar/Isobutane (95/5)
- **Resistive** layer with strips

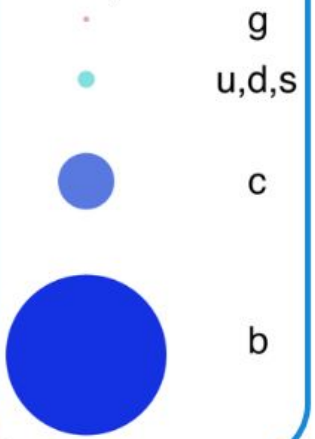


sPHENIX Physics Program

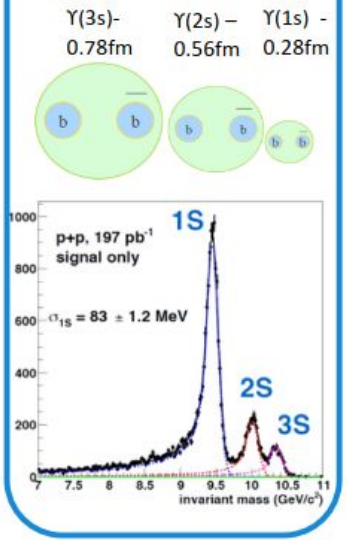
Jet Physics
Vary momentum/ angular size of probe



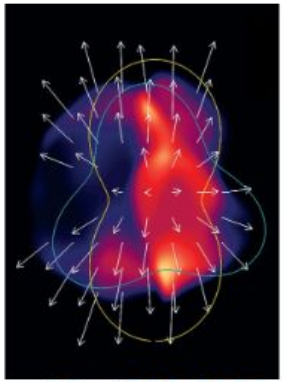
Heavy Flavor
Vary mass/ momentum of probe



Quarkonia
Vary size of probe

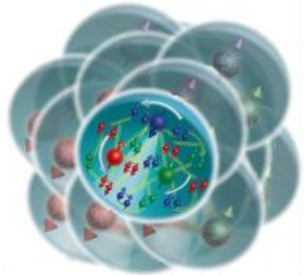


Bulk
Study global/local medium properties



arXiv:1209.6330

Cold QCD
Study proton spin, p_T, and cold nuclear effects

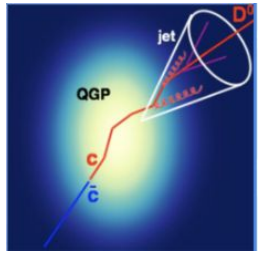


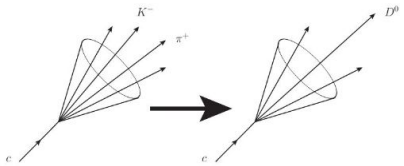
sPHENIX Jet Physics Program

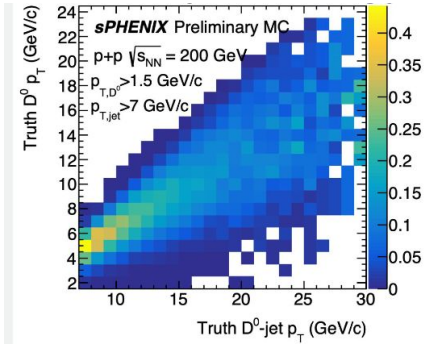
- E.G. D^0 jets
  - Study of heavy-quark initiated jet structure and parton shower

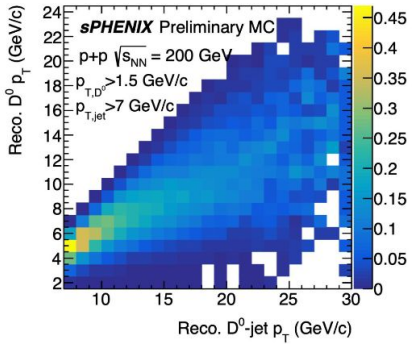
- Process:
  - D mesons reconstructed from D^0 -> $K^-\pi^+$
  - Tracks + clusters from calo combined with particle flow
  - D meson decay daughters removed
    - Replace w/ 4-vector
  - D meson decay daughters removed

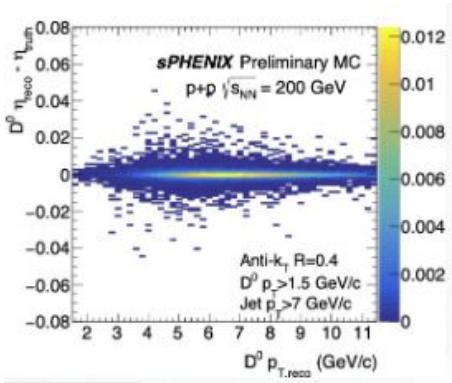
- Requires good p_T and DCA xy resolution
  - $\Delta p_T / p_T < 2$ %
  - σ(DCA xy) < 40 μm

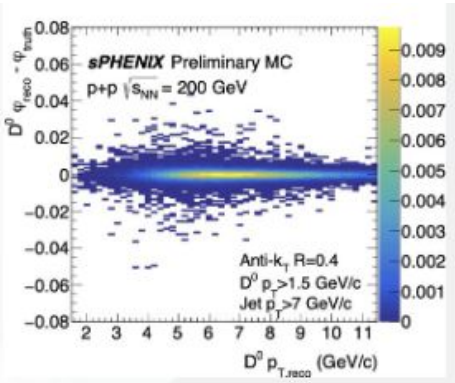










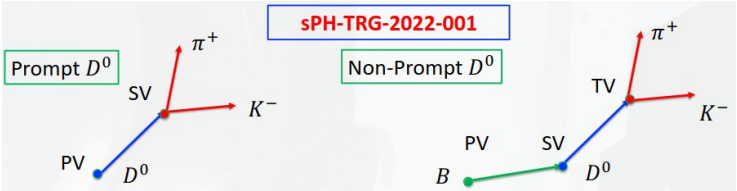


sPHENIX Heavy Flavor Physics

- E.G. B -> D^0 decay

- First fully reconstructed b-hadron from exclusive decays in heavy-ion collisions at RHIC

- Promp/non-prompt D^0 separation:
  - Data-driven method with DCA precisely determined by MVTX
    - DCA resolution < 40 μm for p_T < 0.5 GeV
  - Prompt D^0: v_2 and R_{AA}
    - investigate charm thermalization in QGP
  - Non-Prompt D^0: v_2 and R_{AA}
    - indirect study on b-quark diffusion and hadronization



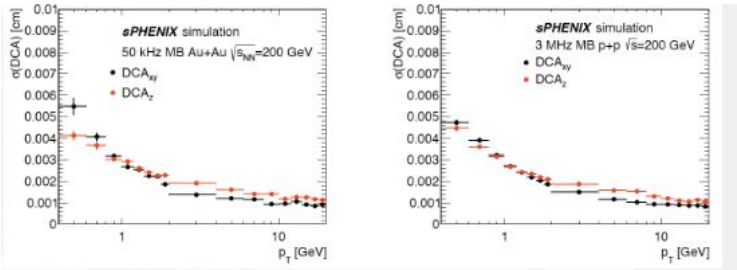
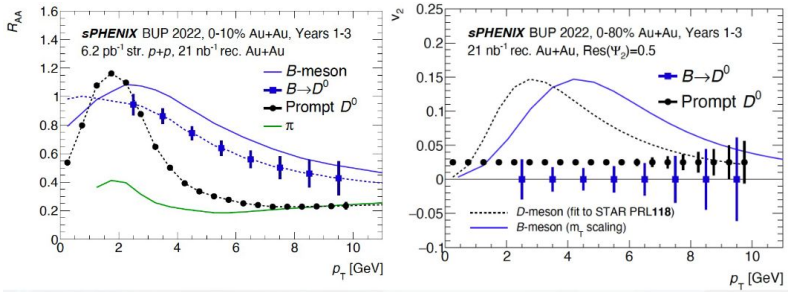


Figure 3. Track DCA to the event vertex in Au+Au and p+p collisions.



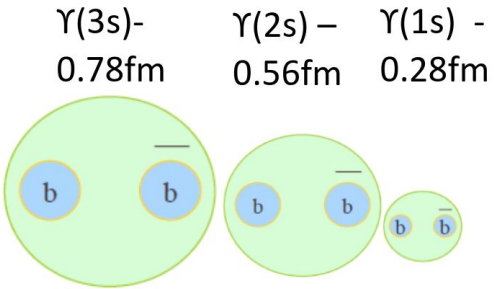
sPHENIX Quarkonia Physics

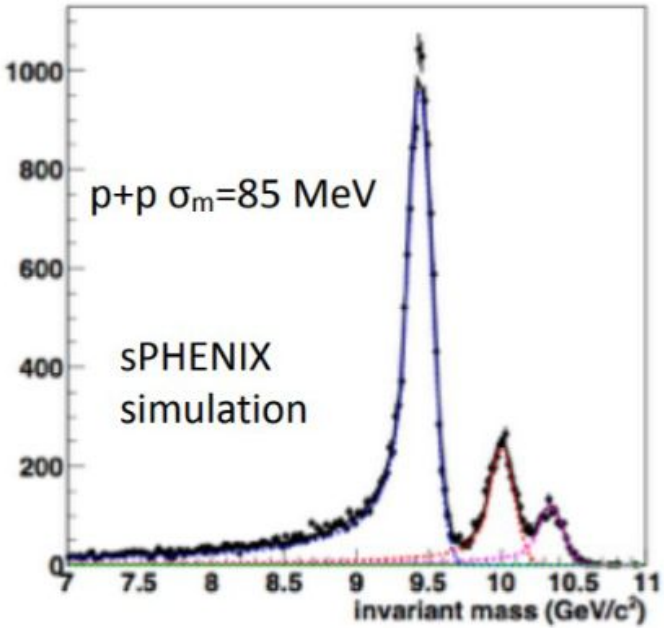
- E.G. Upsilon Y(nS) Measurement

- sPHENIX 1st RHIC experiment to measure multiple Upsilon states

- sPHENIX TPC will provide invariant mass resolution of < 100 MeV/c^2 for di-electron channel

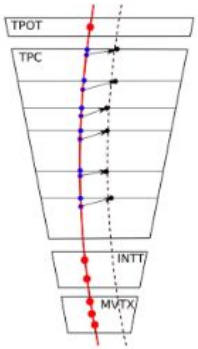
- TPC + MVTX provide good invariant mass resolution down to low p_T

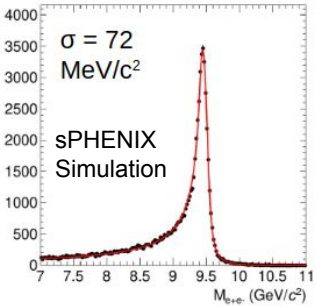




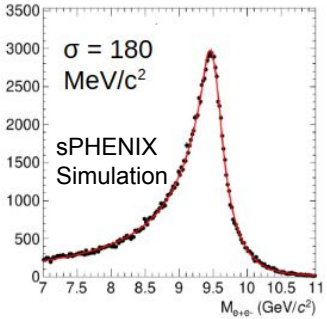
sPHENIX Quarkonia Physics - Upsilon contd.

- Corrections for avg. space charge distortion using TPOT can improve invariant mass resolution
  - Track based correction + time averaged space charge distortions
  - Simulations show improvement to $\sigma^{\Upsilon(1s)}_{\text{inv. mass}} = 75$ MeV/c^2

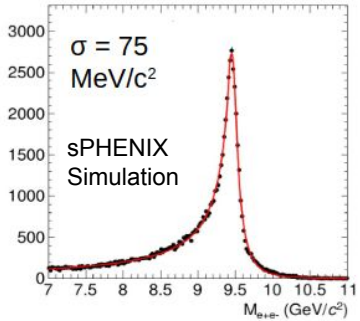




Nominal Upsilon invariant mass distribution in (ideal) simulations



Upsilon invariant mass distribution, with time-averaged space charge distortions and track-based correction (INTT+MVTX)



Upsilon invariant mass distribution, with time-averaged space charge distortions and track-based correction (INTT+MVTX+TPOT)

sPHENIX Bulk Physics Program

sPHENIX Cold QCD Program

Conclusions

- sPHENIX contains state of the art tracking system including silicon and gas drift detectors

- Will provide precision measurements of jets/heavy flavor/quarkonia

- Many ongoing analyses preparing for full tracking data

Acknowledgements/Thank-Yous

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- Tristan Potzmann
- Audrey Francisco-Bosson
- Maxence Vandenbroucke

+ MANY MORE !

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+ **MANY MORE !**