

The sPHENIX open heavy flavor hadron physics program



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for the sPHENIX Collaboration

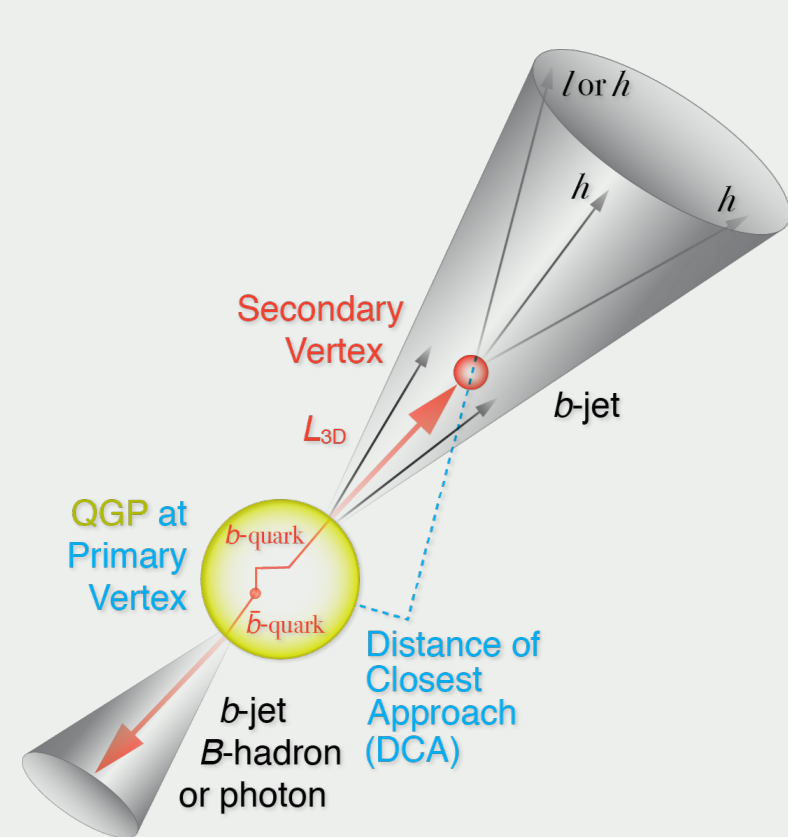
Abstract

Recent data from RHIC and LHC show that R_{AA} and v_2 of charm hadrons are very similar to that of light and strangeness hadrons. The R_{AA} of bottom decay daughters at low p_T seems to be less suppressed than that of light and charm hadrons, suggesting a mass suppression hierarchy. Precision open bottom measurements over a broad momentum range are needed for a detailed understanding of parton energy loss mechanisms and to characterize the transport properties of the strongly coupled QGP medium. The sPHENIX detector at BNL's Relativistic Heavy Ion Collider (RHIC) will have extensive capabilities for jet and Upsilon measurements. A fast MAPS-based silicon vertex detector (MVTX) is proposed to greatly enhance the heavy flavor detection capabilities of sPHENIX. We will present physics simulation studies on the open bottom measurements within the full sPHENIX tracking environment including the MVTX detector. Open bottom reconstruction has been explored via the inclusive non-prompt D^0 daughters and the full exclusive reconstruction of B^+ . Statistical projections on the nuclear modification factor and the elliptic flow measurements will be presented.

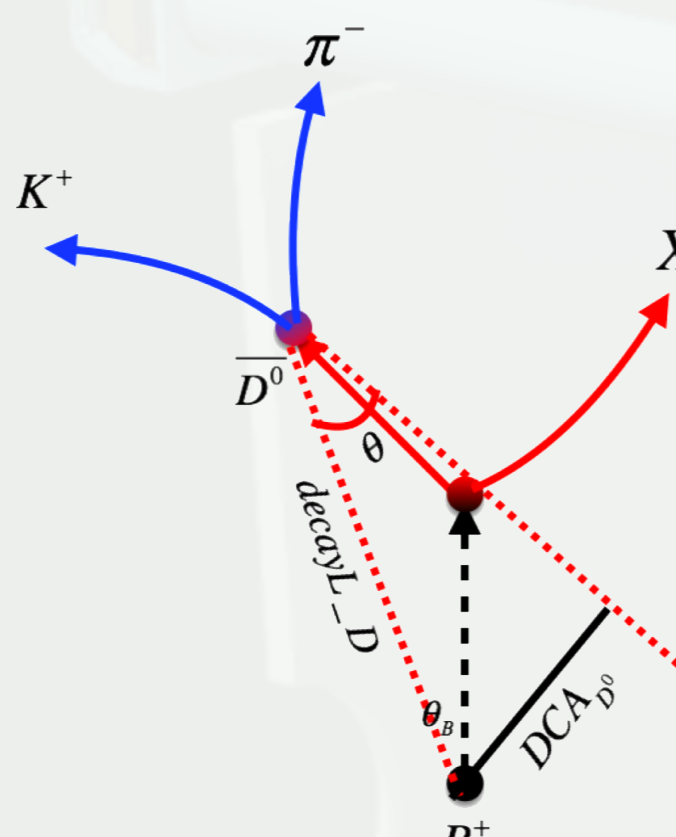
Physics: Heavy Flavor Measurements

- Heavy quarks to probe QGP
- Heavy Flavor hadrons have unique decay topology
- Precision vertex tracker + good momentum resolution + high rate
- Precision charm/bottom observables over wide scales

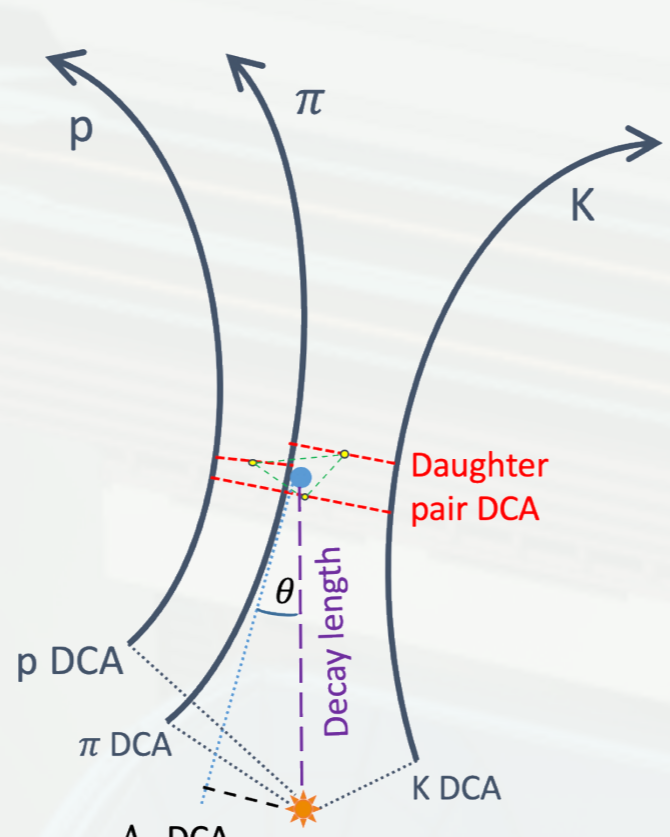
Jet Measurements



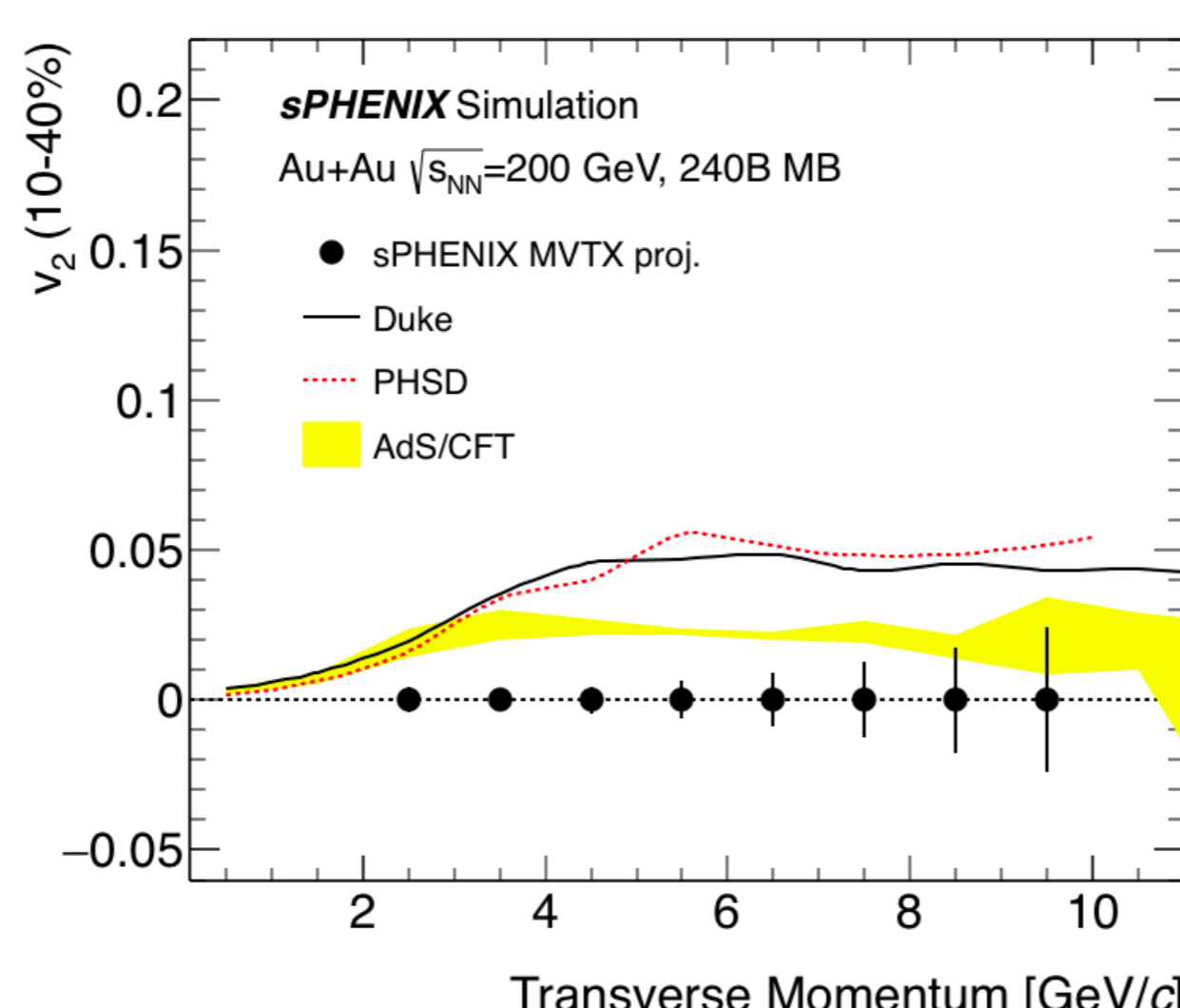
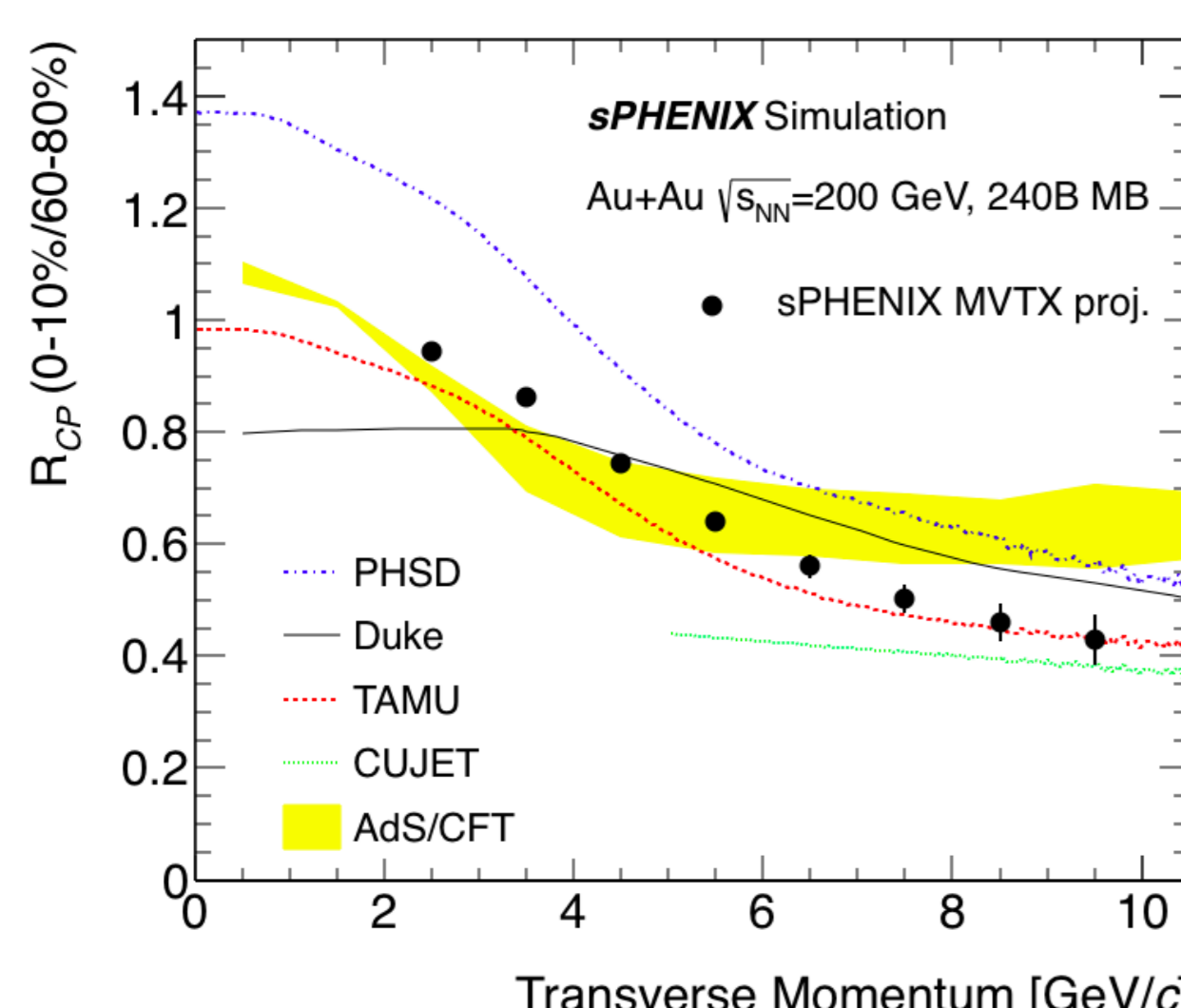
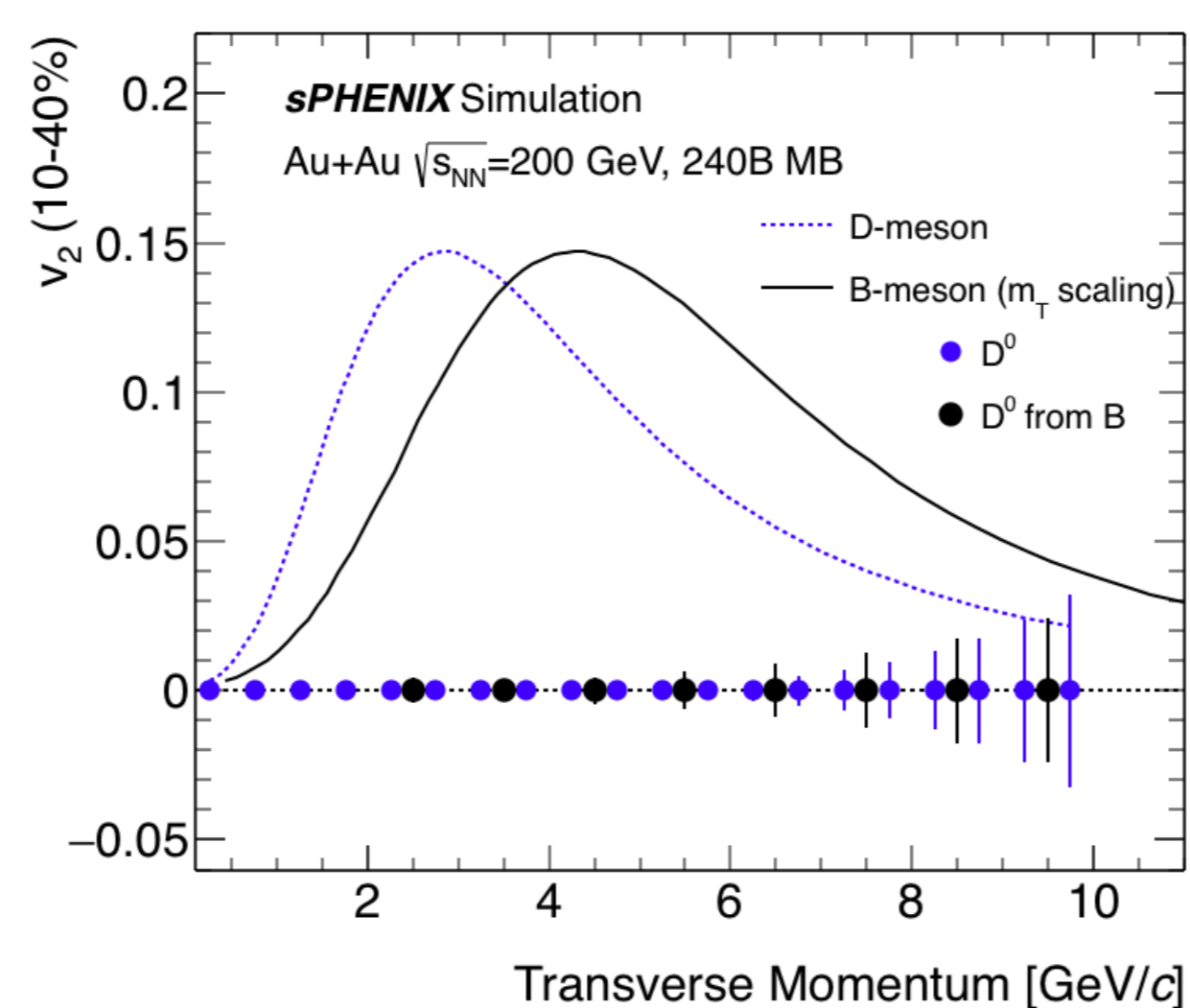
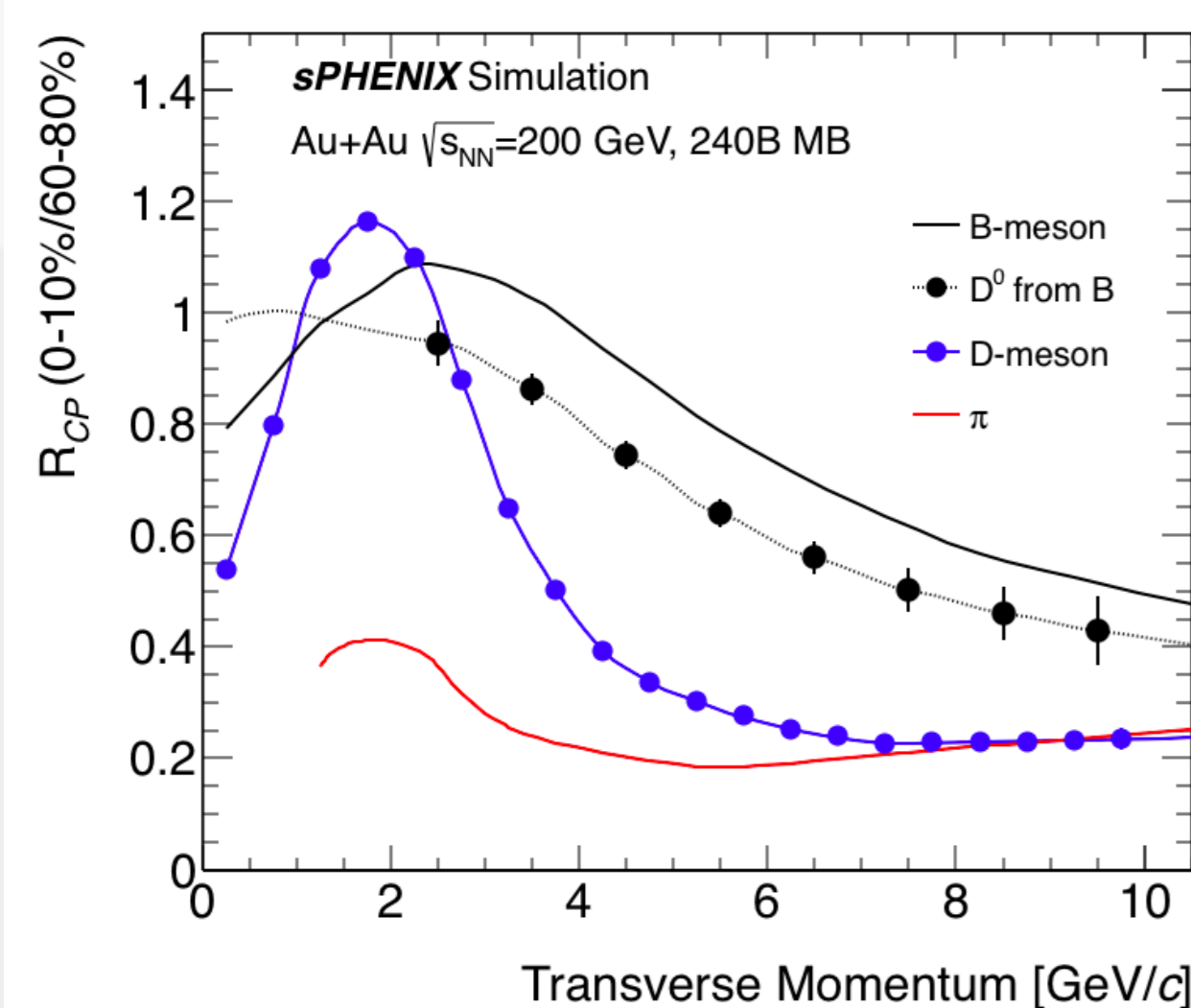
$B \rightarrow \bar{D}^0 + X$



$\Lambda_c \rightarrow p + K + \pi$



Statistical projection



Precision open bottom R_{cp} and v_2 measurements through non-prompt D^0 (i.e. $B \rightarrow D^0$) from 2 – 10 GeV/c

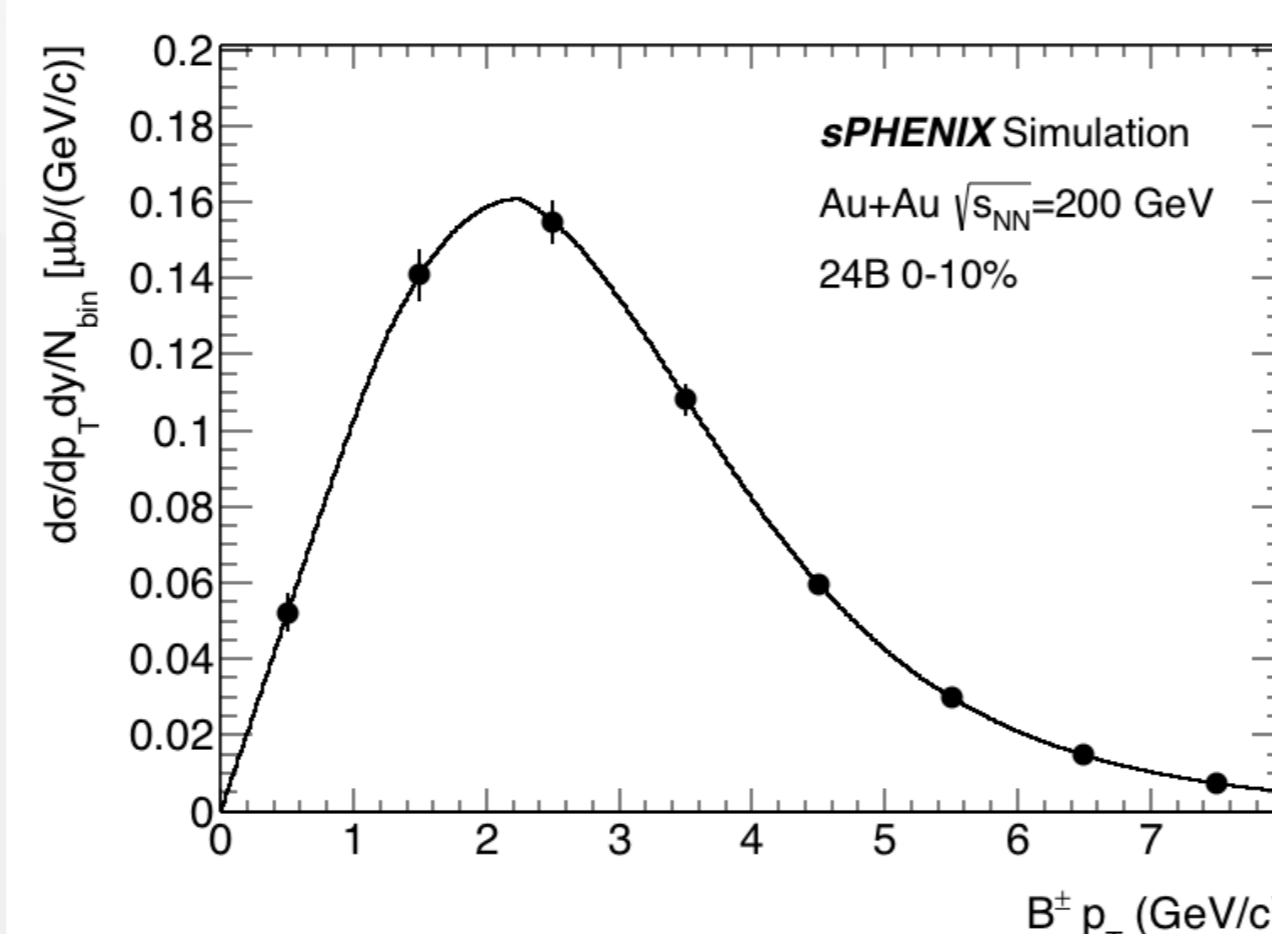
- parton energy loss
- heavy quark diffusion coefficient

Full reconstruction of B^+ meson through exclusive decay channel

- Constrain total B^+ cross section
- Heavy quark hadronization

Ongoing study on sPHENIX upgrade to enable precision measurements of B^+ , Λ_c , prompt and non-prompt D^0 in p+p collisions at $\sqrt{s} = 200$ GeV

(Plots with 240 billion minimum bias events, expected from multi-years sPHENIX operation)

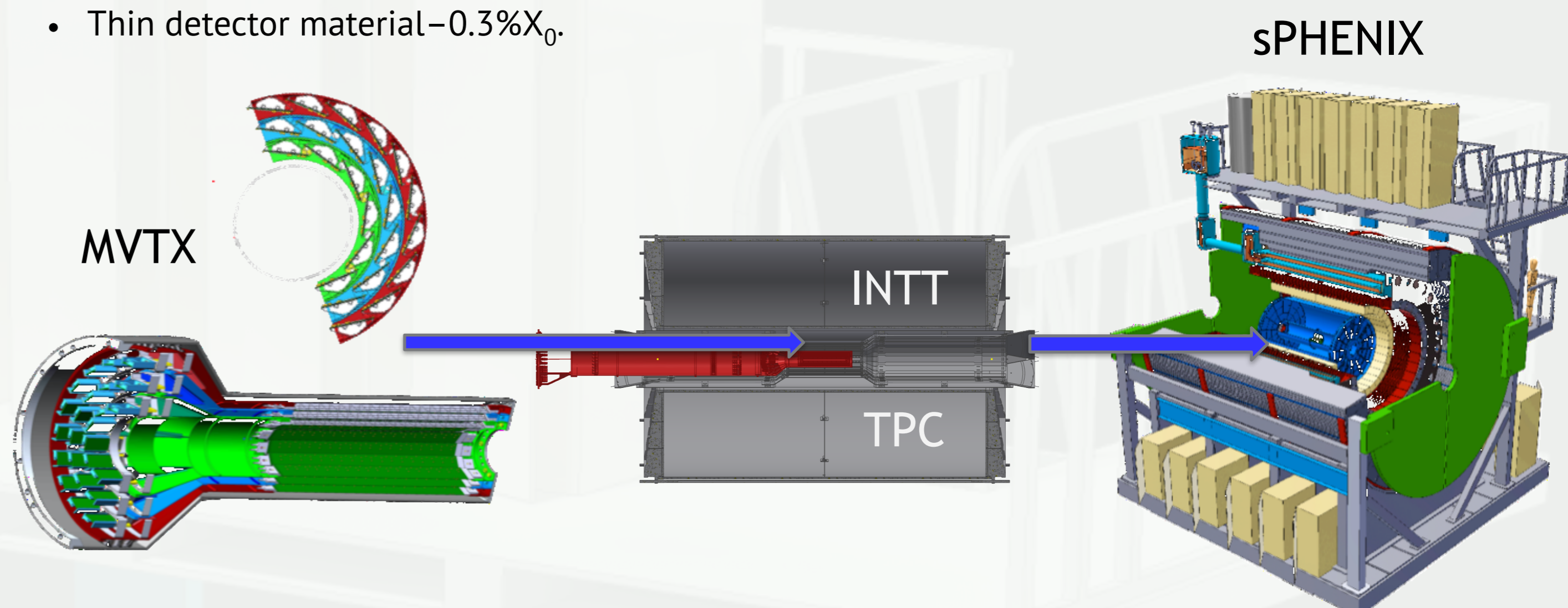


MVTX detector in sPHENIX

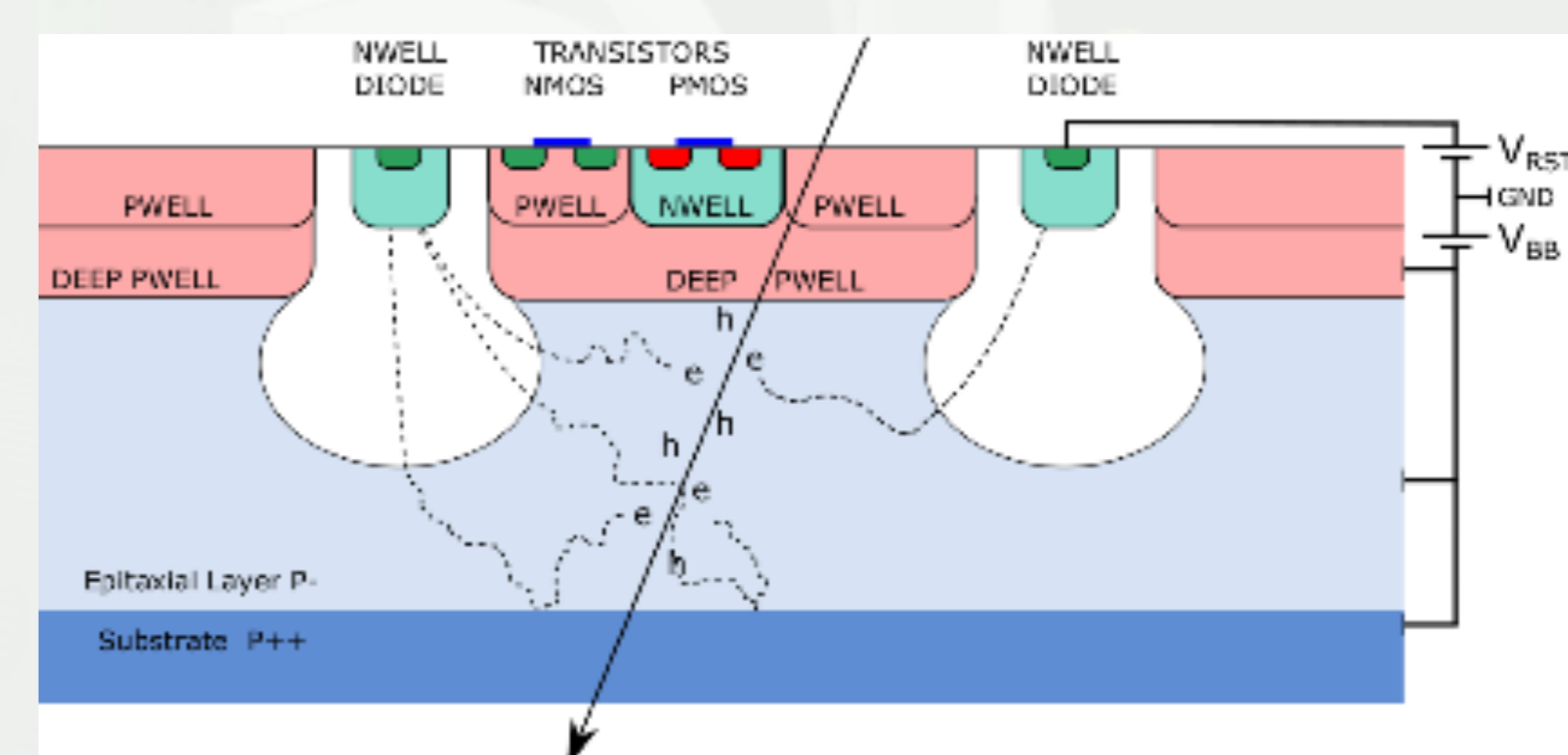
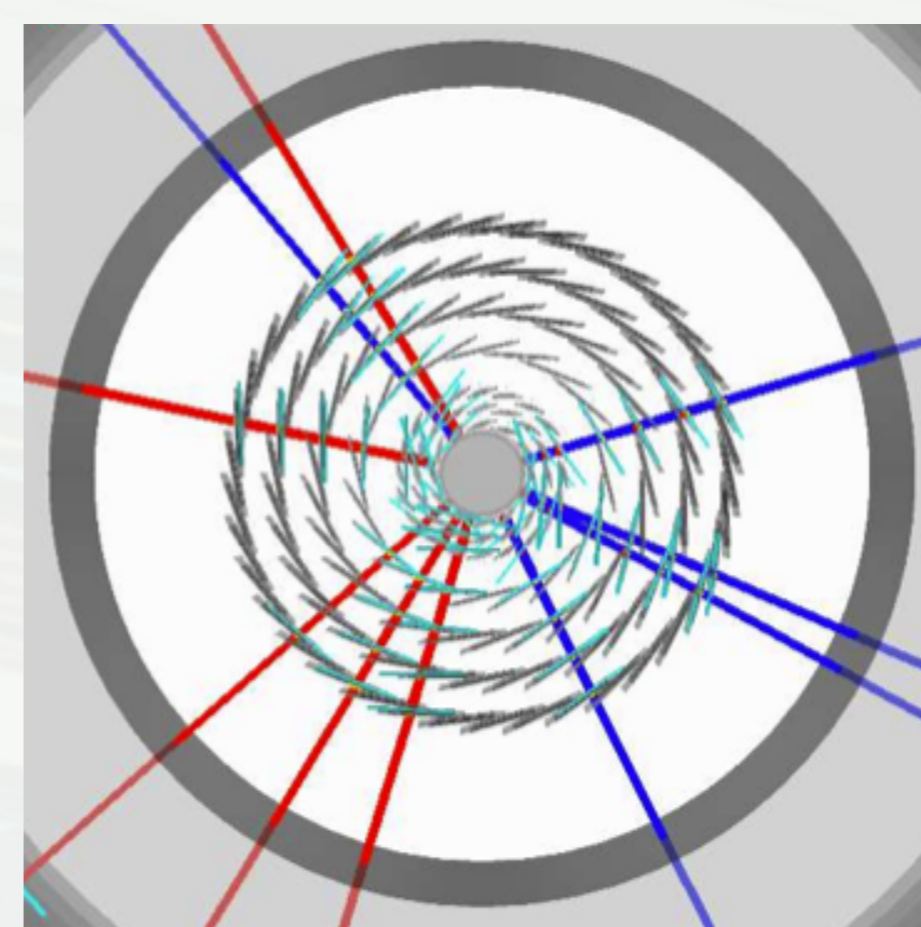
sPHENIX is a next generation high speed multipurpose detector focused on jet, Upsilon and open heavy flavor programs.

MVTX – MAPS vertex detector for precise secondary vertex measurement

- Next generation fast Monolithic Active Pixel Sensor.
- Integration time $\leq 10\mu s$.
- Thin detector material $\sim 0.3\%X_0$.



MVTX simulation



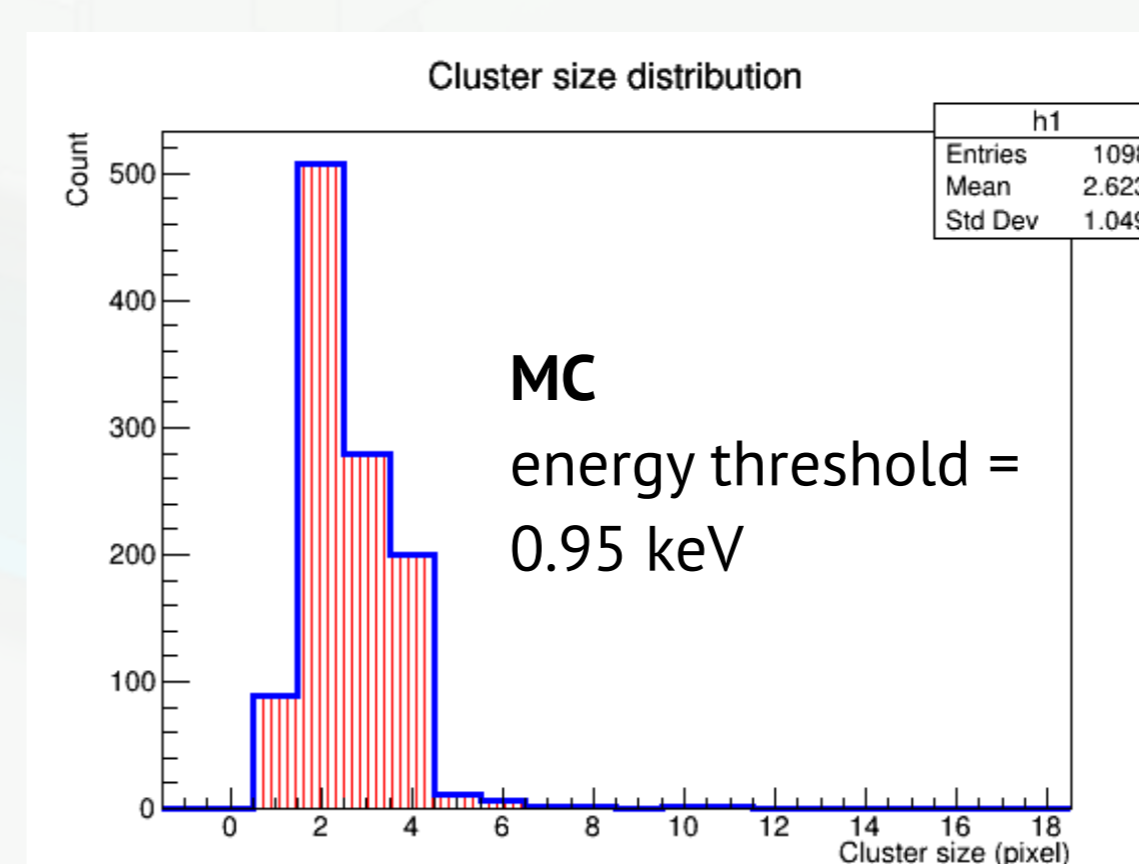
Event display of tracks in TPC+INTT+MVTX.

Simulation and reconstruction of MVTX in sPHENIX software

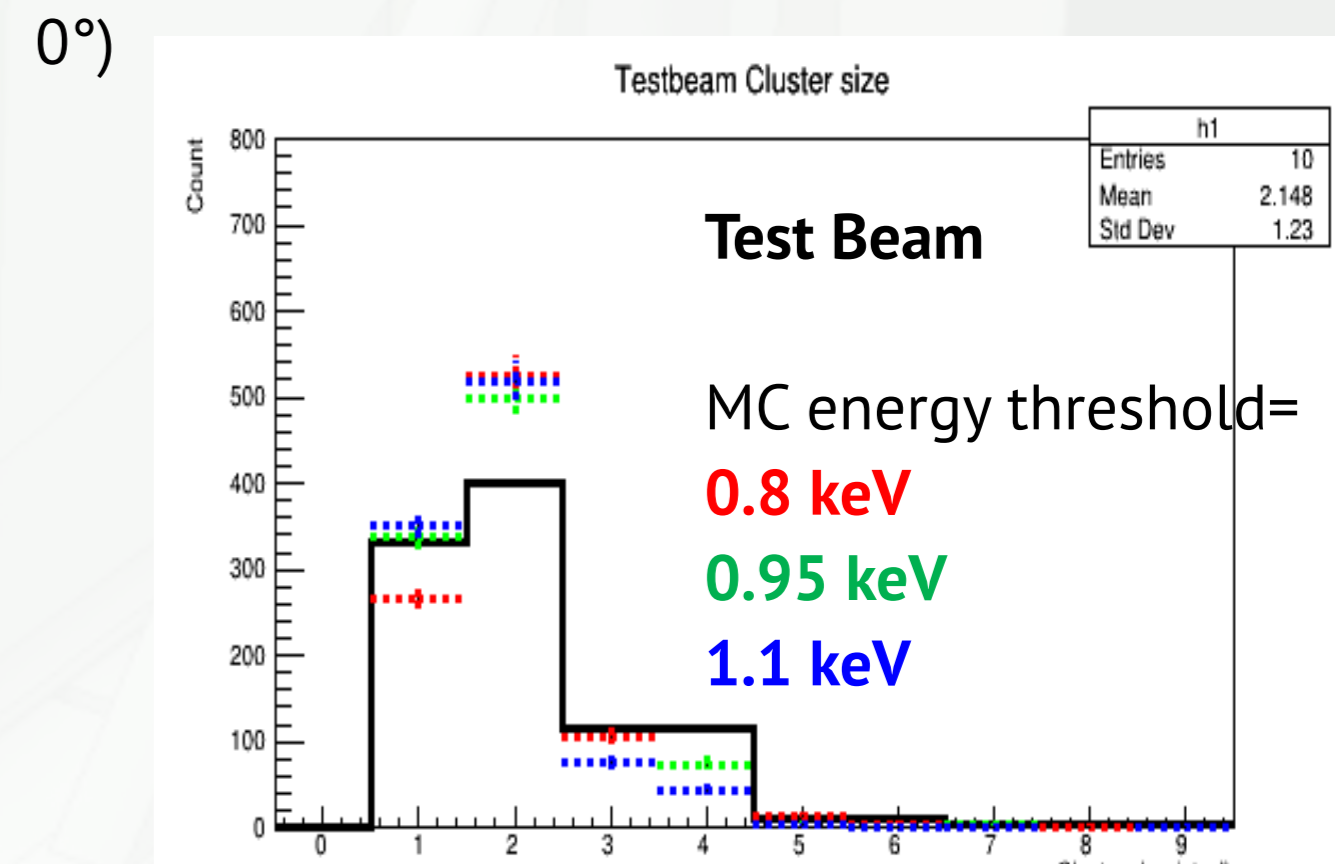
- A charged track goes through the sensor in a layer of MVTX.
- Divide the step in sensor into N segments.
- Charge diffusion radius ranges from R_{min} (8 μm) to R_{max} (25 μm)
- Calculate the overlapping area of circle with pixels to distribute energy deposit in the segment.
- Sum up all segments to get the total energy deposit on each pixel.

Simulation Tuning with Test Beam Data

Cluster size distribution of MVTX hits in simulation and test beam (120 GeV protons @ 0°)



Cluster size in MC with MVTX hits under energy threshold removed



Comparison of MVTX Cluster size in Test Beam data and MC simulation (reduced diffusion R_{min} & R_{max})

Summary

Heavy flavor physics program at RHIC 2023-2025+

- One of the four physics pillars for sPHENIX (in addition to Jets, Upsilon, and cold QCD)
- Precision open bottom measurements over a broad momentum range
- Precision measurements of charm baryons

MVTX detector upgrade is important for heavy flavor measurements at sPHENIX

- Interaction of tracks with MVTX detector has been simulated
- The MVTX prototype beam test data are being used to tune the MC simulation