



sPHENIX capabilities for measuring Λ_c production in Au+Au collisions

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Abstract

A strong enhancement of Λ_c/D^0 ratio compared to the fragmentation baseline is observed in Au+Au collisions at the top energy of the RHIC. This also suggests that Λ_c may be an important component for the total charm cross section. Precision measurements of charm baryons over a broad momentum range are needed for a detailed understanding of hadronization and parton energy loss mechanisms as well as to characterize QGP transport properties.

sPHENIX is a planned next-generation high-rate jet, Upsilon and open heavy-flavor detector at RHIC. A state-of-the-art MAPS-based silicon detector (MVTX) is proposed to enhance heavy flavor detection capabilities greatly. We will present simulation studies of Λ_c baryon measurements in 200 GeV Au+Au collisions utilizing the full sPHENIX tracking capabilities with MVTX. The simulation method for estimating the expected signal and background will be discussed. Statistical projections of the Λ_c/D^0 ratio will be presented.

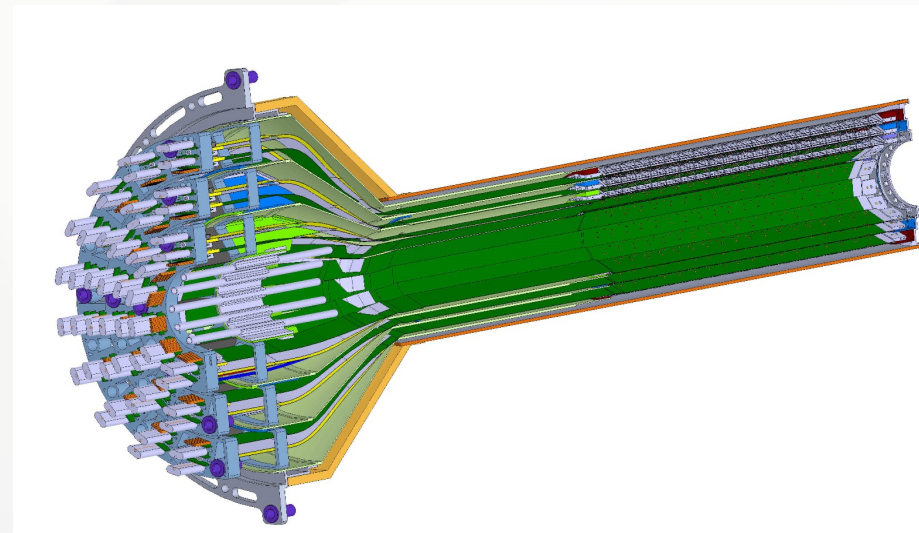
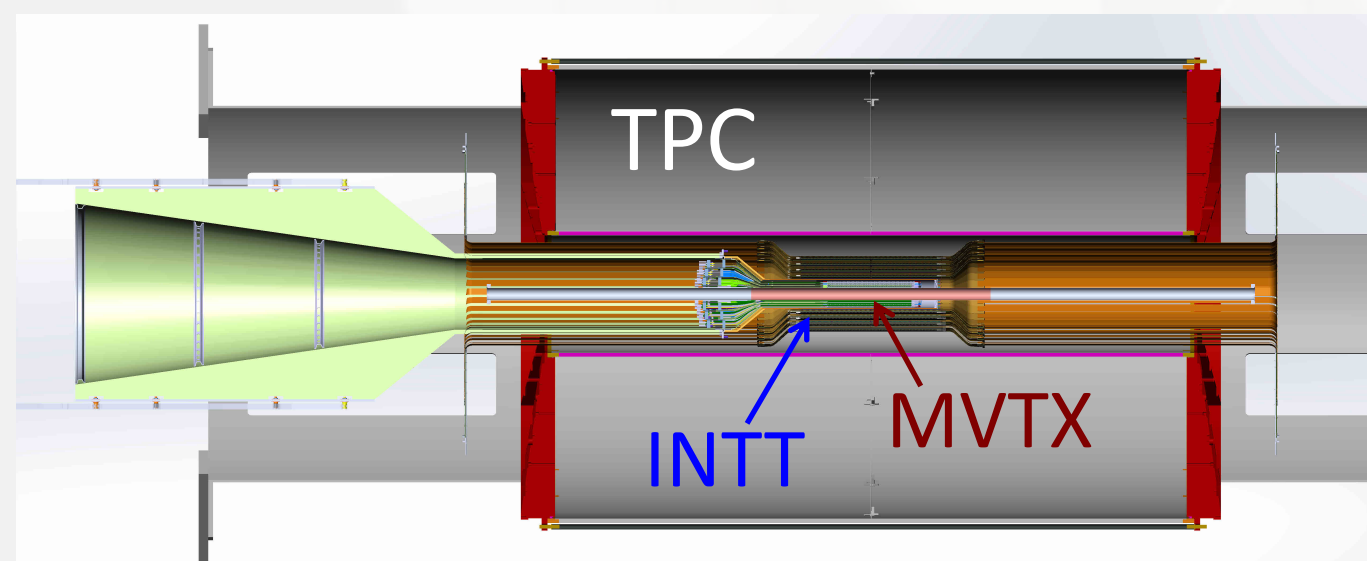
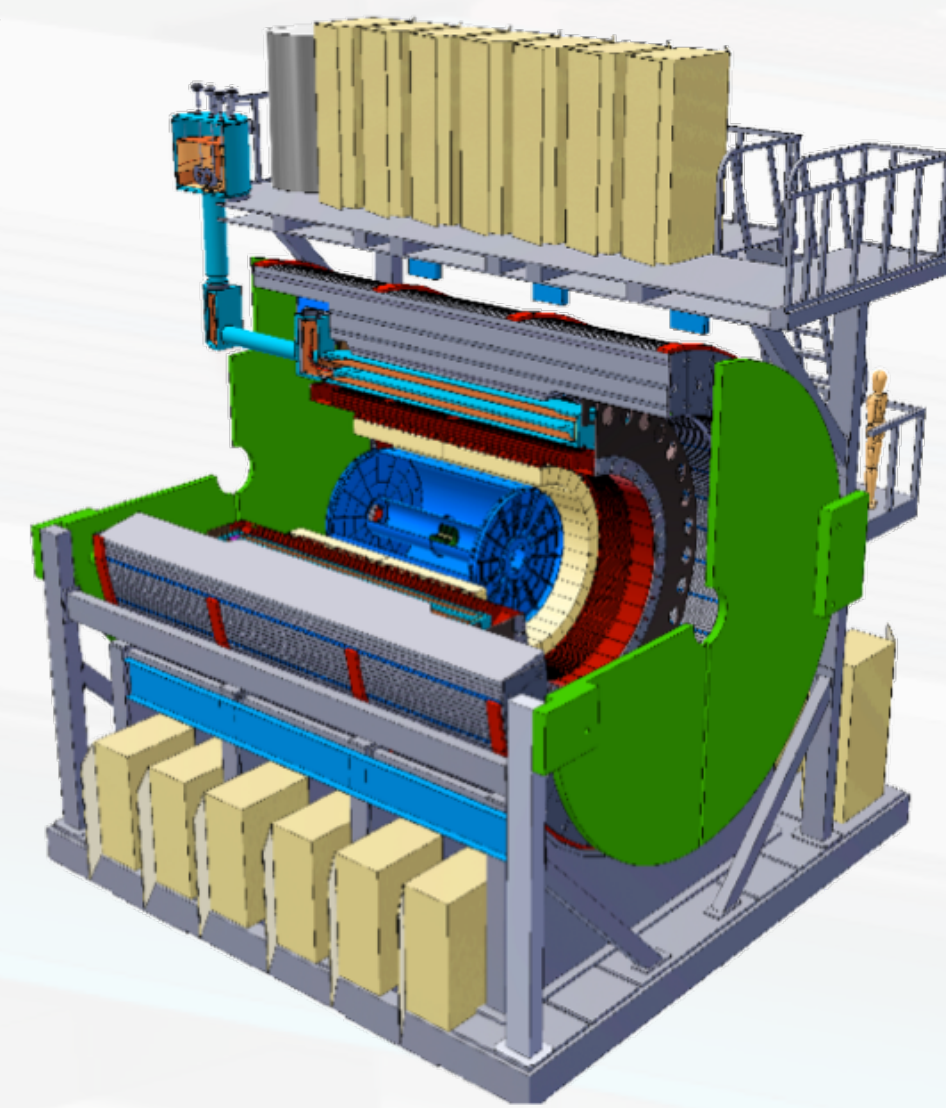
sPHENIX

Next generation high speed multi-purpose detector focused on jet, Upsilon and heavy flavor physics

MVTX

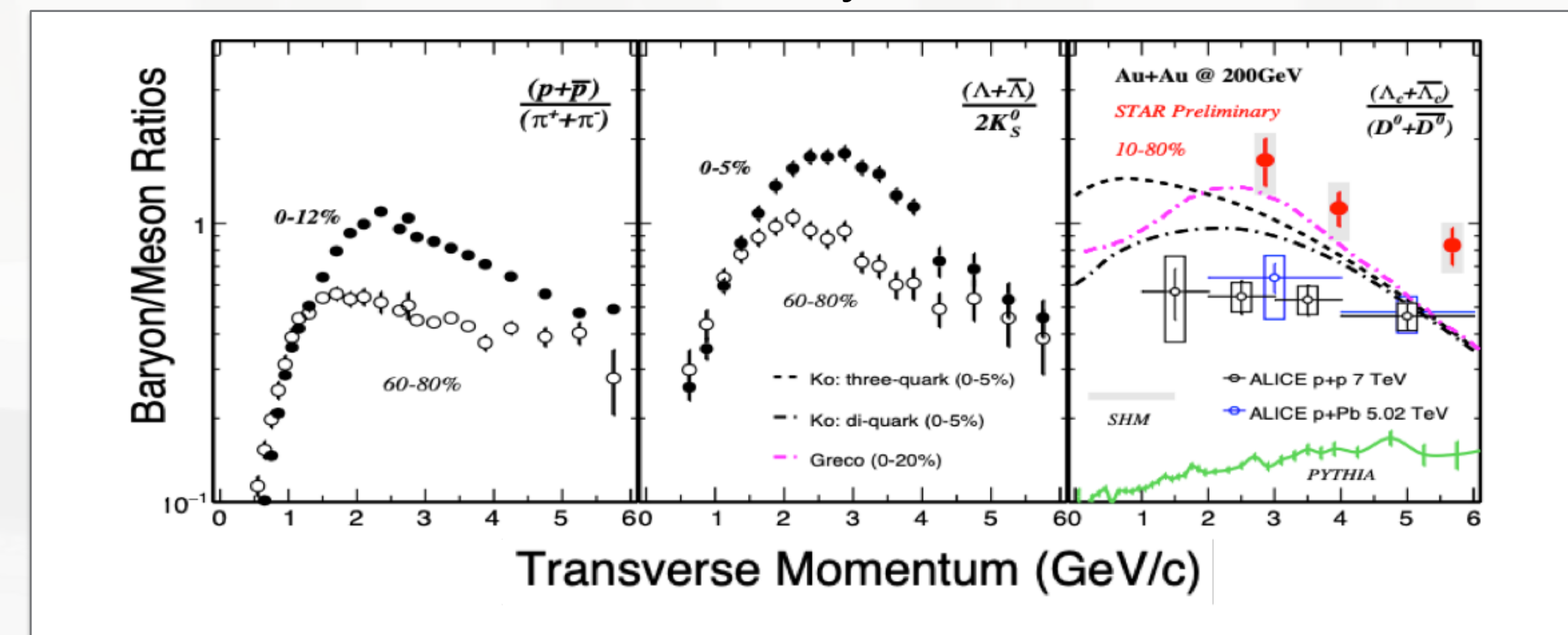
MAPS vertex detector for open heavy flavor measurement

- Next generation fast Monolithic Active Pixel Sensor based on the ALICE ITS upgrade
- Integration time $\leq 10\mu\text{s}$
- Thin detector material – $0.3\%X_0$



Physics motivation

- Heavy quarks: unique probe to study hadronization process
- Large enhancement observed in Λ_c/D^0 ratio in Au+Au collisions w.r.t. the PYTHIA baseline at RHIC
 - coalescence hadronization for charm quarks
 - sizable contribution of charm baryons to total charm cross section

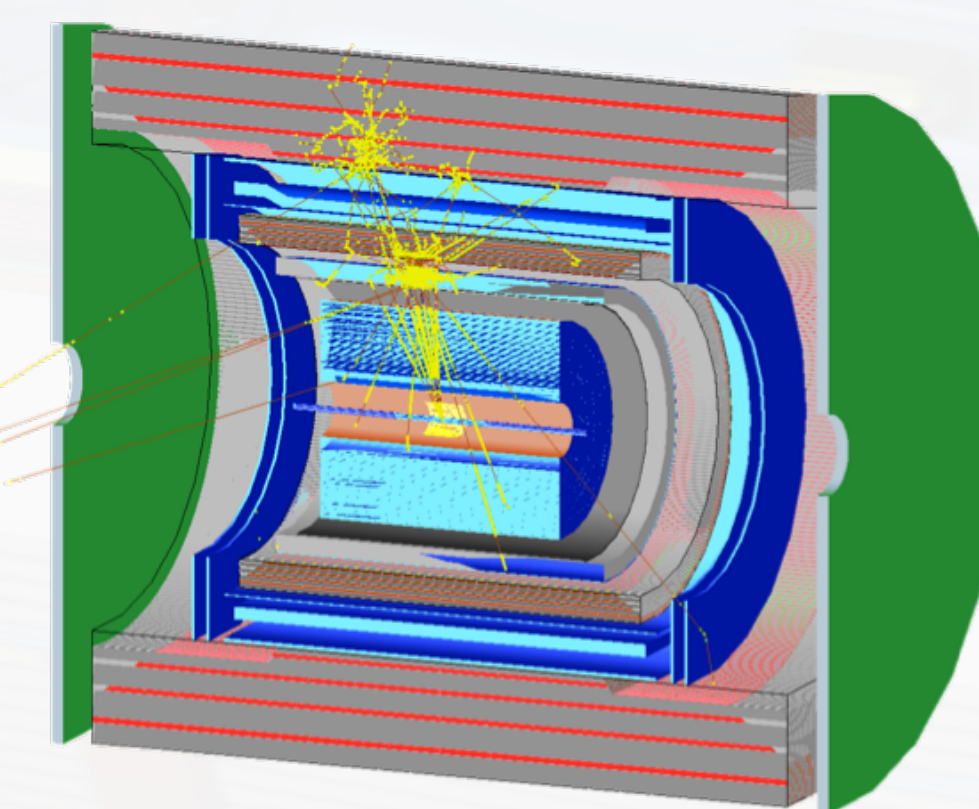


Simulation setup

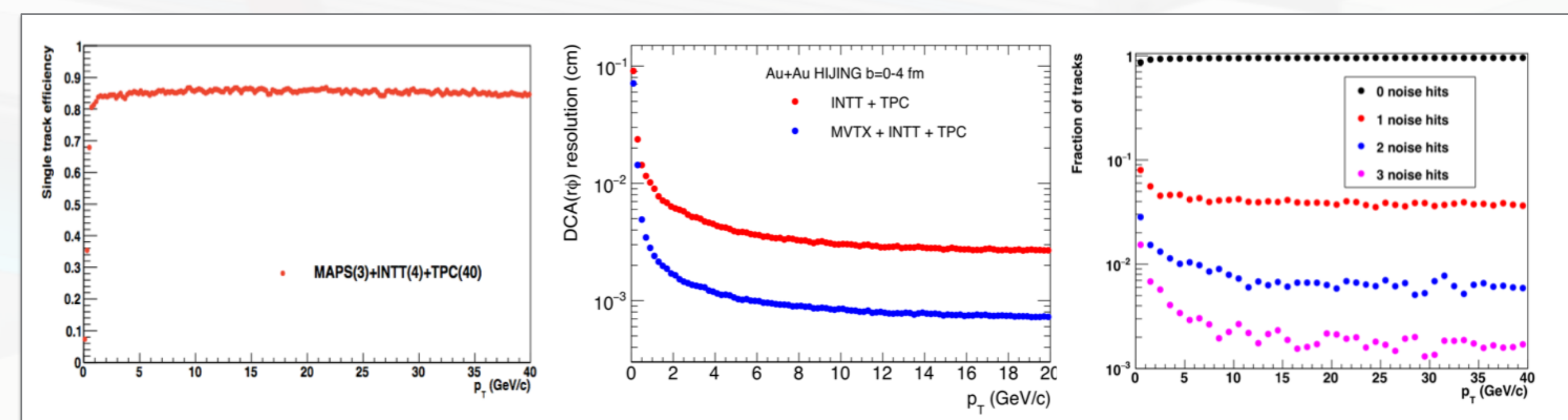
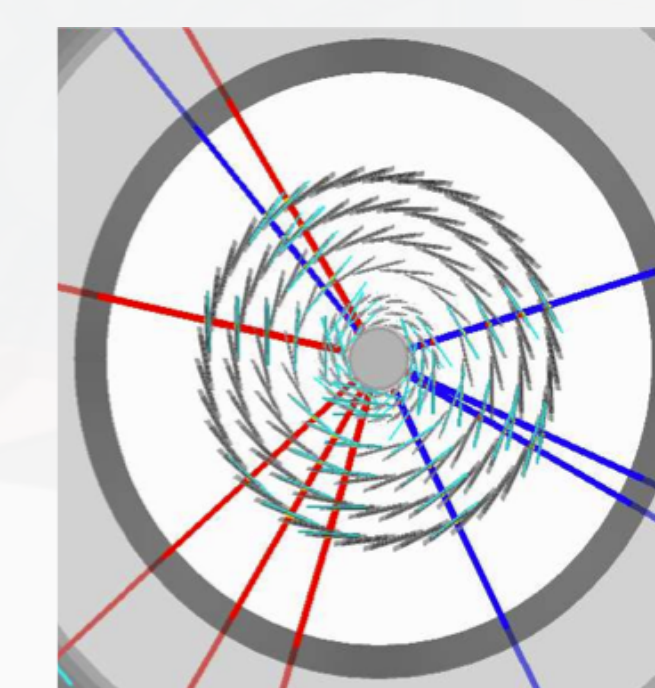
Fast simulation with HIJING+Geant4 tracking performance

- Single track efficiency and DCA from full HIJING+Geant4+GenFit2 simulations
- Fast Monte Carlo simulation to generate the distributions for Λ_c signals as well as combinatorial background
- Topological cuts optimized with TMVA BDT method

sPHENIX Geant4 display of $p_T=30$ GeV/c B^+ -hadron



Tracking with TPC+INTT+MVTX



PDG: $\Lambda_c^+ = udc$
Mass(Λ_c^+) = 2286 MeV
 $c\tau = 59.9 \mu\text{m}$

$\Lambda_c^+ \rightarrow K^0 p^+$ 6.23%



signal

- EvtGen generator including resonance decay channels
- p_T and centrality dependence taken from STAR data

background

- Combinatorial background using measured $\pi/K/p$ spectra
- Correlated background: PYTHIA simulation
 - ~10% of total background at 2 GeV/c
 - dominate at high p_T

Particle identification scenarios

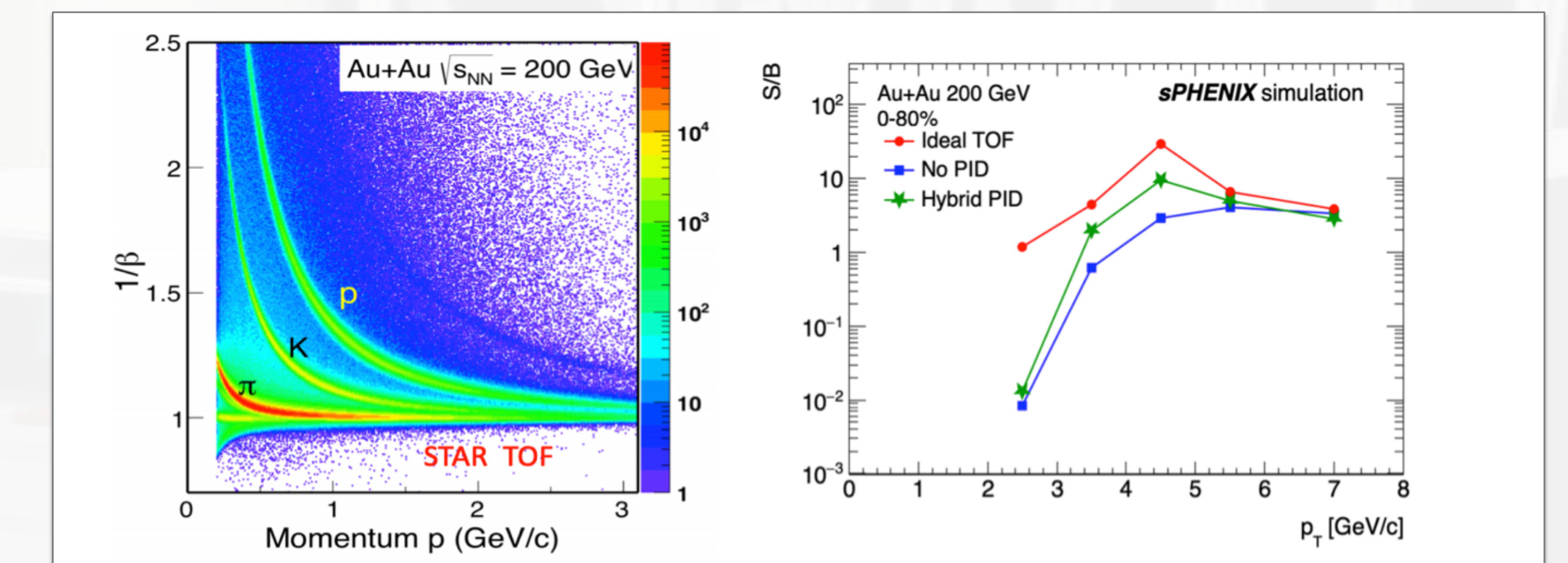
- ~10cm gap reserved between TPC and EMCal for future PID detector upgrade

- A few PID scenarios considered:

(a) no PID (default) (b) hybrid PID (c) ideal PID

in (b) and (c), a PID detector with hadron separation capability equivalent to STAR TOF is assumed

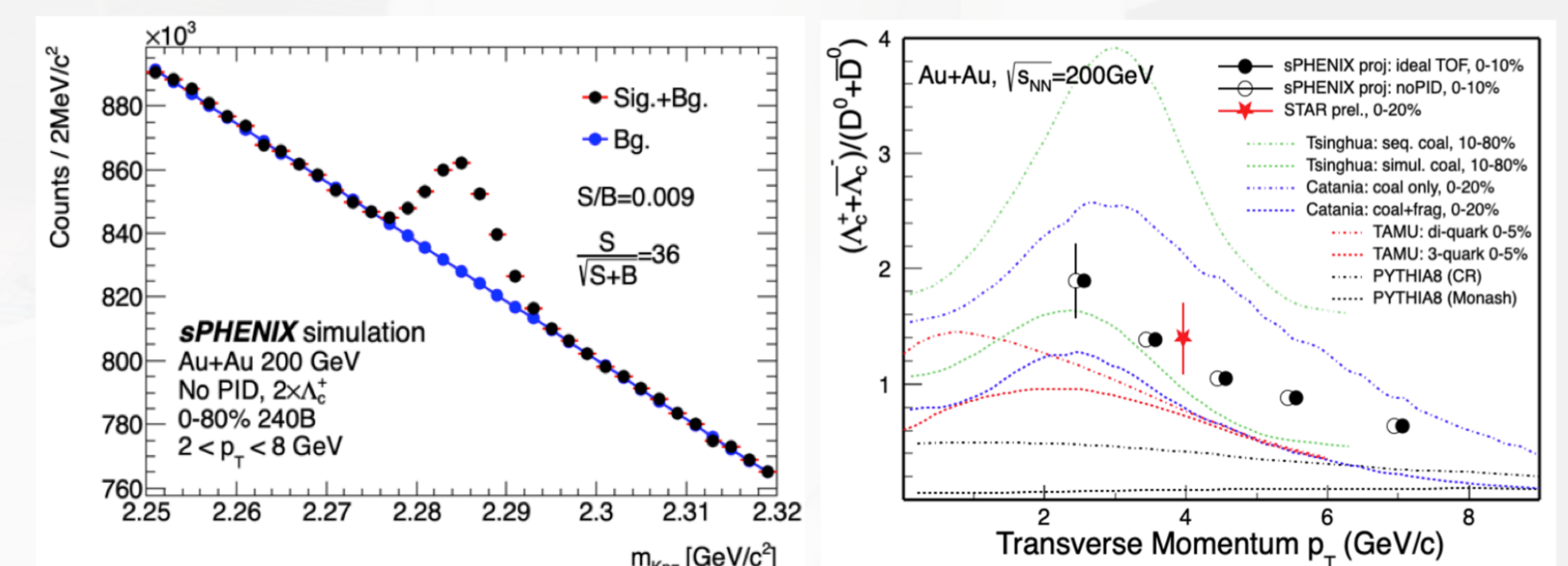
- requirement for sPHENIX TOF: $\sigma_t \sim 25\text{ps}$



A TOF PID detector improves low- p_T Λ_c reconstruction significantly

Physics projections

Projection assuming totally 240 billion MB events in Au+Au 200 GeV.



Summary

- Heavy flavor physics program at RHIC 2023-2027
 - One of the four physics pillars for sPHENIX (in addition to Jets, Upsilon, and cold QCD)
- Precise charm baryon Λ_c measurement over a broad momentum range**
 - charm quark hadronization
 - total charm quark cross section
- MVTX is the key upgrade to sPHENIX in order to enable these measurements
 - These measurements will not be possible if no MVTX



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