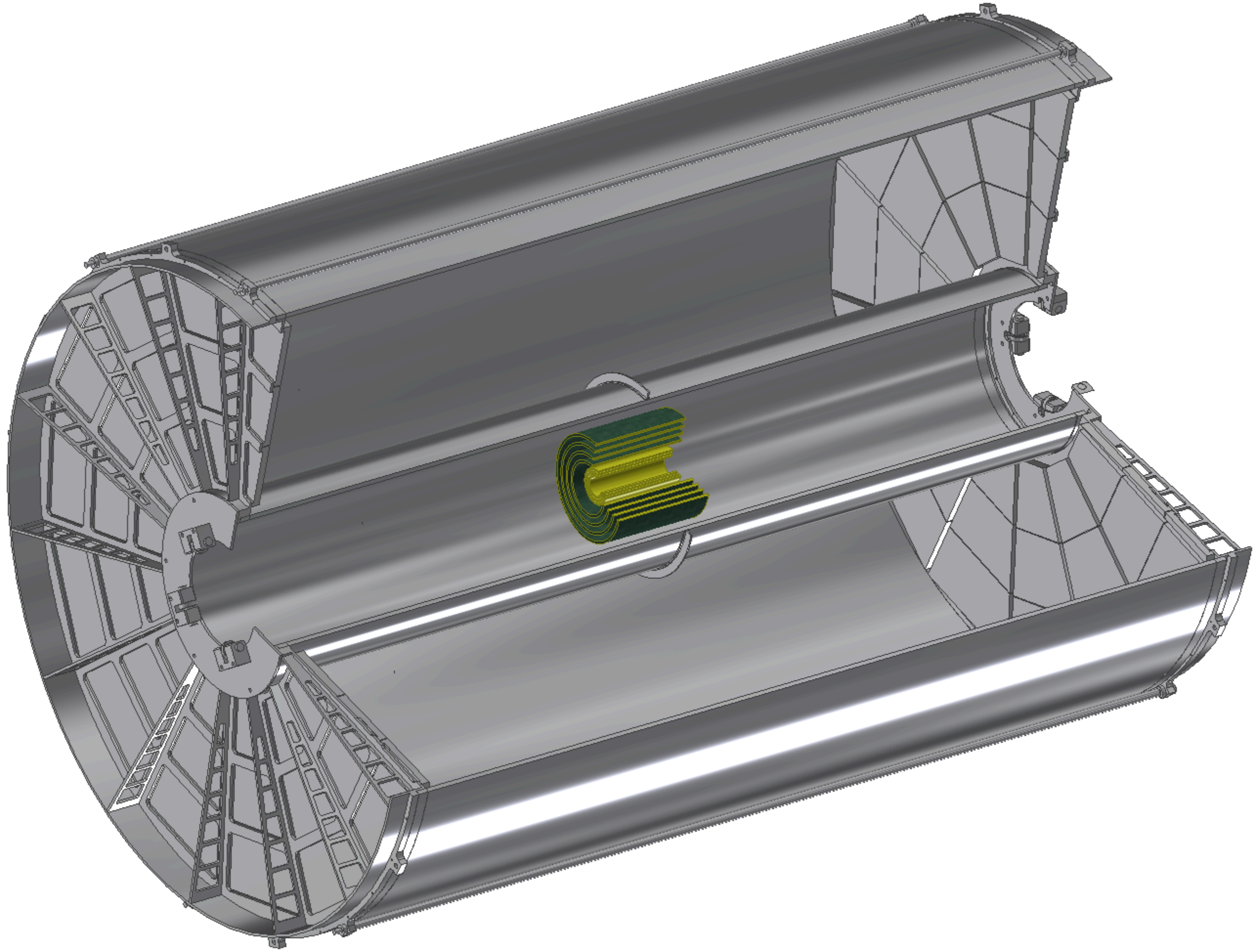
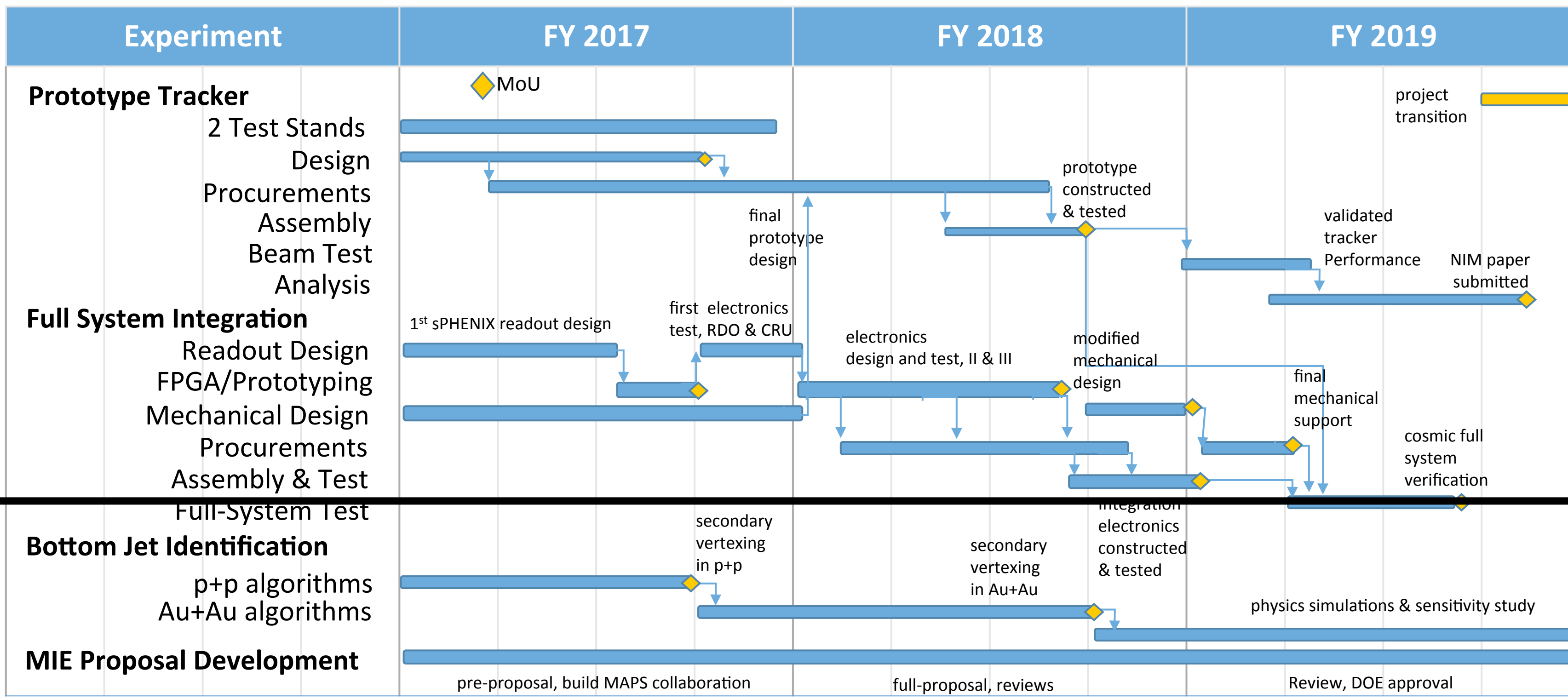


Simulation study of b-jet measurement with MAPS
LDRD/DR feasibility review
Dec. 5, 2016

Sanghoon Lim / Mike McCumber

Goal and Schedule

- Simulation study of b-jet measurement with MAPS
  - Develop b-jet tagging methods and evaluate performance in two years
  - MIE proposal development
  - Using sPHENIX simulation framework to evaluate MAPS performance
- People working on simulation
  - Mike McCumber, Sanghoon Lim, Xuan Li, Sho Uemura, Darren McGlinchey, and a new staff member



LANL proposed sPHENIX tracker configuration with MAPS

Specification for sPHENIX proposed program

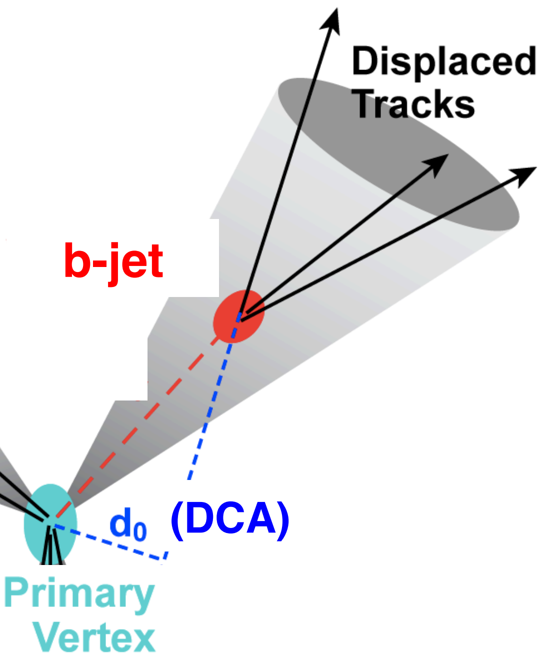
Heavy-flavor jet measurement

→**DCA resolution<100 μm (<50 μm with MAPS)**

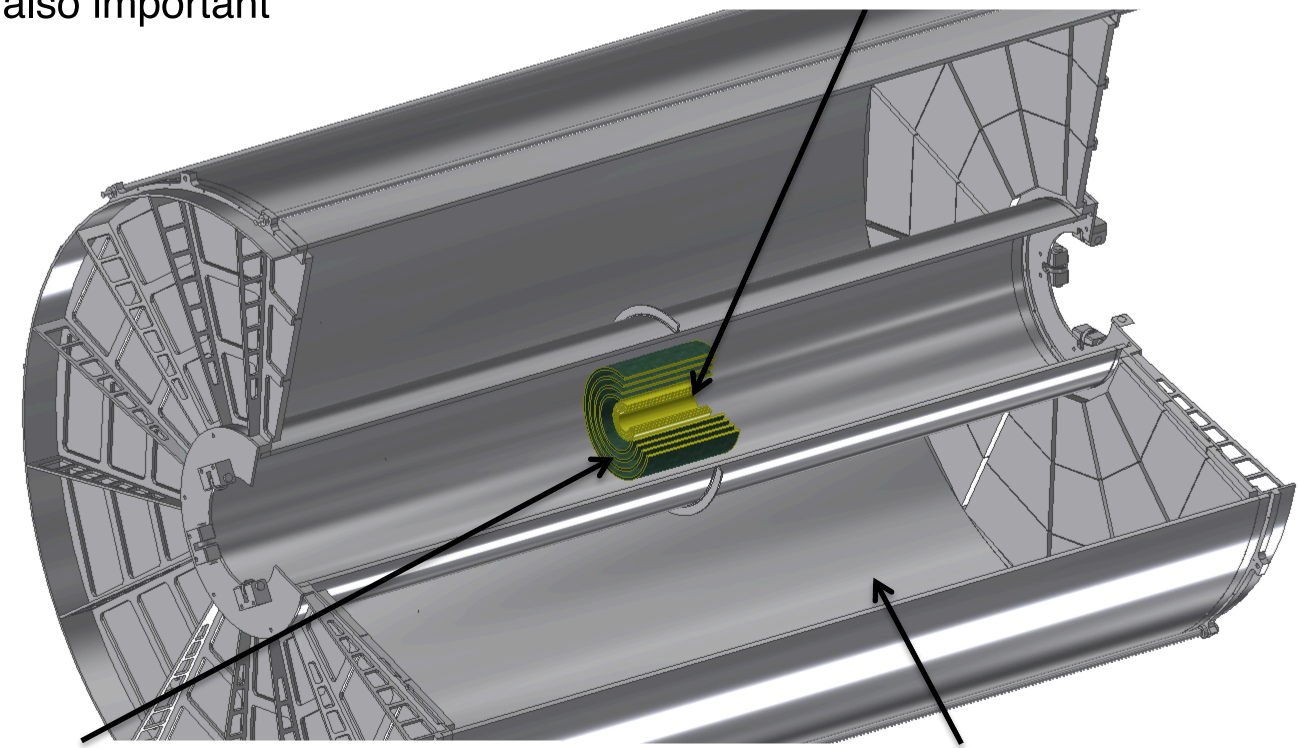
Upsilon (3 states) measurement

→**Mass resolution<100 MeV (~80 MeV with MAPS)**

Tracking efficiency & purity are also important



3-layer MAPS vertex tracker
R = 2.3, 3.2, 3.9 cm
Thickness: 50 μm (0.3% X_0) in each layer
Cell dimension: 28 μm x 28 μm



4-layer silicon strip intermediate tracker (INTT)
R = 6, 8, 10, 12 cm
Thickness: 120 μm (1% X_0) in each layer
Cell dimension: 80 μm x 1.2 cm

60-layer TPC
R = 30-80 cm
Thickness: 60 cm (2.2% X_0)
Cell dimension: 1.5 mm x 1.7 mm

Simulation framework

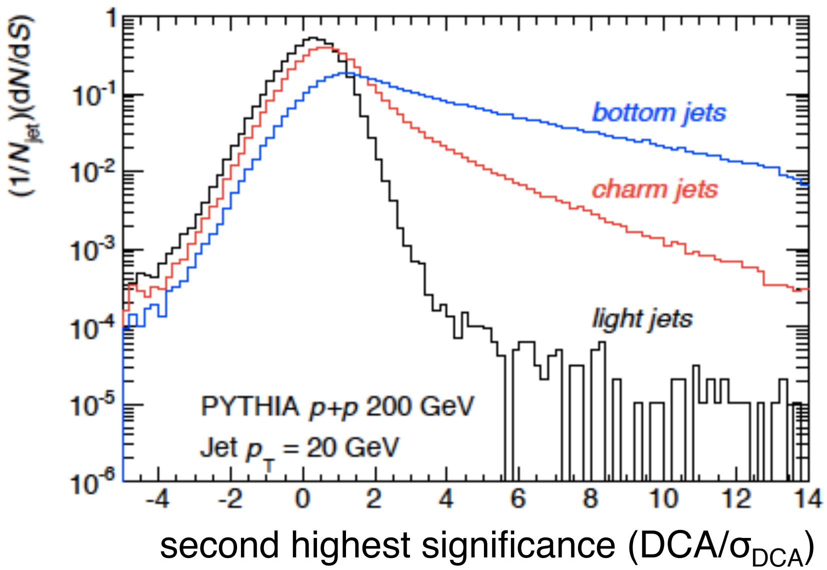
- Use existing sPHENIX simulation framework to evaluate MAPS performance
  uniform cylindrical tracking layers of sensitive material +
  uniform cylindrical layers of inactive support material
  →Realistic detector geometry will be implemented
  - Silicon tracker
    Layers of sensitive Si of pixel (MAPS) or strips (INTT)
    Layers of Cu for supporting materials
  - TPC
    60 layers of active gas (1.5 mm x 1.7 mm cell)
    Layers of inactive material for inner and outer field cage
    Layers of inactive gas at 20-30 cm radius

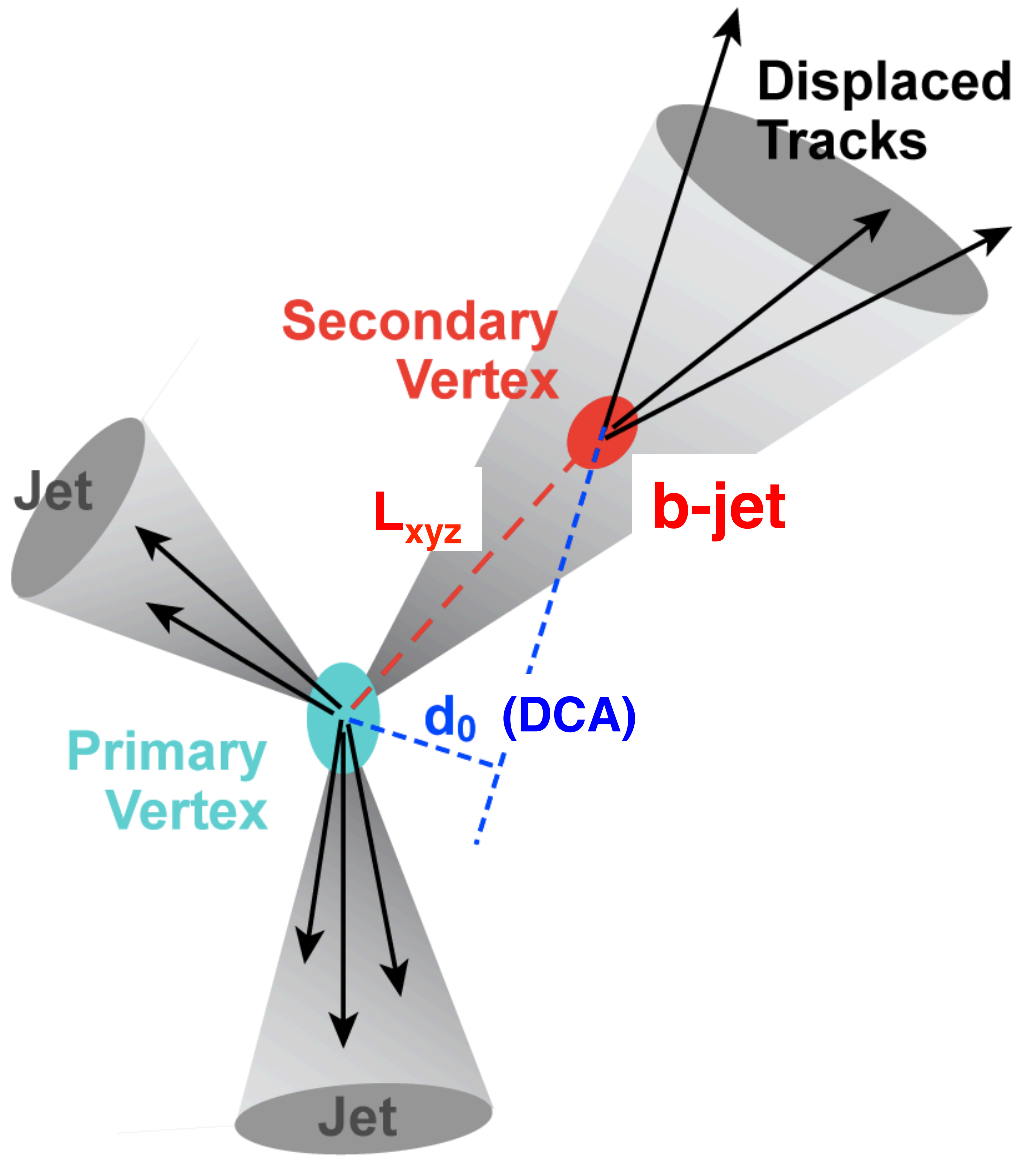
- Tracking procedure

Digitization of G4 hits → Clustering with threshold → Hough transform in helix parameter space → Kalman filter to fit tracks

- Evaluation with truth information

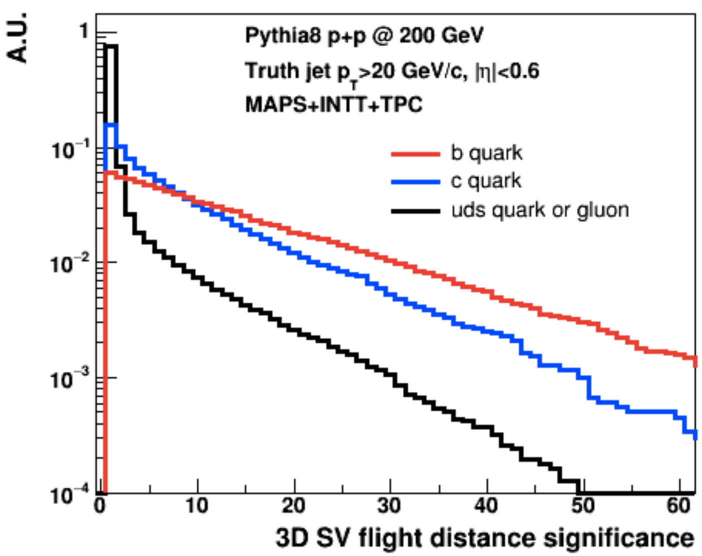
- Track counting method
  - Count the number tracks with large DCA (d_0)
  - Optimization of cuts and evaluation of b-jet tagging **purity vs. efficiency** in p+p collisions (w/ PYTHIA) are underway
  - Performance study in Heavy-ion collisions will be following

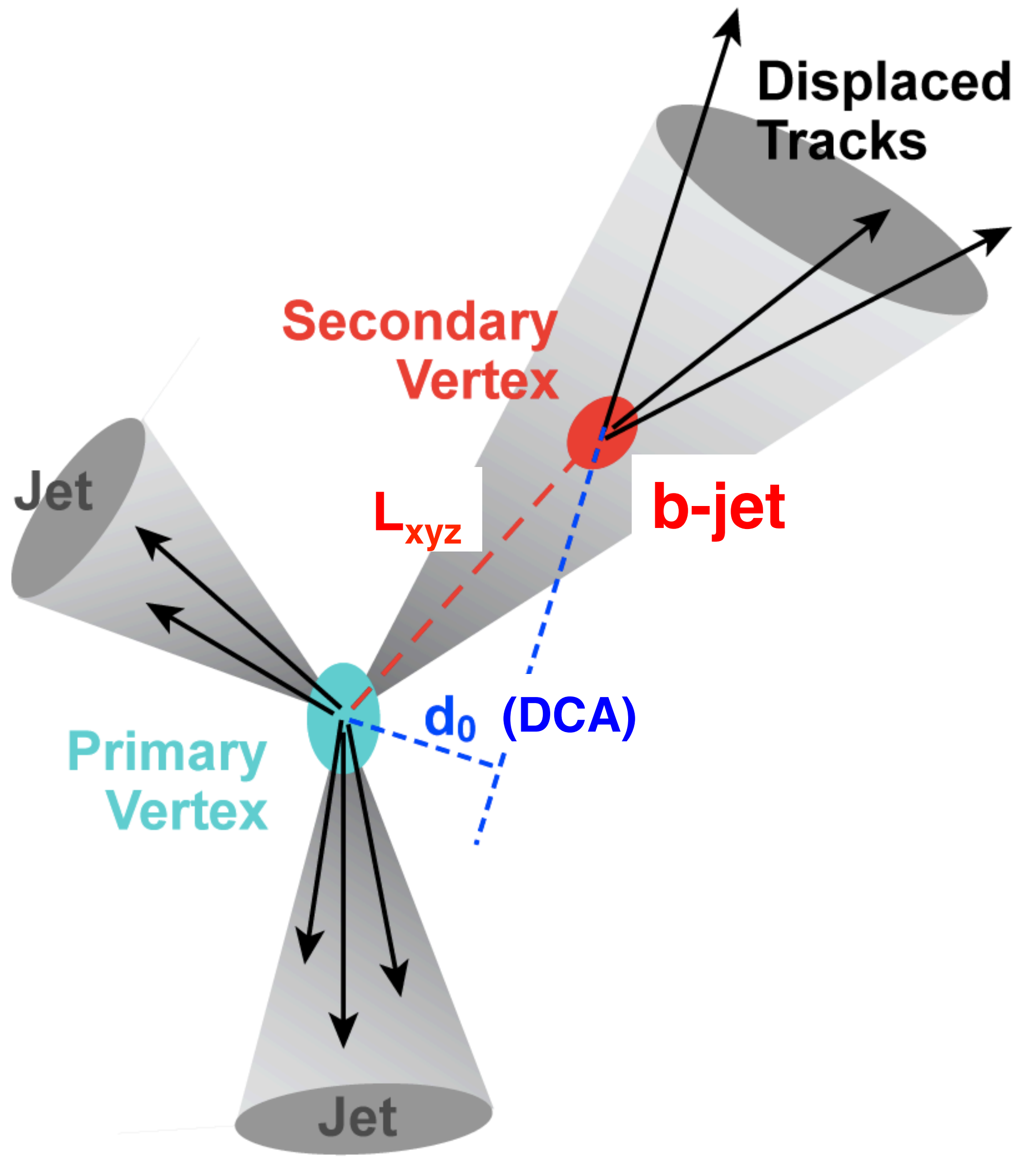




b-jet tagging algorithm II

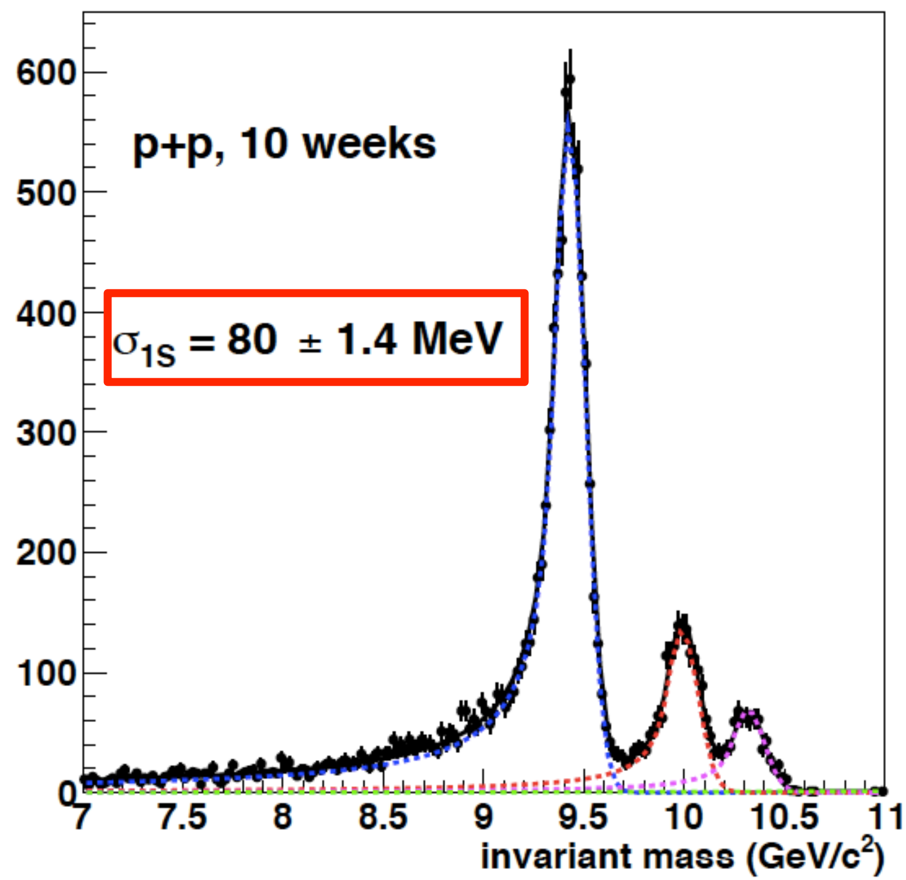
- Secondary vertex method
  - Reconstruct secondary vertex with in a heavy-flavor jet
  - Deviation from the primary vertex (L_{xyz}) of b-jets are expected to be larger than others
  - <20 μm of primary vertex resolution in x/y/z with MAPS





Upsilon mass distribution

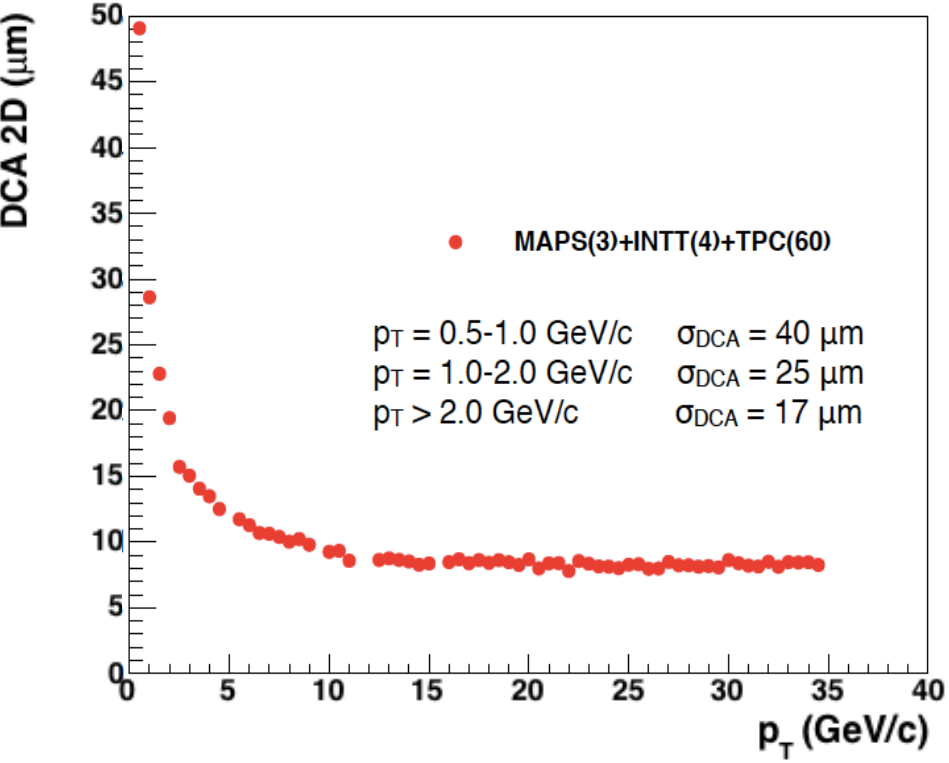
MAPS(3)+INTT(4)+TPC(60)



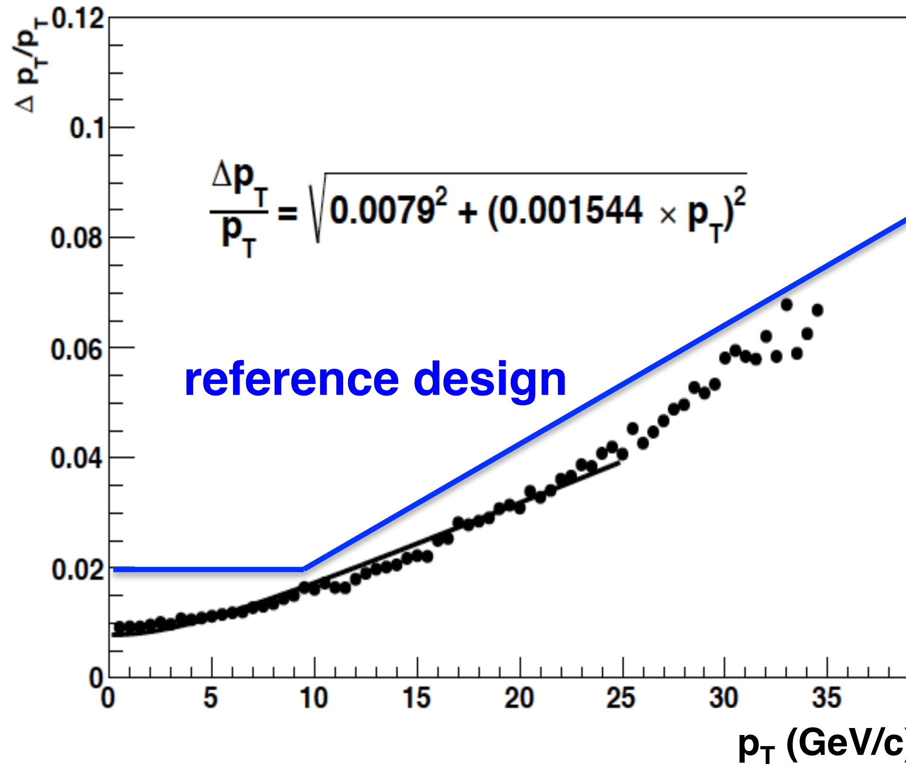
- 80 MeV Upsilon mass resolution in simulation
  (<100 MeV of sPHENIX specification)
  Higher efficiency (~99%) and less material budget (0.3% X_0 per layer) than the alternative option

DCA and momentum resolution

- Embedded simulation
  100 pions embedded into central HIJING events (0-4 fm Au+Au collision)
- DCA resolution in simulation **(<50 μm)** is much better than the sPHENIX specification **(<100 μm)**

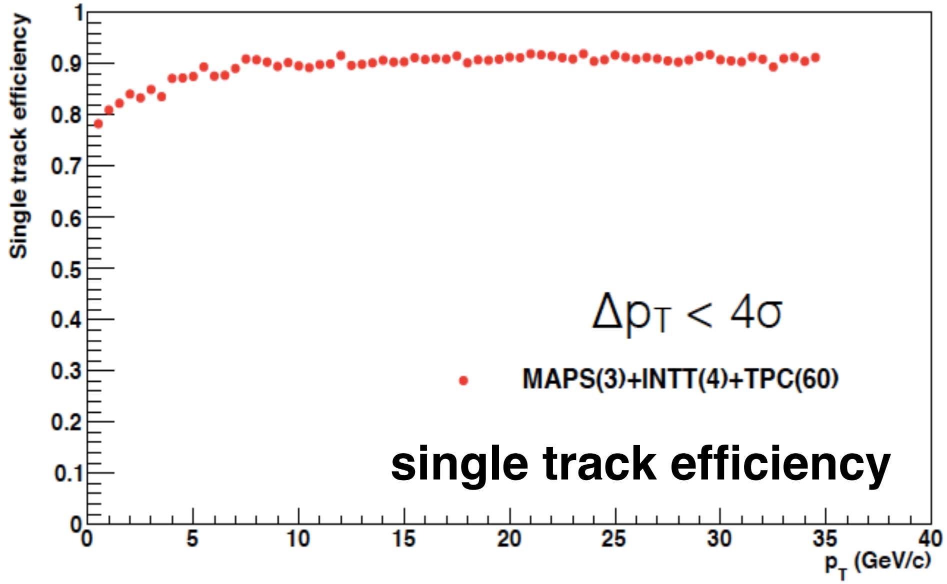


DCA resolution

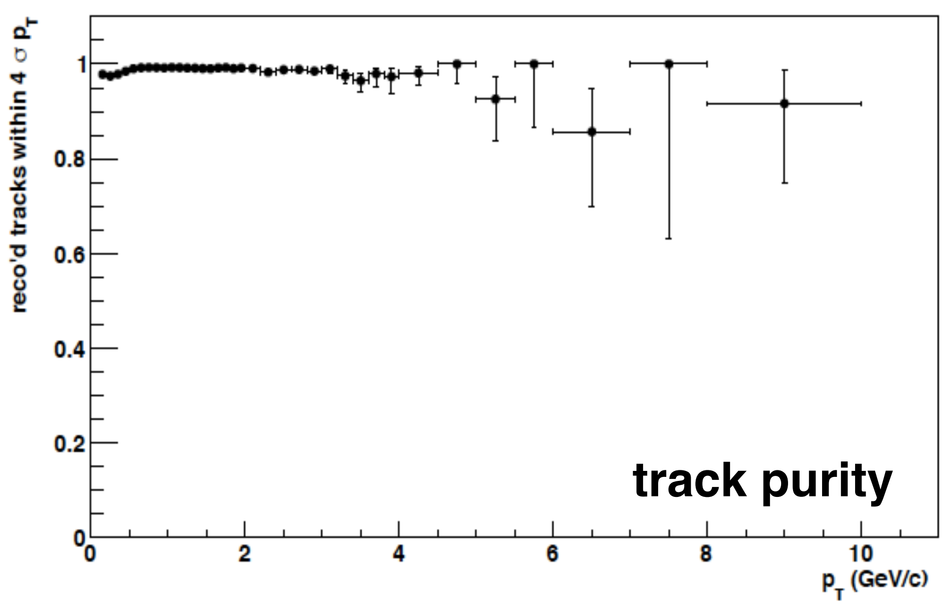


momentum resolution

Single track efficiency and purity



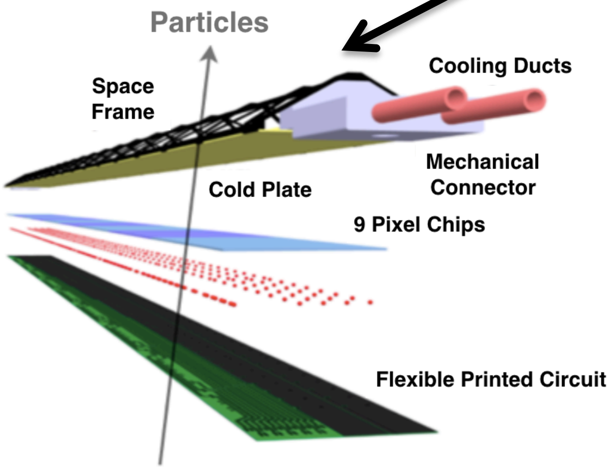
- Embedded pions in central Au+Au events from HIJING
  - Loop over truth tracks and try to find matching reconstructed track
  - Quality cut of reconstructed $p_T < 4\sigma$ from true p_T

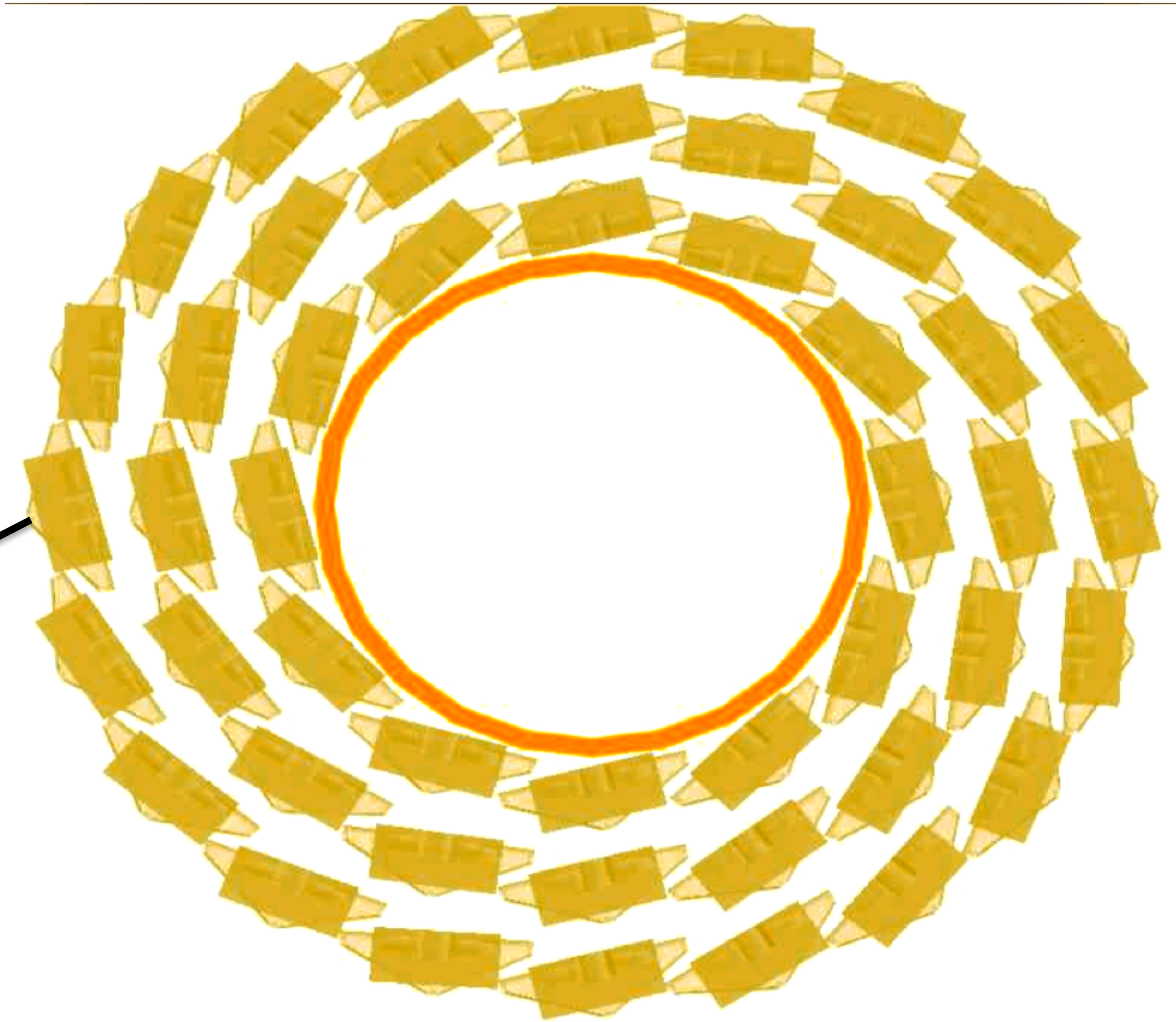


- Purity in central Au+Au events from HIJING
  - Loop over reconstructed track and check reconstructed p_T is within 4σ of true p_T
  - Fake tracks at high p_T are from low p_T tracks of incorrectly reconstructed momentum

Implementation of MAPS ladder geometry

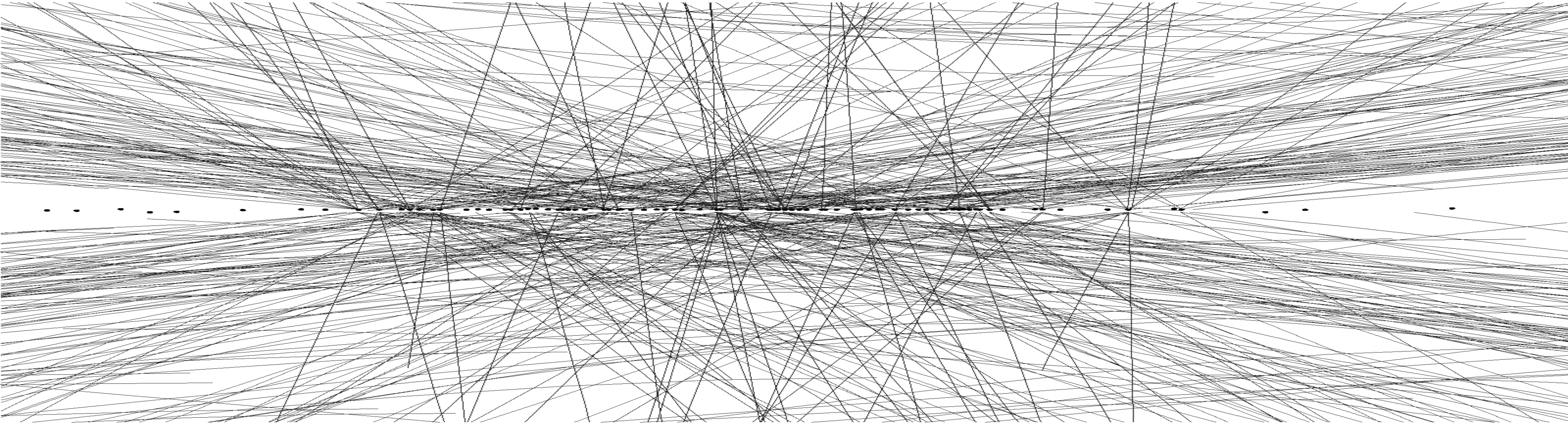
- Import ALICE ITS stave geometry





- Estimation of event pile-up
  - MAPS (~2 μs integration time)
    8 (0.4) events of pile-up in p+p (Au+Au)
    → Multi-vertex tagging (<20 μm vertex resolution in 27 cm length of MAPS)
  - TPC (~18 μs integration time)
    72 (3.6) events of pile-up in p+p (Au+Au)
    → Precise tracking (low (<0.1%) occupancy in MAPS)

- A framework to simulate event pile-up has been developed and implemented
  - Not much degradation of tracking performance in Au+Au collisions (momentum & DCA resolution, tracking efficiency)



Summary and Outlook

- Study of MAPS performance by using sPHENIX simulation framework has been initiated
  - Two b-jet tagging methods are studied in p+p collisions
  - ~80 MeV of Upsilon mass resolution
  - DCA resolution of <30 μm for p_T>1 GeV/c in central Au+Au events
  - Single track efficiency of ~90% in central Au+Au events

- Future plans
  - Realistic geometry will be used for further performance evaluation
  - New tracking and vertex finding (GenFit + RAVE packages) will be implemented
  - The performance of physics measurements in p+p and Au+Au collisions will be evaluated
    →effect of background hits
    →pile-up effect

BACK UP

Event pile-up

- Estimation of event pile-up
  - Peak luminosity
    p+p: 2 MHz → 0.21 chance of an interaction per beam crossing
    Au+Au: 100 kHz → 0.011 chance of an interaction per beam crossing
  - MAPS (~2 μs integration time → 37 beam crossings)
    p+p: 8 events of pile-up → Multi-vertex tagging with MAPS
    Au+Au: 0.4 events of pile-up
  - TPC (~18 μs integration time → 340 beam crossings)
    p+p: 72 events of pile-up
    Au+Au: 3.6 events of pile-up → Precise tracking with MAPS

- A framework to simulate event pile-up has been developed and implemented
  - Not much degradation of tracking performance in Au+Au collisions (momentum & DCA resolution, tracking efficiency)
  - Further study for physics measurement will be done