Studies of Displaced Vertex Distributions using the new FVTX Tracker in PHENIX

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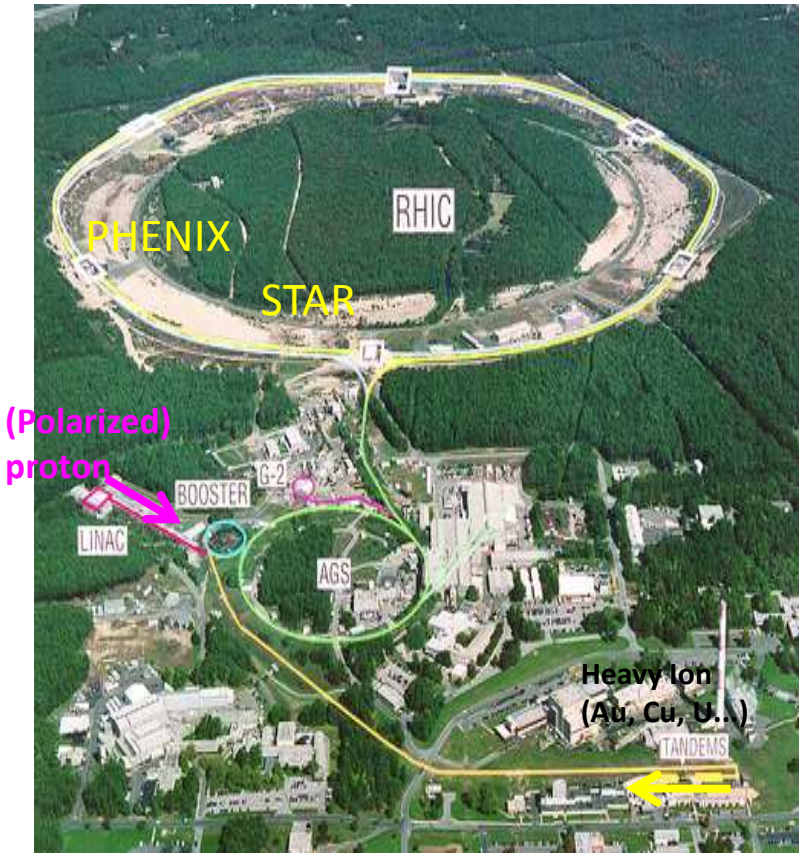
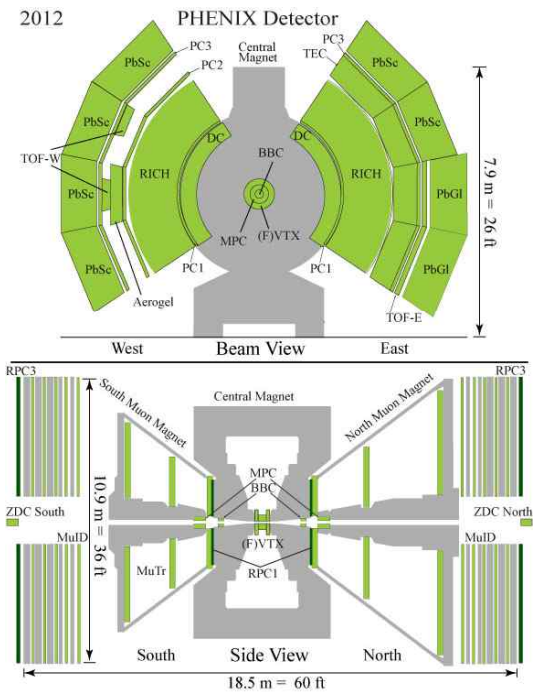
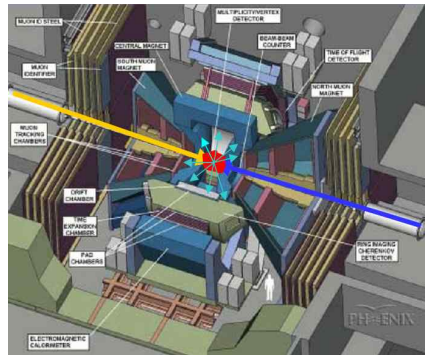
Outline

- PHENIX Forward Muon Spectrometer
- Forward Silicon Vertex Detector (FVTX)
- Displaced Vertex Simulation

PHENIX at RHIC



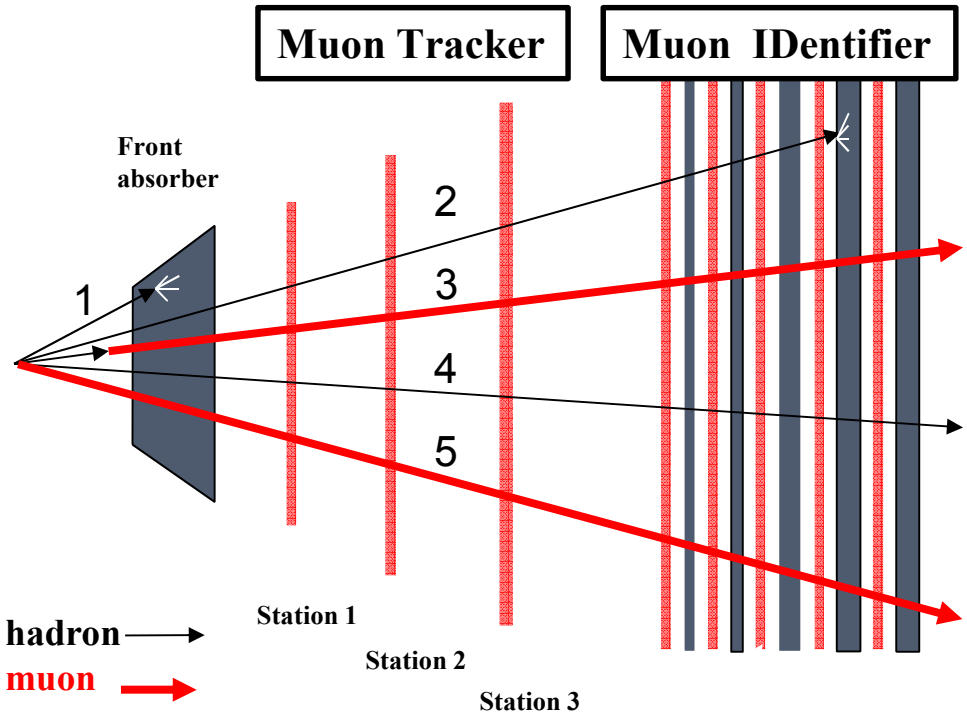




Multi-purpose, collection of detectors
Central Arm for
electron, photon, hadron
Forward Muon Spectrometer
for muon
Very Forward Detectors for
triggering, centrality,
polarimetry.

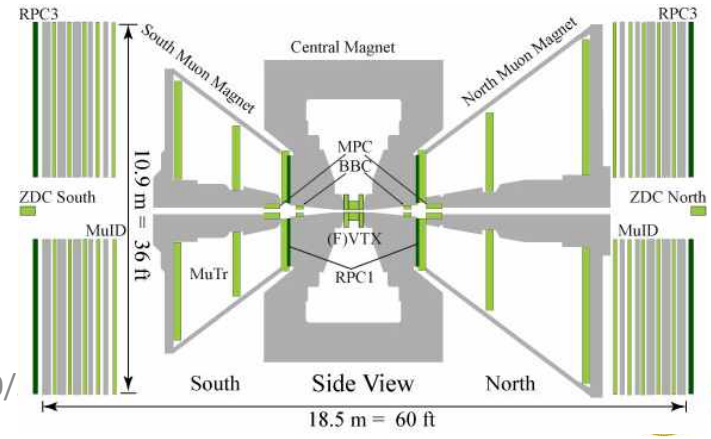
- 3.83 km circumference
- 2 independent rings
- (polarized)proton, heavy ion, light ion

PHENIX Forward Muon Spectrometer



1. $Absorbed : (e^{\pm}, \gamma, p, \pi, K...)$
2. $Stopped\ \ hadron : (\pi, K)$
3. $Decay\ \ muon : (\pi^{\pm} \rightarrow \mu^{\pm} + X,\ K^{\pm} \rightarrow \mu^{\pm} + X)$
4. $Punch\ \ through : hadron\ (\pi^{\pm}, K^{\pm})$
5. $prompt\ \ muon : (B, D \rightarrow \mu + X)$

- North: 1.2<|η|<2.4 South: 1.2<|η|<2.2
- Azimuthal: ΔΦ=2π
- Initial absorber to reduce hadrons that reach the active detectors
- Muon Tracking stations inside magnet to find tracks and measure momentum
- Muon Identifier for μ/π,K separation



Limitations :

- No way to discriminate π/K-->μ, D/B→μ, π/K punch-through (3)(4)(5)
- Mass resolution limited by absorber
- Track isolation information lost by absorber

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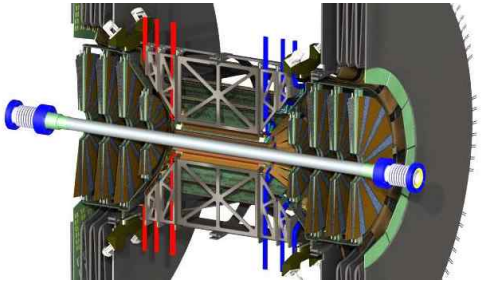
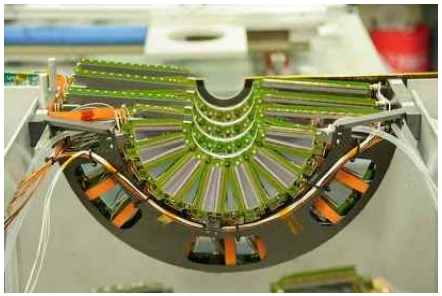
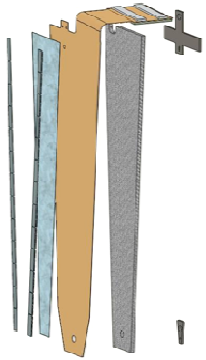
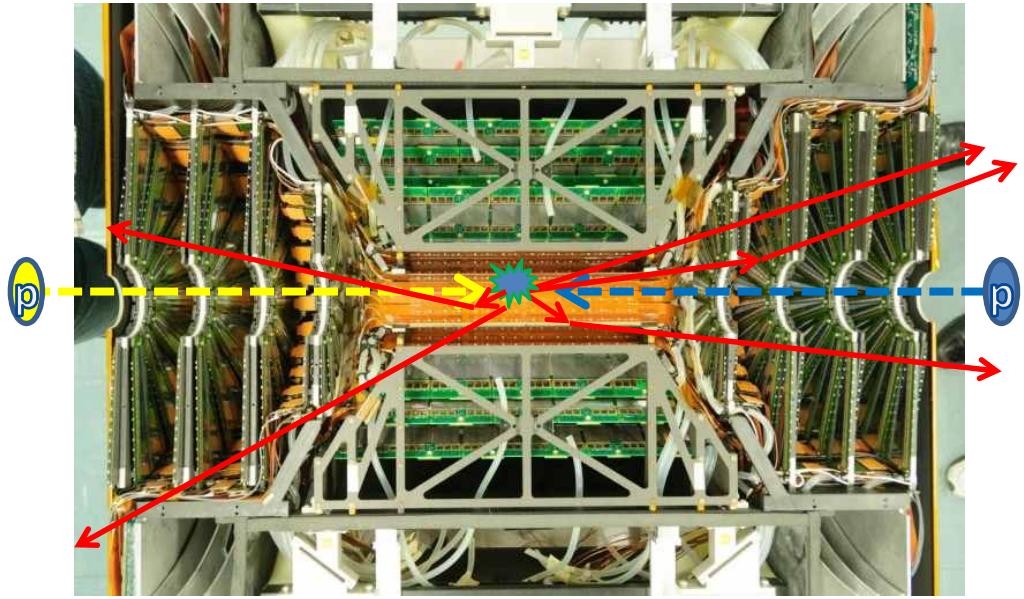
Forward Silicon Vertex Tracker





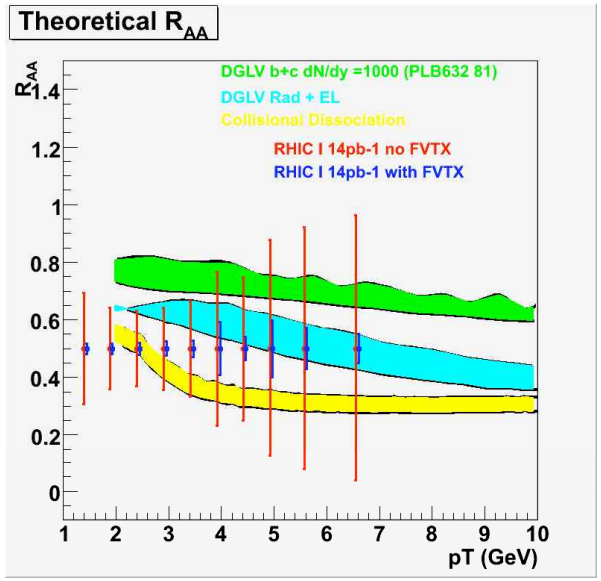




- 1.2<|η|<2.4 , Two Arms, Four tracking stations with full azimuthal coverage, 18.5 cm < |z| < 38 cm
- 75 µm pitch strips in radial direction, 3.75° staggered phi strips
- Radiation length < 2.4%/wedge to minimize multiple scattering
- Over 90% of Detector is operational in 2012

Motivation- c,b separation

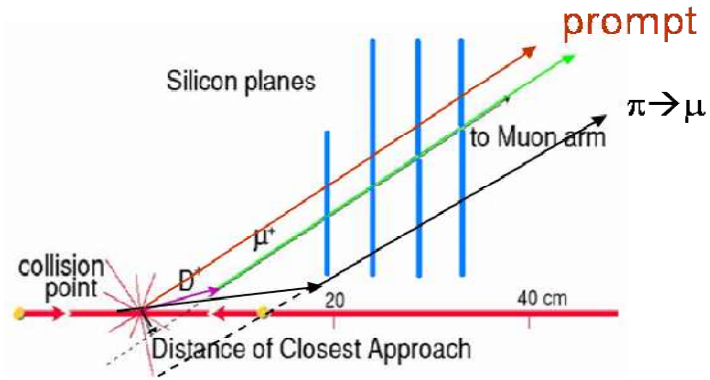
- Previous heavy-quark production measurements studied indirectly via the measurement of leptons(muons) from semileptonic decays of charm or beauty
  - without distinguishing between D- and B-mesons
  - in large systematic errors (backgrounds (π->μ and K-> μ) overwhelm the signal)



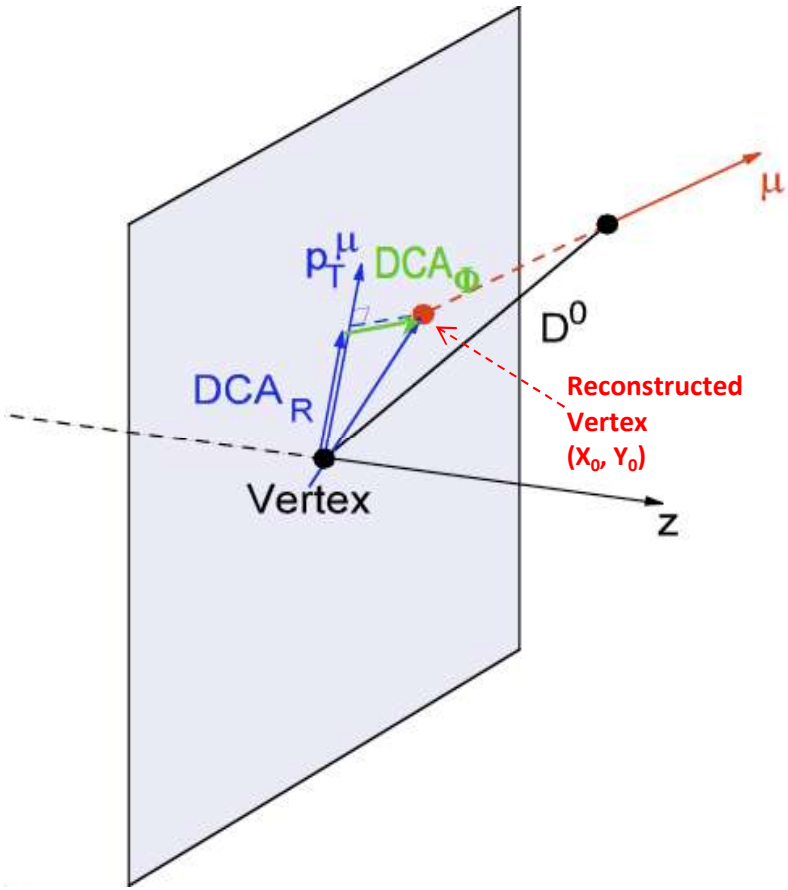
- b quark is expected to have
  - substantially smaller energy loss
  - much more difficult to flow along the medium

- What FVTX can do
  - Identify heavy quark component accurately
  - Separate D,B meson

- How FVTX can do
  - D, B mesons travel ~1 mm (with boost) before semi-leptonic decay to muons
  - By measuring DCA to primary vertex, We can separate D and B from long-lived decays like π, K
  - Muons from D,B mesons have different DCA shape



Displaced Vertex



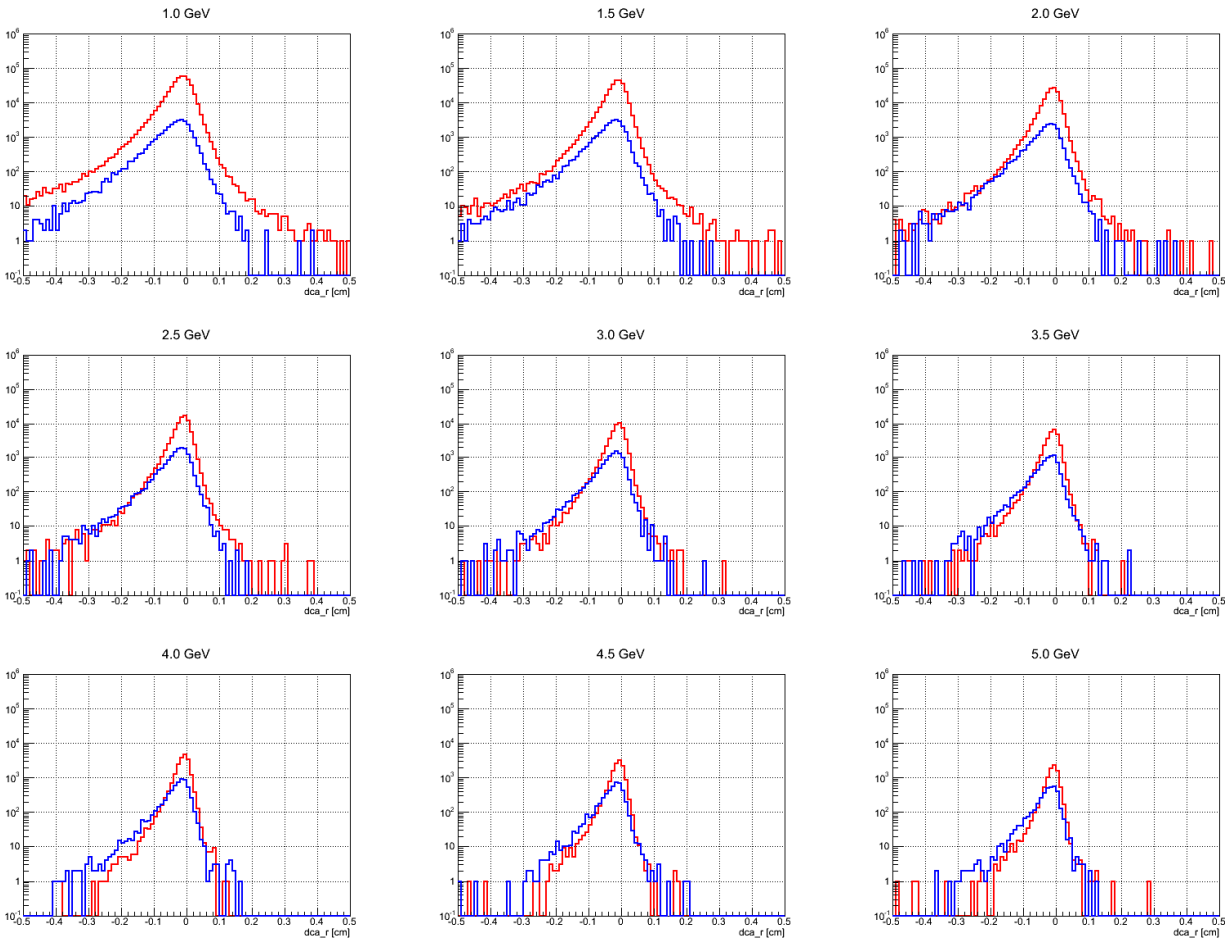
- DCAR (Distance of Closest Approach, R)
  : reconstructed vertex decomposed on muon pT direction (FVTX has better resolution onto R direction)
- DCAϕ : projected onto ϕ direction

$$DCA_R = X_0 \times (\frac{P_x}{P_T}) + Y_0 \times (\frac{P_y}{P_T})$$

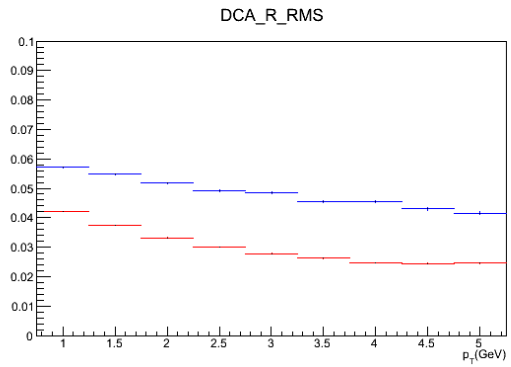
- Flying distance and decay angle of muons from π,K decay, muons from D and B and prompt muon will give us different DCAR distributions
- DCAϕ can help to reject background

Particle	Mean lifetime(ps)	Decay length(mm) at p=3 GeV
π±	2.60×10^4	167×10^3
K±	1.24×10^4	22.9×10^3
D^0	0.410	0.197
B^0	1.530	0.261

DCA$_R$ *p+p* 200 GeV simulation

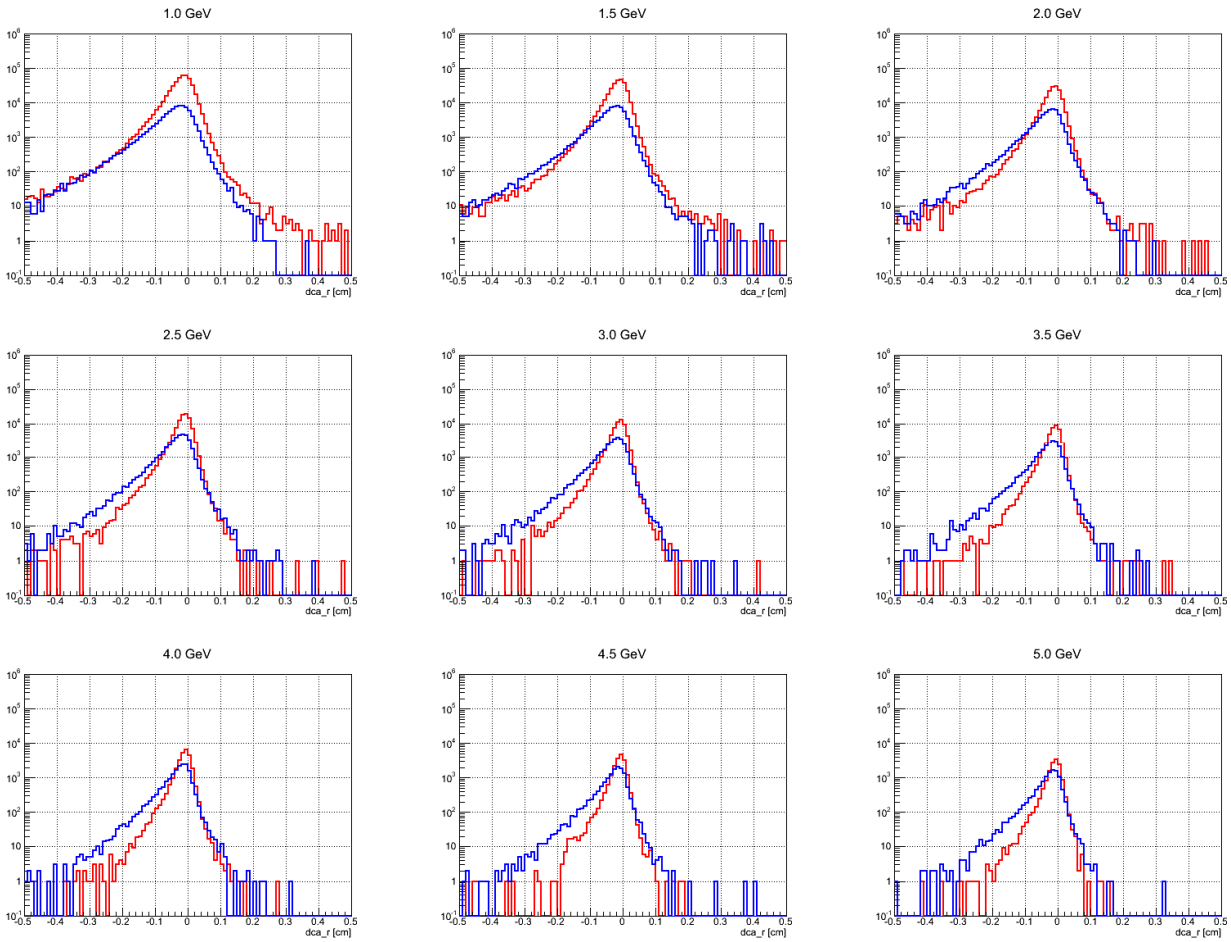


PYTHIA+GEANT simulation
Blue : 50 mil B events
Red : 900mil D events
1-5 GeV muons from D or B mesons shows DCA$_R$ <5mm



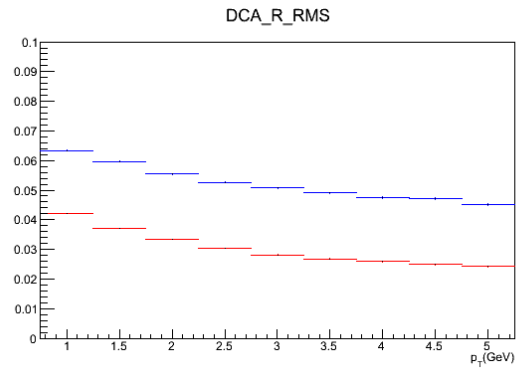
Muons from D mesons have narrower DCA$_R$ distribution
➔ Separate B and D

DCA$_R$ *p+p* 510 GeV simulation

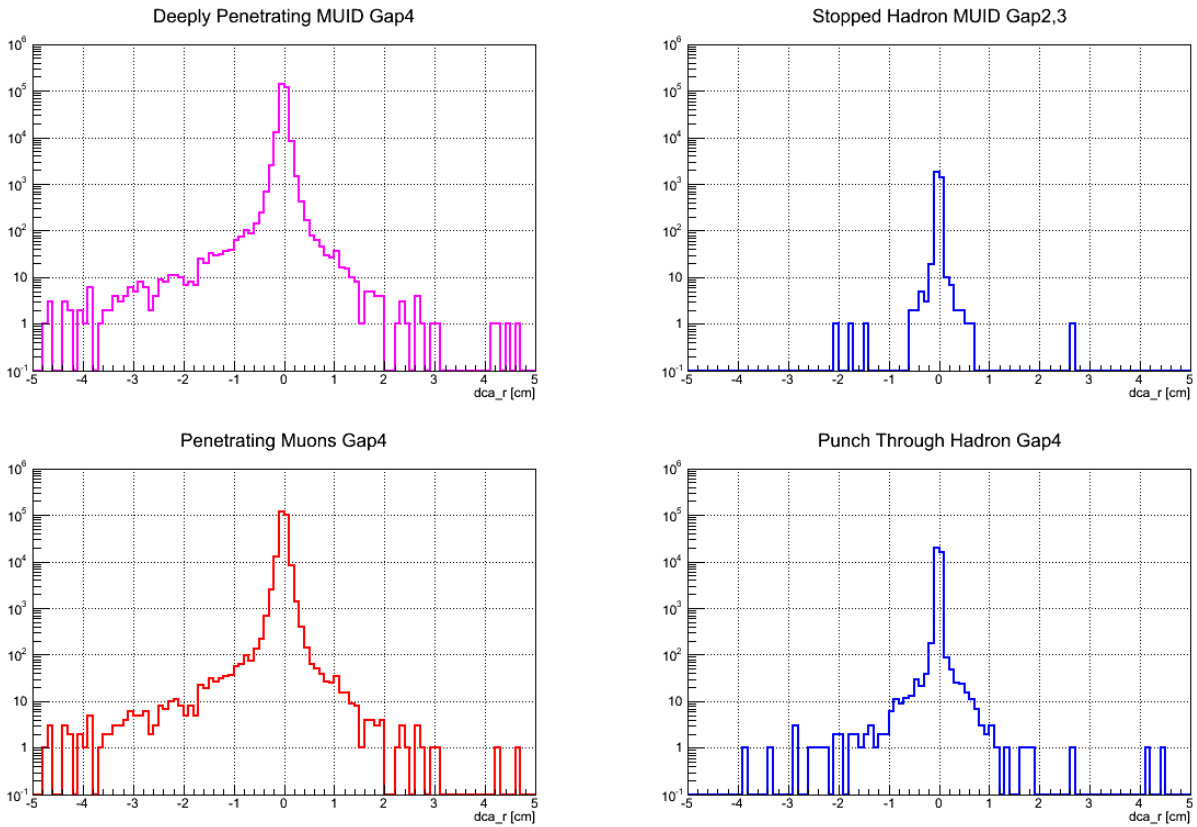


Blue : 50 mil B events
Red : 900mil D events

Using reconstruction code used for real data



DCAR Background simulation

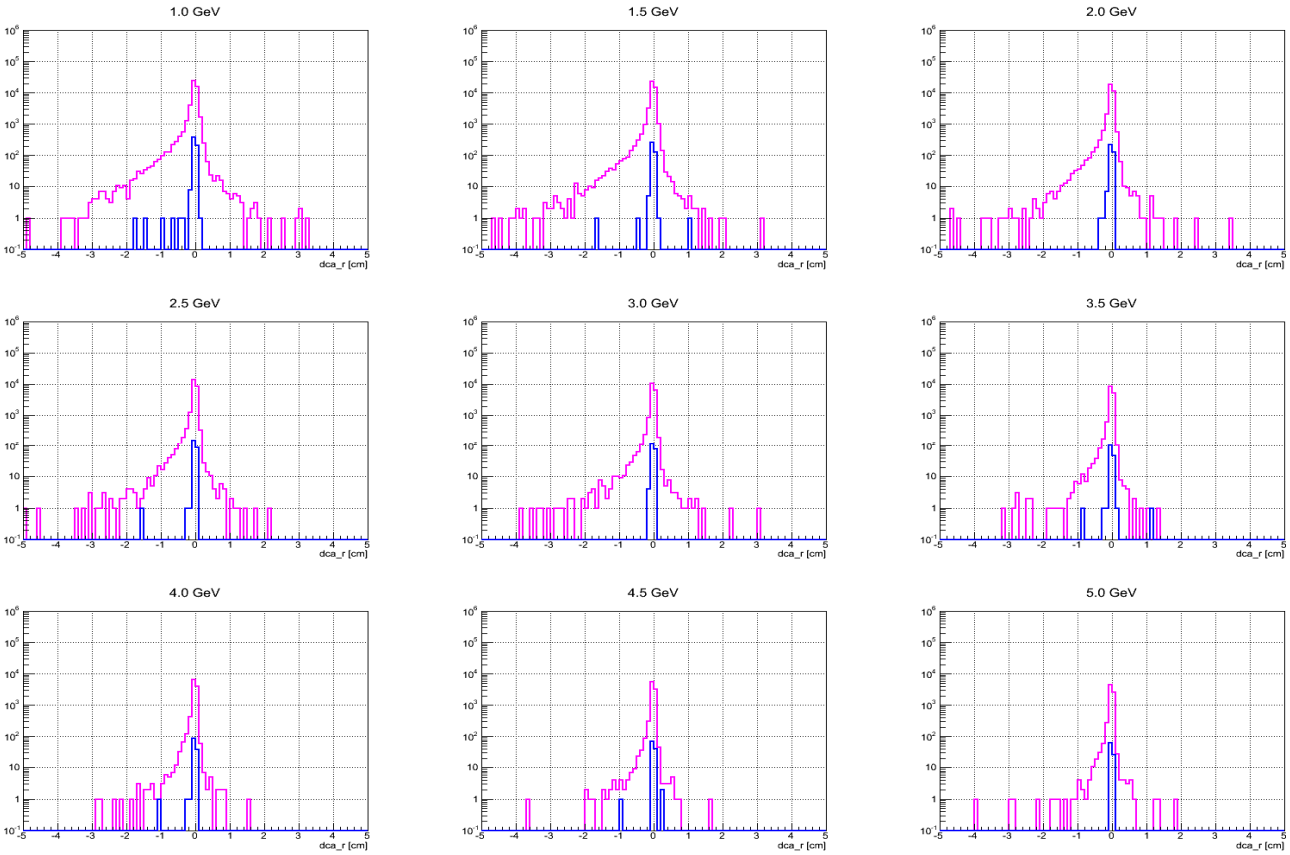


π± input
(π±,K± major source of background)

Magenta : Deeply penetrating muon, hadron
Red : Decay muon from *π±*
Blue : hadrons penetrating front absorber

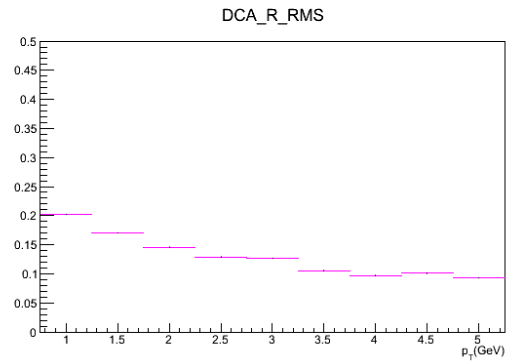
One of the major source of background, decay muon from hadron have broad DCAR distribution

DCA$_R$ background π± 200 GeV



190mil π± generation

Blue : stopped hadron
magenta : deeply penetrating (decay muon including punch-through)



X axis is (-5cm,5cm) ➔ DCA$_R$(π±) >> DCA$_R$(B,D)

Conclusion

- PHENIX Forward Silicon Vertex Tracker is able to measure displaced vertices allow precision heavy flavor measurements.
- The Distributions of the displaced vertex for decay tracks from heavy flavored mesons(B,D) and long-lived ordinary mesons(π,K) are sufficiently different.