Heavy Flavor Physic Simulation @ EicC

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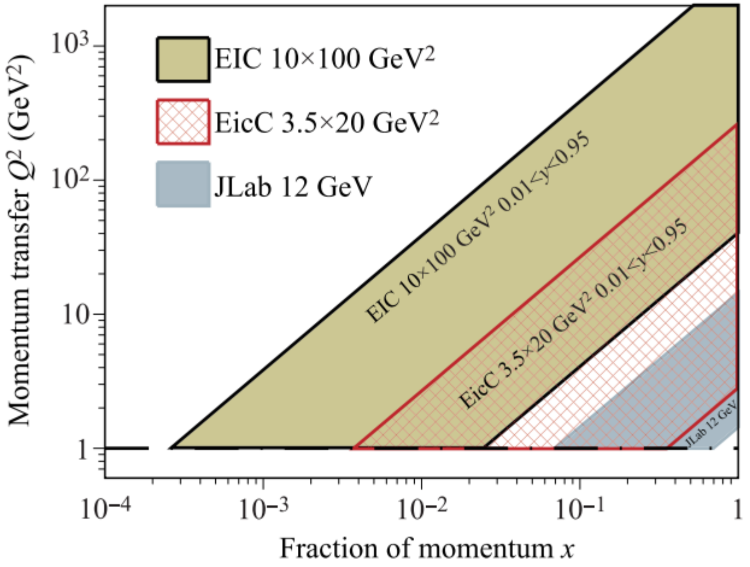
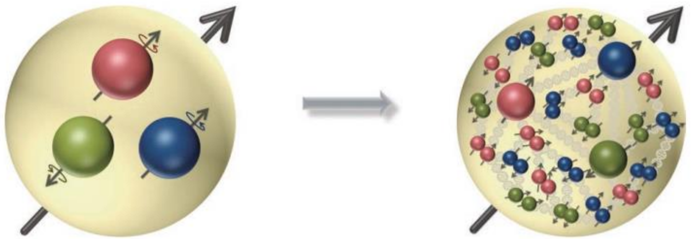
th July, 2022

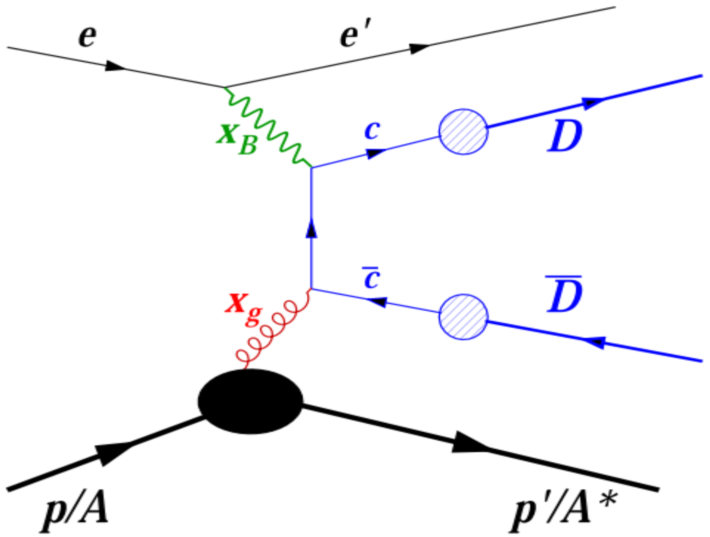
Outline

- Introduction
- Simulation Setup
- Reconstruction and Physic Projection
- Conclusions

Introduction

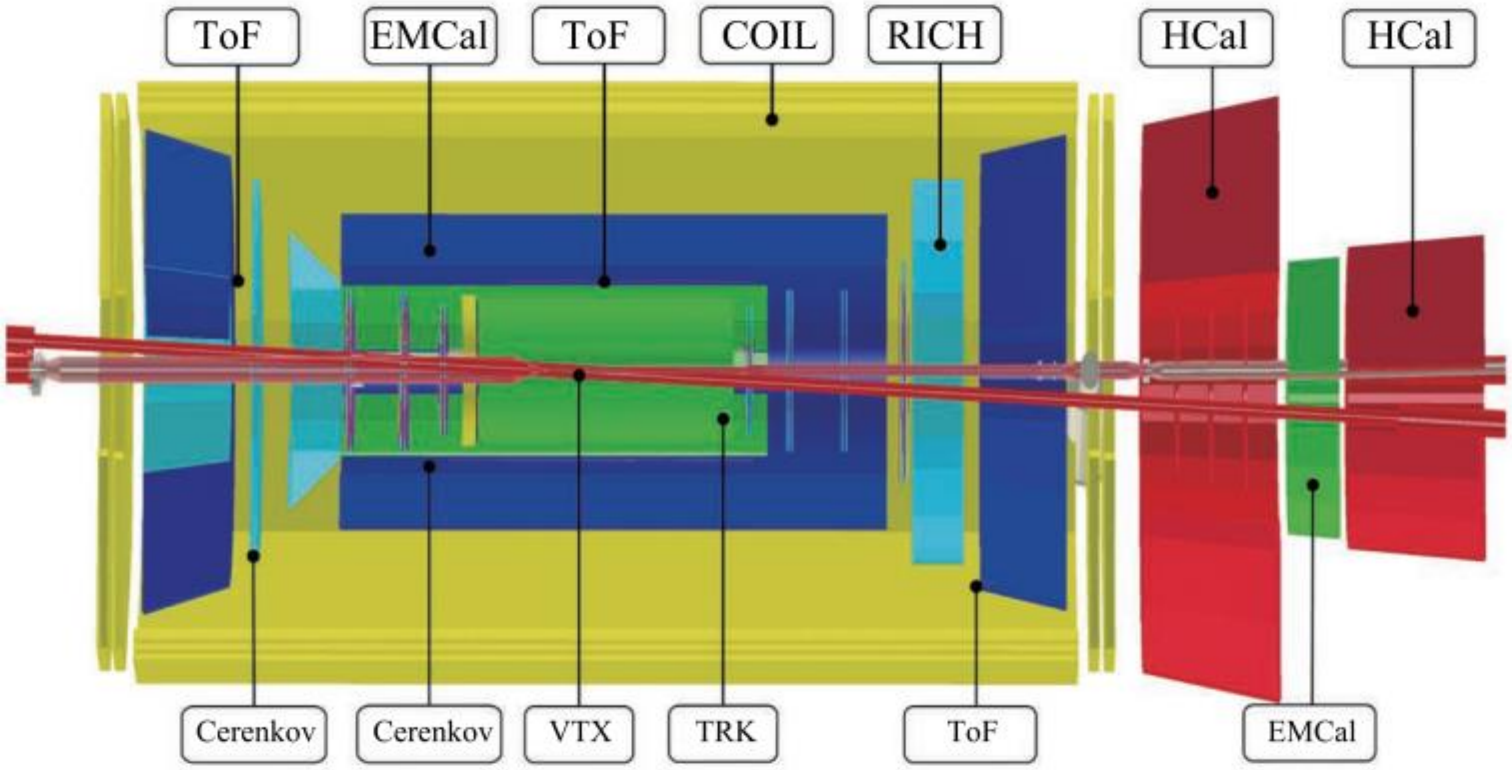


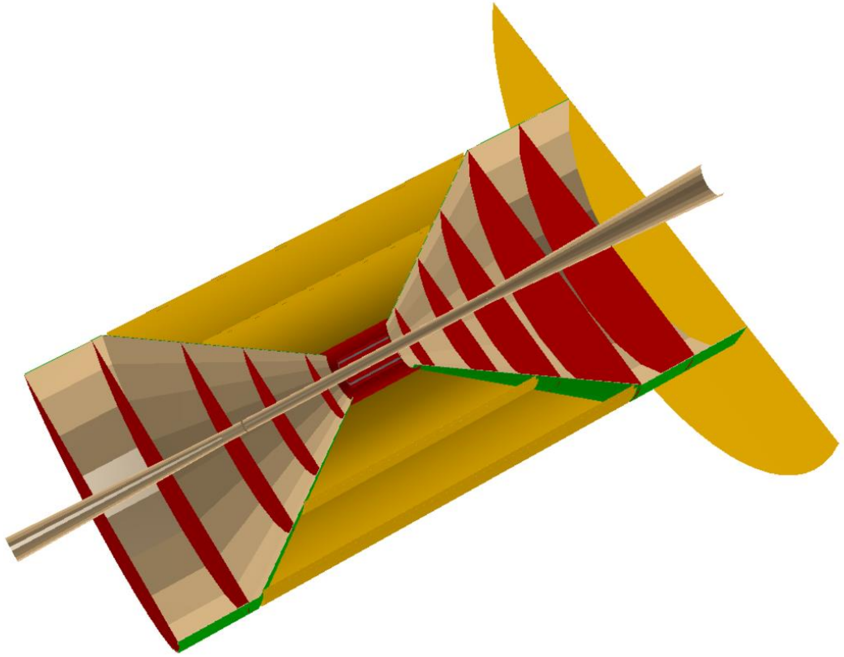




- Why Eic?
  - Electro-magnetic probe for nuclear structure
- Why EicC?
  - High luminosity and unique kinematic converage
- Why heavy flavor?
  - $\gamma g \rightarrow c\bar{c}$: Sensitive to gluon distribution
  - Final state hadrons with large mass: strong interaction with nuclear medium
- In this presentation
  - Physic projection with the latest detector performance: EicC detectors' sensitivity to nuclear physics

Detectors

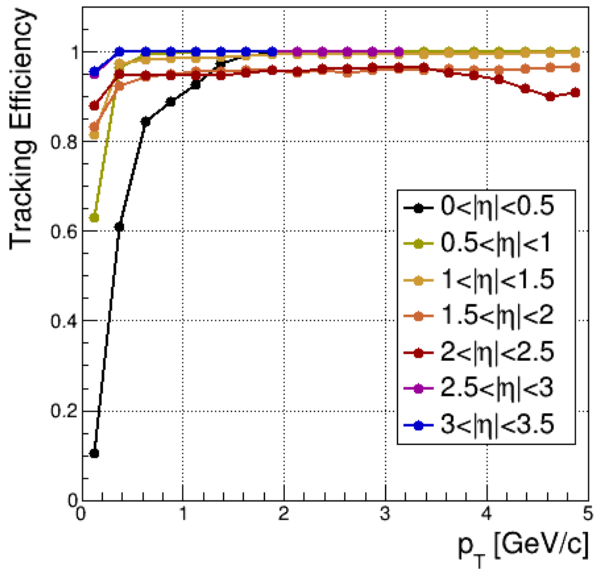


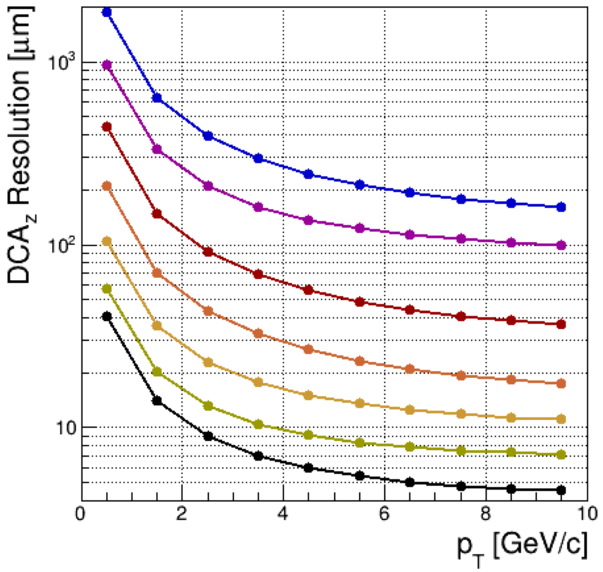


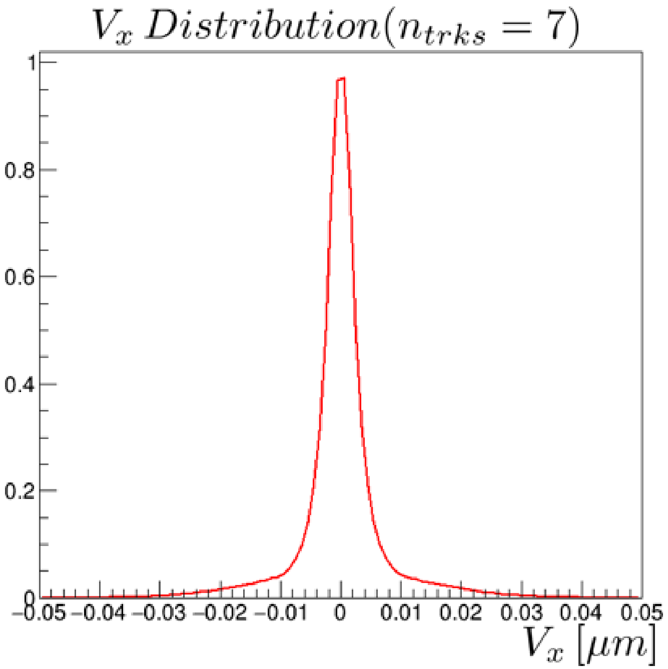
Tracking Detectors & Vertex Detectors

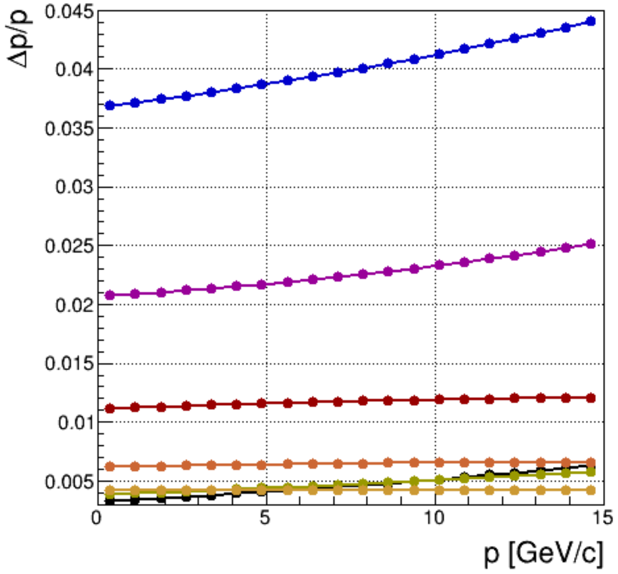
- Latest resolutions applied:
  - EicC_Mvd_DP_v3 (gitee)

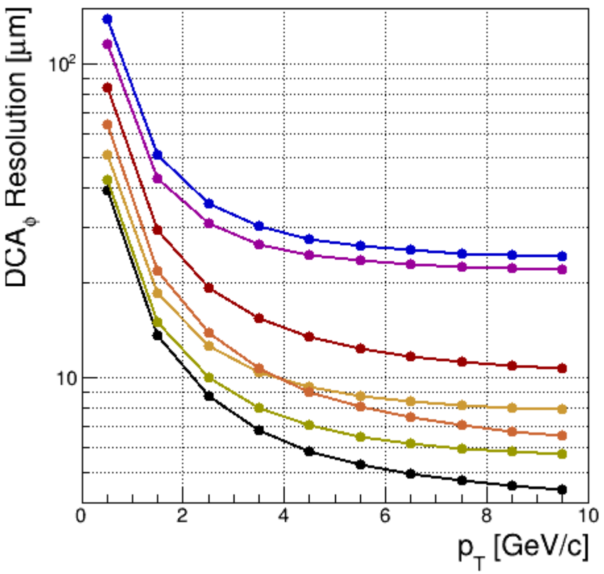
Detectors









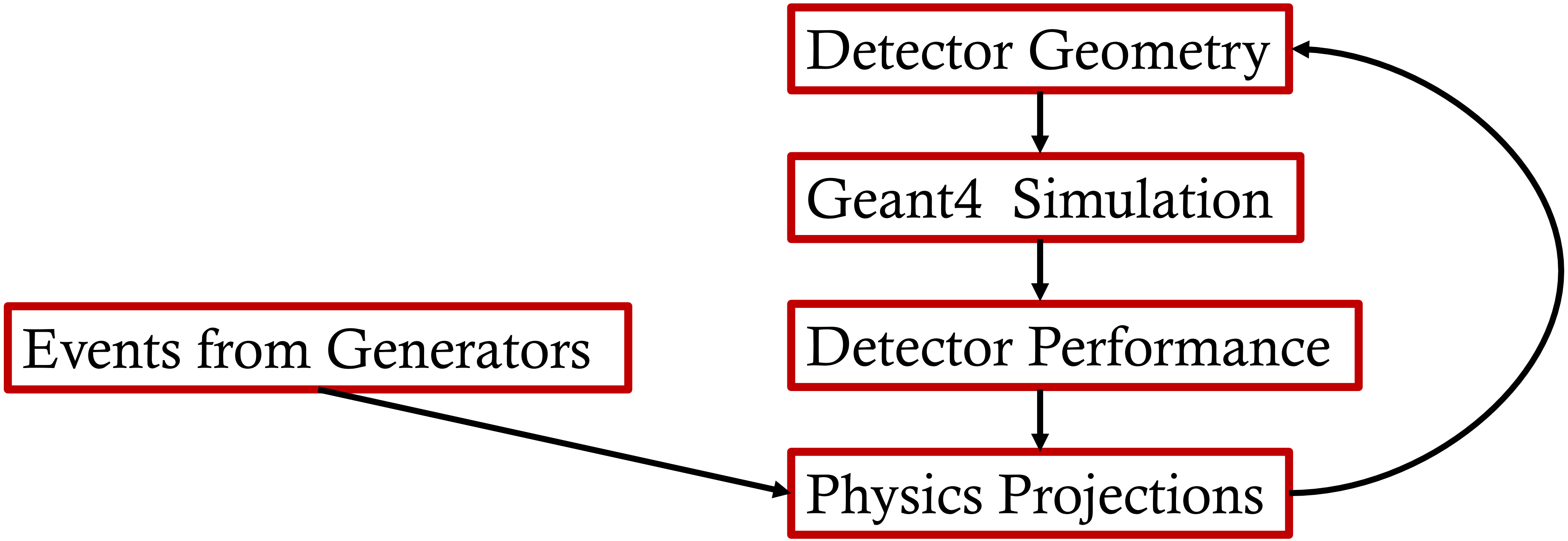


- eID Acceptance
  - $p_e > 0.35GeV/c, p_e < 20GeV/c$
- PID Acceptance (π\K\p)

$\boldsymbol{\eta}$	$[-3.5,1]$	$(-1,1]$	$(1,3.5]$
$\boldsymbol{p_{max}}$	$4\ GeV$	$6\ GeV$	$15\ GeV$

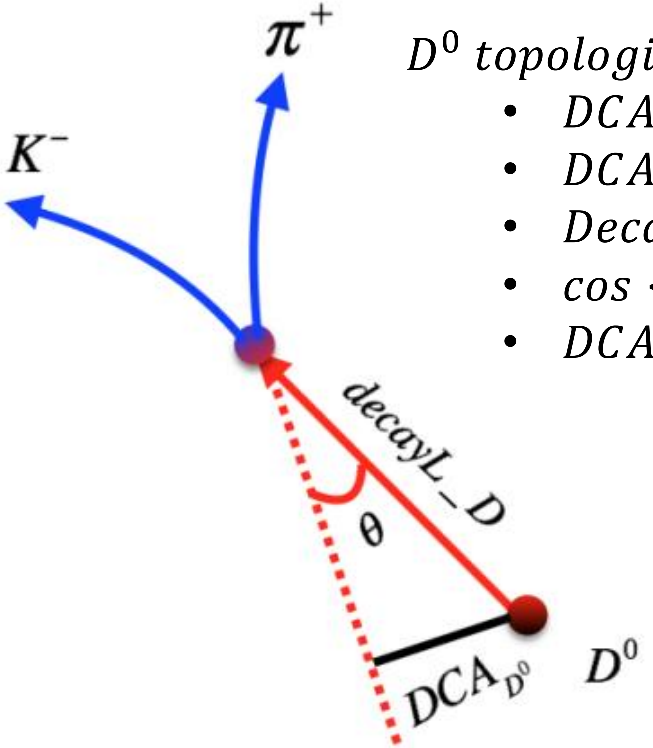
$p_{hadron} > 0.3GeV/c$

Simulation Setup



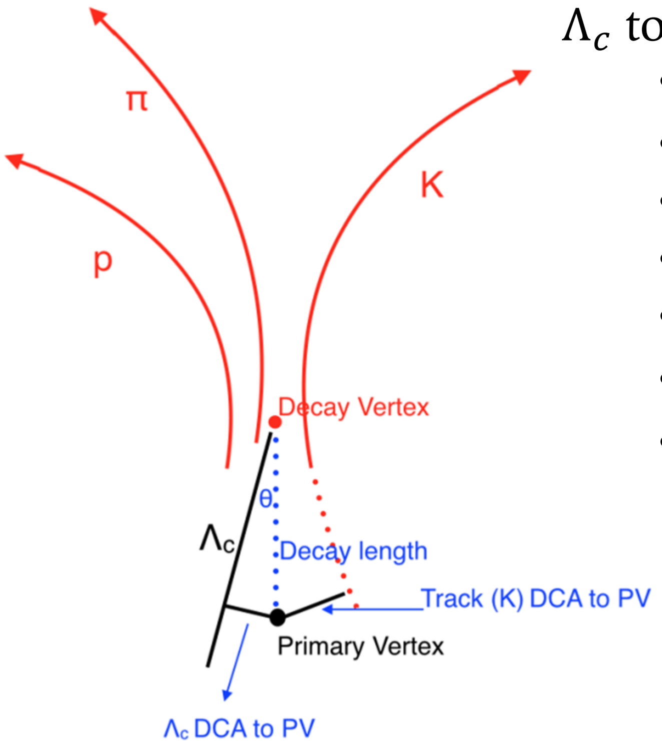
Open Charm Simulation@ EicC

- Two collision systems are studied.
  - $e(3.5\ GeV)p(20\ GeV)$: pythiaeRHIC $L_{int} = 4.032\ fb^{-1}$
  - $e(3.5\ GeV)C(10\ GeV/u)$: BeAGLE $L_{int} = 5.42\ fb^{-1}$
  - $1\ GeV^2 < Q^2 < 100\ GeV^2$
- Background is rejected with TMVA



$D^0\ topological\ cut$

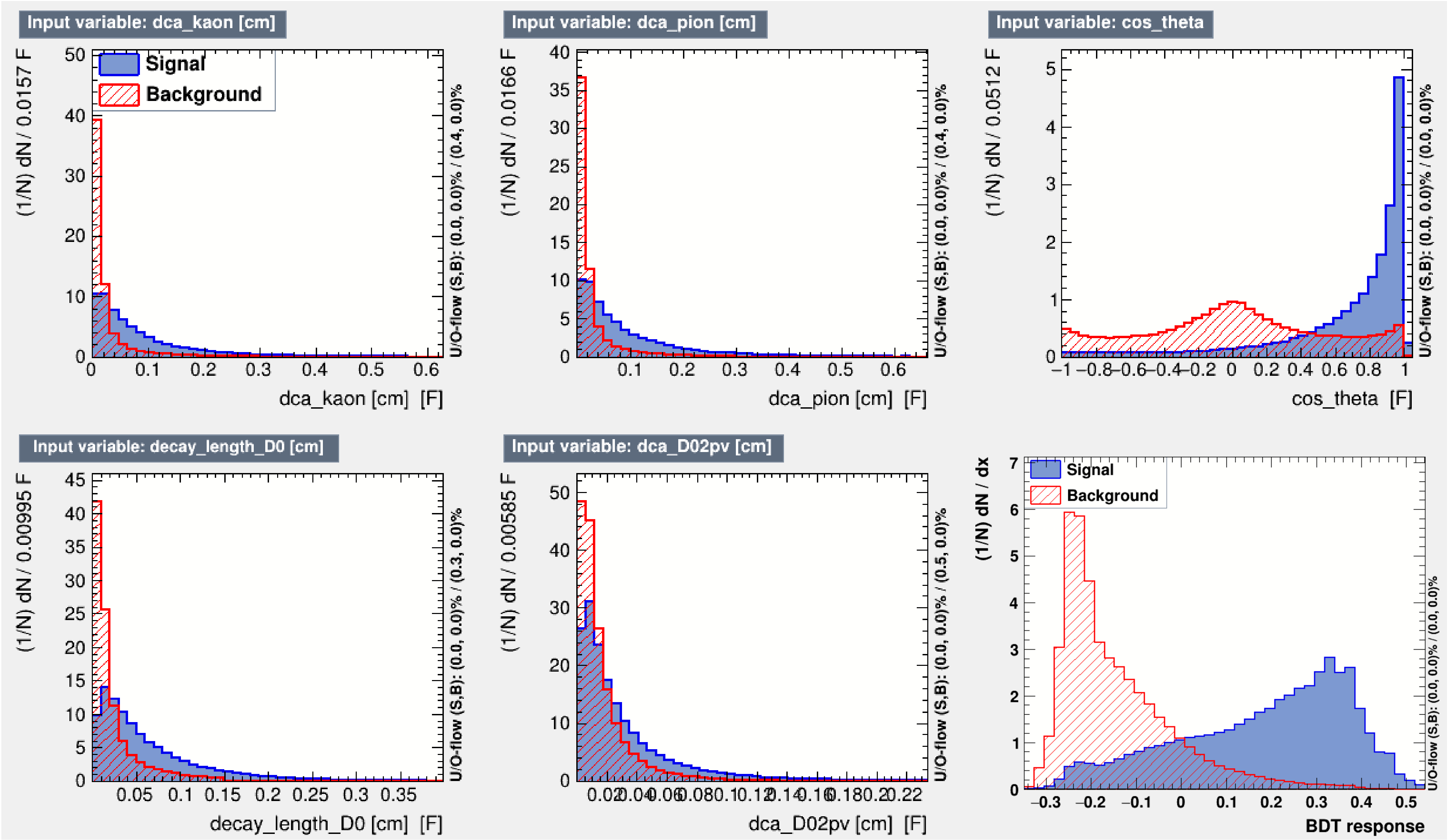
- DCA_K
- DCA_π
- $DecayLength_{D^0}$
- $cos < p_D, l_D >$
- DCA_{D^0}



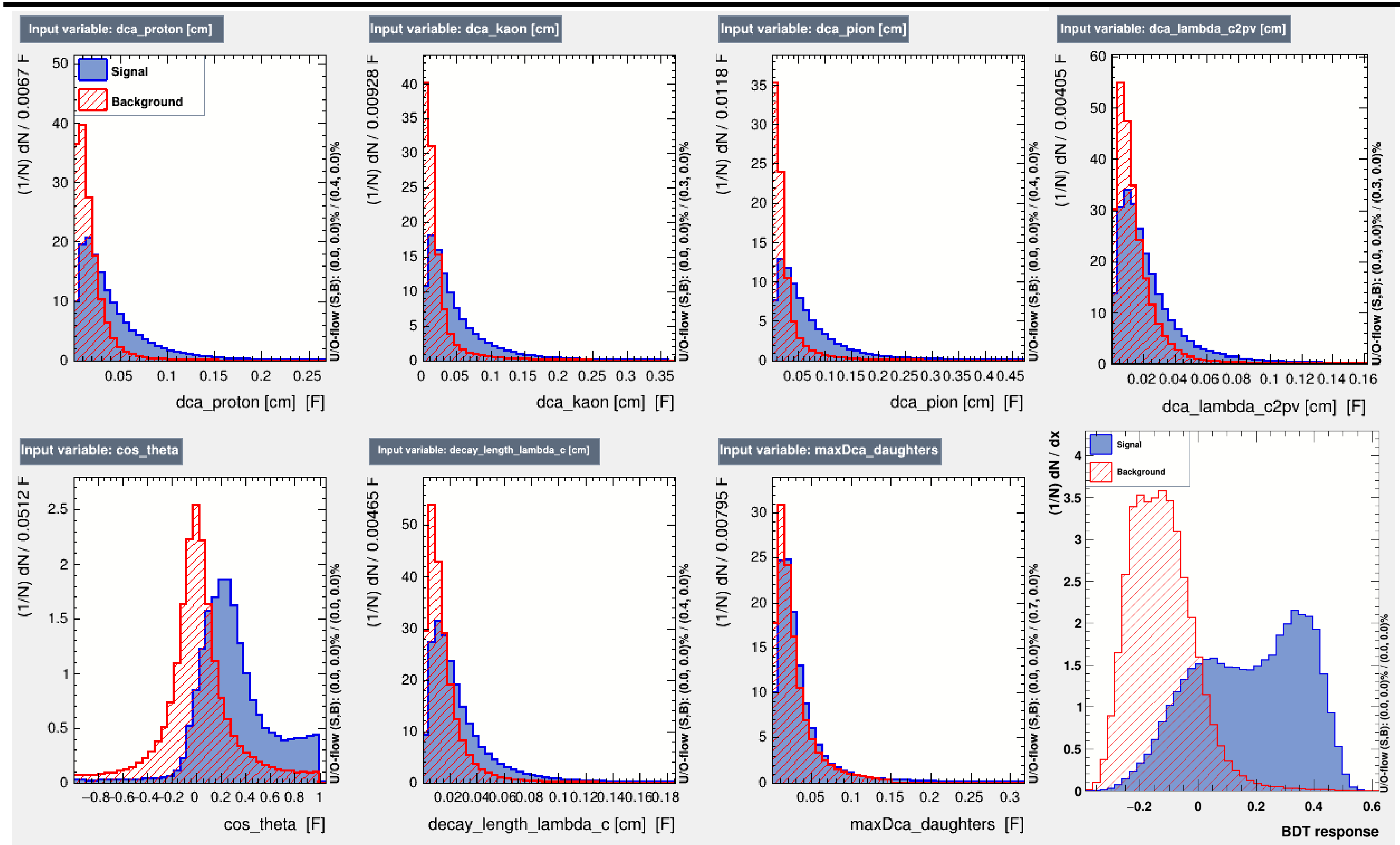
Λ_c topological cut

- DCA_p
- DCA_π
- DCA_K
- $Max\{Dca(DaughterTracks)\}$
- $\cos < p_{\Lambda_c}, l_{\Lambda_c} >$
- $DecayLength_{\Lambda_c}$
- DCA_{Λ_c}

TMVA Performance-D^0

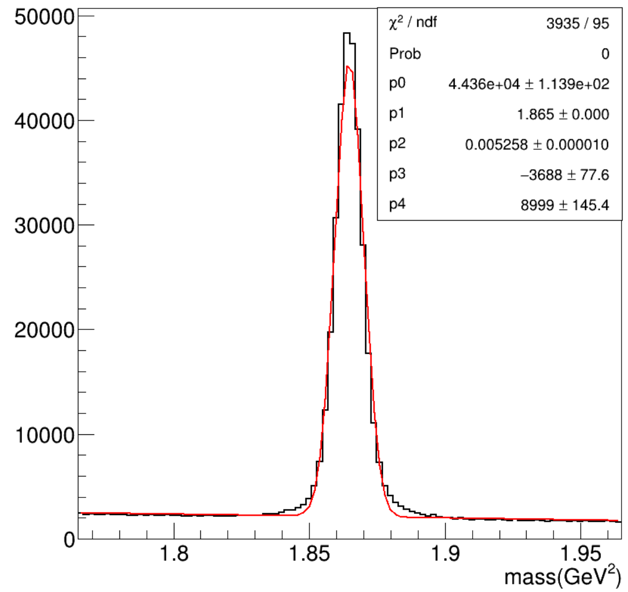


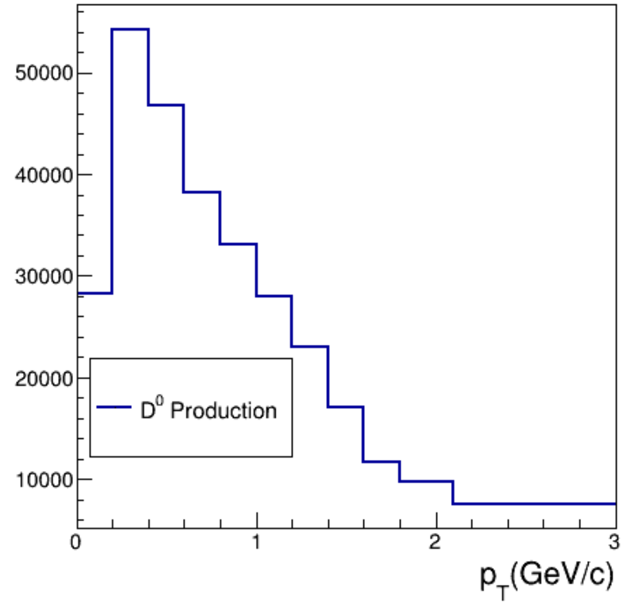
TMVA Performance-Λ_c

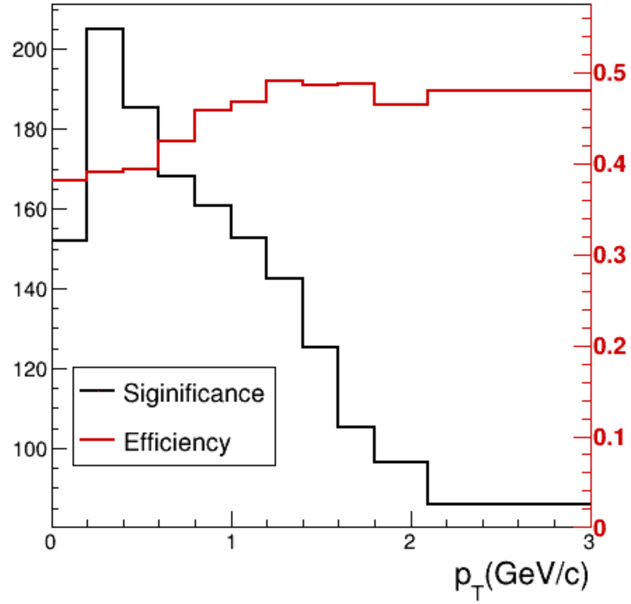


Reconstruction Results in ep system

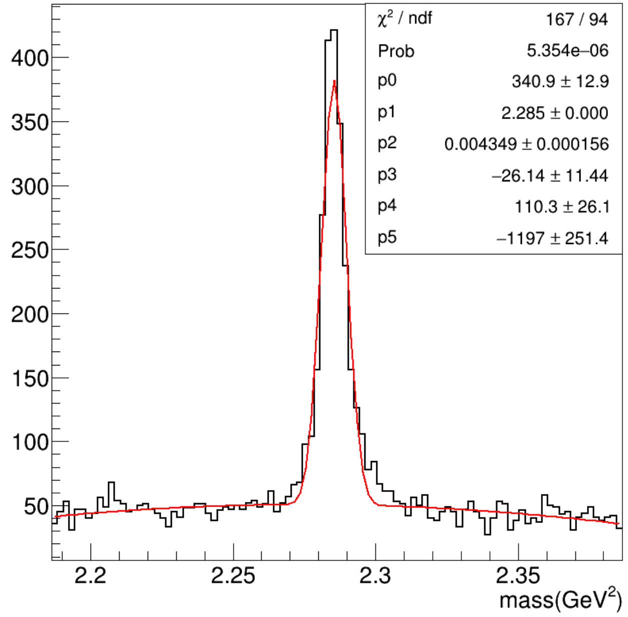
$D^0 + \overline{D^0}$

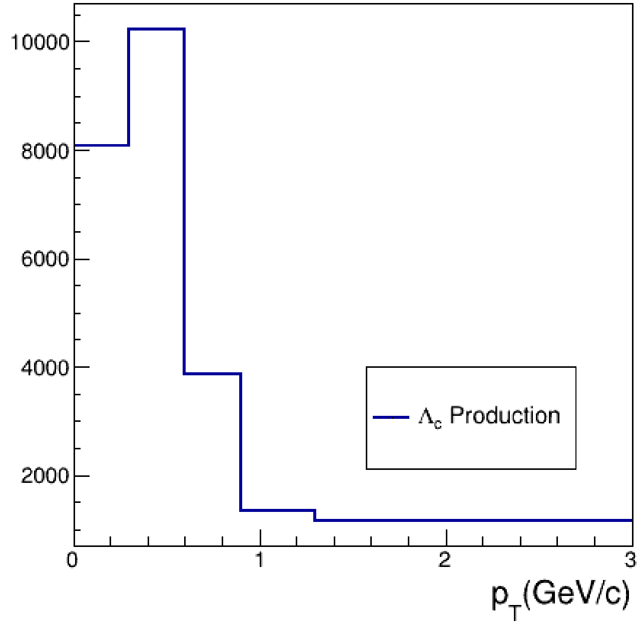


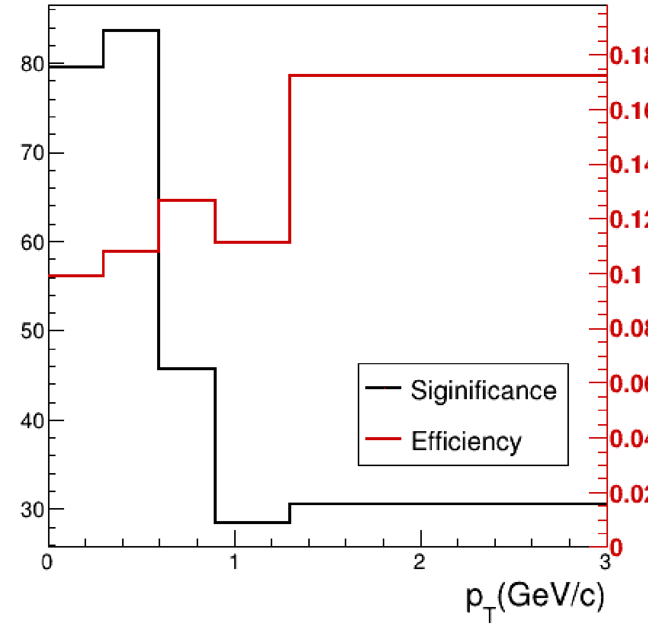




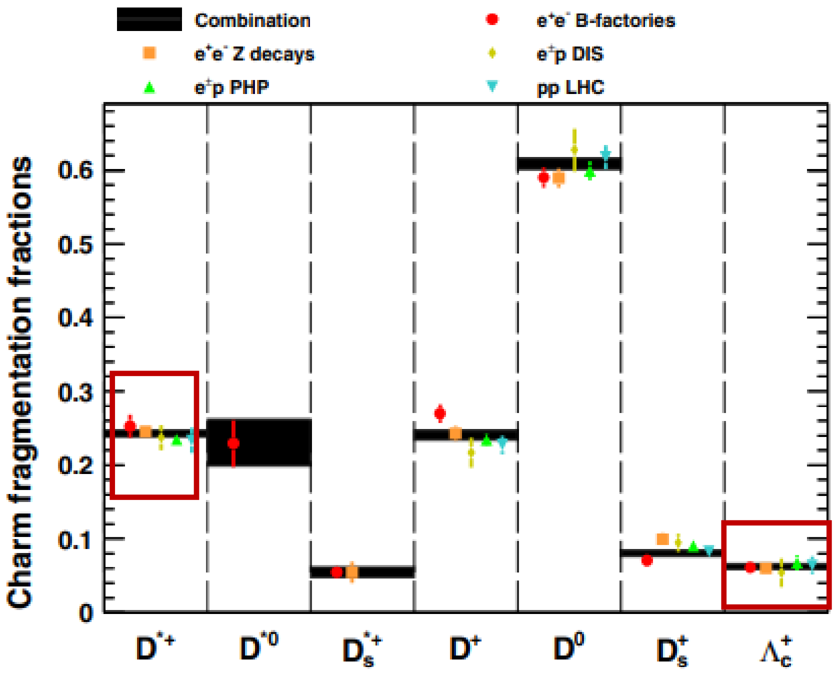
$\Lambda_c^+ + \Lambda_c^-$







Fragmentation and hadronization



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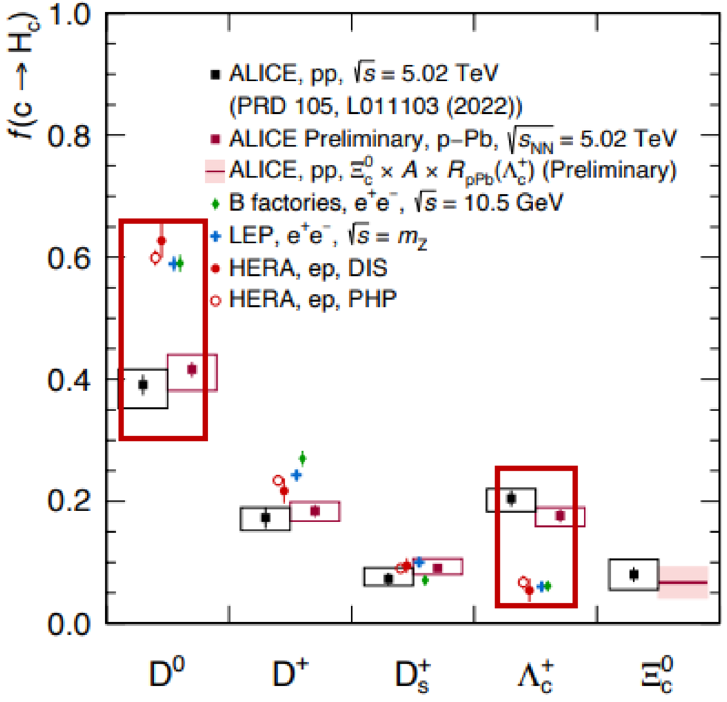
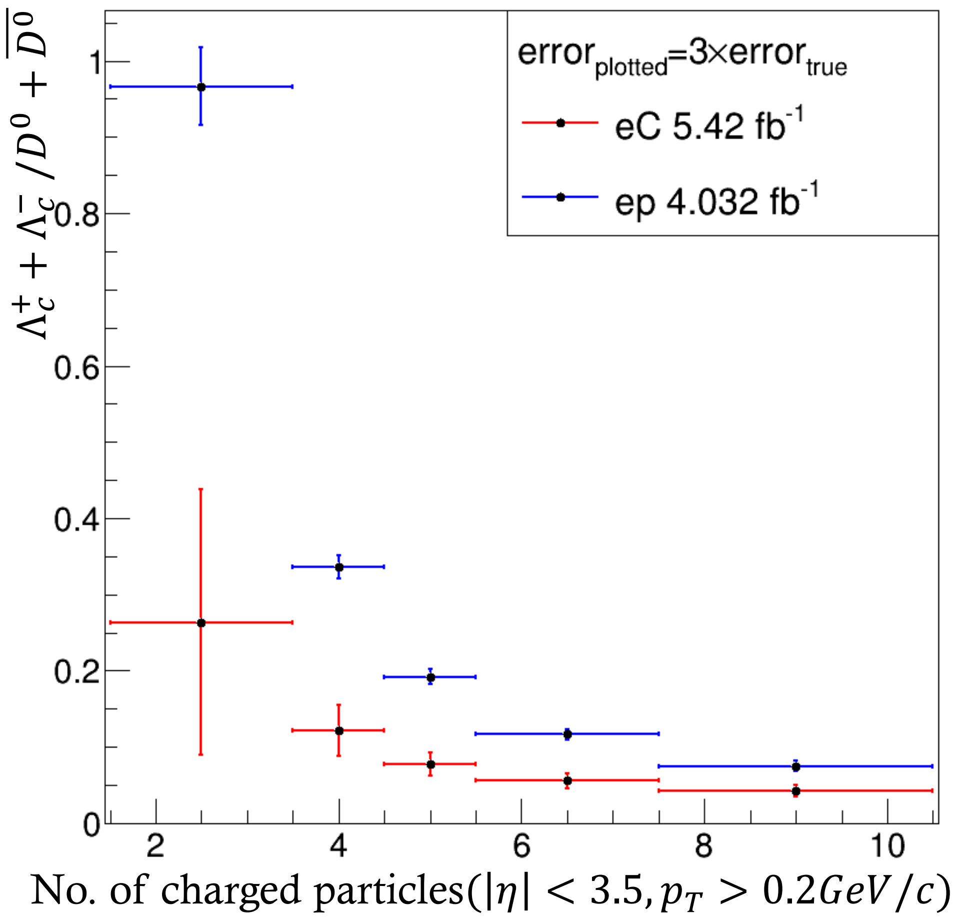


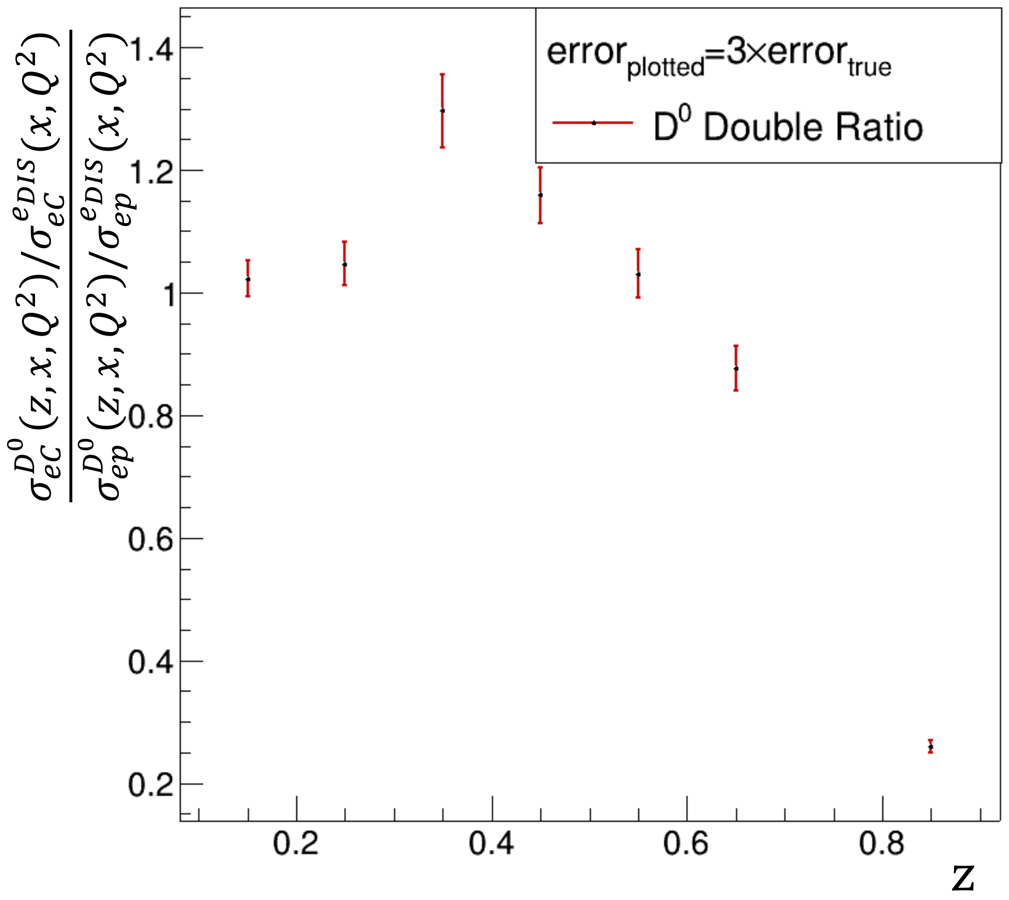
arXiv:2207.07590v1

- How do partons fragment to final state hadrons?
  - Baryon-to-meson ratio

- $\dfrac{\sigma^h_{eA}(z,x,Q^2)/\sigma^{e_{DIS}}_{eA}(x,Q^2)}{\sigma^h_{ep}(z,x,Q^2)/\sigma^{e_{DIS}}_{ep}(x,Q^2)}$
  - $z = \dfrac{p_{proton} \cdot p_{hadron}}{p_{proton} \cdot q}$, energy fraction of hadron with respect to virtual photon in target rest frame
  - $\sigma^{e_{DIS}}$ divided to eliminate PDF effects

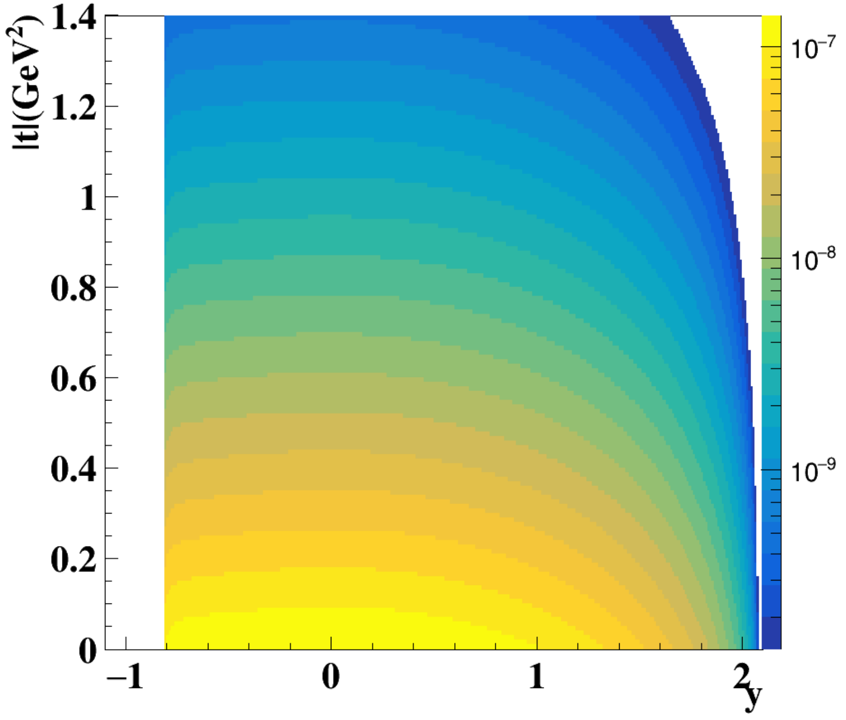
Projection @ EicC

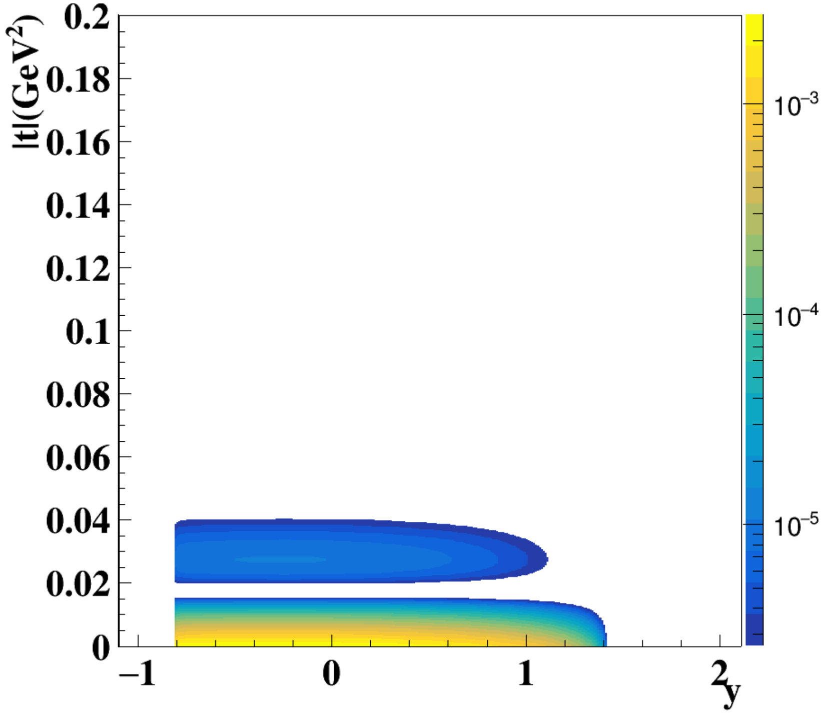


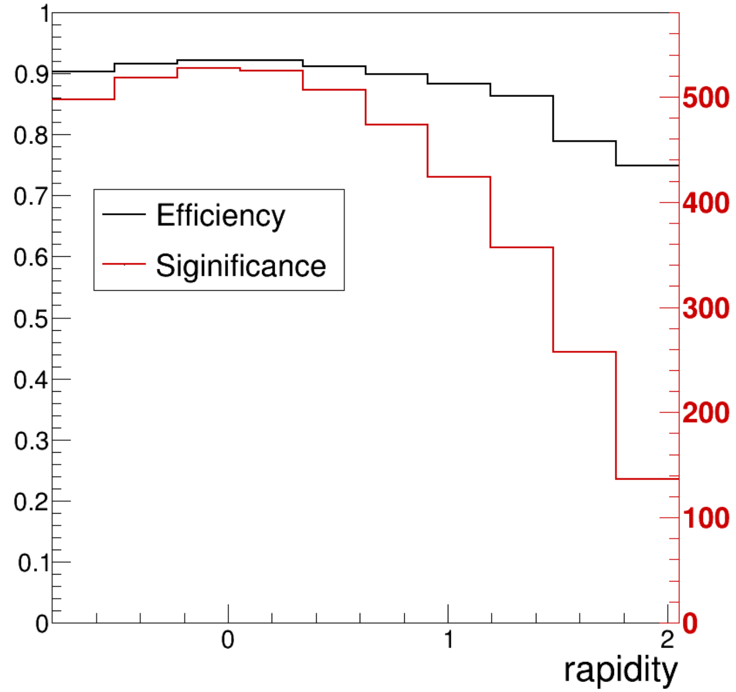


Coherent exclusive J/ψ production

- No Breakup of nucleon(nuclei): $eA \to eA'J/\psi$
- Generator: eSTARLIGHT



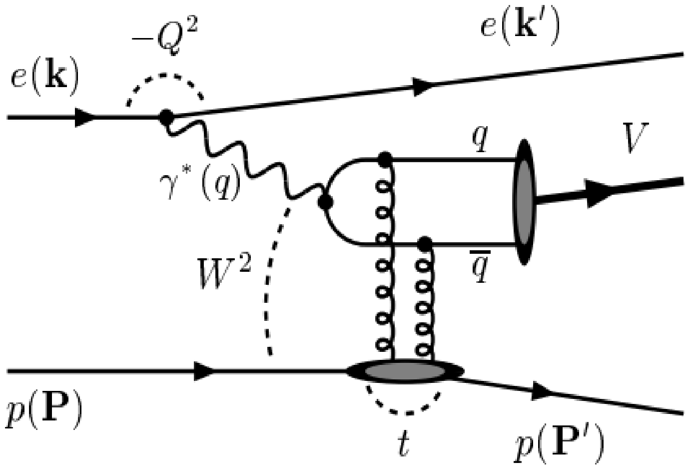


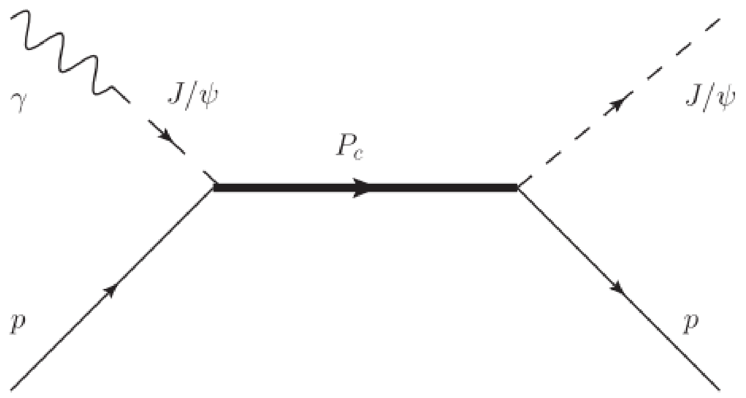


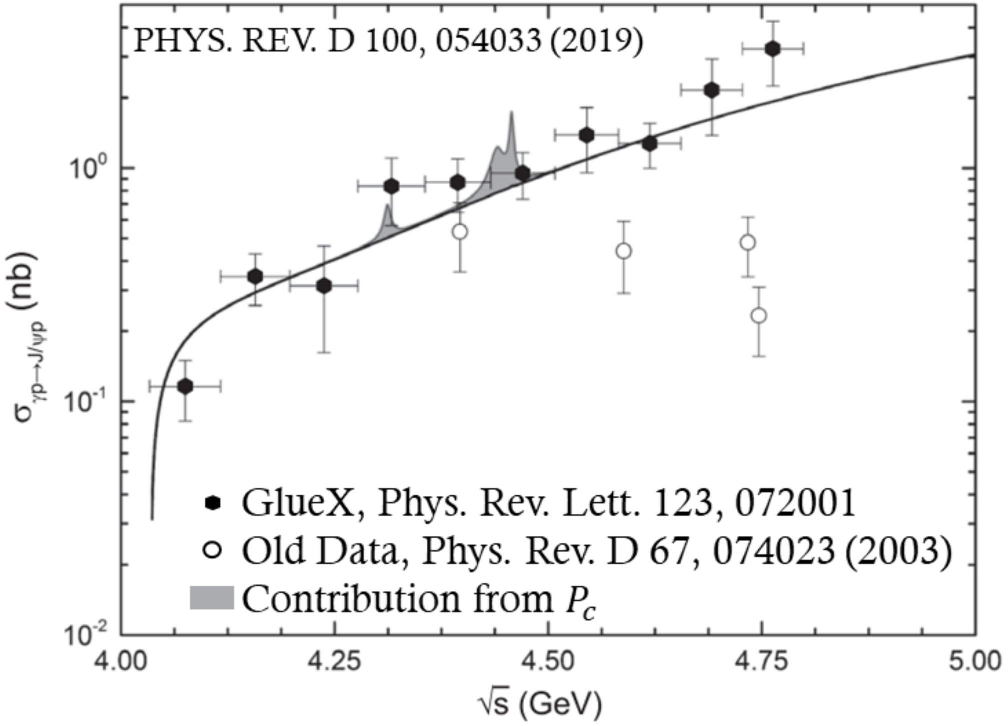
- e(3.5 GeV)p(20GeV):
  - $0\ GeV^2 < Q^2 < 1\ GeV^2$: $50\ fb^{-1}$
- e(3.5 GeV)Au(10.35 GeV/u):
  - $0\ GeV^2 < Q^2 < 1\ GeV^2$: $50/nucleons\ fb^{-1}$

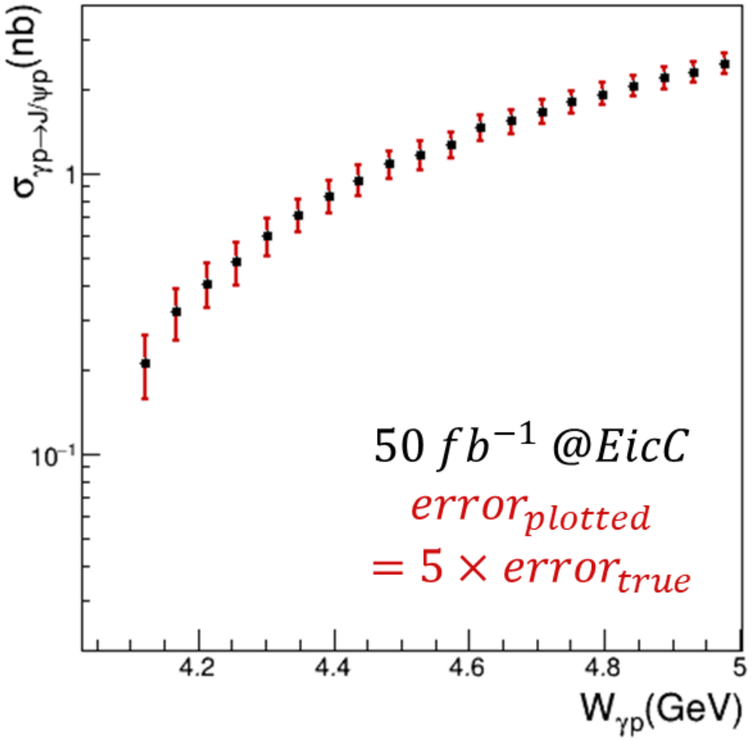
Cross section of J/ψ

- Study exotic states with the enhancement of J/ψ cross section

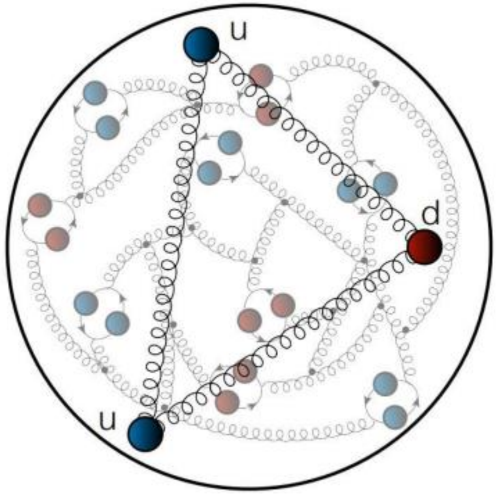








How does proton mass arise?



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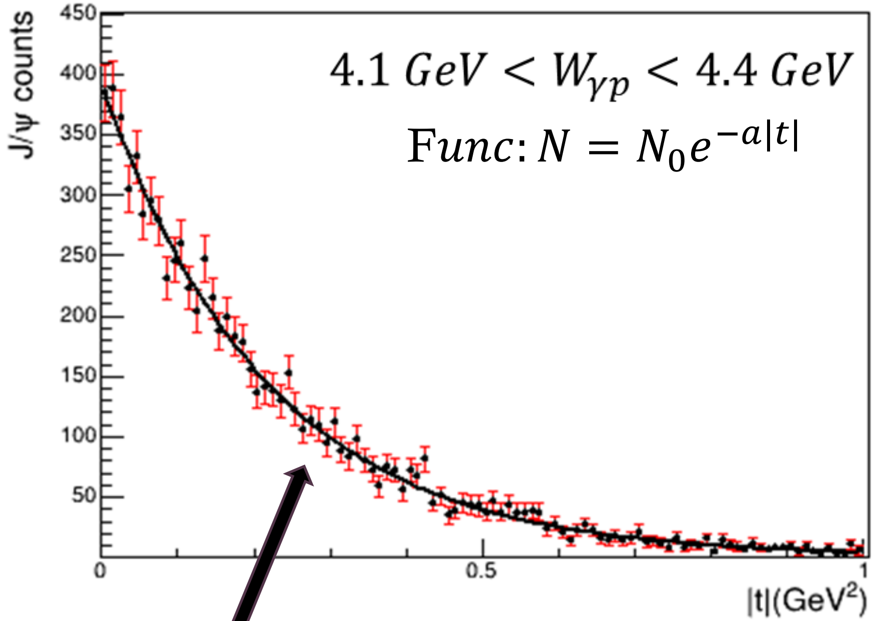
$$M_m = \frac{4+\gamma_m}{4(1+\gamma_m)} b M_N,$$

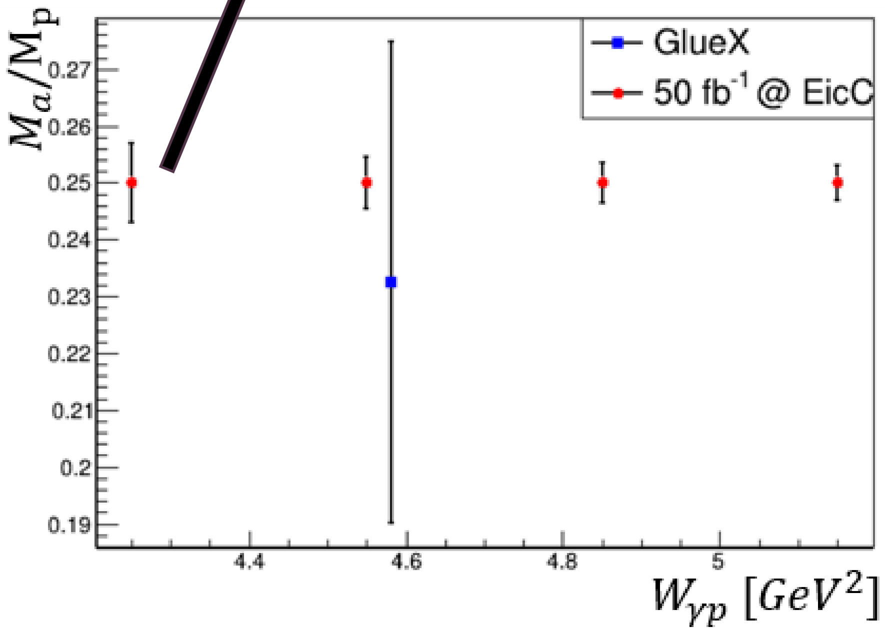
$$M_a = \frac{1}{4}(1-b)M_N,$$

$$M_q = \frac{3}{4}\left(a - \frac{b}{1+\gamma_m}\right) M_N,$$

$$M_g = \frac{3}{4}(1-a)M_N,$$

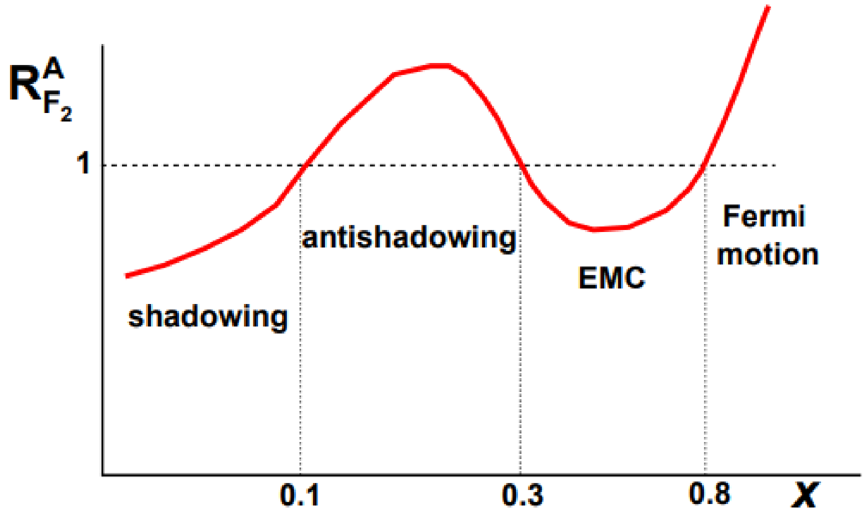
$$\frac{d\sigma_{\gamma N \to J/\psi\, N}}{dt}\Big|_{t=0} \propto (1-b)^2$$



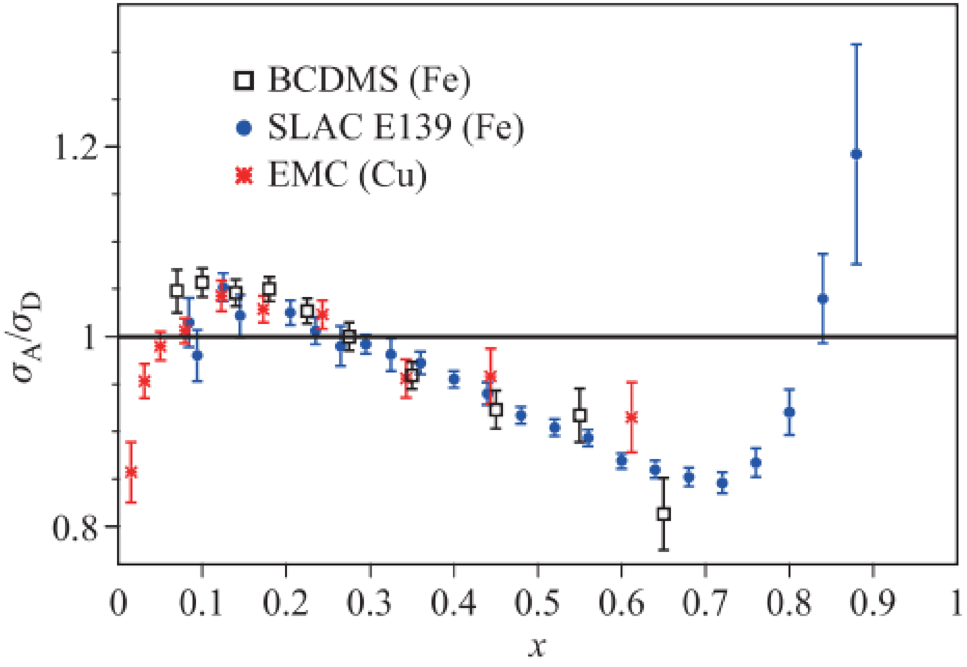


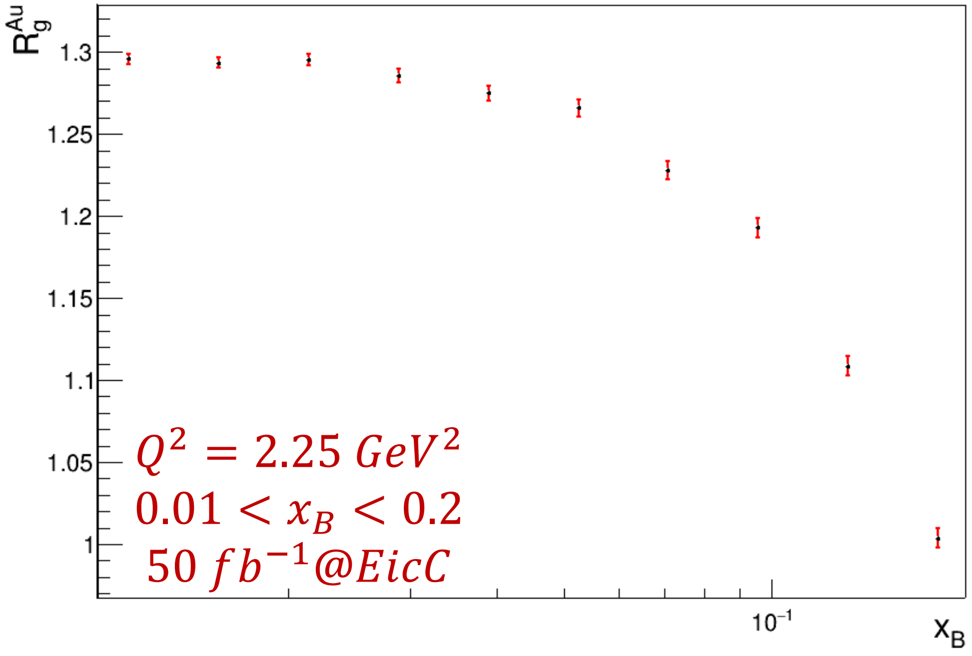
Nuclear Shadowing Effect

- How are PDFs modified by the nuclear medium when nucleon bounded?



EicC White Paper, Front. Phys. 16(6), 64701 (2021)





Conclusion

- Electron-proton collision system and electron-carbon collision system are simulated.
- Several Projections are done with the latest EicC tracking&vertex detector parameters.
  - Near-threshold J/ψ cross section
  - Trace anomaly
  - R_g^{Au}
  - Baryon-to-meson Ratio vs. charged track multiplicity
  - D^0 double ratio vs. z