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Heavy flavor measurements @ ePIC

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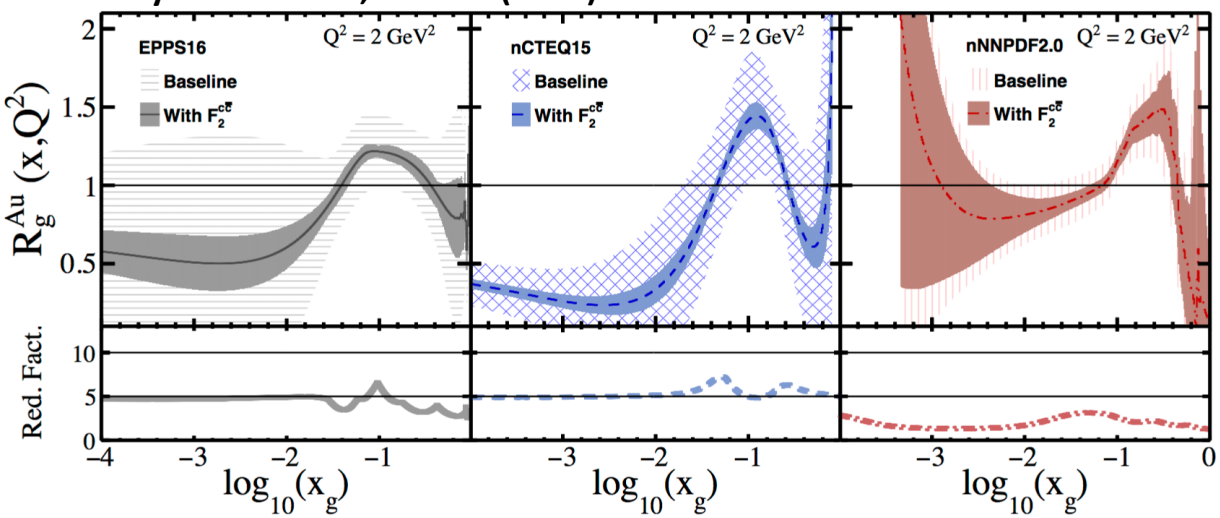
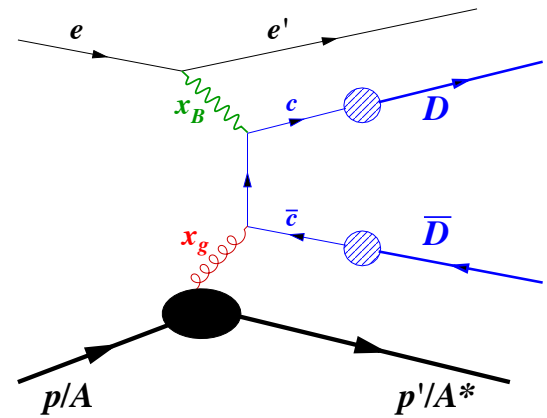
California EIC consortium meeting, 01/28/2023

Physics motivation and key measurements

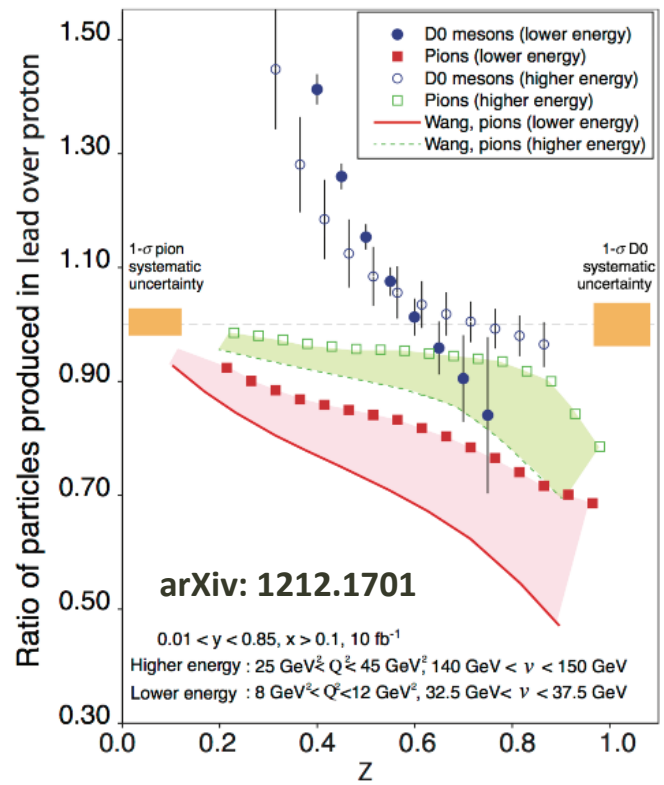
- Study gluon dynamics inside nucleon/nucleus
  - Charm F_2, gluon helicity, gluon TMD measurements (via open charm hadron and tagged charm jets)

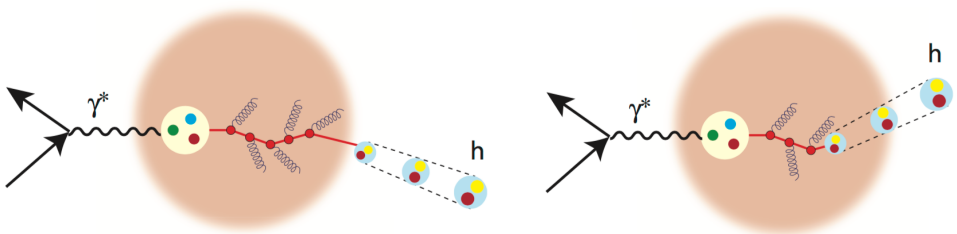
Phys. Rev. D 104, 054002 (2021)





- Study hadronization scale and color transport inside the nuclear medium
  - R_{eA}: open charm hadron (D mesons, Λ_c), D/B tagged jets

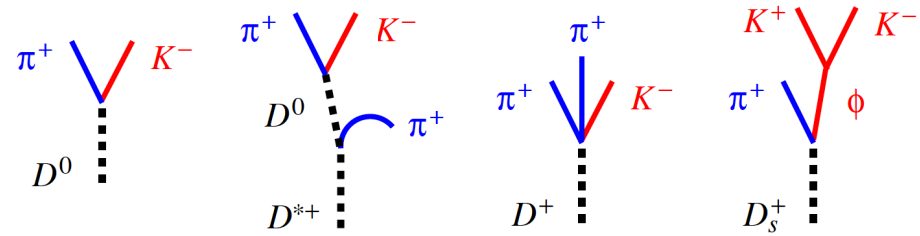




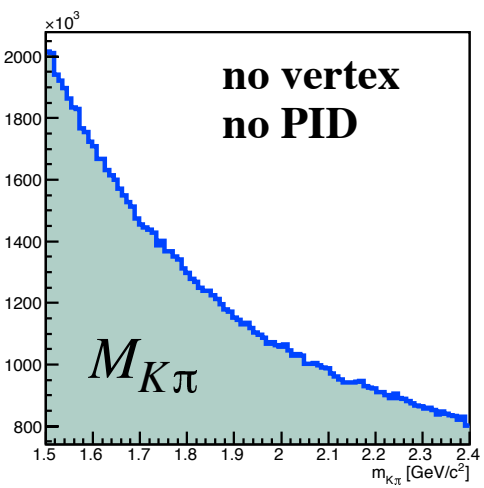
More details of ongoing analysis: https://wiki.bnl.gov/EPIC/index.php?title=JetsHF

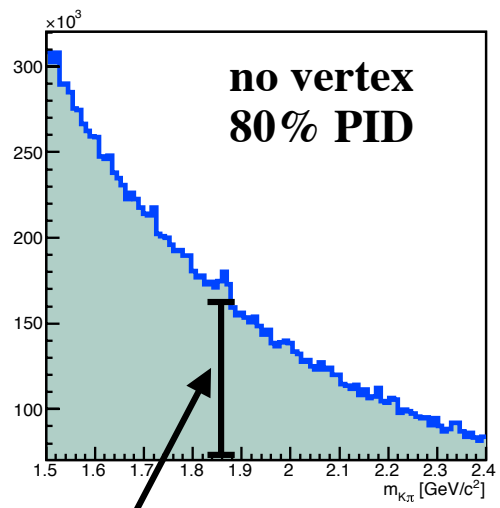
Open charm hadron measurements via hadronic decays

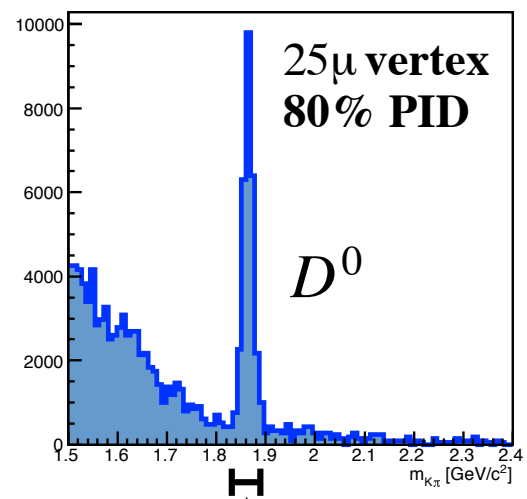
- Key of precision heavy flavor hadron reconstruction ☛ reduce the stat. err. for the signal extraction
  - High statistics (**increase SG**)
    - High luminosity + good detector acceptance
  - High purity (**decrease BG/SG**)



Stat. Err. = √(SG+BG)/SG = √(1/SG+BG/SG)







Particle	cτ
D^0	123 μm
$D^\pm$	312 μm
B^0	456 μm
$B^\pm$	491 μm
Λ_c	60 μm

arXiv: 1610.08536

Reduce the comb. bkg. level

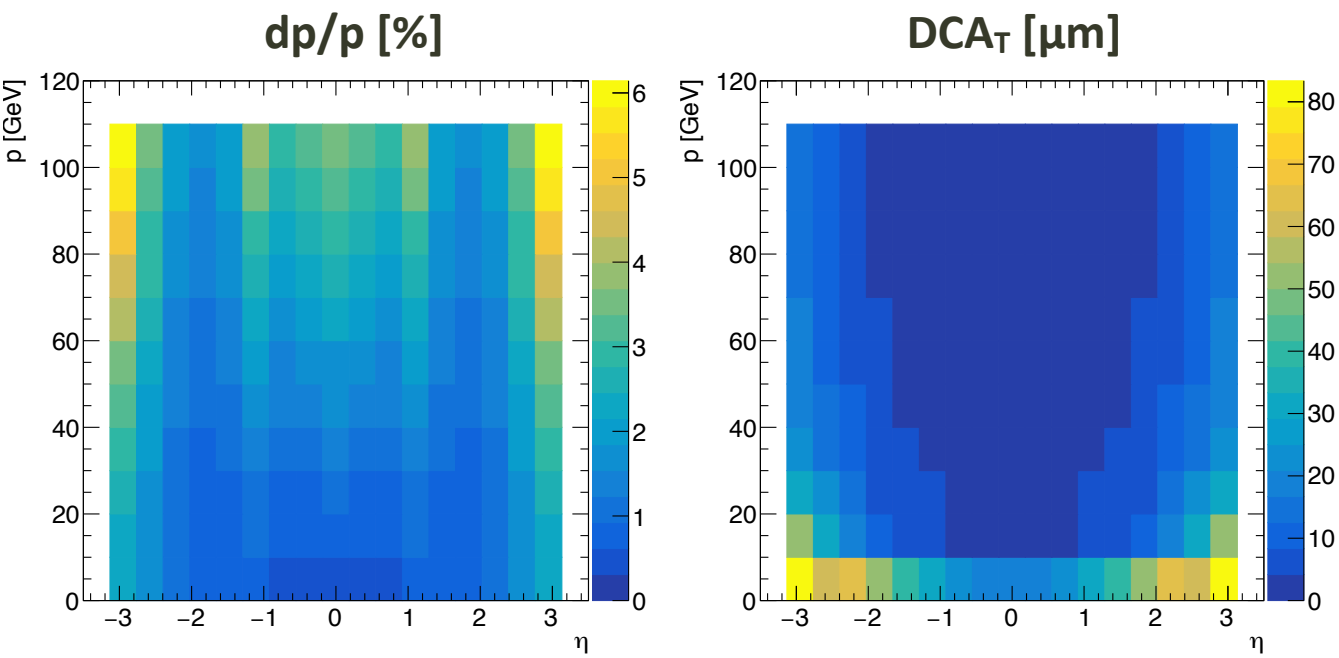
Reduce the integration window

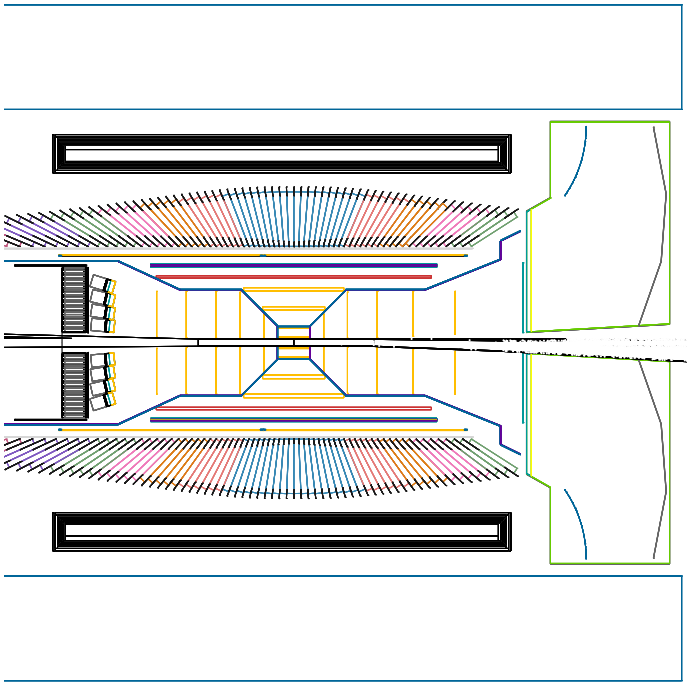
Reduce BG/SG

- Good π/K/p seperation power
- Good pointing resolution
- Good momentum resolution

Detector performance

- Tracking and vertexing





- PID with Cherenkov detectors and TOF: π/K/p separation
  - Forward: dRICH + TOF
  - Barrel: DIRC + TOF
  - Backward: mRICH/pfRICH

Fast simulation setup

- Single track smearing using parameters from fast simuation with ePIC baseline tracking (<u>assuming single pion resolution for all charged particles</u>)
  - p (magnitude) smeared by p resolution along the true p direction
  - Vertex position smeared by $DCA_{r\varphi}$ and DCA_z
- No primary vertex smearing
- PID: π/K/p separation in certain mometum range
  - In the barrel region: no PID if particles can not reach DIRC @76cm: using 2r = ρ = p/(0.3B) ☛ $p_T > 0.19$GeV for 1.7T
  - Without TOF: no π/K/p separation below the firing and detectable threshold for π, no K/p separation below the firing and detectable threshold for K
  - With TOF: detector matrix parameters (low p range identification covered by TOF)

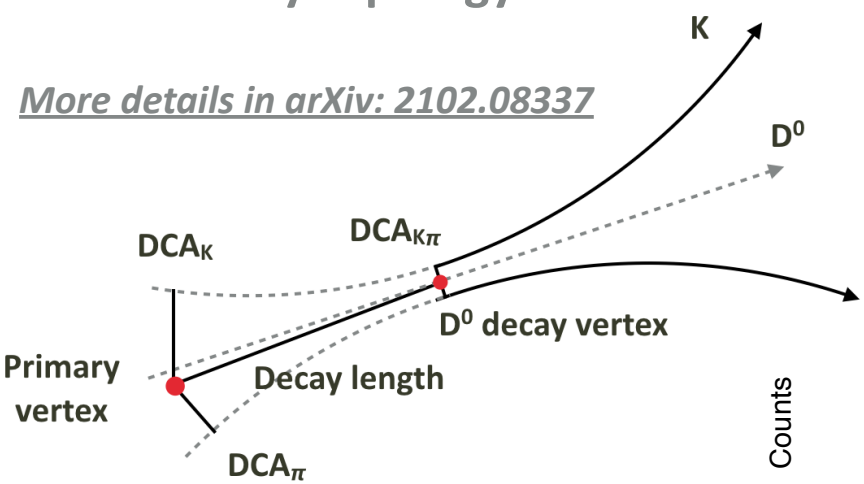
<u>Table from the Yellow Report (YR)</u>

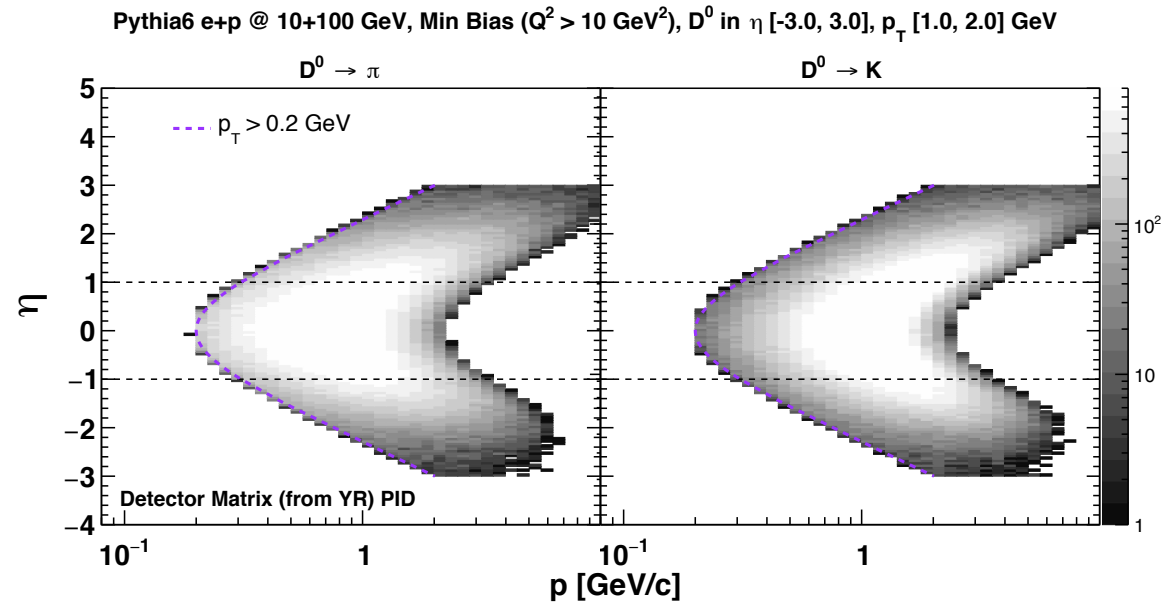
Detector Matrix	
Barrel	< 6 GeV
Forward	< 10 GeV
Backward	< 50 GeV

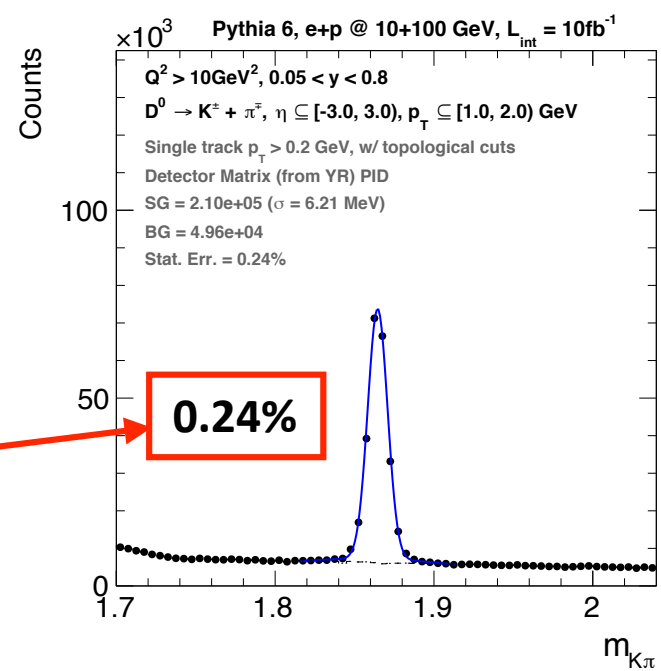
Fast simulation: example of D^0 measurement

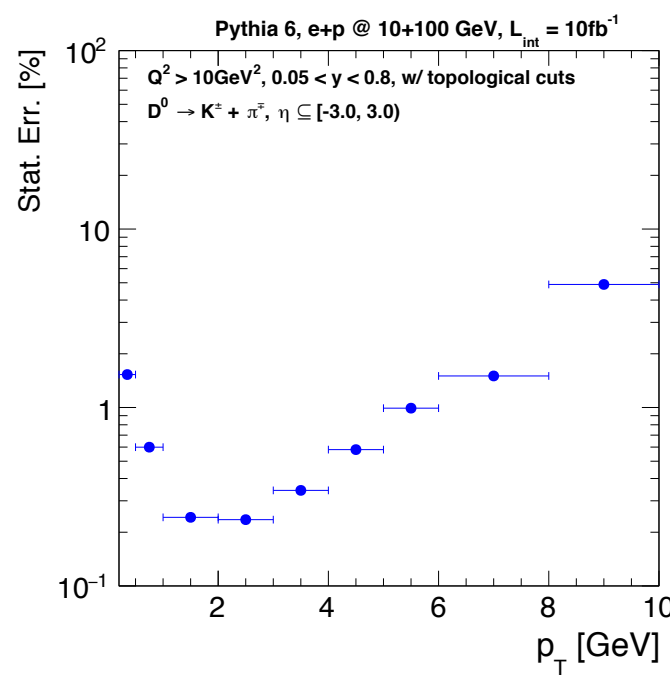
- D^0 selection
  - $p_T > 0.2$GeV
  - Identified π/K (with TOF)
  - Decay topology cuts

More details in arXiv: 2102.08337









0.24%

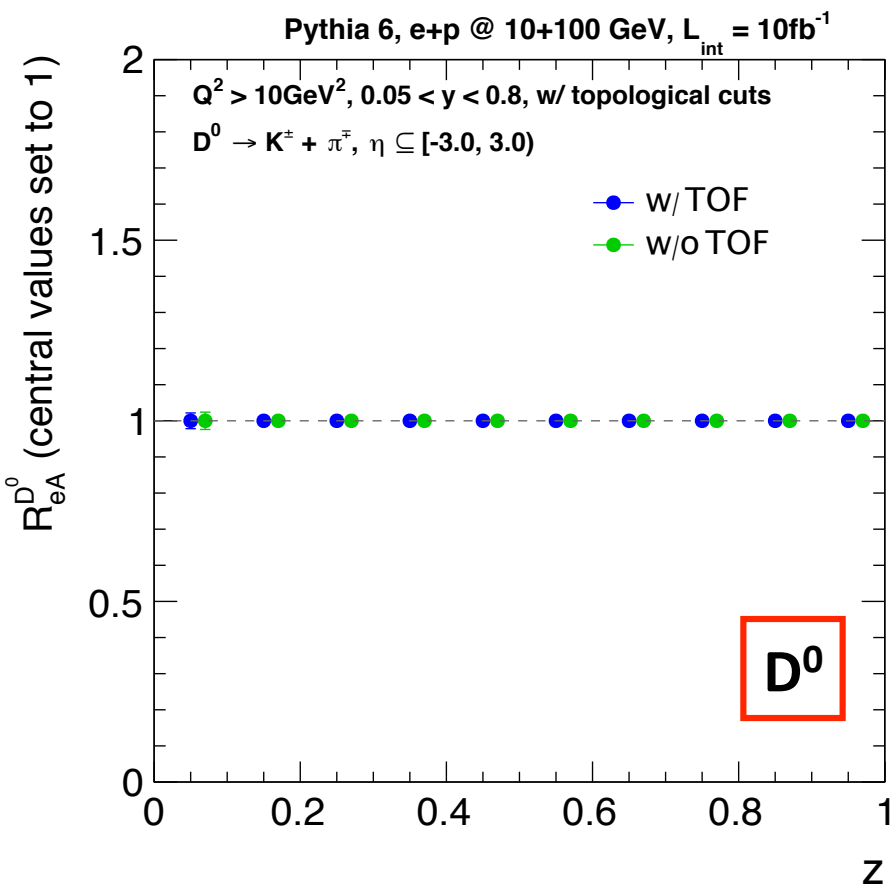
Stat. Err. = sqrt(SG+BG)/SG
= sqrt(1+BG/SG)/sqrt(SG)

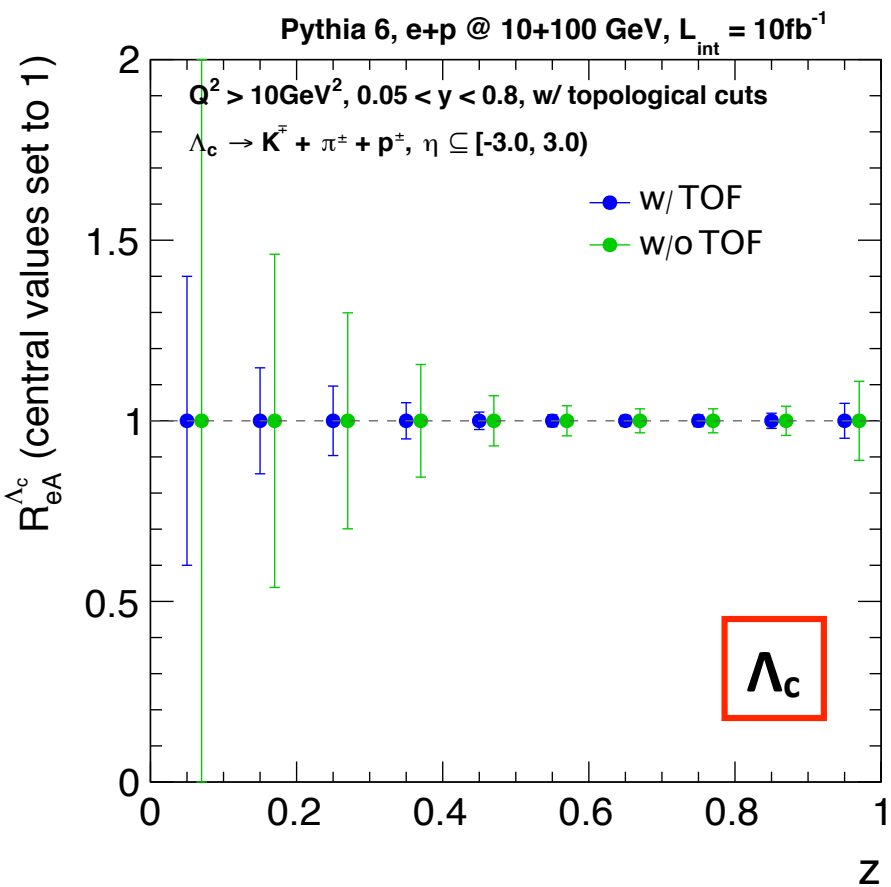
☛ decrease with increasing SG

☛ descrease with descreasing BG

Precision of R_{eA} mesurement

- Projected stat. uncertainty on R_{eA}
  - High accuracy for D^0: <1%
  - Moderate accuracy for Λ_c: 1-10%
- With or without TOF: negligible impact on D^0 measurement but larger impact on Λ_c measurement





Future plan: towards full simulation analysis

- Perform HF analysis in full simulation
  - DIS events on S3 storage (DD4HEP + juggler/eicrecon)
  - Pythia events, beam crossing
  - Event vertex distribution: σ_x = 0.13mm, σ_y = 0.008mm, σ_z = 35.6mm
- Available info
  - Reconstructed particle momentum and matched MC true particles
- Missing info
  - No clear ancestry information for MC true particles (cannot tag the decay ancestry)
  - Reconstructed PID (currently using truth)
  - No reconstructed primary vertex, no reconstructed secondary vertex
  - DCA values not available (currently the tracking algorithm calculate them w.r.t (0,0,0) rather than the true event vertex)
- **More information needed for HF studies in full simulation**

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209, 237, 265, 293, 321, 349, 379, 410
```

Parent and daughter index look wrong: only 27 MC particles saved in this event

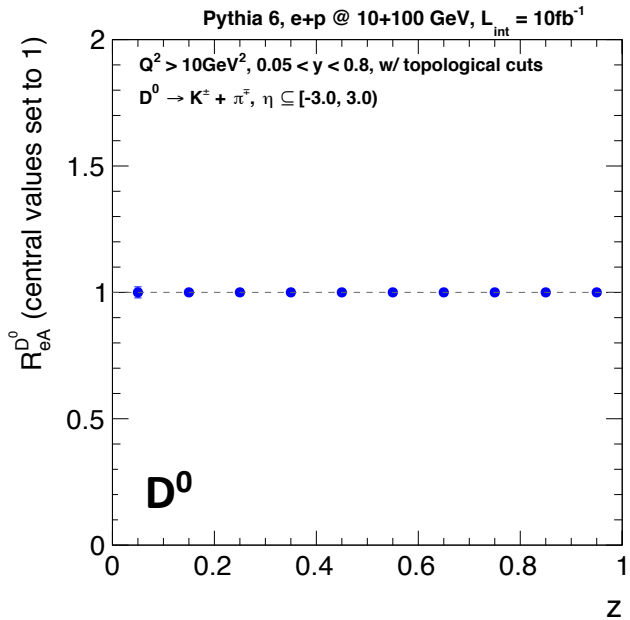
Summary and future plan

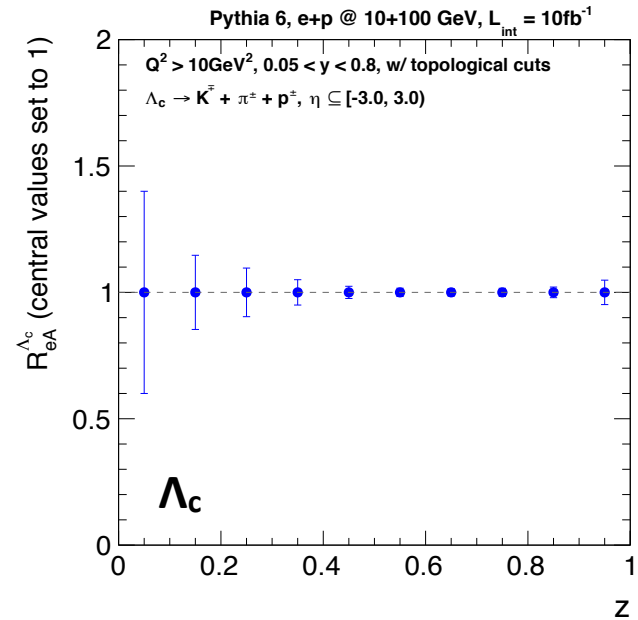
- Rich physics from heavy flavor measurements
- Good tracking/vertexing and PID performance with the EPIC detector
- Some fast simulation has been done: high precision measurement for D^0 and Λ_c
- Next step: test in full simulation the key observables
  - More information needed in the reconstructed output files

BACKUP

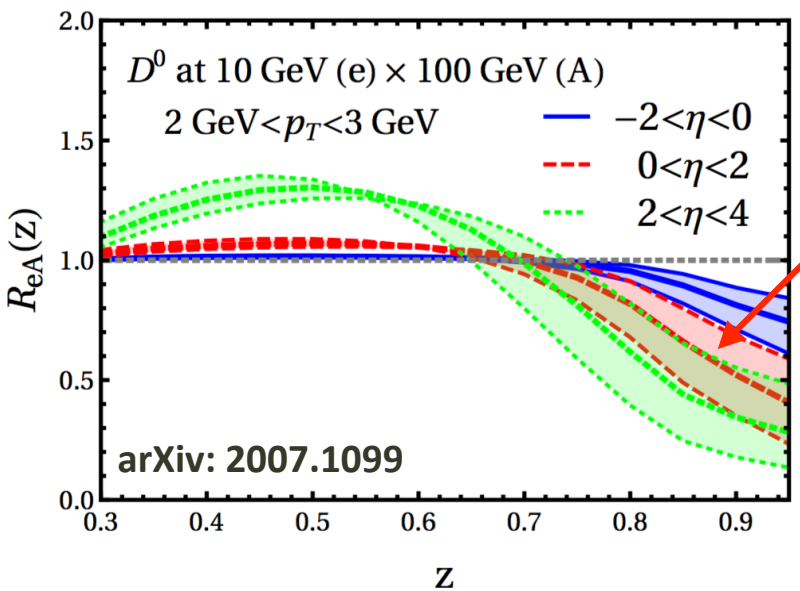
Precision and physics impact

- Projected stat. uncertainty on R_{eA}
  - High accuracy for D^0
  - Moderate accuracy for Λ_c





- Compare to partonic energy loss model
  - Constraining transport coefficient



Transport coefficient varied by a factor of 2