Virtual Reality visuals by Sean Preins

Di-Charm Jet Events and an Estimate of Sensitivity to the Gluon Sivers Asymmetry

Estimate from fast simulation

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ATHENA

OVERVIEW

- Simulation and Methods
- Preliminary Results and Outlook

Simulation and Methods

- Generate NC DIS events with $Q^2>25$ ($\sigma_{PYTHIA8}$ = 24.817nb) with 18x275 configuration → in 100fb^{-1} of EIC data, expect about 2.5B events.
  - Generate 25M events w/ PYTHIA8, CT18NNLO, and the `WeakBosonExchange:ff2ff(t:gmZ)` process only.
  - Scale yields up by 100 for subsequent calculations
- Fast-simulate ATHENA response with DELPHES and delphes_EIC/ATHENA.tcl
- Reconstruction:
  - For this study, given the minimum Q^2, reasonably assume the tagging electron will nearly always be in the detector.
  - Require exactly two R=1 jets, each with p_T>5 GeV, reconstructed in each event.
  - Require both jets pass cut-based charm tagging using displaced tracks or kaons (see https://wiki.bnl.gov/athena/index.php/JetsHF), which is ~23% efficient on real charm jets)

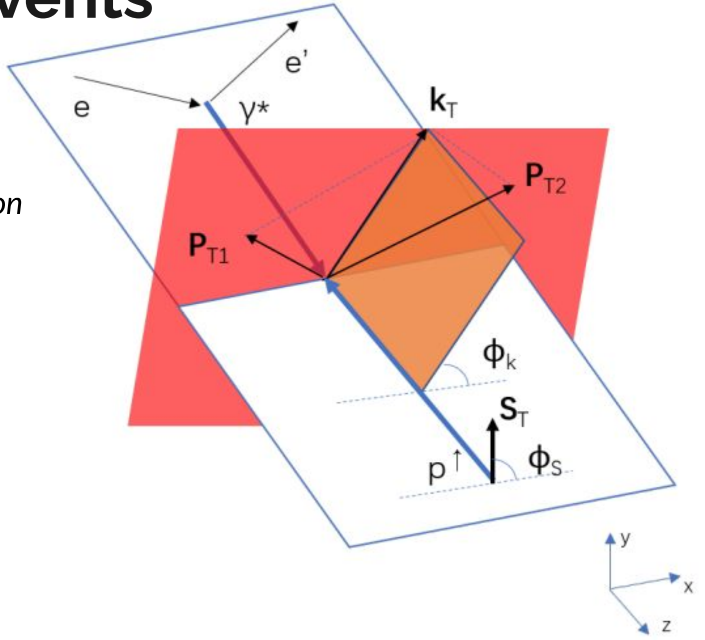
Selection	**Relative Efficiency**
None	100%
Dijets *[True Di-Charm]*	2.56% *[11.6%]*
Charm-Tagged Dijets *[True Di-Charm]*	0.255% *[53.3%]*

Error Estimate for Di-Charm Jet Events

arXiv:1805.05290 and arXiv:2102.08337

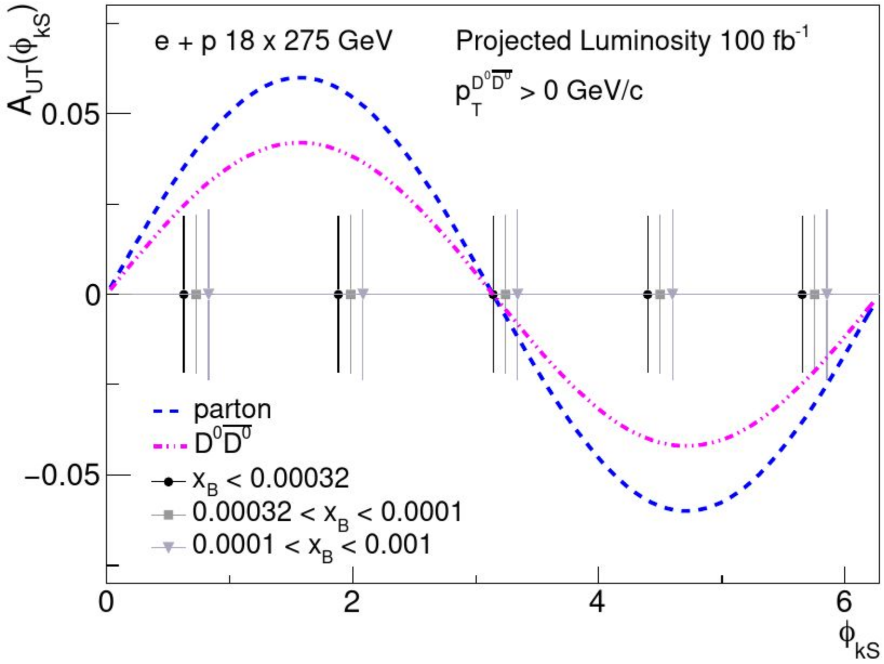
$$\delta A = \sqrt{\frac{1}{P^2 N} - \frac{A^2}{N}}$$

P = 0.70
N = Yield in kinematic region
A = asymmetry

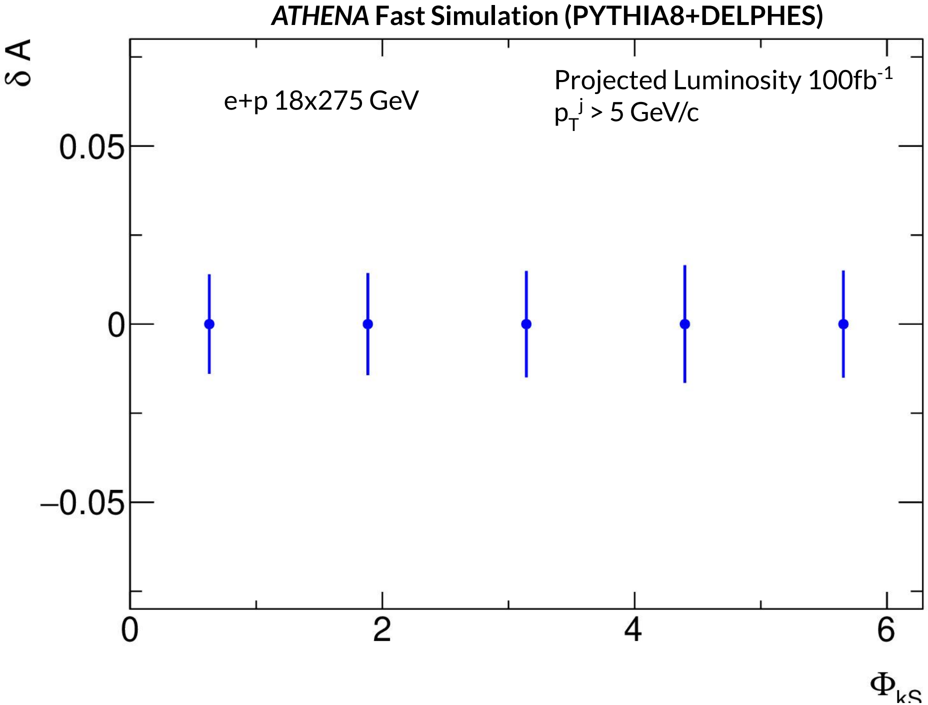


Assume polarization of beam points in y-direction (vertically upward); define ϕ_{kS} as angle between di-jet momentum in transverse plane and proton polarization vector.

For the next step, use only the truth-matched di-charm jet-tagged events in the statistical analysis (53% purity of the tagged di-jet events, or S/B ≅ 1). Since N>>A, neglect second term and focus on δA ≅1/(σP), where σ is the uncertainty on N. For a non-zero background, $\sigma = S/(S + B)^{1/2}$.



arXiv:2103.05419 and arXiv:2102.08337



This Study

The uncertainty on A_{UT} from this di-charm study so far looks like it would be almost a factor of 2 smaller than that predicted in a similar measurement using D^0D^0 pairs. This is reasonable, given the inclusive use of jet reconstruction. Dilution by background subtractions is included in the above, using same assumptions as analysis on left.

OUTLOOK

Conclusions and Outlook

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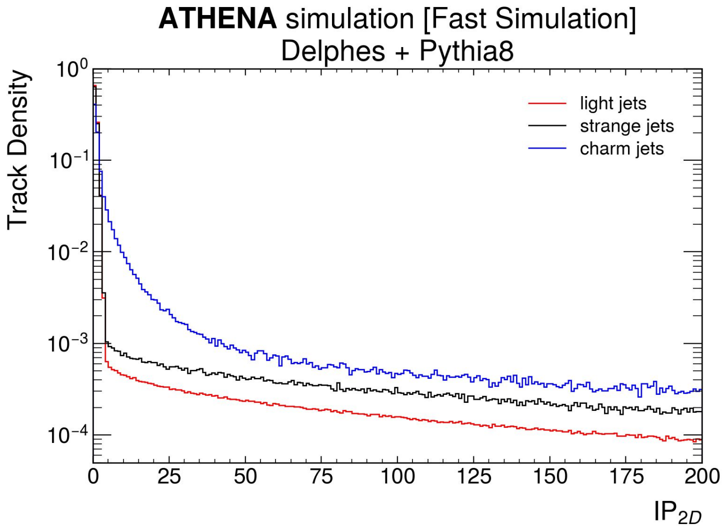
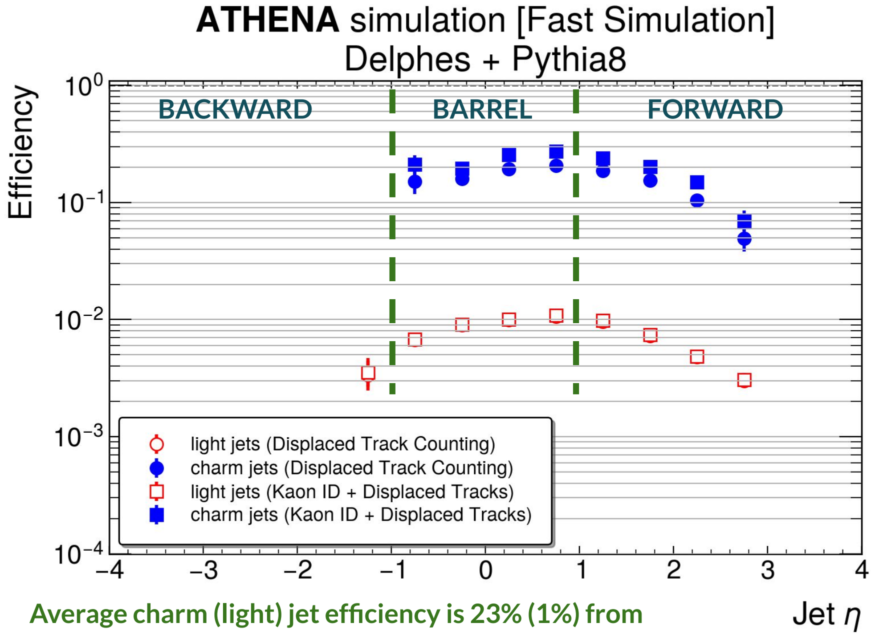
APPENDIX

Charm Identification using Displaced Track Counting and Kaon ID

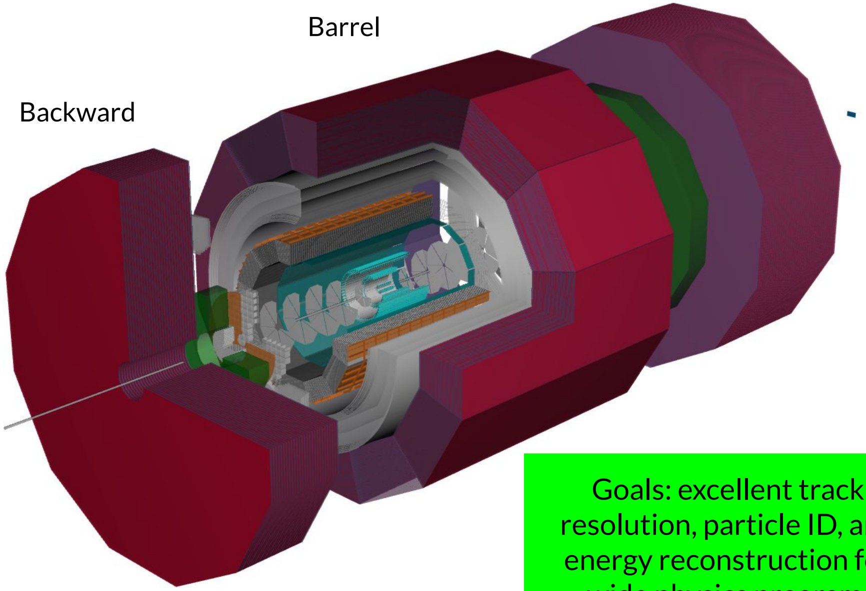


Baseline optimized displaced-track tagger requires <u>3 or more</u> tracks in a jet with p_T>0.5GeV/c and IP2D>3.



Average charm (light) jet efficiency is 23% (1%) from displaced-track tagging or displaced single kaon tagging.

The ATHENA Experiment



Goals: excellent track resolution, particle ID, and energy reconstruction for wide physics program.

Key elements of backward/central/forward parts of detector (*not shown: very low angle components along beam line*):

- **Barrel:** 3T magnet, All-Silicon Tracker + Particle ID (HP-DIRC) + Calorimeters (EMCAL + Iron-Scintillator HCAL)
- **Hadron-going direction (Forward):** Tracking (Silicon Disks + Gas Electron Multiplier Layer), Particle ID (dual RICH), and Calorimeters (Tungsten Powder/Scintillating Fiber EMCAL + Iron-Scintillator HCAL)
- **Electron-going direction (Backward):** Tracking (Silicon Disks + Gas Electron Multiplier Layer), + Particle ID (modular RICH) + Calorimeters (Lead-Tungstate iEMCAL + oEMCAL + Iron-Scintillator HCAL)

Simulation and Methods

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  - Generate 20M events w/ PYTHIA8, CT18NNLO, and the `WeakBosonExchange:ff2ff(t:gmZ)` process only.
- Fast-simulate ATHENA response with DELPHES and delphes_EIC/ATHENA.tcl
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  - Require both jets pass cut-based charm tagging using displaced tracks or kaons (see https://wiki.bnl.gov/athena/index.php/JetsHF), which is ~23% efficient on real charm jets)

Selection	**Relative Efficiency**
None	100%
Dijets *[True Di-Charm]*	1.60% *[11.2%]*
Di-Charm Tagged Jets *[True Di-Charm]*	0.193% *[60.0%]*