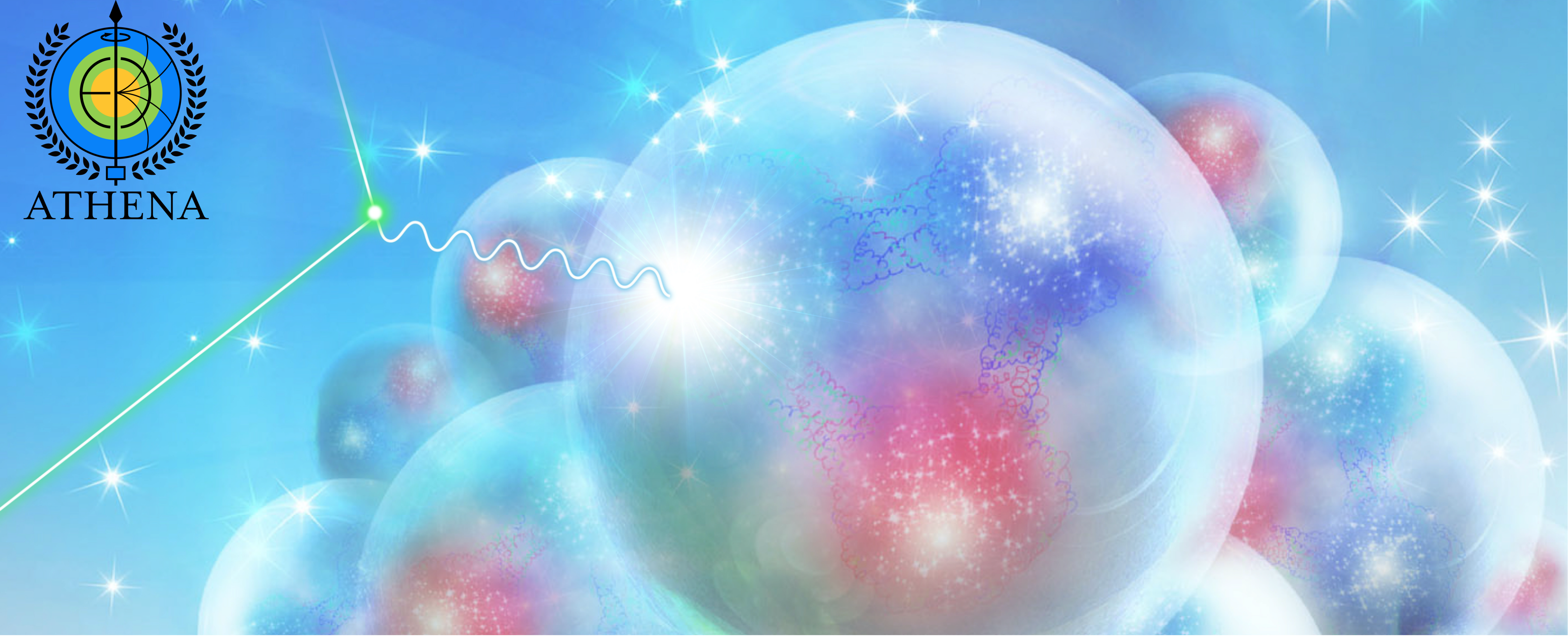

Overview on DPAP physics homework Q&A

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BNL
02. 03. 2022

Physics-related questions

Slide #	**Questions**	**Short descriptions**	**Related sub-systems**
s3-4	G-2: π/e separation	What's the residue π contamination after all combined effects of discrimination?	ECal → ECal+PID (FastSim of PID)
s5-6	G-3: Jet reco' performance	Jet energy scale; Jet energy and angle resolutions	Calorimeters (FastSim: Delphes)
s7-8	G-4: Charm tagging	$A\times\epsilon$, purity, expectation of *charm* cross section over asymmetry	Tracking+PID (FullSim,FastSim)
s9-11	P-1: Diffractive phi	Reproduce EIC whitepaper on J/psi	Tracking (FullSim)
s12-13	G-1: Backward tracking	Physics impact if not meeting YR requirement at backward rapidity?	Tracking (FullSim)
s14	P-2: DVCS ep	Reproduce EIC whitepaper for one [Q^2,x] bin	Far-forward detectors (FastSim: EicSmear plugin)

(Many groups and ATHENA members contributed to answering these questions)

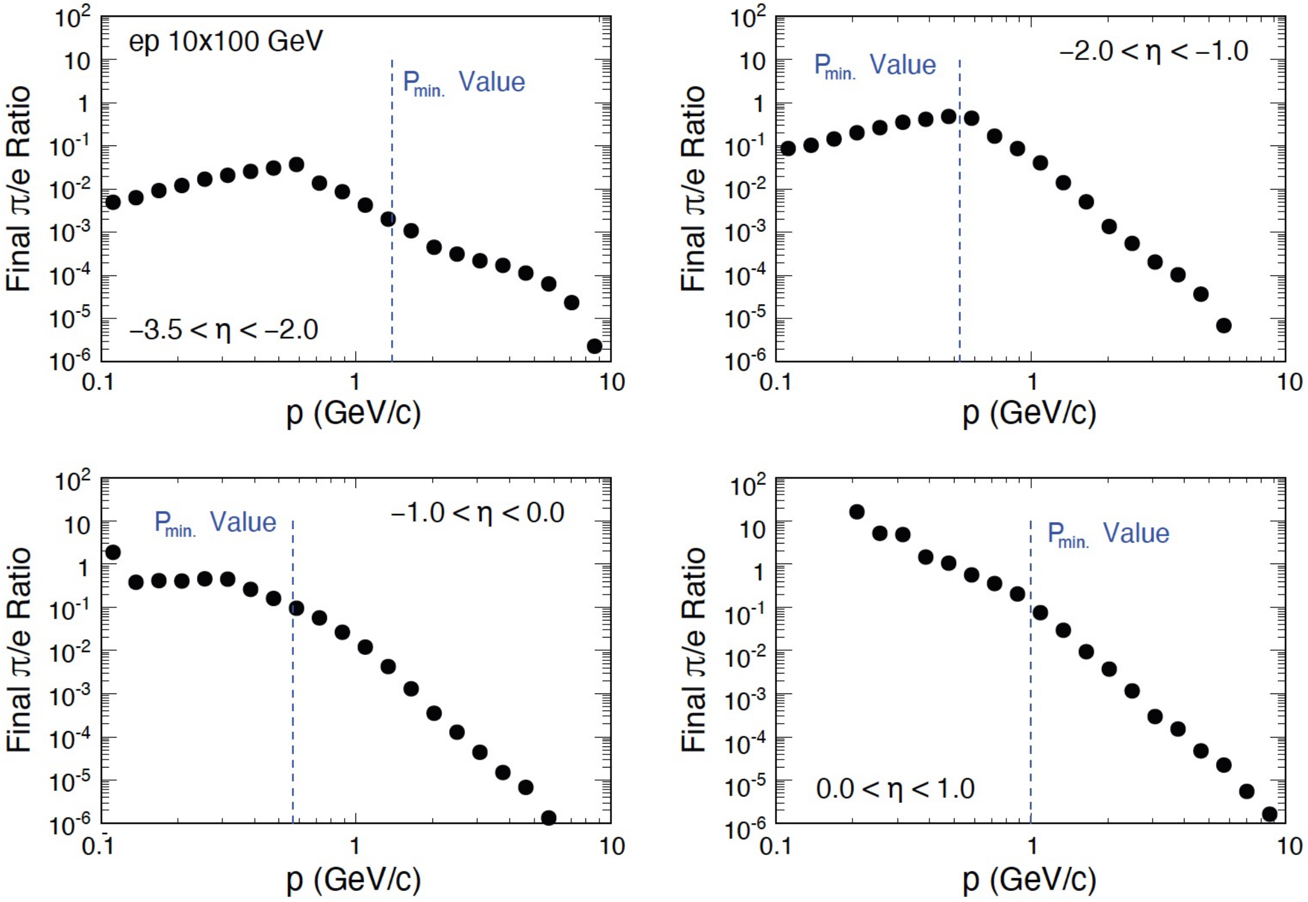
ATHENA

G-2

Q: π^- vs. e^- rejection:
Provide plots for the pion rejection factor and for the remaining pi contamination for the combined effects of all sources of discrimination. The plots should be as a function of the momentum p for the eta bins

- Baseline ATHENA ECal

Figure 3.4 ATHENA Proposal



ATHENA

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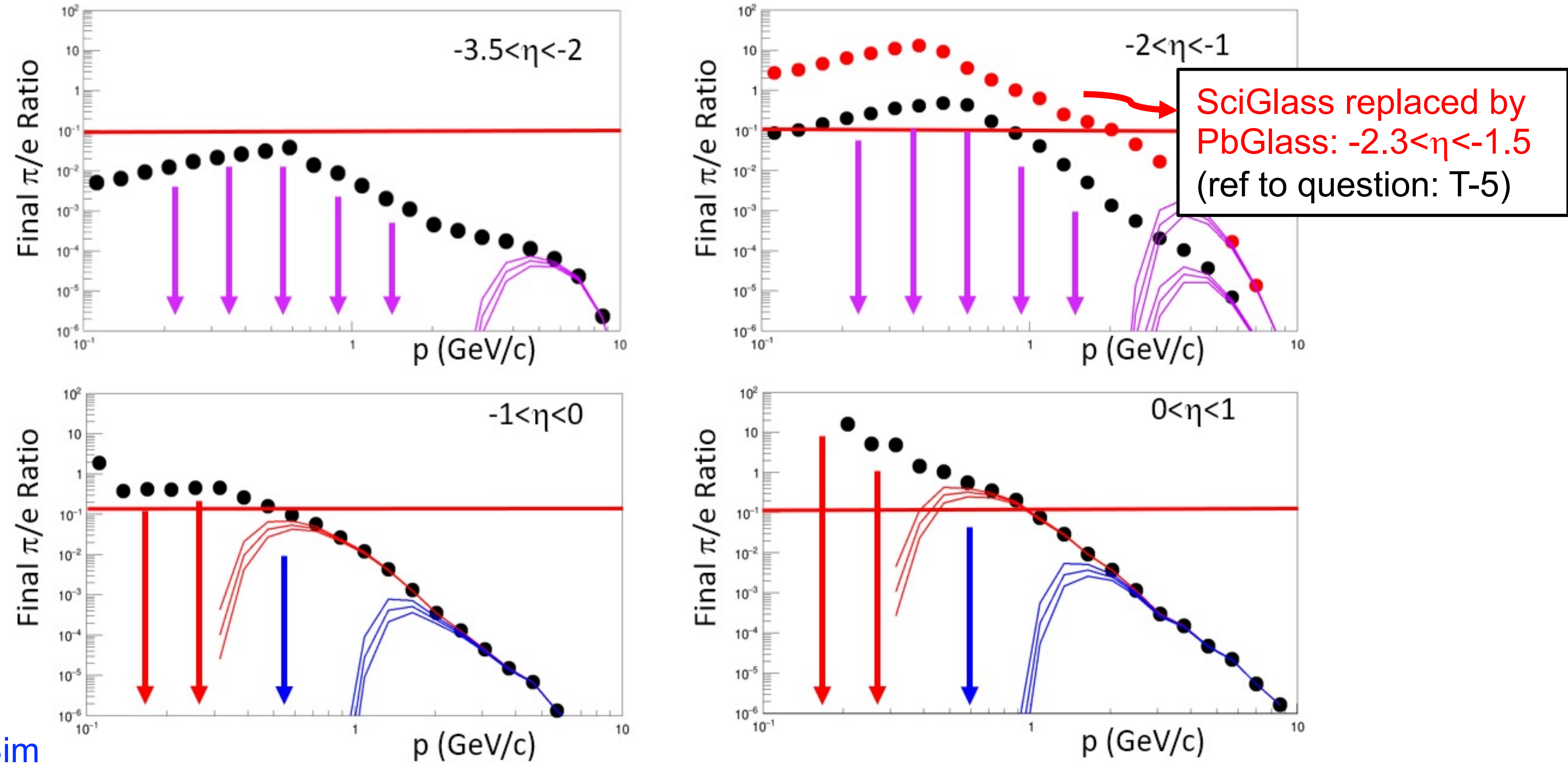
Adding PID detectors

FastSim results; below 10^{-6} indicated by downward arrows



pfRICH
- n=1.02
- $\pi_{threshold}$=0.69 GeV/c
- Cuts set at 90%, 95%, 98% electron efficiency
- Background hits not included.

TOF
- $\sigma_T = 30ps \oplus 20ps$
- $\sigma_T = 36\ ps$
- Analytical Response

DIRC
- n=1.473
- $\pi_{threshold}$=0.13 GeV/c
- Tabulated from FullSim

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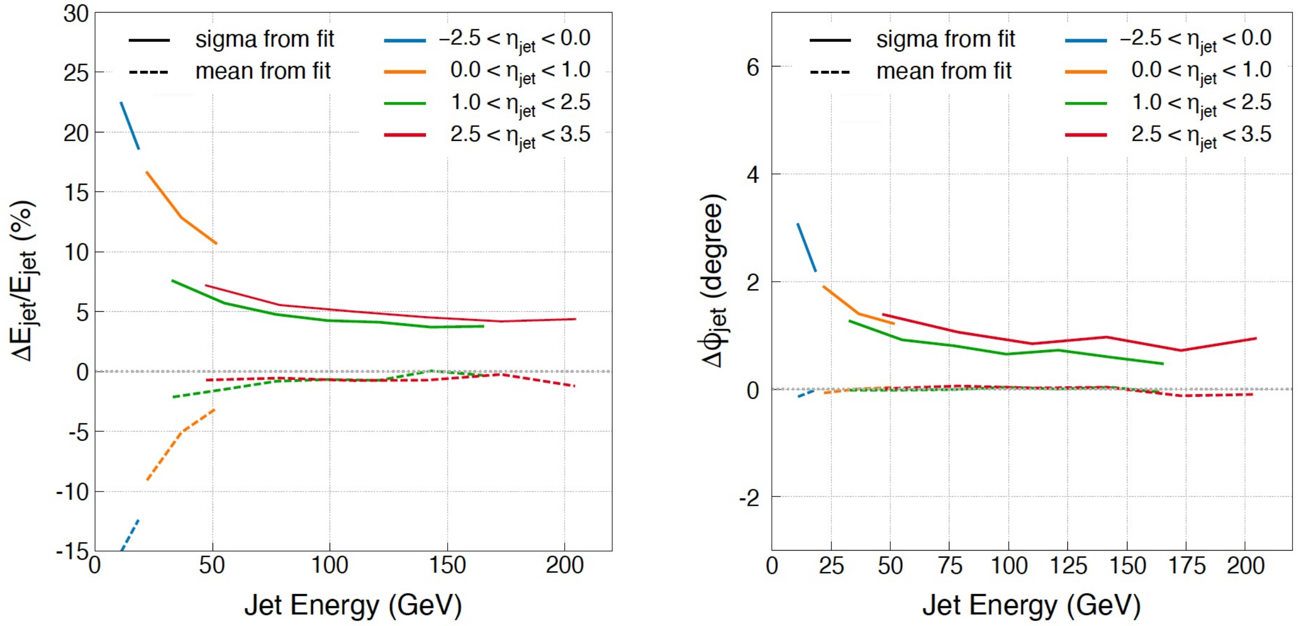
Huge improvements when adding PID

G-3

Q: Provide estimates for the jet energy scale and for the resolution in jet energy and angle. This should be shown as a function of jet energy for different regions of pseudorapidity (central, forward, backward).

Figure 3.6 – ATHENA Proposal



Left: Jet energy scale (dotted lines) and resolution (solid lines) vs jet energy in 4 pseudorapidity regions
Right: Jet angular resolution (solid lines) and mean offset (dotted lines) vs jet energy in 4 pseudorapidity regions

ATHENA

G-3

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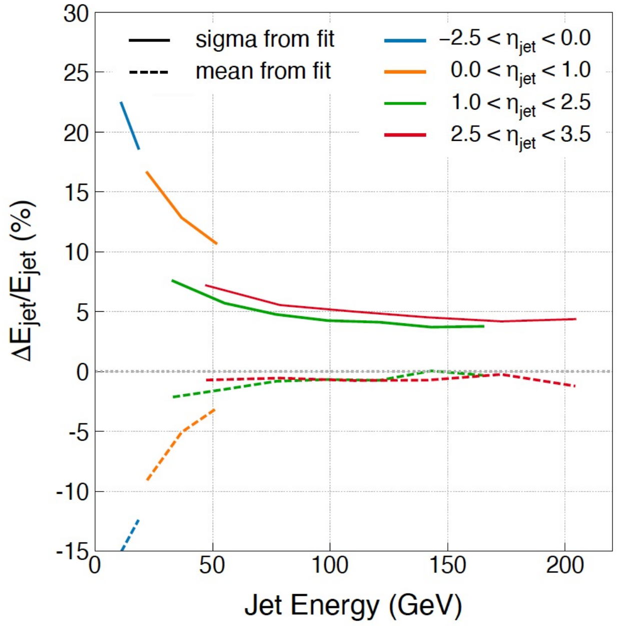

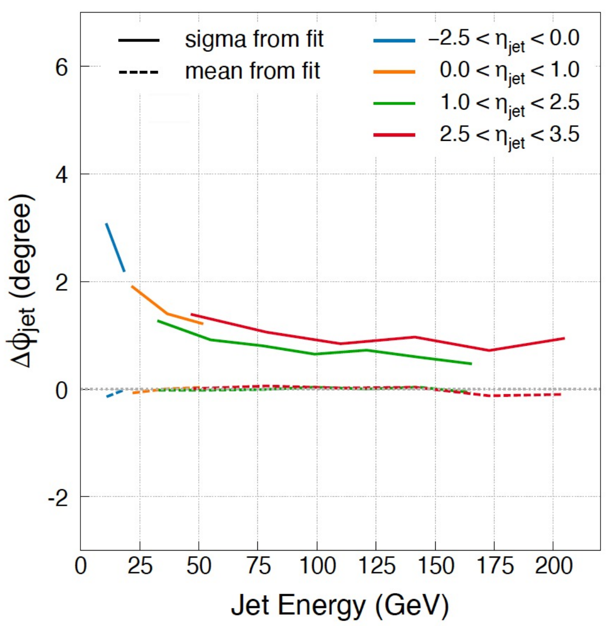

Left: Jet energy scale (dotted lines) and resolution (solid lines) vs jet energy in 4 pseudorapidity regions
Right: Jet angular resolution (solid lines) and mean offset (dotted lines) vs jet energy in 4 pseudorapidity regions

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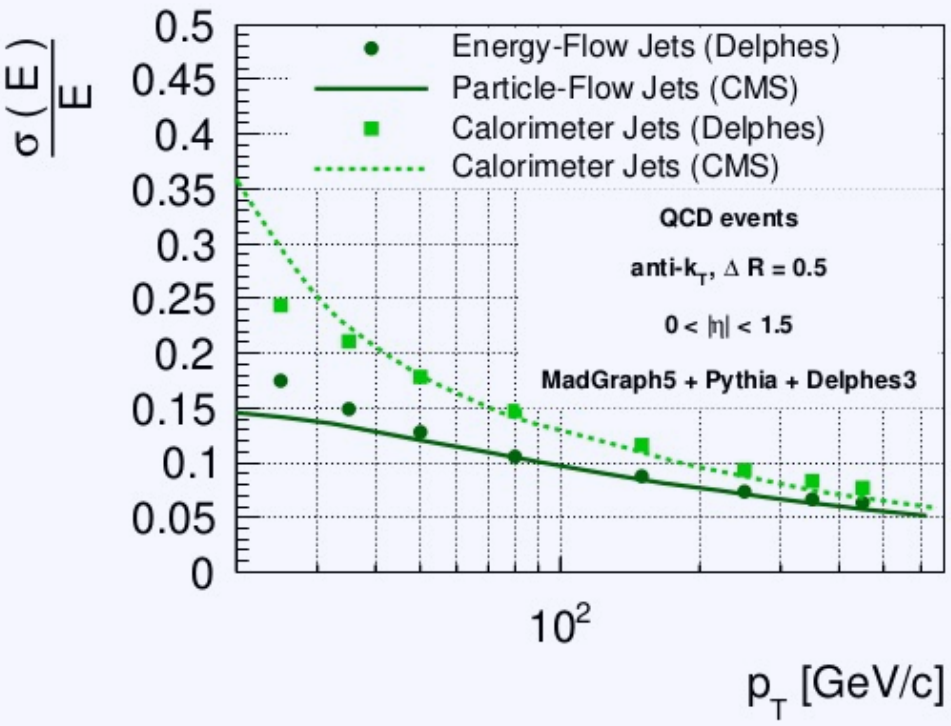
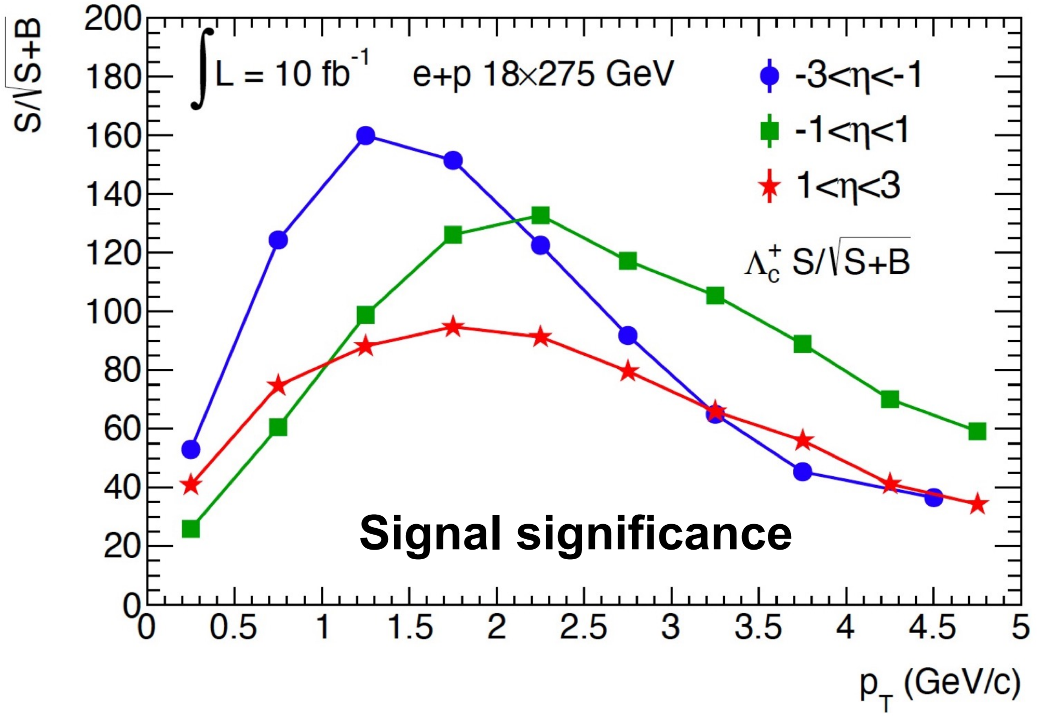
Supporting evidence/validation for choice of FastSim – Delphes; Fast ~ FullSim.



- Ultimate Jet reco' requires tremendous efforts in improving algorithms and calibrations, understanding interplay btw. Subsystems, etc.
- FastSim provides reliable impact study at the current stage.

G-4

Q: charm tagging:
Provide estimates for charm acceptance, efficiency, and purity in different regions of pseudorapidity.
Which are your expectations for measuring charm cross sections in addition to asymmetries?



Performance:

- Non-ATHENA specific studies on Λ_c^+
- Topological reconstruction of $Kp\pi$
- Alternatives: displaced electrons/kaons, 3-body D* decays, etc.

ATHENA

FastSim: tracking + PID

G-4

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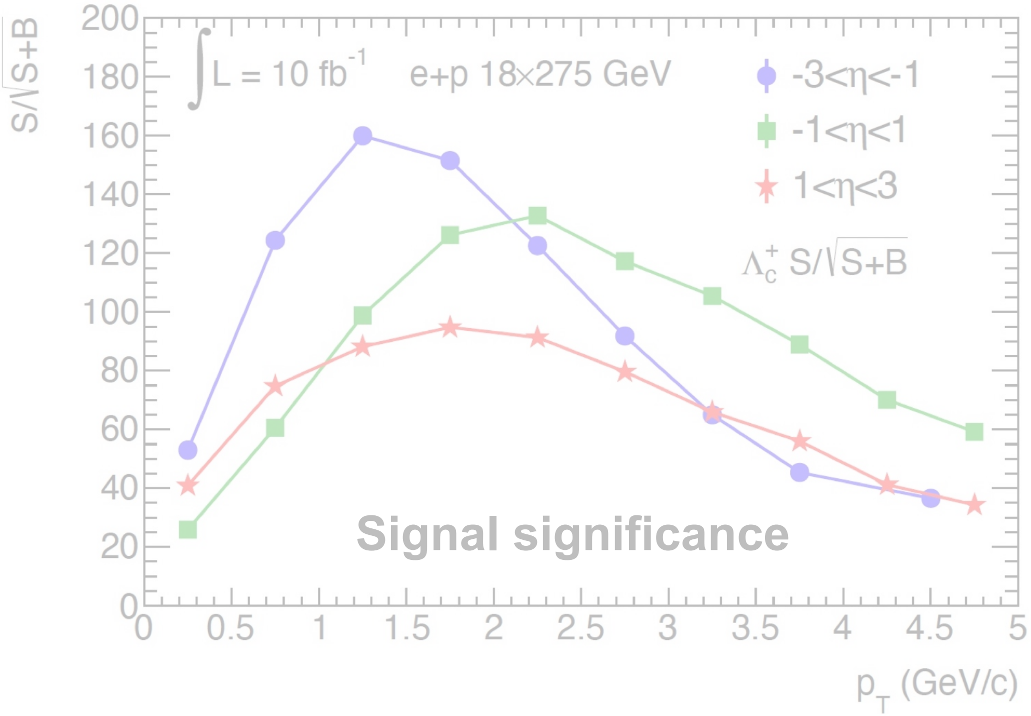
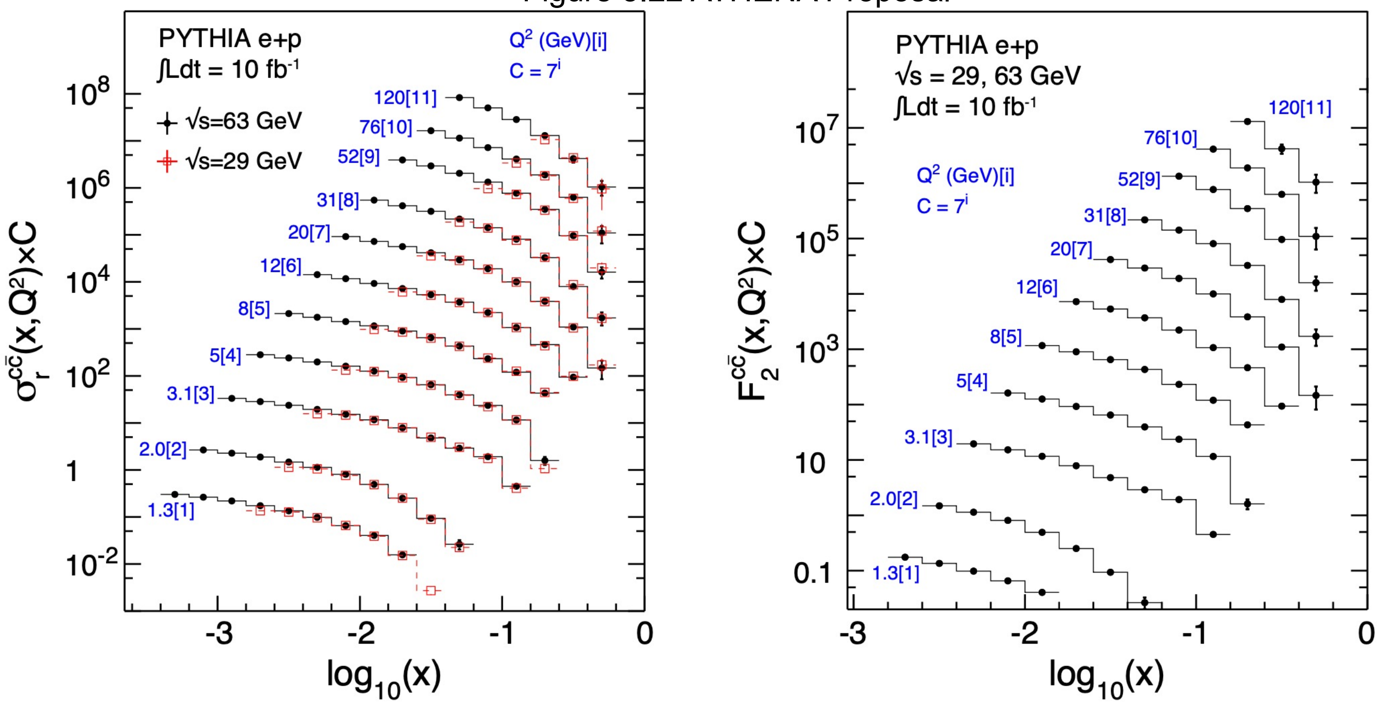


Figure 3.22 ATHENA Proposal



Performance:

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FastSim: tracking + PID

Expectation of charm cross section:

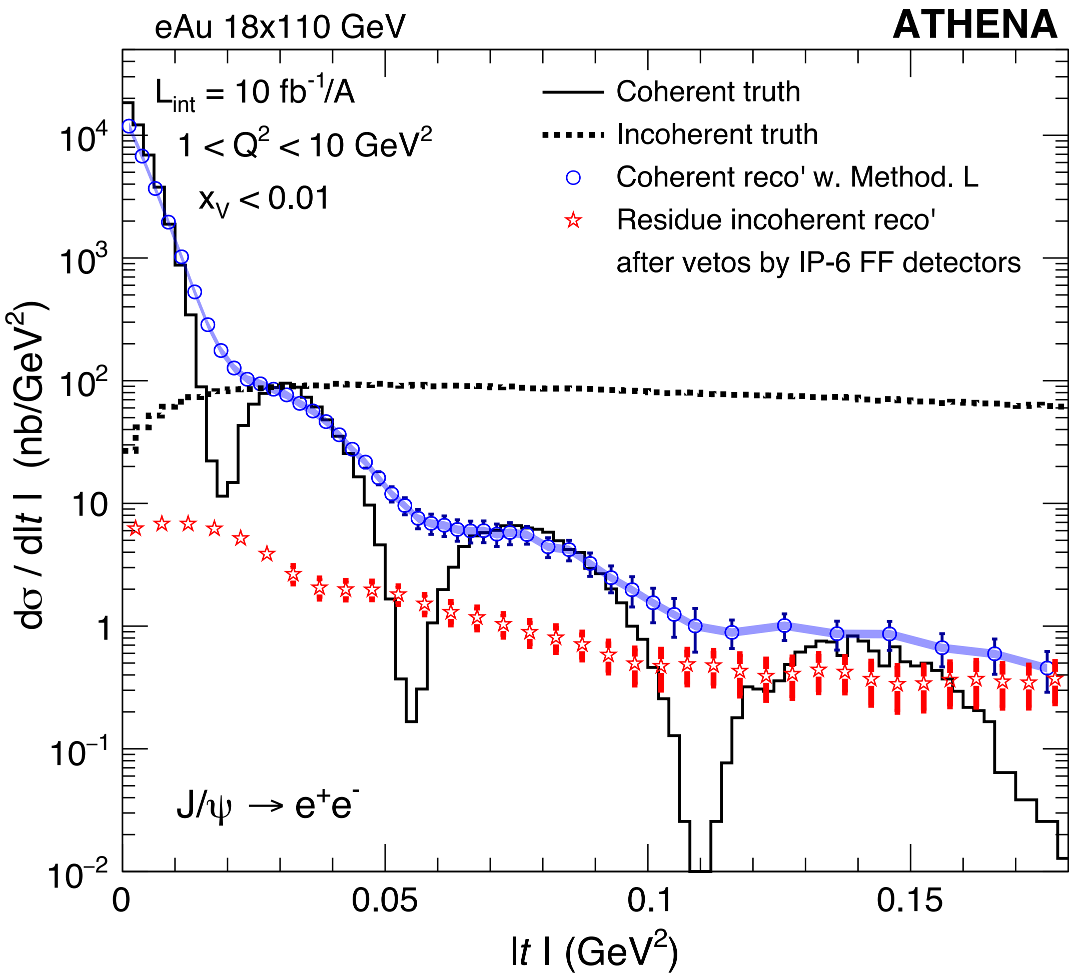
- Systematics dominate but realistic estimation is currently too early and unavailable;

Common/shared systematics:

- Common to all cross section – luminosity, etc
- Common to SIDIS – PID, etc

P-1

Q: Diffractive electroproduction of J/ψ on nuclei. $e + Pb \rightarrow e' + J/\psi + Pb$ and $e + Pb \rightarrow e' + J/\psi + X$. Plot of the cross section vs t for the coherent and the incoherent process with the following settings (cf Figures 7.83 in the YR and 3.23 in the WP):



Incoherent with IP6 FF simulations with ATHENA |t | efficiency and smearing applied based on [Phys. Rev. D 104, 114030], where Incoherent vetoing capability is identical to all EIC detector proposals at IP-6.

✓ *YR requirement: suppress to a level that is less than the coherent*

Uncertainty:

- Error bar = statistical;
- Estimating systematics at the current stage is nearly impossible. Reference: H1 measurement in ep ranged from a few % to 10%

Method L:

- $-t = -(A' - A)^2$, where A' is calculated by four-vectors of e, e' and J/ψ with physical constraints that incoming and outgoing A have the same target nucleus mass, e.g., mass of Au. This method is minimally susceptible to beam effects (see YR for details).

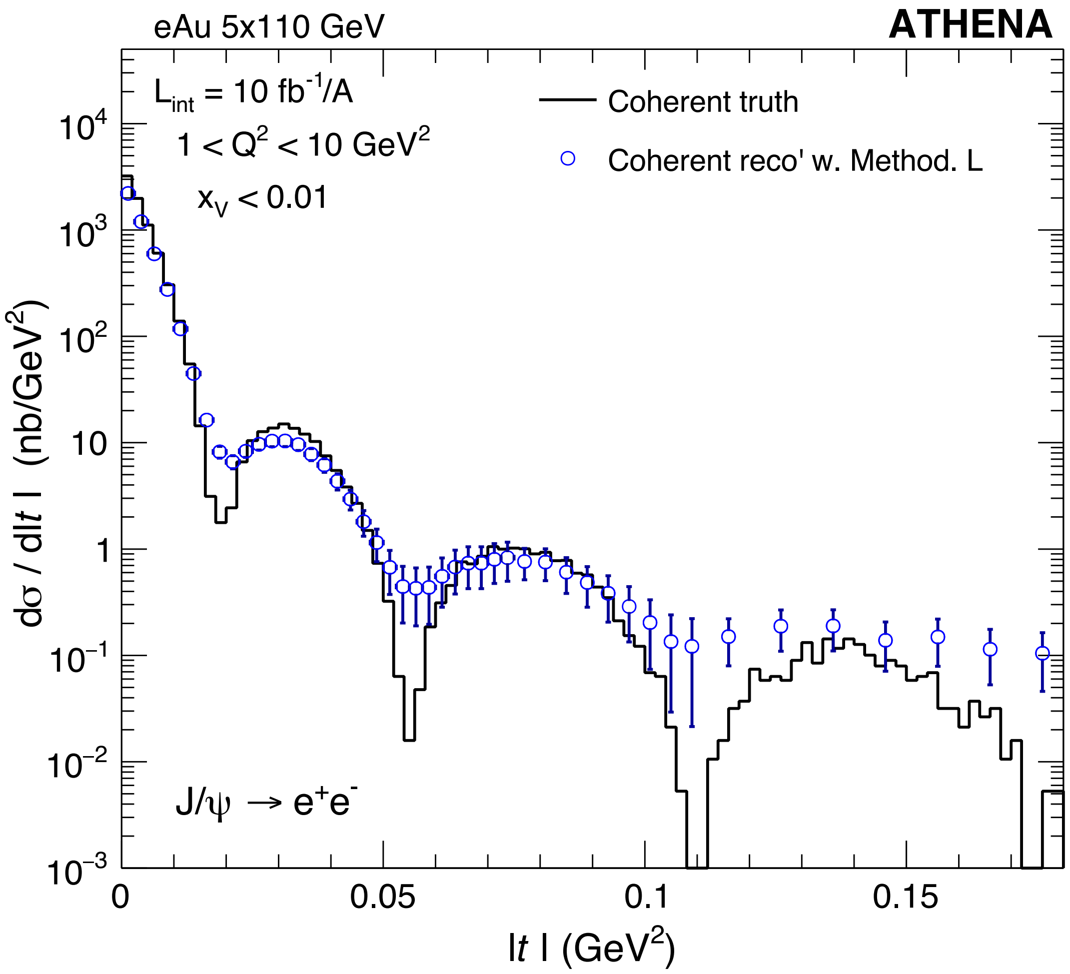
However, this would NOT work for this measurement due to poor |*t* | resolution at top energy

P-1 Extension

- We showed similar studies in answering G-1, here we repeated for J/psi.
- Changing from 18 GeV electron to 5 GeV, the minima are much more visible; Bottleneck is the e' tracking resolution.

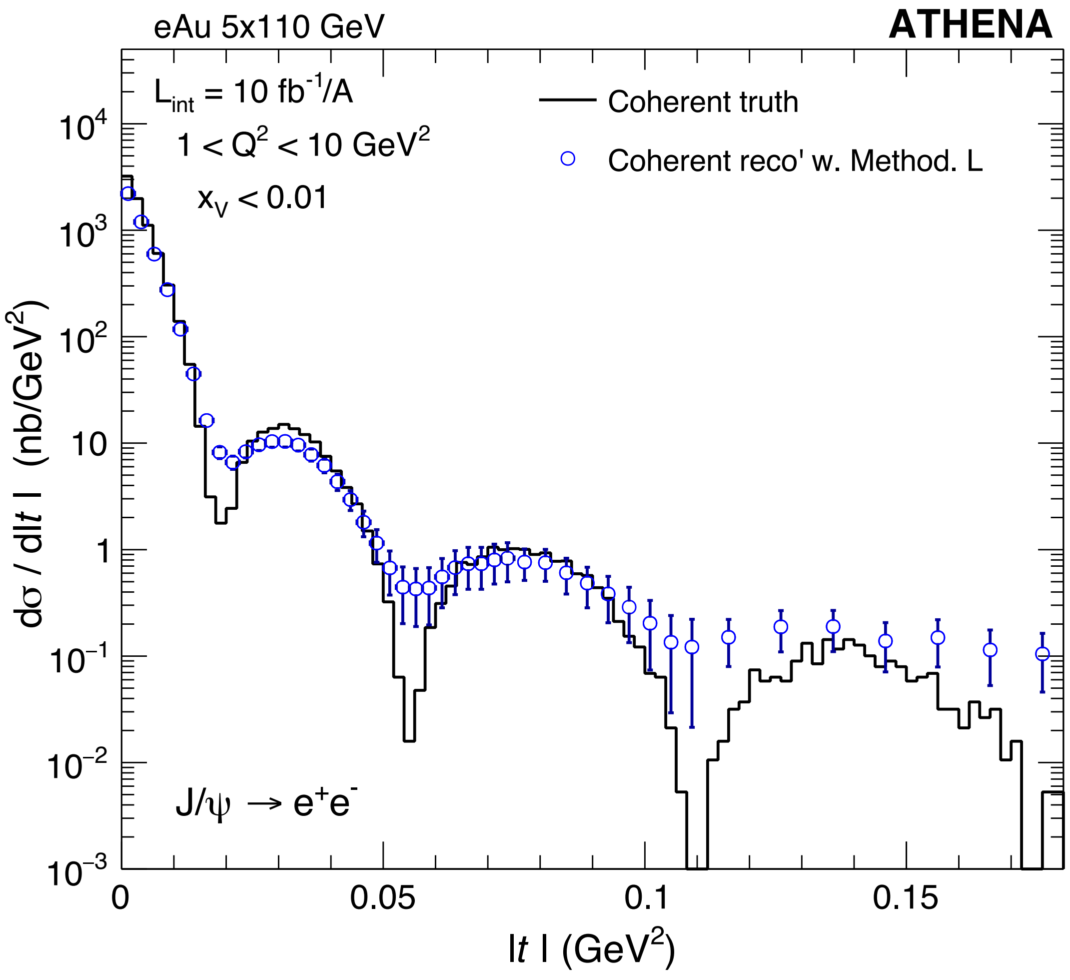
We received a follow-up question on the errors:

- We changed the binning for high $|t|$ for better visibility. Updated statistical errors for 10 fb^{-1}/A luminosity



P-1 Extension

Electron energy	**18 GeV**	**5 GeV**
Peak position of scattered electron in η	~ -3.1	~ -1.8
Average scattered electron p_T	~ 1.12 GeV	~ 0.95 GeV
ATHENA@3T e' p_T resolution (FullSim)	~ 0.025 GeV (2.3% p_T res.)	~ 0.012 GeV (1.3% p_T res.)
ATHENA@1.4T e' p_T resolution (scaled from 3T FullSim)	~ 0.056 GeV (5.0% p_T res.)	~ 0.026 GeV (2.8% p_T res.)



ATHENA Proposal

B = 3T 5x110 e+A > **B = 3T 18x110 e+A** ≈ **B = 1,4T 5x110 e+A** > **B = 1,4T 18x110 e+A**

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G-1

Q: What is the physics impact of not meeting the Yellow Report (YR) tracking requirements at negative eta?

Reminder:
This stringent requirement applies only to exclusive VM production in eA and not to other measurements, when based only on the detection of the scattered electron.

Short answer:
The ATHENA overall design and its 3T solenoid enables a mitigation strategy, by changing the acceptance in which the measurement is conducted, i.e., by moving it into a η range where the resolution is sufficient. This strategy makes the measurement accessible, at the expense of the low-x reach

ATHENA

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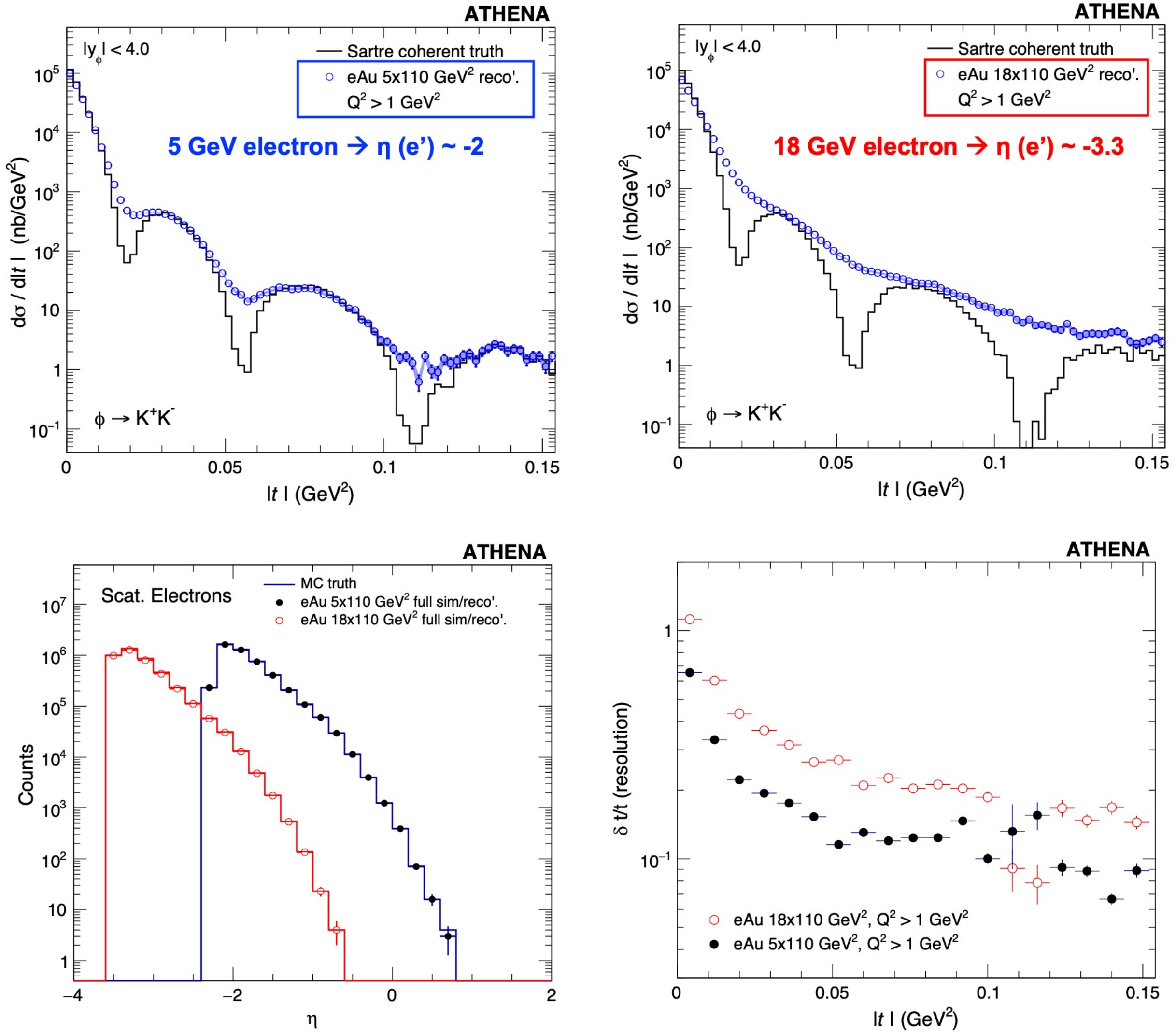

Here for ϕ production but same for other VMs (see answers to P1)

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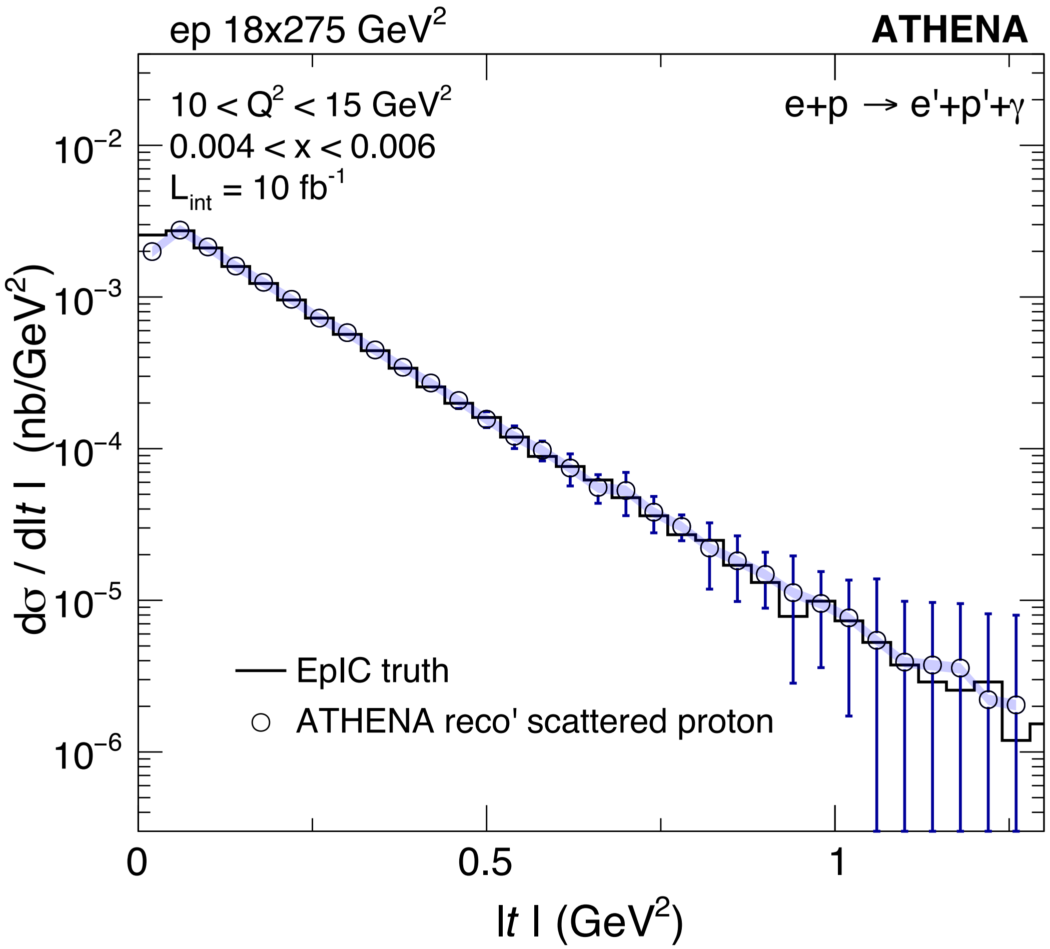
P-2

Q: DVCS on the proton, plot of the cross section for e p -> e p gamma vs. t with 10 GeV^2 < Q^2 < 15 GeV^2 ; 0.004 < x_B < 0.006; integrated luminosity 10 fb^{-1}; beam energies 18 GeV on 275 GeV
Please indicate statistical and total errors separately (e.g. by inner bars for statistical errors).



|*t*|-acceptance is nearly 100% up to 1.7 GeV^2 by measuring the outgoing proton in the Roman Pots

- ***Process: DVCS simulated with ePIC***

$$e + p \to e' + p' + \gamma$$

- **Parameters**
  - 10 < Q^2 < 15 GeV^2
  - 0.004 < x < 0.006
  - Beam energy: 18 GeV x 275 GeV e+p
  - Luminosity: 10 fb^{-1}

- **Uncertainties**
  - 1M simulated events
  - **Error bars (statistical)** are rescaled to 10 fb^{-1} equivalent;
  - **Blue band (systematics):** *assumed* conservative *8%* constant systematics. Note that estimating systematics at the current stage is nearly impossible.

Note: For diffractive process, i.e., DVCS and DVMP, in ep the *t*-resolution is dominated by the far-forward detector performance.

Summary

- All questions raised by the DPAP committee were well addressed;
- Some questions helped improve performance/understanding, e.g., π /e separation, diffractive ϕ, etc.
- Big thanks to groups and members who contributed to provide these answers
- Comments & Questions?

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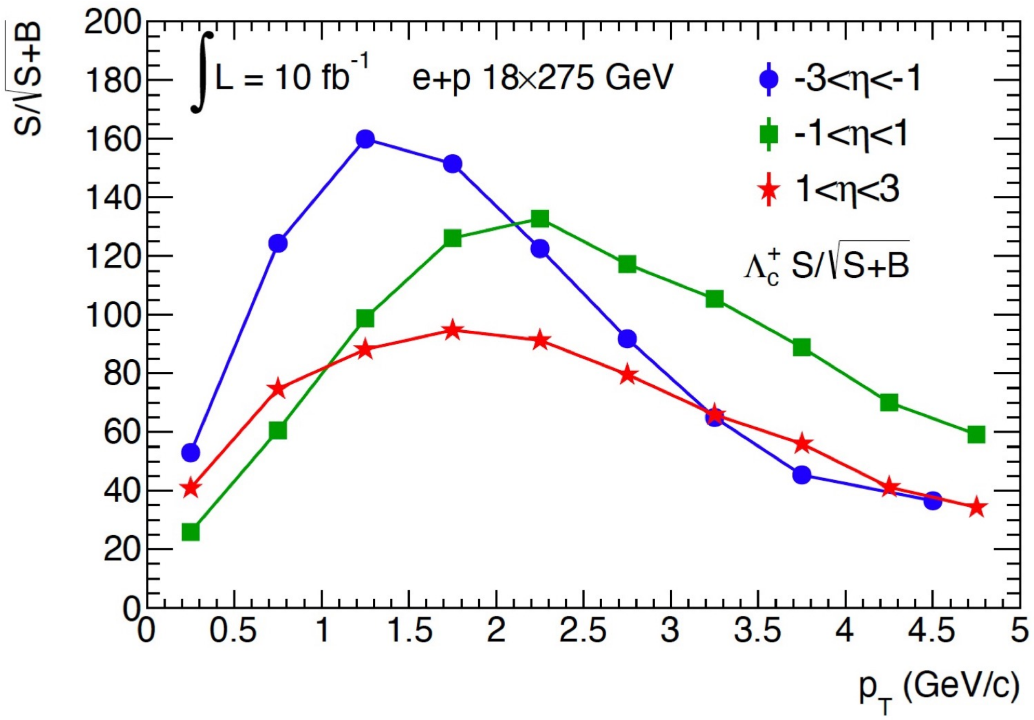
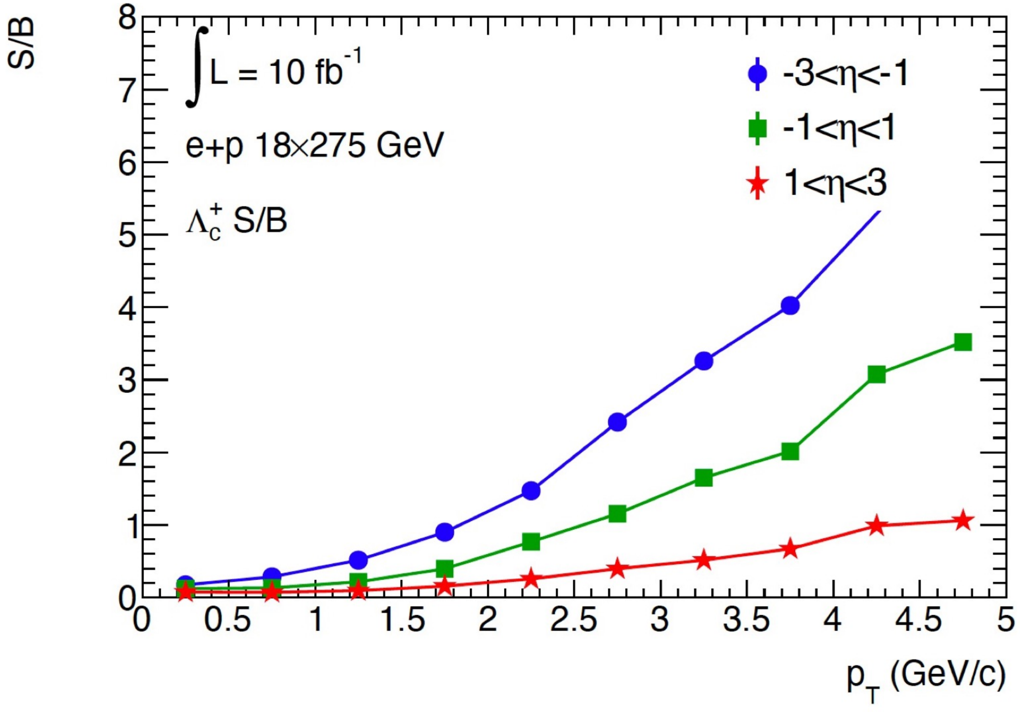
Backup

G-4



Signal significance



Signal to Background ratio

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