

Coherent Deep Virtual Compton Scattering on 4He with CORE@EIC

Charles Hyde

For the CORE Consortium

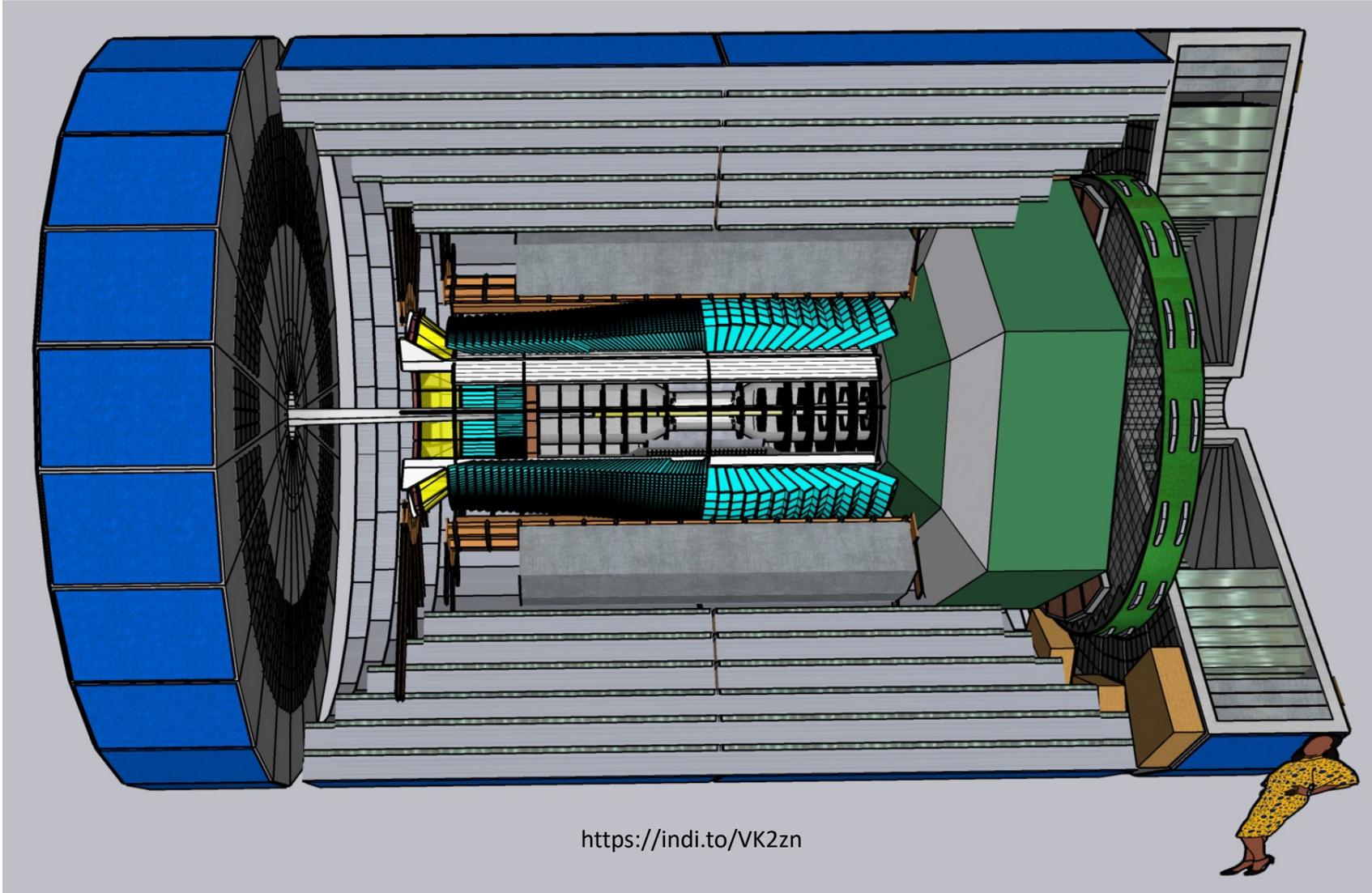
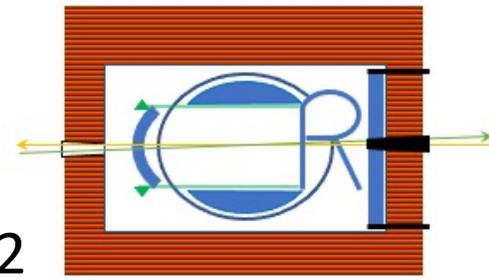
eic.jlab.org/CORE



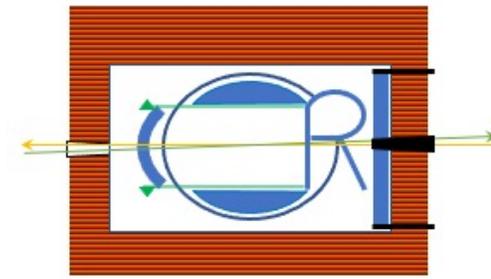
OLD DOMINION
UNIVERSITY

COmpact detectoR for Eic (CORE)

- See talk by G. Schnell, <https://indi.to/cJHgF> Joint WG-1&6: 5 May 2022

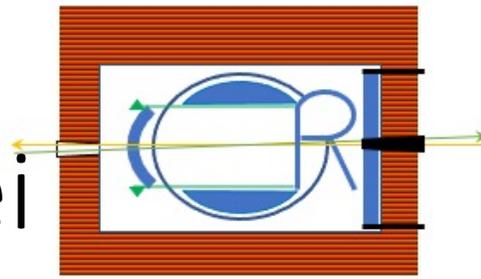


COmpact detectoR for Eic (CORE)

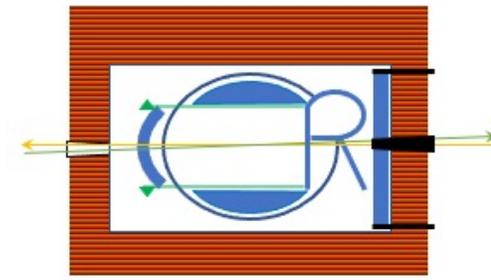


- See talk tomorrow by G. Schnell, WG-6 Length ± 4 m, Radius 2.65 m
- Excellent candidate for a second EIC detector
 - Compact size provides greater flexibility in design of Interaction Region
 - Length ± 4 m, Radius 2.65 m
 - DPAP endorsed capability to execute EIC program
 - Compact size enables investment in high resolution PbWO_4 calorimetry for entire pseudo rapidity range $\eta < 0$ (electro-going hemisphere) .
 - Enables high precision Coherent DVCS on light nuclei from $(e, e'\gamma)$ kinematics alone

Deep Virtual Exclusive Scattering on Nuclei



- The EIC ion storage ring determines the magnetic rigidity P_0 of a stored ion.
 - Total ion momentum is ZP_0
 - Final focus quads & emittance determine angular spread $\sigma(\theta) \approx 0.3$ mrad at IP.
 - Ion rms $P_T = ZP_0 \sigma(\theta)$: Completely washes out diffraction patterns of nuclei.
 - Reconstruct momentum transfer to nucleus without nuclear detection.
- Exclusive Vector meson production. Channels with all charged particles:
 - $(e, e' \rho \rightarrow \pi^+ \pi^-)$, $(e, e' \phi \rightarrow K^+ K^-)$, $(e, e' J/\Psi \rightarrow e^+ e^- \text{ or } \mu^+ \mu^-)$
 - Directly measure $\Delta^\mu = (k - k' - V)^\mu$ with central tracker
- DVCS: ${}^A Z(e, e' \gamma) {}^A Z$ feasible only with excellent γ -resolution



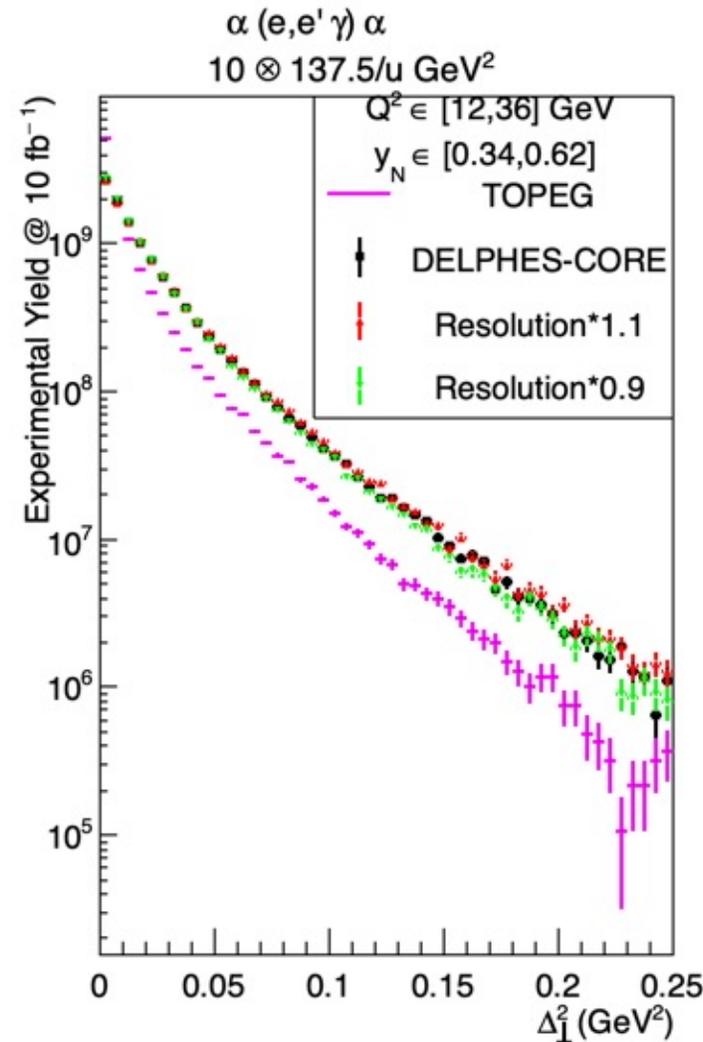
CORE Simulation in DELPHES FastMC

- Si MAPS tracker resolution from dedicated GEANT4 simulation
- EMCal resolution = $1\% \oplus \frac{2\%}{\sqrt{E/GeV}} \oplus \frac{1\%}{E/GeV}$
- ${}^4\text{He}^{++}(e, e'\gamma){}^4\text{He}^{++}$
 - Measure of $\Delta_{\perp}^2 = (k - k' - q')_{\perp}^2 = (P' - P)_{\perp}^2$ is independent of all ion beam effects.
 - Exclusivity is assumed to be determined by vetoing on breakup channels
 - $t = \Delta^2$ reconstructed from Δ_{\perp}^2 and exclusivity constraint

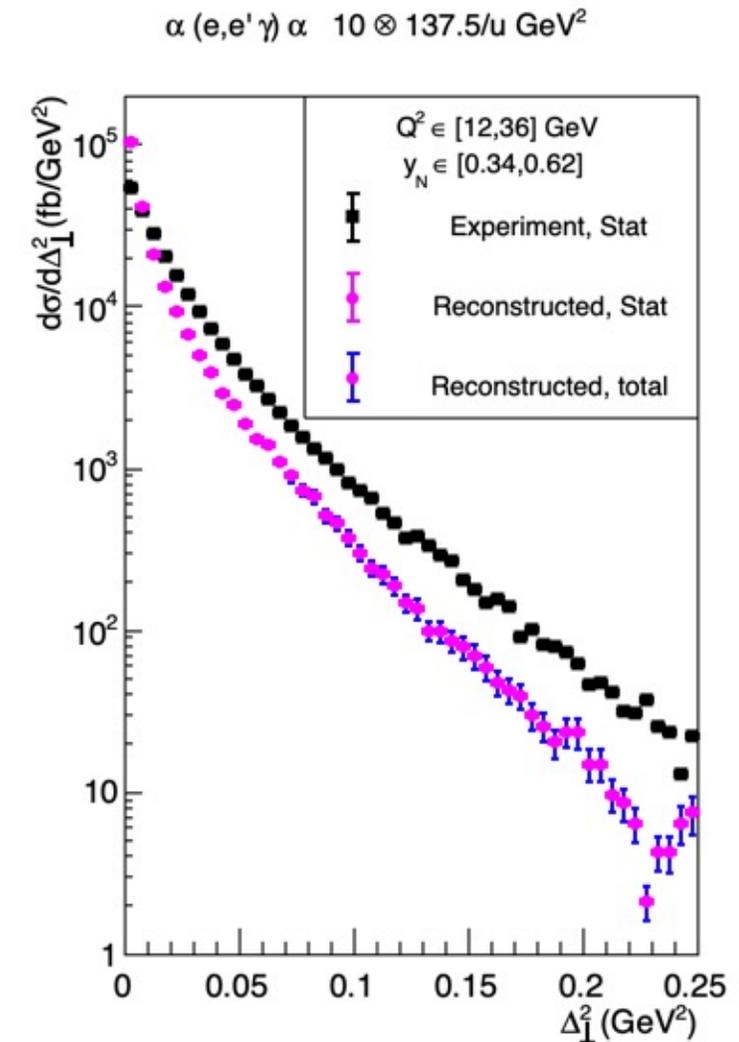
Coherent DVCS on ^4He with CORE@EIC



- TOPEG event generator
 - <https://gitlab.in2p3.fr/dupre/nopeg>
 - $10 \text{ GeV } e^- \otimes 137.5 \text{ GeV per nucleon}$
- DELPHES FastMC
- Systematic uncertainty in reconstructed cross section estimated by varying EMCAL resolution by $\pm 10\%$
- Error bars from uncertainty of bin-migration remain small.

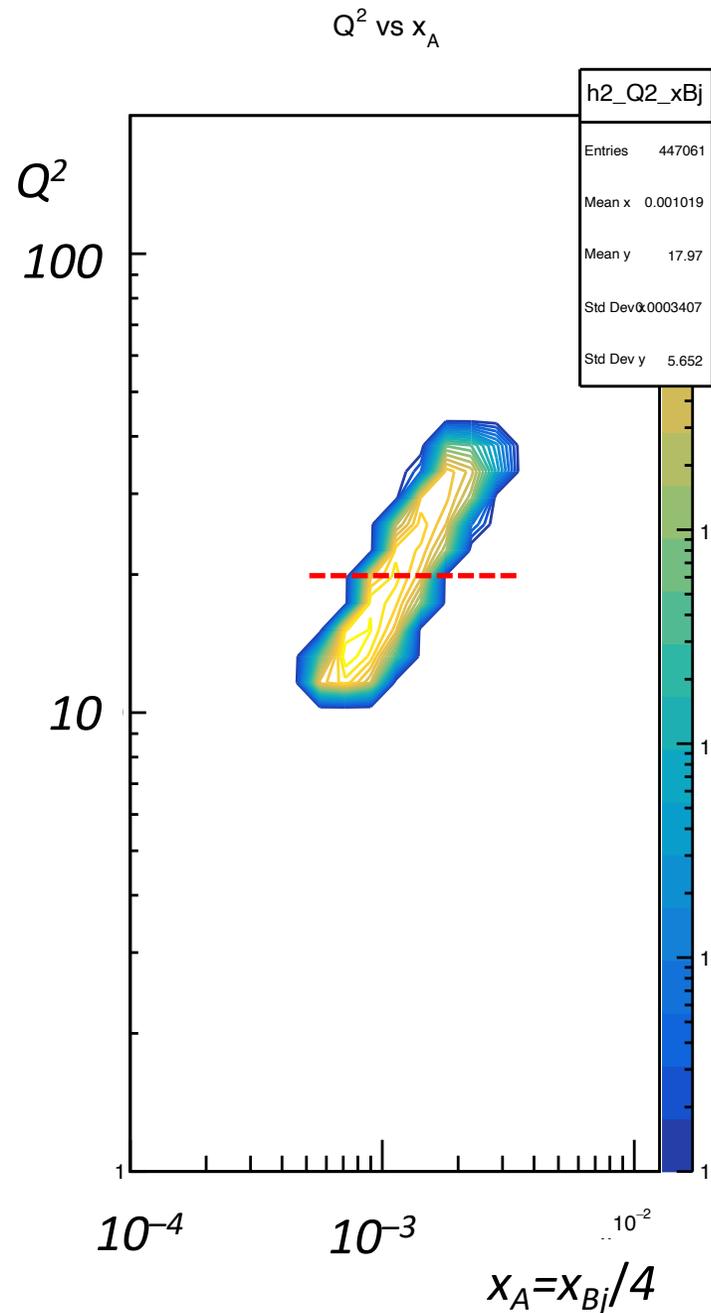


<https://indi.to/VK2zn>

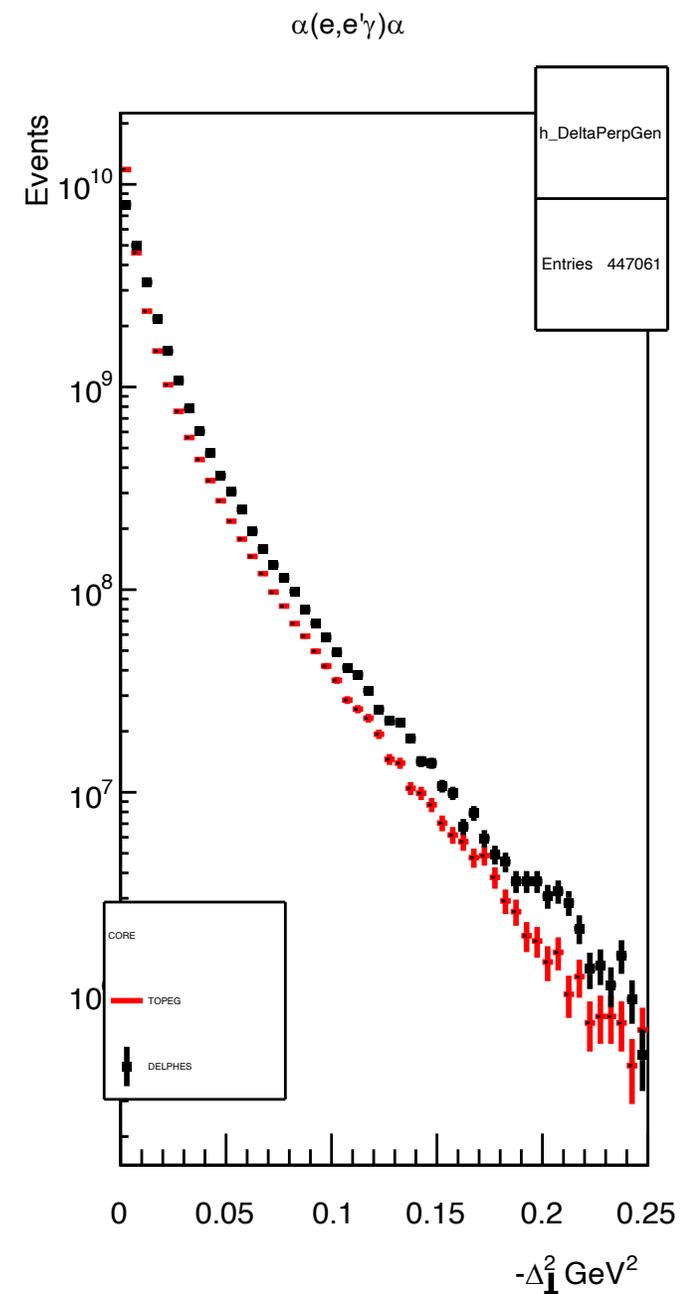


$\alpha(e, e'\gamma)\alpha$

- $Q^2 \in [12, 36]$,
 $y \in [0.62, 0.90]$
- 2.5/fb = 10/fb per nucleon
- Next slide:
 - Subdivide into 2 bins in Q^2 and 5 bins in Δ_{\perp}^2
 - Invariant $\phi_{\gamma\gamma}$ distributions

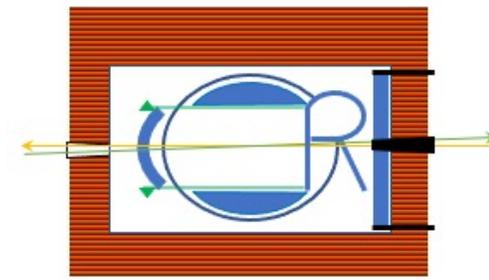
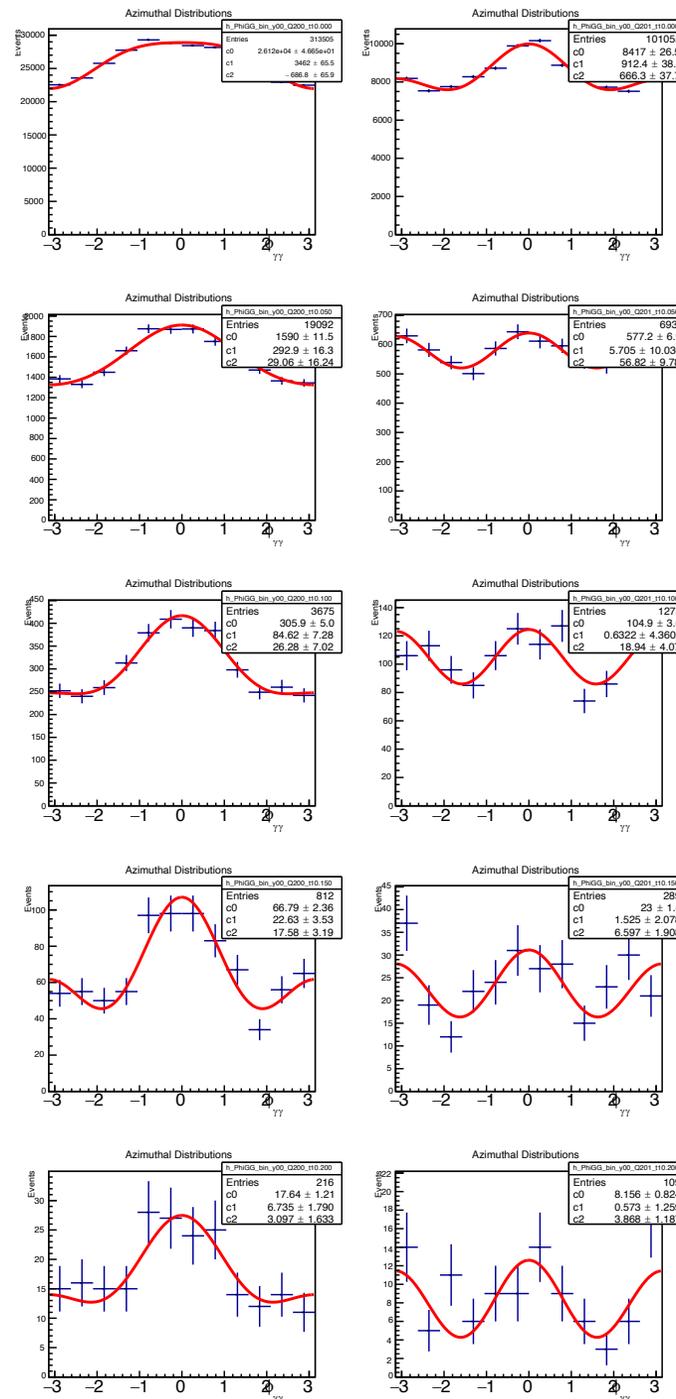


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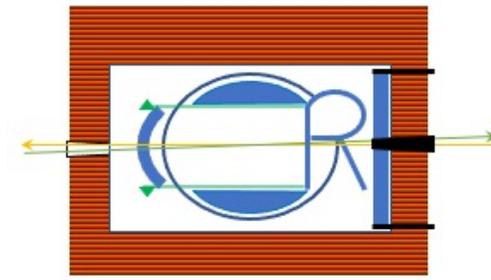


$$\alpha(e, e' \gamma) \alpha$$

- $y \in [0.62, 0.90]$
- $t_0 - t$ bins, top to bottom:
 - $[0.00, 0.05]$
 - $[0.05, 0.10]$
 - $[0.10, 0.15]$
 - $[0.15, 0.20]$
 - $[0.20, 0.25]$
- Left: $Q^2 \in [12, 21]$
- Right: $Q^2 \in [21, 36]$



- Error bars are projected experimental
- Fluctuations are MC statistics



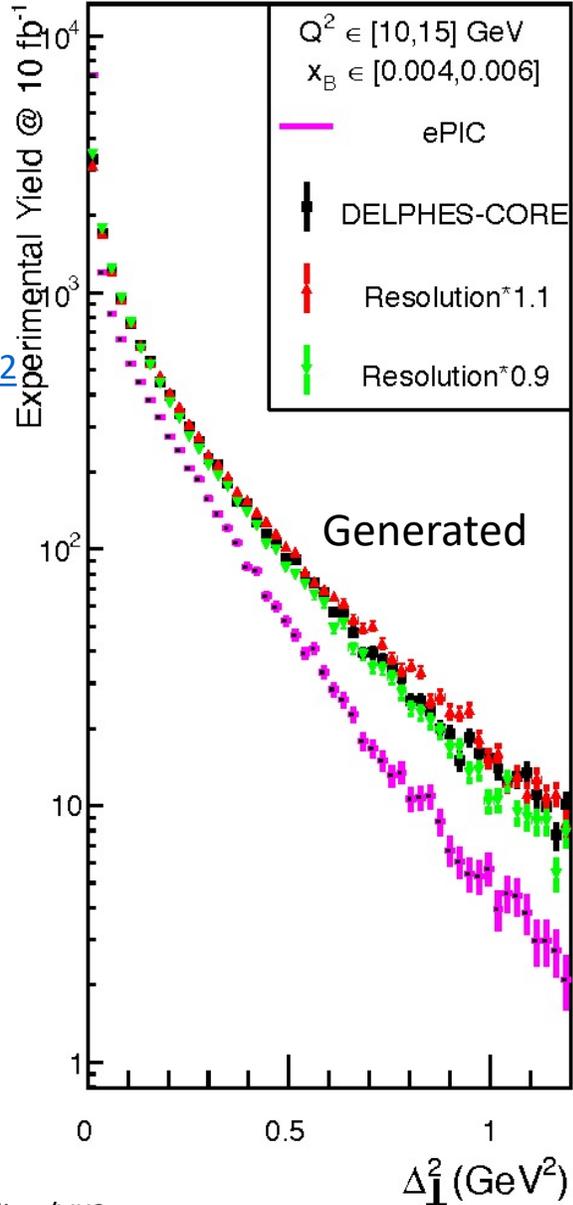
Conclusions

- High resolution EMC calorimetry would enable a precision program of DVCS on nuclei.
- This is an essential complement to Deep Virtual Vector Meson production for transverse imaging of quarks and gluons in nuclei:
 - DVCS has stronger sensitivity to quarks than does Vector Meson production.
- A compact detector for IR8 makes PbWO_4 affordable
 - CORE Barrel EMCal inner radius = 60 cm.

DVCS on proton

- $ep \rightarrow ep\gamma$ vs. $\Delta_{\perp}^2 = (k-k'-q')_{\perp}^2$
- $10 < Q^2 < 15 \text{ GeV}^2$ $0.004 < x_B < 0.006$
- 18 GeV on 275 GeV, $\int Ldt = 10 \text{ fb}^{-1}$
- EpIC DVCS Generator:
indico.ijclab.in2p3.fr/event/7201/contributions/22615/attachments/16627/21557/EpIC_06_01_2021.pdf
- Left panel: Generated Yield, CORE projections with DELPHES FastMC, and with EMCAL resolution width altered by +10% and -10%.
 - $d\sigma/dt = [\text{counts per bin}] / \{[0.024 \text{ GeV}^2] \cdot [10 \text{ fb}^{-1}]\}$
- Right Panel: CORE/DELPHES result in black, with projected experimental statistical errors.
 - **Magenta plot** is projected reconstruction of the cross section with statistical error bars
 - **Blue error bars** (barely distinguishable) Stat \oplus Syst (from $\pm 10\%$ uncertainty in EMCAL resolution).
- Conclusion: Bin-Migration has negligible effect on final reconstruction of $d\sigma/dt$

p (e,e' γ) p
18 \otimes 275 GeV²



p (e,e' γ) p
18 \otimes 275 GeV²

