Réunion du CSI

Rapport de 2ème année de doctorat

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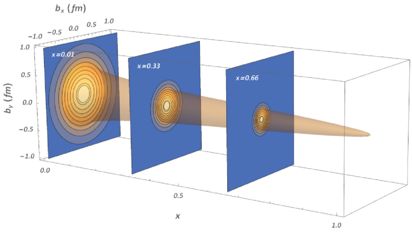
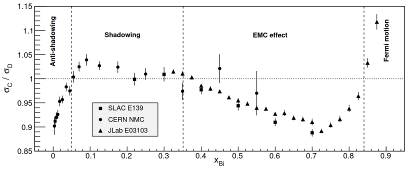
IJCLab

September 28, 2026

Nuclear GPDs

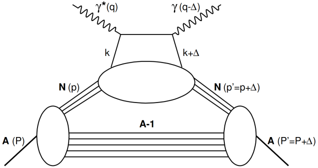
- The Generalized Parton Distributions (GPDs) combine the notion of PDFs and FFs, along with their correlations
- We can access GPDs off the free proton or off a nucleus as a whole
- A direct comparison of these distributions can reveal a variety of nuclear effects
  - *e.g.* modification of the quark confinement size, short range correlation
- This will provide new insights into the understanding of the EMC effect

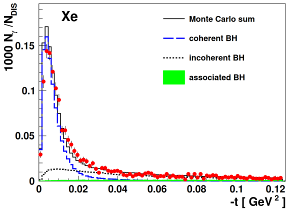


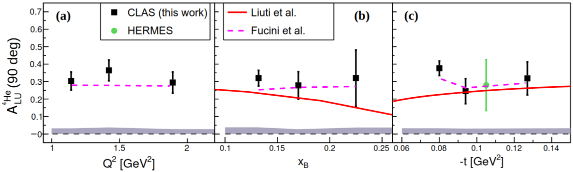


Nuclear coherent DVCS

- We can access quark GPDs in DVCS
- For a nuclear target, the DVCS can be coherent or incoherent
- First measurements by HERMES
  - The recoil nuclei were not detected
  - $-t$ based threshold to separate the channels
  - Measurements affected by large uncertainties
  - No nuclear dependence of the BSA found
- CLAS eg6 : first coherent DVCS off He4
  - The recoil nucleus was detected
  - Coherent and incoherent channels were isolated
  - The coherent BSA is twice the one measured on the free proton

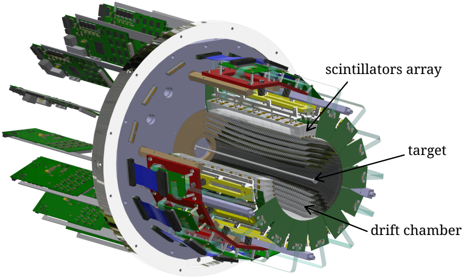






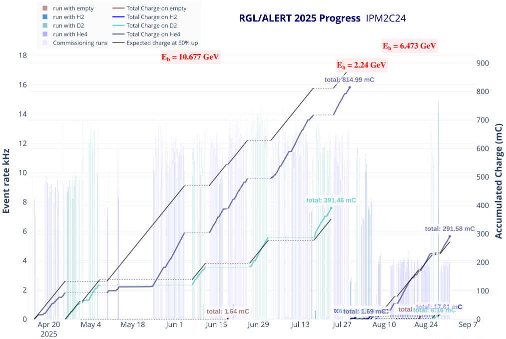
ALERT experiment

- ALERT is an extension of the CLAS eg6 at higher luminosity and 12 GeV
- It based on a new detector, A Low Energy Recoil Tracker
  - Along with the ^{4}He, identify the two isobars ^{3}He et ^{3}H
  - With kinematics: $70 < p < 400$ MeV/c, $\theta > 45^\circ$
  - To be placed inside a 5T solenoid magnet
  - To be transparent to the particles detected by CLAS
- ALERT is a combination of a drift chamber (AHDC) and an array of scintillators (ATOF)



ALERT run period

- The run period took place from April 2025 to September 2025 at JLab
- Run summary
  - Targets: helium, deuterium, hydrogen
  - Beam energies: 2.2 GeV, 6.4 GeV, 10.6 GeV
  - Beam current: up to 325 nA
  - Event rate: 10 kHz
  - 6.42×10^{10} trigger events collected
- My activities at JLab
  - Data monitoring
  - On-call detector expert
  - Target change
  - Target purge
- The data taking was a success



Overview of the ALERT reconstruction

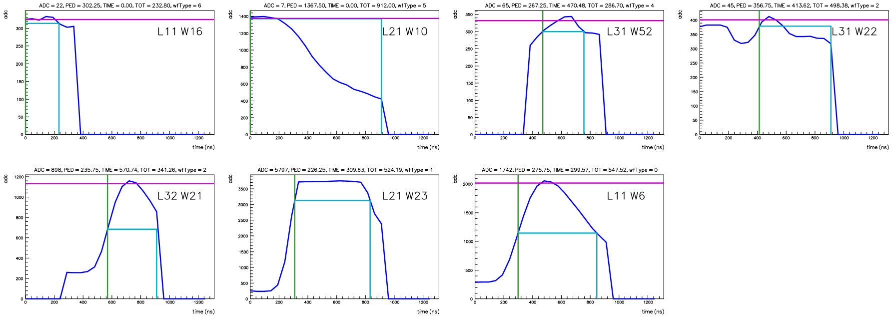
- Decoding
  - From raw data to waveform
  - Waveform processing**
- Hit selection
  - Waveform classification**
  - Selection cuts**
- Track finder
  - MLP/GNN
- Track fitting
  - Helix fitter
  - Kalman Filter*
- Hit matching : AHDC $\rightleftarrows$ ATOF
- Particle identification

- Calibration
  - Time
  - Time-to-distance*
- Alignment
  - Vertex alignment**
  - Phi alignment**
  - Beamline orientation
- Simulation
  - Digitization*
  - Background merging

Waveform classification

- The signals recorded by the AHDC have various shapes
- These different waveforms need specific treatments
- We gather them into seven categories

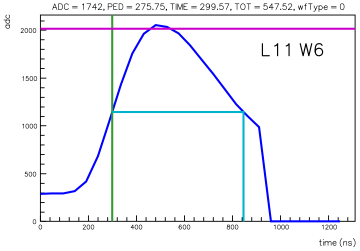
wfType 6 $\rightarrow$ too short	wfType 3 $\rightarrow$ pileup (ongoing work)	wfType 0 $\rightarrow$ normal
wfType 5 $\rightarrow$ decreasing	wfType 2 $\rightarrow$ missing trailing edge	
wfType 4 $\rightarrow$ small ToT	wfType 1 $\rightarrow$ saturated	

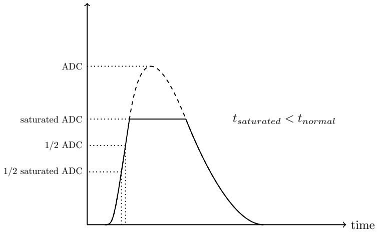


- Only signals with a good leading edge time are relevant (wfType $\leq$ 2)

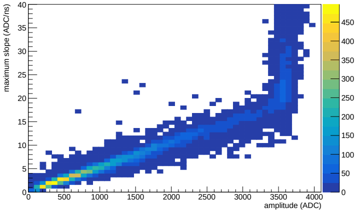
Pulse decoding

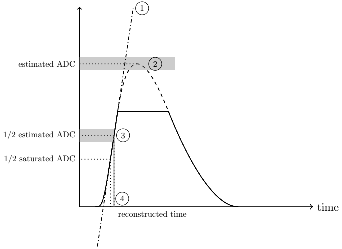
- Procedure for extracting the time
  - Baseline $\rightarrow$ estimated using the 4 first samples
  - Amplitude $\rightarrow$ after baseline subtraction, average of 3 samples around the peak
  - Leading edge time $\rightarrow$ computed at 1/2 amplitude
  - Time over threshold $\rightarrow$ computed if the signal has a trailing edge at 1/2 amplitude
- The leading edge time is well determined for wfType 0 and 2
- However, the time reconstructed for saturated signals is underestimated using the previous method
  - Such bias will impact the reconstruction of α particle



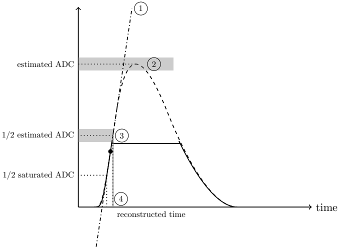


- The maximum slope of the signal is linearly correlated to the amplitude for non-saturated signals
  - We extrapolate the amplitude of saturated signals using this trend
- With the corrected amplitude, we recompute the time at 1/2 amplitude
- We chose this method after comparing it to the one based on the time over threshold





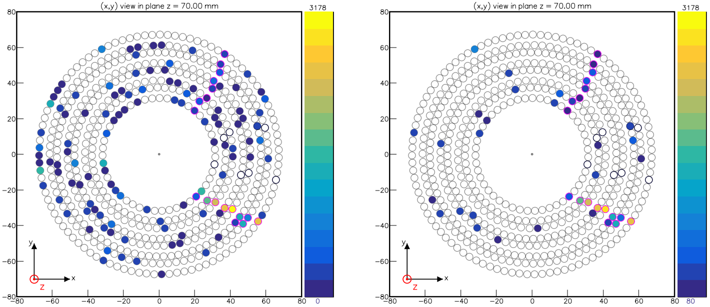
1/2 ADC below threshold



1/2 ADC above threshold

Hit selection

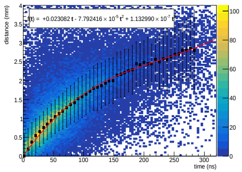
- Selection criteria: wfType ≤ 2 and time cuts
- The occupancy in the AHDC is much lower after the hit selection
- It simplifies the task of the track finder

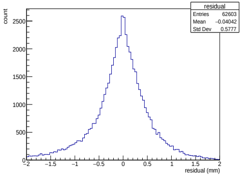


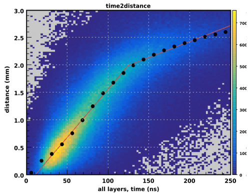
Event display: 325 nA, 10.6 GeV, ^{4}He target

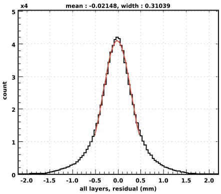
Time-to-distance calibration

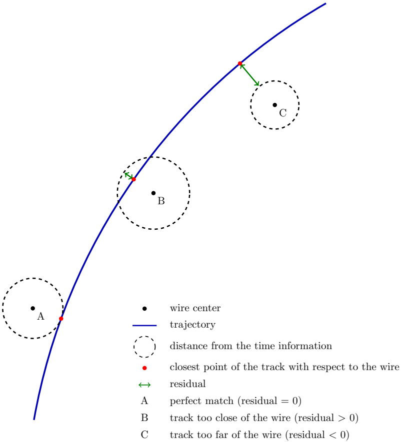
- The AHDC is a Time Projection Chamber
- The position is obtained by means of the time-to-distance
- The expression of the time-to-distance depends on several conditions that vary over the run period: high-voltage, medium composition, magnetic field
- We use an iterative procedure based on the minimization of the residuals





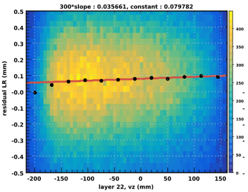


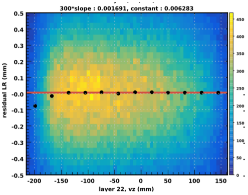


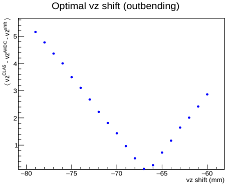


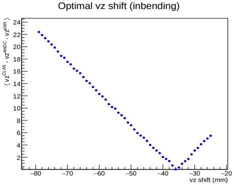
Alignment

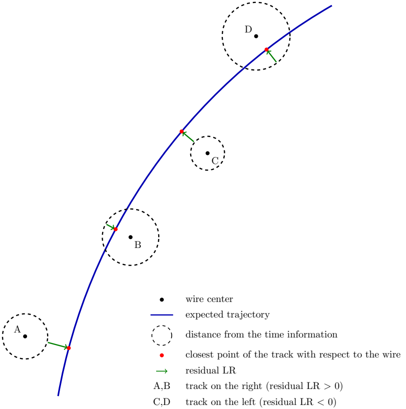
- Extract from data the relative disposition of the detector components
- We use elastic events for which the reconstructed track and the expected track can be compared
  - Phi orientation (by layer or by wire) → residual_LR
  - Z alignment with respect to CLAS → vertex shift over the run period





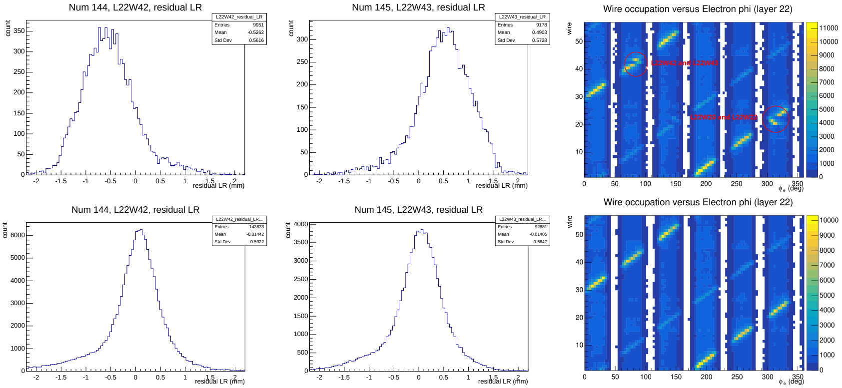






Issues fixed – Wire swaps

- We found some issues in the translation table of the AHDC
- Some wire residual distributions were non-centered or had unexpected shapes
- We found that they were the result of wire swaps as illustrated in the wire occupancy versus the electron phi in elastic events
- In total, four pairs of wires were reversed



Summary – Plan for the final year

- Work done so far
  - 1st year $\rightarrow$ Data taking, monitoring, simulation
  - 2nd year $\rightarrow$ Reconstruction software, calibration, reading, writing
- For the 3rd year, I will do a preliminary analysis of the DVCS off ^{4}He
  - My analysis will be done on a small dataset
  - My work on the software will be oriented on the improvement of the selection of DVCS events

- Timeline
  - Start redaction around February 28, 2027
  - Submit thesis before July 30, 2027
  - Thesis defense before September 30, 2027

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