

# Study of the Nucleon Structure Modifications Induced by SRC Nucleon-Nucleon Pairs via DVCS and EEEMCal Prototype Development for the EIC

Lorena Bucuru Rodríguez, under the supervision of Mostafa Hoballah and Carlos Muñoz

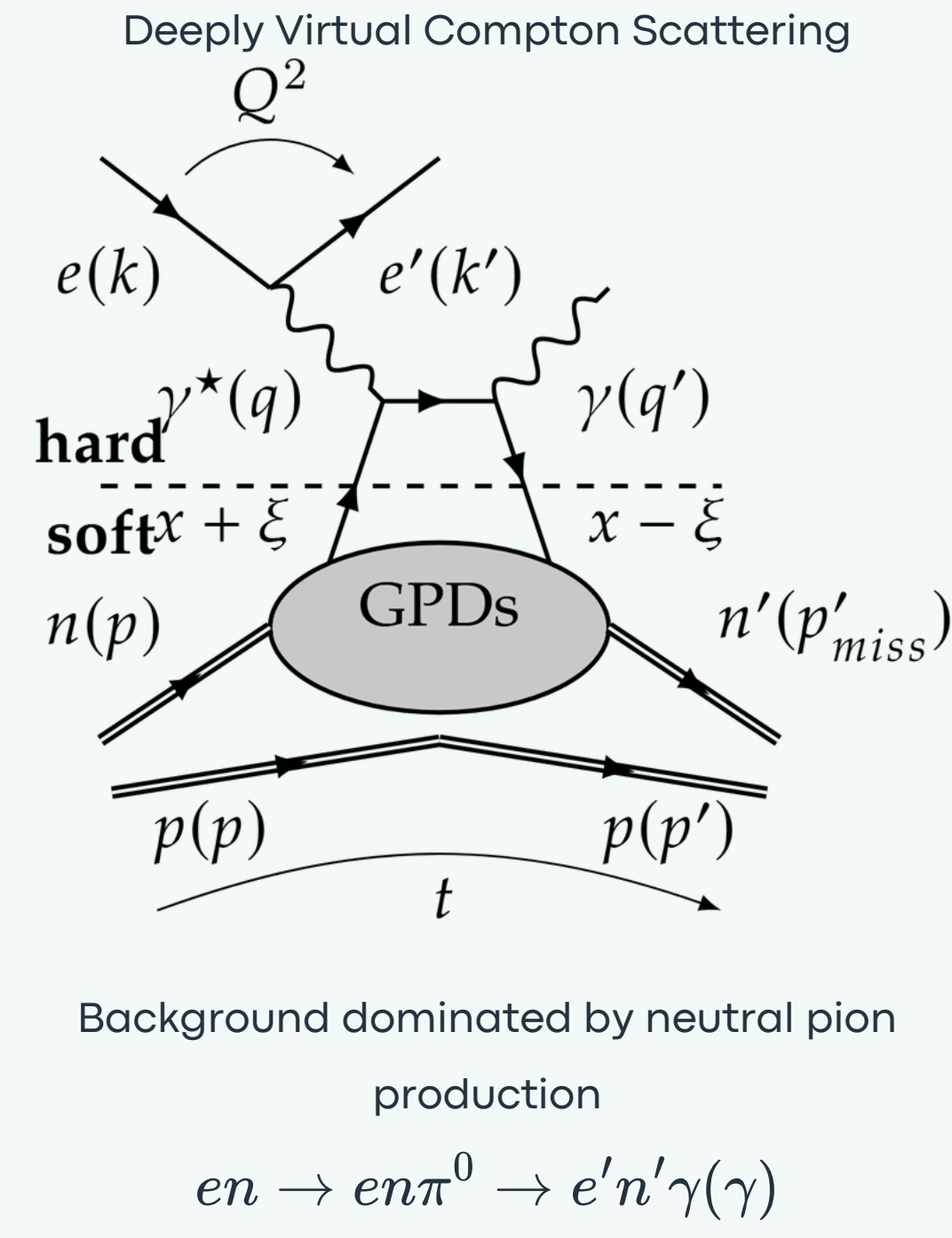
## Introduction

### Nucleon structure in low-energy QCD:

- Generalized Parton Distributions (GPDs): Correlation between transverse position and longitudinal momentum of partons.
- GPDs provide
  - A 3D tomography of the nucleon.
  - Contributions to the nucleon total spin.
  - Access to Gravitational Form Factors.

### Deeply Virtual Compton Scattering

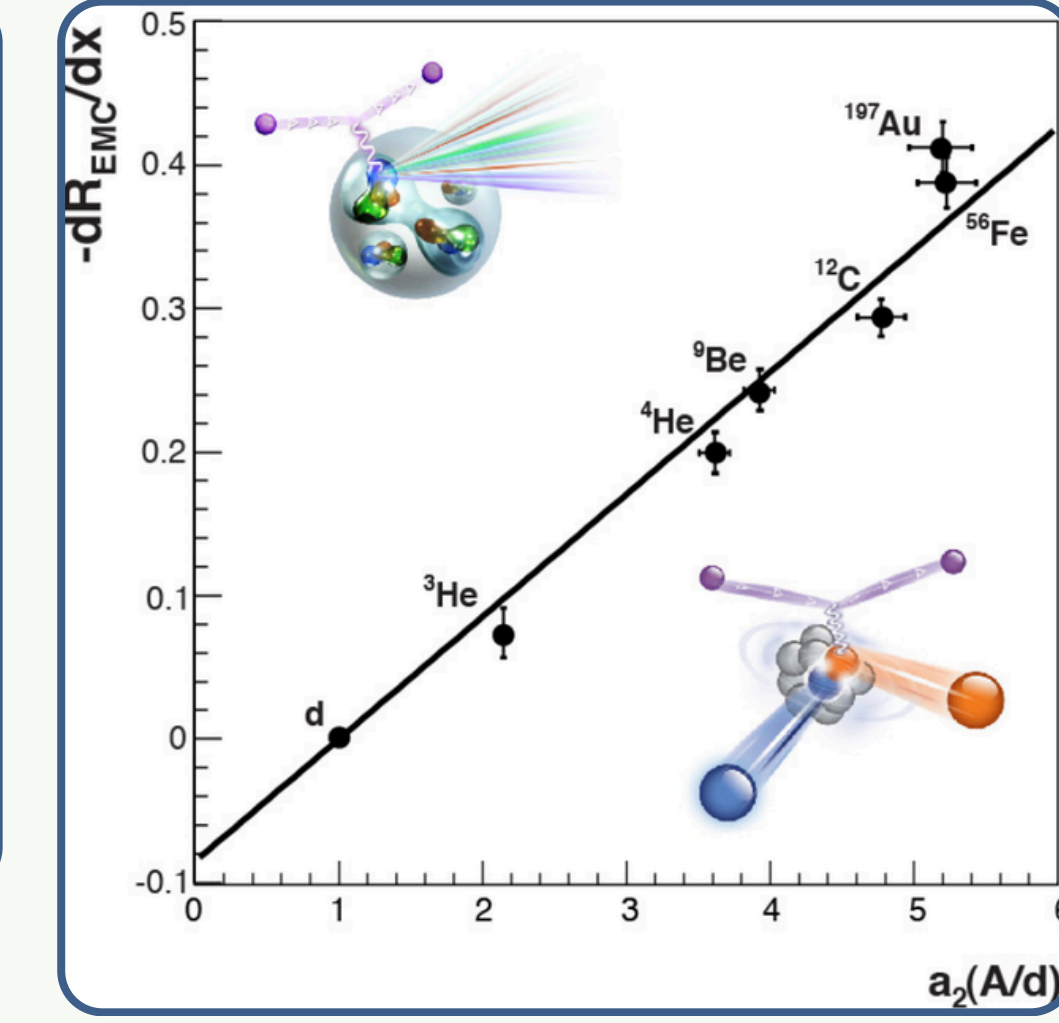
- DVCS: golden exclusive channel to access GPDs
- Observables are expressed through Compton Form Factors:  $\mathcal{H}, \mathcal{E}, \tilde{\mathcal{H}}, \tilde{\mathcal{E}}$



## Motivation

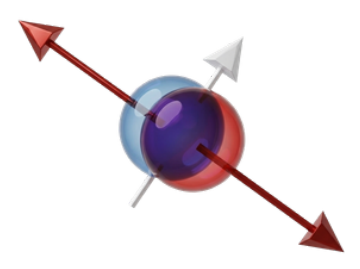
### EMC effect

Modification of parton momentum distributions in bound nucleons. Its correlation with nuclear density and SRC pairs is still under study.



### SRCs

Close nucleon-nucleon pairs with high relative momentum



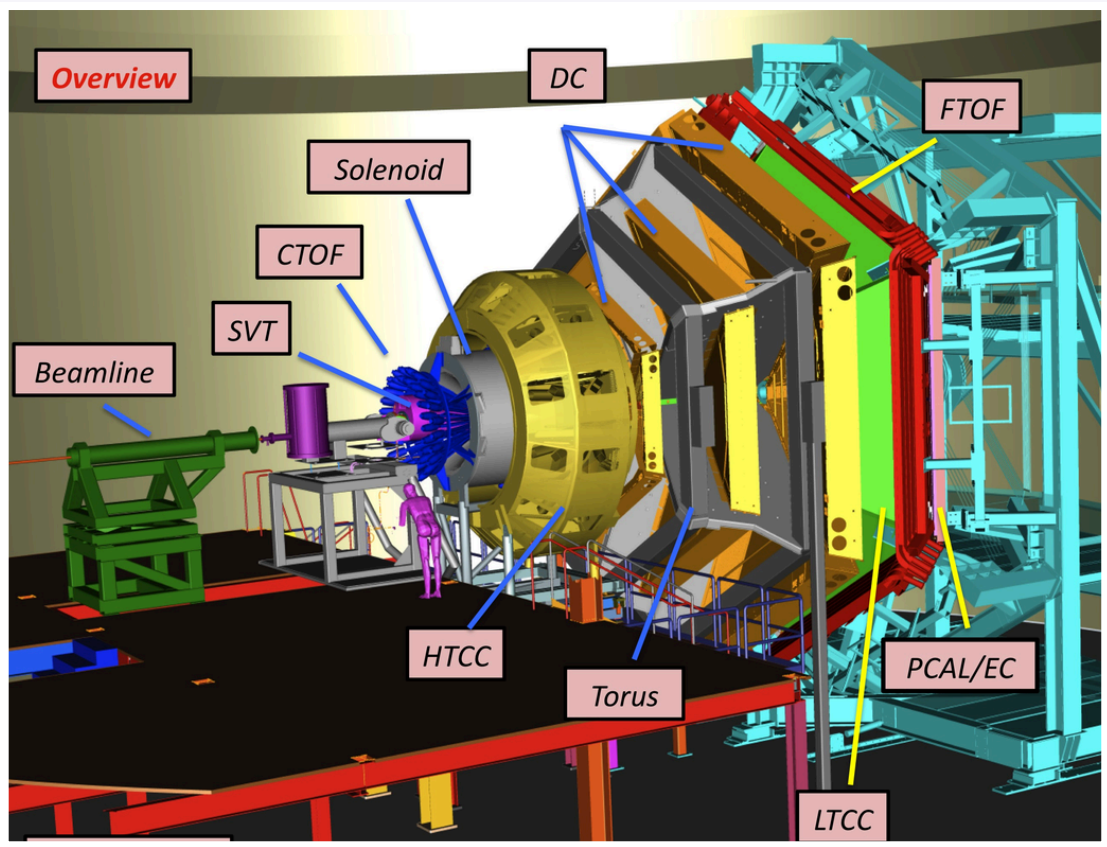
[1] L. B. Weinstein et al., Phys. [2] O. Hen et al., Phys. Rev. C 85, 047301 (2012).

This work explores the European Muon Collaboration (EMC) slope-Short-Range Correlated pair (SRC) connection via DVCS on deuterium.

An observed modification of the Beam Spin Asymmetry (BSA) at high missing momentum would provide evidence that SRCs are linked to nuclear modifications of partonic structure.

## Experimental Features

- CLAS12 is a large-acceptance spectrometer in Hall B at JLab.
- Its forward and central detector systems allow the reconstruction of exclusive final states at high  $Q^2$  and large  $x_B$ , reaching the region where valence quarks dominate.

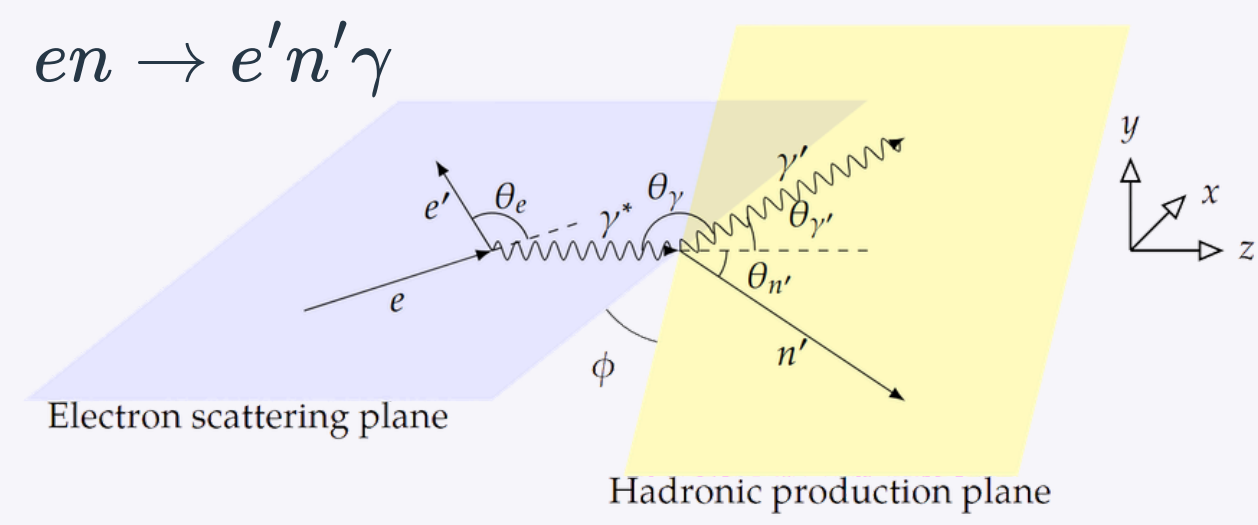


### Experiment

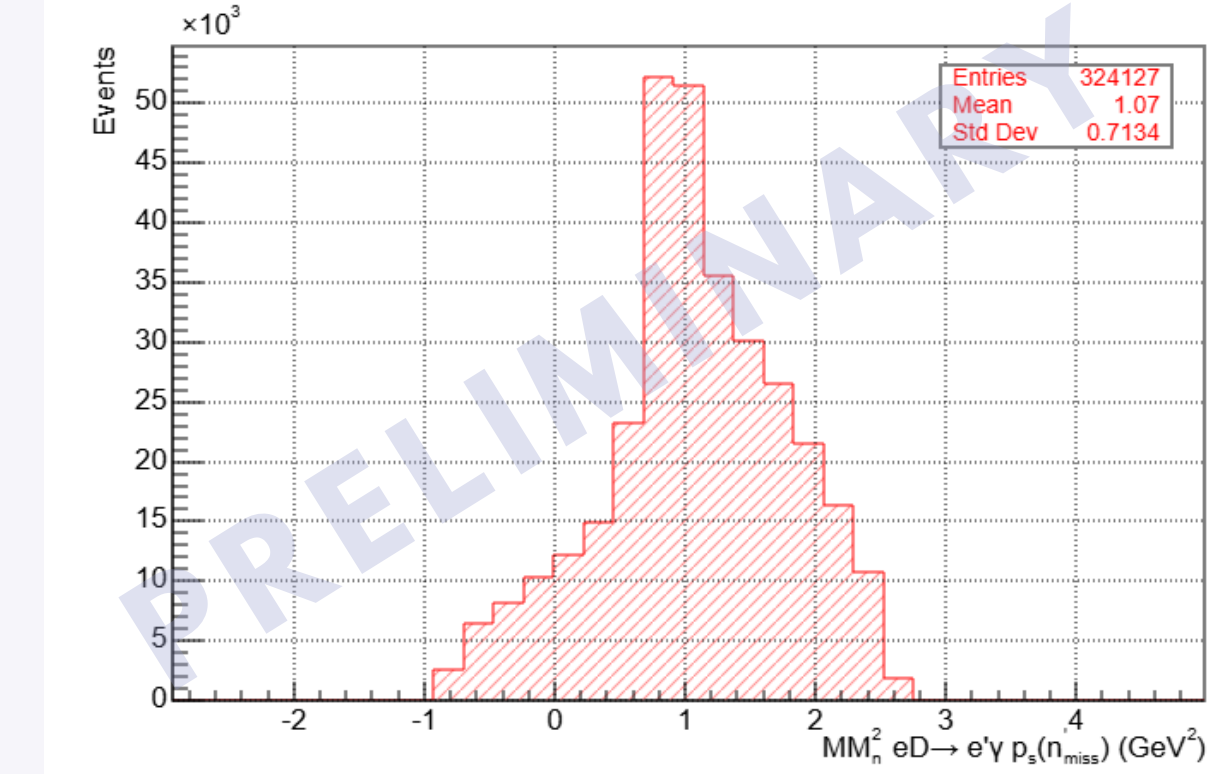
- Beam energy is about 10.6 GeV
- Polarized electron beam ~ 86%
- Unpolarized 5-cm deuteron target

### Kinematic and exclusivity cuts

- $W \geq 2 \text{ GeV}$  •  $Q^2 \geq 1 \text{ GeV}^2$
- $\gamma' \geq 2 \text{ GeV}$  •  $e' \geq 1 \text{ GeV}$
- $\theta_{\gamma x} = \arccos \frac{\gamma_{\text{kin}} \cdot \gamma'}{|\gamma_{\text{kin}}| |\gamma'|} < 10^\circ$
- $|\Delta\phi| = |\angle(\mathbf{n}_{\text{leptonic}}, \mathbf{n}_{\text{hadronic}}) - \angle(\mathbf{n}_{\text{leptonic}}, \mathbf{n}_{\text{hadronic}})| \leq 1.5^\circ$
- Other exclusivity cuts



Data: Missing-mass squared distribution after cuts



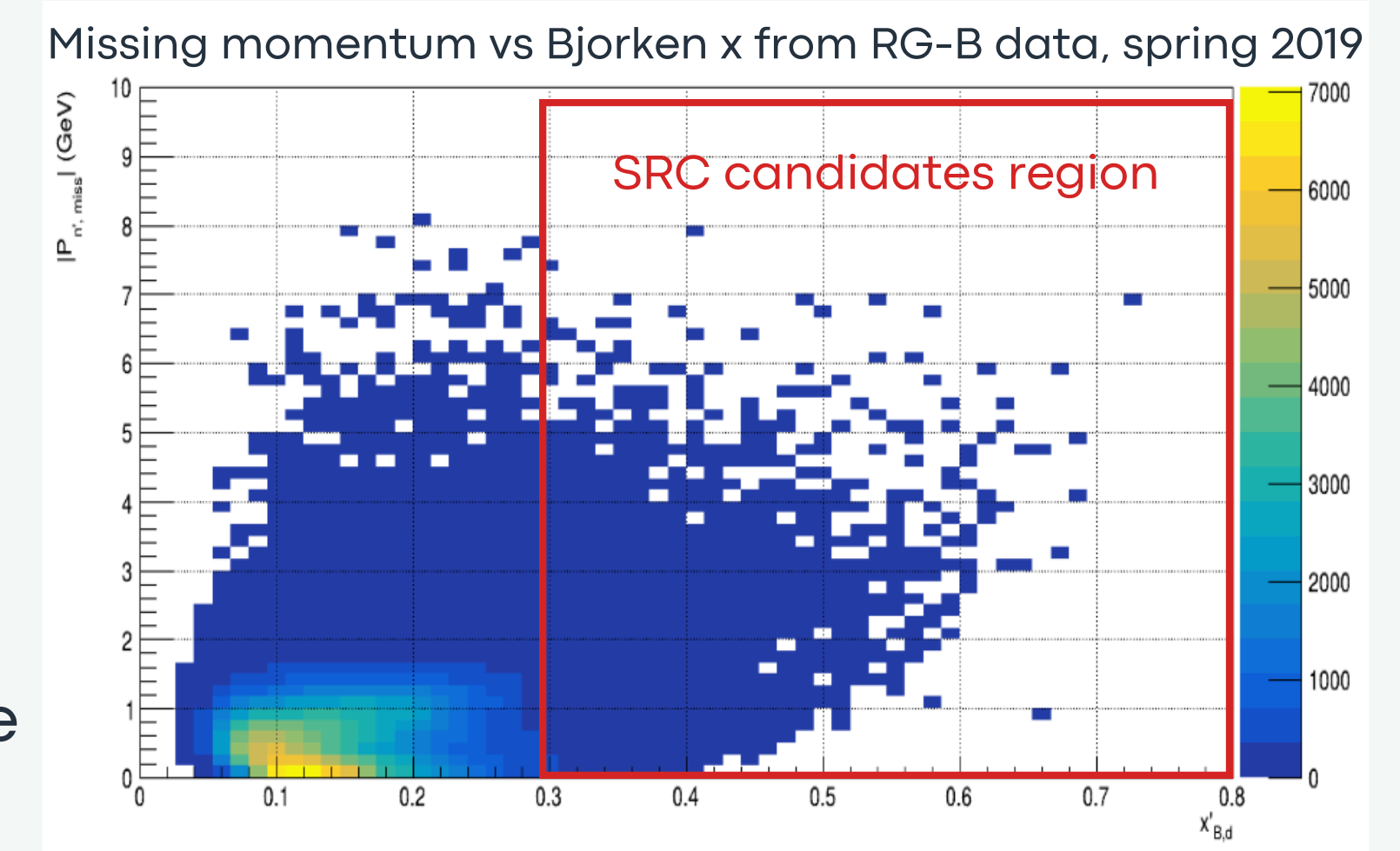
## Beam-Spin Asymmetry

Compton Form Factors can be accessed through the beam helicity dependence:

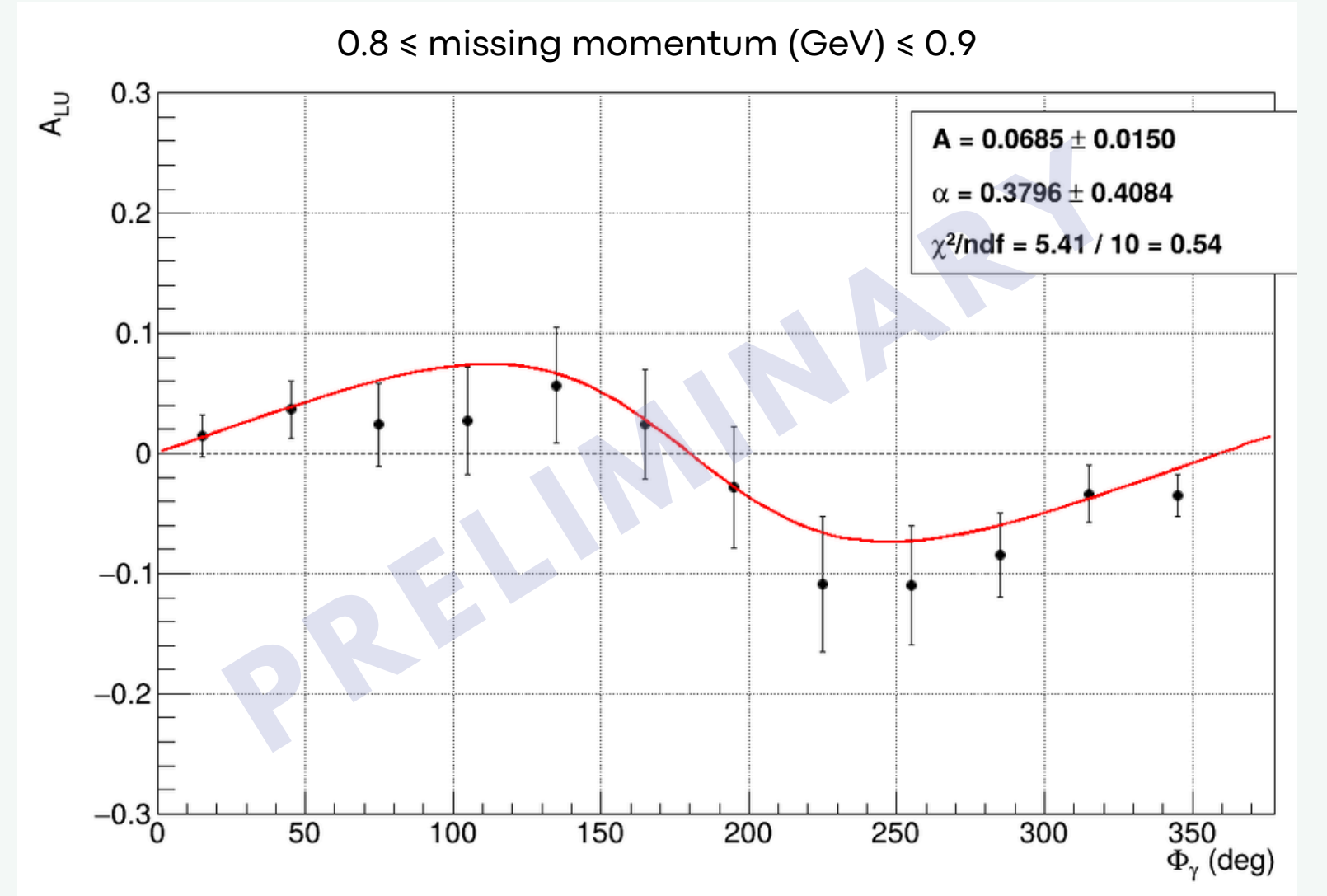
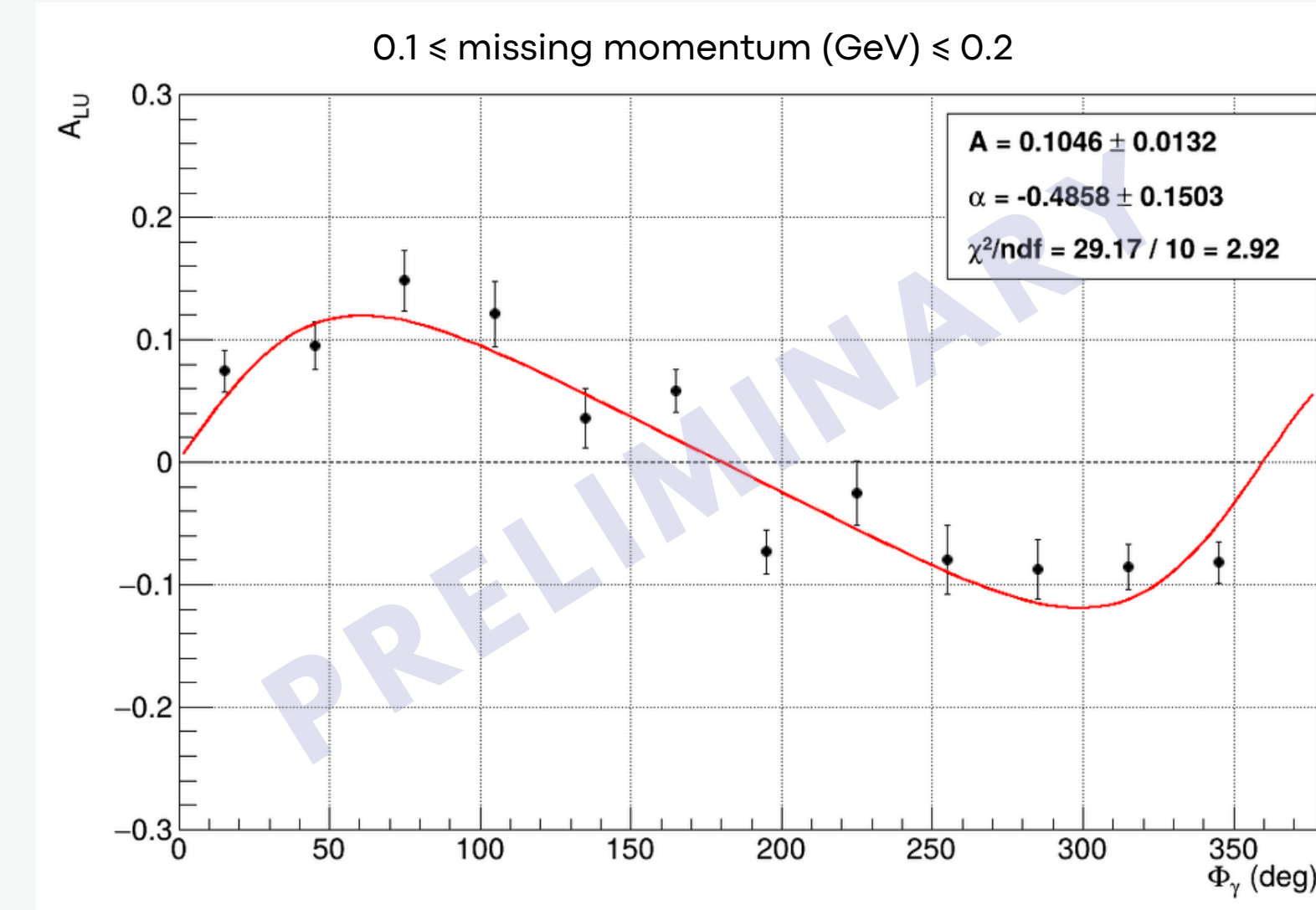
$$A_{LU}(\phi) = \frac{\sigma^+ - \sigma^-}{\sigma^+ + \sigma^-} = \frac{1}{\langle |P_1| \rangle} \frac{N^+(\phi) - N^-(\phi)}{N^+(\phi) + N^-(\phi)} \approx \sin(\phi) \mathcal{I} \{ F_1 \mathcal{H} + \xi (F_1 + F_2) \tilde{\mathcal{H}} - k F_2 \mathcal{E} + \dots \}$$

- $F_1$  = Dirac FF
- $F_2$  = Pauli FF

The raw BSA shows a possible variation as a function of missing momentum, suggesting internal nucleon-structure modification, to be confirmed after  $\pi^0$  background subtraction.

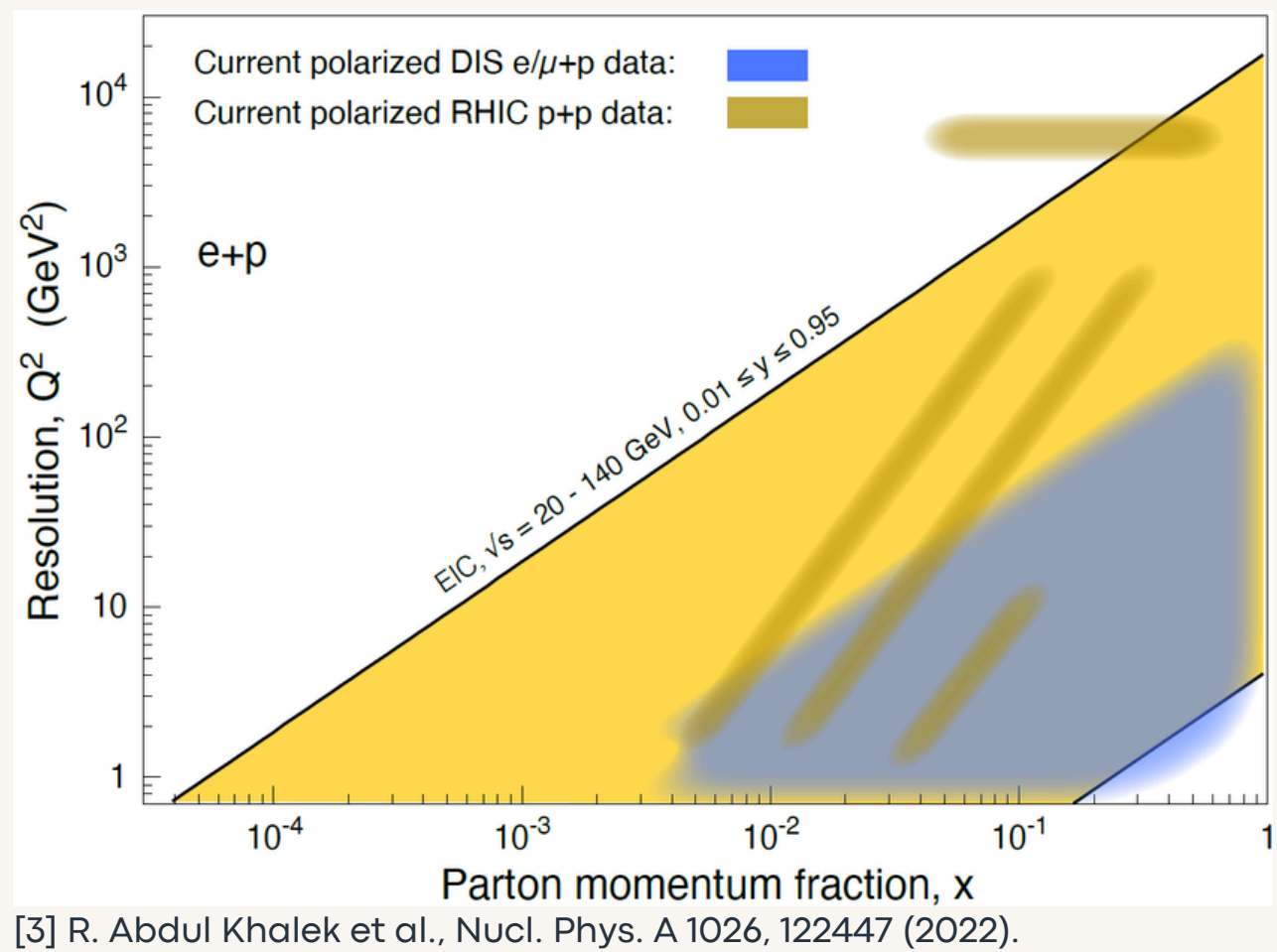


BSA from deuterium data after simple cuts- not background-subtracted



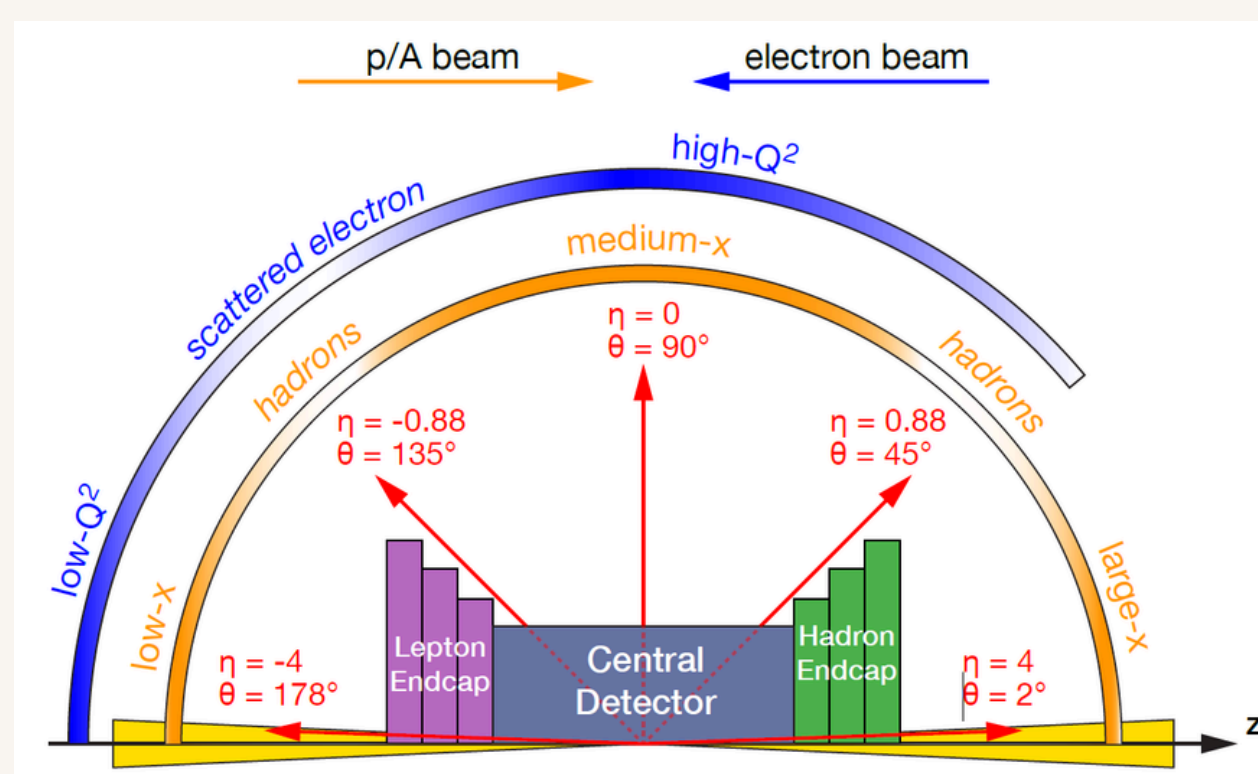
## Electron-Ion Collider

High-luminosity collider of polarized electrons with protons and ions, enabling studies of nucleon and nuclear structure from valence quarks to sea quarks and gluons.



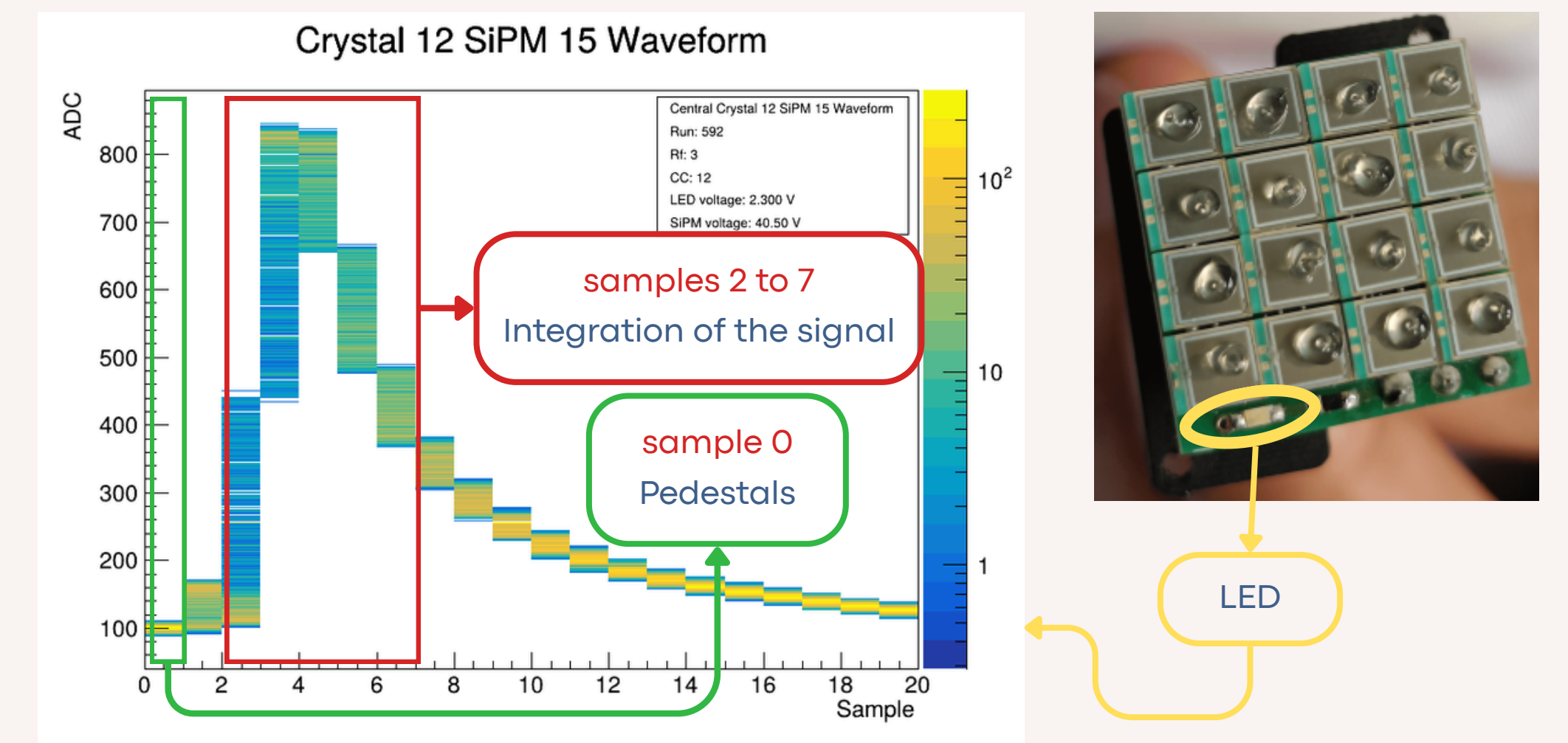
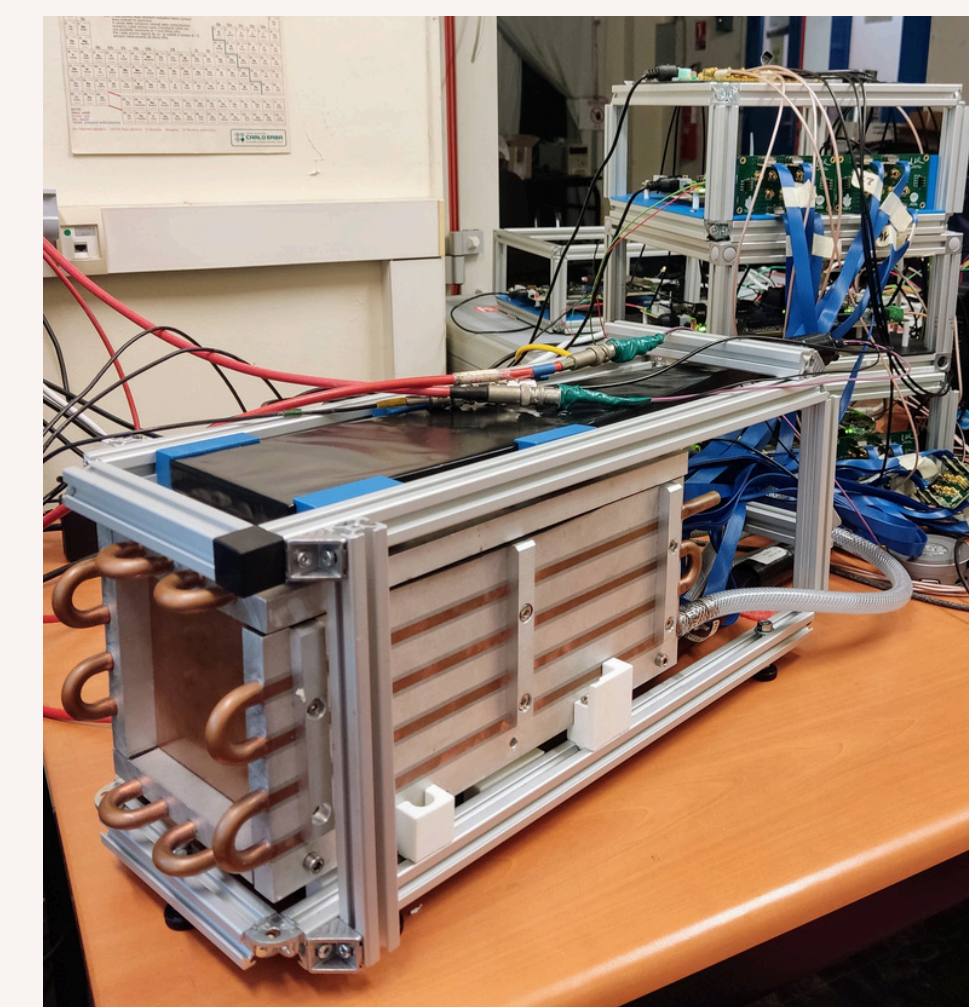
## ePIC Detector and EEEMCal

ePIC is the EIC's first general-purpose detector, providing large-acceptance tracking, calorimetry, and particle identification. The EEEMCal detects backward scattered electrons and electromagnetic showers.

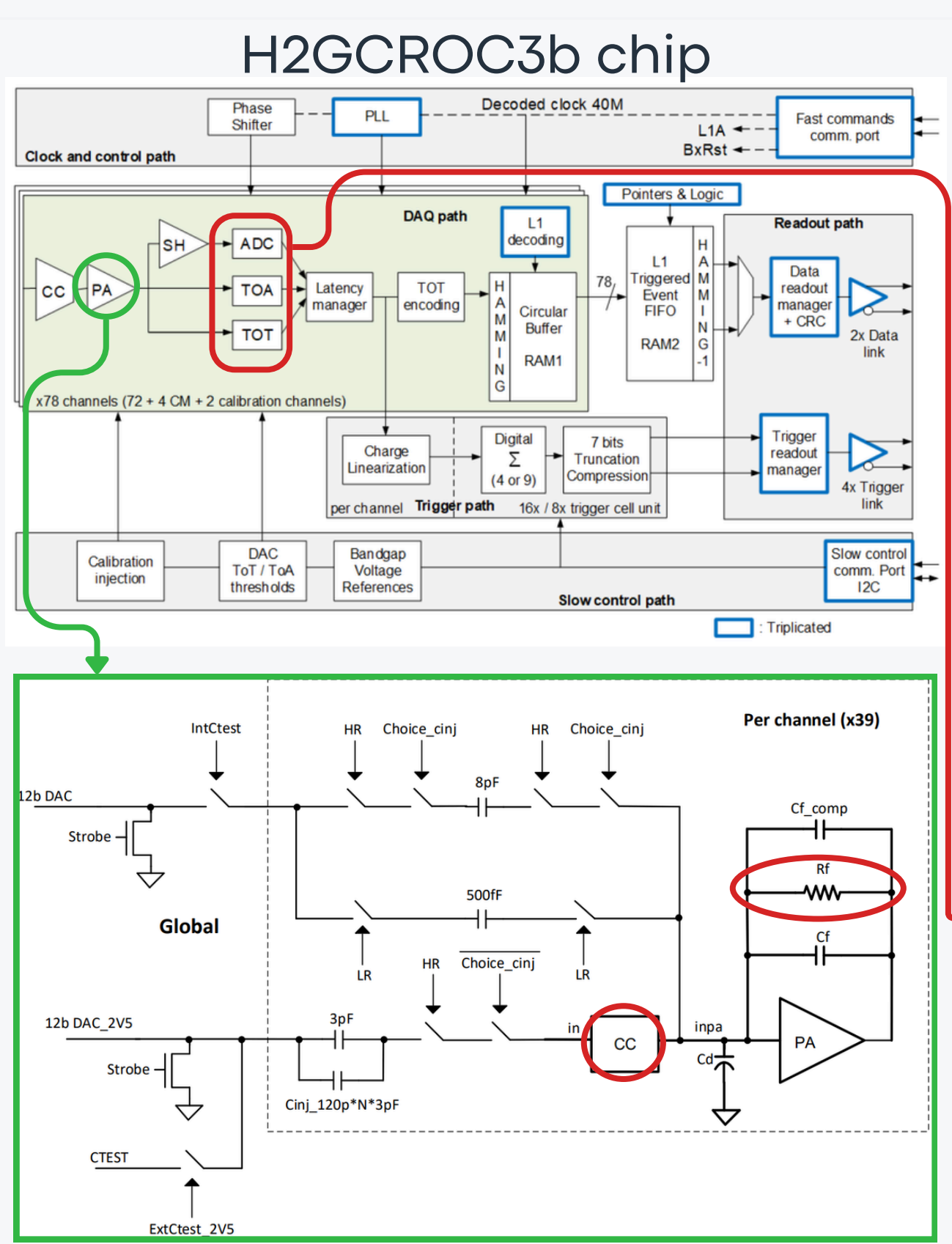


## EEEMCal prototype characterization

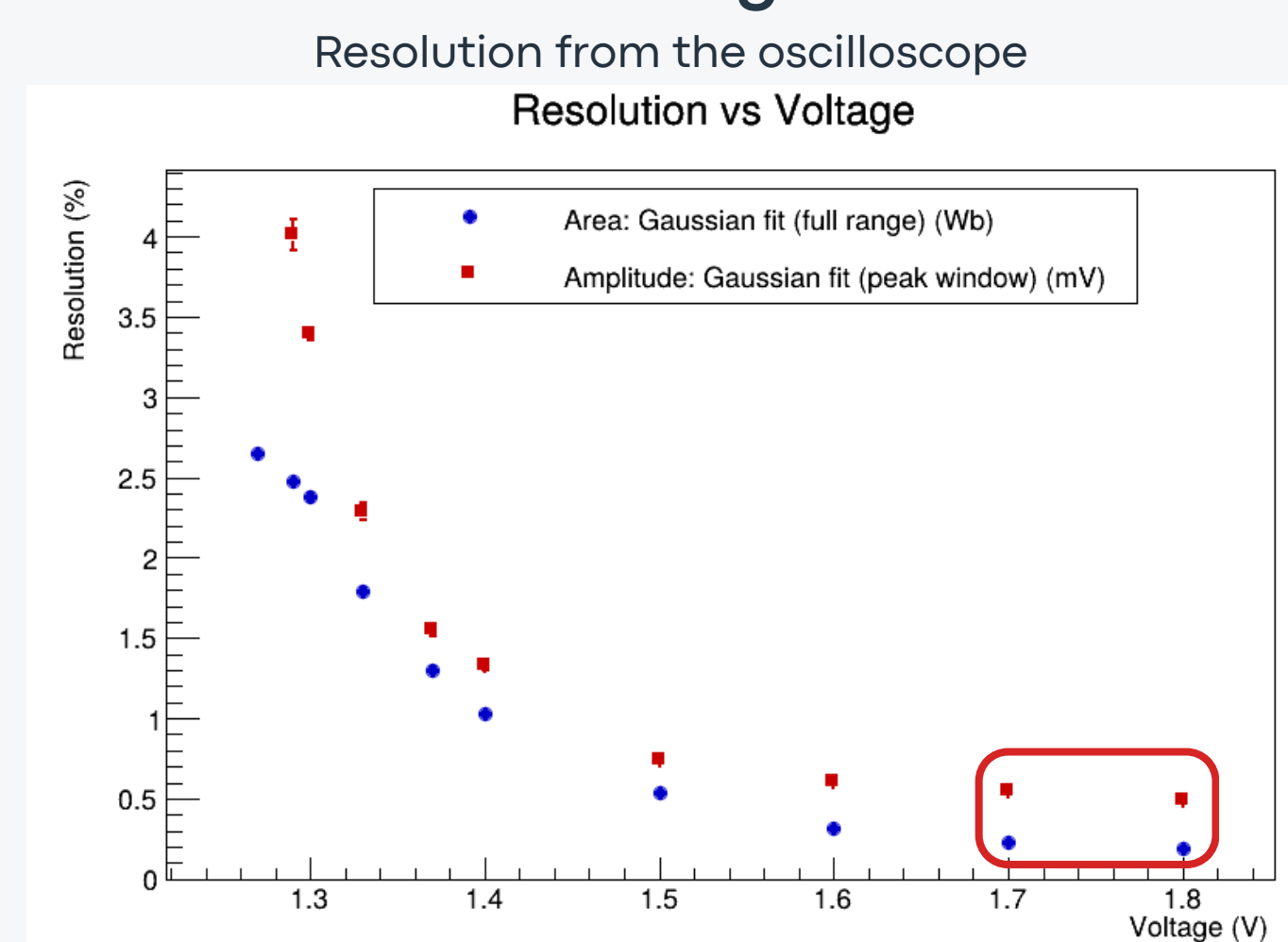
- Study of a 5x5 PbWO<sub>4</sub> crystal matrix for the ePIC Electron Endcap Electromagnetic Calorimeter.
- SiPM-based readout with HGCROC electronics.
- LED scans are used to evaluate ADC and ToT response.
- Optimization of linearity, dynamic range, cross-talk, and energy resolution.
- Optimization of the calibration procedure to improve the detector's resolution.



## EEEMCal prototype Readout Chain

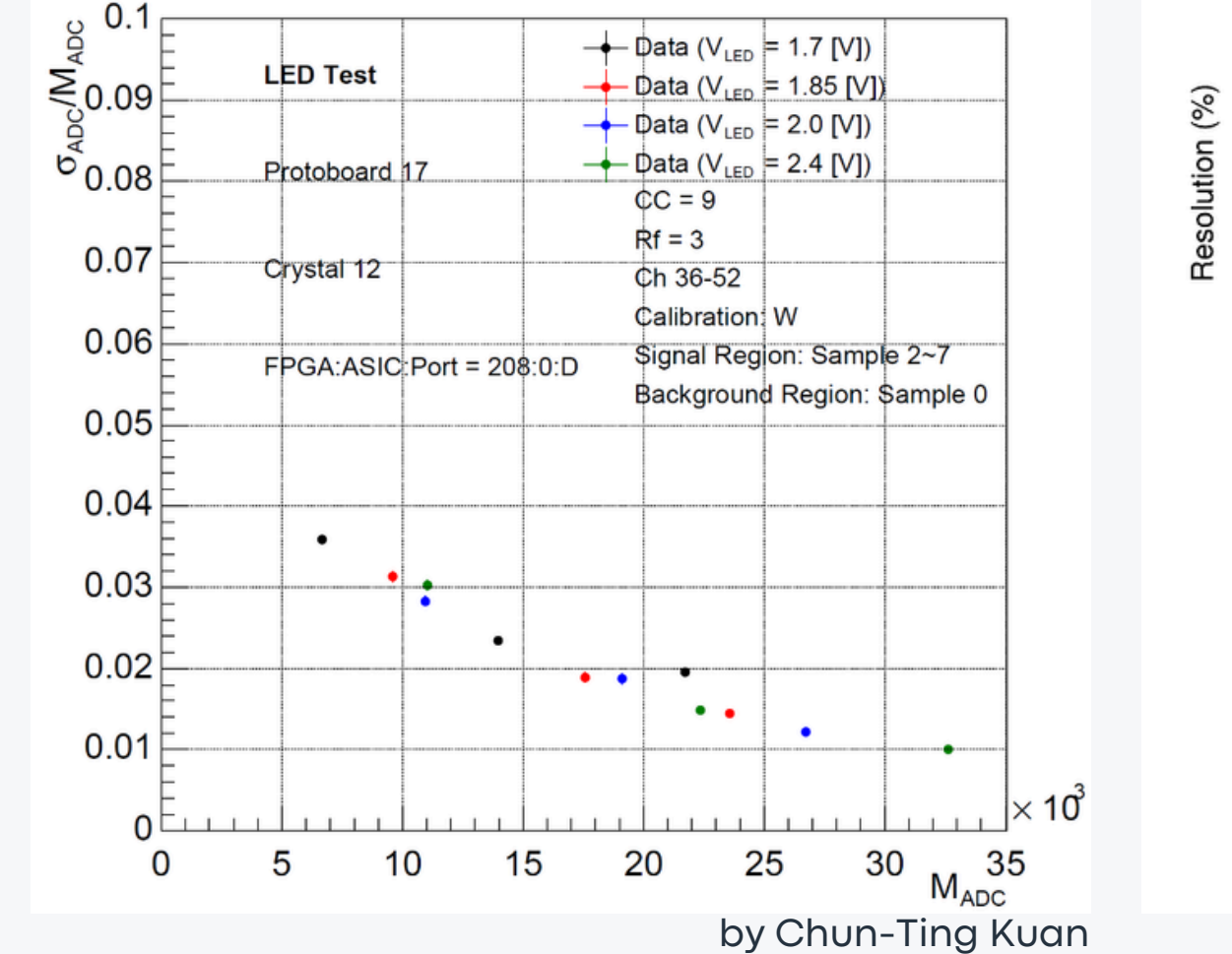


### Resolution in ADC region

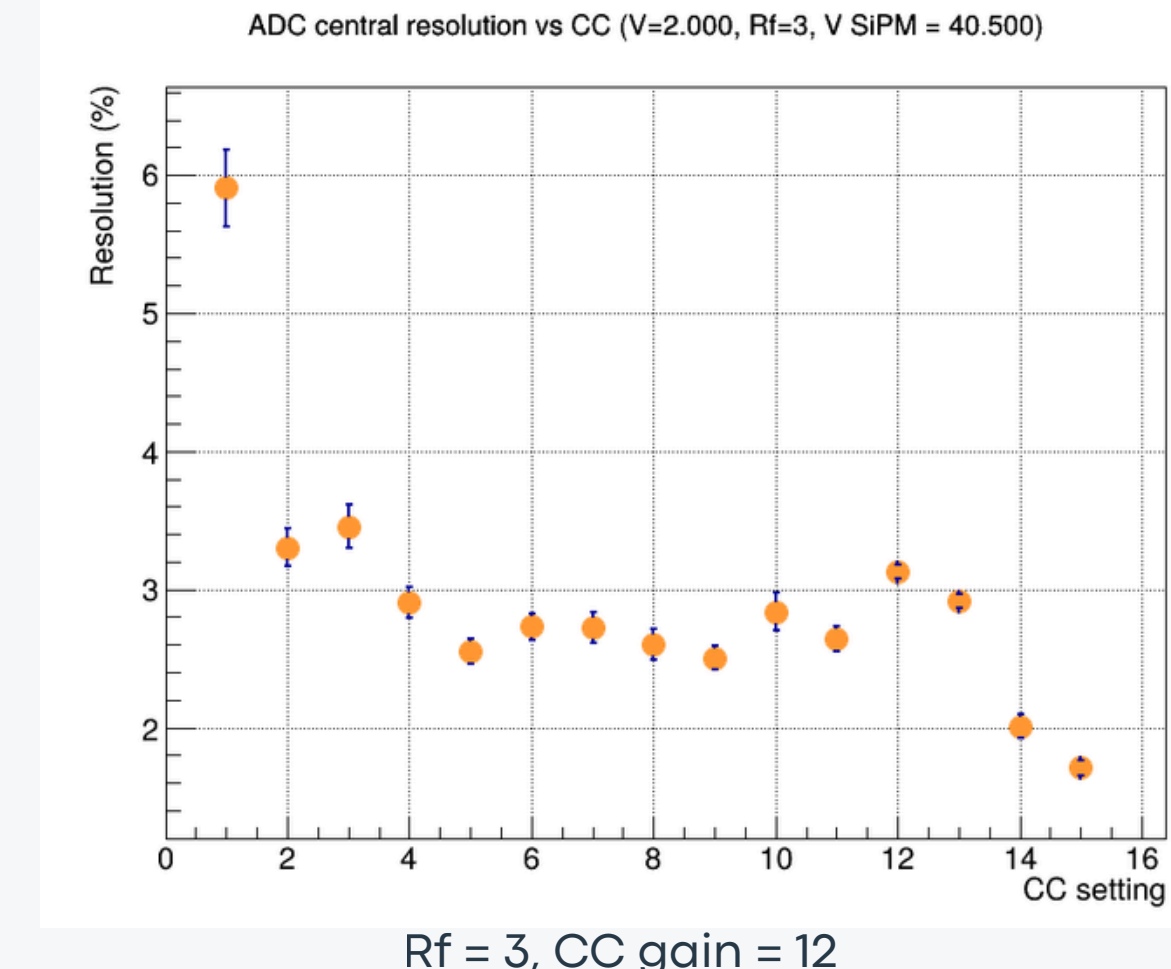


• The resolution obtained with the HGCROC readout is comparable to the oscilloscope reference, validating the prototype readout chain.

### Resolution varying LED voltage



### Resolution varying parameters



- Next steps include measurements with the CALOROC ASIC, the final chip planned for most ePIC calorimeters, and a beam test foreseen around 2027 to validate the energy-resolution performance under realistic conditions.

