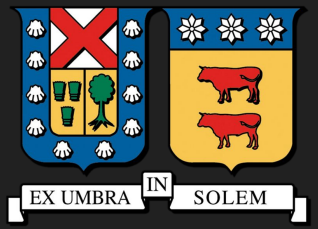
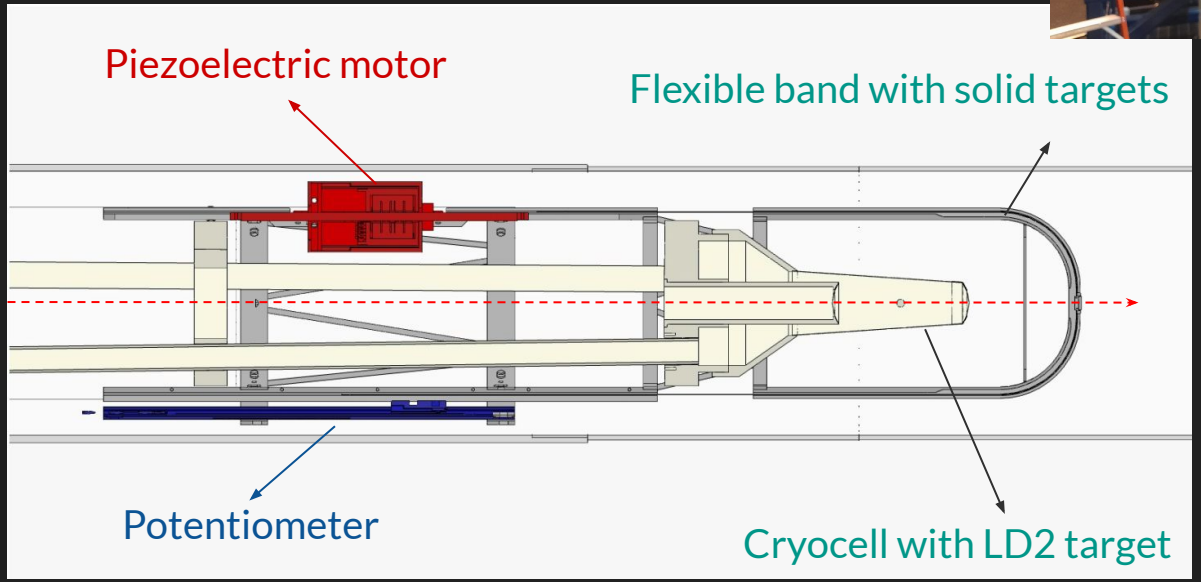
RG-E Experiments Calibration and Analysis Updates

Antonio Radic

CLAS collaboration meeting
July 8 - 11 2025



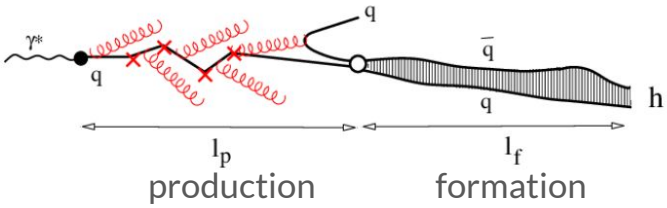
RG-E Double-target system

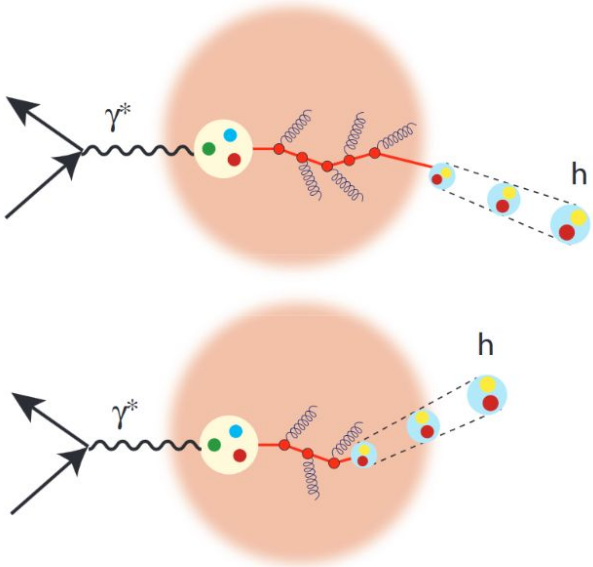


Solid target
- Carbon
- Aluminum
- Copper
- Tin
- Lead

Liquid target
- Deuterium

Hadronization in nuclear media





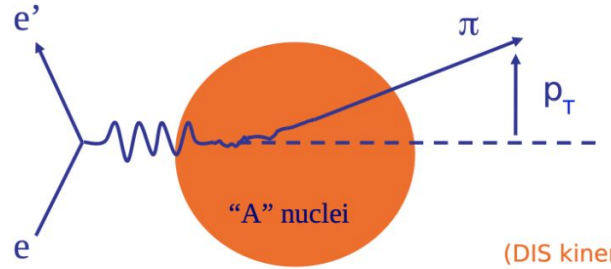
Prehadron formed **outside** the nucleus

Prehadron formed **inside** the nucleus

- l_p: production length. Quark propagates as a colored object.
- l_f: formation length. Color neutral prehadron propagates until becoming a final state hadron.

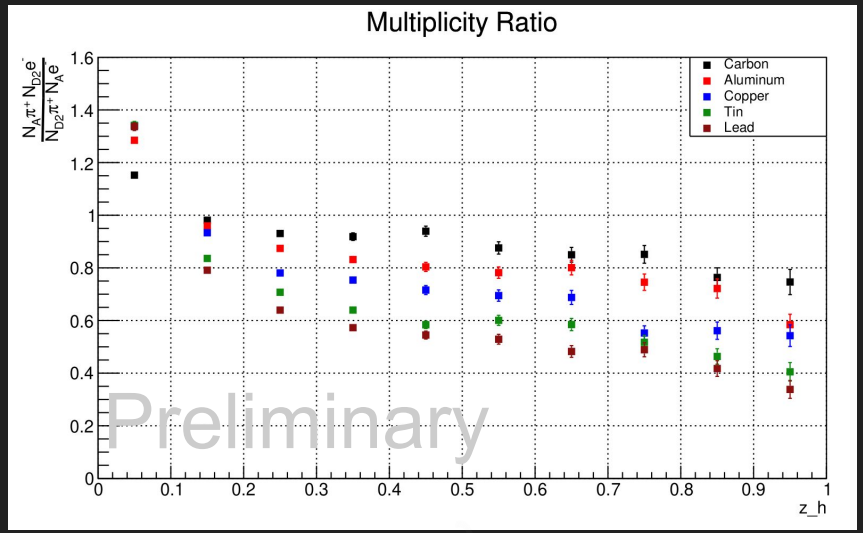
Physics and observables

Transverse momentum broadening: $\Delta p_T^2 = p_T^2(A) - p_T^2(^2H)$



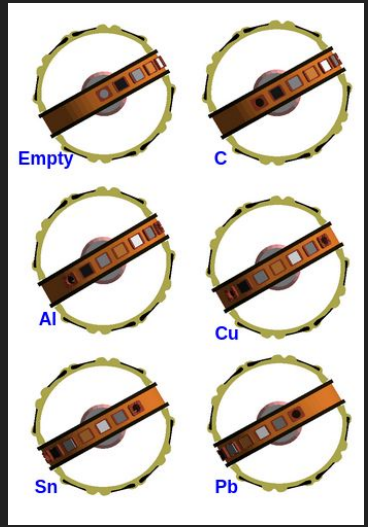
Hadronic multiplicity ratio:

$$R_M^h(z,\nu,p_T^2,Q^2,\phi) = \frac{\left\{\frac{N_h^{DIS}(z,\nu,p_T^2,Q^2,\phi)}{N_e^{DIS}(\nu,Q^2)}\right\}_A}{\left\{\frac{N_h^{DIS}(z,\nu,p_T^2,Q^2,\phi)}{N_e^{DIS}(\nu,Q^2)}\right\}_D}$$

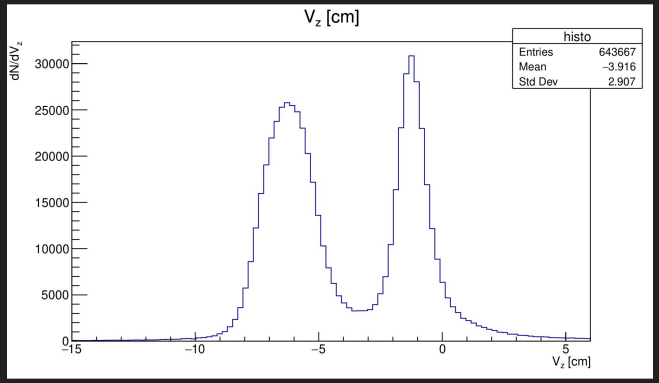


Run summary and data collected

- Data taken in Spring 2024 from March 15th to May 19th
- 10.547 GeV electron beam
- Standard CLAS12 configuration with FT-OFF
- Three layers of FMT
- >95% of data has inbending torus polarity

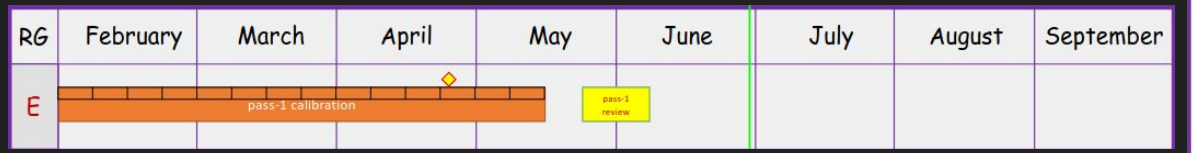


Target	Current (nA)	Days	PAC Days	Accumulated charge (mC)	Integrated luminosity (1/fb)
LD2 + C	85	6.3	3.2	23.17	24.38
LD2 + Al	70	6.8	3.4	20.53	24.23
LD2 + Cu	75	6.6	3.3	21.46	22.42
LD2 + Sn	65	9.8	4.9	27.60	21.58
LD2 + Pb	70	14.4	7.2	43.63	26.76
Pb (only)	160	0.7	0.4	4.98	2.84
C (only)	85	0.6	0.3	2.29	3.79
Total		44.7	22.3	143.66	126.00



RGE Calibration status

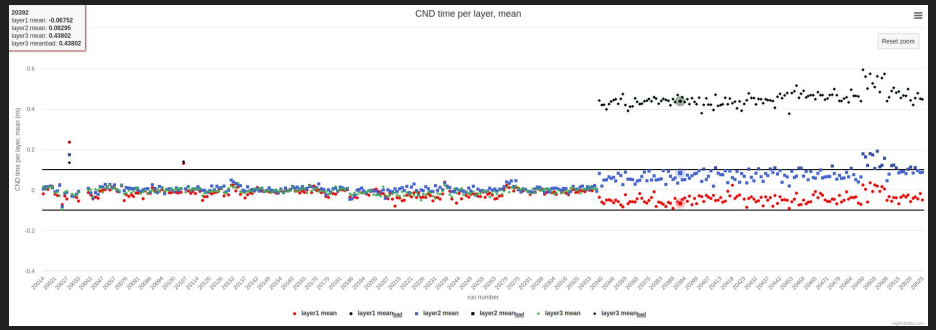
- Last cooked version: pass0.8 (last week)
- Done from last collaboration meeting in March:
  - DC time offset calibration
  - DC calibration (awaiting sign-off)
  - CND calibration (awaiting sign-off)
  - CTOF calibration (awaiting sign-off)
  - ECAL calibration (awaiting sign-off)
  - HTCC calibration
  - LTCC calibration
  - RICH calibration
  - CVT energy loss studies
- In progress:
  - DC TDC widows cuts
- Next Step:
  - AI network training
  - DC tracking efficiency studies DC vs MC

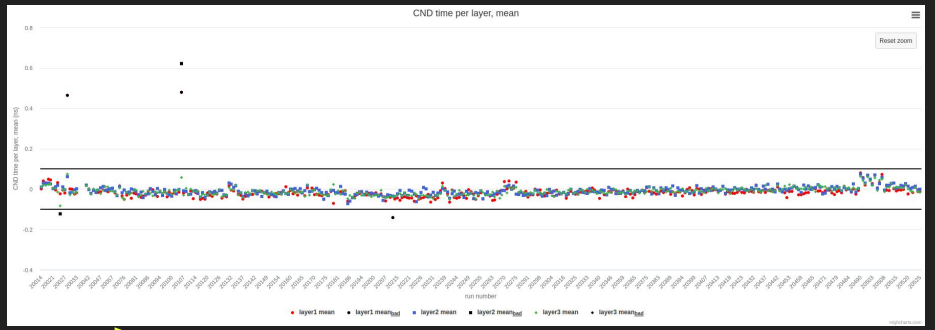


	March 2025	July 2025
DC alignment		
CVT alignment		
FMT alignment		
beam offset calibration		in prog
raster calibration		
fix timing global offsets		
online calibration		
pass-0 (initial assessment)		
DC time offset calibration		
FTOF calibration I		
RF calibration		
DC calibration I		
pass-0 (1st round assessment)		
BAND calibration		in prog
CND calibration		
CTOF calibration	in prog	
DC calibration II		in prog
ECAL calibration		in prog
FT-Cal		
FT-Hodo		
FTOF calibration II		
HTCC calibration		
LTCC calibration		
RICH calibration		
Hardware status	in prog	in prog
pass-0 (2nd round assessment)		in prog
2nd calibration iteration		in prog
AI training		
pass-0 (final assessment)		
cooking of full runs (assessment)		
readiness review		

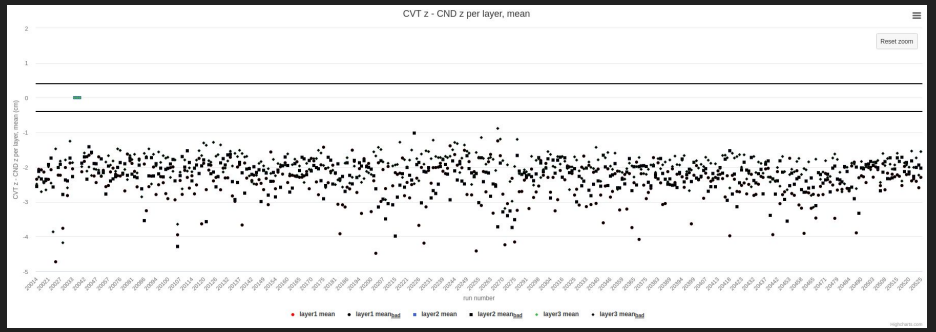
QA Timelines CND

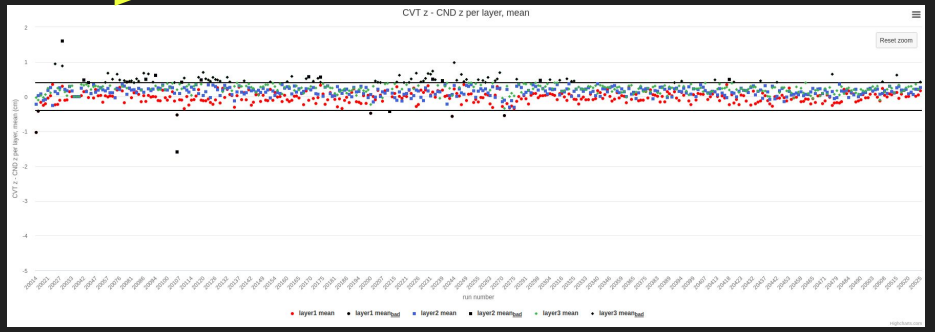
CND time per layer (mean)





pass0.6 → pass0.8

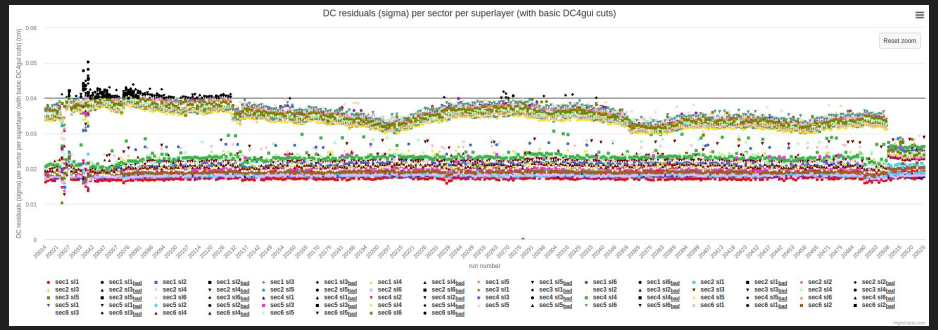


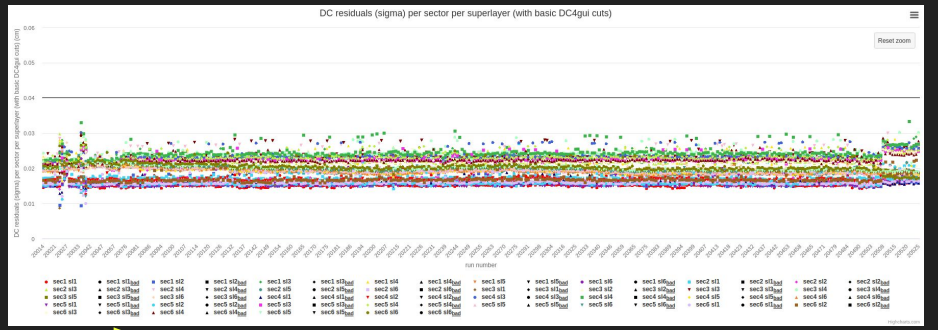


CVT z - CND z (mean)

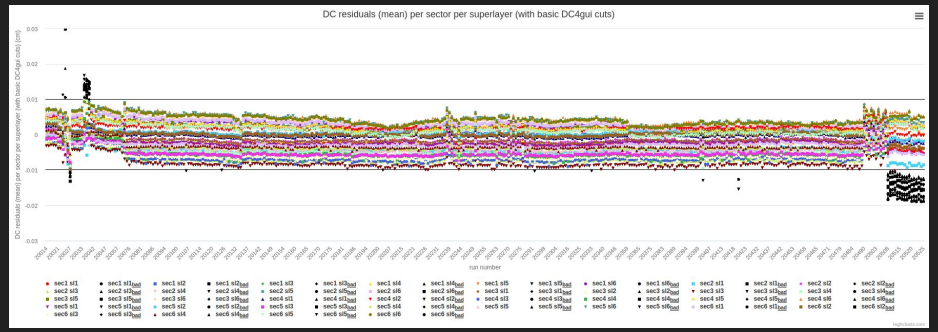
QA Timelines DC

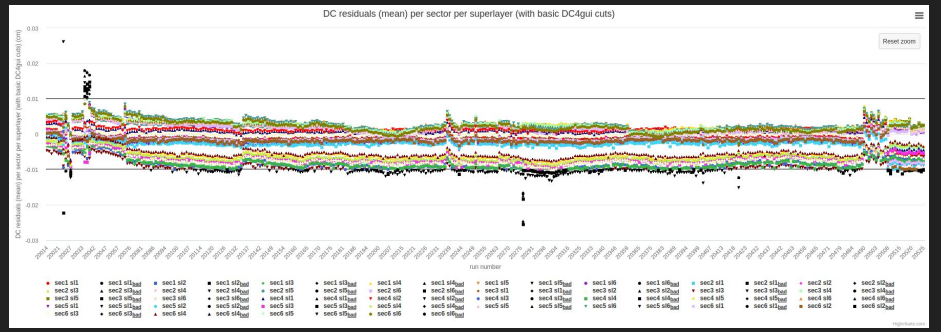
DC Residuals (sigma)





pass0.6 → pass0.8

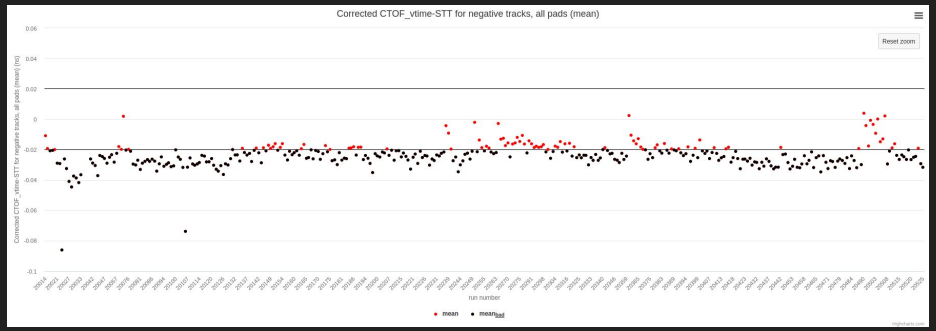


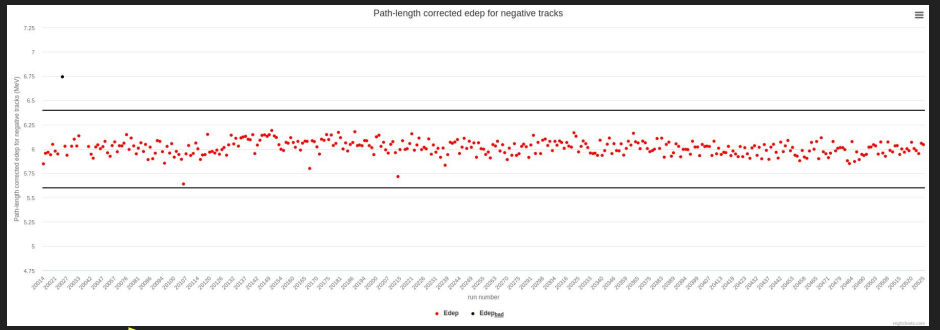


DC Residuals (mean)

QA Timelines CTOF

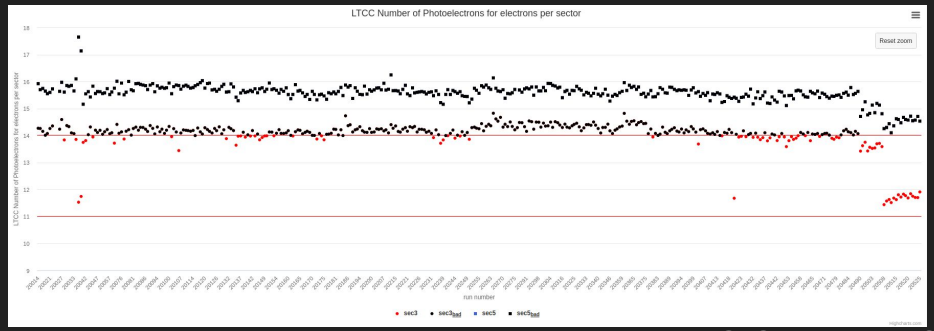
Corrected CTOF vtime-STT for negatives (mean)





pass0.6 → pass0.8

QA Timelines LTCC



LTCC nPhe for electrons

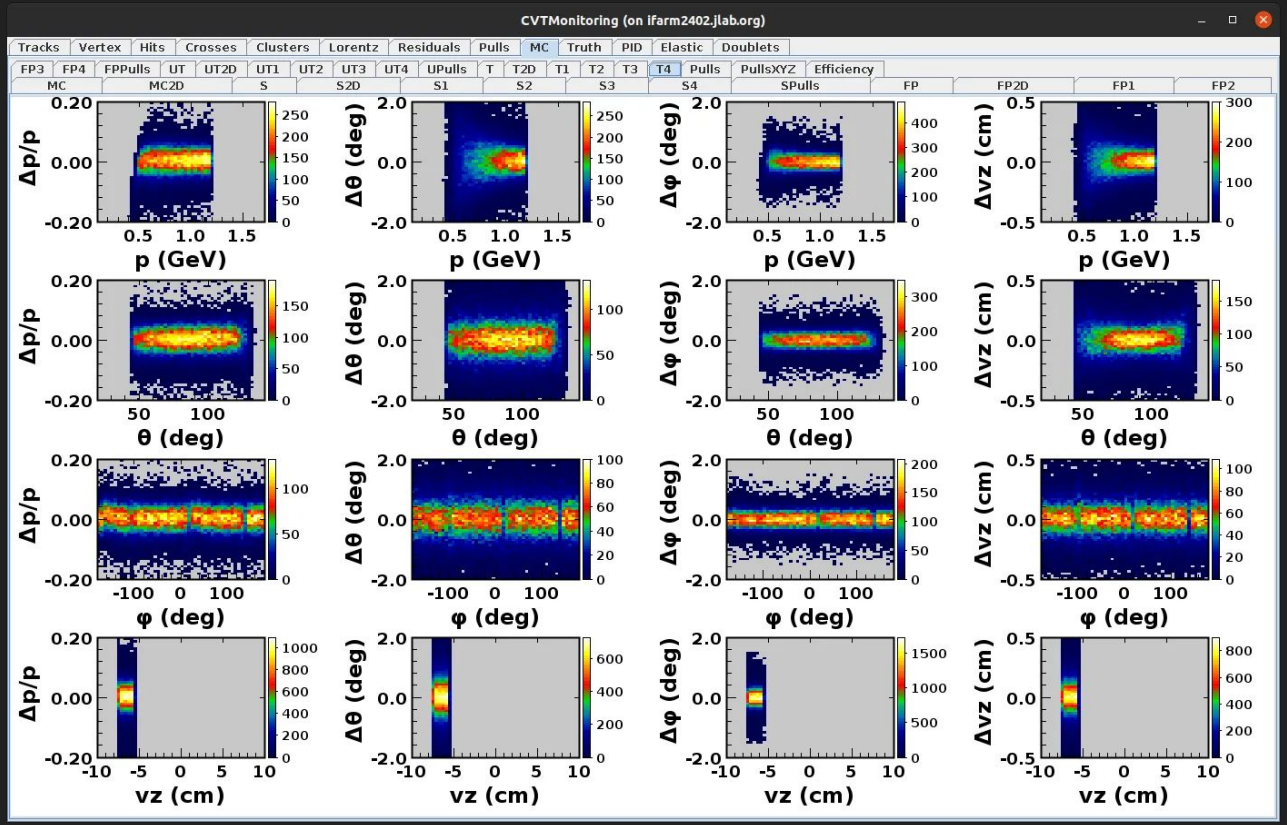
CVT energy loss studies

- Study based in Raffaella simulations studies for RGD
- Implementation of energy loss in CVT uses a single target cell.
- RGE presents a double target configuration.
- Simulations were ran with low momentum deuteron and protons.
- Generated and reconstructed momentum were compared
- Configuration used:
  - LD2+Cu target (vertex from solid target)
  - LD2+Cu target (vertex from liquid target)
  - Empty+Cu target (vertex from liquid target position)

Simulations implementation

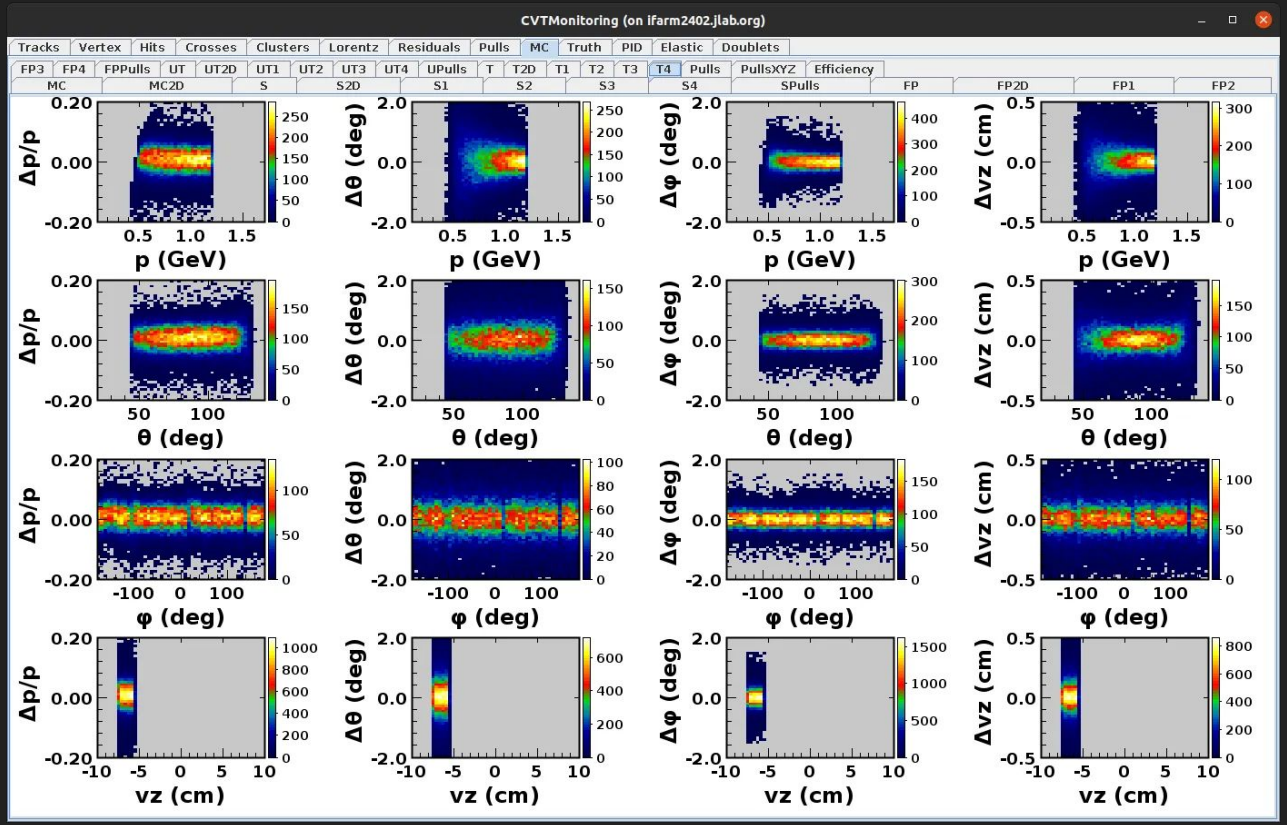
- 100k events per configuration:
  - P = 0.2 -1.2 GeV
  - θ = 45 - 135 deg
  - ϕ = 0 - 360 deg
  - vz = -6.5 ± 1 cm for LD2
  - vz = -1.5 ± 0.018 cm for Cu
- GEMC 5.11.
- Digitization variation: rge_spring_2024_mc.
- Coatjava 11.1.1 for reconstruction.
- Only CVT services.
- elossPid: 2212 for protons and 45 for deuterons in yaml file.
- Reconstructed files analyzed with CVT monitoring code.

Deuteron - Empty+Cu (liquid vertex)



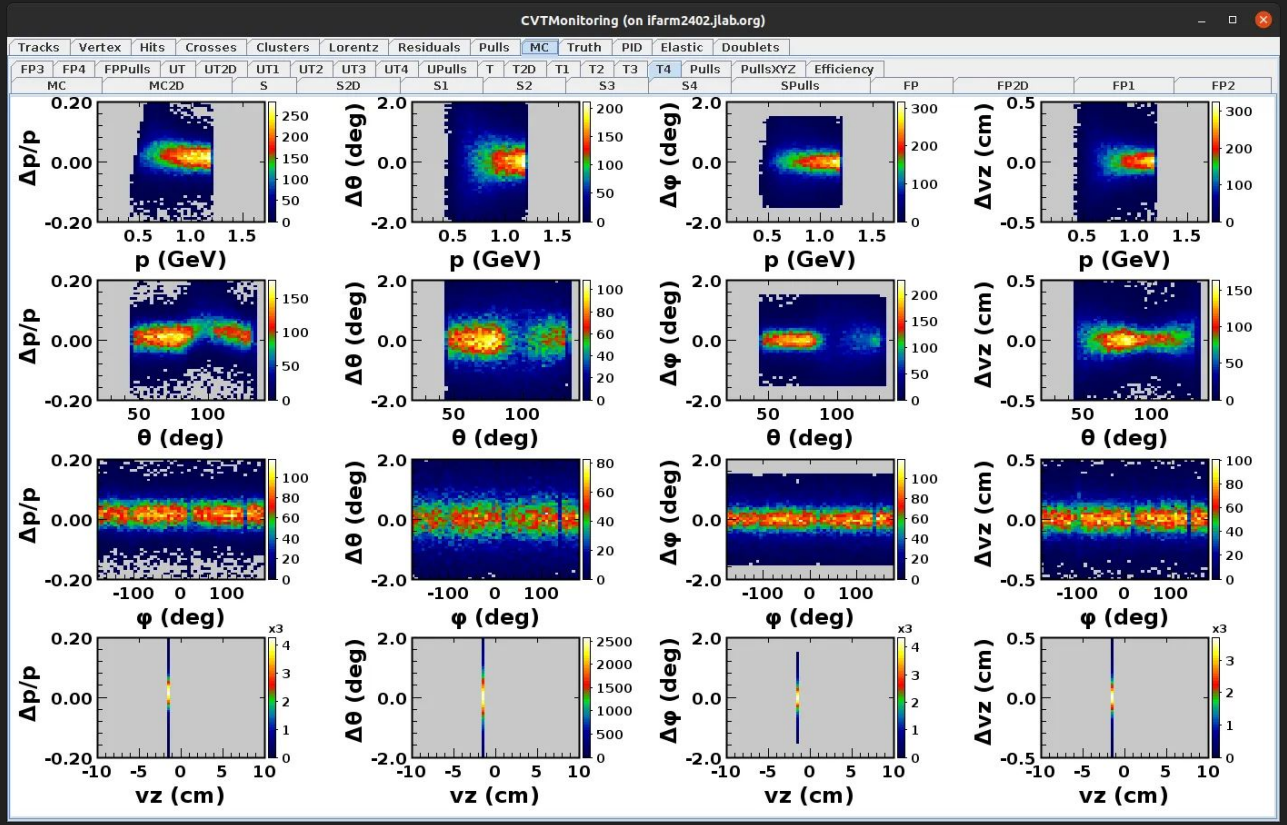
Energy loss for CVT is small for deuteron (and protons)

Deuteron - LD2+Cu (liquid vertex)



Target material effects in CVT energy loss is small for deuterons

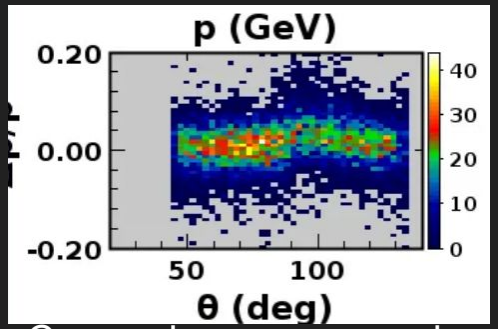
Deuteron - LD2+Cu (solid vertex)



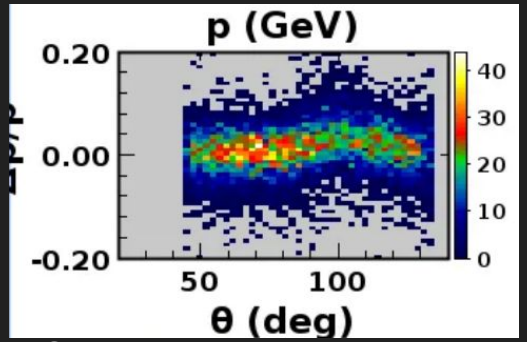
Material around solid target reduces the efficiency for CVT at angles $\theta > 90°$

Current corrections in the software work for double target configuration

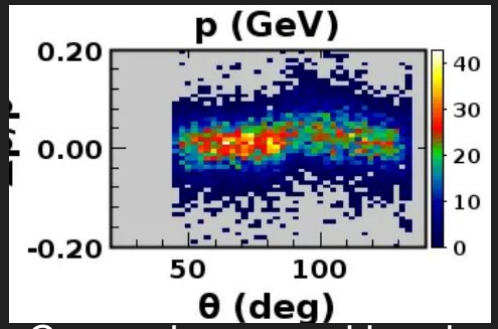
Deuteron - LD2+Cu (solid vertex) - Removing material



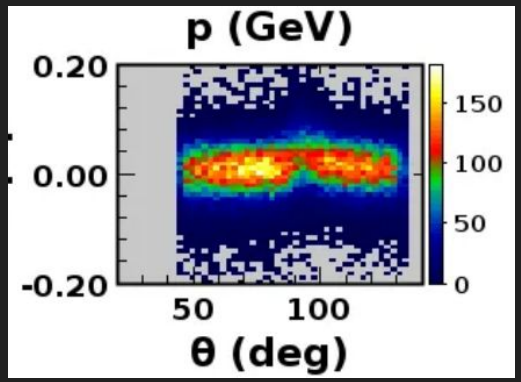
Copper boxes removed



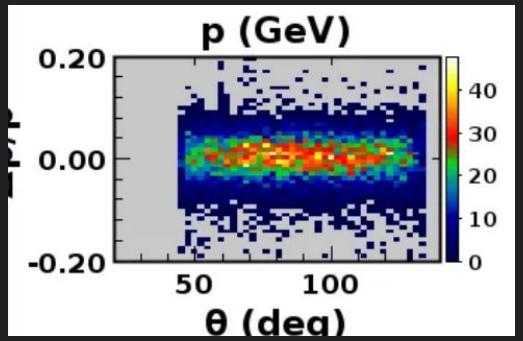
Solid target removed



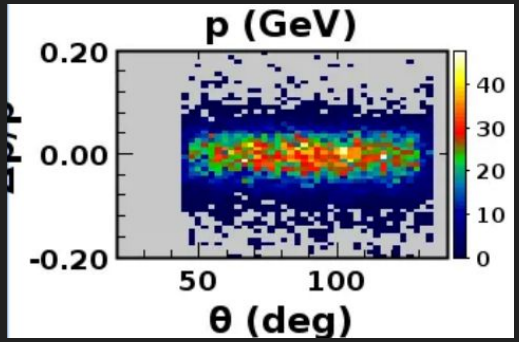
Copper boxes and band removed



Copper boxes, band and tracks removed



Copper boxes, band, tracks and solid target removed



Everything removed

Analyses in progress

- Uditha’s Lambda analysis -> Presentation later
- Ryan’s inclusive analysis -> Next presentation
- Antonio’s pions MR analysis
- Mike’s proton analysis
- Simon’s BEC for pions analysis
- Sebouh’s Di-hadron Correlations analysis

Summary

- Calibration has progressed significantly since last meeting (almost completed)
- Next main tasks: AI network training and DC efficiency studies.
- Pass-1 cooking review by end of August 2025.
- Studies show current energy loss in CVT implementation works for RGE
- Multiple analyses in progress using RGE data.