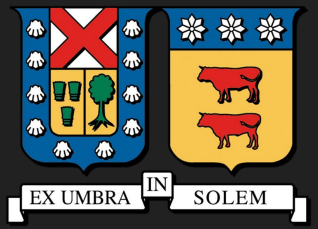
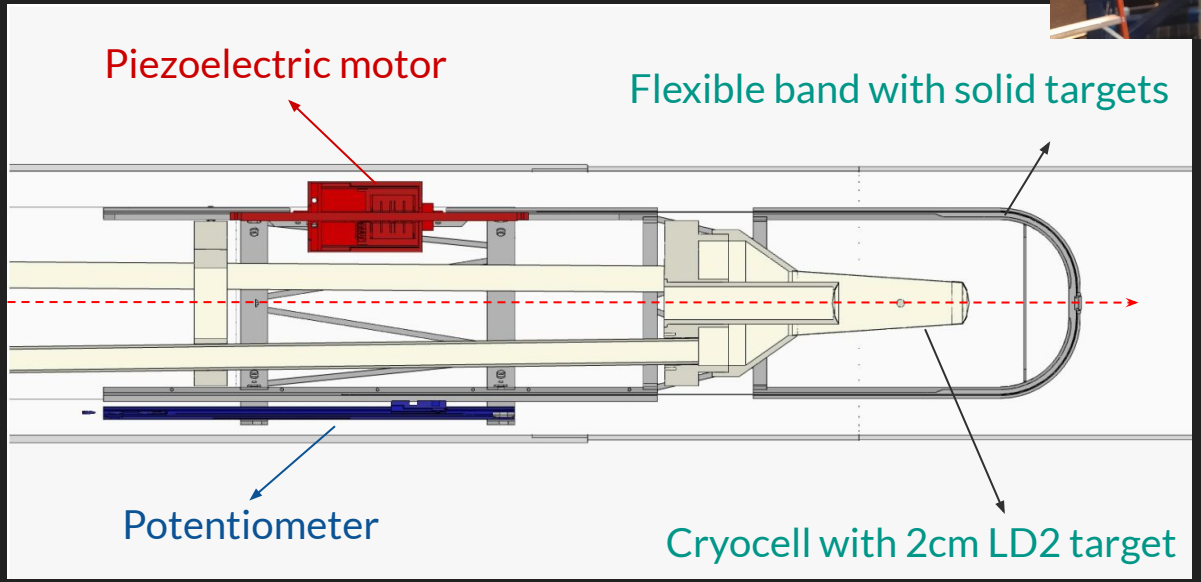
RG-E Updates

Antonio Radic

CLAS collaboration meeting
November 18 - 21 2025



RG-E Double-target system



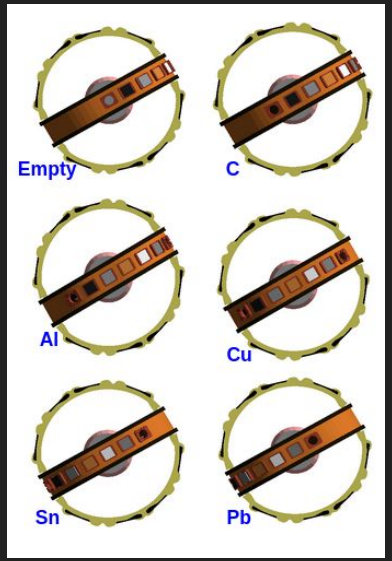
Solid target
- Carbon
- Aluminum
- Copper
- Tin
- Lead

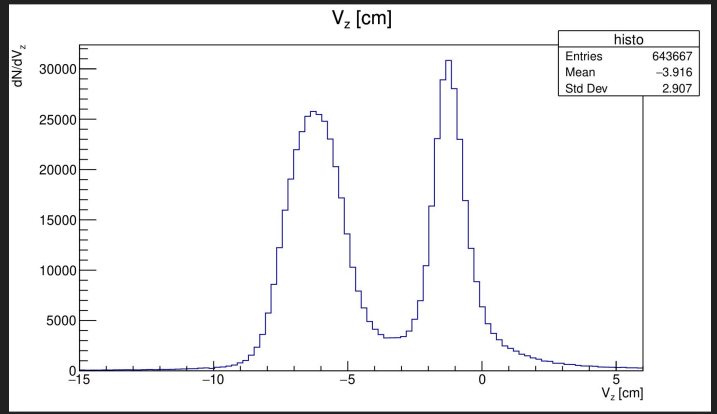
Liquid target
- Deuterium

Run summary and data collected

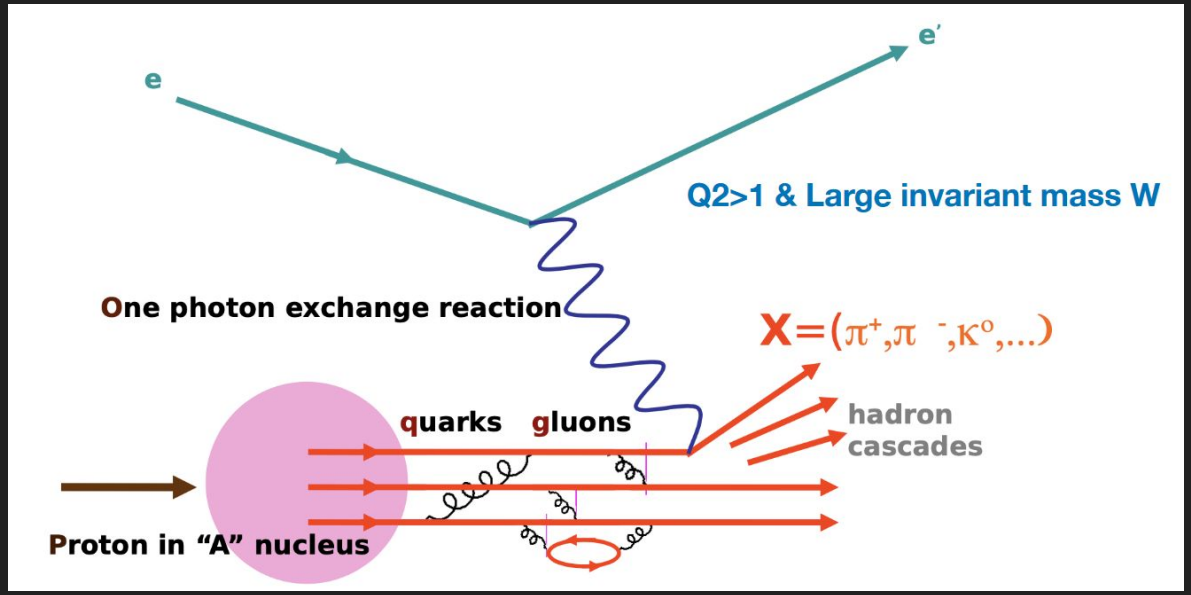
- Data taken in Spring 2024 from March 15th to May 19th
- 10.547 GeV electron beam
- Standard CLAS12 configuration with FT-OFF
- Three layers of FMT
- ~93% of data taking with inbending torus polarity

Target	Production current (nA)	Accumulated charge (mC)	Integrated luminosity (1/fb) (Solid target)	Events
LD2+C	85	25.24	24.38	3,391,704,235
LD2+Al	70	20.53	24.23	2,445,718,954
LD2+Cu	75	21.46	22.42	2,488,996,497
LD2+Sn	65	27.6	21.58	2,754,243,416
LD2+Pb	70	46.84	26.76	4,631,998,074
C only	85	2.29	3.79	148,150,553
Pb only	160	4.98	2.84	23,516,294





Semi-Inclusive Deep Inelastic Scattering (SIDIS)



ν: energy of the virtual photon (energy loss of the incoming electron).

Q2: square of four-momentum transferred.

Q2 > 1 GeV2: Deep process to look inside the structure of the nucleus.

W: invariant mass of the final state X.

W > 2 GeV: Inelastic. This cut removes the resonance region.

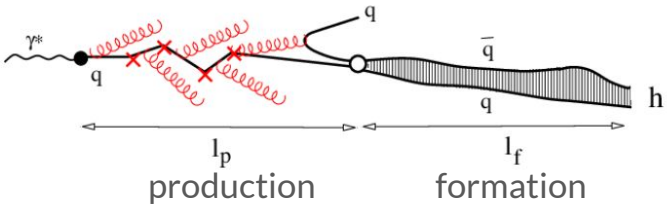
y: fraction of the energy of the initial electron transferred to the virtual photon.

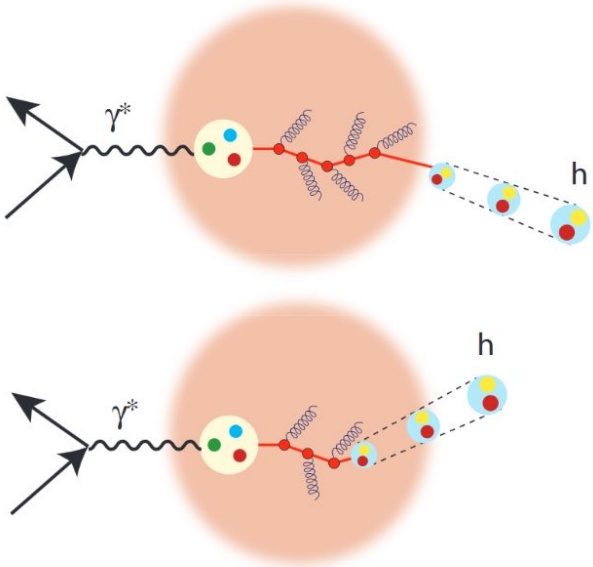
y < 0.85: reduce radiative effects.

Zh: fraction of the virtual photon energy carried to the produced hadron.

Pt: transverse momentum of the hadron with respect to the virtual photon.

Hadronization in nuclear media





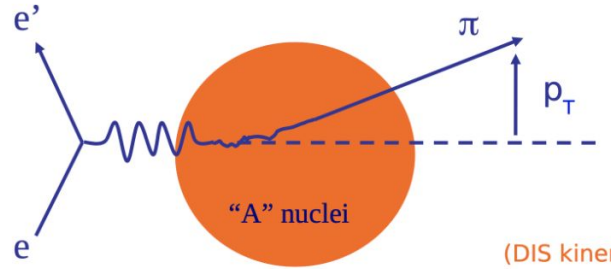
Prehadron formed **outside** the nucleus

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.

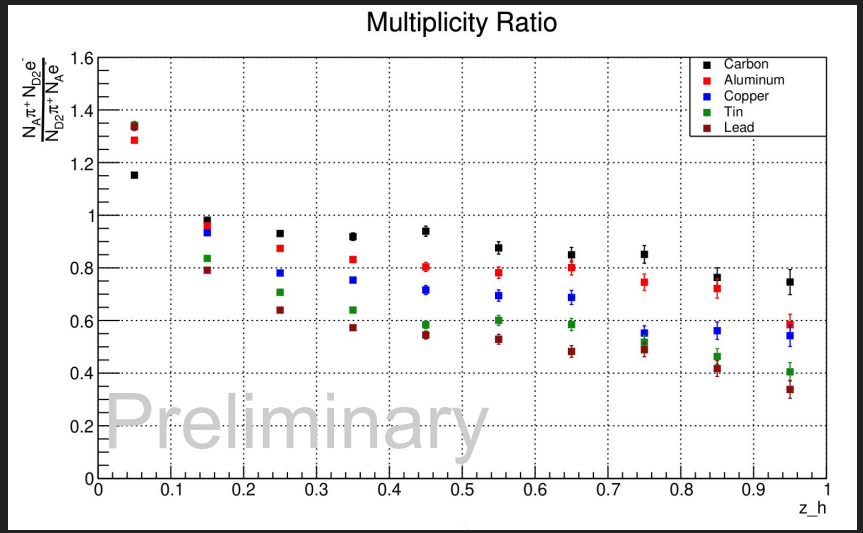
Physics and observables

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



Hadronic multiplicity ratio:

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



RGE Calibration status

- Last cooked version: pass0.9 (last one before cooking review)
- Done from last collaboration meeting:
  - AI network for assisted DC tracking
  - DC tracking efficiency studies DC vs MC
  - Final sign-off of CLAS12 subsystems
- In progress:
  - Physics analysis for review
  - Preparing for review
- Next Step:
  - Calibration review
  - Run pass-1

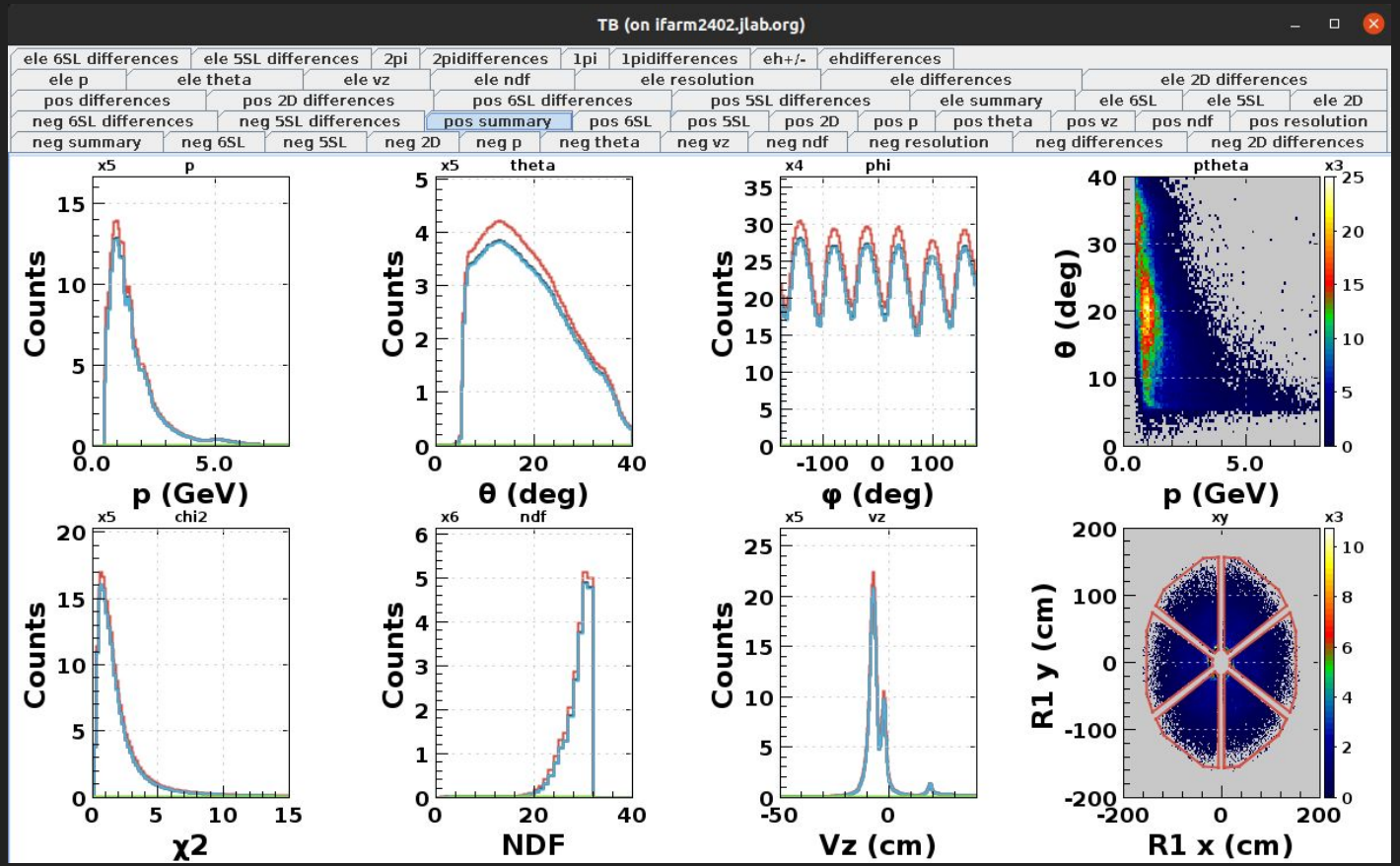
	July 2025	Nov 2025
DC alignment		
CVT alignment		
FMT alignment		
beam offset calibration	in prog	
raster calibration		
fix timing global offsets		
online calibration		
pass-0 (initial assessment)		
DC time offset calibration		
FTOF calibration I		
RF calibration		
DC calibration I		
pass-0 (1st round assessment)		
BAND calibration	in prog	in prog
CND calibration		
CTOF calibration		
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)		in prog
readiness review		

AI network for assisted DC tracking

- Three AI networks were tested for RGE dataset
  - 2 new trained network based on RGE data
  - 1 network previously trained with RGD data
- RGE AI networks trained based on runs:
  - 20150 (LD2+C)
  - 20267 (LD2+Pb)
- All networks were tested on one LD2+C and LD2+Pb run
- Best performance network was chosen for cooking of the whole RGE dataset

AI tracking validation - Pb run and Pb network

- AI
- Conventional
- AI matched with Conventional
- Conventional not matched with AI



AI over Conventional results

Network applied to LD2+C run

C network

charge	type	gain	efficiency
neg	0	1.0810	0.9970
neg	6	1.0707	0.9978
neg	5	1.2906	0.9793

charge	type	gain	efficiency
pos	0	1.0838	0.9946
pos	6	1.0780	0.9958
pos	5	1.1920	0.9714

type	eh+/e	eh-/e
conventional	0.6515	0.1527
ai	0.6966	0.1696

Pb network

charge	type	gain	efficiency
neg	0	1.0868	0.9976
neg	6	1.0757	0.9984
neg	5	1.3118	0.9814

charge	type	gain	efficiency
pos	0	1.0949	0.9953
pos	6	1.0851	0.9964
pos	5	1.2799	0.9747

type	eh+/e	eh-/e
conventional	0.6515	0.1527
ai	0.7023	0.1705

RGD network

charge	type	gain	efficiency
neg	0	1.0765	0.9946
neg	6	1.0670	0.9967
neg	5	1.2703	0.9518

charge	type	gain	efficiency
pos	0	1.0809	0.9916
pos	6	1.0695	0.9929
pos	5	1.3001	0.9664

type	eh+/e	eh-/e
conventional	0.6515	0.1527
ai	0.6951	0.1687

Network applied to LD2+Pb run

C network

charge	type	gain	efficiency
neg	0	1.0735	0.9972
neg	6	1.0635	0.9981
neg	5	1.2891	0.9776

charge	type	gain	efficiency
pos	0	1.0779	0.9952
pos	6	1.0713	0.9962
pos	5	1.2139	0.9731

type	eh+/e	eh-/e
conventional	0.6525	0.1442
ai	0.6937	0.1590

Pb network

charge	type	gain	efficiency
neg	0	1.0785	0.9977
neg	6	1.0677	0.9985
neg	5	1.3113	0.9792

charge	type	gain	efficiency
pos	0	1.0874	0.9957
pos	6	1.0772	0.9966
pos	5	1.3001	0.9753

type	eh+/e	eh-/e
conventional	0.6525	0.1442
ai	0.6983	0.1597

RGD network

charge	type	gain	efficiency
neg	0	1.0688	0.9947
neg	6	1.0601	0.9970
neg	5	1.2563	0.9420

charge	type	gain	efficiency
pos	0	1.0749	0.9924
pos	6	1.0632	0.9936
pos	5	1.3182	0.9677

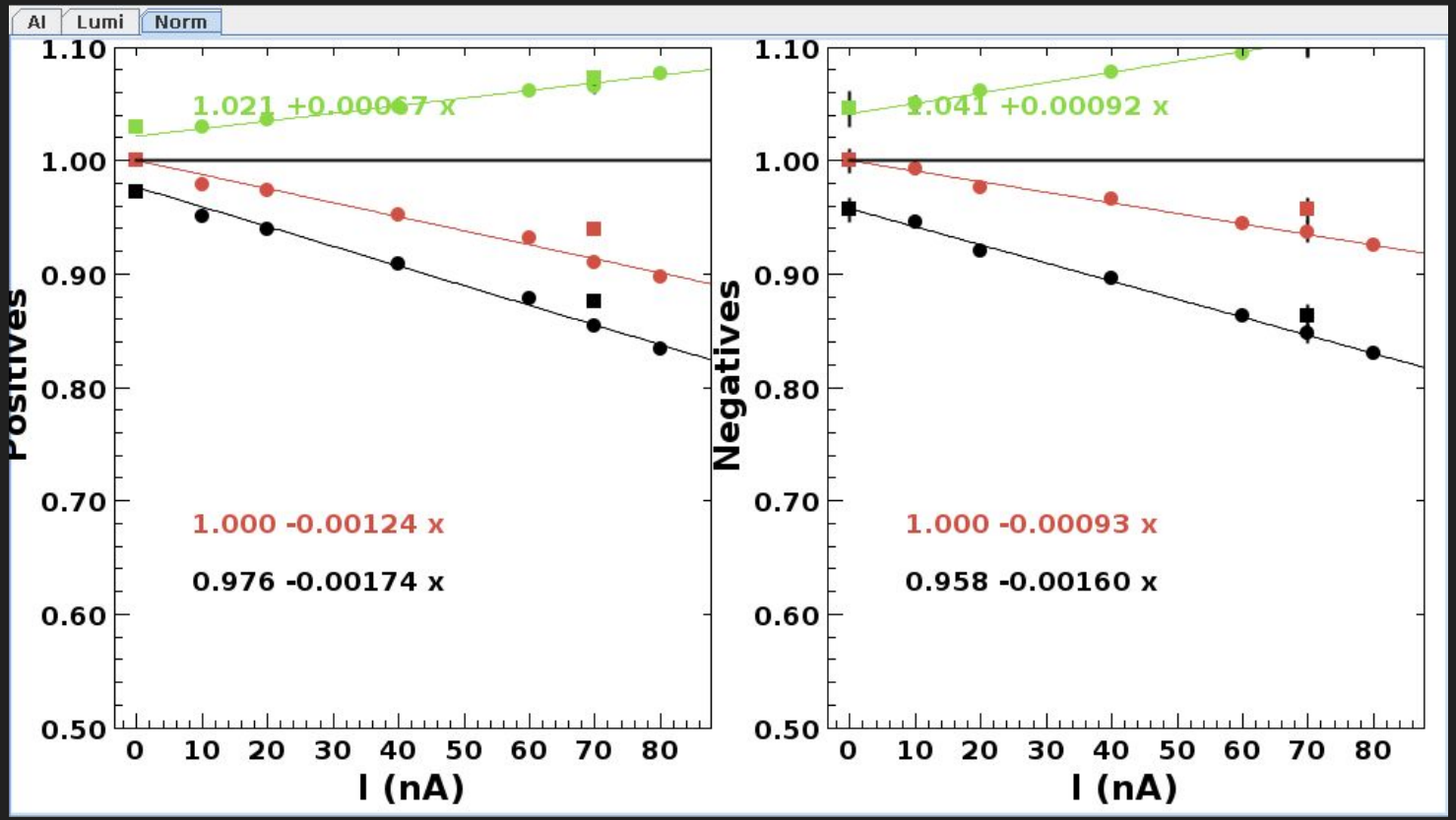
type	eh+/e	eh-/e
conventional	0.6525	0.1442
ai	0.6921	0.1582

DC tracking efficiency studies

- 3 sets of lumi scans
  - LD2+Pb: runs 20236-20243, 10 to 100 nA
  - LD2+Al: runs 20490-20493, 5 to 45 nA
  - LD2+Pb: runs 20494-20505, 5 to 55 nA
  - Production runs 20256 (LD2+Pb) and 20481 (LD2+Al)

- Al
- Conventional
- Al/Conventional Ratio

DC tracking efficiency studies - lumi scans



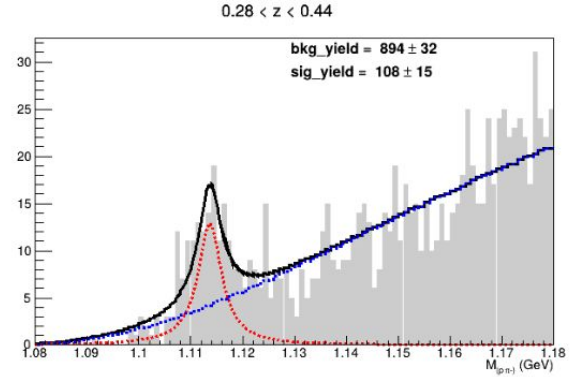
Analyses in progress

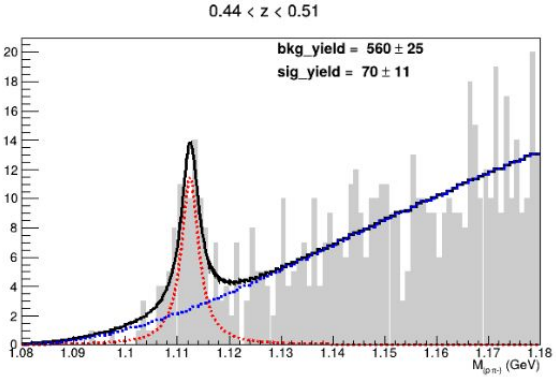
- Uditha’s Lambda analysis
- Ryan’s inclusive analysis -> Next presentation
- Antonio’s pions MR analysis
- Mike’s proton analysis
- Simon’s BEC for pions analysis
- Sebouh’s Di-hadron Correlations analysis
- Sebouh’ Anti-proton analysis

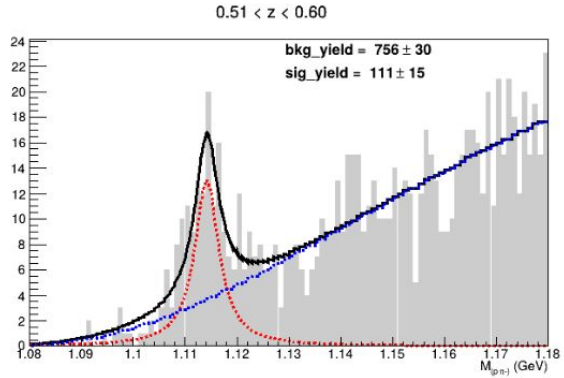
Lambda Invariant Mass Distributions from LD2

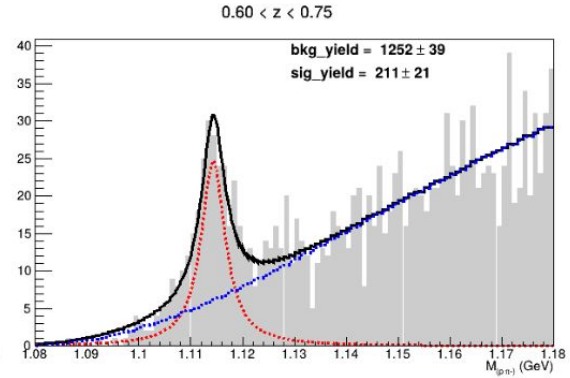
Plots made by Uditha

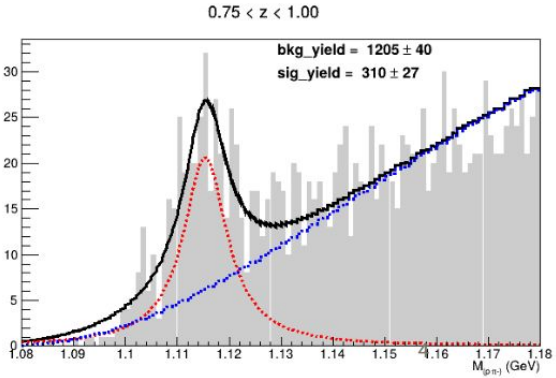
- Bins Used:
  - 0.28 < z < 0.44 (combination of 0.28 < z < 0.38 and 0.38 < z < 0.44)
  - 0.44 < z < 0.51
  - 0.51 < z < 0.60
  - 0.60 < z < 0.75
  - 0.75 < z < 1.00







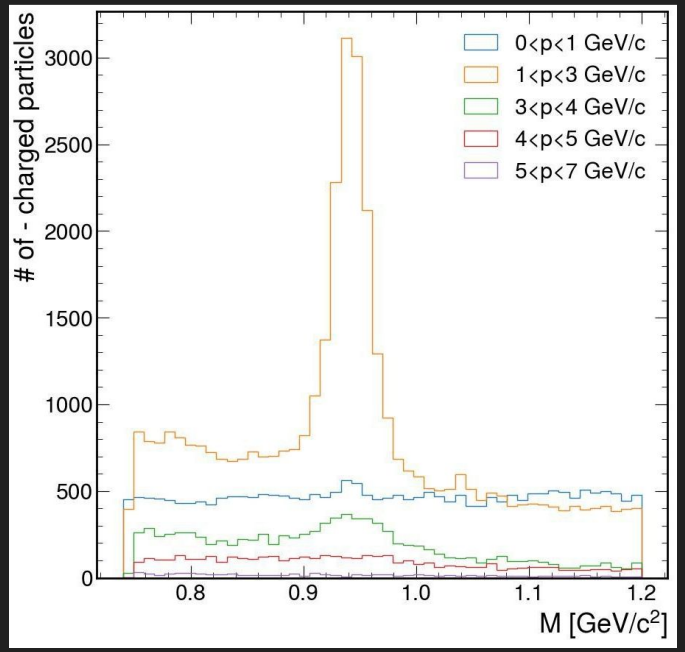


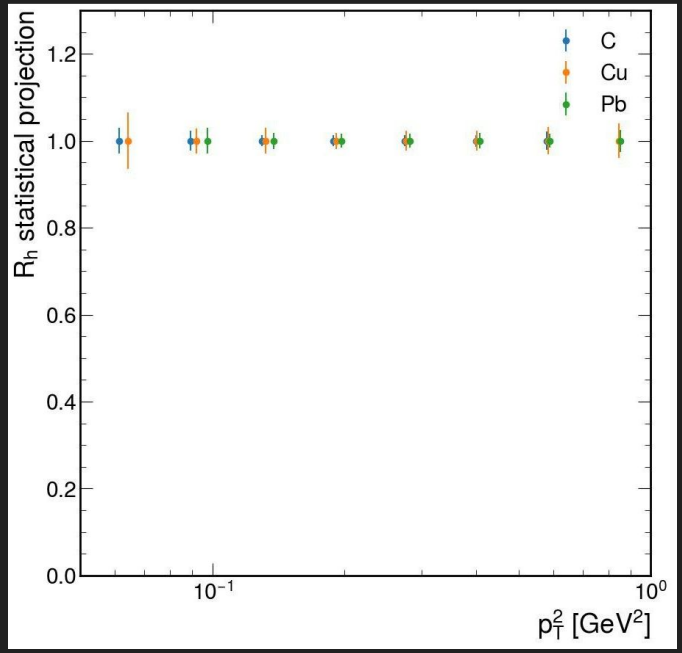


Anti-Proton analysis

Plots by Sebouh

- Invariant mass distributions for Anti-proton candidates indifferent bins in momentum





- Statistical projections for bins in Pt^2 for R_h

Summary

- Calibration almost completed. Pass-1 review soon
- AI network was produced to be used in RGE data that increase tracks yield in DC tracking
- Increase of track efficiency from ~85 to over 90% with new RGE AI network
- Multiple analyses in progress using RGE data