Update on RG-D Run, Calibration and Analysis Status

CLAS Collaboration Meeting March 2024
March 13, 2024

Mikhail Yurov
Mississippi State University

Run Group D

Comprised of two experiments (E12-06-106, E12-06-106A):

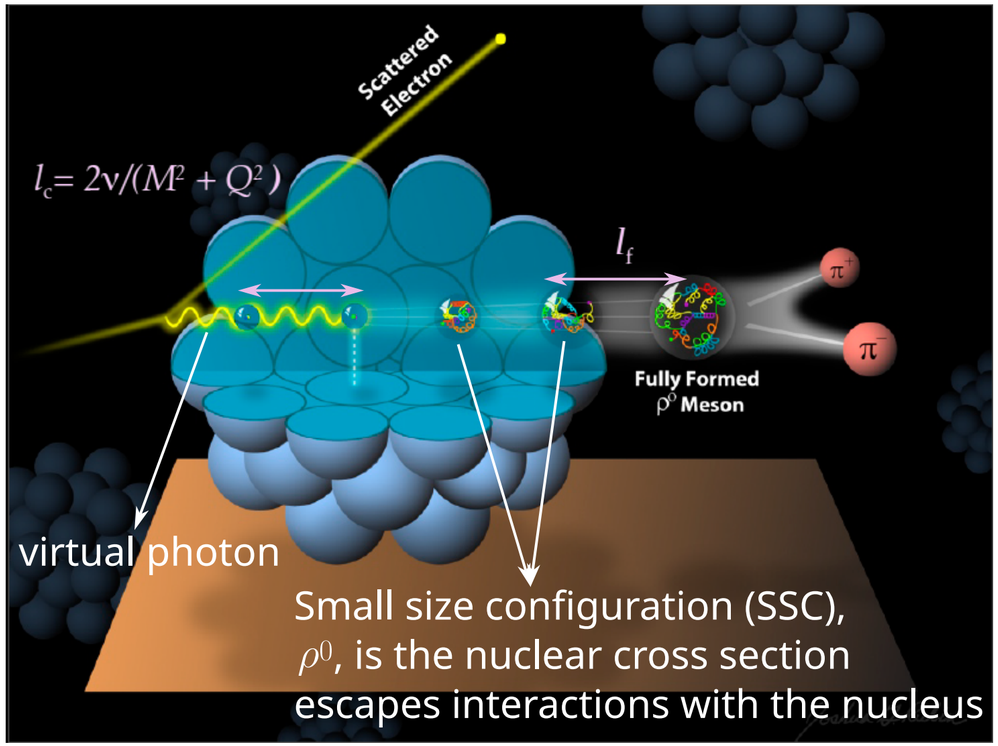
- Study of Color Transparency (CT) in Exclusive Vector Meson Electroproduction off Nuclei
  - Spokespeople: W. Armstrong[1], L. El Fassi[3], K. Hafidi[1], M. Holtrop[4], and B. Mustapha[1]
- Nuclear TMDs in CLAS12
  - Spokespeople: R. Dupré[2], L. El Fassi[3], Zein-Eddine Meziani[1], and Holly Szumila-Vance[5]
- Institutions:
  - [1]Argonne National Lab (ANL), [2]IJCLAB, Orsay, France [3]Mississippi State U. (MSSate), [4]University of New-Hampshire (UNH), [5]Jefferson Lab

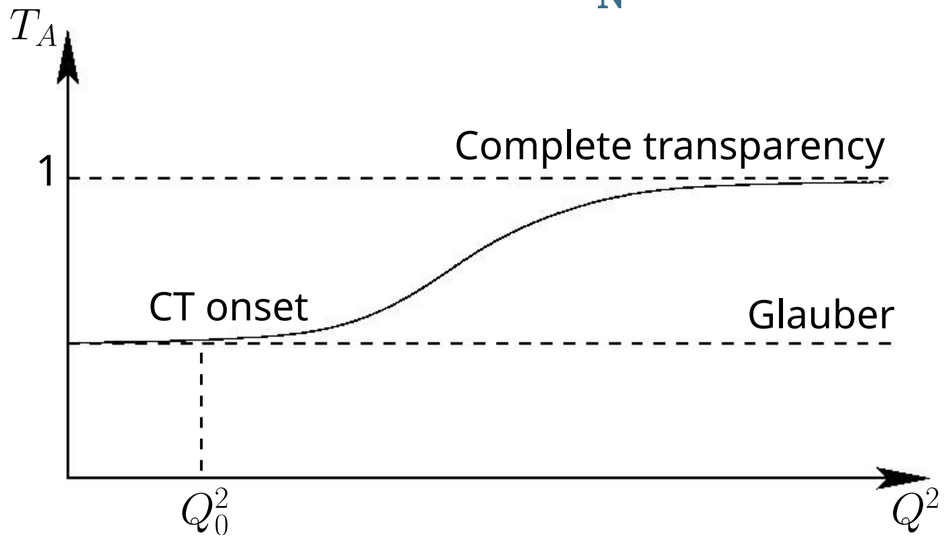
RG-D: CT Experiment

- E12-06-106
  - CT signature - increase of the medium “nuclear” transparency, $T_A = \frac{\sigma_A}{A\,\sigma_N}$, as a function of Q^2
  - ρ^0 - electroproduction for several nuclear targets

σ_A - nuclear cross section

σ_N - free (nucleon) cross section



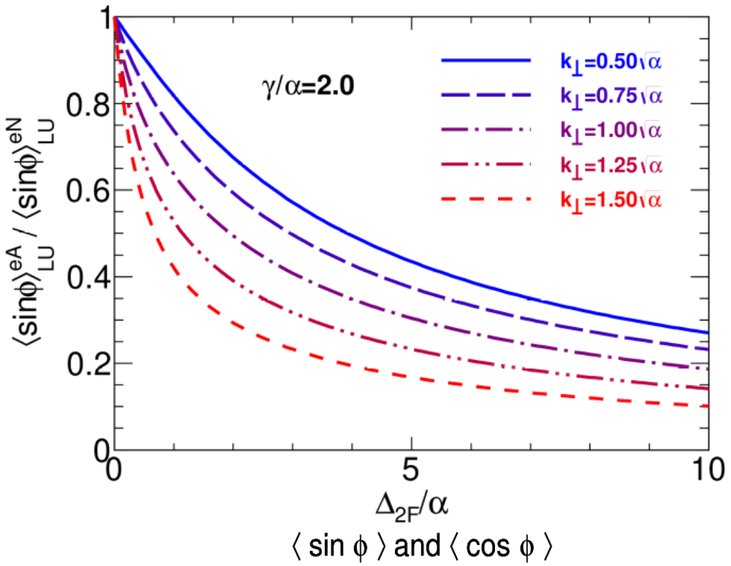


l_c, coherence length - the lifetime of the qq-bar pair

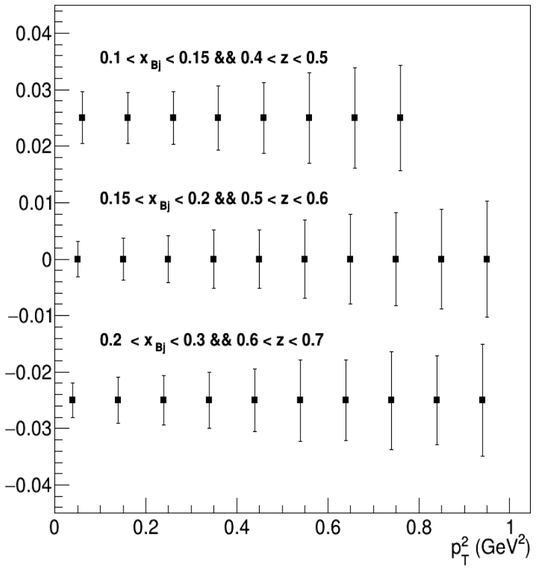
l_f, formation time - the time evolution of SSC to an on-shell ρ^0 meson

RG-D: Nuclear TMDs Experiment

- E12-06-106A aims to explore
  - new approach for nuclear SIDIS
  - fragmentation functions in nuclei
  - missing part of nuclear effects description
  - nuclear asymmetries at the partonic level
- Nuclear TMDs extraction
  - similar to nucleon TMDs
  - different modulation of cross section terms
  - is complicated due to the convolution with fragmentation functions
  - accesses transport coefficient at parton level from first moments



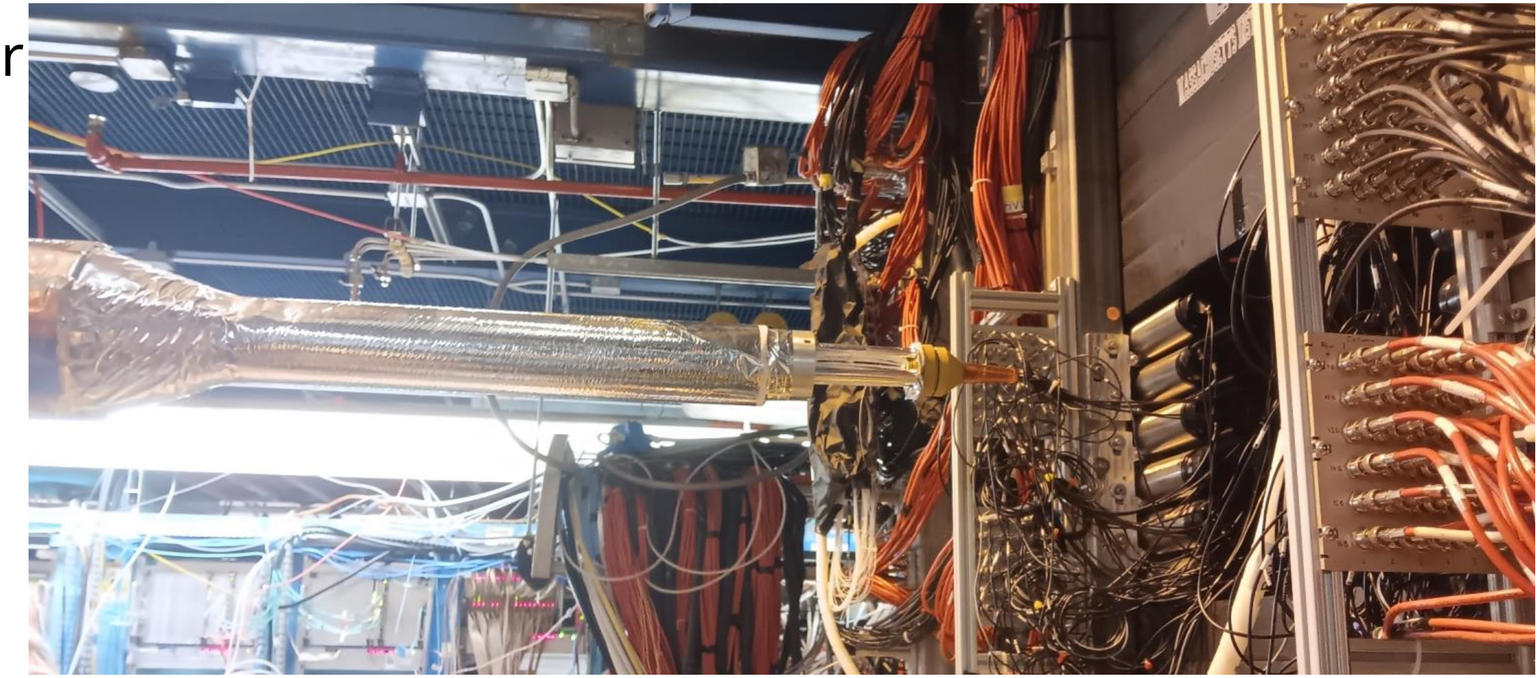
⟨ sin ϕ ⟩ and ⟨ cos ϕ ⟩



Run Configuration

- 10.54 GeV polarized beam
- Standard CLAS12 configuration with FT-OFF and three layers of FMT
- New cryogenic LD2 and the nuclear-foils flag assembly
  - centered at -5 cm for both solid and liquid targets
- RG-A/B in/outbending e^- trigger
- Combination of different beam currents and target thicknesses

91um Cu foils



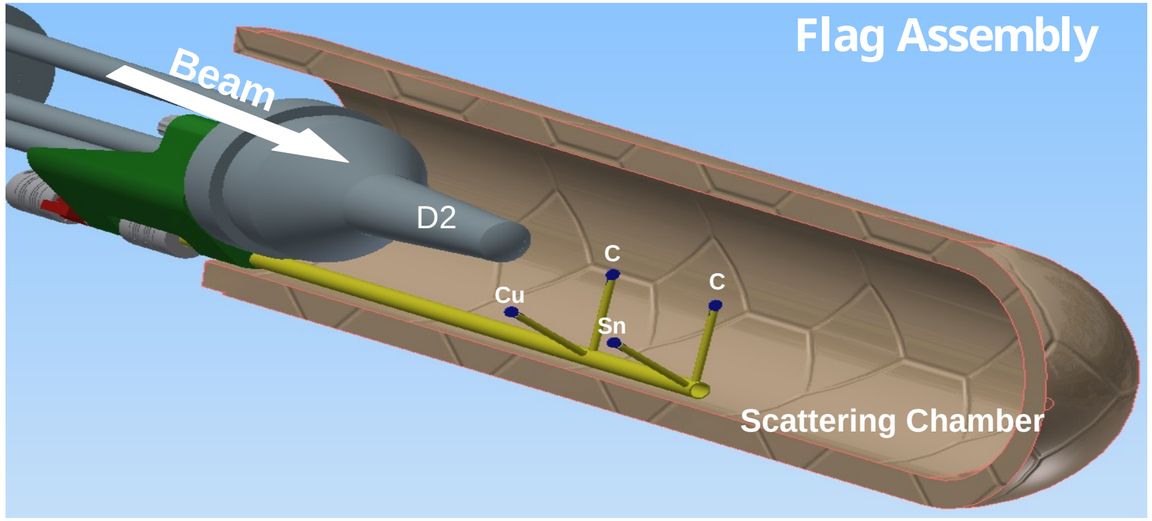
Newly built Hall B cryogenic target

Run Configuration

- Target thicknesses (within 2% X_0)

Targets	Thickness (2 foils) (cm)	Density ($g.cm^{-3}$)	Areal Density (T) ($mg.cm^{-2}$)	Radiation Length (X_0) ($g.cm^{-2}$)	Radiation Lengths (T/X_0) (%)	Beam Current (nA)	Per-nucleon Luminosity (10^{35} cm^{-2} s^{-1})
LD_2	5	0.164	820	125.98	0.65	50 (/ 60)	1.5 (/ 1.8)
^{12}C	0.2 (0.4)	2.2	440	42.7	1.03 (2.06)	50	1.7
^{63}Cu / ^{120}Sn	0.0093 / 0.0171	8.96 / 7.31	83.33 / 125	12.86 / 8.82	0.65 / 1.417	95	0.76

- Adjusted beam currents (preventing X-ray damage to CD, MVT & SVT, by Sn)
- Y. Gotra Lumi. runs analysis



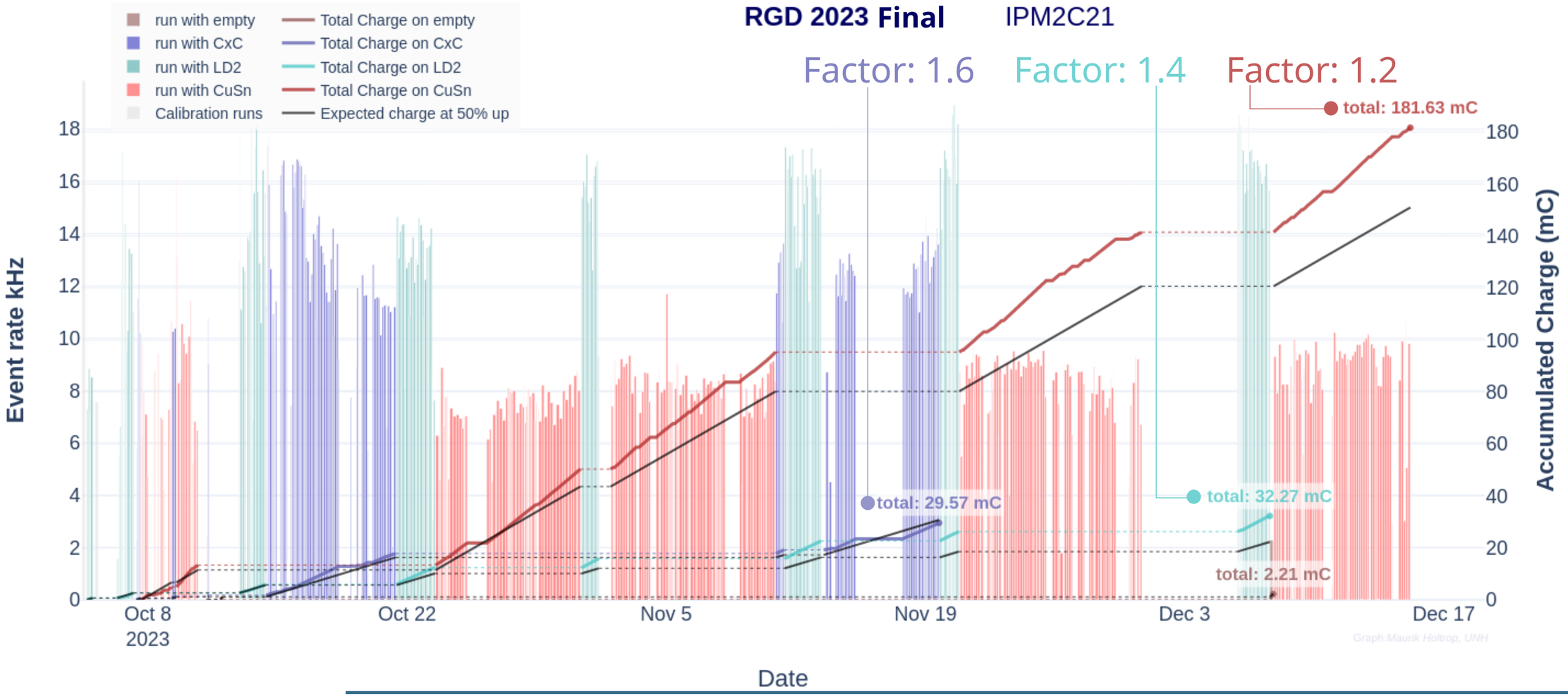
Run Configuration

- Revised run plan
  - Increased beam-time allocation to CuSn targets
  - Adjusted time for LD2 and CxC targets

Targets Configuration (Current Setting)	Beam Time (PAC days)
LD_2 (@ 35 - 50 nA)	1.5
CuSn (@ 130 → 100 nA)	4
LD_2 (@ 50 nA)	1.5
CxC (@ 50 nA)	3.5
LD_2 (@ 60 nA)	0.5
CuSn (@ 90 - 95 nA)	3.5
LD_2 (@ 60 nA)	1
CxC (@ 50 nA)	2.2
LD_2 (@ 60 nA)	0.5
CuSn (@ 95 nA)	8
LD_2 (@ 60 nA)	0.5
CuSn (@ 95 nA)	3
LD_2 (@ 60 nA)	0.5
target change + Møller Meas.	2

Run Configuration

- Successful completion of RG-D data taking (Oct. 04, 2023 - Dec. 15, 2023)
- Final RG-D Collected Data



RG-D Special Studies

- Trigger efficiency

  Thanks to Valery, Ben and Rafayel for preparing and validating RG-D trigger
  Multiple dedicated runs: regular trigger, DC roads, low Q^2 suppression

- DC efficiency

  Thanks to Florian, Veronique, and Aron for the DC efficiency scan analysis
  Dedicated DC HV scan runs: efficiency plateau

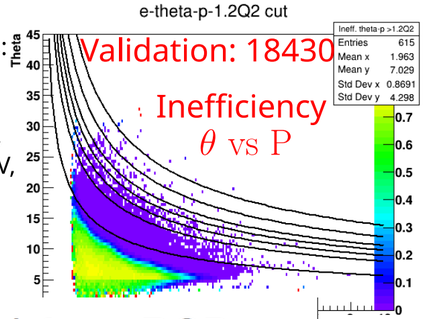
- Alignment

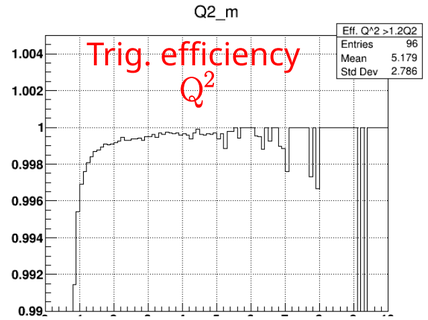
  Thanks to Raffaella and Matthew
  Empty target zero-field runs

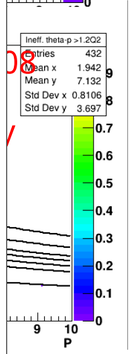
  next talk by Matthew Maynes

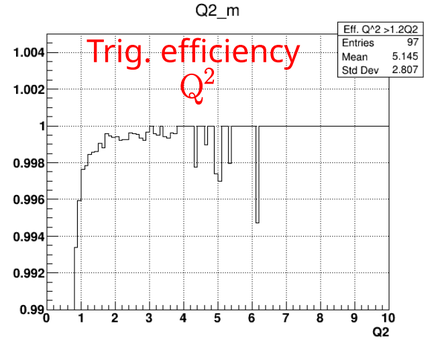
Good electrons:
pid=11,
FD,
PCAL>60MeV,
ETOT>250MeV,

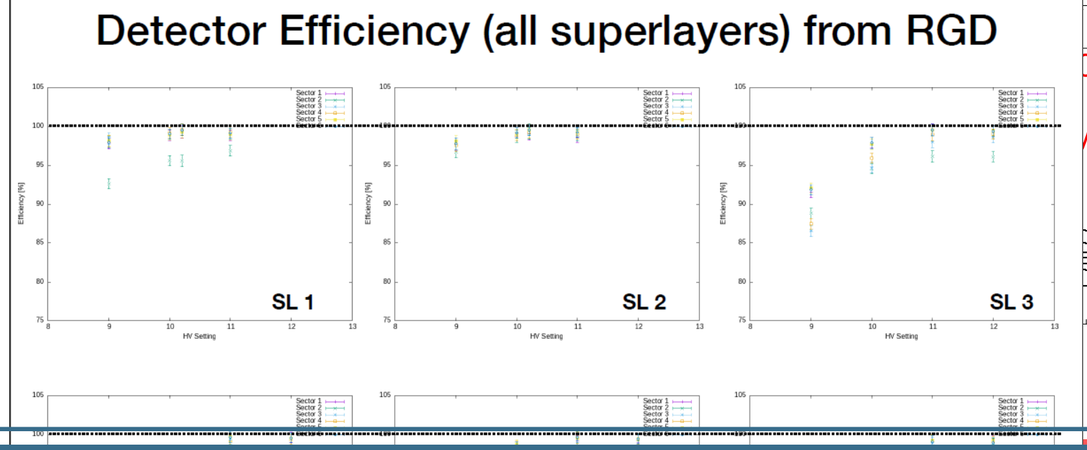
Q^2 lines
6.0 GeV^2







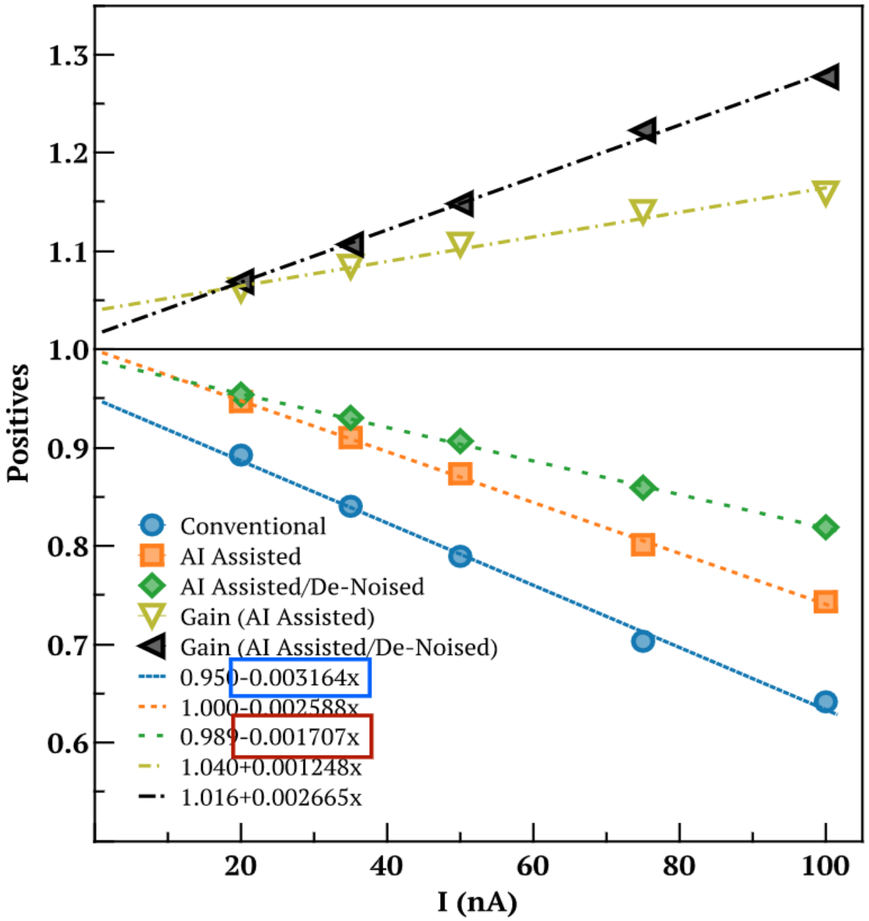


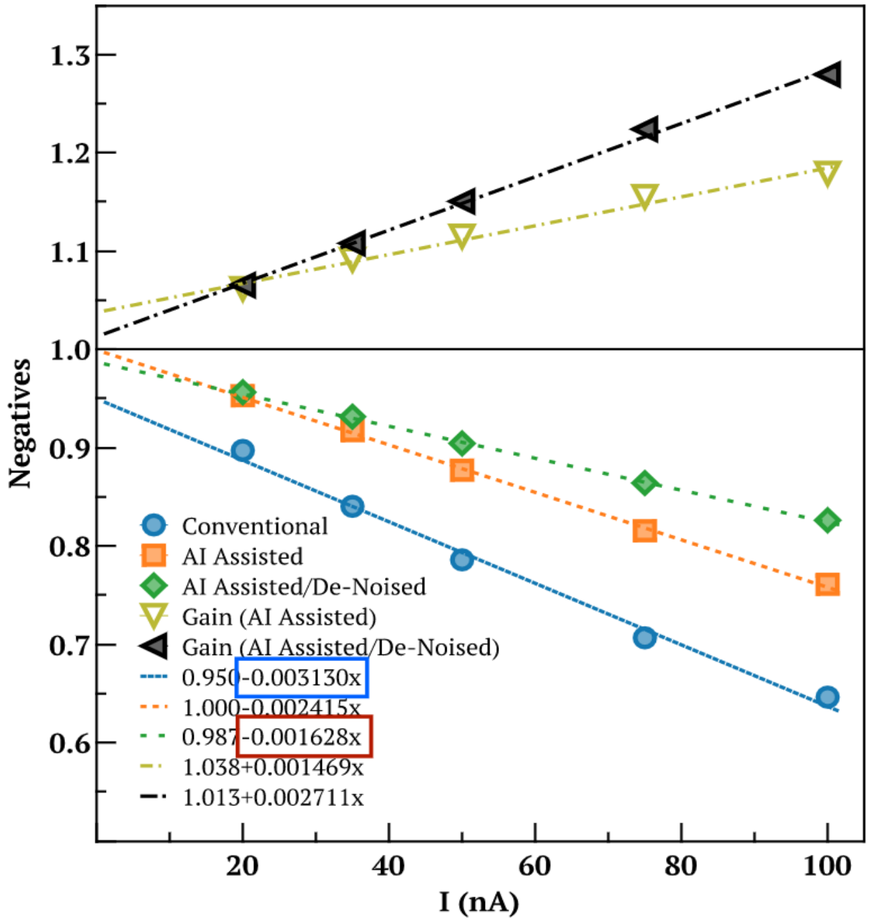


RG-D Special Studies

- Luminosity scans

  Thanks to Raffaella and Gagik for initial analysis and AI-assisted study (RG-B network)

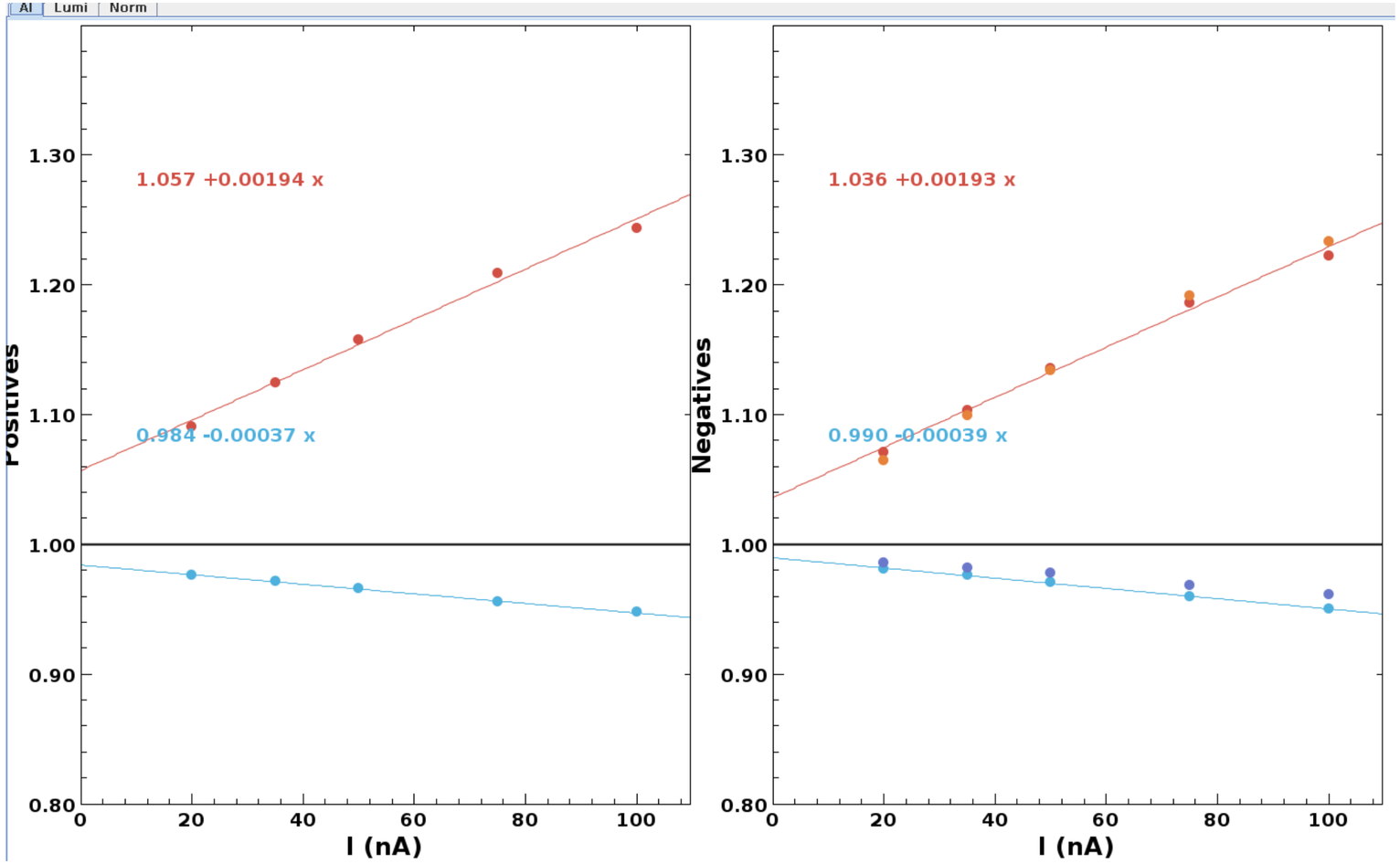




RG-D Special Studies

- Luminosity scans

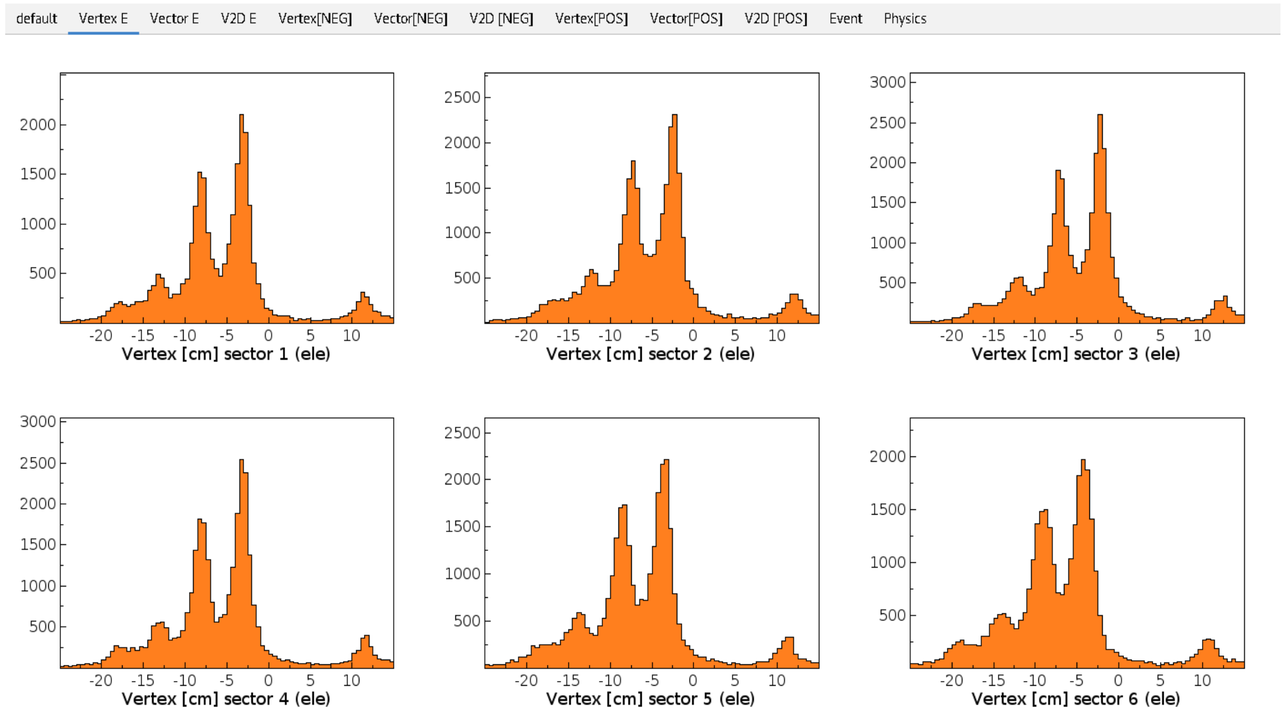
  Thanks to Daniel Matamoros for preliminary dedicated RG-D AI training (run 18305)



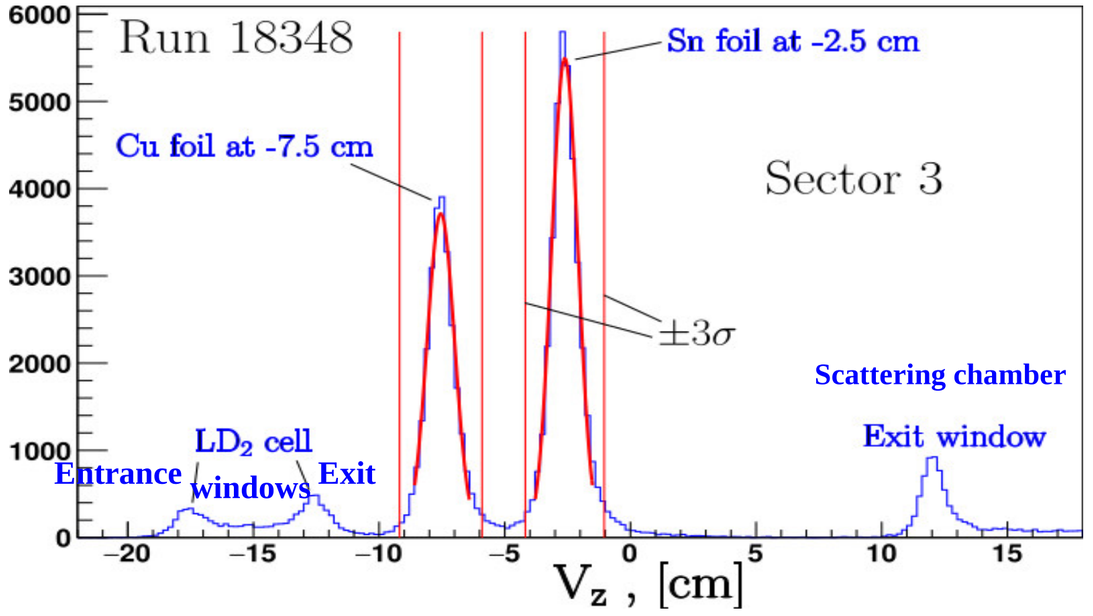
RG-D Special Studies

- Conventional + AI-assisted online reconstruction

  Thanks to Gagik for implementation - first operational during RG-D



online V_z vertex reconstruction



calibration cooking V_z vertex reconstruction

RG-D Calibration

- Online calibration during the run period: **pass0.1 --> pass0.3**
  Thanks to CALCOM group (detector and calibration experts)

  detailed summary of calibration progress:
  https://clasweb.jlab.org/wiki/index.php/Run_Group_D#tab=Calibration_and_Alignment

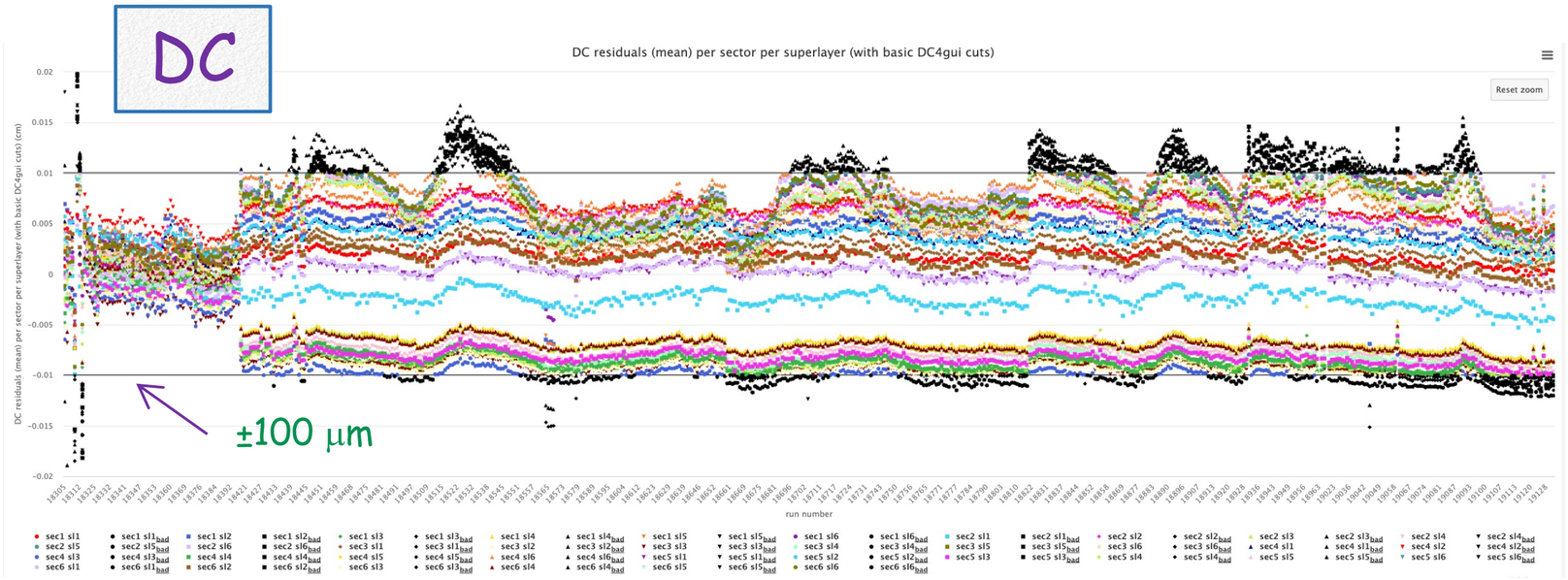
  - BCM calibrations w.r.t. FC, Beam Blocker attenuation
  - Online Calibration/Alignment w/. Empty Target
  - Online calibration for Outbending and Inbending data

- Most recent updates

  - DC: T2D pressure-dependent calibration, L3 sensor pressure values, T0
  - Manual adjustments to RF offsets (of -55/+280 ps)
  - first FMT alignment constants, FMT and BMT HV tables

RG-D Calibration

- Work in progress
  - Thermal contraction of cryo-target system analysis for alignment (RG-K cold/warm target runs)
  - Preparation for Pass0.4 cooking and timelines
  - Preparation for RG-D final calibration review
    - addressing review points from CALCOM



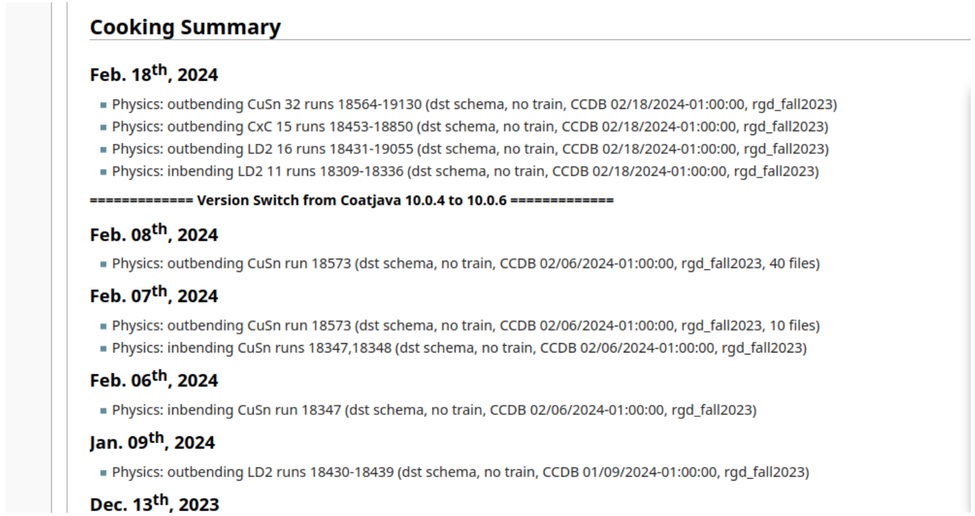
Courtesy of D. Carman

RG-D Data Processing

- RG-D run period 18305 - 19131

detailed summary of online/offline cooking:

https://clasweb.jlab.org/wiki/index.php/Run_Group_D#tab=Data_Processing_2



Cooking Summary

Feb. 18th, 2024

- Physics: outbending CuSn 32 runs 18564-19130 (dst schema, no train, CCDB 02/18/2024-01:00:00, rgd_fall2023)
- Physics: outbending CxC 15 runs 18453-18850 (dst schema, no train, CCDB 02/18/2024-01:00:00, rgd_fall2023)
- Physics: outbending LD2 16 runs 18431-19055 (dst schema, no train, CCDB 02/18/2024-01:00:00, rgd_fall2023)
- Physics: inbending LD2 11 runs 18309-18336 (dst schema, no train, CCDB 02/18/2024-01:00:00, rgd_fall2023)

========== Version Switch from Coatjava 10.0.4 to 10.0.6 ==========

Feb. 08th, 2024

- Physics: outbending CuSn run 18573 (dst schema, no train, CCDB 02/06/2024-01:00:00, rgd_fall2023, 40 files)

Feb. 07th, 2024

- Physics: outbending CuSn run 18573 (dst schema, no train, CCDB 02/06/2024-01:00:00, rgd_fall2023, 10 files)
- Physics: inbending CuSn runs 18347,18348 (dst schema, no train, CCDB 02/06/2024-01:00:00, rgd_fall2023)

Feb. 06th, 2024

- Physics: inbending CuSn run 18347 (dst schema, no train, CCDB 02/06/2024-01:00:00, rgd_fall2023)

Jan. 09th, 2024

- Physics: outbending LD2 runs 18430-18439 (dst schema, no train, CCDB 01/09/2024-01:00:00, rgd_fall2023)

Dec. 13th, 2023

- cooking: coatjava 10.0.4 --> 10.0.6
- "golden run list" compilation is done by Matthew and Lamiaa
- Analysis Coordinator: Lamiaa El Fassi/ Cooking Chef: M. Yurov

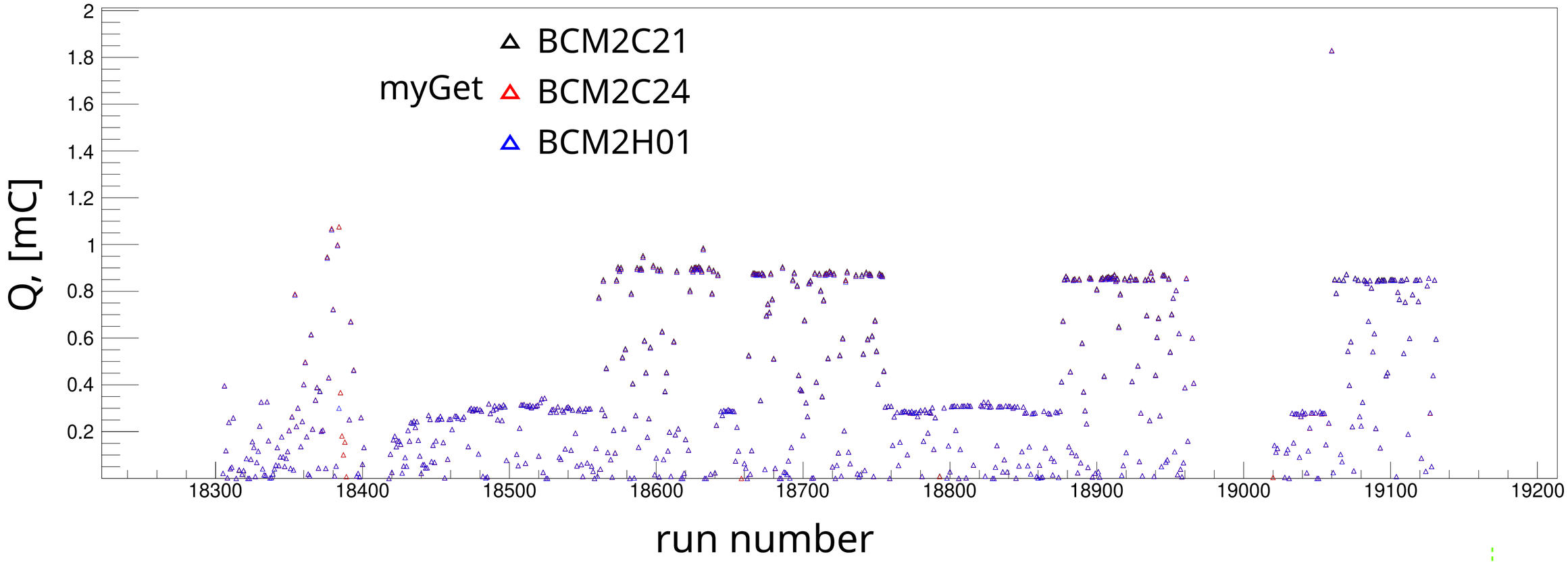
RG-D Data Processing

- RG-D accumulated charge measurements
  - "before" FC gated missing; "after" FC ion pump failure; good FC: **2023-10-07(18353) to 2023-10-17 (18479)**
  - dedicated meeting to discuss the gated beam charge calculation based on BCM and LT data
  - Rafo final calibration constants BCM2C21/24: `https://logbooks.jlab.org/entry/4201989`

- BCM charge extraction
  - Live-time as measured by TS board "B_DAQ:livetime"
  - LT corrected integrated charge - delQ = I(i) * delT * LT(delT) - charge for i-th record
  - Work in progress: comparison to Maurik's analysis

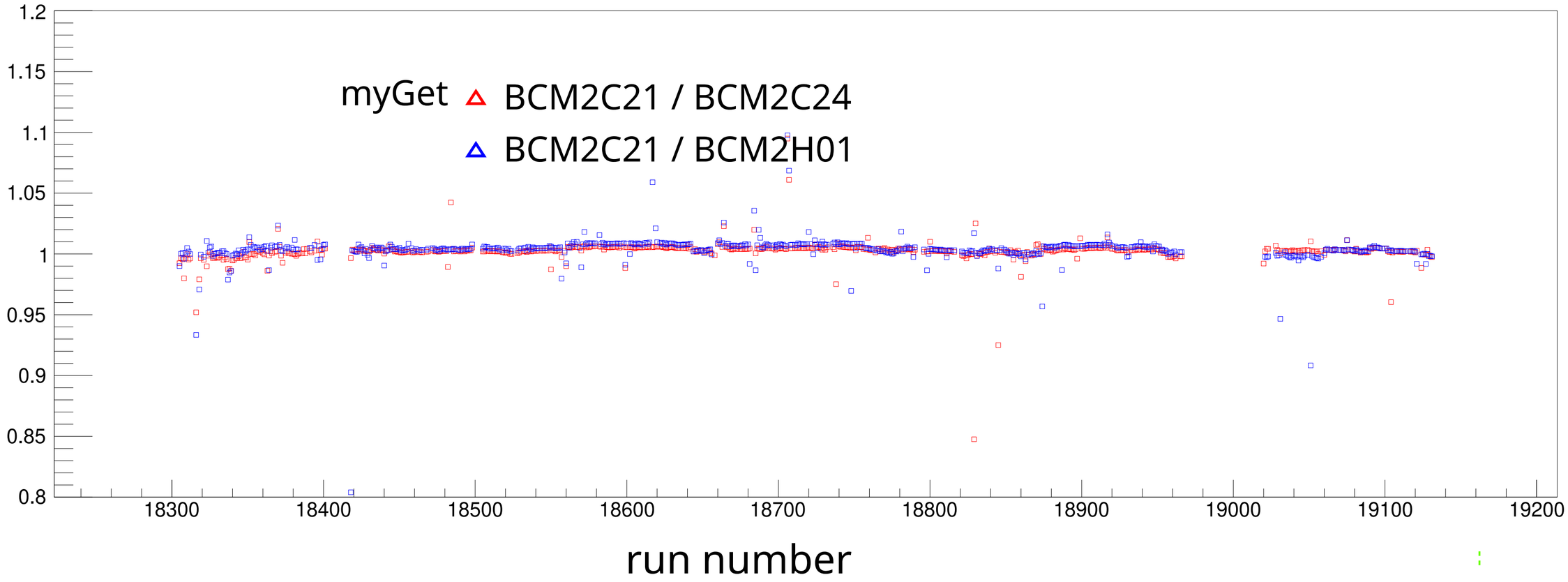
RG-D Data Processing

- RG-D accumulated charge measurements
  - calibrated BCM2C21, calibrated BCM2C24, uncalibrated BCM2H01 [mC]



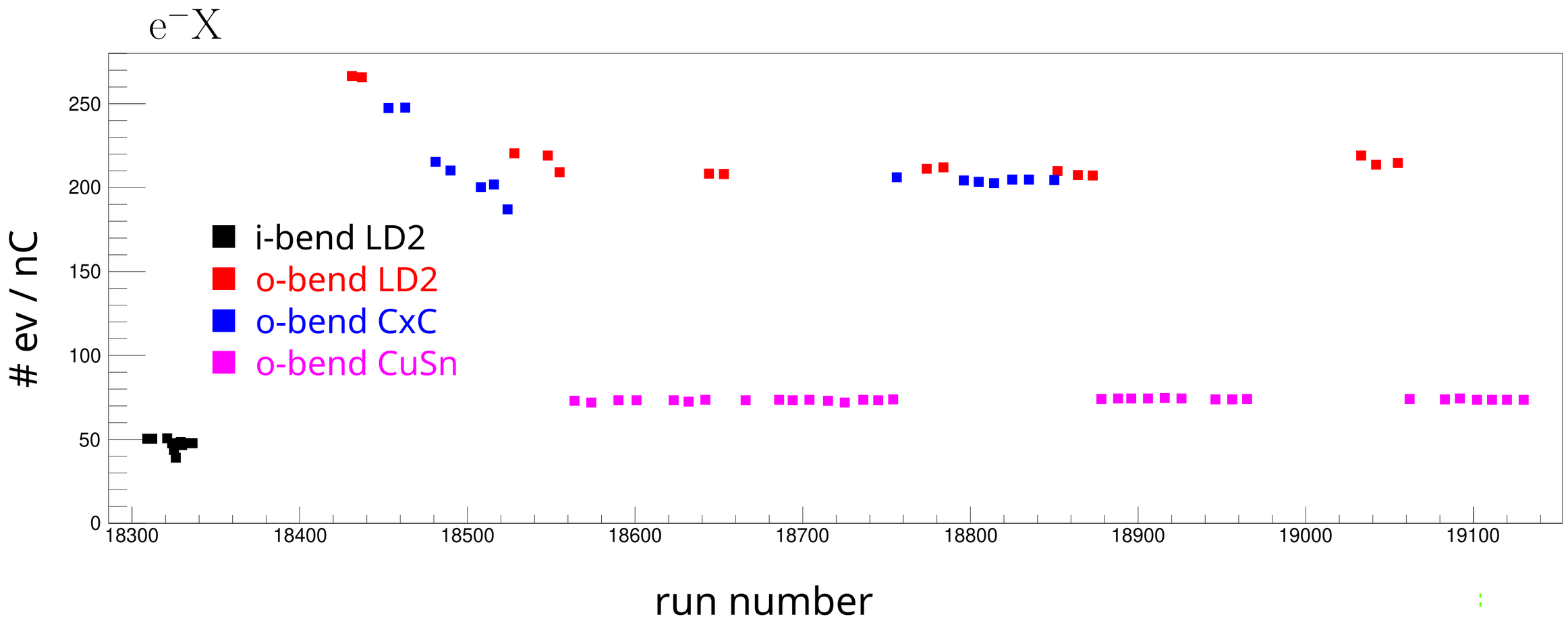
RG-D Data Processing

- RG-D accumulated charge measurements
  - run accumulated LT correctred BCMs charge ratio for the RGD run period



RG-D Data Processing

- RG-D very preliminary yield checks
  - Q-normalized counts for selected number of runs in 4 configurations



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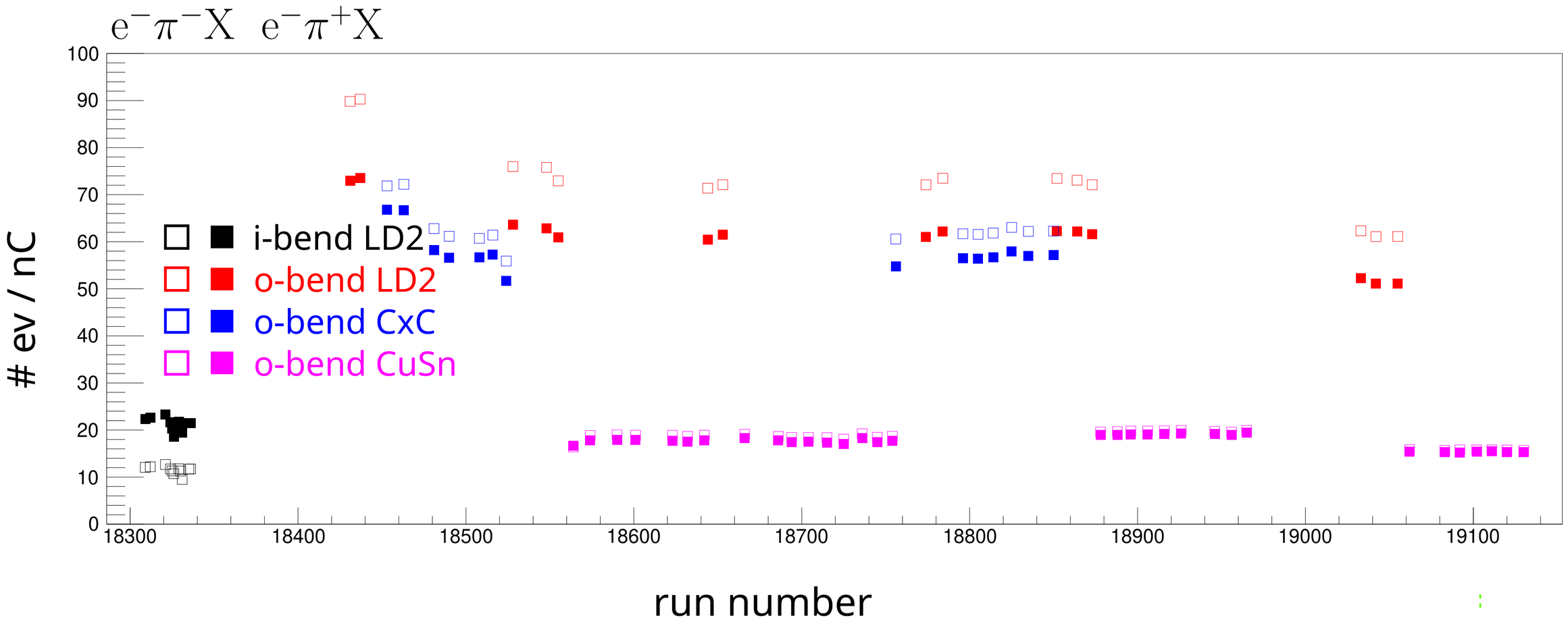

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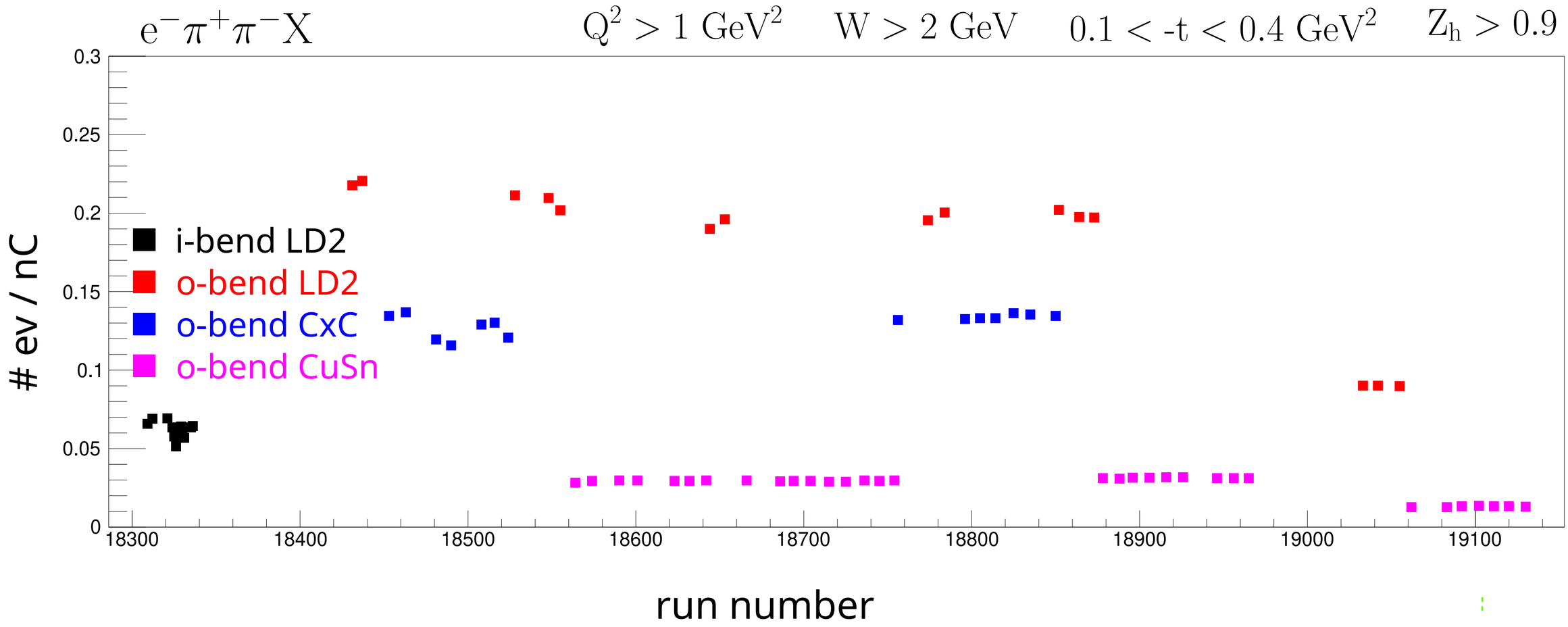
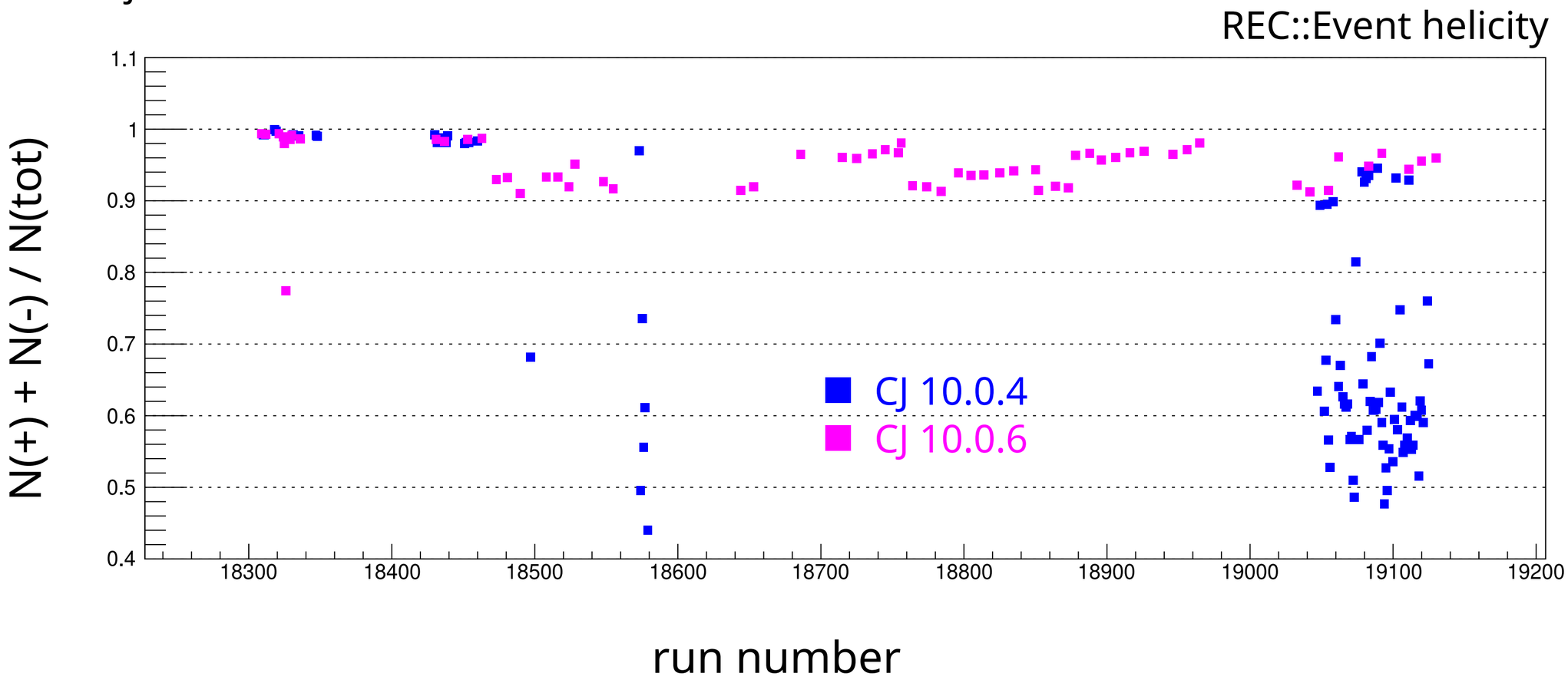


RG-D Data Processing

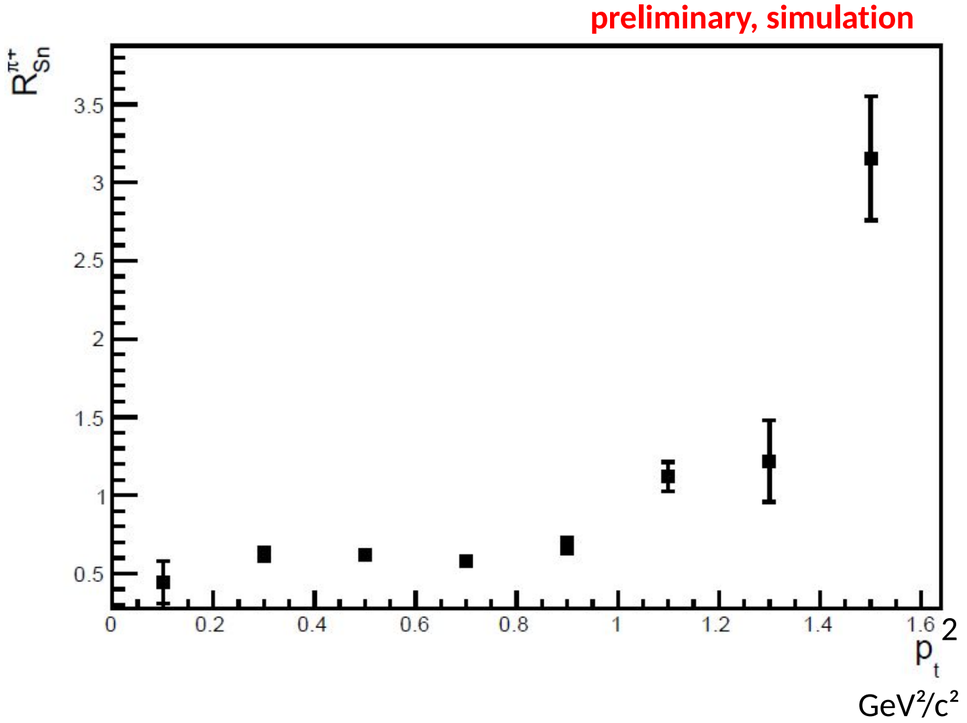
- RG-D helicity efficiency checks (see yesterday's Nathan talk)
  - event misordering due to incorrect configuration
  - coatjava modifications introduced as of 10.0.6



RG-D Data Processing

- Ongoing: analysis development on nuclear TMD observables (Daniel Matamoros)
  - yields, R, P_t, $\cos\phi$ ratio
- Extraction example of $R_A^{\pi}(Q^2,\nu,z,p_t^2) = \dfrac{N_{\pi}^{Sn}(Q^2,\nu,z,p_t^2)/N_e^{Sn}(Q^2,\nu)}{N_{\pi}^{D}(Q^2,\nu,z,p_t^2)/N_e^{D}(Q^2,\nu)}$
  - Pythia event generator on DIS on nucleus with added nuclear effects
  - Full GEMC simulation for π^+production,

Daniel Matamoros RG-D meeting presentation



Summary

- Successful completion of RG-D data taking in Dec. 2023
- Getting ready for RG-D final calibration review (and Pass0.4 cooking)
- Developing analysis tools for CT and nuclear TMD is in progress
  - ANL
    - graduate students: Suman Shrestha (jointly w/. TU; co-advised by Analysis Coordinator)
    - postdocs: Jihee Kim, Shivangi Prasad, Marshall Scott
    - staff: Whitney Armstrong, Sylvester Joosten, Zein-Eddine Meziani, Chao Peng, and Maria Zurek
  - IJCLAB: Raphäel Dupré + Daniel Matamaros
  - JLab: Holly Szumila-Vance
  - MSState: L. El Fassi, Matthew Maynes, and Mikhail Yurov
  - Temple U.: Hamza Atac, Suman Shrestha, Nikolaos Sparveris
  - UCONN: Kyungseon Joo, Timothy Hayward, Utsav Shrestha,....
  - UNH: Maurik Holtrop
  - USC: Yordanka Ilieva
- End-of-run Party

This work is supported in part by the U.S. DOE award #: DE-FG02-07ER41528.