Status Update on the x>1 Analysis

Casey Morean
cmorean@jlab.org

January 12, 2022

*This work was supported by the U.S. Department of Energy, Office of Science, Office of Nuclear Physics, under contract DE-SC0013615.

THE UNIVERSITY OF TENNESSEE KNOXVILLE
Jefferson Lab

Outline

Physics Overview

Commissioning Dataset

- Results from 2018/2019 data
- Finalize manuscript

Full Dataset

- *Online* Physics Results
- Detector Calibrations
- Studies
- Software
- Future Work

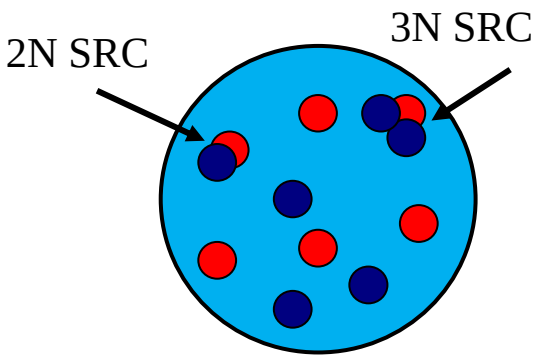
Short Range Correlations (SRCs)

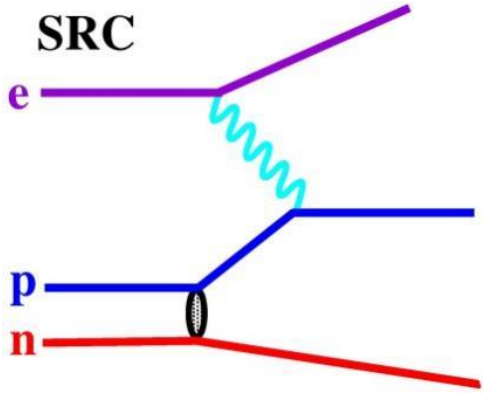
SRCs are characterized by a high back-to-back momentum and a low center of mass momentum

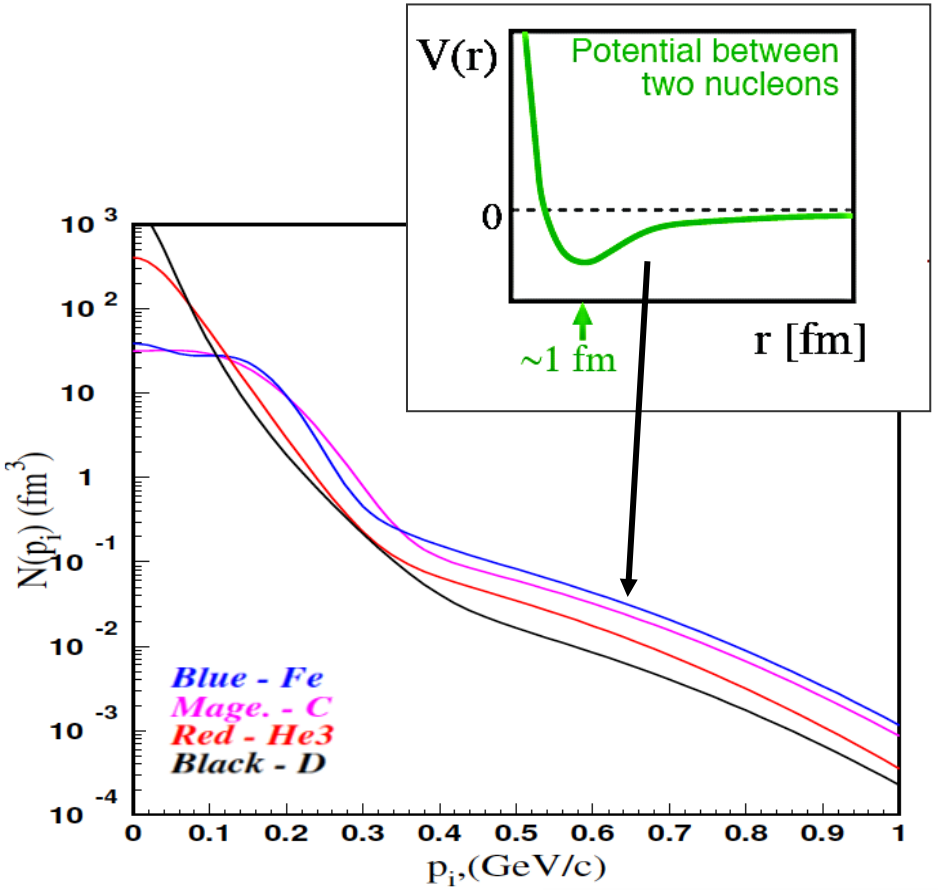
SRCs yield universal structure at high momentum

Scattering from low-momentum suppressed at $x > 1$

Electron-nucleon scattering cross-sections are expected to scale (no Q^2 or x dependence) → plateau in σ_A/σ_D

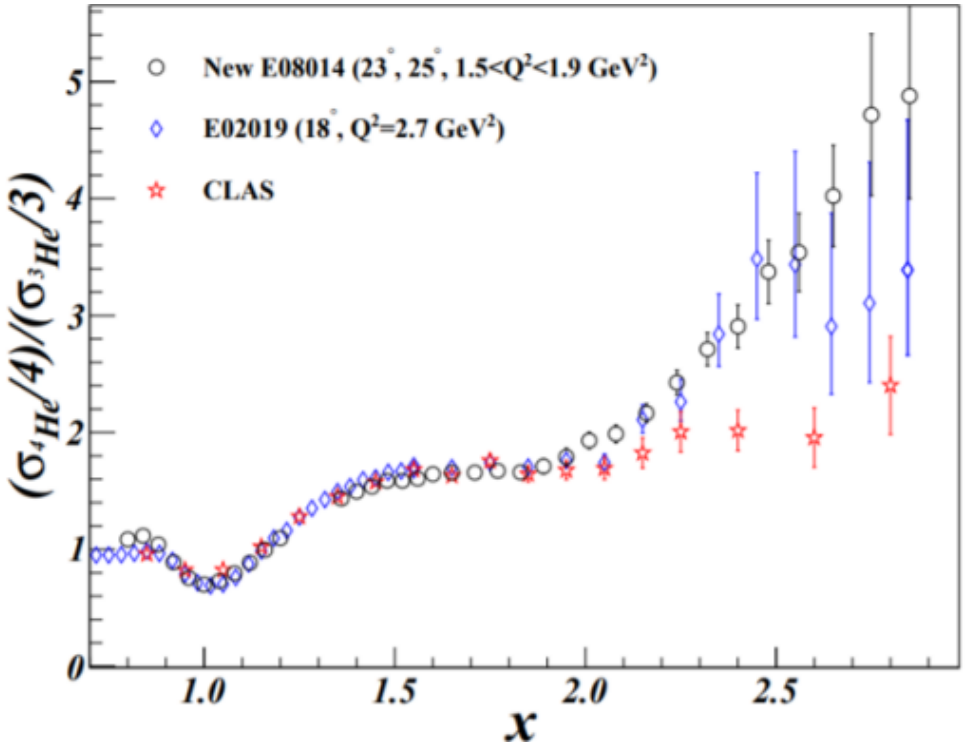




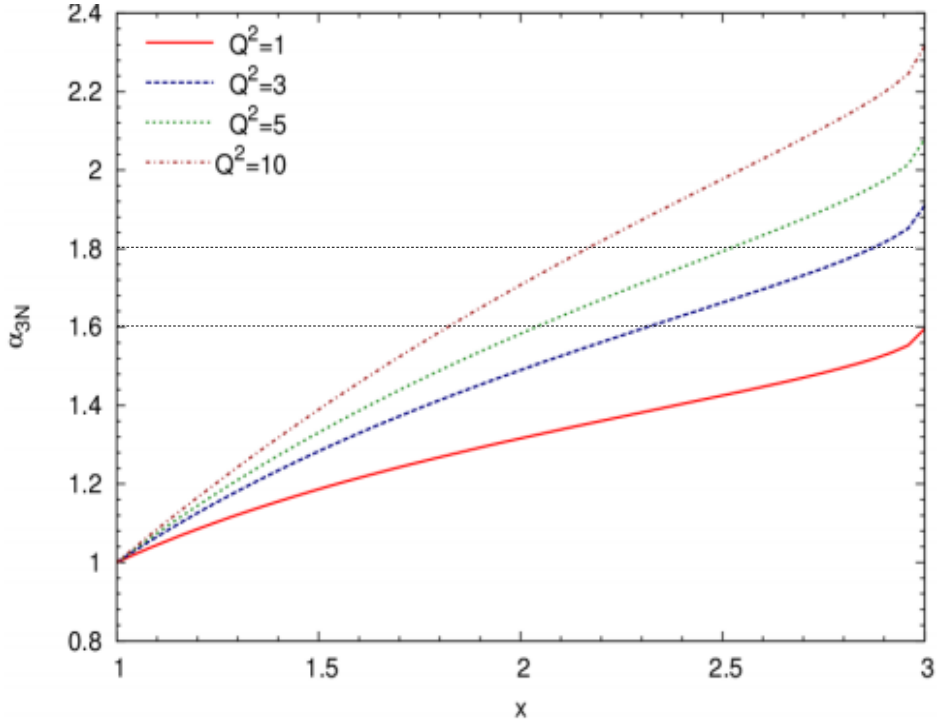


E12-06-105: 3N SRCs at High Q^2

- α_{3N} allows for more precise determination of SRC onset
- Current work suggests 3N SRCs do not become dominant until higher Q^2
  - α_{3N} of around 1.6-1.8; Q^2 >3 GeV^2
- Proposed subset of nuclei reaches highest Q^2 in the minimal amount of time



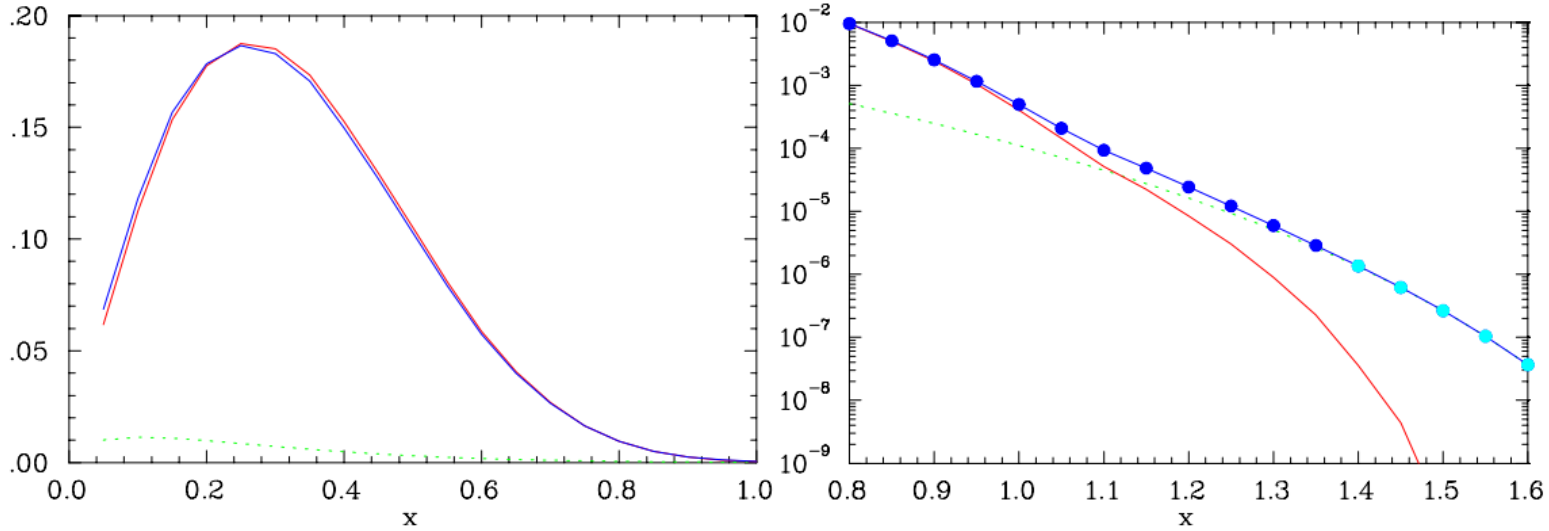
Z. Ye. et al. PRC 97, 065204 (2018)

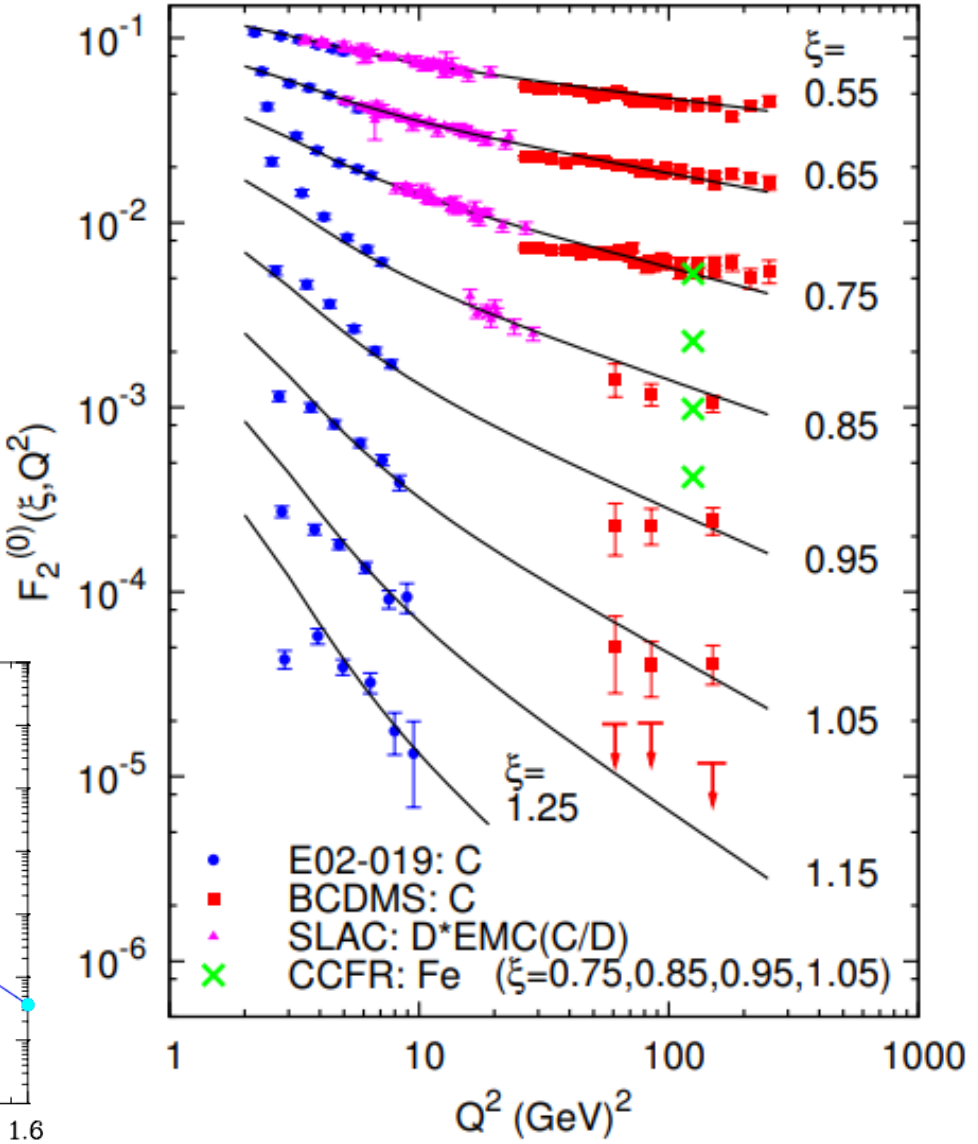


N. Fomin et al. Ann. Rev. Nucl. Part. Sci. 67, 129 (2017)

E12-06-105: Superfast Quarks

- Higher beam energy allows us to use deep inelastic scattering to probe PDFs at x>1
  - Q^2 in the 7-9GeV ^{2} range
- Phenomenological fit to world data (black lines)
- First order target mass corrected structure function, $F_2^{(0)}$
- JLab data E02-019 has a 'relatively high' DIS contribution event at 6 GeV

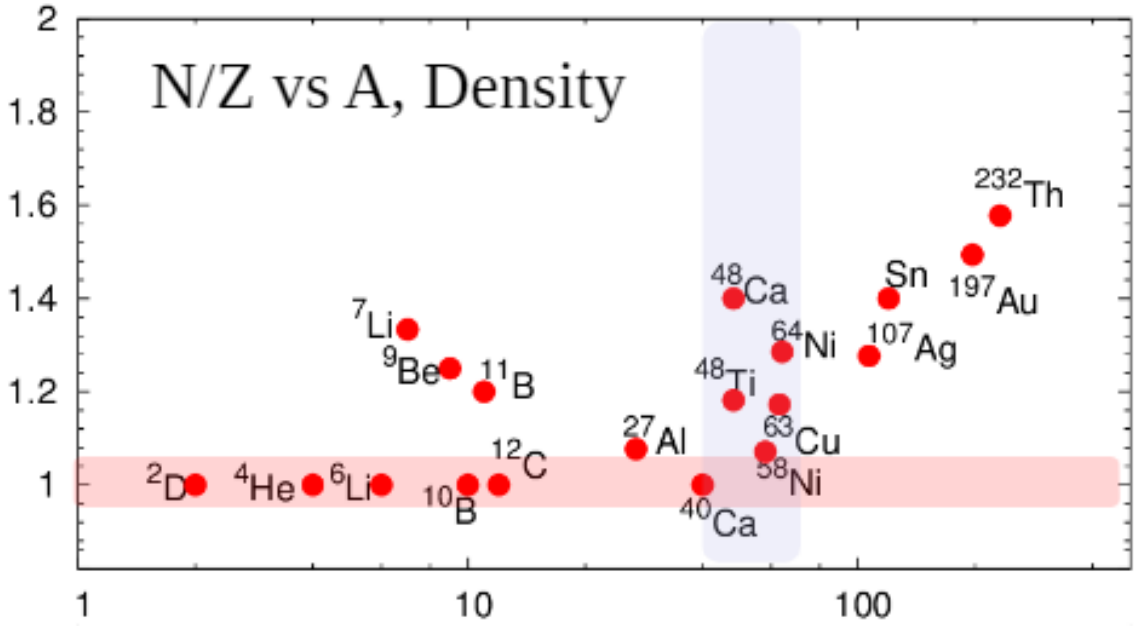


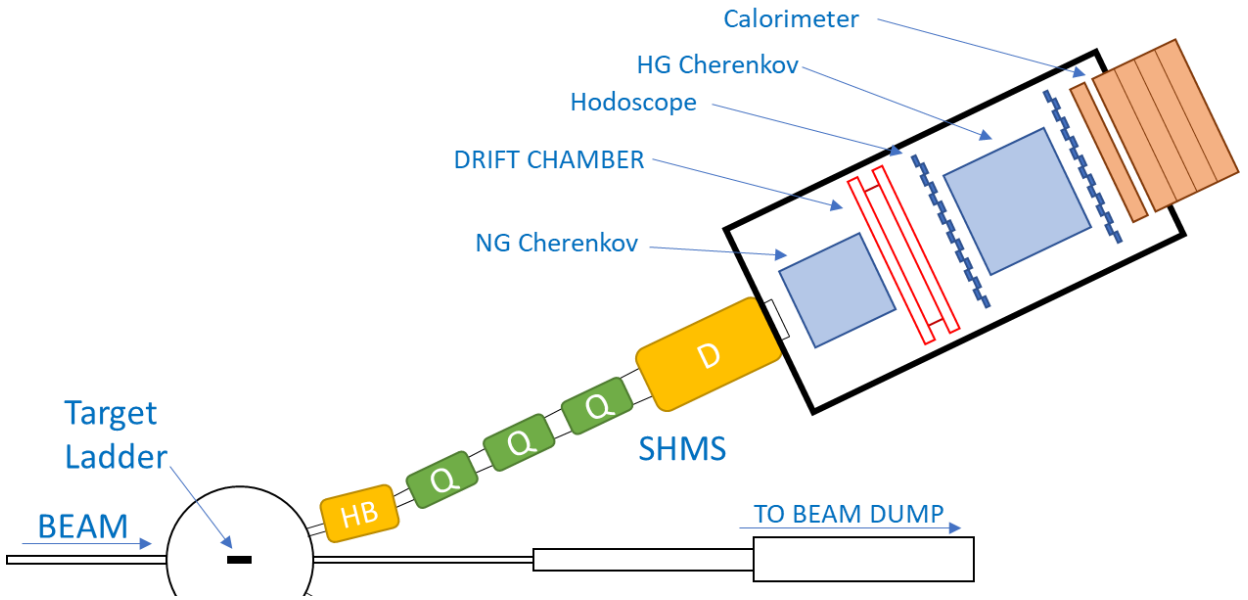


Inclusive Scattering Experiments in Hall C

E12-06-105 ($x > 1$ experiment)

- Inclusive Scattering from Nuclei at $x > 1$ in the quasielastic and deeply inelastic regimes

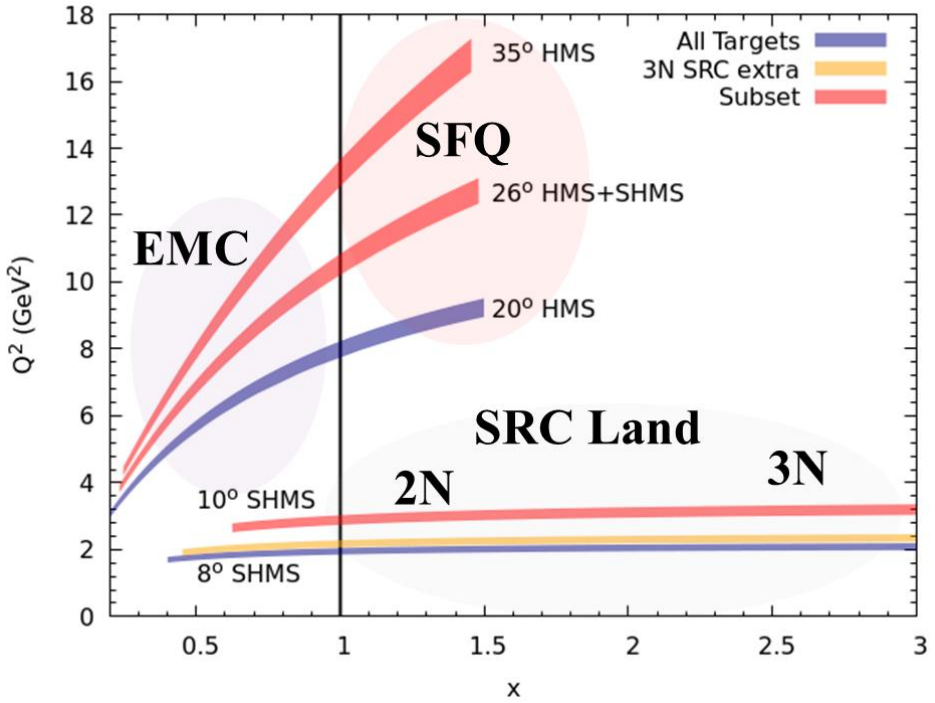


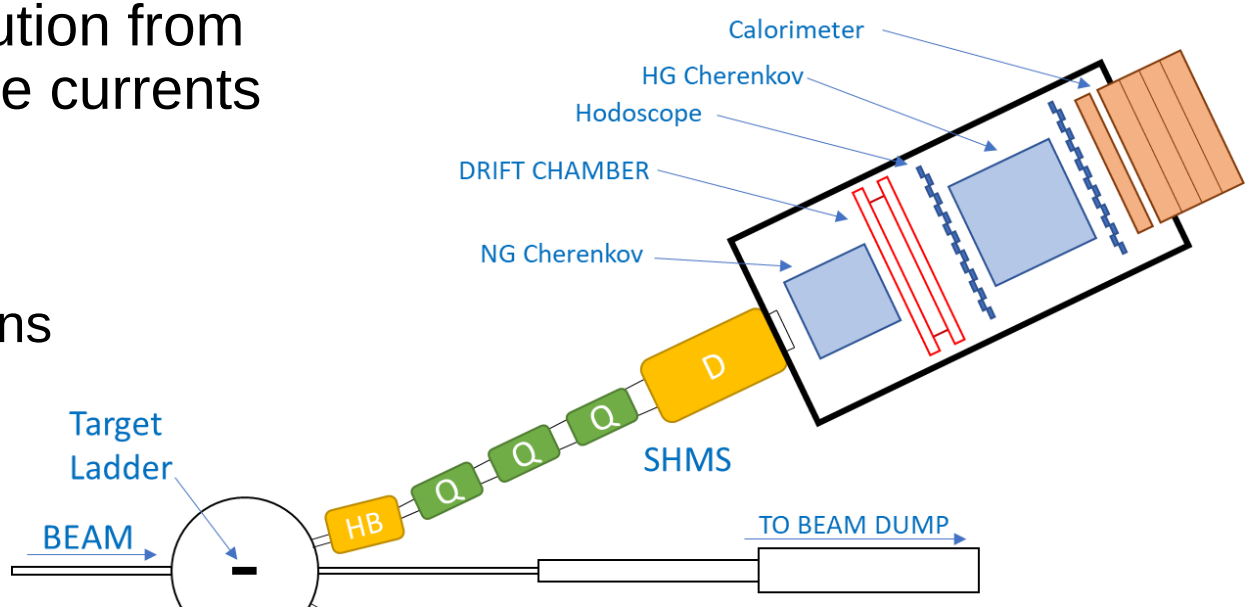


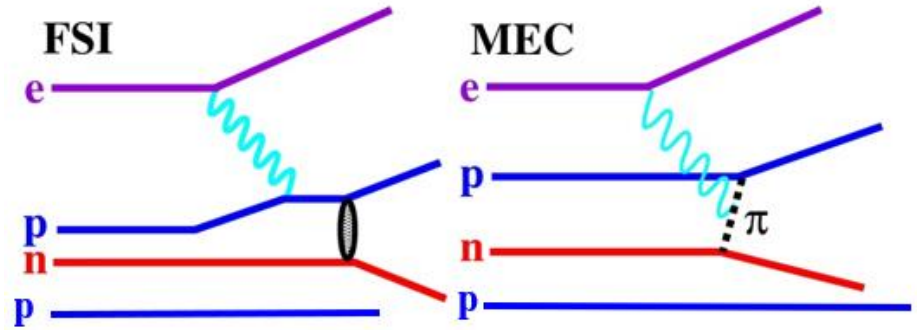
Parameter	SHMS Design
Range of Central Momentum	2 to 11 GeV/c for all angles
Momentum Acceptance δ	−10% to +22%
Scattering Angle Range	5.5 to 40 degrees
Solid Angle Acceptance	> 4.0 millisterradians
Horizontal Angle Resolution	0.5 - 1.2 mrad
Vertical Angle Resolution	0.3 - 1.1 mrad
Vertex Length Resolution	0.1 - 0.3 cm
Tracking Rate Capability	5 MHz
Beam Capability	Up to 70μA

Inclusive Scattering Experiments in Hall C

- Kinematics are chosen to minimize contribution from final-state interactions and meson exchange currents ($Q^2 > 1, \nu > 0.5$ GeV/c)
- FSIs - Re-scattering of struck nucleon
- MEC – Scattering from virtual exchange mesons

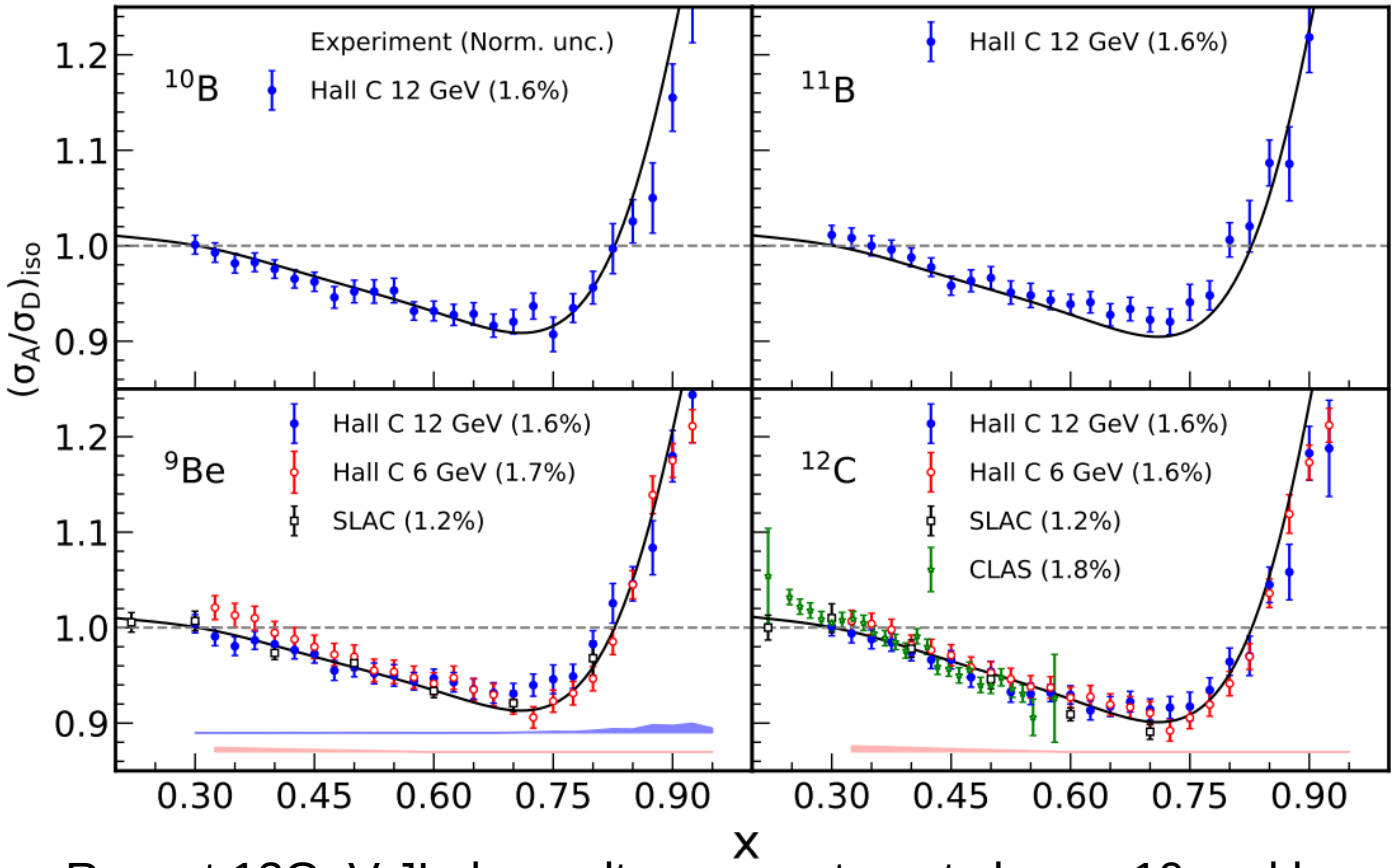


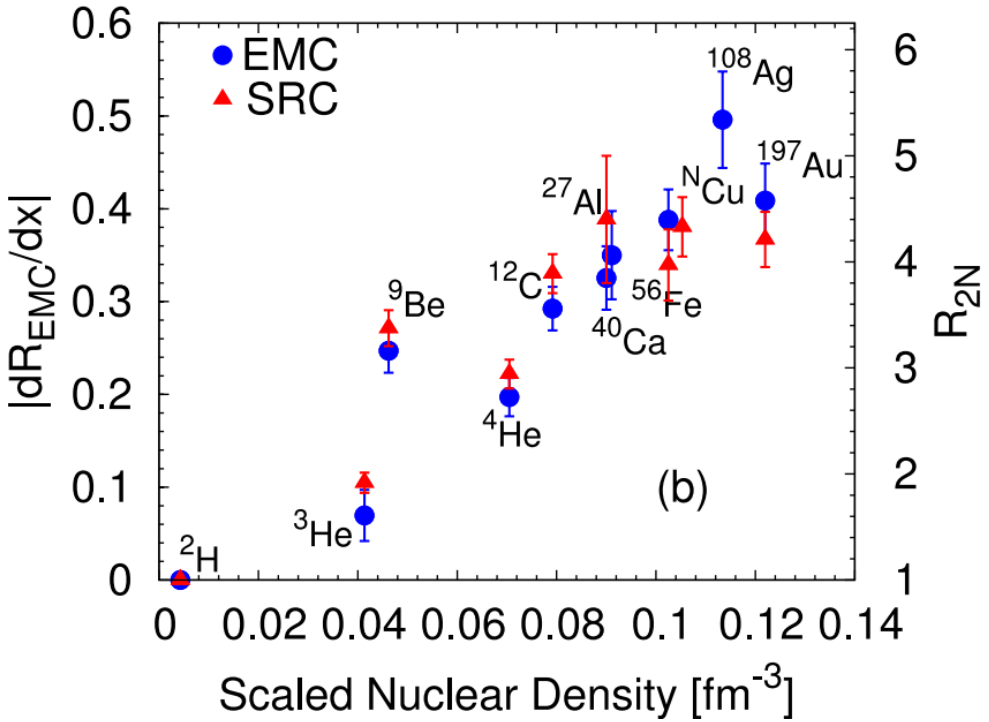




Connection to EMC effect

Modification of proton and neutron structure functions in the nuclear medium



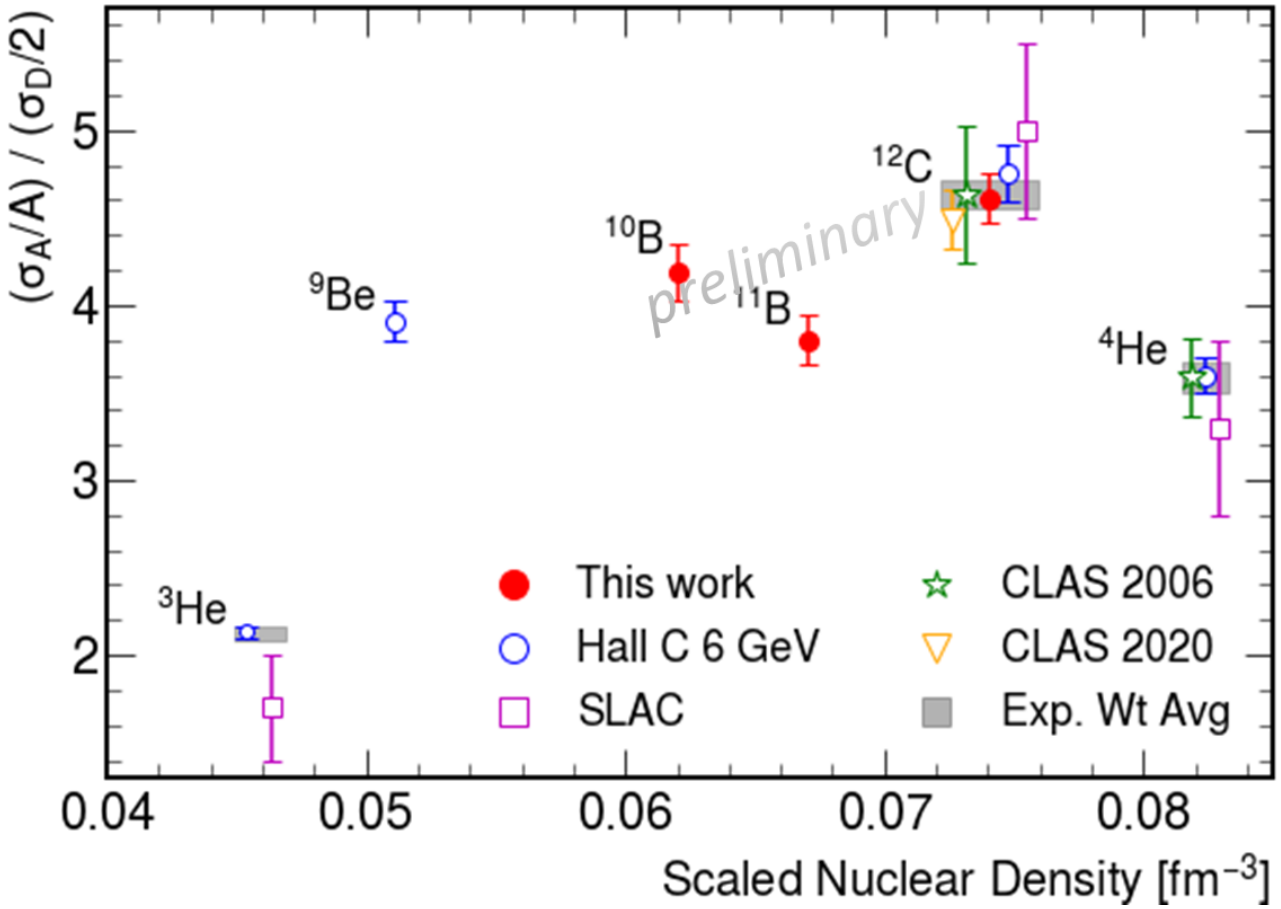


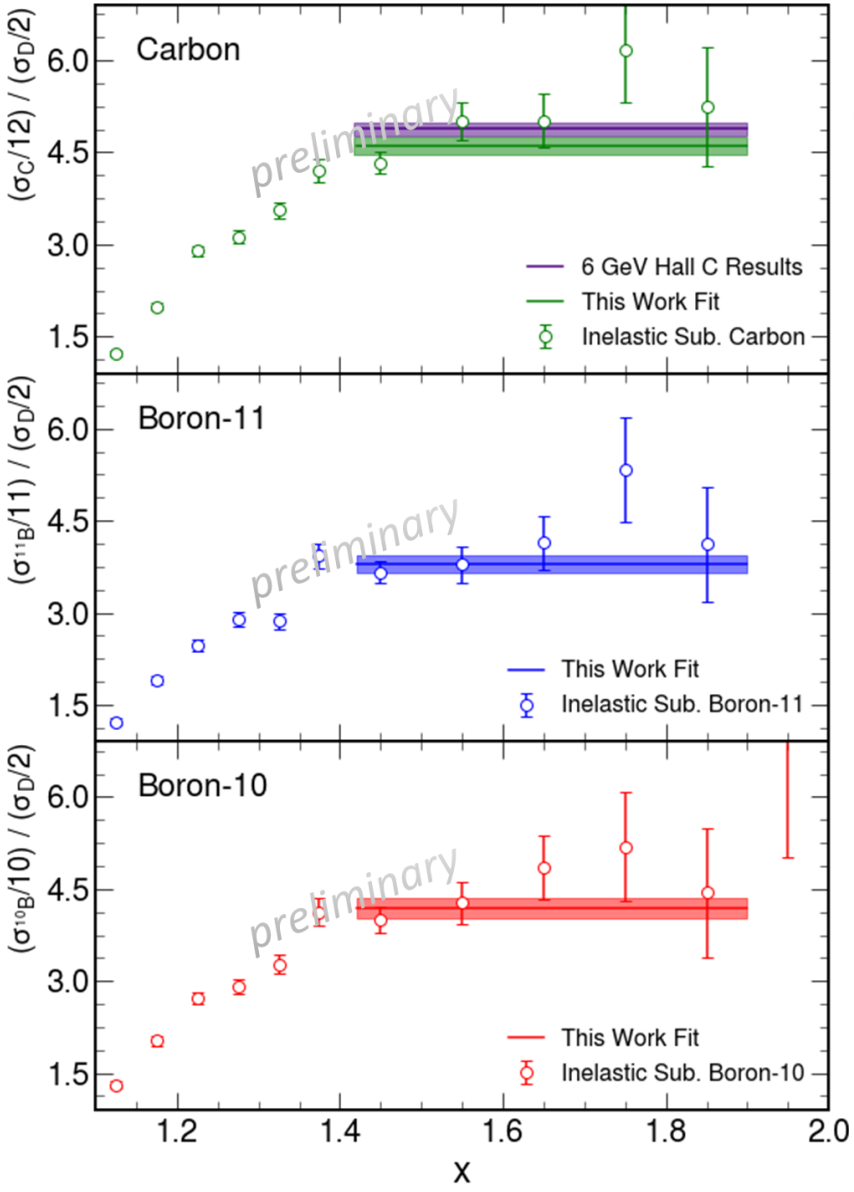
Recent 12GeV JLab results on new targets boron-10 and boron-11 (Submitted to PRL, awaiting final review)

SRCs and the EMC effect approximately scale with nuclear density

Results on B10 and B11 (2019)

First measurements of B10/B11
Expand knowledge of EMC-SRC correlation on light nuclei



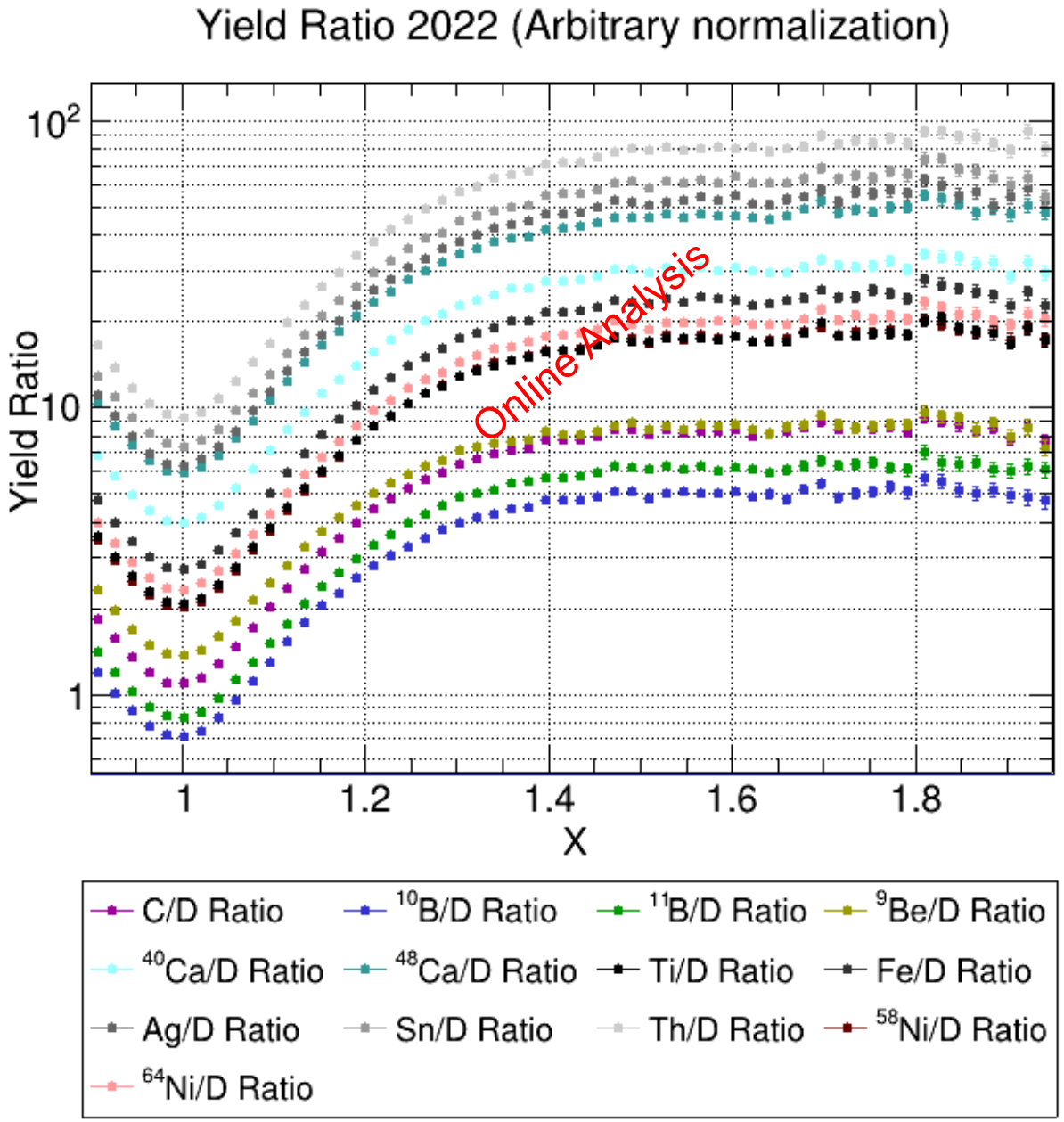


Statistical errors only (2σ here, systematic errors will decrease significance slightly)

Online Physics Results – 2N SRCs

Preliminary 2N SRC Charge Normalized Yields (2022)

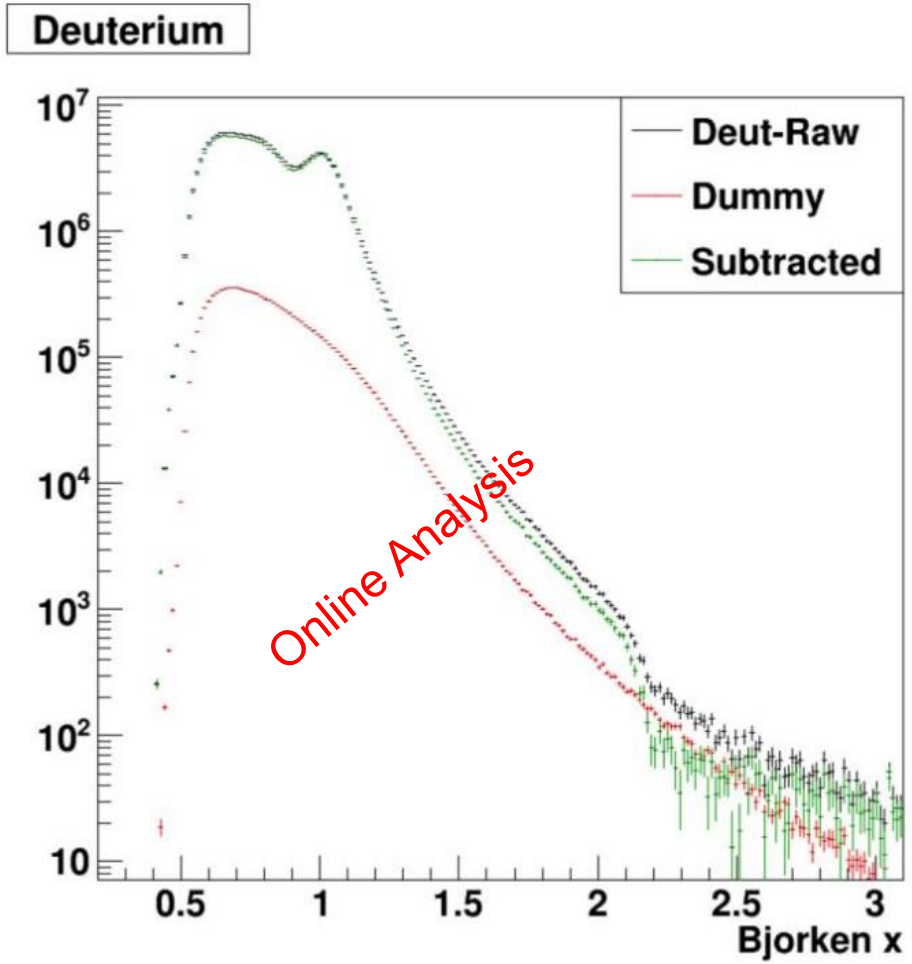
- Statistical error bars shown for all targets on first target ladder (taken last week!)
- Quick to first pass because of the experience gained with the previous data
  - ✓ Online Calibrations
  - ✓ Live-time measurements
  - ✓ Optics checks
  - ✓ BCM checks
  - ✓ Carbon and Aluminum subtraction

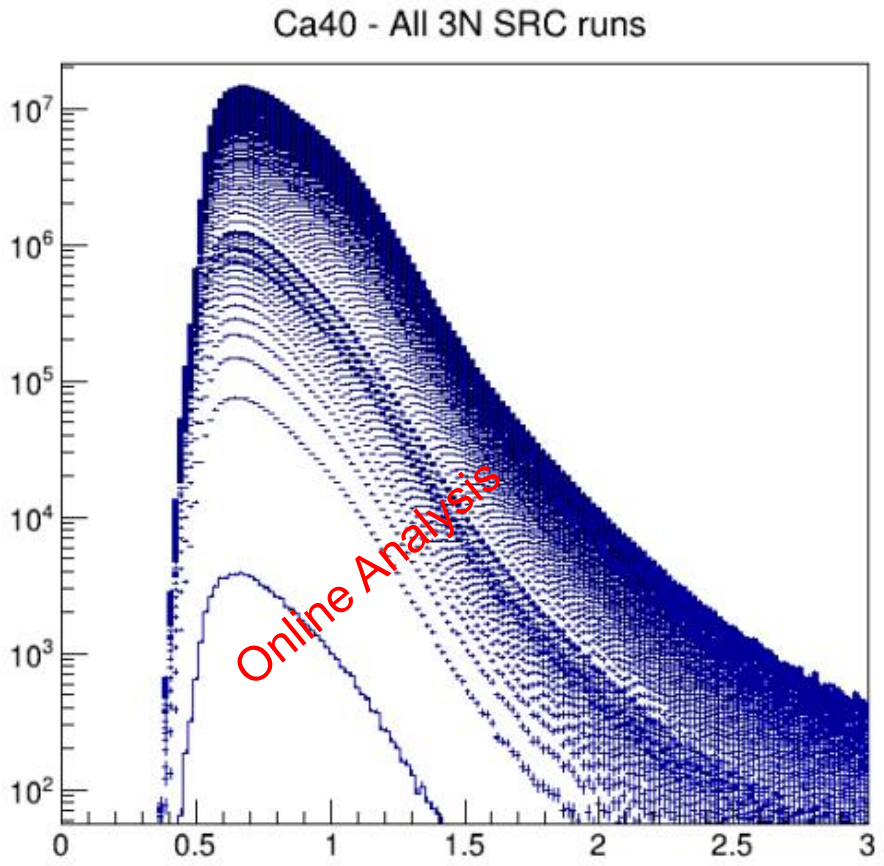


Online Physics Results – 3N SRCs

Preliminary 3N SRC Charge Normalized Yields Ca40 & D2 (2022)

- Al subtraction on D2, Quick stack of all runs on Ca40

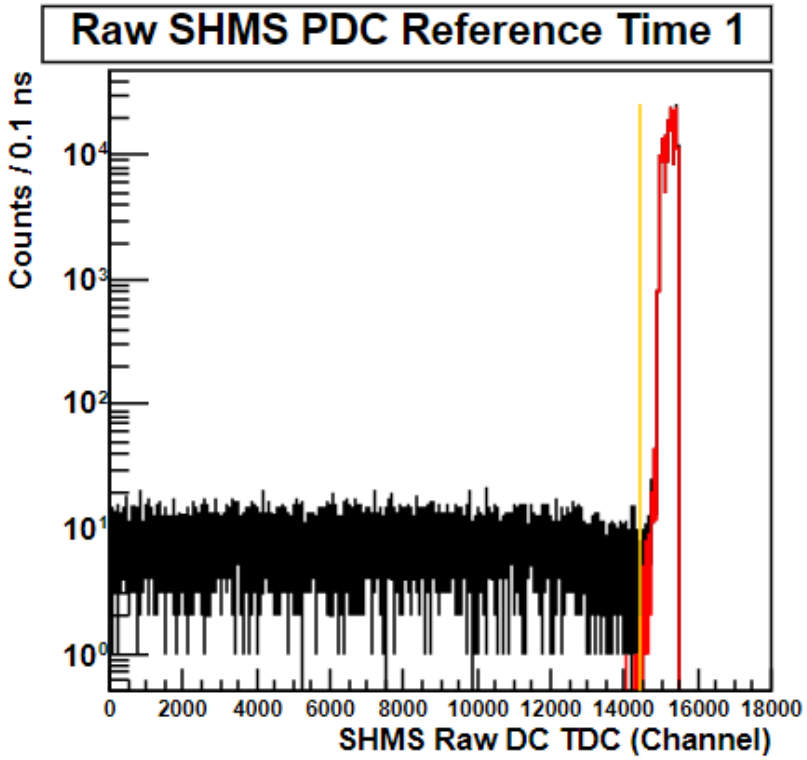


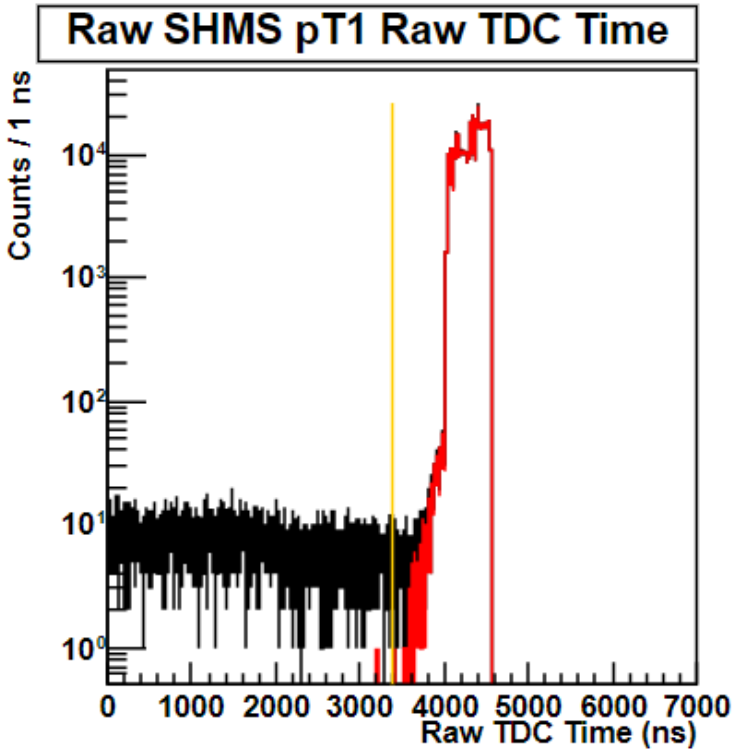


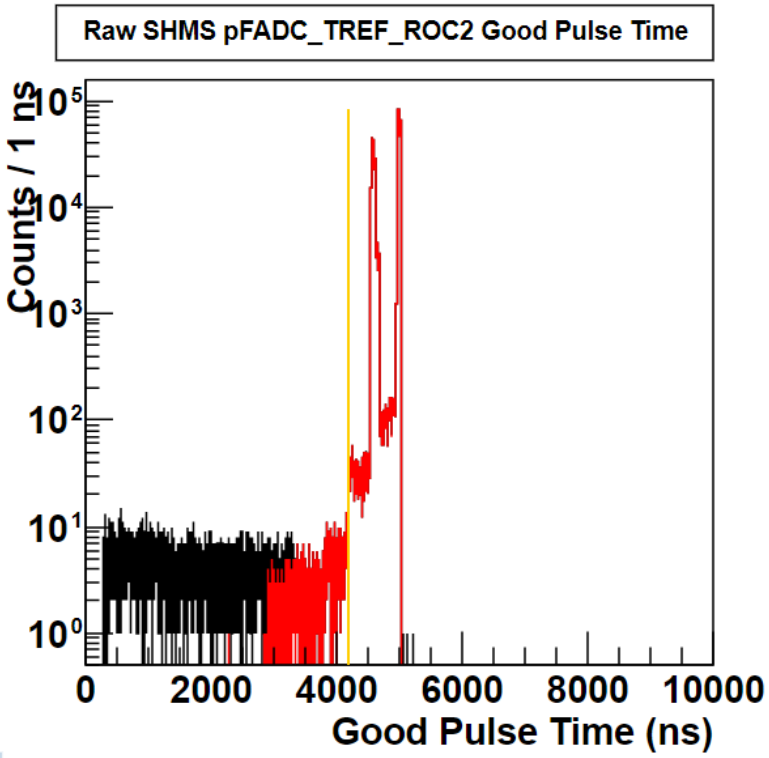
Online Detector Calibrations – Timing Windows & Reference Times

Reference times were set quite easily.

- There was a question of whether we should use a cut on goodscinhit==0 or not.

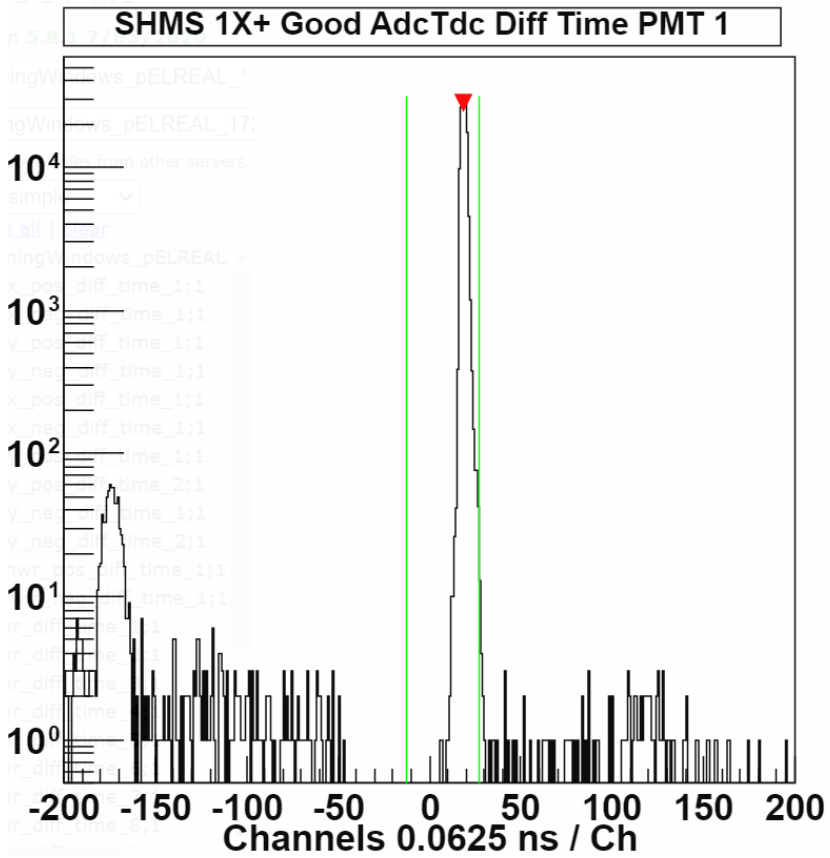


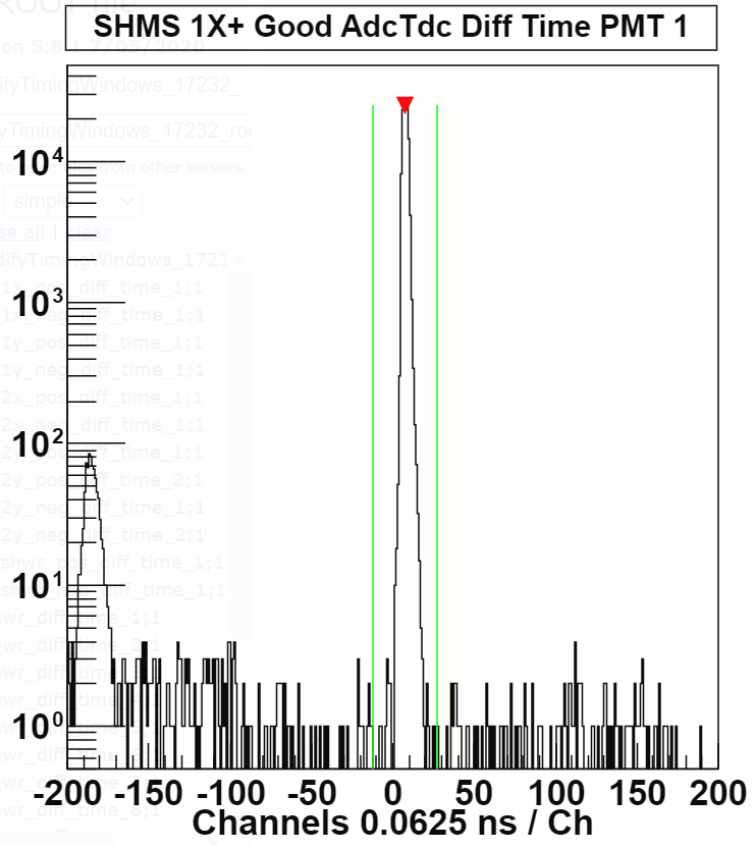




Online Detector Calibrations – Timing Windows & Reference Times

Timing window cuts were easily set with the ‘calibration’ script.





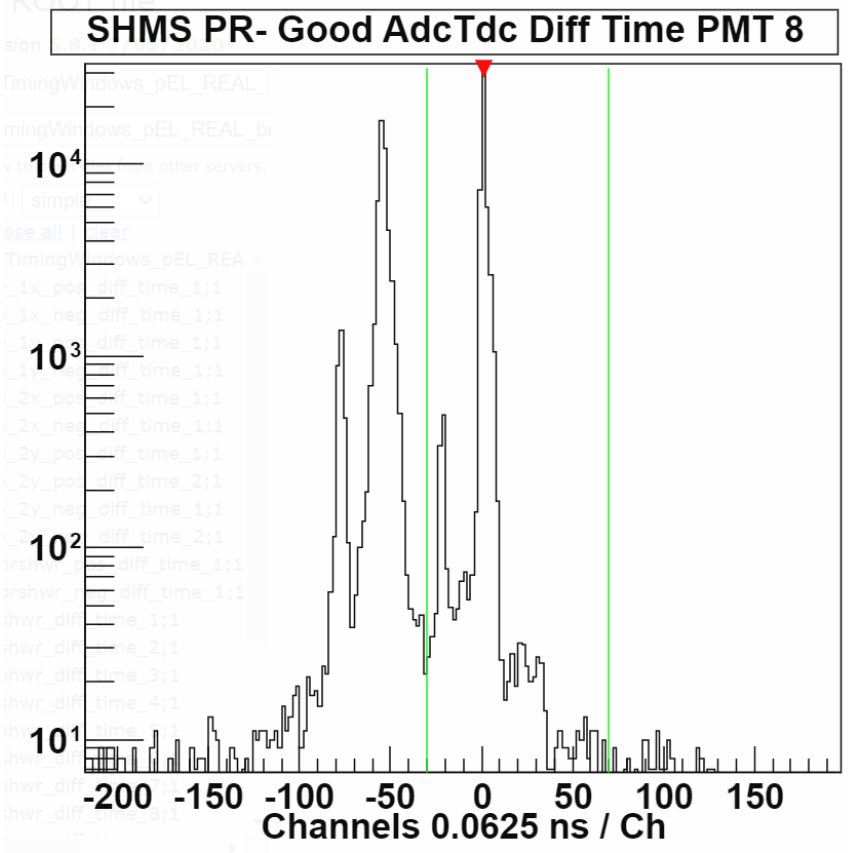
Online Detector Calibrations – Timing Windows & Reference Times

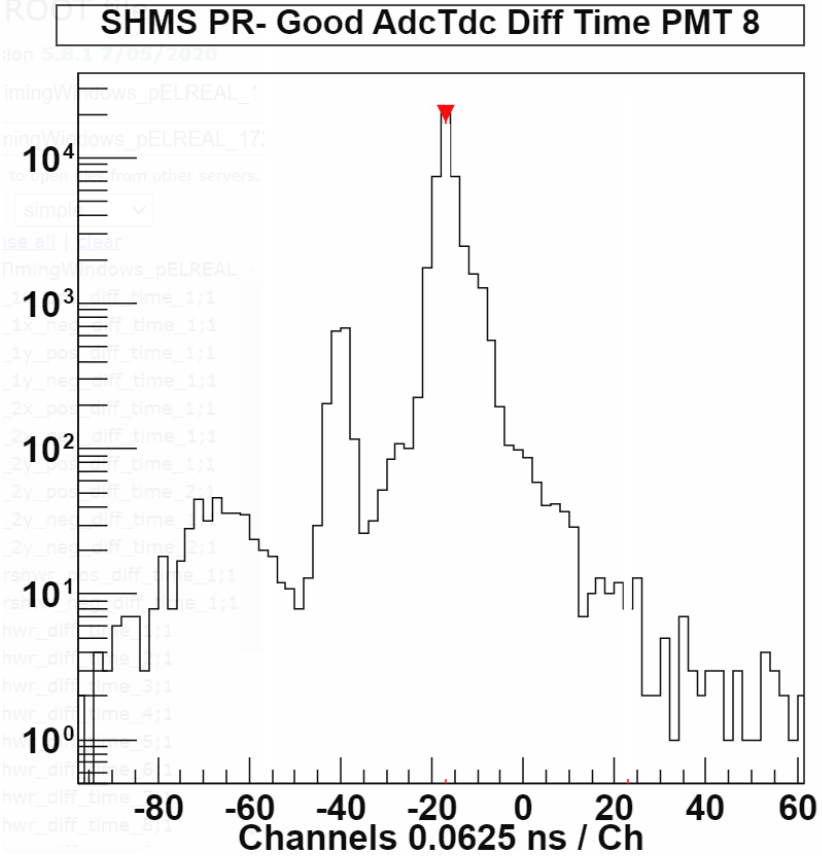
EXCEPT we saw <u>quadrouple</u> peaking in the preshower

- A holdover from an older version of a parameter file where the adc_tdc_offsets were adjusted individually.

Was “phodo_adc_tdc_offset = 154., 125., 224., 196.” not “phodo_adc_tdc_offset = 200., 200., 200., 200.”

- Some separate peaks are still seen, but we can keep the timing cuts wide open (most likely).





Online Detector Calibrations – Calorimeter, Drift Chambers & NGC

SHMS calorimeter calibrated with Q2 defocused run

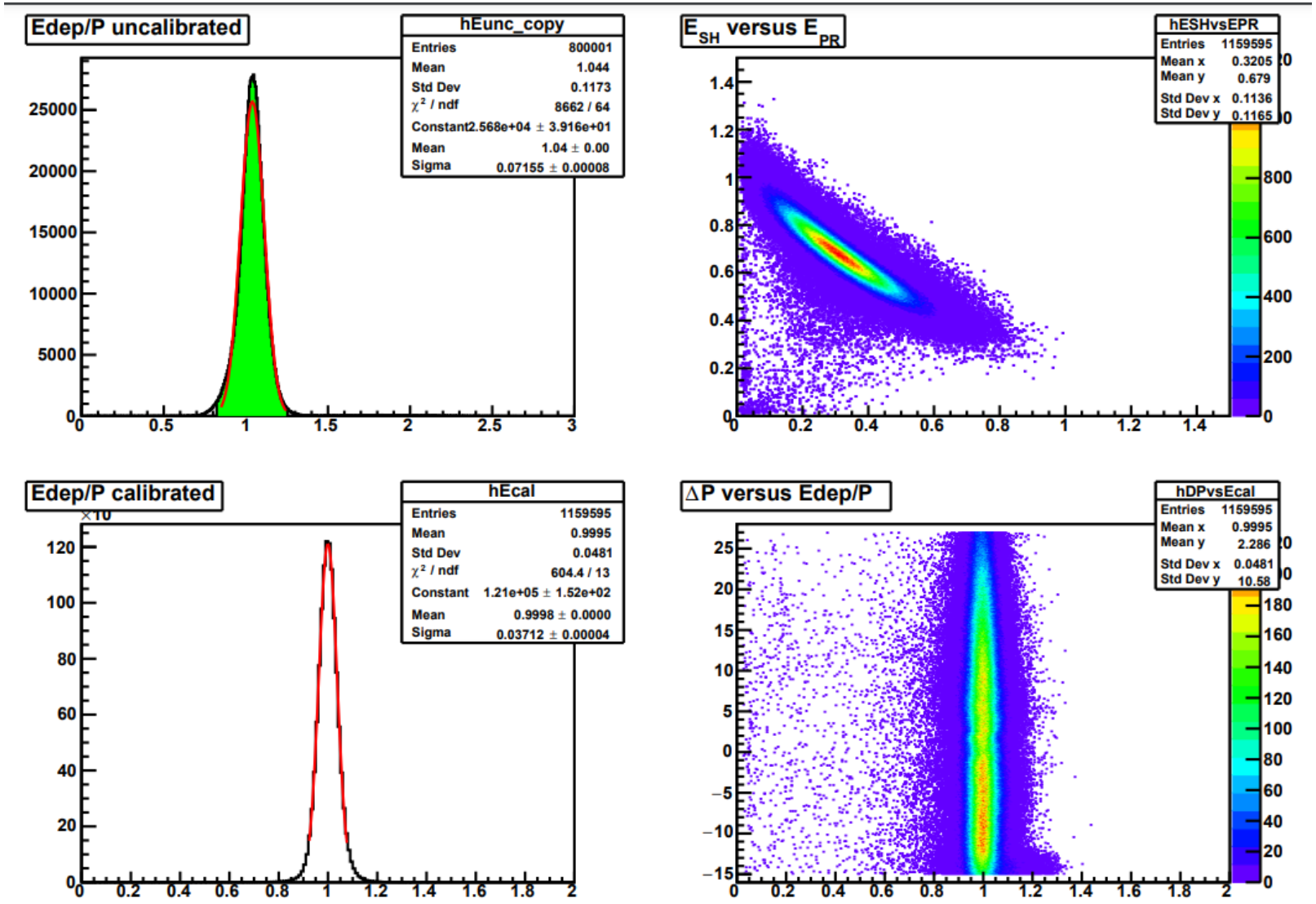
- Needs done for each setting nominally.
- Needs compared to delta scan performed at beginning of experiment.

It would be nice if the calorimeters didn't need calibrated at every different momentum setting

Drift Chamber calibration hasn't been done since CaFe.

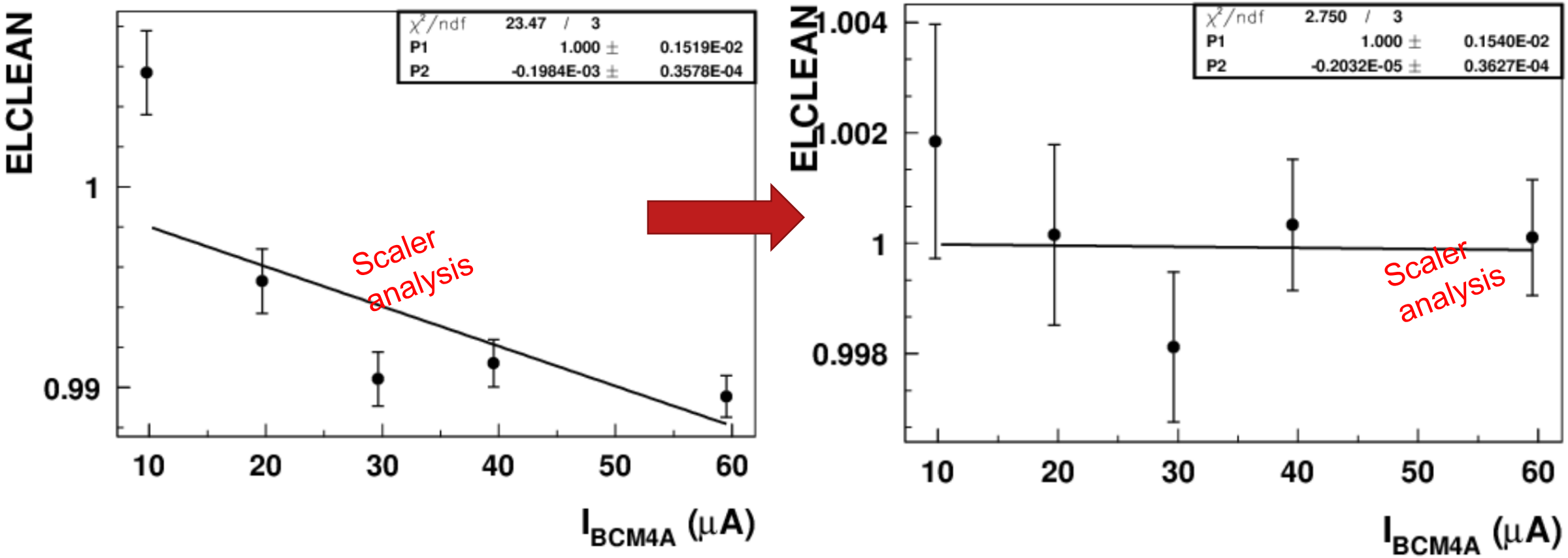
- It looks acceptable most of the time.

NGC – See Cameron Cotton's Talk tomorrow morning!



Online Studies – Luminosity (Cryogenic Boiling) & cryogen EOS

Does Carbon boil?
Correction applied to make Carbon NOT boil (~0.17uA offset)

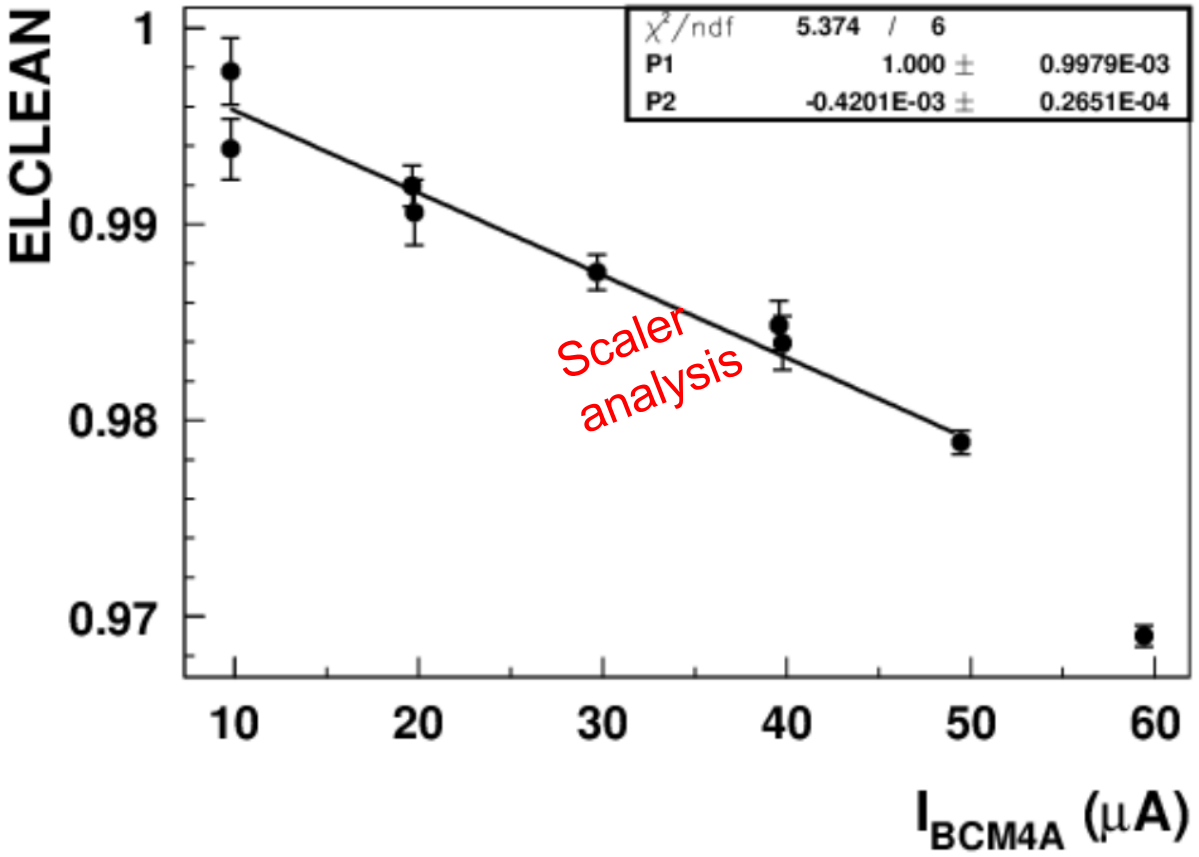


Online Studies – Luminosity (Cryogenic Boiling) & cryogen EOS

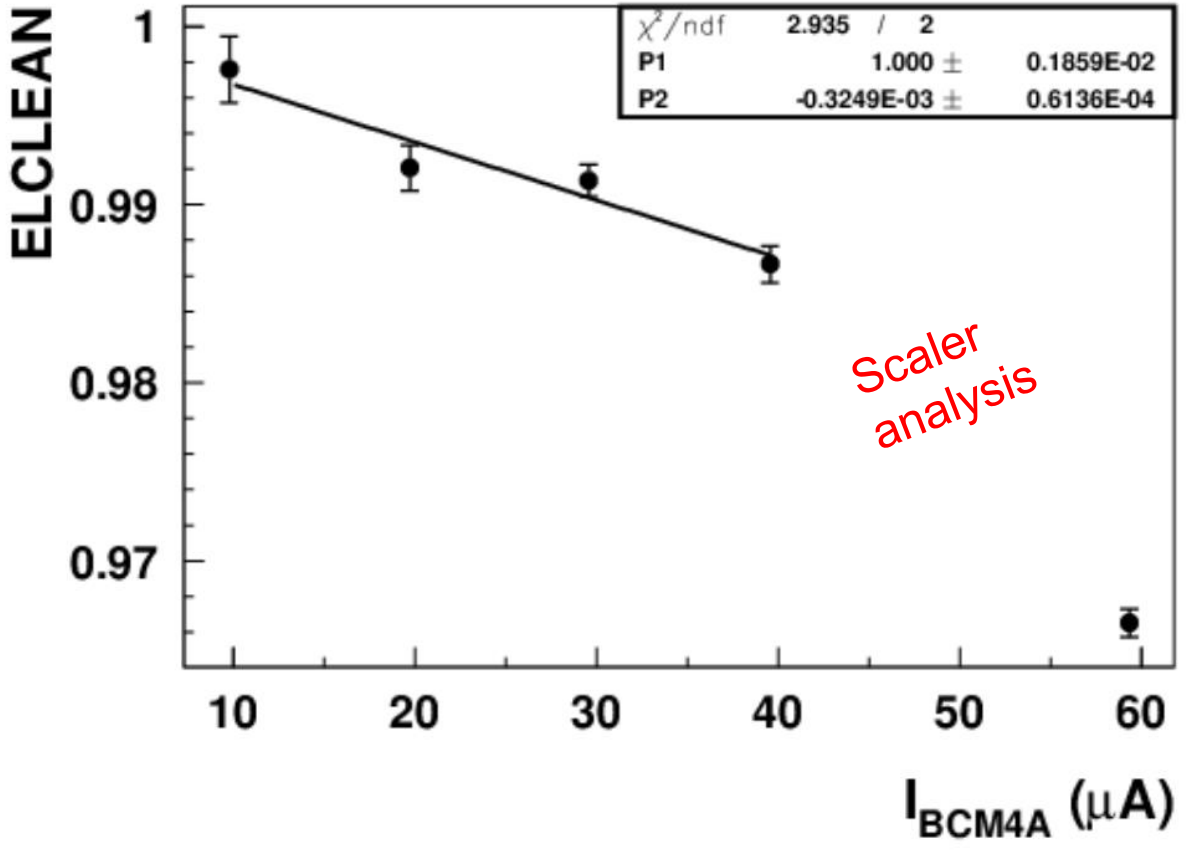
Boiling doesn't look all that linear as expected from 6GeV

- 60uA is an outlier in first boiling analysis, so lets do it again!

Hydrogen



Deuterium

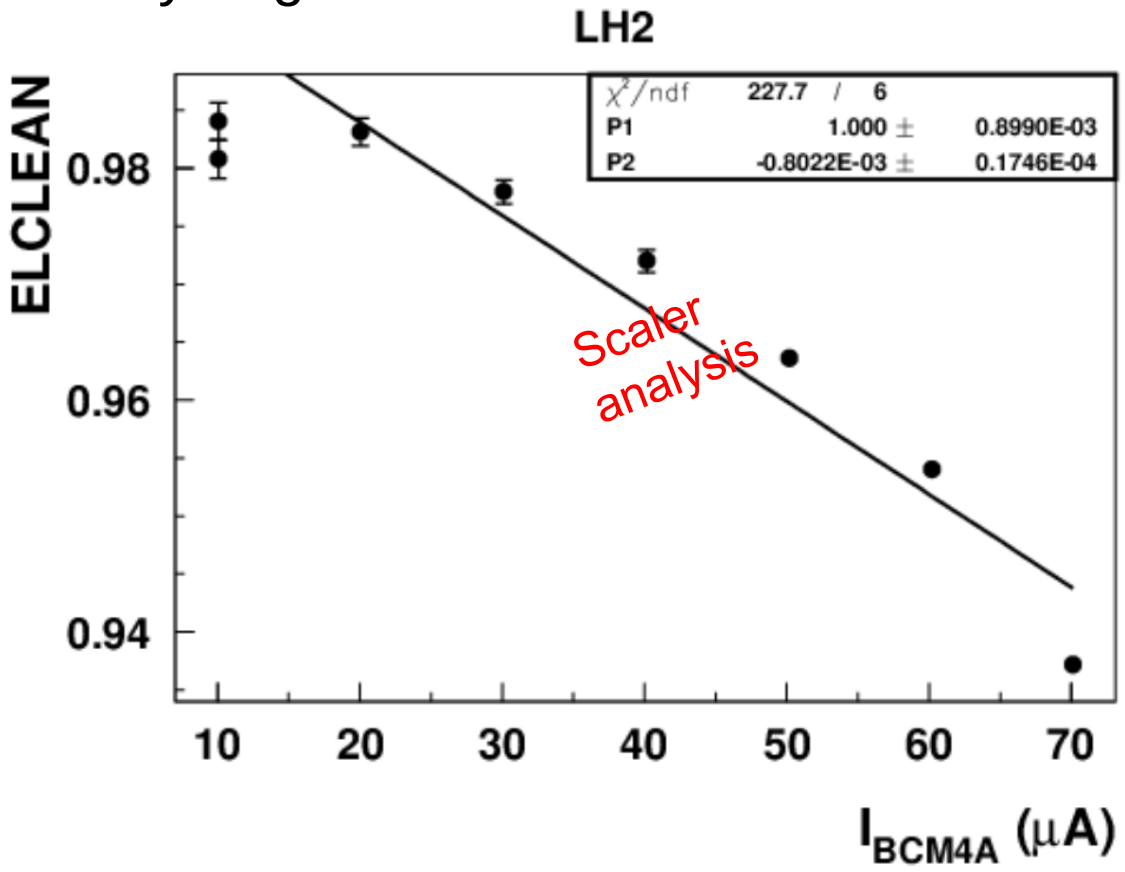


Online Studies – Luminosity (Cryogenic Boiling) & cryogen EOS

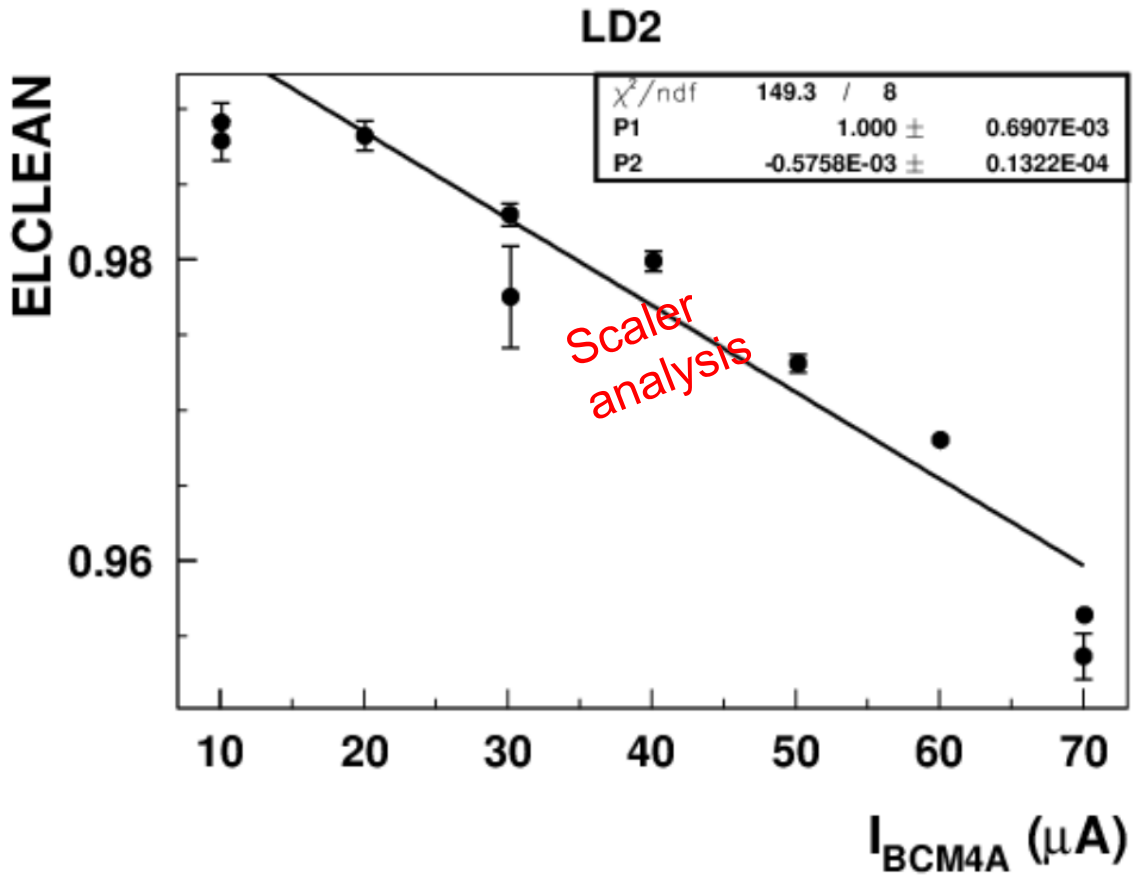
Boiling doesn't look all that linear as expected from 6GeV

- Now 70uA is an outlier and 60uA looks okay?!

Hydrogen

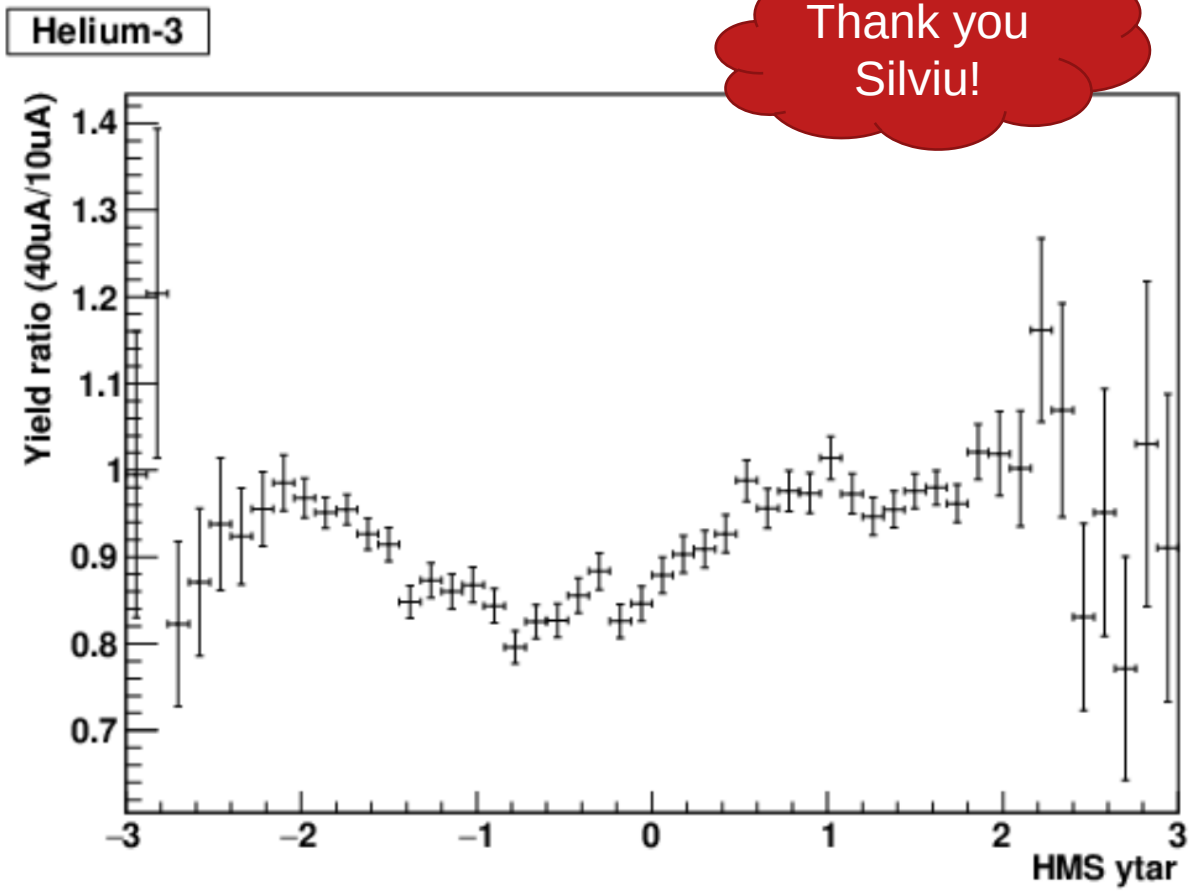


Deuterium

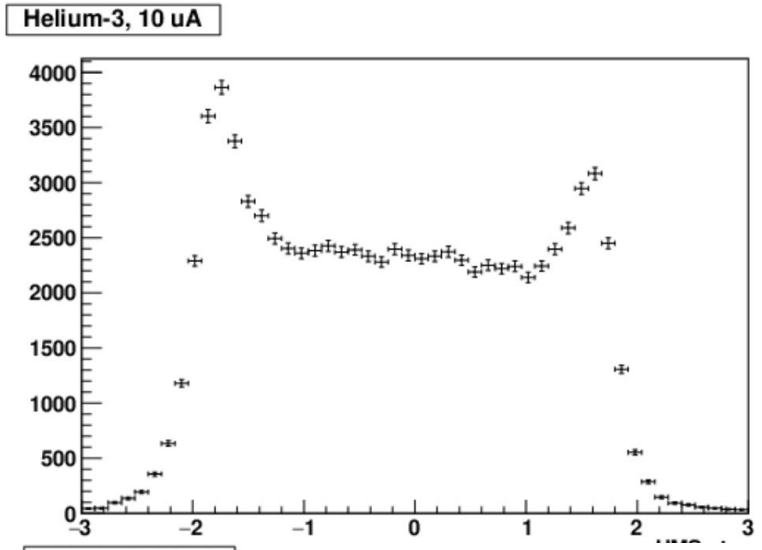


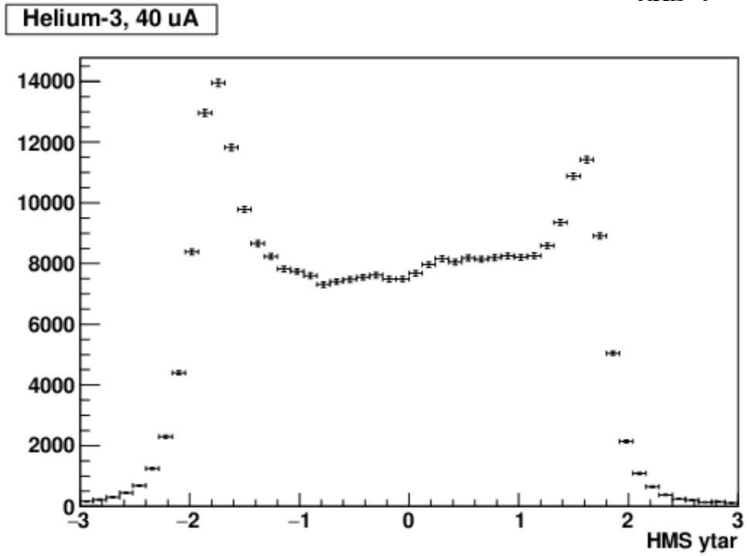
Online Studies – Luminosity (Cryogenic Boiling) & cryogen EOS

Should do a tracking analysis.
There is also ytar dependent boiling in thicker helium targets that needs accounted for



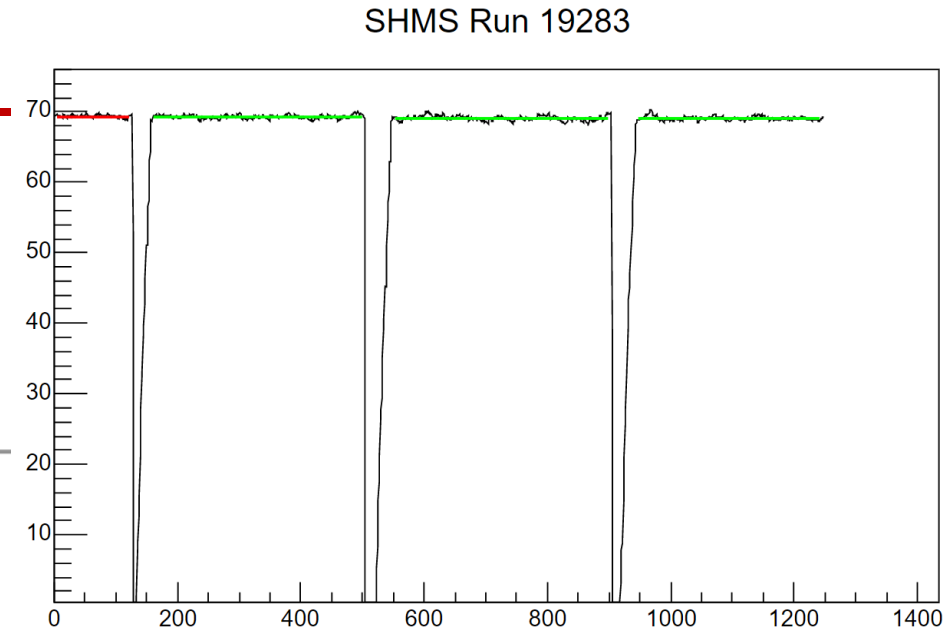
Thank you Silviu!

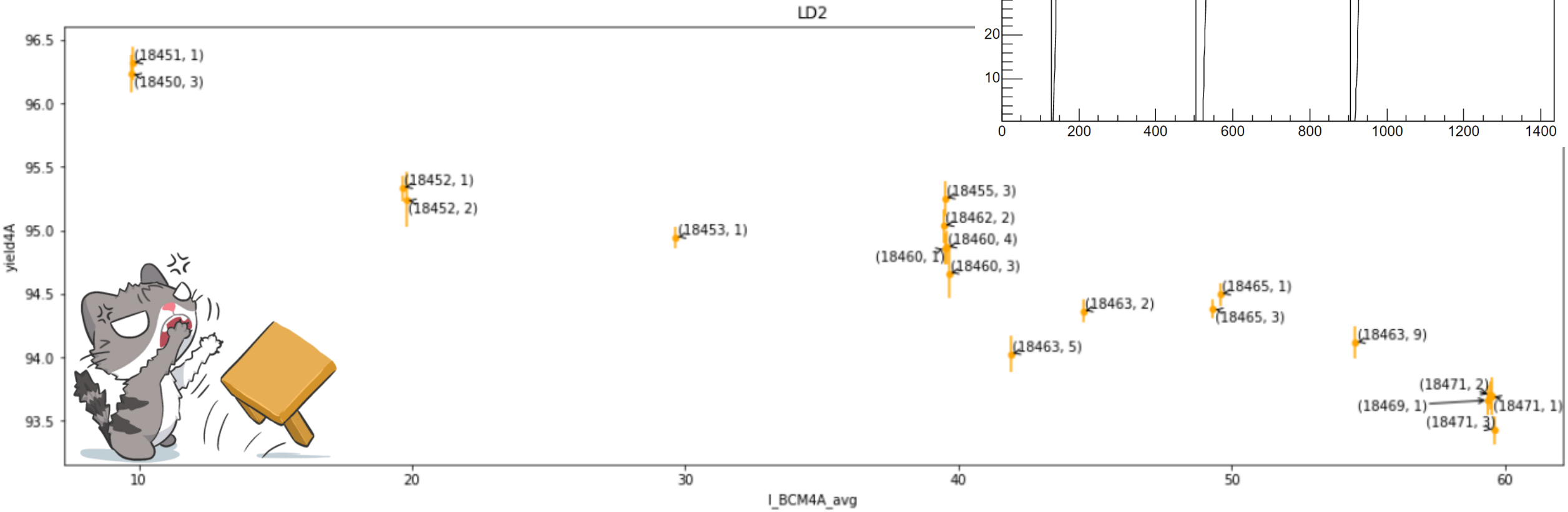




Online Studies – Luminosity (Cryogenic Boiling)

What if we split up the beam ON and beam OFF times and gave a buffer on either end, so the target is in a ‘steady state’?

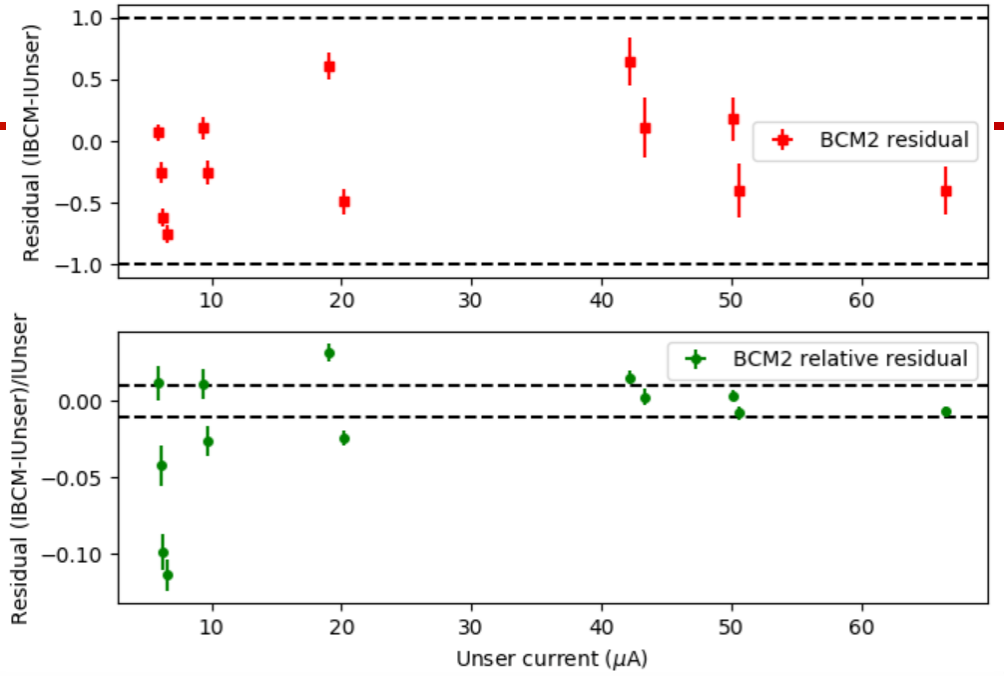


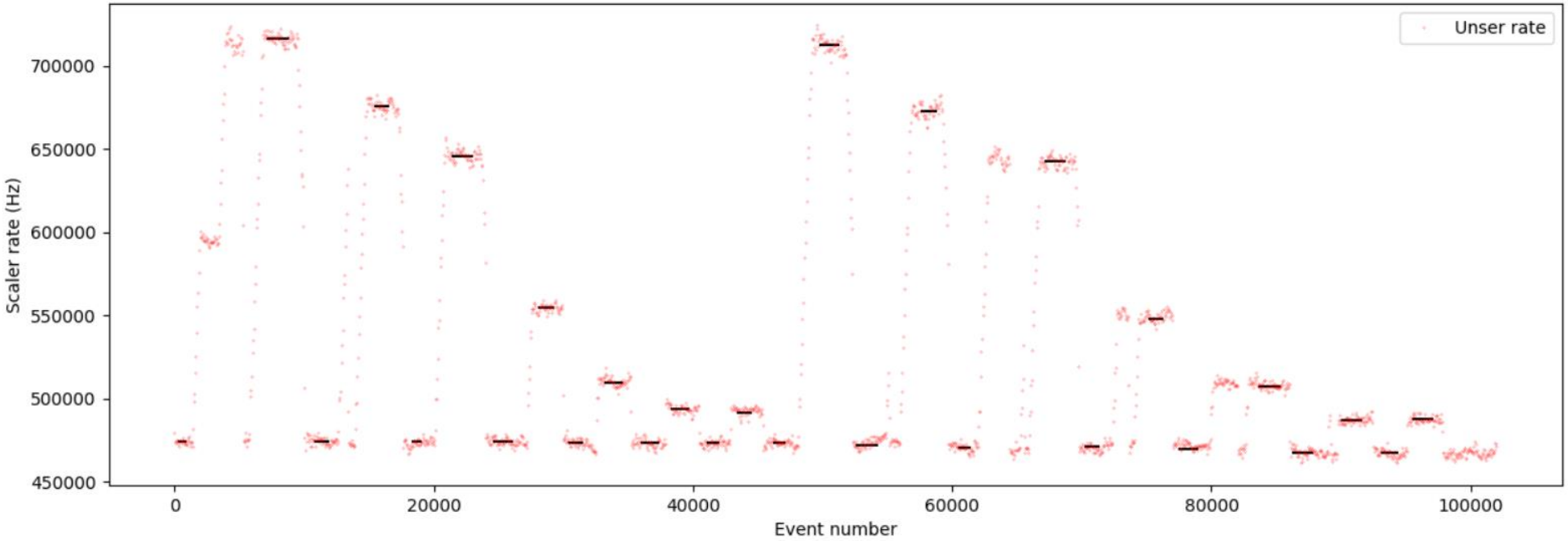


Online Studies – BCM stability / BCM scans

BCM calibrations performed with quite stable results

- Some discrepancy at low currents compared to Unser as expected.
- Active temperature loop went out for a portion of the run. We have redundant BCMs and they are stable over longer periods.
- Should check that MCC is taking the beam completely away when doing a BCM scan

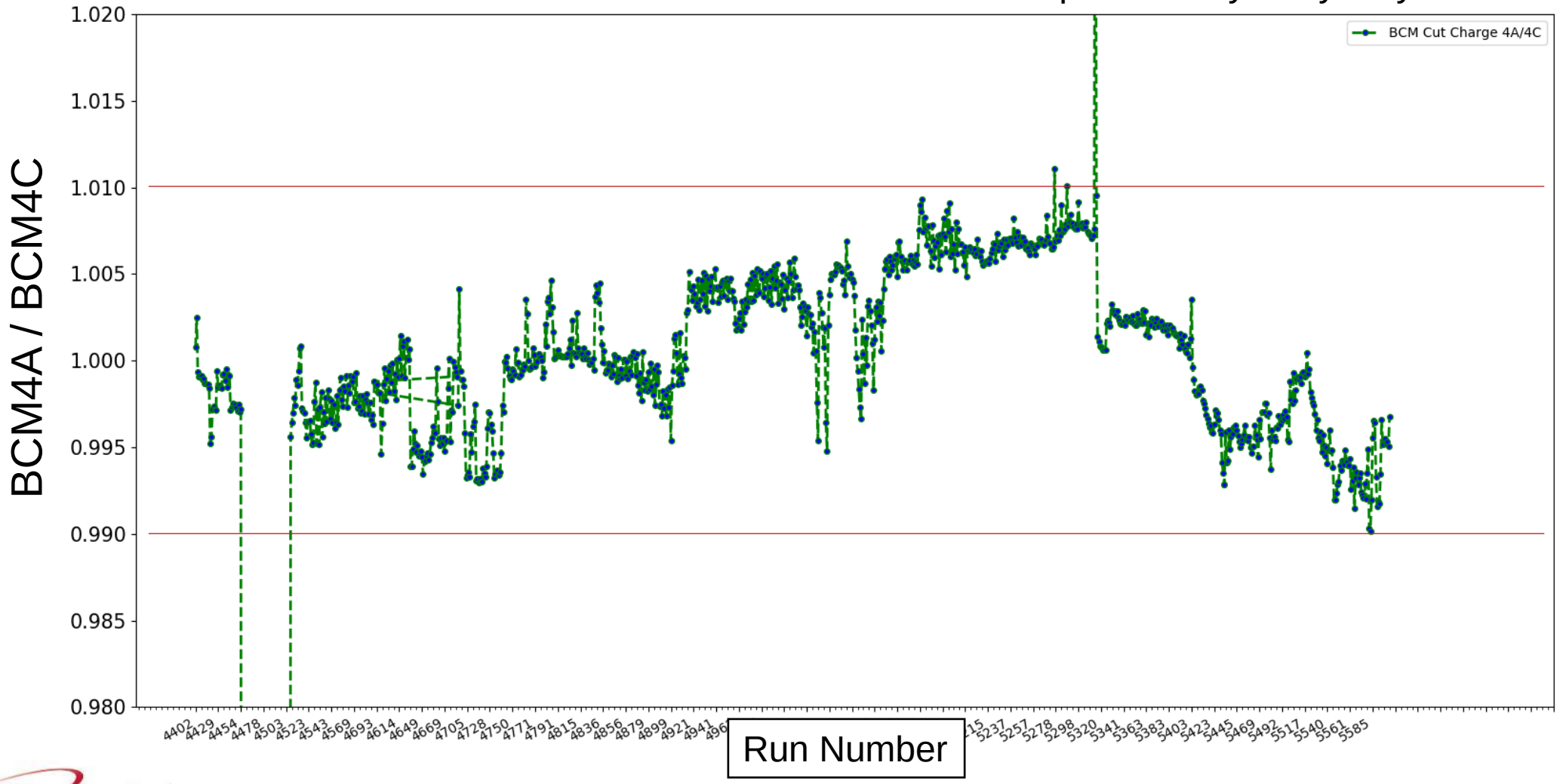




Online Studies – BCM stability / BCM scans

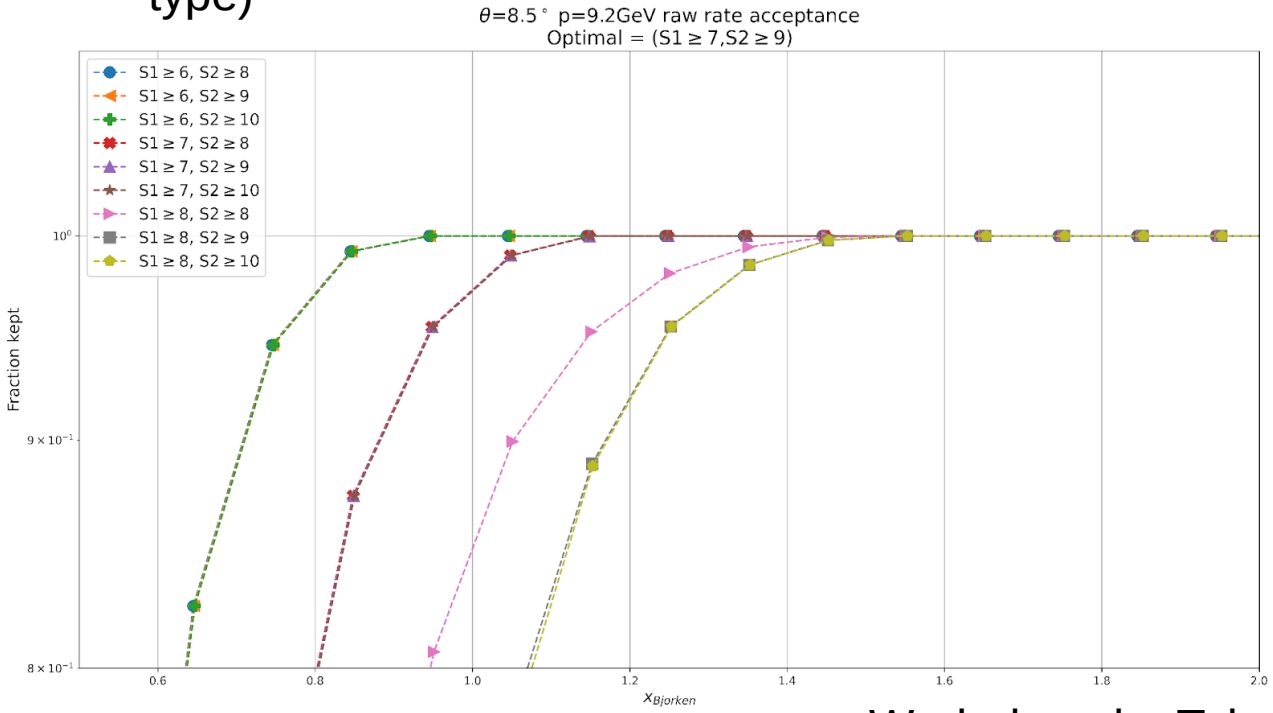
BCMs are quite stable over long periods.

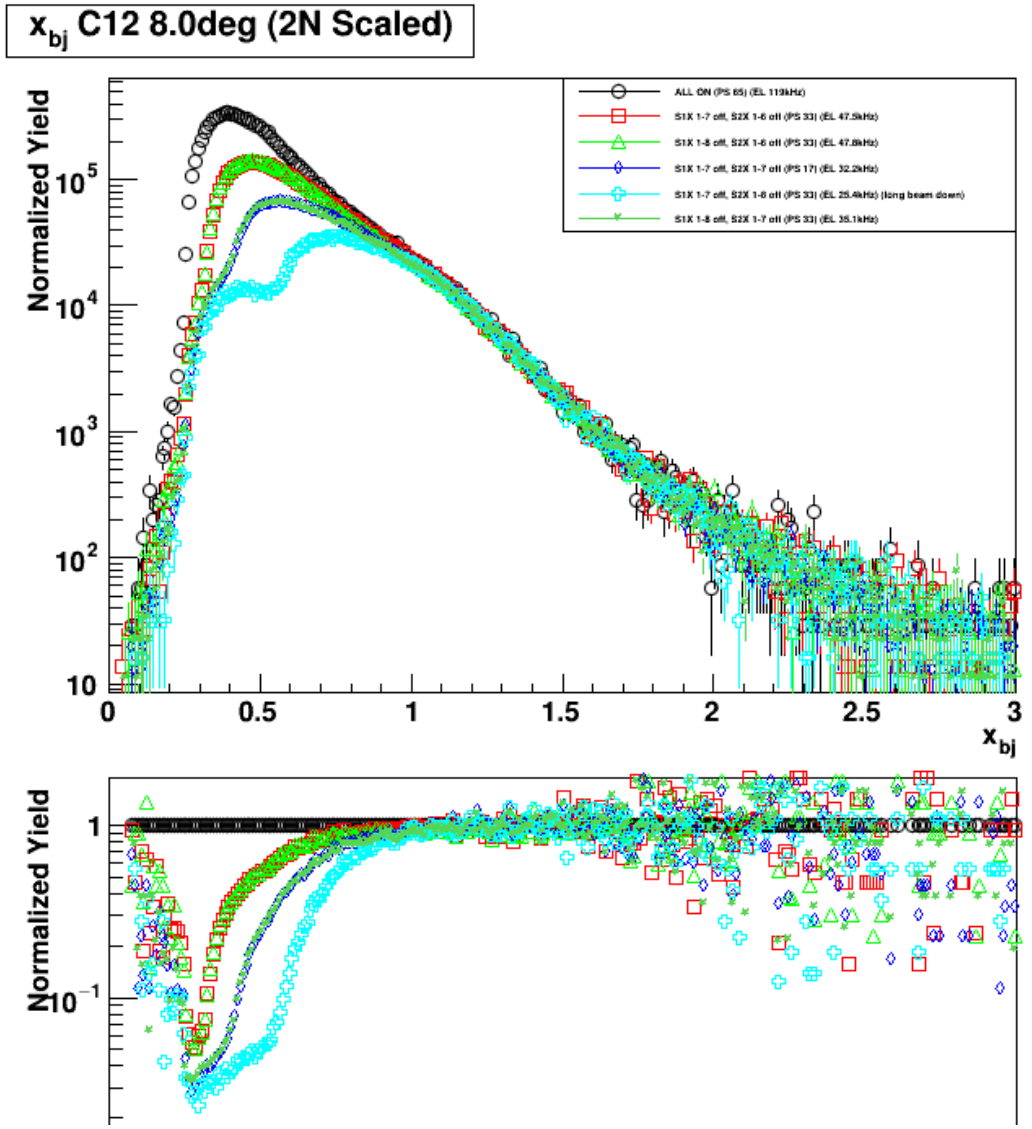
Plot provided by Abhyuday Sharda



Online Studies – DAQ Rate / Paddle Studies

- It was critical to reduce DIS rate by turning off paddles.
- Paddle study ensured no differences in cross-section of interest as paddles were turned off.
- Pre-scaled rate was bumped up to 8kHz for the SHMS after studying it. (We only used one trigger type)

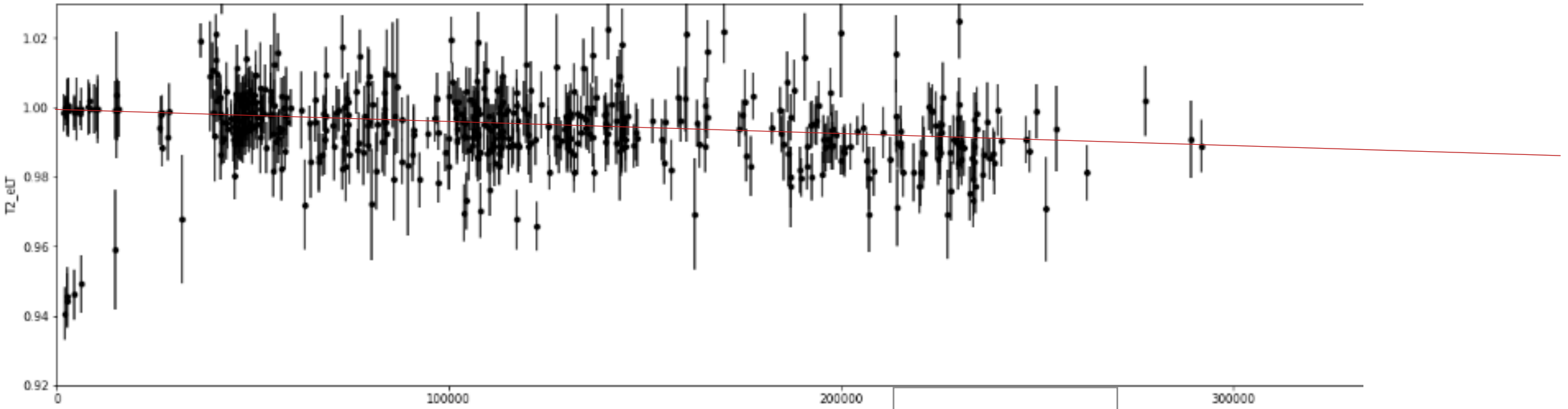




Work done by Tyler Hague

Online Studies – Electronic Live-Time

- First check of electronic live-time using EDTM (single trigger type)
- With the small gates and capping S1X (S2Y) rates to ~1MHz we see predictable electronic live-time.
- Lots of scatter. Need a tight current cut on both scaler (TS) and trigger (T) trees. With more time and effort this will be a global parameterization for electronic deadtime. (Won't need EDTM system for every run)



¾ Rate

Software

Firmware upgrade

- Used during online running, will revert to develop for offline analysis

Data volume

- Volatile allocation is not large enough to replay large segments of data, must use mss.
- Issues with specifying relative path in swif2, fixed now
- Functionality of jcache tapeRemove was broken, fixed now. Did you know you can put files in MSS and remove them with tapeRemove? You should be using it and don’t put large files in /work/!

HMS momentum offset

- hcana applies hard-coded bpm mispointing to delta!

Future – Post Feb. 20th

1. Make pass0 right away
2. Do detector calibrations for each setting (everyone!)
3. Look at elastics and calculate offsets
4. Efficiencies (tracking, etc.)
5. Fully developed studies (boiling, etc.)
6. Iterate XEM2 model and calculate radiative corrections
7. Determine EOS for cryo targets
8. Data-to-MC
   - scintillator planes ON or OFF.
   - Add ytar dependent effect for target boiling.

Summary & Outlook

- Rich physics program between experiments E12-06-105 and E12-10-008
  - 2N SRCs, EMC Effect, investigation of SRC-EMC correlation
  - Superfast quark distributions, high-x QCD moments, high-x nuclear structure function

- We need you! Please, take shifts. There is a lot of physics coming out of these two experiments
  - Exploring shared shift taking requirements
- Many new faces - We need a hall C software workshop

Post-Docs and Graduate Students

Cameron Cotton
UVA

Ryan Goodman
UTK

Abishek Karki
MSU

Casey Morean
UTK

Abhyuday Sharda
UTK

Zoe W – UNH
Ramon O - UTK
Sebastian M - SMU

Burcu Duran
UTK

Tyler Hague
LBL

Shujie Li
LBL

<u>Spokespersons</u>
Nadia Fomin, Dave Gaskell, John Arrington, Donal Day, Aji Daniel

<u>Special Thanks</u>
Bill Henry, Mark Jones, Dave Mack, Simona Malace, Eric Christy

Questions?