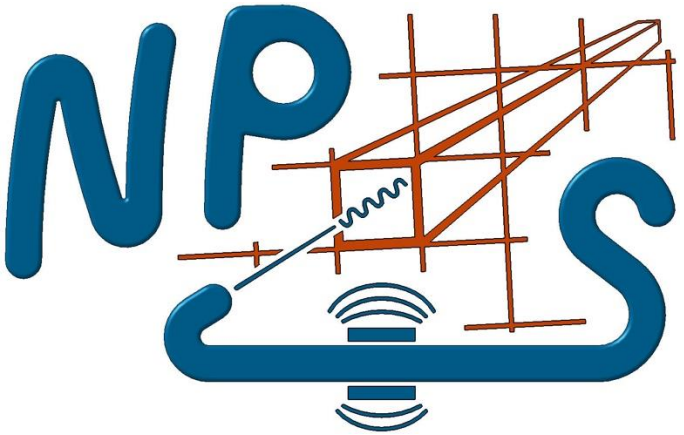
BCM/Unser Calibration Update for NPS 2023-2024



Thank you to experts Dave Mack, Dave Gaskell, and Mark Jones

Christine Ploen

Tuesday, May 6, 2025

Jefferson Lab

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BCM/Unser Calibration Update – Overview

1. BCMs At A Glance: Which BCM?
2. Fit refinements
3. Next Steps

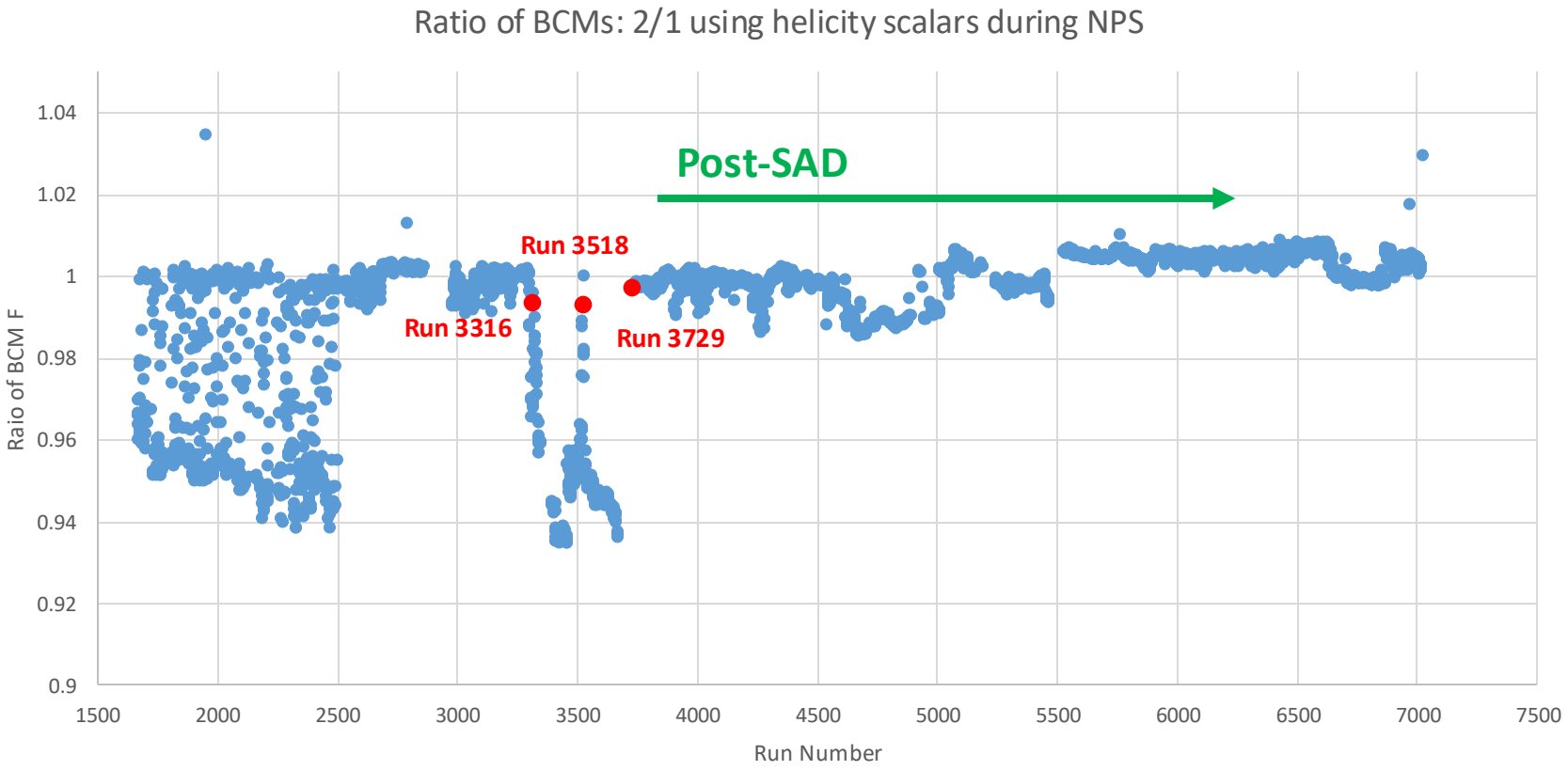
BCM Personalities at a glance

features	BCM1	BCM2	BCM4A	BCM4B	BCM4C
Saturation				~ 30 uA	(Based on calibrations from earlier run periods) ~ 60 uA
Stability	Unstable at few % level	~1% gain change			15-20% gain change!
Thermal	BCM1/2	BCM1/2	BCM4A,B,C	BCM4A,B,C	BCM4A,B,C
Ana/Dig	Digital	Digital	Analog	Analog	Analog

BCMs 2 and 4A have both range and stability,
but *4A is the best to use.*

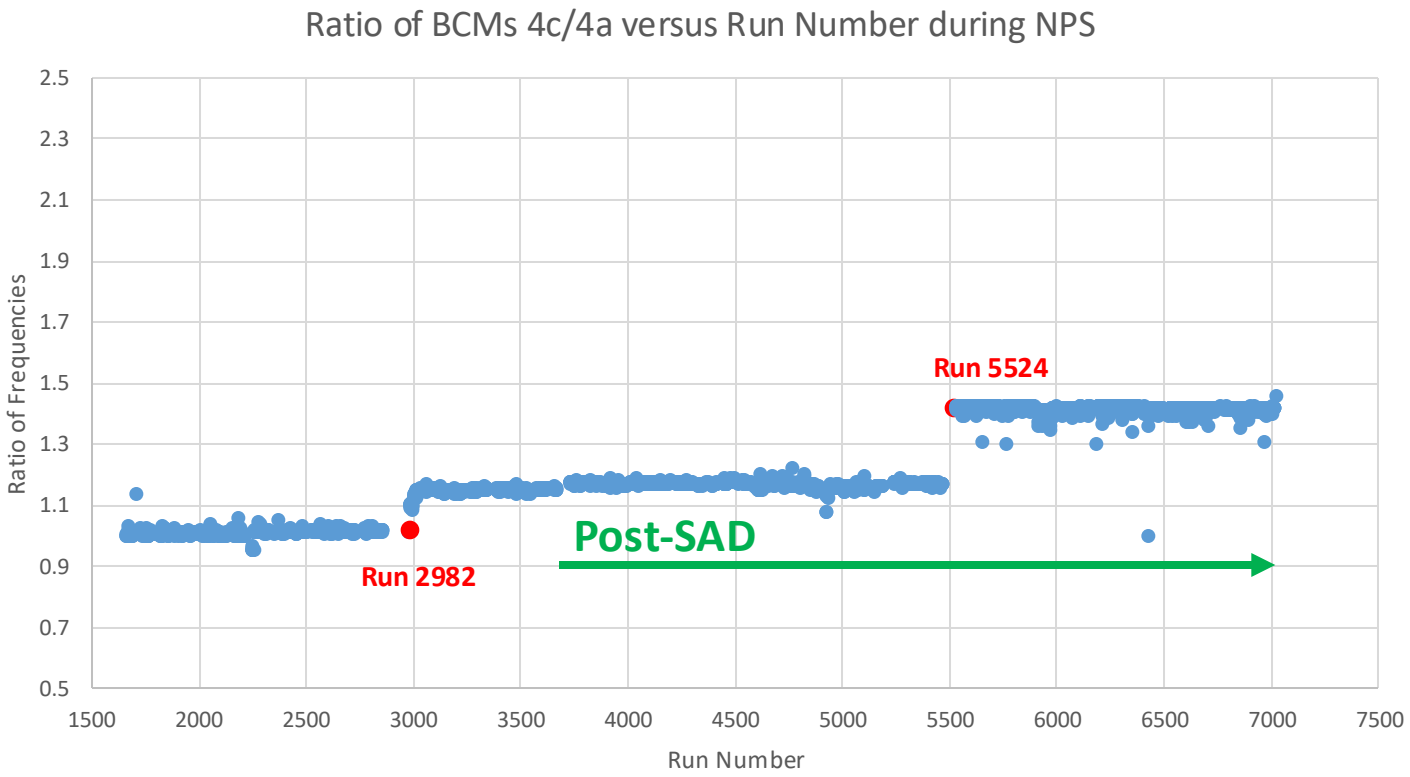
Which BCM?

- BCM1 is known to be unstable at the 1% level.
- BCM2 had a failed thermocouple and there's evidence of a small gain drift early in the run period (~ 0.8%)
- Some instability can be seen by plotting helicity scalers of BCM2/BCM1:



Which BCM?

- On the other hand, BCM4B saturates around 25 uA, and BCM4C had large gain steps twice during experiment!



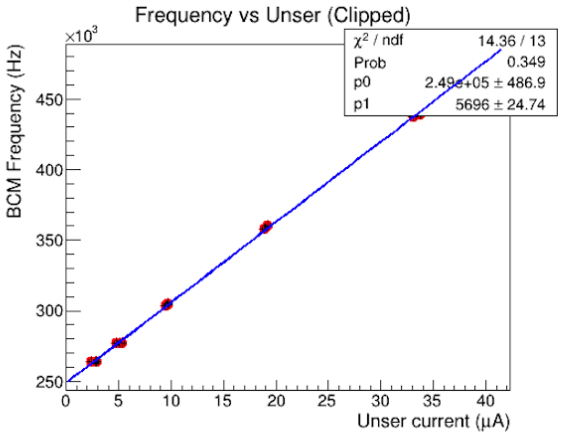
Which BCM?

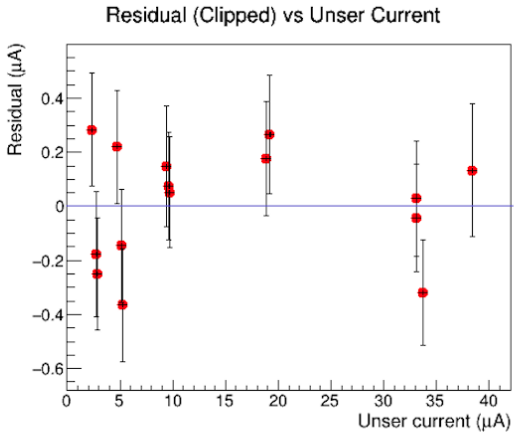
- Solution: ***use BCM4A for normalization.***
  - ✓ Stable gain, offset throughout the year.
  - ✓ No saturation issues in our current range.

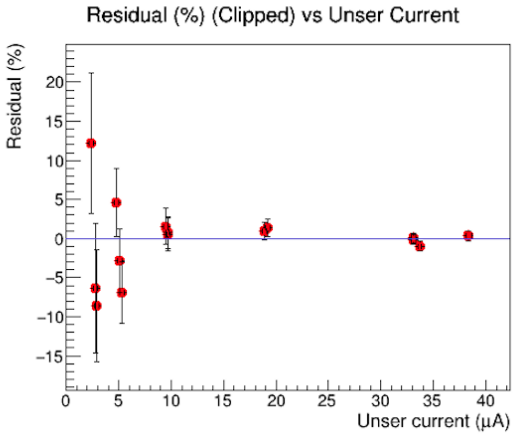
- Fine tuning calibrations for BCMs 2 and 4C can be done in the replay, but ***using BCM4A is the most straightforward.***

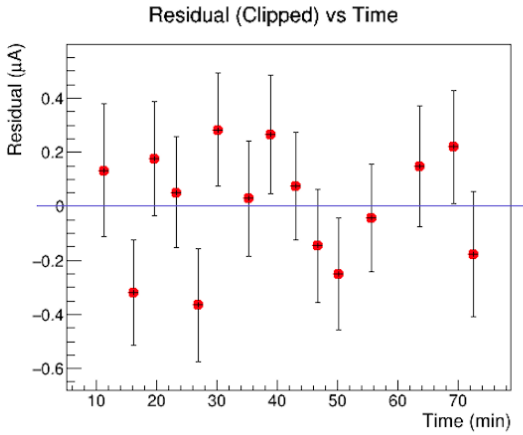
Analysis Plots & Code Expansion

Below: Example 4 Panel Plots used in analysis
(Run 1422, BCM2)







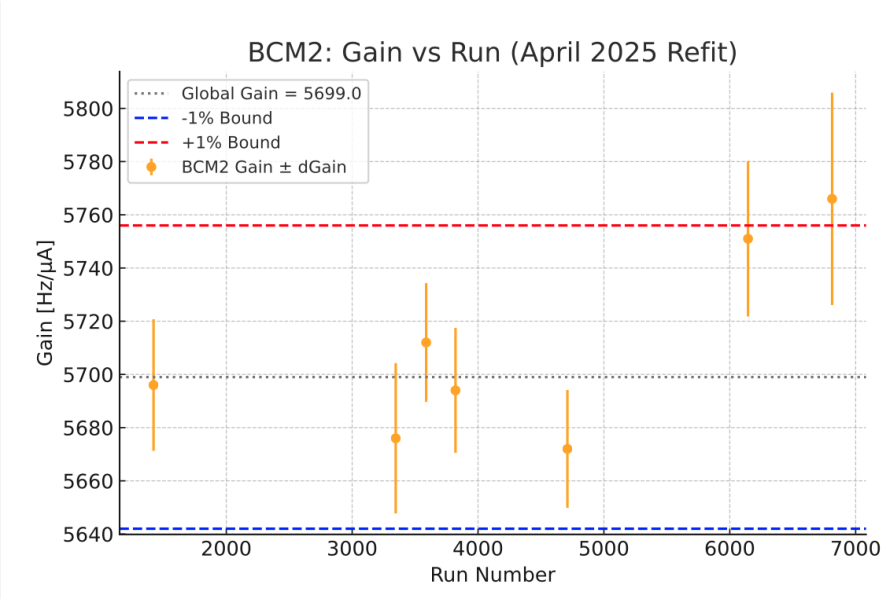


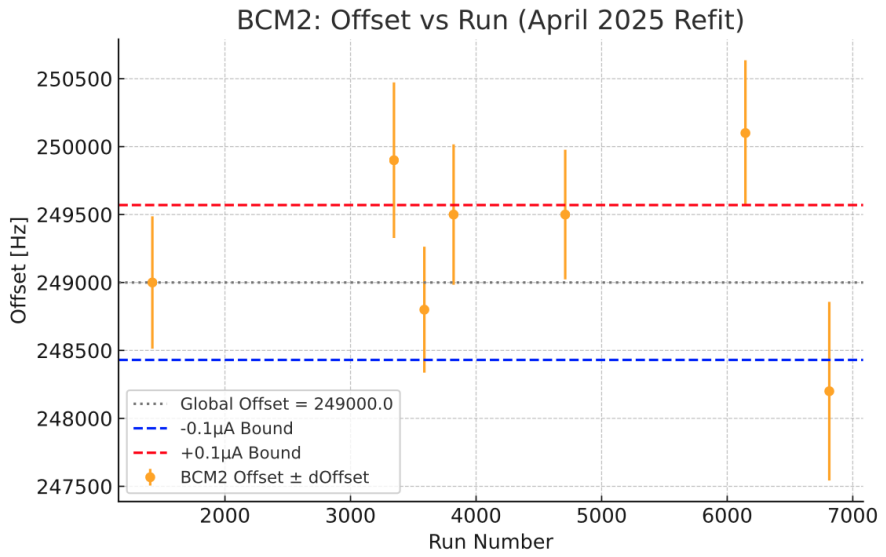
To refine the fits, I reorganized the existing code to output the rates, currents, times, errors, signal-to-noise, standard deviation, and decision (KEEP/REMOVE) for each point. This retained the residual analysis plots while quantifying the standard deviation and SNR. It also allowed for a more streamlined analysis.

Fit Probability

Run Number	Date	Chi^2/ndf Fit Probability	Notes
1422	Sept 25, 2023	0.35	***Gain & Offset very close to global fit values;*** Replay used these throughout experiment
2157	Oct 23, 2023		Not used – bad run
3346	Nov 29, 2023	0.73	
3588	Dec 12, 2023	0.81	
3821	Jan 23, 2024	0.009	Using RMS Unser noise restores reasonable p-value
4710	Feb 25, 2024	0.0003	Using RMS Unser noise restores reasonable p-value
6145	April 22, 2024	0.205	
6813	May 12, 2024	0.36	

Calibration Runs vs Global Weighted Fit (BCM 2)





Run	Gain	dGain	Offset	dOffset
Global Fit	**5699**	**12.36**	**2.49E05**	**249.3**
1422	5696	24.74	2.49E05	486.9
3346	5676	28.24	2.50E05	572.5
3588	5712	22.32	2.49E05	463.4
3821	5694	23.46	2.49E05	516.6
4710	5672	22.15	2.50E05	477
6145	5751	29.22	2.50E05	535.5
6813	5766	39.93	2.48E05	657.4

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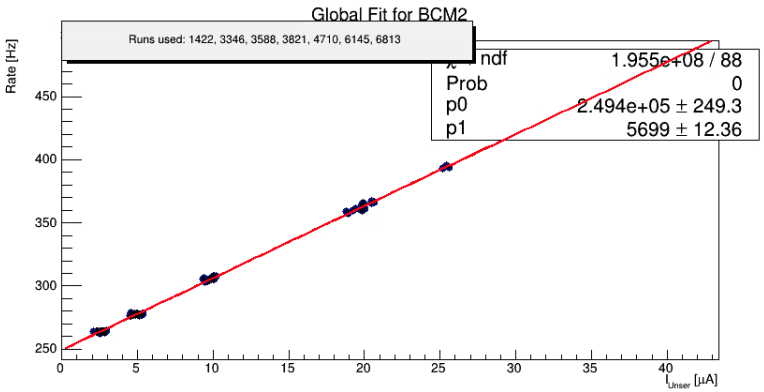
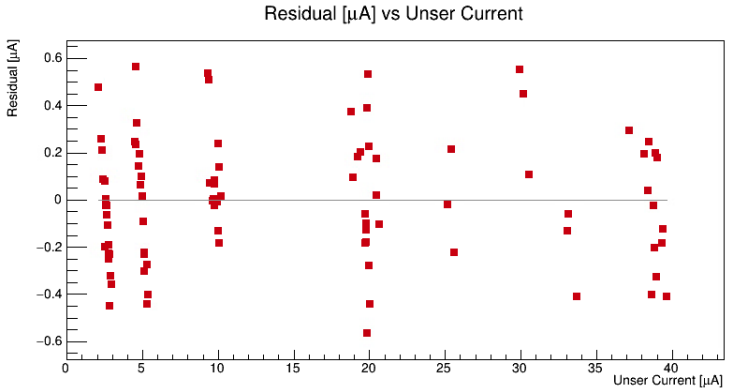
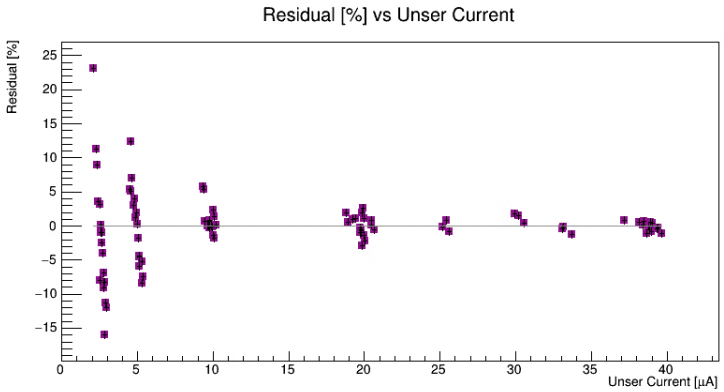
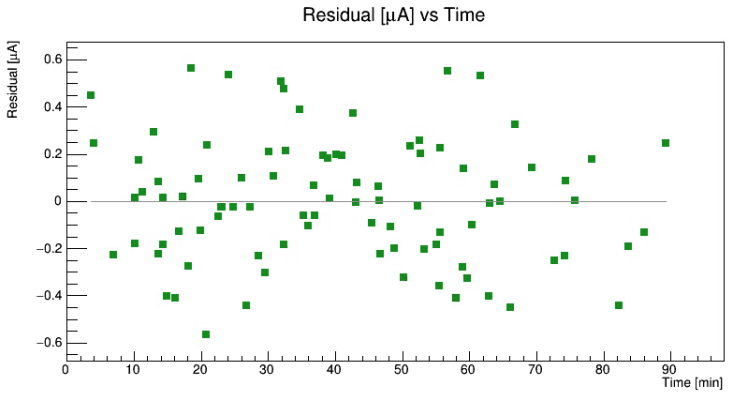
Calibration Runs vs Global Weighted Fit (BCM 2)









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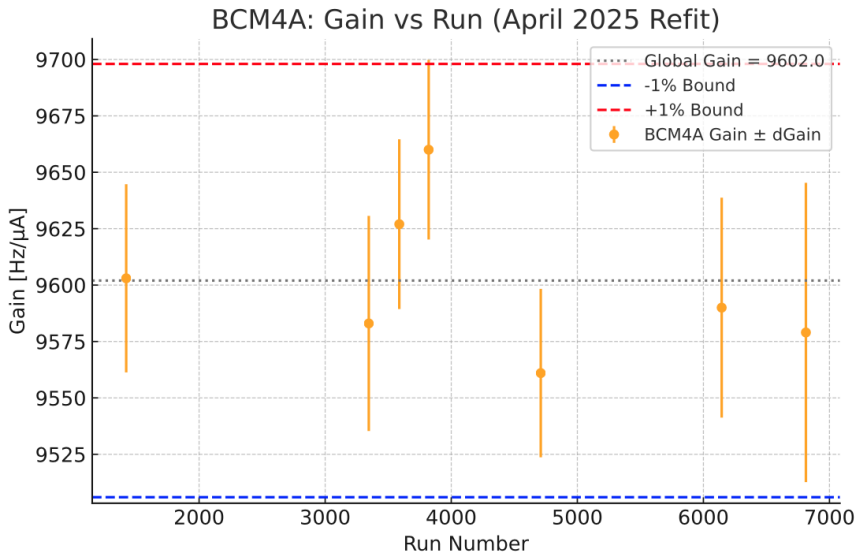
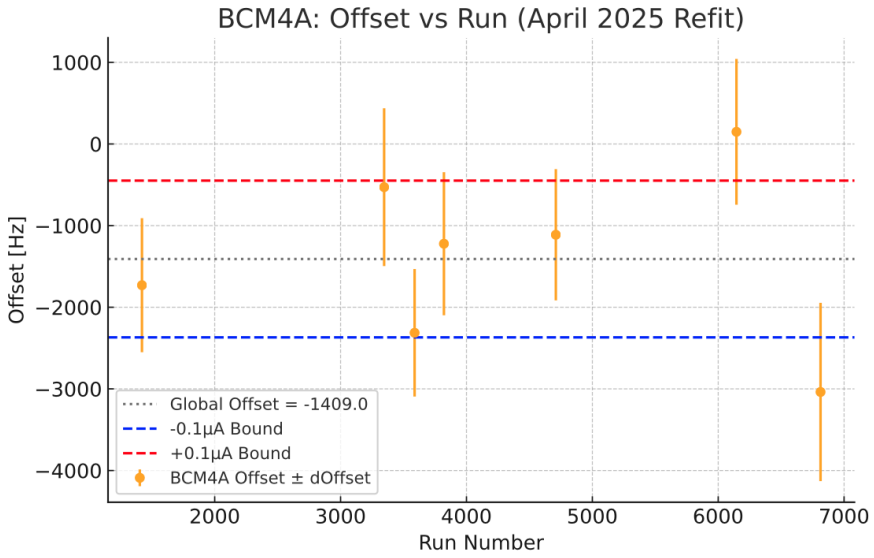
Calibration Runs vs Global Weighted Fit (BCM 4A)





Run	Gain	dGain	Offset	dOffset
Global Fit	**9602**	**20.59**	**-1409**	**415.5**
1422	9603	41.7	-1730	820.9
3346	9583	47.67	-528.8	966.5
3588	9627	37.62	-2313	781
3821	9660	39.8	-1222	876.4
4710	9561	37.33	-1112	803.9
6145	9560	48.74	149.5	893.1
6813	9579	66.33	-3038	1092

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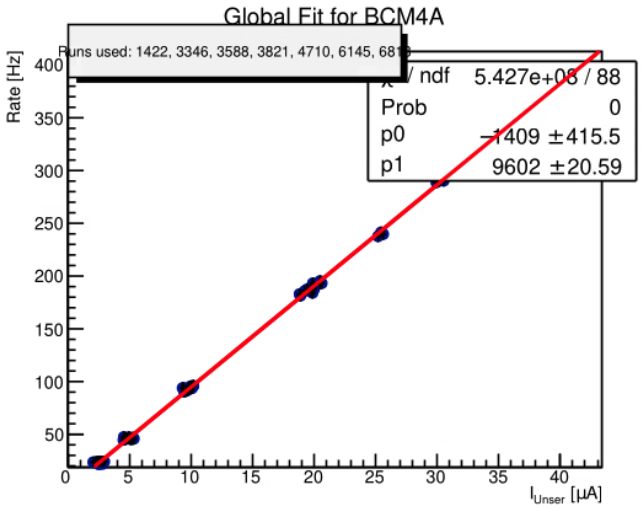
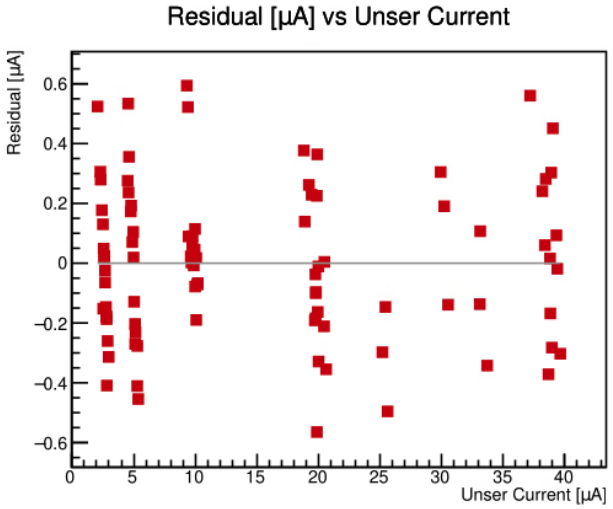
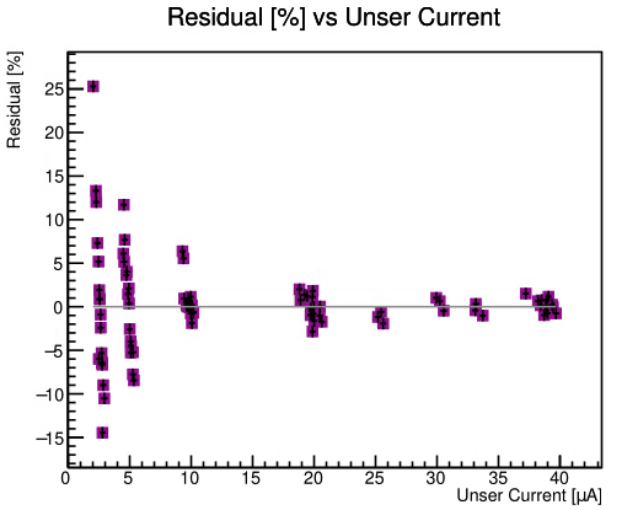
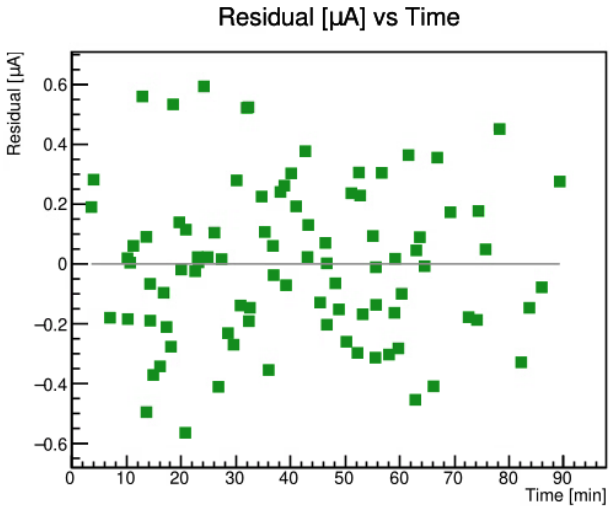
Calibration Runs vs Global Weighted Fit (BCM 4A)

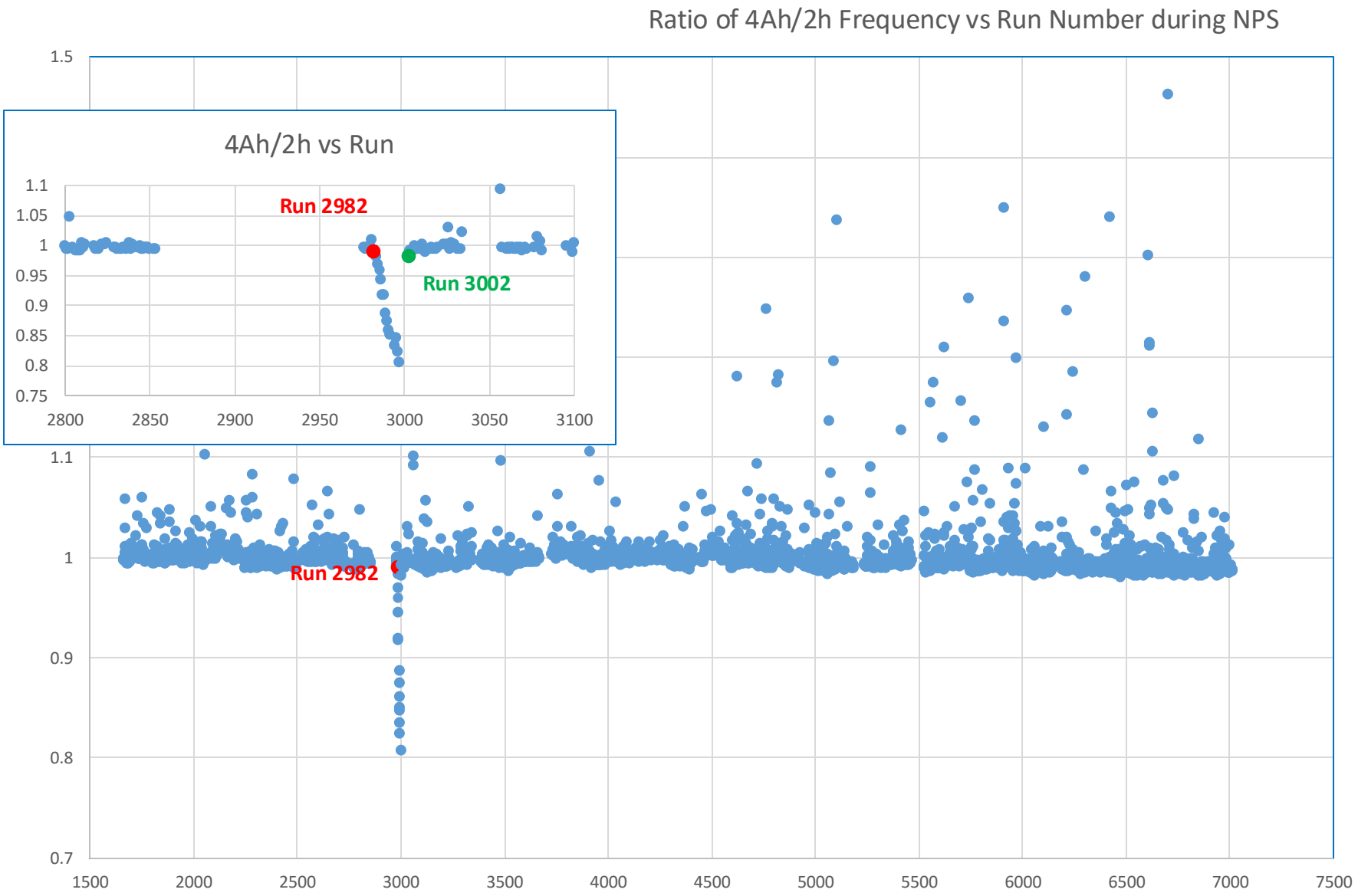








To Do: What are these runs?

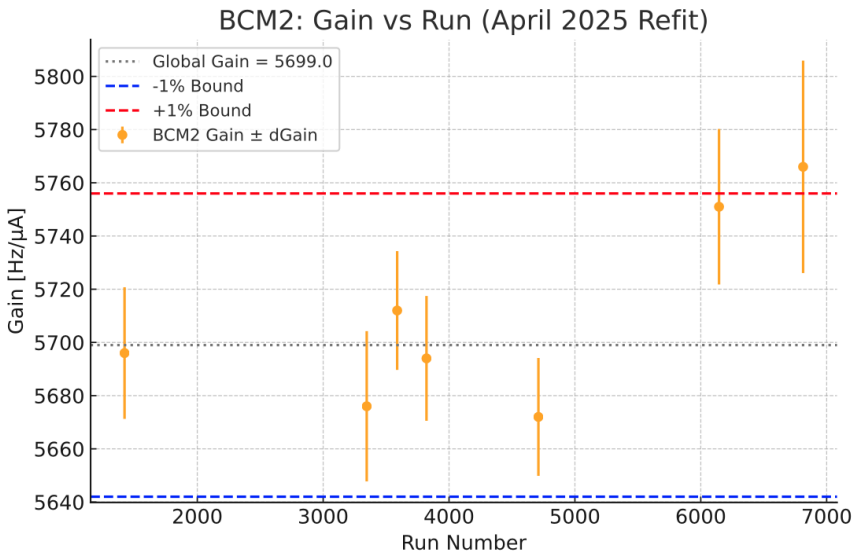


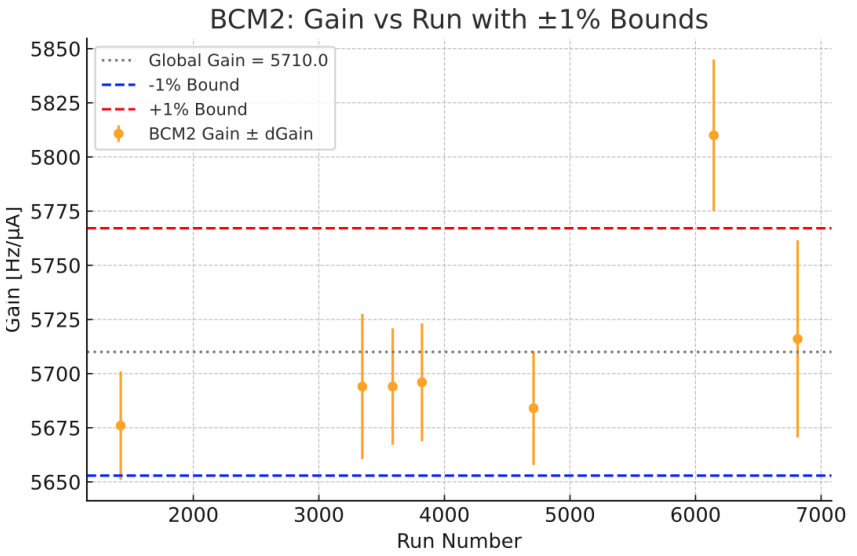
To Do:

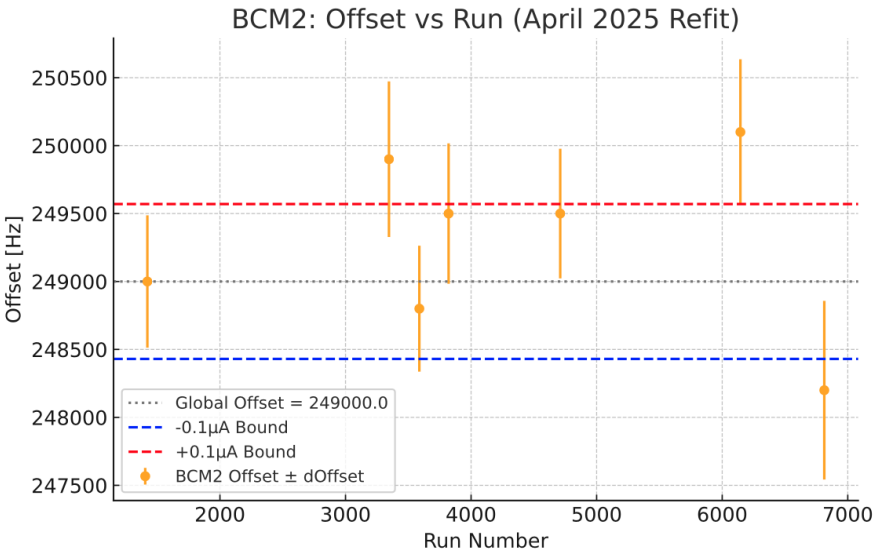
- Finish Bob Michael's study of 4A/2 Helicity rates
- Adjust data points to achieve reasonable probability in global fits.
- Understand offset with respect to luminosity studies.
- Update nps_replay calibration to reflect new understanding.

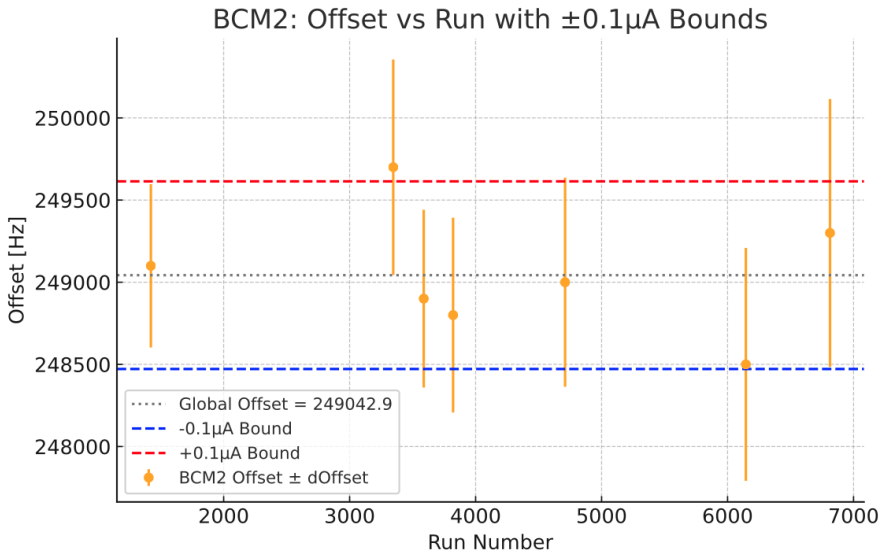
- Thank you!

Extra: Compare to Pass 1 Fit









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