BCMs and Charge For E12-06-114:DVCS

Bishnu Karki

Ohio University

DVCS Collaboration Meeting

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Outline:

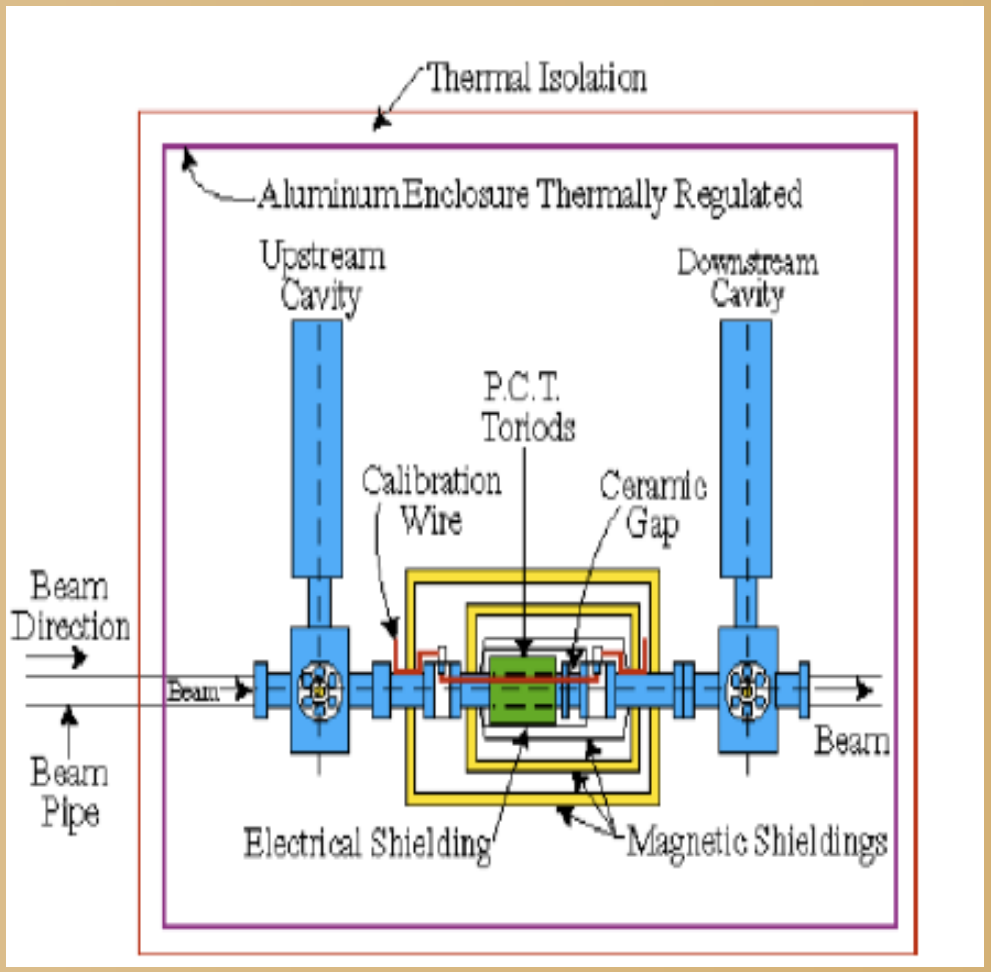
- **Introduction:**
- **Unser / BCM Calibration:**
- **Charge Comparison:**
- **Conclusion:**

Introduction:

- Uncertainty in charge has significant impact on measured cross section.
- BCMs needs to be well calibrated for charge precision.

BCM Hardware:

- Two BCMs: UpStream (U) and DownStream(D)
- Multiple receivers for each BCM:
- **Analog:** X1 : U1 and D1
  X3 : D3
  X10 :D10
- **Digital:** Unew and Dnew
- Output from the BCM receivers are sent to Voltage to Frequency (V-F) converter then to Scaler.
- BCM Measures **relative current** so need to calibrated against Unser.



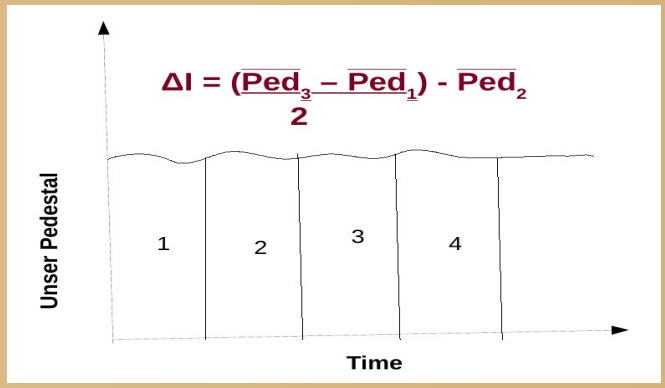
Unser / BCM Calibration:

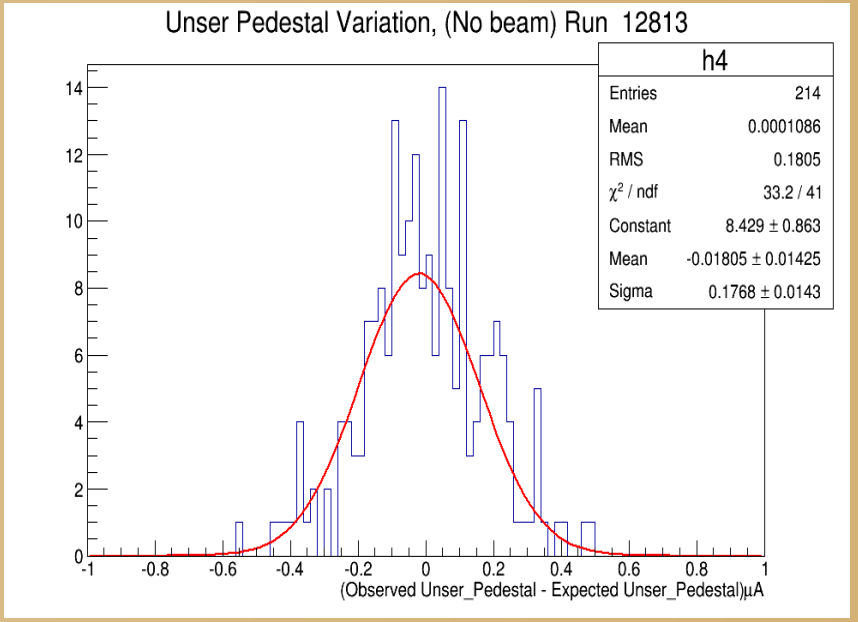
Unser:

- Unser output is proportional to input current.
- Easy to calibrate.
- Uncertainty in Unser is 0.2 μA.
- Unser pedestal drifts in unpredictable way over time scale of several minutes.
- **Calibration Procedure:**

➔ First Calibrate Unser with known current source.

➔ Then use Unser current to calibrate BCMs.

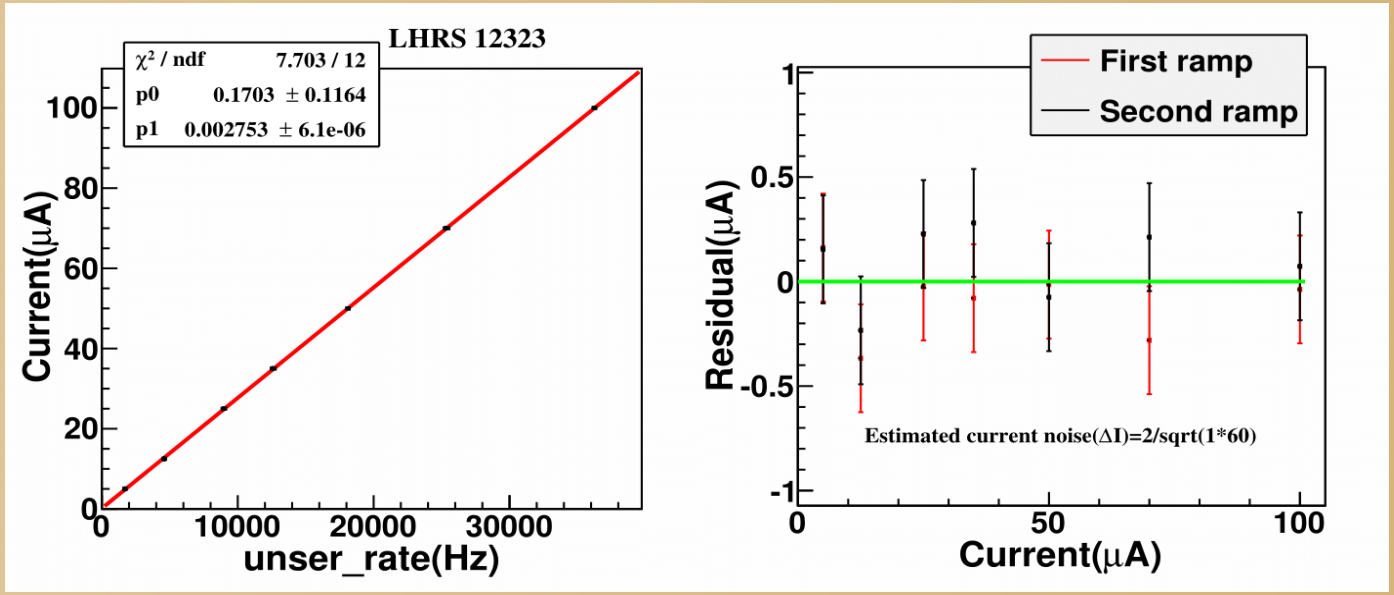




Unser /BCM Calibration:

Unser Calibration:

- Unser is calibrated with known injected current in Hall A ($f_{unser} \rightarrow I_{unser}$).
- With precise knowledge of beam current from Unser, BCMs are calibrated ($f_{BCM} \rightarrow I_{BCM}$).



Unser / BCM Calibration:

Unser Gain Stability:

Unser gains Fall 2016

Run	Gain X 10^{-6} (μA/Hz)	Error X10^{-6}
23217	2506	5
23779	2504	5

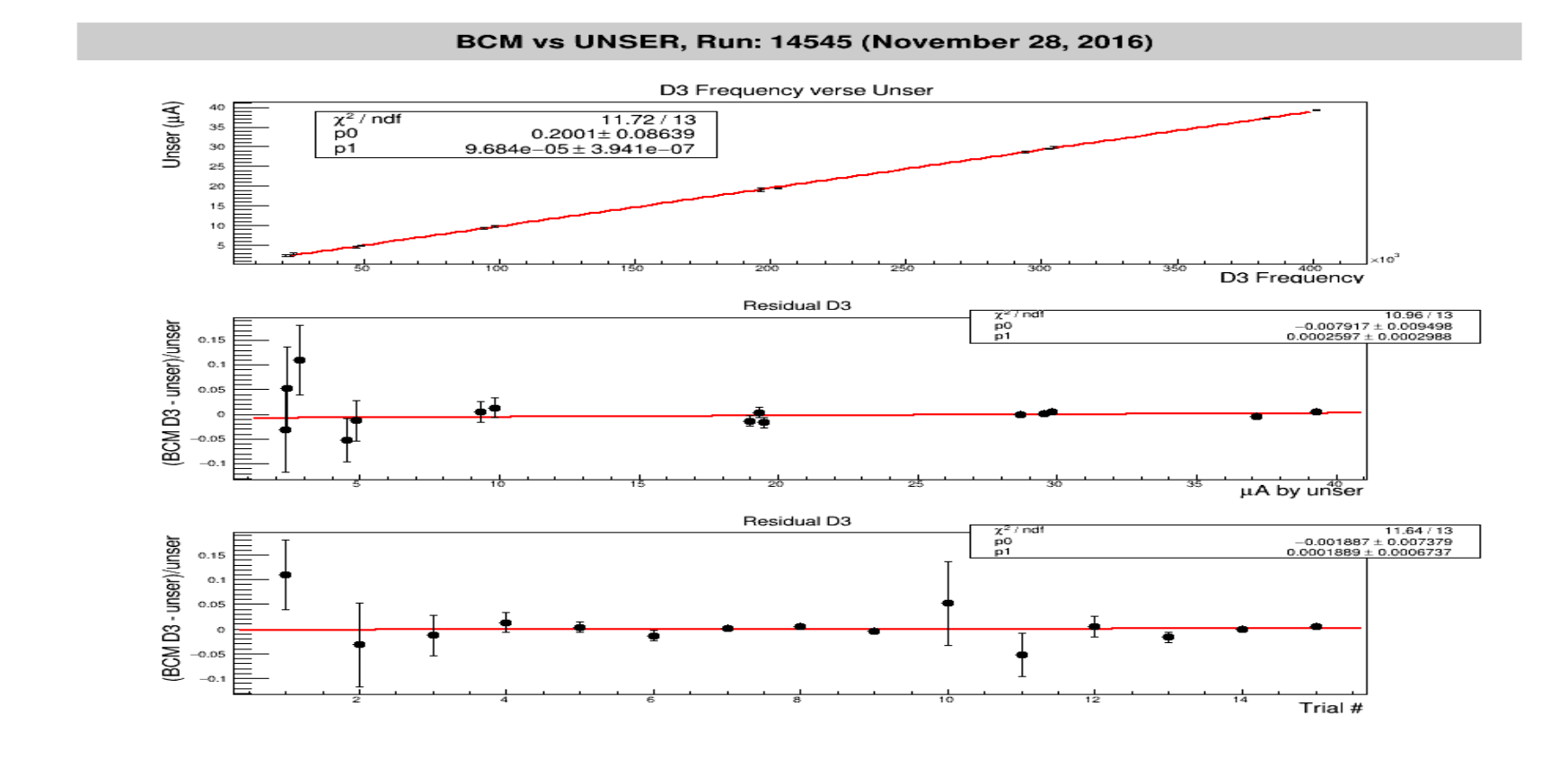
Unser Gain Spring 2016

Run	Gain X 10^{-6} (μA/Hz)	Error X10^{-6}
Fall 2014	2755	7
21590	2754	6
12323	2753	6
22324	2753	6

Unser gains are stable within the error bar for particular run period.

Unser / BCM Calibration:

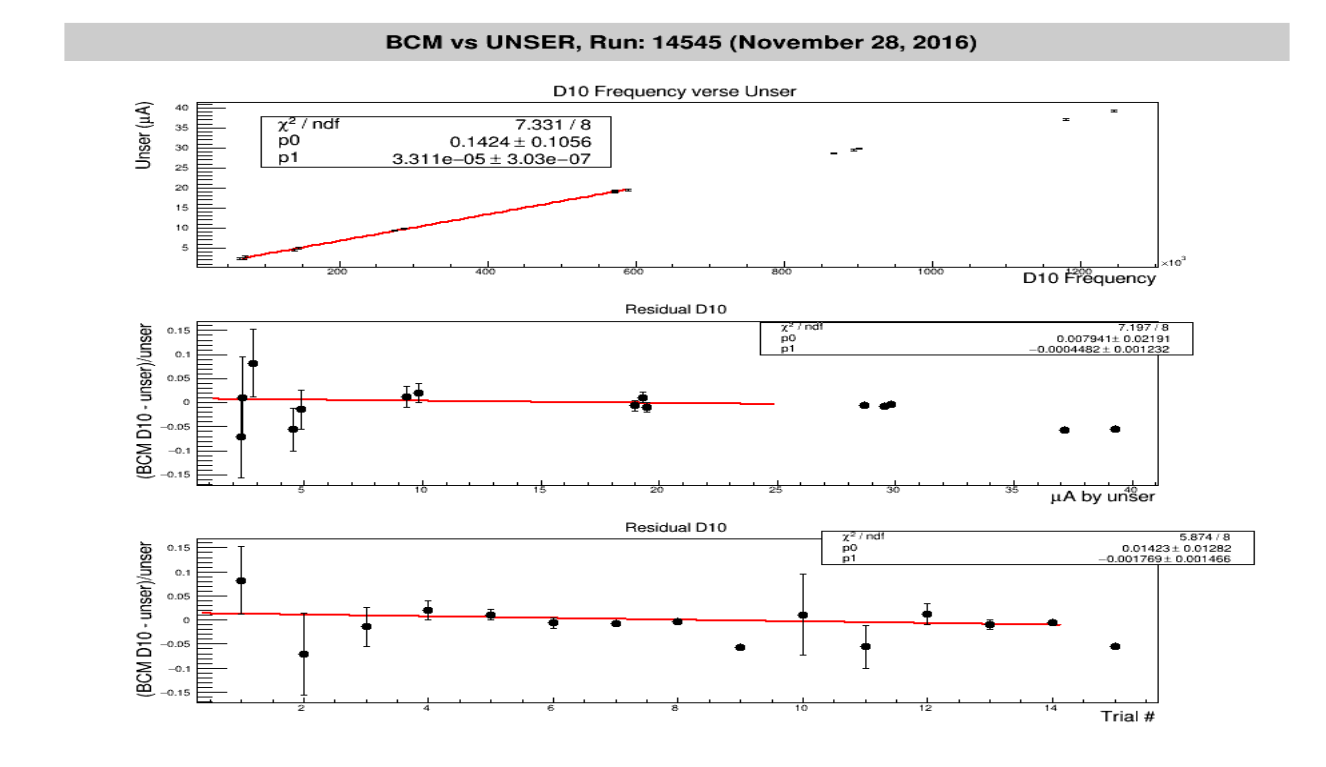
BCM Calibration:



- **Using Unser current the BCMs are calibrated.**

Unser / BCM Calibration:

Linearity Range:



Device	U1	D1	D3	D10	Unew	Dnew
I (μA)	10-60	10-60	0-60	0-25	**0-60**	**0-60**

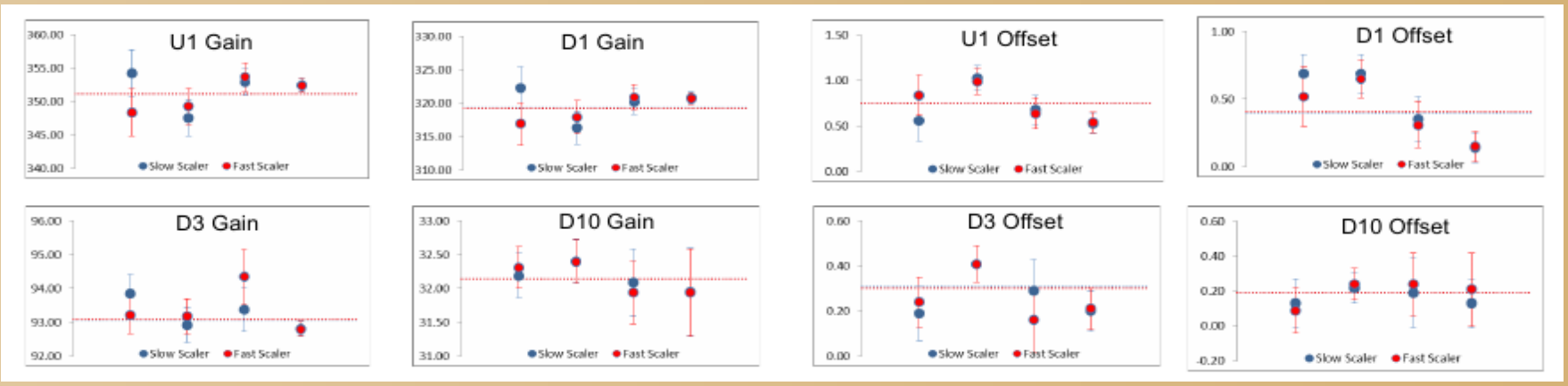
Stability Gains & Offsets:

Spring 2016:

12508 - 13015	Gains from run 12514 & 12916
13100 - 13261	Gains from run 13220
13279 - 13418	Gains from run 13447

Spring 2016 Calibration Coefficient

Global Calibration from Spring 2016 by Zach		
BCM's	**Gain (x 10-6 μA/Hz)**	**Offset (μA)**
U1	351.17 ± 0.72	0.75 ± 0.06
D1	319.28 ± 0.65	0.41 ± 0.06
D3	93.09 ± 0.18	0.30 ± 0.05
D10	32.14 ± 0.18	0.19 ± 0.06
Unew and Dnew (Run 12514 & 12916)		
Dnew	172.15 ± 0.66	0.19 ± 0.06
Unew	199.25 ± 0.76	0.20 ± 0.06
Unew and Dnew (Run 13220)		
Dnew	249.95 ± 1.41	0.10 ± 0.12
Unew	295.64 ± 1.66	0.20 ± 0.12
Unew and Dnew (Run 13447)		
Dnew	42.94 ± 0.25	0.04 ± 0.12
Unew	50.05 ± 0.29	0.05 ± 0.12



- The gains for new receivers changed multiple times.
- Analog BCMs: gains are stable so we can do global calibration.

Stability Gains & Offsets:

Fall 2016 & Fall 2014

Fall 2016 Calibration Coefficient

October 15-2016 (Run 13852) High I (GMP)		
BCM's	Gain (x 10-6 μA/Hz)	Offset (μA)
U1	384.4 ± 0.82	1.1 ± 0.08
D1	329.2 ± 0.69	0.49 ± 0.09
D3	95.49 ± 0.17	0.38 ± 0.07
D10	32.98 ± 0.27	0.24 ± 0.10
Dnew	215.54 ± 0.38	0.13 ± 0.07
Unew	254.6 ± 0.45	0.15 ± 0.07

November 2-2016 (Run 14252)		
BCM's	Gain (x 10-6 μA/Hz)	Offset (μA)
U1	383.1 ± 3.43	1.28 ± 0.16
D1	326.3 ± 2.93	0.81 ± 0.16
D3	97.7 ± 0.60	0.13 ± 0.09
D10	34.36 ± 0.32	-0.12 ± 0.11
Dnew	223.6 ± 1.37	-0.0003 ± 0.09
Unew	258.1 ± 1.6	0.003 ± 0.09

Global Calibration (Nov 2 and Nov 26)

BCM's	Gain (x 10-6 μA/Hz)	Offset (μA)
U1	384.84 ± 1.86	1.10 ± 0.11
D1	328.77 ± 1.59	0.62 ± 0.11
D3	97.05 ± 0.32	0.19 ± 0.06
D10	33.72 ± 0.22	0.03 ± 0.08
Dnew	224.23 ± 0.74	-0.01 ± 0.06
Unew	255.50 ± 0.85	0.05 ± 0.06

November 26-2016 (Run 14545)

BCM's	Gain (x 10-6 μA/Hz)	Offset (μA)
U1	388.63 ± 2.49	0.77 ± 0.16
D1	331.68 ± 2.12	0.34 ± 0.17
D3	96.84 ± 0.39	0.20 ± 0.09
D10	33.11 ± 0.30	0.14 ± 0.11
Dnew	224.37 ± 0.91	0.0 ± 0.09
Unew	254.89 ± 1.04	0.03 ± 0.09

Fall 2014 Calibration Coefficient

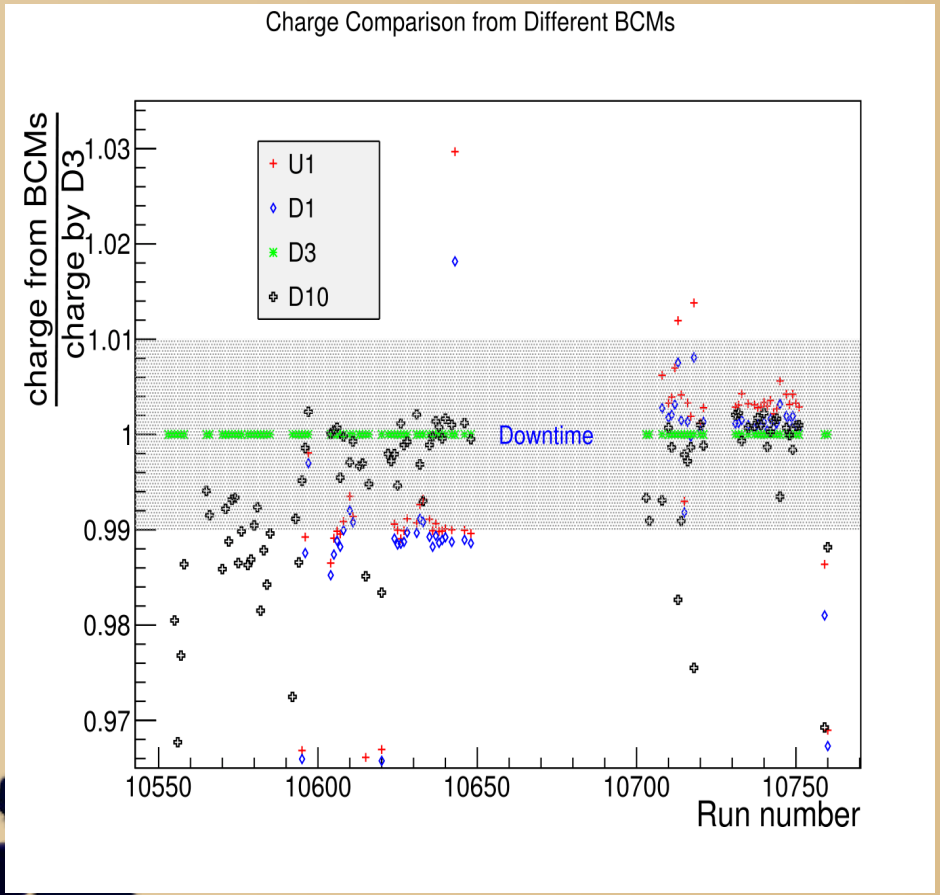
Dec 12 -2014 (Run 10505)

BCM's	Gain (x 10-6 μA/Hz)	Offset (μA)
U1	515.9 ± 9.99	0.56 ± 0.29
D1	454.53 ± 8.8	0.55 ± 0.22
D3	127.4 ± 1.6	0.39 ± 0.17
D10	45.65 ± 0.57	0.031 ± 0.17

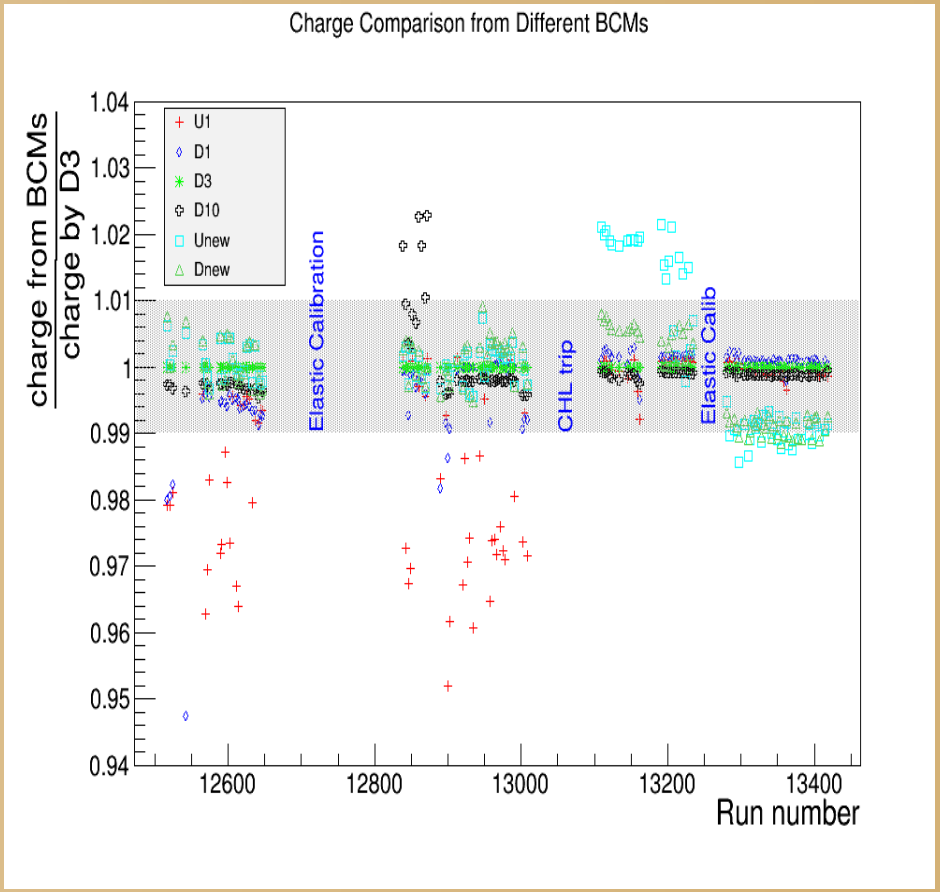
- **For Fall 2016, combined analysis from Nov 2 and Nov 26 can be used.**
- **Only one calibration run in Fall 2014 .**

Charge Comparison:

- Charge (Q) = ∫ I dt

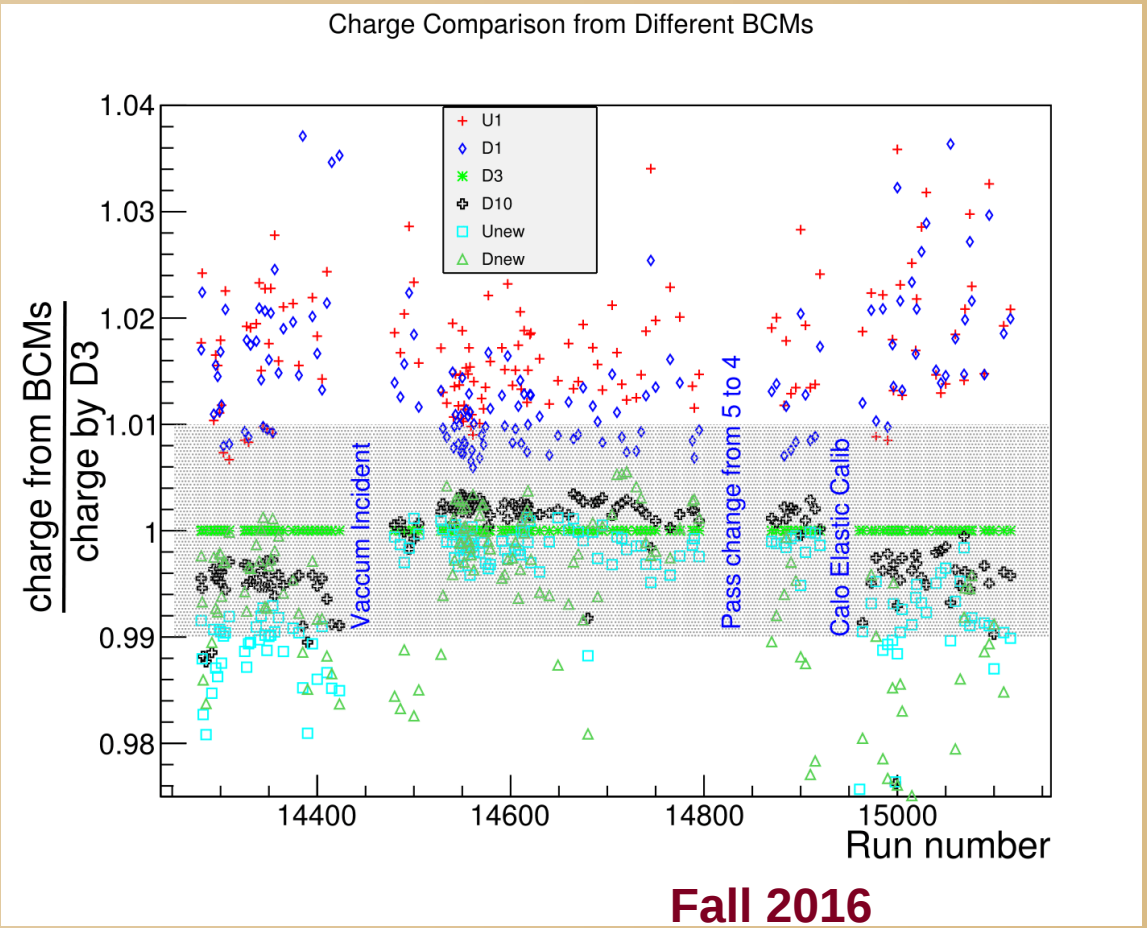


Fall 2014



Spring 2016

Charge Comparison:



Fall 2016

- **The charge from different BCMs agrees within 1%.**
- **New receivers are noisy and gains are not stable.**
- **U1 and D1 are not linear below 10 μA.**
- **D3 and D10 are linear within our range (5–20 μA) and gains are stable.**

Slow Vs. Fast Scaler:

- **Charge from fast and Slow Scalers are in agreement for runs above 5 minutes.**

Gains and Offsets:

Fall 2016:

Global Calibration (Nov 2 and Nov 26)		
BCM's	**Gain (x 10-6 μA/Hz)**	**Offset (μA)**
U1	384.84 ± 1.86	1.10 ± 0.11
D1	328.77 ± 1.59	0.62 ± 0.11
D3	97.05 ± 0.32	0.19 ± 0.06
D10	33.72 ± 0.22	0.03 ± 0.08
Dnew	224.23 ± 0.74	-0.01 ± 0.06
Unew	255.50 ± 0.85	0.05 ± 0.06

12508 - 13015	Gains from run 12514 & 12916
13100 - 13261	Gains from run 13220
13279 - 13418	Gains from run 13447

Fall 2014:

Dec 12 -2014 (Run 10505)		
BCM's	**Gain (x 10-6 μA/Hz)**	**Offset (μA)**
U1	515.9 ± 9.99	0.56 ± 0.29
D1	454.53 ± 8.8	0.55 ± 0.22
D3	127.4 ± 1.6	0.39 ± 0.17
D10	45.65 ± 0.57	0.031 ± 0.17

Spring 2016:

Global Calibration from Spring 2016 by Zach		
BCM's	**Gain (x 10-6 μA/Hz)**	**Offset (μA)**
U1	351.17 ± 0.72	0.75 ± 0.06
D1	319.28 ± 0.65	0.41 ± 0.06
D3	93.09 ± 0.18	0.30 ± 0.05
D10	32.14 ± 0.18	0.19 ± 0.06
Unew and Dnew (Run 12514 & 12916)		
Dnew	172.15 ± 0.66	0.19 ± 0.06
Unew	199.25 ± 0.76	0.20 ± 0.06
Unew and Dnew (Run 13220)		
Dnew	249.95 ± 1.41	0.10 ± 0.12
Unew	295.64 ± 1.66	0.20 ± 0.12
Unew and Dnew (Run 13447)		
Dnew	42.94 ± 0.25	0.04 ± 0.12
Unew	50.05 ± 0.29	0.05 ± 0.12

Conclusion:

- Unser gains are stable within a same run period.
- The gains for analog BCMs are stable within same run period so global calibration coefficient can be used for one run period.
- Different BCMs agrees with each other within 1%.
- D3 and D10 are linear in our current range and their gains are stable.
- Charge from slow and Fast Scaler are in agreement for run more than 5 minutes.

Thank you for your Attention

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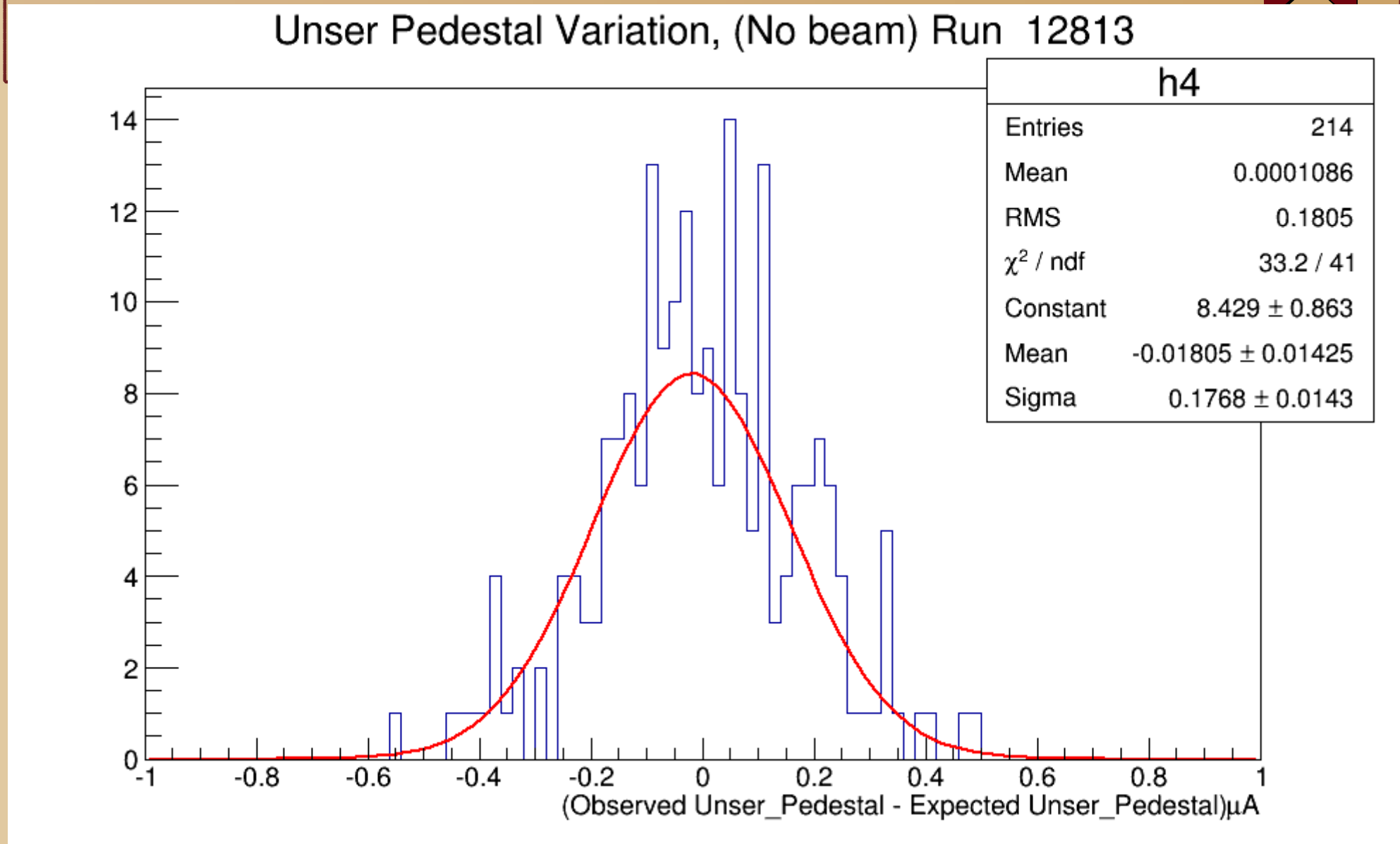
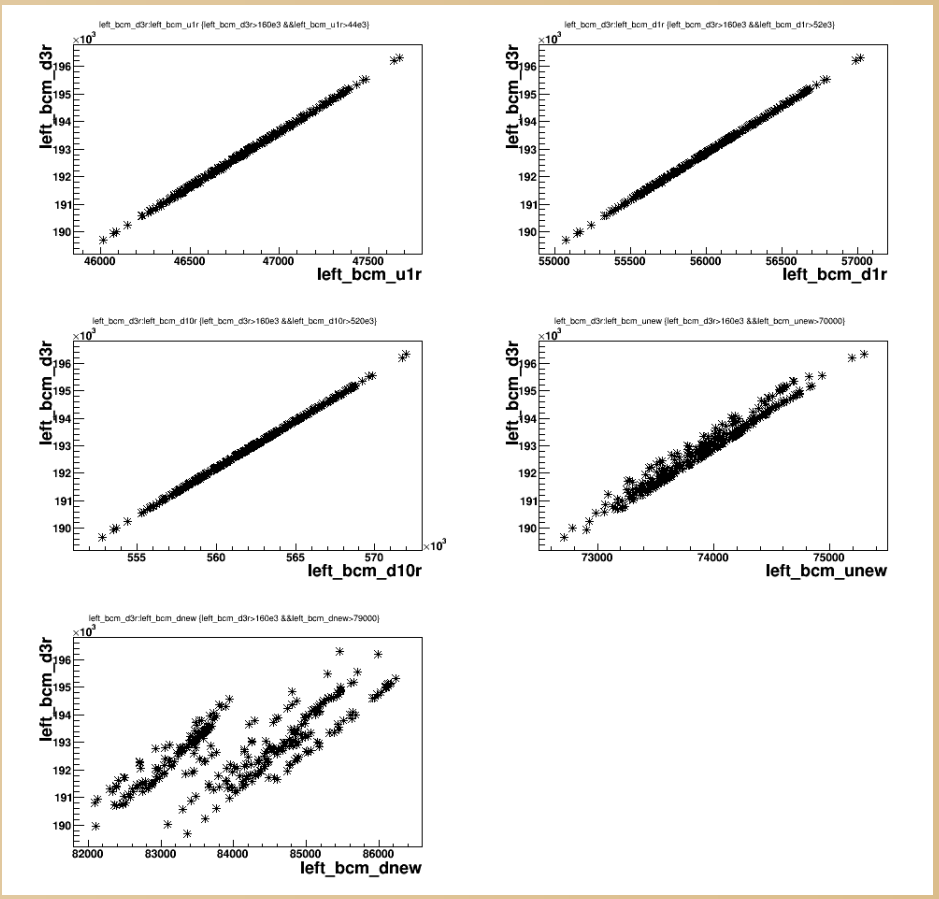
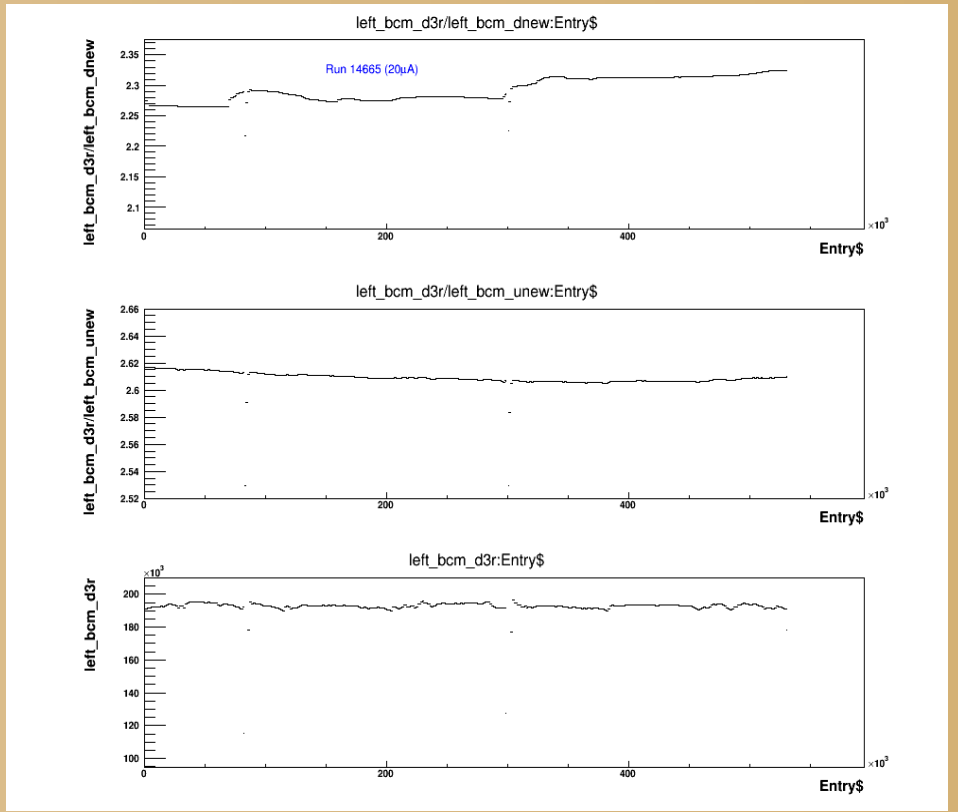
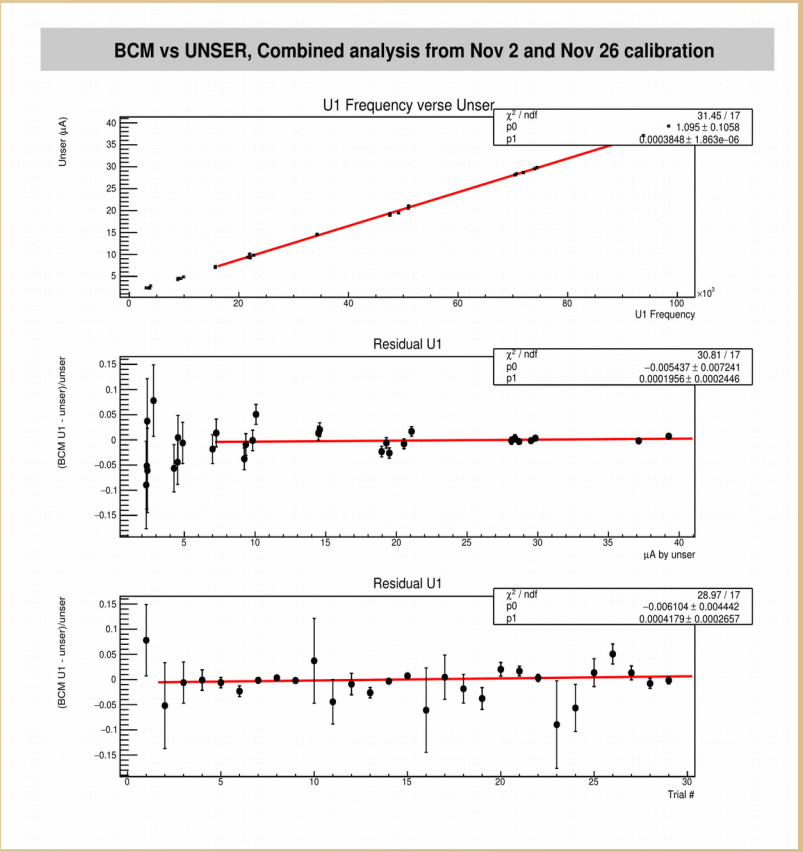

Unser Pedestal Variation, (No beam) Run 12813
h4
Entries 214
Mean 0.0001086
RMS 0.1805
χ² / ndf 33.2 / 41
Constant 8.429 ± 0.863
Mean -0.01805 ± 0.01425
Sigma 0.1768 ± 0.0143
14
12
10
8
6
4
2
0
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1
(Observed Unser_Pedestal - Expected Unser_Pedestal)μA

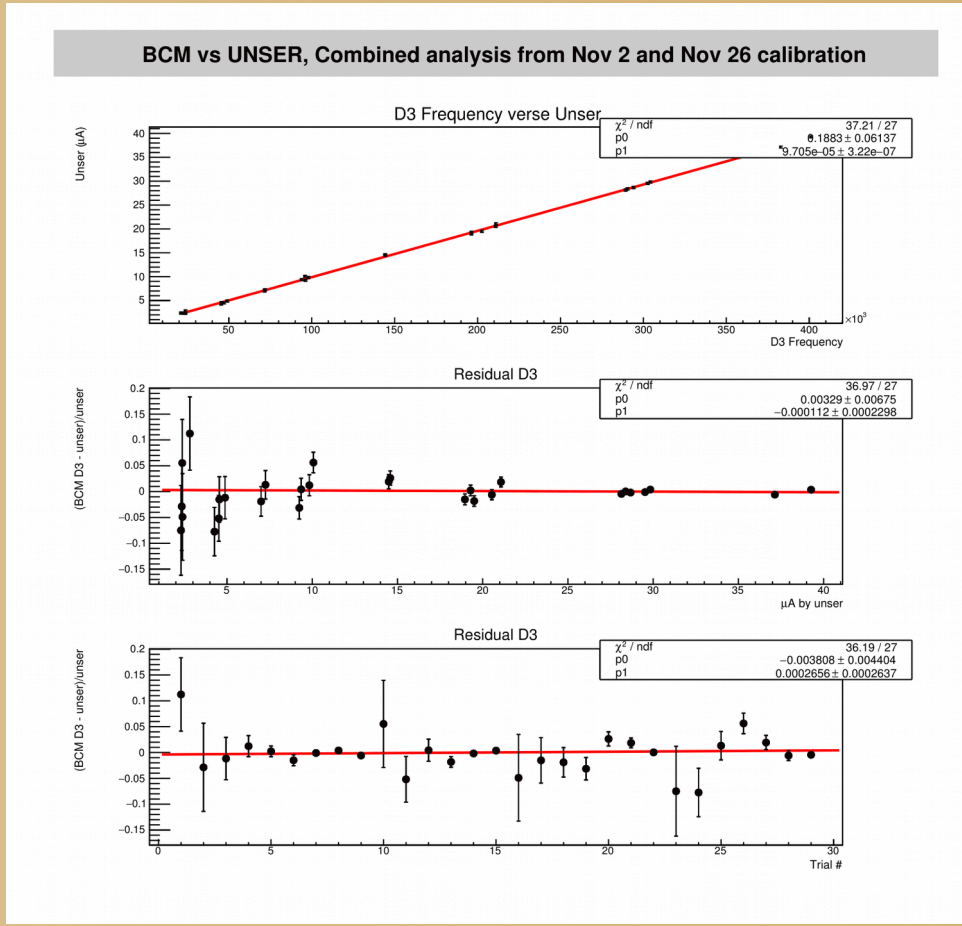
BCMs Correlation:



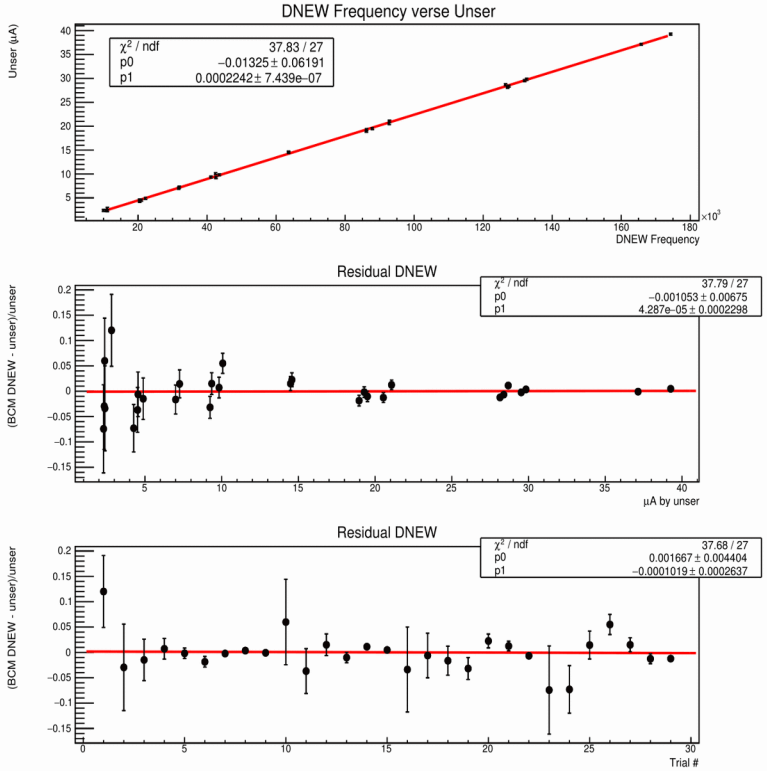


Global Calibration

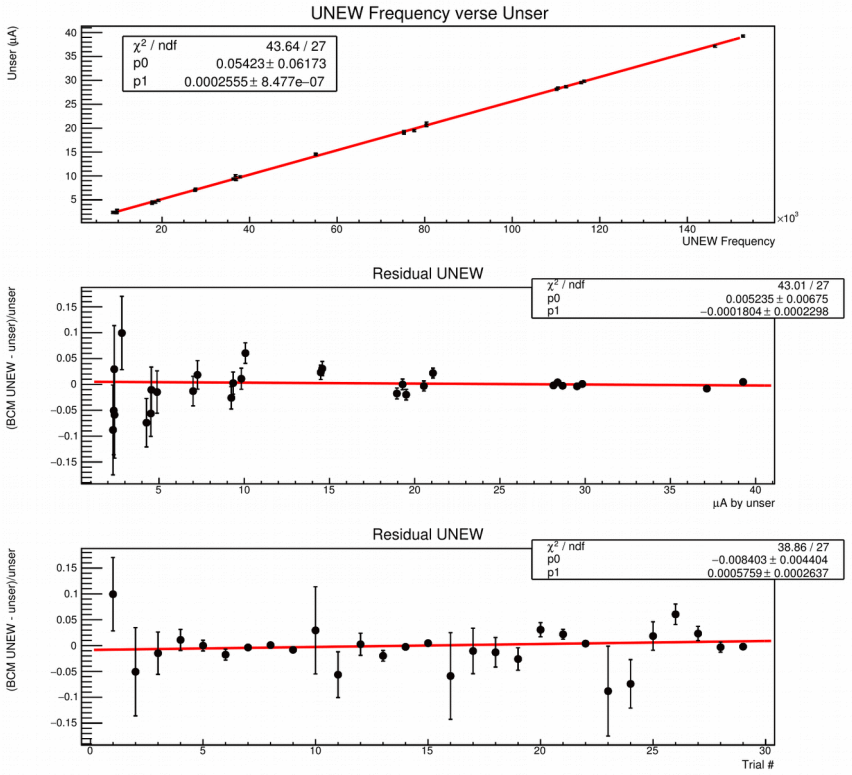




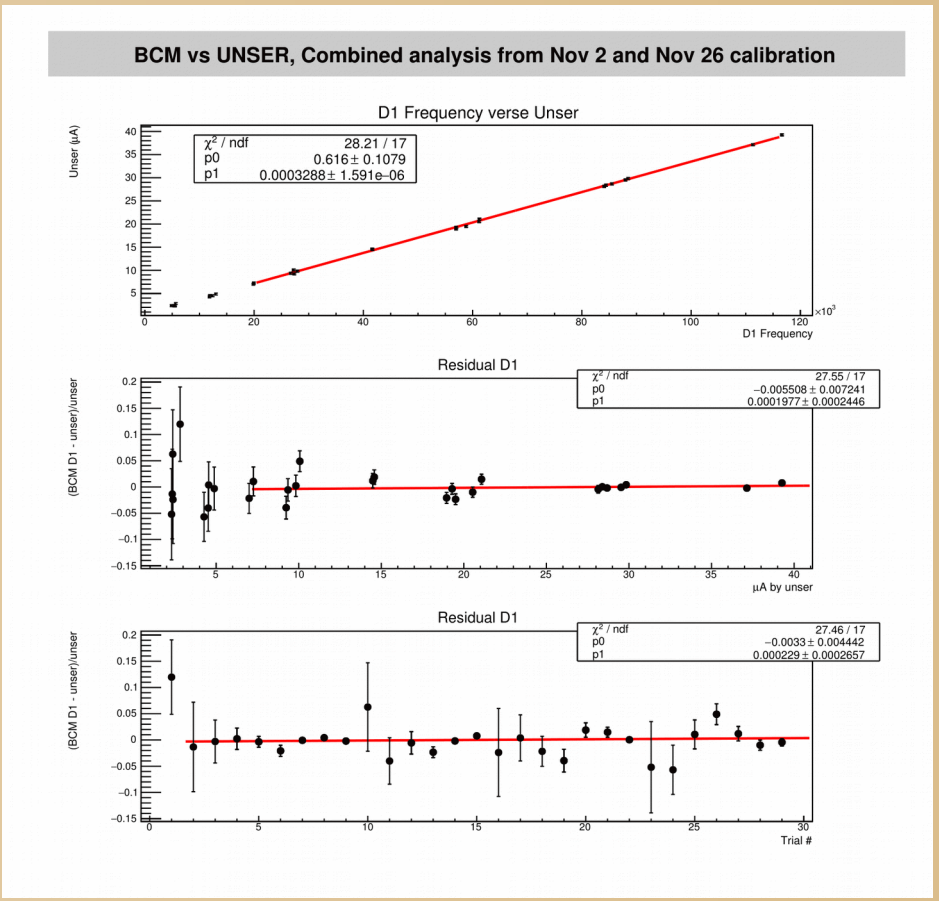
BCM vs UNSER, Combined analysis from Nov 2 and Nov 26 calibration

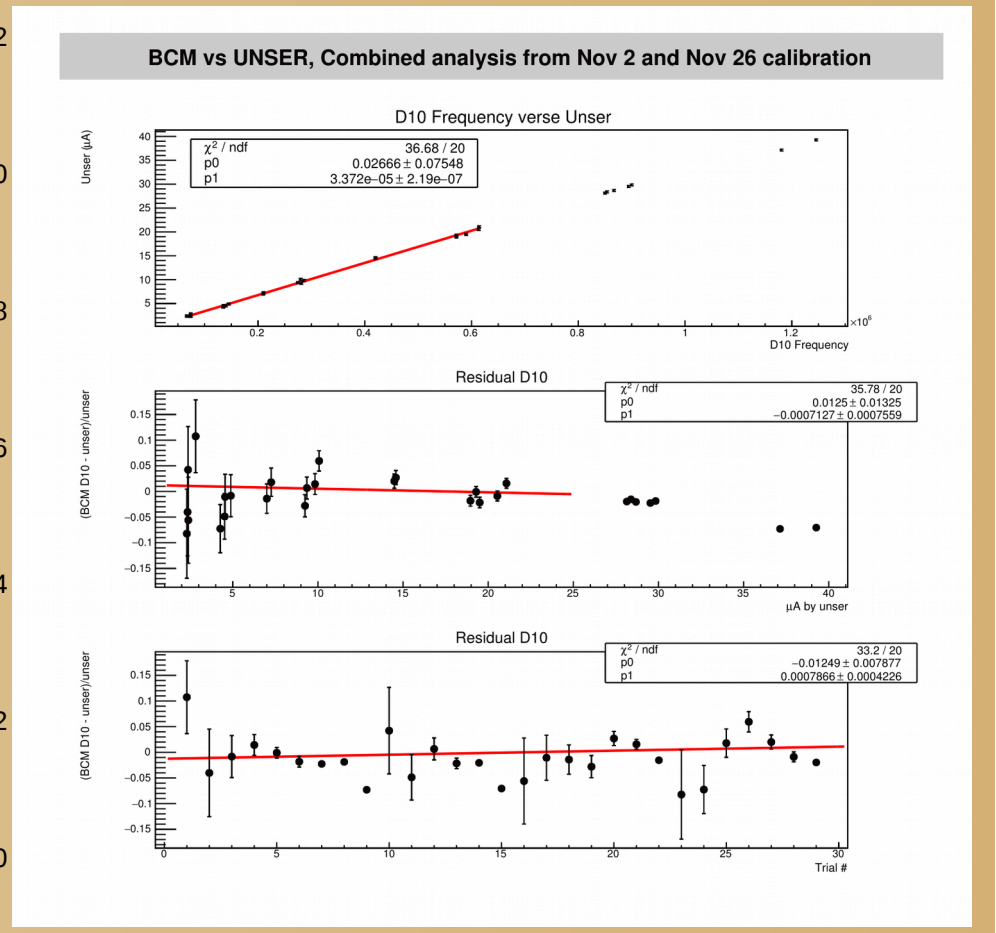


BCM vs UNSER, Combined analysis from Nov 2 and Nov 26 calibration



BCM Calibration Fall 2016





Gain Offsets Spring 2016

Spring 2016 Calibration Coefficient

Feb-16 -2016 (Run 12514)

BCM's	Gain (x 10-6 μA/Hz)	Offset (μA)
U1	354.3 ± 3.5	0.57 ± 0.22
D1	322.3 ± 3.2	0.55 ± 0.22
D3	93.9 ± 0.57	0.19 ± 0.12
D10	32.2 ± 0.33	0.14 ± 0.14
Dnew	172.9 ± 1.33	0.046 ± 0.13
Unew	200.7 ± 1.21	0.034 ± 0.12

April-10-2016 (13220)

BCM's	Gain (x 10-6 μA/Hz)	Offset (μA)
U1	352.9 ± 2.1	0.68 ± 0.16
D1	320.2 ± 1.88	0.35 ± 0.16
D3	93.38 ± 0.65	0.29 ± 0.13
D10	32.09 ± 0.49	0.19 ± 0.19
Dnew	249.0 ± 1.6	0.15 ± 0.12
Unew	294.3 ± 1.4	0.25 ± 0.12

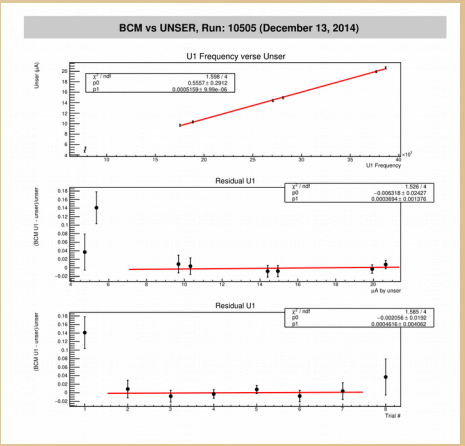
March-04-2016 (Run 12916)

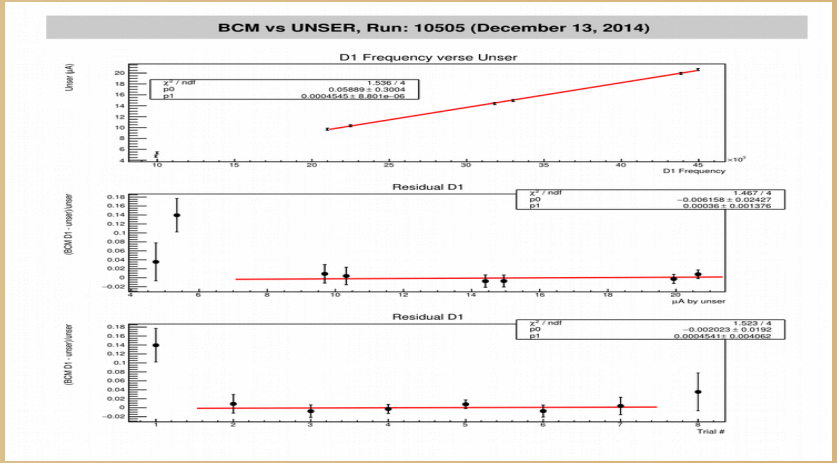
BCM's	Gain (x 10-6 μA/Hz)	Offset (μA)
U1	347.5 ± 2.7	1.05 ± 0.15
D1	316.3 ± 2.4	1.016 ± 0.14
D3	92.9 ± 0.51	0.41 ± 0.08
D10	32.39 ± 0.31	0.23 ± 0.094
Dnew	172.7 ± 0.94	0.23 ± 0.08
Unew	199.8 ± 1.1	0.25 ± 0.08

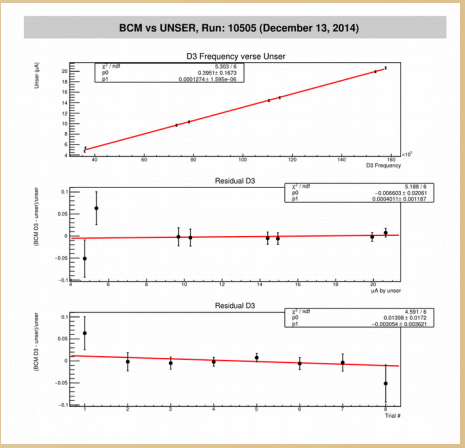
April-21-2016 (13447)

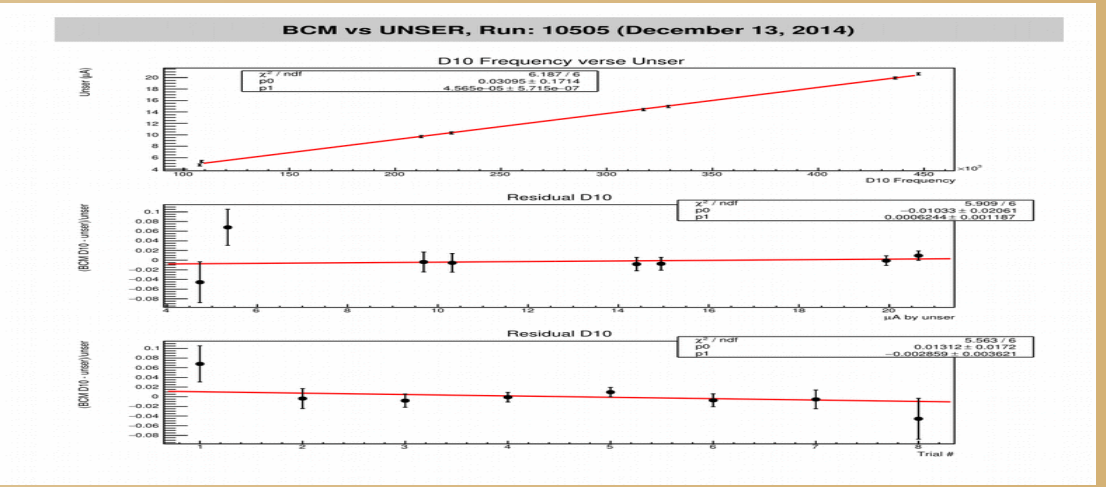
BCM's	Gain (x 10-6 μA/Hz)	Offset (μA)
U1	352.5 ± 0.98	0.53 ± 0.11
D1	320.8 ± 0.89	0.14 ± 0.11
D3	92.82 ± 0.22	0.19 ± 0.09
D10	31.95 ± 0.65	0.13 ± 0.21
Dnew	42.92 ± 0.25	0.038 ± 0.12
Unew	50.02 ± 0.29	0.045 ± 0.12

BCM Calibration Fall 2014

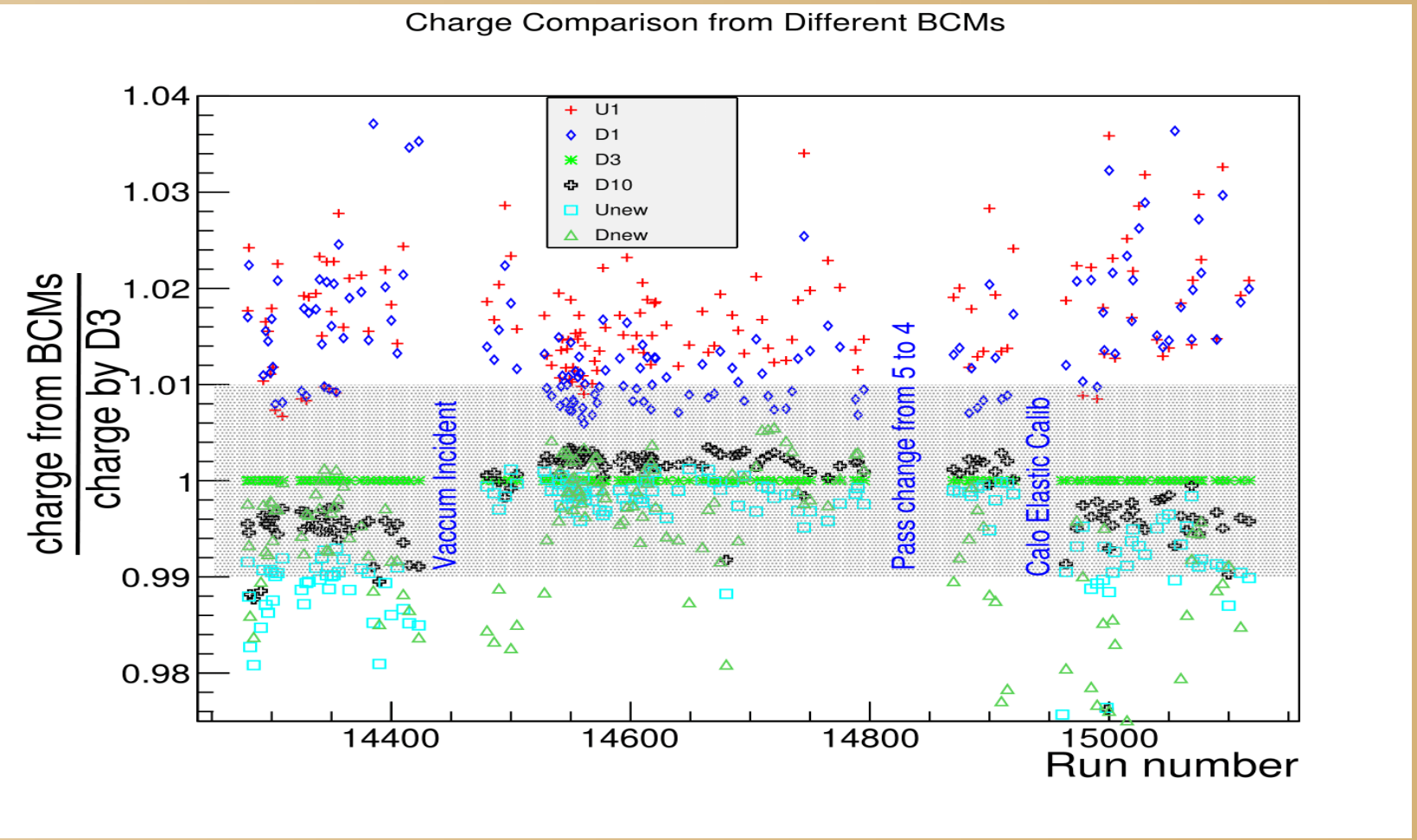




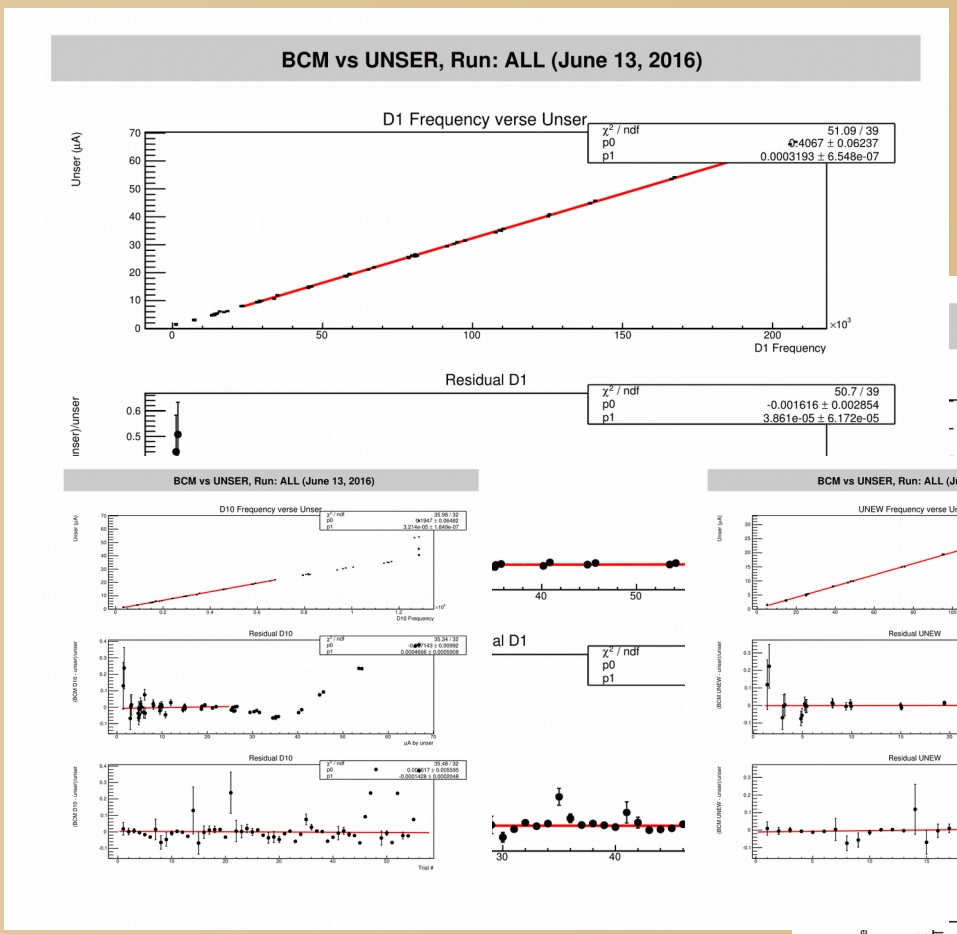


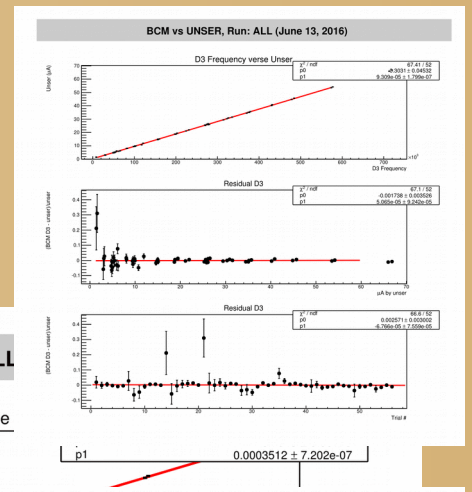


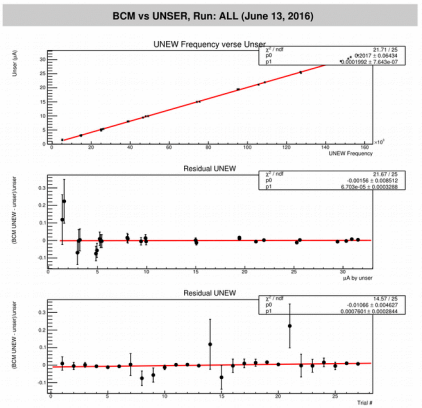
Charge comparison Fall 2016

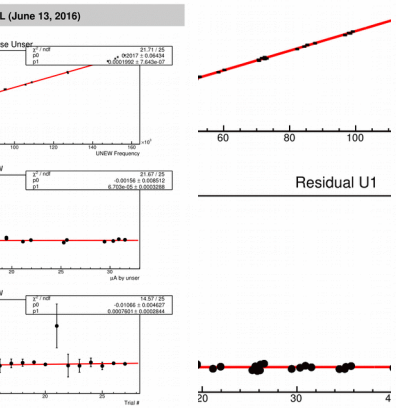


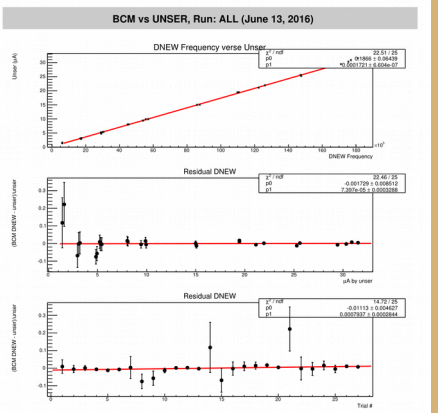
BCM calibration Spring 2016

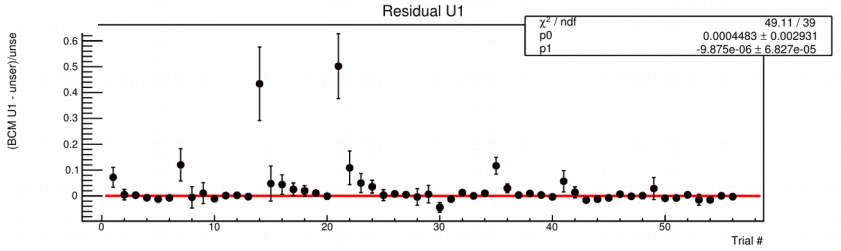
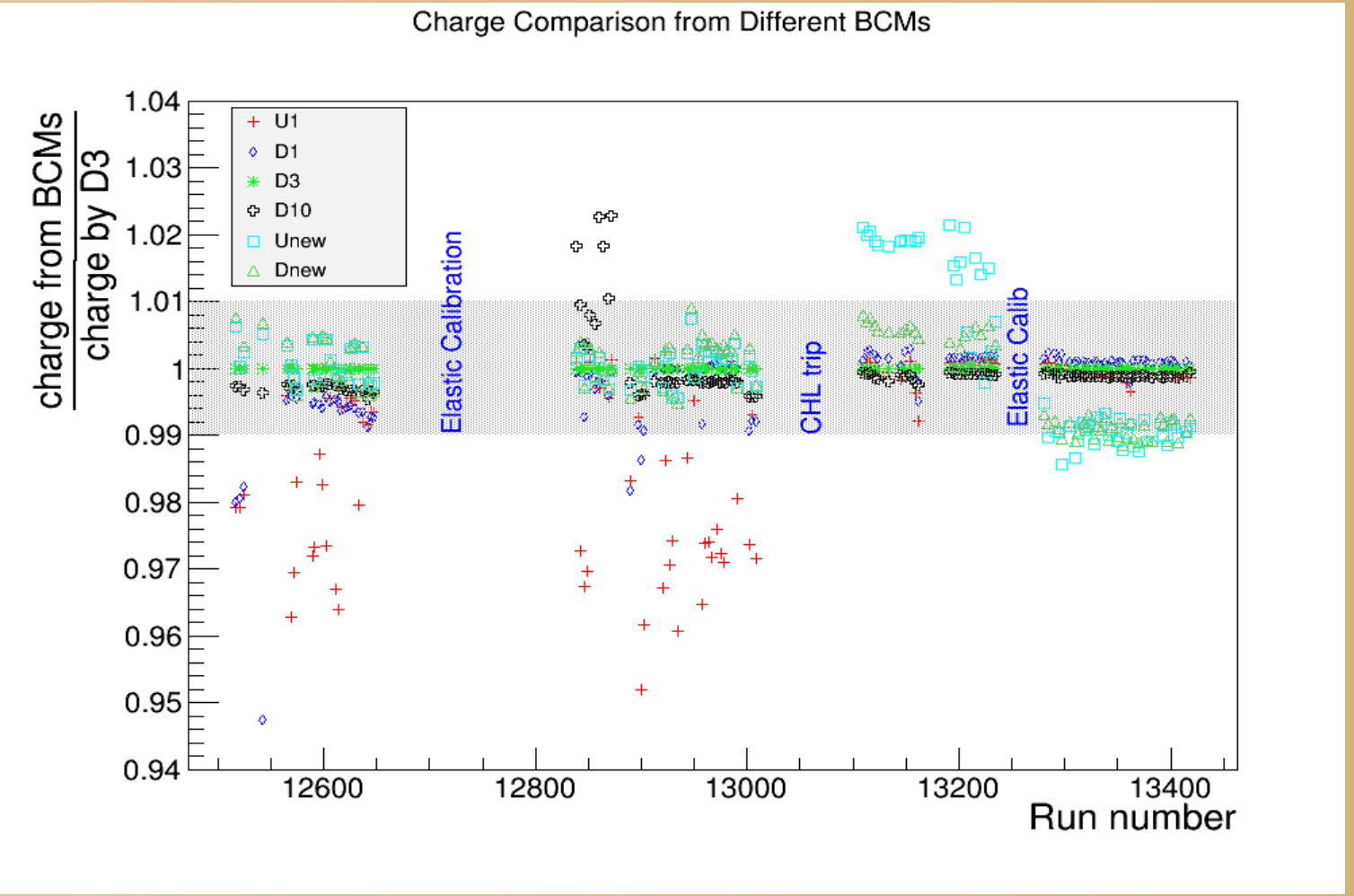












Charge Comparison Spring 2016