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LIGHT SUM SQUARE

SUPER BIAS SELECTION: NON-SOURCE BOXES

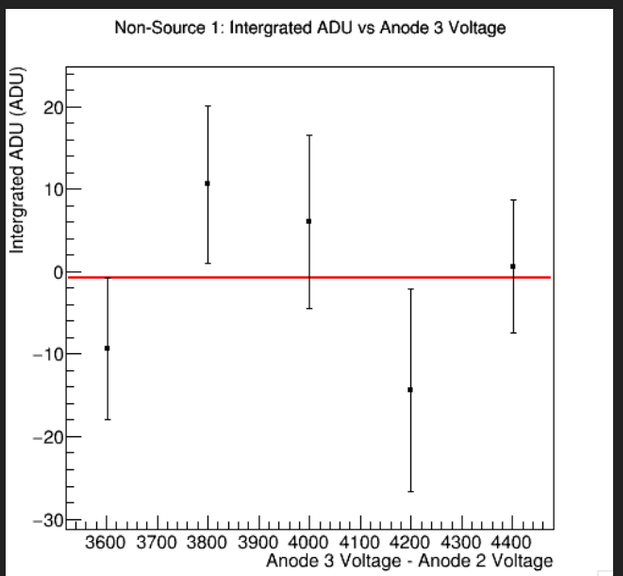
- I have been looking at non-source boxes to ascertain super bias frames stability
- I found this work not very conclusive on selection but could help lead to a systematic uncertainty on to data
- I have made a google docs version for anyone that wants to take a look at the whole thing: https://docs.google.com/spreadsheets/d/1sC1RTL3dgDcykfbQSnUk5NyiHi55_44_Y-BoGtQKyXE/edit?usp=sharing

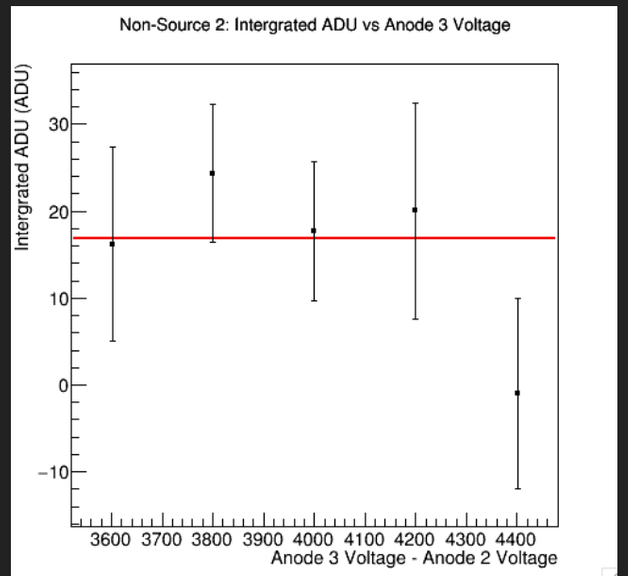
SUPER BIAS COMPARISON LABELLING

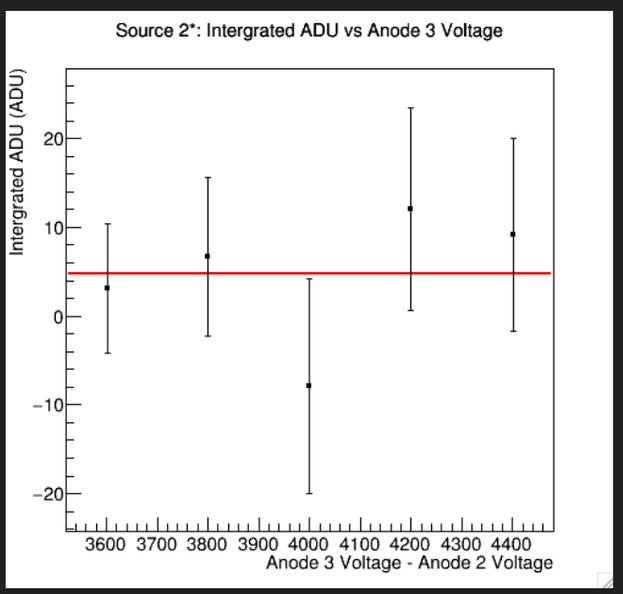
Voltage Scheme	Voltage Configuration	Anode 1 Voltage (V)	Anode 2 Voltage (V)	Anode 3 Voltage (V)	Number of Runs	First Run Number	Last Run Number
A	1	1200	2400	3600	15	2081070	2081084
	2	1400	2600	3800	15	2081085	2081111
	3	1600	2800	4000	15	2081114	2081128
	4	1800	3000	4200	15	2081129	2081155
	5	2000	3200	4400	17	2081165	2081181
	Bias	0	0	0	20	2081183	2081211
	Bias	0	0	0	20	2080166	2080186
Voltage Scheme	**Voltage Configuration**	**Anode 1 Voltage (V)**	**Anode 2 Voltage (V)**	**Anode 3 Voltage (V)**	**Number of Runs**	**First Run Number**	**Last Run Number**
B1	-2	1200	2400	2400	10	2084009	2084018
	-1	1200	2400	2800	10	2083126	2084008
	0	1200	2400	3200	10	2083116	2083125
B2	1	1200	2400	3600	16	2082009	2082024
	2	1200	2400	3800	15	2082025	2082039
	3	1200	2400	4000	15	2082040	2082054
	4	1200	2400	4200	15	2082055	2082069
	5	1200	2400	4400	15	2082070	2082084
	6	1200	2400	4600	10	2082085	2082094
	7	1200	2400	4800	10	2082095	2082104
	8	1200	2400	5000	10	2082105	2083001
	Bias	0	0	0	20	2083002	2083021
					136		
Voltage Scheme	**Voltage Configuration**	**Anode 1 Voltage (V)**	**Anode 2 Voltage (V)**	**Anode 3 Voltage (V)**	**Number of Runs**	**First Run Number**	**Last Run Number**
C	-4	1200	1400	2600	10	2083106	2083115
	-3	1200	1600	2800	10	2083096	2083105
	-2	1200	1800	3000	10	2083086	2083095
	-1	1200	2000	3200	10	2083076	2083085
	0	1200	2200	3400	10	2083066	2083075
	1	1200	2400	3600	11	2083022	2083032
	2	1200	2600	3800	11	2083035	2083045
	3	1200	2800	4000	10	2083046	2083055
	4	1200	3000	4200	10	2083056	2083065

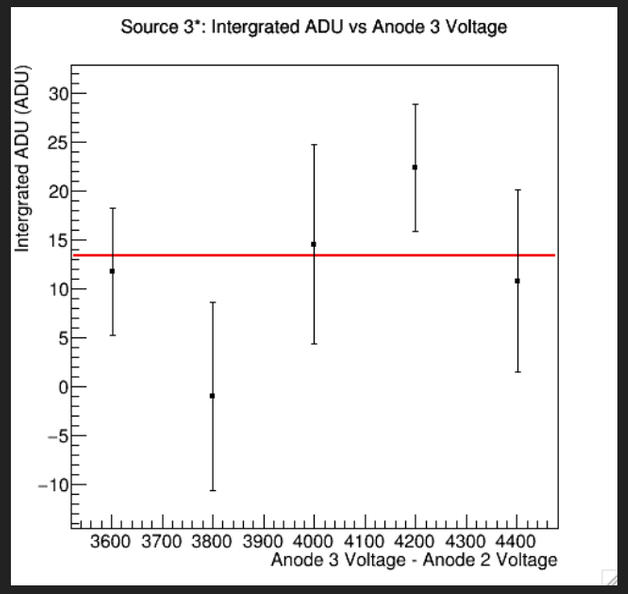
- Schemes labeled A, B1, B2 & C
- Super bias frames are labeled A1, A2, B & C
- Each Scheme is run with a super bias frame taken the evening of and before it was takenhttps://docs.google.com/spreadsheets/d/1sC1RTL3dgDcykfbQSnUk5NyiHi55_44_Y-BoGtQKyXE/edit?usp=sharing

SCHEME A SUPER BIAS A1

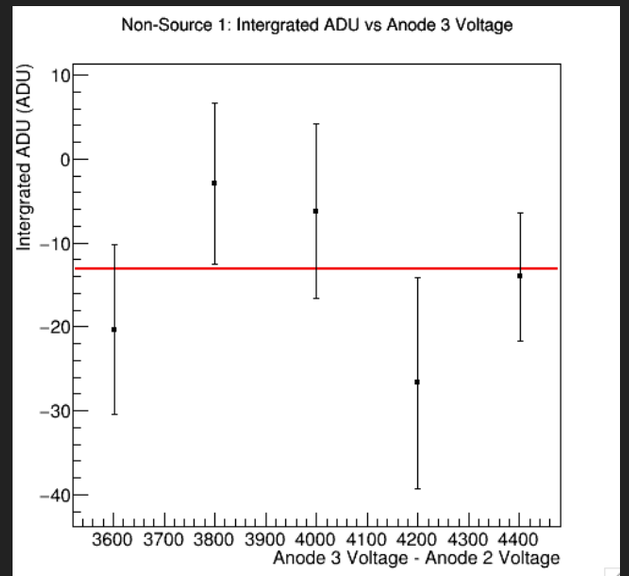


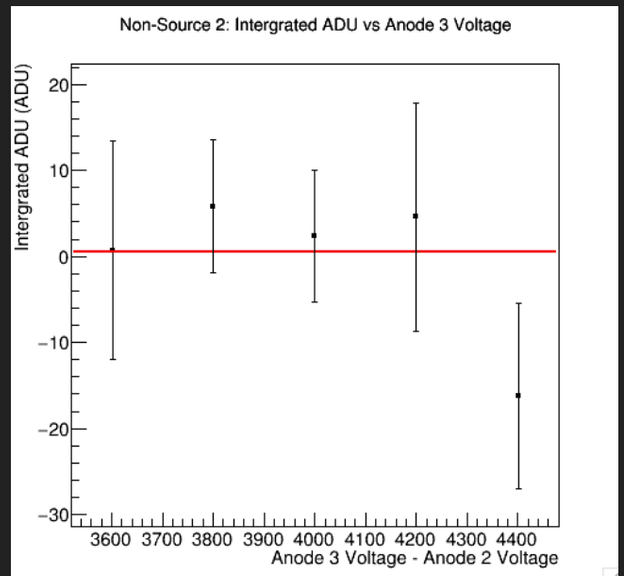


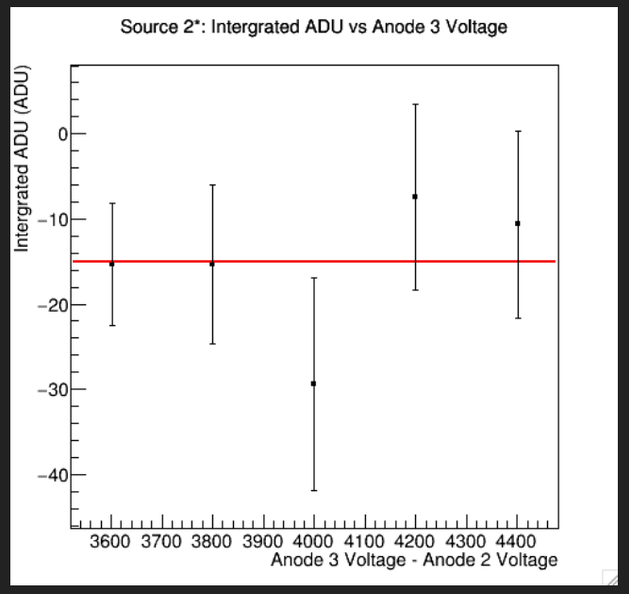


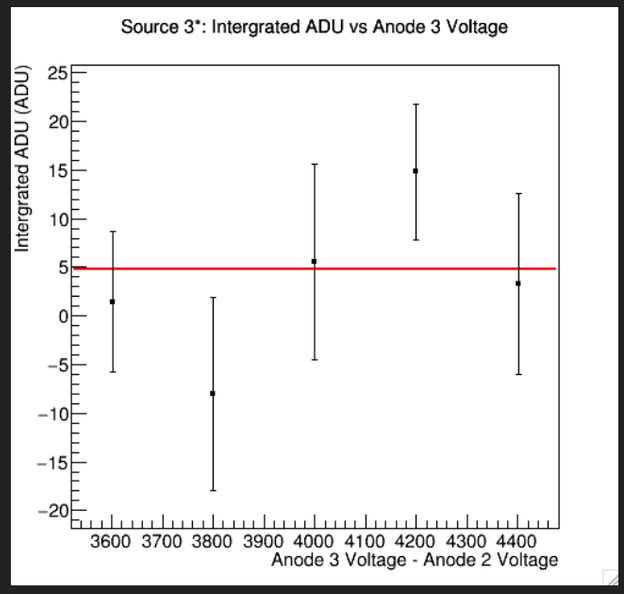


SCHEME A SUPER BIAS A2





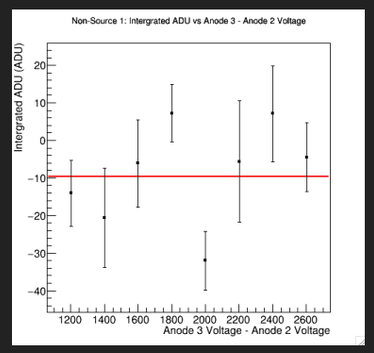




COMPARISON: NS1 – SUPER BIAS A1 VS A2

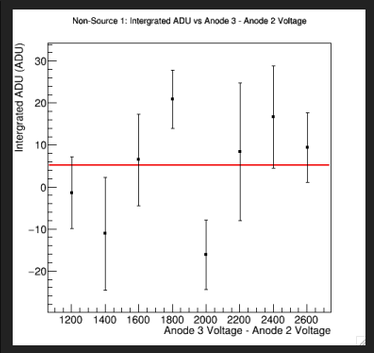
SCHEME A SUPER BIAS A1

Box	ns1	
Mean (ADU)	**Error (ADU)**	
−9.30	8.57	Avg. Mean
10.59	9.57	-1.26
6.07	10.47	Mean StDev
−14.31	12.28	10.40
0.63	8.13	Avg. Error
		9.80



SCHEME A SUPER BIAS A2

Box	ns1	
Mean (ADU)	**Error (ADU)**	
−20.33	10.07	Avg. Mean
−2.93	9.66	-14.03
−6.21	10.37	Mean StDev
−26.64	12.57	9.79
−14.04	7.61	Avg. Error
		10.05



- So here we have the mean and error for each voltage setting for a non-source box and bias frames A1 and A2
- In blue we have the average mean, average error and the standard deviation of the means
- Shown boarded in pink we have the residuals of the means per voltage setting, the average residual and their stand deviation

SBF residuals (ADU)	
11.04	Avg Diff
13.52	12.77
12.28	Diff StDev
12.33	1.38
14.66	

COMPARISON: SCHEME A – SUPER BIAS A1 VS A2

Box	ns1	
Mean (ADU)	Error (ADU)	
−9.30	8.57	Avg. Mean
10.59	9.57	-1.26
6.07	10.47	Mean StDev
−14.31	12.28	10.40
0.63	8.13	Avg. Error
		9.80

Box	ns1	
Mean (ADU)	Error (ADU)	
−20.33	10.07	Avg. Mean
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−6.21	10.37	Mean StDev
−26.64	12.57	9.79
−14.04	7.61	Avg. Error
		10.05

SBF residuals (ADU)	
11.04	Avg Diff
13.52	12.77
12.28	Diff StDev
12.33	1.38
14.66	

Scheme A				Residules			
Source		Bias Frame		Non-Source Boxes		Source Box	
		A1	A2	Avg Res.	Res. StDev	Avg Res.	Res. StDev
ns1	Avg Mean	-1.26	-14.03	12.77	1.38	21.43	2.06
	Mean StDev	10.40	9.79				
	Avg Error	9.80	10.05				
ns2	Avg Mean	**15.48**	**-0.54**	16.01	1.41		
	Mean StDev	9.68	8.98				
	Avg Error	10.09	10.42				
s2*	Avg Mean	**4.64**	**-15.62**	20.26	1.51		
	Mean StDev	7.72	8.40				
	Avg Error	10.11	10.19				
s3*	Avg Mean	**11.74**	**3.42**	8.32	1.33		
	Mean StDev	8.42	8.19				
	Avg Error	8.43	8.70				
Average	Avg Mean	**7.65**	**-6.69**	14.34	1.41		
	Mean StDev	9.05	8.84				
	Avg Error	9.61	9.84				

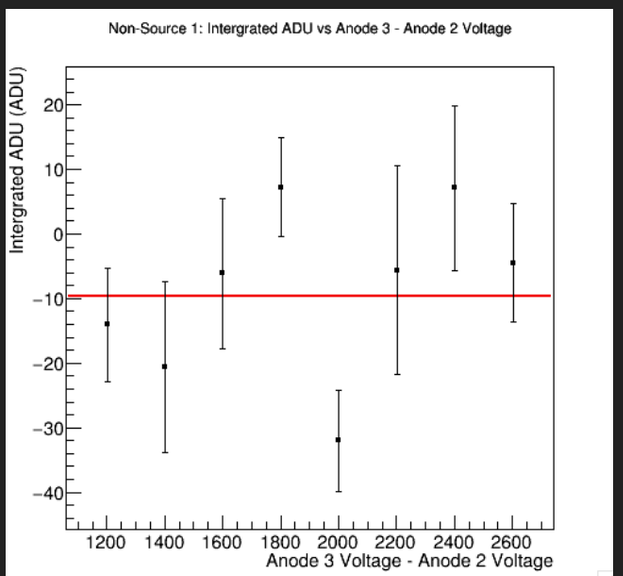
- We then take the highlighted vales for each non-source box for a given scheme
- We also have the residual

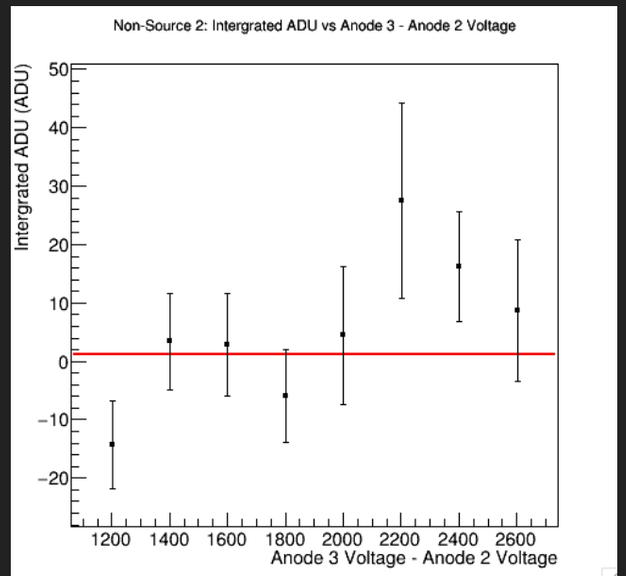
COMPARISON: SCHEME A – SUPER BIAS A1 VS A2

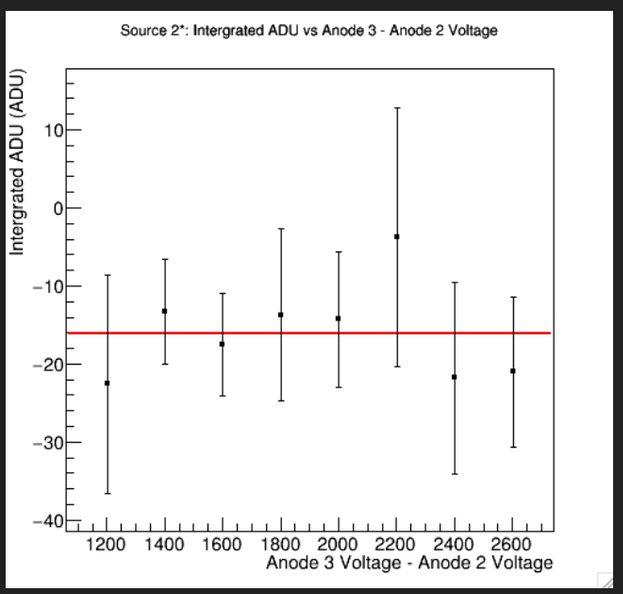
Scheme A				Residules			
Source		Bias Frame		Non-Source Boxes		Source Box	
		A1	A2	Avg Res.	Res. StDev	Avg Res.	Res. StDev
ns1	Avg Mean	**-1.26**	**-14.03**	12.77	1.38	21.43	2.06
	Mean StDev	10.40	9.79				
	Avg Error	9.80	10.05				
ns2	Avg Mean	**15.48**	**-0.54**	16.01	1.41		
	Mean StDev	9.68	8.98				
	Avg Error	10.09	10.42				
s2*	Avg Mean	**4.64**	**-15.62**	20.26	1.51		
	Mean StDev	7.72	8.40				
	Avg Error	10.11	10.19				
s3*	Avg Mean	**11.74**	**3.42**	8.32	1.33		
	Mean StDev	8.42	8.19				
	Avg Error	8.43	8.70				
Average	Avg Mean	**7.65**	**-6.69**	14.34	1.41		
	Mean StDev	9.05	8.84				
	Avg Error	9.61	9.84				

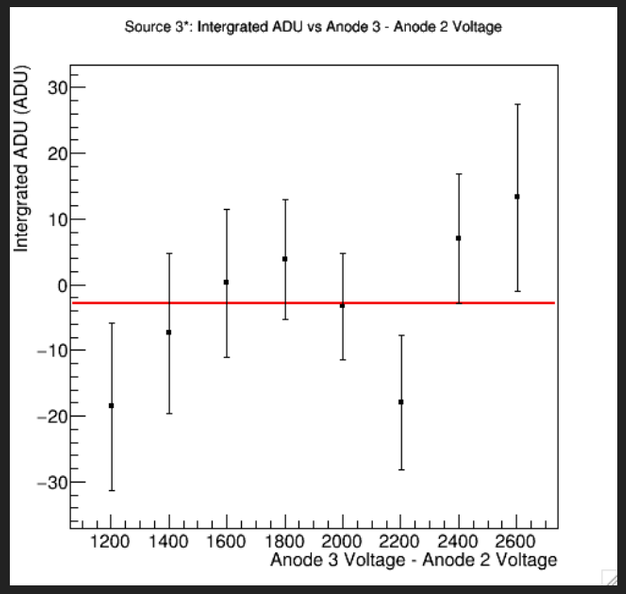
- For a given source or non-source the residuals have a low standard deviation of 1-2 ADU
- Both bias frames have an average mean of all non-source boxes within the StDev and Avg. Error of 0 ADU -> However, note that A2 seems to have a gradient

SCHEME B2 SUPER BIAS A2

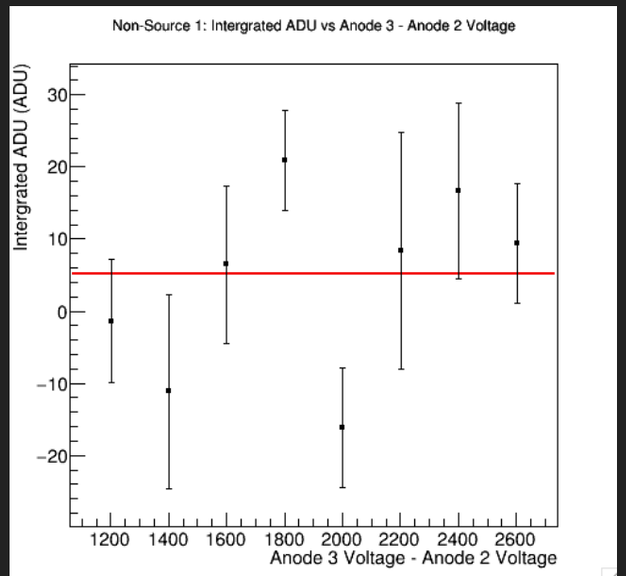


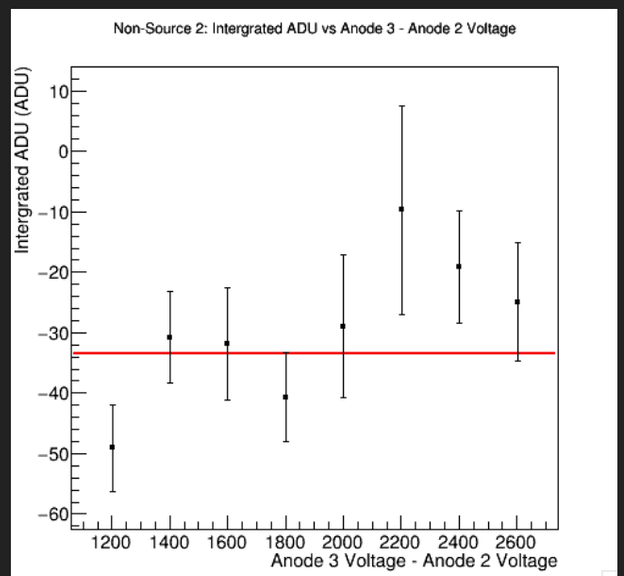


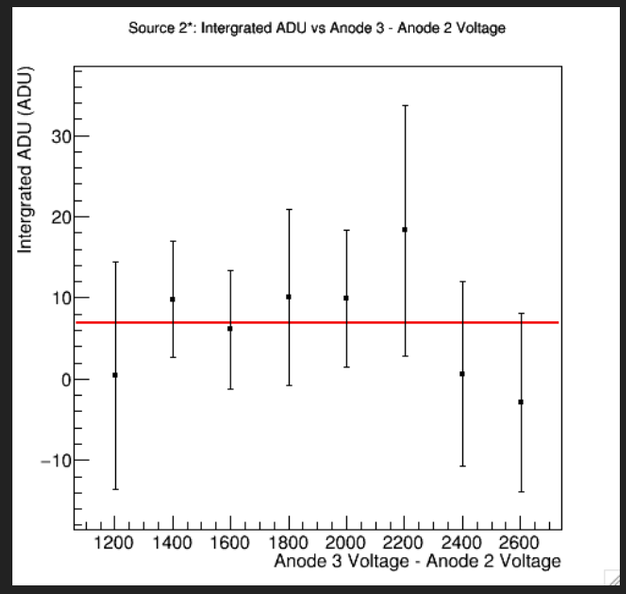


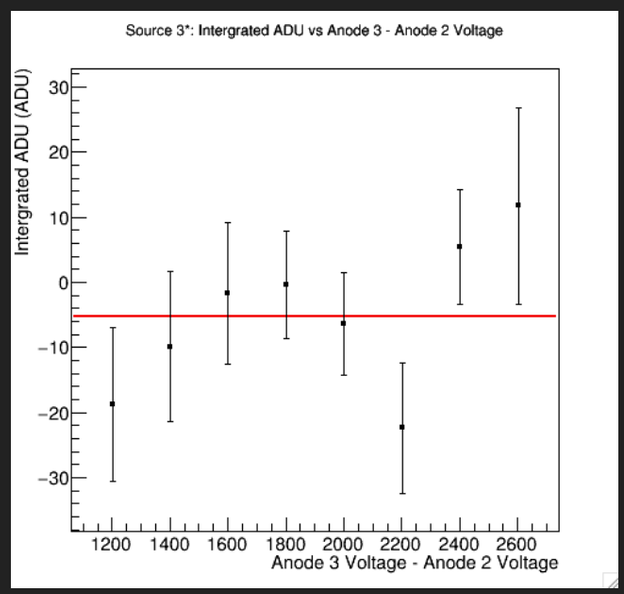


SCHEME B2 SUPER BIAS B







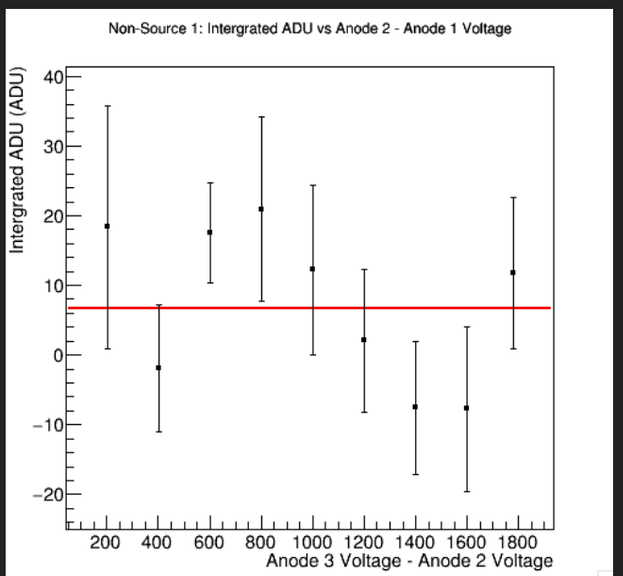


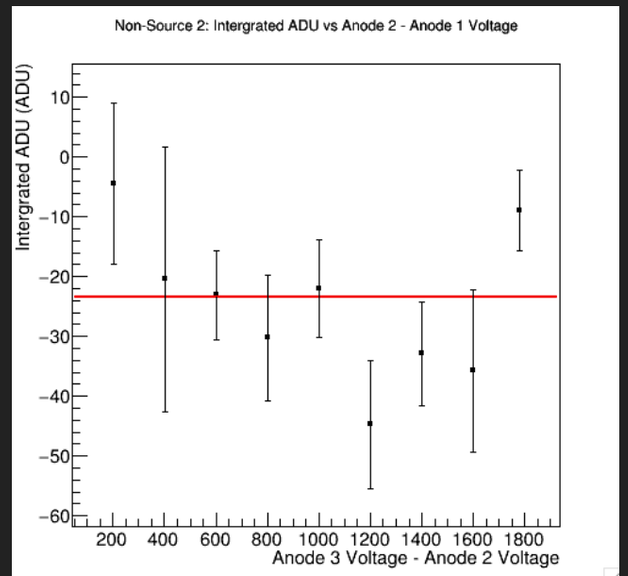
COMPARISON: SCHEME B2 – SUPER BIAS A2 VS B

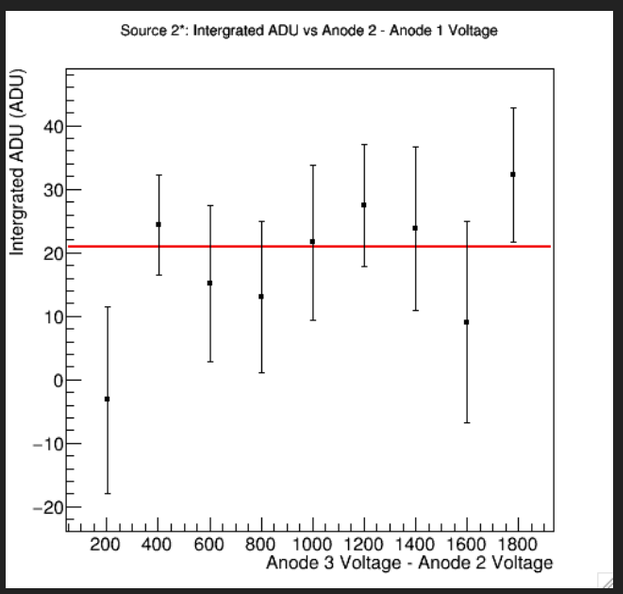
Scheme B2				Residules			
Source		Bias Frame		Non-Source Boxes		Source Box	
		A2	B	Avg Res.	Res. StDev	Avg Res.	Res. StDev
ns1	Avg Mean	-8.55	4.15	-12.70	2.20	-1.58	27.00
	Mean StDev	13.37	12.90				
	Avg Error	10.88	10.65				
ns2	Avg Mean	5.37	-29.37	34.74	1.20		
	Mean StDev	12.79	12.17				
	Avg Error	10.32	9.98				
s2*	Avg Mean	-15.98	6.56	-22.53	1.91		
	Mean StDev	6.21	6.91				
	Avg Error	10.67	10.68				
s3*	Avg Mean	-2.88	-5.27	2.39	1.42		
	Mean StDev	11.37	11.57				
	Avg Error	10.95	10.54				
Average	Avg Mean	-5.51	-5.98	0.47	1.68		
	Mean StDev	10.94	10.89				
	Avg Error	10.71	10.46				

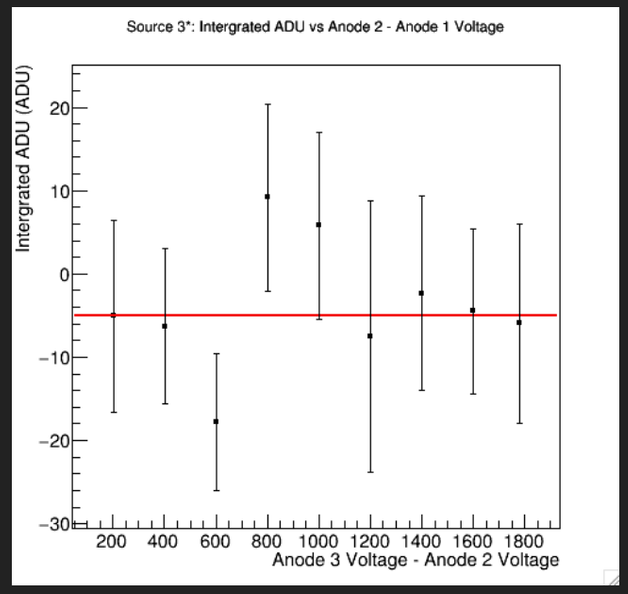
- For a given non-source the residuals have a low standard deviation of 1-2 ADU, however the standard deviation for the source box is 27 ADU! -> I can look into this measure the sum instead of fitting the source box pixels
- Both bias frames have an average mean of all non-source boxes within the StDev and Avg. Error of 0 ADU
- The source box residuals have a huge range of between 56 ADU!

SCHEME C SUPER BIAS B

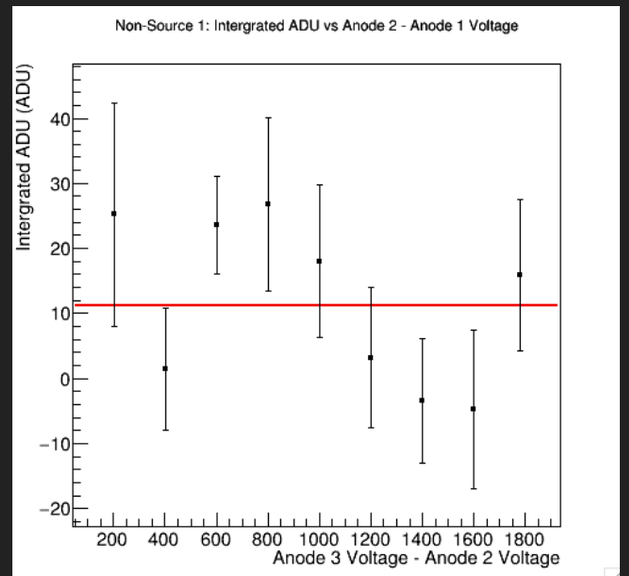


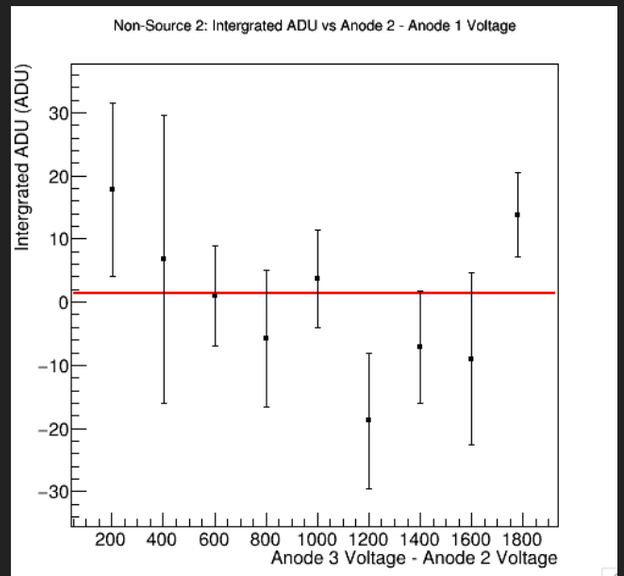


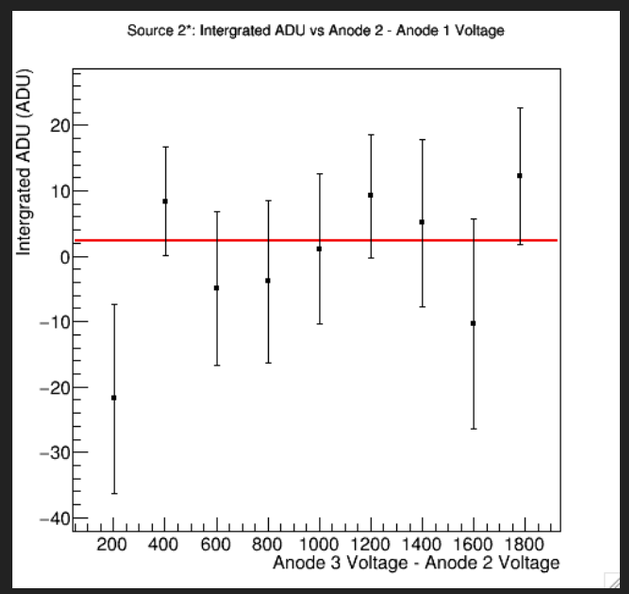


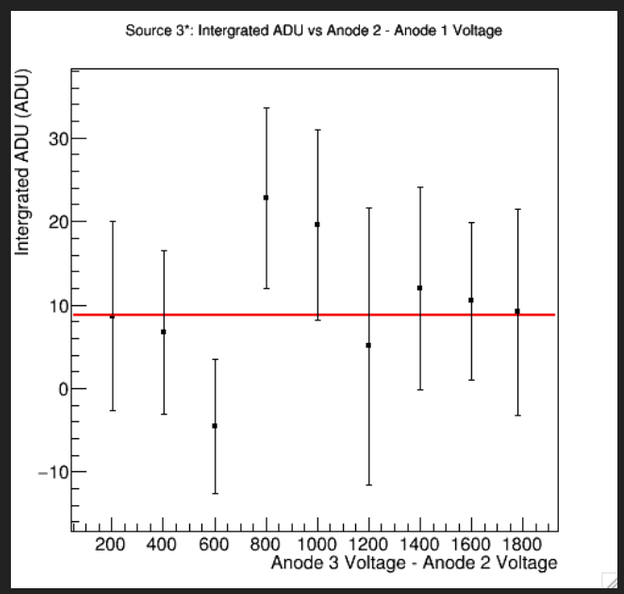


SCHEME C SUPER BIAS C







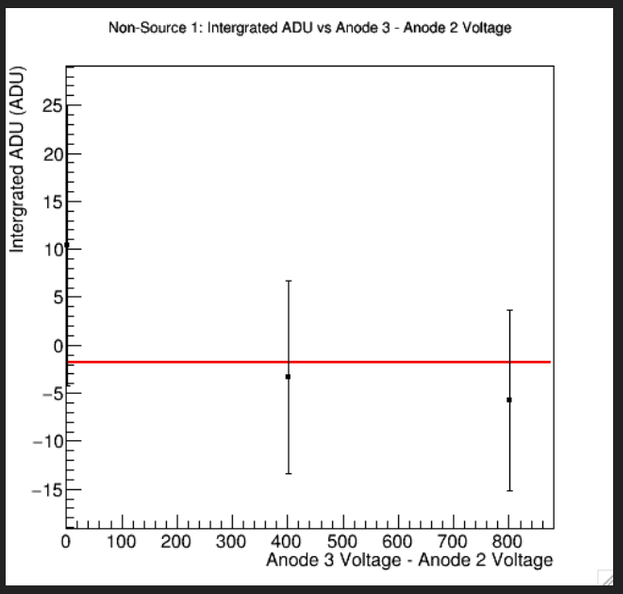


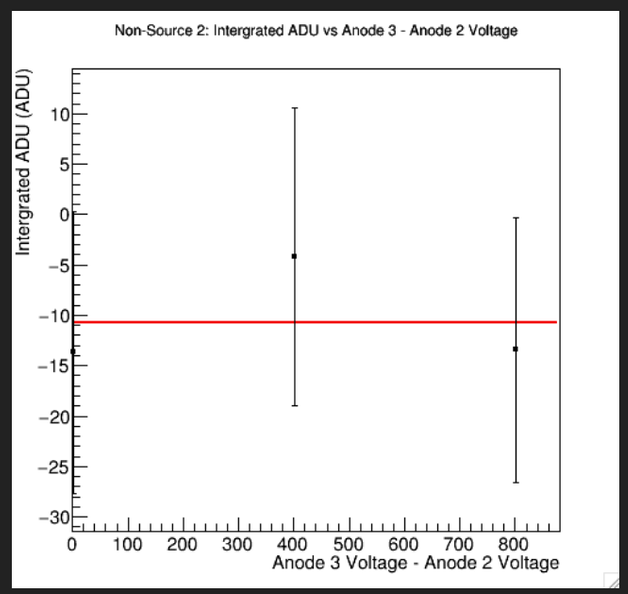
COMPARISON: SCHEME C – SUPER BIAS B VS C

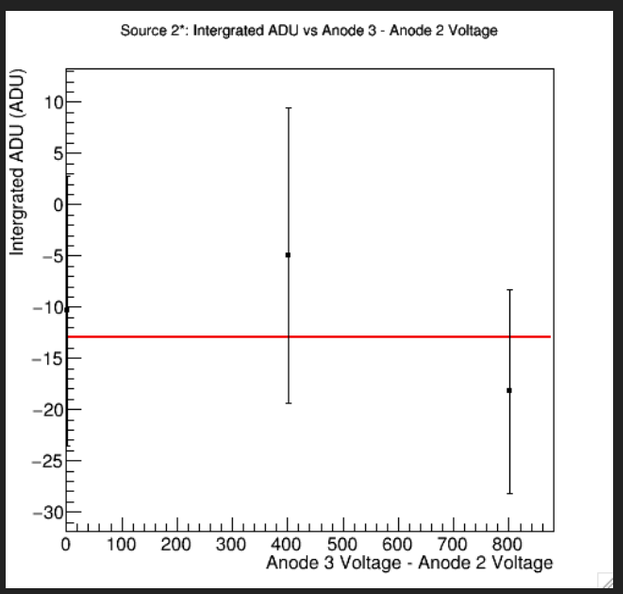
Scheme C				Residules			
Source		Bias Frame		Non-Source Boxes		Source Box	
		B	C	Avg Res.	Res. StDev	Avg Res.	Res. StDev
ns1	Avg Mean	7.32	11.78	-4.45	1.82	-37.73	1.45
	Mean StDev	11.26	12.67				
	Avg Error	11.27	11.49				
ns2	Avg Mean	-24.73	0.29	-25.01	1.72		
	Mean StDev	12.78	11.66				
	Avg Error	11.31	11.42				
s2*	Avg Mean	18.17	-0.55	18.72	1.51		
	Mean StDev	10.85	10.90				
	Avg Error	11.99	11.91				
s3*	Avg Mean	-3.83	10.00	-13.83	0.84		
	Mean StDev	7.78	7.97				
	Avg Error	11.27	11.31				
Average	Avg Mean	-0.76	5.38	-6.14	1.47		
	Mean StDev	10.67	10.80				
	Avg Error	11.46	11.53				

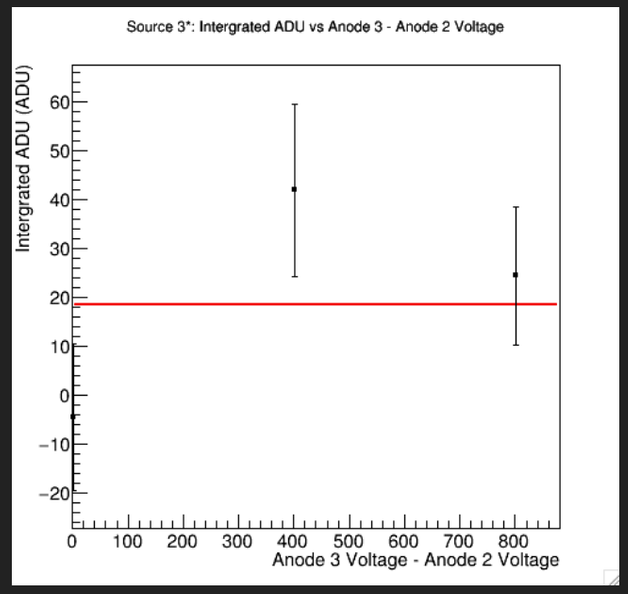
- For a given source or non-source the residuals have a low standard deviation of 1-2 ADU
- Both bias frames have an average mean of all non-source boxes within the StDev and Avg. Error of 0 ADU
- The source box residuals have a huge range of between 56 ADU!

SCHEME B1 SUPER BIAS B

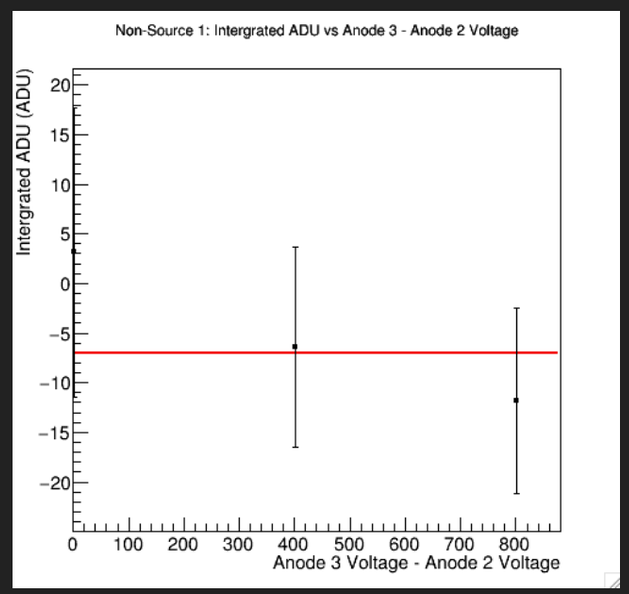


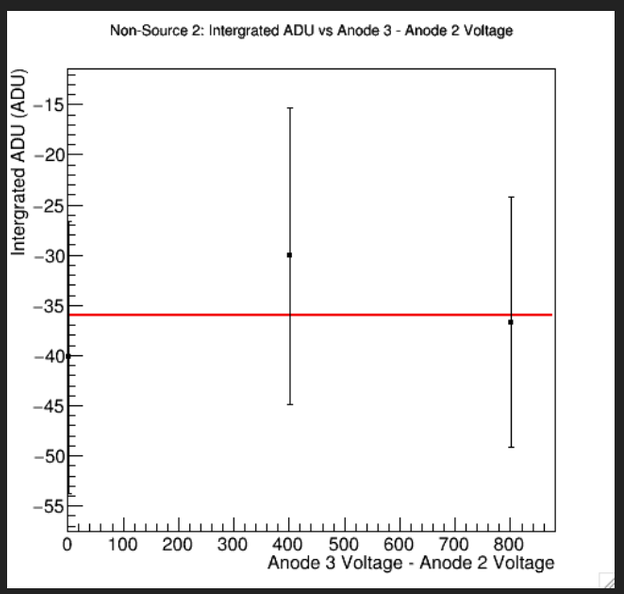


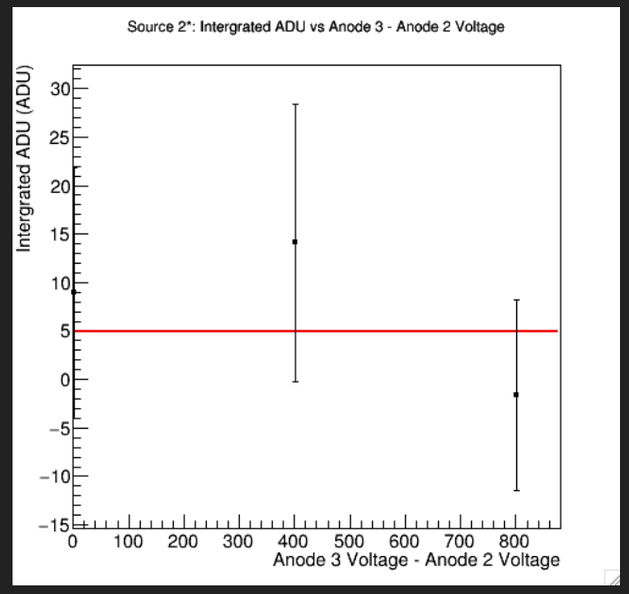


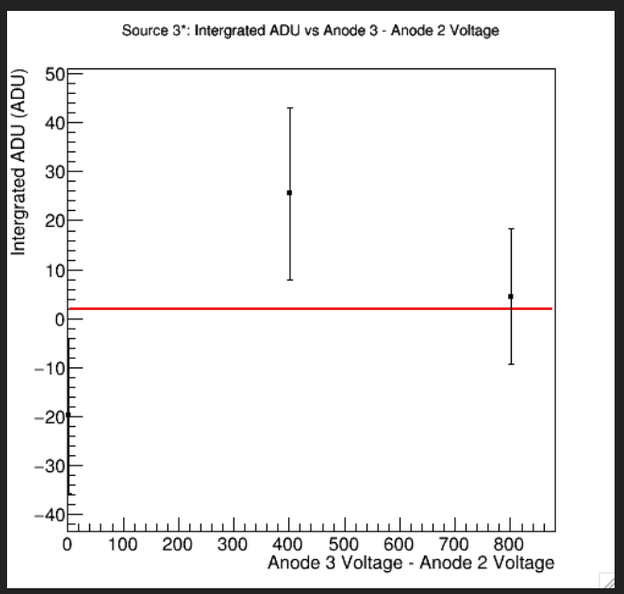


SCHEME B1 SUPER BIAS C









COMPARISON: SCHEME A – SUPER BIAS A1 VS A2

Scheme B1				Residules			
Source		Bias Frame		Non-Source Boxes		Source Box	
		B	C	Avg Res.	Res. StDev	Avg Res.	Res. StDev
ns1	Avg Mean	-5.01	0.49	-5.50	2.17	-37.81	1.95
	Mean StDev	7.56	8.71				
	Avg Error	11.34	11.36				
ns2	Avg Mean	-35.63	-10.42	-25.20	1.75		
	Mean StDev	5.12	5.42				
	Avg Error	13.61	13.99				
s2*	Avg Mean	7.16	-11.18	18.34	1.45		
	Mean StDev	7.99	6.69				
	Avg Error	12.37	12.47				
s3*	Avg Mean	3.39	20.55	-17.16	2.36		
	Mean StDev	22.71	23.41				
	Avg Error	15.73	15.63				
Average	Avg Mean	-7.52	-0.14	-7.38	1.93		
	Mean StDev	10.85	11.06				
	Avg Error	13.26	13.37				

- For a given source or non-source the residuals have a low standard deviation of 1-2 ADU
- Both bias frames have an average mean of all non-source boxes within the StDev and Avg. Error of 0 ADU -> However, note that A2 seems to have a gradient

SYSTEMATIC ESTIMATION

Non-Source Box Residules				
	A	B2	C	B1
ns1	12.77	-12.70	-4.45	-5.50
ns2	16.01	34.74	-25.01	-25.20
s2*	20.26	-22.53	18.72	18.34
s3*	8.32	2.39	-13.83	-17.16

Source Box Residules				
s5	21.43	1.58*	-37.73	-37.81

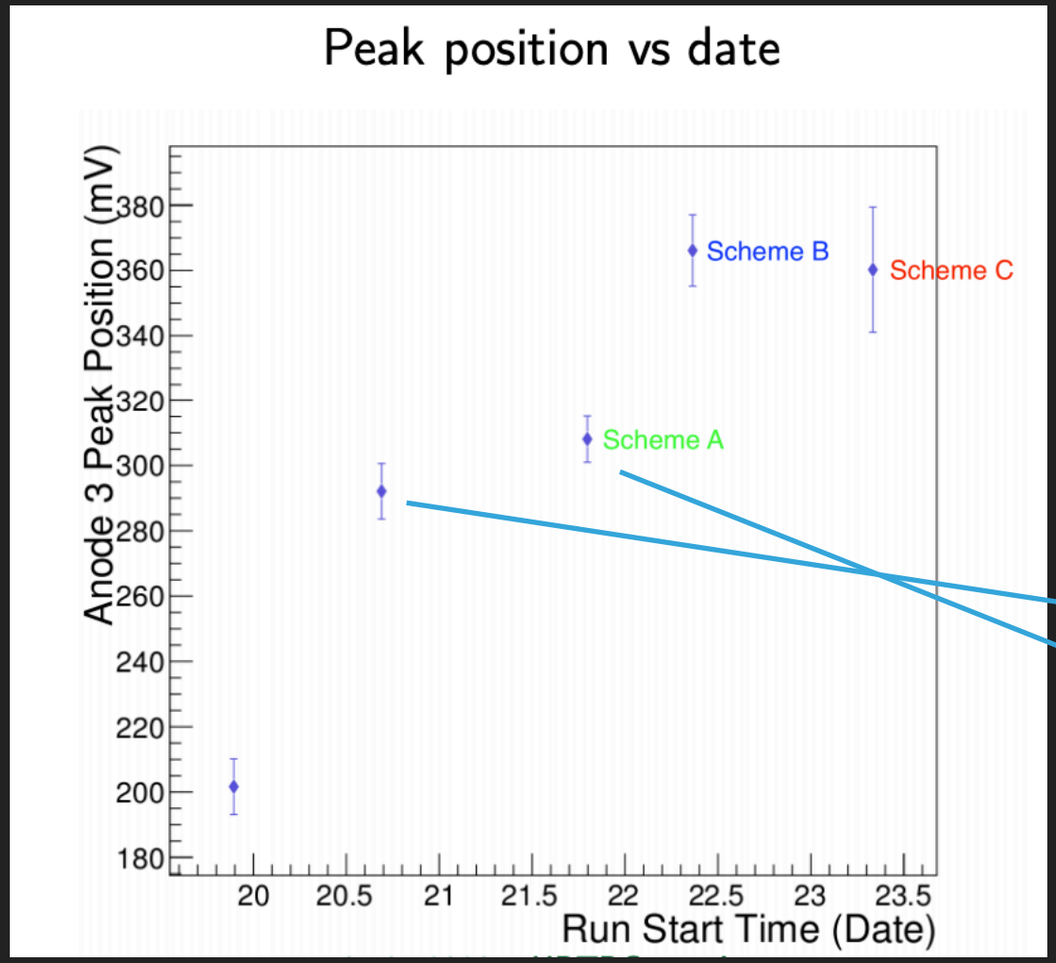
*very high StDev

Scheme	Res. StDev (ADU)
A	5.05
B2	25.04
C	18.59
B1	18.96
All	17.11

- We will likely need a systematic error per scheme (/per bias frame) -> I believe looking at the StDev of the residuals should give us an indication on it's value
- The table in pink (green) shows the non-source (source) box residuals per scheme & box
- The table in blue shows the standard deviation of all these values and per scheme

INITIAL GAS AGEING

- Here I've used a single bias frame for all schemes (A1)
- I am currently processing the data from the 19th and will post in slack when it's done



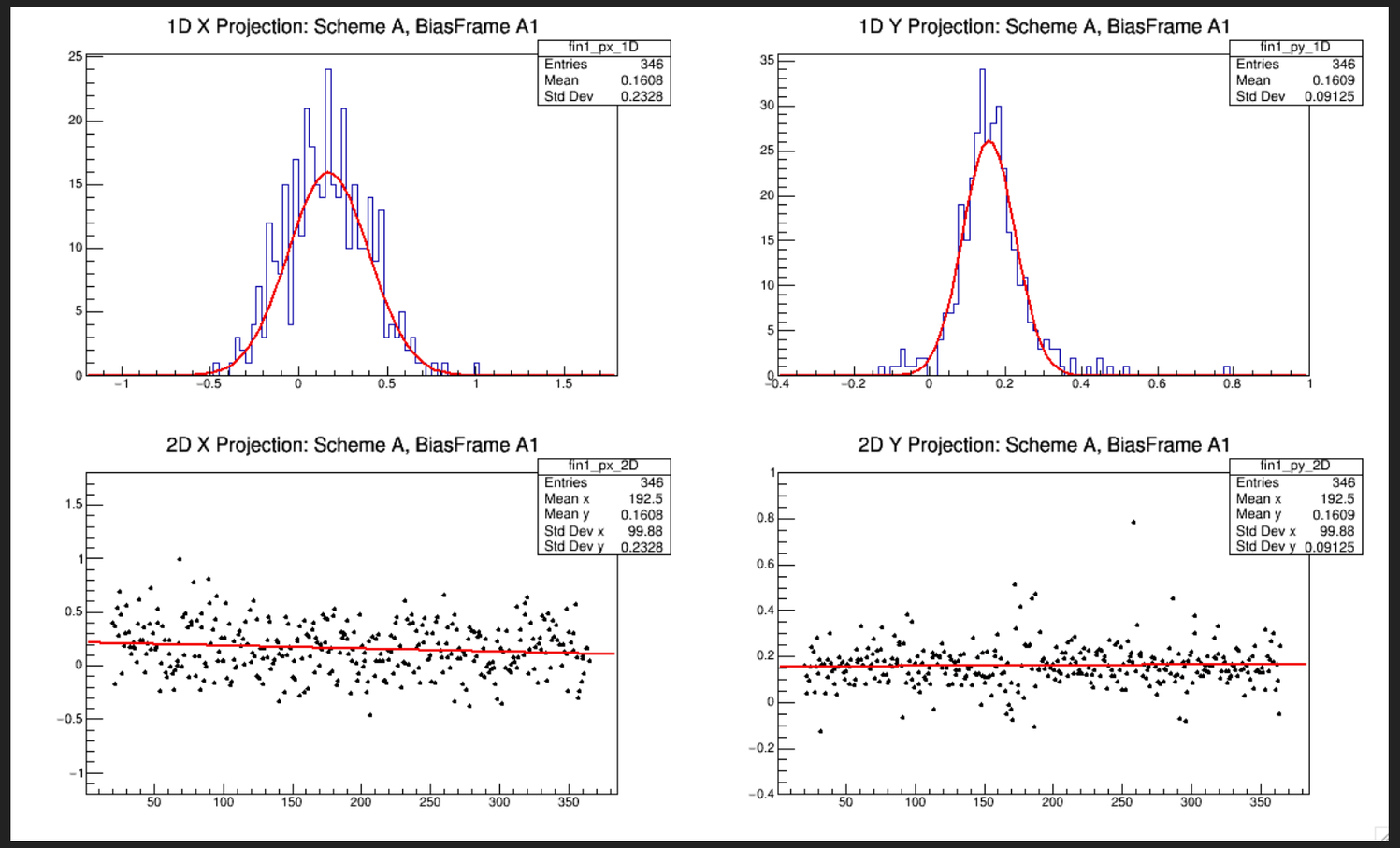
Scheme	Mean (ADU)	Error (ADU)
A1	357.48	8.00
A2	383.20	11.88
B	364.94	14.30
C	366.93	10.33

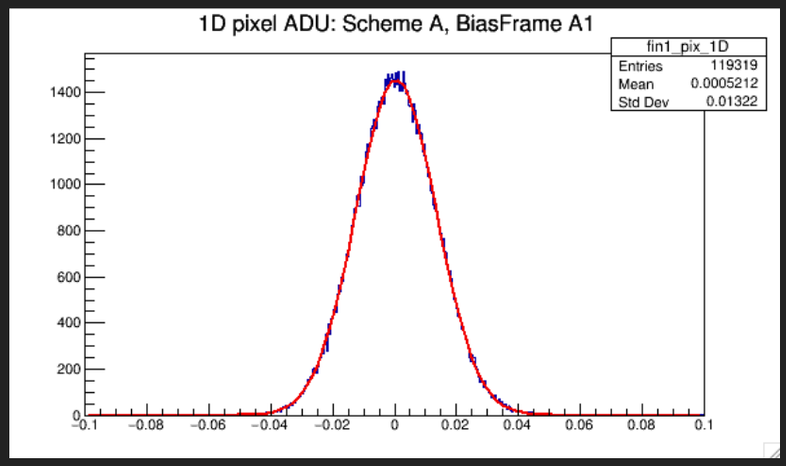
SUPER BIAS COMPARISON

- Look into Scheme B2 as we are getting a large residual StDev in the source box i.e. not a constant integrated ADU difference between the two bias frames per run
- Finish processing first data point for gas ageing plot and send out on slack personally
- In my slides from last week, discussed with Abbey and in the RHUL Wednesday group meeting I went over some simple improvements I could make to the row correction -> I could get these changes made in 5 mins and gets the jobs running, this would greatly aid in SBF selection and improve the accuracy of the final plots. The changes are:
  - No longer omit non-source boxes in row correction process
  - Omit bottom left corner in row correction process -> as the temp of CCD changes over time that corner is more greasy affected leaving us with with a changing cold or hot spot after super bias frames subtraction

BACK UP SLIDES

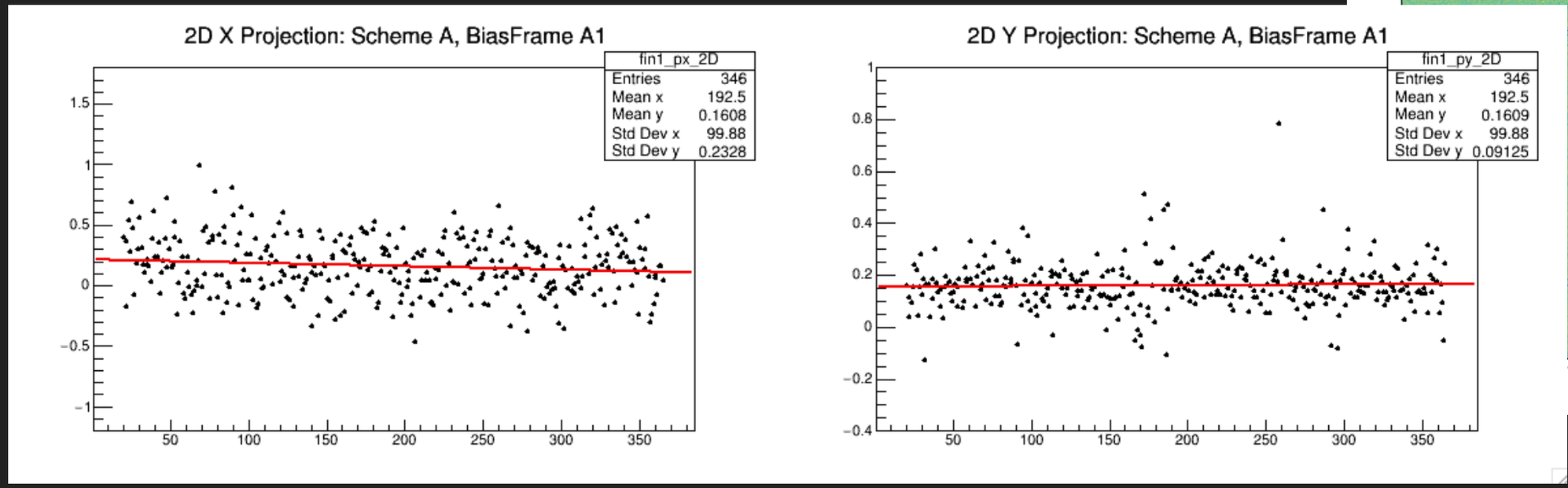
SUPER BIAS COMPARISON

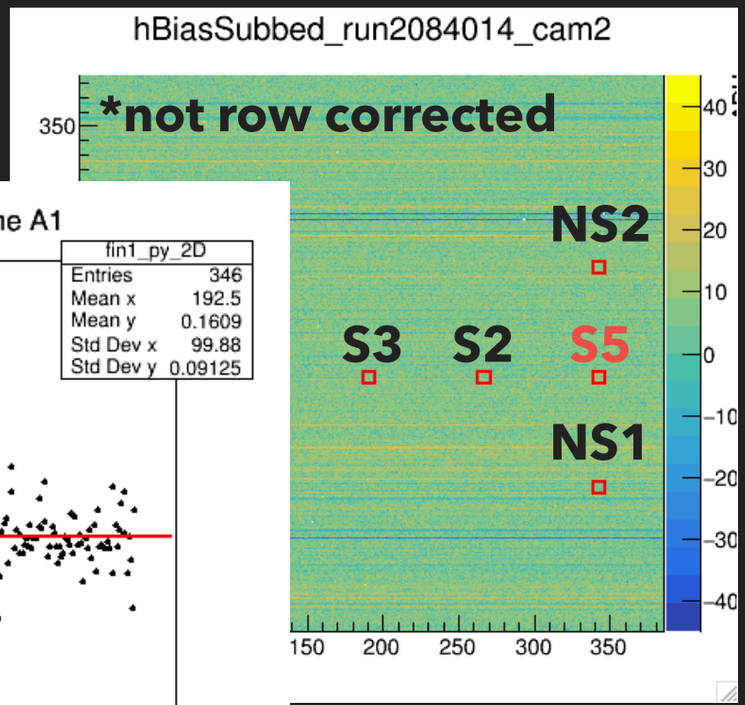




- To take a closer look at the suitability of super bias frames I've written a macro which simply takes TH2 of all events from a super bias subtracted scheme summed together and after omitting hot pixels and the source box plots the 1D and 2D x and y projections
- We currently omit pixels near the source box and where x or y are within 20 pixels of edge as we get some weird edge effects

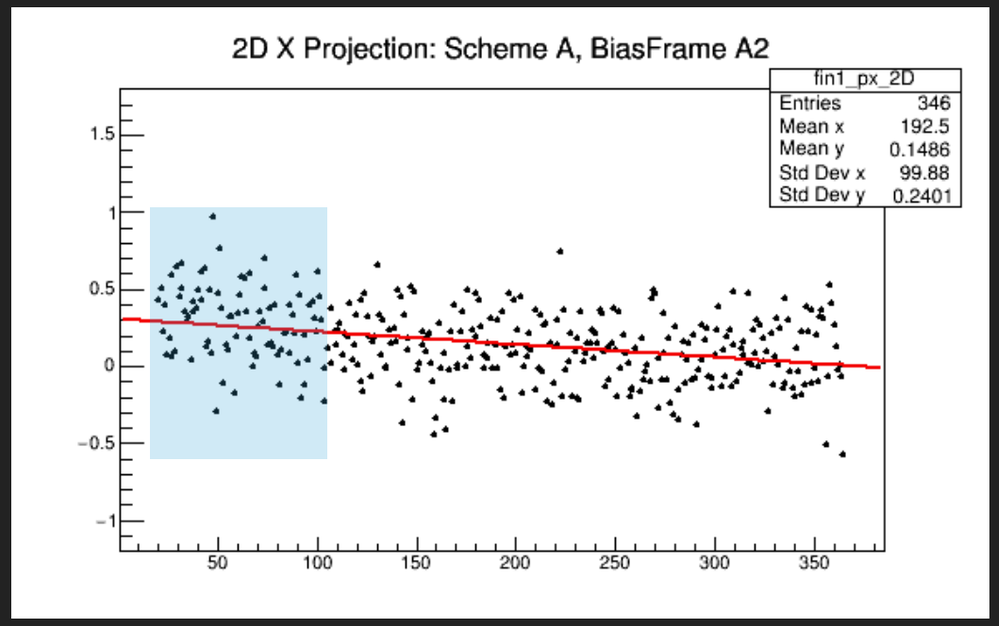
ROW CORRECTION RECAP

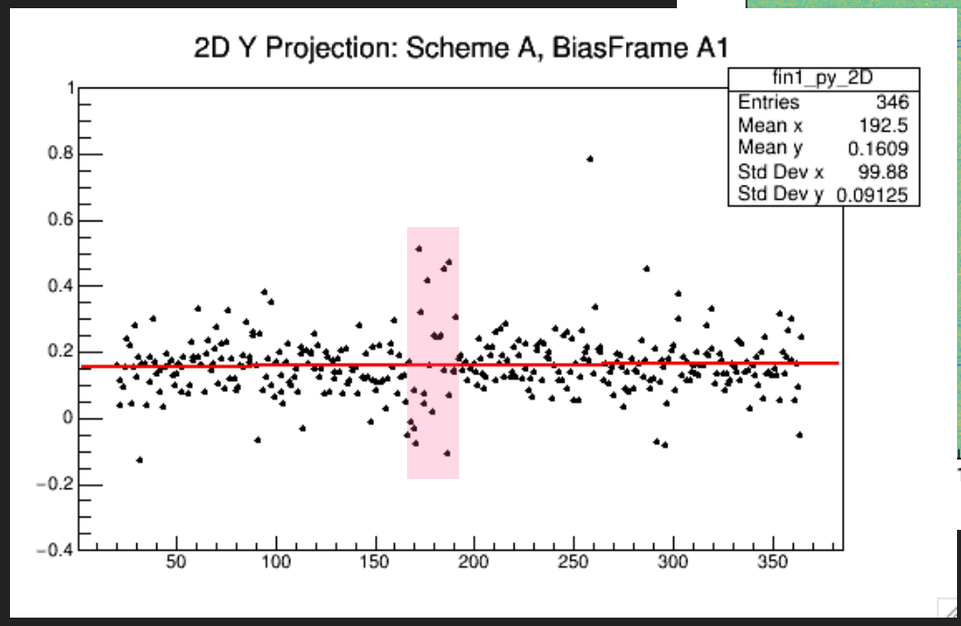


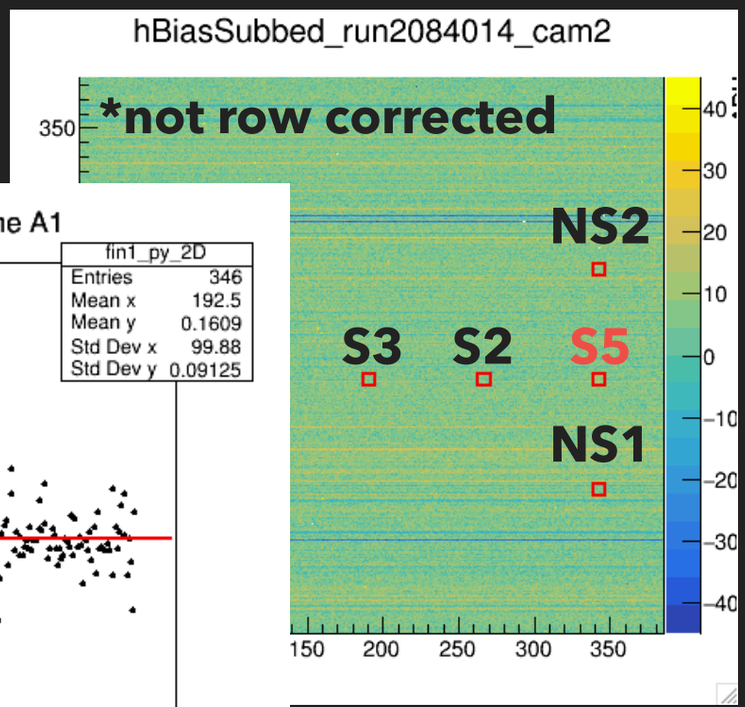


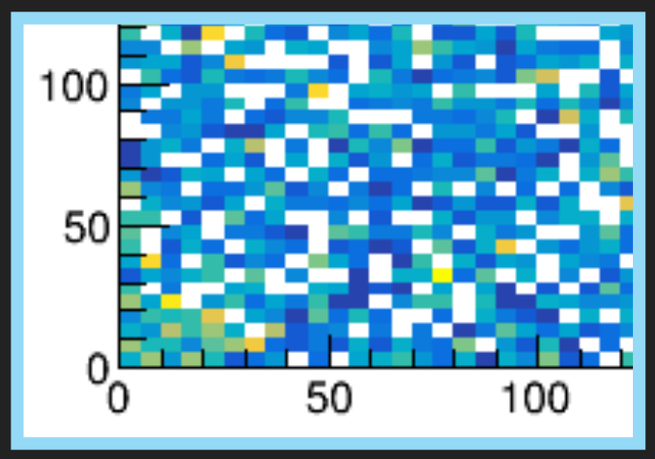
- Force the ADU sum of each rows = 0 ADU
- For row correction the following pixels are omitted in this sum:
  - Pixels 3 sigma out of the rows 1D pixel ADU distribution
  - Pixels within 10 of the edges in x
  - Pixels within 9 pixels from any source or non-source boxes -> 27 pixels per row per box -> 81 pixels in source rows

FEATURES IN PROJECTIONS



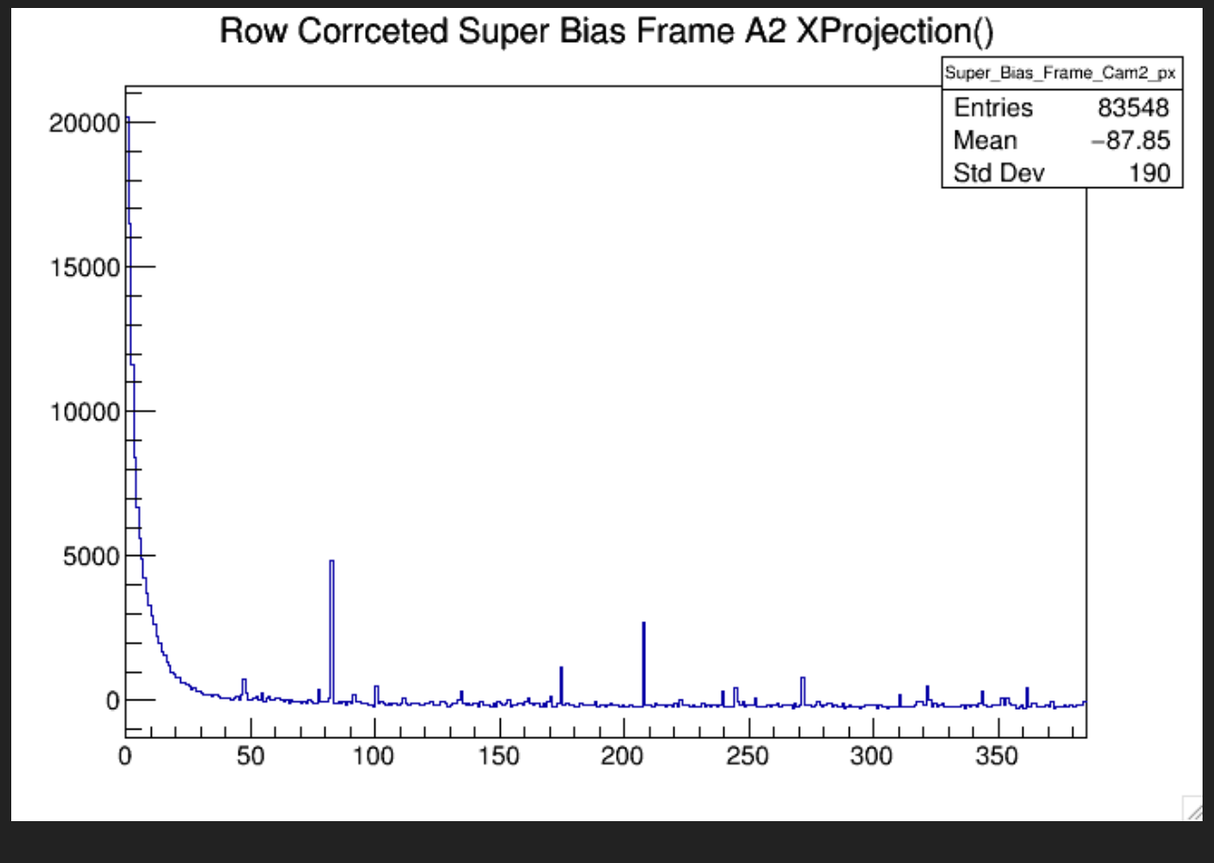


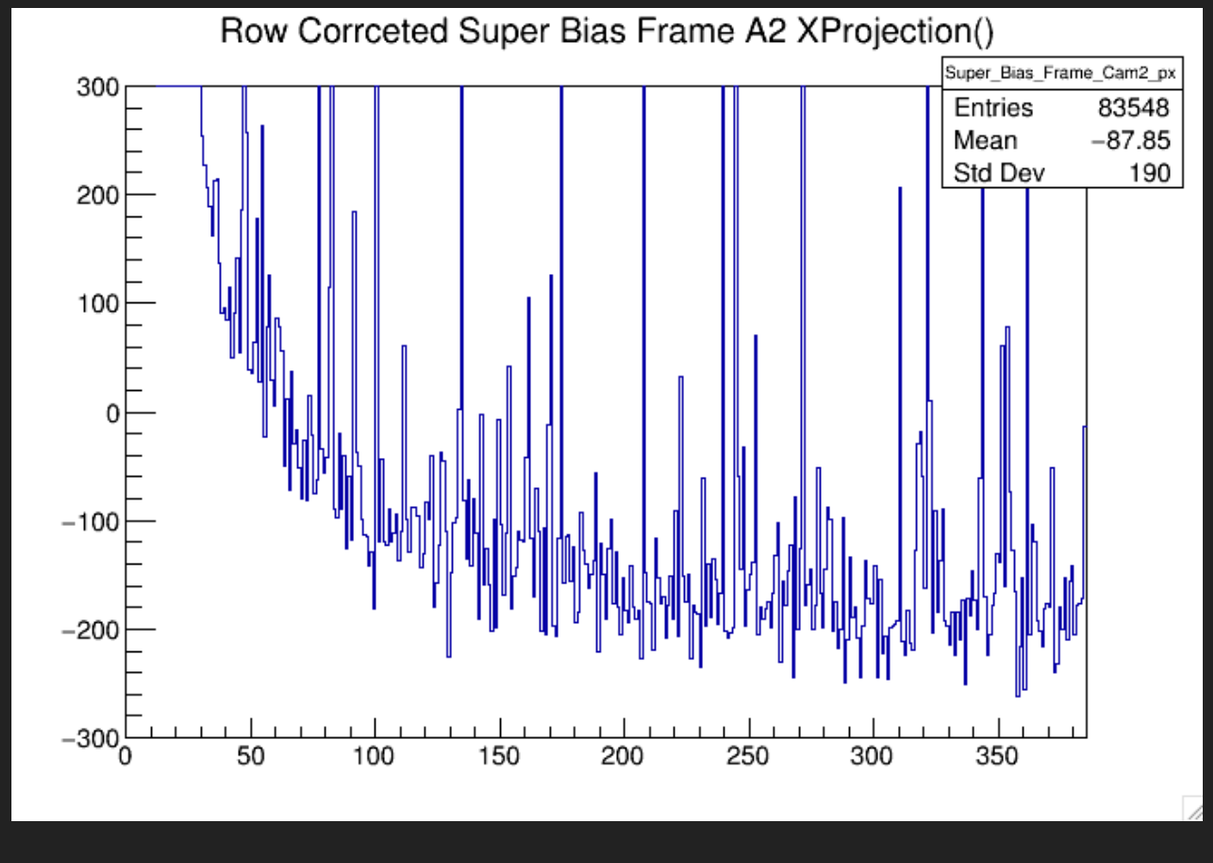




- High/Low region at x < 100 is due to mismatch of temperature of bottom left corner between event and bias frames -> not seen in y projection as row correction conceals this in a projection
- Higher variance here due to reduced number of pixels used in row correction sum

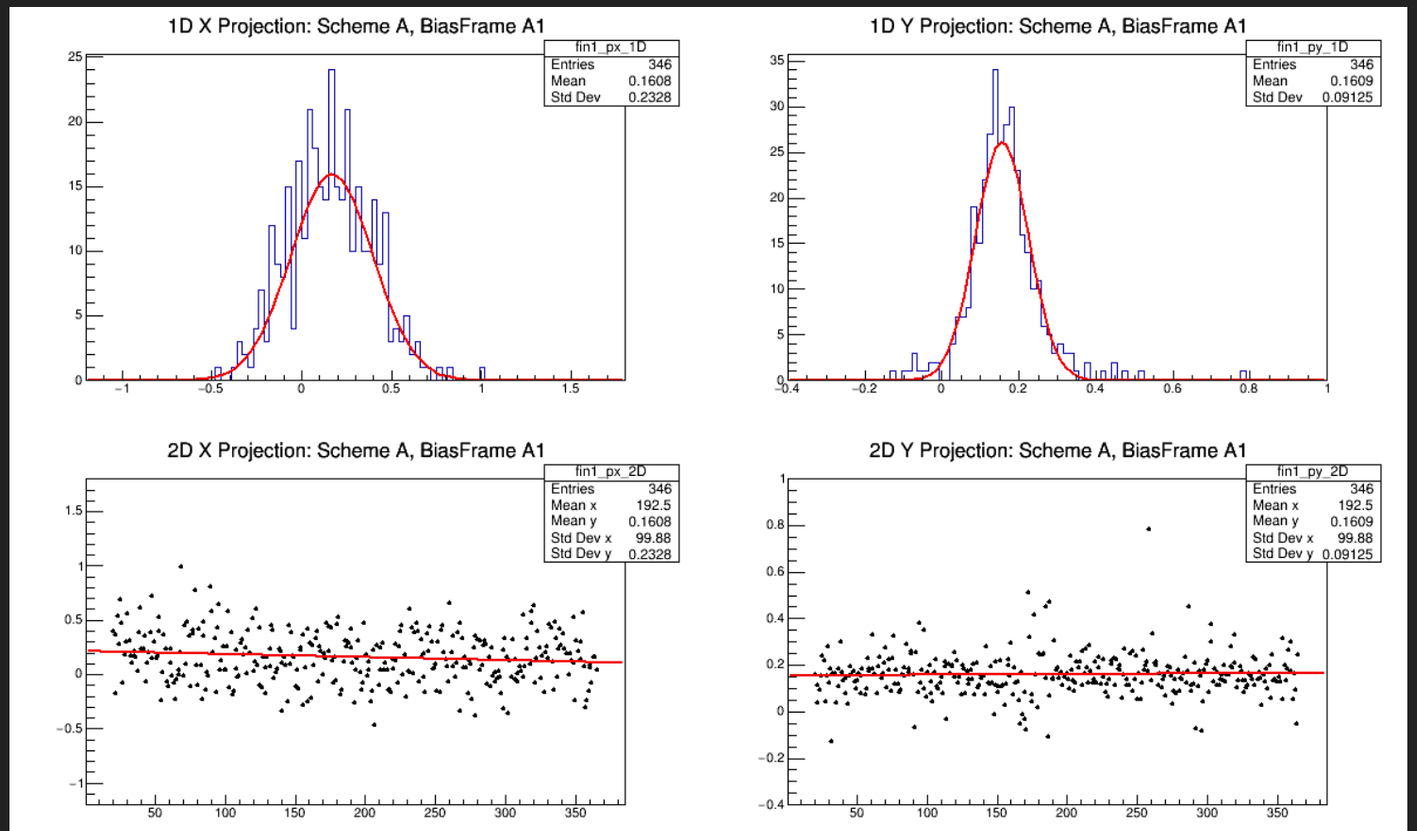
LIGHT SUM SQUARE X PROJECTIONS OF ROW CORRECTED BIAS FRAME: A2

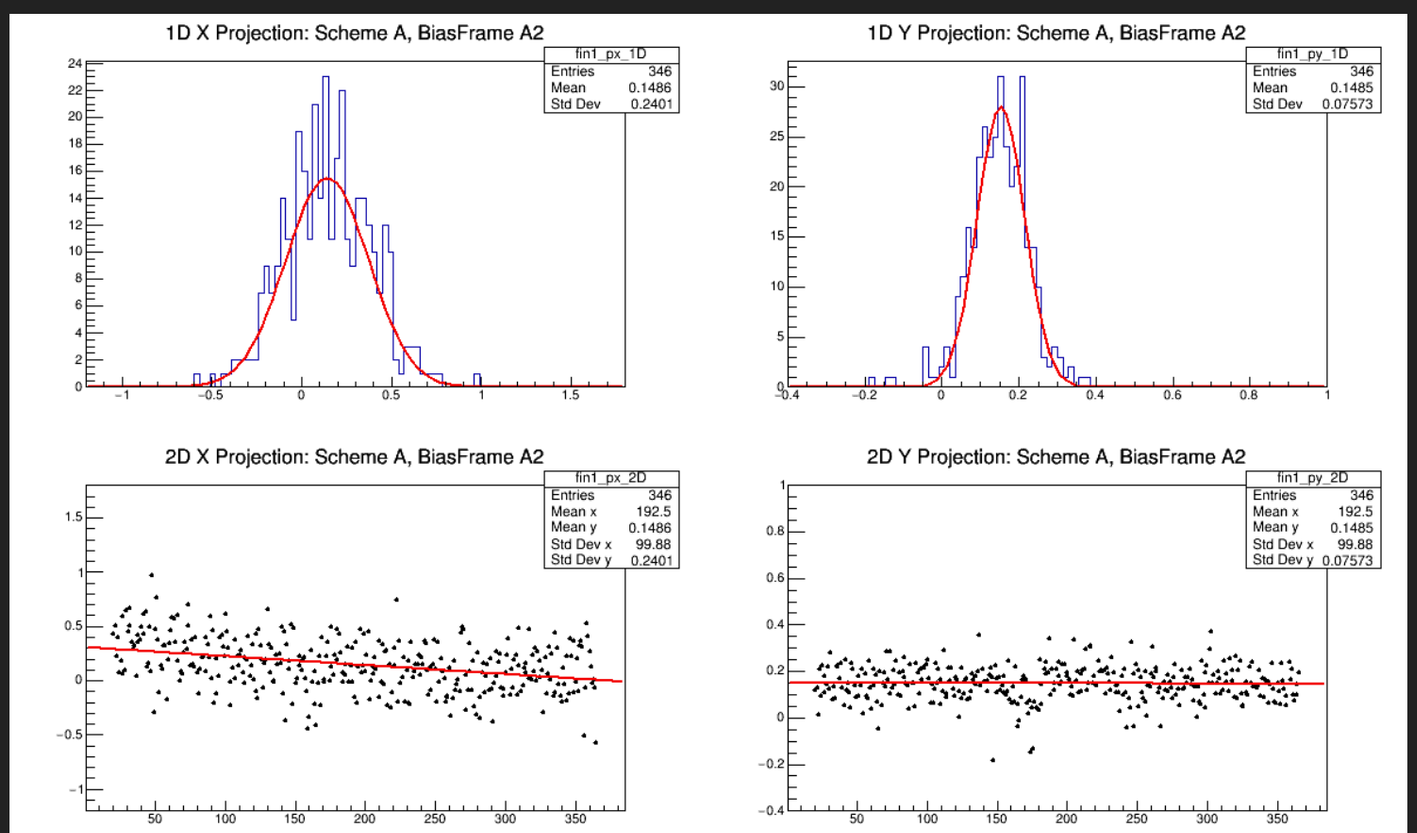




- These plots are the x projection of super bias frame A2 after it has had rudimentary row correction applied
- This quite effectively demonstrates how a temp difference in the BL corner can high or low spot in low x values

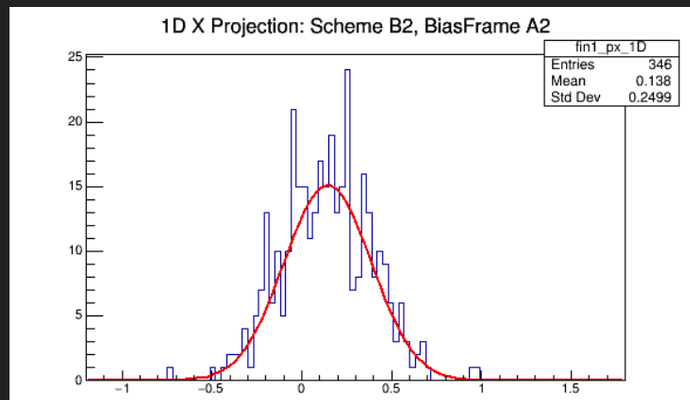
SUPER BIAS COMPARISON: SCHEME A

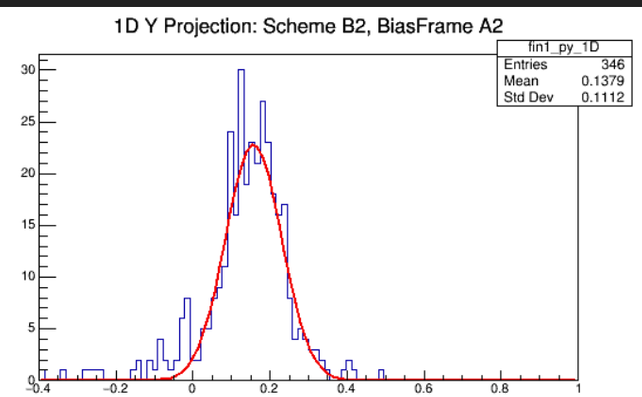


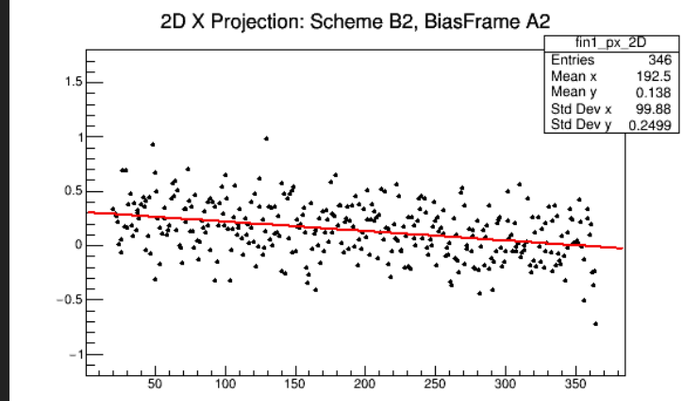


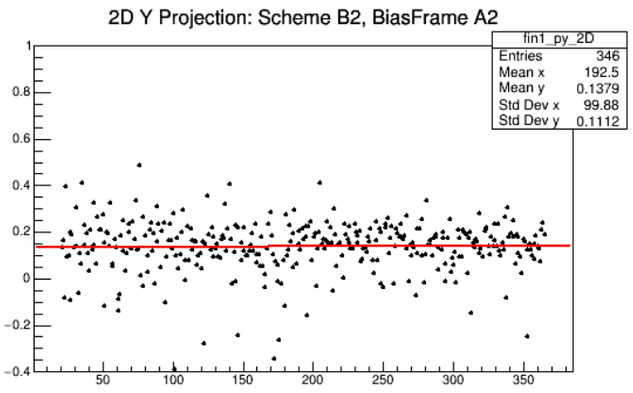
- These slides show the projection plots for each scheme with the each super bias frame taken directly before and after it chronologically for comparison
- Discussion and improvements follow

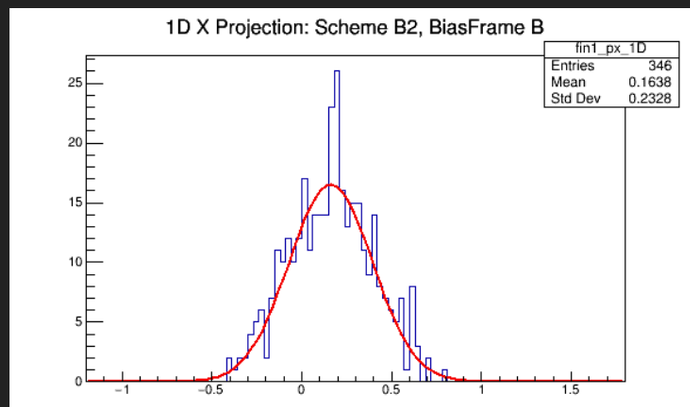
SUPER BIAS COMPARISON: SCHEME B2

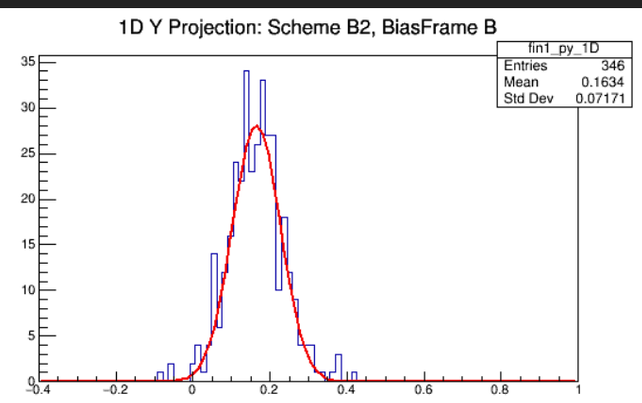


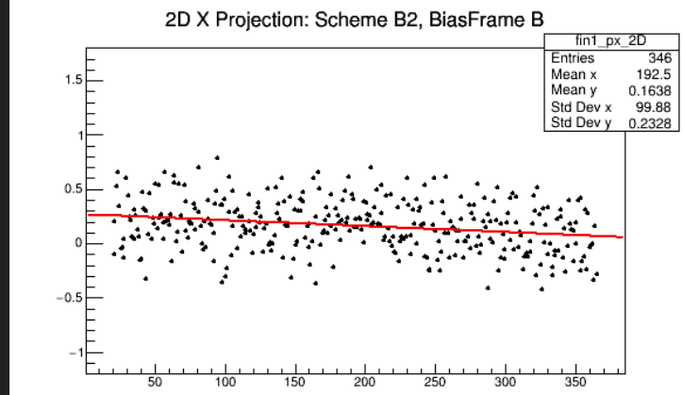


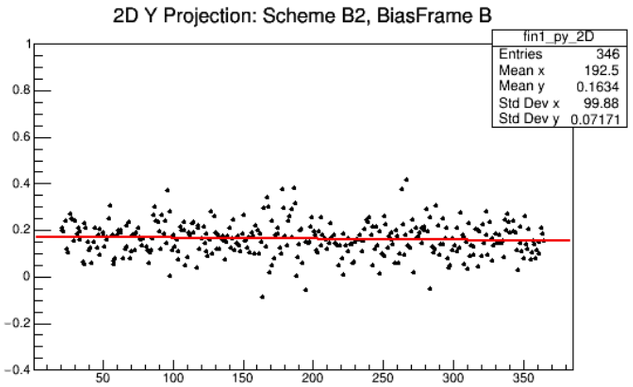






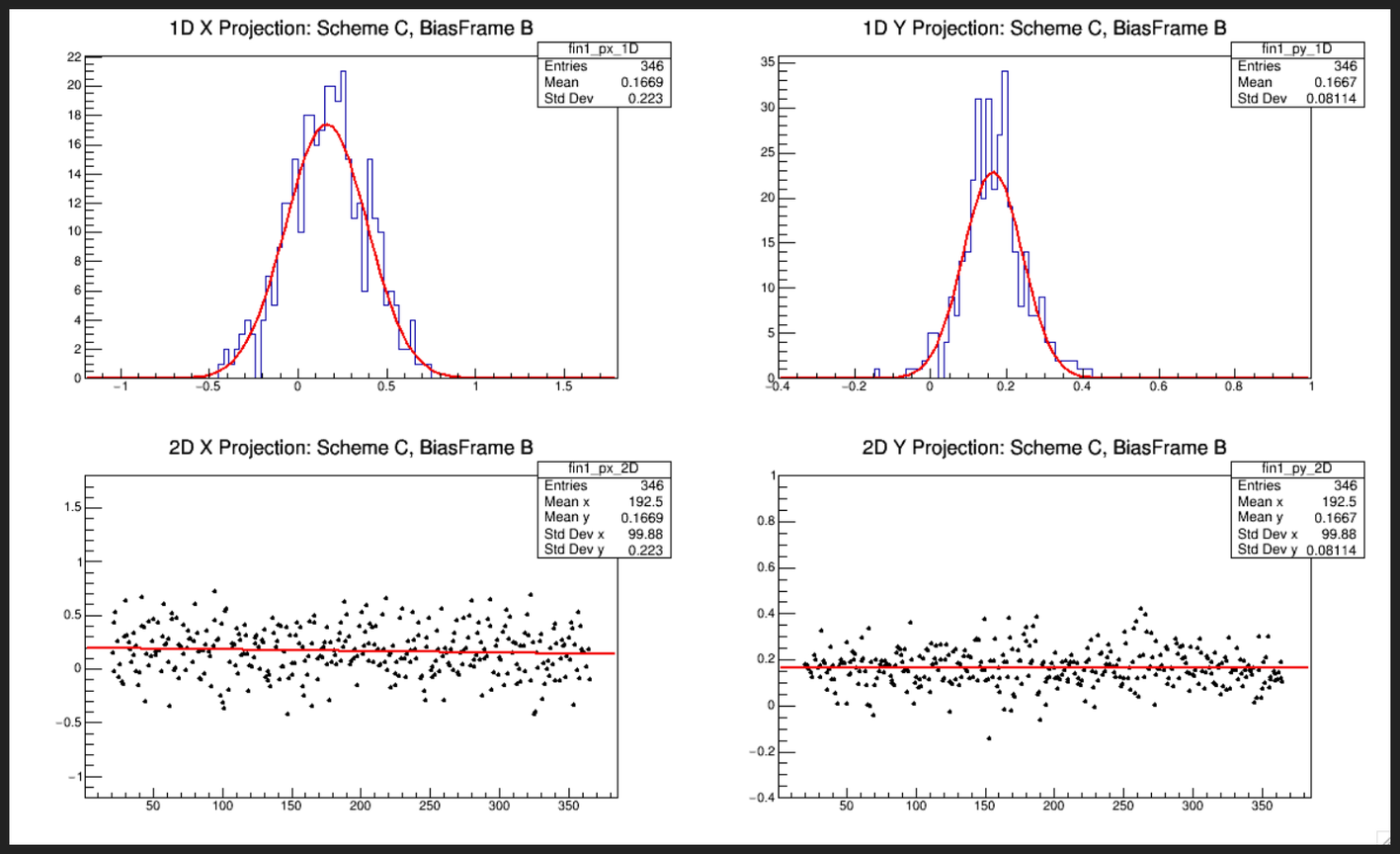


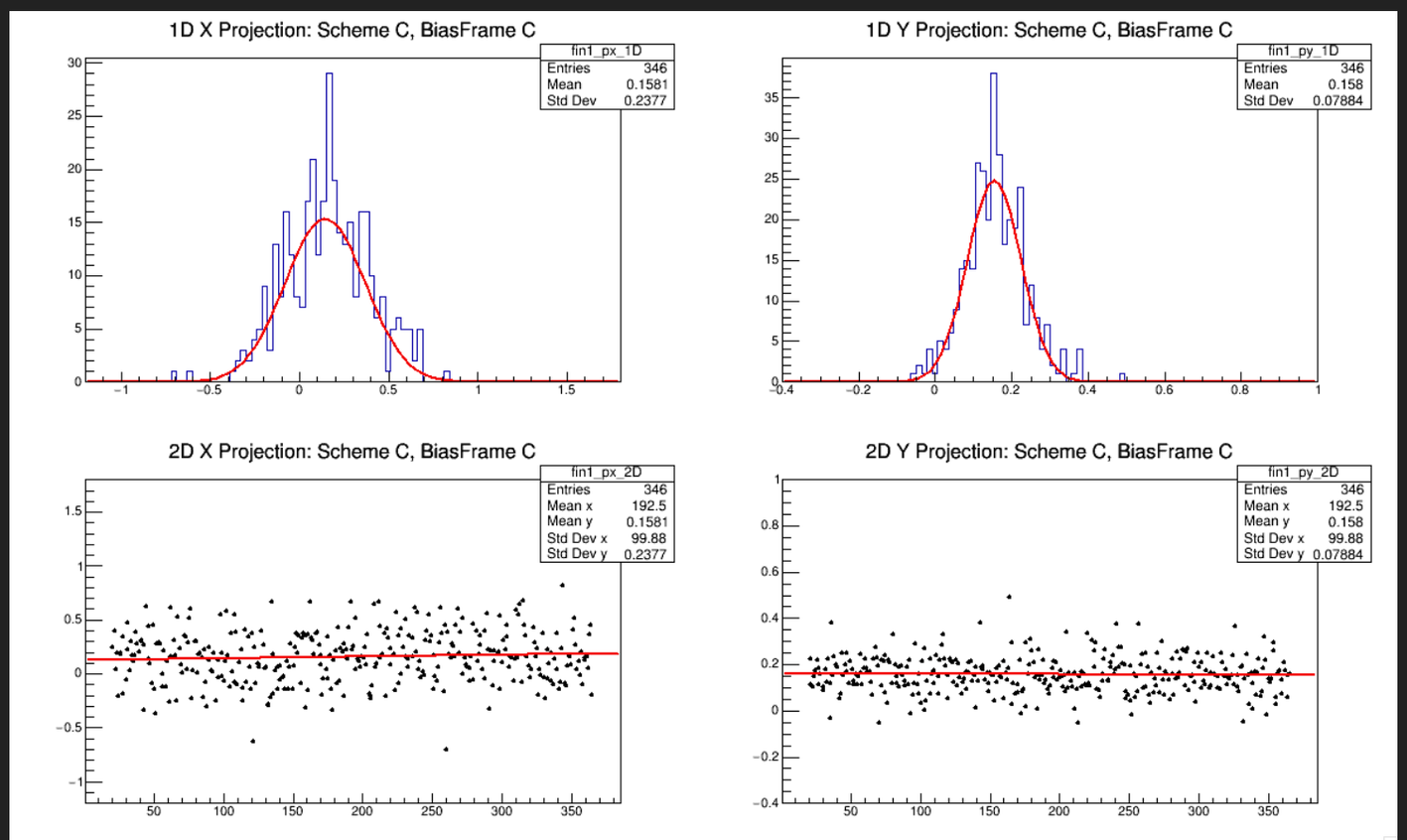




- These slides show the projection plots for each scheme with the each super bias frame taken directly before and after it chronologically for comparison
- Discussion and improvements follow

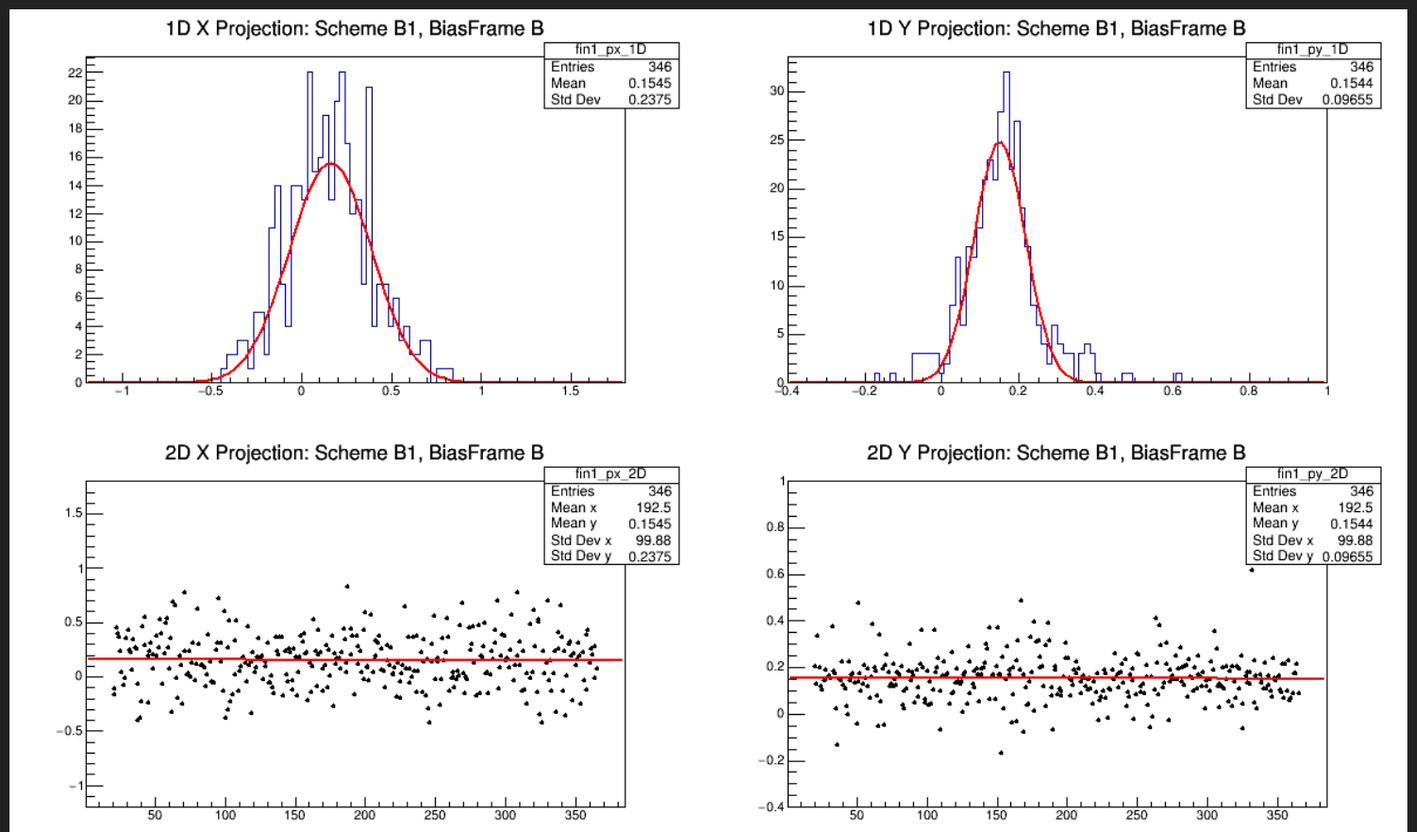
SUPER BIAS COMPARISON: SCHEME C

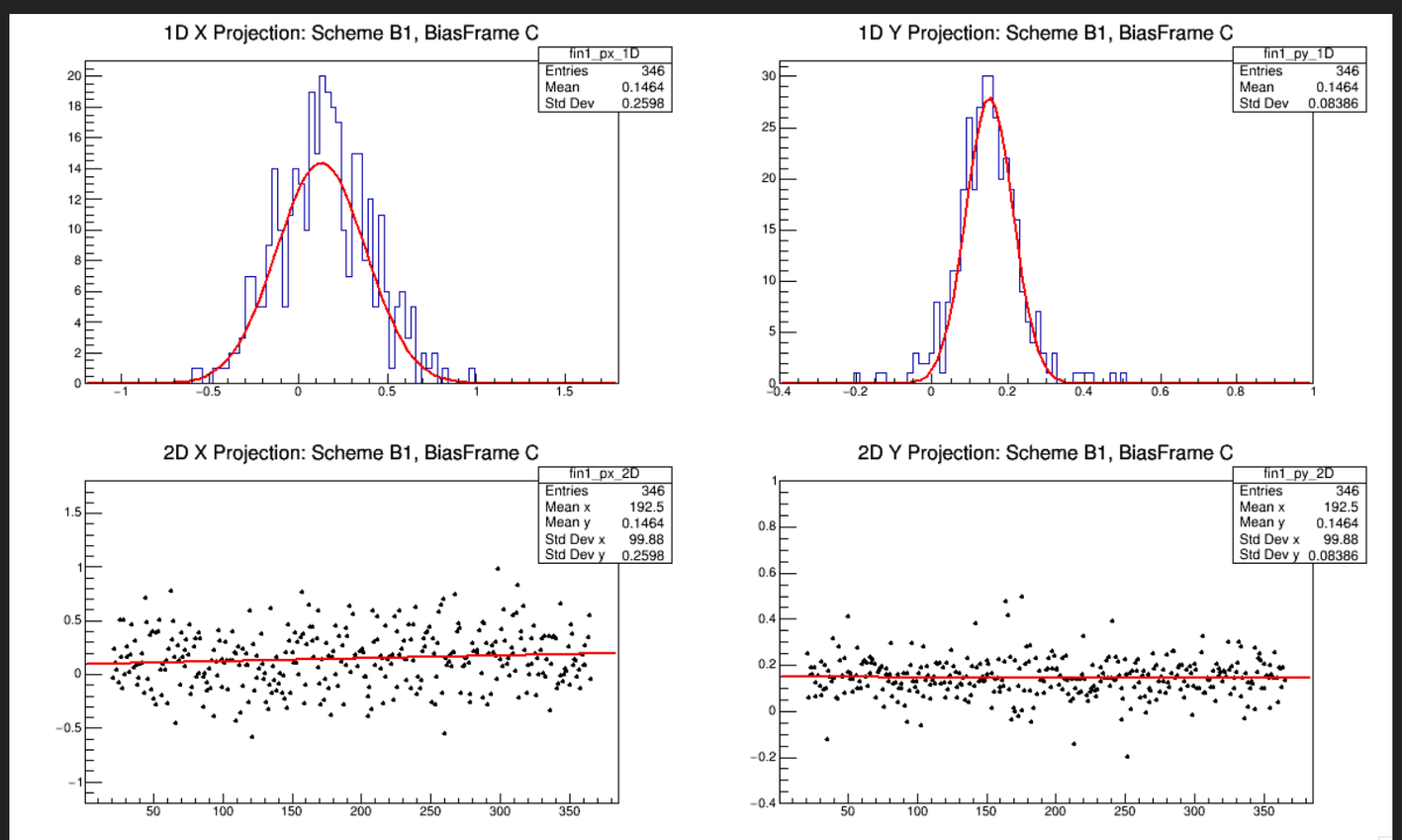




- These slides show the projection plots for each scheme with the each super bias frame taken directly before and after it chronologically for comparison
- Discussion and improvements follow

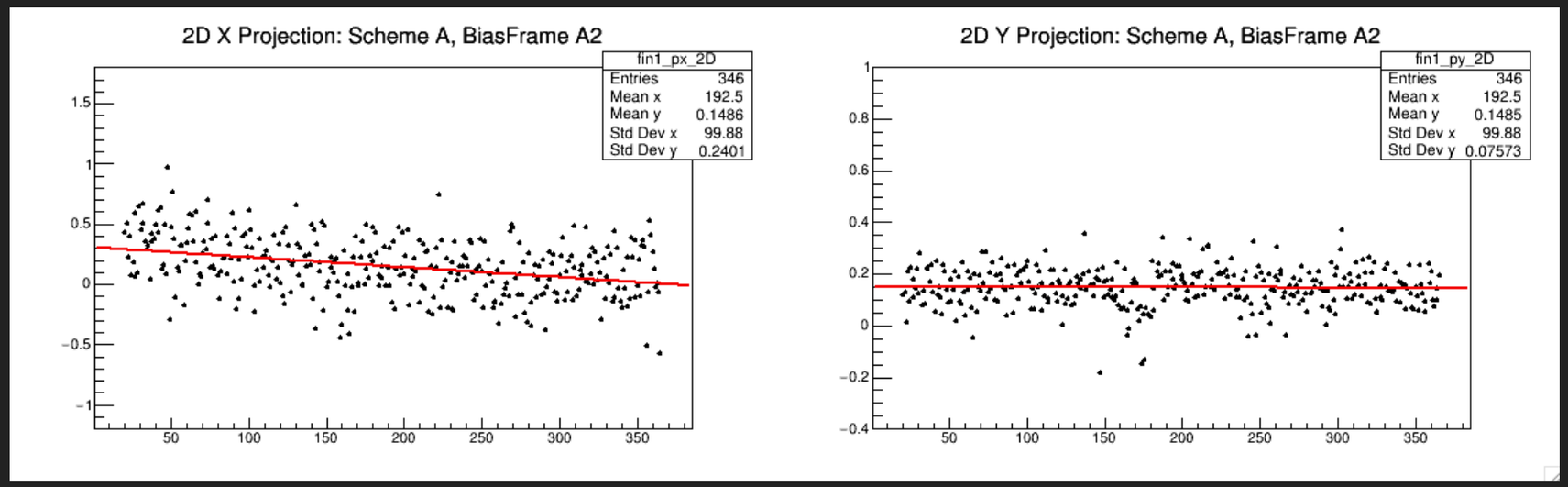
SUPER BIAS COMPARISON: SCHEME B2



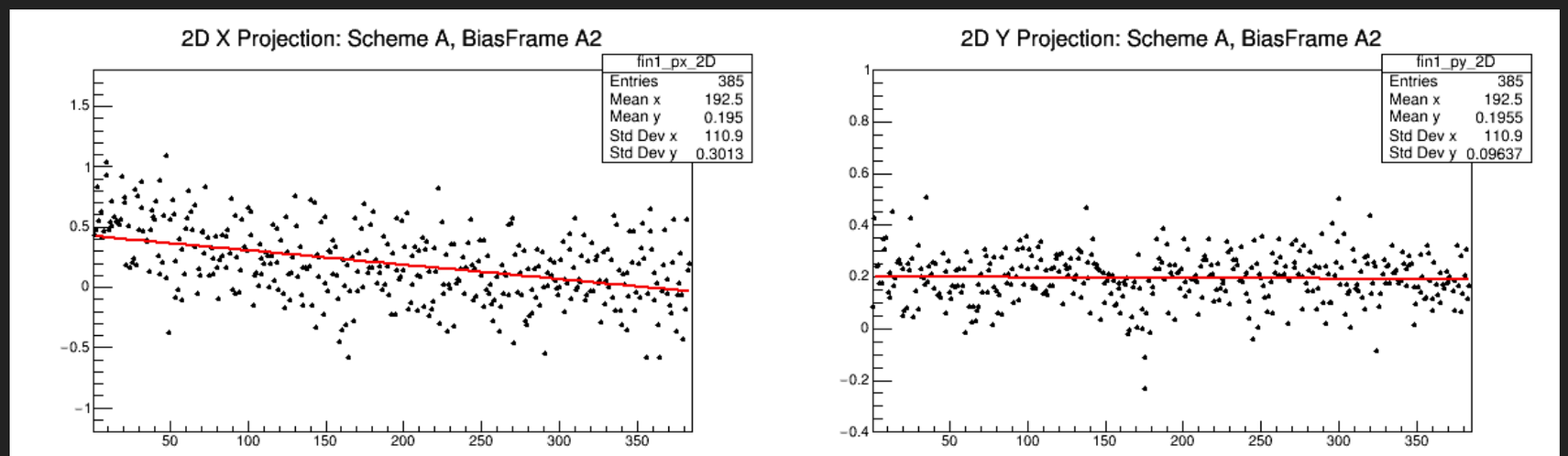


- These slides show the projection plots for each scheme with the each super bias frame taken directly before and after it chronologically for comparison
- Discussion and improvements follow

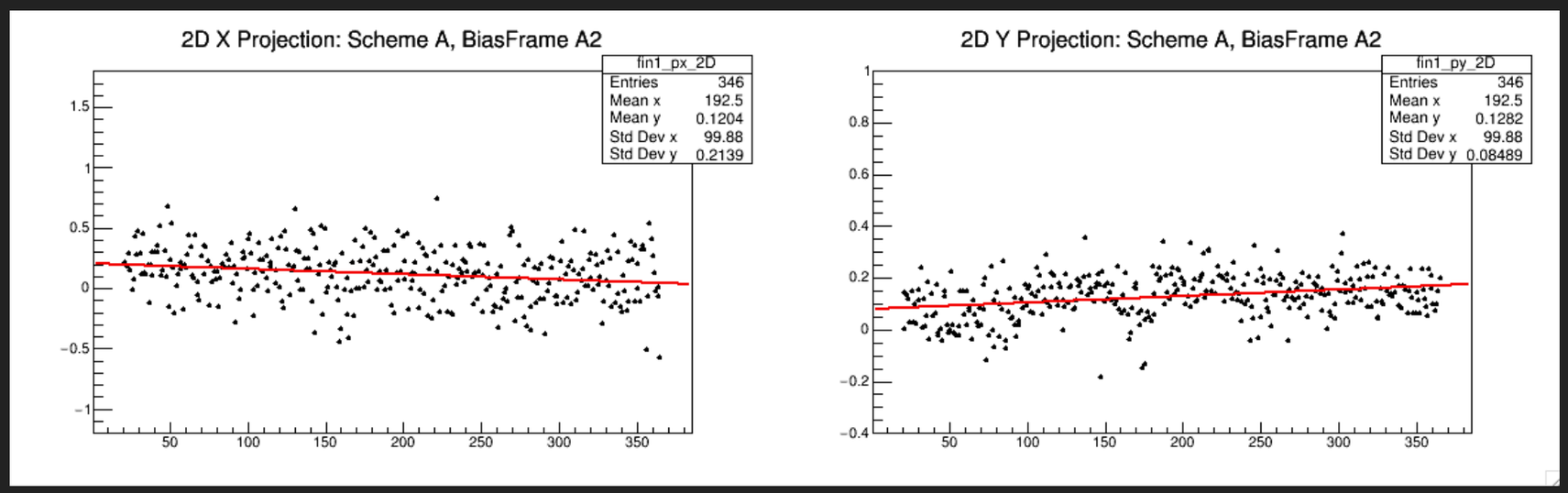
SUPER BIAS COMPARISON: DEEPER LOOK



- Scheme A with Super Bias A2 as previously shown



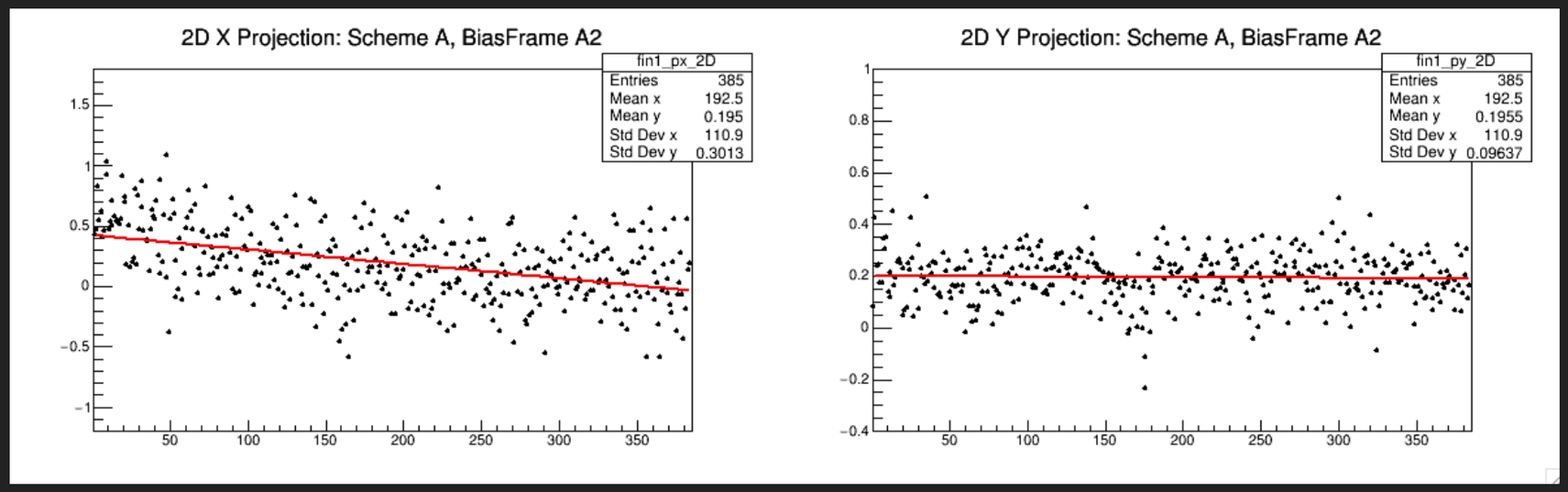
- Don't omit pixels near edge -> need to double check 10 pixels is reasonable



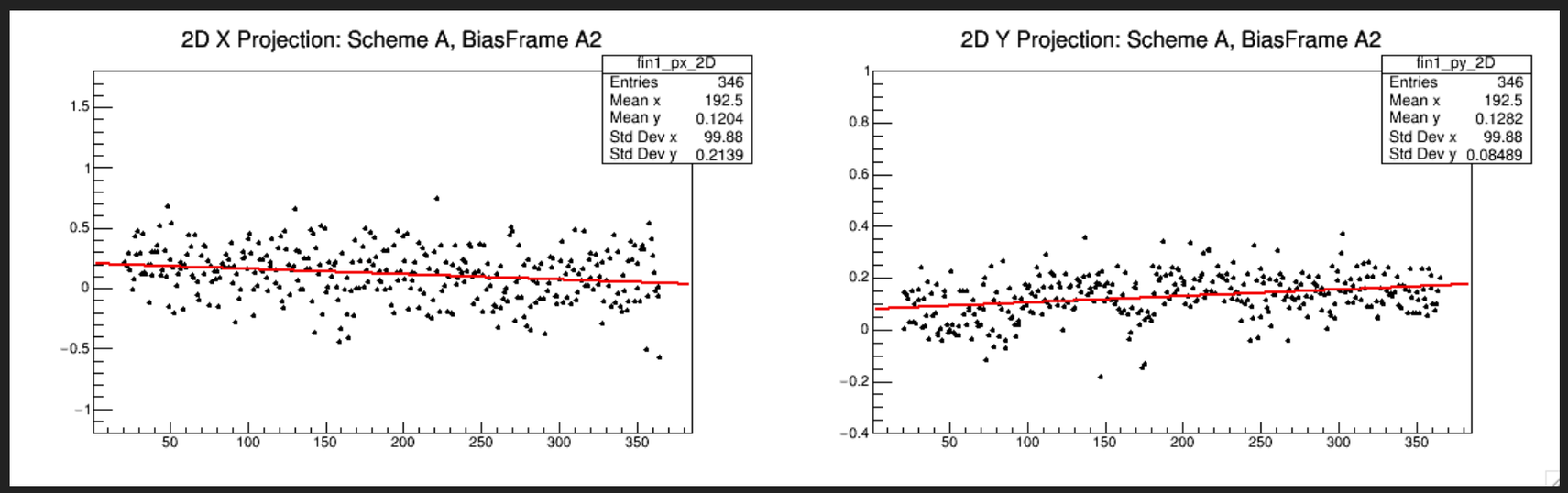
- Omit pixels within 100 of bottom left corner -> Improves X, Y drops where corner was as corner not omitted in row correction

TO DO

- Edit row correction to no longer omit pixels near non-source locations in row correction sum calculations -> This will lower variance where it matter most
- Omit pixels in bottom left corner in both row correction and bias frame projection macro -> This will remove influence from BL corner mismatch which should not effect the source location measurement (at [x=343,y=176]) but will allow projection plots to more clearly indicate which bias frames better match the CCDs state when taking said data



- Don't omit pixels near edge -> need to double check 10 pixels is reasonable

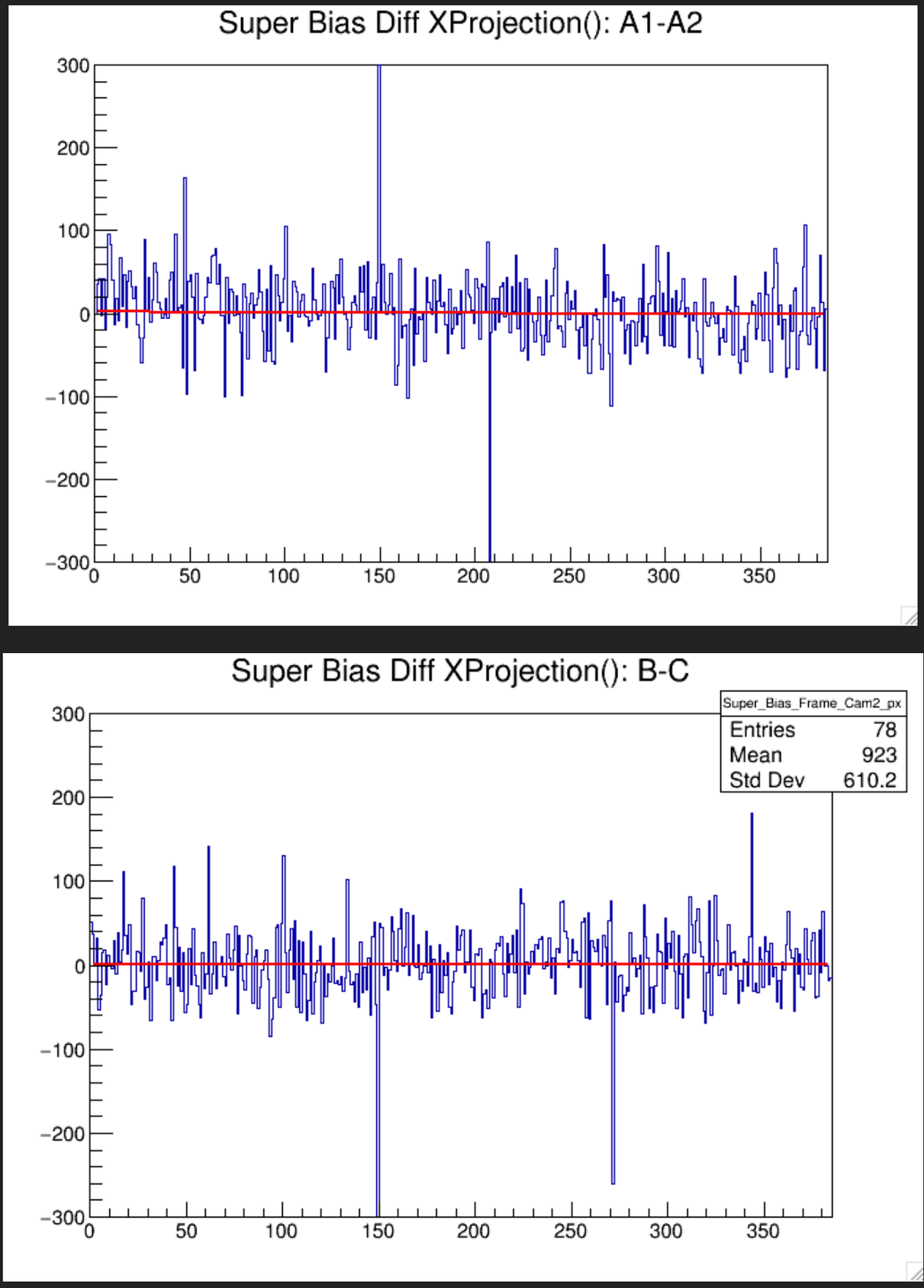


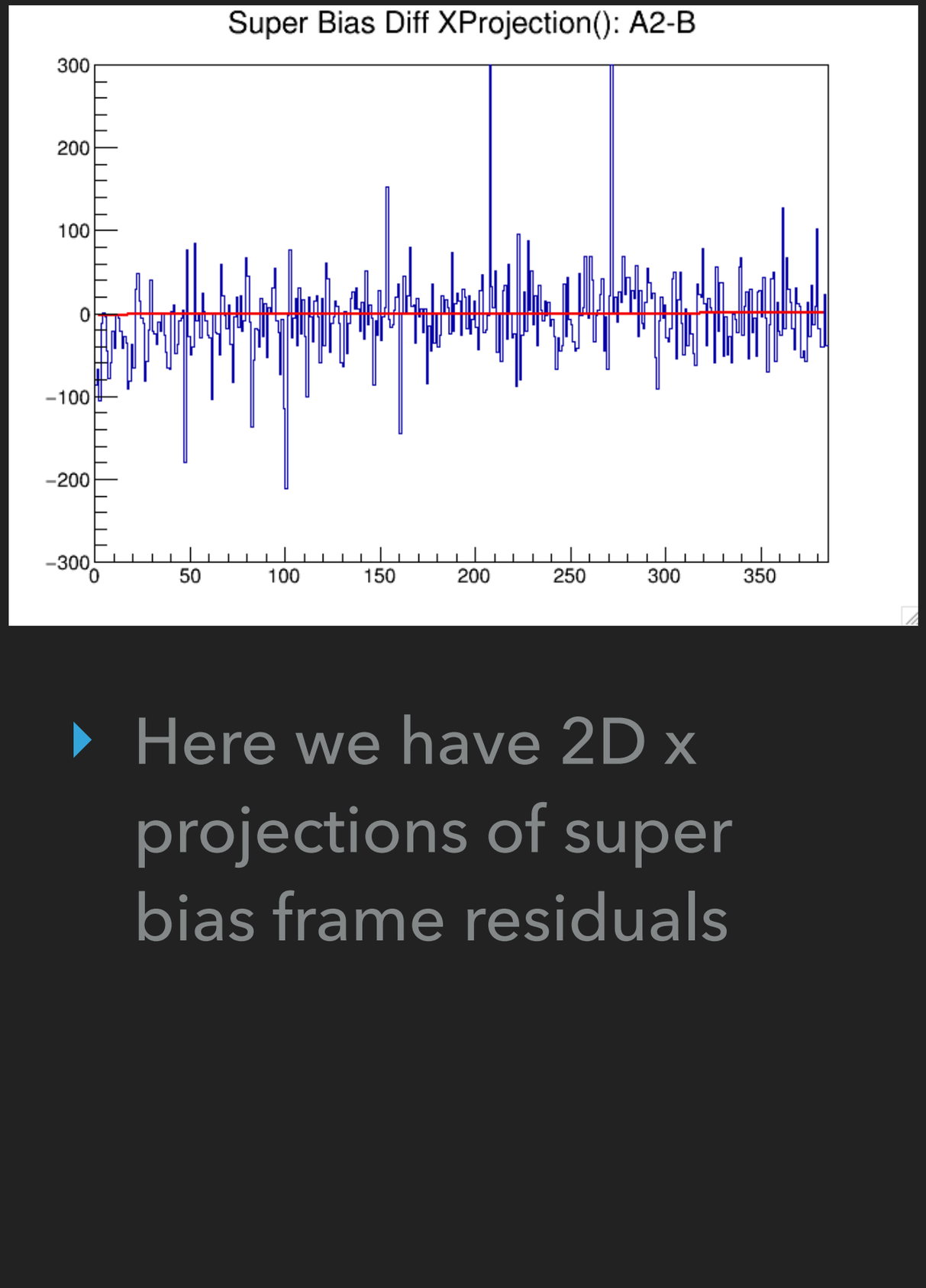
- Omit pixels within 100 of bottom left corner -> Improves X, Y drops where corner was as corner not omitted in row correction

BONUS SLIDES:

X PROJECTIONS OF BIAS FRAME RESIDUALS & GRADIENT IN SB_A2

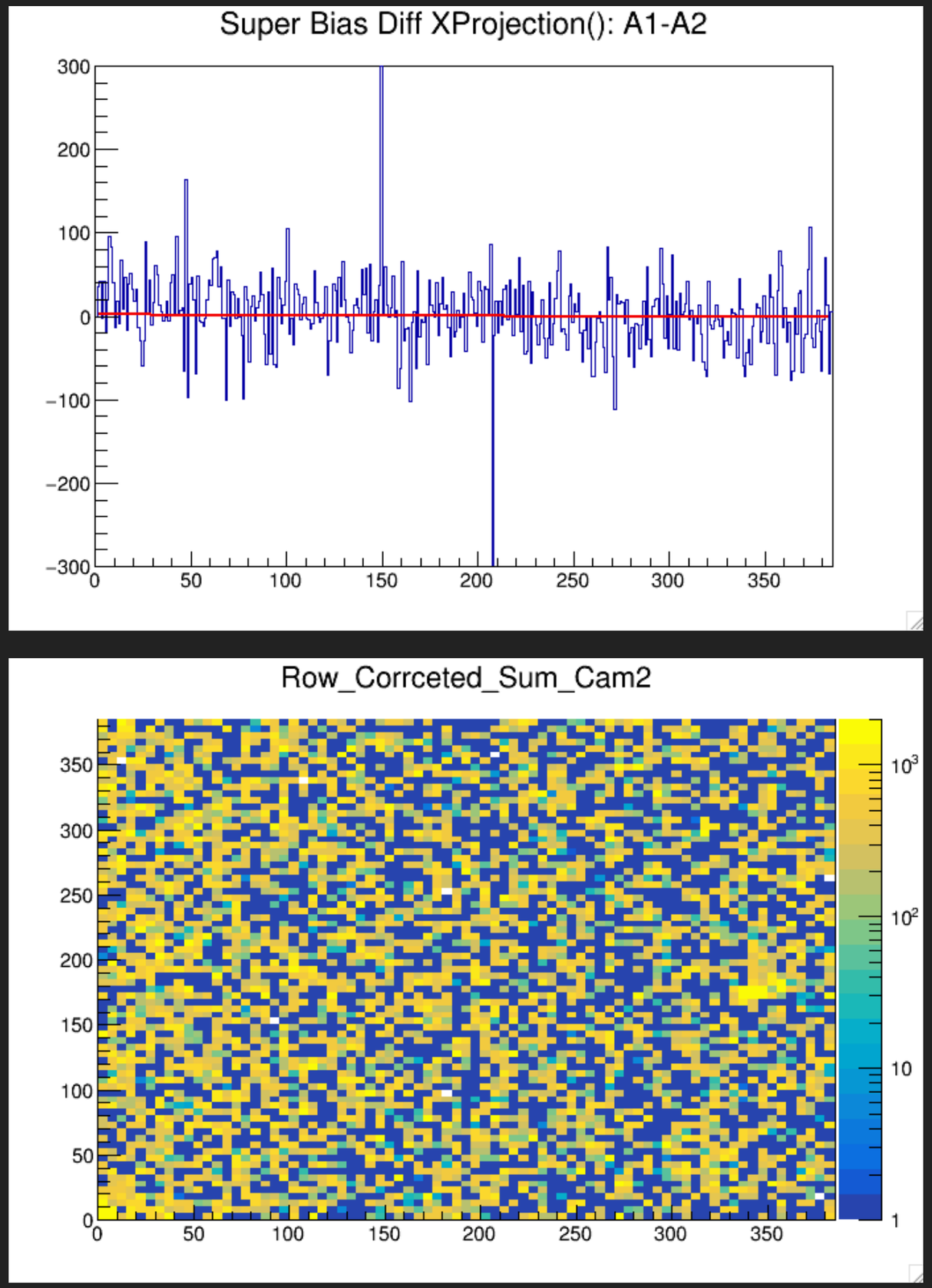
X PROJECTIONS OF BIAS FRAME RESIDUALS

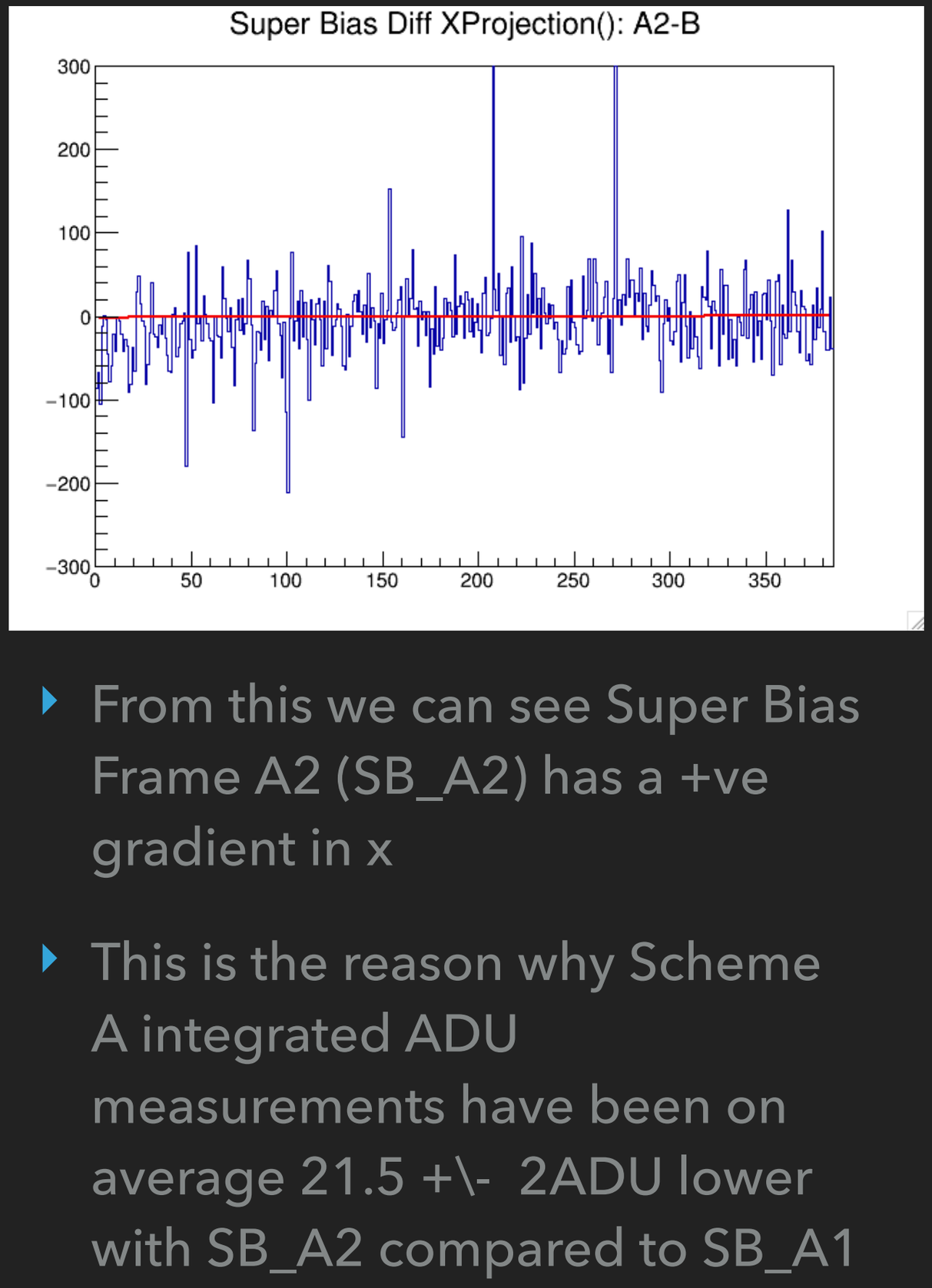




- Here we have 2D x projections of super bias frame residuals

X PROJECTIONS OF BIAS FRAME RESIDUALS: SB_A2



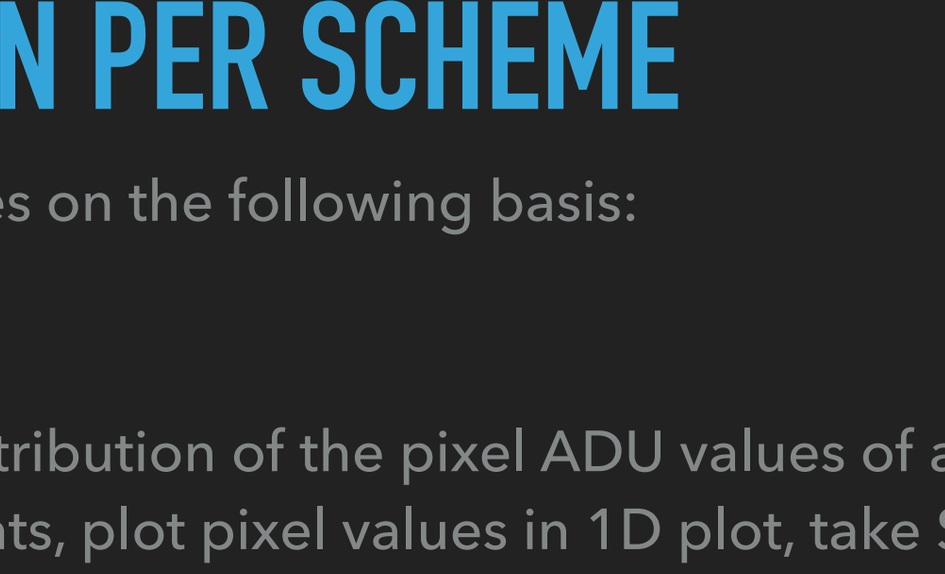


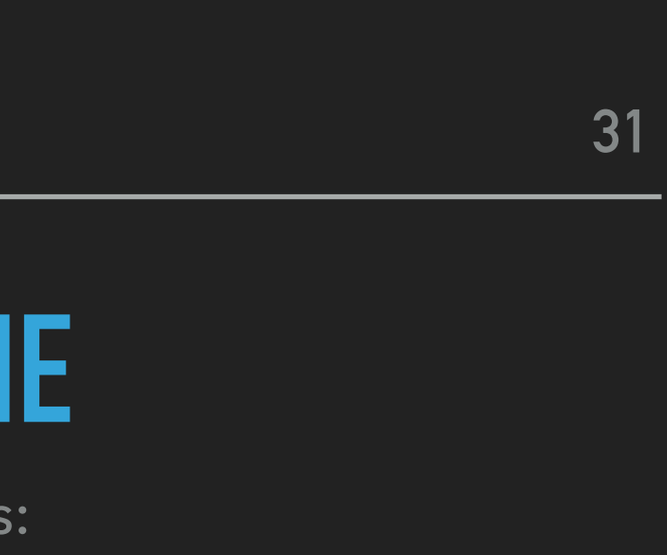
- From this we can see Super Bias Frame A2 (SB_A2) has a +ve gradient in x
- This is the reason why Scheme A integrated ADU measurements have been on average 21.5 +\- 2ADU lower with SB_A2 compared to SB_A1

SUPER BIAS COMPARISON PER SCHEME

- I have been comparing super bias frames on the following basis:
  - Their mean and error
  - The standard deviation of the 1D distribution of the pixel ADU values of all summed events in a scheme (i.e. sums all events, plot pixel values in 1D plot, take StDev)
  - The average RMS of all events in a scheme

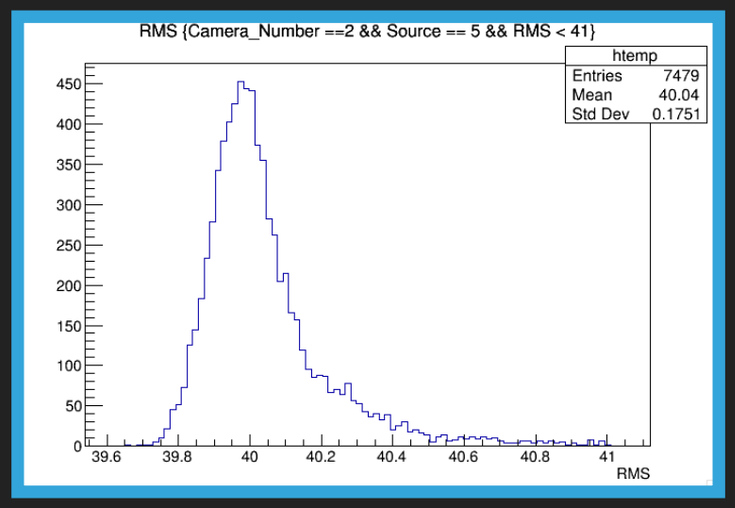
Scheme	Bias Frame			Scheme	Bias Frame	
A	A1			A	A2	
Mean (ADU)	Error (ADU)	Z StDev (ADU)		Mean (ADU)	Err	
383.197	11.879	0.01729		358.689	13	
384.16	8.80642	RMS (ADU)		361.599	9.	
380.788	8.75129	40.04		360.705	9.	
381.665	9.93145			361.254	10	
374.073	8.82169			354.495	8.	

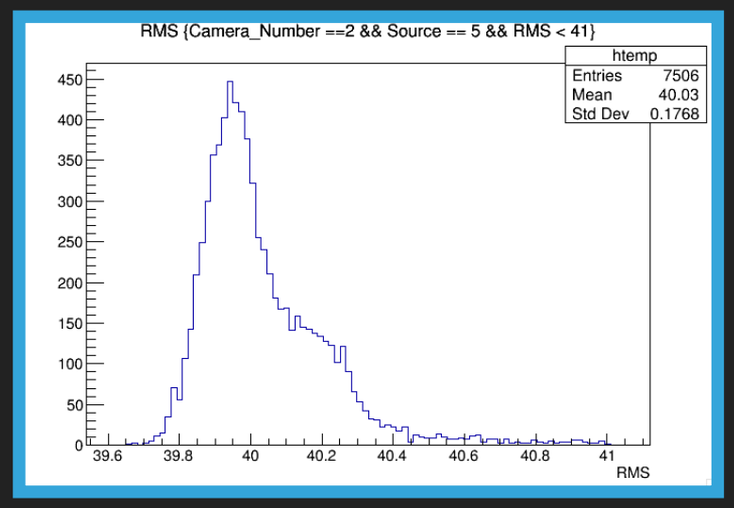




SUPER BIAS COMPARISON: SCHEME A

Scheme	Bias Frame			Scheme	Bias Frame	
A	A1			A	A2	
Mean (ADU)	Error (ADU)	Z StDev (ADU)		Mean (ADU)	Error (ADU)	Z StDev (ADU)
383.197	11.879	0.01729		358.689	13.0174	0.01756
384.16	8.80642	RMS (ADU)		361.599	9.20796	RMS (ADU)
380.788	8.75129	40.04		360.705	9.04348	40.03
381.665	9.93145			361.254	10.7462	
374.073	8.82169			354.495	8.83112	

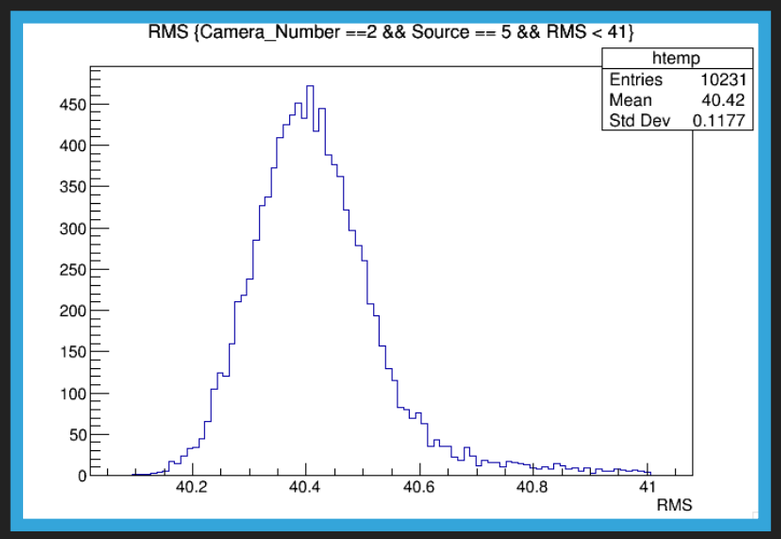


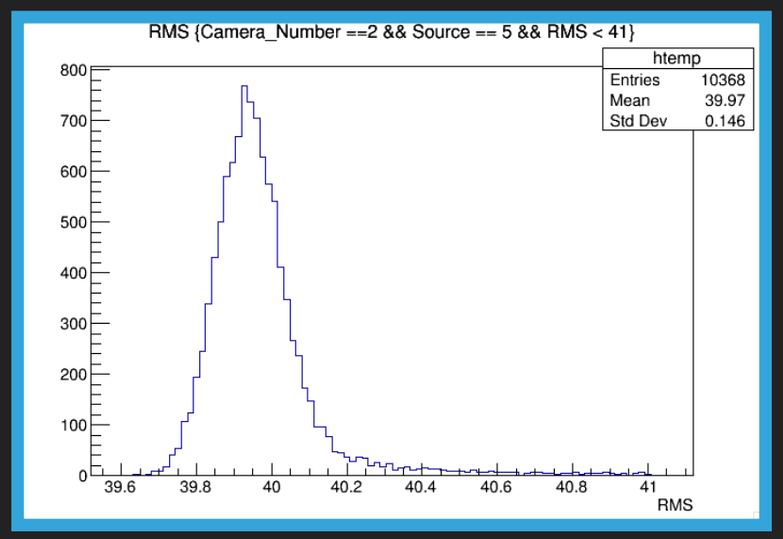


- Both A1 and A2 similar
- A2 mean approx 20 ADU lower than A1
- A2 event RMS shape looks off

SUPER BIAS COMPARISON: SCHEME B2

Scheme	Bias Frame			Scheme	Bias Frame	
B2	A2			B2	B	
Mean (ADU)	Error (ADU)	Z StDev (ADU)		Mean (ADU)	Error (ADU)	Z StDev (ADU)
285.479	21.4274	0.01309		344.801	13.5149	0.01257
333.202	14.34	RMS (ADU)		351.101	10.7585	RMS (ADU)
397.497	19.9632	40.42		369.971	12.6762	39.97
420.364	20.6032			400.075	11.78	
399.287	10.0932			393.641	10.1895	
390.825	14.5621			381.929	14.8688	
426.793	8.57594			426.625	7.4123	
446.396	22.8053			444.344	14.0968	





- Erratic mean difference between A2 and B
- Red flag: A2 significantly larger event RMS and Z StDev

SUPER BIAS COMPARISON: SCHEME C & B1

Scheme	Bias Frame			Scheme	Bias Frame	
C	B			C	C	
Mean (ADU)	**Error (ADU)**	**Z StDev (ADU)**		**Mean (ADU)**	**Error (ADU)**	**Z StDev (ADU)**
341.323	9.48257	0.01469		380.767	10.0127	0.01455
336.1	13.1961	**RMS (ADU)**		373.5	13.2984	**RMS (ADU)**
321.351	12.9757	39.94		360.69	11.7689	39.97
348.893	11.7067			387.195	11.4468	
358.834	11.2392			396.908	11.4939	
352.303	8.66987			386.928	8.99866	
275.262	8.26364			313.191	8.60268	
203.487	9.9074			240.178	9.47575	
89.2484	7.59346			127.026	6.5232	

Scheme	Bias Frame			Scheme	Bias Frame	
B1	B			B1	C	
Mean (ADU)	**Error (ADU)**	**Z StDev (ADU)**		**Mean (ADU)**	**Error (ADU)**	**Z StDev (ADU)**
280.318	18.016	0.04843		315.885	17.9568	0.04826
254.994	16.7873	**RMS (ADU)**		293.821	17.32	**RMS (ADU)**
273.083	16.4262	39.98		312.125	17.4076	39.92

- B and C very similar
- But mean difference of approx 40 ADU
- Scheme B1 large error -> need to look into

SUPER BIAS COMPARISON PER SCHEME

- I have been comparing super bias frames on the following basis:
  - Their mean and error
  - The standard deviation of the 1D distribution of the pixel ADU values of all summed events in a scheme (i.e. sums all events, plot pixel values in 1D plot, take StDev)
  - The average RMS of all events in a scheme

Scheme	Bias Frame			Scheme	Bias Frame	
A	A1			A	A2	
Mean (ADU)	Error (ADU)	Z StDev (ADU)		Mean (ADU)	Err	
383.197	11.879	0.01729		358.689	13	
384.16	8.80642	RMS (ADU)		361.599	9.	
380.788	8.75129	40.04		360.705	9.	
381.665	9.93145			361.254	10	
374.073	8.82169			354.495	8.