Parity Meeting

BCMS, BPMS, SAMs

Caryn Palatchi 04/7/2016

What Monitors/Detectors do we have?

- **BPMS**
- 4a,4b,8,12 (will get 14)
- (will get 3 Musson triplets X,Y)

- **BCMs**
- 1MHz ubcm,dbcm1x,dbcm3x,dbcm10x
- New Musson Ubcm, Dbcm
- Scaler of UNSER
- (will get 3 Musson triplets Q)

- **HALO monitors**
- Halo1,Halo2,Halo3,Halo4→scaler channels

- SAMs
- 2,4 – unity gain, 50MOhm
- 1,5 – High gain base, 100kOhm
- 3,7 -High gain base, 36kOhm
- 4,8 - High gain base, (36kOhm->)300kOhm

- EPICS
- Unser, hac_bcm_average

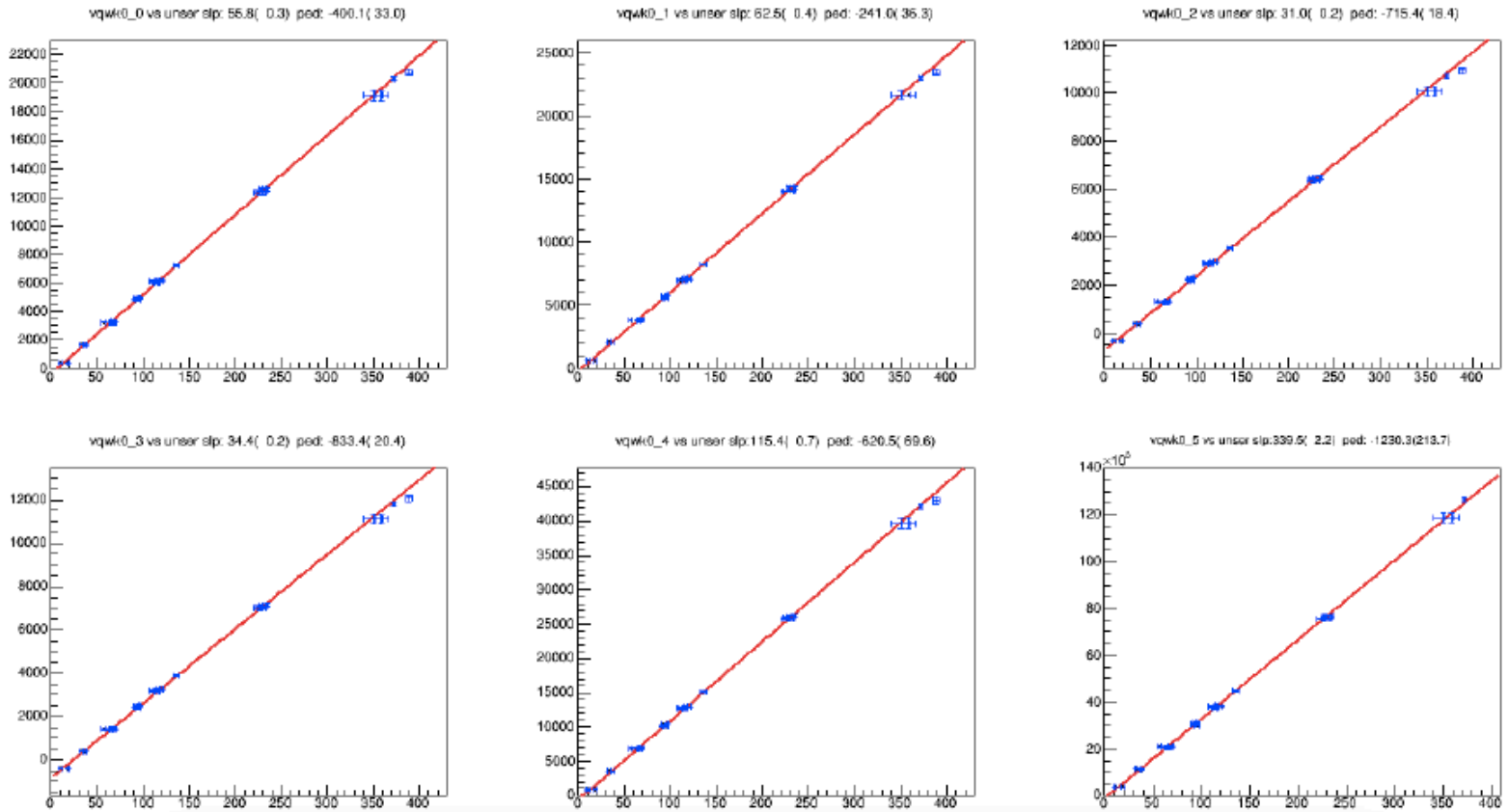
- DAQ
- Have Hall A DAQ alone
- Have Injector DAQ alone – pan/crl , BPM0I07

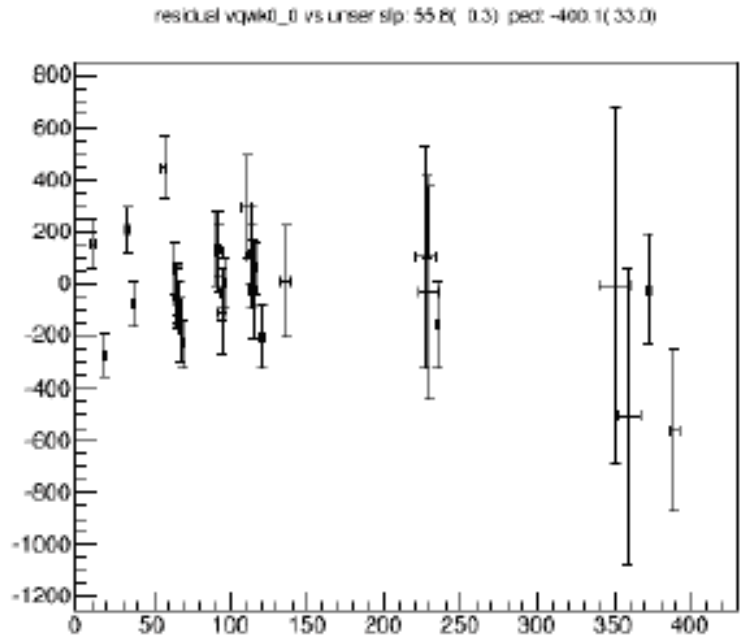
BCMS

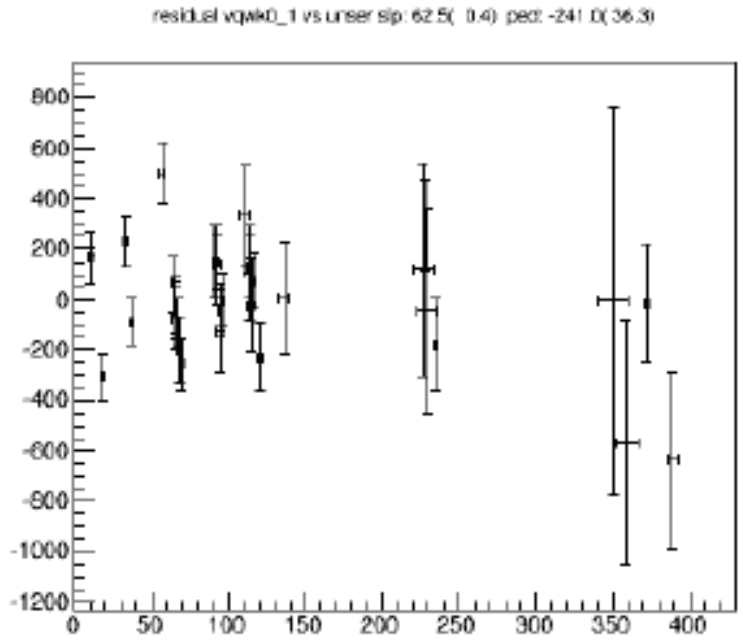
- Able to do a real calibration – FINALLY – with scaler copy of UNSER
- 1MHz Bcm's are OK most of the time
  - (aside from Pairsynch pickup)
  - (aside from intermittent failure resulting in noise and 5% shifts)
- New Musson BCMs are NOT OK
  - Looks like a 4-8ms delay

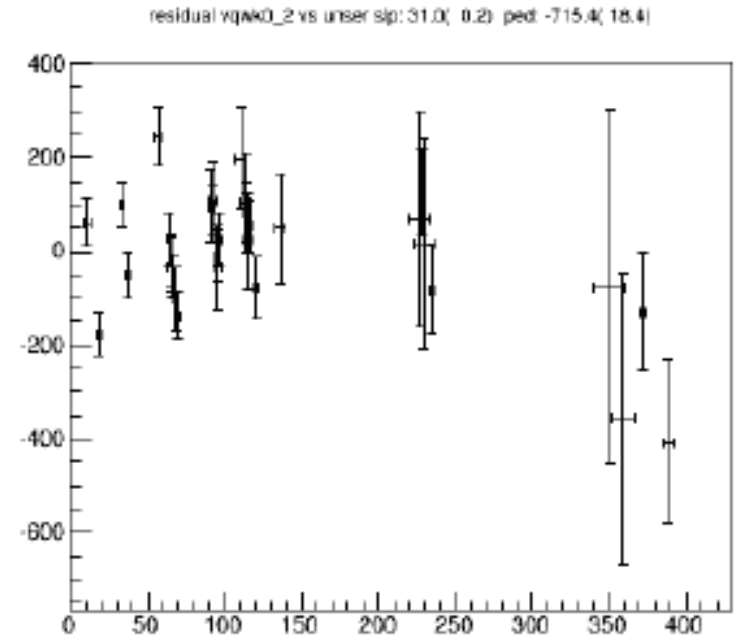
BCM calibration

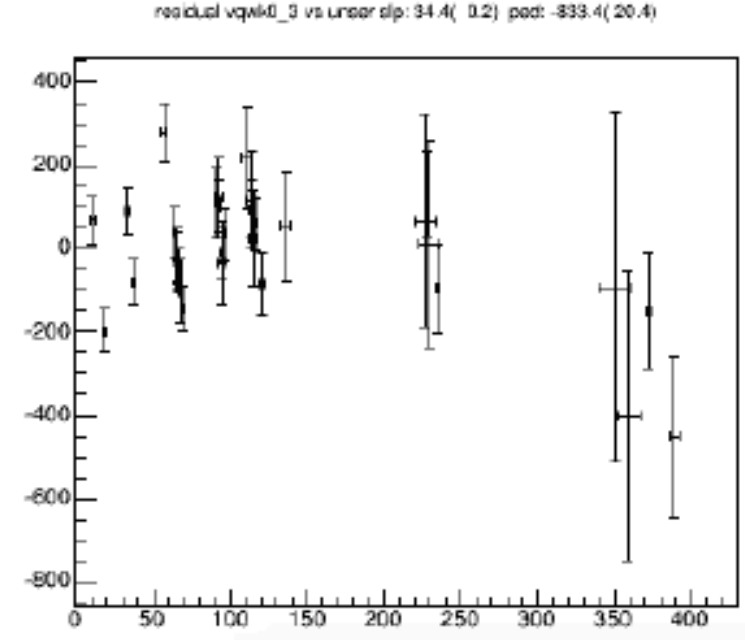
- Scaler copy of Unser – Ciprian's Run2370
- Currents: 1-30uA

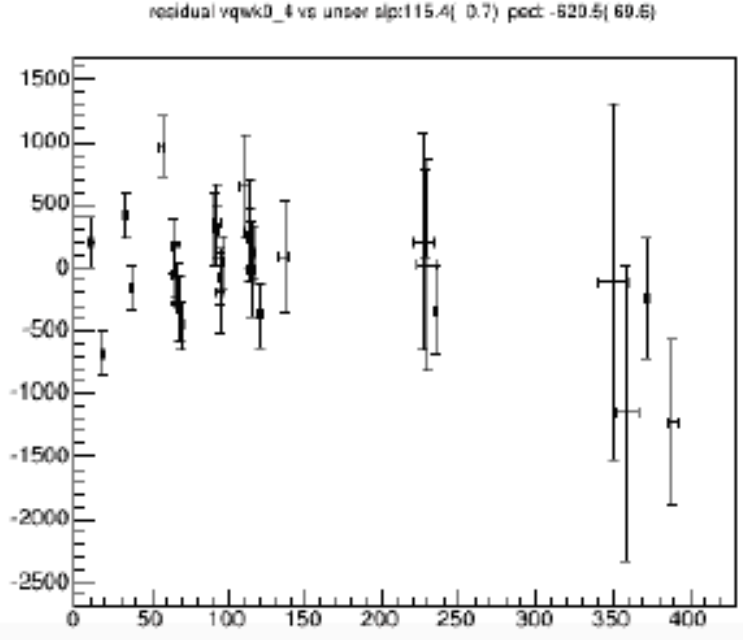


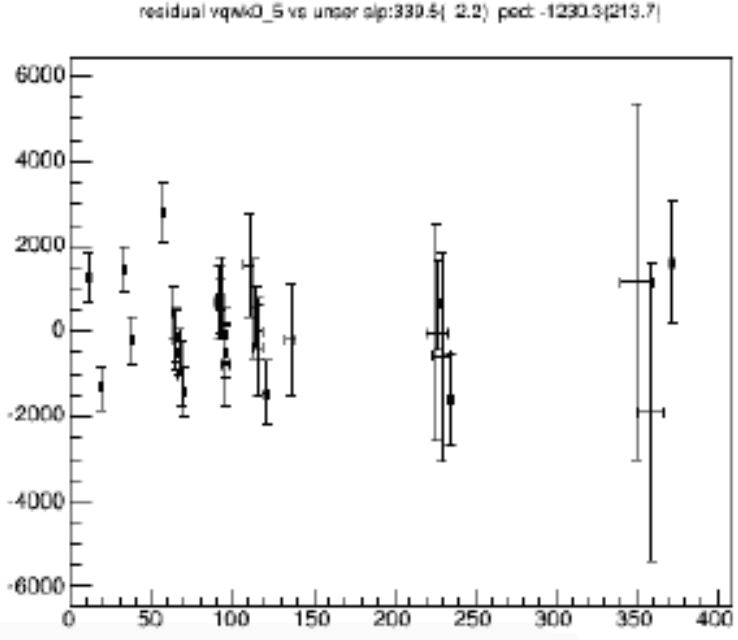

residual vqwk0_0 vs unser slp: 55.6(0.3) ped: -400.1(33.0)


residual vqwk0_1 vs unser slp: 62.5(0.4) ped: -241.0(36.3)


residual vqwk0_2 vs unser slp: 31.0(0.2) ped: -715.4(18.4)

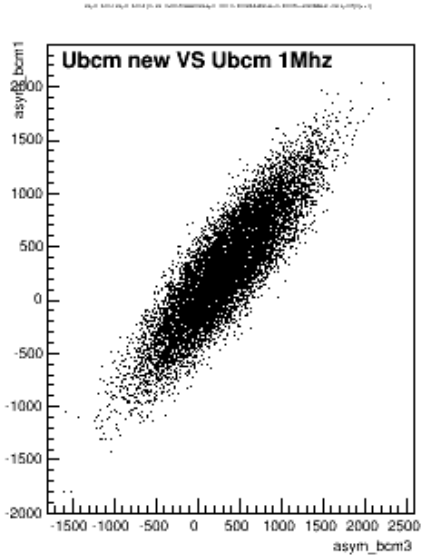

residual vqwk0_3 vs unser slp: 34.4(0.2) ped: -833.4(20.4)

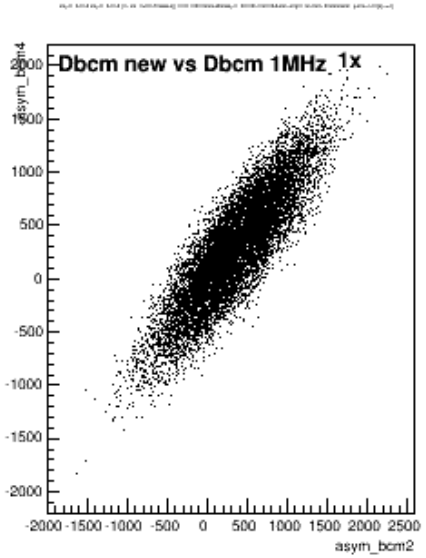

residual vqwk0_4 vs unser slp:115.4(0.7) ped: -620.5(69.6)

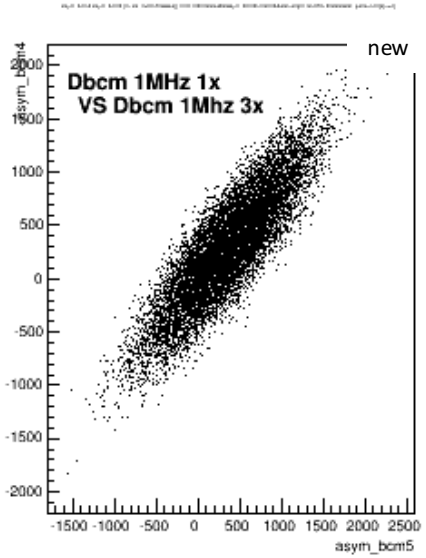

residual vqwk0_5 vs unser slp:339.5(2.2) ped: -1230.3(213.7)

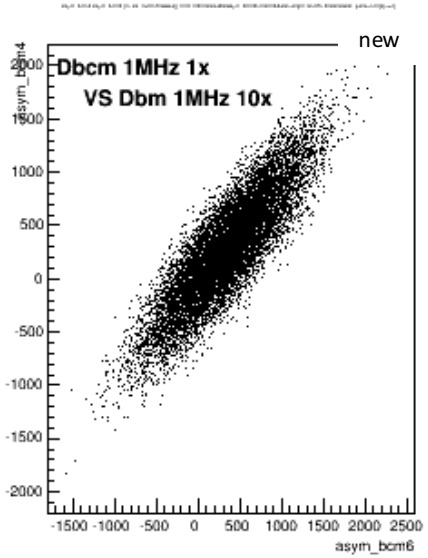
Run2333, 12uA, 15cm LH2

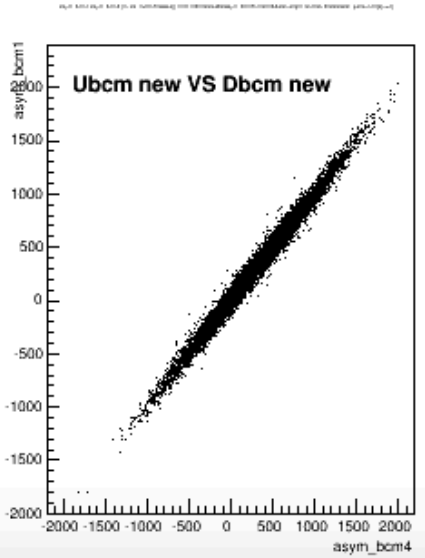
How are the BCMs doing? BCM correlations

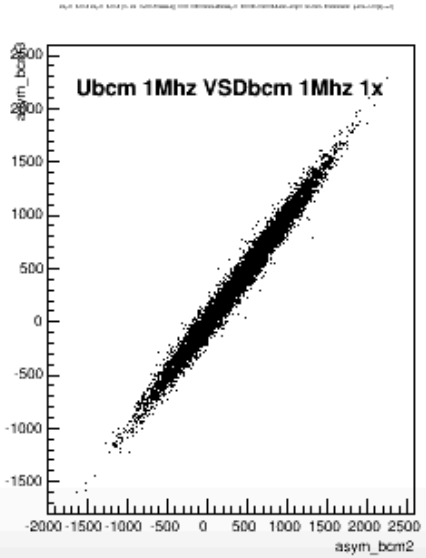


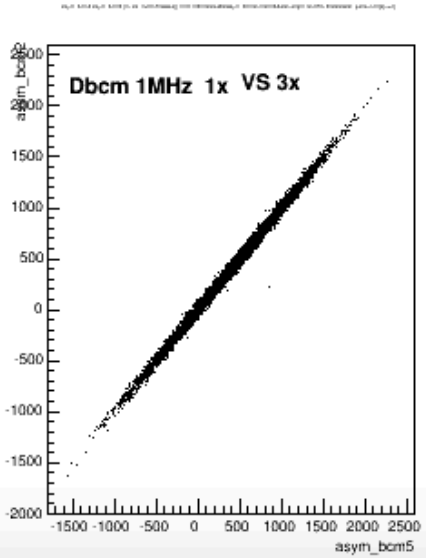






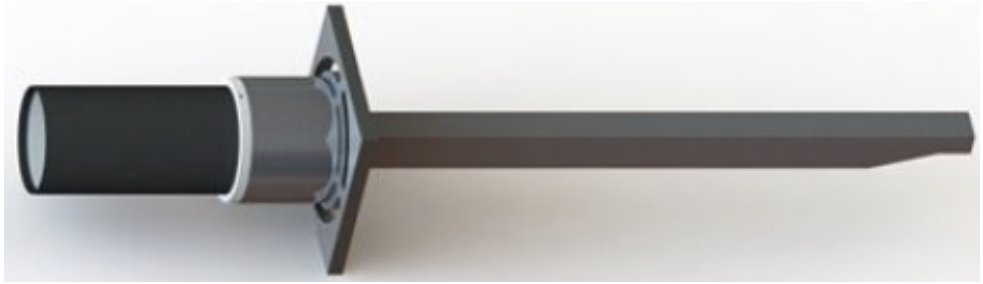


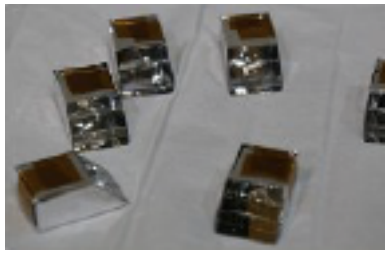




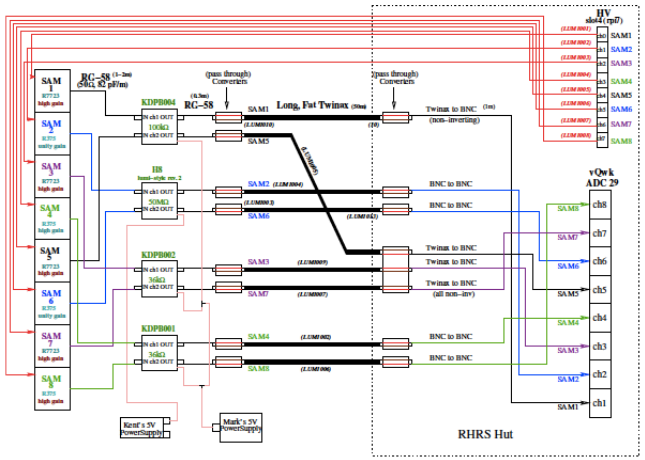
- Double differences on 1MHz receivers
  - double difference is small
- Double difference on New Musson receivers
  – small
- But if compare between receivers on same cavity
  – two readouts disagree
  – but can't tell which bcm is noisy
- **Need something which breaks this degeneracy**
  – use SAMs

8 Small Angle Monitors (SAMs)





SAM configuration (Jan 2016)

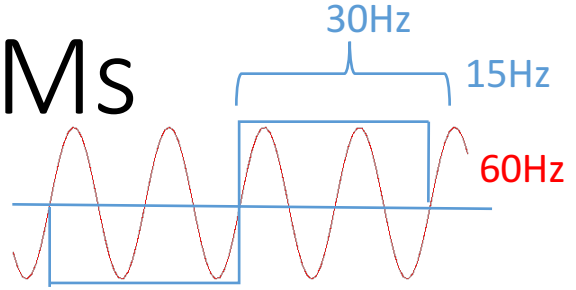


- high sensitivity to helicity-correlated beam parameters
- 8 quartz detectors with light guides placed symmetrically around beam line downstream of pivot
- Symmetric 8 piece design helps **disentangle beam position and angle** HCBP's

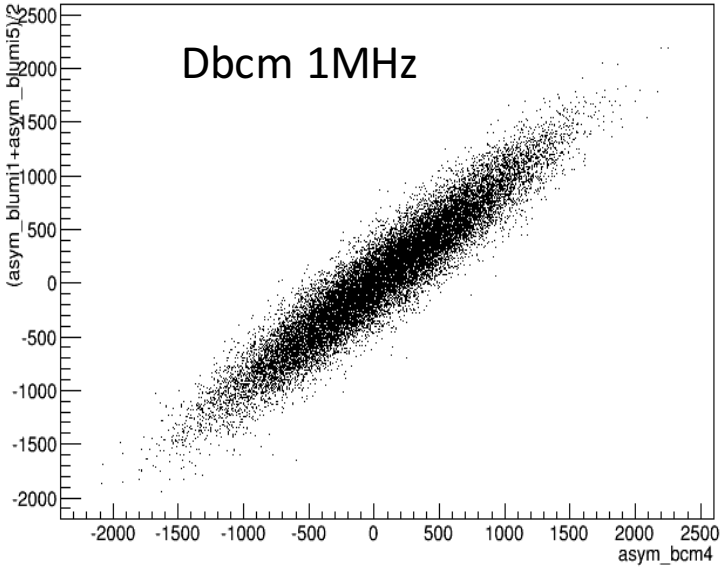
Are the BCMs OK? Which BCM is least noisy?

- Use SAMs as independent measure of beam current noise to establish BCMs working
- Is one bcm more correlated with the SAMs than another? Yes – the 1 MHz system
- Use correlations between SAMs and bcms to establish which bcm is least noisy – the 1MHz system is less noisy
- Does the 1MHz system have less uncorrelated noise wrt the SAM than the new Mussons – for different frequencies? 30Hz,60Hz,120Hz...? Yes.

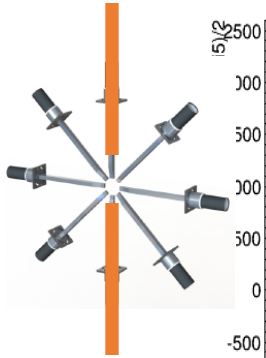
Comparison of old/new BCMs using SAMs



<SAM pair 1,5>



Downstream BCM – 1MHz



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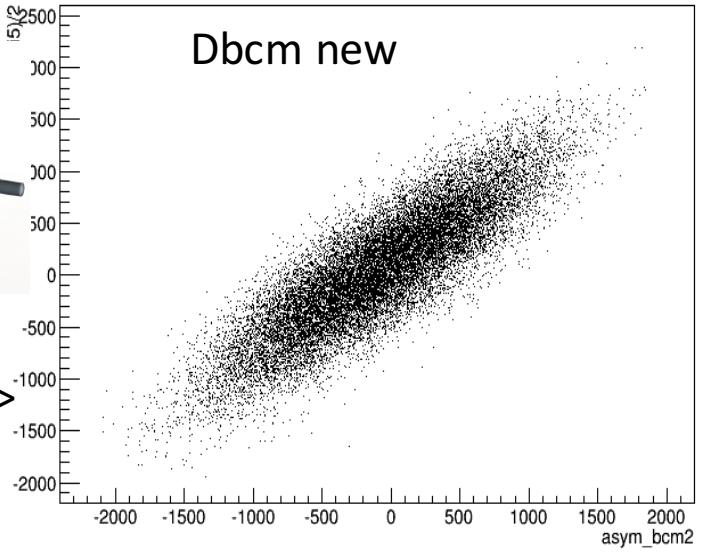


Downstream BCM – NEW

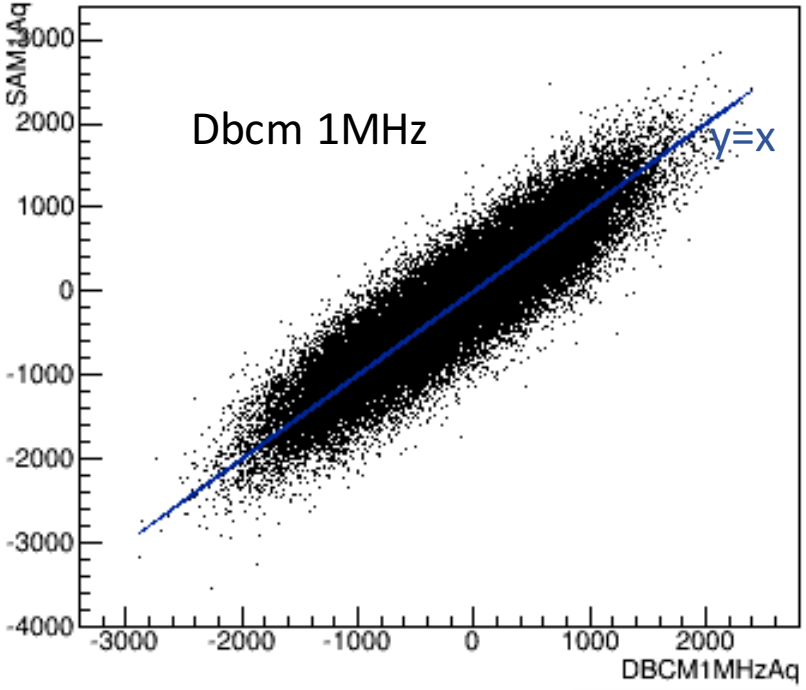
Examine plot of Asam vs Aq (different bcms)

-see more noise in new Musson receivers than in old 1MHz system

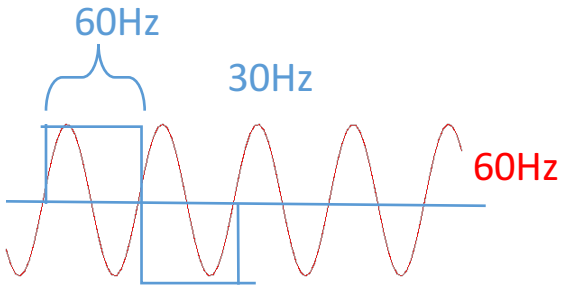
THIS is 30Hz sampling ONLY!

60Hz beam noise w/o 60Hz electronic noise: ((b1+b2) – (b3+b4))/ sum

<SAM pair 1,5>



Downstream BCM – 1MHz



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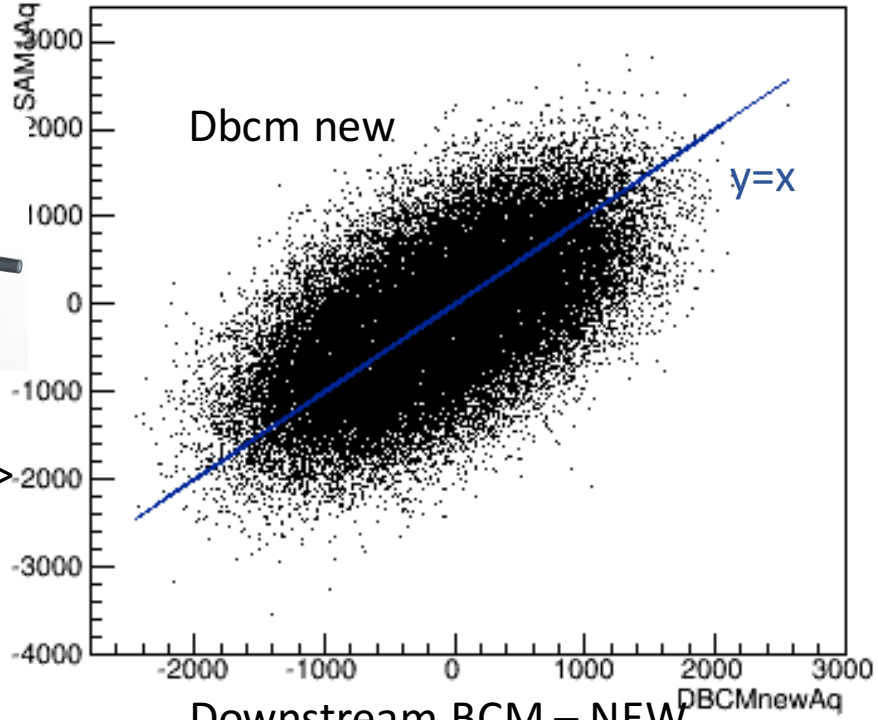
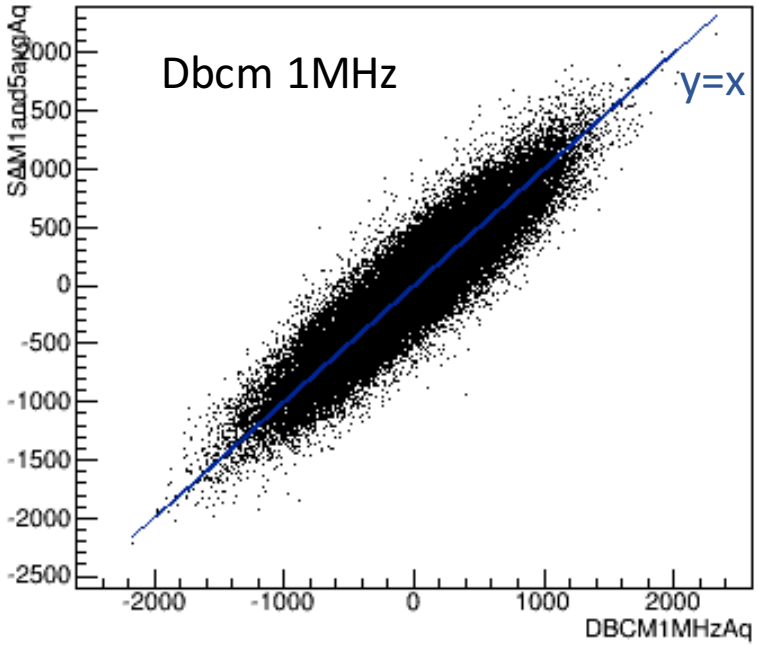


Downstream BCM – NEW

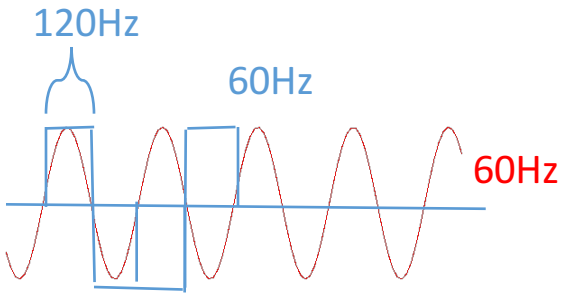
THIS is 60Hz sampling ONLY!

Get at 120Hz with blocks: 1/2((b1-b2)/sum+(b4-b3)/sum)

<SAM pair 1,5>



Downstream BCM – 1MHz



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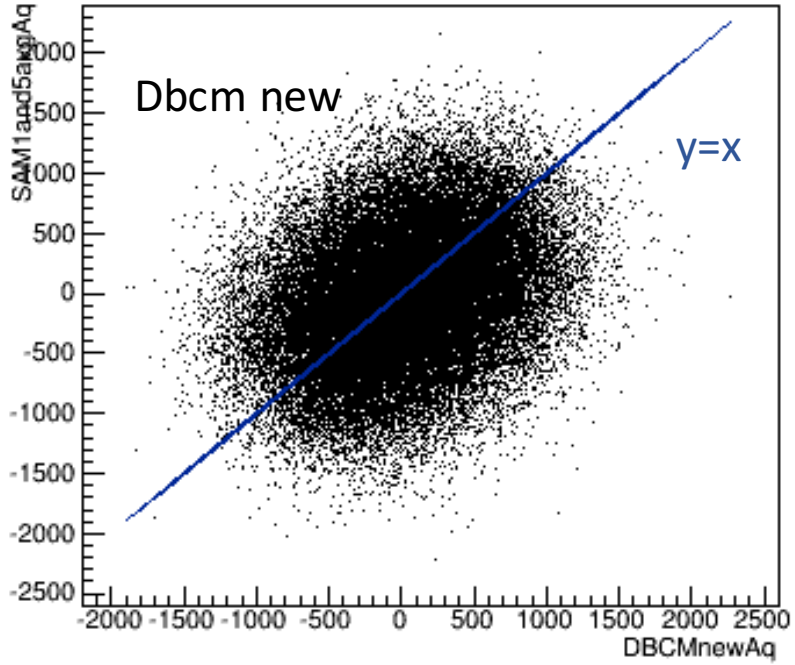
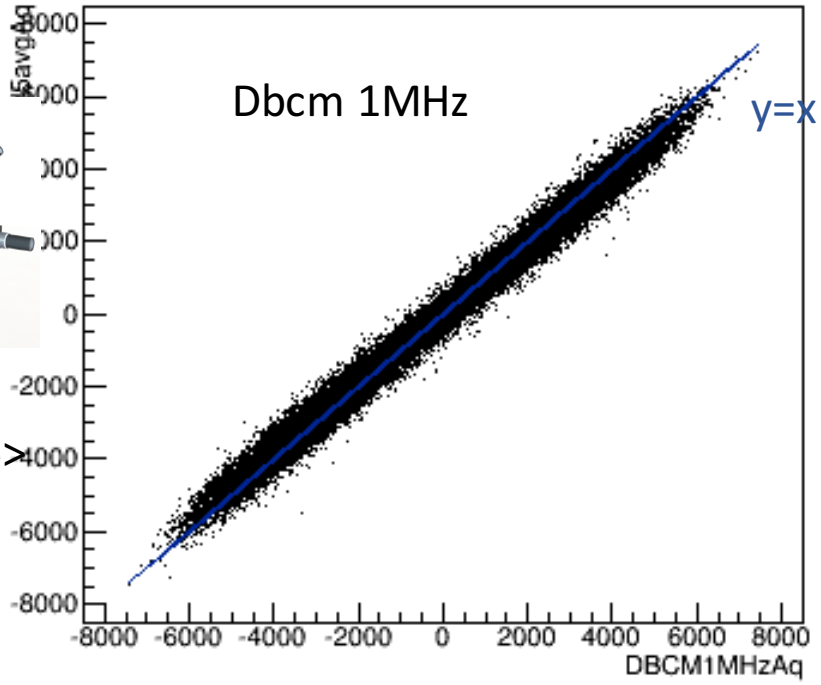


Downstream BCM – NEW

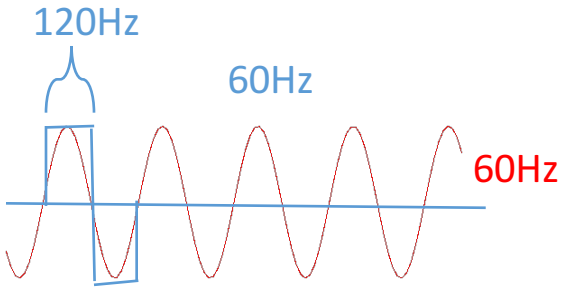
THIS is 120Hz sampling ONLY

What about 60Hz in the 120Hz : b1-b2

<SAM pair 1,5>



Downstream BCM – 1MHz



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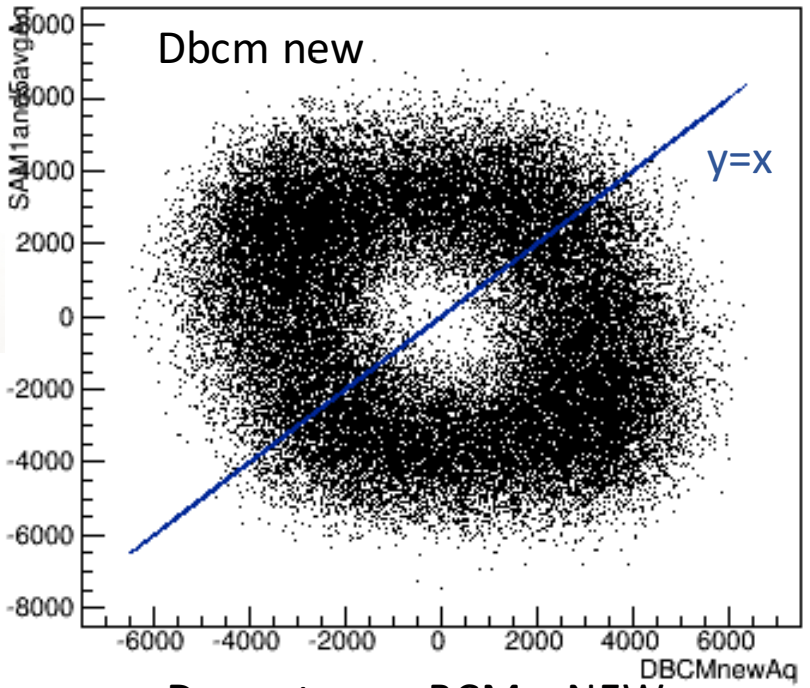
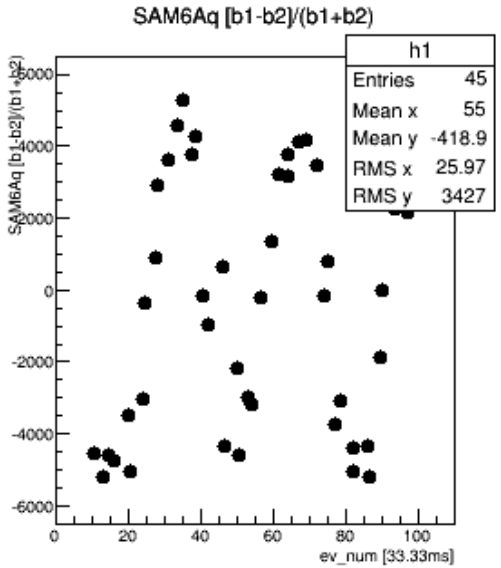
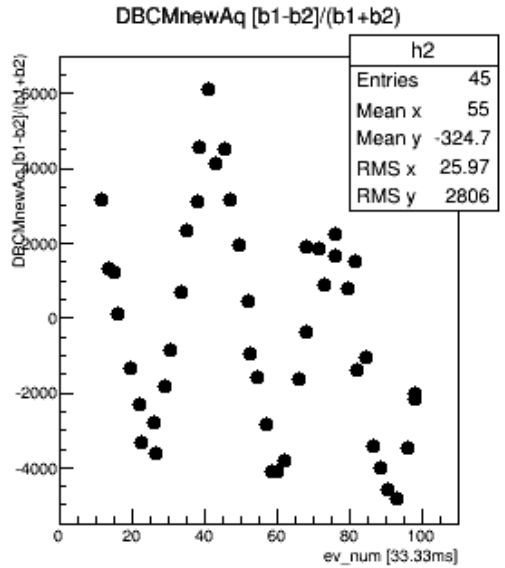


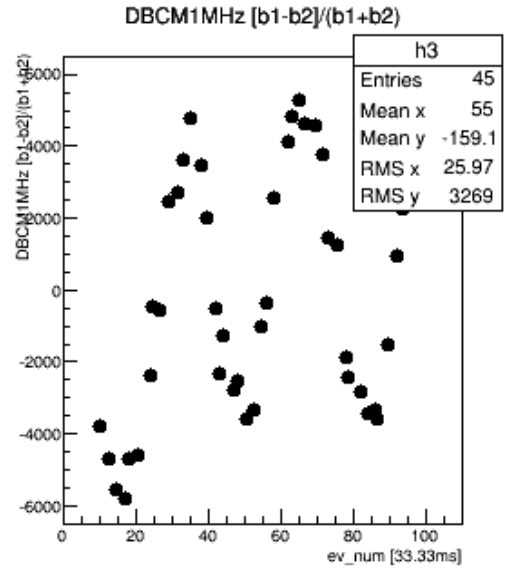
Downstream BCM – NEW

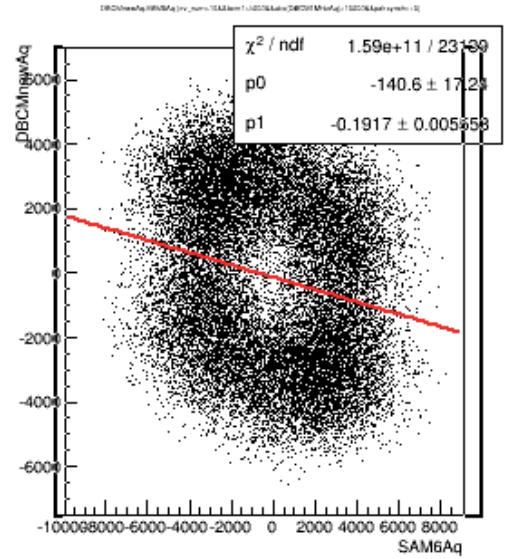
THIS is 120Hz sampling ONLY!

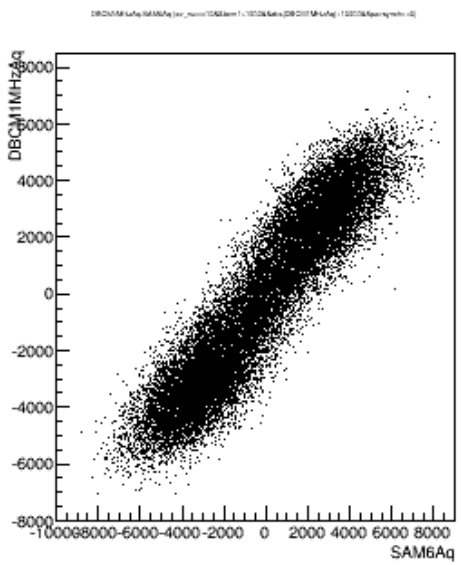
60Hz Charge Oscillation (5000ppm) in Beam - beat frequency observed - OUT OF PHASE in new Musson bcms

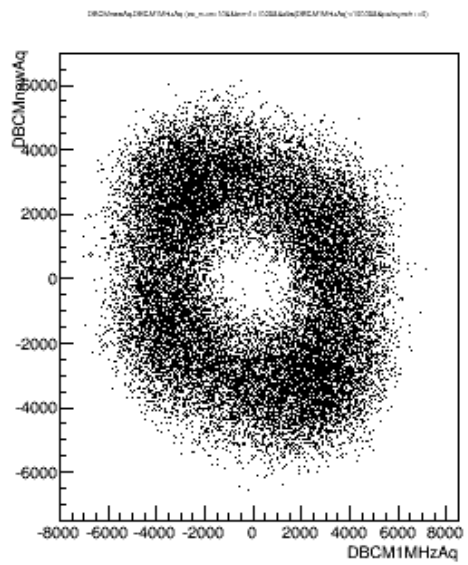


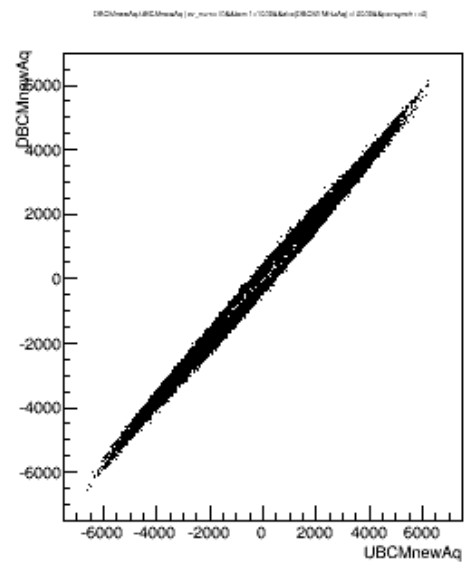


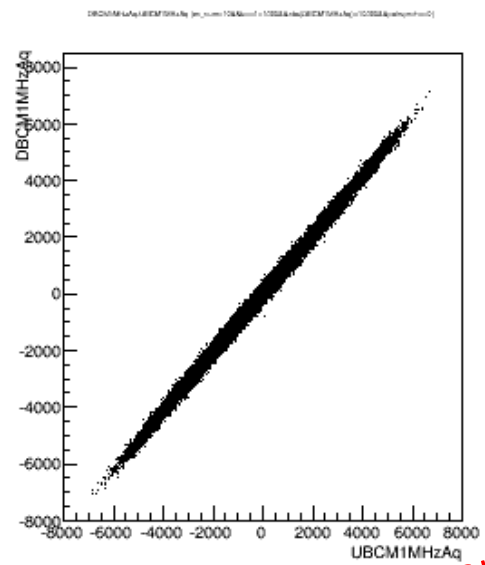








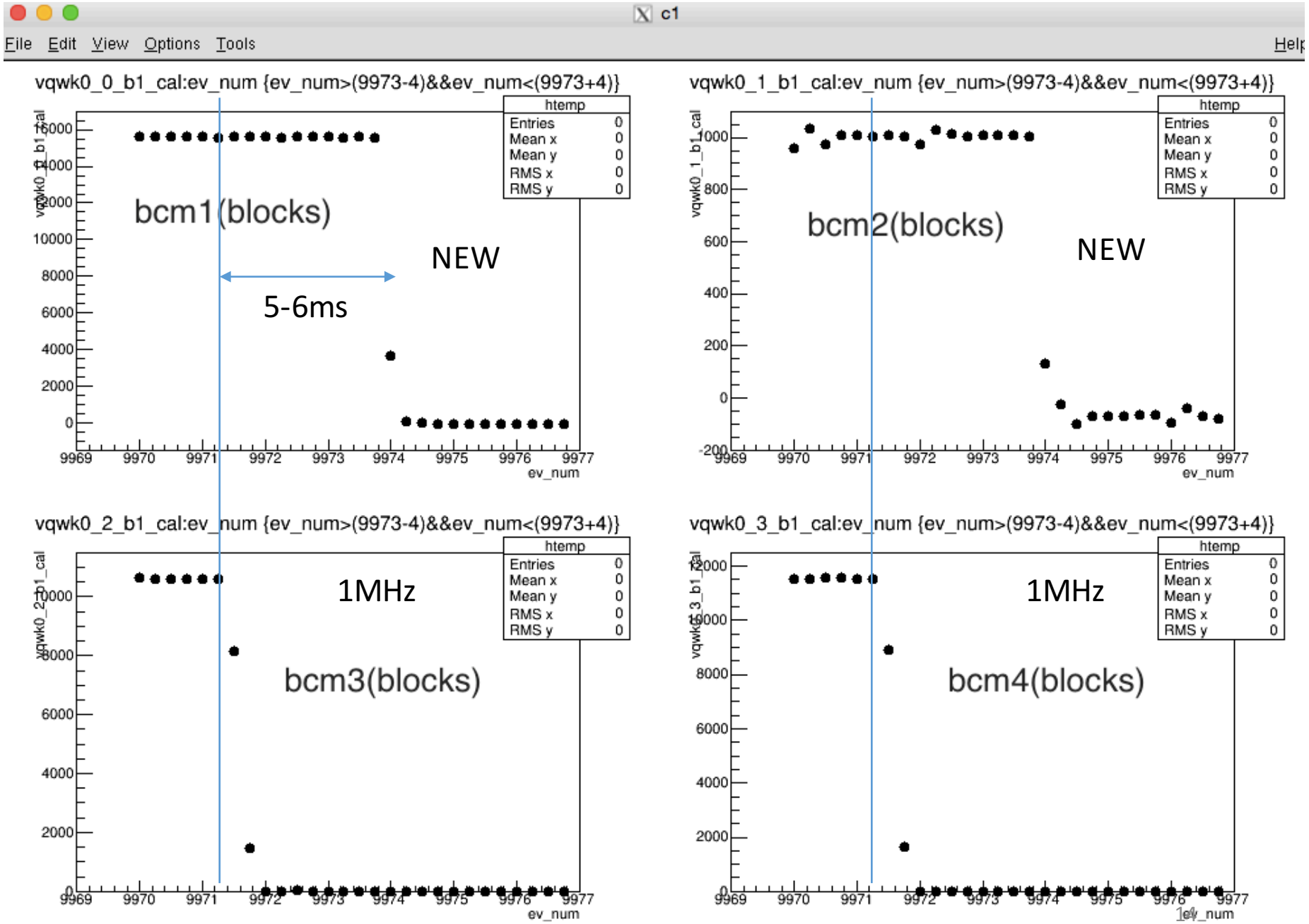




THIS is 120Hz sampling ONLY!

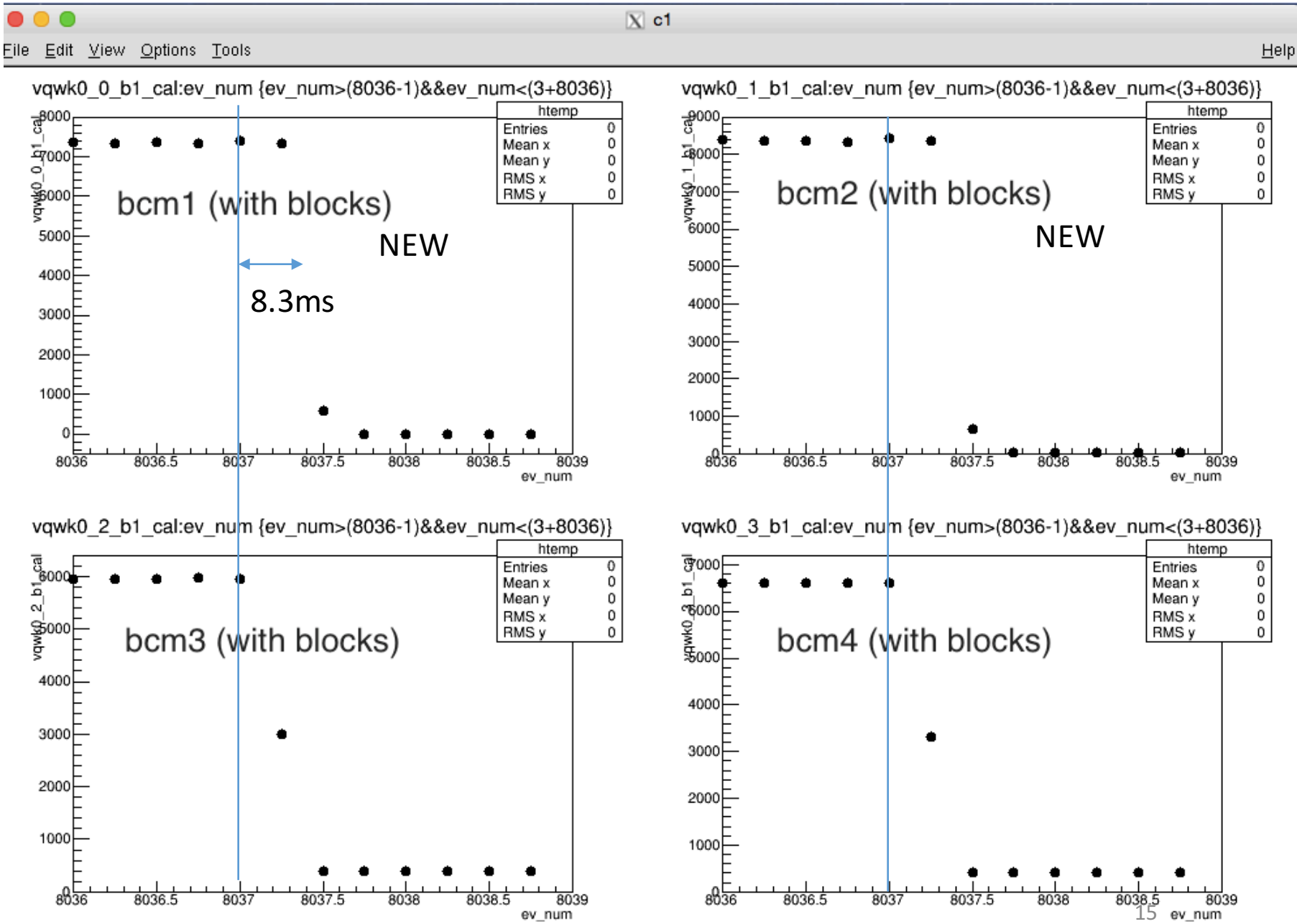
4-8ms delay?

- December run
- Beam Trip
- 480Hz
- Blocks 1.92kHz
- 5-6ms delay



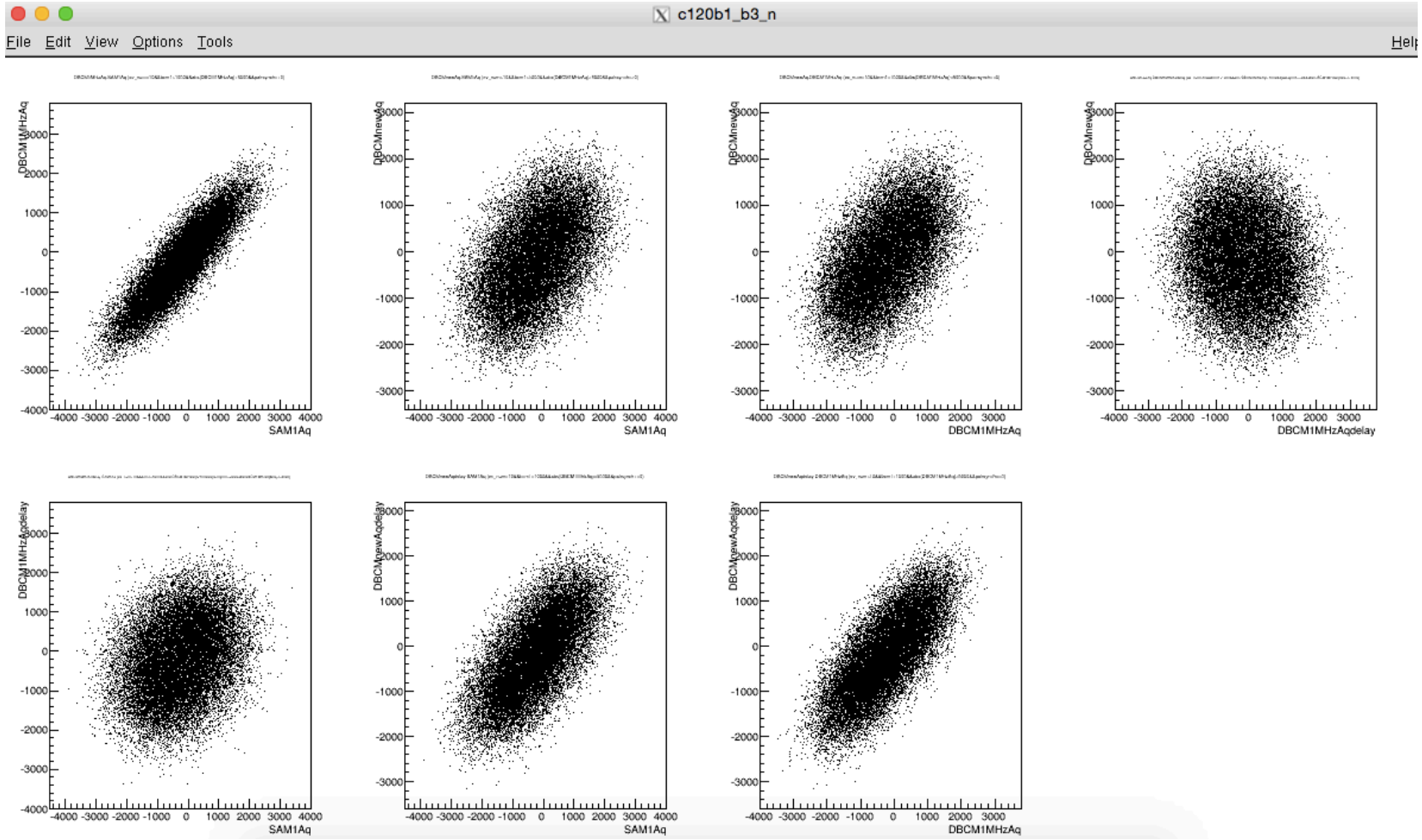
4-8ms delay?

- March run
- Beam Trip
- 30Hz
- Blocks 120Hz
- 8ms delay



4-8ms delay in New Musson bcms?

- Examine correlations
- Delay by 1 block – 8ms
- Correlations improve for new Mussons



Besides GIANT delay, what else can we say?

- As we up the frequency… things improve
- DD in 1MHz system beats sqrt(2) statistics from 1/2data-> as we increase rep rate, we are ‘winning’ in that the level of noise at 30Hz is more than at 60Hz, 120Hz
- SAM normalized widths (after factoring in sqrt(2) from ½ data), decrease with frequency – we are ‘winning’ at higher frequencies in terms of noise
- Doing blocks in such a way that we pickup 60Hz noise, gives HUGE widths – great for regression

Which BCM is least noisy – 30Hz,60Hz,120Hz? The 1MHz system

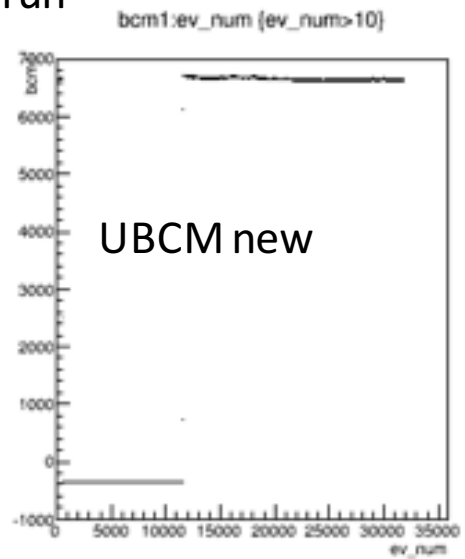
		b1+b2-b4-b3/sum	b1-b2+b4-b3/sum	1/2((b1-b2)/sum+(b4-b3)/sum)	b1-b2/sum
	30Hz	60Hz combo	120Hz combo	120Hz combo	120Hzcombo
(<SAMpair15>-<SAMpair37>) RMS	160.9	211.4	206.5	206.5	298.0
(SAMpair15combo-dbcmnew) RMS	**306.9**	**631.8**	**636.8**	636.9	4319.0
(SAMpair15combo-dbcm1MHz) RMS	**191.3**	**251.8**	**224.8**	224.8	342.7
dbcmnew-dbcm1MHz RMS	**255.5**	**611.1**	**619.7**	619.8	4436.0
dbcmnew RMS	584.8	719.0	514.8	514.9	2695.0
dbcm1MHz RMS	576.4	774.3	548.8	548.9	3013.0
(<SAMpair15>-<SAMpair37>) Mean and RMS PS[0]=0	145.0	211.1	205.7	205.6	297.4
ubcm1MHz -dbcm1MHz Mean and RMS	75.0	93.5	85.6	85.6	206.8
sqrt((SAMpair15combo-dbcmnew)^2-(SAMpair15combo-dbcm1MHz) ^2)	**240.0**	**579.5**	**595.8**	595.9	4305.4

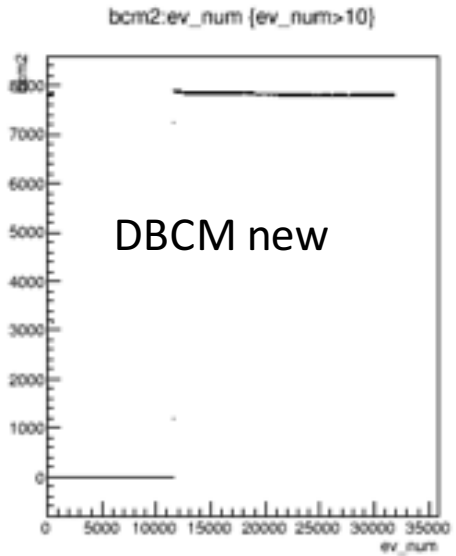
Why? Not because of higher frequency noise, but because bcms have a GIANT DELAY

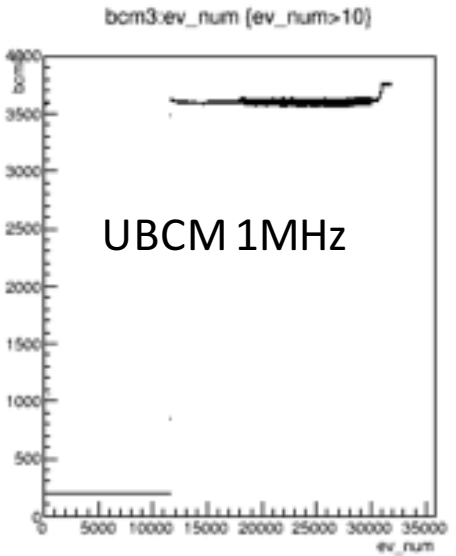
- Quantitative - examine Asam - Aq(different bcms) RMS - see that 1MHz system gives smaller widths than new Musson receivers(when working)
- Double check- compare asymmetry double difference between 1MHz and new Musson bcms with quadrature difference of SAM asymmetries normalized wrt 1MHz and new Mussons. See that the numbers are close meaning that most of the width comes from the new musson receiver compared with the old.

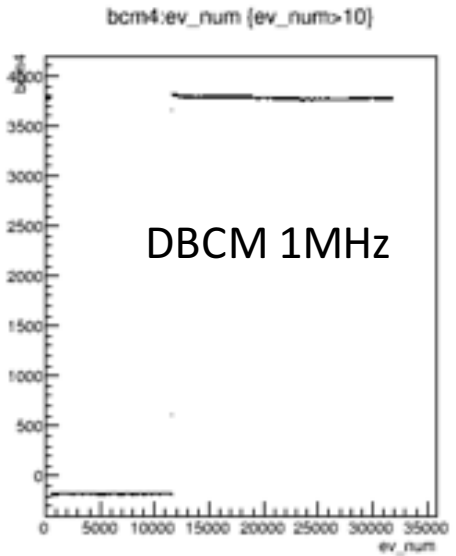
Be aware - Intermittent 1MHz bcm system hiccup

Feb 25 run

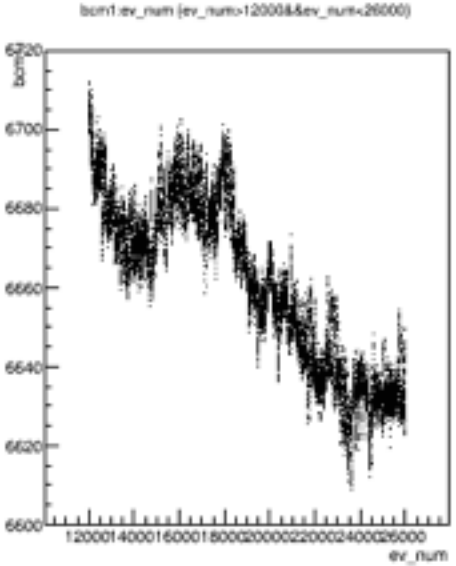


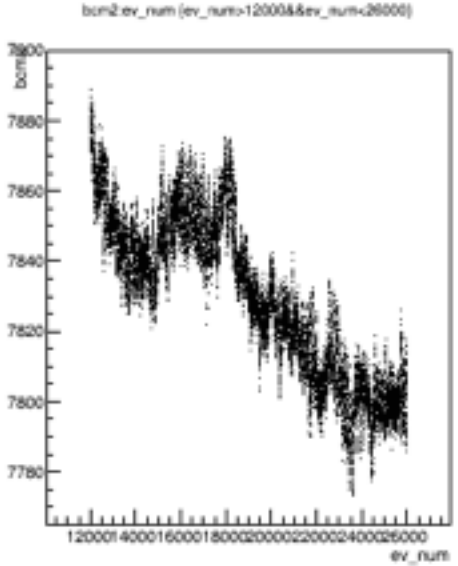


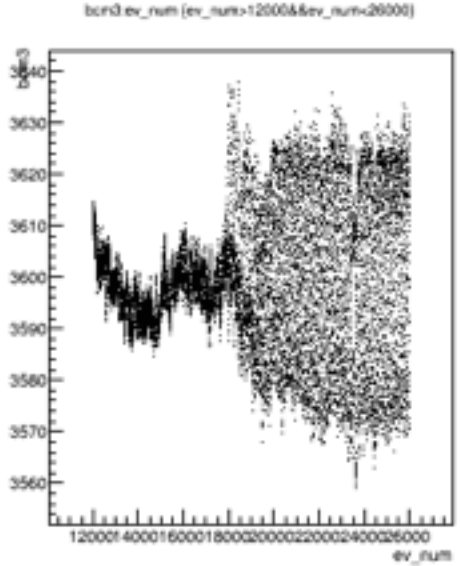


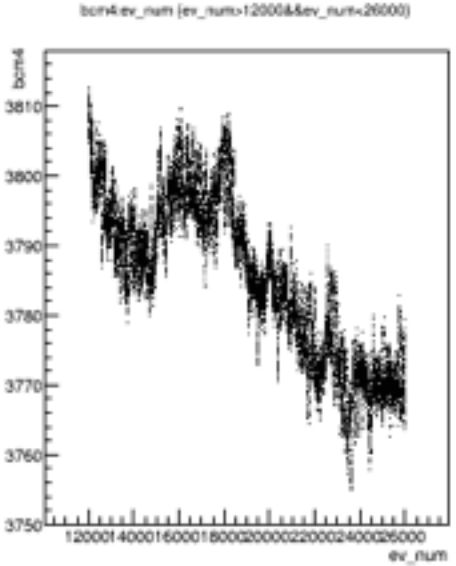


time



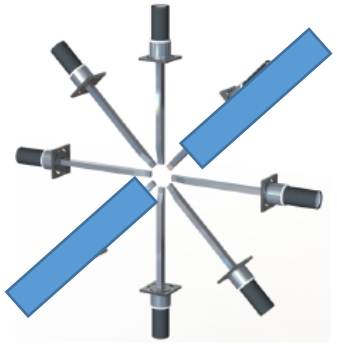






time

SAMs – Asymmetry widths scaling with E



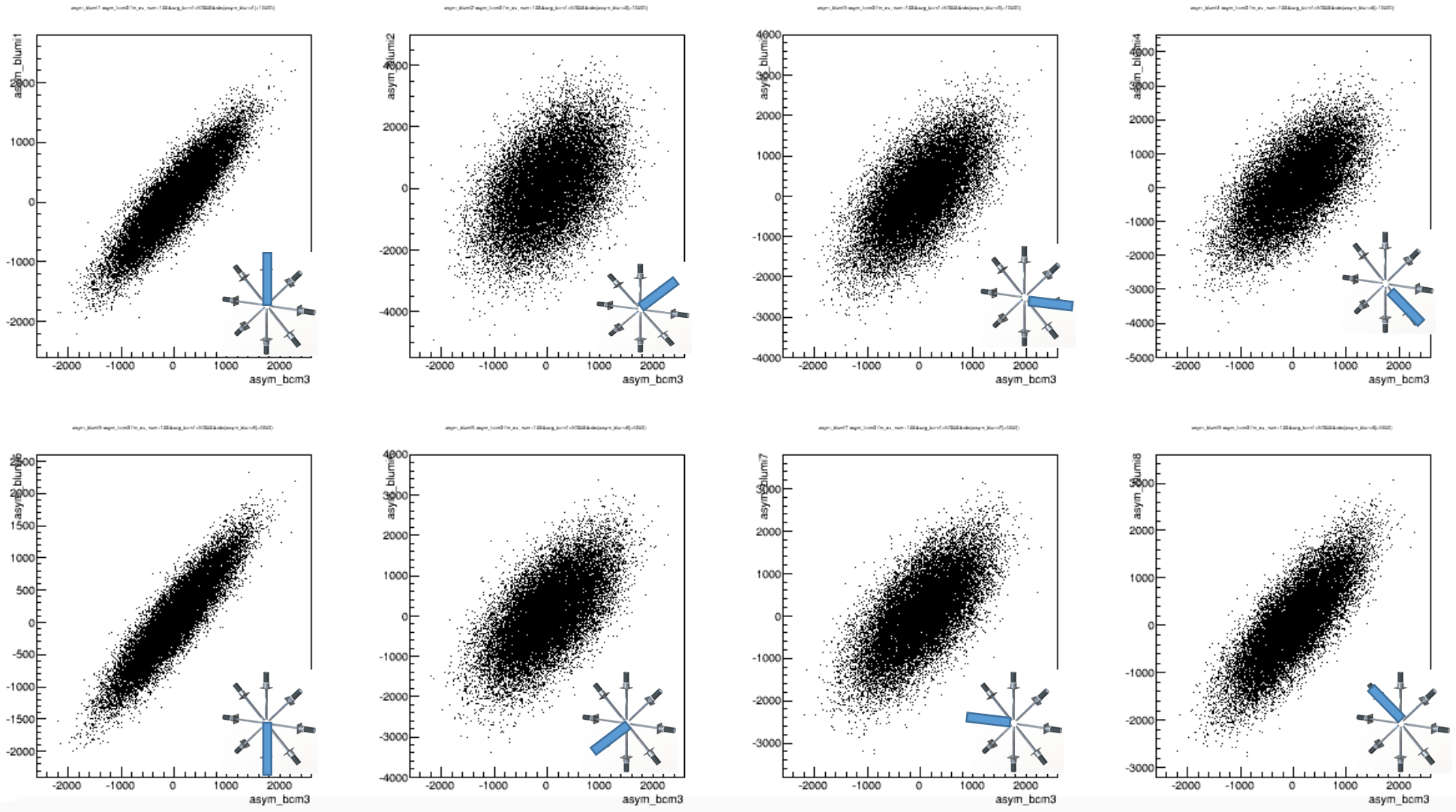
- Analyze rates and widths
- 2 SAMs have **unity gain tubes – can estimate rates from them** (assuming 5pe's per hit)
- Examine SAM pairs and correlations with bcm, bpms, and with each other
- Calculate the rate with unity gain sams current– assuming 5pe's/count
- Estimate counting statistics for SAMs from unity gain tubes
- Try to understand asymmetry widths and scaling with energy, current, frequency
- Have data for LH2 target at 2.2GeV, 4.4GeV, 8.8GeV 10-20uA

RESULTS

- Measured widths are narrower than predicted widths
- Gap between predicted and measured closes with higher energy
- Gap between predicted and measured closes with lower current
- We think this may partly be because of target boiling
- Noisier beam would be better for regression
- Using vqwk blocks in such a way that we pickup 60Hz noise in beam oscillation, gives HUGE widths – great for regression

Run2333, 12uA, 15cm LH2 HV 1/5=-650V,2/6=-75V,3/7=-800V,4/8=-500V

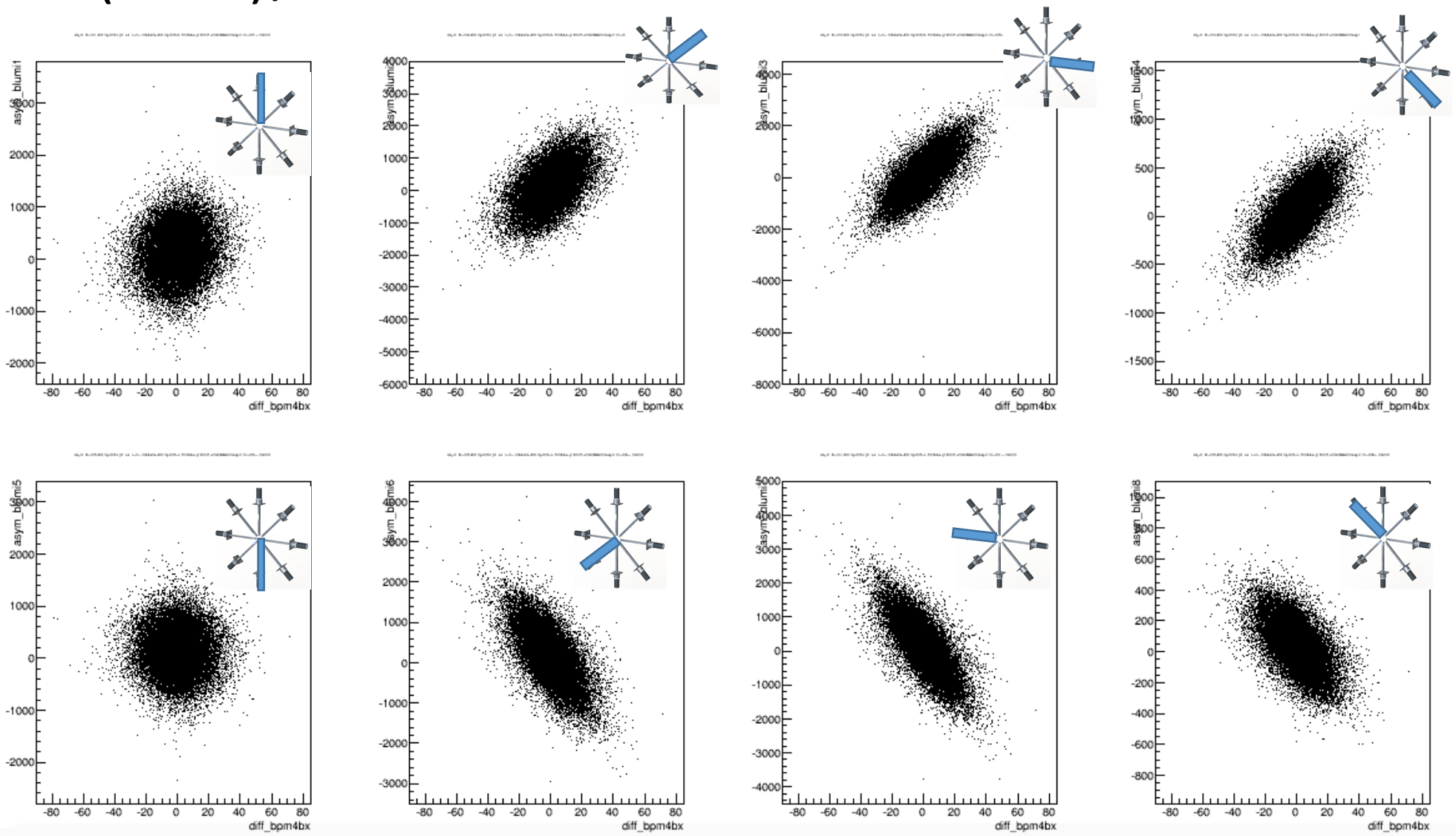
SAMs & Upsteam BCM 1MHz correlations



NORMALIZE SAMS TO A BCM TO ELIMINATE BCM CORRELLATED NOISE

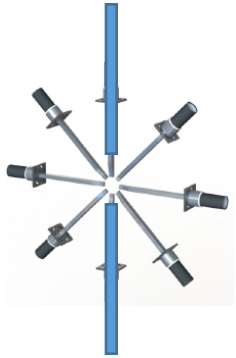
Run2349, 20uA, low E, 15cm LH2 HV 1/5=-600V,2/6=-75V,3/7=-700V,4/8=-500V

BPM(4eX)/SAM correlations

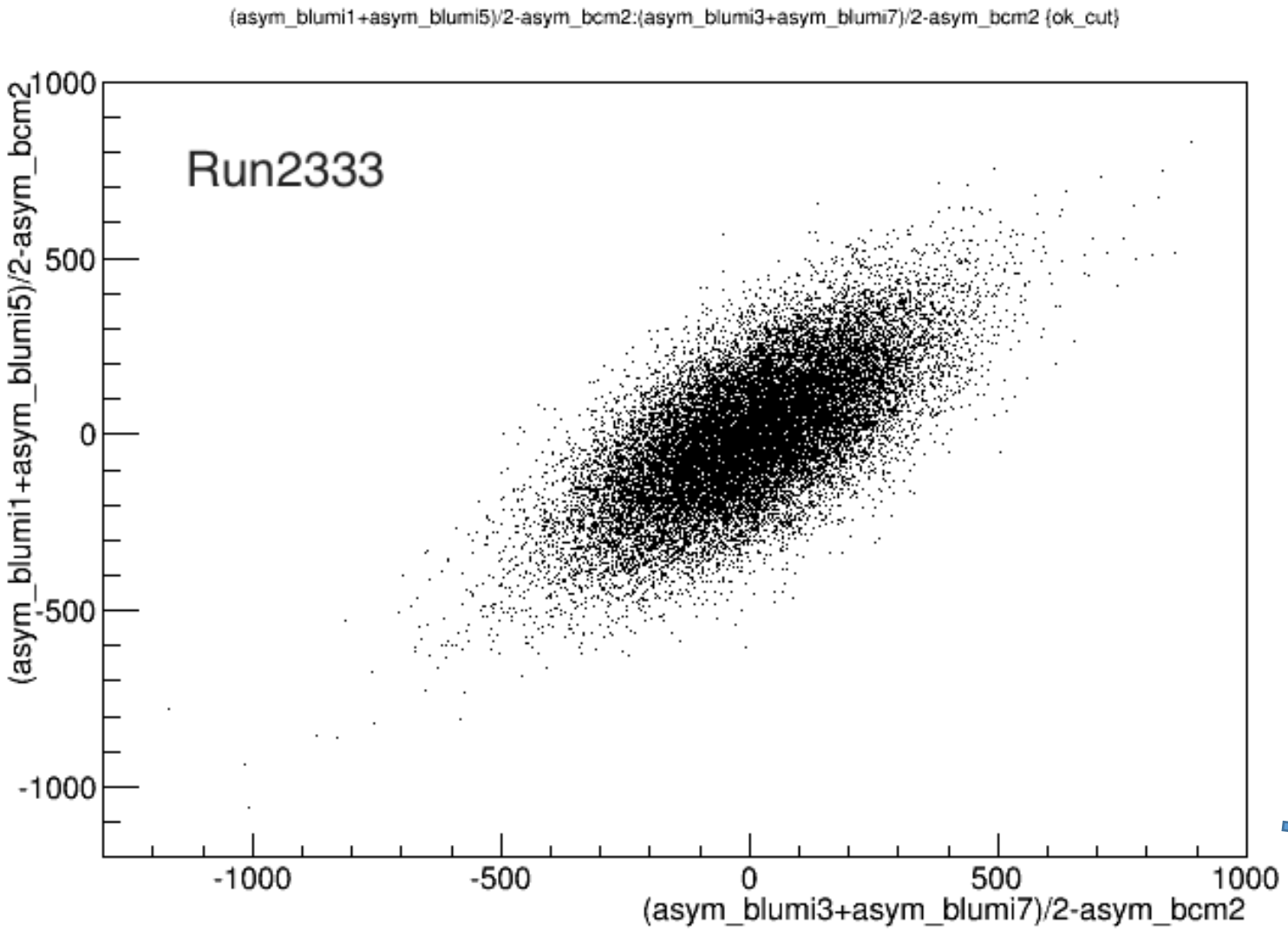


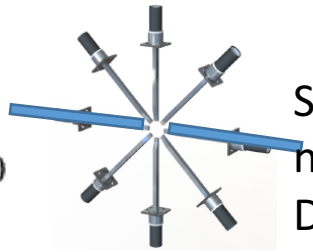
TAKE COMBINATIONS OF SAM PAIRS TO ELIMINATE BPM CORRELLATED NOISE

Additional Common Mode Noise – i.e. Target Boiling



SAM pair 1,5 normalized to DBCM(1MHz 1x)

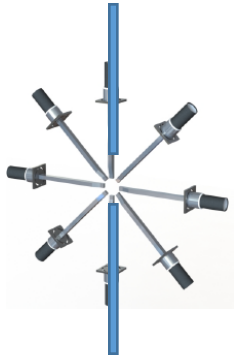




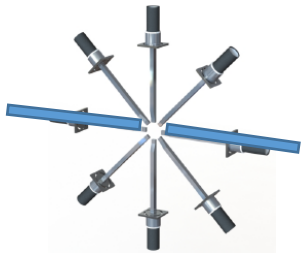
SAM pair 3,7 normalized to DBCM(1MHz 1x)

Eliminate common mode noise between SAM pairs by taking pair DIFFERENCE

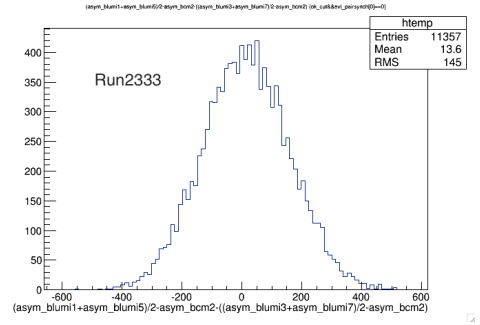
Run2333- 4.4GeV, 12uA HV1/5=-650V,HV2/6=-75V,HV3/7=-800V,HV4/8=-500V



SAM pair 1,5
normalized to
DBCM(1MHz 1x)

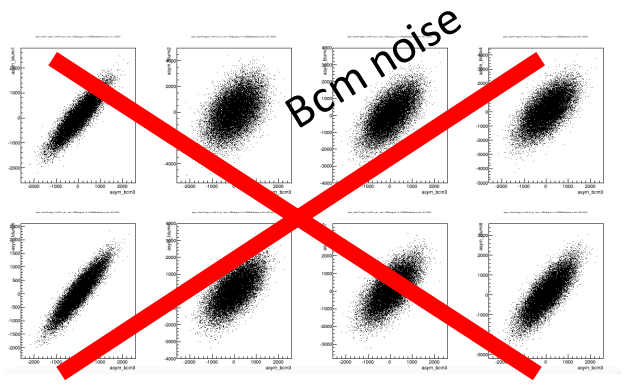


SAM pair 3,7
normalized to
DBCM(1MHz 1x)

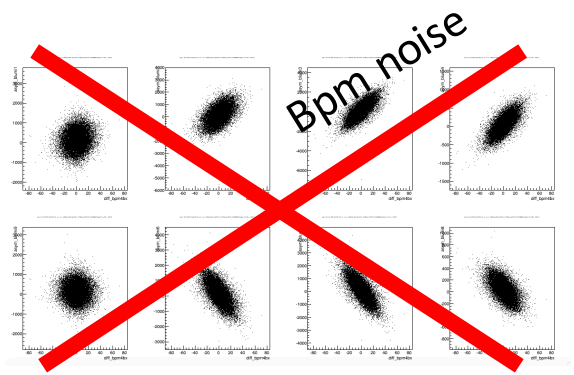


Asymmetry Width
w/o common mode noise (target boiling)
w/o beam position/angle noise
w/o beam current noise

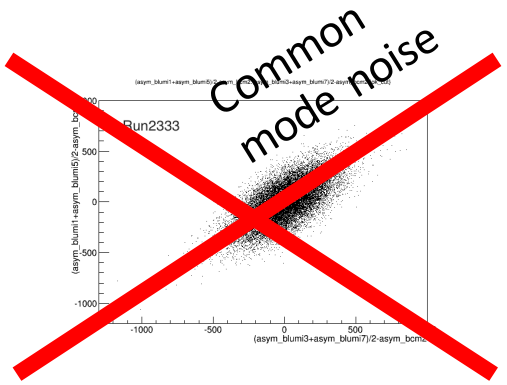
Normalize SAMs to BCM



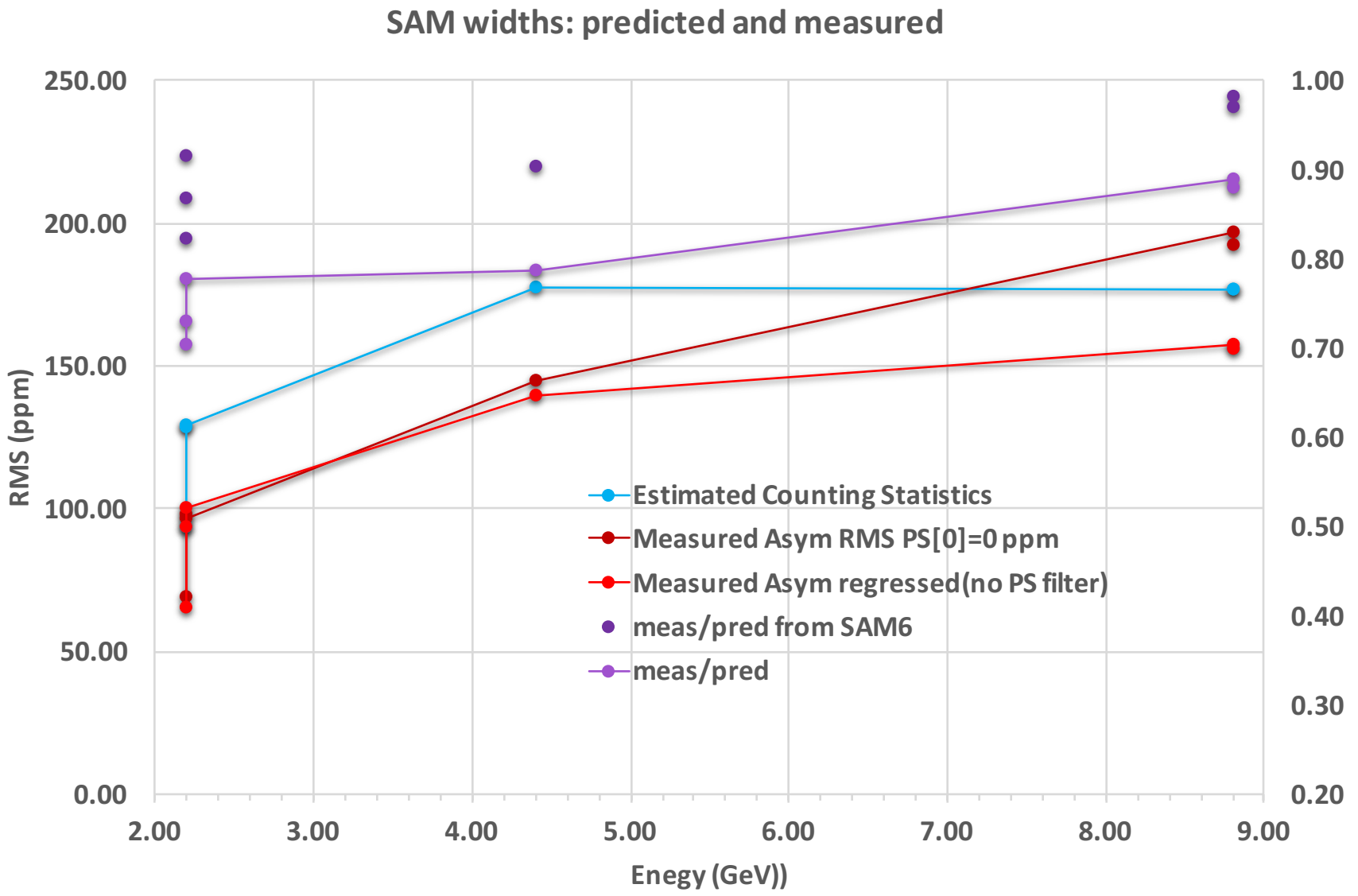
Combine SAM pairs



Take SAM pair differences



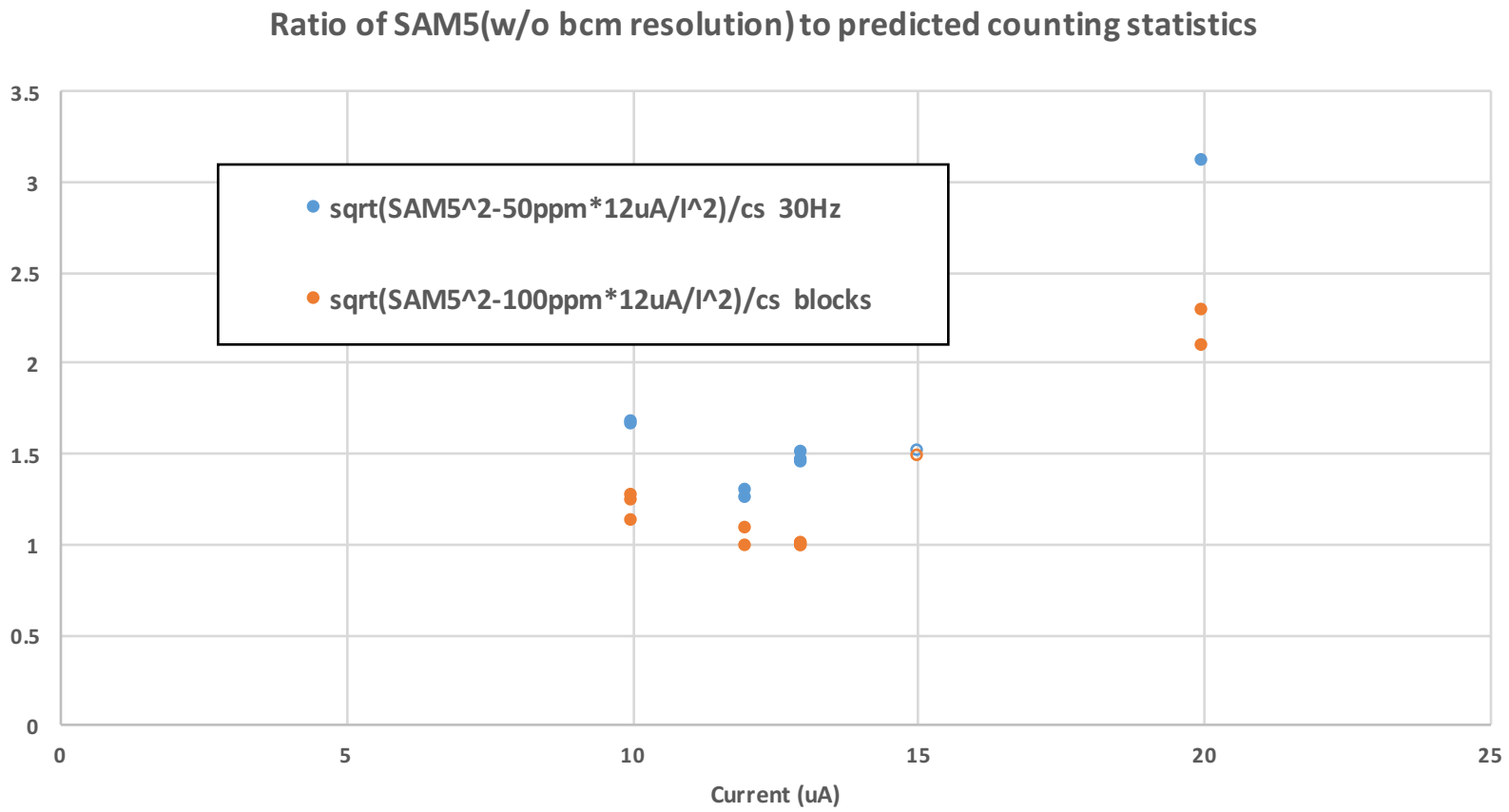
Summary of SAM widths



If do regression (with new Musson ubcm)…

Run	Current uA	Energy GeV	Est. SAM pair diff	from SAM2	from SAM6	Measured Asym RMS PS[0]=0 ppm	Measured Asym regressed(no PS filter)	meas/pred	from SAM2	*from SAM6*
2349	20	2.2	93.48	117.89	79.82	68.91	65.74	0.703	0.557	0.823
2356	10	2.2	128.24	166.92	108.01	98.29	93.74	0.7309	0.561	0.867
2356b	10	2.2	129.04	165.01	109.51	96.53	*100.3*	0.777	0.607	0.915
2333	12	4.4	177.36	214.56	154.57	145	139.5	0.786	0.6501	0.902
2358	13	8.8	176.76	199.55	160.34	196.7	157.3	0.889	0.788	0.981
2359	13	8.8	176.88	199.55	160.51	192.7	155.8	0.880	0.780	0.970

Regressed widths – evidence for target boiling

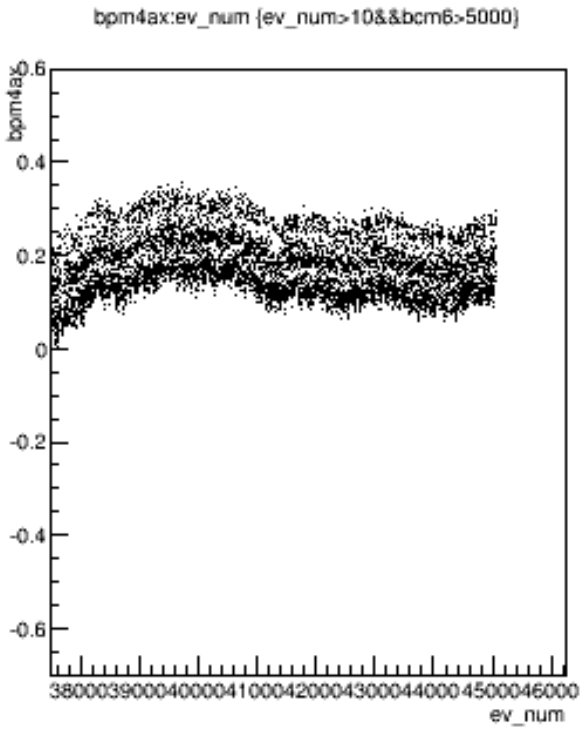


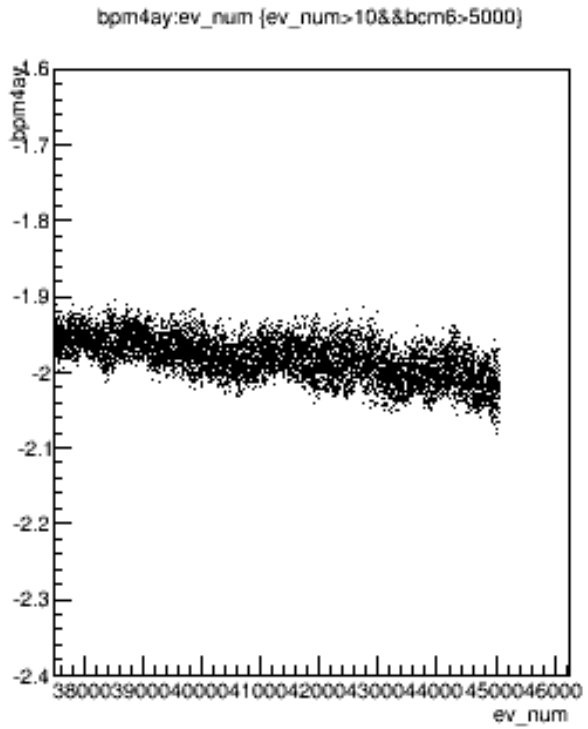
- Gap between predicted and measured closes with lower current, higher frequency – subject to effectiveness of regression

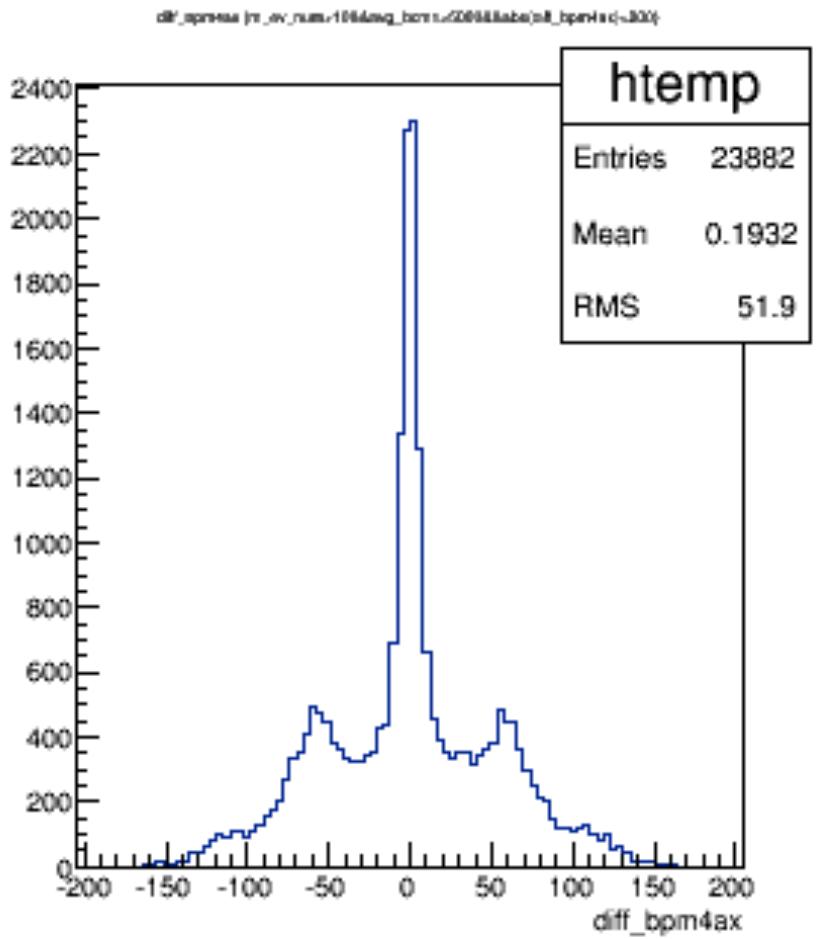
BPMS

- BPM 4a has a problem – it appears in difference measurements at 30Hz
- Injector BPM 0I07 has the same problem
- It may be that this is not a problem at higher frequencies – would need to flip at higher rate with beam on to confirm
- the behavior in 4a appears to stem from 4axp and 4axm wire channels jumping up and down
- Hard to study because - Injecting noise for beam off does not perfectly mimic nature of noise when beam is on.

BPMs – 4a multiple levels

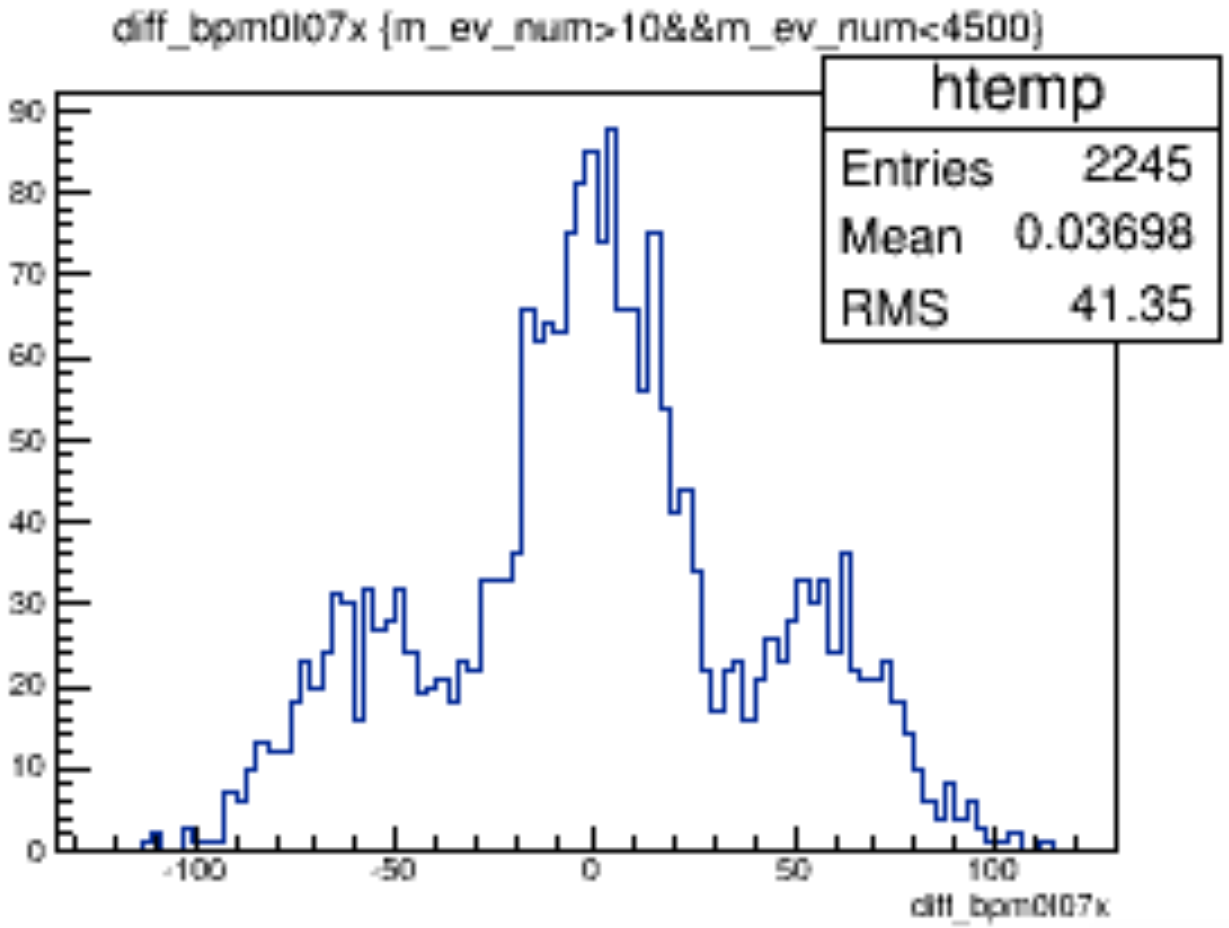


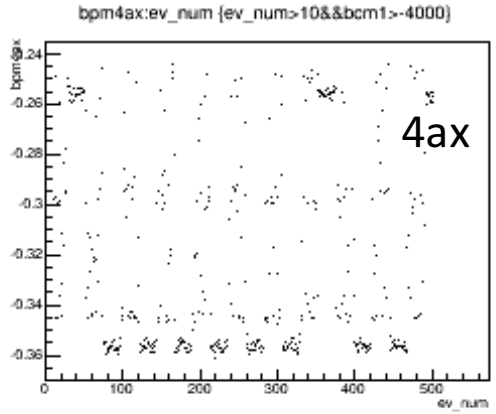




Study by injecting cavity oscillations
https://ace.phys.virginia.edu:80/HAPPEX/160325_105247/Run2411Screen_Shot_2016-03-24_at_4.22.21_PM.png

BPMS – effect also observed in injector bpm

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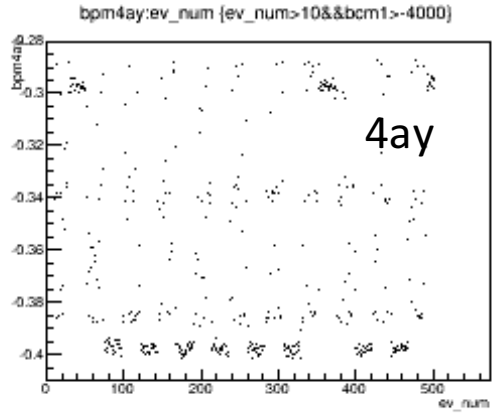
4ax
ev_num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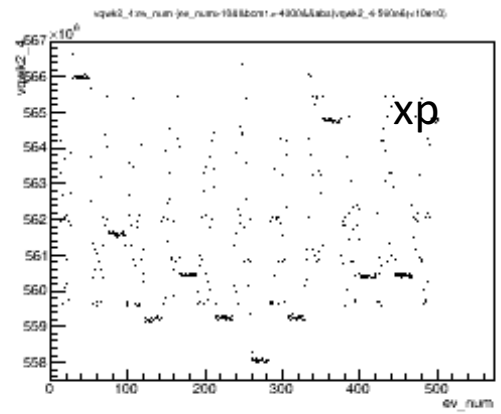
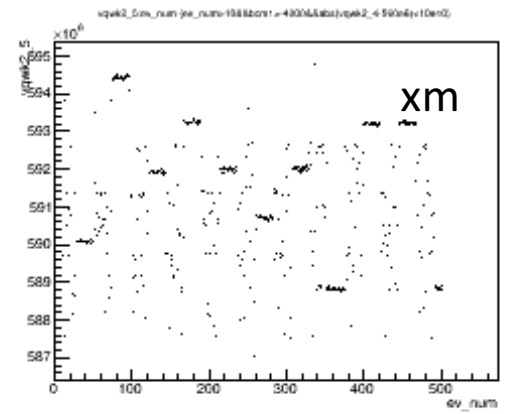
4ay
ev_num


xp
ev_num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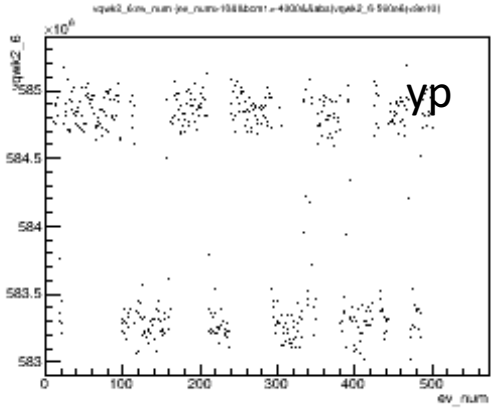
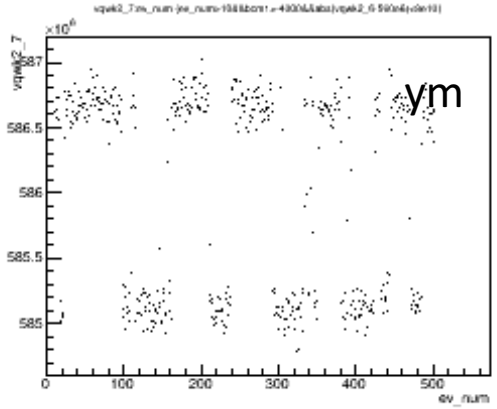

yp
ev_num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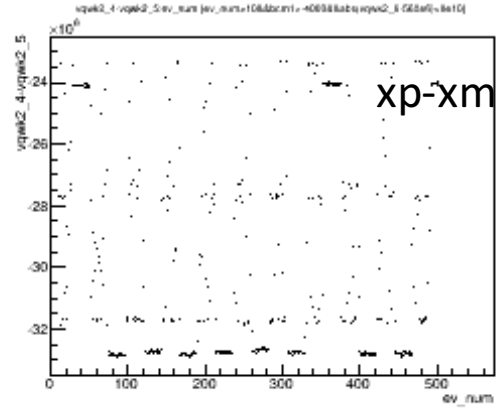
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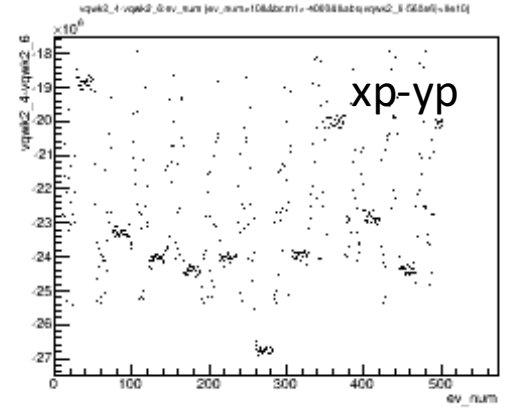
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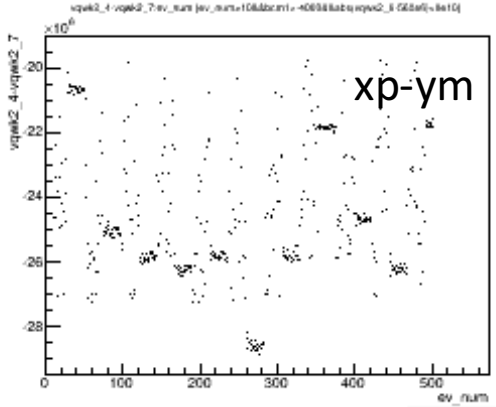
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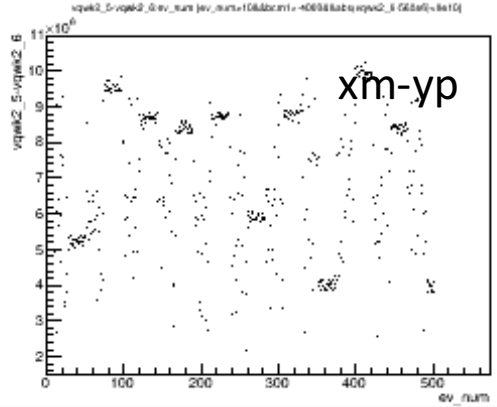
ev_num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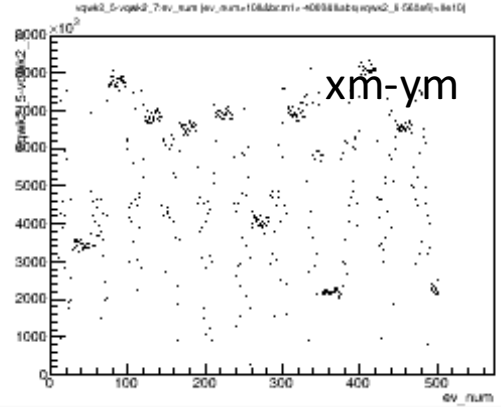
ev_num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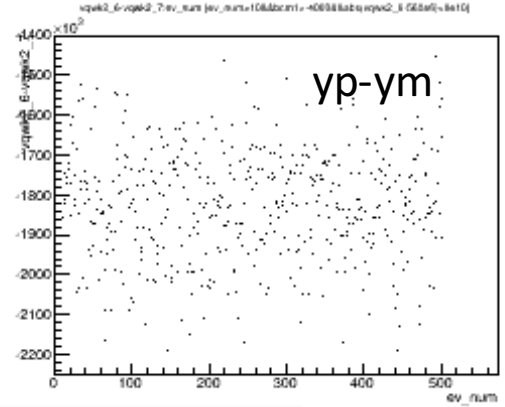
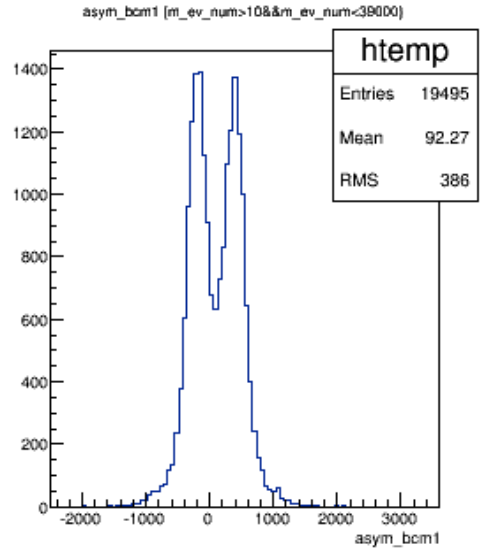
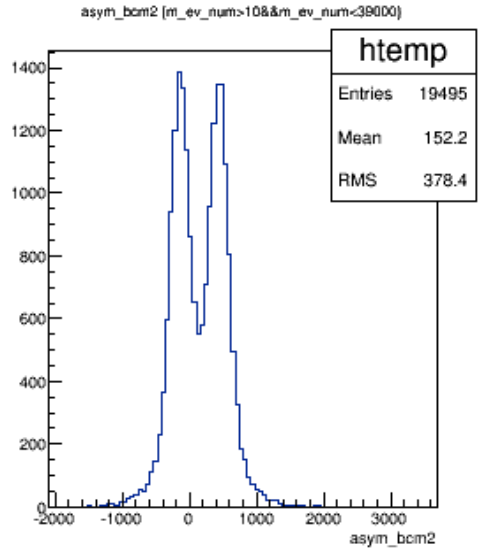

yp-ym
ev_num

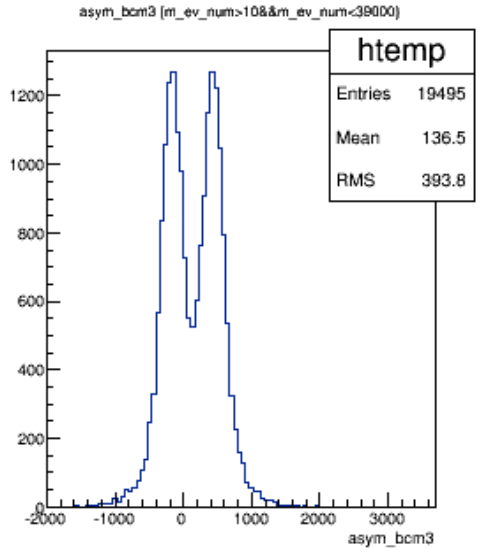
Pairsynch Pickup

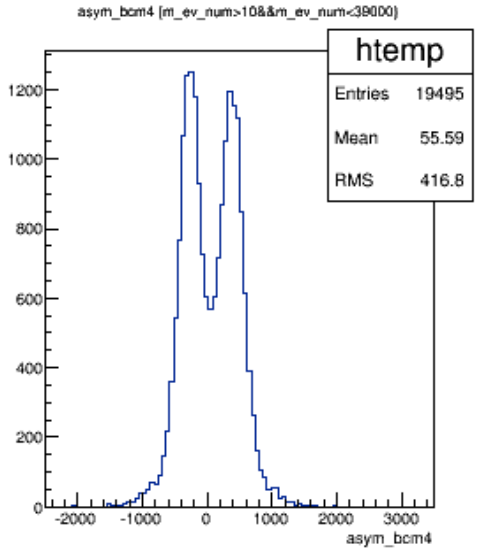
- Had helicity pickup issues in the RHRS in Decemeber, had to unplug helicity altogether from channels in our RHRS daq
- Have 100-ppm level PS pickup in bcms and SAMs

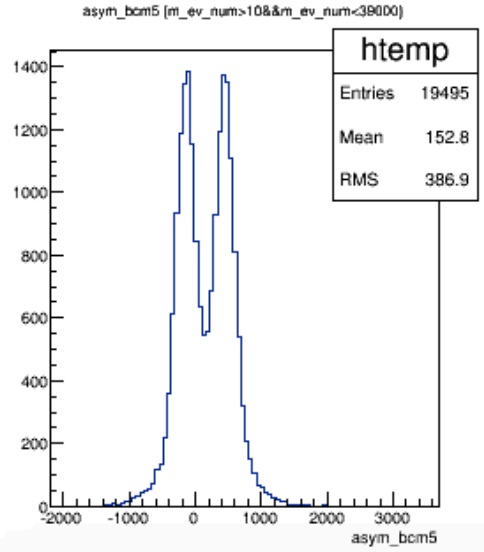
BCM asymmetries – PS pickup(100-200ppm) Run2349, 20uA

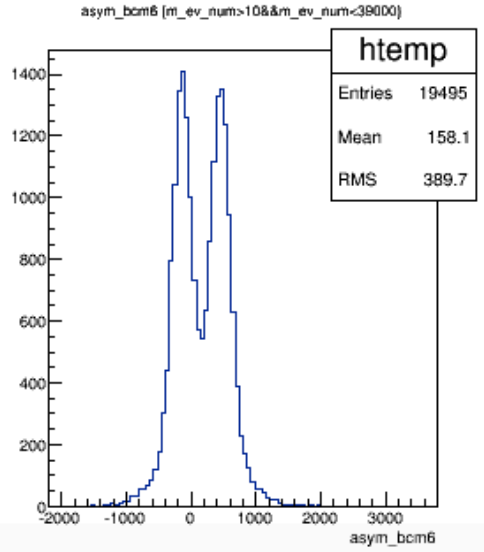


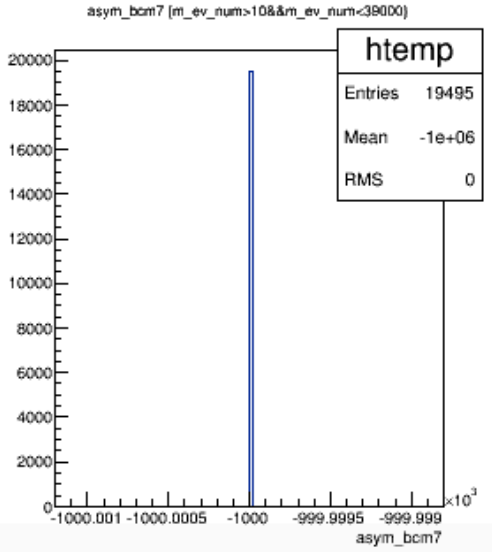












Pair Synch pickup – why/how help?

- 100ppm of PS pickup is a lot and we have to cut on PS to make sense of data
- Furthermore…..
- If we have PS pickup from electronics – we could have Helicity pickup
- If we have 100ppm of PS pickup – we could have 100ppm of Helicity pickup
- THERE SHOULD NOT EXIST THE POSSIBILITY OF HELICITY PICKUP IN PARITY EXPERIMENTS – but logical signals go everywhere
- Logical signals – Hel,QRT, PS, should be shorter than Tsettle and not bleed into Tstable….could do this during summer

So, what are the beam characteristics?

- 20uA, 2.2GeV

	dbcm 1x	ubcm 1MHz	dbcm 3x	dbcm 10x
	bcm2	bcm3	bcm5	bcm6
Aq(ppm)	153	137	153	158
Aq(ppm) PS[0]=0	-135	-165	-142	-138
Aq(ppm) PS[0]=1	440	438	448	454
Aq RMS(ppm)	378	394	387	390
Aq RMS(ppm) PS[0]=0	245	253	249	252
Aq RMS(ppm) PS[0]=1	247	254	252	255
mean (ch)	8220	7133	2.75E+04	7.99E+04

	bpm4ax	bpm4ay	bpm4bx	bpm4by	bpm8x	bpm8y	bpm12x	bpm12y
diff_bpm	0.2	0.2	-0.05	0.03	0.1	-0.06	0.08	-0.03
diff_bpm RMS	52	45	12	9	14	8	8	8

Summary

- New Musson bcms large 4-8ms delay
- SAMs – seem ok- We can estimate rates from unity gain SAMs and analyze how observed widths relate to counting statistics for different beam energies, currents, frequencies
- Use SAMs as independent measurement to establish how bcms working
- 1MHz intermittent hiccups
- Calibrated our bcms with scaler copy of Unser
- We have the injector daqs running , we have data collected with it, getting there
- Bpm4a issue – now also injector BPM0I07 issue - double level – solving…but ok
- Pair synch pickup issue – has to get fixed from logic signals - can get solved
- (Triplets not working – no signal – being commissioned)