Frequency analysis and digital filtering

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Outline

Analysis of December data

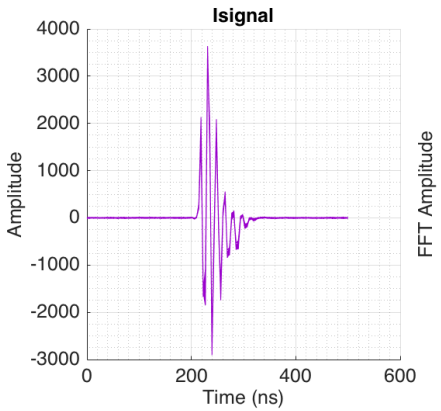
- Frequency analysis of the I and Q signals from the single port study on IPBY.
- Digitally filter waveforms to remove static signal – see if improves resolution.
- Integrate the FFT over the static signal region and look at mean and σ across a data set.

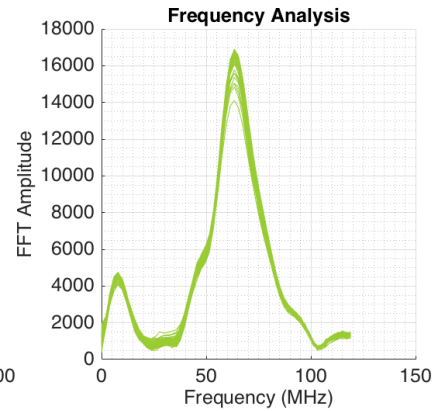
Frequency analysis of single port IPBY

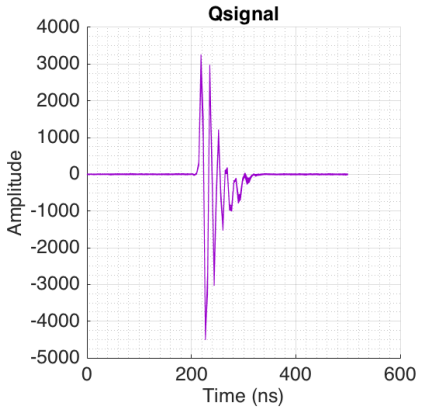
- Port 1 and 2 of IPBY through separate electronics.
- Charge: 0.32 x 10^{10}.
- Waist approximately on IPB.
- jitRun7_0dB_ipbpm_151209

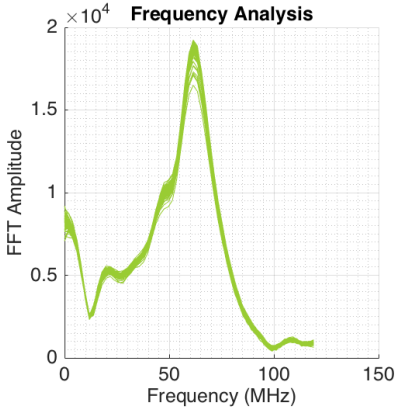
Different magnitudes and waveform shapes from two ports.

PORT 1 (electronics A)

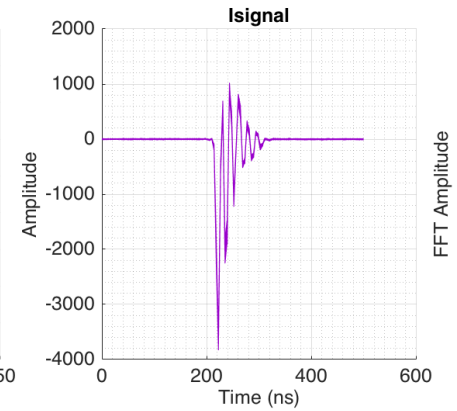


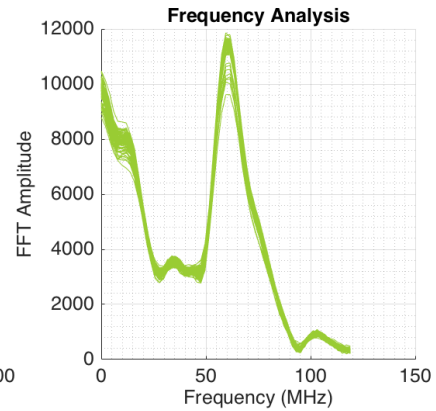


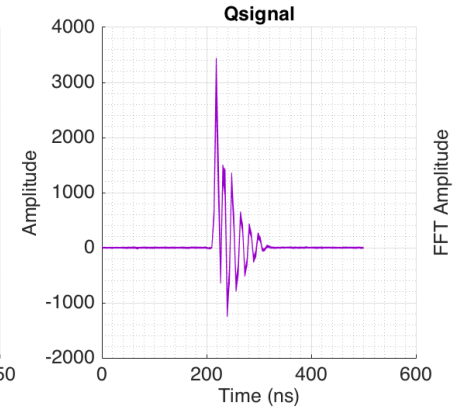


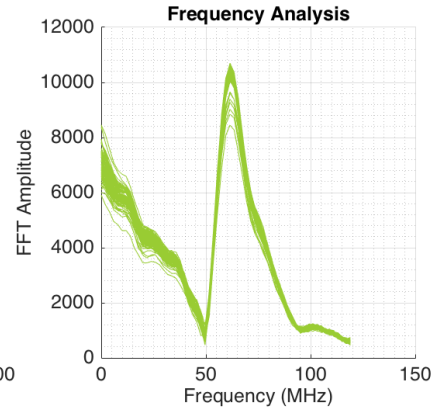


PORT 2 (electronics B)



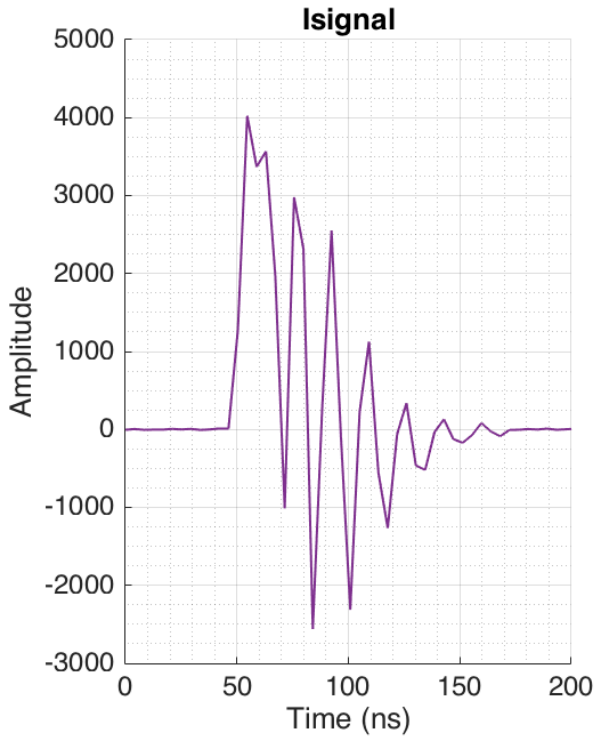


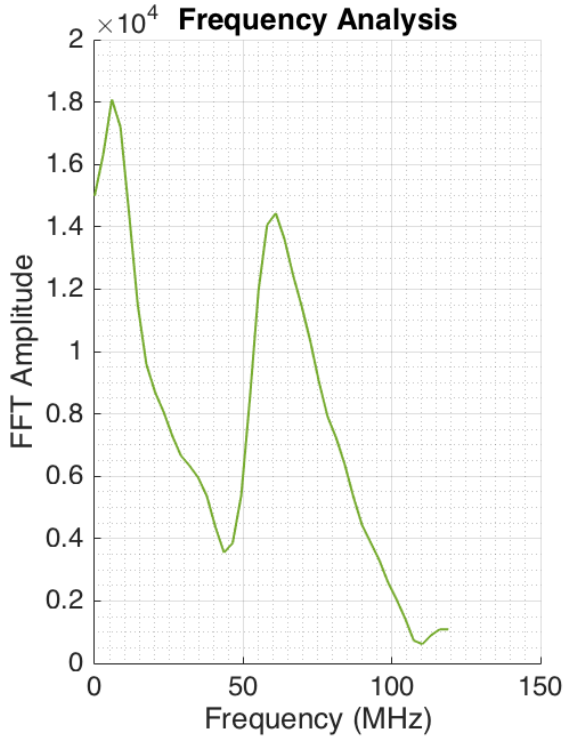


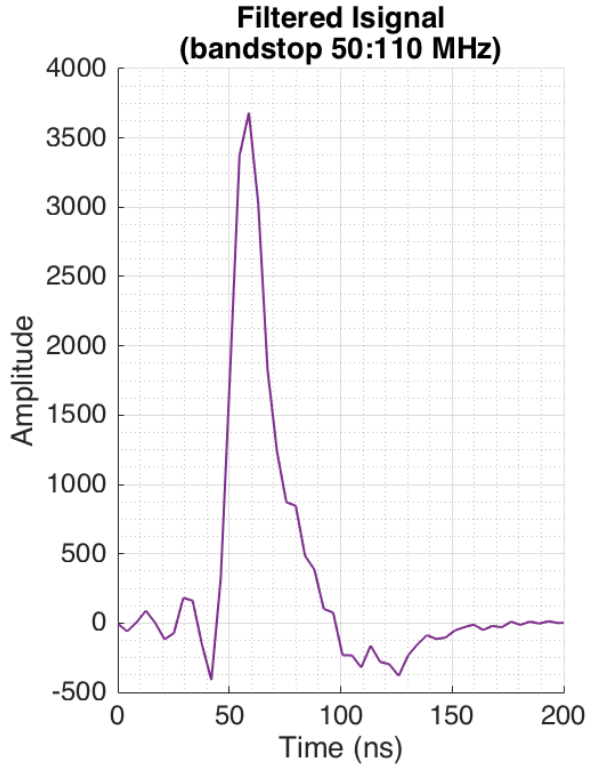


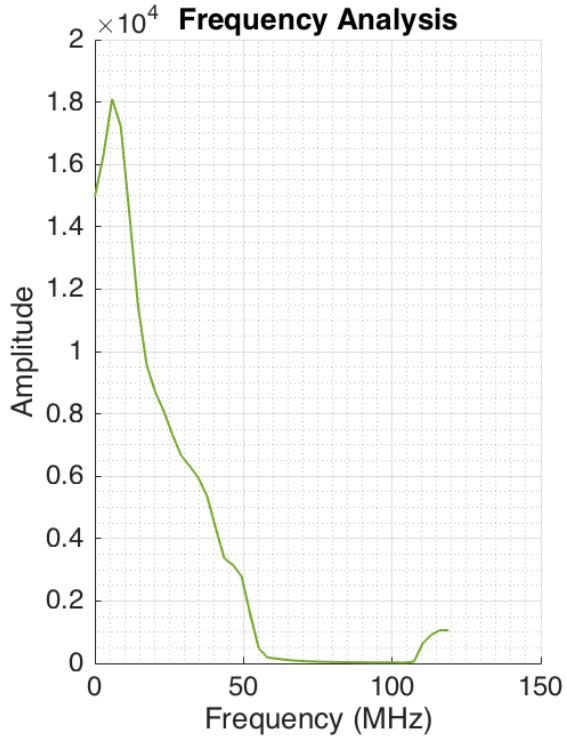
Digital filtering on static waveform

Filter IP BPM signal using a digital bandstop from 50 to 110 MHz to remove unwanted static signal.



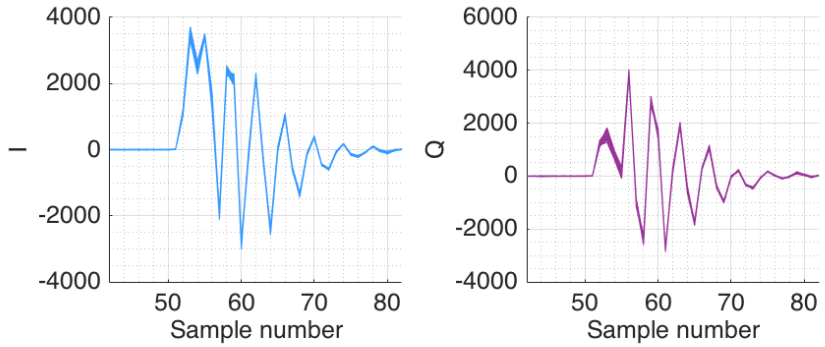






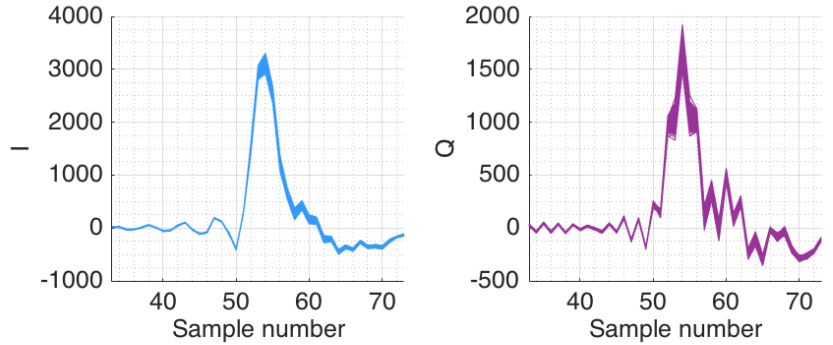
Example of digital filtering IPBY

jitRun1_0dB_ipbpm_150612

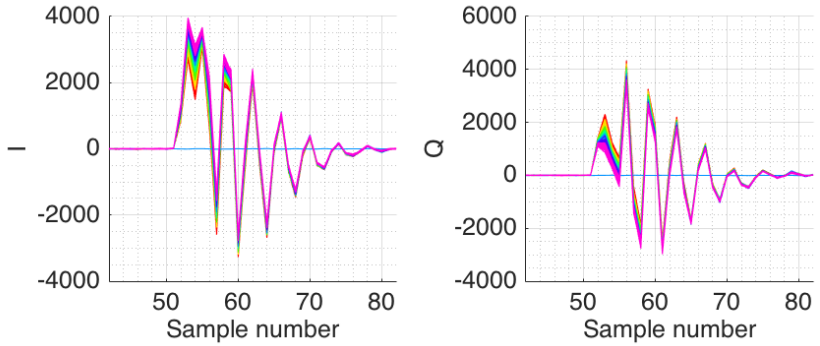


Apply digital bandstop filter 50 to 110 MHz to the jitter run and mover scan

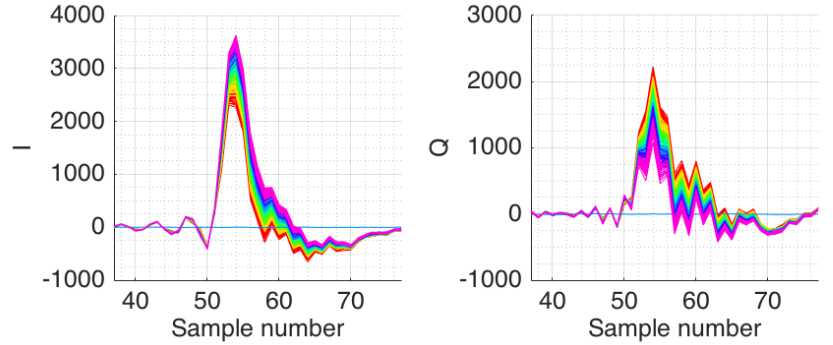
jitRun1_0dB_ipbpm_150612



IPByCal2_0dB_ipbpm_150612



IPByCal2_0dB_ipbpm_150612



3BPM resolution with digital filtering

- Filtering reduces the resolution slightly at 0dB, but not at 10dB.

						DIGITAL FILTERING BANDSTOP 50 TO 110 MHZ		
Jitter Run	Attenuation (dB)	Charge (x 10^{10})	Geometric (nm)	Fitting Mean (nm) 3 Param	Fitting Mean (nm) 5 Param	Geometric (nm)	Fitting Mean (nm) 3 Param	Fitting Mean (nm) 5 Param
jitRun1_0dB_ipbpm_150612	0	0.72	43 ± 1	39 ± 1	31 ± 4	41 ± 1	35 ± 3	25 ± 2
jitRun3_0dB_ipbpm_150612	0	0.69	71 ± 2	64 ± 4	31 ± 3	58 ± 2	54 ± 3	31 ± 3
jitRun4_10dB_ipbpm_150612	10	0.71	134 ± 4	61 ± 19	17 ± 2	155 ± 4	76 ± 19	17 ± 2
jitRun5_10dB_ipbpm_150612	10	0.72	145 ± 4	58 ± 19	16 ± 1	165 ± 5	70 ± 17	16 ± 1

Geometric = Geometric method for predicting resolution.
Fitting Mean 3 Parameters = Fitting method for predicting resolution. Mean of predictions at all three BPMs. Fitting to I' with a constant (3 parameters).
Fitting Mean 5 Parameters = Fitting method for predicting resolution. Mean of predictions at all three BPMs. Fitting to I and Q with constant (5 parameters).
Sampling using integration. Integration window chosen to minimise mean resolution result. For sample numbers used see detailed table in appendix.

Resolution at 0dB to10dB

Plot of the charge normalised resolution as a function of attenuation. Shows the minimal resolution using both geometric and fitting (5 parameter) methods.

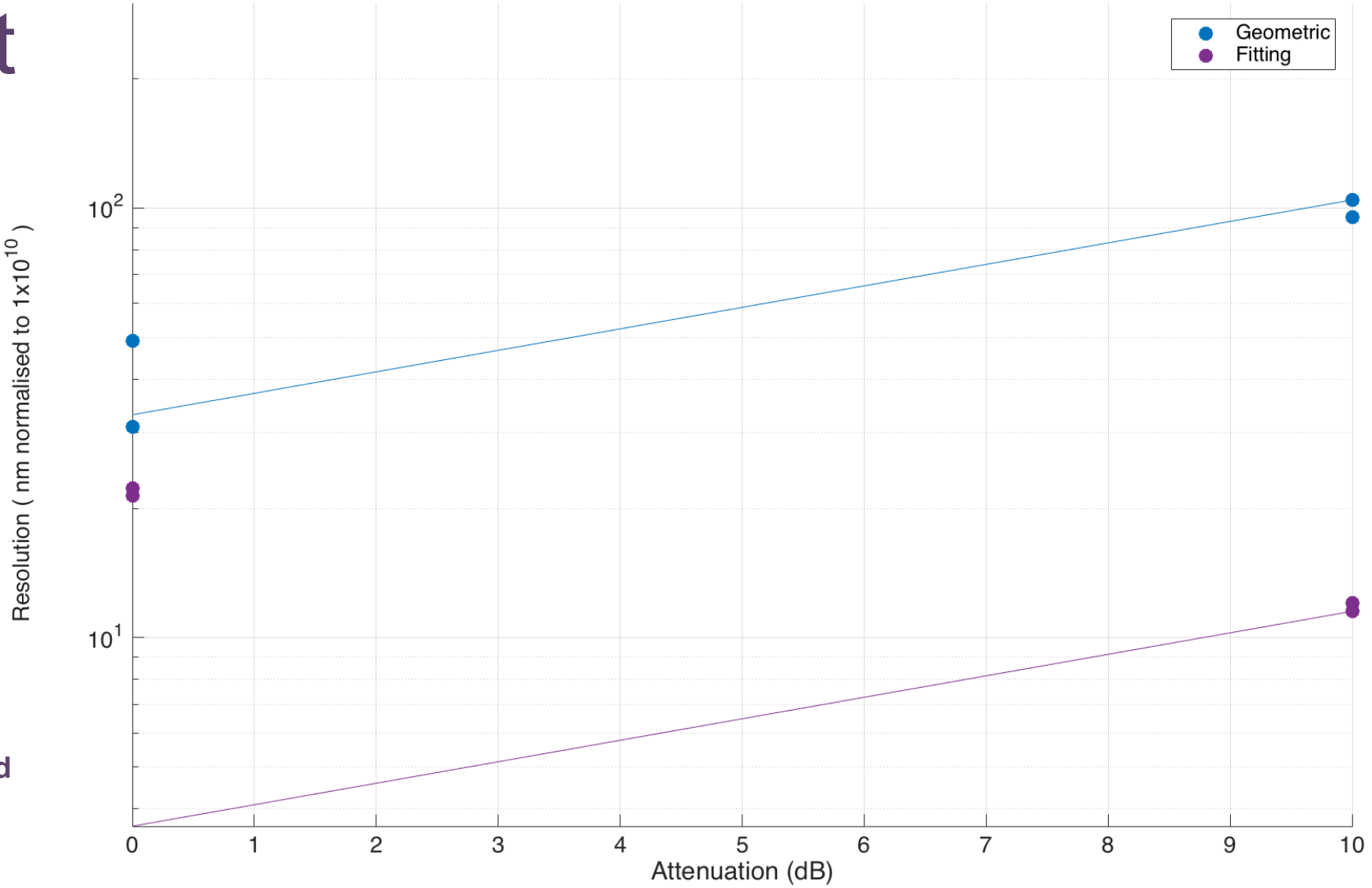
jitRun1_0dB_ipbpm_150612

jitRun3_0dB_ipbpm_150612

jitRun4_10dB_ipbpm_150612

jitRun5_10dB_ipbpm_150612

Line shows 10 dB resolution scaled down to 0 dB. Geometric method scales. Fitting method does not.



Resolution at different attenuations

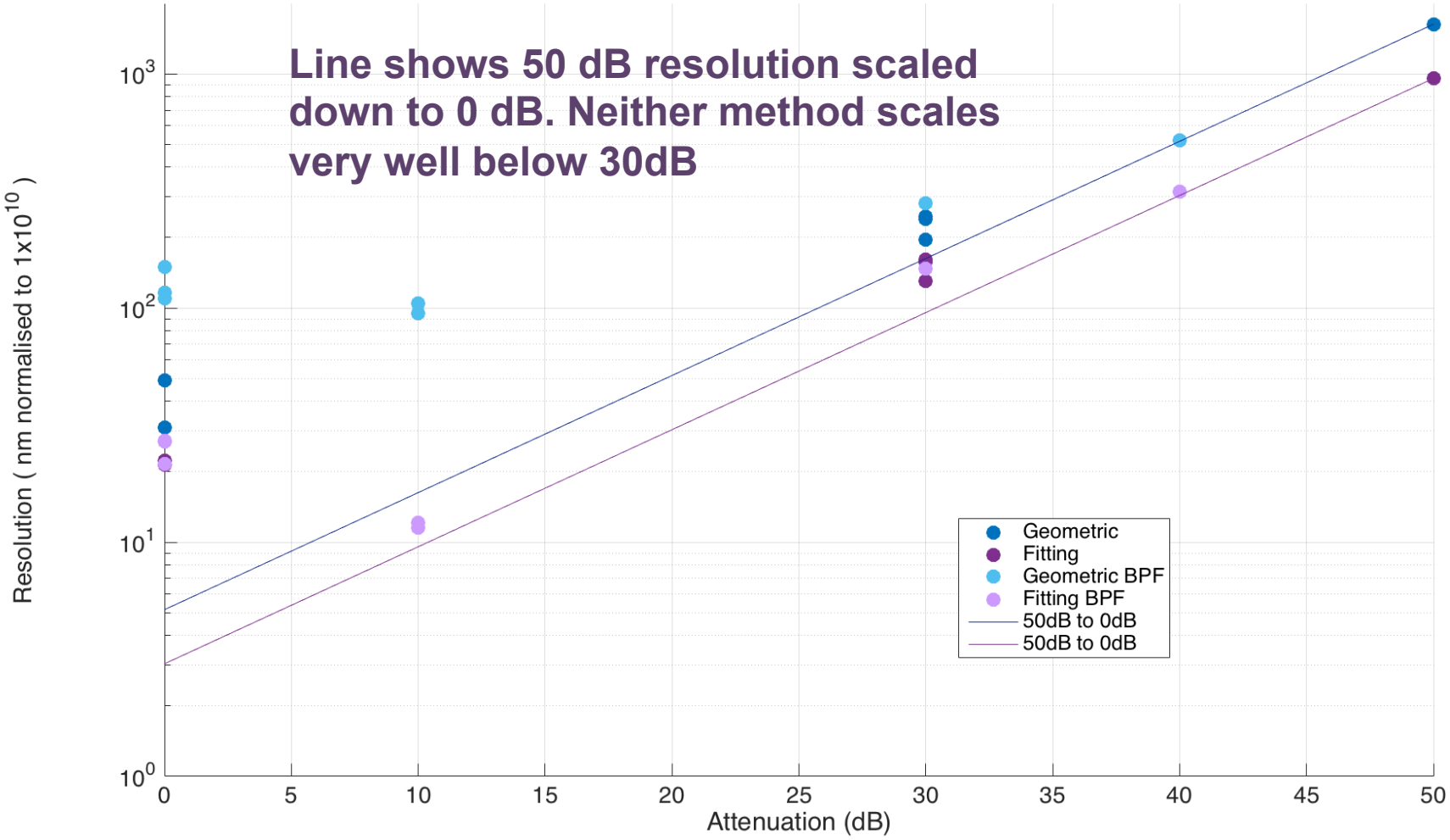
Resolutions at lots of different attenuations from various studies.

No BPFs

jitRun1_0dB_ipbpm_150612
jitRun3_0dB_ipbpm_150612
jitRun4_10dB_ipbpm_150612
jitRun5_10dB_ipbpm_150612
jitRun1_30dB_055_ipbpm_151218
jitRun2_30dB_055_ipbpm_151218
jitRun3_30dB_055_ipbpm_151218
jitRun4_50dB_055_ipbpm_151218

KNU C-band BPFs

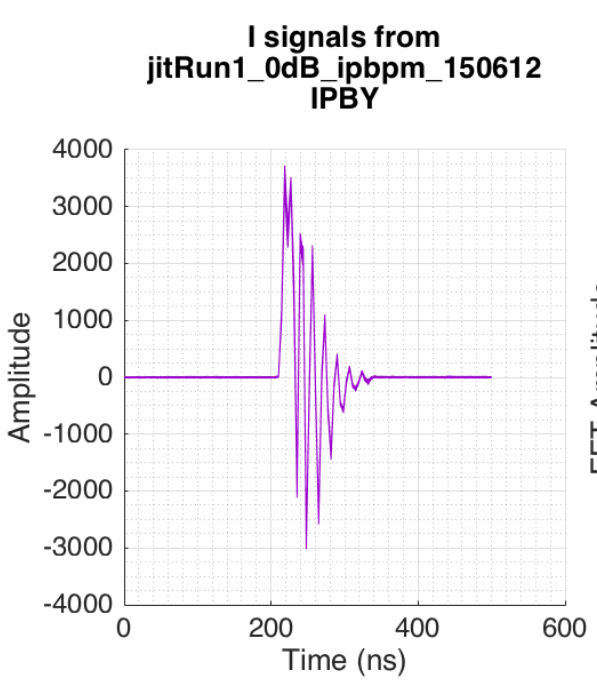
jitRun1_0dB_055_BPF_ipbpm_151218
jitRun3_0dB_055_BPF_ipbpm_151218
jitRun4_0dB_055_BPF_ipbpm_151218
jitRun7_30dB_055_BPF_ipbpm_151218
jitRun8_40dB_055_BPF_ipbpm_151218

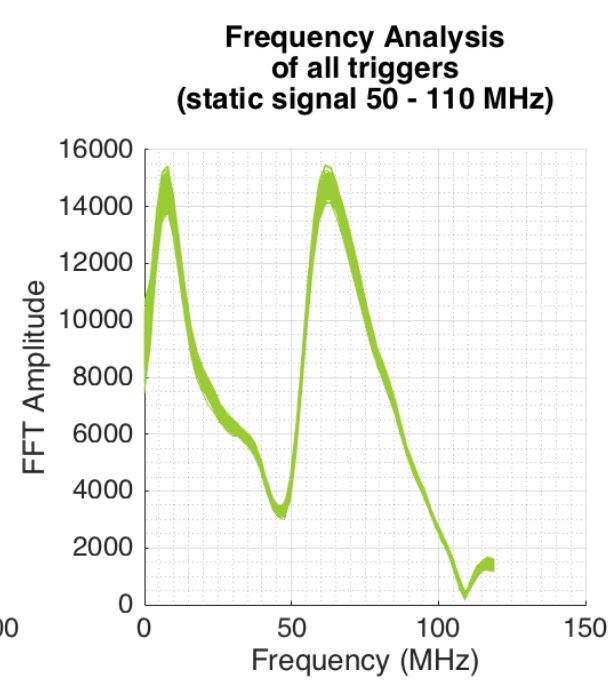


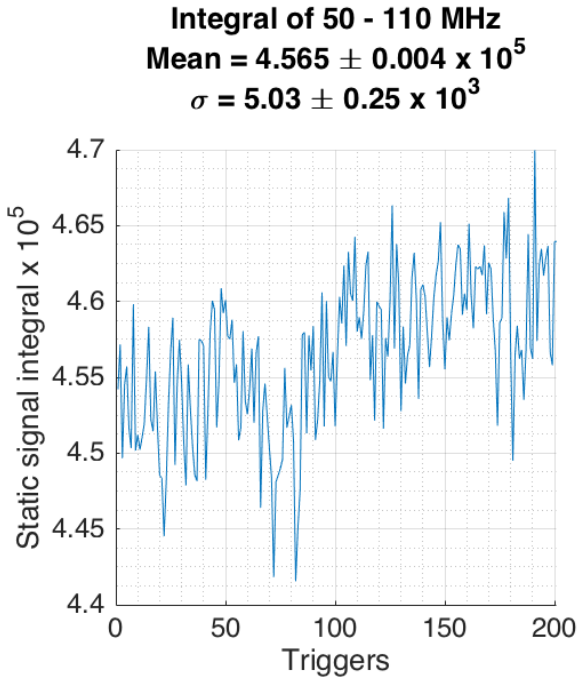
Integrating FFT 50-110 MHz

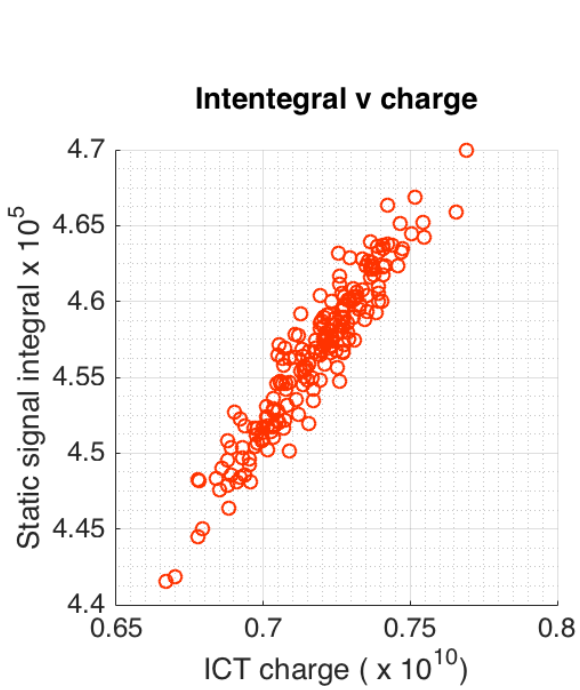
Integrating the FFT over the static signal (50 to 110 MHz) and found the mean and σ intensity.

- Noticed the integral of the static signal of each trigger has a clear dependence on the ICT charge.









Resolution and static signal intensity noise

- Tauchi-san suggested looking at the relationship between σ intensity and resolution.

Jitter Run	Attenuation (dB)	Charge (x 10^{10})	Geometric (nm)	Fitting Mean (nm) 3 Param	Fitting Mean (nm) 5 Param	Standard dev. of static waveform intensity integral
jitRun1_0dB_ipbpm_150612	0	0.72	43 ± 1	39 ± 1	31 ± 4	5.03 ± 0.25
jitRun3_0dB_ipbpm_150612	0	0.69	71 ± 2	64 ± 4	31 ± 3	7.26 ± 0.36
jitRun4_10dB_ipbpm_150612	10	0.71	134 ± 4	61 ± 19	17 ± 2	1.14 ± 0.06
jitRun5_10dB_ipbpm_150612	10	0.72	145 ± 4	58 ± 19	16 ± 1	1.11 ± 0.06

σ appears to be smaller for the 10 dB data sets, where the resolution is also smaller (although only with the fitting method – with the geometric method the resolution scales)

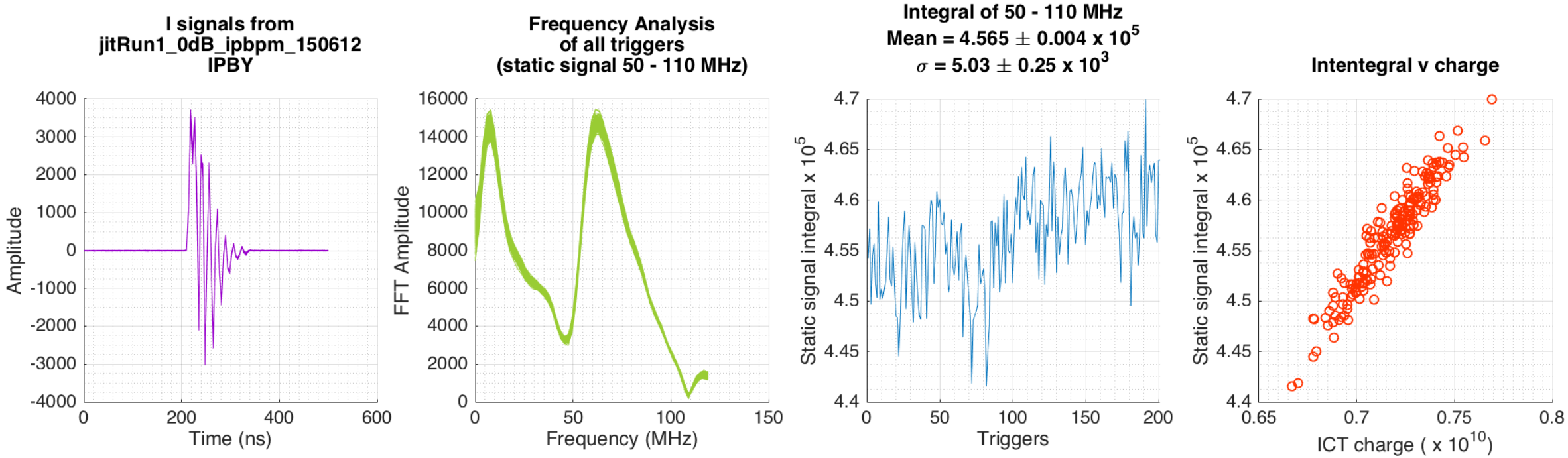
Appendix
(more data and plots)

3BPM resolution data analysis

								DIGITAL FILTERING BANDSTOP 50 TO 110 MHZ				
jitrun	**Charge (x 10^{10})**	**BPM**	**Calibration file**	**Geometric (nm)**	**Fitting Res (nm) 3 param**	**Mean (nm)**	**Fitting Res (nm) 5 params**	**Mean(nm)**	**Geometric (nm)**	**Fitting Res (nm) 3 param**	**Mean (nm)**	**Fitting Res (nm) 5 params**	**Mean(nm)**
jitRun1_0dB_ipbpm_150612	0.72	IPA	IPByCal2_0dB_ipbpm_150612	43 ± 1 (56:58)	42 ± 3	39 ± 1 (56:58)	37 ± 3	31 ± 4 (56:59)	41 ± 1 (56:58)	36 ± 3	35 ± 3 (56:59)	28 ± 2	25 ± 2 (56:59)
		IPB	IPByCal2_0dB_ipbpm_150612		37 ± 2		31 ± 2			30 ± 2		24 ± 1	
		IPC	IPCyCal1_0dB_ipbpm_150612		38 ± 3		23 ± 2			39 ± 4		22 ± 2	
jitRun3_0dB_ipbpm_150612	0.69	IPA	IPByCal2_0dB_ipbpm_150612	71 ± 2 (57:60)	62 ± 5	64 ± 4 (57:60)	27 ± 2	31 ± 3 (53:55)	58 ± 2 (57:59)	59 ± 5	54 ± 3 (57:58)	32 ± 3	31 ± 3 (55:59)
		IPB	IPByCal2_0dB_ipbpm_150612		58 ± 3		29 ± 2			53 ± 3		26 ± 1	
		IPC	IPCyCal1_0dB_ipbpm_150612		71 ± 7		38 ± 3			51 ± 5		35 ± 3	
jitRun4_10dB_ipbpm_150612	0.71	IPA	IPAyCal2_10dB_ipbpm_150612	134 ± 4 (57:58)	35 ± 2	61 ± 19 (54:55)	13 ± 1	17 ± 2 (53:55)	155 ± 4 (53:60)	53 ± 3	76 ± 19 (54:58)	13 ± 1	17 ± 2 (53:55)
		IPB	IPAyCal2_10dB_ipbpm_150612		50 ± 3		19 ± 1			61 ± 3		18 ± 1	
		IPC	IPCyCal7_10dB_ipbpm_150612		99 ± 6		19 ± 1			114 ± 7		21 ± 1	
jitRun5_10dB_ipbpm_150612	0.72	IPA	IPAyCal2_10dB_ipbpm_150612	145 ± 4 (57:58)	33 ± 2	58 ± 19 (54:55)	13 ± 1	16 ± 1 (53:55)	165 ± 5 (53:60)	50 ± 3	70 ± 17 (54:58)	13 ± 1	16 ± 1 (53:55)
		IPB	IPAyCal2_10dB_ipbpm_150612		47 ± 2		18 ± 1			58 ± 3		17 ± 1	
		IPC	IPCyCal7_10dB_ipbpm_150612		95 ± 6		17 ± 1			104 ± 6		18 ± 1	

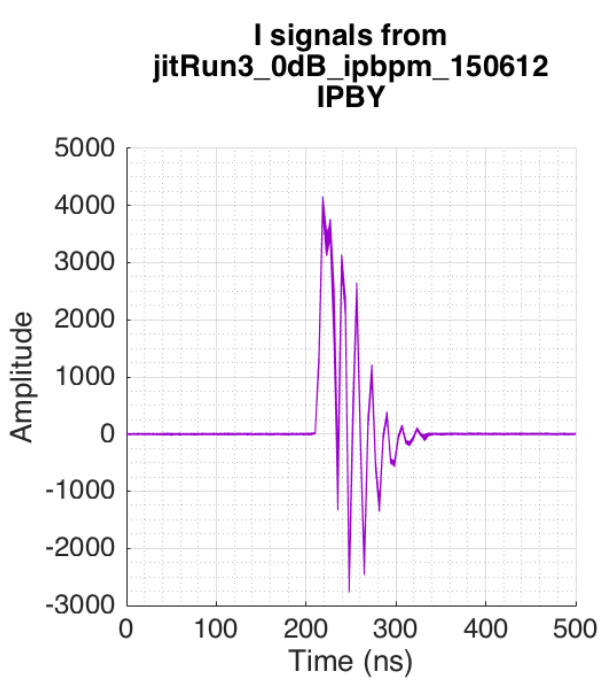
Integrating FFT 50-110 MHz

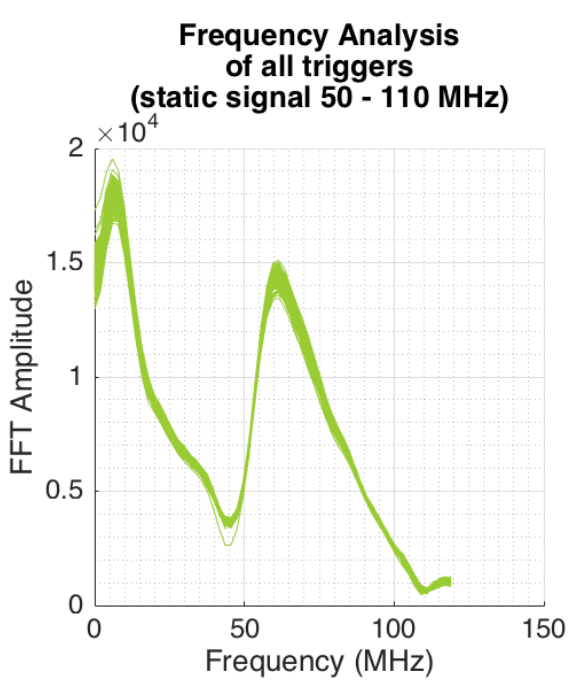
- jitRun1_0dB_ipbpm_150612

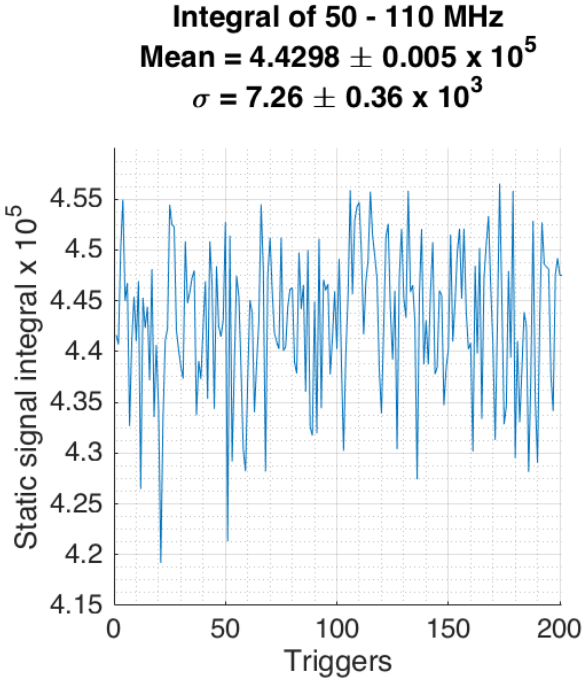


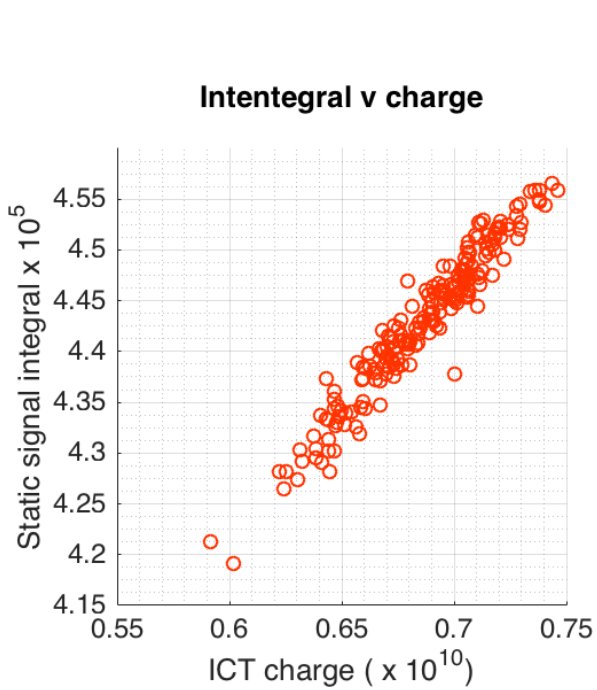
Integrating FFT 50-110 MHz

- jitRun3_0dB_ipbpm_150612



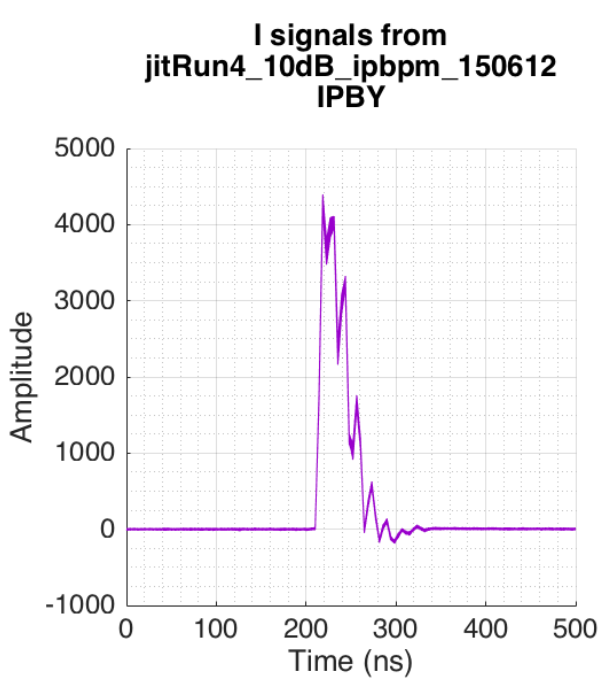


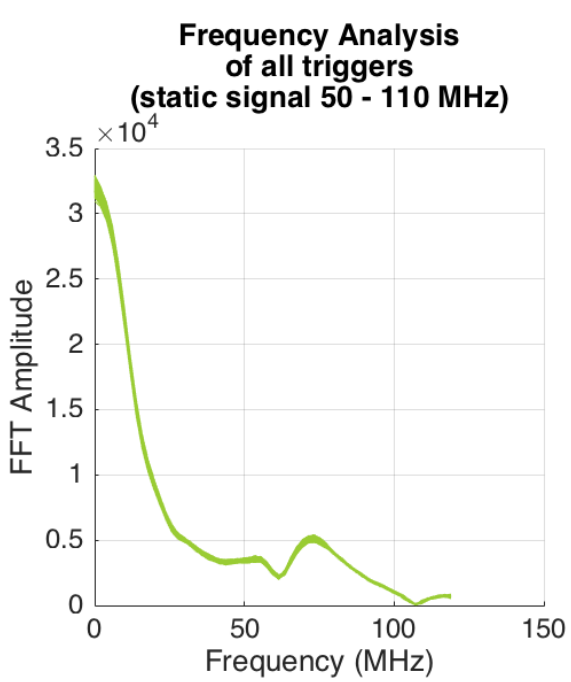


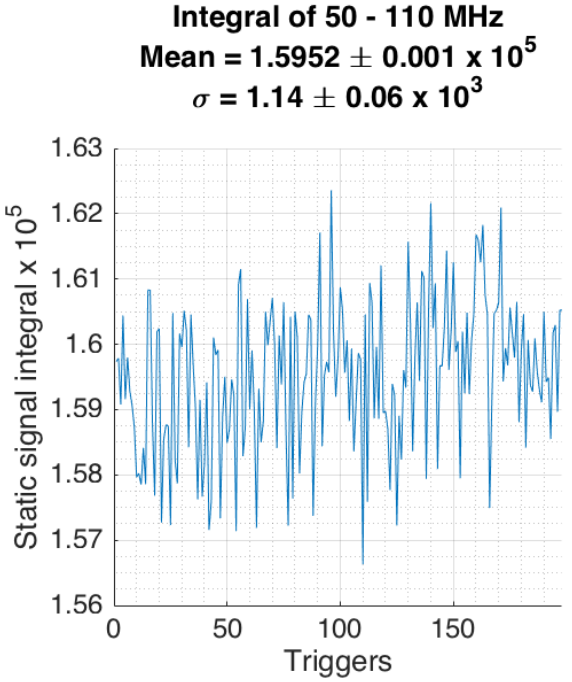


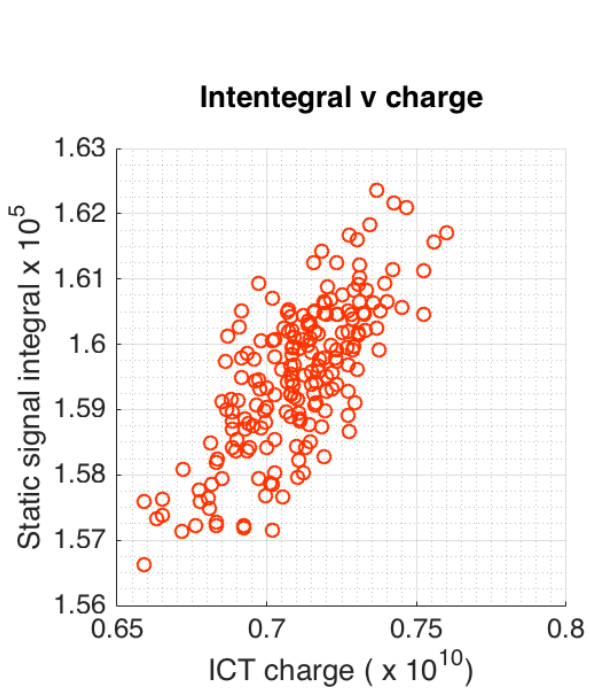
Integrating FFT 50-110 MHz

- jitRun4_10dB_ipbpm_150612









Integrating FFT 50-110 MHz

- jitRun5_10dB_ipbpm_150612