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Wakefield Studies (LRW/SRW) Update

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AST Mtg

24 January 2020

Test Plan for Dec. 17-18, 2019

- Plan to minimize the higher-order mode (HOM) signals in CC1 and CC2 by steering with 3 sets of correctors. CC1 OK
- Plan to test HOM quadrupole detector at 3.25 GHz for the first time in CC1 upstream (US) and downstream (DS). OK
- Perform H/V101 scans and record dipolar and quadrupolar HOMs in CC1, dipolar HOMs in CC2, and the rf BPM bunch by bunch positions. Use RTK MATLab script for data.   OK
- Identify any near-resonant oscillations in the rf BPM data. OK
- Evaluate the beam trajectories and alignment of the two cavities.   CC1 OK, but CC2 HOMs elevated.
- Evaluate a beam-offset monitor (BOM) from CC1 US dipolar signals and rf BPM data. (in progress)

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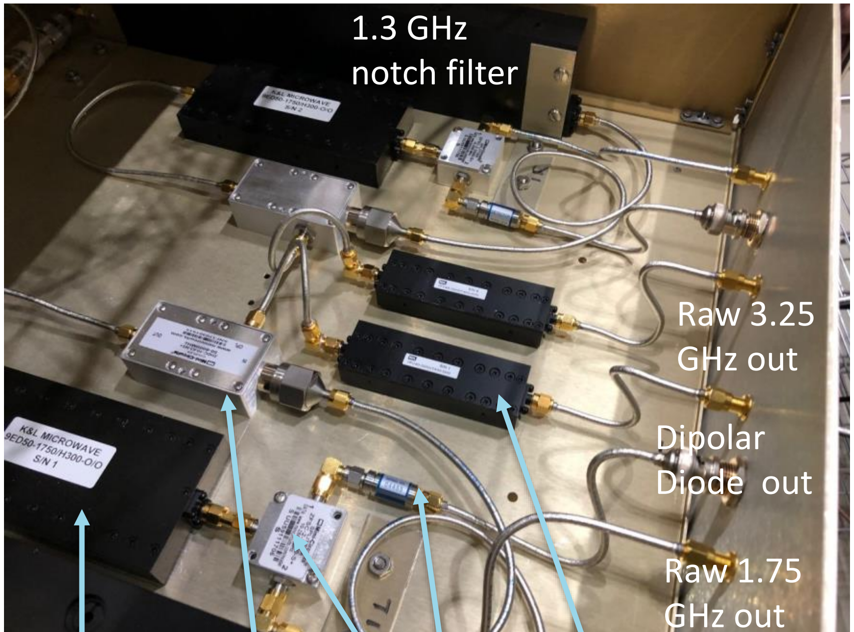
HOM revised electronics for CC1

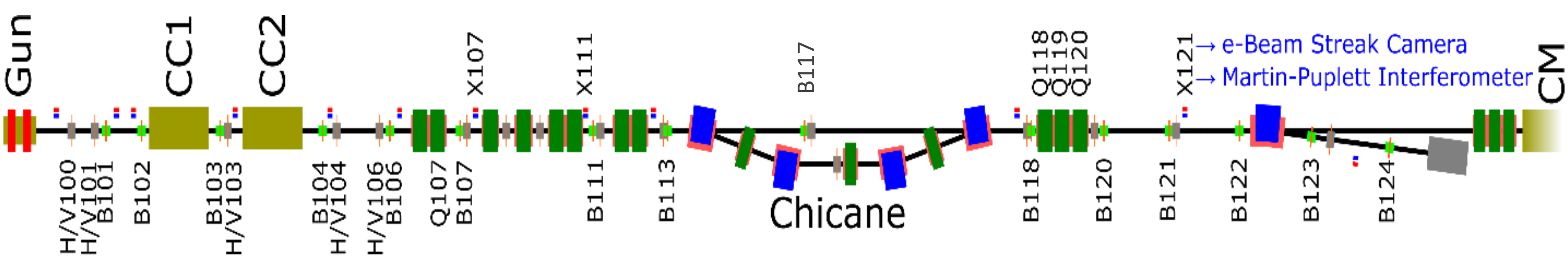
- Dipole and Quadrupole modes filtered then Schottky diodes



Photos by RTK

FAST Configuration and Unique Diagnostics Available

- Photocathode (PC) rf Gun beam injected into TESLA Cavities at 3 MHz micropulse repetition rate.
- Two single cavities with two corrector sets before CC1 and one set before CC2 allow localization of vertical effect to mostly second cavity using corrector H/V103 with HOMs minimized in CC1 for the tests.
- Streak camera views the X121 and X124 OTR screens and provides ~1-ps resolution so multiple time slices in 4 sigma-t.
- Wakefield Model indicates effects should be at 50-µm level for an offset of 1 mm, σ_t =10ps, and Q~2.4 nC. (V. Lebedev calc.)



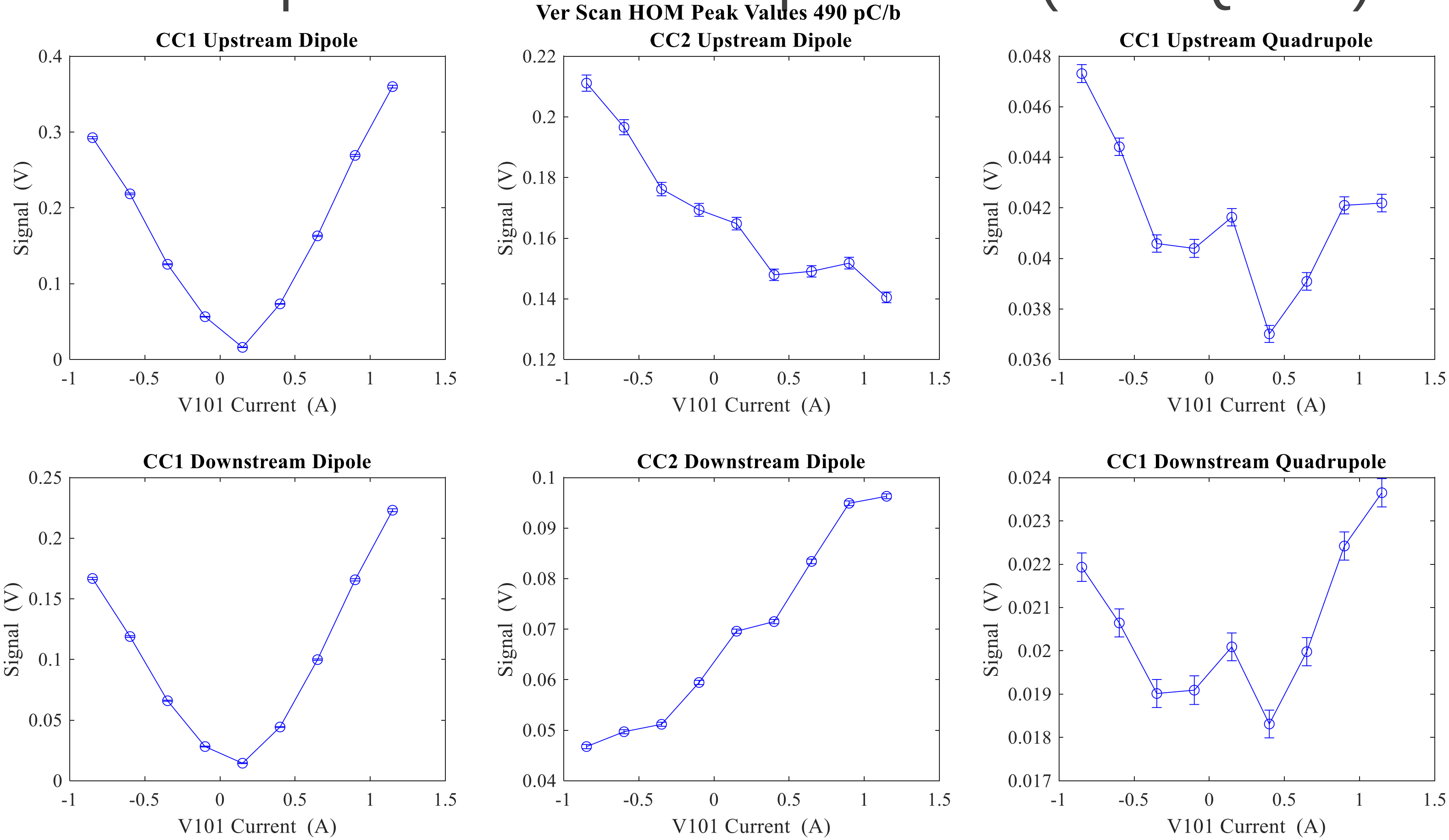
V101 scan: CC1 and CC2 HOMs

- 500 pC/b, 50 b, 100 shots

CC1 Dipolar | CC2 Dipolar | (CC1 Quad.)

US

DS



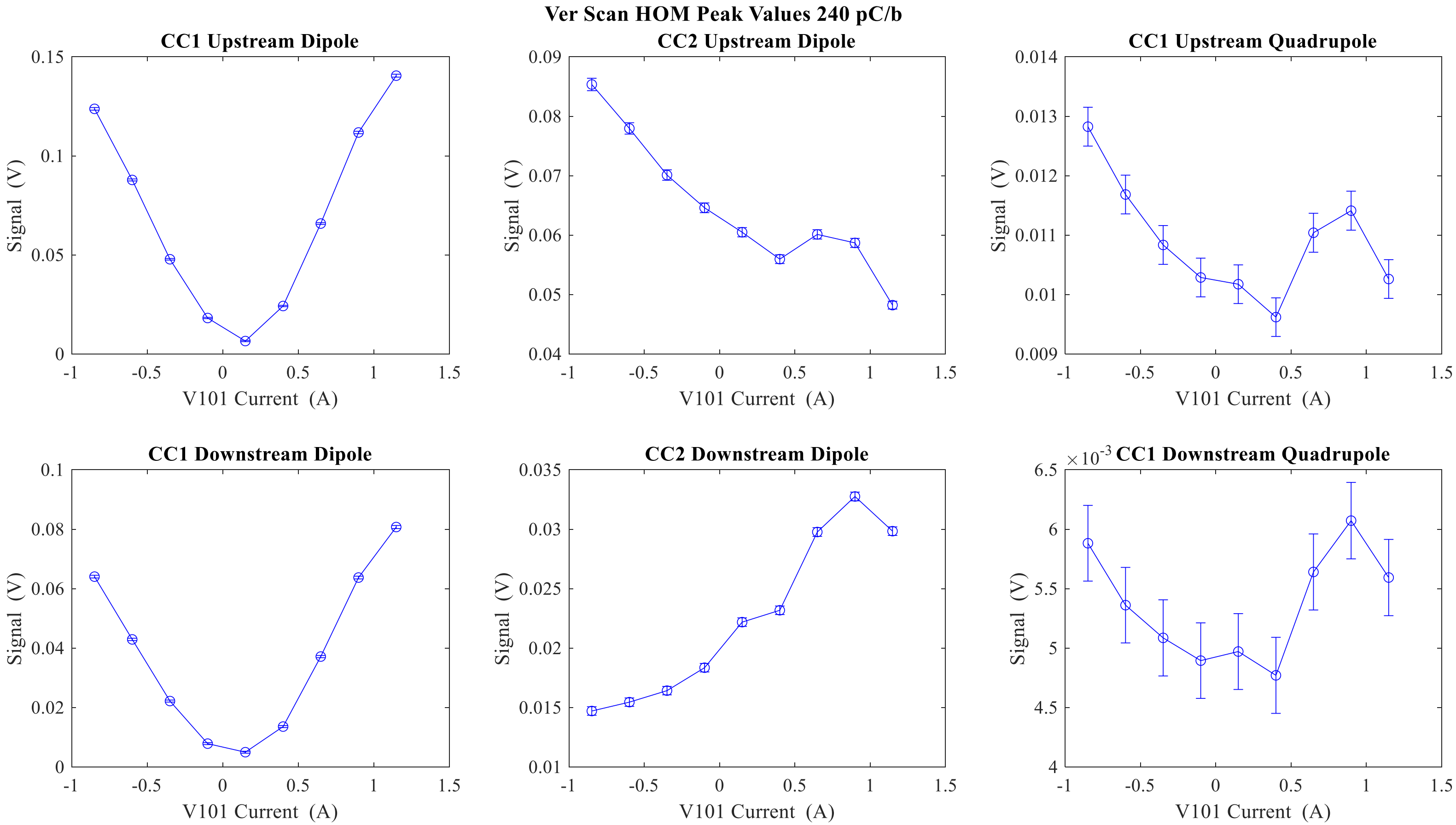
V101 scan: CC1 and CC2 HOMs

- 250 pC/b, 50 b

CC1 Dipolar CC2 Dipolar (CC1 Quad.)

US

DS



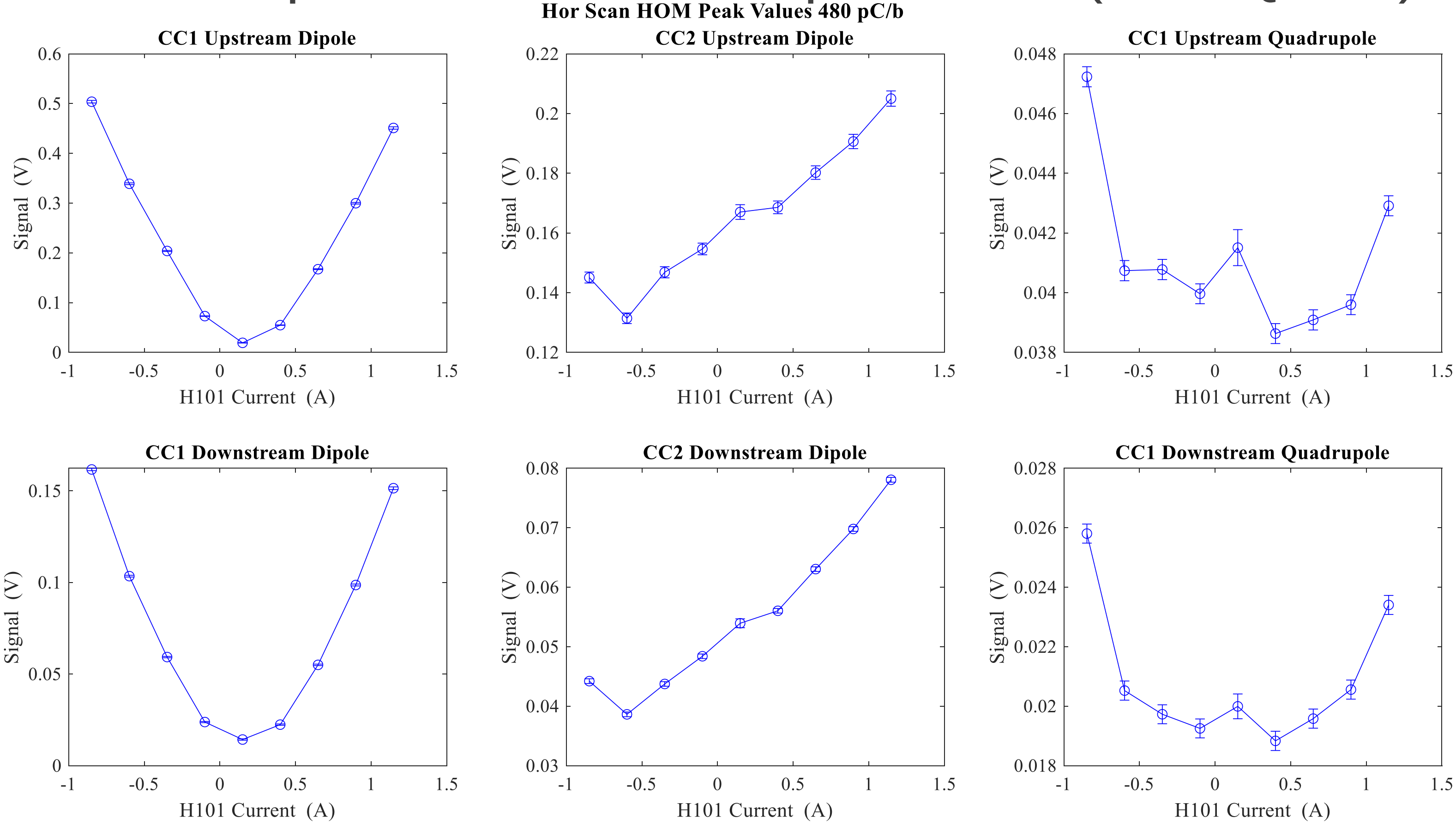
H101 scan: CC1 and CC2 HOMs

- 500 pC/b

CC1 Dipolar | CC2 Dipolar | (CC1 Quad.)

US

DS



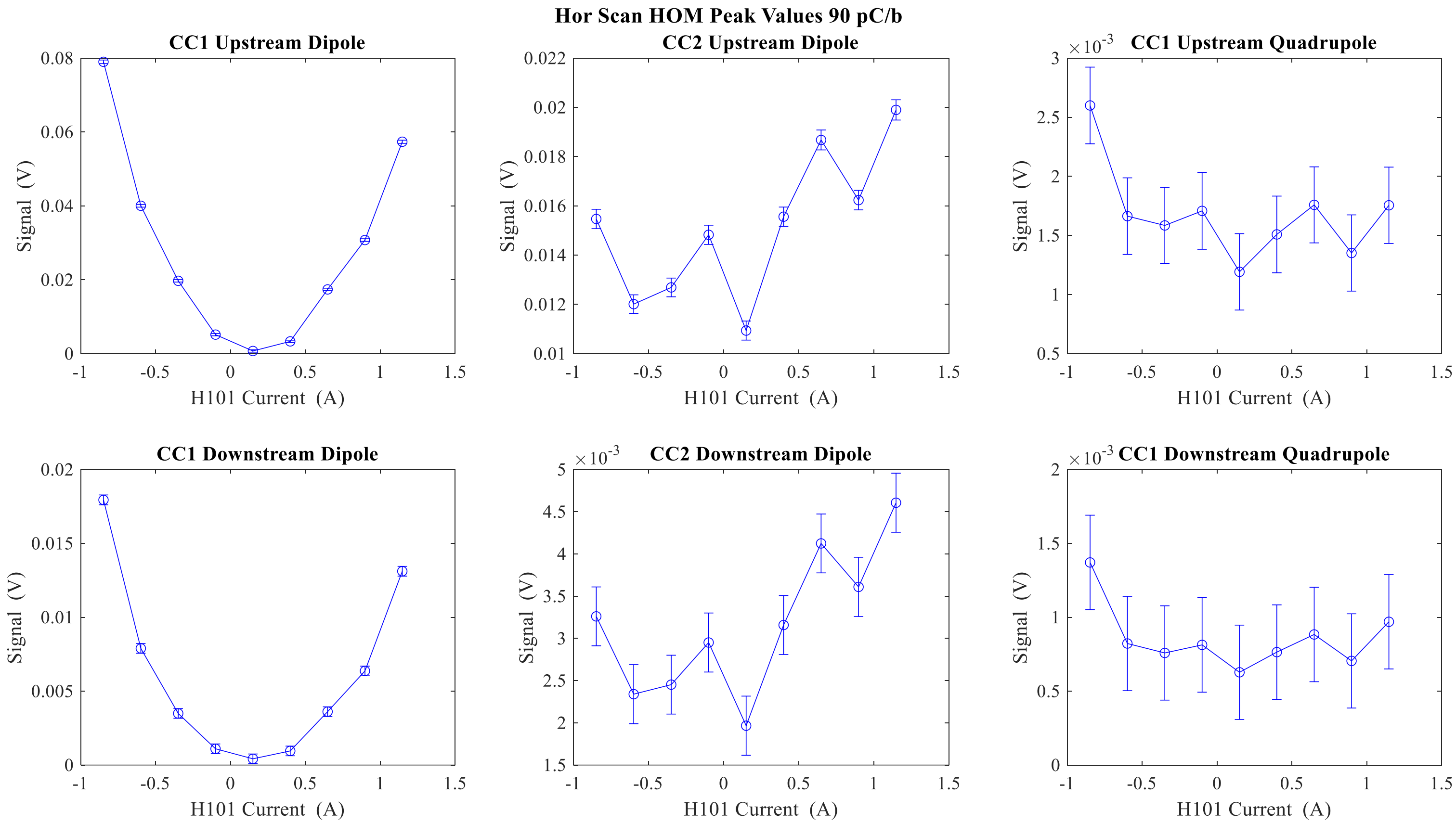
H101 scan: CC1 and CC2 HOMs

- 90 pC/b, 50 b 1000 shots

CC1 Dipolar   CC2 Dipolar   (CC1 Quad.)

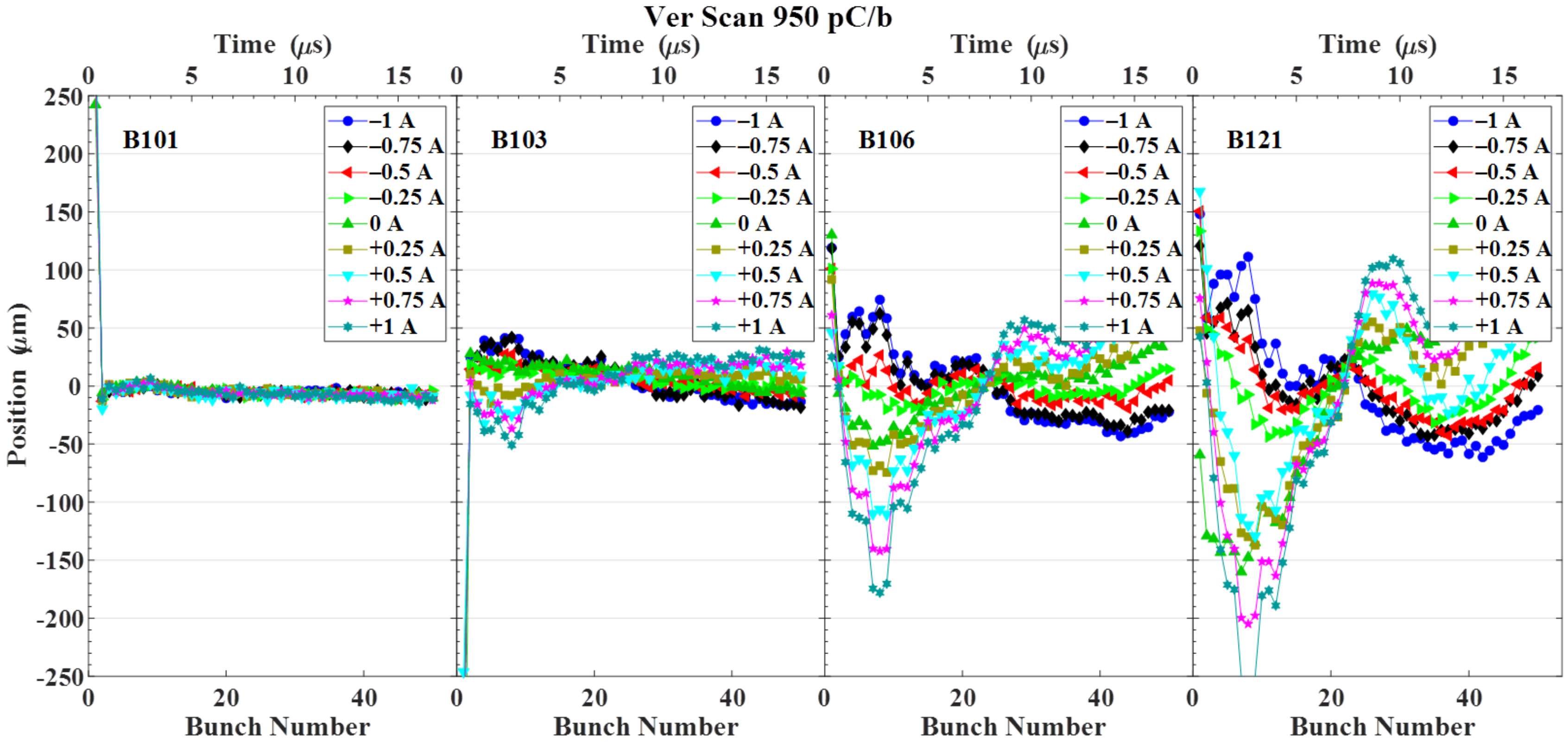
US

DS



rf BPM Array Data for V101 scan 12-17-19

- Centroid oscillations seen in drift down stream. 950 pC/b
- CC2 Mode 14 is near-resonant with a beam harmonic.



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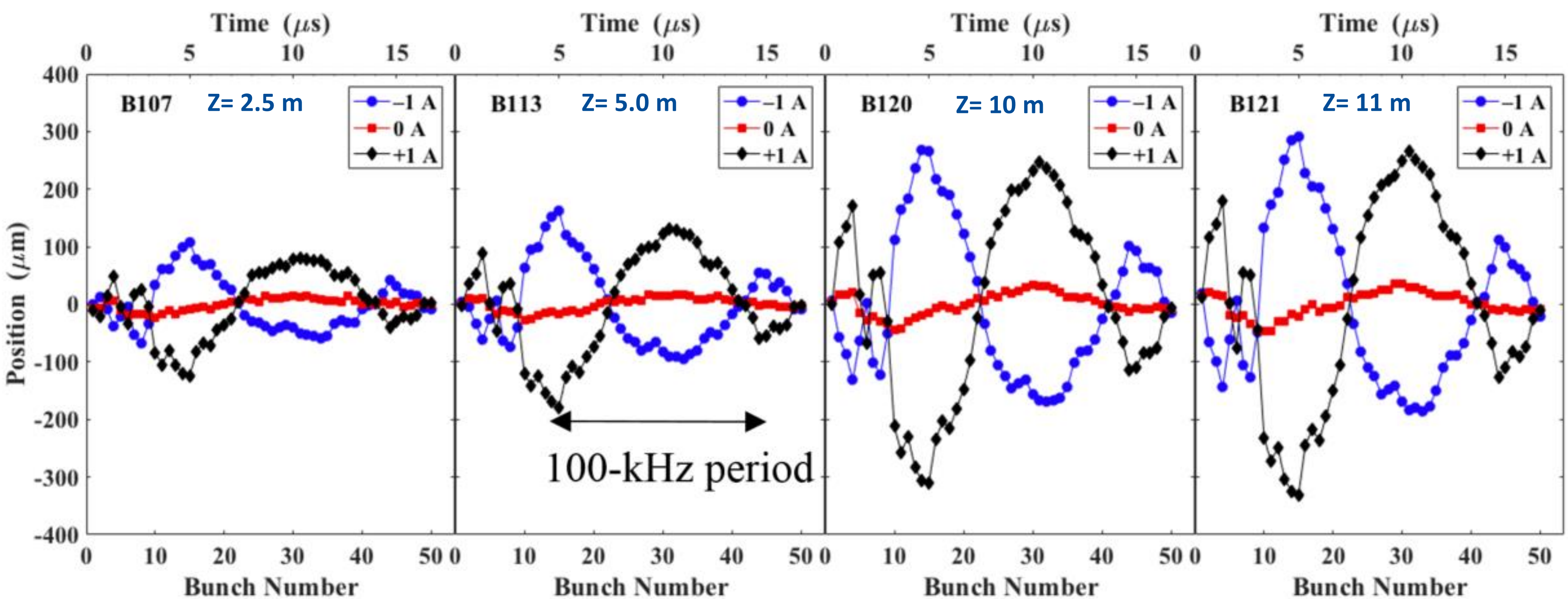
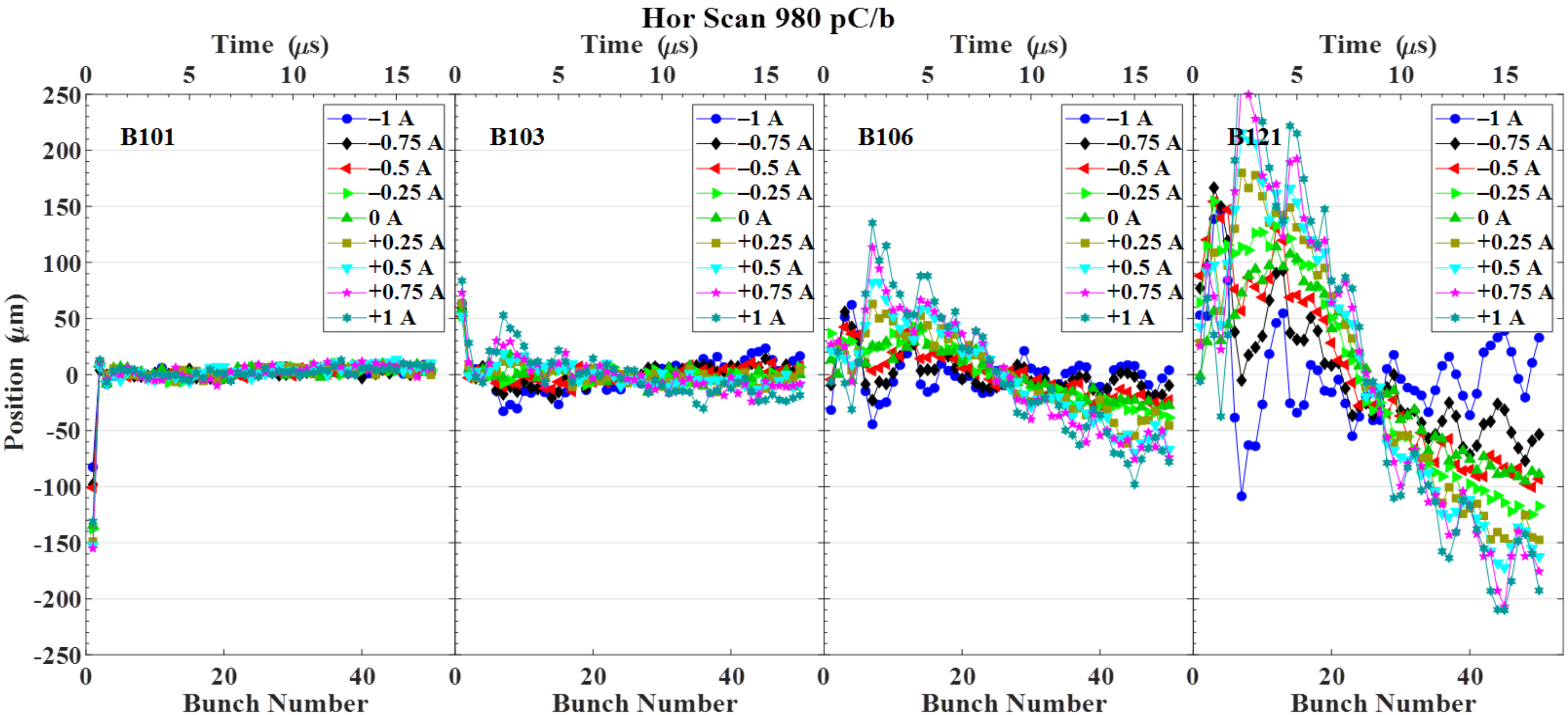
Centroid Vertical Oscillations Observed to Grow with Drift

- Comparison of sub-macropulse motion with corrector currents at V101= -1, 0, +1 A. Correlation with excited HOMs. 1000 pC/b
- Attributed to near resonance of beam harmonic and CC2 dipole mode 14 (A.H. Lumpkin et al., Phys. Rev. A-B **21**, June 2018).



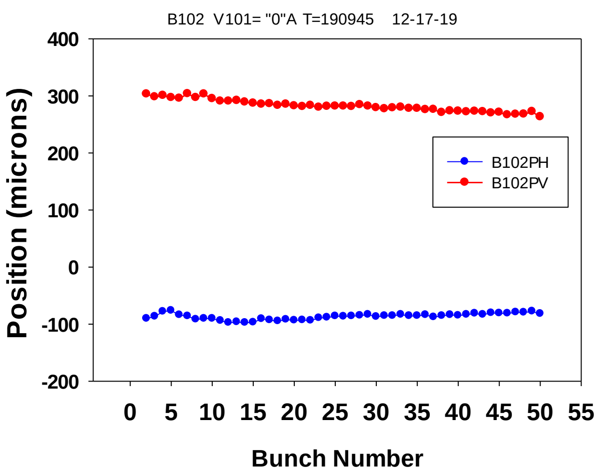
rf BPM data for H101 scan 12-18-19

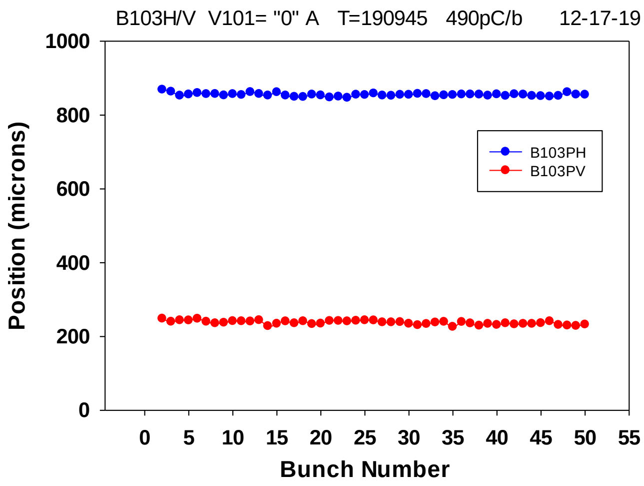
- Sub-macropulse Centroid slew and oscillation seen at 980 pC/b.

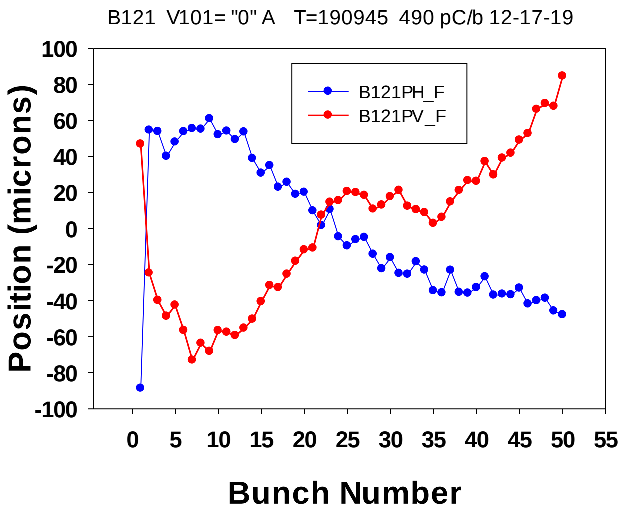


B102 and B103 BPMs for V101 = "0"A 12-17-19

- B102 Beam position logged at x/y= -0.1/+0.3 mm. Survey data center of this BPM is x/y = +0.28/-0.55 mm.
- B103 Beam position logged at x/y= 0.8/0.2 mm. Survey data center of this BPM is x/y = -3.48/4.25 mm. Indicates we may be off at CC2 by few mm (see B121) although centered in CC1 based on US and DS dipolar HOMs. CC1 higher grad.







Next Studies Shifts Objectives: Strawman

- Two 4-hr shifts: Improve HOM signal balance-Peter, John S.
  - Improve steering into CC2, Jinhao's, Chipscript on corrector scans. Survey point implies right and down with H/V103(?).
  - Sikora measurements of 1b with amplifier (parasitic w IOTA), V/H103 scans saved and plotted
- LRW Shift 3. Improved trajectory and quad. mode channel,
  - H/V101 scans, 0.5 A steps 9 sets with charges of 500,?
- LRW Shift 4: V103 scan with charges, Sol. scan and/or iris change, beam sizes tracked at 9-way and X107, Quad. HOMs
- SRW Shift 5, min. HOMs. Steer to X121, setup streak camera, take data for 500 pC/b, 1000 pC/b, 2000 pC/b, V101 at ref and ±1 A from ref. Prob. need larger laser spot on PC.
- SRW Shift 6, continue charges and V103 at ref and ±2 A, ±1A

Sikora: Wide band Amplifier ZX60-53LNB-S+

- 500 MHz – 5 GHz: 20 dB gain, +5V needed. Also for bypass.

Wideband

Low Noise Bypass Amplifier ZX60-53LNB-S+

50Ω 0.5 to 5 GHz

The Big Deal

- Very wideband, 500 MHz – 5 GHz
- Ultra-flat gain, ±0.6 dB from 700 to 2000 MHz
- Low NF over entire frequency band
- Internal bypass switching extends useable dynamic range

CASE STYLE: GD958

Product Overview

Mini-Circuits ZX60-53LNB-S+ is a low-noise amplifier offering industry-leading performance over its full frequency range from 500 MHz to 5 GHz. It contains internal switching, allowing the user control of the amplifier to handle both high and low signal levels by bypassing the LNA in the presence of large signals. The internal MMIC amplifier ZX60-53LNB-S+ utilizes E-PHEMT technology to achieve excellent noise figure performance in a unique cascade configuration enabling the combination of very wide band performance and flat gain. This model comes in a 48X30mm small connectorized package.

Key Features

Feature	Advantages
Ultra-wideband: 500 MHz – 5 GHz	Ideal for a wide range of receiver applications including military, commercial wireless, and instrumentation.
Very flat gain	Ideal for broadband or multi-band applications. Just one, cost-efficient model required for multiple frequency usage.
High IP3: 48 dBm typ. (bypass mode)	Provides enhanced linearity over broad frequency range under high signal conditions.
Internal bypass switch feature	Unique design handles low to high signal levels with minimal noise distortion.
Small size: 1.88" x 1.18"	This unique unibody size and construction enables the ZX60-53LNB-S+ to be used in compact connectorized applications.

Wideband

Low Noise Bypass Amplifier ZX60-53LNB-S+

50Ω 0.5 to 5 GHz

Features

- Wideband: 0.5-5 GHz
- Built-in Bypass switching
- Low Noise figure: 1.28 dB typ. at 2 GHz
- High Gain: 21.3 dB typ. at 2 GHz
- Ultra Flat Gain: ±0.6 dB from 0.7 to 2 GHz
- P1dB: +21.6 dBm typ. at 2 GHz
- Specified over full band operation

Applications

- Wireless Base Station Systems
- Test and Measurement Systems
- Multi-Band Receivers

Generic photo used for illustration purposes only

CASE STYLE: GD958

Connectors	Model
SMA	ZX60-53LNB-S+

+RoHS Compliant
The +Suffix identifies RoHS Compliance. See our web site for RoHS Compliance methodologies and qualifications

Electrical Specifications at 25°C, Zo=50Ω and 5V, unless noted

Parameter	Condition (GHz)	Amplifier-ON			Amplifier-Bypass	Units
		Min.	Typ.	Max.	Typ.	
Frequency Range		0.5		5.0	0.5-5.0	GHz
Noise Figure	0.5		1.12		—	dB
	1.0		1.16		—	
	2.0		1.28		—	
	3.0		1.4		—	
	4.0		1.46		—	
	5.0		1.63		—	
Gain	0.5	—	22.0	—	-0.84	dB
	1.0	—	21.9	—	-0.96	
	2.0	19.5	21.2	23.9	-1.15	
	3.0	—	20.2	—	-1.4	
	4.0	—	19.0	—	-1.8	
	5.0	—	17.9	—	-1.8	
Gain Flatness	0.7 - 2.0		±0.6		±0.19	dB
Input VSWR	0.5	—	1.44	—	1.18	:1
	1.0	—	1.42	—	1.33	
	2.0	—	1.34	1.85	1.55	
	3.0	—	1.37	—	1.59	
	4.0	—	1.28	—	1.75	
	5.0	—	1.38	—	1.84	
Output VSWR	0.5		1.81		1.21	:1
	1.0		1.68		1.37	
	2.0		1.31		1.54	
	3.0		1.30		1.47	
	4.0		1.87		1.71	
	5.0		2.43		2.04	
Output Power @1dB compression AMP-ON[1] Input Power @1dB compression AMP-Bypass[1]	0.5		20.8		32.0	dBm
	1.0		21.0		—	
	2.0		20.9		33.0	
	3.0		20.0		—	
	4.0		19.8		—	
	5.0		19.0		27.0	
Output IP3	0.5		35.3		45.4	dBm
	1.0		33.3		46.9	
	2.0		34.8		45.5	
	3.0		35.4		—	