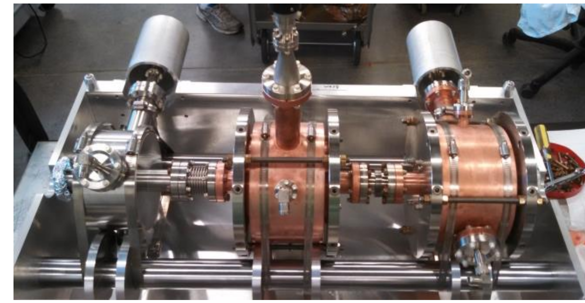
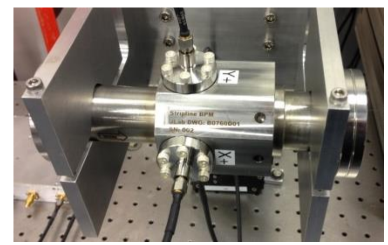
Hall D FFB

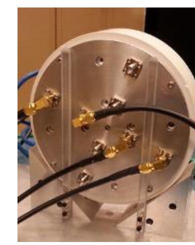
6/8/2015

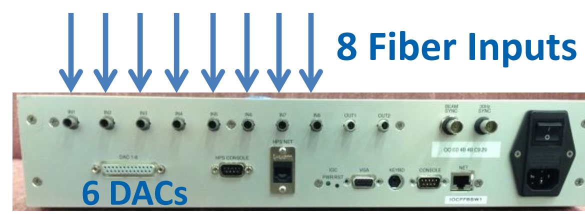
Fast Feedback Electronics

- All electronics for the position devices stream digital data out a fiber
- Any 8 devices can be connected to the FFB Chassis via fiber
- 6 magnets (3 vertical & horizontal sets) are used to cancel beam motion
- Based on Hall A & C FFB Systems
  - 2 position devices and 2 magnet sets are used
  - The algorithm kicks beam with magnets and records position response to self calibrate
  - Holds trajectory constant
  - Feedback to 120 Hz then feed forward for higher 60Hz harmonics to 1 kHz
- Low currents will limit FFB bandwidth



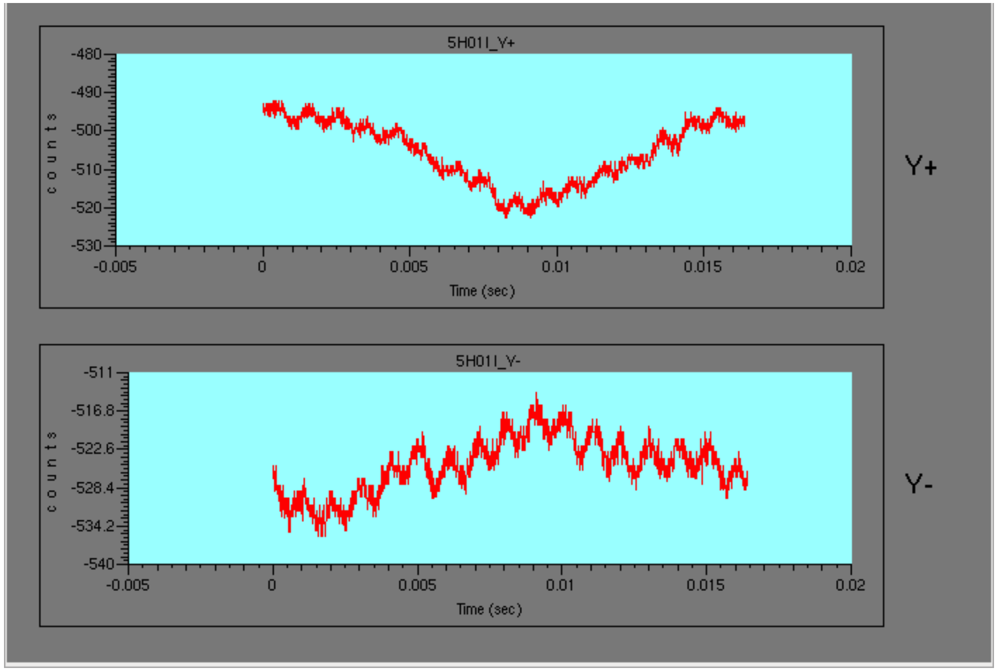






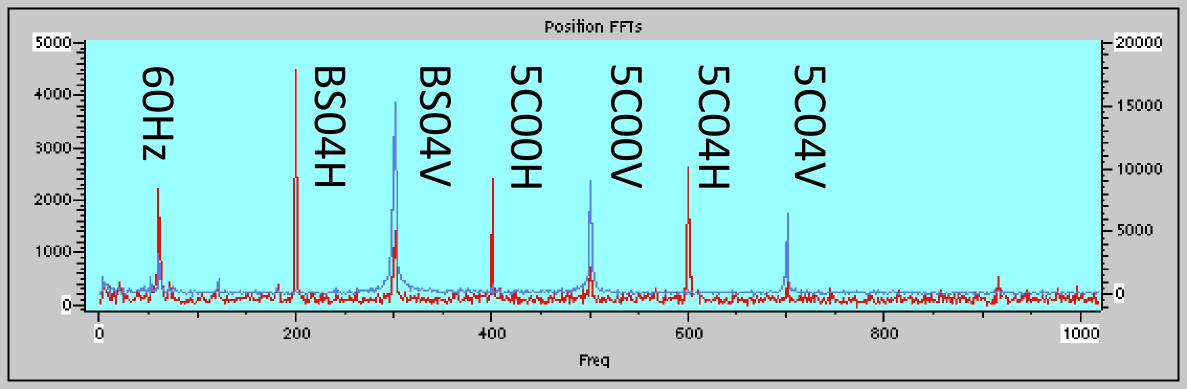
Fast Feedback Testing

- Hardware was verified using beam
  - Fiber data
  - Magnet Controls
- Magnets mapped correctly
- Good response at 5.5GeV with headroom for 12GeV



Active Collimator time domain response to 1kHz FFB magnet kick

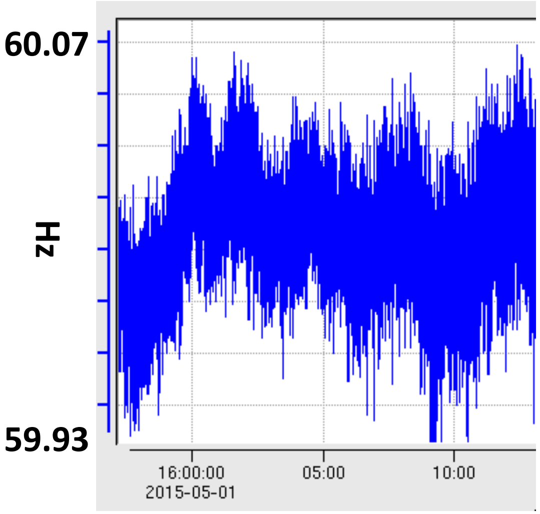
IPM5C07 Stripline Frequency Response

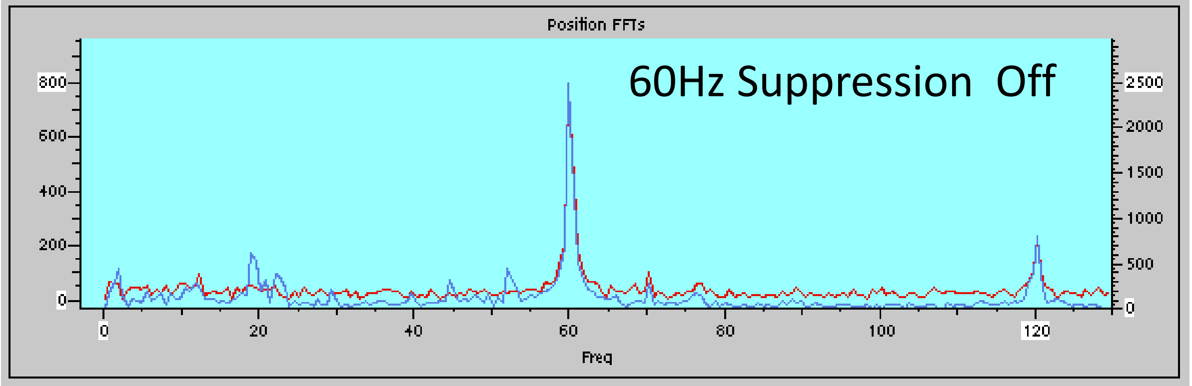


Fast Feedback Testing

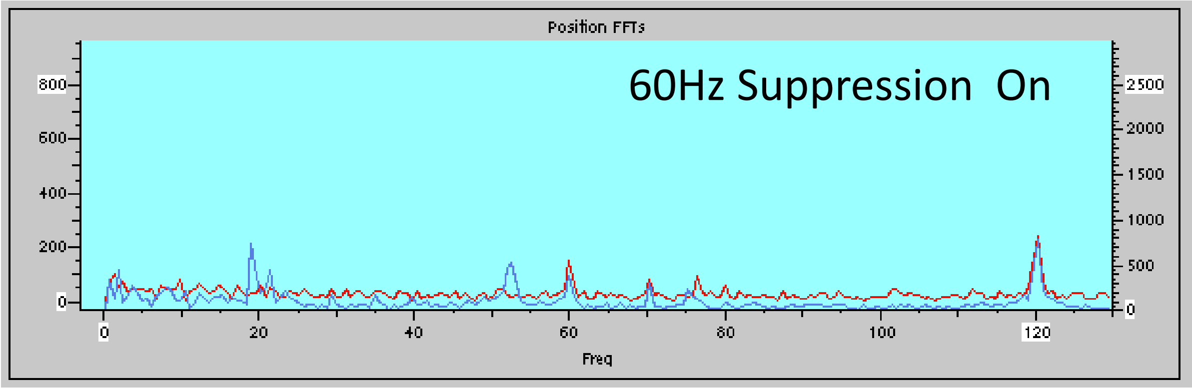
- Not enough time to implement full FFB algorithm
- Line-synchronized 60Hz Feedforward suppression algorithm used last 2 days of the run
- Also engaged slow EPICS position locks to steady the beam

60Hz Line Frequency
Wanders ~0.14Hz





IPM5C07 Stripline Frequency Response



FFB System

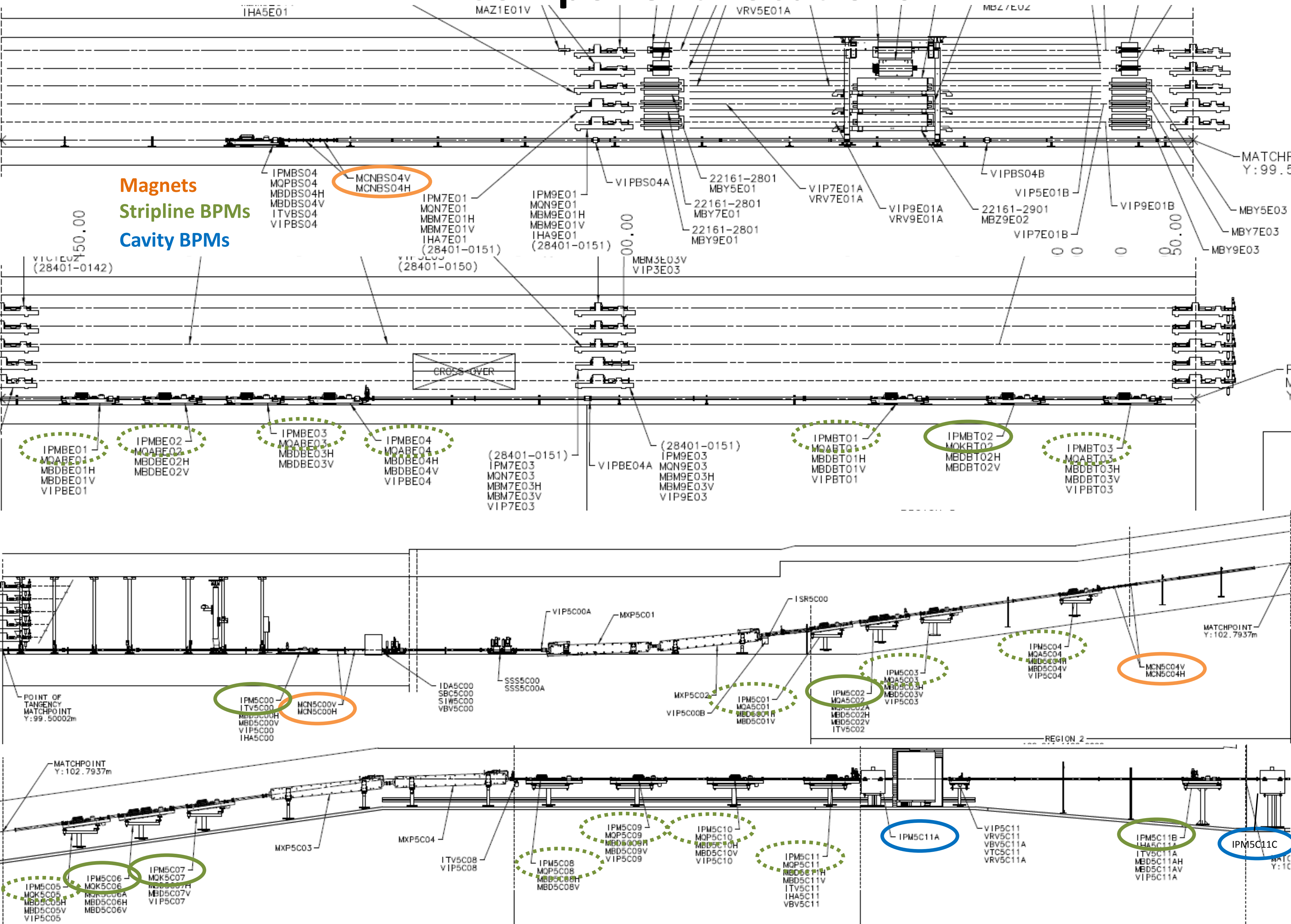
Inputs

- 7 Stripline BPMs
  - BT02, 5C00, 5C02, 5C06, 5C07, 5C11B, AD00
  - Others?
- 1 Active Collimator
- 2 Cavity BPMs?
  - 5C11A, 5C11C

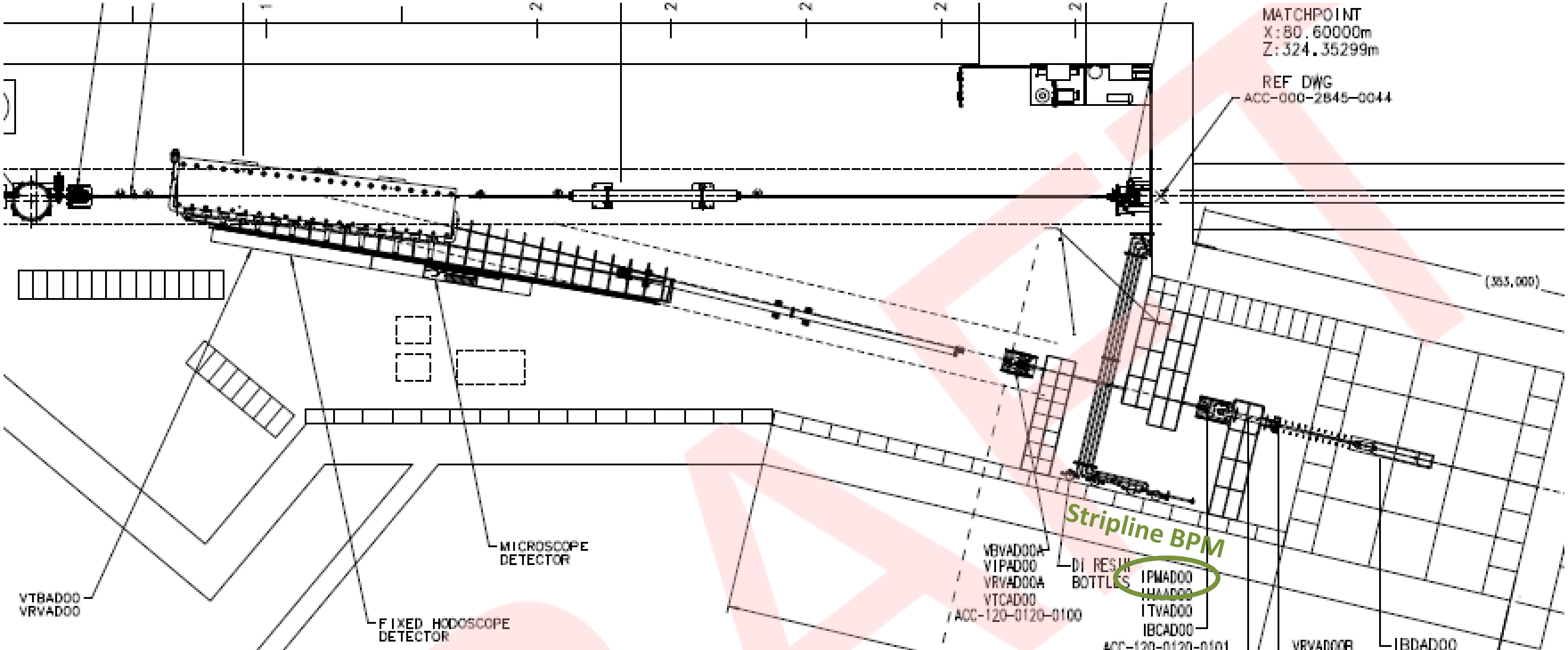
Outputs

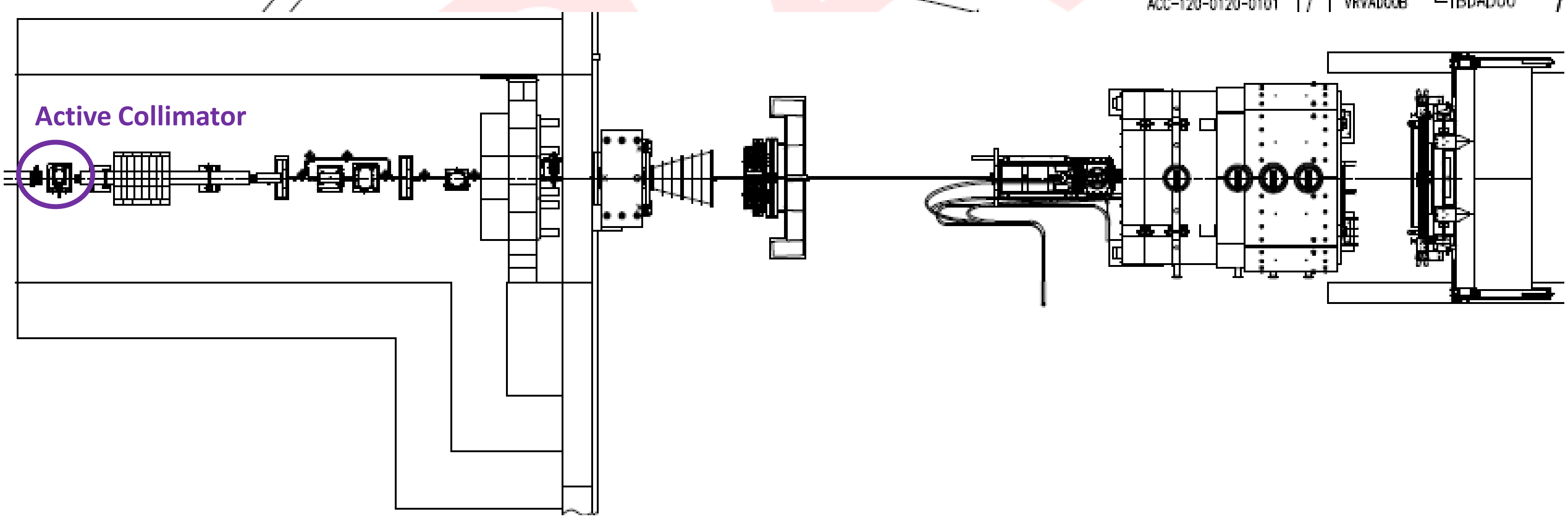
- 3 Horizontal/Vertical Magnet Pairs
  - BS04H/V
  - 5C00H/V
  - 5C04H/V
- 1kHz Magnet Response Bandwidth

FFB Component Locations

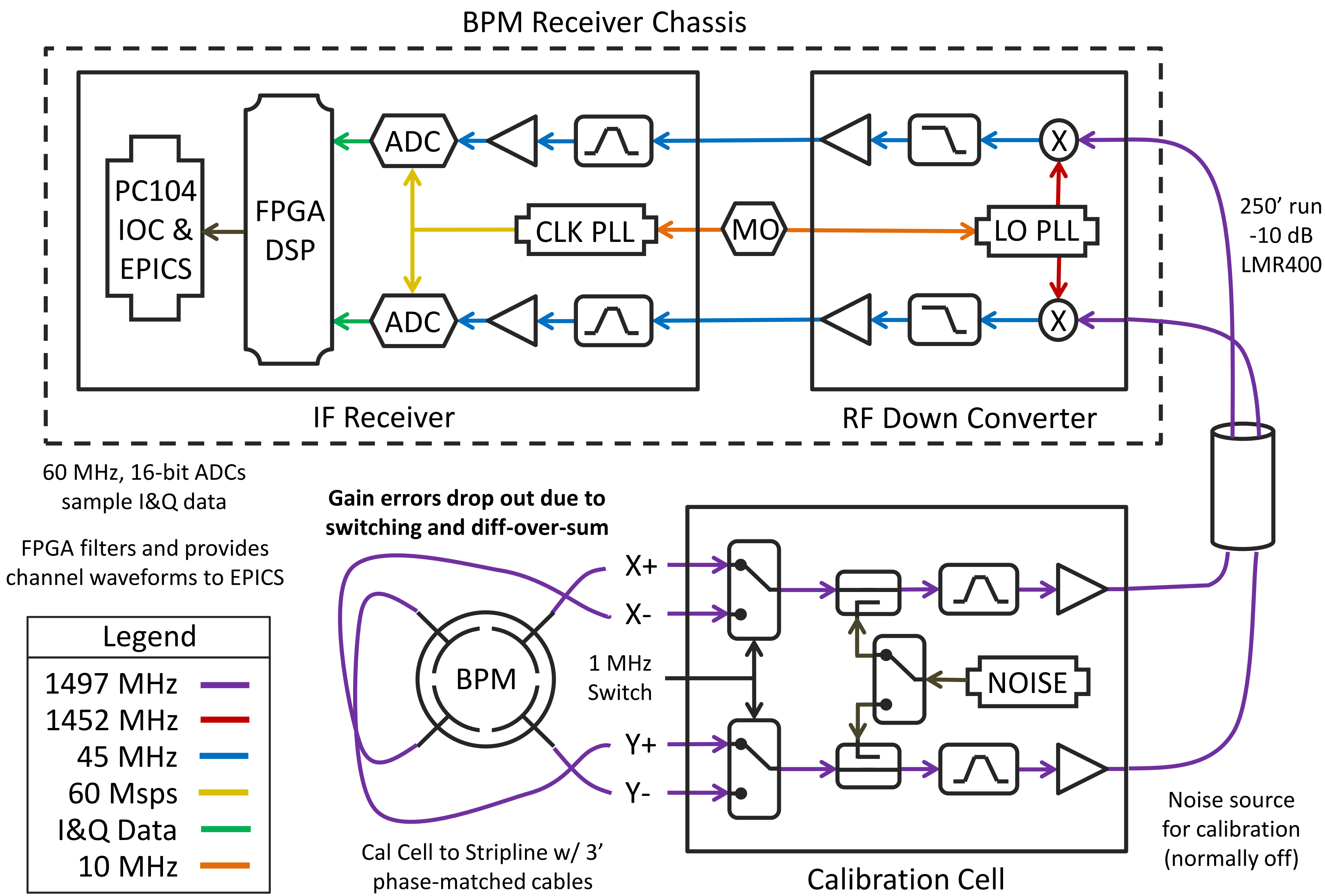


FFB Component Locations

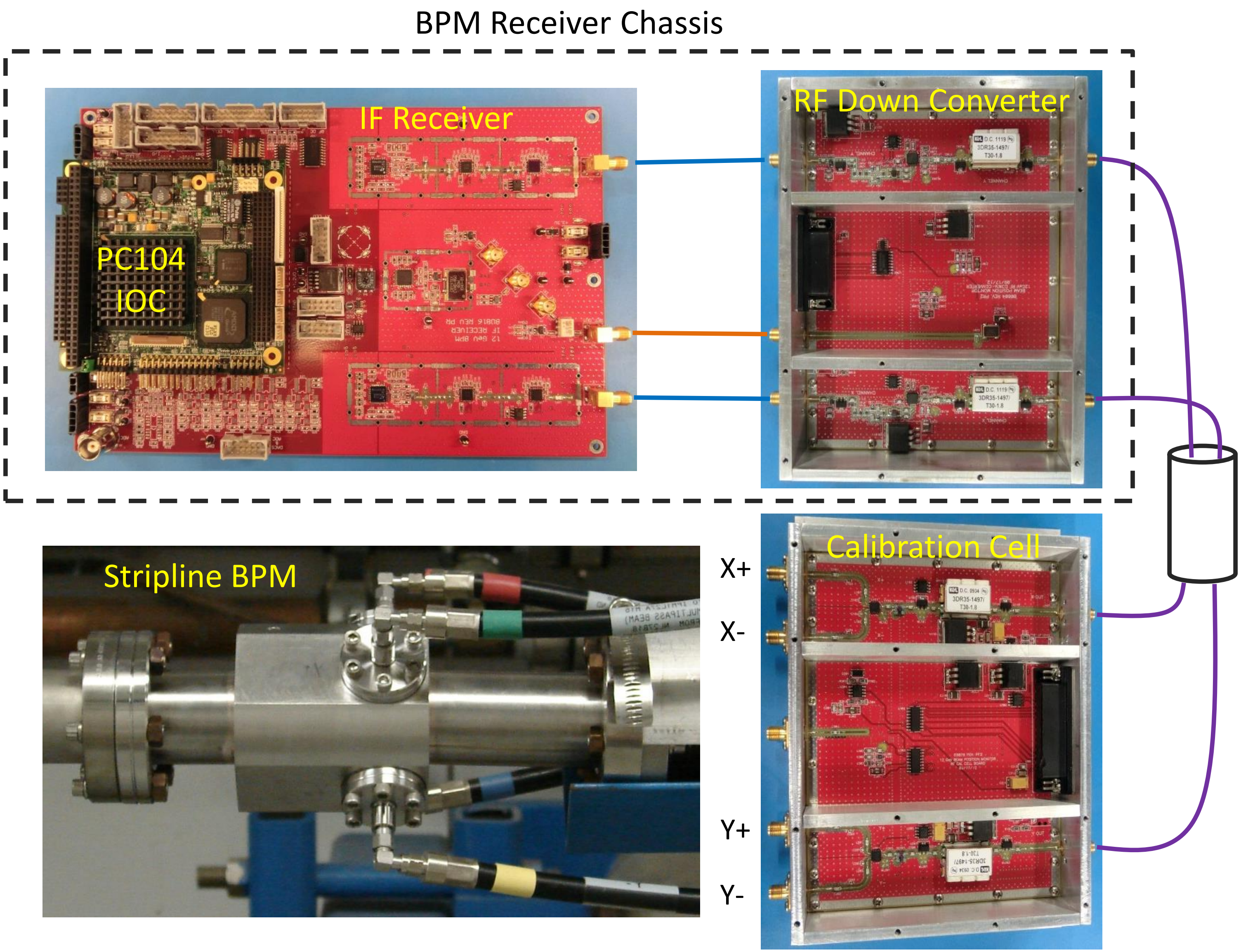




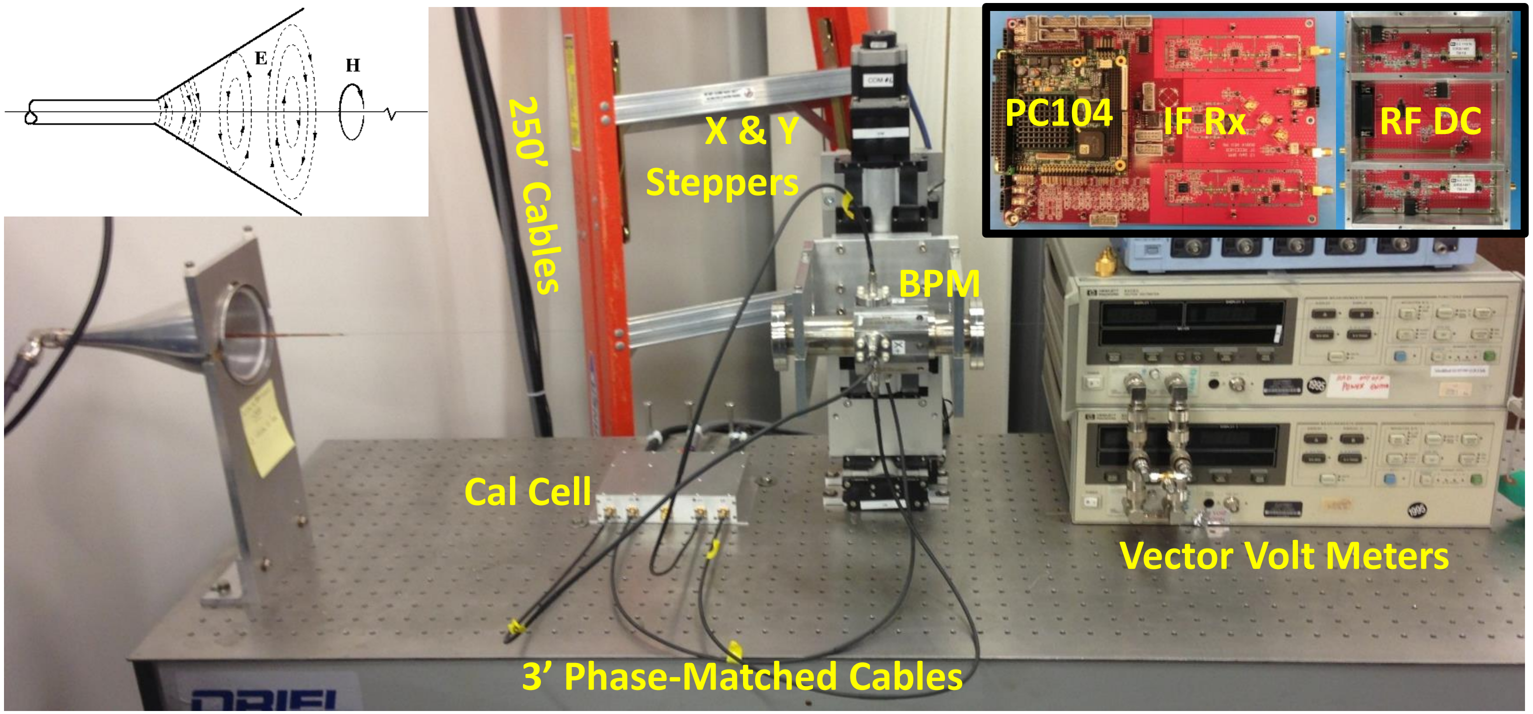
Stripline BPM Electronics



Stripline BPM System Components



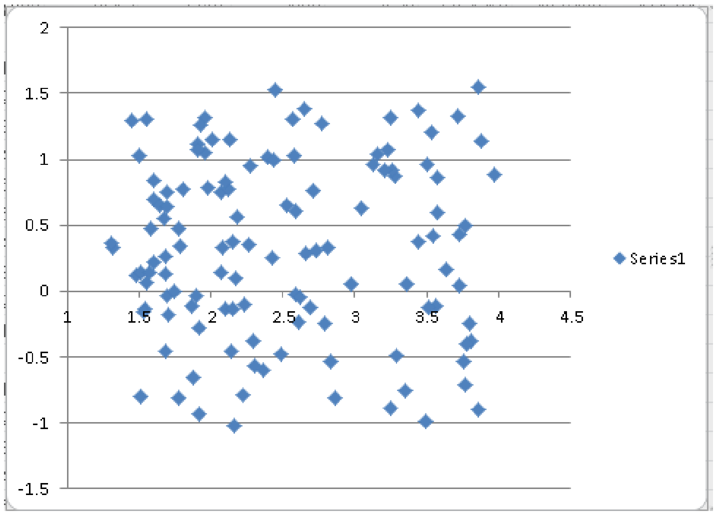
BPM Test Stand



- Goubau Line with Stripline BPM on X and Y stages
- Vector Volt Meters used for BPM characterization
- Calibration Cell & 250' of LMR400 RF/control cables
- RF Down Converter & IF Receiver on another bench

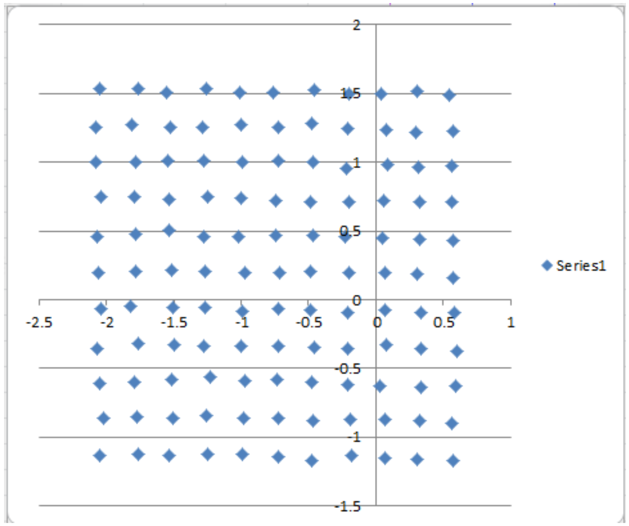
BPM Test Stand Stripline Electronics Testing

~30 nA @ 10 Hz



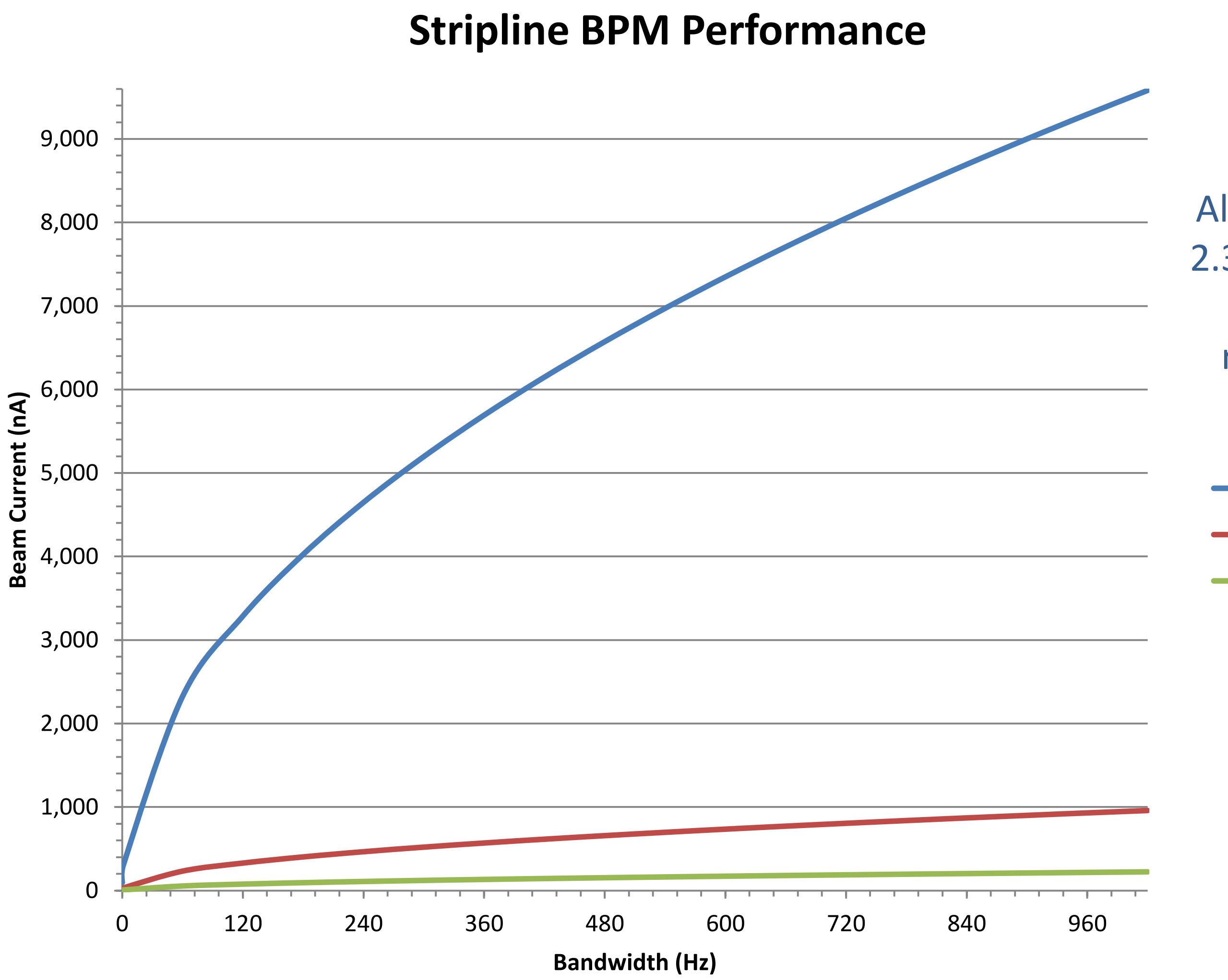
Position map improves by tightening bandwidth

~30 nA @ 1 Hz



- Improving the signal-to-noise improves performance
- Filtering down to 1 Hz instead of 10 Hz gives an improvement factor of about 3.2
- This square root of bandwidth improvement holds true as long as the noise is Gaussian

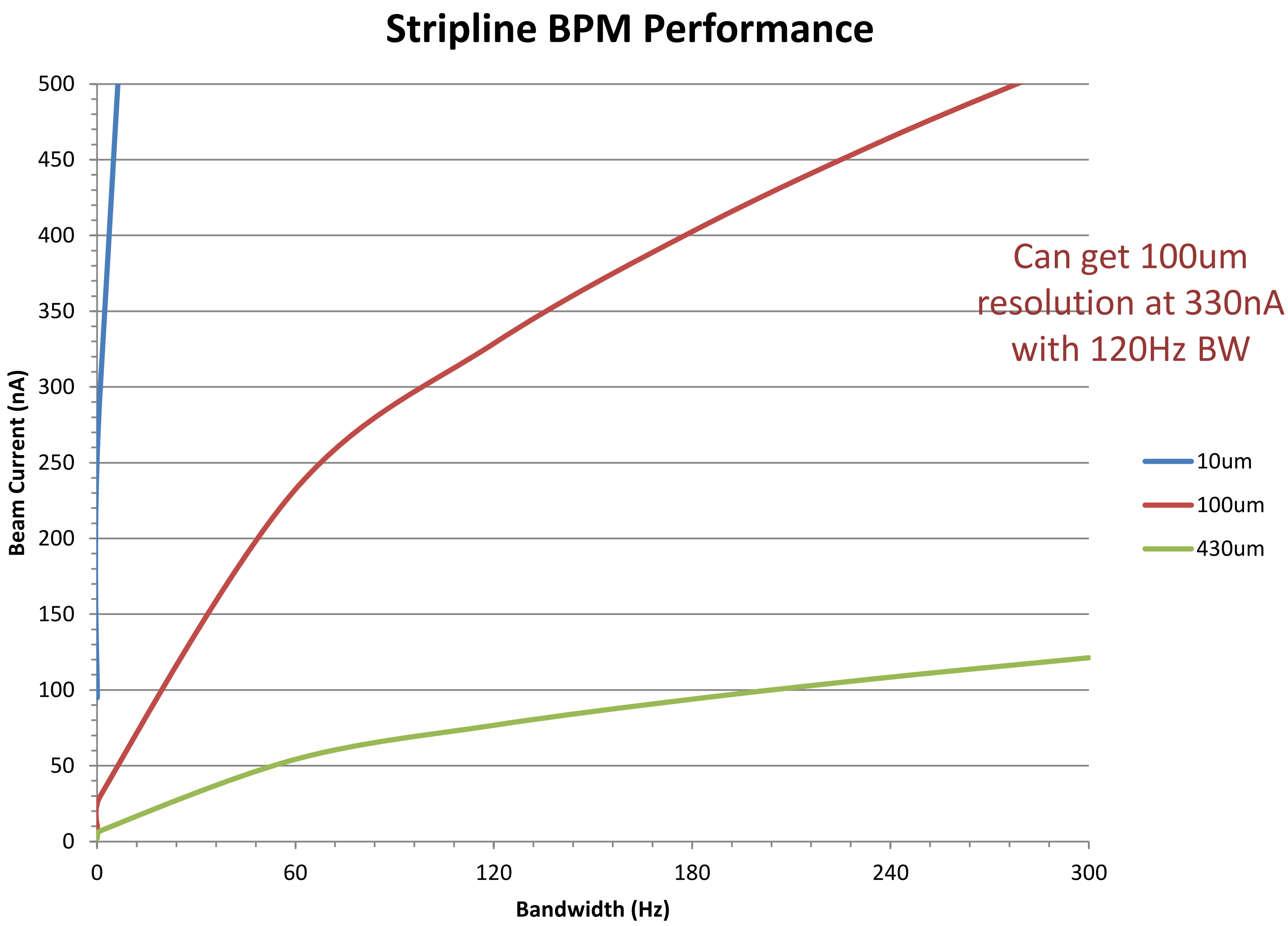
Stripline BPM Performance



Already need 2.3uA at 60Hz for 10um resolution

	10um
BW Hz	Beam nA
0.1	95
1	300
60	2,324
120	3,286
180	4,025
240	4,648
300	5,196
360	5,692
420	6,148
480	6,573
540	6,971
600	7,348
660	7,707
720	8,050
780	8,379
840	8,695
900	9,000
960	9,295
1,020	9,581

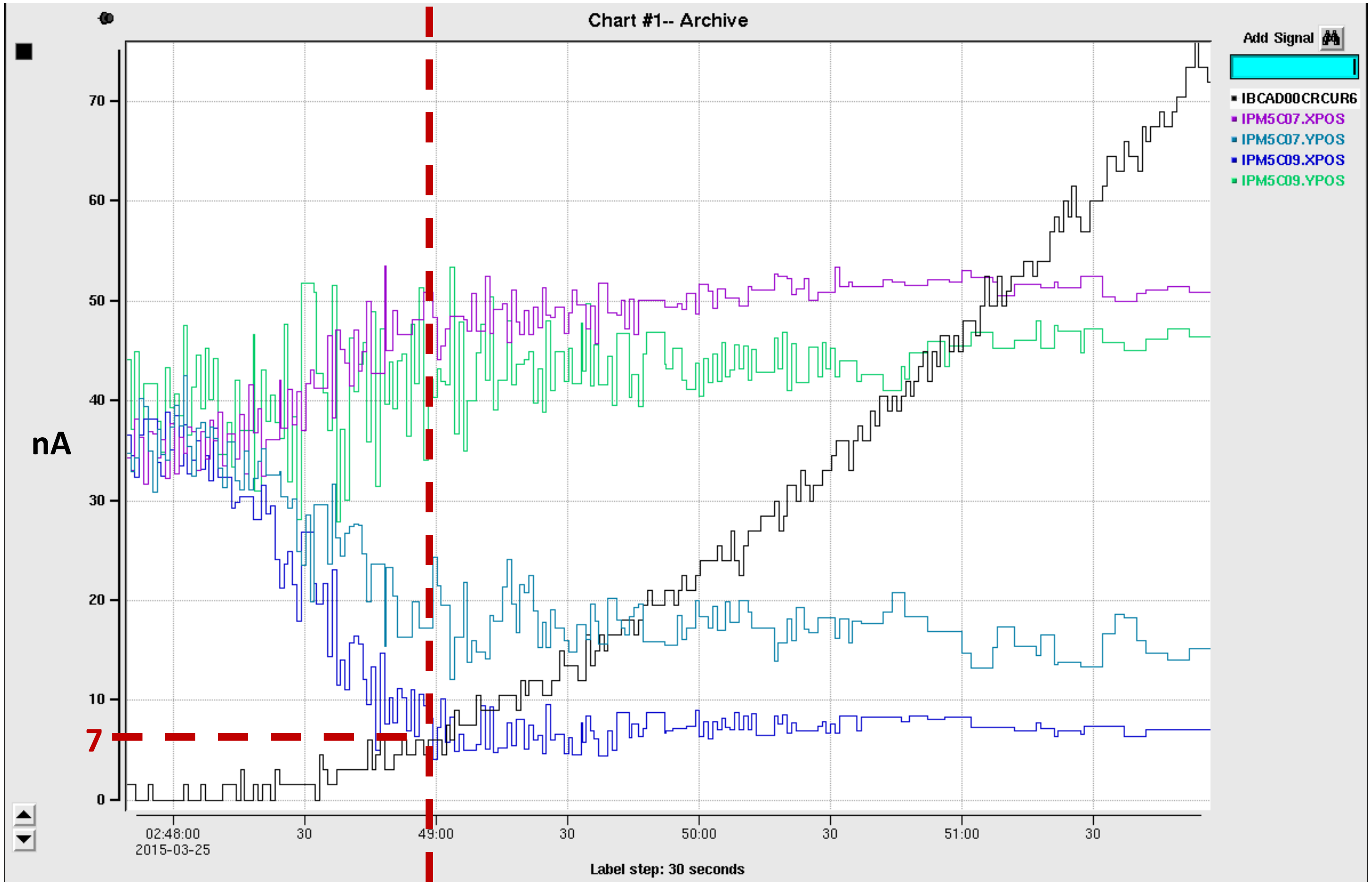
Stripline BPM Performance



Can get 100um resolution at 330nA with 120Hz BW

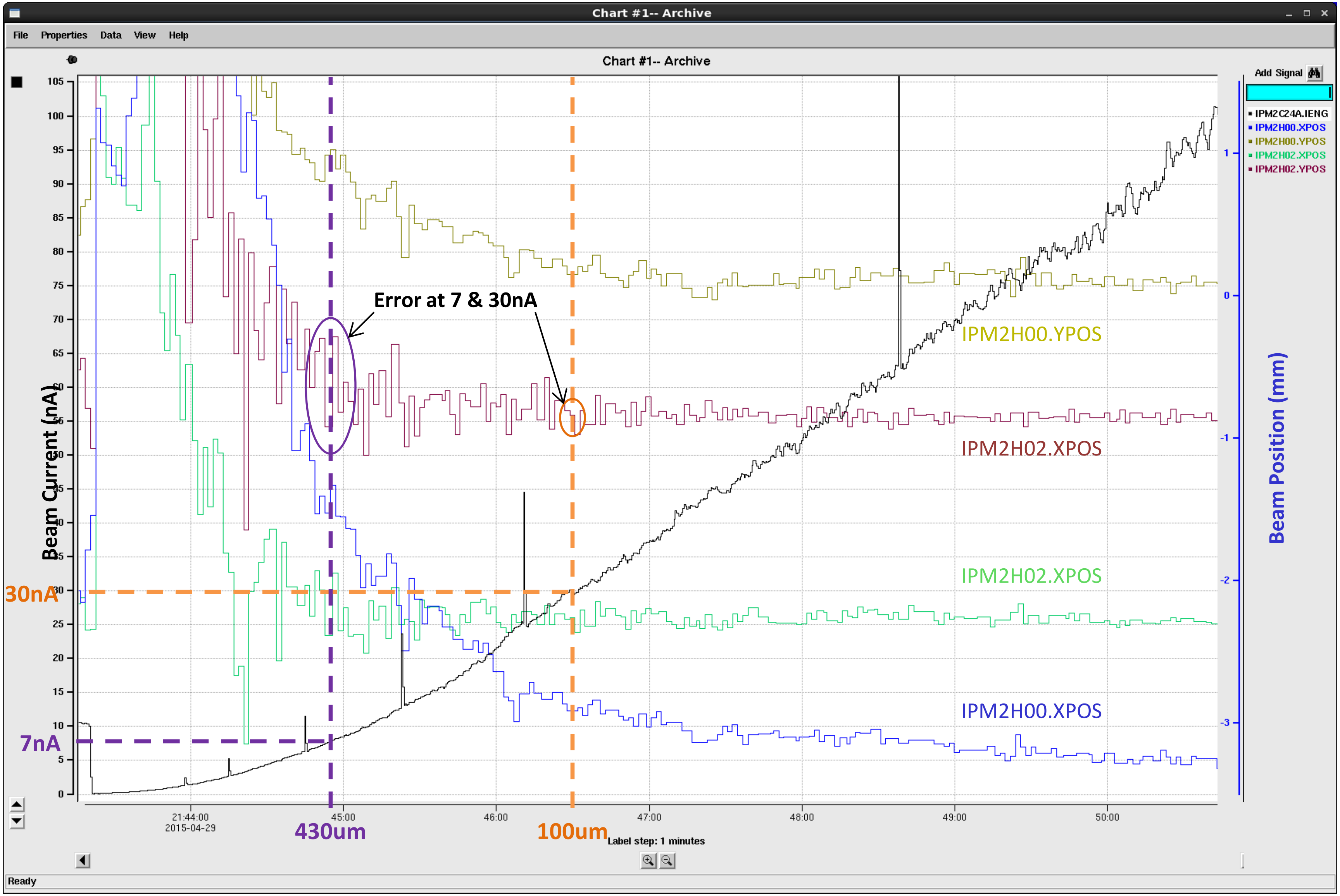
	100um	430um
BW Hz	Beam nA	Beam nA
0.1	9	2
1	30	7
60	232	54
120	329	77
180	402	94
240	465	108
300	520	121
360	569	133
420	615	143
480	657	153
540	697	163
600	735	171
660	771	180
720	805	188
780	838	195
840	869	203
900	900	210
960	930	217
1,020	958	224

Stripline BPM Performance (1Hz)



- The plot shows Hall D current in black ramping from 0 to 75 nA
- The 5C07 and 5C09 BPM positions settle at about 7nA and accuracy improves as the signal-to-noise goes up (bandwidth of ~1Hz)

Stripline BPM Performance (1Hz)

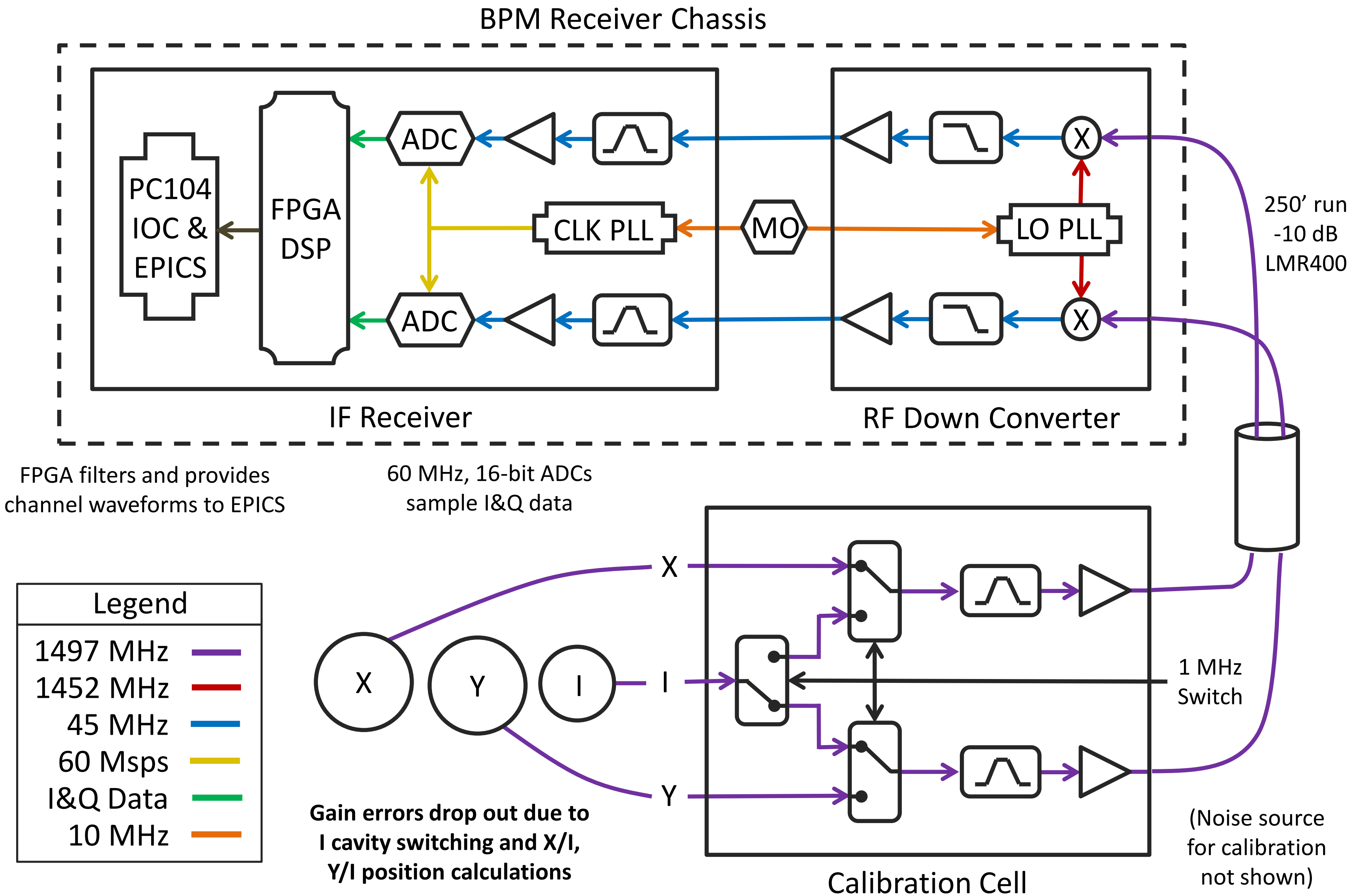


FFB Stripline BPMS

- 330nA @ 120Hz Bandwidth => 100um resolution
- 330nA @ 1kHz Bandwidth => 290um resolution

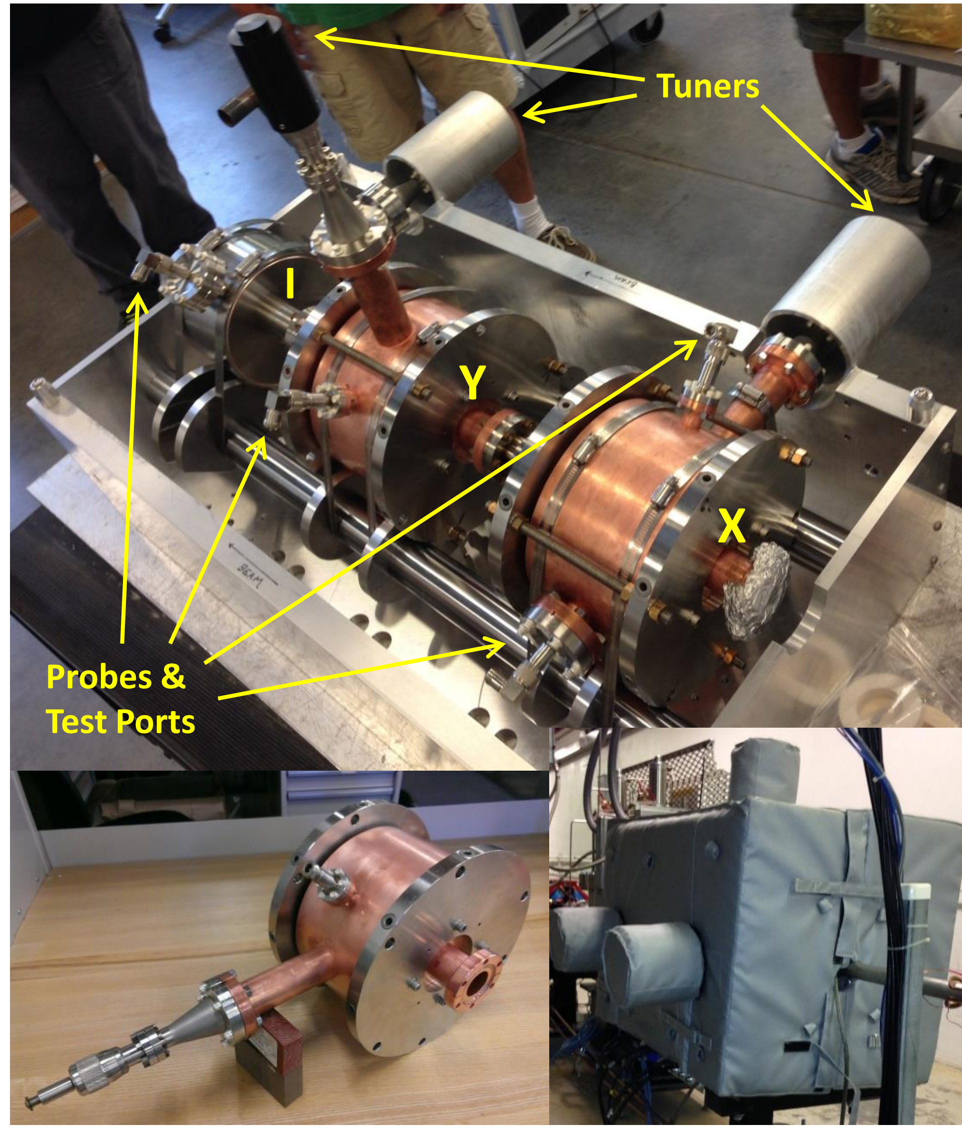
- 33nA @ 120Hz Bandwidth => 1mm resolution
- 33nA @ 1kHz Bandwidth => 2.9mm resolution

Cavity BPM Electronics



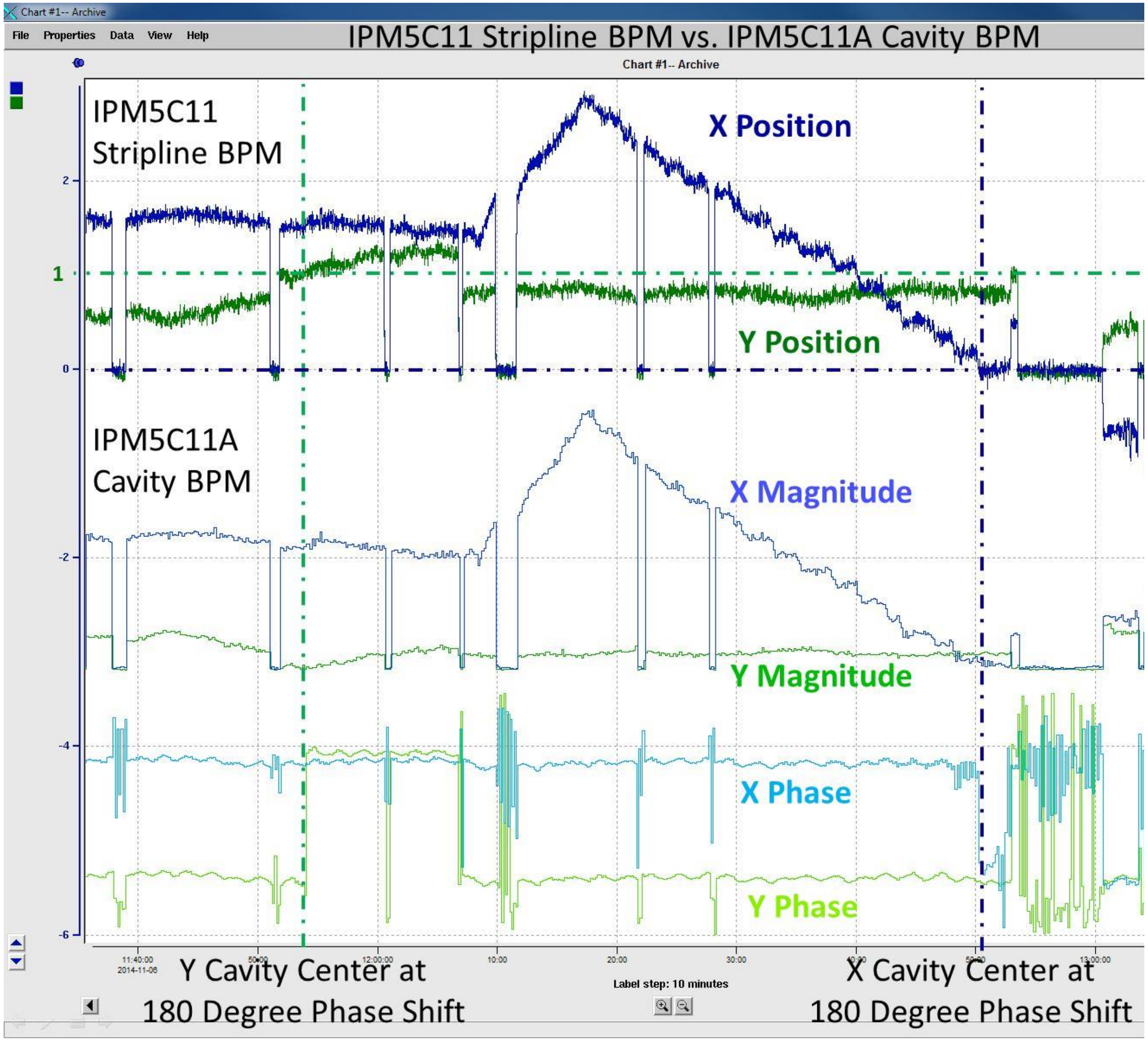
Cavity Beam Position Monitors

- Electromagnetic field excited by beam
  - TM_{110} Mode
  - Probe antenna picks up field
  - Test also used to excite field
  - Copper coated to increase Q
- Tuning port for centering at 1497MHz
  - Annually/vacuum broken
  - Temperature stabilized
- 1497 MHz Probe signals get down converted
- Positions go as X/I and Y/I
- IPM5C11A & IPM5C11C



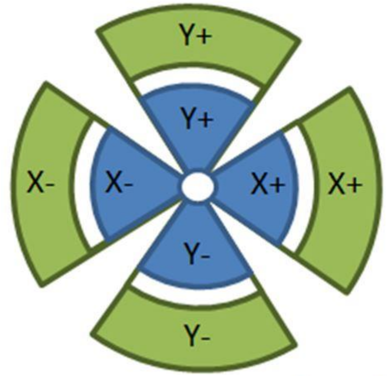
Cavity BPM Testing

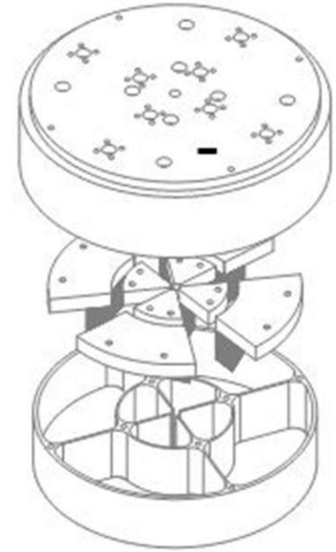
- Behaves as expected vs. Stripline BPM
- Signal goes to zero at cavity center
  - Phase shifts 180 degrees
  - Phase used to determine sign of position
- More commissioning time needed
- Aim to have valid positions down to 100pA beam currents at 1Hz

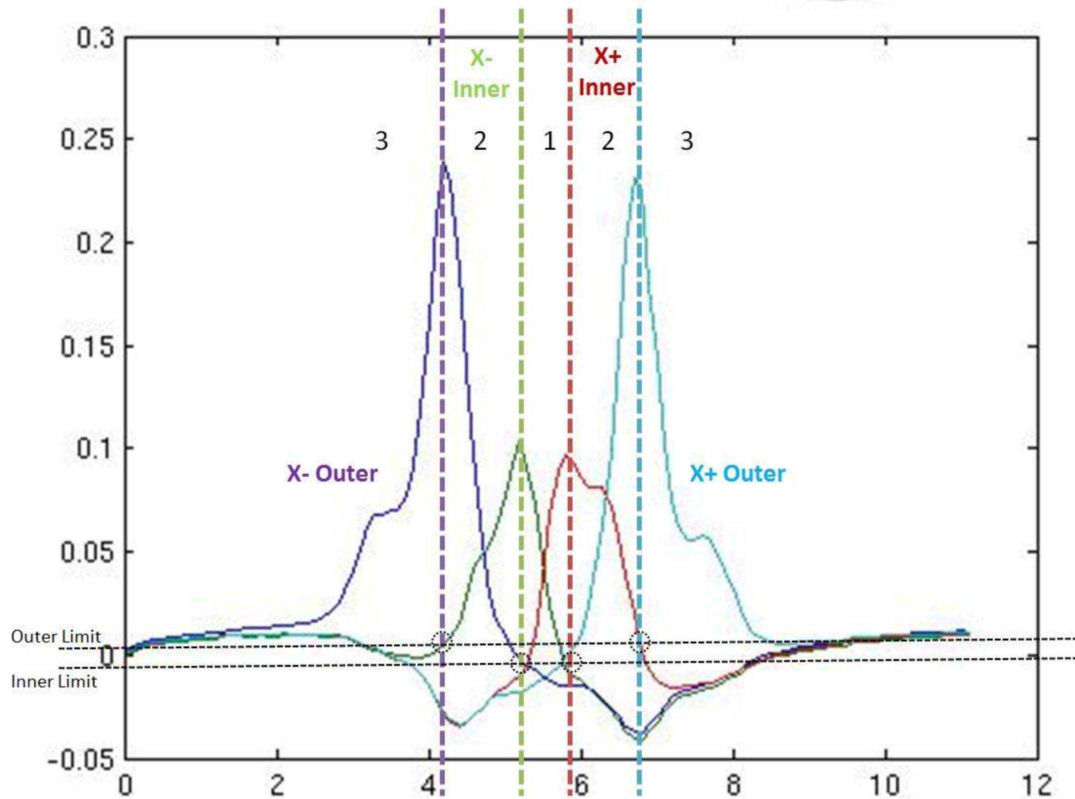


Active Collimator

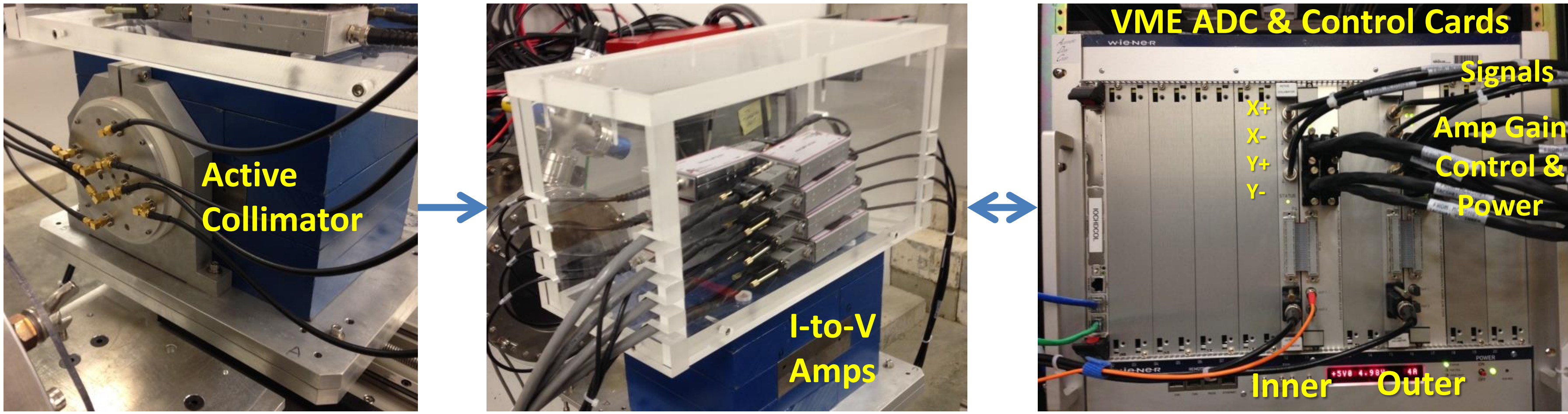
- Richard Jones design
  - Tungsten pin-cushion wedges
  - Intercepts photon beam
  - Current output
- Difference-over-sum can be used on inner wedges when close to center (region 1 on the plot)



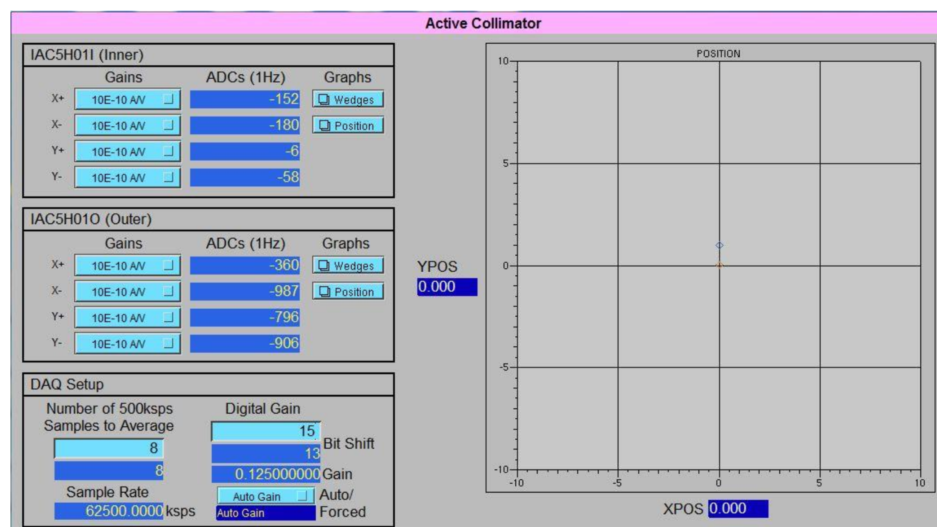




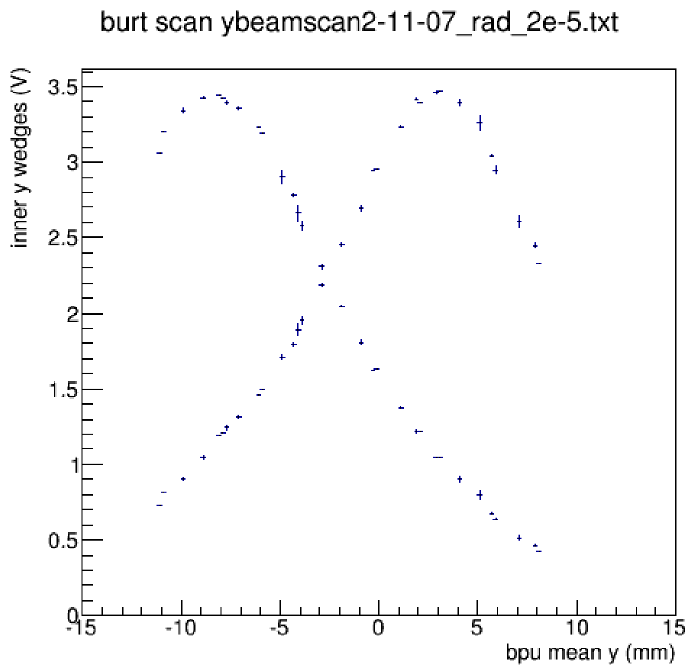
Active Collimator Electronics



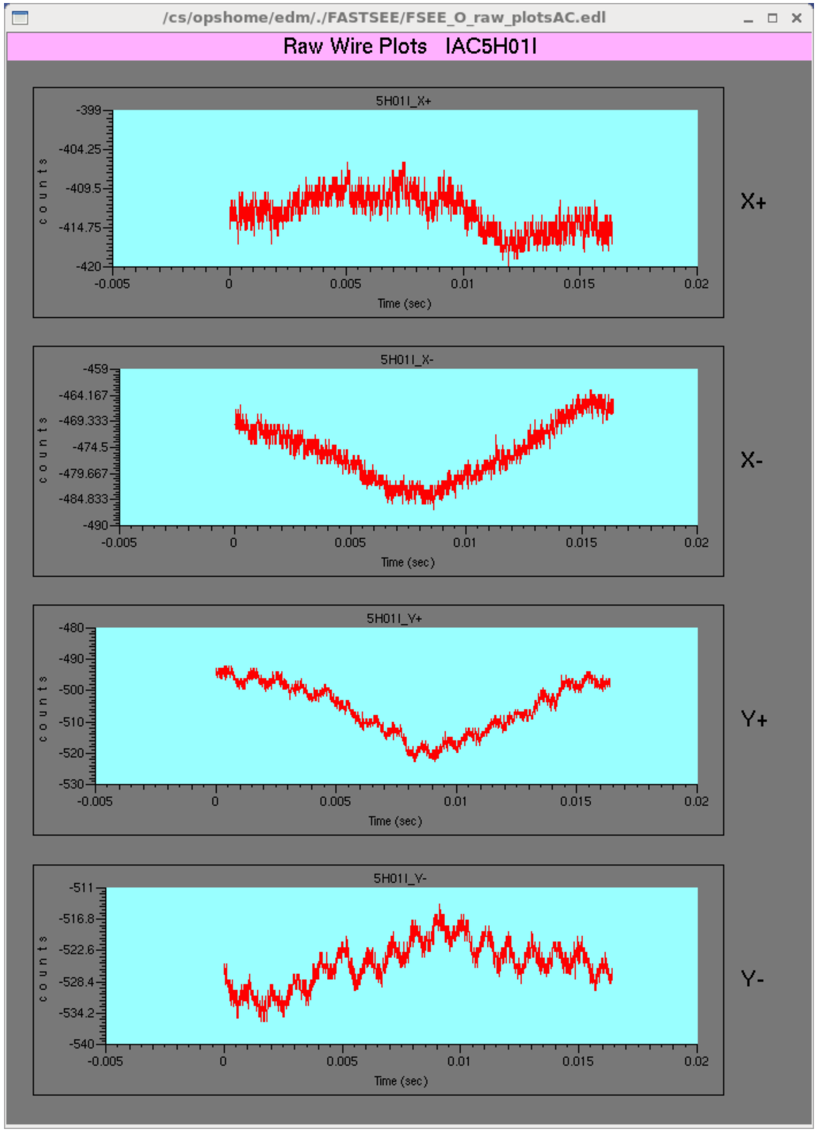
Active Collimator outputs go to adjustable gain I-to-V amplifiers then VME ADC/control boards



Active Collimator Testing



- Performs well, data above taken using X-stage to move through beam
- Hall D takes raw EPICS data and is calculating positions
- Engineering/Ops is also displaying waveforms, diff/sum positions and will soon have FFTs available



FFB Questions

- Adjustable bandwidth for feedback DSP chain?
  - Set it for 120Hz (100um @ 300nA)
- Separate Feedforward DSP chain?
  - Bandwidth?
  - Adjustable?
- What beam currents do we want to target?
- Cavity BPMs?