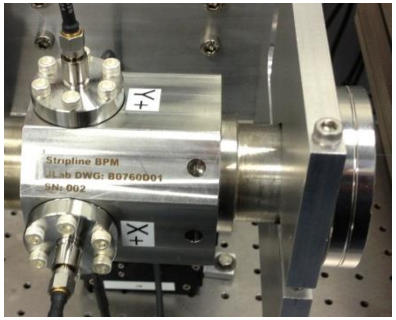
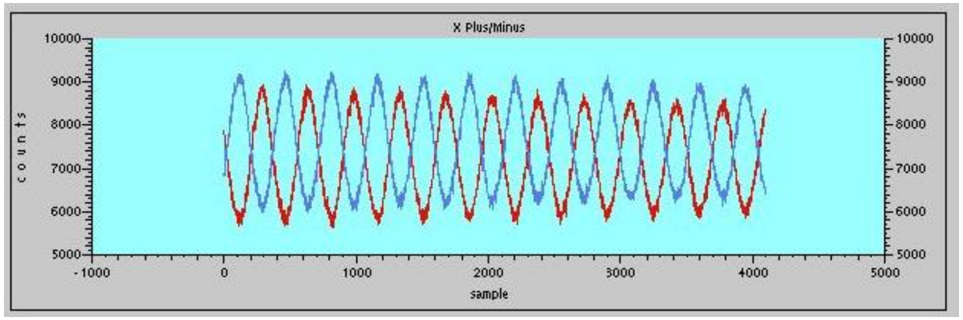
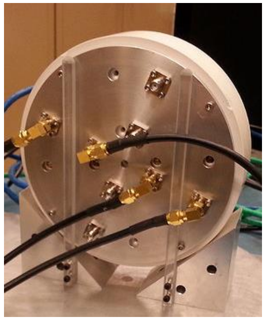
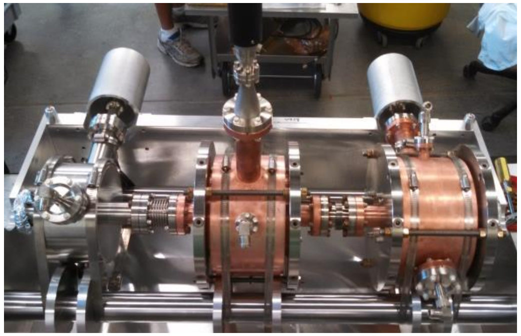


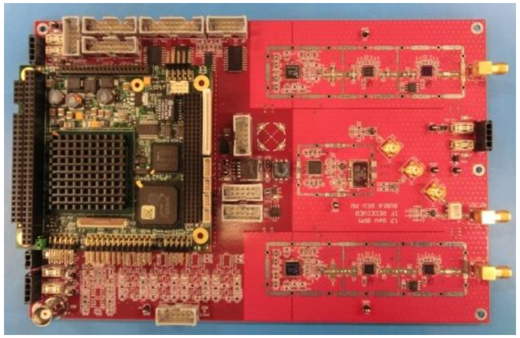




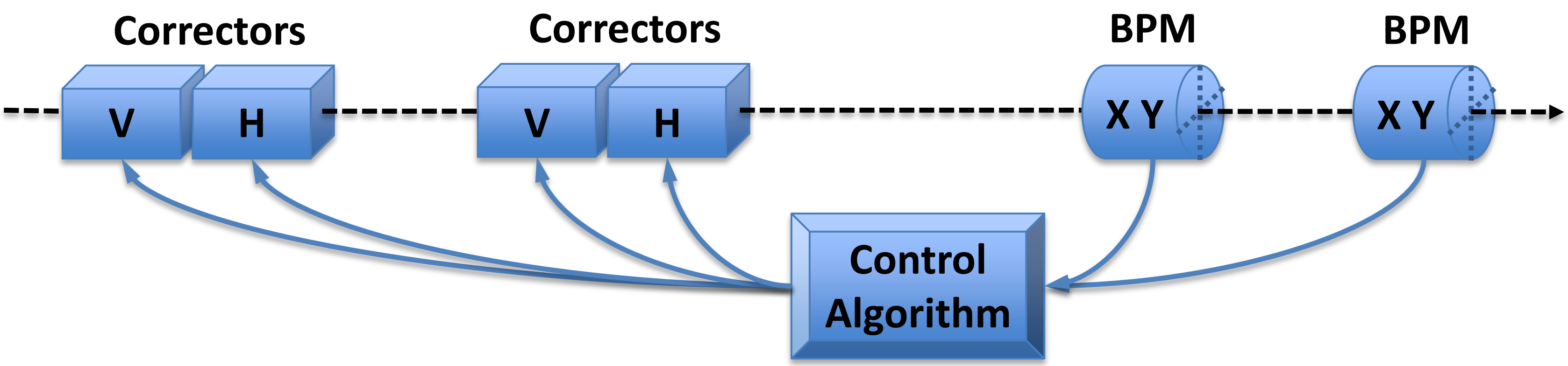
Hall D Fast Feedback



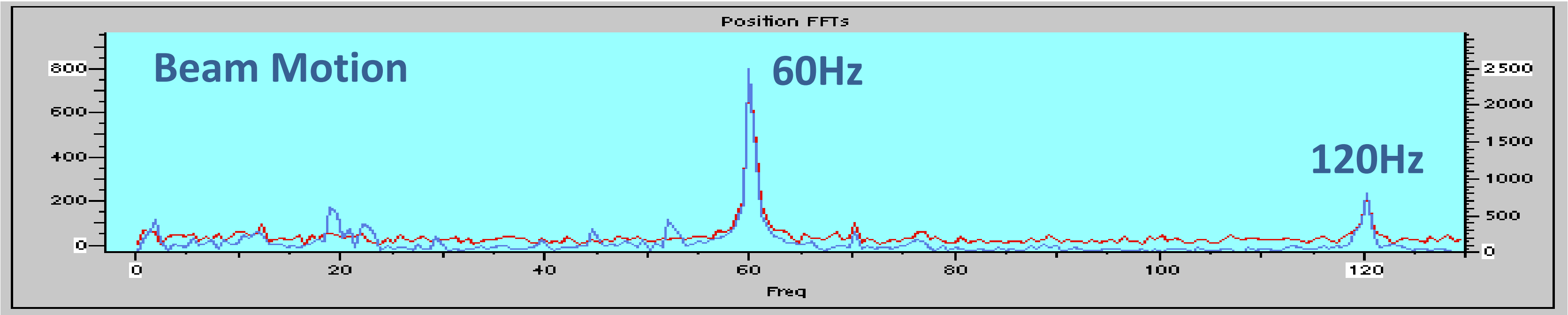
Trent Allison
Ops StayTreat
2015



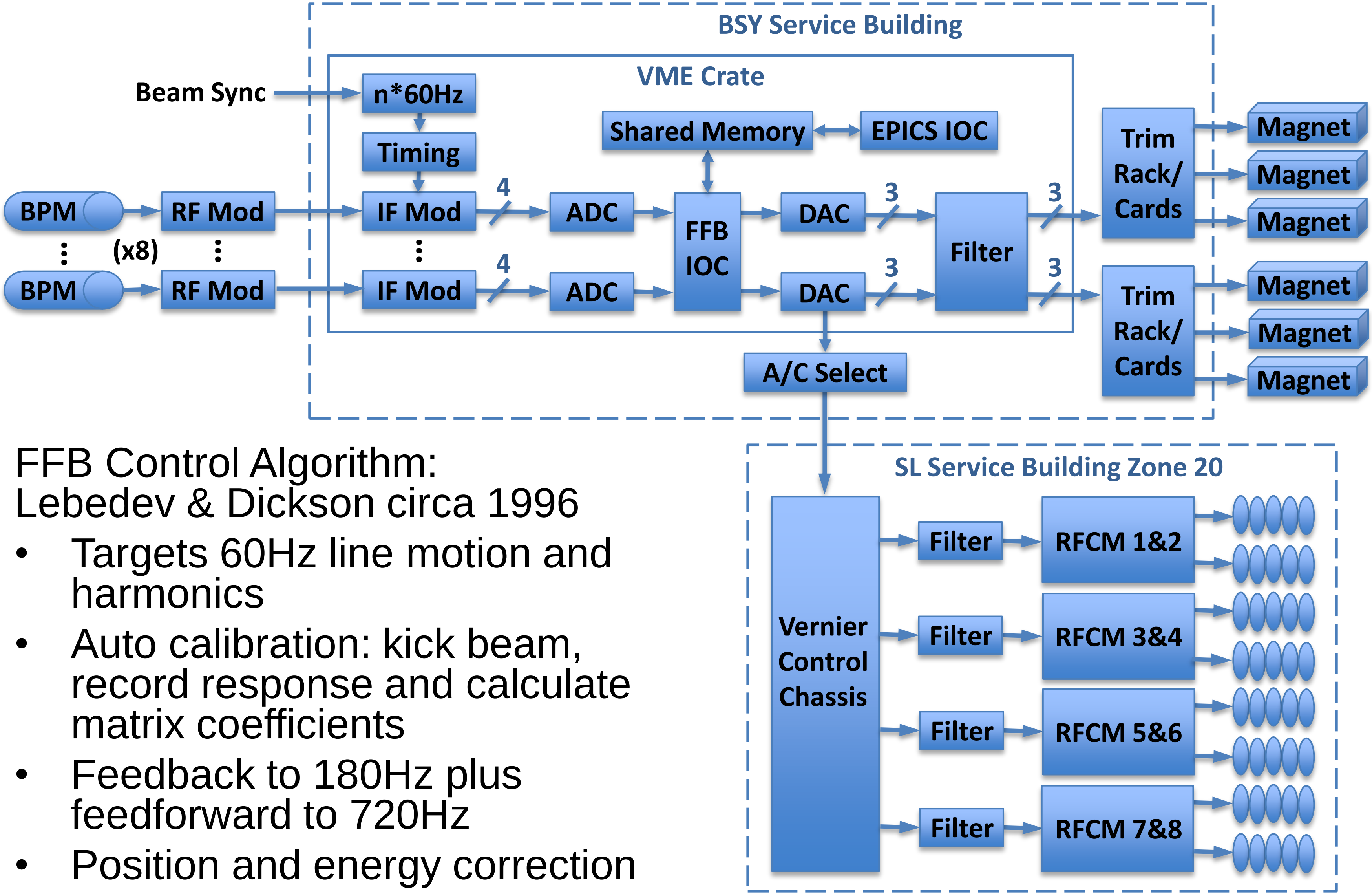
Hall D FFB Overview



- Data from 2 BPMs used to control 2 sets of correctors
  - Locking position at 1 point does not stabilize the trajectory or downstream position, 2 points are needed
  - Element locations are selected based on the optics
- Main goal is to compensate for 60Hz line motion



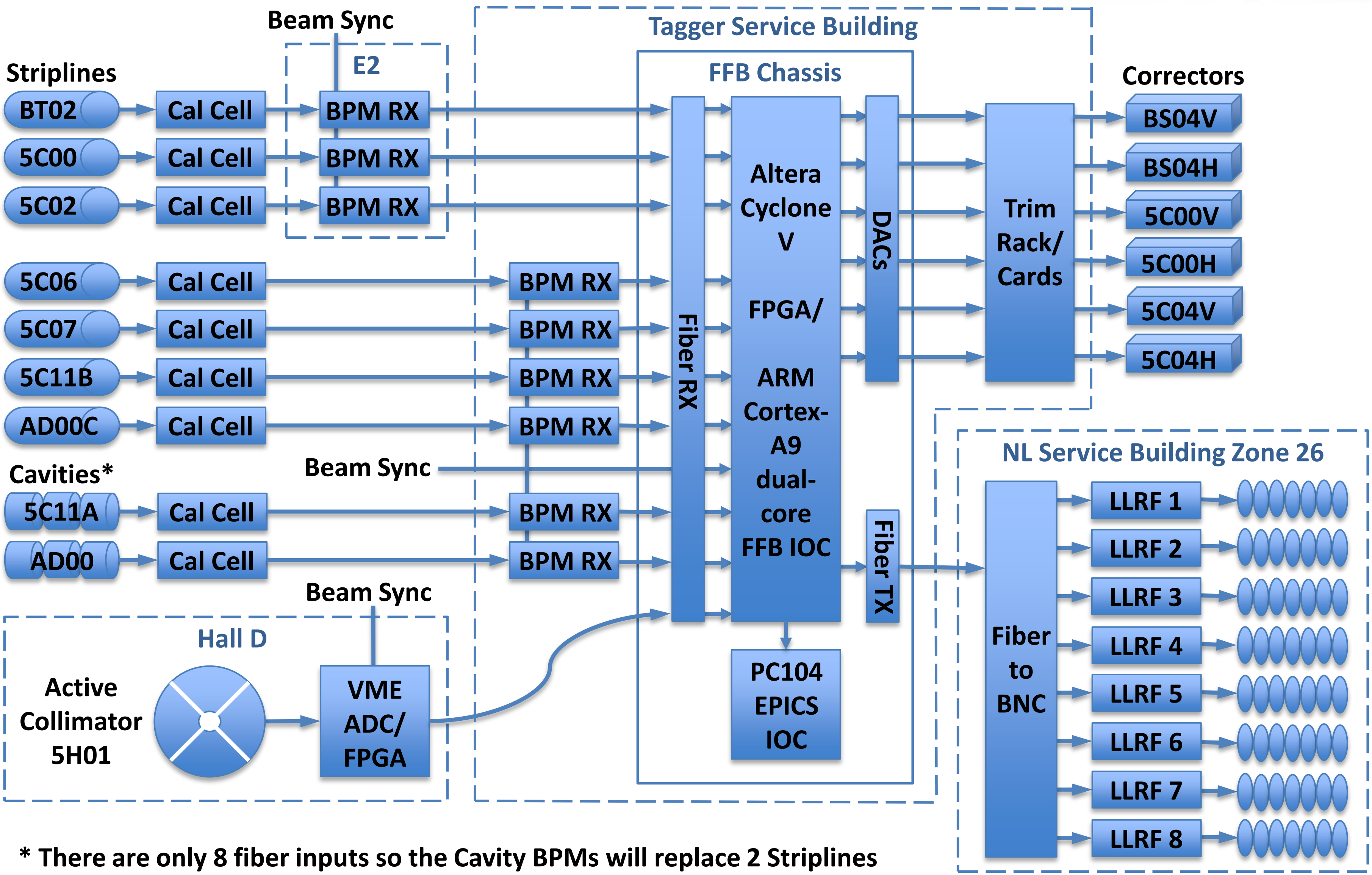
Based on Halls A & C FFB



FFB Control Algorithm:
Lebedev & Dickson circa 1996

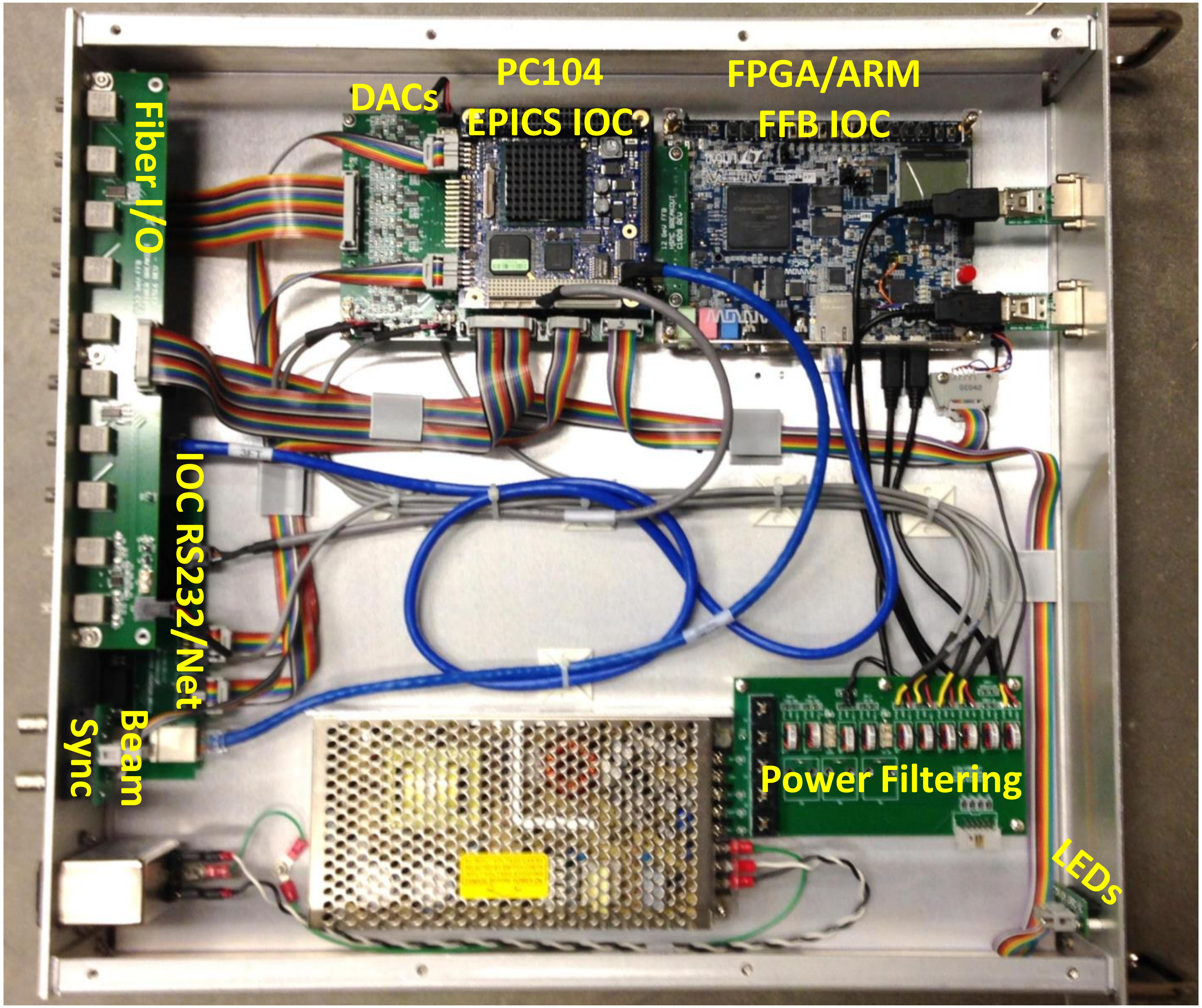
- Targets 60Hz line motion and harmonics
- Auto calibration: kick beam, record response and calculate matrix coefficients
- Feedback to 180Hz plus feedforward to 720Hz
- Position and energy correction

Hall D FFB



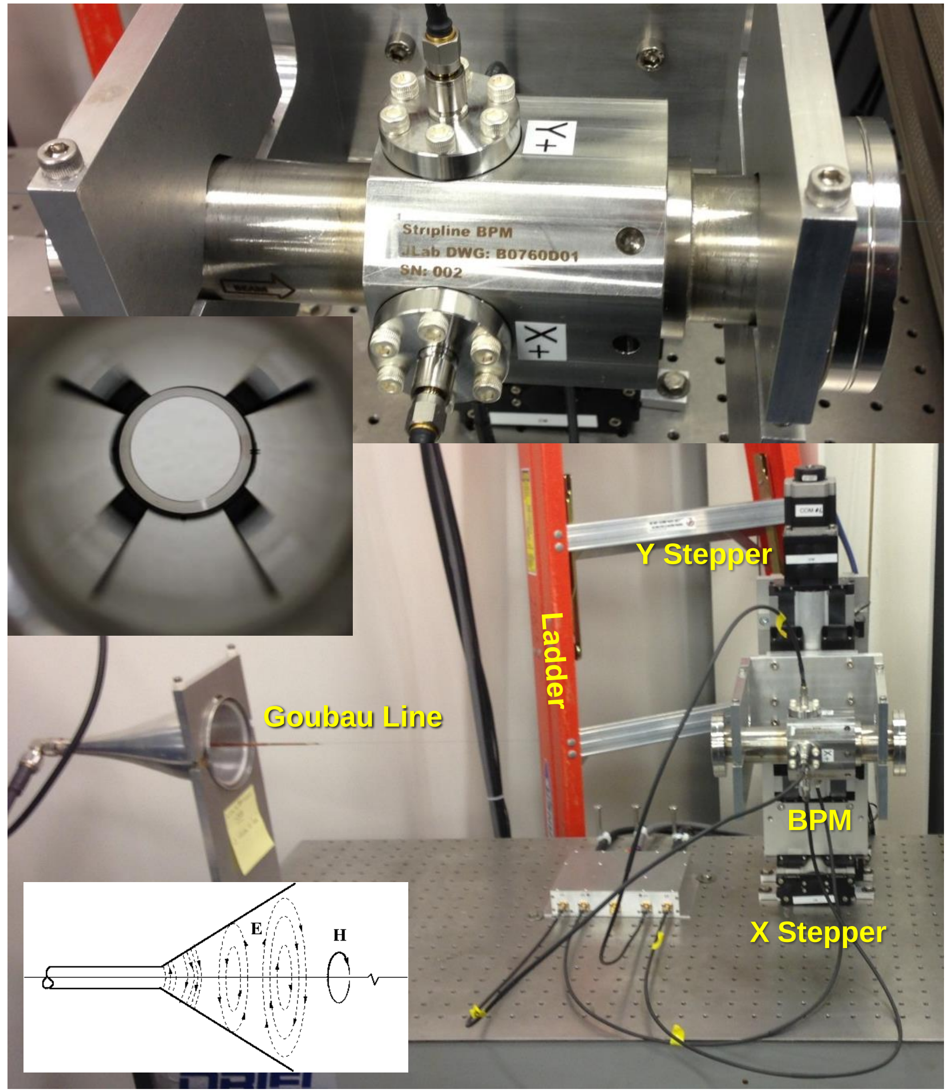
* There are only 8 fiber inputs so the Cavity BPMs will replace 2 Striplines

Hall D FFB Chassis



Stripline BPMs

- Used instead of M15 antenna BPMs
  - Easier & more precise manufacturing
  - No hand bending of antennas
  - Better sensitivity
  - 50 ohm devices
- Position calculated as difference-over-sum
- Each characterized with Goubau Line BPM Test Stand

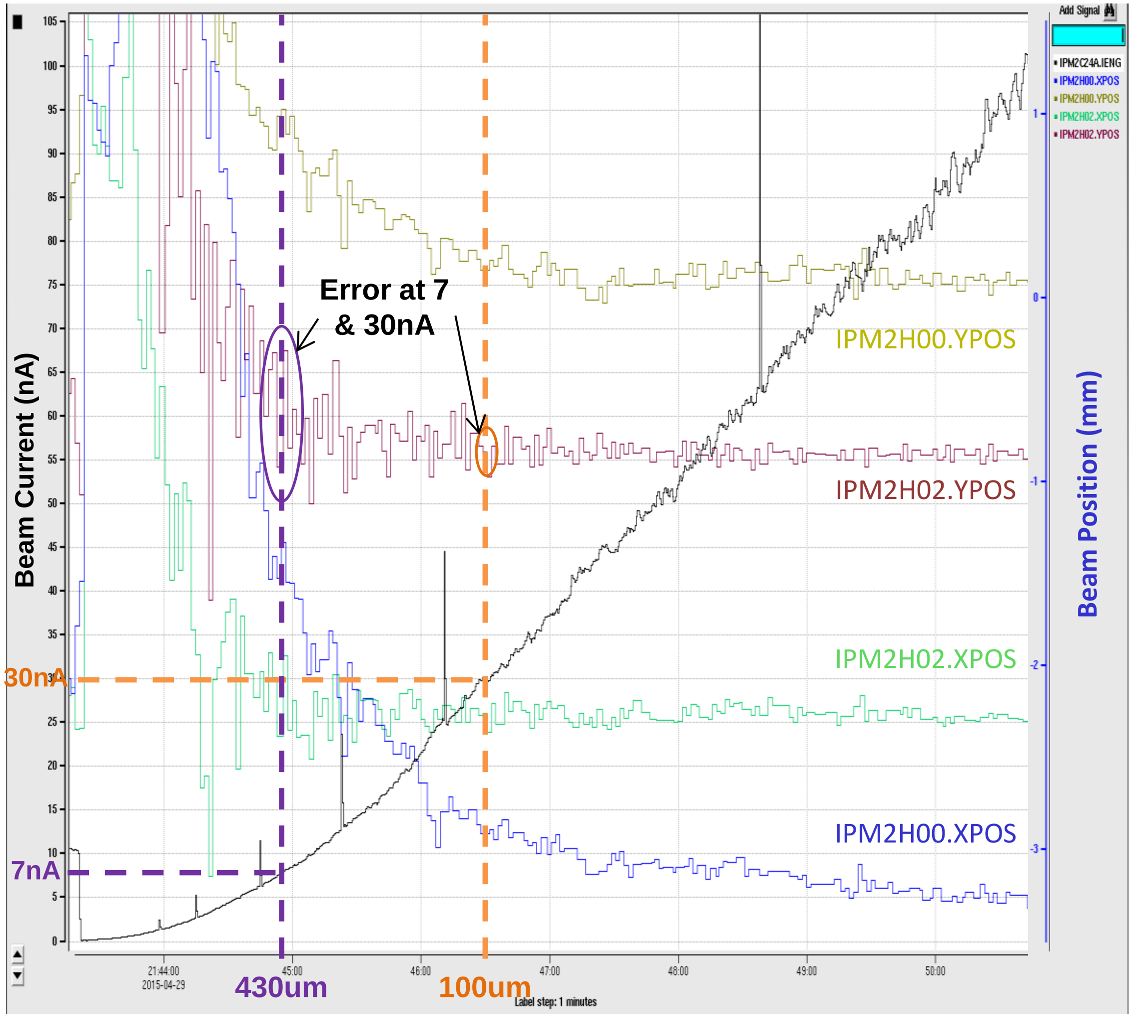


<u>26 Striplines</u>

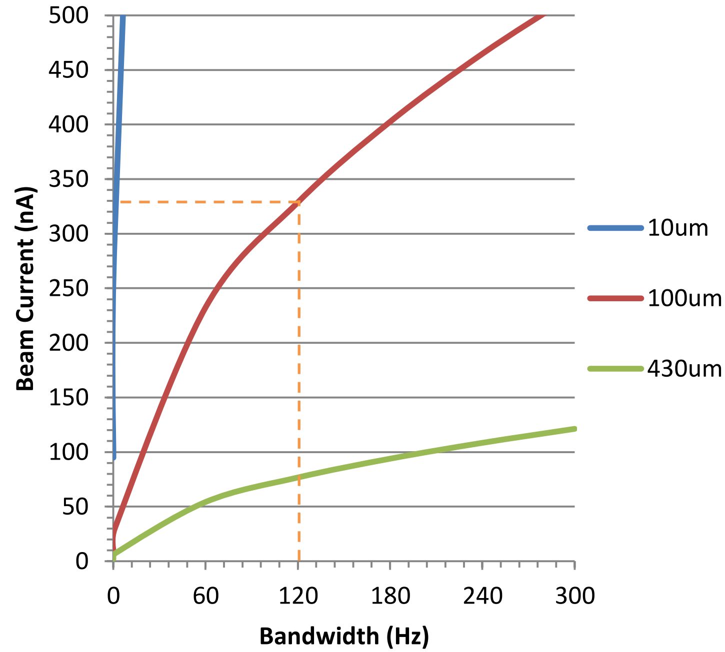
IPMBS00
IPMBS01
IPMBS02
IPMBS03
IPMBS04
IPMBE01
IPMBE02
IPMBE03
IPMBE04
IPMBT01
IPMBT02
IPMBT03
IPM5C00
IPM5C01
IPM5C02
IPM5C03
IPM5C04
IPM5C05
IPM5C06
IPM5C07
IPM5C08
IPM5C09
IPM5C10
IPM5C11
IPM5C11B
IPMAD00C

Stripline Bandwidth vs Resolution

Current Ramp from 0 to 100nA with 1Hz Bandwidth



Stripline BPM Performance

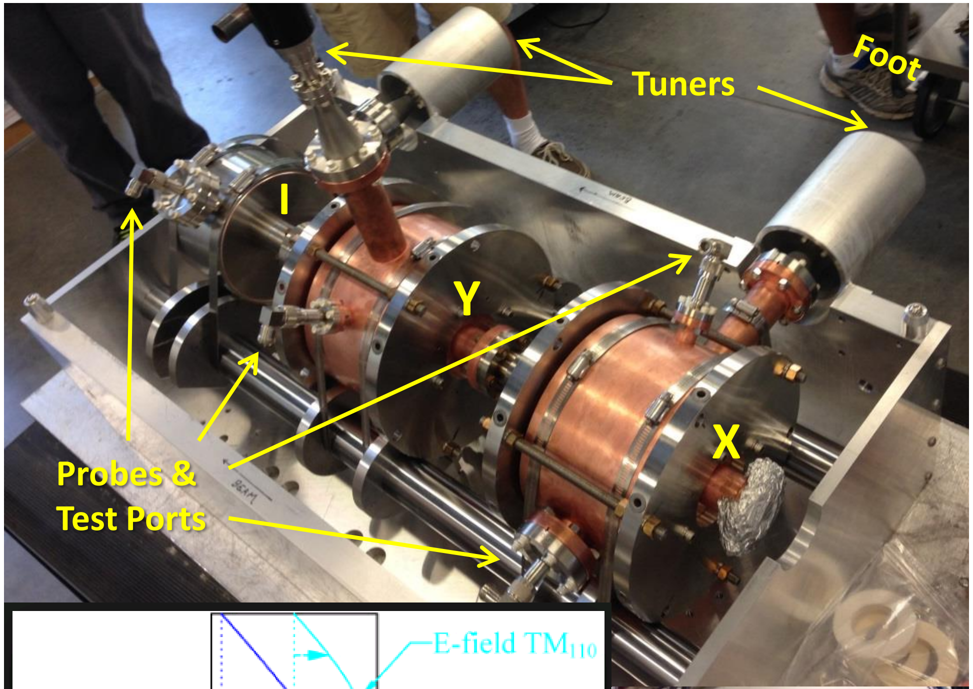


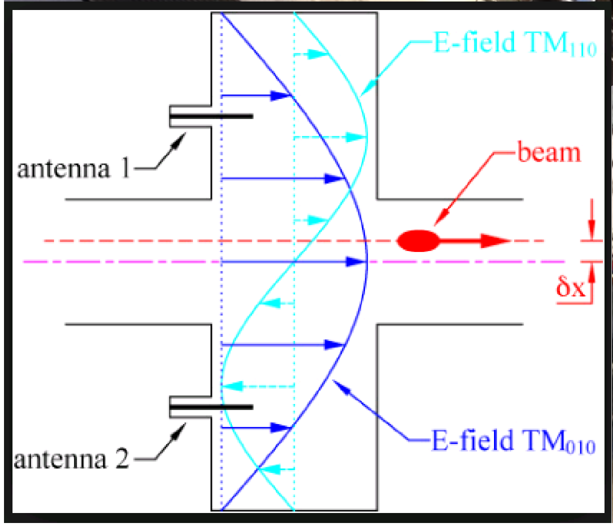
100um resolution at 330nA with 120Hz BW

	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

Cavity BPMs

- IPM5C11A at shield wall, IPMAD00 at Goniometer
- Positions go as X/I & Y/I
- Electromagnetic field excited by beam
  - BCM: TM_{010} Mode
  - BPM: TM_{110} Mode
    - Signal disappears at boresight
- Tuning port for centering at 1497MHz
  - Temperature stabilized
- Better sensitivity than Striplines

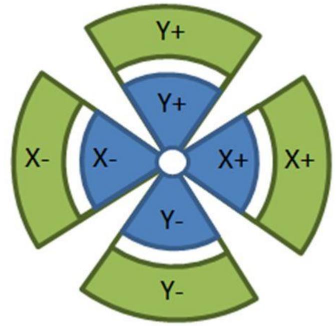


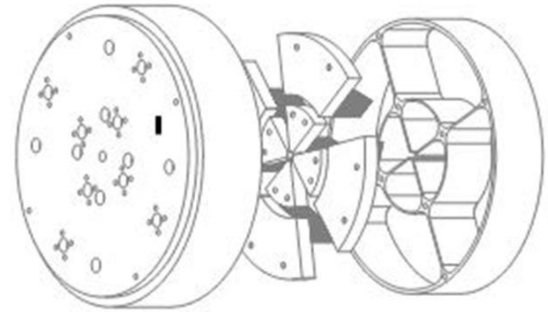


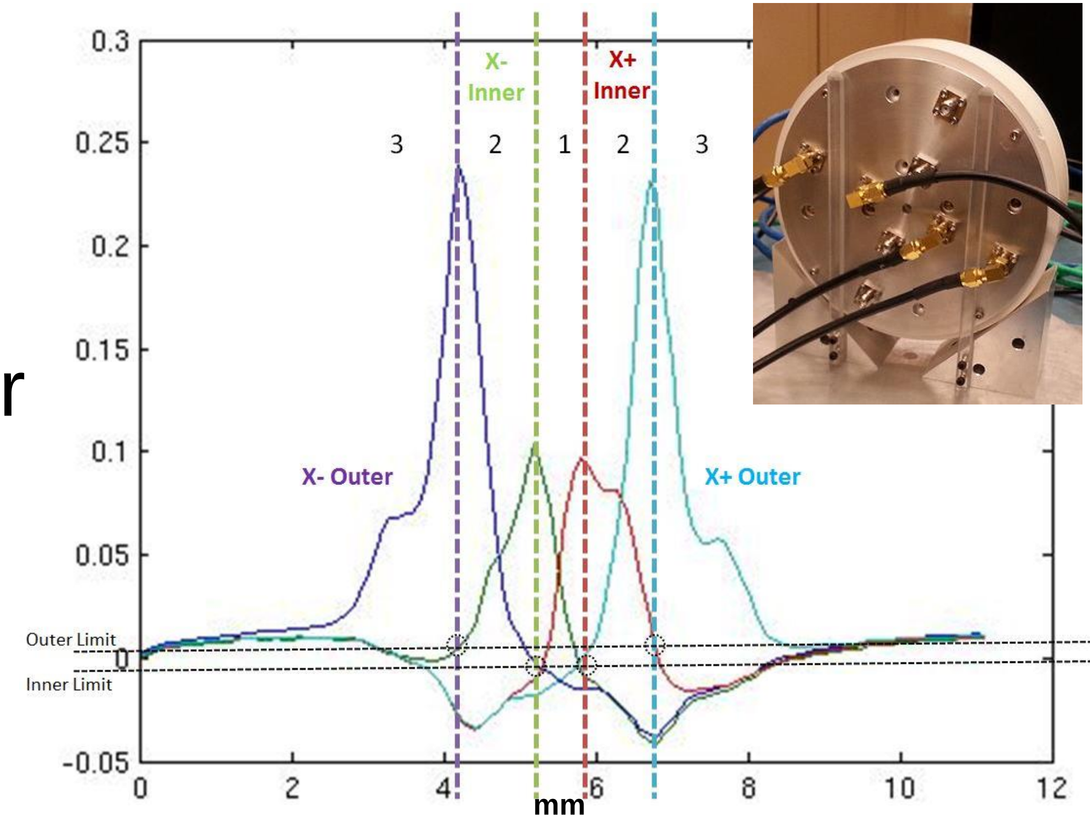
Jefferson Lab

Active Collimator

- IPC5H01 in Hall D Alcove
- Intercepts photon beam
  - Tungsten pin-cushion wedges
  - Current output
- Difference-over-sum used on inner wedges for FFB (region 1)
- Works at low beam currents

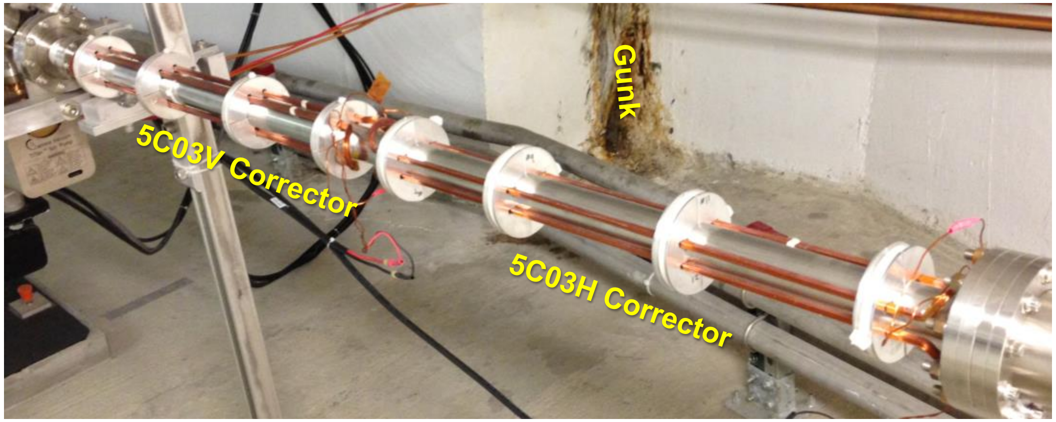






Hall D FFB Algorithm

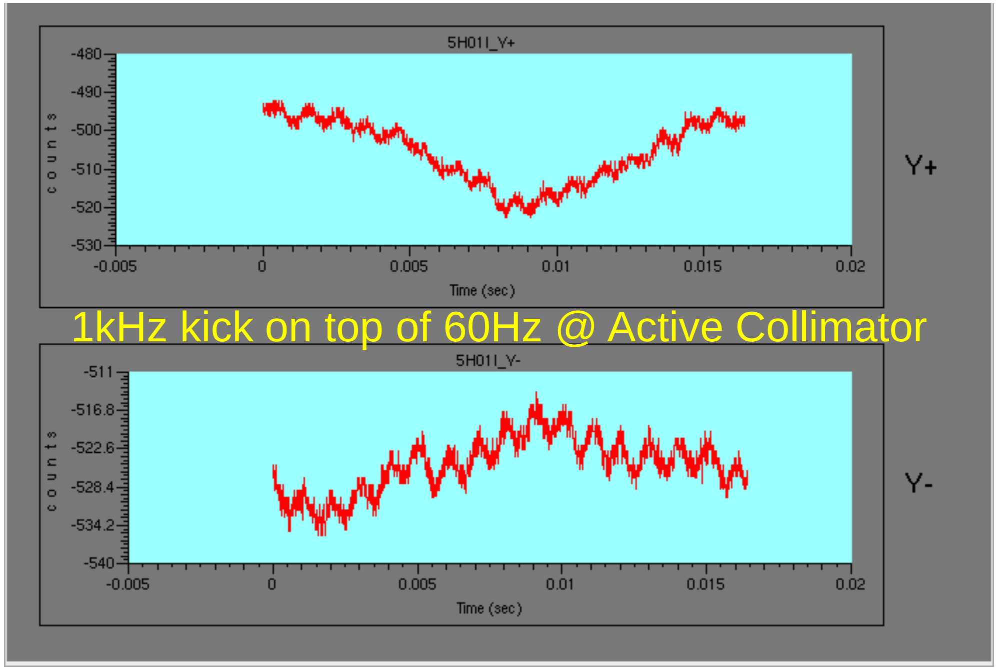
- Correctors up to 1kHz
- Hall A&C FFB @ 10uA
  - Hall D: 5nA to 500nA
  - SEE: 20um @10uA
  - Striplines: 100um @ 330nA/120Hz BW
  - Use Cavity BPMs & Active Collimator for lower currents



- Plan A: Hall A&C style feedback and feedforward
  - 1.8ksps data & DACs (due to hardware limitations in A&C)
- Plan B: High bandwidth feedback (no feedforward)
  - Take advantage of 30ksps fiber data and 1MHz DACs
  - Must have low latency and good signal-to-noise
- Plan C: 60Hz line-locked feedforward only (last run)

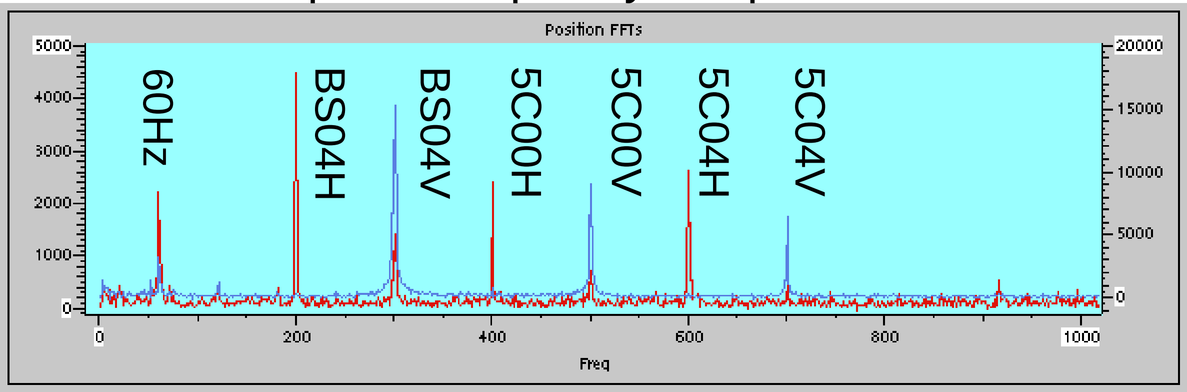
Hardware Testing

- Hardware was verified using beam
  - Fiber data to FFB
  - Magnet controls
- Magnet locations mapped correctly
- Good response at 5.5GeV with headroom for 12GeV



Active Collimator plot of time domain response to 1kHz FFB magnet kick at BS04V

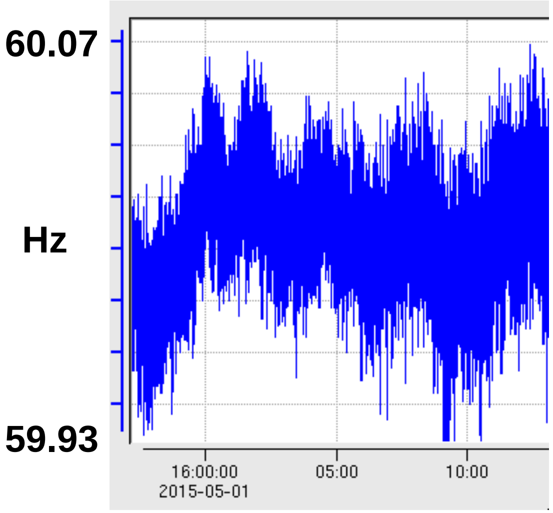
IPM5C07 Stripline Frequency Response

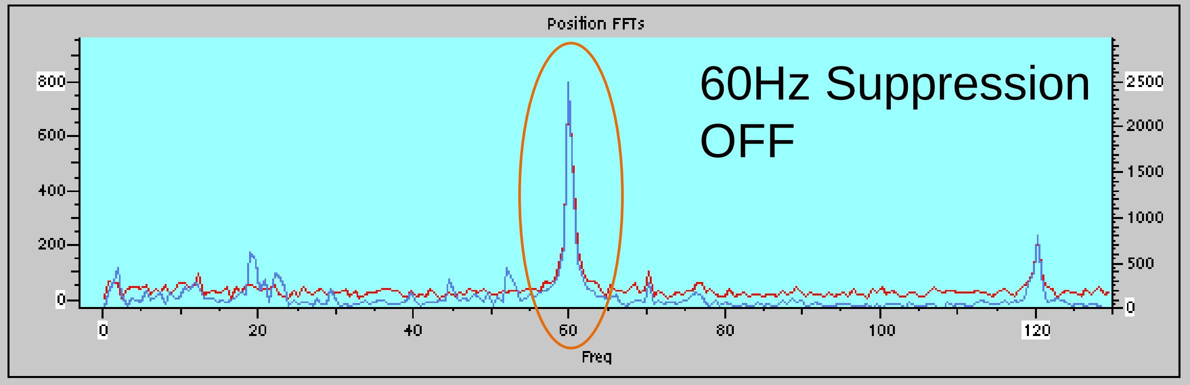


60Hz Suppression (Plan C)

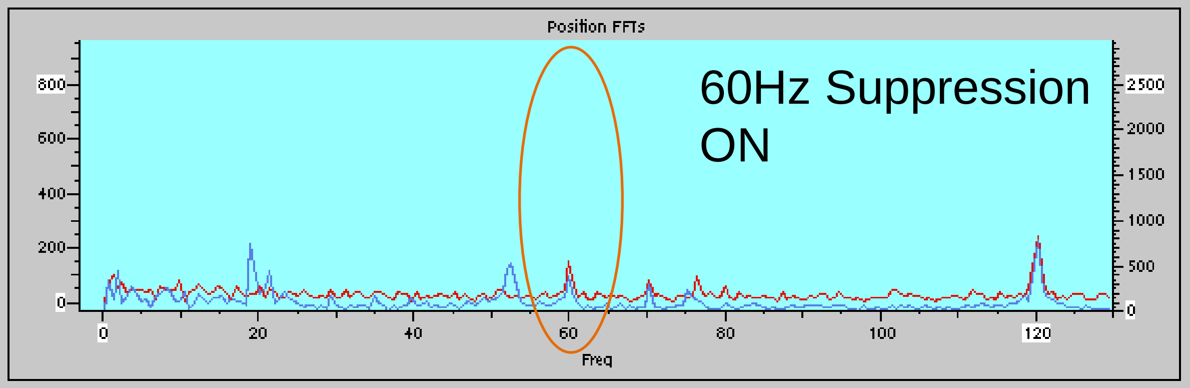
- Line-synchronized 60Hz Feedforward suppression algorithm used last 2 days of the run
- Also engaged slow EPICS position locks to steady the beam

60Hz Line Frequency Wanders ~0.14Hz





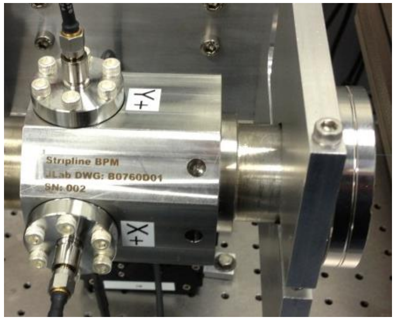
IPM5C07 Stripline Frequency Response

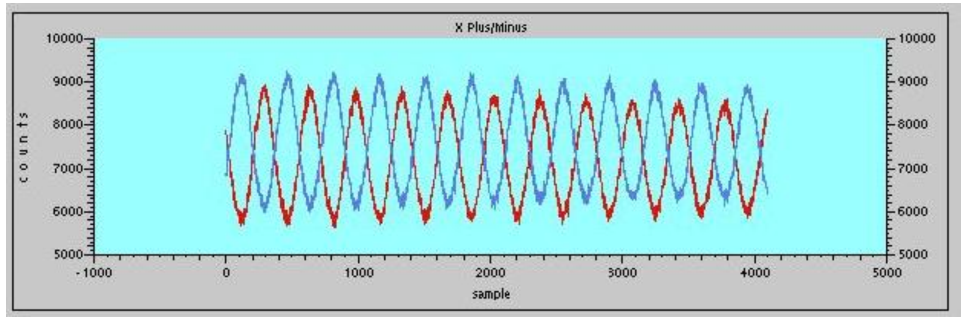


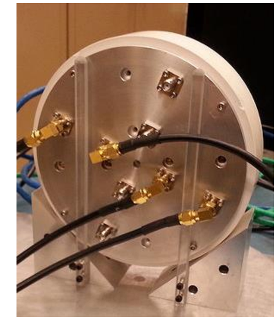
Hall D FFB To Do

- Implement Hall A&C FFB algorithm (Plan A)
  - Translate into the new electronics
  - Incorporate Active Collimator
  - Incorporate Cavity BPMs
- Commission Cavity BPMs (beam time)
  - Finish firmware and software
  - Measure bandwidth & current limitations
- Commission Active Collimator (beam time)
  - Measure bandwidth & current limitations
- Iterative FFB testing and tweaking (beam time)

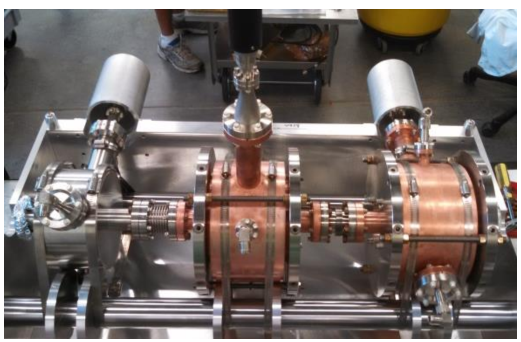
Hall D Fast Feedback

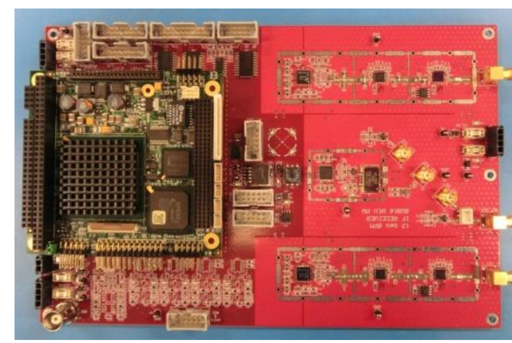






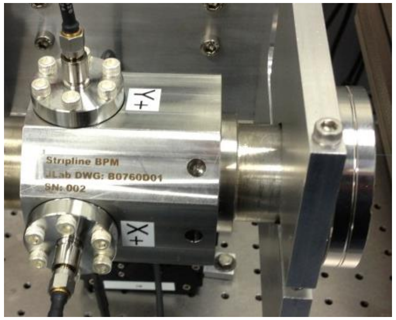
Questions?

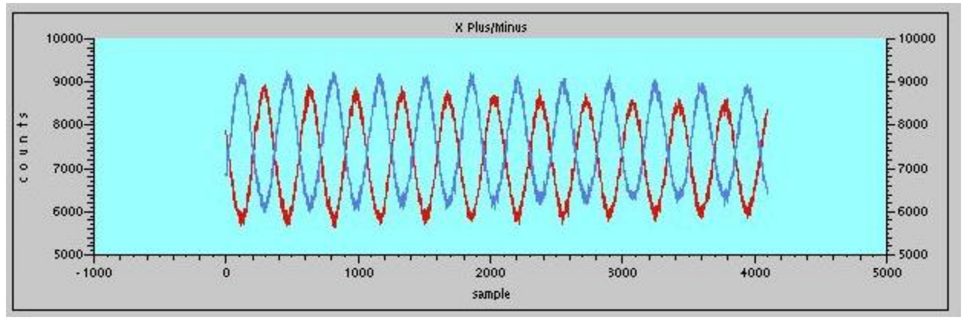


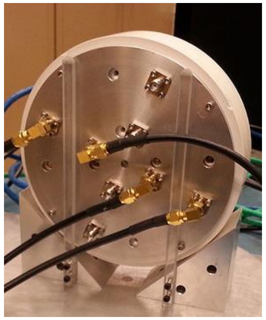


Hall D FFB Team: Trent Allison, Brian Bevins, Keith Cole, John Musson, Todd Satogata & Scott Windham

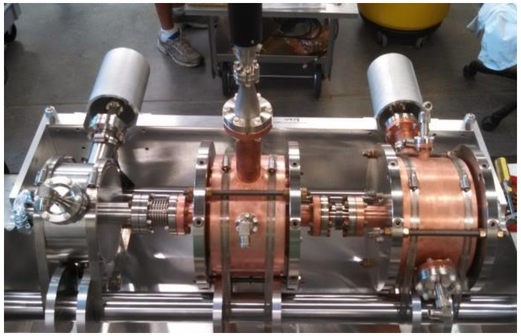
Hall D Fast Feedback

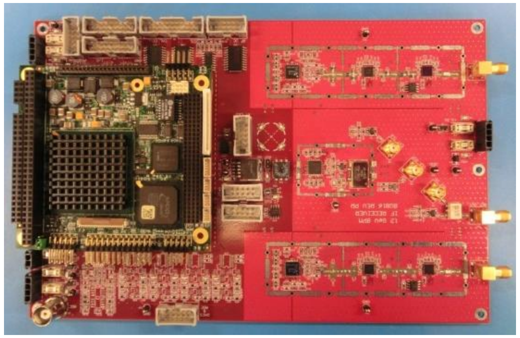






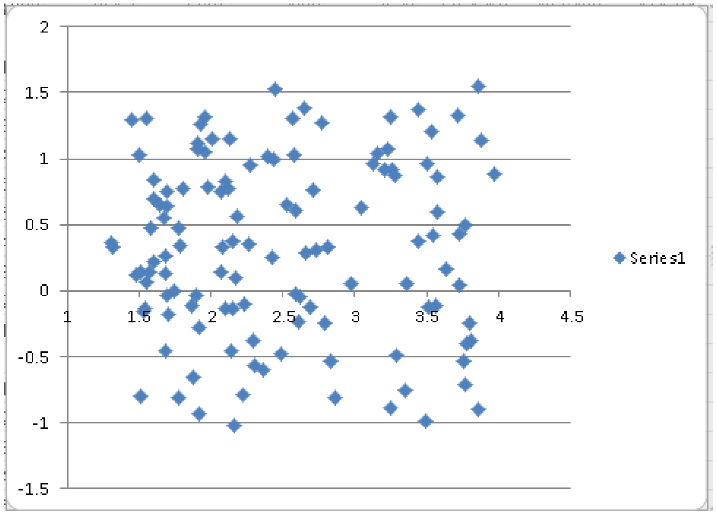
Backup Slides…





Bandwidth vs Resolution

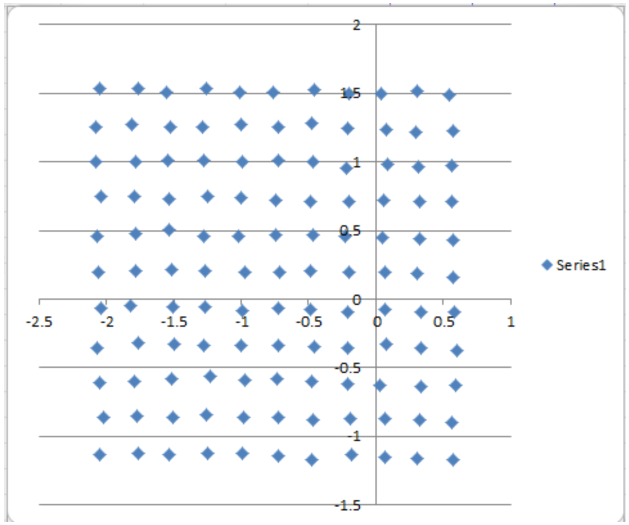
~30 nA @ 10 Hz



250 um
Step Scan

Position map improves by tightening bandwidth

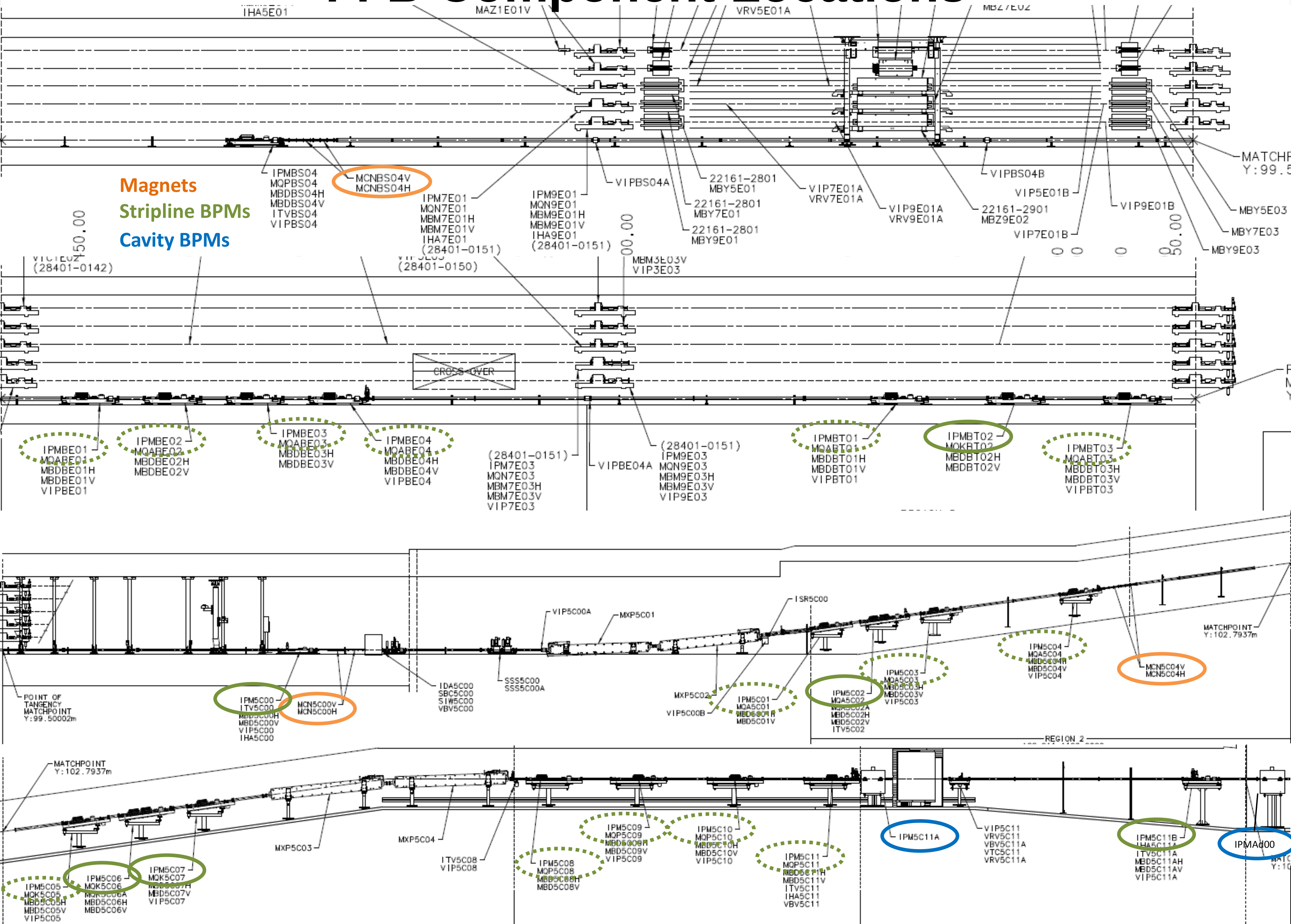
~30 nA @ 1 Hz



- 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

FFB Component Locations

Magnets
Stripline BPMs
Cavity BPMs



FFB Component Locations