FETS BPMs – Calibration and Signal Processing

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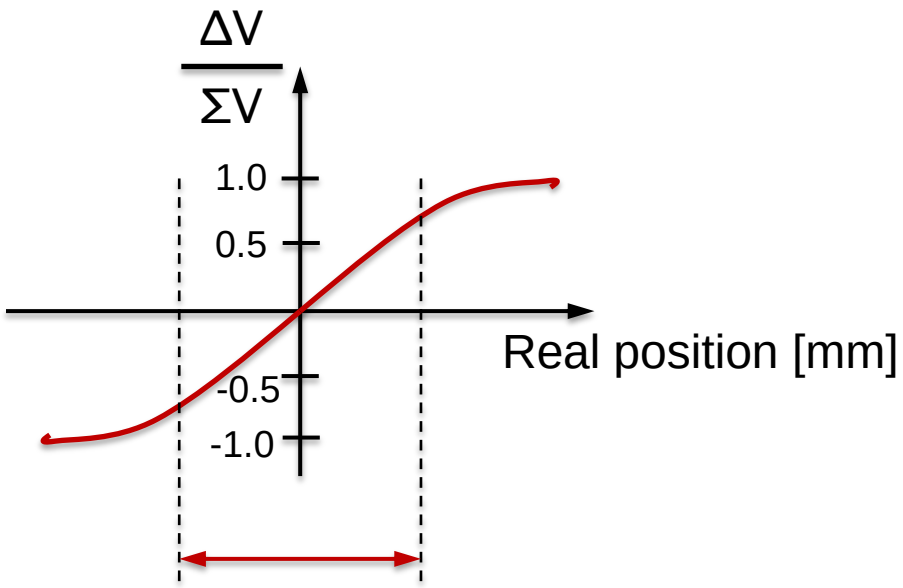
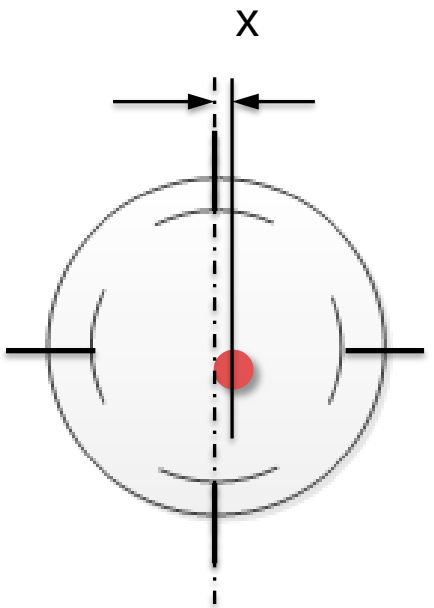
Contents

- BPM Calibration – a quick recap
- Issues with previous calibration methods
- Signal Processing
- Calibration Results
- Next steps

Linearity, Sensitivity & Offset



Linear region



$$x = \frac{1}{S_x}\frac{\Delta V}{\Sigma V} + dx$$

x = position (mm)

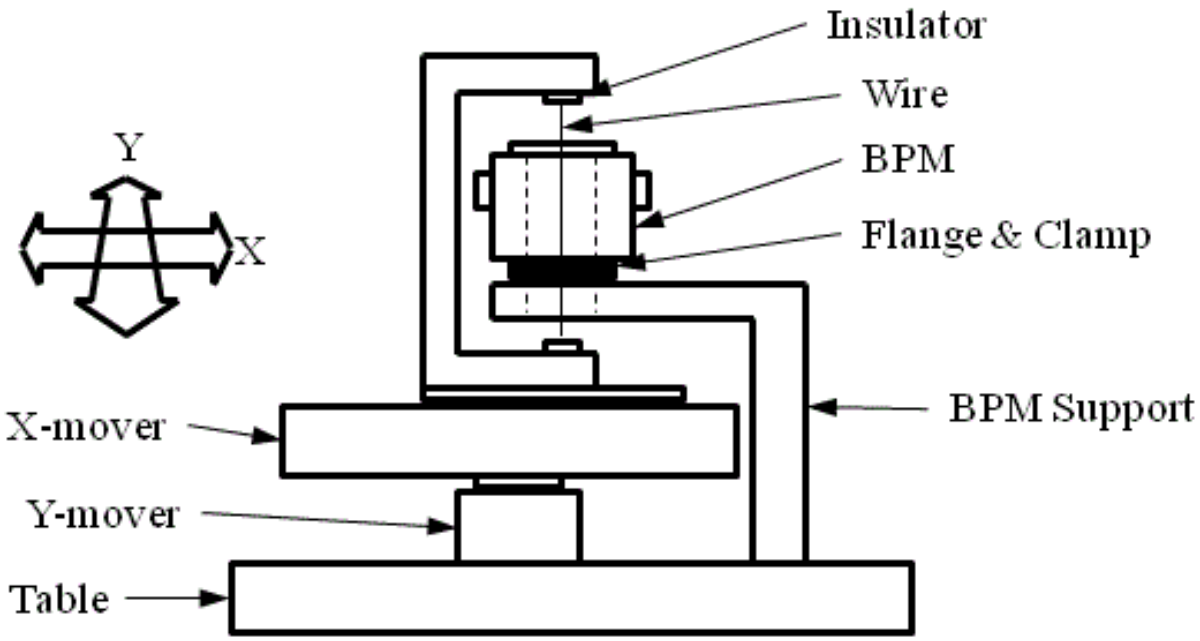
S_x = sensitivity (mm/V)

$\Delta V = V_{right} - V_{left}$

$\Sigma V = V_{right} + V_{left}$

dx = offset

BPM Wire Rig



- Wire has CW RF at 324 MHz 18 dBm
- Electrodes read out by 1 GHz BW (4 GS/s) 4-ch oscilloscope or mixer electronics/digitizer
- VI controls wire movement and scope readout

Previous Calibration Issues

- The wire-rig system was extremely sensitive to external parameters:
  - Position of cables from electrode to oscilloscope
  - Proximity of wire wrt frame (aluminium)
  - Day of the week….
- The signal level is few mV and scope is 8-bit at 4 GS/s
  - Quantisation noise on signal
  - Drift over ms due to 50 Hz mains
- Fitting code struggled with DC offset
  - Accurate amplitude measurement difficult
  - Position had large uncertainty

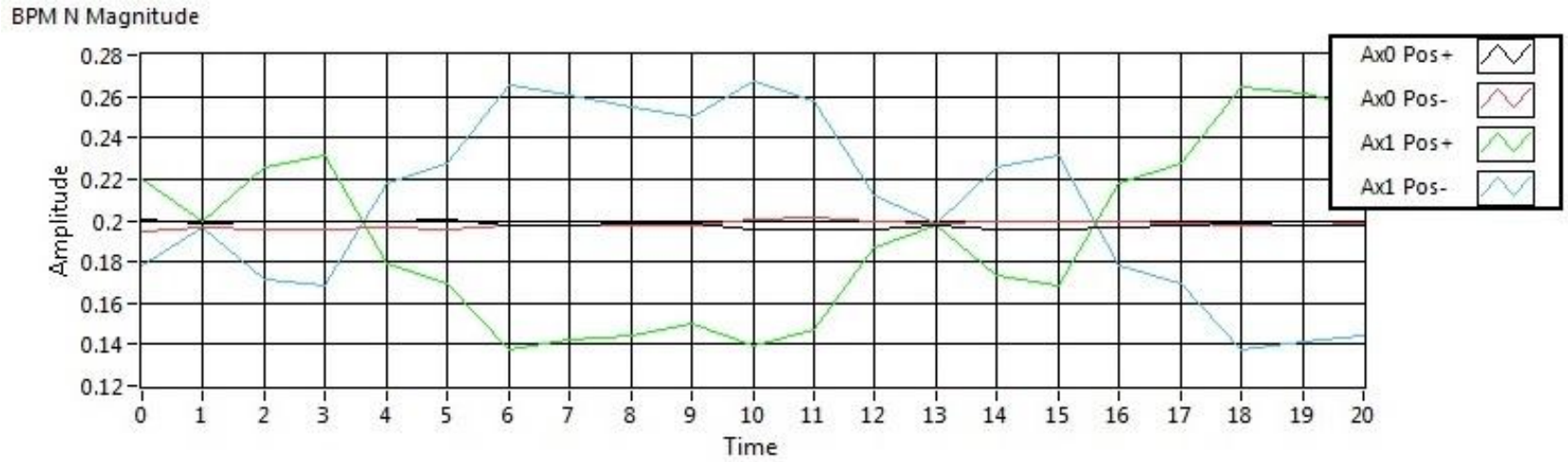
Electronics Test

- Signal from BPM electrode mixed to IF = 10.125 MHz
  - Input signal AC-coupled using transformer
  - Variable gain between transformer and mixer
  - 3 stages of gain after mixer
  - 10.125 MHz BP filter after gain
- Testing each mixer channel
  - Input signal -47 dBm (approx 1 mV_{rms})
  - Input LO = -7 dBm
  - Output = approx 0 dBm (gain of circuit between input and mixer is unknown)
  - ***Stable (<1% output variation) over 24 hours***

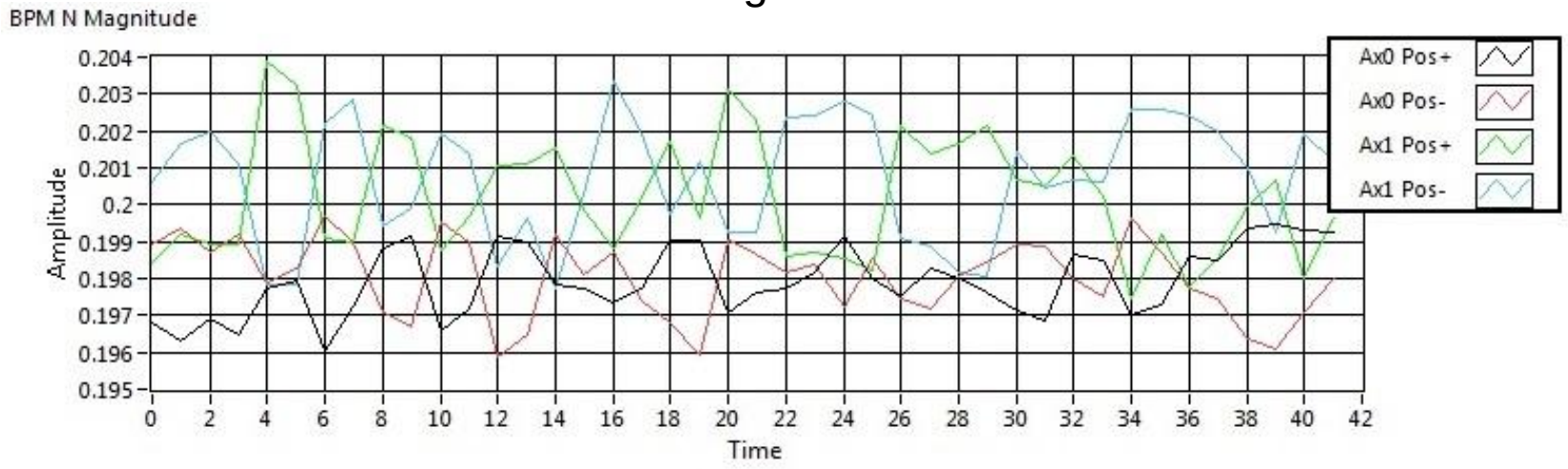
FPGA Code Precision

- Evaluate contribution of Digitizer and FPGA code to the position uncertainty
  - Digitizer is 12-bit, with fixed input range -1 V to +1 V
    - Ideally matched to output level of mixer channels
  - Calculated maximum uncertainty of 3% for the digitizer (using datasheet values)
  - Measured uncertainty for digitizer of 1% for typical input signal levels
  - Final FPGA position calculation uncertainty on a typical sample length (25.5 µs) **< 10 µm** (based on sensitivity $S_{x,y}$ of 0.1)

Digitizer Calibration

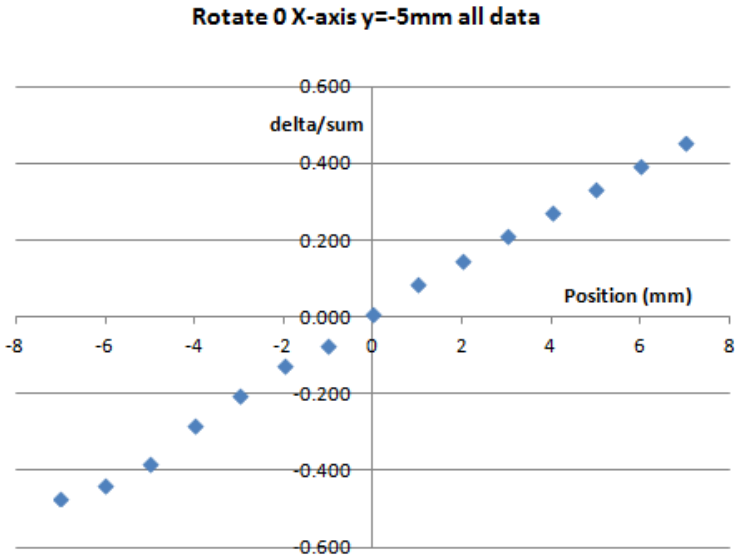


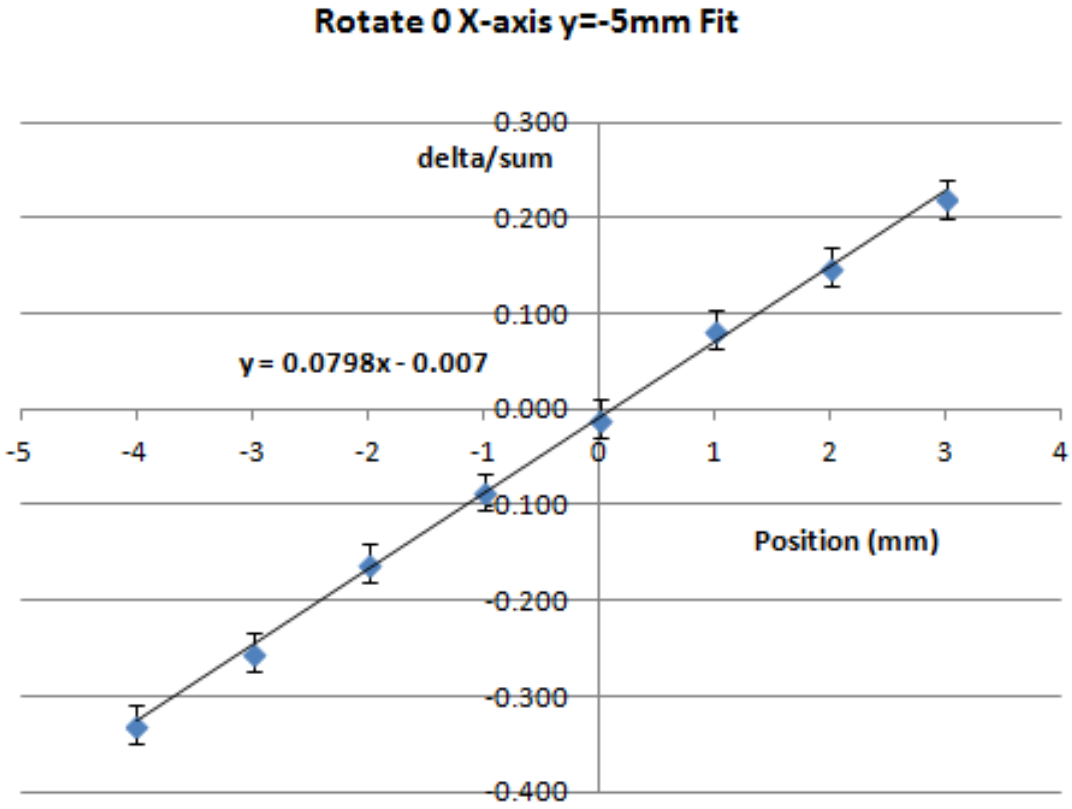
Uncalibrated digitizer channels



Offset corrections, course gain correction

Typical Sensitivity Scan





Wire Position using Mixer/Digitizer/FPGA

- Complete system tested March 2015
- New perspex frame to hold the wire
- Agreement between axes within 2% (self-consistent)
- **BUT** sensitivity from simulation ~ 0.1, wire-rig ~ 0.08
  - Error is down to the wire-rig and not the electronics/digitizer/FPGA
- Where is the issue?
  - The connection between the electrode and the SMA connector has caused problems
  - Squeezing the female part of the connection enables much better conduction at 324 MHz

Next Steps

- Re-measure sensitivities after checking the electrode connections
- Evaluate the manufacturing defect on the BPMs
- Measure strip-line sensitivity and compare with CERN results
- Perform ‘grid-scans’ on bore of BPM
- Evaluate electronics in more detail (temp stability, crosstalk, 1 dB compression etc)
- Investigate the latest version of the CERN mixer electronics and control code
- Complete measurements and submit abstract to IBIC 2015
- Await year 2 funding to build mixer electronics & cabling

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