



# LHC Beam Position System

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## Implications for Machine Protection

Internal MPP Review

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# MPP Related BPM Issues

- Dependence of BPM readings on intensity
- Dependence of BPM readings on temperature
- Sensitivity Settings for the BPM system



# General Performance

- Excellent availability
  - Only 10 channels out of 2150 currently masked (0.5%)
    - Rms noise too high or extreme offsets
  - Crates now rarely require reboot
    - Cause of remaining crashes still not understood
- Real-time data
  - Now transmitted to orbit feedback at 25Hz
- Modes
  - Currently using asynchronous IIR mode
    - Makes use of all data without requiring timing
  - Moving to synchronous mode using bunch ID can make position reading more robust but may impact on availability
    - Relies on fast timing & correct phase-in (seems to be reliable)
    - Will need input on bunch filling scheme
      - Can start by always measuring bunch 1



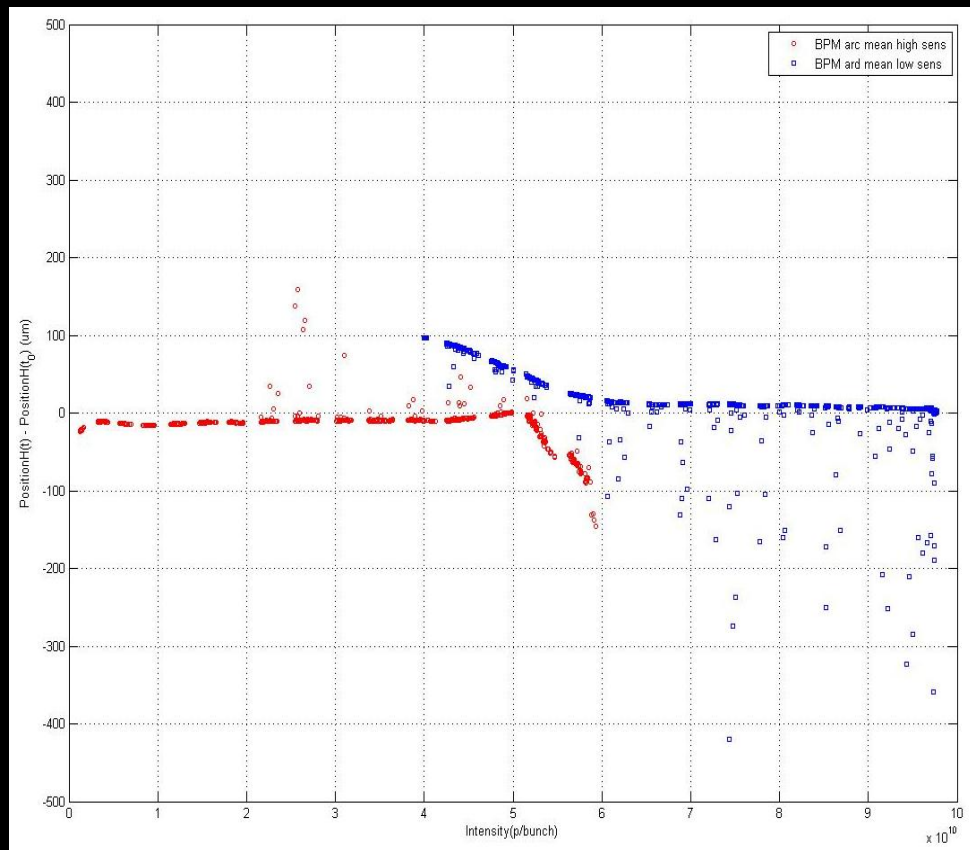
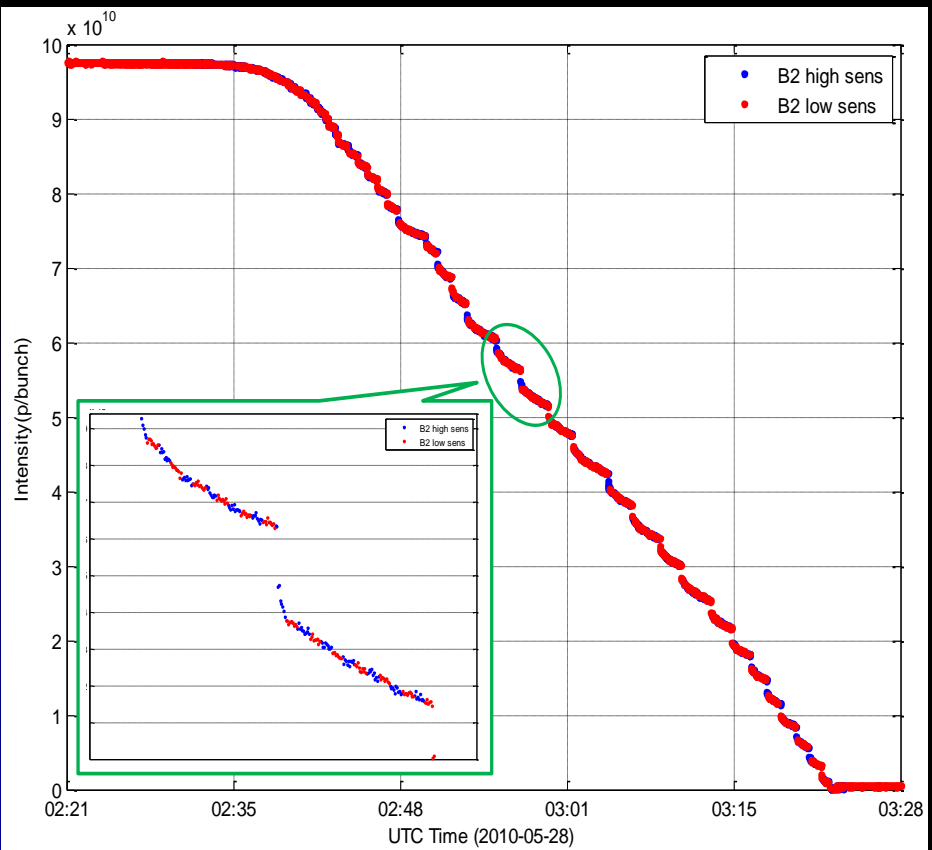
# Dependence of BPM Readings on Bunch Intensity

- BPMs work on bunch to bunch basis
  - Only depend on bunch intensity
- BPMs can be used in 2 sensitivity modes
  - High sensitivity
    - From  $\sim 1 \times 10^9$  to  $\sim 5 \times 10^{10}$
  - Low sensitivity
    - From  $\sim 5 \times 10^{10}$  to  $\sim 2 \times 10^{11}$
  - Only changes threshold for bunch detection
    - No gains changed
    - Required to make system immune from reflections generated by imperfect cabling, connections & BPMs.
- MDs have shown that
  - B2 behaves as expected
  - B1 has a grey zone between  $3 \times 10^{10}$  and  $5 \times 10^{10}$  where neither sensitivity gives required results



# BPM Dependence on Intensity - Beam 2

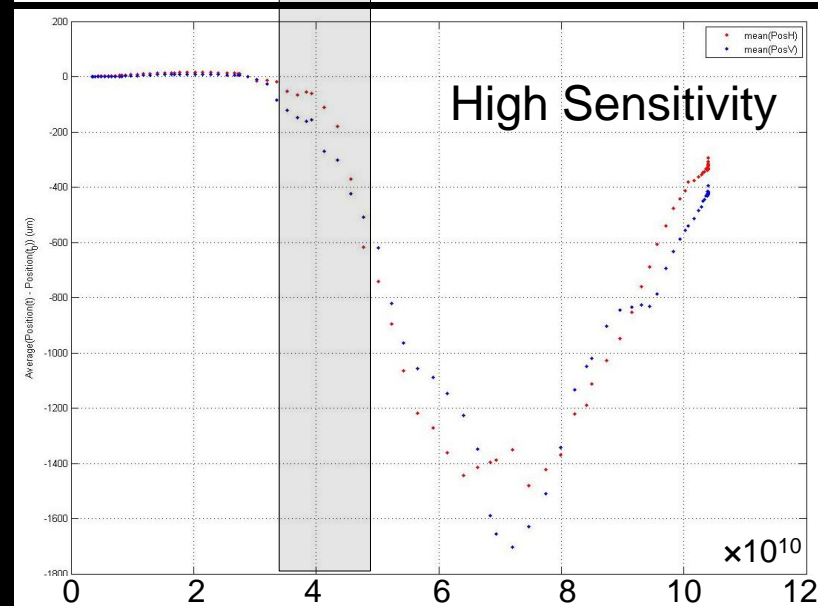
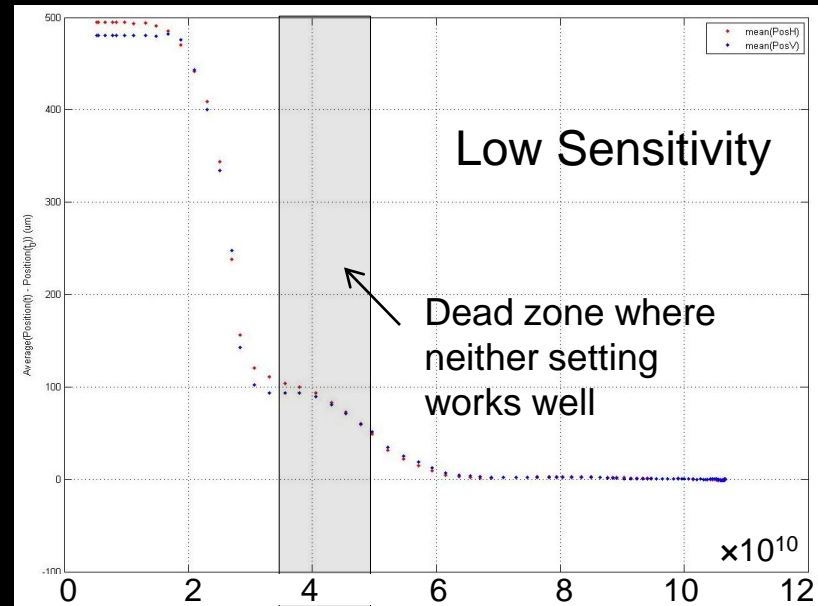
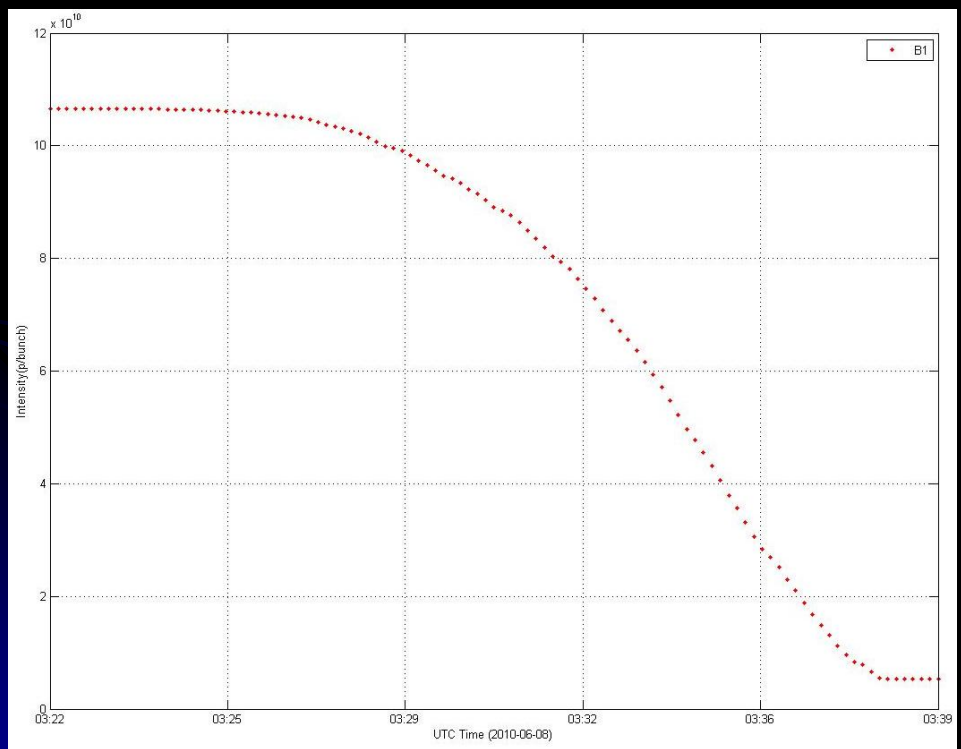
- One nominal bunch of  $1 \times 10^{11}$  slowly scraped away using a primary collimator
- Sensitivity constantly changed from high to low
  - Outliers due to acquisition overlapping two sensitivity ranges
- Sensitivity ranges seen to overlap as expected at around  $5 \times 10^{10}$





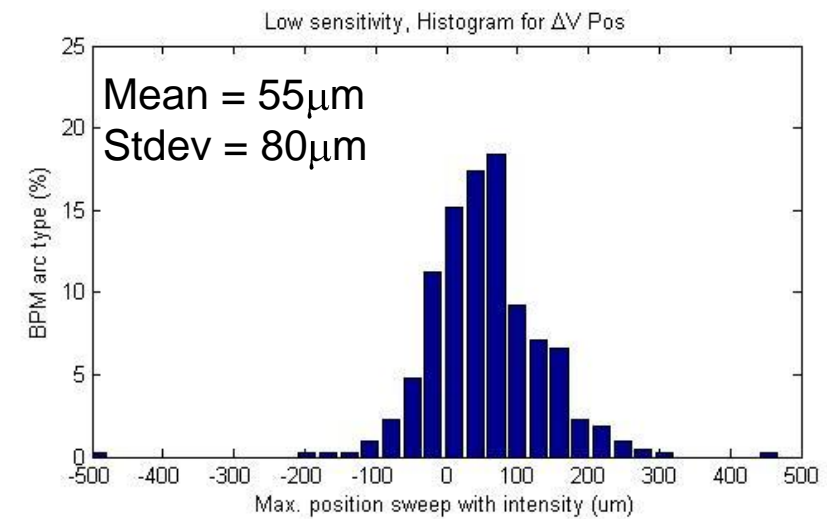
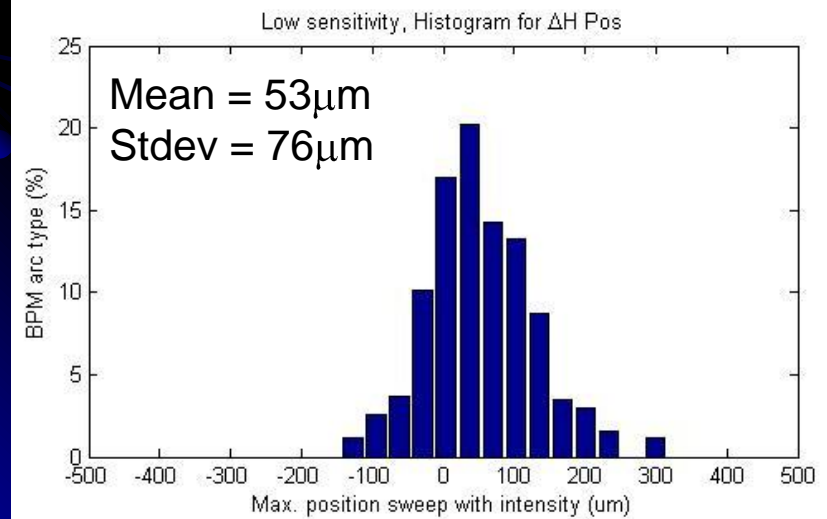
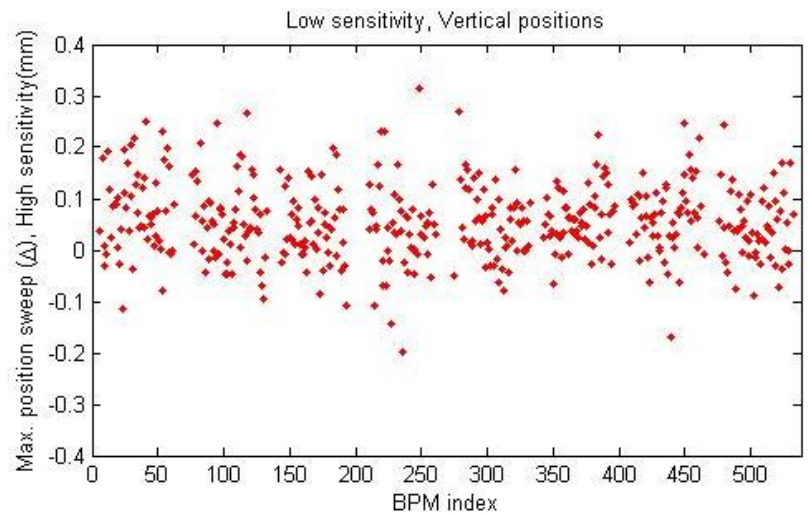
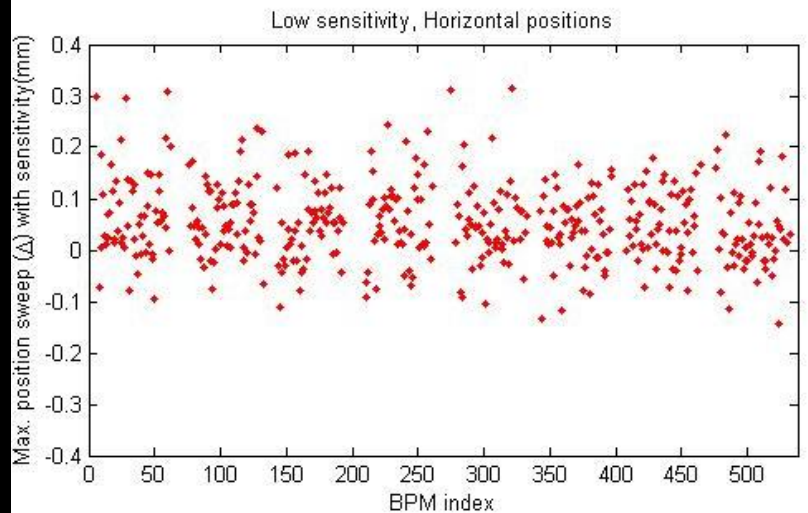
# BPM Dependence on Intensity - Beam 1

- One nominal bunch of  $1 \times 10^{11}$  slowly scraped away using a primary collimator
  - 2 fills – one for low sensitivity and one for high sensitivity



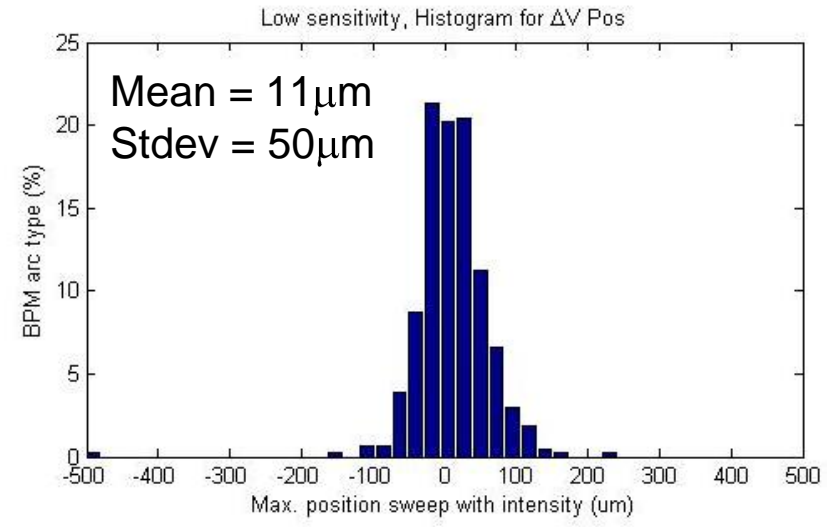
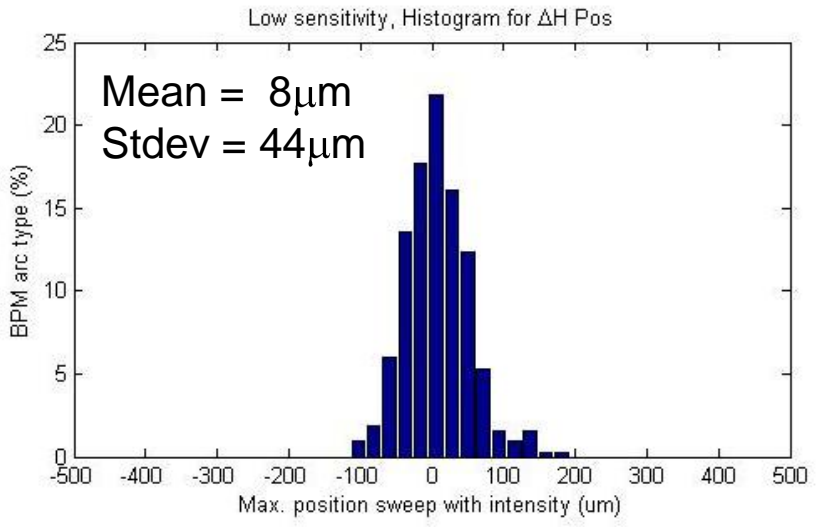
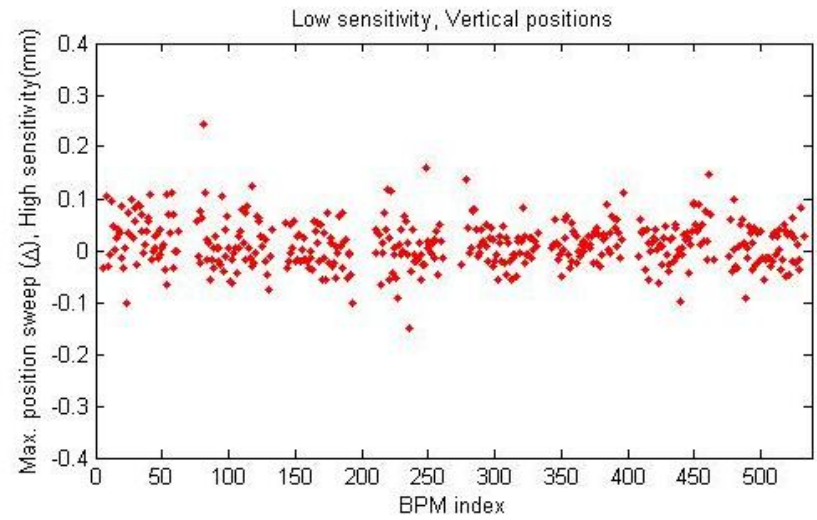
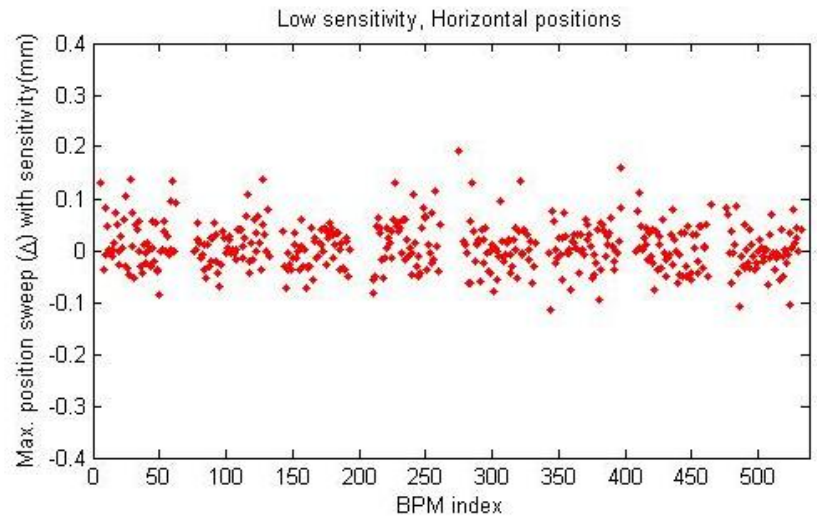


# B1 Arc BPM variation - $5 \times 10^{10}$ to $1 \times 10^{11}$





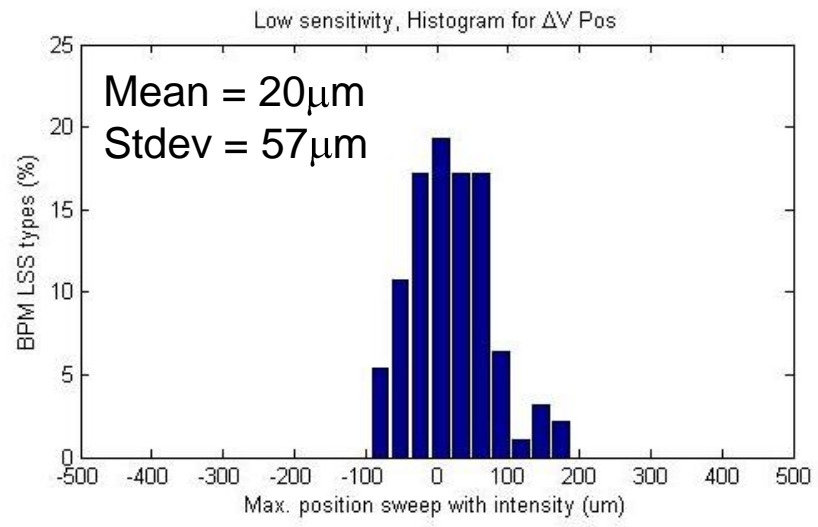
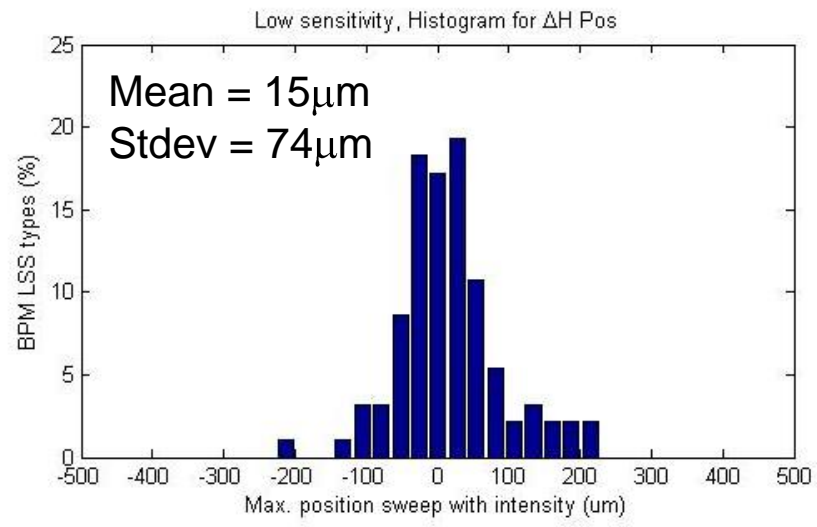
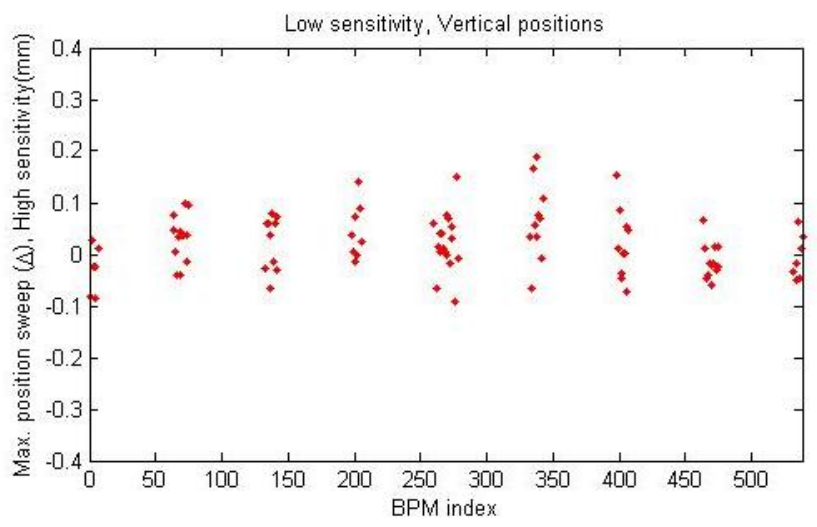
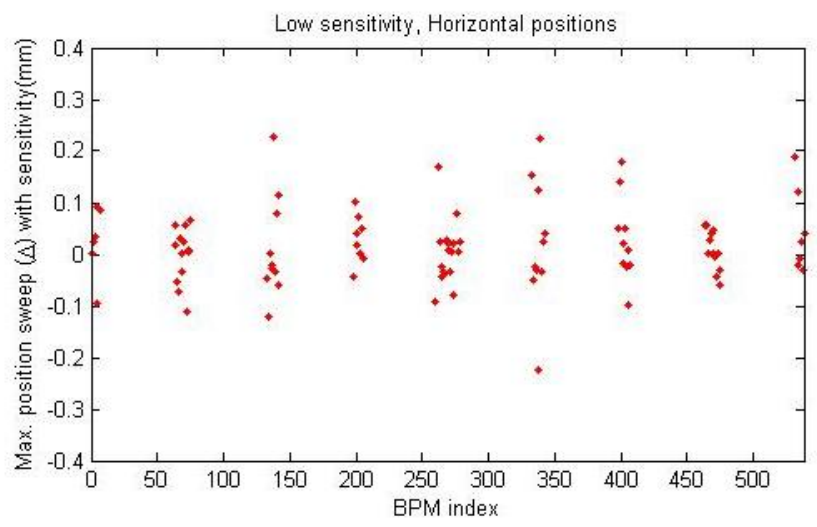
# B1 Arc BPM variation - $6 \times 10^{10}$ to $1 \times 10^{11}$







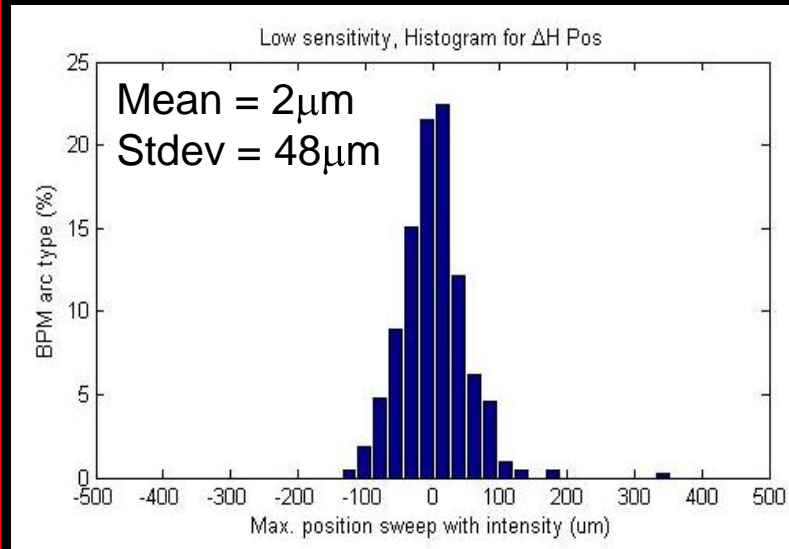
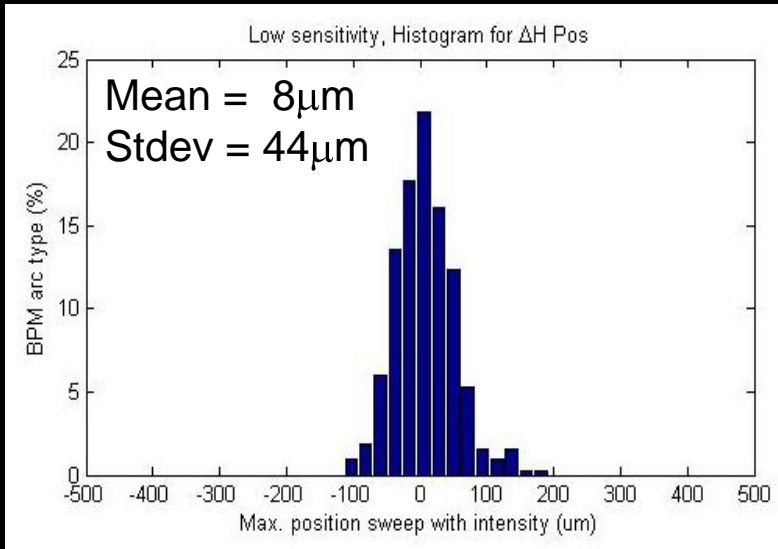
# B1 LSS BPM variation - $6 \times 10^{10}$ to $1 \times 10^{11}$



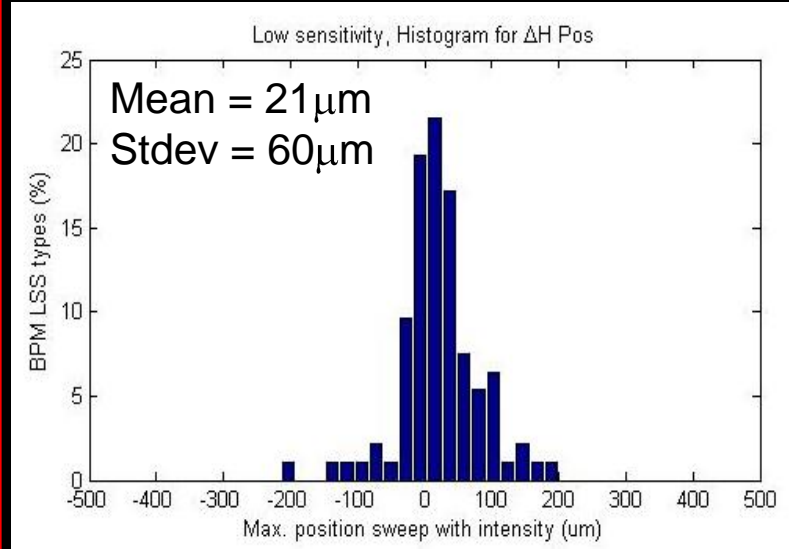
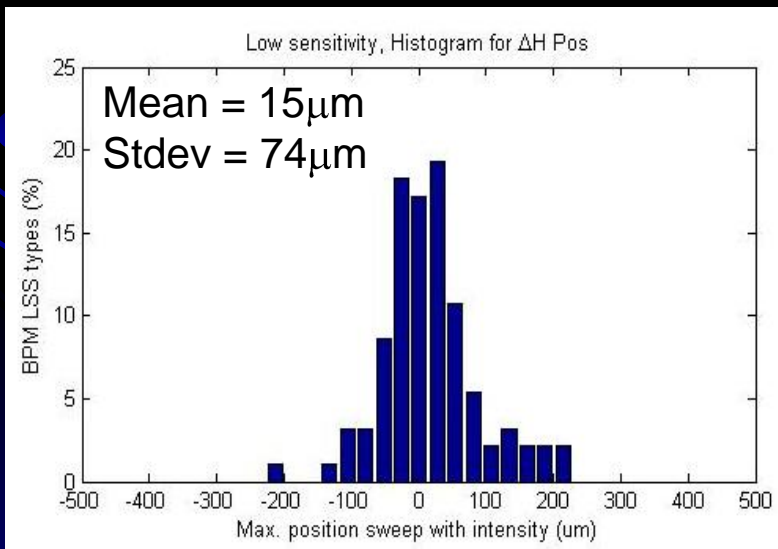


# B1 v B2 Comparison - $6 \times 10^{10}$ to $1 \times 10^{11}$

Arc BPMs



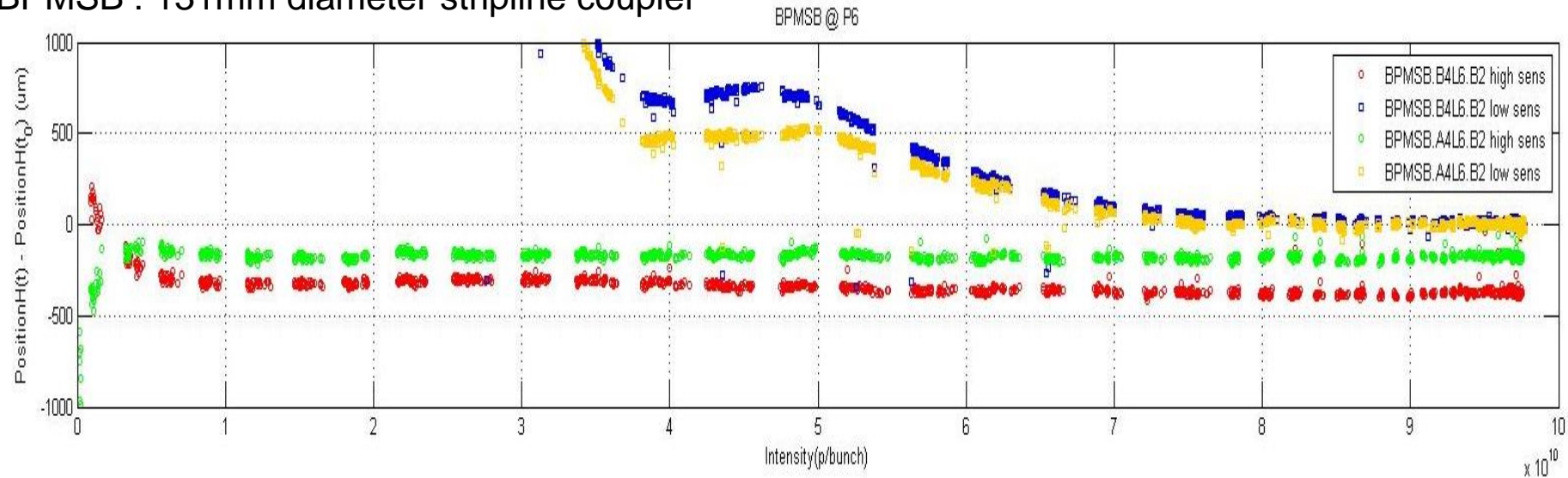
LSS BPMs



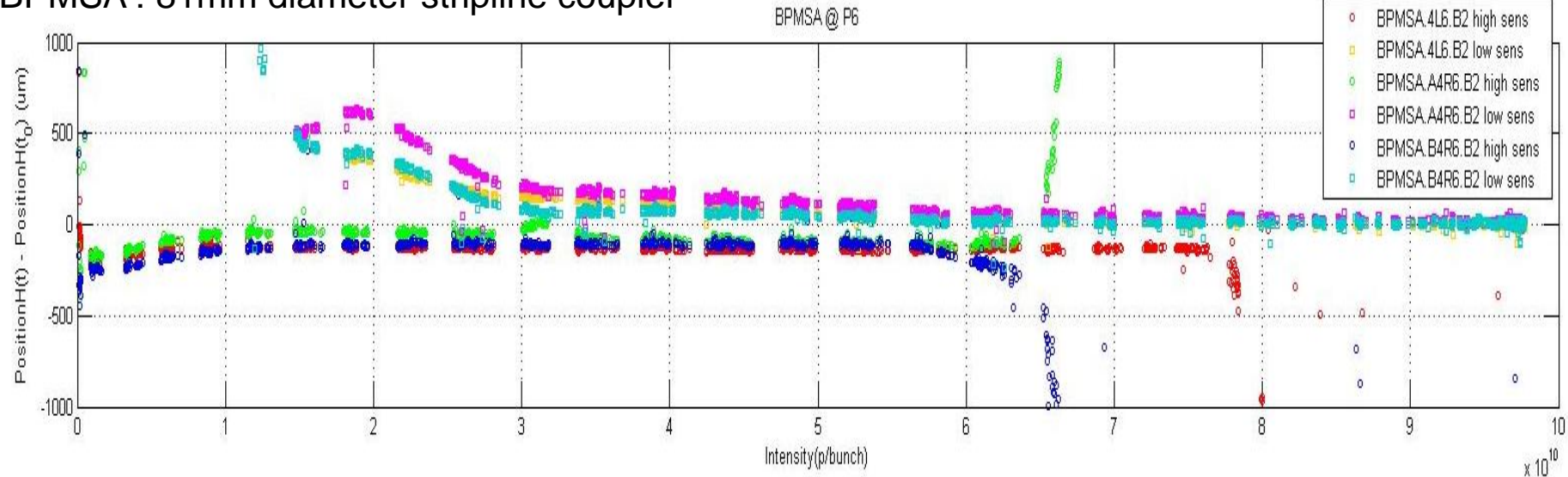


# Interlock BPMs in LSS6 – Beam 2

BPMSB : 131mm diameter stripline coupler



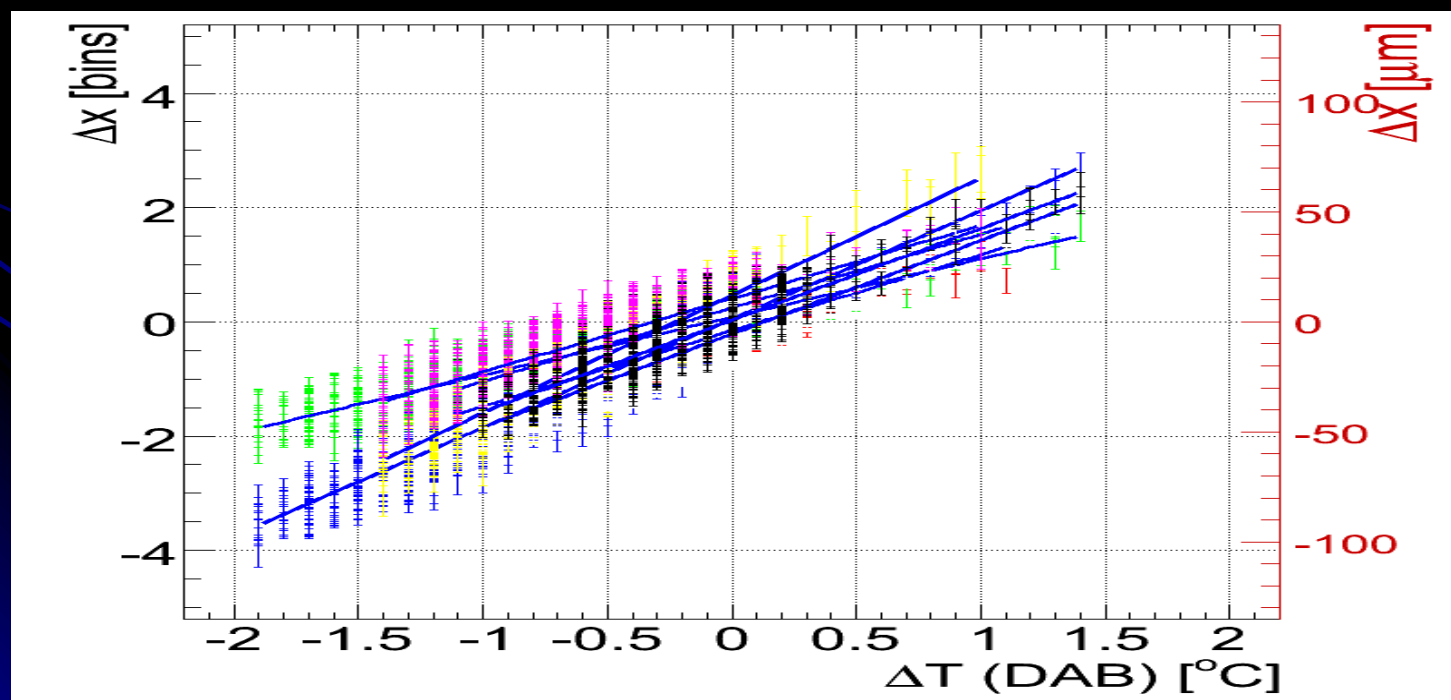
BPMSA : 81mm diameter stripline coupler





# BPM Position Dependence on Temperature

- Main component known to suffer temperature dependence is the wide band time normaliser integrator card
  - Located on surface
    - Prone to relatively large temperature variation
  - Position encoded in pulse length  $10 \pm 1.5\text{ns}$ 
    - Temperature affects offset & hence integral
      - position dependence should be minimal
  - Clear correlation between acquisition card temperature and position





# BPM System Conclusions

- Position dependence on intensity
  - Max variation with intensity  $<200\mu\text{m}$  for  $6\times 10^{10}$  to  $1\times 10^{11}$
  - Beam 1 in high sensitivity still to be understood for  $3.5\times 10^{10}$  to  $5\times 10^{10}$ 
    - Hypothesis that intensity card is influencing B1 power supplies
- Position dependence on temperature
  - Temperature variations ( $\sim 50\mu\text{m} / ^\circ\text{C}$ )
    - New software being tested to correct for this on-line
- Other Issues
  - How reproducible are we?
    - Difficult to measure – calibration shows little variation apart from temperature
  - Influence of other beam on directional BPMs in the IRs
    - New firmware & software using synchronous mode & bunch selection being tested to overcome this
      - May also help overcome B1 issues in high sensitivity
  - Interlock BPMs in LSS6
    - Need to adapt large aperture pick-up amplitudes
      - Work always in high sensitivity?
        - Would not work below  $5\times 10^9$  & above  $\sim 1.2\times 10^{11}$
    - Otherwise need to learn how to cope with sensitivity switching