XBPM Experience and Plans at Diamond Light Source

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Outline

- XBPMs in use at Diamond
- Simulation of XBPMs
- Calibration of XBPMs
- Subtraction of Dipole Background
- Short and Long Term Beam Stability
- Issues and Solutions
- Plans for the Future

Orbit Stability Requirements in 3rd Generation Light Sources

Beam stability should be better than 10% of the beam size

$$\Delta x < 0.1 \cdot \sigma_x \qquad \Delta x' < 0.1 \cdot \sigma_{x'}$$

$$\Delta y < 0.1 \cdot \sigma_y \qquad \Delta y' < 0.1 \cdot \sigma_{y'}$$

For Diamond nominal optics (at short straight sections)

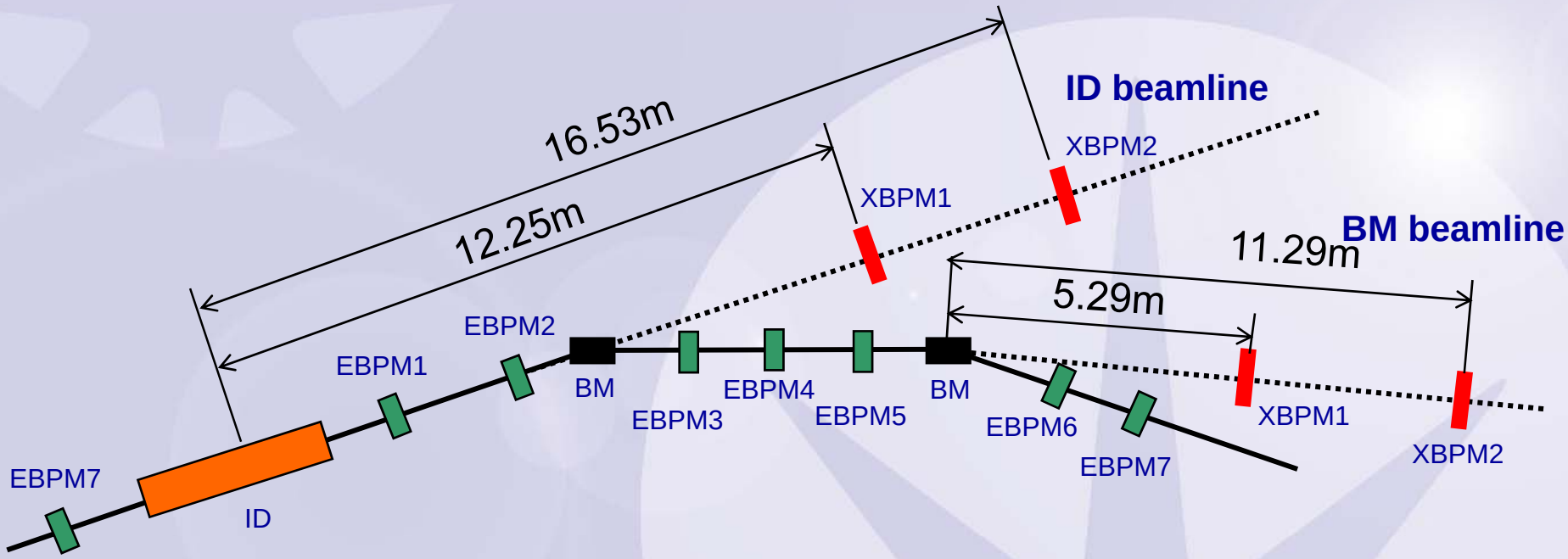
$$\Delta x < 0.1 \cdot 123\,\mu m = 12.3\,\mu m \qquad \Delta x' < 0.1 \cdot 24\,\mu rad = 2.4\,\mu rad$$

$$\Delta y < 0.1 \cdot 6.4\,\mu m = 0.6\,\mu m \qquad \Delta y' < 0.1 \cdot 4\,\mu rad = 0.4\,\mu rad$$

XBPMs in use at Diamond

- XBPMs are white beam, tungsten vane, photo emission
- A pair of XBPMs is installed in each in-vacuum planar undulators front end (10 pairs) where possible
- One pair of these is for canted beams of two IDs in one straight
- One pair of XBPMs on helical undulator (Apple II HU64), one more pair to be added soon
- One pair on bending magnet beamline, two more pairs to be added soon
- 24 XBPMs currently in use, 6 more to be added
- Equipment is funded by Beamlines; installation, commissioning, maintenance, support by Machine Diagnostics Group

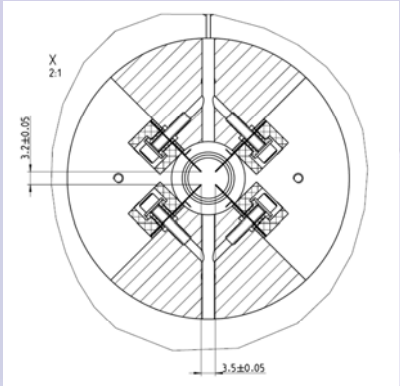
Layout of Diamond Arc and XBPMs

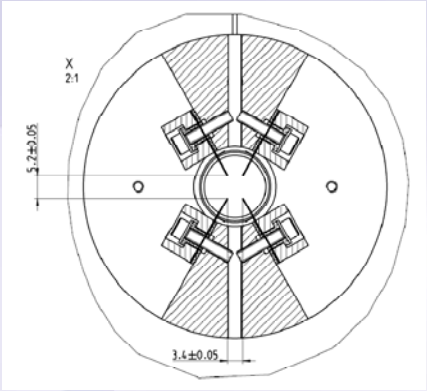


Blade Geometries

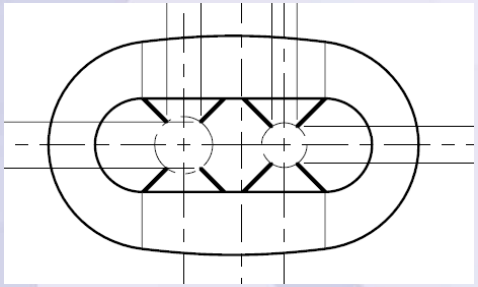
XBPM1 XBPM2

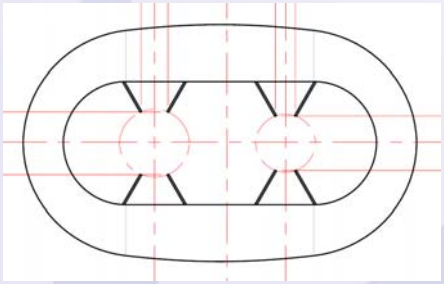
- Single undulator beam



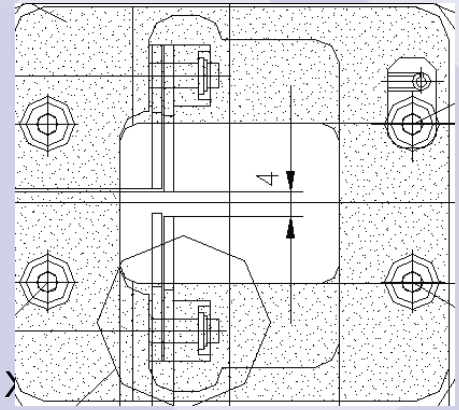


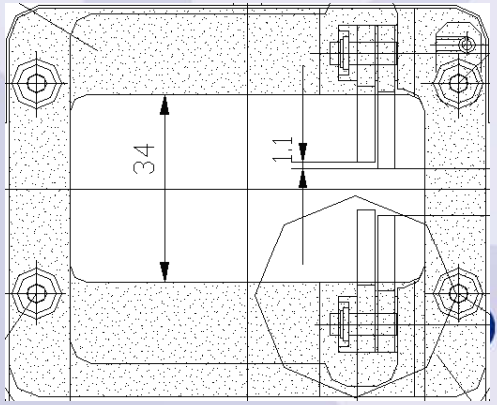
- Double undulator beam



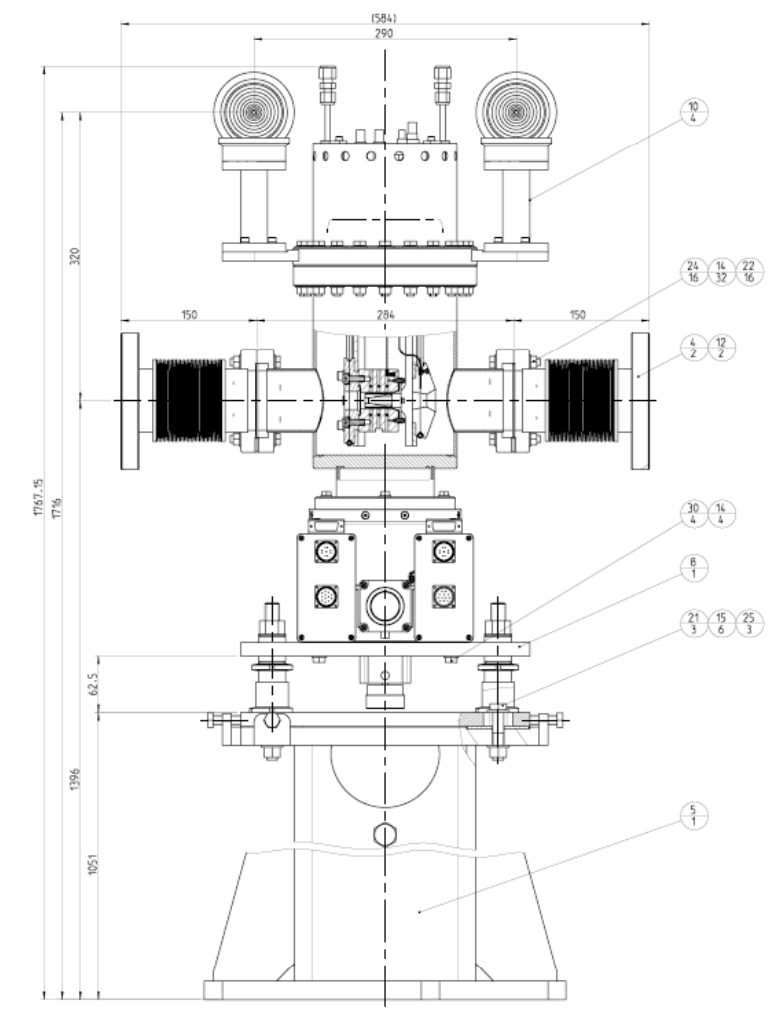


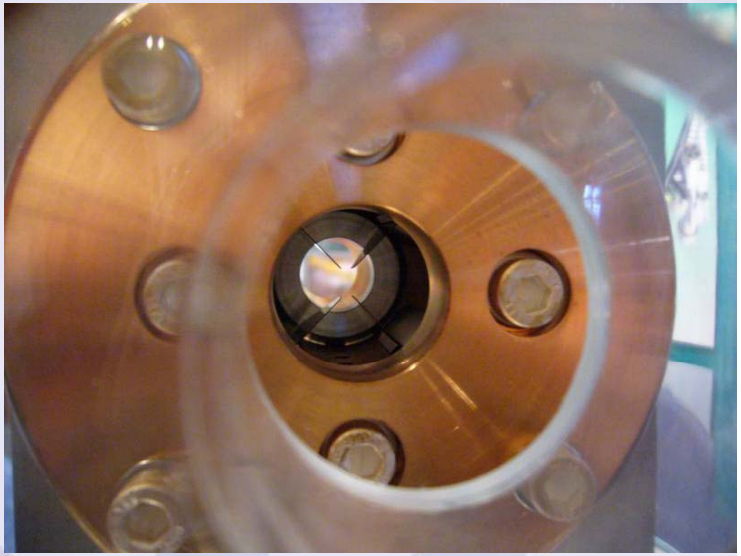
- Staggered Pair for dipole



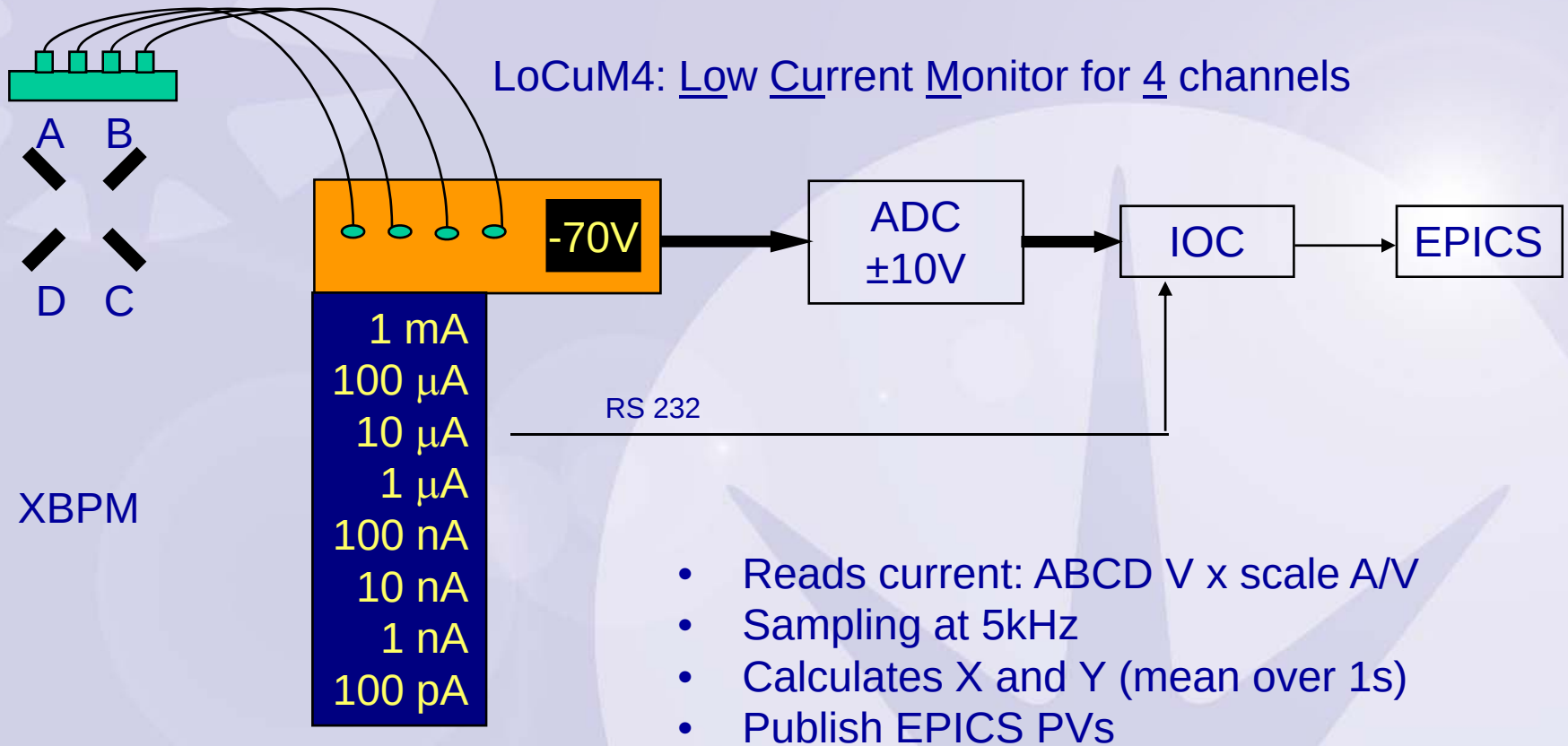


XBPMs from FMB/Bessy Design





XBPM integration into Control System

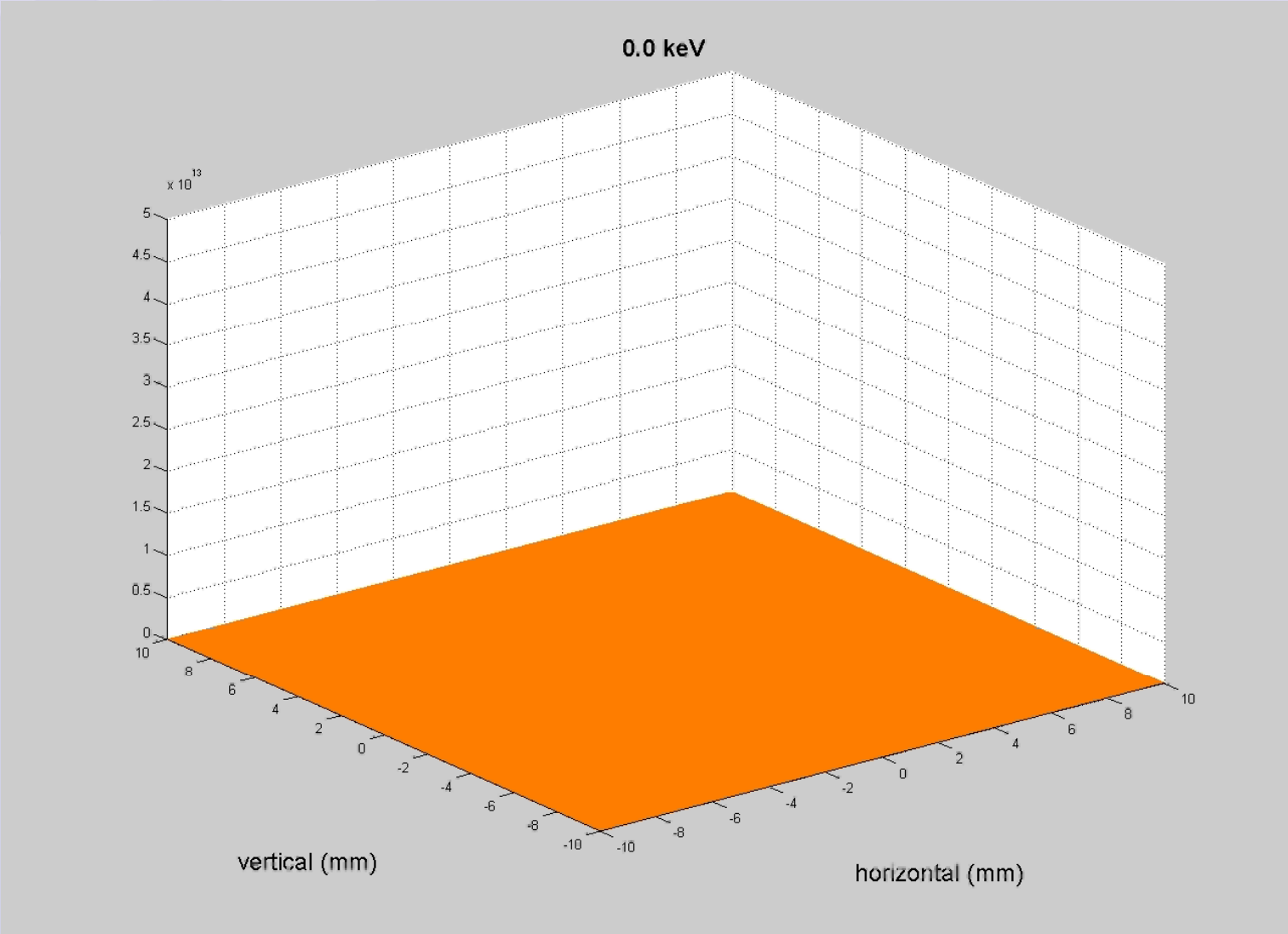


- Reads current: ABCD V x scale A/V
- Sampling at 5kHz
- Calculates X and Y (mean over 1s)
- Publish EPICS PVs

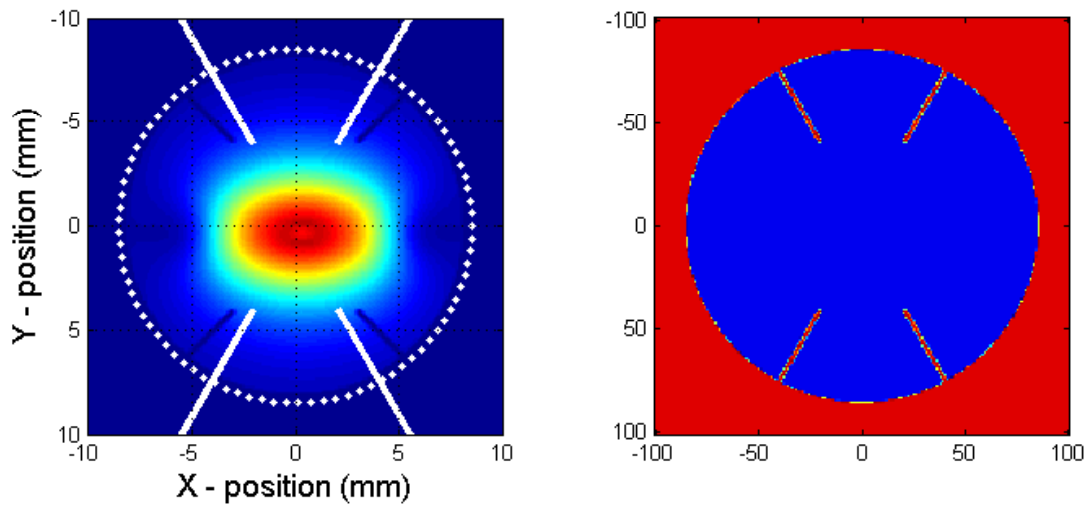
Simulation of XBPM

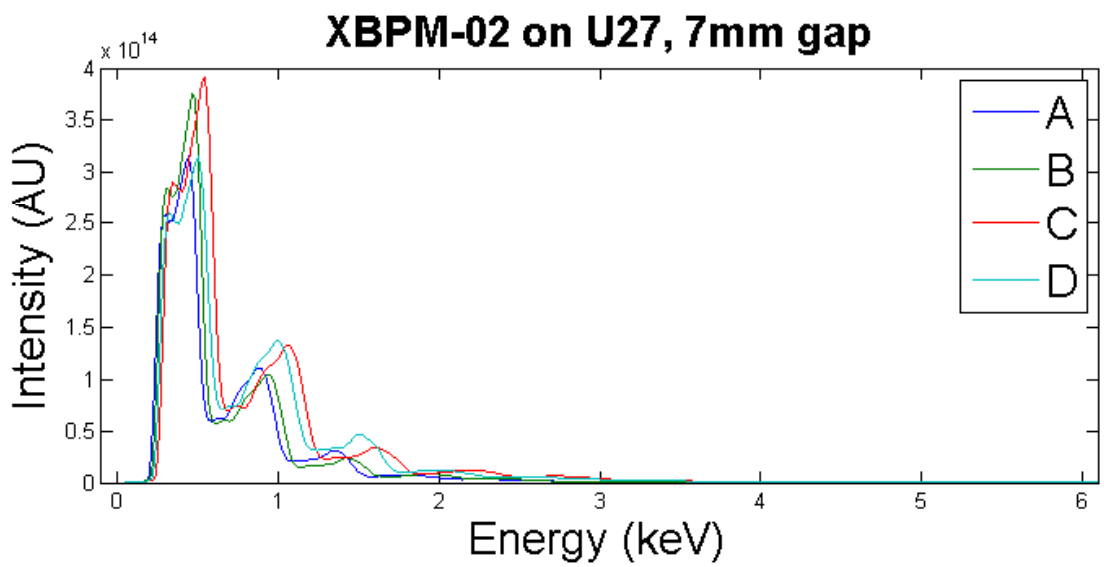
- Calculate photon density distribution for many energies (up to 20th harmonic) using SRW
- Import to matlab and weigh with photo electric cross section, integrate to create photon yield distribution
- Integrate over area of individual blades
- Calculate beam position from Δ/Σ

SRW simulation of photon flux



Example of blade current simulation



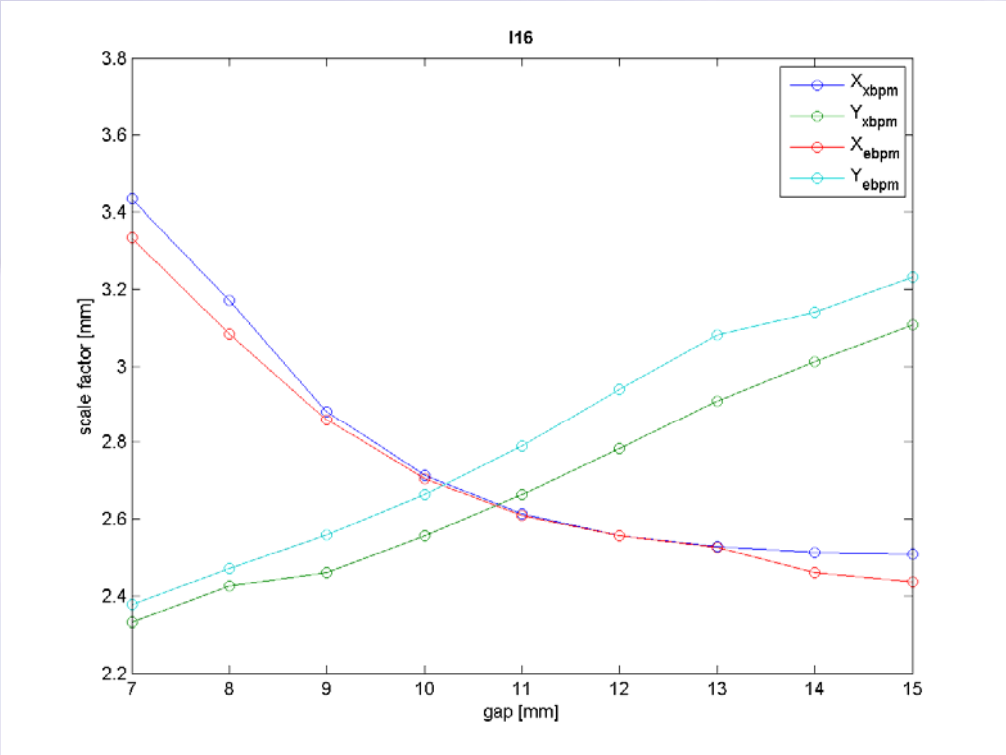


Calibration

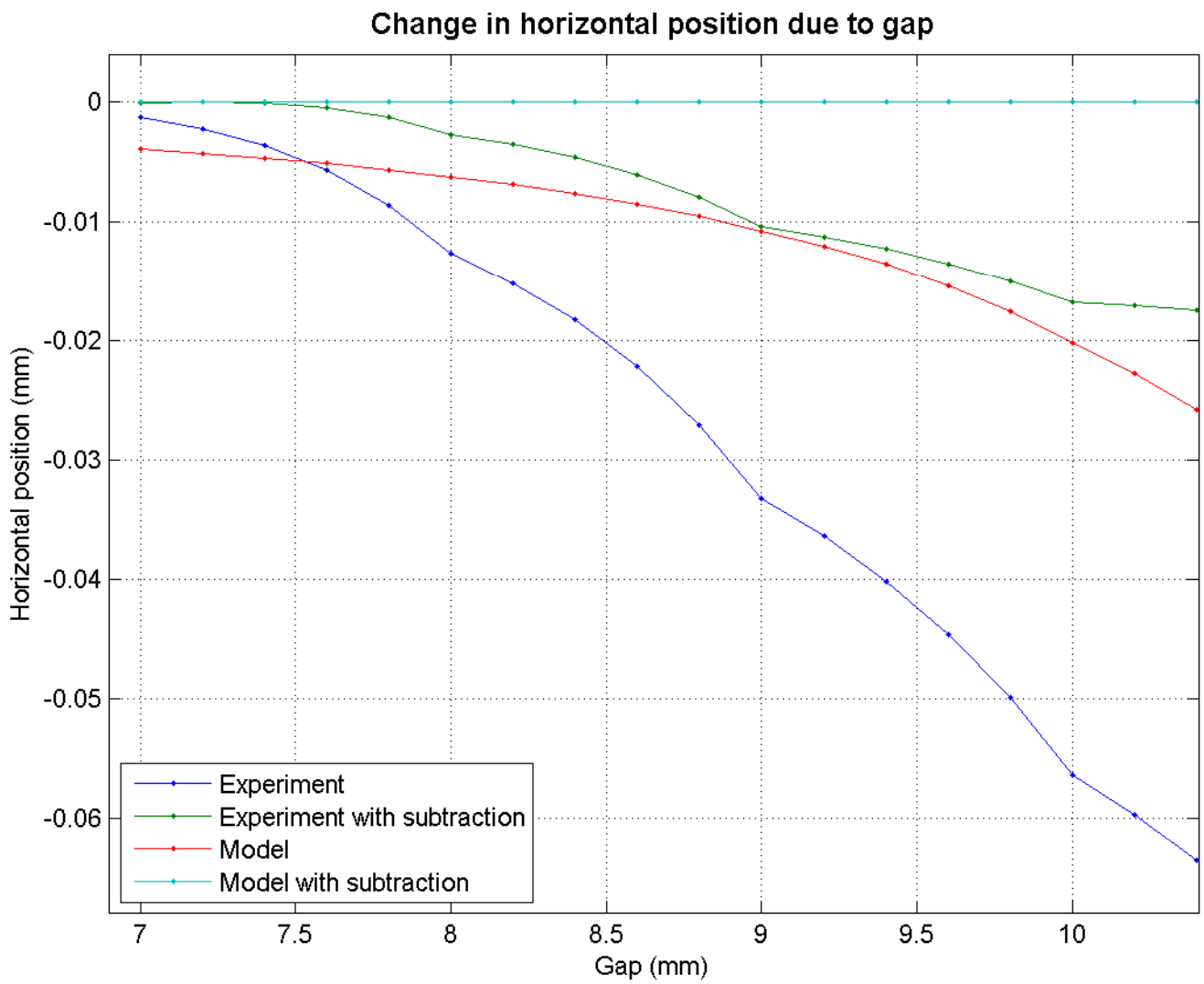
$$X = K_x \frac{(A+D)-(B+C)}{A+B+C+D}$$

$$Y = K_y \frac{(A+B)-(C+D)}{A+B+C+D}$$

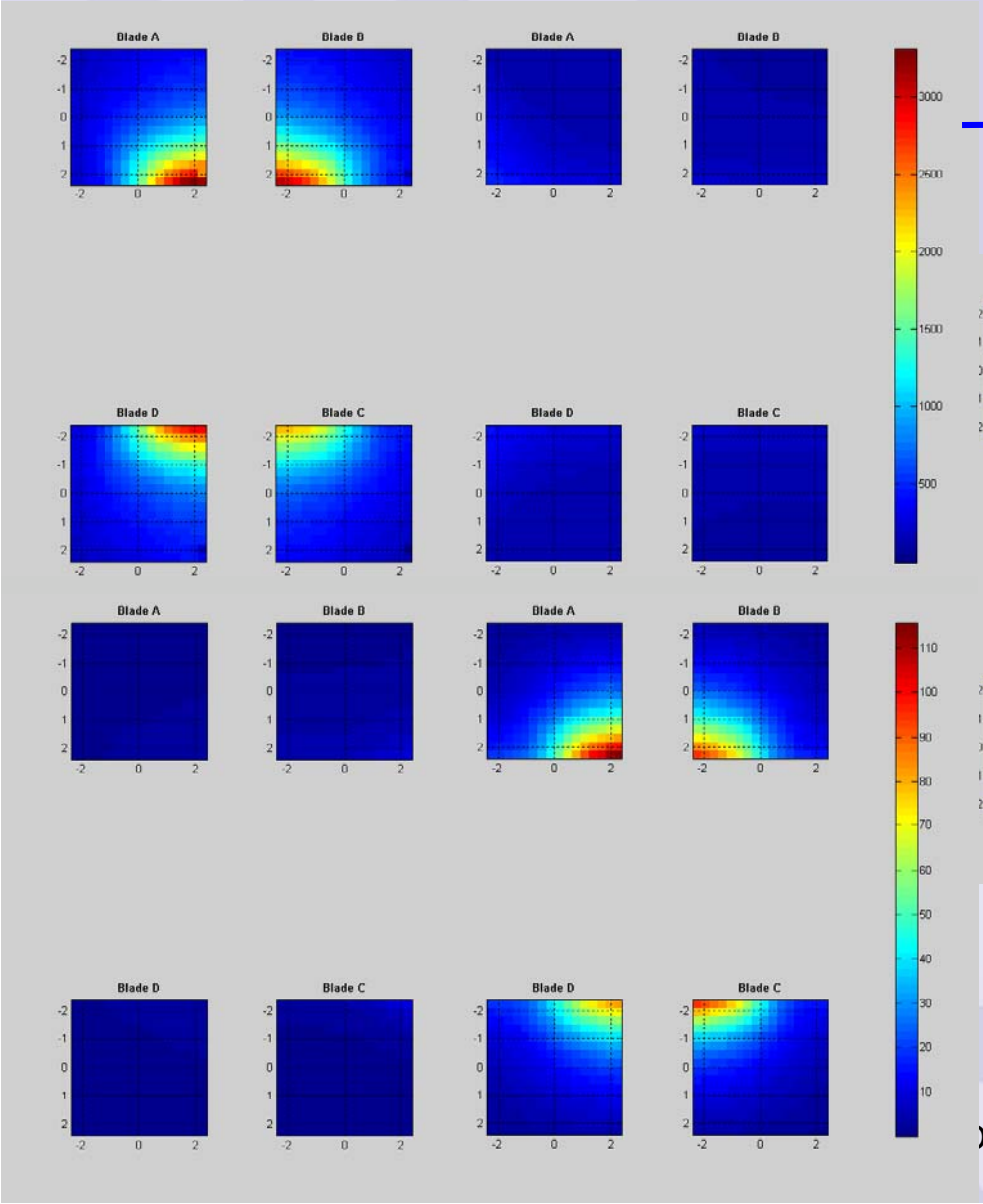
- Move stage or beam
- Read ratio
- Calculate $K_{x/y}$ for each ID gap and store in LUT

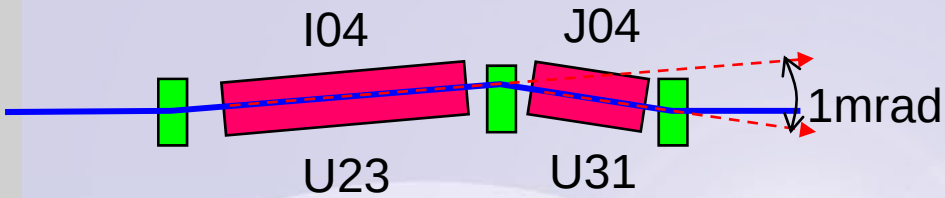


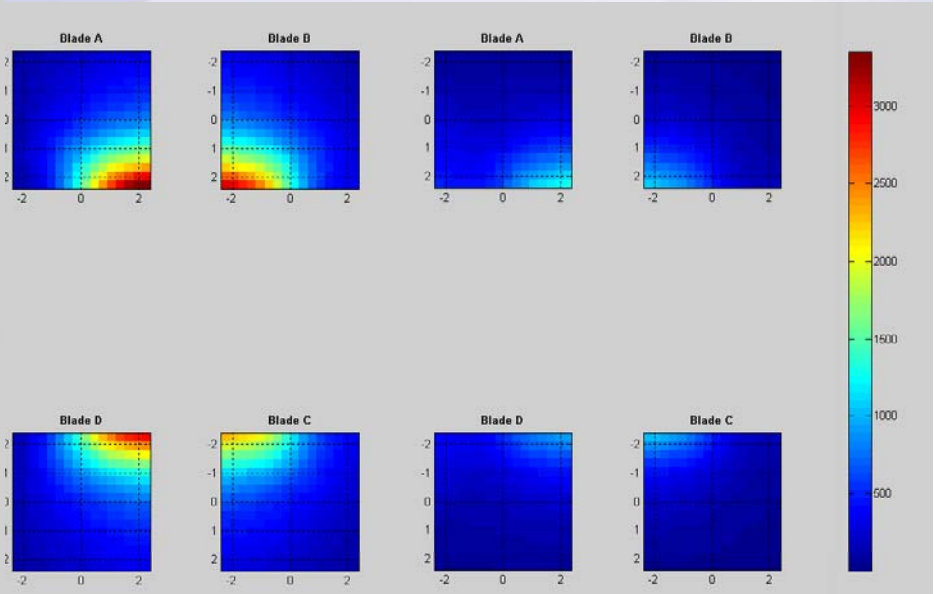
Background Subtraction in Simulation and Measurement



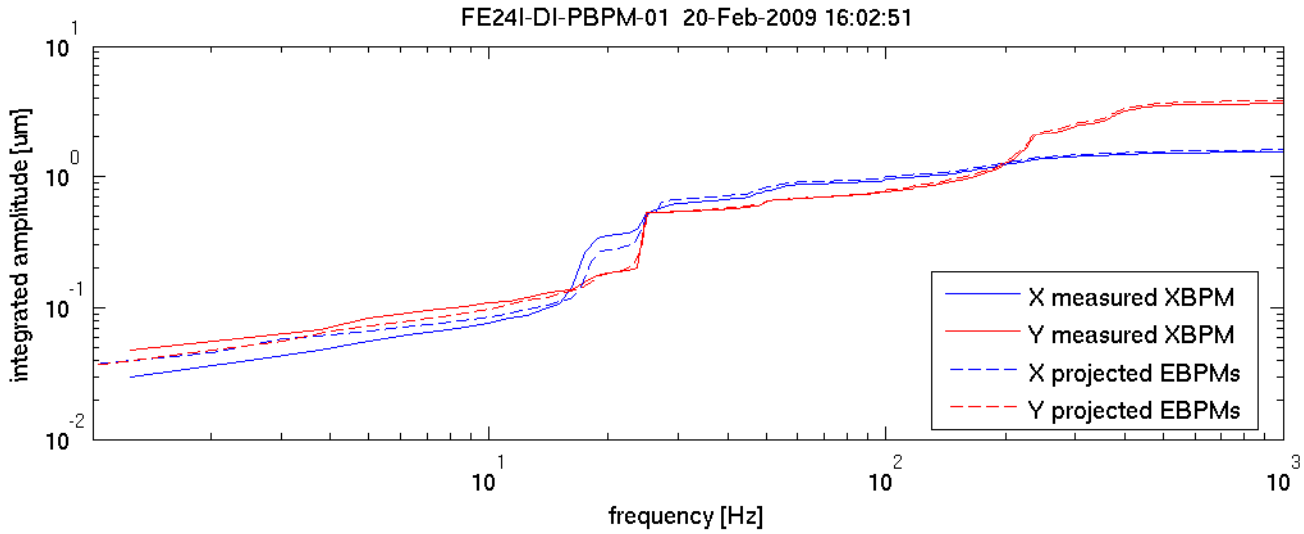
Two Beams in one Front End

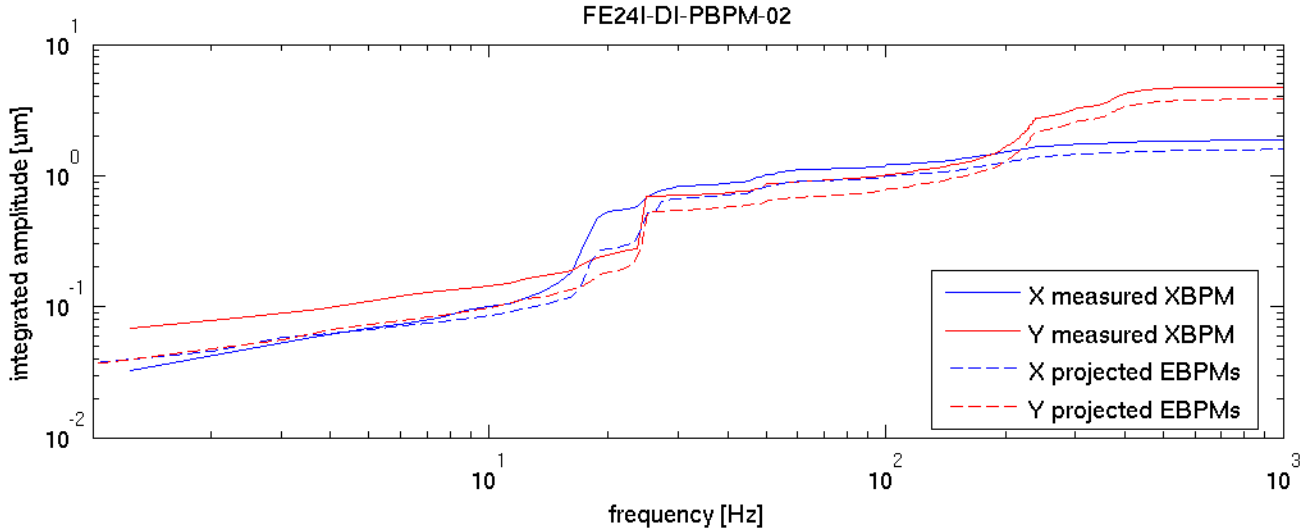




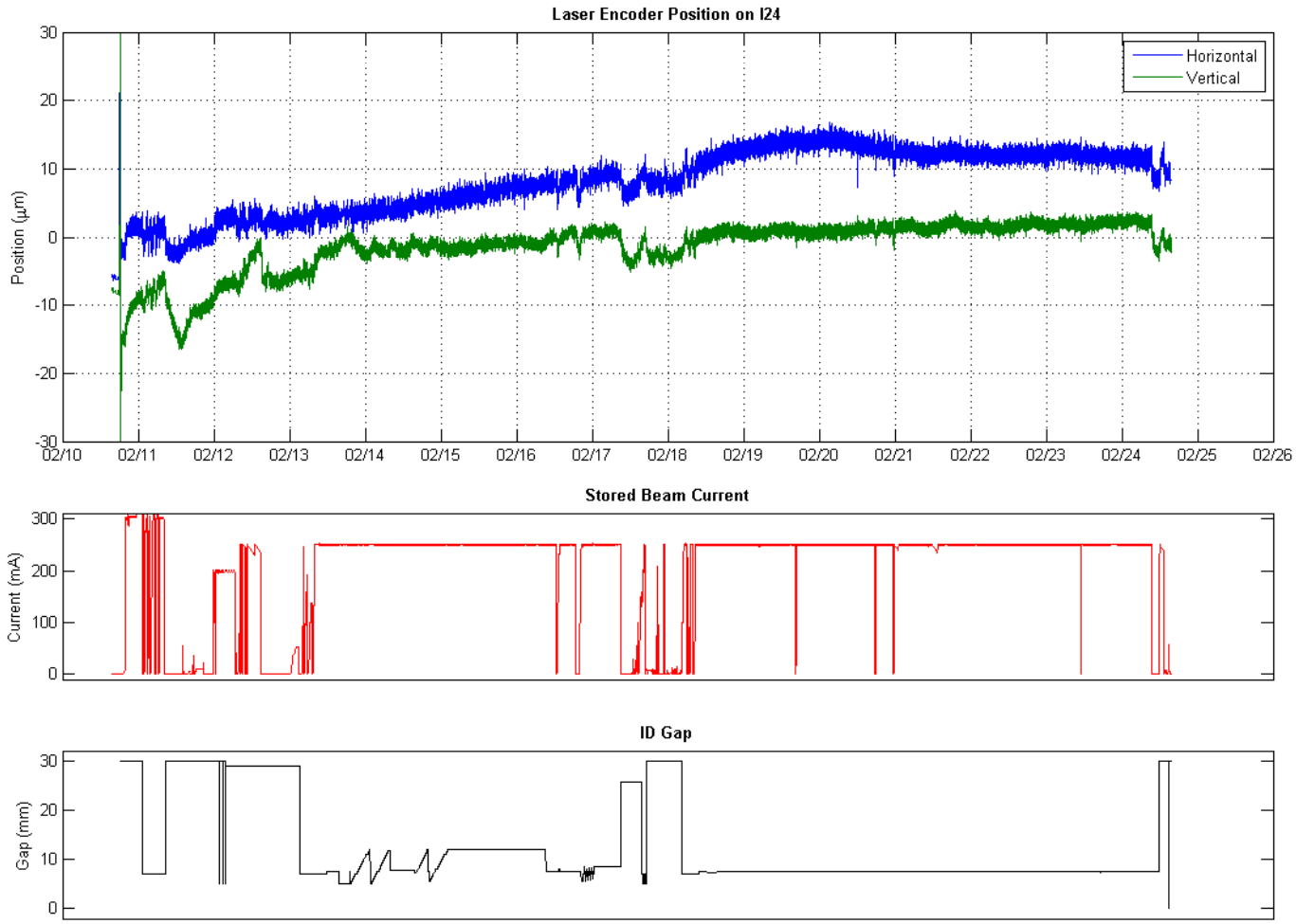


Short Term Beam Stability

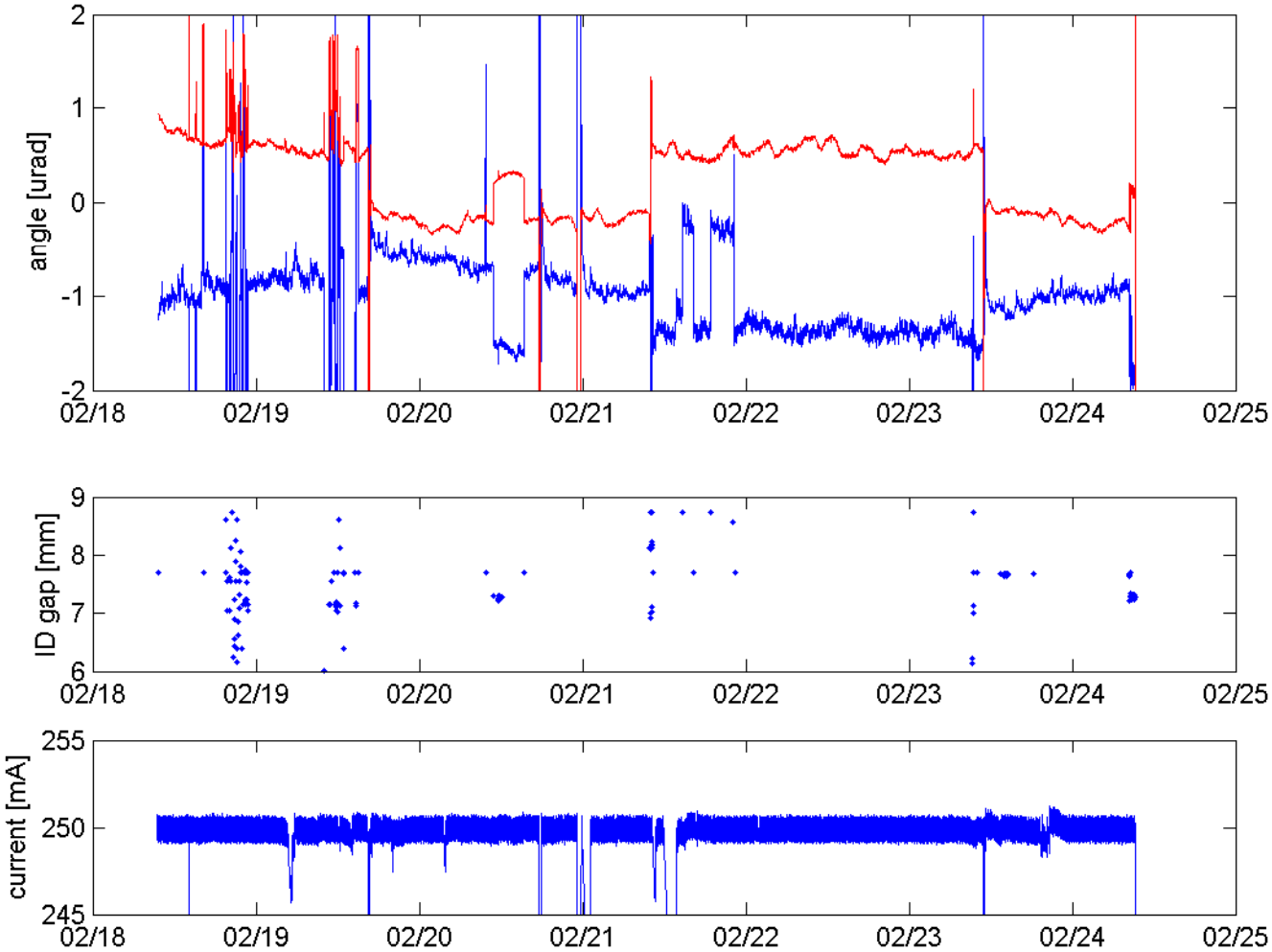




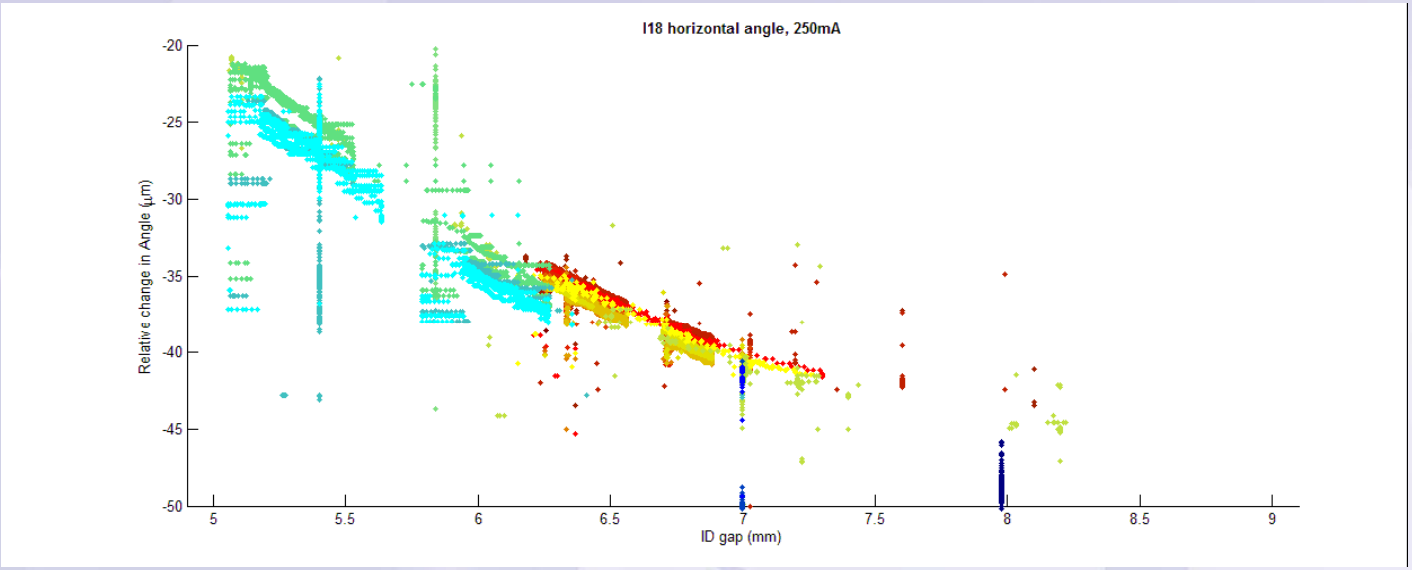
Long Term Observation of Mechanical Stability

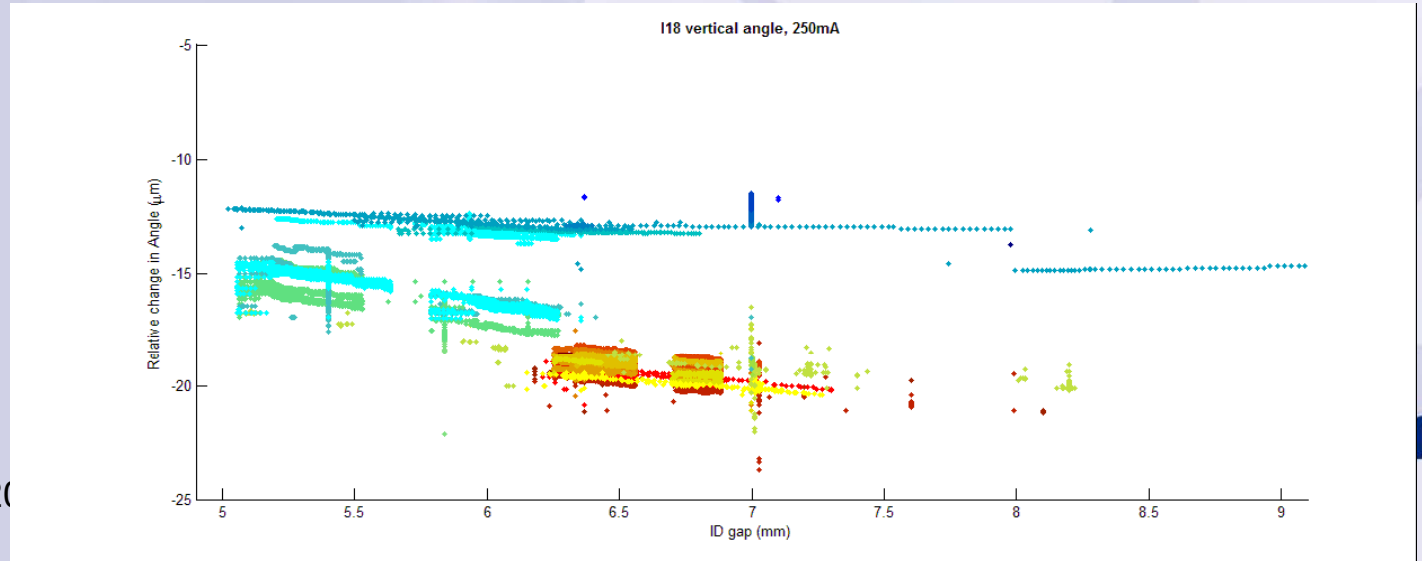


Long Term Observation I03

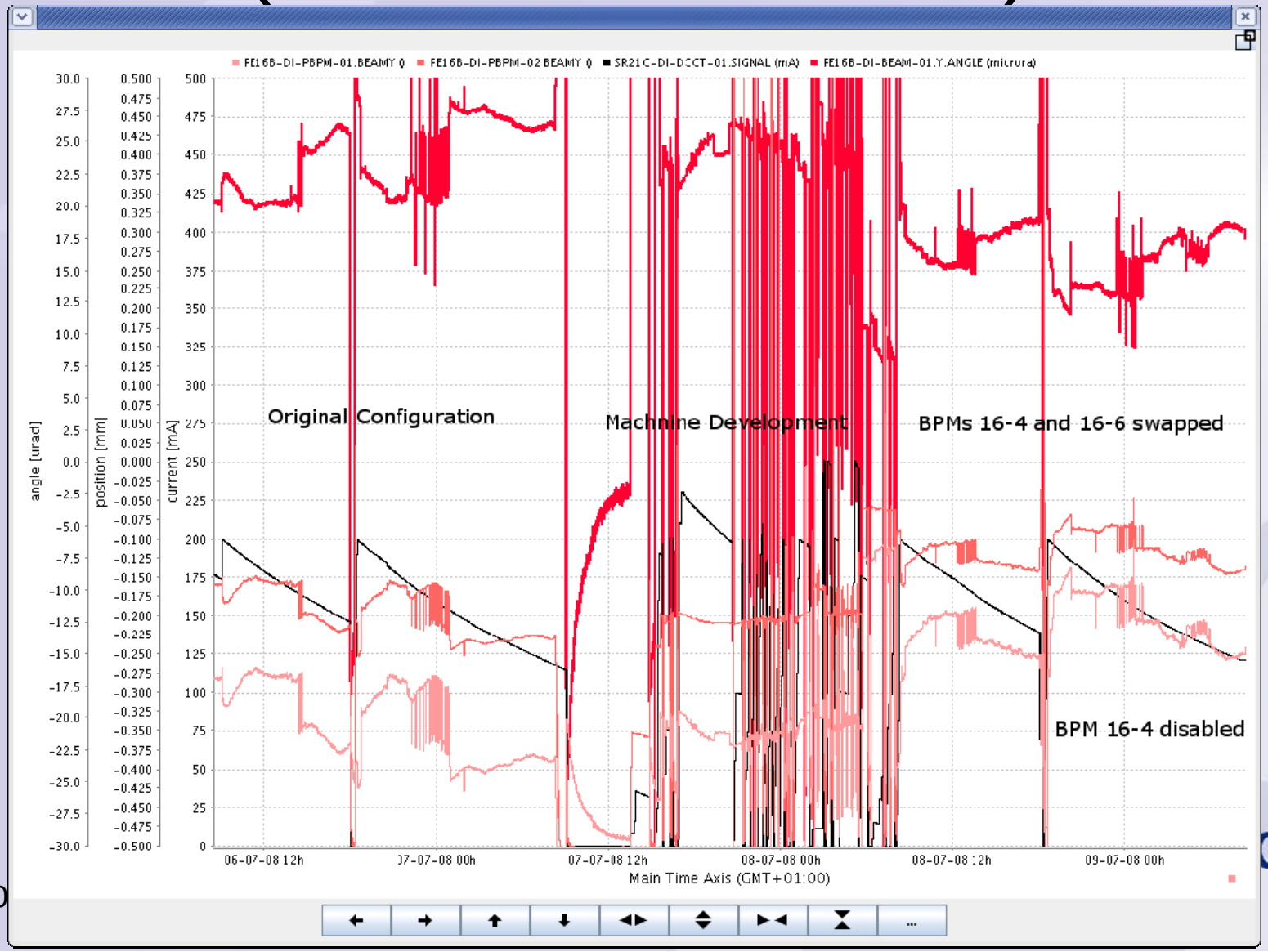


Beam Angle v Gap (Dipole Background Corrected)



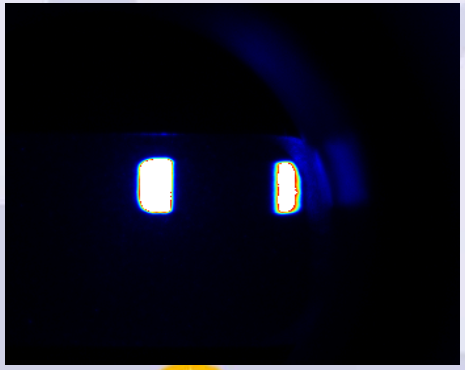


Jumps in one EBPM (with orbit feedback)

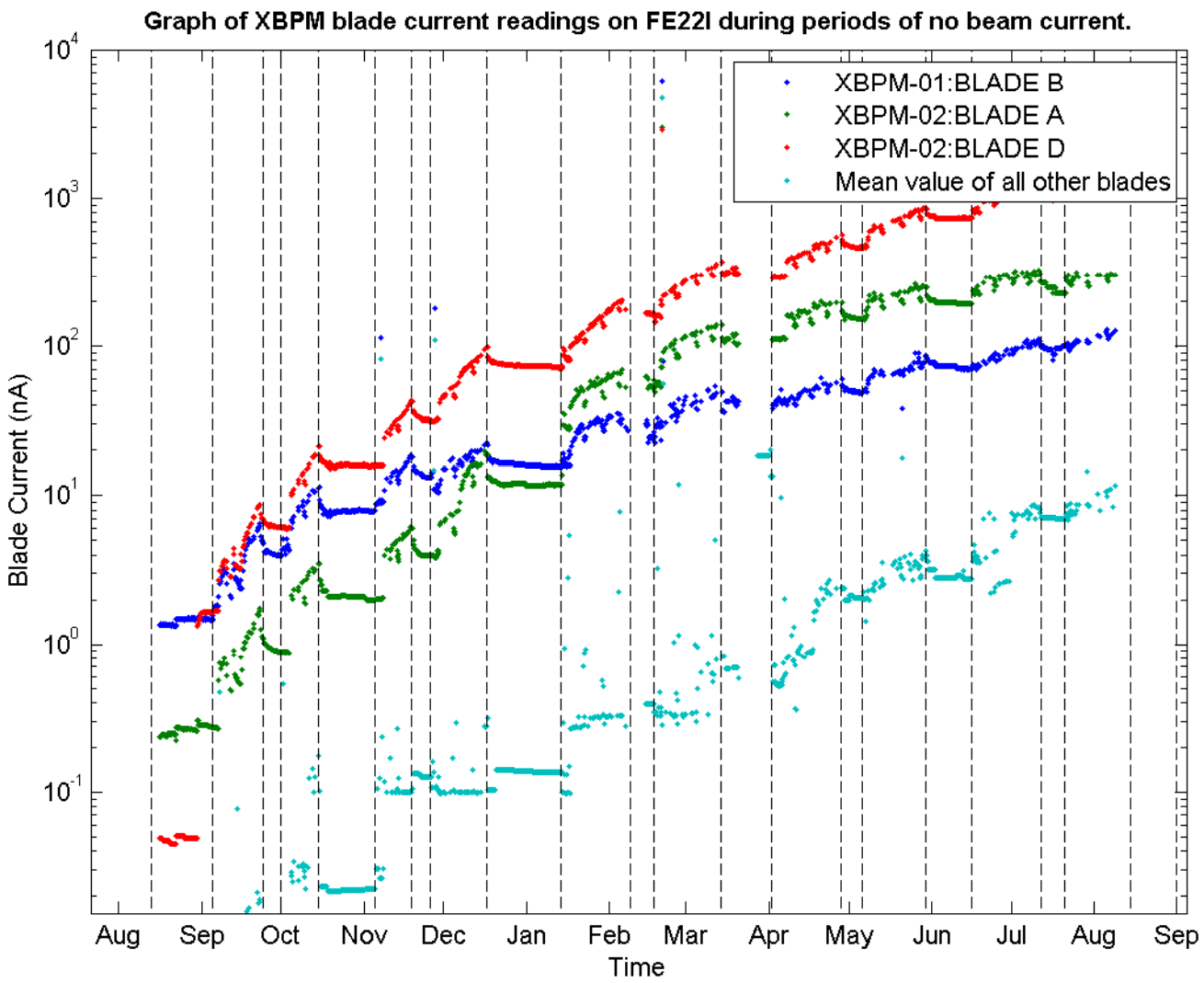


Some Issues and Solutions

- Rising dark current caused by contamination of blade insulator (apparently fixed in latest design)
- Heating of aperture on HU64 with smallest gap and centred beam
- Changing beam shape from HU64 makes position calculation difficult to impossible
- One temperature sensor dropped into beam
- Y stages sometimes sticky

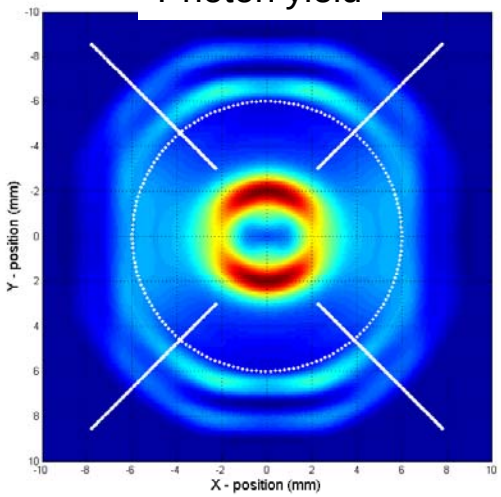


Rising Dark current

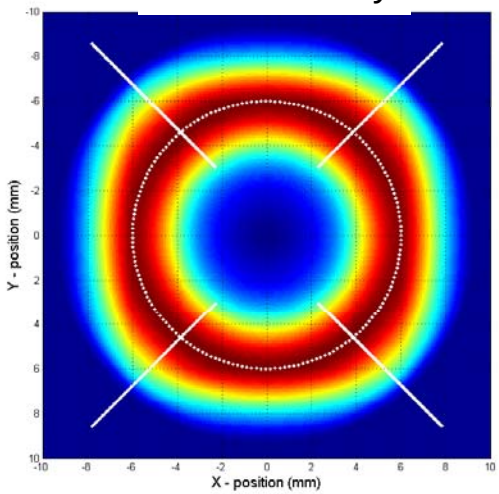


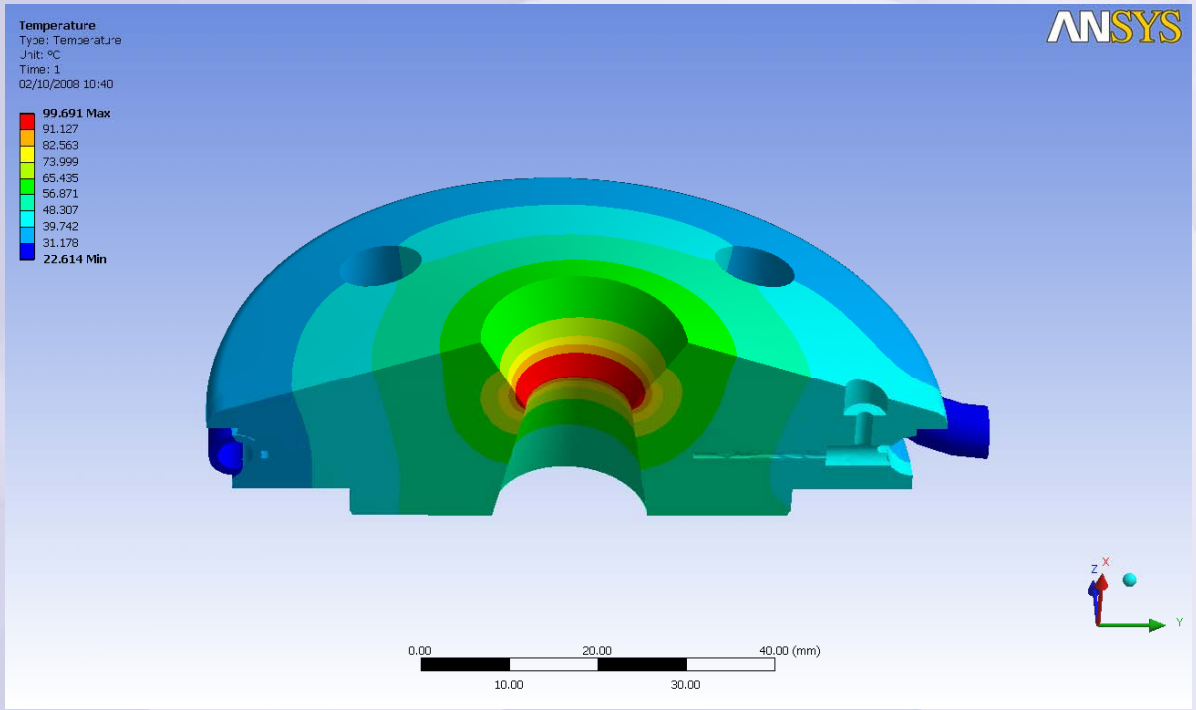
Heating of XBPM1 aperture from HU64 at 16mm gap

Photon yield

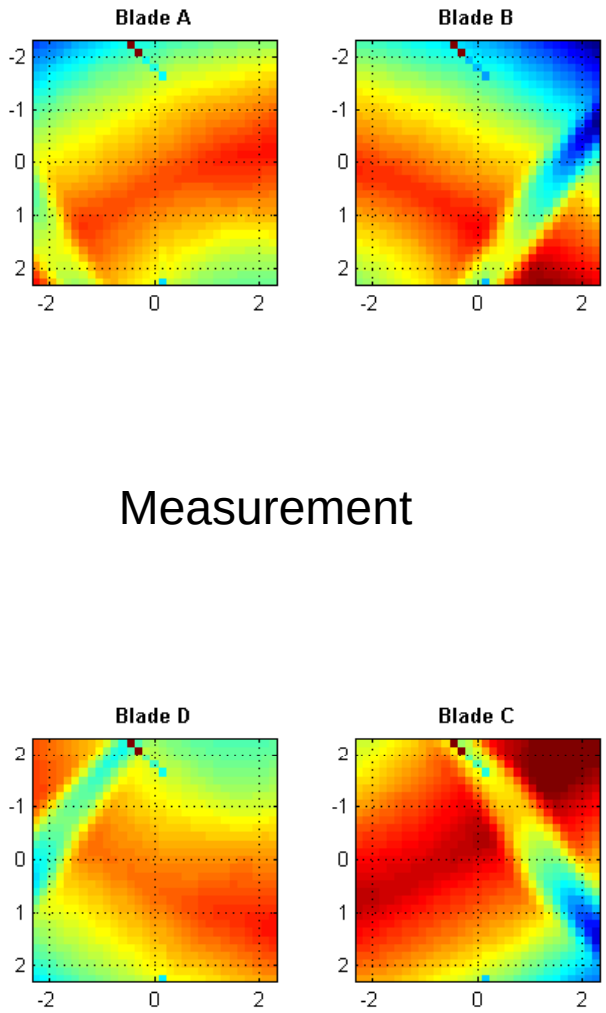


Power density

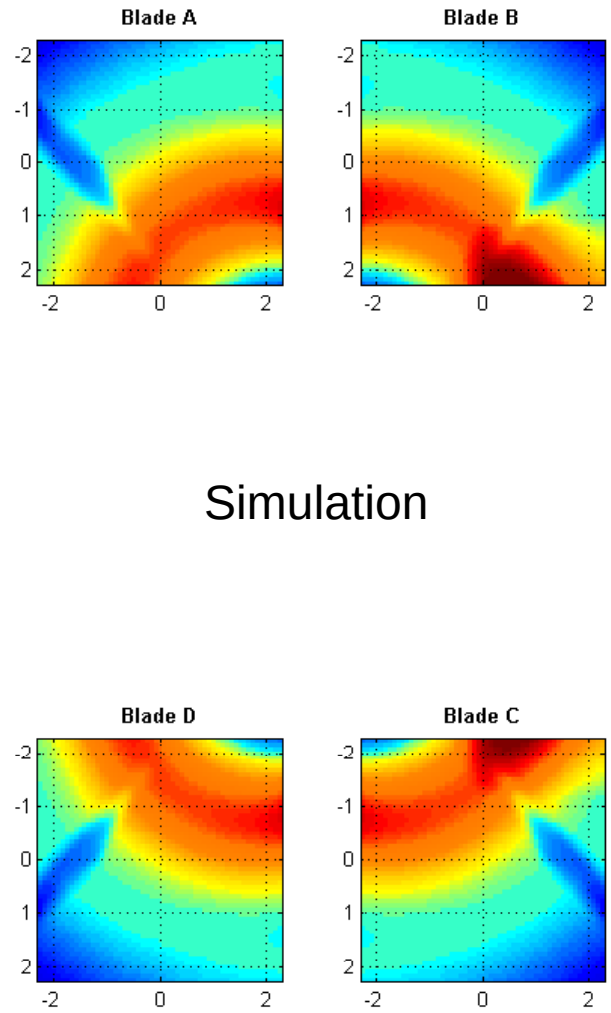




Challenging Beam Shapes from HU64

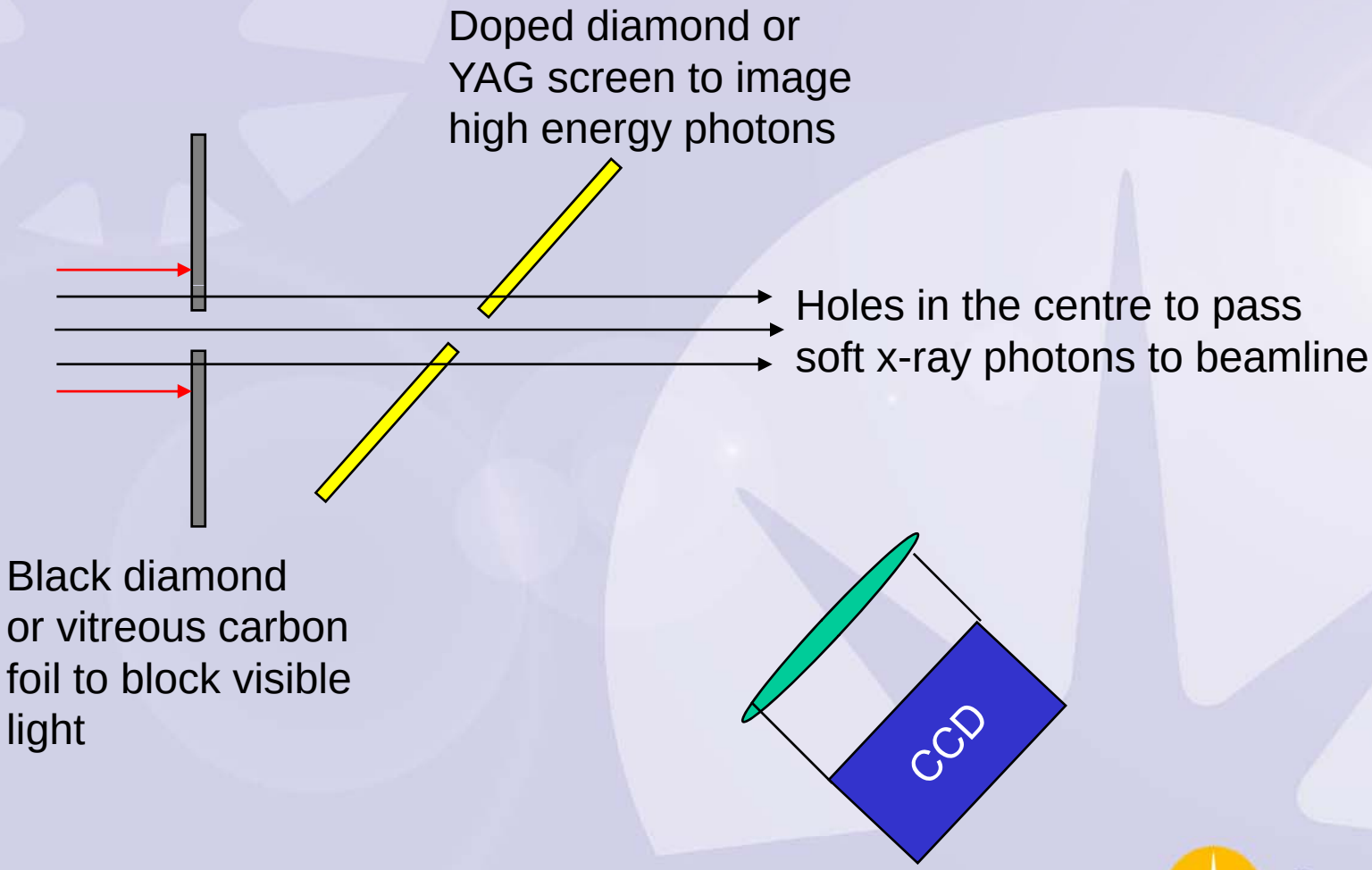


Measurement

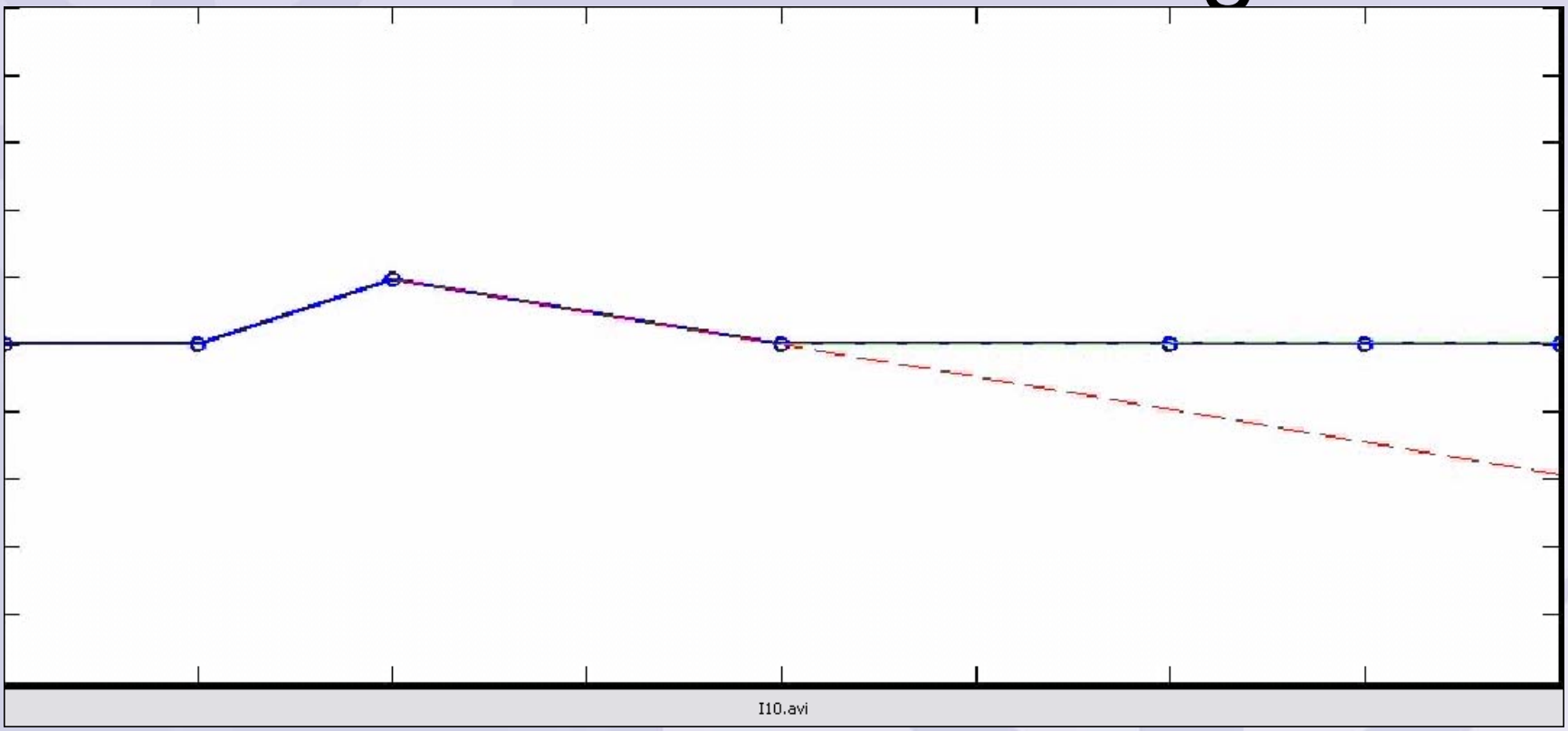


Simulation

An Idea for the Future



Planned Fast Switching IDs



- Need to synchronise XBPM reading with beam switching (10Hz) to align both beams

Experimental Inclusion of XBPMs in FOFB

- Slow ‘slave’ feedback successfully tested
  - New ‘golden orbit’ offsets are calculated from XBPM readings every 2s
  - Keeps beam centred in both XBPMs
  - No complaints from beamlines about stability, so not in use at the moment
- Fast feedback (10kHz update rate):
  - Hardware in preparation
    (ADC -> FPGA -> FOFB network)
  - Benefits not sure yet

Acknowledgements

- Diamond: Cyrille Thomas, Jose Brandao-Neto, Ian Gillingham, Houcheng Huang
- Karsten Holldack (BESSY), Joachim Lange (FMB)
- Oleg Chubar (Soleil and NSLS II) for SRW