Bimorph mirrors – Performance and optimization on the microfocus spectroscopy beamline at Diamond

P. Quinn

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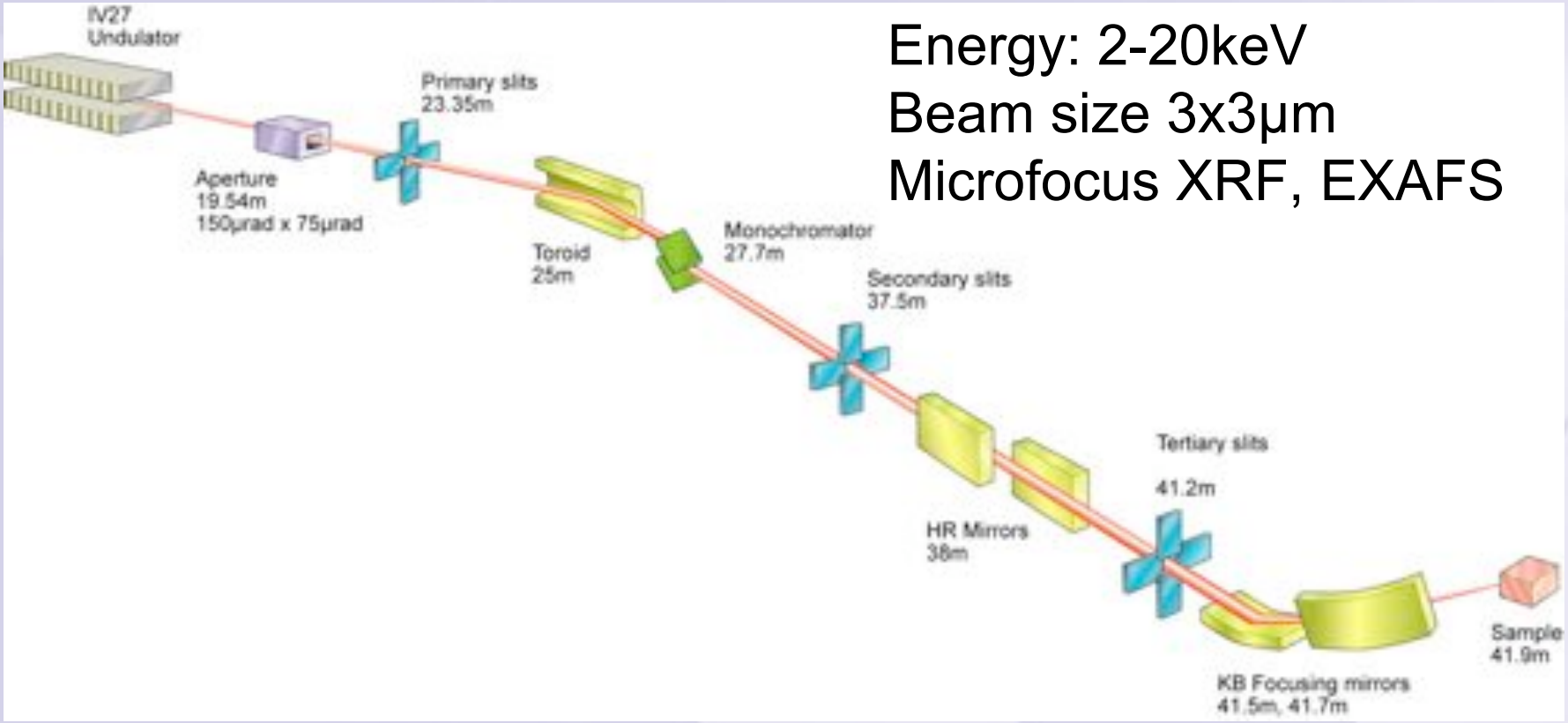
I18 – Beamline overview



Energy: 2-20keV
Beam size 3x3µm
Microfocus XRF, EXAFS

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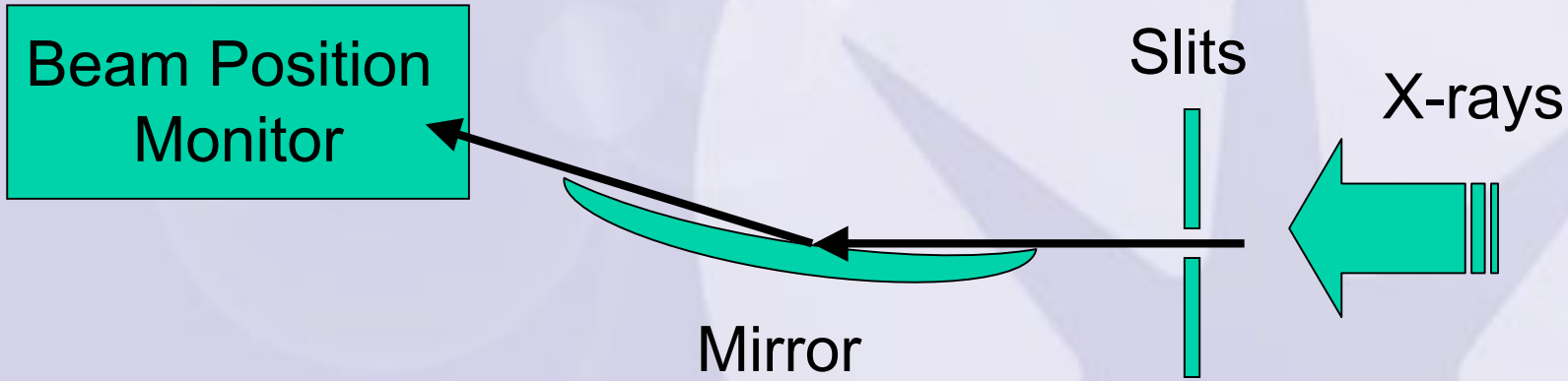
KB System

- SESO Mirrors
  - Vertical mirror
    - 200mm long
    - 8 electrodes
  - Horizontal mirror
    - 150mm long
    - 8 electrodes
  - Mirrors :
    - Silica 2.5 mm thick
    - Cr, Pt and Pd stripes (~50-60nm)
- Oxford Danfysik (FMB) power supply and motion control
- Operated in He for first year then switched to vacuum

Focusing on the beamline

- In-situ optimization – Pencil beam technique



Focusing on the beamline

- Scan across mirror recording beam position
- For each piezo
  - Increment the voltage
  - Rescan the mirror
  - Store the differential metrology
- Builds an interaction matrix, solve

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Focusing on the beamline

- Limited to 5-7 microns:
  - Attempted various schemes, longer acquisition, different settling times, etc.
- Reasons:
  - Nonlinearity of mirror
  - Experimental limitations:
    - Short mirror requires narrow slit and small movements of slits
    - sampling
    - Power supply

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Additional optimization

- Difficulty getting good focus using Interaction Matrix method

- Alternative approach:
  - Try to minimize the FWHM of the beam

Additional optimization

Principle:

- Determine beam profile (knife edge scan)
- Observe changes in profile with voltage change
- Adjust mirror voltages to reduce profile

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Optimization

Choice of algorithm:

- Gradient based algorithms can be problematic
  - How to choose step size for gradient ?
  - Slightly noisy data (always some noise in the profile)
- Pattern search - stencil type algorithm better
  - Non-gradient based
  - User defined initial voltage changes, gradually reducing to smaller step sizes
  - Noise tolerant
- Nelder Mead optimization

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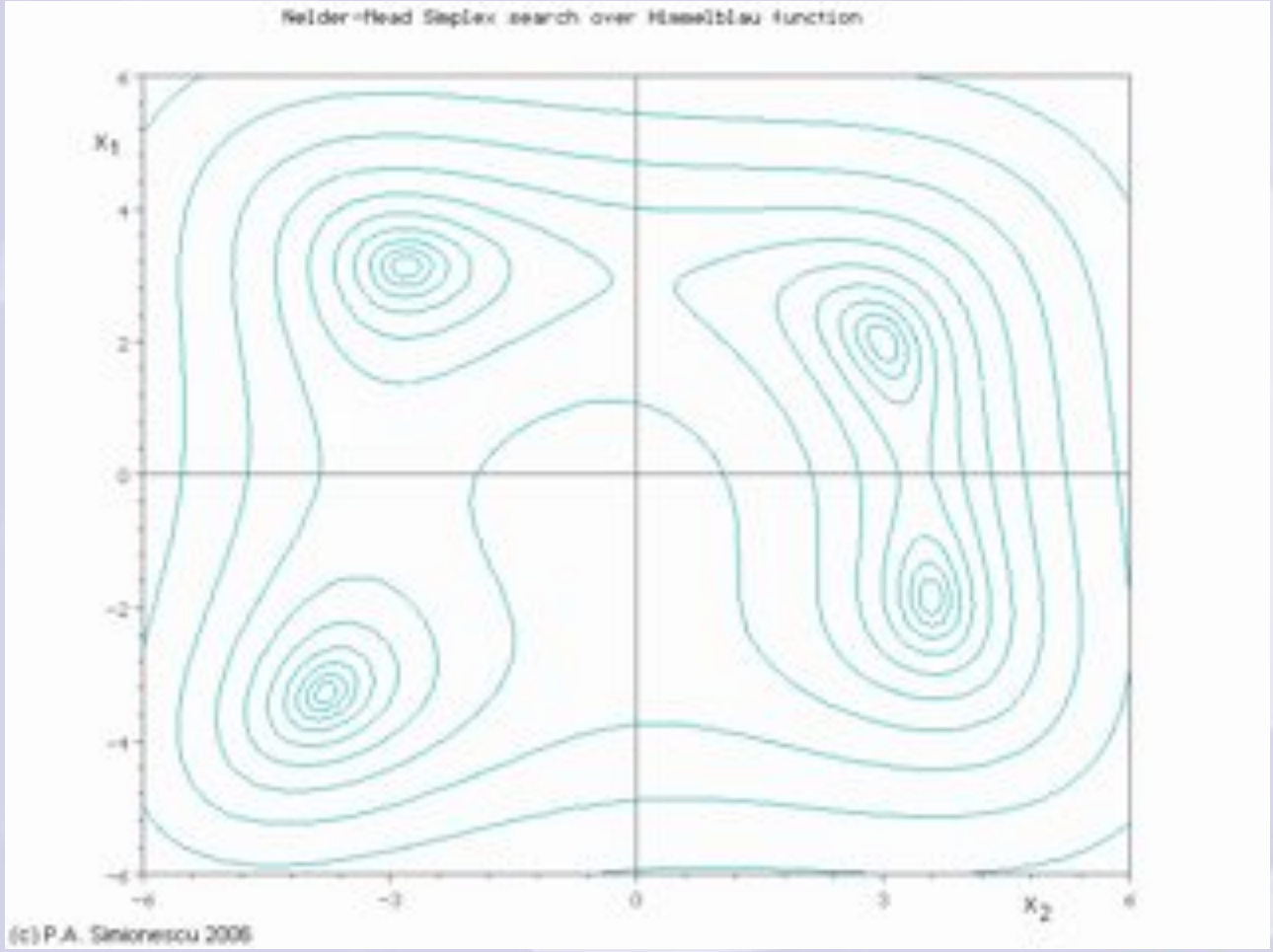
Nelder Mead - example



What to minimize ?

- Initially started with reducing FWHM
  - Doesn't guarantee nice shape
- Minimize difference between beam profile and a desired "model" function, e.g. gaussian

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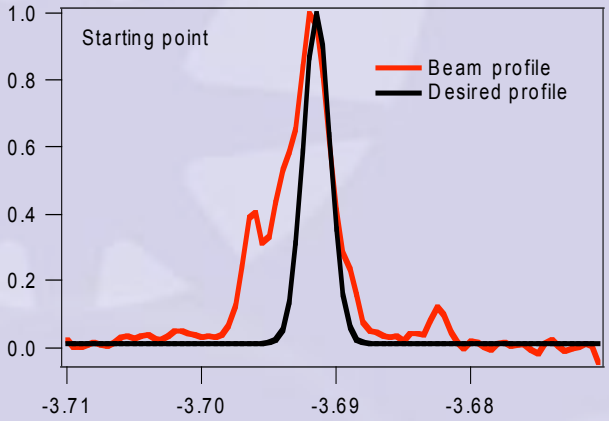
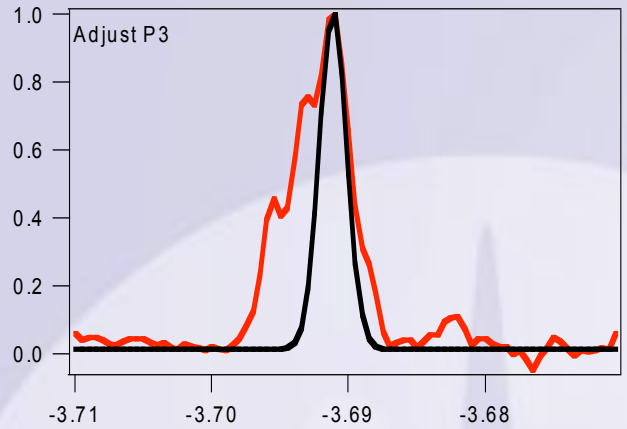
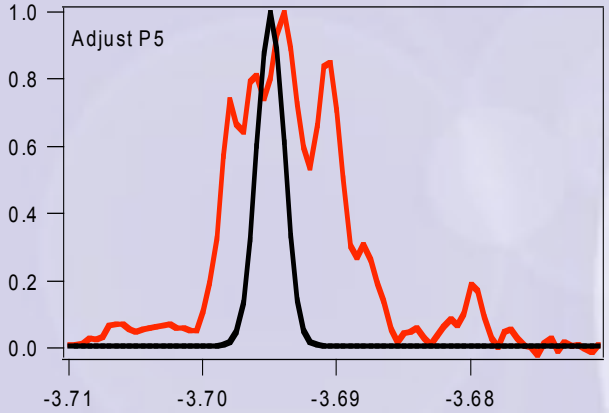
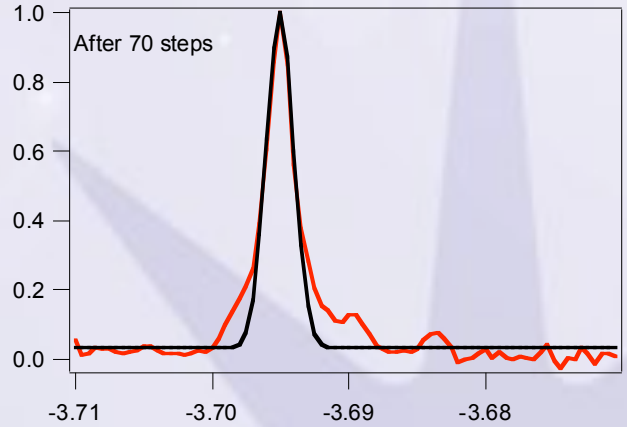
In progress









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Bimorph Optimization

- Achieve 3 micron focus
- Run takes 2-3 hours to optimize
- If could replace knife edge scans with an x-ray eye would be quicker

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Focusing on the beamline

- Problems:
  - Focusing takes too long:
    - User runs typically 3 days
  - Stability:
    - Focus not maintained : frequent re-focusing required
      - Beam movement?
    - Focus degrades over user run

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Bimorph – Degraded ?

- Best focus currently around 3 microns:
  - Should be 1 micron based on specification/slope errors
- Initially had large beam vibrations:
  - 2 micron rms
  - Gradually reduced vibrations but focus not improving
- Visible streaking on central mirror stripe
- Remove vertical mirror for testing (Aug 08)

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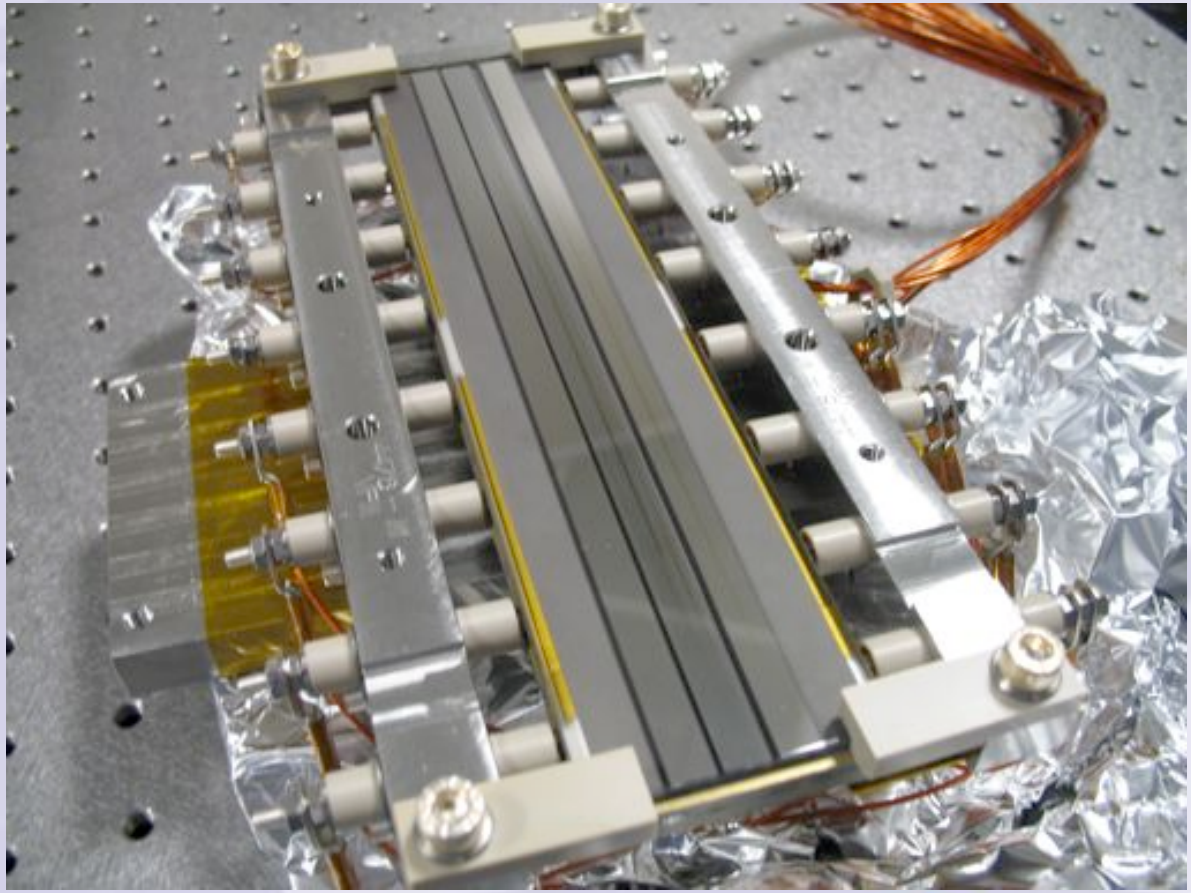
Bimorph tests

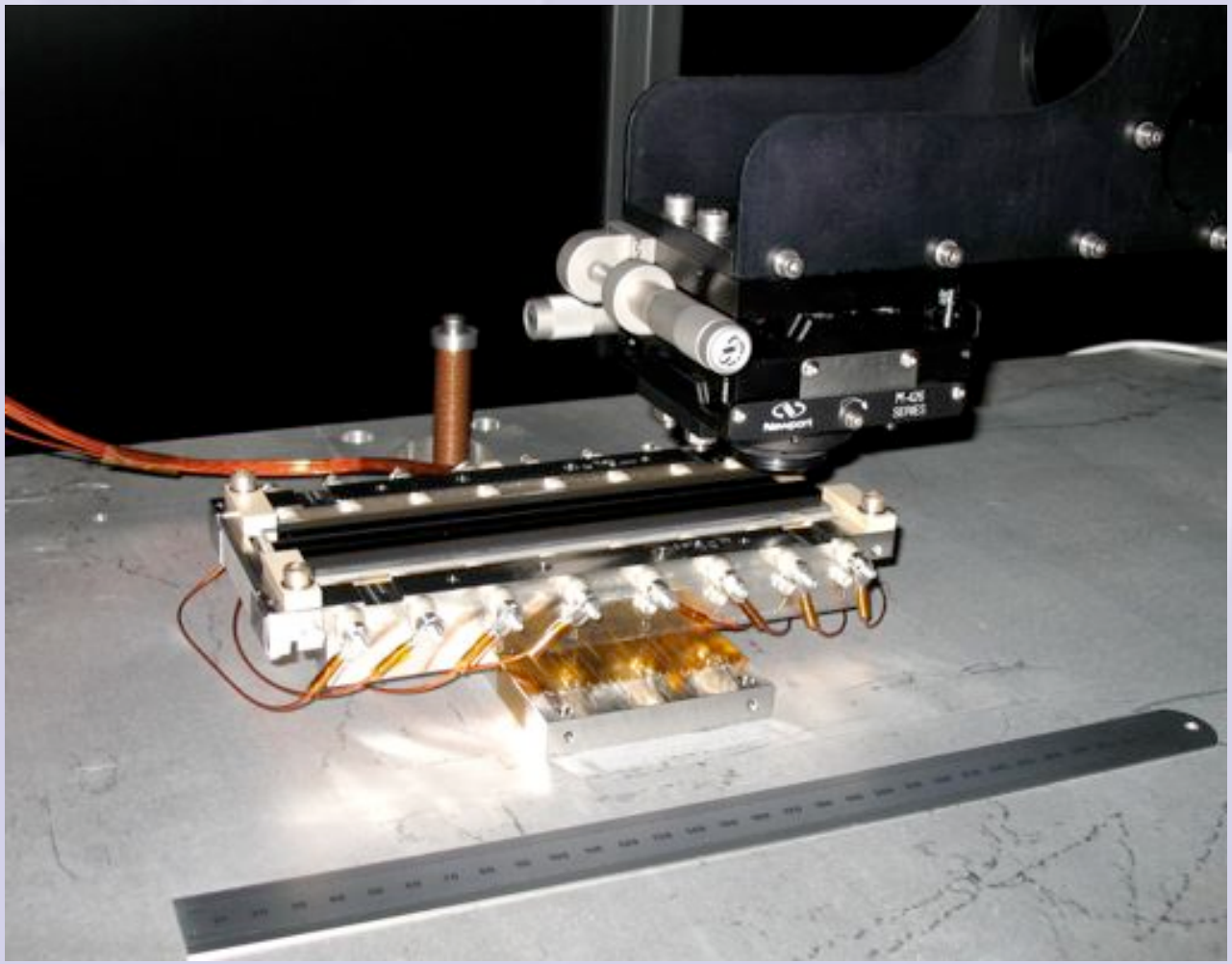
Vertical mirror
200mm long

150 mm central block

Additional electrode
at each end



Bimorph tests



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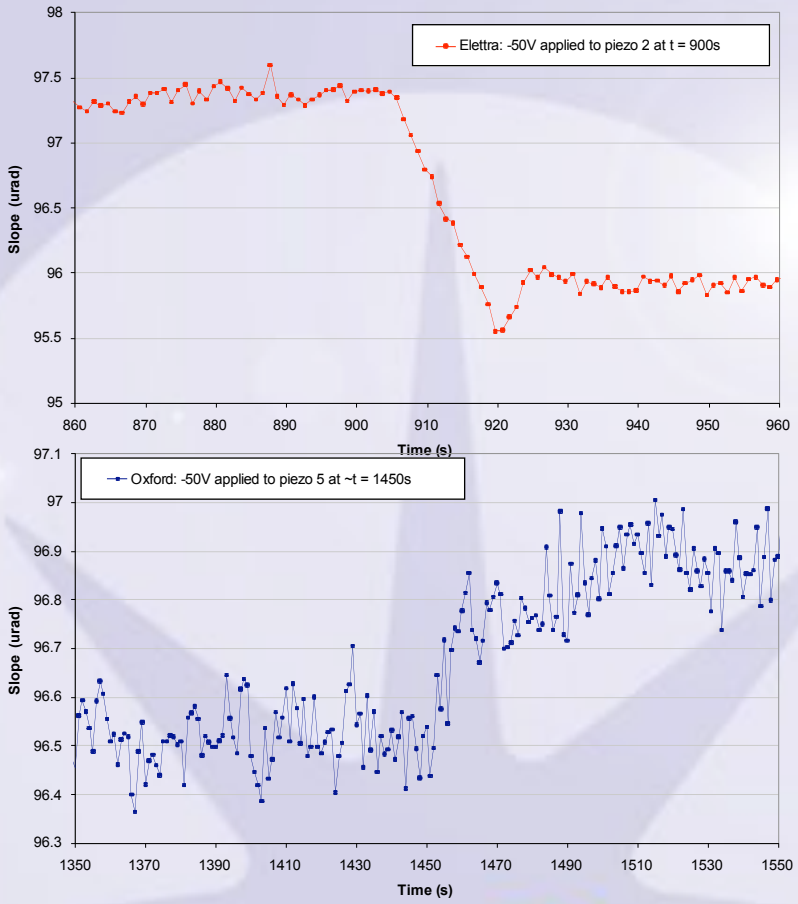
Metrology lab

S. Alcock

Bimorph tests

- OD and Elettra power supplies
  - Comparable stability
  - Comparable settling times



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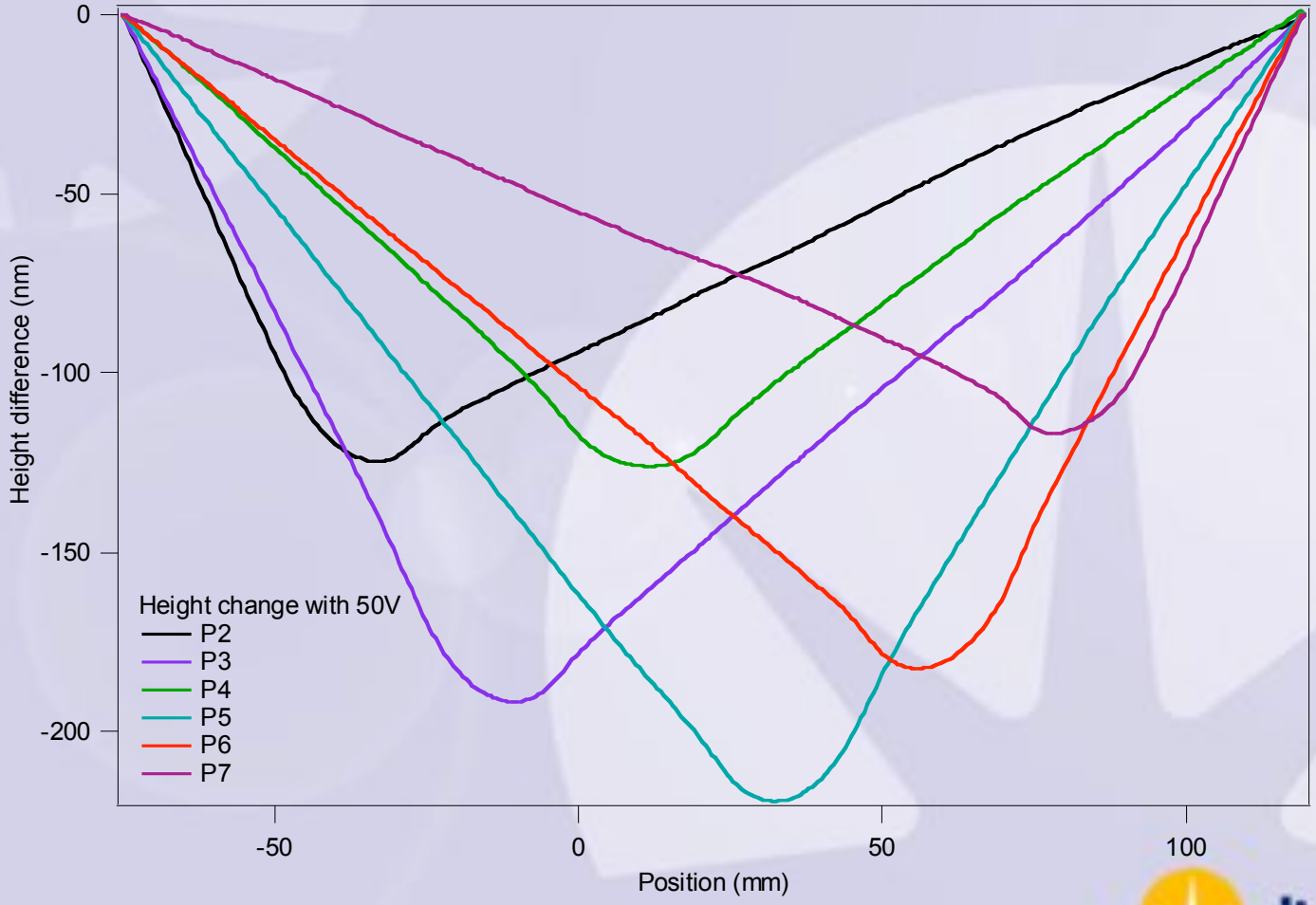

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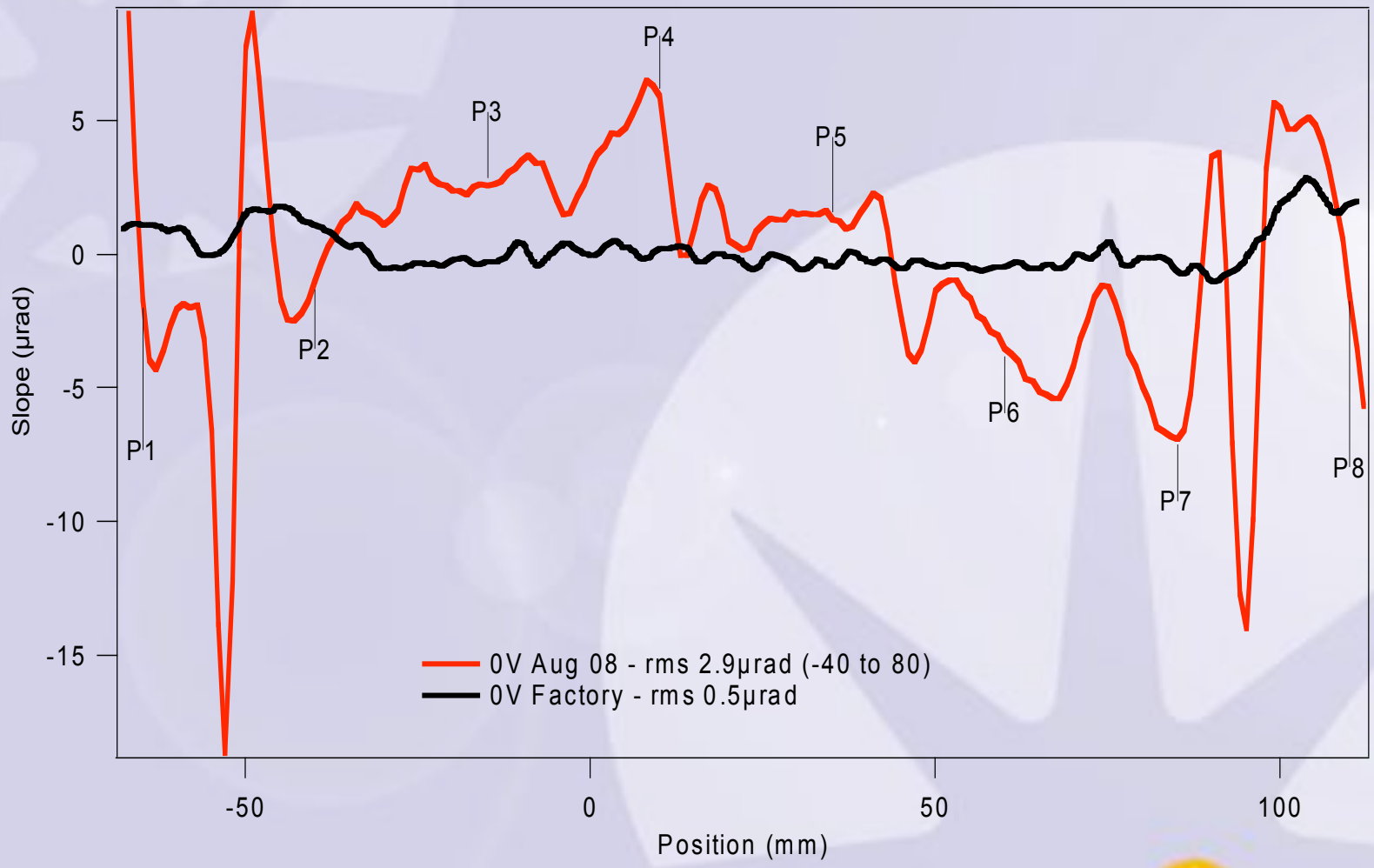
Slope errors



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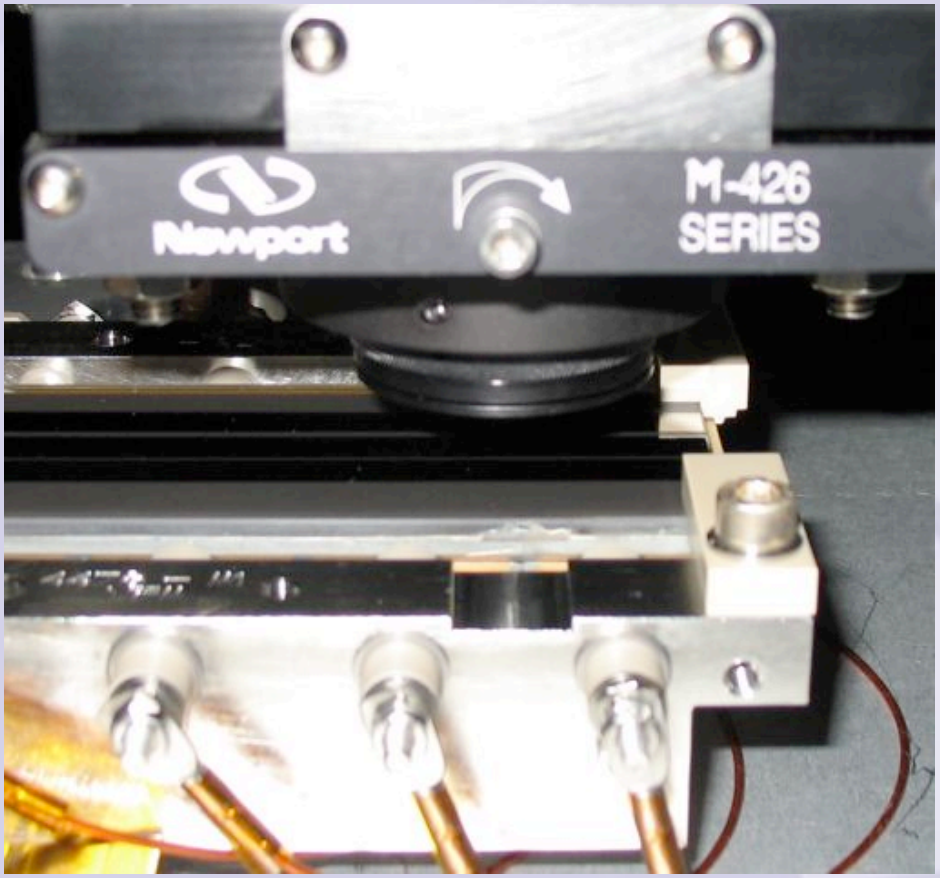

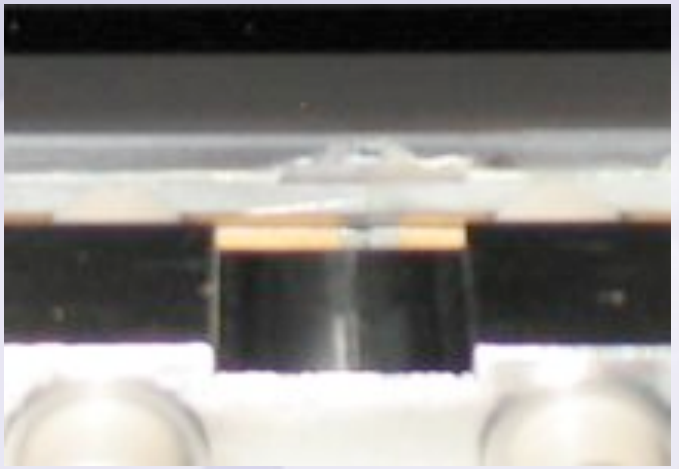

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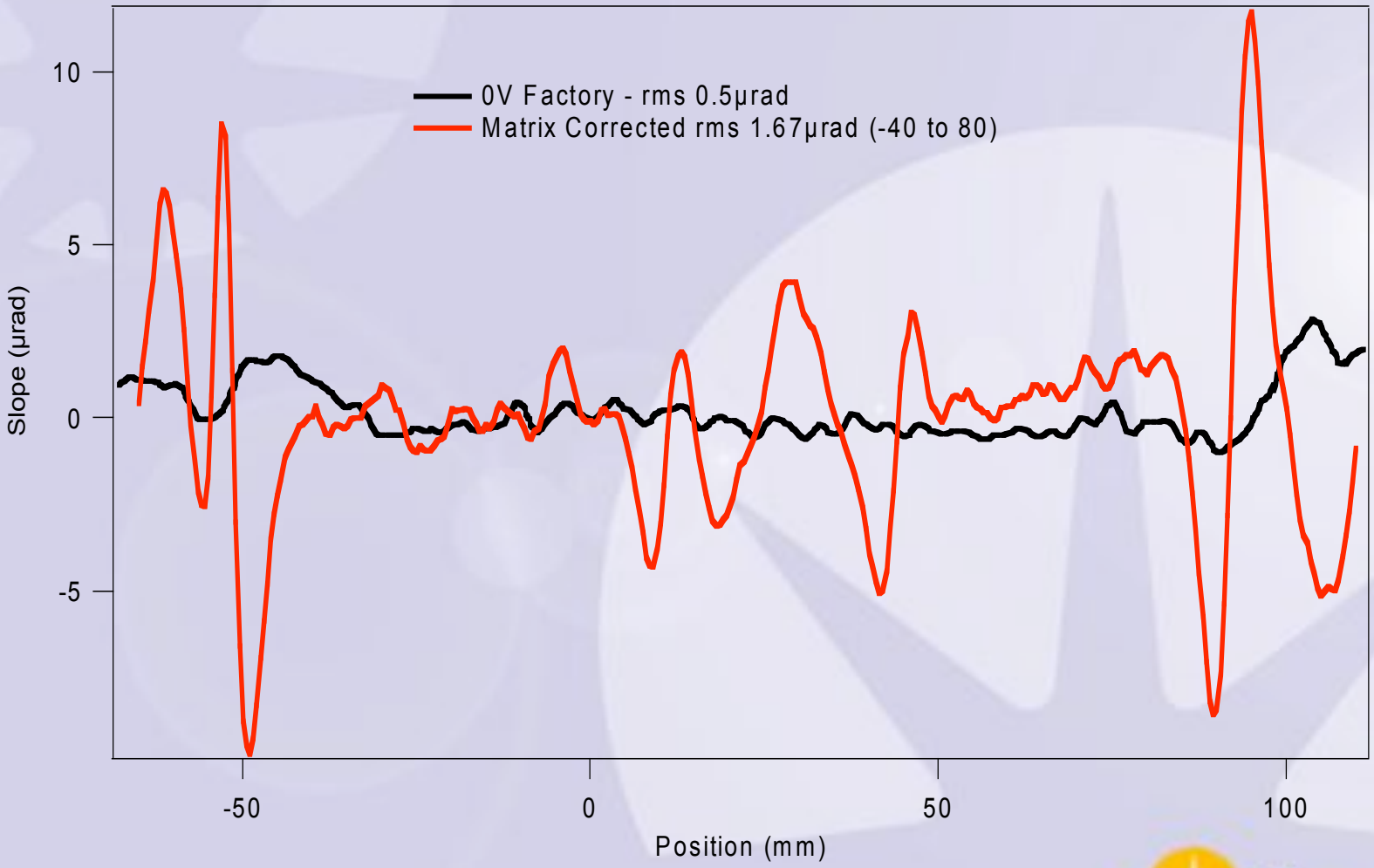

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Slope errors

- Similar on all 3 stripes
  - Only 2 stripes used on beamline : substrate?
- 1.5 µrad slope error = 3 micron beam (Shadow calculations)
- Central 120mm of mirror can be used.

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Slope errors

Causes?:

- Interlock system : Switches off power with pressure
- Glue
- Frequent re-focusing

Conclusions

- Developed alternative methodology for focussing
- Mirror slope errors have gotten worse.
  - Need to replace the mirror to achieve 1micron spot but will it degrade again?

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