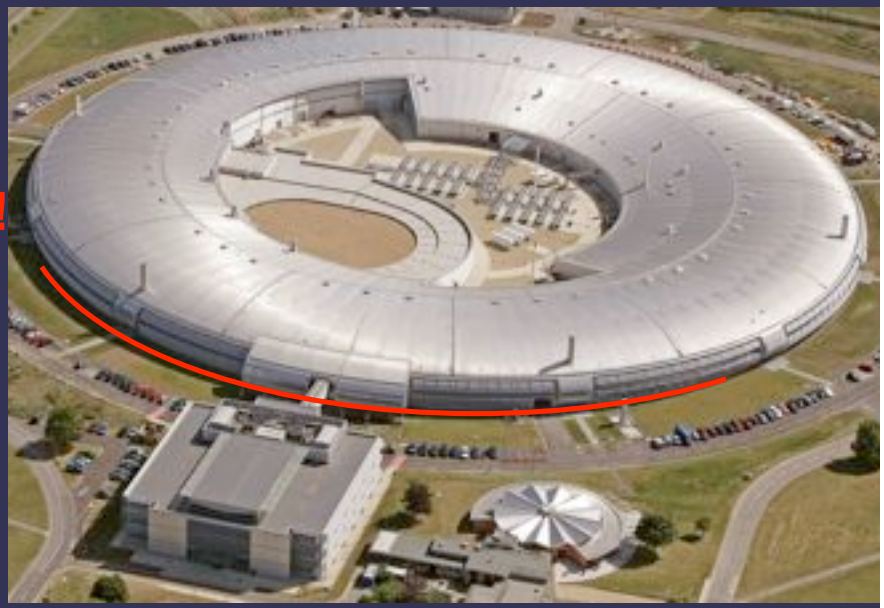
Using the SMP to optimize the shape of adaptive bimorph optics

BIG piezos!



Dr. Simon Alcock, Diamond Light Source

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DLS Optics & Metrology

Group leader:
- Kawal. J. S. Sawhney

Ex-situ, optic testing (cleanroom)
- Simon Alcock
- Geoff Ludbrook

In-situ, bimorph testing (beamline)
- John Sutter

Ray tracing & nano-focussing
- Lucia Alianelli

Optics technician:
- Hiten Patel

Metrology cleanroom lab, physical metrology lab, & peripheral lab (x-ray source & diffractometer)

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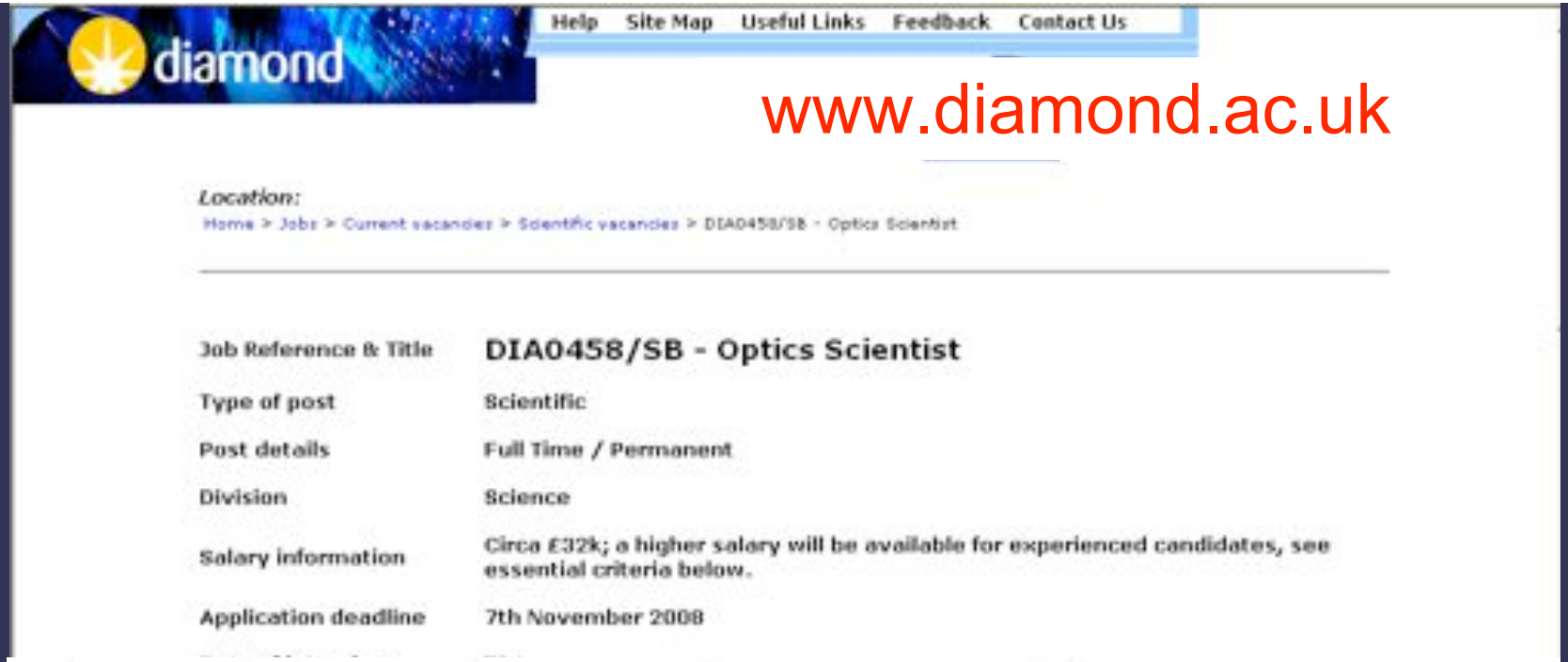


Duties

- Contribute to the optical design and commissioning of beamlines, working in close collaboration with beamline scientists;
- Support beamline scientists in specifying, procuring and testing of beamline optics;
- Work on one or more of the following: soft x-ray polarimetery, nano-focusing optics for hard x-rays, nano-instrumentation;
- Undertake research in the field of X-ray optics;
- Publish work in peer-reviewed journals.

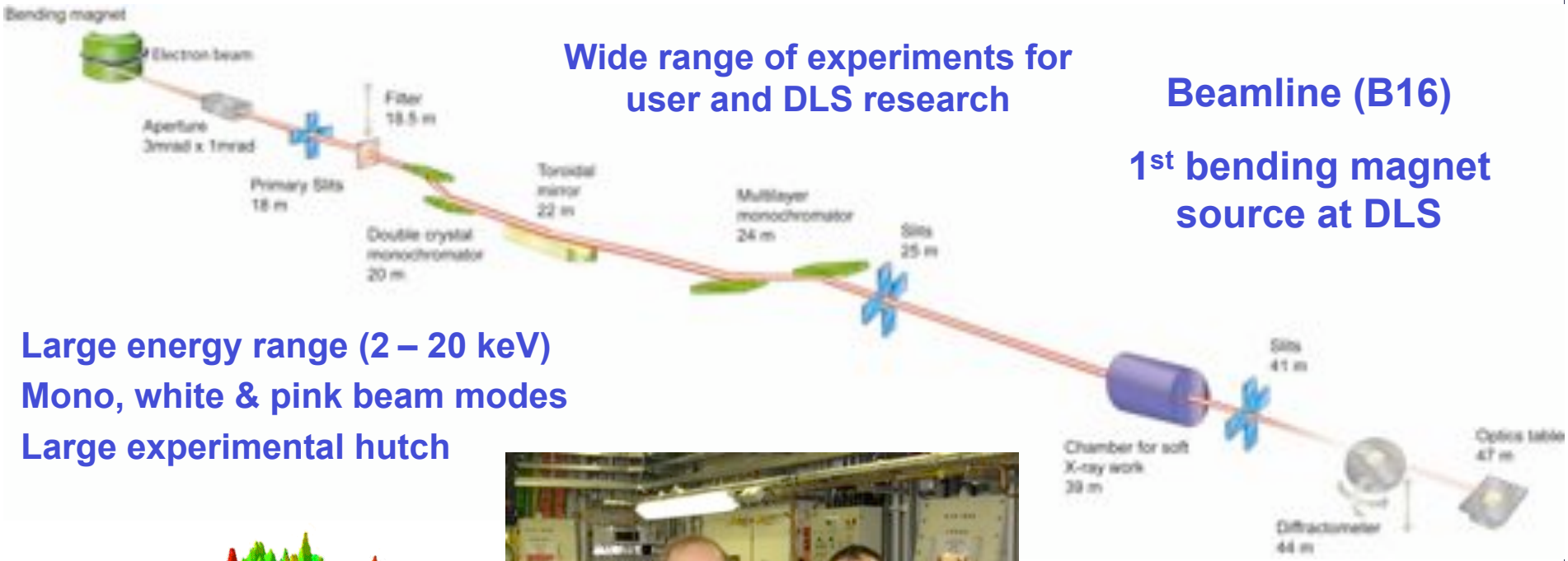
Qualifications and Experience: Essential

- PhD in physics, material science, applied optics or related disciplines; or equivalent qualification or experience;
- Experience in one or more of the following : beamline design, beamline instrumentation, synchrotron optics or metrology of beamline optics;
- Ability and initiative to get to the heart of the problem and take it effectively through to completion;
- Good interpersonal, communication and presentational skills;
- Ability to work as part of a multi-disciplinary team;
- Self motivated;
- Must be available to travel occasionally in UK and overseas including overnight absences;

Synergy with “Test” beamline

- Testing optics, detectors, and controls
- Development of novel experiments & techniques

Further information:
Kawal Sawhney

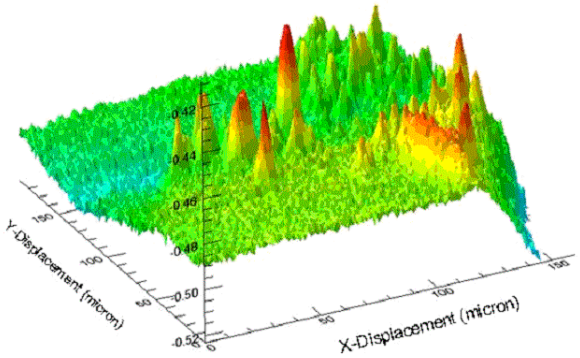


Wide range of experiments for user and DLS research

Beamline (B16)

1st bending magnet source at DLS

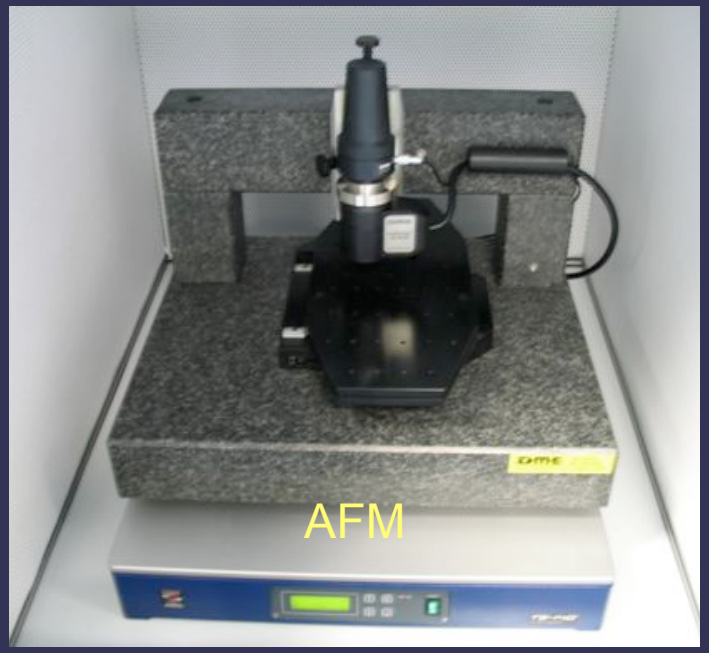
Large energy range (2 – 20 keV)
Mono, white & pink beam modes
Large experimental hutch



First users Jan 2008.

M. Moore et al

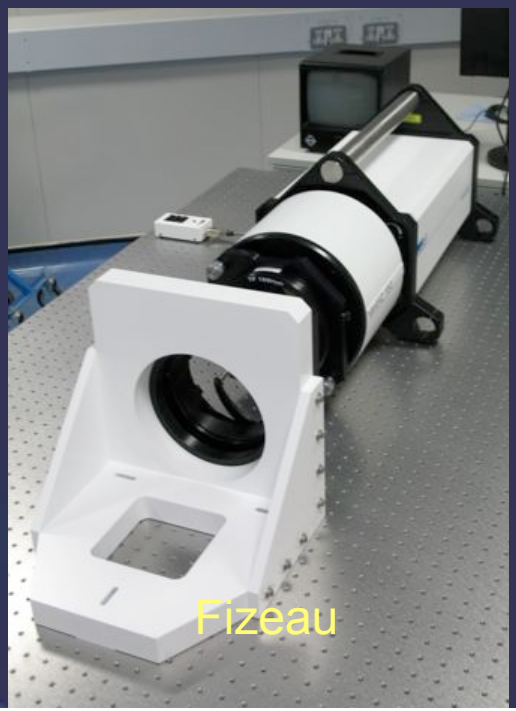
Nano-collimator study of metal inclusions in artificial diamond



AFM

SMP

Optics & Metrology cleanroom
Class 10k (ISO7)



Fizeau

Micro interferometer

Metrology instruments

Atomic defects

Surface roughness

Shape / Slope errors

Atomic Force Microscope (AFM)
- Atomic surface defects
- Lateral scan size: 50µm x 50µm
- Lateral resolution: <1nm
- Vertical accuracy: 0.01nm

Phase shifting micro-interferometer
- Micro-topography
- Lateral scan size: 60µm – 10mm (+ stitching)
- Lateral resolution: 0.1µm – 9µm
- Vertical accuracy: 0.05nm (rms)

Fizeau interferometer
- 3-D height measurement
- Beam diameter: 150mm
- Lateral scan size: 150mm – 1500mm
- Accuracy: <1nm rms (λ/100 PV)

Slope measuring profiler (SMP)
- 3-D slope measurement
- Lateral scan size: 1500mm x 300mm
- Lateral resolution: <0.5mm
- Repeatability <100nrad

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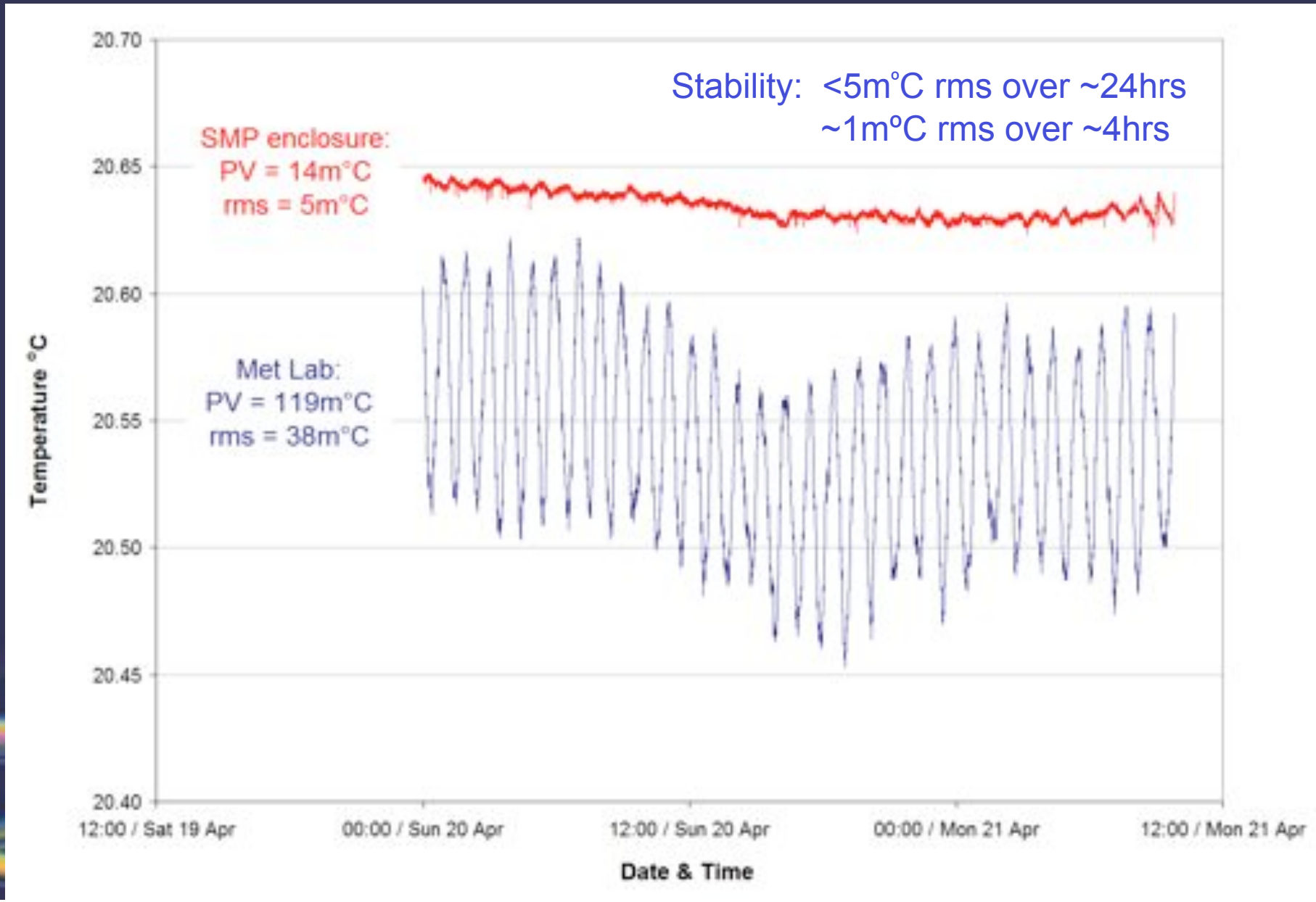
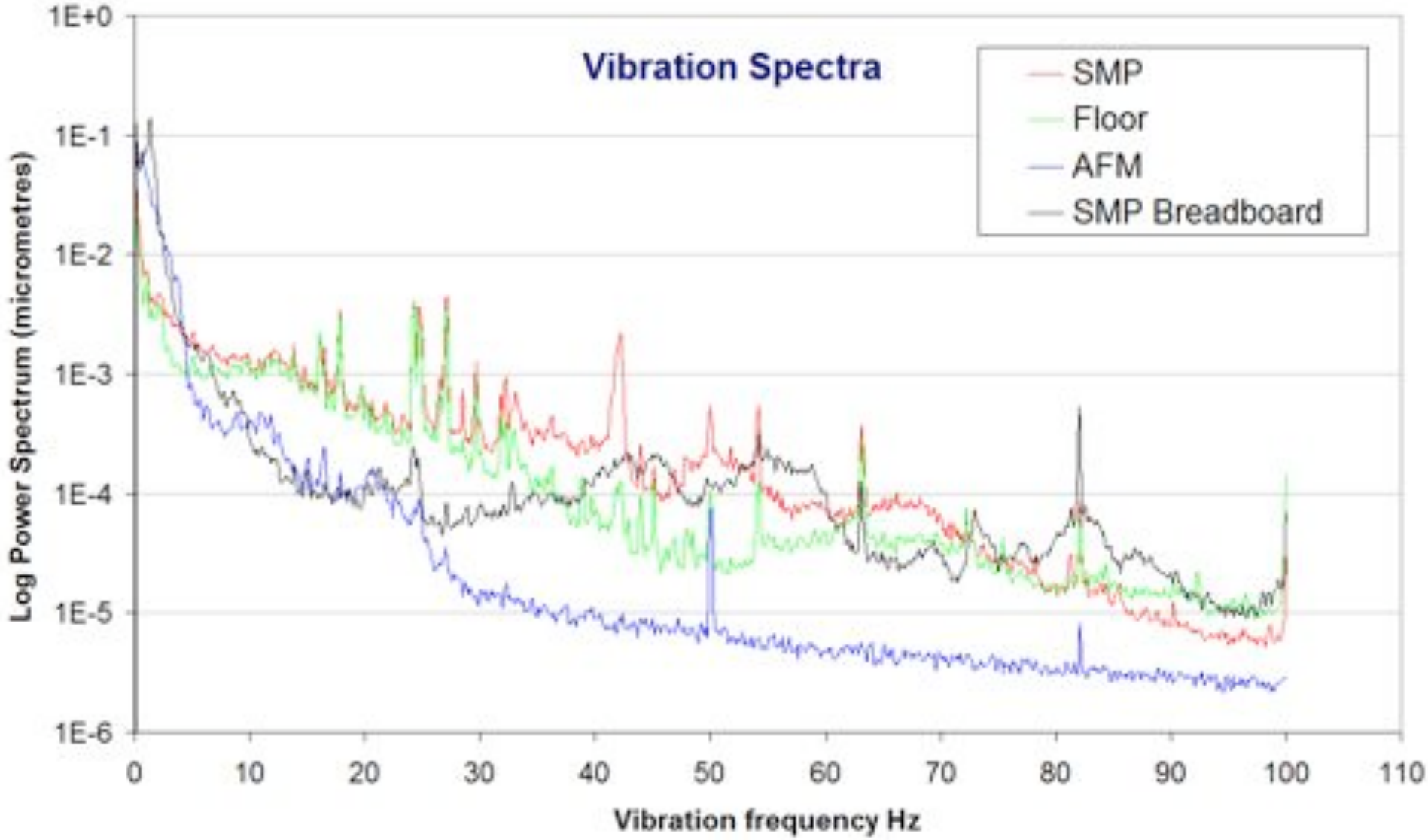
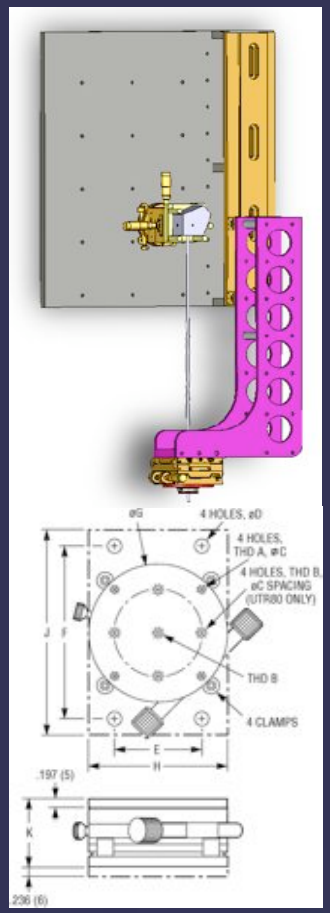
Cleanroom temperature stability

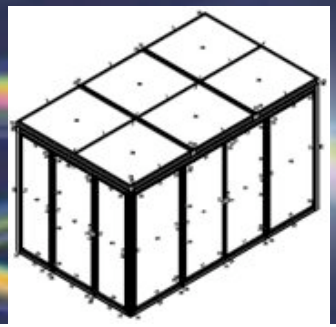


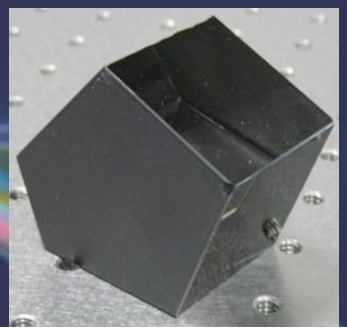
Vibrational stability

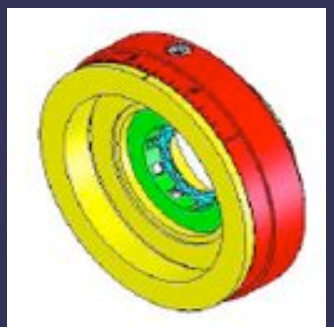


Slope Measuring Profiler (SMP)









DLS / BESSY Collaboration

DLS team: Simon Alcock, Stewart Scott (Engineering), Ulrik Pedersen (Controls), Rob Walton (Software), and Kawal Sawhney.

Thanks and acknowledgement to Frank Siewert, Thomas Zeschke, Fred Senf, and associated staff at BESSY, for their expert knowledge and support in helping to develop the SMP.

F. Siewert, T. Noll, T. Schlegel, T. Zeschke, and H. Lammert, "*The Nanometer Optical Component Measuring machine: a new Sub-nm Topography Measuring Device for X-ray Optics at BESSY*", AIP Conference Proceedings 705, American Institute of Physics (2004) 847-850

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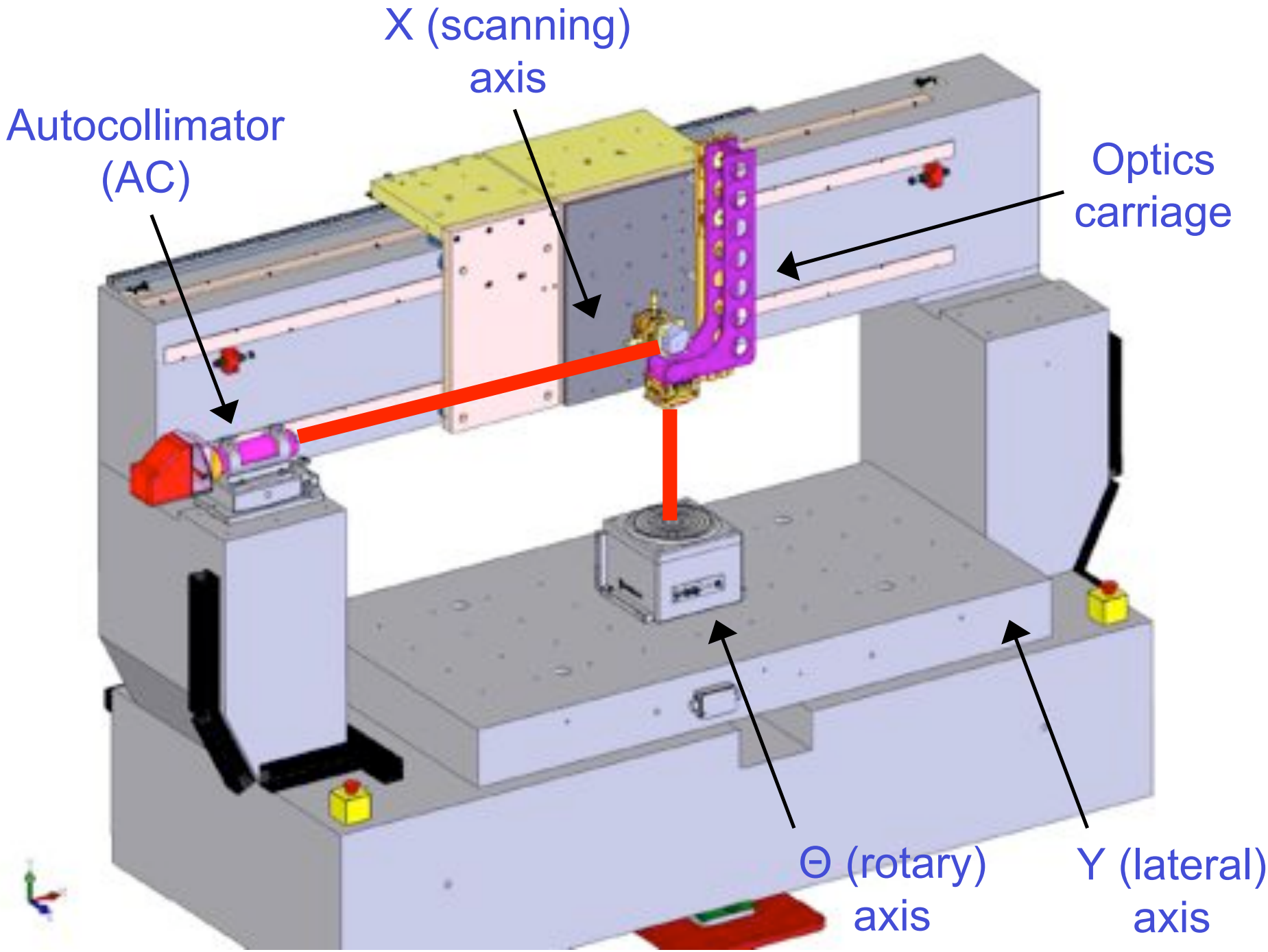
X (scanning)
axis
Autocollimator
(AC)
Optics
carriage
Θ (rotary)
axis
Y (lateral)
axis

SMP specifications I

SMP Specifications [1]		
Axis	Bridge: X axis	Lower axis: Y axis
Model	DLS 3672	DLS 3672
Motor Type	LEM-S-4	LEB-S-4
Measuring system	Heidenhain LIF171 internal10X interpolation	Heidenhain LIF171 internal10X interpolation
Stroke [mm]	1505	302
Resolution [µm] Bi-directional repeatability (3_	0.1	0.1
[1] Specifications valid over the central 80% of travel.		

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SMP specifications II

Specifications [3]		
Axis	Rotary : _ axis	
Model	RT200	
Motor t ype	DC + belt	
Feedback system	RE36.000 lines/revolution 25X interpolation	
Travel	360	[°]
Resolution [4]	0,36	[Arcsec]
Repeatability (3 _	± 1	[Arcsec]
Positioning accuracy including repeatability (3 _	± 2	[Arcsec]
Concentricity	± 0,2	[µm]
Flatness of rotation	± 0,2	[µm]
Maximum velocity	3	[RPM]
Axial load capacity	100	[kg]

[3] Specifications valid per axis, without external load, and measured at 25 mm height above the table surface
[4] With additional 25X interpolation, and 4X interpolation in the controller

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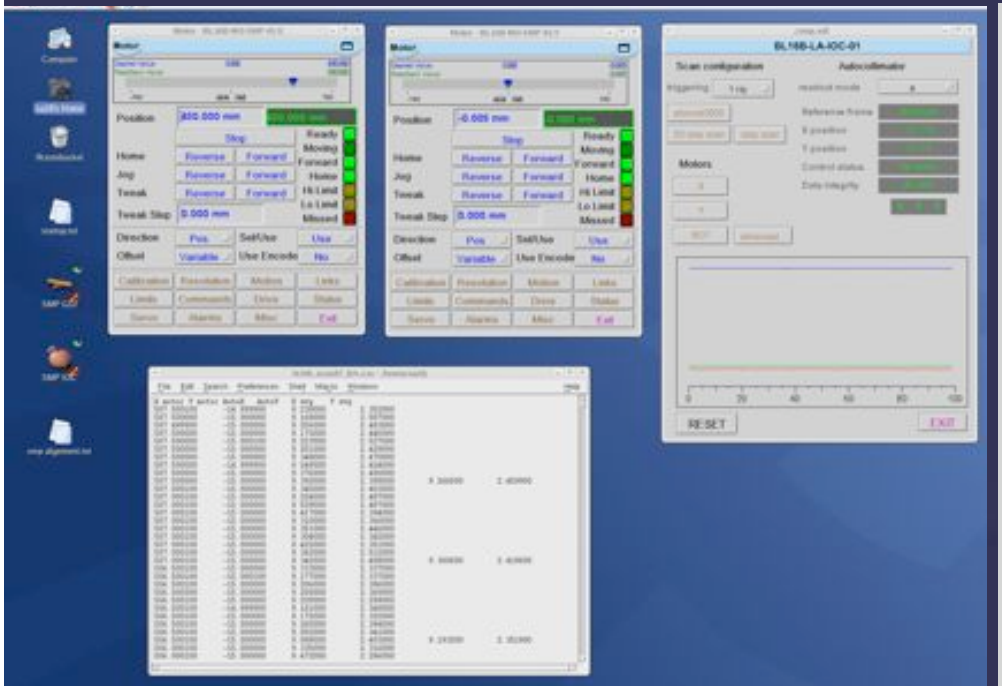
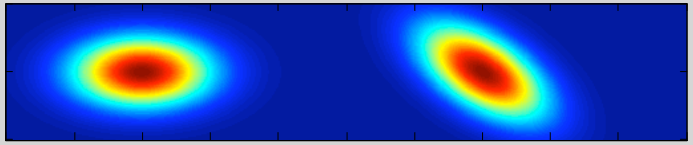
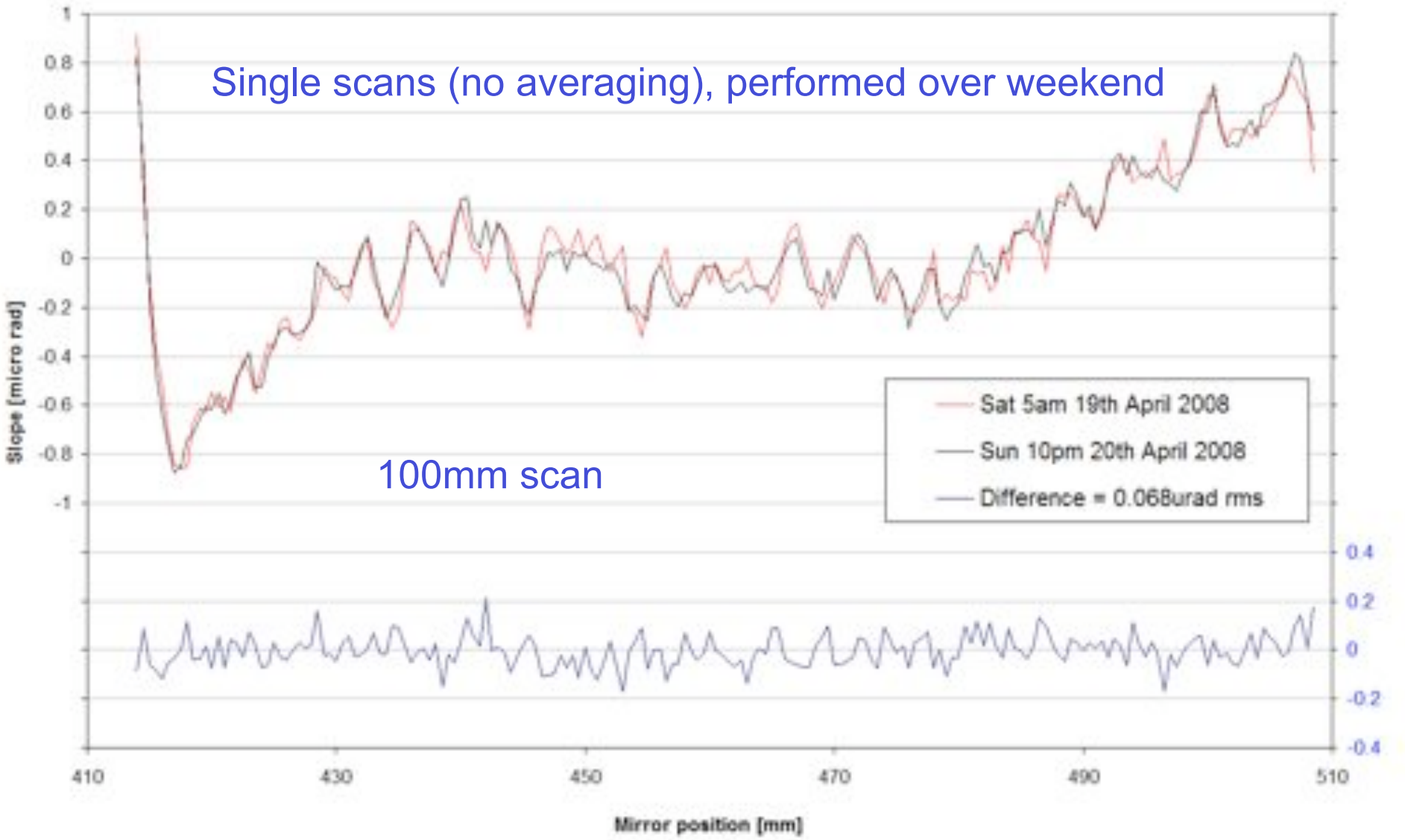
SMP Controls & Analysis

- Scan types: step (discrete), flyscans (continuous), and stability
- EPICS interface (via PMAC controller) to SMP & A.C
- Python command scripts for sequential scans & waiting
- Automatic data analysis and error flagging
- Matlab with LabCA interface to EPICS
- Delta-Tau (PC104, “Turbo” PMAC “Clipper”) with Ethernet/RS232





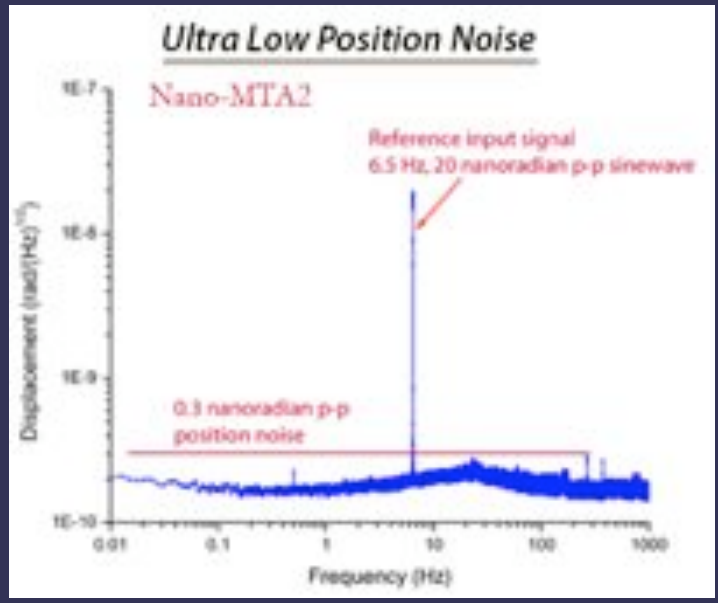
SMP repeatability ~68nrad



Piezo tip / tilt stage (angle calibration)

- Generate a certified tip / tilt angle to calibrate angle measuring systems.
- Range of motion: up to 10milliradian
- Resolution ~10nrad (with 20bit interface)
- Open or closed loop

Demonstration stage to be tested (Autumn 08).



Technical Specifications

Range of motion (per axis)	2.0 mradian
Resolution	4.0 nradian
Range of motion (extended)	5.0 mradian
Resolution	10 nradian
Resonant Frequency (unloaded)	5 kHz ±20%
Scanning Speed (full amplitude)	up to 400 Hz
Optics	1" diameter mirror mounting area
Body Material	Al or Invar and Titanium
Controller	Nano-Drive™/Nano-Drive™85

Mad City Labs, piezo stage (for 1 inch optics)

SMP projects

- Investigating the MCL piezo tip / tilt stage
- Calibrating the AC against a recognised, angular standard
- Actively participating in the “Round Robin” project
- Further development and automation of controls and visualisation software, including ex-situ test procedures

Pushing the SMP to its performance limits!

Pushing optics to their limits!

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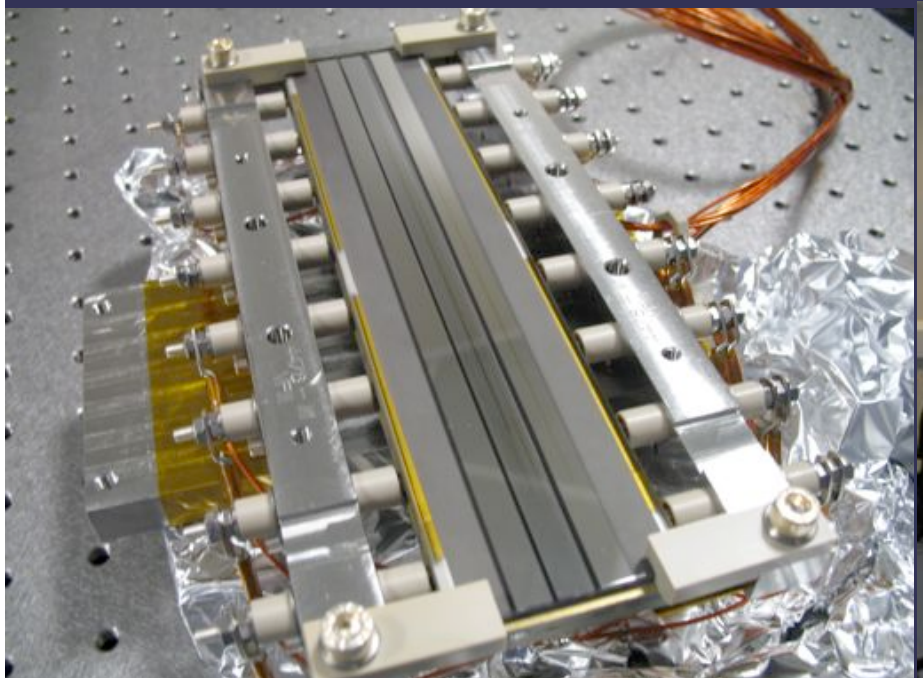
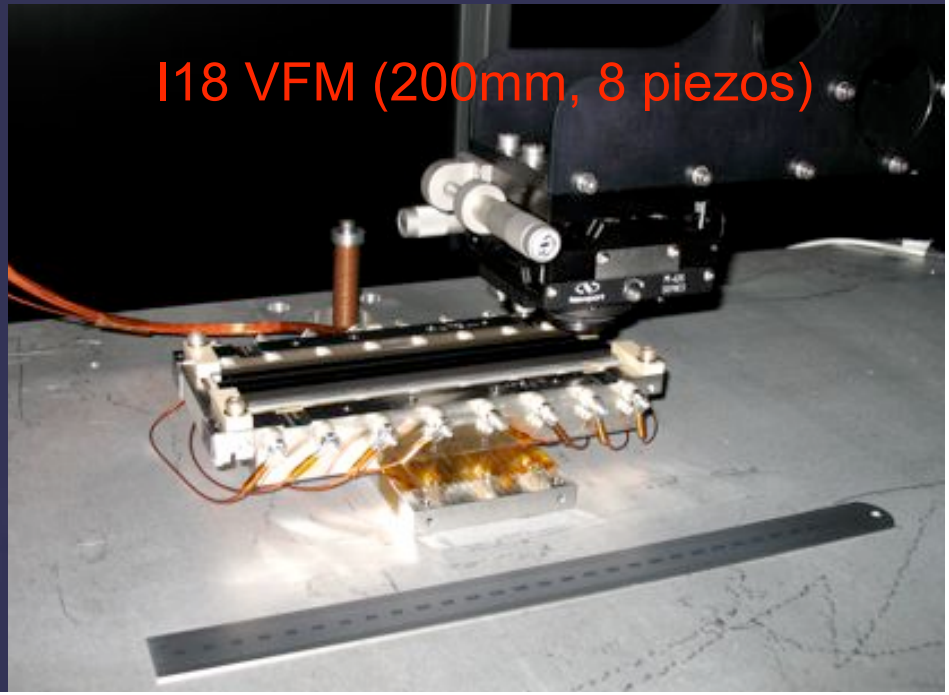
Bimorph optics at DLS

- Earlier presentations by Andy Dent & Paul Quinn
- Wide variety of length, piezo spacing, coatings, & geometry
- Slope / height scans using SMP & Fizeau interferometer
- Micro-topography using micro-interferometer & AFM
- In-situ beamline testing (John Sutter)



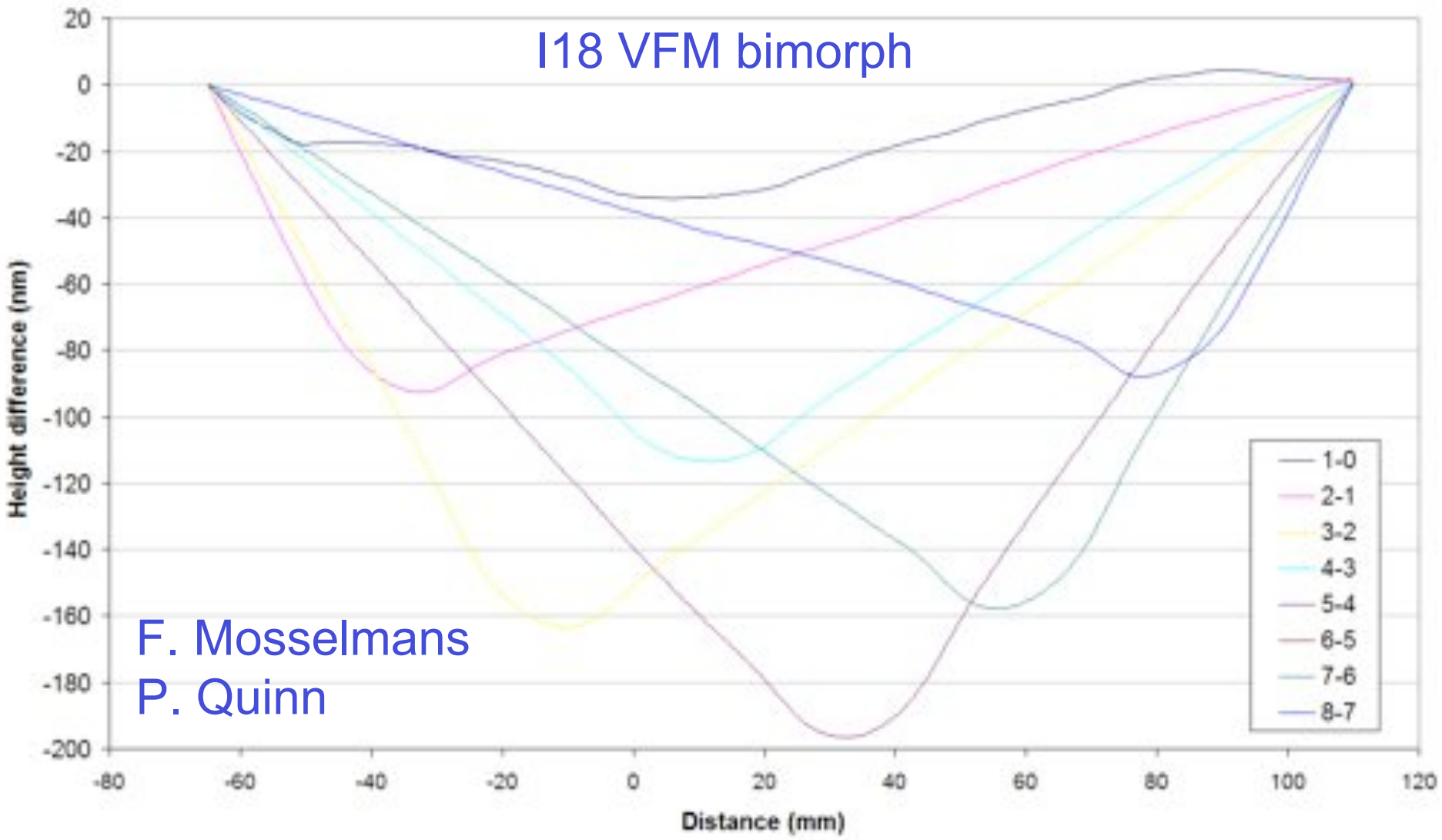
Recent SMP results

- I18 VFM: 3 days of testing (27th – 29th Aug 08).
- I07 HFM & VFM: 2 weeks of testing (end July 08)
- Scans along different coating stripes.
- Matrix scans and slope / height optimisation.
- “Hysteresis” (backlash) of piezo response.
- Stability (overnight).
- Temporal behaviour of piezos (voltage change).



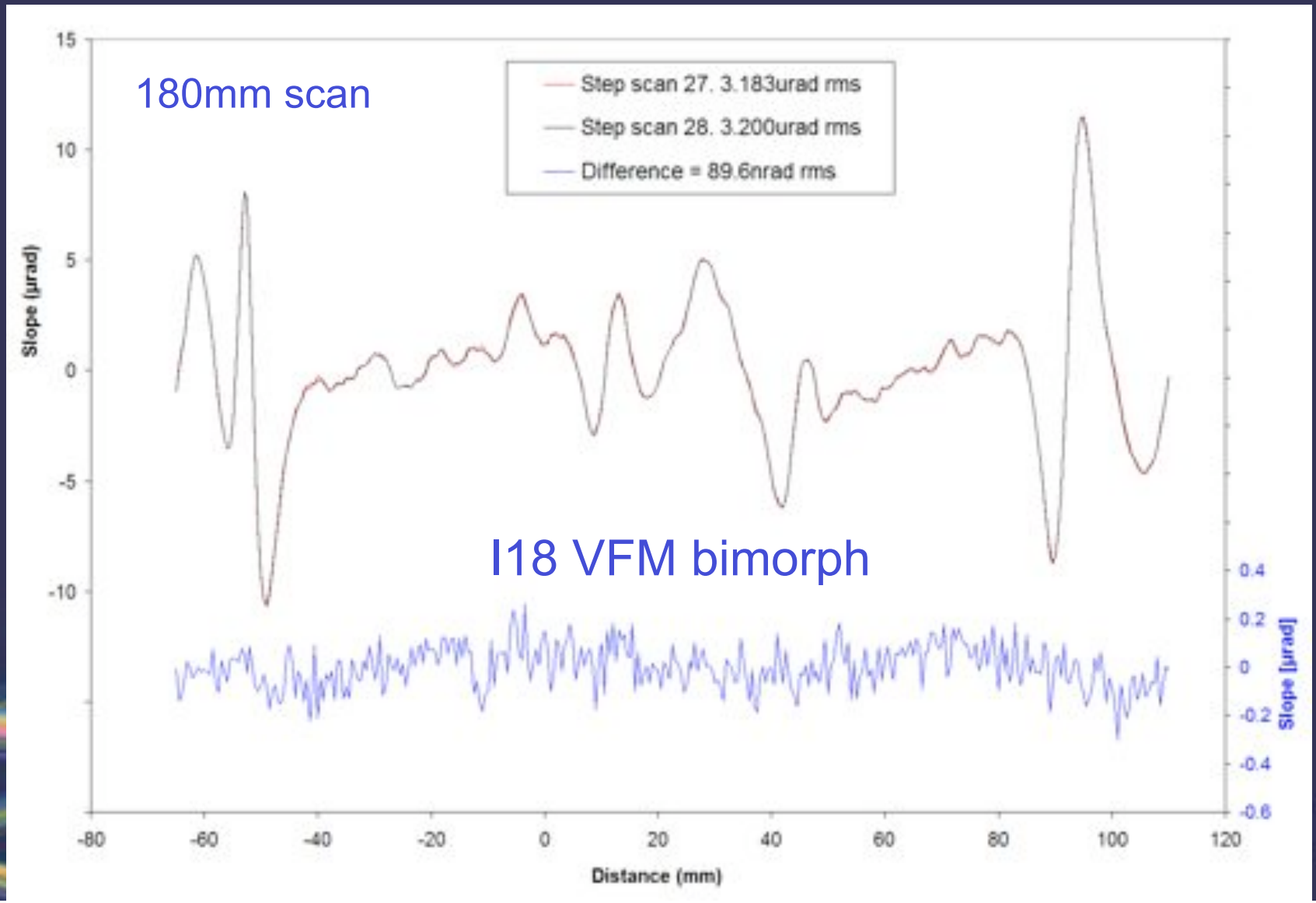
Matrix scans (R. Signorato *et al.*)

- Single scans (no averaging), “work hours”, scientists in lab.

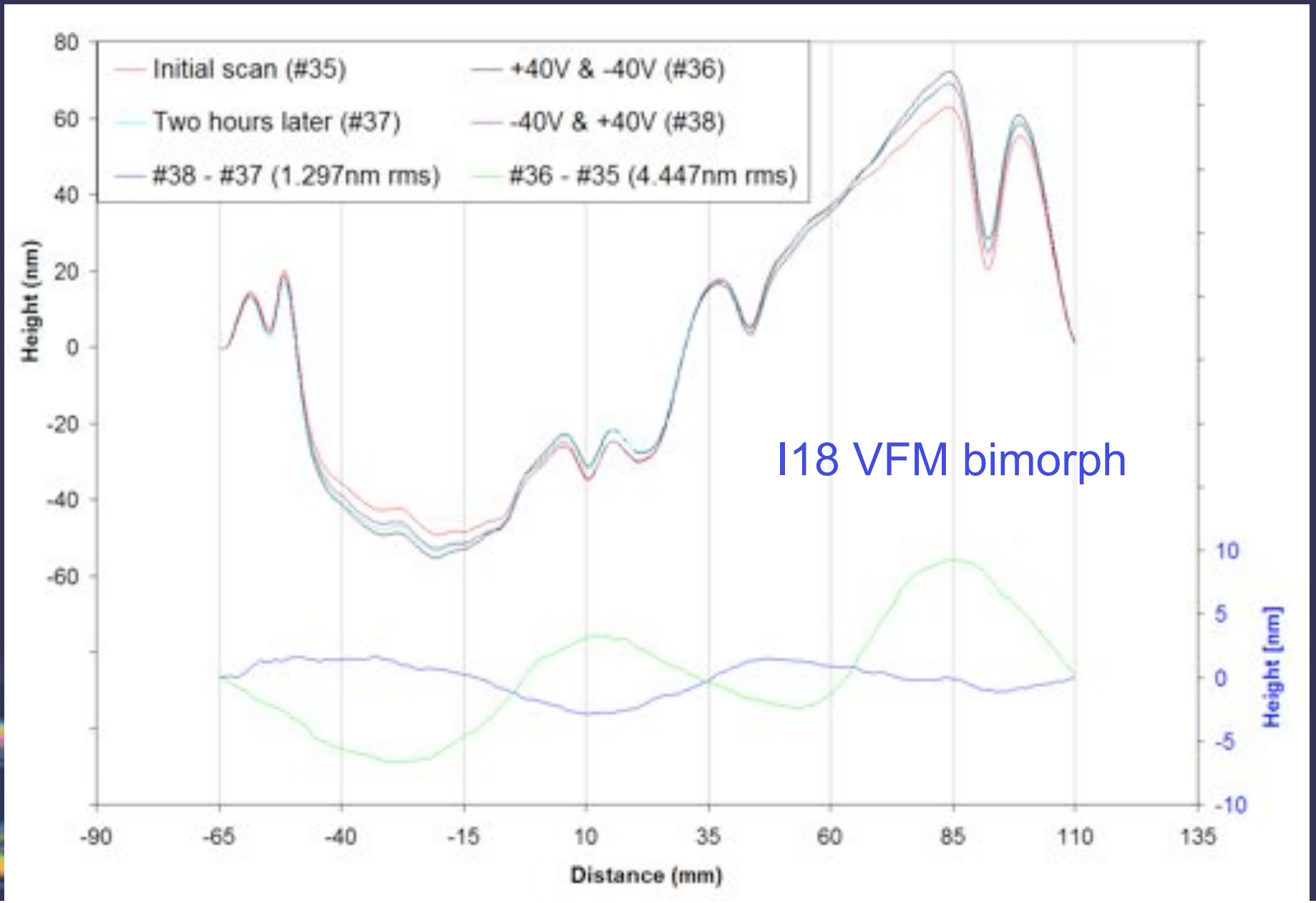


Repeatability of the SMP

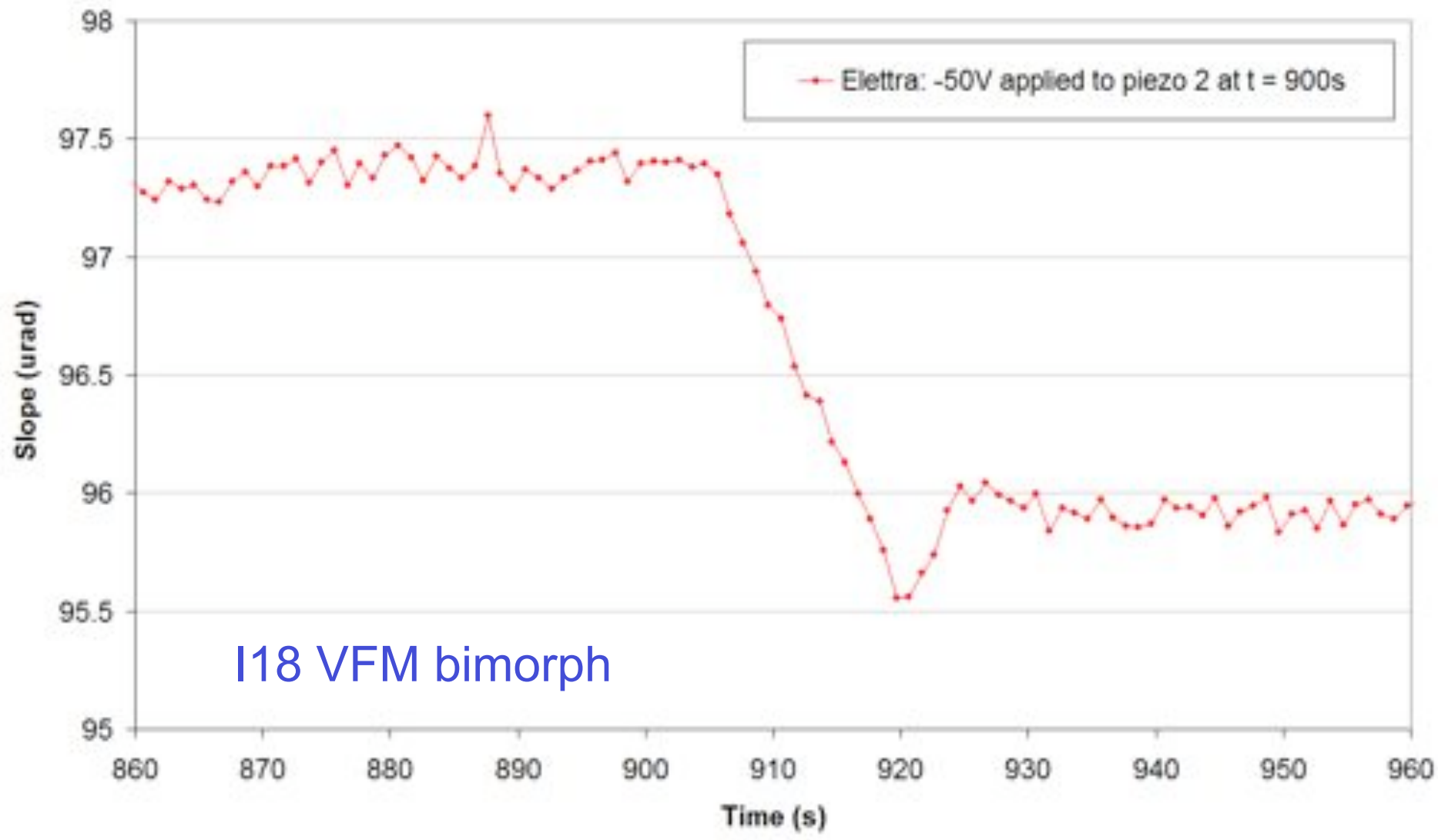
- Single scans (no averaging), “work hours”, scientists in lab.



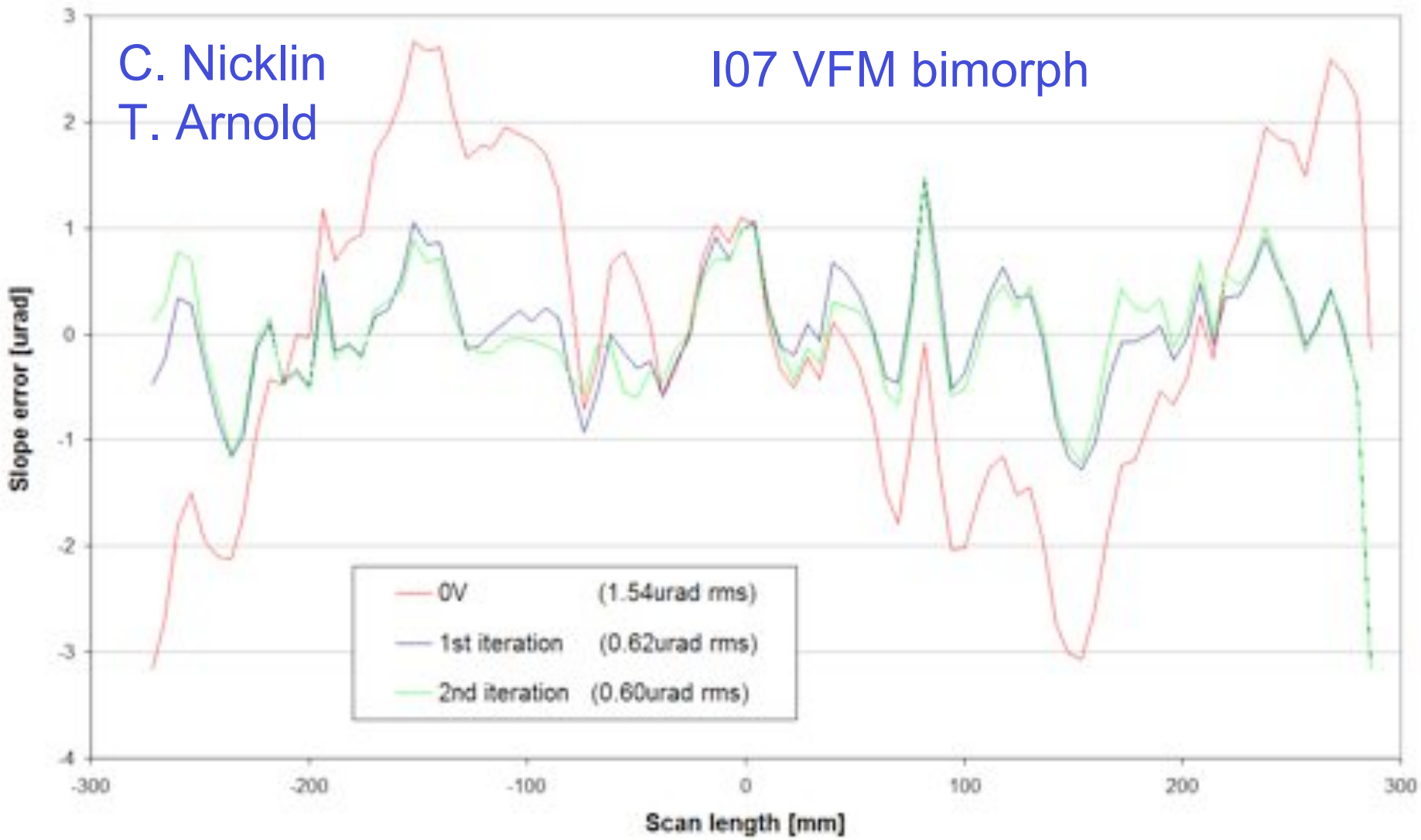
Piezo hysteresis



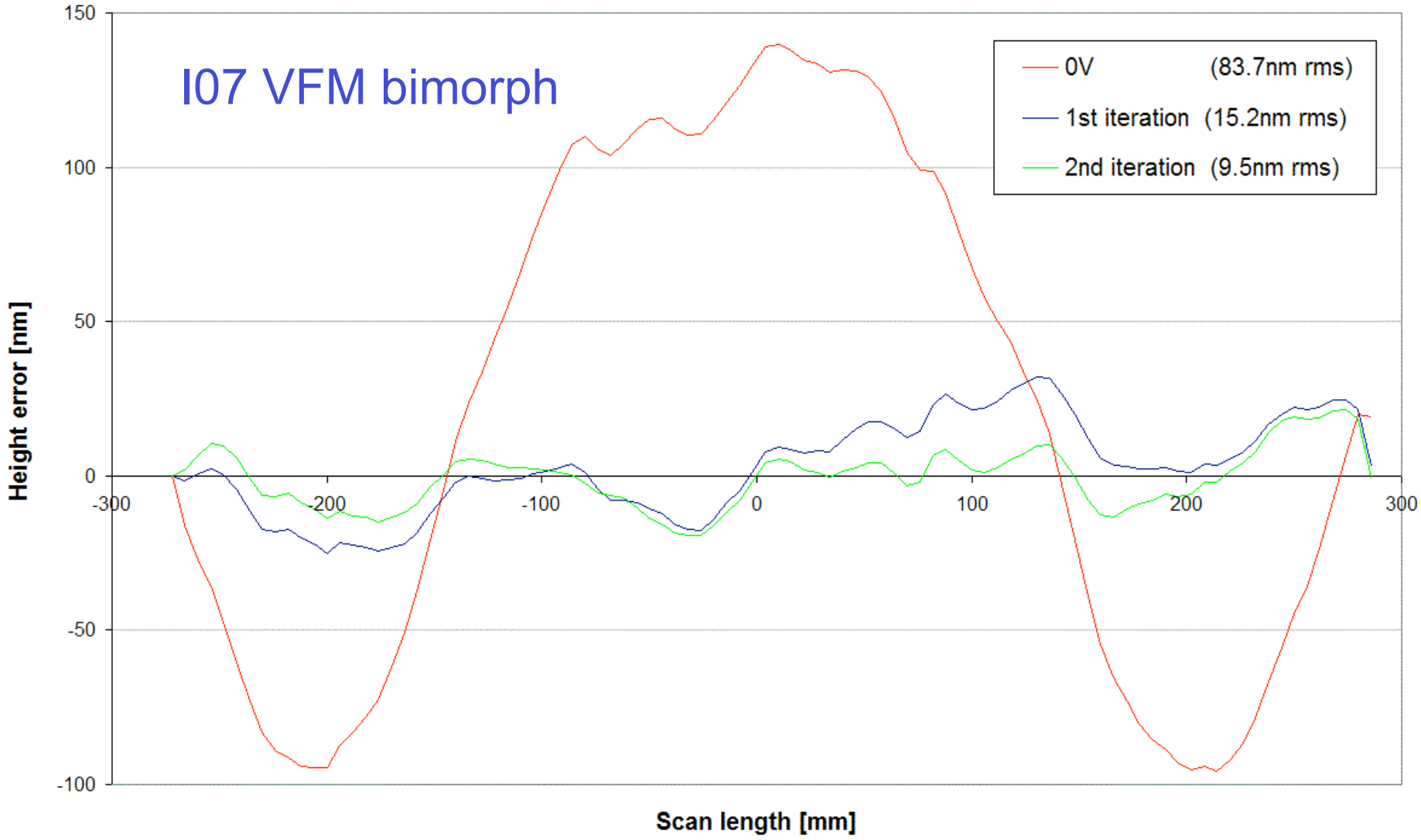
Temporal behaviour of single piezo in response to voltage change



Slope error reduction (using Matrix method of Signorato *et al.)*



Height error reduction



Summary & Future

- Established a cleanroom laboratory, with exceptional temperature & vibrational stability, required for high grade metrology.
- Suite of complementary metrology instruments, capable of high accuracy, micro-topography and slope / height measurements.
- On-going metrology development & research
- …and most importantly, Lots of Collaborations!

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