Using a Fizeau interferometer to characterise bimorph mirrors

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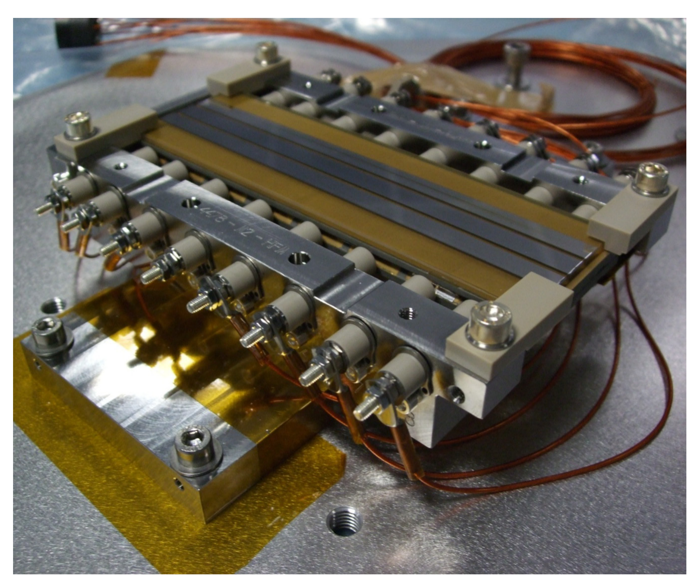
Introduction

- Bimorph mirrors enable correction of local figure errors and global changes to curvature
- Fizeau interferometer [1,2] can capture 2D surface data in less than 1 minute

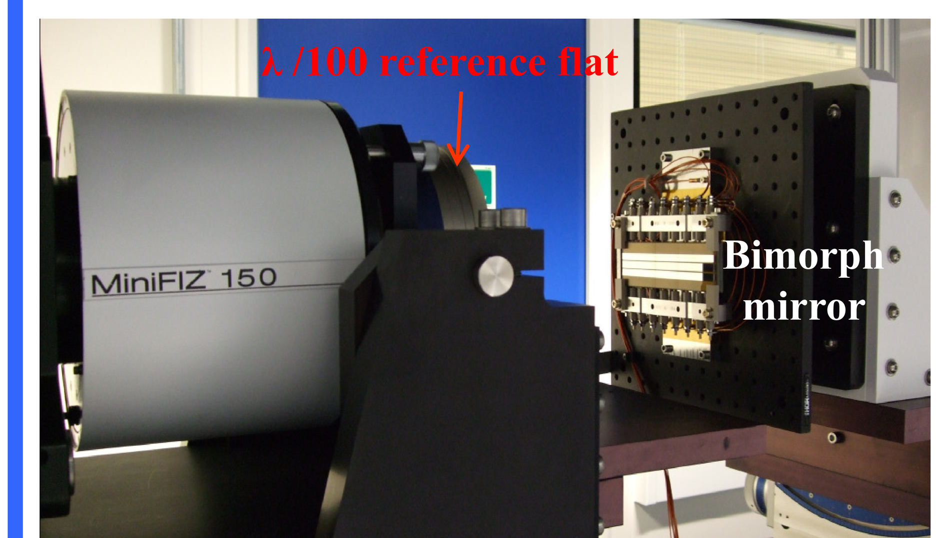
  → *Permits rapid examination of dynamic deformations in mirror topography*
- Figure error and radius of curvature can be measured as a function of time after voltages are applied to the piezos of a bimorph mirror
- Noise levels sufficiently low to record nm-level, dynamic changes to mirror morphology
- Complementary technique to slope measuring profilers such as the Diamond NOM [3]

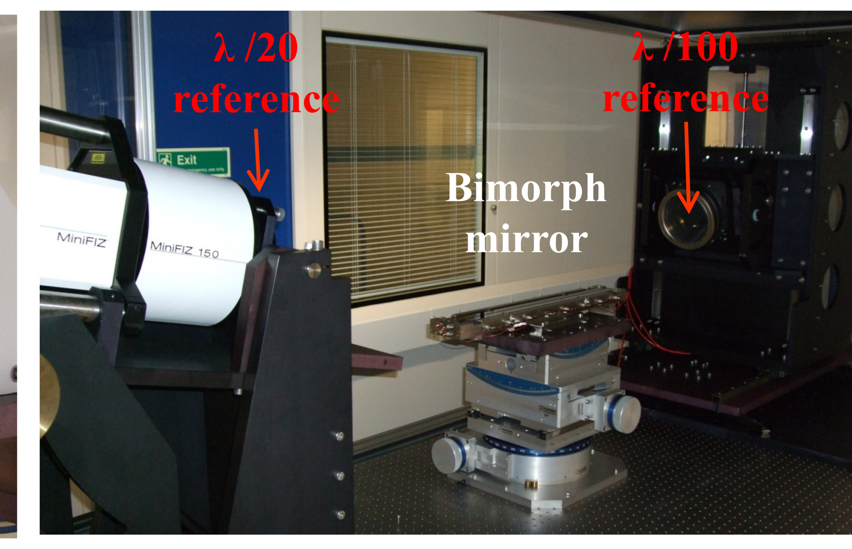
Experimental

- Fizeau (MiniFiz150) interferometer can operate in single pass, double-pass, or stitching modes
- High quality reference optics (λ/100 and λ/20 PV)
- Upgraded mechanics, goniometer, and reflector stage to mount mirrors in beamline geometry
- Two, 8 channel bimorph mirrors:
  - 150mm long HFM
  - 650mm long VFM

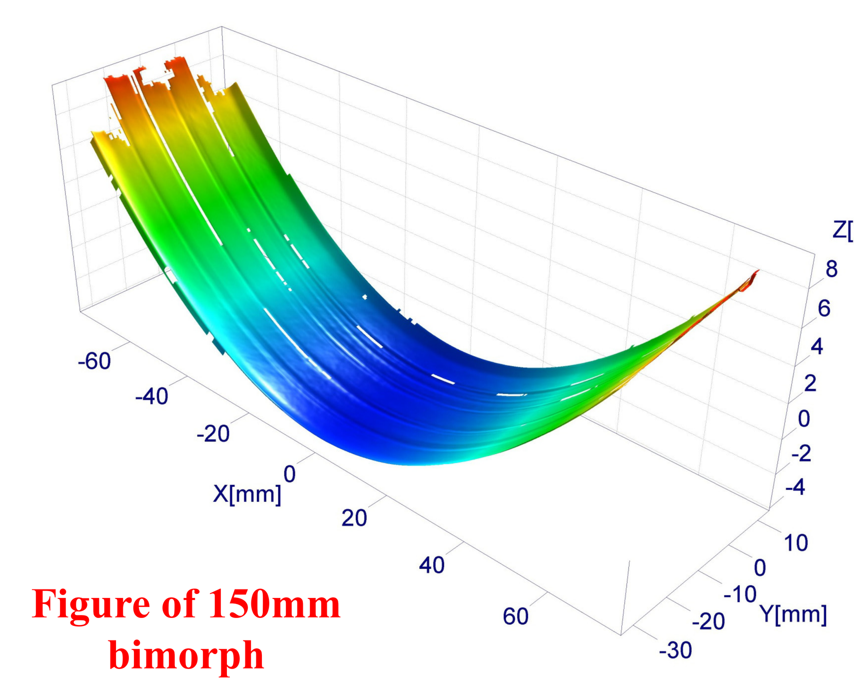


Fizeau Interferometer System

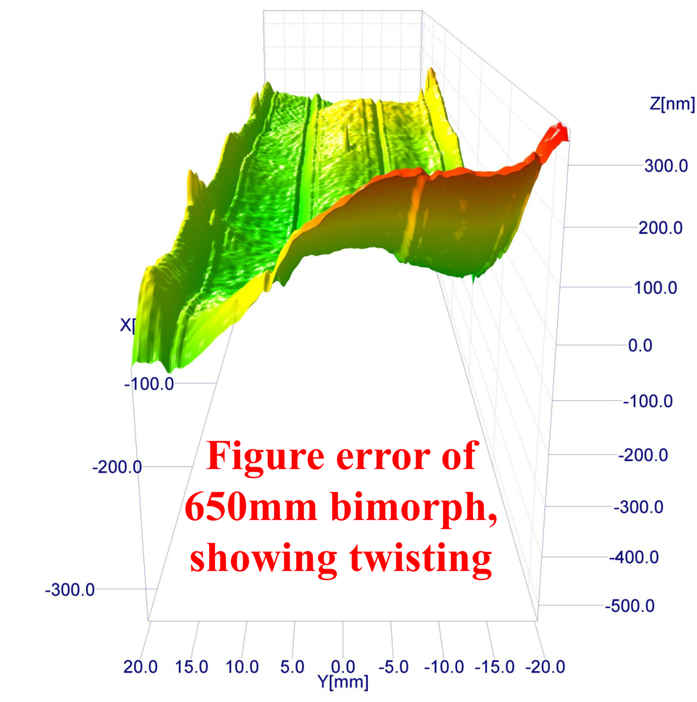




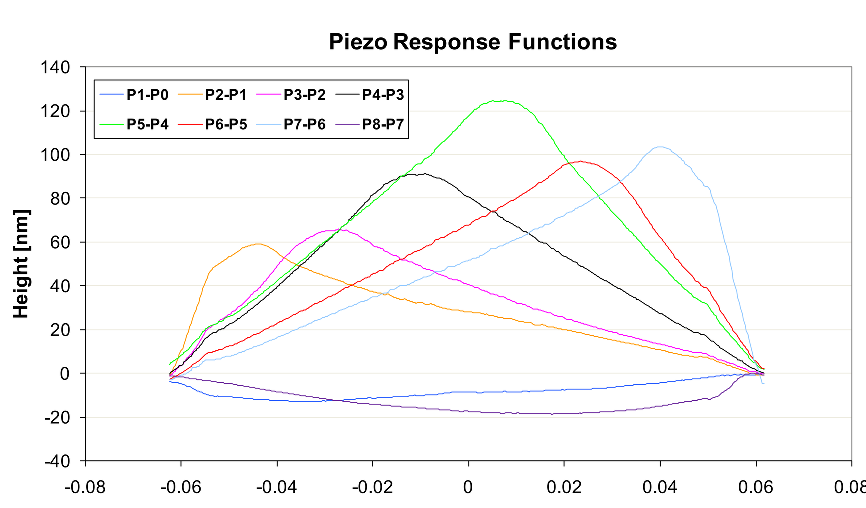
Single Pass Geometry

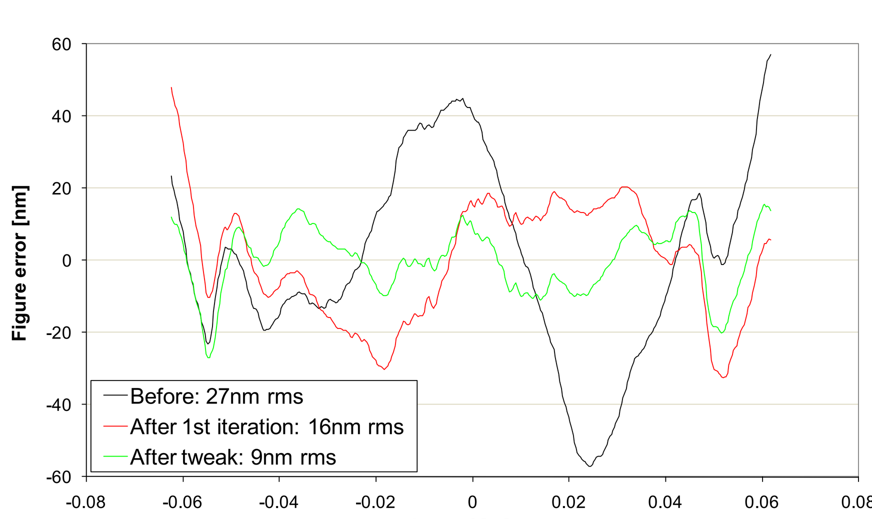


Double Pass Geometry



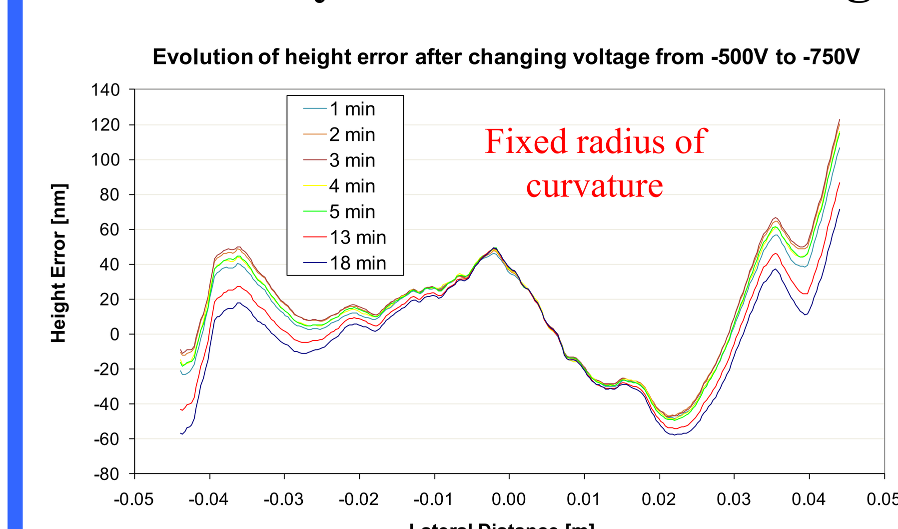
Results: Correcting Figure Errors

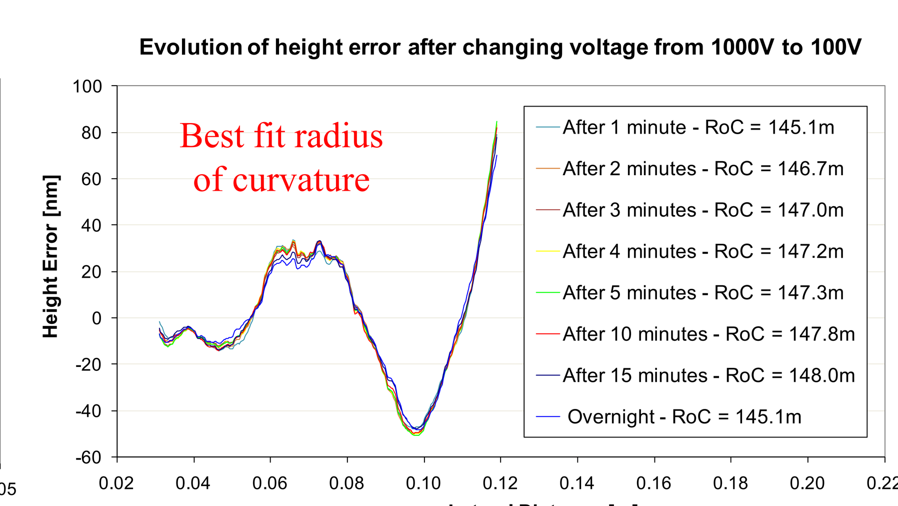


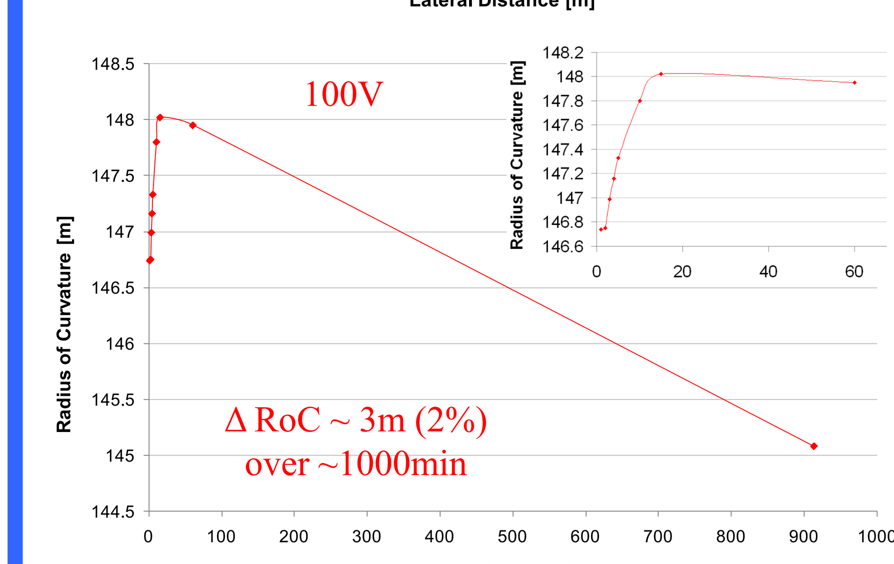


- Use MiniFiz to measure full surface of bimorph mirror under test
- Apply fixed voltages to each piezo in turn and record surface topography along central tangential line
- Difference between successive scans shows how each piezo responds to a given voltage
- Matrix correction technique used to determine optimum voltages required to minimise initial figure error (black)
- Figure error improved from 27nm to 16nm rms by single matrix iteration (red)
- Further improvement to 9nm rms after tweak (green)

Results: Dynamic Evolution of Figure

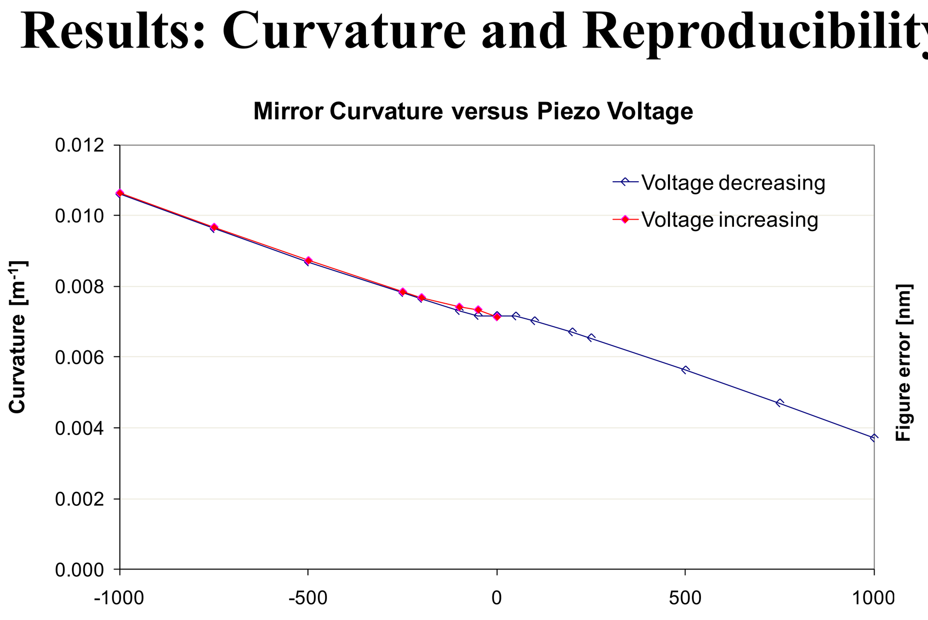


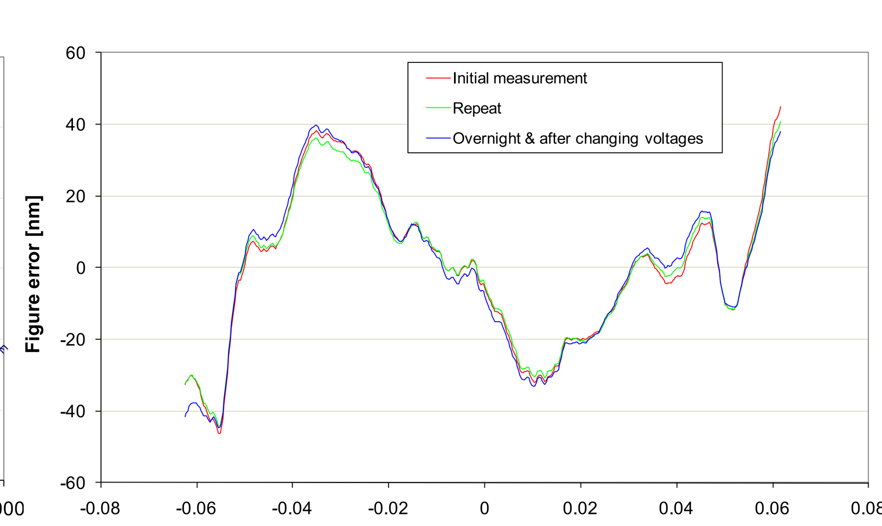




- Figure (curvature) evolves dynamically as a function of time:
  - Initial change over ~20minutes
  - Followed by exponential decay of curvature over several hours (also observed by Diamond-NOM)
- Figure error does not change significantly over time

Results: Curvature and Reproducibility





- Radii of curvature varied between 269m and 94m for applied voltages of ±1000V
- No significant hysteresis effects
- Can routinely "dial-up" required curvature

Figure error very repeatable & reproducible:

- Initial measurement
- Repeat scan straight after 1st measurement
- Rescan after changing voltages and leaving overnight

Conclusions

- Custom-built, MiniFiz system can measure entire mirror assemblies in single or double pass mode, and in the required beamline orientation.
- 2-D figure data of the complete mirror surface is acquired in <1min, enabling dynamic studies of active bimorph mirrors.
- Recording piezo response functions and using the Matrix correction method enables the figure errors of active bimorph mirrors to be quickly and systematically corrected. In this manner, the figure error was improved from 27nm to 16nm rms. An additional small correction further improved this to 9nm rms.
- Measuring at one minute intervals, we observe dynamic evolution of the figure (curvature) of bimorph mirrors. After an initial change in ~20 minutes, the curvature then "relaxes" in an exponential fashion over several hours. The figure error is remarkably constant.
- Technique is complementary to slope measuring profilers, such as Diamond NOM [3] which have superior height and slope resolution, but take much longer to acquire full 2-D data.

References

[1] Ludbrook G.D., Alcock S.G., Scott S., "A double-pass Fizeau interferometer system for measuring the figure error of large synchrotron optics." Proc. SPIE 7801 (2010).

[2] Ludbrook, G. D., Alcock, S. G., and Sawhney, K. J. S., "A Fizeau interferometer system, with double-pass and stitching for characterising the figure error of large (>1m) synchrotron optics", Proc. SPIE 7389 (2009).

[3] Alcock, S. G. *et al.*, "The Diamond-NOM: A non-contact profiler capable of characterizing optical figure error with sub-nanometre repeatability," Nucl. Instr. and Meth. A 616, 224-228 (2010).

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