Hanger mounting system for vertically deflecting synchrotron radiation mirrors.

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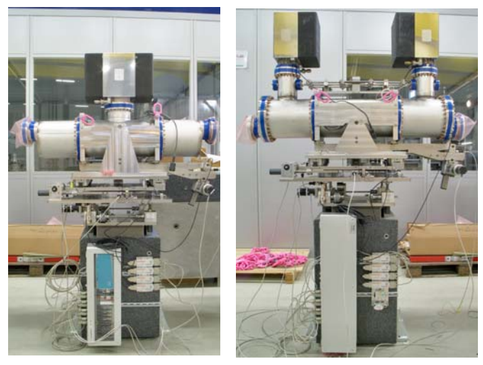
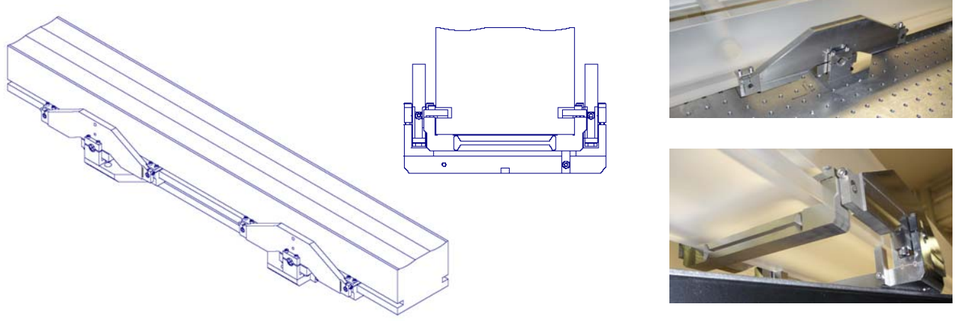
The excellent performance of upgraded 3rd generation and new synchrotron radiation sources asks for a reconsideration of the methods of mounting optical components and systems.
Here, the supports for mounting and bending vertically deflecting mirrors inside UHV chambers for the use at PETRA III at DESY are presented. Special constraints are the very low emittance of the electron beam of 1nmrad leading to highly collimated photon beams and very small vertical source sizes. The large distance from the source to the experiment of up to 100m also requires special care in terms of stability issues.

The support system (patent applied for with #10 2011 009 584.5) is designed to preserve the manufacturing quality of a mirror without adding additional error contributions by the mounting the mirror. The figures of merit are the tangential slope error and the requested bending radius. The results of the simulation by finite element calculation and the measured performance largely exceeds the quality of a Bessel type mount for long (1m range) plane mirrors and also for bendable mirrors with a tangential radius of 2-20km.
All measurements have been performed at the Helmholtz Zentrum Berlin at the Institute for Nanometre Optics.

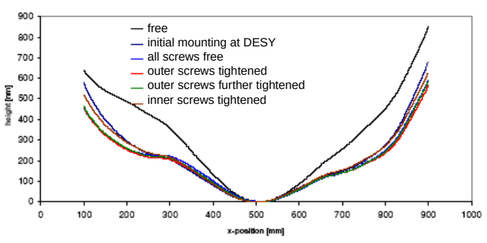


Plane mirror (left) and pneumatic bender mirror system (right) for PETRA III with external degrees of freedom for alignment and pneumatic bending. Inside the vacuum chambers 1m long partially coated fused silica mirrors with 3 optical surfaces each are mounted. These systems are installed and in operation at PETRA III beamline P09.

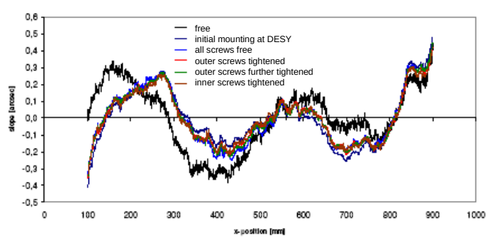
Beamline Mirror: support



Drawing and pictures of the hanger type support with mounted mirror and detail of the anti-twist flexible hinges at each hanger system. The metrology values of this fused silica SESO mirror are: tangential radius > 150 - 200km, slope error = 0.16 arcsec RMS = 0.77 µrad RMS

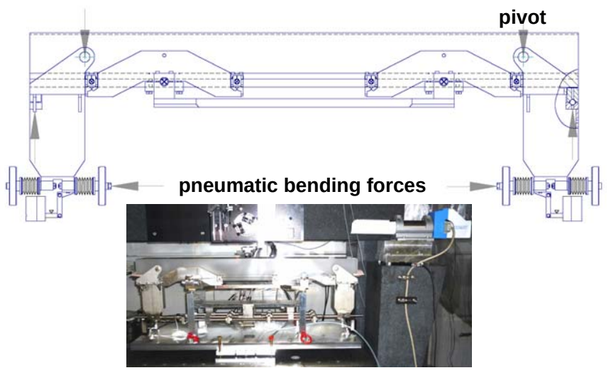


The absolute shape in terms of height [nm] of the plane mirror under different mounting conditions. In this case mounting the mirror leads to larger radii and better best fit of the slope values.



Best-fit slope [arcsec] profile after subtraction of the optimized sphere. The hanger mounting scheme is tolerant to the actual forces and moments applied to mount the mirror.

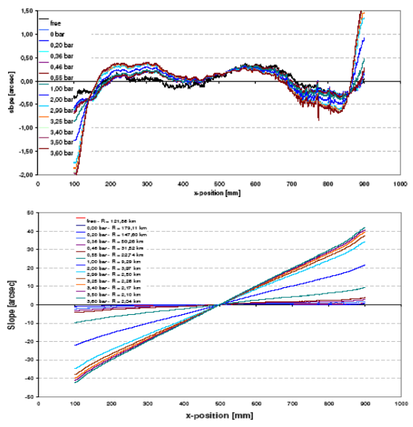
Beamline Mirror: support + pneumatic bender



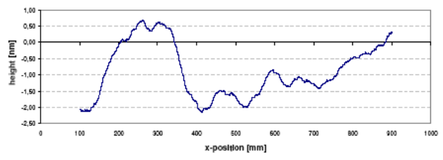
Drawing of the hanger mount with attached bender system and picture taken during measurement.

Measurements of a fused silica mirror of 1m length manufactured by SESO.
The metrology values for the mirror are:
tangential radius > 150 - 200km
slope error = 0.16 arcsec RMS = 0.77 µrad RMS

The results show a deterministic bending behavior vs. the applied pressure and an excellent stability of 3nm PV of the bending radius over 24 hours. The hanger mount provides a stable basis for the bender system.

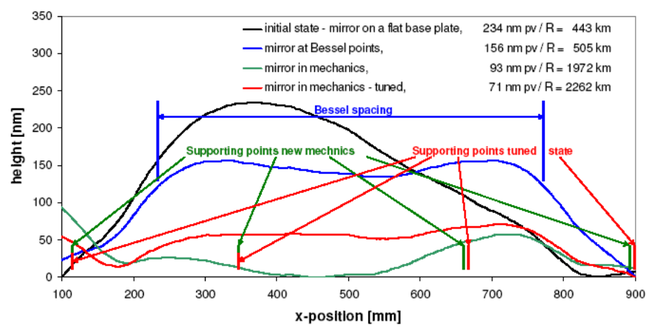


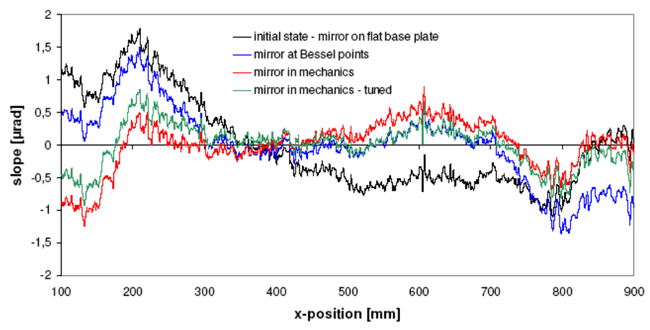
**Development of the slope while bending the mirror.
0 bar to 3.6 bar == 179km to 2km radius of curvature**

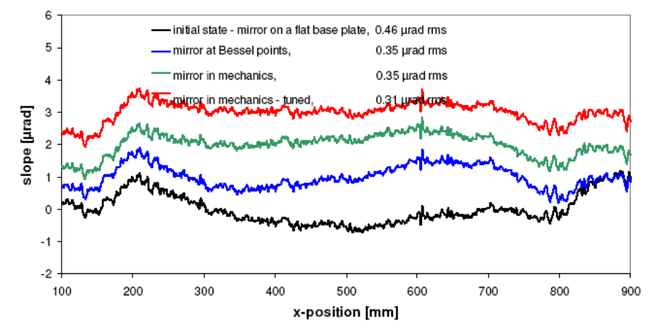


Difference of 3nm PV of two height scans of the bent mirror with a time difference of 24 hours.

Metrology Mirror: support





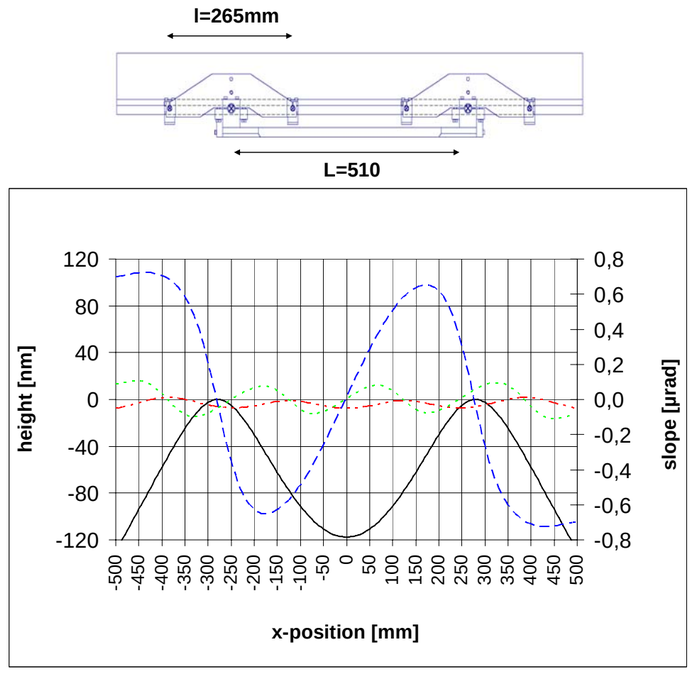


In order to quantify the results measured at the beamline mirror a special metrology silicon mirror has been ordered and made by Carl Zeiss Laser Optics.
The metrology values provided by Zeiss are:
tangential radius > 1000 km
slope error = 0.074 arcsec RMS = 0.358 µrad RMS

The test procedure is comprised of the steps:

- mirror placed on a flat base plate
- mirror mounted at the Bessel points,
- mirror mounted in the new support mechanics
- tuning the distance of the supporting points

The height results (top left graph) clearly shows the advantage of the hanger support over a Bessel support.
The overall slope (centre left graph) in the tuned hanger mount is comparable to the residual slope (bottom left graph) after removal of the best fit tangential radius. The residual slope is positively affected by all mounting schemes, but is still dominated by the manufacturing errors.



**FEA results for the plane mirror support. Shown is the difference in height and slope between the conventional Bessel support (black, blue) support and the hanger support (red, green).
The geometry of the hanger support has been optimized by FEA. The dimension of the test system is based on these results, with the addition that the actual distance "L" has been made tunable in order to account for manufacturing tolerances. The distance "l" inside each hanger is fixed.**

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