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A new alignment system to enable the face side inspection of synchrotron optics

The challenging demands on ultra-precise reflective optical elements for beamline application at 3rd generation storage rings like BESSY-II and PETRA-III, or at Free Electron Laser Sources like LCLS and the European XFEL require a shape preserving alignment of such components.
Thus the inspection of mirrors in the face side condition is an essential topic to characterize high performance synchrotron mirrors as well as the mechanic clamping systems used. For this reason a mechanical alignment system was developed based on the principle parallel kinematics for nanoscale cartesian motions [1;2]. This new alignment system [figure 10] is installed at the BESSY-NOM [3] in the BESSY-II optics laboratory of the Helmholtz Zentrum Berlin (HZB) since end of 2010. Deformation of the optics caused by the mirror clamping as well as the influence of gravitational effects can be measured.

Principle: parallel kinematics for cartesian motions

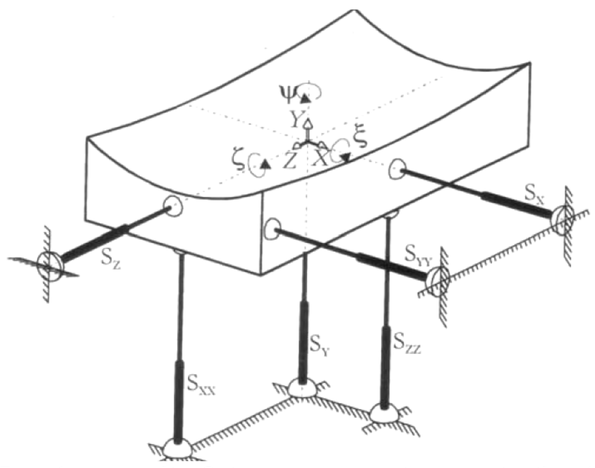

Figure 1: principle of the Cartesian parallelkinematic alignment platform[4]

Due an interaction between the movements of 6 kinematic rods:
- aligned with respect to Cartesian axes,
- variable in the lenght,
- pivot-mounted,
- individually adjustable,

a system with all degrees of freedom (3 rotations about the Cartesian axes and 3 translations along these axes) are implemented.

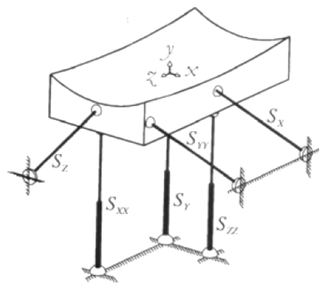

Figure 2: translation along the y-axis

extending or shortening of the rods S_{xx}, S_y and S_{zz} by the same amount of lenght

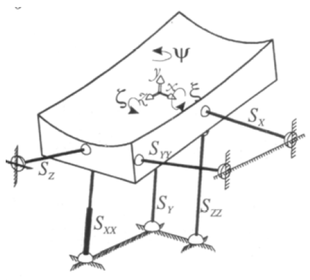

Figure 3: rotation about the x-axis

extending or shortening of the rod S_{xx}

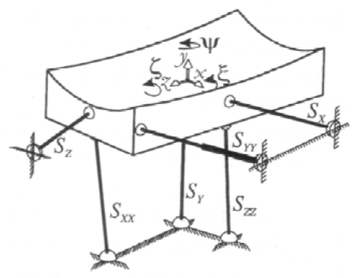

Figure 4: rotation about the y-axis

extending or shortening of the rod S_{yy}

Measurements on a plan mirror for PETRA-III at DESY

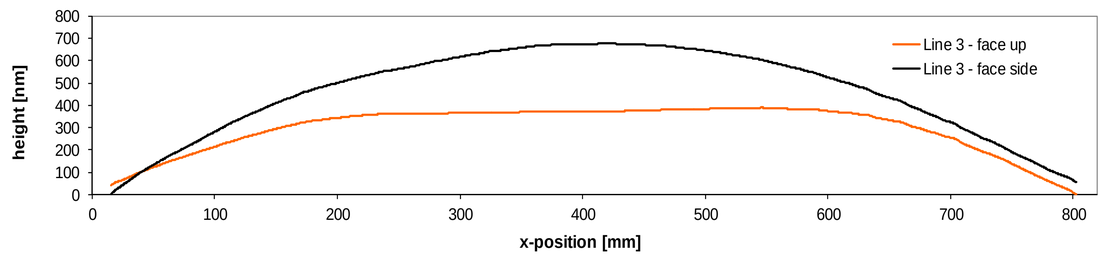

Figure 5: comparison of absolute height

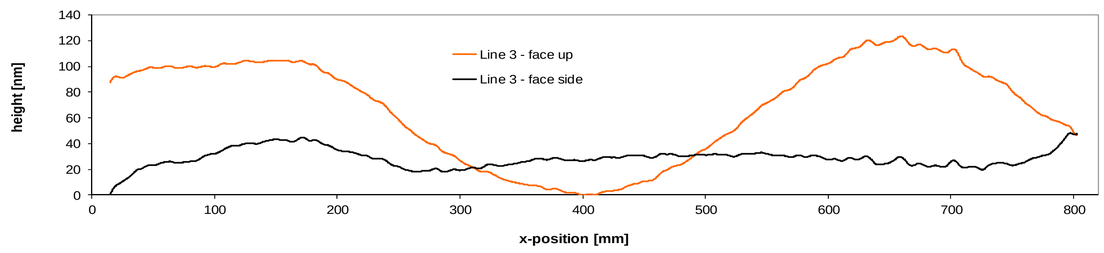

Figure 6: comparison of profiles of residual heights

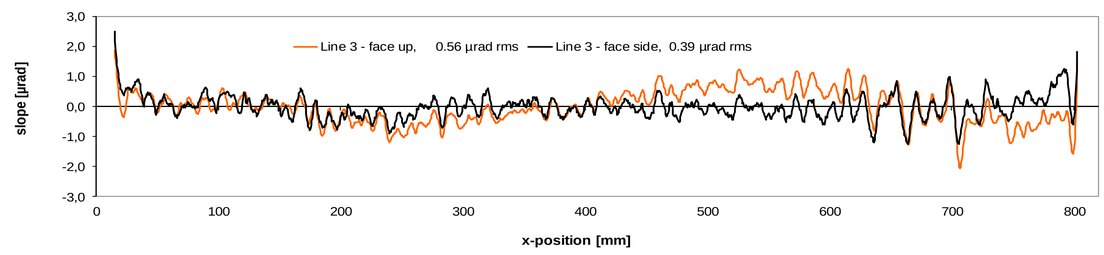

Figure 7: comparison of profiles of residual slopes

Design and Performance

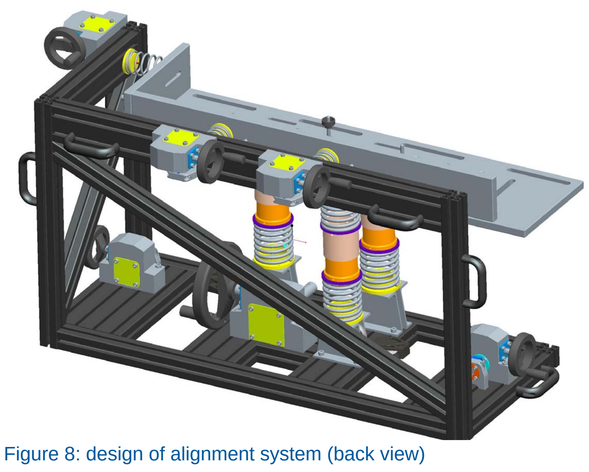

Figure 8: design of alignment system (back view)

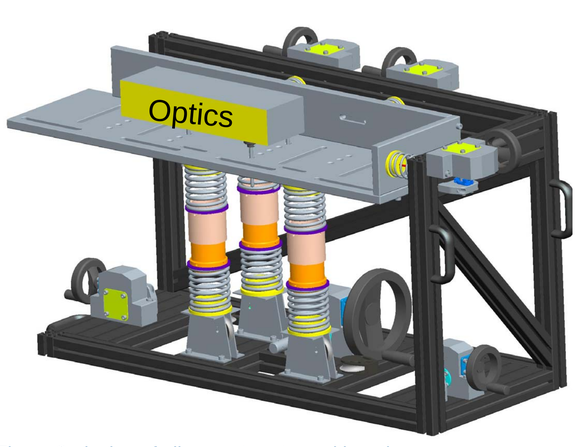

Figure 9: design of alignment system with optics

- Rods realized due ropes prestressed by springs[5]
- Inspection of large optics up to 1000 mm in lenght and 120 mm in width
- adjustable range: ± 5° for rotation; ± 10 mm along the y-axis
- positioning resolution: 5arcsec for rotation; 11µm for translation
- relaxation time: 24h after initial alignment

Figure 10: the alignment system (back view)

Figure 11: the alignment system (front view)

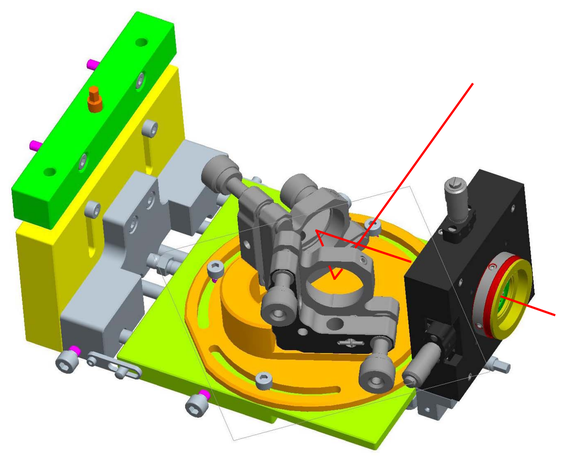

Figure 12: the horizontal pentaprism to enable face side measurements [6]

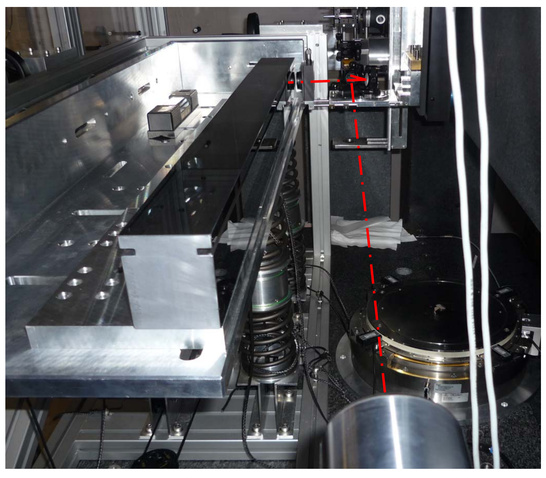

Figure 13: the new alignment system on the NOM with a mirror under test (plan mirror for PETRA-III at DESY, l=820mm)

1_Tino Noll, Karsten Holldack, Gerd Reichardt, Olaf Schwarzkopf, Thomas Zeschke, *Parallel kinematics For nanoscale Cartesian motions*, Precision Engineering 33 (2009) 291–304
2_T. Noll, W. Gudat, H. Lammert, *WO 02/16092 A1 Device for Multi-Axis fine Adjustable Bearing of a Component* (2001)
3_F. Siewert, T. Noll, T. Schlegel, T. Zeschke, H. Lammert, *The nanometer optical component measuring machine: a new sub-nm topography measuring device for x-ray optics at BESSY*, AIP CONFERENCE PROCEEDINGS Volume: 705 (2004)
4_Tino Noll, *Elastische parallelkinematische Führungsgetriebe für ultrapräzise Bewegungen im Vakuum*, thesis (2003), Abb.:28-33
5_ *EP 1 650 590 B1 / DE 10 2004 052 155.7 Justiervorrichtung zur hochgenauen Positionierung eines Objekts* (2004)
6_Samuel K. Barber, Gregory Y. Morrison, Valeriy V. Yashchuk, Mikhail V. Gubarev, Ralf D. Geckeler, Jana Buchheim, Frank Siewert, Thomas Zeschke *Developmental long trace profiler using optimally aligned mirrorbased pentaprism,* Proc. of SPIE, Vol. 7801-2 (2010)

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