# Simultaneous estimation of the surface shape and the instrument error function from a highly redundant set of LTP data

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The accuracy of slope measurement with LTPs depends on the radius of the surface under test (SUT). It is clearly shown by the results of the recent COST P7 Round Robin[1] where the level of discrepancy between different instruments increases with the curvatures of the measured reference surfaces. The most obvious reason for this influence is that the optics of the LTP is not perfect and induces systematic errors that are dependant on the position of the return beam on the optics elements. The systematic error therefore depends of slope being measured.

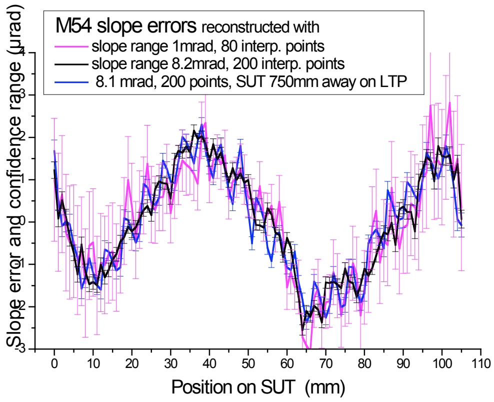
The situation is even worse with strongly curved surfaces, having a slope range larger than the measuring range of the LTP, which require tilting the surface in several steps and applying a stitching procedure. In such a case, the systematic errors of the instrument are propagated and amplified by the stitching procedure and can yield serious distortions of the measured shape. A common work-around is to limit the individual amplitude of the measured segments, thus limiting the amplitude of the defect but increasing the number of segments, i.e. the number of tilted positions of the SUT[2]. This raises the following questions: why restrict the measuring range? Couldn't the instrument error function be extracted from the high redundancy of highly overlapped full range measurements and subtracted from the data?

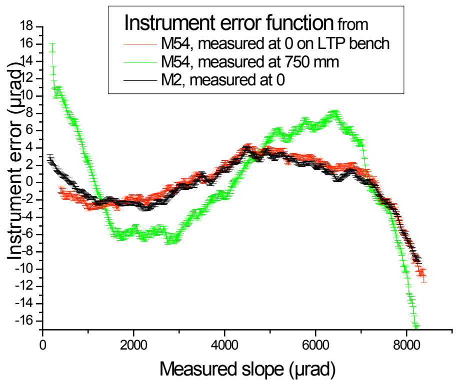
Reformulating the stitching problem to introduce the instrument error function lets give a positive answer to the last question. To the usual variables of the stitching problem, that are the surface slopes at the measured steps and tilt offset values, we add the instrument error function defined as the difference between the actual and measured slopes versus the measured one. As the measured slopes are continuous, this error function needs to be modeled by an interpolation function defined by a discrete set of parameters. A global solution of the problem is then searched as a best fit of the model defined by this extended set of parameters to the recorded data.

The stitching algorithm was implemented under Origin and applied to the processing of data of a two different mirrors called M2 (R=21.4m, L=190mm) and M54 (R=7.77m, L=110mm). Several recording configurations have been tested on mirror M54, varying the tilt step between individual traces, and the position of the mirror on the LTP bench. Reconstructions have been done varying the slope range used and the number of spline segments interpolating the instrument error.

The figures below show some of the results. The short range oscillations of the reconstructed surface slope and uncertainties are reduced by a larger overlap of the recorded data sets either by increasing the number of tilt steps either by increasing the used slope range, but the general shape is not affected. The error function is similarly affected by the data redundancy but is scaled with the position of the SUT on the LTP bench revealing its link to the spherical aberration of the LTP lens.

Extension of the procedure to mirrors that in principle do not require stitching is likely to improve the accuracy of the LTP.




## References


[1] A. Rommeveaux; M. Thomasset; D. Cocco; F. Siewert, in *Modern developments in X-ray and Neutron Optics*, A. Erko et al eds. Springer series in optical Sciences **137**, 213-218 (2008)

[2] A. Rommeveaux, private communication.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