Recent developments in Speckle Angular Metrology (SAM) for X-ray mirrors at Diamond Light Source

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Introduction

A novel metrology instrument - Speckle Angular Measurement (SAM)[1] has been developed at Diamond Light Source. The precision achievable using SAM during the characterisation of X-ray optics is demonstrated to reach levels below 20 nrad. Additionally, we demonstrated the advantages of using SAM to X-ray mirror manufacturers. The benefits of this metrology instrument are:

- ✓ **Able to characterise strongly curved optics**
- ✓ **Easy integration with LTP and NOM**
- ✓ **High precision**
- ✓ **Portable device**
- ✓ **High accuracy**
- ✓ **Developed using open-source software**
- ✓ **Can provide 1D and 2D surface profile maps**
- ✓ **Low cost**

Principle of Speckle angular measurement (SAM)

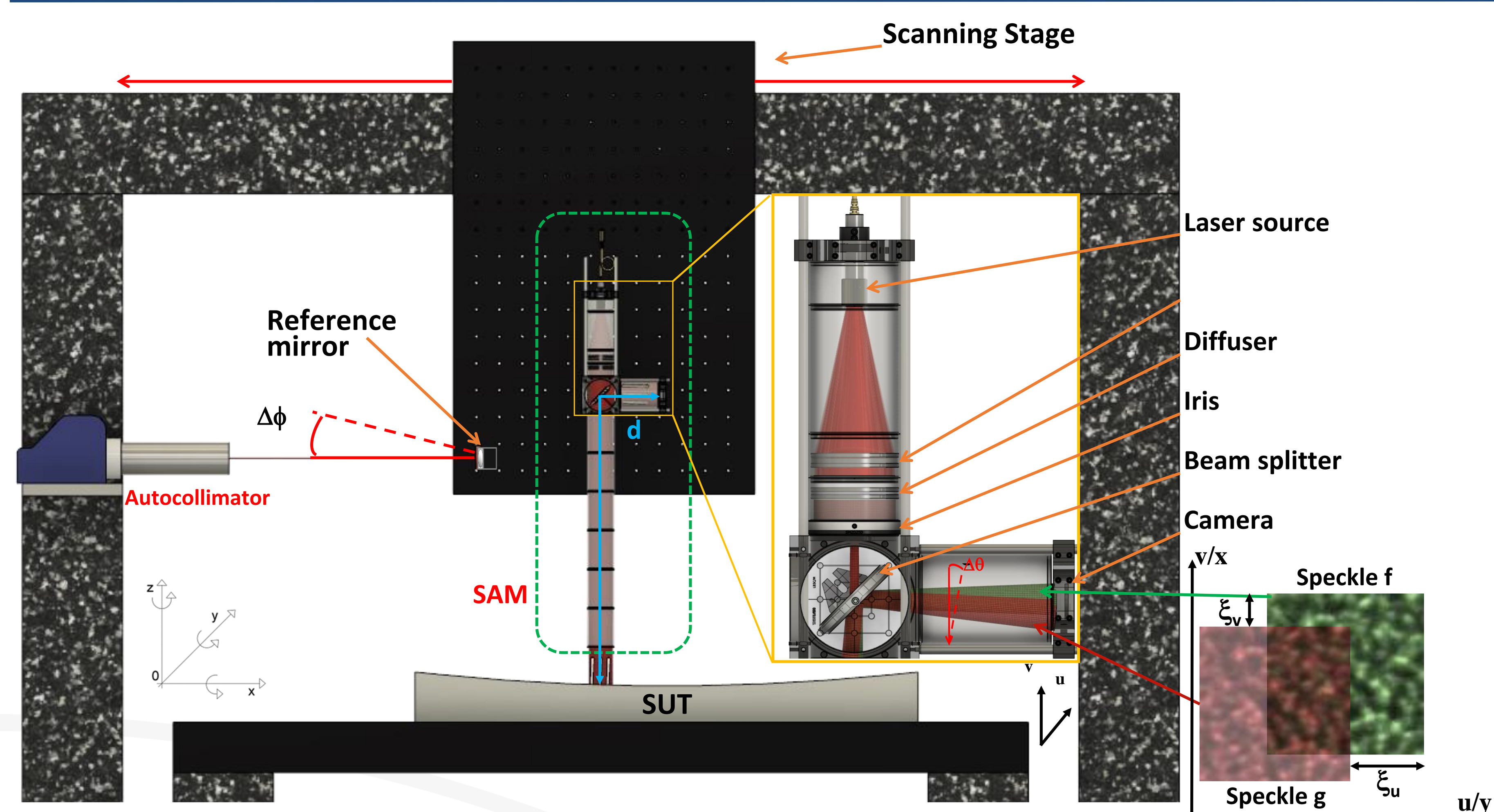


Figure 1. SAM schematic representation

Experimental setup

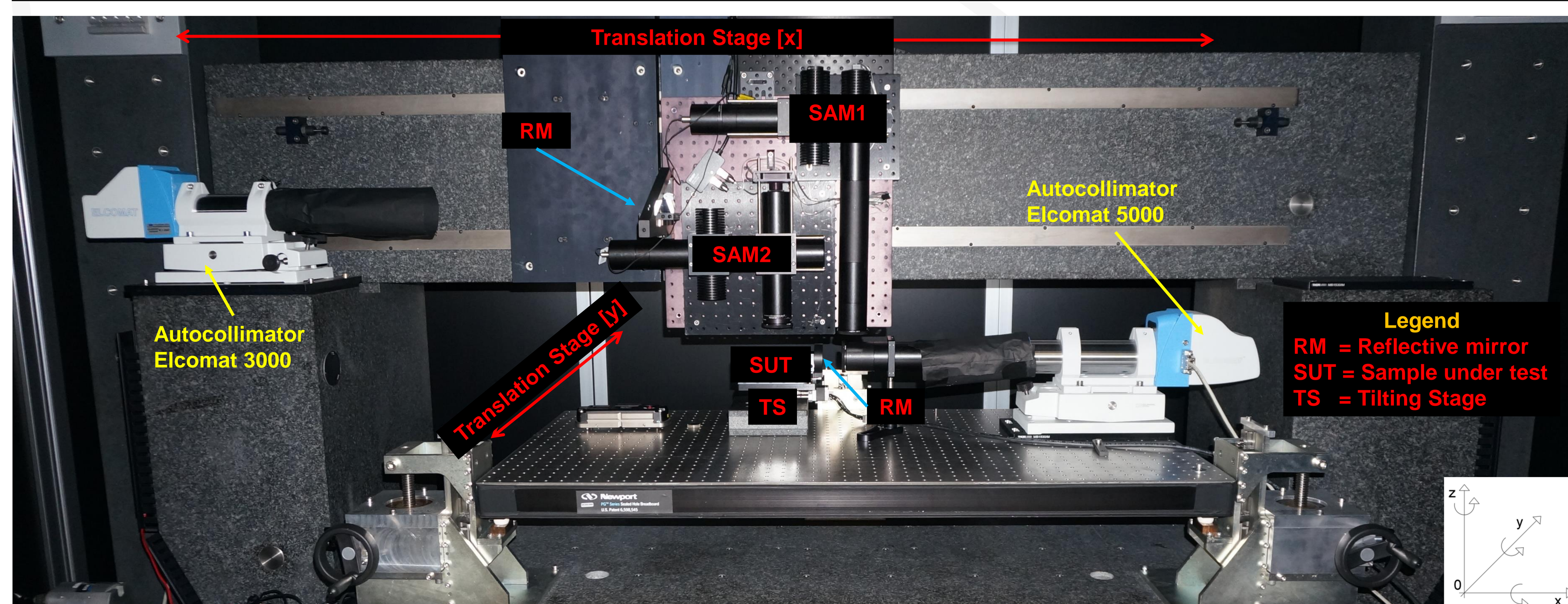


Figure 2. SAM experimental setup. Integrated SAM scan head into Diamond NOM

SUT alignment procedure and SAM stability/precision

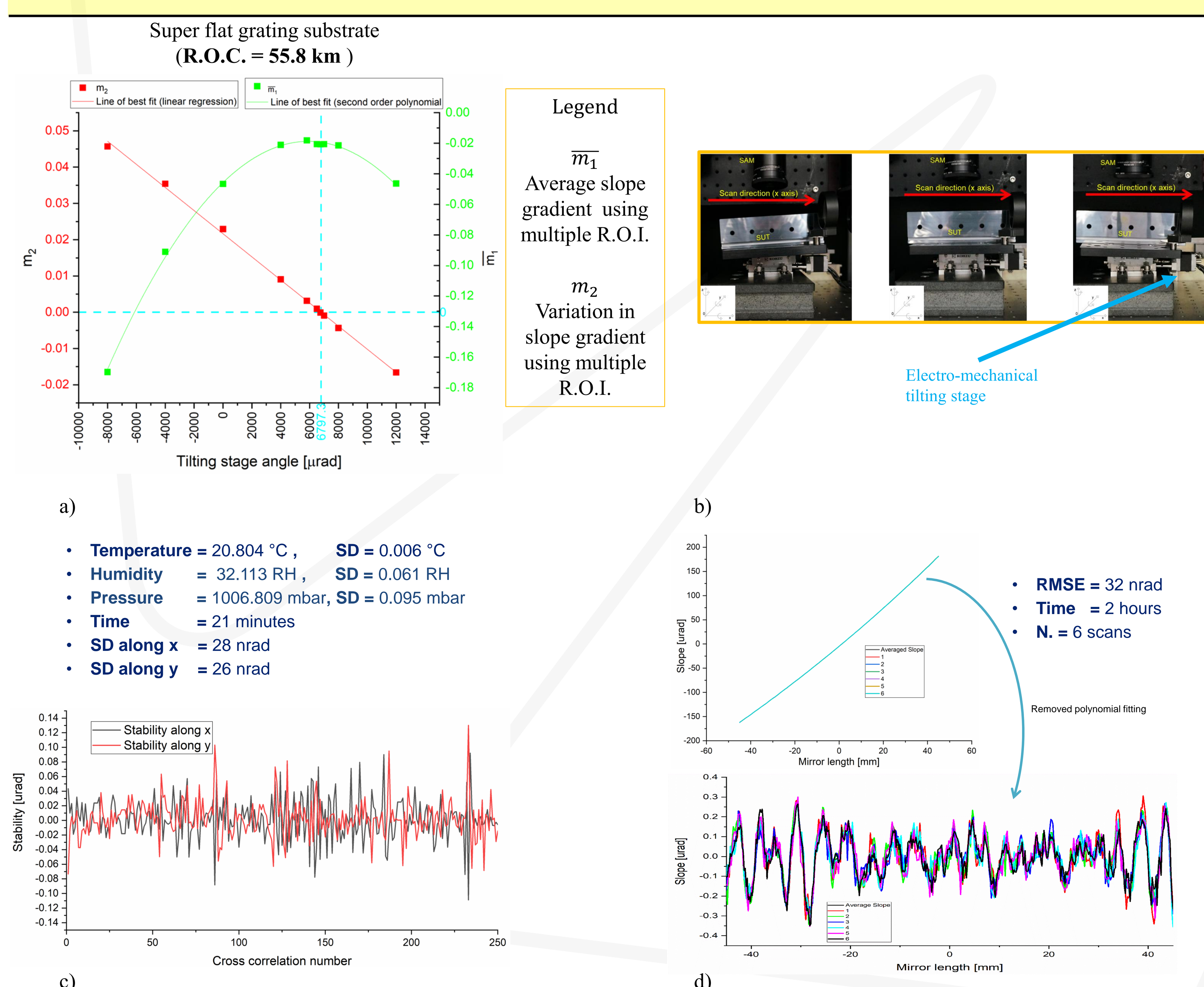
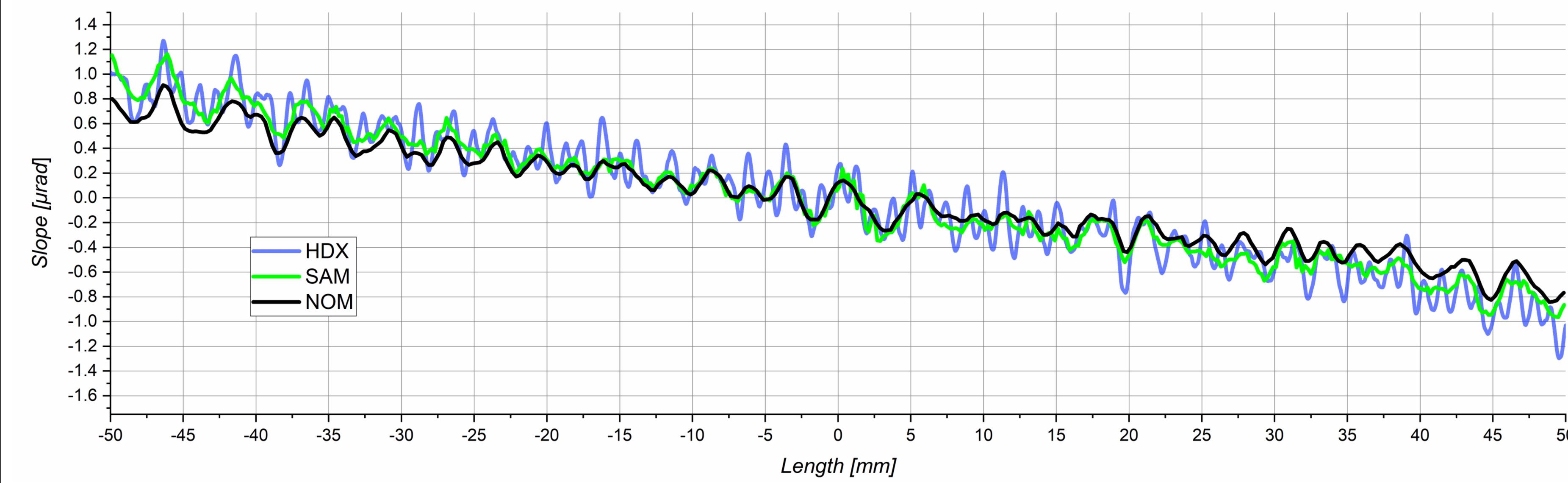


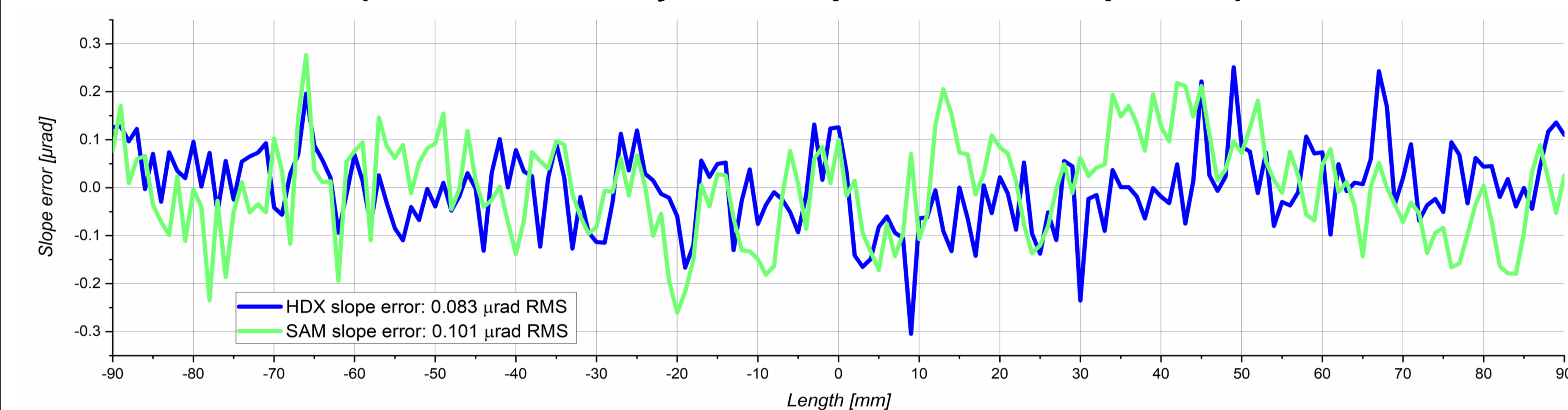
Figure 3. Alignment procedure and systematic error correction during the characterization of a super flat substrate (a). Visual representation of the alignment procedure of a SUT using SAM (b). SAM Potential stability (c) and precision (d)

Results

(1) Super-flat substrate. Absolute slope measurements



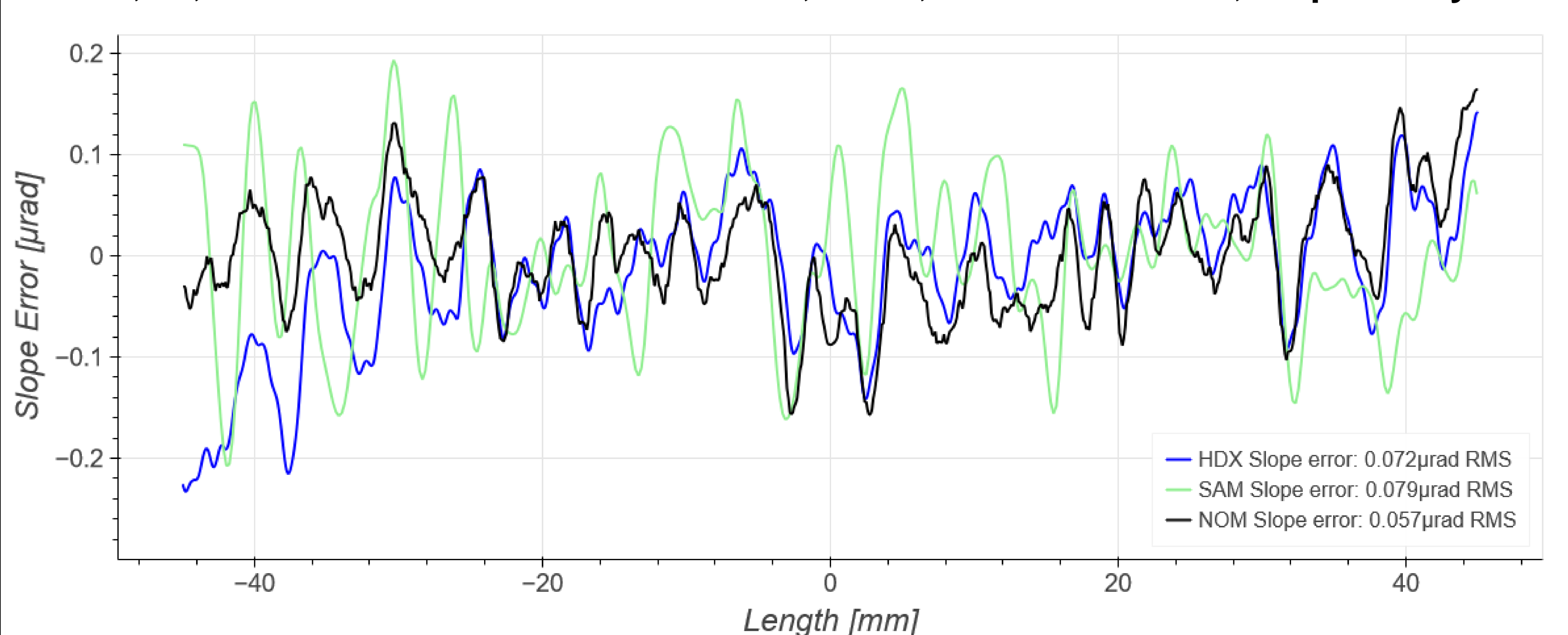
(2) Cylindrical substrate with < 4% reflectivity. Slope error measurements (Removed best cylindrical profile from slope data)



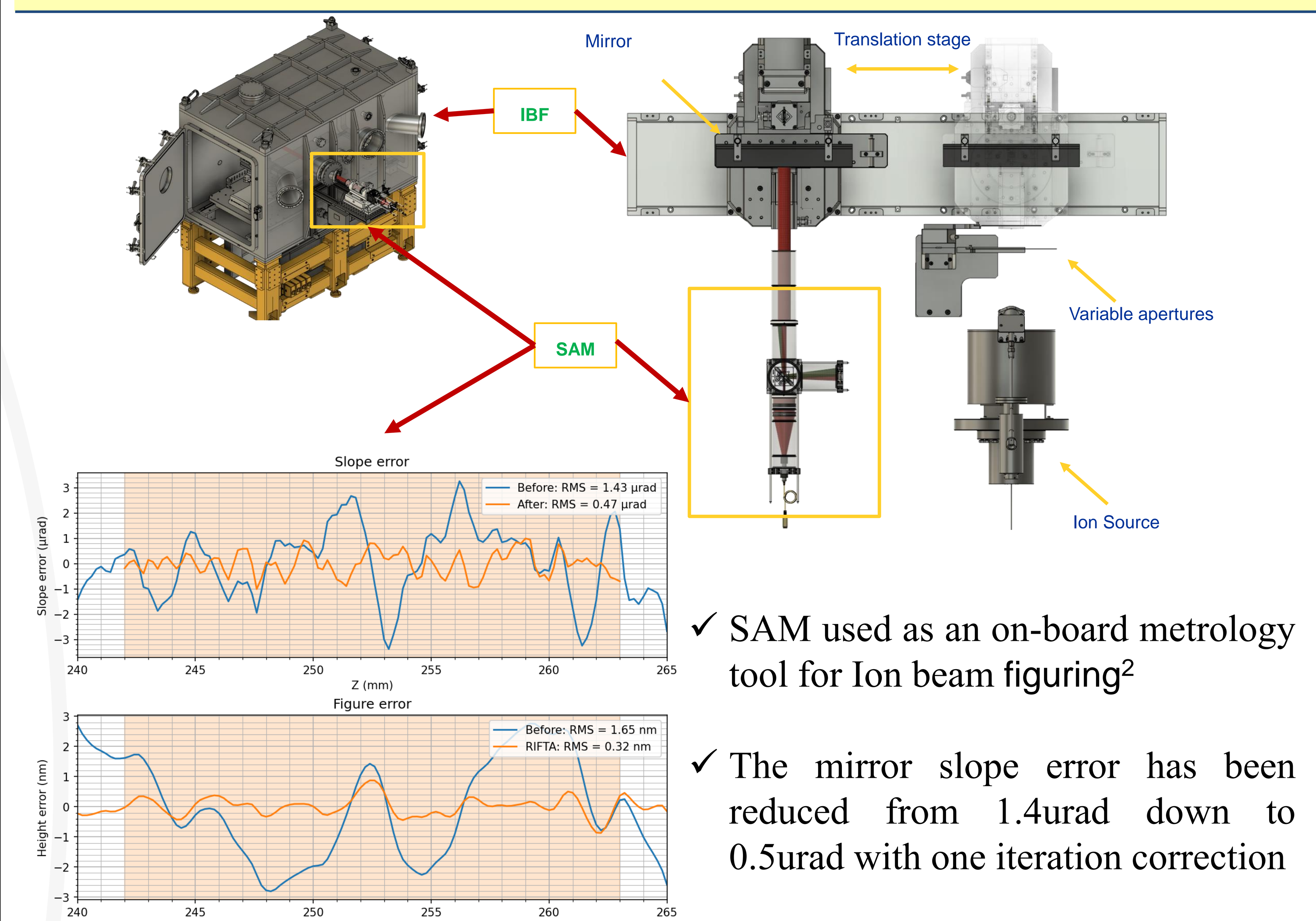
SUT retrieved mean radius of curvature from absolute slope measurements			
SAM		HDX	
Gradient of slope [rad/m]	0.00862179	Gradient of slope [rad/m]	0.00860988
ROC [m]	1/0.0086227= 115.972	ROC [m]	1/0.00860988 = 116.146

(3) Elliptical mirror. Slope error measurements

P, Q , and θ values were fixed at 49.6 m, 0.4 m, and 2.9865 mrad, respectively



On-board metrology for Ion beam Figuring (IBF)



- ✓ SAM used as an on-board metrology tool for Ion beam figuring[2]
- ✓ The mirror slope error has been reduced from 1.4urad down to 0.5urad with one iteration correction

References

[1] Wang, H., Moriconi, S. & Sawhney, K. **Nano-precision metrology of X-ray mirrors with laser speckle angular measurement. Nature - Light Sci Appl 10, 195 (2021).**

[2] Hand M, Alcock D, Hillman M, Littlewood R, Moriconi S, Wang H and Sawhney.K **Ion beam figuring and optical metrology system for synchrotron x-ray mirrors. SPIE Vol. 11109, Adv. Metrol. X-Ray EUV Opt. VIII, 111090A (2019)**

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