SYNCHROTRON LIGHT SOURCE

The Optics Laboratory at ALBA

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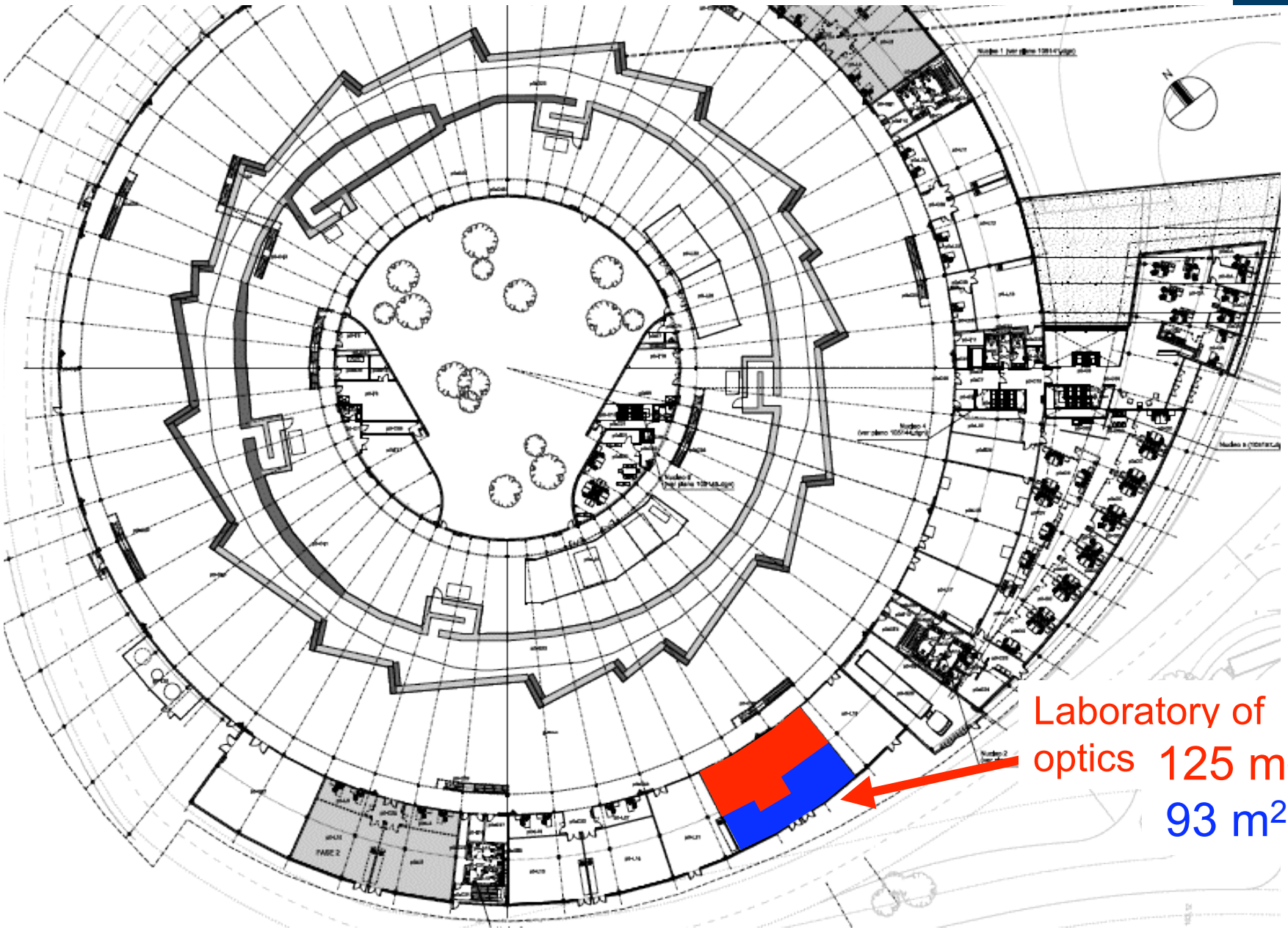
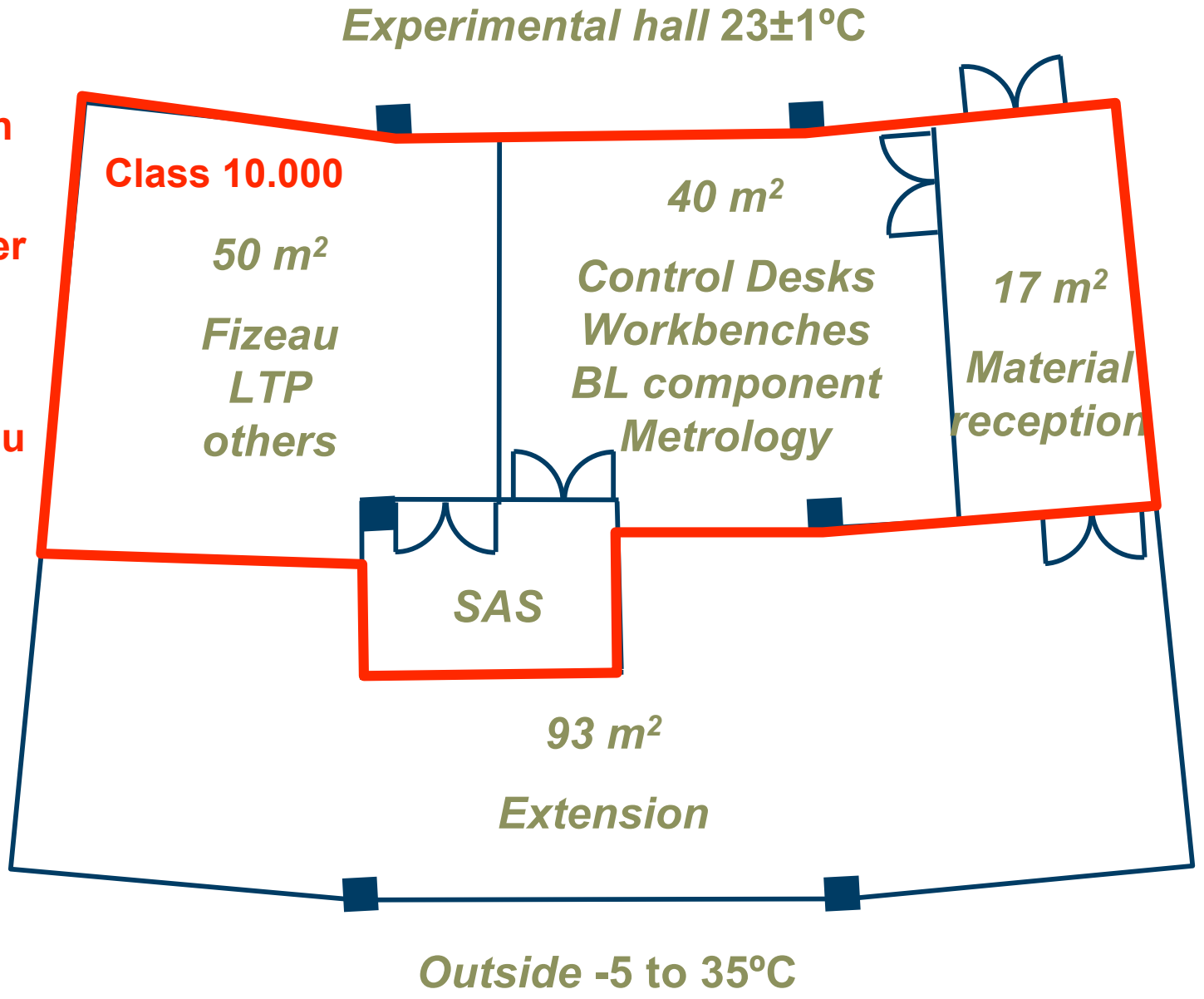
Space



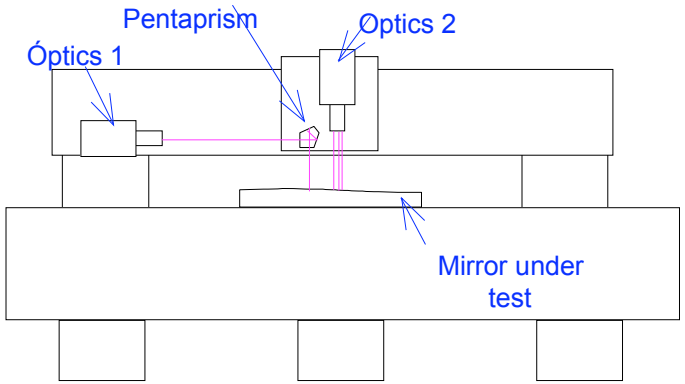
Spaces

- Thermal isolation
- HVAC: FanCoil + PID heater
- Overpressure
- local Enclosures for LTP and Fizeau



Instruments

LONG TRACE Profilometer (May 2009)	
Bench and stages	Q-Sys
LTP Optics 1	Elcomat 3000-8 + pentaprism
LTP Optics 2	Collaboration CELLS-UAB
LTP Enclosure	Local company



Fizeau interferometer (Available)	
Supplier	ADE PhaseShift Minifiz 100 (KLA-Tencor)
Aperture	100 mm
Zoom	1x to 4x
Others	Telecentric imaging
	Adjustable Lateral Coherence

Fizeau-based metrology until fall 2009

- **Functionality:**
  - How to use the Fizeau interferometer to qualify our mirrors?
- **Uncertainty:**
  - How to improve the **repeatability** and **stability**?
  - How to improve **accuracy**, limited by:
    - Reference surfaces error
    - Alignment errors
    - Model approximations
    - Phase shift calibration, CCD nonlinearities ...
    - Diffraction (roughness, dust, edges, IF optics)

Fizeau-based metrology until fall 2009

- **Functionality:**
  - How to use the Fizeau interferometer to qualify our mirrors? **Grazing incidence setup**
- **Uncertainty:**
  - How to improve the **repeatability** and **stability**? **Environment stability, then averaging**
  - How to improve **accuracy**, limited by:
    - Reference surfaces error
    - Alignment errors
    - Model approximations

    } **Data processing**

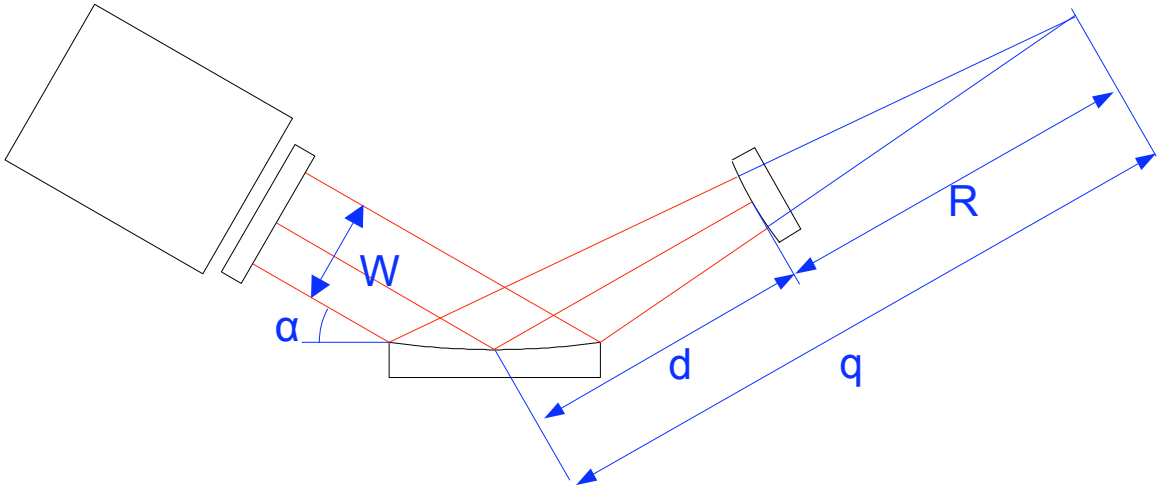
    - Phase shift calibration, CCD nonlinearities …
    - Diffraction (roughness, dust, edges, IF optics)

    …instrument performance, partial coherence

Fizeau Setup for ALBA phase 1

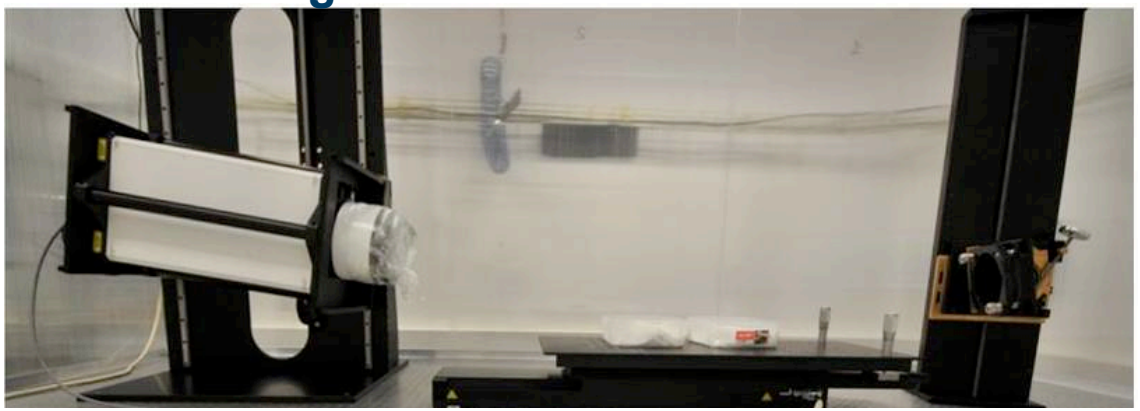
- 7 beamlines will be installed along 2009, 4 HXR + 3 SXR.
- Most of them should be measured using the Fizeau at grazing incidence

35	Mirrors and gratings
20	Benders
8	Gratings
7	Polished to shape



89	surface maps
40	Flats
20	Elliptic cylinders (!)
13	Meridional cylinders
7	Toroidal (!)
5	Polynomial
2	Sphere
2	Sagittal cylinders

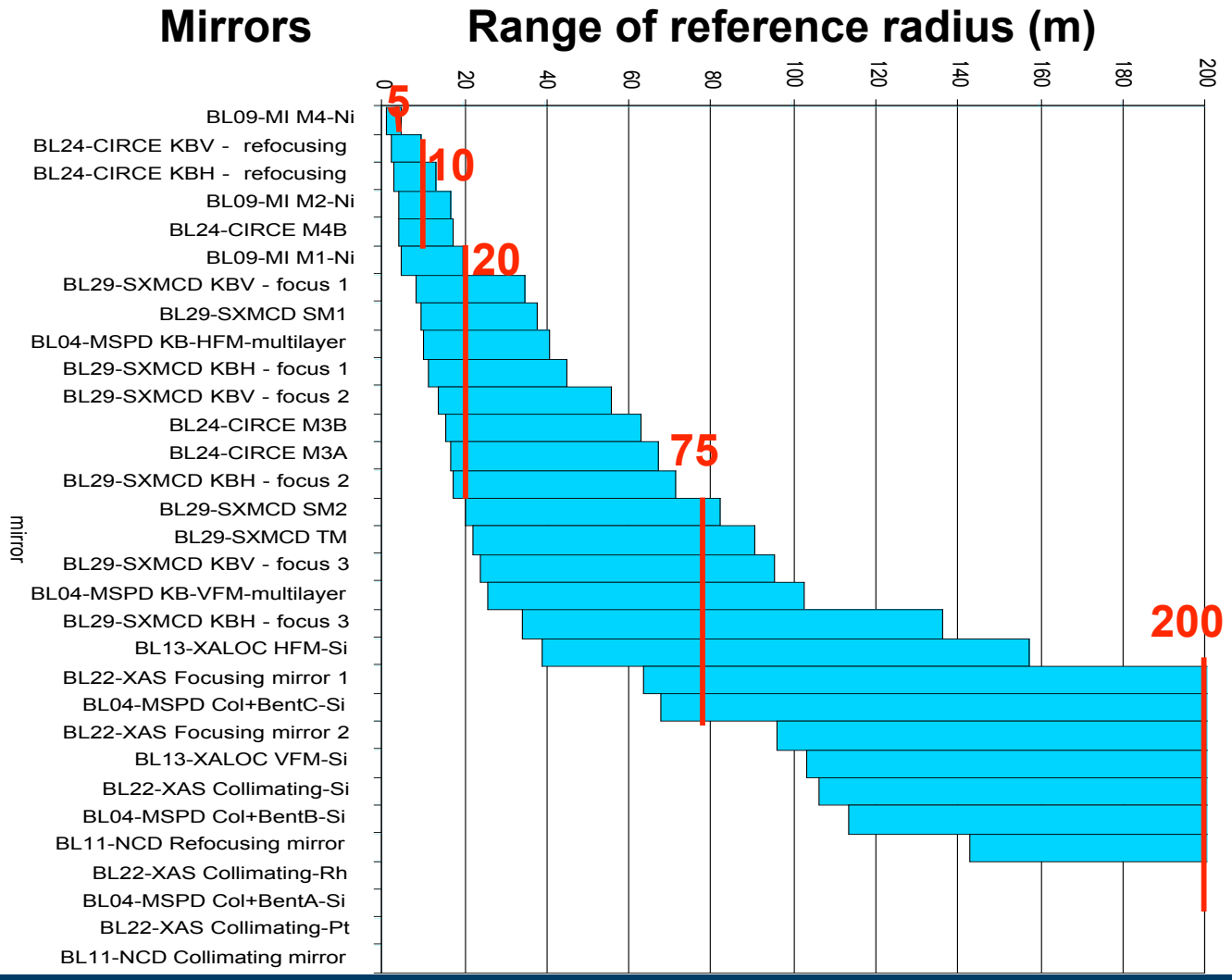
Vertical arrangement



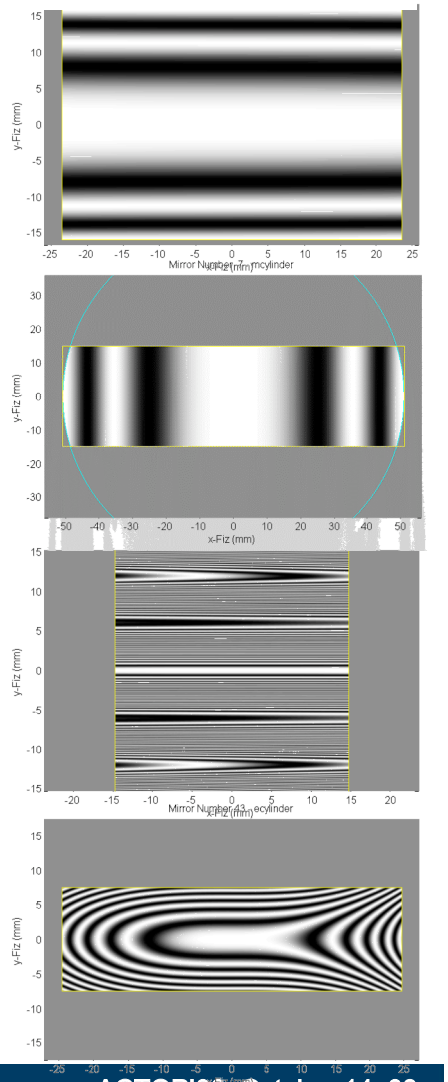
Reference spheres for ALBA phase 1

- Eeach mirror can be measured using a range of angles and zoon

- 5 reference spheres are enough to measure ca. 90% of our mirrors

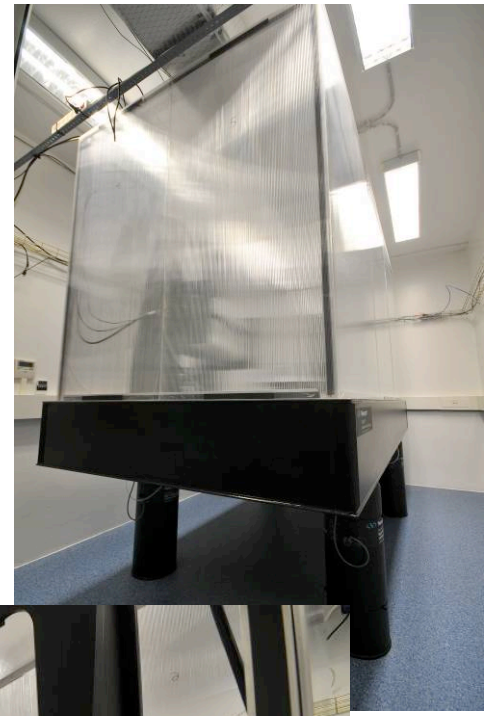


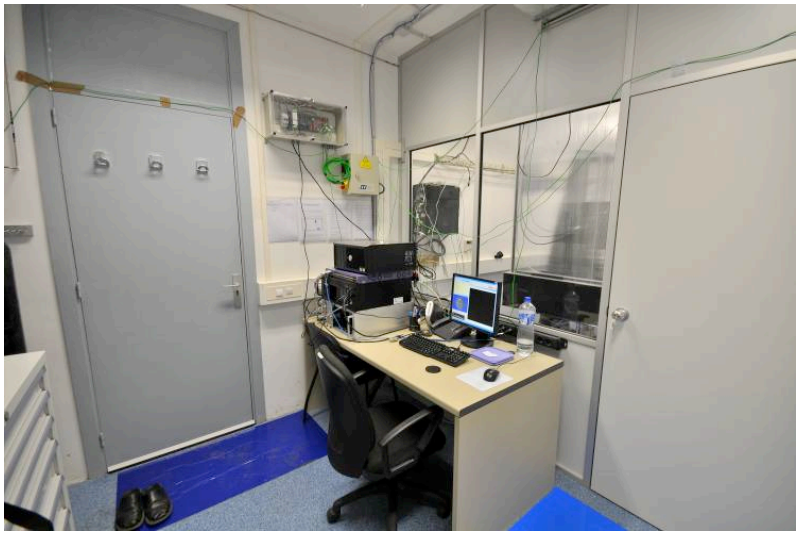
Simulated fringe patterns

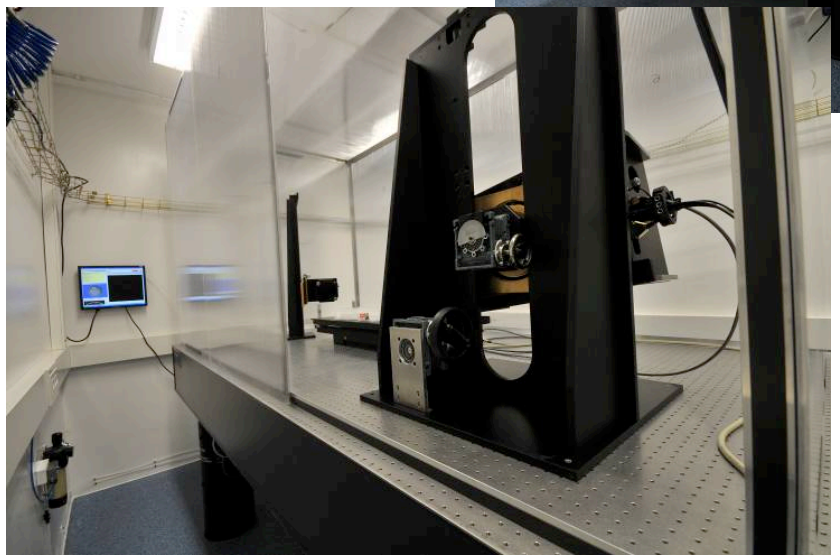


Temporary laboratory

A *temporary laboratory* is available at the University
- Reduced Space: Interferometer setup only
- Room Temperature stability ±0.4ºC
- Enclosure Temperature stability ±0.1ºC
- Overpressure

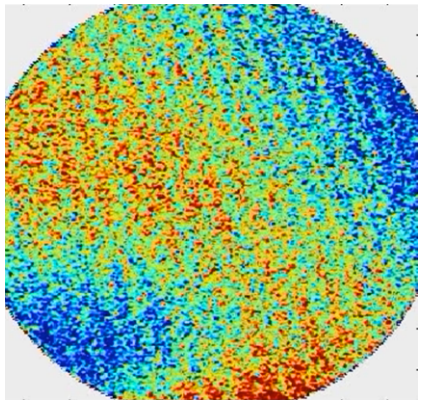




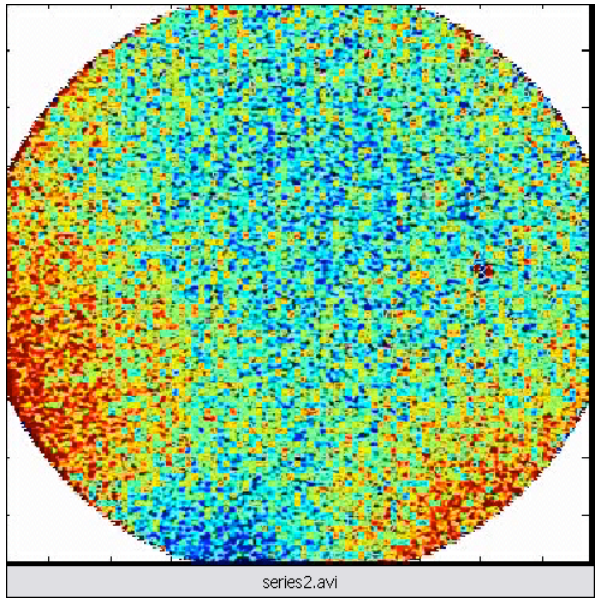


Fizeau repeatability (point to point)

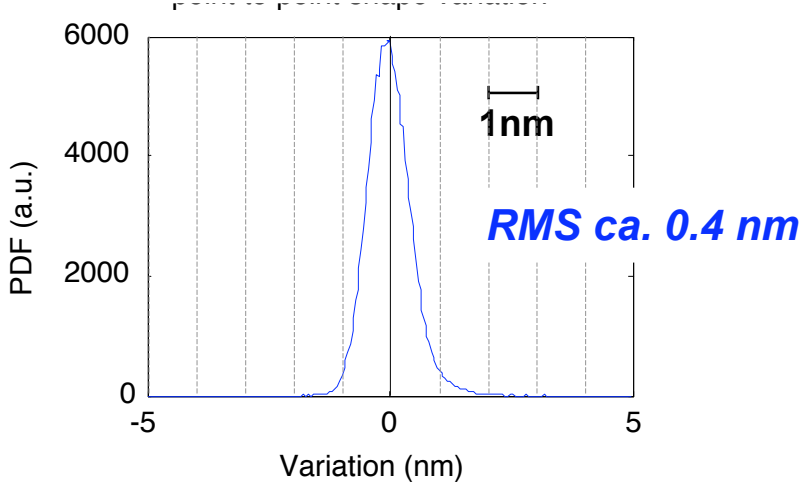
2080 datasets are acquired in 8h, and compared to the first dataset



- **Turbulences + Acoustic Noise**
- **CCD noise + Speckle**
- **PhShift Calibration**

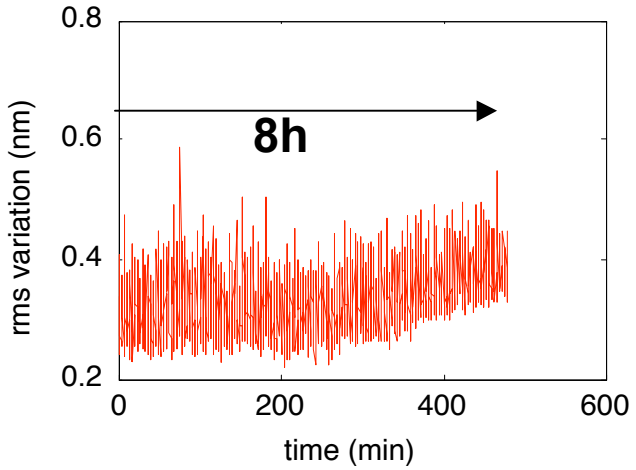


Histogram of point to point deviation of the nth dataset from the 1st dataset



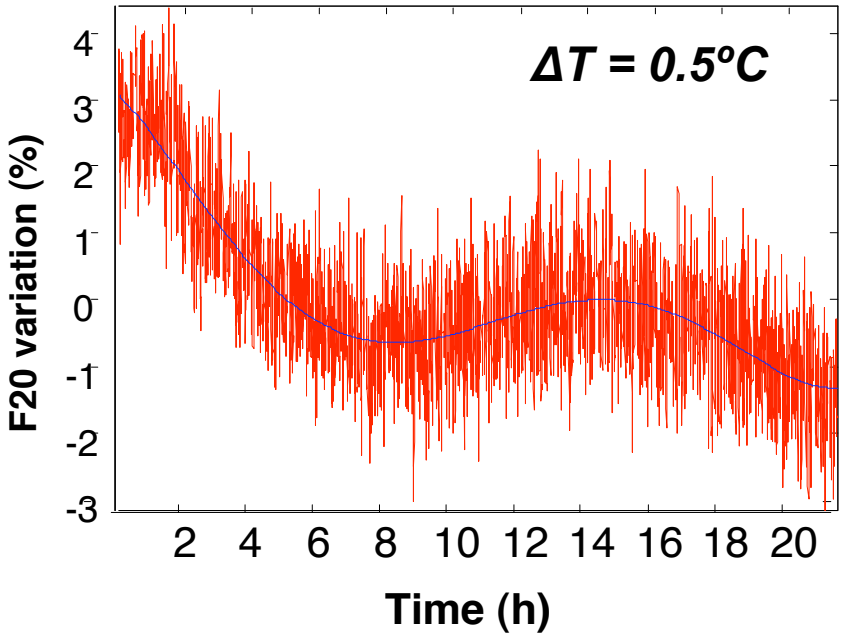
RMS ca. 0.4 nm

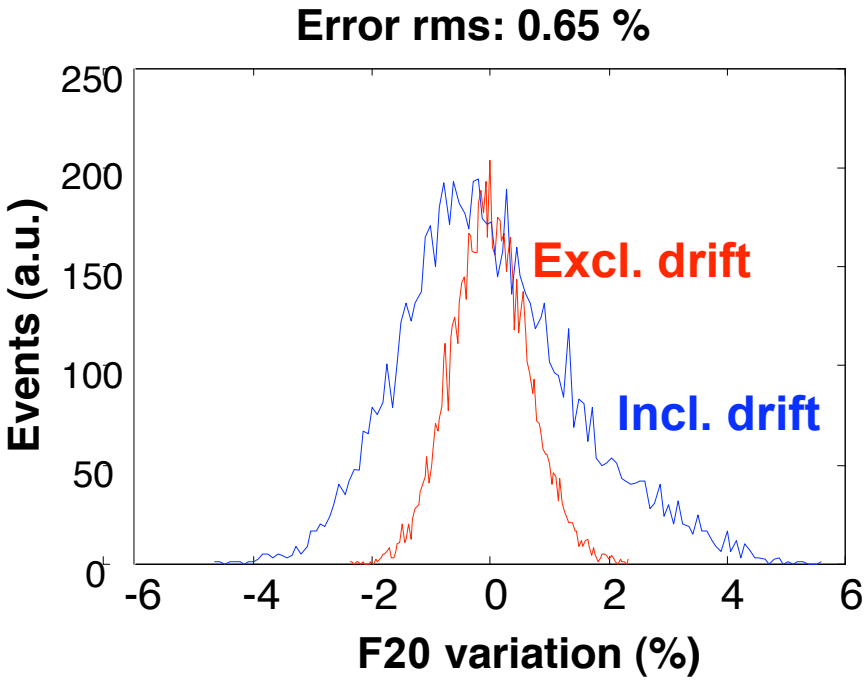
Time varation of the point differences



Fizeau repeatability (F_{20} term)

The F_{20} term of (curvature) the wavefront is measured during 22h

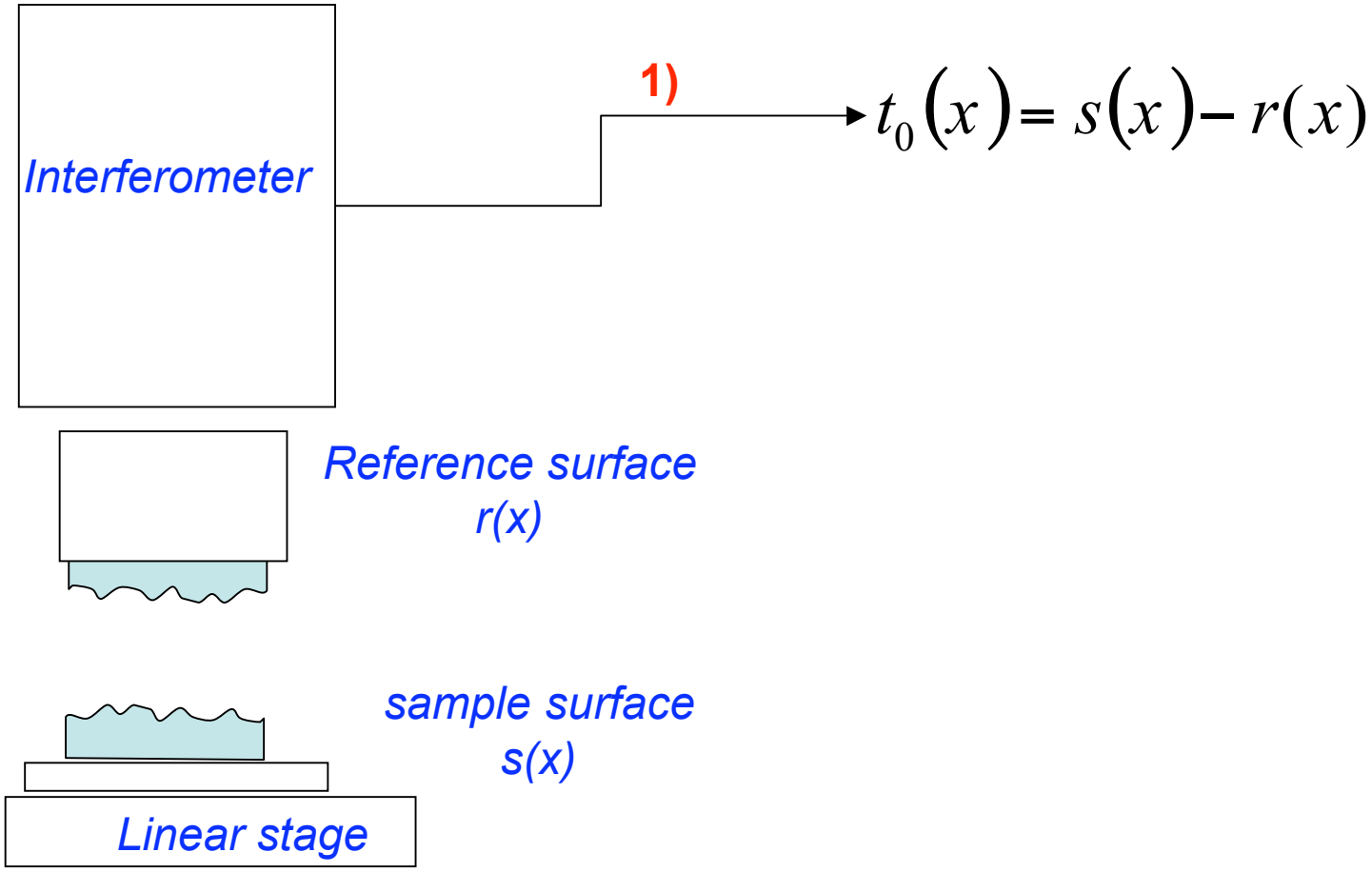




Maximum drift: 0.7% per hour →average to improve repeatability

Accuracy – Lateral shearing on a Fizeau

Lateral shearing technique is used to elliminate the reference surface error



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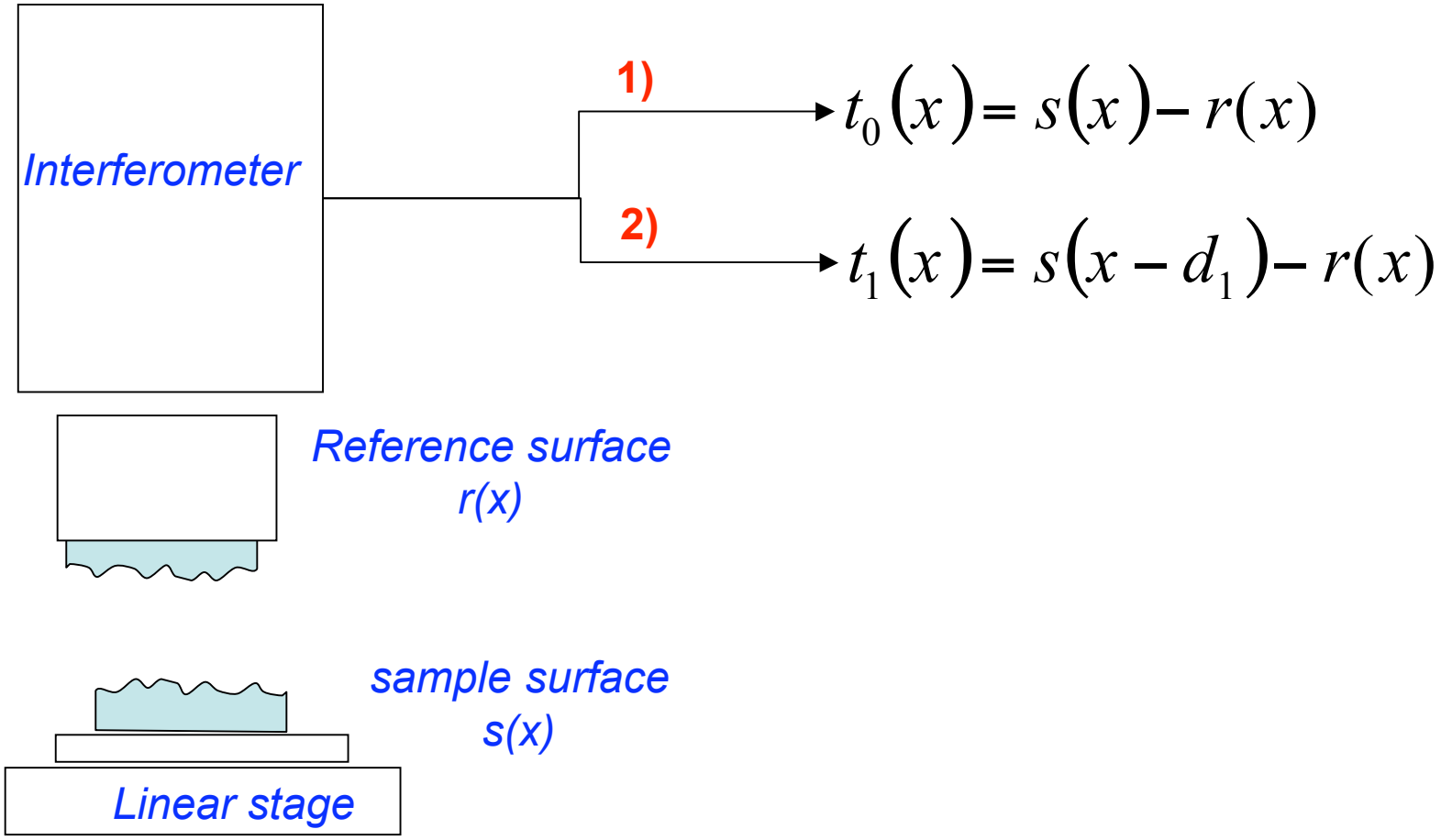

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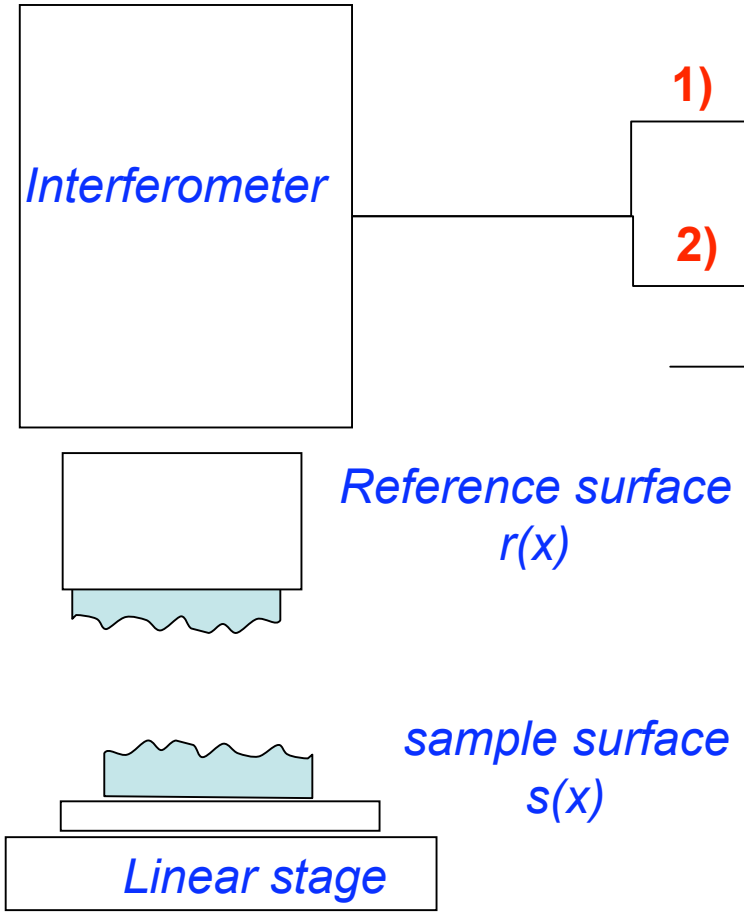


1) $t_0(x) = s(x) - r(x)$

2) $t_1(x) = s(x - d_1) - r(x)$

$$w_1(x) = s(x - d_1) - s(x)$$

FT

Shearing Transfer Function

$$\frac{1}{1 - \exp(-i2\pi d_1 u)}$$

FT^{-1}

$$s(x)$$

Lateral Shearing implementation

1. *Discretization of the method*

   Natural extension (*Elster et al.*)

   →retrieve data out of the intersection

   →extends dataset to a periodic function

2. *Singularities of the Shear transfer function*

   Linear combination of data corresponding to different displacements

3. *Systematic errors*

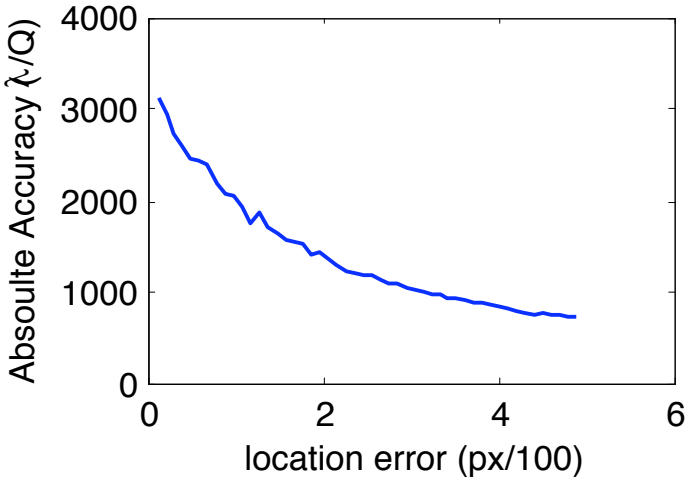
   Displacement errors → Correlation

   Pitch errors → Pitch correction

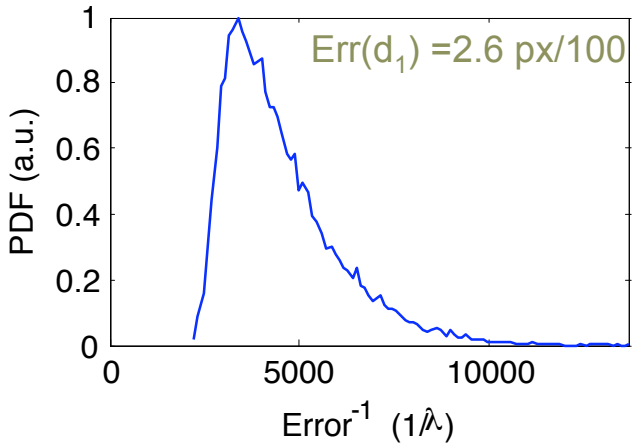
Systematic errors: Location accuracy

The error of the reconstructed function depends on the sample function.

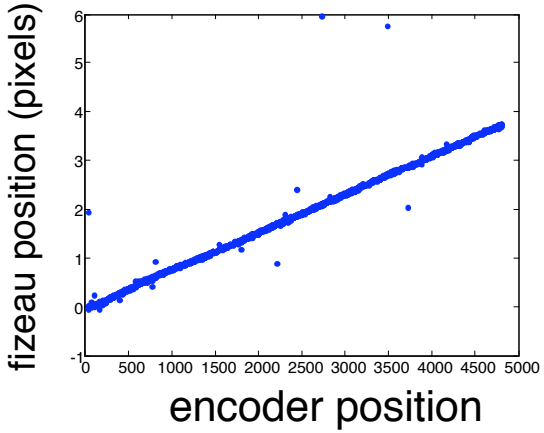
Reconstruction accuracy as a function of the location error

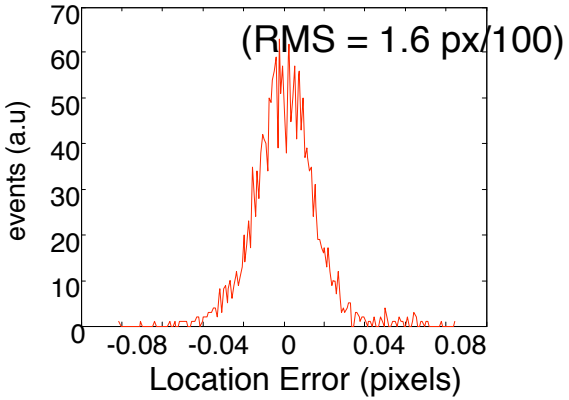


Histogram of the accuracy of the reconstruction



The shift distance is determined by crosscorrelation of the images





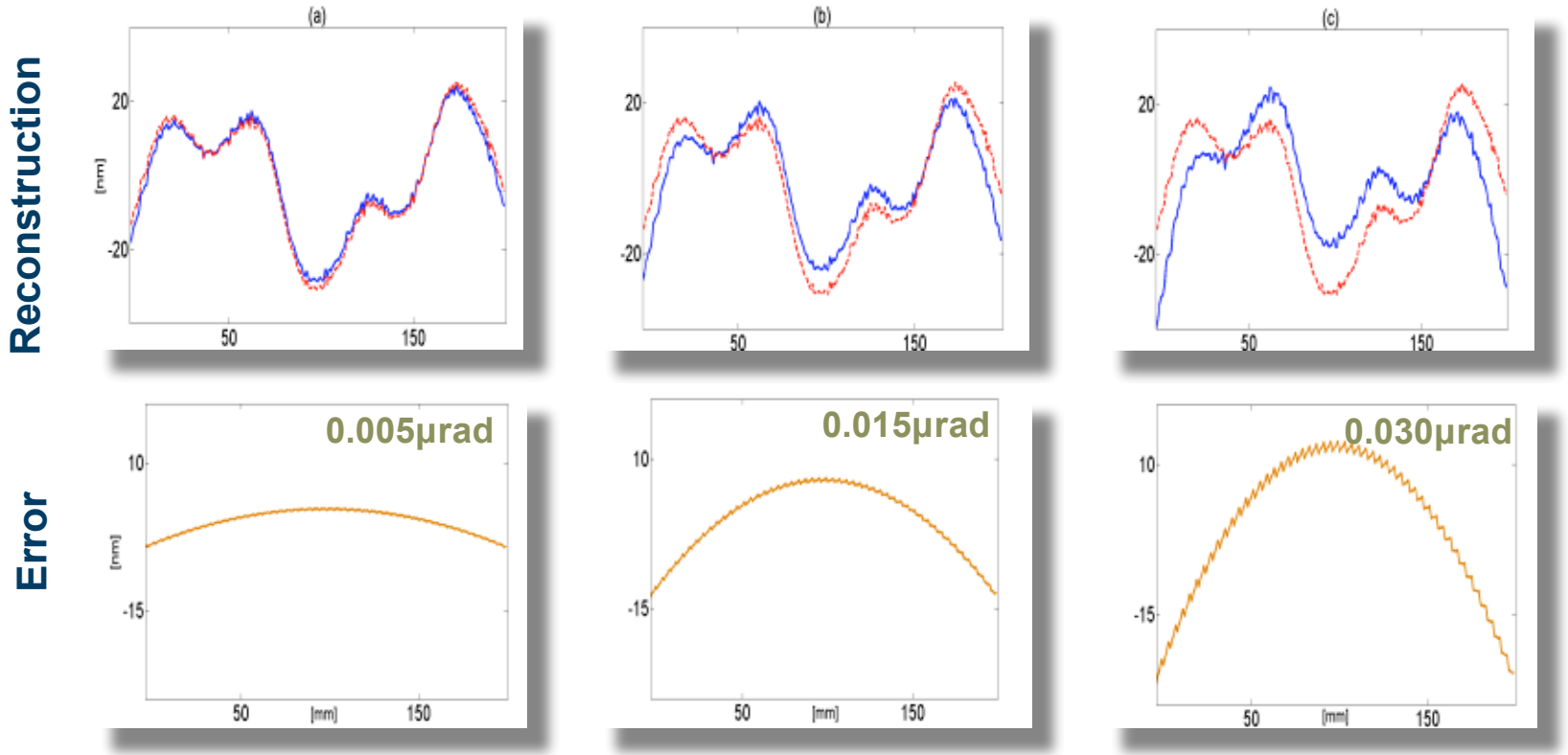
Systematic errors: Pitch error

The pitch error on the translation of the stage adds a quadratic function to the reconstruction

$$w_1(x) = s(x - d_1) - s(x) + Ax + B$$

'Integration'

Curvature error



Systematic errors: Pitch estimation

The pitch can be estimated from known data to the level of few nrad

s(x) =

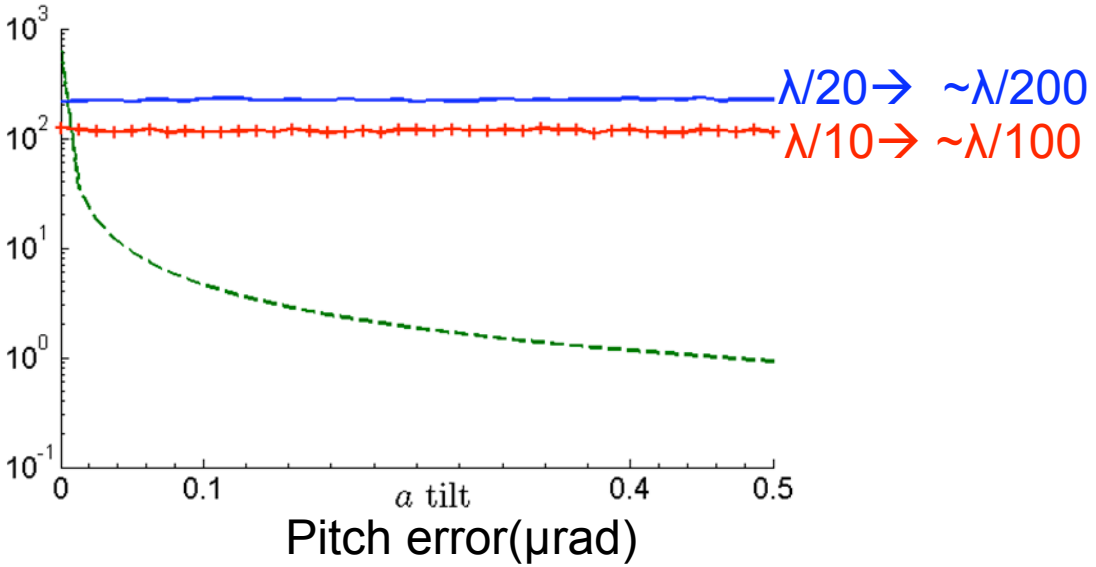
s(x-d) =

+ *A*·x

$$A = -\frac{\sum w_1(x)}{\sum x} + \delta A$$

$$\sum_x w_1(x) = \sum \blacksquare - \sum \blacksquare - A\sum x$$

$$\delta A = \frac{\sum_x \blacksquare - \sum_x \blacksquare}{\sum_x x}$$



Conclusions …

- 90% of ALBA phase 1 mirror will be characterized with a Fizeau interferometer in grazing incidence. An LTP will be available in the future.
- Shearing method, after controlling systematic errors, can improve the accuracy of the measurement by a factor 10.

… and future work

- Extend algorithms to 2D
- Shearing and Stitching
- Shearing on LTP data
- …

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