

High Frequency UHV Mechanical X-Ray Beam Chopper

Nahikari Gonzalez, Carles Colldelram, Salvador Ferrer, Carlos Escudero

ALBA-CELLS Synchrotron, Cerdanyola del Vallès, Spain

Abstract

An in vacuum mechanical chopper has been designed and built to perform X-ray Absorption Spectroscopy (XAS) experiments with operating liquid electrochemical cells at the NAPP end station of ALBA Synchrotron (BL24, CIRCE Beamline). While operating the liquid electrochemical cell, in order to separate the weak currents induced by the X-ray absorption process at the working electrode in contact with the liquid electrolyte (total electron yield signal or TEY) from the faradaic current established between the electrodes when applying a bias, the incoming beam must be chopped at a certain frequency (ω) and then, by means of a lock in amplifier, the signal at this frequency ω can be extracted and measured. The in vacuum chopper developed at ALBA can operate at variable frequencies and when inserted in the X-ray beam path, produces pulses with a certain frequency ω , therefore modulating the TEY signal. This new chopper design, improves previous designs which used piezo-actuated choppers constrained to work at fixed oscillating frequencies [1].

The design consists of a slotted disk that spins around an axis by means of an UHV stepper motor. A LED and photodiode based UHV sensor ensures that frequency drifts do not affect the measurements. The motor is hold by an internally water cooled OFHC support, which allows long duration experiments at high speeds without stopping.

[1] Velasco-Velez et al, *Science* **2014**, 346, 831–834

Design Description

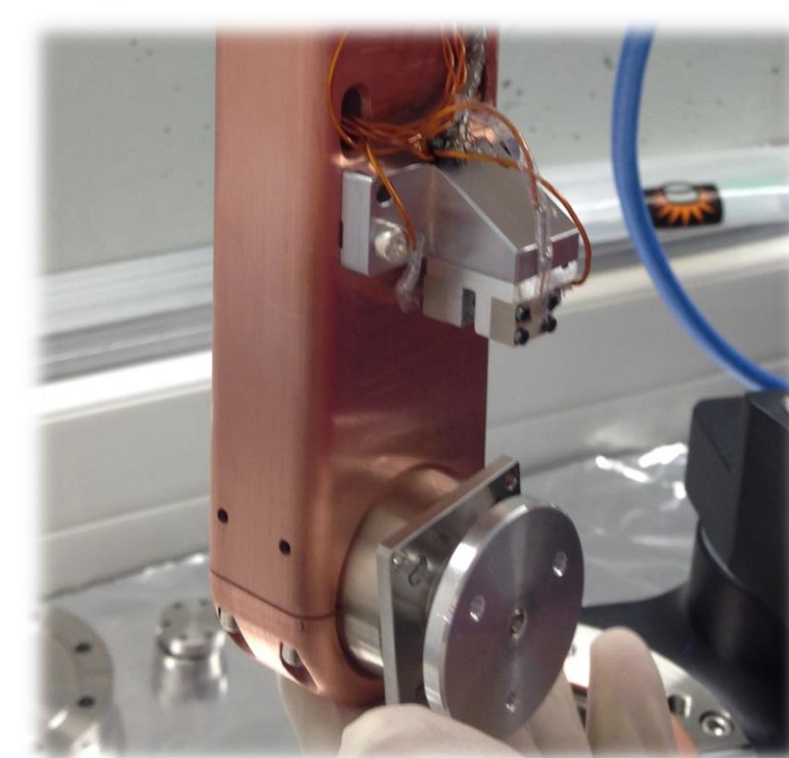
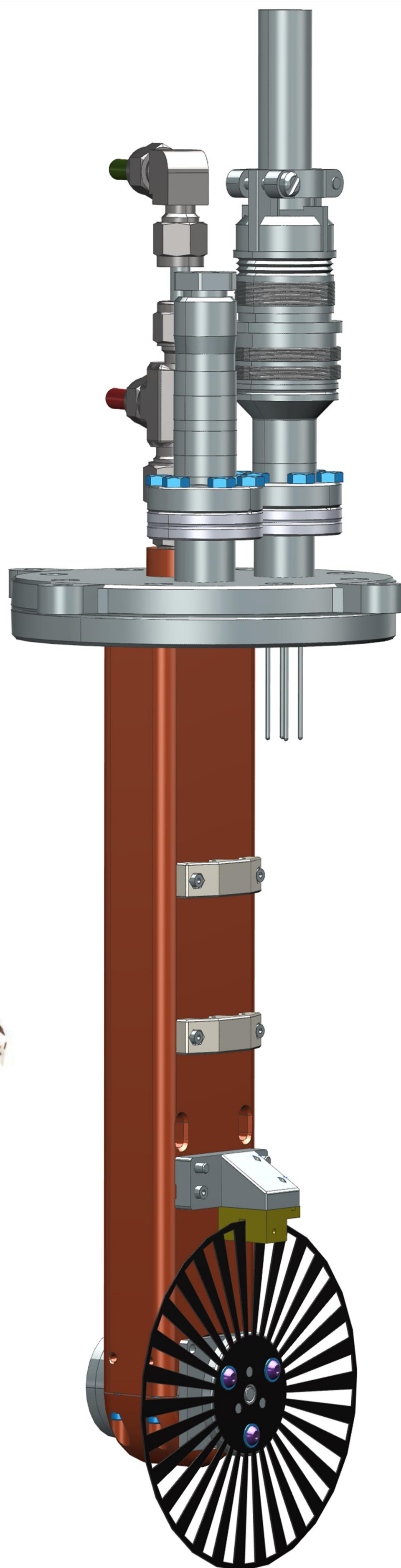
The chopper consists of a slotted disk that spins by means of an UHV stepper motor.



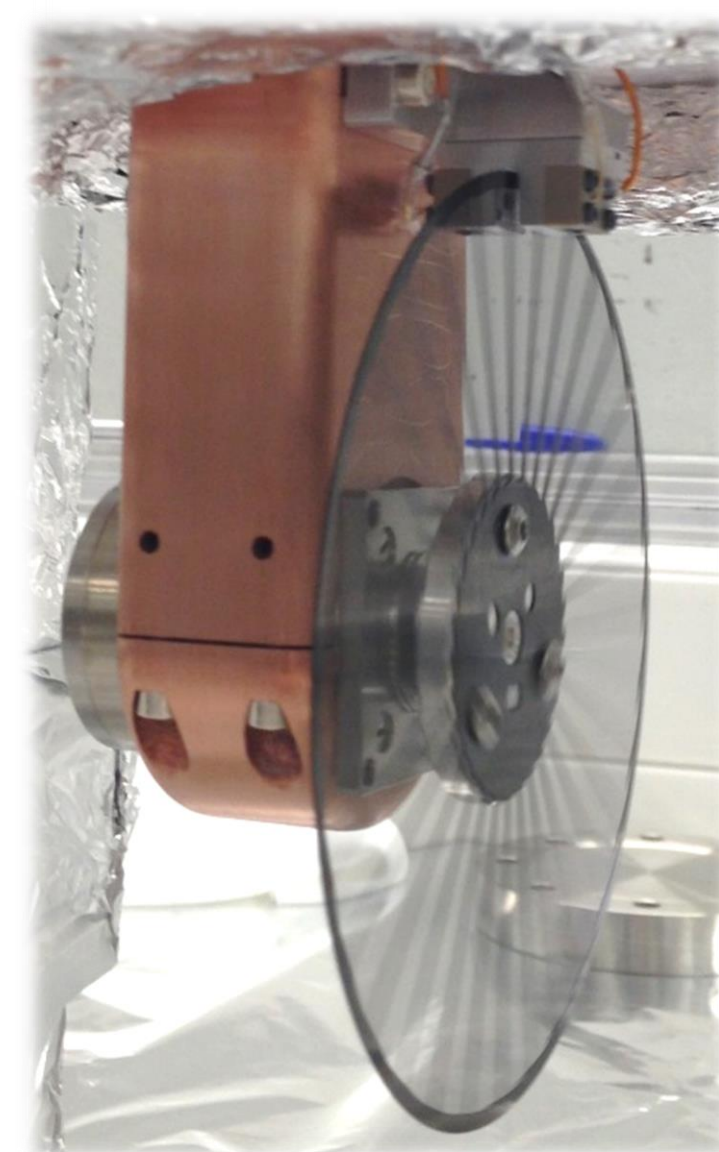
- Located downstream the M3 mirror of the NAPP branch at BL24, CIRCE.
- Rigid and stable structure with levelling elements.
- Motorized linear motion to enable in-out translation.



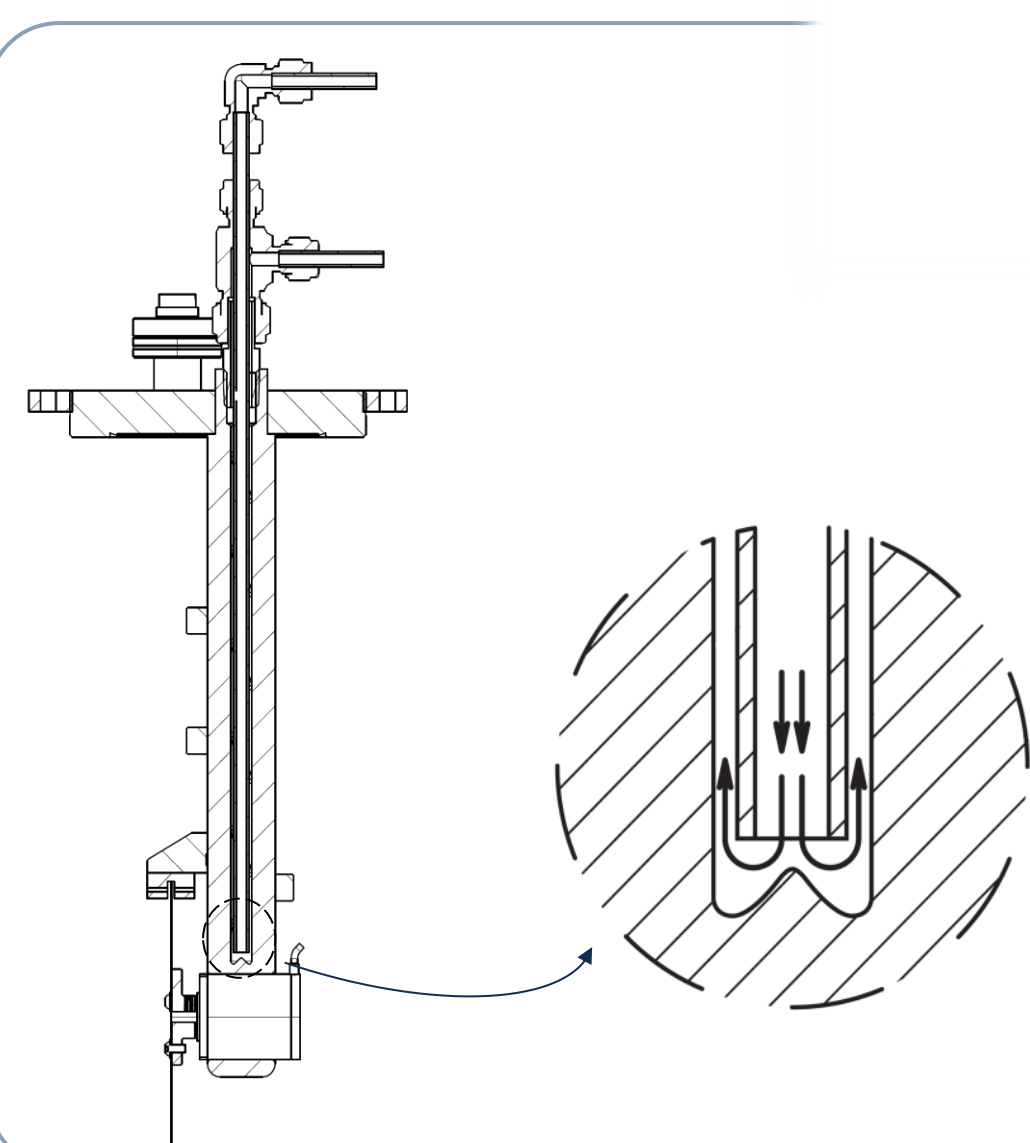
Phyton VSS.32.200.1,2
UHV Stepper Motor



UHV sensor based on a LED
and a photodiode to ensure
speed stability



Thorlab's UHV compatible
slotted disk



- Motor hold by a OFHC support with internal water recirculation to cool down the stepper motor.
- Minimum gap between water and motor maximizes the heat exchange capacity.

Specifications

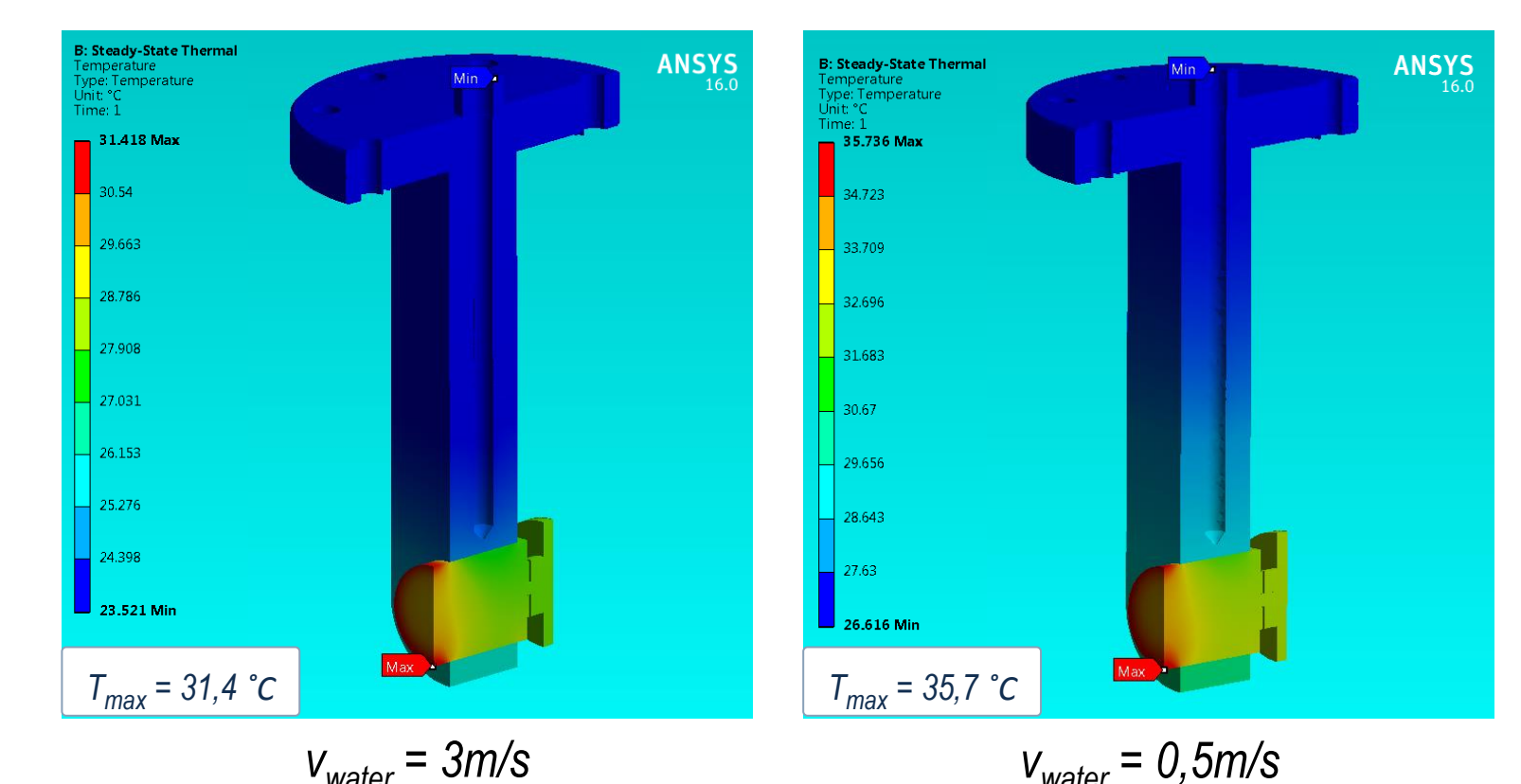
- High and stable rotation speed above 1 kHz continuously for hours.
- Controlled and variable frequency.
- Fully UHV compatible (10^{-9} – 10^{-10} mbar).
- In-out motion in order to remove it from the beam path.
- To allow the synchronization with the chopped electron yield current by means of a lock-in amplifier.

Design Simulations

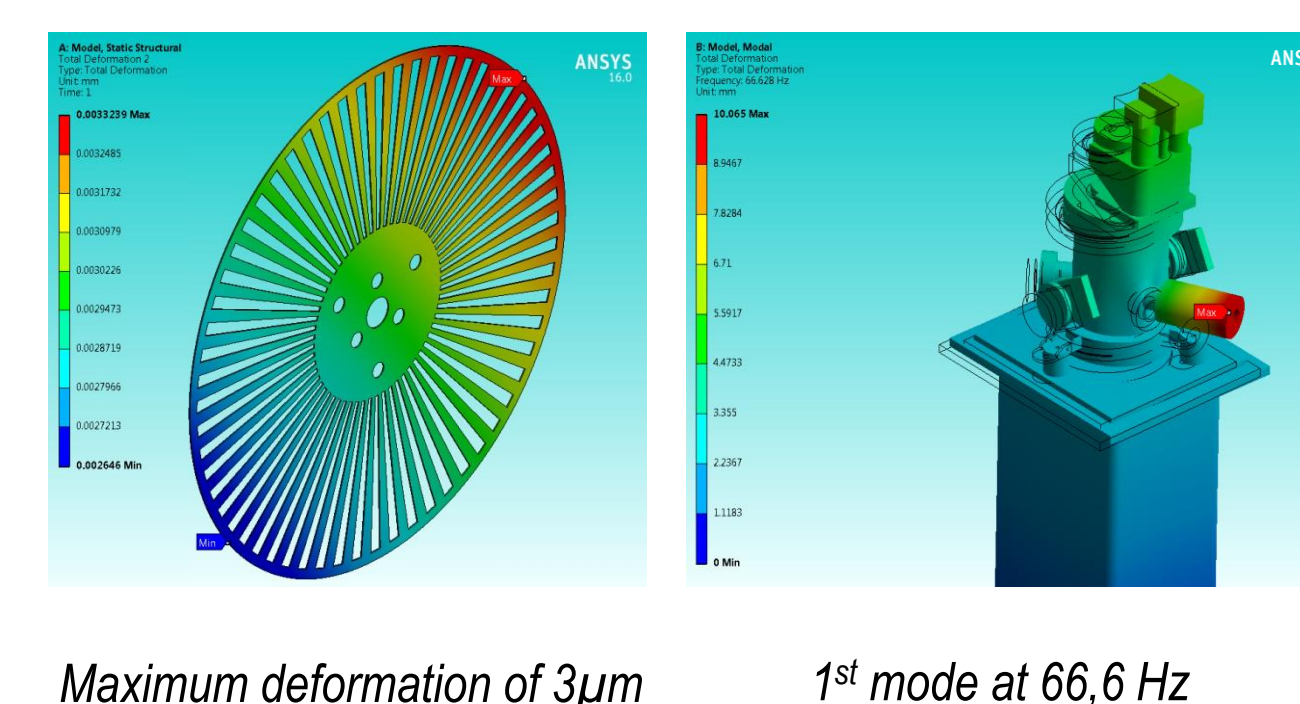
Thermal Calculations

Boundary Conditions:

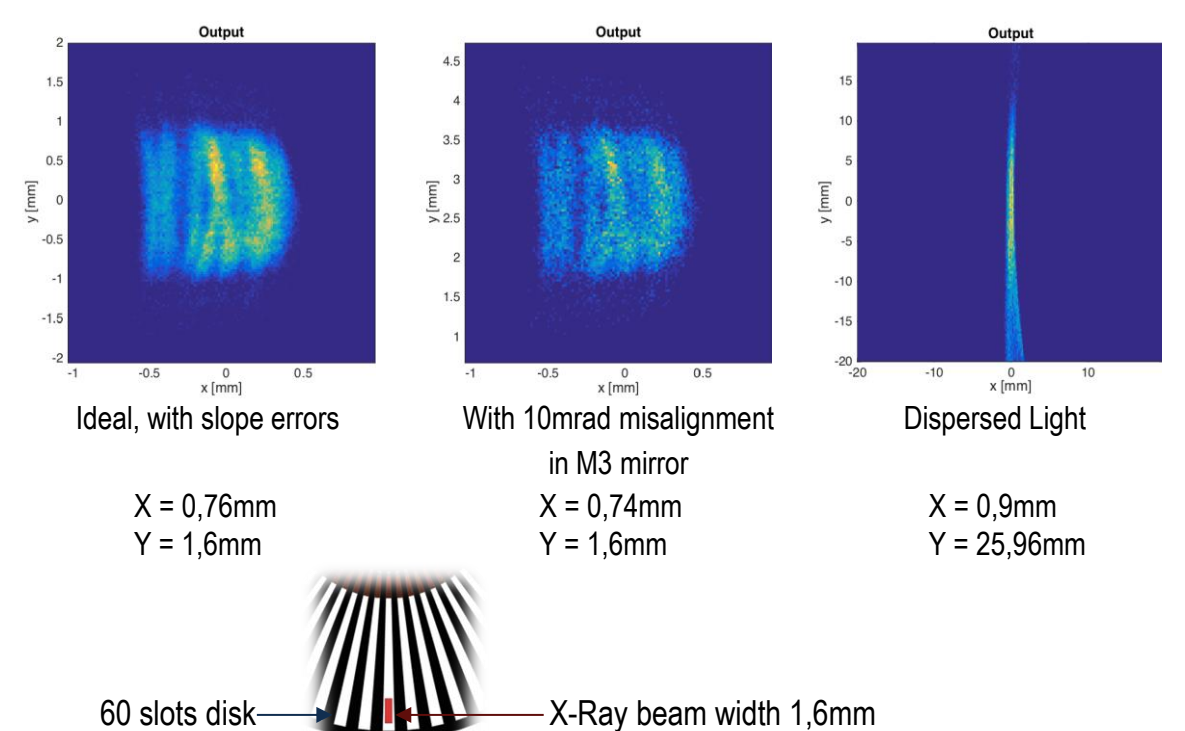
- $P_{motor} = 15 \text{ W}$
- $T_{water} = 23 \text{ }^{\circ}\text{C}$
- $K_{conductance} = 2000 \text{ W/m}^2 \cdot ^{\circ}\text{C}$
- *In vacuum*



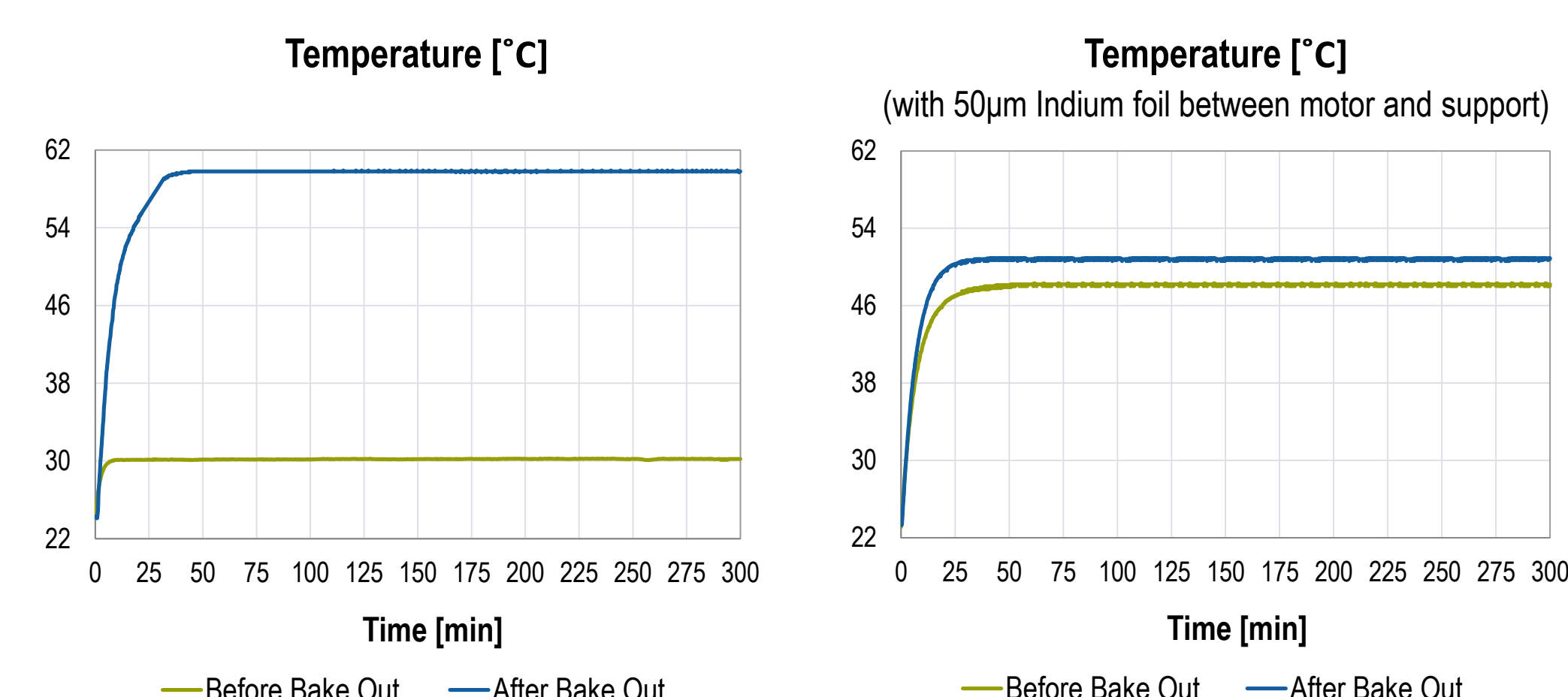
Static & Vibrational Analysis



Ray tracing at chopper position



Test & Results



- 2.000 rpm
- $T_{water} = 23,5 \text{ }^{\circ}\text{C}$
- $Q_{water} = 3 \text{ l/min}$
- *In vacuum*
- Cooling capacity is lost with the bake out.
- ✓ Possible to work beyond stepper motor manufacturer temperature limitations and over the speed specified by the catalogue for hours uninterruptedly in UHV.