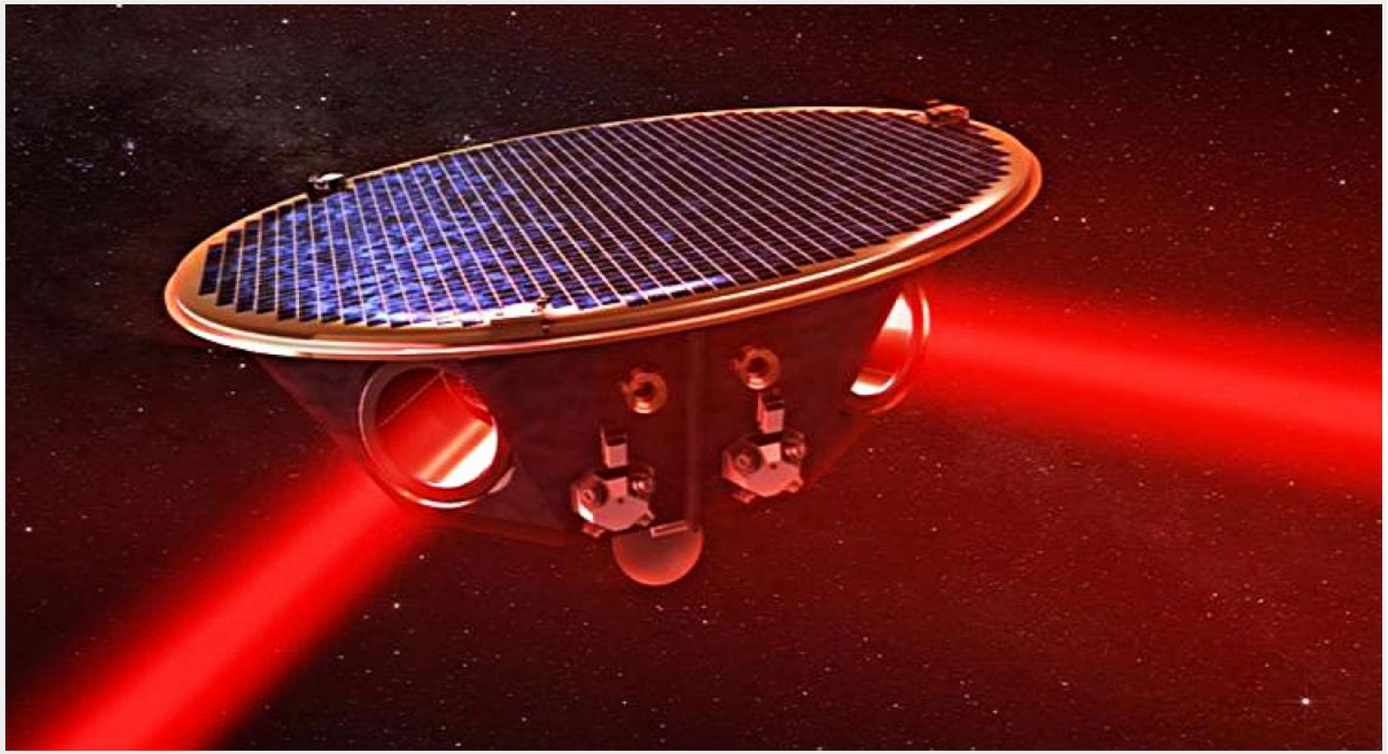
LISA Mission and the Czech involvement

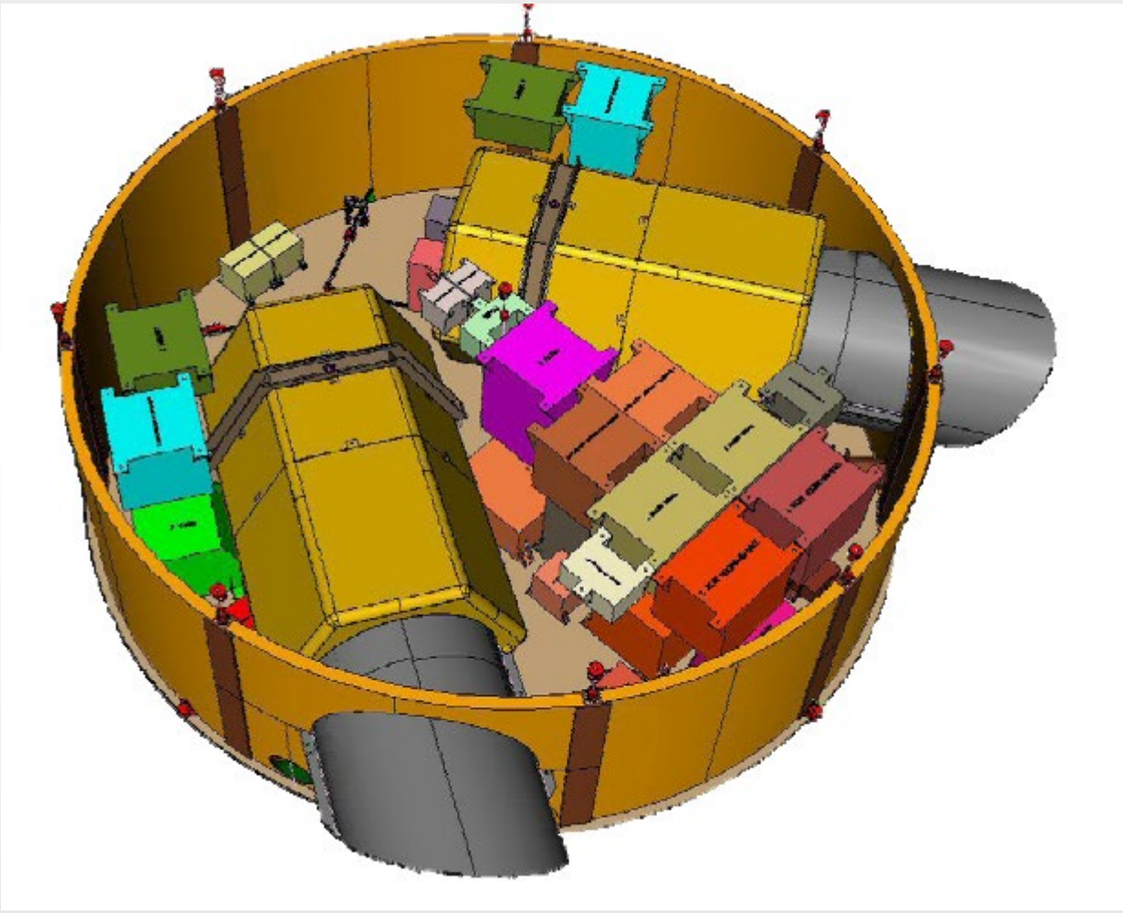
Asen Christov

(on behalf of the teams from FZU, UFA, IT, ASU)

29.9.2021

Laser Interferometer Space Antenna

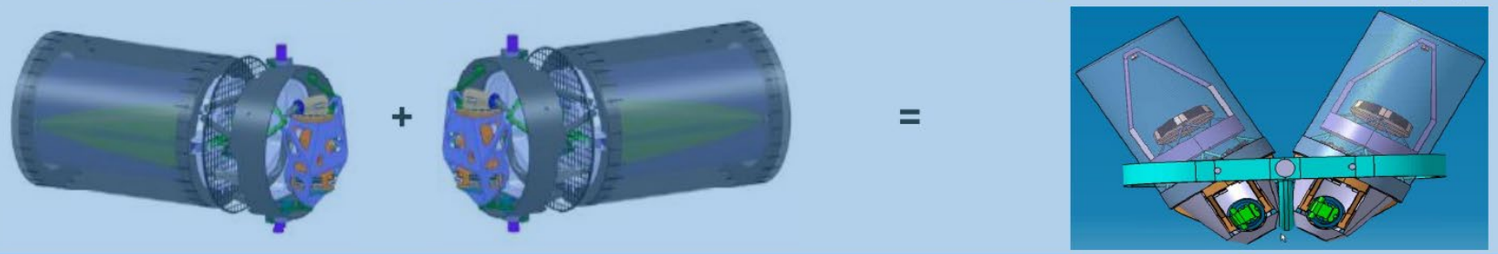




Telescope + Optical Bench + Grav.Ref. Sensor = Moving Optical SubAssembly

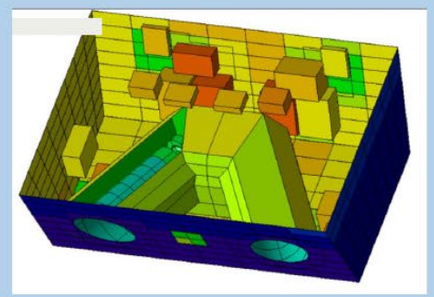
(T) (OB) (GRS) (MOSA)

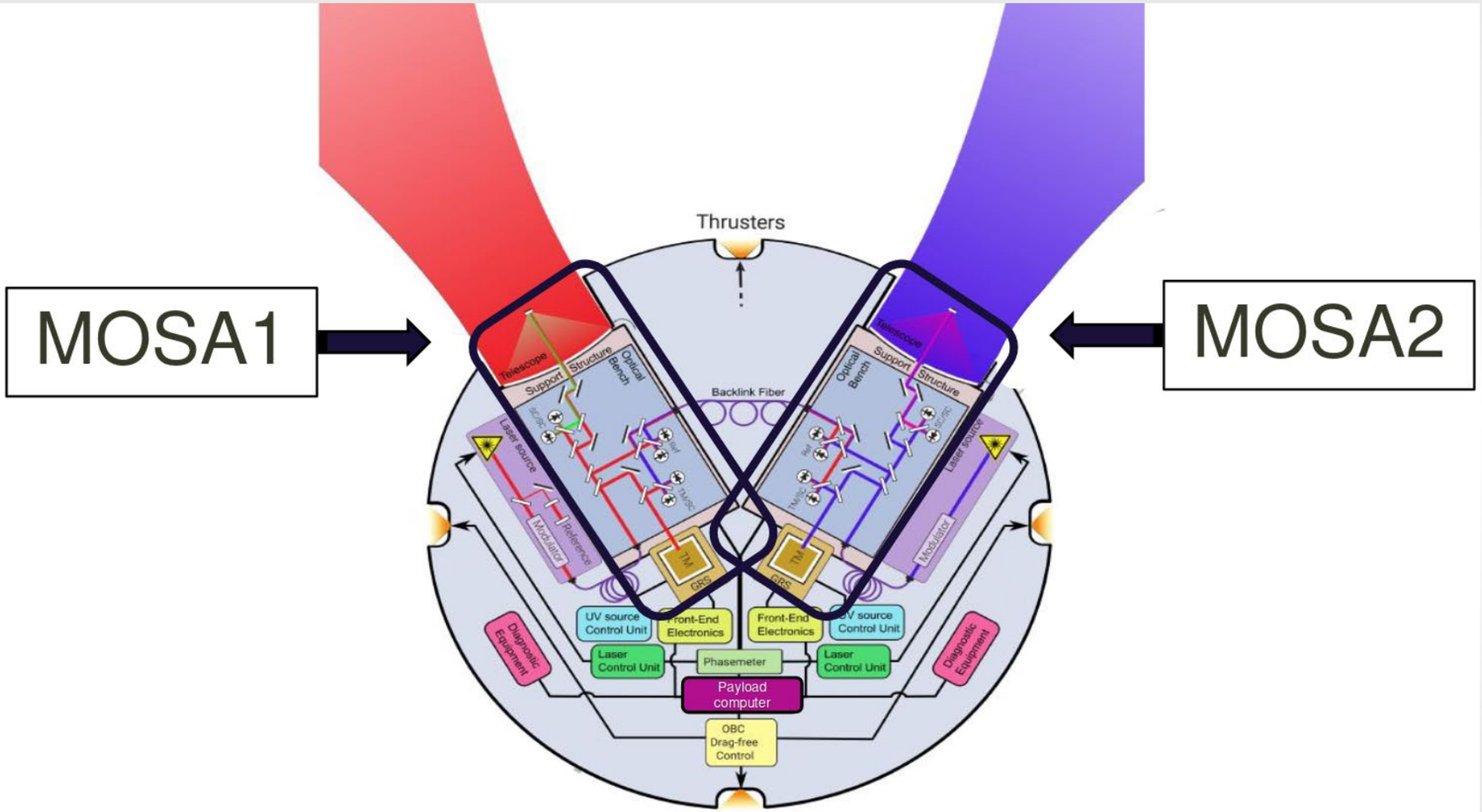
2x MOSA = LISA Core Assembly (LCA)



LCA + Electronics boxes = Payload

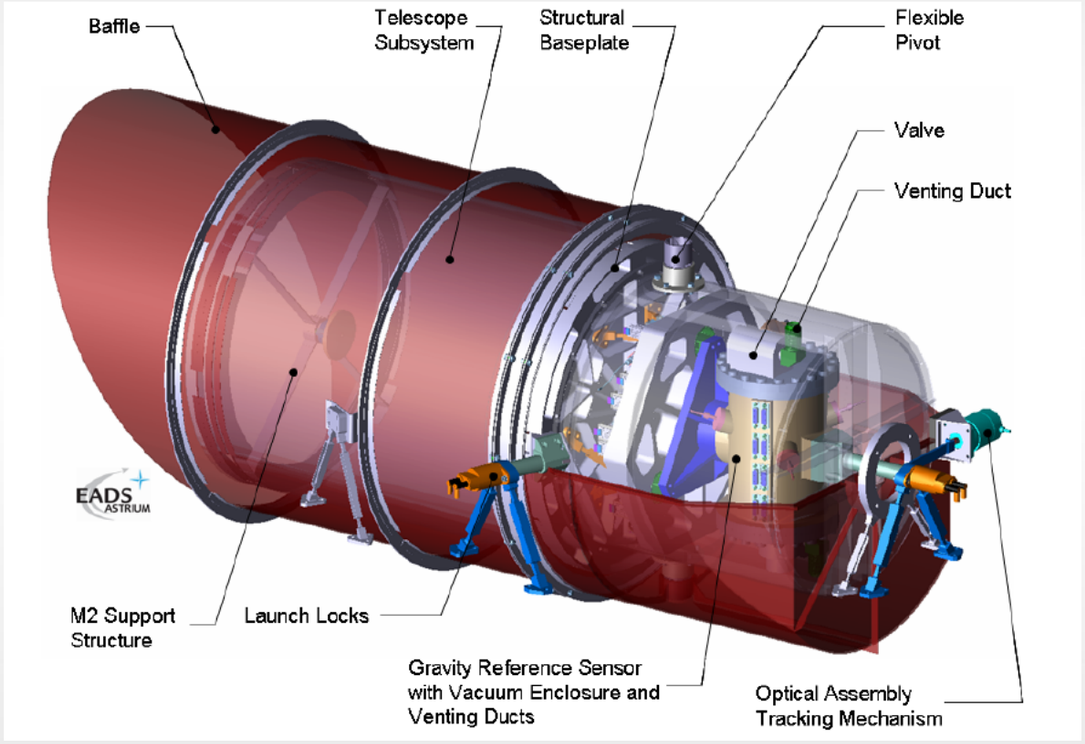
(Phasemeter, Laser Assembly, GRS FEE, Computers (on-board+payload), etc.)

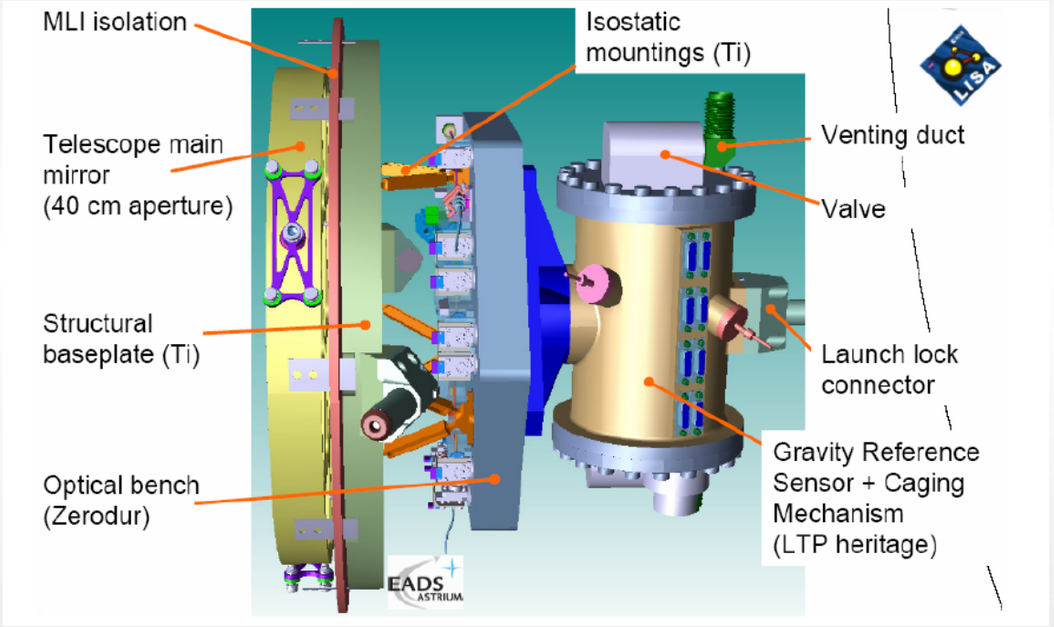




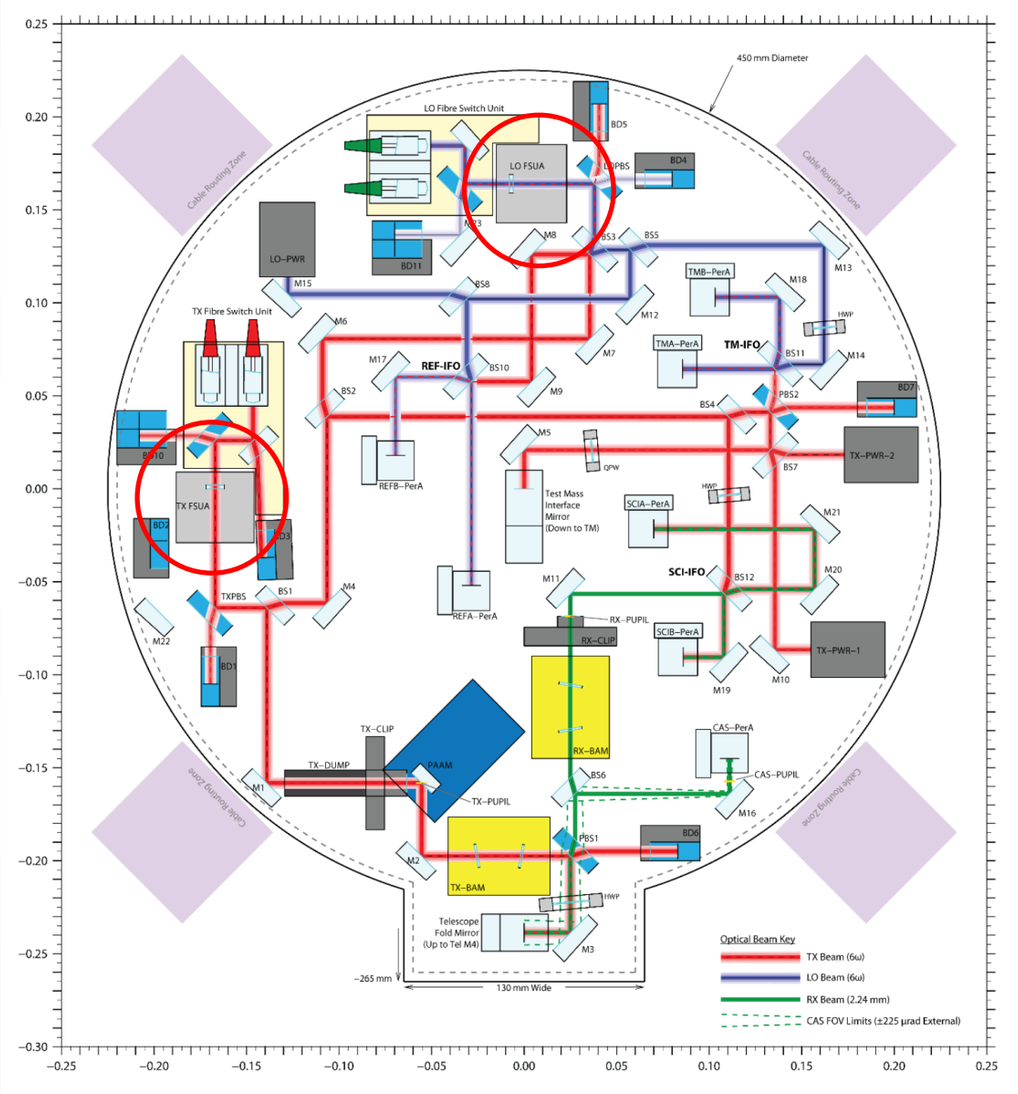
MOSA = Moving Optical Sub-Assembly

- *Telescope (T) + Optical Bench (OB) + Gravitational Reference Sensor (GRS) mounted on a mechanical structure*
- *Additional subsystems (i.e. laser, phasemeter, diagnostics) are required for performance validation*


Baffle
Telescope Subsystem
Structural Baseplate
Flexible Pivot
Valve
Venting Duct
EADS ASTRIUM
M2 Support Structure
Launch Locks
Gravity Reference Sensor with Vacuum Enclosure and Venting Ducts
Optical Assembly Tracking Mechanism


MLI isolation
Isostatic mountings (Ti)
Telescope main mirror (40 cm aperture)
Venting duct
Valve
Structural baseplate (Ti)
Launch lock connector
Gravity Reference Sensor + Caging Mechanism (LTP heritage)
Optical bench (Zerodur)
EADS ASTRIUM

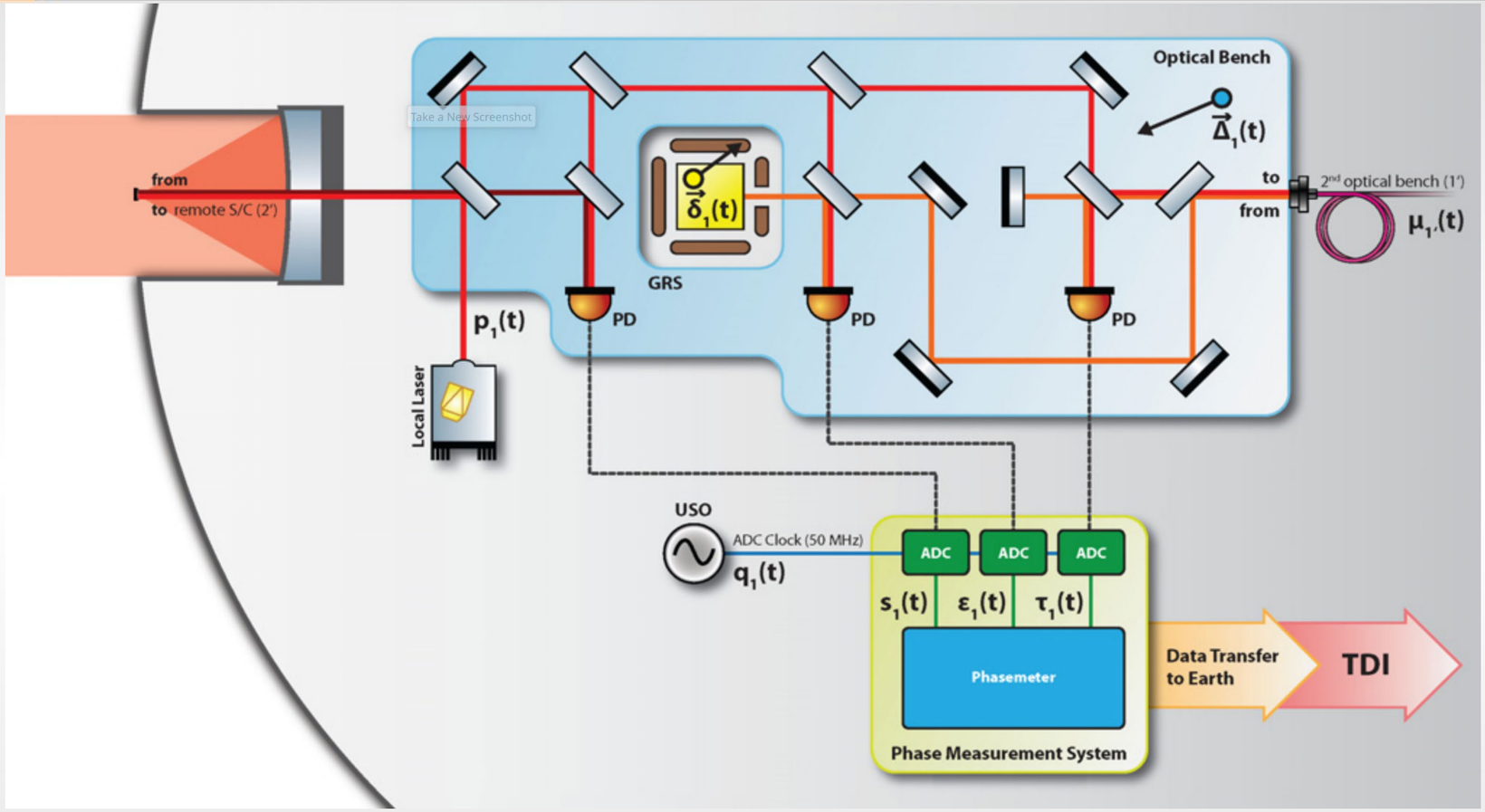
FSUA



Each optical bench:

- TX FSUA:
  - Laser light 1.2 W,
  - small fraction is used for local interferometry
  - most over the Point-Ahead Angle Mechanism to the remote spacecraft.
- LO FSUA:
  - obtained from the TX laser on the second OB of the spacecraft via the Backlink Fiber.
  - allows to establish a phase reference between the two independent TX lasers on board each spacecraft
- (RX beam): received from the distant spacecraft

Distance measurement

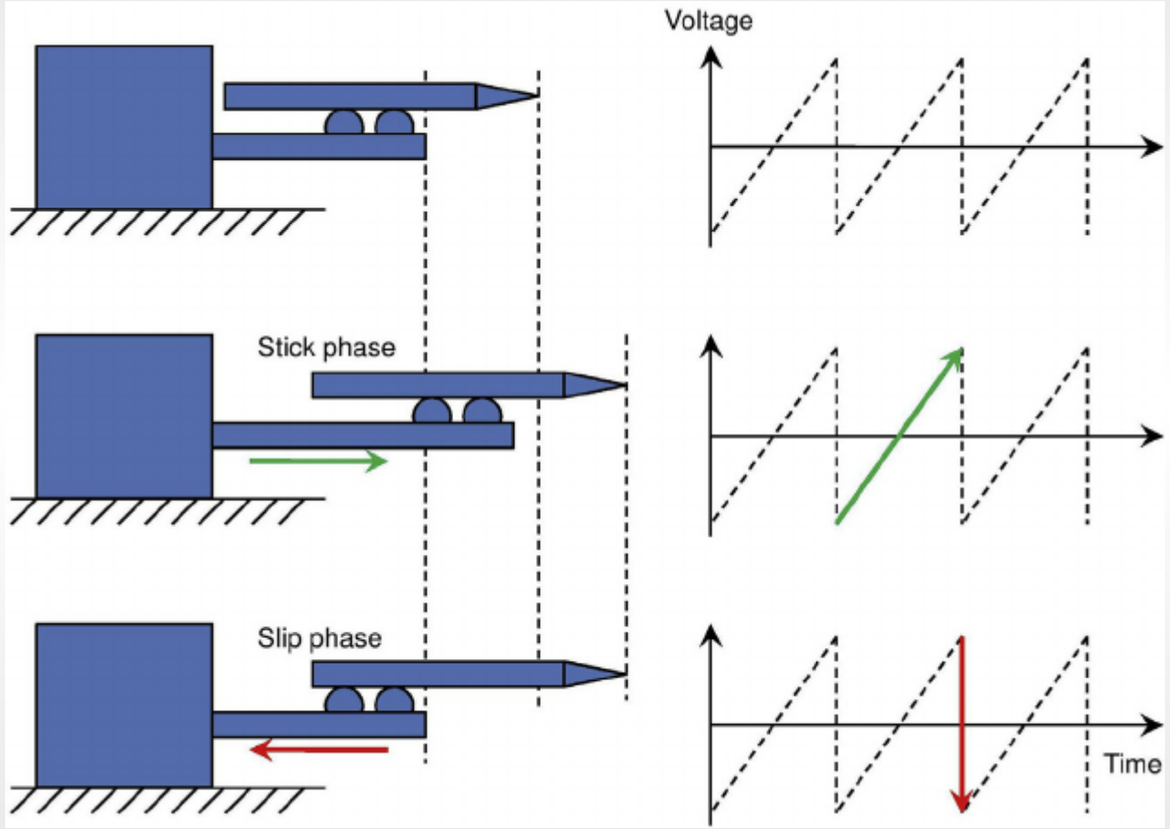


s1 - distant spacecraft signal
ε1 – test mass signal
τ1 – reference signal

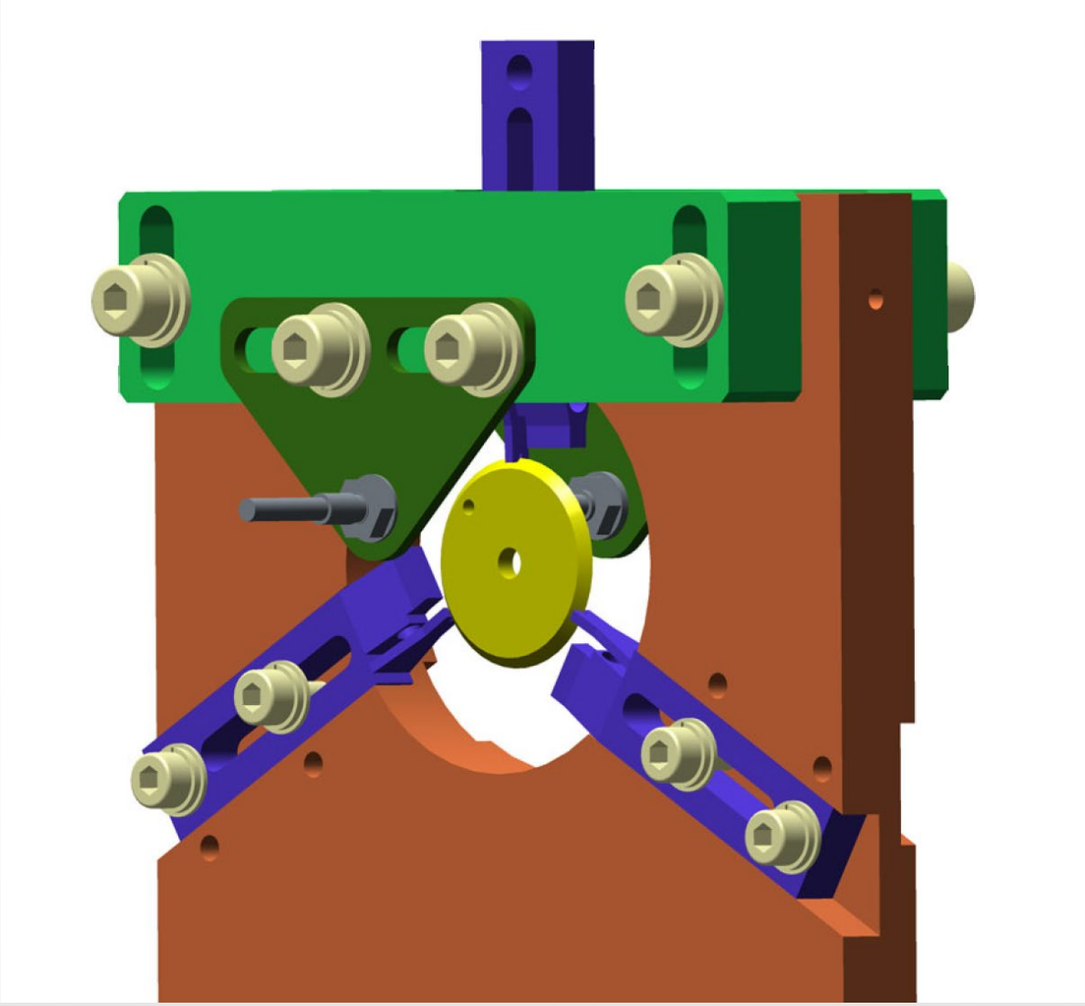
Czech contribution

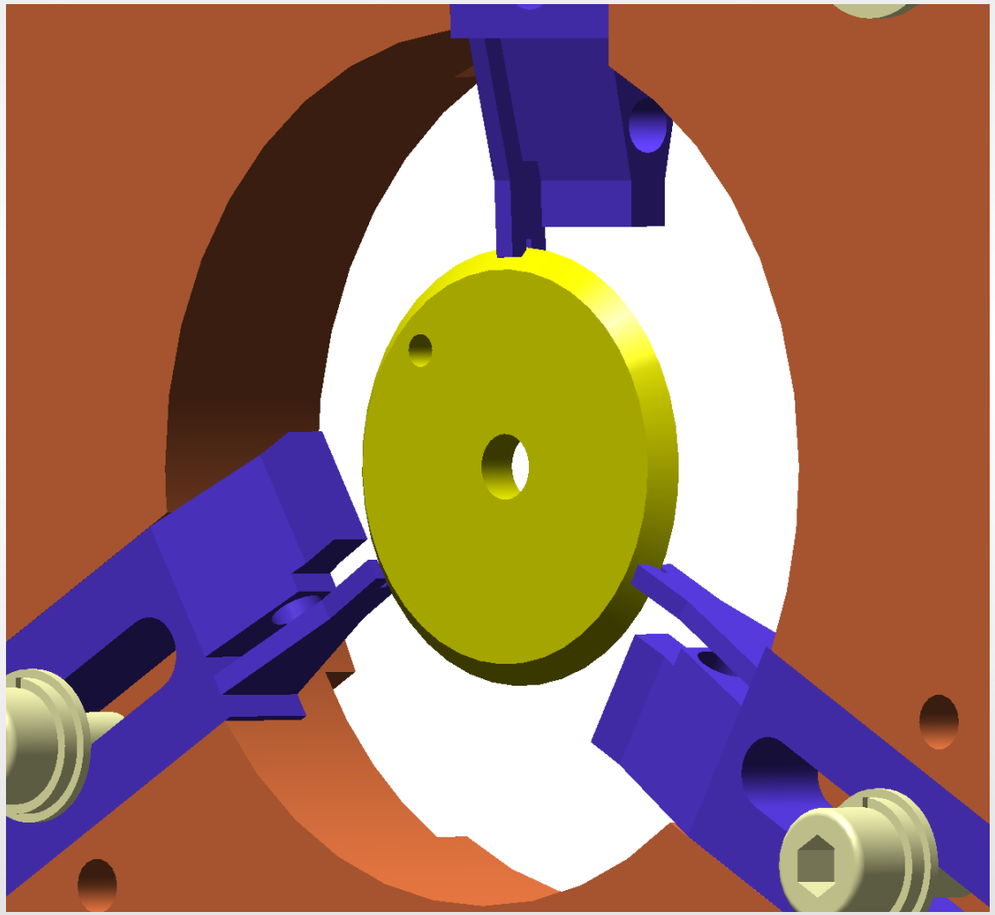
- Responsible for developing, testing and manufacturing a mechanism for switching between the two laser beams on each spacecraft, the “Fibre Switch Unit Actuator“ FSUA.
- The physics Institute, CAS
- The Institute of Atmospheric Physics, CAS
- The Institute of Thermomechanics, CAS
- The Astronomical Institute, CAS
- number of Czech companies
- 400 000 EUR from the contribution of the Ministry of Education, Youth and Sports to the ESA PRODEX programme.
- The total cost of the Czech participation is expected to reach 5.3 million EUR.

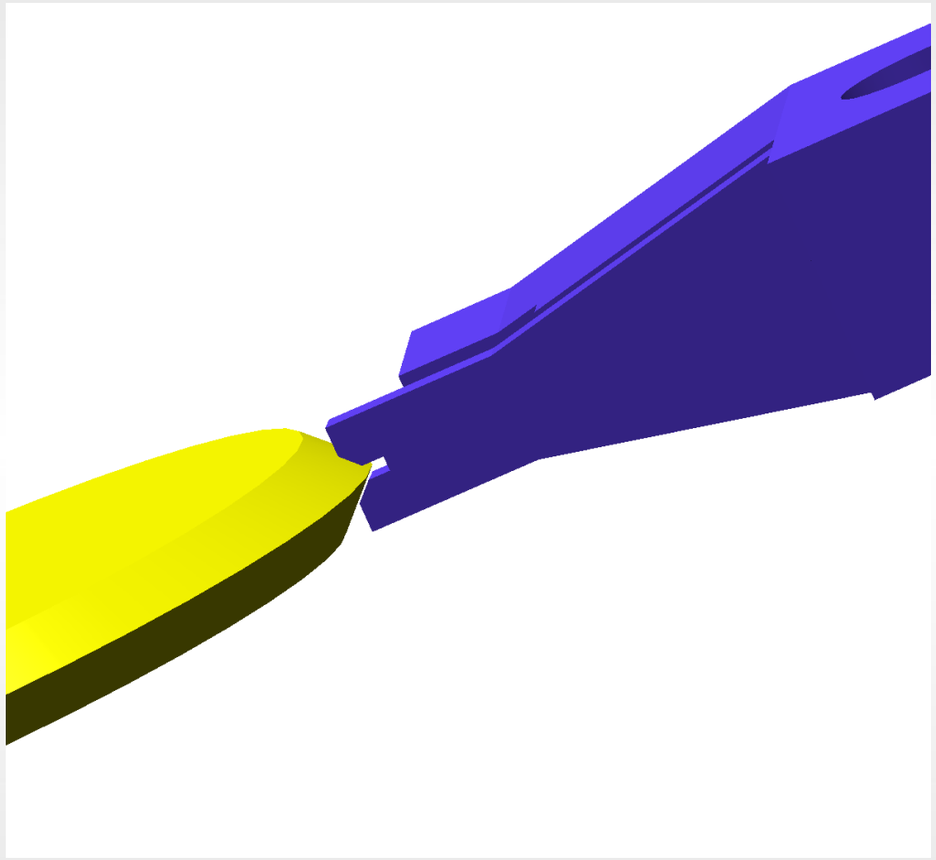
Slip-Stick piezo drive

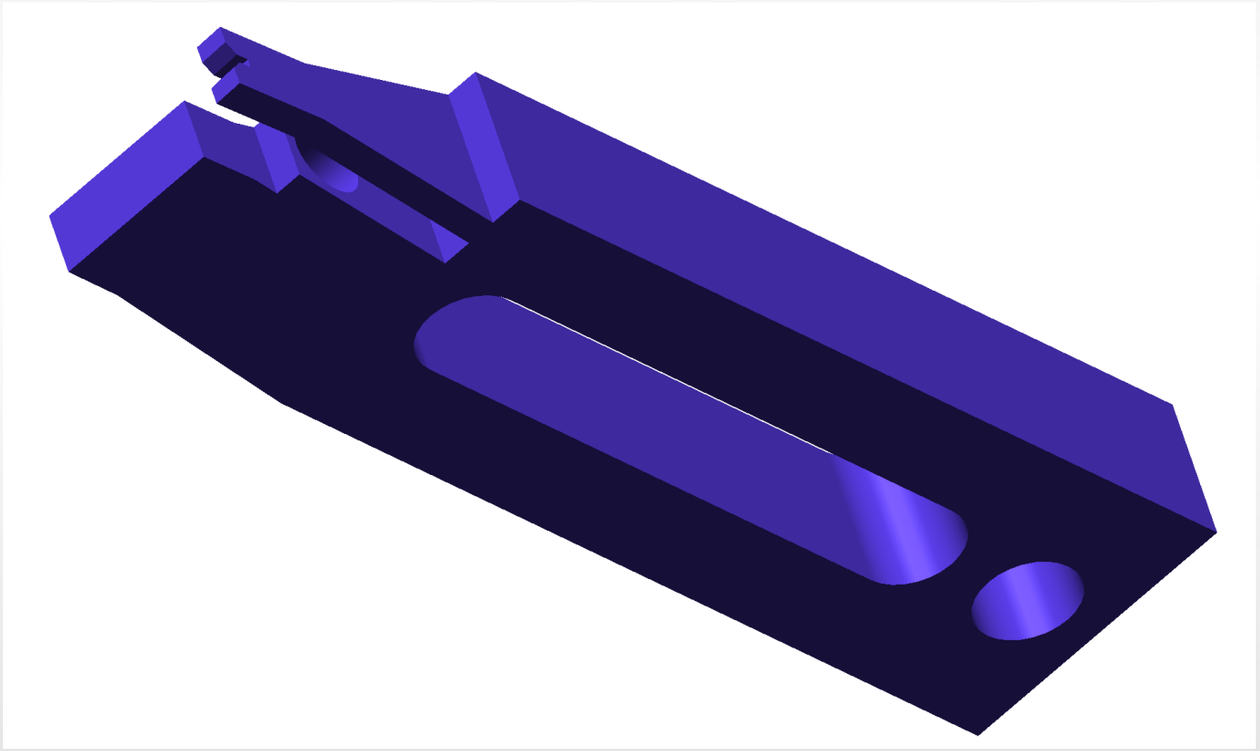


Test Stand

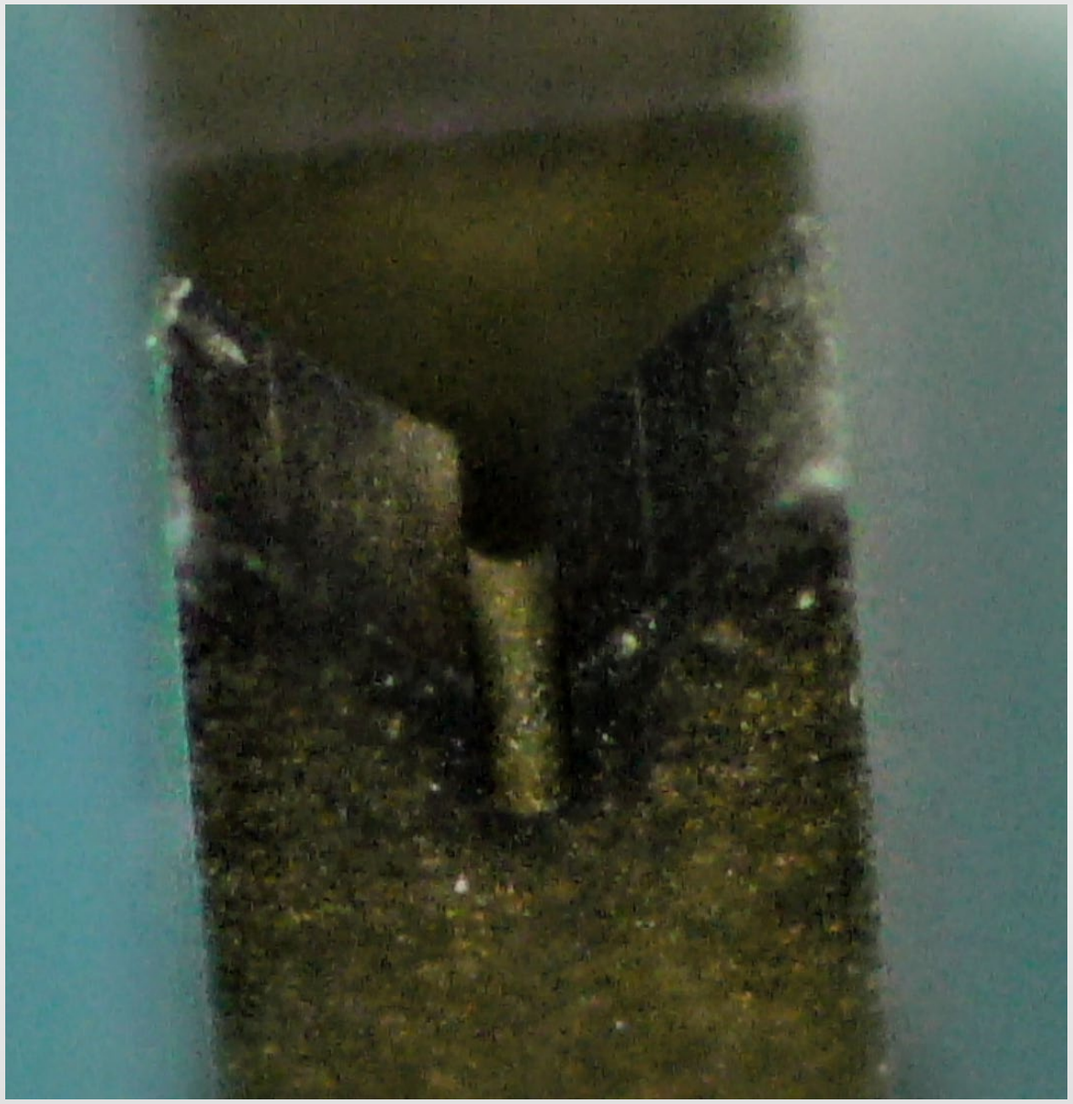


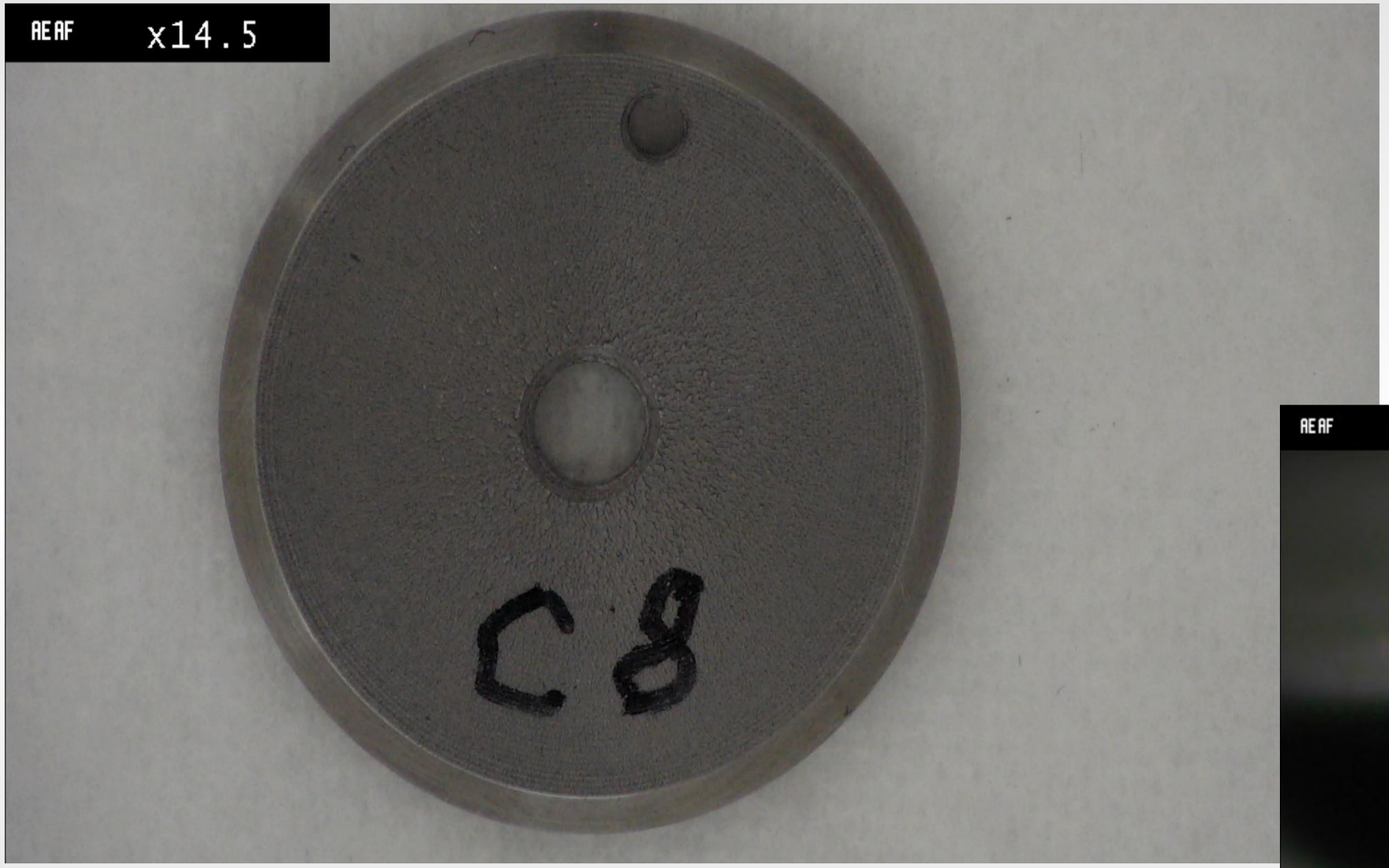


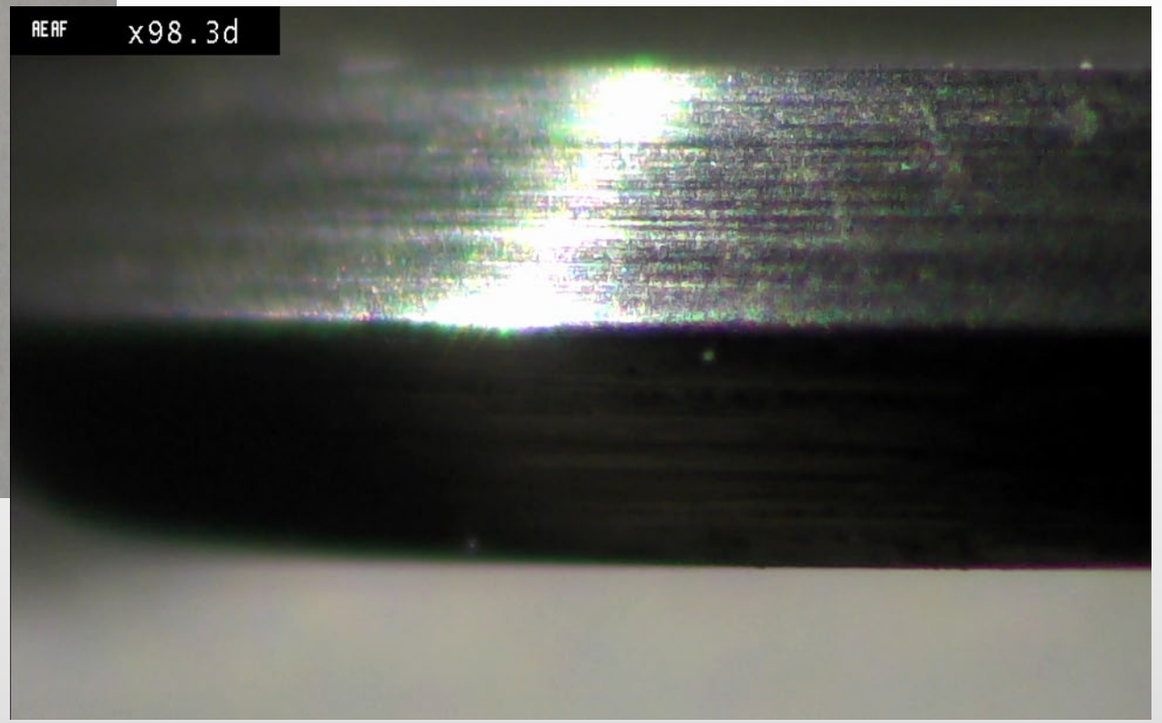




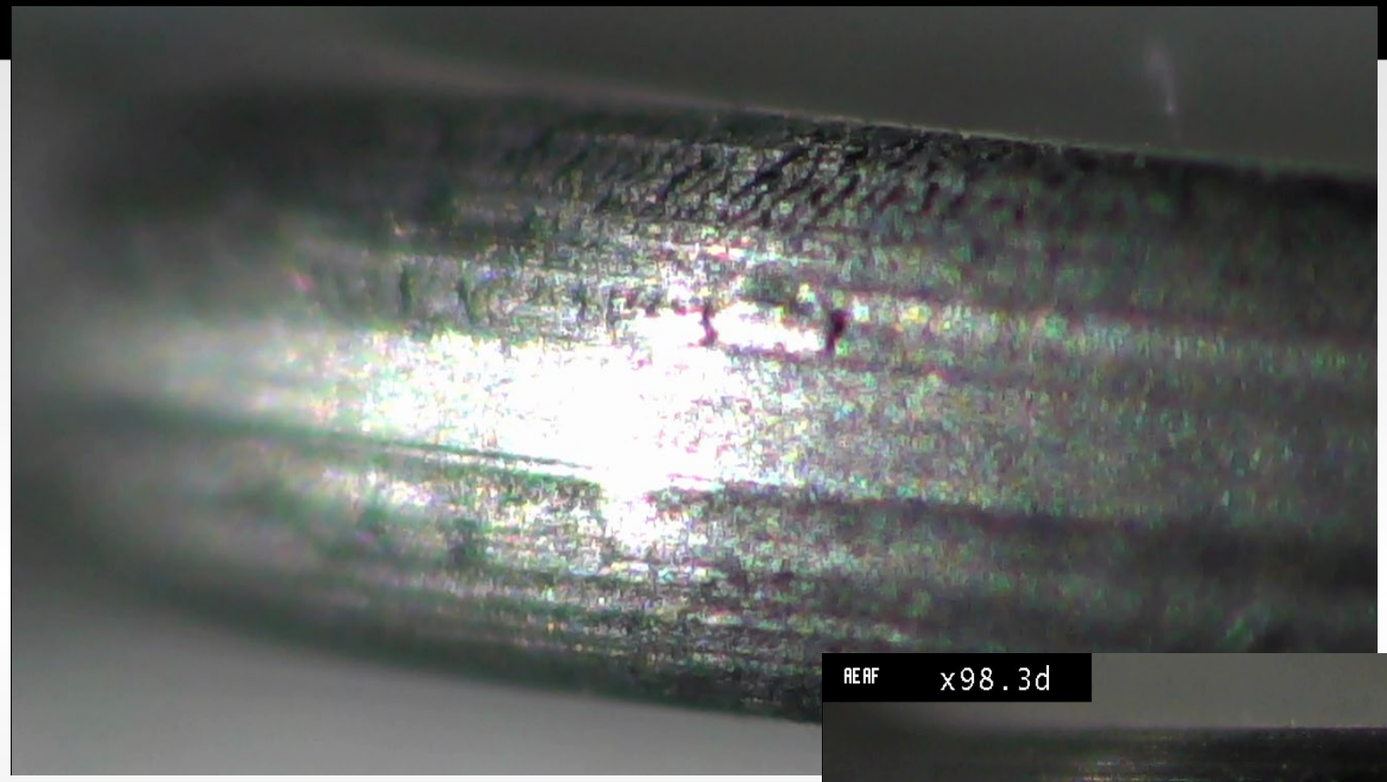

#F01
HF07
HF06
HF05
HF04

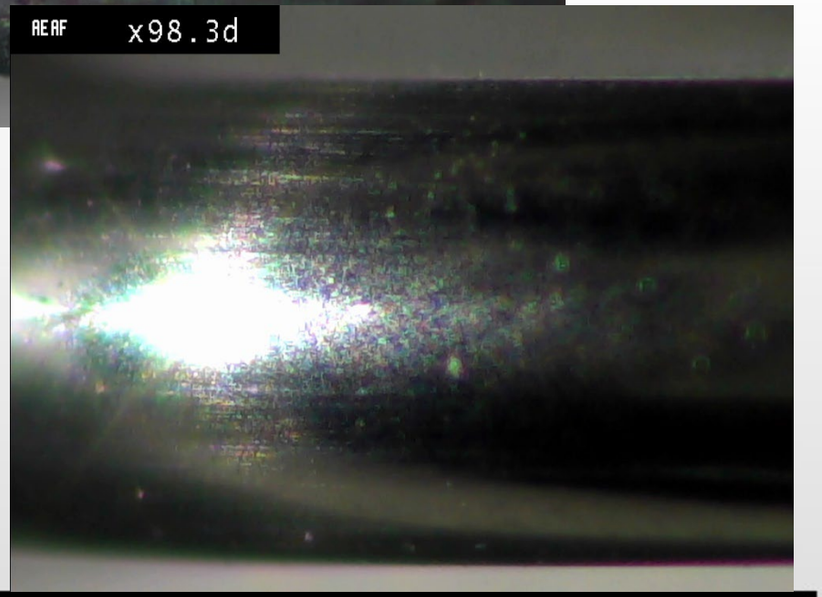



AE AF
x14.5
C8

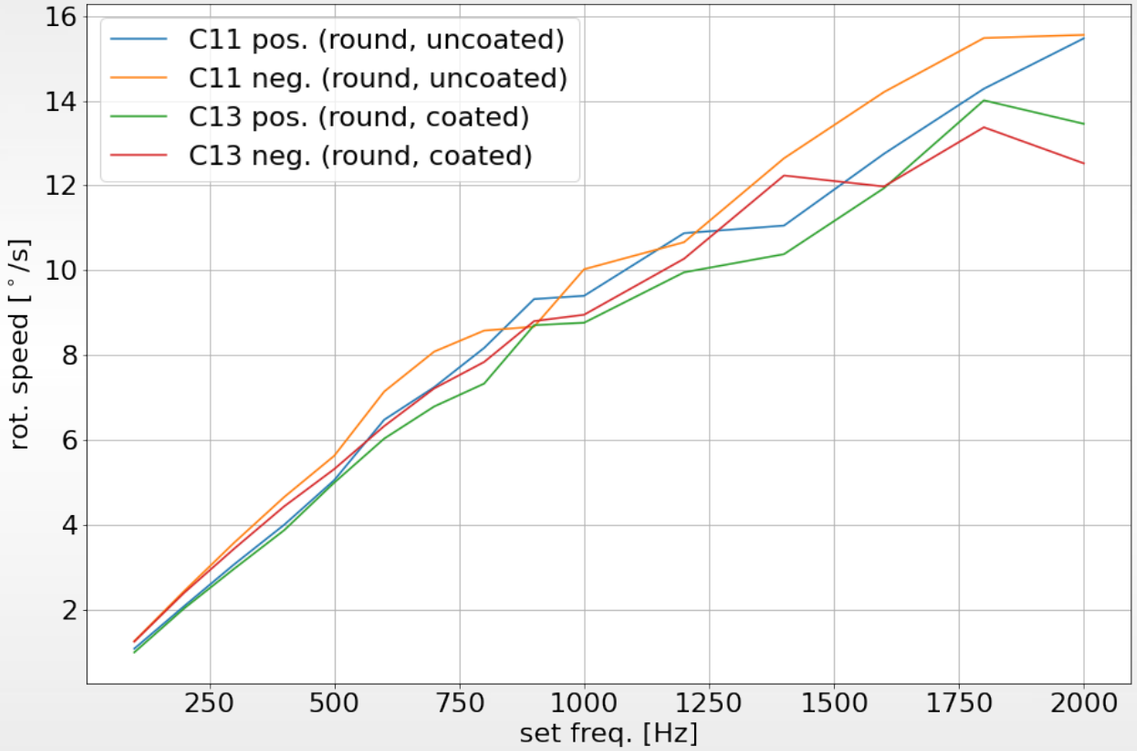

AE AF
x98.3d


C11



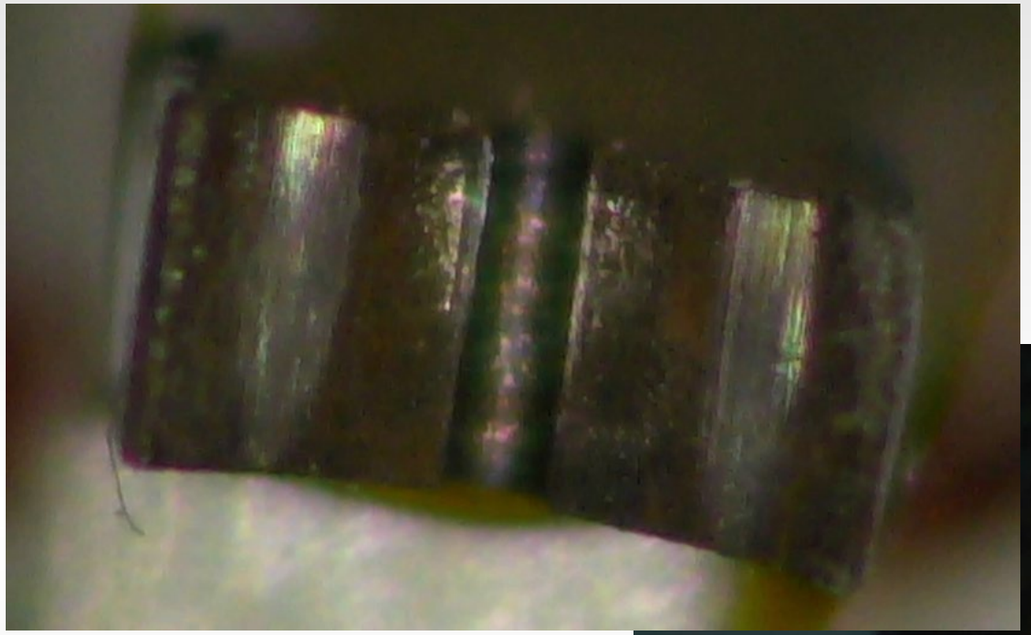

AE AF
x98.3d

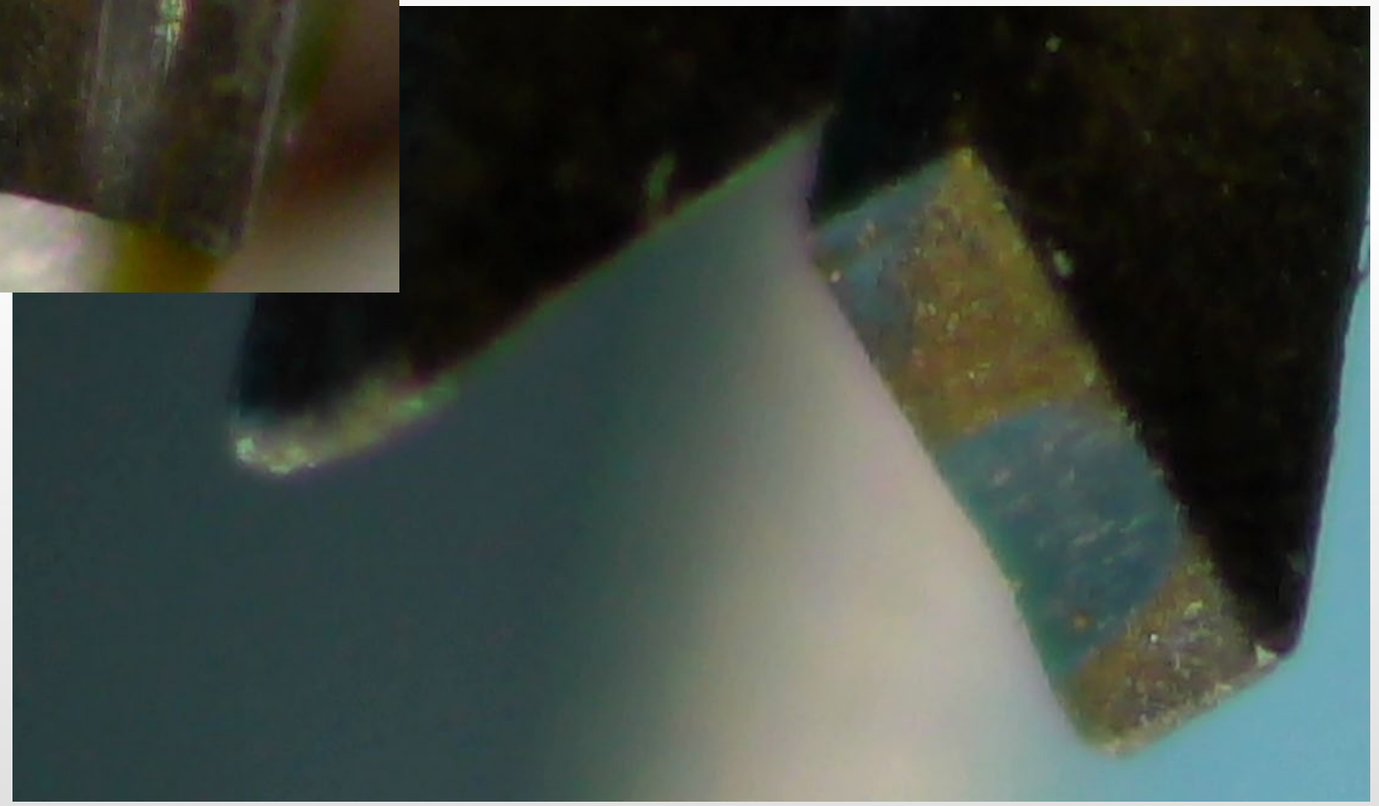
Rotation speed in air



- Consistent results in both directions
- Coatings do not have significant impact

Damage after 6700 rotations

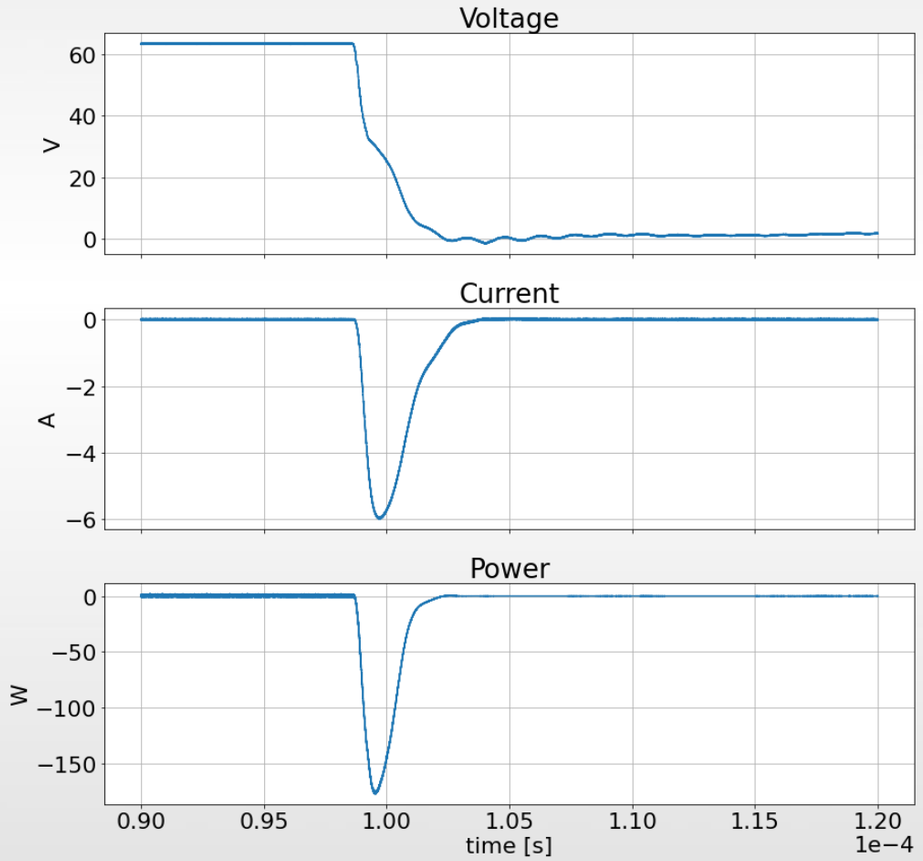




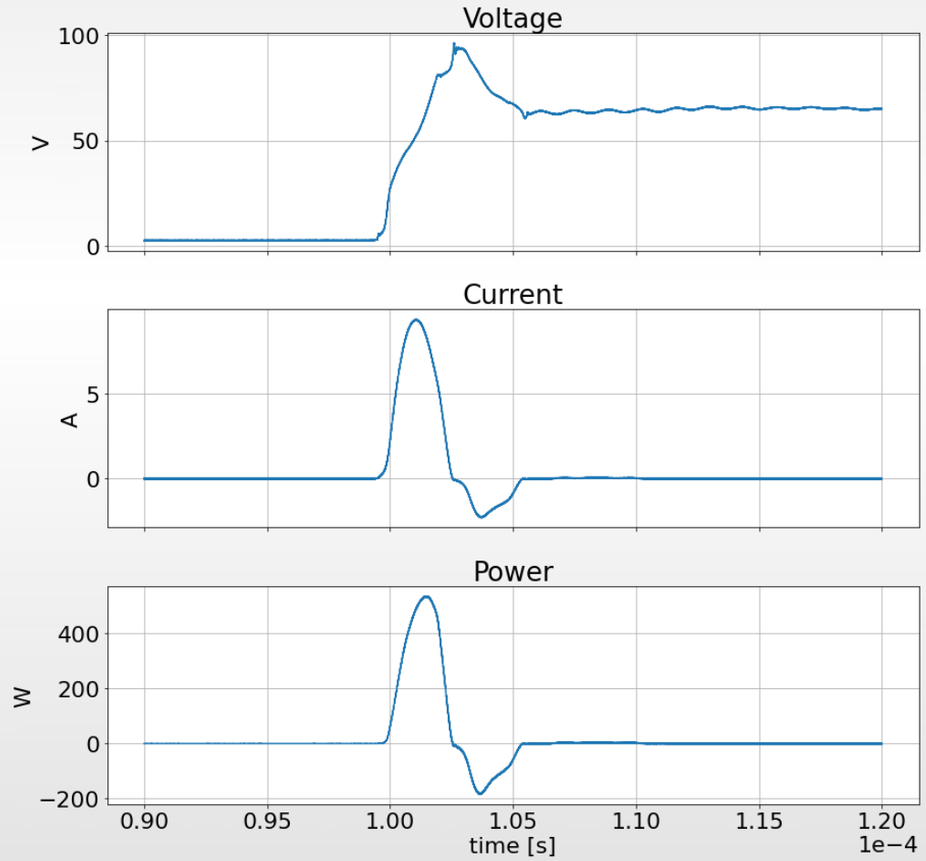
- Too high contact stress for the materials
- Too low force holding the rotor
- → We need to change the design concept

Power consumption measurements

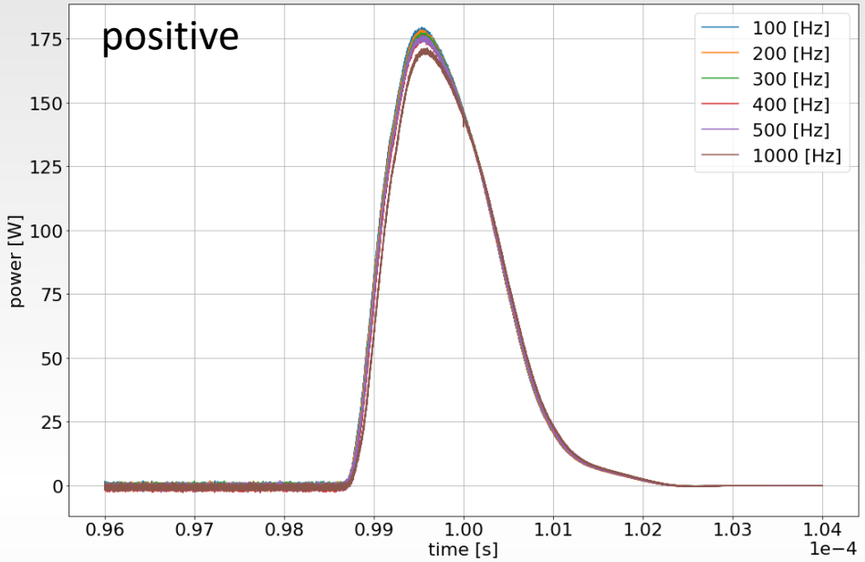
Freq set(meas) [Hz] = 300(282.00), Ampl set(meas) [V] = 54(61.57)

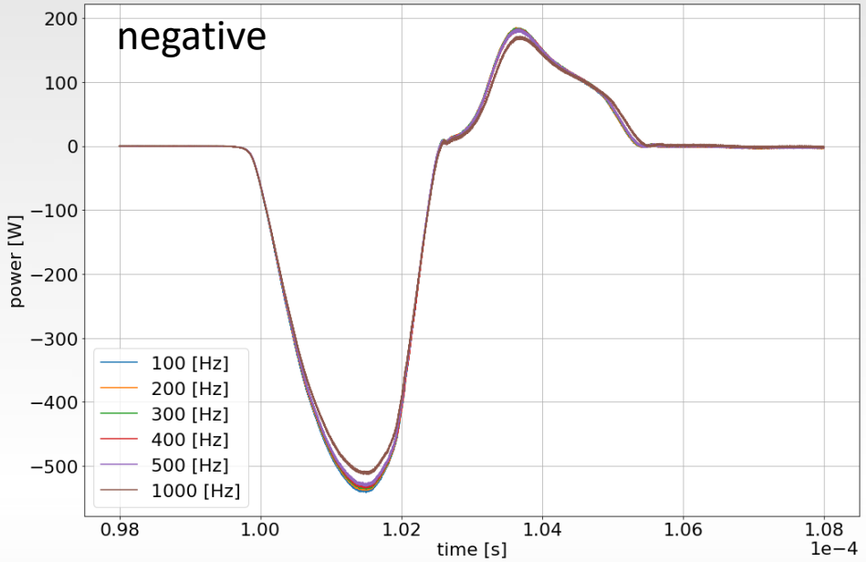


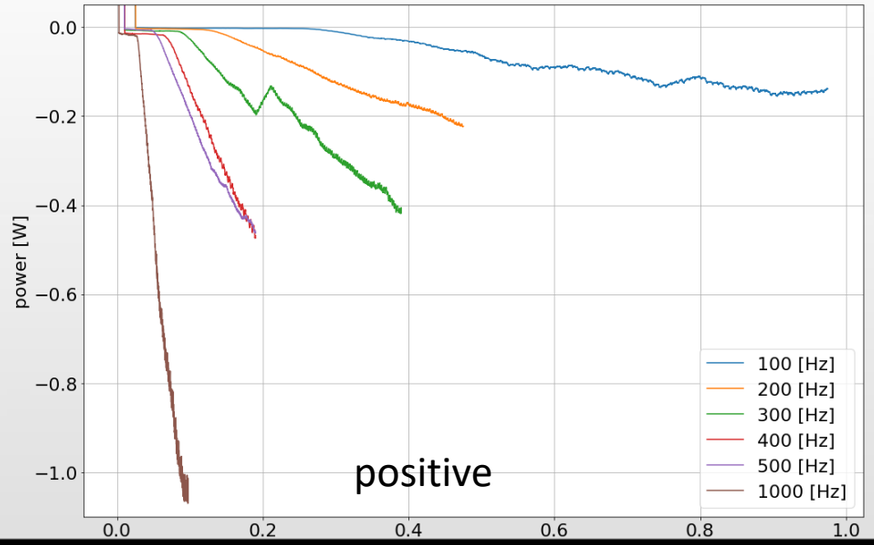
Freq set(meas) [Hz] = 300(282.71), Ampl set(meas) [V] = 54(62.24)

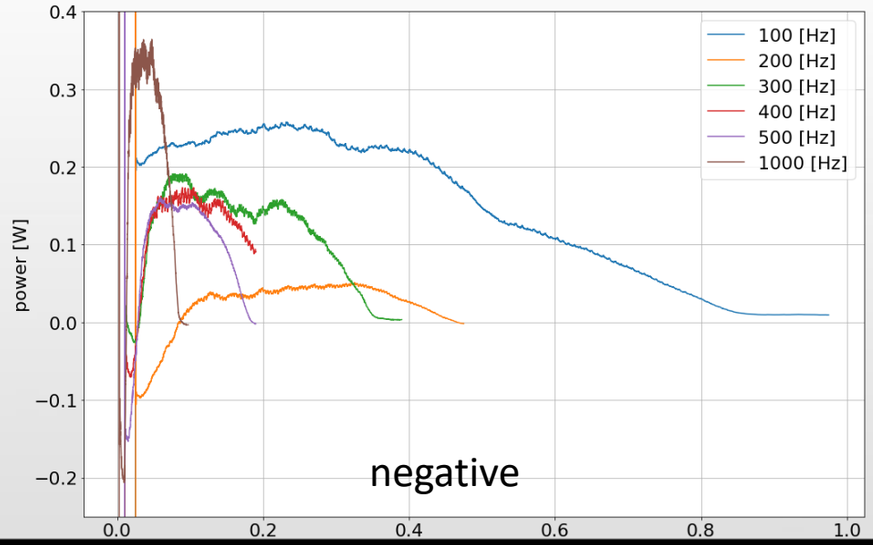


Frequency dependence

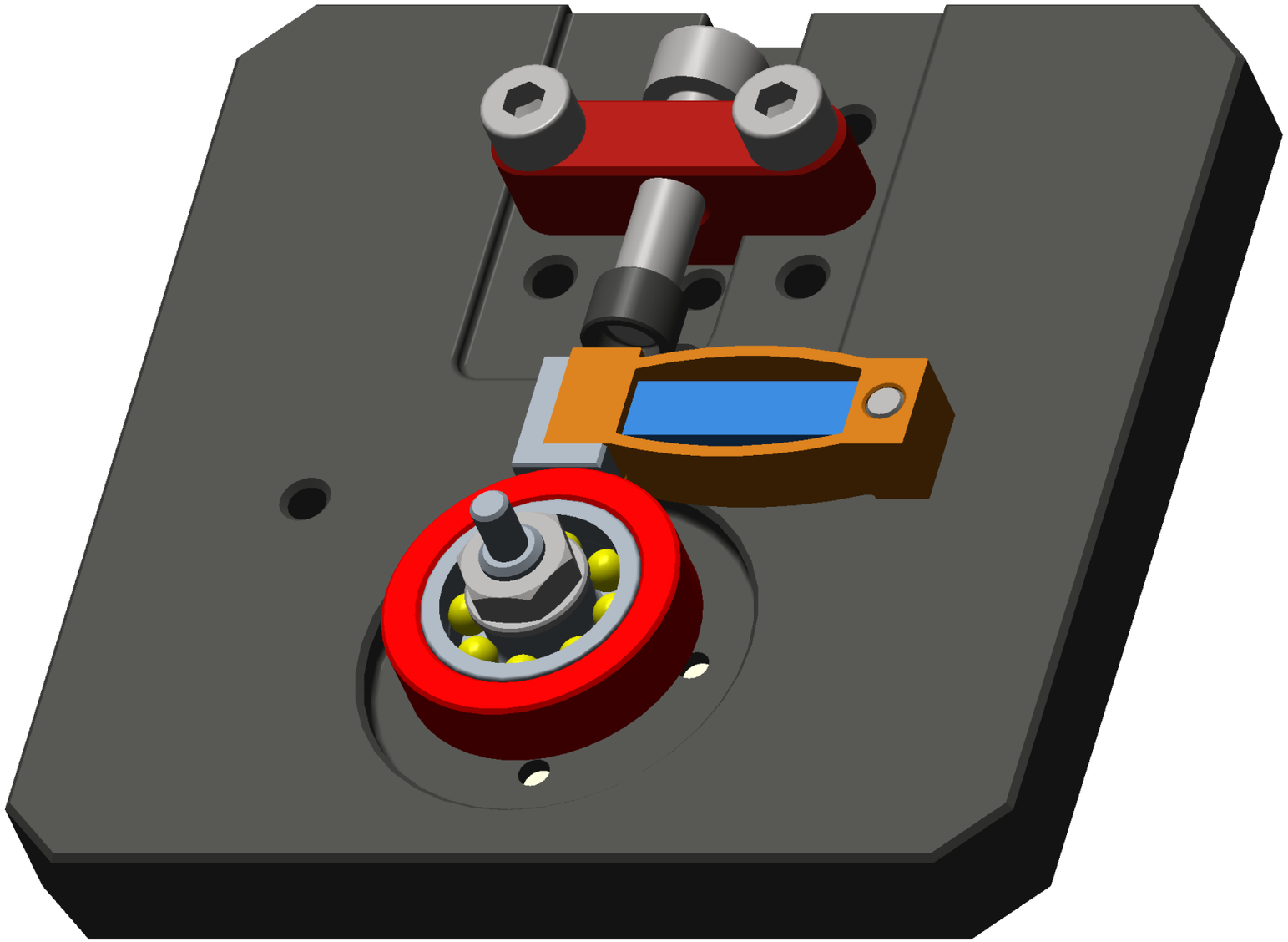






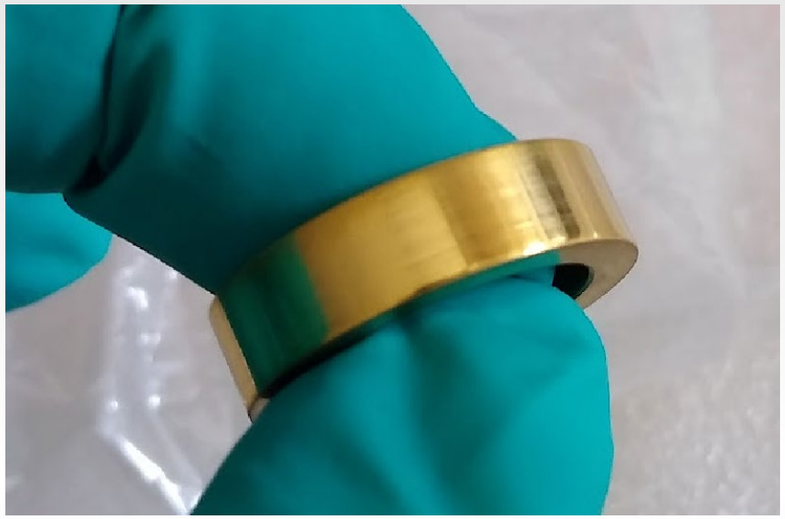


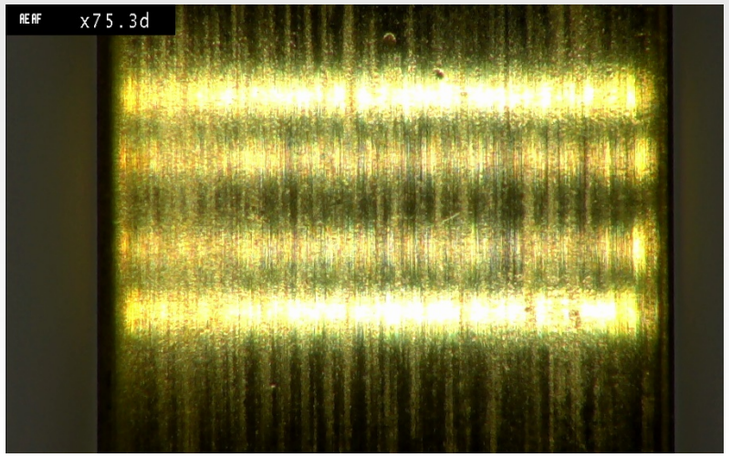
IT test stand

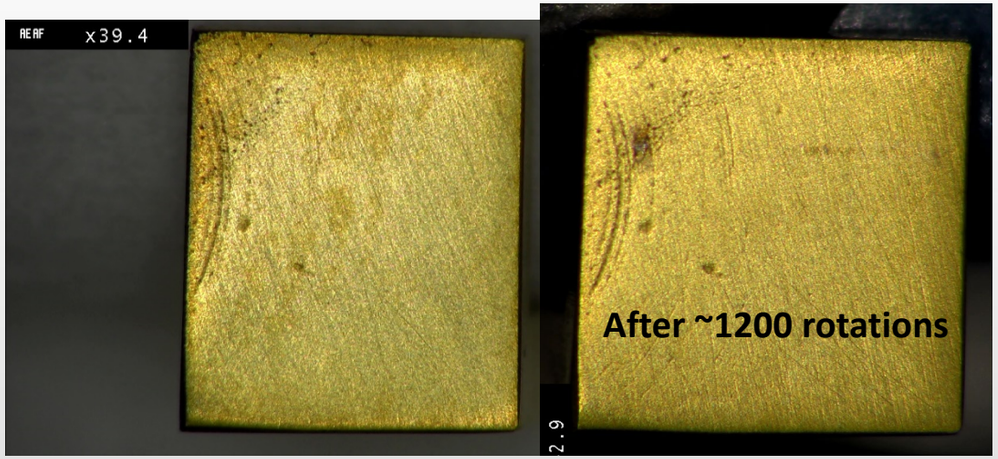


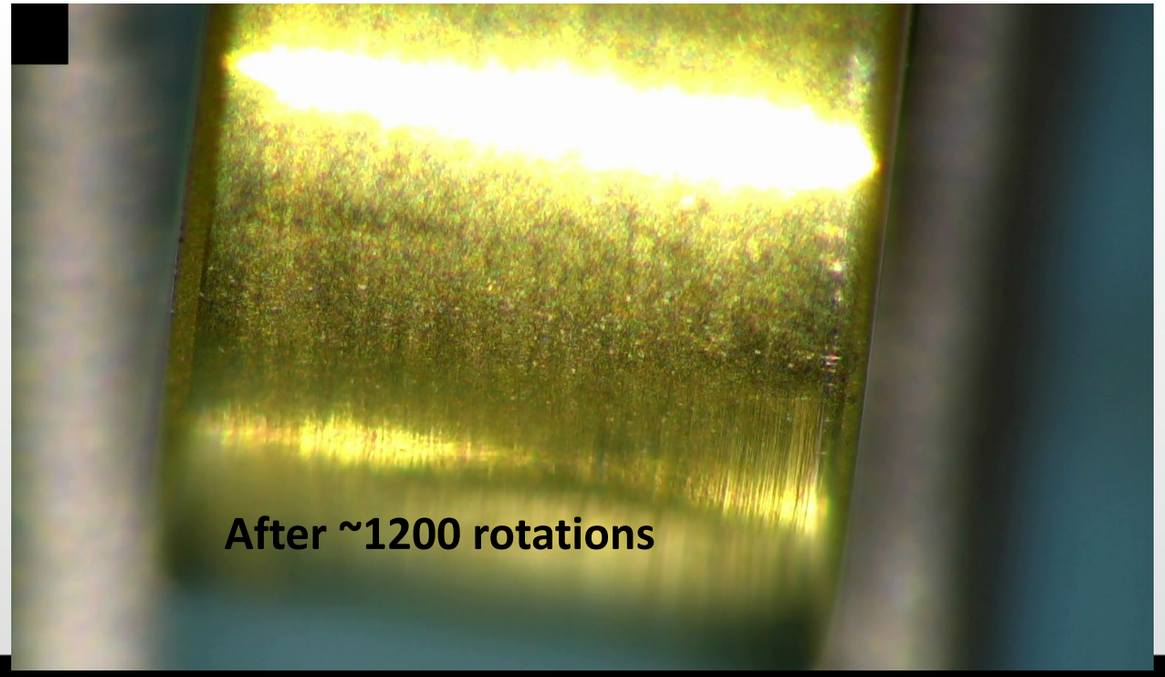
- Different configuration
- Lower contact stress

- Testing different combinations of surfaces

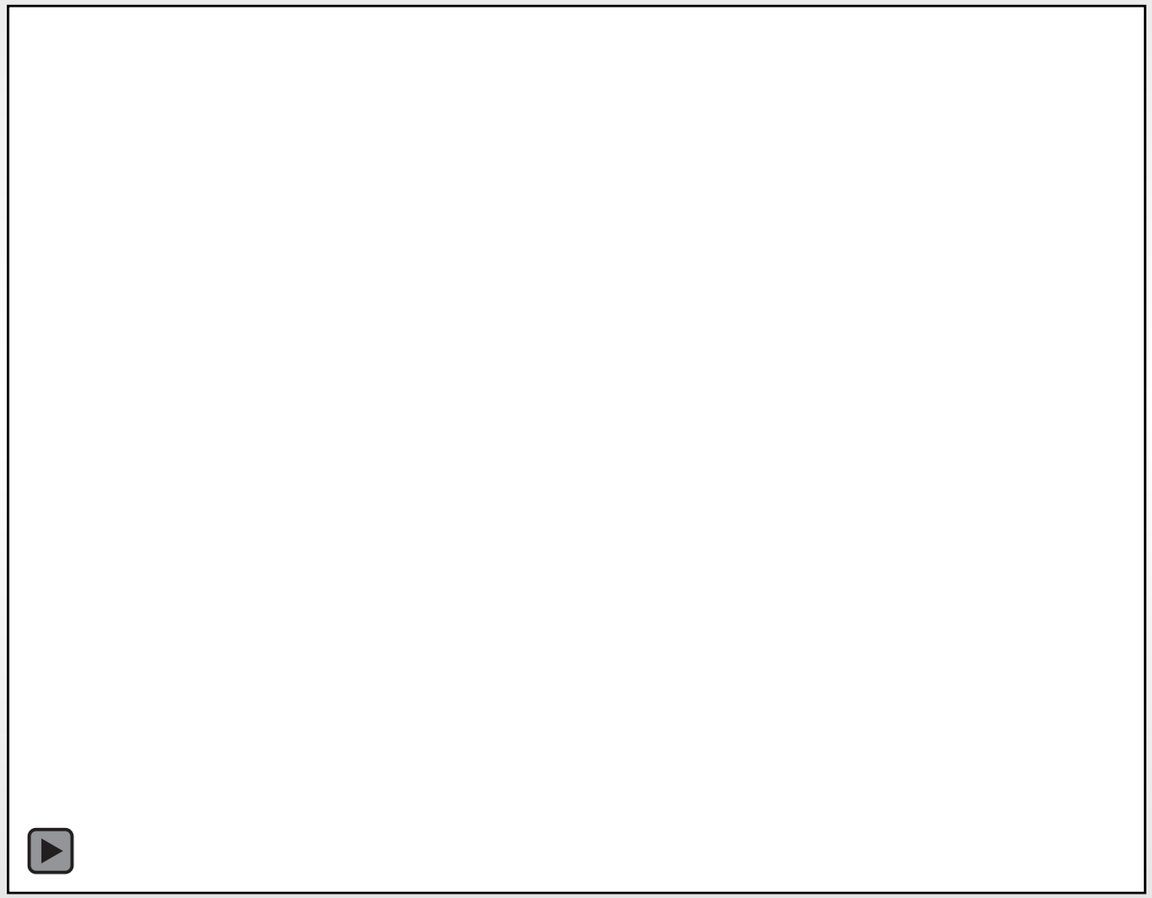



REAF
x75.3d


REAF
x39.4
After ~1200 rotations


After ~1200 rotations

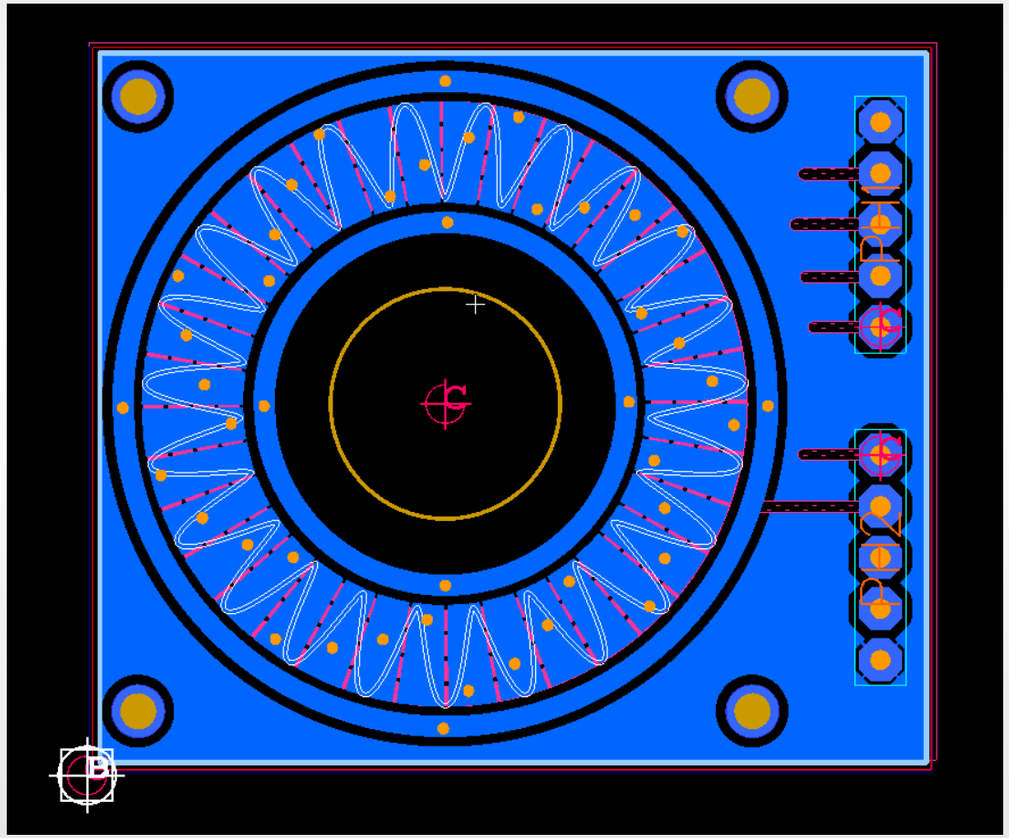
Cold welding



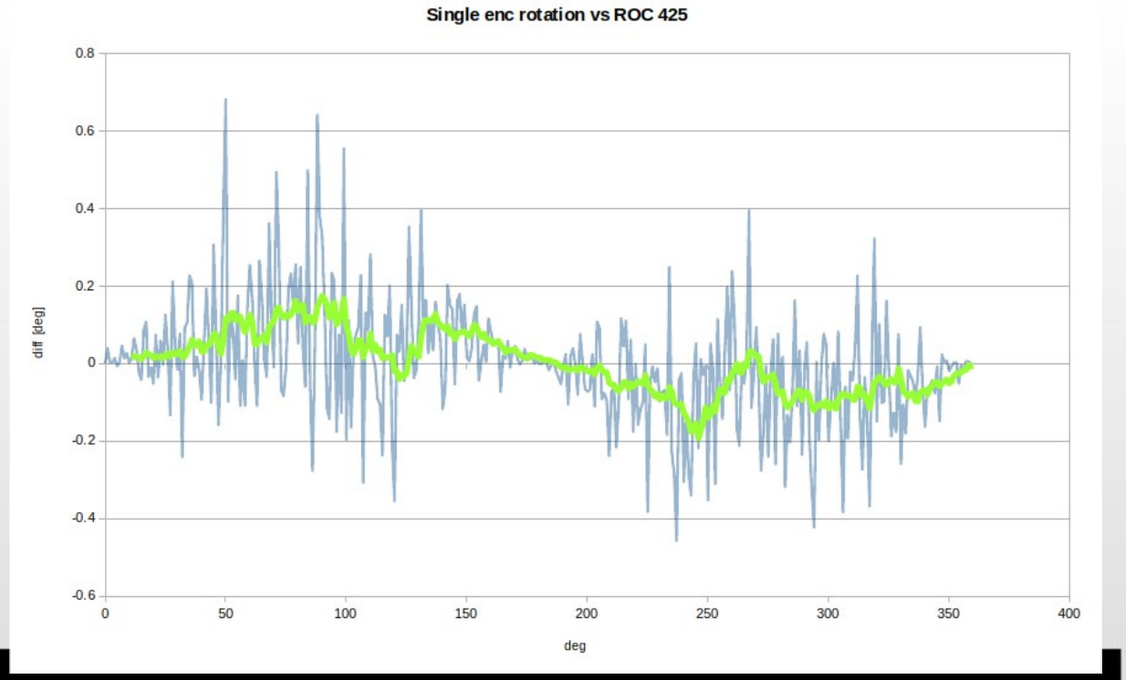
- Parts made of the same metal
- Very flat
- Vacuum
- No movement for a long time

- Prevention: coating with different materials
- Advantage: Tribology layer

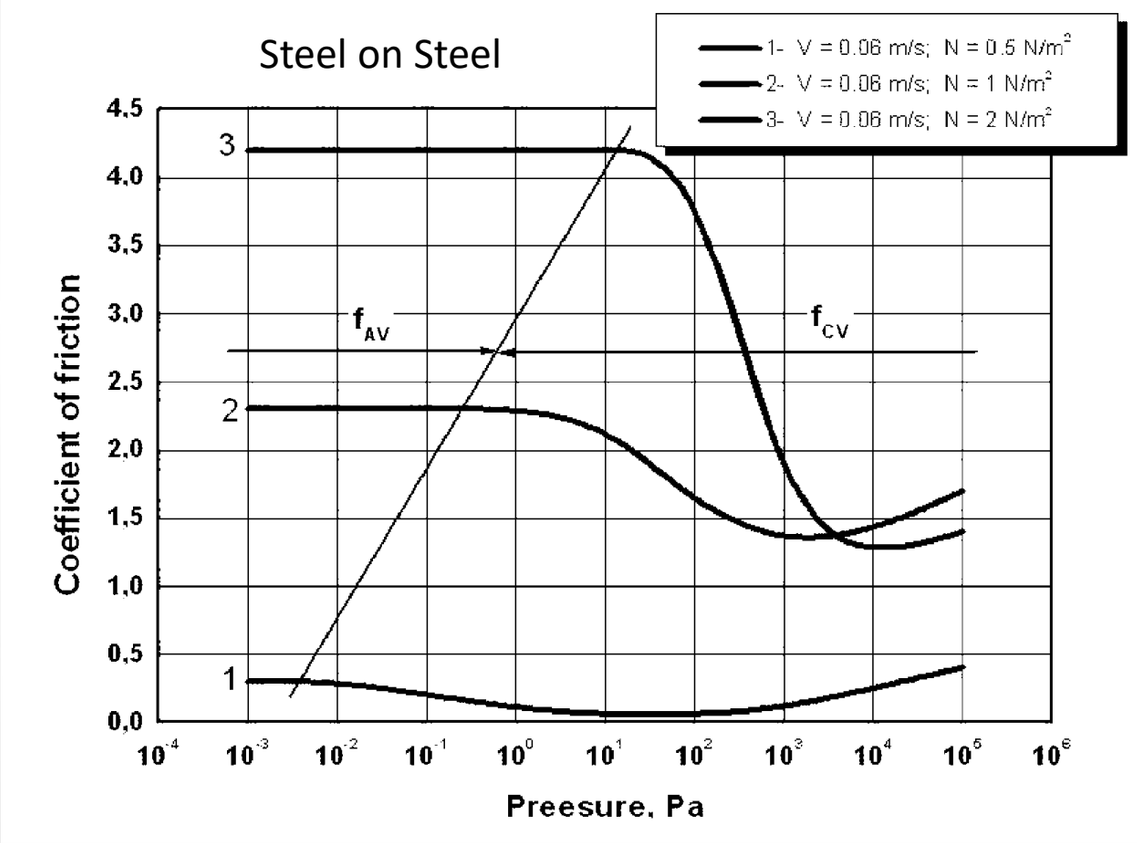
Position encoder - Institute of Atmospheric Physics



- High precision
- Absolute position
- Strict spatial limitations
- Capacitive sensing



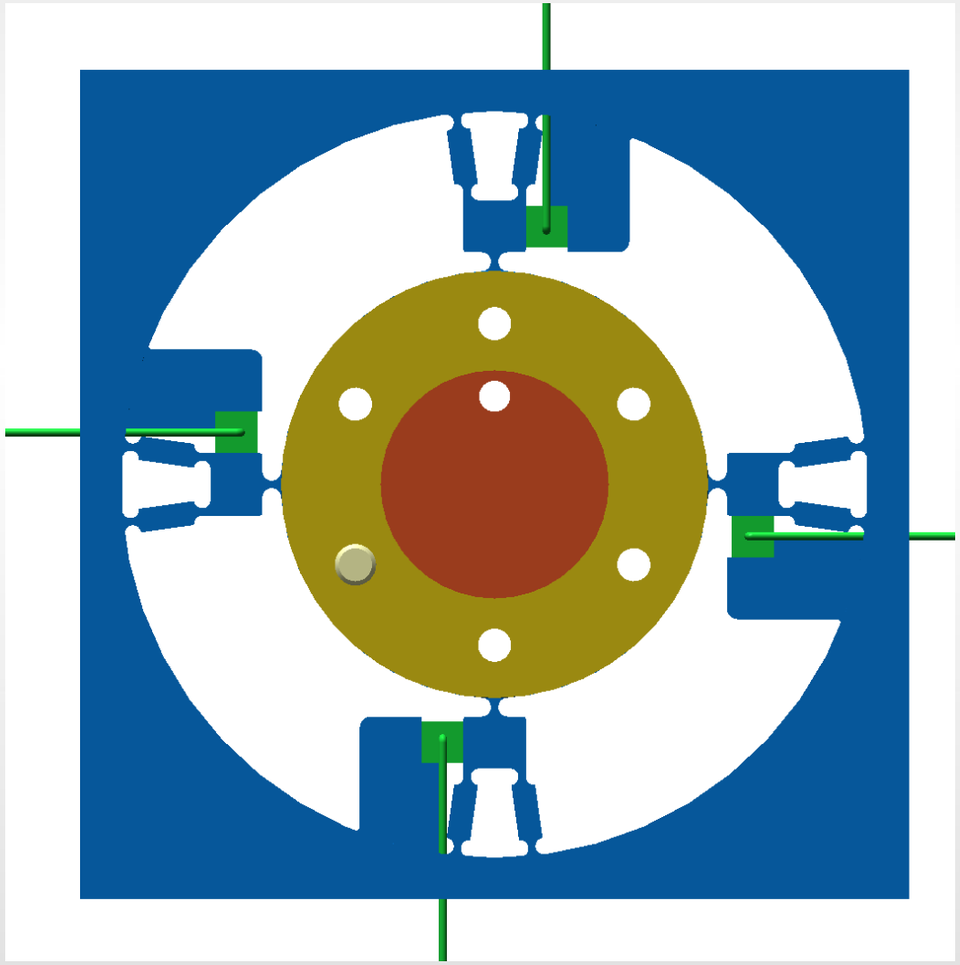
Testing in vacuum

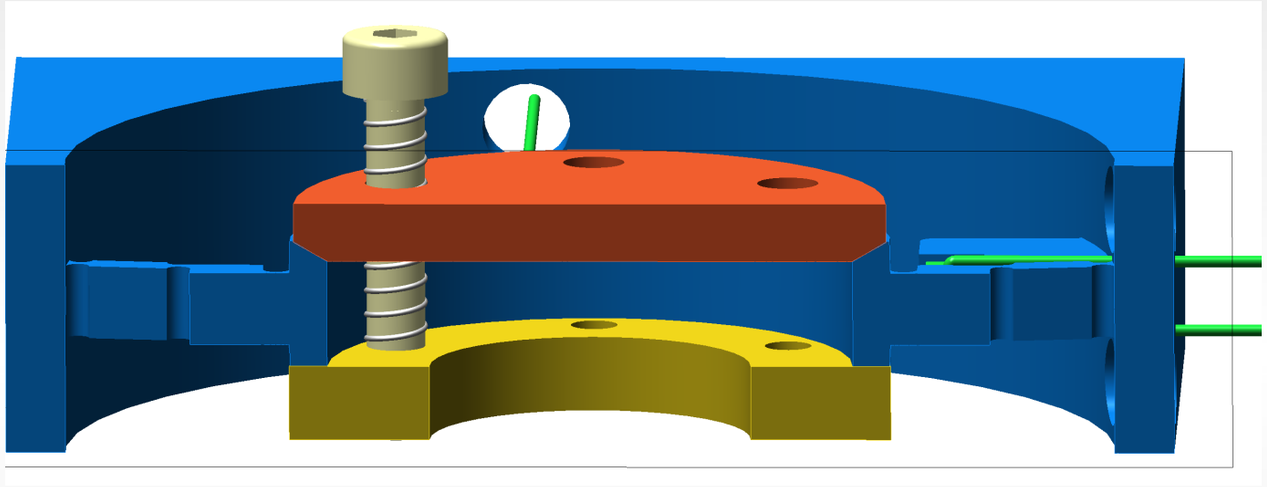


- Moving our test stands to vacuum
- Friction changes
- Heat dissipation changes
- Crucial set of tests

Outlook - instead of conclusions ;-)

Very preliminary – next design iteration





+ Larger contact surfaces
- Heavier
+-? Cold welding