



Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Federal Institute of Metrology METAS

maxon motor
driven by precision



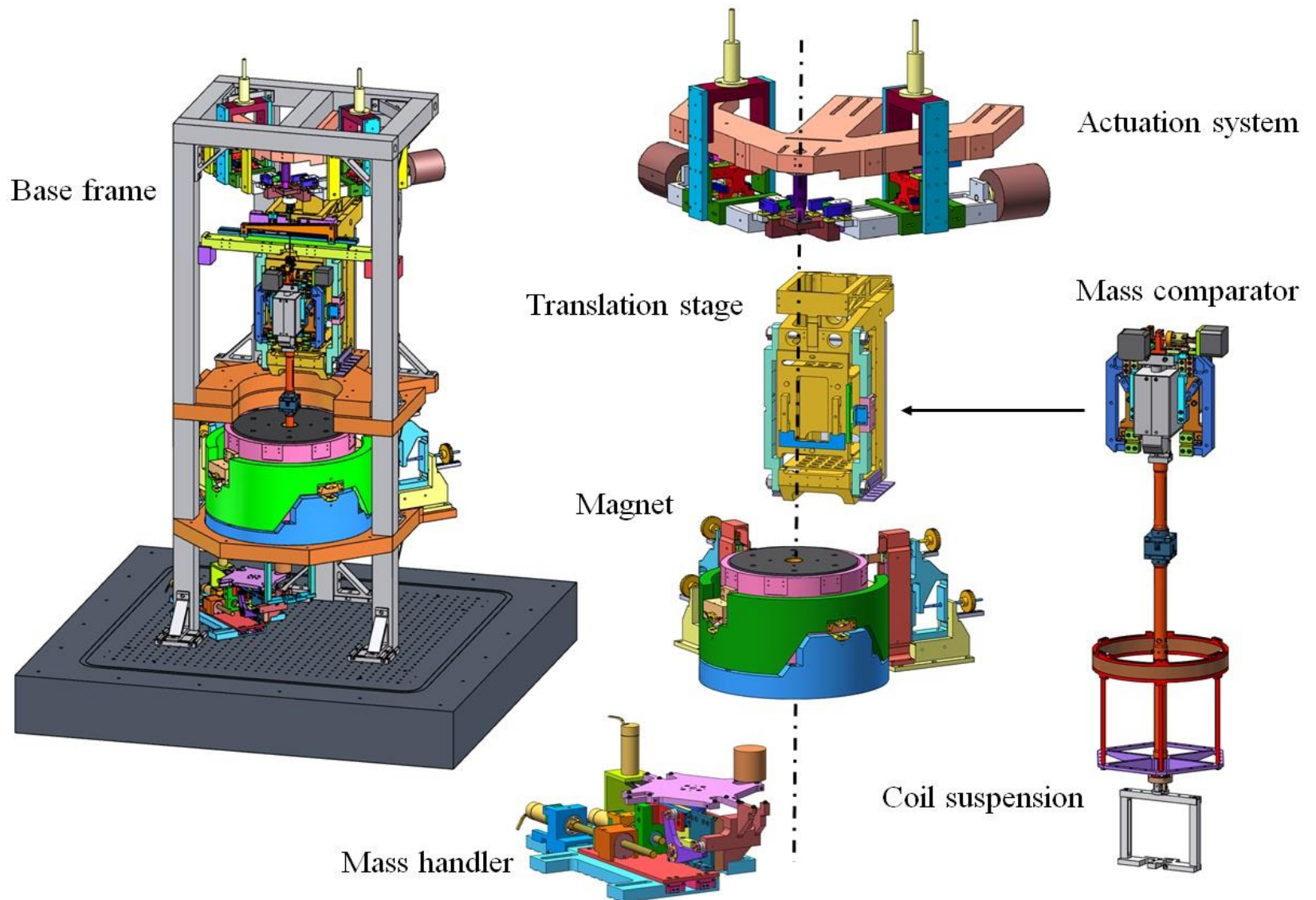
The METAS watt balance Mark II: Progress Report

Ali L. Eichenberger

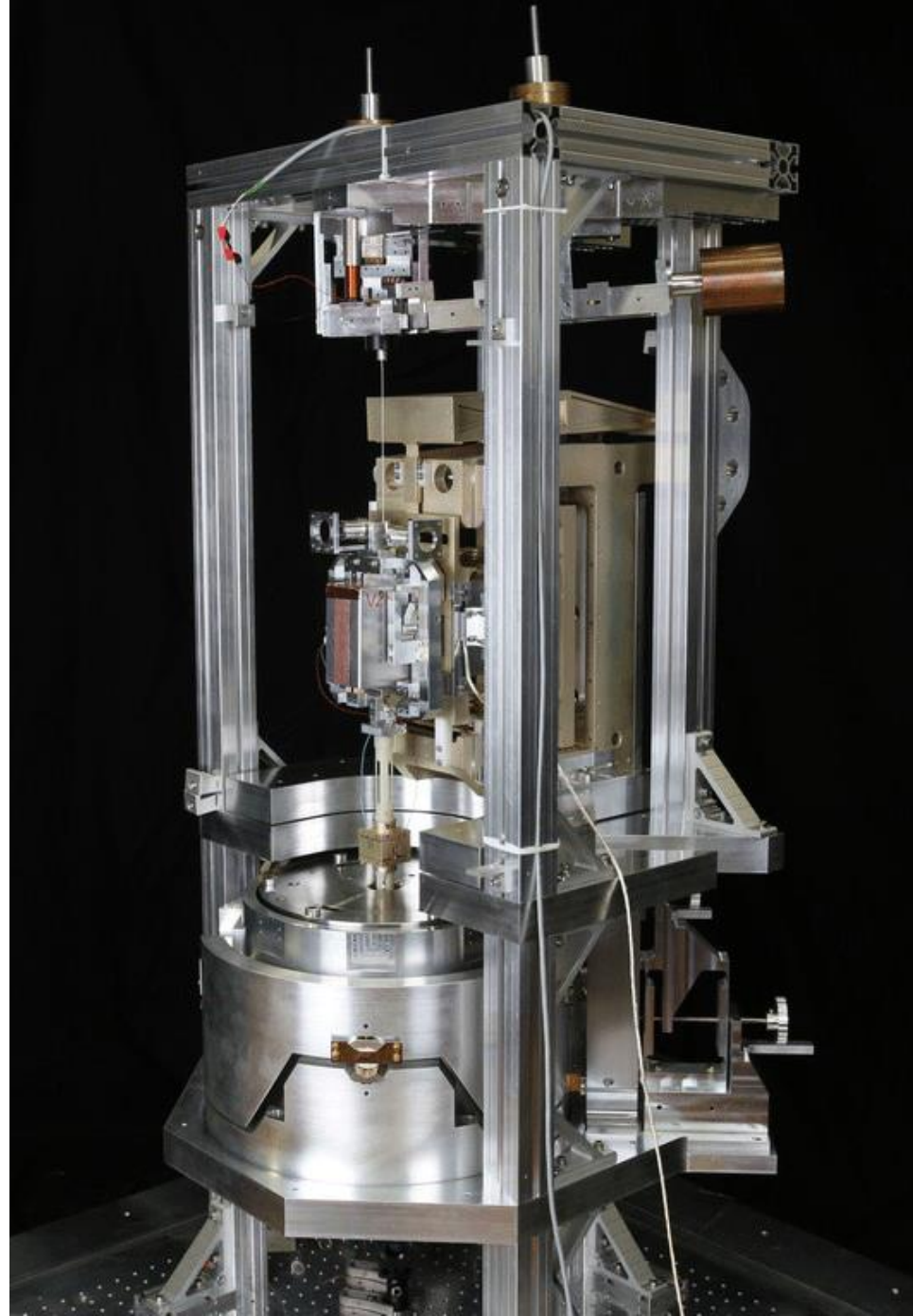
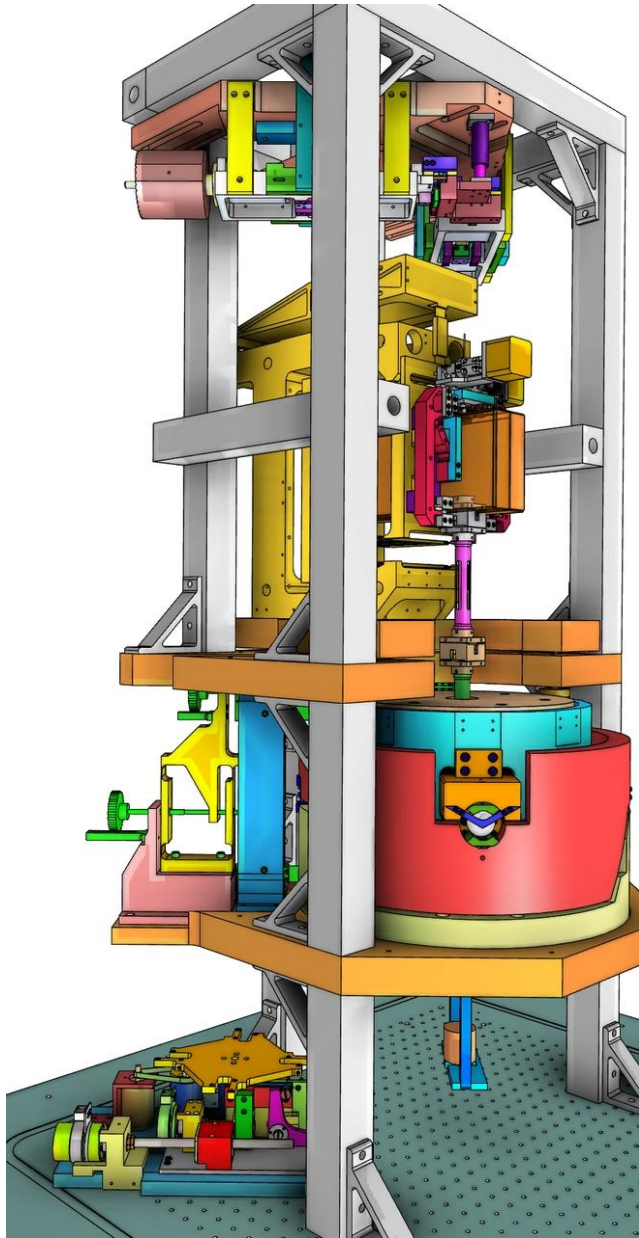
Outline

- Short reminder
 - Magnet - coil assembly
- Dynamic phase
 - Laser interferometer
 - Field profile
- Static phase
 - Load cell
 - Stopper
 - Mass exchanger
- Next steps

BWM II Overview



Mechanical system



Magnet-Coil Assembly

- ♦ Magnetic gap

$H = 50 \text{ mm}$

$w = 8 \text{ mm}$

- ♦ Radial field

$B = 0.65 \text{ T}$

T_{dep} minimized

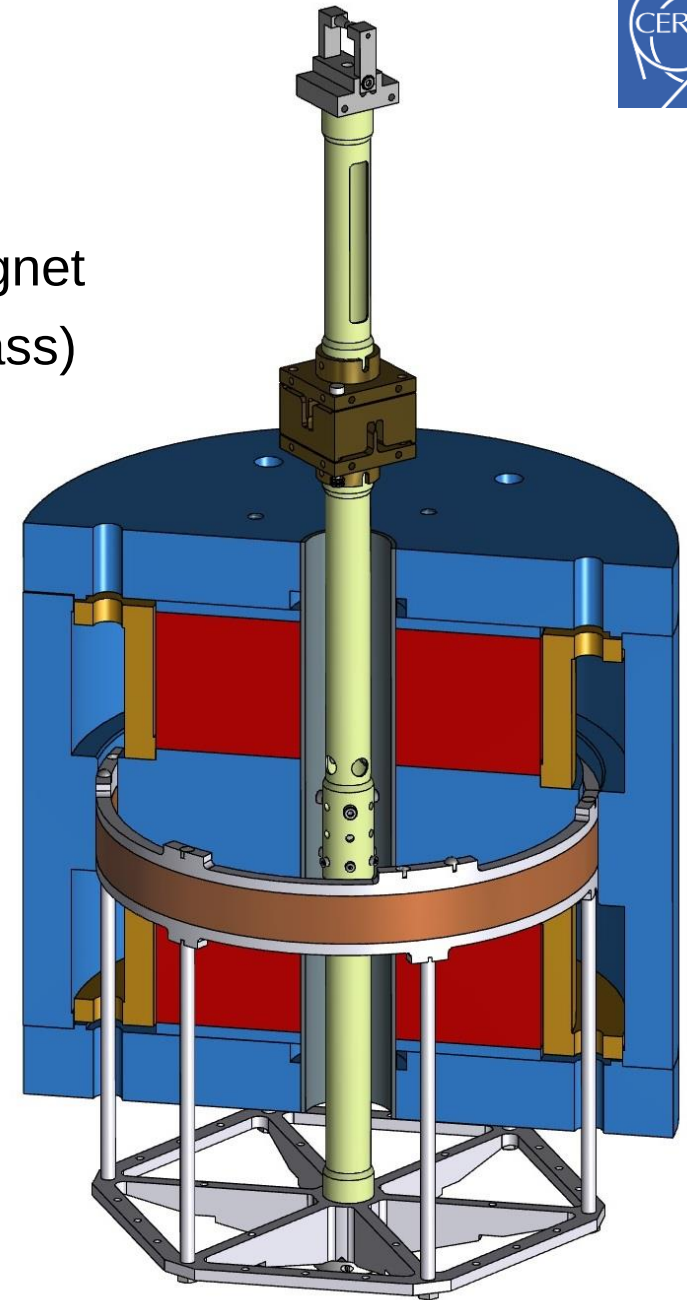
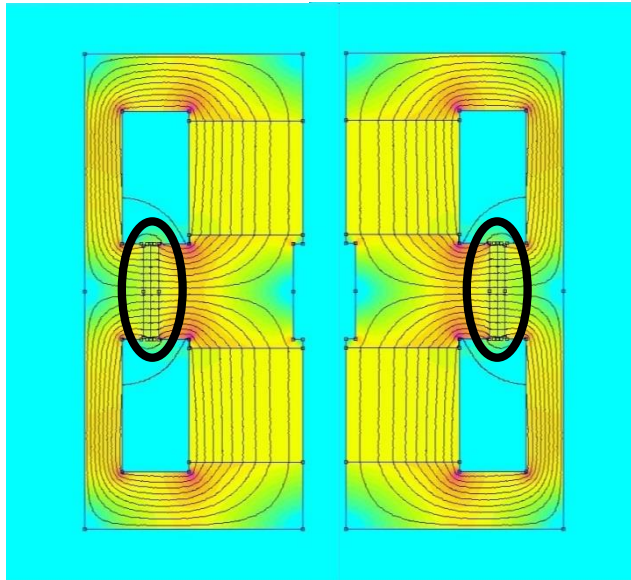
Permanent magnet

Center ring (brass)

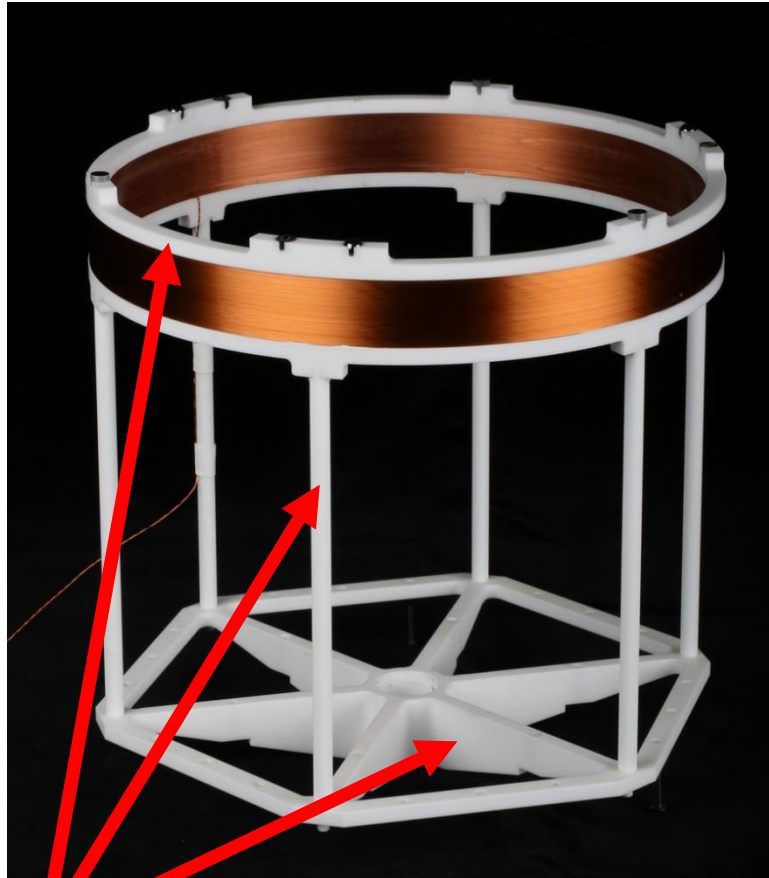
Yoke

Magnetic shunt

Coil



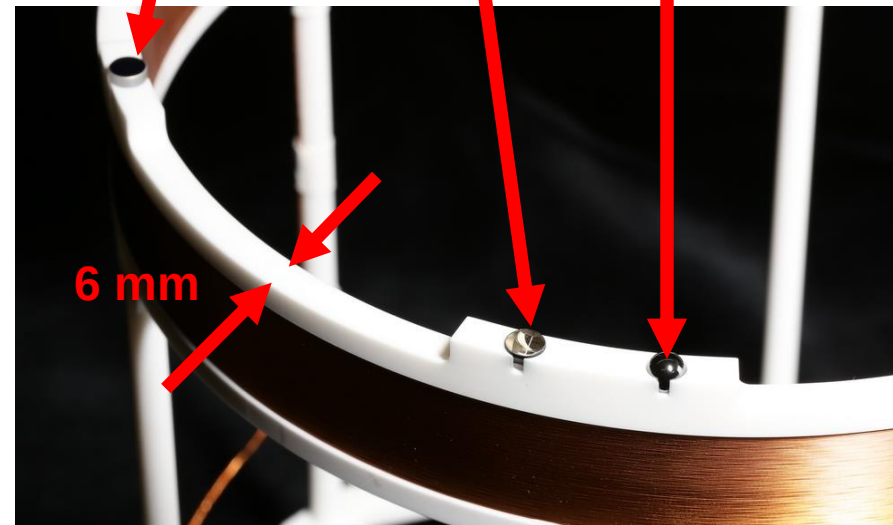
The Coil Frame



Mirror

Corner cube

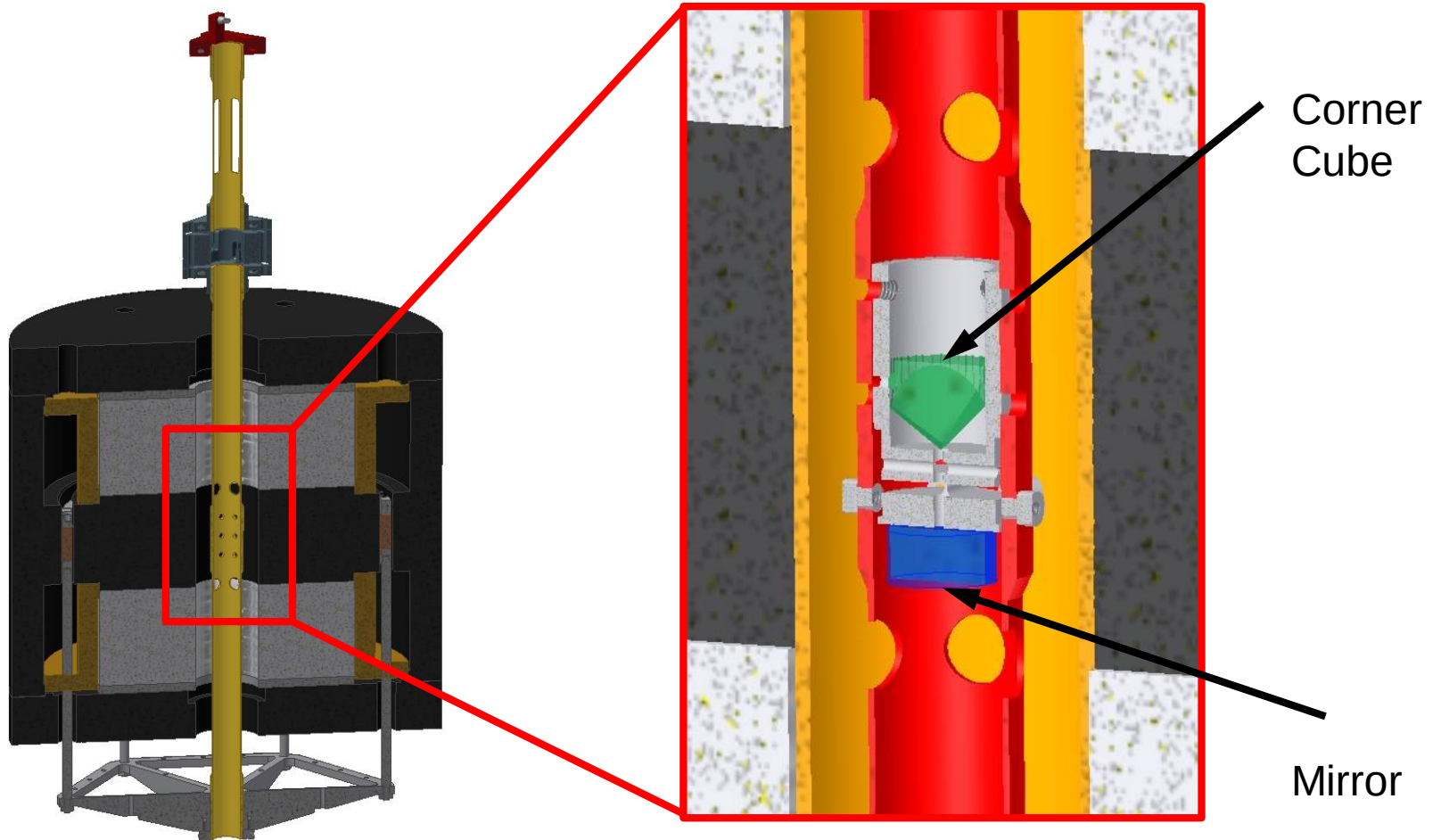
Ceramic ball



Macor[®]

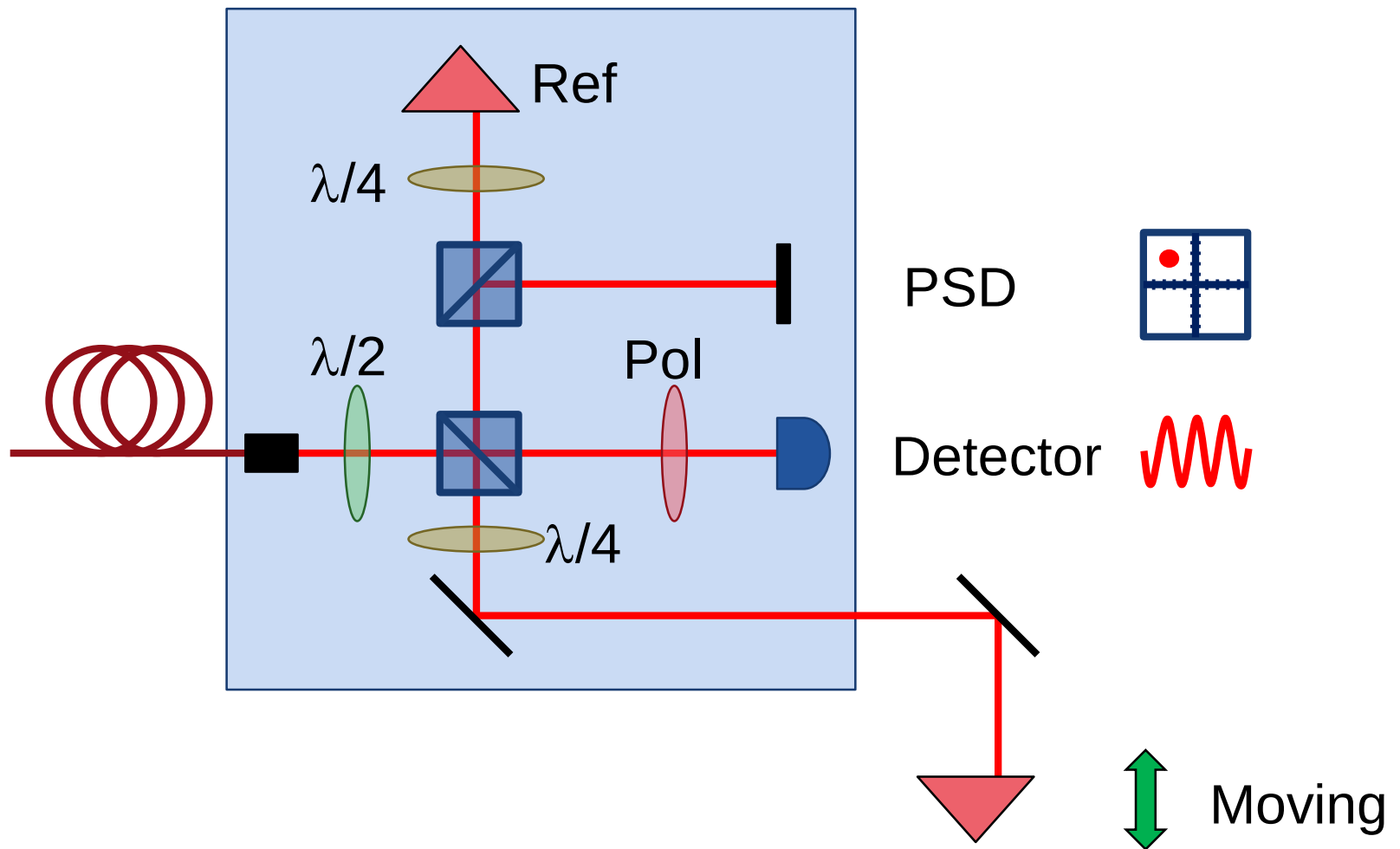
Laser Interferometer

♦ Moving reflectors



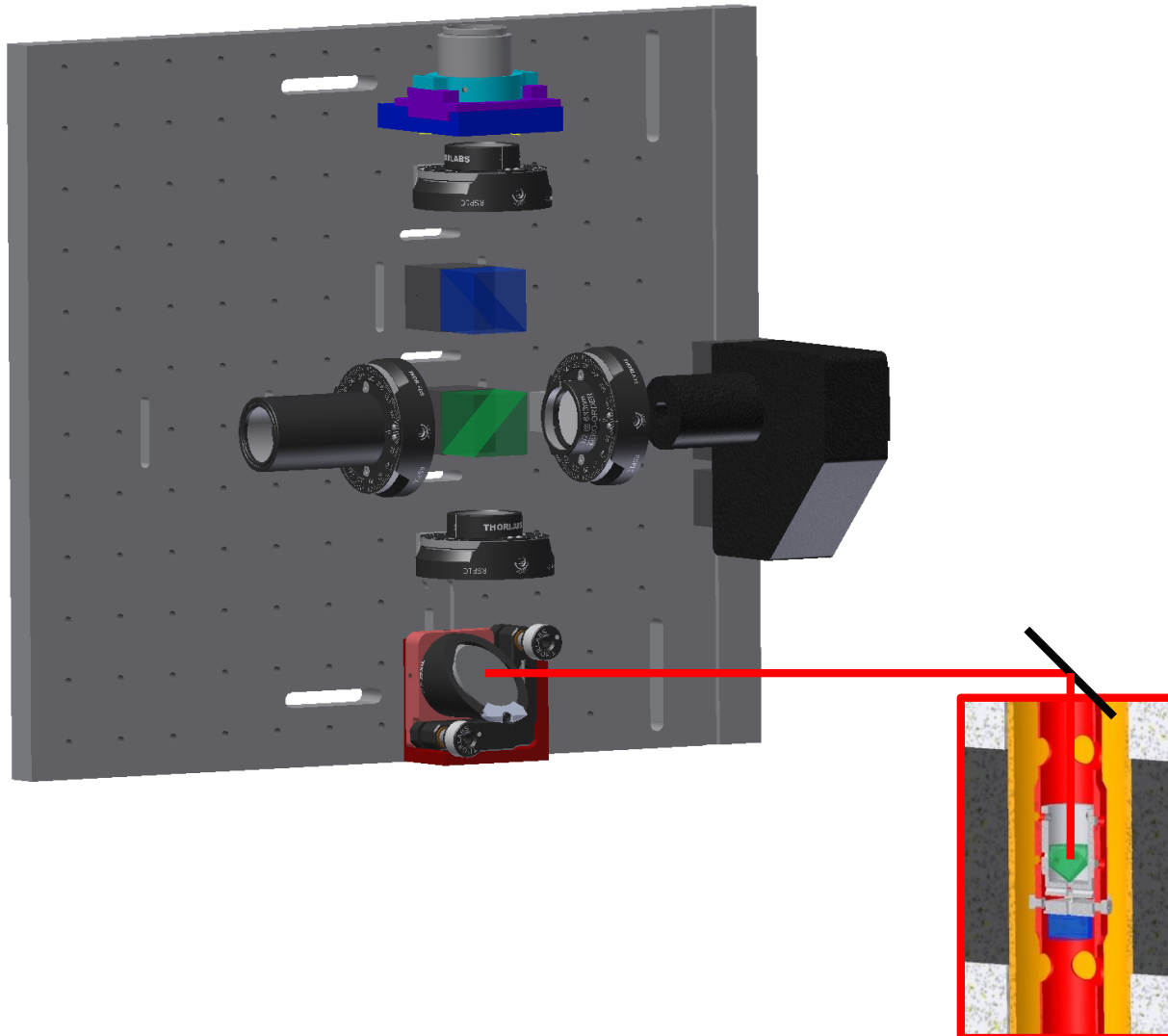
Laser Interferometer

♦ Michelson interferometer



Laser Interferometer

♦ Michelson interferometer



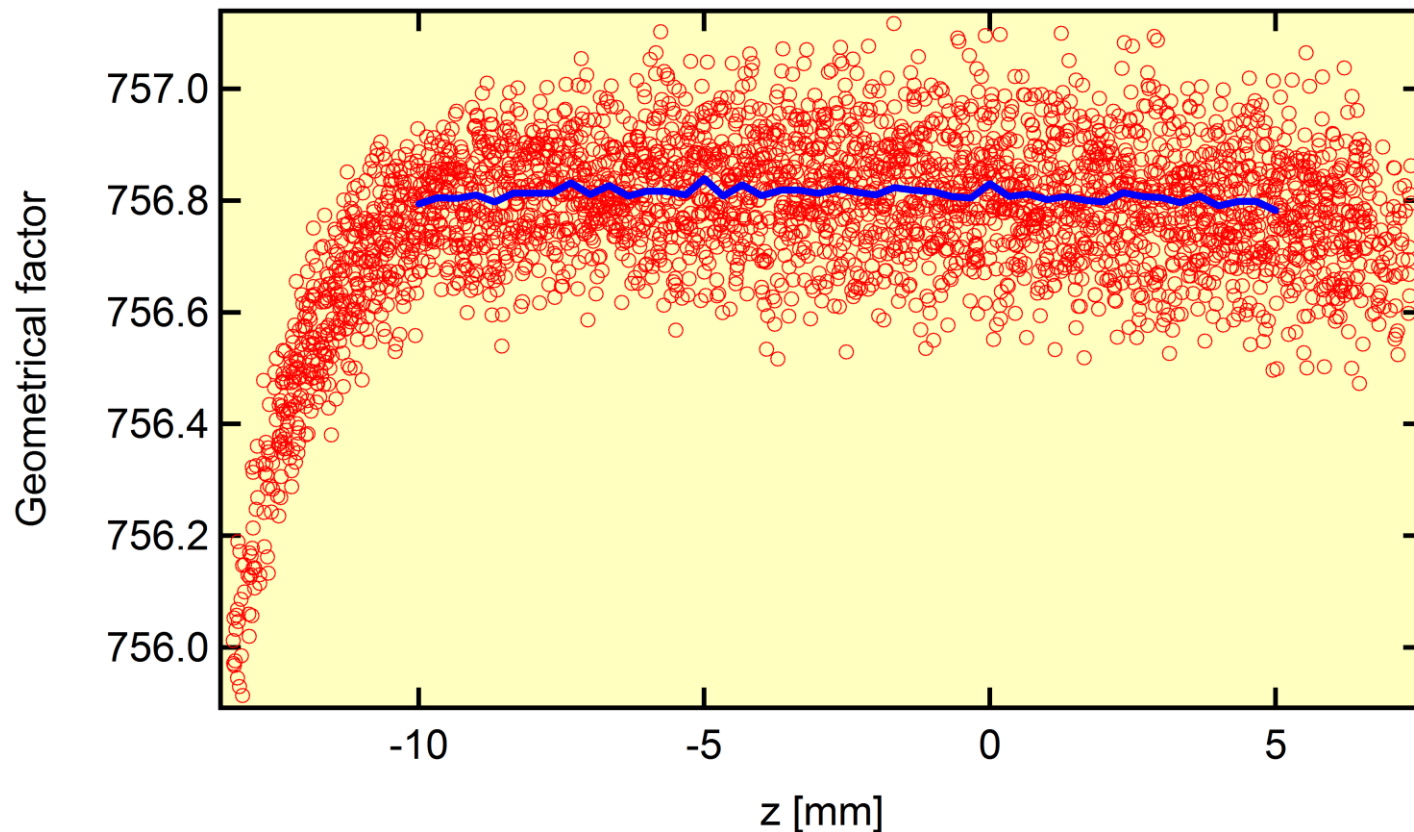
Field Profile

- ◆ Velocity control:
 - Voice coil linear motor
 - Optical encoder (resolution: 100 nm)
 - Software PID (mono-zone)
- ◆ Velocity measurement:
 - Michelson interferometer in central tube
 - Brilliant Instruments TIA (3x) for time tags
- ◆ Voltage measurement:
 - Agilent 3458A
 - (1 V scale, nplc=10, Azero off)
- ◆ Typical parameters:
 - $v = 1.3 \text{ mm/s}$
 - $U = 1 \text{ V (75 pts)}$
 - $d = 22 \text{ mm}$



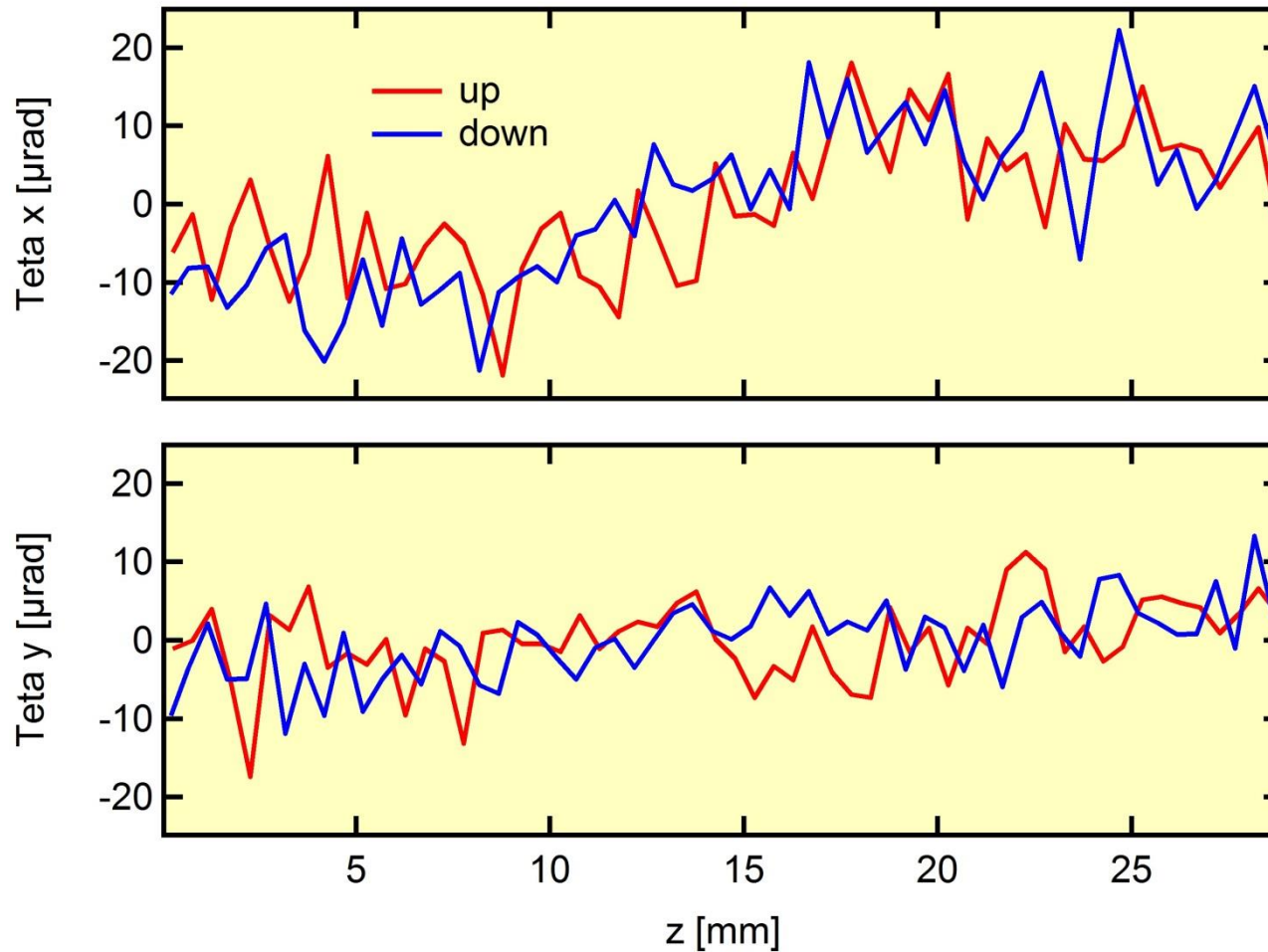
Field Profile (January 2015)

- ◆ 44 curves taken in 15 minutes
- ◆ No fit (just average)
- ◆ Slope < 1 ppm/mm



Field Profile

♦ Stability of coil motion



♦ Mirror on coil frame

♦ x: $\pm 10 \mu\text{rad}$

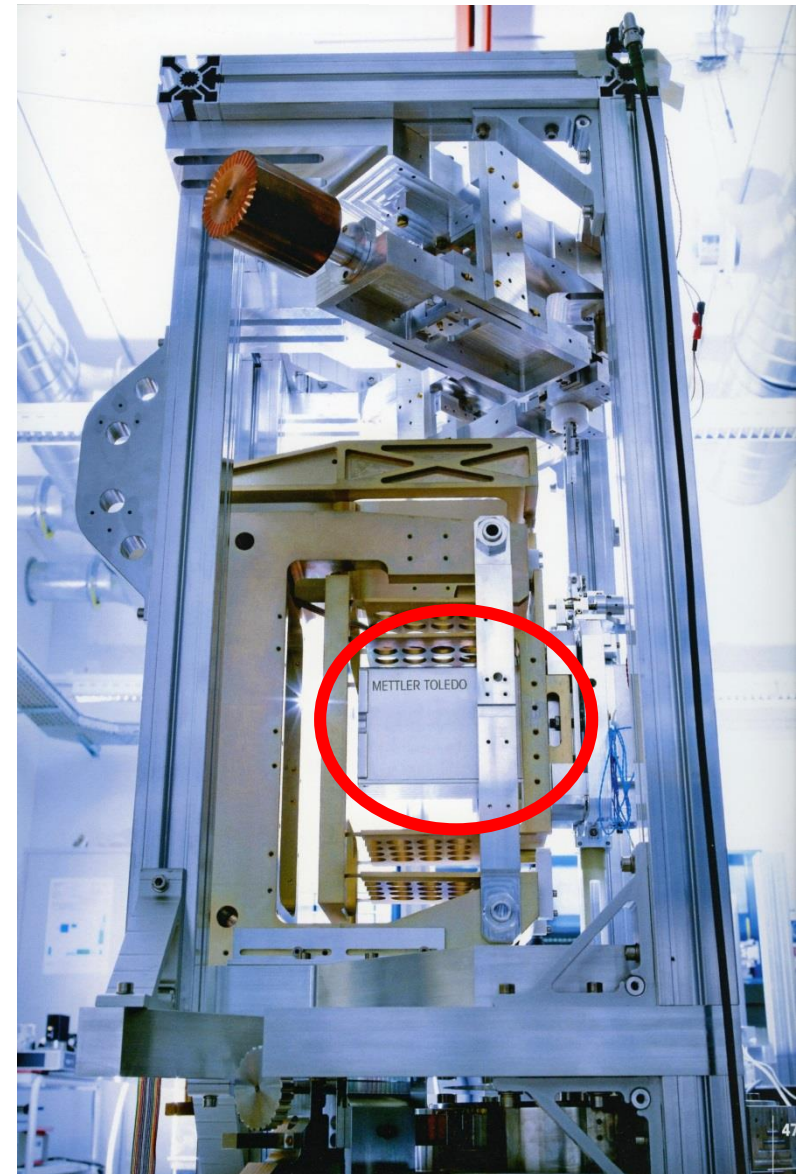
♦ y: $(10 \mu\text{rad})$

Load Cell

- ♦ Integrated in translation stage
- ♦ 3rd generation:
mounted but locked !

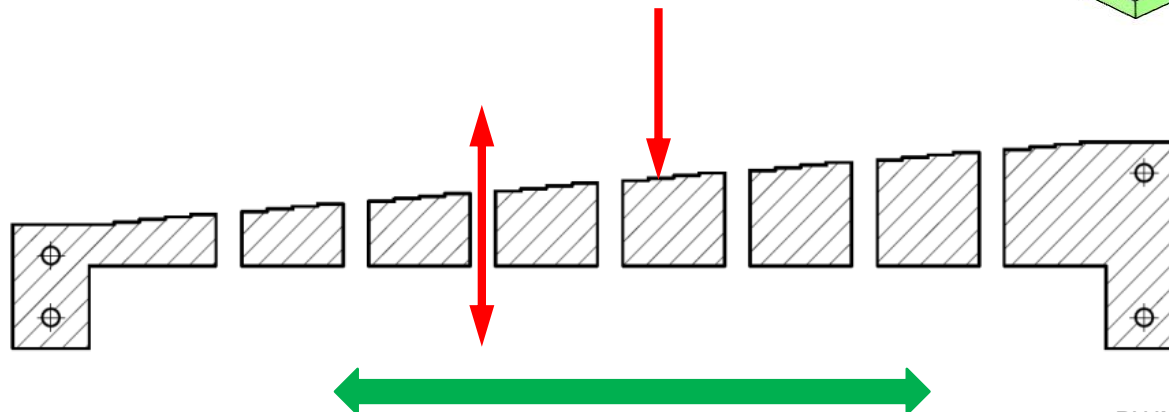
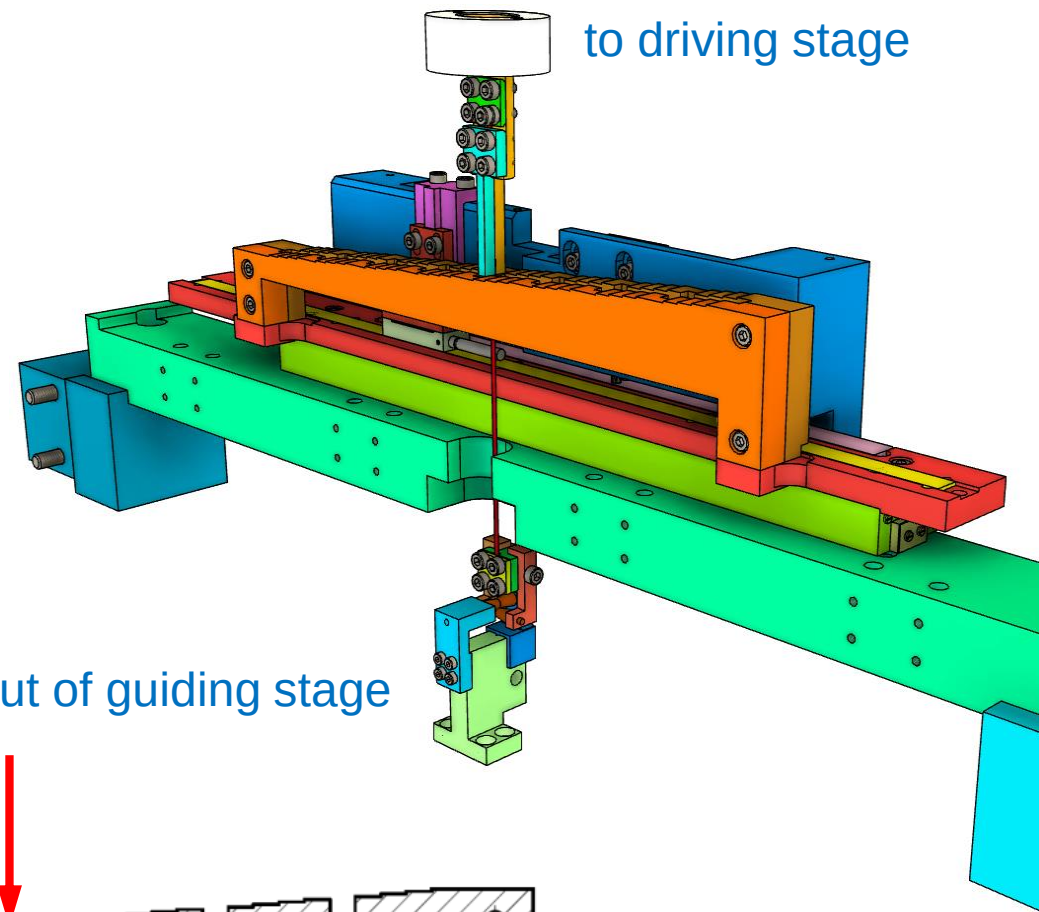
L = 1'800 g	(=)
r ~ 3 µg	(-)
Hinge thickness	(+)
Robustness	(++)

- ♦ 4th Generation: under test
Same as 3rd generation but
r < 1 µg (++)

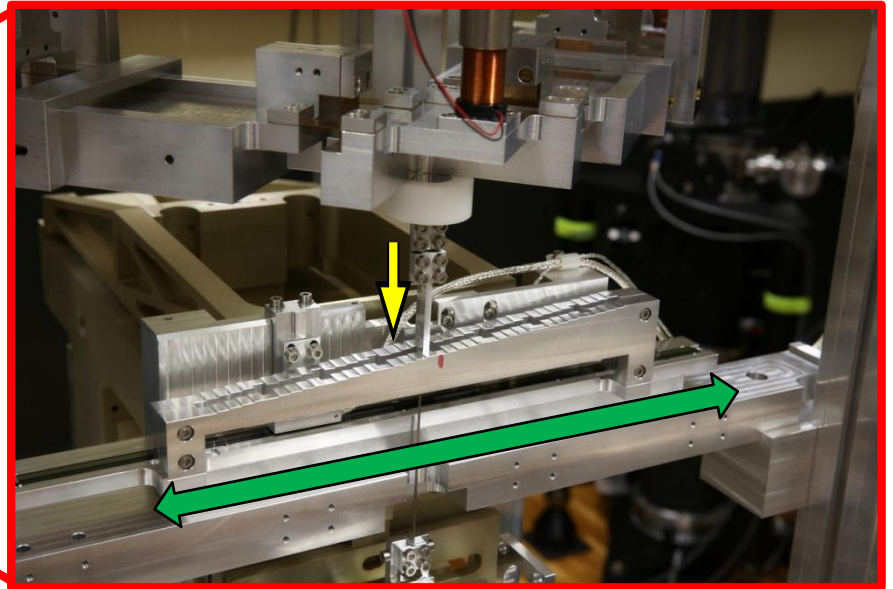
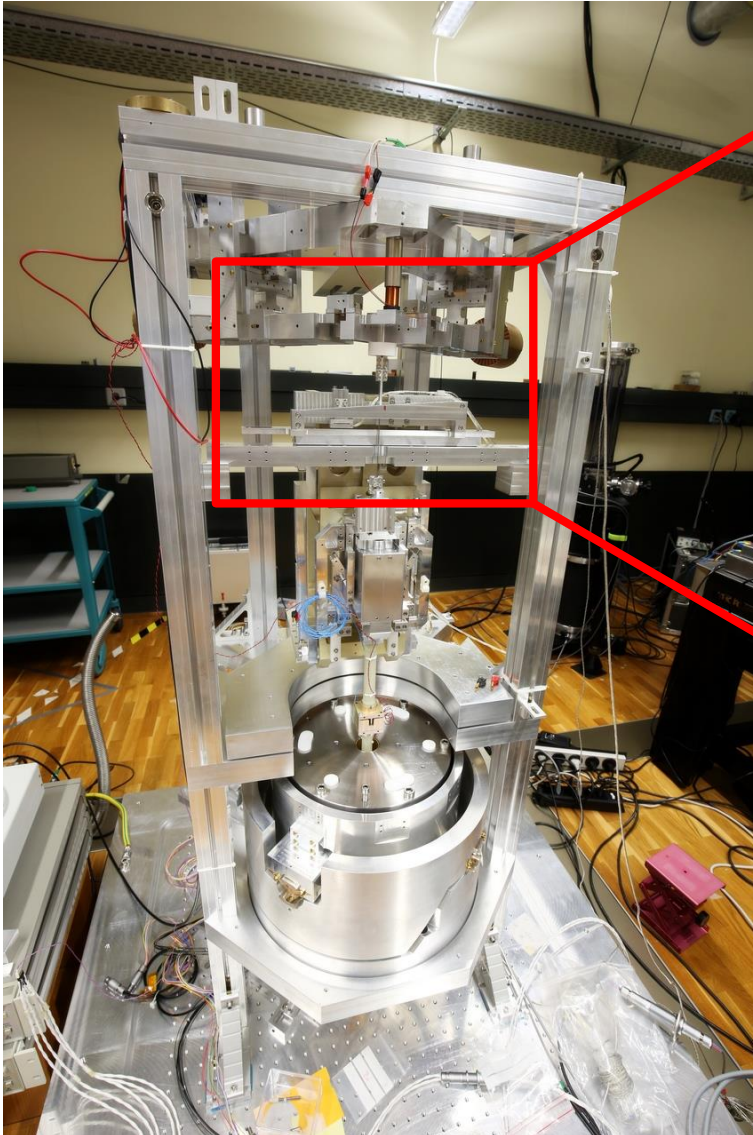


Mechanical stop

- ♦ Passing through or blocking mechanism
- ♦ Adjustable vertical blocking position:
 $\pm 8 \text{ mm}$ with 0.5 mm steps
- ♦ Horizontal piezo axis with a resolution of $5 \mu\text{m}$

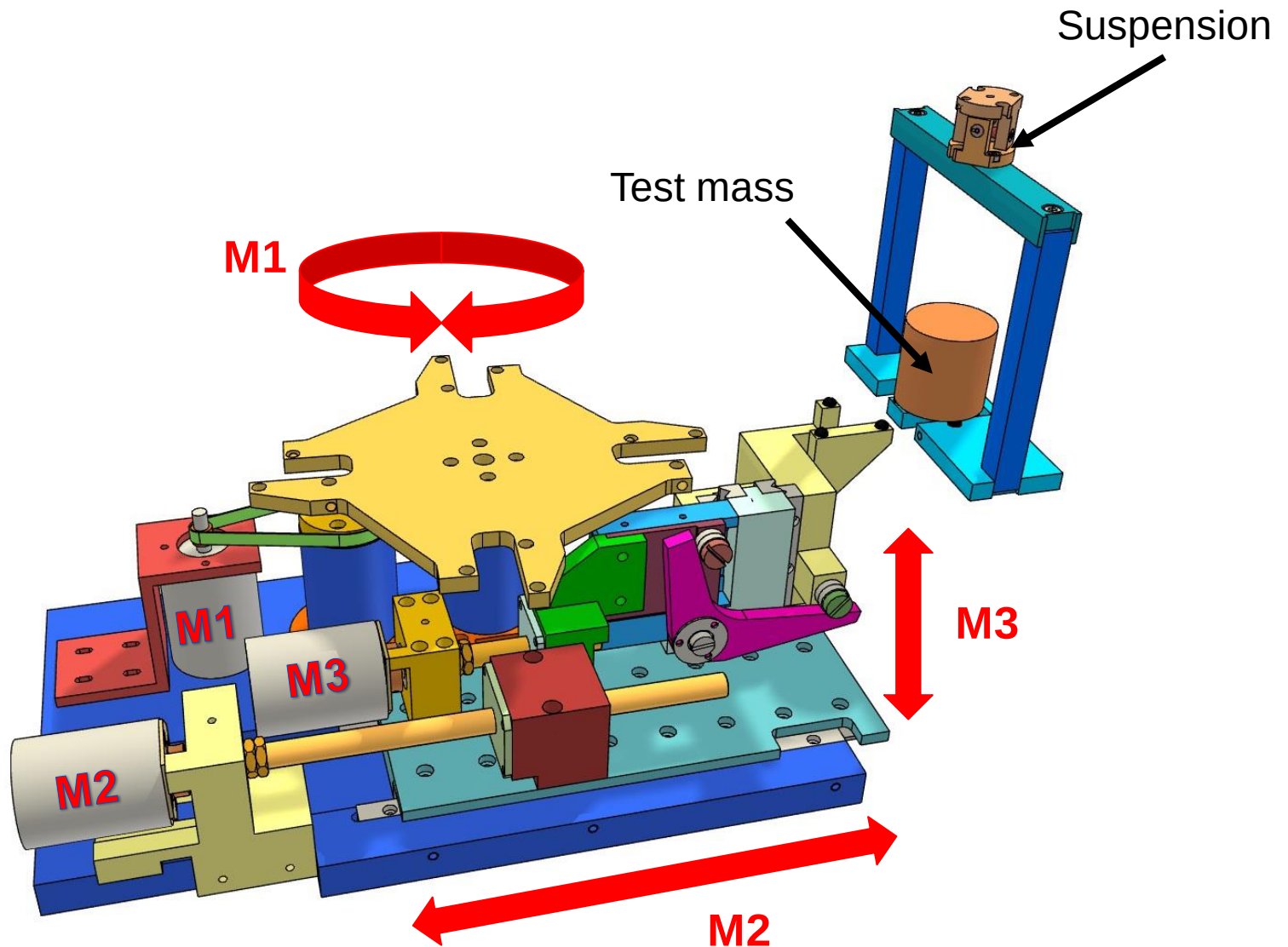


Mechanical stop

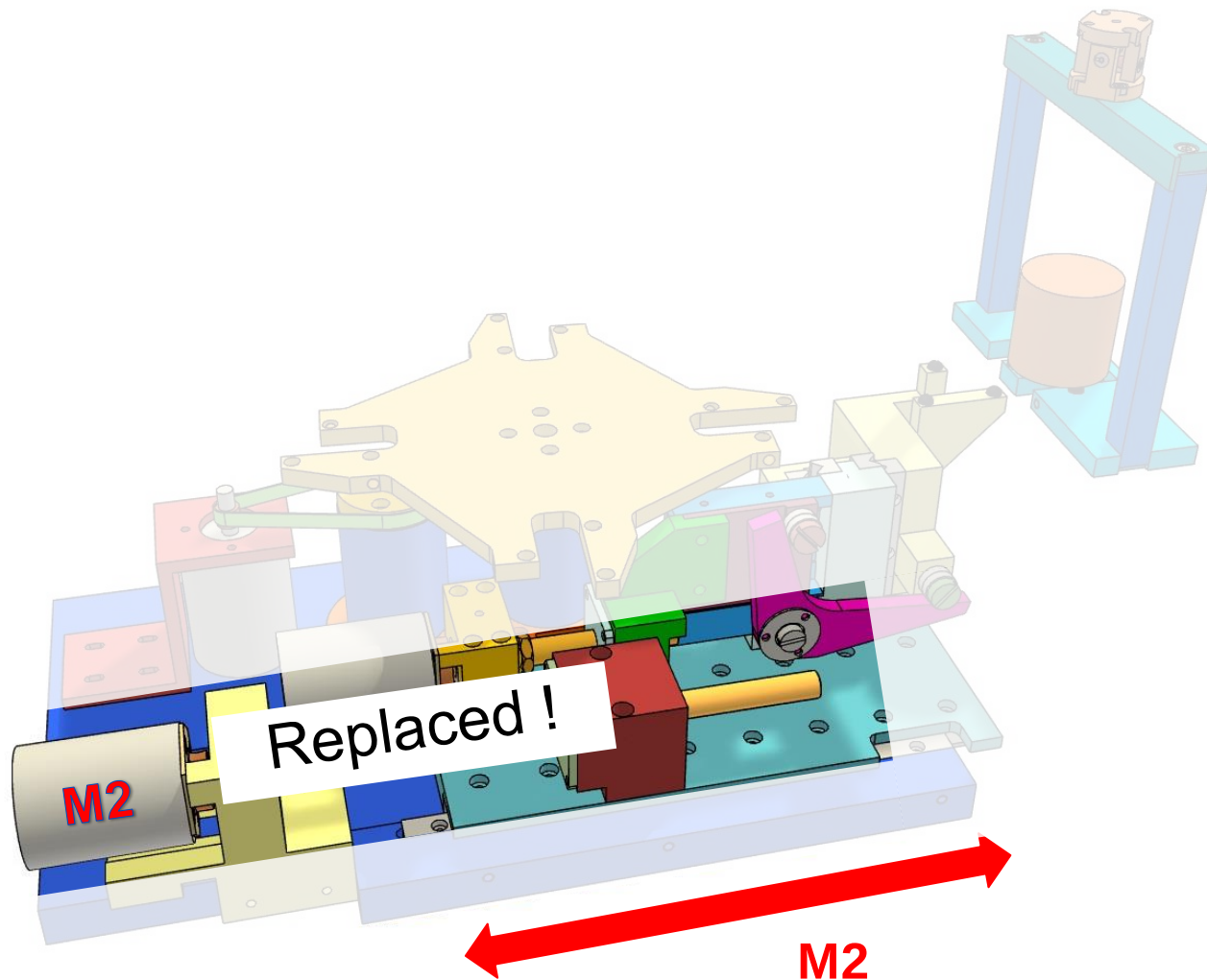


± 8 mm with 0.5 mm steps

Modification of mass handler



Modification of mass handler



The Test Masses



- ♦ Main material OFHC Copper
- ♦ Hardening layer Trigold 10 μm
(Au 75%; Cu 21%; In 4%)
- ♦ Good tribological properties (wear)
- ♦ Hard ~400 Vickers (pure Cu ~40 Vickers)
- ♦ Set:



Next steps

- Alignment
motion & laser, e-force, mass transfer
- Software
velocity regulation, user friendly interface
- Full cycles
F/I measurement
- Monitoring system(s)
coil position & angle, temperature,...
- Measurements in vacuum

2015

1st quarter

2nd quarter

2nd half

BWM II Team



♦ @ METAS

H. Baumann (20%)
A. Eichenberger (100%)
B. Jeckelmann

♦ Partners

D. Genoud, D. Reber (Mettler-Toledo)
D. Tommasini (CERN)
Prof. R. Clavel (EPFL)
D. Picamoles (Maxon)

EMRP SIB03 kNOW project



Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Federal Institute of Metrology METAS

THANK
YOU!



maxon motor
driven by precision



EPFL
ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

