

Control of a rotating MagLev sample manipulator

DSPE lunch lecture

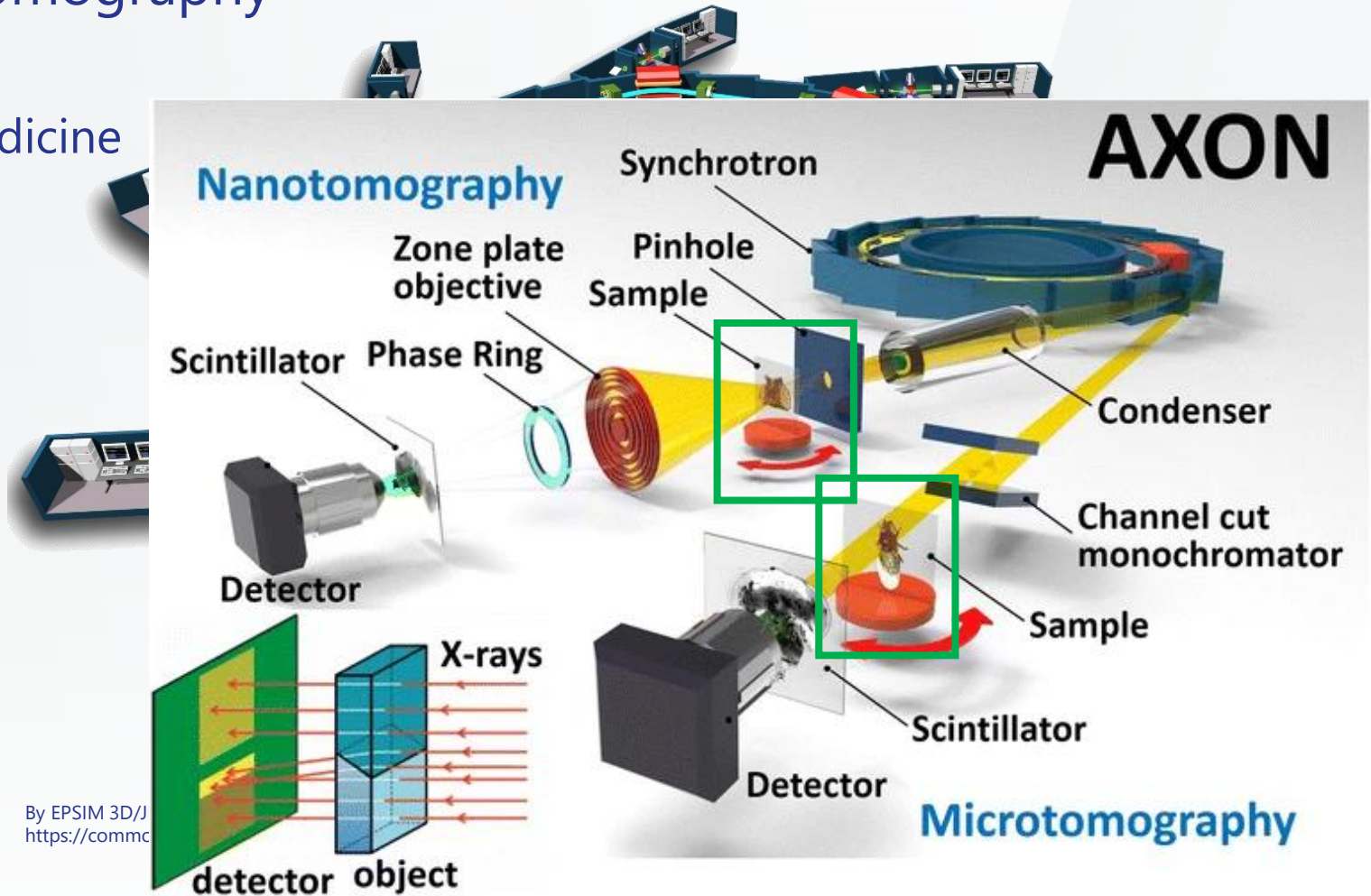
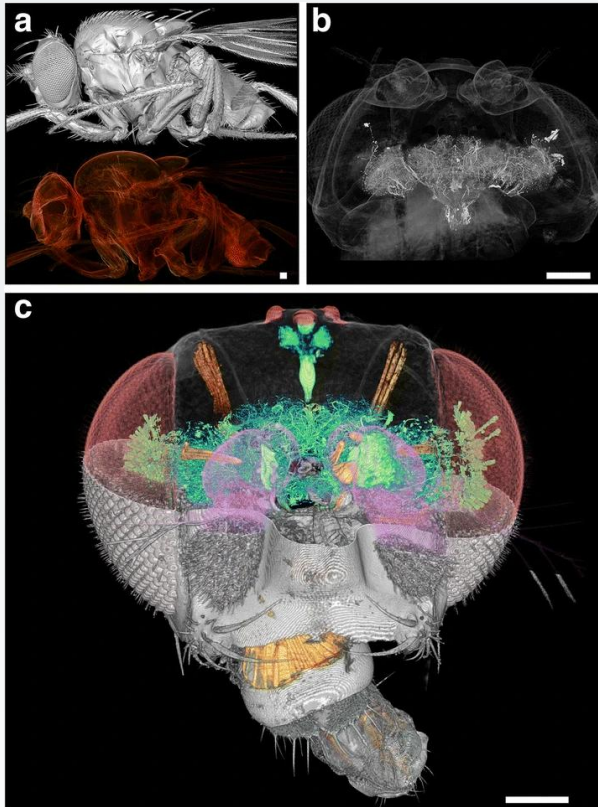
08-05-2023

R. Faassen, M. Wijnhoven, W. Pancras, D. Laro, T. Ruijl, et. al

Confidential

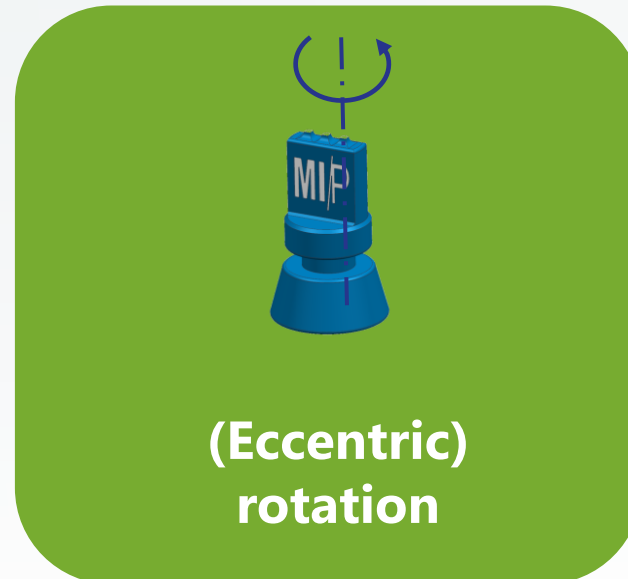
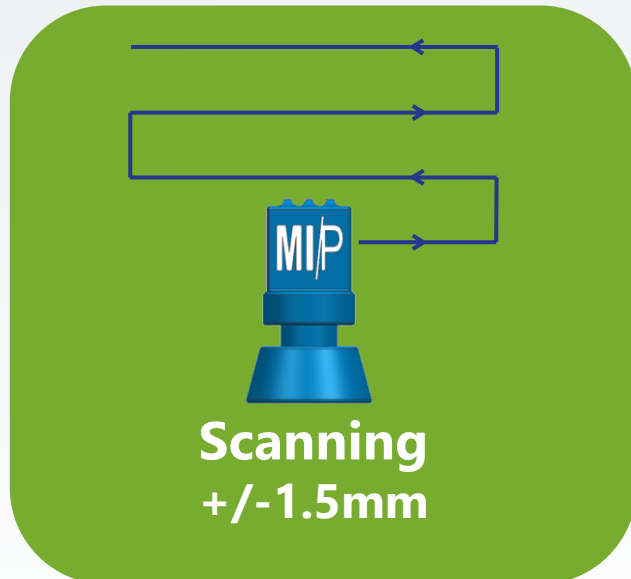
Introduction

- Synchrotron imaging and tomography
 - Sub-nanometer to mm scale
 - Material science, biology, medicine



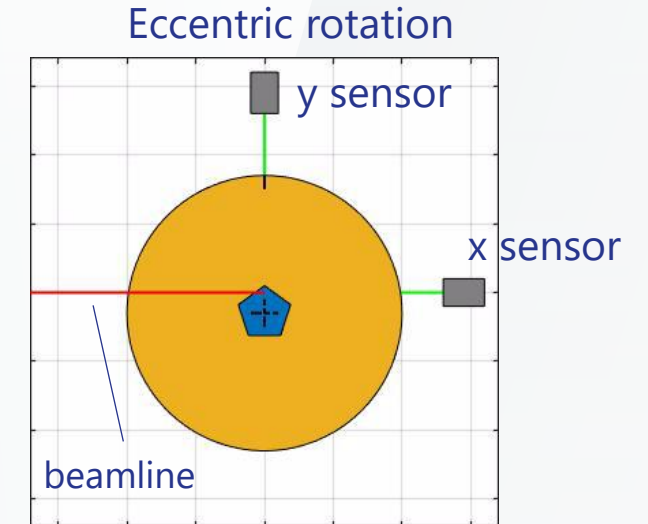
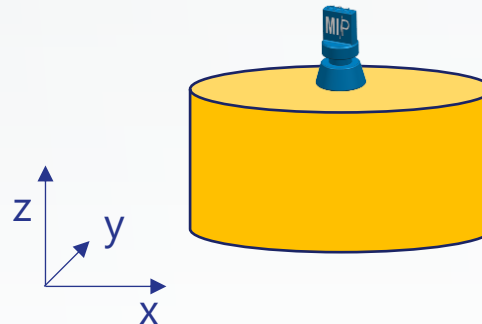
Introduction

- Current state-of-the-art:
 - Stacked Piezo stages
 - Rotational errors in RZ due to bearings
- Goal:
 - Electromagnetic levitation and actuation

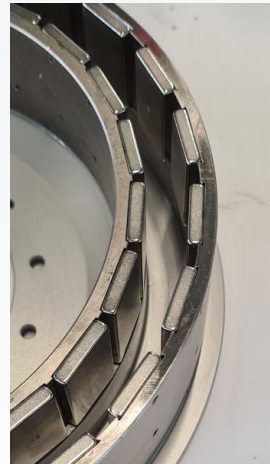
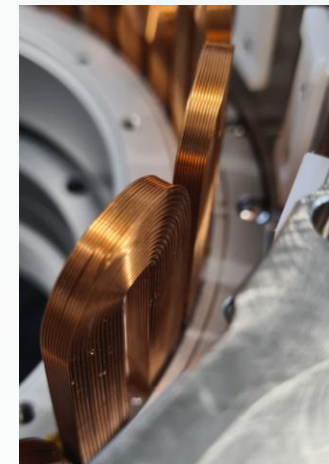
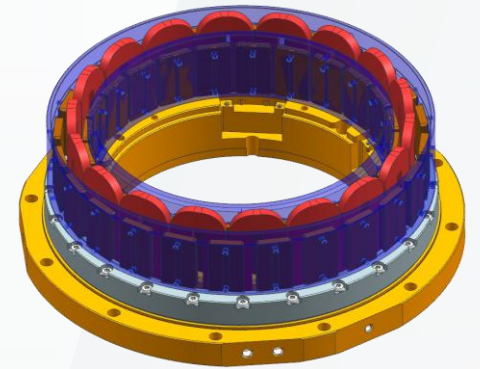
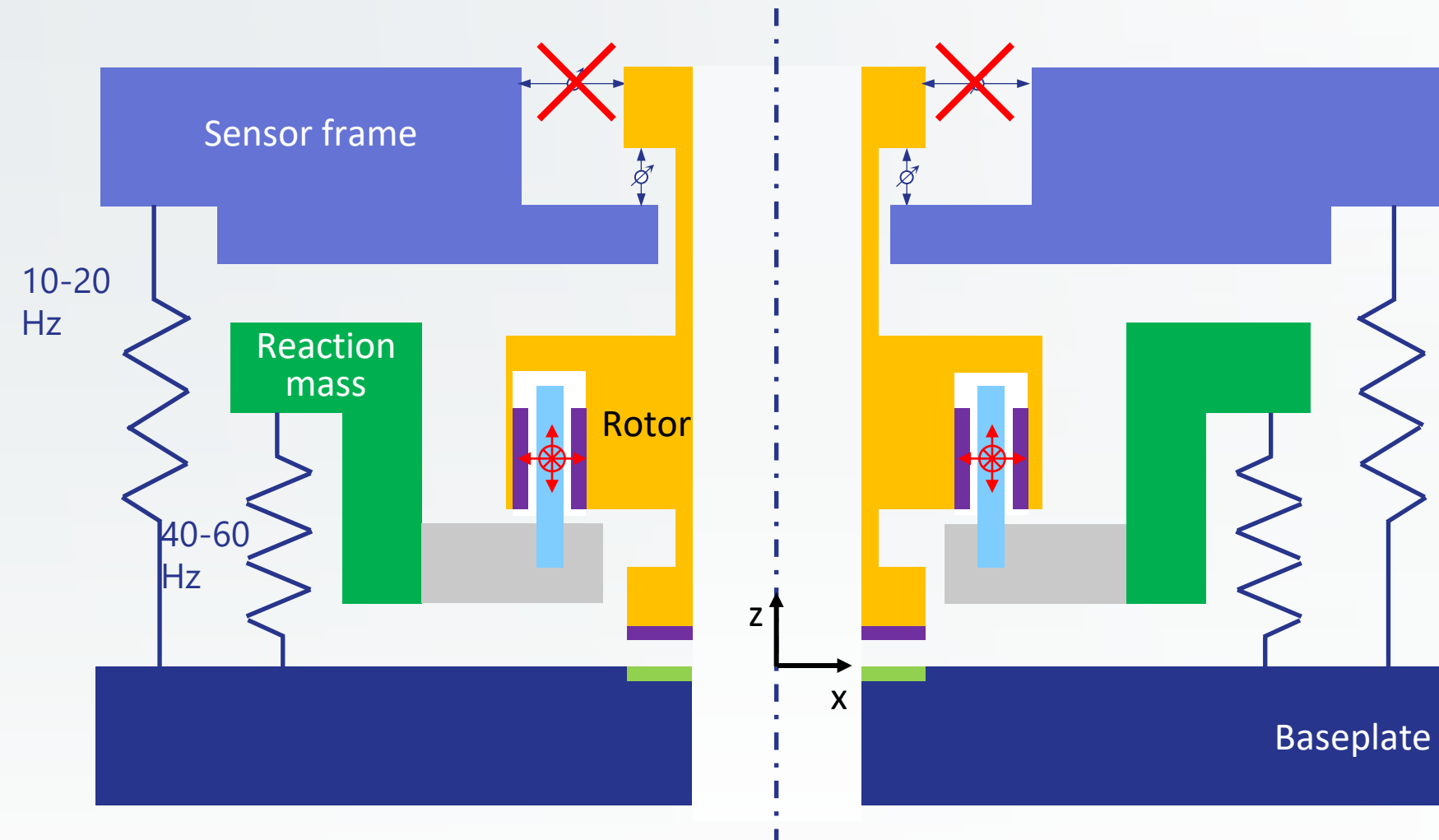


Specifications

- Contactless floating stage
- Infinite RZ stroke
- X, Y, Z stroke ± 1.5 mm
- RX, RY: keep upright, no active stroke
- Architecture prepared for 20 nm accuracy
- Architecture prepared for vacuum/cleanroom conditions
- Setup to be used for fair demonstrations

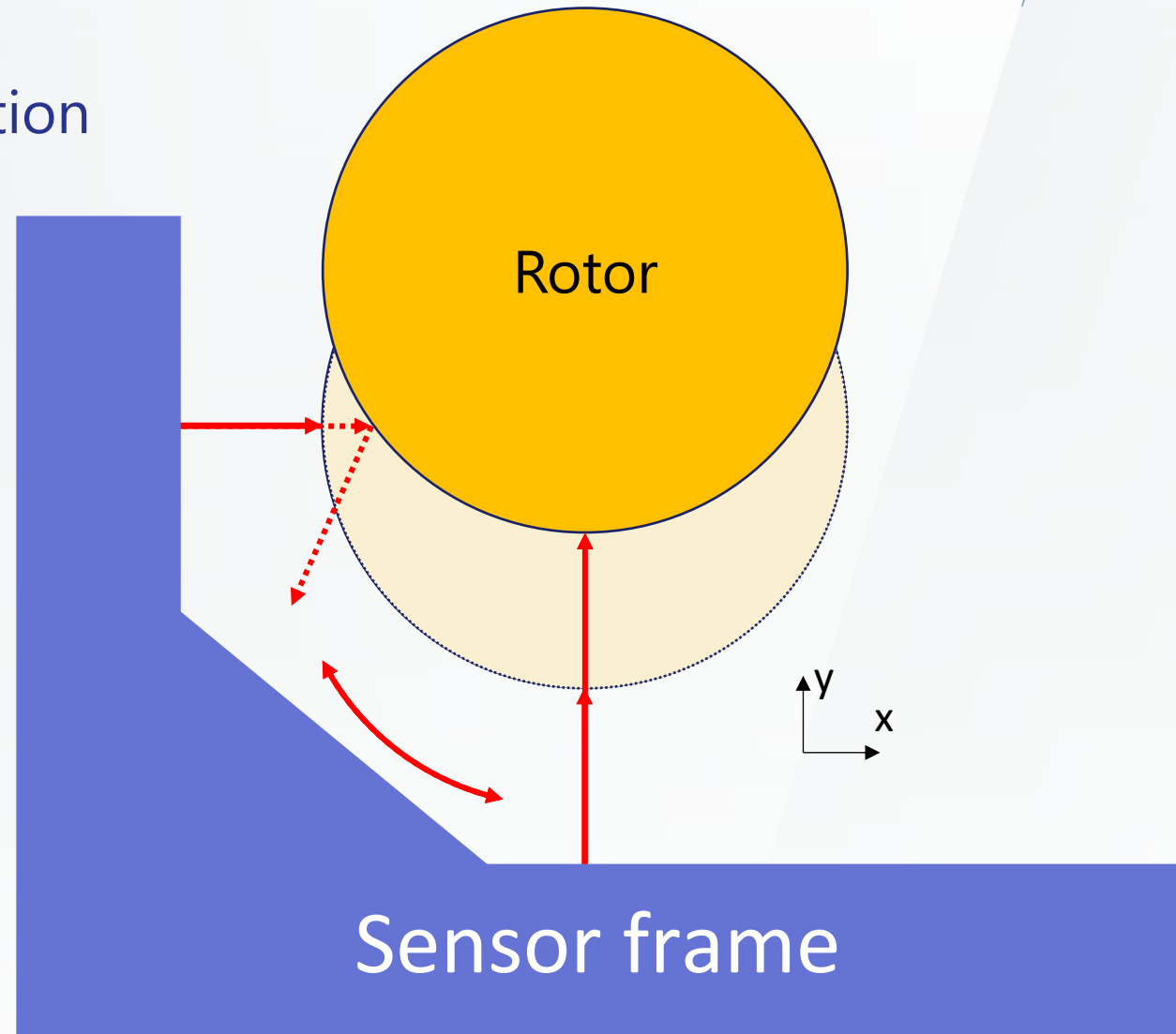


Schematic layout

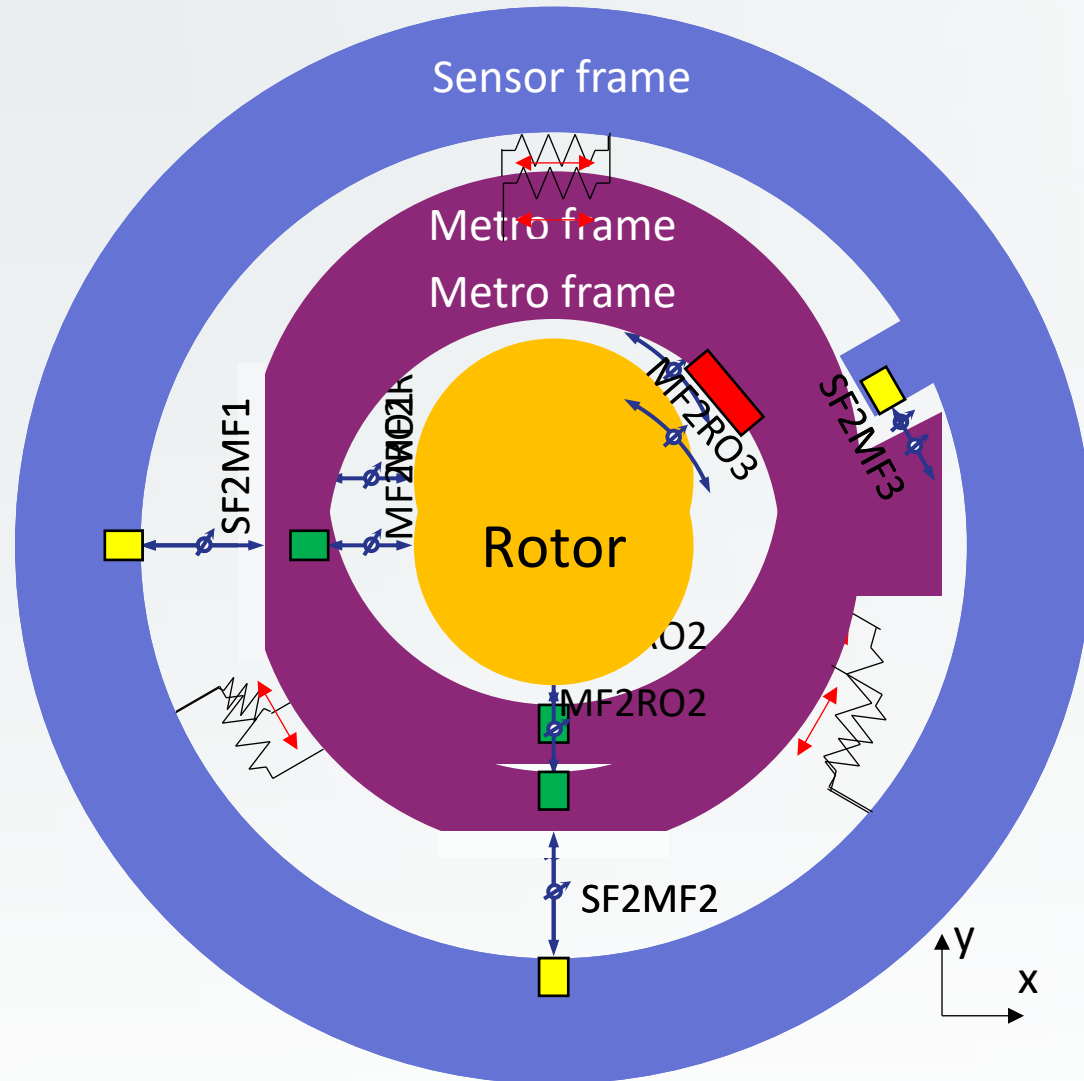


In plane measurement problems

- Crosstalk between X and Y direction
- IFM Beam missing detector
- Range of RZ encoder



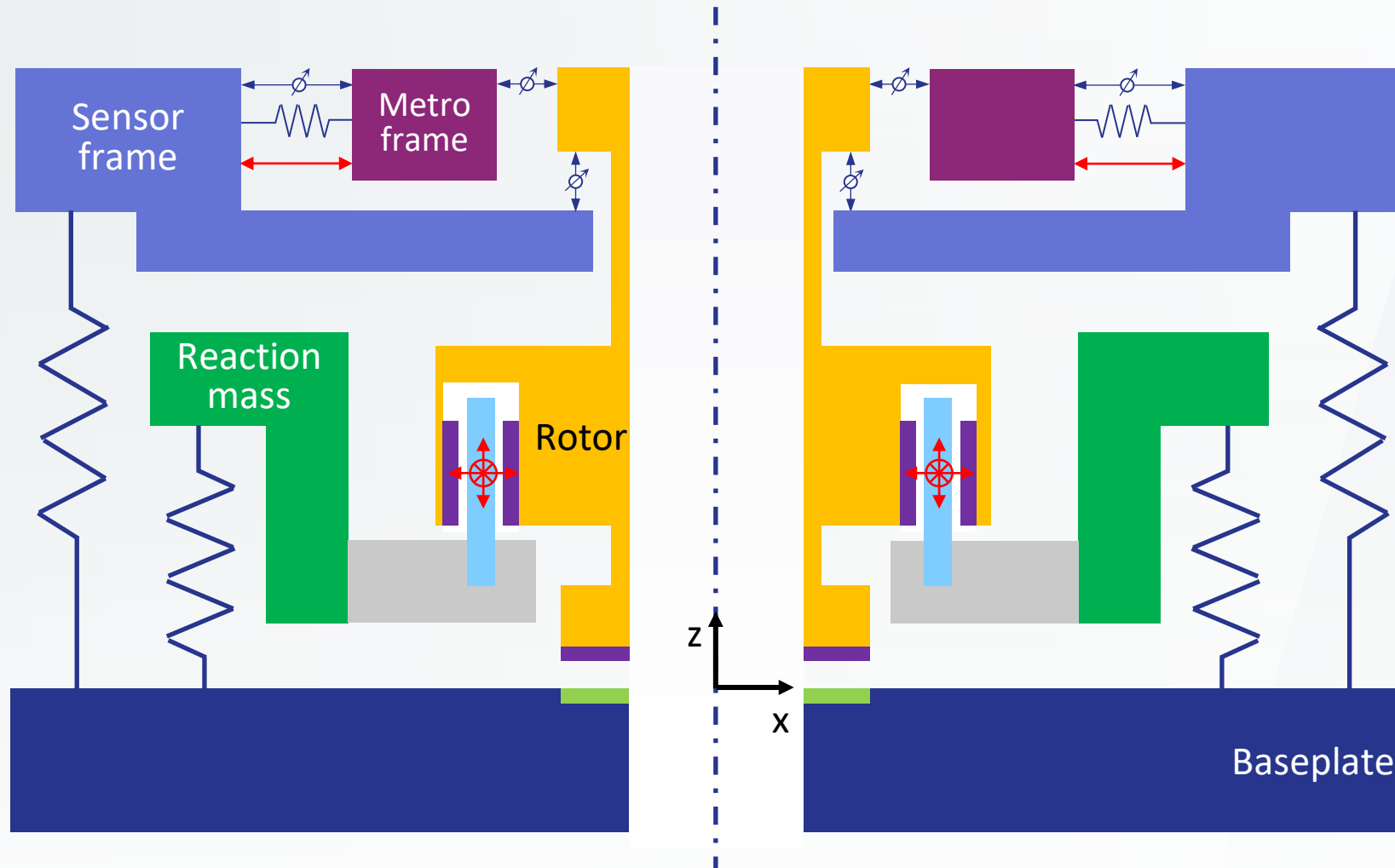
Additional active metrology frame



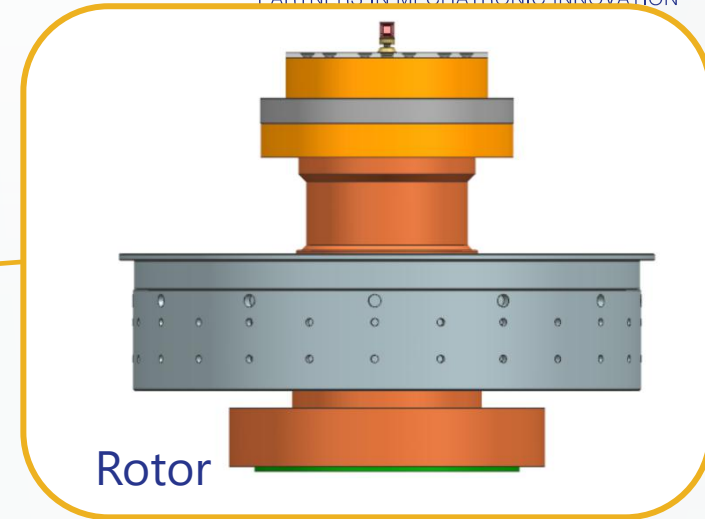
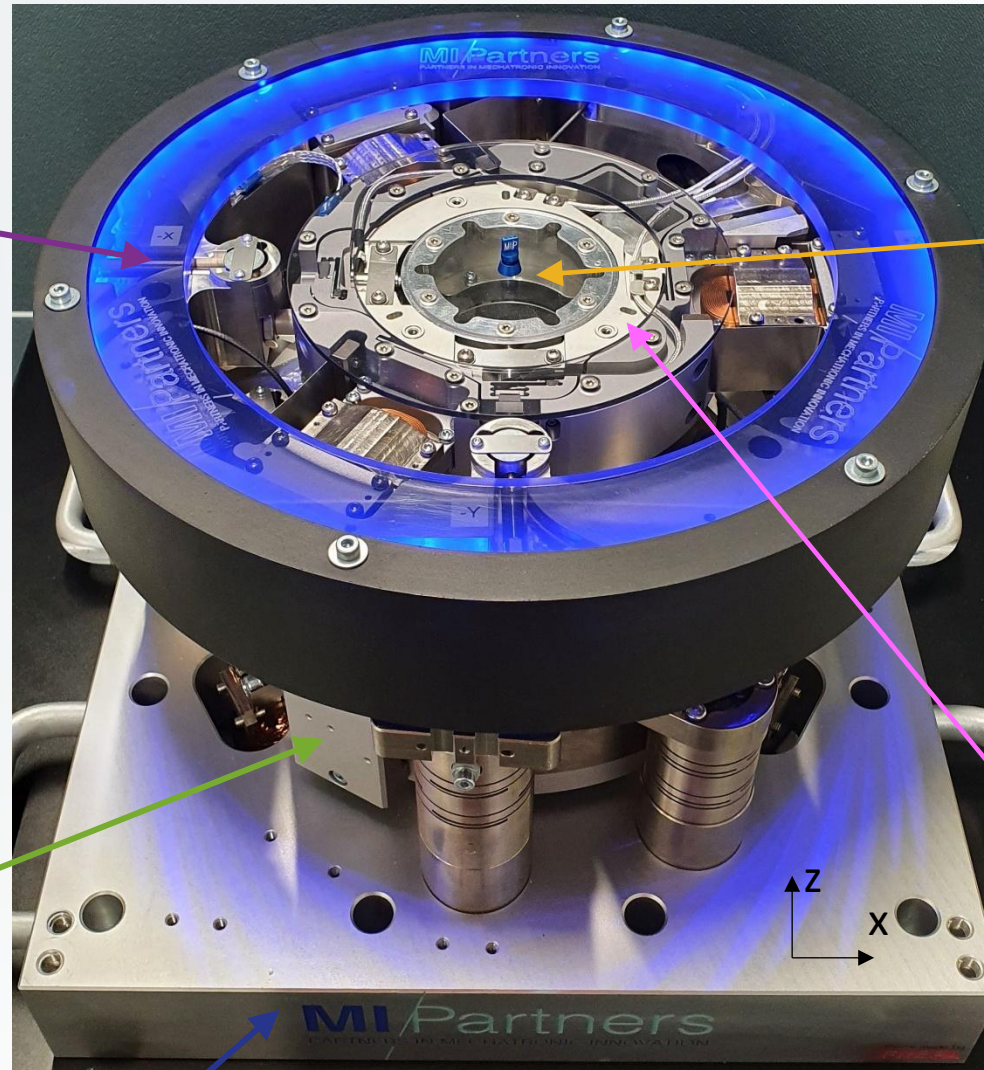
- Eddy current sensors
(to be replaced with interferometers in the future)
- Capacitive sensors
- Absolute rotary encoder

- Additional metrology frame solves in-plane measurement problems
 - Rotor position should not be influenced by Metro frame position

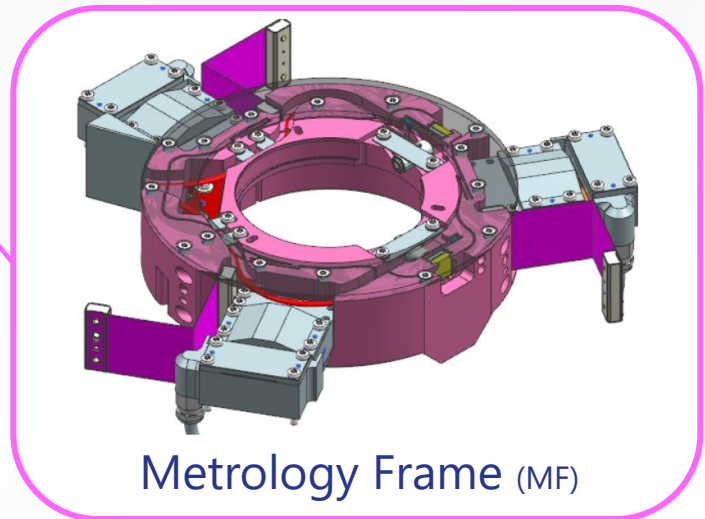
Schematic layout revised



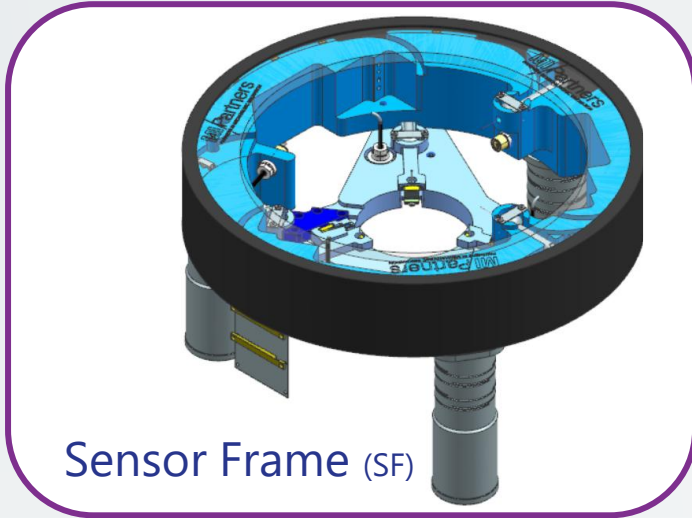
Overview Maglev manipulator



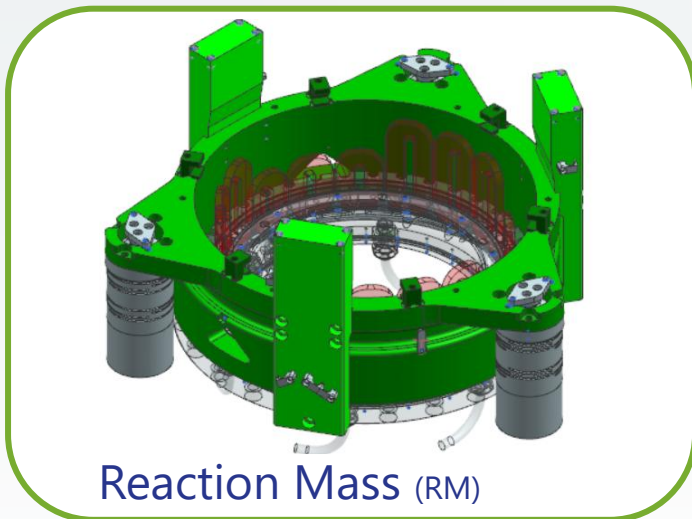
Rotor



Metrology Frame (MF)



Sensor Frame (SF)

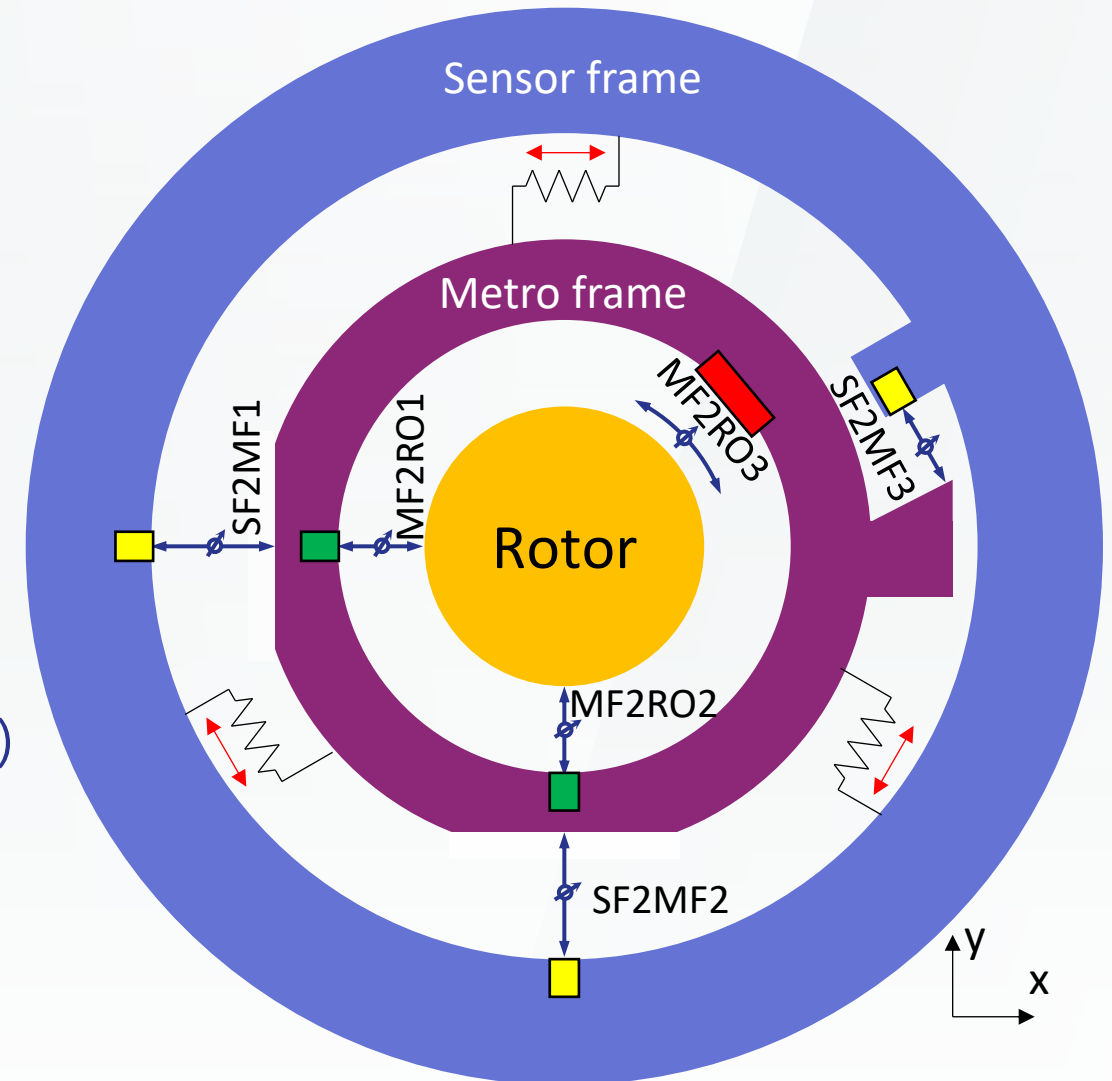


Reaction Mass (RM)

Base Plate (BP)

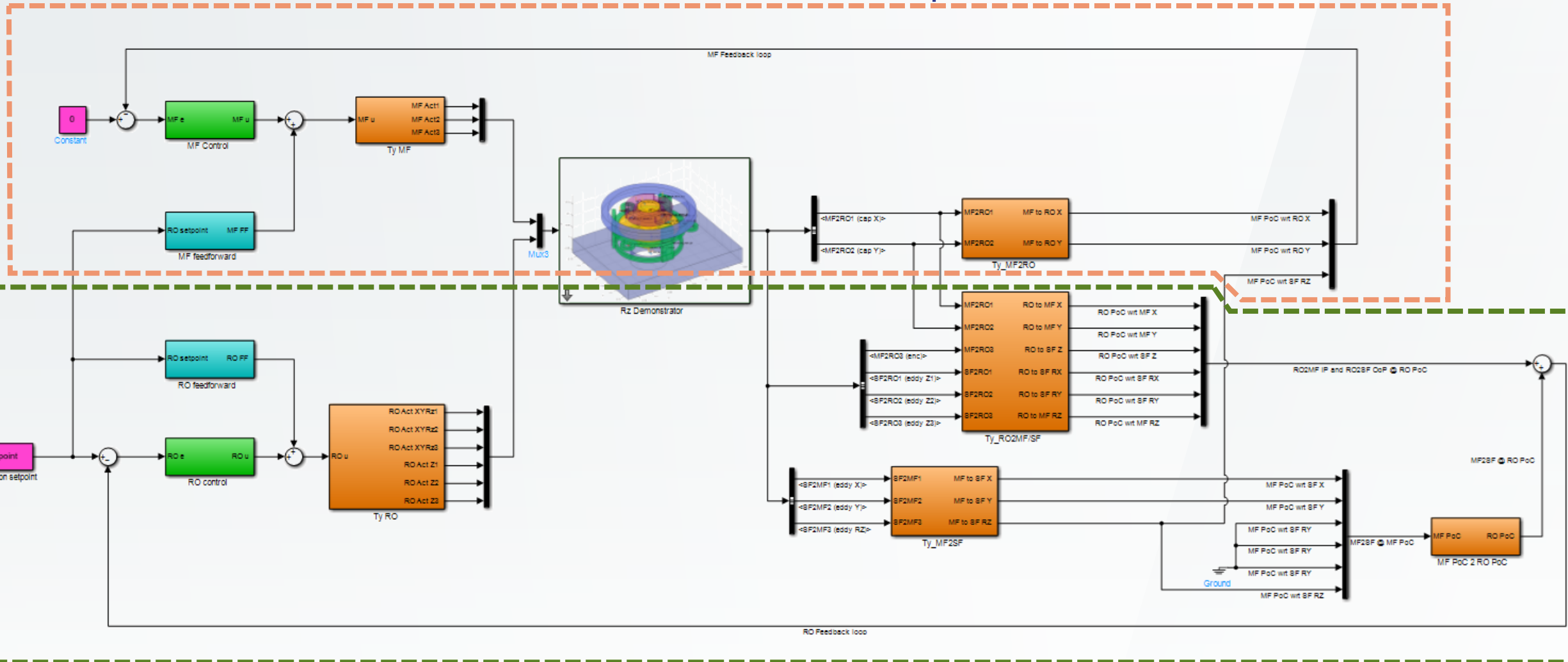
Control

- Rotor controlled w.r.t. Sensor frame (6DOF)
 - 120 Hz bandwidth
 - Addition of SF2MF and MF2RO sensors
 - Goal: setpoint tracking and disturbance rejection
- Metro frame controller w.r.t. Rotor (X,Y)
 - 50 Hz bandwidth drift control
 - Goal: Keep gap constant
 - Rotor position is not influenced by Metro frame position
- Metro frame controller w.r.t. Sensor frame (RZ)
 - 50 Hz bandwidth drift control
 - Goal: Keep RZ of MF zero
 - Rotor position is not influenced by Metro frame position



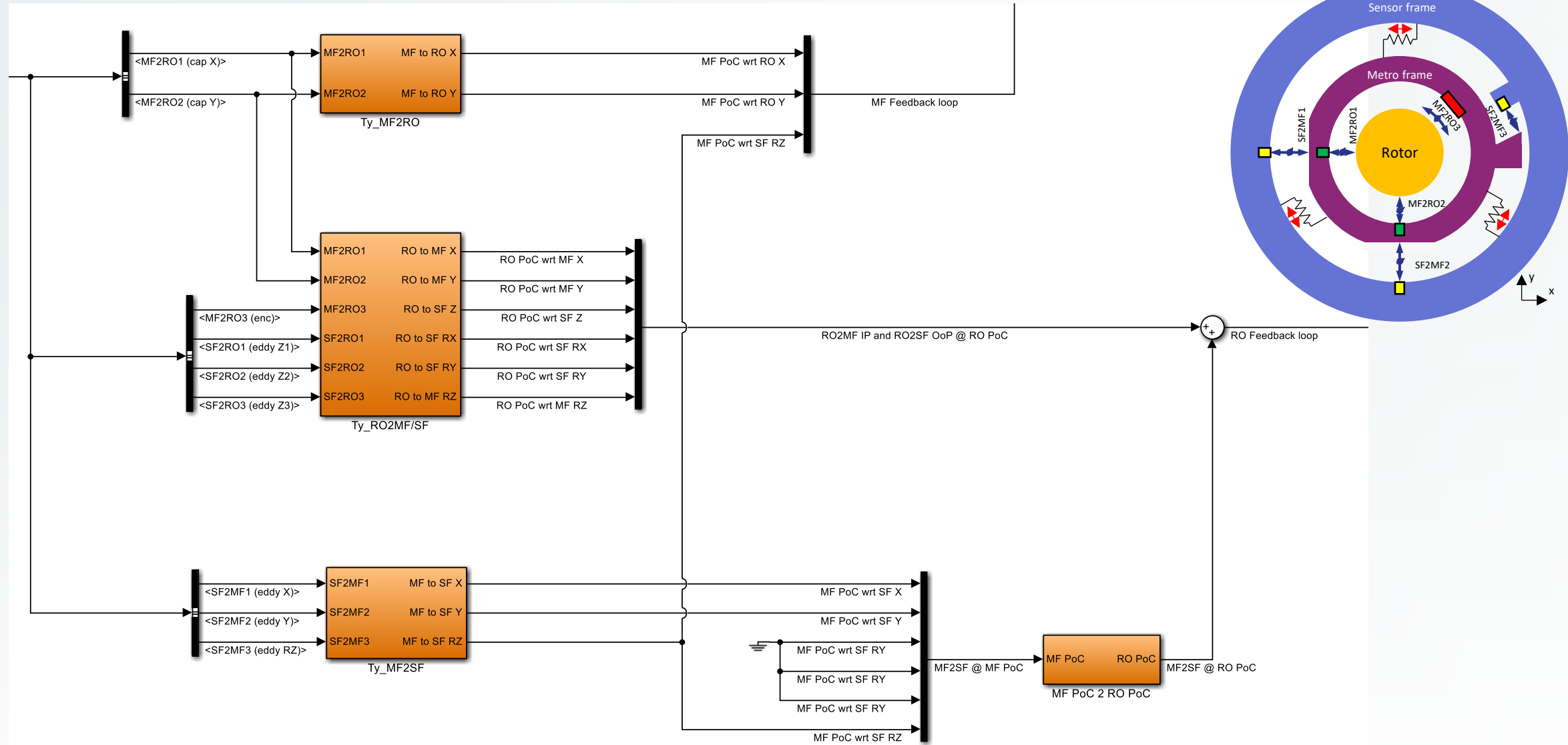
Control architecture (simplified)

MF Loop

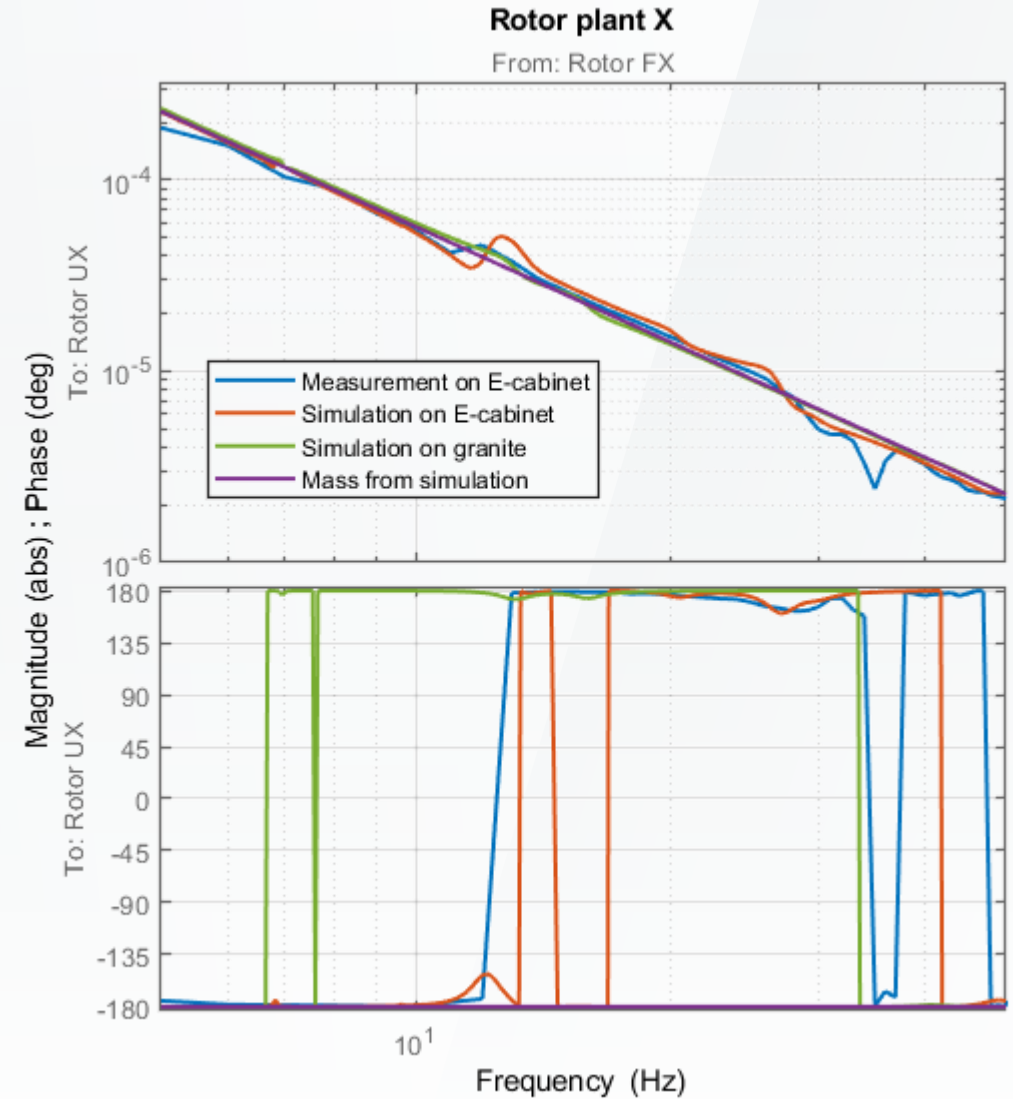
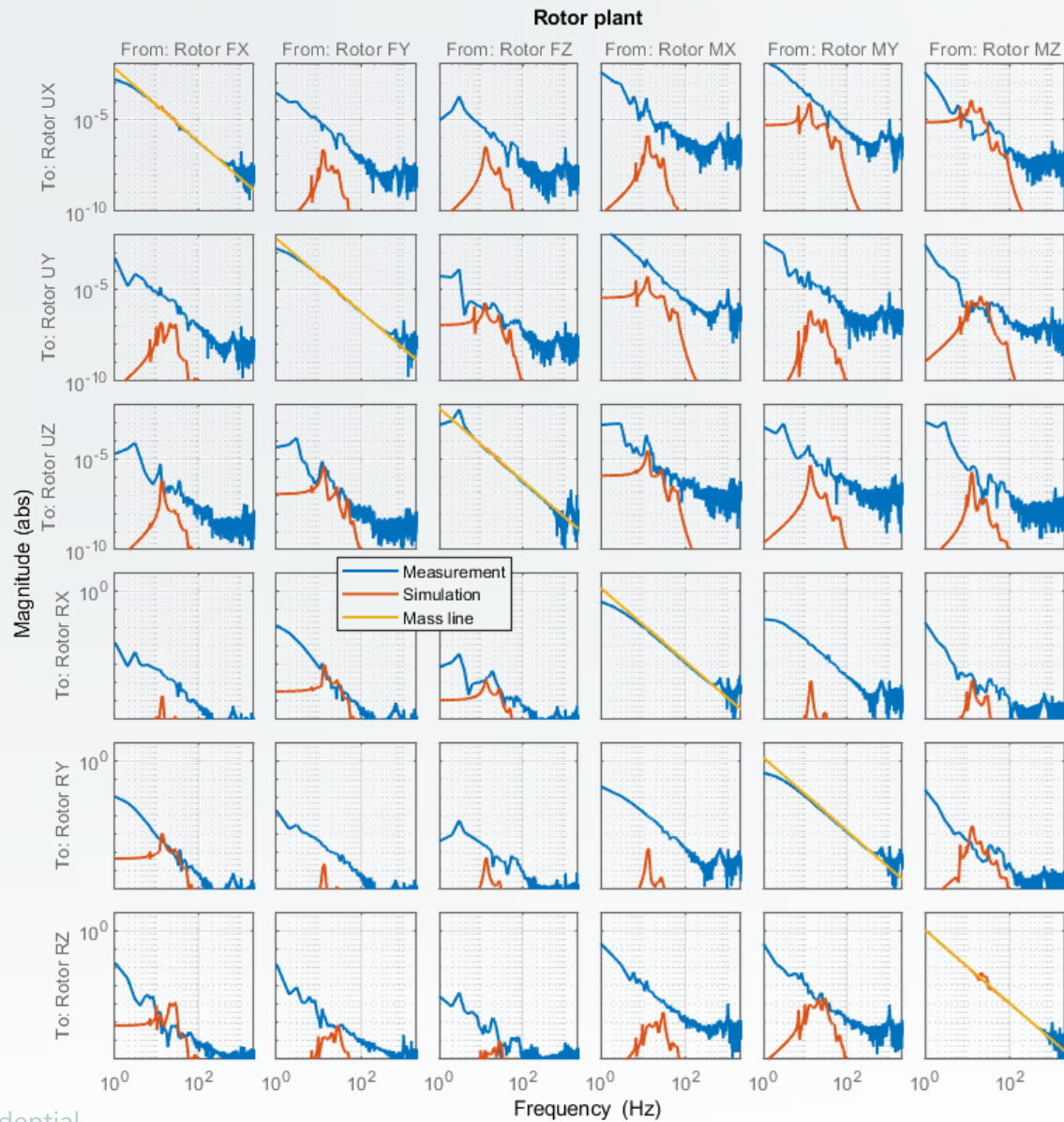


Rotor Loop

Sensing



Rotor plant



Conclusions

- 6DOF magnetically levitated sample manipulator has been designed and built
- Infinite RZ stroke
- X, Y, Z, stroke of ± 1.5 mm
- Additional active metrology frame solves measurement problems
- 120 Hz BW is achieved.
- Future upgrade, e.g. with interferometers instead of eddy current sensors, will increase performance to order of 20 nm (3σ)



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www.mi-partners.nl



+31(0)40-2914920



info@mi-partners.nl



Habraken 1199, 5507 TB Veldhoven, The Netherlands

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Sensor locations

