

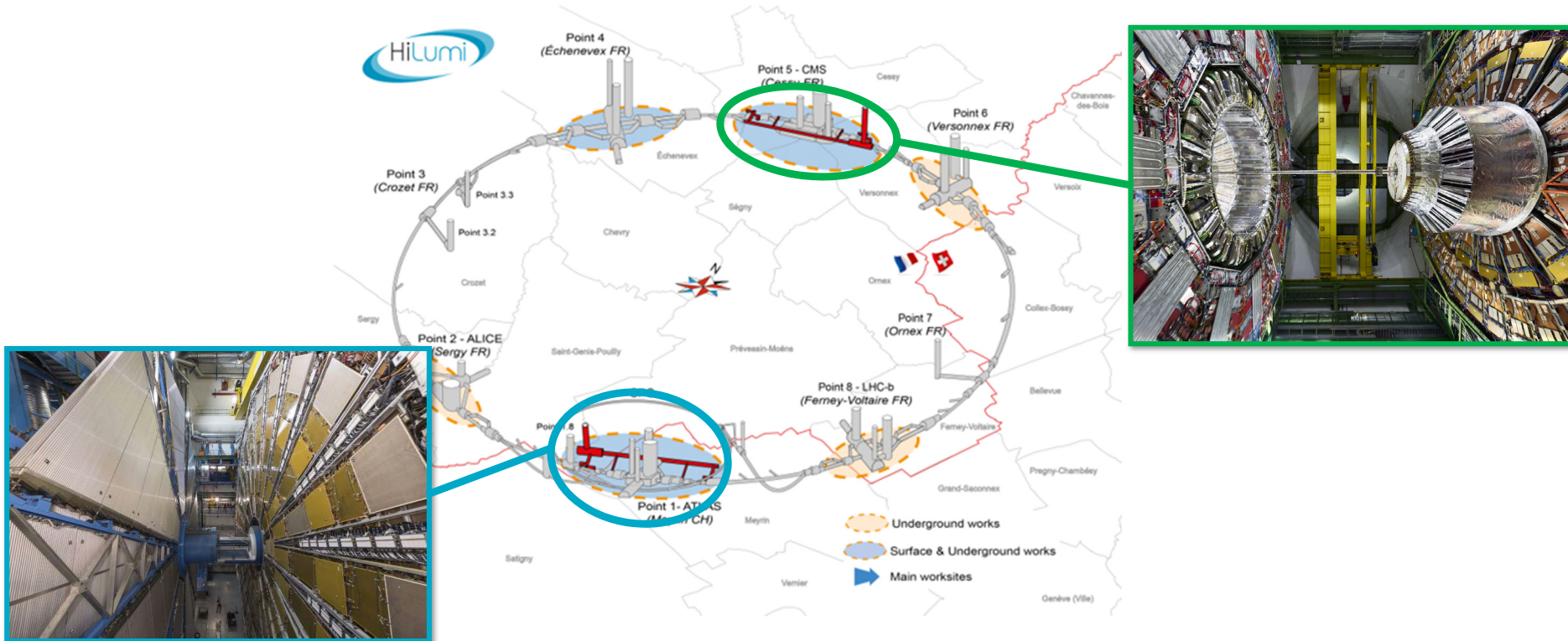


DEVELOPMENT OF A MICROMETER RESOLUTION MOTORIZED ADAPTER

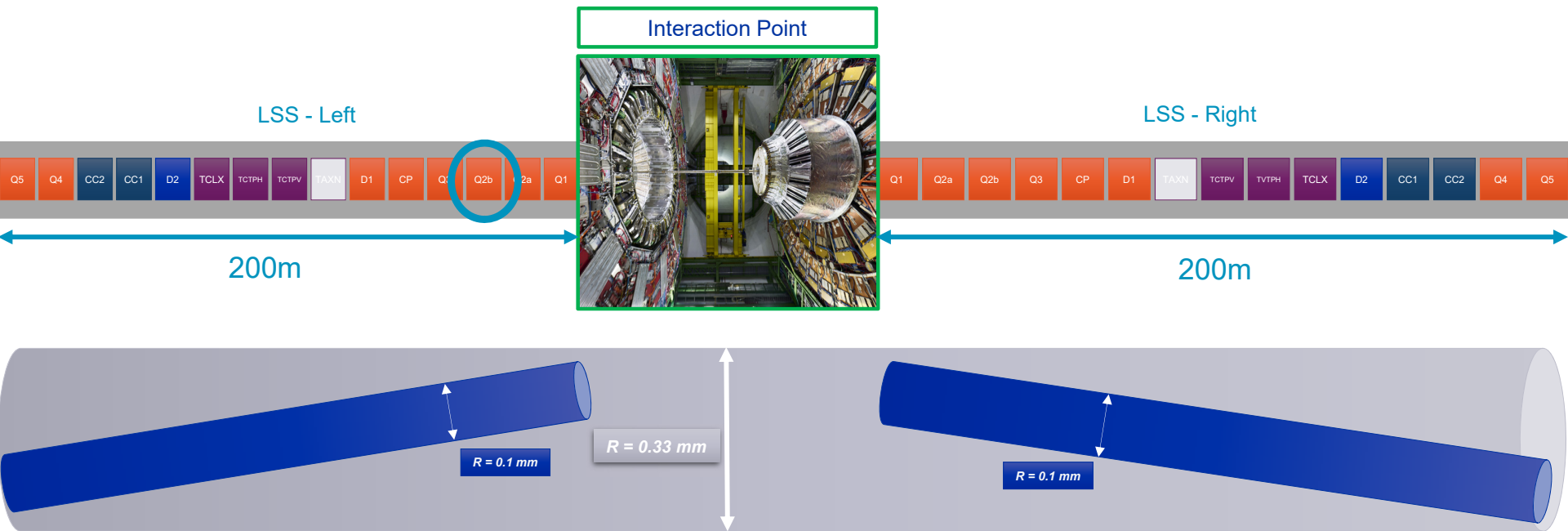
12th International Conference on Mechanical Engineering Design of Synchrotron Radiation Equipment and Instrumentation
Beijing, China, November 06-10 2023, (michel.noir@cern.ch) – THOAM01



The HL-LHC Project - Overview



Alignment requirements for the components

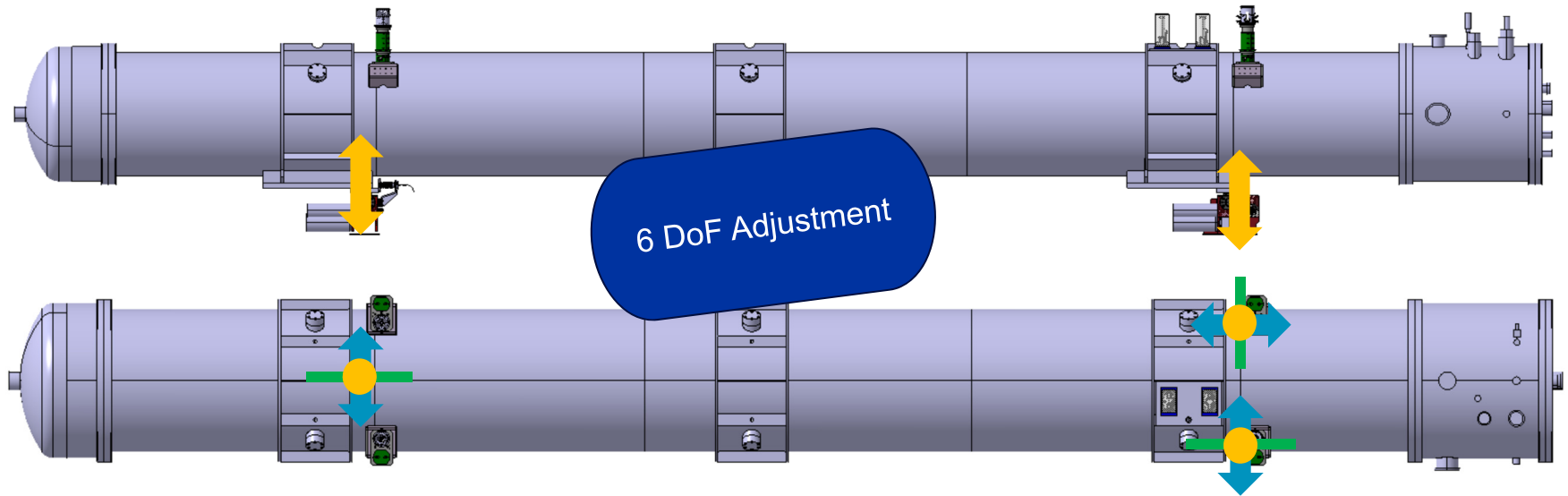


Magnet position adjustment - Kinematic

— Free movement

↔ Motorized actuation - Radial

↕ Motorized actuation - Vertical

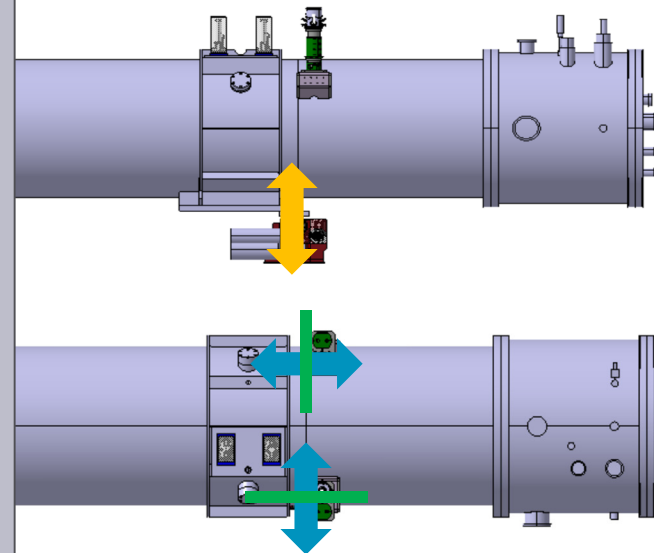
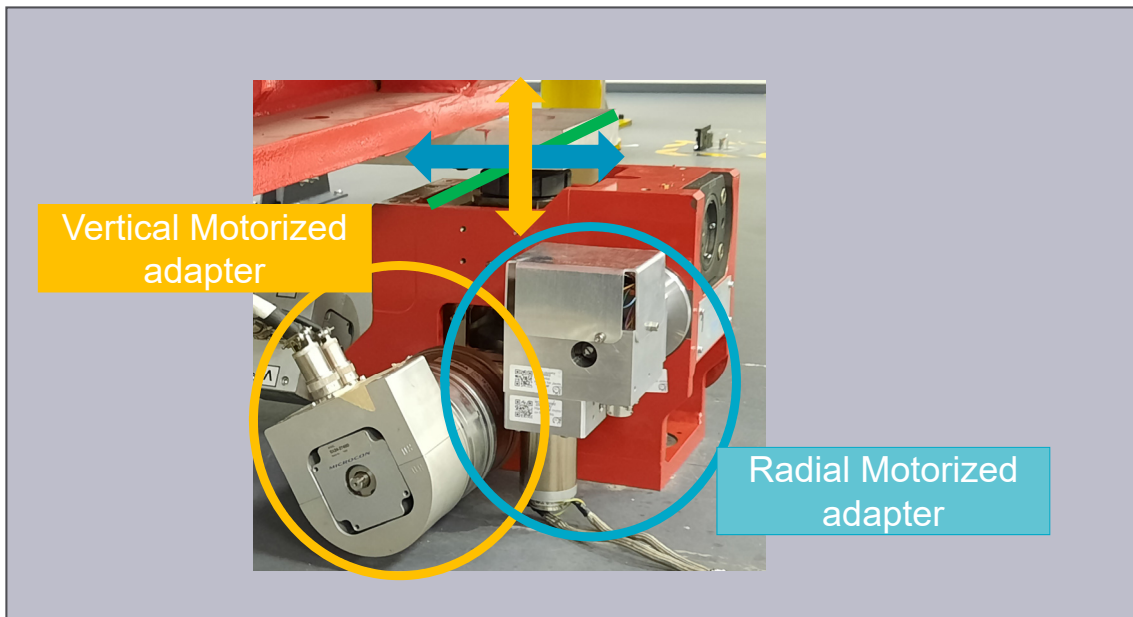


Magnet position adjustment - Kinematic

— Free movement

↔ Motorized actuation - Radial

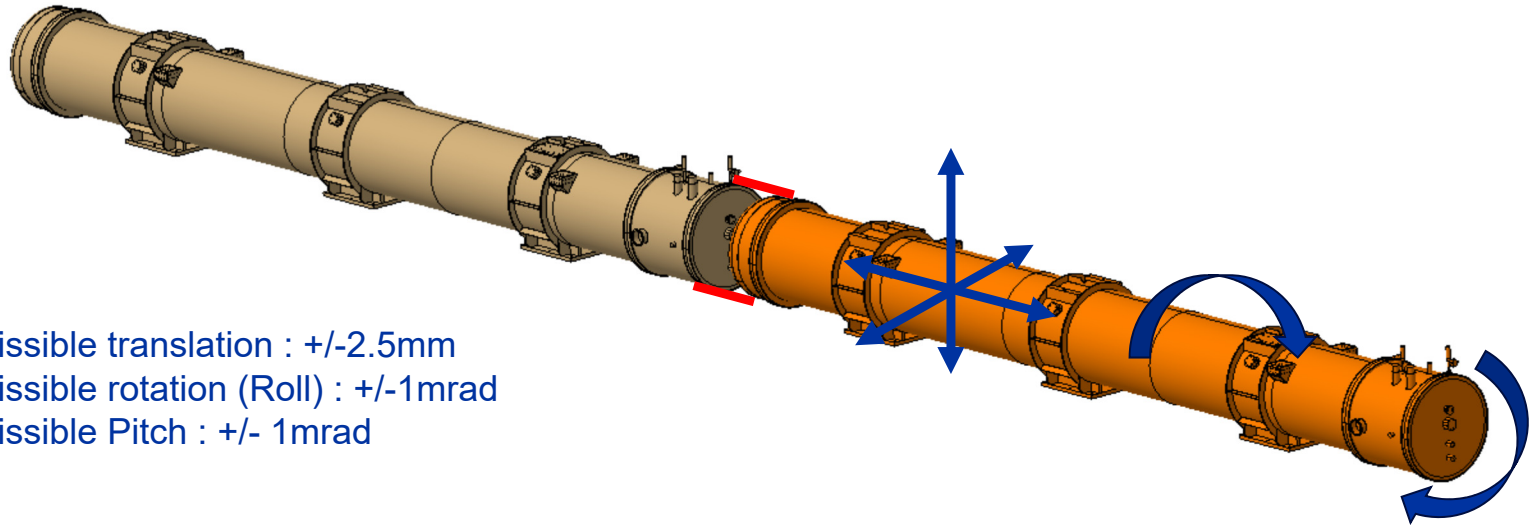
↕ Motorized actuation - Vertical



Alignment requirements for the components

LSS - Left

LSS - Right

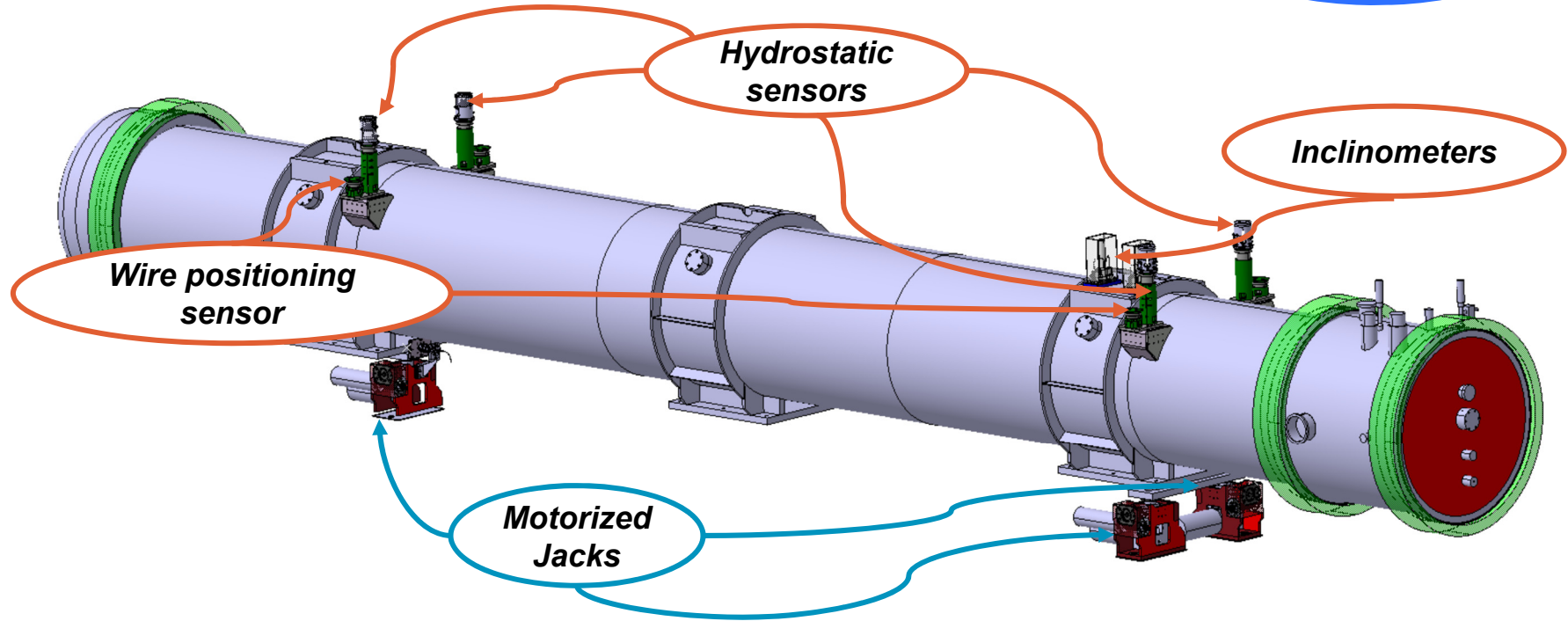


- Admissible translation : $\pm 2.5\text{mm}$
- Admissible rotation (Roll) : $\pm 1\text{mrad}$
- Admissible Pitch : $\pm 1\text{mrad}$

Magnet position adjustment - equipment

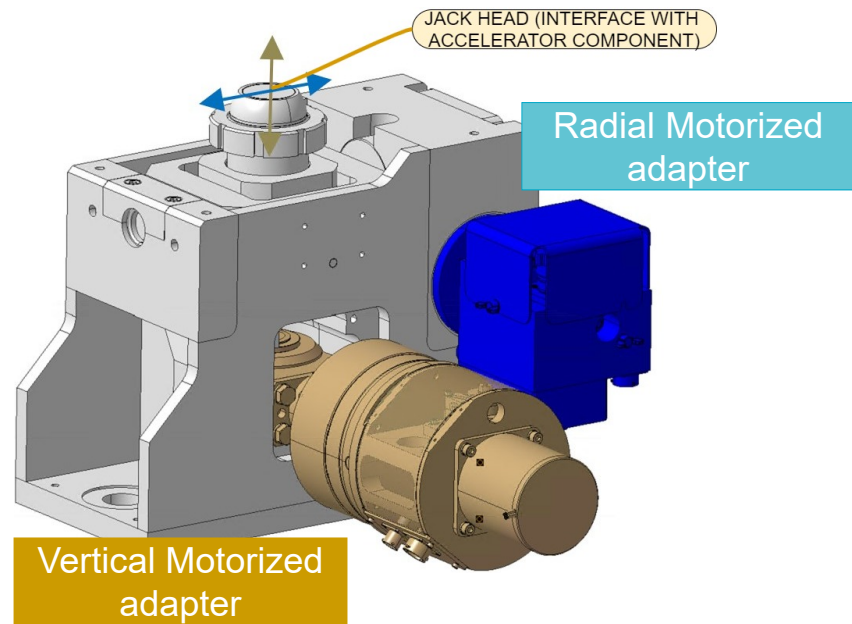
SENSOR

Actuators



Content

- Actuation system
 - Vertical Position adjustment
 - Radial Position adjustment
- Position Monitoring
 - Stroke monitoring system
 - Nominal position adjustment
 - Test results
- Mechanical safety
 - Mechanical End-stop
 - Qualification tests



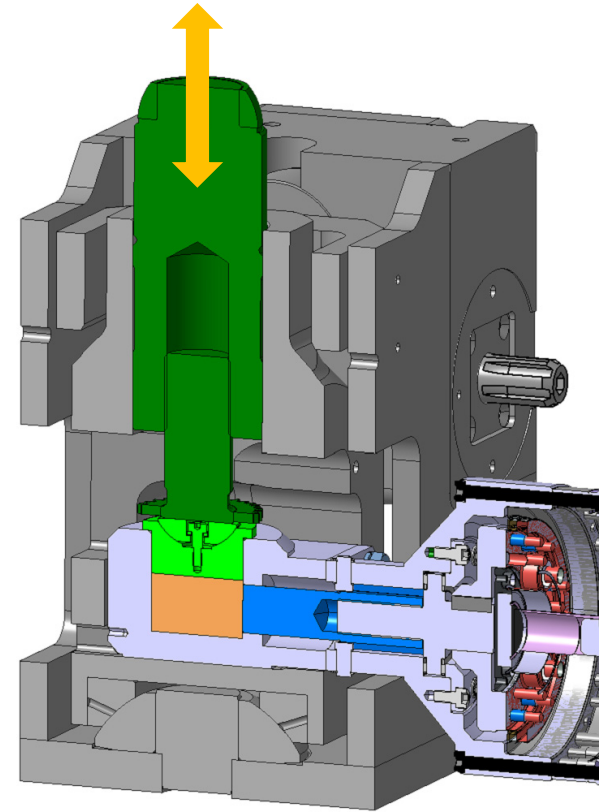
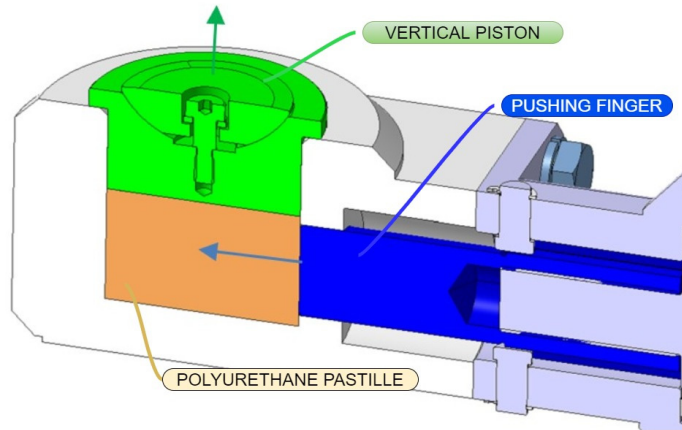
ACTUATION SYSTEM

POSITION MONITORING

MECHANICAL SAFETY

Vertical position adjustment

- Safe Working Load of 17.5t
- Quasi-hydraulic solution using polyurethan
 - Angular transmission
 - Anti-backlash thanks to pastille stress
- Irreversibility integrated in the pushing finger thread



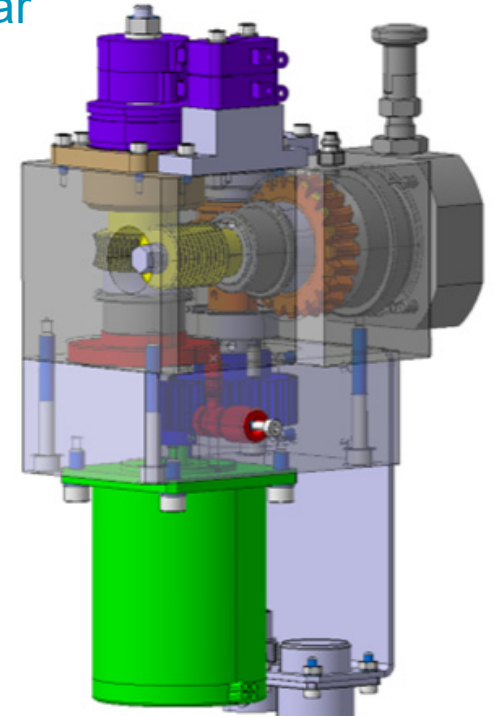
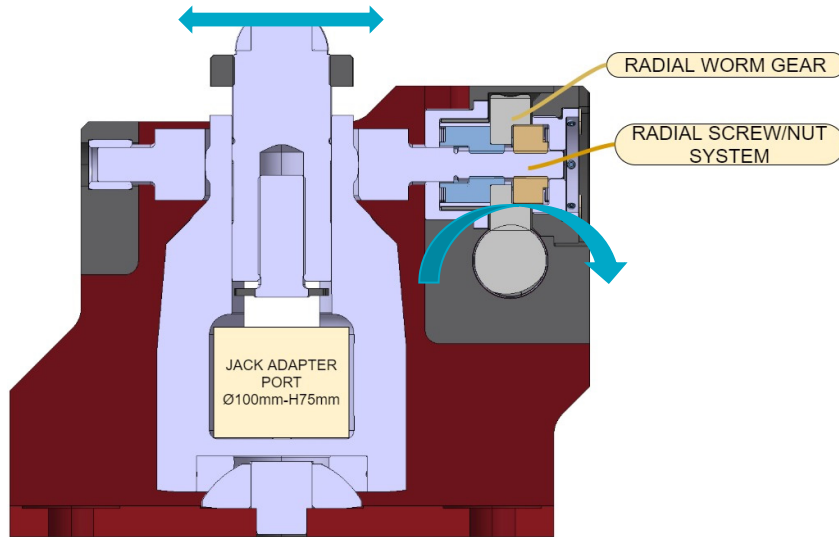
ACTUATION SYSTEM

POSITION MONITORING

MECHANICAL SAFETY

Radial position adjustment

- High gear ratio incorporated in the Jack itself → Worm Gear
- Driving output for the radial adapter → Rotation
- Use of an anti-backlash system → Fine resolution



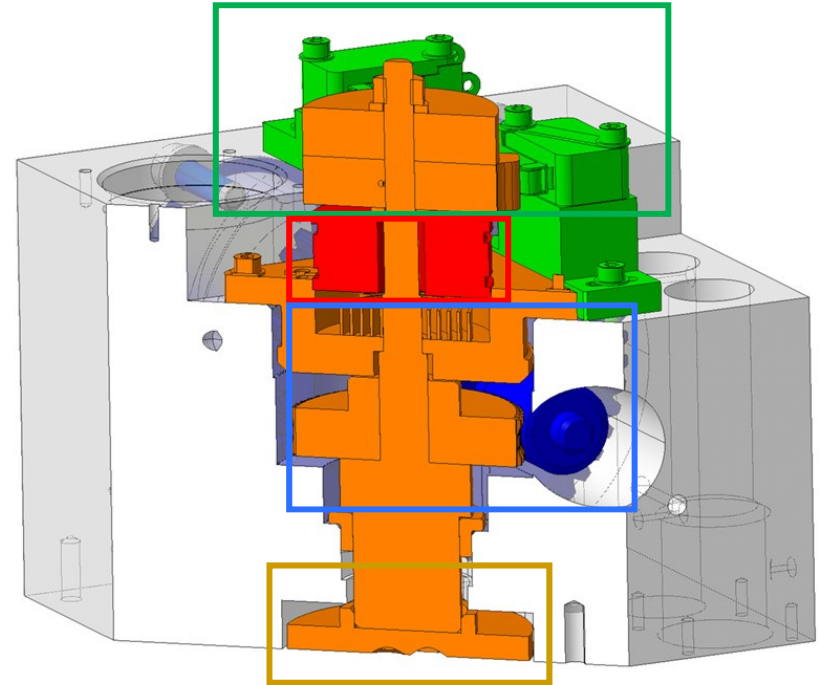
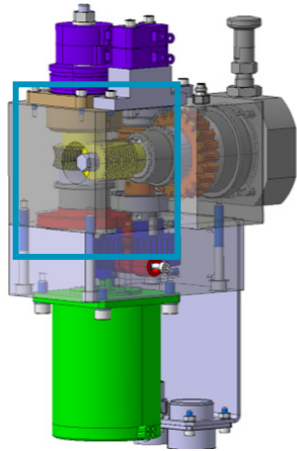
ACTUATION SYSTEM

POSITION MONITORING

MECHANICAL SAFETY

Stroke monitoring system

- One-turn sensor axis with anti-backlash feature.
- Use of resolver in absolute configuration thanks to calibration.
- Installation of electrical end-switches



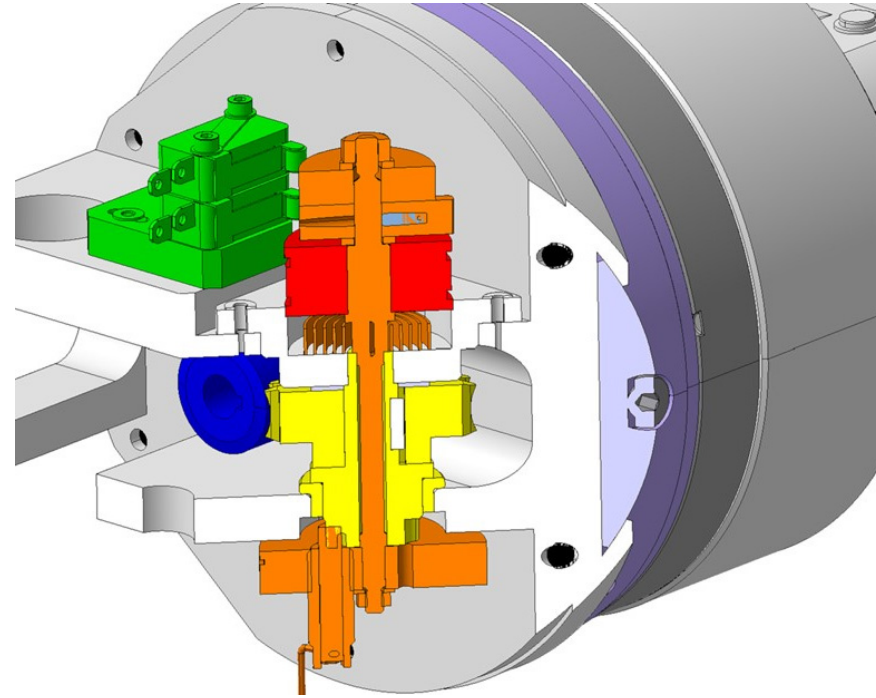
ACTUATION SYSTEM

POSITION MONITORING

MECHANICAL SAFETY

Nominal Position Adjustment

- Complete sensor axis position can be configured onsite.
- Adjustment performed at the same time on all stroke monitoring elements



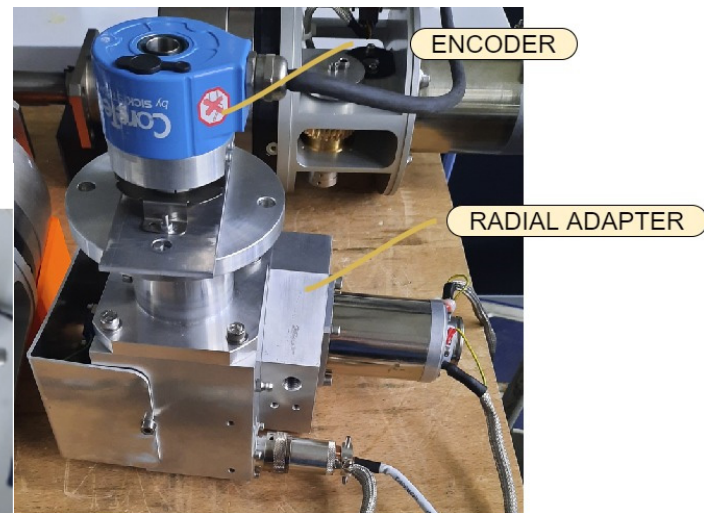
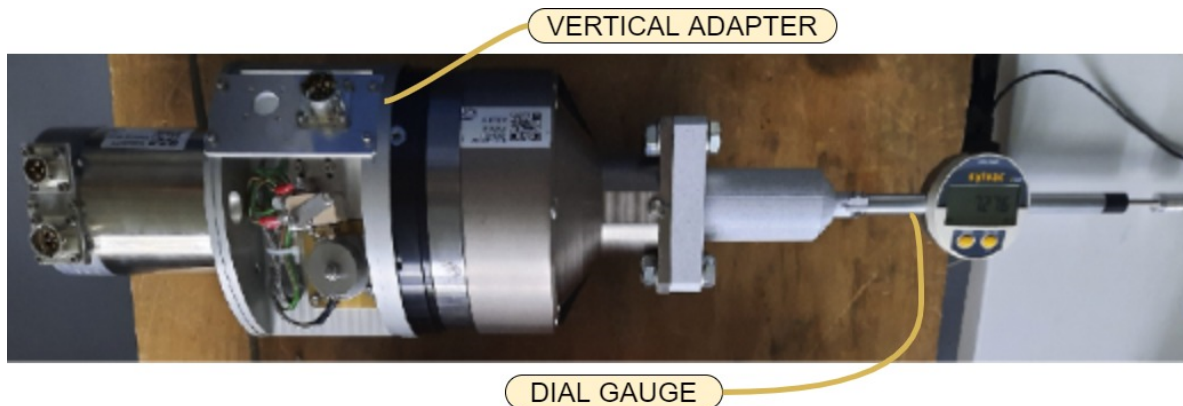
ACTUATION SYSTEM

POSITION MONITORING

MECHANICAL SAFETY

Position monitoring - qualification

- Two test configuration developed to verify position monitoring performances
- Comparison performed between motor step counting, resolver reader and measured output.



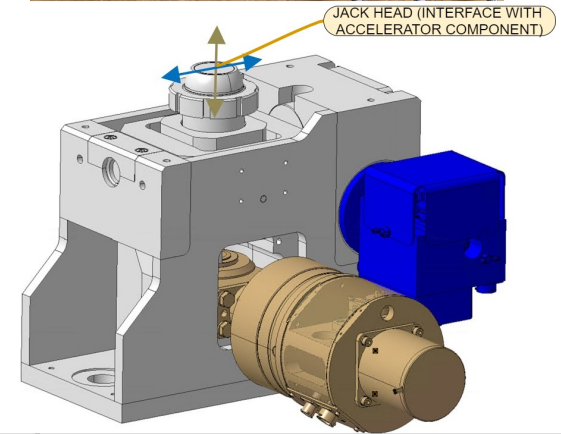
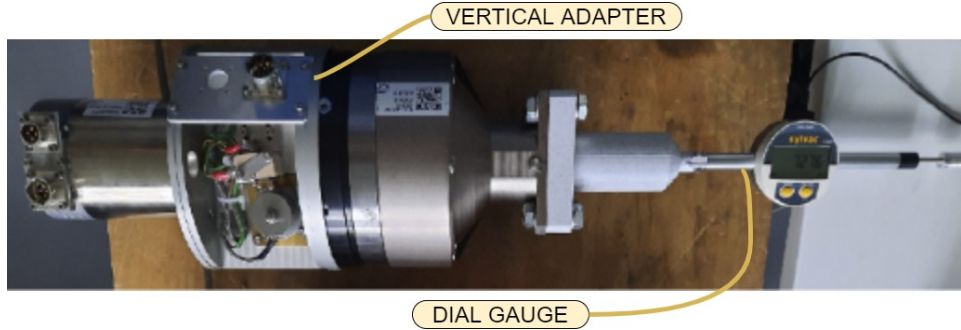
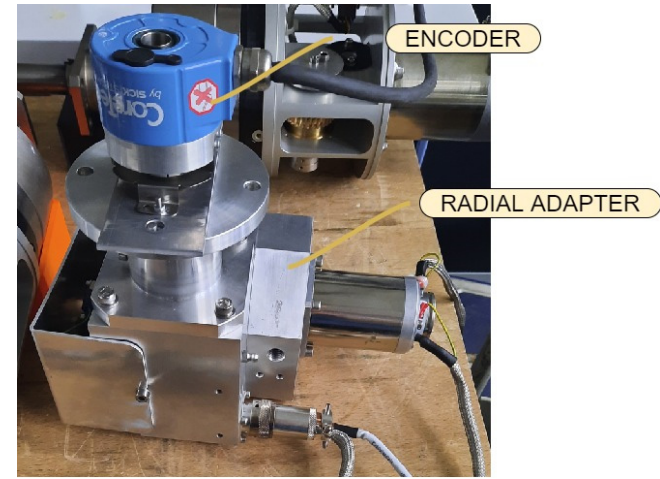
ACTUATION SYSTEM

POSITION MONITORING

MECHANICAL SAFETY

Position monitoring - qualification

- Two test configuration developed to verify position monitoring performances
- Comparison performed between motor step counting, resolver reader and measured output.
- All results are computed as a jack motion estimation defect value



ACTUATION SYSTEM

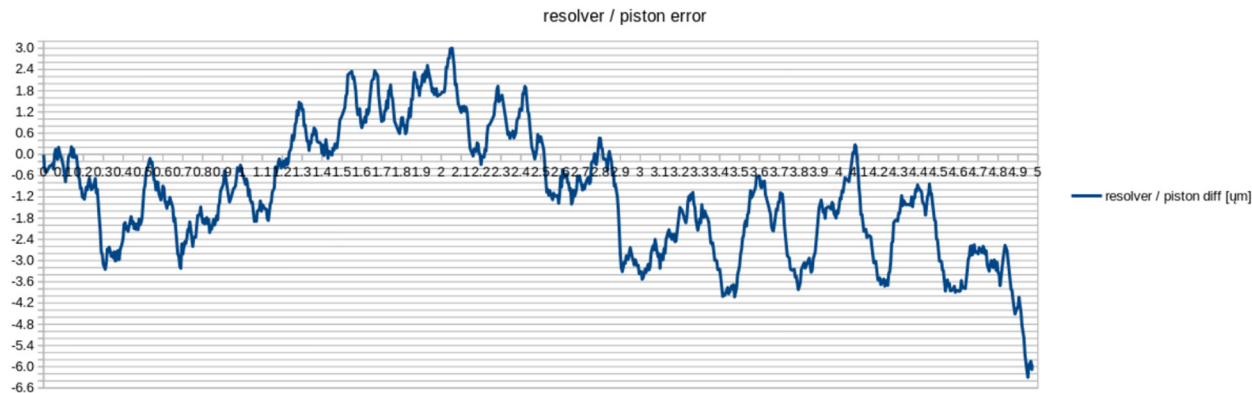
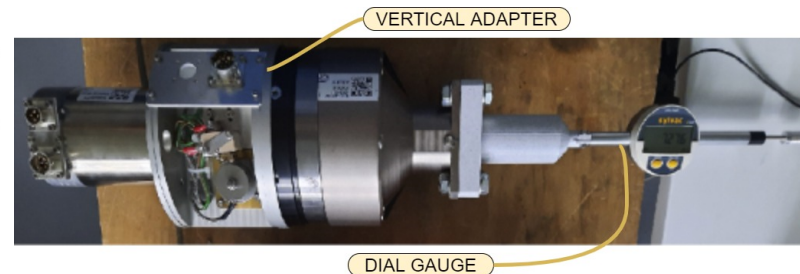
POSITION MONITORING

MECHANICAL SAFETY

Position monitoring - qualification

Table 1: Position Parameters for the vertical adapter

PARAMETER	SPECIFICATION	RESULT
Total Stroke [mm]	5 ± 0.05	4.952
Repeatability [μm]	0.5	0.05
Backlash [μm]	1	0.02
Absolut position [μm]	20	6



ACTUATION SYSTEM

POSITION MONITORING

MECHANICAL SAFETY

Position monitoring - qualification

Table 1: Position Parameters for the vertical adapter

PARAMETER	SPECIFICATION	RESULT
Total Stroke [mm]	5 ± 0.05	4.952
Repeatability [μm]	0.5	0.05
Backlash [μm]	1	0.02
Absolut position [μm]	20	6

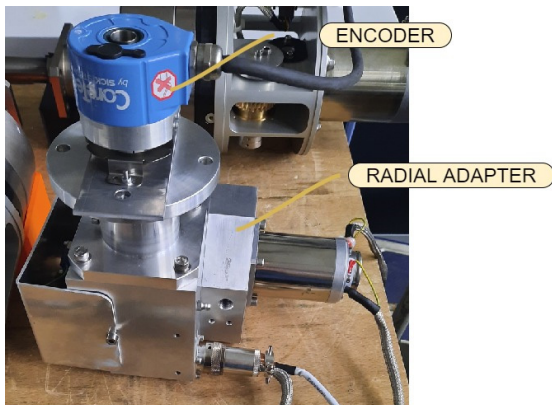
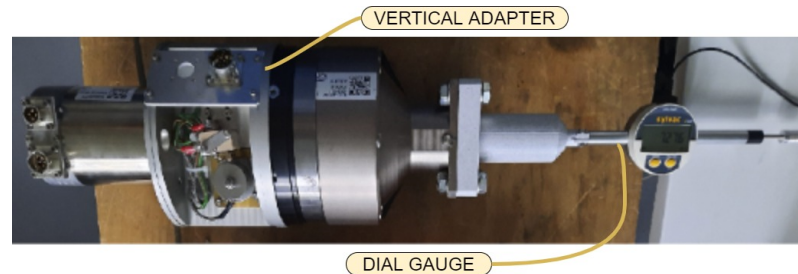


Table 2: Position Parameters for the radial adapter

PARAMETER	SPECIFICATION	RESULT
Total Stroke [mm]	5 ± 0.05	4.971
Repeatability [μm]	0.5	0.05
Backlash [μm]	1	0.25
Absolut position [μm]	20	10

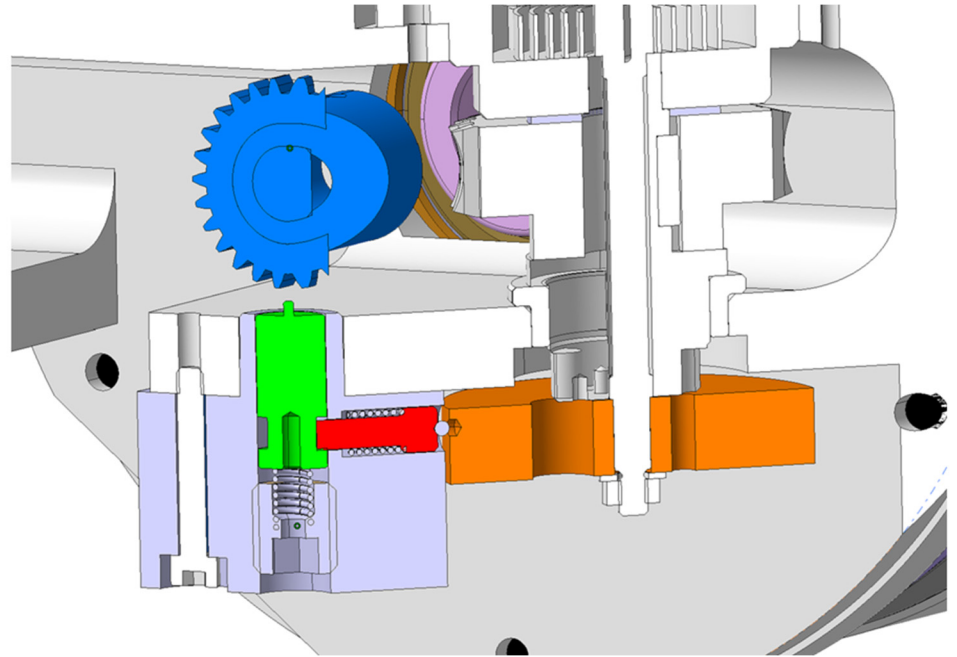
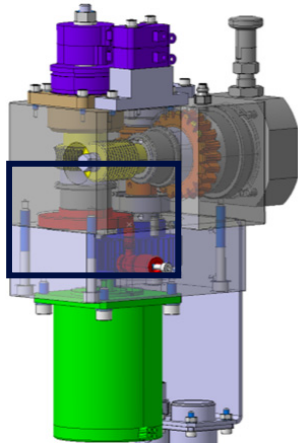
ACTUATION SYSTEM

POSITION MONITORING

MECHANICAL SAFETY

Mechanical safety - design

- Independent triggering of a mechanical end-stop – Factory settings
- Direct action on the motor pinion for miniaturisation (stress is limited)



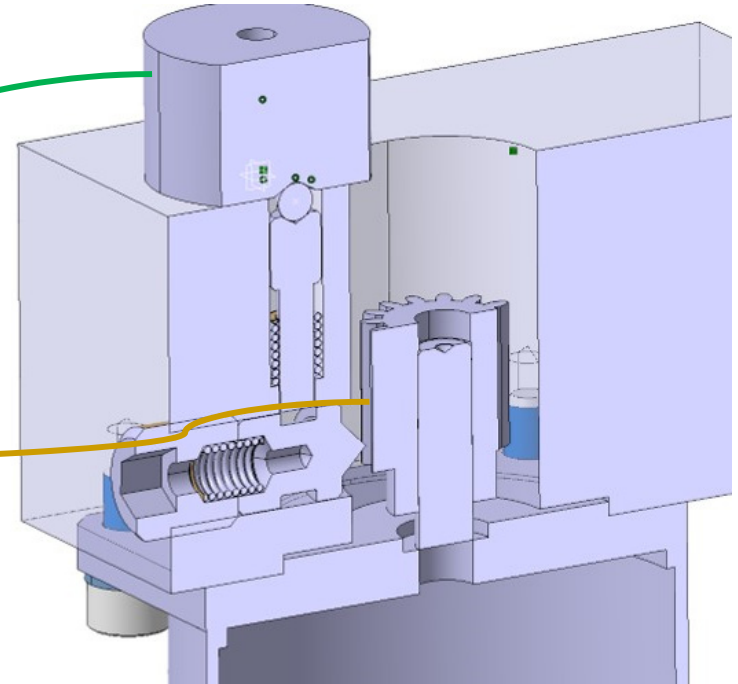
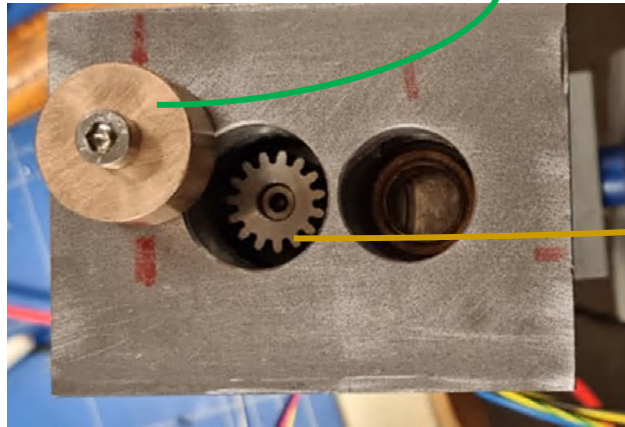
ACTUATION SYSTEM

POSITION MONITORING

MECHANICAL SAFETY

Mechanical safety - qualification

- First triggering prototype has been built to validate feasibility
- Actuation of the trigger up to 75 times without any problem



ACTUATION SYSTEM

POSITION MONITORING

MECHANICAL SAFETY

Mechanical safety - qualification

- Locking pin size and shape adjusted
- Instantaneous locking of the adapter
- Irreversible operation – adapter refurbishment necessary

ACTUATION SYSTEM

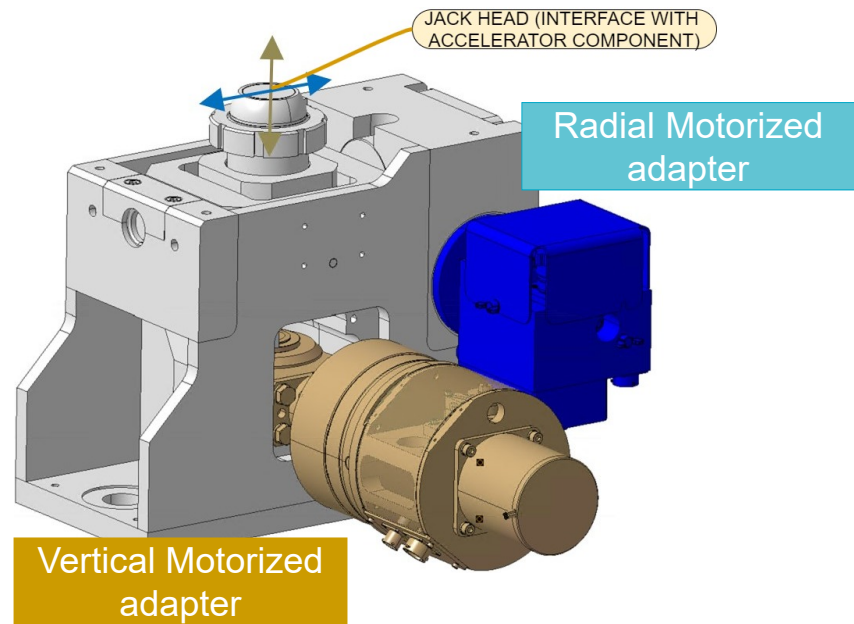
POSITION MONITORING

MECHANICAL SAFETY



Conclusion

- Both motorized adapters individual tests are successful and resolution overpassed expectations.
- Single magnet configuration to be settled to perform:
 - Loaded test.
 - 6 DoF adjustment test.
 - Durability test.
- Serial production will be organized for next year.



ACTUATION SYSTEM

POSITION MONITORING

MECHANICAL SAFETY

THANKS FOR YOUR ATTENTION

谢谢倾听



[1] G Apollinari, I Béjar Alonso, and L Rossi O Brüning M Lamont. High-Luminosity Large Hadron Collider (HL-LHC): Preliminary Design Report. CERN Yellow Reports: Monographs. Geneva: CERN, 2015.

[2] O Aberle et al. "High-luminosity large hadron collider (HL-LHC): Technical design report." In: (2020).

[3] Andreas Herty et al. "HL-LHC full remote alignment study." In: 10th International Particle Accelerator Conference, Melbourne, Australia. 2019, pp. 19–24.

[4] Piotr Biedrawa et al. Full remote alignment system for the High-Luminosity Large Hadron Collider HL-LHC. Tech. rep. Geneva: CERN, 2022.

[5] Mateusz Sosin 2589302. Full Remote Alignment System software - Functional Specification. Tech. rep. 2022.

[6] Mateusz Sosin et al. "Design and study of a 6 Degree of Freedom universal adjustment platform for HL-LHC components." In: 10th Int. Particle Accelerator Conf.(IPAC'19), Melbourne, Australia, 19-24 May 2019. JACOW Publishing, Geneva, Switzerland. 2019, pp. 3720–3722