CGEM Insertion Test

Stefano Gramigna on behalf of the working group

IDC Upgrade Meeting - 2024/07/08

Outline

- Aims
- Setup
- Operations
- Conclusion

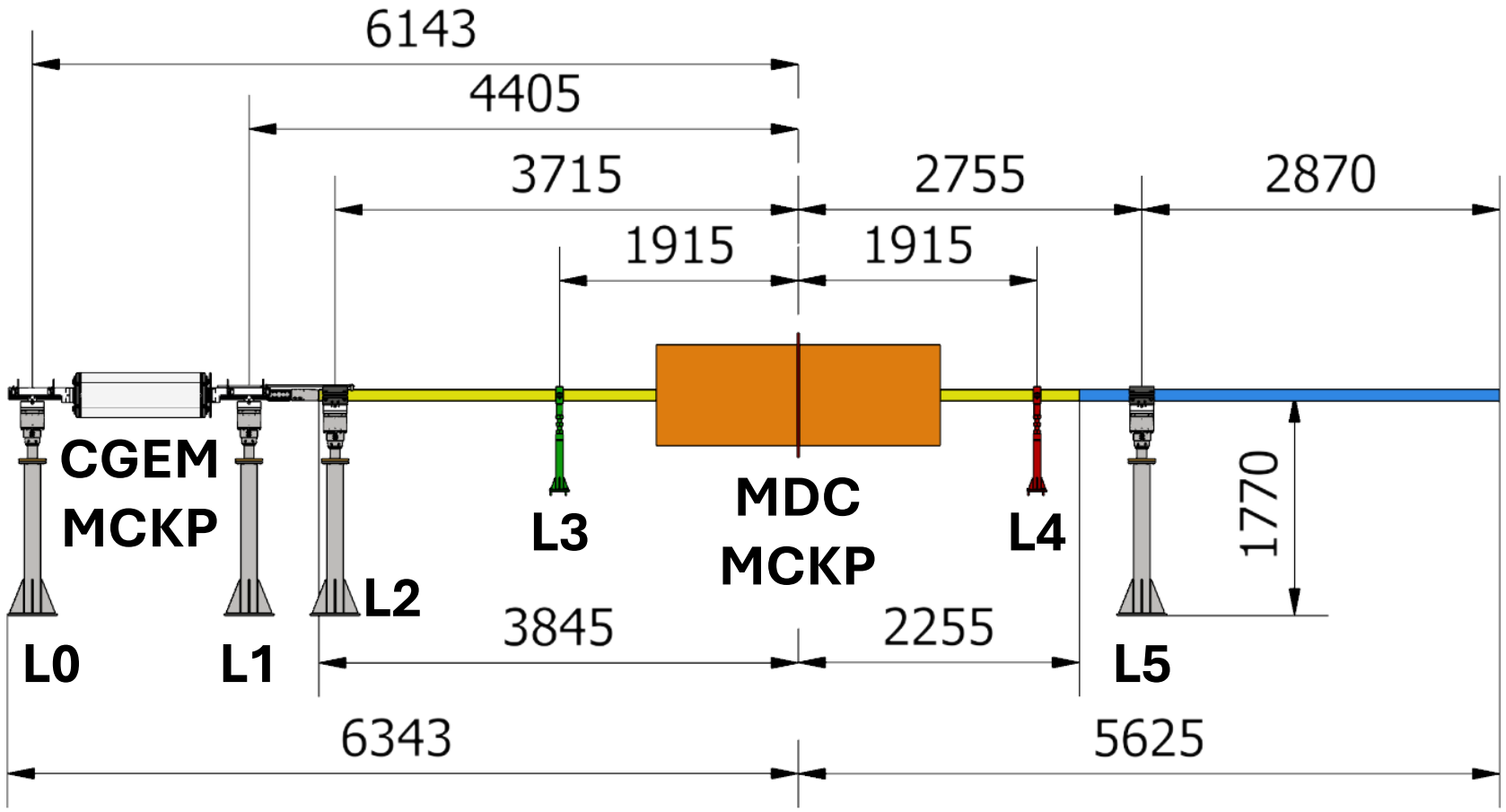
Insertion Test

Aims of the Second Insertion Test

- Prove the **feasibility** of the insertion with real dimensions **OK**
- Test changes and improvements to the **tooling** **OK**
- Finalize the **procedure** for CGEM installation **WIP**
- **Practice** with the rail adjustment mechanisms **OK**

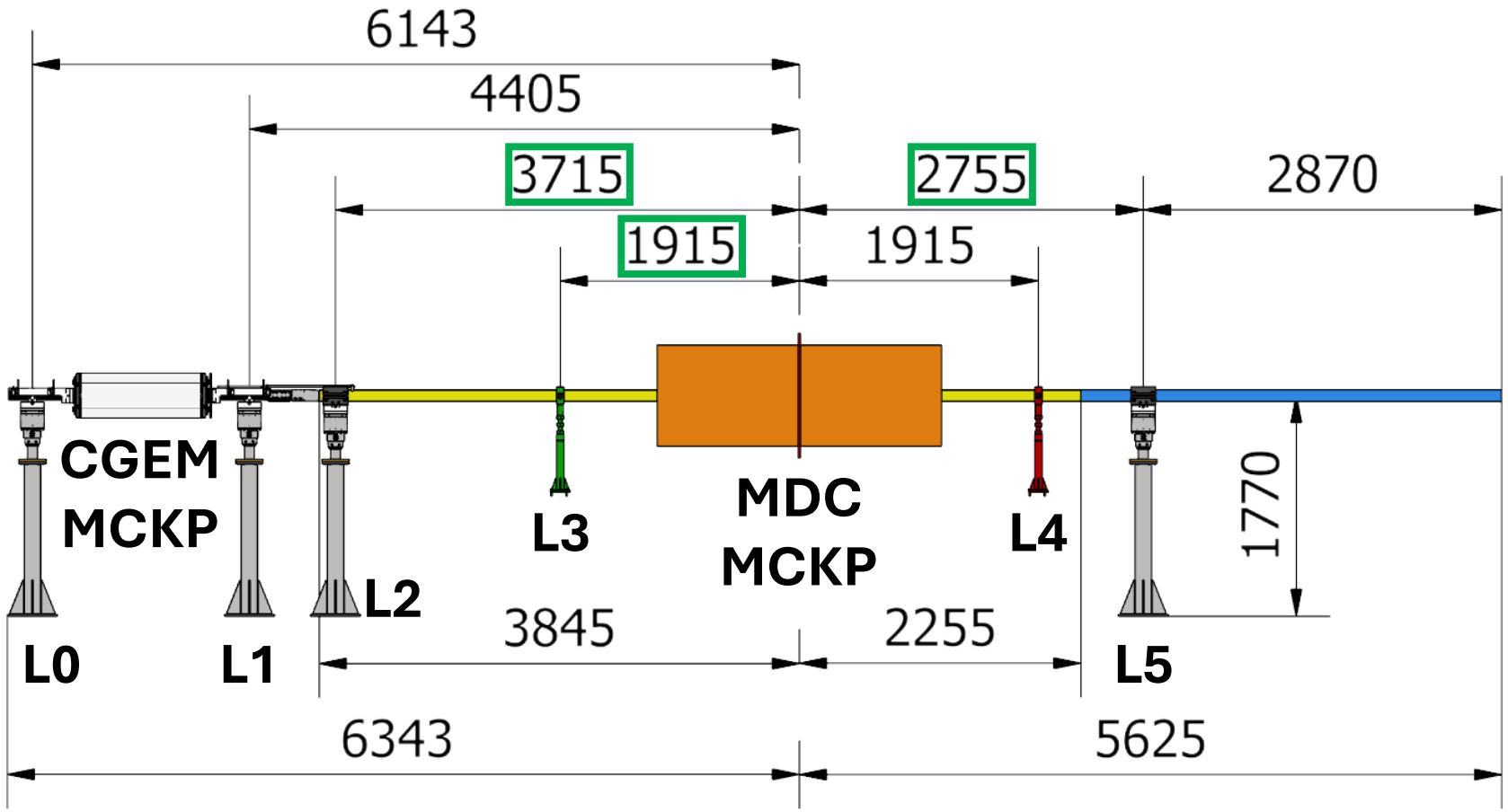
Test Setup

Test Setup


6143
4405
3715
2755
2870
1915
1915
CGEM
MCKP
L3
MDC
MCKP
L4
1770
L0
L1
L2
3845
2255
L5
6343
5625

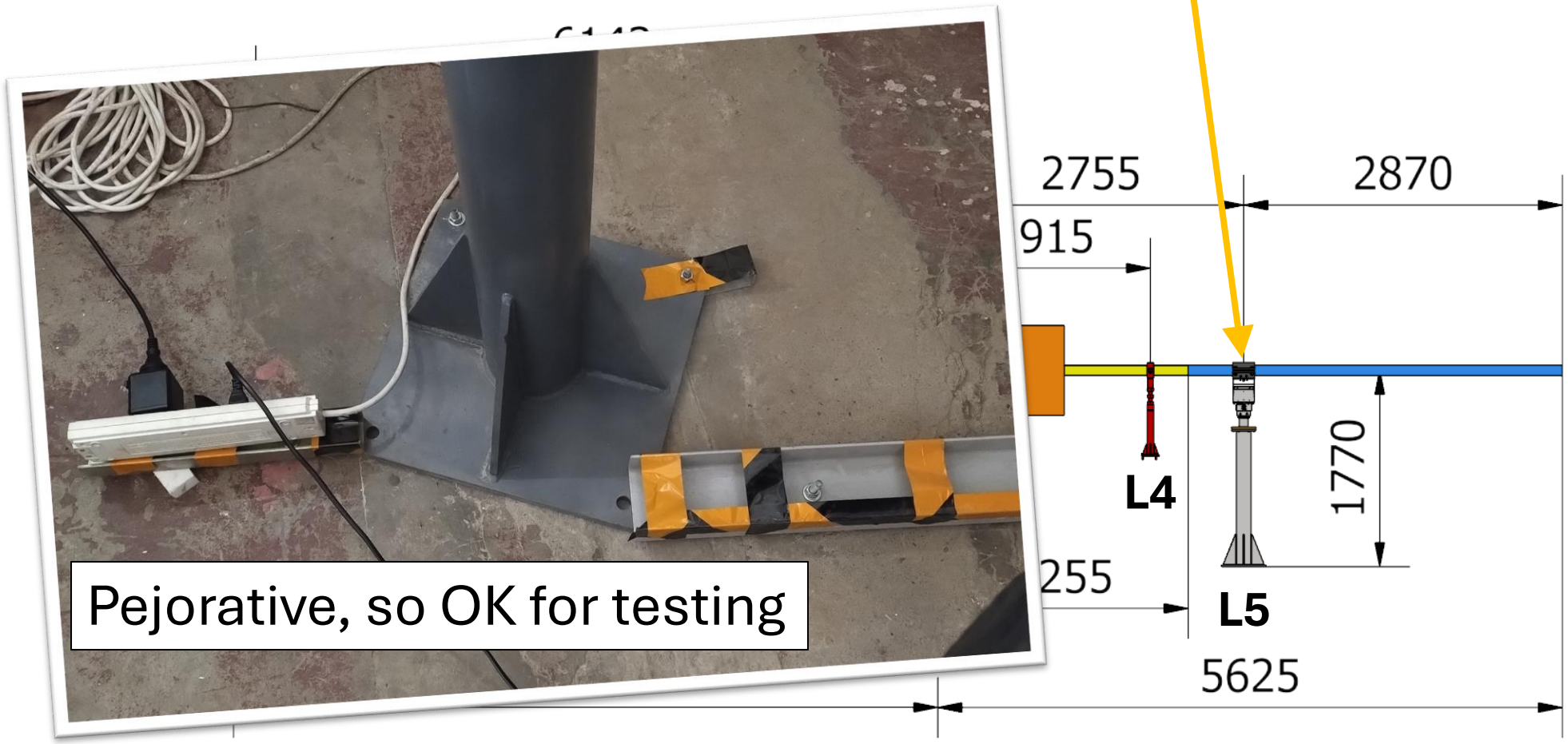
Test Setup

These important dimensions were respected



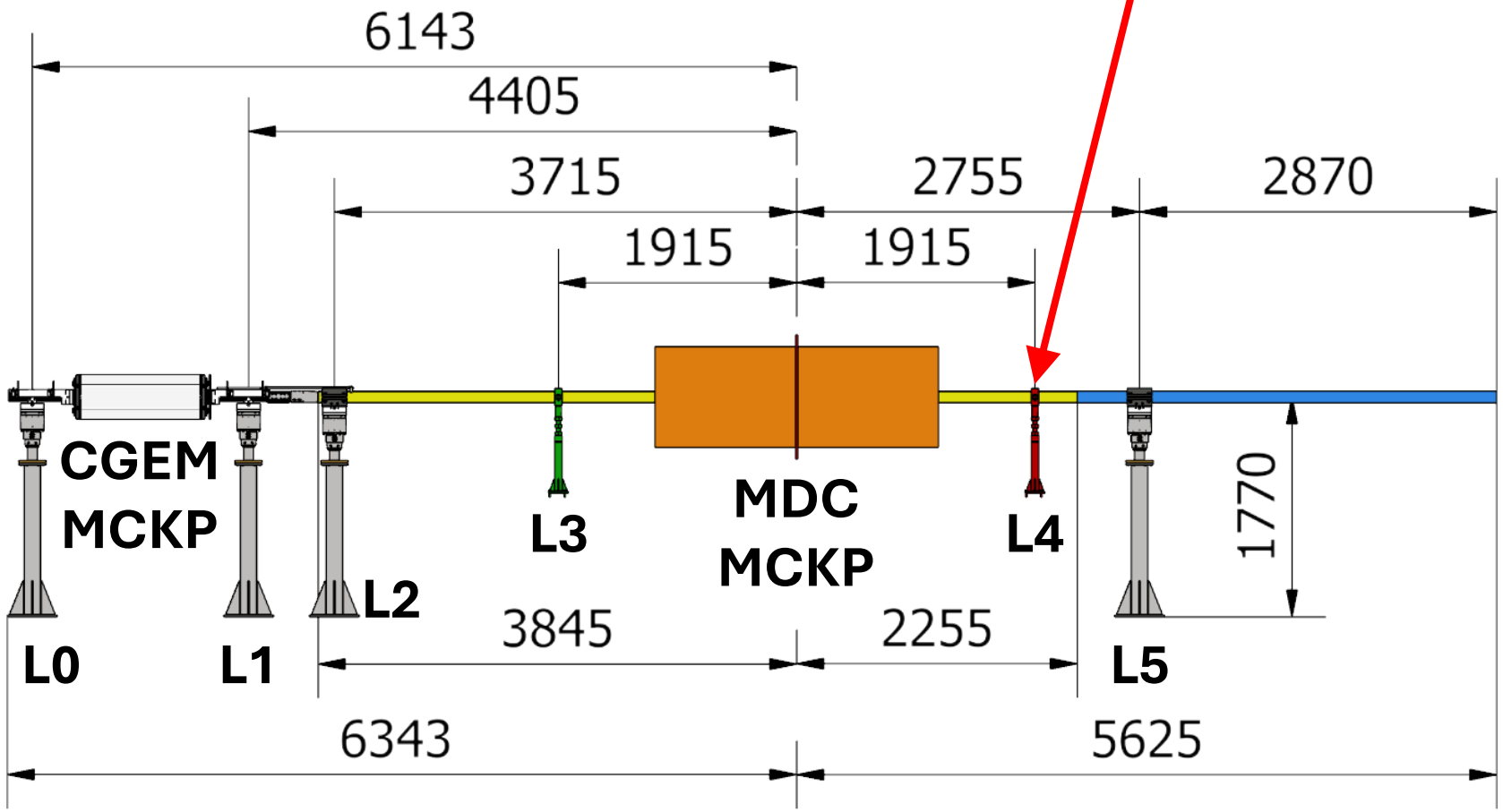
Test Setup

L5 could not be bolted directly to the floor due to the presence of some pipes



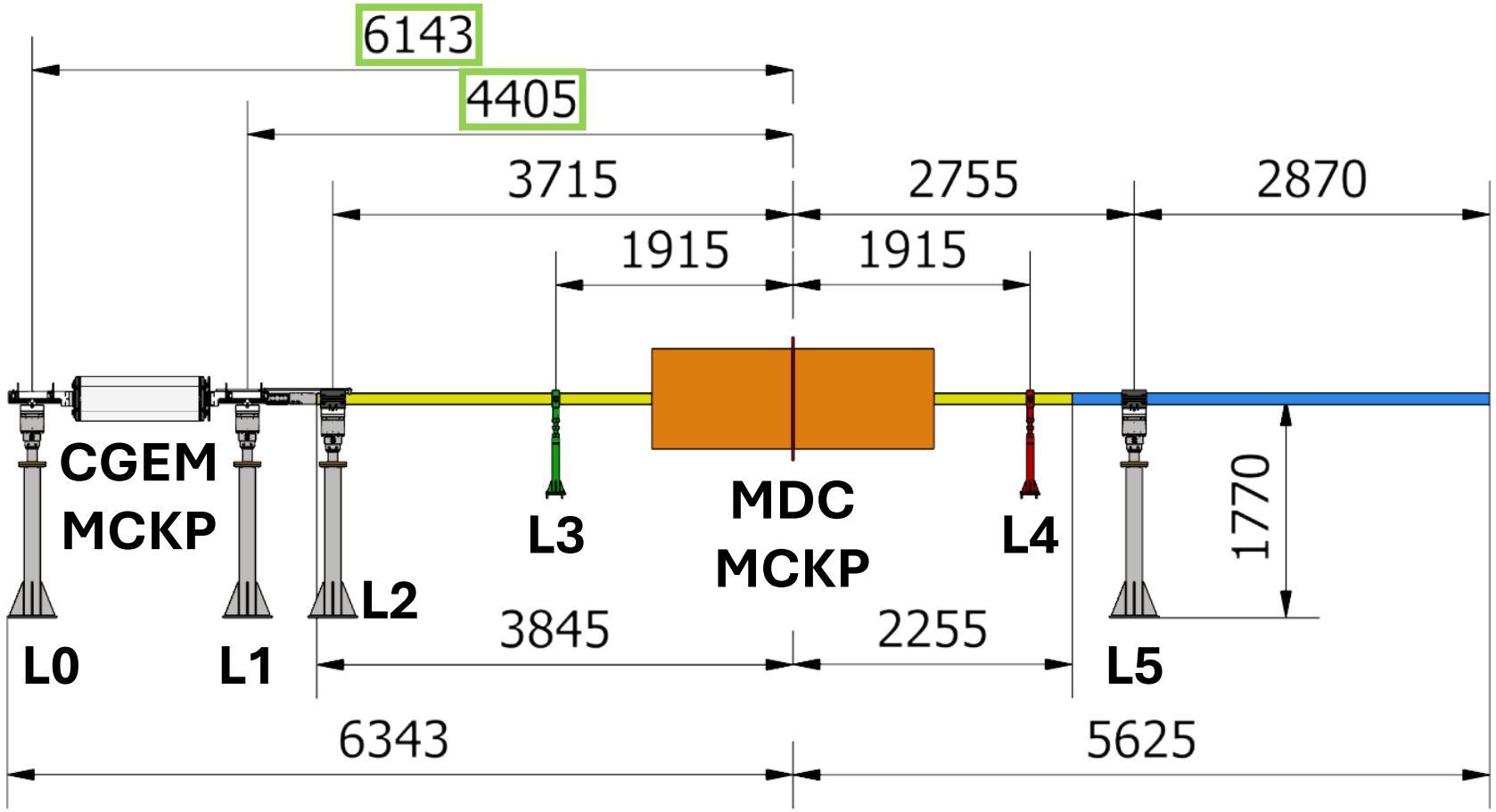
Test Setup

No space for mounting L4 in the setup
...but we did not need to use it



Test Setup

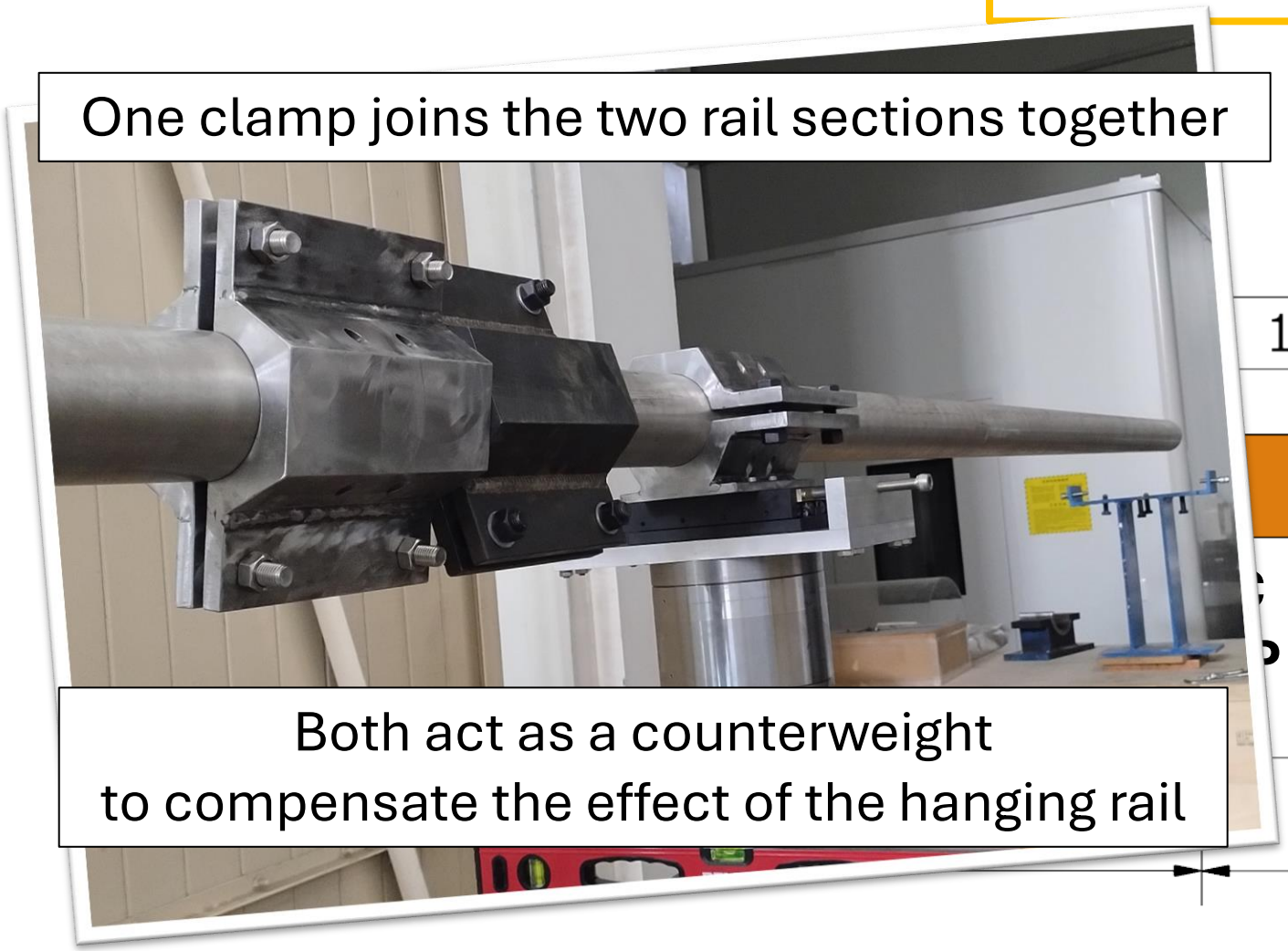
These dimensions fit the concrete platform but they are not necessarily final

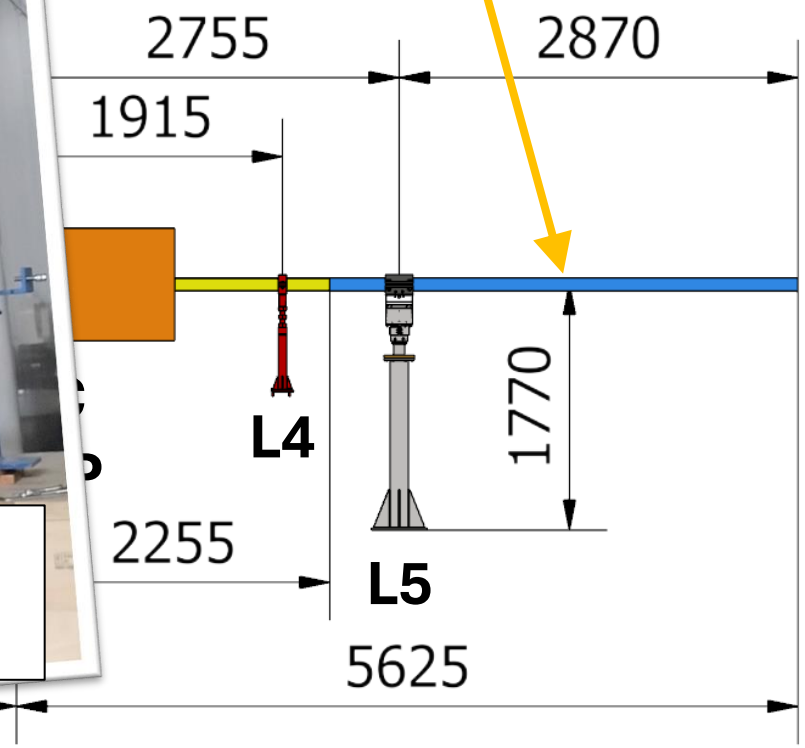


Test Setup

This hanging part of rail was an issue but we found a solution

One clamp joins the two rail sections together





Both act as a counterweight
to compensate the effect of the hanging rail

Issues with New Legs' Production

UNSATISFACTORY QUALITY OF PARTS PRODUCTION

"Workarounds" are necessary to make the legs usable

Asymmetry of the MDC Mock-up

The MDC mock-up is 1 mm longer on the top
Shims had to be used to compensate this effect and test CGEM anchoring

Operations

Preliminary Test Timeline

Mon 07/01	Tue 07/02	Wed 07/03	Thu 07/04	Fri 07/05	Sat 07/06	Sun 07/07
Procedure preparation	Procedure Review	Trolley support pre-alignment	Transfer of the trolley onto the rail	Insertion	Anchoring	Trolley extraction
Test setup preparation	Test setup preparation	Trolley support alignment	Travel towards the MDC			Trolley insertion
						Mockup extraction

As presented at the last CGEM Workshop

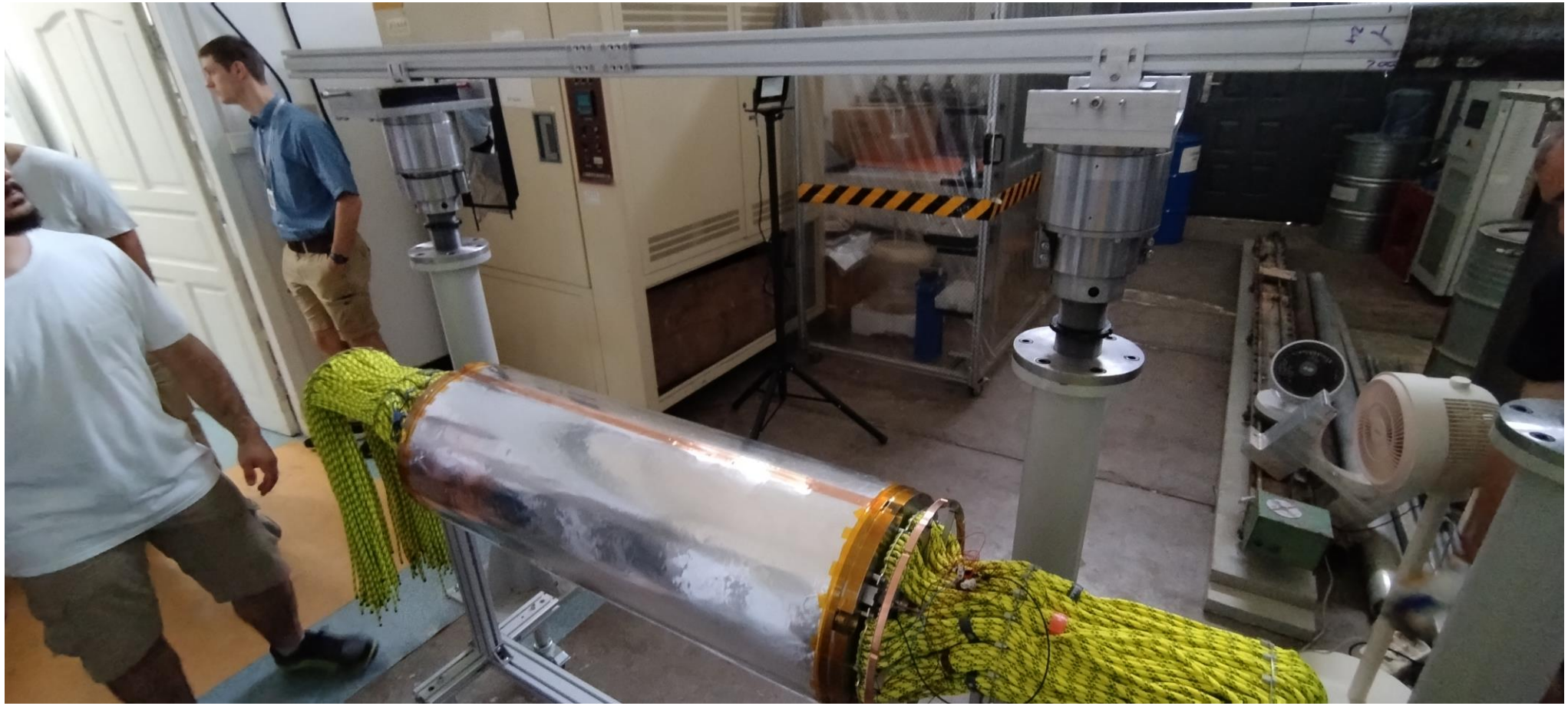
Actual Test Timeline

Mon 07/01	Tue 07/02	Wed 07/03	Thu 07/04	Fri 07/05	Sat 07/06	Sun 07/07
Procedure preparation	Procedure preparation	Procedure preparation	Trolley support pre-alignment	Insertion	Anchoring	Trolley extraction
Test setup preparation	Test setup preparation	Test setup preparation	Trolley support alignment			Trolley insertion
			Transfer of the trolley onto the rail			Mockup extraction
			Travel towards the MDC			Cleanup of the working area

Phases of the test

1. **Transport** → Not tested | Dedicated test in future
2. **Rail coupling** → **TESTED**
3. **Transfer to the rail** → **TESTED**
4. **Travel towards the MDC** → **TESTED**, Intrinsic
5. **Insertion** → **TESTED**
6. **Anchoring** → **TESTED, setup had to be adapted**
7. **“Cabling”** → **Not a real test** | Dedicated test ongoing
8. **Trolley extraction** → **TESTED**
9. **Mockup extraction** → **TESTED**

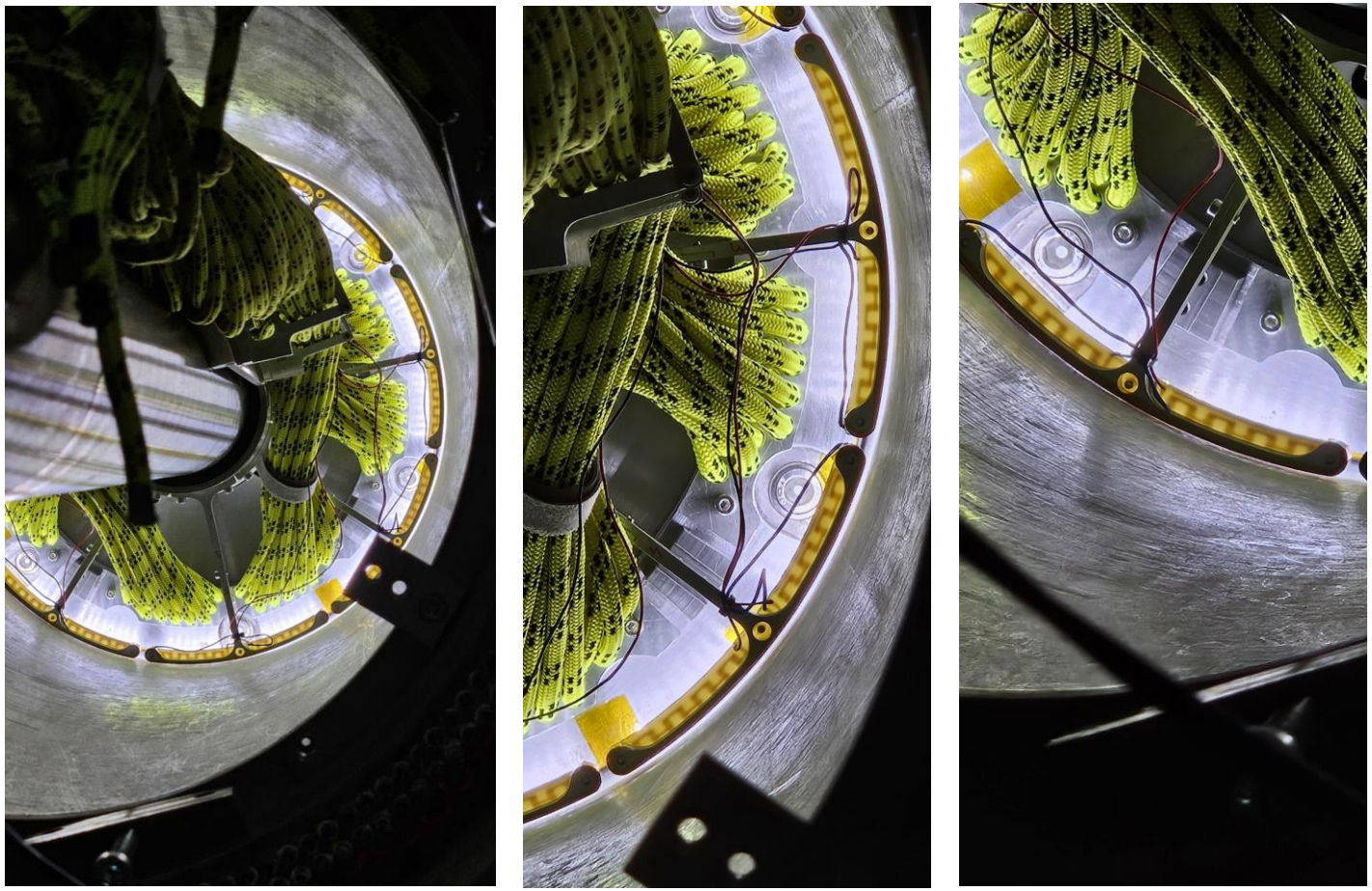
DAY 1: Trolley Support Pre-alignment



DAY 1: Trolley Support Alignment and Rail Coupling

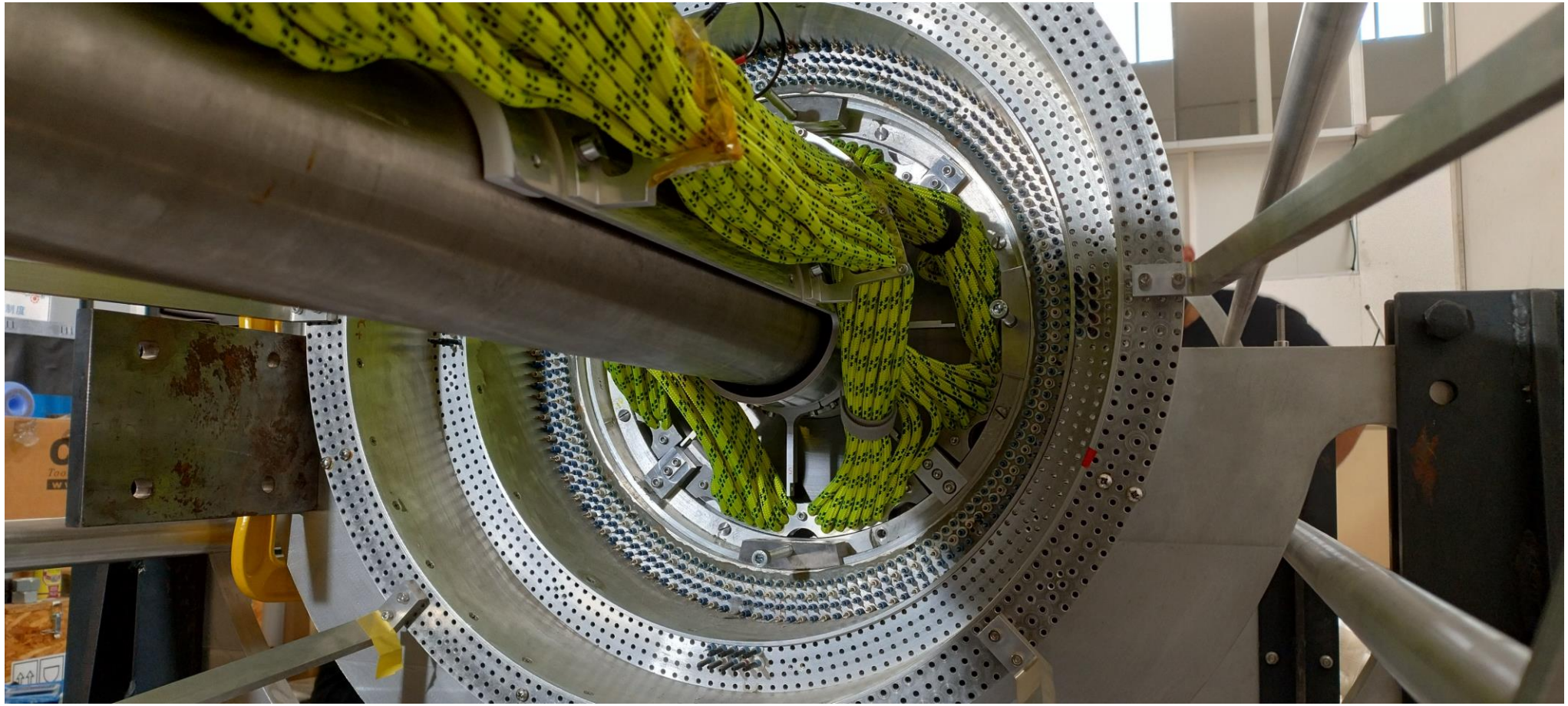
DAY 1: Travel towards the MDC Mock-up

DAY 2: Insertion



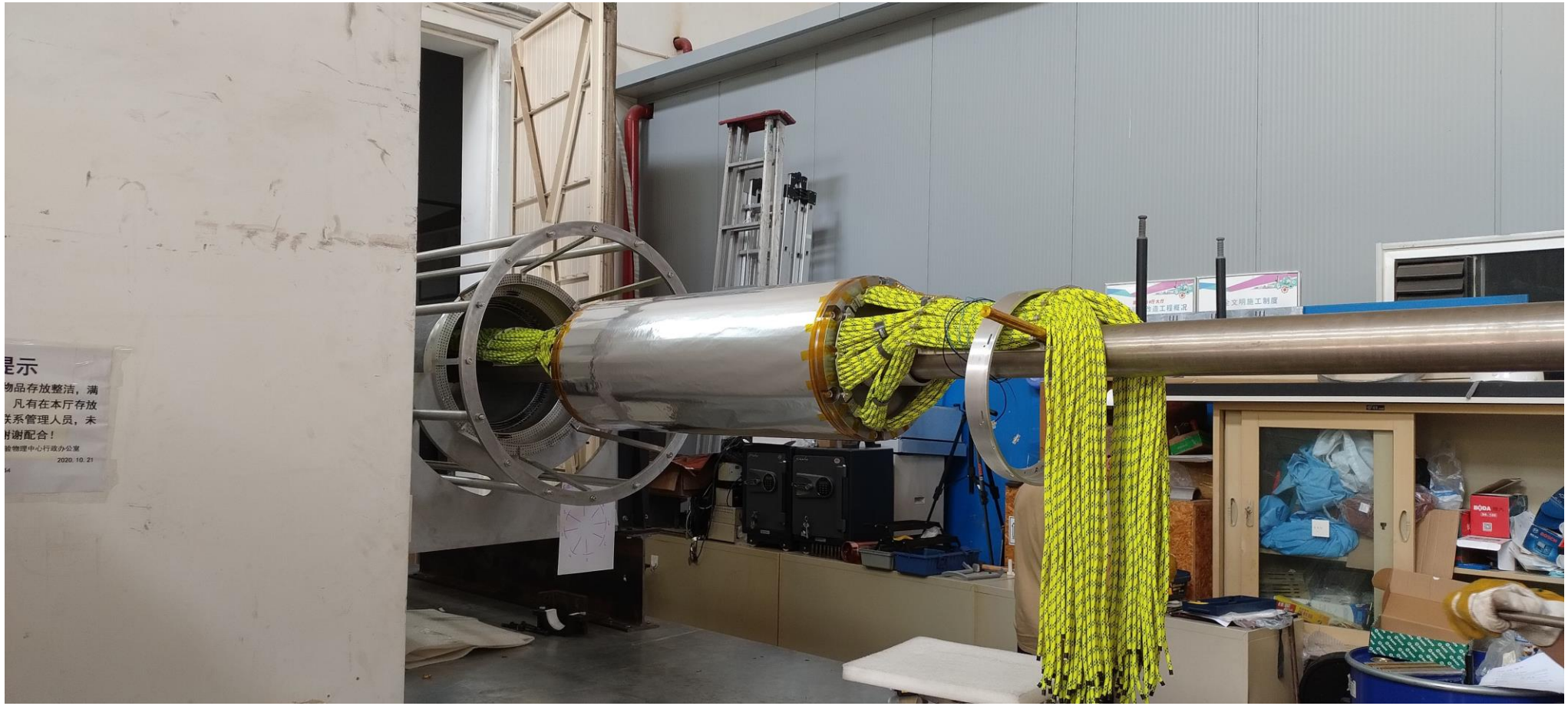
DAY 2: Insertion Complete

DAY 3: Anchoring



DAY 4: Trolley Extracted

DAY 4: Mockup Extracted



DAY 4: Mockup Extracted

Conclusion

- The second insertion test of the CGEM-IT was **SUCCESSFUL**
- Despite all the issues encountered in having the setup ready, the **test** was **completed within schedule** and the area was freed for testing IDC removal
- All the **upgrades to the tooling** have been **tested** and will be reviewed in the light of updated information
- **Feasibility** of the insertion **with realistic conditions** has been **confirmed**
- **Few non-critical improvements** can still be considered before installation
- The final insertion procedure and a full risk assessment report will be compiled after gathering suggestions from all participants

Thanks for your attention

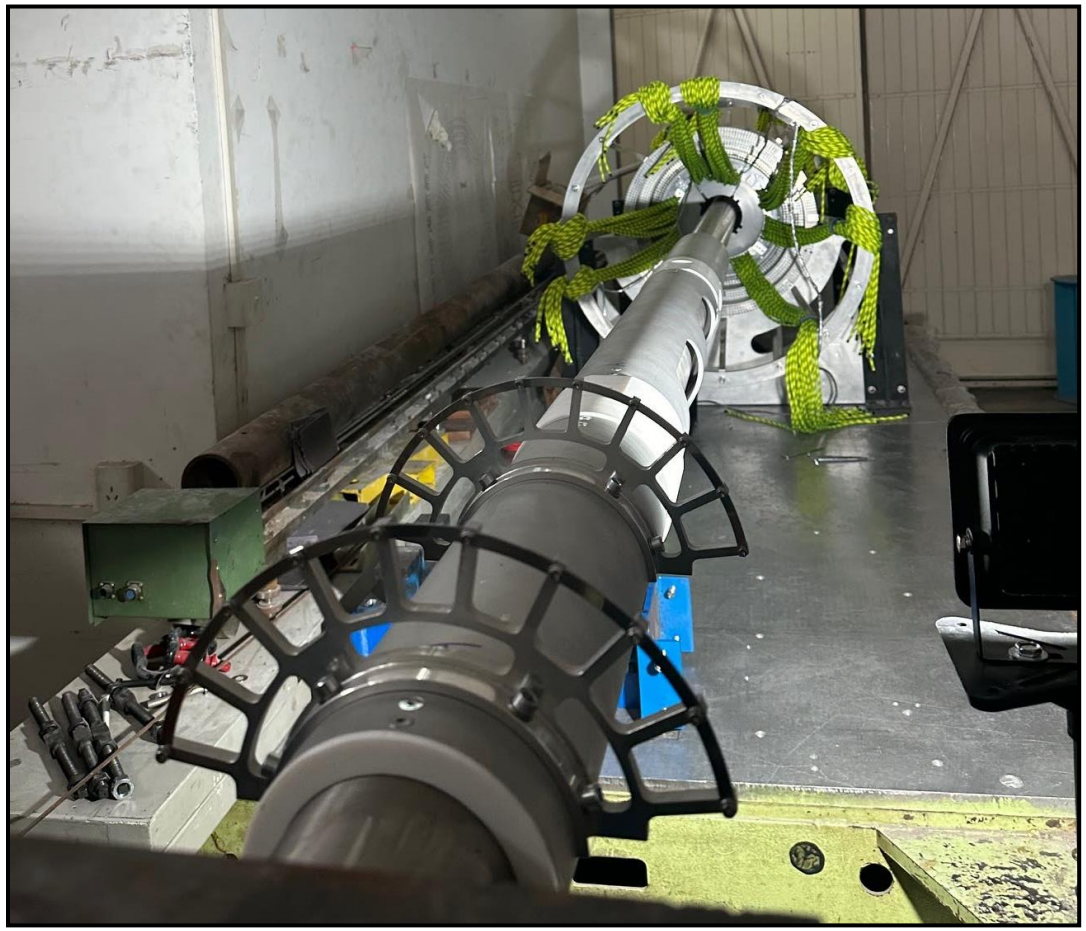
Special thanks to:

All the colleagues who took part in the insertion test, going above and beyond in these two weeks of non-stop efforts

All the people that actively provided support to the activities from far and near

Backup

Recap of the First Insertion Test



The previous test was **SUCCESSFUL**, **but**:

- The **span between** the rail's support **legs** was **not the real one**
- The **support legs** were too **flexible**, unrealistically worsening the rail's deflection
- Several **fragilities in the design of the trolley and support legs** were identified

A **second test**, closer to the real case, was deemed necessary to ensure safe installation

What Was Done and What to Do Next

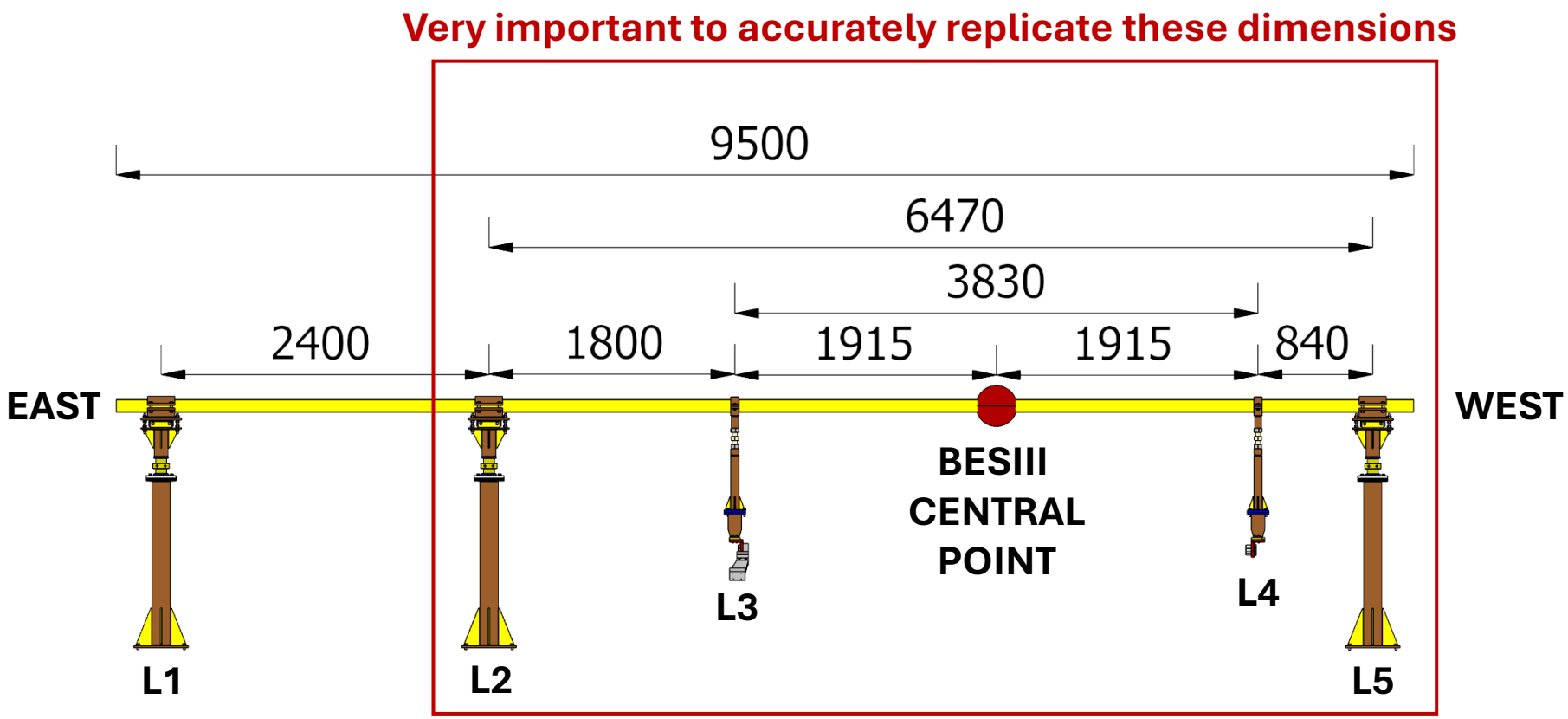
Phases of the last insertion test

1. **Transport** → **~ OK** | Not the final solution
2. **Rail coupling** → **~ OK** | Could be improved
3. **Transfer to the rail** → **~ OK** | Could be improved
4. **Travel towards the MDC** → **OK** | No issues
5. **Insertion** → **~ OK** | Could be improved
6. **Anchoring** → **NOT OK** | Setup unsuitable
7. **“Cabling”** → **OK** | Not a real cabling test
8. **Trolley extraction** → **OK** | No issues

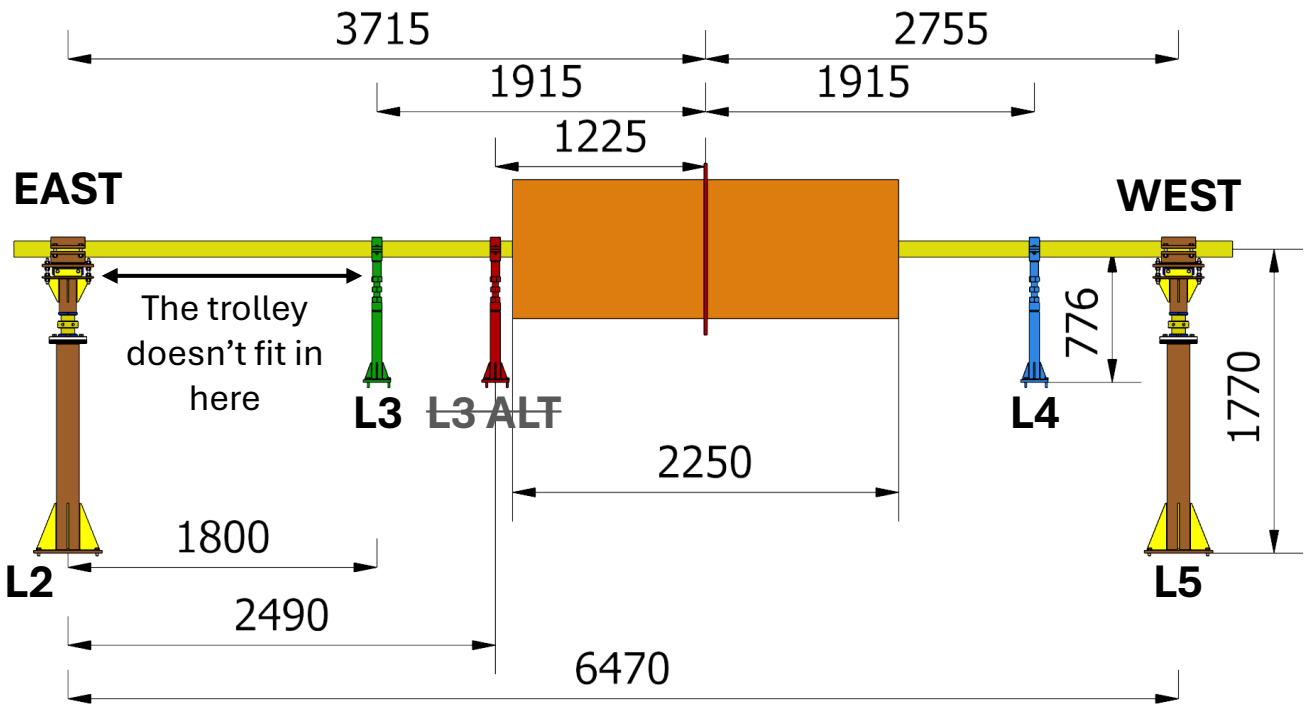
Phases of the future test

1. **Transport** → Not tested | Dedicated test in future
2. **Rail coupling** → **?** | Depends on parts ETA
3. **Transfer to the rail** → **?** | Depends on parts ETA
4. **Travel towards the MDC** → Intrinsic to the test
5. **Insertion** → **To be re-tested** | Major changes
6. **Anchoring** → **To be re-tested**
7. **“Cabling”** → Intrinsic to the test | Dedicated test
8. **Trolley extraction** → **To be re-tested**
9. **Mockup extraction** → **To be tested**

Insertion Setup as of the 2017 Documentation



Setup



- **Real L3 position**
- ~~**Alternative L3 position (if trolley legs not ready)**~~
- **Real L4 position**
- **MDC mockup volume**

L0 and **L1** (not in the scheme) for transferring the trolley to the rail

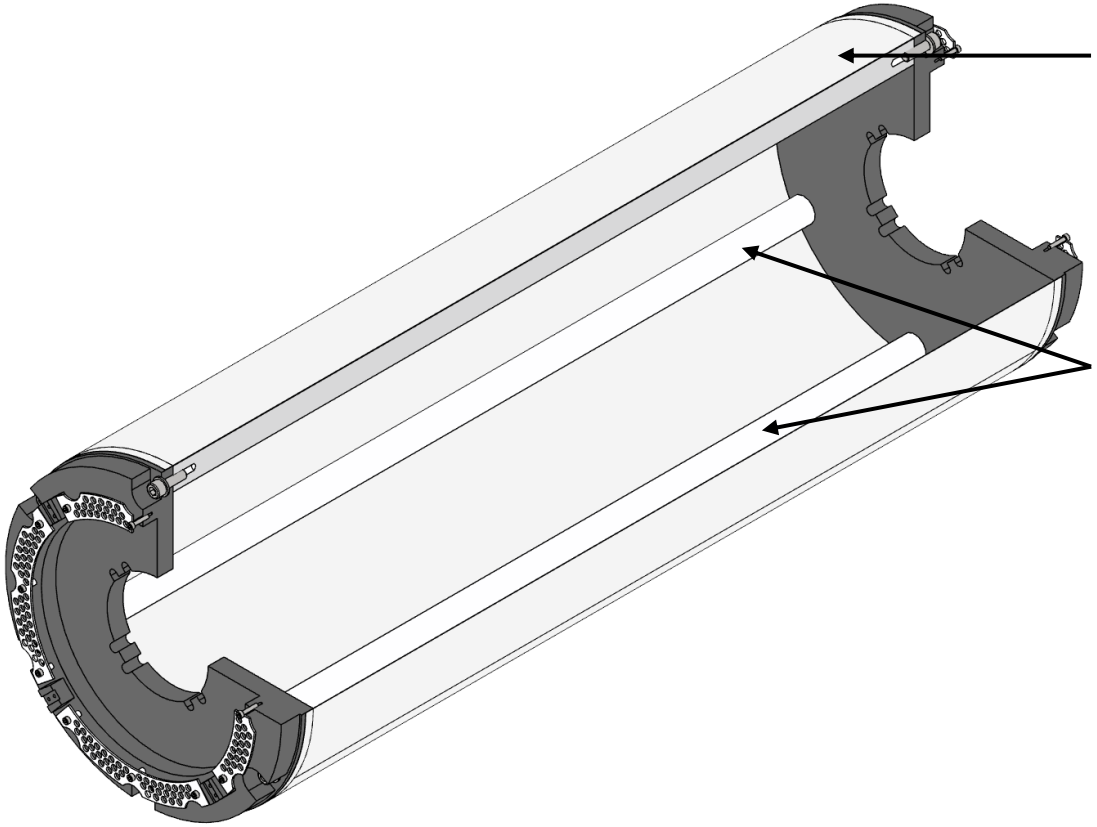
L2 Eastern adjustment leg for insertion

L3 necessary for transferring the trolley to the rail

L4 can be used as **backup** if the control given by L2 and L5 is insufficient

L5 Western adjustment leg for insertion

Mockup



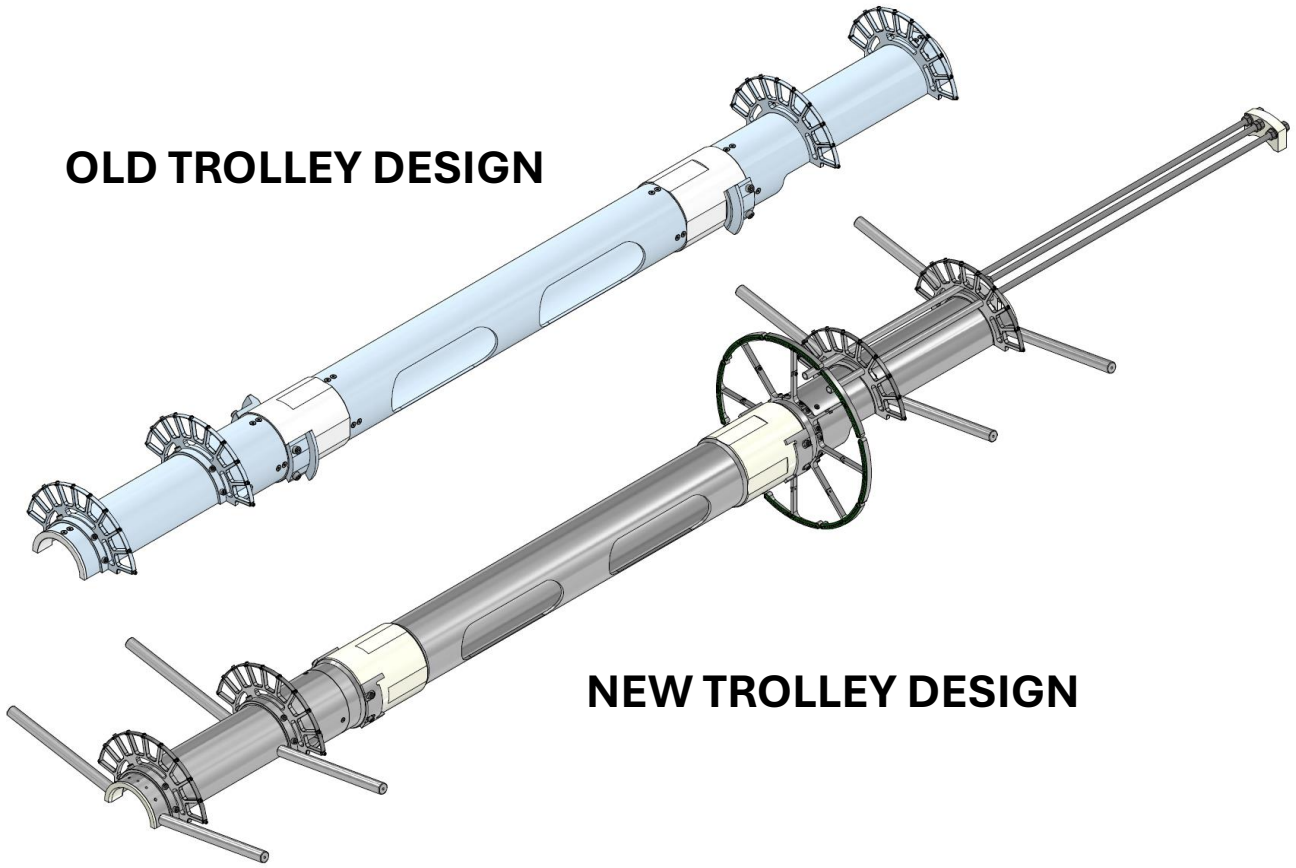
Aluminated Mylar reference surface:

+ More rigid
+ Conductive (for testing the contact alarm)

Aluminum spacers Ø30 mm

+ Tangent to the reference surface (Better fidelity)
+ More rigid structure
+ More precise manufacturing
+ Easier assembly
- Slightly heavier

Trolley: Overview

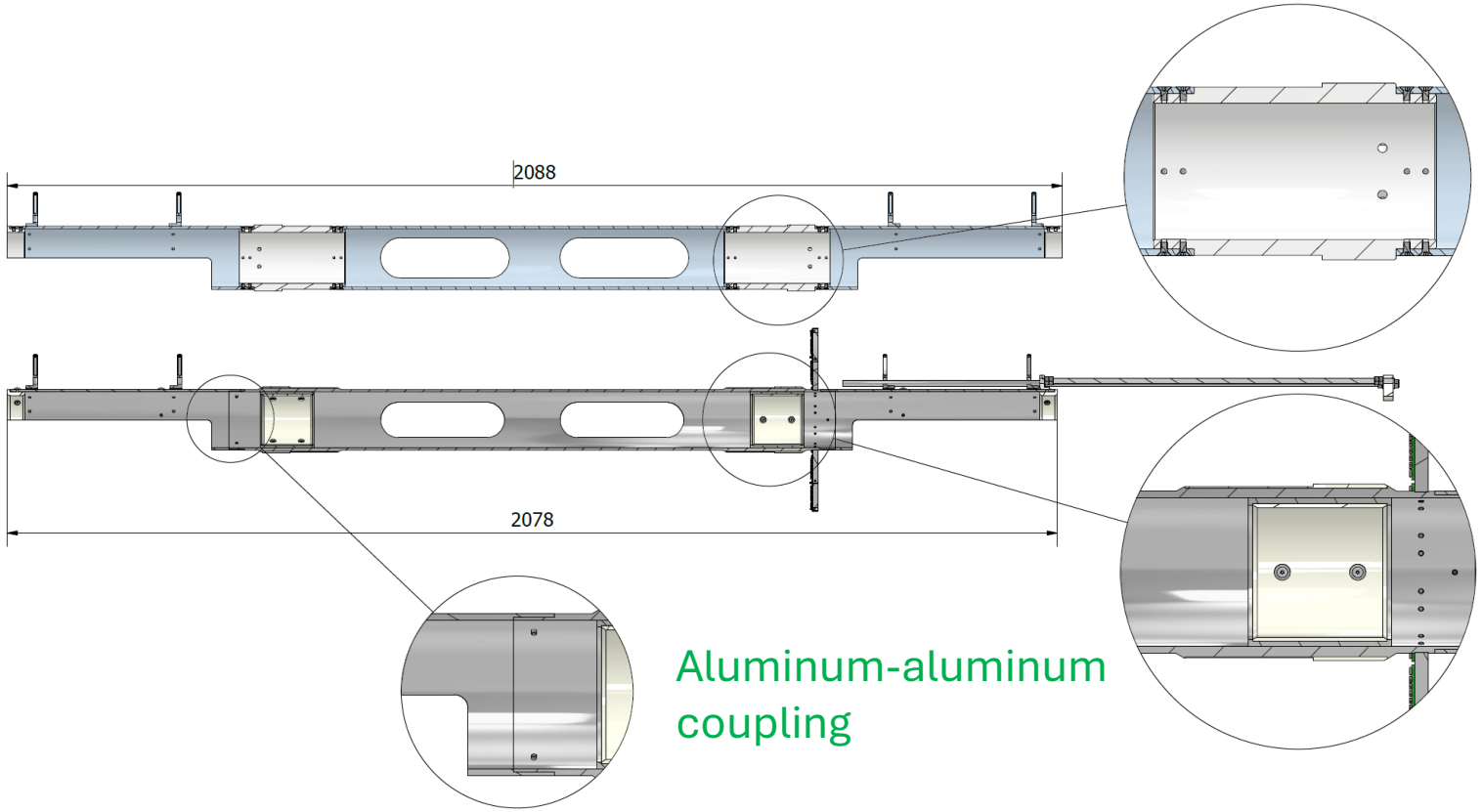


The old insertion trolley was **prone to bending** at the PTFE joints between aluminum pipe sections

➔ Great risk for the detector

Several other minor adjustments and quality-of-life improvements adopted

Trolley: Main Changes



Detector resting on the joint

Aluminum-PTFE coupling

PTFE trolley-detector interface

PTFE trolley-rail interface

Aluminum-aluminum coupling

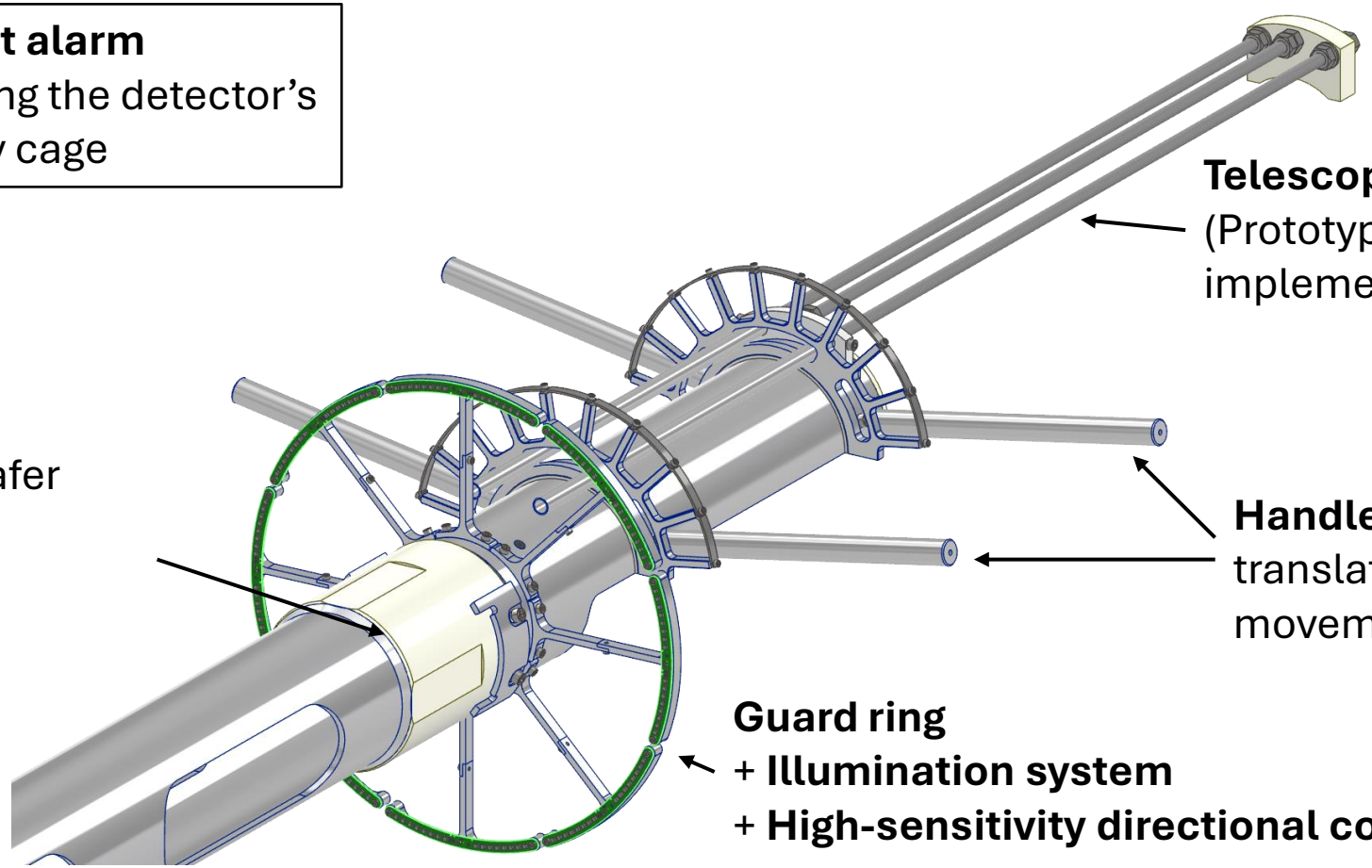
Detector resting on a single, continuous pipe section

PTFE trolley-detector interface

PTFE trolley-rail interface

Trolley: Additional Features

\+ **Contact alarm** exploiting the detector's Faraday cage



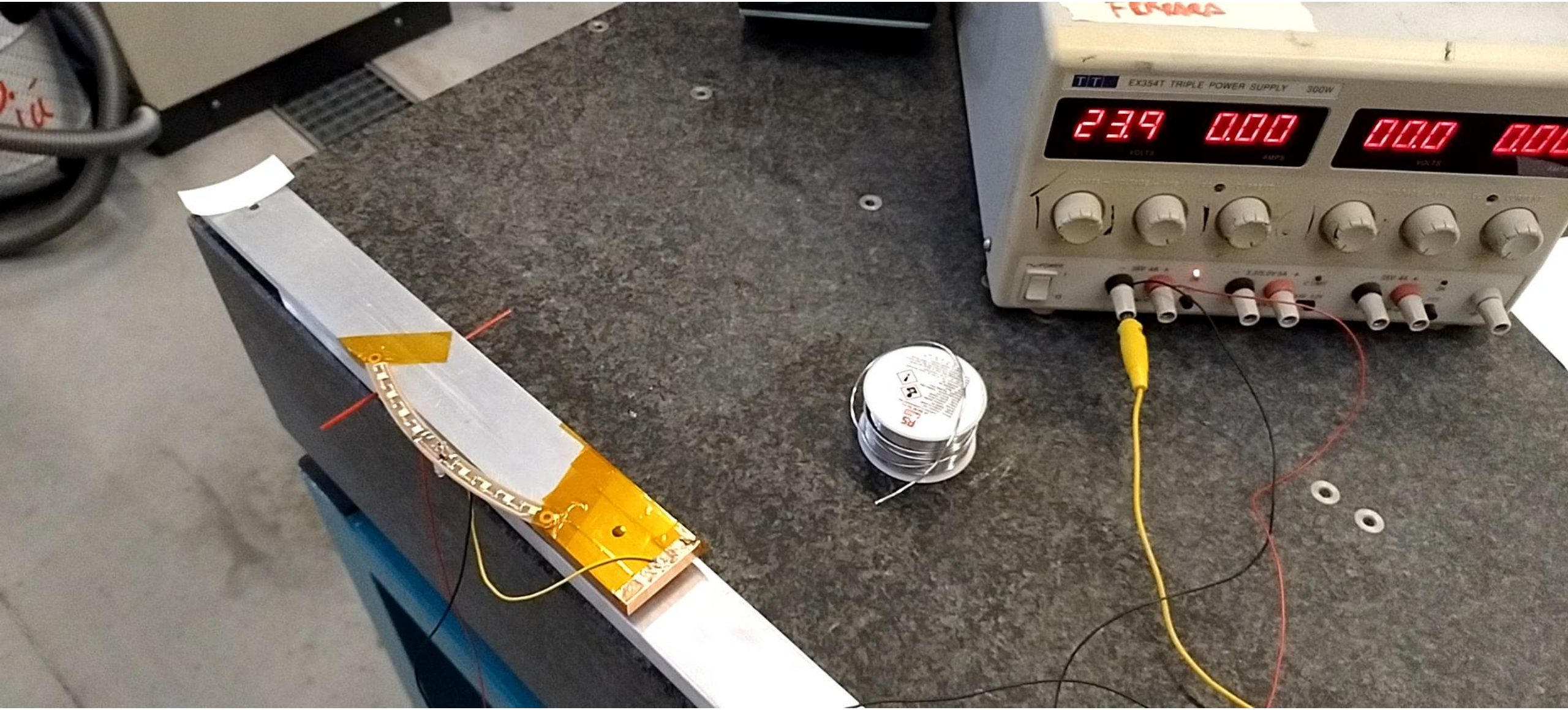
Telescopic cable holder (Prototype already implemented in previous test)

Bevels for safer extraction

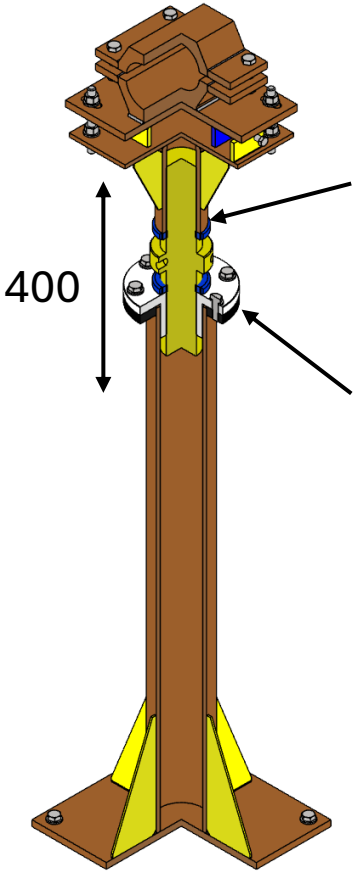
Handles for finer control on translational and rotational movement

Guard ring
+ Illumination system
+ High-sensitivity directional contact indicator

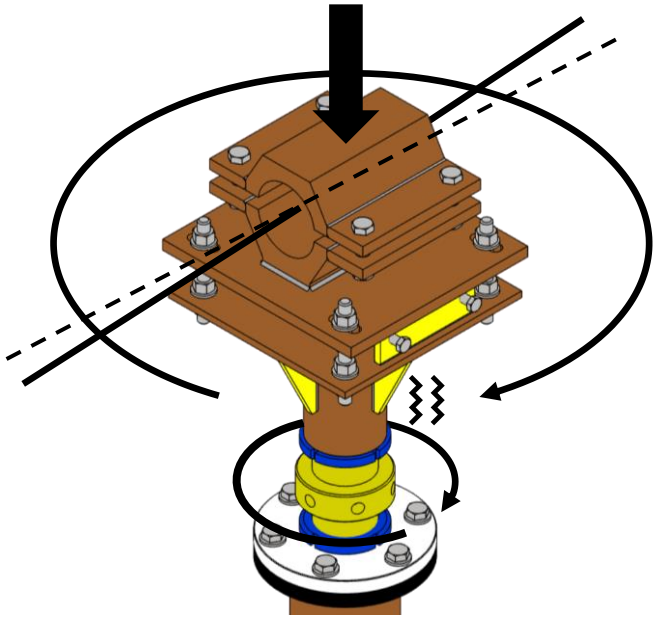

BESS
FERRARA
23.9
0.00
00.0
0.00


EX354T TRIPLE POWER SUPPLY 300W
23.9
0.00
00.0

Legs: Main Issues

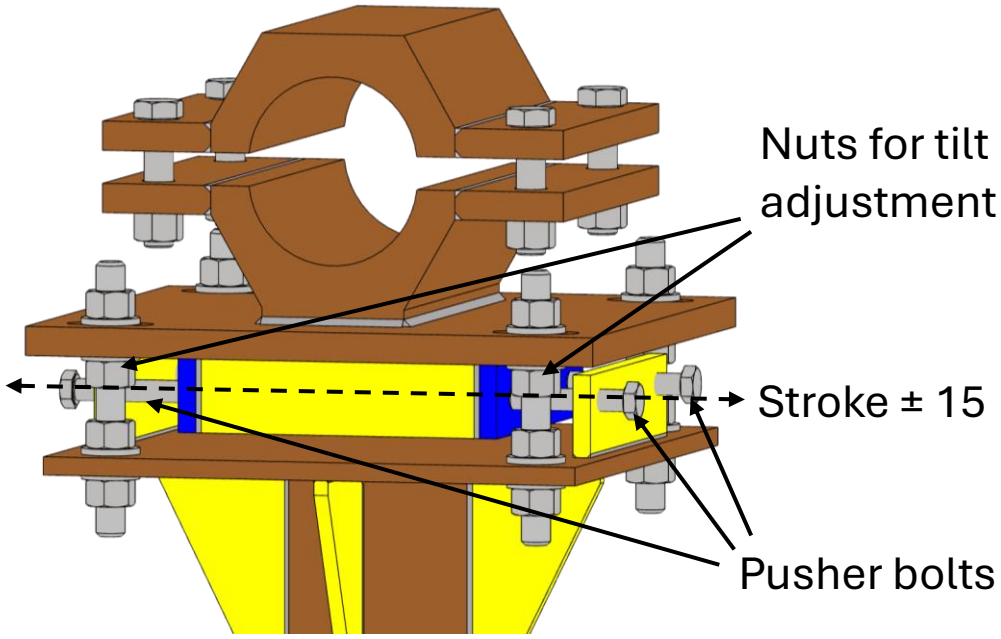


When **adjusting the height** under load, friction may transfer torque to the head

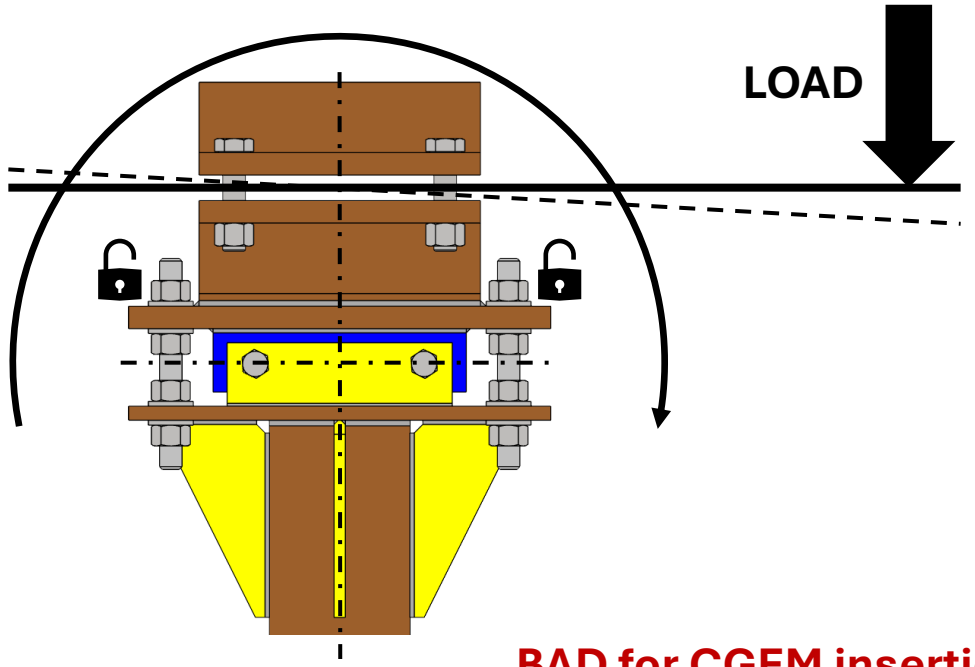


Uncontrolled movement in the horizontal direction

Legs: Main Issues



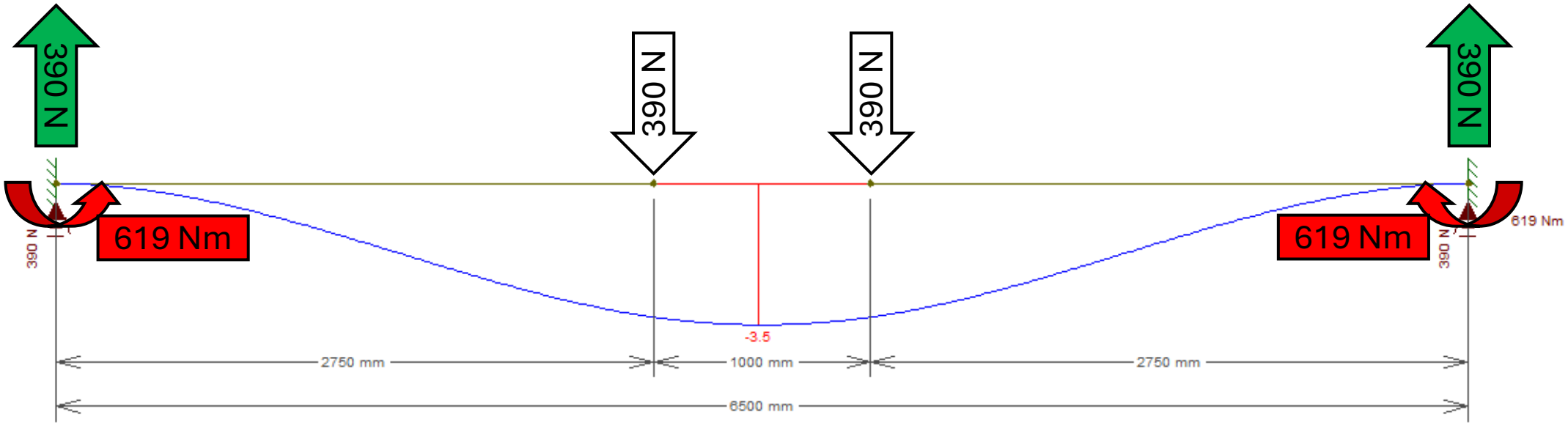
Unlocking the nuts to adjust tilt or horizontal position leads to **uncontrolled movement of the rail in the vertical direction**



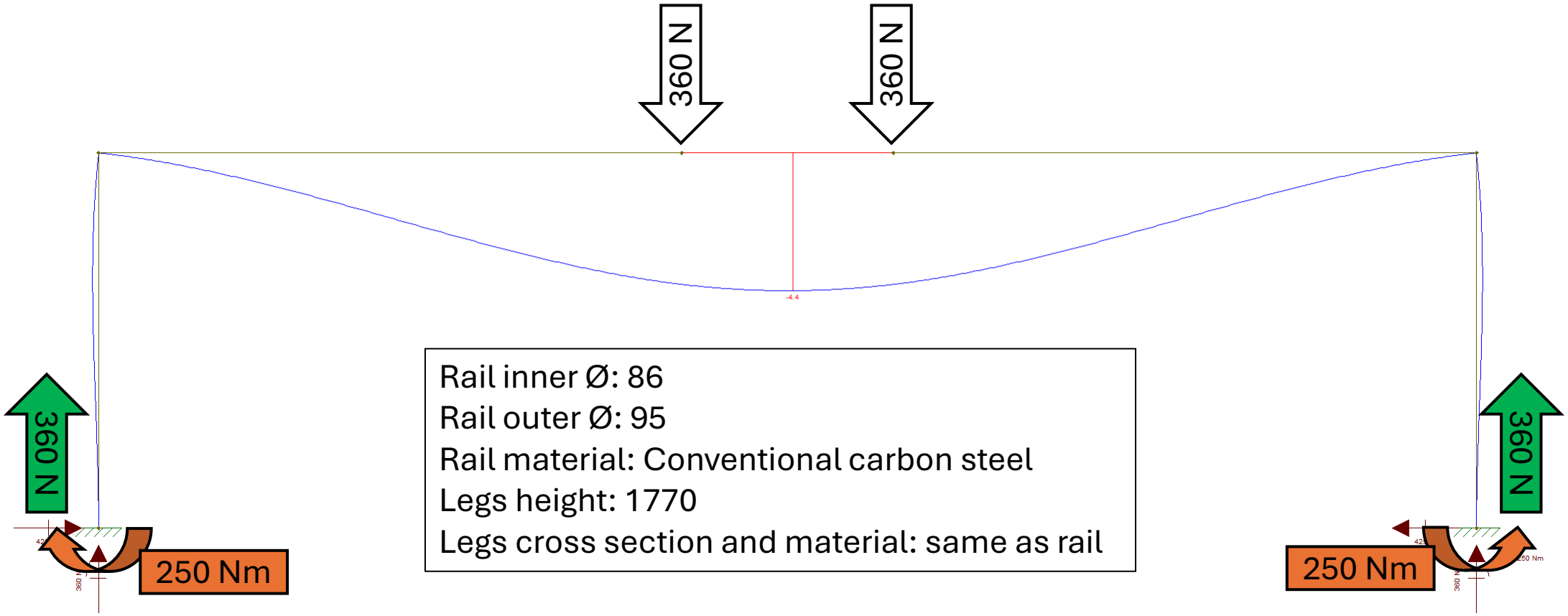
BAD for CGEM insertion

Legs: Load Simulation

Rail inner Ø: 86
Rail outer Ø: 95
Rail material: Conventional carbon steel
Perfectly rigid legs



Legs: Load Simulation



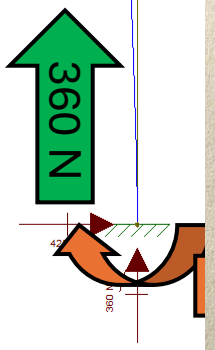
Rail inner Ø: 86
Rail outer Ø: 95
Rail material: Conventional carbon steel
Legs height: 1770
Legs cross section and material: same as rail

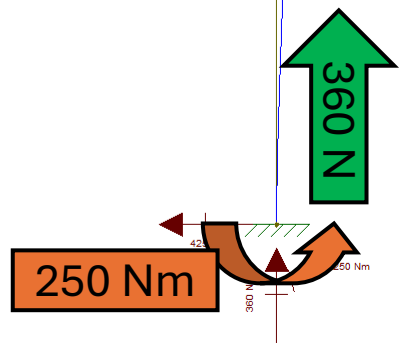
Legs: Load Simulation

"Give me a lever long enough and I shall complicate your design requirements"

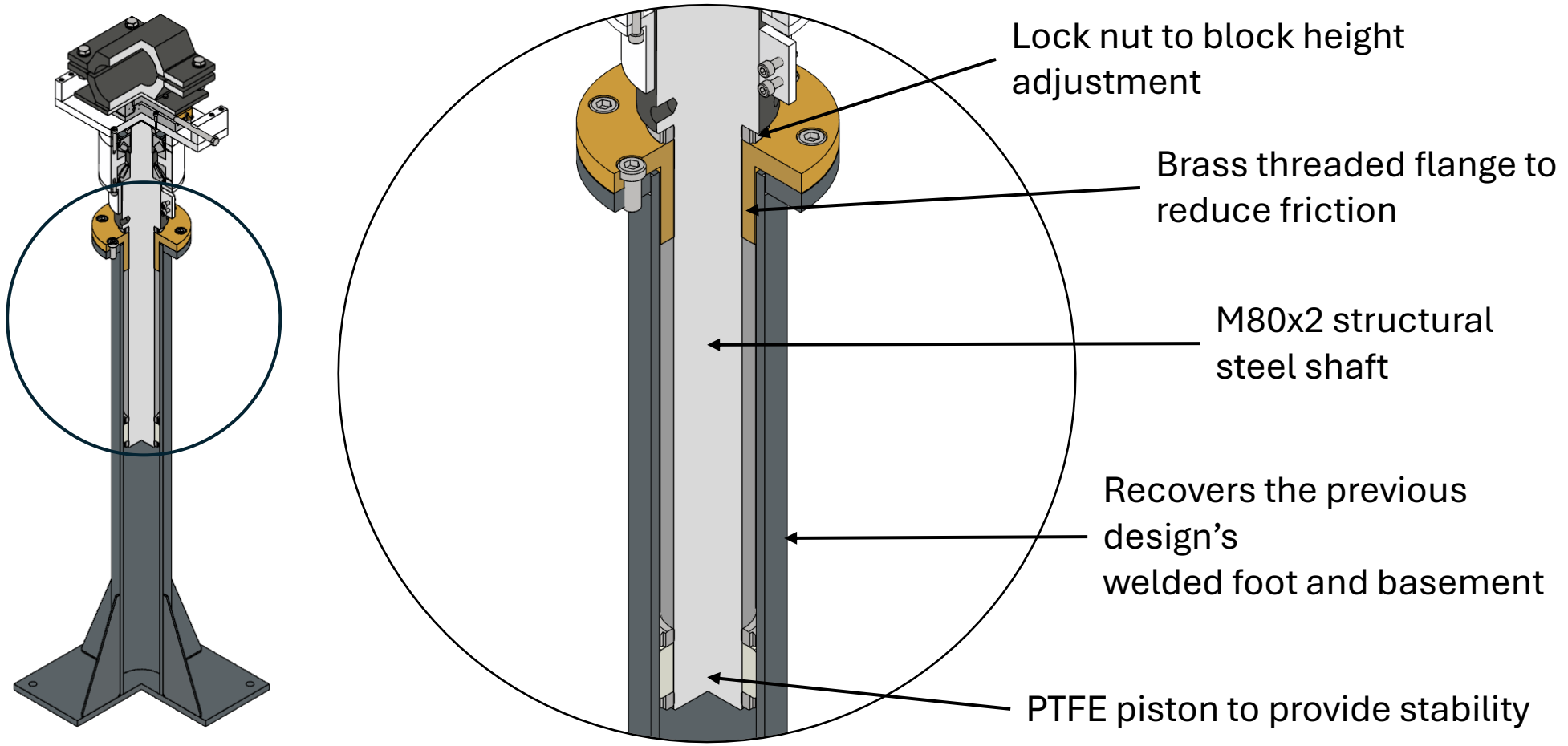
- Archimedes (probably)

86
95
: conventional carbon steel
770
ection and material: same as rail

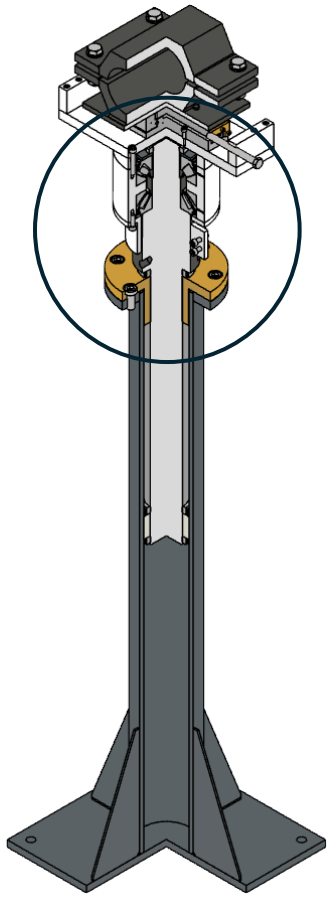


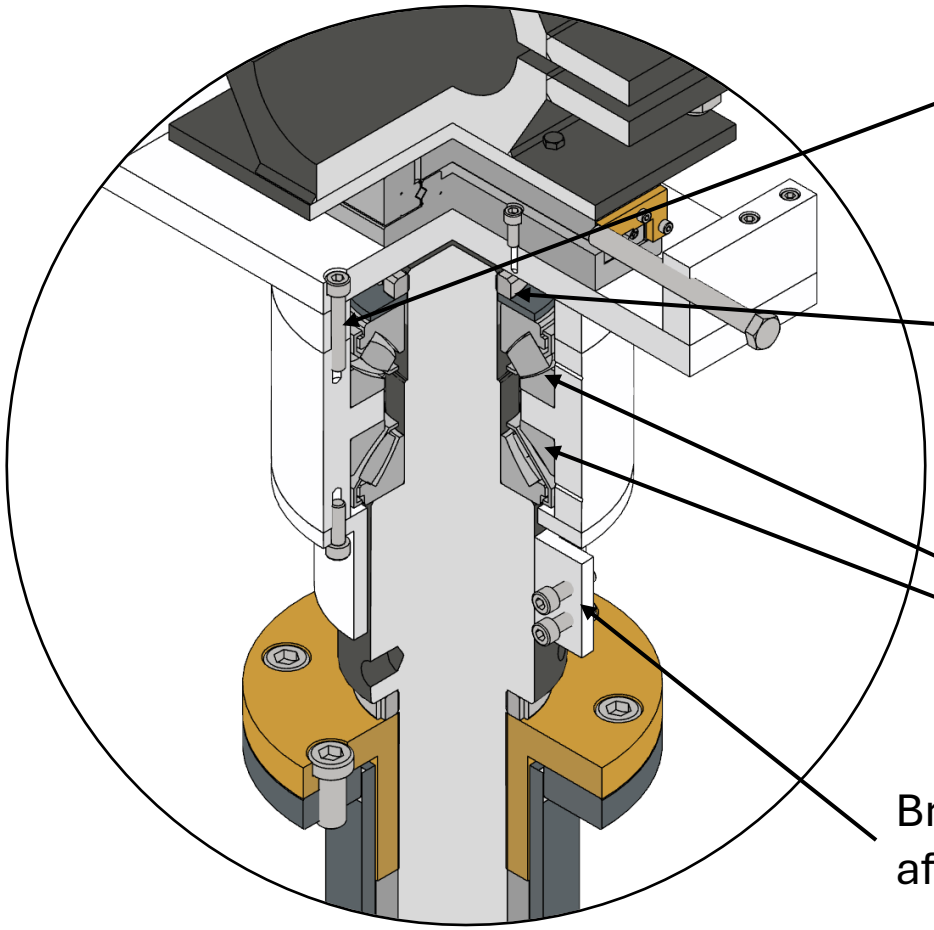


Legs: New Design



Legs: New Design





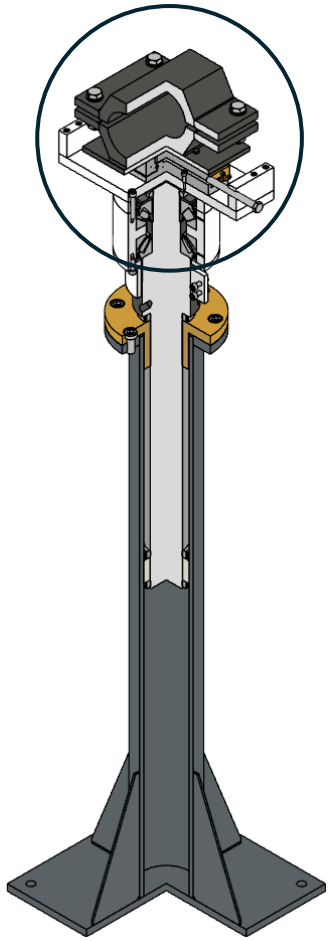
6xM8 holes for mounting the head

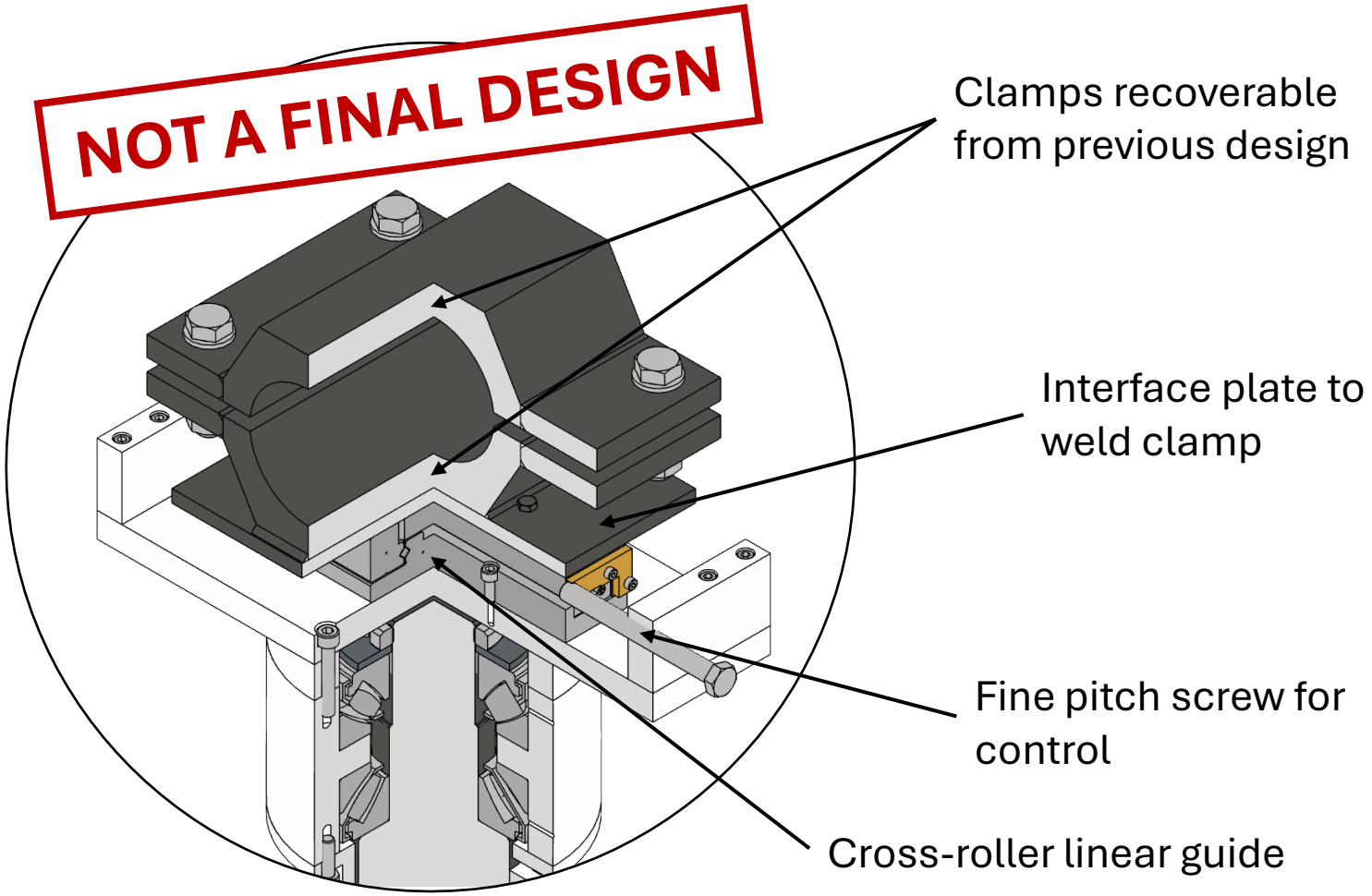
Lock nut to pre-load bearings

Bearings to decouple shaft and head rotation

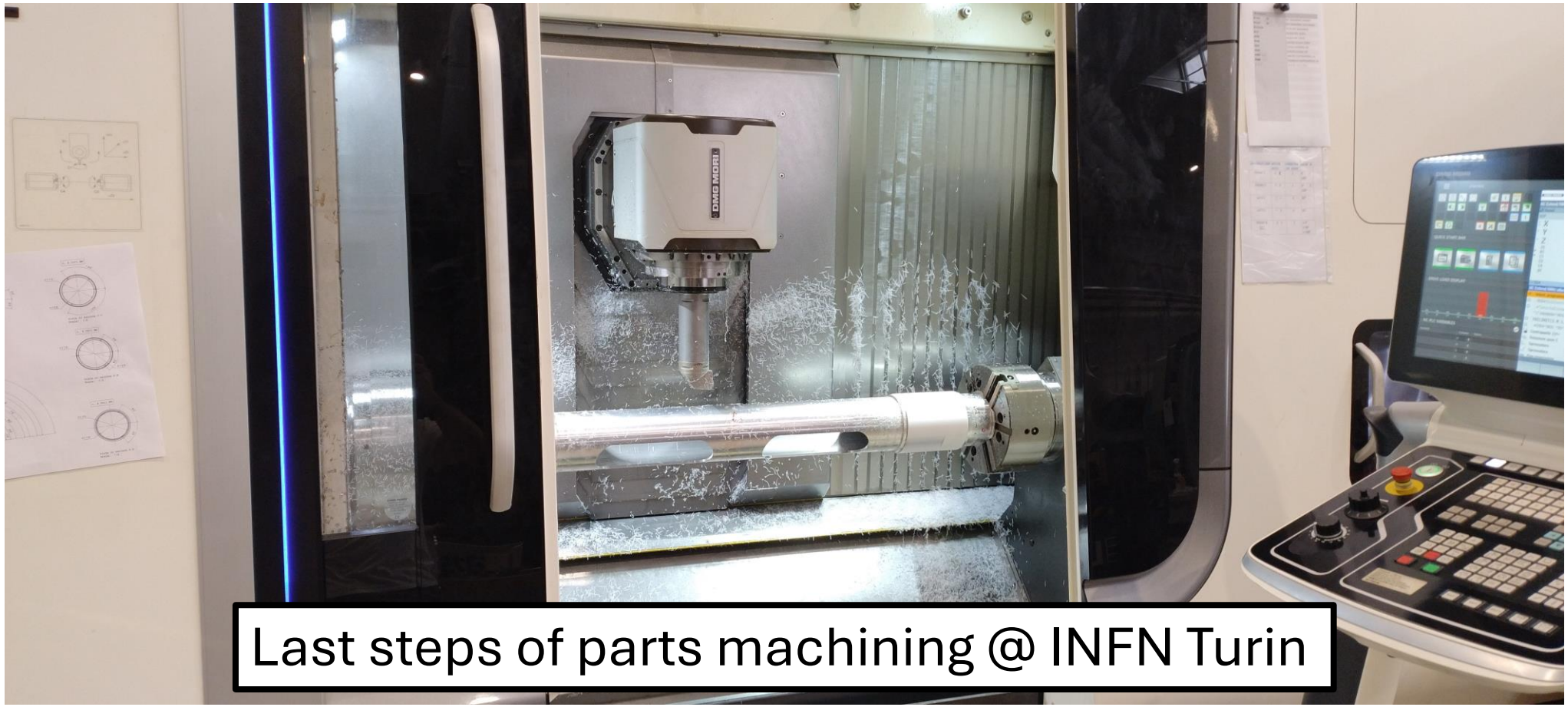
Brake to block free rotation after adjustment

Legs: New Design

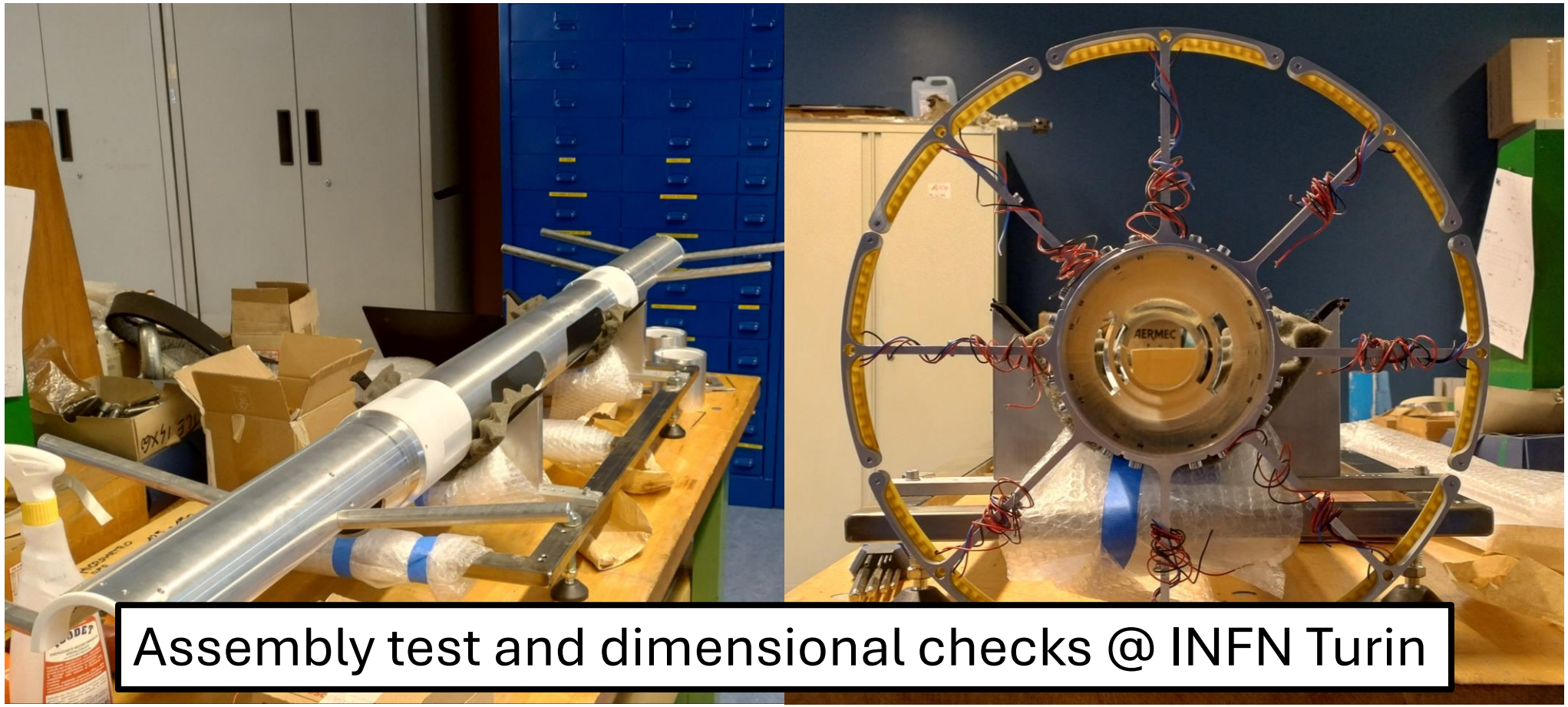




Status of Trolley and Mock-up - Thu 06/20



Status of Trolley and Mock-up - Thu 06/21



Assembly test and dimensional checks @ INFN Turin

Status of Trolley and Mock-up - Thu 06/24

Status of Trolley and Mock-up - Thu 06/28

Mockup on the new trolley and sensor system test @ IHEP

Status of Trolley and Mock-up - Thu 06/28

Status of Support Legs

05/28 drawings for lower half of the legs ready
06/07 drawings for top half of the legs ready
06/17 All drawings for insertion test ready
06/28 Parts delivered at IHEP

Remarkable effort to achieve a very fast production
Many parts are out of tolerance
Issues with the assembly currently under investigation

LAST MINUTE UPDATE:
2 out of 4 legs made usable for the test just this morning
Parts to recover the other 2 should arrive at IHEP tomorrow afternoon

Preliminary Test Timeline - People

From 06/25 | Mr. GRAMIGNA Stefano (University of Ferrara and INFN Ferrara – BESIII member)

From 06/25 | Eng. MENEGATTI Nicholas (INFN Ferrara – member of the electronics division)

From 06/25 | Dr. SCODEGGIO Marco (INFN Ferrara – BESIII Member)

From 06/25 | Mr. TESAURO Roberto (INFN LNF – Detector development and construction division member)

From 06/30 | Dr. AMOROSO Antonio (University of Turin and INFN Turin – BESIII member)

From 06/30 | Dr SOSIO Stefano (University and INFN Turin – BESIII member)

From 07/01 | Mr. BOROTTO DALLA VECCHIA Fabio (INFN Turin – head of the mechanical workshop division)

From 07/01 | Eng. MEREU Paolo (INFN Turin – head of the mechanical design division)

From 07/03 | Eng. MELCHIORRI Michele (INFN Ferrara – member of the design and mechanical workshop division)

Local support:

Dr. OUYANG Qun, Dr. MA Xiaoyan, Dr. DONG Mingyi, Dr. DONG Jing, Eng. JING Xiaoping, Eng. FU Jinyu

The Checklist from the Review

Suggested Improvements: the Details

- ✓ Increase CGEM-IT mockup rigidity (change the bars separating the wheels)
- ✓ Bolt the joint between the rail and the trolley support
- ✗ Replace the accelerometers acquisition system with dataloggers
- ✓ Prepare a detailed checklist for all operations
- ✓ Have a dedicated supervisor or two to oversee the operations
- ✓ Improve the adjustment mechanism of the trolley support legs
- ✓ Bolt the trolley support legs to the floor when coupling to the rail
- ✓ Implement the telescopic cable holder in the insertion trolley
- ✓ Add handles to ease pushing, pulling and rotating the trolley
- ✗ Add a bubble level to keep trolley rotation in check during movements
- ✓ Add a sensor array in front of the detector
- ✓ Add a light source on the trolley
- ✗ Reduce the trolley's friction with rollers, bearings or polymer inserts
- ✓ Redesign the positioning tool for the insertion brackets
- ✗ Procure crank-keys and crank-screwdrivers to facilitate operations in cramped spaces
- ✓ Have a second spotlight positioned at the east side during insertion
- ✓ Have dial indicators pointing at the rail to gauge corrections

Lots of additional hardware improvements That should increase the overall safety of the operations

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✓ OK for test

✓ Uncertain for test
OK for installation

✗ Canceled for test
Uncertain for installation

✗ Canceled for test and installation