WP5.2 – Transport Analysis Collimator Jaws

L. Hannemann, F. Carra, L. Puddu

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Background – Need for Simulation

- Collimator production at CINEL, Italy
- Street transport of produced collimators to CERN

Purpose of the Simulation

1. Identify Imposed Loads:
   - **Goal:** Understand the mechanical loads and stresses applied to the collimators during street transport.
2. Assess Structural Integrity:
   - **Critical Element Identification**: Pinpoint the most vulnerable parts of the collimator system.
   - **Damage Assessment**: Ensure the collimators can withstand transportation without suffering damage or deformation.
3. Find suitable transportation frame

Critical Element Identification

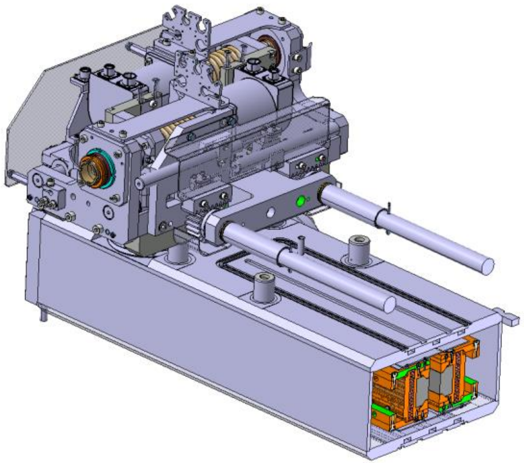
- **Initial Focus:**
  - Jaw selected as primary component for assessment (importance and vulnerability).
- **Broader Considerations:**
  - Other critical components: e.g., parallel “drift tube” in 2-in-1 collimators or RF fingers.
- **Flexible Approach:**
  - Open to expanding analysis for comprehensive transport readiness.

TCLP Analysis and Future Considerations

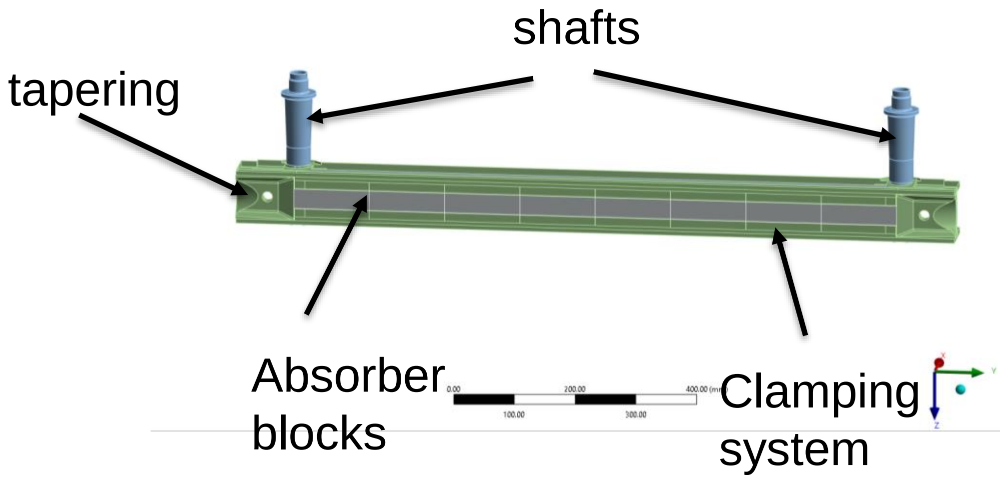
- **TCLP as First Analysis**: benchmarking the analysis procedure
- **Further Considerations**
  - TCSPM Jaws: To be analysed later due to the delicate nature of the graphite jaw material.
  - TCSP Jaws
  - TCLPX Jaws: Less critical due to the bulkiness of the design, though will be reviewed for completeness.

Background – Collimator Setup TCLP

TCLP Collimator cross Section

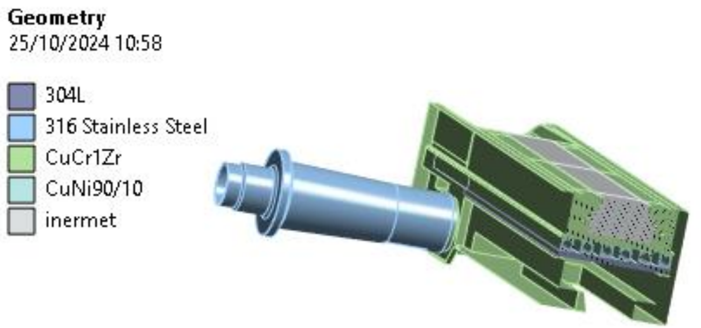


Jaw with shafts in vertical orientation



- **Assembly**: The jaws are fixed to **two shafts** and are positioned within a housing.
- **Orientation**: **Vertical orientation** during transport.

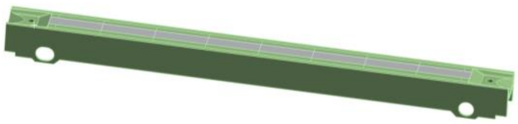
Material Properties TCLP and Collimator Setup



Material	Yield Strength [MPa]	Ultimate Strength [MPa]
Steel 304 L	210	515
Steel 316L	205	515
CuCr1Zr	293	510
CuNi90/10	109.2	319.5
Inermet180	613	681

First Step: Modal Analysis

Jaw without shafts

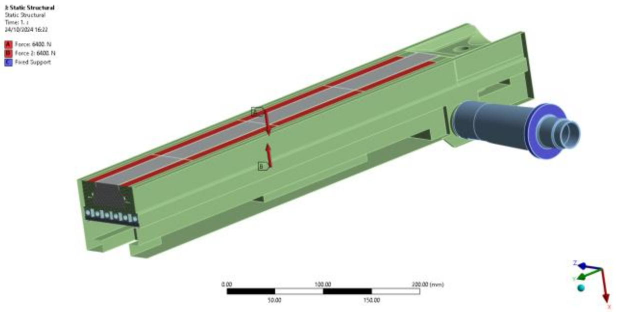


- **Objective of Simulation:**
  - Conduct a modal analysis on the jaw without the shaft to evaluate its vibrational characteristics.
- **Reasoning:**
  - Benchmark simulation results against real measurements on a jaw in the same condition.
  - Validate the accuracy of the simulation through comparison with actual data.
- **Expected Outcome:**
  - If the simulation accurately reflects real measurements, it confirms the reliability of further vibrational analysis.
  - A successful modal benchmarking provides confidence that subsequent simulations will accurately predict vibrational behavior.

TCLP Jaw with shaft: Simulation Setup

Static Structural → Modal Analysis → Random Vibrations

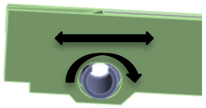
Boundary Conditions and Assumptions



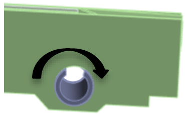
1. Forces Applied:
- Two forces (64KN) are simulated to represent the clamping system on the blocks.

2. Fixed Support:
- Fixed support is applied where the shafts are connected to the collimator setup.

- DoF:



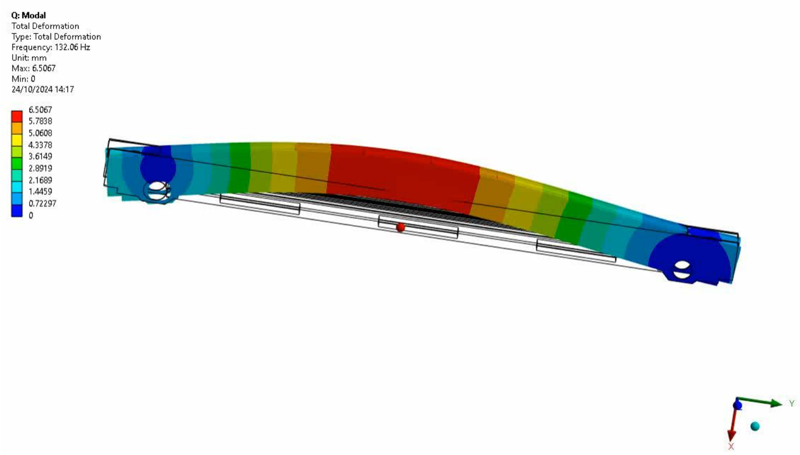
- Rotational and translational



- Rotational

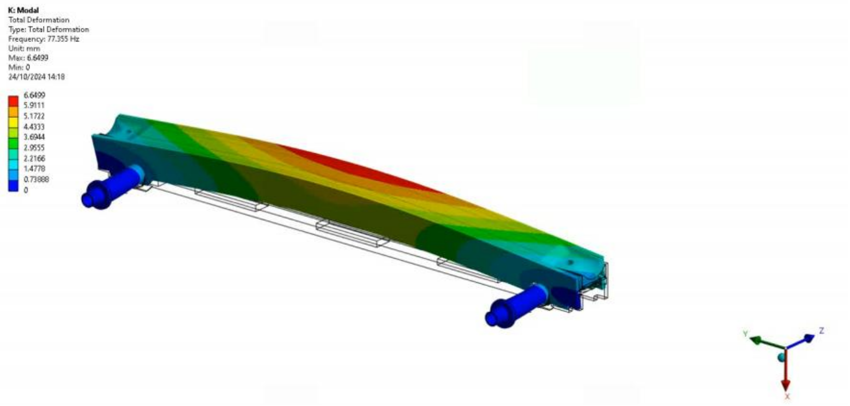
First Bending Modes

Jaw without shaft



First bending moment: 132Hz

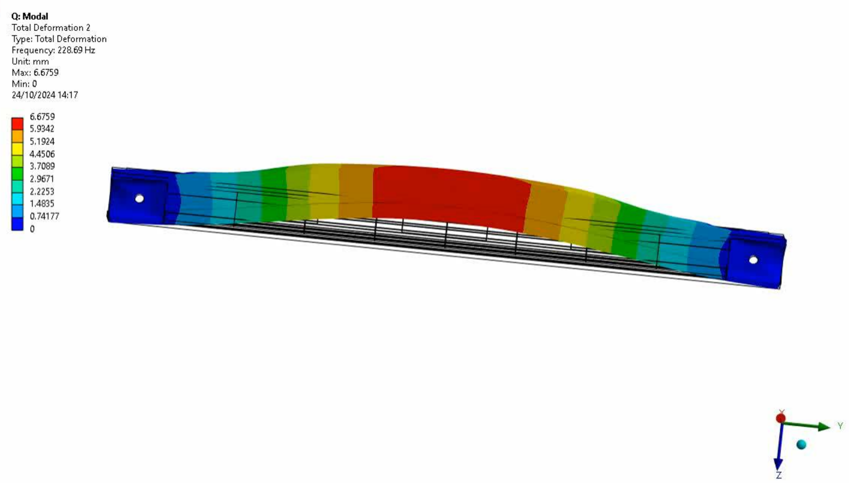
Jaw with shaft



First bending moment: 77Hz

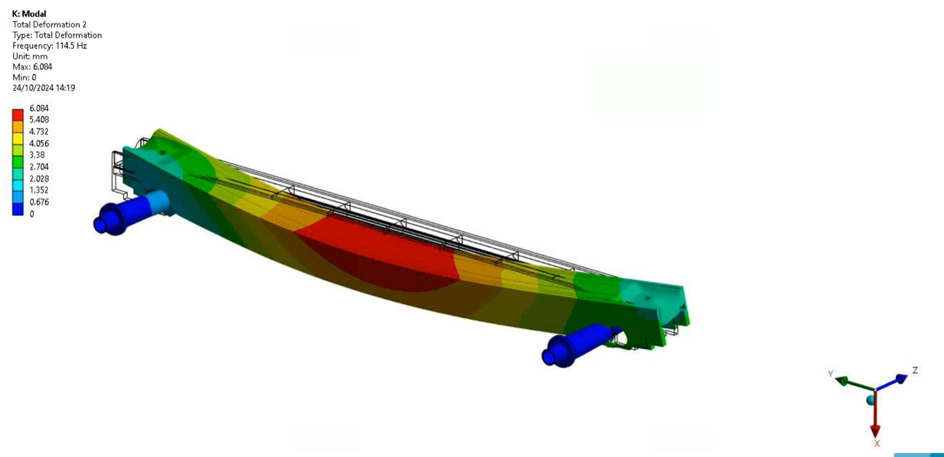
Second Bending Modes

Jaw without shaft



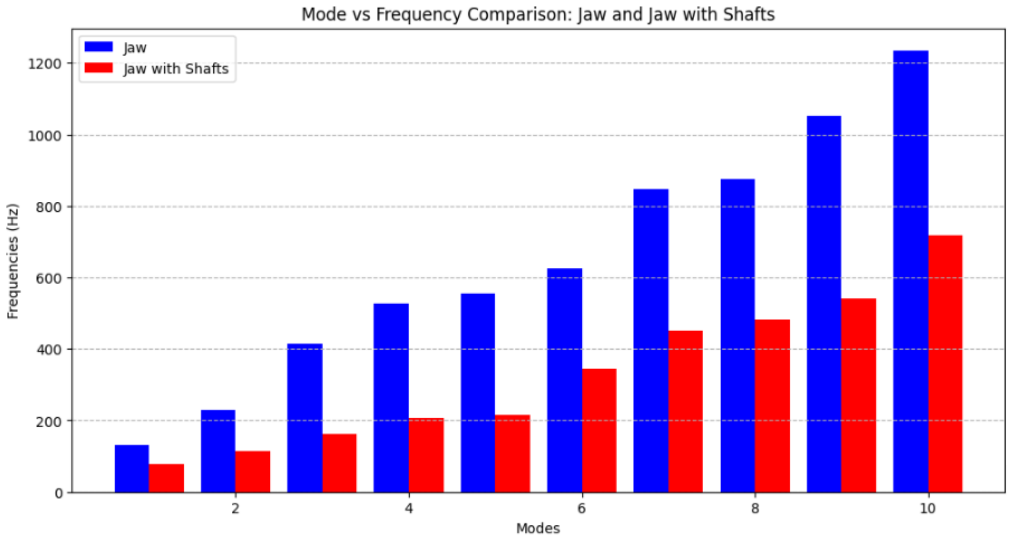
Second bending moment: 228 Hz

Jaw with shaft



Second bending moment: 114 Hz

Results Modal Analysis
Natural Frequencies



Mode	Frequency (Jaw)	Frequency (Jaw with Shafts)
1.0	132.06	77.355
2.0	228.69	114.5
3.0	414.99	160.82
4.0	528.07	206.62
5.0	555.87	216.57
6.0	624.57	343.51
7.0	847.53	452.54
8.0	876.14	483.08
9.0	1052.8	541.27
10.0	1235.2	717.81

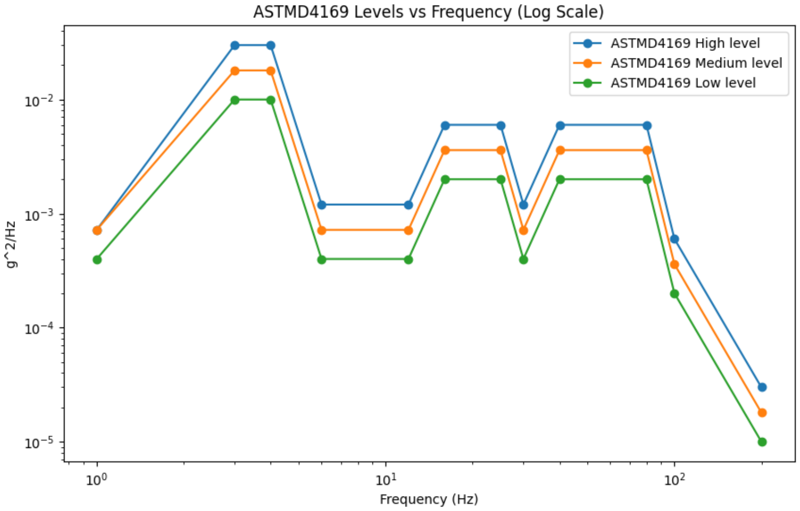
•**Observation**: Modes with the shaft are approximately **50% smaller** compared to the modes without the shaft.

•**Next Steps**: We will continue the analysis **focusing on the jaws with the shaft**.

Random Vibrations – PSD Norm Input

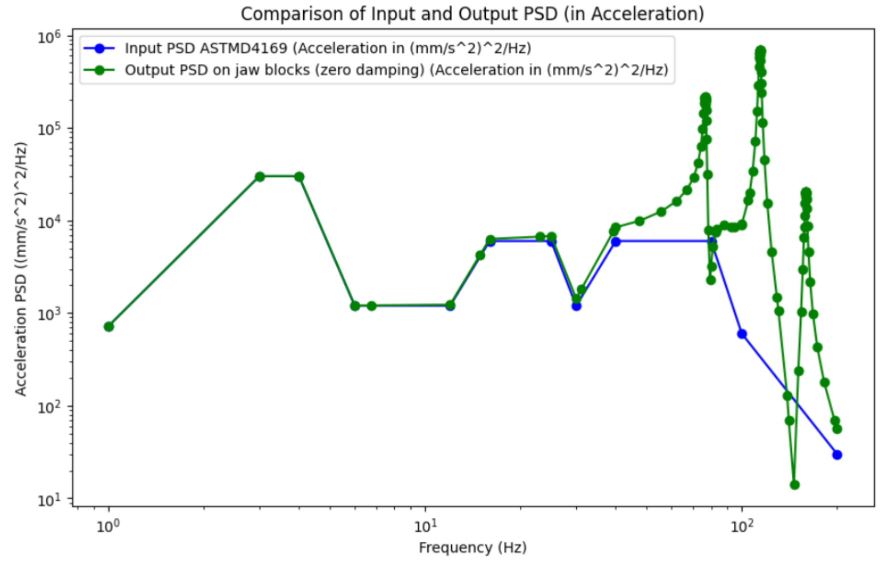
Acceleration PSD → Input → Random Vibrations

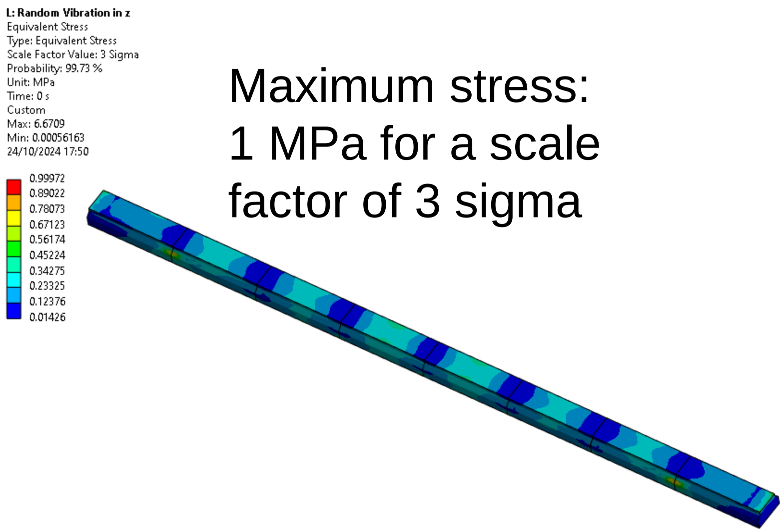
ASTMD4169 Norm



- Evaluate the durability of packaging for products transported by road (trucks, vans, etc.)
- 3 PSD levels provided by standard
- High level PSD applied in **z-direction** on the shafts.

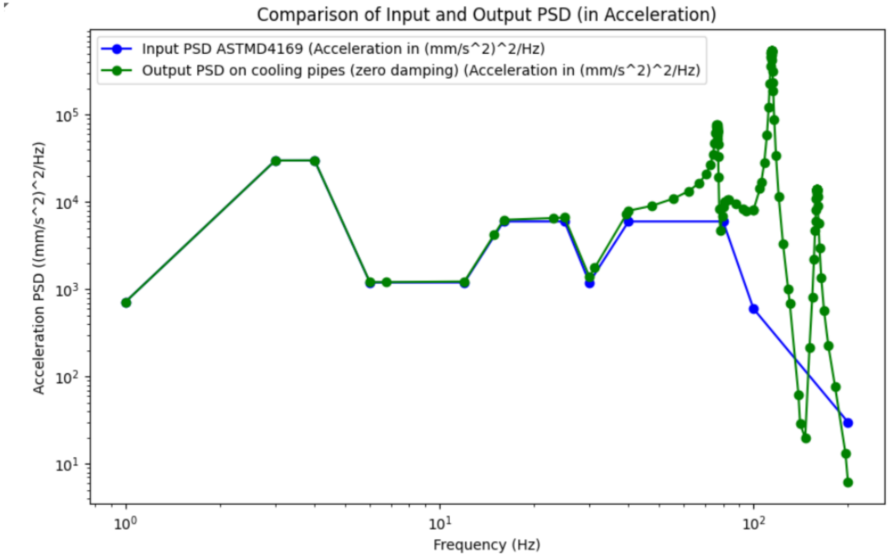
Stress on Blocks for ASTMD4169 Input Z-Direction

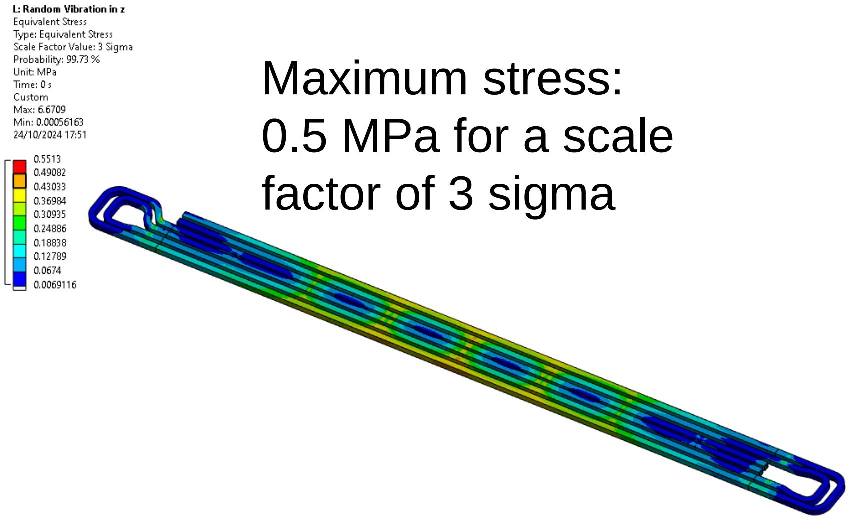




Maximum stress:
1 MPa for a scale factor of 3 sigma

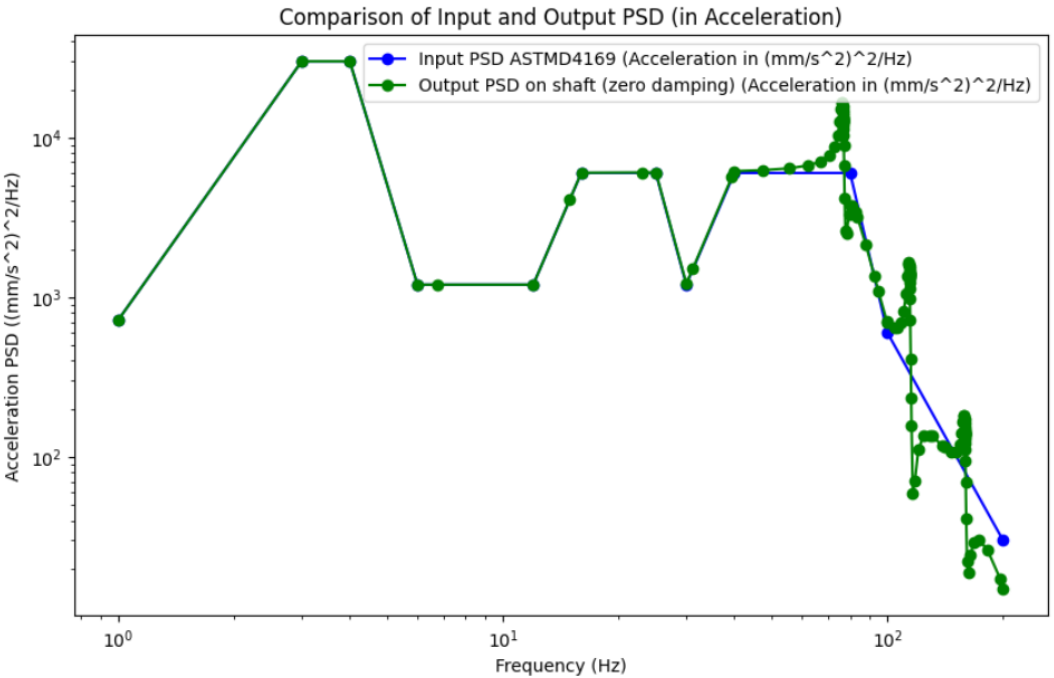
Stress on Blocks for ASTMD4169 Input Z-Direction

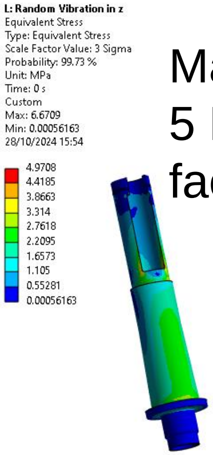




Maximum stress:
0.5 MPa for a scale factor of 3 sigma

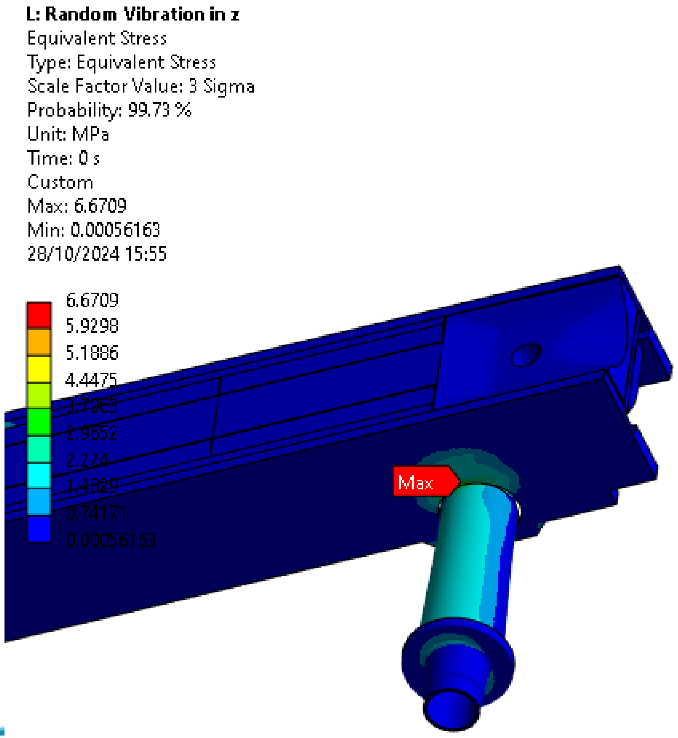
Stress on Shafts for ASTMD4169 Input Z-Direction





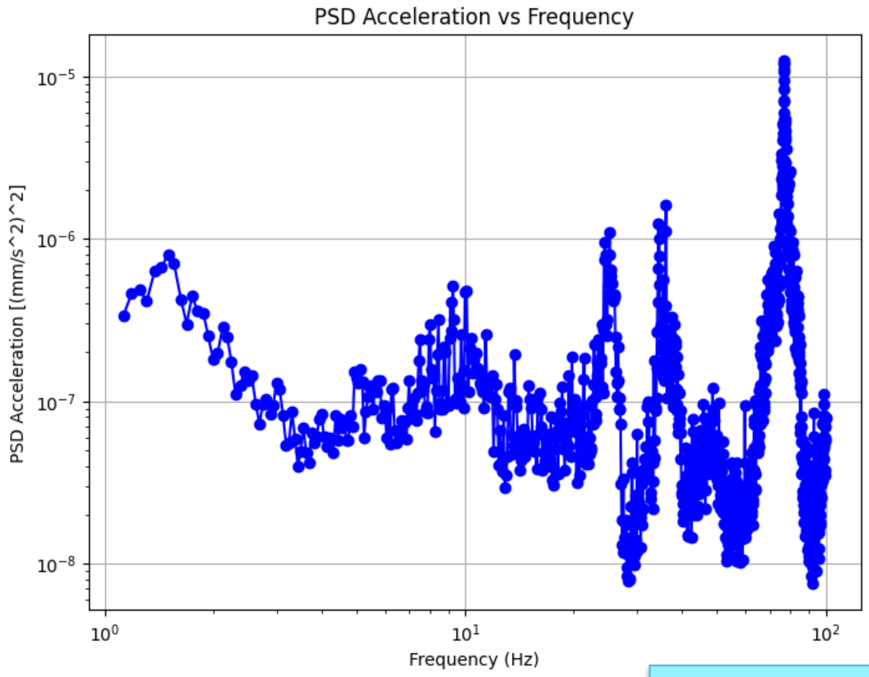
Maximum stress: 5 MPa for a scale factor of 3 sigma

Max Stress for ASTMD4169 Input



Maximum overall stress:
6.7 MPa for a scale factor of 3 sigma

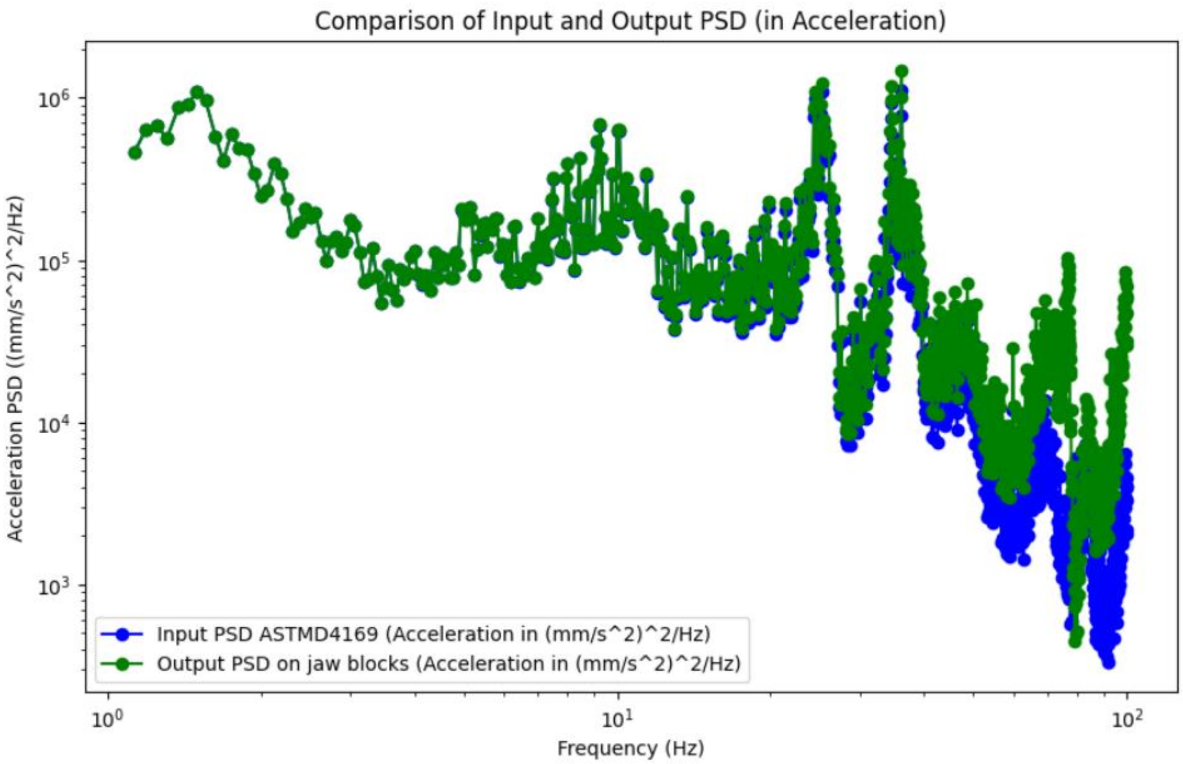
Random Vibrations – Experimental Input

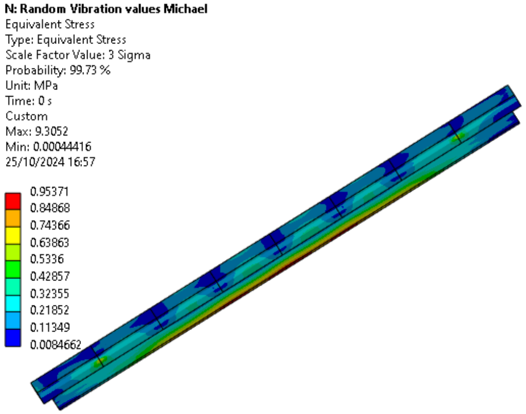


- EDMS reference: https://edms.cern.ch/document/2755675/2
- Maximum PSD acceleration on the frame of the cryomodule in z-direction

Acceleration PSD → Input → Random Vibrations

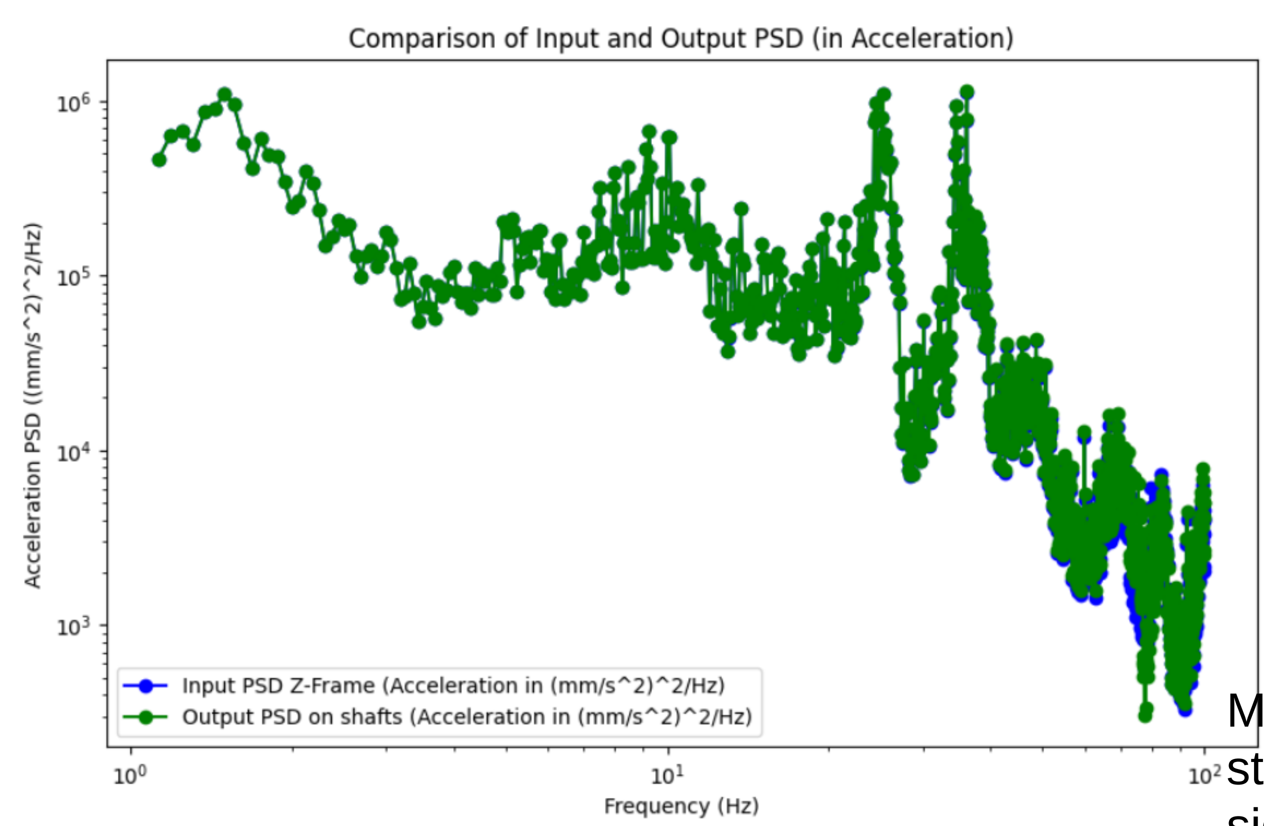
Stress on Blocks for Z-Frame Input

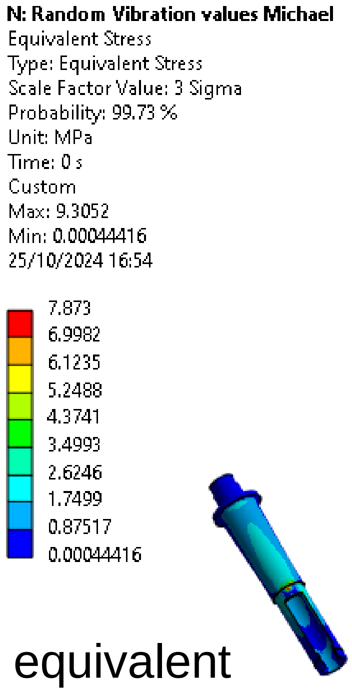




Max. equivalent stress: 1MPa for 3 sigma scaling

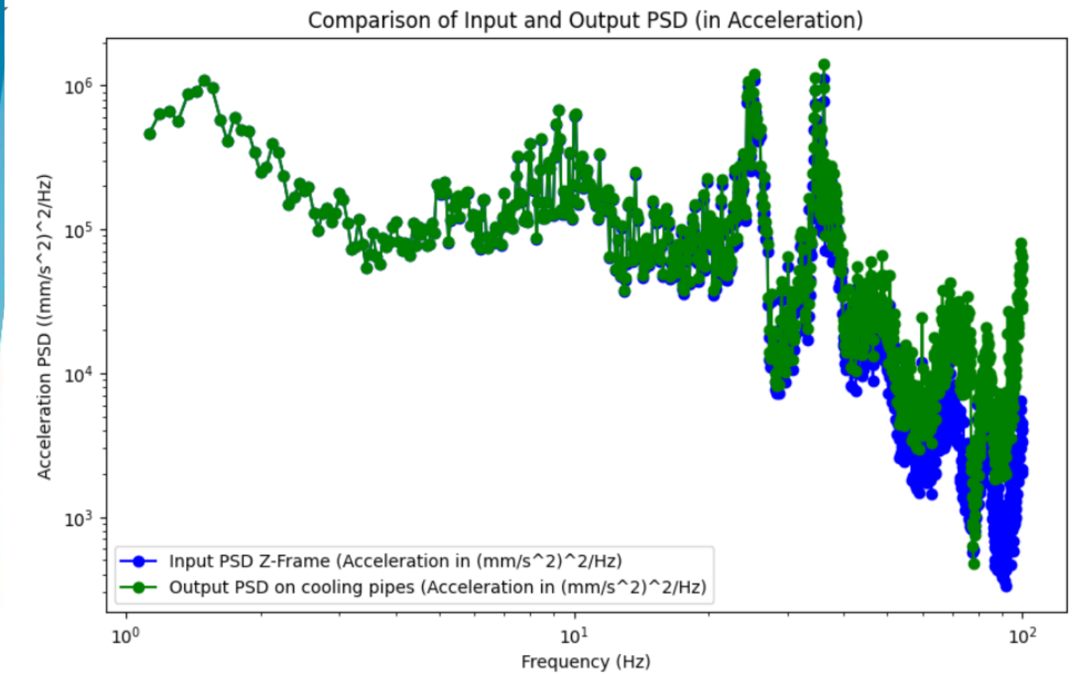
Stress on Shafts for Z-Frame Input

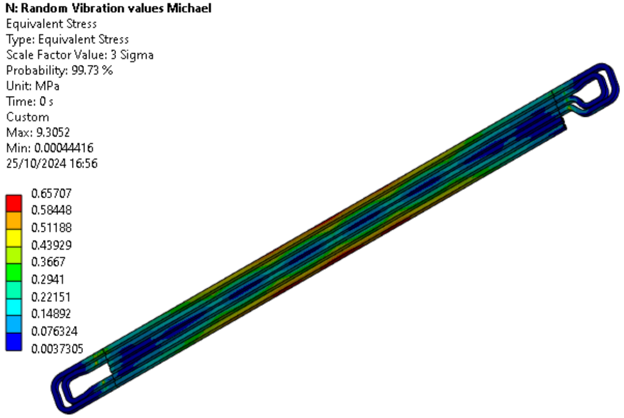




Max. equivalent stress: 8MPa for 3 sigma scaling

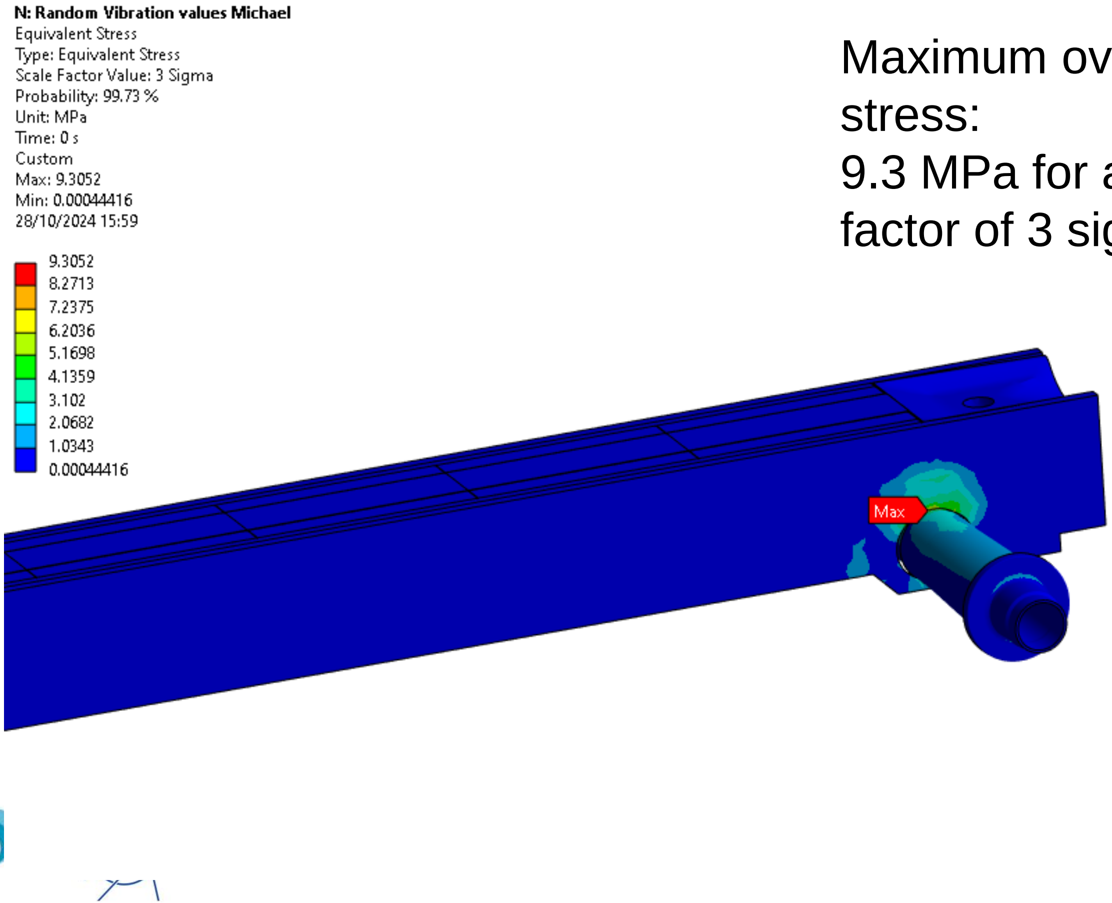
Stress on Cooling pipes for Z-Frame Input





Max. equivalent stress: 0.7 MPa for 3 sigma scaling

Maximum Stress for Z-Frame Input

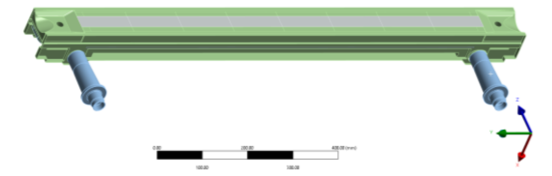


Maximum overall stress:
9.3 MPa for a scale factor of 3 sigma

Summary TCLP

	Max Equivalent Stress [MPa]		Max Directional Deformation [mm]	
	ASTMD4169	Cryomodule z-frame	ASTMD4169	Cryomodule z-frame
Blocks	1	0.72	0.03 (x-direction)	0.02 (z-direction)
Shaft	4.97	7.87	0.0014 (x-direction)	0.013 (x-direction)
Cooling pipes	0.55	0.65	0.027 (x-direction)	0.017 (z-direction)

Z-direction input



Conclusion: Current Progress and Key Observations

- **Methodology Applied**
  - **New Analysis Approach**: Method applied to collimator equipment for the first time.
  - **Starting Focus**: Began with TCLP and jaws as the initial subjects of analysis.
- **Preliminary Observations**
  - **No Major Issues**: Early review indicates no significant concerns.
  - **Additional Focus**: Potential optimization of the transport frame could be beneficial.

Next Steps and Future Analysis Plans

- **Future Analysis**
  - **Broader Analysis for LS3 Collimators**:
    - **TCSPM**: Pay close attention to graphite blocks due to their fragility.
    - **2-in-1 Drift Tube**: Potentially analyse further.
- **Upcoming WP5.2 Meeting**
  - **Discussions with M. Guinchard**: Review results and assess any experimental needs.
  - **Strategy Presentation**: Share proposed approach and findings at the next WP5.2 meeting.

Thank you for your attention