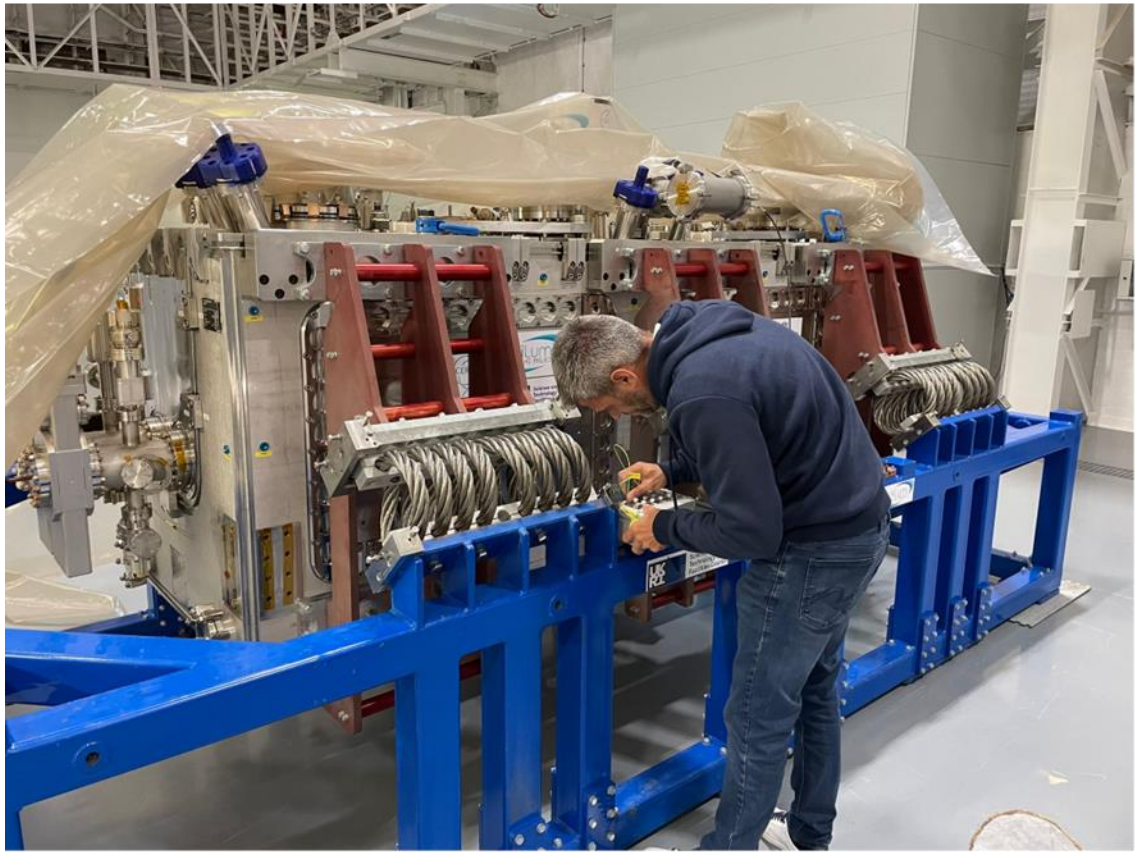
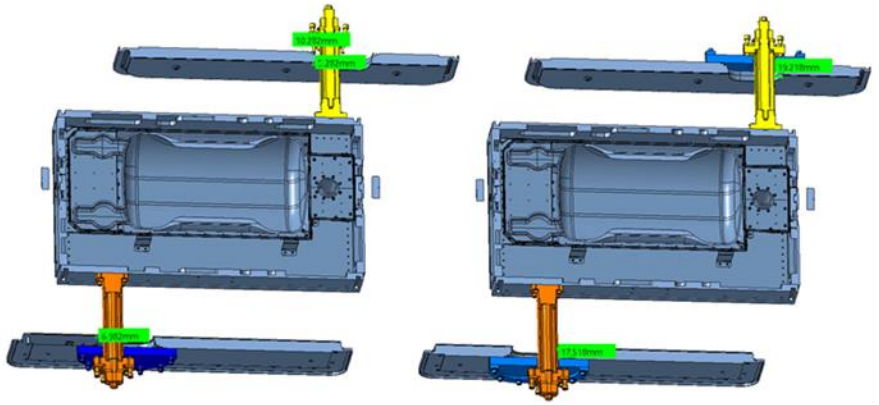
Mechanical measurements, experience during transport and testing of cryomodules

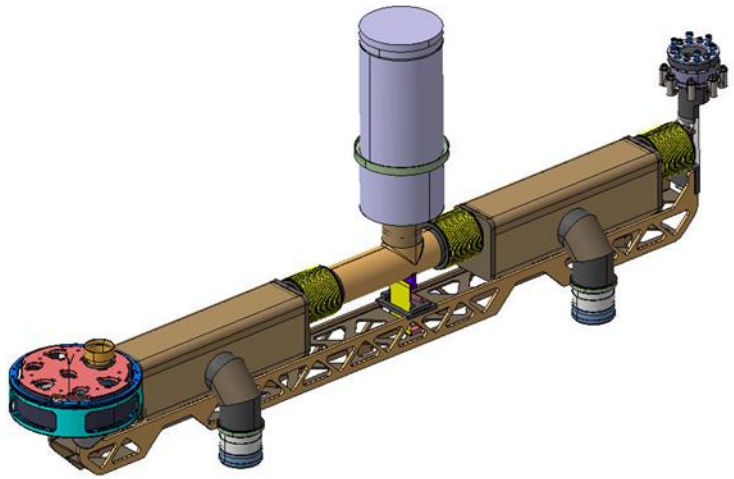
EN/MME Mechanical Measurement Lab

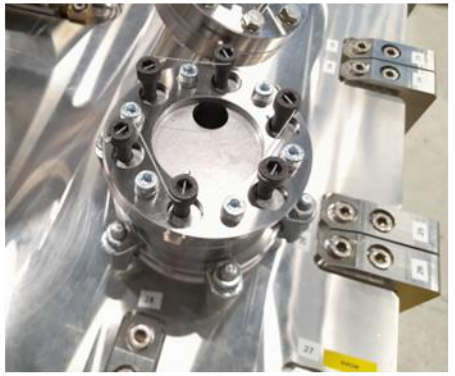
M. Guinchard, **D. Thuliez**

STFC Transport frame and Transport restraints



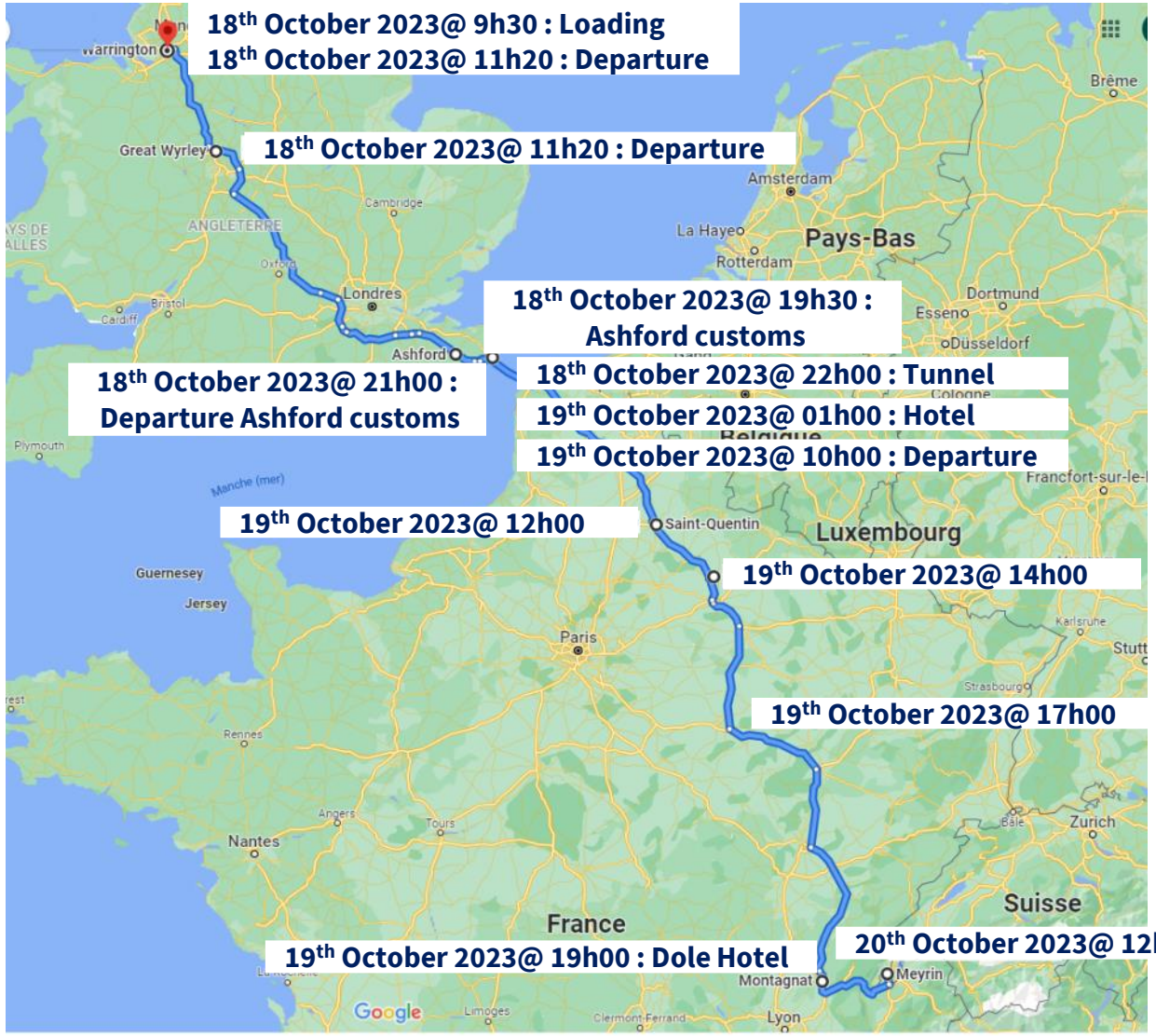






*Installation of restraints was monitored with the mechanical instrumentation (optical fibres)

Timeline

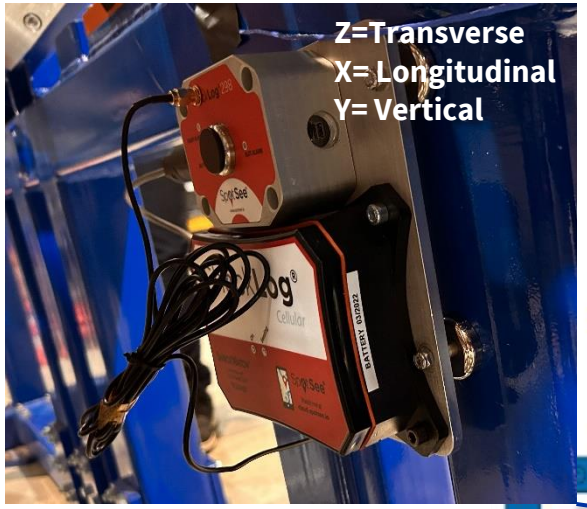


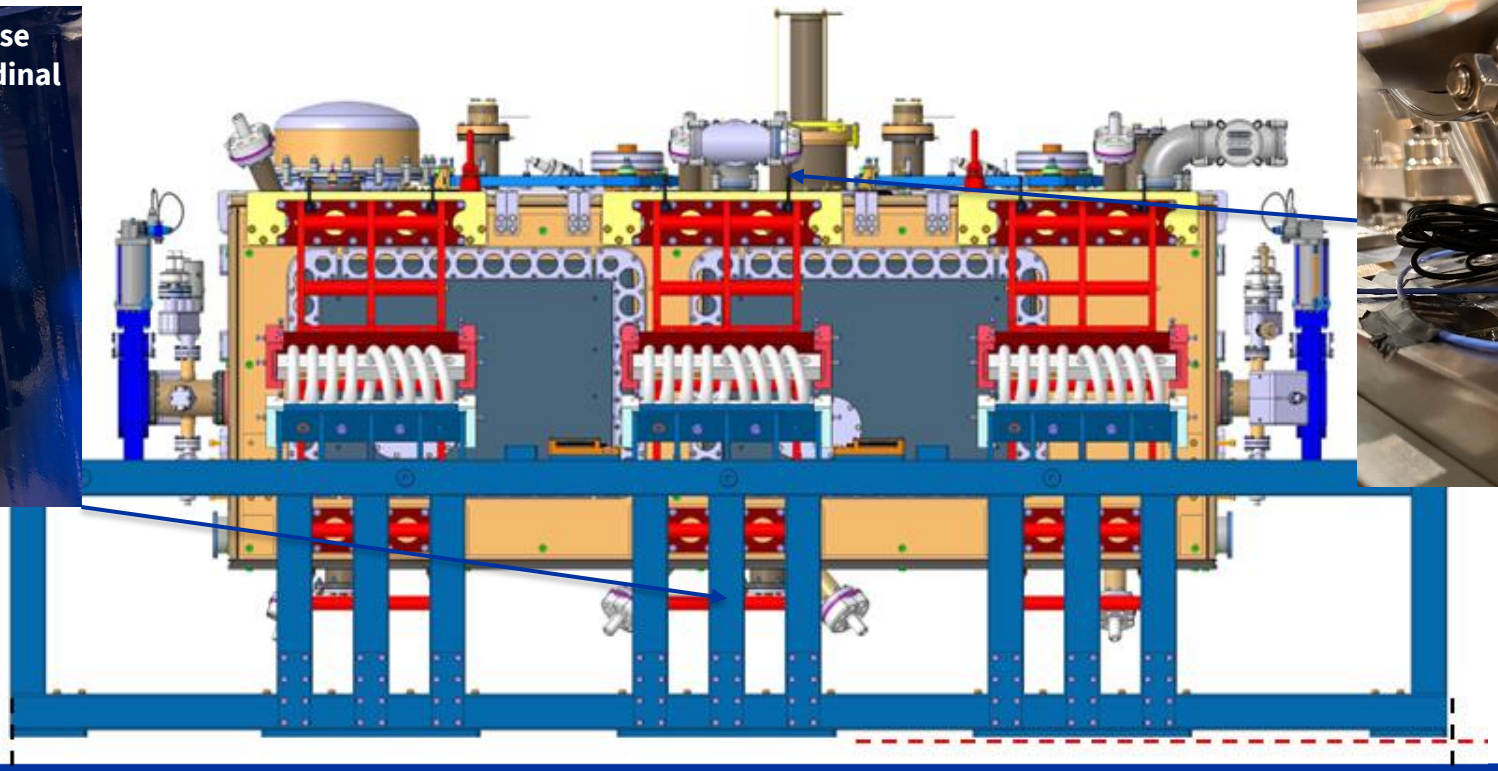
Huge thanks to Pierre-Loic (driver), Christophe (driver) and David (instrumentation) for the efforts !

Baseline Vibration and shock instrumentation

2 Shocklog® Systems with GPS and GSM connections worldwide: shocks, Temp, HR, Tilt :

- Cryomodule (3 directions)
- Transport frame (3 directions)

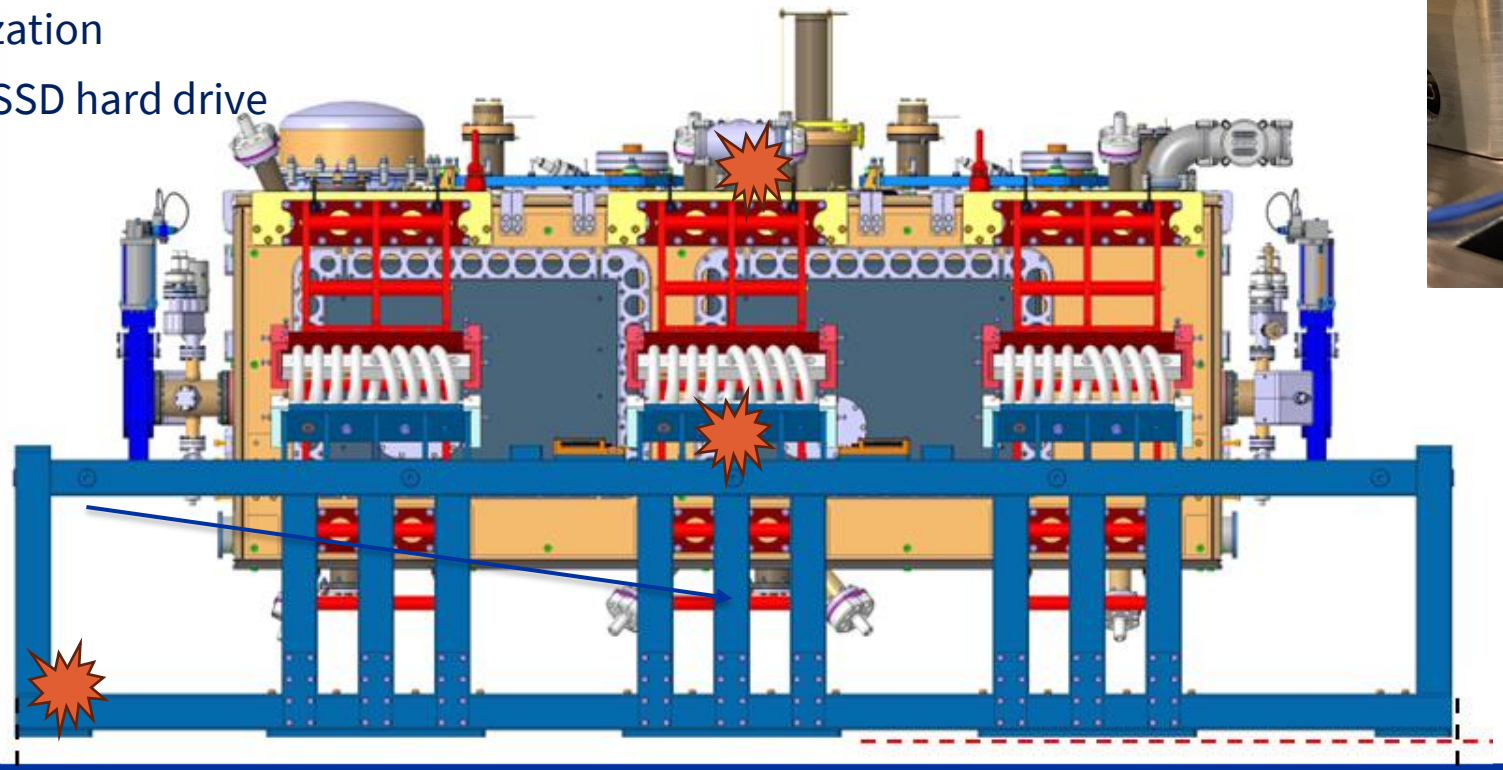




CERN Instrumentation – Extra

<u>Continuous vibration monitoring</u> system based on :

- 3 ICP triaxial accelerometers PCB-356A14
- Spectrum Analyzer with real time FFT analysis <u>MicroQuantus</u>®
  - Online visualization
  - Storage in an SSD hard drive
  - Fs : 1024 Hz

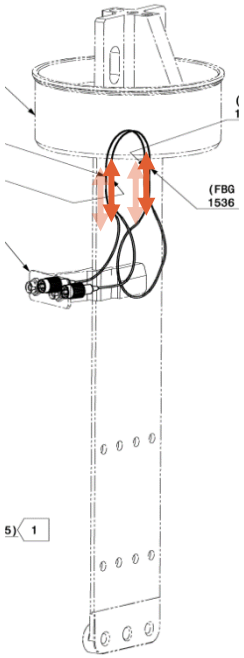


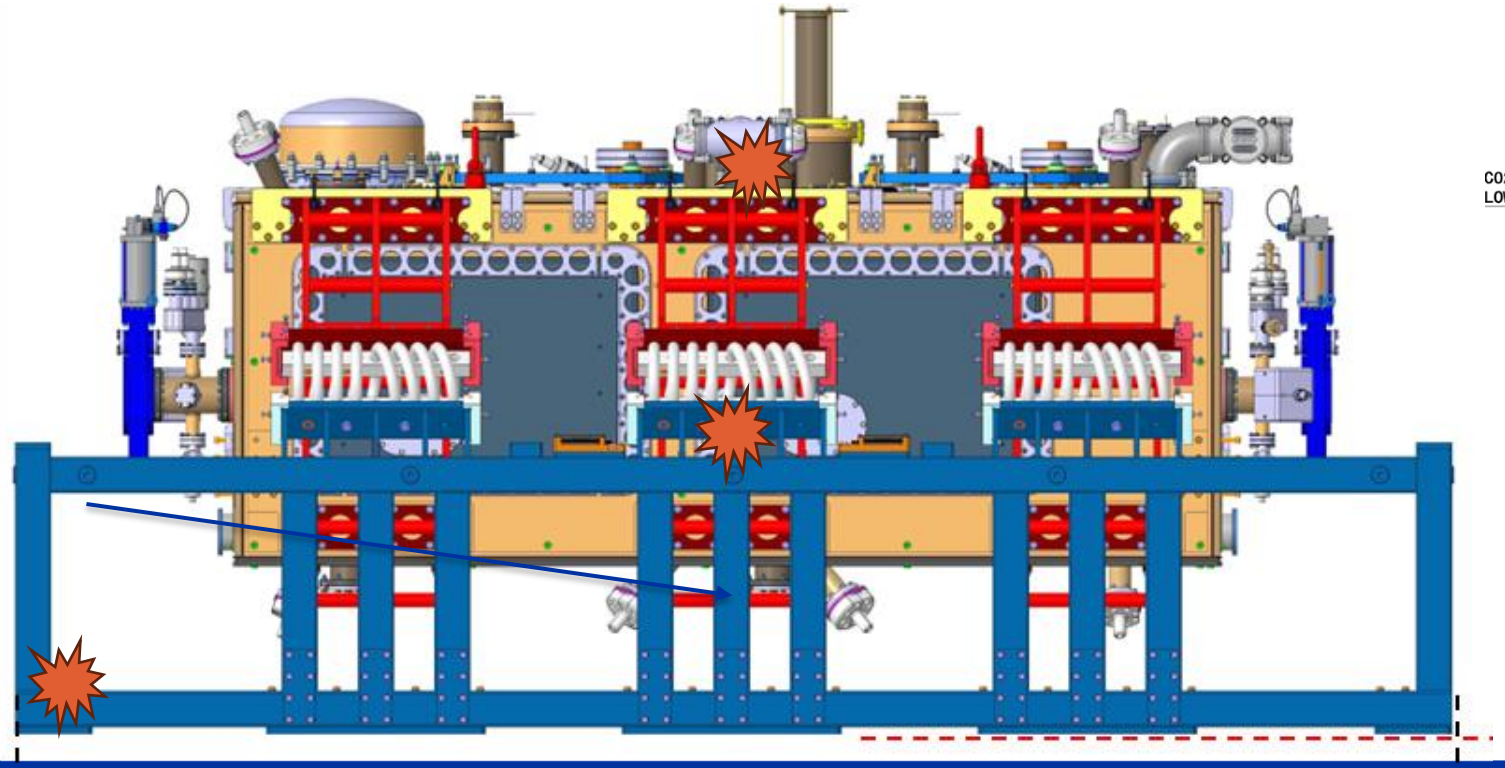
CERN Instrumentation – Cryomodule

<u>Continuous strain measurements</u> installed on blades and FPC tubes :

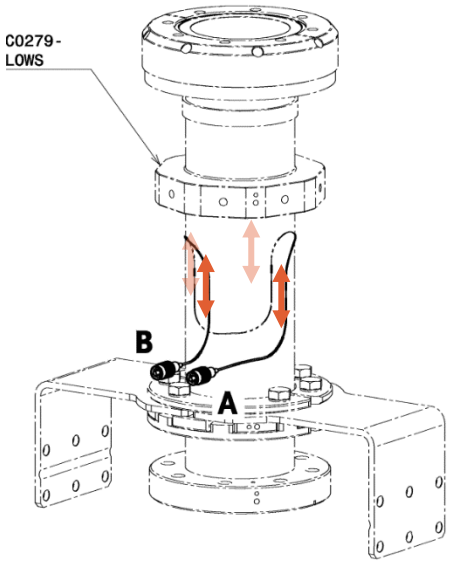
- Optical strain measurements based on FBG
- Online visualization with recording at 1000 Hz

Extra

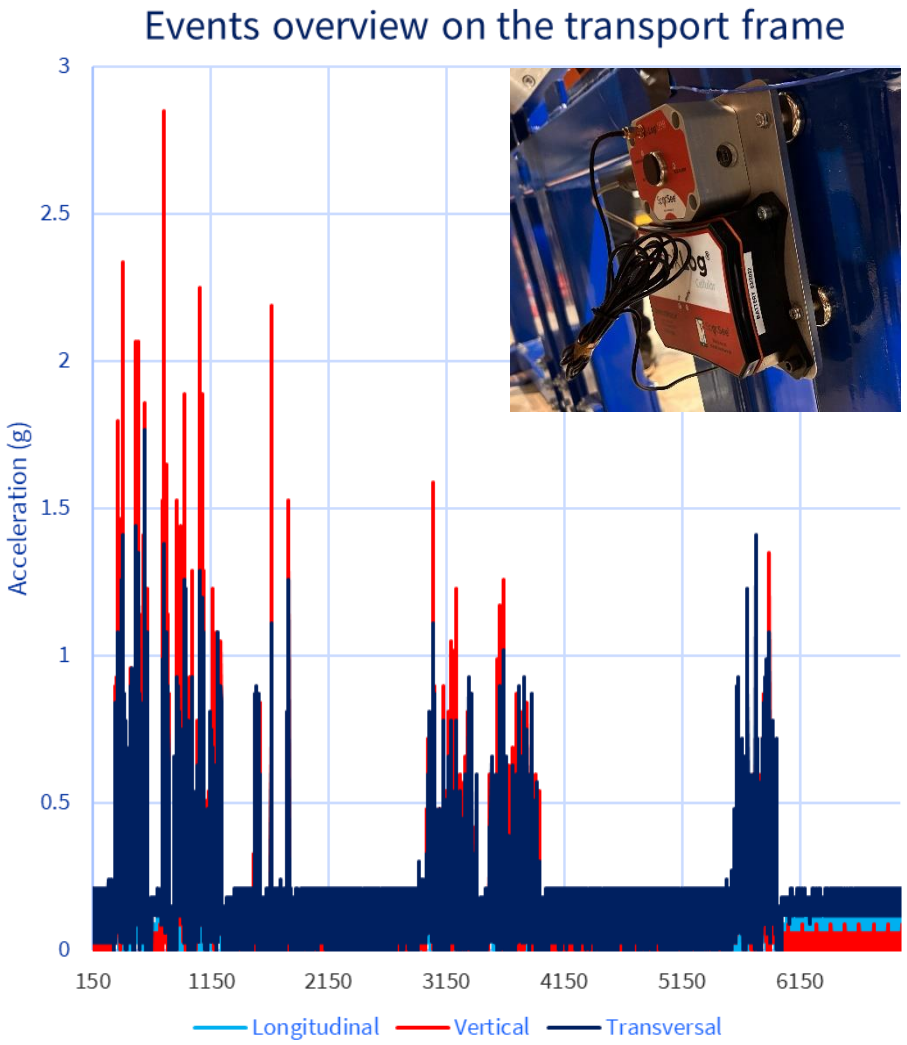


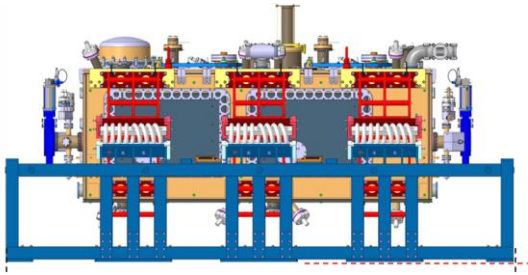


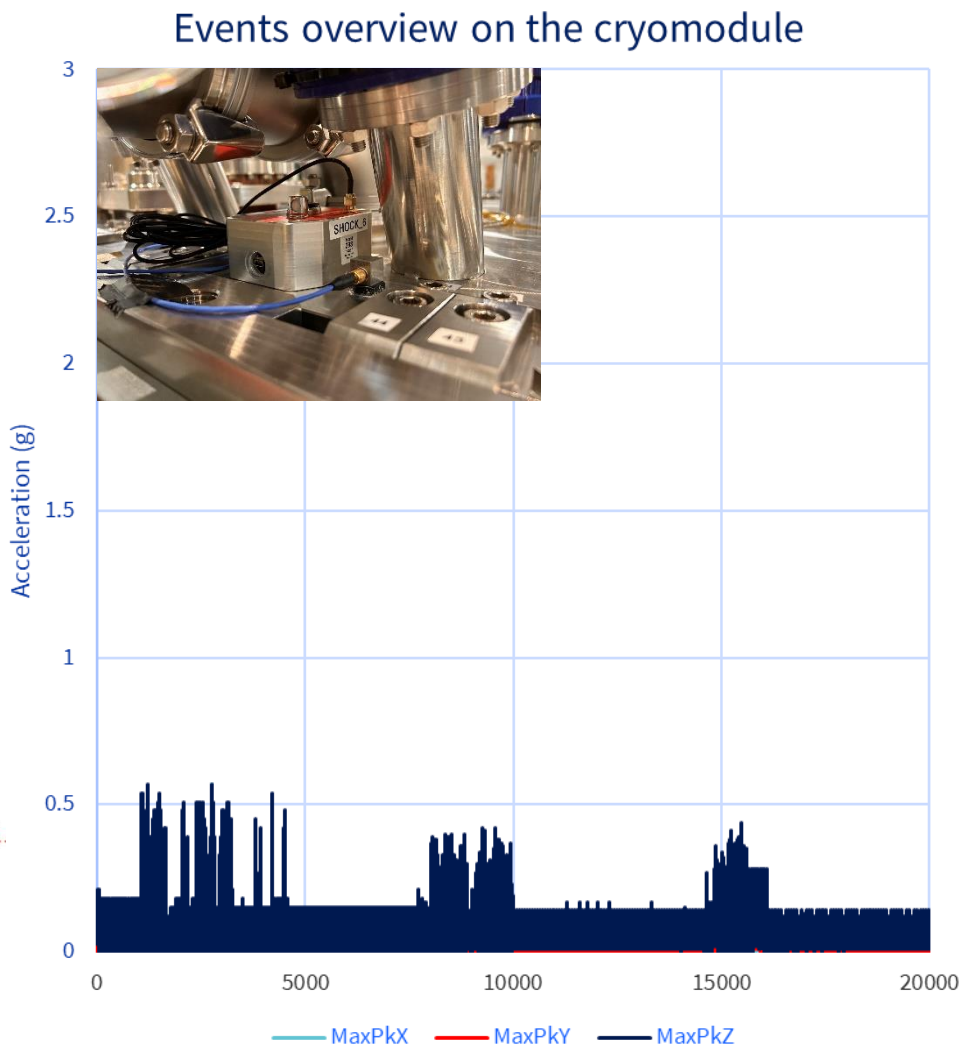
Baseline



Results – Shocklog units







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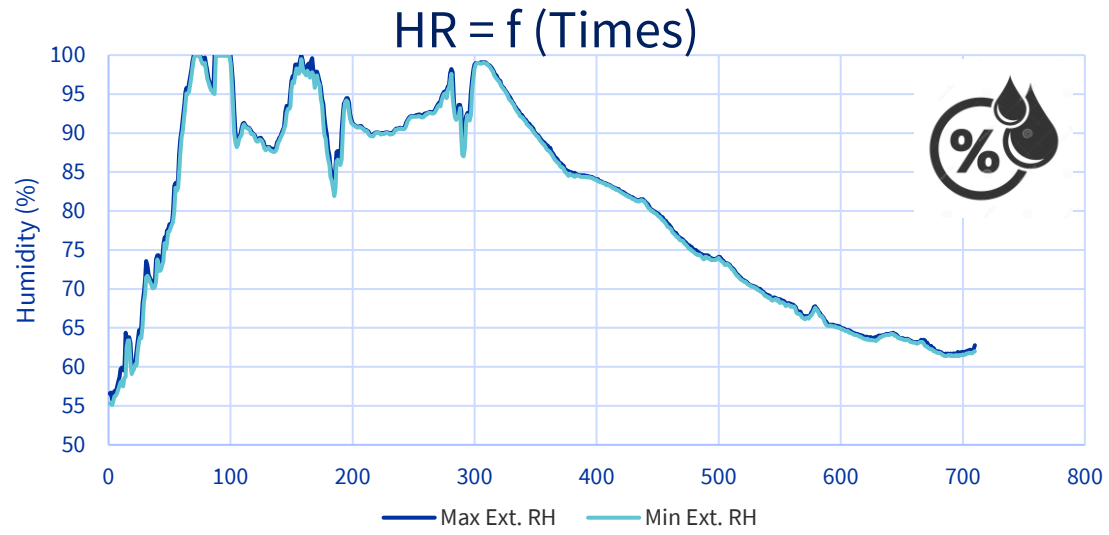
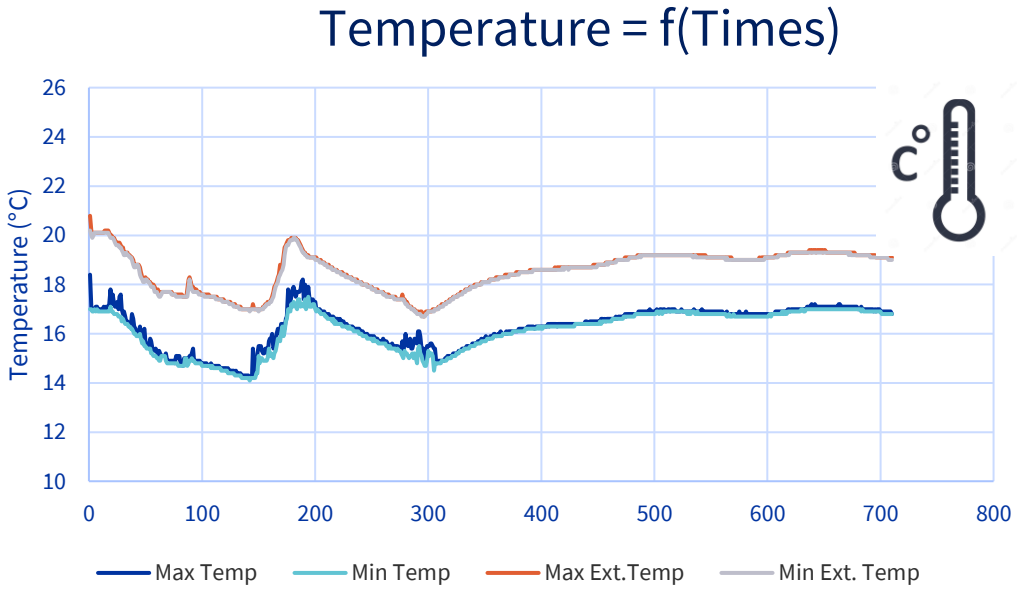
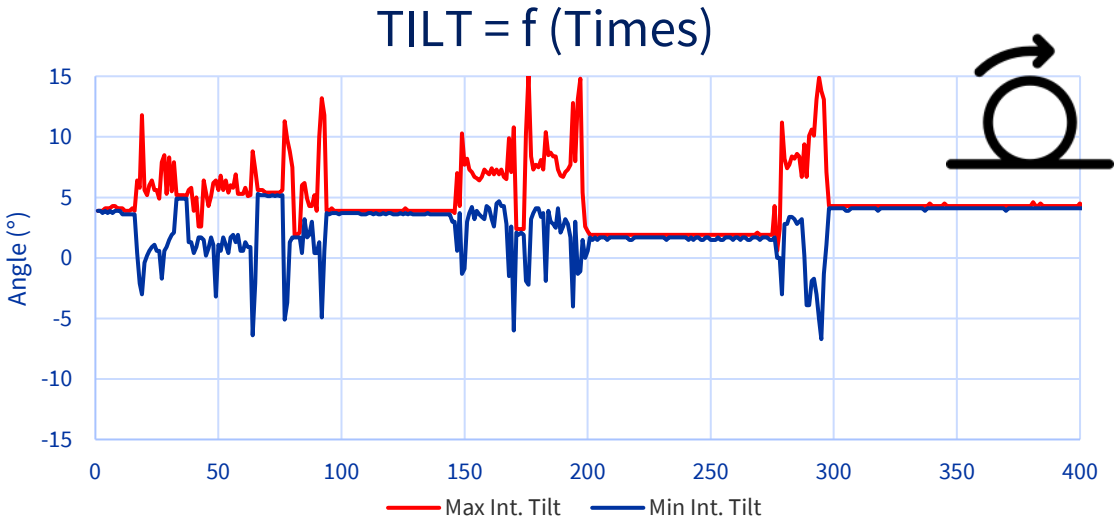
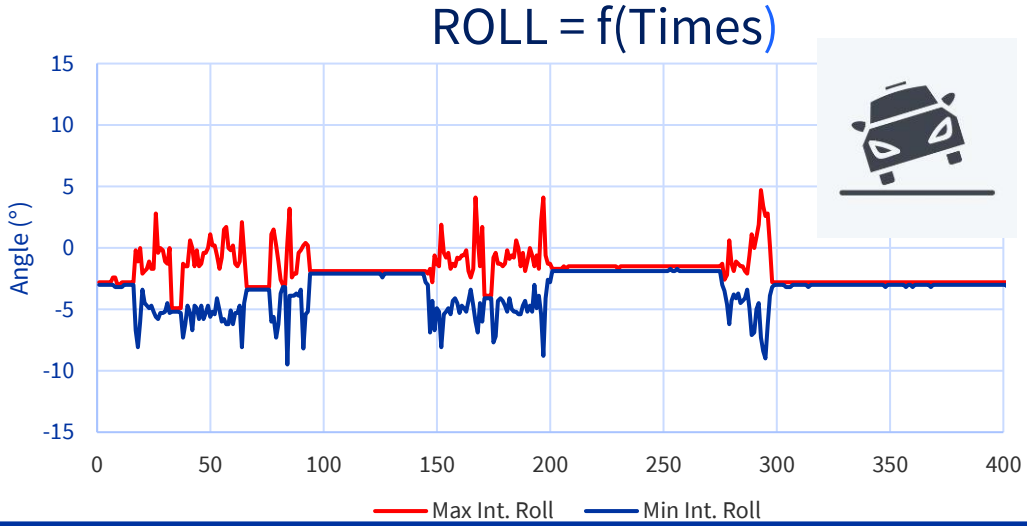
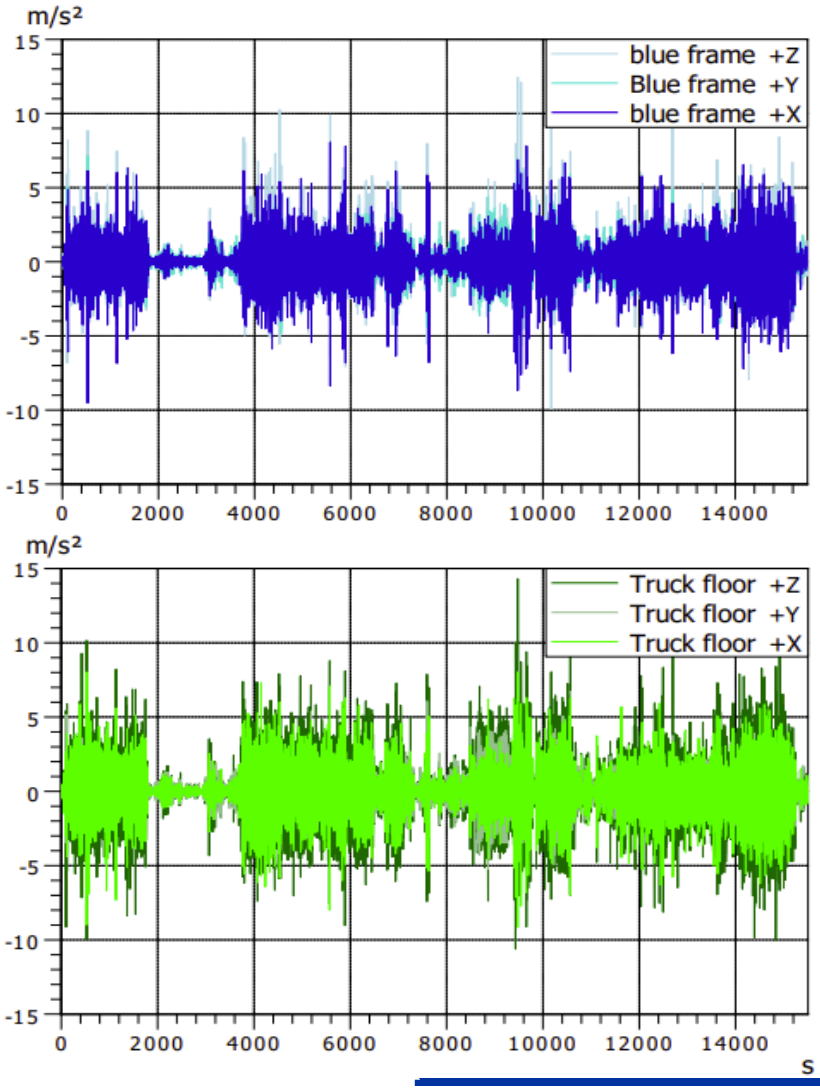




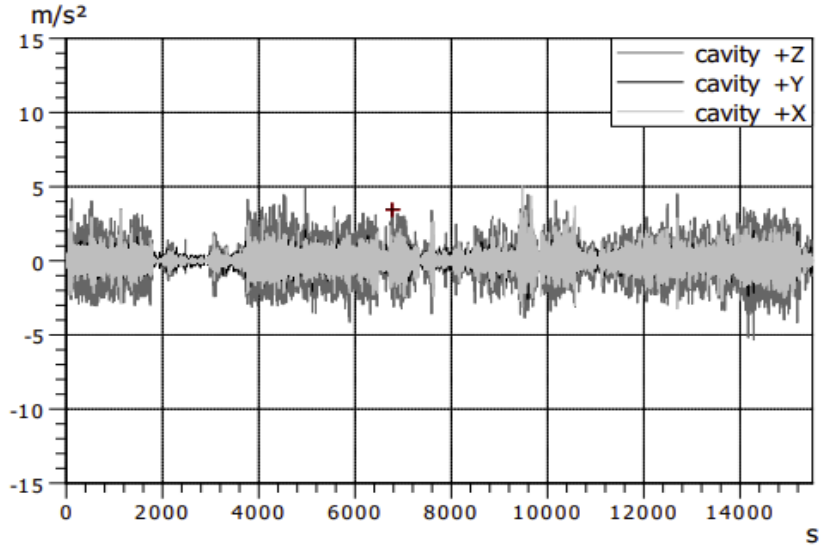


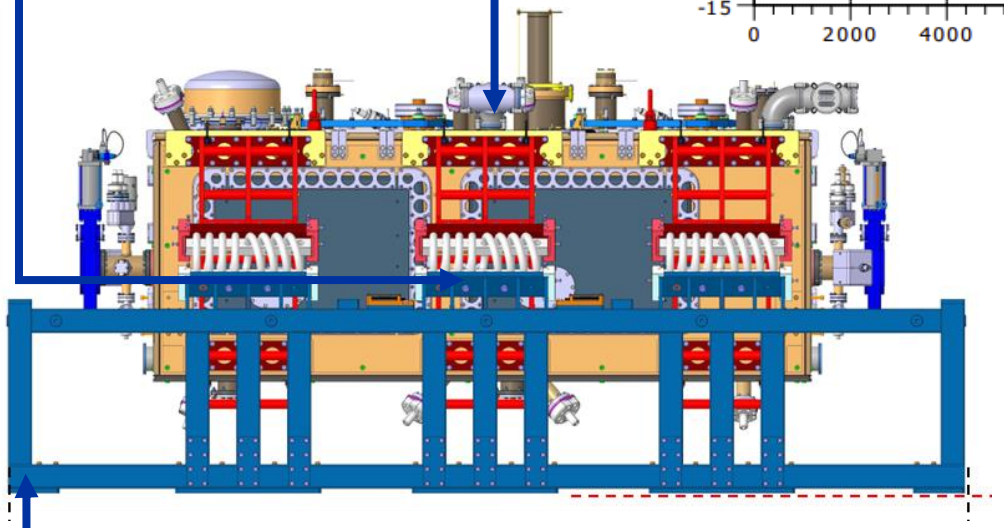


Results – Vibration monitoring system

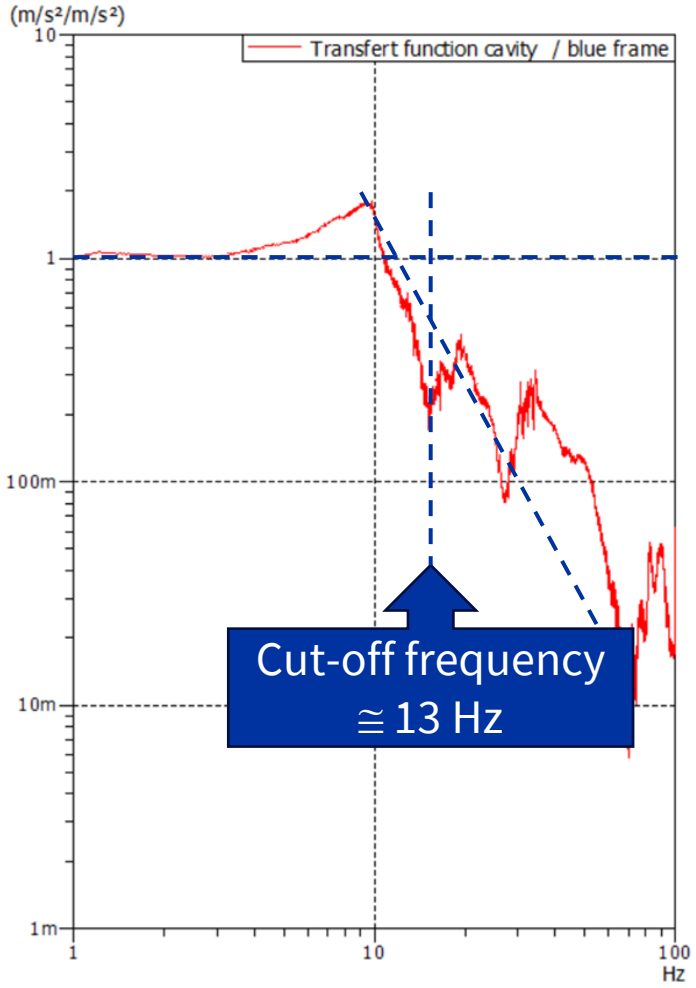


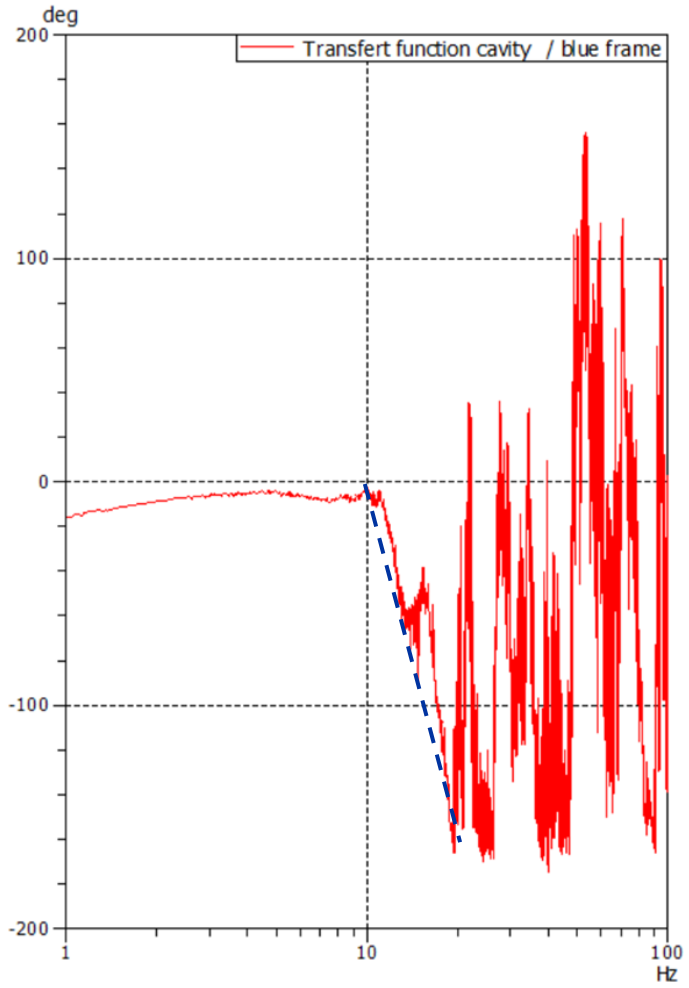
Set of data from Warwick to Ashford Customs

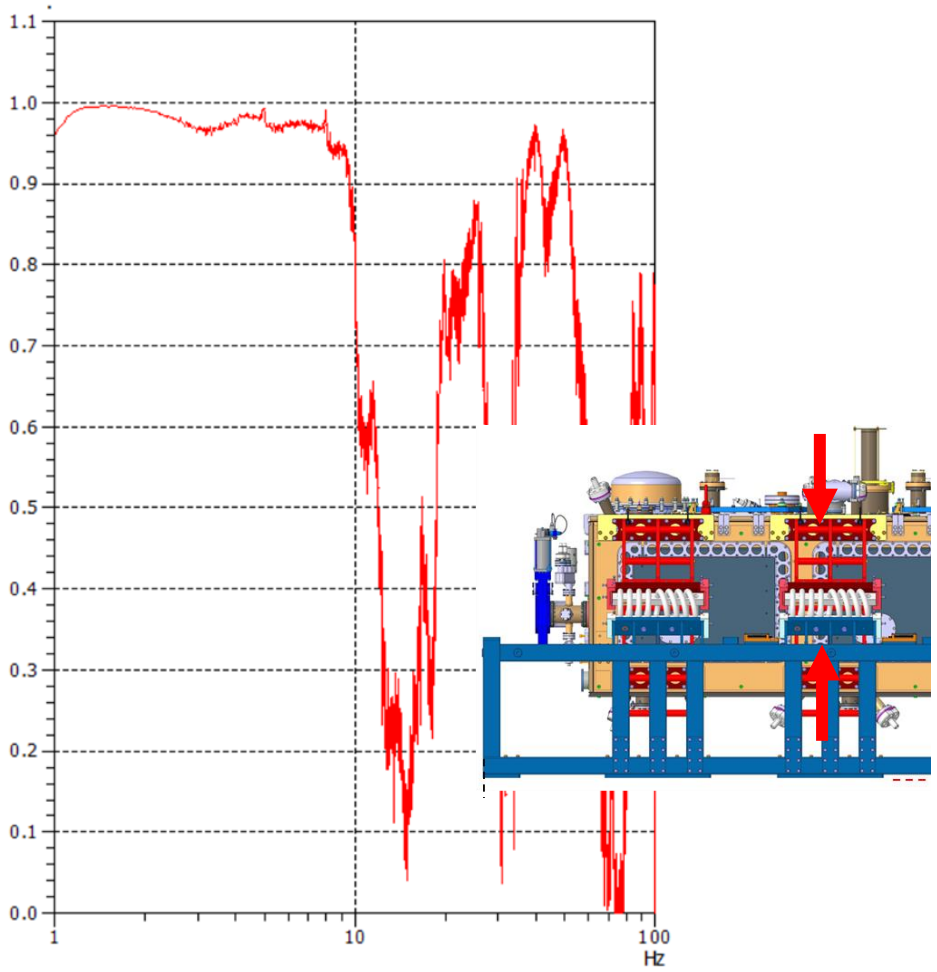




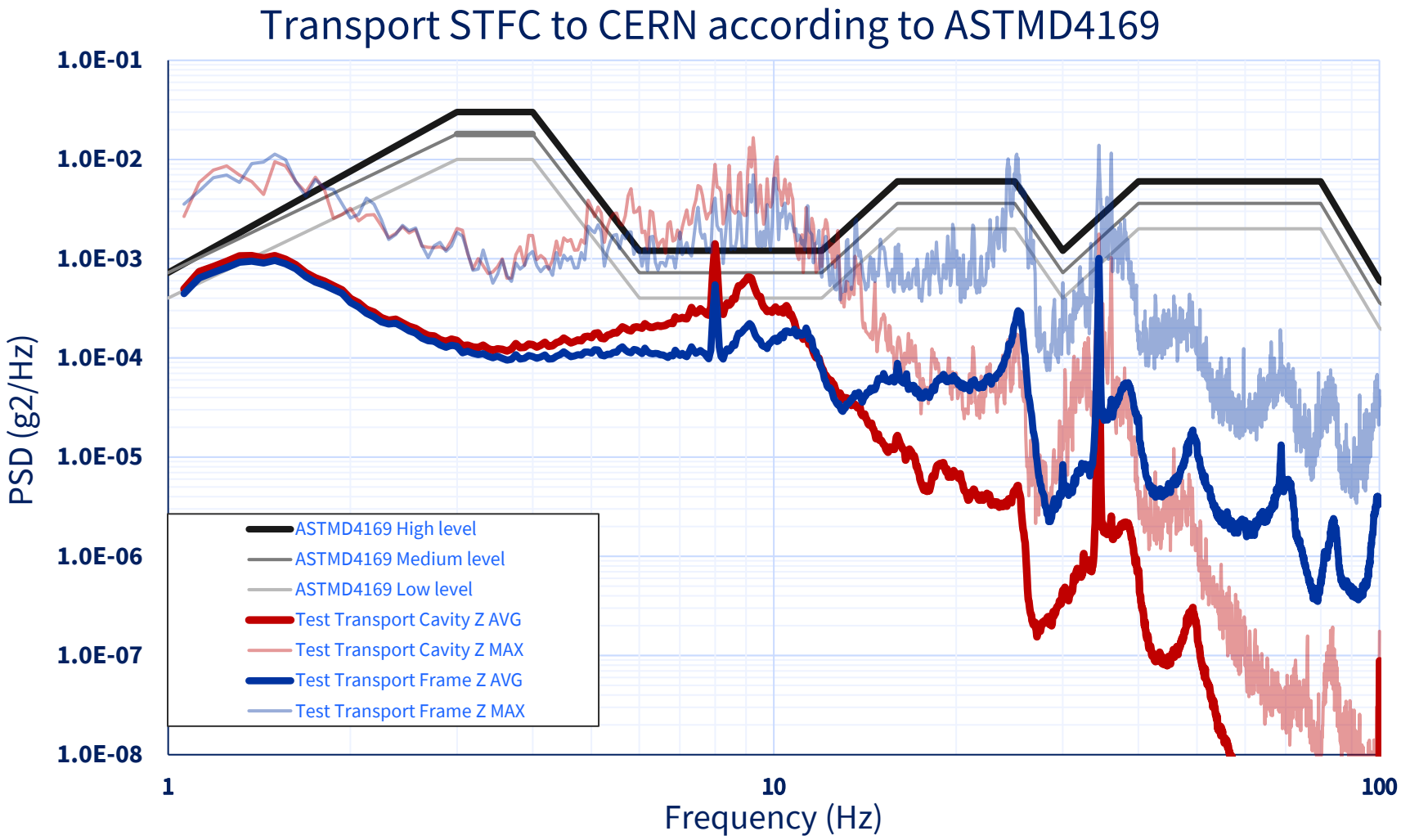
Results – Vibration monitoring system – Transfer function

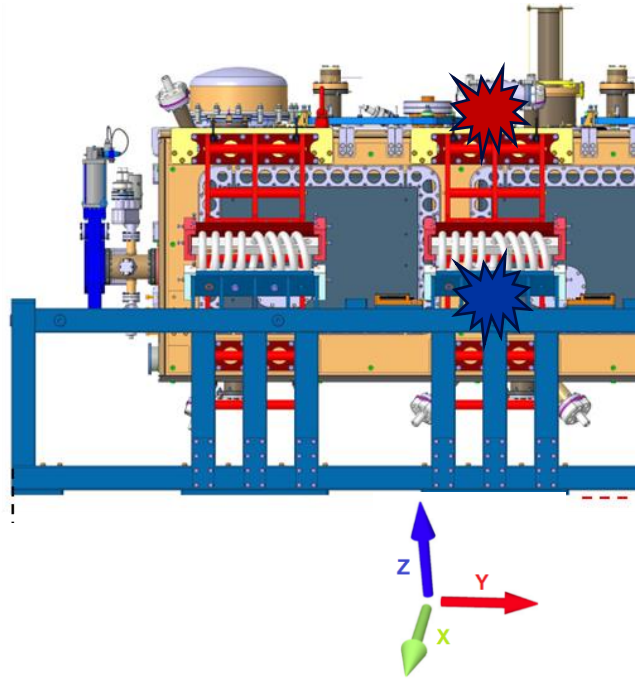




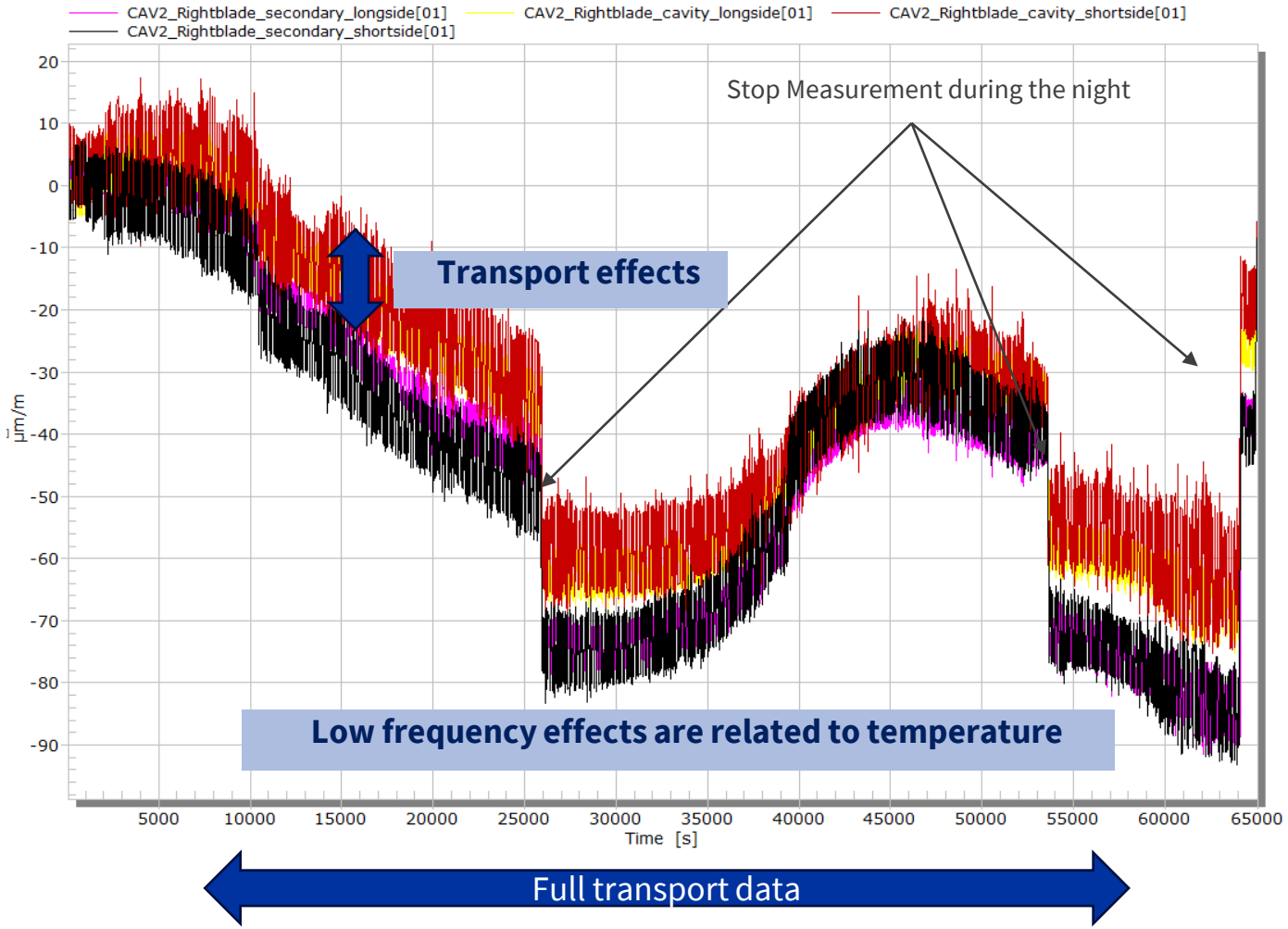


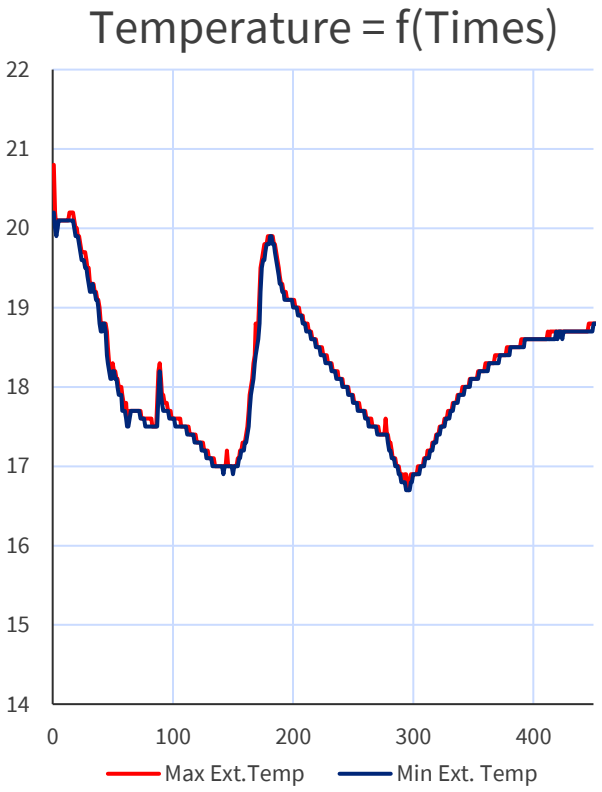
Results – Vibration monitoring system

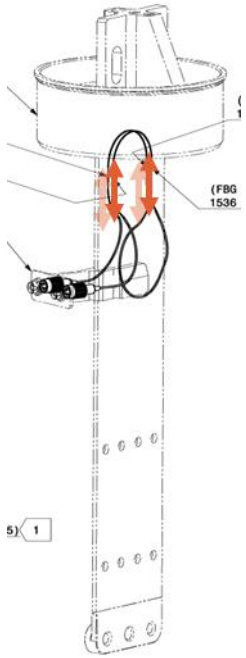




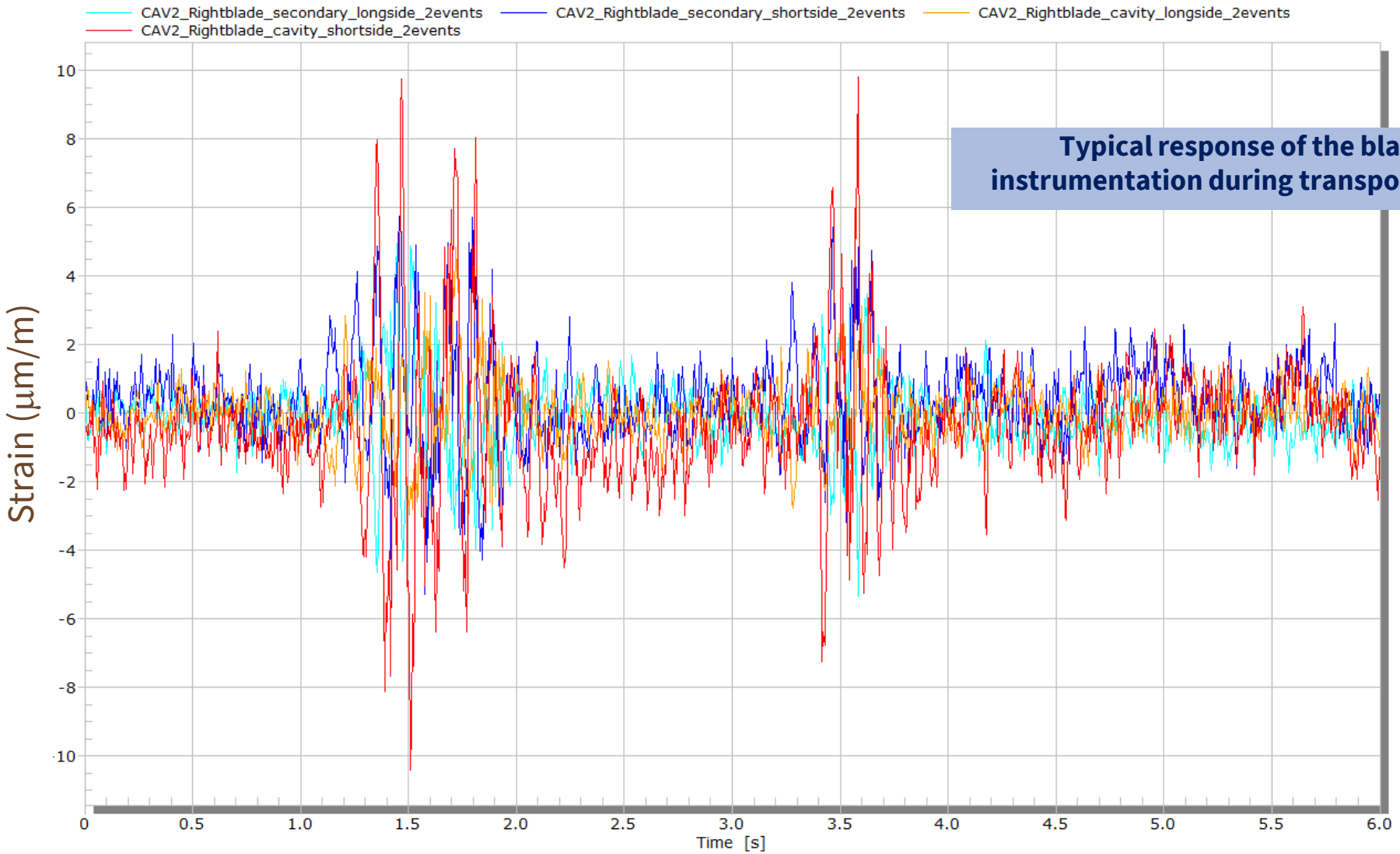
Results – Optical strain measurement system



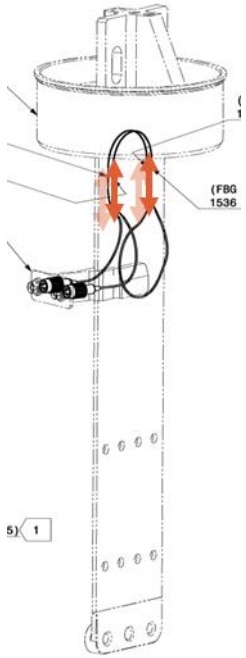




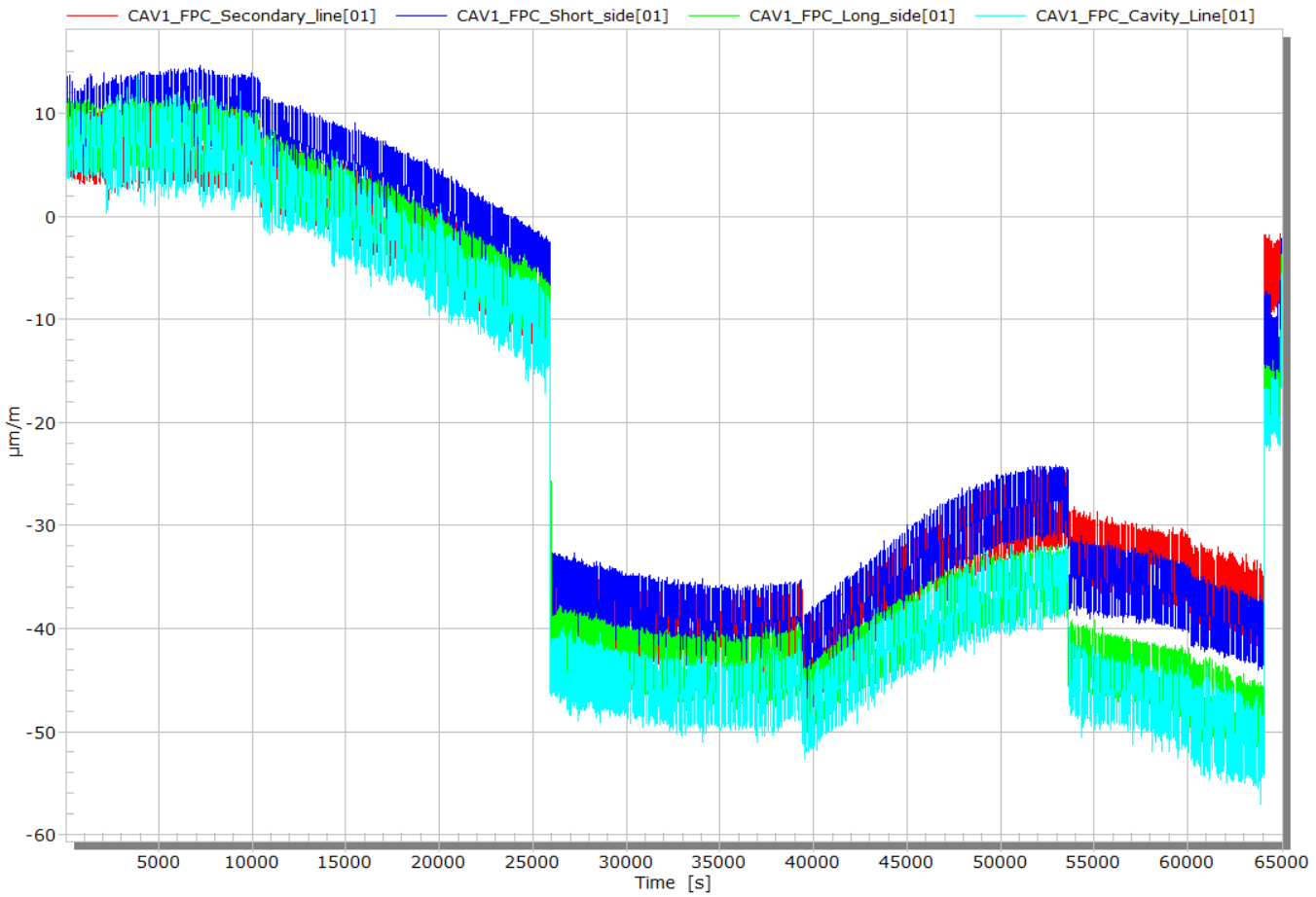
Results – Optical strain measurement system



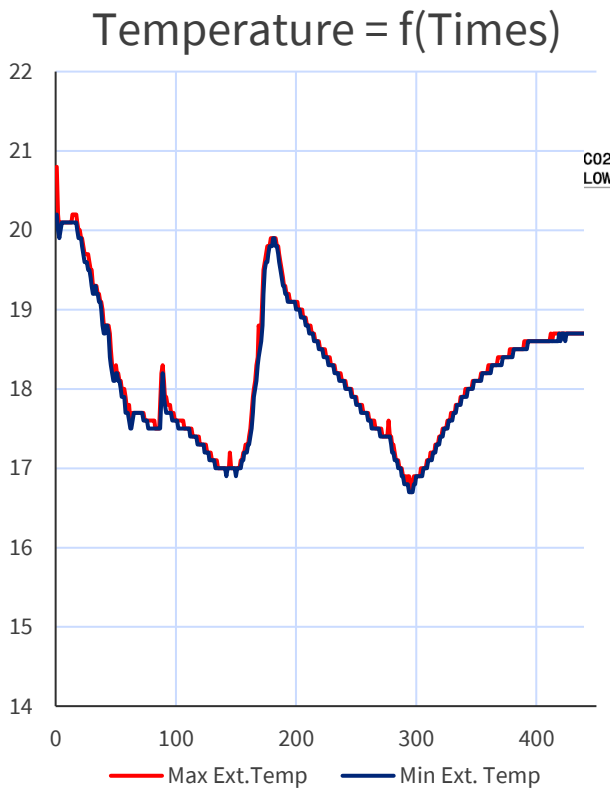
Typical response of the blade instrumentation during transport event

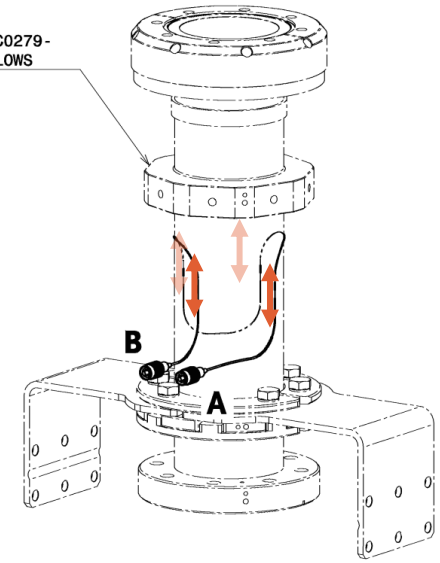


Results – Optical strain measurement system



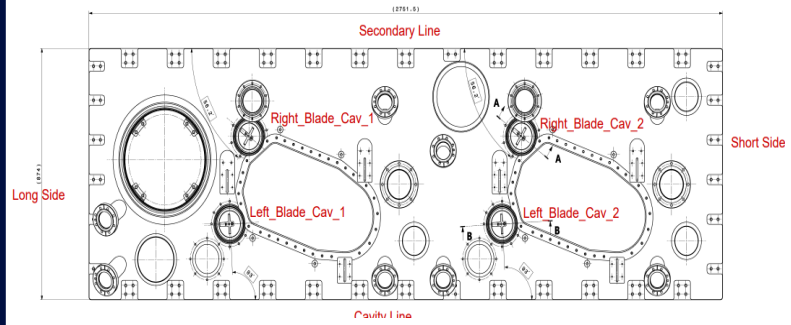
Full transport data

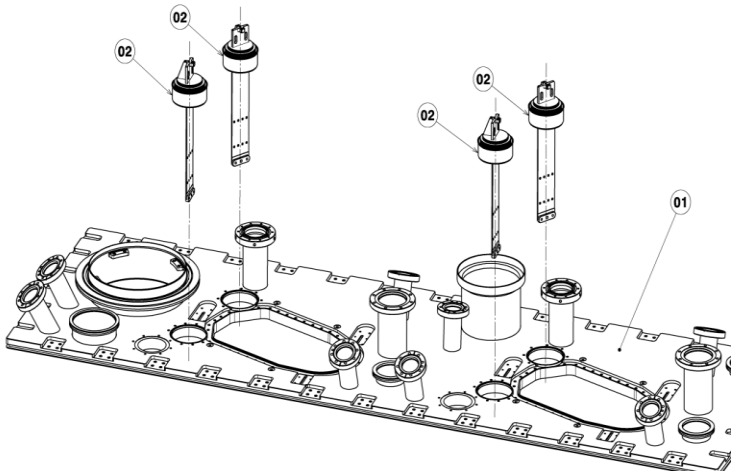




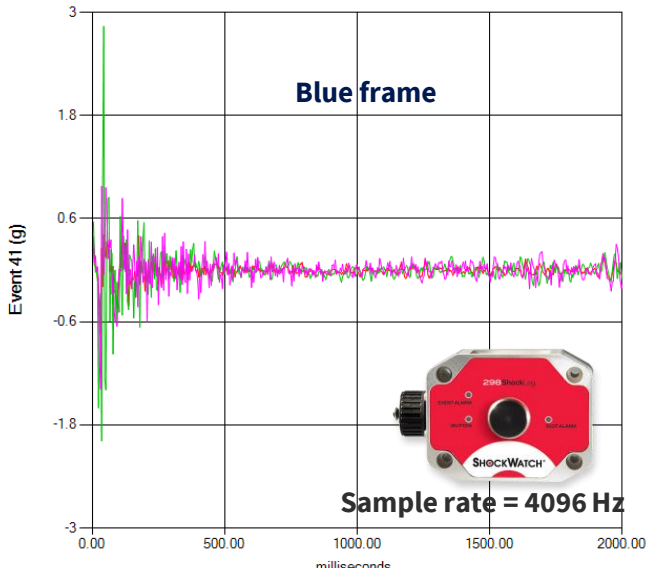
Results – Optical strain measurement system

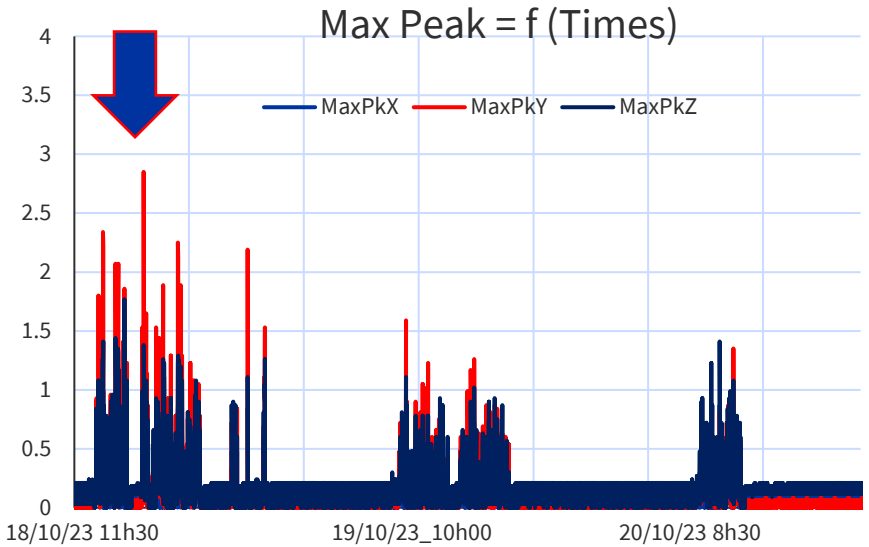
	18th August 2023	17th October 2023	23th October 2023	variation due to transport
	Strain (µm/m)	Strain (µm/m)	Strain (µm/m)	**Strain (µm/m)**
CAV1_FPC_Secondary_Line	29.12	-13.4	-23.8	**-10.4**
CAV1_FPC_Short_Side	-29.91	-43.41	-59.47	**-16.06**
CAV1_FPC_Long_Side	17.97	-76.33	-99.1	**-22.77**
CAV1_FPC_Cavity_Line	104.7	-24.16	-46.58	**-22.42**
CAV1_RightBlade_Cavity_Long Side	299.1	281.62	262.4	**-19.22**
CAV1_RightBlade_Secondary_Long Side	22.24	-43.96	-52.49	**-8.53**
CAV1_RightBlade_Secondary_Short Side	-268.3	-418.47	-447.9	**-29.43**
CAV1_RightBlade_Cavity_Short Side	-388.7	-489.43	-519.1	**-29.67**
CAV1_LeftBlade_Secondary_Long Side	90.7	59.36	26.7	**-32.66**
CAV1_LeftBlade_Cavity_Long Side	6.579	-47.39	-41.57	**5.82**
CAV1_LeftBlade_Cavity_Short Side	-147.3	-242.3	-267.74	**-25.44**
CAV1_LeftBlade_Secondary_Short Side	-103.3	-146.14	-161.43	**-15.29**
CAV2_FPC_Secondary_Line	-73.02	-129.23	-141.69	**-12.46**
CAV2_FPC_Short_Side	41.06	-19.99	-29.3	**-9.31**
CAV2_FPC_Long_Side	168.6	64.92	53.54	**-11.38**
CAV2_FPC_Cavity_Line	48.74	-44.96	-58.38	**-13.42**
CAV2_LeftBlade_Secondary_Long Side	-182.9	-139.04	-170.8	**-31.76**
CAV2_LeftBlade_Cavity_Long Side	-34.94	-153.79	-169.67	**-15.88**
CAV2_LeftBlade_Cavity_Short Side	-360.1	-411.13	-387.81	**23.32**
CAV2_LefttBlade_Secondary_Short Side	48.44	-23.51	-42.46	**-18.95**
CAV2_RightBlade_Cavity_Short Side	-44.86	-97.98	-118.8	**-20.82**
CAV2_RightBlade_Secondary_Short Side	-184.1	-321.01	-354.98	**-33.97**
CAV2_RigthBlade_Secondary_Long Side	150.6	98.07	64.25	**-33.82**
CAV2_RightBlade_Cavity_Long Side	26.02	-5.79	-31.13	**-25.34**

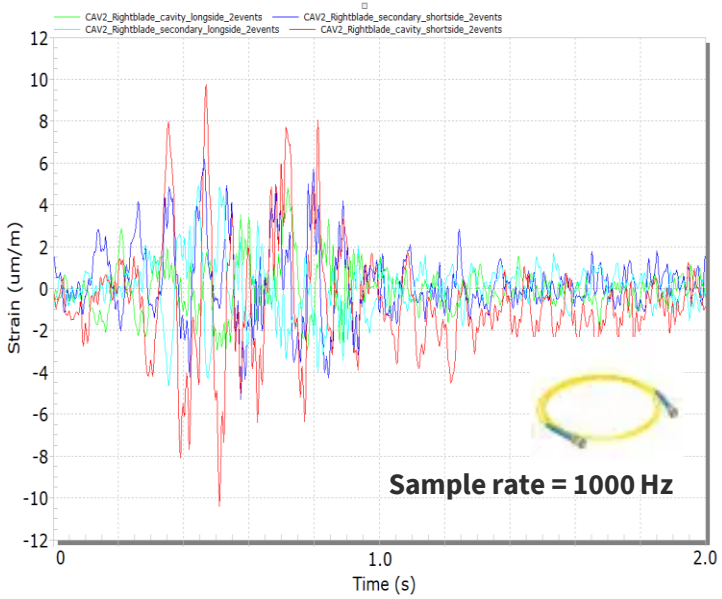


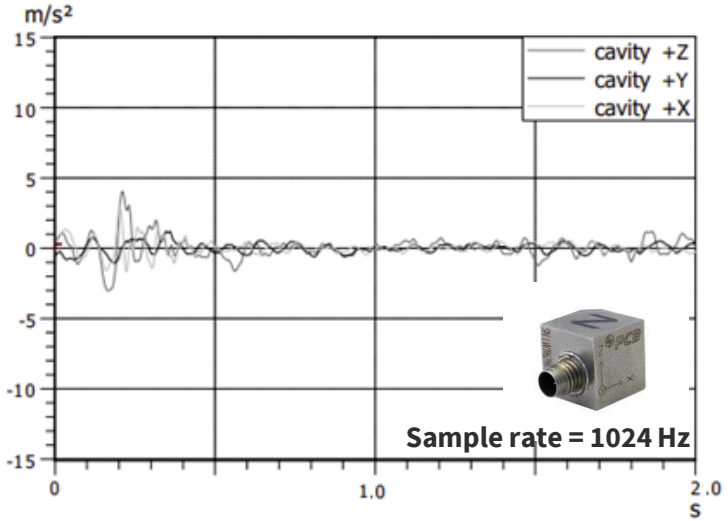


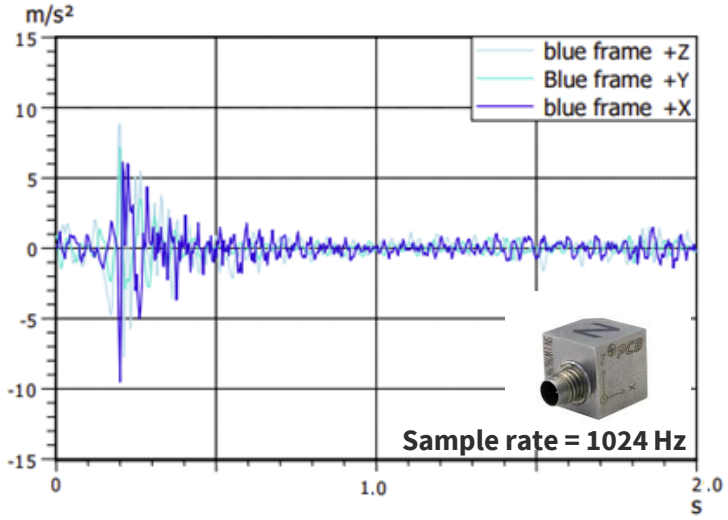
Results – Worst case event

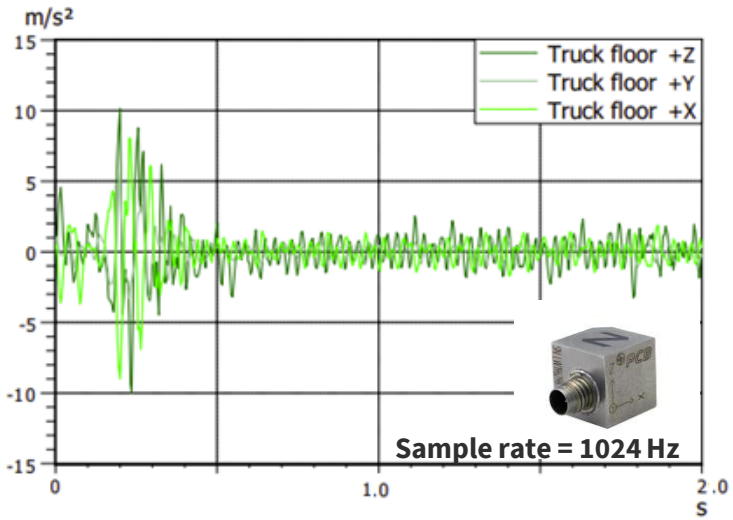












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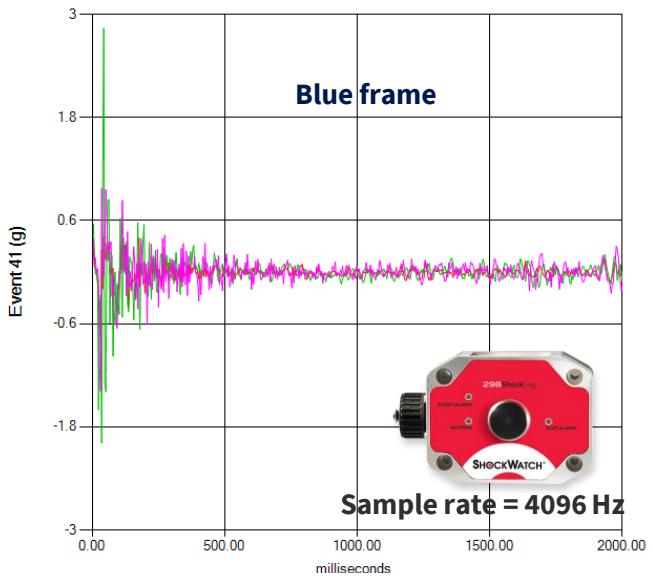
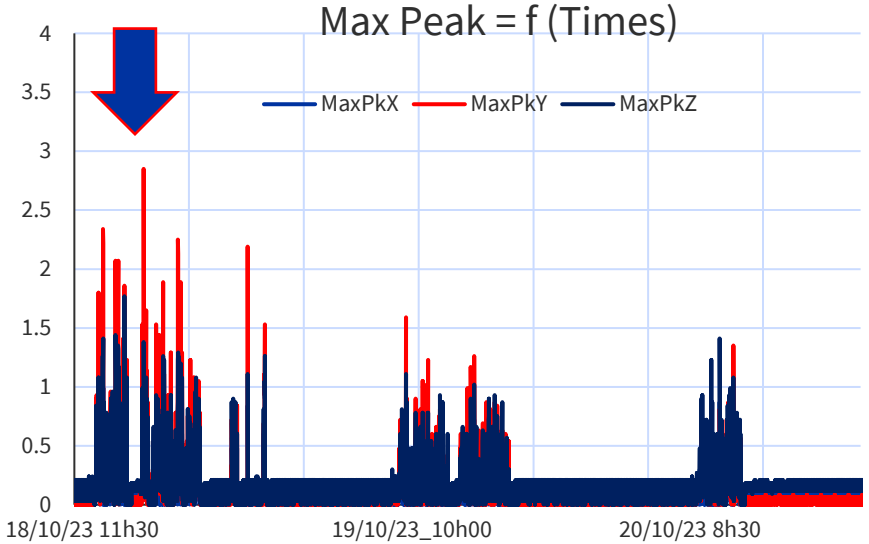
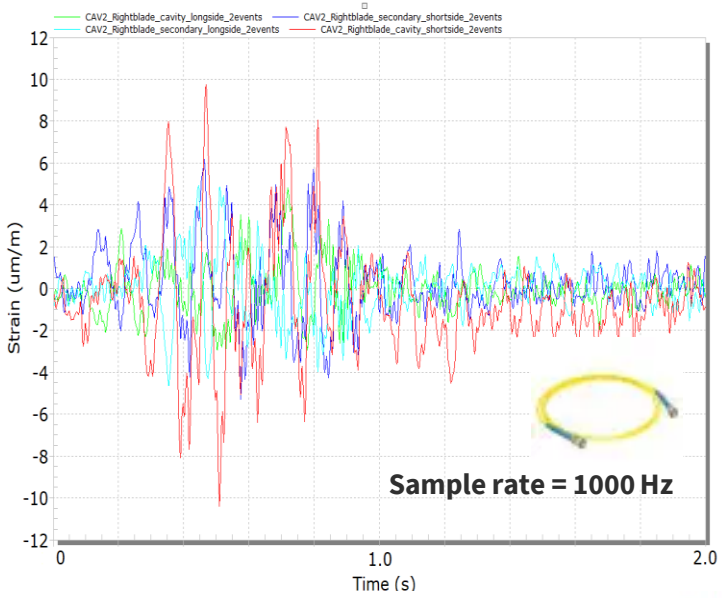
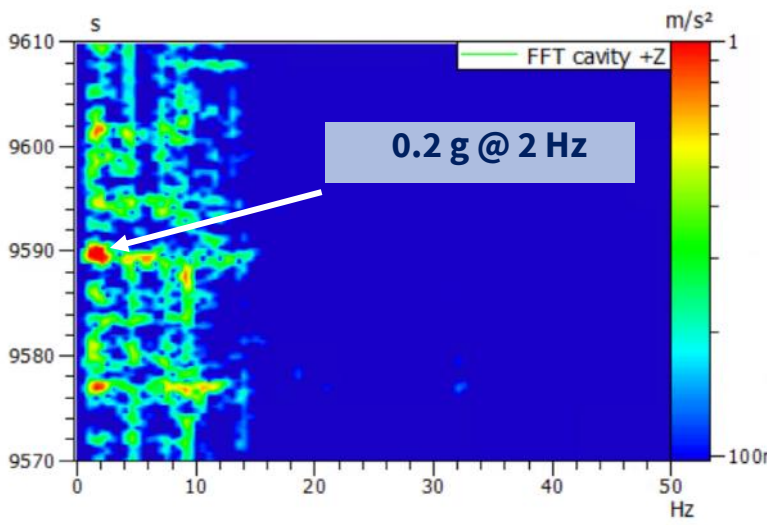
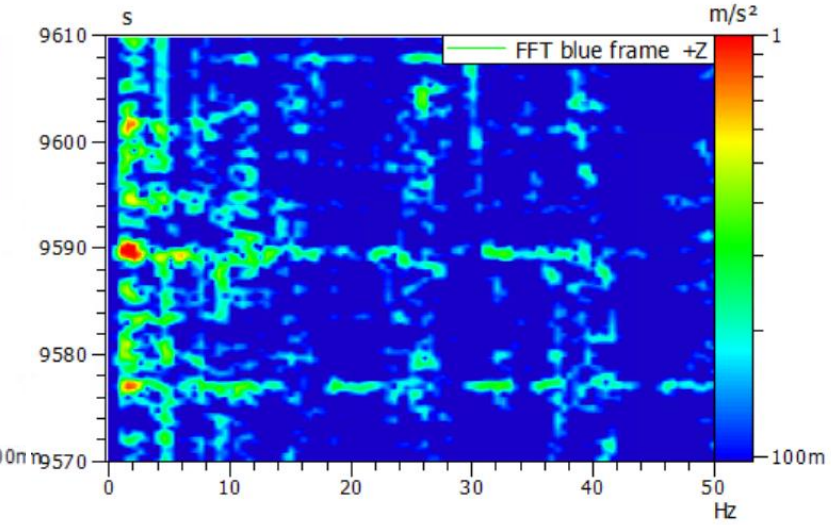
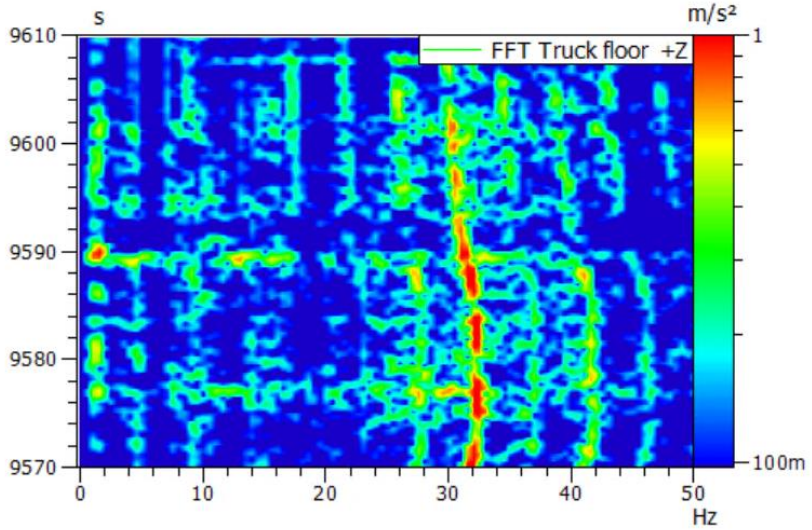






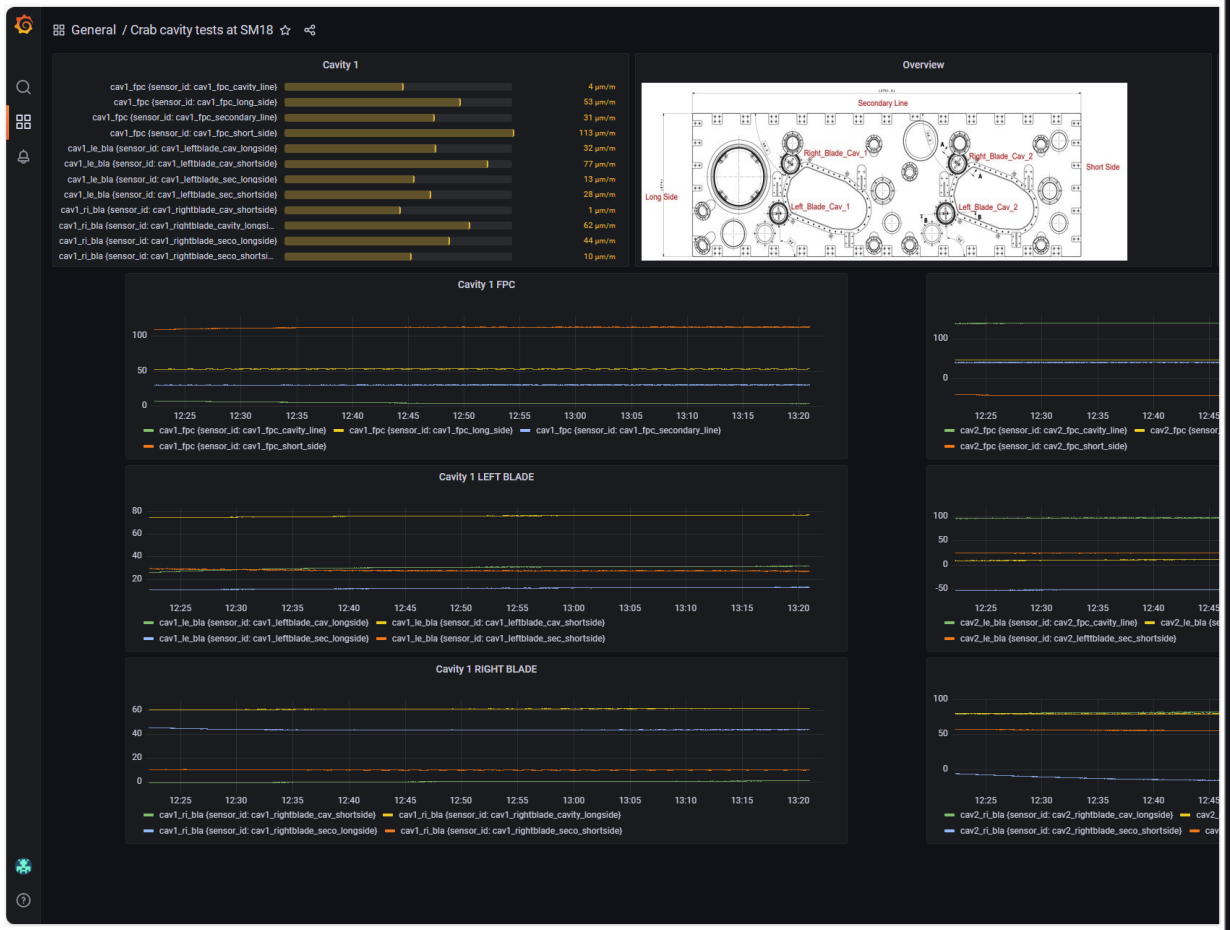






Use of the mechanical instrumentation during repair

- Continuous optical strain monitoring : (https://mml.web.cern.ch/)

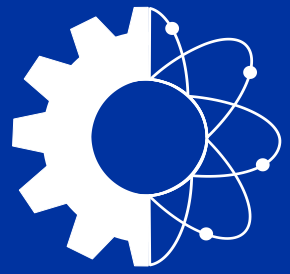


Summary Transport

		Min value	Max Value
Shocklog Data	Temperature	14 °C	20 °C
	Humidity	55 %	100 %
	Tilt	- 7 °	+15 °
	Roll	-10 °	+5 °
	Vertical RFD acceleration (@4096 Hz)	/	< 0.6 g
	Longitudinal RFD acceleration (@4096 Hz)	/	< 0.6 g
	Lateral RFD acceleration (@4096 Hz)	/	< 0.6 g
Monitoring system	Vertical RFD acceleration (@1024 Hz)	/	< 0.5 g
	Longitudinal RFD acceleration (@1024 Hz)	/	< 0.5 g
	Lateral RFD acceleration (@1024 Hz)	/	< 0.5 g
	Strains on blade components	/	+/- 20 μm/m
	Strains on FPC components	/	+/- 20 μm/m

Summary Transport and Mechanical instrumentation

- **The transport of the SPS RFD cryomodule from STFC to CERN was a success.**
- **Transport frame combined with transport restraints**
- **No damage linked to transport was found**
- **Two shock logs as baseline during transport**
- **The extra instrumentation during the first DQW and RFD (from TRIUMF transport)**
- **The strain measurements on the FPC pipe can/should be used more extensively during the assembly and recorded. Requires training + some preparation**
- **FPC strain gauges > base line**



Engineering Department