

Vibration studies on TTF-like cryomodules

A summary of the work done so far

Serena Barbanotti

Second Cryomodule Microphonics and Resonance Control Workshop

New York City, 25 October 2018



Outlook

01 Vibration measurements at the Tesla Test Facility (now FLASH accelerator)

- Ground motion measurements
- Measurements on cryomodules: FLASH, CMTB
- Measurements with Wire Position Monitors

02 Measurements in the XFEL tunnel

- Validation of the module support system and alignment principle

03 XFEL cryomodules

- Measurements at AMTF
- Using piezo as vibration sensors

04 Future plans for CW XFEL Modules

- Characterization of an XFEL cryomodule
- Possible optimization of the module design

Vibration measurements at TTF-FLASH

Vibration studies at FLASH and CMTB

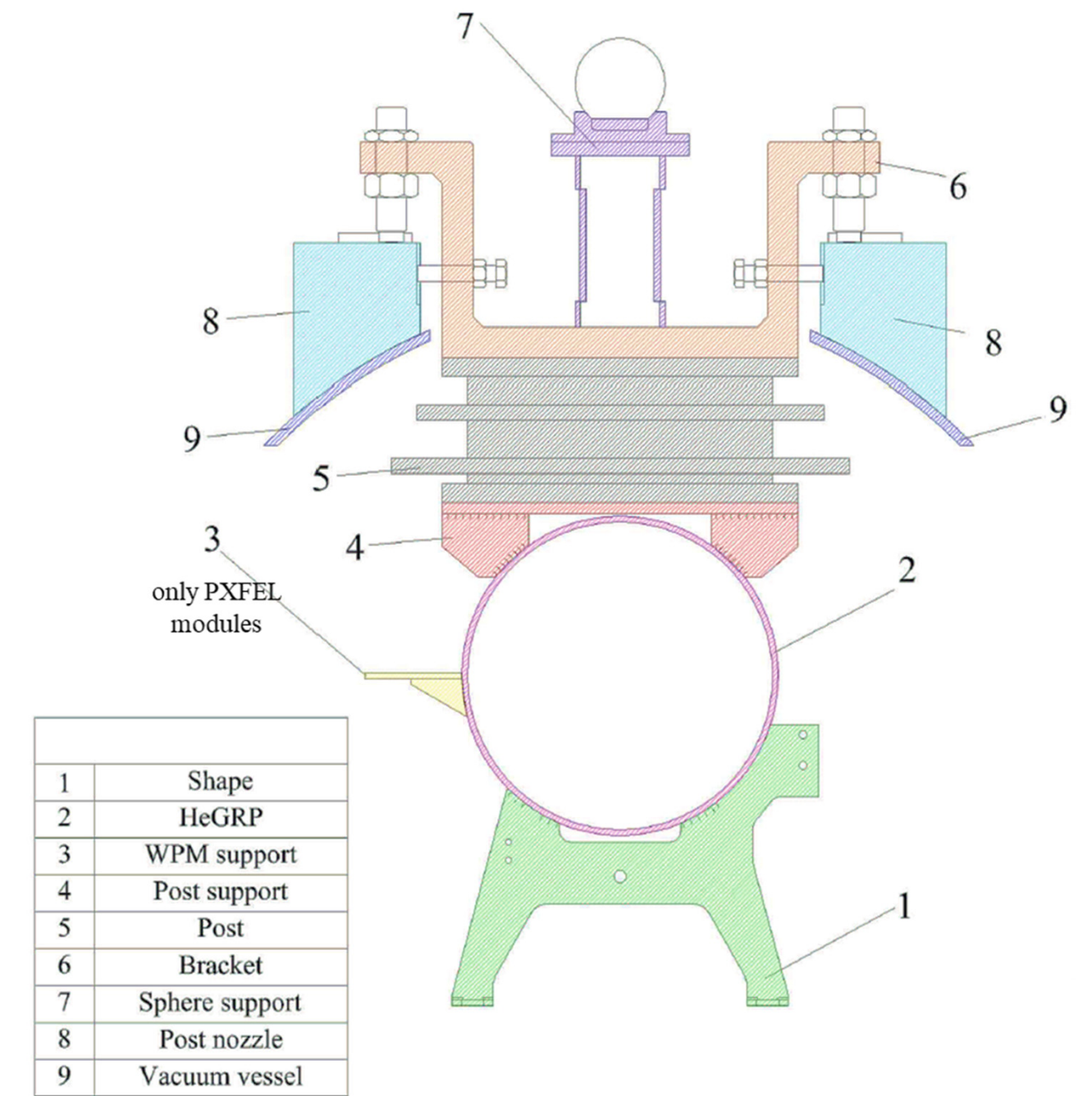
2004-2007 – DESY vibration group and INFN Milano LASA

Tools developed to perform and compare vibration measurements

- DESY: using geophones, piezo and seismometers to measure PSD / RMS
- INFN-Mi-LASA: using the Wire Position Monitors as vibration sensors

Different studies performed

- Ground motion at DESY and in the world
- Vibration at the quadrupole at different cryogenic conditions
- Vibration at the cavities
- Vibration transfer functions between vessel, GRP, quadrupole

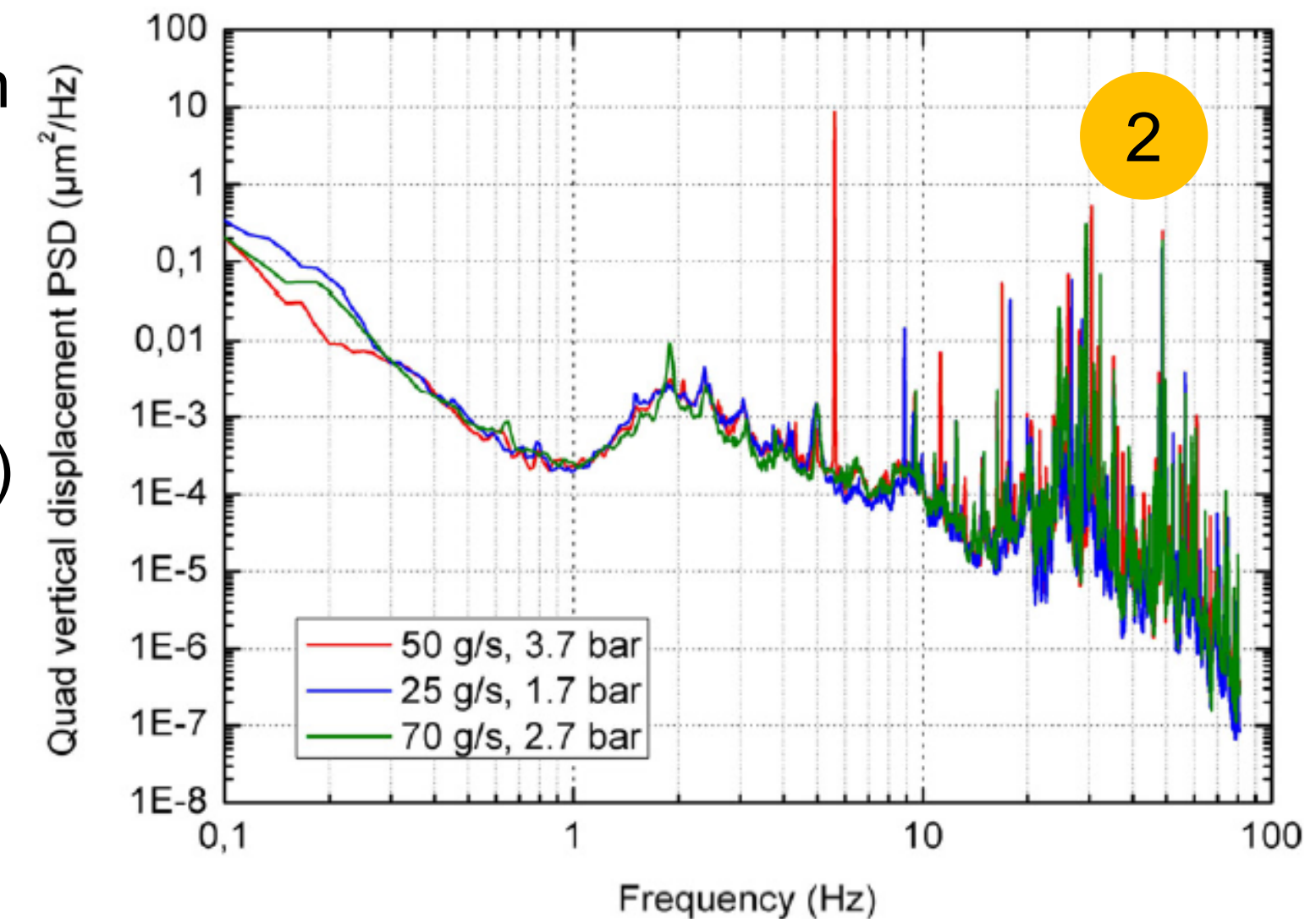
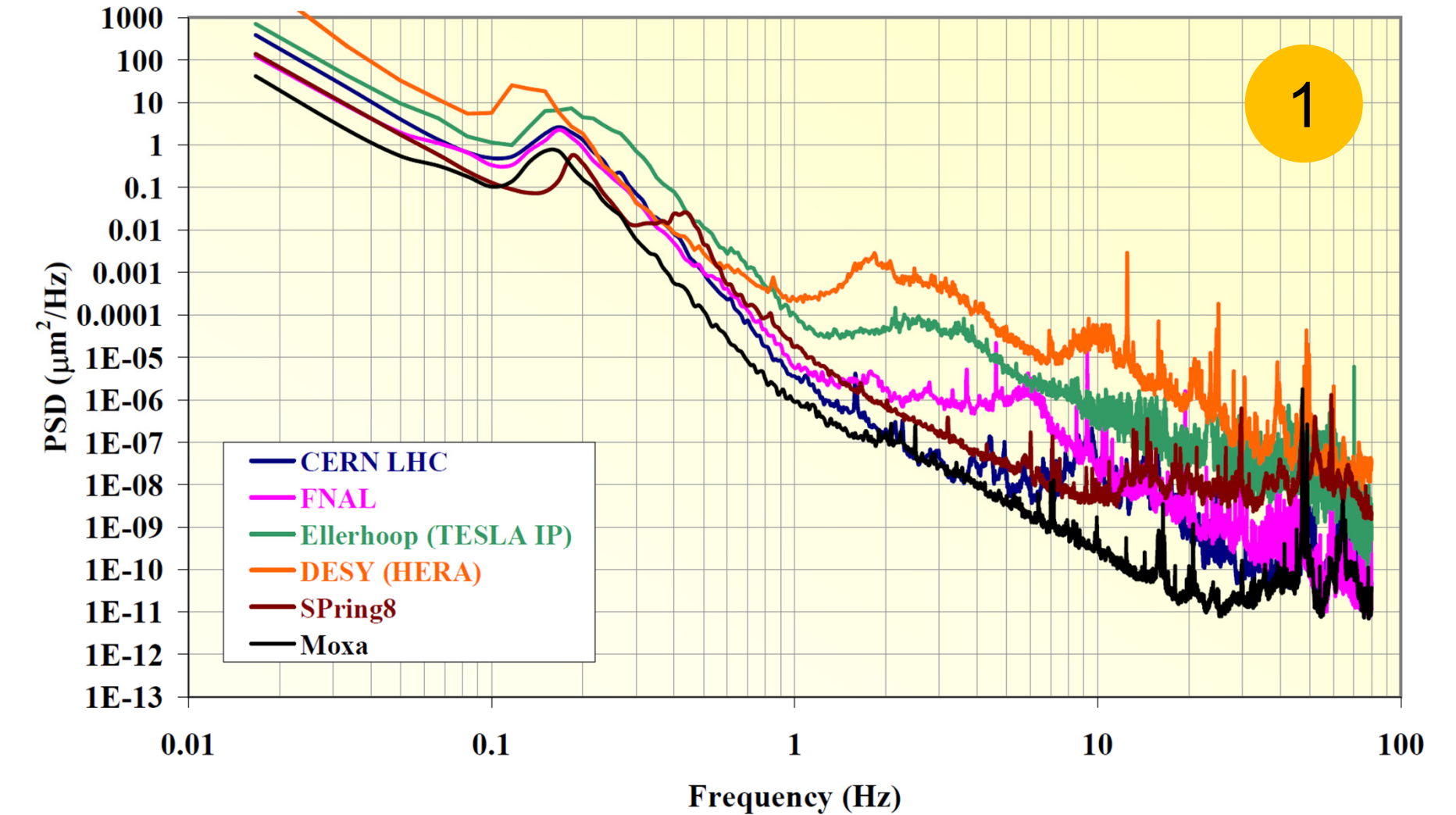


Vibration studies at FLASH and CMTB

2004-2007 – DESY vibration group and INFN Milano LASA

Some significant results (my personal opinion)

- Ground motion studies at different DESY sites **1**
- Almost no effect of cryogenic operation conditions on vibrations at the quadrupole **2**
- Study of quadrupole stability at CMTB
 - Low freq. (1-30 Hz) vertical stability not affected by refrigeration system
 - Low freq. (1-100 Hz) vertical stability not affected by high gradient RF operation
- Study of the transfer functions between vessel, GRP and quadrupole
 - Amplitudes of the vibrations in the hundreds of nm
 - Motion is transmitted almost completely from vessel to quadrupole (at low freq.)
- WPM study
 - Comparison of vibrations at different positions along the GRP
 - quieter at the middle?



Further information

<https://vibration.desy.de/>

<http://www.srf.mi.infn.it/publications/topic.2006-05-02.3276868848>

Superconducting RF accelerator group at LASA

Site Map Accessibility Contact

Search Site Search only in current section

Home Members ILC Activities HPPA Activities e-sources Activities Publications Schools & Tutorials News Events Log in

You are here: Home → Publications → WPM: Publications & Presentations

Navigation

- Members
- ILC Activities
- HPPA Activities
- e-sources
- Publications
- Presentations
- Papers
- Cryomodules
- Publications
- WPM: Publications & Presentations
- Superconducting Cyclotrons: Publications & Presentations
- Schools & Tutorials
- How to reach us
- News
- Events
- Conference Links
- LASA

WPM: Publications & Presentations

Title	Description
A new Wire Position Monitor readout system for ILC cryomodules	2007 IEEE Nuclear Science Symposium Conference Record
Current Cryomodules and Changes for ILC	C. Pagani, presented at the 2005 ILC Physics and Detector Workshop in Snowmass, August 14-27, 2005
Cryostats and Cryomodules: Design Choices and Implications	R. Pierini, presented at the SPL Meeting at CERN, 20 July 2005
The Wire Position Monitor (WPM) as a Sensor for Mechanical Vibration for the TTF Cryomodules	SRF05
Mechanical Vibration Measurement on TTF Cryomodules (using WPMs as Detectors)	A. Bosotti, Contributed oral presented to the PAC2005 in Knoxville, 16-20 May 2005
Mechanical Vibration Measurements on the TTF Cryomodules	PAC05
Analysis of the Cold Mass Displacements at the TTF	EPAC04
INFN - LASA Activity for TTF/TESLA	A. Bosotti, presented at the TESLA Collaboration Meeting in DESY Zeuthen, 21-23 January 2004
Contributi e attività di Milano in TTF/TESLA	R. Michelato, presented at the Workshop "Fisica e tecnologia degli acceleratori e tecniche correlate" in Capri, 2-4 June 2003
Laboratory Report: INFN Milano - LASA	D. Sartore, presented at the TESLA Collaboration Meeting in Frascati, 26-28 May 2003

1 2 Next 3 items »

RSS feed — Send this — Print this —

October 2018

Mo	Tu	We	Th	Fr	Sa	Su
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

News

- Matlab R2007b Oct 22, 2007
- Matlab R2006b Nov 13, 2006
- ILC School Talk added Jul 28, 2006
- Matlab R2006a Apr 20, 2006

More news...

INFN Sezione di Milano - Laboratorio LASA, Via Fratelli Cervi 201, 20090 Segrate, Milano, Italy. Page loaded on 2018/10/16 15:33:39.690 GMT+2



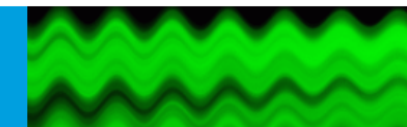
ACCELERATORS | PHOTON SCIENCE | PARTICLE PHYSICS
Deutsches Elektronen-Synchrotron
A Research Centre of the Helmholtz Association

Google Custom Search

DESY HOME | RESEARCH | NEWS | ABOUT DESY | CAREER | CONTACT

GROUND VIBRATIONS

Compilation of ground motion measurements



HOME

Home /

EQUIPMENT

[Compilation of ground motion measurements](#)

DATA ANALYSIS

This homepage is a compilation of ground motion measurements which have taken place since 2002, not only in DESY but in many high energy and synchrotron radiation laboratories around the world. This database of ground motion data is therefore a very first of its kind.

OVERVIEW

SITES MEASURED

DOWNLOAD

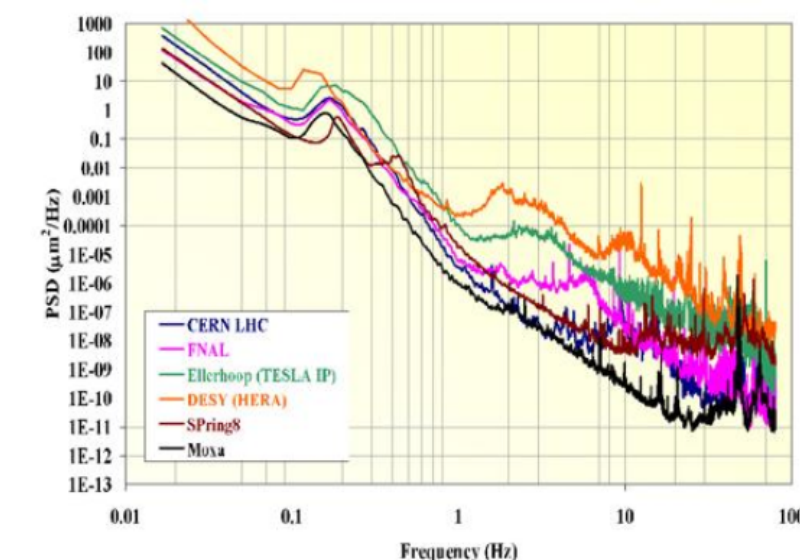
Since 2006, we have expanded our vibration studies program and have concentrated our efforts on vibration study of accelerator components, in particular, quadrupoles in both room and superconducting temperatures, in accelerating modules. This study is aimed for both the European X-ray Free Electron Laser (XFEL) and the International Linear Collider (ILC).

DOCUMENTS

CONTACT US

ABOUT

Our data, both ground motion in various sites and vibration studies of accelerating modules, is available for download. Please contact us if you have any questions.



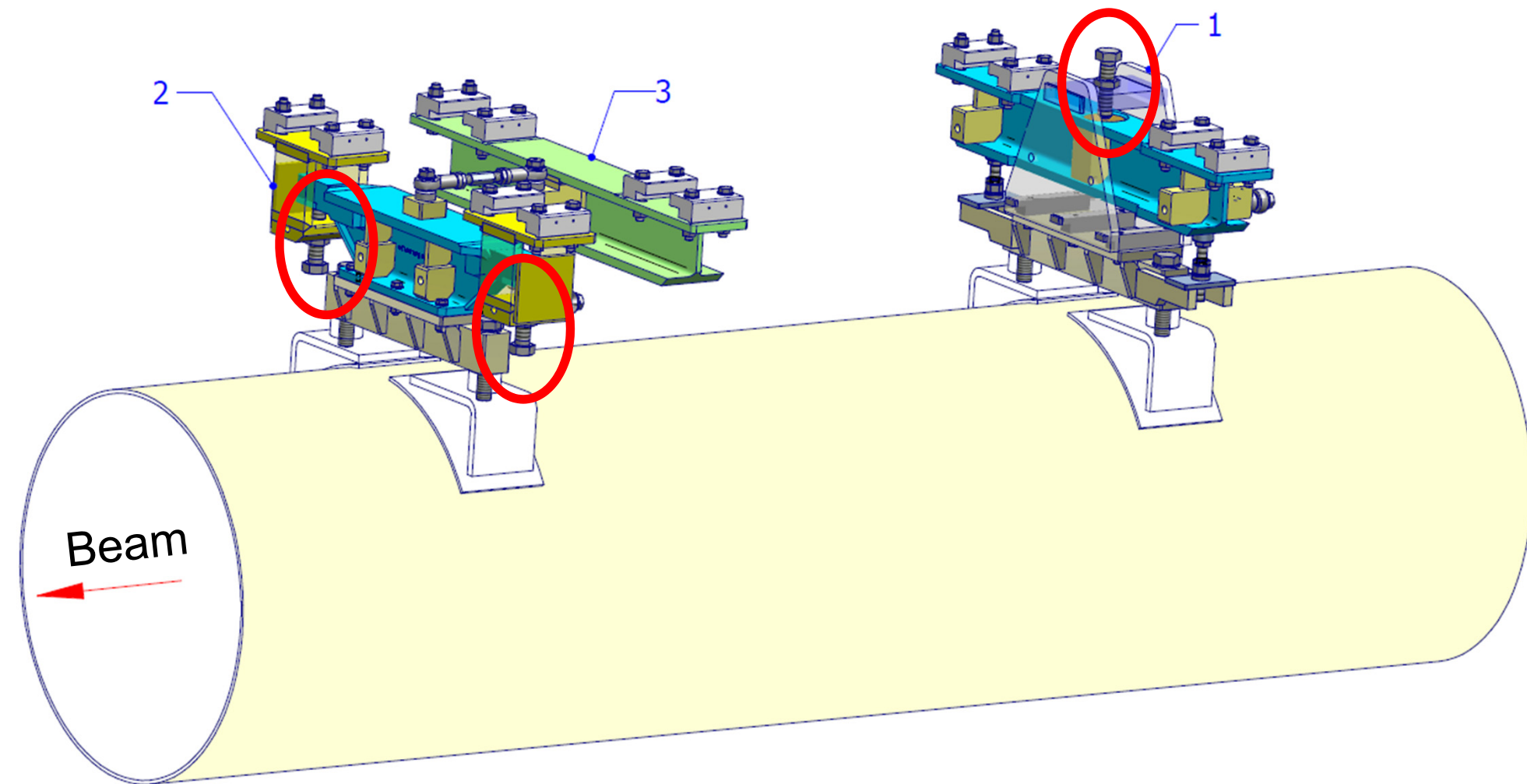
Vibration measurements in the XFEL tunnel

Measurements in the XFEL tunnel

2015 - DESY MEA Group (further information: N. Meyners)

Case study

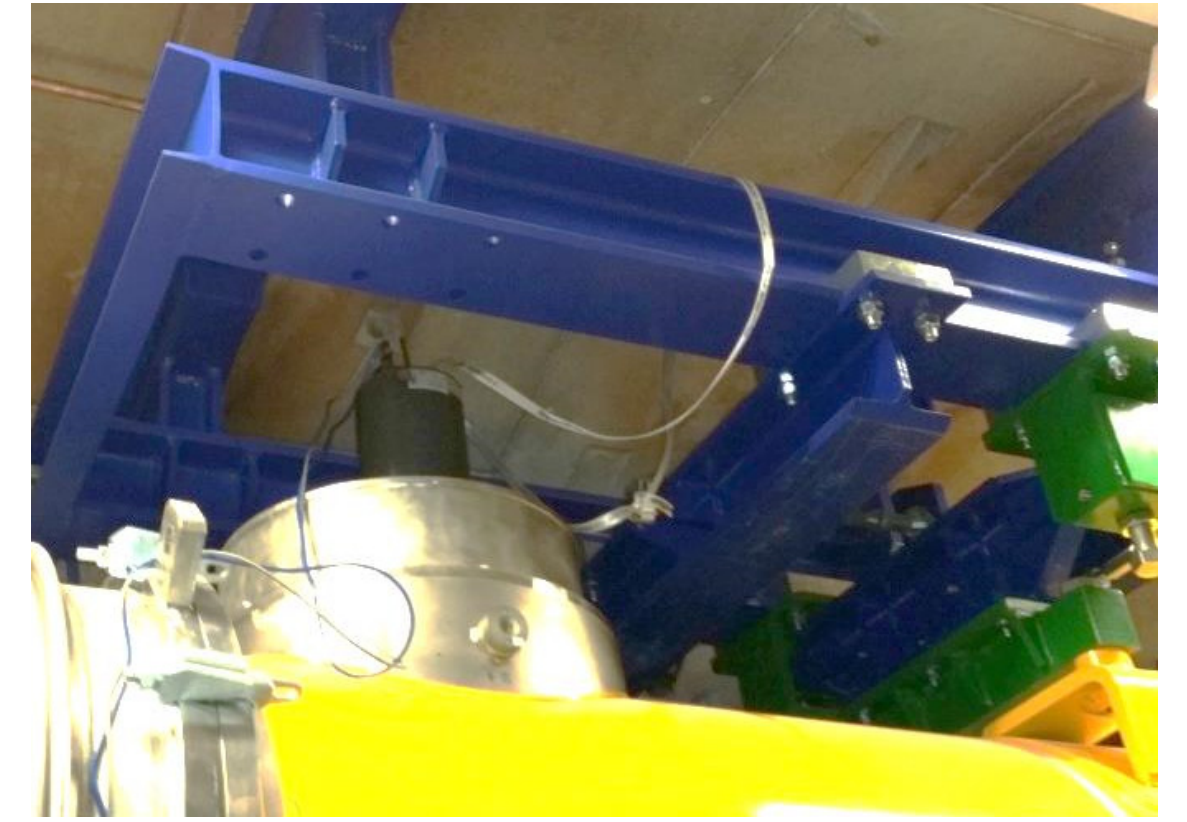
- XFEL cryomodules hang from the ceiling



- Position is adjusted with bolts -> influence of the bolt length on the cryomodule vibration spectrum?

Measurement campaign

- Measurement performed on a single hanging cryomodule with seismometers (Guralp CMG-6TD, bandwidth 30s – 100 Hz) on the tunnel ground and on the post cover
- Vertical position of the support bolts changed and measurement repeated

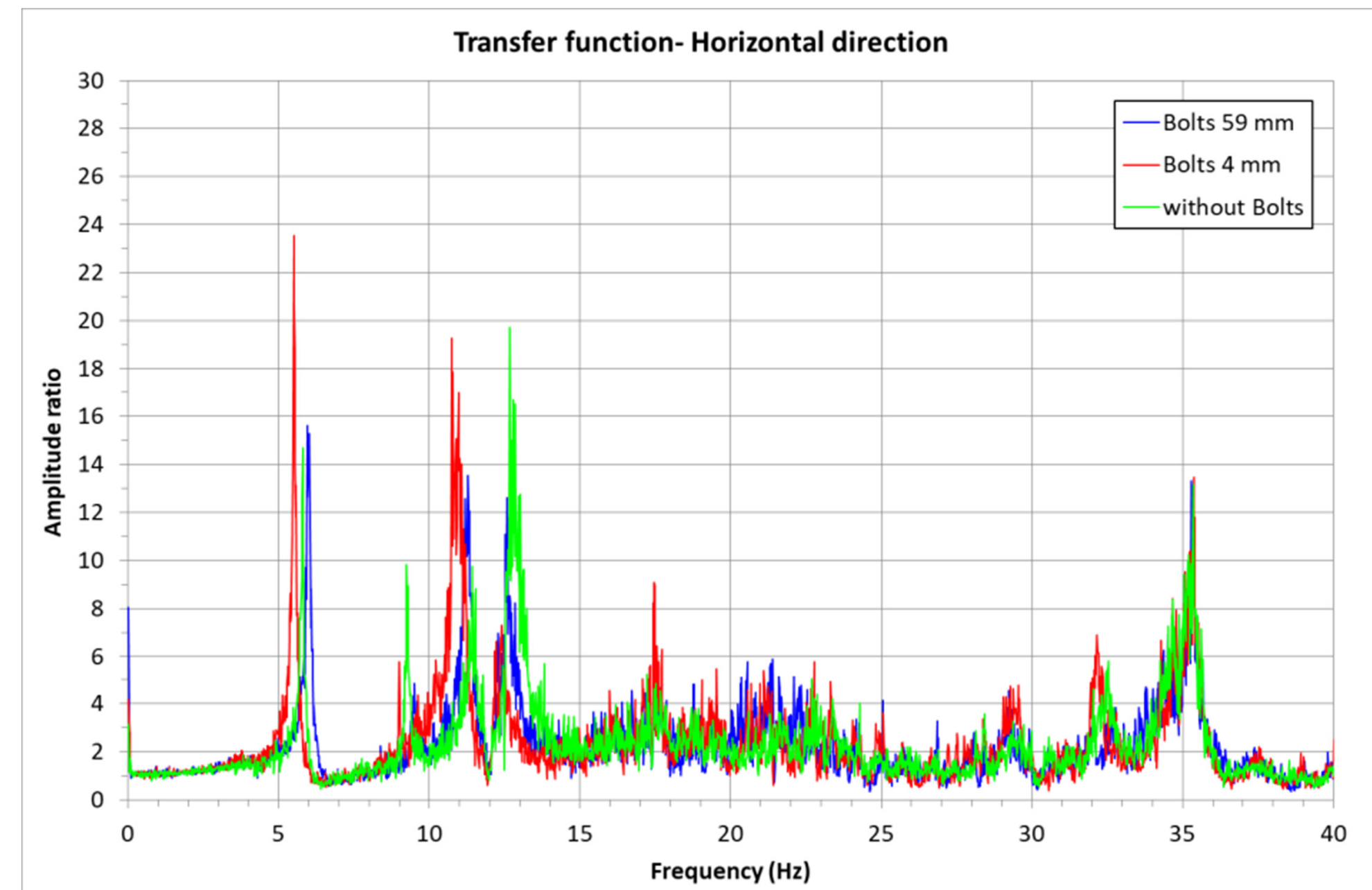
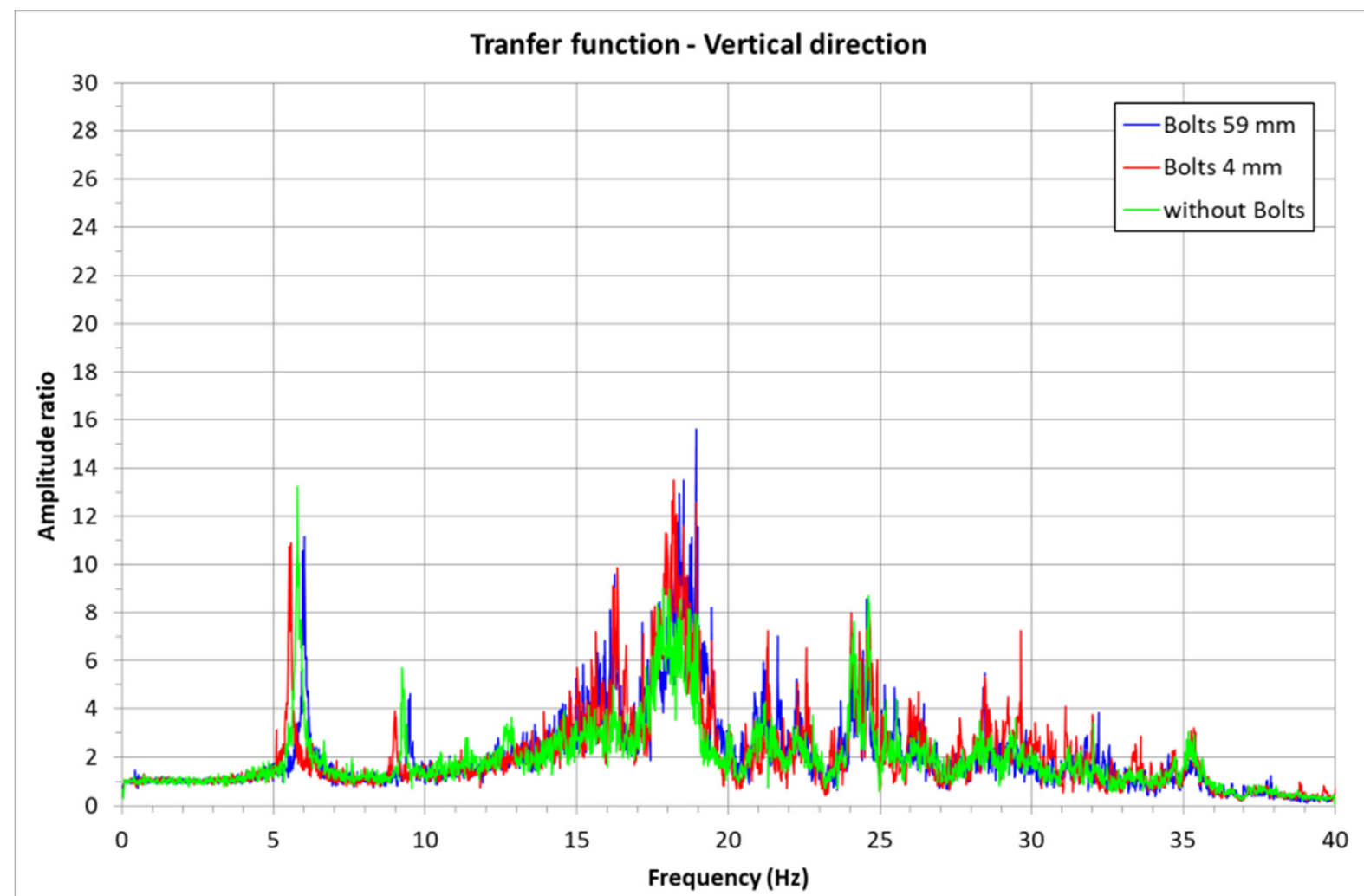
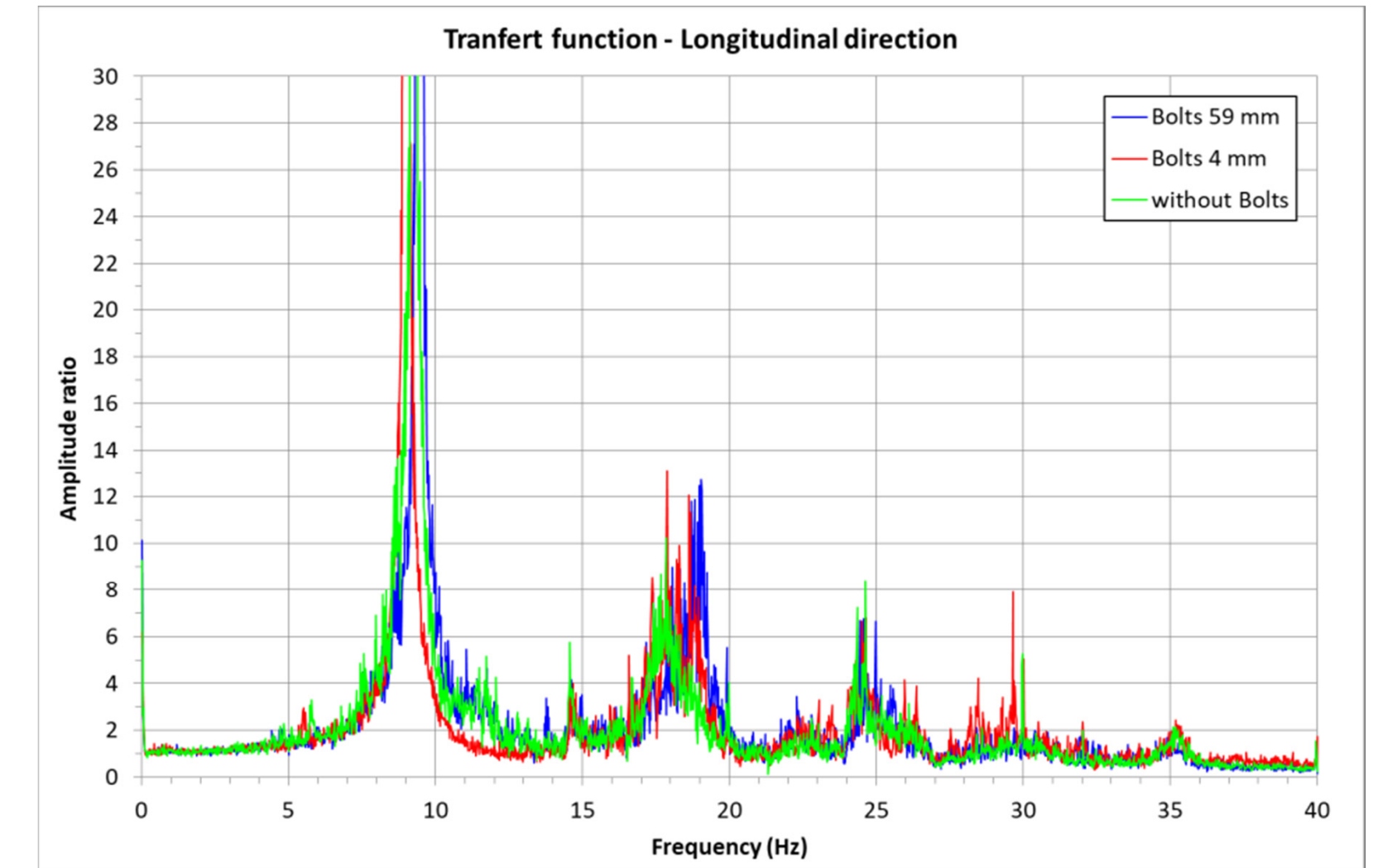


Measurements in the XFEL tunnel

2015 - DESY MEA Group (further information: N. Meyners)

Results

- No real changes at different bolt positions
→ validation of the support system
- Measurement of the vibration spectrum
→ can be used as comparison for further studies



Vibration measurements on XFEL cryomodules

Vibration measurements on cryomodules in the AMTF hall

2014 - Internship M. Ajerrar, MSK Group (further information: J. Branlard)

Test plan

- Cryomodules installed on the horizontal test stand XATB3
- Measurement with geophones at one position on the vessel, longitudinal and vertical direction
- Parallel measurement with the piezo sensors
- Measurement with and without RF
- Cold measurements
- Equipment used:
 - Endevco 7703A-1000
 - DeltaShear Uni-Gain Type 4379



Vibration measurements on cryomodules in the AMTF hall

2014 - Internship M. Ajerrar, MSK Group (further information: J. Branlard)

Results and conclusions

- Measurements on the cryomodule XM5 in the test stand 3 showed:
 - **Higher sensitivity** to vibration in **the longitudinal direction** (maybe depending on the test stand set up)
 - **Main vibration contribution** comes from 10 Hz **RF repetition rate** (Klystron farther away than in the tunnel).
 - Observed **frequencies at 10.5 Hz and 15 Hz**, might come from **modes of the vacuum vessel** on its support system.
- Measurements on XM8 confirm the **vacuum pumps** as source of **vibration around 50 Hz**.
- Some measurements on the cavities (piezo), but difficult to compare
- Fluctuations at the cooling system of the klystron (modulator + klystron) might also affect the module

→ **Further studies recommended**

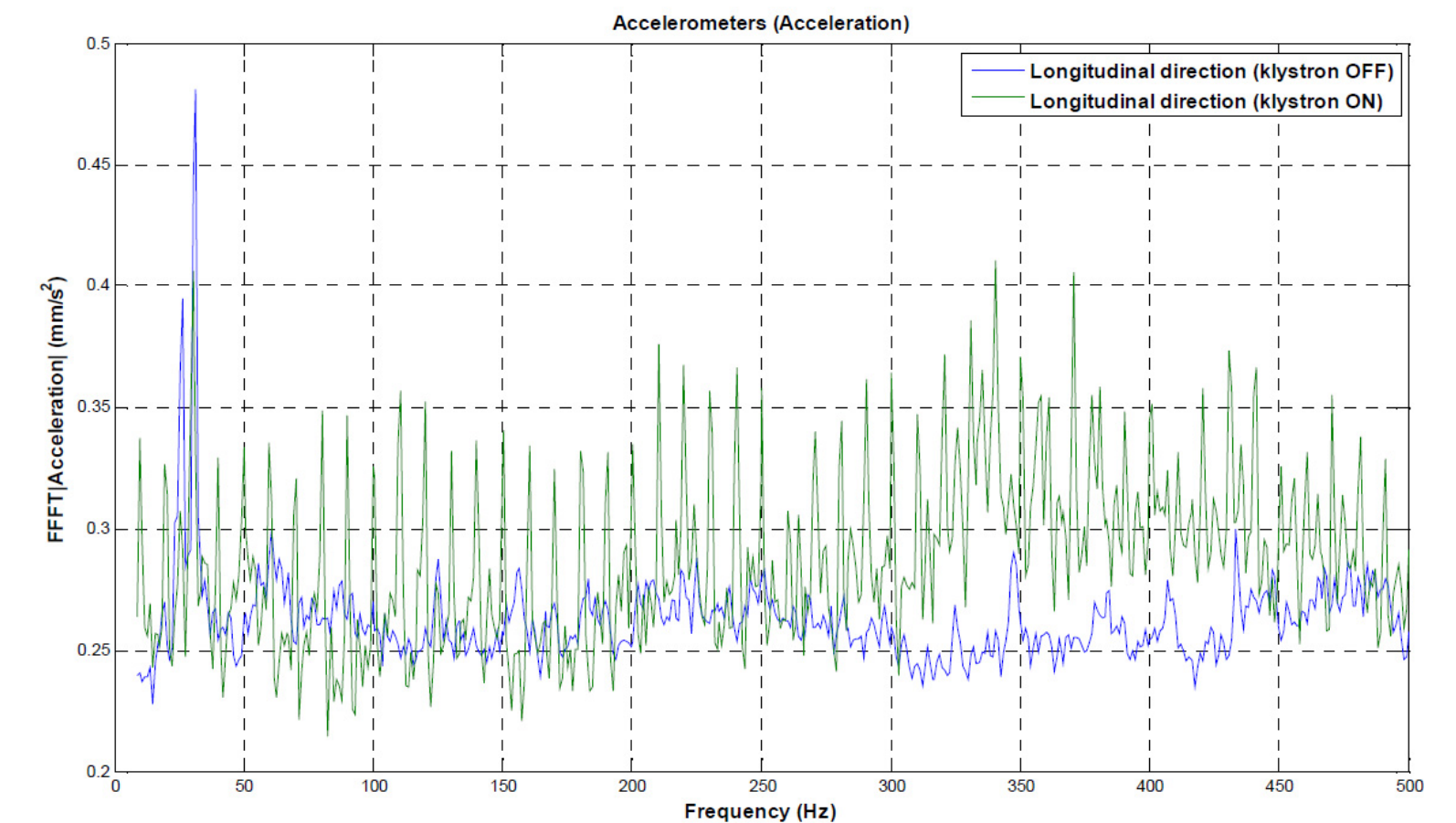


Figure 6.6- FFT of vibration (klystron ON) vs FFT of vibration (klystron OFF) in the longitudinal direction.

Using piezo to measure vibrations on XFEL modules

The cryogenic look into microphonics

Why did we come to this idea?

- In 2017 we noticed pressure fluctuations in the 2.2 K forward pipe at the XFEL tunnel

Frequency ~ 0.2 Hz

The pressure sensors are at the feed / end / string connection boxes

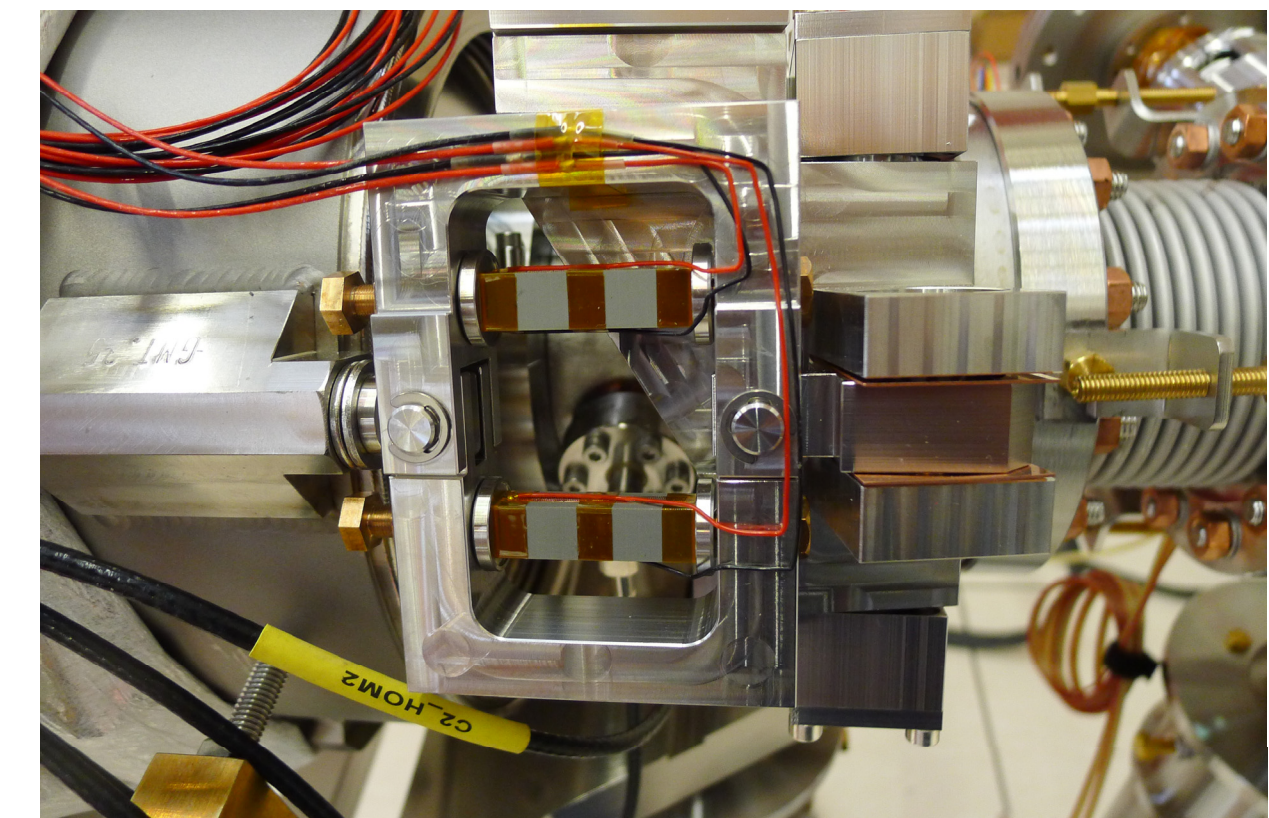
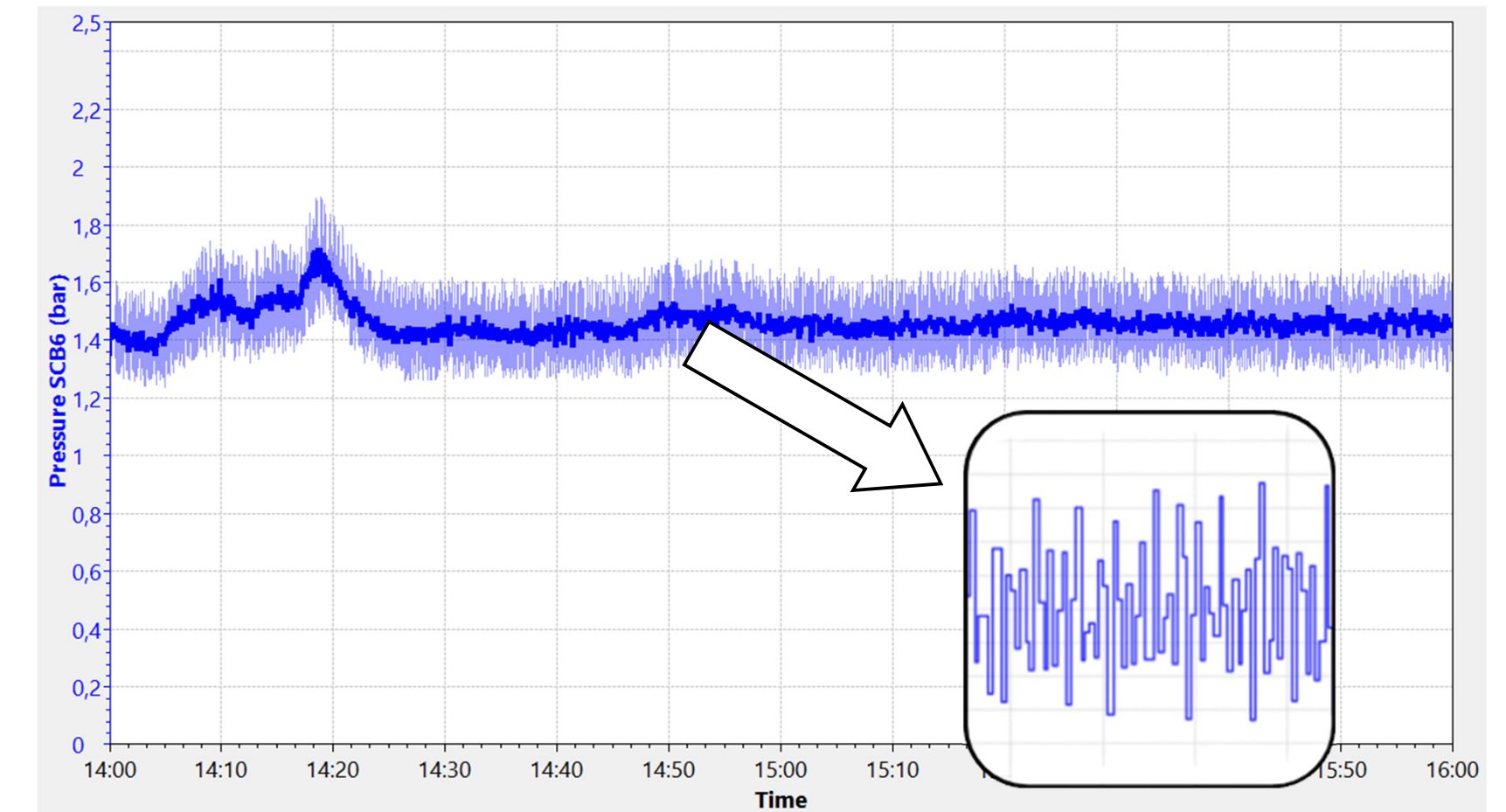
only 12 positions along the tunnel

not representative of the cavity status

The pressure values are not constantly recorded with high resolution -> FFT data difficult to obtain

- To better understand the situation and look closer to the cavities, we decided to try to use the piezo sensors at the cavities to look for this vibration

Pressure fluctuation in the SCB6 2.2 K F pipe



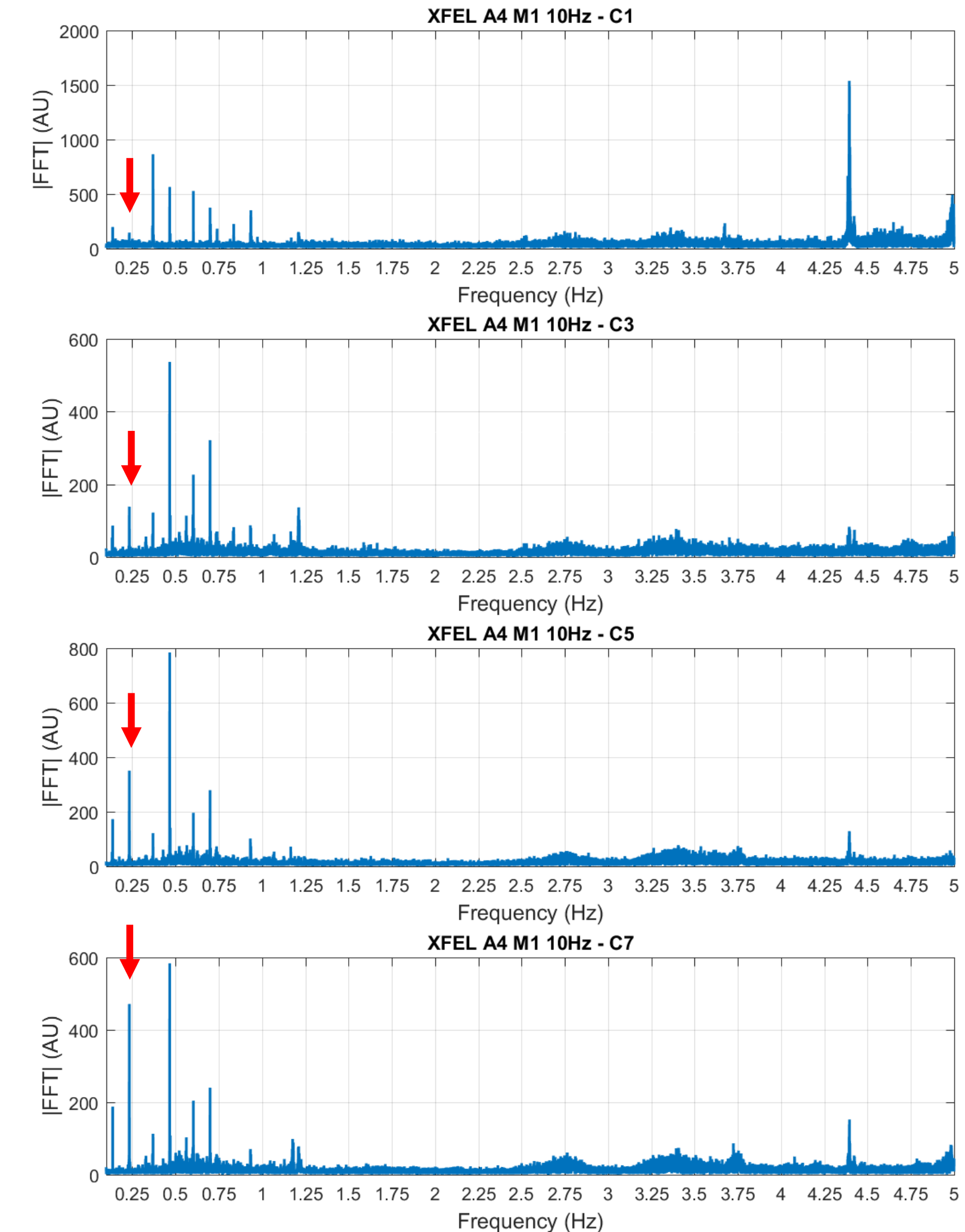
Using piezo to measure vibrations on XFEL modules

The cryogenic look into microphonics

How do we use the piezo?

- Measure the piezo voltage with a frequency of 10 Hz
- Data analysis in Matlab: FFT and, to be refined, PSD
- 3 RF stations investigated without RF (12 modules, 96 cavities)

- Results: ~ 0.2 Hz frequency well visible at almost all cavities
- Measurement repeated at different cryogenic status



Using piezo to measure vibrations on XFEL modules

Comparing different cryogenic systems

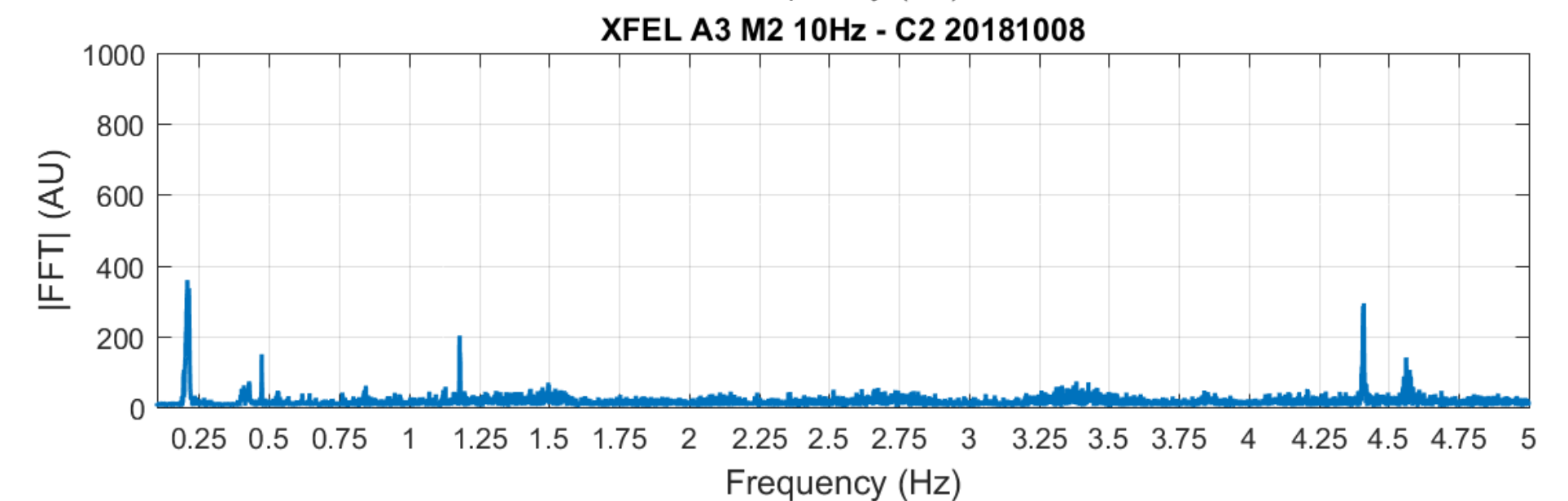
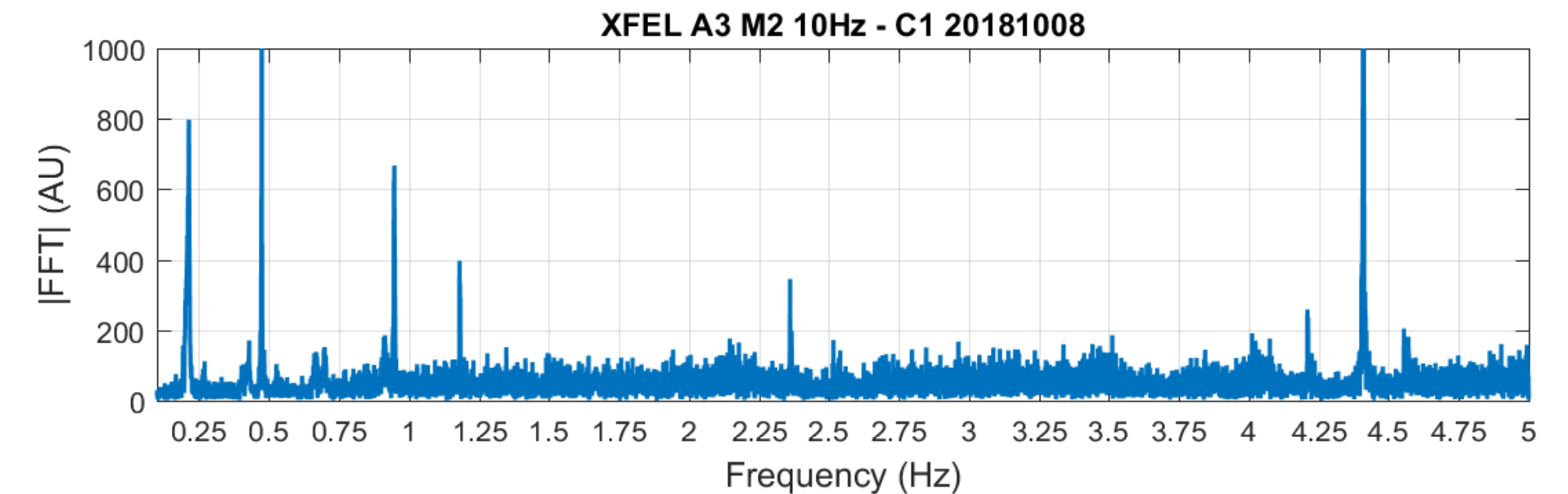
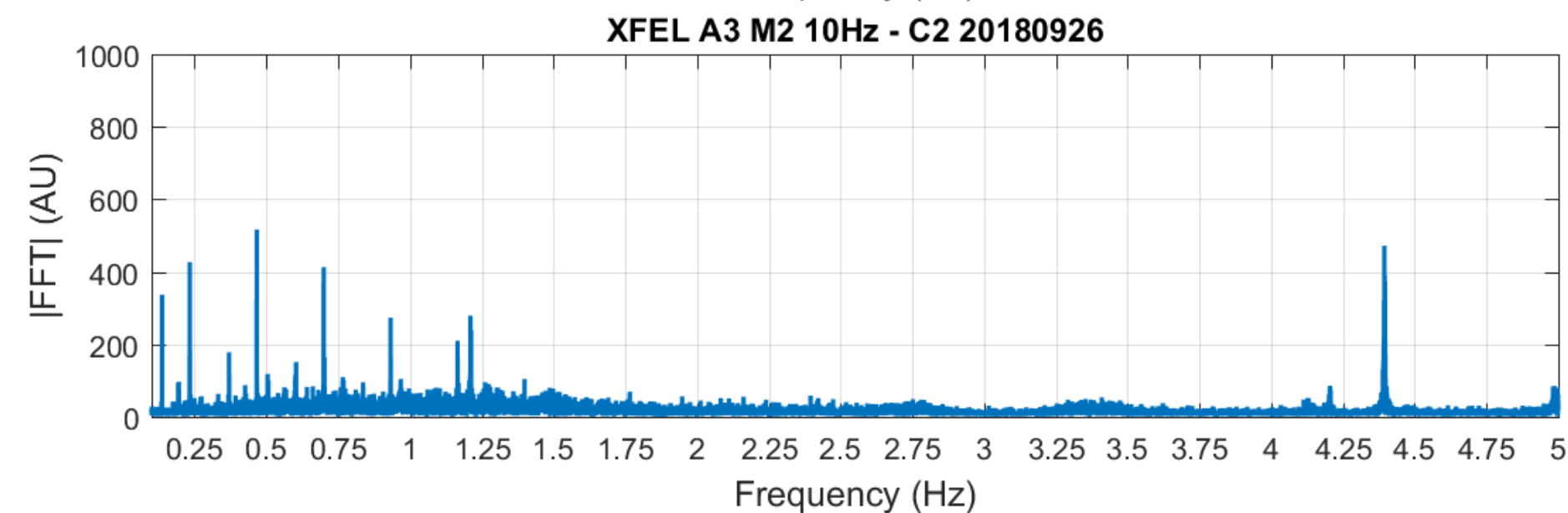
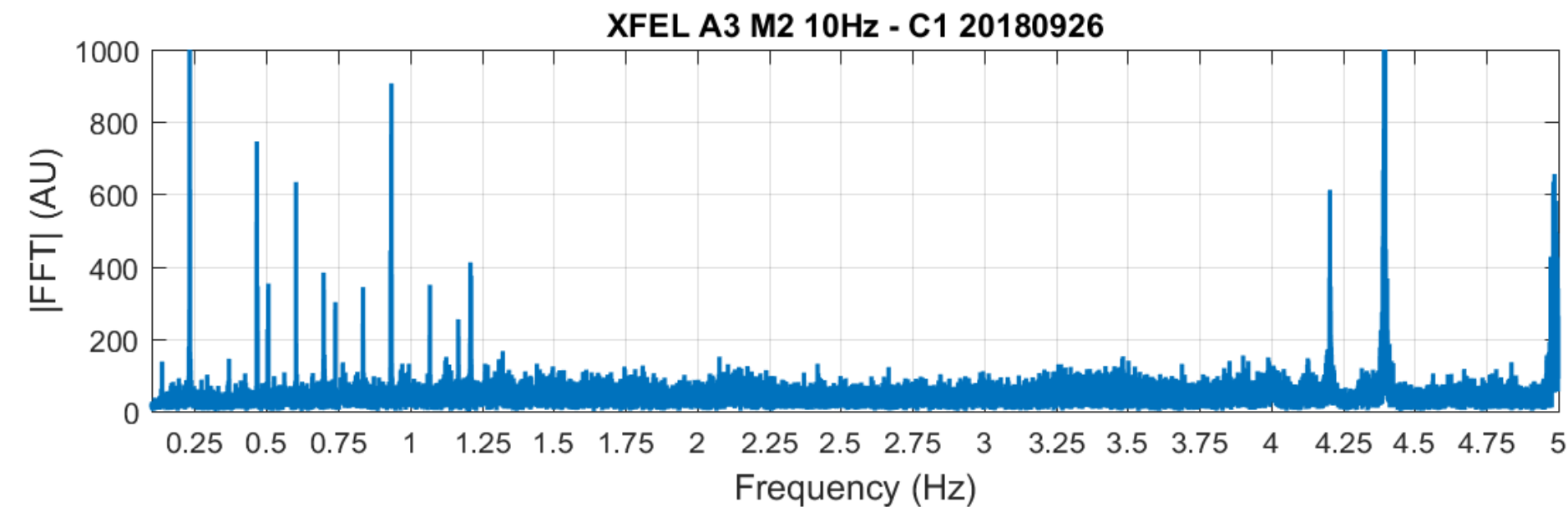
Left: Cold Compressors

- Direct pumping at the 2K level
- In the same building

Right: Warm Compressors

- Pumping of the warm gas
- In the AMTF building

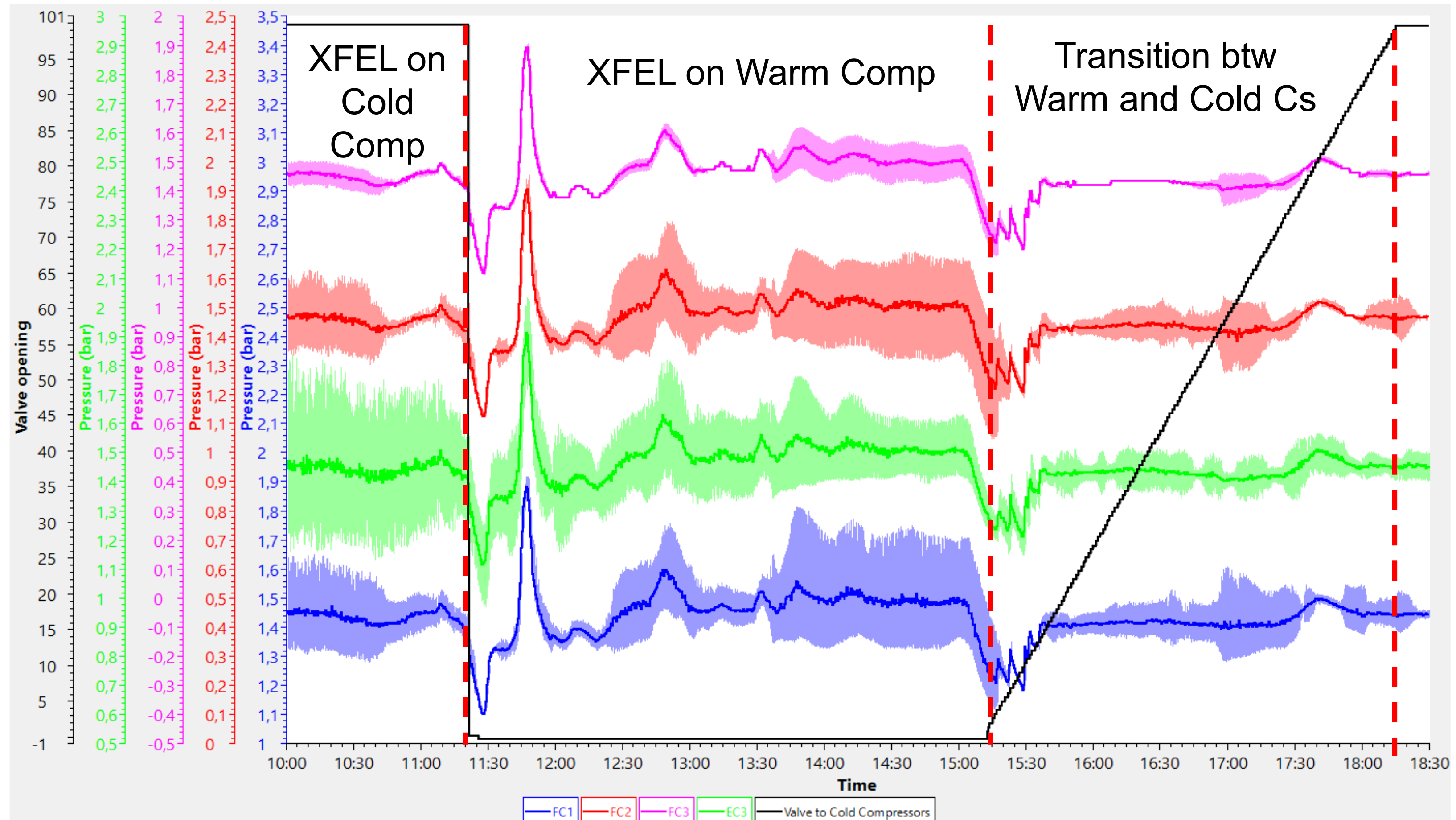
Data in the frequency domain - XFEL A3 M2



Using piezo to measure vibrations on XFEL modules

Comparing different cryogenic systems

Actually, it is much more complicated...



Using piezo to measure vibrations on XFEL modules

The cryogenic look into microphonics

Where are we now

- We have a probable interpretation:

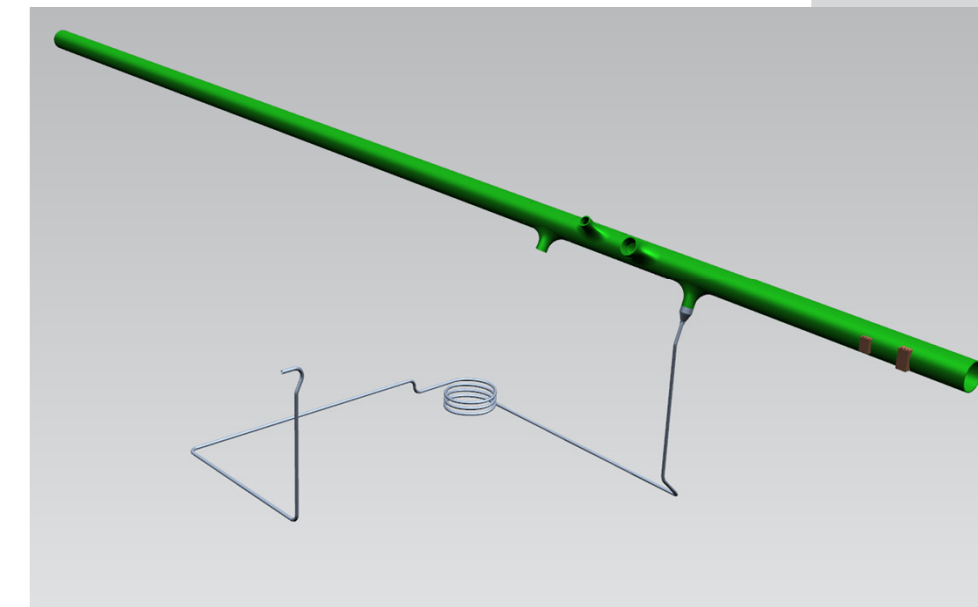
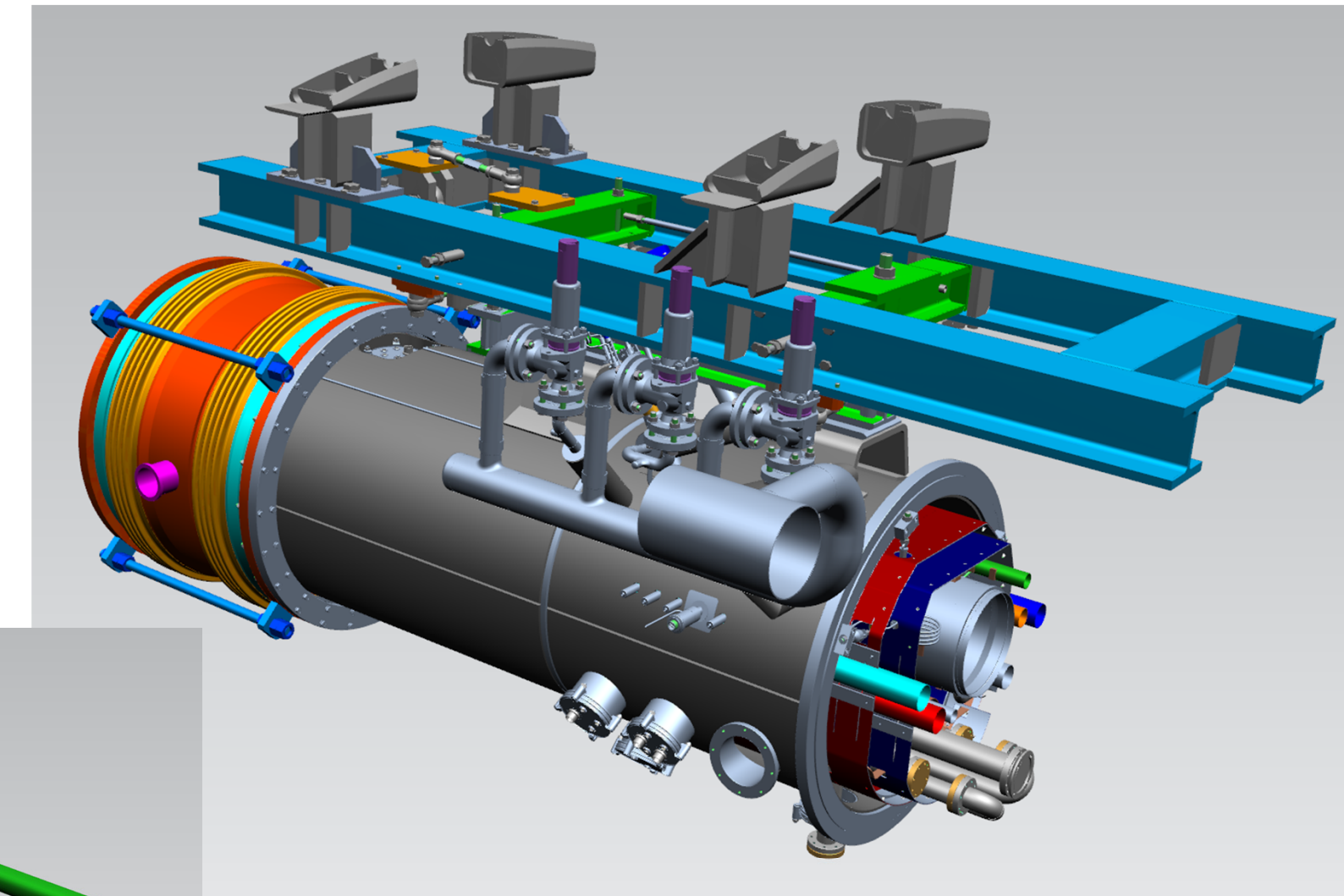
Travelling wave propagating along the 2.2 K He pipe with sound velocity

difficult to demonstrate
still missing the source

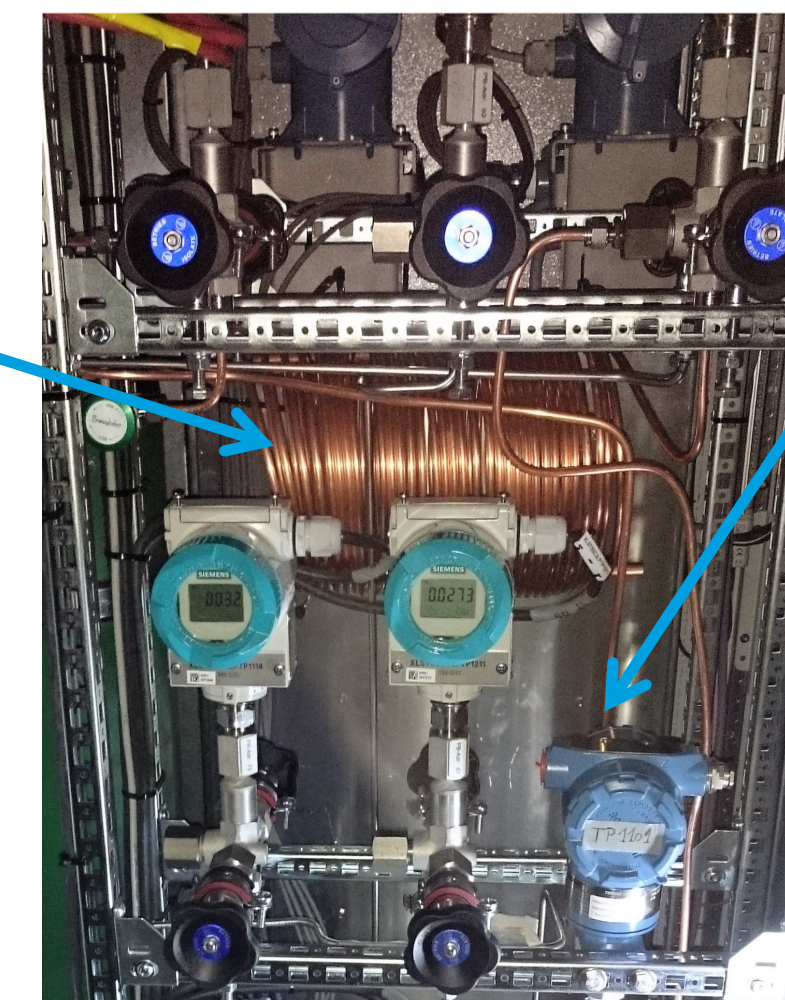
- We have an idea for the mitigation:

Add ~20m long capillaries at the pressure sensor locations to damp the oscillations in the pipe

But... are we damping the oscillations in the whole pipe or only at the measuring point?



20 m capillar



Pressure measuring point

Using piezo to measure vibrations on XFEL modules

The cryogenic look into microphonics

Next steps

- Further extend the capillaries at the SCB and monitor in parallel with the nearby piezo
- Expand the use of piezo to all the XFEL RF stations as soon as the piezo drivers are available
 - More systematic work: compare different module positions in a string or cavity positions in a module
 - Compare different locations along the linac -> is there a way to recognize a travelling wave?

Additional options

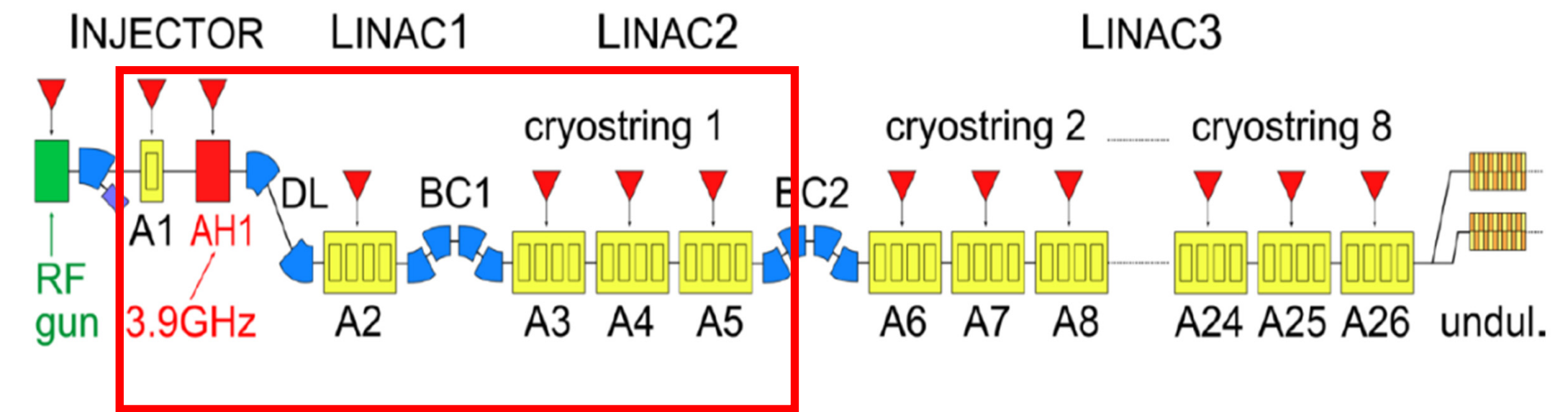
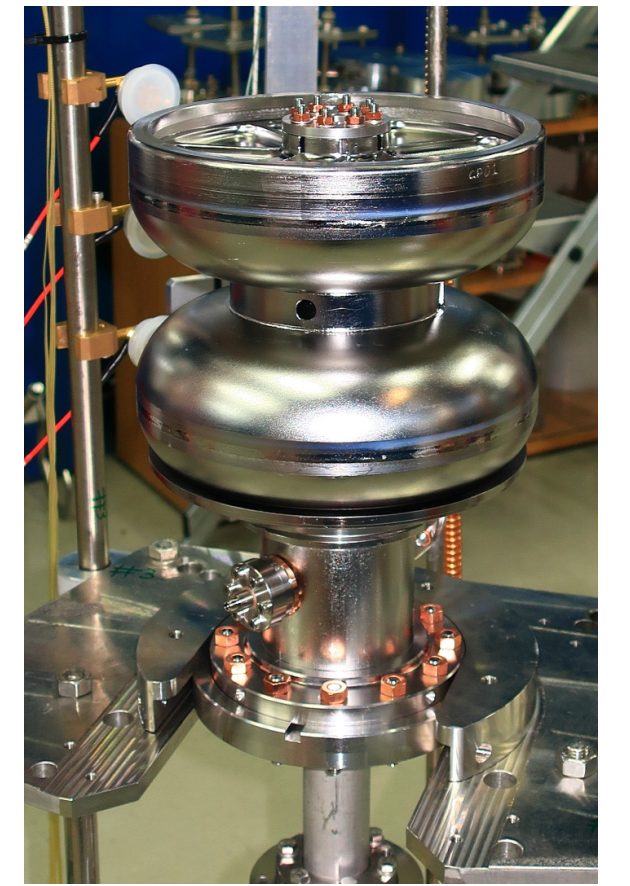
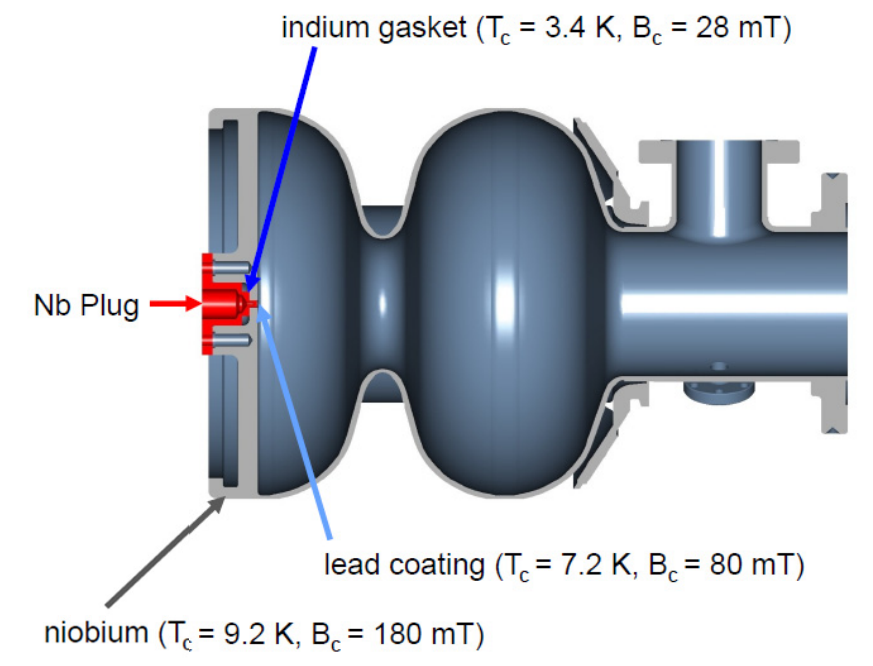
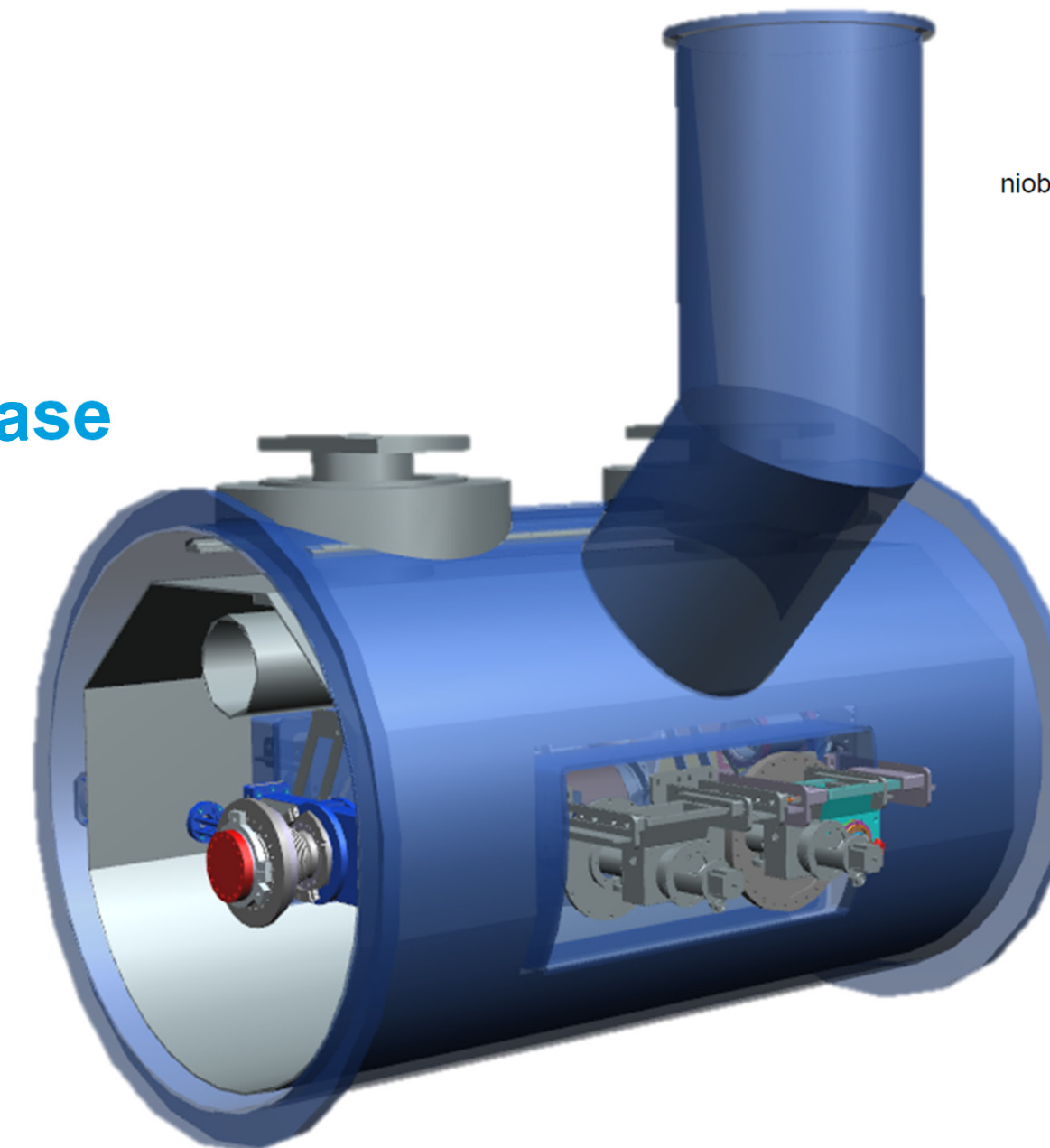
- Compare different cryogenic systems → CMTB - FLASH cryoplant, AMTF - XFEL cryoplant
- Compare different working conditions → AMTF - single module test stand, warm compressors
XFEL - whole linac, cold compressors

Plans for the XFEL CW cryomodules

Plans for the XFEL CW upgrade

CW R&D program at DESY for the XFEL CW upgrade

- CW-SRF Gun being developed at DESY
 - new cryomodule design needed
 - reduction of microphonics as parameter during the design phase
 - test cryomodule → can be used for optimization
- Design of CW 1.3 GHz cryomodules
 - Need of design changes at the cavity tank level (at least)
 - Possibility of design modifications on the whole cryomodule
 - Implement lessons learnt at LCLSII
 - Implement lessons learnt from vibration studies



Replace with CW components

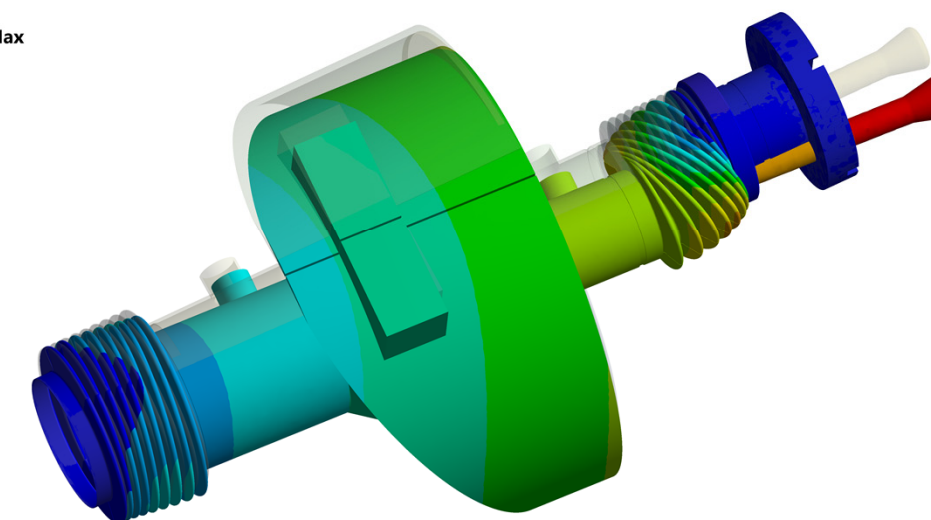
Plans for the XFEL CW upgrade

In the near future

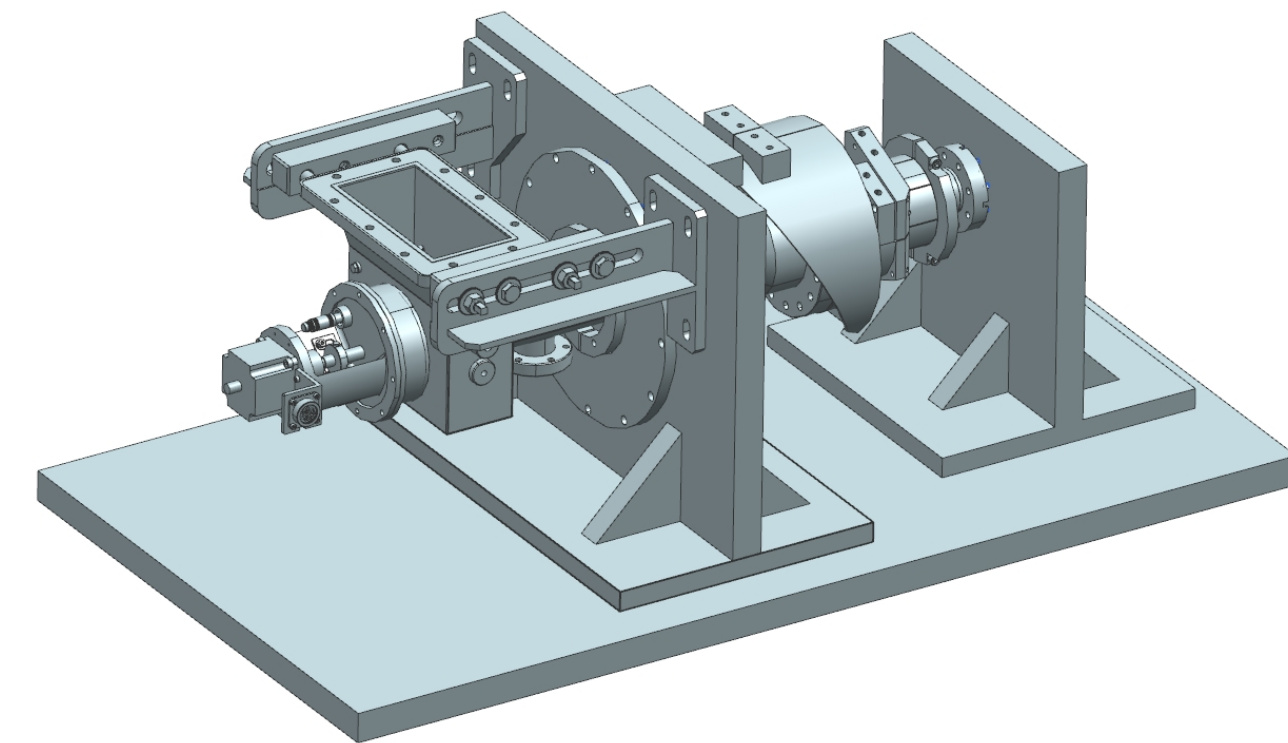
- Fully characterize a 1.3 GHz XFEL cryomodule
 - AMTF test stand available -> warm and cold, with and without RF
 - Module available
 - Sensors available (piezo and geophones), acquisition system and data analysis need to be improved
- Compare results with calculations / simulations / ...
 - Look for possible design optimization
 - Detailed analysis of subcomponents (couplers →)

D: Modal - swept bellows - inside fixed
Total Deformation - Mode 1 - 18,611 Hz
Type: Total Deformation
Frequency: 18.611 Hz
Unit: m
17-Oct-18 10:30

0.026241 Max
0.023326
0.02041
0.017494
0.014579
0.011663
0.0087471
0.0058314
0.0029157
0 Min



0.000 0.050 0.100 (m)
0.025 0.075



Conclusions

What did I learnt so far

Lot of work done at DESY on vibration measurements

- At different facilities
- From different groups
- With different scopes

What's missing

- A comprehensive look on the microphonics issue at the cryomodule level
 - Separate contributions from the cryomodule itself or the environment
 - Design optimization
- Coordination between RF / control requirements and mechanical aspects

Thank you

Contact

DESY. Deutsches
Elektronen-Synchrotron

www.desy.de

Serena Barbanotti
MKS Group
serena.barbanotti@desy.de
+49 40 8998 5628