

Environment Monitoring and Beamline Stability Control

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On behalf of the Beamline Engineering Division

**Tuesday, October 20,
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- **Environment Monitoring**
- **Optics Vibration Measurements and Controls**
- **Problems and Questions**
- **Summary**

Environment Monitoring

Environment monitoring



Environment monitoring functionality

FEL-II束线站环境监测系统-设备位置监测大屏

Pressure

Temperature

Ground
Vibration

QMO压力
H4-PRESS-001-Env
压力值: 102.29kPa
R CMD 在线

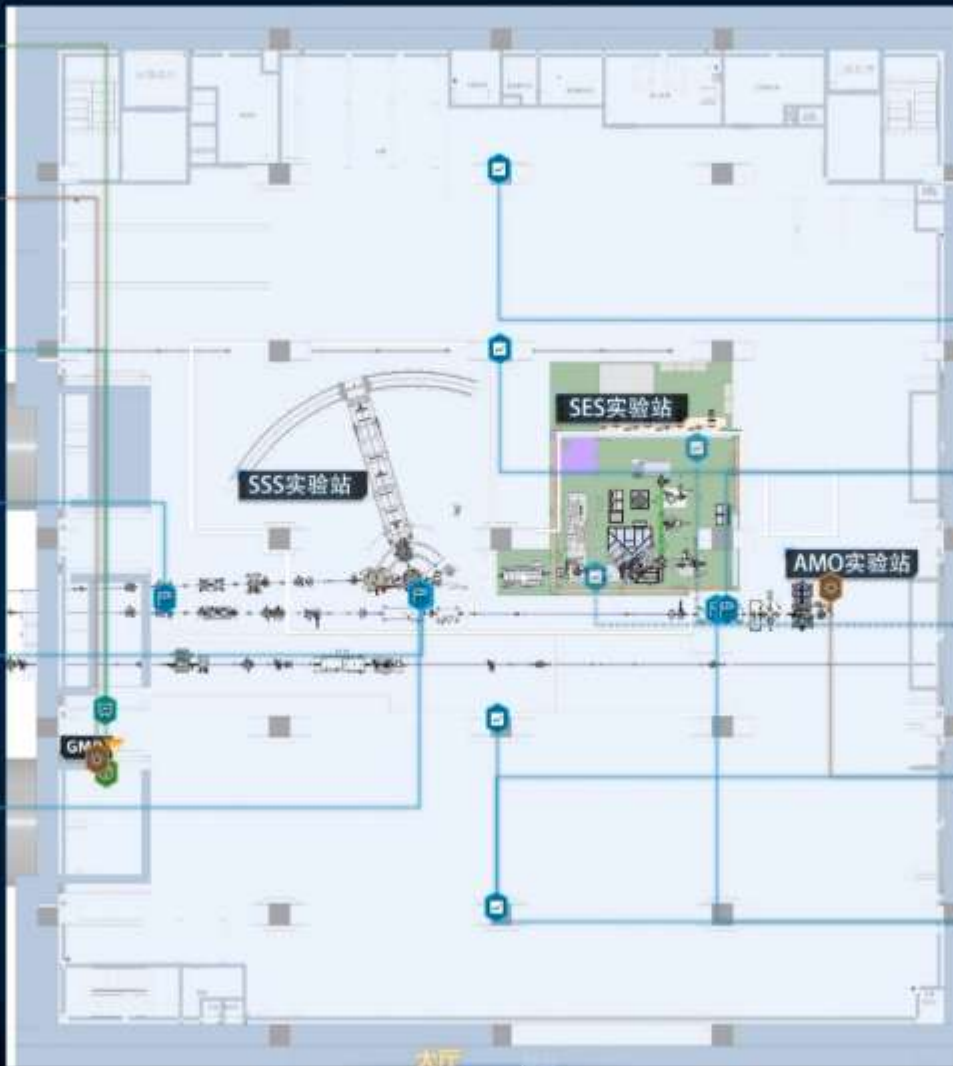
QMO温度
H4-TEMP-001-Env
温度: 24.7°C
湿度: 61.6%RH
R CMD 在线

QMO振动仪
H4-VIB-001
速度RMS: 2.228µm/s
R CMD 在线

速度7#速度传感器
H4-VVEL-001-Env
位移RMS: 0.373µm
速度RMS: 27.35µm/s
R CMD 在线

速度8#速度传感器
H4-VVEL-003-Env
位移RMS: 0.045µm
速度RMS: 15.07µm/s
R CMD 在线

速度10#速度传感器
H4-VVEL-004-Env
位移RMS: 0.553µm
速度RMS: 14.84µm/s
R CMD 在线



2 Temp. Sensor in Exp. Hall
1 Press. Sensor
8 Accl. sensor
7 Ground vel. sensor

加速度3#加速度传感器
H4-VACC-001-Env
速度RMS: 48.88µm/s
R CMD 在线

加速度4#加速度传感器
H4-VACC-002-Env
速度RMS: 80.25µm/s
R CMD 在线

加速度5#加速度传感器
H4-VACC-003-Env
速度RMS: --
R CMD 在线

AMO温度
H4-TEMP-002-Env
温度: 24.8°C
湿度: 60.1%RH
R CMD 在线

速度13#速度传感器
H4-VVEL-005-Env
位移RMS: 0.32µm
速度RMS: 33.24µm/s
R CMD 在线

速度14#速度传感器
H4-VVEL-006-Env
位移RMS: 0.05µm
速度RMS: 27.307µm/s
R CMD 在线

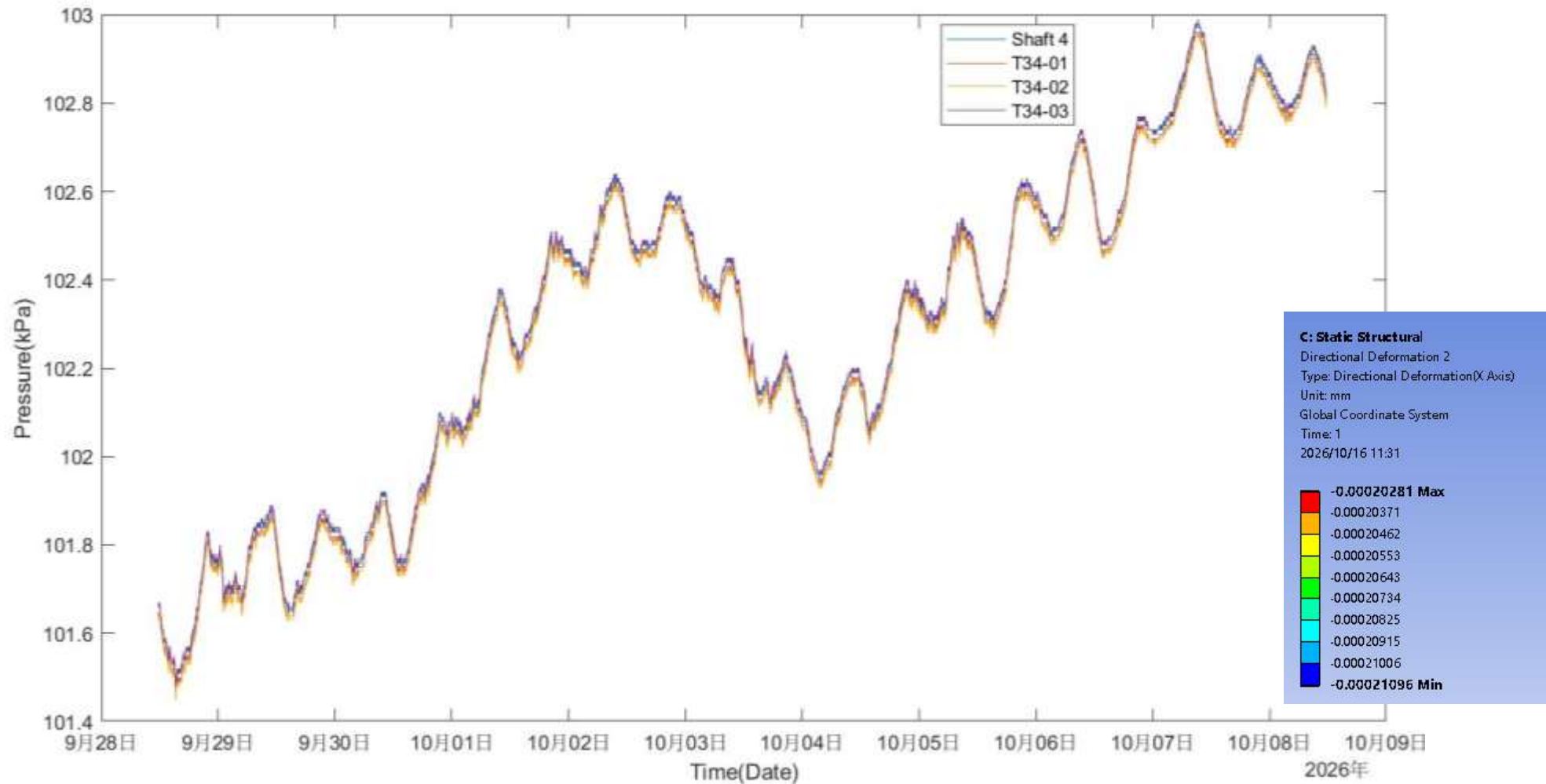
加速度6#加速度传感器
H4-VACC-004-Env
速度RMS: --
R CMD 在线

加速度11#加速度传感器
H4-VACC-005-Env
速度RMS: 33.44µm/s
R CMD 在线

速度12#速度传感器
H4-VACC-006-Env
速度RMS: 32.07µm/s
R CMD 在线

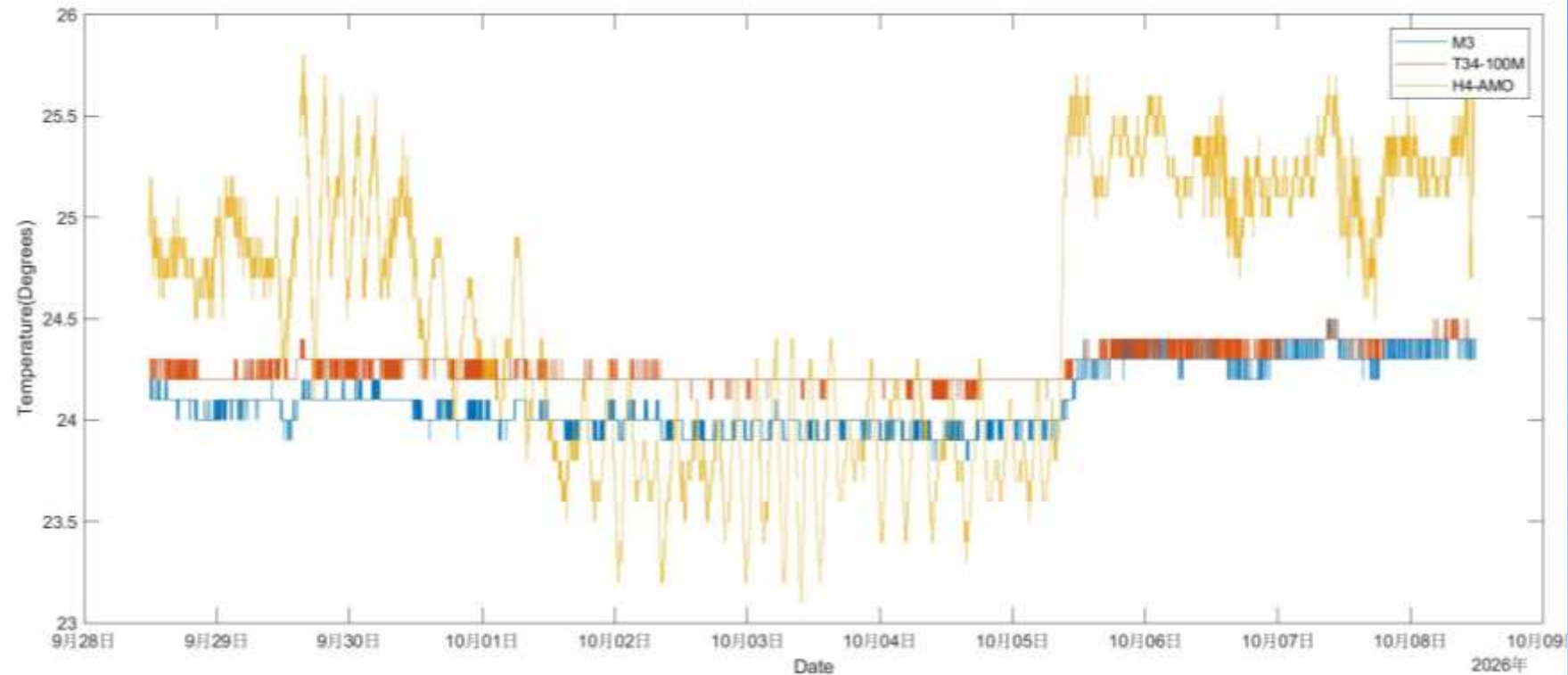
Pressure Change

1500Pa changes in 10 days, introducing 460nrad pitch changes for mirrors.



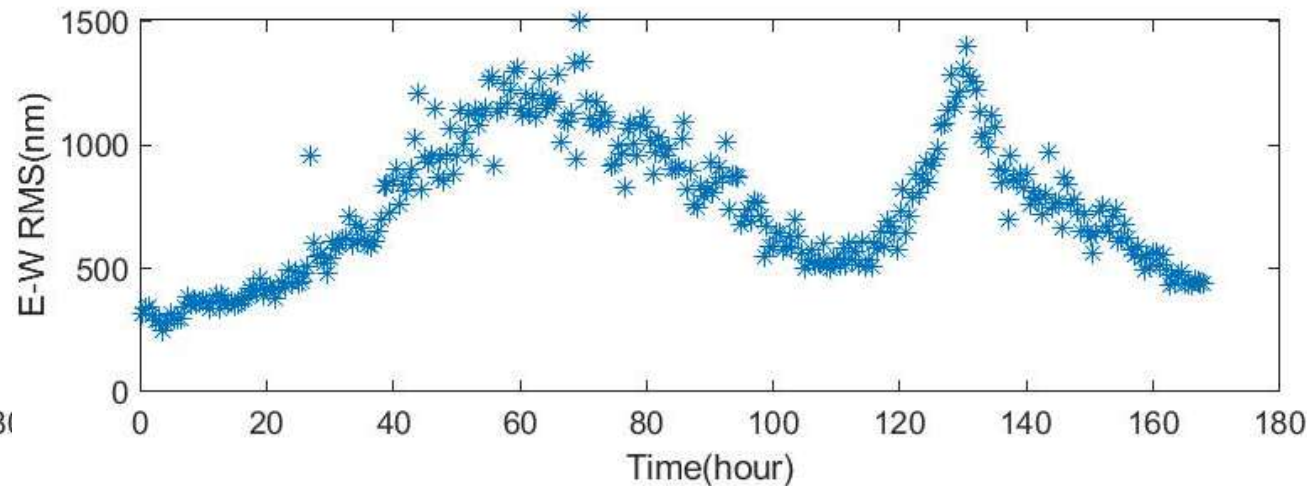
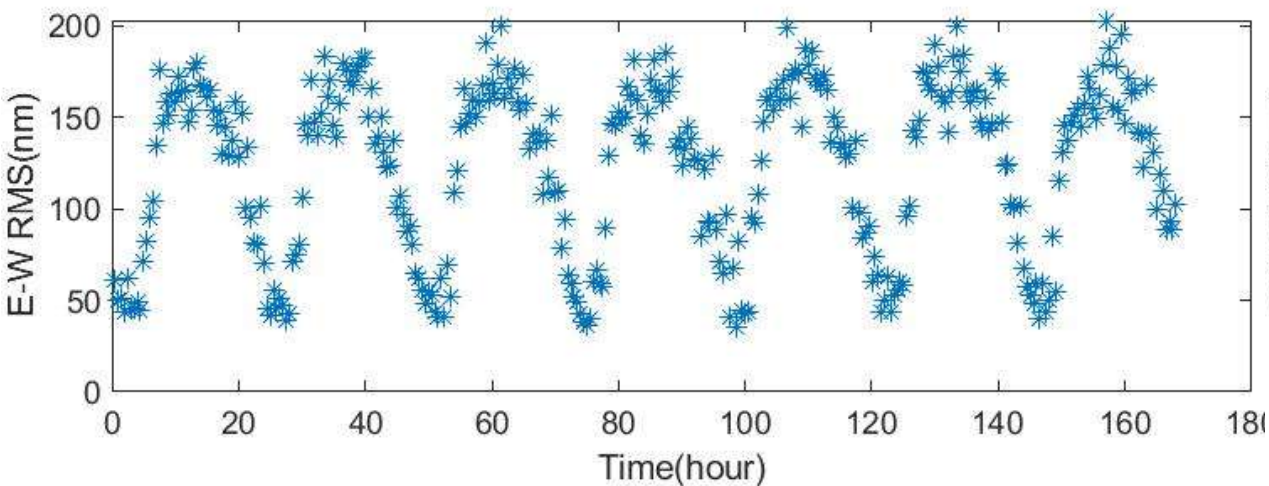
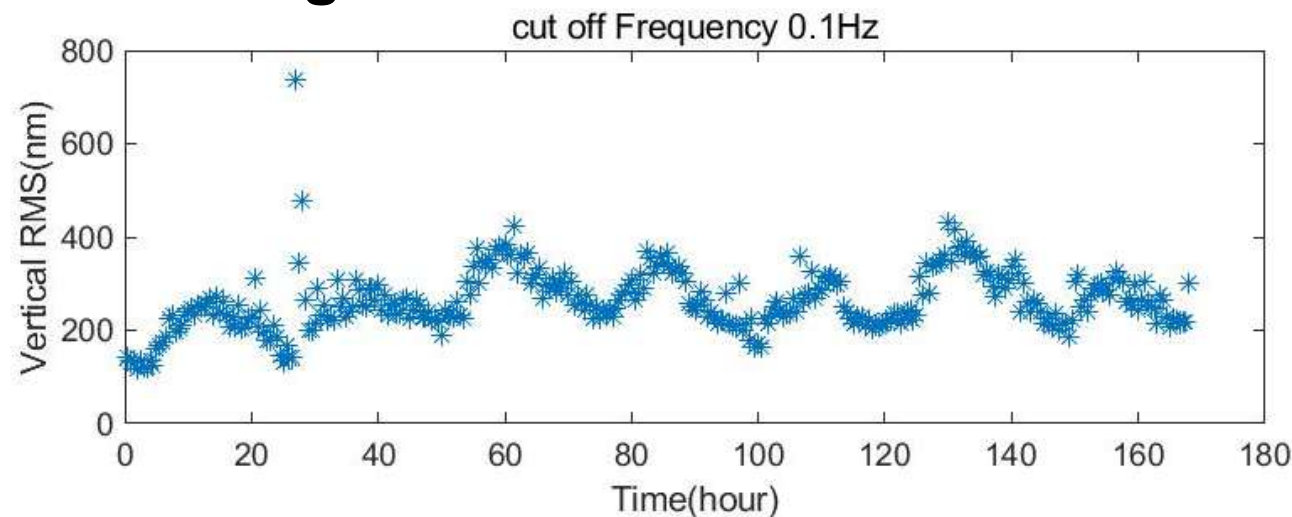
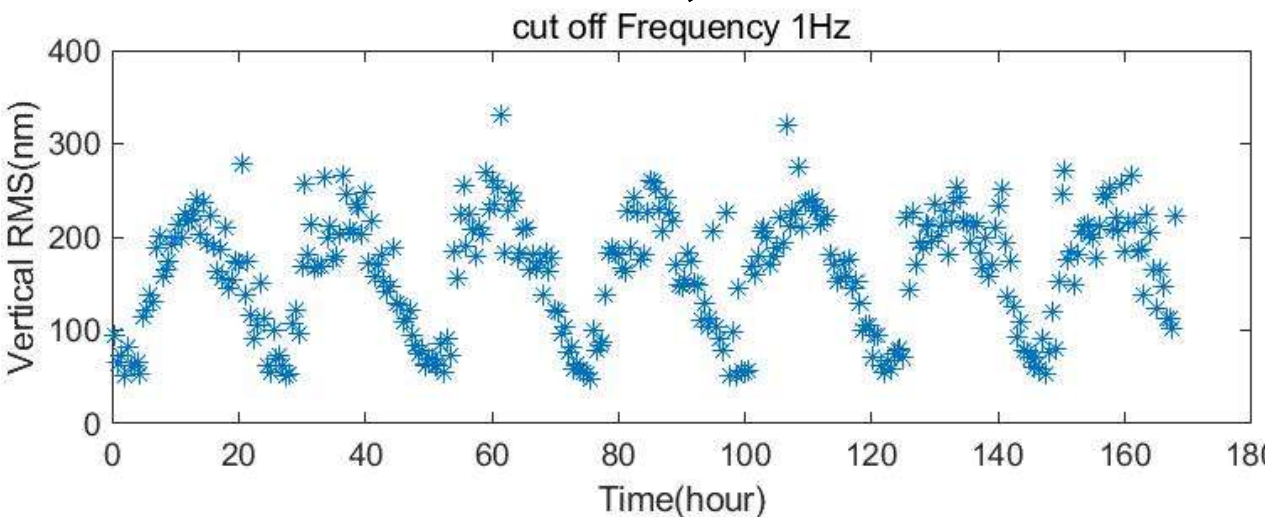
Temperature Change

- Tunnel temperature $\pm 0.1^{\circ}\text{C}$;
- Mirror chamber $\pm 0.25^{\circ}\text{C}$ (Introduces 562nrad);
- Experimental hall $\pm 1^{\circ}\text{C}$

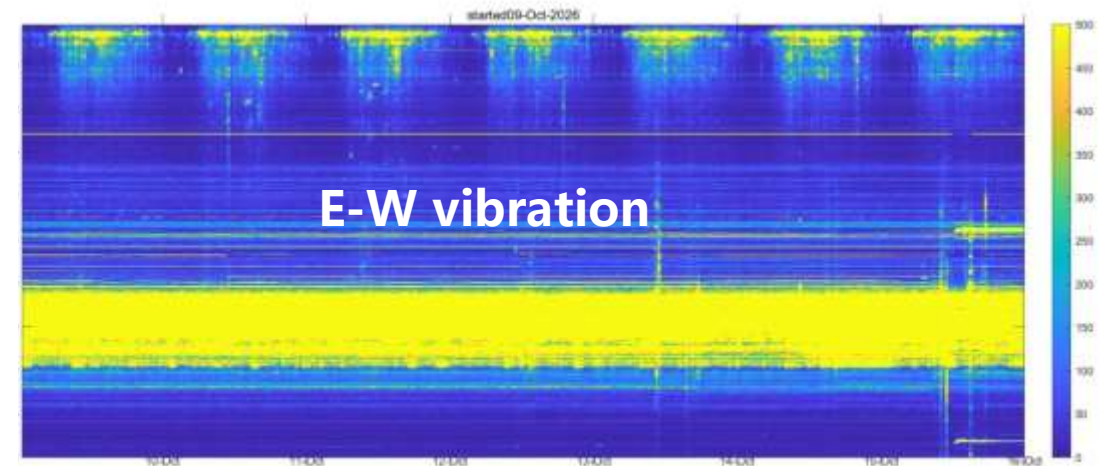
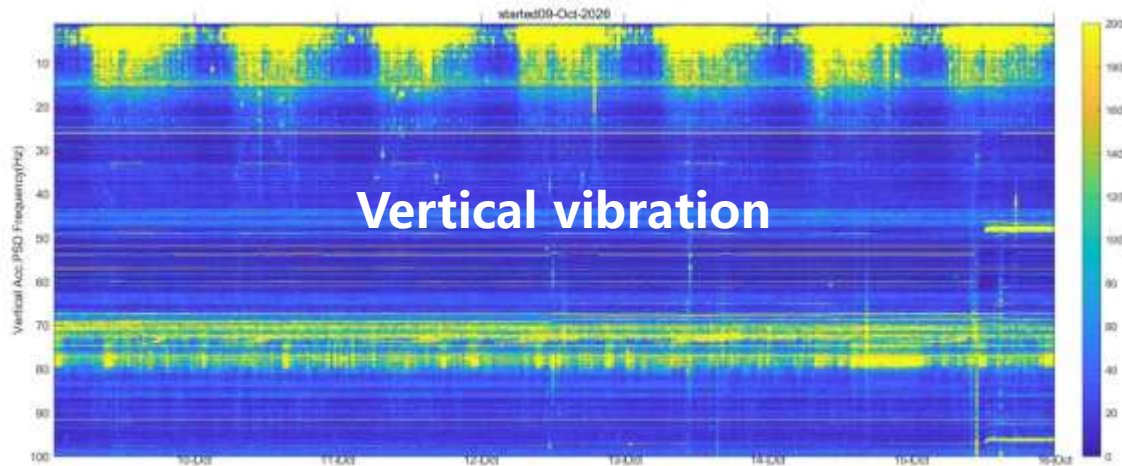
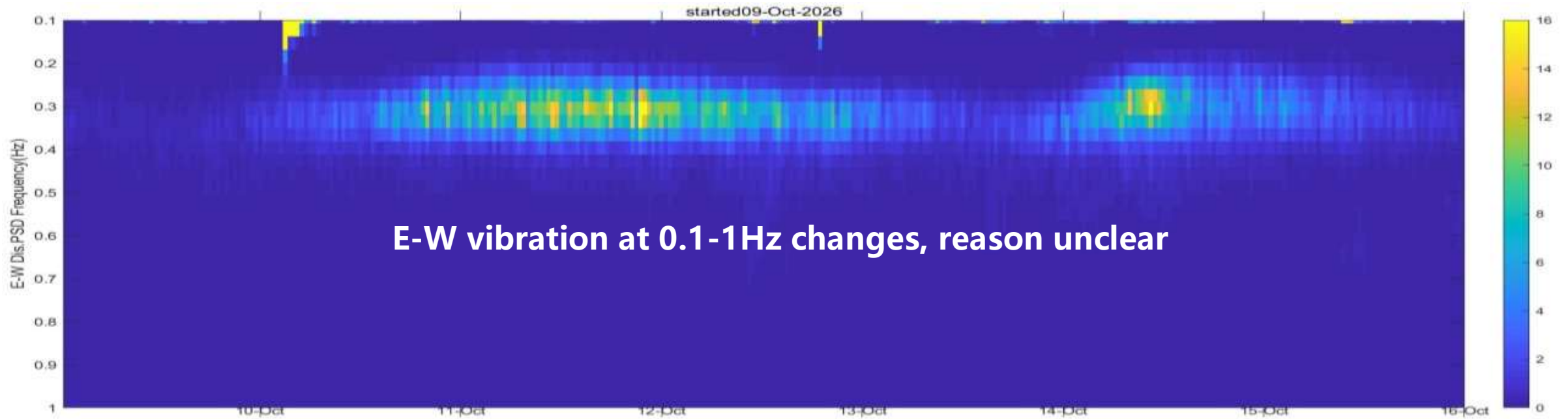


Ground vibrations

- 1-100Hz: Vertical vibrations is 50~300nm, Horizontal vibration is 50~200nm.
- On E-W direction, vibration at 0.1~1Hz is strong.

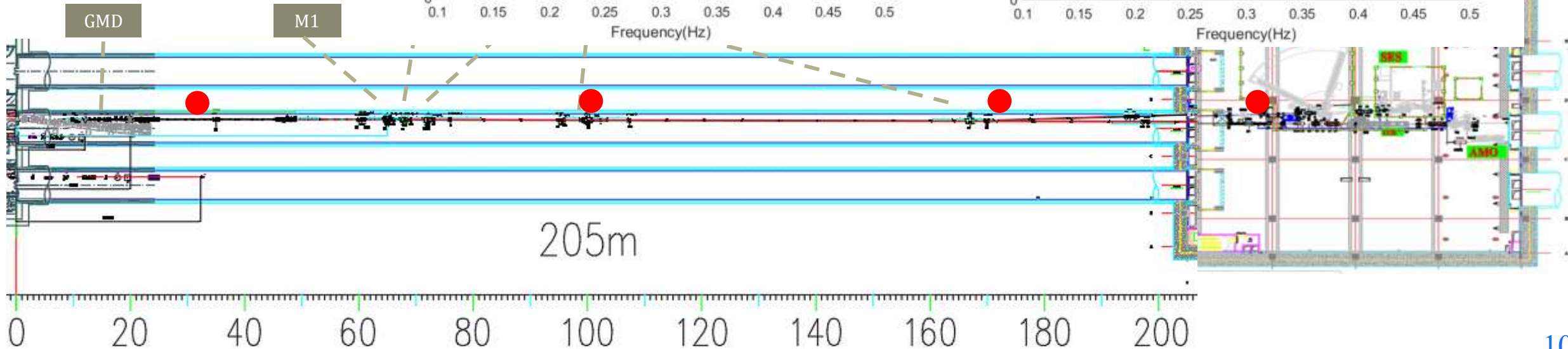
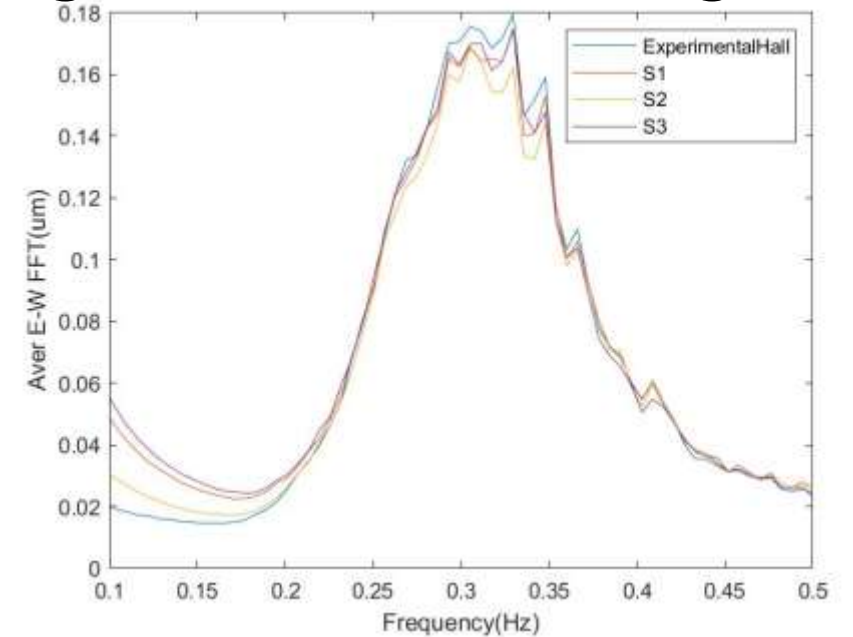
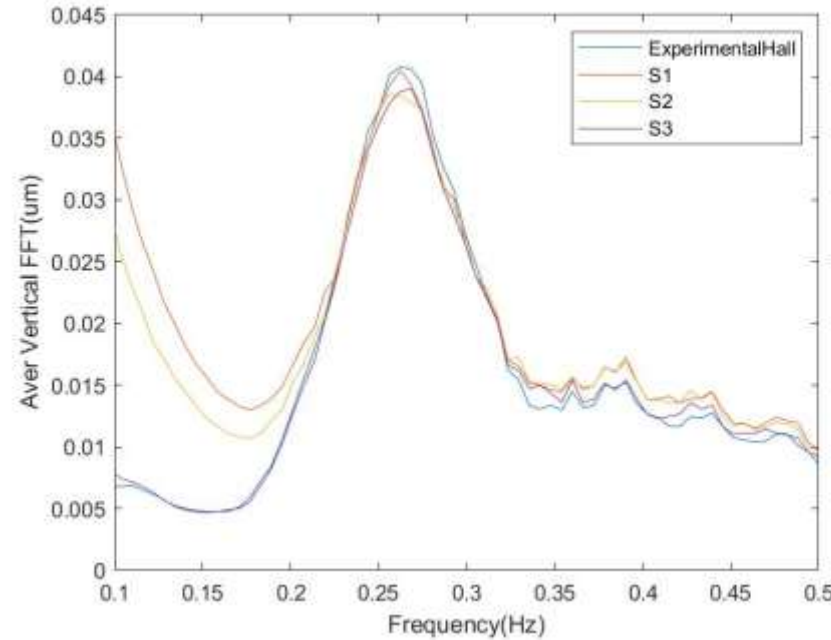


Ground vibrations



Low Frequency Vibration Monitoring

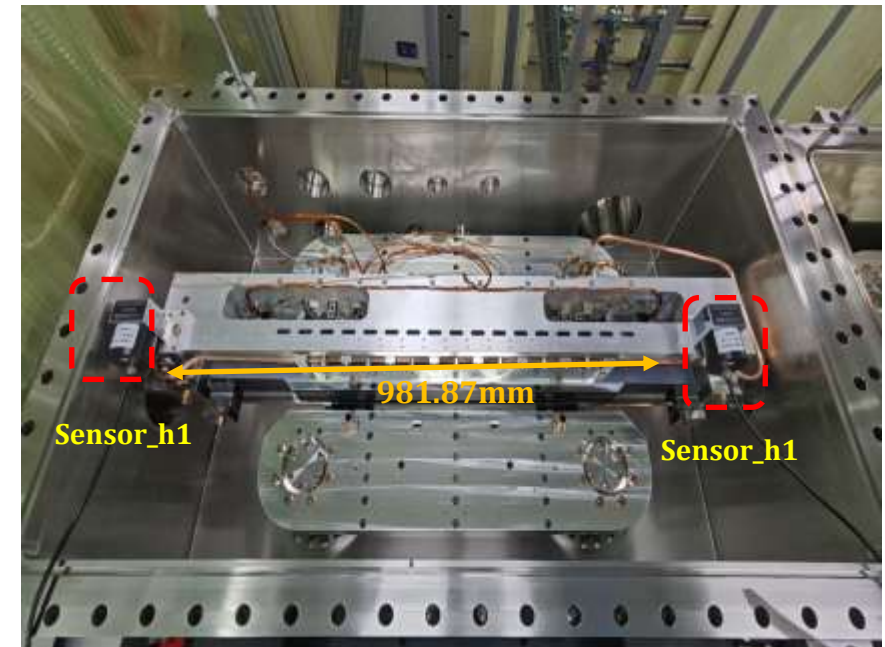
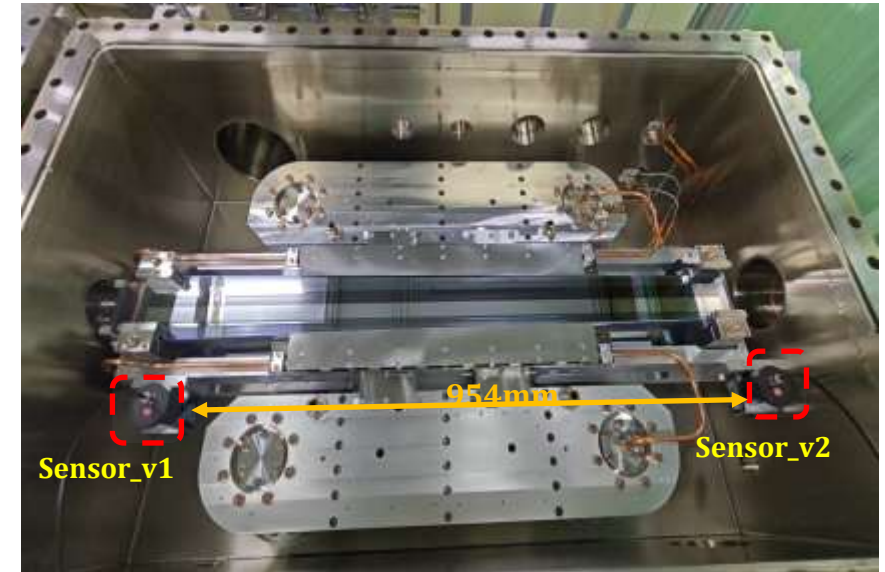
- E-W vibration at 0.1-1Hz are on the same magnitude in 230m length.



Optics Vibration Measurements and Controls

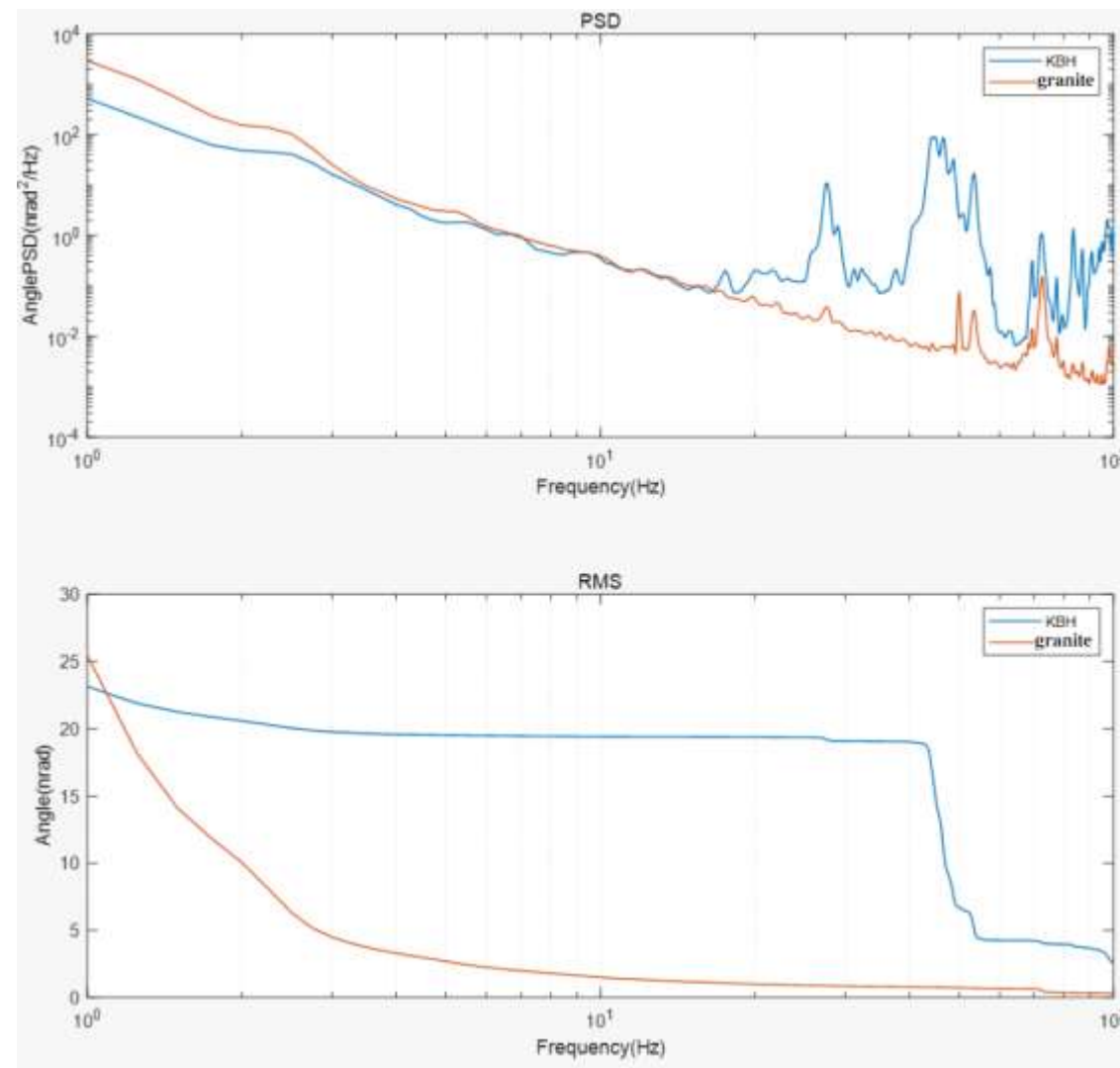
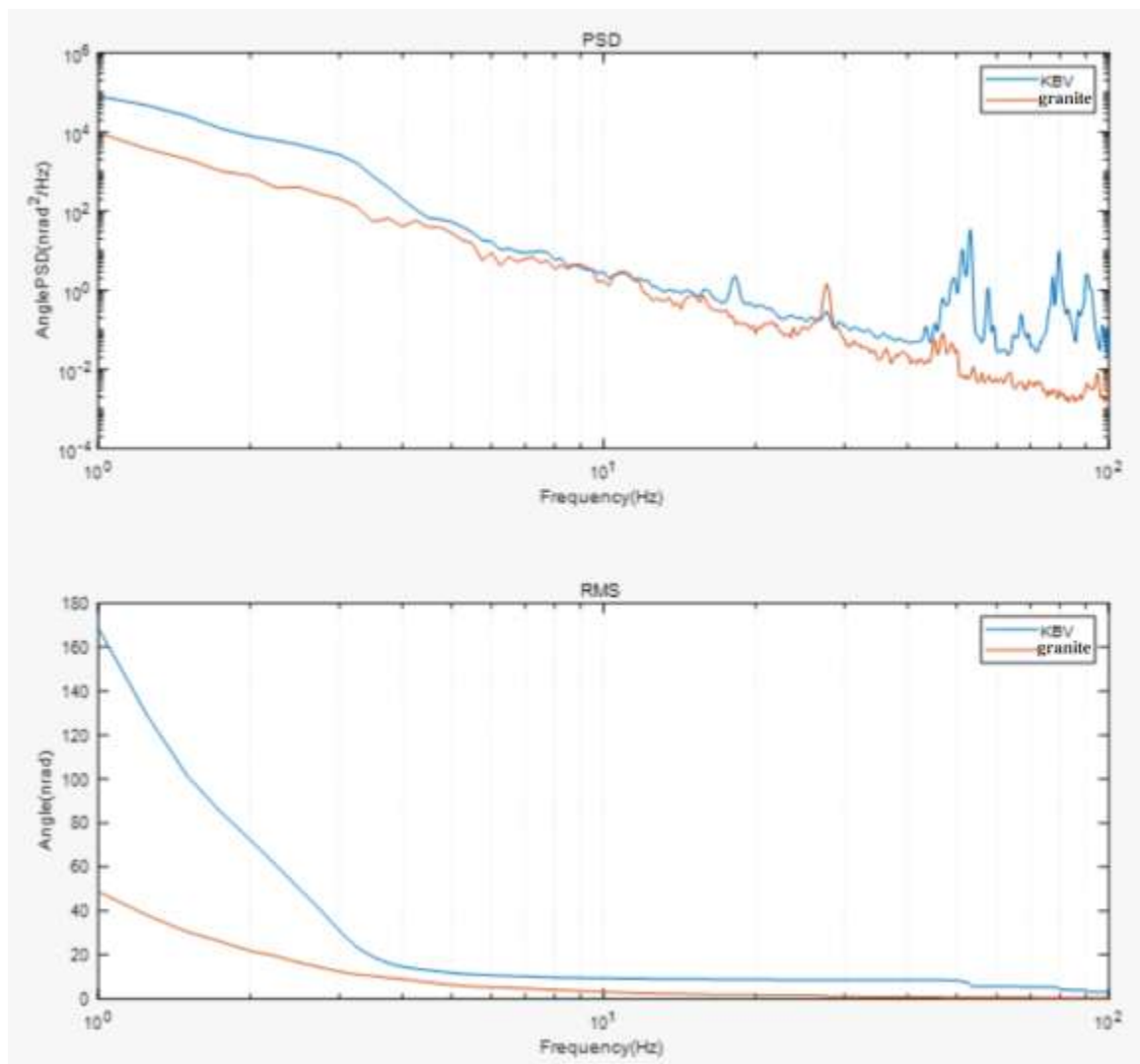
Mirror stability measurement on site

Name of Mirrors	Stability(nrad)
M1-FEL-II	18
M2a-FEL-II	<50nrad
M2b-FEL-II	/
M3-FEL-II	42
PGM-Mirror	114(1-256Hz) 10(10~256Hz)
AMO-KB-VFM	170(1-256Hz) 10(10~256Hz)
AMO-KB-HFM	23
SES-KB-VFM	32
SES-KB-HFM	20
HSS-KB-VFM(FEL-I)	15
HSS-KB-HFM(FEL-I)	21
SSS-Optical chamber-Mirror	28.5
SSS-Optical chamber-Grating	32



AMO-KB mirror vibration test

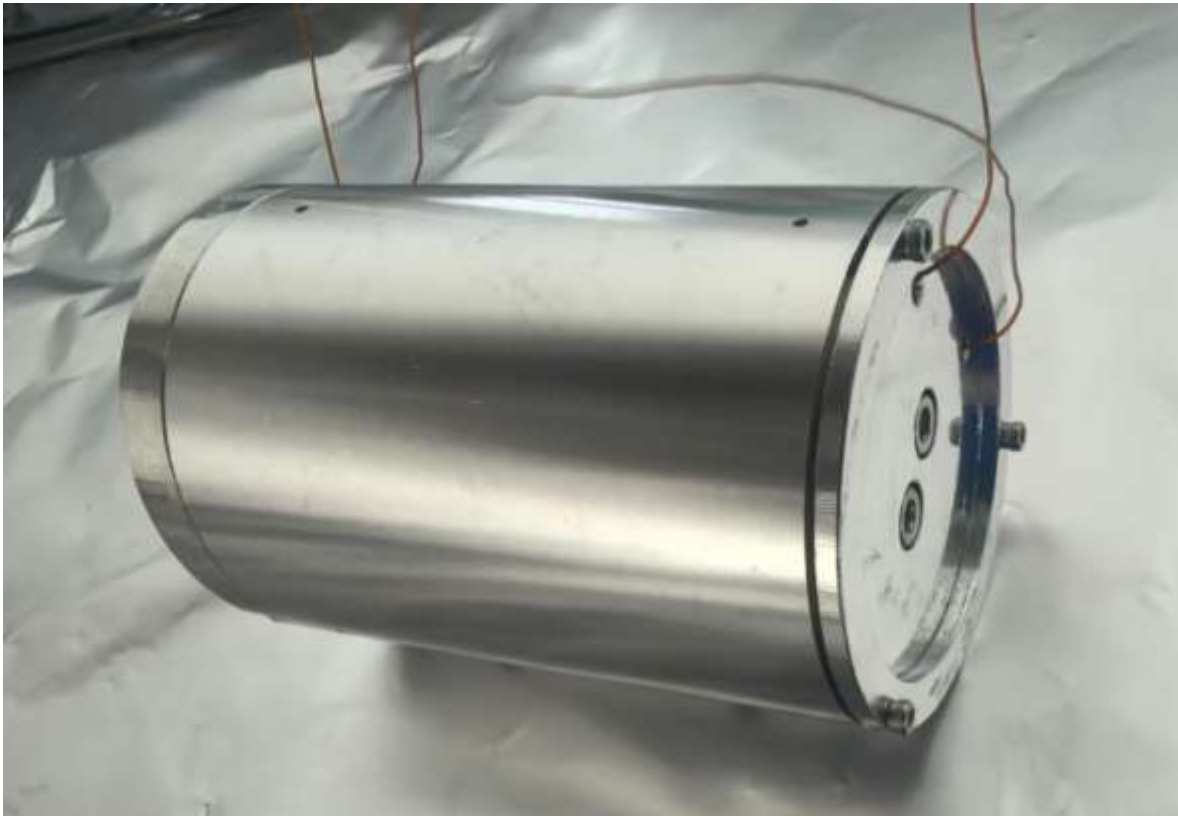
- Compared to the granite, low-frequency vibration increased much.



Vibration controls

- Outgassing rates meet the requirements for FEL-I beamlines.

Damper outgassing rate
($6.13\text{E-}^9\text{TorrL/s}$)

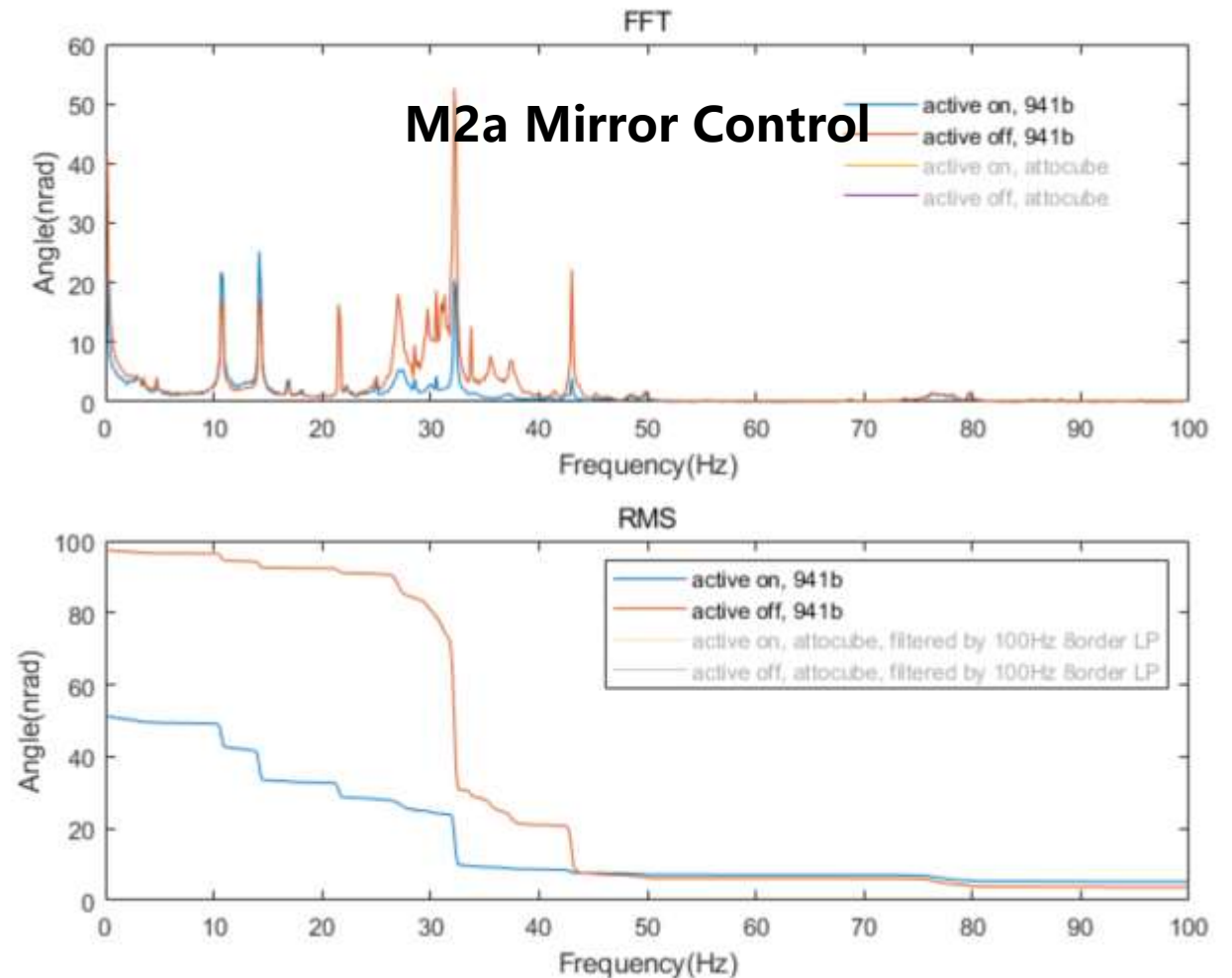


Sensor outgassing rate
($3.7\text{E-}^7\text{TorrL/s}$)



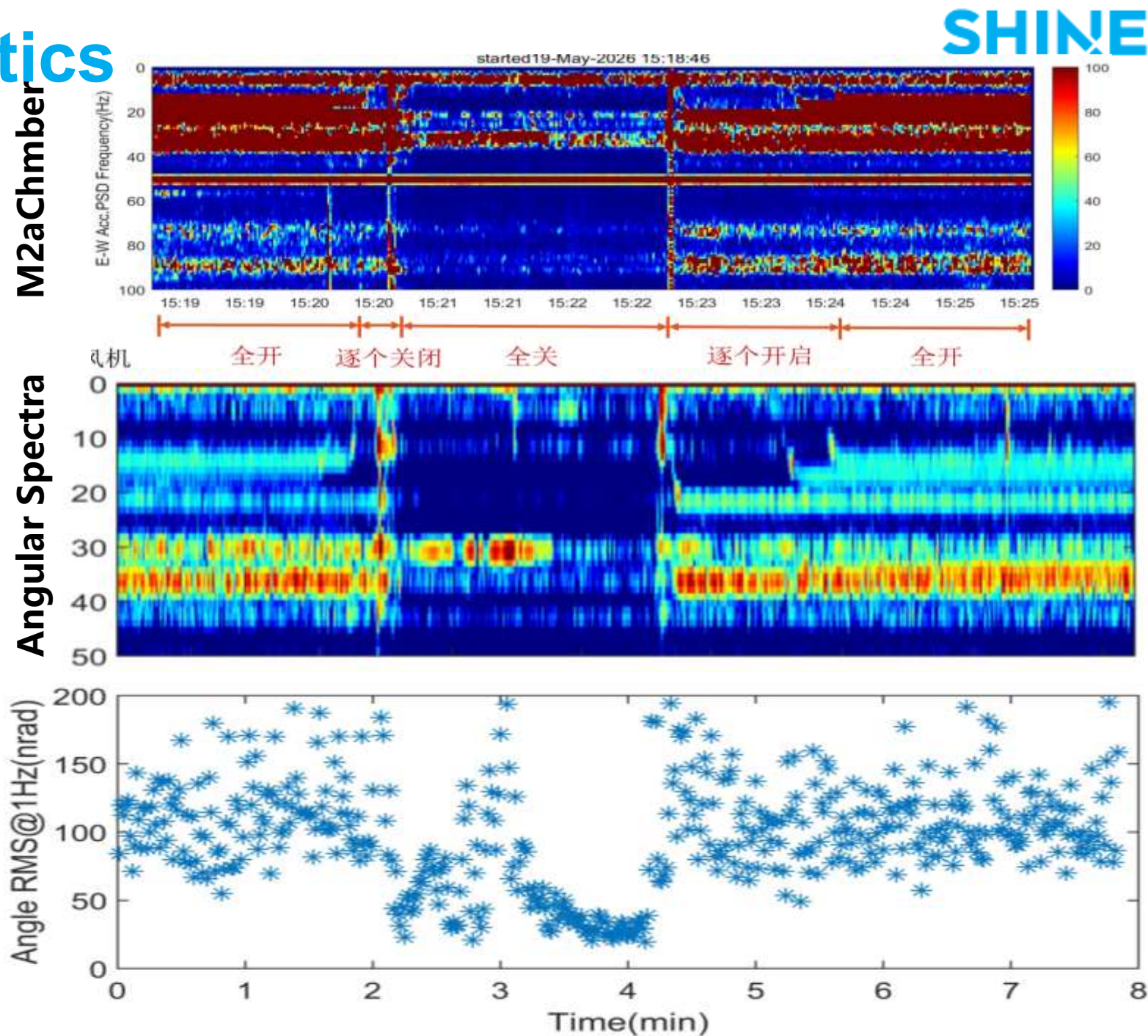
Vibration controls

- Control algorithm improve to damp more frequencies other than modal frequencies.



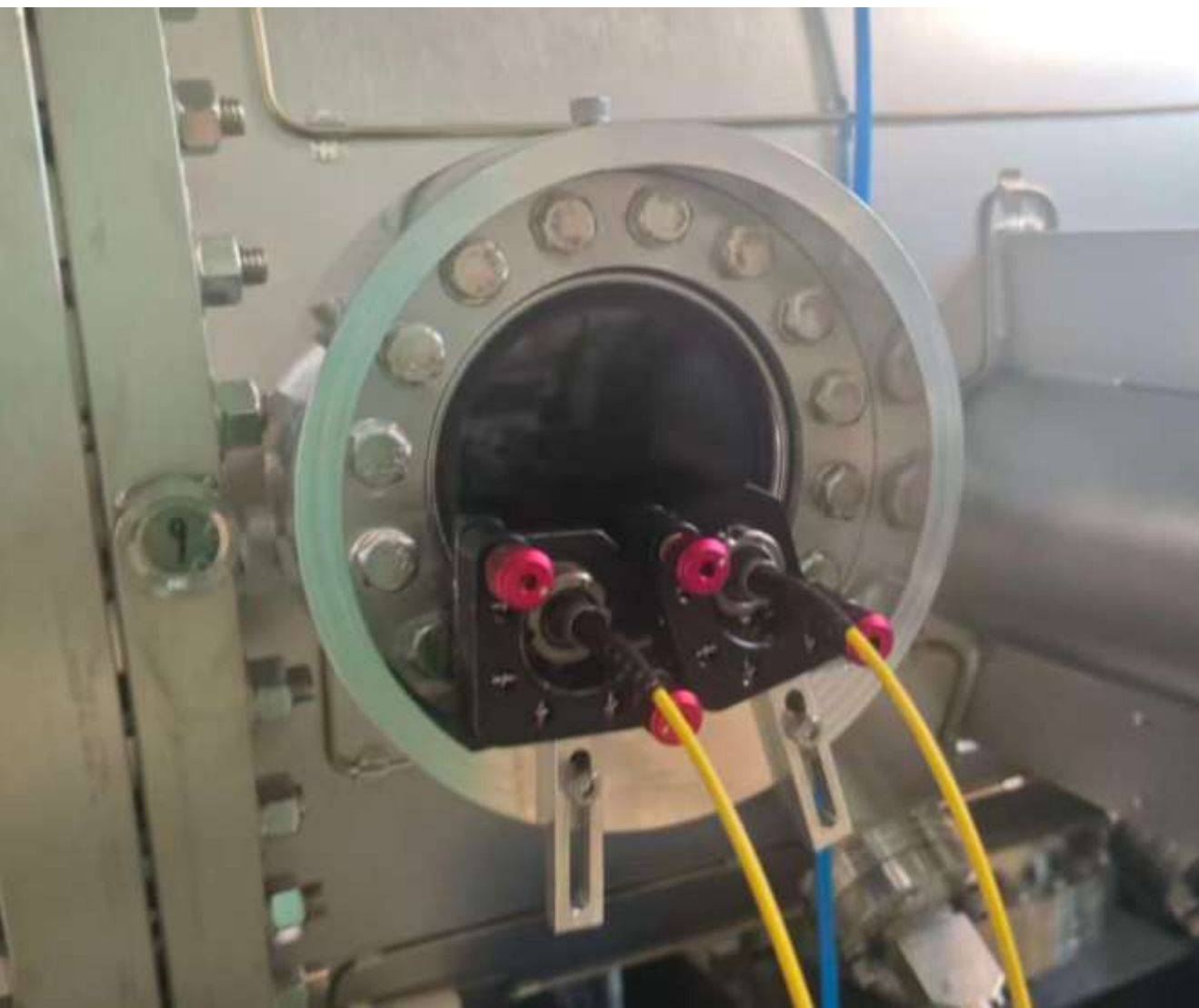
Vibration Diagnostics

- Laminar flow tent introduced lots of vibration, and caused the M2a mirror vibration more than 100nrad, after switching of the machine, vibration decreased to less than 50nrad.



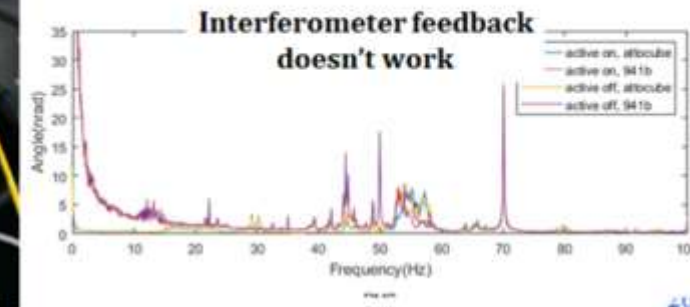
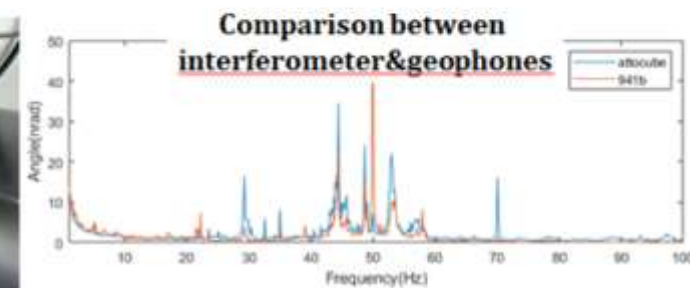
Online angle measurement

- Methods to measure mirror vibrations.



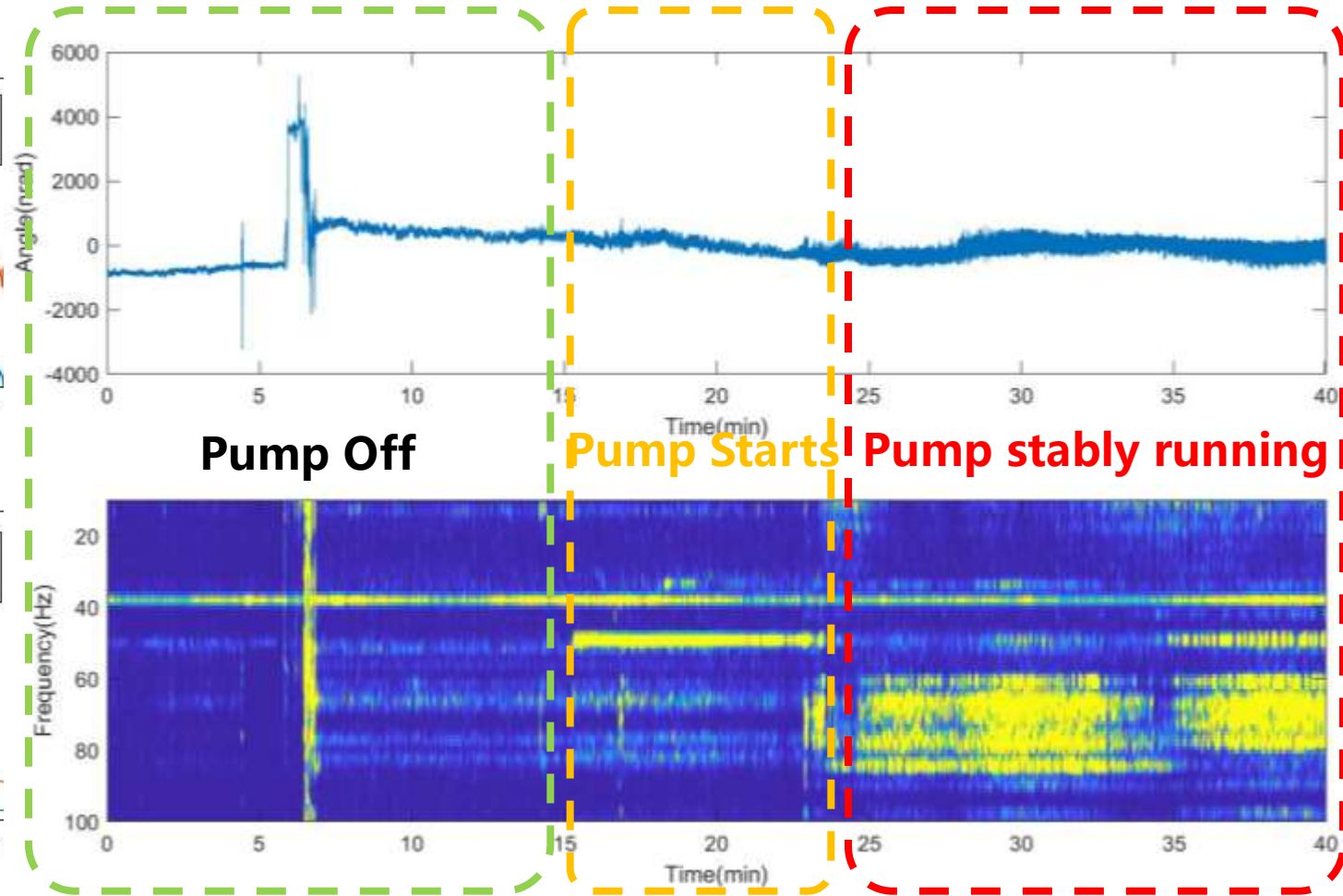
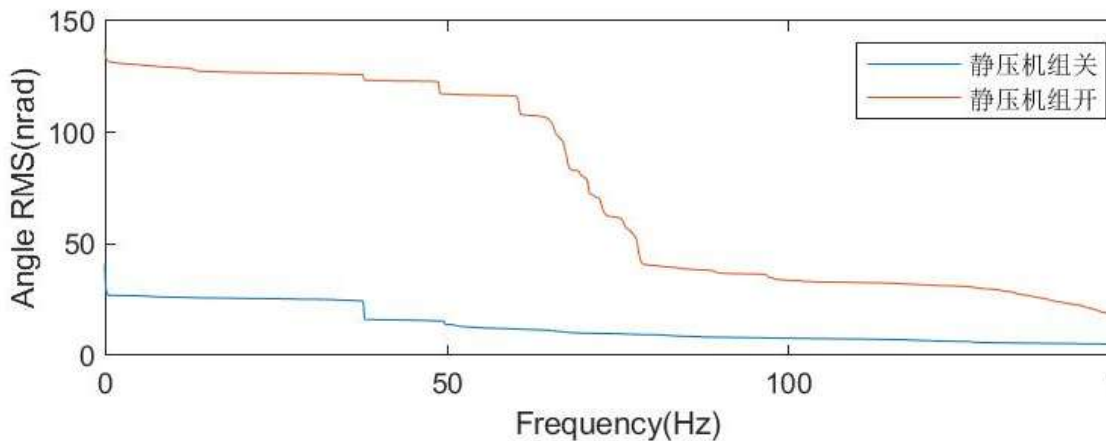
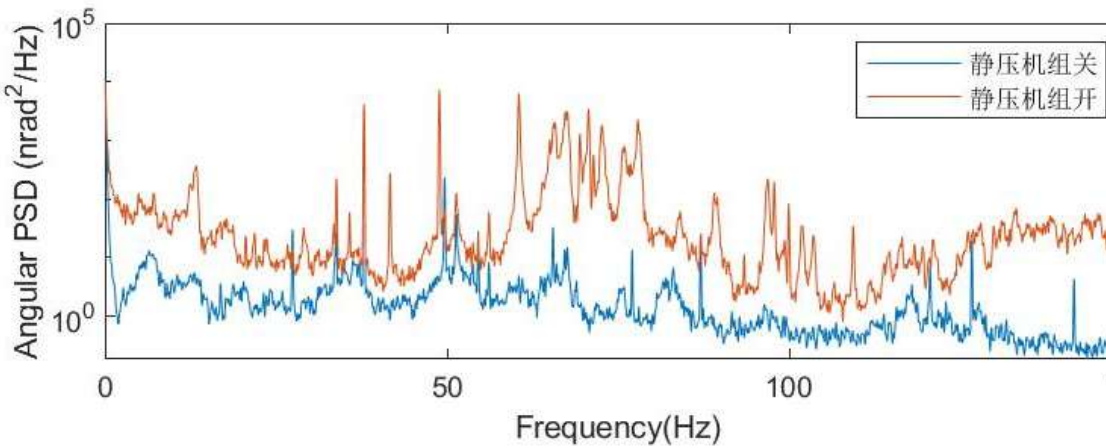
Interferometer measurement

Interferometer feedback failed for M1 so far.



Online angle measurement

- Water cooling pump introduced chamber vibration caused angular vibration increased from 25nrad to 130nrad.



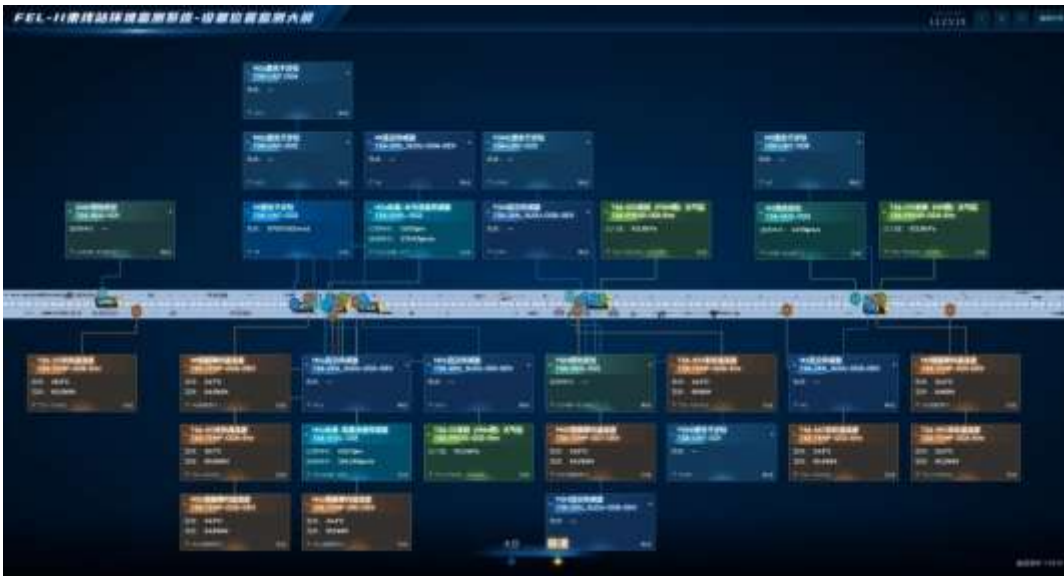
Problems and Questions

Data storage questions

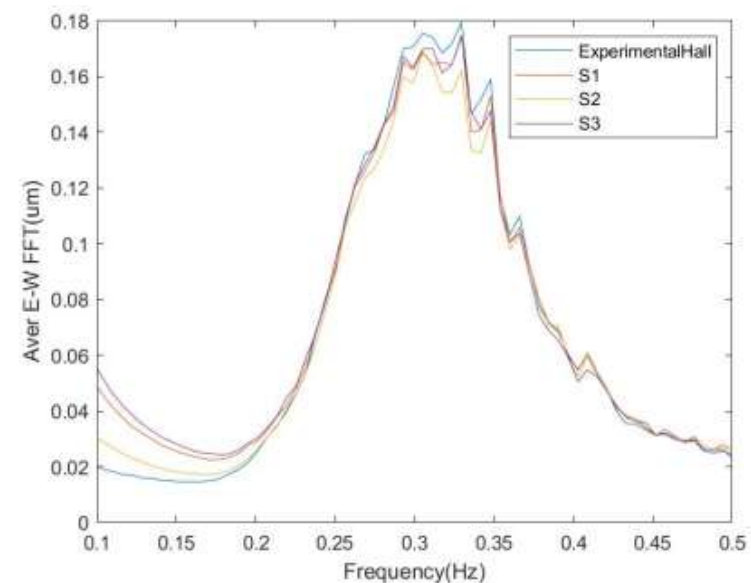
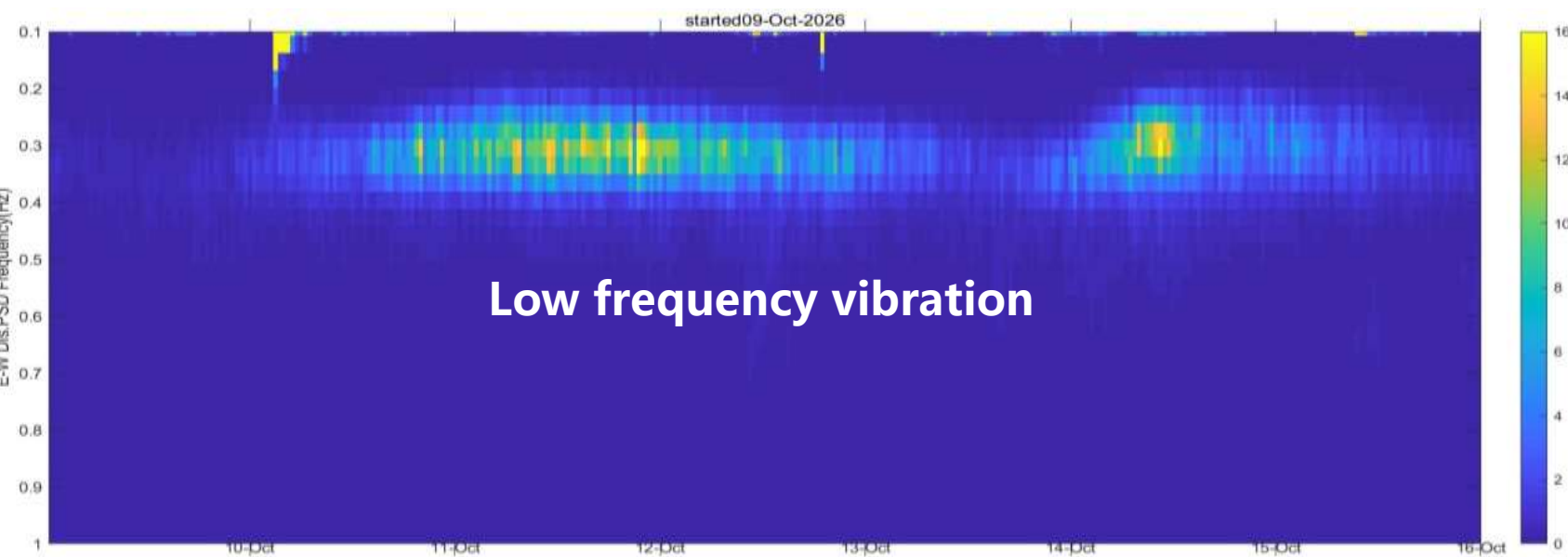
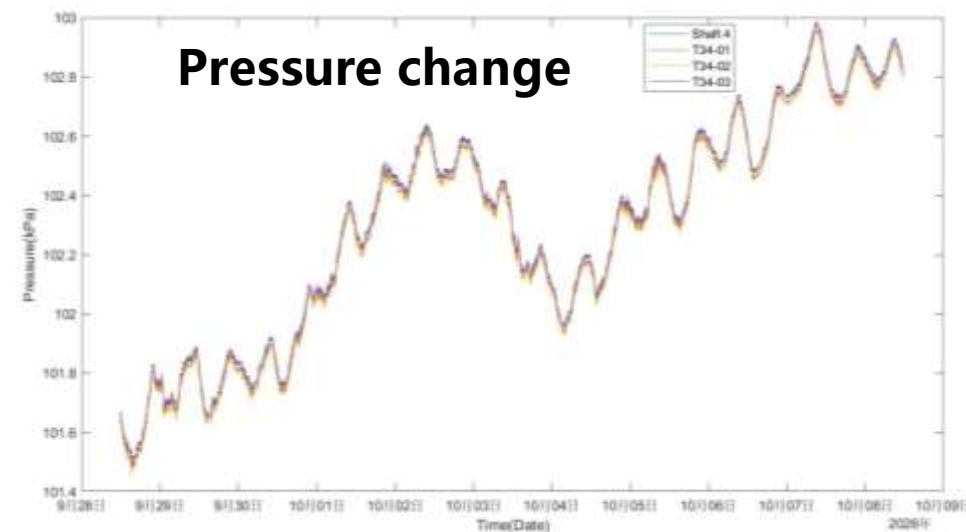
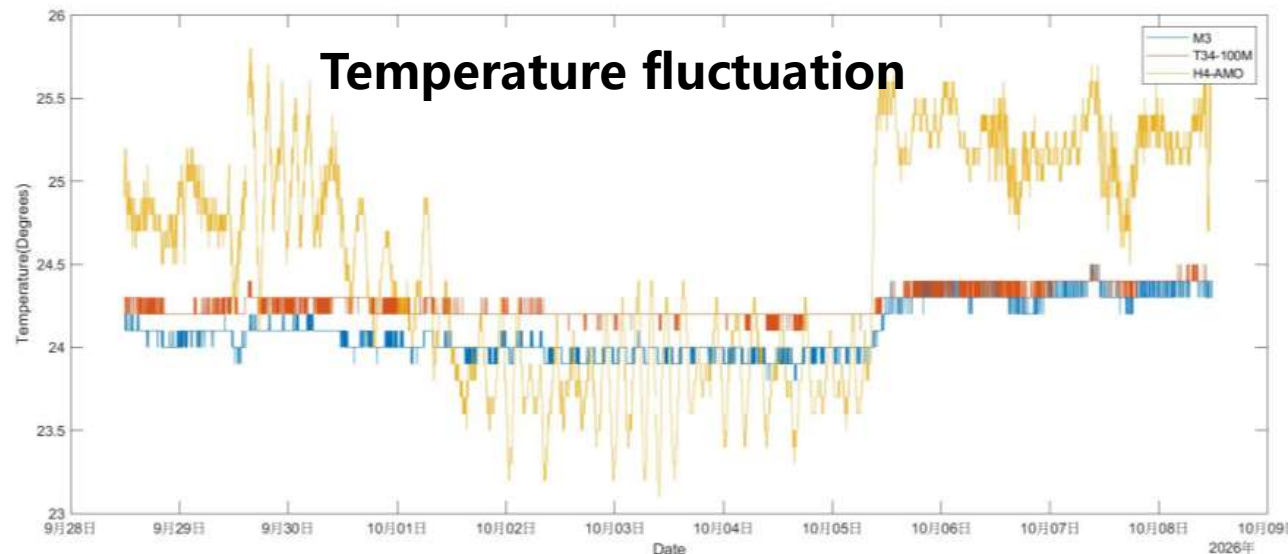
- ❑ 20+ vibration sensors with 512Hz sampling frequencies.
- ❑ 16 channels with 5Hz sampling frequencies.

waveform data is 22G/day.

- ❑ Preliminary solution is to store only PSD data(every minute or half hour) after one year.



Influences on beam stability



□ Summary

- Environment monitoring has been installed and integrated.
- Optics vibration is below 50nrad on site.
- Active damping is ready for test in FEL-I.

□ Future work

- Online optics vibration monitoring for FEL-II.
- Relationship between environment and beam stability.

□ Questions

- Data storage(the environment monitoring system generate 22G/day. How much/long data to store)
- Beam stability related with environment.