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First High power test of ESS high-β elliptical cavity

Poster THPO066

Han Li

On behalf of FREIA & CEA team

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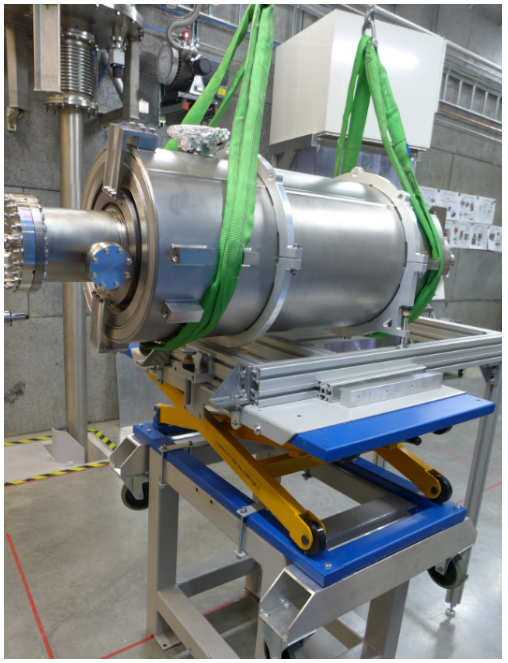
RF Test Goals

- The test of high-β elliptical cavity has the following goals:
  - ✓ verify cooling and operational performance,
  - ✓ verify RF power tation and LLRF performance,
  - ✓ verify power coupler conditioning procedure, coupler ability and performance,
  - ✓ verify cavity intrinsic ability, accelerating performance, mechanical behaviour,
  - ✓ verify cold tuning system (CTS) ability and performance,

- Typical measurements:
  - ✓ RF behaviour during cool down,
  - ✓ Coupler conditioning and cavity package conditioning,
  - ✓ Achieve maximum gradient,
  - ✓ Cryogenic heat loads,
  - ✓ Loaded Q-factor, eigen and external Q, $Q_0 = f(E)$ curve,
  - ✓ Dynamic Lorentz detuning and mechanical modes,
  - ✓ Field emission onset and multipacting barriers,
  - ✓ Sensitivity to helium pressure fluctuations,
  - ✓ Tuning sensitiviy,
  - ✓ Filling time.



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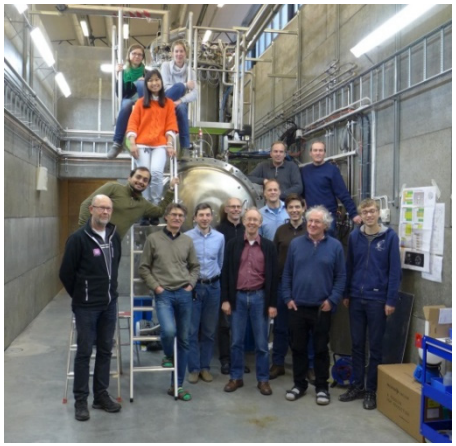
What and Whom?

FREIA



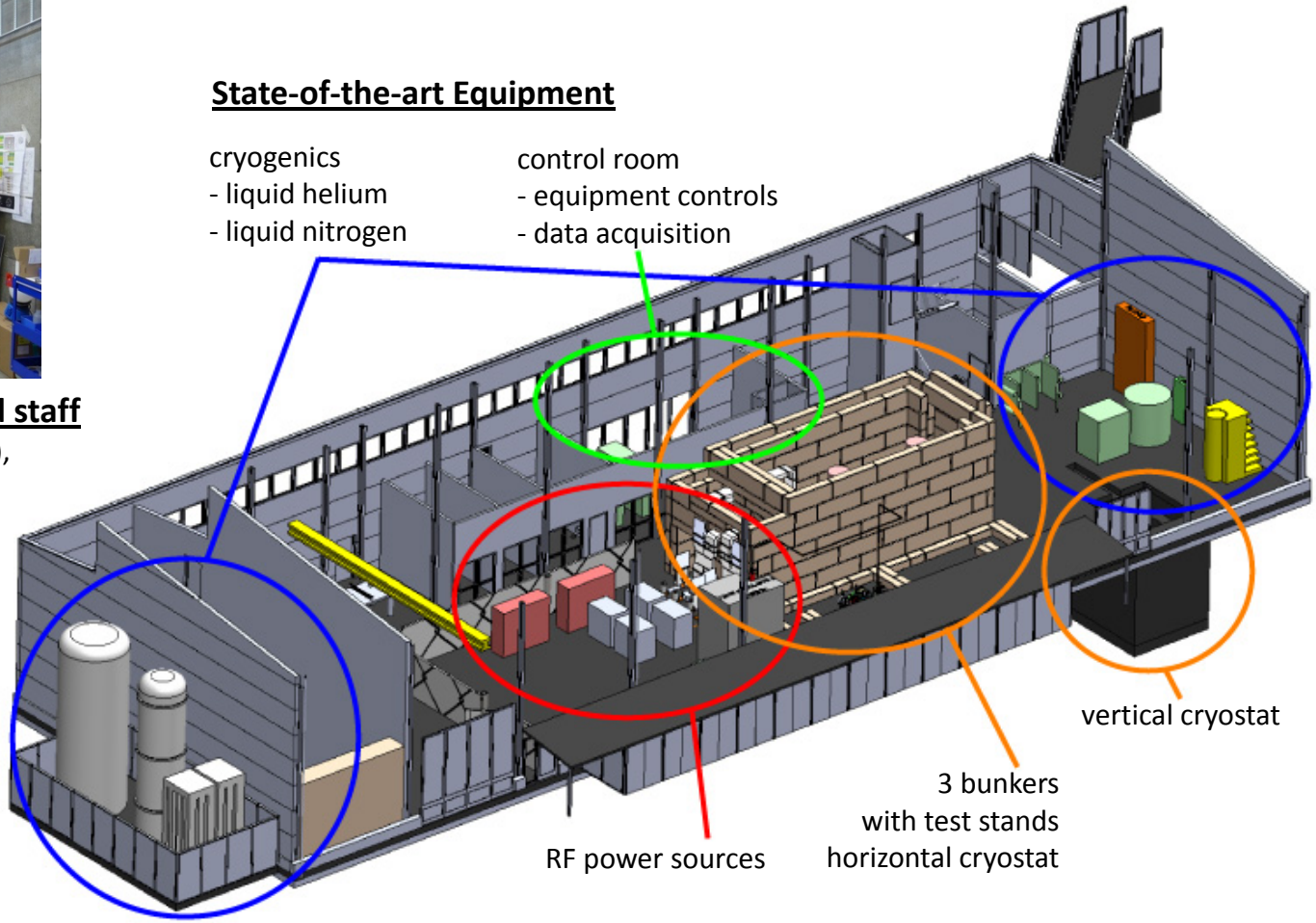
Competent and motivated staff
collaboration with physics (IFA), engineering (Teknikum), TSL and Ångström workshop

Facility for Research Instrumentation and Accelerator Development

State-of-the-art Equipment

cryogenics
- liquid helium
- liquid nitrogen

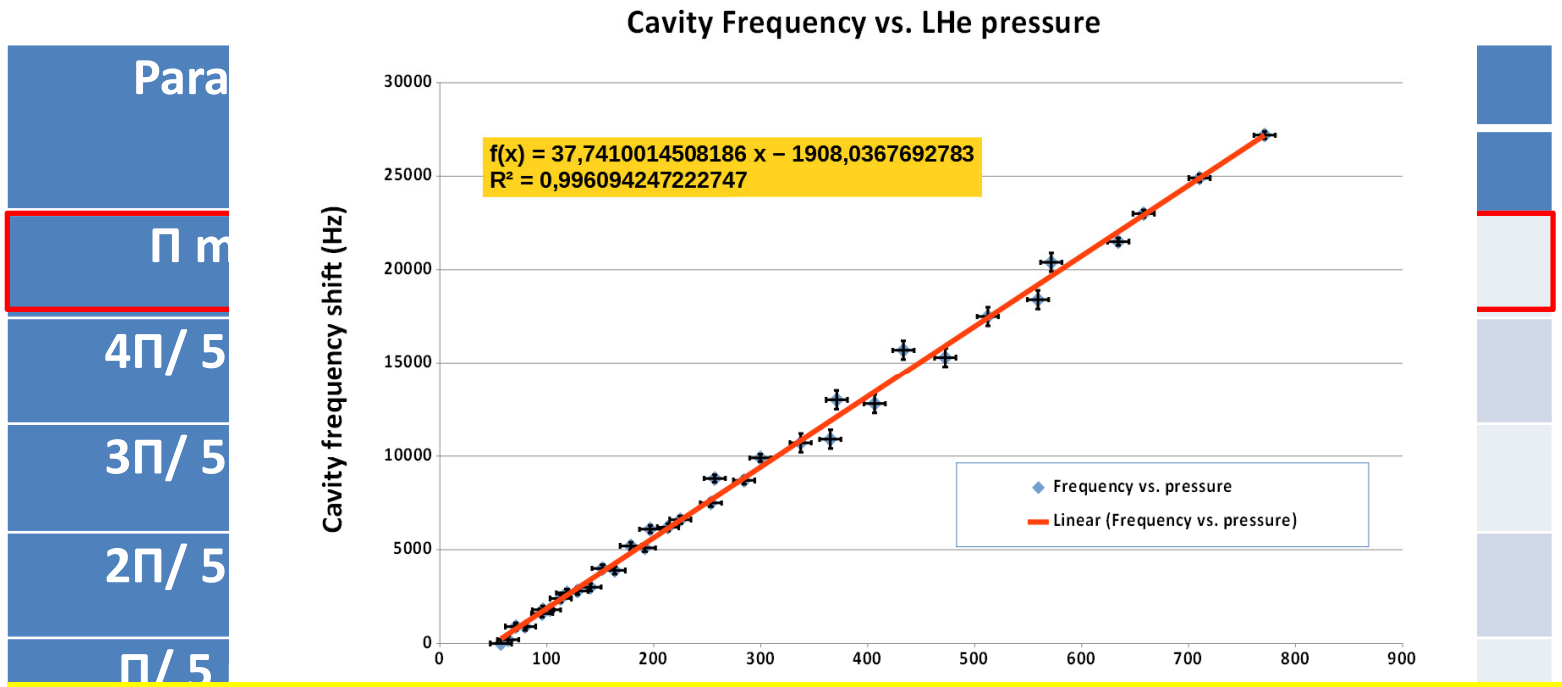
control room
- equipment controls
- data acquisition



Funded by KAWS, Government, Uppsala Univ.

Frequency checking

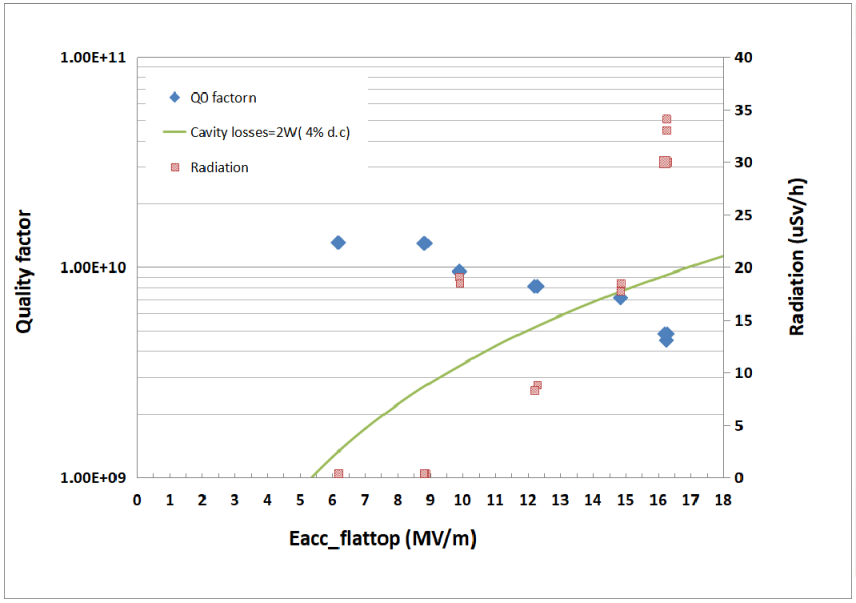
- Frequency checking during cool down to study the cavity behavior
  - ✓ The longitudinal modes of the first passband at different temperatures
  - ✓ Key frequencies at certain temperature
  - ✓ Pressure sensitivity

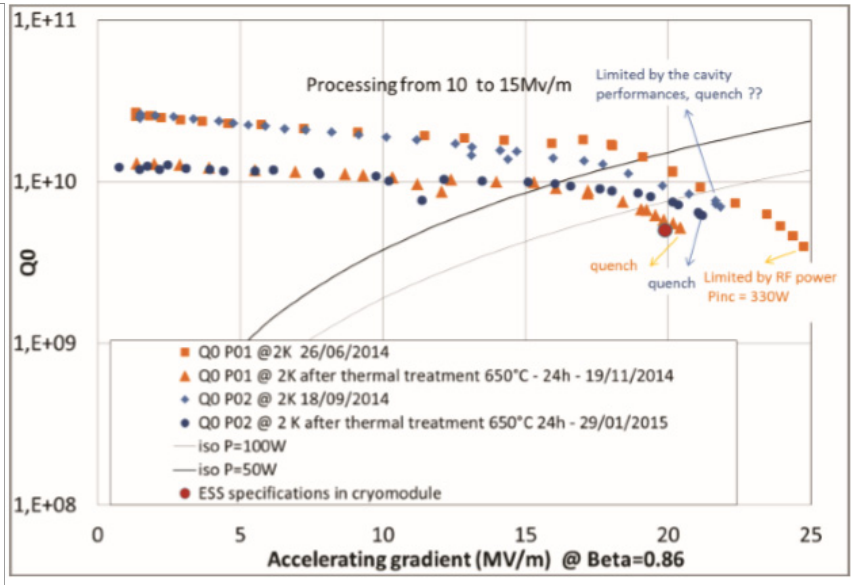


Frequency sensitivity to Pressure= 37 Hz/mbar

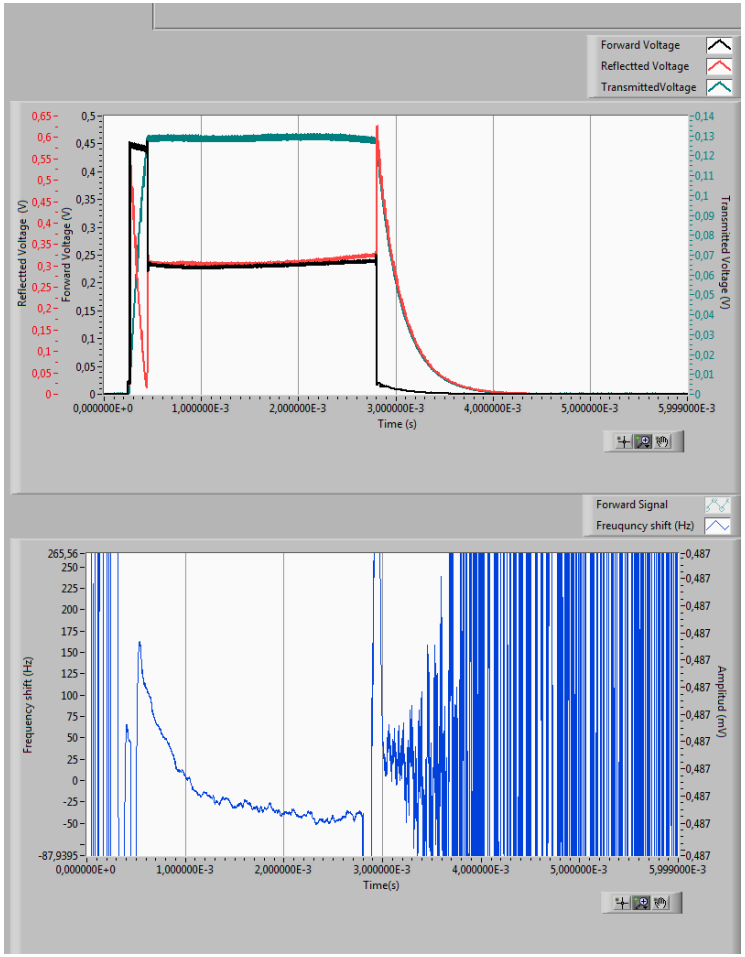
Quality factor

- The Q factor measurement is based on the self-exited loop at FREIA.
- Operated at a pulse mode of 2.55 ms duration and 14 Hz repetition rate.
- A Q factor of 1.3×10^{10} at low field and 7.1×10^{9} at 15 MV/m was determined.
- The average cavity package dissipated power at 15 MV/m is about 2 W .
- The Q_{ext} for FPC has been studied both at room temperature and cold with different medthod.

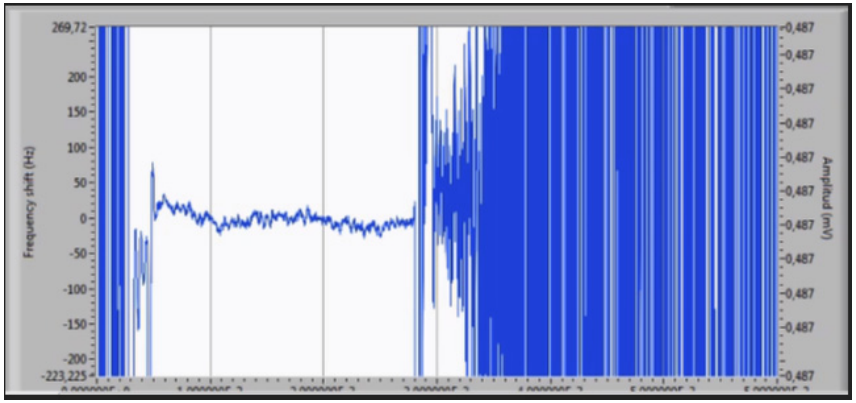




Lorentz force detuning



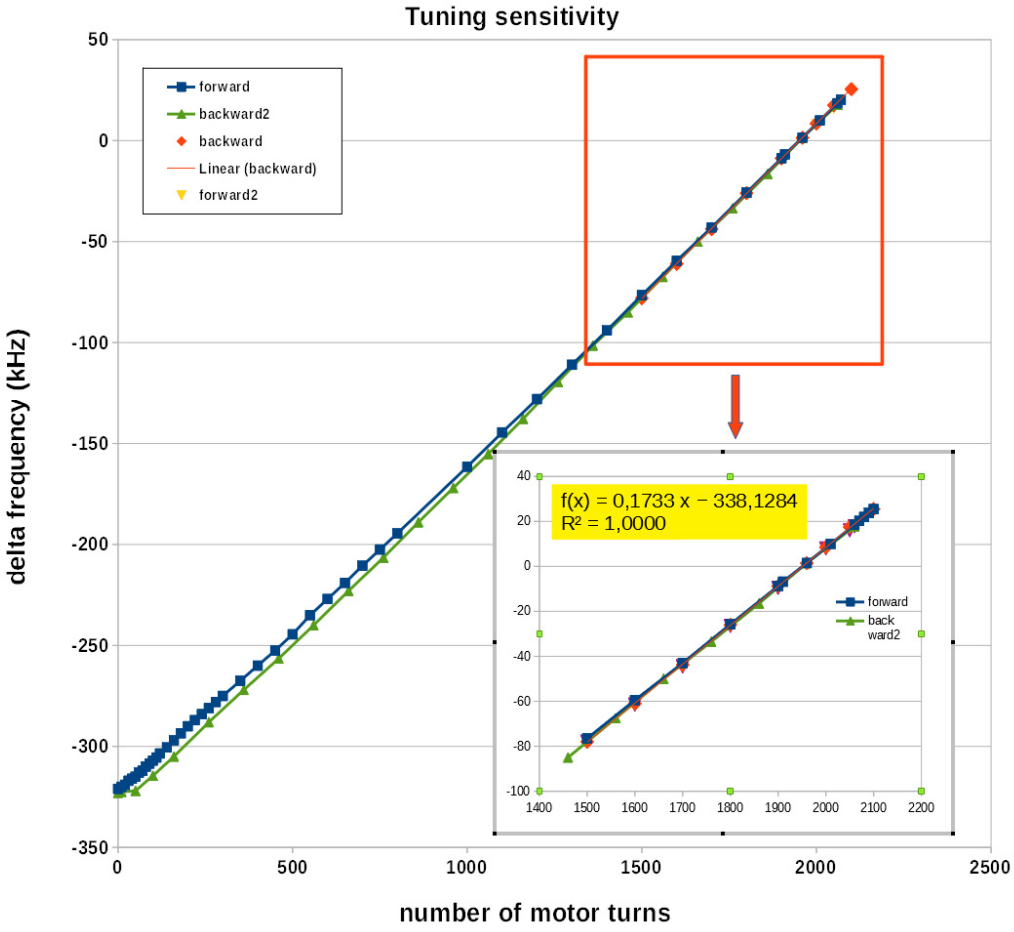
- The dynamic Lorentz detuning was studied by a signal generator driven system with step forward pulse.
- LFD coefficient of -1 Hz/(MV/m)^2 is measured.
- The fast frequency compensation with piezo is under study.



No piezo compensation

With piezo compensation

Cold tuning system



- Distance is defined as the longitudinal deformation of the cavity.
- Good linearity of the CTS has been found around the operation region.
- Stepper motor tuning range is bigger than 340 kHz.

Tuning sensitivity = 173 kHz/mm

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Conclusion

- First high power test of ESS elliptical cavity package
- Successful verification of operational performance of cavity & RF systems
- Important milestone before cryomodule series fabrication

Acknowledgment

- Support by funding from the European Union's Horizon 2020 Research
- Thanks our collaborators from CEA colleagues
- Thanks helpful discussions with ESS experts
- Thanks all colleagues of FREIA for their hard work