First High power test of ESS high-\(\beta\) elliptical cavity

Poster THPO066

Han Li

On behalf of FREIA & CEA team

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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.
**What and Whom?**

Facility for Research Instrumentation and Accelerator Development

**State-of-the-art Equipment**
- cryogenics
  - liquid helium
  - liquid nitrogen
- control room
  - equipment controls
  - data acquisition

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

**Funded by**
- KAWS,
- Government,
- Uppsala Univ.
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

<table>
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<tr>
<th>Parameter</th>
<th>Frequency (MHz)</th>
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<tbody>
<tr>
<td>3(\pi/5)</td>
<td>698,464</td>
</tr>
<tr>
<td>2(\pi/5)</td>
<td>694,370</td>
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<td>(\pi/5)</td>
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<td>(\pi)</td>
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<td>3(\pi/5)</td>
<td>702,848</td>
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<td>(\pi)</td>
<td>702,227</td>
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</table>

Frequency sensitivity to Pressure = 37 Hz/mbar
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 $1.3 \times 10^{10}$ at low field and $7.1 \times 10^{9}$ at 15 MV/m was determined.
- The average cavity package dissipated power at 15 MV/m is about 2 W.
- The $Q_{\text{ext}}$ for FPC has been studied both at room temperature and cold with different methods.
The dynamic Lorentz detuning was studied by a signal generator driven system with step forward pulse. LFD coefficient of $-1 \text{ Hz}/(\text{MV/m})^2$ is measured. The fast frequency compensation with piezo is under study.
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
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

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- Thanks our collaborators from CEA colleagues
- Thanks helpful discussions with ESS experts
- Thanks all colleagues of FREIA for their hard work