Modified ELBE Type Cryomodules for the Mainz Energy Recovering Superconducting Accelerator MESA

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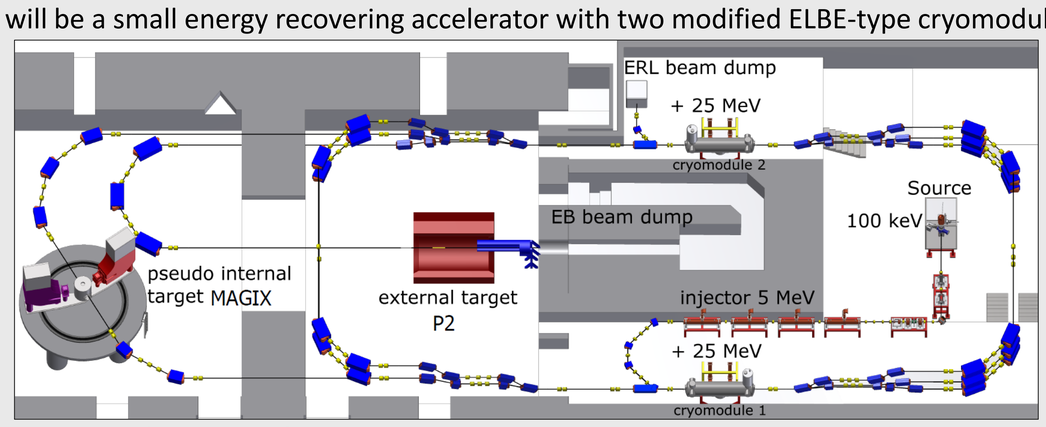
Abstract

At the Institut für Kernphysik of Johannes Gutenberg-Universität Mainz, the new multi-turn energy recovery linac MESA is under construction. Two modified ELBE-type cryomodules with two 9-cell TESLA/XFEL cavities each will provide an energy gain of 50 MeV per turn. Those are currently in the production process at RI Research Instruments GmbH, Bergisch Gladbach, Germany. Modifications for the tuner and the HOM damper are under development. In addition, a 4K/2K Joule Thomson expansion stage will also be integrated into the cryomodule. The current status of the development of the cryomodules and their modifications will be discussed.

Mainz Energy Recovering Superconducting Accelerator (MESA)

MESA will be a small energy recovering accelerator with two modified ELBE-type cryomodules.

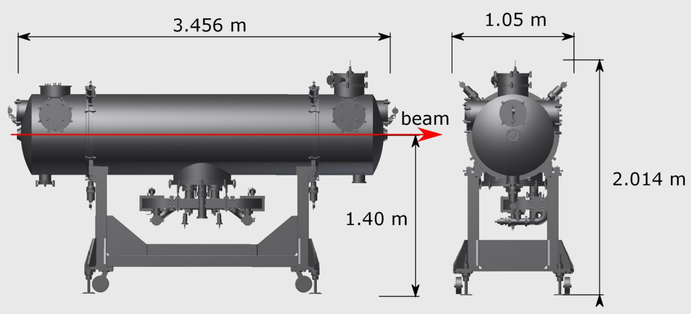


Possible configuration of MESA. The existing beam dump is in the centre of the beamline.

- MESA will be installed in already existing halls of the Institut für Kernphysik and in an additional experimental hall
- Two different operation modes: **E**xternal **B**eam (EB) and **E**nergy **R**ecovery **L**inac (ERL)
  - EB: parity violation experiment P2, fixed target
  - ERL: high resolution spectrometer MAGIX, pseudo internal target

Specifications of MESA Cryomodules

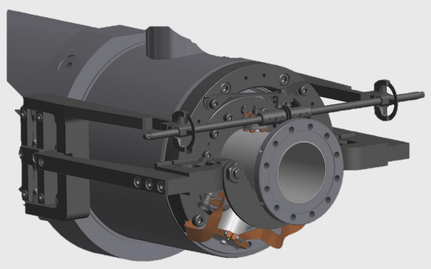
- Cryomodules are based on ELBE-type, used at HZDR, Germany
- Each module contains two 9-cell TESLA/XFEL-type cavities
- Major modifications are made to:
  - the tuner (XFEL/Saclay tuner)
  - the higher order mode damper (sapphire feedthrough)
  - the helium supply (4K/2K expansion)



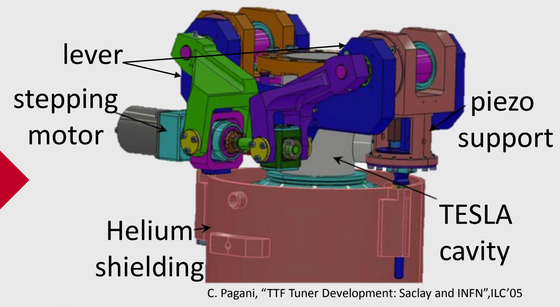
Envelope drawing of the cryomodules based on ELBE-type cryomodules with dimensions.

Parameter	Value
Energy gain per cryomodule	≥ 25 MeV
Specified cryogenic losses per cryomodule	40 W @ 2K
Accelerating field per cavity	≥ 12.5 MV/m
Operation Mode / Beam duty cycle	Continuous Wave / 100 %
Passes in EB mode	3
Passes in ERL mode	4 (2 ramp up, 2 ramp down)
Beam current (EB/ERL)	150 µA / 1 (10) mA

Tuner Changes



ELBE tuner used at HZDR.



C. Pagani, "TTF Tuner Development: Saclay and INFN",ILC'05

XFEL/Saclay tuner, may be used by MESA.

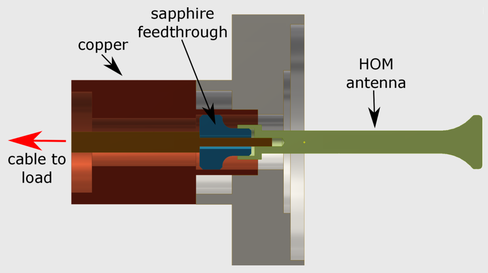
Changes:

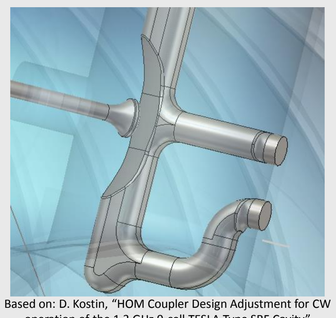
- The ELBE-type tuner will be replaced by XFEL/Saclay-type tuner
- Piezo support at XFEL/Saclay tuner will allow fast feedback (needed for multi-turn and ERL)
- Tuning range is ±460kHz at 2K

Higher Order Mode (HOM) Damper

Changes:

- Because of the c.w. operation mode with duty cycle of 100%, the heating of the HOM antenna could cause quenching
- Replacement of the insulator of the HOM antenna with sapphire to optimize the thermal conductivity



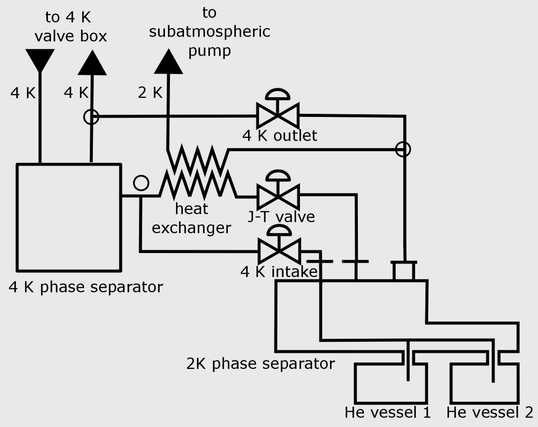


Based on: D. Kostin, "HOM Coupler Design Adjustment for CW operation of the 1.3 GHz 9-cell TESLA Type SRF Cavity"

Left: *HOM antenna with sapphire insulator (blue) for better thermal conductivity in order to damp the HOMs of c.w. usage. Design by Kyocera.*
Right: *Coupling of the F-part and the HOM antenna (both silver) into the cavity (light blue). F-part design by DESY.*

- Simulations are ongoing
- Additional copper wires as heat bridges will be installed after simulation

4K/2K Joule-Thomson Expansion

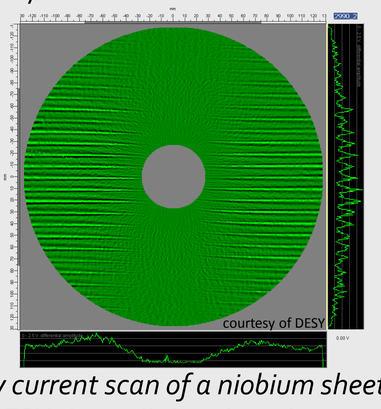


Preliminary diagram of the 4K/2K helium stage

- **ELBE-type:** Module did not contain a 2K helium supply
- **MESA-type:** Á integrated 2K stage will contain:
  - 4 K phase separator
  - 4K/2K heat exchanger
  - Joule Thomson valves
  - 2K phase separator
- **Pro/Con:**
  - 2K stage will be as close as possible to the He vessel
  - Microphonics are an issue

Quality Control of the Niobium Sheets

- Quality control of the 78 niobium sheets was made by an optical analysis and an eddy current scan at DESY.
- Optical analysis allows to see mechanical damage, eddy current scans can show invisible damages and impurities
- The results are:
  - 59% of the sheets were without complaints
  - 36% of the sheets had small complaints but are suitable
  - 5% had impurities and/or damage on both sides and are considered not to be used for building a cavity
- Further investigations of the defects at the 5% off-specification batch may be done.
- Scanning electron microscope measurements may help to identify the type of defect



Eddy current scan of a niobium sheet at DESY. A small signal can be seen at the coord. -5/70

Status of Manufacturing the Cryomodules

- Most components are ordered and delivered
- The niobium sheets to build the half cells are delivered and tested with eddy current scan.
- The half cell fabrication will start in October 2015
- The **cryomodules will be delivered in mid 2017**
- First test with electron beam at 2K will be done within the same year

Outlook and Acknowledgement

Within the next 2 years, the cavities and cryomodules will be built. A horizontal RF test of the cavities will be done mid to end 2016. Simulations of the thermal conductivity will be done until end of 2015. The detailed planning of the 4K/2K expansion will be done with consultation of DESY.

We would like to thank DESY SRF-staff for all their help, especially J. Iversen for the opportunity to measure the niobium sheets in no time.

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