FREIA Laboratory

Rocío Santiago Kern

on behalf of

The FREIA Division

8th of April 2014
Overview

• The FREIA Laboratory
• Overview of Activities
• Work for the ESS Accelerator
• Spoke Cavity Testing
• RF Power Station
• Containment Vessel
• Pumping Requirements
• Helium Liquefier
The FREIA Laboratory

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 HEP & NP (IFA),
solid-state electronics (Teknikum),
Ångström workshop and TSL

Funded by
KAWS,
Government,
Uppsala Univ.

vertical cryostat
3 bunkers with test stands
RF power sources
horizontal cryostat

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Overview of Activities

SRF Spoke Cavities & Linac

LHe and LN2 Distribution

Solid-state RF Amplifiers

ESS neutrino Super-beam

Neutron Generator

THz FEL

4th Generation Nucl. Power

R. Santiago Kern, 8th of April 2014

From Large-scale Vacuum Systems to Vacuum Metrology
Work for the ESS Accelerator

European Spallation Source (ESS)  
Lund, Sweden

Neutron Source  
Proton Kinetic Energy 2 GeV  
5 MW Average Power

Optimus

Frequency [MHz] | Total # of cavities | Total # of cryomodules
--- | --- | ---
352.21 | 26 | 13

1 spoke prototype 1 prototype cryomodule

will be tested at high power at FREIA
Spoke Cavity Testing

• To test the spoke cavity, three main subsystems are needed:

- RF power
- Containment Vessel
- Cryogenics

To avoid radiation in public areas:

- Spoke Cavity (superconducting)
- Bunker

Courtesy of P. Duthil
RF Power Station

2 independent systems to power the cavity

**ESS pre-series #1**
- 352 MHz, 400 kW pulsed
  - FREIA 2pc
  - ESS linac 28pc
- FREIA design based on TH595 (most competitive solution)

**Solid-state R&D station**
- 352 MHz, 400 kW pulsed
  - FREIA 1pc
- Commercial design
  - 1 kW transistors
  - 8 kW modules
  - coaxial combiner

**Plus**
- Testing 1 kW transistors → Create a Solid-state RF power source
  \[ N \times 1 \text{ kW} = N \text{ kW} ; N=2, 4, 8...400 \]
- Studying power combination possibilities
Helium Liquefier

- Manufactured by Linde Kryotechnik AG
- **Over 140 l/h** at 4.5K
- 2000 l LHe dewar
- 100 m³ gasbag
- HNOSS connected in **closed loop**
Containment Vessel

- **HNOSS**: Horizontal Nugget for Operation of Superconducting Systems
  - Design by *Accelerator and Cryogenic Systems*, France
  - Manufactured by *Cryo Diffusion*, France
- **Isolates** cavity from
  - Room temperature by thermal conduction (vacuum) and thermal radiation (thermal shield)
  - Earth’s magnetic field (magnetic shield)
- **Distributes** cryogens (LN$_2$ and LHe)
- Contains piping and valves to produce and store 4K and 2K LHe
- **HNOSS characteristics:**
  - **Inner length** 3240 mm
  - **Inner diameter** 1300 mm
  - Houses up to two cavities + ancillaries
  - Reasonable simple access to and replacement of the cavities.
  - Many ports (access, instrumentation, pumping, safety valves, viewports, etc)
Pumping Requirements

**Insulation Vacuum**

- High degassing rates (MLI)
- Insulation Vacuum: $10^{-4}$-$10^{-5}$ mbar
  (with cryopumping $10^{-6}$ mbar)

- **Temperature variation: 4K-2K**
  - T Variation $\rightarrow$ P variation
  - **Gas Helium** flow (not air!)
  - Requires big capacity
    (over 7000 m$^3$/h at 10 mbar)

**Beam Vacuum:** $10^{-10}$-$10^{-11}$ mbar $\rightarrow$ **Ion/Getter pump**
Thank you for your attention!