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FREIA Laboratory

Rocío Santiago Kern

On behalf of the FREIA team

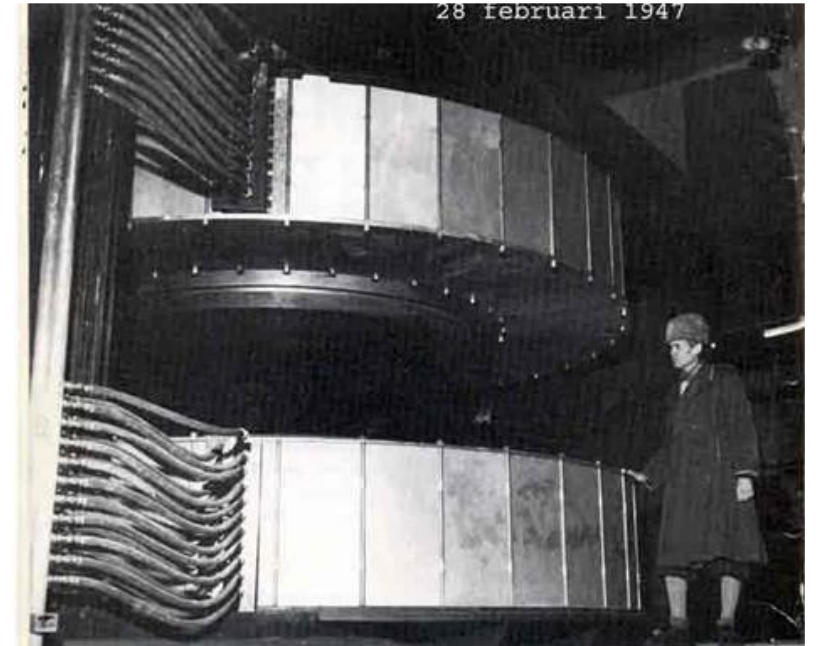
Outline

- Uppsala's Accelerator History
- The "idea" of FREIA
- FREIA
- Infrastructure
- Cryostats
 - Horizontal HNOSS
 - Vertical Gersemi
 - Portable CoW
- Main Projects
- Other projects



Uppsala's Accelerator History

- 1940's: The(odore) Svedberg proposes to build a cyclotron
- Gustaf Werner synchro-cyclotron (1947 - 2016)
 - nuclear physics & oncology
- CELSIUS ring (1984 - 2005)
 - nuclear & particle physics
- CTF3/CLIC (since 2005)
- FLASH/XFEL (since 2008)
- Skandion clinic (est. 2015)



The "Idea" of FREIA

- Once it was decided that ESS would be built in Sweden
- Need for a facility to test ESS superconducting equipment
 - Other facilities available "part time" due to their own projects
 - Reduce logistics by having a facility in Sweden



Work Packages Short descriptions

- **WP6: Normal Conducting Linac (INFN, S. Gammino)**
 - This Work Package will be responsible for the design of the elements of the front-end up to the warm-to-cold transition (proton source, beam transport system, radio frequency quadrupole and drift tube linacs).
- **WP7: High-Energy Beam Transport, Normal Conducting Magnets and Power Supplies (ISA, S. Pape-Møller)**
 - This Work package is concerned with the design of a High Energy Beam Transport system. And it will also define standards for the normal conducting magnets, the corresponding power supplies, beam dumps and collimators for the whole Linac.
- **WP8: Radio Frequency Systems (Uppsala U, R. Ruber)**
 - This Work Package addresses the design and development of the RF power generation at 352 MHz and 704 MHz, its control and its distribution system for the ESS Linac.



Extended Writing Group



Romuald Duperrier (30 years ago)



Steve Peggs



Cristina Oyon



Josu Eguia



Guillaume Devanz

Work Package (work areas)

1. Management Coordination – ESS (Mats Lindroos)
2. Accelerator Science – ESS (Steve Peggs)
3. Infrastructure Services – Tekniker, Bilbao (Josu Eguia)
4. SCRF Spoke cavities – IPN, Orsay (Sebastien Bousson)
5. SCRF Elliptical cavities – CEA, Saclay (Guillaume Devanz)
6. Front End and NC linac – INFN, Catania (Santo Gammino)
7. Beam transport, NC magnets and Power Supplies – Århus University (Søren Pape-Møller)
8. RF Systems – Uppsala university (Roger Ruber)



Test stand strategy

- 704 MHz test stand for SC elliptical cavities and a cryomodule
 - Possible sites CERN, CEA, Uppsala and DESY (after XFEL)
 - Study and costing in progress for CERN, CEA and Uppsala
 - Focus in Uppsala on RF source, control and distribution
- 352 MHz test stand for SC spoke cavities and cryomodules
 - One test stand at CEA
 - One test stand under construction at IPNO in Paris
- 352 MHz test stand for NC structures
- Test area for Ion Source development in Catania



Roger Ruber



Søren Pape Møller



Santo Gammino

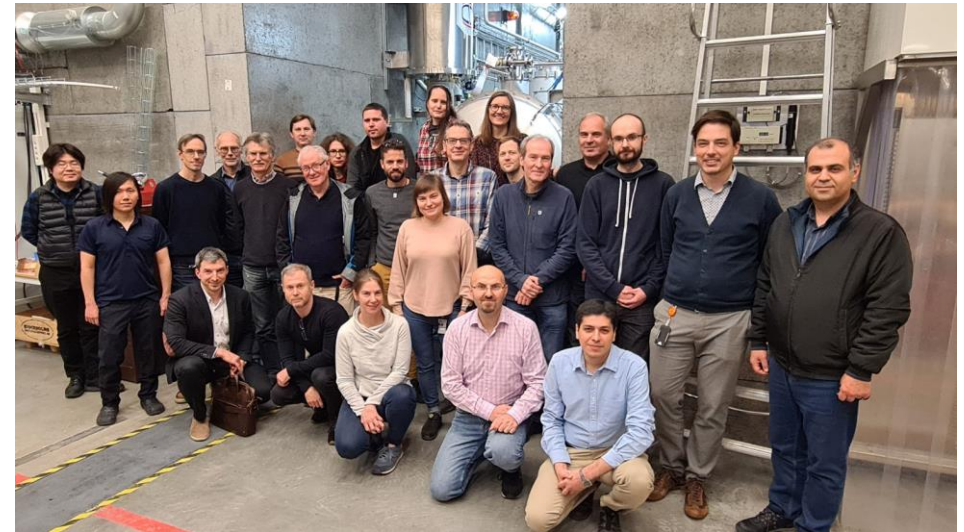


Sebastien Bousson



FREIA Facility for REsearch Instrumentation and Accelerator Development

Funded by KAW, UU and Swedish government, inaugurated in 2013



About 25 Researchers, engineers and students



FREIA Infrastructure

Cryo system:

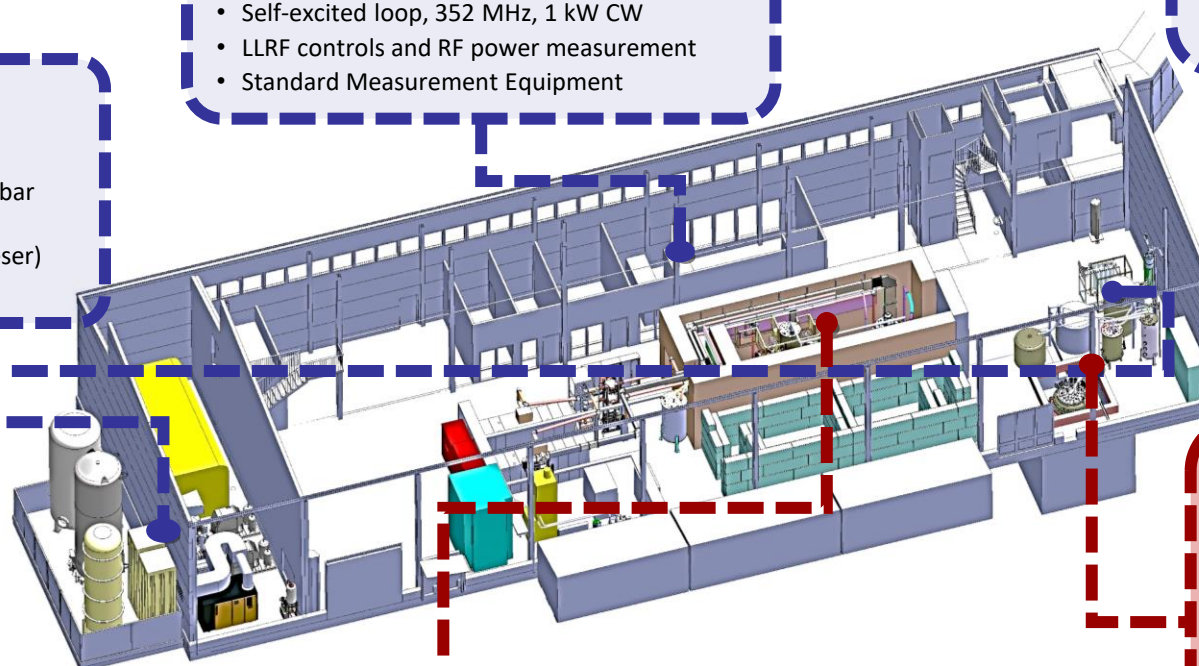
- 2000 L dewar (+ 1000 L extra dewar)
- 140 L/h liquefier
- 19.2 m³ high pressure storage at 200 bar
- 132 kW recovery compressors
- 100 m³/h circulating compressor (Kaeser)
- 100 m³ gas bag

Control Room

- The overall control system is based on EPICS
- Self-excited loop, 352 MHz, 1 kW CW
- LLRF controls and RF power measurement
- Standard Measurement Equipment

The FREIA hall

- 1000 m² large, 10 m high
- Has a 6.3-ton movable crane and other mechanical equipment
- Small workshops for mechanics and electronics and 50 m² control room
- Office space for ~20 people



Gersemi - Vertical Cryostat

System for testing superconducting devices such as accelerating cavities and magnets

- Dimensions: 1.1 m diameter, 2.8 m height
- Range of operation: 1.8 to 4.5 K, 16 to 1250 mbar
- Pressure stability at 16 mbar: +/- 0.1 mbar
- Cooling power at 1.8 K: 90 W
- Maximum allowed weight up to 5 ton
- 2 x 2 kA power converters
- 1 kW RF power in a self-excited loop



HNOSS- Horizontal Cryostat

System for testing superconducting cavities.

- Inner measures 3.2 m length and 1.19 m diameter
- Range of operation: 1.8 to 4.5 K, 16 to 1250 mbar
- Internal warm magnetic shielding: mu-metal, 1 mm
- Pressure stability at 16 mbar: +/- 0.1 mbar
- Cooling power at 1.8 K: 90 W

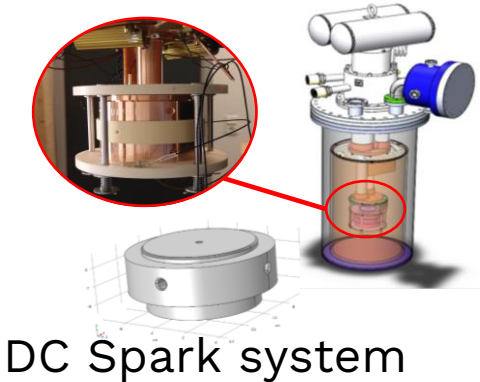
Uppsala

Stockholm

FREIA Infrastructure



Helium Liquefier



DC Spark system



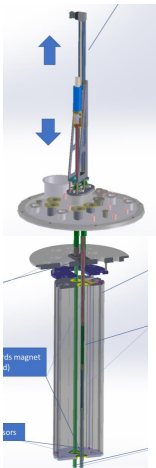
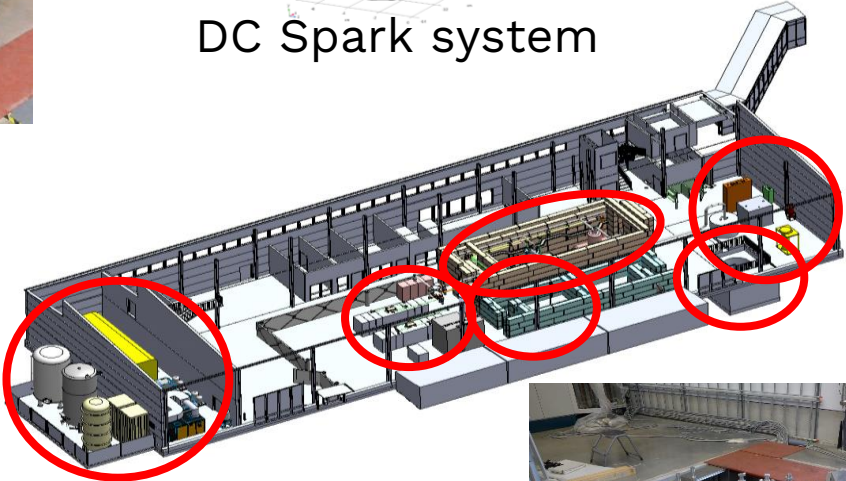
Horizontal Cryostat
HNOSS



Vertical Cryostat
Gersemi

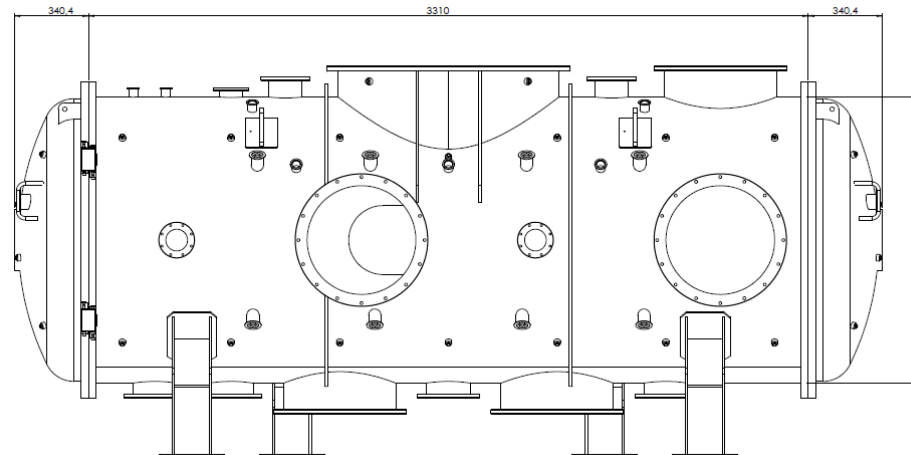


Power Amplifiers
RF Distribution System



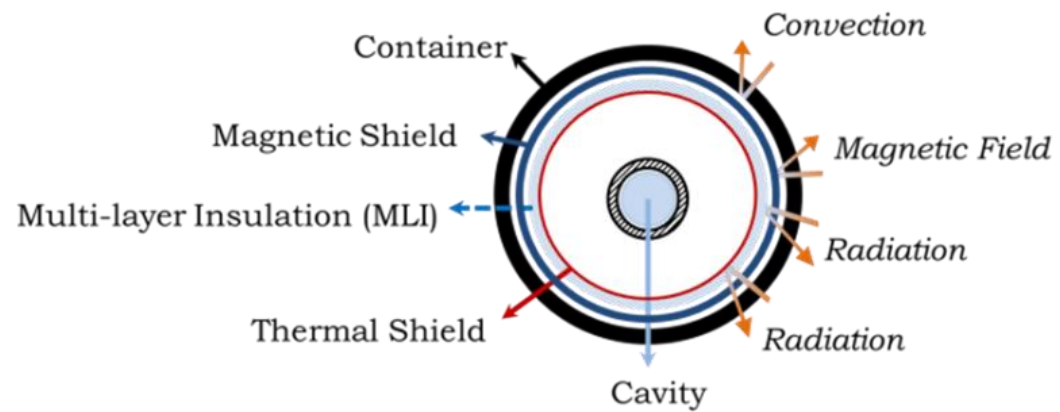
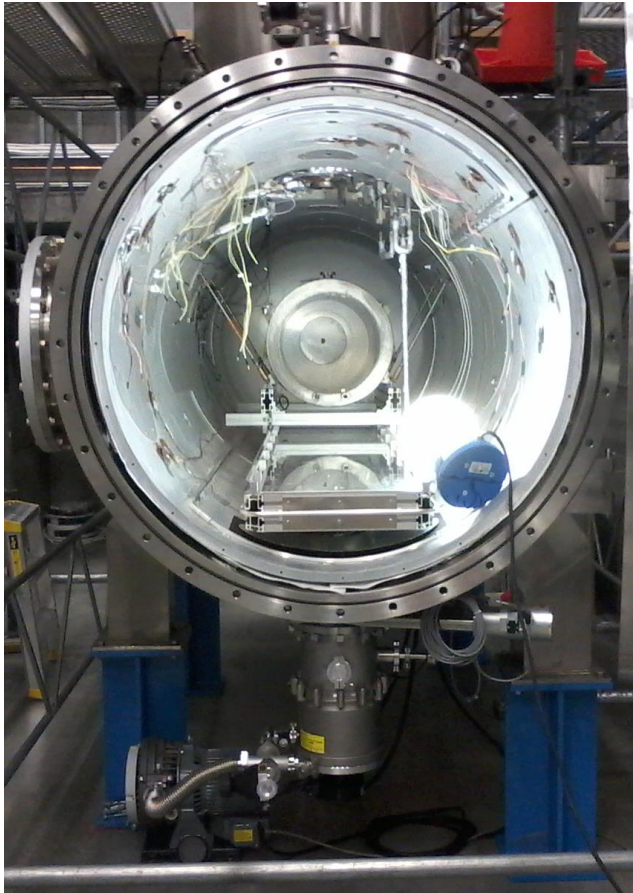
HNOSS (horizontal cryostat)

- For testing of superconducting cavities testing equipped with Helium tank
 - Alone, and/or
 - With fundamental power coupler, and/or
 - Cold tuning system
- Can accommodate up to 3 cavities
- Has two parts
 - Valvebox: contains all the valves, tanks and most of the piping
 - The cryostat itself: houses the cavities and the table (or tie-rods)



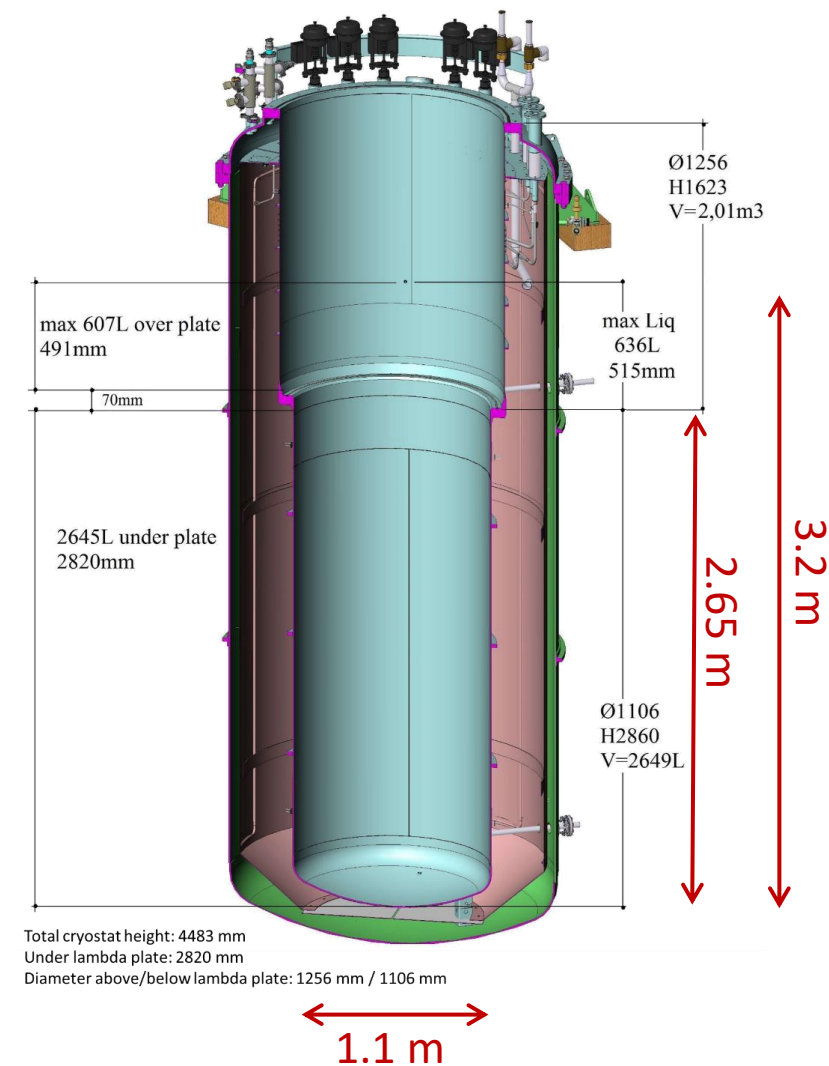
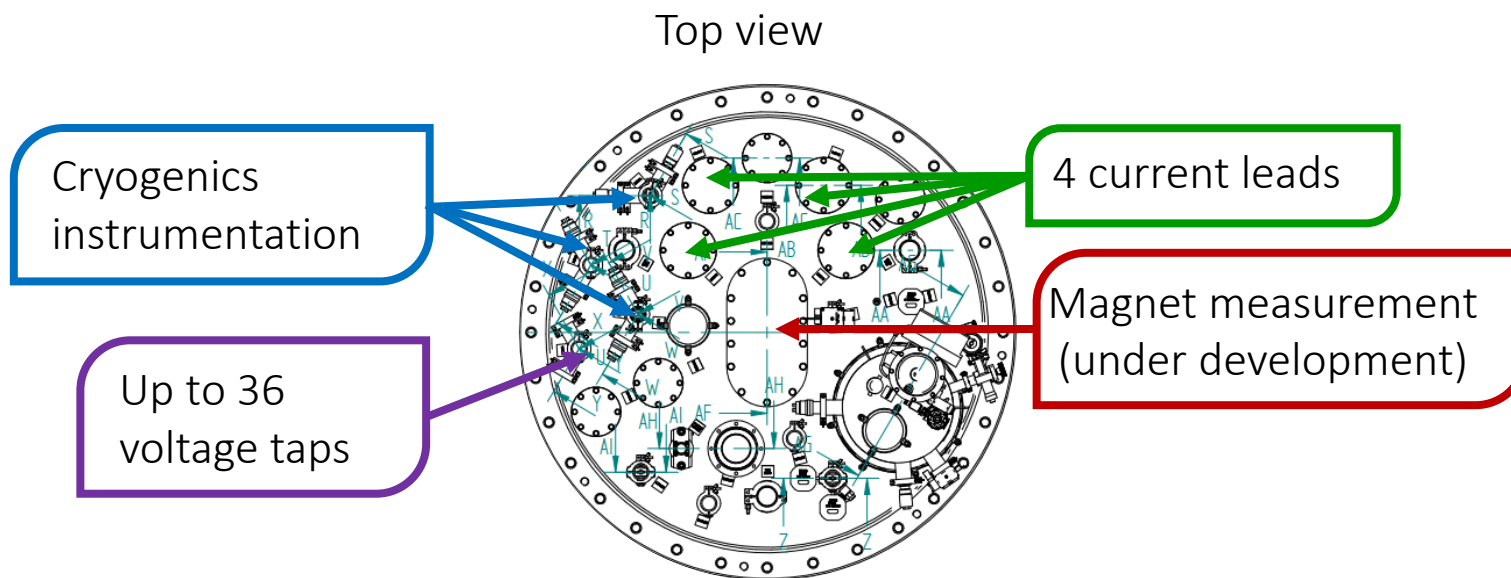
Total volume ca. 7 m³

HNOSS (horizontal cryostat)



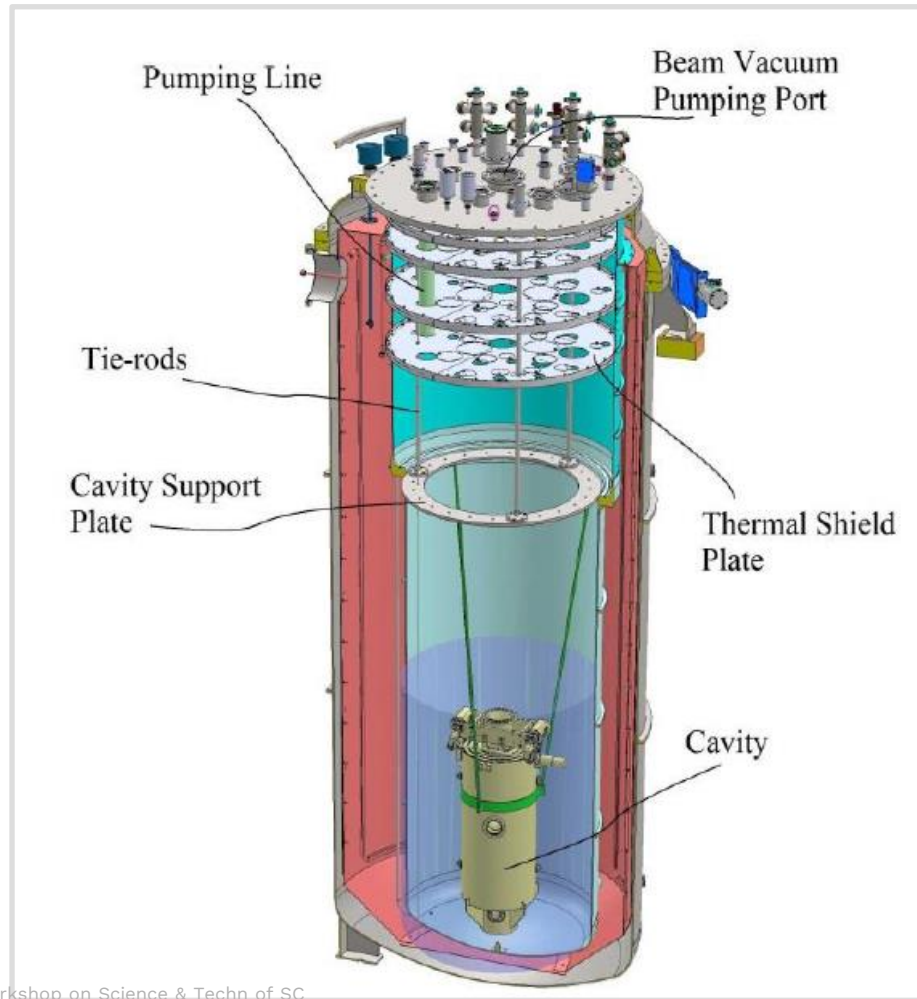
Gersemi (vertical cryostat)

- Two inserts
 - For cavity testing (without lambda plate)
 - For magnet testing (with lambda plate)
- Magnet insert
 - Superconducting magnets at temperatures between 4.2 K and 1.9 K, at atmospheric pressure
 - Up to 350 kJ



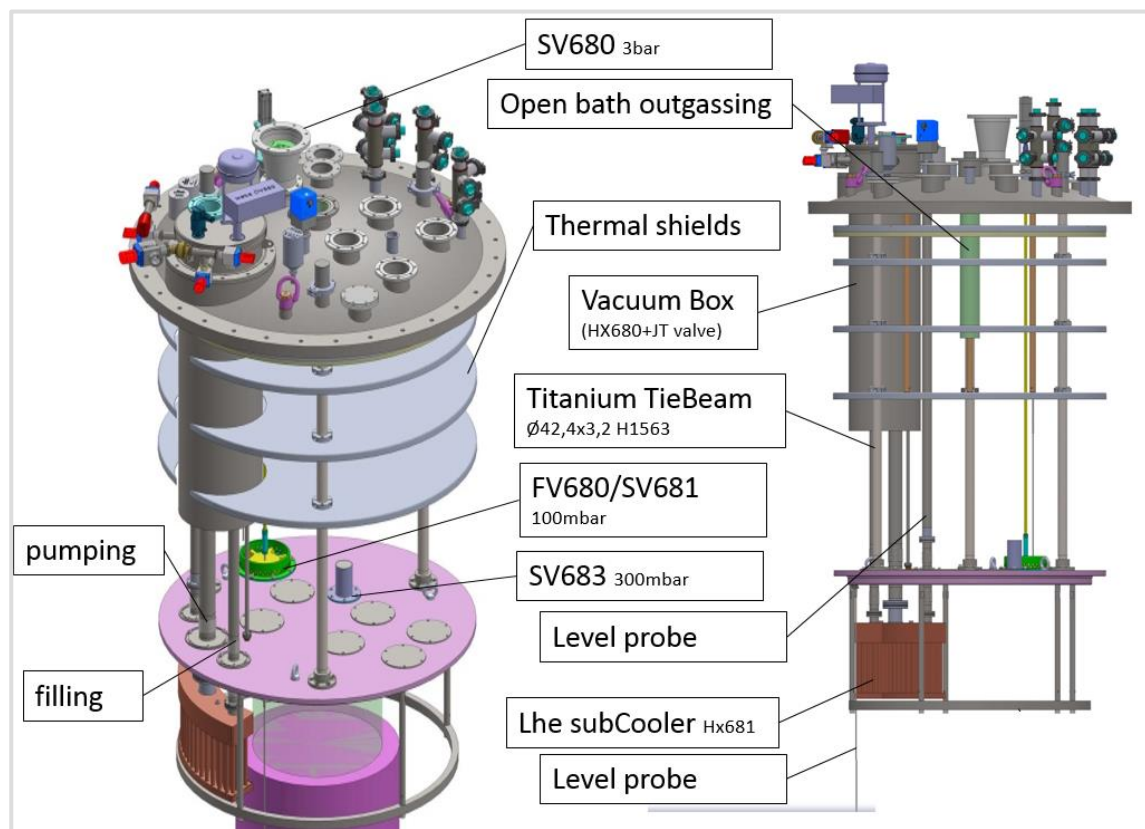
Gersemi (vertical cryostat)

Cavity Insert



Gersemi (vertical cryostat)

Magnet Insert

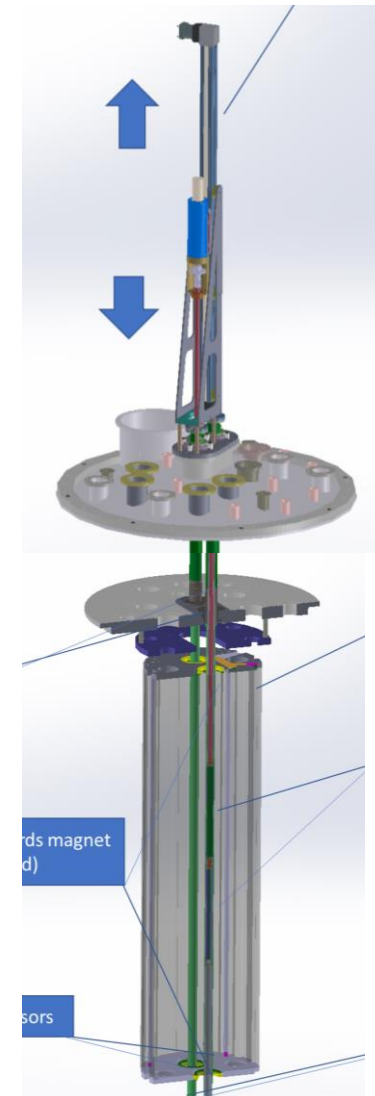
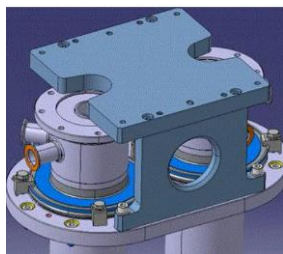


Gersemi (vertical cryostat)

Anticryostat for Magnet Insert

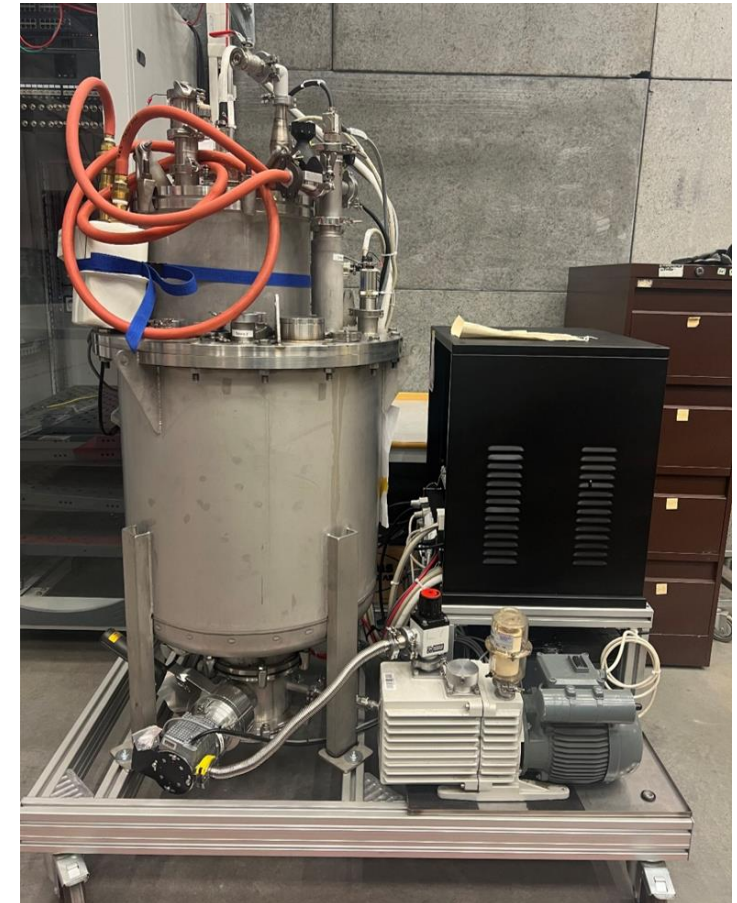
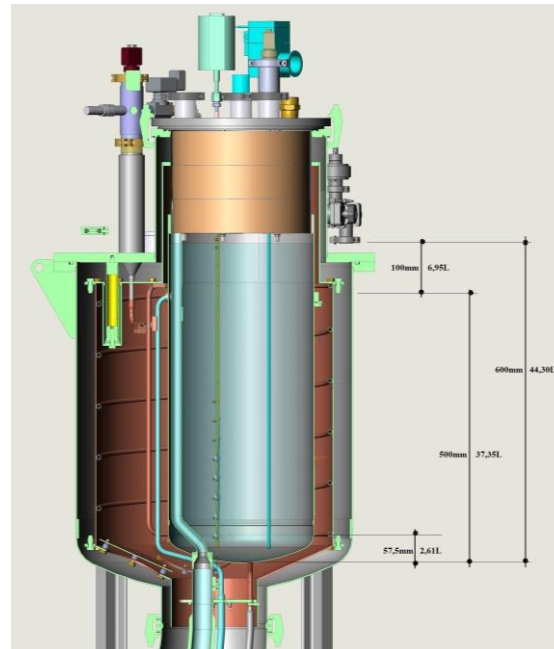
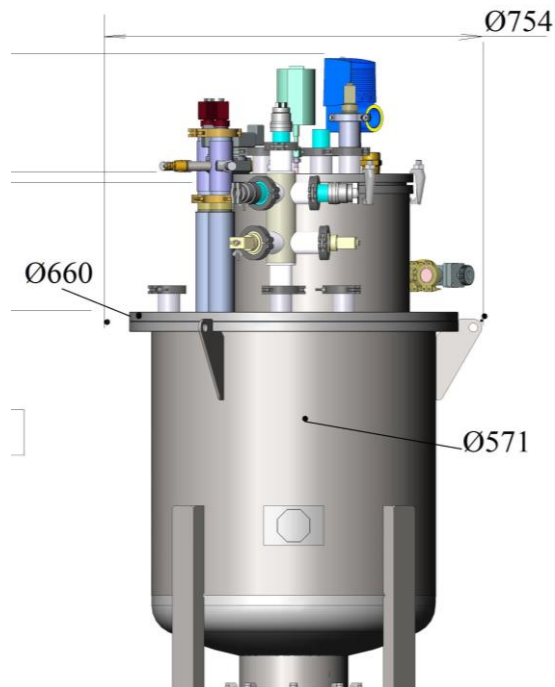


- Done in collaboration with CERN (KM5676/TE/HL-LHC)
 - Finalized July 2025
- For magnetic field measurements
 - at room temperature and pressure
 - At different locations thanks to a rotating coil
- Main characteristics:
 - Magnet's max aperture: 50 mm
 - Length for rotating coils: 500 mm
 - Max magnet length: 2.2 m (max displacement 2.3 m from lambda plate)



CoW (Cryostat on Wheels)

- A portable Cryostat
- Used for testing of small super-conducting devices
- Cryogens are LHe at 4.2 K or LN₂ environments
- Top flange can be modified



Main Projects

- From 2015 to 2024 for ESS
 - Test of a couple of double-spoke cavities with and without fundamenta power coupler (FPC)
 - Test of a high-Beta elliptical cavity with FPC
 - Test of 14 double-spoke cryomodules (2 cavities each)



EUROPEAN
SPALLATION
SOURCE



Romea (double spoke) with FPC



High-Beta Elliptical with FPC



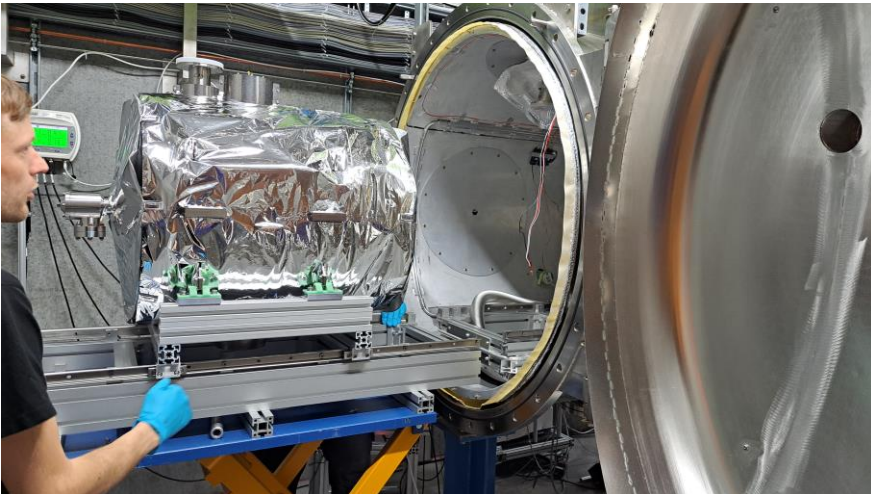
Prototyppe double spoke cryomodule



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Main Projects

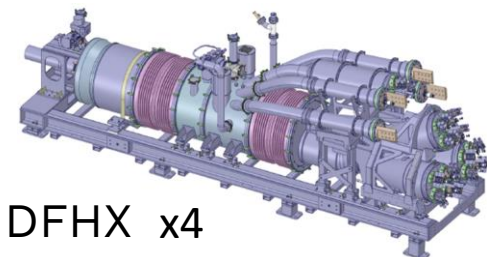
- Since 2024 for SCK-CEN (MYRRHA project, MYRRHA-Phase I: Minerva accelerator)
- Test of 53 single spoke cavities (352.2 MHz, CW)
- Test of 26 (tbc) single-spoke cryomodules (2 cavities each)



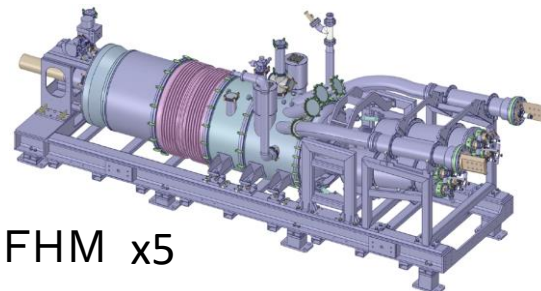
OTHER PROJECTS

Cold Boxes

- Cryostats for the cold powering of magnets, part of the upgrade of the HL-LHC
- Project QC and part of manufacturing
- Status: completed December 2024



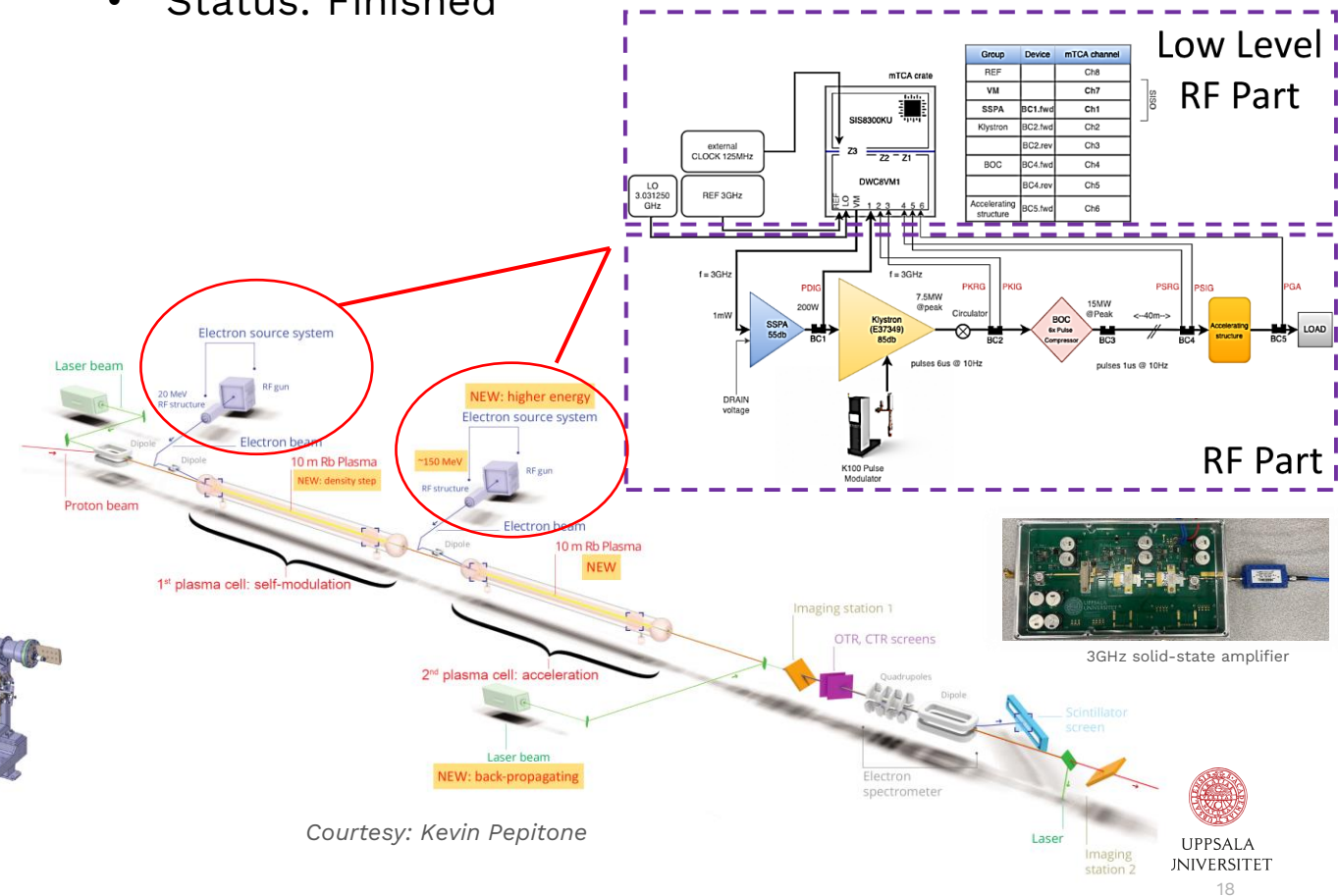
DFHX x4



DFHM x5

AWAKE

- Develop and deliver RF systems for the two electron injectors
- Status: Finished

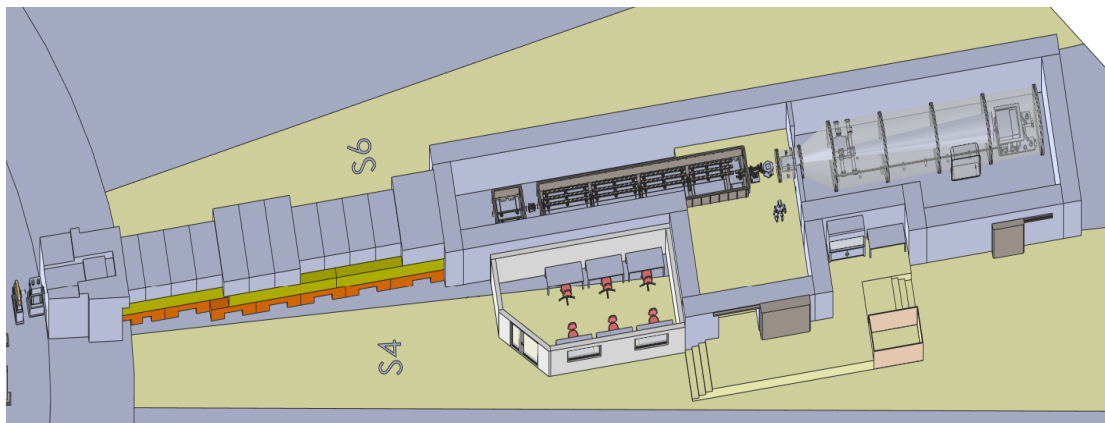


Courtesy: Kevin Pepitone

OTHER PROJECTS

SAGA (at ESS)

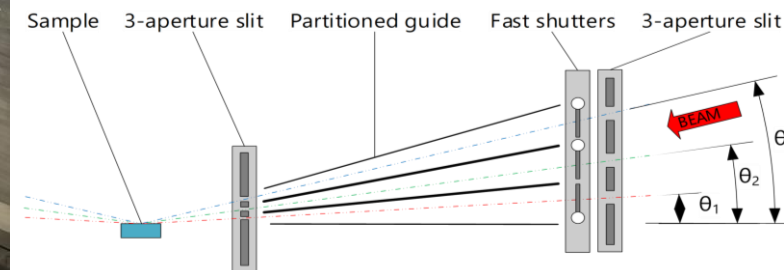
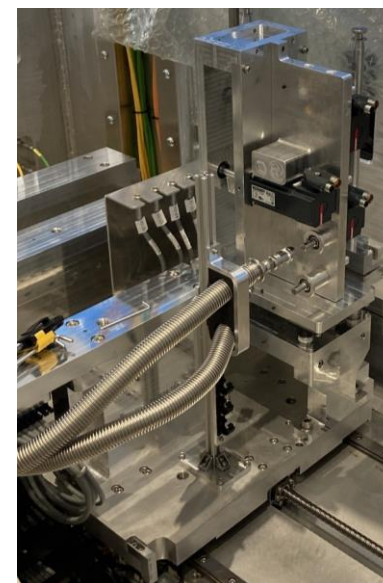
- Proposal for a Surface Scattering beamline
- Surface Analysis using Grazing Angle neutron scattering
- Status: Ongoing



Courtesy: Marek Jacewitz

Freia Instrument (at ESS)

- Reflectometer for soft condensed matter and lifesciences
- Instrument upgrade by building a fast shutter that will selectively absorb neutrons within three possible collimation trajectories
- Status: Installed at ESS, waiting for SATs ongoing

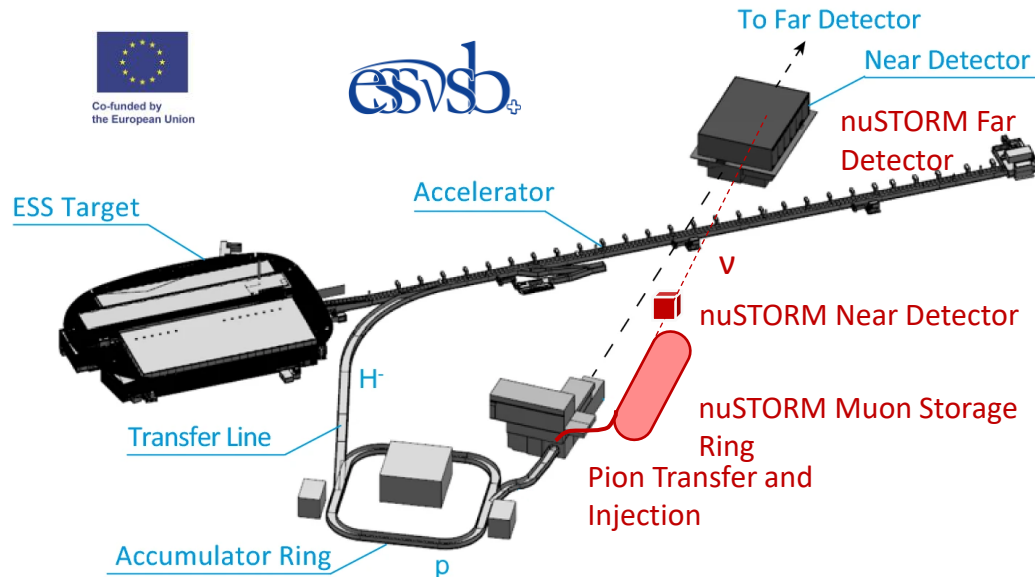


Courtesy: Marek Jacewitz

OTHER PROJECTS

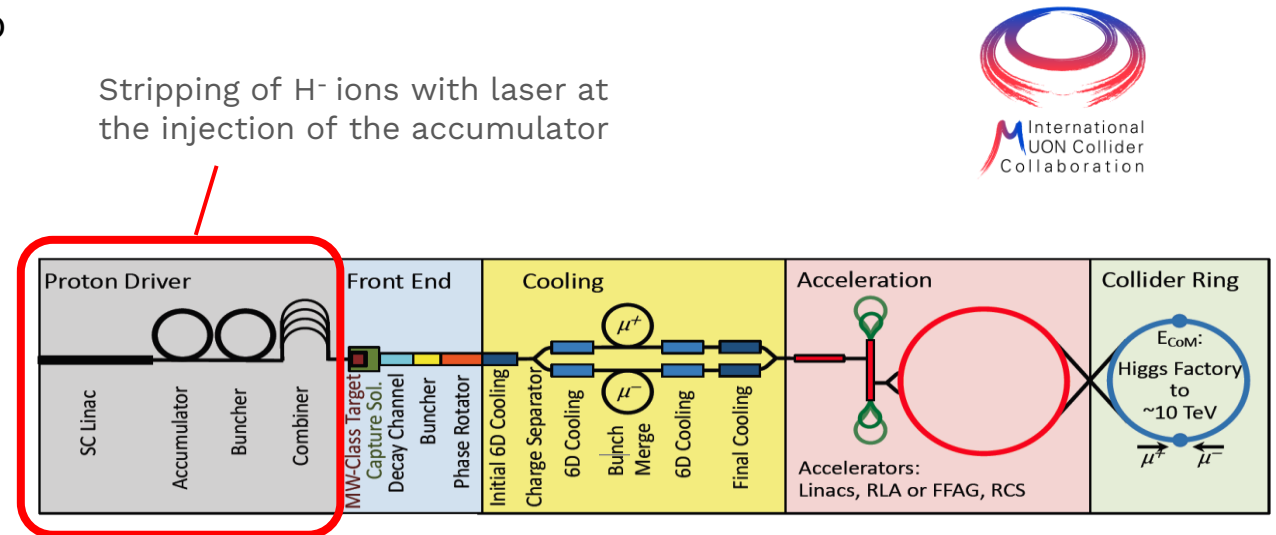
ESSnuSB and ESSnuSB+

- Project investigating Charge-Parity Violation in the leptonic sector (matter-antimatter asymmetry)
- ESSnuSB: Designed two transfer lines and an accumulator ring
- ESSnuSB+: Designing a muon storage ring for neutrino production (nuSTORM)
- Status: Ongoing



Muon Collider

- Proton driver used to produce the muons
- Status: Ongoing



Courtesy: Natalia Milas

More information by Anatoliy Opanasenko

Thank you

