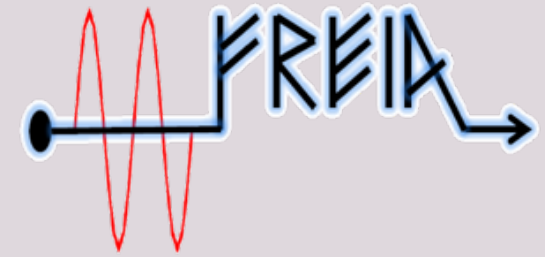




UPPSALA  
UNIVERSITET



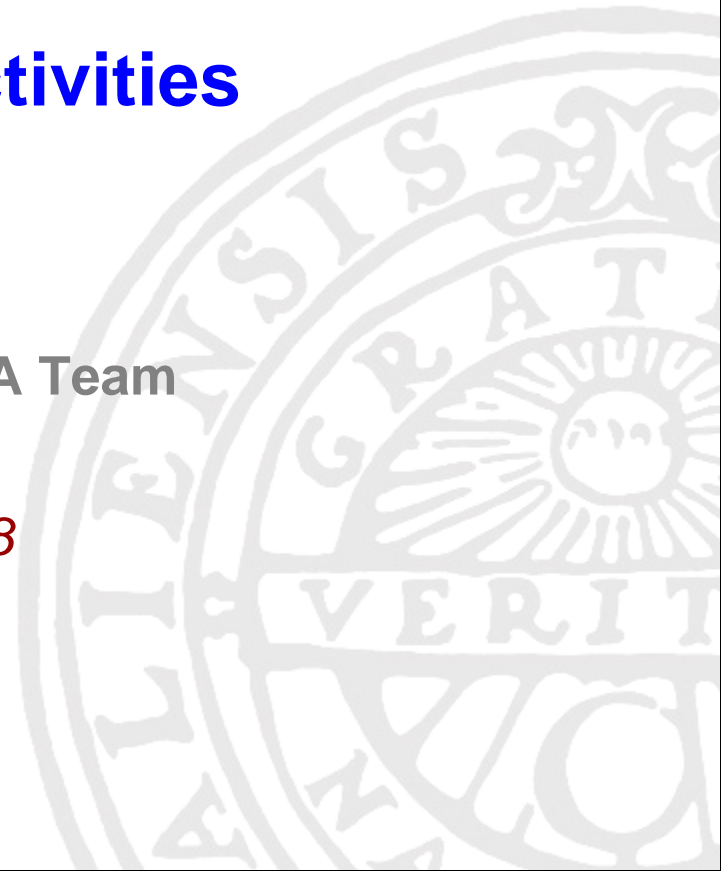
# FREIA Laboratory

Facility for Research Instrumentation and Accelerator Development

## Overview of R&D Activities

Roger Ruber for the FREIA Team

*CERN, 20 June 2018*



## 1477: Uppsala University, oldest in Scandinavia

- 25'000 students, 7'000 staff
- historical profiles: Linné, Rudbeck, Celsius, Ångström, Svedberg

## 1940's: The(odore) Svedberg builds a cyclotron

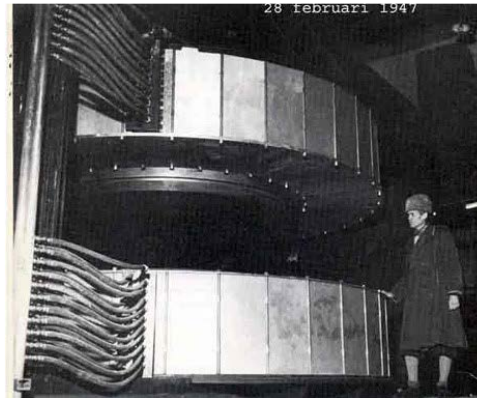
- Gustaf Werner synchro-cyclotron (1947 - 2016)
  - nuclear physics & oncology
- CELSIUS ring (1984 - 2005)
  - nuclear & particle physics

## 2000's: External projects

- CTF3/CLIC (since 2005)
- FLASH/XFEL (since 2006)
- ESS (since 2009)

## 2010's: New ventures

- FREIA laboratory (est. 2011)
- Skandion clinic (est. 2015)



## Facility for Research Instrumentation and Accelerator Development

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

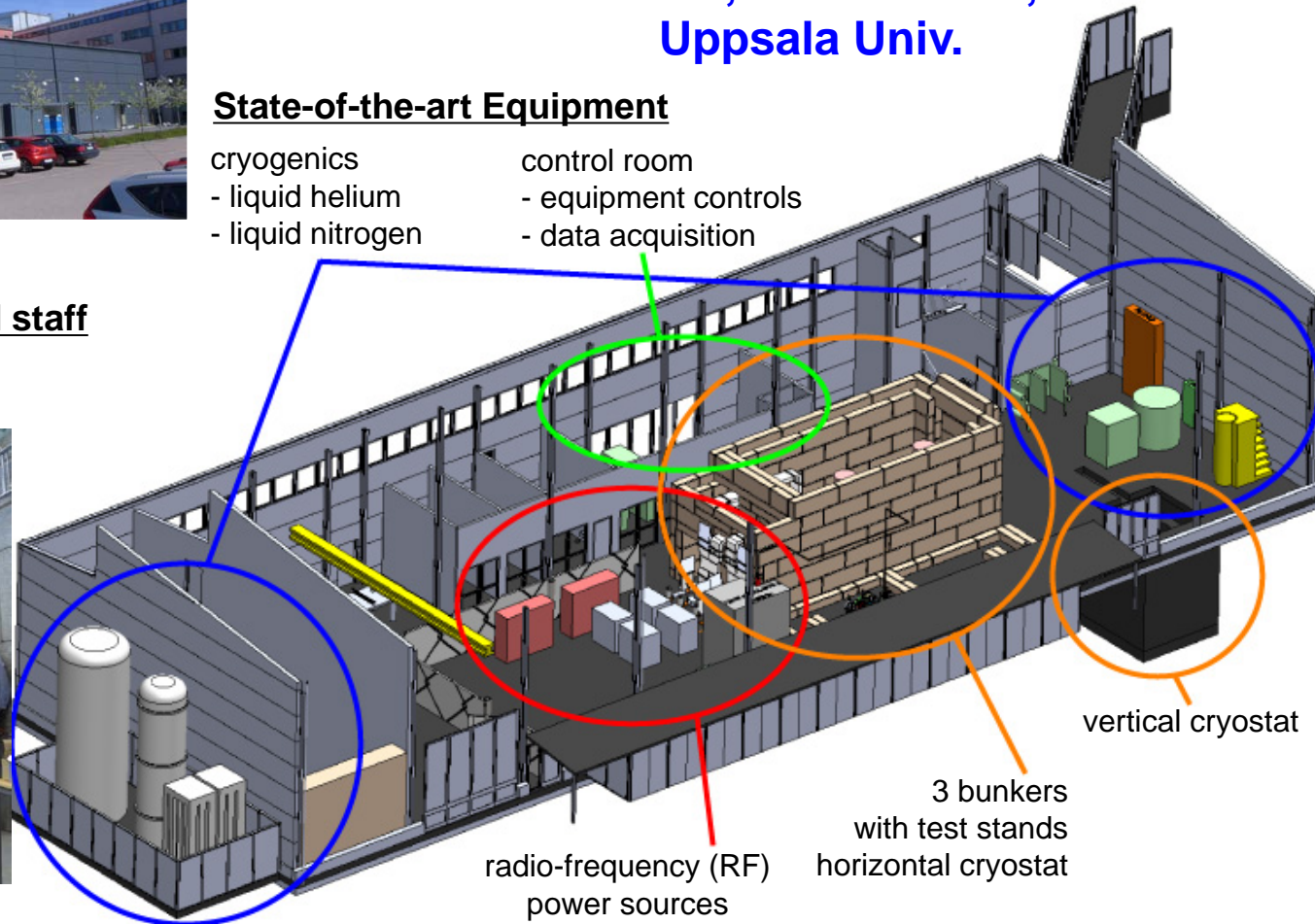


### State-of-the-art Equipment

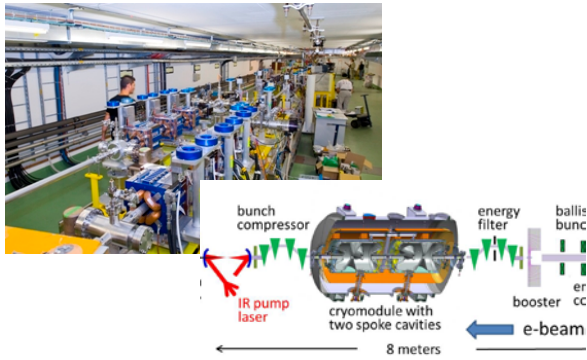
- |                   |                      |
|-------------------|----------------------|
| cryogenics        | control room         |
| - liquid helium   | - equipment controls |
| - liquid nitrogen | - data acquisition   |

### Competent and motivated staff

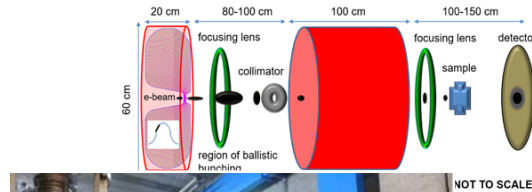
collaboration of physics (IFA)  
and engineering (Teknikum).



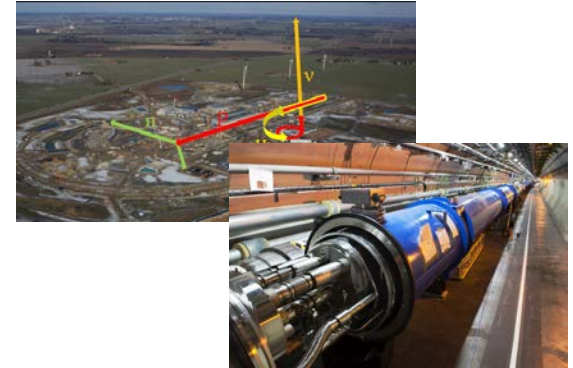
## Ultra Bright Electron Beams



## Advanced Instrumentation



## High Intensity Proton Beams



## SC Cavities & Magnets



## Cryogenics



## RF Generation & Control





- **Helium liquefaction**

- 150 l/h at 4.5K (LN2 pre-cooling)
- 2000 l LHe dewar/buffer, 3+1 outlets
- cryostats connected in closed loop

- **Gas recovery**

- 100 m<sup>3</sup> gasbag
- 3x 25 m<sup>3</sup>/h compressor
- 10 m<sup>3</sup> 200 bar storage

- **2K Pumping**

- ~3.2 g/s at 10 mbar
- ~4.3 g/s at 15 mbar
- 110(90)W at 2.0(1.8)K

- **Liquid nitrogen**

- 20 m<sup>3</sup> LN2 tank



## "HNOSS" Horizontal Cryostat

- test of SRF cavities
  - 3240 x  $\varnothing$ 1200mm inner volume
  - up to two cavities simultaneously,
  - each equipped with helium tank,
- low or high power RF testing
  - power coupler (top, bottom, side)
  - (cold) tuning system
- operation range 1.8 to 4.5K.



## "Gersemi" Vertical Cryostat

- test of SC magnets or SRF cavities
  - 3.2m x  $\varnothing$ 1.1m total volume
  - 2.65m x  $\varnothing$ 1.1m below lambda plate
  - design includes joint for lambda plate
- operation modes (1.8 to 4.5 K)
  - vacuum
  - saturated bath
  - pressurized bath (20K heat exchanger)



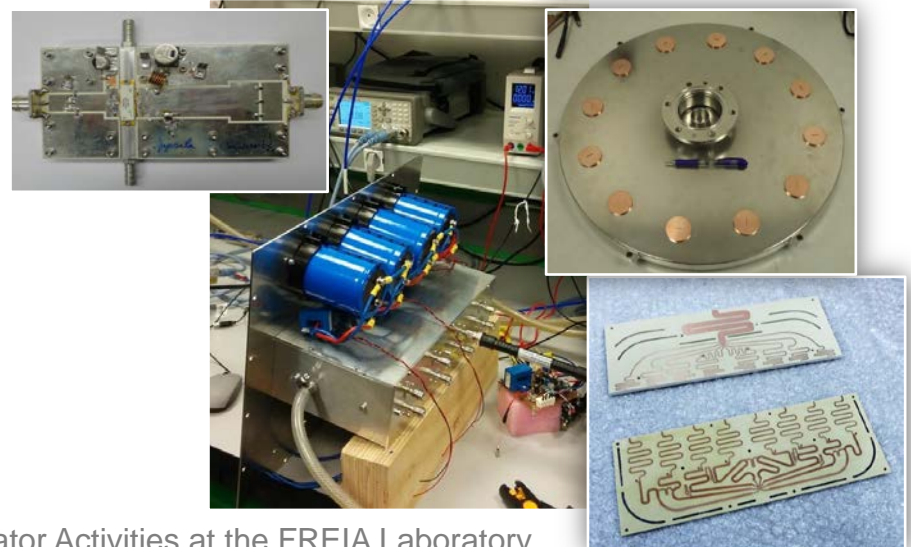
## Vacuum Tube

- 352 Dual-tetrode
  - 2x 400 kW, 3.5 ms, 14-28 Hz
- 352 / 400 MHz
  - 50 kW CW (loan from CERN)
- 704 MHz Klystron
  - 1.1 MW, 3 ms, 14 Hz (loan from ESS)



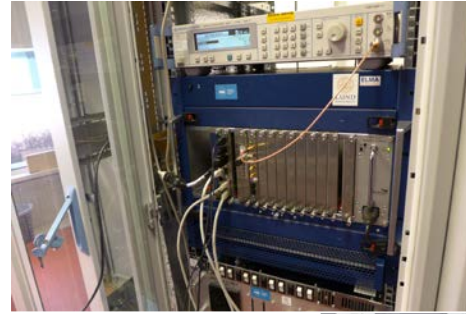
## Solid State R&D

- single transistor
  - 1250 W and 70% efficiency
- 8 transistor demonstrator
  - 10 kW with ~70% efficiency
- compact low-loss combiners
  - 200 kW 12-to-1 cavity combiner
  - 10 kW 8-to-1 planar gysel combiner
  - 20 kW 2-to-1 planar gysel combiner



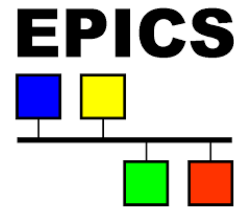
- **Uppsala LLRF**

- Self excited loop 352/704 MHz
  - pulsed or CW operation
- Nat. Instr. PXI and LabVIEW
  - digital phase control for SEL
  - extended RF measurements



- **Lund Univ./ESS LLRF**

- $\mu$ TCA includes timing system
- external signal generators



- **Controls and Safety Interlock**

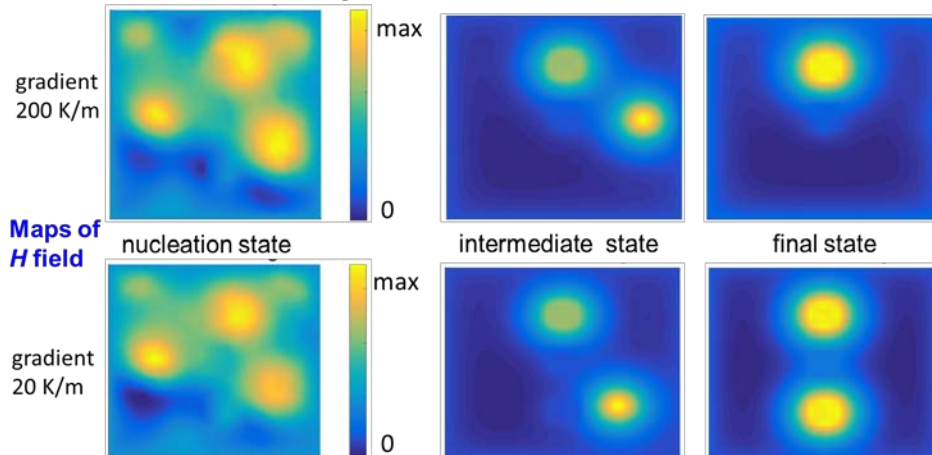
- Siemens PLC, NI cRIO
- EPICS interface with data archiver
- connecting different sub-systems:  
cryogenics, cryostats, ...





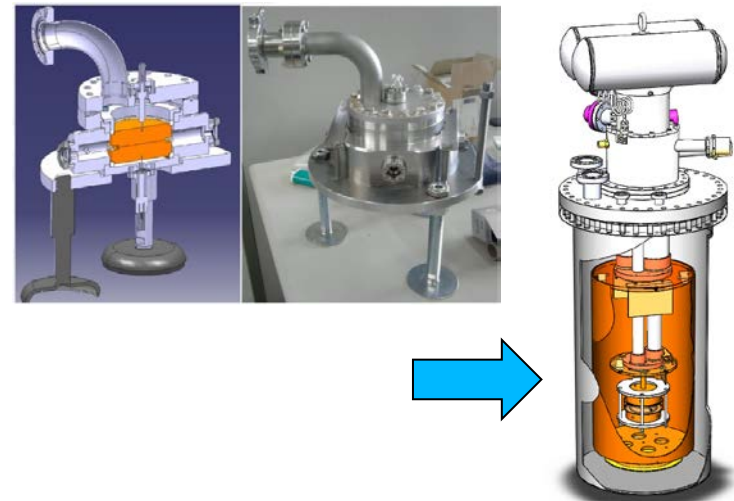
## Time-dependent GL Model

- Impact of spatial gradients on Q0 upon cooldown
  - trapped ambient magnetic field leads to the residual resistance
- developing a simulation environment based on the first-principle model to study different scenarios of cooldown
  - time-dependent Ginzburg-Landau
  - supports that the flux expulsion is temperature gradient dependent



## Cold DCspark

- field emission and BDR as a function of temperature
- complement to RF tests
  - allows in depth studies of the fundamental physics of high-fields (e.g. material and surface science)
  - possibility to find new and potentially important connections between the high-gradient NC and SC fields



## Uppsala University & FREIA Laboratory actively supporting accelerator and instrumentation R&D

