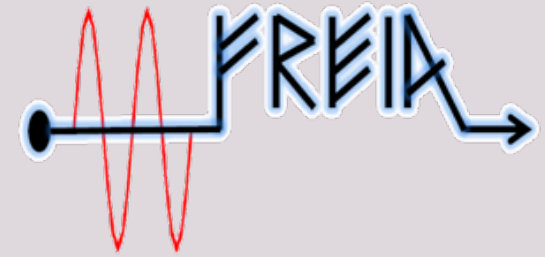




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FREIA Laboratory

Facility for Research Instrumentation and Accelerator Development

Status of the Uppsala University HL-LHC Contribution

Tord Ekelof for the FREIA Laboratory Team

CERN, 15 October 2018



Facility for Research Instrumentation and Accelerator Development

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

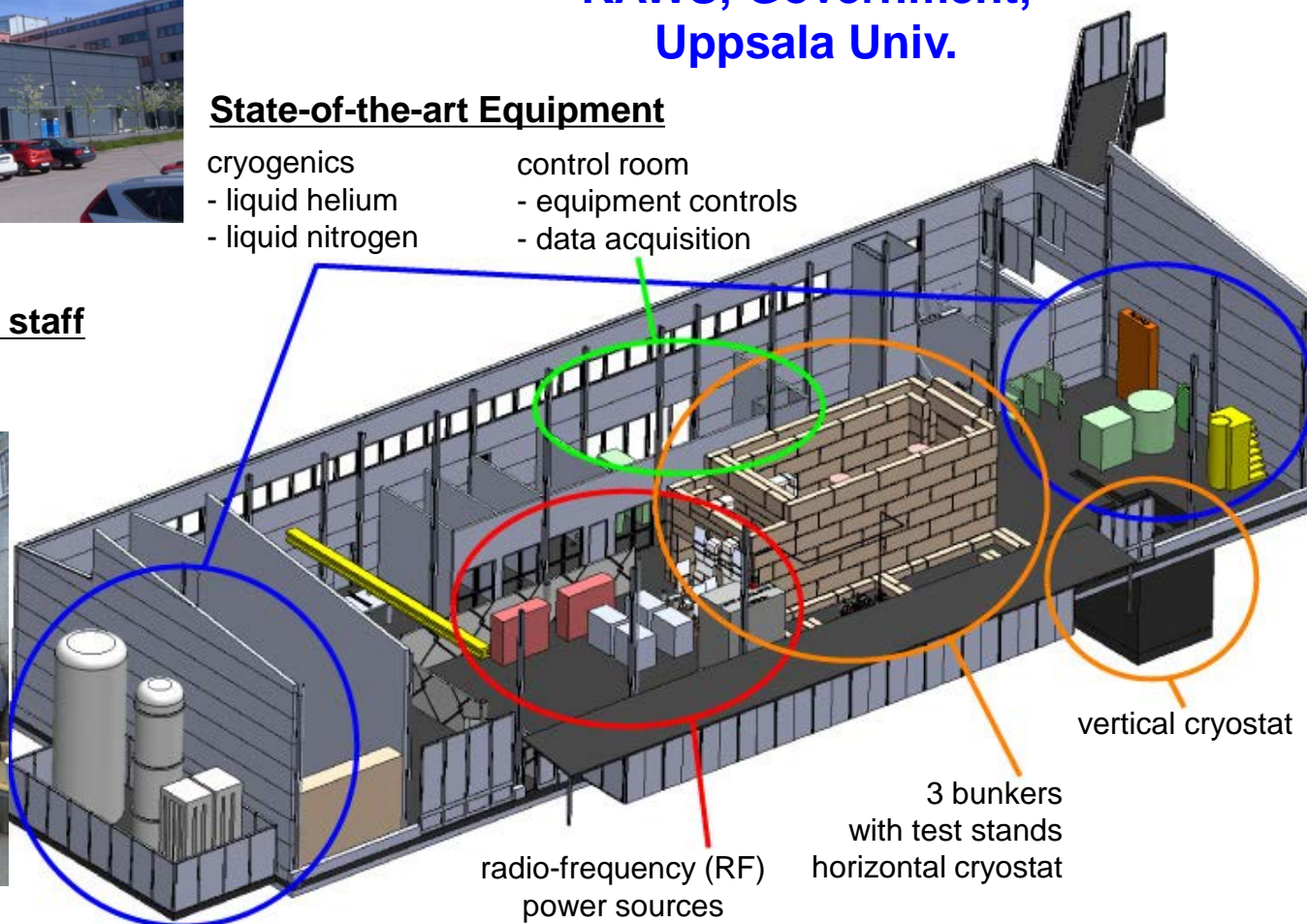


State-of-the-art Equipment

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

Competent and motivated staff

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



- **Hélène single spoke cavity (IPNO)**

- antenna, low power
- self-excited loop (SEL)
- RF calibration procedures



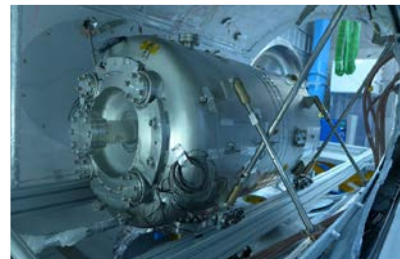
- **Germaine double spoke (IPNO)**

- antenna and cold tuner, low power
- cryogenics: cooling, heat load
- LLRF, SEL
- Q_0 , gradient, microphonics



- **Romea cavity package (IPNO)**

- power coupler and tuner, nominal gradient
- Q_0 and gradient, microphonics, fill time, Lorentz force detuning (LFD)
- tuner operation



- **RF Station 352 MHz (2x)**

- acceptance and functional test
 - including till now RF distribution components
- soak test
- pulsed and CW operation on cavity

- **RF Station 704 MHz**

- acceptance & operation of modulator

- **High- β elliptical cavity package (CEA)**

- power coupler, tuner
- Q_0 and gradient, microphonics, fill time, LFD
- LLRF/tuner operation



- **ESS Cryomodules**

- prototype, arrived August 2018

“HNOSS” Horizontal Cryostat

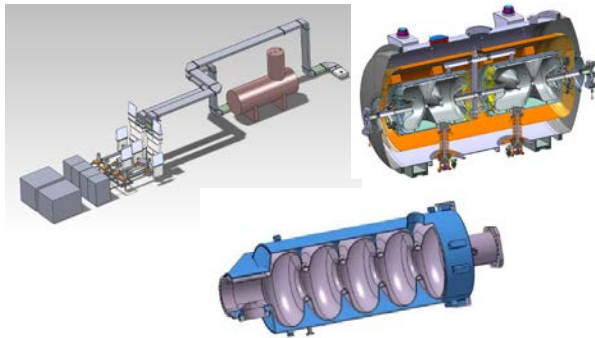
HNOSS = Horizontal Nugget for Operation of Superconducting Systems

- Test of superconducting cavities/devices
 - 3240 x \varnothing 1200mm inner volume
 - up to two cavities simultaneously,
 - each equipped with helium tank,
- Low or High power RF testing
 - fundamental power coupler (top, bottom, side)
 - (cold) tuning system
- Operation in the range 1.8 to 4.5K.



High Brilliance Proton Beams

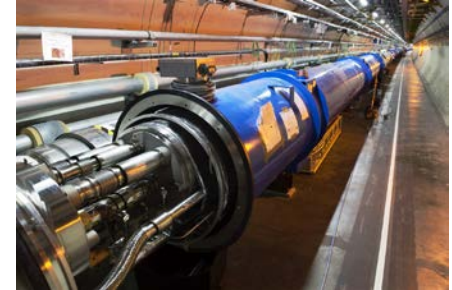
ESS Superconducting Linac



ESS Neutrino Super Beam

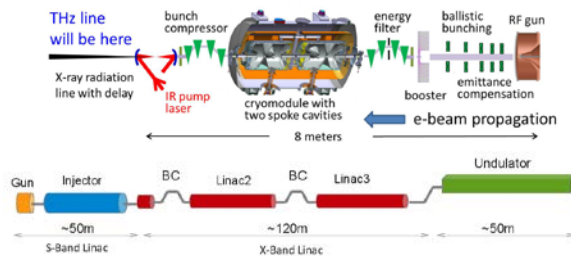


HiLumi LHC



High Brilliance Electron Beams

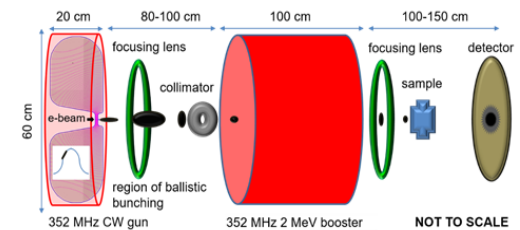
FELs



CLIC



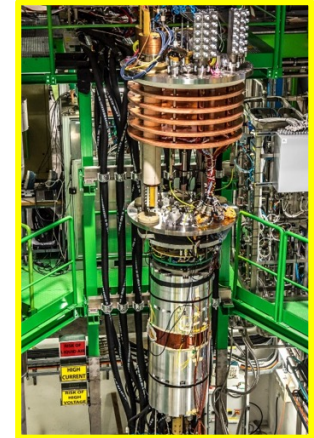
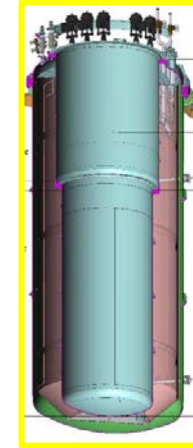
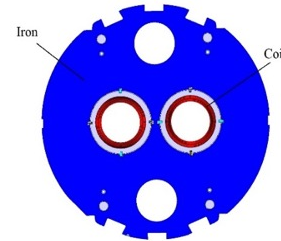
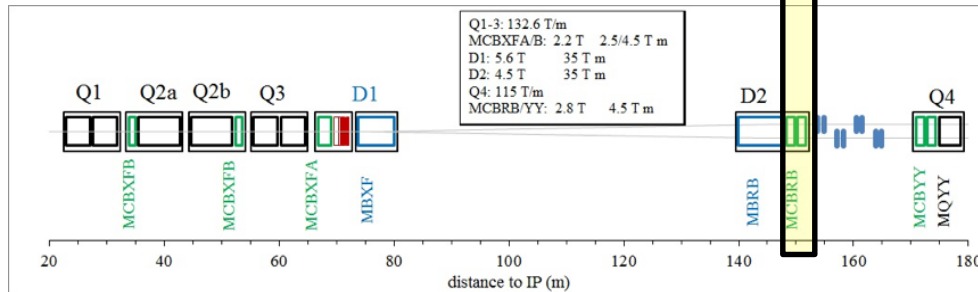
Ultrafast Electron Diffraction



*) FEL = Free Electron Laser

MCBRB

LBRD (D2)



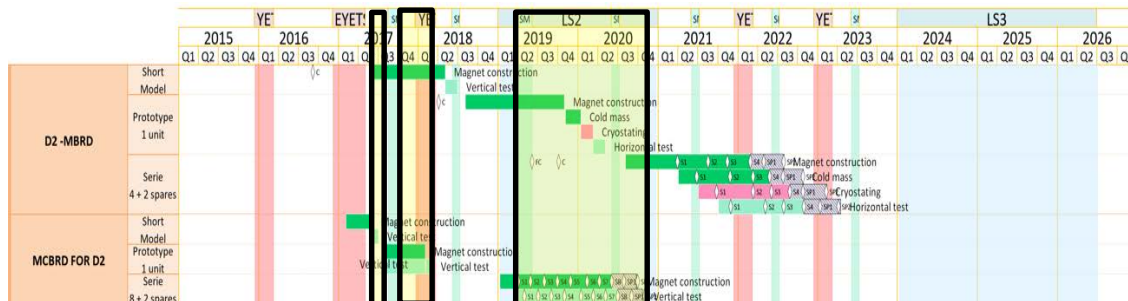
Double aperture ☐ 1.7 kA
2 NbTi dipoles ☐ Moved with overhead crane
Diameter /Length : 630/1600 mm ☐ Max current Proto: 3.2 kA



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50 % CERN and 50% FREIA

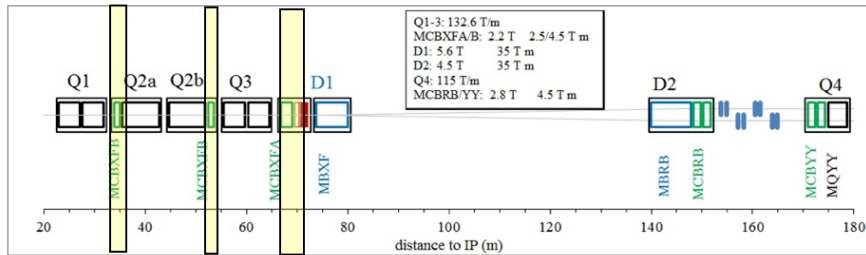


1 proto + 12 series magnets
to be tested

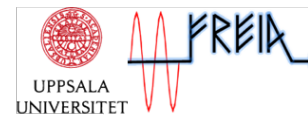
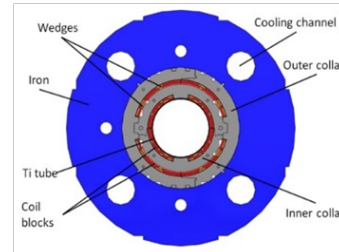
MCBXFA/B

test stand: CERN / FREIA

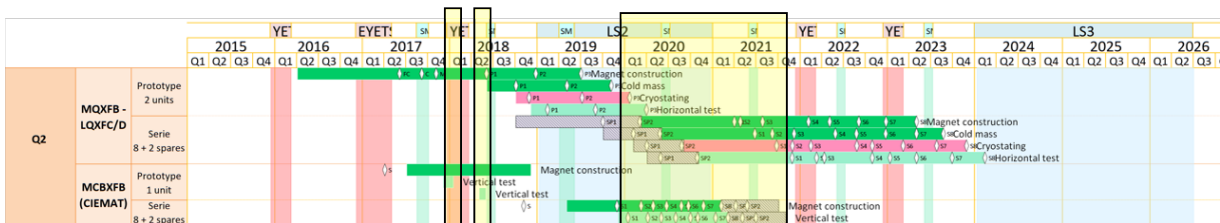
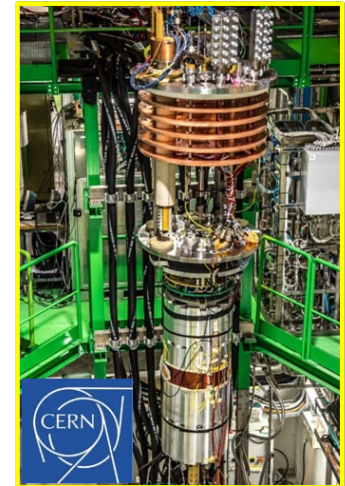
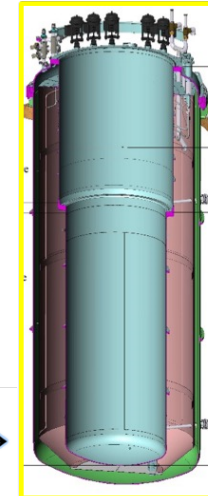
LQXFC(Q2a) LQXFD(Q2b) CP



- ☐ VERTICAL TEST
- ☐ Single aperture/nested
- ☐ 2 NbTi dipoles
- ☐ Length/Diameter : 1500/630 mm
- ☐ Test @ CERN D; @UPSALLA
- ☐ 1.7 kA with EE and dump
- ☐ Moved with overhead crane
- ☐ Max current Proto: 3.2 kA
- ☐ Max energy: 0.24 MJ
- ☐ Total weight: 2.9 t



50 % CERN and 50% FREIA



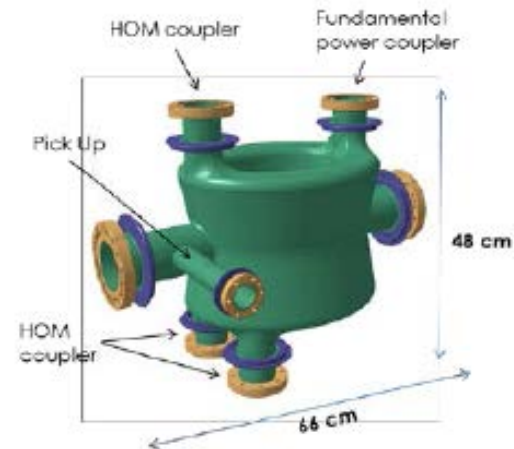
Marta Bajko for 7th Collaboration Meeting for HL -LHC Nov. 2017 Madrid

18 + 3 prototype magnets to be tested

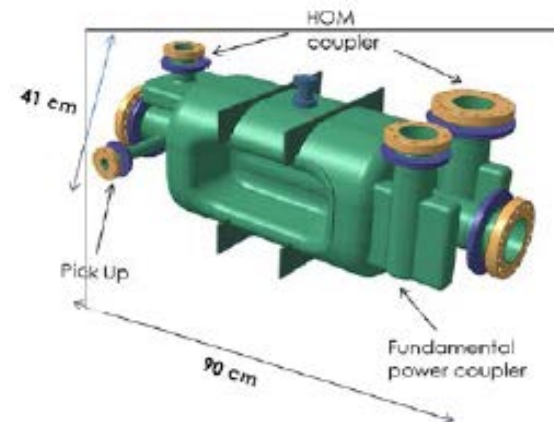
Test Responsible: Marta Bajko (CERN)
Roger Ruber (FREIA)

The agreement with CERN is that also crab cavities will undergo cold tests in Uppsala

Double Quarter Wave Crab Cavity



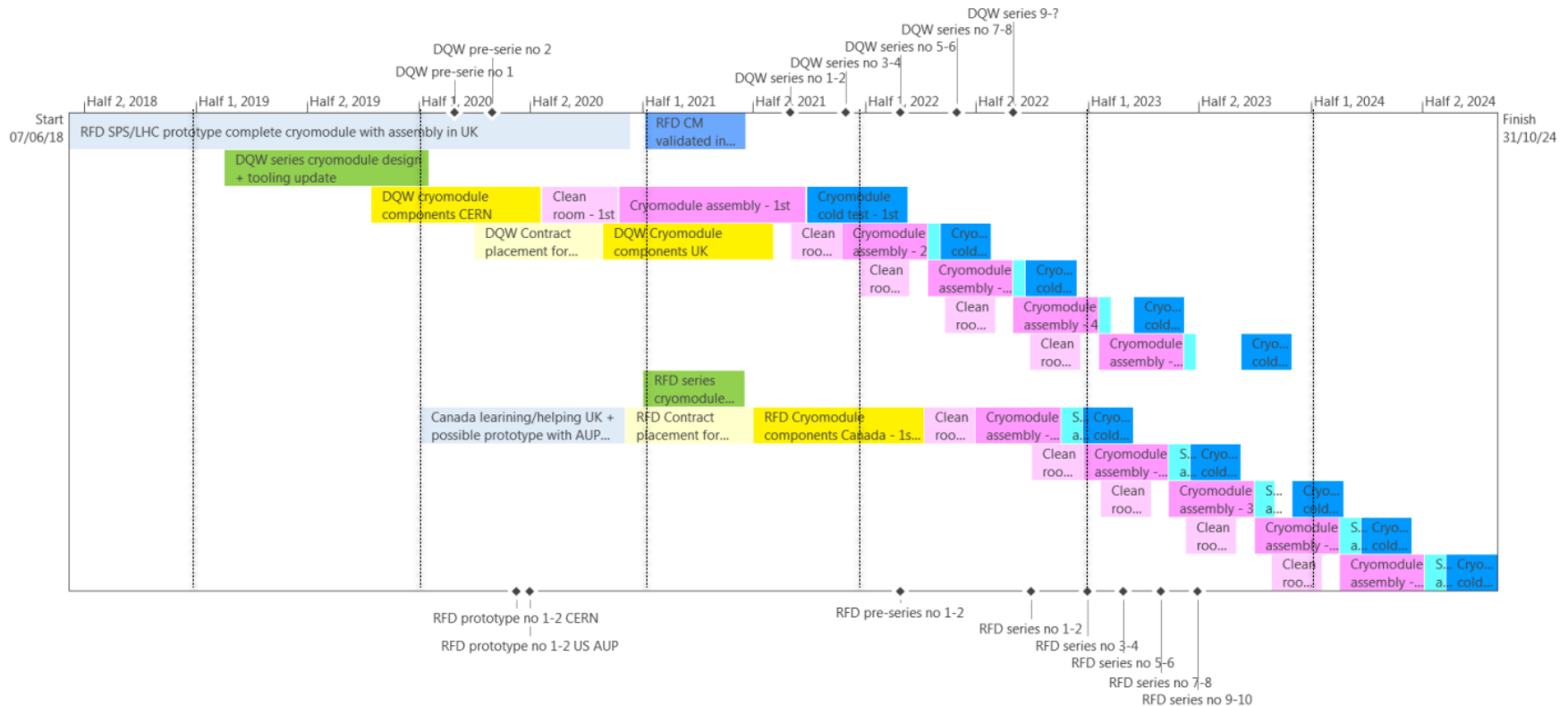
RF Dipole Crab Cavity



Crab Cavity Test Plan

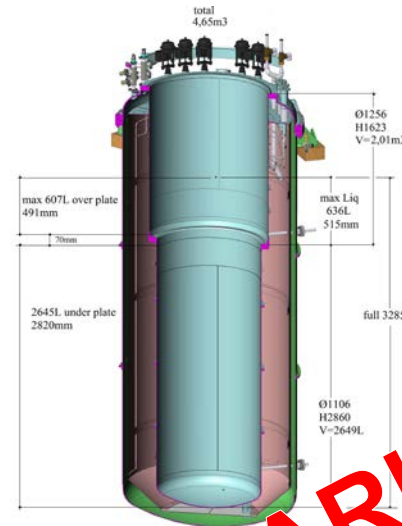


- Two Double Quarter Wave Crab Cavities are currently being tested in the SPS at CERN. Two RF Dipole Crab Cavities will be delivered to CERN at the end of 2020 and they will also be tested in the SPS. For the moment it is not clear when there will be a need for Crab Cavity tests in Uppsala.



“Gersemi” Vertical Cryostat

- Under commissioning
- Test of SC cavities & magnets
 - 3.2m x \varnothing 1.1m total volume
 - 2.65m x \varnothing 1.1m below lambda plate
 - design includes joint for lambda plate
- Operation in the range 1.8 to 4.5K
- Three operation modes
 - vacuum
 - liquid bath
 - pressurized bath with 2K heat exchanger



Available as ARIES
Trans National Access Facility

“Gersemi” Arrival & Positioning



05-Mar-2018 (081030)
Gersemi arrival at FREIA



15-Mar-2018 (P1040500)

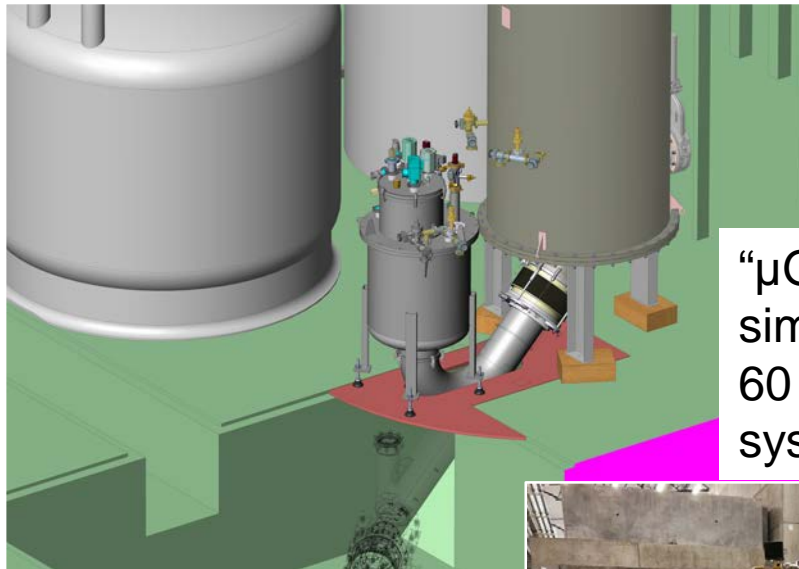


13-Mar-2018 (P1040470)



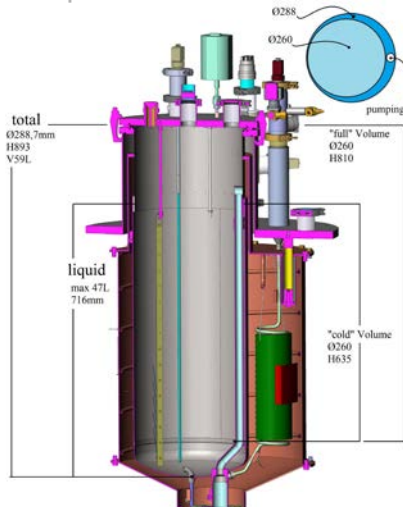
16-Mar-2018 (P1040527)

“ μ Gersemi” Simulator & Valve Box



“ μ Gersemi”
simulator
60 l cryostat for
system test

“ μ Gersemi” simulator



2-May-2018 (100442)



2-May-2018 (100425)

helium distribution
cold box



Liquid (Saturated) Bath Insert

- (sub-)atmospheric liquid bath
- mainly for SRF cavities



Pressurized Bath Insert

- pressurized liquid bath
 - 2K heat exchanger
- mainly for (small) SC magnets
 - magnet + insert max 6 ton
 - nominal operation 4 barG max.
 - max. stored energy ~500 kJ
 - ports for current leads
 - 4x 2kA current leads (ordered)
 - central oval port for field measurement
 - field measurement system itself not yet foreseen

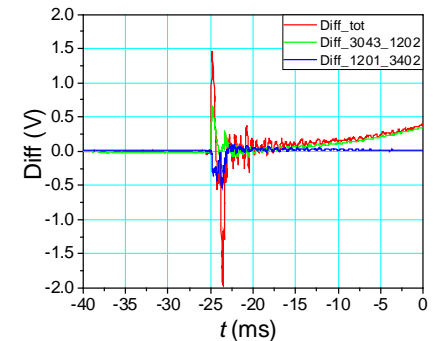
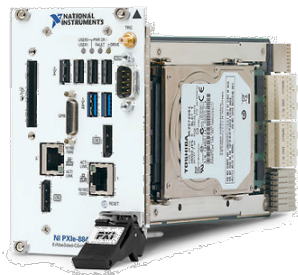


No vacuum insert (yet) → use HNOSS

A FREIA physicist Kevin Pepitone has been stationed at CERN and has learned how to protect and train a magnet. He also learned how to use different software and scripts for data analysis

Many equipment have been bought for data acquisition and magnet protection (i.e. NI-DAQ, NI-DMM...)

Software have been reused or adapted to FREIA acquisition system by Adriaan's team



Everything will be installed and tested at FREIA in the coming months.

Discussions are still ongoing on the power converters

Delays on energy extraction ?

Delays on magnet manufacturing ?



Gersemi Commissioning Plan

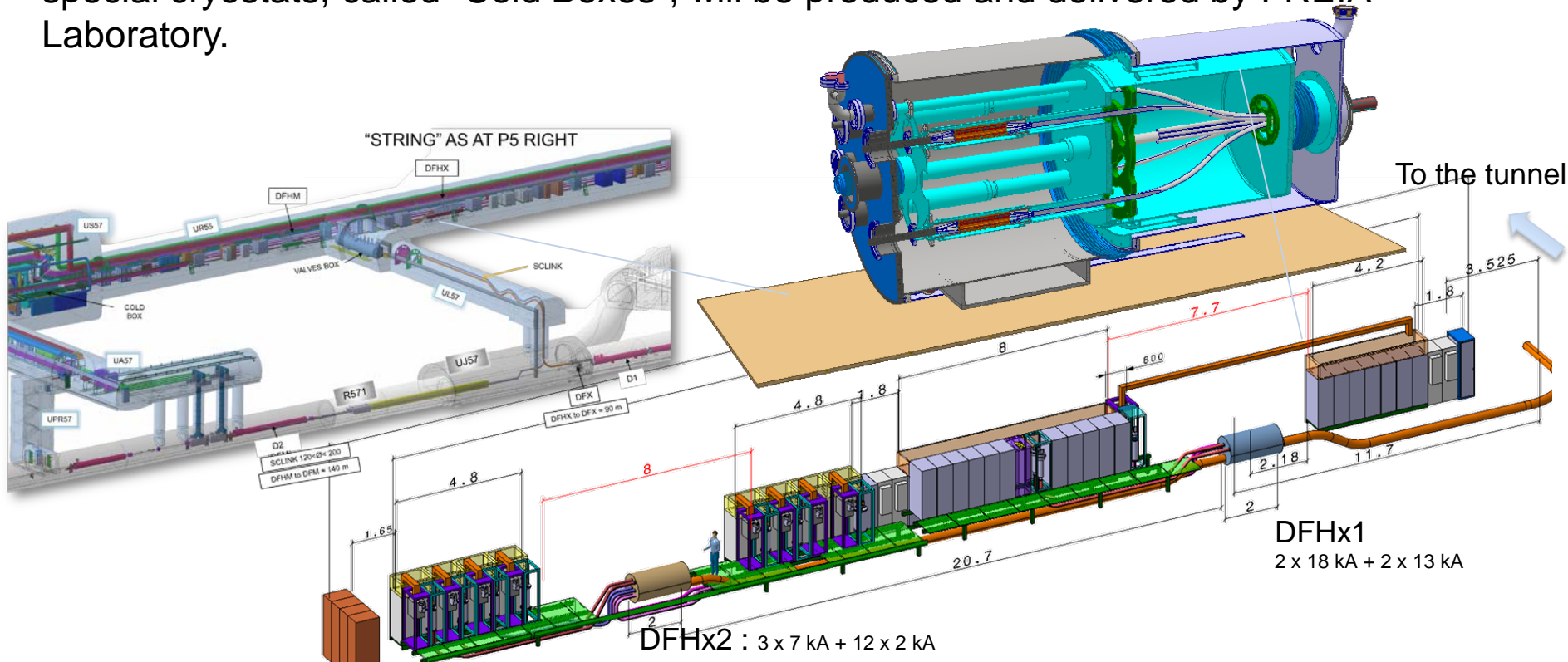


	October					November				December					January			
Task	1	8	15	22	29	5	12	19	26	3	10	17	24	31	7	14	21	28
VB repair	■												■	■				
Simulator test		■											■	■				
Simulator removal			■										■	■				
VCS connection				■									■	■				
Leak test				■									■	■				
Liquid insert installation					■	■							■	■				
Test							■	■	■				■	■				
Warm-up										■			■	■				
Magnet insert preparation							■	■	■				■	■				
Magnet insert installation											■	■	■	■				
Test													■	■	■	■		
Warm-up													■	■				■

DFHX Cold Boxes under discussion



- In the HL-LHC the power converters for the superconducting magnets near the collision regions will be subject to too high radiation background and need to be installed in a special underground gallery separate from the LHC tunnel and connected via ca 100 m long superconducting cables. These cables are cooled with cold He gas and composed of two different cables in series, made from different SC materials: HTS and MgB_2 . The two kind of cables need to be spiced together in a special cryostat. The plan is that 10 such special cryostats, called “Cold Boxes”, will be produced and delivered by FREIA Laboratory.



- The FREIA Laboratory at Uppsala University in Sweden has by now acquired extensive experience of and equipment for testing superconducting accelerator cavities for the European Spallation Source
- Uppsala University signed in 2016 a K-contract with CERN for tests of LH-LHC corrector dipoles and crab cavities
- FREIA has since then acquired and installed, in addition to the existing horizontal cryostat, a vertical cryostat which is now under commissioning and will be used for the HL-LHC magnet and cavity tests.
- Uppsala University is currently discussion an second HL-LHC K-contract for the design and fabrication by FREIA Laboratory of 10 so called Cold Boxes for the long HL-LHC superconducting current leads.