UPPSALA UNIVERSITET

FREIA

FREIA Laboratory

Facility for Research Instrumentation and Accelerator Development

Status of the FREIA Test Stand

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on behalf of the FREIA Team

Dry-run aTAC, ESS, 2 April 2019

Facility for Research Instrumentation and Accelerator Development

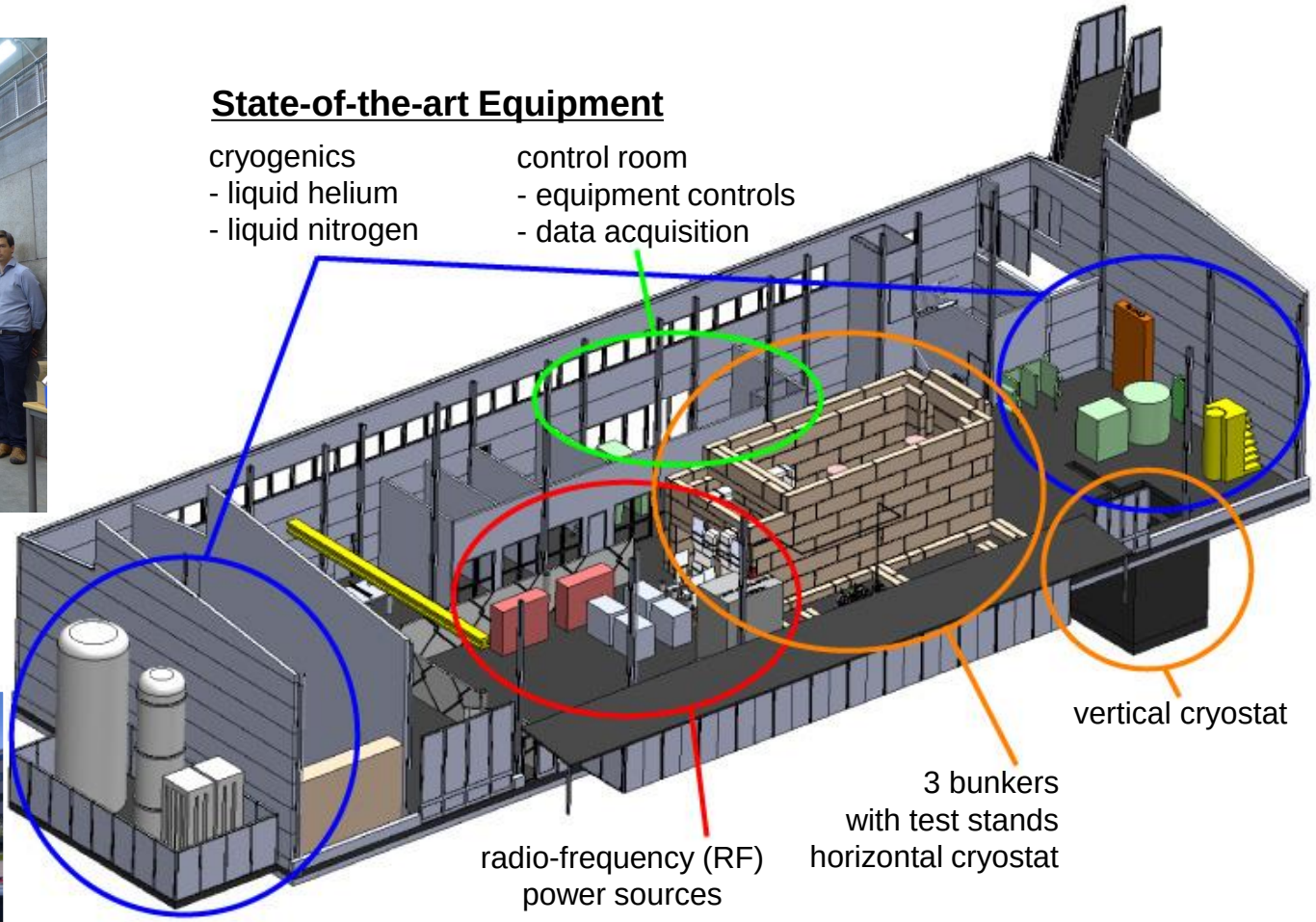
Competent and motivated staff

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

State-of-the-art Equipment

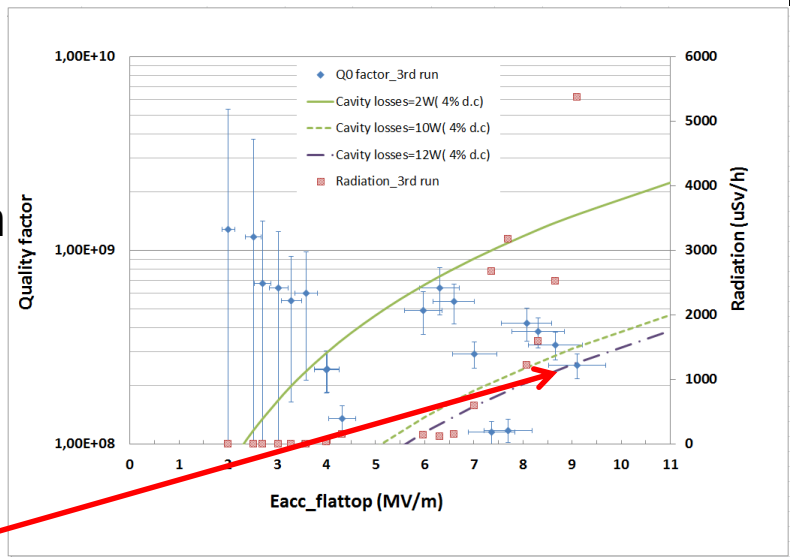
cryogenics
- liquid helium
- liquid nitrogen

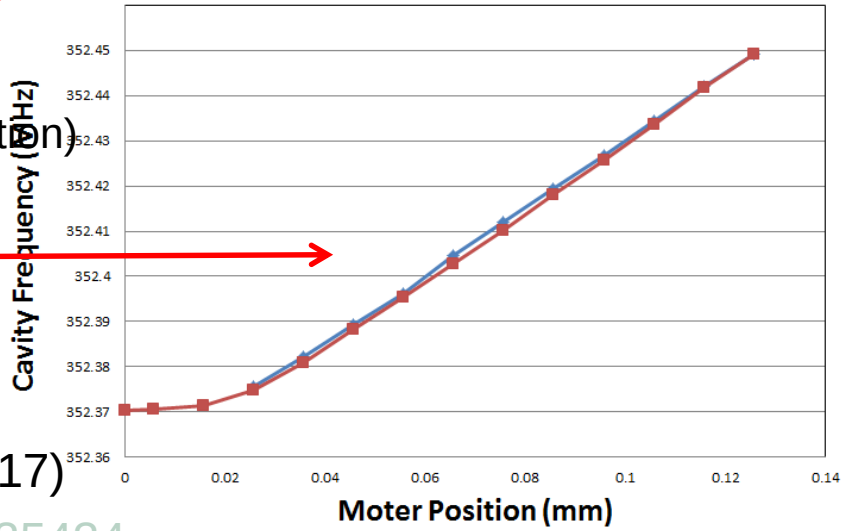
control room
- equipment controls
- data acquisition



Double Spoke Cavity Package (2017)

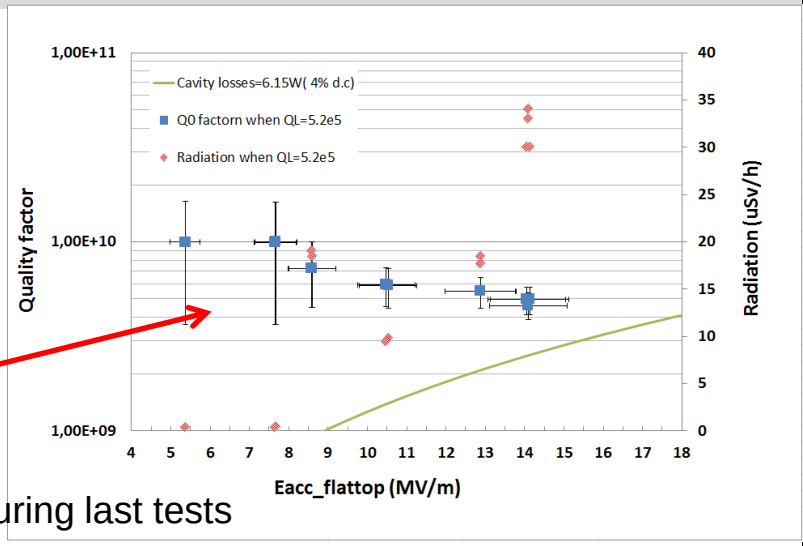
- Test from March – May 2017
- Warm
  - RF conditioning with IPNO then FREIA system
    - about 30h; multipacting in 20-60 kW region
    - max 120 kW forward power (limit set by IPNO)
- Cold
  - RF conditioning with FREIA system
    - about 30h; 3 major multipacting regions
  - RF testing
    - Q_0 = 2.6 x10^8 at 9 MV/m (w/ heat load correction)
    - Lorenz force detuning ~400 Hz at 9 MV/m
    - cavity tuning sensitivity = 150 kHz/mm@2K
    - pressure sensitivity = +27.1 Hz/mbar
- Final status/results
  - results presented at SLHiPP-7 (9 June 2017)
  - full report published: urn:nbn:se:uu:diva-335434

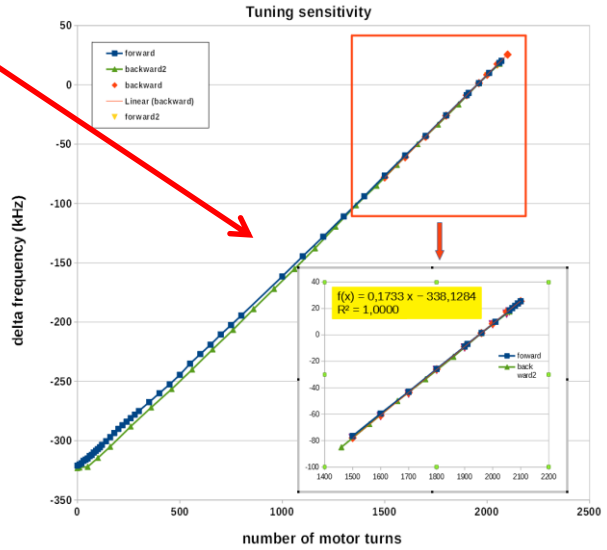




High-β Elliptical Cavity Package (2018)

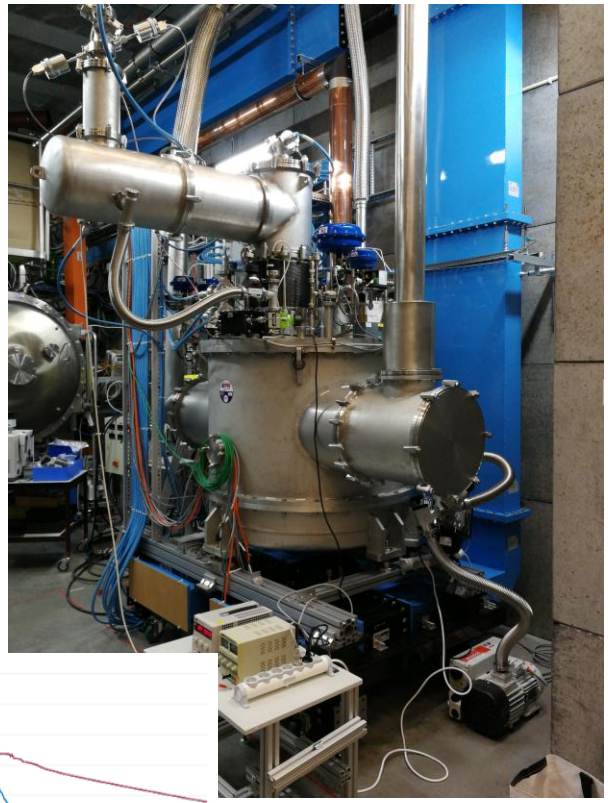
- 1st run in June 2018
- Warm-up and open to fix tuner problem
- 2nd run in August 2018
  - cooldown, then RF re-conditioning at cold
  - measurement
    - Q_0 preliminary result >10^9
      - not much multipacting, cavity and coupler very quiet during last tests
    - Lorenz force detuning, cavity tuning sensitivity
      - lost some motor steps during 1st movement, others ok
  - test of new electronics for cold tuner system as being developed by our Polish colleagues
    - preliminary satisfied with the results
- Final status/results
  - cavity back to CEA, modulator/klystron to ESS
  - results presented at SLHiPP-8 (12 June 2018)
  - full report published: urn:nbn:se:uu:diva-371627

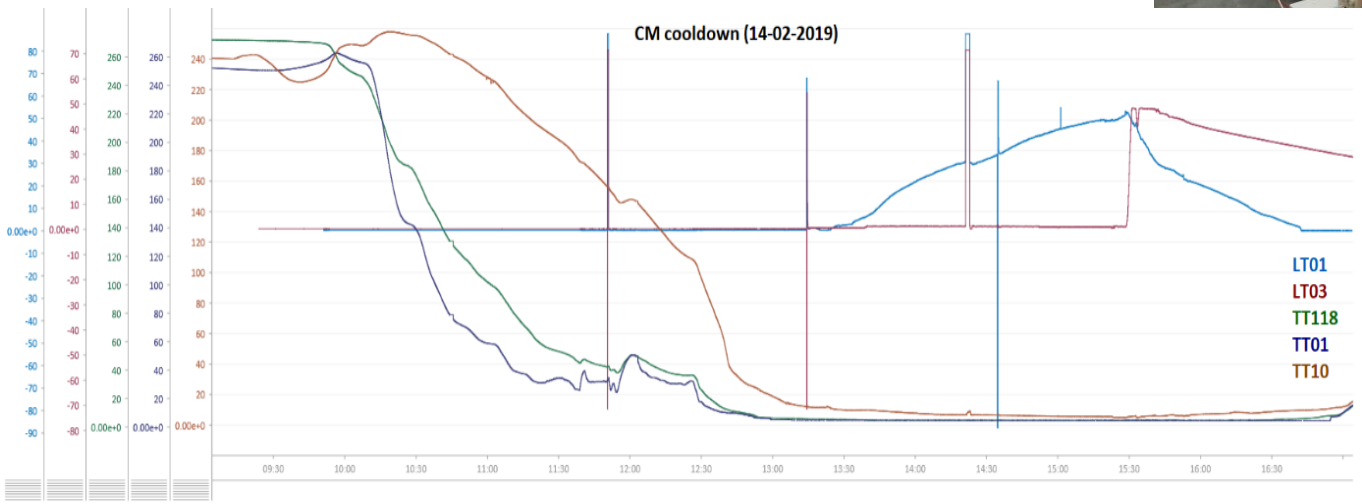




Spoke Valve Box Prototype (2019)

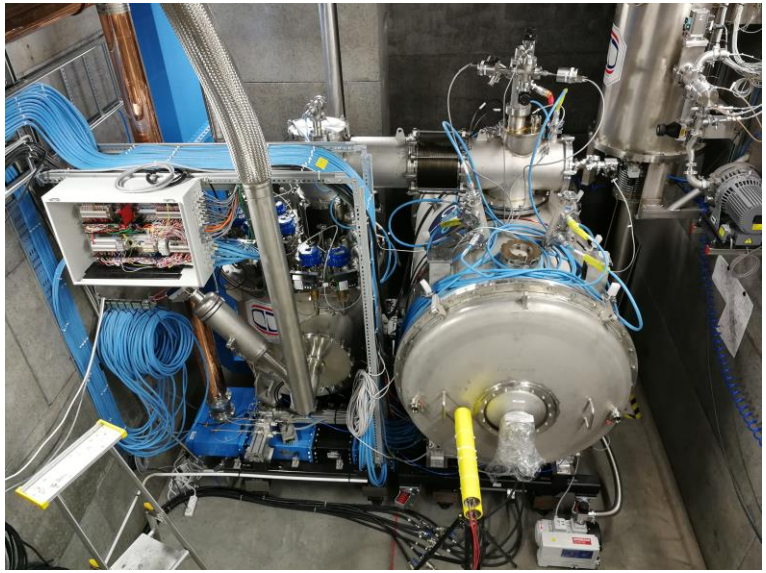
- cryo test run with simulator (Dec + Jan)
  - commissioning controls & functionality test
- thermo-acoustic oscillations
  - installed RLC-circuit to damp the oscillations (test with cryomodule cool down)



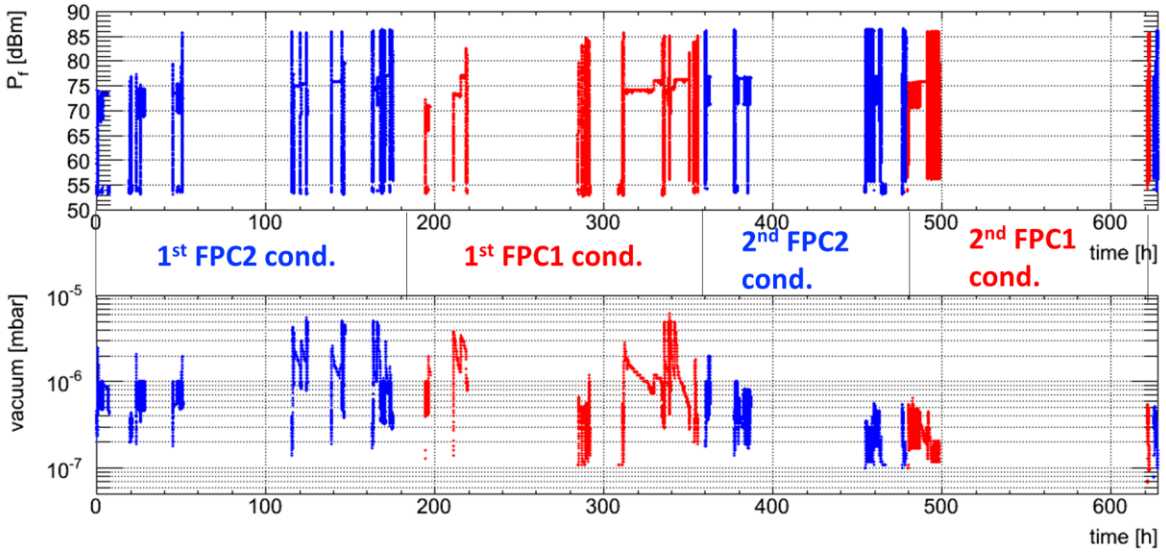


Spoke Cryomodule Prototype (2019)

- RF conditioning (warm)
  - took about 77 h run time (627 h real time)
    - 1st conditioning ~50 hours
    - 2nd conditioning ~20 h (cross-contamination)
  - MP bands were consistent with HNOSS test
    - strength of MP levels depends on pulse length, 1st and 2nd conditioning…
  - fully automatic system conditioning system
    - commissioned, now implemented to run 24h/day



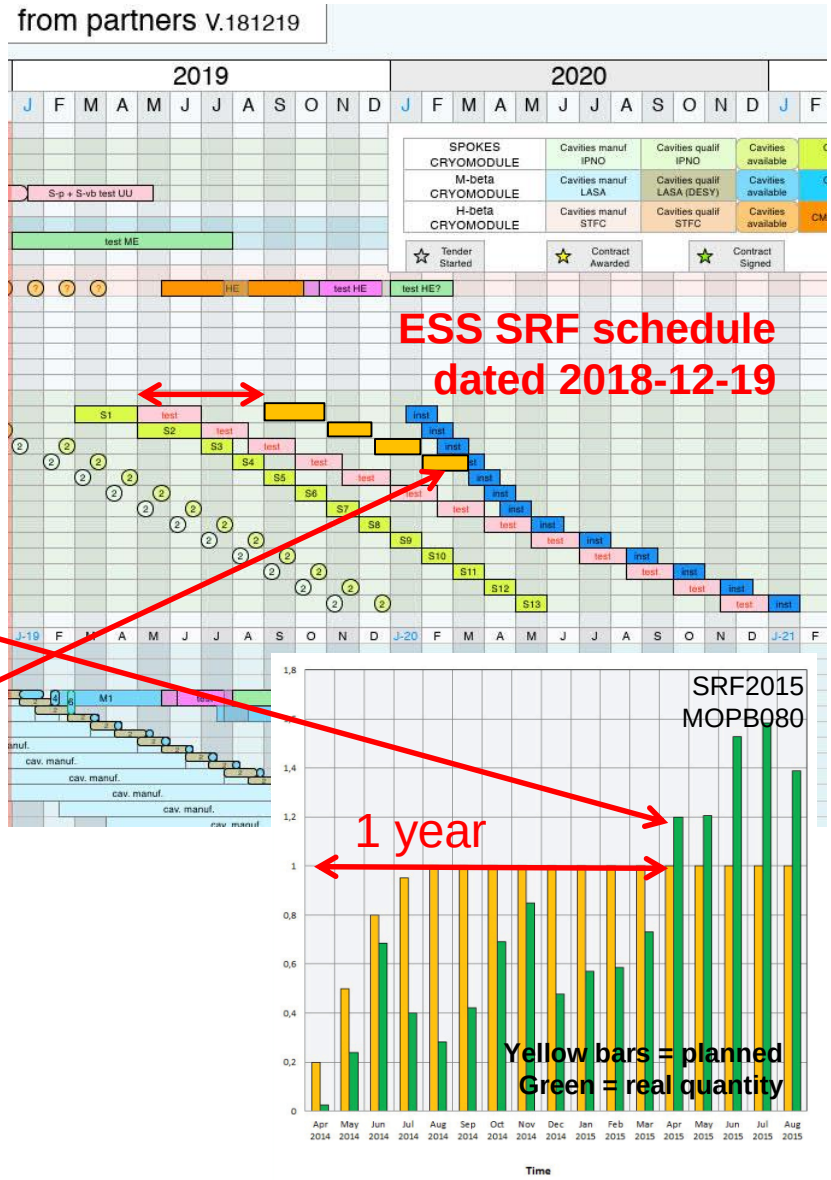
Cooldown will start this week ...



Series Spoke Cryomodule Testing (13x)

- Acceptance testing of 13 cryomodules
  - best estimate: 6 weeks/module
  - ESS schedule:
    - 4 to 6 weeks/module,
    - 8 weeks for cryomodule S1,
    - driven by installation planning
  - DESY experience:
    1 year to reach “full speed”

- Present planning
  - first series cryomodule arrives in Summer (4 months delay compared to Dec.2018)
  - will “hit” installation schedule by S3 or S4 (transportation!)



Cryomodule Test Schedule

	time [days]	time [weeks]	in bunker [days]
Arrival, unpacking, initial inspection	2.5		
Installation, connection to valve box	5.0		5.0
Warm test	2.0		2.0
Cool down	2.0		2.0
Cold test	5.0		5.0
Warm-up*	4.0		4.0
Disconnect, packing, shipment	4.5		3.0
TOTAL	25.0	5.0	21.0
Spare and wasted time, 20% (DESY statistics)	5.0		4.2
GRAND TOTAL	**30.0**	**6.0**	**25.2**

= 4 to 5 weeks

Time given in 8h work days, 1 shift/day.
Not including weekend, holidays and vacation.
*) Warm-up is shorter if during weekend

Cryomodule Test Plan Draft

Warm Test	Cool Down	Cold Test	Warm-up
✓ Central cavity frequency ✓ Q_{ext}	✓ Frequency shift vs. temperature	✓ Coupler cold conditioning	✓ Frequency shift vs. temperature
✓ Coupler warm conditioning		✓ Cavity conditioning	
		✓ Central frequency ✓ Loaded Q and Q_{ext}	
		✓ Steady heat load	
		✓ Q_0 ✓ Dynamic heat load ✓ Reach 12 MV/m ✓ Tuning range of the slow step tuner	
		✓ Stabilization of the cavity field with LLRF using only RF compensation / with fast piezo	

CRYO

VNA

SGD
signal generator driven

SEL

Lund LLRF

NOTE: final optimized & minimized list under discussion (ESS/IPNO/UU)

Foreseen & Unforeseen Issues

- Operations take longer time than scheduled
  - RF conditioning scheduled for 2 days, present indication 3 to 4 days
    - discussing mitigation by conditioning both couplers simultaneous and improving vacuum pumping possibilities
- No staff for 24h operation
  - partly mitigate by automatic operation for RF conditioning, cool down, warm-up
  - SSM authorization does not allow un-attended operation if producing radiation
- Not sufficient staff resources for high-peak workload
  - difficult to find replacement for high power RF & electronics engineer
  - several engineers working part-time (at/near retirement)
- No time allotted for re-test or failure
  - also: no space at Uppsala to “store” extra cryomodules
- No time allotted for vacation
  - also: multiple sick-leave will squeeze staff resources

Summary

FREIA Cryomodule Test Stand up and running !

- procedures developed and tested on HNOSS
- procedure validation and optimization ongoing on prototype

- strongly motivated personnel to make it work
- support from ESS and IPNO when needed (RF/SRF/vacuum/...)

BUT:

- tight in scheduled time & available resources