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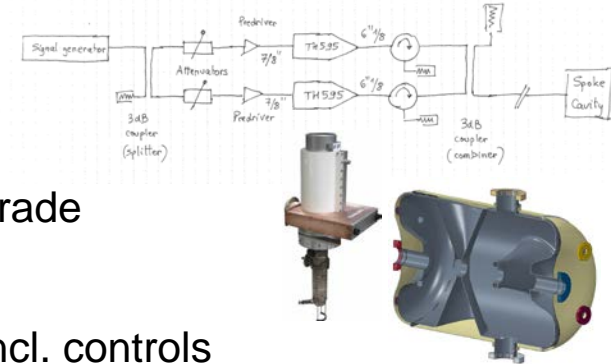
The FREIA Test Program

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for the Uppsala Accelerator Group & FREIA

20-21 November 2013, Uppsala
ESS-FREIA Spoke Cavity Testing Review and Planning Meeting

1) Contribution to the technical design & construction effort

- design concept spoke accelerating cavity power source
- design concept radio-frequency (RF) power distribution
- survey test stand infrastructure and requirements
- study of upgrade scenarios RF systems for ESS power upgrade



2) Development power station for spoke cavities

- soak test with water cooled load, then accelerating cavity, incl. controls
- collaboration with industry to develop vacuum tube and solid-state based prototypes

3) System test, power station with spoke cavity and cryostat-module

- fully dressed prototype cavity (in test cryostat)
- complete prototype module (2 spoke cavities)

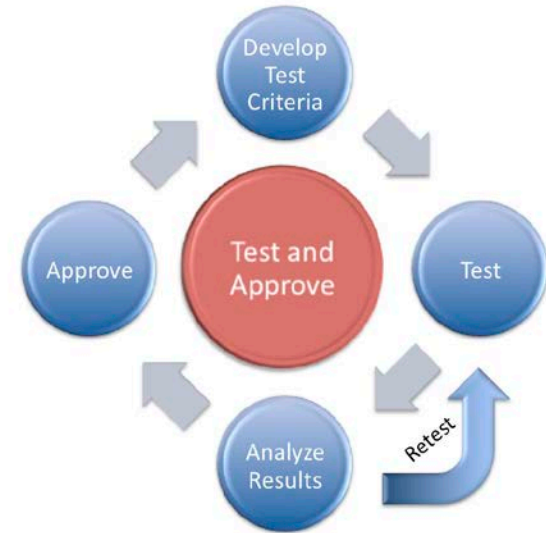
4) Acceptance test cryostat-modules (proposal submitted)

- for all final modules before installation

Test Stand Matrix	f [MHz]	P [kW]	prototype				series			
			low power where	high power when	low power where	high power when	low power where	high power when		
P0 Cavities										
ion source	--	--	LNS		LNS				on site	
LEBT buncher	352	10	LNS ?		LNS ?				on site	
RFQ	352	1000	CEA		CEA				on site	
MEBT	--	--	ESS-B ?		ESS-B ?				on site	
DTL	352	2100	LNL		CEA (10004)				on site	
double spoke	352	240	IPNO		UU 2014/5		??		--	
medium beta	704	500	CEA		CEA		DESY ?		--	
high beta	704	900	CEA		CEA		DESY ?		--	
P1 Couplers										
double spoke	352	800	IPNO		CEA		??		??	
medium beta	704	650	CEA ?		CEA		??		??	
high beta	704	1200	CEA		CEA		??		??	
P2 RF System										
modulator	--	5600	--	--	ESS		--		ESS	
NC linac	352	2800	--	--	ESS		--		ESS	
double spoke	352	300	--	--	UU 2014		--		ESS	
medium beta	704	600	--	--	ESS		--		ESS	
high beta		1200	--	--	ESS		--		ESS	
P3 Cryomodule										
double spoke	352	2x 300	IPNO		UU 2015/6		IPNO		UU 2017/8	
medium beta	704	4x650	CEA	--	CEA	--	CEA/ESS		ESS	
high beta	704	4x1200	--	--	--	--	CEA/ESS		ESS	

Criteria to judge the test results

- **Efficiency**
 - to reduce electricity costs
 - reuse cooling water
- **Stability**
 - relative fast response to perturbations
 - predictability of the system
 - requires testing of extreme conditions
- **Reliability**
 - slow variations such as drift and aging that affect parameters
 - abrupt failure of something
 - requires long-term soak testing





- **RF power station & RF distribution**

- achieve required performance: 14 Hz, $2.9+t_{\text{fill}}$ ms, power-to-beam+overhead kW_{peak}
- stable long term operation
- safe handling of reflections, sparking, interlocks and faults

- **LLRF and controls**

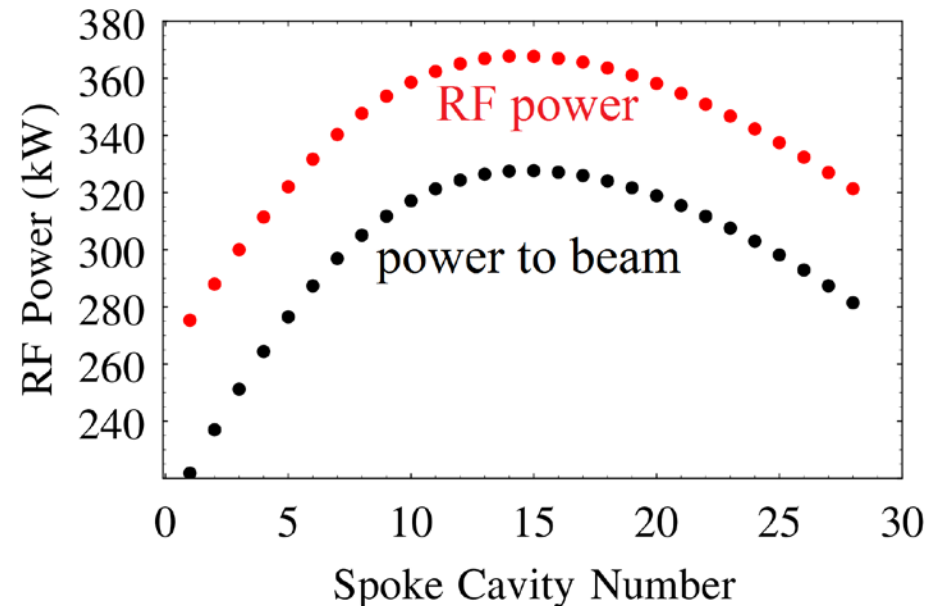
- RF control (1% amplitude, 1° phase)
- compensation Lorentz detuning & microphonics

- **Spoke cavity**

- achieve required performance:
 E_{acc} , Q_0 , f_0 , losses
- stable long term operation

- **Spoke cryo-module**

- as for single cavity
- no undesirable coupling between cavities
- achieve cryogenic requirements:
cool down, losses





How ?



• General idea

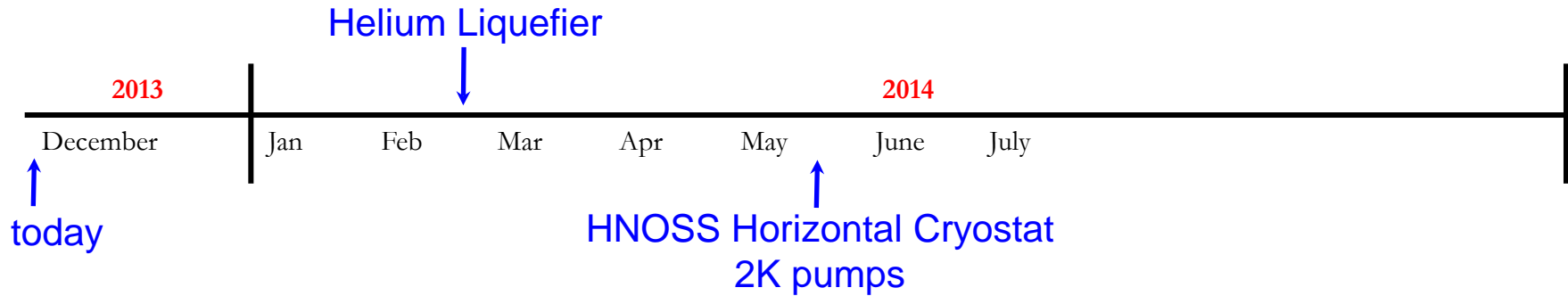
- commission and test infrastructure before arrival sub-systems
 - new facility, so must commission equipment to guarantee proper operation
 - personnel should have time to familiarize with equipment
- commission and test each equipment before combining
 - limited time line towards arrival of cavity
 - limited learning curve towards prototype cryo-module testing

• Will be first major test for FREIA & ESS (of a whole accelerator section)

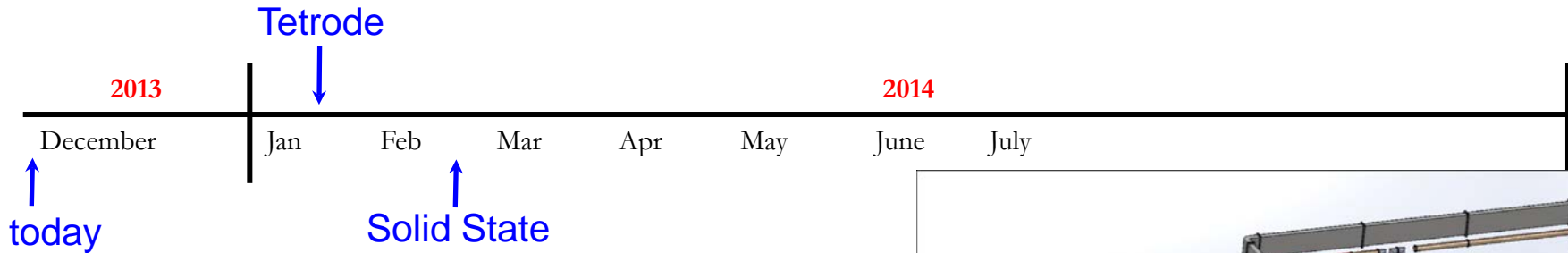
- critical for decision towards cavity series production
- critical for decision towards RF & LLRF component design and procurement



Cryogenics & Cryostat



- **Helium and Nitrogen Cryogenics: contract with Linde**
 - factory test (cold box & controls): January
 - delivery & installation: February-March
 - commissioning & acceptance test (by Linde): March-April
- **HNOSS Cryostat and Transfer Lines: contracts with ACS and Cryo Diffusion**
 - factory test (LN2): April
 - delivery & installation: May-June
 - commissioning (by UU and ACS): Summer
- **Sub-atmospheric pumps: tender launched last week**
 - delivery & installation: May-June
 - commissioning: Summer



- **Tetrode based: contract with Electrosys**

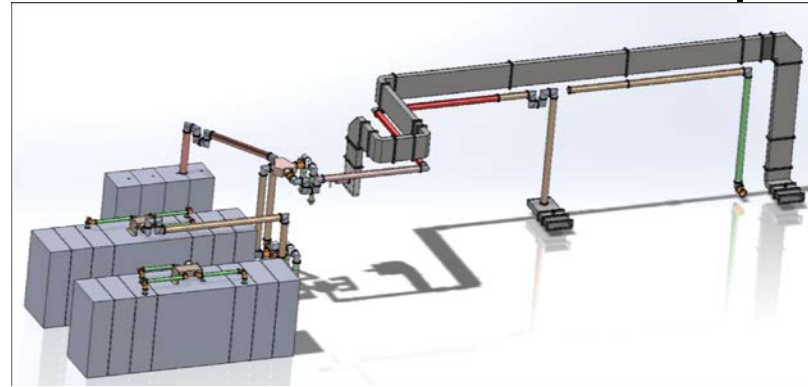
- factory test tetrodes (Thales, Thonon): this week
- factory test (Electrosys):
- delivery & installation: January-February
- commissioning and acceptance test (by Electrosys): February-March

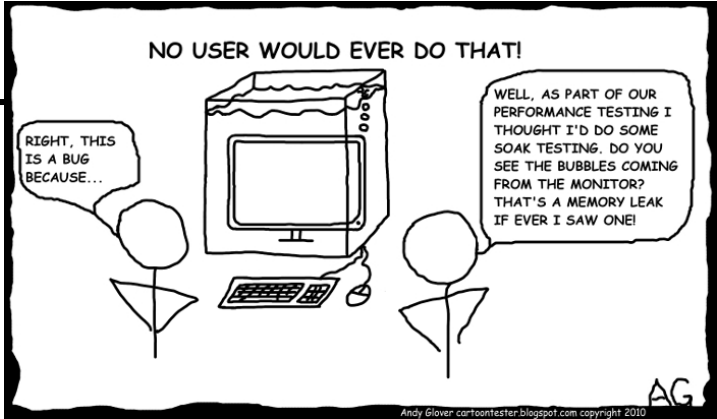
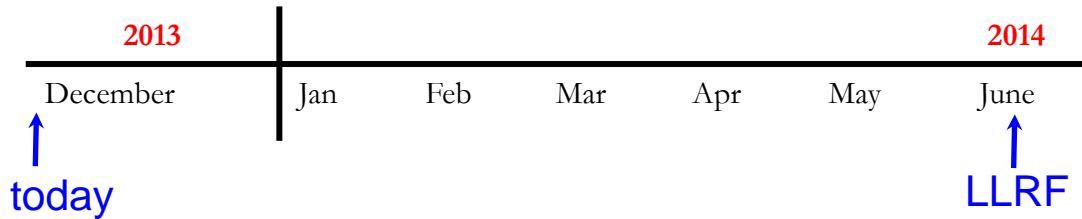
- **Solid-state based: Siemens development**

- on loan to Uppsala, expected delivery: February

- **RF Distribution**

- circulator and loads ordered
- tender of remaining parts now under preparation





- **Safety**

- radiation monitoring
- personnel & equipment safety interlocks

- **Equipment controls**

- base controls included in contracts (Cryo Diffusion, Electrosys, Linde)
- overall integration by Uppsala (EPICS based), working with equipment manufacturers

- **Data acquisition and monitoring**

- RF measurements (amplitude, phase)
- infrastructure & environment monitoring (temperature, pressure & humidity)
- ... any special experiments ...

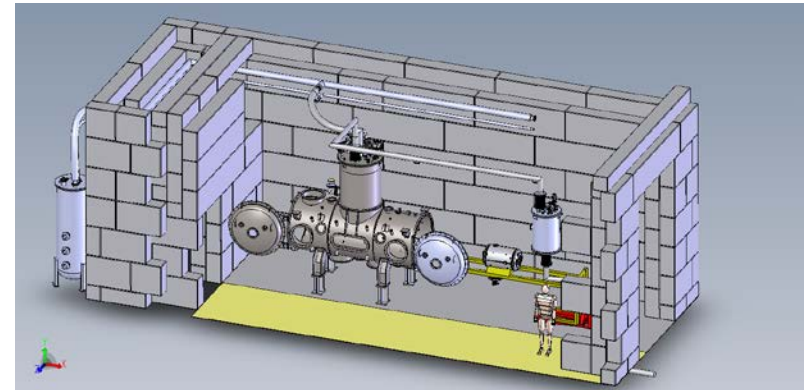
- **LLRF**

- under development at Lund, updated as testing progresses...

Only after all other systems have been successfully commissioned

Then...

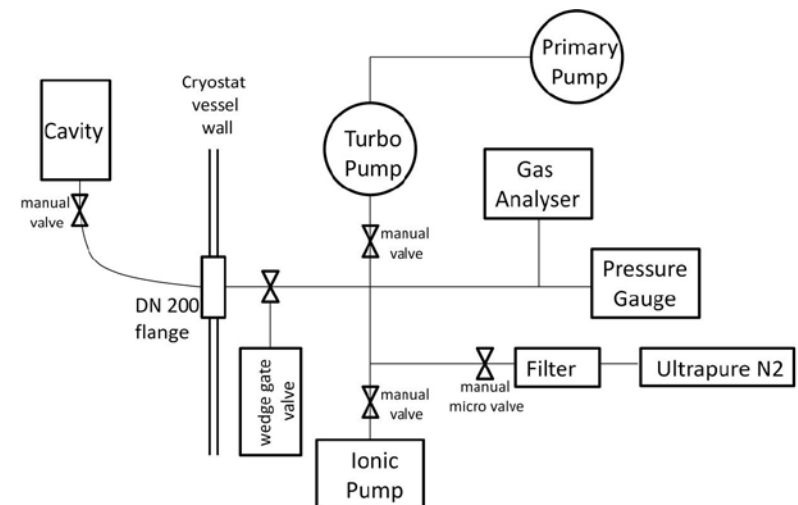
- install cavity into cryostat
 - tooling under design by ACS
- connect cavity vacuum pumping
 - always keep pumping if possible...
- connect to cryogenics, RF etc.
- connection & functionality test
 - RF couplers, tuners and instrumentation



**Note that this will be the first time
(for cavity, cryostat and team)**

Expect extra time for

- connections
- cool down, RF conditioning, testing...

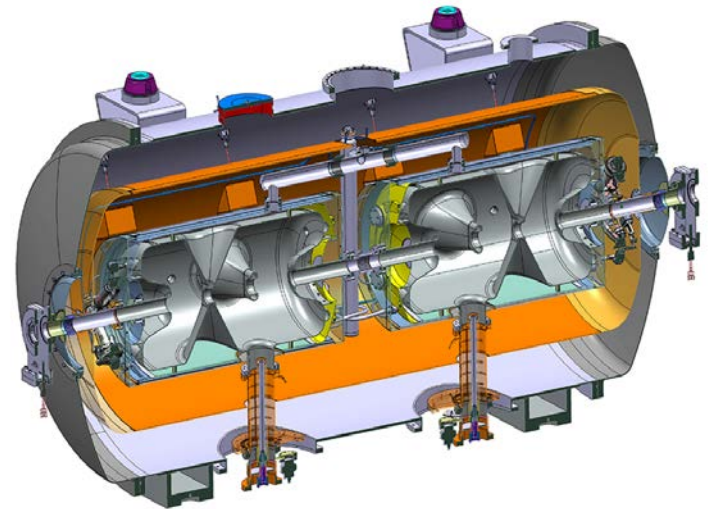


We have one year to test the first spoke cavity

- should make optimum use to do it careful
- exhaustive testing for efficiency, stability and reliability
- do it carefully and learn how to operate equipment and assembly
- polish any issues
 - to prepare for order of series production
 - arrival of prototype cryo-module

Prototype spoke cryo-module

- repeat the single cavity experience
- test cryostat behaviour
- search for any correlation and interactions between cavities
- polish any issues and learn to install/test/remove
 - prepare for series testing of cryo-modules



- Further discussions during this meeting
 - We have ideas on the testing but want to discuss with you for your input and experience
 - Onset to a commonly agreed test program

Thanks to you all !



At present many IT projects disregard to test extra non-functional characteristics of the systems they implement

<http://blog.qatetestlab.com/2011/04/01/how-to-involve-non-functional-testing-in-your-project/>