SPL needs for RF tests in SM18

Wolfgang Weingarten

21 January 2010

Outline

- Functionality of existing cryo-bunkers and their general parameters
- RF tests foreseen in SM18
- Cryogenic needs
- Schedule 2010-12 and related work
- Conclusion

Functionality of SM18 vertical SRF test cryostats and bunkers

SPL related items in RED

Vertical cryostat V3: dedicated to SPL study (704 MHz)
Testing sample cavities
Test of individual cavities for SPL study
Extensive tests of individual cavities for SPL project, if approved
Vertical cryostat V4: dedicated to quadrupole resonator (400 MHz)
Test of quadrupole resonator (R&D for SPL and HIE-ISOLDE cavities)
Vertical cryostat V5: dedicated to HIE ISOLDE project (101 MHz)
Test of quarter wave resonator prototypes
Series tests of quarter wave resonators
Vertical cryostat V6: dedicated to LHC cavities (400 MHz)/SOLEIL
Soleil cavity
RF tests of LHC spare cavities
Bunker 1: SOLEIL/LINAC4/SPL study (352/704 MHz)
SOLEIL cryomodule test
SPL Cryomodule Test in horizontal cryostat in pulsed mode
Bunker 2: LHC cryomodules (400 MHz) & HIE-ISOLDE (101 MHz)
Series tests of quarter wave resonator cryomodules
RF tests of LHC spare cryomodules

General parameters for SM18 vertical cryostats and bunkers

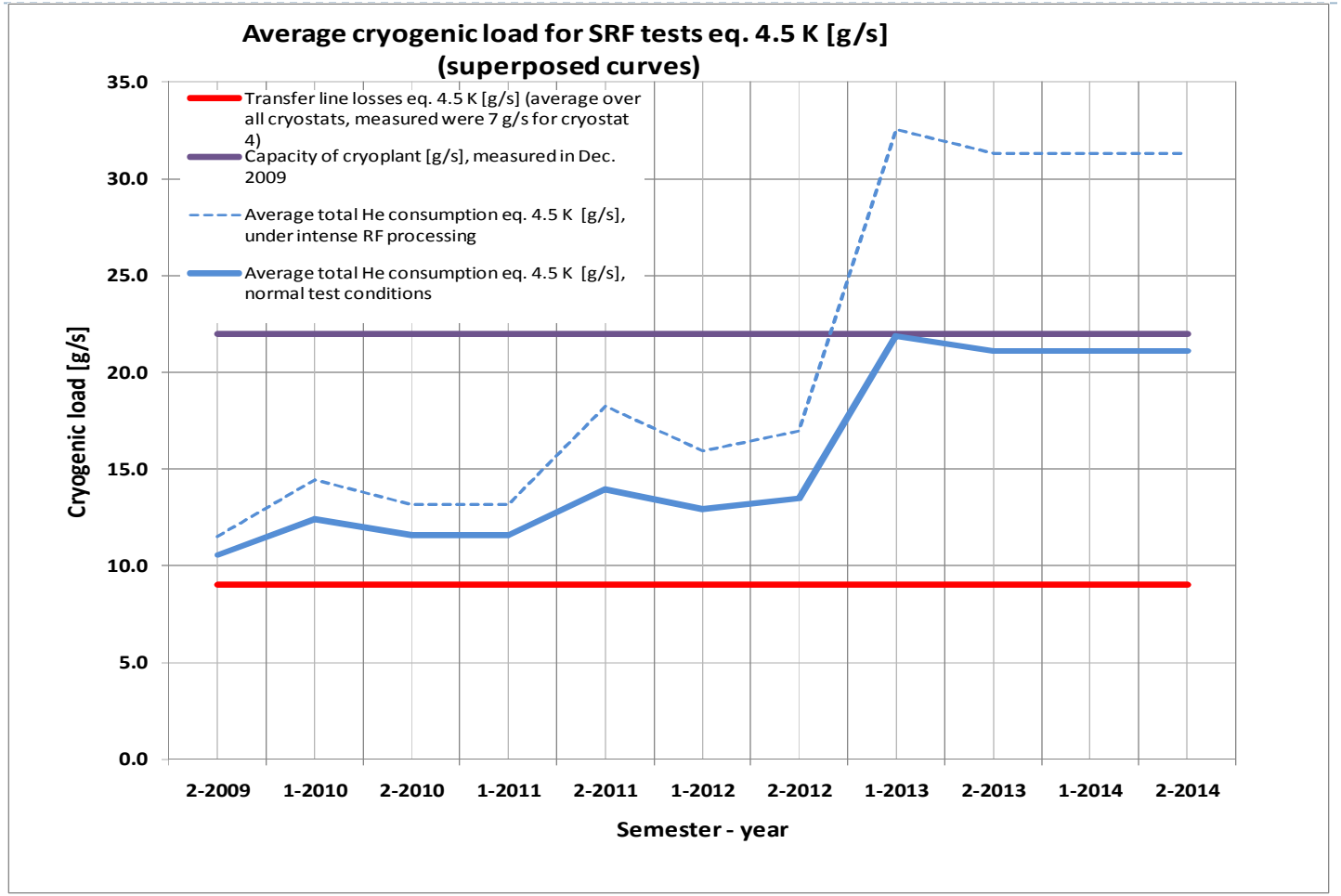
General parameter	V3	V4	V5	V6	B1	B2
RF frequency [MHz]	**704**	400 - 1200	100	400	**352 – 704**	101 - 400
Typical temperature range [K]	**1.8 – 4.5**	1.8 – 4.5	4.5	4.5	**1.8 - 4.5**	4.5
Nominal installed RF power (depending on whether power coupler is mounted or not)	**300 W**	200 – 400 W	600 W	300 W	**300 W – 1 MW (pulsed)**	300 W – 300 kW

SPL related items in RED

SRF tests foreseen in SM18

Plan of SRF testing activities (SM18), version 19 Nov 2009		Number of RF tests per semester								
		2-2009	1-2010	2-2010	1-2011	2-2011	1-2012	2-2012	1-2013	2-2013
Vertical cryostat V3: dedicated to SPL study (704 MHz)	**TOTAL**	**1**	**2**	**2**	**2**	**8**	**5**	**6**	**20**	**20**
Testing sample cavities (e.g. ▱ = 0.5)		1	2	2						
Test of individual cavities					2	3				
Extensive tests of individual cavities (test rate in full activity is at least 40 per year for 6 years)						5	5	6	20	20
Vertical cryostat V4: dedicated to quadrupole resonator (400 MHz)	**TOTAL**	**2**	**2**	**2**	**2**	**2**	**0**	**0**	**0**	**0**
Test of quadrupole resonator (R&D for SPL and HIE-ISOLDE cavities)		2	2	2	2	2				
Vertical cryostat V5: dedicated to HIE ISOLDE project (101 MHz), test possibly in cryolab	**TOTAL**	**0**	**9**	**10**	**10**	**10**	**0**	**0**	**0**	**0**
Test of quarter wave resonator prototypes (1 - 2 per month)			9							
Series tests of quarter wave resonators (10)				10						
Series tests of quarter wave resonators (20, not yet completely funded)					10	10				
Vertical cryostat V6: dedicated to LHC cavities (400 MHz)/SOLEIL	**TOTAL**	**2**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Soleil cavity		1	1							
RF tests of LHC spare cavities		1	1							
Bunker 1: dedicated to SOLEIL/LINAC4/SPL study (352/704 MHz)	**TOTAL**	**0**	**1**	**0**	**0**	**0**	**1**	**1**	**3**	**3**
SOLEIL cryomodule test			1							
SPL Cryomodule Test in horizontal cryostat in pulsed mode (1 MW per cavity)							1	1	3	3
Bunker 2: dedicated to LHC cryomodules (400 MHz) & HIE-ISOLDE	**TOTAL**	**1**	**1**	**1**	**1**	**0**	**2**	**2**	**2**	**0**
Series tests of quarter wave resonator cryomodules (6)							2	2	2	
RF tests of LHC spare cryomodules		1	1	1	1					

SM18 Cryogenic needs for SRF



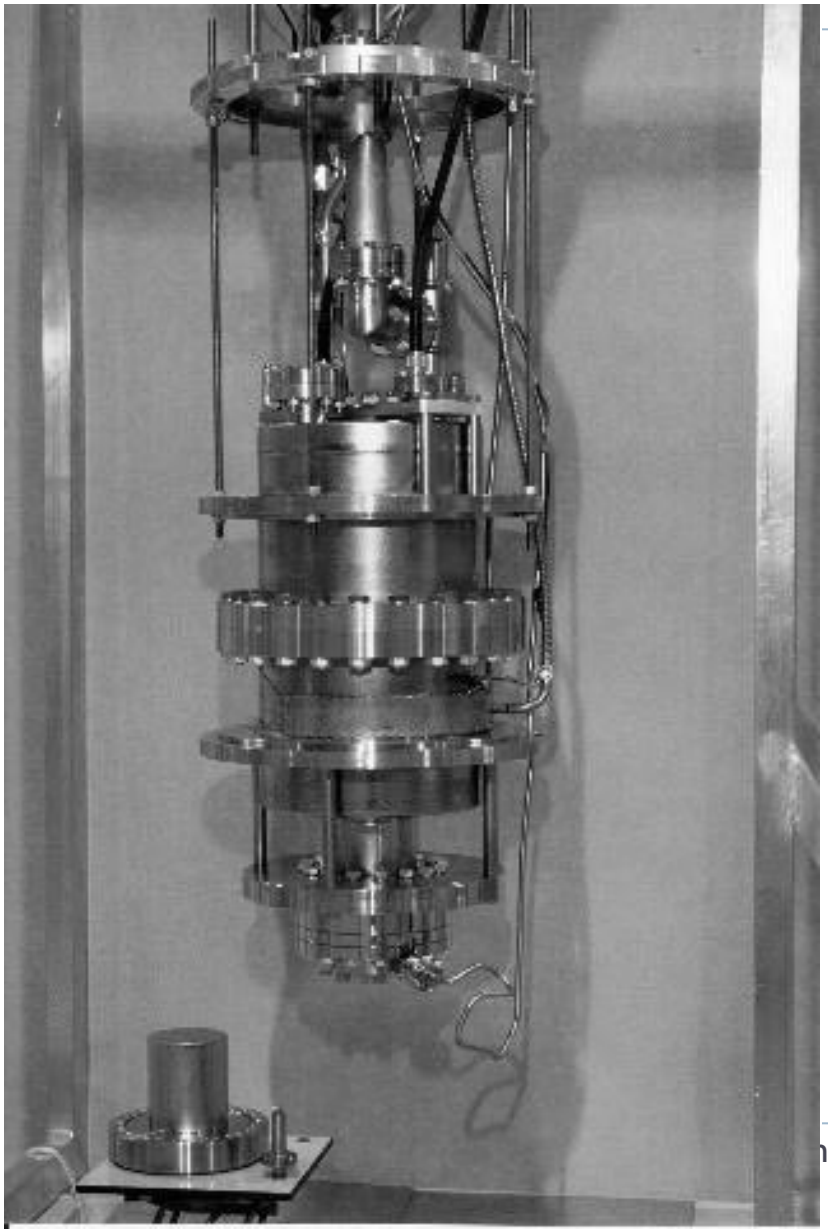
Average estimated cryogenic load (equivalent to 4.5 K) for the RF tests in SM18 for 2009 – 2014 (numbers beyond 2013 are estimations provided the SPL will be approved)

Schedule 2009

- *Manage and coordinate working group* (Weingarten/Chel)
  - Organize cavity design and construction WG/resources plan
  - Organize periodical coordination meetings
- *Ancillary equipment I (power coupler)* (Montesinos)
  - Conceptual specification
- *Surface analysis tools* (Junginger)
  - Commissioning of quadrupole resonator for validating surface treatments
- *Surface preparation and clean rooms (*Calatroni)
  - Ordering of electropolishing equipment
- *Design/Manufacture of cavities (*Capatina)
  - Mechanical optimization of cavity shape
  - Design of magnetic shielding of individual cavities (S. Sgobba, T. Junginger)
- *Ancillary equipment III (HOM coupler)* (Glock)
  - Conceptional specification

SM18 related items in RED

Commissioning of quadrupole resonator for validating surface treatments



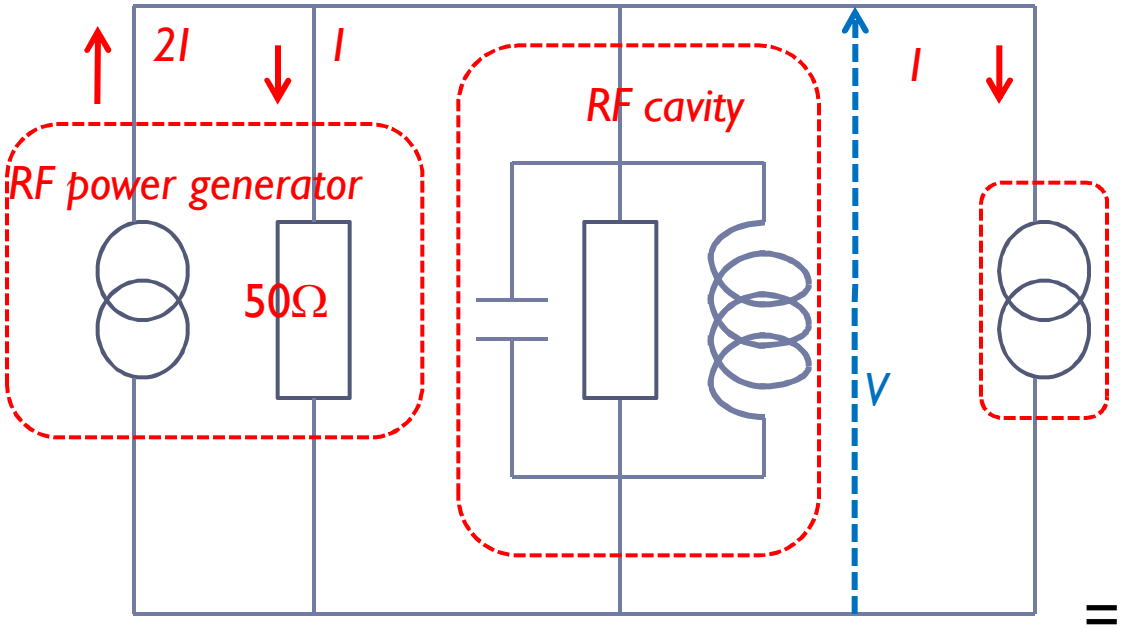
- Quadrupole resonator for testing SRF samples at 400, 800, 1200, … MHz

Schedule 2010

- *Manage and coordinate working group* (Weingarten/Chel)
  - Organize periodical coordination meetings
- *Surface preparation and clean rooms* (request by RF-KS)
  - Ordering monitoring systems for assembly
- *RF testing at low temperatures* (request by RF-KS)
  - Refurbish low power RF layout, controls and cabling for vertical cryostat no. 3
  - Provision of magnetic shielding for vertical cryostat
  - Design of magnetic shielding for cryomodule
  - Testing sample cavities
- *RF power equipment* (ref. to WG1)
  - Order 704 MHz high power amplifier
  - Design and construct of pulsed power converter for the RF amplifier
- *Ancillary equipment I (power coupler)* (Montesinos)
  - Technical design specification
  - Start fabrication
  - Provision of warm conditioning test stand (Saclay)

SM18 related items in RED

RF power equipment



$V = E_a \cdot L$

$Q_{ext} = V/(R/Q \cdot I \cdot \cos\phi)$

$L = 1.065$ m $E_a = 25$ MV/m

$\phi = 15°$ $I = 40$ mA

$\tau = 2$ msec $f_{rep} = 50$ Hz

$R/Q_{linac} = 566\ \Omega$

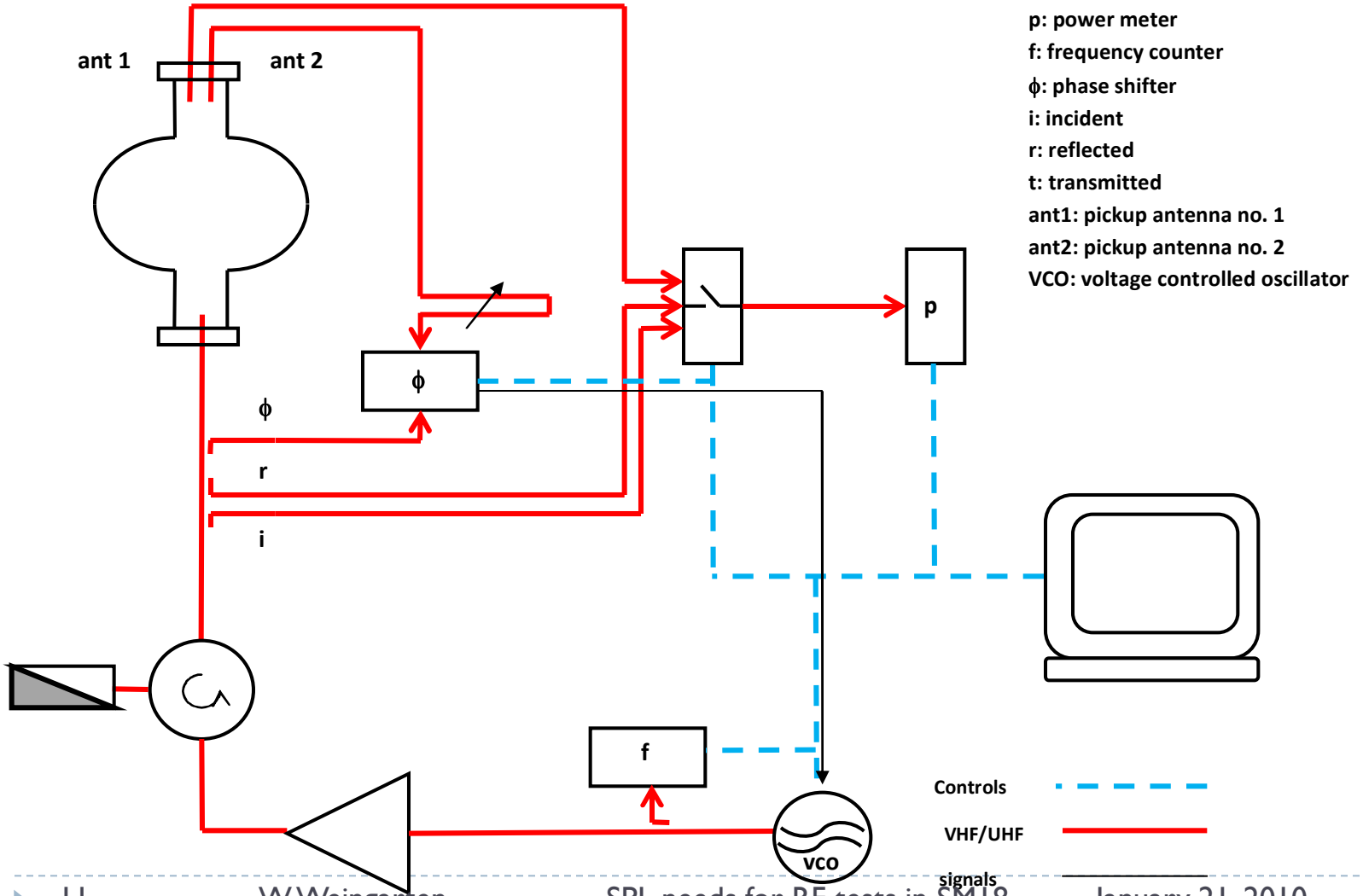
$\Rightarrow Q_{ext} = Q_L = 1.2 \cdot 10^6$

$\Rightarrow P = V \cdot I \cdot \cos\phi = 1$ MW peak

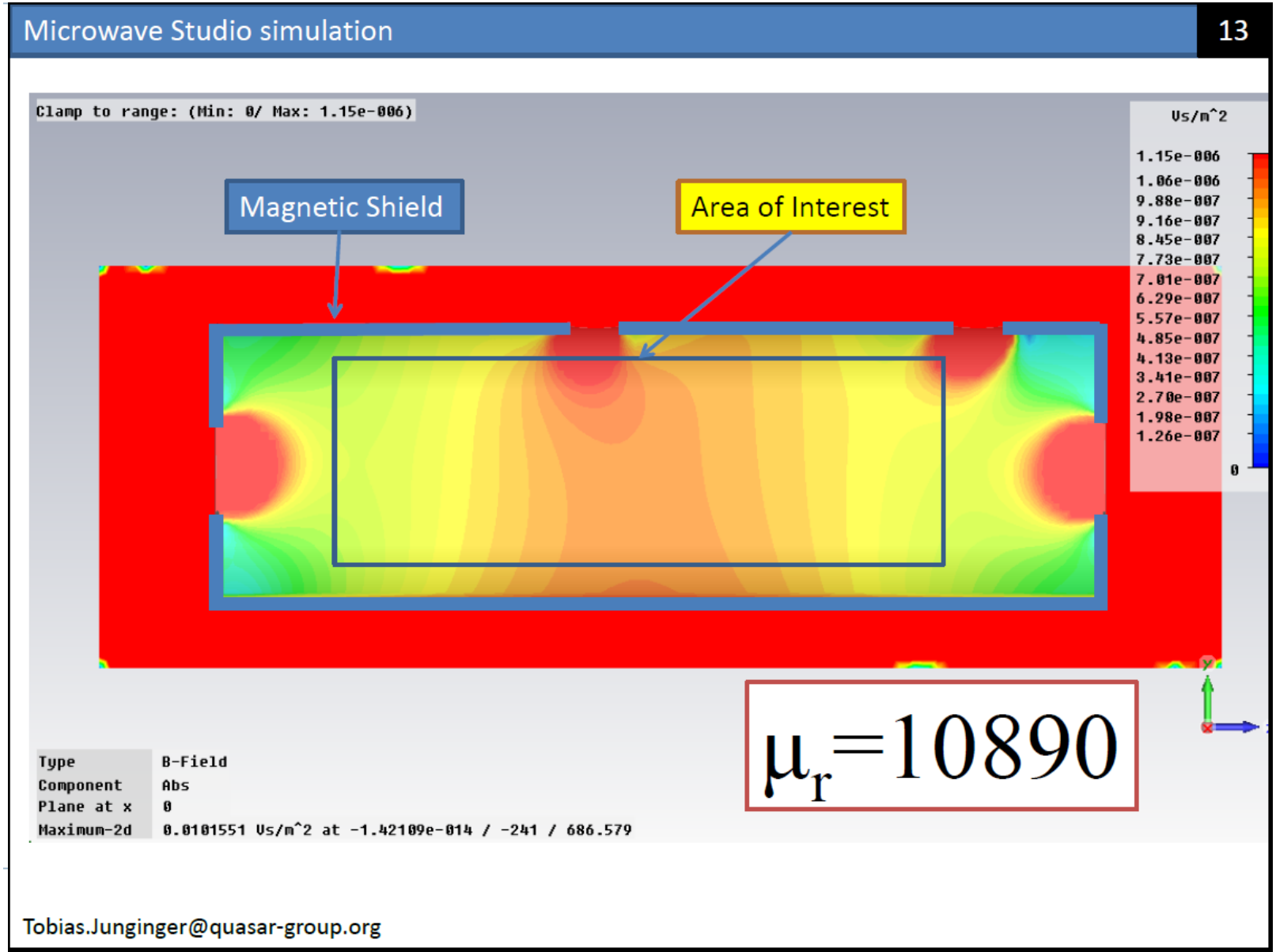
- BUT: without beam P = 250 kW
- => in SM18 we can feed 4 cavities simultaneously with a 1 MW klystron

Refurbish low power RF layout, controls and cabling for vertical cryostat no. 3

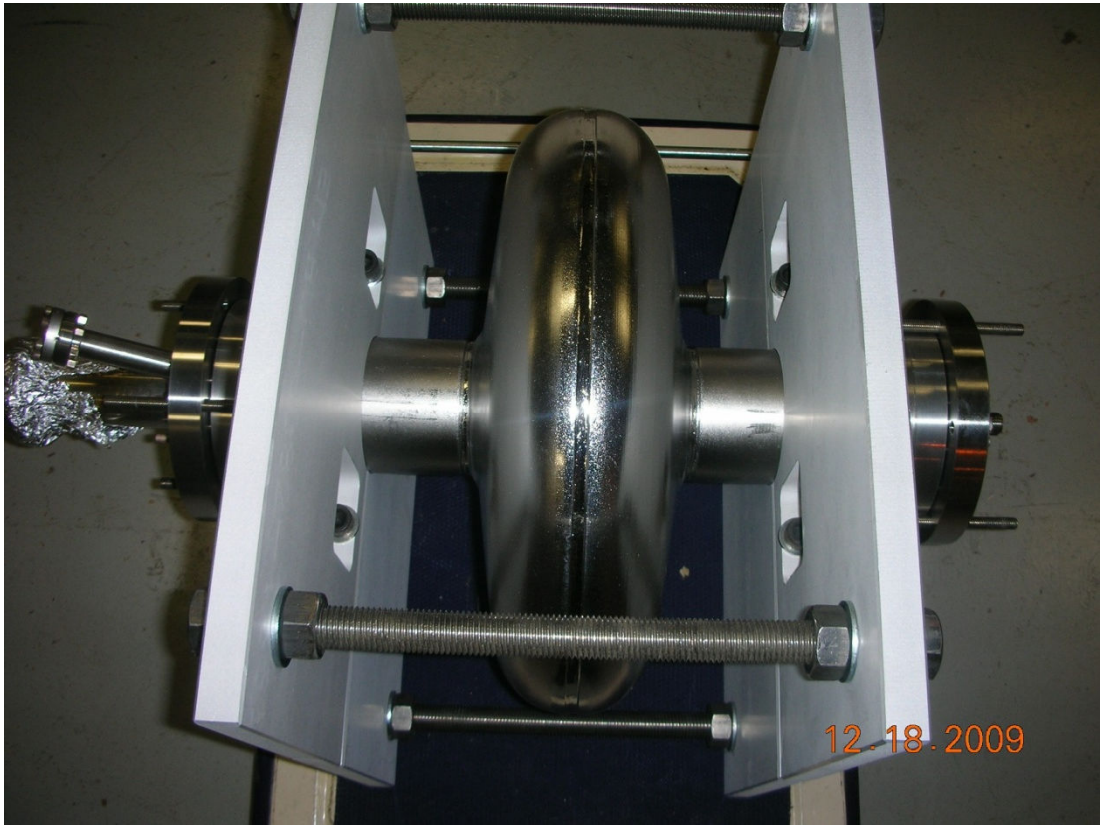
- ***RF scheme for vertical tests***



Design of magnetic shielding for cryomodule



Testing sample cavities



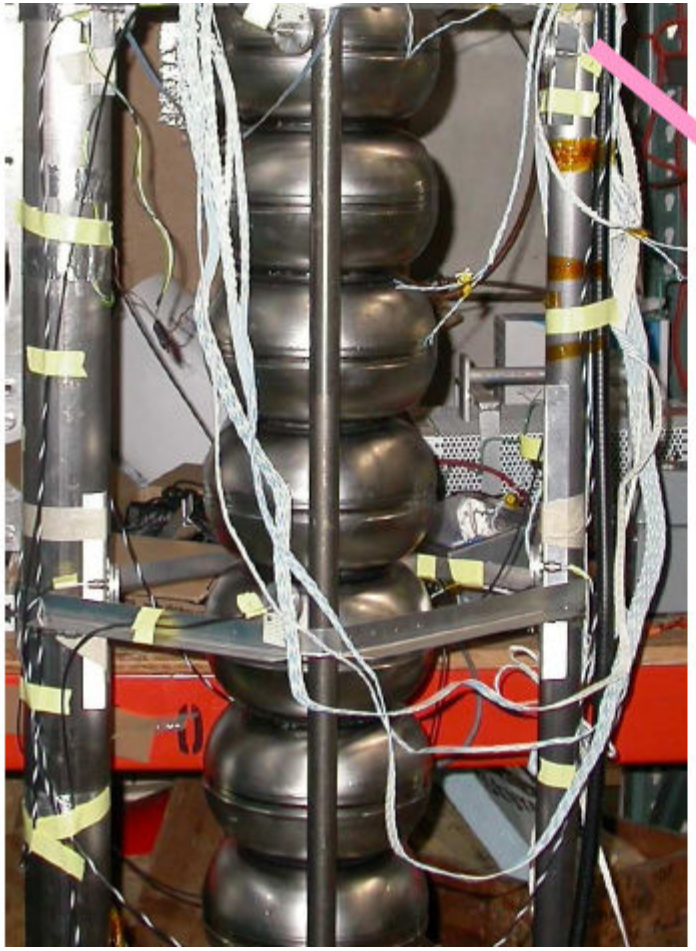
- 704 MHz monocell cavity (β = 0.5) manufactured by CEA/Saclay and available at CERN for validating surface preparation procedures and test equipment

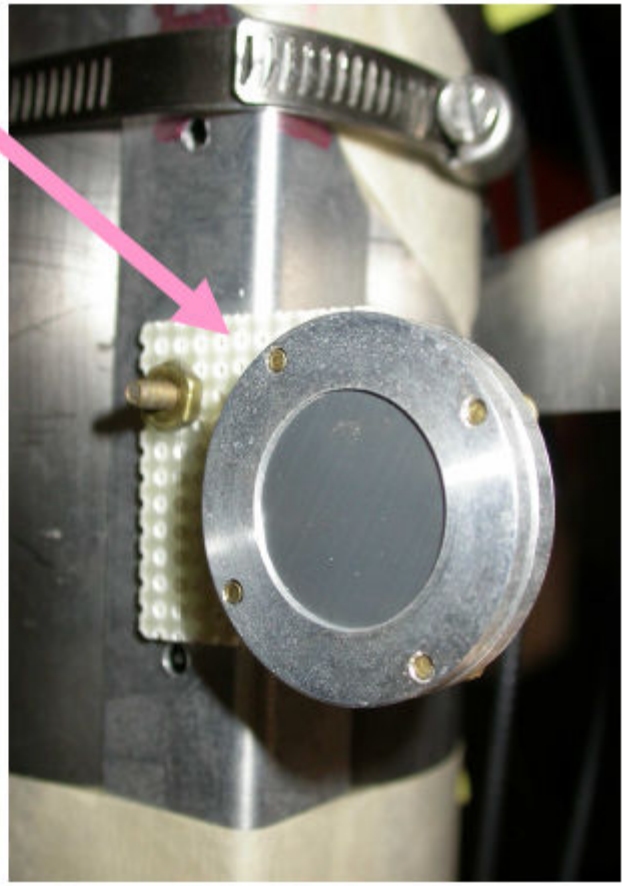
Schedule 2010 cont'd

- *Design/Manufacture of cavities*
  - RF optimization of cavity shape/Definition of synergies across labs (with BNL (Calaga))
- *Ancillary equipment III (HOM coupler)* (request by RF-KS)
  - Validation of design with Cu cavity
- *Ancillary equipment IV (Inspection equipment for on-line and post mortem analysis)* (request by RF-KS)
  - Quench detection in HeII by "second sound" (possibly with Univ.'s Göttingen/Wuppertal)
  - Upgrade inspection equipment (Questar® type)
  - Design temperature mapping equipment
- *Cryogenics for RF tests* (Vuillerme)
  - Design cryogenic equipment for vertical and horizontal cryostats and helium distribution (4.5 and 2 K)
- *Surface preparation and clean rooms* (Calatroni)
  - Ordering processing systems (HPR)
  - Processing of sample sc cavities

SM18 related items in RED

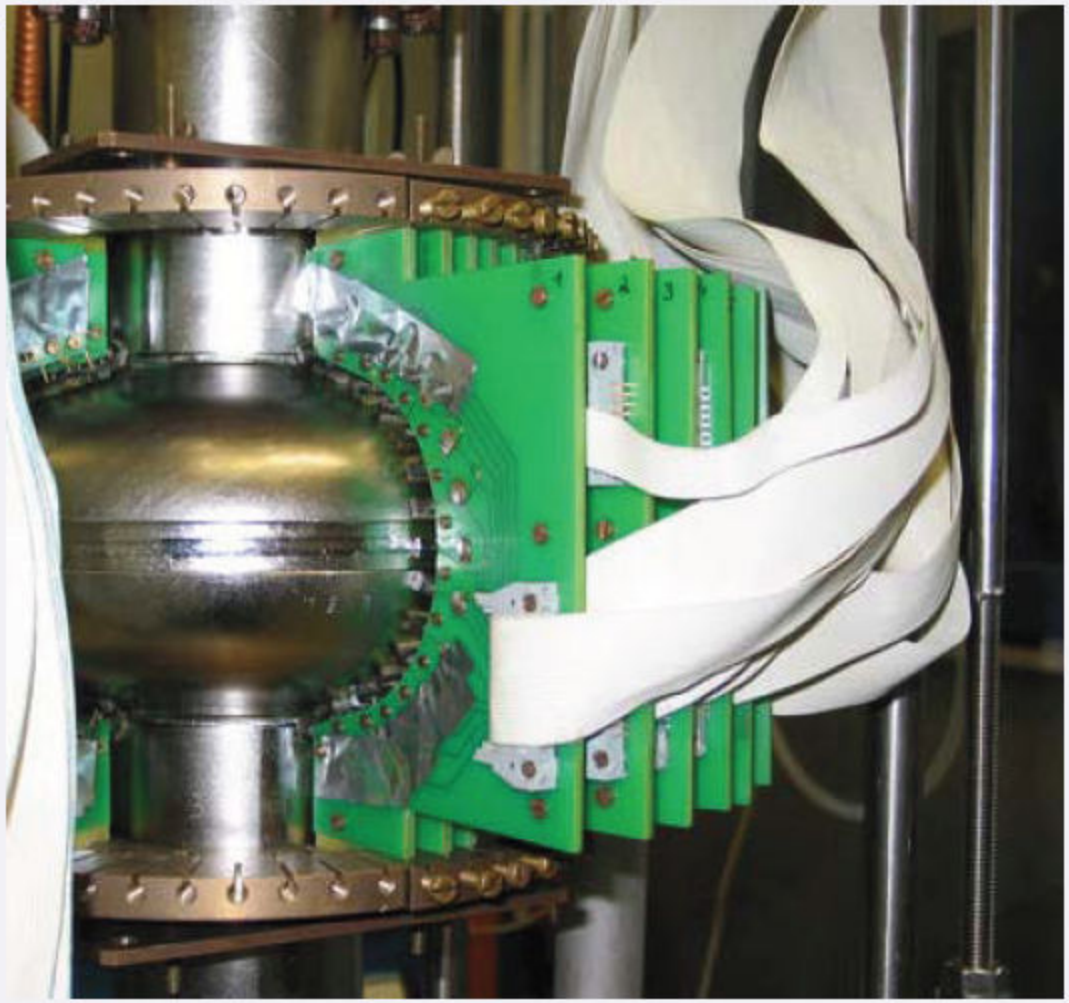
Quench detection in HeII by "second sound"





Second sound detection system in use at Cornell University adopted from Z A Conway TTC report 2008-006

Design temperature mapping equipment



Temperature mapping equipment
in use at DESY
adopted from D. Reschke, WD MöCller
TTC meeting DESY Jan 2008

Schedule 2010 cont'd

- *Water rinsing stations* (Calatroni)
  - Ordering processing systems upgrade b. 118 (hardware and control)
- *Ancillary equipment II (Frequency tuner)* (Capatina)
  - Adaptation of CEA tuner to SPL cavity
- *Design/Manufacture of cavities* (Capatina)
  - Manufacture of Cu cavity model
  - Individual cavity tuning and field flatness tuning equipment
  - Purchase of niobium
  - Writing technical specification
  - Start fabrication of Nb cavities
- *Ancillary equipment III (HOM coupler)* (Glock, Rostock)
  - Technical design specification

SM18 related items in RED

Schedule 2011

- *Manage and coordinate working group* (Weingarten/Chel)
  - Organize periodical coordination meetings
- *Surface preparation and clean rooms* (request by RF-KS)
  - Upgrade of clean room equipment
  - Processing of sc cavities
- *RF testing at low temperatures* (request by RF-KS)
  - Perform RF tests of individual cavities in vertical cryostat
- *RF power equipment* (ref. to WG1)
  - Acquire and commission high power equipment for RF test in bunker
- *Ancillary equipment I (power coupler)* (Montesinos)
  - Conditioning of power couplers
- *Ancillary equipment III (HOM coupler)* (request by RF-KS)
  - RF test on sc cavity
  - Start fabrication
- *Ancillary equipment IV (Inspection equipment for on-line and post mortem analysis)* (request by RF-KS)
  - Manufacture and commission temperature mapping equipment

SM18 related items in RED

Schedule 2011 cont'd

- *Cryogenics for RF tests* (Vuillerme)
  - Acquire and install cryogenic equipment for vertical and horizontal cryostats and helium distribution (4.5 K)
  - Acquire and install cryogenic equipment for helium pumping and purification (2 K)
- *Surface preparation and clean rooms* (Calatroni)
  - Treatment of SPL cavities as requested
- *Design/Manufacture of cavities (Chel, CEA)*
  - Manufacture of cavities by CEA (Saclay)
- *Ancillary equipment II (Frequency tuner) (Chel, CEA)*
  - Fabrication of 8 (+1) tuners
- *RF testing at low temperatures (Chel, CEA)*
  - Low power tests (validation) of externally built cavities in CEA (Saclay)
- *Design/Manufacture of cavities (Olry, CNRS)*
  - Manufacture of cavities by CNRS (Orsay)
- *RF testing at low temperatures (Olry, CNRS)*
  - Low power tests (validation) of externally built cavities in CEA (Saclay)

SM18 related items in RED

Schedule 2012

- *Manage and coordinate working group* (Weingarten/Chel)
  - Organize periodical coordination meetings
  - Preparation of design report and cost estimate

SM18 related items in RED

- *Surface preparation and clean rooms* (request by RF-KS)
  - Assembling of complete cryomodule with 8 cavities in SM18
- *RF testing at low temperatures* (request by RF-KS)
  - Extensive tests of sc cavities in SM18
  - Perform RF tests of cryomodule in bunker
- *RF testing at low temperatures (Chel, CEA)*
  - High power tests in Cryholab CEA (Saclay)/cryomodule (CERN)
- *RF testing at low temperatures (Olry, CNRS)*
  - High power tests in Cryholab CEA (Saclay)/cryomodule (CERN)

Conclusion

1. Available funding (for the SPL study) is taken as granted.
2. This funding must very soon entail hiring additional personnel and acquiring equipment for tasks such as
   - *Surface preparation and clean rooms*
   - *RF testing at low temperatures*
   - *Ancillary equipment III (HOM coupler validation on cold cavity)*
   - *Ancillary equipment IV (Inspection equipment for on-line and post mortem analysis)*

- *With these two conditions satisfied we have a realistic chance to assemble and test the fully equipped SPL cryomodule in the first half of 2012.*