Report from WG2 (cavity) and objectives of the meeting

W. Weingarten / CERN

3rd SPL Collaboration Meeting CERN
11 – 13 Nov 2009

sLHC

Participants (as of today)

- CERN
  - BE-RF (coordination, low and high power RF tests, rinsing, clean rooms, ancillaries, inspection)
  - TE-CRG (cryogenics SM18)
  - TE-VSC (surface preparation)
  - EN-MME (manufacture)
- CEA - Saclay (manufacture, low power RF tests, ancillaries, surface preparation)
- CNRS - Orsay (manufacture)
- TEMF Uni Darmstadt (em simulations: interaction of power coupler with beam)
- Uni Rostock (em simulations of HOM coupler)
- Uni Goettingen/Wuppertal (diagnostics) [1]
- BNL (manufacture)
- TRIUMF (manufacture)

[1] to be confirmed by fall 2010

Participants

Tentative planning

No.	*Task*	2009	2010	2011	2012	Coordination
1	**CERN/CEA-Saclay**					
1.1	*Manage and coordinate working group*					Weingarten/Chel
1.1.1	Organize cavity design and construction WG/resources plan	x				
1.1.1	Organize periodical coordination meetings	x	x	x	x	
1.1.1	Preparation of design report and cost estimate				x	
2	**CERN**					Weingarten/Calatroni
2.1	**CERN-BE-RF**					Weingarten
2.1.1	*Surface preparation and clean rooms*					request by RF-KS
2.1.1.1	Ordering monitoring systems for assembly		x			
2.1.1.2	Ordering test systems upgrade		x			
2.1.1.3	Upgrade of clean room equipment			x		
2.1.1.4	Processing of sc cavities			x		
2.1.1.5	Assembling of complete cryomodule with 8 cavities in SM18				x	
2.1.2	*Water rinsing stations*					request by RF-KS
2.1.2.1	Ordering processing systems upgrade b. 252					
2.1.3	*RF testing at low temperatures*					request by RF-KS
2.1.3.1	Refurbish low power RF layout, controls and cabling for vertical cryostat no. 3		x			
2.1.3.2	Design & provision of magnetic shielding for vertical cryostat		x			
2.1.3.3	Testing sample cavities		x			
2.1.3.4	Perform RF tests of individual cavities in vertical cryostat			x		
2.1.3.5	Extensive tests of sc cavities in SM18				x	
2.1.3.6	Perform RF tests of cryomodule in bunker				x	

Participants (2)

No.	*Task*	2009	2010	2011	2012	Coordination
2.1.4	*RF power equipment*					ref. to WG1
2.1.4.1	Order 704 MHz high power amplifier		x			
2.1.42	Design and construct of pulsed power converter for the RF amplifier		x			
2.1.4.3	Acquire and commission high power equipment for RF test in bunker					
2.1.5	*Ancillary equipment I (power coupler)*					Montesinos
2.1.5.1	Conceptual specification	x				
2.1.5.2	Technical design specification		x			
2.1.5.3	Start fabrication		x			
2.1.5.4	Provision of warm conditioning test stand					
2.1.5.5	Conditioning of power couplers					
2.1.6	*Design/Manufacture of cavities*					
2.1.6.1	RF optimization of cavity shape/Definition of synergies across labs					with BNL (Calaga)
2.1.7	*Ancillary equipment III (HOM coupler)*					request by RF-KS
2.1.7.1	Validation of design with Cu cavity					
2.1.7.2	RF test on sc cavity					
2.1.7.3	Start fabrication		x			
2.1.8	*Ancillary equipment IV (Inspection equipment for on-line and post mortem analysis)*					request by RF-KS
2.1.8.1	Quench detection in HeII by "second sound"					possibly with Univ.'s Göttingen/Wuppertal
2.1.8.2	Upgrade inspection equipment (Questar® type)			x		
2.1.8.3	Design temperature mapping equipment		x			
2.1.8.4	Manufacture and commission temperature mapping equipment			x		
2.1.9	*Surface analysis tools*					Junginger
2.1.9.1	Commissioning of quadrupole resonator for validating surface treatments	x				
2.2	***CERN-TE-CRG***					Vuillerme
2.2.1	*Cryogenics for RF tests*					
2.2.1.1	Design cryogenic equipment for vertical and horizontal cryostats and helium distribution (4.5 and 2 K)		x			
2.2.1.2	Acquire and install cryogenic equipment for vertical and horizontal cryostats and helium distribution (4.5 K)			x		
2.2.1.3	Acquire and install cryogenic equipment for helium pumping and purification (2 K)			x		

Participants(3)

No.	*Task*	2009	2010	2011	2012	Coordination
2.3	***CERN-TE-VSC***					Calatroni
2.3.1	*Surface preparation and clean rooms*					
2.3.1.1	Ordering of electropolishing equipment	x				
2.3.1.2	Processing of sample sc cavities		x			
2.3.1.3	Ordering processing systems		x			
2.3.1.4	Treatment of SPL cavities as requested			x		
2.3.2	*Water rinsing stations*					
2.3.2.1	Ordering processing systems upgrade b. 118					
2.4	***CERN-EN-MME***					Capatina
2.4.1	*Ancillary equipment II (Frequency tuner)*					
2.4.1.1	Adaptation of CEA tuner to SPL cavity		x			to be defined
2. 4.2	*Design/Manufacture of cavities*					
2.4.2.1	Mechanical optimization of cavity shape					
2.4.2.2	Design of magnetic shielding of individual cavities					
2.4.2.3	Individual cavity tuning and field flatness tuning ?					
2.4.2.4	Purchase of niobium		x			
2.4.2.5	Writing technical specification		x			
2.4.2.6	Start fabrication of cavities		x			

No.	*Task*	2009	2010	2011	2012	Coordination
3	**CEA-Saclay**					Chel/Devanz
3.1	*Design/Manufacture of cavities*					
3.1.1	Manufacture of cavities by CEA (Saclay)			x		
3.2	*Ancillary equipment II (Frequency tuner)*					
3.3.1	Fabrication of 8 (+1) tuners			x		
3.3	*RF testing at low temperatures*					
3.3.1	Low power tests (validation) of externally built cavities in CEA (Saclay)			x		
3.3.2	High power tests in Cryholab CEA (Saclay)/cryomodule (CERN)				x	
4	**CNRS-Orsay**					Olry
4.1	*Design/Manufacture of cavities*					
4.1.1	Manufacture of cavities by CNRS (Orsay)			x		
4.2	*RF testing at low temperatures*					
4.2.1	Low power tests (validation) of externally built cavities in CEA (Saclay)			x		
4.2.2	High power tests in Cryholab CEA (Saclay)/cryomodule (CERN)				x	

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Participants (4)

No.	*Task*	2009	2010	2011	2012	Coordination
5	**TEMF TU Darmstadt**					Weiland/Müller
5.1	*Ancillary equipment I (Power coupler)*					
5.1.1	Simulation of parasitic effects on beam of power coupler					
6	**Uni Rostock**					Van Rienen/Glock
6.1	*Ancillary equipment III (HOM coupler)*					
6.1.1	Conceptional specification	x				
6.1.2	Technical design specification		x			
7	**BNL - USA**					Ben-Zvi
7.1	*Design/Manufacture of cavities*					
7.1.1	Manufacture of SPL cavities					
8	**TRIUMF - Canada**					Baartman/Laxdal
8.1	*Design/Manufacture of cavities*					
8.1.1	Manufacture of SPL cavities ($\beta = 0.65$)					

Coordination with other programs

- FP 7 - Eucard (Grant agreement no. 227579)
  - Networking activities
    - Work Package 4: Accelerator Science Networks: EuroLumi and RFTech
  - Joint Research activities
    - Work Package 10: Superconducting RF technology for proton accelerators and electron linear accelerators
      - Task 2. SC Cavities for Proton Linacs, Electro-polishing and surface investigations.

        Design and fabrication of two β = 1 ; 5-cell 704 MHz elliptical cavities (if budget frame sufficient)

        Sub-task 2: Design and fabrication of β = 1; 704 MHz elliptical cavity. Preparation of the cavity and assembly in clean room. Development of a vertical EP bench and upgrade of HPR and field-flatness set-ups suited to the cavity size and weight. This sub-task is under responsibility of CEA-DSM-Saclay. The cavity interfaces with a cryomodule will be studied with CERN.
- FP 7 - SLHC-pp [1] (Grant agreement no. 212114)
  - WP RF systems
    - Study of field stabilization in pulsed mode
    - Power test of RF system at CEA-Saclay 704 MHz test stand

[1] Large Hadron Collider upgrade - preparatory phase

Coordination with other programs (2)

- "Contribution de la France au CERN"
  - Design and procurement of 2 helium vessels for β = 1 cavities
  - Fabrication and procurement of 8 (+1) tuners for β = 1 cavities
  - 3D model of a 704 MHz 1 MW power coupler for elliptical cavities qualified at CEA-Saclay (**√**)
  - 3D model of a active frequency tuner for 704 MHz elliptical cavities (**√**)
  - Required new or upgraded equipment:
    - Construction of vertical EP station
    - Modification of set-up for field flatness tuning
    - Modification of high pressure water rinsing system
    - Modification of vertical insert of cryostat
- BMBF German Universities (Rostock, Darmstadt, …)
  - electromagnetic simulations and diagnostics[1]

[1] to be confirmed

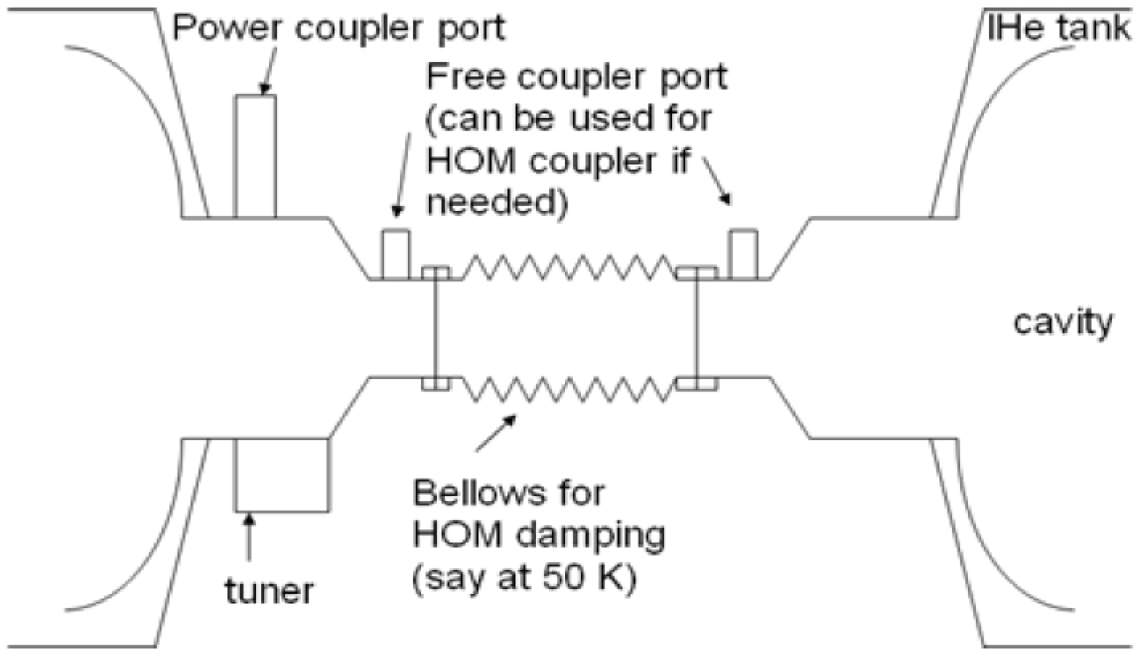
HOM workshop

http://indico.cern.ch/contributionListDisplay.py?confId=57247

1. **HOM spectrum:** The HOMs possessing a significant interaction with the beam (high R/Q) cluster around only few frequency bands: TE_{111}, TM_{110} and TM_{011}.
2. **Upper tolerable limit for Q_{ext} from the beam break up point of view:** Notwithstanding further more complete simulations, a Q_{ext} of $10^6 – 10^8$ seems tolerable.
3. **Worst case maximum tolerable RF power absorbed by the HOM coupler:** this situation may occur if the machine line coincides with one of the frequencies of HOMs with a high R/Q. The cavity geometry should be chosen in such a way to avoid this situation.
4. **"Most elegant solution":** using the cut-off features of the beam tubes in such a way as to confine the fundamental mode and possibly unavoidably a few HOMs and to let pass into the beam tubes all other HOMs to be damped there. However, possible trapped modes must be identified and eliminated by a suitable choice of the cavity geometry.
5. **"Next but less elegant solution":** tapered beam tube (not necessary symmetric for both cavity ends) with a bigger diameter close to the cavity to house the power coupler and a smaller diameter further off providing sufficient damping to the fundamental and less or no damping to the HOMs. The HOM power may propagate still further into the connection bellows between cavities. That part of the beam tube with the smaller diameter may be equipped with ports that may take antenna type HOM coupler(without notch filter) in case they are needed (c.f. scheme below). During the discussion no fundamental objections were raised concerning this idea.

HOM Workshop (2)

“Artists” view



Recommendations by the chairpersons (collected after the meeting)

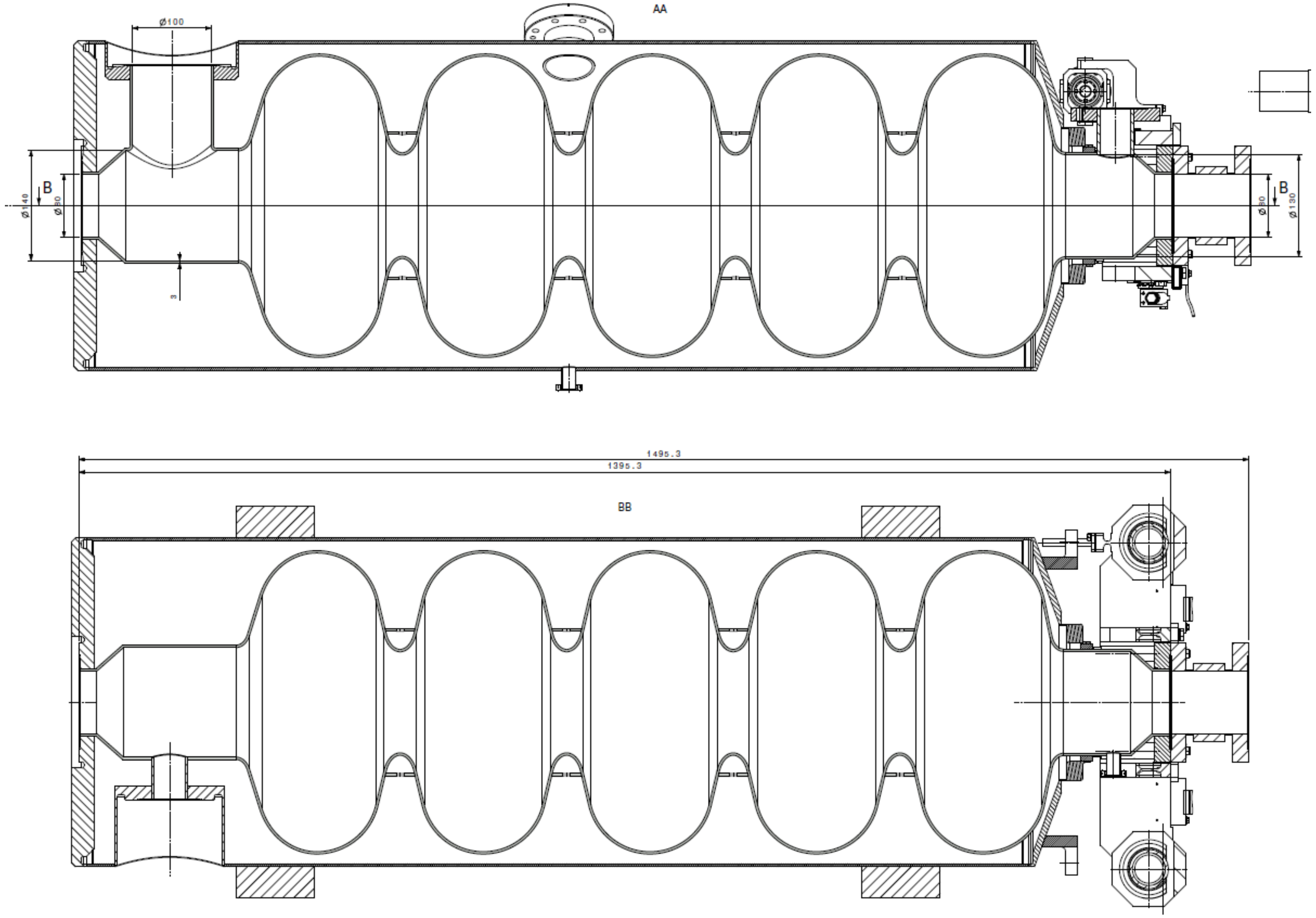
Therefore we recommend

(1) to build the demonstrator by using at maximum the existing experience, recipes and technical solutions, i.e. the CEA-Saclay/XFEL design as baseline, unless they turn out to be not adaptable to, or not needed for, the SPL project.

(2) to perform a comprehensive study, in parallel to the work on the demonstrator, about all the mechanical and electrical topics which were mentioned in the preceding conclusions. The results of this study may require the manufacture of related hardware, i.e. cavity equipped with stainless steel He tank and modified tuner.

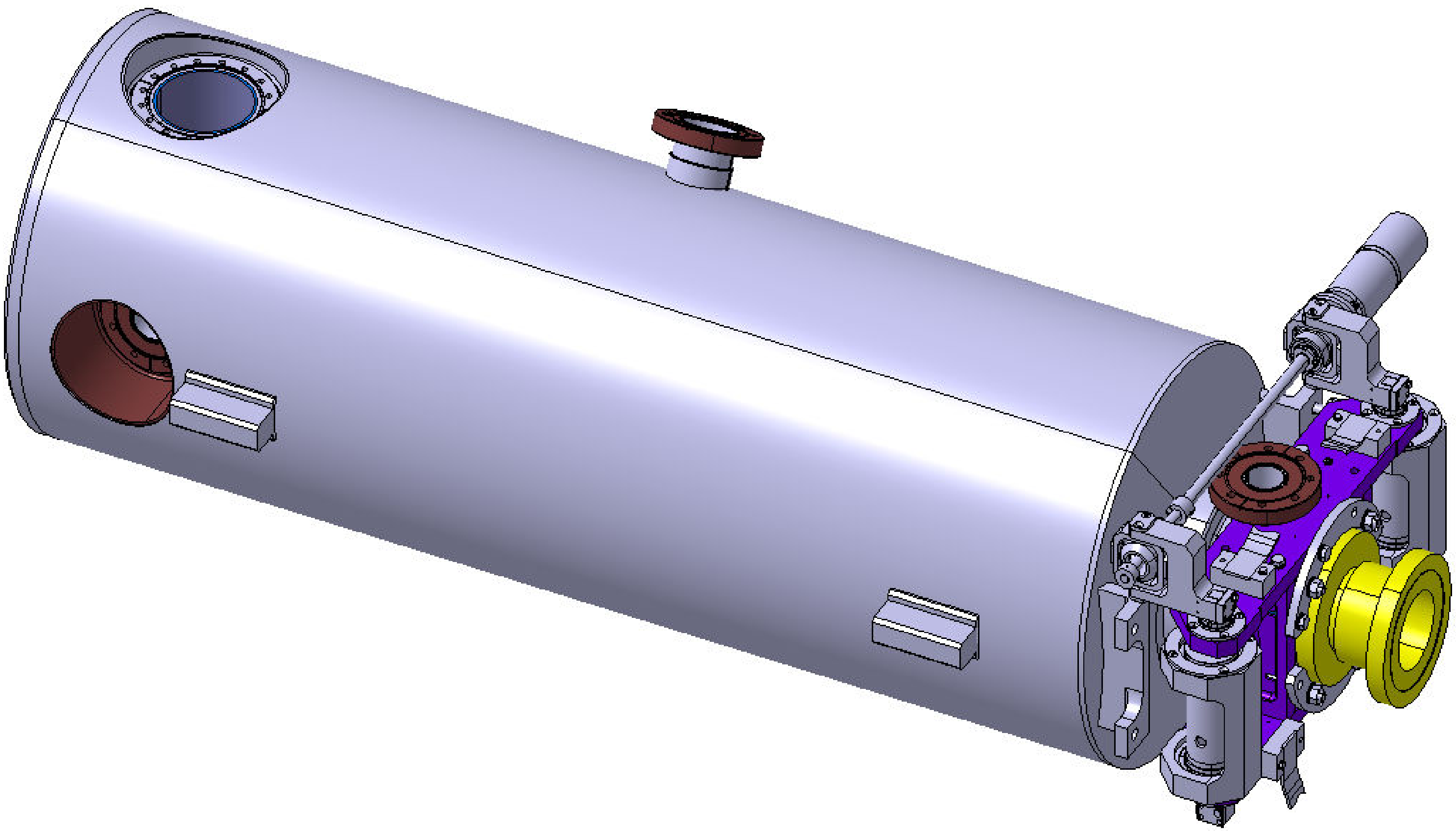
Mechanical issues Workshop - follow up

provided by Thierry Renaglia



Mechanical issues Workshop- follow up (2)

provided by Thierry Renaglia



Meetings of Working Group

WG "Cavities" meeting No. 1.rev 29 Juni 2009

Objective:

SPL cavities Working Group meeting to define a first iteration of the limiting structure of the cavities including ancillaries

Participants:

S. Chel, G. Devanz, J. Plouin (all CEA), G. Olry (CNRS), W. Weingarten, S. Weisz (all CERN)

Location and venue:

CEA Saclay on 20 June 2009

…

Power coupler: directed vertically, with HOM coupler port in opposite direction (180 degrees); 2nd HOM coupler port at other end of cavity in perpendicular direction than the 1st one

HOM couplers, if needed, shall be dismountable

Flanges and joints: manufactured from NbTi with Al joint

Diameter of beam tubes end flanges 80 mm

Saclay tuner is adopted, consisting of a mechanical and a piezo-electrical tuner

…

WG "Cavities" meeting No. 2.rev Draft 8 Sep 2009

Objective

- Continue the definition of "interfaces" wrt. responsibilities and technical issues
- Prepare the WG meeting at SRF09 in Berlin

Participants

S. Chel, G. Devanz (CEA), G. Olry (CNRS), O. Capatina, E. Montesinos, W. Weingarten (CERN)

Location and venue

CEA Saclay on 4 Sep 2009

…

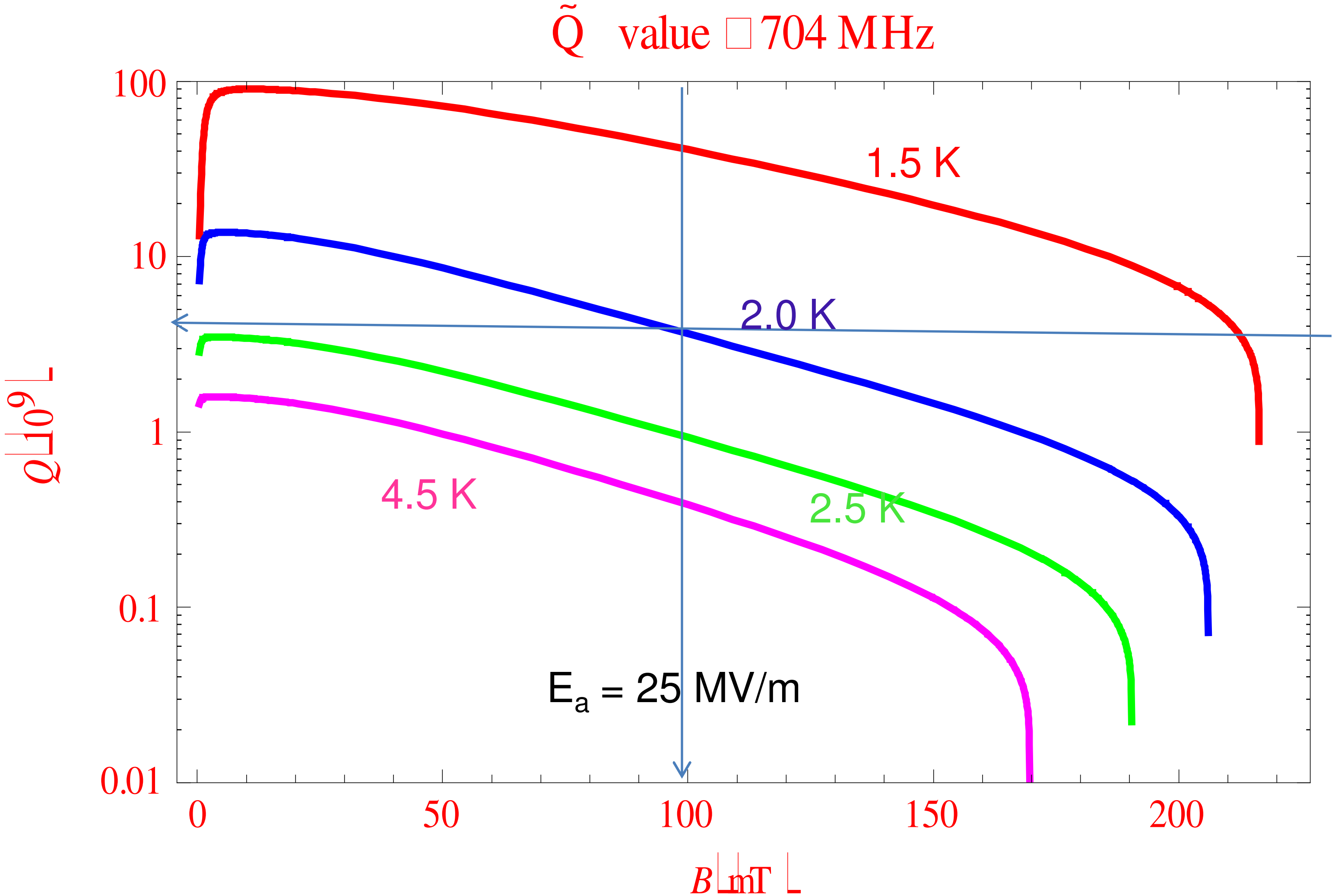
HOM coupler workshop:
The requirements to the external Q-values might allow a damping scheme in the beam tubes (bellows) in between cavities.

The question whether one needs or not HOM coupler ports for e.g. beam diagnosis remains open
(since we decided to foresee them).

…

Specifications LP-SPL; HP SPL

Q-value at 1.5, 2.0, 2.5 and 4.5 K, averaged over ~ 1500 data points (R_s ,T ,f ,B)



Specifications LP-SPL; HP SPL

LP-SPL

kinetic energy 4 GeV

beam power (@ 4 GeV) 0.16 MW

repetition rate 0.6 - 2 Hz

beam pulse length 0.9 ms

average pulse current 20 mA

protons p. pulse 1.1 10^{14}

length (SC linac, nominal) 450 m

HP-SPL

kinetic energy	5 GeV
beam power (@ 4 GeV)	3-8 MW
repetition rate	50 Hz
beam pulse length	0.4-1.2 ms
average pulse current	20/40 mA
protons p. pulse	1-3 10^{14}
length (SC linac, nominal)	525 m

max. gradient (β=0.65/β=1)	19.3/25 MV/m
RF frequency	704 MHz
Q_0 (β=0.65/β=1)	5.8/8.4 x 10^9
(R/Q) (β=0.65/β=1)	290/570 Ω

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Objectives of the meeting with regard to WG 2

- Inform participants of the SPL Study of the status and decisions taken up till now (baseline design)
- Check the “baseline design” of the cavity, tuner, He tank, possibly power coupler, including the interfaces to the cryo-module, with regard to the specification parameters of the LP-SPL and identify pending issues and deadlines for decisions
- Identify and prioritize missing items/devices/facilities not yet available or addressed or covered by resources
- Identify items not compatible with the specification parameters of the HP-PL or other proposals and go for synergies with the aim to define “the” standard p-linac cavity & accessories
- Define the precise contribution of each partner (deliverables and planning) and the interactions between partners (names of persons in charge, exchange of information/hardware, planning of meetings, …)

  Make use and check the “Tentative planning” (in this presentation)
- Define WG2 periodic meetings and information exchange policy; decide on the envisaged dates in 2010