CARE/JRA3: Second Quarterly Report 2008
31/10/2008

Title: High Intensity Pulsed Proton Injectors (HIPPI)

Coordinator: M. Vretenar (CERN), Deputy: A. Lombardi

Participating Laboratories and Institutes:

Institute (participant number)	Acronym	Country	Coordinator	Scientific Contact	Associated to
CCLRC Rutherford Appleton Laboratory (20)	CCLRC	UK	P. Norton	C. Prior	
Commissariat à l'Energie Atomique (1)	CEA	F	R. Aleksan	A. Mosnier	
CERN (17)	CERN	CH	G. Guignard	M. Vretenar	
Forschungszentrum Jülich (7)	FZJ	D	R. Tölle	R. Tölle	
Gesellschaft für Schwerionenforschung, Darmstadt (4)	GSI	D	N. Angert	L. Groening	
Institut für Angewandte Physik - Frankfurt University (5)	IAP-FU	D	U. Ratzinger	U. Ratzinger	
INFN-Milano (10)	INFN-Mi	I	S. Guiducci	C. Pagani	INFN
CNRS Institut de Physique Nucléaire d'Orsay (3)	CNRS-IN2P3-Orsay	F	T. Garvey	G. Olry	CNRS
CNRS Laboratoire de Physique Subatomique et de Cosmologie (3)	CNRS-LPSC	F	T. Garvey	J.M. De Conto	CNRS
INFN-Naples	INFN-Na	I	S. Guiducci	V.G. Vaccaro	INFN

Main Objectives: Research and Development of the technology for high intensity pulsed proton linear accelerators up to an energy of 200 MeV.

Cost:

Total Expected Budget	**EU Funding**
12 M€ (FC) + 2.7 M€ (AC) **Total 14.7 M€**	**3.6 M€**

1 **Management Activity** 3
1.1 Meetings 3
2 Dissemination Activity 6
2.1 List of talks 6
2.2 List of papers 6
3 Additional staff hiring 8
4 Status of the Work 9
4.1 Work Package 1 : Management and Communication 10
4.2 Work Package 2: Normal Conducting Accelerating Structures 11
4.3 Work Package 3: Superconducting Accelerating Structures 24
4.4 Work Package 4: Beam Chopping 28
4.5 Work Package 5: Beam Dynamics 32
Appendix 1: Gantt chart at end of October 08 42

1 MANAGEMENT ACTIVITY

1.1 Meetings

The Spring Work Package meetings took place as foreseen between May and June 2008. The WP2 (Normal Conducting) meeting was organized at Grenoble by LPSC on June 10th and 11th. The meeting was devoted to a review of the ongoing work and to the preparation of the common assessment that will be the final deliverable of the Workpackage. The WP4 (chopper) had its meeting at CERN on June 20th. The WP5 hold its meeting at GSI Darmstadt on May 15th.

The last HIPPI Annual Meeting took place at CERN (Geneva), in the Accelerator and Beams Department, from October 29th to 31st.

CERN that has provided the Activity Coordination over the 5 year duration of the project has taken the charge of organising this last meeting. Being the last meeting of the series, its goals and structure were slightly different from previous years. The usual presentations on the status of the three accelerator projects supported by HIPPI (CERN Linac4, GSI FAIR and RAL High Power Proton Drivers) took place at the beginning of each session. The four Workpackage sessions were shorter, ~1.5 hours each, and were devoted to the usual summary of work done in the last year. After the WP sessions, a time of about one hour was devoted to the preparation of the common deliverables (common assessment), to be provided by the different Workpackages. The External Scientific Advisory Committee (ESAC) had the additional task of summarising the overall achievements of the JRA and give input to the comparative assessments of the different Workpackages. The last session of the meeting was devoted to a summary of status of the missing deliverables and to the plan for providing them before the end of the Activity. Visits of the CERN linacs, of the Linac4 Test Stand and of the Linac4 prototypes took place during the meeting. As usual, the meeting was concluded by the presentation from the chairperson of the ESAC.
At the meeting took part 38 participants from 10 Laboratories (9 participants to HIPPI, plus one external Laboratory).

The year 2008 has seen three important Conferences with active participation of the HIPPI members, HIPPI-related talks and an important number of papers submitted from HIPPI: the European Particle Accelerator Conference (Genoa, June), the HB Workshop (Nashville, August) and the finally the LINAC08 Conference (Victoria, September).

Table 1.1.1a: Overview of meeting, workshop and event (co)organized by the Activity or with Activity contributions

	Jan	Feb	March	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
CARE & HIPPI												
CSC Meeting				9 Paris					17-18 CERN			
WP2 Meeting						10-11 Grenoble						
WP3 Meeting												
WP4 Meeting						20 CERN						
WP5 Meeting					19 GSI							
HIPPI Annual Meeting										29-31 CERN		
CARE Meeting												2-5 CERN
Collaboration meetings												
LINAC4 Review	29-30 CERN		.									
ISTC CCDTL Meeting			10-13 CERN									
Conferences, workshops												
EPAC 2008						23-27 Genoa (I)						
HB2008								25-29 Nashville (TN, USA)				
LINAC 2008									28-3 Victoria (BC, Canada)			

Table 1.1.1b: List of meeting, workshop and event (co)organized by the Activity

Date	Title/subject	Location	Main organizer	Number of participants	Comments and Web site
19 May 2008	WP5 Meeting	Darmstadt (D)	GSI		
10-11 June 2008	WP2 Meeting	Grenoble (F)	LPSC	10	
20 June 2008	WP4 Meeting	Geneva (CH)	CERN		
29-31 October 2008	HIPPI Annual Meeting	Geneva (CH)	CERN	38	http://indico.cern.ch/conferenceDisplay.py?confId=39839

2 DISSEMINATION ACTIVITY

2.1 List of talks

Some talks relevant to HIPPI were presented during the second quarter of 2008. The list is given in Table 2.1.

Table 2.1: List of talks presented by the JRA

L. Groening (GSI)	Simulation of Experiments on Transverse rms-emittance growth along an Alvarez DTL	HB2008	http://neutrons.ornl.gov/workshops/hb2008/index.shtml
R. Tiede (IAP)	Konus Beam Dynamics Designs Using H-Mode Cavities	HB2008	http://neutrons.ornl.gov/workshops/hb2008/index.shtml
F. Gerigk (CERN)	Beam Dynamics in Linac4 at CERN	HB2008	http://neutrons.ornl.gov/workshops/hb2008/index.shtml
A. Lombardi (CERN)	CERN Linac Upgrade Activites	LINAC08	http://www.triumf.info/hosted/LINAC08/index.html

2.2 List of papers

Table 2.2: List of document issued by the NA or JRA

#	*CARE document type and number*	*Title*	*Authors and Labs*	**Date**
1	CARE-Note-2008-003 -HIPPI	Consideration on field ramp for the Linac4 DTL design	E. Sargsyan, A. Lombardi, CERN	06/2008
2	CARE-Report-08-14-HIPPI	HIPPI-Relevant Activities at IAP-Frankfurt on the Development of the Room Temperature CH-DTL Second Report	G. Clemente[1], H. Podlech[1], U. Ratzinger[1] R. Tiede[1], S. Minaev[2]IAP Frankfurt ITEP, Moscow	
3	CARE-Report-08-015-HIPPI	The Julich triple spoke resonator	H. Glückler1, W. Günther1, M. Pap1, R. Tölle1, E. Zaplatin1,G. Olry2, G. Michel2, S. Bousson2, P. Szott2 F. Eozenou3, Y. Gasser3 1) FZJ;2) IPN Orsay,3) CEA Saclay.	
4	CARE-Report-08-016-HIPPI	HIPPI Work Package 4 (WP4): The RAL† Fast Beam Chopper Development Programme Progress Report for the period: January 2007 –	M. A. Clarke-Gayther† † STFC/RAL	

		June 2008		
5	CARE-Report-08-020-HIPPI	Cern chopper final report ,	F. Caspers, T. Kroyer, M. Paoluzzi	
6	CARE-Report-08-021-HIPPI	CCDTL section for Linac4	G. De Michele1, F. Gerigk1 M. Pasini1, M. Vretenar1, A. Tribendis2 1) CERN, Geneva, Switzerland 2) BINP, Novosibirsk, Russia	
7	CARE-Report-08-027	Benchmarking of measurement and simulation of transverse rms-emittance growth	L. Groening, W. Barth, W. Bayer, G. Clemente, L. Dahl, P. Forck, P. Gerhard, I. Hofmann, G. Riehl, and S. Yaramyshev GSI; D. Jeon ORNL ; D. Uriot CEA-Saclay.	
8	CARE-Conf-08-020-HIPPI (LINAC08)	Development of a cell-coupled drift tube linac (CCDTL) for Linac4	Y. Cuvet, F. Gerigk, G. De Michele, M. Pasini, S. Ramberger, M. Vretenar, R. Wegner, CERN, E. Kenzhebulatov, S. Kryuchkov, E. Rotov, A. Tribendis, BINP, Novossibirsk, Russia M. Naumenko, VNIITF, Snezhinsk, Russia	10/2008
9	CARE-Conf-08-021-HIPPI (LINAC08)	Status of the Linac4 project at CERN	M. Vretenar, C. Carli, R. Garoby, F. Gerigk, K. Hanke, A.M. Lombardi, S. Maury, C. Rossi, CERN	10/2008
10	CARE-Conf-08-022-HIPPI (LINAC08)	CERN Linac upgrade activities	A.M. Lombardi, CERN	10/2008
11	CARE-Conf-08-024-HIPPI (LINAC08)	Development status of the pi-mode accelerating structure (PIMS) for Linac4	P. Bourquin, R. De Morais Amaral, G. Favre, F. Gerigk, J-M. Lacroix, T. Tardy, M. Vretenar,R Wegner, CERN	10/2008
12	CARE-Conf-08-025-HIPPI (LINAC08)	Drift tube linac design and prototyping for the CERN Linac4	S. Ramberger, N. Alharbi, P. Bourquin, Y. Cuvet, F. Gerigk, A.M. Lombardi, E. Sargsyan, M. Vretenar, CERN, A. Pisent,INFN/LNL	10/2008
13	CARE-Conf-08-026-HIPPI (LINAC08),	Diagnostics and measurement strategy for the CERN Linac4	K. Hanke , G. Bellodi, JB Lallement, A. Lombardi B. Mikulek, E. Sargsyan, CERN, M. Hori Max-Plank Institute ,	10/2008
14	CARE-Conf-08-013-HIPPI (epac08)	Beam dynamics layout and loss studies for the fair p-injector	G. Clemente† , L.Groening, GSI, Darmstadt, Germany U. Ratzinger, R.Tiede, IAP Frankfurt S.Minaev, ITEP,	07/2008

			Moscow.	
15	CARE-Conf-08-014-HIPPI (epac08)	A hybrid quadrupole design for the ral front end test stand (FETS)	C. Plostinar, M. Clarke-Gayther, S. Jago, STFC/RAL/ISIS, P. Davis, University of Oxford.	07/2008
16	CARE-Conf-08-015-HIPPI (epac08)	The development of a fast beam chopper for next generation high power proton drivers	Michael A. Clarke-Gayther, STFC	07/2008
17	CARE-Conf-08-016-HIPPI (epac08)	Status of the RAL front end test stand	.P. Letchford, M.A. Clarke-Gayther, D.C. Faircloth, D.J.S. Findlay, S.R. Lawrie, P. Romano, P. Wise (STFC RAL, Didcot, UK), F.J. Bermejo (Bilbao, Spain), J. Lucas (Elytt Energy, Madrid, Spain), J. Alonso, R. Enparantza (Fundación Tekniker, Elbr, Spain), S.M.H. Al Sari, S. Jolly, A. Kurup, D.A. Lee, P. Savage (Imperial College of Science and Technology, London, UK), J. Pasternak, J.K. Pozimski (Imperial College of Science and Technology, London; STFC RAL,), C. Gabor, C. Plostinar (STFC RAL)	07/2008
18	CARE-Conf-08-019-HIPPI (LINAC08)	Simulation of experiments on transverse rms-emittance growth along an Alvarez dtl	L. Groening, W. Barth, W. Bayer, G. Clemente, L. Dahl,P. Forck, P. Gerhard, I. Hofmann, G. Riehl, S. Yaramyshev, GSI, D. Jeon, SNS, ORNL, D. Uriot, CEA	10/2008
19	CARE-Conf-08-018-HIPPI (HB2008)	Investigation of the beam dynamics layout of the fair proton injector	G.. Clemente, L.Groening, GSI, U. Ratzinger, R. Tiede, IAP Frankfurt	09/2008
20	CARE-Conf-08-019-HIPPI (LINAC08)	Benchmarking of measurement and simulation of transverse rms-emittance growth along an alvarez dtl	L. Groening, W. Barth, W. Bayer, G. Clemente, L. Dahl, P. Forck, P. Gerhard, I. Hofmann, G. Riehl, S. Yaramyshev, GSI, D. Jeon, SNS, ORNL, D. Uriot, CEA Saclay.	10/2008
21	CARE-Conf-08-023-HIPPI (LINAC08)	Emittance measurement instrument for a high brilliance h− ion beam	C.Gabor† 1, C.R.Prior1, A.P.Letchford1, J.K.Pozimski1+2, 1STFC/RAL 2Imperial College London,	10/2008

22	CARE-Conf-08-027-HIPPI (LINAC08)	704 mhz HIGH POWER COUPLER AND CAVITY DEVELOPMENT FOR HIGH POWER PULSED PROTON LINACS	J. –P. Charrier, S. Chel, M. Desmons, G. Devanz, Y. Gasser, A. Hamdi, P. Hardy, J. Plouin, D. Roudier, CEA Saclay	10/2008
23	CARE-Conf-08-028-HIPPI (LINAC08)	Shunt impedance studies in the isis linac	C. Plostinar, A. Letchford STFC /RAL	10/2008

2.3 Web site

The HIPPI web site (**http://mgt-hippi.web.cern.ch/mgt-hippi/**) contains the most recent information on the JRA activity.

3 ADDITIONAL STAFF HIRING

There has been no additional staff hiring in 2008.

4 STATUS OF THE WORK

4.1 Work Package 1 : Management and Communication

The main Management activities in the 2nd Quarter 2008 have been:

- the preparation of the HIPPI Annual Meeting, both for the logistics (the meeting took place at CERN) and for the scientific preparation (scientific programme, recommendations from the ESAC reviewers).

- the follow-up of the HIPPI milestones and deliverables: contacting the responsible persons for the different deliverables, keep track of the delays, and when the deliverable is achieved be sure that the proper supporting document is prepared and submitted required a constant care from the Coordinators.

The main problem that had to be addressed during the 2nd Quarter was the definition of the criteria and of the responsibilities for the preparation of the common assessment, which are the last deliverable from HIPPI. In general terms, it was decided to give the task of collecting the material from the different laboratories and of writing the draft common assessment to a young member of HIPPI who was only partly involved in the activity of the Workpackage to be assessed. The advantage is to have a new fresher look from someone who has probably more time for an accurate analysis and is less biased towards common ideas or towards particular solutions. Moreover, putting together these assessments is an excellent way for a newcomer in the field to gain experience and to establish contacts.

As for the timing and scope of the deliverables, the main decisions taken after consultation with the HIPPI partners and with the CARE Management were:

1. The deliverable on beam measurements with the chopper line at CERN was replaced with the assembly and testing of all chopper line components, in the real environment but without beam. This is the consequence of the delay for technical reasons by more than 2 years of the delivery of the RFQ accelerator. This RFQ is outside of HIPPI, and is required to provide the beam for the tests. Several alternative options have been considered (moving the chopper to another laboratory, testing with electrons, etc.) but for all these options the scientific results were considered minor with regard to the large resources to be invested.

2. The deliverable on cavity testing at the high-power test stand at CEA Saclay has been replaced with coupler testing at the same test stand. The test stand is now completed, but because of delays in the preparation of the cavity the high-power tests can take place only at the end of 2009. Instead of delaying the end of the CARE programme waiting for this test, it has been decided to accept as deliverable the test of the cavity coupler, which will demonstrate the efficiency of the test stand and that can take place in February 2009. The CEA has engaged to complete the test of the cavity in 2009 after the end of HIPPI.

3. The deliverable on CH tuner tests will be provided only in February 2009. The cavity is ready, vertical tests have been made and only minor work is required for the most significant horizontal test.

It is therefore foreseen that all HIPPI activities will be completed in February 2009.

4.2 Work Package 2: Normal Conducting Accelerating Structures

4.2.1 Drift Tube Linac

4.2.1.1 Activities at CERN (WBS 2.1.4)

During 2008, CERN has continued its work on the production of a Drift Tube Linac prototype, which is financed outside of the HIPPI Activity, but whose results are analysed and discussed within HIPPI.

Following the machining of parts in industry, CERN continued with the copper plating of the cavity and the end-caps. The quality of the copper plating will be tested in the final RF measurements.

In order to test the drift tube mounting well before the final pieces would be available and in order to get a good idea on the requirements for the drift tube assembly, pieces for a two cell pre-prototype structure (Figure 4.2.1) were manufactured and assembled at CERN.

Figure 4.2.1: The CERN DTL pre-prototype structure.

The assembly of the two dummy drift tubes showed that the drift tube assembly procedure for the final drift tubes must be defined in detail and all parameters for weld connections must be found in advance in order to achieve the required tolerances.

The final drift tube manufacturing procedure is the following:

- Machining of drift tube parts with main references
- Assembly of drift tube with stem by e-beam welding
- Vacuum test of cooling circuit
- Final machining of magnet holder and references
- Insertion of the permanent magnet quadrupole (PMQ)
- Closure of drift tube by e-beam welding
- Metrology

For the assembly of the prototype structure, the welding procedure for the drift tube to stem connection was tested on samples. Based on the results of these tests the 12 prototype drift tubes were assembled and mounted in the prototype DTL cavity (Fig. 4.2.2).

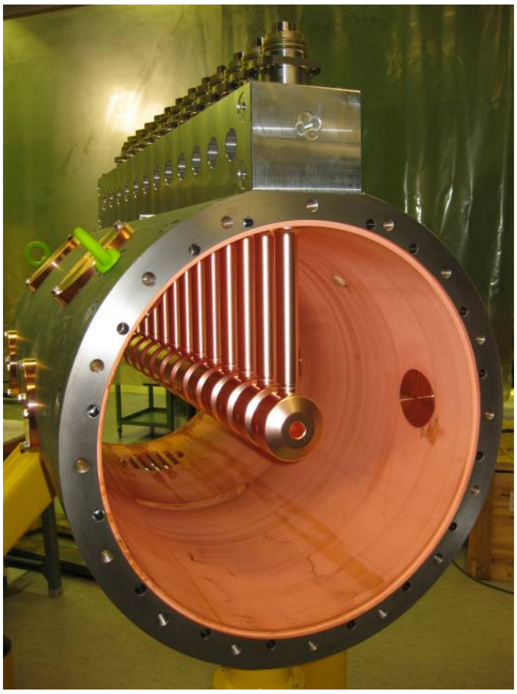


Figure 4.2.2: The assembled DTL prototype.

The drift tube positions were measured by laser tracker and all were found to be within tolerances which are ±0.1 mm and ±3 mrad in all three dimensions. The final results are listed in the table below:

	Survey				
	Center calculated				
No point	X (horiz)	Y (long)	Z (vert)	Y (yaw)	Z (roll)
1	0.015	0.000	-0.002	0.000E+00	-1.655E-04
2	-0.035	0.142	0.016	1.407E-03	-1.200E-03
3	0.041	0.063	-0.007	4.244E-04	6.210E-05
4	-0.018	0.029	-0.003	1.283E-03	-4.037E-04
5	0.008	0.001	-0.021	-1.604E-03	-6.621E-04
6	-0.066	0.057	0.003	-8.483E-04	-2.472E-03
7	0.050	0.042	0.016	5.487E-04	-8.283E-05
8	0.042	0.075	0.005	-1.180E-03	1.553E-04
9	-0.056	0.136	-0.025	5.074E-04	-7.145E-04
10	0.026	0.108	0.033	-2.589E-04	1.118E-03
11	-0.007	0.146	-0.008	5.488E-04	-6.006E-04
12	-0.002	0.074	-0.007	-9.841E-04	1.968E-04

AVG	0.000	0.073	0.000	-1.292E-05	-3.975E-04
STDEV	0.038	0.052	0.016	9.717E-04	8.781E-04
MID	-0.008	0.073	0.004	-9.806E-05	-6.770E-04
MAXMIN/2	0.058	0.073	0.029	1.506E-03	1.795E-03
MAXABS	0.066	0.146	0.033	1.604E-03	2.472E-03

Following the good results of the alignment tests, the cavity will be closed and tested with RF at low and high power. These tests and further prototyping work will qualify the final construction methods.

4.2.2 H-mode DTL (IAP Frankfurt)

4.2.2.1 RF cold model design & construction (WBS 2.2.2)

The last period of the HIPPI activities have been completely focused on the preparation of the technical drawings of the FAIR prototype. An example is shown in Fig. 4.2.3.

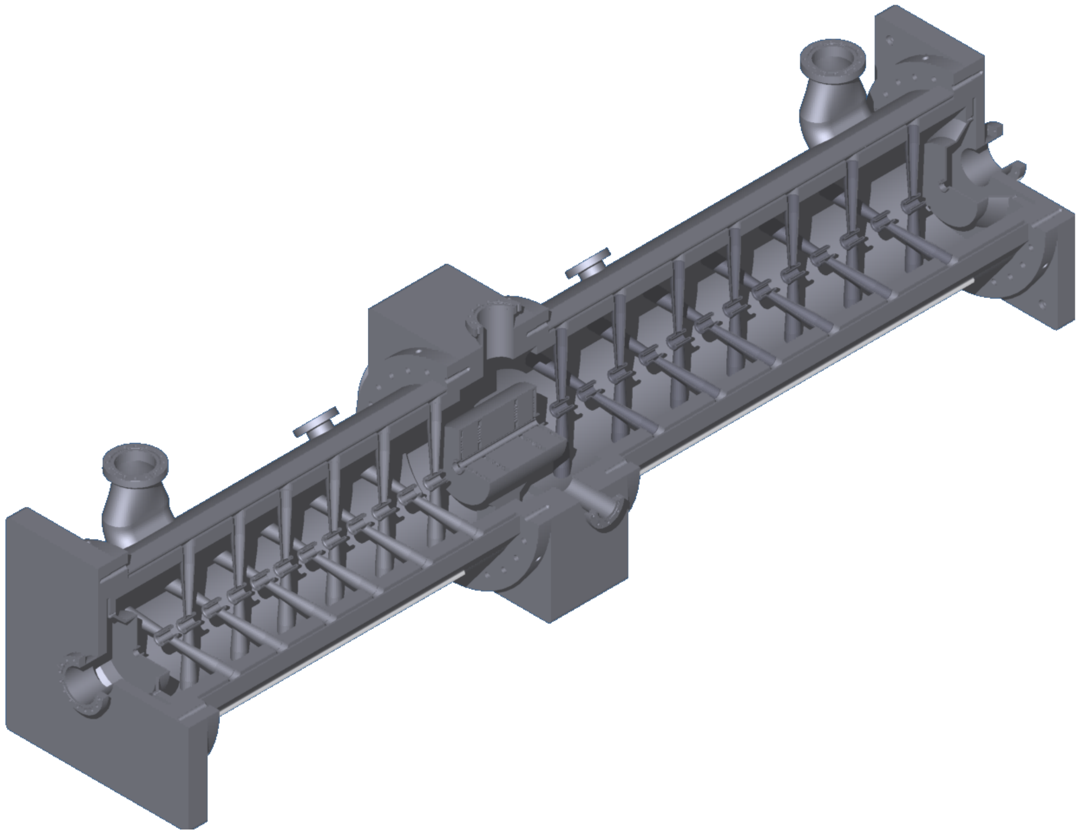


Fig.4.2.3: The second resonator of the FAIR proton injector

The attention was focused, in particular, in the definition of the building strategy for the coupling cell and for the intertank section which connects uncoupled resonators.

As shown in Fig. 4.2.4 and 4.2.5 the adopted solution is very similar in both cases: in the quadrupole triplet is located in a parallelepiped box which is flanged to the resonators resulting in a very compact and reliable design.

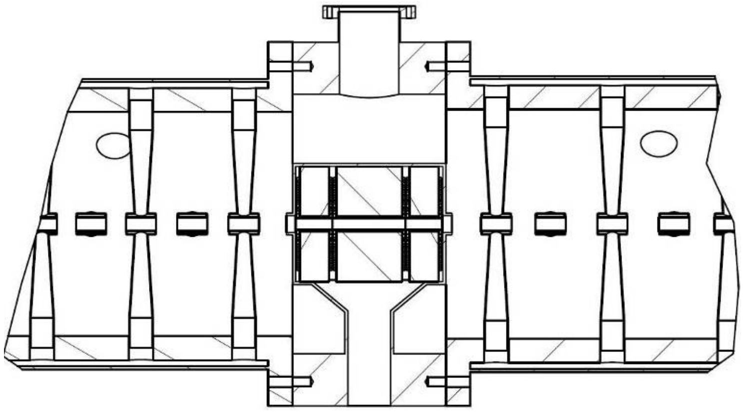


Figure 4.2.4: A detail of the coupling cell: the upper flange will be used as RF port

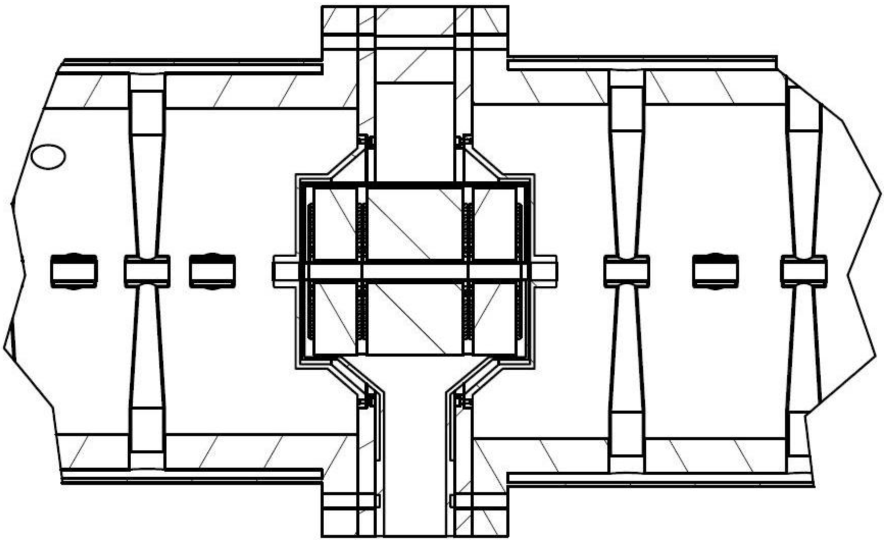


Figure 4.2.5: A detail of the intertank section between non coupled resonators

In parallel, a first stem has been produced in order to investigate the mechanical stability together with the welding procedure which will be used during the construction.

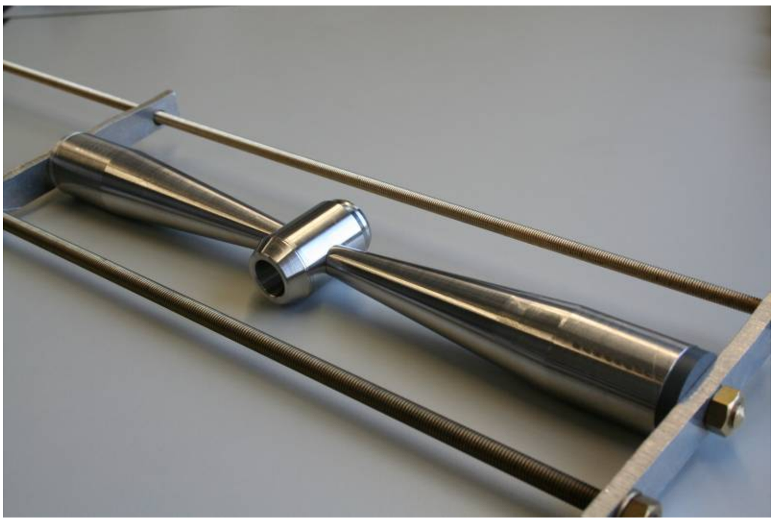


Figure 4.2.6: the stem of the CH

Further investigations have been carried out in order to evaluate the maximum flow of cooling water which can be stood during operation.

In conclusion, the status of the first FAIR cavity (full-scale prototype) is well advanced and the production is expected to start within the first half of 2009. Afterwards, the cavity will be tested with a 3.0 MW klystron at the new RF test stand in construction at GSI.

4.2.3 Pi-Mode Structure (PIMS) at CERN

The scaled cold models of the PIMS at 704 MHz that were built have been measured. The first objective was to compare different coupling slot geometries. Simulations predict that a modified slot geometry would cause less losses in the coupling slot region. In order to verify these results, 3 models have been built, each consisting of 3 coupled cells. The reference module is equipped with slots of standard shape for a coupling coefficient of k=3%. The other 2 modules use the modified slots at k=3% and k=5%. All modules were tuned to resonate at the same frequency (705.150 MHz) and bead pull measurements were performed to evaluate the R/Q values. They are compared to measurements (see Table 1). The agreement between simulations and measurements is very good, so that the simulated values can be trusted and the PIMS design can profit from a novel coupling slot geometry that allows to increase the coupling coefficient (electromagnetic stability) and the efficiency (effective shunt impedance per length) at the same time.

Table 1: Comparison of simulated and measured R/Q values for 3 models equipped with different coupling slots.

slot type	simulated R/Q [Ω]	simulated R/Q, relative to std. slots [%]	measured R/Q, relative to std. slots [%]
standard slots, k=3%	214.1	100.0	100.0
modified slots, k=3%	222.2	103.8	104.1
modified slots, k=5%	228.4	106.7	106.8

The second objective of the cold model tests was to build a 7 cell module, to tune it, to measure the resonant frequencies of the TM_{01}-mode band and compare theses values to simulated ones in order to validate the models developed for our simulations. Figure 1 shows a picture of the bead pull measurement and Figure 2 the measured field profile. The resonant frequencies of the TM_{01}-mode band are listed in Table 2. The agreement is good for both, the 3 dimensional model, simulated with the electromagnetic field simulation package GdfidL and the equivalent circuit model.

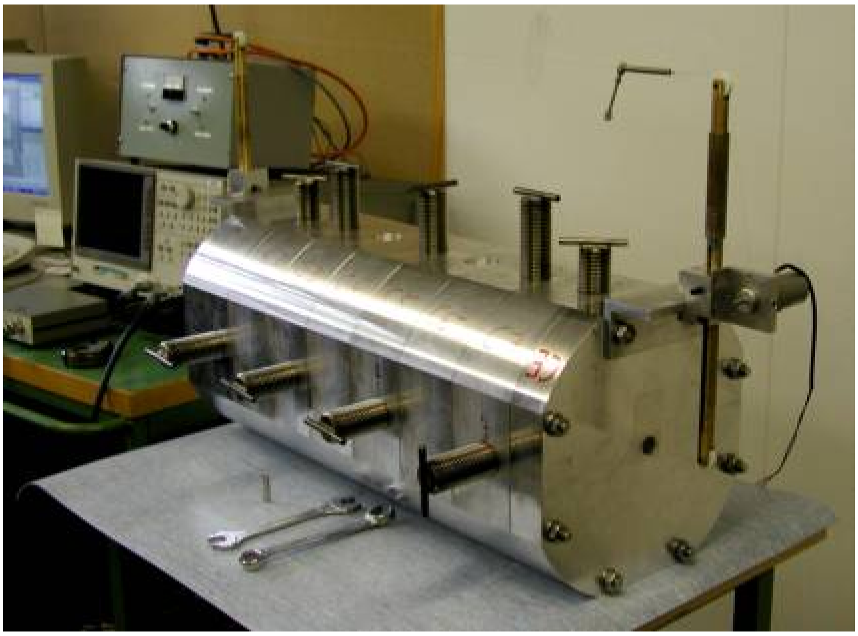


Figure 4.2.**7:** Bead pull measurement of a 7 cell PIMS module.

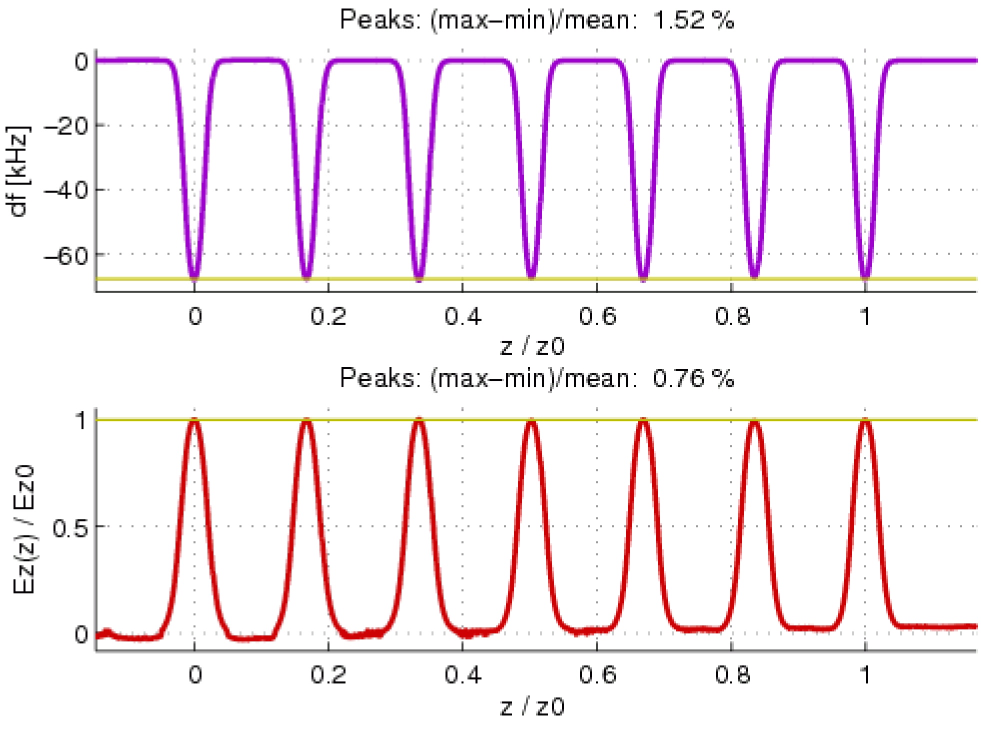


Figure 4.2.8: Bead pull measurement result of the 7 cell model. On the top, the frequency shift due to the perturbation induced by the bead, at the bottom the corresponding, normalised electric field along the symmetry axis.

Table 2: Comparison of measurement and simulation results for the first 7 modes of the 7 cell PIMS model.

	$f_1=f_\pi$	f_2	f_3	f_4	f_5	f_6	f_7
measured [MHz]	704.536	706.362	711.179	717.966	725.809	733.267	738.874
GdfidL sim. [MHz]	704.498	706.283	710.971	717.958	726.025	733.581	738.975
equiv. circuit sim. [MHz], k_{23}=5.04%, k_{12}=4.70%	704.536	706.299	711.153	718.056	725.872	733.362	738.901

The design of the hot prototype for the 1st PIMS module has been finished, a complete mechanical design is ready, technical drawings have been produced and the production has just started. Several issues have been investigated for this purpose:

1. Tuning rings have been studied (see Figure 4.2.9). The radial width is 70mm and the height is 7.7mm. In this way, the resonance frequency of each cell can be reduced by up to 2.5 MHz.

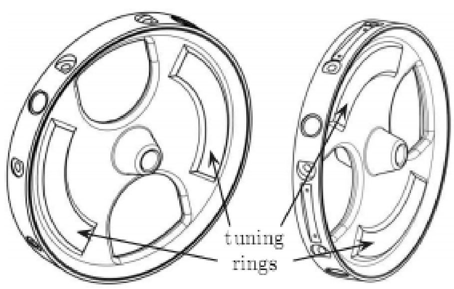


Figure 4.2.9: Tuning rings will be used to adjust the resonance frequency of each cell.

2. The end cells have been investigated (see Figure 4.2.10) as their resonance frequency needs to be lowered to attain a flat field in the pi-mode (by about 5 MHz for the PIMS hot prototype). The volume of the end cell is extended in a region of strong magnetic fields. The outer curvature radius is increased. These 2 features lead to an increase of the overall shunt impedance of about 4%.

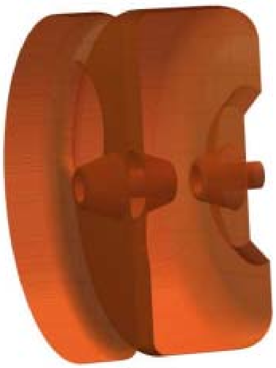


Figure 1.2.10: An end cell of a PIMS module.

3. A wave guide coupler has been designed. The dimensions are w=50mm for the width (this was the maximum possible due to the available space for the central cell) and h=116mm for the height (this is enough to accommodate 2 cooling channels and provide enough space for screwing the cavity and the wave guide connection together). The length L was adjusted to reach the desired cavity to wave guide coupling coefficient of beta=1.2.

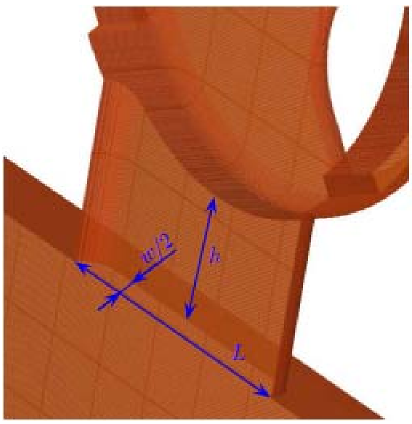


Figure 4.2.11**:** The wave guide coupler. L is the length, w the width and h the height of the coupling slot.

4. Effects that influence the resonant frequency have been analysed for the PIMS of Linac4: frequency shift due to change from air to vacuum Δf≈ +114 kHz, frequency shift due to weld shrinkage of 0.2 mm on each weld Δf≈ -310 kHz, frequency change caused by the ring needed for a sophisticated welding solution Δf≈ -190 kHz, frequency shift due to thermal expansion for a duty cycle of 10% Δf≈ -200 kHz.

For a comparison of different accelerating structures, the effective shunt impedance per length has been calculated as a function of the kinetic energy of the particles to be accelerated. PIMS and SCS (side coupled structure) for low duty cycle and high duty cycle operation are compared, see Figure 4.2.12.

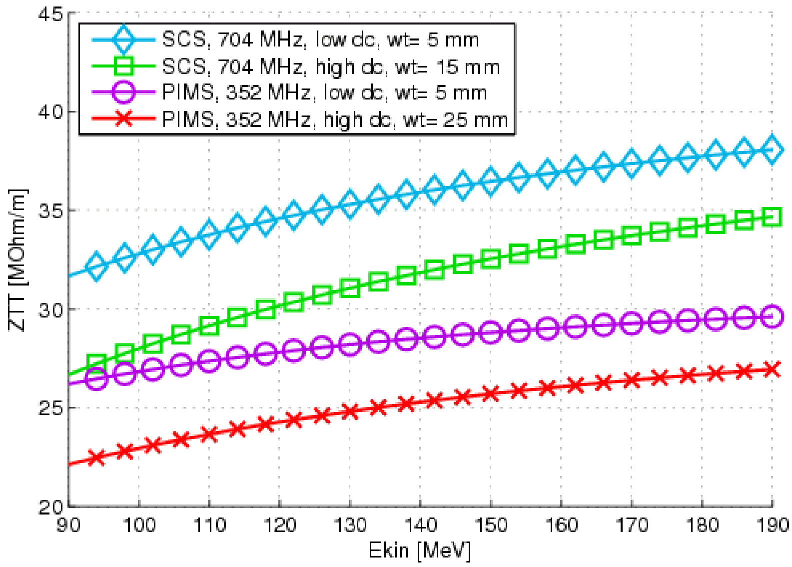


Figure 4.2.12**:** The effective shunt impedance per length in dependence of the particle energy for different accelerating structures and different duty cycles.

Several effects lower the shunt impedance of the PIMS compared to the virginal cell simulated with Superfish. A detailed study has been carried out and the results are listed in Table 3.

Table 3: A summary of effects that reduce the shunt impedance of a PIMS module.

reason	**ZTT reduction [%]**
coupling slots	11.0
surface roughness	7.0
wave guide coupler (1/7 for ZTT total)	2.0
end cells (2/7 for ZTT total)	-4.0
reduction in conductivity due to heating **(SPL duty cycle 10%)**	3.5
reduction in conductivity due to heating **(Linac4 duty cycle 0.1%)**	0.0
e-beam welding groove for welding discs and cylinders	2.0
tuning rings (df= -1.5 MHz … +1.0 MHz)	3.3
piston tuners	1.0
sum, Linac4, duty cycle 0.1%	**22.3**
sum, SPL, duty cycle 10%	**25.8**

For the series production, another 11 PIMS modules have to be designed, as the dimensions change from module to module due to the increased particle speed. For the hot prototype, extensive simulations runs were performed to eliminate the influence of the meshing on the calculated resonance frequency. The overall time spent on GdfidL simulations was several month and the final prediction of the resonance frequency is not better than ±250 kHz (at 352 MHz resonant frequency). An investigation was started therefore to find out if HFSS can perform these calculations quicker and / or with better precision than GdfidL. The comparison was started on reference cavities. Both codes give very good results and agree well. Thereafter, PIMS cells were simulated and the measured values for the cold model were taken as the reference. Both codes again achieve reasonable precision for the resonant frequency (better than ±1‰). The precision that can be achieved with HFSS is mainly limited by the memory available, the simulation time is in the order of 1 to 5 hours while the simulation time limits the accuracy that can be reached by GdfidL. As different meshings can be easily investigated with GdfidL, not only a resonant frequency can be calculated but also a tendency for the resonance frequency in dependence of the mesh. This can be used to estimate the simulation precision. HFSS simulations on the other hand are more tricky to initiate as the mesh is automatically refined. The calculated resonance frequency depends on the initial mesh and the refinement. Estimations of the absolute simulation precision are very difficult to obtain.

In conclusion, both simulation packages, GdfidL and HFSS, can be used to simulate the PIMS modules. The precision reached by both codes are comparable, if a sophisticated model is used for HFSS. Good models for GdfidL are available for the hot prototype of the PIMS while they still need to be developed for HFSS.

Table 4.2 a : Status of the Sub tasks in WP2 which are supposed to have started according to the MS project breakdown in Annex 1

WBS #	Title	Original begin date (Annex 3)	Original end date (Annex 3)	Estimated Status	Revised end date
2.1	**Drift Tube linac**				
2.1.1	DTL Design	July 2004	June 2007	100%	
2.1.5	DTL Coupler prototype construction	July 2005	June 2007	100%	
2.1.4	DTL beam dynamics design	January 2004	June 2008	100%	
2.2	**H mode DTL**				
2.2.2	RF cold model design & construction	January 2004	January 2005	100%	
2.2.3	RF model construction	December 2004	June 2005	90%	December 2008
2.3	**Side Coupled Linac**				
2.3.2	RF model mechanical design	July 2004	December 2004	100%	June 2006
2.3.3	RF model construction	January 2005	December 2005	100%	November 2006
2.3.4	RF model testing	January 2006	June 2006	100%	End 2007
2.3.5	SCL module design	January 2006	June 2007	100%	December 2007
2.4	**Cell Coupled DTL**				
2.4.2	Pre-prototype high power RF tests	July 2004	March 2005	100%	July 2006
2.4.3	Prototype mechanical design	January 2005	December 2005	100%	
2.4.4	Revision of design	October 2005	October 2006	100%	December 2007
2.4.5	Prototype high-power RF tests	August 2006	June 2007	100%	December 2007

Table 4.2b: Status with respect to the interim reports and deliverables due in 2008 according to the MS project breakdown

WBS #	Title	Due date in Annex 1	Status	Revised delivery date
2.1.1	Drift tube linac optimized design	December 08	Delayed January 09	January 2009
2.1.2	H mode DTL design finished	December 08	On schedule	December 2008
	Comparative assessment normal conducting structures	December 08	On schedule	January 2009

4.2 Work Package 3: Superconducting Accelerating Structures

INFN-Milano

Cavity assembly with tuner (subtask 3.1.13)

In progress.

CEA-Saclay

Power coupler design and engineering (subtask 3.1.7)

All the parts of the coupler are now in Saclay.

The outer conductor of the cold part of the coupler has been plated with 10 microns copper at CERN, using microwave sputtering (fig. 4.3.1). The doorknobs, made of aluminium, have been tested in Saclay. As expected, their bandwidth is only a few MHz (fig. 4.3.1).

Figure 4.3.1 : Copper plating of the outer conductor (left)
Doorknobs with adaptors for RF measurements (right)

We will now proceed with the assembly of couplers on the “coupling box” in Saclay clean room. Then, couplers will be installed on the test stand and the conditioning should start in November 2008.

Vert. test & final welding of cavity B (subtask 3.1.14)

Results of RF tests

The cavity has been tested in May in a vertical cryostat after a fast cooldown. The Q_0(Eacc) characteristic curve at T = 1.8 K is shown on figure 4.3.2. A multipactor (MP) barrier was encountered between 8 and 10 MV/m, and was processed in about 2 hours. The field emission onset field is 10 MV/m. The electron loading becomes significant (detuning observed) above 13 MV/m and could not be processed. The cavity operation was limited by a thermal quench. At the maximum Eacc=15 MV/m, the peak surface fields are Epk= 50 MV/m and Bpk=83 mT. After this test, the cavity was vacuum baked using standard parameters (115 °C for 70 h) inside the vertical cryostat and cooled down again without any venting or processing. The BCS surface resistance was reduced by 25% (see fig. 4.3.3). The MP barrier reappeared, and the processing took 3 hours, longer than before baking, which might be explained by an increase in the SEE coefficient. However, the cavity performance at 1.8 K was not changed by the baking process. The cavity has been simulated with the MUPAC multipactor code. The observed MP barrier corresponds to a 2 point resonant trajectory in the equator region starting at Eacc= 8.1 MV/m.

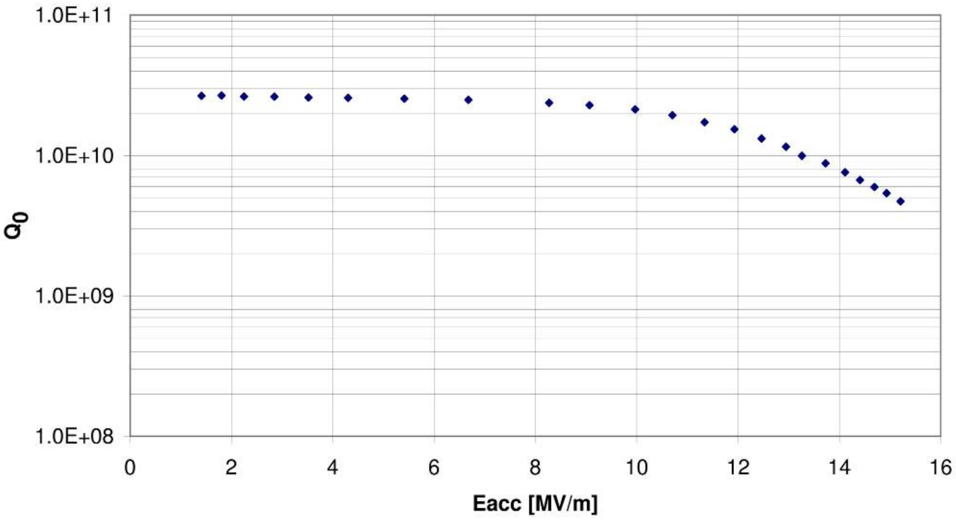


Figure 4.3.2 : Q0/Eacc curve measured for the cavity B.

In order to keep the cavity length as constant as possible, a stiffening tube linking the helium tank to the otherwise free cavity end was installed at the position of the tuning system (see fig.4.3.3). This spacer ensures a high external stiffness k_{ext} to allow the static K_L to be measured in optimal conditions. Its efficiency can first be assessed when pumping on the He bath to reach 1.5 K. The He pressure drops from atmospheric pressure to a few mbar.
The cavity detuning is recorded during this phase (fig. 4.3.4). The measurement of the static K_L at 1.8 K is shown on figure 4.3.4. Due to slight temperature variations during the measurements, the He pressure was not constant, therefore the data have been corrected using the experimental df/dP coefficient. The data set is limited to Eacc<13 MV/m since above this value, the cavity is loaded with field emission electrons.

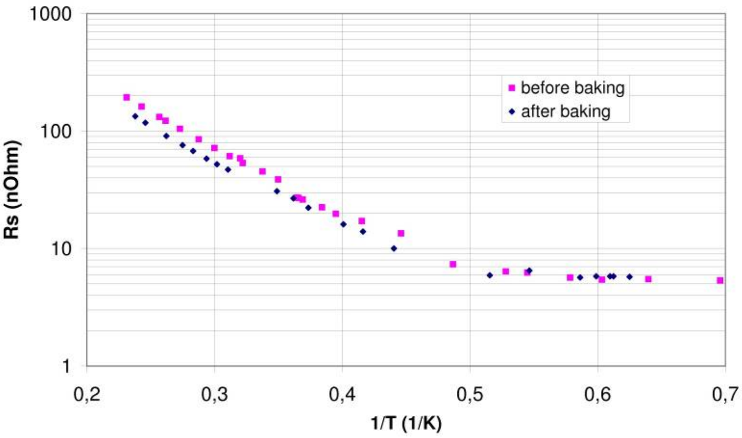
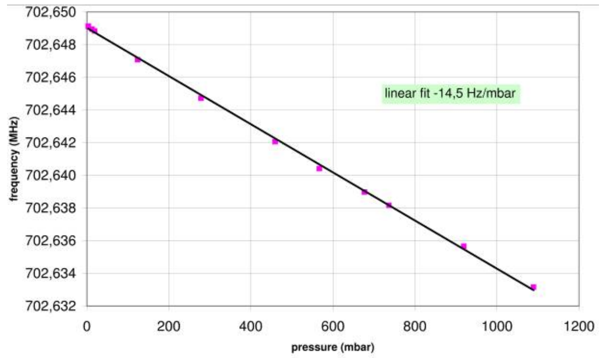


Figure 4.3.3 : Cavity with helium tank and stiffening tube (left)
Measurements or the surface resistance during RF test (right)



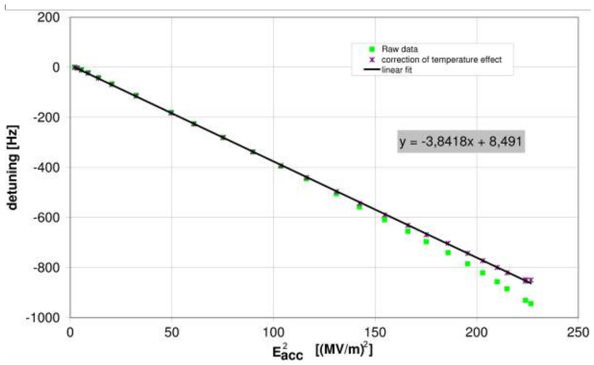
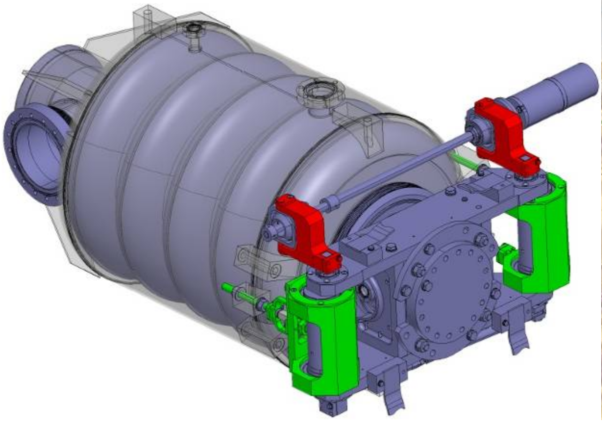


Figure 4.3.4 Helium pressure sensitivity measurements (left). Lorentz detuning measurements (right)

<u>Piezo tuner</u>

The fast piezo tuner, based on the Saclay-II tuner design, has been optimized for the 700 MHz cavity. The piezo support consists of a stainless steel elastic frame holding a single 30 mm piezo stack. It is designed in order to apply an adjustable preload on the piezo, limiting the influence of the spring constant of the cavity. The slow tuning range is +/- 2.5 MHz. The tuner is attached between the He tank and the square shaped beam tube flange opposed to the power coupler port (fig. 4.3.5) in such a way it doesn't increase the overall length of the cavity.



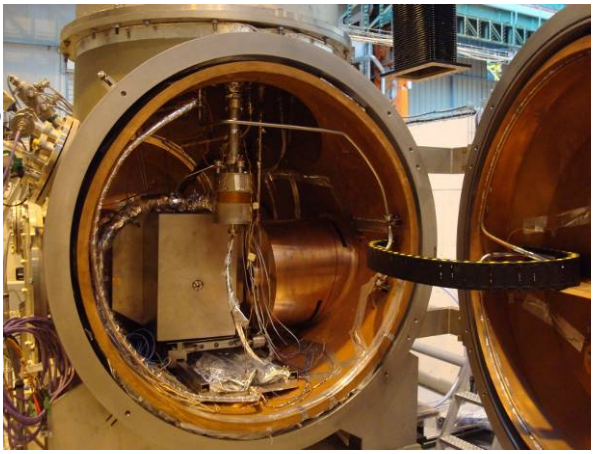


Figure 4.3.5 Cavity equipped with He tank and piezo tuner (left)
The cavity with its magnetic shield inside Cryholab (right)

The CryHoLab horizontal cryostat is only partially shielded therefore a magnetic shield for the cavity had to be designed. The average magnetic field in CryHoLab at its new location is 20 µT. The surface resistance measured on the cavity is 6 nΩ at 1.8 K at very low accelerating field in a vertical cryostat which is well shielded. In order to keep the extra superconductor surface resistance due to trapped magnetic flux below 2 nΩ in CryHoLab, an extra shielding factor of 33 is needed, to reach a maximal residual field of 0.6 mT. The shield has been designed with Vector Fields OPERA code. Much effort was done to reduce the magnetic field penetration due to the coupler port. The shield is operating at 1.8 K and surrounds both the cavity and the tuner. It has been fabricated out of 1.5 mm thick Cryoperm® alloy. It can be seen partially on figure 4.3.5.

FZ-Juelich

Integration of coupler and tuning options (subtask 3.2.8)
Work is in progress.

Manufacturing of 352 MHz Multi-gap Resonator (subtask 3.2.10)
After preparing the remaining contours for electron beam welding the cavity could be closed. With the help of CEA Saclay a time slot for BCP could be found. The thickness of the niobium sheets could only be measured in the regions of large radii of curvature (ultra sonic measurement heads). Especially in the end cap regions no reliable measurements were possible. Two BCP runs were planned, each with the cavity in horizontal position, sending the acid in via the lower coupler port, and taking the out coming fluid from all three other openings back to the closed acid circulation system (Fig. 4.3.6). Filling and emptying took about 8 minutes. Fresh acid circulated for about 70 minutes through the cavity. For the second run the flanges were detached, and the cavity was turned about the horizontal axis by 180 degrees before the flanges were re-attached again. After the second BCP process HPR could immediately follow at Orsay University (Fig. 4.3.6 – see Orsay report).

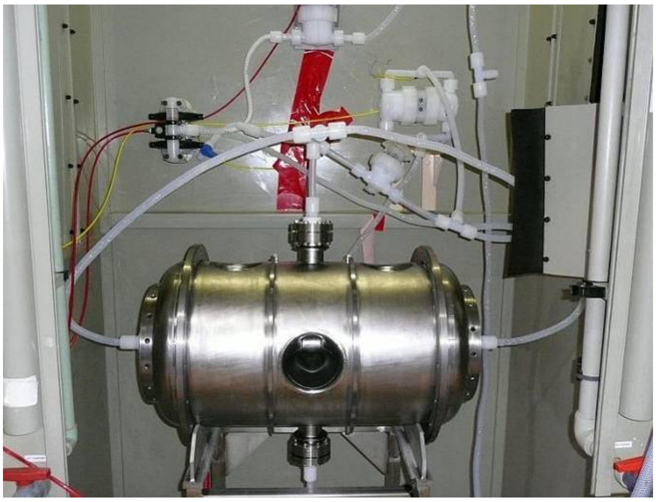
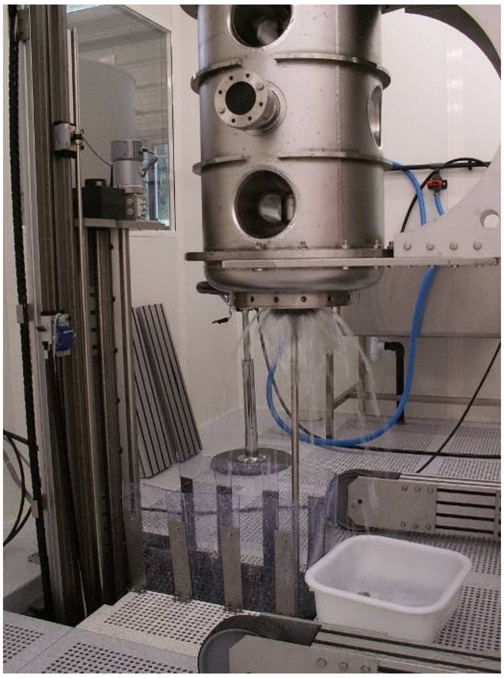



Figure 4.3.6 : Chemical preparation of the 3-spoke cavity at Saclay (left)
High Pressure Rinsing of the 3-spoke cavity at Orsay (right)

The amount of removed niobium was estimated via the duration of the treatment. Fresh acid could be used, and the removal was estimated to be about 130 µm. The ultra sonic measurements indicated that the removal was not homogenuous. However, the measurement conditions (curved surfaces) are not in favour of ultra sonic heads. Quality of surface preparation will be checked by measuring the RF performance of the cavity.
The clean and evacuated cavity was shipped back to Juelich. In the last fabrication step the small stiffening rings were laser welded to the cavity body. In parallel modifications to the Juelich bath cryostat have been made to allow proper cavity mounting.

Measurements of the 352 MHz Multigap Resonator

Preparation of the cavity for insertion into the vertical bath cryostat included attaching thermo-elements, installing a siphon for removal of He gas from the lower end cap, installing RF lines for (critical) coupling and for the field probe, line for vacuum pump, etc (Fig. 4.3.7). Cool down revealed no problems, and a first measurement could start quickly (Fig. 4.3.8). For the second measurement the upgrade of our testing facility for 2K operation could be verified. The raw data are given in the above diagram. Detailed analysis and further measurements are in progress.

Figure 4.3.7 : The 3-Spoke cavity in the cryostat frame at Juelich

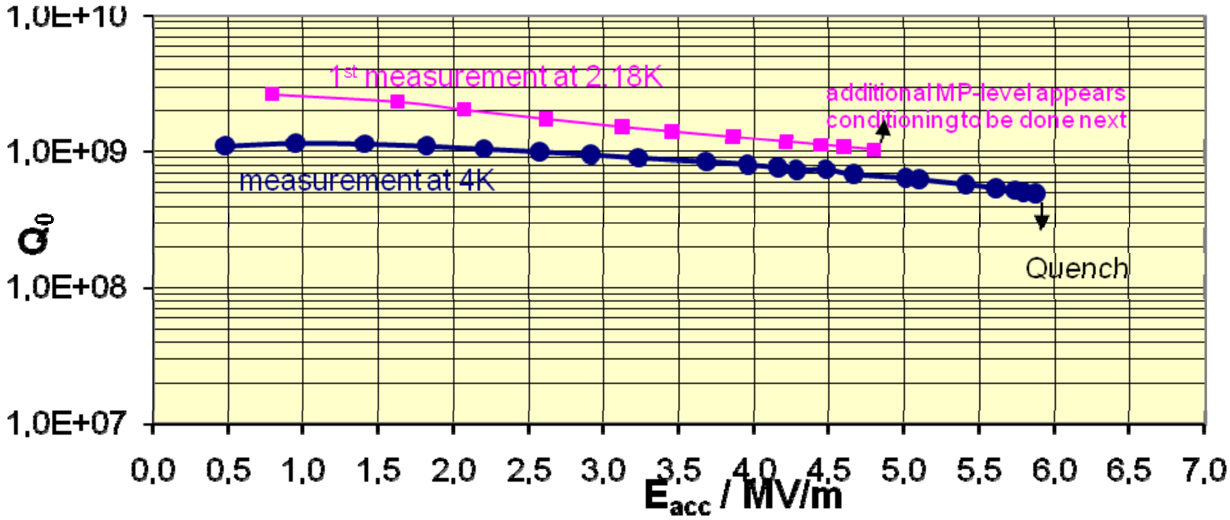


Figure 4.3.8 : First measurements of the 3-Spoke cavity

IPN-Orsay

Evaluation of 352 MHz 2-gap prototypes (subtask 3.2.3)

Horizontal cryostat CM0

New test at 4K in May 2008 with the beta 0.15 spoke cavity and its tuning system equipped with 2 piezo-actuators.

Total static losses reduced to 5 Watts (instead of 10 Watts in the first configuration) thanks to a better thermalization of the tuning system (extra copper braids, see figure 4.3.9), the helium buffer (new fastening lugs) and the frame support (connected to the helium vessel).

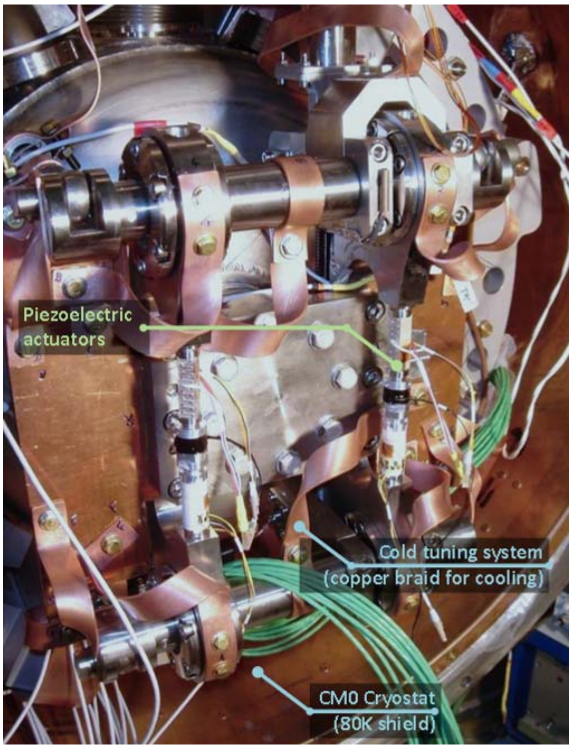


Figure 4.3.9: Tuning system of the spoke cavity with its piezoelectric-actuators

Test of the tuning system with piezos

First test of piezoelectric-actuators has been done on the tuning system. One of them acted as a sensor.

Preloading (of about 2 kN) of the piezo was done thanks to the expansion of an aluminum piece by heating it up. The ceramic bloc (see sketch in figure 4.3.10) thermally isolated the aluminum piece from the rest of the tuning system.

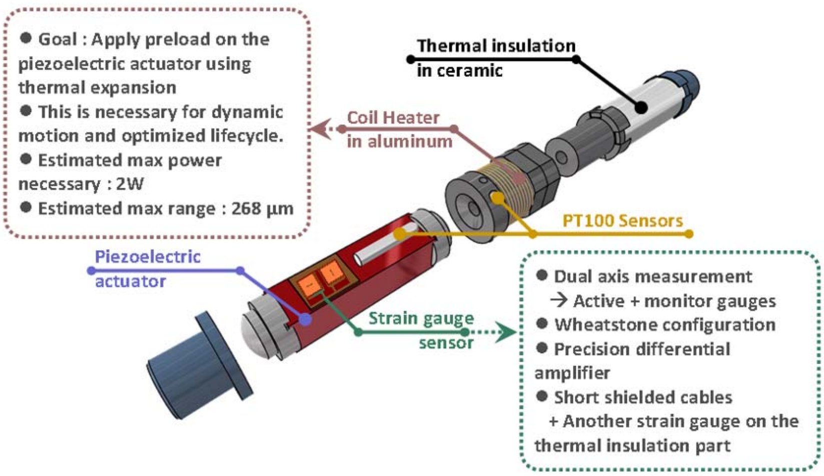


Figure 4.3.10 : Sketch of the piezoelectric set-up

We varied the voltage from 0 to 150 V, giving us a total stroke of 11 µm and a frequency variation of 1.1 kHz (see Fig. 4.3.11).

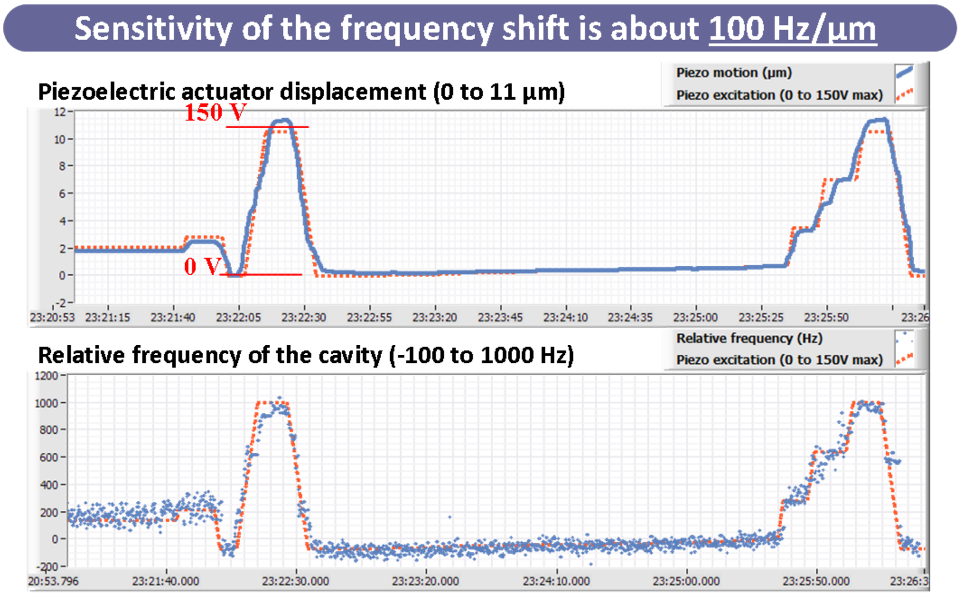


Figure 4.3.11 : Response of the cavity frequency while changing the piezoelectric length

Construction of Coupler Prototype (subtask 3.2.5)

Coupling cavity

This cavity is needed for the RF conditioning and tests of the RF couplers. It has been delivered by end of July 2008 (Fig. 4.3.12) and the frequency tuning to 352 MHz has to be done (with bulk copper plungers).

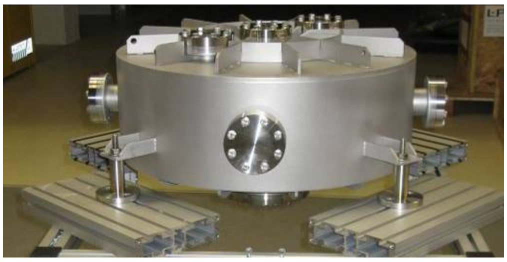


Figure 4.3.12 : New coupling cavity

RF coupler

2 loops (made of copper tube) have been brazed on the connecting tube between the coupler window and the cavity flange. This circuit will be cooled by liquid nitrogen and should intercept the heat flux coming from 300K.

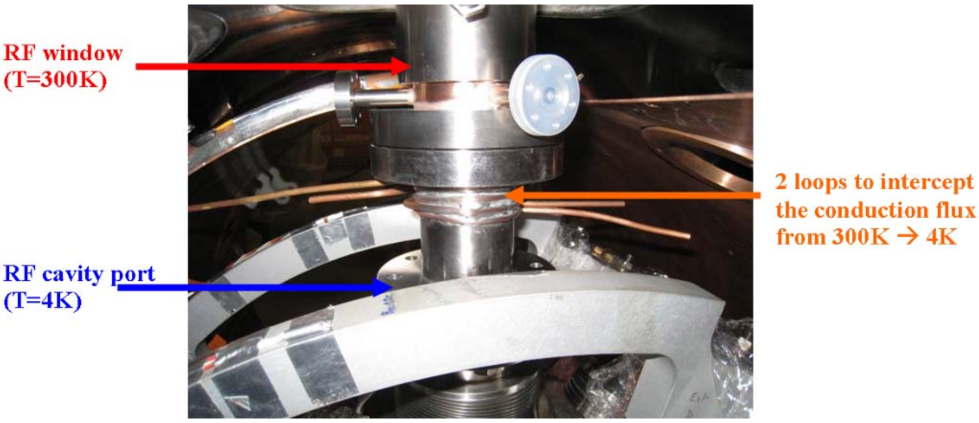


Figure 4.3.13 : RF coupler mounted on the spoke cavity

The assembly of the RF couplers on the coupling cavity will take place in October in our clean room. The conditioning process should start end of October.

RF design of 352 MHz multi-gap resonator (subtask 3.2.6)

The first cavity prototype of 352 MHz multigaps resonator has been built at FJZ Jülich. The final stiffeners realized on the prototype, essential elements for reducing the Lorentz forces detuning, are slightly different from the former proposed versions because of technical constrains and timing. The stiffeners on the prototype consist in two niobium ribs (10mm x 20mm) welded on cylindrical body, two rings (18mm x 40mm) welded at the extremities of the cylinder and a niobium ring (18mm x 35mm) at each end cup, see figure 4.3.14. The prototype has been cleaned at IPN Orsay (Fig. 4.3.6). The cavity is fixed by the rings on the cylinder.

Figure 4.3.14: 3-Spoke prototype with its stiffeners

Accord to the final prototype design, the coupled numerical calculations have been performed at IPN Orsay using the simulations package including the CAD code Catia, the mechanical code Cast3m and the electromagnetic code Opera3D.

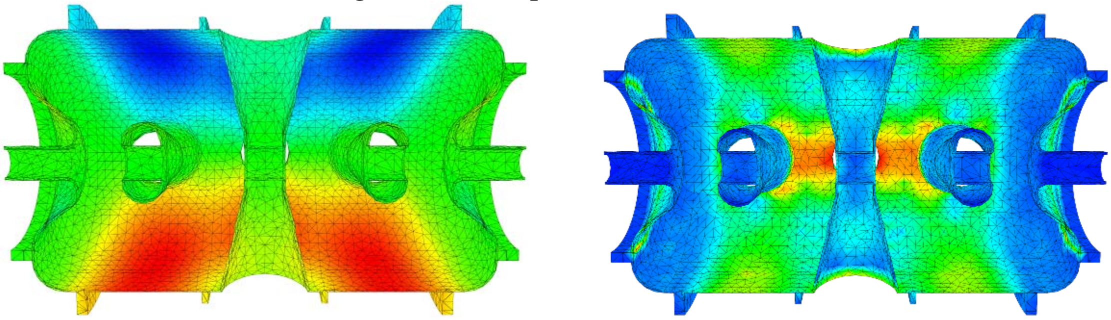


Figure 4.3.15: Deformation due to Lorentz forces (left)
Von Mises stress under I bar pressure (right)

The results of the simulation estimate the Lorentz forces factor to be -1.4 Hz/(MV/m)**2 for the stiffened prototype while this factor is -5.5 Hz/(MV/m)**2 without any stiffener. The pressure sensibility has been also evaluated since the cavity is operated at vacuum condition; the frequency shift due to the pressure at the external side of the cavity is 9.24 Hz/mbar.
The dynamical simulations results concerning the structure's vibration modes are satisfying because the first mode is very high :

mode	Without stiffener	Stiffened 1st prototype
1	243	578
2	453	669
3	576	685
4	621	695

The simulations results predict the good mechanical behaviours for this first prototype; it could be confirmed by the tests realized at FJZ Jülich.

IAP-Frankfurt University

Measurements of tuning system (subtask 3.3.3)

All parts of the horizontal cryostat are now assembled and aligned. A first vacuum test of the inner cold mass has been performed successfully. The liquid nitrogen cooling system is prepared and closed now; it has been extended by an additional cooling loop at the pump port of the cavity. A first cold test is currently performed. A driver for the slow mechanical tuner has now been designed and constructed and allows either a manual or a computerized operation. This device has passed a first test run. The driving speed of the stepping motor can easily be changed and will be adjusted during the first performance test with the cavity. Before that there will be a cold test of the cryostat without cavity, to check for cold leaks and thermal issues. The piezos are currently underlying a second performance test regarding the frequency dependence of their actuation. The basic idea is to transform the translation of piezo into an angle variation of a mirror, which can be observed by a reflected laser beam.

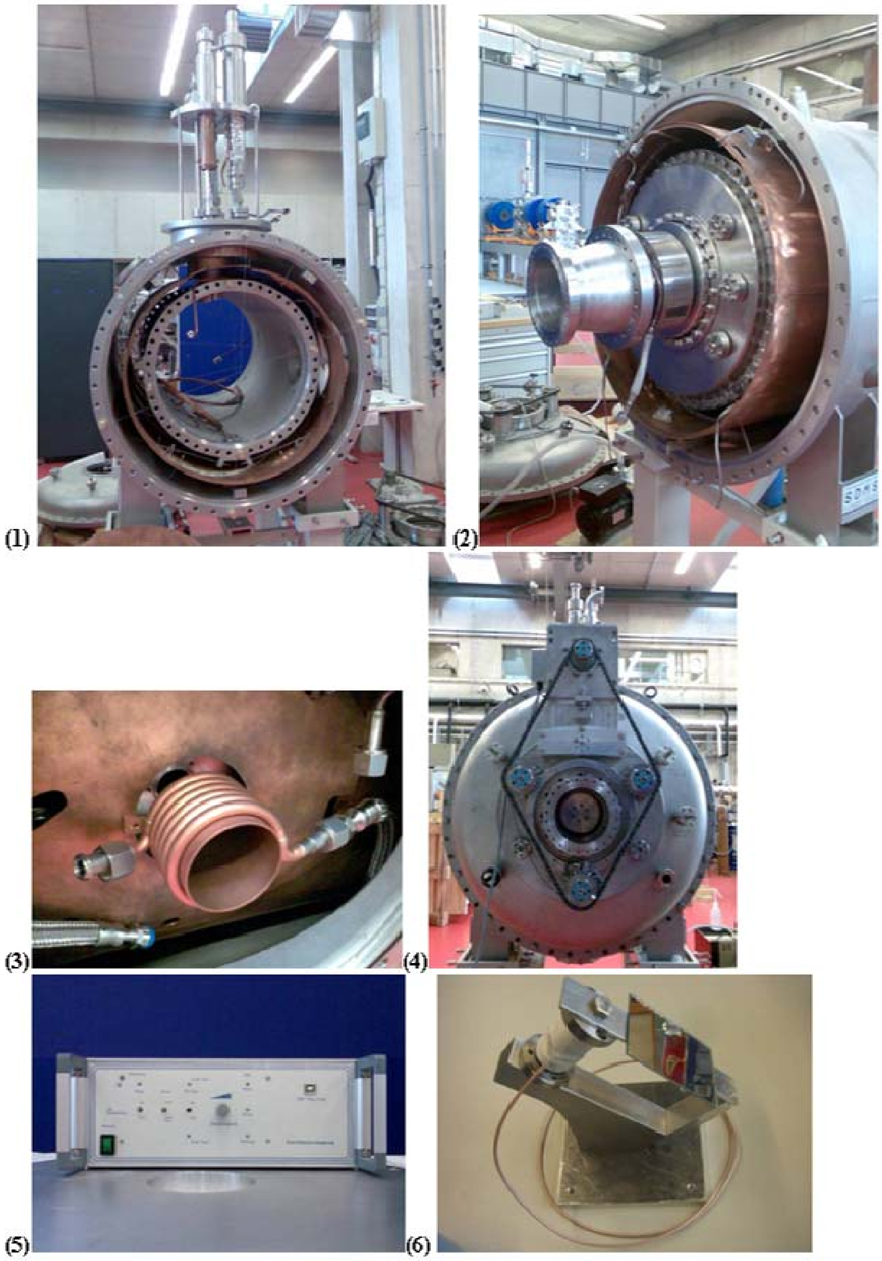


Figure 4.3.16 : (1) The cryostat during alignment procedure (2) Beam lead-through including piezo retainer (3) Cooling loop at pump port (4) The slow mechanical tuner at performance check (5) The control unit of the mechanical tuner (6) Set-up for piezo frequency response measurement.

WBS	Title	Participants	Original begin date	Original end date	Estimated Status	Revised end date
3.1	**Elliptical cavities**					
3.1.2	Tuner design	INFN	07 / 2004	12 / 2005	100%	
3.1.3	Integration of piezo design	INFN	07 / 2004	12 / 2005	100%	
3.1.4	Tuner construction	INFN	01 / 2006	06/2006	100%	
3.1.6	Construction cavity B	CEA	11 / 2005	06/2006	100%	
3.1.7	Power coupler design & engineering	CEA	01 / 2005	04/2006	100%	
3.1.9	RF coupler construction	CEA	05 / 2006	05/2007	100%	04/2008
3.1.8	RF source order and preparation	CEA	07 / 2004	12/2006	100%	
3.1.10	Modulator preparation for test stand	CEA	01 / 2005	12/2006	100%	
3.1.11	RF source testing	CEA	01 / 2007	04 / 2007	100%	
3.1.12	High power pulsed tests	CEA	05/2007	06/2007	100%	12/2007
3.1.13	Cavity A assembly with tuner	INFN	06/2006	03/2007	85%	10/2008
3.1.14	Vert. test & final welding of cavity B	CEA	07/2006	03/2007	100%	03/2008
3.2	**Spoke cavities**					
3.2.2	Evaluation of 700 MHz prototype	FZJ	09 / 2004	09 / 2005	100 %	
3.2.4	Design of coupler prototype	IPNO	01 / 2004	12 / 2005	100%	
3.2.5	Construction of coupler prototype	IPNO	01 / 2006	06 / 2006	100%	
3.2.8	Final design of 352 MHz multigap res.	FZJ-IPNO	07 / 2005	06 / 2006	100 %	
3.2.9	Test of coupler prototype	FZJ-IPNO	07/2006	07/2007	50%	10/2008
3.2.10	Manufacturing of 352 MHz multigap res	FZJ-IPNO	04/2006	09/2007	100%	05/2008
3.3	**CH resonators**					
3.3.1	Design of tuning system	IAP-FU	01 / 2004	06 / 2006	100 %	
3.3.2	Construction of tuning system	IAP-FU	01/2006	12/2006	100%	
3.3.1	Measurements of tuning system	IAP-FU	01/2007	06/2007	90%	10/2008

Table 4.3a : Status of the Sub tasks in WP3 which are supposed to have started according to the MS project breakdown in Annex 1

Table 4.3b: Status with respect to the interim reports and deliverables due in 2008 according to the MS project breakdown

WBS #	Title	Due date in Annex 1	Status	Revised delivery date
3.1.4	Cavity A ready (milestone)	March 2007	Delayed	June 2008
3.2.6	Spoke prototype ready	October 2007	Done	May 2008

4.4 Work Package 4: Beam Chopping

Web-site: http://lombarda.home.cern.ch/lombarda/WP4/WP4main.htm

CERN:

The important achievement for this quarter is the complete assembly of the chopper line. All the elements have been installed and the line is under vacuum. In particular , concerning the HIPPI activities, the two choppers and the dump have beem installed. A picture of the transfer line can be seen in Fig 4.1.1

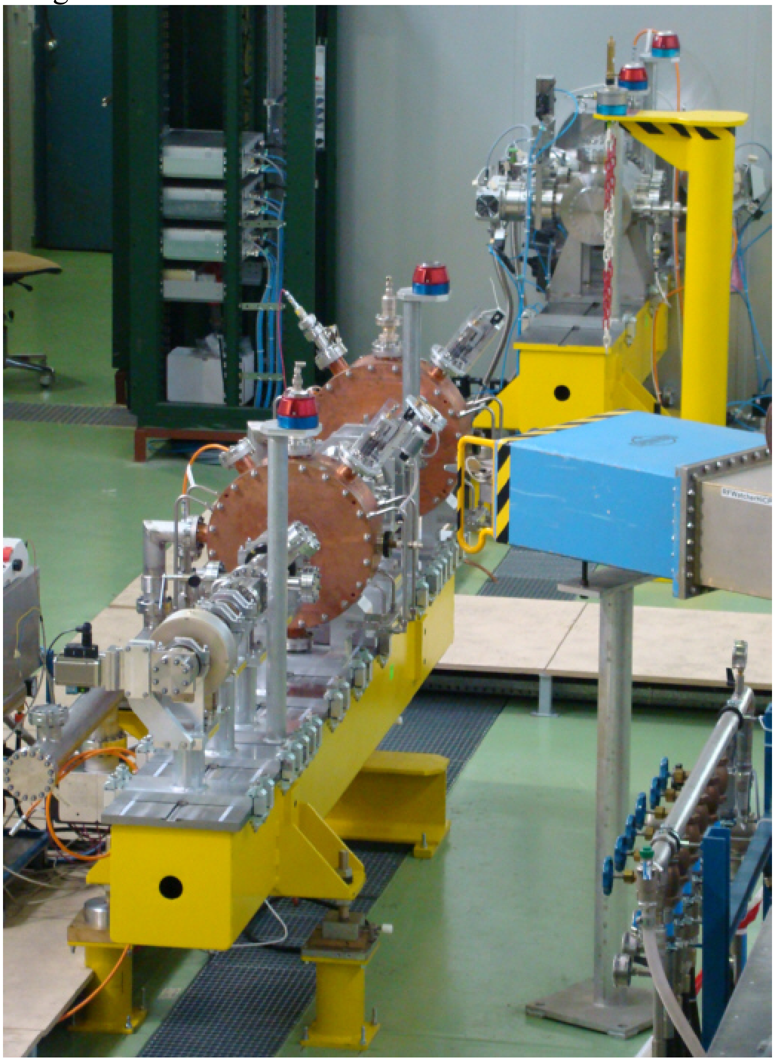


Figure 4.4.1 The CERN 3 MeV test stand line. In the background the H- source and LEBT assembly in progress; in the foreground the chopper line assembled and under vacuum.

The Chopper structure is already completed since 2007 and it is presently assembled in the 3MeV test stand line. Work on the chopper driver has continued in the second quarter of 2008.

.

RAL :

Important aspects of the RAL HIPPI WP4 activity for the period May to October 2008:

1.) Fast chopper electrodes - slow-wave structures: The design of three test assemblies has been completed. Two of these, the so called 'Coaxial' and 'Helical' test assemblies have been manufactured on-site, in RAL's Millimetre - Wave Technology (MMT) development facility (c/o J. Spencer, M. Beardsley). The remaining 'Planar' test assembly will be manufactured and tested in the first quarter of 2009. An electro-polishing technique has been developed that enables a simultaneous 'fine tuning' of strip-line characteristic impedance, together with the formation of a controlled edge radius. The measured high frequency (HF) characteristics of the 'Coaxial' and 'Helical' assemblies are encouraging, and indicate that there is good agreement with the HF characteristics predicted by the 3D high frequency design code (CST Microwave Studio). These initial assemblies are regarded as 'test beds' for the materials and design concepts to be employed in the subsequent 'short length' planar and helical prototype electrode designs, and are providing important information on the following:

- Accuracy of the 3D high frequency design code.
- Construction techniques.
- NC machining and tolerances.
- Selection of machine-able ceramics and of copper and aluminium alloys.
- Electroplating and electro-polishing.

The design and manufacture of the subsequent planar and helical 'short length' prototype structures, will build on the experience gained from the preliminary test assemblies, and should facilitate the choice of a candidate design for the full scale structure.

Effort has continued during this period on the selection and sourcing of suitable materials, and of specialised RF parts.

In particular, a manufacturer of high stability, vacuum compatible, and 'radiation hard', semi-rigid coaxial cable has been identified (Meggitt Safety Systems). The current RAL 'Helical' electrode design utilises a semi-rigid coaxial cable (UT390) with a solid PTFE dielectric, a polymer that is not 'radiation' hard. The replacement of these cables with 'Meggitt' SiO_2 dielectric, hermetically sealed cables, is a strategy that promises to address this weakness in the current design.

2) RAL fast pulse generator (FPG) : No activity in this quarter

3) RAL slow pulse generator (SPG): Upgrades to the SPG high voltage power supply, auxiliary power supplies, and to cooling, have been made during this period. Tests indicate that the 4 kV rated switch (Behlke model no. HTS 41-06-GSM-CF-HFB), when operated at the required FETS potential of 3 kV, is now generally compliant with the FETS SPG requirements. The new 'Scheme A' optical design for the FETS MEBT significantly lowers the SPG voltage requirement to ± 1.5 kV for a bipolar, or 3.0 kV for a unipolar SPG implementation. The results of the 4 kV SPG tests indicate that a unipolar implementation of the 'slow' chopper, may now be viewed as a practical possibility.

5) HIPPI 08 : Preparation and presentation of a talk and an animation on:'Beam Chopper Development for Next Generation High Power Proton Drivers', HIPPI 08, Meyrin, CERN, Geneva, Switzerland, 29th to 31st October, 2008

Table 4.4a: Status of the Sub tasks in WP4 which are supposed to have started according to the MS project breakdown in Annex 1

WBS #	Title	Original begin date (Annex 1)	Original end date (annex1)	Estimated Status	Revised end date
4.1	Chopper structure A (CERN)				
4.1.7	Prototype testing w/o beam	January 2006	December 2007	finished	
4.2	Chopper Line				
4.2.3	Beam line assembling	June 2005	December 2007	Finished	
4.3	Chopper structure B (RAL)				
4.3.3	Prototype construction	January 2006	June2007	finished	May2008
4.3.4	Prototype testing	November 2007	June2008	finished	December 2008

Table 4.4b: Status with respect to the interim reports and deliverables due in 2007 according to the MS project breakdown

WBS #	Title	Due date in Annex 1	Status	Revised delivery date
4.2.3	Chopper A beam line assembling.	December 2007	100%	December 2008
4.3.3	Chopper B Prototype ready	June 2007	delivered	June 2008
4.2.3	Beam line assembling	June 2005	100%	December 2008
	Comparative assessment of chopper design	December 2008	100%	December 2008

4.5 Work Package 5: Beam Dynamics and Diagnostics

Collaborative work on code benchmarking (GSI/Frankfurt/Saclay)

Evaluations of UNILAC data on high intensity Ar^{10+} beam and comparison with codes has been continued and brought to final conclusion. The introduction of distributions in the codes close to those measured has improved the agreement and shown the importance of detailed equivalence beyond rms equivalence. PARTRAN and DYNAMION results have been included and the final deliverable as comprehensive document prepared.

Work at RAL on nondestructive ion beam diagnostics at the Front End Test Stand

A recent aspects of work concerning the non destructive photo detachment diagnostics at RAL is the emittance reconstruction by moving the particle detector (which is in general used to determine the transverse angular momentum). This feature allows to measure beam profiles along a short drift length. Using a Baysian statistics method called Maximum Entropy (MaxEnt) a relatively low (3...10) number of profiles is sufficient to reconstruct the missing 2dim projected view achieving a good agreement with the entrance distribution. Further studies about the necessary phase advance were also performed.

Another aspect was investigated experimentally at the ion source development rig where the laser was "simulated" by a movable slit. After a drift this collimated beam was then mapped with a scintillator allowing to understand the same slit--point transformation of the PD emittance instrument. Some of the measured features might be helpful to optimise ion source and sector magnet.

CEA Beam Dynamics developments

Development of a code which allows to investigate plasma evolution coupled with the Maxwell equations dynamically. For space charge compensated LEBT line, numerical investigations which are in a good agreement with measurements showed how it is possible to reduce the emittance growth by playing with the nature and the partial pressure of the different gas in the vacuum pipe. We plan experiments in December with the SILHI LEBT to refine the code predictions.

Table 4.5a : Status of the Sub tasks in WP5 which are supposed to have started according to the MS project breakdown in Annex 1

WBS #	Title	Original begin date (Annex 3)	Original end date (Annex 3)	Estimated Status	Revised end date
5.1	Code development				
5.1.1	Preparation, Dev. of 3D space charge routines, Testing	January 2004	June 2006	100%	December 2007
5.1.3	Neutralization and ECR source model.	January 2004	December 2005	100%	December 2008
5.1.6	Codes preparation for SC linacs	January 2004	December 2006	100%	June 2007
5.1.7	Code comparison and benchmarking	January 2005	September 2008	95%	
5.2.2,3	Measurement campaigns	June and Oct. 2006		100%	July 2007
5.3	Diagnostics and collimation				
5.3.4	Non-interceptive bunch measurement construction (GSI)	January 2005	December 2006	100%	April 2007
5.3.9	Halo monitor tests and improvement (CERN)	January 2004	June 2005	100 %	March 2007
5.3.7	Beam profile monitor design (FZJ)	January 2005	June 07	100%	
5.3.6	On-line transmission control (GSI)	October 2005	September 2007	100%	

Table 4.5b: Status with respect to the interim reports and deliverables due in 2008 according to the MS project breakdown

WBS #	Title	Due date in Annex 1	Status	Revised delivery date
5.2.3	Code benchmarking	October 2008	delivered	
5.4	Simulations (and experiments)at CERN	December 2008	Report in preparation	
5.5	Comparative assessment	December 2008	On time	

Appendix 1: Gantt chart at end of October 2008

ID	Task Name
1	**WP2: NORMAL CONDUCTING STRUCTURES**
2	**2.1 Drift Tube Linac**
3	2.1.4 DTL beam dynamics design
4	**2.2 H-mode Drift Tube Linac**
5	2.2.7 CH-prototype construction, tests
6	2.2.8 CH-DTL beam dynamics study
7	**2.3 Side Coupled Linac**
8	2.3.4 RF model testing
9	**2.4 Cell Coupled Drift Tube Linac**
10	2.4.5 Testing of ISTC prototype
11	**WP3: SUPERCONDUCTING STRUCTURES**
12	**3.1 ELLIPTICAL CAVITIES**
13	3.1.12 High power pulsed tests
14	**3.2 SPOKE CAVITIES**
15	3.2.10 Manufacturing of 352MHz multi-gap prototype
16	3.2.11 Evaluation of 352MHz multi-gap prototype
17	**3.3 CH RESONATOR**
18	3.3.3 Measurement of tuning system
19	**WP4: CHOPPING**
20	**4.1 CHOPPER STRUCTURE A**
21	4.1.7 Prototype testing
22	**4.2 CHOPPER LINE**
23	4.2.3 Beam line assembling
24	**4.3 CHOPPER STRUCTURE B**
25	4.3.4 Prototype testing
26	**WP5: BEAM DYNAMICS**
27	**5.1 Code development**
28	5.1.3 Neutralization and ECR source modelization stu
29	5.1.8 Code benchmarking with experiment
30	**5.3 Diagnostics and collimation**
31	5.3.7 Beam profile monitor design