CARE/JRA3: Annual Report 2004

Title: High Intensity Pulsed Proton Injectors (HIPPI)

Coordinator: R. Garoby (CERN), Deputy: M. Vretenar

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	R. Garoby	
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	T. Junquera	CNRS
CNRS Laboratoire de Physique Subatomique et de Cosmologie (3)	CNRS-LPSC	F	T. Garvey	J.M. De Conto	CNRS

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

The HIPPI JRA has started operating in January 2004. Being based on activities already pursued inside the participant laboratories, the scientific and technical work was immediately productive. On the other hand, management and coordination were new and took some time to establish, both inside the Work Packages and at the level of the JRA.

For that purpose, each of the 4 scientific Work Packages organized its own workshop, before the summer 2004 (see Table 1.1.1a). At these occasions, the scientific and technical work was reviewed, the links between participants were strengthened and plans were drawn by the Work Package Coordinators for a proper coordination and reporting.

An important issue has been the adaptation of the tasks addressed inside WP2 to complement the work done in the three parallel projects supported by the ISTC (International Science and Technology Centre) in Moscow (Russia) concerning normal conducting accelerating structures for the CERN project (Linac4).

At the level of the JRA, regular monthly contacts took place between the members of the HIPPI steering committee (WP coordinators, HIPPI coordinator and his deputy). Activity reports were issued and communicated to the CARE management. These documents and more detailed information are available on the HIPPI web-site (http://mgt-hippi.web.cern.ch/mgt-hippi/). A general HIPPI meeting took place at the end of September, hosted by the University of Frankfurt. All participating laboratories were represented as well as the External Scientific Advisory Committee. Although focused on the review of the scientific and technical activities, it was also used for discussing management issues like the procedures of reporting, the preparation of CARE04 and the planning for the next 18 months.

1.1 Meetings

1.1.1 List of meetings

The list of events concerning HIPPI during the year 2004 is shown in Table 1.1.1a. More details are given in Table 1.1.1b (web-site or address of the minutes).

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

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
CARE & HIPPI												
CSC meetings		23 Paris				24 & 25 Warsaw					5 Hamburg	
Workshop WP2					3 & 4 Grenoble							
Workshop WP3						6 & 7 Saclay						
Workshop WP4					10 & 11 CERN							
Workshop WP5						4 Darmstadt						
Joint workshop with BENE "Physics with a multi-MW proton source"					25 till 27 CERN							
HIPPI yearly meeting									29 till 1/10 Frankfurt			
CARE yearly meeting											2 till 5 Hamburg	
Other collab.												
IPHI - SPL				26 & 27 Saclay								
ISTC			8 till 10 CERN 29 till 2/04 Moscow		13 & 14 CERN							
Miscellaneous												
HIF2004 (Elba Island)						5 till 8 Elba Island						
SPSC									22 till 28 Villars			
EPAC'04							5 till 9 Lucerne					
LINAC'04								16 till 20 Lubeck				
ICFA HB'04										18 till 22 Bensheim		

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
March 8-10	ISTC projects # 2875	CERN (CH)	CERN	11	https://edms.cern.ch/file/489417/2/Summary_meeting_10_03_04.pdf
March 29 - April 2	ISTC projects # 2888 and 2889	Moscow (Russia)	ITEP (Moscow) IHEP (Protvino)	23 27	https://edms.cern.ch/file/474222/1/ITEP_March04.pdf https://edms.cern.ch/file/474208/1/IHEP_April04.pdf
April 26-27	IPHI-SPL collaboration meeting	Saclay (France)	IPHI	40	https://edms.cern.ch/file/466511/1/SUMMARY_5th_IPHI_CERN.pdf
May 3-4	Workshop of HIPPI WP2	LPSC (Grenoble)	HIPPI WP2	~ 10	http://hippiwp2.in2p3.fr/liste%20meeting%20minute.htm
May 10-11	Workshop of HIPPI WP4	CERN (CH)	HIPPI WP4	~ 10	http://lombarda.home.cern.ch/lombarda/WP4/WP4-Chopper/programme.htm
May 13-14	ISTC projects # 2888 and 2889	CERN (CH)	CERN	15	https://edms.cern.ch/file/474241/1/CERN_May04.pdf
May 25-27	Physics with a Multi-MW proton source	CERN (CH)	CARE (BENE + HIPPI) + EURISOL	~ 120	http://physicsatmwatt.web.cern.ch/physicsatmwatt/
June 4	Workshop of HIPPI WP5	GSI (Darmstadt)	HIPPI WP5	18	http://www-w2k.gsi.de/lhofmann/HIPPI%20WP5/WP%205%20main%20page.html
June 5-8	HIF04 - High Intensity Frontier Workshop	Elba Island (Italy)	INFN	~ 80	http://www.pi.infn.it/pm/2004/
June 6-7	Workshop of HIPPI WP3	Saclay (France)	HIPPI WP3	17	http://hippiwp3.in2p3.fr/Liste%20fichier%20meeting%20minutes.htm
July 5-9	9th European Particle Accelerator Conference	Lucerne (CH)	EPAC conference	991	http://www.epac04.ch/index.html
Aug. 16-20	22nd International Linear Accelerator Conference	Lubeck (Germany)	LINAC conference	272	http://www.linac2004.de/
Sept. 22-28	SPSC Villars meeting on Future Fixed Target Experiments at CERN	Villars (CH)	SPSC (CERN)	~ 100	http://committees.web.cern.ch/Committees/SPSC/Villars-info.html
Sept. 29 – Oct. 1	HIPPI annual meeting	Frankfurt University	HIPPI JRA	38	http://hippi04.web.cern.ch/hippi04/index.htm
Oct. 28-22	33rd ICFA Adv. Beam Dynamics Workshop on High Intensity and High Brightness Hadron Beams	Bensheim (Germany)	GSI	130	http://www.gsi.de/search/events/conferences/ICFA-HB2004/index_e.html
Nov. 2-5	CARE annual meeting	DESY (Hamburg)	CARE	203	http://care04.desy.de/

1.1.2 General meetings

The only general meeting where all contributors to HIPPI were invited was “HIPPI04”. It lasted 2.5 days (from September 29 till October 1) and was hosted by the University of Frankfurt. All participating institutes were represented (CCLRC-RAL: 3, CEA: 4, CERN: 5: FZJ: 5, GSI: 9, IAP-FU: 7, INFN-Milano: 1, CNRS-IPNO: 2, CNRS-LPSC: 2) with a total of 38 people. Two of the three members of the External Scientific Advisory Committee (ESAC) were present and participated actively to the discussions. Based on this information, they have since published their first report [Annex 2 and http://hippi04.web.cern.ch/hippi04/ESAC_report_2004_final.pdf].

A brief summary is given in Appendix 1. A comprehensive summary has been published [http://hippi04.web.cern.ch/hippi04/HIPPI04_Summary.pdf]. All talks are available on the HIPPI04 web-site [http://hippi04.web.cern.ch/hippi04/index.htm].

1.2 External Scientific Advisory Committee

1.2.1 Composition

The ESAC has the following members:

- Andrea Pisent — INFN Legnaro (Italy)
- James E. Stovall — retired; previously SNS Oak Ridge (USA)
- Yoshiharu Yamazaki — JAERI Tokai (Japan)

1.2.2 Report of the ESAC

As mentioned above, two of the three ESAC members (A. Pisent and J.E. Stovall) participated actively to the annual HIPPI meeting, “HIPPI04”. They received the files of the talks during the week preceding the workshop. Y. Yamazaki who could not be physically present, contributed nevertheless to the edition of the first ESAC report (Appendix 2).

Preliminary recommendations were presented during the last session of HIPPI04. The final ESAC report was delivered for the CARE04 meeting in DESY (November), where it was analysed and debated by the participants in HIPPI who were present (~ 10 people). The ESAC highly praised the importance of HIPPI and the quality of the work done by the participants. The main recommendations can be summarised as follows:

- Define a set of HIPPI performance goals,
- Improve communication between WP4, 3 and 2 with WP5 (beam dynamics),
- Analyse and compare the relative merits of quadrupoles using permanent magnet w.r.t. electromagnets or hybrid devices,
- Analyse and compare alternative focusing lattices in the DTL,
- Better use information on recently designed high power RF couplers,
- Learn more about modern DTL construction techniques recently used in Japan and USA,
- Compare different CCL designs,
- Study the problems associated with driving multiple superconducting cavities from a single RF amplifier.

The possible answers and the lessons learnt by the HIPPI participants have been summed-up in an internal document. Action is being made on all these points to prepare adequate work for the next ESAC review.

2 DISSEMINATION ACTIVITY

2.1 List of talks

Table 2.1: List of talks at workshops and conferences made by JRA members and which are about (or include) activities carried within HIPPI

#	Subject	Speaker/Lab	Event	Date	Talk Web site	CARE-Conf
1	The potential of the SPL at CERN	R.Garoby/ CERN	Physics with a Multi-MW proton source workshop	25.5.04, Geneva (CH)	(PPT, PDF)	
2	The SPL at CERN: characteristics and potential	R.Garoby/ CERN	HIF04 - High Intensity Frontier Workshop	5.6.04, Elba (I)	(ppt)	
3	Development of Normal and Superconducting CH-structures	H. Podlech/ IAP-FU	XXII International Linear Accelerator Conference	16-20.8.04, Luebeck (D)		CARE-Conf-04-011-HIPPI
4	Development of the Unilac towards Megawatt Beams	W. Barth/ GSI	XXII International Linear Accelerator Conference	16-20.8.04, Luebeck (D)		CARE-Conf-04-026-HIPPI
5	Overview of High Intensity Linac Programs in Europe	M. Vretenar/ CERN	XXII International Linear Accelerator Conference	16-20.8.04, Luebeck (D)	(PDF)	
6	Review of Fast Beam Chopping	F. Caspers/ CERN	XXII International Linear Accelerator Conference	16-20.8.04, Luebeck (D)	(PDF)	
7	Proposal for the upgrade of the CERN proton accelerator complex	R. Garoby/ CERN	SPSC Villars Meeting on a Future Fixed Target Programme at CERN	22-28.9.04, Villars (CH)	(PPT)	
8	Long term simulation of halo formation and beam loss in high intensity machines	G.Franchetti/ GSI	33rd Advanced Beam Dynamics Workshop	18-22.10.04, Bernsheim (D)	(ppt)	
9	The SPL at CERN	R. Garoby/ CERN	33rd Advanced beam Dynamics Workshop	18-22.10.04, Bernsheim (D)	(ppt)	CARE-Conf-04-022-HIPPI
10	The 70MeV p-Injector Design for FAIR	U. Ratzinger/ IAP-FU	33rd Advanced beam Dynamics Workshop	18-22.10.04, Bernsheim (D)	(ppt)	
11	RAL proton drivers and ISIS upgrade plans	C. Prior/ RAL	33rd Advanced beam Dynamics Workshop	18-22.10.04, Bernsheim (D)	(pdf)	
12	Benchmarking linac codes for the HIPPI project	G.Franchetti/ GSI	33rd Advanced beam Dynamics Workshop	18-22.10.04, Bernsheim (D)	(pdf)	CARE-Conf-04-021-HIPPI
13	High Intensity Beams at CERN and the SPL Study	M. Vretenar/ CERN	DAE Symposium on Nuclear Physics	6-10.12.04, Varanasi (IN)		

2.2 List of papers

Five types of papers have been defined in CARE:

1. CARE/HIPPI Document (internal HIPPI documents)
2. CARE-Pub (Journal publications)
3. CARE-Report (Reports to EU)
4. CARE-Conf (Contributions to conferences)
5. CARE-Note (Notes of CARE interest),

Documents in categories 2 and 5 are reviewed, and category 4 needs the approval of the HIPPI Coordinator. For publication in category 2, a review committee is designated by the CARE coordinator to evaluate the scientific content.

To be approved as a CARE/HIPPI publication, a paper must comply with the following basic criteria. It has to be:
1. pertinent to the JRA,
2. consistent with CARE politics, presenting no problems with authors and colleagues,
3. original (not published before, apart internal notes),
4. of sufficiently high scientific level,
5. written in a decent form (no evident errors in English, figures readable, etc.),
6. acknowledge the EU support via the sentence: "*We acknowledge the support of EU through the CARE I3, contract number RII3-CT-2003-506395*".

Until now, HIPPI has produced 19 conference papers, 1 journal publication, 1 document and 1 report. They are listed in Table 2.2. The distribution between the different categories is expected to stay the same in the future, with many conference papers, few journal publications and few internal documents.

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

#	CARE document type and number	Title	Authors and Labs	Date
1	CARE-Conf-04-002-HIPPI	A new 180 MeV H- linac for upgrades of ISIS	F. Gerigk – CCLRC-RAL	07/2004
2	CARE-Conf-04-003-HIPPI	Space-charge problem in low energy superconducting linacs	N. Vasukhin, R. Maier, Y. Senichev - FZJ	07/2004
3	CARE-Conf-04-004-HIPPI	Triple-spoke cavities at FZJ	E. Zaplatin, W. Braueutigam, R. Maier, M. Pap, M. Skrobucha, R. Stassen, R. Toelle - FZJ	07/2004
4	CARE-Conf-04-007-HIPPI	The CERN SPL chopper concept and final layout	F. Caspers, Y. Cuvet, J. Genest, M. Haase, M. Paoluzzi, A. Teixeira – CERN	07/2004
5	CARE-Conf-04-008-HIPPI	A fast beam chopper for next generation high power proton drivers	M.A. Clarke-Gayther – CCLRC-RAL	07/2004
6	CARE-Conf-04-009-HIPPI	A space charge algorithm for ellipsoidal bunches with arbitrary beam size and particle distribution	A. Orzhekhovskaya, G. Franchetti	07/2004
7	CARE-Conf-04-011-HIPPI	Development of room temperature and superconducting CH structures	H. Podlech – IAP-FU	08/2004
8	CARE-Conf-04-012-HIPPI	KONUS beam dynamics design of a 70 mA, 70 MeV proton CH-DTL for GSI-SIS12	R. Tiede, G. Clemente, H. Podlech, U. Ratzinger, W. Barth, L. Groening, Z. Li, S. Minaev – IAP-FU	08/2004
9	CARE-Conf-04-013-HIPPI	Design of the RT CH cavity and perspectives for a new GSI proton linac	Z. Li, R. Tiede, U. Ratzinger, H. Podlech, G. Clemente, K. Dermati, W. Barth, L. Groening - GSI	08/2004
10	CARE-Conf-04-014-HIPPI	Beam dynamics for a new 160 MeV H- linac at CERN (Linac4)	F. Gerigk, E. Benedico-Mora, A. Lombardi, E. Sargsyan, M. Vretenar - CERN	08/2004
11	CARE-Conf-04-016-HIPPI	The SPL front-end: a 3 MeV H- test stand at CERN	C. Rossi, L. Bruno, F. Caspers, R. Garoby, J. Genest, K. Hanke, M. Hori, D. Kuchler, A. Lombardi, M. Magistris, A. Millich, M. Paoluzzi, E. Sargsyan, M. Silari, T. Steiner, M. Vretenar, P.Y. Beauvais, P. Ausset	08/2004

12	CARE-Conf-04-018-HIPPI	A dedicated 70 MeV proton linac for the antiproton physics program of the future Facility for Antiproton and Ion Research (FAIR) at Darmstadt	L. Groening, W. Barth, L. Dahl, R. Hollinger, P. Spadtke, W. Vinzenz, S. Yaramishev, Z. Li, U. Ratzinger, A. Schemp, R. Tiede - GSI	08/2004
13	CARE-Conf-04-019-HIPPI	Investigation of the beam matching to the GSI-Alvarez DTL under space charge conditions	S. Yaramishev, W. barth, L. Dahl, L. Groening, S. Richter - GSI	08/2004
14	CARE-Conf-04-015-HIPPI	Design of Linac4, a new injector for the CERN Booster	R. Garoby, K. Hanke, A. Lombardi, C. Rossi, M. Vretenar - CERN	08/2004
15	CARE-Conf-04-017-HIPPI	Development of a 352 MHz Cell Coupled Drift Tube Linac prototype	Y. Cuvet, J. Genest, C. Vollinger, M. Vretenar - CERN	08/2004
16	CARE-Conf-04-025-HIPPI	Space charge compensation in Low energy proton beams	A. Benismail, R. Duperrier, D. Uriot, N. Pichoff - CEA	08/2004
17	CARE-Conf-04-022-HIPPI	The SPL at CERN	R. Garoby - CERN	12/2004
18	CARE-Conf-04-021-HIPPI	Benchmarking linac codes for the HIPPI project	A. Franchi, G. Franchetti, L. Groening, I. Hofmann, A. Orzhekovskaya, S. Yaramishev – GSI, A. Sauer – IAP-FU R. Duperrier, D. Uriot – CEA F. Gerigk – CCLRC-RAL	12/2004
19	CARE-Conf-04-026-HIPPI	Heavy ion high intensity upgrade of the GSI UNILAC	W. Barth, L. Dahl, M. Galonska, J. Glatz, L. Groening, R. Hollinger, S. Richter, S. Yramishev	12/2004
20	CARE-Report-04-004-HIPPI	Second quarterly report of HIPPI	R. Garoby, M. Vretenar - CERN	07/2004
21	CARE-Pub-04-001	Beam halo in high-intensity hadron accelerators caused by statistical gradient errors	F. Gerigk - CCLRC-RAL	02/2004
22	CARE/HIPPI-Document-04-001	Conceptual Design and Radiological Issues of a Dump for the 3 MeV Test Facility	L. Bruno, M. Magistris, M. Silari - CERN	

2.3 Web site

The HIPPI web site (**http://mgt-hippi.web.cern.ch/mgt-hippi/**) has been set up during 2004, and went through a complete update in October 2004. It gives access to:

- Work Package web sites (minutes and presentations of WP meetings, general information), maintained by the WP coordinators, intended for direct communication and exchange of information inside the Work Packages.
- HIPPI Publication list.
- Job offers.
- Web site of the Annual Meeting(s), with information and presentations of the annual meeting. The first one is at the URL: **http://hippi04.web.cern.ch/hippi04/index.htm**
- Links to useful web page (parallel projects in the US and Japan, useful information).

The Work Package coordinators and the Laboratory link-persons contribute to keep the information up to date.

3 ADDITIONAL STAFF HIRING

Job openings are advertised both on the HIPPI and on the CARE web sites. Actions have been taken in the main laboratories participating to HIPPI, to have a link to the CARE job age added to the main job page of the Laboratory. This has been done in particular in the CERN and CEA web sites.
The situation at the end of 2004 is summarized in Table 3.

Table 3: Temporary staff hiring

#	Lab	Job Type	Duration	Work subject	Status
1	CERN	Post Doc	3 years	RF and RF structure (supervisor: M. Vretenar)	Hired on October 1, 2004
2	CERN	Scientific Associate	3 years	Beam dynamics (supervisor: A. Lombardi)	Hired on July 1, 2004
3	GSI	Staff	3 years	Beam dynamics (supervisor: W. Barth / I. Hofmann)	Searching since July 2004
4	CCLRC-RAL	Staff	3 years	Beam dynamics and RF (supervisor: C. Prior)	Searching since August 2004

4 STATUS OF THE WORK

The resources used by the participants during the year 2004 are summarised in Table 4. The costs mentioned correspond to payments; more is committed which will only be paid in 2005. IAP-FU and INFN-Milano have not been able to spend at the foreseen rate. Detailed explanations are given in the following chapters 4.2 (WP2) and 4.3 (WP3). In both cases the main issue is the delay in finding adequate personnel to hire.

Table 4: Status of the expenditures per participant for HIPPI

JRA3	**Participant (cost model)**	**Permanent staff including indirect cost (Euros)**	**Additional Staff including indirect cost (Euros)**	**Durable Equipment including indirect cost (Euros)**	**Consumables and Prototyping including indirect cost (Euros)**	**Travel including indirect cost (Euros)**	**Real costs including indirect cost (Euros)**	**Direct cost**	**Sub-contract**	**Indirect cost**	**First received payment (Euros)**
1	CEA (FC)	249,620			44,144	6,625	300,389	191,566	0	108,822	239,960
3	*CNRS-IN2P3*	*30,610*	*0*	*0*	*0*	*0*	*30,610*	*25,509*	*0*	*5,102*	*7,500*
	CNRS-LPSC	*53,414*	*0*	*0*	*0*	*1,685*	*55,099*	*45,916*	*0*	*9,183*	*9,000*
	CNRS(FCF)	84,024	0	0	0	1,685	85,710	71,425	0	14,285	16,500
4	GSI(FC)	156,567	33,588	159	0	2,875	193,189	140,740	0	52,449	127,500
5	IAP-FU(AC)	*0*	74,286	0	0	3,552	77,838	64,865	0	12,973	108,750
7	FZJ(FC)	381,027	0	0	25,189	3,249	409,465	238,319	0	171,146	112,405
10	INFN-Mi(AC)	*0*	13,592	0	0	1,560	15,151	12,626	0	2,525	22,500
17	CERN (AC)	*0*	130,015	0	306,865	13,046	449,927	374,939	0	74,988	97,500
20	CCLRC (FC)	238,668	0	0	20,272	7,119	266,059	126,836	0	139,223	96,000
	Grand total	**1,109,906**	**251,481**	**159**	**396,470**	**39,711**	**1,797,728**	**1,221,317**	**0**	**576,411**	**821,115**

4.1 Work Package 1 : Management and Communication

The participating laboratories have acknowledged reception of 75 % of the E.U. allocation for the first 18 months. Efforts are being made to organize accounting in a convenient way, both for the laboratories and the activity coordinator who has to integrate the information (see Table 4).

One quarterly and three intermediate activity reports have been published since the beginning of the year (http://mgt-hippi.web.cern.ch/mgt-hippi/activity_reports/activity_reports.html).

The ESAC members have been nominated and the yearly HIPPI event is now organized (http://hippi04.web.cern.ch/hippi04/index.htm).

Between end 2003 and end 2004, i.e. after the HIPPI approval, the ISTC (International Science and technology Center) in Moscow has approved three projects for the construction in Russia of prototypes of normal conducting accelerating structures for the CERN project (Linac4). Two of these prototypes concern structures planned to be studied in WP2 of HIPPI. Therefore, to avoid duplication of efforts, the management of HIPPI negotiated the adaptation of the contributions of the CNRS-LPSC, CEA and CERN to complement the ISTC projects . Exchange of information between HIPPI and the ISTC projects is encouraged, but teams, work plan and resources will remain separate. Russian institutions will be only financed by the ISTC.

In the frame of the ISTC project #2888, a full scale DTL Alvarez prototype will be built in Russia. It is worth mentioning that, although some work was foreseen on this subject inside WP2, such a realization was not possible with the resources in HIPPI. The quadrupoles in the drift tubes will use permanent magnets. However, only a single drift tube will be equipped with a quadrupole; the others being “dummy”. Magnetic measurements will be performed at CERN. (More details are given in sections 4.2 and 4.3). The high power waveguide coupler will be jointly designed by the CEA and CNRS-LPSC (sub-task 1.1.2: “Development of critical DTL components”). Because of the unexpectedly high cost of the 700 MHz klystron needed for the high power test place at Saclay, this will be the only contribution of the CEA to the Alvarez DTL developments. High power RF tests will be done at CERN.

In the frame of the ISTC project #2875, a CCDTL prototype will be built. It will be the device foreseen in WP2 - task 1.4.2 (Prototype design, construction, test). The preliminary design will be done inside HIPPI, while detailed design and construction will be delegated to the Russian laboratories. Testing will be done at CERN, again inside HIPPI.

4.2 Work Package 2: Normal Conducting Accelerating Structures

The work done during 2004 differs slightly from the original work planned at the beginning of HIPPI. The differences come from some adjustment of the tasks within the collaboration (e.g: DTL) and from some delays due to external constraints (e.g: H mode DTL), or to local difficulties (e.g: lack of doctoral student for SCL at LPSC). The Russian contribution via the ISTC projects is now well coordinated with the work taking place inside HIPPI, and duplications are carefully avoided.

4.2.1 Drift Tube Linac

4.2.1.1 *DTL and coupling port design*

The sharing of work between the laboratories has been defined. CERN will take care of the magnetic measurements, using internal resources (from the AT Department) that are not integrated into HIPPI.
The Russian team [ITEP (Moscow)+ VNIIEF (Sarov)] is progressing in the design of the DTL full prototype that will use the coupler designed and built inside HIPPI. Investigations are being made in Russia (Sarov) on laser welding techniques for DTL drift tubes.
The input coupler will be designed and built (operating prototype) by CEA and CNRS-LPSC. CEA will do the RF design, CNRS-LPSC will follow with the thermal design in collaboration with CEA, and finally CNRS-LPSC will produce the prototype. A sketch of the coupling scheme is shown in Figure 4.2.1.1a. A preliminary RF design has been done. After reception of precise parameters (from the Russian team), the final RF design has started.

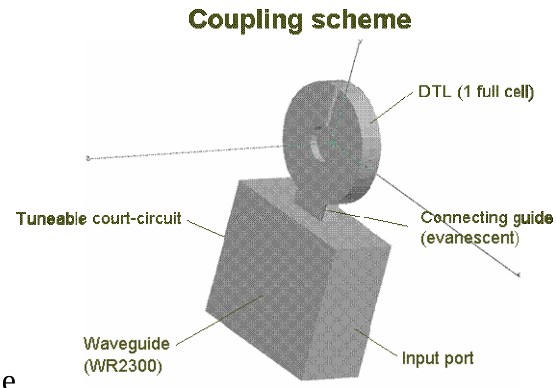


Figure 4.2.1.1a: DTL coupling scheme

The tunability of the system has been studied on the preliminary design. Figure 4.2.1.1b shows the external quality factor achieved versus the position of the short circuit. A range of about ±100mm is required. These data have to be adjusted following the final RF design.

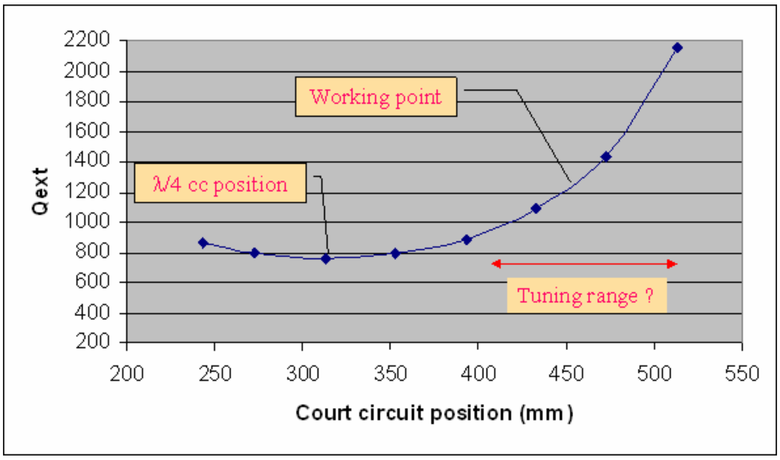


Figure 4.2.1.1b: Coupling range

4.2.1.2 *DTL beam dynamics*

Theoretical work: A study on the influence of statistical quadrupole gradient errors in high-intensity hadron machines has been made and published in PRSTAB [1]. This study shows that parametric particle-core resonances can be triggered not only by initial mismatch but also by statistical errors and thus contribute to the development of beam halo.

In a joint effort between CERN and RAL, the current Linac4 design has been refined and simulated with PATH at CERN and with IMPACT at RAL. It was found that the energy spread of the source has a significant influence on the emittance growth in the DTL. While both codes show the same general trends, the estimated amount of losses in the MEBT scraper differ slightly (Figure 4.2.1.2). The results were presented at the LINAC04 conference [2].

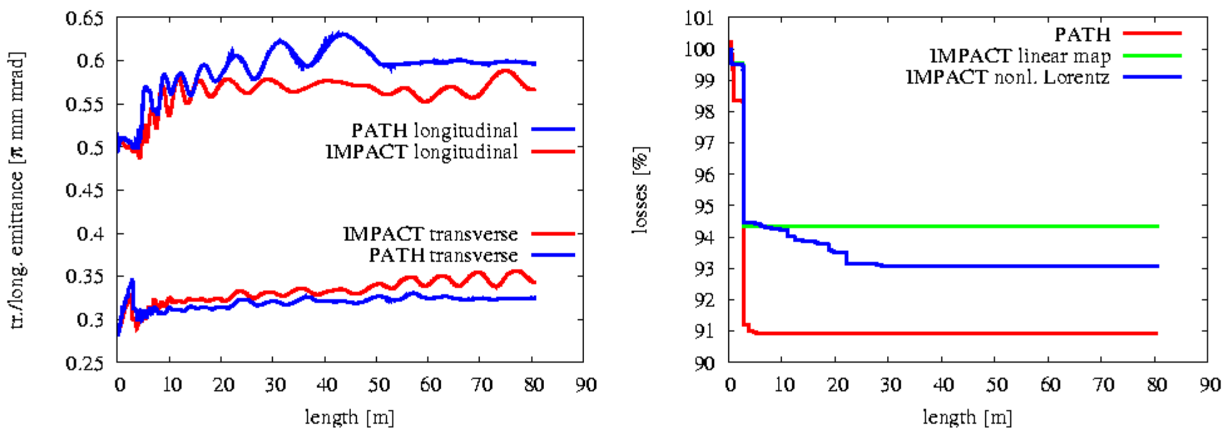


Figure 4.2.1.2: Linac4 simulation results

Conversion scripts have been developed to simplify the comparison between codes. So far conversions can be done from Trace3D to IMPACT, IMPACT to Trace3D, MAD8 to Trace3D, TraceWin to IMPACT. A number of bash/python scripts and fortran routines have been written to simplify the submission and evaluation of a large number of IMPACT simulations with different error sets, involving gradient, alignment, rotation, and RF errors. These have been used in [1], [2], and [3], and they are used right now in an effort to specify error tolerances for Linac4. A python script to use genetic algorithms for beam matching has been written that uses IMPACT as tracking code. First results are encouraging but further work is needed.

4.2.1.3 *DTL design*

A 180 MeV H^- linac for upgrades of the ISIS accelerator at RAL has been designed. It is based on 7 DTL tanks, operating at 234.8 MHz, which accelerate the beam to an energy of 90 MeV. Beyond this energy, the CERN SCL linac section (used in Linac4), operating at 704.4 MHz, is assumed for acceleration up to 180 MeV. The DTL was designed with SUPERFISH and the beam dynamics were simulated with IMPACT. The motivation for the design as well as technical details, were presented at EPAC04 [3]. It was shown that the triple frequency jump is possible, but that the matching at this transition deserves more work. Future work should also include a new chopper line design that will evolve from the ESS design. A possible site layout is shown in Figure 4.2.1.3.

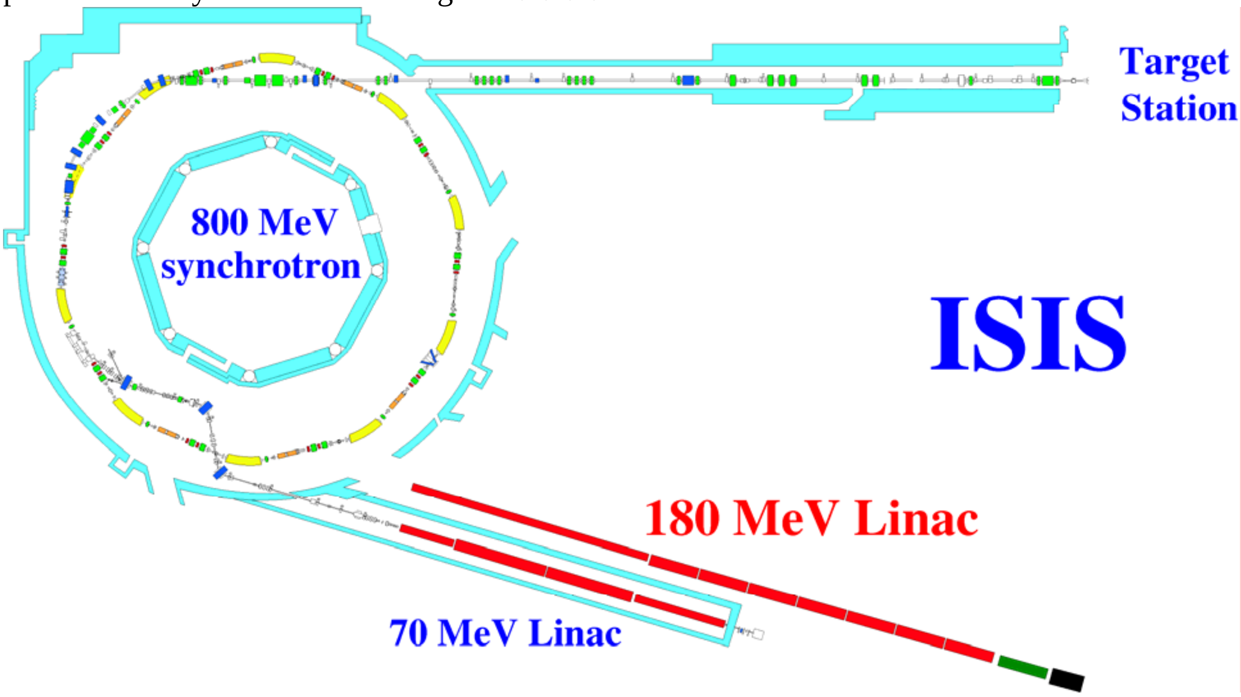


Figure 4.2.1.3: Accelerators layout on the RAL site

A re-assessment of the possible frequency choices for the new ISIS has started in view of the planned front-end test stand at RAL. A 200 MHz front-end would make use of existing knowledge at RAL on 200 MHz RF sources and RFQs, while 234.8 or 352.2 would fit better into the HIPPI context [4].

Additional staff for Rutherford Laboratory

A HIPPI position has been advertised and interviews have been held. Two candidates were chosen as suitable and an offer is made to the preferred one. The person should start working in the first quarter of 2005.

References for 4.2.1.2 and 4.2.1.3 paragraphs

[1] F Gerigk, “Beam halo in high-intensity hadron accelerators caused by statistical gradient errors”, PRSTAB, 7, 064202 (2004), CARE-PUB-04-001
[2] F Gerigk, E Benedico Mora, A Lombardi, E Sargsyan, M Vretenar, “Beam dynamics for a new 160 MeV H- linac at CERN (Linac4)”, LINAC04, CARE-Conf-04-0014-HIPPI

[3] F Gerigk, talk+paper “A new 180 MeV H- linac for upgrades of ISIS”, EPAC04, CARE-Conf-04-002-HIPPI
[4] F Gerigk, “Arguments to choose the frequency for a new 180 MeV linac and the associated front-end test stand at RAL”, technical note: FETS-TN-04-001.

4.2.2 H-mode DTL

The design work on beam dynamics for the GSI Proton Linac of the FAIR facility is completed and the basic parameters (nb of tanks, choice of the front end option) are defined.
As an intermediate step during the beam dynamics design procedure, different matching schemes between RFQ and the first CH-DTL tank have been investigated.
The main alternatives were:

- A very compact MEBT with no external buncher cavity between RFQ and CH-DTL, and with quadrupole triplet lenses integrated into the first CH cavity.
- A more conventional design, including an external MEBT buncher cavity and consisting of “short”, multicell CH-DTL’s without integrated quadrupole triplet lenses.

The second option was finally favoured, because it increases the system flexibility with respect to changes in the beam out of the RFQ (i.e. beam current, phase space distributions).
An intermediate design has been presented at the 2004 LINAC Conference.

The delay in the beam dynamics design activities has resulted from the following events:

- The design current for the DTL section was redefined from 70 to 90 mA.
- RFQ design results (simulated output beam parameters) for the GSI Proton Linac were not available before September 2004, and had to be carefully used to optimize the RFQ-DTL matching section and to minimize emittance growth along the DTL.
- The multi turn injection scenarios into the synchrotron are still discussed, with impact on the beam requirements at the DTL exit.

The design of the 352 MHz room temperature CH-DTL cavity has progressed along the following steps:

- Optimization with Microwave Studio^{TM} (single cell cross section optimization for low velocities, as well as multi cell cavity numerical simulations).
- In-house development of concepts for technical design alternatives.
- Commissioning of a design and fabrication study by industry (company “NTG”). The study has been completed in October 2004. The results (including definite recommendations on manufacturing techniques and tools) are presently discussed and will be utilized for fixing the final CH prototype design.

Cavity construction is based on a double walled tank with stems welded directly to the inner wall (no common carrying girder needed any more). Stems have an integrated cooling channel. The half drift tubes are press-fitted into a central bore hole (Figure 4.2.2).
Based on the preparatory work (beam dynamics and cavity mechanical design) the technical design work on the CH prototype cavity has now begun.

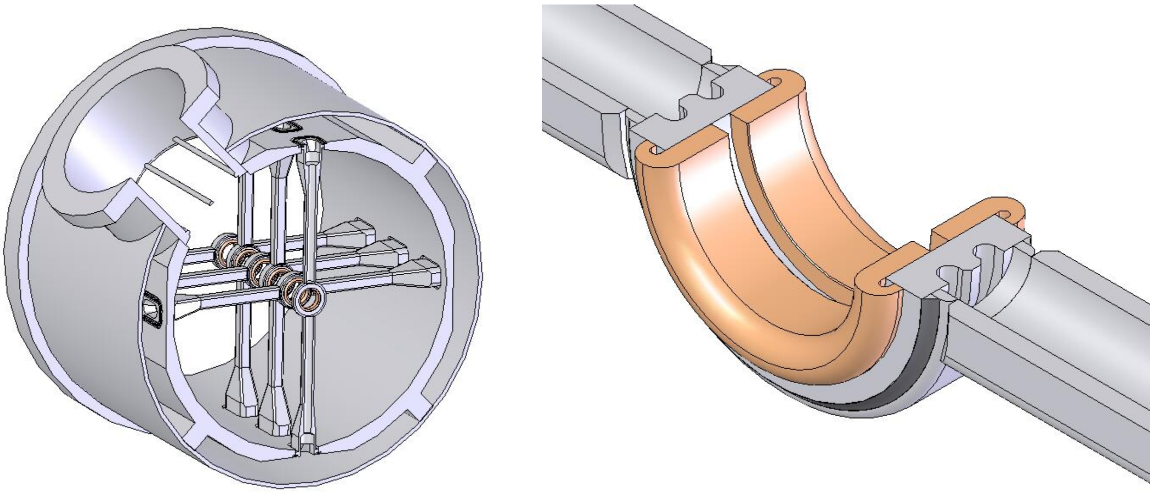


Figure 4.2.2: Favoured CH-DTL mechanical design option

***Cold model issue**:* A cold model was initially foreseen in the case of a sophisticated, long cavity with integrated triplets, to gain confidence for the prototype cavity and with the hope to reuse the main part of the existing sc CH model (the project budget is quite tight).
Meanwhile the design of the room temperature CH has evolved noticeably from the existing model. Besides, the cavity being shorter in the new design and without integrated lenses, simulation can more safely be trusted. This is why the decision has been made to measure directly the frequency and to tune the field flatness on the prototype cavity.
In addition, a stainless steel multicell model cavity is presently built at IAP-FU, in order to investigate manufacturing and assembly details on a sample resonator. For the room temperature CH-DTL, there is no experience available by now with respect to these issues.
This shows that the cold model tasks were shifted from rf aspects to the investigation of mechanical design and fabrication options.

4.2.3 Side Coupled Linac:

A Side Coupled Linac (see basic sketch in Figure 4.2.3a) is a good solution for the 90-160 MeV part of pulsed proton linacs like LINAC4 at CERN or for the high energy part of the ISIS upgrade linac. Advantages are: easy machining, compactness, high shunt impedance, absence of parasitic modes, well established tuning procedures, existing experience at CERN (LIBO prototype, 3 GHz, for medical purposes).
The 90-160 MeV part of LINAC4 will be made of 5 modules, 4 tanks per module, 11 accelerating cells per tank. The accelerating gradient will be 4 MV/m, and the power 3 MW per klystron.

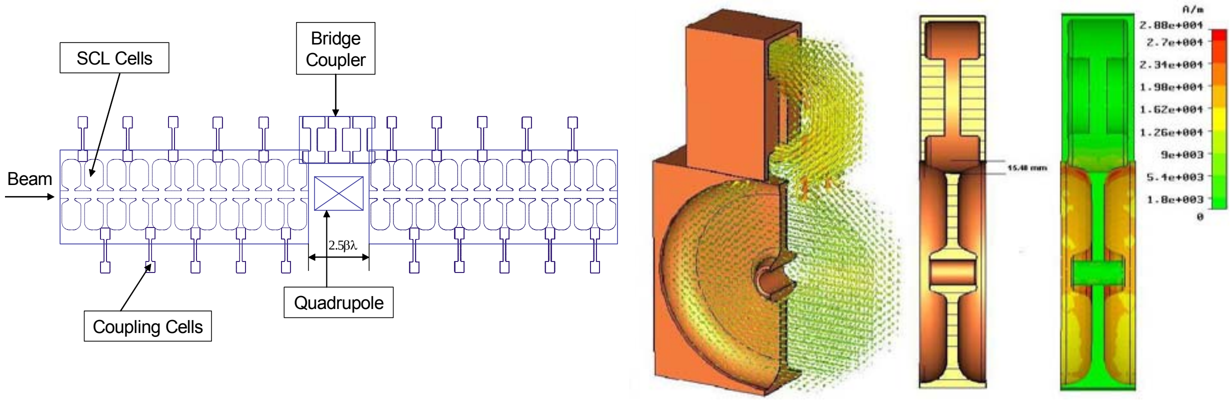


Figure 4.2.3a: SCL tank overview (left) and 3D RF simulations of the cavities (right)

Studies started in collaboration between CERN and LPSC on the basis of a CERN design. It is a new field of activity for LPSC. They include the study of RF analytical models, the mechanical design and 3D RF simulations of the cavities. The objective is to build a “cold” multi-cell model for low RF level studies (like tuning procedures) and to perform technological studies.
At CERN, an equivalent circuit analysis for a complete SCL module is in preparation, in order to optimize the value of the cell-to-cell coupling coefficient. The RF design of the bridge couplers is almost finished.
At LPSC, a study is also performed to optimize the coupling coefficient “k”, via an analytical model of the system. This model will be used to define the mechanical tolerances versus the significant parameters (e.g.: number of cells, coupling factor etc), and the tuning procedures. In particular, a compromise has to be made between a high value of k (less strong mechanical tolerances, better field uniformity) and a high-enough quality factor. In parallel to the analytical studies, and for the same goals, the development of associated simulation tools is done by using MAPLE.
A preliminary drawing of the cavity has been made and sent to the Russian ISTC team in BINP (Novosibirsk) to start the technological studies (Figure 4.2.3b).
The major difficulty encountered at LPSC is the missing doctoral student and this may lead to some delays. Some alternative solutions have to be considered with permanent staff members.

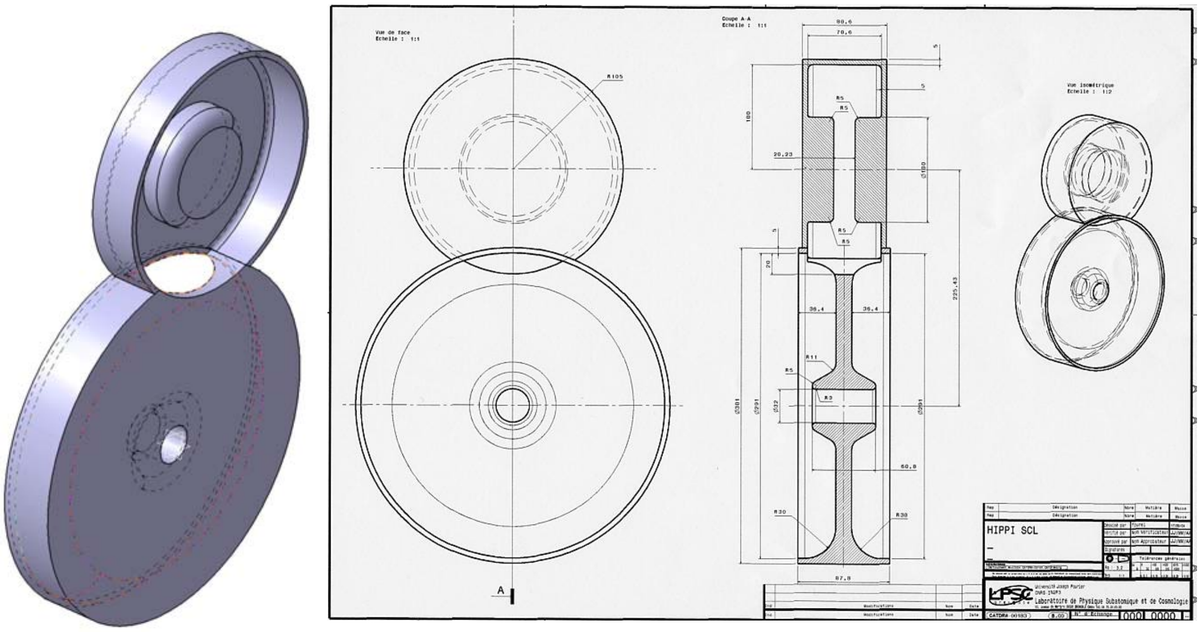


Figure 4.2.3b: Preliminary design of the cells (acceleration and coupling)

4.2.4 Cell Coupled DTL

The CCDTL pre-prototype being built at CERN has required an unexpected effort during the year 2004, which led to some delay in the construction. However, this is not going to delay the high power tests at CERN, which are still foreseen to start in April 2005. A 3D representation of the assembled pre-prototype is shown in Figure 4.2.4.

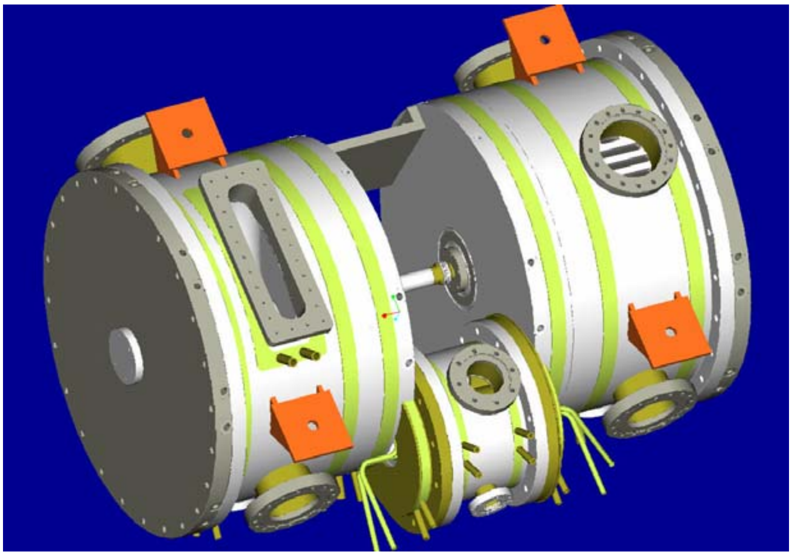


Figure 4.2.4: CCDTL pre-prototype (CERN-built)

The main difficulty encountered during production was due to porosities at the location of the electron beam weld, probably because of impurities in the stainless steel. Repair involved local re-machining and re-welding. In parallel with the construction of the pre-prototype, all the ancillary equipment needed for the tests (waveguide connection, support, vacuum seals, cooling circuitry, etc.) has been designed and ordered. The last component still to built is the waveguide connection, foreseen to go into production in the first months of 2005. This component is needed only for the high power tests. After repair of the weldings, the CERN CCDTL pre-prototype has successfully passed a complete vacuum test, indicating that the problems have been solved and that the work can proceed.
The preparation of the copper plating for this device has started in September. The plating procedure has been defined and a set of tools for supporting the parts in the electrolysis baths has been designed and built. The first Nickel bath will be applied during the months of December.
In the mean-time, three theoretical studies have been performed, to prepare the measurements on the prototype and to support the design of the new prototype that is being designed and built in Russia (ISTC project #2875). A new series of extensive 3D RF simulations for the calculation of the RF coupling coefficient has been launched, backed by measurements on a small test cavity at 3 GHz, to assess the reliability of the simulation tools. Calculations, which have an estimated accuracy of 10 %, predict a coupling coefficient of 1.2, for a required value between 1 and 2. Therefore, the present design of the input coupler is already in production. After a calculation of the effect of alignment errors, an alignment strategy for a full CCDTL module has been defined. Finally, an analysis of the equivalent electrical circuit of a CCDTL module has shown that the foreseen 0.8% cell-to-cell coupling is sufficient for tuning and stabilization of the structure.

The design of the second prototype, to be built in Russia as part of the ISTC project #2875, has started in 2004, with the definition of final dimensions and type and size of ports and openings. The mechanical design and the construction of this prototype will be done at BINP (Novosibirsk) and at VNITEF (Snezinsk). The general mechanical drawing has been finalized during fall 2004, and the execution drawings will be made at the beginning of 2005. The copper plating procedure for this prototype has been defined at Snezinsk.

Table 4.2a : Status of the Sub tasks in WP2 which are supposed to have started according to the MS project breakdown in Annex 3

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	On time	Unchanged
2.1.2	Decision on prototyping	April 26, 2004	April 26, 2004	100 %	September 2004
2.1.3	Prototype component development	May, 2004	June 2007	On time	unchanged
2.1.4	DTL beam dynamics design	January, 2004	June, 2008	On time	unchanged
2.2	**H mode DTL**				
2.2.1	RF model CH tank 1, RF design	January, 2004	August, 2004	See note	See note
2.2.2	RF cold model design & construction	January, 2004	January, 2005	50%	December, 2005
2.2.3	RF model construction	December, 2004	June, 2005	20%	June 2006
2.2.4	Beam dynamics design CH tank 1	January, 2004	June, 2004	80%	June 2005
2.3	**Side Coupled Linac**				
2.3.1	RF model, RF design	January, 2004	July, 2004	~25%	*delayed*
2.3.2	RF model mechanical design	July, 2004	December, 2004		*probably delayed*
2.4	**Cell Coupled DTL**				
2.4.1	Pre-prototype construction	January, 2004	June, 2004	95 %	November 2004
2.4.2	Pre-prototype high power RF tests	July, 2004	March, 2005	Start delayed till March 2005	October 2005
2.4.3	Prototype mechanical design	January, 2005	December, 2005	10%	On time

Note: RF measurements will be done directly on the prototype cavity. Refer to the ”cold model issue” in paragraph 4.2.2.

4.3 Work Package 3: Superconducting Accelerating Structures

The first annual HIPPI-WP3 meeting was held on June 7-8 in Saclay (CEA).
Presentations and minutes are on the HIPPI-WP3 web site [http://hippiwp3.in2p3.fr/].

INFN-Milano

4.3.1 Cavity A vertical test (WBS 3.1.1)

The so-called cavity A (the elliptical cavity Z502 designed by INFN-Milano and fabricated by ZANON under the TRASCO/ADS Program) has been pre-tuned in Milano at 5% field flatness and leak-checked to prepare for the vertical tests. It then has been shipped to CEA-Saclay where the preparation and RF tests have been performed. Figure 4.3.1 shows the cavity being prepared for the vertical test, together with the experimental data of the quality factor Q_0 as a function of the accelerating field.

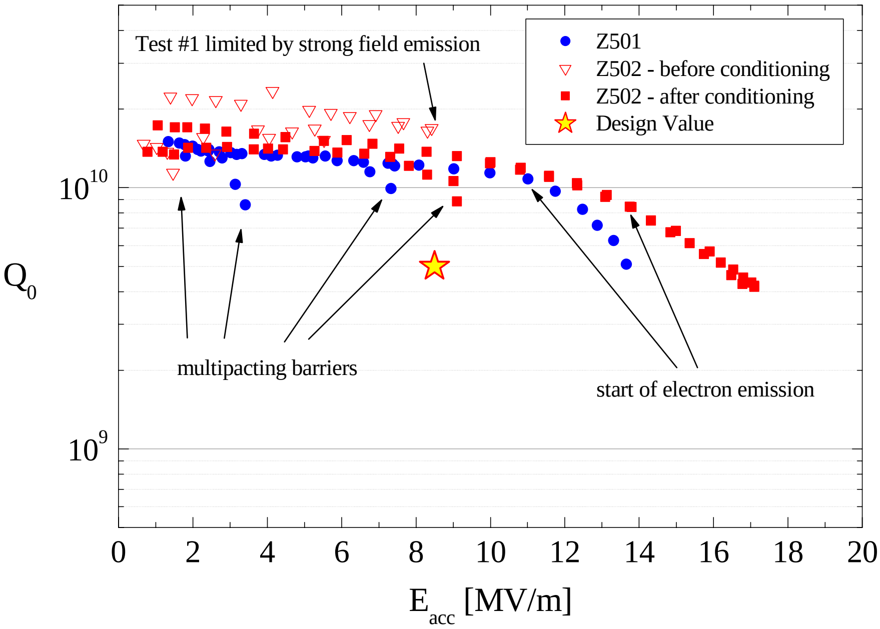


Figure 4.3.1: Cavity A

4.3.2 Mechanical design of tuner and 3.1.3 Integration of piezo design (WBS 3.1.5)

The investigation of the tuner design and of the helium tank have started, by a suitable scaling of the coaxial tuner originally proposed for the TTF/TESLA cavities. The tuner is a completely flexural system that is made-up of two annular rings attached to the cavity helium tank and connected by means of thin angled blades to a central ring which is free to rotate azimuthally. A motor controls, through a leverage system the azimuthal motion of the central ring. This rotation is changed by the tuner into a longitudinal force between the two portions of the cavity tank which are welded to the cavity tube and connected through a short bellow. The concept is illustrated pictorially in Figure 4.3.2.

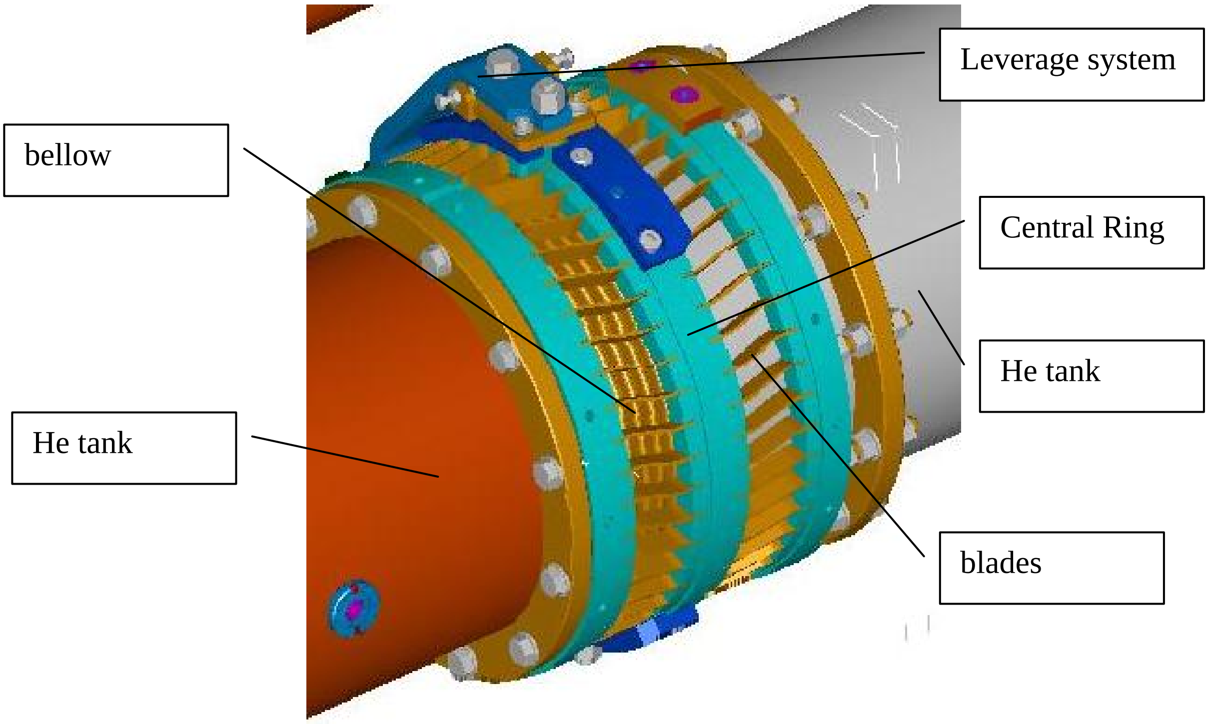


Figure 4.3.2: Tuner design

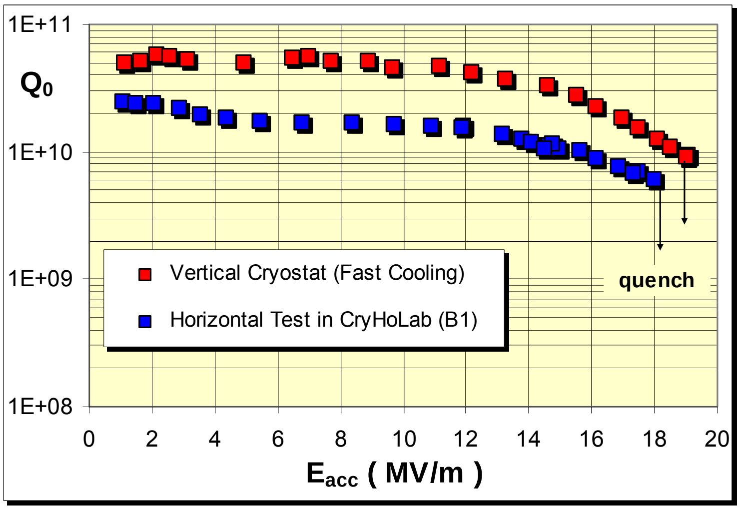
The work is aimed at the coupled analysis (mechanical-electromagnetic) of the tuner-cavity system, in order to provide slow and fast tuning capabilities and to allow Lorentz forces compensation at the design accelerating gradient. The tuner design will be defined for the end of the year 2005, in order to start detailed planning of its engineering and construction. The Engineer hired in July under CARE (85% on JRA1 budget and 15% on JRA3 budget) is fully dedicated to the tuner design, in both JRA1/JRA3 versions. The tuner work has been concentrated until now on the JRA1 (TTF/TESLA cavity) geometry, where we have clearer requirements from the RF point of view.
A geometric scaling of the tuner assembly will be made for the application in HIPPI, and by a fine optimization of the blades angle, the longitudinal excursion of the tuner will be adapted to meet the tuning requirements. For the HIPPI case, there is still no complete linac/RF system design to fully constrain the analysis. A project working point will instead be defined in term of accelerating field, Q_{ext}, allowed frequency shift for Lorentz Force Detuning, etc. All these should come from a "system" analysis and depend on details of the linac RF distribution and control schemes, etc. A detailed analysis of these design choices is planned in 2005, and will provide the final constraints on the tuner design for HIPPI. As a starting point, due to the similar operating parameter, we can assume a Q_{ext} in the range from 5 10^5 to 10^6, and a piezo compensated frequency swing smaller than 300 Hz.
Due to administrative delays inside the INFN, the tuner work has started in July 2004 and will end in December 2005.

CEA-Saclay
Organization of the first annual HIPPI-WP3 meeting held on June 7-8 in CEA-Saclay.
Preparation of the WP3 session of the annual HIPPI’04 meeting.

4.3.3 700 MHz test stand preparation (WBS 3.1.8)

The first half of the year has been dedicated to the preparation and adaptation of the test stand “CryHoLab” which is a master piece of the program. This test stand (Figure 4.3.3 – left)

includes the horizontal cryostat itself, the liquefier, the compressor and the GHe pumping system in order to operate at 1.8 K. As both "HIPPI" and "SRF" programs will use this test stand for cavity measurements, the 700 MHz low power RF equipments needed for HIPPI can be switched to the other similar 1300 MHz RF equipments required for SRF.
We performed the test of a 704 MHz beta=0.65 5-cells cavity (Figure 4.3.3 – right), which is not a cavity of the HIPPI program though it could be used for higher energy part of high intensity proton superconducting linacs. The good performances of this cavity (17 MV/m with a Qo above 510^9) showed that the test bench is now fully operational for measuring the 700 MHz cavities of the HIPPI program. The whole installation (cryostat, cryogenic system and RF equipments) will have to move to a new experimental hall in second half of 2005.



View of the test stand CryHoLab

Performance of a 704 MHz beta=0.65 5-cells cavity (Variation of Qo is due to the residual magnetic field)

Figure 4.3.3: CryHoLab photograph and measurement results at Saclay

In two years from now, the 700 MHz high power plant has to be ready to allow testing fully equipped 700 MHz cavities (cavity A from INFN and cavity B from Saclay). Study has started of the upgrade of an existing HV modulator. The commercial procedures for the purchase of the 1 MW klystron and the circulator are already launched, the goal being to receive the material in the first half of 2006. The klystron specifications are as follows:

- frequency: 704.4 MHz (-0.7dB bandwidth ± 1 MHz)
- minimum peak power: 1 MW
- minimum average power: 100 kW (d.c. 10% ; 50 Hz - 2 ms)
- RF power output: WR 1150 or WR1500
- maximum cathode high voltage: 95 kV
- maximum current: 22 A

This power plant will be connected either to the horizontal cryostat for testing a cavity or to a coupler bench for testing and processing the high power couplers developed in the program.

The work on this bench is very preliminary. The aim is to define, at the beginning of 2005, the general concepts required to start studies and drawings. The data acquisition and monitoring system needed for coupler processing is under development.

4.3.4 Cavity A vertical test (WBS 3.1.1)

In parallel, work has started on the elliptical cavities. The so-called cavity A (the elliptical cavity Z502 designed by INFN-Milano) has been prepared and tested at Saclay. Some mechanical adaptations (protection flanges, trolley, cryostat set-up) were necessary. A BCP chemical treatment (100 microns + 20 microns) has been performed as well as the usual high pressure rinsing for this kind of cavity (June 2004). Once mounted in the vertical cryostat, the cavity showed a leak requiring permanent pumping during the test at 1.7K. The cavity quenched several times at an intermediate gradient (7 MV/m), but, after some processing, it reached 16 MV/m with a Qo value of 5.10^9, limited by field emission. The Lorentz forces detuning coefficient was found to be in the range 20 and 33 Hz/(MV/m)^2, higher than the calculated value. In a joint action, CEA & INFN will design and fabricate stiff mechanical pieces to keep constant the cavity length during the cold RF power test (second part of the program).

4.3.5 Design of cavity B (WBS 3.1.5)

Cavity B, the second elliptical cavity of the program, is presently being designed. It is also a 5-cells 704.4 MHz with a beta=0.47. Since the coupling port has to host a 100 mm diameter power coupler, the beam tube has been widened on the coupler side to a diameter of 130 mm, making the cavity asymmetric. The RF parameters computed for the optimal beta of 0.51 are Epk/Eacc = 5.52, Bpk/Eacc = 3.33 mT/(MV/m) and r/Q = 183 Ohms. Stiffeners are under study to increase the mechanical resistance to He pressure bursts and minimize the dynamic Lorentz detuning in pulsed mode operation. The use of two series of stiffening rings greatly improves the mechanical behaviour of the cavity while maintaining a wide tuning range. Cavity construction is now planned to begin half a year later than initially foreseen, without consequence on the delivery date which is kept in June 2006.

FZJ

4.3.6 Test stand preparation (WBS 3.2.1)

The test stand for superconducting cavities could be completed. Suitability has been tested by performing some measurements on other superconducting resonators.

4.3.7 Evaluation of 700 MHz resonator (WBS 3.2.2)

Although major problems occurred with the electron beam welding machine in FZJ, causing a delay of about 3 months, the 760 MHz beta=0.2 triple spoke resonator could finally be completed (Figure 4.3.7). The last weld is done and the resonator has passed the vacuum test successfully. Any further unexpected difficulties in the following preparation steps will definitely cause a delay of this subtask. The chemical treatment at Saclay is scheduled for early 2005, immediately followed by measurements on the test stand in FZJ. Test couplers are available. Presently this activity is on time. An intermediate report is due in March 2005.

Triple spoke Nb cavity without endcaps

Complete triple spoke Nb cavity

Figure 4.3.7: Triple spoke cavity built for FZJ

4.3.8 3.2.6 RF design of 352 MHz multigaps resonator (WBS 3.2.6)

For the 352 MHz beta=0.48 superconducting triple spoke resonator, the design is fairly advanced. Minor adjustments are still needed for the RF design. Niobium sheets have been ordered which shall be delivered at the end of 2004. The second wall for the liquid Helium containment is being optimized for stability of the whole system. This second wall would allow the resonator to be tested in the Orsay cryogenic test facility. Copper prototypes for the end-caps and for the cylindrical surface of the cavity have been delivered and are being optimized. The corresponding geometrical parameters of the resonator have been frozen. Present considerations address the analysis of mechanical eigenmodes of the cavity. The issue of RF coupler is worked upon in close collaboration with IPN Orsay. Two access ports are planned, one for a 100 mm coupler, the other for a 56 mm coupler. Presently this activity is on time. A design report concerning the RF design is due in may 2005.

IPN-Orsay

4.3.9 Evaluation of 352 MHz 2-gap prototypes (WBS 3.2.3)

The beta 0.15, 352 MHz, 2-gap Spoke Resonator is now fabricated (without its Stainless Steel helium vessel). A checking procedure before delivery is foreseen the 14 December 04. The cavity will then be delivered on December 20, 2004, and the cold test is planned to start in February 2005. A 3D drawing is shown in Figure 4.3.9.

A beta 0.35, 352 MHz, 2-gap Spoke Resonator was tested last May and showed very good performance (indeed a record) by reaching the accelerating gradient of 16.2 MV/m with $Q_0 > 10^9$. We are studying the possibility of adding a helium tank in Titanium. Technical consultations with industries have begun.

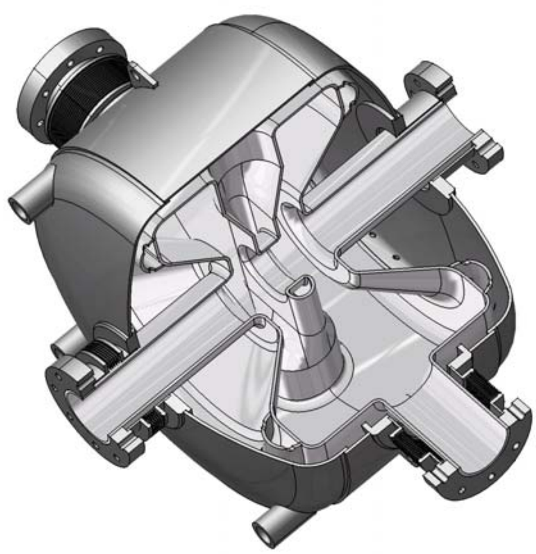


Figure 4.3.9: Single spoke cavity at Orsay

4.3.10 Design of coupler prototype (WBS 3.2.4)

The prototype power coupler is in the design phase. An RF comparative study of the ceramic window design (disc or cylinder) has been performed. The drawings for the ceramic window block are presently in progress. Industry consultations will start in January 05. The window block will be ordered beginning of 2005. The coupler prototype should be ready at the end of 2005. The preliminary tests of the prototype will start at beginning of 2006.

4.3.11 RF design of multigap spoke resonator (WBS 3.2.6)

Cross check modeling calculations of the preliminary multigap spoke FZJ design started in September 04.

IAP-FU

4.3.12 CH resonators (WBS 3.3)

The CH-cavity is a good candidate for a High-Intensity-Pulsed-Proton-Injectors (HIPPI). To demonstrate the promising properties obtained by simulations, a 19-cell superconducting CH-prototype cavity has been designed. It is a non-scaled cavity with a frequency of 350 MHz with a β of 0.1. The cavity has been fabricated and is ready to be treated chemically to clean the surface. Figures 4.3.12a to 4.3.12d illustrate the fabrication process history of ACCEL©, Bergisch-Gladbach.

Fig. 4.3.12a: Some Niobium parts of a sc. CH-prototype for HIPPI. Tank end cell (left), two girders (right) and one drift tube part (middle)

Fig. 4.3.12b: Welded Niobium girder + stem part of the sc CH-cavity for HIPPI

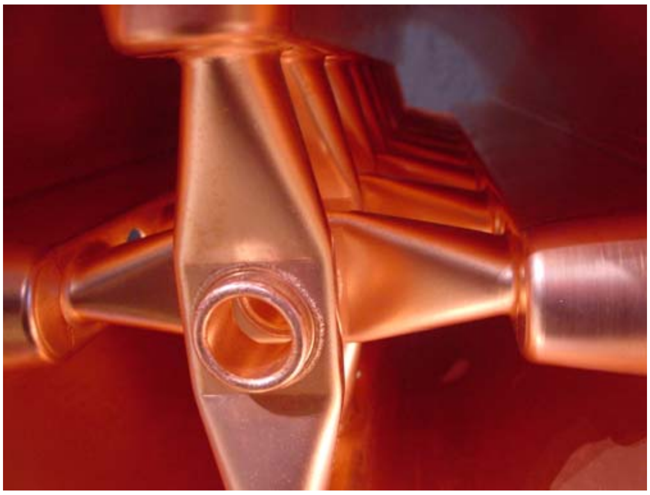


Fig. 4.3.12c: Niobium girder + stem part welded in the resonator of the sc CH-cavity

Fig. 4.3.12d: The superconducting Niobium CH-prototype cavity before the final welding of the end cells.

Recently low level RF measurements have been performed to measure the field distribution. Figure 4.3.12e shows a comparison between the bead pull measurement and MicrowaveStudio simulations. The agreement is excellent and a flat field distribution has been obtained in a superconducting multi cell H-mode cavity.

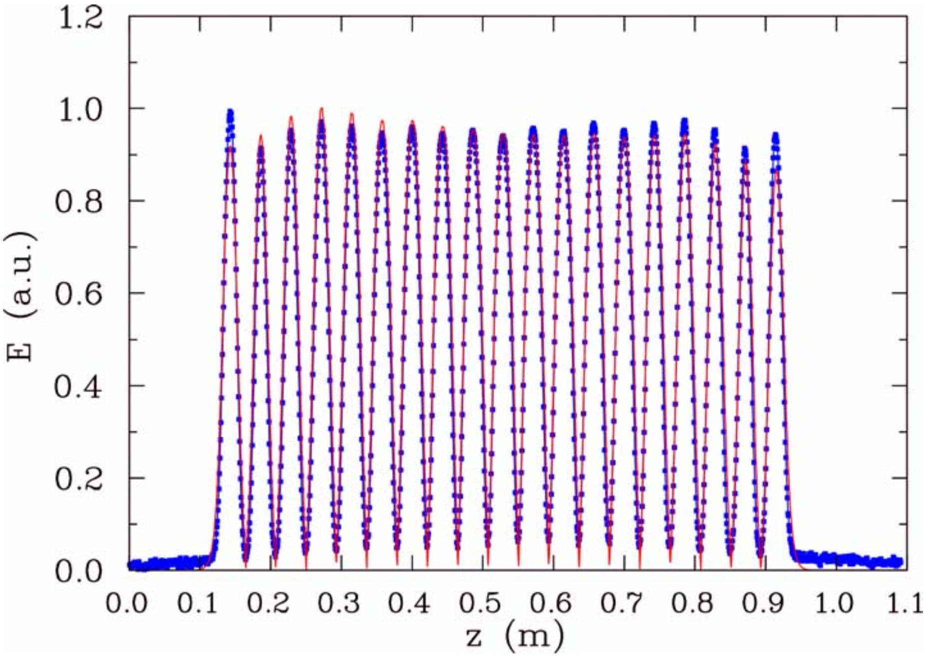


Fig. 4.3.12e: Measured (blue) and simulated field distribution of the CH-prototype cavity.

In a next step the cavity will be conditioned at room temperature to process possible multipacting levels. End of the year 2004 and begin of 2005, the first cold tests will start in the new cryogenic laboratory in Frankfurt. This laboratory has already been put successfully into operation during the year 2004. A superconducting 176 MHz Half-Wave-Resonator has been tested several times. The infrastructure like cryostat, helium recovery system, pumping and the control system, which has been developed at the IAP worked very well. Figure 4.3.12f shows the cryogenic laboratory during the first cold tests.

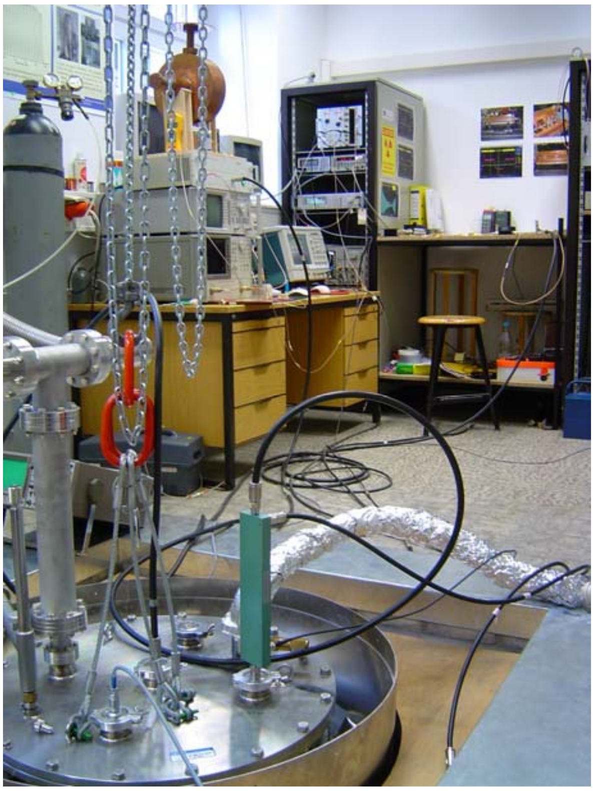


Fig. 4.3.12f: The cryogenic laboratory during a test of a superconducting Half Wave Resonator

RF coupling to the cavity is a very important topic. Different methods have been investigated: inductive coupling with a loop and capacitive coupling with an antenna. The external Q-value, which measured the coupling strength, has been simulated and then measured with our modified room temperature copper model. It was possible to determine the coupling strength over several orders of magnitude with very good accuracy. Figure 4.3.12g shows the position of the capacitive coupler (top) and the external Q-value as a function of the coupler position (measurement and simulation, bottom).

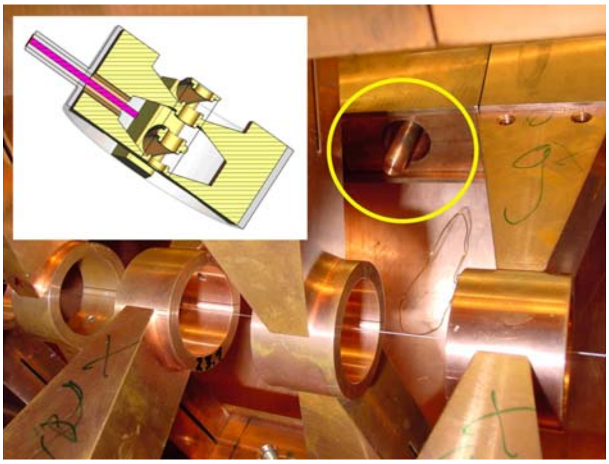
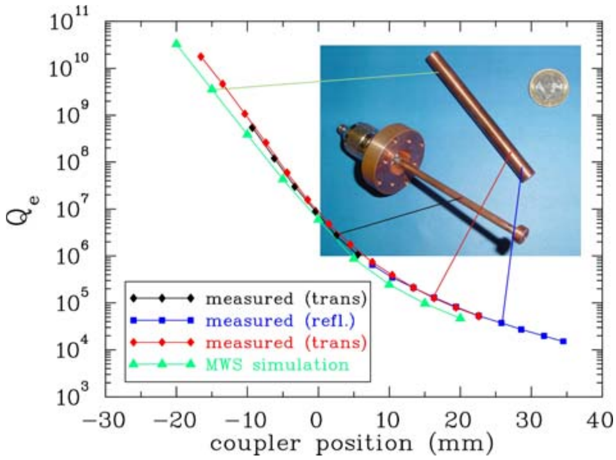


Fig. 4.3.12g: Position of the capacitive coupler, which will be used for the cold tests of the CH-cavity (top)



Comparison of the external Q-value (coupling-strength) between measurements and simulations (bottom)

4.3.13 Study of tuning system (WBS 3.3.1)

Microwave Studio simulations are being used to investigate different tuning methods for sc. CH cavities. Figure 4.3.13a shows tuning cylinders, which can be welded into the girders after the cavity production (static tuning). A small height of the cylinder increases the frequency due to the decreased inductance. For a certain height the tuner decreases the frequency because of the increased capacitance. Figure 4.3.13b shows the frequency as function of the tuner height. These cylinders can also be used to optimize the field distribution.

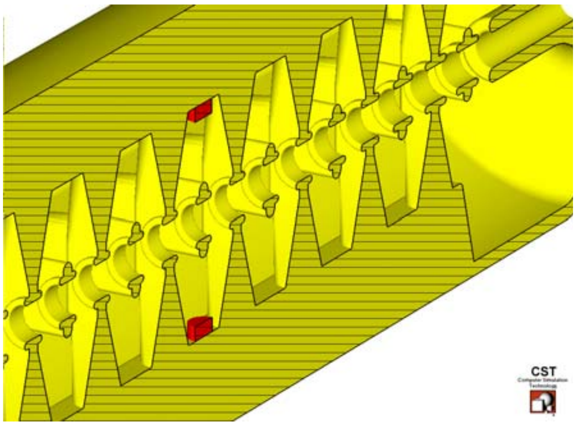


Fig. 4.3.13a: Tuning cylinder can be used to tune the frequency and the field distribution

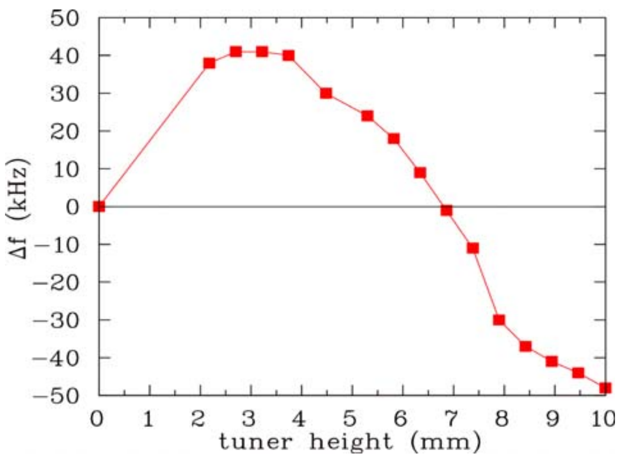


Fig. 4.3.13b: With MWS® simulated frequency shift of the cavity as function of the height of the tuning cylinders.

Another tuning method is to stretch and to squeeze the cavity end cells by a slow and fast mechanical tuner. Figure 4.3.13c shows the frequency shift by changing the length of the end cells. The typical frequency shift is about 190 kHz/mm.

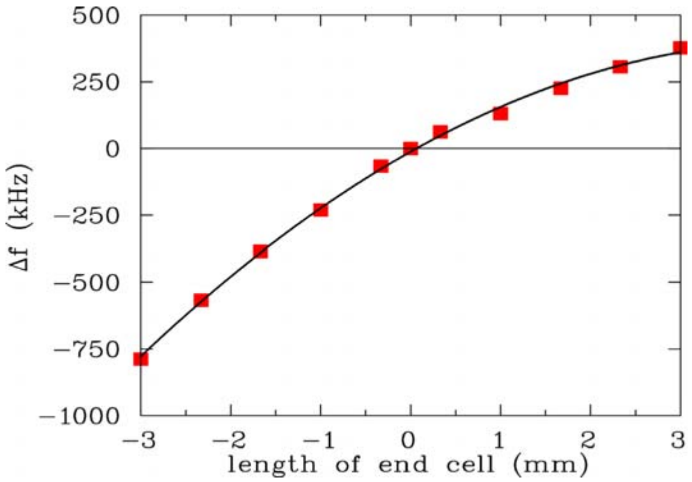


Fig. 4.3.13c: MWS® simulated frequency shift as function of the length of the end cells

Conclusion and future work: Up to the begin of 2005 a superconducting 352 MHz CH-structure will be redesigned with Microwave Studio, including the beta profile obtained from LORASR® particle dynamics simulations and aiming for the best beam matching between possible parts of an injector. With a frozen beta profile it is necessary to re-optimize the cavity with respect to field flatness, total rf power consumption, rf power peak densities, mechanical stability and Lorentz-Forces due to the pulsed operation mode of a HIPPI facility.

During the year 2004 the superconducting CH-prototype cavity has reached the final stage of production and the first low power measurements have been performed very successfully. The cryogenic laboratory in Frankfurt has been put into operation, the infrastructure and the control system worked very well. First comparisons of the static tuning sensitivity between MWS© simulations and corresponding bead-pull measurements of a 19-cell 310 MHz copper model at the IAP showed a good agreement. For a more precise check the copper model must be modified. This will be finished at the beginning of 2005. In addition, the development of a mechanical tuner for the superconducting CH-cavity has been started (since March 2004) simultaneously with a structural analysis using the program ANSYS© at GSI (since November of 2004). They will be finished at the beginning of 2005 and the technical design stage, including detailed construction drawings will be started at March 2005.

Table 4.3a : Status of the Sub tasks in WP3 which are supposed to have started according to the MS project breakdown in Annex 3

WBS #	Title	Participants	Original begin date (Annex 3)	Original end date (Annex 3)	Estimated Status	Revised end date
3.1	**Elliptical cavities**					
3.1.1	Cavity A vertical tests	INFN-CEA	01 / 2004	12 / 2004	100%	On time
3.1.2	Mechanical design of tuner	INFN	07 / 2004	12 / 2004	10%	12/2005
3.1.3	Integration of piezo design	INFN	07 / 2004	12 / 2004	10%	12/2005
3.1.4	Tuner construction	INFN	01 / 2005			06/2006
3.1.5	Design cavity B	CEA	07 / 2004	12 / 2004	40%	06/2005
3.1.6	Construction cavity B	CEA	01 / 2005			
3.1.7	Power coupler design & engineering	CEA-LPSC	01 / 2005			
3.1.8	RF source order and preparation	CEA	07 / 2004		10%	On time
3.2	**Spoke cavities**					
3.2.1	Test stand preparation at FZJ	FZJ	04 / 2004	09 / 2004	100%	
3.2.2	Evaluation of 700 MHz prototype	FZJ	09 / 2004	05 / 2005	75 %	On time
3.2.3	Evaluation of 352 MHz 2gaps-prototype	IPNO	06 / 2004	12 / 2004	40 %	06 / 2005
3.2.4	Design of coupler prototype	IPNO	01 / 2004	04 / 2005	20 %	12 / 2005
3.2.5	Test of coupler prototype	IPNO	05 / 2005			
3.2.6	RF design of 352 MHz multigaps-prototype	FZJ-IPNO	01 / 2004	04 / 2005	50 %	On time
3.2.7	Design of coupler and tuner	FZJ-IPNO	01 / 2004	04 / 2005		
3.2.6	Engineering of resonator coupler tuner	FZJ-IPNO	05 / 2005			
3.3	**CH resonators**					
3.3.1	Study of tuning system	IAP-FU	01 / 2004		50 %	On time

Table 4.3b: Status with respect to the interim reports and deliverables to be done in 2004 according to the MS project breakdown

WBS #	Title	Due date in Annex 1	Status	Revised delivery date
3.1.1	Cavity A vertical tests	12/2004	100% Work done, report to be written and delivered	01/2005
3.1.2	Mechanical design of tuner	12/2004	Delayed, see text	12/2005

4.4 Work Package 4: Beam Chopping

The WP4 has a web-site (**http://hadorn.home.cern.ch/hadorn/My_Webs/WP4main.htm** **m**aintained by **Beatrice.Hadorn@cern.ch**) where all the relevant informations are kept up to date.

The goal of WP4 is the assessment of two different devices (Chopper A and Chopper B) to provide a deflecting voltage sufficient to selectively remove micro-bunches at an energy of a few MeV and at a frequency of 350 MHz with a repetition rate of 40 MHz. This operation is needed to prepare a high intensity pulsed beam for the injection in a circular machine.

The two approaches described in the HIPPI proposal have been developed independently in CCLRC-Rutherford Appleton Laboratories and at CERN. The work is proceeding in parallel with frequent and fruitful exchanges of information and expertise. The progress of the work of WP4 is steady in both laboratories. In particular the collaboration between the two institutions (CERN and RAL) involved in this working package has been strengthening throughout the year with fruitful results for both parties. At CERN there have been some difficulties due to lack of support from the drawing office (low priority with respect to other projects) which have produced some delay in the delivery of the chopper plates. Notwithstanding these delays, most of the milestones for the year 2005 can be probably met on time. The work at each laboratory will be detailed further on.

At two occasions during the year 2004, all the WP4 participants met together: during the WP4 yearly meeting at CERN (10-11 May) and at the HIPPI04 meeting in Frankfurt (30 Sep-1 Oct).

The WP4 yearly meeting for 2004 took place at CERN on May 10 and 11. A total of 10 people (2 from RAL, 8 from CERN) participated full-time. Discussions were focused on the following issues: chopper structure, chopper drivers, dump, beam dynamics and also chopper tests with and without beam. The highlight of the workshop was that the chopper structure developed at RAL has evolved considerably and can now be fitted in a quadrupole, as the CERN structure. The beam dynamics in the two proposed chopper lines has been compared with two codes (at RAL and at CERN) giving similar results. Finally, discussion started on the possibility of testing the RAL chopper in the 3MeV chopper line developed at CERN.

During the general meeting of HIPPI04 the participants of WP4 could exchange ideas also with the participants of WP5, and therefore complete the picture of the chopper line as an integral part of a chain of accelerators. This synergy is very important and therefore it was decided to hold next year meeting together with WP5 (hosted by RAL at Cosener's House near Oxford, April 13-15, 2005).

Several papers have been published. An important one, summarizing the joint efforts of the participants, is an invited talk at LINAC04 titled "REVIEW OF FAST BEAM CHOPPING ".

One position was advertised on the CARE web site offering a three year tem contract to work on chopper related issue at CERN. The contract was assigned on May 25, 2004. The selected candidate has started on July 1, 2004 in the AB division / ABP group, under the supervision of A. Lombardi. This person has reported about the progress of his work at HIPPI04,

The progress of the work for each subtask in the two laboratories is detailed below.

4.4.1 CERN

Chopper structure (subtask 4.1.1)

A technical solution for the ceramic plate has been successfully tested at CERN, and the result of the work presented at EPAC04. The completion of the drawing for execution has been farmed out to industry due to the overload of the CERN drawing office. The preliminary drawings were sent out by in November. After checking, construction will start and should be finished 6 weeks later. In the first quarter of 2005 the prototype is expected to be ready for laboratory testing (vacuum and electrical tests).

Chopper driver (subtask 4.1.3)

Optimisation of the driver amplifiers towards the target values continued during the all time although the work on the driver was stopped for 2 months due to the unavailability of the CERN staff member having started the project, and to the summer holidays. A system providing 70% of the needed voltage and rise-time is available thus allowing preliminary tests of the chopper structure. It is estimated that with the current availability of manpower a system proving the required outputs in terms of Voltage and rise time will be probably realized by the end of 2005. A measured response of the amplifier is shown in Figure 4.4.1.

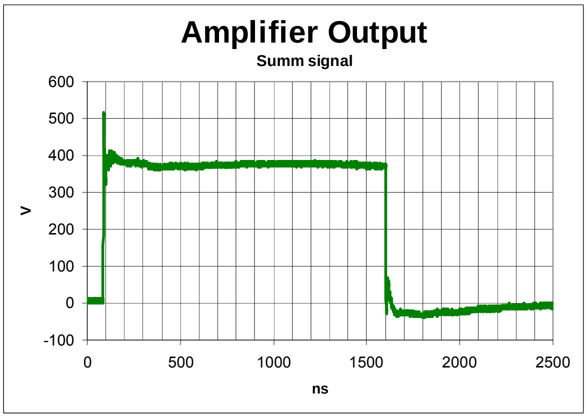


Figure 4.4.1: Measured amplifier output for chopper structure

Dump (subtask 4.2.1)

The conceptual design is finished. Integration in the beam-line has to be finalized before the construction of the dump can start. It is nevertheless expected that the deadline for end of construction could be maintained (June 2005).

4.4.2 RAL

The prototype fast transition time / short duration pulse generator has been delivered to RAL, and has been the subject of extensive acceptance testing (part of subtask 4.3.1). These tests have shown that the pulse generator meets all key specifications except the requirement for pulse droop. The problem has been discussed with the manufacturer, and has involved an extensive search for a specialized ferrite component. Samples of these components have now been tested, and a bulk order has been placed with the supplier. These components were delivered to RAL in June 04, and tested. As the results of these tests were successful, the original 18 pulse generator cards have been retro-fitted with new higher permeability ferrite cores. A further 18 pulse generator cards have been manufactured and these have also been fitted with the upgraded ferrite parts. The upgraded pulse generator will produce positive, and negative polarity pulses with amplitudes of ~ 1.4 kV, transition times of ~ 2 ns, and pulse widths of up to ~ 15 ns. Preliminary acceptance measurements on the phase 2 design, carried out at the manufacturer's premises (Kentech Instruments) on 4th October indicated that the key pulse droop specification had now been met. The phase 2 pulse generator was delivered to RAL on Tuesday 26th October, for final acceptance testing.

The prototype slower transition time, high voltage pulse generator modules were developed at RAL (part of subtask 4.3.1). The electronics design has been developed and checked using a 'SPICE' based circuit simulator (MicroCap 7™). These fan cooled high voltage modules must fit in a confined space, and so the design is challenging. . Specialised parts with long lead times, have been delivered to RAL, and detailed drawings have been through several modification and checking cycles, and are now ready for manufacture. A high voltage 'dummy' load module will be used to simulate the inductive and capacitive loads of up to four adjacent 'slow' chopper electrodes, and a 3D CAD drawing and a set of detailed 2D drawings for manufacture, have been completed. The design of additional support modules (ancillary power supplies and a cooling module) are at an advanced stage.

Discussions on the possibility of modifying the design of the RAL slow wave electrode structure C (Figure 4.4.2), for installation and testing on the CERN Linac front-end test facility are at a preliminary stage.

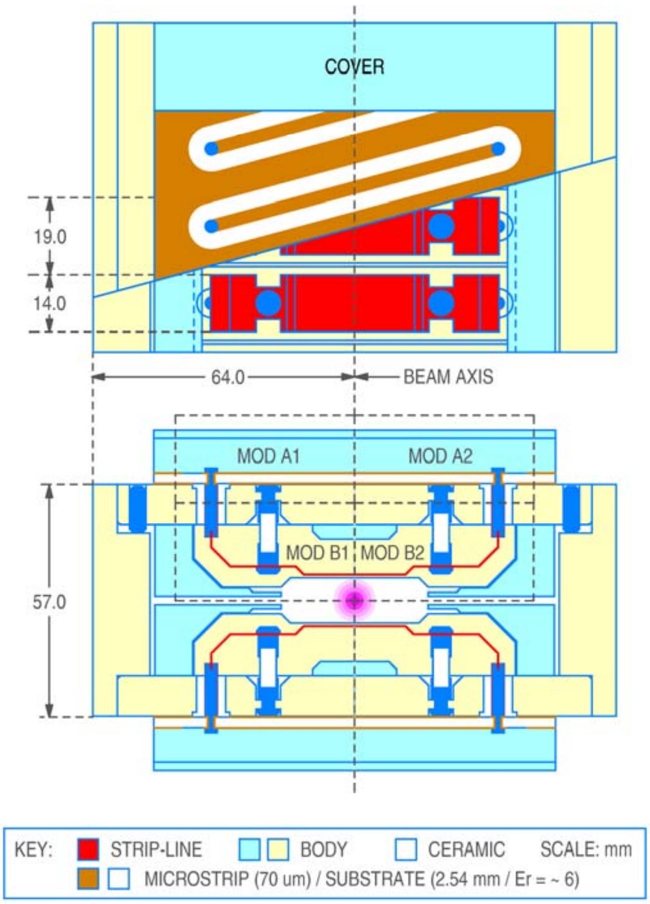


Fig. 4.4.2: Slow wave electrode structure C. Version integrable in the CERN 3 MeV test line

Table 4.4a : Status of the Sub tasks in WP4 which are supposed to have started according to the MS project breakdown in Annex 3

WBS #	Title	Original begin date (Annex 3)	Original end date (Annex 3)	Estimated Status	Revised end date
4.1	Chopper structure A (CERN)				
4.1.1	Pre-prototype construction	January 2004	June 2004	Start delayed to November 2004	January 2005
4.1.2	Pre-prototype testing	July 2004	November 2004	Start delayed to January 2005	June 2005
4.1.3	Driver construction & testing	January 2004	December 2004	30 %	June 2005
4.1.4	Full scale prototype design	January 2005			On time
4.2	Chopper line (CERN)				
4.2.1	Dump design	January 2004	June 2004	70 %	December 2004
4.2.2	Dump construction	July 2004	June 2005	Start delayed	
4.3	Chopper structure B (RAL)				
4.3.1	Pre-prototype design and test	January 2004	June 2005	30 %	On time
4.3.2	Prototype design	January 2005			On time

4.5 Work Package 5: Beam Dynamics

4.5.1 Joint Code Benchmarking Project

In the framework of the code benchmarking subtask in WP5, a 3D linac code comparison and benchmarking program have been initiated. In the first part the validation of the space charge solvers, comparing the calculated electric field of a common initial distribution with a semi-analytical solution, was carried out with mutual exchange of data between the participating partners. In order to study the effects of numerical noise on the single particle dynamics first, the calculated single particle tunes have been compared with an analytical prediction. Five codes have been used so far: IMPACT , DYNAMION, TOUTATIS, PARMILA and HALODYN. Other codes, already available like PARMELA and PATH as well as under development at the IAP-FU and at the FZJ will be included in the near future. Details about the code benchmarking project can be found in: http://www-linux.gsi.de/_franchi/HIPPI/code_benchmarking.html and in a paper by A. Franchi et al., *Benchmarking Linac Codes for the HIPPI Project*, presented at the ICFA-HB2004 workshop in Bensheim, October 18-22, 2004. Particle tracking in the lattice of the UNILAC DTL section is under preparation for validation with experimental emittance measurements to be carried out in 2005/06 (see some results illustrated in Figure 4.5.1).

Numerical tune shift (at bunch center) generated by different codes and for three different mesh resolutions (grids with 32, 64 and 128 cells). The three considered odes behave similar and suggest a "universal" dependence on mesh size ~ $\Delta x^{3/2}$. Consequences of this and other scaling laws will enter into later code optimization.

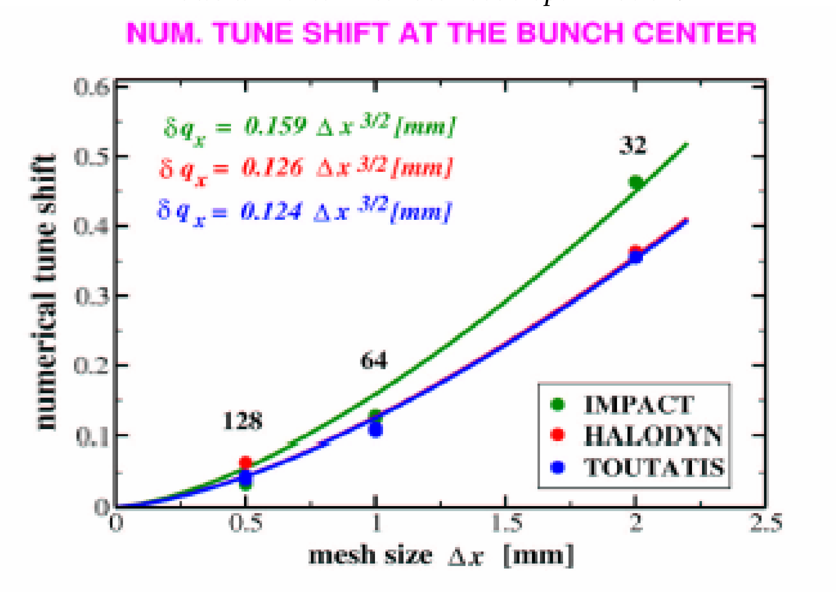


Figure 4.5.1: Numerical tune shift at the bunch centre

4.5.2 CEA

4.5.2.1 *ECR source modeling*

A Finite Difference Time Domain solver to simulate the propagation of the EM waves in the ECR box is under development (with the possibility to integrate the motion of electrons and ions in the box; coupling between the plasma and the wave by including current and charge densities in the FDTD solver; include collision effects). Results have been presented at HIPPI04.

4.5.2.2 *Beam space charge neutralization study*

First calculations for a simple drift using a PIC method shows a good agreement with theoretical predictions for the rise time of a continuous beam in CW (~20 ms) (for IPHI LEBT and MEBT lines); for bunched beams a very different behavior is found with incomplete neutralization (15%). Results have been presented at HIPPI04.

4.5.2.3 *Code comparison*

Comparison of Poisson solvers has been progressing with TOUTATIS, and results were included into the *Code Benchmarking Project.*

4.5.3 CERN

4.5.3.1 *Simulation of the 3 MeV line*

The code with all the elements of the line has been made ready and validated and the diagnostic of the line has been added. A simulation of the commissioning of the line has been carried out: it gives guidelines on setting the buncher phase to an appropriate value by beam measurements, energy and energy spread measurements and emittance measurements via quadrupole scan.

4.5.3.2 *End-to-end simulations for LINAC4*

They have been carried out and shown 75% emittance growth from the source to 160 MeV/u. Longitudinal emittance growth was traced back to mismatch effects in the DTL. Code comparisons with TRACEWIN, PATH, TOUTATIS and IMPACT have been initiated and first results were presented at HIPPI04 (PATH – IMPACT).

4.5.3.3 *Halo measurement device design and construction.*

All the components are in house. The vacuum chamber for the final assembly is not ready yet. The detector will be assembled by the end of the year.

4.5.4 FZJ

4.5.4.1 *Code development*

In order to compare the analytical model for space charge development with simulation results the beam dynamics was simulated in a periodical transport channel. At the same time the behavior of the space charge dominated beam in dependence on particle distribution was investigated. The obtained results were consistent with the analytical approach and with the general conception. Active participation in the *Code Benchmarking Project* has been initiated.

4.5.4.2 *Beam profile monitor*

For beam profile measurements based on light radiation of atoms excited by a particle beam a test chamber was developed and installed in cooperation with JINR Dubna in the COSY-JESSICA beam-line to test the efficiency of visible light production of different gases and vapors. The test chamber was successfully tested. Furthermore, the fast electronics for the multi-anode photomultiplier tubes were developed and first tests were performed.

4.5.5 GSI

4.5.5.1 *Preparation of Benchmarking Experiment in the UNILAC Alvarez DTL.*

Simulations in preparation of the experimental proposal to carry out benchmarking experiments for high intensity beams and comparison with computer codes have been performed. First measurements using the so far available diagnostics in the UNILAC Alvarez-DTL have been evaluated in this preparation campaign. The request for official experimental beam time in 2005/06 for an *"Experimental study of high-intensity effects on beam quality in the DTL section of the UNILAC"* has been submitted to the GSI Experimental Committee in the name of the WP5 participants, and approval of the requested beam time has meanwhile been confirmed.

4.5.5.2 *Code Benchmarking Project*

For this joint undertaking of WP5/beam dynamics the necessary development of analytical space charge solvers as reference solutions was carried out. Algorithms to evaluate the quality of different electric field solvers (Poisson solvers) have been developed and implemented. Static comparisons for several participating codes were carried out (see also under 1)

4.5.5.3 *Fluorescence Beam Profile Monitor*

Due to the lack of non-destructive standard methods, first studies have been performed concerning the method of fluorescence detection from the residual gas in the 400 nm wavelength range, using an image amplified CCD camera. At an external beam dump behind the UNILAC facility the method was tested with a preliminary experimental set-up detecting one transverse plane only. This activity is continuing with the installation of an improved system behind the last module of the UNILAC for both transverse planes, and the development of the data acquisition and presentation systems which are needed for the planned prototype.

4.5.6 IAP-FU

The development of the LORASR-code is presently driven by current applications, e.g. the design of the GSI Proton Linac, as well as by the WP5 *code benchmarking project* (Alvarez calculation implementation). The main activities related to common code development have been in 2004: (a) development of a complete new graphical input version; (b) Increasing the particle number in the simulations up to 10^5; (c) faster PIC implementation. The main activities related to the Alvarez DTL test simulations for code benchmarking have been: Calculation of "Alvarez-type" gap field distributions for "norm gaps" by Microwave Studio™ simulations and parameterization of the approximated Ez(ri,z) distributions along different radial positions. Adaptation of the LORASR gap transformation subroutine to the Alvarez DTL.

4.5.7 **RAL**

The IMPACT code has been used to study the effect of gradient errors on the beam dynamics performance. It was found that the effect of errors is enhanced by space charge. In the code comparison PATH-IMPACT initial discrepancies could be reduced and better agreement achieved. Remaining differences are due to the integration with nonlinear Lorentz forces.

Table 4.5a : Status of the Sub tasks in WP5 which are supposed to have started according to the MS project breakdown in Annex 3

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	40 %	On time
5.1.2	LORASR development	January 2004	December 2005	50 %	On time
5.1.3	Transport in 3D map implementation	January 2004	December 2005	50%	On time
5.1.4	Improvement, modeling high current	January 2004	June 2006	40%	On time
5.1.5	Codes preparation for 3 MeV test stand	January 2004	December 2006	50 %	On time
5.1.6	Codes preparation for SC linacs	January 2004	December 2006	30 %	On time
5.2	Experiment at UNILAC: preparation & simulations	January 2004	June 2006	25 %	On time
5.3	Diagnostics and collimation				
5.3.1	Profile measurement prototype design and construction (GSI)	July 2004	February 2005	70%	On time
5.3.2	Profile measurement testing (GSI)	March 2005	June 2006		
5.3.3	Non-interceptive bunch measurement design (GSI)	October 2004		20%	On time
5.3.4	Halo measurement device design & construction (CERN)	January 2004	June 2005	70 %	On time
5.3.5	Beam profile monitor design (FZJ)	January 2005			
5.3.6	Collimators design (CERN)	January 2005	December 2006		

5 PLAN FOR THE NEXT 18 MONTHS

The Gantt charts for the work planned during the next 18 months are shown in Appendix. (Subset of a chart covering the first 30 months).
The foreseen expenditures and the funding requested by each participant are given in Table 5.

Table 5: Status of the foreseen expenditures per participant during the next 18 months

JRA3	Participant (cost model)	Permanent staff including indirect cost (Euros)	Additional Staff including indirect cost (Euros)	Durable Equipment including indirect cost (Euros)	Consumables and Prototyping including indirect cost (Euros)	Travel including indirect cost (Euros)	Expected costs including indirect cost (Euros)	Direct cost	Sub-contract	Indirect cost	Requested funding (Euros)
1	CEA (FC)	675,000	100,000	350,000	400,000	2,000	1,527,000	1,027,000	0	500,000	450,000
3	*CNRS-IN2P3*	*70,000*	*0*	*0*	*20,000*	*0*	*90,000*	*75,000*	*0*	*15,000*	*20,000*
	CNRS-LPSC	*261,000*	*0*	*0*	*35,000*	*3,000*	*299,000*	*249,167*	*0*	*49,833*	*31,000*
	CNRS(FCF)	331,000	0	0	55,000	3,000	389,000	324,167	0	64,833	51,000
4	GSI(FC)	365,000	190,000	95,300	7,000	13,300	670,600	530,000	0	140,600	240,000
5	IAP-FU(AC)	*0*	275,000	0	230,000	5,000	510,000	425,000	0	85,000	210,000
7	FZJ(FC)	479,000	132,000	0	110,000	9,000	730,000	358,661	0	371,339	251,000
10	INFN-Mi(AC)	*0*	22,990	0	30,000	8,000	60,990	50,825	0	10,165	30,000
17	CERN (AC)	*0*	345,000	0	150,000	15,000	510,000	425,000	0	85,000	250,000
20	CCLRC (FC)	520,460	351,476	0	257,000	5,000	1,133,936	625,307	0	508,629	128,000
	Grand total	**2,370,460**	**1,416,466**	**445,300**	**1,239,000**	**60,300**	**5,531,526**	**3,765,960**	**0**	**1,765,566**	**1,610,000**

Appendix 1: ***Short minutes of the annual HIPPI meeting (HIPPI'04)***

The first annual meeting of HIPPI has been hosted by the Institut fur Angewandte Physik in Frankfurt (Germany) from Wednesday 29, September till Friday 1, October 2004. Each Work Package has been treated during a half-day session, the last half-day being used by the External Scientific Advisory Committee (ESAC) to prepare a preliminary assessment and present it. There were 38 participants, coming from the nine laboratories participating into HIPPI, plus 2 members of the ESAC. All information concerning this event, including a detailed summary, is available at the url: http://hippi04.web.cern.ch/hippi04/index.htm.

For the management and coordination of HIPPI, means to improve and speed the internal procedures (preparation of reports, publications, etc.) have been discussed. The procedure to be followed for the preparation of reports and publications inside CARE has been recalled, and the overall paper production by HIPPI in 2004 has been reviewed. Moreover, the detailed work plan for the next 18 months has been discussed and finalized, including a first overview of the financial requests. The preparation of the yearly CARE meeting (November – Hamburg) was also briefly debated.

Amongst the important points for the WP on Normal-Conducting structures (WP2) was the convergence of the RAL linac design towards a scheme compatible with the CERN Linac4. The low-energy part is still peculiar to the RAL design, but the high-energy section (90-180 MeV) has been changed to an SCL design identical to the CERN one, which is now developed inside HIPPI. This remarkable synergy has to be credited to HIPPI and it is an excellent illustration of its interest. Another important subject was the communication of the results of the decision on prototyping for the DTL: this activity is organized to complement the ISCT-funded DTL development in Russia, and HIPPI will develop an RF coupler prototype. Both CH and CCDTL developments are making an advance in the construction of prototypes. The progress with the SCL is somehow slower, and a more detailed workplan for the collaboration between the HIPPI laboratories has been elaborated to try and make the best use of recent realizations in the USA and in Japan.

For the WP on Super-conducting structures (WP3), the main progress concerns the preparation and test of the 5-cell elliptical cavity, which was carried-out in June 2004. The preparation for the high-power test stand is progressing, contacts have been established with klystron manufacturers and a suitable klystron-power supply configuration has been worked out. The design of components is progressing in all laboratories, including design of tuners and couplers. The development of "Spoke-type" cavities is going on in collaboration between IPN-Orsay and FZ-Juelich, centered on extensive testing of existing devices and on the preparation for the construction of new ones. An important discussion has taken place for the common definition of "cavity length", to be used in normalizing and comparing performances of accelerating structures. Some partial conclusions are: use optimum β rather than geometrical β, use $\beta\lambda/2$ for the length definition, AND be prepared to furnish 3 other parameters (the 'core length', the real estate gradient and the energy gained in the cavity at optimum β and optimum phase).

During the session of the WP on beam chopping (WP4), detailed information was given about the two alternative chopper designs. Information exchange during 2004 has been very fruitful, the RAL driver results orienting the development at CERN in a new direction, and the RAL chopper being influenced by some CERN options. A strategy has been initiated for testing also the RAL device in the 3 MeV test line at CERN.

In the fifth WP, significant progress has been reported in all involved beam dynamics activities. No report was made about diagnostics, but previous meetings and direct communication indicate that work progresses satisfyingly in that field also. The efforts in beam dynamics can be divided into four categories: (i) development of design-oriented codes to cope with the needs from specific structures (case of CH), (ii) study with simulations of specific mechanisms leading to beam degradation, (iii) code-benchmarking, and finally (iv) preparation of experiments to test code results. Discussions have underlined the importance of sufficient flexibility of the involved codes to allow comparisons of efficiency and cost between different structures. Significant attention must be paid to the mechanisms of emittance formation between source and LEBT. Modeling by simulation should be compared with experimental data. In this context the understanding of space charge neutralization, largely ignored so far, has found special attention. Using the proper input distribution into the RFQ is crucial for the study of halo downstream and for the validity of end-to-end simulations, as demonstrated for Linac4. The benchmarking efforts have shown first success of comparison between different codes: Linac4 was analyzed with both PATH and IMPACT. First results on a systematic comparison of space charge resolution for fixed input distributions have reflected the importance of smoothing techniques.

In the conclusion part of the meeting, the ESAC presented a preliminary version of his assessment (cf. Appendix 2) and C. Prior announced that the Rutherford Laboratory has volunteered to organize HIPPI'05 on September 28-30, 2005, in the vicinity of Oxford.

Appendix 2

Report of the External Scientific Advisory Committee of the HIPPI JRA inside CARE

September 29 – October 1, 2004

Introduction

The first general meeting of the European Collaboration on High-Intensity Pulsed Proton Injectors (HIPPI04) was held in Frankfurt from the 29th of September through the 1st of October, 2004. The objectives of the HIPPI collaboration are to encourage and coordinate accelerator research and development activities, which are distributed among nine European laboratories, to establish a technology base supporting a new class of high-intensity accelerators within the European Community. To the same end, HIPPI supports the improvement of existing accelerator facilities at GSI, RAL and CERN. The collaboration expects continuing support from the European Union at a level of ~3M€/yr through 2008.

The committee heard approximately 28 presentations covering the technical work undertaken at 9 institutions since January, 2004 as well as plans for future work and facility improvements. The technical sessions were organized by work package.

Work Package 4	Choppers
Work Package 2	Normal Conducting RF Accelerating Structures
Work Package 3	Superconducting Accelerating Structures
Work Package 5	Beam Dynamics

Committee Membership

Andrea Pisent	INFN, Legnaro, Italy
James Stovall	Los Alamos/Oakridge, USA (retired)
Yoshishige Yamazaki	JAERI, Tokai, Japan (in abstentia)

Charge to the Committee

The External Scientific Advisory Committee (ESAC) was asked to evaluate the technical work completed to date as well as proposed activities within in the framework of HIPPI. The purpose of this report is to provide an independent assessment of these activities and make recommendations for future guidance to the HIPPI management. Specifically, the committee was asked to address the following questions:

1. General. Please review and comment on the overall scientific quality of the research carried out. What were the most important accomplishments of the first year? How does the work compare with the international level?
2. Labs & Groups. Does the work presented by the different labs match with the HIPPI work plan for the first 18 months? Is it consistent and sufficiently transparent scientifically? Comment on the proper use of resources in the first year. Is it clear how the groups proceed in the second year?
3. Work Packages. Comment on the effectiveness of interaction within WP's. Is there enough visibility of WP collaboration? Comment on what needs to be strengthened.

General Assessment

While there are at least 3 new high-current proton injectors under construction worldwide, the committee knows of no new (funded) facilities presently under design except for possible upgrades. The HIPPI activities, therefore, represent the bulk of R&D activities addressing high-current linac technology under way worldwide. The committee (two members in attendance) has chosen to concentrate primarily on the technical aspects of the work and have not addressed the work planning or use of resources for which we ask management's indulgence.

In general, the HIPPI work is being carried out by individuals who are well recognized in the accelerator community for their special expertise and who, in some cases, are serving as mentors to younger scientists. We find the work to be of high quality and are encouraged to see HIPPI being used as a vehicle for recruiting new members to the fraternity of accelerator designers. It is very encouraging to see that some of the funding will be directed towards facility improvements aimed at advancing the art. Such investment is rarely seen except as a part of a large construction project.

Because there are no common, well-defined goals with specific performance objectives or deliverables, assuring strong collaborations among multiple institutions is challenging for the work-package managers. The committee is pleased to observe no reluctance among the participants to collaborate with their colleagues and in a few cases to note strong inter-lab collaborations.

In many cases the work presented represents continuing efforts associated with projects that predate HIPPI that have not necessarily been redefined. In a few cases it was not clear how the work directly supported the HIPPI objectives. It may be helpful to define a hypothetical set of HIPPI performance goals or ranges of performance parameters so that committee members and researchers could more easily access the relevancy of their work.

Work Package 4, Beam Chopping

While the HIPPI activities are focused on the technologies applicable to linear accelerators up to an energy of ~200 MeV, we can assume that some applications will include injection into circular machines, synchrotrons, or storage rings. To facilitate "lossless" extraction, the circulating beam must include an extraction gap. This gap must be created, or chopped out, at low energy and preserved, without degrading beam quality, through the final energy. To minimize machine activation, it is important to chop the beam cleanly, leaving no partially chopped microbunches.

Two approaches were presented both of which rely on electrostatic deflection but differ in amplifier design, duty cycle, and beam-line design. In both approaches the primary challenges are to make the rise time of the deflection voltage shorter than the time between beam bunches (~2 ns at 352 MHz), operate with a high duty factor (~2.4 MHz) and minimize beam emittance growth.

The "fast-slow" chopper system, developed at RAL, has enjoyed several years of R&D support and its engineering design is already fairly mature. Recently, its performance has been simulated for high-current beams resulting in further design refinements. The modular high-voltage, fast-transition pulse generator represents a state-of-the-art development. Measurements of its performance have demonstrated that it will meet the demanding performance requirements. This chopper design should exceed the expected performance of the SNS chopping system.

The CERN approach uses a double meander-line deflector housed within a large aperture quadrupole. The deflection plates are driven by high- and low-frequency pulse amplifiers to achieve the required rise time. Measurements using prototype amplifiers have demonstrated the validity of the approach, but indicate further design work is required to meet voltage and bandwidth requirements.

In both concepts, dissipating the power of the chopped beam is challenging and in both cases, credible solutions supported by thermal analysis were presented. Plans are under way to test a modified RAL slow-wave chopper using a 3-MeV beam at CERN.

This work package addresses a difficult problem that others have struggled with. The approaches presented are original, sophisticated and represent reasonable risk. Both approaches are transparent and compare very favorably with previous work internationally. The most important recent accomplishments in this work package are probably waveform measurements of the prototype pulse generators and high-current beam simulations. While there are only two laboratories addressing choppers, this work package is exemplary in the degree of technical collaboration and scientific quality demonstrated to date.

The chopper is just one of many devices comprising a complex, integrated system. The committee recommends that WP-4 collaborate with WP-5, Beam Dynamics, to investigate the "long-range" effects that the two chopper designs may have on beam quality at high energy using realistic particle distributions in a representative ~1-GeV linac.

Work Package 2, Normal Conducting Accelerating Structures

The committee heard presentations from 6 laboratories that addressed 4 different accelerating structures and 3 linac upgrade programs. Both CERN and RAL are contemplating replacing their existing injector linacs with higher-energy, higher-current machines. GSI is planning the construction of a new pulsed injector with a relatively low duty cycle. Initial physics designs for both proposals draw from the latest understanding of high-current beam dynamics and simulation studies have been initiated to characterize and analyze their performance under error conditions. With the exception of the CCDTL structure in the CERN design, both designs are very conventional, but appear to be sound and address all of the major concerns associated with such high-current devices. Because of limitations on the initial quadrupole lens strength, an analysis of alternate quad laws would be an appropriate task. Further numerical studies should include the MEBT, RFQ, and choppers beginning with as realistic a particle distribution as possible. Since the LEBT, MEBT, and chopper have been identified as sources of emittance growth, alternate designs of these regions may be a fruitful area of study

CERN has initiated a collaboration with the International Science & Technology Center (ISTC) in Moscow to prototype certain portions of the LINAC4 drift-tube linac (DTL). The level of technology offered by the collaborating institutions appears in some specific fields to be somewhat dated. Specifically, circular-pole PMQs and LINAC2- type girder-mounted drift tubes with vacuum bellows have been abandoned in recent DTL designs. While copper-plated structures have recently demonstrated very good rf properties, it is not clear what hot diffusion bonding offers. Other engineering concerns such as e-beam welding and laser welding of copper, vacuum outgassing and radiation damage of PMQs has been addressed and resolved in other projects. The IPHI DTL prototype represents an excellent piece of engineering. The logic for the hybrid quadrupole lens (containing both permanent-magnet and electromagnet components) proposed for LINAC4, seems mostly historical and is not compelling. An objective comparison of the virtues of EMQs and PMQs would be helpful including a benefit analysis of adjustability. The design of a 1-MW rf coupler is good technical work, but does not appear to draw on the designs of existing devices that meet and exceed the performance requirements.

These choices may be appropriate for CERN's upgrade project, but the committee considers them inconsistent with the HIPPI objectives of extending the technology base. Finding ways to reduce costs is very important. However, it is incumbent on the design engineer to be fully cognizant of the advantages and disadvantages of the most recent developments in DTL design worldwide. The committee recommends that WP-2 add to its list of tasks a survey and evaluation of DTL design features realized within the past 5-10 years against which it can compare and defend its design choices.

The coupled-cavity DTL (CCDTL) prototype under construction at CERN is an excellent example of the type of development work that should be supported by HIPPI. This structure has the potential for reducing the cost of a significant portion of a high-current linac. While there have been mechanical difficulties, the physics basis of the cavity design is sound. It would be very helpful for WP-5, Beam Dynamics, to evaluate the performance of this structure compared to a more conventional design (RAL linac, for example) to determine its effect on beam quality, sensitivity to errors, and limits of applicability in beam current and energy.

A coupled-cavity $\pi/2$-mode structure (CCL) is the clear choice for the high-energy portion of a room-temperature injector linac. This structure comes in several varieties. CERN has selected the side-coupled linac (SCL) structure. However, because there is not unanimity within the community, it would be an appropriate task for the HIPPI collaboration to objectively compare the virtues of the various candidate structures, again in light of recent fabrication and operating experience.

The initial work on coupled-circuit SCL models appears to be rigorous, but does not yet take into account the realities of the mechanical assemblies. The design and tuning procedures developed for the SNS SCL, recently commissioned in the US, are mature and could serve as an excellent guide to this effort. While it is certainly valuable to fully understand the physics starting from first principals, it should be the objective of HIPPI not just to propagate the knowledge base, but also to extend it, which requires a good understanding of the state-of-the-art. The same comments apply to the engineering designs. Conservative designs based on working hardware may be appropriate for construction projects; however, the HIPPI collaboration should be taking risks to investigate alternate mechanical designs, tuning, and fabrication techniques.

The prospect of accelerating high currents in a CH-mode DTL structure is very intriguing and is an excellent HIPPI development activity. The large emittance growth and beam loss predicted by initial simulations is a serious concern for a high-power machine. On the other hand, the injector proposed for GSI (70 MeV, 0.05% duty cycle) is an excellent opportunity to test new accelerating structures. The engineering approach of evaluating mechanical design variants involving industry is exemplary. This philosophy could serve as a good topic for collaboration among members of this work package.

Work Package 3, Superconducting Accelerating Structures

Work package 3 addresses the development of superconducting (SC) linac structures in the intermediate energy range (~5-250 MeV), to be operated in pulsed high-duty-cycle mode. This is a relatively new and challenging field since there are, at present, no operating superconducting linacs having these characteristics and none presently under construction. The advantages of these structures, with respect to normal conducting (NC) structures, include more efficient power conversion and larger bore diameter. In some cases, the structures offer additional flexibility allowing, for example, the acceleration of multiple ions. The primary challenges of these new structures include mastering the Lorenz-force detuning (LFD) in pulsed operation and preserving the beam, since the focusing periods are generally longer than in NC linacs.

The research groups involved in this work package, from six institutions (CEA, CNRS IPNO and LPSC, FZJ, IAP-Fu and INFN-Mi), have shown results from cavity prototypes developed in the three main European industries that represent the leaders in this technology worldwide. IAP-Fu has developed a very demanding 19-gap prototype CH superconducting structure. IPNO has realized a prototype spoke cavity (352 MHz, β=0.35). CEA, Saclay and INFN-Mi have developed low-β elliptical cavities operating at 704 MHz (β=0.47 at Mi and β=0.65 at Saclay). These spoke and elliptical cavities have reached and surpassed their design accelerating fields. Some experience in the field of spoke cavities has also been gained at FZJ with the construction of a triple-spoke 760-MHz prototype (β=0.2).

The measurement of the LFD factor K (frequency detuning over accelerating field squared) is specifically important for HIPPI, and data are needed to design a control system required to react the detuning forces experienced under pulsed mode operation. Measurements of K are delicate and still not entirely reproducible, but measurements have been made for the IPNO spoke cavity and the INFN-Mi and CEA elliptical cavities. The committee recommends continuing efforts to improve these measurements. For the elliptical cavities in particular, where their mechanical design is mature, WP-3 should investigate whether resources would better be expended on new cavity prototype designs optimized to minimize LFD, or concentrated on developing compensation schemes with piezo tuners.

The test of high-power couplers operating at 704 MHz is important and deserves the development of a dedicated test facility that will be unique in Europe. This facility planned at CEA will include a klystron having peak power of 1.2 MW, and operating at 50 Hz with a 1.2-ms pulse width. The committee agrees on the opportunity to choose a power range higher than strictly necessary for HIPPI cavity development that would also support testing of high-energy accelerating structure couplers.

Future plans for other members of the collaboration include the following activities: IAP-FU will develop a tuner for their 19-gap cavity, INFN-Mi will develop a coaxial tuner concept for elliptical cavities, FZJ will develop a triple-spoke cavity at 352 MHz (β=0.48), and IPN will construct and test a β=0.15 2-gap spoke cavity. Results in these fields are important and are expected within the next year.

The committee recommends a closer collaboration with WP-5. Development of linac architectures capable of preserving the quality of high-current beams to high energies is crucial for the success of these SC linacs. Particularly in the case of CH cavities whose design is integrated with KONUS beam dynamics, a deeper theoretical investigation is needed to demonstrate that these structures will be able to accelerate intense beams while preserving beam quality. Partly related to the integration between beam dynamics and cavity design was an interesting discussion held in Frankfurt about the best definition of accelerating field to be shared by the community. Indeed, the choice of the conventional cavity length is important for the comparison of cavity performances, and $\beta_0\lambda/2$ multiplied by the number of gaps (for structures operating in the π mode) is a very natural definition. On the other hand, for practical mechanical design, the choice of cavities with small overall length is important.

The collaboration among members of this work package is very strong. Some design choices have been made together since previous projects and common use is made of existing infrastructures and measuring devices. Such continued collaboration will assure optimum use of the high-power RF test stand presently under development.

The committee recommends collaboration with SNS on elliptical cavity operational issues. Moreover, it is felt important to investigate multi-cavity power/control scenarios since, according to SNS experience, the RF system design is a very important cost driver for the linac. Finally, the committee underlines the importance of comparisons of NC and SC solutions. Such comparison studies should be an important deliverable at the completion of HIPPI.

Work Package 5, Beam Dynamics

The beam-dynamics studies along with the development of high-current diagnostics is one of the highlights of the HIPPI activities, since a full understanding of the beam-dynamics issues is required to guide the design and improvements of high-current machine designs. Feasibility studies of linac architectures and the associated beam quality for intense beams (including beam emittance and particle loss) are the primary activities of this work package. While reliability, availability, and cost performance are important issues that should be taken into account in any new machine design, they must be optimized or compromised on the basis of the beam dynamics. The HIPPI program is realizing a long dream in the accelerator community of empirically verifying schemes proposed for increasing beam intensity. To this end, the task of WP-5 is to properly organize the scope of the work in two complimentary areas, theoretical and experimental i.e. the beam experiments with diagnostics and the code developments with benchmarking. The efforts of the six laboratories RAL, CEA (Saclay), CERN, FZJ, GSI and Frankfurt University appear to be well coordinated.

Preparations for benchmarking the code LORASR are in progress at IAP Frankfurt. Input particle distributions provided by GSI were loaded and output field components have been generated. Routines have been added to allow LORASR to simulate the beam dynamics in a DTL with quadrupole magnets located in the drift tubes. LORASR has been used for a preliminary analysis of a GSI UNILAC DTL tank 1 for a proof-of-principle (POP) experiment. In this work, the beam was not matched and rough estimates were used for the cavity geometry and field data. A PC-based version of the code has also been prepared. The LORASR group plans to incorporate the faster particle-in-cell (PIC) routine, and add routines to simulate additional elements such as solenoid lenses, SC CH-DTL, etc. The committee believes that the problems are well addressed in the future planning.

End-to-end simulations are very important to understand and optimize the emittance growth budget throughout the linac. The group in charge of this task has already performed an end-to-end simulation for the CERN LINAC4 design and evaluated one the optimized LEBT design and the efficiency of collimation. A system for the end-to-end simulations has been set up.

The committee is very impressed with the ambitious working program on the space-charge neutralization and the modeling of the ECR ion source. These are very complicated processes including the two opposite charges. Although both are very important processes affecting emittance growth, neither has been taken into account in simulations to date. Emittance growth is very sensitive to the initial charge distribution, which is determined by the ion source and by space-charge neutralization in the LEBT. However, no optimization of the charge distribution based on a theoretical approach has yet been carried out. The working plan is definitely addressing this optimization. The code Cartago is used for the analysis of the space-charge neutralization, while the code SIMECRIS is used for modeling the ECR ion source. The committee strongly encourages these ambitious efforts, which so far have been overlooked or unfunded.

In the HIPPI collaboration, beam dynamicists will become experimental users of accelerator facilities, a concept that seems very reasonable from the accelerator physicists' viewpoint, but which has not traditionally enjoyed wide support. Without empirical studies to compliment our theoretical work, development of the high-intensity, high-energy proton accelerators will not advance. The committee congratulates the collaboration on its success in obtaining the beam time on the UNILAC for the beam-dynamics experiments. However; we are concerned that two campaigns of 98 hours will be too short to develop a full understanding of the complex beam dynamics in the UNILAC.

The behavior observed in the initial simulations results from a mixture of rf defocusing, longitudinal debunching, mismatch, space charge, etc. The committee recommends that the team develop a clear understanding of these effects, and rigorously prepare hypotheses to test experimentally with thorough analysis and numerical simulations.

Benchmark testing is in progress for IMPACT, TOUTATIS, HALODYN, and DYNAMION. Special care has been taken to analyze the error propagation. In particular, the scaling law proposed has been confirmed for a Gaussian bunch by TOUTATIS and HALODYN, and partially by IMPACT. UNILAC DTL simulations have begun without the space charge using IMPACT and HALODYN.

Recommendations:

1. Diagnostics for the beam-dynamics experiments will be very important. In particular, reliable emittance and profile monitors, both vital to a successful experiment, will be very difficult to obtain. Since beam measurement by fluorescence is promising in this sense, the development of this device should be strengthened.

2. The LORASR code should be included in benchmark testing already in progress for the IMPACT, TOUTATIS, HALODYN, and DYNAMION as soon as possible. The team should also consider the inclusion of PARMELA, which has been used extensively to characterize SNS.

3. The DYNAMION code uses a direct particle-particle space-charge solver, while the other three codes use PIC solvers. A comparison between the two solvers is of particular interest because of the close-encounter problem inherent to the particle-particle solver and should be incorporated into the future work plan.

4. Field and the alignment errors should be included in future end-to-end simulation studies. In addition to mismatch, these errors can be an important source of emittance growth.

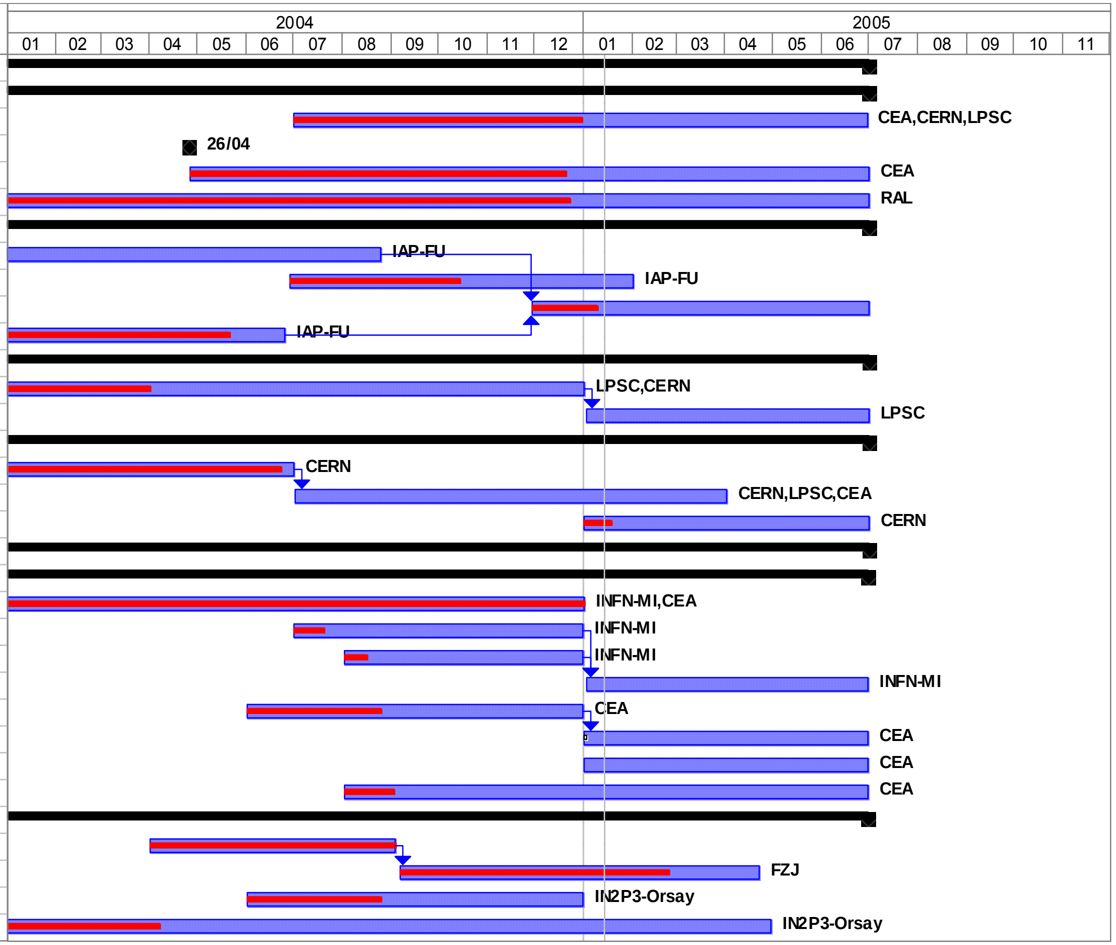
HIPPI ESAC Review
September 29 – October 1, 2004

Wednesday 29, September, morning		
9h30	Welcoming address	
9h45	Introduction and scope of the meeting	R. Garoby
	WORK PACKAGE 4 (***Chopper***)	
10h00	Introduction by the WP coordinator (10'+5')	A. Lombardi
10h15	RAL Activity (20'+10')	M. Clarke-Gayther
10h45	*Coffee break*	
11h00	CERN chopper with highlight on the amplifier tests/problems/possible solutions (20'+10')	M. Paoluzzi
11h30	Dump and collimator for the CERN 3 MeV line(20'+10')	A. Lombardi
12h00	Chopper measurement strategy (20'+10')	E. Sargsyan
12h30	*End of session*	
Wednesday 29, September, afternoon		
	WORK PACKAGE 2 (***Normal Conducting RF struct.)***	
14h00	Introduction by the WP coordinator (5'+5')	J.M. De Conto
14h10	Activities at RAL: Statistical errors and beam halo, the 180 MeV linac upgrade for ISIS (30'+10')	F. Gerigk
14h50	Status of the RT CH-DTL development and beam dynamics layout of the GSI Proton Linac (40'+10')	R. Tiede
15h40	*Coffee break*	
16h00	DTL: IPHI experience, coupling calculations, general design (30'+10')	P.E. Bernaudin / M. Vretenar
16h40	CCDTL developments (30'+10')	M. Vretenar
17h20	Side coupled cavities design (30'+10')	M. Vretenar / J.M. Deconto
18h00	*Adjourn*	

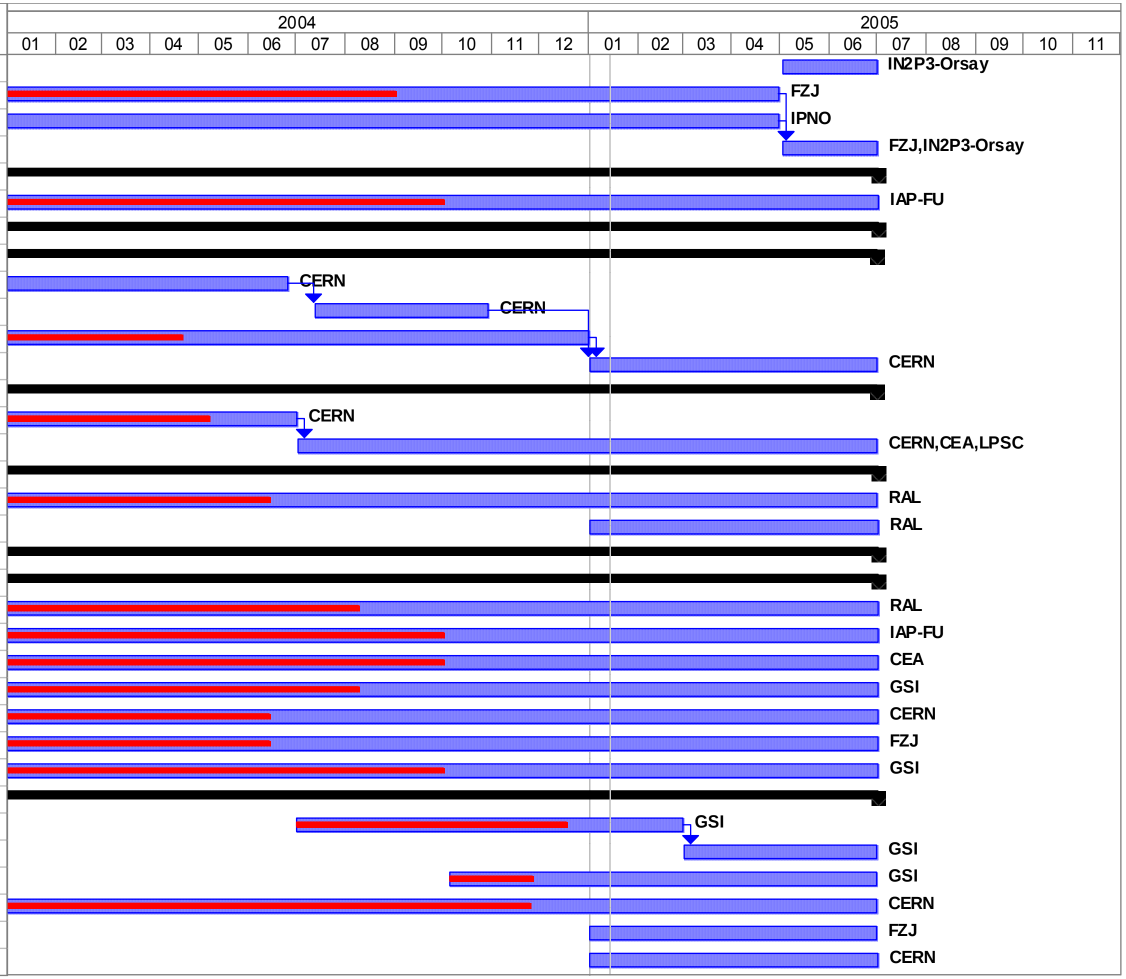
Thursday 30, September, morning		
	WORK PACKAGE 3 (***Superconducting RF structures***)	
9h00	Introduction by the WP coordinator (5’+5’)	S. Chel
9h10	Status of the sc CH-DTL development (20’+10’)	H. Podlech
9h40	Status of the spoke developments at IPN (20’+10’)	G. Olry
10h10	Status of triple spoke developments at Juelich (20’+10’)	E. Zaplatin
10h40	*Coffee break*	
11h00	Status of the elliptical cavity developments at INFN (20’+10’)	P. Pierini
11h30	Status of the elliptical cavity developments at Saclay (20’+10’)	S. Chel
12h00	Low-Beta SC RF Cavity Length Definition (10’+10’)	E. Zaplatin
12h20	*End of session*	
Thursday 30, September, afternoon		
	WORK PACKAGE 5 (***Beam Dynamics***)	
14h00	Introduction by the WP coordinator (10’+5’)	I. Hofmann
14h15	Status of the LORASR code preparation for benchmarking (20’+5’)	R. Tiede
14h40	End-to-end simulations of LINAC4 with emphasis on the halo measurement at 3 MeV (20’+5’)	A. Lombardi
15h05	Status of the CEA activities (20’+5’)	R. Duperrier
15h30	*Coffee break*	
15h50	Status of beam dynamics experiments at the UNILAC (20’+5’)	L. Groening
16h15	Space charge effect at different initial distributions between 2.5 MeV and 50 MeV (20’+5’)	N. Vashyukin
16h40	First Steps on Path/IMPACT code comparison for LINAC4 (10’+5’)	F. Gerigk
16h55	Status of HIPPI code benchmarking (15’+5’)	A. Franchi
17h15	More presentation or discussion	
18h00	*Adjourn*	

Appendix 3: Detailed implementation plan (Gantt chart) for the first 18 months as described in the Technical Annex

ID	Task Name	Deliverables
1	**WP2: NORMAL CONDUCTING STRUCTURES**	
2	**2.1 Drift Tube Linac**	
3	2.1.1 DTL design	
4	2.1.2 Decision on prototyping	
5	2.1.3 Prototype component development	
6	2.1.4 DTL beam dynamics design	
7	**2.2 H-mode Drift Tube Linac**	
8	2.2.1 RF model CH tank1 RF design	
9	2.2.2 RF cold model design & construction	
10	2.2.3 RF model construction	
11	2.2.4 Beam dynamics design CH tank1	06/05 Design report
12	**2.3 Side Coupled Linac**	
13	2.3.1 RF model RF design	
14	2.3.2 RF model mechanical design	
15	**2.4 Cell Coupled Drift Tube Linac**	
16	2.4.1 Pre-prototype construction	
17	2.4.2 Pre-prototype high-power RF tests	06/05 Report
18	2.4.3 Prototype mechanical design	
19	**WP3: SUPERCONDUCTING STRUCTURES**	
20	**3.1 ELLIPTICAL CAVITIES**	
21	3.1.1 Cavity A vertical tests	12/04 Report
22	3.1.2 Mechanical design of tuner, leverage system, n	12/04 Design report
23	3.1.3 Integration of piezo design	
24	3.1.4 Tuner construction	
25	3.1.5 Design cavity B	
26	3.1.6 Construction cavity B	
27	3.1.7 Power coupler design & engineering	
28	3.1.8 RF source order & preparation	
29	**3.2 SPOKE CAVITIES**	
30	3.2.1 Test stand preparation at FZJ	
31	3.2.2 Evaluation of 700 MHz resonator in vertical cry	03/05: Evaluation report
32	3.2.3 Evaluation of 352 MHz 2-gap res. in vertical cr	
33	3.2.4 Design of coupler prototype	

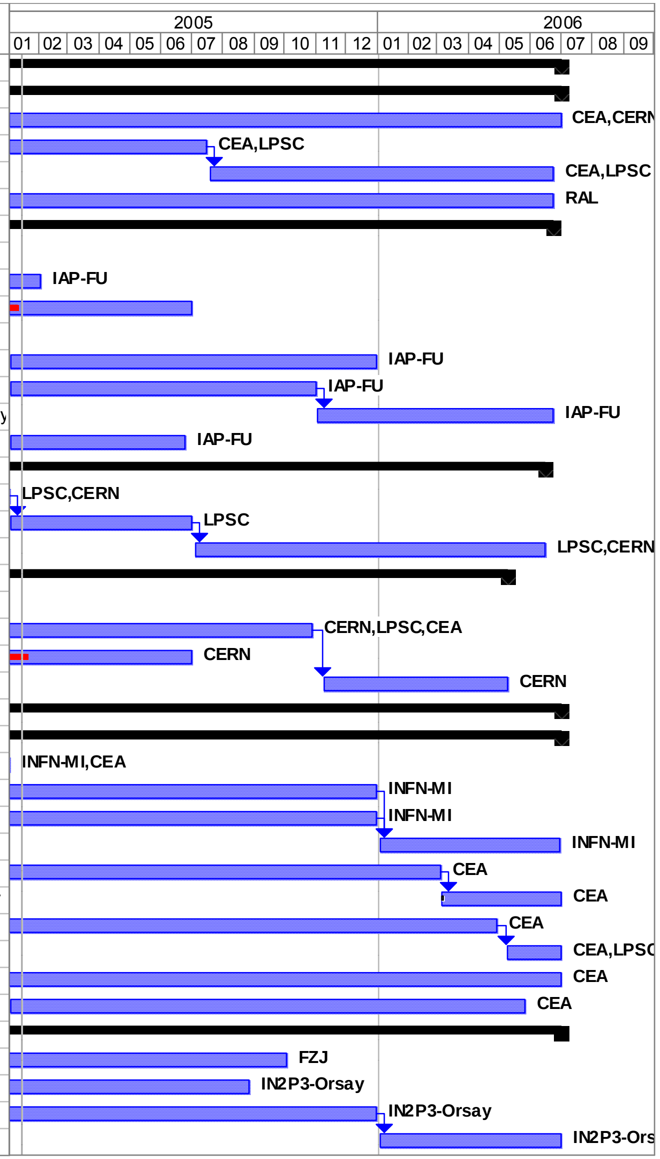


ID	Task Name	Deliverables
34	3.2.5 Test of coupler prototype	
35	3.2.6 Design of 352 MHz multi-gap resonator	05/05 Design report
36	3.2.7 Design of coupler and tuner	
37	3.2.8 Engineering of resonator, coupler and tuner	
38	**3.3 CH RESONATOR**	
39	3.3.1 Study of tuning system	06/05 Conceptual report
40	**WP4: CHOPPING**	
41	**4.1 CHOPPER STRUCTURE A**	
42	4.1.1 Pre-prototype construction	03/05 report
43	4.1.2 Pre-Prototype testing	06/05 Design report
44	4.1.3 Driver construction, testing	
45	4.1.4 Full scale prototype design	
46	**4.2 CHOPPER LINE**	
47	4.2.1 Dump design	06/05 Report
48	4.2.2 Dump construction	
49	**4.3 CHOPPER STRUCTURE B**	
50	4.3.1 Pre-prototype design and test	06/05 Report
51	4.3.2 Prototype design	
52	**WP5: BEAM DYNAMICS**	
53	**5.1 Code development**	
54	5.1.1 Preparation 3D space charge routines, testing	
55	5.1.2 LORASR development	
56	5.1.3 Transport in 3D map implementation	
57	5.1.4 Improvement, modelling high current	
58	5.1.5 Code preparation for 3 MeV test stand	
59	5.1.6 Codes preparation for SC linacs	
60	**5.2 Experiment at UNILAC preparation, simulations**	
61	**5.3 Diagnostics and collimation**	
62	5.3.1 Profile measurement prototype design, constru	
63	5.3.2 Profile measurement testing	
64	5.3.3 Non-interceptive bunch measurement design	
65	5.3.4 Halo meas. device design, construction	
66	5.3.5 Beam profile monitor design	
67	5.3.6 Collimators design	



Appendix 4: Detailed implementation plan (Gantt chart) for the second 18 months period

ID	Task Name	Milestones	Deliverables
1	**WP2: NORMAL CONDUCTING STRUCTURES**		
2	**2.1 Drift Tube Linac**		
3	2.1.1 DTL design		
5	2.1.3 DTL coupler prototype design		
6	2.1.5 DTL coupler prototype construction and testing		
7	2.1.4 DTL beam dynamics design		
8	**2.2 H-mode Drift Tube Linac**		
9	2.2.1 RF model CH tank1 RF design		
10	2.2.2 RF cold model design & construction		
11	2.2.3 RF model construction		
12	2.2.4 Beam dynamics design CH tank1		
13	2.2.5 CH model cavity tests	Dec-05 Intermediate repor	
14	2.2.6 CH-prototype design		
15	2.2.7 CH-prototype construction		Dec-06: Prototype ready
16	2.2.8 CH-DTL beam dynamics study	Jun-05 Design report	
17	**2.3 Side Coupled Linac**		
18	2.3.1 RF model RF design		
19	2.3.2 RF model mechanical design		
20	2.3.3 RF model construction and testing		
21	**2.4 Cell Coupled Drift Tube Linac**		
22	2.4.1 Pre-prototype construction	Jun-05 Intermediate repor	
23	2.4.2 Pre-prototype high-power RF tests		
24	2.4.3 Contribution to ISTC prototype construction	Jun-06 Prototype ready	
25	2.4.4 Revision of design after prototype testing		Dec-06: Design report
26	**WP3: SUPERCONDUCTING STRUCTURES**		
27	**3.1 ELLIPTICAL CAVITIES**		
28	3.1.1 Cavity A vertical tests		
29	3.1.2 Tuner design		
30	3.1.3 Integration of piezo design		
31	3.1.4 Tuner construction and testing	Dec-05 Intermediate repor	
32	3.1.5 Design cavity B		
33	3.1.6 Construction cavity B		Jun-06: cavity B ready
34	3.1.7 Power coupler design & engineering		
35	3.1.9 RF coupler construction		
36	3.1.8 RF source order & preparation		
37	3.1.10 Modulator preparation for 700 MHz test stand		
38	**3.2 SPOKE CAVITIES**		
40	3.2.2 Evaluation of 760 MHz resonator in vertical cry	Mar-05 Intermediate repor	
41	3.2.3 Evaluation of 352 MHz 2-gap res. in vertical cr	Oct-05 Intermediate report	
42	3.2.4 Design of coupler prototype		
43	3.2.5 Test of coupler prototype		



ID	Task Name	Milestones	Deliverables	2005: 01 02 03 04 05 06 07 08 09 10 11 12; 2006: 01 02 03 04 05 06 07 08 09
44	3.2.6 RF design of 352 MHz multi-gap resonator	May-05 Design report		FZJ
45	3.2.7 Engineering of resonator, coupler and tuner			FZJ,IN2P3-Orsay
46	3.2.8 Final design of 352 MHz multi-gap prototype			FZJ,IN2P3
47	**3.3 CH RESONATOR**			
48	3.3.1 Design of tuning system	Jun-05 Intermediate repor		IAP-FU
49	3.3.2 Construction of CH tuning system			IAP-FU
50	**WP4: CHOPPING**			
51	**4.1 CHOPPER STRUCTURE A**			
52	4.1.1 Pre-prototype construction	Jun-05 Design report		CERN
53	4.1.2 Pre-Prototype testing	Mar-05 Intermediate repor		CERN
54	4.1.3 Driver construction, testing			
55	4.1.4 Full scale prototype design			CERN
56	4.1.5 Full scale prototype construction		Aug-06: Prototype ready	CERN
57	4.1.6 Pre-prototype testing w/o beam			CERN
58	**4.2 CHOPPER LINE**			
59	4.2.1 Dump design			
60	4.2.2 Dump construction	Jun-05 Intermediate repor		CERN,CEA,LPSC
61	4.2.3 Beam line assembling			CERN,CEA
62	**4.3 CHOPPER STRUCTURE B**			
63	4.3.1 Pre-prototype design and test	Jun-05 Intermediate repor		RAL
64	4.3.2 Prototype design	Jun-06 Design report		RAL
65	4.3.3 Prototype construction			RAL
66	**WP5: BEAM DYNAMICS**			
67	**5.1 Code development**			
68	5.1.1 3D space charge routines dev., testing			RAL
69	5.1.2 LORASR development	Dec-05 Intermediate repor		IAP-FU
70	5.1.3 Neutralization and ECR source modelization st			CEA
71	5.1.4 Improvement, modelling high current			GSI
72	5.1.5 Code preparation for 3 MeV test stand	Jun-06 Intermediate repor		CERN
73	5.1.6 Codes preparation for SC linacs			FZJ
74	5.1.7 Code comparison and benchmarking			GSI,RAL,I
75	**5.2 Experiment at UNILAC**			
76	5.2.1 Preparation, simulations			GSI
77	5.2.2 First experiment campaign			GSI
78	**5.3 Diagnostics and collimation**			
79	5.3.1 Profile measurement prototype design, constru	Mar-05 Prototype ready		GSI
80	5.3.2 Profile measurement testing			GSI
81	5.3.3 Non-interceptive bunch measurement design			GSI
82	5.3.4 Non-interceptive bunch measurement const. ar	Jun-05 Components ready		GSI
83	5.3.5 Halo meas. device design, construction	Jun-05 Prototype ready	Jun-05 Final report	CERN
84	5.3.6 On-line transmission control			GSI
85	5.3.7 Beam profile monitor design			FZJ
86	5.3.8 Collimators study			CERN

ACKNOWLEDGEMENTS

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