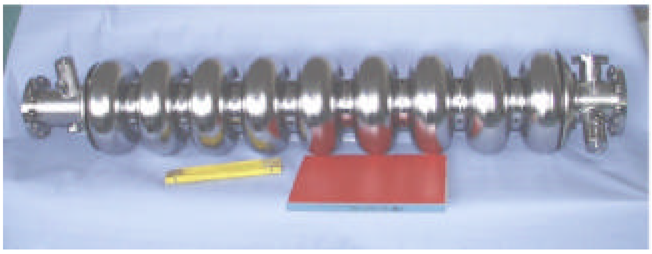
JRA1 in the CARE proposal

Title: Research and Development on Superconducting Radio-Frequency Technology for Accelerator Application

Acronym: SRF

Co-Coordinators : D. Proch, DESY, T.Garvey, CNRS-Orsay



Participating Laboratories and Institutes:

Institute (Participating number)	Acronym	Country	Coordinator	SRF Scientific Contact	Associated to
DESY (6)	DESY	D	D. Proch	D. Proch	
CEA/DSM/DAPNIA (1)	CEA	F	R. Aleksan	O. Napoly	
CNRS-IN2P3-Orsay (3)	CNRS-Orsay	F	T.Garvey	T.Garvey	CNRS
INFN Legnaro (10)	INFN-LNL	I	S. Guiducci	E. Palmieri	INFN
INFN Milano (10)	INFN-Mi	I	S. Guiducci	C. Pagani	INFN
INFN Roma2 (10)	INFN-Ro2	I	S. Guiducci	S. Tazzari	INFN
INFN Frascati (10)	INFN-LNF	I	S. Guiducci	M. Castellano	INFN
Paul Scherrer Institute (19)	PSI	CH	V. Schlott	V. Schlott	
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IPJ Swierk (13)	IPJ	PL	M. Sadowski	M. Sadowski	

Industrial Involvement:

Company Name	Country	Contact Person
ACCEL Instruments GmbH	D	M. Peiniger
WSK Mess- und Datentechnik GmbH	D	F. Schölz
E. ZANON SPA	I	G. Corniani
Henkel Lohnpoliertechnik GmbH	D	B. Henkel

Main Objectives:

Research and Development of the technique allowing the realization of superconducting cavities reaching high accelerating gradient (>35 MV/m) and lower RF losses (higher quality factor). Realization and tests of prototype cavities leading to the improvement of the TTF facility for accelerator R&D.

Research and Development on radio-frequency systems and components to improve the technical performance and reliability of superconducting RF linear accelerators while reducing cost. Verification of design improvements on TTF with high gradient cavities and beam

Cost:

Total expected Budget	Requested EU Funding
4.7 M€ (FC) + 4.3 M€ (AC) **Total 9 M€**	**5.033 M€**

Title: R&D on Superconducting Radio-Frequency Technology for Accelerator Application

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0. Introductory Remarks

In accordance with the recommendations of the referees the Joint Research Activities SRFCAV and SRFTECH have been combined into one JRA which we call Superconducting RF (SRF) and the requested budget has been reduced to 65% of the original combined request. In order not to de-scope the combined JRA considerable efforts of the collaborating partners had to be made. After intensive discussion the following actions have been agreed on:

- Increasing the laboratory contribution to manpower
- Increasing the laboratory contribution to consumables
- Slightly reducing the number of prototypes
- Advantage of such a combined research activity is improved communication and increased synergies through joint meetings with consequent savings in management costs.

With these measures taken by the participating laboratories the goals and deliverables of the original proposals are not significantly changed. Nevertheless, some small reduction in the number of proto-types is to be expected. However, the contribution to industrial partners has not been changed since this would have caused a considerable reduction in the deliverables.

The technical workpackages for the new JRA together with the scientific and technical excellence, an implementation plan, Gantt charts, expertise of the participating institutes, justification of the requested financing, exploitation of the results and risk assessment are described in greater detail in the following.

1. SCIENTIFIC AND TECHNOLOGICAL EXCELLENCE

Superconducting accelerating systems have been in use successfully for electron and heavy ion accelerators. Although the SRF (Superconducting Radio Frequency) technology has reached a state of maturity, substantial improvements are required to exploit the intrinsic potential of the superconducting material. Great effort was started within the framework of the international collaboration TESLA. The superconducting test accelerator TTF and all necessary infrastructures for the preparation of superconducting resonators were set up and have been in operation for several years. A remarkable increase of the accelerating gradient was achieved. Further improvements up or near to the maximum intrinsic properties of the superconducting Niobium material are expected by consequent continuation of the R&D effort. In SRF, a joined R&D activity is proposed for the development of novel cavity fabrication and preparation techniques and for the development of cheaper, more reliable ancillary RF components (tuners, couplers etc….). This will result in prototype components to be tested under realistic operating conditions in the TTF linac and it will result in the improvement of the performance of this infrastructure.

1.1 Objectives and originality of the joint research activity

1.1.1. *Objectives*

The objective of the proposed project is to improve the quality and performance of the superconducting test accelerator TTF (Tesla Test Facility) at DESY. This installation combines:

- A RF electron gun,
- superconducting accelerating units,
- beam diagnostics and
- undulators for FEL operation and it is a
- unique test facility to explore operating conditions of a high gradient superconducting accelerator.

In the future, the operating time will be equally shared between experiments to investigate accelerator physics issues and FEL SASE operation for synchrotron light application.

To prepare the superconducting accelerator components for installation into the test facility, a well equipped preparation area has been built up at DESY and at some of the partner laboratories including clean-rooms, chemical facilities and cryogenic test stands for acceptance tests of components.

This unique combination of available infrastructures for preparation and operation of superconducting RF components facilitates the development and successful tests of new and innovative SRF accelerator technology.

The ultimate objectives of the proposed research activity are

- to increase the accelerating gradient from 25 to 35 MV/m and
- to increase the quality factor from 5×10^9 to 2×10^{10},
- to improve the reliability, operating performance and availability of the superconducting accelerating system and to

achieve a cost reduction of the SRF cavities and their associated components. .

The main steps towards these goals are

- ✓ implementation of electro-polishing for better surface quality (roughness <1µm),
- ✓ exploration of new fabrication methods such as vacuum arc coating,
- ✓ improving the methods for quality control (sensitivity),
- ✓ developing improved input couplers,
- ✓ developing new cold tuner systems,
- ✓ improving the reliability of RF components and developing low-cost proto-types,
- ✓ performing integrated tests of the individual developments in cavities, couplers, tuners….

Detailed deliverables are shown in Table 1.2.1a (in the section discussing implementation plan).

1.1.2 *State of the art and technical innovations*

Superconducting RF technology has been applied increasingly during the last two decades in high energy storage rings and linear accelerators for particle physics and nuclear physics. A new superconducting proton accelerator for a neutron spallation source is under construction at SNS, USA. Altogether, more than 1000 metres of superconducting RF structures with an integrated accelerating voltage of about 5000 million volts are in operation.

Further advance in the R&D activities is important for the future progress in high energy physics, in nuclear physics and in synchrotron radiation research. The challenges for the R&D are numerous, for example extremely low RF losses at CW operation or at high gradients close to the theoretical limit, reliable and reproducible fabrication and treatment methods, elimination of dark currents, reliable and efficient accelerating systems and cost effective methods for fabrication in industry.

Due to the intensive R&D effort in the frame of the TESLA collaboration, it has been possible to increase substantially the achievable accelerating fields of superconducting cavities, to work on alternative fabrication and treatment methods, and to show a way to reduce the cost for cavities by a substantial factor.

The proposed R&D activity will strengthen the worldwide leadership in superconducting cavity technology demonstrated at the TTF accelerator test facility. New SRF accelerator projects like TESLA and the superconducting X-ray FEL will directly benefit from the expected improvements in reliability and performance.

1.2 Implementation plan of the joint research activity

SRF is articulated around 11 work packages:

- one work package dedicated to management and communication (M&C)
- the ten others targeting the main objectives as described below

All tasks aim at an improvement of the quality of the accelerator test facility TTF. Deliverables will be in form of scientific reports, proposals for design or treatment changes, approved new fabrication methods and construction of prototypes.

WP1 (Management and Communication, M&C) oversees and coordinates the work of all work packages, organizes Steering Committee meetings, ensures proper reviewing and reporting as well as dissemination of knowledge within the JRA SRF and the CARE project.

WP2 (Improved Standard Cavity Fabrication, ISCF) aims at improving the present cavity fabrication technology. It is based on the operating experience with superconducting cavities in the test linac TTF. There is an obvious need to modify at least partially the cavity design and the preparation procedures to improve the performance and reliability of the SRF accelerating system.

WP3 (Seamless Cavity Production, SCP) follows the idea to fabricate the actual cavity (excluding the end groups with auxiliary components like input coupler ports, higher order mode dampers…) by a method that avoids welding. This would eliminate possible performance degradation by a low quality weld. There are two methods of seamless production: spinning and hydro-forming. Very encouraging results are obtained with single cell cavities. This technology will be extended to multi-cell cavities.

WP4 (Thin Film Cavity Production, TFCP) works on a new method of thin film coating by vacuum arc technology. Instead of fabrication of a cavity from bulk Niobium, a Copper cavity will be coated at the inside by a thin (several µm thick) superconducting Niobium layer. As compared to the sputter coating method (as being developed by CERN) the novel method of vacuum arc coating promises superior superconducting film properties. First results on samples support this expectation. Two different methods using a planar or a linear source will be investigated.

WP5 (Surface Preparation, SP) investigates new methods of surface cleaning. There are two different topics: electro-polishing and dry ice cleaning. Electro-polishing will produce smoother surfaces as compared to the widely used chemical polishing method. There are very encouraging results on single-cell and nine-cell cavities (in collaboration with KEK, Japan), which can be excited to considerable higher RF fields. In this work package, the optimum EP parameters will be investigated first with single cells. As a next step, this technology will be adapted to the geometry of multi-cell cavities. In parallel, a new method of EP with self-stabilising parameters will be further developed for single cell and multicell cavities.
Dry ice (CO_2) cleaning is expected to clean surfaces from dust or residual contaminations much more effectively than the presently used technique of high

pressure water. It is under use in the semiconductor industry but was never applied to SRF cavities.

WP6 (Material Analysis, MA) extends the methods of quality control of Niobium material and cavity surfaces. At present, an eddy current scanning technique is implemented in the acceptance procedure of Niobium sheet from industry. It is a quantitative measure of the purity that can be used to detect inclusions beneath the surface of the sheet material. This scanning technique can be improved further in sensitivity by implementation of a superconducting Squid sensor. A second way is to develop a simpler flux gate magnetometer for use at the industrial plant.
DC field emission scanning is a very sensitive method for detection of small surface contaminations. This technology will be further developed for a systematic evaluation of the surfaces of samples, which travel together with the cavity during the different steps of preparation. It is envisaged to install a nearly in-situ quality control of the preparation steps by this method.

WP7(Couplers) The aims of this WP include new input coupler designs as well as construction of prototypes. Results from the tests of prototypes will also be delivered, the tests being carried out on a dedicated high power tests stand recently built at Orsay. Among the delivered hardware will be a titanium-nitride coating bench designed to allow coating of several coupler ceramic windows simultaneously. RF "conditioning" studies will also be provided. The TTF couplers were specified for 210 kW peak power in normal operation with higher powers (~ 1 MW) at short pulse lengths for cavity conditioning. We aim to develop couplers that will comfortably handle 1 MW peak powers for pulse lengths of 1.3 milliseconds at 5 Hz repetition rate. Such couplers are necessary to match the progress aimed for in the cavity fields. In addition it is hoped that the conditioning studies will lead to a procedure allowing faster conditioning times than at present (typically of the order of one week).

WP8 (Tuners) The development of active tuner systems is imperative for operation of SC cavities at high gradient. Four of the participating laboratories are investigating innovative tuner systems as well as developing the electronic drive circuitry necessary for them. These tuners are the <u>deliverables</u> of this WP. Especially innovative will be the development of tuners based on piezo-electric and magneto-strictive effects. Tuners are required to counteract the so-called Lorentz de-tuning effect when the cavities are pulsed at high field so as to maintain the phase and amplitude constant during the RF pulse, whilst minimising additional RF power needed for field control. We aim to develop tuners capable of correcting 1 kHz of de-tune so allowing the cavities to operate stably at 35 MV/m. This should be compared with existing tuners on TTF which correct for fields of ~ 15 – 20 MV/m. Long life-time is also a major issue and we aim to develop tuners allowing for 20 years of operation.

WP9 (Low level RF) This WP is comprised of a large number of sub-tasks all of which are aimed at improving the performance, reliability and ease of operability of the LLRF system, both hardware electronics and software, while at the same time allowing significant cost reductions. These sub-tasks will result in the following <u>deliverables</u> :

? design and construction of a detector of single bunch transients,

? automation of the LLRF,
? development of an optimal controller,
? development of exception handling routines,
? high performance optimisation routines for operation at different cavity fields,
? cost optimisation and reliability studies,
? studies of radiation damage to electronic hardware,
? development of a low cost, compact, high performance multi-channel down-converter,
? development of digital RF feedback control system,
? development of a highly stable frequency distribution system,
? development of a data management system,
? RF gun control.

It is important to note that all of these tasks are independent of the others and that each contributes individually to the improvement of the RF system.

WP10 (Horizontal Cryostat Integration Tetsts) The deliverables of this WP concern the results of tests performed on SC cavities in CRYHOLAB (shown as test 1, test 2 etc..., in Gantt chart), a test infra-structure built by an IN2P3-CEA collaboration at Saclay. This facility will allow integrated tests of cavities equipped with improved components resulting from developments in other WP's within the JRA (tuners and couplers). Novel thermometric calibration techniques will be developed for use during these tests.

WP11 (Beam Diagnostics)Two different diagnostics will be designed and constructed within this work package. The first will be an RF cavity based beam position monitor (BPM). This device will have a resolution five times better than existing devices while maintaining high temporal resolution. The second will be a non intercepting emittance monitor based on millimetre wave radiation emitted by diffraction effects as the beam traverses a slotted aperture. These diagnostics, both of which will be tested on TTF, constitute the deliverables of this WP.

The main deliverables of the research activities of SRF will be the construction of prototypes of superconducting cavities for the TTF Test Facility with

- high accelerating gradients (> 35 MV/m) and
- lower RF losses (higher quality factor) and
- improved reliability,

as well as prototypes of,

- input power couplers,
- active tuning systems,
- beam diagnostics,
- results of tests of the above components integrated together in a horizontal cryostat.

A more detailed description of the expected deliverables for each work package and each task is given below (table 1.2.1a)

Table 1.2.1a: Overview of deliverables in the 6 work packages

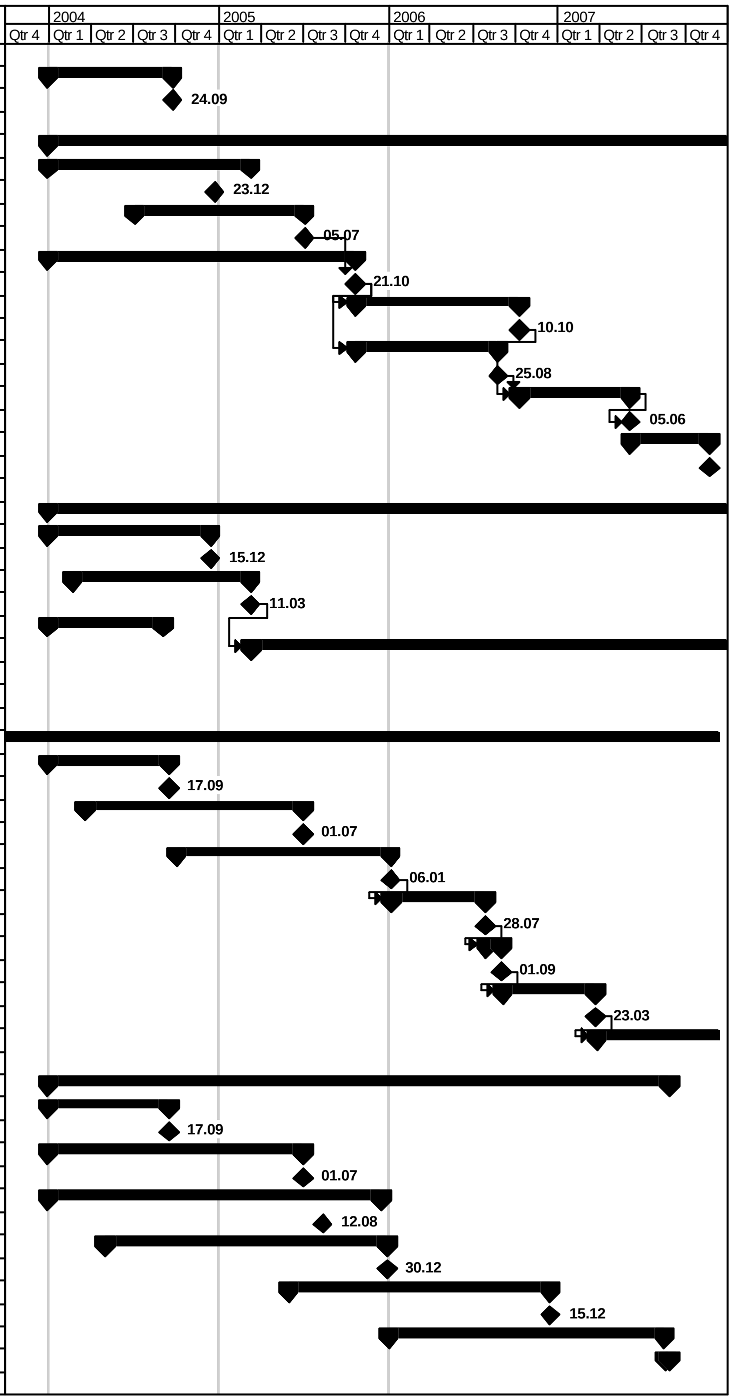
WP1	Management & Communication
	Deliverables: Coordination of the Work Packages in the JRA, organisation of plenary meetings, follow up of schedule and money flow, status reports
WP 2	Improved Standard Cavity Fabrication
Task 2.1	Reliability analysis
	The performance of cavities and auxiliary components in TTF will be analysed. A correlation between obvious degradation of performance (*e.g.*, reduction of the usable accelerating gradient, enhanced dark current) and unusual steps in fabrication and treatment procedures will be investigated
	Deliverables: reports, proposals for design and treatment changes
Task 2.2	Improved component design.
	Based on the findings of task 2.1 design and treatment of components will be revised
	Deliverables: Modified design of components, new methods of cavity treatment, reports, drawings, work plans
Task 2.3	EB welding
	New components will be fabricated for exploring the improved performance
	Deliverables: fabrication of prototypes (cavities, auxiliary components)
WP 3	Seamless Cavity Production
Task 3.1	Seamless cavity production by spinning
	Design, commissioning and operation of a machine for spinning multicell cavities

	Deliverables: Description of optimum parameters for spinning and production of prototypes
Task 3.2	Seamless cavity production by hydroforming
	Design, commissioning and operation of a machine for hydroforming of multicell cavities.
	Deliverables: Description of optimum parameters for hydroforming and production of prototypes
WP 4	Thin Film Cavity Production
Task 4.1	Linear arc cathode coating
	Development of a method to coat a Cu cavity with a linear arc cathode
	Deliverables: Reports about the vacuum arc technology, setting up of an experimental apparatus for coating, design, fabrication and commissioning of multicell coating apparatus, coating of single cell and multicell cavities
Task 4.2	Planar arc cathode coating
	Development of a method to coat a Cu cavity with a planar arc cathode
	Deliverables: Reports about the vacuum arc technology, setting up of an experimental apparatus for coating; design, fabrication and commissioning of multicell coating apparatus, coating of single cell and multicell cavities
WP 5	Surface Preparation
Task 5.1	EP on single cells
	Exploring the best parameter set for EP on single cells
	Deliverables: Reports about kinematics of EP with various conditions of chemical mixtures and temperature; influence of
	cathode geometry; definition of the best working parameter set; EP on a series of single cells
Task 5.2	EP on multicells
	Extrapolation of EP parameter from single cell to multicell cavities
	Deliverables: design, fabrication and operation of a multicell EP apparatus, EP on a series of multicell cavities
Task 5.3	Automated EP
	Development of a technology for self stabilising the best EP parameters under industrial operating conditions
	Deliverables: Report about stabilising chemical reactions during EP, design, fabrication and operation of an automated EP system, EP of a series of single and multicell resonators.
Task 5.4	Dry ice cleaning
	Development of an apparatus for CO_2 cleaning of cavities
	Deliverables: Reports about principles of CO_2 cleaning of cavities, Design, fabrication and operation of a prototype CO_2 cleaning apparatus, CO_2 cleaning of a series of single-cell and multi-cell cavities
WP 6	Material Analysis
Task 6.1	SQUID scanning
	Improvement of eddy current scanning by use of SQUID detectors
	Deliverables: Reports about technology of SQUID scanning,

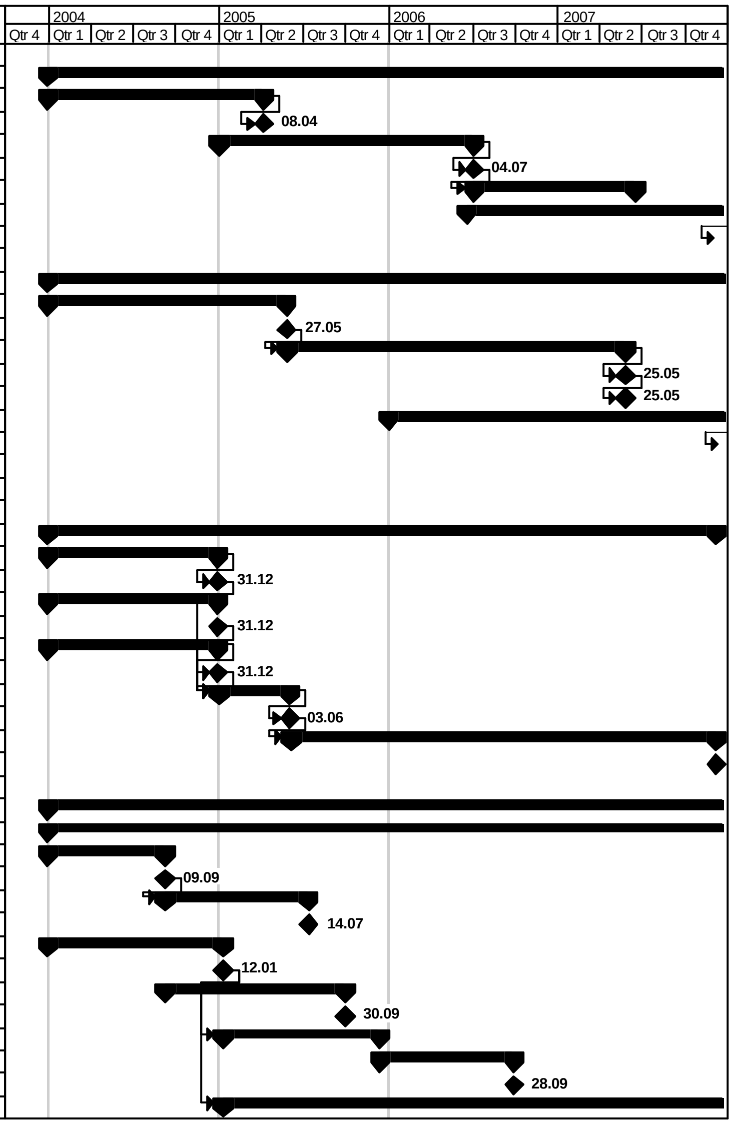
	design, fabrication and operation of a prototype scanner, definition of best operating conditions, design of an industrial SQUID scanning machine
Task 6.2	Flux gate magnetometry
	Evaluation of flux gate magnetometry for material scanning
	Deliverables: Reports about technology of flux gate magnetometry, design, fabrication and operation of a prototype scanner, definition of best operating conditions, design of an industrial flux gate magnetometry scanning machine
Task 6.3	DC field emission scanning
	Development of a quality control of extremely clean surfaces.
	Deliverables: DC field emission scanning on samples from travellers of cavity treatments. Establish correlation between RF performance and DC scanning results, explore sensitivity of DC scanning, definition of a DC scanning method for industrial use
WP7	Power Couplers **Deliverables: Coupler prototypes. Results of conditioning studies. Titanium-nitride coating system.**
WP8	Cavity Tuners
	Deliverables: Piezo-electric tuners, equipped with their electronic controls. Maneto-strictive tuner prototypes. Radiation hardness tests of tuners. Actuator studies for tuners.
WP9	Low Level RF **Deliverables: Improved reliability and technical performance of LLRF. Studies on cost reduction. New, cheaper hardware. Improved software.**
WP10	Cryostat Integration Tests **Deliverables: Integrated tests of components, resulting from other work-packages, in the CRYHOLAB cryostat.**
WP11	Beam Diagnostics **Deliverables:Novel emittance monitors. New, improved beam position diagnostics.**

The JRA1 is scheduled to last four years. A multi annual 4 year implementation plan for SRF is shown below and on the following pages.

ID	Task Name
1	**2. Improved standard cavity fabrication**
2	**2.1 Reliability Analysis**
9	2.1.7 MS Final report on reliability issue
10	
11	**2.2 Improved component design**
12	**2.2.1Documentation retrieving**
20	2.2.1.9 MS Report about new design for components
21	**2.2.1.10 Stiffness optimazation**
25	2.2.1.14 MS Final Report for new components
26	**2.2.2 Review of criticality in welding procedures**
31	2.2.2.5 MS Report about welding parameters
32	**2.2.3 Finalise new component design**
34	2.2.3.2 MS New components design finished
35	**2.2.4 Finalise new cavity design**
37	2.2.4.2 MS New cavity design finished
38	**2.2.5 New design of complete cavity**
40	2.2.5.2 MS New complete cavity design finished
41	**2.2.6 Fabricate cavity of new design**
43	2.2.6.2 MS Cavity of new design finished
44	
45	**2.3 EB welding**
46	**2.3.1 Design tooling**
52	2.3.1.6 MS Tools design finished
53	**2.3.2 Tools production**
59	2.3.2.6 MS Tools fabrication finished
60	**2.3.3 Welding**
63	**2.3.3.3 MS start production welding**
66	
67	
68	**3. Seamless cavity production**
69	**3.1 Seamless by spinning**
70	**3.1.1 Design spinning apparatus**
73	3.1.4 MS Drawings of spinning machine finished
74	**3.1.2 Fabrication of spinning machine**
79	3.1.2.5 MS Spinning apparatus ready
80	**3.1.3 Evaluation of spinning paramers**
85	3.1.3.5 MS Spinning parameters defined
86	**3.1.4 Spinning of 1-celll cavities**
89	3.1.4.3 MS 1-cell spinning parameters defined
90	**3.1.5 Extention of spinning apparatus to multicells**
92	3.1.5.4 MS Start of Muli-cell spinning
93	**3.1.6 Spinning of multi-cell cavities cavities**
96	3.1.6.6 MS Parameters of multi-cell spinning defined
97	**3.1.7 series production of multi-cell cavities**
99	
100	**3.2 Seamless by hydroforming**
101	**3.2.1 Design hydroforming machine**
104	3.2.1.3 MS Drawings matrix & support finished
105	**3.2.2 Construction of hydroforming machine**
111	3.2.2.6 MS Construction of hydr. machine finished
112	**3.2.3 Construction of tube necking machine**
119	3.2.3.7 MS Construction tube necking machine finished
120	**3.2.4 Development of seamless tubes for 9-cell cavities**
123	3.2.4.3 MS seamles tubes ready
124	**3.2.5 Development of tube necking**
127	3.2.5.3 MS Tube necking machine operational
128	**3.2.6 Hydroforming of seamless cavities**
131	**3.2.6.3 MS Hydroformed 9-cell cavities ready**
134	



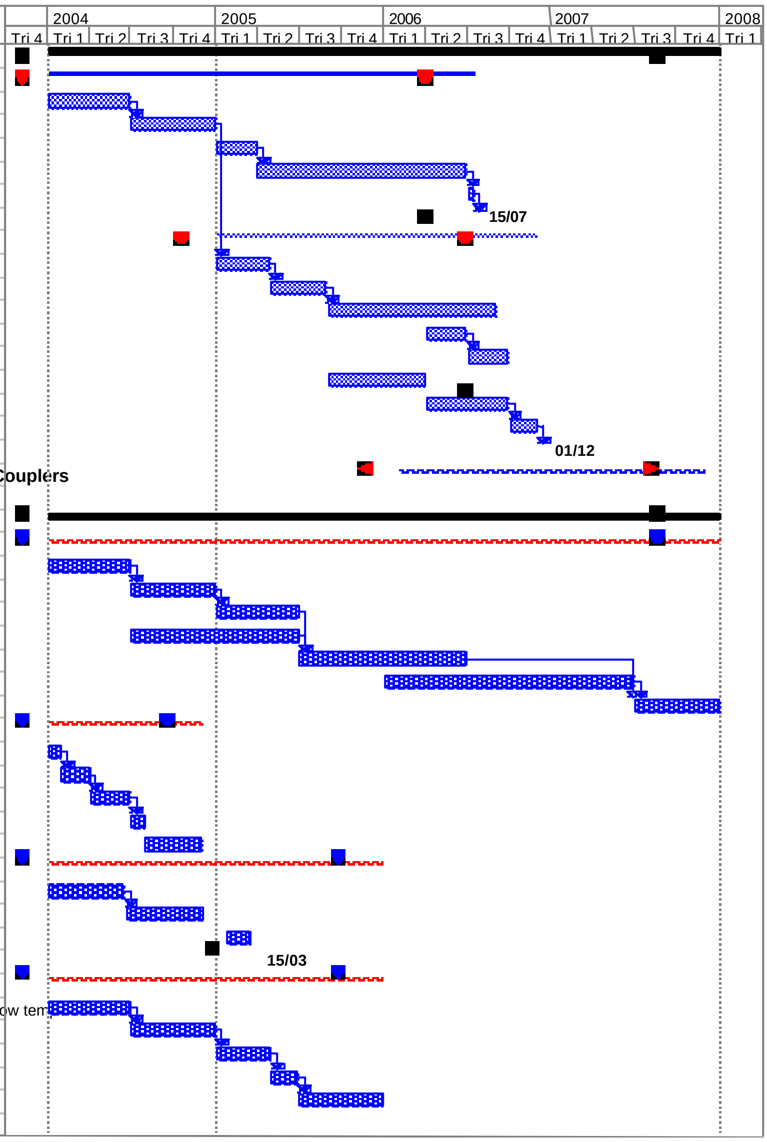
ID	Task Name
136	**4. Thin film cavity production**
137	**4.1 Linear-arc cathode coating**
138	**4.1.1 Installation & commissioning of coating apparatus**
142	4.1.1.4 MS Coating apparatus operational
143	**4.1.2 Coating of single cells without microdroplet filtering**
145	4.1.3.4 MS Droplet filter ready
146	**4.1.4 Coating of single cell with microdroplet filtering**
148	**4.1.5 Design and commissioning multi-cell coating**
150	4.1.5.4 MS First multicell coating
151	
152	**4.2 Planar-arc cathode coating**
153	**4.2.1 Modification of a planar-arc & trigger system**
156	4.2.1.3 MS Planar arc system fully tested
157	**4.2.2 Routine Operation of planar arc system**
160	4.2.2.5 MS Summary report on quality of planar arc coating
161	4.2.2.5 MS First multicell coating
162	**4.2.3 Studies of other HTC superconducting coating**
164	4.2.3.4 MS Report on quality of superconducting properties
165	
166	
167	**5. Surface preparation**
168	**5.1 EP on single cells**
169	**5.1.1 EP on samples**
173	5.1.1.4 Milestone: best EP parameters
174	**5.1.2 Single cell cavities**
176	5.1.2.2 Milestone: 3 cavities fabricated
177	**5.1.3 Build EP chemistry for single cells**
181	5.1.3.4 MS First operation of EP set-up
182	**5.1.4 Operation of single cell EP**
184	5.1.4.5 Milestone: first RF measurement of EP cavity
185	**5.1.5 Continuous operation, search for best parameters**
187	5.1.5.6 Milestone: EP parameters fixed
188	
189	**5.2 EP on multi-cells**
190	**5.2.1 Transfer of param. from 1 cell to multi cell equipment**
191	**5.2.1.1 Finish EP setup nine-cells at DESY**
194	5.2.1.1.3 MS Proof-of-Principle experiment Hot water rinse
195	**5.2.1.2 Optimize electrode shape**
198	5.2.1.2.3 MS Electrode design fixed
199	**5.2.1.3 Fix process parameters/ Quality control**
204	5.2.1.3.5 MS Process parameters fixed
205	**5.2.2 Laser roughness**
209	5.2.2.4 MS Roughness measurement finished
210	**5.2.3 Oxipolishing as final chemical cleaning**
214	**5.2.3.4 MS Proof-of-Principle experiment Oxipolishing**
217	5.2.3.7 MS OP for 9-cells finished
218	**5.2.4 Transfer Electropolishing technology to industry**



ID	Task Name	2004–2007 (Qtr 4 2003 – Qtr 4 2007)
227	**5.3 Automated EP (AEP)**	
228	**5.3.1 prototype EP installation**	
232	5.3.1.4 MS First operation	14.09
233	**5.3.2 EP computer control**	
237	5.3.2.4 MS Software ready	28.09
238	**5.3.3 Operation of AEP prototype**	
243	5.3.3.4 MS Automated EP is defined	23.09
244	**5.3.4. Alternative electrolytes**	
248	5.3.4.4 MS Conclude experimental results	09.06
249	**5.3.5 Define best AEP**	
254	5.3.5.5 MS Concude on best electrolyte	17.08
255		
256	**5.4 Dry ice cleaning**	
257	**5.4.1 Installation of full system for 1-3 cell cavities**	
262	5.4.1.5 MS Start of operation	01.12
263	**5.4.2. Optimisation of cleaning parameters**	
267	5.3.2.4 MS Cleaning parameters fixed	31.05
268	**5.4.3 VT 9-cell cleaning apparatus**	
273	5.4.3.5 MS Start 9-cell cleaning	30.11
274	**5.4.4 VT Cleaning of 9-cell cavities**	
276	**5.4.5 Design & construction of H 9-cell cleaning apparatus**	
281	5.5.5.5 MS Start 9-cell cleaning	04.04
282	**5.4.6 Cleaning of horizontal nine-cell cavity**	
284		
285		
286	**6. Material Analysis**	
287	**6.1 Squid scanning**	
288	**3.1.1 Produce calibration defects**	
291	6.1.1.3 MS Calibration defects ready	30.09
292	**6.1.2 Design components of Squid scanner**	
295	6.1.2.3 MS Scanner table ready	30.11
296	**6.1.3 Construction of scanning apparatus**	
301	6.1.3.5 MS Scanning apparatus ready	16.12
302	**6.1.4 Scanning of sheets with artificial defects**	
306	6.1.4.4 MS Classification of defects finished	08.02
307	**3.1.5 Scanning of production sheets**	
311	6.1.5.4 MS Final report	
312		
313	**6.2 Flux gate magnetometry**	
314	**6.2.1 Produce calibration defects**	
317	6.2.1.3 MS Calibration defects finished	01.07
318	**6.2.2 Design components of flux gate scanner**	
322	MS 6.2.2.4 MS Design Scanner finished	03.09
323	**6.2.3 Fabrication of flux gate scanner**	
329	6.2.3.6 MS Flux gate scanner ready	10.06
330	**6.2.4 Comissioning of flux gate scanner**	
333	6.2.4.3 MS Flux gate scanner operational	30.06
334	**6.2.5 Operation of flux gate scanner**	
337	6.2.5.3 MS Conclusion of flux gate scanning operation	14.03
338	**6.2.6 Comparison with SQUID scanner**	
340	6.2.6.4 Conclude SQUID vs. flux gate scanner	
341		
342	**6.3 DC field emission studies of Nb samples**	
343	**6.3.1 Quality control scans**	
346	6.3.1.3 MS Start scanning activity	04.06
347	6.3.1.6 MS First report on BCP/EP and DIC surface	01.12
348	**6.3.1.7 Continue QA scanning**	
350	**6.3.2 Detailed measurements on strong emitters**	
352	6.3.2.2 MS Start strong emitter evaluation	20.05
353	**6.3.2.1 I/V curves and current limits**	
356	6.3.2.4 MS Intermediat report on strong emitter investigations	05.05

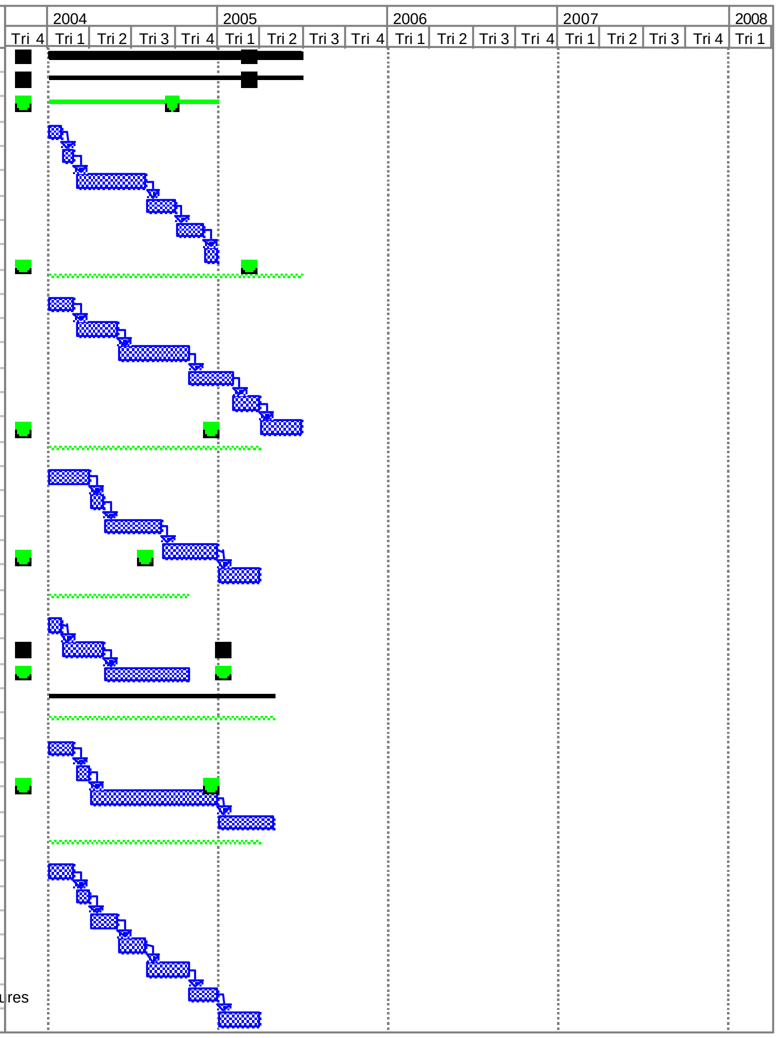
(slightly revised version 19.02.2004 (Table 2.1.1.b, Organisation chart accordingly))

Nº	Nom de la tâche
1	**WP7: COUPLERS**
2	**7.1 New Proto-type Coupler**
3	RF Simulations of Coupler
4	Detailed Engineering Drawings
5	Call for tenders
6	Prototype Fabrication in Industry
7	Low Power tests
8	High Power Tests and Conditioning
9	**7.2 Fabrication of TiN Coating Sytem**
10	Mechanical design of vacuum chamber
11	Fabrication drawings
12	Construction of vacuum chamber
13	Define vacuum needs
14	Appropriation of vacuum equipment
15	Design of electronic circuitry
16	Fabrication of electronics in industry
17	Installation and Test at Orsay
18	First Window Coating
19	**7.3 Conditioning Studies of Proto-type Couplers**
20	
21	**WP8: TUNERS**
22	**8.1 UMI TUNER**
23	Control electronics
24	Tuner design
25	Tuner fabrication
26	Fast piezo tuner design
27	Piezo fabrication and bench tests
28	Cavity-tuner-coupler integration
29	Pulsed RF tests
30	**8.2 Magneto-strictive Tuner**
31	Complete specification
32	Conceptual design
33	Protoype and performance evaluation
34	Finalise tuner and drive electronics design
35	Test of tuner
36	**8.3 CEA Tuner**
37	Design Piezo + Tuning System
38	Fabrication
39	Installation RF
40	Declare "Ready for experiment"
41	**8.4 IN2P3 Activity**
42	Characteise actuators/piezo -sensors at low tem
43	Test radiation hardness of piezo tuners
44	Integration of piezo and cold tuner
45	Cryostat tests
46	Tests with pulsed RF
47	

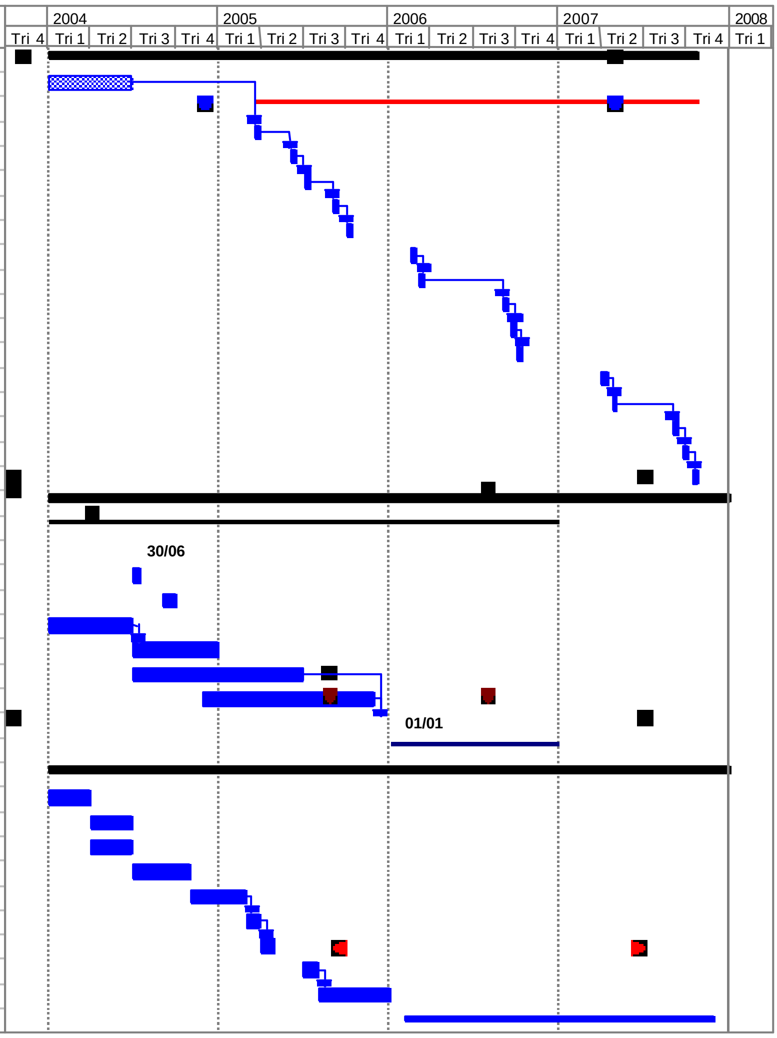


(slightly revised version 19.02.2004 (Table 2.1.1.b, Organisation chart accordingly)

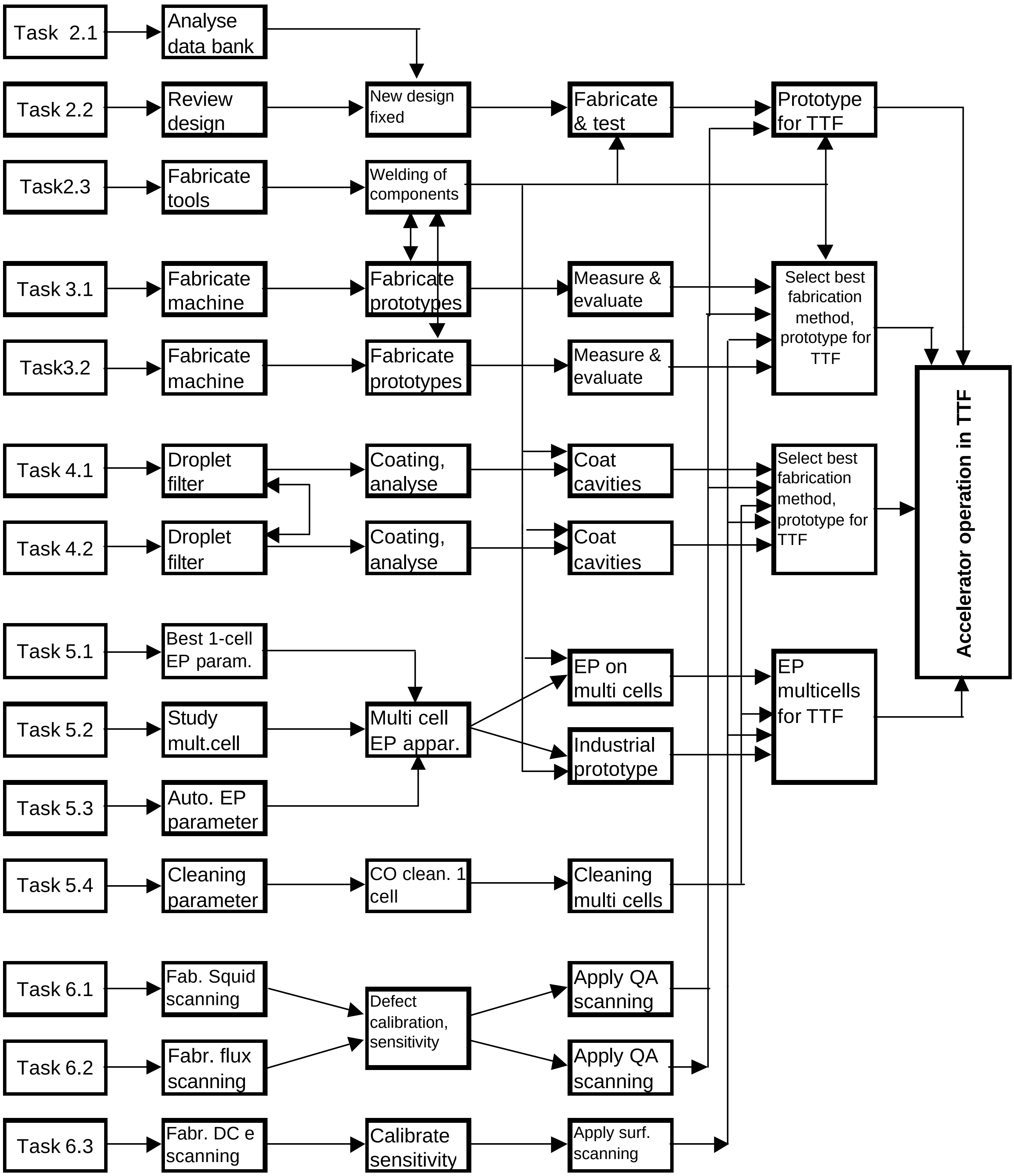
N°	Nom de la tâche
48	**WP9: LOW LEVEL**
49	**9.1 OPERABILITY AND TECHNICAL**
50	**9.1.1 Transient detector**
51	Define requirements
52	Electronics design
53	Build prototype and evaluate
54	Final design of detector
55	Install and
56	Tests with beam
57	**9.1.2 LLRF Automation**
58	Dialogue with industrial experts
59	Develop full specification
60	Implement FSM for
61	Test and evaluation
62	Implement
63	Evaluation and acceptance by
64	**9.1.3 Control Optimisation**
65	Specification of sytem
66	Conceptual design of
67	Performance
68	Implementation in DSP
69	Implementation and tests on
70	**9.1.4 Exception Handling Routines**
71	Specification
72	Design of exception handler
73	Implementation and tests on
74	**9.2 LLRF COST AND**
75	**9.2.1 Cost and Reliabilty Study**
76	Identify cost drivers and present LLRF
77	Develop cost reduction ideas
78	Build prototypes and evaluate
79	Final design of LLRF
80	**9.2.2 Radiation Damage Study**
81	Identify critical electronics issues
82	Evaluate TESLA radiation
83	Develop tests for components
84	Procure ands assemble test set
85	Data acquisition from radiation
86	Analyse results and develop countermesures
87	Implement countermesures and verify



Nº	Nom de la tâche
122	**WP10: CRYOSTAT INTEGRATION**
123	**10**
124	**10**
125	Test 1
126	Test 2
127	Test 3
128	Test 4
129	Test 5
130	Test 1
131	Test 2
132	Test 3
133	Test 4
134	Test 5
135	Test 1
136	Test 2
137	Test 3
138	Test 4
139	Test 5
140	**WP11:BEAM**
141	**11.1 Beam Position Monitor**
142	Present BPM installed in TTF
143	Cryogenic measurements on
144	Beam tests of BPM on
145	Design of BPM
146	Fabrication of BPM
147	Development of new hybrid coupler and
148	Design of Digital Signal
149	New BPM ready for
150	Beam Tests with new BPM
151	**11.2 Beam Emittance Monitor**
152	Slit width simulations
153	Slit design
154	Optics simulations
155	Optics appropriations
156	System assembly and tests
157	Mechanical assemblt at
158	Optical assembly at
159	Integration of controls into
160	Beam tests at
161	Succesive measurements



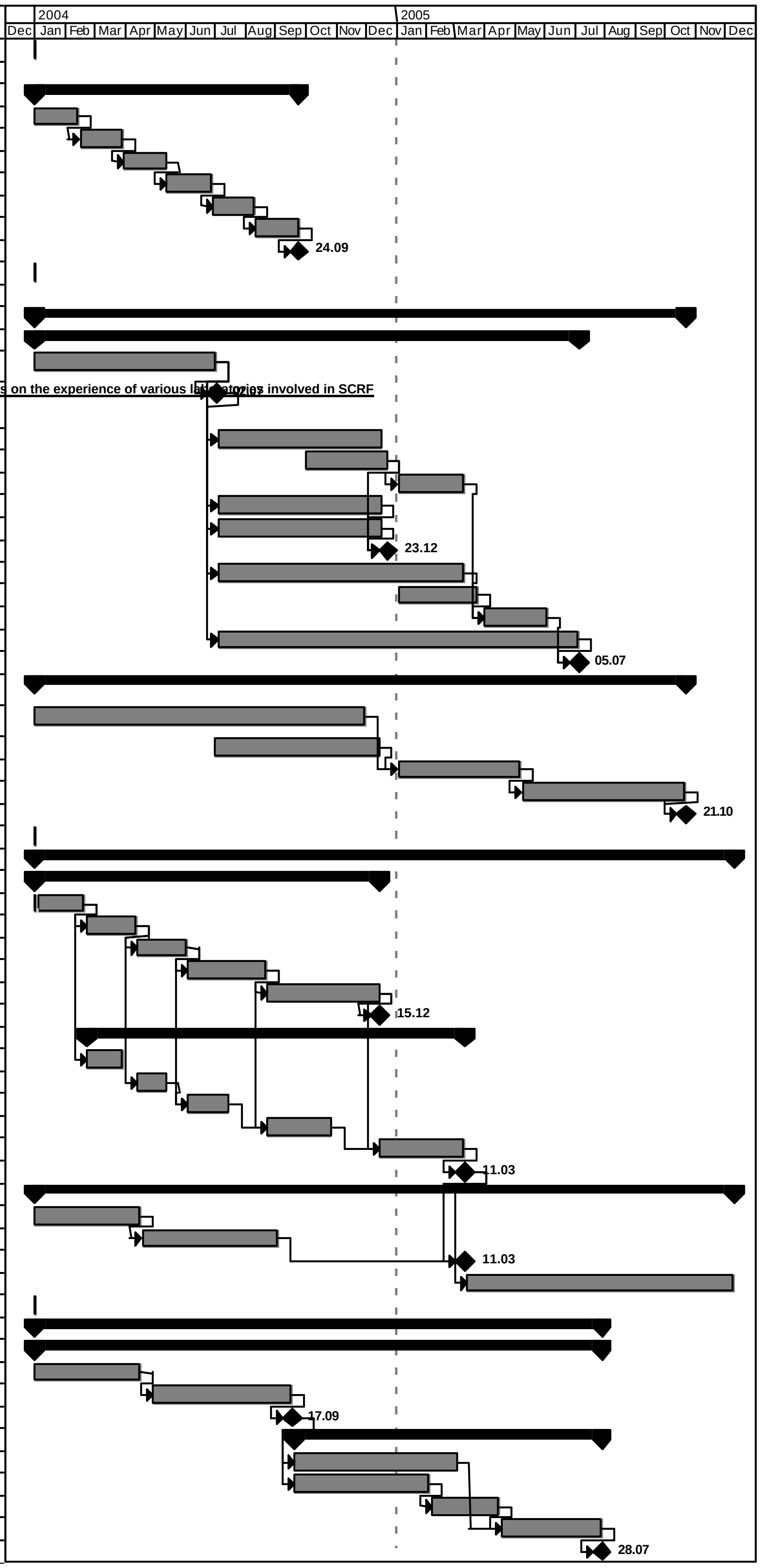
Pert Chart of the interdependencies in SRF



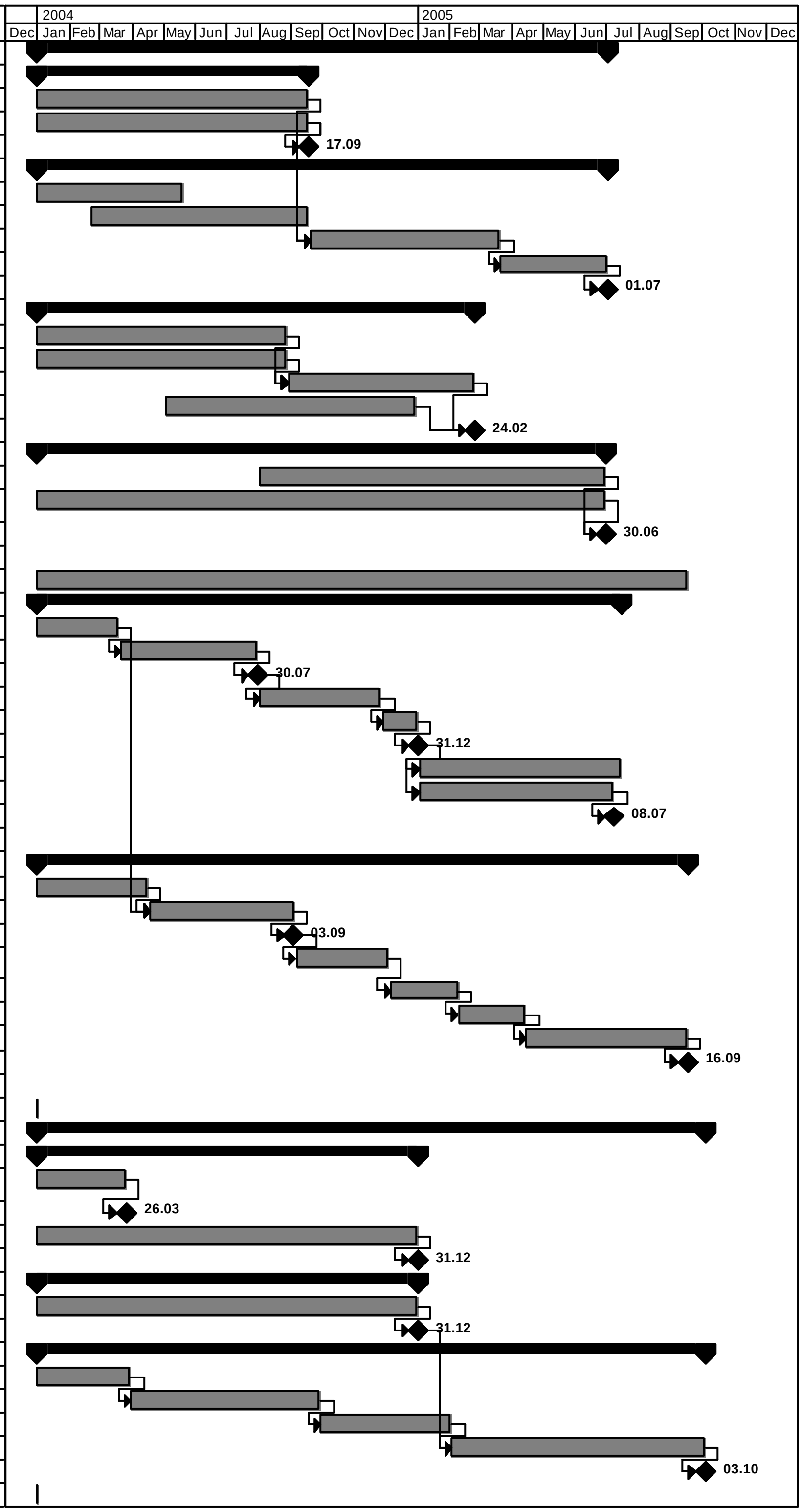
1.2.1 Implementation plan for the first 18 months

A detailed implementation plan of the 11 work packages for the first 18 months indicating milestones is shown below.

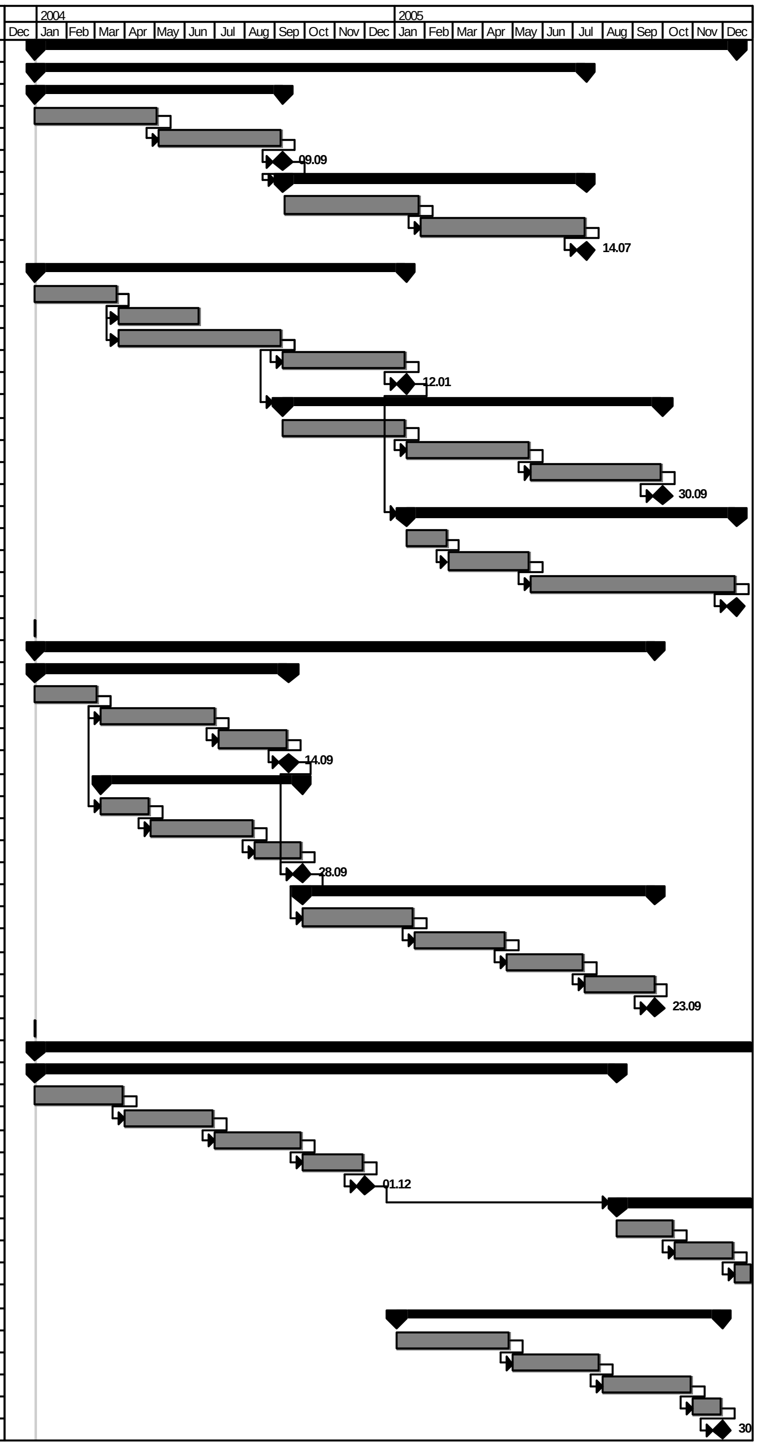
ID	Vorgangsname
1	**JRA SRF 18 month schedule**
2	
3	**2.1 Reliability Analysis**
4	2.1.1 Review of data bank: cavity fabrication
5	2.1.2 Review of data bank :cavity treatment
6	2.1.3 Review of data bank :cavity VT performance
7	2.1.4 Review of data bank: string assembly
8	2.1.5 Review of dat bank: string performace
9	2.1.6 Establish correlations
10	**2.1.7 MS Final report on reliability issue**
11	
12	
13	**2.2 Improved component design**
14	**2.2.1Documentation retrieving**
15	2.2.1.2 Acces and study of Jlab, DESY, LLAN, KEK experience and solution on components
16	**2.2.1.3 MS Summary report on the status of the art on ancillaries on the experience of various laboratories involved in SCRF**
17	2.2.1.4 Sealing material and shape design
18	2.2.1.5 Flange preliminary design
19	2.2.1.6 Material and geometrics compatibility
20	2.2.1.7 Final assembly design
21	2.2.1.8 End plate preliminary design
22	**2.2.1.9 MS Report about new design for components**
23	2.2.1.10 Stiffness optimazation
24	2.2.1.11 Manufactoring procedure analysis
25	2.2.1.12 Final assembly design
26	2.2.1.13 Other ancillaries design
27	**2.2.1.14 MS Final Report for new components**
28	**2.2.2 Review with vendors of criticality in welding procedures**
29	2.2.2.1 Review of available parameters on vendor welding machine
30	2.2.2.2 Definition of prototype requirements for tests
31	2.2.2.3 Welding test on specimens
32	2.2.2.4 Analysis of the results
33	**2.2.2.5 MS Report about welding parameters**
34	
35	**2.3 EB welding**
36	**2.3.1 Design tooling**
37	2.3.1.1 Tools for flange welding
38	2.3.1.2 Tools for pipe welding
39	2.3.1.3 Tolls for stiffening rings
40	2.3.1.4 Tools for single cell welding
41	2.3.1.5 tools for 9-cells
42	**2.3.1.6 MS Tools design finished**
43	**2.3.2 Tools production**
44	2.3.2.1 Tools for flange welding
45	2.3.2.2 Tools for pipe welding
46	2.3.2.3 Tolls for stiffening rings
47	2.3.2.4 Tools for single cell welding
48	2.3.2.5 tools for 9-cells
49	**2.3.2.6 MS Tools fabrication finished**
50	**2.3.3 Welding**
51	2.3.3.1 Commissioning welding machine
52	2.3.3.2 Test welding
53	**2.3.3.3 MS start production welding**
54	2.3.3.4 Single cell welding
55	
56	**3.1 Seamless by spinning**
57	**3.1.1 Design spinning machine**
58	3.1.1.1 Drawings of the matrices
59	3.1.1.2 Drawings of the support system
60	**3.1.1.3 MS Design finished**
61	**3.1.2 Construction of spinning machine**
62	3.1.2.1 fabrication of machine parts
63	3.1.2.2 Sofware for the machine
64	3.1.2.3 assembly of machine
65	3.1.2.4 Comissioning of the machine
66	**3.1.2.5 MS Commissioning finished**



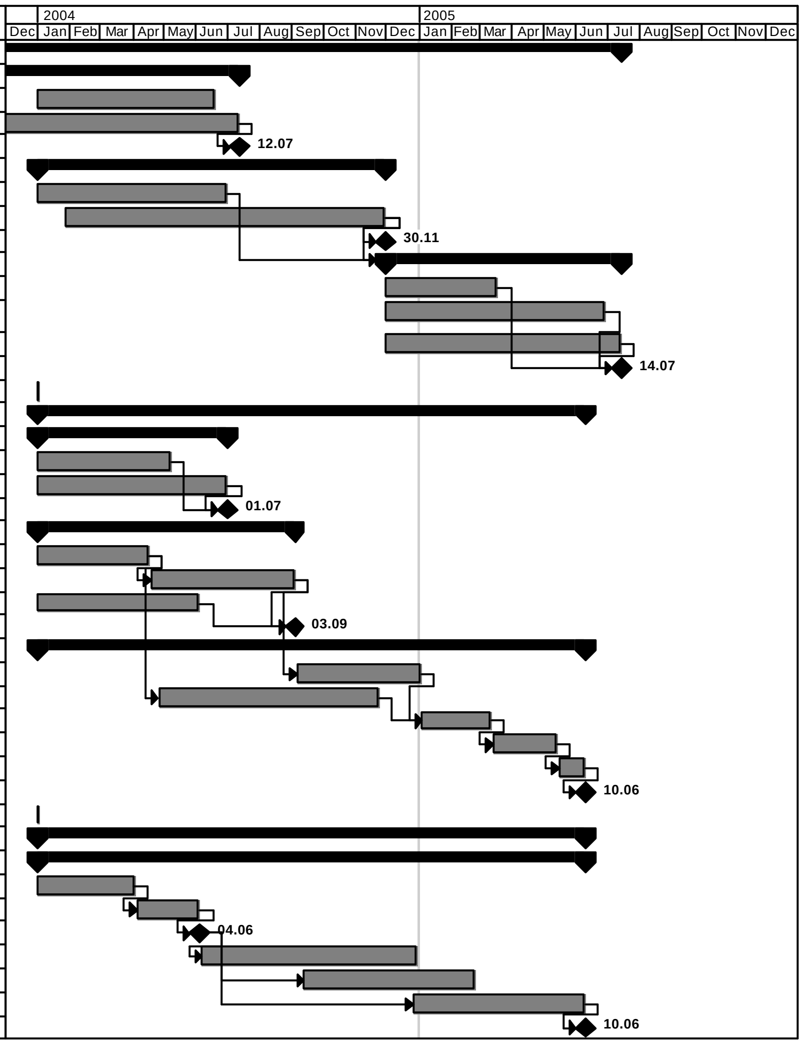
ID	Vorgangsname
68	**3.2 Seamless by hydroforming**
69	**3.2.1 Design hydroforming machine**
70	3.2.1.1 Drawings of the matrices
71	3.2.1.2 Drawings of the support system
72	**3.2.1.3 MS Design finished**
73	**3.2.2 Construction of hydroforming machine**
74	3.2.2.1 Hydraulic for machine
75	3.2.2.2 Sofware for the machine
76	3.2.2.3 Machine fabrication
77	3.2.2.4 Comissioning of the machine
78	**3.2.2.5 MS Commissioning finished**
79	**3.2.3 Construction of tube necking machine**
80	3.2.3.1 Drawings of the support system and turning mechnism
81	3.2.3.2 Drawings of the necking mechanism
82	3.2.3.3 Construction of the tube necking machine
83	3.2.3.4 Software for the tube necking machine
84	**3.2.3.5 MS Necking machine ready**
85	**3.2.4 Development of seamless tubes for 9-cell cavities**
86	3.2.4.1 Fabrication and inspection of bulk Nb test tubes
87	3.2.4.2 Fabrication and inspection of bimetallic NbCu test tubes
88	**3.2.4.3 MS Seamless tubes ready**
89	
90	
91	**4.1 Linear-arc cathode coating**
92	4.1.1 Modification of a prototype facility for single cells
93	4.1.2 Optimization of a triggering sustem
94	**4.1.3 MS trigger system ok**
95	4.1.4 Study of arc current reduction and stabilization
96	4.1.5 Optimization of the powering system
97	**4.1.6 MS Start of coating**
98	4.1.7 Coating of single cells without microdroplet filtering
99	4.1.8 Design and construction of a microdroplet filter system
100	**4.1.9 MS Droplet filter for LA ready**
101	
102	**4.2 Planar-arc cathode coating**
103	4.2.1 Modification of a planar-arc system
104	4.2.2 Optimization of the laser triggering system
105	**4.2.3 MS Trigger system ready**
106	4.2.4 Characterization of samples coated at different conditions
107	4.2.5 Characterization of Nb-coated sapphire samples
108	4.2.6 Characterization of Nb-coated copper samples
109	4.2.7 Quantitative investigation of the microdroplet problem
110	**4.2.8 MS Define need of droplett filter for PA**
111	
112	
113	**5.1 EP on single cells**
114	**5.1.1 EP on samples**
115	5.1.1.1 Establishing method of surface characterisation (roughness, reflectometry)
116	**5.1.1.2 MS Surface characterisation fixed**
117	5.1.1.3 Series of EP with samples for surface investigations
118	**5.1.1.4 MS best EP parameters**
119	**5.1.2 Single cell cavities**
120	5.1.2.1 Order Nb and fabricate 3 cavities
121	**5.1.2.2 MS 3 cavities fabricated**
122	**5.1.3 EP chemistry on single cells**
123	5.1.3.1 Design of EP set-up
124	5.1.3.1Fabrication of EP set-up
125	5.1.3.3 Commissioning of EP set up
126	5.1.3.4 First operation of EP set-up
127	**5.1.3.5 MS define working parameters**
128	



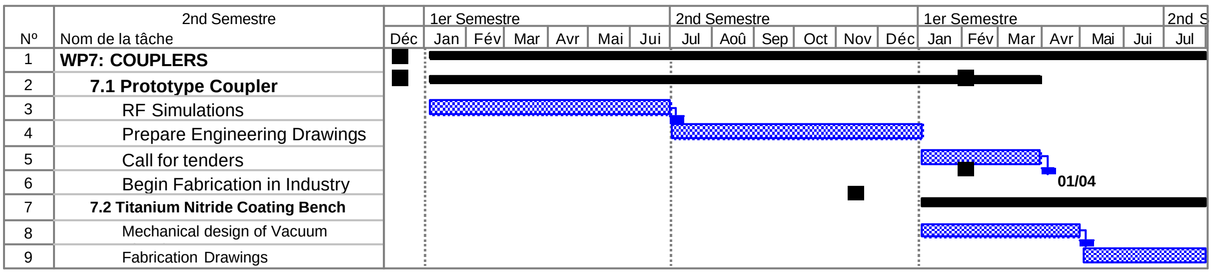
ID	Vorgangsname
129	5.2 EP on multi-cells
130	5.2.1 Transfer of parameters from single cell to multi cell equipment
131	5.2.1.1 Finish EP setup nine-cells at DESY
132	5.2.1.1.1 Improved gas cleaning system
133	5.2.1.1.2 Design for hot water rinsing
134	5.2.1.1.3MS Proof-of-Principle experiment Hot water rinse
135	5.2.1.2 Optimize electrode shape
136	5.2.1.2.1 Develop computer model/ Evaluate software
137	5.2.1.2.2 Design improved electrode
138	5.2.1.2.3 MS Electrode design fixed
139	5.2.1.3 Fix process parameters/ Quality control
140	5.2.1.3 .1 Setup chemical lab
141	5.2.1.3 .2 Bath aging
142	5.2.1.3 .3 Bath mixture
143	5.2.1.3 .4 Alternative (salt) mixtures
144	5.2.1.3.5 MS Process parameters fixed
145	5.2.2 Laser roughness
146	5.2.2.1 Evaluate existing systems
147	5.2.2.2 Specify laser sytem
148	5.2.2.3 Built laser system
149	5.2.2.4 MS Roughness measurement finished
150	5.2.3 Oxipolishing as final chemical cleaning
151	5.2.3.1 Laboratory studies
152	5.2.3.2 Design of OP system
153	5.2.3.3 Setup one-cell system
154	5.2.3.4 MS Proof-of-Principle experiment Oxipolishing
155	
156	5.3 Automated EP (AEP)
157	5.3.1 prototype EP installation
158	5.3.1.1 Design installation
159	5.3.1.2 Fabricate/ order components
160	5.3.1.3 Assemble EP installation
161	5.3.1.4 MS First operation
162	5.3.2 EP computer control
163	5.3.2.1 Design control architecture
164	5.3.2.2 develope software
165	5.3.2.3 Test of software
166	5.3.2.4 MS Software ready
167	5.3.3 Operation of AEP prototype
168	5.3.3.1 Correlate surface finish/ conductance
169	5.3.3.2 Determine optimum conductance
170	5.3.3.3 Optimize atomated operation
171	5.3.3.5 Design report on AEP
172	5.3.3.4 MS Automated EP is defined
173	
174	5.4 Dry ice cleaning
175	5.4.1 Installation of full system for 1-3 cell cavities
176	5.4.1.1 installation of CO2 piping
177	5.4.1.2 installation of motion system
178	5.4.1.3 installation of controll system
179	5.4.1.4 Commissioning
180	MS 5.4.1.5 Start of operation
181	5.4.2. Optimisation of cleaning parameters
182	5.4.2.1 Sample cleaning
183	5.4.2.2 1-cell cavity cleaning
184	5.4.2.3 fix best cleaning parameters
185	MS 5.4.2.4 Cleaning parameters fixed
186	5.4.3 VT 9-cell cleaning apparatus
187	5.4.3.1 Design 9-cell apparatus VT
188	5.4.3.2 Fabricated 9-cell apparatus
189	5.4.3.3 Installation of 9-cell apparatus
190	5.4.3.4 Commissioning of 9-cell apparatus
191	MS 5.4.3.5 Start 9-cell cleaning

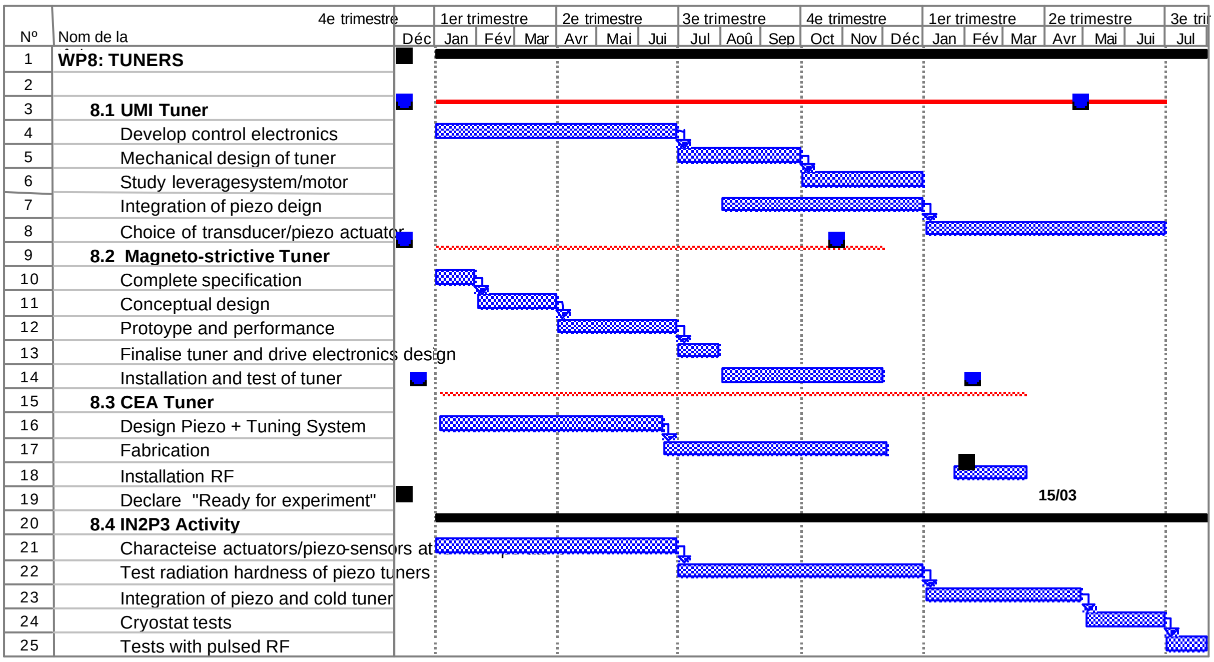


ID	Vorgangsname
194	**6.1 Squid scanning**
195	**6.1.1 Produce calibration defects**
196	6.1.1.1 Production of surface defects
197	6.1.1.2 Production of bulk defects
198	**6.1.1.3 MS Calibration defects finished**
199	**6.1.2 Design components of Squid scanner**
200	6.1.2.1 Design of the scanning table and support
201	6.1.2.2 Design of the SQUID cooling system
202	**6.1.2.3 MS Design Scanner finished**
203	**6.1.3 Construction of scanning apparatus**
204	6.1.3.1 Fabrication of the SQUID
205	6.1.3.2 Fabrication and purchase of components for SQUID scanner
206	6.1.3.3 Software for the SQUID scanner
207	**6.1.3.4 MS construction scanner finished**
208	
209	**6.2 Flux gate magnetometry**
210	**6.2.1 Produce calibration defects**
211	6.2.1.1 Production of surface defects
212	6.2.1.2 Production of bulk defects
213	**6.2.1.3 MS Calibration defects finished**
214	**6.2.2 Design components of flux gate scanner**
215	6.2.2.1 Design of the scanning table and support
216	6.2.2.2 Design of flux gate head
217	6.2.2.3 Design of operations software
218	**MS 6.2.2.4 MS Design Scanner finished**
219	**6.2.3 Fabrication of flux gate scanner**
220	6.2.3.1 Fabrication of flux gate head
221	6.2.3.2 Fabrication of scanner table
222	6.2.3.3 Implemention of software
223	6.2.3.4 comissioning of flux gate scanner
224	6.2.3.5 Calibration of flux gate scanner
225	**6.2.3.6 MS Flux gate scanner ready**
226	
227	**6.3 DC field emission studies of Nb samples**
228	**6.3.1 Quality control scans**
229	6.3.1.1 Modification of Scanning apparatus
230	6.3.1.2 Calibration of Scanning apparatus
231	**6.3.1.3 MS Start scanning activity**
232	6.3.1.4 BCP and HPR samples
233	6.3.1.5 EP and HPR samples
234	6.3.1.6 BCP/EP and DIC samples
235	**6.3.1.7 MS First report on BCP/EP and DIC surface**



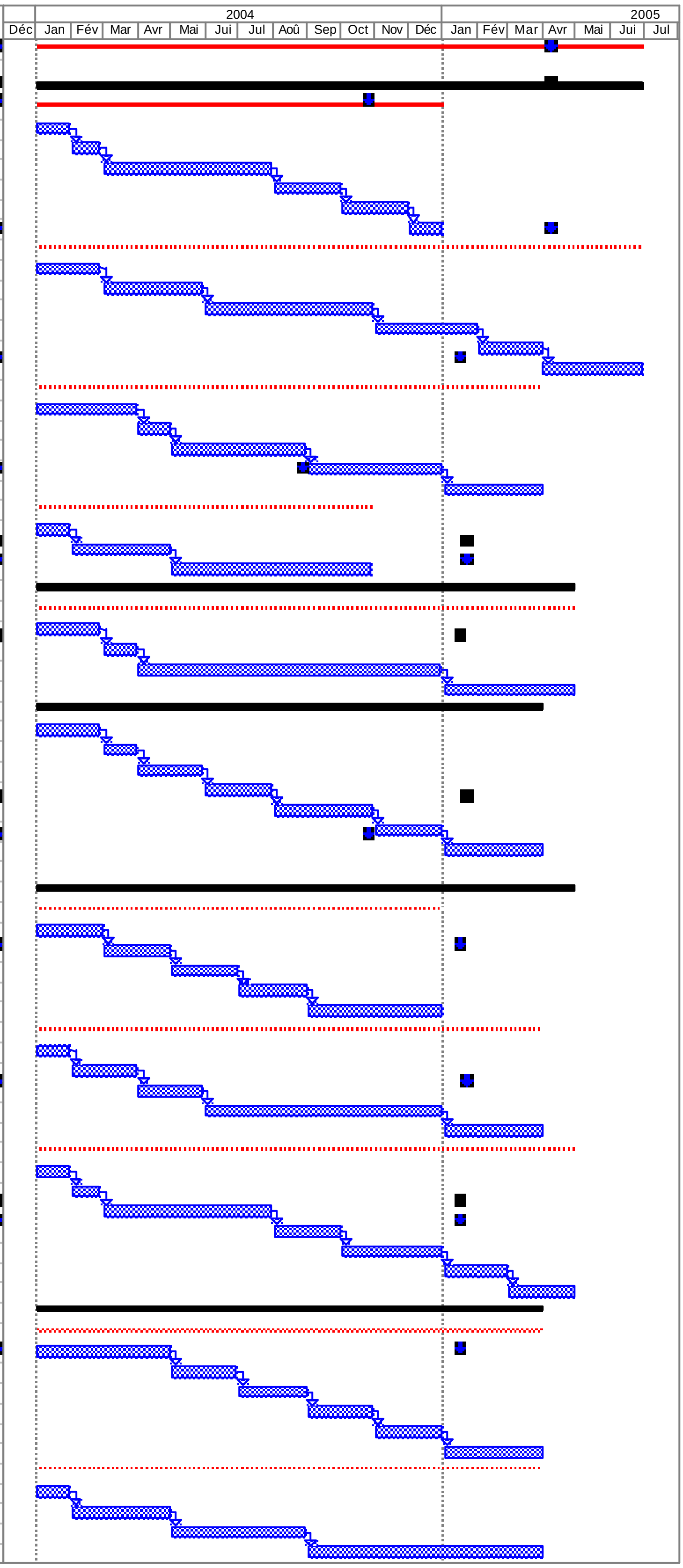
(slightly revised version 19.02.2004 (Table 2.1.1.b, Organisation chart accordingly)





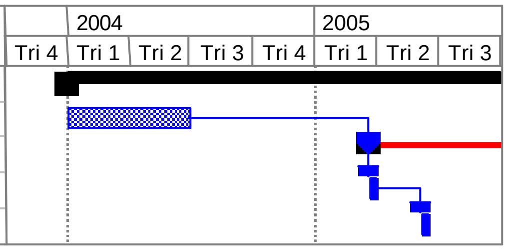
(slightly revised version 19.02.2004 (Table 2.1.1.b, Organisation chart accordingly))

Nº	Nom de la tâche
1	**W9: LOW LEVEL RF**
2	
3	**9.1 OPERABILITY AND TECHNICAL**
4	**9.1.1 Transient detector**
5	Define requirements
6	Electronics design
7	Build prototype and evaluate
8	Final design of detector
9	Install and commission
10	Tests with beam
11	**9.1.2 LLRF Automation**
12	Dialogue with industrial experts
13	Develop full specification
14	Implement FSM for subsystems
15	Test and evaluation
16	Implement improvements
17	Evaluation and acceptance by operators
18	**9.1.3 Control Optimisation**
19	Specification of sytem
20	Conceptual design of controller
21	Performance simulations
22	Implementation in DSP hardware
23	Implementation and tests on TTF
24	**9.1.4 Exception Handling Routines**
25	Specification
26	Design of exception handler
27	Implementation and tests on TTF
28	**9.2 LLRF COST AND RELIABILITY**
29	**9.2.1 Cost and Reliabilty Study**
30	Identify cost drivers and present LLRF
31	Develop cost reduction ideas
32	Build prototypes and evaluate
33	Final design of LLRF system
34	**9.2.2 Radiation Damage Study**
35	Identify critical electronics issues
36	Evaluate TESLA radiation
37	Develop tests for components
38	Procure ands assemble test set up
39	Data acquisition from radiation tests
40	Analyse results and develop countermesures
41	Implement countermesures and verify
42	
43	**9.3 HARDWARE**
44	**9.3.1 Multichannel Downconvertor**
45	Study and compare technologies
46	Select optimal PCB design
47	Build prototype and evaluate
48	Finalise multichannel downconverter
49	Determine charactersitics
50	**9.3.2 Third Generation RF Control**
51	Integrate system generator with VHDL
52	Complete specification
53	Demostrate simulator
54	Final design of RF electronic board
55	Evaluate performance on
56	**9.3.3 Stable Frequency Distribution**
57	Complete specification
58	Conceptual design of frequency
59	Build prototype and evaluate
60	Final design
61	Procurement and assembly of subsytems
62	Installation and commissioning
63	Performance tests with beam
64	**9.4 SOFTWARE**
65	**9.4.1 Data Management Development**
66	Specification
67	Conceptual design with DOOCS
68	Prototype
69	User evaluation
70	Finalise design
71	Implementation on TTF
72	**9.4.2 RF Gun Control**
73	Write specification
74	Design of controller
75	Procurement and assembly
76	Installation and test

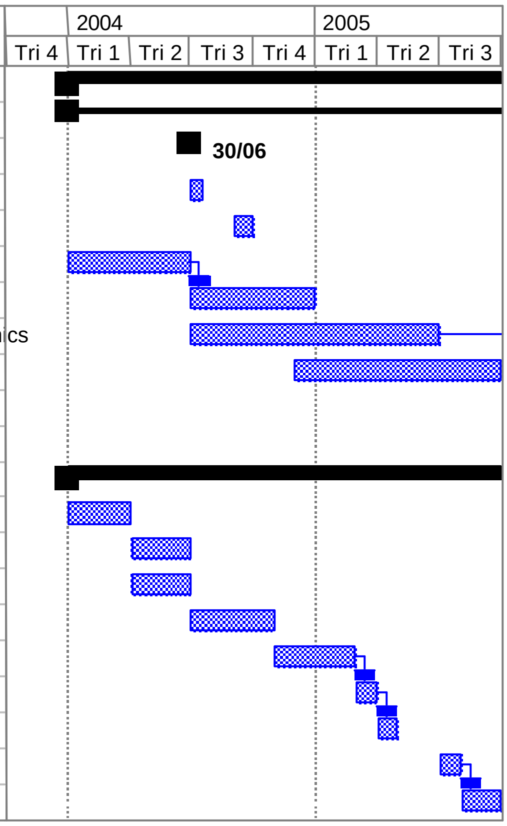


(slightly revised version 19.02.2004 (Table 2.1.1.b, Organisation chart accordingly)

Nº	Nom de la tâche
122	**WP10:CRYOSTAT INTEGRATION TESTS**
123	**10.1 Displace CRYHOLAB**
124	**10.2 Integration tests in Cryostat**
125	Test 1
126	Test 2



Nº	Nom de la tâche
140	**WP11:BEAM**
141	**11.1 Beam Position Monitor**
142	Present BPM installed in TTF module
143	Cryogenic measurements on BPM
144	Beam tests of BPM on TTF
145	Design of BPM Cavity
146	Fabrication of BPM Cavity
147	Development of new hybrid coupler and electronics
148	Design of Digital Signal Processing
149	New BPM ready for Installation
150	Beam Tests with new BPM
151	**11.2 Beam Emittance Monitor**
152	Slit width simulations
153	Slit design
154	Optics simulations
155	Optics appropriations
156	System assembly and tests
157	Mechanical assembly at TTF
158	Optical assembly at TTF
159	Integration of controls into TTF
160	Beam tests at TTF



2. QUALITY OF THE MANAGEMENT

2.1 Management and competence of the participants

2.1.1 *Management structure*

SRF is articulated around one management and ten technical work packages. As detailed in tables 2.1.1a and 2.1.1b and illustrated in the following diagram each work package is managed by a work package leader.

All partners of this research activity are members of the international TESLA (Tera Electron Volt Energy Superconducting Linear Accelerator) collaboration. During several years this collaboration worked successfully on the technical developments for a proposed 500 GeV linear collider (TESLA). The results are documented in a detailed design report. The work was organized and documented by regular plenary meetings every 6 months, technical meetings on request, progress reports and publications. In addition, delegations from many institutes worked at the DESY site during installation, commissioning and operation of the TTF test accelerator. Based on the experience of the TESLA collaboration the R&D work for the proposed JRA is organized by

- plenary meetings every 6 months at one partner laboratory with progress reports on technical, schedule and financial issues, organized by the JRA coordinator.
- Working meetings by video/audio conferences on request of the task leaders
- Short progress reports every 2 months by task leaders

International steering committee

An external Scientific Advisory Committee (ESAC) will be installed to review the progress of the JRA. Members are

H. Padamsee, Cornell University, USA, Chair
P. Kneisel, Jlab, USA
R. Campisi, Jlab, USA
J. Knobloch, BESSY, Germany
W. Weingarten, CERN, Switzerland

(slightly revised version 19.02.2004 (Table 2.1.1.b, Organisation chart accordingly)

Table 2.1.1.a: Work package and management team

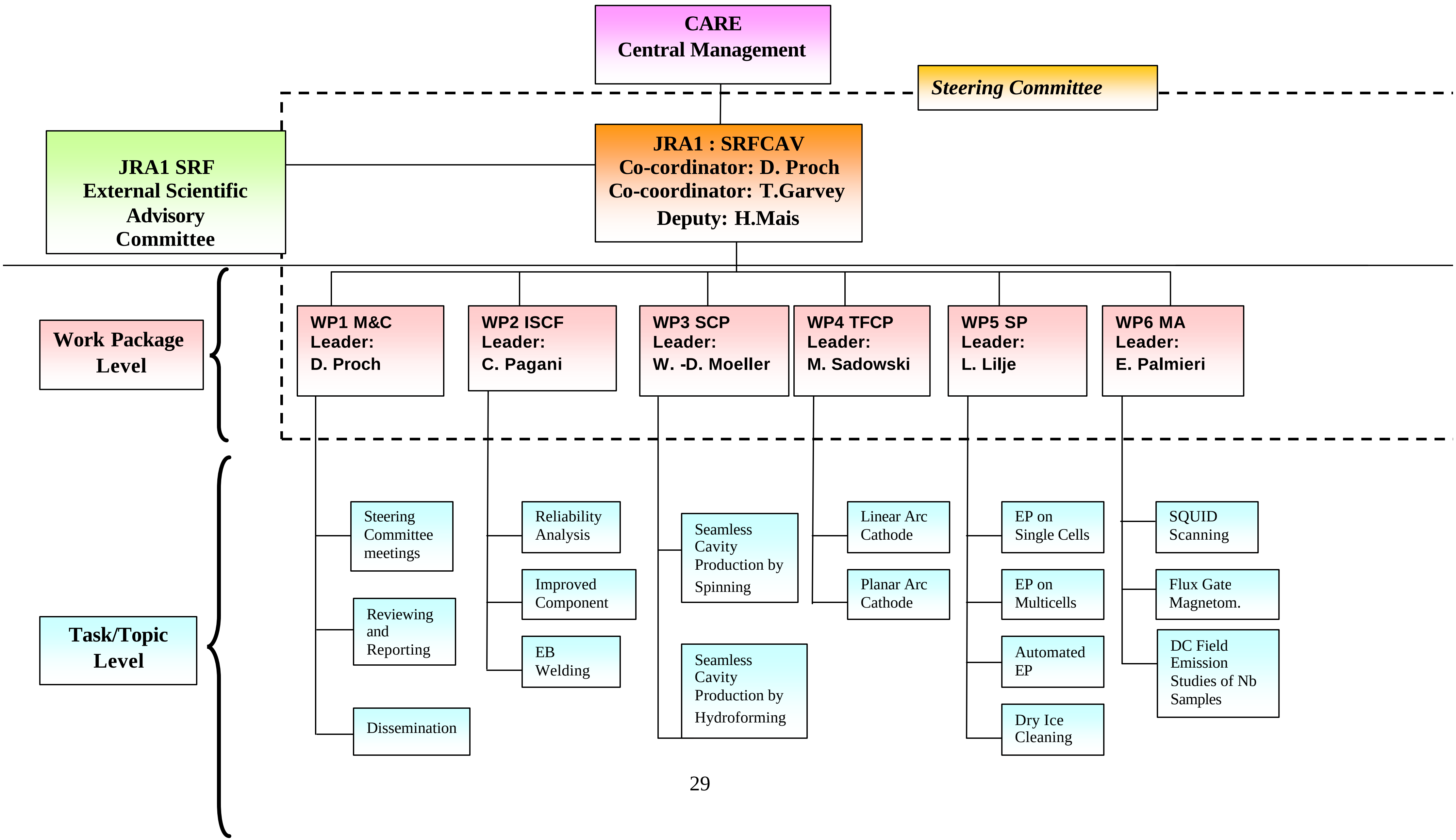
SRFcoordinators	D. Proch (DESY), T. Garvey (CNRS-Orsay)		
Deputy	H. Mais (DESY)		
Work Package	Full name	Short name	Leaders
WP1	Management and Communication	M&C	D. Proch
WP2	Improved Standard Cavity Fabrication	ISCF	C. Pagani
WP3	Seamless Cavity Production	SCP	W.-D. Moeller
WP4	Thin Film Cavity Production	TFCP	M. Sadowski
WP5	Surface Preparation	SP	L. Lilje
WP6	Material Analysis	MA	E. Palmieri
WP7	Power Couplers	COUP	M. Omeich
WP8	Cavity Tuners	TUN	P. Sekalski
WP9	Low level RF	LLRF	S. Simrock
WP10	Cryostat Integration Tests	CIT	B. Visentin
WP11	Beam Diagnostics	BD	M. Castellano

Table 2.1.1.b: List of WPs and tasks

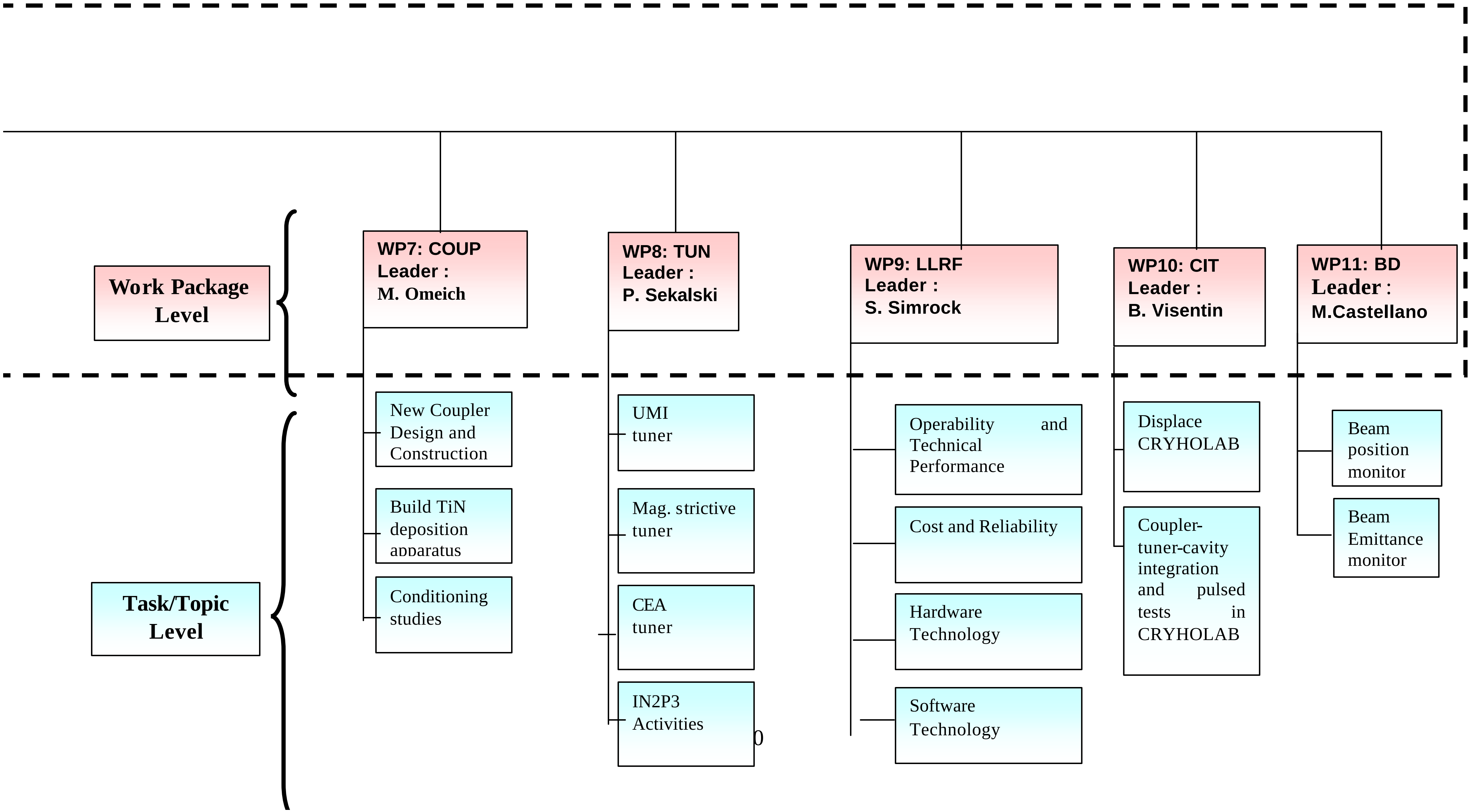
SRF- leaders D. Proch, T. Garvey, deputy H. Mais		
Work package/Task	**Work package/ task leader**	**Laboratory**
1 Management and Communication (M&C)	***D. Proch***	DESY
2 Improved Standard Cavity Fabrication (ISCF)	***C. Pagani***	INFN Mi
2.1 Reliability analysis	L. Lilje	DESY
2.2 Improved component design	P.Michelato	INFN Mi
2.3 EB welding	J. Tiessen	DESY
3 Seamless Cavity Production (SCP)	***W.-D. Moeller***	DESY
3.1 Seamless cavity production by spinning	E. Palmieri	INFN LNL
3.2 Seamless cavity production by hydroforming	W. Singer	DESY
4 Thin Film Cavity Production (TFCP)	***M. Sadowski***	IPJ
4.1 Linear arc cathode	J. Langner	IPJ
4.2 Planar arc cathode	S. Tazzari	INFN Ro2
5 Surface Preparation (SP)	***L. Lilje***	DESY
5.1 EP on single cells	C. Antoine	CEA
5.2 EP on multicells	A Matheisen	DESY
5.3 Automated EP	E. Palmieri	INFN LNL
5.4 Dry ice cleaning	D. Reschke	DESY
6 Material Analysis (MA)	***E. Palmieri***	INFN LNL
6.1 Squid scanning	W. Singer	DESY
6.2 Flux gate magnetometry	M. Valentino	INFN LNL
6.3 DC field emission studies of Nb samples	D. Reschke	DESY
7 Couplers (COUP)	***M. Omeich***	CNRS-Orsay
7.1 New proto-types	L. Grandsire	CNRS-Orsay

7.2 Titanium-nitride coating system	L. Grandsire	CNRS-Orsay
7.3 Conditioning studies	P. Lepercq	CNRS-Orsay
8 Tuners (TUN)	***P. Sekalski***	TUL
8.1 UMI tuner	A. Bosotti	INFN Mi
8.2 Magneto-strictive tuner	A. Grecki	TUL
8.3 CEA tuner	P. Bosland	CEA
8.4 IN2P4 activities	M. Fouaidy	CNRS Orsay
9 Low Level RF (LLRF)	***S. Simrock***	DESY
9.1 Operability and Technical performance	S. Simrock	DESY
9.2 Cost and reliabilty	M. Grecki	TUL
9.3 Hardware technolgy	R. Romaniuk	WUT-ISE
9.4 Software technology	Jezynski	WUT-ISE
10 Cryostat Integration Tests	***B. Visentin***	CEA
11 Beam Diagnostics (BD)	***M. Castellano***	INFN-Frascati
11.1 Emittance monitor	M. Castellano	INFN-Frascati
11.2 Beam position monitor	C. Magne	CEA

(slightly revised version 19.02.2004 (Table 2.1.1.b, Organisation chart accordingly)



(slightly revised version 19.02.2004 (Table 2.1.1.b, Organisation chart accordingly)



2.1.2 Role and expertise of the partners

Table 2.1.2.a illustrates the participation of the different institutes in the work packages as well as the degree of integration.

Table 2.1.2.a: Work Package participation

Partic.	WP1 M&C	WP2 ISCF	WP3 SCP	WP4 TFCP	WP5 SP	WP6 MA	WP7 COUP	WP8 TUN	WP9 LLRF	WP10 CIT	WP11 BD
DESY	x	x	x		x	x			x		
CEA					x			x		x	x
INFN-LNL		x	x		x	x					
INFN-MI		x						x			
INFN-RO2				x							x
INFN-LNF											x
IPJ		x		x							
CNRS-ORSAY							x	x		x	
PSI									x		
TUL								x	x		
WUT									x		

Table 2.1.2.b details the role of each participant and the size of the research effort in person-months, while Table 2.1.2.c summarizes the expertise and relevant infrastructures of each participant.

Table 2.1.2.b: Manpower contribution to the project

Institute	DESY	CEA	CNRS-Orsay	INFN-LNL	INFN-Mi	INFN-Ro2	INFN-LNF	PSI	TUL-DMCS	WUT-ISE	IPJ
Permanent Staff Contribution (pers.-month	871	210	320	357	129	189	132	28	55	69	246

DESY:
DESY has a long lasting experience in accelerator design and operation for high energy physics. Superconducting magnets and cavities were developed for the storage ring HERA. The major activity of the last years was devoted to the design of TESLA. Within the framework of an international collaboration, the test facility TTF was established. It includes major installations for cavity treatment and measurement. The TTF test accelerator is in operation since several years. In the future, it will partially be used as a SASE Free Electron Laser facility as well as a test bed for the operation of high quality superconducting accelerating systems.

CEA:
CEA/DSM/DAPNIA, in collaboration with IN2P3-Orsay, has built the first TTF electron injector, comprising a 250 kV thermo-ionic gun, a super-conducting capture cavity and the transport and low-energy diagnostic beam lines. It has also built the RF module prototype for the SOLEIL synchrotron and recently tested it under beam conditions at the ESRF. It has also built the so-called Super-3HC harmonic super-conducting RF modules needed to increase the beam current in the SLS (PSI, Zurich) and ELETTRA (Trieste) synchrotron light sources, with a successful operation at PSI.
Besides these super-conducting RF activities, the laboratory bears expertise on building high intensity proton sources, with the IPHI project, and on designing and building high field super-conducting magnets such as the LHC lattice quadrupoles and the ALEPH and CMS detector solenoids and the ATLAS toroid.

INFN-LNL:
The superconductivity laboratory was founded at LNL in 1987. Its initial scope was the feasibility study for Niobium sputtered quarter wave copper resonators, a task particularly difficult due to the narrow gap inside the cavity. This problem was solved in 1992 with the successful fabrication of prototypes achieving high gradients and low RF losses. Nowadays, around 40 resonators have been fabricated at LNL and have been installed inside the LNL ALPI heavy ion accelerator. During the past years, several facilities have been constructed, for example a chemical plant of industrial type for the surface treatment (chemistry and electrochemistry) of resonators before deposition, and several sputtering machines.
In 1993, the laboratory has been heavily involved in a special INFN project concerning the "study of alternative methods of fabrication of multicell cavities". Starting from a blank of

Copper or Niobium, a seamless cold forming technique for multicell cavities has been proposed. The method has been successfully tested on monocell resonators that achieve very high performance such as 40 MV/m.
For the time being, the superconductivity laboratory is still involved in both research activities and together with the University of Padova, great efforts are made to transfer the developed expertise and know-how in the construction of accelerating cavities to industry by offering master degrees for students in this innovative technology.

INFN-Mi:
LASA is involved in the design of superconducting linacs (for example for a high intensity cw proton linac for waste transmutation) and in manufacturing components. Single cell and five-cell, superconducting, low beta elliptical cavities (704 MHz, beta 0.5) have been designed and produced. They will be tested in a vertical test facility after high pressure rinsing (HPR) in a class 10-100 clean room.
The Laboratory has designed and upgraded the TTF cryostats, which have been manufactured under LASA's supervision in industry and have been assembled at DESY with the collaboration of DESY experts.
Large expertise also exists in topics relevant to JRA PHIN . For example, photo cathodes are routinely produced at LASA and new materials and analyzing techniques are studied for an improved performance of the cathode production.

INFN Ro2:
Senior staff of the group at the University of Roma "Tor Vergata" has been involved in the construction and operation of accelerators at the Frascati INFN National Laboratory, including the SC linear accelerator LISA, now decommissioned. They have also taken part – from the very beginning– in the TESLA-TTF collaboration. For TTF, they have been involved in the design and construction of the TESLA module cryostat and in the transfer of SC cavity technology to Italian industry. They have contributed significantly to the design, construction and operation of beam diagnostics for TTF1 and TTF2 including the necessary acquisition, handling and control systems.
One of the group members has worked for several years at CERN on the problems of SC Nb sputter–coated copper cavities.
Facilities available on the premises include a laboratory fully equipped for UHV work where, among others, thin SC film sputtering and UHV arc discharge facilities have been and are operated. Equipment for sample analysis and characterization is also either owned by the group or accessible within the University.

IPJ:
The main research areas of the Department of Plasma Physics &Technology (P-V) at IPJ-Swierk are the theoretical and experimental analysis of selected problems in plasma physics, especially of high-current pulse discharges. One particular subject is the study of the modification of various materials by means of pulsed plasma-ion streams and vacuum-arc discharges.
Large-size research facilities exist, *e.g.*, plasma-focus devices such as PF-150, PF-360 and PF-1000 (the largest Mather-type PF-facility in the world), multi-rod plasma injectors (so-called RPI-guns or IONOTRONS) for basic research and material engineering, special

current- and voltage-pulse generators for research and industrial laboratories, as well as some basic equipment for vacuum-arc plasma technologies (mostly for the deposition of thin superconducting layers).

INFN-Frascati :

This institute will develop together a non-intercepting diagnostic to characterise the emittance of the electron beam under full power operating conditions. The basis of the emittance monitor is a measurement of the angular distribution of the diffraction radiation of the electron beam passing through a slotted aperture. The group will design the monitor as well as the precision movers to position it within the beam pipe. They will integrate the control of the diagnostic into the general control system of TTF and finally install and use the system on the TTF linac. They have extensive experience in diagnostics having already installed many optical monitors on the TTF linac.

CNRS-IN2P3-Orsay

This group has considerable experience in the design and construction of electron linacs for use in different research fields, including the 600 MeV LEP Injector linac, the linac of the far infra-red free electron laser - CLIO, a short pulse 9 MeV photo-injector (ELYSE) for pulsed radiolysis. They also built, in collaboration with the CEA, the first TTF injector. In addition they have performed research programmes on experimental RF power sources, high gradient structures, RF guns, positron sources and superconducting cavities.

TUL-DMCS:

This Institute will develop a magneto-strictive frequency tuner to combat Lorentz force de-tuning of the cavities. They will also study radiation damage effects of the analogue and digital electronics and develop counter measures to extend the life-time of LLRF components. They will develop an automated system for the operation of the LLRF in the framework of an industrial standard (Finite State Machine). They will develop a Data Management system capable of storing and retrieving all component data necessary to derive phase and amplitude calibration parameters of the cavities. This system will be designed to allow operator friendly data entry and access in order to allow reliable and reproducible operation of the accelerator.

ISE Technical University of Warsaw:

This group will develop a high phase stable reference to ensure picosecond synchronisation of all RF signals. The system will be used to distribute the RF over the 300 m of the TTF linac and will be designed to be compatible for a 30 km linac. They will also develop a digital feedback system using high-speed real-time data processing for RF control. They will develop a simulation model for vector sum of the SC cavities and implement a real-time model on a high performance computing platform for optimum performance of the cavities at different operating gradients, as required by the FEL. The electronic hardware developed will include a low cost, compact, high performance multi-channel down converter with a high degree of linearity, large bandwidth and excellent signal to noise ratio.

Paul Scherrer Institute:

This institute will develop optimal controlling routines for the SC cavities working close to the limit of their capability in the presence of beam loading, Lorentz force de-tuning and micro-phonic noise. They will also develop "exception handling techniques" to minimise the recovery time of the system following fault conditions, thus increasing the reliability of the accelerator. Finally, they will develop a specific RF control system for the radio-frequency photo-injector of TTF.

Table 2.1.2.c: Expertise and relevant infrastructure of participants

Institute	Specific Expertise	Infrastructure relevant to the project
DESY	Design, fabrication and operation of superconducting cavities Design, fabrication and operation of superconducting magnets Operation of the SRF test accelerator TTF Accelerator controls, computing Networking, video communication tools Experience of far remote operations of the Tesla Test Photo-injector Digital and analogue electronics, low level RF controls	TTF, CHECHIA Pitz
CEA	Chemical bath (conception, preparation and titration) EP expertise (Nb samples) Clean room (HPR and mounting) Thermal treatment (purification with Ti and baking) RF test stand Surface characterization (optical microscope, SEM, STM, AFM, 3D-profilometer, topological analysis, brightness-meter) Chemical composition analysis of the surface (XPS, SIMS, HFS...)	CRYHOLAB Chem Lab Cryo Lab
INFN-LNL	SRF accelerator design & operation (ALPI) Chemistry and electrochemistry Material surface treatments Plastic deformation of materials and forming technology Clean room (HPR and mounting) Thin film technology and PVD machine construction Non-destructive evaluation techniques, in particular flux gate magnetometry	ALPI Chem Lab Mat Lab TF Lab
INFN-Mi	Cryostat design and manufacturing for TTF RF and mechanical design for elliptical cavities SC elliptical cavities and components manufacturing and testing Development of multi-particle beam dynamics codes Proton linac design SC linac reliability studies Photo cathode production for TTF, BESSY and FNAL Optical and surface properties studies and measurements of photo cathodes	RF Lab PH Lab Cryolab
INFN-Ro2	Accelerator physics and technology, High current discharges, UHV technology Superconducting layers Beam diagnostics Control systems	SRF Lab Coat Lab
IPJ	High-current discharges, Plasma diagnostics, Plasma-ion streams,	IONOTRON UHV-Arc NEOPHOT-32

	Vacuum-arc discharges, Superconducting layers	
CNRS-Orsay	Coupler design, electromagnetic simulations, RF measurements, High Power tests capability, ultra – high vacuum	
INFN-LNF	Electronics, optics, electron beam diagnostics, controls	
PSI	Development and operation of (digital) feedback systems for particle beam stabilization and RF- control, research and development of accelerator instrumentation and data processing electronics	
TUL	Full-custom design and HDL synthesis of modern ASIC-VLSI circuits Data acquisition and processing systems, control systems, power electronics, hardware-software code designof digital systems, software tools for system design and simulation	
WUT	Analogue digital and mixed electronic systems and instrumentation, microwave and optical/photonic circuits and systems, microprocessor and computer and software engineering, distributed and multi-channel measurement systems, multi-gigabit optical links and networks,FPGA/DSP systems design, Internet engineering, image processing systems	

List of most relevant publications per participating institution

DESY

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CEA

C. Antoine, B. Aune, D. Bloess, J.P. Charrier, E. Chiaveri, L. Ferreira, E. Häbel, L. Lilje, J.P. Popov, H. Safa, B. Thony, “TESLA electropolishing of single cells” *TESLA-Report 99-06*,p 85-87, March 1999

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B. Aune, *et al.*, “The Superconducting TESLA Cavities” *Phys. Rev. ST-AB*, 3(9), September 2000, 092001.

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WUT-ISE

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2.2 Justification of financing requested

2.2.1 Detailed cost breakdown

Among the eleven partners in SRF, nine use the Additional Cost, Flat rate model (AC) and two use the Full Cost (FC) model.
To accomplish the tasks described in section 1.2, the costs per work package for each participant are given in table 2.2.1.a. The internal costs for manpower not accounted for in table 2.2.1.a for participants using the AC cost model are summarized in table 2.2.1.b, and a preliminary profile of the requested EU funding over the 4 years of the activity is shown in table 2.2.1.c.

Table 2.2.1.a: Summary of expected costs and requested EU funding [k€]

Acronym	Cost	WP1: M&C		WP2: ISCF		WP3: SCP		WP4: TFCP		WP5: SP		WP6: MA	
	Model	Exp. Cost	Req. Cost	Exp. Cost	Req. Cost	Exp. Cost	Req. Cost	Exp. Cost	Req. Cost	Exp. Cost	Req. Cost	Exp. Cost	Req. Cost
DESY	AC	160	160	185	185	256	256	0	0	490	490	275	275
CNRS-Orsay	FC	*70*	20							0	0	0	0
CEA	FC	10	10		0		0		0	1101	230		
INFN-LNF	*AC*	*10*	*10*										
INFN-LNL	*AC*		*0*	*70*	*70*	*190*	*190*		*0*	*140*	*140*	*10*	*10*
INFN-Mi	*AC*			*200*	*200*				*0*		*0*		
INFN-Ro2	*AC*		*0*		*0*		*0*	*252*	*232*		*0*		
INFN Sub total		10	10	270	270	190	190	252	232	140	140	10	10
IPJ	AC			50	25		0	350	210		0		
PSI	AC												
TUL-DMCS	AC	10	10										
WUT-ISE	AC												
Summe WP		260	210	505	480	446	446	602	442	1731	860	285	285

Acronym	Cost	WP7: COUP		WP8: TUN		WP9: LLRF		WP: 10 CIT		WP11 : BD		**Total**	
	Model	Exp. Cost	Req. Cost	Exp. Cost	Req. Cost	Exp. Cost	Req. Cost	Exp. Cost	Req. Cost	Exp. Cost	Req. Cost	**Exp. Cost**	**Req. Cost**
DESY	AC	0	0	0	0	215	215	0	0	0	0	1581	1581
CNRS-Orsay	FC	1626	535	115	55			240	120			2051	730
CEA	FC			90	75			698	150	724	100	2623	565
INFN-LNF	*AC*									*195*	*195*	*205*	*205*
INFN-LNL	*AC*											*410*	*410*
INFN-Mi	*AC*			*135*	*135*							*335*	*335*
INFN-Ro2	*AC*									*117*	*117*	*369*	*349*
INFN Sub total		0	0	135	135	0	0	0	0	312	312	1319	1299
IPJ	AC											400	235
PSI	AC					360	0					360	0
TUL-DMCS	AC			94	94	149	149					253	253
WUT-ISE	AC					370	370					370	370
Summe WP		1626	535	434	359	1094	734	938	270	1036	412	**8957**	**5033**

Table 2.2.1.b Internal costs not accounted for in the above table for participants using the AC cost model.

Participant	DESY	INFN-LNF	INFN-LNL	INFN-Mi	INFN-Ro2	IPJ	PSI	TUL-DMCS	WUT-ISE
Costs [k€]	5282	2118	2885	518	690	919	260	288	390

Table 2.2.1.c Profile of requested EU funding over JRA SRF duration [k€]

Spending Profile JRA SRF									
Laboratory	2004	205		206		207		first 18m	total
	total	total	first 6 m	total	first 6 m	total	first 6 m		
DESY	569,16	497,54	212,96	340,39	173,91	173,91	94,86	782,12	1581
CNRS-Orsay	262,8	248,2	116,8	138,7	80,3	80,3	43,8	379,6	730
CEA	203,4	192,1	90,4	107,35	62,15	62,15	33,9	293,8	565
INFN-LNF	*73,8*	*69,7*	*32,8*	*38,95*	*22,55*	*22,55*	*12,3*	*106,6*	*205*
INFN-LNL	*147,6*	*139,4*	*65,6*	*77,9*	*45,1*	*45,1*	*24,6*	*213,2*	*410*
INFN-Mi	*120,6*	*113,9*	*53,6*	*63,65*	*36,85*	*36,85*	*20,1*	*244,4*	*335*
INFN-Ro2	*125,64*	*118,66*	*55,84*	*66,31*	*38,39*	*38,39*	*20,94*	*181,48*	*349*
INFN Sub Total	467,64	441,66	207,84	246,81	142,89	142,89	77,94	675,48	1299
IPJ	84,6	79,9	37,6	44,65	25,85	25,85	14,1	122,2	235
PSI	0	0	0	0	0	0	0	0	0
TUL-DMCS	91,08	86,02	40,48	48,07	27,83	27,83	15,18	131,56	253
WUT-ISE	133,2	125,8	59,2	70,3	40,7	40,7	22,2	192,4	370
Summe	1811,88	1671,22	765,28	996,27	553,63	553,63	301,98	2647,36	5033

2.2.2 Justification of requested durable equipment

In work package WP4, an innovative technology of vacuum arc coating of Copper/Niobium cavities is proposed. In table 2.2.2.a, the requested durable equipment is described.

Table 2.2.2.a Requested durable equipment in SRF

WP 4.1	Units	Item	Type	Price [€]
	2	Turbomolecular pump	Balzer TPU180H	20000
	2	TP power supply	Balzers TCP380	10000
	2	Diaphragma pumps	Pfeiffer MD4	10000
	2	Vacuum control unit	Balzers TPG300	10000
	1	QM Spectrometer	Balzers QMS200	12000
	1	Pulsed Laser	Big-Sky CRN Nd: YAG	20000
	1	Power supply	APS Co. 100-200	8000
			Sum	90000
			EU requested	**45000**
WP 4.2	1	Turbomolecular pump	Balzer TPU180H	10000
	1	Pulsed Laser	Big-Sky CRN Nd: YAG	20000
	1	Power supply	APS Co. 100-250	10000
			Sum	40000
			EU requested	**20000**

A vacuum turbomolecular pump is needed to modify the experimental facility in order to improve ultra-high vacuum conditions for the vacuum-arc deposition of superconductor layers.
A new laser system is required to optimize the triggering of vacuum arc discharges without introducing impurities, and the new power supply unit is necessary in order to improve the stabilization of arc currents.
In order to enable the partner institutes in Swierk and Rome to study deposition processes under similar conditions and at the same time, identical laboratory tools (durables) are needed.

2.2.3 Industrial Subcontractors

<u>Improved component design (ISCF task 2.2; task 2.3)</u>

Topics for the industrial contracts are:
- the improvement of the design of cavities,
- the improvement of the design of auxiliary components, such as connections to vacuum tanks and to liquid He circuits, flange technology and so on,
- the identification of costly and critical fabrication steps,
- the development of methods suitable for industrial mass production.

There is a large experience with the production and operation of about 50 superconducting RF cavity units at the test facility TTF. Based on this expertise, the design, fabrication methods and quality assurance philosophy will be examined in order to reduce fabrication costs, increase reliability and introduce mass production technology.
The companies ACCEL Instruments GmbH in Germany and E. ZANON SPA in Italy have been involved in the past in the fabrication of superconducting cavities not only for TTF but also for other European and international research institutions. Both companies are worldwide leading industrial experts in the field of superconducting RF technology. **There is an agreement between the two companies to support a joint effort to improve the design and fabrication of Niobium cavities.** ACCEL will concentrate on the actual Niobium cavity body whereas ZANON will work on the connecting parts. The requested EU support for each of the companies is 75 k€. Both companies are ready to contribute the same amount (75 k€ each).

<u>Squid scanning apparatus (MA task 6.1)</u>

In this task, a novel Squid scanner for quality control of the Niobium material will be developed. This will improve the present technology of eddy-current scanning of Niobium sheets with a normal conducting coil. The Squid sensor will:

- enhance the sensitivity for finding material defects,
- increase the penetration depth of the scanned bulk material,
- allow faster scanning by covering an enlarged sampling spot.

The company WSK Mess- und Datentechnik GmbH has a long lasting experience in material analysis. Recently, a Squid scanning apparatus developed at WSK was used by the W.C. Heraeus GmbH company to examine sputter targets for material defects or inclusions. In the proposed contract, this technology will be adapted to the needs of scanning sheets and tubes used in cavity fabrication. It will also include the preparation of test defects, calibration procedures and comfortable software to identify and document the different scanning results.
The amount of EU support for this task amounts to 100 k€. The company WSK declared to contribute additional 100k€.

<u>Electropolishing (EP) on multicell cavities (SP, task 5.2)</u>

Electropolishing of the inner surface of a Niobium cavity will produce a much smoother surface than what can be obtained by the present method of chemical cleaning. As already demonstrated on single cells, this has also a high potential to improve the superconducting properties of multi-cell accelerating structures. After exploring the principle parameters on single cell experiments, this technology will be transferred to multi-cell preparation. The aim is to incorporate chemical industry at this stage in order to approach industrial standards as early as possible.
The company Henkel Lohnpoliertechnik GmbH is specialized on chemical and electro-chemical treatment of stainless steel and special alloys. These preparation techniques are needed for materials used in pharmaceutical, bio-technical and semiconductor industry. Henkel has advised and helped with its expertise when DESY started experiments on electropolishing. The professional expertise of this company, as well as their engagement with our cavity treatment, is a strong argument to incorporate Henkel into a design study for an industrialized installation for electro-chemical treatment of Niobium cavities. The requested EU support for this study amounts to 40 k€.

(slightly revised version 19.02.2004 (Table 1.2.2.b, Organisation chart accordingly)

3. EUROPEAN ADDED VALUE

3.1 Interest for European research infrastructures and their users

The technology of SRF accelerating systems was developed by several laboratories and institutes in the USA, Japan and Europe. Industrial competence in designing and building SRF components is established in Japan and Europe with a strong leadership of three European companies.
The challenging problems for increased exploitation of superconducting RF technology in accelerators are the achievable accelerating voltages of the cavities and the cryogenic losses. The accelerating gradient is ultimately determined by the properties of the superconducting material. Gradients are usually a factor of 2 to 5 below the intrinsic parameters of the commonly used Niobium. A better understanding of these limitations and their solutions therefore requires further R&D in this area.
The cryogenic loss is determined by the (dynamic) superconducting RF loss and the (static) cryostat loss. Large progress has been made with the development and construction of the TTF cryostats. There is hope to further reduce the superconducting losses by improving the cleaning methods for cavities (short term goal) or by thin-film technology (long term goal).

At present, four European accelerators use routinely superconducting RF technology: the heavy ion accelerator at INFN in Legnaro, the electron proton collider HERA, the electron linac at TTF (DESY) and DALINAC at Darmstadt. New projects in Europe using this technology are TESLA, the VUV-FEL (under construction at DESY), the ELBE accelerator at Forschungszentrum Rossendorf, the X-Ray FEL (proposal for a European FEL laboratory recently approved by the German government) and the planned proton linear accelerators needed for neutron spallation sources (ESS) or for transmutation machines.

Within the framework of an international collaboration, a unique SRF accelerator test facility (TTF) was established at DESY. Most partners of SRF are involved in this activity by developing, installing and commissioning components as well as by participating in the operation of TTF. This activity is documented in numerous TESLA reports, the latest being the Technical Design Report for TESLA and the X-Ray FEL. (http://tesla.desy.de/new_pages/TDR_CD/start.html, and http://tesla.desy.de/new_pages/tdr_update/start.html).

In addition to the central accelerator test facility TTF, there are SRF R&D activities at several European laboratories. These laboratories are participating to JRA1 (SRF) and to JRA PHIN (superconducting RF gun). There is vigorous communication, exchange of R&D results and coordination of research work amongst these partners within the TESLA collaboration. The bundled research activities of the participating institutions in the JRA will allow to develop and build new and innovative accelerator components and to test them in the TTF accelerator. This will not only be of importance for the performance of the TTF and the machines using superconducting RF technology, but it will also be an important and essential input for all future projects using this challenging technology.

As a summary, the proposed research activities of SRF will:

- strengthen the transfer and exchange of know how and expertise between the main European research centers interested in this field. In particular, the expected innovative results will:

- improve the performance and accessibility of the above mentioned infrastructures. The joined experience – especially with TTF– will be essential for the design of future linear collider projects (TESLA), the European X-ray FEL, planned transmutation machines and neutron spallation sources, devices which open new and exiting prospects to the European research community.

3.2 Exploitation of results

The aim of SRFis to explore and apply novel fabrication technologies for superconducting accelerating structures. The expected progress due to the combined research activity will lead to prototype components, which – as a direct exploitation – can be installed into TTF and which will result in a superior operation of this device. Furthermore, concerning costs and performance, all future projects, which intend to use superconducting RF technology will benefit strongly from these developments. This is especially true for the proposed European X-Ray FEL, which will be the first large scale example, where this innovative technology can be applied.

In this respect, it is important that industrial partners be incorporated in the JRA on a partially self-financed basis. This will not only strengthen the competence and leadership of the involved European companies in this technology, but it will also allow them to be competitive and to occupy a large market share in the fabrication of superconducting accelerator components needed for the aforementioned future European and world-wide infrastructures.

The outcome of the project will not merely consist of the documentation of the results of our studies. Although prototypes of many devices will indeed be built, it is intended that certain tasks will conclude with the construction of finalised versions of components which can be fully exploited on the TTF linac. This is particularly true of intended developments on the LLRF system, cavity tuners and beam diagnostics. Thus, as examples, novel tuner designs, improved beam monitoring and critical developments in RF controls will all be features of the improved infra-structure.

As a general rule, SRF participants will share freely all information related to their activity and will publish the results of their work in international journals and conferences.

3.3 Risk assessment

A rating of the risk has been defined: Risk Level 1 to 3 (**RL1-3**). The meaning of this is given in the table below.

Risk Level	Meaning
RL1	Low Risk: minor error might happen, could be easily corrected since no technical challenge is involved. Scope of the project is unchanged. Minor impact on schedule (<3 months) or cost (<5%) might be necessary.
RL2	Medium Risk: A small downgrading of the final objectives might be required. Alternatively, a small delay and cost increase might be necessary (<20%) to maintain the initial objectives.
RL3	High Risk: Significant downgrading of the objectives might be required. Alternatively, more R&D (more time and more money by more that 20%) would be required.

Low Risk (RL1)
This group contains tasks 2.1, 2.3, 3.1, 3.2, 5.1 and 5.3. In task 2.3, Niobium test arrangements or prototypes are fabricated with an existing high quality electron beam welding facility. In task 2.1, correlations between observed performance degradation of superconducting cavities in the TTF linac and manufacturing, treatment or assembly procedures should be investigated. All relevant data are collected in a large database. The risk of failure for both tasks is low so that there is no need for alternative solutions.

Tasks 3.1, 3.2, 5.1, 5.2, 5.3: In all these cases, single-cell cavities have been manufactured or have been treated and were successfully tested. The task is to transfer the production method from single-cell to multi-cell cavities. This is a challenging engineering design task, but no principle physical or chemical problems are expected. Therefore, the risk of failure is low. An alternative solution for tasks 3.1 and 3.2 is to manufacture three-cell cavities and weld them together to form a nine-cell resonator.

This group also contains 7.1, 8.1, 8.2, 8.3, 8.4, 9.2, 10.1, 10.2, 11.1 and 11.2 (referring to Gantt chart). Some small scheduling difficulties could be envisaged from the desire to test components coming from many institutes in CRYHOLAB at CEA/Saclay but the risks remain minor. For almost all of the tasks of WP9, the risks are minor due to the vast experience and competence of the groups involved. The only exceptions are mentioned below. Task 11.2 does not present a serious technical risk. However, the schedule of this task is clearly dependent on having a fully commissioned 1 GeV beam on TTF and therefore any scheduling difficulties on TTF would have consequences for the emittance measurements. But within a four year time frame this is clearly a low risk.

Medium Risk (RL2)
This group contains task 6.1, 6.2 and 6.3. New methods of QC of Niobium material will be investigated. A prototype of SQUID scanner is under investigation by WSK. Thick Niobium discs for sputter targets will be examined. It needs to be investigated, whether this technology is applicable to thin Niobium sheets for cavity production. A prototype of flux gate magnetometer is under consideration at the partner laboratory in Legnaro.

In both cases, the expected sensitivity is not only determined by the measurement principle but also by the performance of the sensor electronics and the reduction of noise by intelligent software. The risk of failure is not negligible; an alternative solution is to further enhance the sensitivity of the well-established eddy current scanning by adding noise cancellation by software, which has to be developed for the proposed task anyhow.

DC field emission scanning (task 3.6) was successfully used to scan samples of cleaned surfaces and to identify locations of high DC field emission. This could be used as a QC method to check cavity cleaning techniques. However, it remains to prove whether the results obtained with a DC technique are also of relevance for examination of SRF surfaces.

This group also contains 7.2, some sub-tasks within 9.3 and 9.4 and 11.2. The construction of the TiN coating system represents a medium risk in that much of the fabrication work will be performed in industry and there exists a possibility that calls for tendering procedures will result in delays with respect to the schedule shown, but certainly not lengthy delays. The majority of the tasks of 9.3 and 9.4 are RL1 but the use of some new technologies and previously untested software make some sub-tasks RL2. In any case, one should note that the
activities of this WP are foreseen to be complete within only two years and, as our project is nominally for four years, there is sufficient time to make up for minor difficulties

High Risk (RL3)
This group contains tasks 4.1, 4.2 and 5.4. Vacuum arc coating is a well-known technology for thin film coating but has never been applied to SFR surfaces before. The expected improvement as compared to the magnetron sputter method is probable but carries a large risk of failure. However, the prospect of getting higher accelerating gradients at lower RF losses has the tremendous potential to increase the efficiency and to lower the investment and operating costs of SRF accelerating systems. Therefore, it seems extremely worthwhile to investigate this alternative method.

Dry ice cleaning (5.4) is used in semiconductor production but was never applied to SRF surfaces. Surface imperfections like small (micro size) particles are the most probable reason for field emission, one of the dominant limitations of the accelerating gradient of SRF cavities. Dry ice cleaning is a very efficient method to remove particle-like and film-like contaminations. Furthermore, there is no water involved in the cleaning process, which is of benefit for the vacuum components. The large potential of this method outweighs by far the high risk of failure. A modest alternative is to improve the high pressure water cleaning by optimizing the operation parameters.

Another task in this category is 7.3. The results of research for a suitable power coupler conditioning procedure are inherently difficult to foresee. There may be no recipe for better conditioning than those which are known today. Of course, if one considers that the deliverables of the task are the results of studies for better conditioning techniques, then the activity could be considered RL1. However, if the deliverable is to be considered as a well documented and clearly established procedure for rapid conditioning, then this must be considered RL3.

Monitoring the success and impact of the proposed research activity

The success of the proposed research activities can be monitored by

- measuring the achieved accelerating gradients,
- measuring the RF losses and
- documenting the operating performance

of the developed prototype cavities in TTF.

One can also monitor success of the research activity by comparing the results obtained in certain WP's with respect to the initial goals. For example the parameters and specifications aimed for in WP7 and WP8 will be tested in the Coupler Test Lab and CRYHOLAB respectively. The power handling capacity and conditioning period of couplers as well as the correctable 'de-tune' of cavities by the active tuners will be an obvious measure of success. Indeed CRYHOLAB will be the ideal instrument in which to quantify the level of progress made on many issues covered by this JRA. The practical applications of the developments made in WP9 to the TTF linac will provide direct evidence of the impact of the Low Level RF studies. The increased reliability of the machine which should result from these developments will have an impact on the programme of accelerator R&D foreseen on TTF as well as on the FEL user programme. Equally, the improvements in beam diagnostics emerging from WP11 will be evident from high resolution measurements of beam position and emittance. Evidently, the sum of the published literature resulting from the studies described in this JRA will be a measure of the progress achieved.

The impact of the results of JRA SRF will manifest itself in the use of the new fabrication methods such as vacuum arc coating, electropolishing for better surfaces and improved quality control

- by other laboratories for their research activities in superconducting RF technology thereby improving the performance and accessibility of their infrastructures,
- by industrial companies for the large scale production of superconducting cavities thereby rising their competitiveness and expertise in this modern technology.