

# Memorandum of Understanding

## for Collaboration in the R&D of fast ramping high field dipole magnets for the SIS300 synchrotron of the FAIR facility

### between

The Facility for Antiproton and Ion Research, hereinafter referred to as FAIR, presently being represented by GSI, Darmstadt, Germany, as the Host Laboratory,  
on the one hand,

### and

The National Institute of Nuclear Physics, hereinafter referred to as INFN, Rome, Italy, represented by Mr. Roberto Petronzio, President,  
on the other hand.

### Preamble

- a) A Memorandum of understanding on the Preparatory Phase of the International FAIR Project (Facility for Antiproton and Ion Research), **Annex 1**, has been signed, as of November 24, 2005, by the following countries: People's Republic China, Finland, France, Germany, Greece, Italy, India, Poland, Romania, Russian Federation, Spain, Sweden, United Kingdom.
- b) An increasing demand of magnets characterized by relatively intense field (5-6 T) and fast ramping speed (1-1.5 T/s), comes from particle accelerators field. The SIS300 synchrotron for the new accelerators complex FAIR requires 54 superconducting dipoles, 7.8 m long, 92 mm coil ID, 4.5T field, ramped at 1T/s, curved.
- c) High dissipative phenomena in AC regime are induced in superconducting Rutherford cables. Fast ramping magnets may have problems of quenching and of high operation costs of the cooling systems. Specific R&Ds on cables and on magnets are needed.
- d) Superconducting cables R&D.  
There are three main sources of AC loss in superconducting Rutherford cables, requiring R&D specific activities:
  - 1) magnetic hysteresis in the superconducting filaments: critical R&D for reducing filament dimensions;
  - 2) coupling losses between filaments: critical R&D for reducing/optimizing interfilament resistivity and minimizing twist pitch;
  - 3) coupling losses between strands: critical R&D for reducing/optimizing cross-over interstrand resistance and adjacent resistance.

- e) Dipole magnet R&D.
  - i) Industrial assessment of feasibility of fast ramping curved magnet.
  - ii) Optimization of winding quality (i.e. field quality) using low losses conductors.
  - iii) Optimization of thermal exchange between conductor and cooling fluid.
  - iv) Choice of fatigue resistant components.
  - v) Conceptual design of curved magnet.
- f) Within FP6 of EC an R&D programme in the field of fast ramping magnets is developed by the Networking Activity N3: *High–Energy High–Intensity Hadrons Beams (HHH)* of the Integrated Infrastructure Initiative (I3) “*Coordinated Accelerator Research in Europe*” (acronym: *CARE*). In the *HHH*-Network of *CARE*, the Pulsed Magnet Working Group (PMWG) takes advantage of collaboration among major European Organisations: CEA, CERN, GSI, INFN.

## THE PARTIES AGREE AS FOLLOWS

### Article 1: Parties to this MoU

The Parties to this MoU are INFN, acting on behalf of the INFN groups in the INFN Sections and Laboratories, listed in **Annex 2**, and FAIR, represented for the time being by GSI, as Host Laboratory. The Parties acknowledge that INFN will rely on industries with recognized expertise in the field.

### Article 2: Purpose of this MoU

The purpose of this MoU is to define the R&D activities finalised to the development of the superconducting dipole for SIS300, agreed between the Parties, and carried out by INFN. It further sets out organizational, managerial and financial guidelines to be followed by the Parties.

### Article 3: Duration of this MoU and its Extension

- 3.1 This Memorandum of Understanding will become effective for each Party upon signature. The R&D activities finalized to development of the superconducting dipole are foreseen to be carried out in four years. The actual termination date will be set out by the Steering Committee which manages this MoU, according to Art. 6.
- 3.2 This MoU may be extended at any time by mutual agreement of the Parties.

### Article 4: The R&D Programme and the Specific INFN Tasks

- 4.1 The R&D programme in fast ramping magnets is finalized to the development of a prototype of a curved dipole, with an effective length of 3.8 m. Significant preparatory activity has been already developed (see **Annex 6**).

The R&D programme includes:

- studies, design and models
- low losses superconductor development
- superconducting filaments and strand characterization
- cold mass construction and test
- cryostat design and construction
- integration of coil and cryostat.

The specific INFN tasks are reported in **Annex 3**.

- 4.2 Rutherford cable. As far as the Rutherford cable is concerned, the strategy is to perform the low losses superconductor development in two main stages, with decreasing filament diameters, keeping good electric transport and stability. Crucial role can play the development of winding models to test mechanical and structural aspects of the superconductive cable.

**Annex 4** shows the structure of the R&D programme for conductor development.

- 4.3 Construction and test of the cold mass. It is performed in collaboration with industry. An effective and fast way to construct the prototype is to re-utilize, after modifications, the LHC tools, which are available. INFN will set up a cold mass test station at the LASA Laboratory, where cold mass cryogenic and electrical tests, using a vertical cryostat, will be performed.

- 4.4 Design and construction of the horizontal cryostat. The integration between the cold mass and the horizontal cryostat will be performed at the LASA Laboratory, to be then sent to GSI for a test in real operating conditions.

**Annex 5** shows the structure of the R&D programme for cold mass construction and magnet tests.

## **Article 5: Scheduling**

The implementation plan for the R&D programme, which includes one year of the preparatory phase, is given in **Annex 6**.

## **Article 6: Management**

The R&D programme is managed by a Steering Committee composed of three representatives for each organization, INFN and FAIR/GSI.

The Parties will nominate their representatives.

At the first meeting of the Steering Committee, one of its members shall be appointed as Chair with the simple majority of the votes of the members present or represented.

## **Article 7: Financial Provisions**

The costs of the R&D programme of this MoU, excluding INFN personnel costs, is shown in **Annex 7**. There are two kinds of costs: a) costs related to the development of the prototype, b) INFN indirect costs (facility upgrades, travels, consumables). The total cost of the R&D programme (without personnel cost) is estimated to be 4717 Keuro. GSI supports the R&D programme for an amount of 1000 Keuro. The remaining project costs are in charge of INFN, subject to the approval of the annual budget of the Institute, during the years covered by this MoU. The INFN staff engaged in this R&D programme amounts to 11 FTEs.

The Financial Provisions of this Article may be revised at any time by mutual agreement between the Parties, according to the implementation and results of the R&D programme.

## **Article 8: Safety regulations**

- 8.1 All equipment brought to the FAIR/GSI site must comply with FAIR/GSI's safety regulations and standards. If relevant, the design, test criteria and testing of equipments should be discussed well in advance with FAIR's safety officials. All equipment brought to FAIR/GSI must be accessible for inspection.

## **Article 9: Access rights**

- 9.1 Access Rights for Execution of the R&D Programme.

The Parties agree to provide access to all Pre-Existing Know-How, limited to the Pre-Existing Know-How held by their laboratories, departments or services involved in the R&D programme of this MoU.

In particular, the Access Rights to the Pre-existing Know-How needed for carrying out the work under the R&D programme shall be granted on a royalty-free basis.

- 9.2 Access Rights for Use of Knowledge.

The Parties agree that the Access Rights to the Pre-Existing Know-How needed for use in research activities or/and to the own Knowledge needed for use in research activities shall be granted on a royalty-free basis.

In case of Access Rights to the Pre-Existing Know-How or to the own Knowledge for Use in the development, creation and marketing of a product or process, or for creation and provision of a service, Access Rights shall be granted on fair and non discriminatory conditions.

## **Article 10: Intellectual Property**

- 10.1 Each Party shall be entitled to utilize for its own purpose any acquired knowledge, whether patentable or not, as well as any expertise developed during the execution of the programme of this MoU.
- 10.2 If a patentable discovery related to this MoU is made by one Party, the other shall be informed thereof as soon as possible in order to reach a mutual agreement on further steps to be taken, it being understood that every Party shall be entitled to a utilization licence as provided for under paragraph 10.1.

**Article 11: Amendments**

This MoU may be amended at any time with the agreement of its signatories or of their appointed successors. Any such amendments will be subject to the prior agreement of the Steering Committee.

**Article 12: Applicable Law**

The Parties shall agree to refer to the regulations in force at the site where the activities are performed.

**Article 13: Disputes**

Any dispute concerning this MoU which cannot be solved amicably between the Parties, shall be submitted to the good offices of the Chair of the Steering Committee who may, at his/her discretion, adopt any form of arbitration process.

**Article 14: Annexes**

All the Annexes are an integral part of this MoU. Annexes may be added to this MoU on mutual consensus. They are understood to be the planning basis for this R&D programme on fast ramping dipole magnets.

This MoU is produced in 2 originals which are signed by INFN and GSI representing FAIR.

Done in Darmstadt

Done in Rome

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For GSI representing FAIR

For INFN

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Director of Research

President

## **ANNEXES**

Annex 1	FAIR-MoU (version signature as of November 2006)
Annex 2	INFN Sections and Laboratories involved in the R&D programme
Annex 3	Specific INFN tasks in the R&D programme
Annex 4	Structure of the R&D programme for conductor development
Annex 5	Structure of the R&D programme for cold mass construction and test
Annex 6	Implementation plan for the R&D programme
Annex 7	Cost implementation plan for R&D programme

**Memorandum of Understanding**  
  
**on the Preparatory Phase**  
**of the International FAIR Project**  
**(Facility for Anti Proton and Ion Research)**

**Preamble**

The international **F**acility for **A**ntiproton and **I**on **R**esearch (**FAIR**) will provide the European science community with a worldwide unique and technically innovative accelerator system to perform forefront research in the sciences concerned with the basic structure of matter, and in intersections with other fields. The facility will deliver an extensive range of primary and secondary particle beams from protons and their antimatter partners, antiprotons, to ion beams of all chemical elements up to the heaviest, uranium, with in many respects unique properties and intensities.

The specific research programs to be carried out at the new facility include: The structure of Hadrons with beams of antiprotons; nuclei far from stability, nuclear astrophysics, and fundamental symmetries with beams of short-lived nuclei; compressed nuclear matter and the phase transition to the Quark Gluon Plasma at high baryon density in nucleus-nucleus collisions; bulk matter in the high-density plasma state; Quantum Electrodynamics in extremely strong fields, ion-matter interactions; symmetries and properties of anti-matter.

In February 2003, based on a recommendation by the German Science Council (Wissenschaftsrat), the project has been approved by the German Government, provided that 25% of the costs are carried by other countries. The FAIR project is open for participation worldwide.

Based on these developments, the signatories of this Memorandum of Understanding want to enter the preparatory phase of the international FAIR project.

The present Memorandum of Understanding is of limited duration and implies no legal commitment for the construction and operation of FAIR.

However, by signing this Memorandum of Understanding the Parties express their interest in participating in the construction and operation of FAIR.



## **Article 1**

### **Purpose**

The purpose of the Memorandum of Understanding is to provide the basis for the international co-operation regarding the preparatory phase of FAIR.

During the preparatory phase all documents will be generated which are needed to decide on the construction and operation of FAIR such that it can reach the performance goals in a cost effective manner.

These documents include at least:

- A technical report for the SIS18 upgrade, the SIS 100, SIS 300, the storage rings CR, RESR, NESR, HESR, the production targets, the Super Fragment Separator, the beam lines, and the experimental facilities
- A time line for the construction and commissioning
- A proposal for the operation of the facility
- A determination of the projects cost and the cost break down (design, construction, operation and de-commissioning)
- A funding scenario
- A proposal concerning the organizational structure of the project in its two phases, construction and operation
- A draft agreement on partnership for construction and operation of FAIR.

## **Article 2**

### **FAIR International Steering Committee and Working Groups**

The work in the preparatory phase of FAIR is co-ordinated by the FAIR Steering Committee (SC-FAIR), consisting of one representative for each of the signatories of this Memorandum of Understanding. The representatives are appointed by the signing bodies.

The SC-FAIR will supervise all work and aspects related to the project in the preparatory phase.

Two Working Groups have been established with the following functions:

- The Working Group on Science and Technical Issues (STI-FAIR) will develop the scientific goals and the overall layout of FAIR including its technical design. It will explore the cost for the construction and operation of the facility.
- The Working Group on Administrative and Funding Issues (AFI-FAIR) will work out a legal framework and an organizational scheme for the construction and operation of FAIR. It will reach consensus on the cost for the construction and operation of the facility.

Both Working Groups will report to the SC-FAIR and will work together with the Interim FAIR Project Group located at GSI, to prepare:

- at the end of 2004 an interim report of their findings,

- by the mid of 2005 the elements necessary for the decision by the participating countries to construct and operate FAIR,
- by the end of 2005 the final documents as specified in Article 1.

### **Article 3 Host Laboratory**

The international FAIR project will be located in Darmstadt, with GSI as host laboratory, which will provide the necessary administrative support.

### **Article 4 International FAIR Project Team**

An international FAIR project team will be established by the SC-FAIR and hosted by GSI.

### **Article 5 Forms of Cooperation between Participating Institutions**

The R&D work during the preparatory phase is carried out by international collaborations.

Within the framework of this Memorandum of Understanding activities may be identified which can include the exchange of personnel and equipment, workshops, the exchange of information etc. These activities and their funding will be specified in Appendices which will be appended to this Memorandum in due course and will serve as a record of contributions during the preparatory phase.

### **Article 6 Duration**

This Memorandum of Understanding will become effective for each party upon signature. The preparatory phase covered by this Memorandum of Understanding should be completed by mid 2006. It can be extended by mutual consent.

### **Article 7 New Parties**

This Memorandum of Understanding is open to European and international parties, upon unanimous agreement by the SC-FAIR.

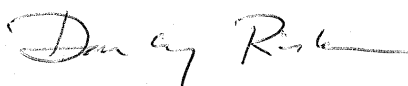
## Article 8 Difficulties

The parties in the framework of this Memorandum of Understanding will do their utmost to settle amicably any differences and difficulties, which may arise out of this Memorandum of Understanding or the co-operation itself.

## Article 9 Changes, Language

1. Changes of this Memorandum of Understanding have to be agreed upon in writing by all signatories.
2. This Memorandum of Understanding is done in English language only, in as many copies as there are parties, each of them equally valid.

For Finland  
Helsinki Institute of Physics:

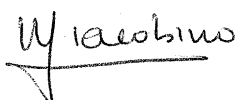


Prof. Dr. D. Riska  
Director

Done in *Helsinki*

on *Sept 22 / 04*

For France



Dr. E. Giacobino  
Director General

Done in *Paris*

on *8 DEC. 2004*

For Germany  
Federal Ministry of Education and Research:



Dr. H. Schunck  
Director General

Done in *Bonn*

on *Sept 13 / 04*

For Greece  
Institute of Electronic Structure and Laser FORTH-IESL:

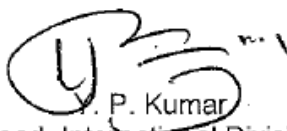


Prof. Dr. C. Fotakis  
Director

Done in *Heraclion*  
*FORTH*

on *November 11, 2004*

For India  
Department of Science and Technology

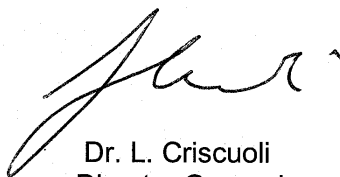


V. P. Kumar  
Head, International Division

Done in *New Delhi*

on *November 2005*

For Italy  
Ministry of Education, University and Research:

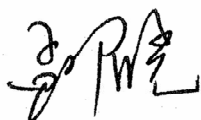


Dr. L. Criscuoli  
Director General

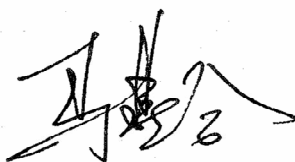
Done in

on *Dec 6 / 04*

For the People's Republic of China  
Ministry of Science and Technology:



Meng Shuguang  
Deputy Director-General

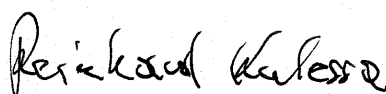


Ma Yanhe  
Deputy Director-General

Done in *Berlin*

on *24. 11. 2005*

For Poland  
Ministry of Science and Information Technology



Prof. Dr. R. Kulesza  
Jagiellonian University, Kraków

Done in *Warsaw*

on *18. Jan. 2005*

For Romania  
Ministry of Education and Research of Romania

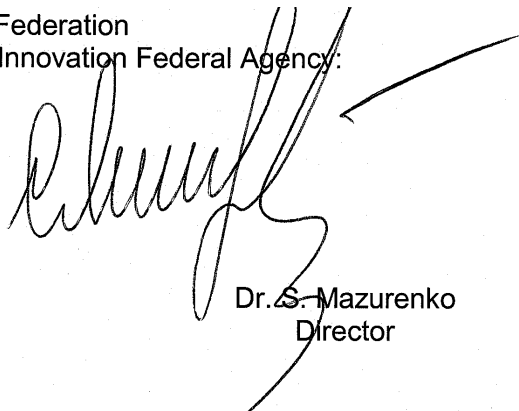


Prof. Dr. A. Anton  
President of National Authority for Scientific Research

Done in *Bucharest*

on *7 April 2006*

For Russian Federation  
Science and Innovation Federal Agency:



Dr. S. Mazurenko  
Director

Done in *Moscow*

on *11 Nov. 2004.*

For Spain  
Ministry of Science and Education:



Dr. S. Ordóñez Delgado  
Secretary of State

Done in

on

For Sweden  
Swedish Research Council:

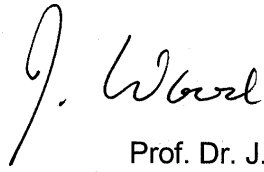


Prof. Dr. P. Omling  
Director General

Done in *Stockholm*

on *Sept. 21 2004*

For United Kingdom  
Council for the Central Laboratory of the Research Councils:



Prof. Dr. J. V. Wood  
Chief Executive

Done in *Rutland*.  
on *13<sup>th</sup> September*  
*2004*

## **Annex 2**

### **INFN Sections and Laboratories involved in the R&D programme**

- INFN–Genoa Section
- INFN–Milan Section (LASA Laboratory)
- INFN–Frascati National Laboratory (LNF)

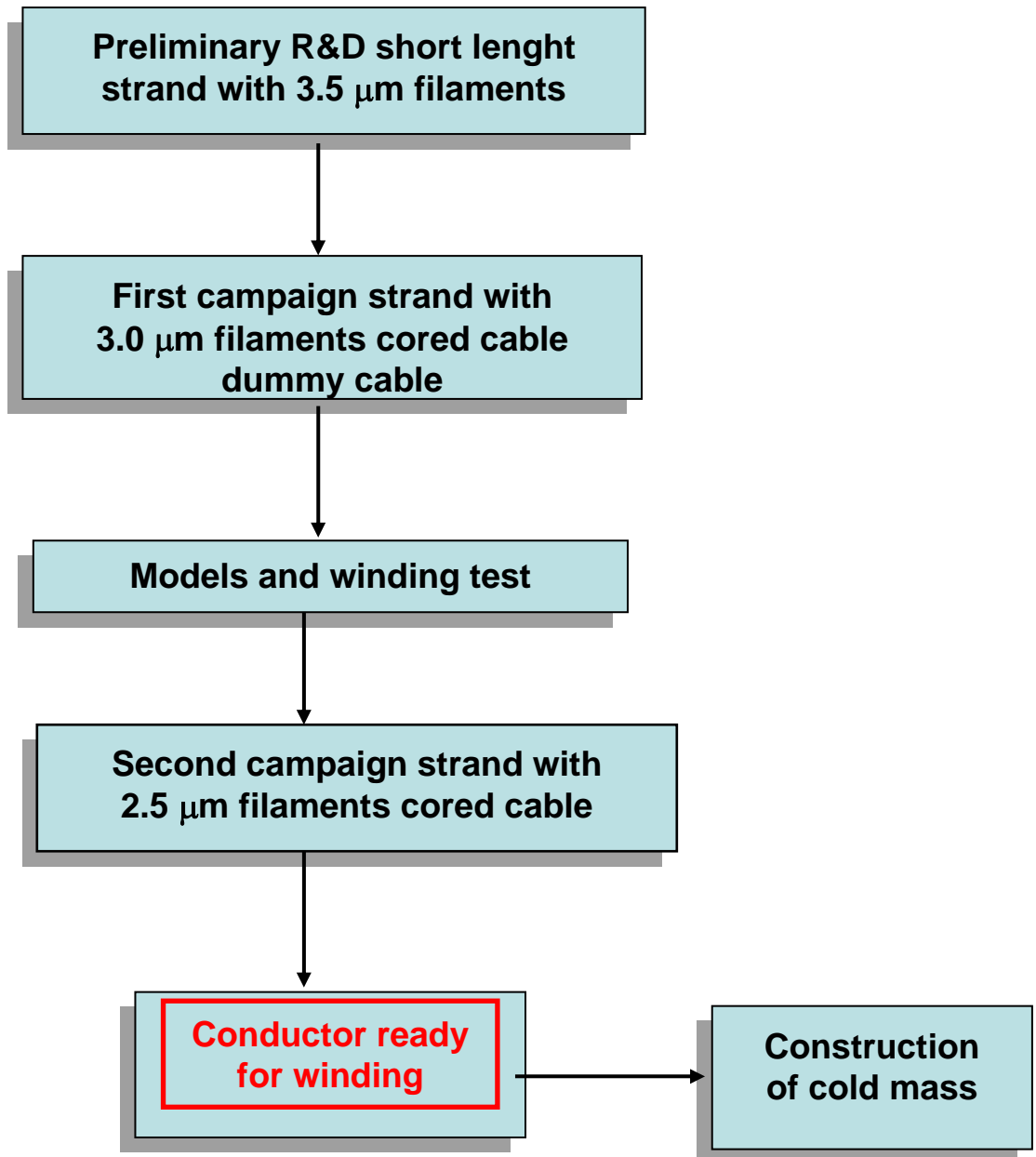
## Annex 3

### Specific INFN tasks in the R&D programme

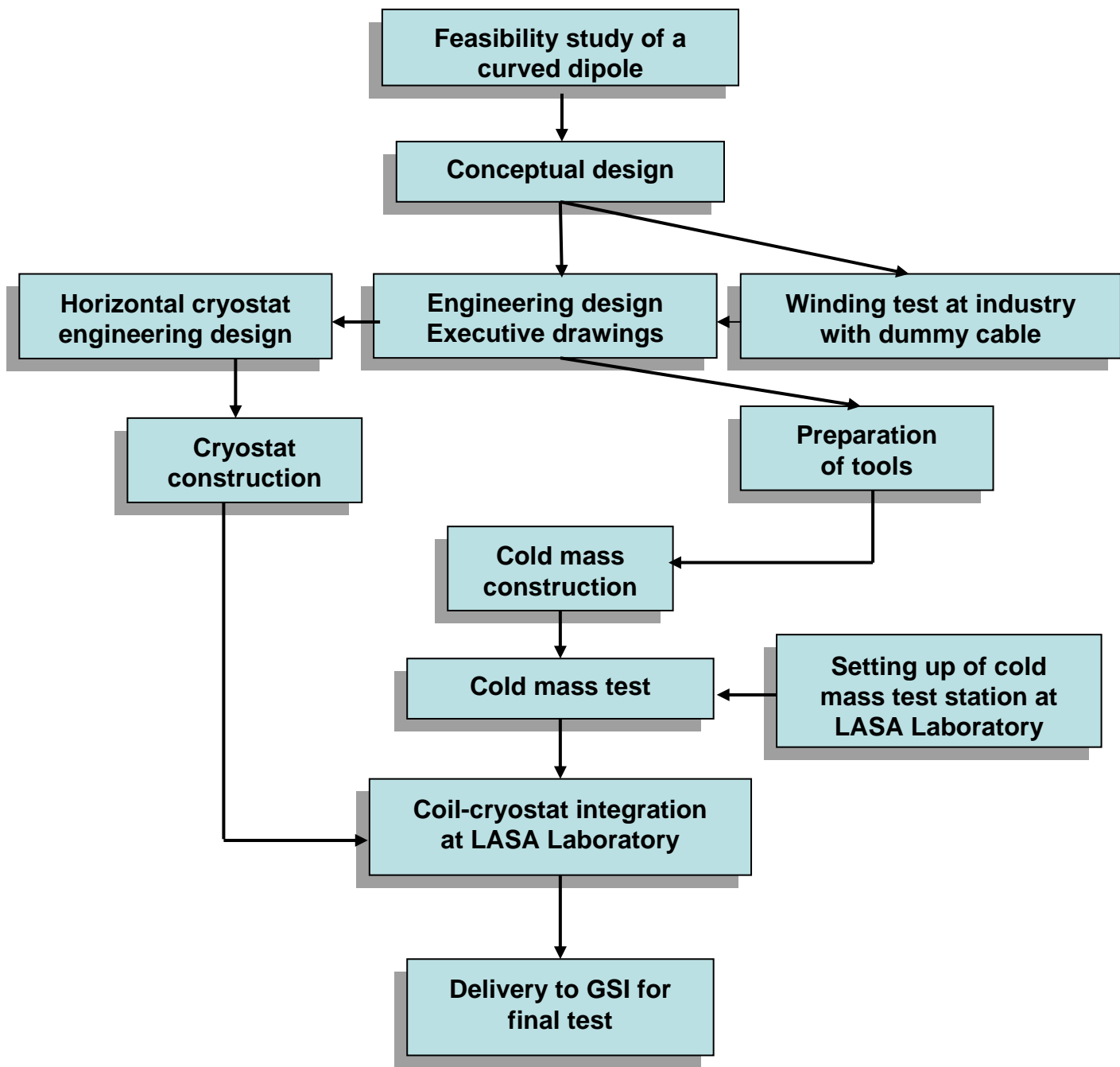
- INFN–Genoa Section
  - Finite Element Analysis: mechanical, thermal design
  - Cold mass construction, in collaboration with industry
  - Quality controls on cold mass
  - Strands characterization: dissipation measurements in AC regime
  - Rutherford cable characterization: critical current measurements
- INFN-Milan Section (LASA Laboratory).
  - Magnetic design, harmonic and quench analyses
  - Conductor construction, in collaboration with industry
  - Conductor follow up design
  - Strand characterization: critical current measurements
  - Rutherford cables characterization: interstrands resistance measurements
  - Cold mass test
  - Coil-cryostat integration
  - Fatigue studies of materials
- INFN-Frascati National Laboratories (LNF)
  - Cryostat construction
  - Follow up horizontal cryostat design
  - Strands characterization: structural and morphological features
  - Strands characterization: measurements of losses in hysteresis cycles



## R&D programme for conductor development

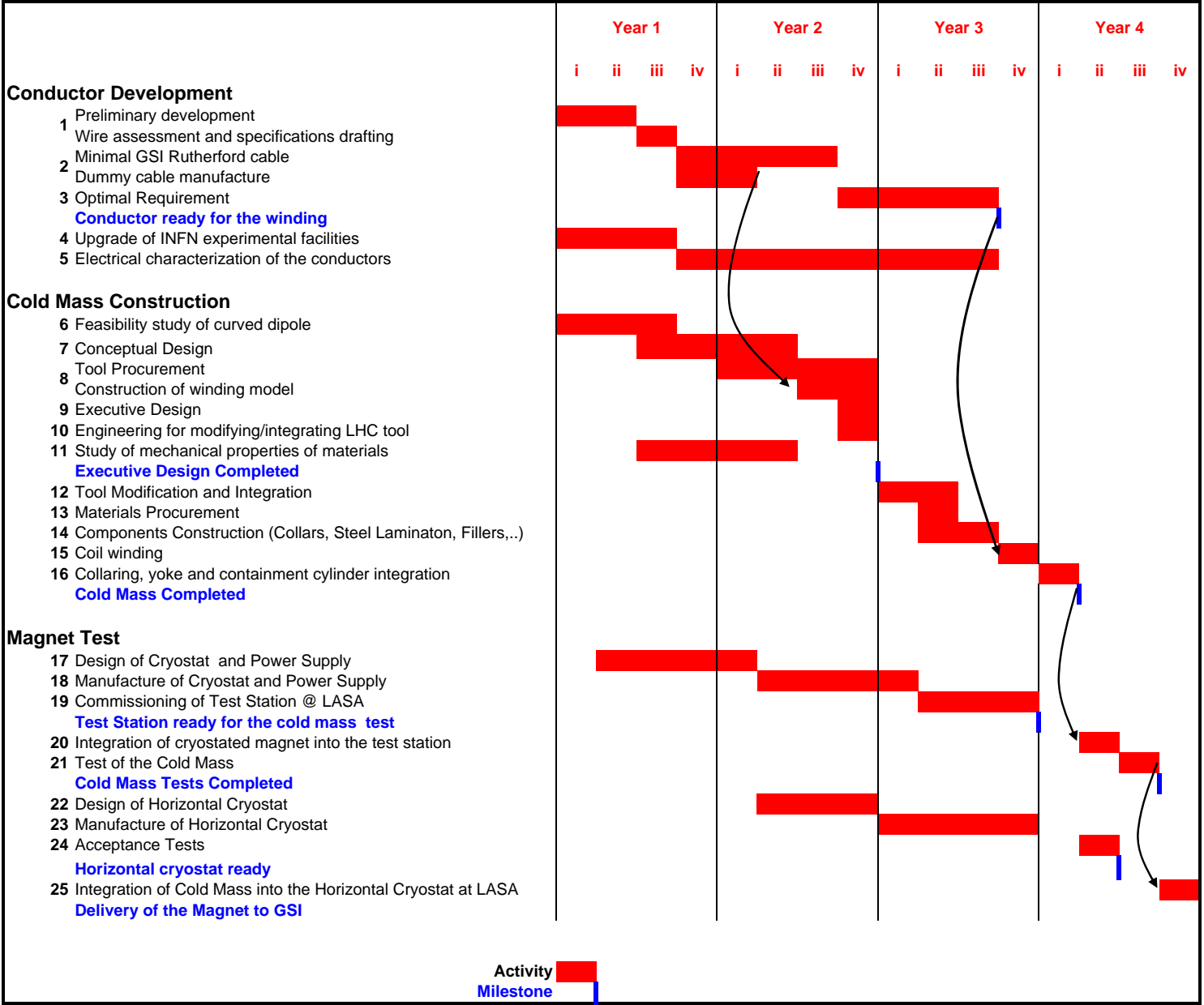


R&D programme for cold mass construction and test



Annex 6

Implementation plan  
for conductor development, cold mass construction, magnet test  
including the preparatory phase (Year 1)



## Annex 7

**Costs of the R&D programme activities  
including the preparatory phase (without personnel cost)  
(k€)**

		<b>TOTAL</b>
	<b>Conductor Development</b>	
1,2,3	Development and manufacture of Rutherford cable	600
4	Upgrade of INFN experimental facilities	145
5	Electrical characterization of the conductors	382
	<b>Prototype Design and Construction</b>	
6,7	Studies, Design and Follow up	283
8	Tool Procurement and Construction of curved winding model (Including Engineering for winding Design and Required tool)	888
9	Executive Design	96
10	Engineering for modifying/integrating LHC tool	36
11	Study of mechanical properties of materials	140
12	Tool Modification and Integration	264
13,14,15,16	Materials and costs for cold mass construction	577
	<b>Cold Mass test</b>	
17,18,19	Vertical Cryostat and Power Supply	620
20,21	Test of Cold Mass	70
22,23,24	Design and Construction of Horizontal Cryostat	200
25	Integration of Cold Mass into the Horizontal Cryostat at LASA	50
	<b>Travels</b>	
	National Travels	92
	International Travels	274
	<b>GRAND TOTAL</b>	<b>4717</b>