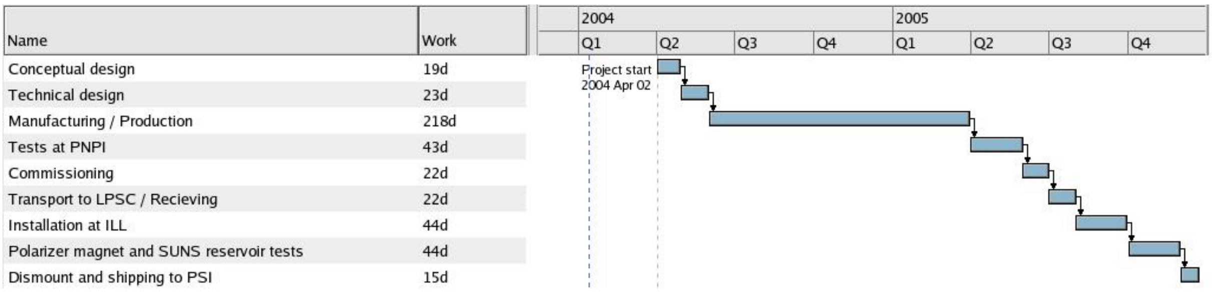
Superconducting solenoid

Time schedule

Name	Start	Finish	Work
Conceptual design	Apr 2	Apr 28	19d
Technical design	Apr 28	May 31	23d
Manufacturing / Production	May 31	Mar 31	218d
Tests at PNPI	Mar 31	May 31	43d
Commissioning	May 31	Jun 30	22d
Transport to LPSC / Recieving	Jun 30	Aug 1	22d
Installation at ILL	Aug 1	Sep 30	44d
Polarizer magnet and SUNS reservoir tests	Sep 30	Dec 1	44d
Dismount and shipping to PSI	Dec 1	Dec 22	15d



Outline Design

The superconducting magnet system proposed is based on a cryostat with the horizonthal warm bore of 160 mm in diameter which contains a superconducting solenoid wound with NbTi conductors of various diameters (1.0-1.2- 1.5 mm). The coil is built in by means of "B-stage" interlayer insulation tapes which have to be heat treated after the winding.

The operational current and the field in the centre of the magnet system are 312.5 A and 4 T respectively. The safety margin of the solenoid is about 22% relative to the critical current of the magnet.

The coil is wound on a stainless steel former of 5 mm in thickness. To decrease the resistance of electrical joints the different diameter pieces of the superconductors are soldered at the copper cylinders placed at a spool flange.

The coil will be directly cooled in a helium bath. The initial volume of liquid helium in the bath is about 50 liters which will give possibility of continuous running of the magnet system without additional filling-up helium above two months. The cold mass will have an 80 K radiation screen cooled by liquid nitrogen. The surfaces of the helium bath and radiation screen will be covered by stainless steel foil sputtered with high purity Al in an atmosphere of helium gas. The radiation heat flux for such surfaces is about 20 mW/m2. Expected time to refuel the liquid nitrogen in the cryostat is two weeks.

It is planned to use HTS current leads of American Superconductor – CryoSaver Current Leads CS050030. In these current leads HTS filaments are placed in a low thermal conductivity matrix. The composite conductor has a very high current density translating into a small cross-section of conductor and a low heat leak. These current leads display heightened tolerance for strain and thermal cycling. They are designed for conduction cooling and requires no helium flow.

For current leads of American Superconductor conductive heat leak at 64 K - 4.2 K per pair is 0.21 W only. The cold mass will be supported from the outer vacuum case by means of vertical tension ties/tubes and horizontal cables which will be used for current leads housings and helium supply simultaneously. They will be designed both to support the cold mass against the forces that exist between the coil and the iron yoke and to centralize the coil. The iron yoke (or optionally opposing external superconducting winding) will be used to screen stray fields of the coil. It will be nominally low carbon steel grade and produced in sections that will be readily handle in the assembly area. The sections will be connected by bolting. Quench protection will be fully passive and the coil temperature after the quench will not exceed approximately 50 K.

The main parameters and dimensions of the solenoid magnet are included in the table 1. Field distributions Bz(r,0) and Bz(0,z) at the operational current 312.5 A are given in tables 2 and 3. Stages of the project are listed in the table 4. The total time needed to realize the project is 15 months. A break down of the cost estimate for the magnet system is given in table 5. The estimated budget of the project is 50 kEuros.

Table 1. Magnet system parameters

1.	Inner radius of the 1st coil	m	0.1025
2.	Outer radius of the 1st coil	m	0.1085
3.	Length of the 1st coil	m	0.155
4.	Length of the conductor	m	265
5.	Number of turns of the 1st coil		4x100
6.	Conductor diameter in the 1st coil	mm	1.5
7.	Inner radius of the 2nd coil	m	0.1085
8.	Outer radius of the 2nd coil	m	0.1181
9.	Length of the 2nd coil	m	0.155
10.	Length of the conductor	m	707
11.	Number of turns of the 2nd coil		8x124
12.	Conductor diameter m the 2nd coil	mm	1.2
13.	Inner radius of the 3rd coil	m	0.1181
14.	Outer radius of the 3rd coil	m	0.1281
15.	Length of the conductor	m	1160
16.	Length of the 3rd coil	m	0.155
17.	Number of turns of the 3rd coil		10x150
18.	Conductor diameter in the 3rd coil	mm	1.0
19.	Inner radius of the winding mandrel	m	0.1
20.	Diameter of the "warm bore"	m	0.08
21.	Operational current	A	312.5
22.	Critical current	A	400
23.	Maximal field in the coil at the operational current	T	5.16
24.	Safety factor (Icr/Iop)		1.28
25.	Inductance	H	1.6
26.	Maximal energy	kJ	128
27.	Total weight of the conductor	kg	19.3

Table 2. Field distribution Bz(r,0) at the operational current

R (m)	By (T)
0.	4.0
0.01	4.01
0.02	4.04
0.03	4.09
0.04	4.17
0.05	4.27
0.06	4.39
0.07	4.54
0.08	4.91
0.09	5.74
0.1	5.10

Table 3. Field distribution Bz(0,z) at the operational current

Z (m)	By (T)
0	4.00
0.01	3.99
0.02	3.92
0.03	3.82
0.04	3.67
0.05	3.50
0.06	3.29
0.07	3.07
0.08	2.83
0.09	2.58
0.1	2.33

Table 4. Stages of the project.

1.	Conceptual design	1 month
2.	Technical design	1 month
3.	Manufacturing drawings and production	10 months
4.	Tests at the supplier place	2 months
5.	Commission	1 month
	Total	15 months

Table 5. Budgetary Cost

1.	Design	kEuros	10.0
2.	Superconductor, winding production magnet test in a auxiliary cryostat	kEuros	16.0
3.	Cryostat and the iron yoke including the cost of the tooling	kEuros	9.0
4.	Instrumentation	kEuros	8.0
5.	Power supply	kEuros	7.0
	Total	kEuros	50

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The superconducting solenoid will fulfil two purposes:

- first, it will polarize the UCN at the entrance of the spectrometer.

- secondly, it will increase the transmission efficiency of the Al window isolating the vacuum of the nEDM spectrometer from the vacuum of the UCN source.

This solution has been proposed and successfully tested at ILL by the PNPI group. Details on the performed tests can be found in the EDM proposal. At present, a preliminary conceptual design of a coil and its associated cryostat meeting our demands has been proposed by Evgueni Kochournikov from JINR in Dubna (see attached document 1).

Our group from LPSC (Laboratory for Subatomic Physics and Cosmology, Grenoble, France) is planning to join the nEDM collaboration in a near future. We are in the process of getting an official approval from our authorities (CNRS-IN2P3) to get involved in this project. Funding request for the Superconducting Solenoid has already been addressed to our funding agency and we expect a positive answer within the next months. Once the financing will be obtained, we will take responsibility for this task and a contract will be established between CNRS-IN2P3 and PNPI.

Assuming a budget allocation around March, we have prepared a time schedule (see attached document 2) starting April 1st, 2004 that will allow to get an operating magnet by the end of 2005 at PSI. The construction will be done in Russia under supervision of E. Kochournikov over a period of 15 months. After a series of tests in Russia, the magnet will be delivered to our collaboration end of June 2005 to be eventually shipped to Grenoble. Further tests will be then carried-out with the ILL UCN source in fall 2005 for the final qualification of the system. The operating superconducting magnet could be finally shipped to PSI by the end of 2005.