WP7 HFM Status

F. Kircher (CEA Saclay) **and Gijs de Rijk** (CERN)

EuCARD 3rd Annual meeting

Warsaw, 25-27 May 2012

WP7 High field magnets

- Task 1: Coordination and communication
- Task 2: Support studies
- Task 3: High field model
- Task 4: Very high field dipole insert
- Task 5: High Tc superconductor link
- Task 6: Short period helical SC undulator
- Deliverables, Milestones and conclusions

Task 1: Coordination and communication (1)

After the kick-off in February 2009, 9 collaboration meetings were held (at CEA, CERN, PWR, UNIGE, CNRS Grenoble and Warsaw)

Task 1 activities in the last months:

- Task review visits:
  - 2 Warsaw 28-29/2, 4 Grenoble 19/4, 5 CERN 15/5, 6 RAL 13/3
- Organization of the collaboration meetings
- external (ESAC) reviews,
  - 12 Dec 2011 Short Model Coil
  - 28-29 March March 2012: 2nd Dipole review

Plans for next semester:

- Organize the next collaboration meeting 18-19/9 at INFN-LASA Milano
- Organize the 3rd dipole review
- 2nd EC periodic report
- Some reshuffle of budget between partners inside tasks and tasks

Task 2: Support studies (1)

Macej Chorowski & Jarek Polinski (PWR) PWR, CEA, CERN

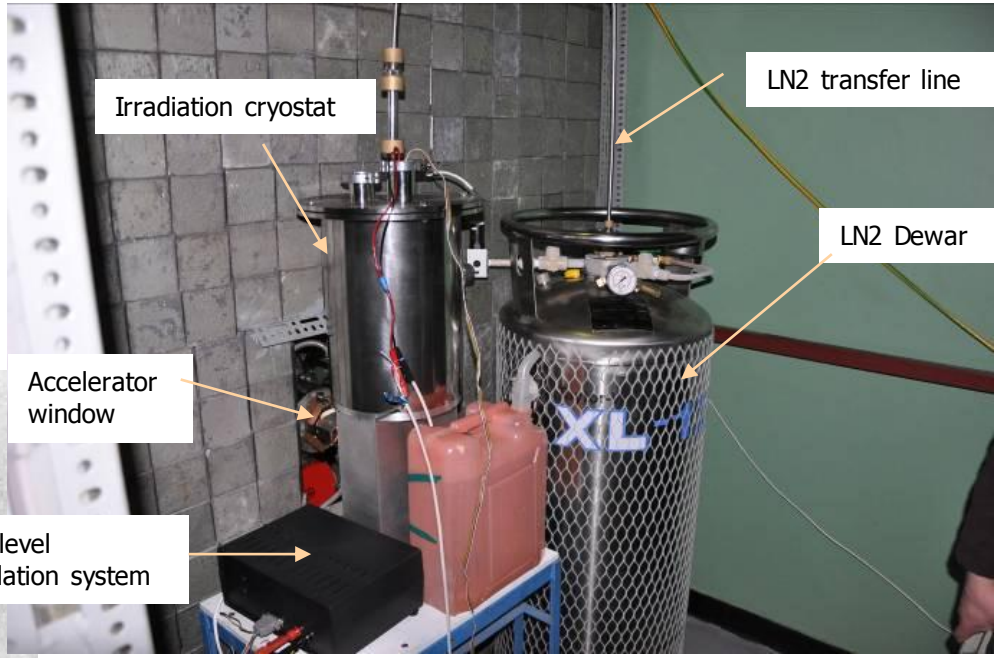
[7.2.1 minor delay, personnel: +, material +]

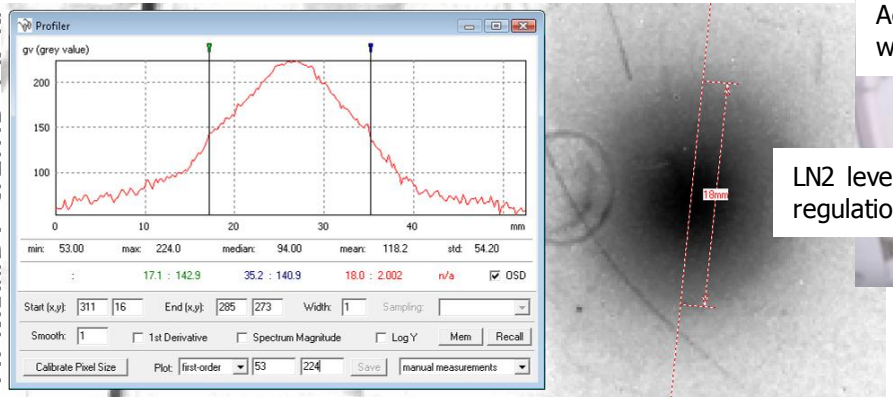
[7.2.2 task on schedule, personnel: +, material +]

7.2.1 Radiation studies for insulation and impregnation (PWR)

Select radiation hard insulation/impregnation for Nb_3Sn magnets

Irradiations have started at NCBJ Swierk in March 2012

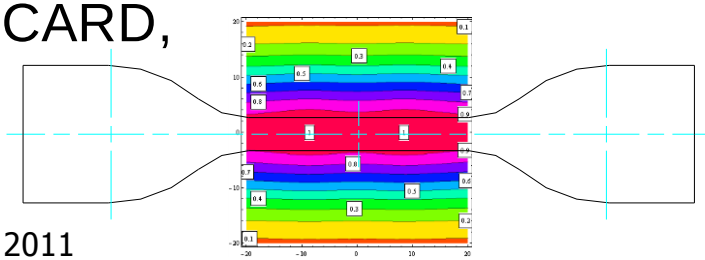




Courtesy J. Polinski (PWR)

Task 2: Support studies (2)

- Samples shape selected for electrical (1 spot), mechanical (4 spots), and thermal (5 spots) test samples
- Schedule of irradiation and testing within EuCARD, but slide to M48



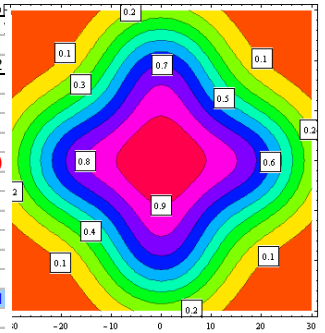
Achieved Oct 2010

„Sample test map" report

Achieved Nov 2011

M 7.2.1 has been delivered

EuCARD WP 7: HFM Task 2 Start = 01/04/09	1st year				2ed year				3td year				4th	
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14
	3	6	9	12	15	18	21	24	27	30	33	36	39	42
				EuC Rep				EuC Rep				EuC Rep		
Sub-task 2.1: Radiation resistance certification														
Methodology for coil radiation resistance certification								M(24)						D(42)
Determination of radiation types and doses	IM													
Determination of irradiated sample tests scope						IM								
Selection of the Institute capable of the irradiation						IM								
Test samples production														
Irradiated sample test set-ups preparation								IM						
Sample irradiation													IM	
Irradiated sample tests (mech+elec+therm)														IM



Achieved Oct 2010
„Sample test map" report

Achieved

SOLTAN Institute Warsaw has been selected

Achieved Nov 2011

Irr. cryostat is installed at NCBJ, Świerk

Started at the beginning of March 2012

Courtesy J. Polinski (PWR)

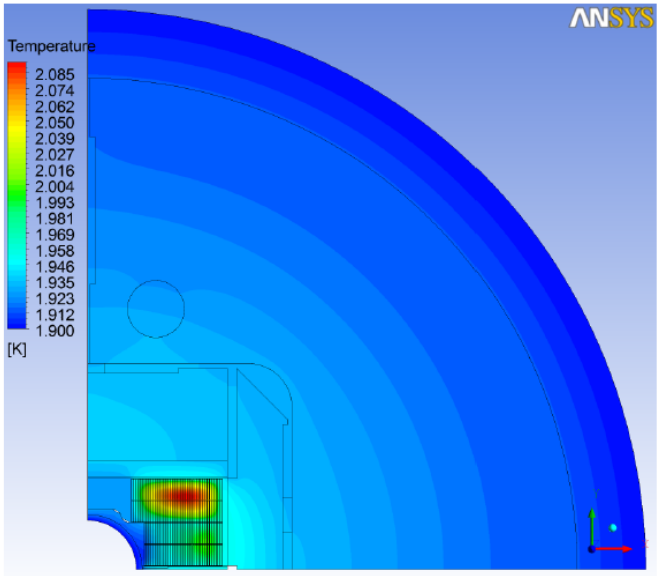
Studies | Manuf | Tests | WP - Work Package Report

M - Mileston | IM - Inter. Milestons | D - Deliverables | EuC - EuCARD Report

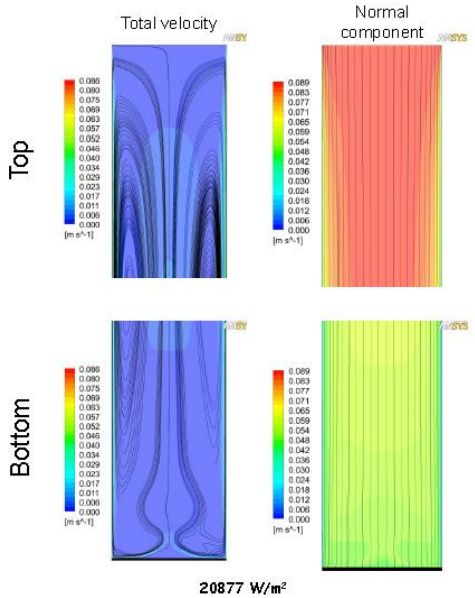
Task 2: Support studies (3)

7.2.2 Thermal models and design (CEA, CERN, PWR)

- HeII thermal tests cryostat at PWR built and being commissioned now, expected to be operational for measurements in May
- Thermal measurements ongoing at CEA
- Thermal Model for task-3 dipole (Fresca2) finished (deliverable report done: to be uploaded)
- HeII FE model in progress and on schedule



Courtesy S. Pietrowicz (PWR)



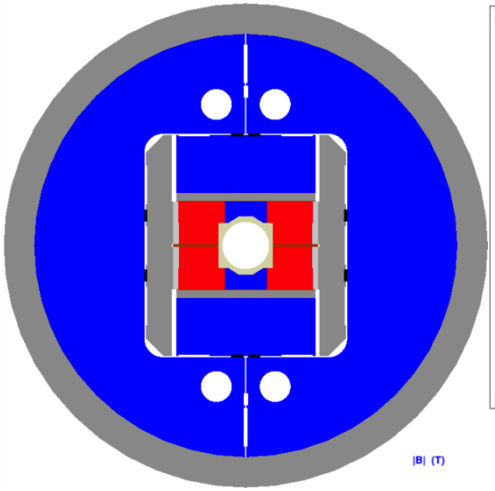
Courtesy J. Polinski (PWR)

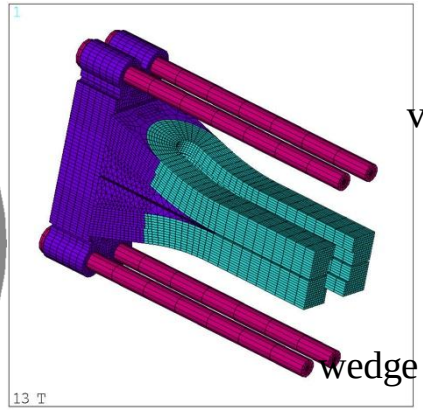
Task 3: High field model (1)

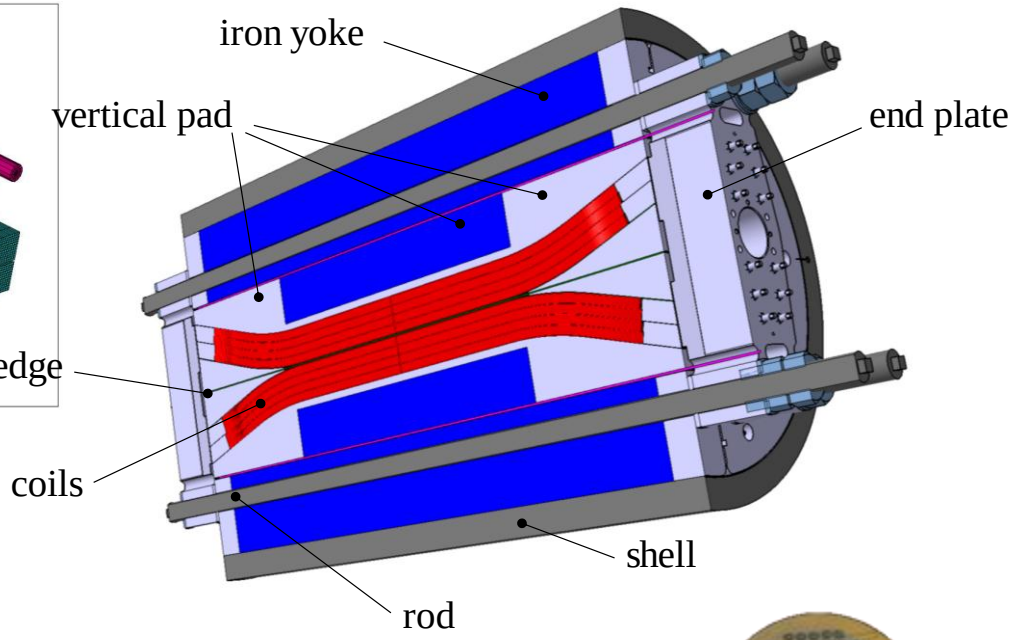
Jean-Michel Rifflet (CEA) CEA, CERN, PWR

[task delayed by 9 months, personnel: +, material +]

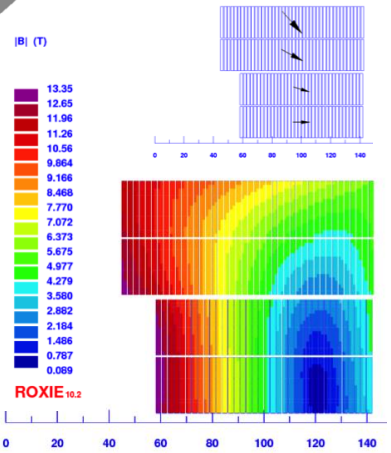
- Objective: Design, build and test a 1.5 m long, 100 mm aperture dipole with a design field of 13 T, using Nb_3Sn high current Rutherford cables.

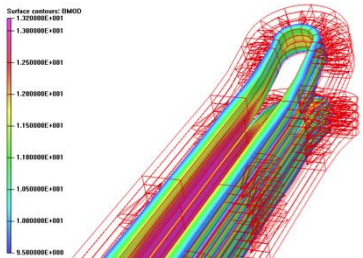


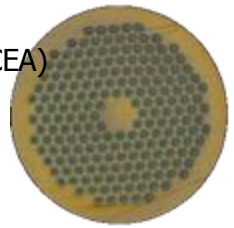




Courtesy P. Ferracin, L. Oberli (CERN), P. Manil (CEA)



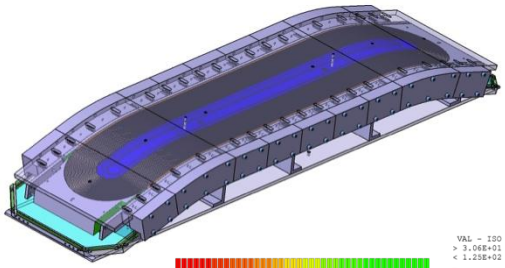


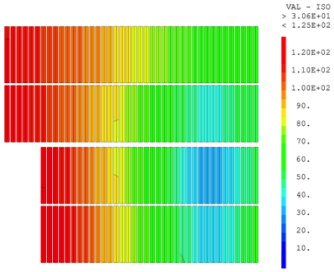


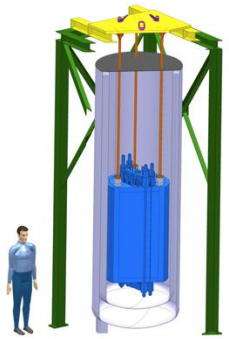
Task 3: High field model (2)

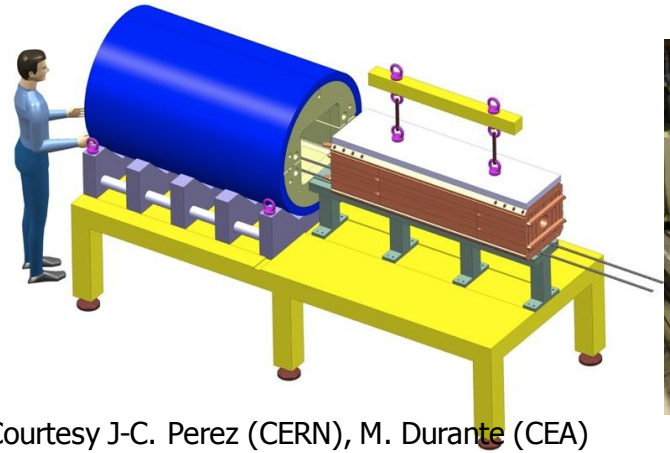
- Procurement of strand on course (38 km received)
- Construction of structure ongoing
- Tooling design nearly complete and construction is in progress
- Quench modeling in progress (but we know from the work done that the magnet is safe to quench)
- First Cu test coil winding start in July 2012
- First Nb3Sn coil winding to start in Q4 2012

So, the project is doing well, but….



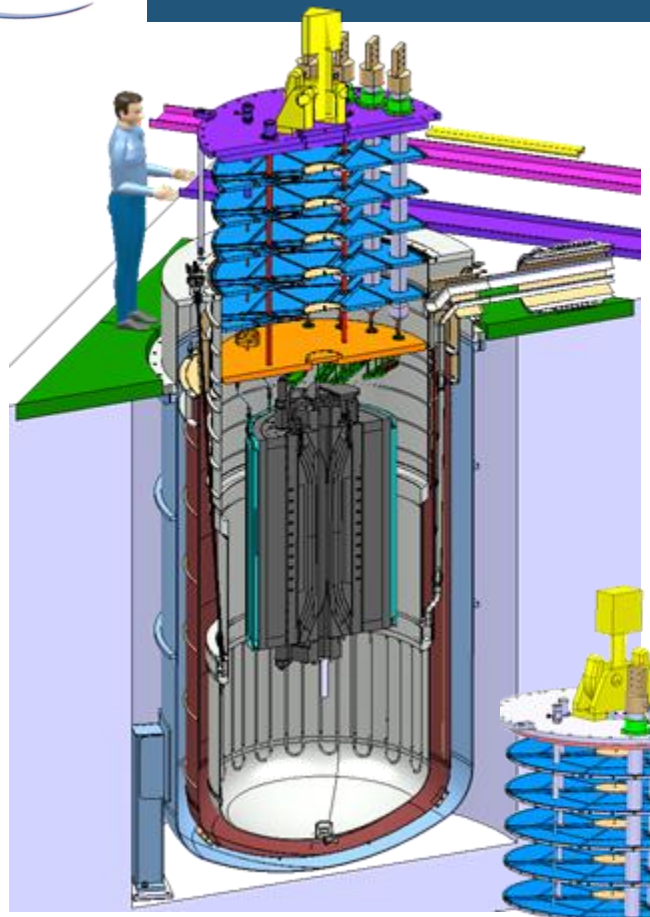


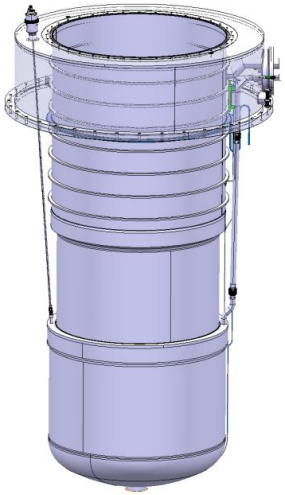


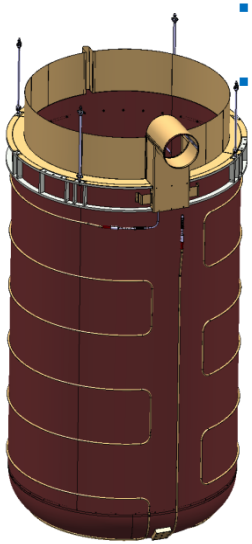


Courtesy J-C. Perez (CERN), M. Durante (CEA)

Cryostat design (CERN)







Helium vessel (Max. p= 4 bar)

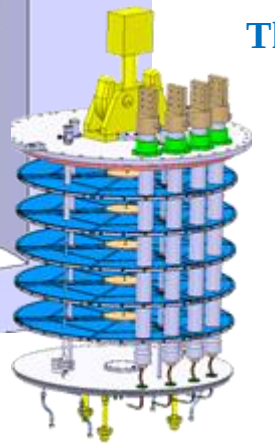
- Neck: DI: 1612 mm, Length : 1744 mm, Thickness : 3 mm
- Middle part: DI: 1500 mm, Length: 1245 mm, Thickness: 8mm
- Lower part: DI: 1630 mm, Useful length: 1800 mm, Thickness: 8 mm

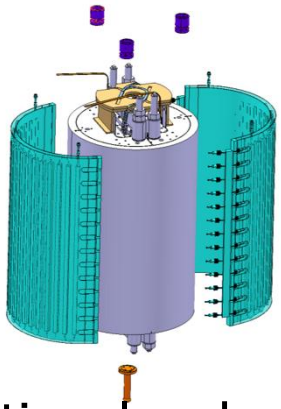
Cooling time 80 K to 4.2 K: 12 h
Cooling time 4.2 K to 1.9 K: 36 h

Vacuum vessel (Max. p= 1.5 bar)

- DI : 2300 mm, Length : 3845 mm, Thickness : 8 mm, Weight: 2.8 t

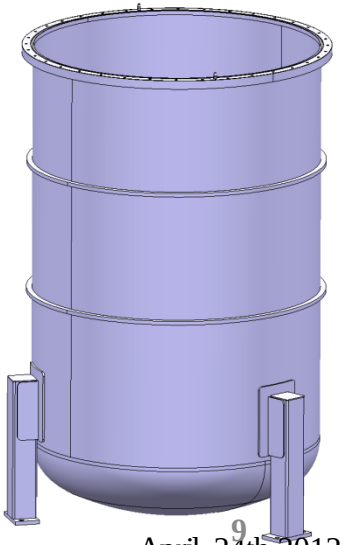
Thermal shiel





Magnet pre cooling:

- pressurized He (15 bar, 80 K)



Insert

- Total Length: 4415 mm
- Top plate: Ø 1800 mm, Thickness: 50 mm
- Lambda plate: Ø 1600 mm, Thickness: 50 mm
- Magnet centering

Will be operational end summer 2013

Courtesy M. Bajko, A. Vande Craen (CERN)

Task 3: High field model (4)

The ESAC high field dipole design review was held at CERN, on March 28-29

Some selected remarks:

- Significant progress since last review …
- The team is now aware of the challenge (RMC)
- Change in task deliverable (→ single coil tested in the Fresca2) much more realistic.
- From the standpoint of magnet operation at 13 T, cabling degradation as high as 20 % could be tolerated
- Build the RMC magnet to test racetrack Nb3SN cables, layer jump, leads ….

- Wait for this test results before winding the 3 other coils .
- Declare success and do not proceed in making the rest of the coils, before results have been analyzed and reviewed

- EuCARD deliverables, “Test structure with 1 SC double pancake by April 2013”, appears to be very challenging.
- The obvious show-stopper is the testing cryostat where the first cold test can be anticipated only at October 2013 or later. The committee strongly suggests the team to speed up the preparation of the testing cryostat so that the first test can be made by April 2013.

Task 4: Very high field dipole insert (1)

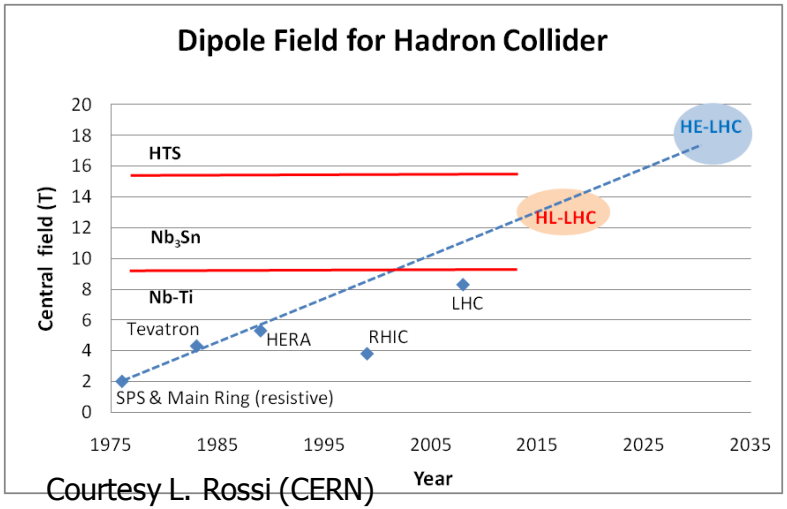
Pascal Tixador (CNRS Grenoble-INPG)

CNRS, CEA, KIT, INFN, TUT, UNIGE,PWR

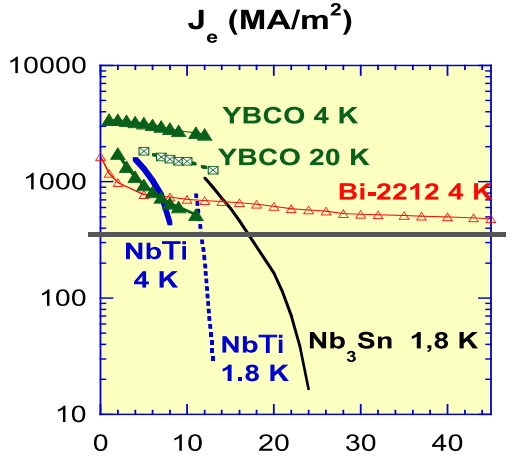
[task on schedule, personnel: +, material +]

- Objective:
  Design and realization of a high temperature superconductor (HTS) very high field dipole insert (6 T), which can be installed inside the 13 T Nb_3Sn dipole of task 3

NB: test of the two dipoles together is not part of the present EuCARD contract but will be done by CERN in the Fresca2 magnet



Courtesy L. Rossi (CERN)

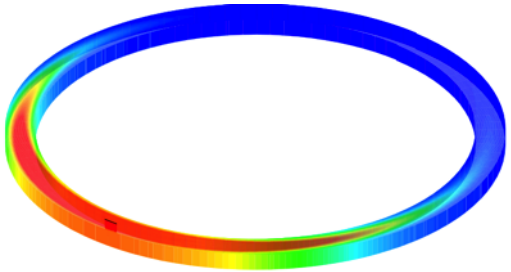


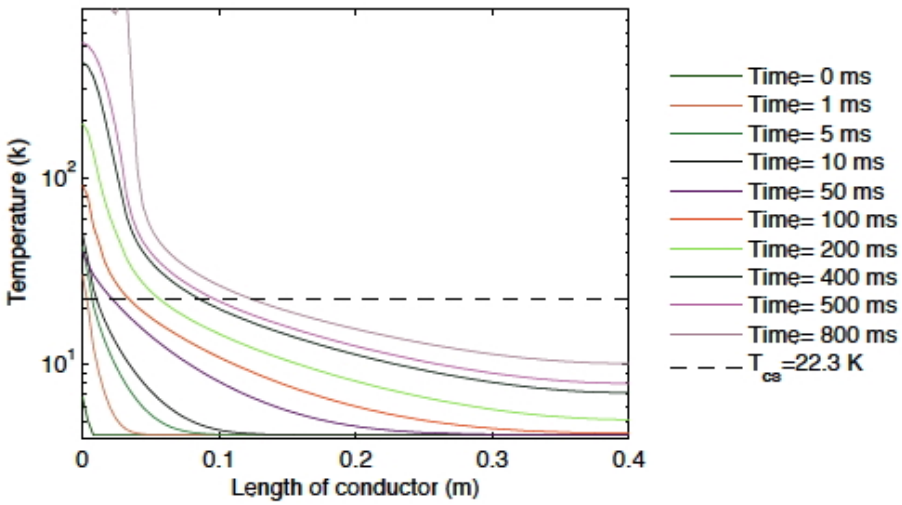
Courtesy P. Tixador (Grenoble), J-M. Rey (CEA)

Task 4: Very high field dipole insert (2)

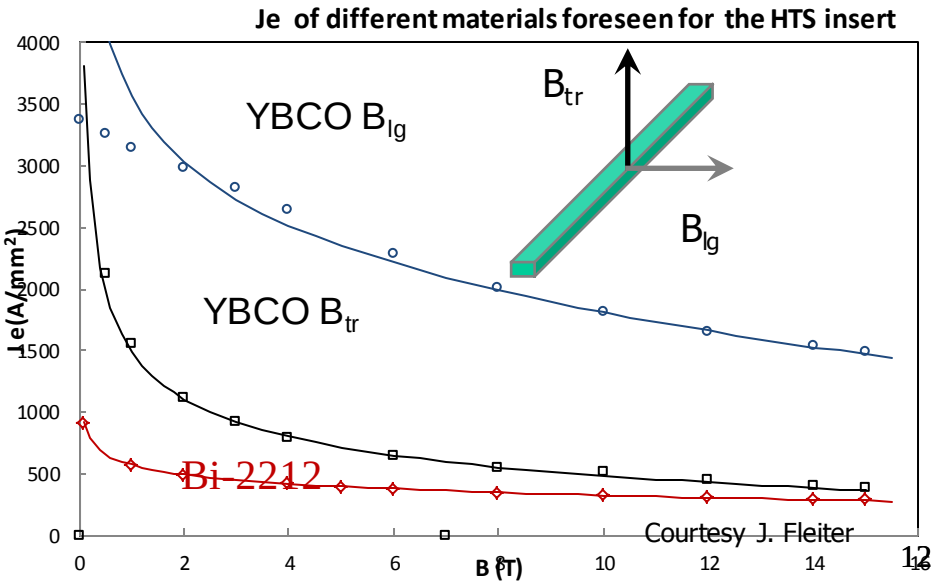
Specification, characterization and quench modeling:

Quench modeling for HTS coils is a key development to master the HTS technology.
Models exists (TUT & LASA): final parameters to be input





Courtesy A. Stenvall

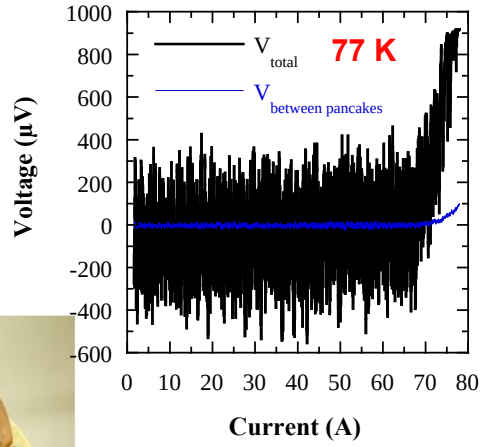


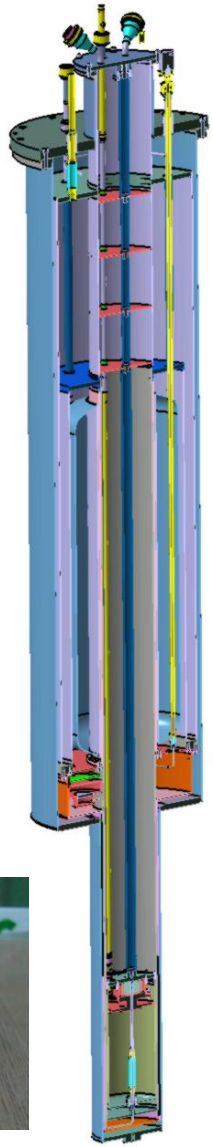
Courtesy J. Fleiter

Task 4: Very high field dipole insert (3)

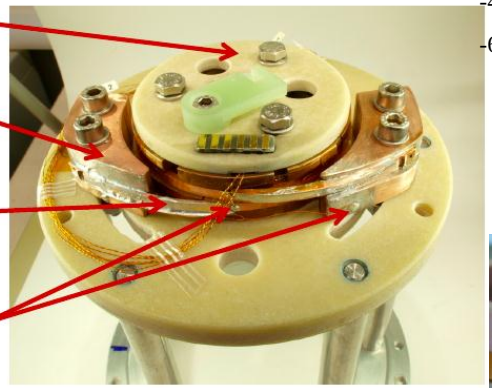
Test solenoids in YBCO tape

- >2 coils made and tested at Grenoble & KIT
- Used to calibrate the quench models, the manufacturing technology, connections etc.
- Establish limiting parameters (stress etc.)





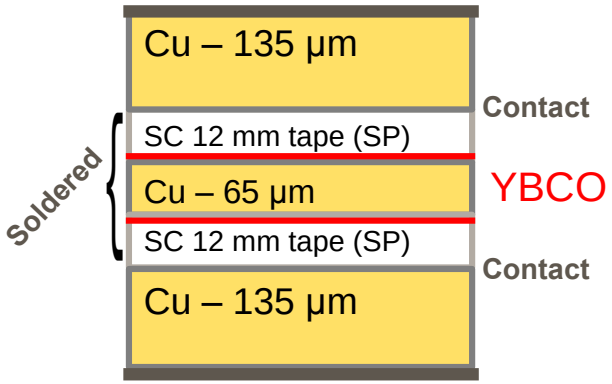
- Fixing of DP with top cover
- Current terminals made of copper
- Curved tape guiding made of copper
- Voltage taps placed at current terminals and at cc-tape directly after tape guiding
- Additional fixing by impregnation with beeswax

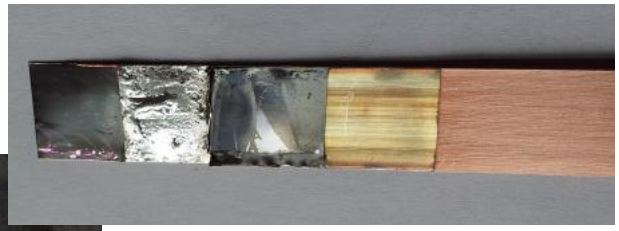


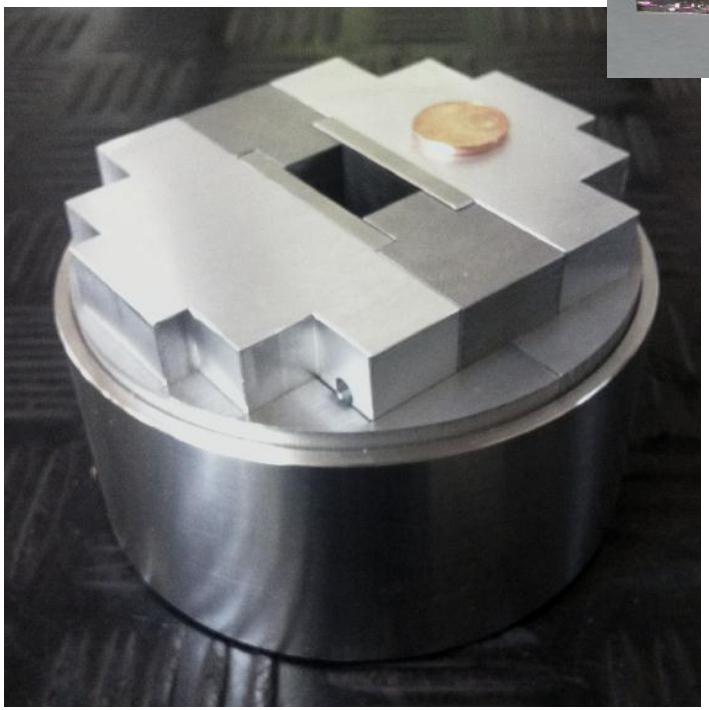
Courtesy P. Tixador (Grenoble), J-M. Rey (CEA)

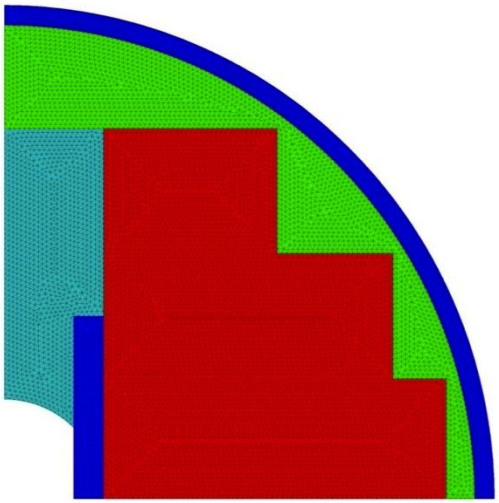
Task 4: Very high field dipole insert (4)

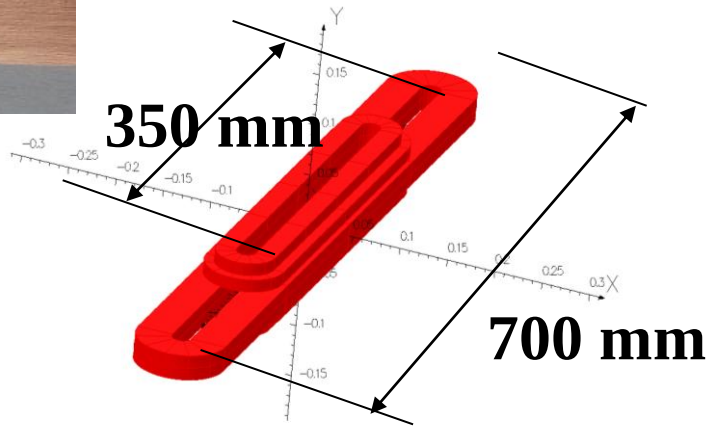
- Conceptual design of the insert done, working on detailed issues.
  - Connections, mechanics, insulation, assembly
- Prototype double conductor tape exists









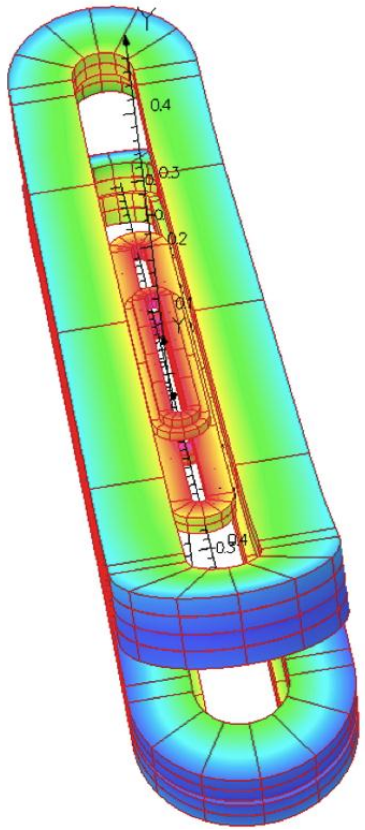


3D geometry

Task 4: Very high field dipole insert (5)

Construction plan:

- Make first a single pancake coil and test in Grenoble in 10 T perpendicular field:
  - Confirm manufacturing details
  - Get angular field dependence on I_c
- The insert will be ready by end summer 2013
- The HFM test station at CERN is being build with an insert test option integrated
- Test of the insert at CERN in Fresac2 in second half 2014



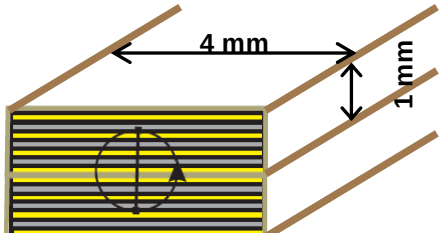
Task 5: High Tc superconducting link (1)

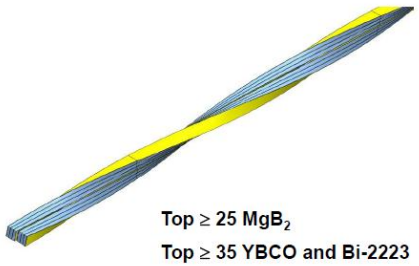
Amalia Ballarino (CERN) CERN, COLUMBUS, BHTS, SOTON

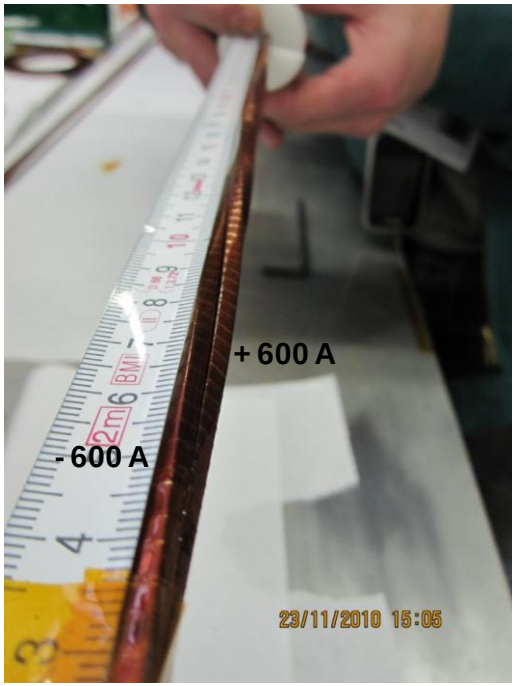
[task on schedule, personnel: +, material +]

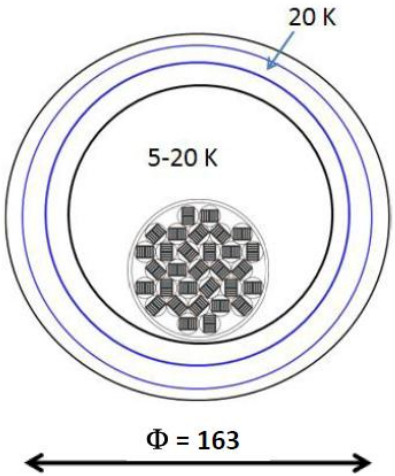
Deliver: a Superconducting link, 20 m long, containing 48 HTS cables rated at 600 A- DC (M40). The Task includes design and assembly activities – but not the test of the final prototype.

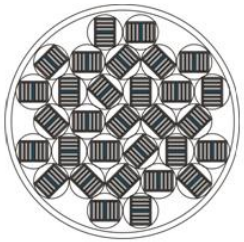
CERN will perform the test of the prototype link









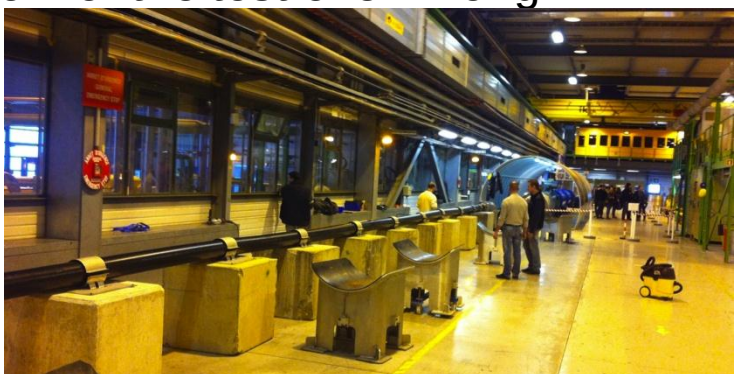


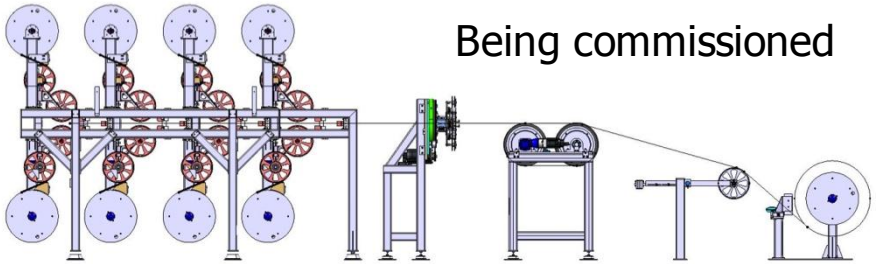
24 × 2 × 600 A

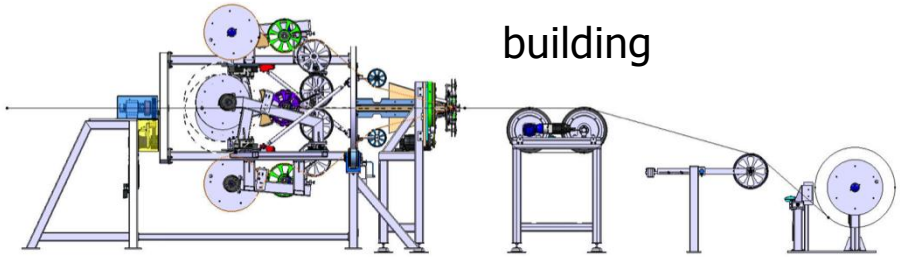
Task 5: High Tc superconducting link (2)

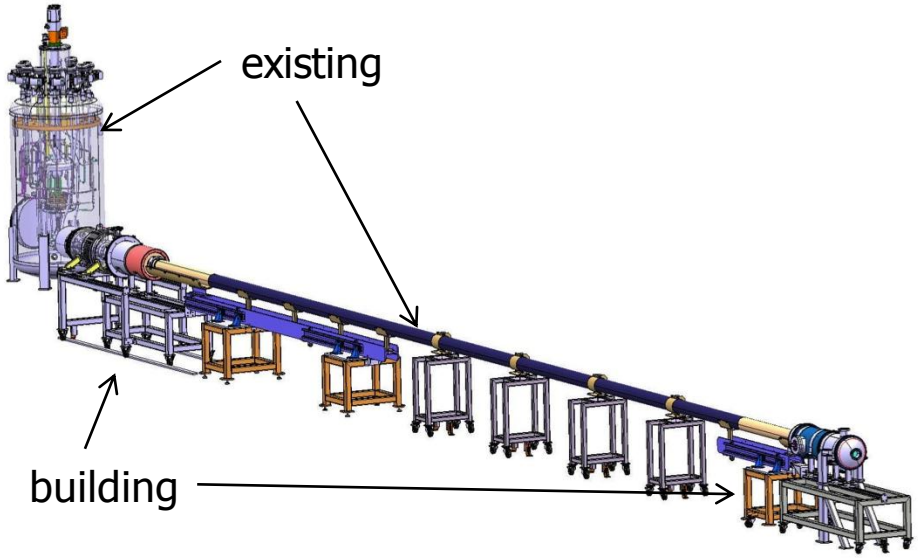
Ongoing:

1) Design of cabling machine for assembly of 20 m long cable of link at CERN
2) Construction at CERN of a test station for the test of prototype link
3) Upgrade of DAQ at the University of Southampton for the test of 5 m long prototype links assembled at CERN









Task 5: High Tc superconducting link (3)

- Task on schedule:
  - The cabling machines are planned to be fully commissioned by end of summer 2012, when cabling of 20 m long HTS cables will start.
  - Assembly of prototype link: planned to be ready by Q3 2012.
  - Test at CERN end this year
- This work is needed for the LHC and is a HL-LHC priority activity

Task 6: Short period helical undulator (1)

Short period undulator for the ILC positron source

Jim Clarke (STFC-DL) STFC (DL and RAL)

Period 11.5 mm , field >1 T

Aim :

- fabricate and test a short helical undulator prototype using Nb_3Sn wire.
- With: 11.5 mm period and winding bore of 6.35 mm.
- Nb_3Sn usage for high current density and large thermal margin to go higher than the 0.86 T (on axis B) achieved for Nb-Ti

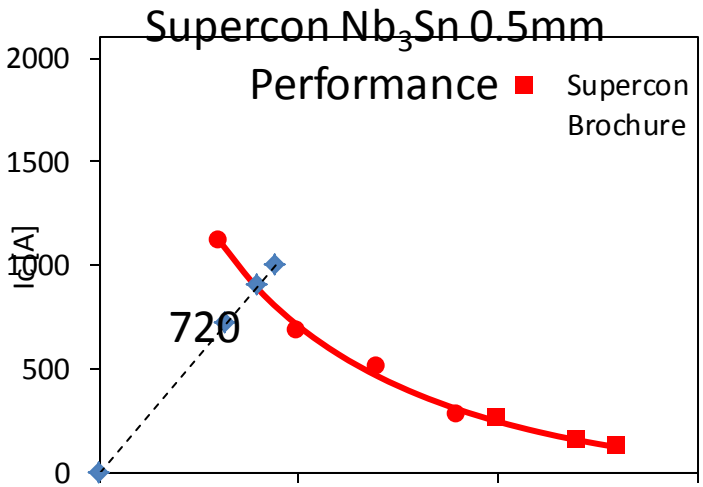
Primary challenges:

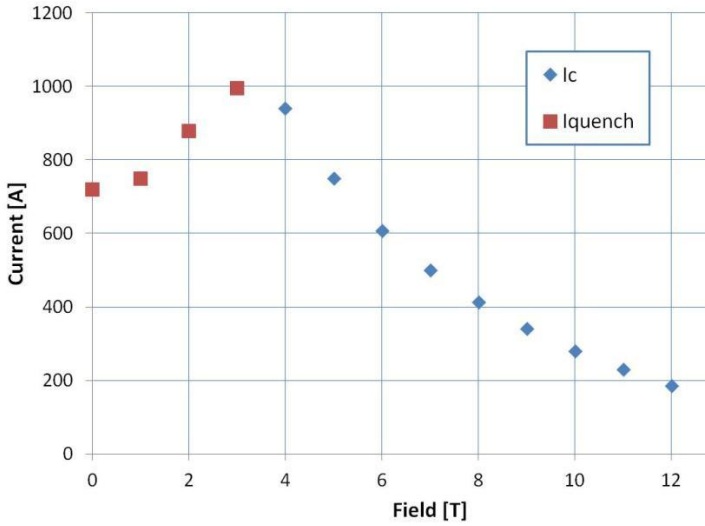
- The Nb_3Sn conductor
- Nb_3Sn insulation system (compatibility with heat treatment at 650C)
- Thin insulation (high current density).

Task 6: Short period helical undulator (2)

- High J_c performance Nb3Sn displays magneto-thermal instabilities at low fields.
- RRP (OST) 0.5 mm strand is too unstable (too performant !) for the undulator
- Supercon 0.5 mm strand is less unstable: tested at Supercon and CERN
  - Will probably limit the I_c to <720 A

So, build, test and see !

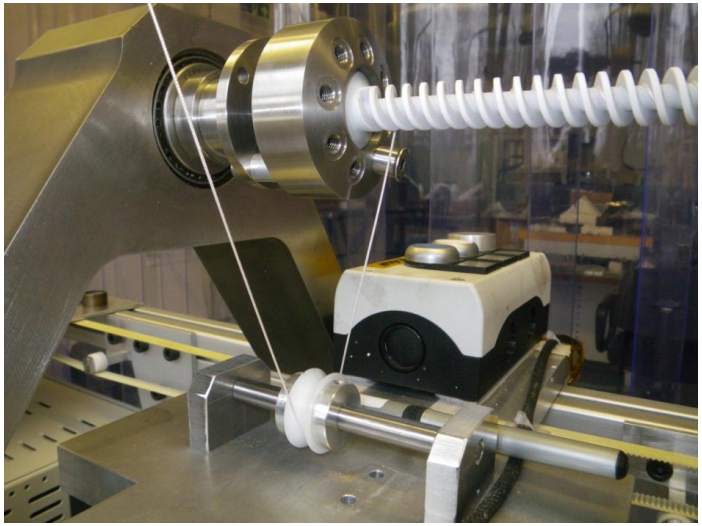




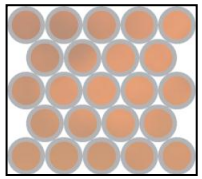
Courtesy J. Clarke, G. Ellwood (STFC)

Task 6: Short period helical undulator (3)

- First test winding of wiggler done (with no bore)
- Developments done:
  - Winding technology of helical coils with single wires)
  - Mechanical: Beam-tube & helical Fe form
  - Insulation (coatings)
  - Impregnation (charge epoxies)
- 2 protos will be made (same length 30 cm)
- Will be on-time



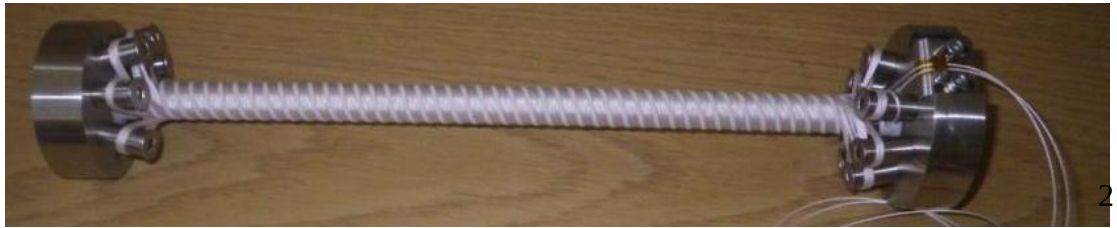
Courtesy J. Clarke, G. Ellwood (STFC)



Hex packing

3.25 mm wide

PF = 48 %



Milestones

Mile-stone	Description/title	Nature	Delivery month	Comment	
7.1.1	1st annual HFM review meeting	O	M12		done
7.1.2	2nd annual HFM review meeting	O	M24		done
7.1.3	3rd annual HFM review meeting	O	M36		done–24/4
7.1.4	Final HFM review meeting	O	M48		
7.2.1	Methodology for the certification of radiation resistance of coil insulation material	R	M30		done
7.2.2	Preliminary heat deposition model for a dipole Nb_3Sn model magnet	R	M12	publication on web	done
7.2.3	Engineering heat deposition model for a dipole Nb_3Sn model magnet	R	M24	publication on web	done
7.3.1	First Dipole Nb_3Sn coil finished	D	M45	1 coil ready for mounting	
7.3.2	Dipole Nb_3Sn model magnet finished	D	M42	Ready for cold test	error
7.4.1	HTS conductor specifications for insert coils	R	M12		done
7.4.2	Two HTS solenoid insert coils	D	M30		done
7.5.1	Final design report HTS link	R	M34		Done 23/4
7.6.1	Short prototype SC helical undulator fabricated and tested	D	M36		

Deliverables

Deliverables of tasks	Description/title	Nature	Delivery month	
7.1.1	HFM web-site linked to the technical & administrative databases	O	M48	
7.2.1	Certification of the radiation resistance of coil insulation material	R	M42	Delay M48
7.2.2	Thermal model for a dipole Nb_3Sn model magnet	R	M36	Done - tbu
7.2.3	Superfluid helium transport model for the thermal design of the high field model magnet	R	M43	
7.3.1	Dipole model test with one superconducting coil; results analyzed	R	M48	redefine
7.4.1	A HTS dipole insert coil constructed	D	M48	redefine
7.5.1	HTS 20 m 600 A link assembled	P	M40	
7.6.1	Final prototype SC helical undulator measured	R	M48	

Task3 (dipole) proposal for new deliverables:

- Design report by M45
- All components procured for the single sc coil magnet M48
- LN2 test of structure M48

Task4 (insert) proposal for new deliverables:

- Design report M45
- All components procured for the insert M48
- Small single pancake coil tested M48

Conclusions

- All task will successfully conclude scientific and engineering point of view

- The timing is sliding for the dipole and the insert beyond the end of EuCARD