Critical aspects in the development of a curved fast ramped superconducting dipole for FAIR SIS300 synchrotron.

P.Fabbricatore[1], F. Alessandria[2], G. Bellomo[2], S. Farinon[1], U. Gambardella[3] , J.Kaugerts[4], R.Marabotto[5], H.Müller[4], R.Musenich[1], G.Moritz[4], M. Sorbi[2], and G. Volpini[2]

(1) INFN-Genova, Italy

(2) INFN-LASA and Milan University, Physics Department, Italy

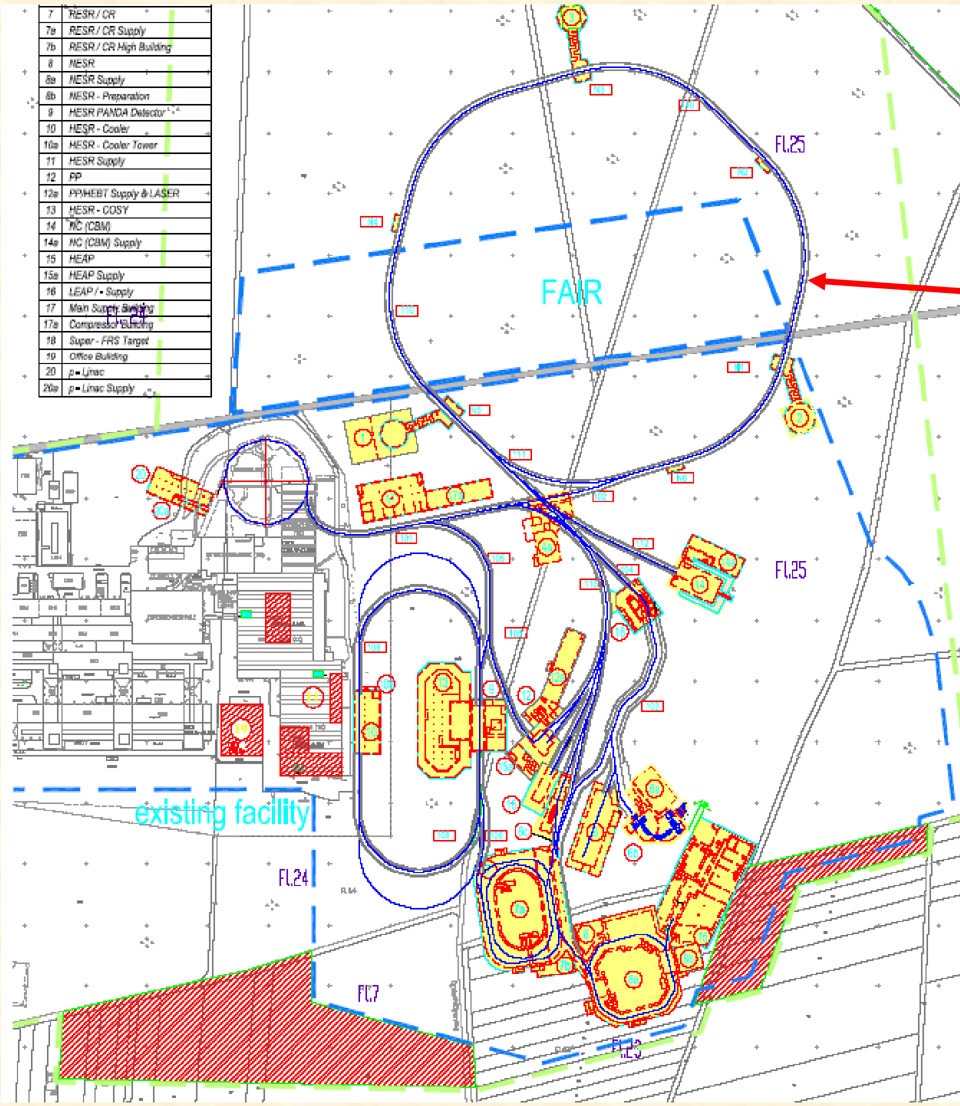
(3) INFN-Laboratori di Frascati, Italy

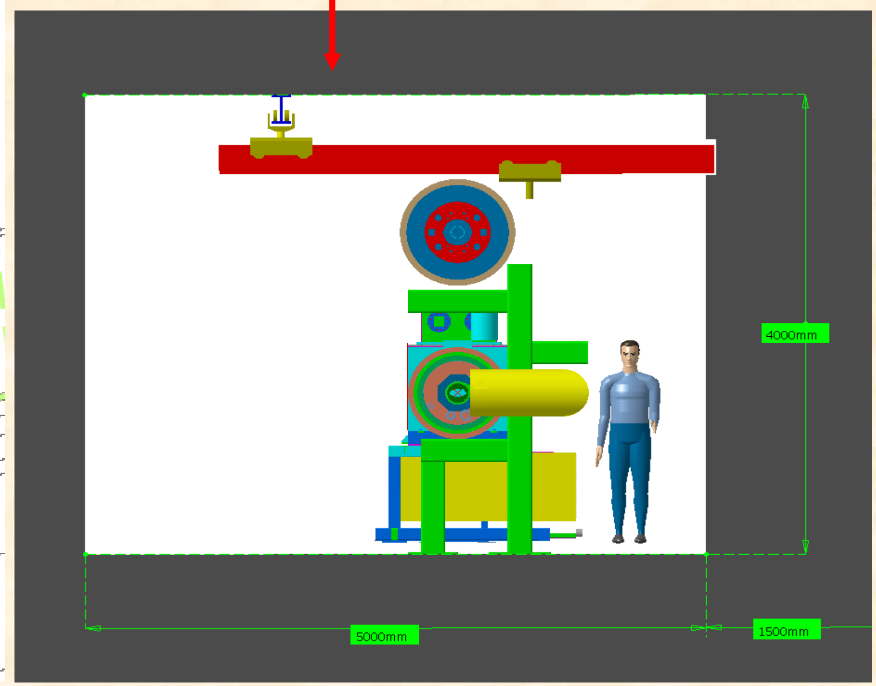
(4) GSI-FAIR, Germany

(5)ASG-Superconductors (former Ansaldo), Genova, Italy,

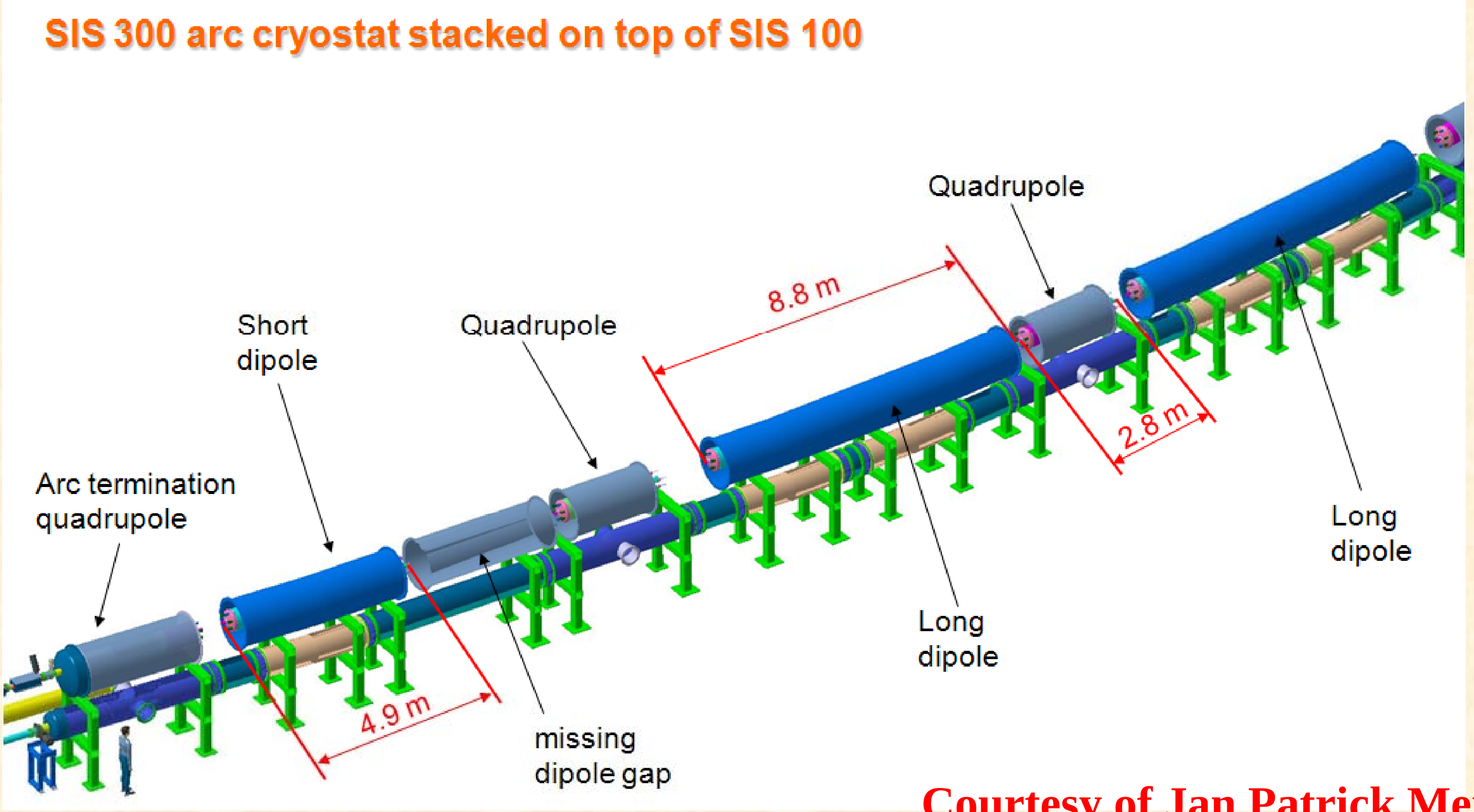
The facility **FAIR** including the synchrotrons

SIS100 and SIS300





48 long dipoles – Magnetic length 7.89 m
12 short dipoles – Magnetic length 3.94 m



Courtesy of Jan Patrick Meier

We are working on the development of a design for these magnets. The achievement of this target is passing through a R&D activity aimed to the construction of **a model of the short dipole**.

Nominal field	4.5 T
Ramp rate	1.0 T/s
Radius of curvature	66 1/6 m
Magnetic length	3.784 m
Bending angle	3 1/3 deg.
Coil aperture diameter	100 mm
Max operating temperature of LHe	4.7 K
Current sharing temperature	5.7 K
Operating conditions (fraction of I_c on the load line)	69%

Criticities of SIS300 dipoles→ Demand for R&D

1) Ac losses

The ac losses in the cable depend on **B** and **dB/dt**. The heat generated shall be efficiently removed for avoiding premature quenching. The ac losses shall be kept at a minimum level for keeping the cryogenic costs at an acceptable level

	Aperture (mm)	B (T)	dB/dt (T/s)	Q (W/m)
LHC	53	8.34	0.0075	0.18
RHIC	80	3.5	0.07	0.35
SIS300	**100**	4.5	**1**	**<10**

→Development of a low loss conductor (G.Volpini presentation yesterday)

→ Maximize the heat flow to the coolant

Contribution to ac losses (ramping) 34.4 W

Hysteresis	36.5 %
Coupling Strand	10.7 %
Interstrand Ra+Rc	5.9 %
Total conductor	(53.1 %)
Collars + Yoke eddy	4.0 %
Yoke magn	16.2 %
Beam pipe	12.2 %
Collar-Keys-Pins	8.7 %
Yoke-Keys-Pins	5.8 %

(M.Sorbi presentation tomorrow)

2) Manufacturing difficulties

The need of a low loss conductor imposes the use of a cored cable, stiffer than a simple Rutherford cable, so making the winding harder

The curvature of R=66.67 m (sagitta 120 mm on long dipoles and 28 mm on short ones) introduces further manufacturing complexity

→ Development of the winding technologies for curved poles with cored cable. This activity is under progress in ASG-Superconductors. At present we have many evidences that a suitable manufacturing methodology can be obtained

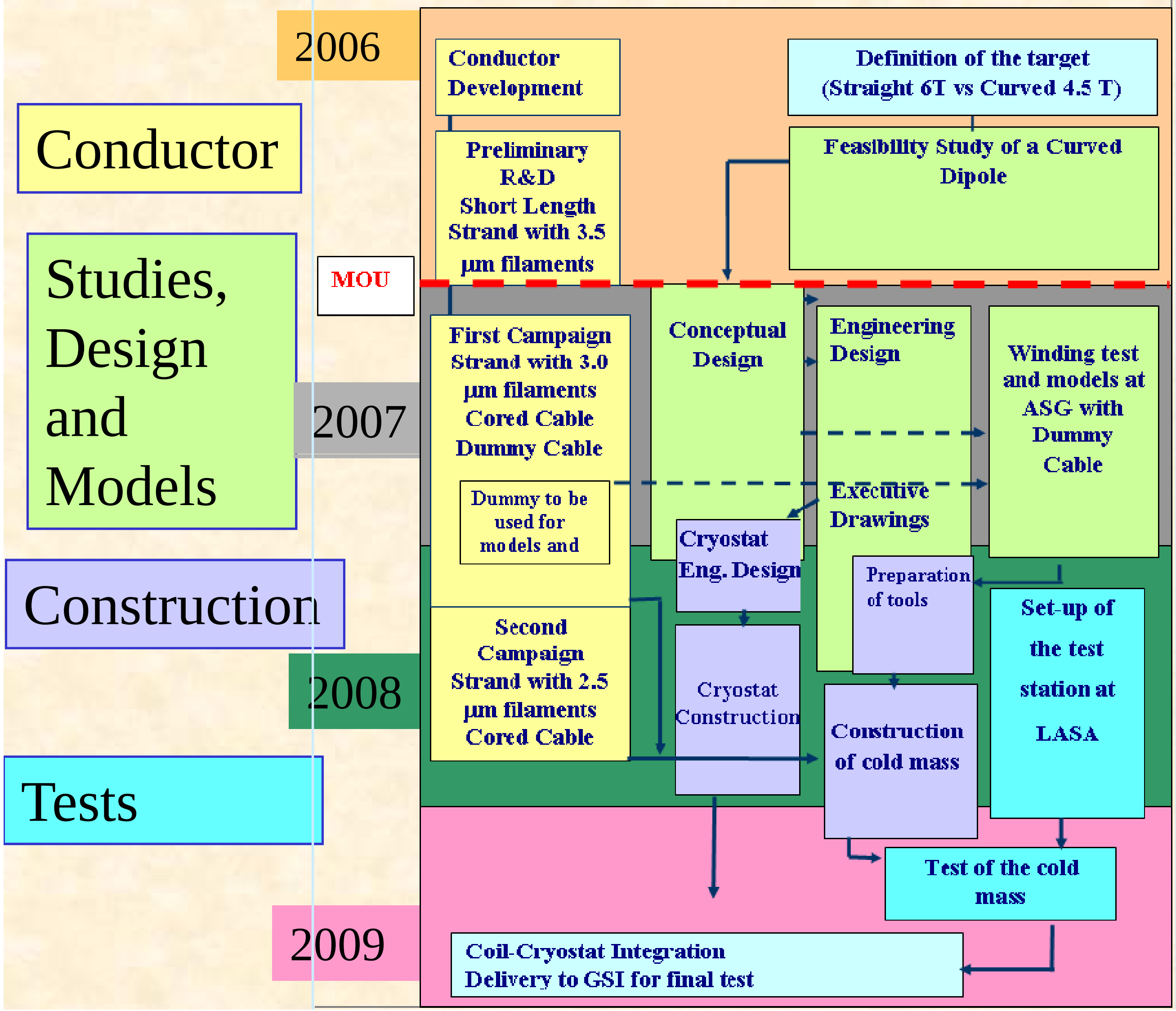
3) Fatigue load

The magnets shall be cycled 10 million times, consequently the design shall be optimised in view of severe fatigue loads. Radiation effects may even weaken the material with respect mechanical and electrical strength.

→ Mechanical design optimization to be checked through experimental results on the model

(See S. Farinon presentation)

MASTER PLAN OF THE R&D ACTIVITIES: **DiSCoRaP**



The INFN R&D program for curved SIS300 dipole

Final goal:

3.8 m long

4.5 T

curved **model dipole** in its horizontal cryostat

We are moving according our starting assumptions:

1) **The coil should be wound curved**

This solutions allows defining without uncertainty the geometrical dimensions of a curved stress-free coil.

Once cured, the coil can be handled in simple and safe way for the following manufacturing operations (collaring, insertion in the iron yoke, …).

2) A single layer coil mechanically supported only by the collars.

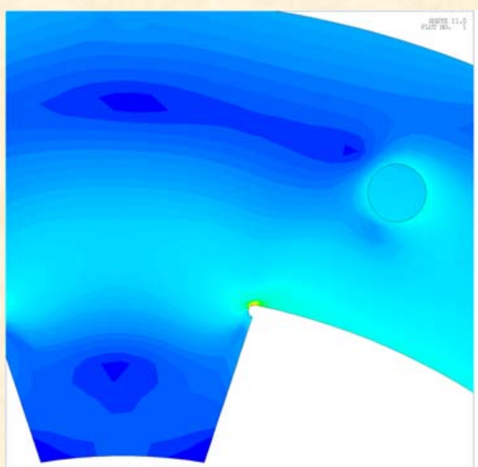
These important choices was based on the reason that the **mechanical coupling between two curved layers or between a curved collared coil and a curved yoke appeared to be critical operations.**

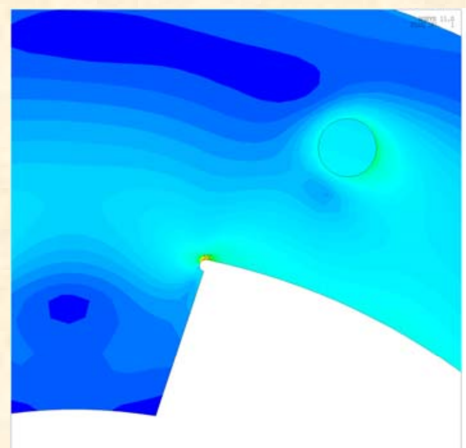
Nevertheless fatigue problems in the collar led us to give some mechanical roles to the iron lamination for limiting the coil-collar deformation during enegization

energization @ 4.5 T

peak VM stress=579 MPa

Only collars provides the mechanical strength





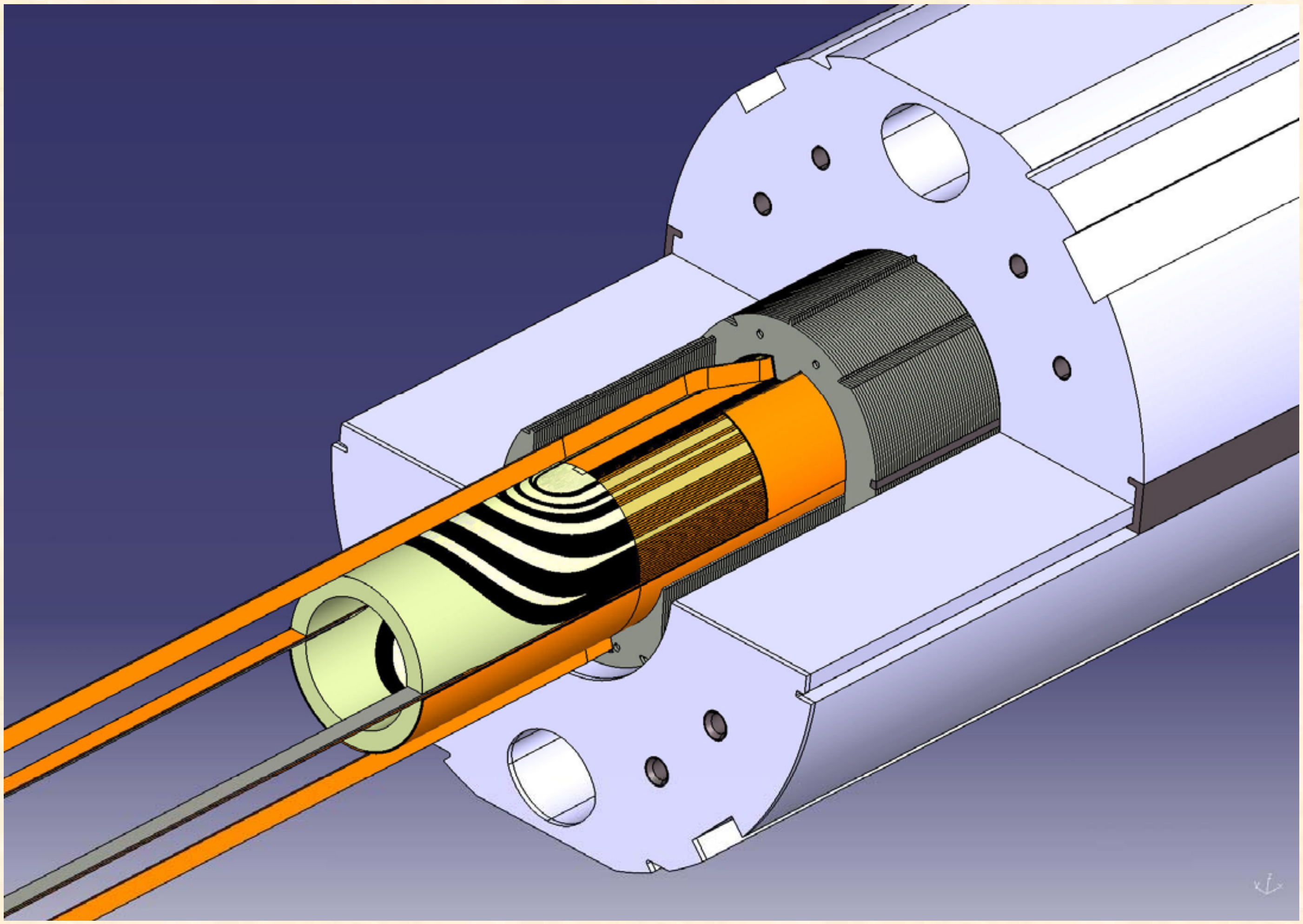
energization @ 4.5 T

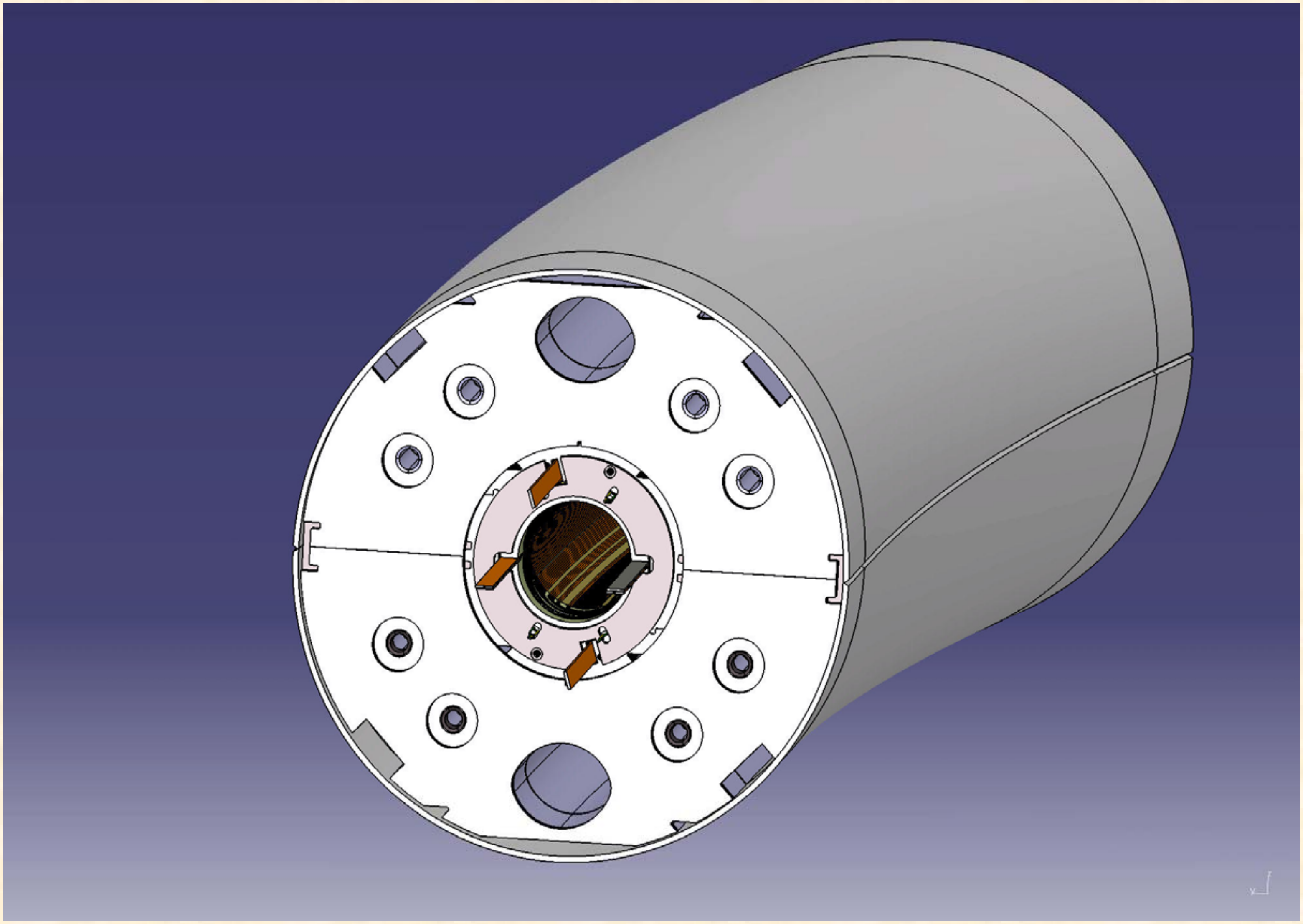
peak VM stress= 338 MPa

Iron laminations limits deformations

(See S. Farinon presentation)

The design of the model is close to be finalised (Summer 2008)





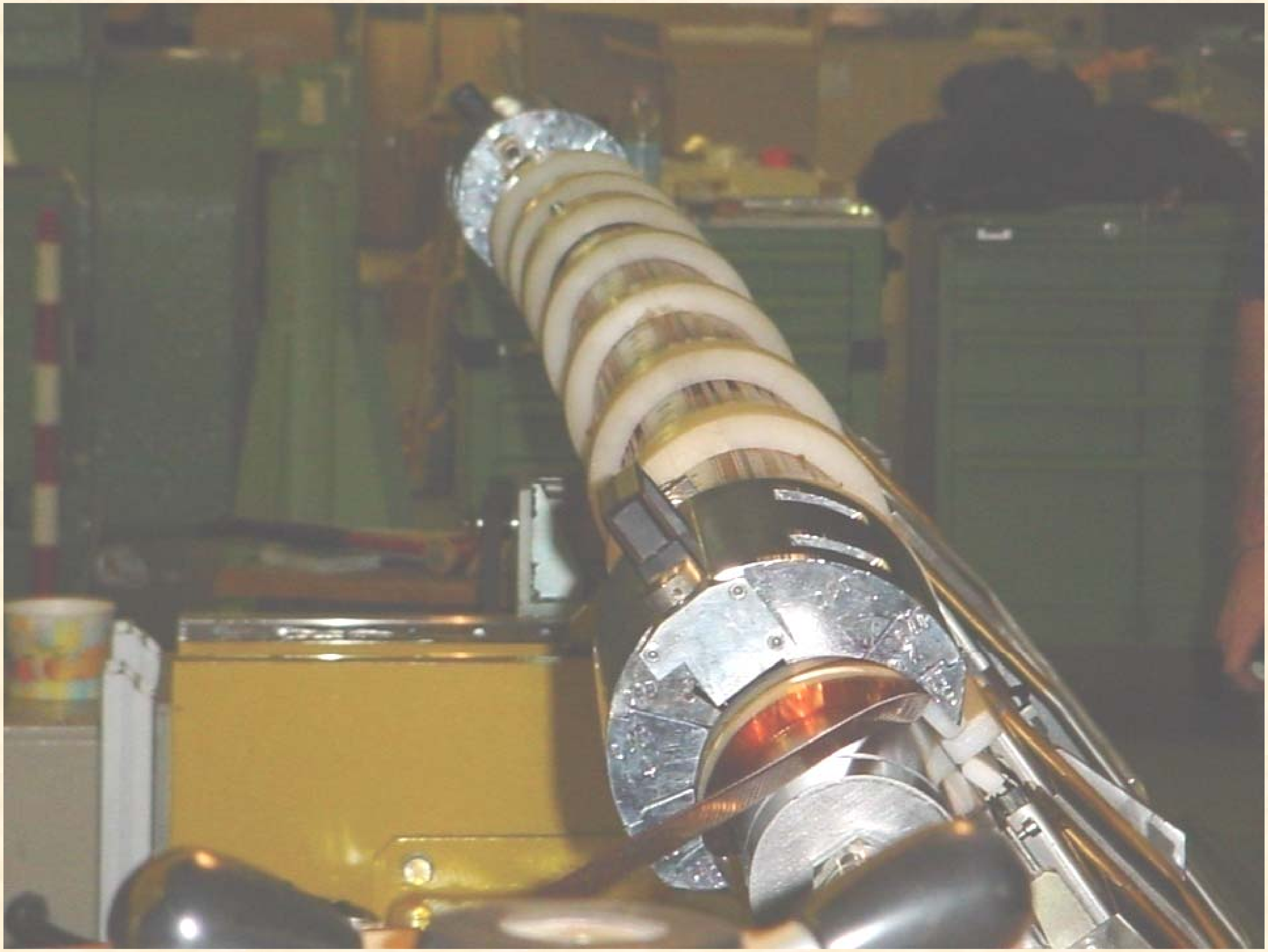
Winding activities ongoing at ASG Superconductors

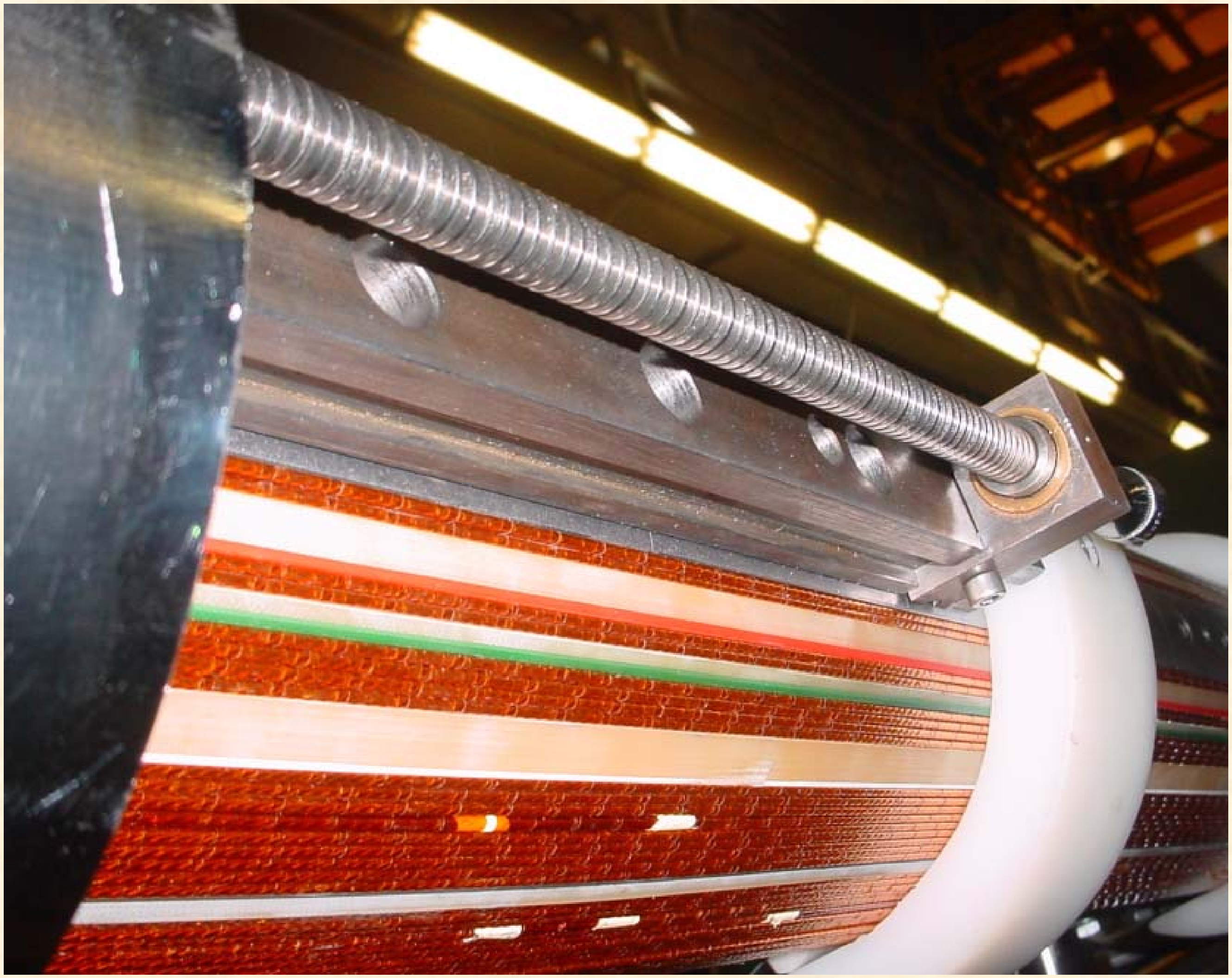
Target: Cured poles construction with a dummy cored cable for assessing the winding technology

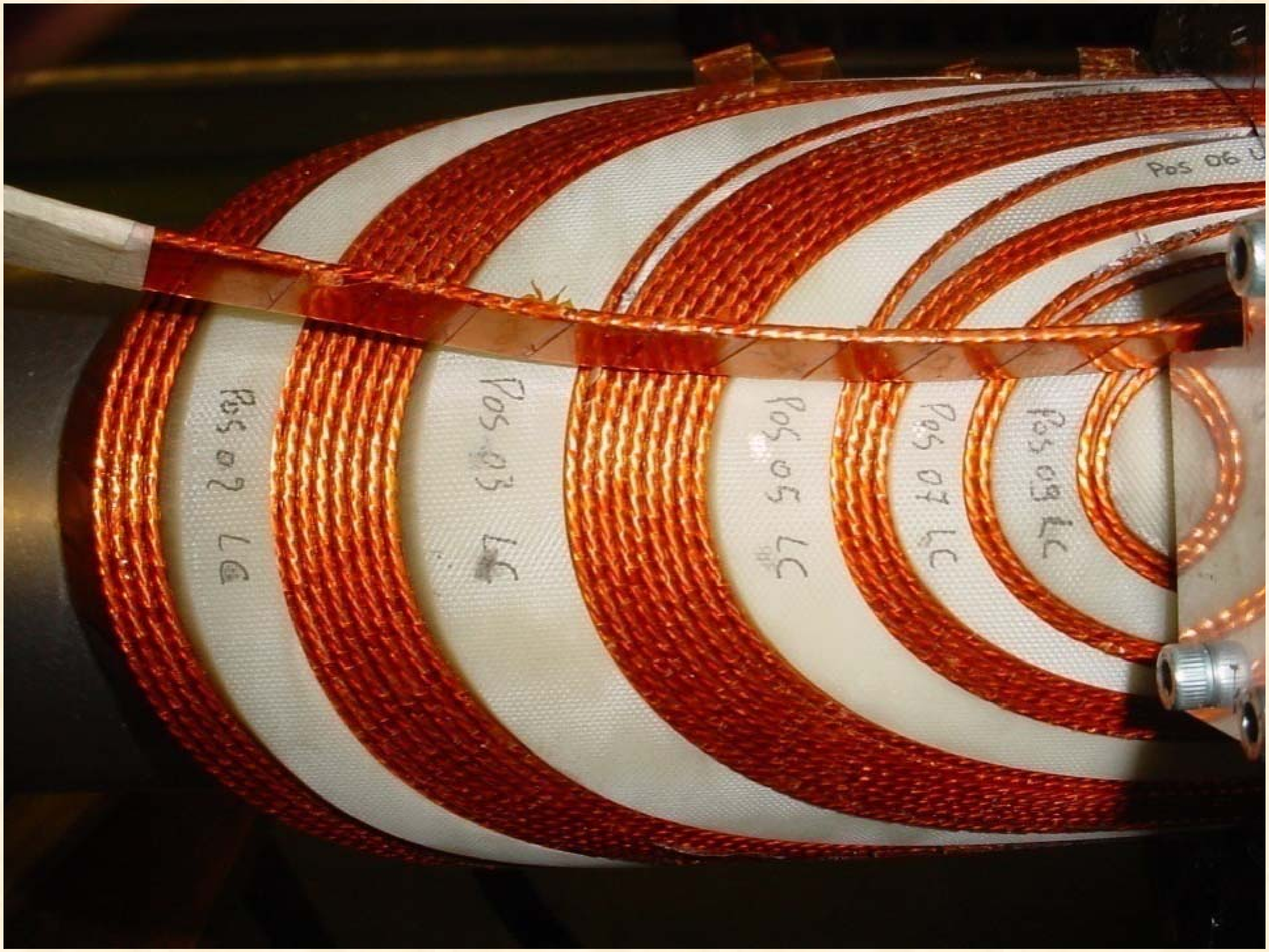
The curved mandrel was constructed using wire-spark erosion technique.

The manufacture of this component was difficult due to the curvature and the tight tolerances

Winding tests with LHC outer layer conductor



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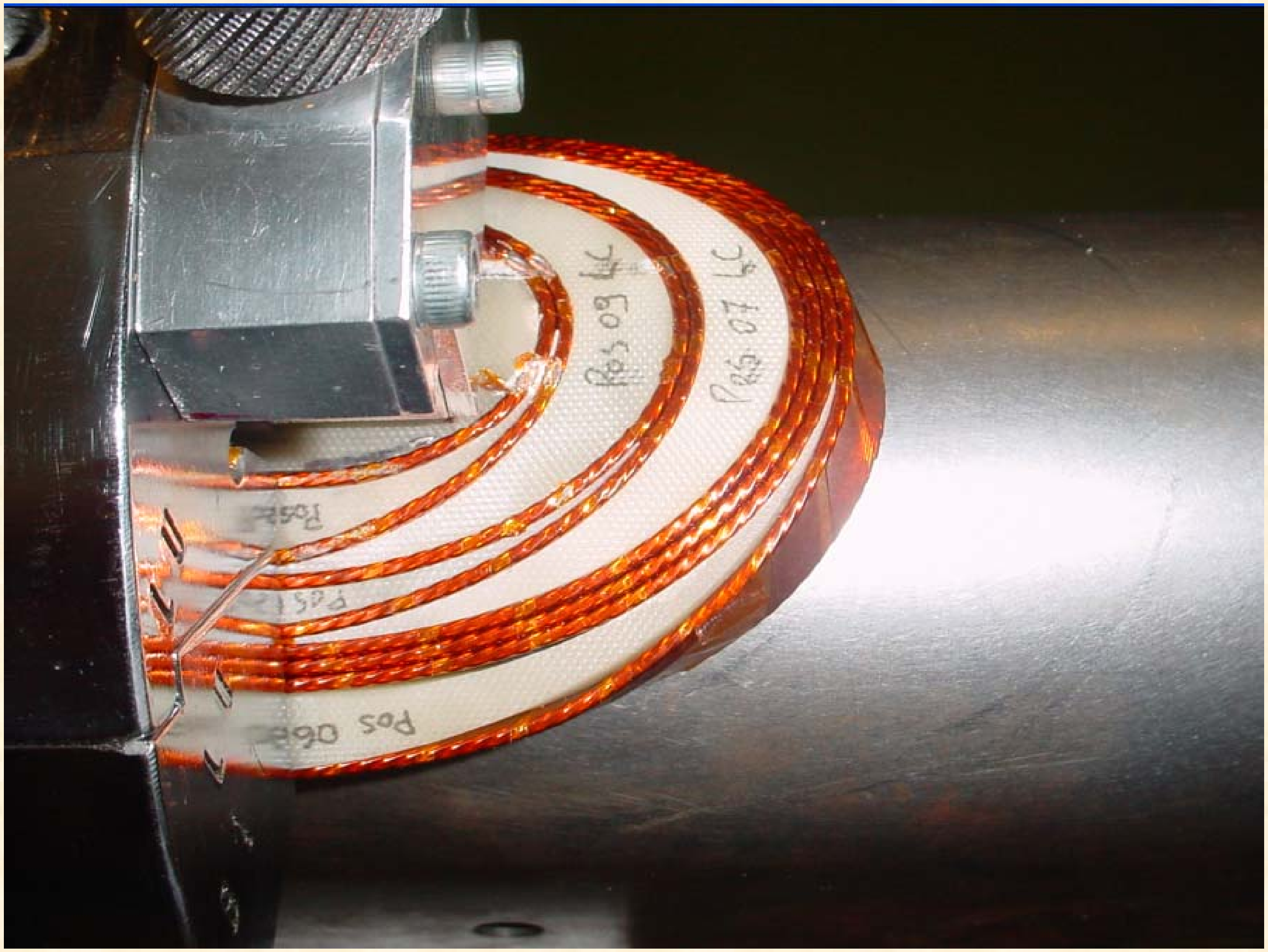
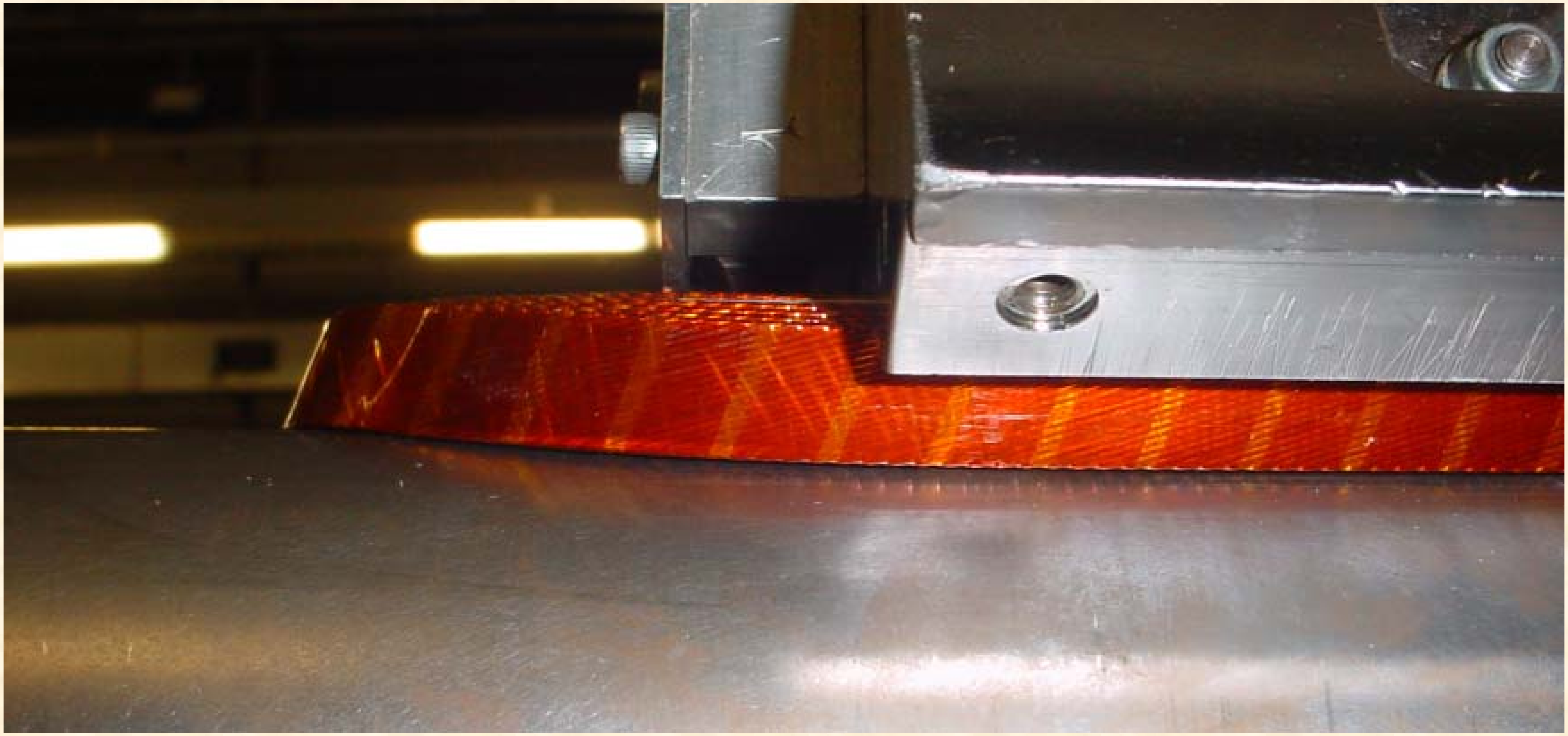
Winding tests with cored cable



The winding operation involving the cored cable has been completely implemented and now we are ready for constructing the poles to be cured. This will conclude the winding test.



Conclusions

Low loss cable, heat removal, fatigue, methods for manufacturing a curved winding are the main problems we are facing with the R&D activity DiSCoRaP .

Design, winding test and conductor development are going on with the final target of a model coil in its horizontal cryostat ready within 2009.

At present we have not found major problems. The winding tests are giving encouraging indications.