ASG presentation and activities

Roberto Penco (consultant to ASG)

The near past:

Ansaldo Superconduttori

ACTIVITY		SITE
LHC	Dipoles (30+386)	Internal area (14000 m^2)
LHC	Corrector Quadrupoles (200+50)	ORMET (300 m^2)
CMS	Solenoid (5 modules)	SEIGEN (2700 m^2)
W7X	Stellarator (30 non planar coils)	BIC (1200 m^2)
ATLAS	Barrel toroids (16 coils)	Internal area

180 workers

70 employers

LHC - Internal Clean Area

LHC - ORMET Area

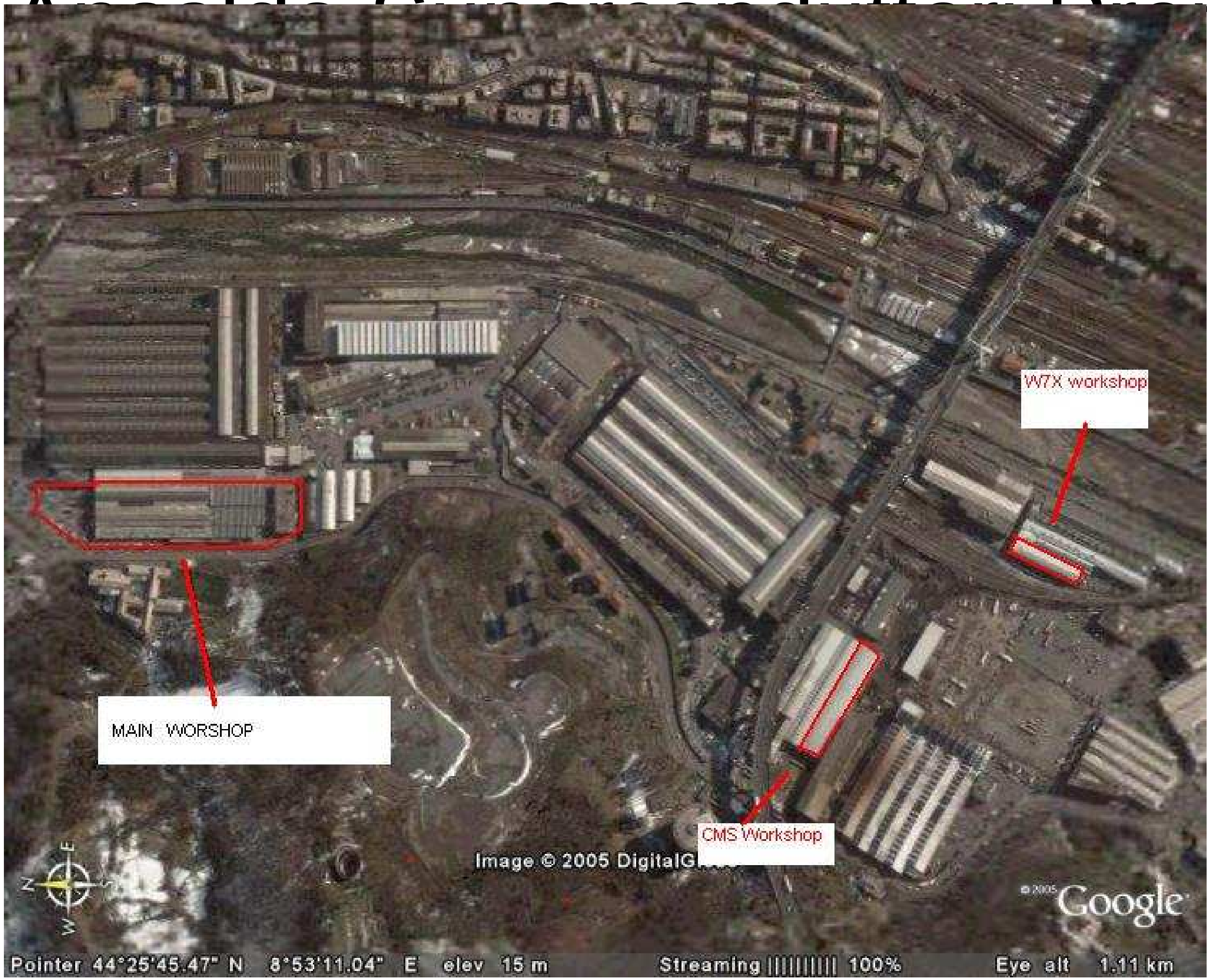
CMS - SEIGEN Area

CMS - SEIGEN Area

W7-X - BIC Area

Atlas-internaal area

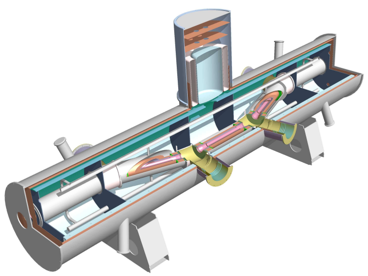
Ansaldo Superconduttori Premise



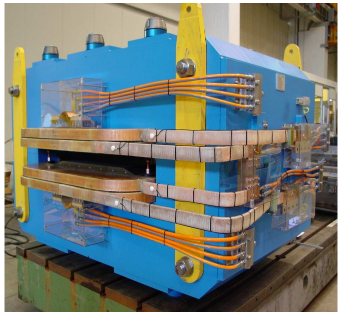
Nowadays:

capability to expand and contract workers and workshops

ACTIVITY		
EFDA GYROTRON (8T)	**delivered**	60 workers
CNAO ACCELERATOR RESISTIVE MAGNETS	**almost finished**	50 employers
KATRIN DPS2		
ITER impregnation sample		
SIS300 dipole prototype (DISCORAP)		
MgB2 Activity (MRI , DIPOLE , FCL ecc)		



Katrin DPS



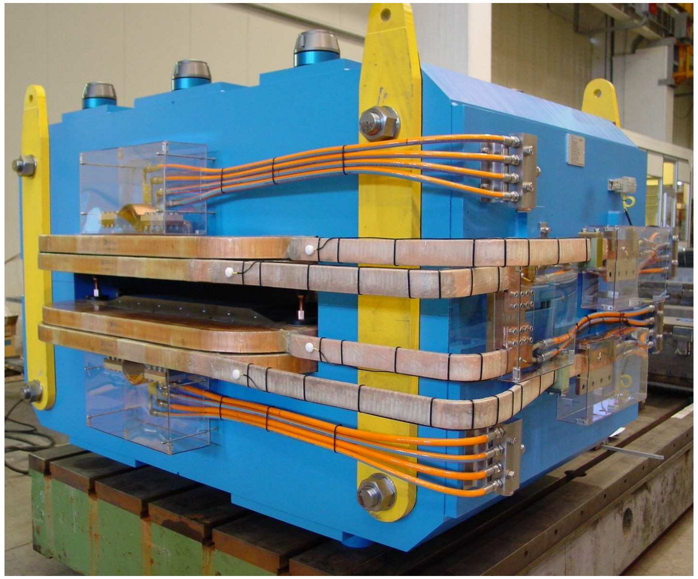
CNAO

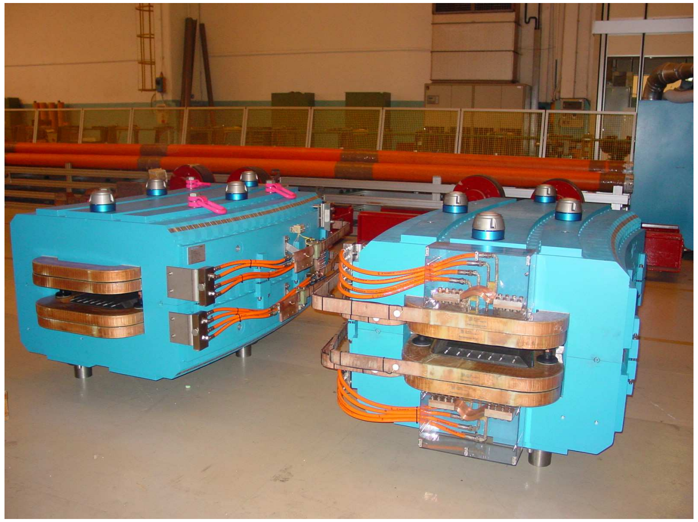
ITER SAMPLE

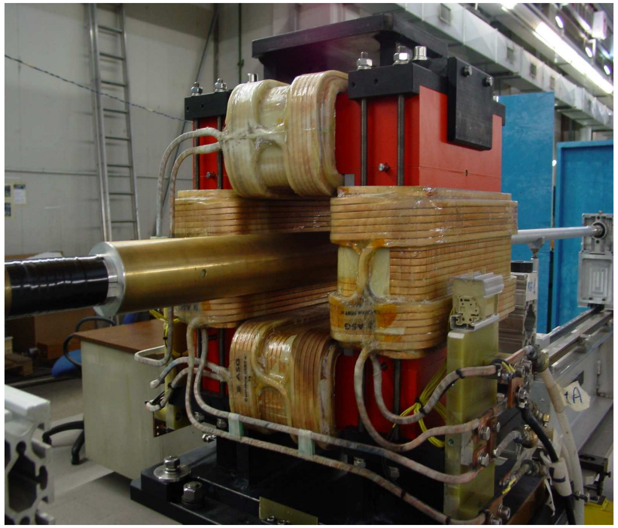
Gyrotron magnet

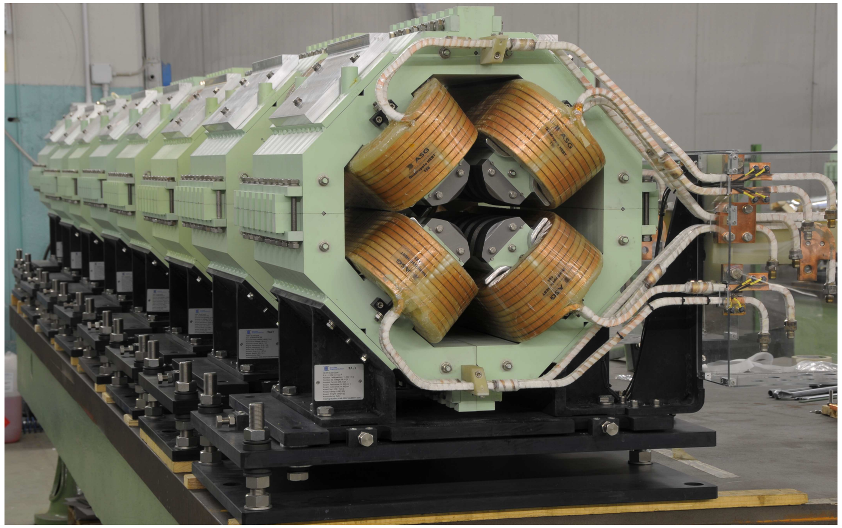
MgB2 MRI

Resistive Magnets for CNAO

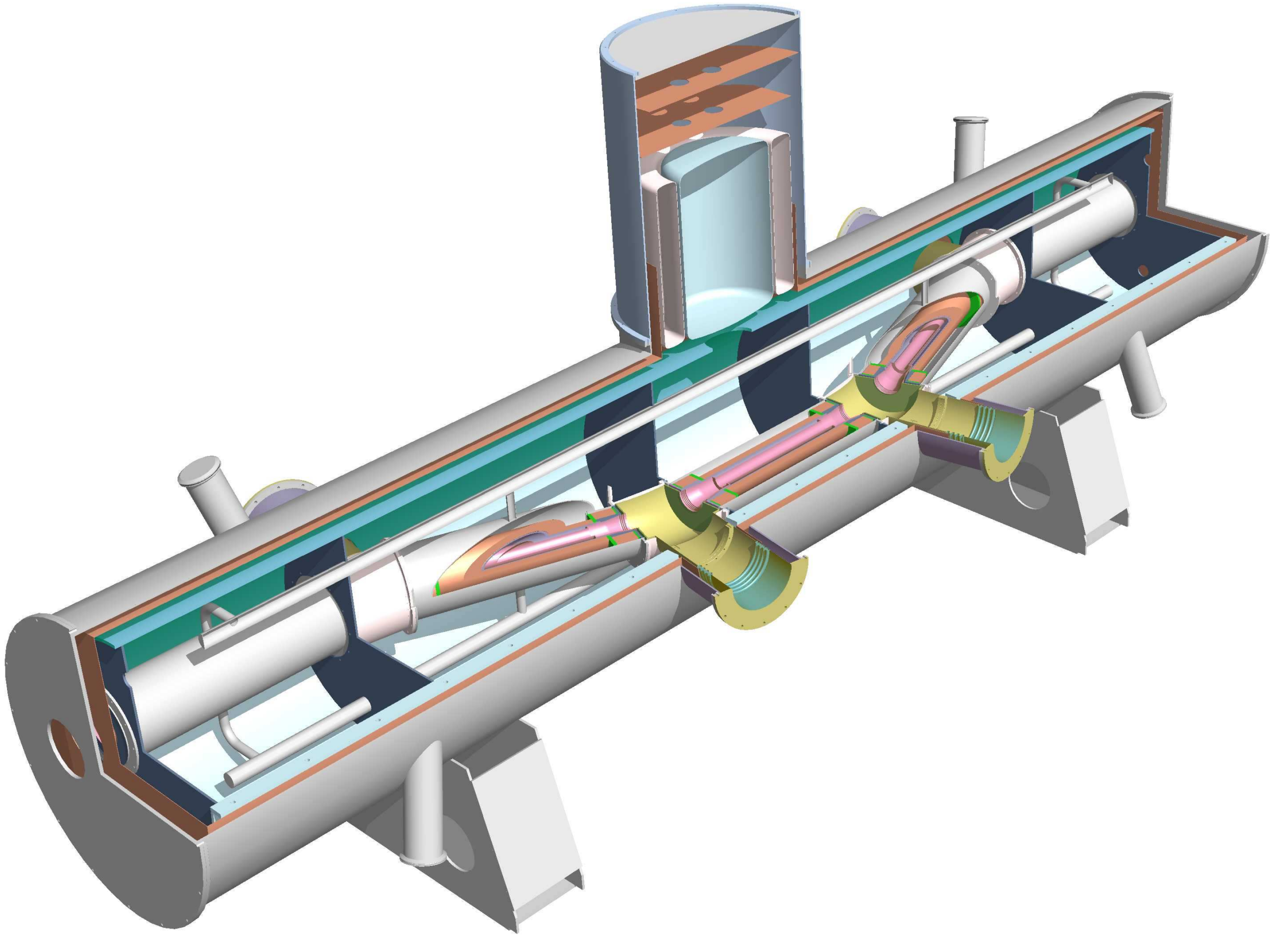








KATRIN – DPS2



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KATRIN – DPS2

To day under final assembly

Factory LHe cryogenic test within few months

Gyrotron magnet for EFDA

ITER impregnation test

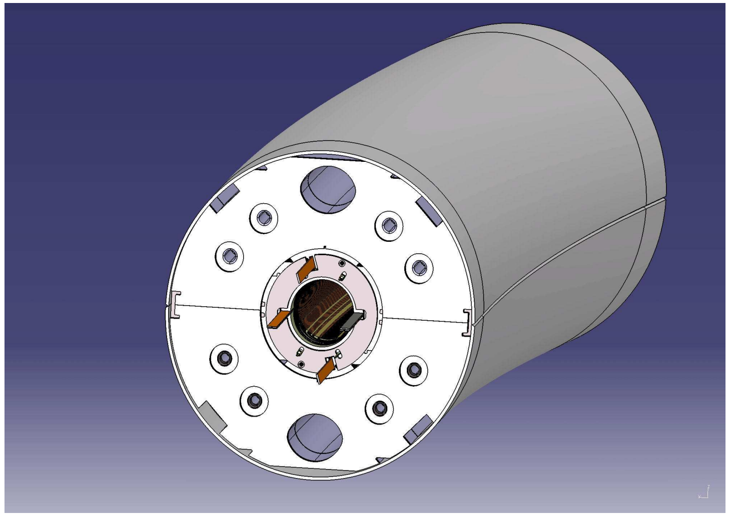
New resin with height neutron resistance capability

60% epoxy

40% cyanoester

SIS 300 – DISCORAP : INFN project

ASG is building a 4 m long SIS300 curved prototype.



A **special winding machine** **able to directly wind curved poles was design , built and successfully tested with several superdummy cables**

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- **Winding of real pole will start soon .**
- **The other tooling to complete the prototype are under construction**

Details will be given in other presentations to morrow

0.5 T MgB_2 magnet for MRI

Why Open MRI?

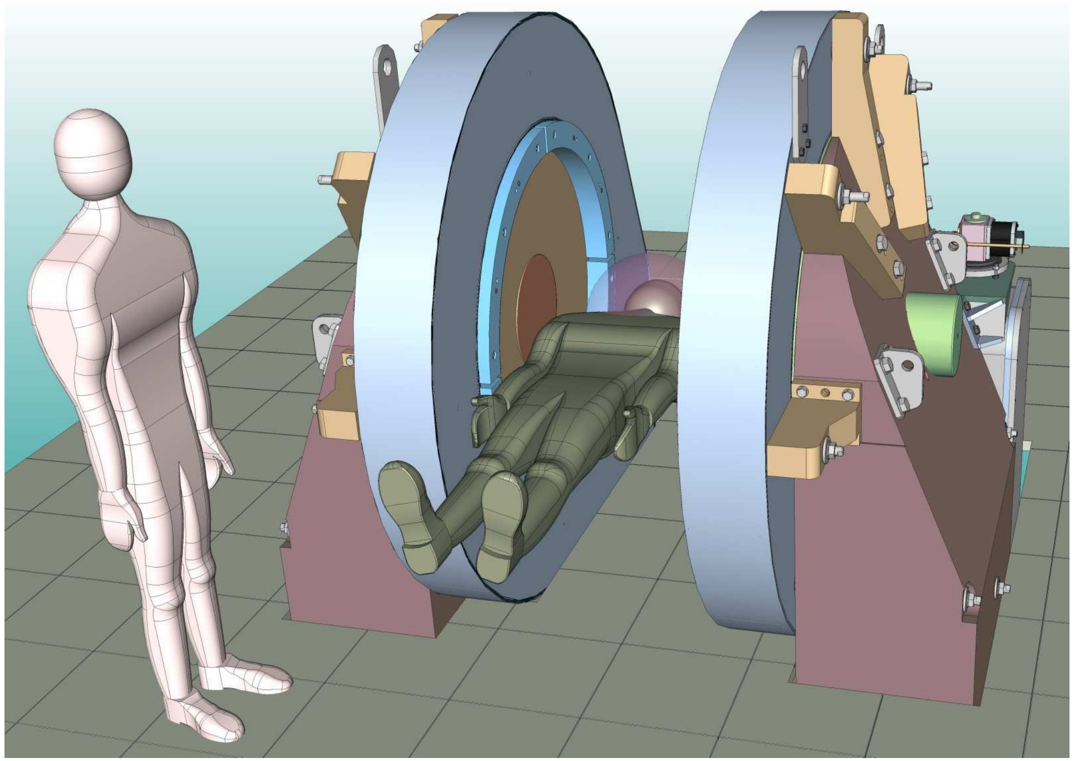
Patient comfort

Open-sky MRI magnets reduce claustrophobic rejection

Flexible positioning
of the patient

Interventional MRI

Possibility of interaction between the surgeon and the patient



Pictorial view of the MR Open installation

Why Cryogen Free?

Quench

No problems of overpressure due to helium boiling inside the cryostat during the transition sc to normal state

Easy installation

Space saving compared to LHe technology

Easy maintenance

No cryogenic liquid refill (cost saving)

Why MgB_2?

Working temperature 15-20 K
Coils cooled by cryocoolers only (much easier and more efficient than for LTS also considering possible He shortage)

Cheaper than the other HTS tape (BSCCO)
Lower cost of materials and simple manufacturing process.
Cost reduction up to 1-2 $/KAm expected

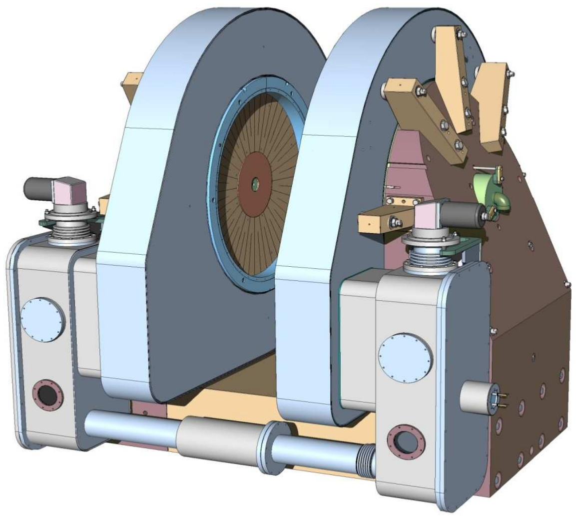
Reacted and wound coils
No heat treatment after the coil fabrication,
no high T resistant materials,
of course need care in the winding operation

The Prototype Magnet

The Magnet "MR Open"

Magnet assembly

The magnet consists of a U-shape ferromagnetic yoke and two MgB_2 coils (one for each pole, 12 DP total)

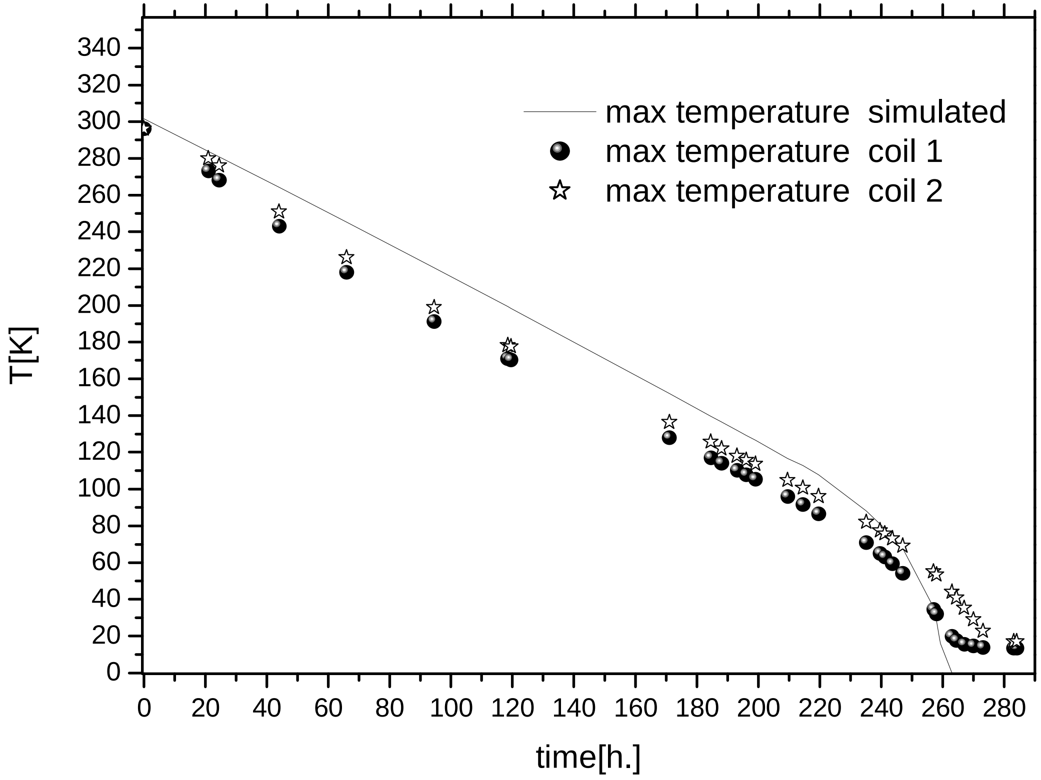


The magnet "MR Open"

Main Magnet Parameters	
Nominal Field	0.5 T
Peak Field on the Conductor	1.3 T
Nominal Current	90 A
Number of Pancakes	12
Conductor Length (total)	18 Km
Inductance	60 H
Overall Dimensions	2x2x2.4 m
Patient Available Gap	0.6 m
Weight	25000 Kg

Cryogenic Tests

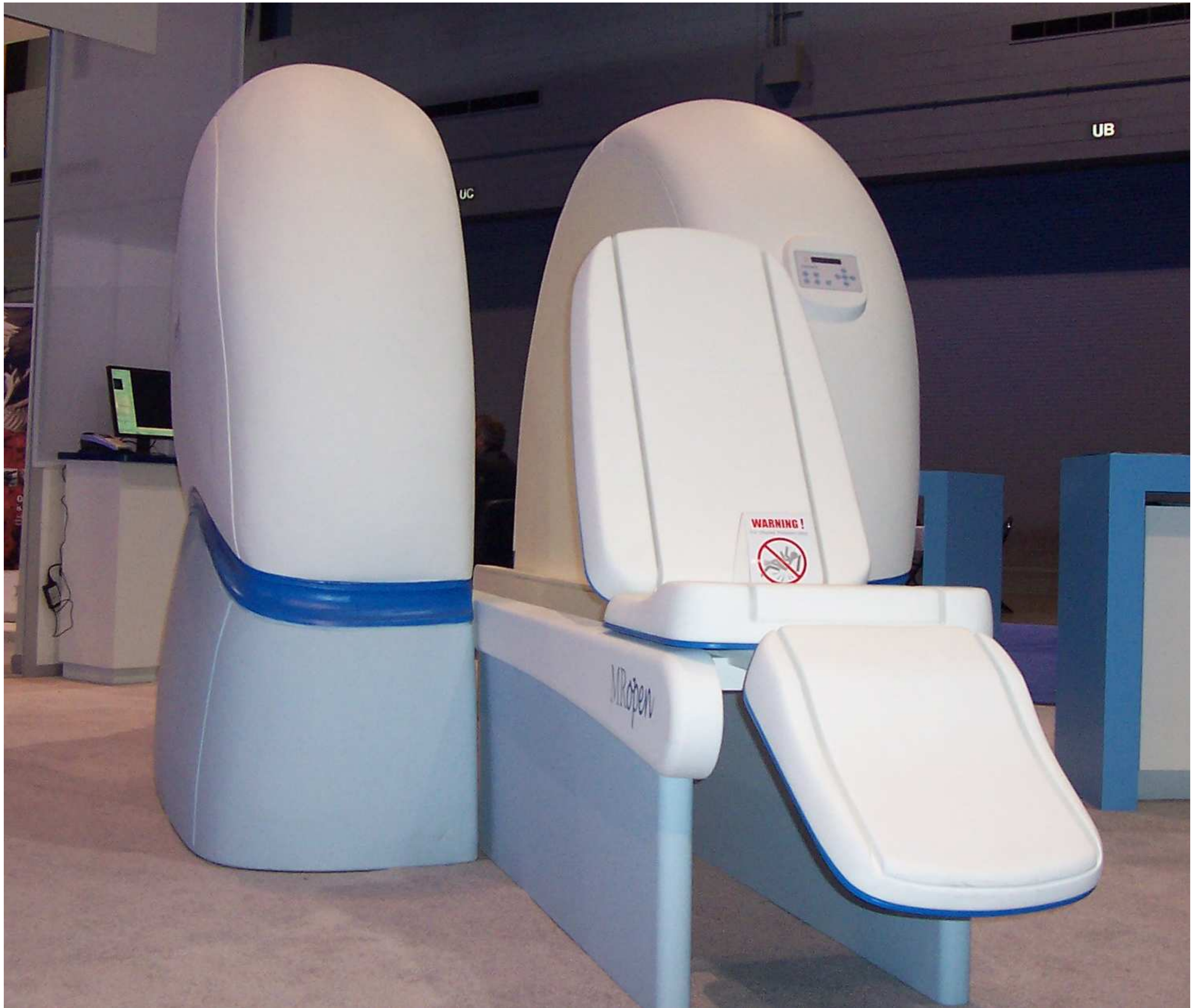
Cooling down parameters	
Cooling down time	11 days
Max T difference in the cool-down	25 K
Max T difference in steady state	1 K
Min T achieved	12 K
Static insulating vacuum	<10^{-6} mbar



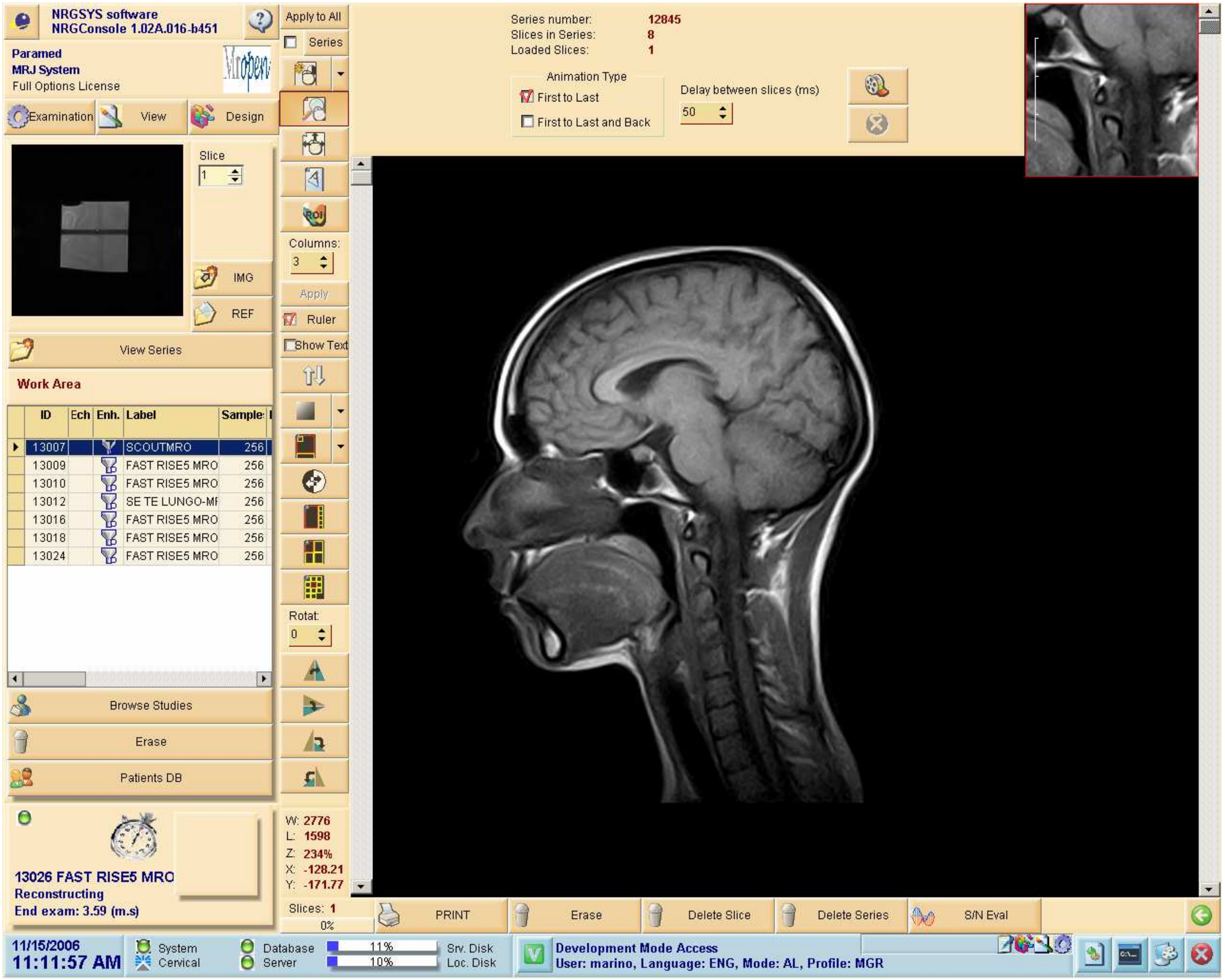
Magnet cool down

Good agreement between measurements and transient thermal FEM calculation (ANSYS)

The “MR Open” Next Generation (3)



MR Images Acquisition (3)



The Second “MR Open” (1)

News from ASG

A magnet, with similar characteristics to the prototype, has been constructed and *successfully tested*

Performances

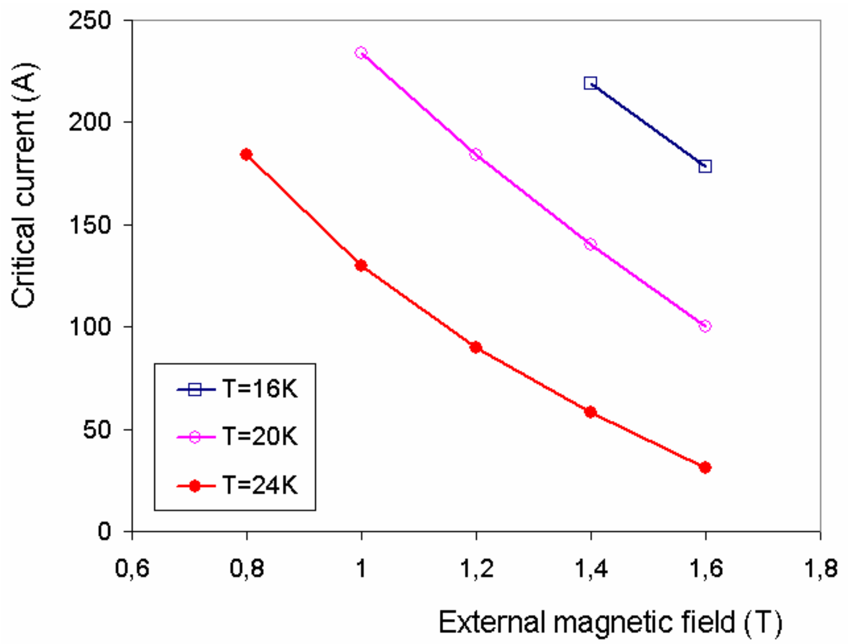
Estimated improved performances (mechanical, thermal, magnetic)

Installation

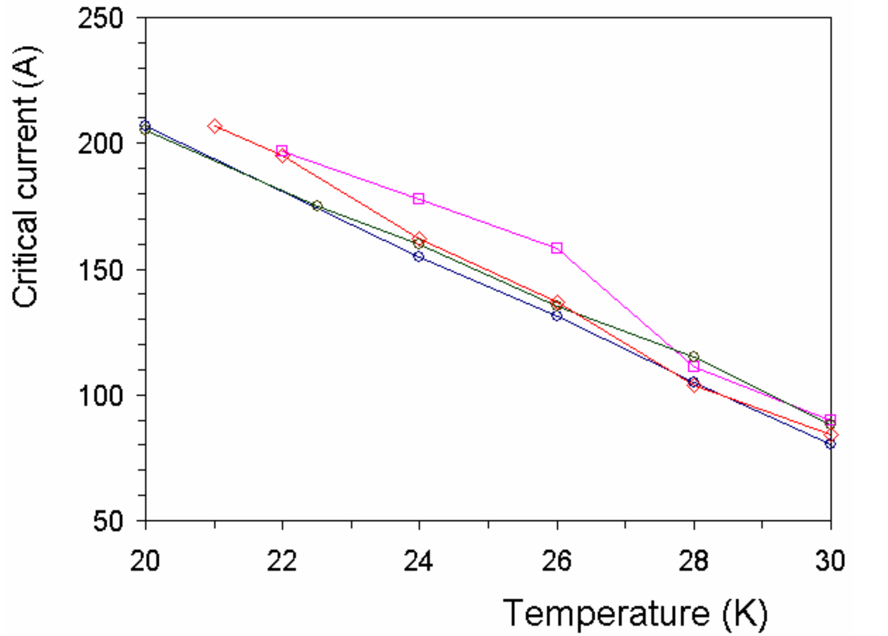
Foreseen in a private clinic in Italy

The second “MR Open” during the assembly

The Second "MR Open" (2)



Characterization of short samples taken from the conductor used for the second magnet.



Quench current of four bunches made by three double pancakes.

⇨ at B=1 T and T=20 K, critical current increased at least of 40% respect to the prototype magnet data (both short sample and double pancakes), hence higher critical current margin.

Conclusion (2)

The second "MR Open"

- A second MR Open, has been constructed and *tested*
- Installation foreseen in a private clinic in Italy
- Several "MR Open" will be manufactured before the end of 2008

The next "MR Open" generation

- ASG is presently involved in the design of total body MR Open magnet (0.6 Tesla, **persistent mode operation**, open, cryogen free, MgB2 windings).

The other ASG MgB_2 projects

Solenoid react & wind cryogenicfree coil the manufacturing

Overall dimensions:
Inner diameter: 135 mm
Outer diameter: 200 mm
Winding height: 175 mm
No. Turns: 980
Tape length: 500 meters

R.Penco

Solenoid react & wind coil – the results(1)

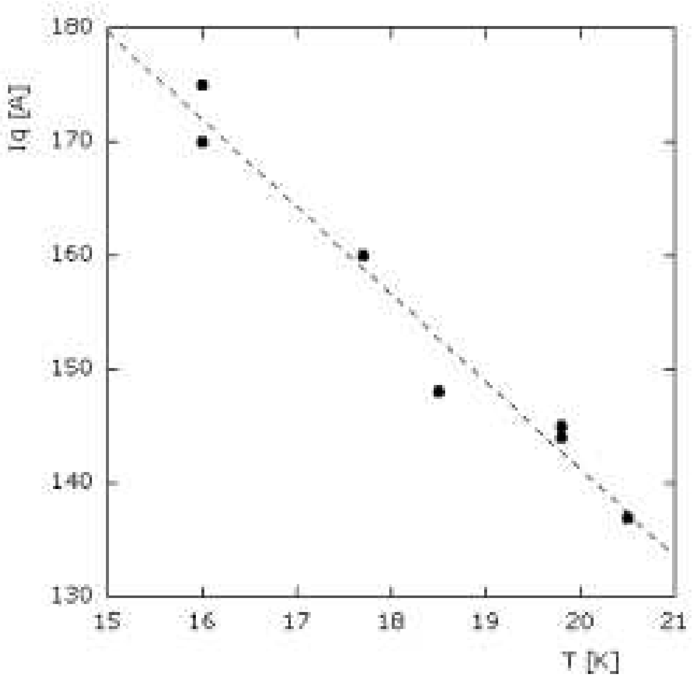


Fig. 7. Spontaneous quenches at temperatures between 16 and 20.5 K

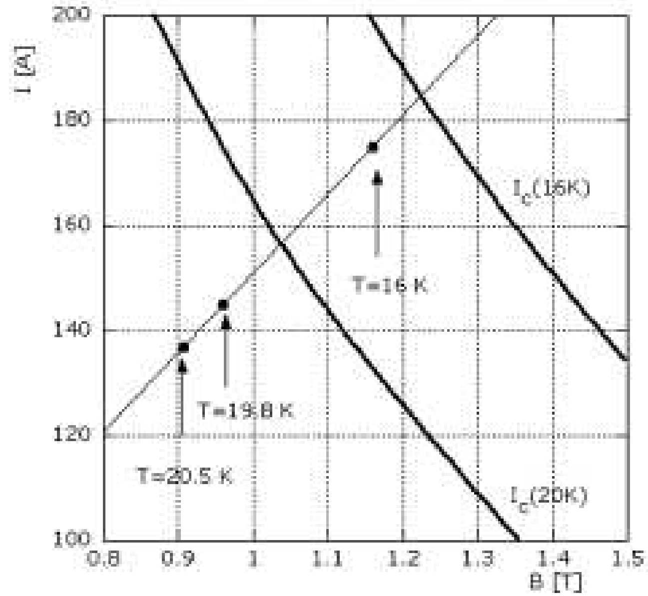


Fig. 8. Magnet load line and wire critical current lines (at 20 K and at 16 K). B is the maximum magnetic flux density on the inner layer, but outside the nickel clad. Black dots represent three of the spontaneous quenches.

- IEEE on appl superc.,vol 17,no. 2, june 2007

Solenoid react & wind coil – the results(2)

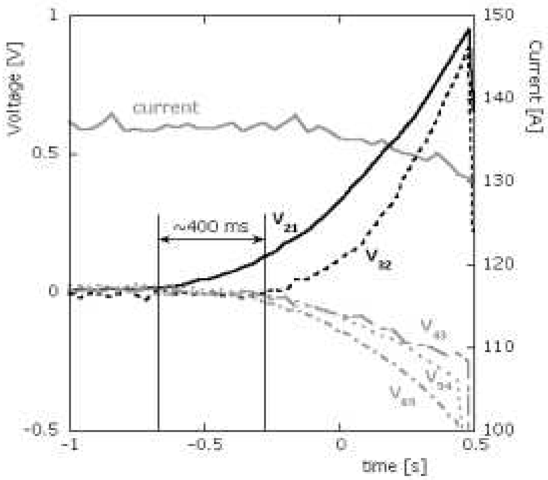


Fig. 9. Evolution of current and voltage during a spontaneous quench at 20.5 K, I_c = 137 A.

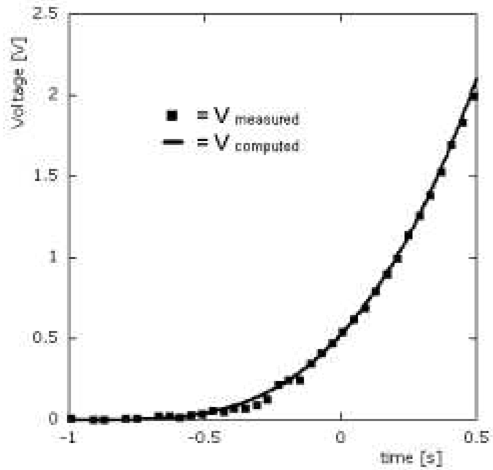
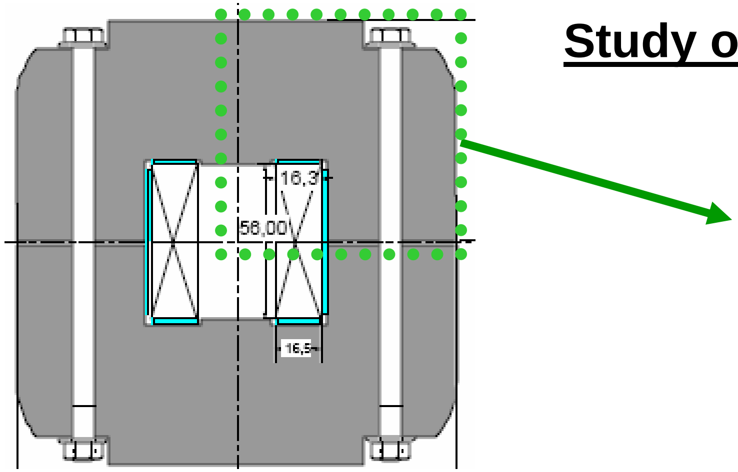


Fig. 11. Comparison between the experimentally measured total magnet resistance (at 20.5 K, I_c = 137 A)

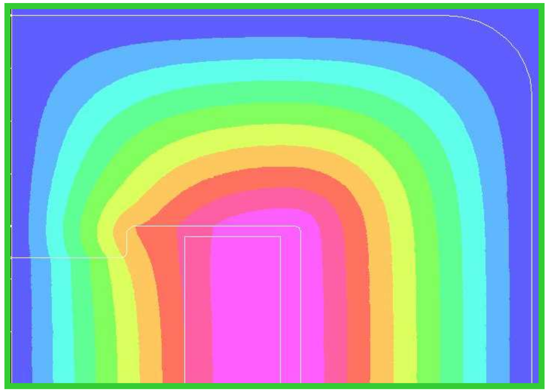
Longitudinal quench propagation rate 11.5cm/s

Transeversal propagation rate ≈ 1cm/s

MARIMBO Project in Collaboration with INFN



Study of a dipole magnet for particle accelerators

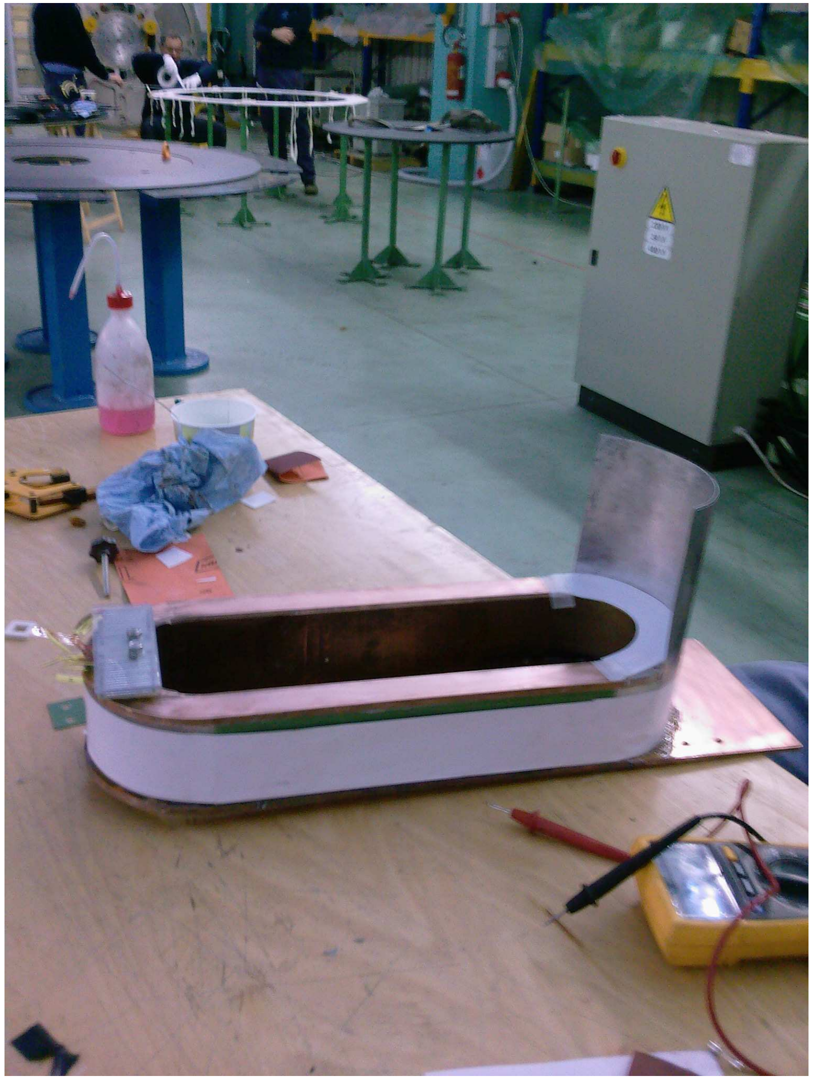


22 layers	
15 turns per layer	
Nominal current	200 A
B0	1.7 T
Length	500 mm
Bending radius	120 mm

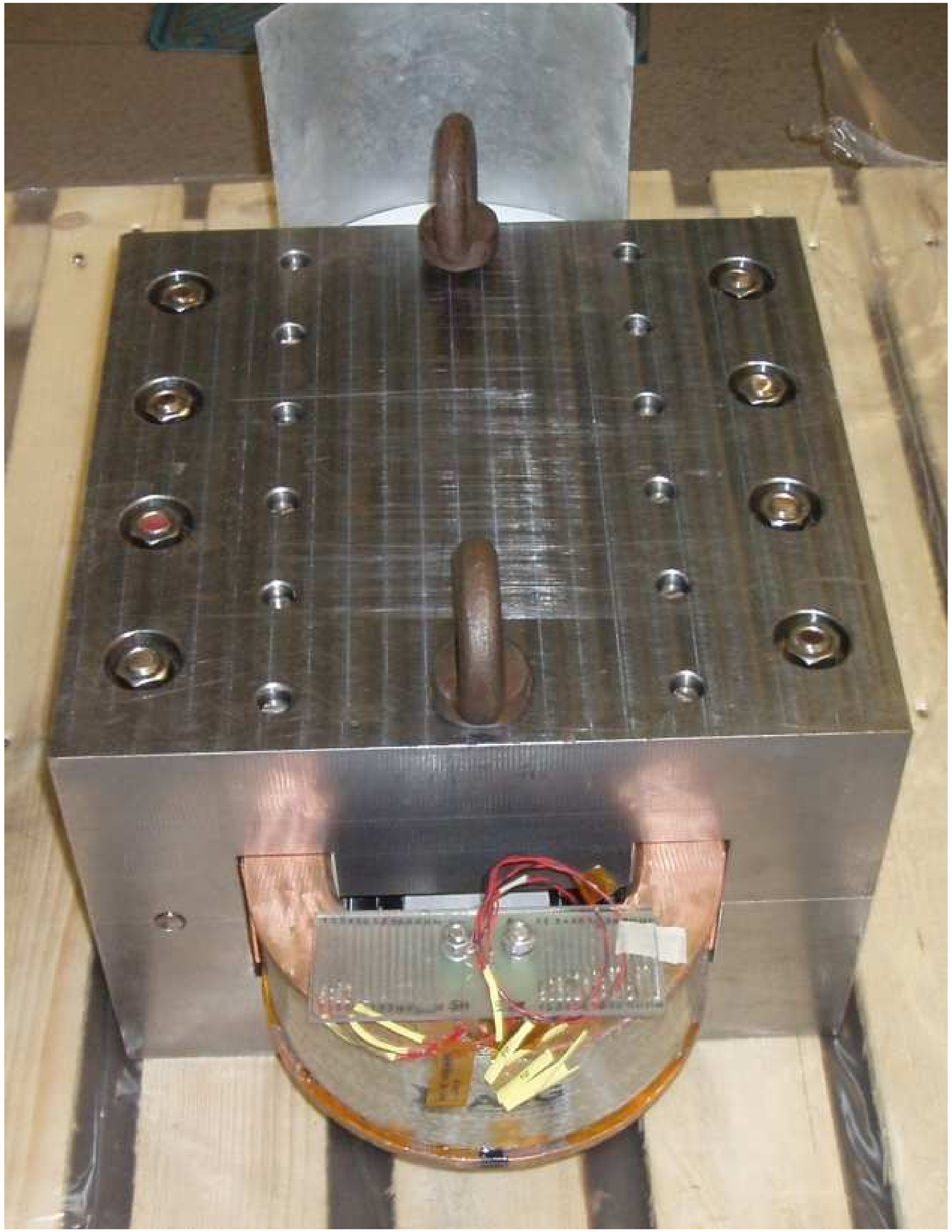
winding picture(1)

winding picture(2)

winding picture(3)

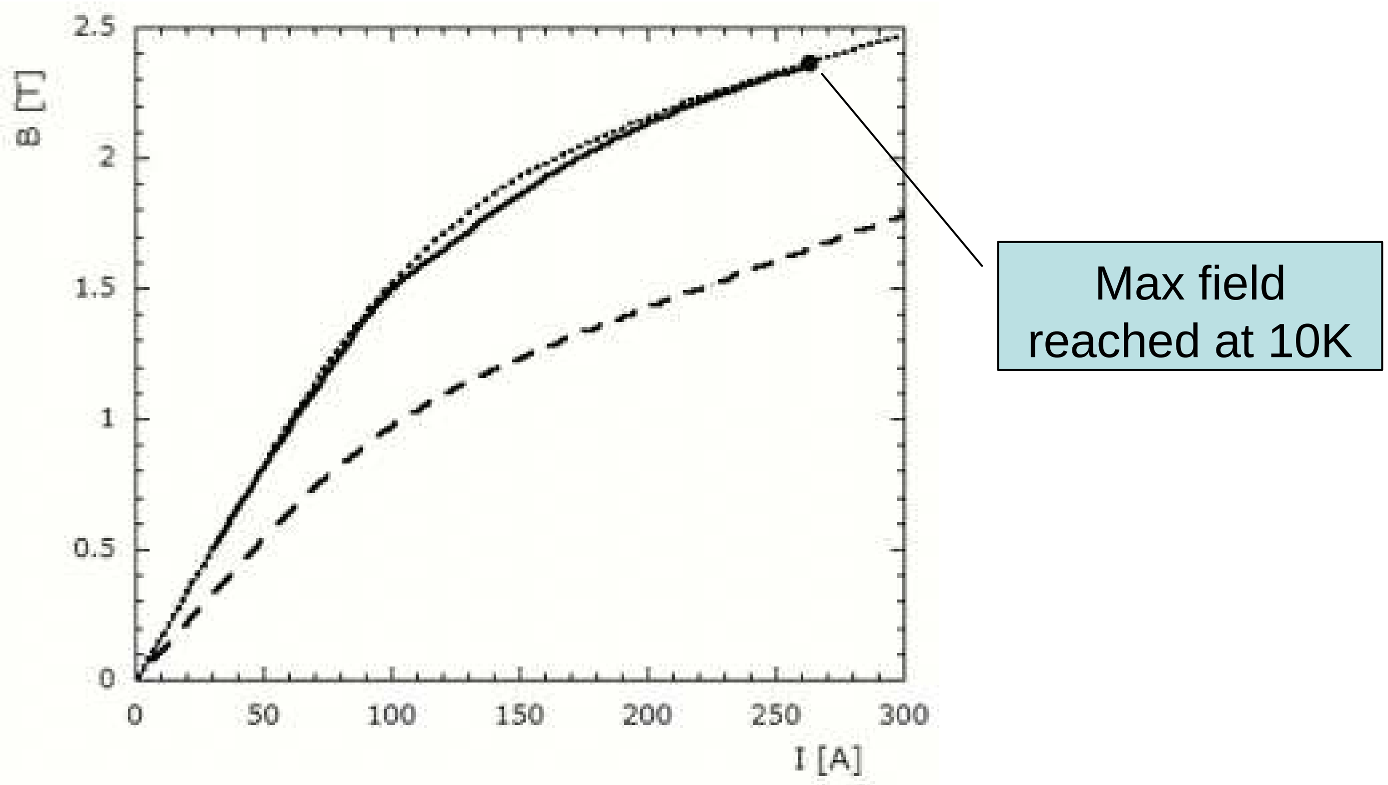


winding picture(4)

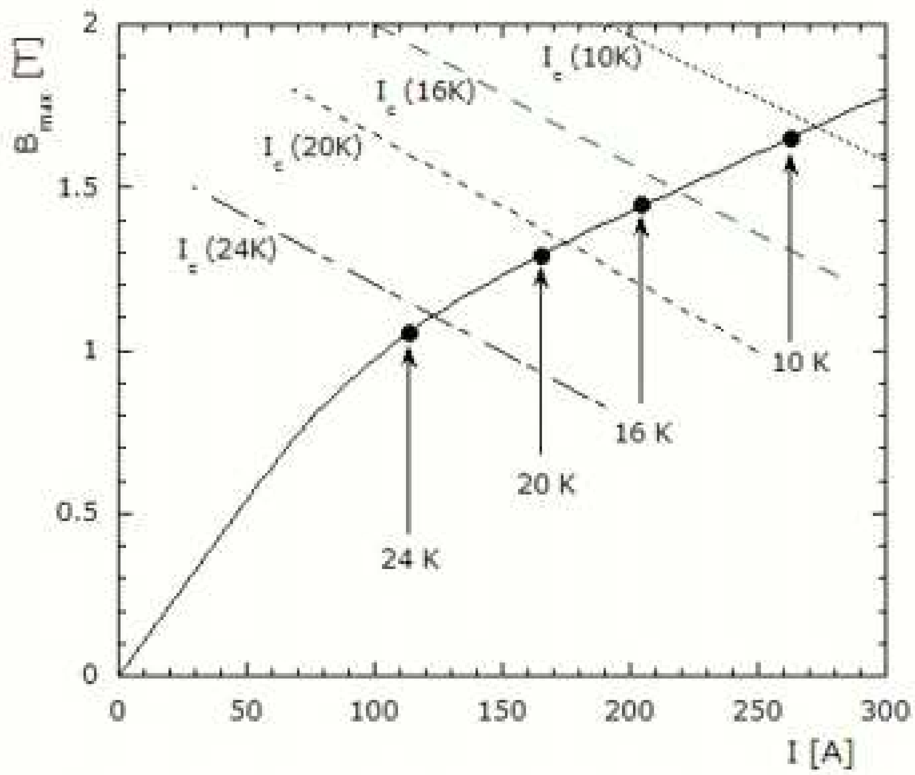


winding picture(5)

MARIMBO
Field in the center and field on the conductor (dashed)



MARIMBO
Load line , short sample Ic and quench



•No training

•The quenches , within the temperature error , occurs at the s.s. critical current

FCL windings

MgB2 multifilamentary tape

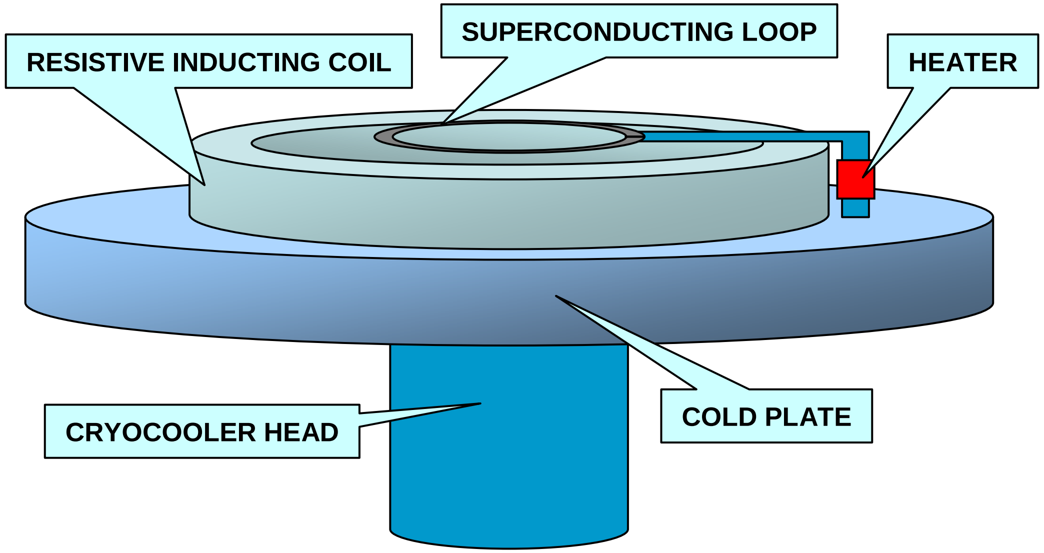
Five no-inductive coils have been produced

Succesfully tested by ASG and CESI 2006/7

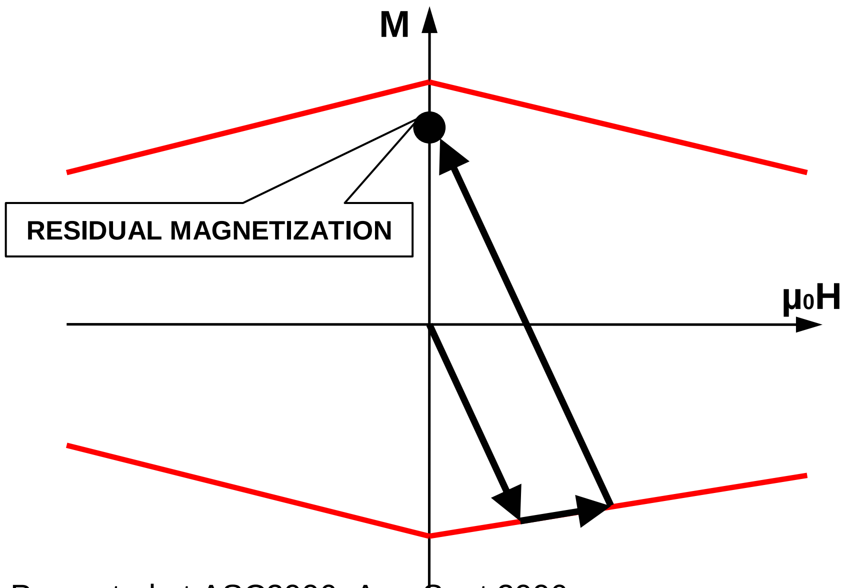
IEEE Transactions on Appl. Superc., Volume 17, Issue 2, June 2007 Page(s):2742 – 2745

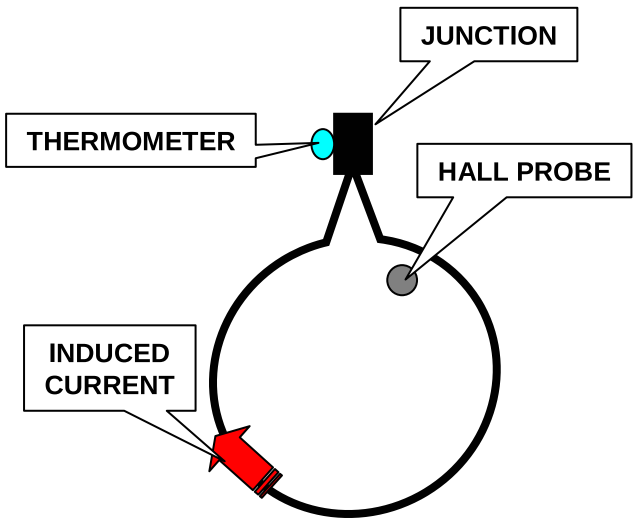
Persistent current measurement method: <u>inducting method</u>

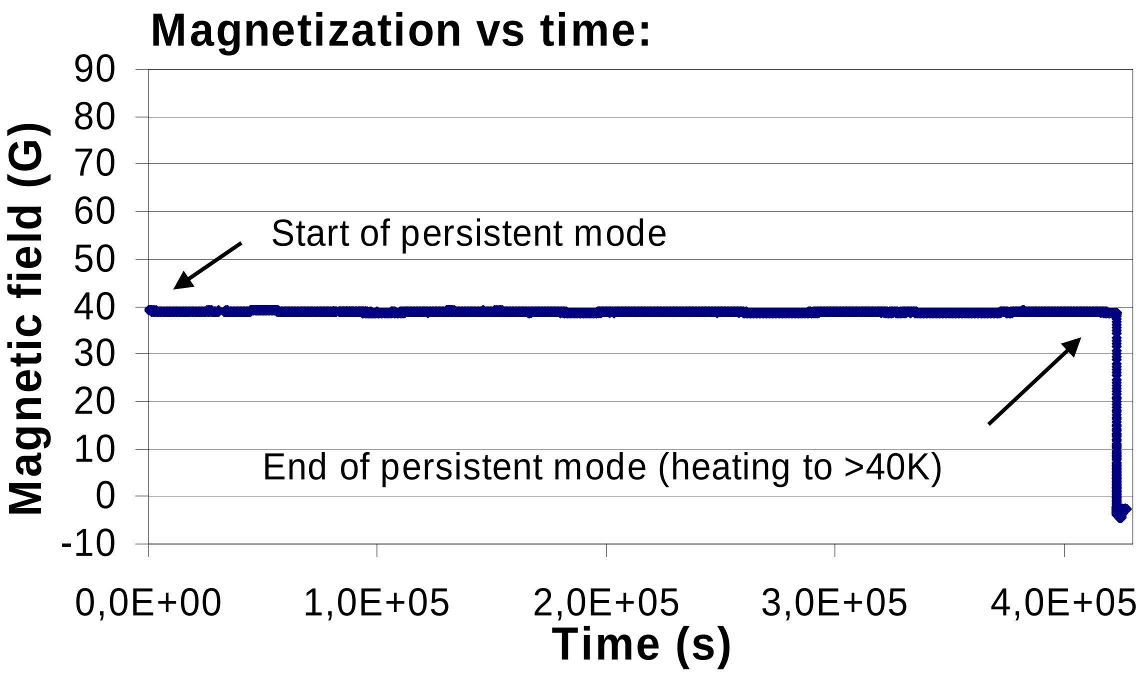
Persistent current in a "junctioned" loop



Measurement highlights:
- -operating temperature: 14 to >40 Kelvin;
- -temp. stability: <0.01 Kelvin
- -inducting field: up to 500G







Results from test:

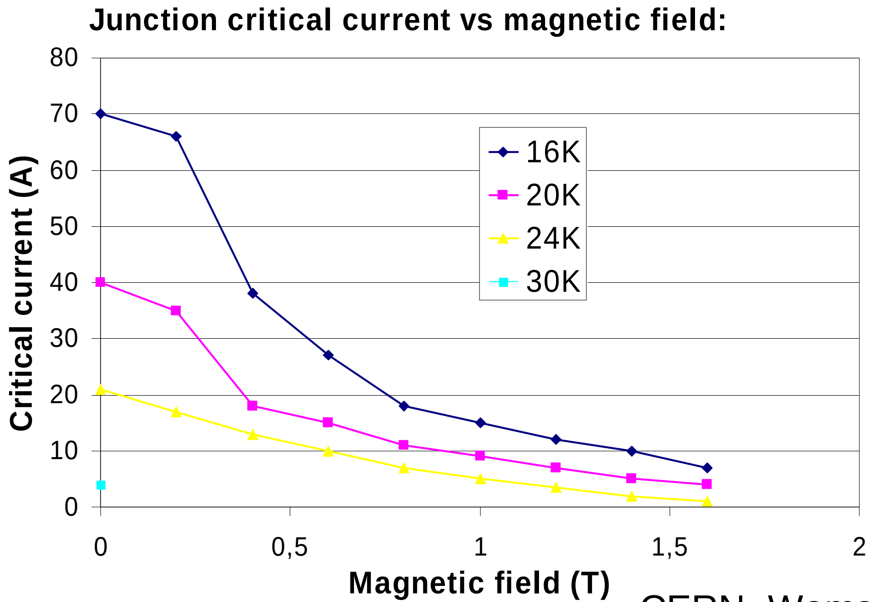
-Persisting magnetic field:
39 Gauss

-Maximum p.to p. excursion:
0.5 Gauss

-Duration of measurement:
420,000 seconds

-Inductance:
$2x10^{-7}$ Henry

R < 10^{-14} Ohm



Presented at ASC2006, Aug-Sept 2006

Another confirmation from
"short sample"-like test.

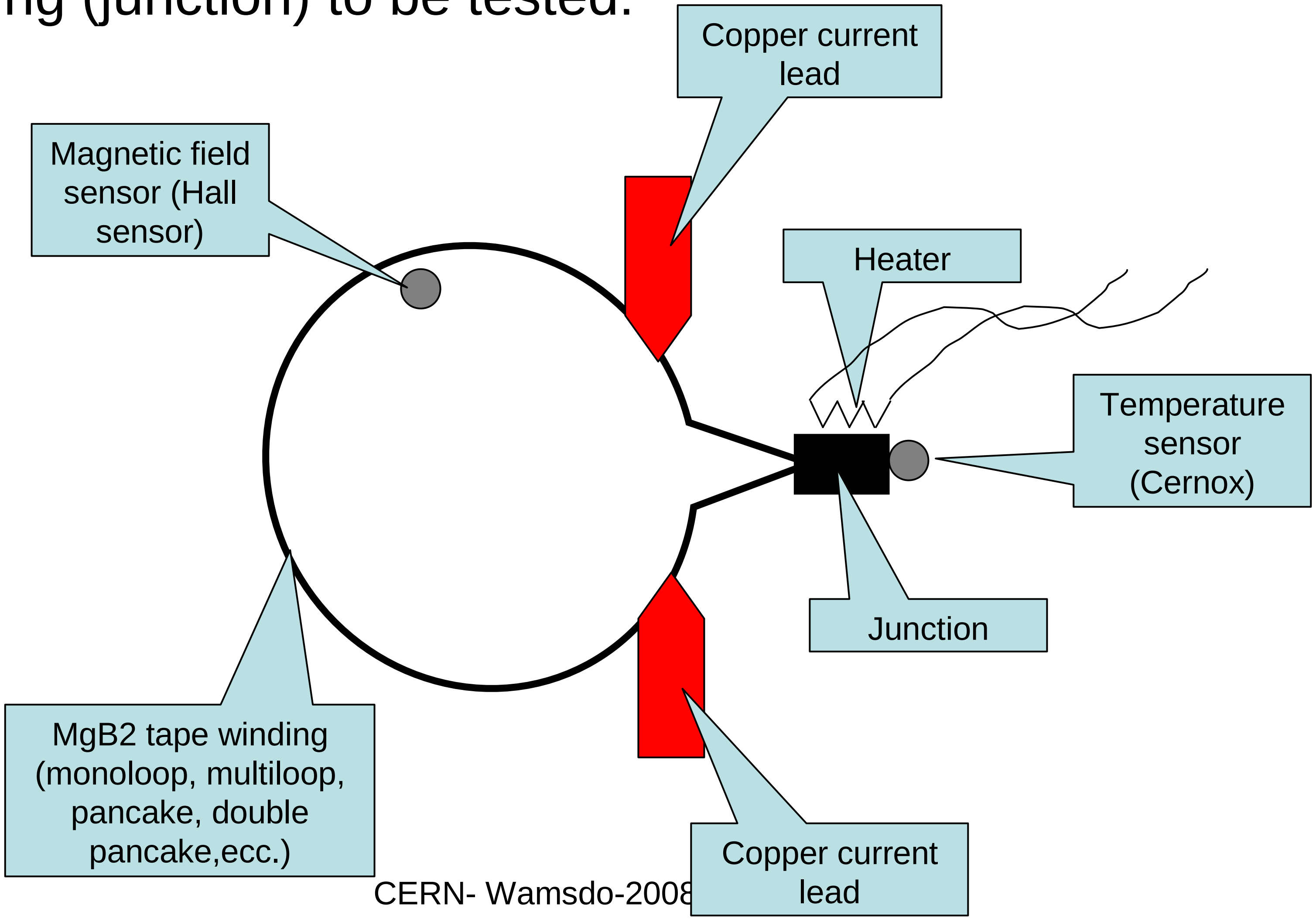
For example:

40 Amperes @20K, 0Tesla

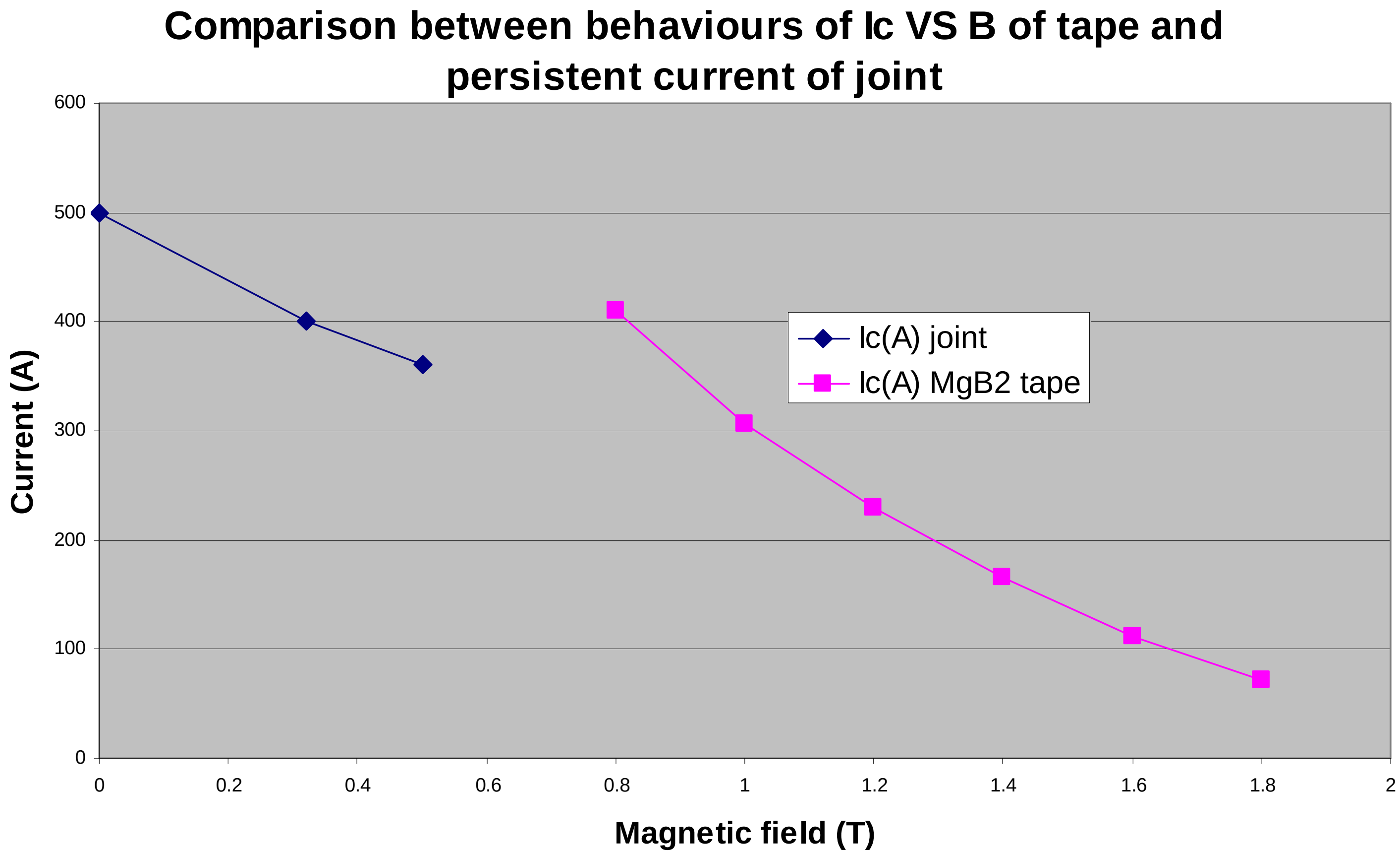
9 Amperes @20K, 1Tesla

Persistent current measurement method: <u>direct current feeding</u>

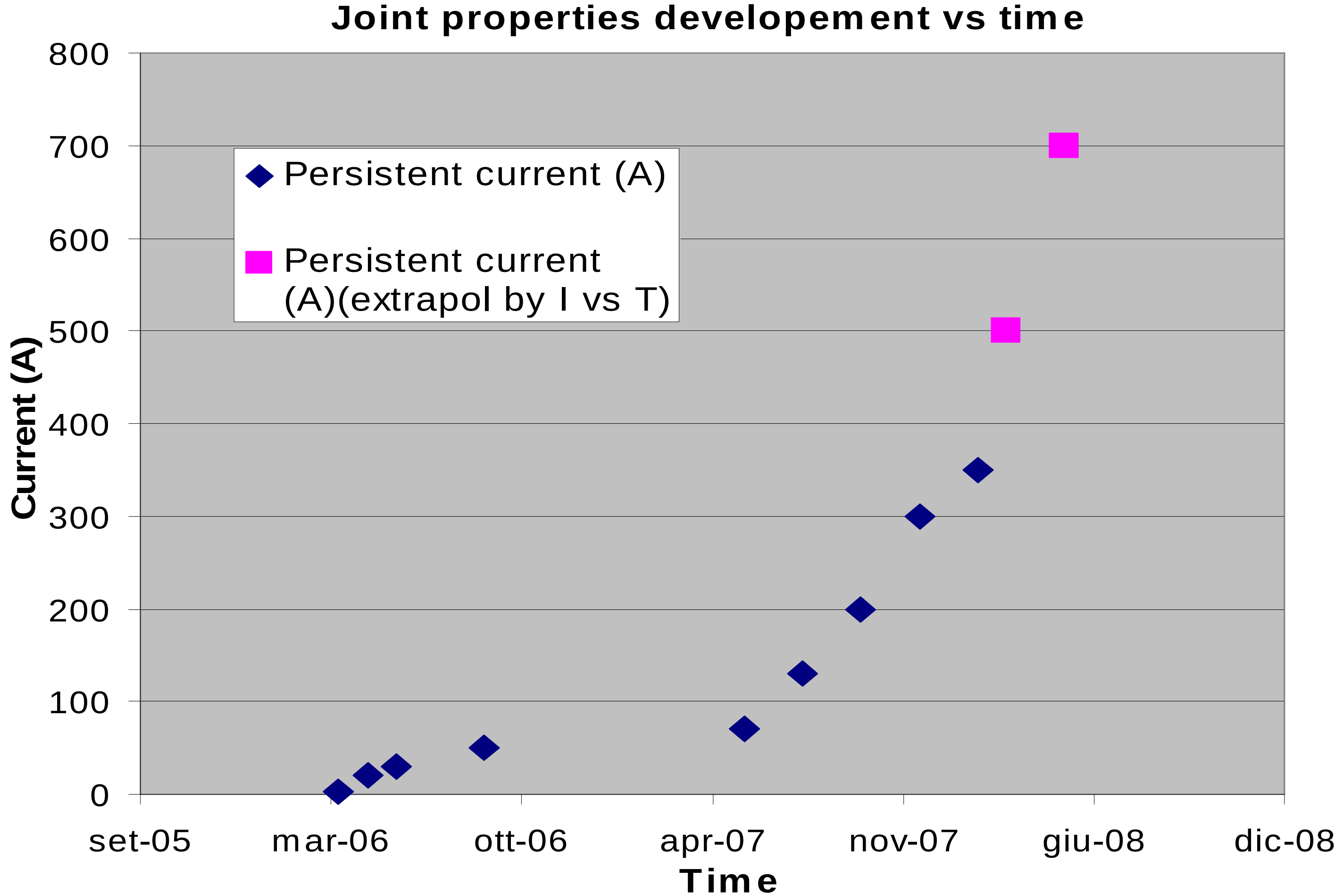
Winding (junction) to be tested:



Example of behaviour of persistent current VS magnetic field@20K



Rough statistics about persistent current at 20Kelvin, self-field VS time



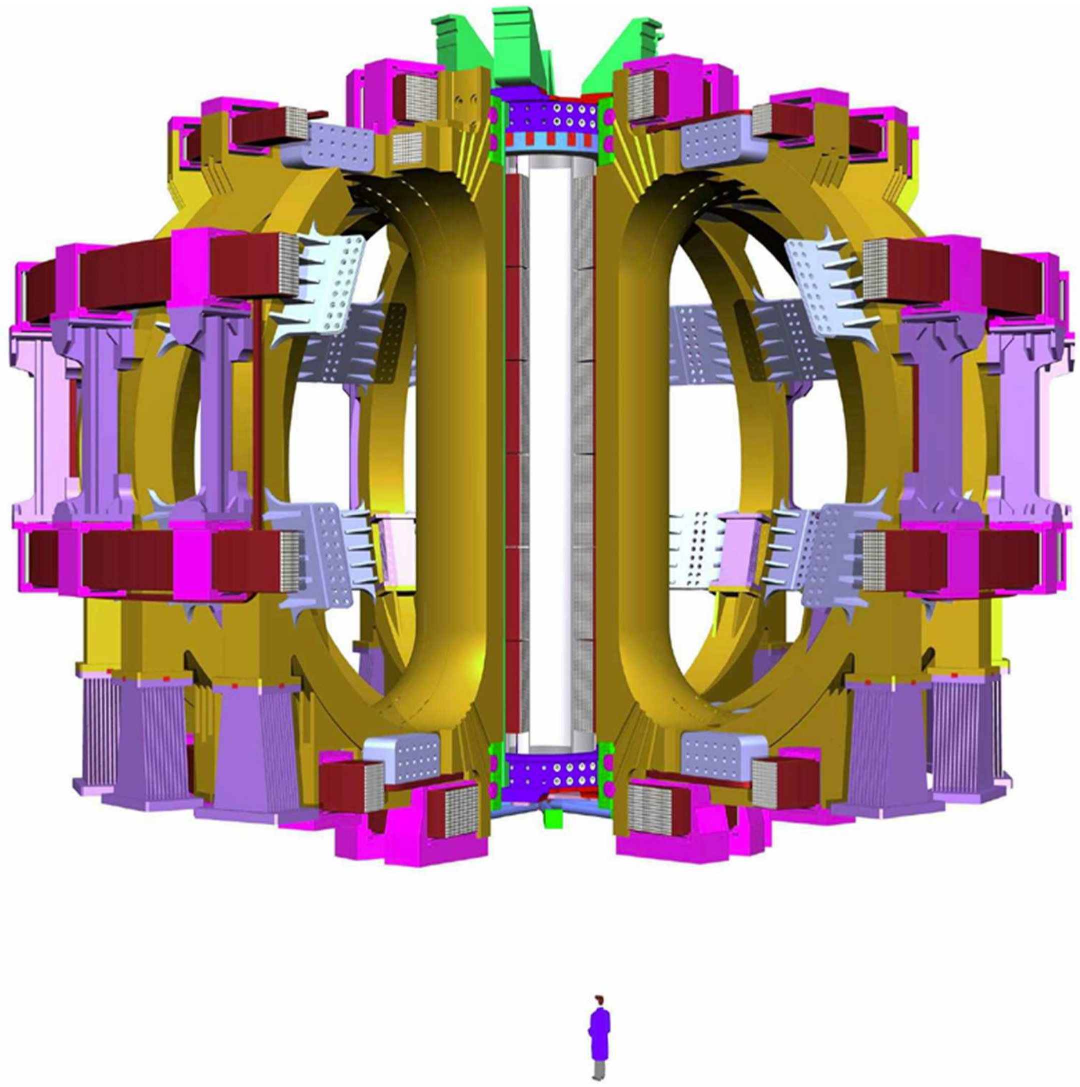
N.B.:extrapolation is necessary due to the impossibility of feeding current value larger than 400-500 A. In fact instability, due to local heating (i.e.: Joule heating in the current leads-MgB2 wire transfer) cause loop quench.

Conclusion on MgB2 Application in ASG

In the last two year a total of more than 40 MgB2 windings of different dimension and shape were built in ASG:

No mayor problems were found on these winding performance compare with the calculated ones

ITER sc Coils



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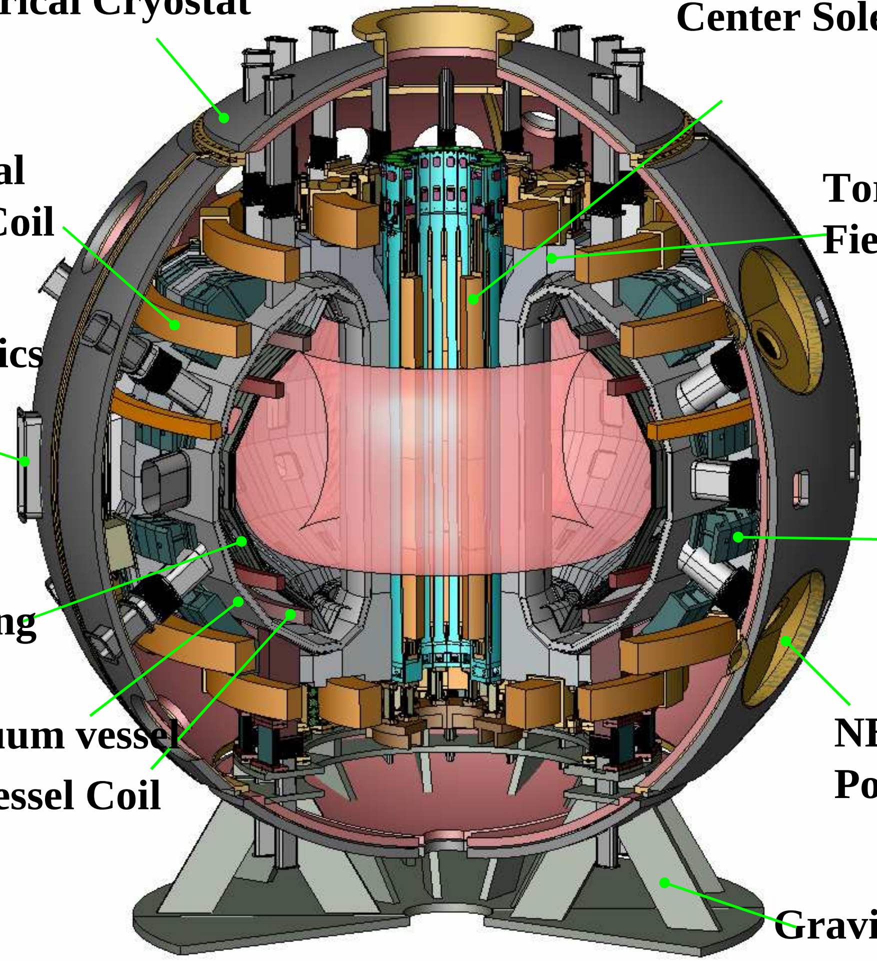
Basic Machine Parameters of JT-60SA



high-S for DEMO
ITER similar

Plasma Current I_p(MA)	3.5 / 5.5
Toroidal Field B_t (T)	2.59 / 2.72
Major Radius (m)	3.16 / 3.01
Minor Radius (m)	1.02 / 1.14
Elongation, κ_{95}	1.7 / 1. 83
Triangularity, δ_{95}	0.33 / 0. 57
Aspect Ratio, A	3.10 / 2.64
Shape Parameter, S	4.0 / 6.7
Safety Factor q_{95}	3.0 / 3.77
Flattop Duration	100 s (8 hours)
Heating & CD power	41 MW x 100 s
N-NBI	34 MW
ECRH	7 MW
PFC wall load	10 MW/m^2
Neutron (year)	4 x 10^{21}

D_2 main plasma + D_2 beam injection

The near future:

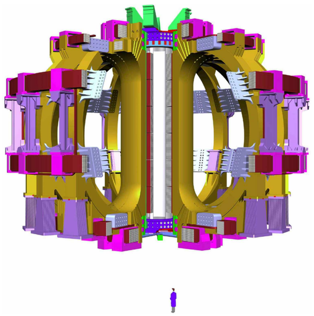
ACTIVITY	SITE

ITER : EUROPEAN Toridal field coils (72 double pancake) ?????

More than 25000 m2 : Some external area will be necessary !!

JT60 : ITALIAN TF Coils for JAPAN ????

2500 ext area + 4000 m2 internal



In ASG: there will be anyway 10000m2 still free for other activities…

(like Future Dipoles for High Energy Physics !!!)