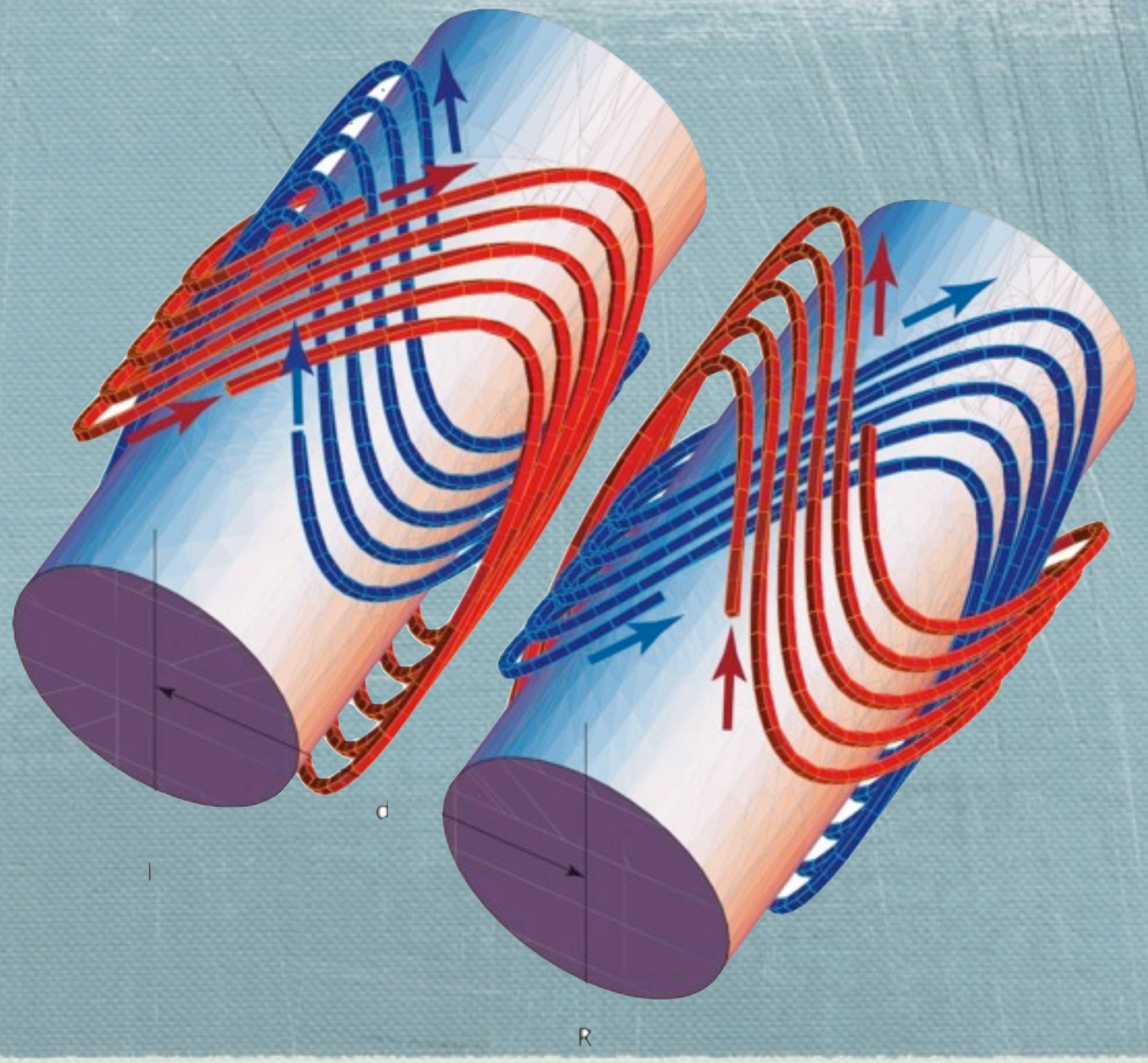


QD0 recents progresses

Eugenio Paoloni INFN & Università di Pisa

after a very fruitful talk with G. Volpini & G. Bellomo (INFN LASA), P. Fabbricatore (INFN Genova)

Main progresses

- Fruitful review of the QD0 design made by Giovanni Volpini, Pasquale Fabbricatore and Giovanni Bellomo
- SC Wire candidate chosen with their help
- Funding from INFN for prototypes construction in 2010

Good news! :)

- Bellomo, Fabbricatore and Volpini did ***not*** said:

"YOUR DESIGN CONCEPT
WILL
NOT GONNA WORK!"

Bad news… : (

- Bellomo, Fabbricatore and Volpini did ***not*** said:

"YOUR DESIGN CONCEPT HAVE GOOD CHANCES TO WORK!"

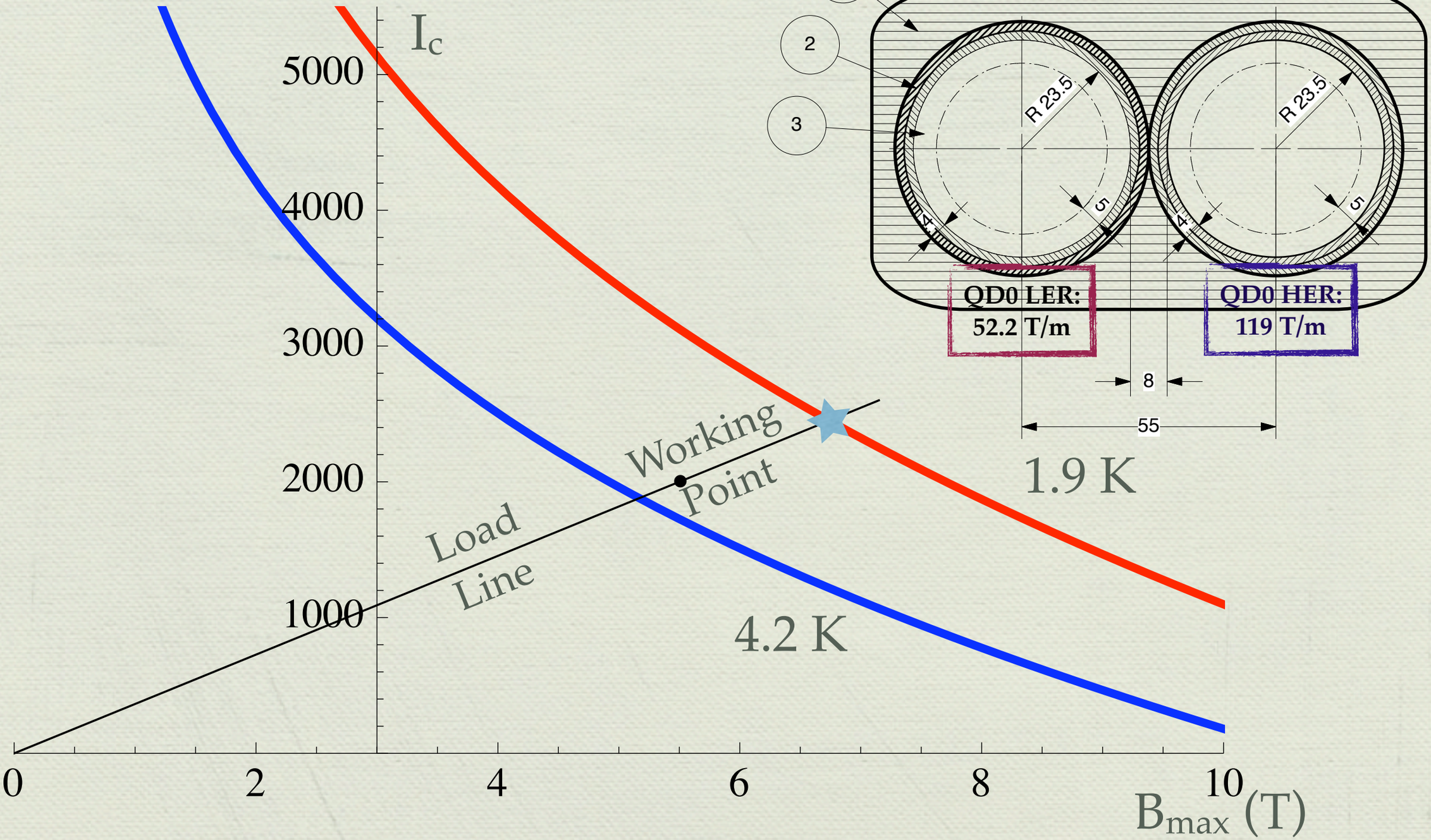
Main outcomes of the review

- SC Wire candidate from LUVATA (as Kirk too suggested)
- Persistent currents effect can spoil the field quality
- The QD0 and the compensating solenoid are tightly coupled (mechanically, magnetically and thermally) and should be considered as a single design problem
- Show stoppers can be hidden behind every corner: the construction of prototypes to check every aspect is mandatory

Superconducting wire

- The experts advice is to use a commercial NbTi SCwire
- Volpini contacted LUVATA:
- CMS wire (12 km available, needed < 1 km)
- Bare diameter 1.28 mm
- Cu/SC = 1.1
- Jc = 3200 A/mm^2 @ 5T 4.2 K

Margin on the load line ~20%

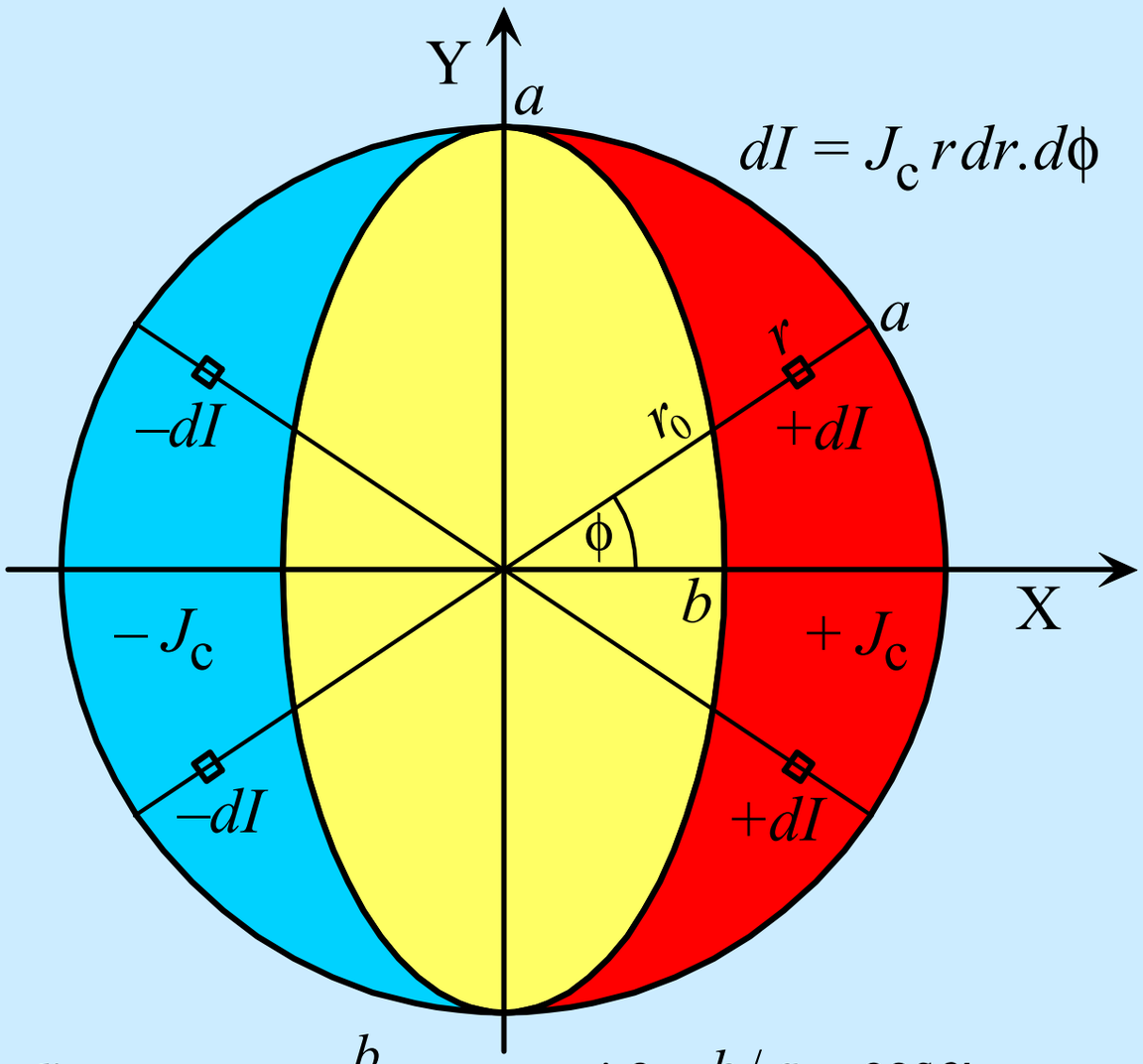


Field quality better than 10^{-5}

Introduction

- Any change in the field near a superconductor induces eddy currents. These eddy currents are of a persistent nature due to zero resistance in the superconductor.
- Such eddy currents produce field distortions (harmonics) depending on several factors, such as superconductor properties, ramp direction, ramp rate, etc.
- An understanding of these effects is important in the measurements of superconducting magnets.

Filament Magnetization: 1st Up Ramp



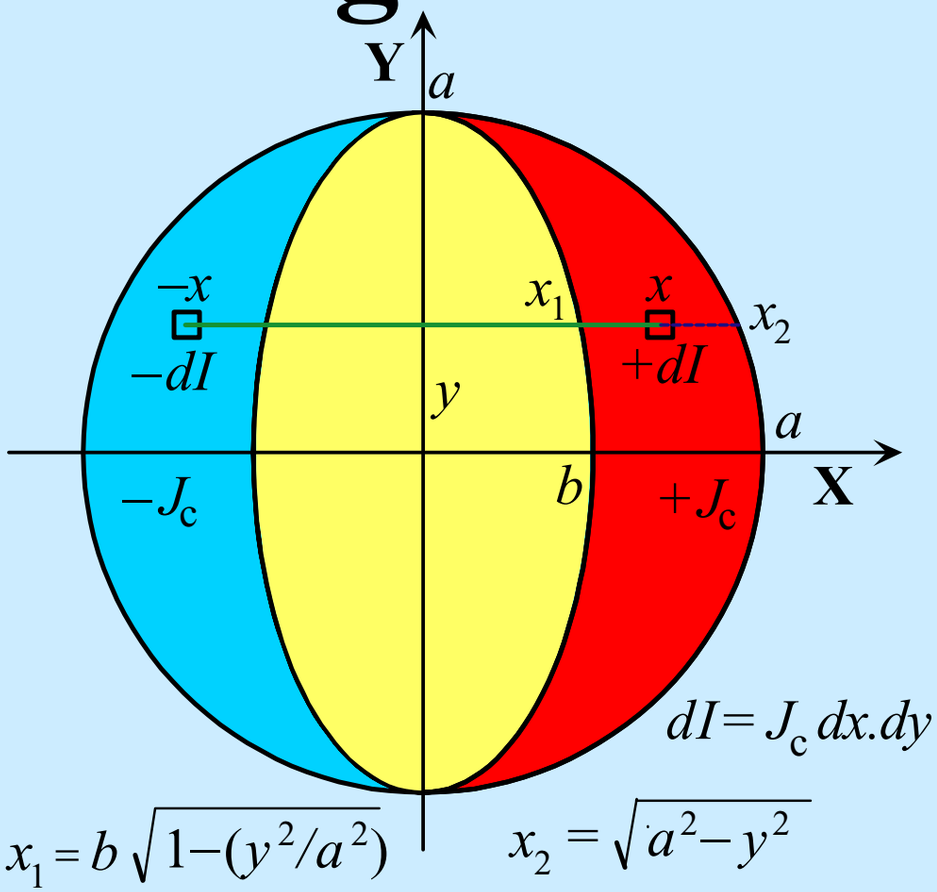
$$r_0 = \frac{b}{\sqrt{\cos^2\phi + e^2 \sin^2\phi}};\ e = b/a = \cos\alpha$$

When the external field is increased from zero to a small value, B_a, shielding currents are set up such that the field inside is zero. The boundary of shielding currents may be approximated by an ellipse.

$$\left(\frac{B_a}{B_p}\right) = \left[1 - \frac{\cos\alpha}{(\sin\alpha)/\alpha}\right]$$

$$B_p = \left(\frac{2\mu_0 J_c\, a}{\pi}\right);\quad B_a \le B_p;\quad 0 \le \alpha \le \pi/2$$

Magnetic Moment: 1st Up Ramp



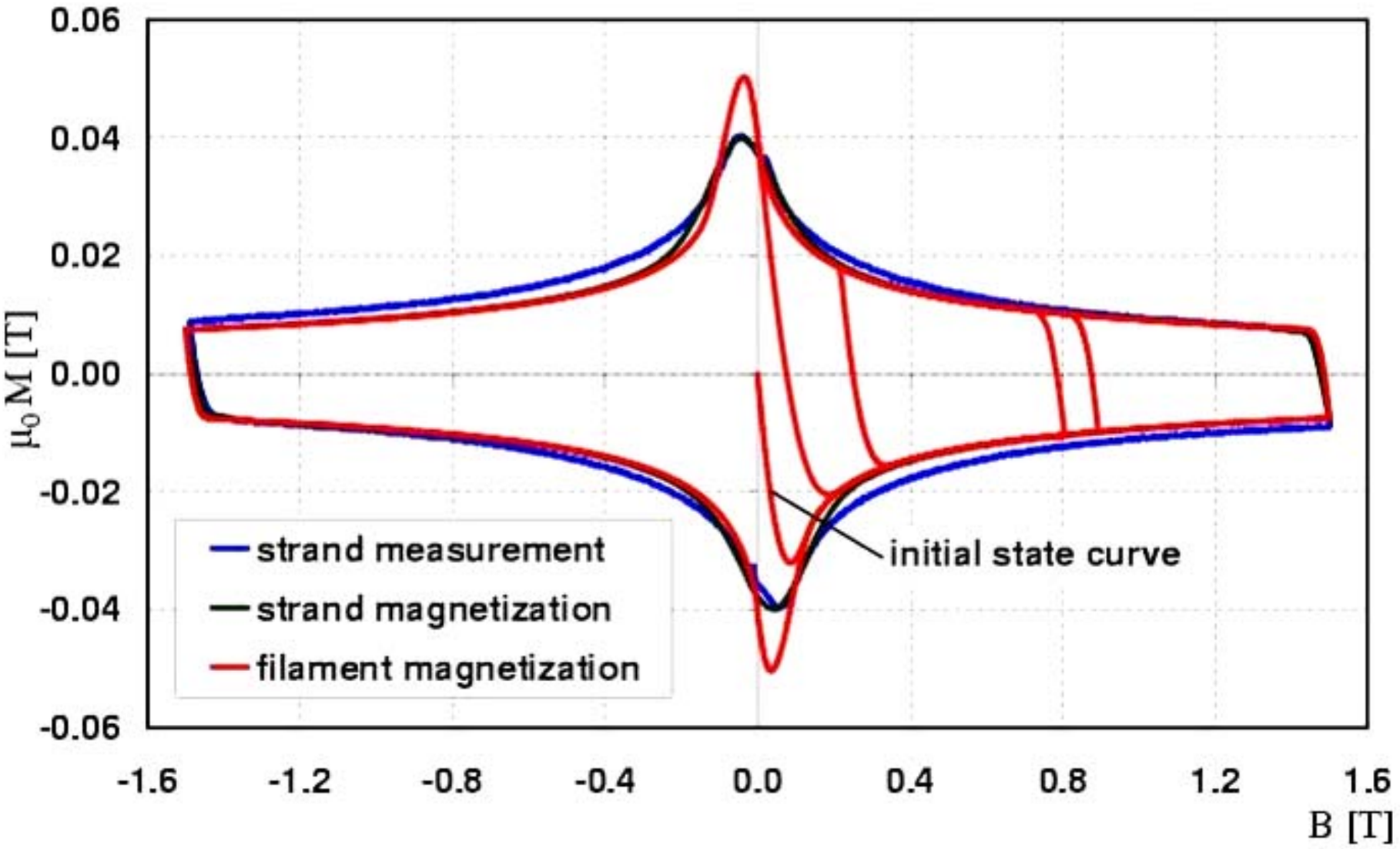
The persistent currents produce a magnetic moment. The Magnetization, or the magnetic moment per unit volume, can be calculated by integrating over elemental loops.

$$M = \frac{-2\mu_0 J_c}{\pi a^2}\int_{-a}^{a} dy \int_{x_1}^{x_2} x\,dx = -\left(\frac{4}{3\pi}\right)\mu_0 J_c\, a\left[1-\frac{b^2}{a^2}\right]$$

$$\left|M_{\text{peak}}\right| = \left(\frac{4}{3\pi}\right)\mu_0 J_c\, a$$

Magnetization is proportional to the critical current density, and the filament diameter.

Magnetization in LHC Strands



Evaluation of the effect

- Evaluation the magnetic field on the conductor in operational condition
- Determination the Jc at that value of the B field
- Polarization the conductor
- Evaluate the field distortion
- … work in progress ...

Simulation tools

- Opera is an expensive software tool:

Tipo documento	Numero	Data
Offerta	3	02/02/2009

Destinatario

I. N. F. N. - Sez. di Pisa
Largo B. Pontecorvo, 3
56127 Pisa (PI)

Destinazione

I. N. F. N. - Sez. di Pisa
Largo B. Pontecorvo, 3
56127 Pisa (PI)

In caso vengano riscontrati dati errati nella fattura si prega di darne tempestiva comunicazione.

Descrizione	Q.tà	Prezzo unitario	Sconto	Importo	C. Iva
Licenza a tempo indefinito per il seguente software:					
OPERA-3d Post Processor Versione Linux	1	7.920,00	25%	5.940,00	20
I canoni di licenza indicati sono comprensivi di manutenzione e supporto per un anno.					

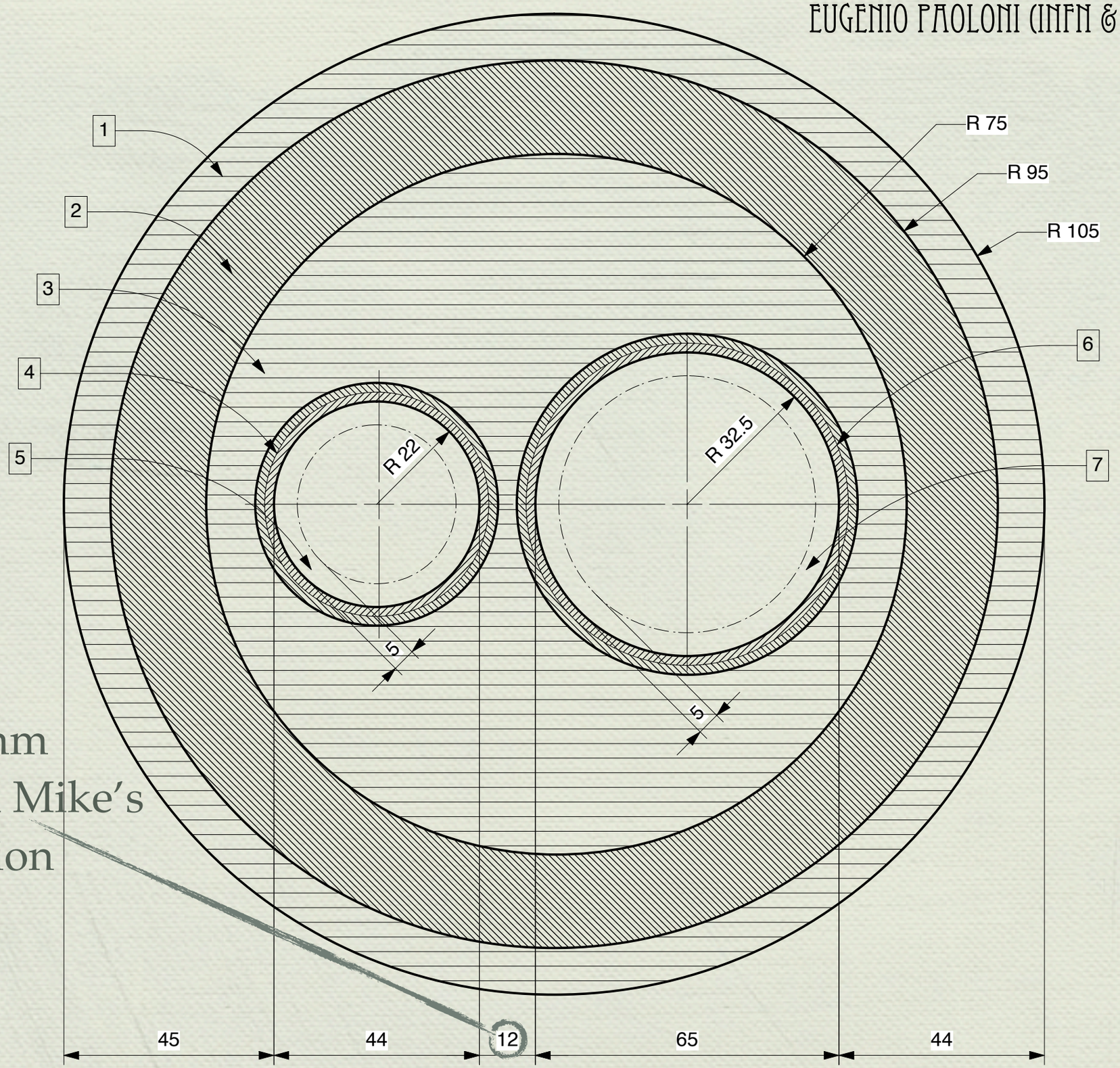
Simulation tools II

- Iron free magnets are “easy” to simulate:
  integrate over the whole space J times the Green’s function.
- C++ code under development to do efficiently the job.
- C++ translation of the Mathematica code that build the “twin quad” configuration ready.

COLD MASS V0.0 DESIGN

EUGENIO PAOLONI (INFN & UNIVERSITÀ DI PISA)

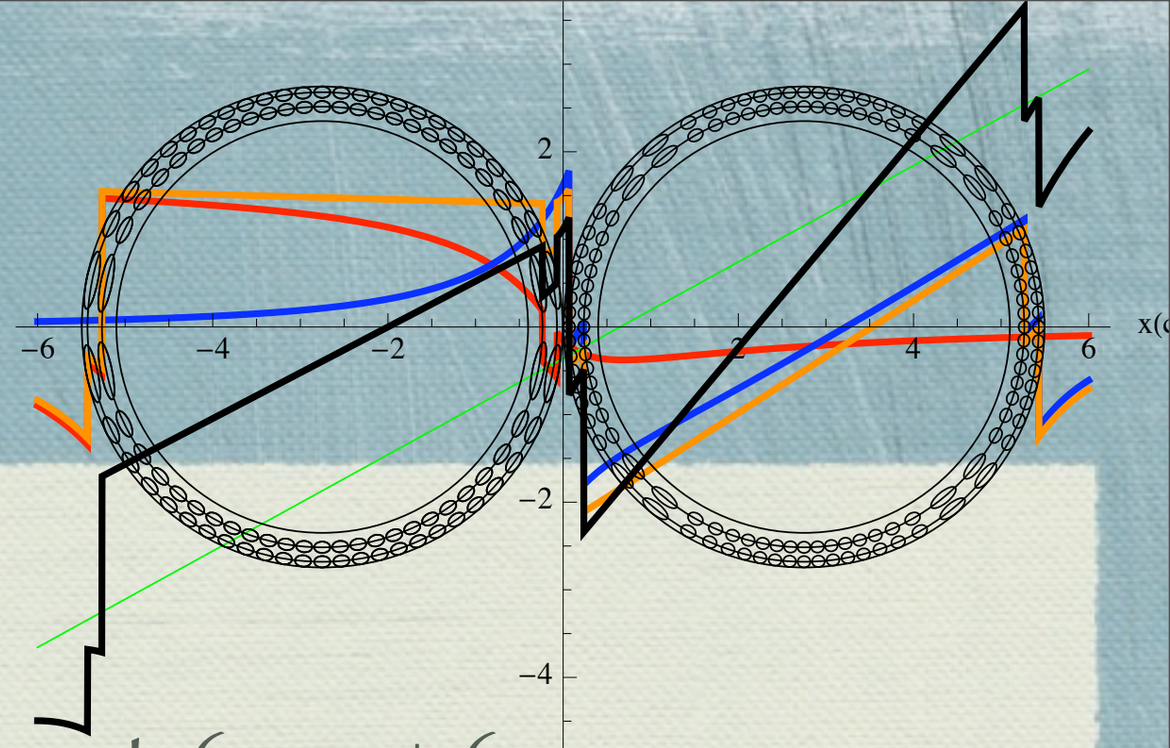
Notes
1. External collar
2. External quadrupole windings
3. Internal collar
4. HER Quadrupole windings
5. Cold to warm transition
6. LER Quadrupole windings
7. Cold to warm transition



It was 8 mm
+2x2 mm from Mike's optimization

ALL THE DIMENSIONS ARE EXPRESSED IN MILLIMITERS

Mike's 2mm



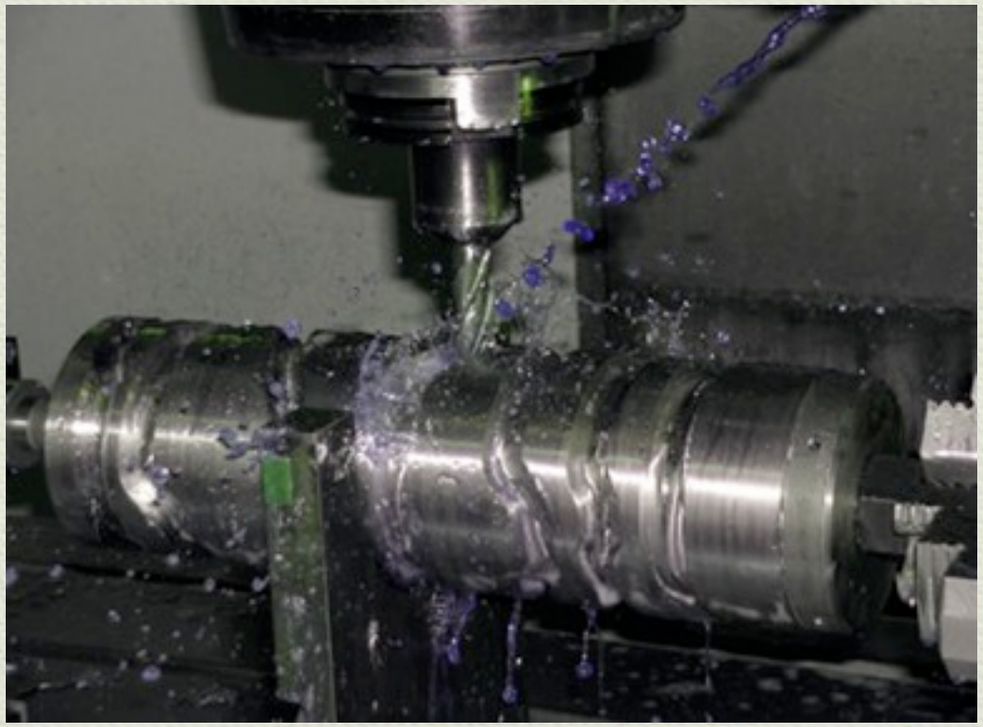
- How to take profit of this 2mm?
- Total space for windings and support: 6mm + 6mm
- SC wire diameter: 1.3 mm
  - We need 2 or 4 layers hence 2.6 mm (5.2 mm) taken by SC
  - 4 layers option: 0.8 mm left for the mechanical support
    0.2 mm per layer ~ twice the thickness of the aluminium of a can of beer (Present design assume 0.7 mm / layer)
  - 4 layers option very attractive… need a mechanical proto.

Mechanical prototype I

- Fabbricatore, Volpini and Bellomo suggested to start quickly a prototype construction of a normal conducting single quadrupole using the double helix concept
  - Mechanical support feasibility
  - Winding procedure
- They recognize that such a small magnet (~100 spire/layer) can be winded manually in an INFN lab

Mechanical Prototype II

- In the INFN Pisa mechanical workshop there is a 4 axis CNC the ~ ideal tool to carve the grooves in the support cylinder



Conclusions

- Next steps:
  - C++ code for B field simulation
  - Field distortion from persistent currents evaluation
  - Mechanical design and engineering