Science & Technology Facilities Council

Summary of Sessions 5 & 6

Jim Clarke

STFC Daresbury Laboratory and The Cockcroft Institute

Workshop on Special Compact and Low Consumption Magnet Design,
28th November 2014

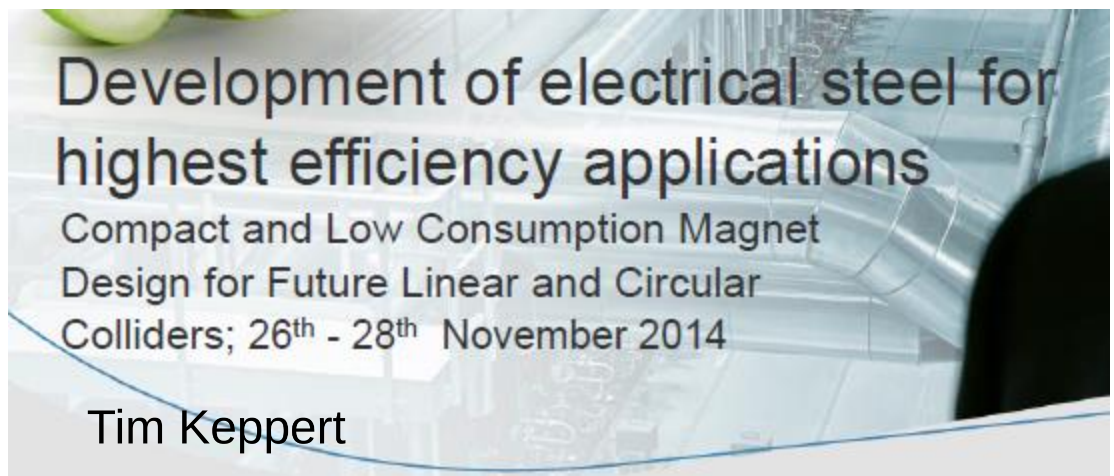
Overview

- Session 5: Industrial Perspective
- Session 6: Short Communications

Permanent (and Soft) Magnetic Materials for Accelerators

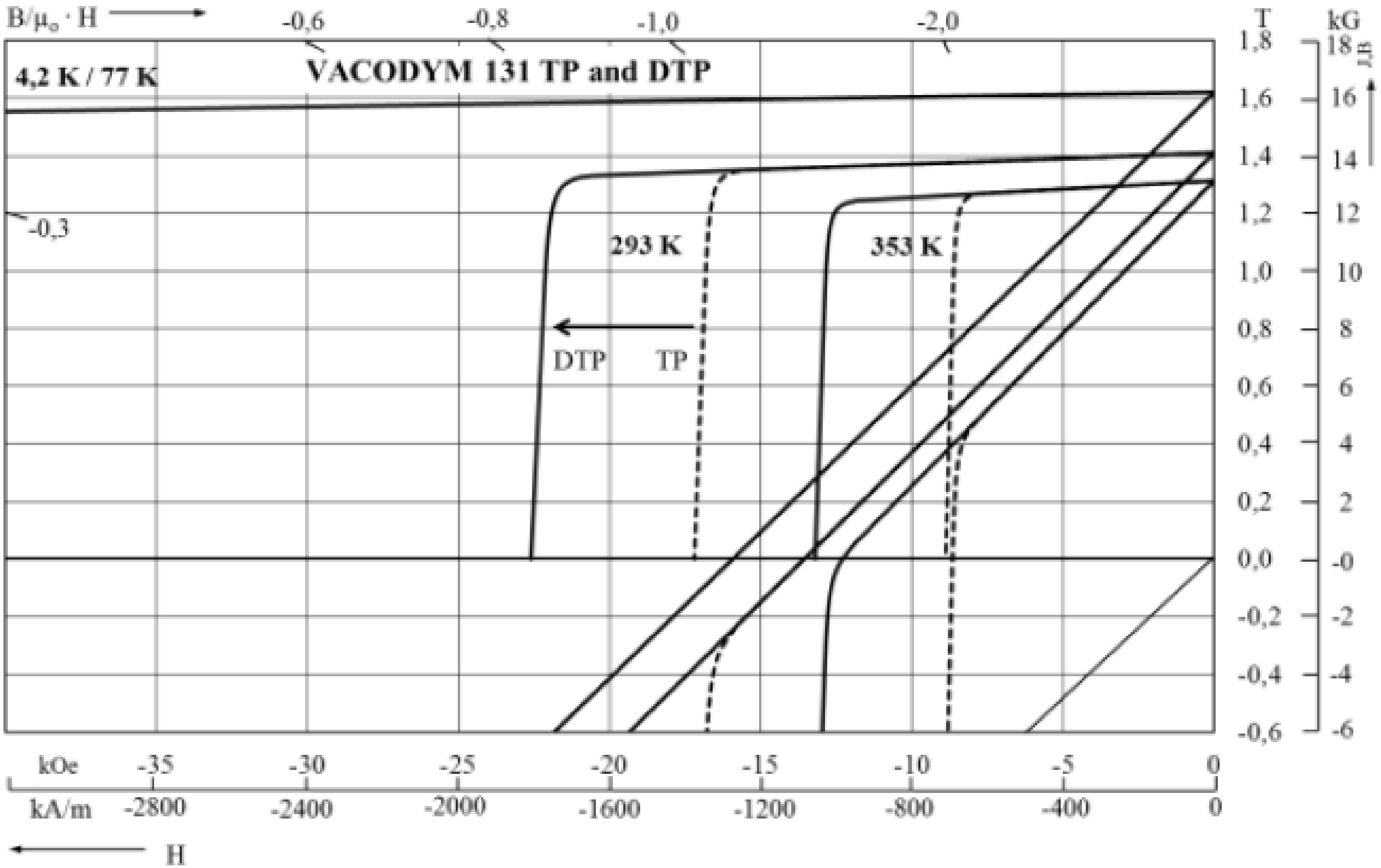
Workshop on Special Compact and Low Consumption Magnet Design, CERN, Geneva 26.-28.Nov. 2014

Franz-Josef Börgermann, Ch. Brombacher, F. Fohr, K. Üstüner
Vacuumschmelze GmbH & Co. KG



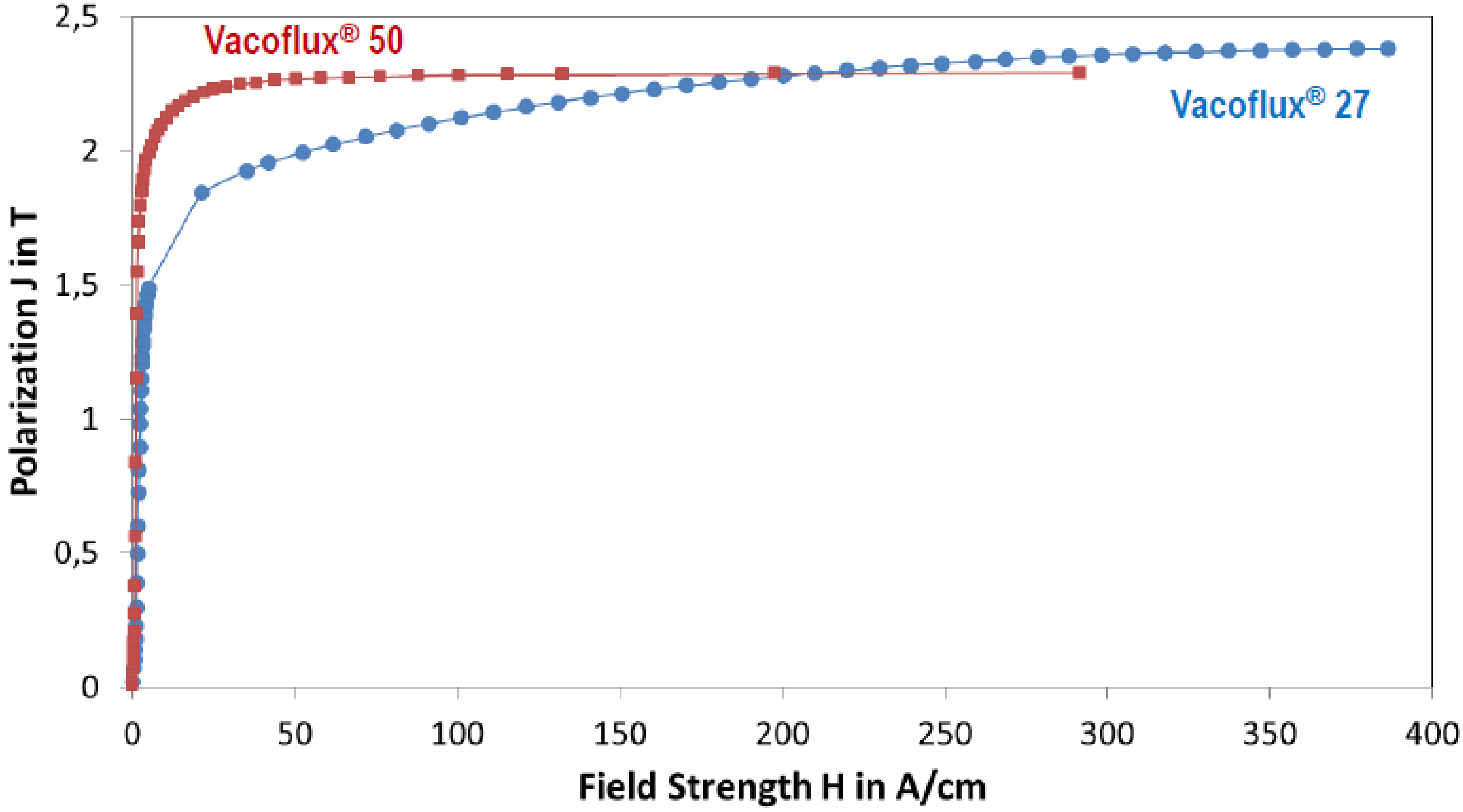
Tim Keppert

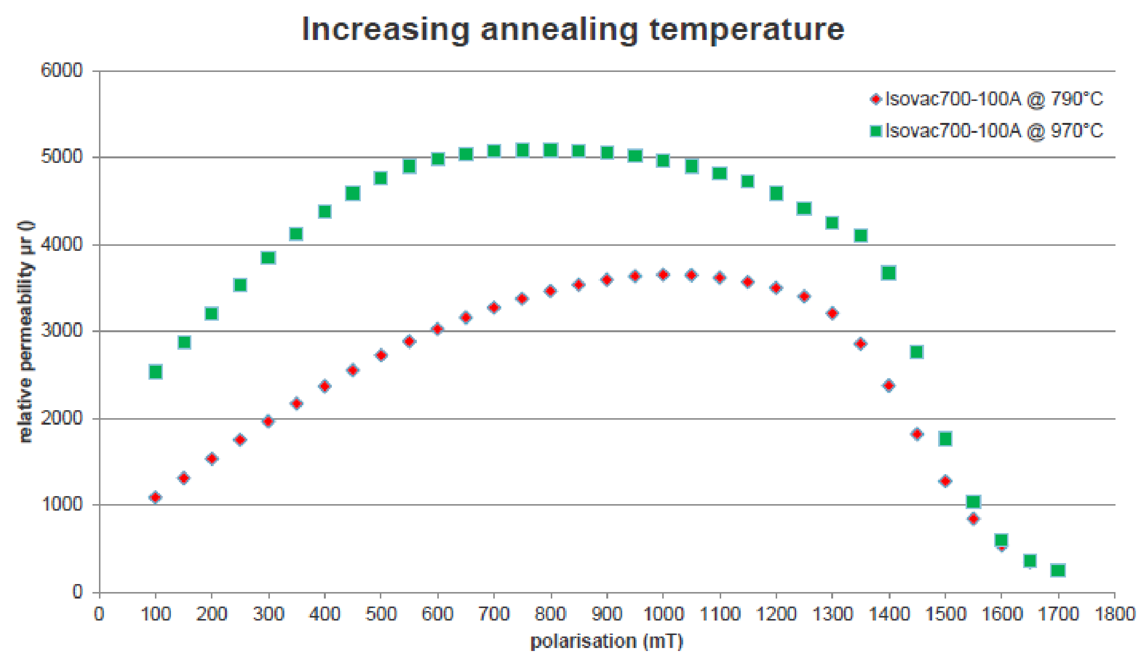
VACODYM® 131 for use at Cryogenic temperatures



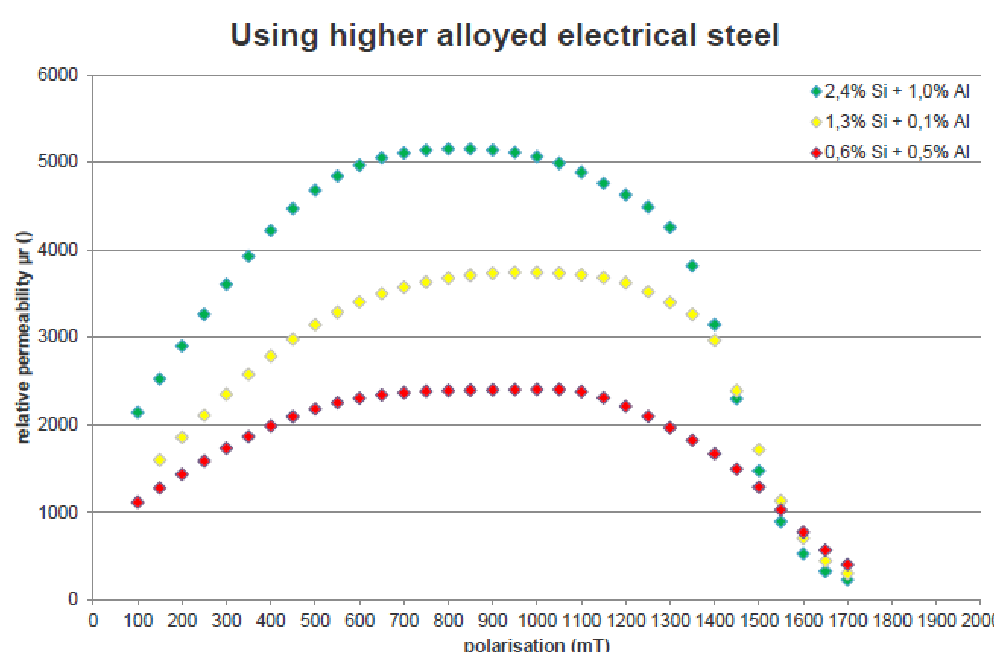
Demagnetization curves of VACODYM® 131 TP and DTP at cryogenic temperatures, room temperature and elevated temperature

Comparison of Static Initial Magnetization Curves VACOFLUX®50 vs. VACOFLUX®27





Increasing annealing temperature
Isovac700-100A @ 790°C
Isovac700-100A @ 970°C
relative permeability µr ()
polarisation (mT)
0
1000
2000
3000
4000
5000
6000
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800

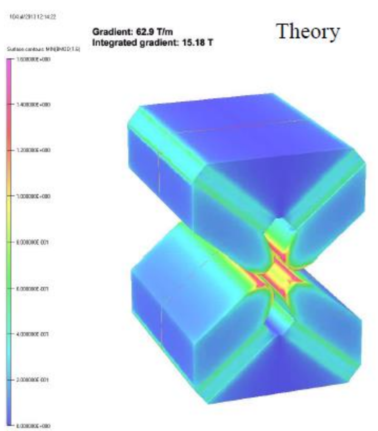


Using higher alloyed electrical steel
2,4% Si + 1,0% Al
1,3% Si + 0,1% Al
0,6% Si + 0,5% Al
relative permeability µr ()
polarisation (mT)
0
1000
2000
3000
4000
5000
6000
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000

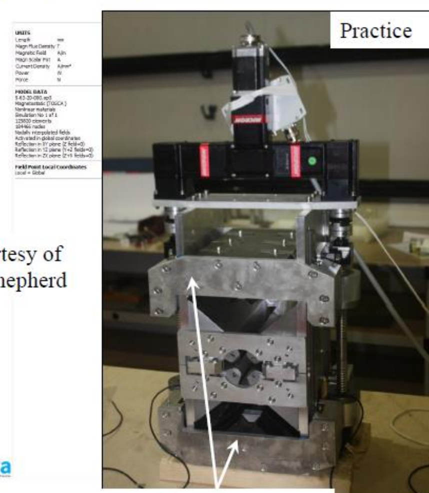
Industrial Challenges of Compact Magnet Production

Norbert Collomb, STFC
J. Clarke, B. Shepherd, N. Marks, STFC-ASTeC
M. Modena, A. Bartalesi, M. StruikCERN

2.3 High Strength prototype



Courtesy of
B. Shepherd

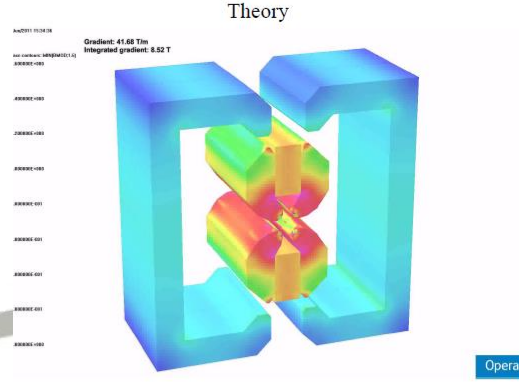


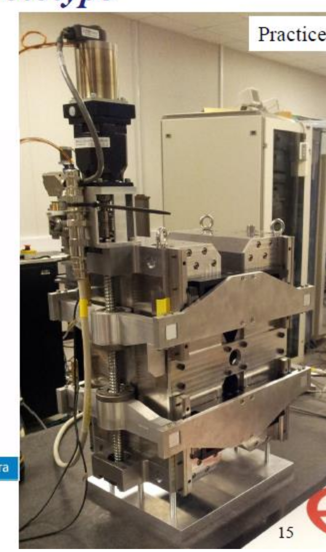
Complete Prototype.
Note the "open jaws".

2.4 Low Strength prototype

Completely different design where the Permanent Magnet is drawn out from the yokes towards a shroud, essentially creating a short circuit for the flux.

Theory





5 Conclusion

In conclusion, the CLIC Drive Beam Decelerator Permanent Magnet Quadrupole requirement calls for at least two different design solutions.

The High Strength solution covers 60% of the requirement (3.5T – 14.8T Integrated gradient; 1:4.5 ratio).

The design is such that manufacture and assembly are reasonably straight forward.

Analysis of the prototype assembly process, performance and design has resulted in a revision that relaxes previously tight tolerances.

Close liaison with suppliers has taken this a step further and subsequently cost and lead times have been reduced.

5 Conclusion

The Low Strength solution covers the remaining 40% of the requirement (0.45T – 8.8T I.G.).

To cater for the large adjustment range (1:11 ratio) the design is distinctly different to the HS version.

This solution involves high accuracy machined components to be assembled at different stages.

Alignment of these and the linear motion system is challenging.

It requires a dedicated "metrology – positioning" closed loop assembly system in addition to skilled professionals for final adjustment meaning it will be time consuming.

Improvements to the prototype have been identified to alleviate some of the complexity and close tolerance requirements.

Both CLIC Permanent Magnet Quadrupole solutions can be manufactured in the time scale stated at the beginning.

The Loss Budget of the SIS100 Fast Ramped Superferric Magnets

Anna Mierau, Alexander Bleile, Egbert Fischer, Pierre Schnizer

GSI Darmstadt

Beam guiding magnets for SIS100 – Design options

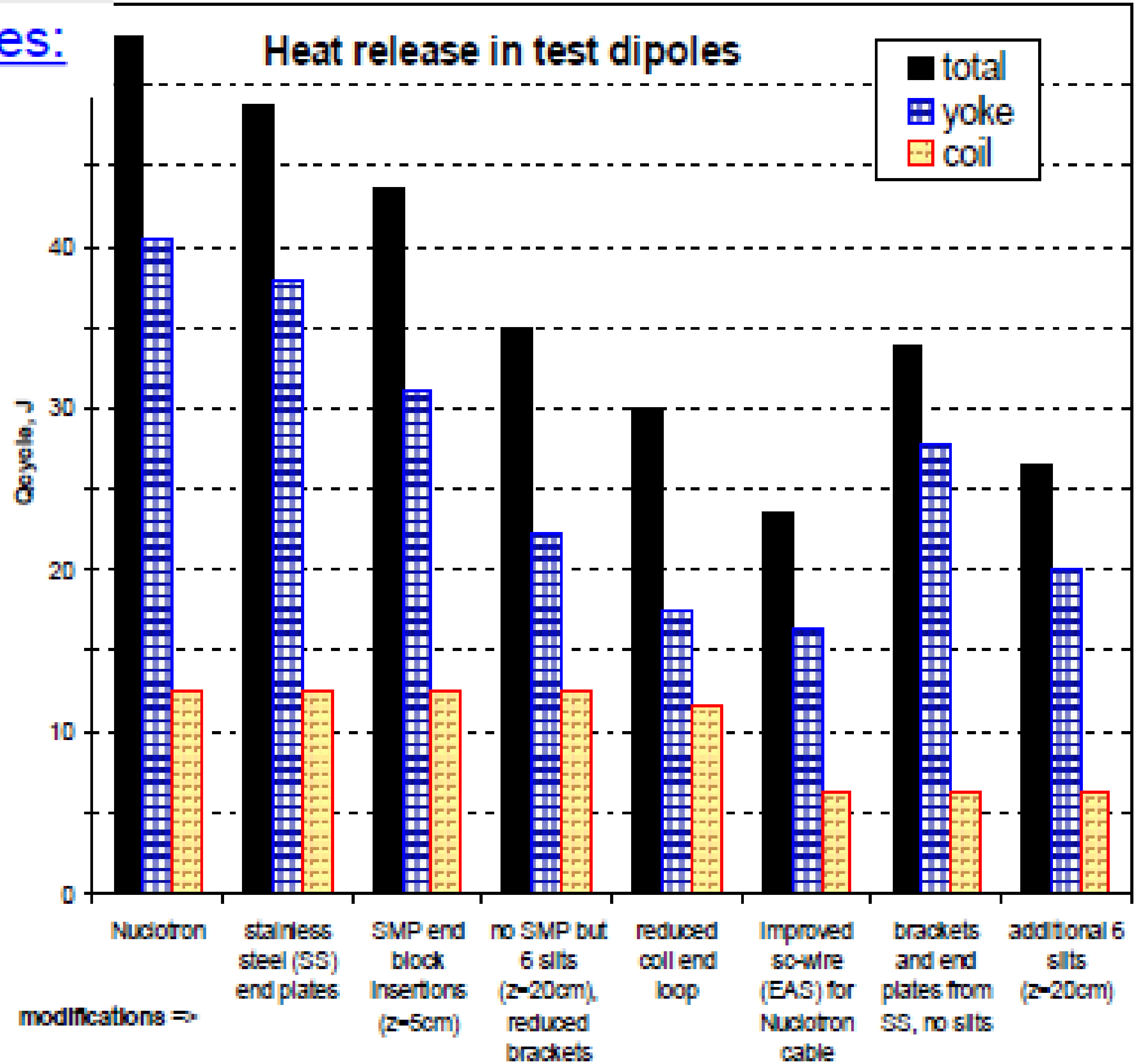
- Iron: warm / cold
- Beam pipe: warm / cold
- Cable: resistive / superconducting (Nuclotron type, CICC, Rutherford)

Pro resistive magnets	Pro supersonducting magnets
• No cryogenics • No cryostat • No complex coil restrain • No quench detection and protection system	• High current density • Small coil, low inductance ➢ small stored energy • Higher fields • No resistance for DC mode ➢ low power consumption ➢ ‚Amp-turns' are cheap ➢ low-voltage power supply

The choice between resistive and superconducting magnet designs is determined by cost (including capital and long-term operation) and additional requirements (e.g.: cryo pumping of the beam pipe)

Beam guiding magnets for SIS100 – Design optimisation

Reduction of AC losses:



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Multi-stacked dipoles: a cost cutting configuration.

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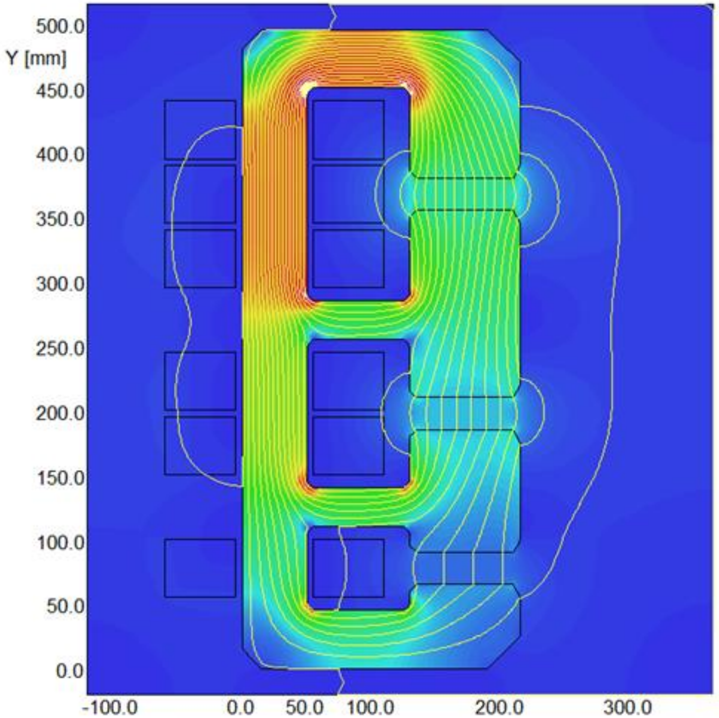
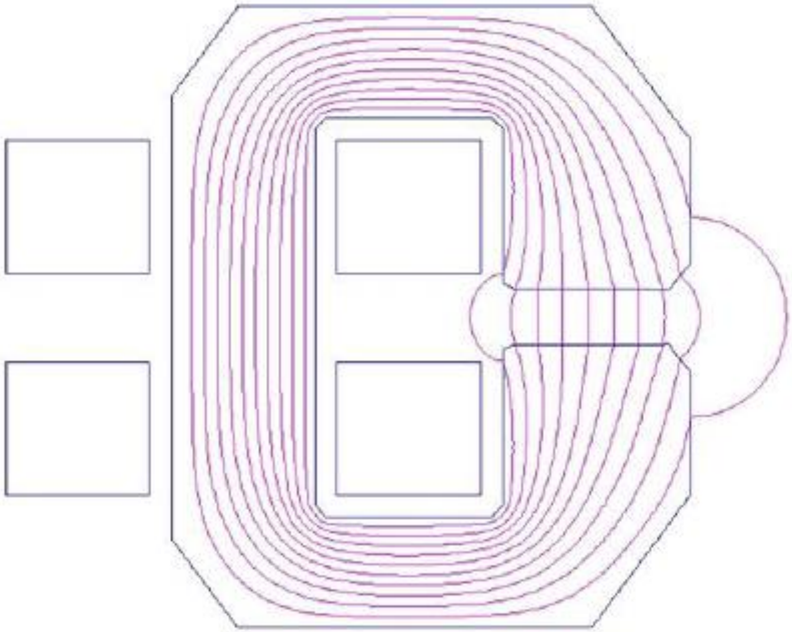
Science & Technology Facilities Council

Initial proposal for circulating dipole:



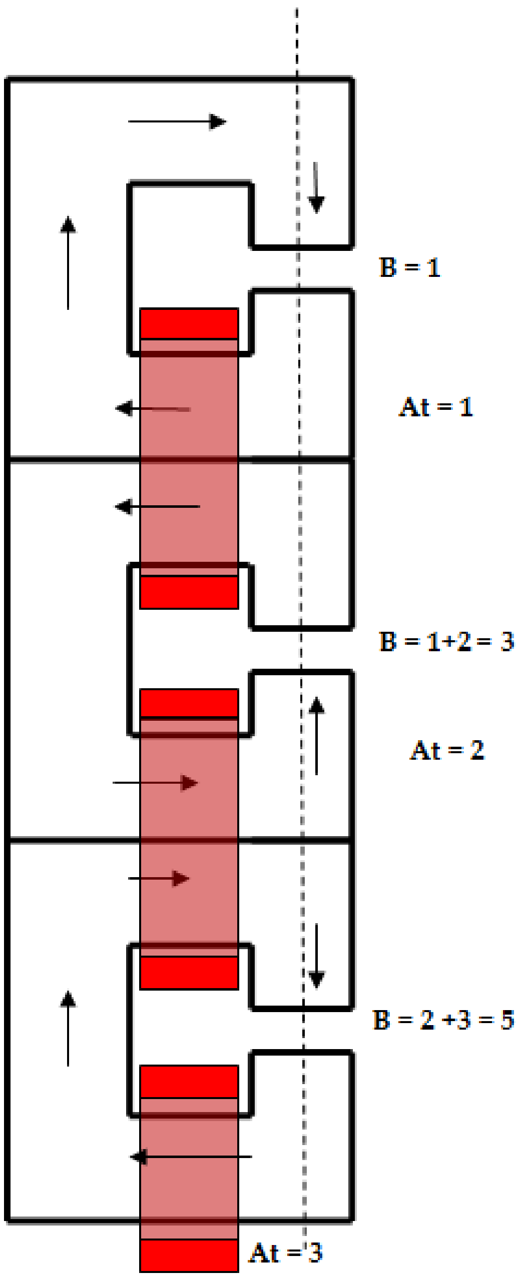


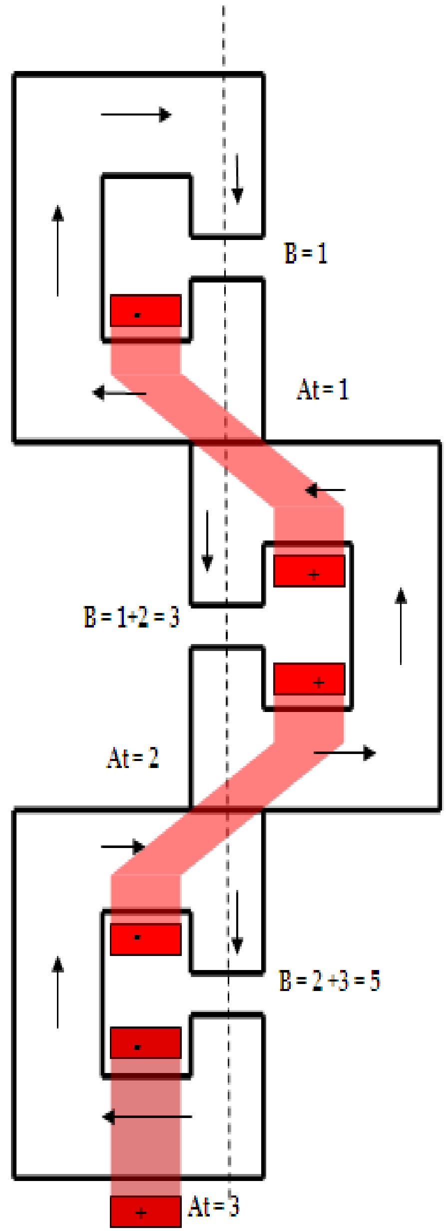
A. Milanese, O. Bruning, CERN;

CERN-ECFA-NuPECC Workshop, June 2012.

LHec; A Large Hadron Electron Collider at CERN;

Section 9.2.1 p 335





In both cases, there is a reduction of required amp-turns by a factor of 1/3.

Coil volume and losses are reduced by approximately that factor.

Development of a Hybrid Permanent Magnet Quadrupole

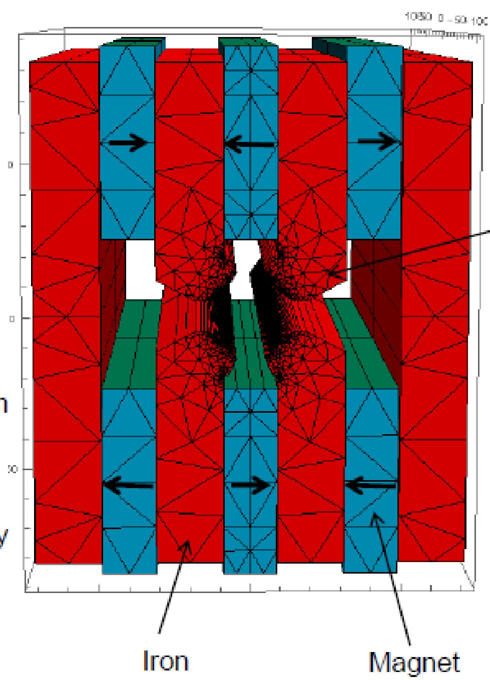
CERN
Workshop on special compact and low consumption magnet design
November 2014

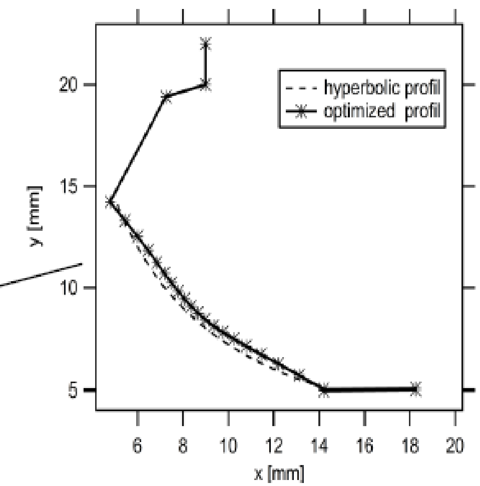
P. N'gotta, J.Chavanne, G. Le Bec

H-type structure, simple mechanical parts

Characteristics

- 36 NdFeB magnets (Br =1.1T)
- Steel ARMCO
- Simple and flexible structure
- Simple magnet block shape
- Magnets far from electron beam (radiation damage protection)
- Large space for X-rays beam port, extension possibility





- 3D optimization
- Gauss-Newton algorithm + SVD
- Result in 5 iterations (<10min)

(Le Bec et al., IPAC14)

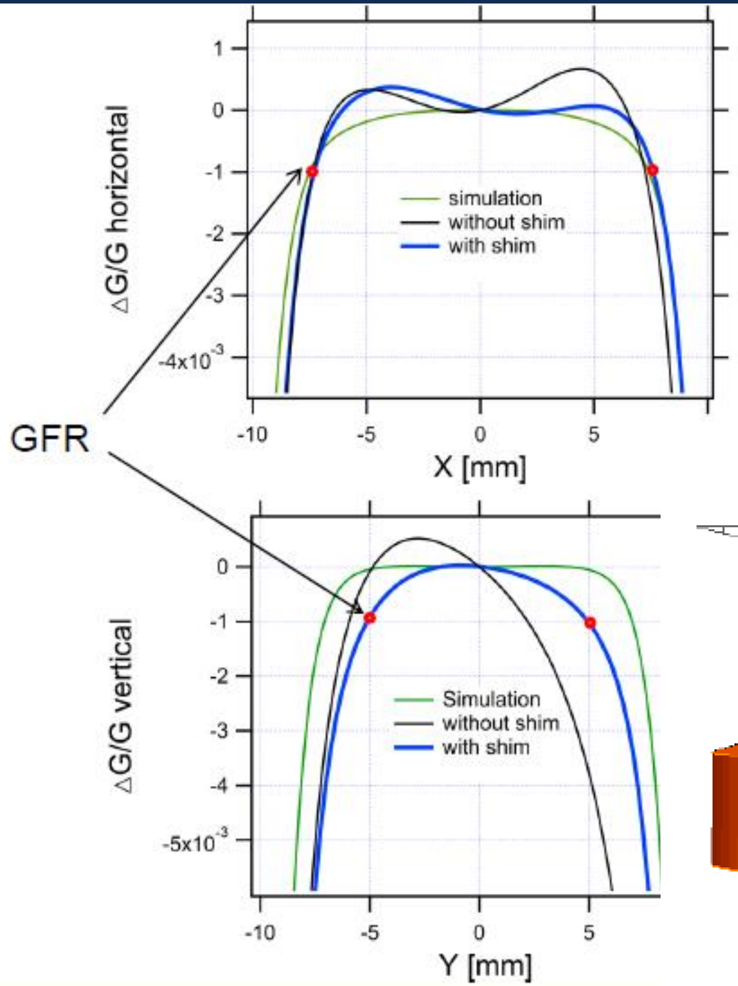
Results

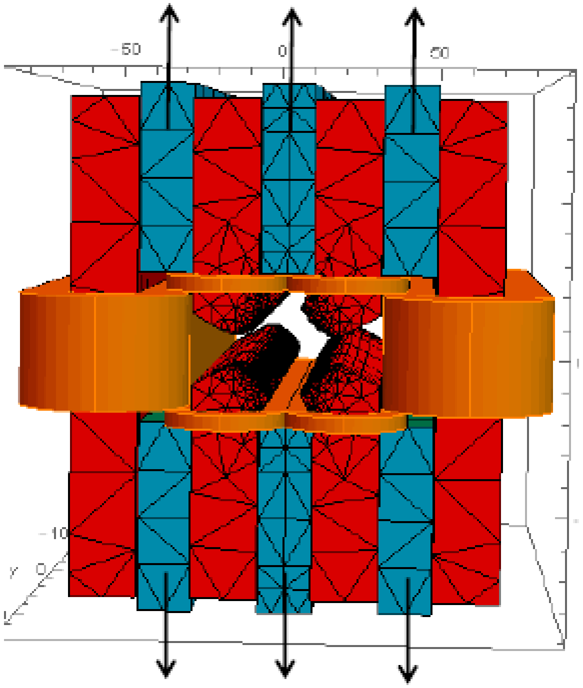
- Stretch wire method
- Nominal gradient: 82T/m
- Field quality (harmonics)

@ 7 mm, $(b_n / b_2) \cdot 10\,000$

$b_3 = 3.8 \quad b_5 = 5.2$

$b_6 = -8.4 \quad b_{10} = -7$





- 5 mm magnet translation
- Current density: 1 A/mm2
- Field tuning: ± 1%

Impressions

- I very much appreciated having talks from industrial colleagues explaining their latest thoughts, ideas, capabilities, etc
- In general, huge quantities of magnets to us (e.g. 42,000 quadrupoles) is not necessarily a big deal to industry – good news!
- Magnet designers of all ages are still generating clever ideas!

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