Science & Technology Facilities Council

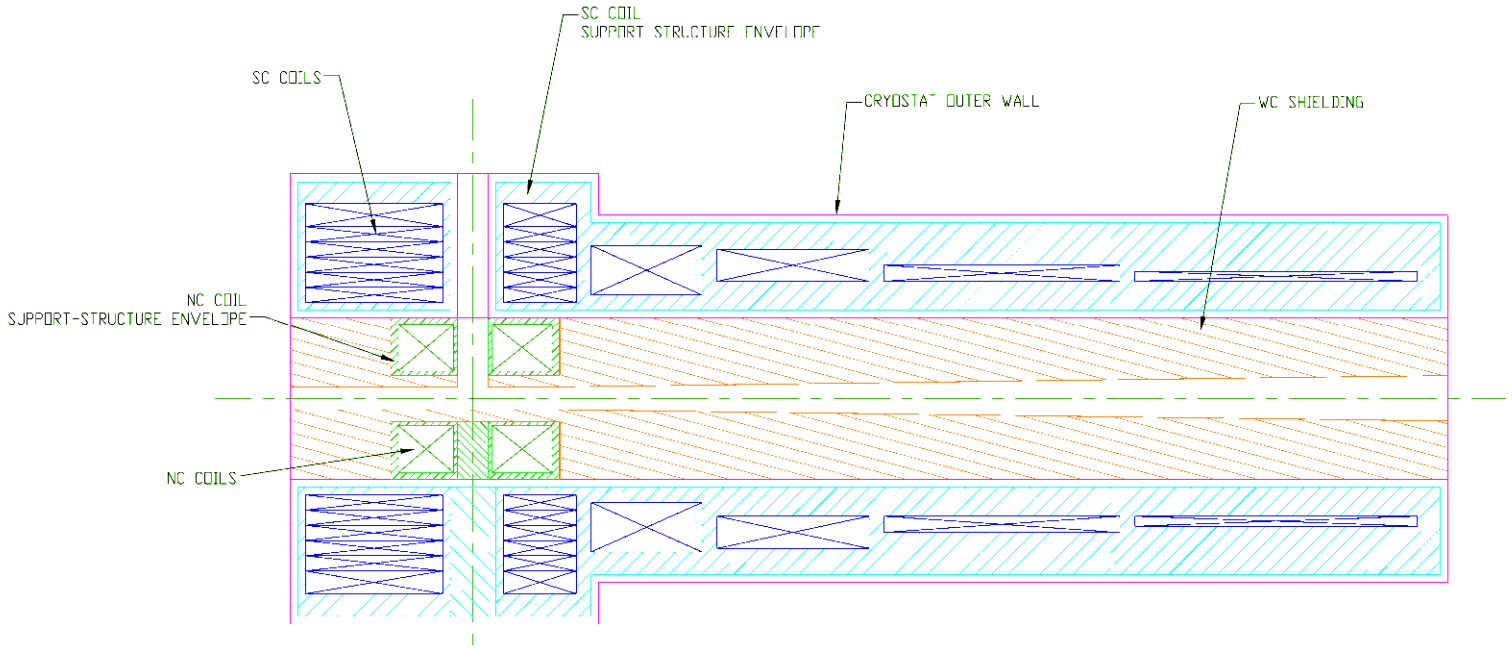
Helmholtz Capture Solenoid Update

Peter Loveridge
P.Loveridge@rl.ac.uk
STFC Rutherford Appleton Laboratory, UK

2nd Princeton-Oxford High Power Target Meeting
6-7 November-2008

Overview

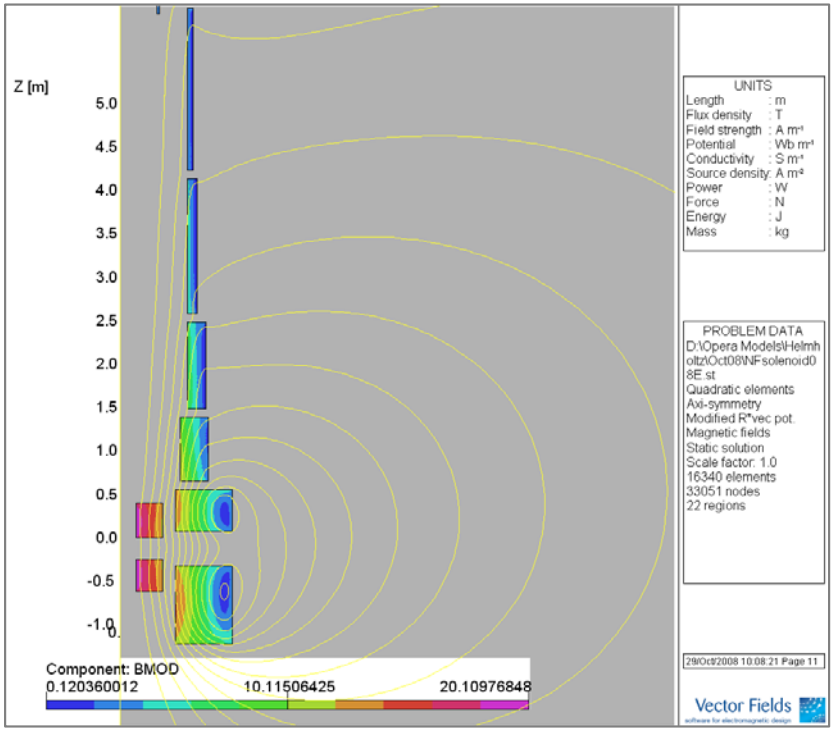
- Purpose
  - To investigate the feasibility of a proposed capture solenoid with an axial (“Helmholtz”) gap
- Method
  - Development of Study-2 design…
    - Split both the 1st SC coil and the NC insert coil in two
    - Downstream coils remain unchanged
    - Introduce current grading in the SC “Helmholtz” coils
  - Investigate a potential mechanical design with lateral target entry/exit slots
    - Start with min slot size 20 mm x 200 mm, -an optimistic case!



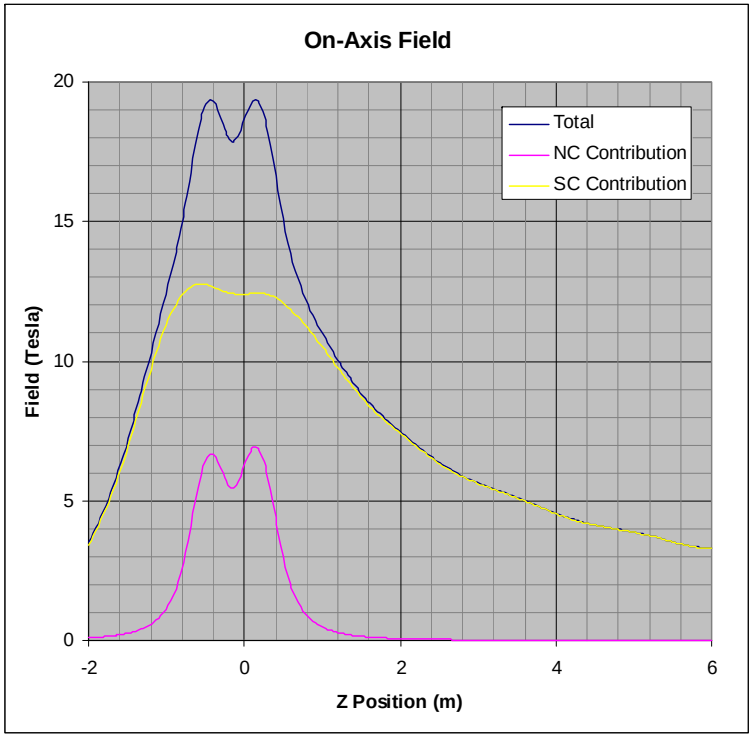
Conceptual layout of the Helmholtz capture solenoid

On-axis Field Profile

- SC contribution
  - ~12 Tesla, flat plateau in target region
- NC contribution
  - ~7 Tesla, unwanted trough in target region
- Total
  - Close approximation to the study-2 field with the exception of the trough in the target region



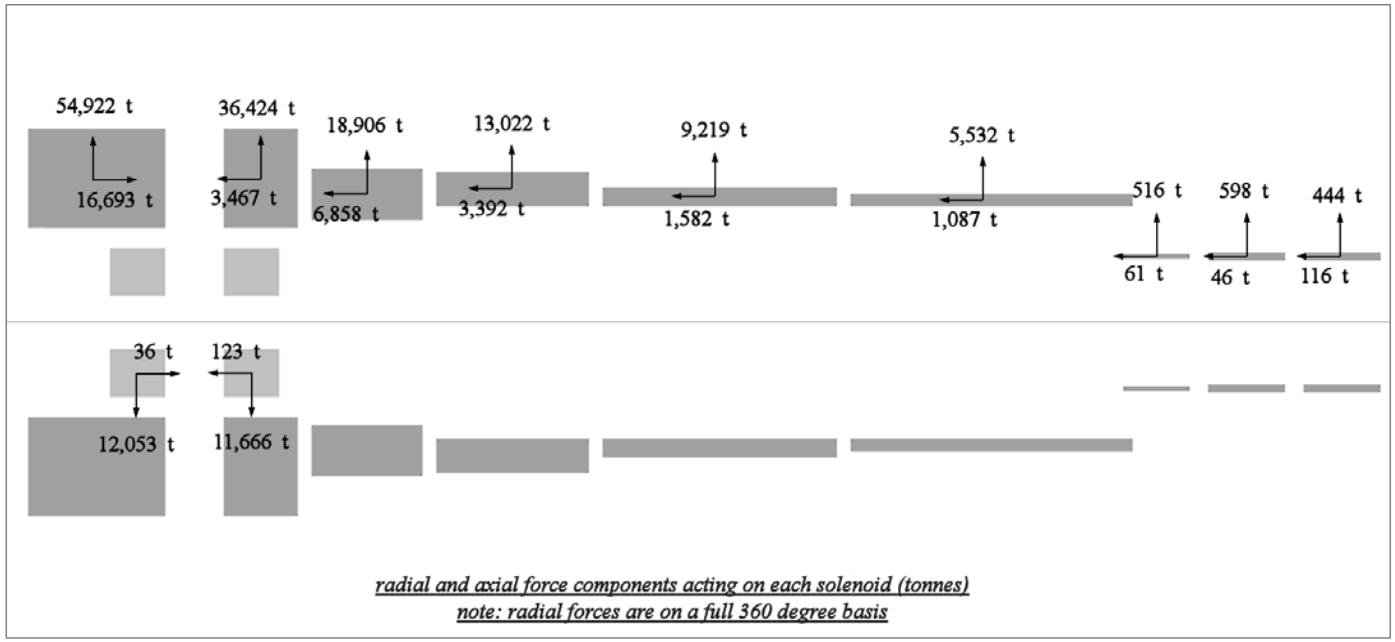
Magnetic field plot (Tesla)



On-axis field profile

Inter-Coil Forces

- Axial Forces
  - Cumulative axial compressive force ~ 16,000 metric tonnes!
  - Axial Forces balanced between first 6 SC coils
    - Must house all these coils in a single cryostat to avoid transferring loads up to room temperature
  - Huge attractive axial forces must be transferred across the Helmholtz gap
    - Requires careful mechanical design
- Radial forces
  - Equivalent to an internal pressure of ~1500 bar! In coils SC01and SC02
  - Leads to large hoop-stresses as seen in study-2 design
  - Strength of NC insert coil is a particular concern



Magnetic force plot from an early Helmholtz geometry iteration

Summary

Status

- Have developed a (very) conceptual design for a capture solenoid with lateral target entry/exit slots (200 mm x 20 mm)
  - Includes a basic level of realism:
    - "Reasonable" current densities in SC and NC coils
    - 1st guess at space envelopes for cryostat, coil support-structure, shielding

Issues

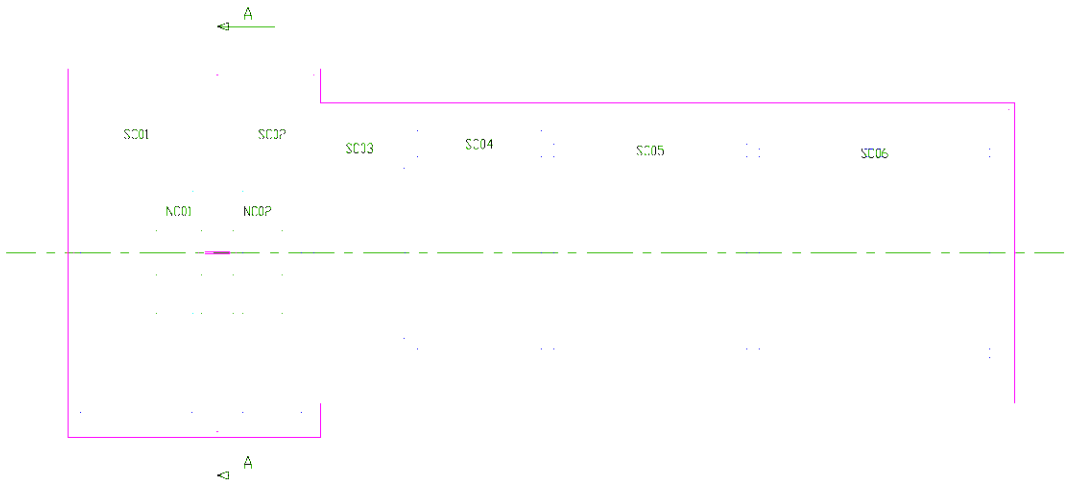
- Effect of field trough on pion capture (John Back)
- How to cope with the huge inter-coil forces
- Large tensile hoop stresses in coils

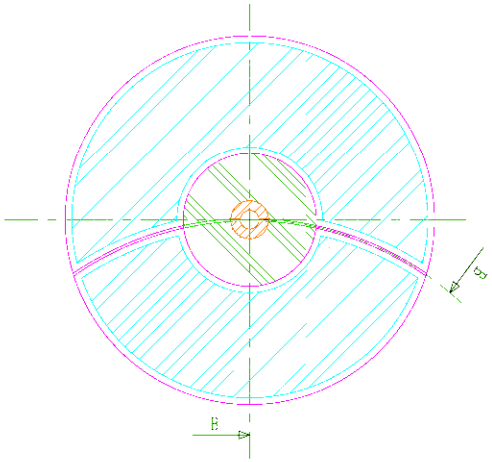
- How to integrate with a solid target system

Comments:

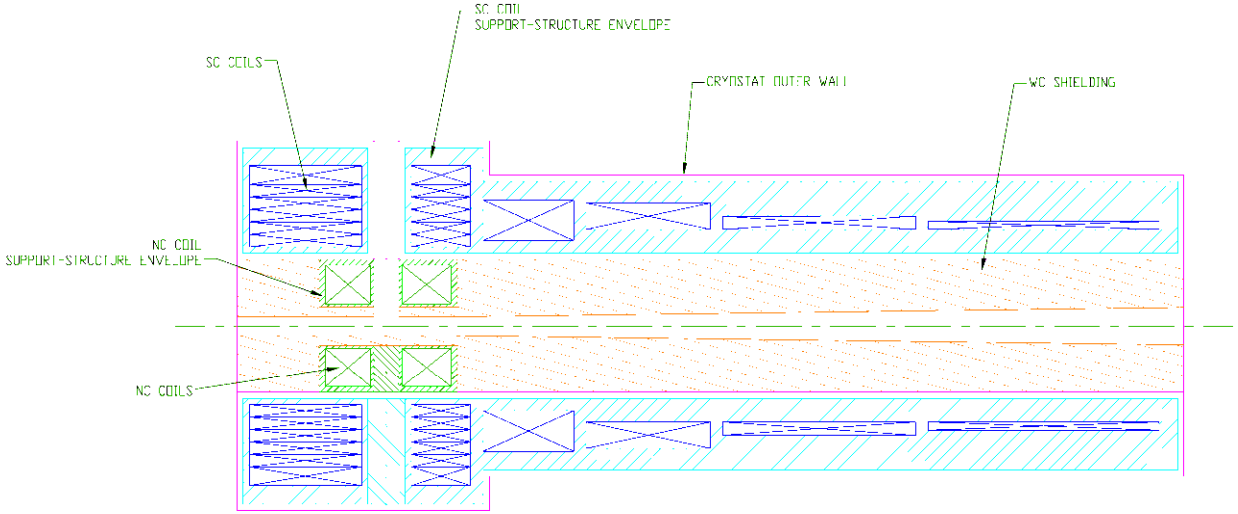
- The combination of ***very high field*** and ***large bore*** required by the capture solenoid constitutes a formidable engineering challenge
- We should keep an open mind about what kind of magnet geometry would best suit a solid target system.

A1 | NF-2001-002-A | Sheet 1 OF 1 | PROJECTION | THIS DRAWING CONFORMS TO BS 8888





SECTION A-A



SECTION B-B

NOTES:
1. COILS SC01 TO SC06 ARE HOUSED IN A SINGLE CRYOSTAT
2. THE RESULTING INTER COIL FORCES ARE BALANCED WITHIN THE CRYOSTAT
3. THE COIL SUPPORT STRUCTURE FORMS PART OF THE COLD MASS
4. THE NC INSERT MAGNET IS MOUNTED IN THE WARM BORE OF THE CRYOSTAT
5. 400 MM AXIAL SPACING (HELMHOLTZ GAP) BETWEEN COILS SC01 AND SC02
6. 250 MM AXIAL SPACING (HELMHOLTZ GAP) BETWEEN COILS NC01 AND NC02
7. TARGET ACCESS SLOT DIMENSIONS 200 x 20 MM
8. REF VECTOR FIELDS MODEL (NFsolenoid08E)

ISSUE	DATE APPD	MOD. No.	DRN. BY	CHKD BY.	APPD BY.	STATUS
A	--/---/--	------	PL	---	---	

TOLERANCES UNLESS STATED ± mm	FINISH ---------- REMOVE ALL BURRS	ORIGINAL SCALE 1:20 DO NOT SCALE
MATERIAL & SPEC. -------	SURFACE TEXTURE µm ✓ UNLESS STATED	

USED ON

CENTRAL LABORATORY OF THE RESEARCH COUNCILS RUTHERFORD APPLETON LABORATORY, CHILTON, DIDCOT, OXON OX11 0QX.

TITLE
SUPERCONDUCTING 'HELMHOLTZ' SOLENOID CONCEPT
LAYOUT DRAWING

A1 | NF-2001-002-A | SHEET 1 OF 1

A1 | NF-2001-002-A | Sheet 1 OF 1