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Modelling of a Superconducting Helical Undulator for a Polarised Positron Source

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for the HeLiCal Collaboration

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HeLiCal Collaboration

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Talk Contents

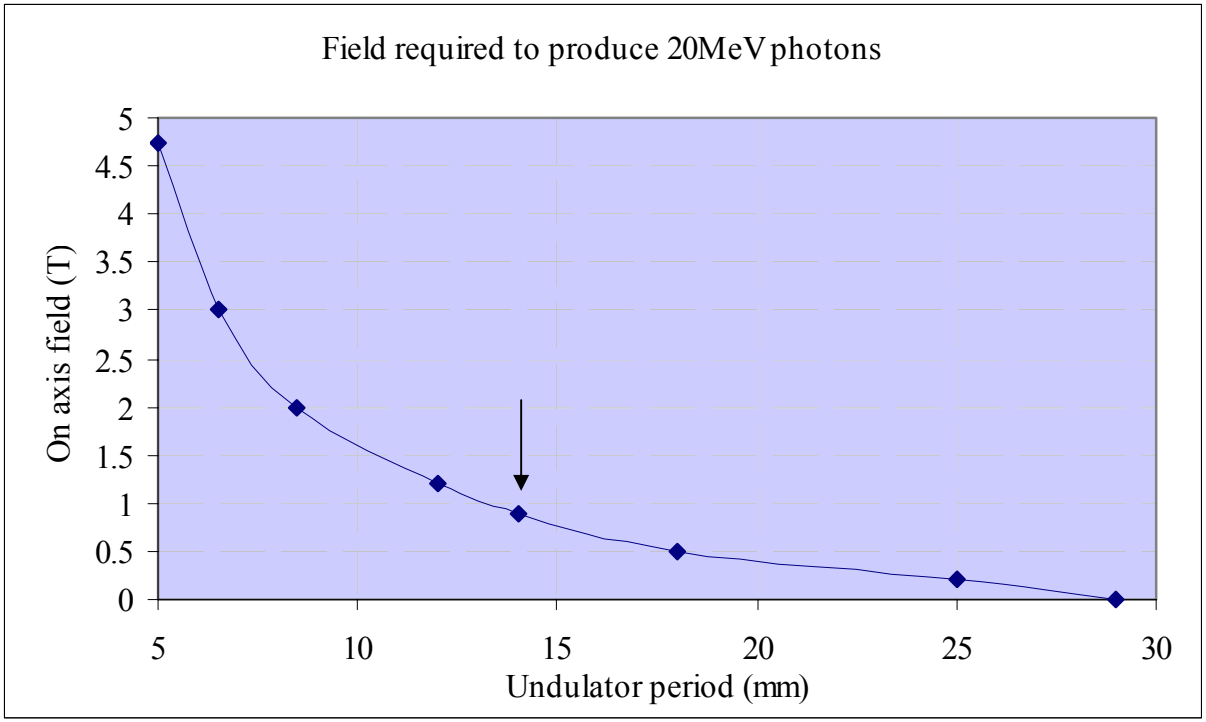
- Motivation
- Specification for the SC Undulator Prototype
- Magnetic modelling
- Prototype Fabrication
- Summary

Motivation

- An efficient and simple method for the production of positrons is one of the challenges for a future e^+e^- linear collider.
- A method of producing polarised positrons as a result of the interaction of polarised photons with a target, has been suggested and is currently under study by the HeLiCal Collaboration and by other groups.
- A helical type undulator is required for the production of polarised photons.
- An undulator design can be based on both the superconducting and the pure permanent magnet technologies.
- RAL team is carrying out R&D on the superconducting helical undulator design.

Parameters of the SC Undulator Prototype

- Pitch: 14 mm
- Bore: 4 mm
- Field on axis: 0.85 T
- Geometry: bi-conductor helical
- Technology: superconducting
- Prototype length: 20 periods



Magnetic Modelling

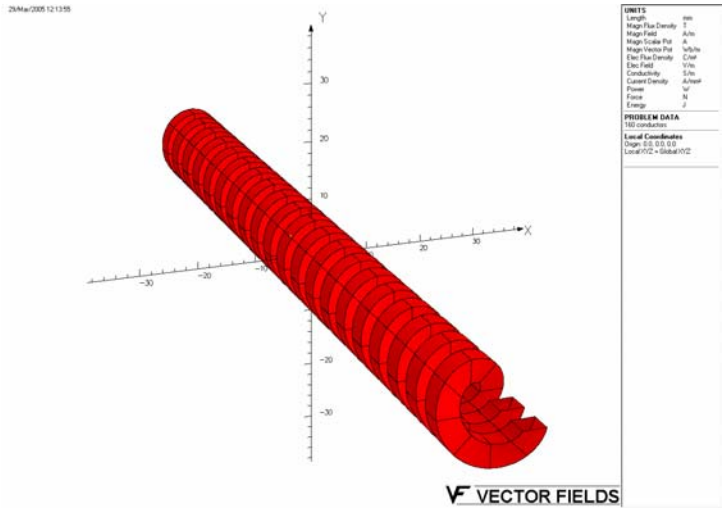
3d model of the undulator:

- **Winding aspect ratio**: the highest field on axis is achieved with a rectangular winding with the smallest radial height – to- length ratio;

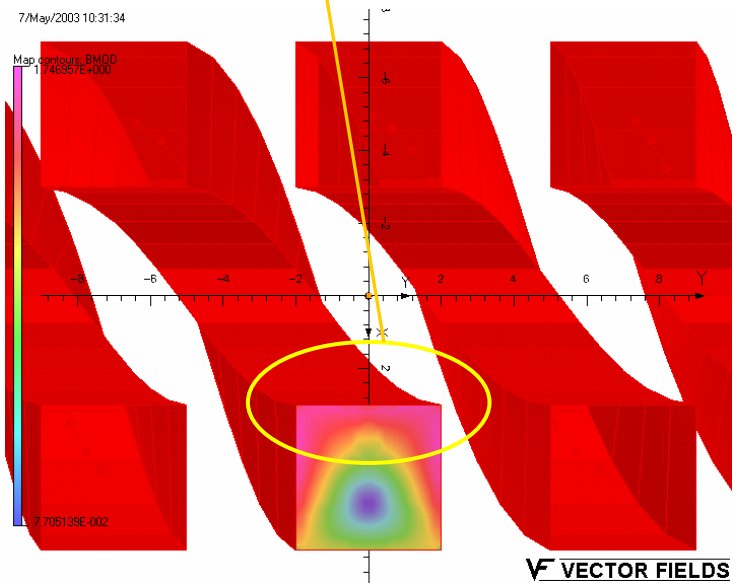
- **Winding current**: to produce 0.8 T-field on axis a 1000 A/mm2 current density is required (winding - 4mm * 4 mm ; winding internal diameter - 6 mm; pitch - 14 mm);

- **Peak field**: is 1.74 T for this configuration

- **Tolerance effects** on central field value: winding radius variation of 0.1 mm leads to 4.2 % change in the on axis field value, the changes induced by changing the winding period by 0.1 mm are at the level of 3%.



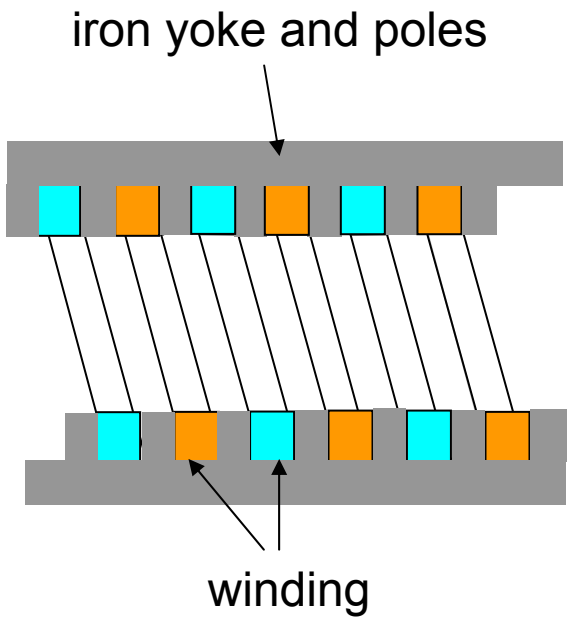
Region with the highest peak field



Magnetic Modelling (2)

Inclusion of iron in the former (2D model):

The modelling indicated that inclusion of iron in between winding and from outside can increase the field on axis up to 40% thus allowing to reduce the winding current and a superconductor margin for a given field.



Magnetic Modelling (3)

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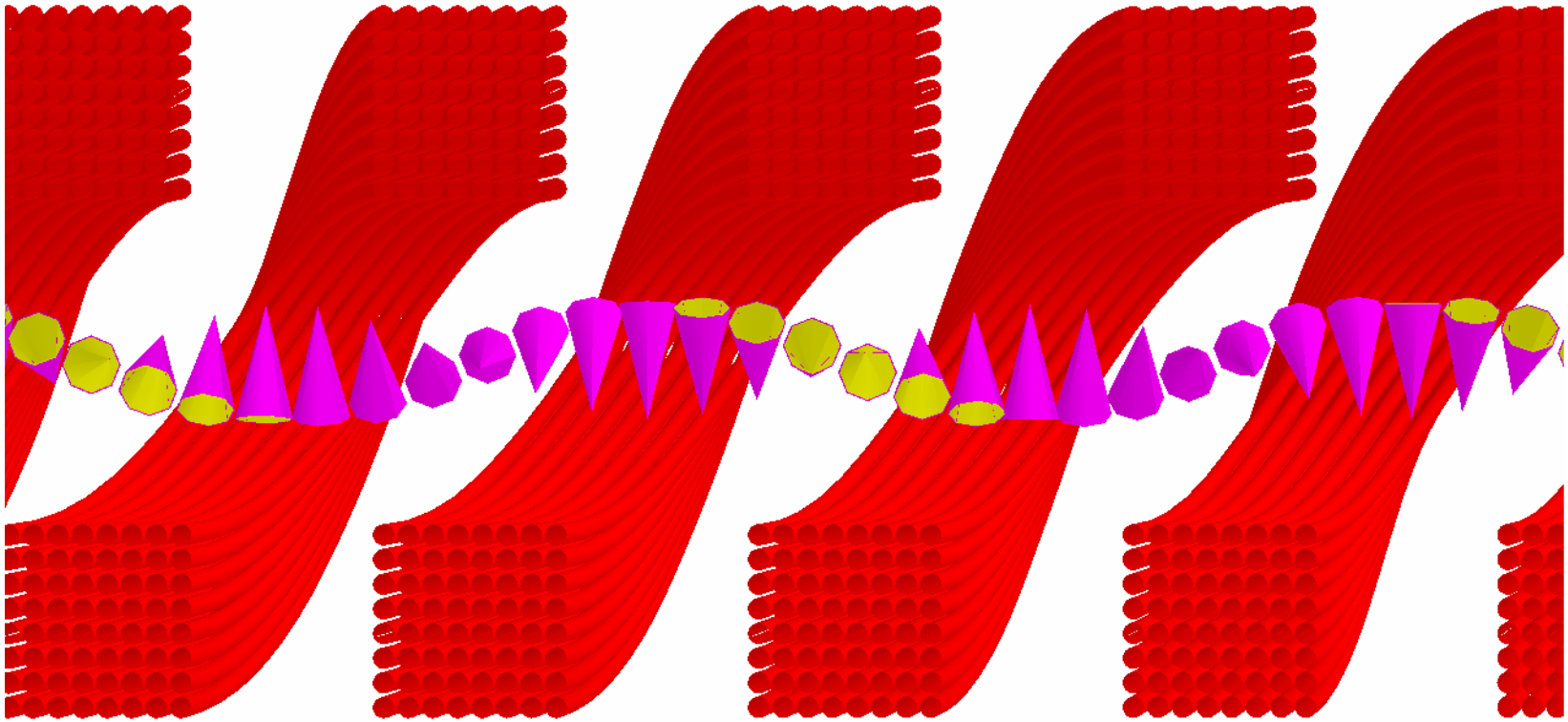
More sophisticated model

Multi-wire winding model in Opera 3d

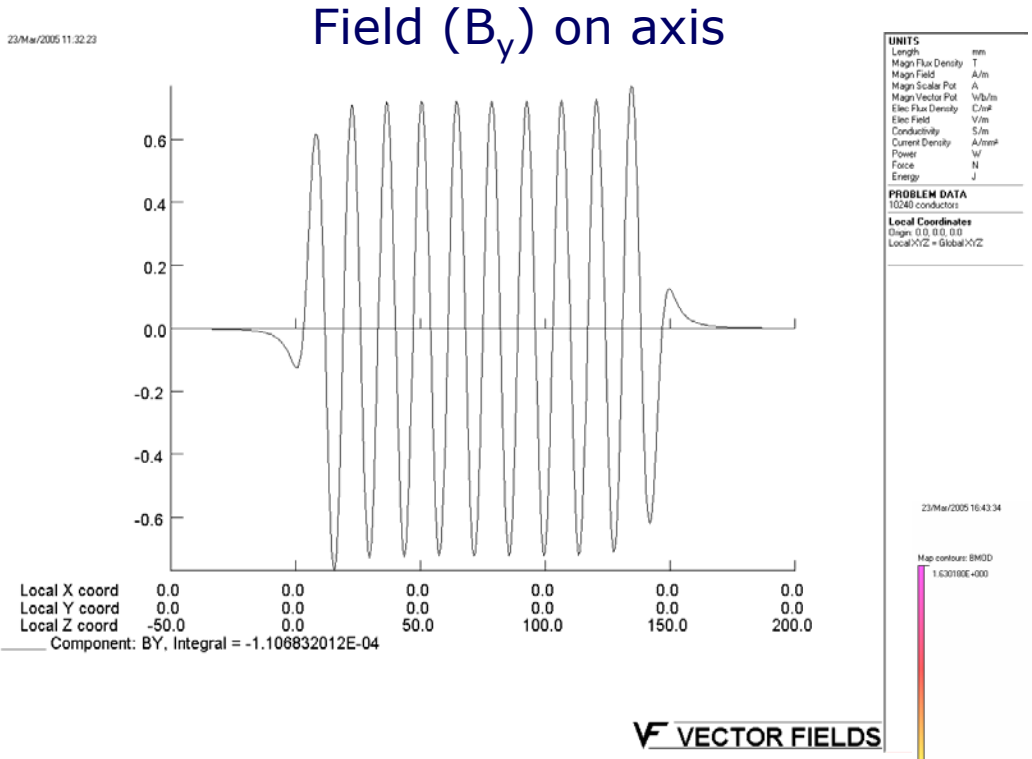


Model parameters:
dimensions and positions of individual wires;
wire current

VECTOR FIELDS

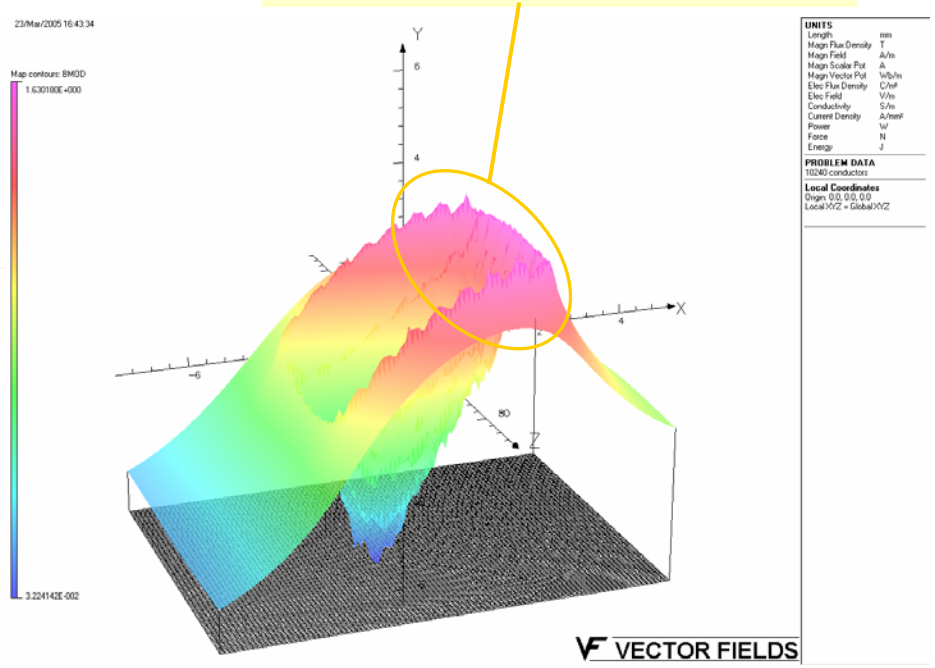
Magnetic Modelling (4)

Field (B_y) on axis

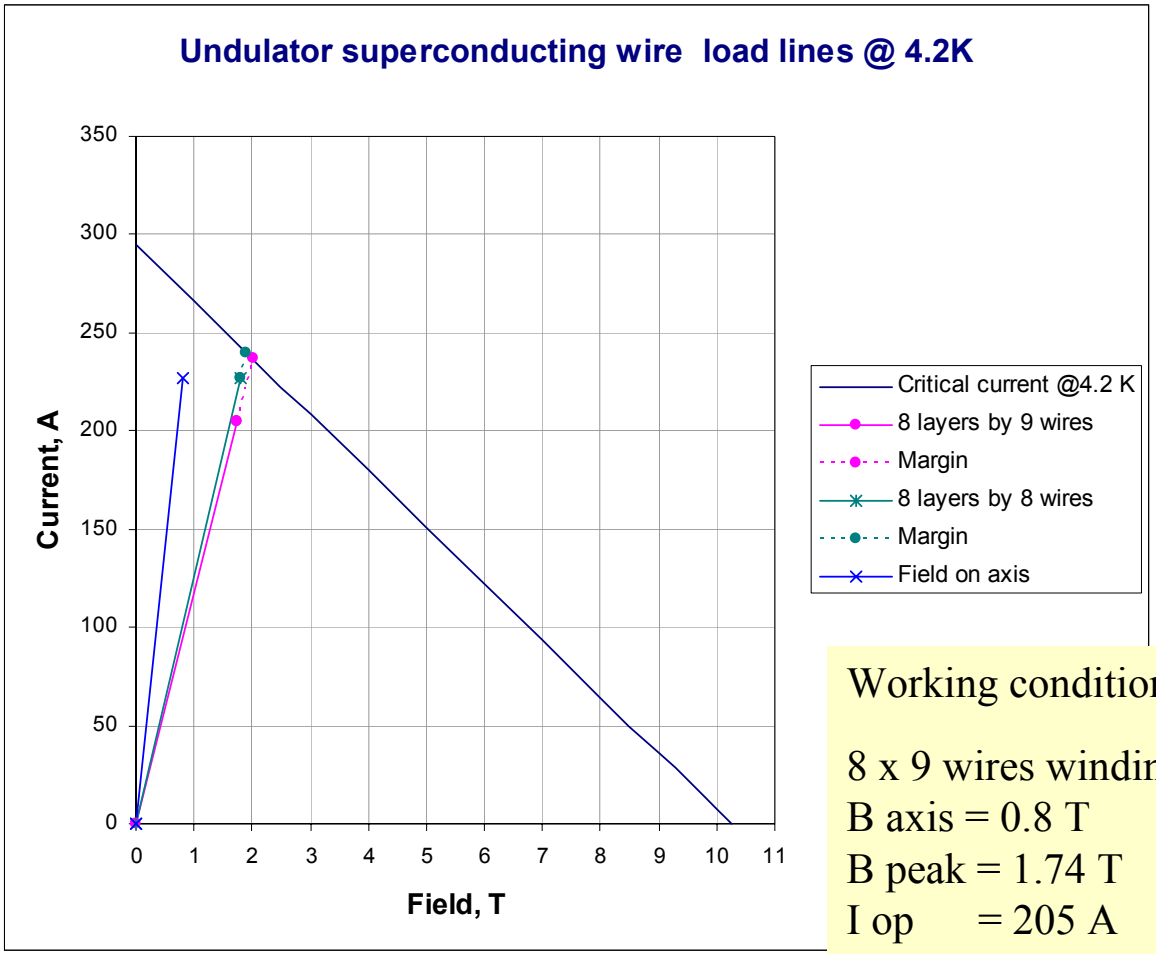


Field profile inside winding block of SC wires

Region with the highest peak field



SC Wire Selection



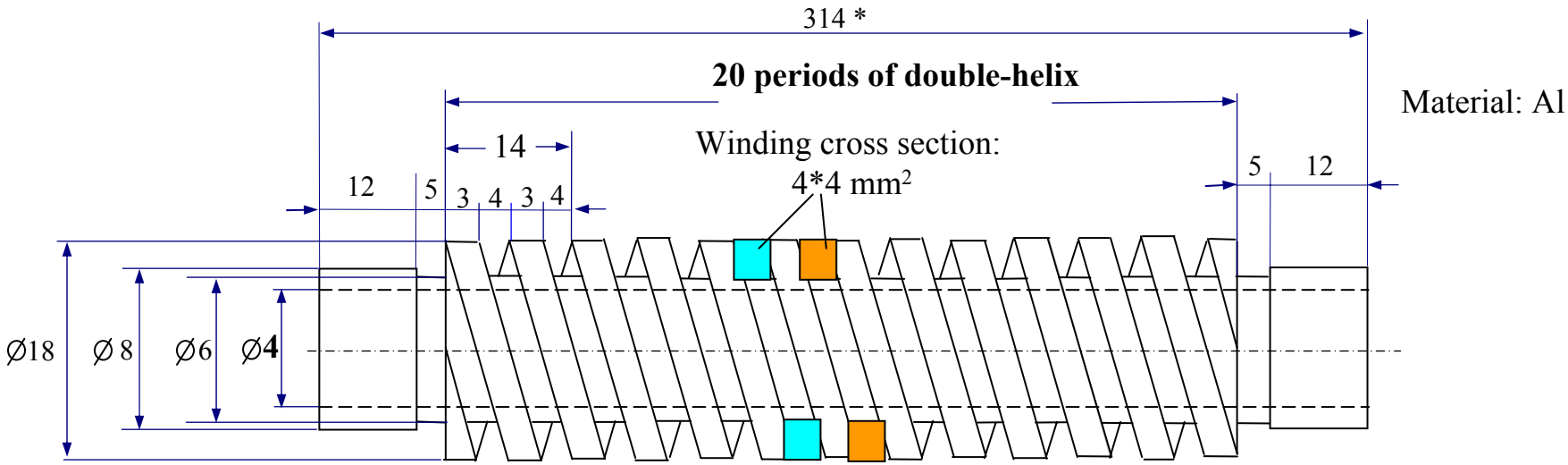
Wire:
VACRYFLUX 5001
Type F54-1.35

Consists of	54 NbTi filaments in Cu-matrix;
Ratio Cu:NbTi	1.35 : 1
Bare diameter	0.4 mm
Insulated diameter	0.438 mm
Critical currents	151 A @ 5T
	36 A @ 9T

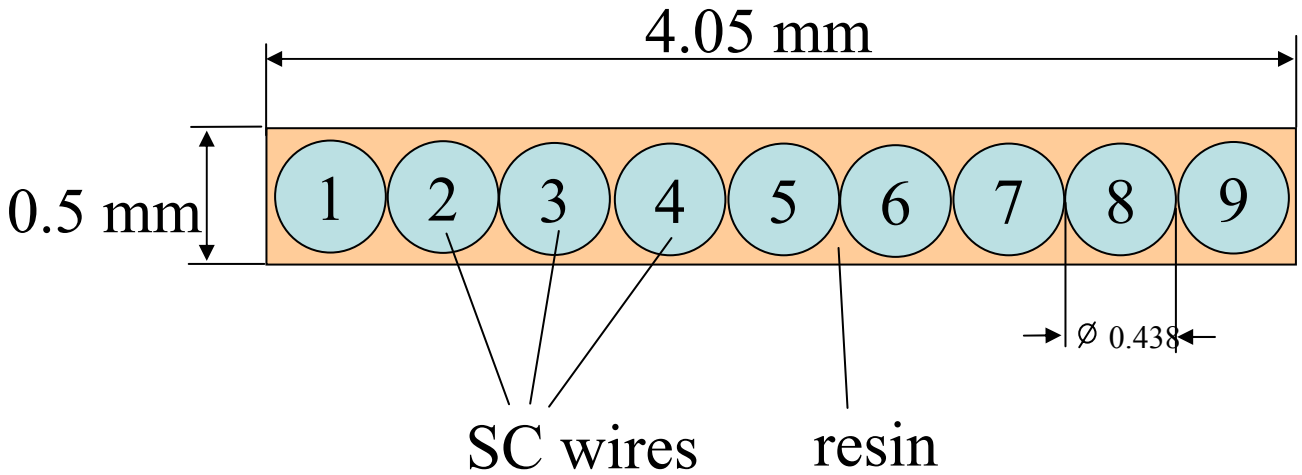
Working conditions:

8 x 9 wires winding:	8 x 8 wires winding:
B axis = 0.8 T	B axis = 0.8 T
B peak = 1.74 T	B peak = 1.8 T
I op = 205 A	I op = 226.5 A
86 % of Ic	94 % of Ic

Winding Geometry

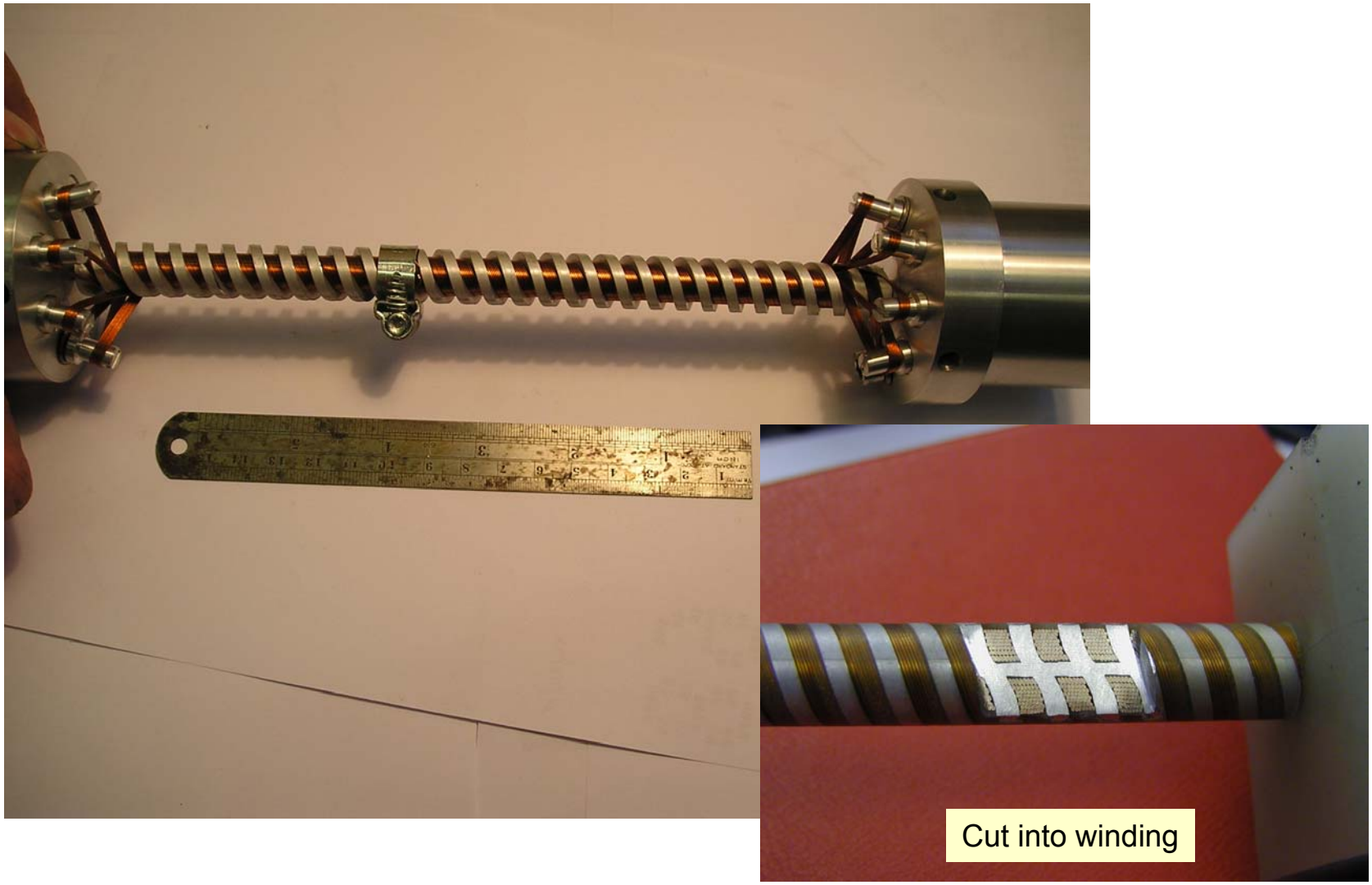


Superconducting wire ribbon

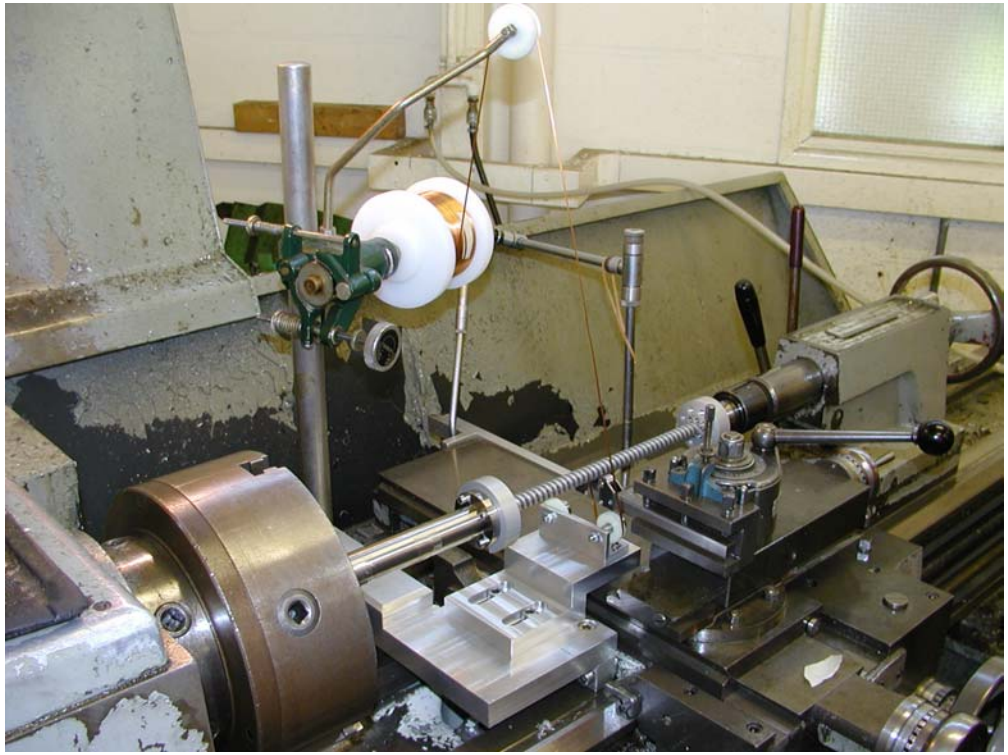


Undulator Winding Check

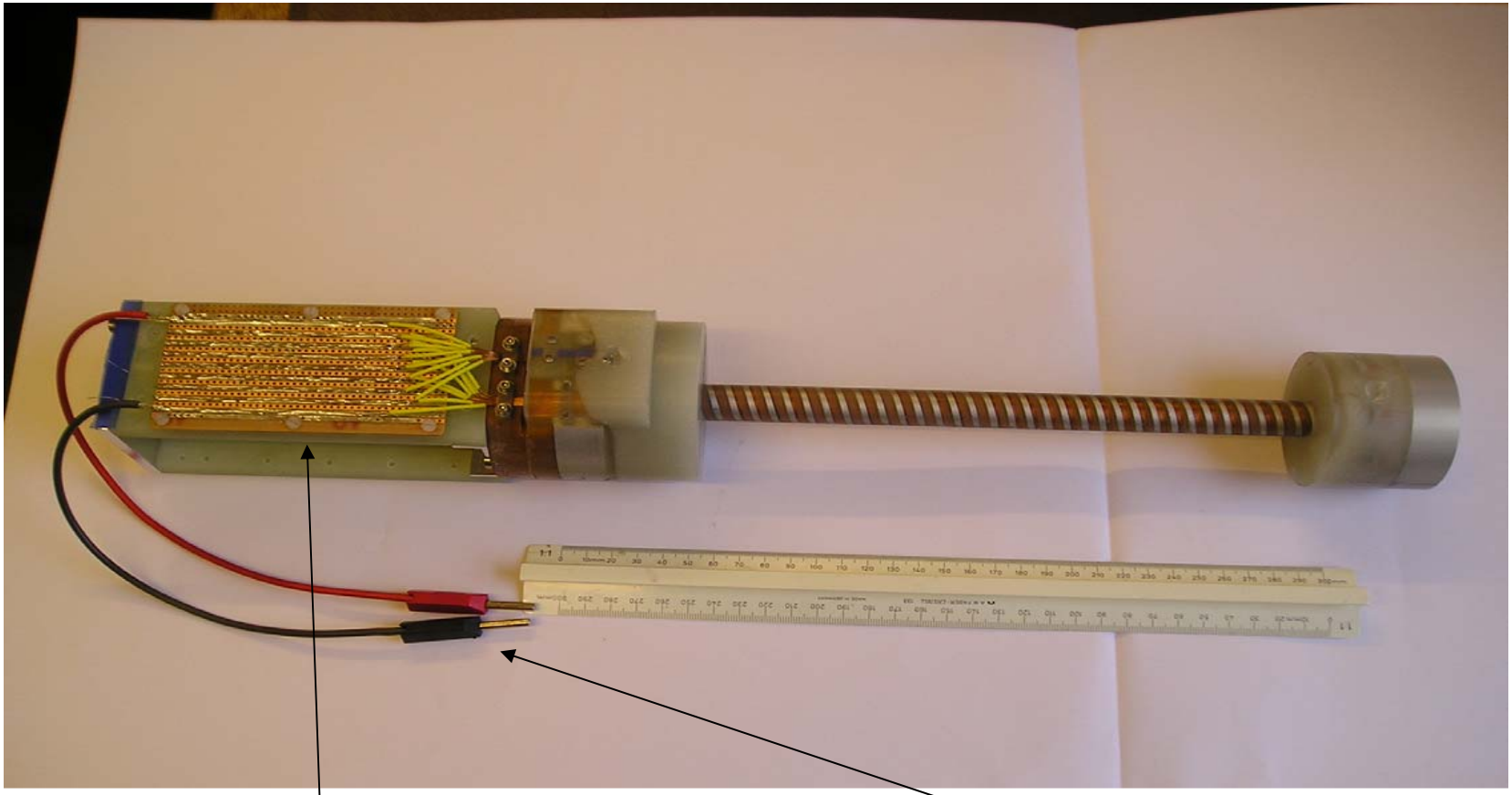
Undulator model was winded with a superconducting wire ribbon and then vacuum impregnated.



Undulator Prototype Winding



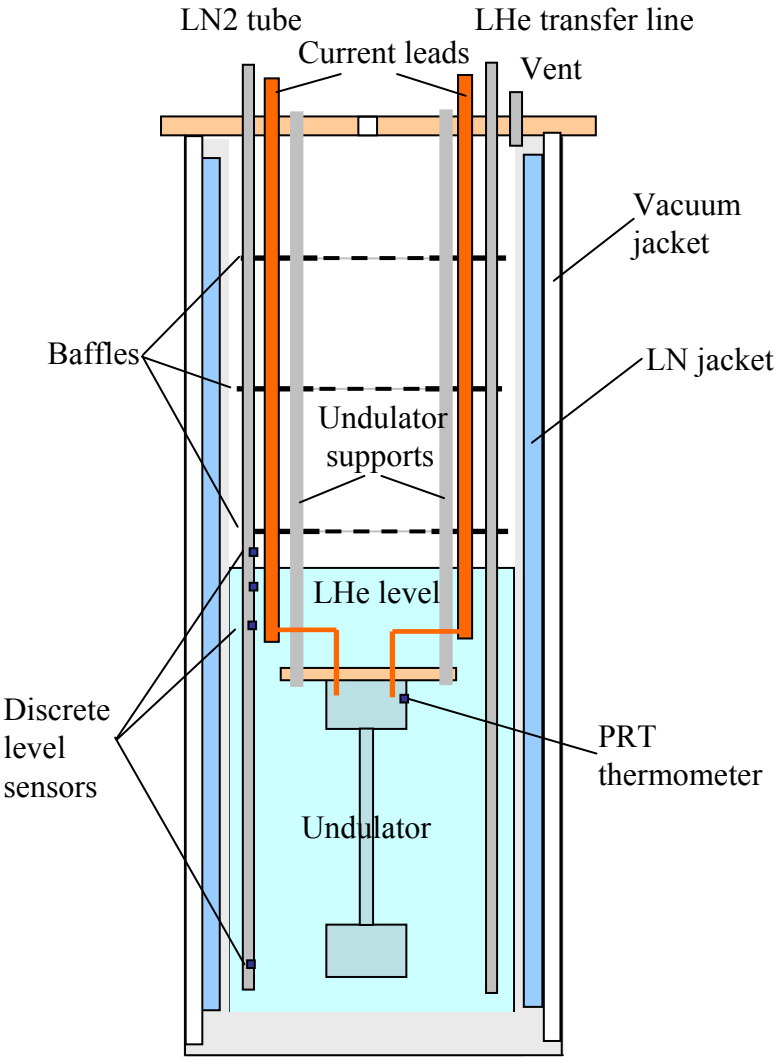
Undulator Prototype Completed



Wiring plate

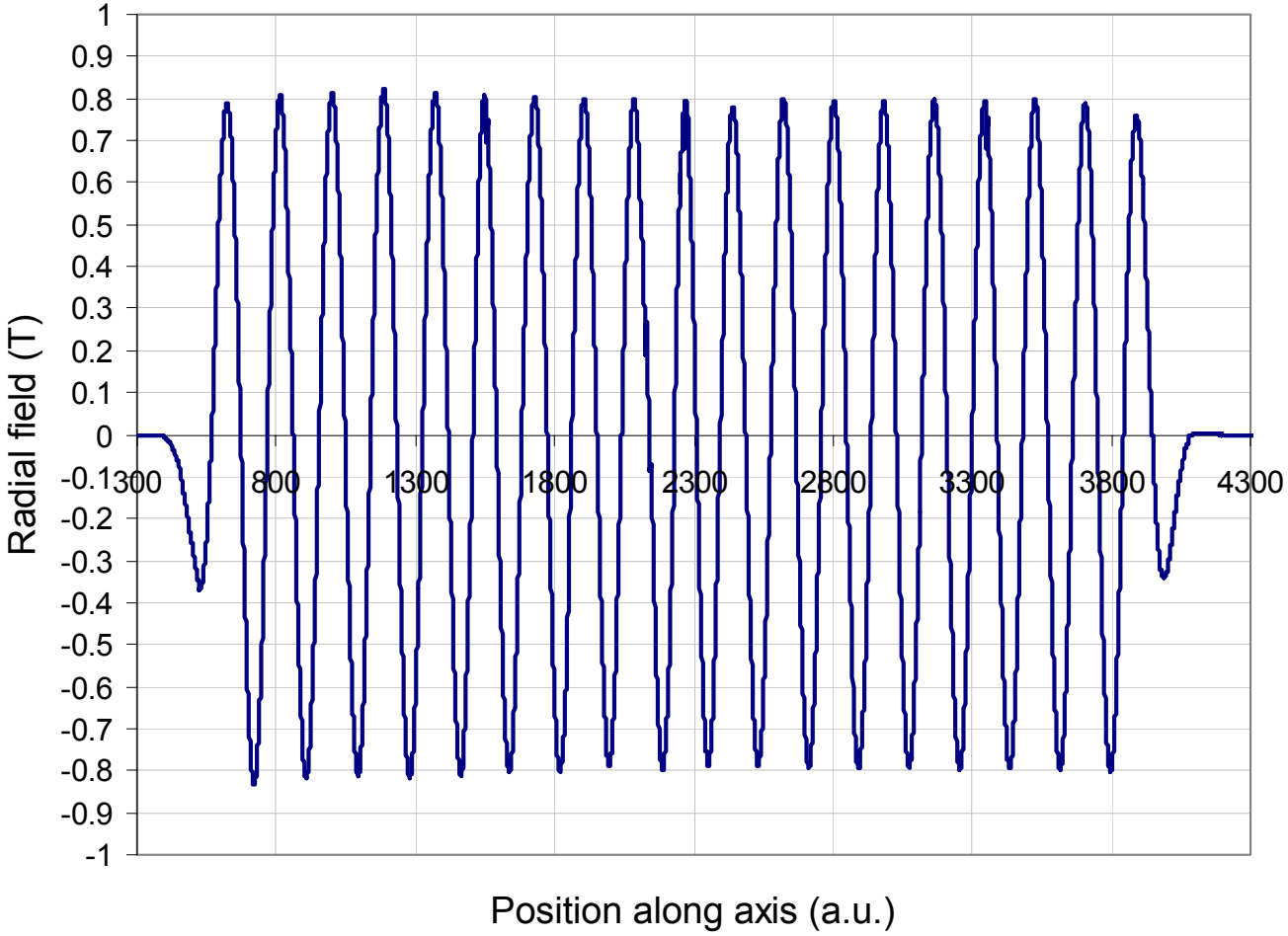
Current leads for room temperature test

Undulator Cold Test Assembly



Cold Test Results

Profile of the axial component of the magnetic field on the undulator axis.



Summary

- The UK HeLiCal Collaboration is working on the feasibility study for the superconducting helical undulator.
- An intensive technological R&D programme is underway.
- OPERA 2d and 3d packages are used for a magnetic modelling.
- First prototype of the SC undulator has been built at RAL. Cold test shows that the undulator reaches it nominal working field without quenching and delivers the required field profile.
- A possibility to build and to test in a beam a full-scale undulator module is under discussion.