



## Status of Prototype ILC Undulator programme at RAL

James Rochford  
for  
HeLiCal Collaboration

ILC Positron source meeting  
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Daresbury



CCLRC  
Technology

## HeLiCal Collaboration



CCLRC Technology Rutherford Appleton Laboratory:

D.E. Baynham, T.W. Bradshaw, A.J. Brummitt, F.S. Carr, Y. Ivanyushenkov,  
A.J. Lintern, J.H. Rochford

CCLRC ASTeC Daresbury Laboratory and Cockcroft Institute:

A. Birch, J.A. Clarke, O.B. Malyshev, D.J. Scott

University of Liverpool and Cockcroft Institute:

I.R. Bailey, P. Cooke, J.B. Dainton, L.J. Jenner, L.I. Malysheva

University of Durham, CERN and Cockcroft Institute :

G.A. Moortgat-Pick

DESY:

D.P. Barber, P. Schmid

## Status of ILC Undulator R&D programme

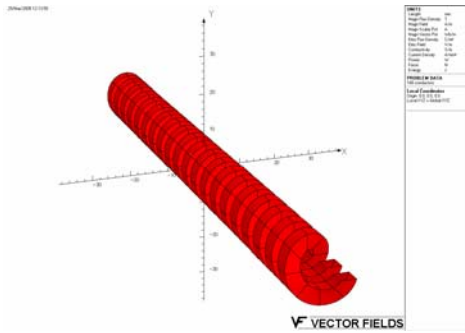
- Working technical specification
- Undulator prototyping R&D programme
- Summarise current status and future plans

- Undulator period: as close as possible to 10 mm
- Field on axis: to produce 10.7 MeV photons (first harmonic)
- Field homogeneity:  $\leq 1\%$
- Vacuum bore: to have beam stay clear of 4 mm => about 5 mm for vacuum bore and about 6 mm for magnetic bore
- Superconductor (NbTi) working point : about 80% of short sample critical current.
- Modular design -module length: 4 m

### Programme to manufacture a prototype

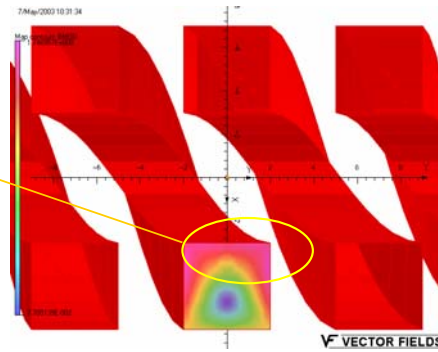
- Develop reliable magnetic modelling technique
  - To define final characteristics of prototype
- Develop undulator manufacturing technique
  - To define methods necessary to manufacture the final prototype
- And finally the design, manufacture and test of a full scale undulator module

## Modelling-non magnetic formers

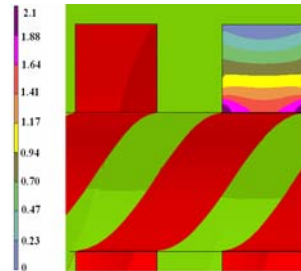
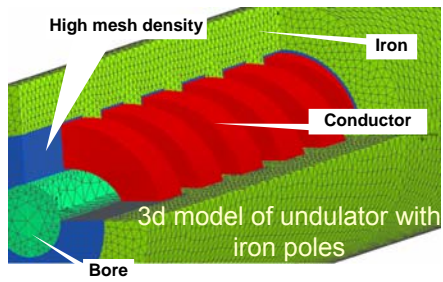


**Nonmagnetic former**- $p= 14$  mm,  
 $b= 6$  mm, winding -  $4\text{mm} * 4$  mm );  
 $J=1000$  A/mm<sup>2</sup> produces 0.8T on  
axis

Region with the highest peak field  
Limits superconductor operation

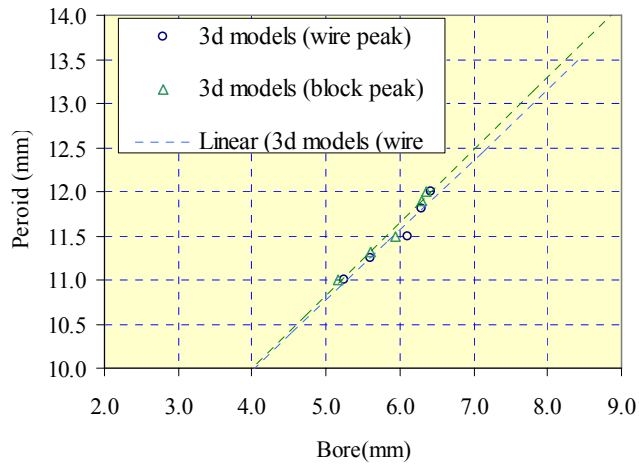


- **Field on axis:** can be enhanced by the former poles made of magnetic material. The inclusion of magnetic material outside the winding also increases the peak field.



Inclusion of full iron poles, J  
400A/mm<sup>2</sup>, Field units (T)

To deliver 10MeV photons assuming 7 wire wide  
1:1 NbTi winding with operating point of 80%



Conclusion so far:  
For NbTi a period of 10  
mm means very small  
bore -unpractical!

Realistic figures:  
Beam stay clear - 4 mm  
Vacuum bore - 5 mm  
Winding bore - 6 mm  
Period - 11.5 mm



	I	II	III	IV	V
Former material	Al	Al	Al	Iron	Iron
Pitch, mm	14	14	12	12	11.5
Groove shape	rectangular	trapezoidal	trapezoidal	trapezoidal	rectangular
Winding bore, mm	6	6	6.35	6.35	6.35
Vac bore, mm	4	4	4	4.5 (St Steel tube)	5.23* (Cu tube)
Winding	8-wire ribbon, 8 layers	9-wire ribbon, 8 layers	7-wire ribbon, 8 layers	7-wire ribbon, 8 layers	7-wire ribbon, 8 layers
Sc wire	Cu:Sc 1.35:1	Cu:Sc 1.35:1	Cu:Sc 1.35:1	Cu:Sc 1.35:1	Cu:Sc 0.9:1
Status	Completed and tested	Completed, tested and sectioned	Completed and tested	Completed and tested	Manufacture completed to be tested

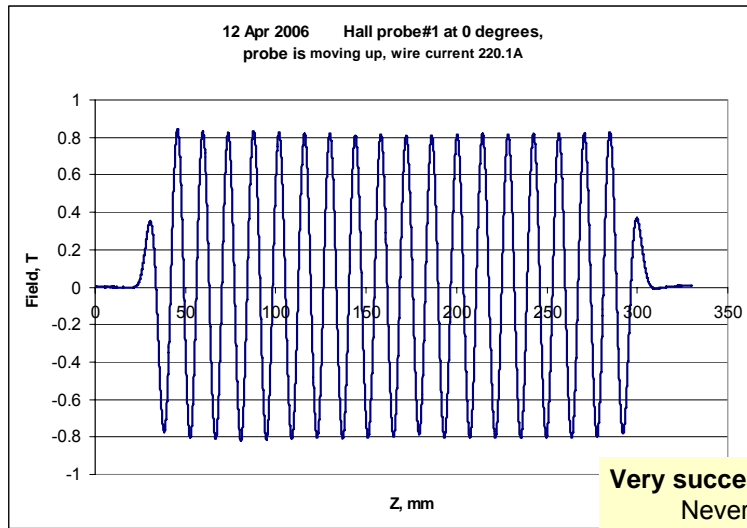
## Prototypes family

First 4 300mm long  
prototypes

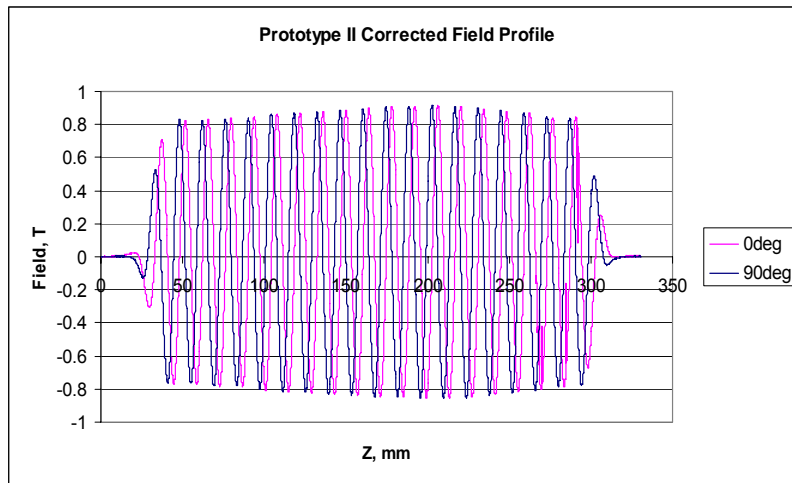


Final 500mm long  
prototype-  
Almost ready to test !





**Very successful prototype:**  
Never quenched;  
Reached the design field;  
Quite good field profile  
Homogeneity ~7%

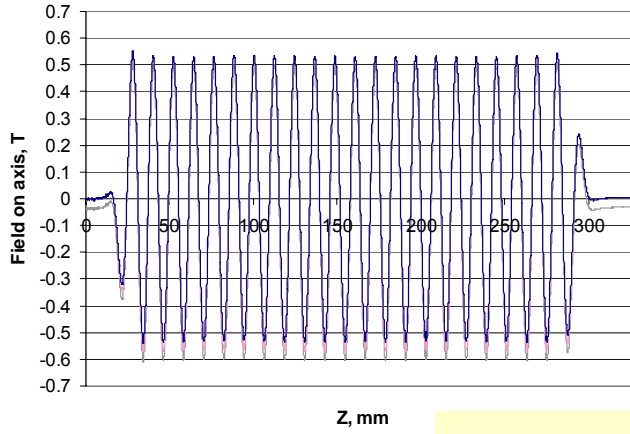


Field on axis varies by -2% for 100  $\mu\text{m}$  increase in winding bore

→ +/- 1% variation in the field translates into +/- 50  $\mu\text{m}$  precision in winding bore for pitch 14 mm

## Prototype III results

Prototype III Field Profile  
at 200A



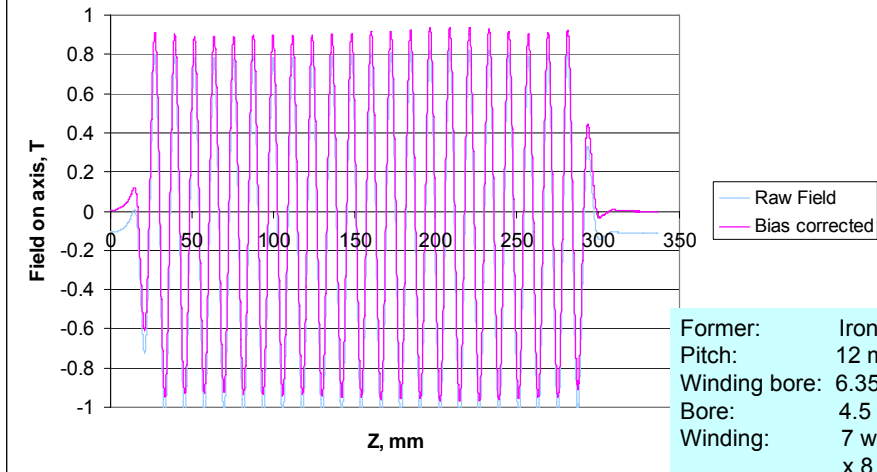
Period 12 mm  
Winding bore 6.35 mm  
7-Wire Ribbon  
8 Layers  
Wire Cu:Sc = 1.35:1

Measured field = 0.533 T ( $\pm 0.4\%$  St.Dev.,  
 $\pm 0.8\%$  max)

## Prototype IV results

**Prototype IV Field Profile**  
with all 7 wires in use at 200A

Measured field: 0.91 T  
+/- 1.6% St.Dev



Undulator magnetic structure	Measured field		Prediction by Opera 3d
	T	normalized	
Non-magnetic (Al) former	0.53	1.00	0.52
Magnetic (Bright steel) former	0.91	1.71	
Magnetic former and yoke	0.97	1.83	0.96 (for 1010 steel)

Undulator geometry:

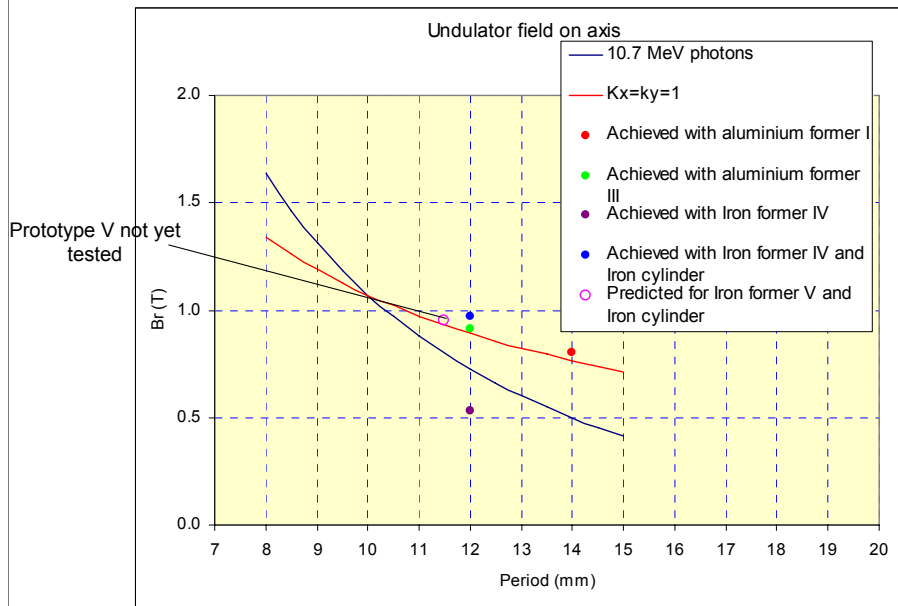
Period: 12 mm

Winding bore: 6.35 mm

Winding: 8 layers of 7-wire ribbon

Wire current: 200A

## Short prototypes result summary







### **R&D programme almost completed**

- can now define final characteristics of a 4 meter prototype as follows
- The former which is 11.5mm pitch with a 6.35 Dia winding bore.
- 7 wire NbTi ribbon
- Operating at 80% short sample
- Using an iron former
- The overall length of the cryostat is 4m.



### **Status**

- Complete the Helical Undulator R & D Programme by February 2007
- Design, Manufacture and test a 4m long Helical Undulator Module :
  - Conceptual design is completed
  - Module ready by Oct 2007

### **Future**

- Subject to funding
  - Beam test of 4-m undulator module at Daresbury Lab – late Oct 2007.
  - Pre-production prototype – 2008-09.