Polarised Positron Source: Helical Undulator Task Report

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Contents

Task report for HURD

- R&D program update
- Full scale module construction progress
- Physics studies update
- Summary of task

Prototypes family

First four 300mm long prototypes

Fifth prototype, 500mm long

Science & Technology Facilities Council

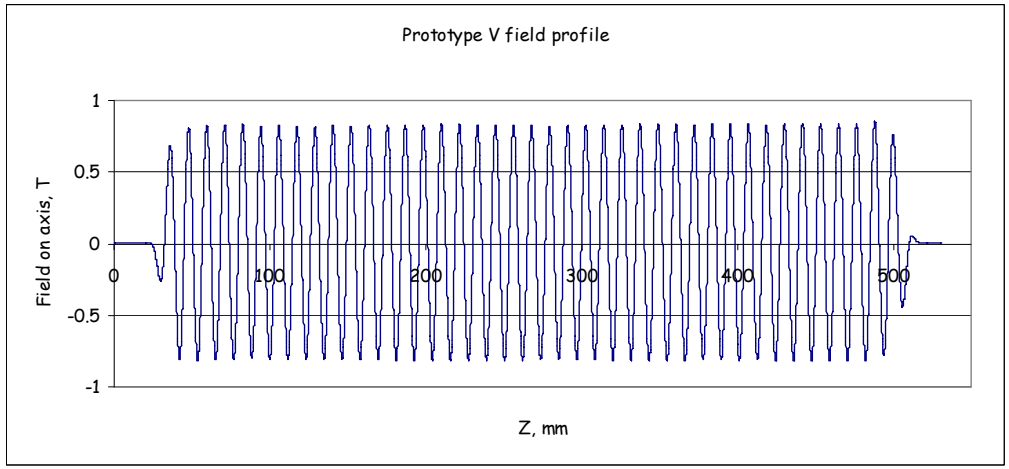
Matrix of built and tested prototypes

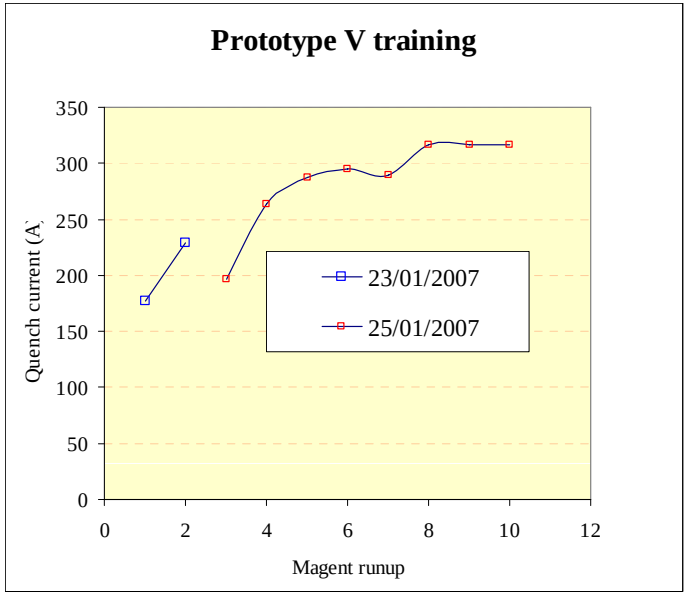
	I	II	III	IV	V	V'
Prototype goal	Winding technique verification	Check effect of mechanical tolerances	Prototype with reduced period	Check effect of iron	Prototype with final period	Quench study with improved impregnation
Length, mm	300	300	300	300	500	500
Former material	Al	Al	Al	Iron	Iron	Iron
Winding period, mm	14	14	12	12	11.5	11.5
Winding bore, mm	6	6	6.35	6.35	6.35	6.35
Vacuum bore, mm	4	4	4.5	4.5	5.23	5.23
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	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	Cu:Sc 0.9:1
Field at test current, T	0.8	0.9	0.53	0.96	0.82	-
Test current, A	220	220	200	200	200	-
Quench current, A	-	-	-	-	[illegible]	315

RDR Parameters

Measurements for Prototype V

1st results from prototype V





Measured field at 200A

0.822 T +/- 0.7 %
(spec is +/- 1%)

Prototype V details

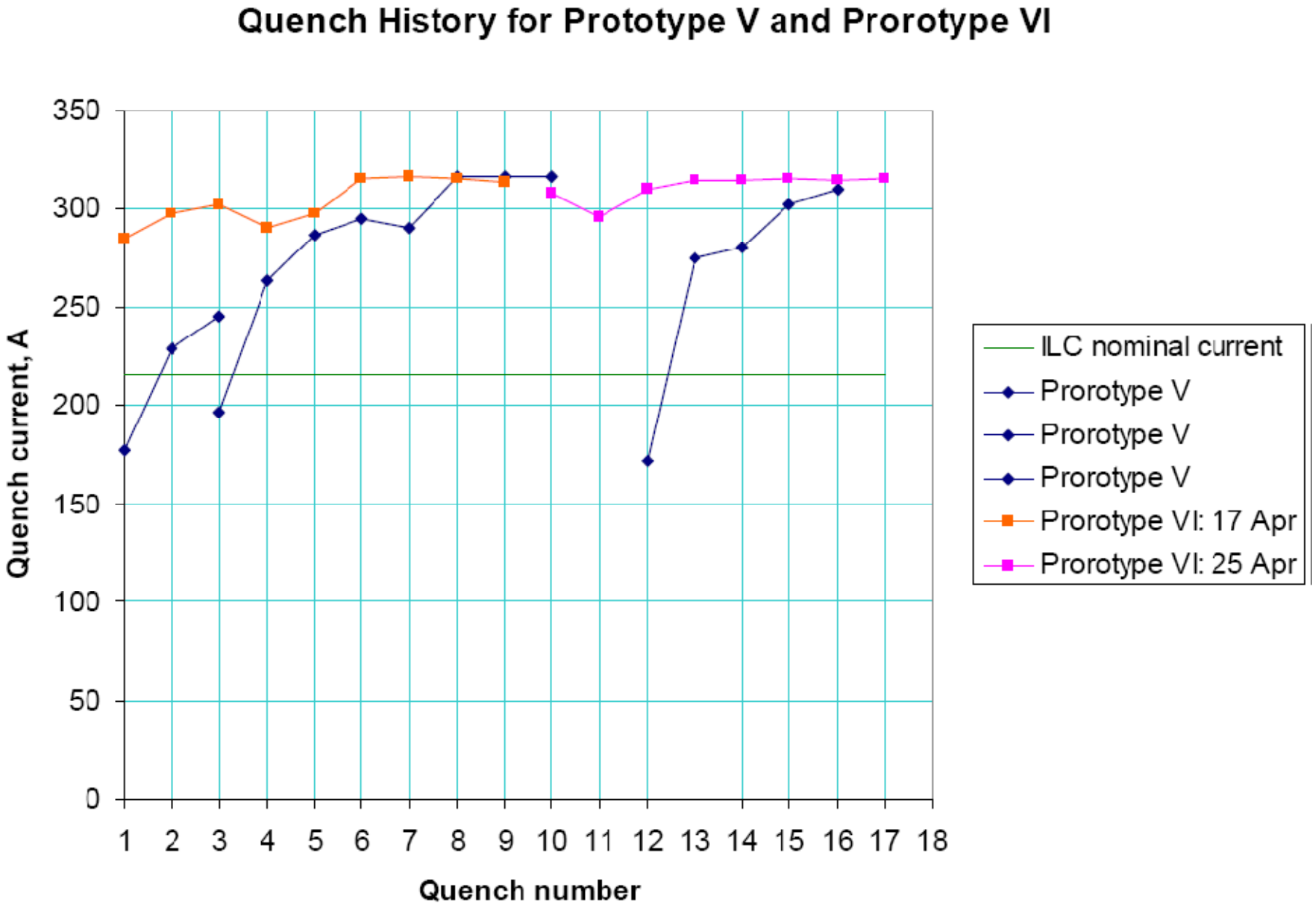
Period : 11.5 mm
Magnetic bore: 6.35 mm
Configuration: Iron poles and yoke

Quench current 316A

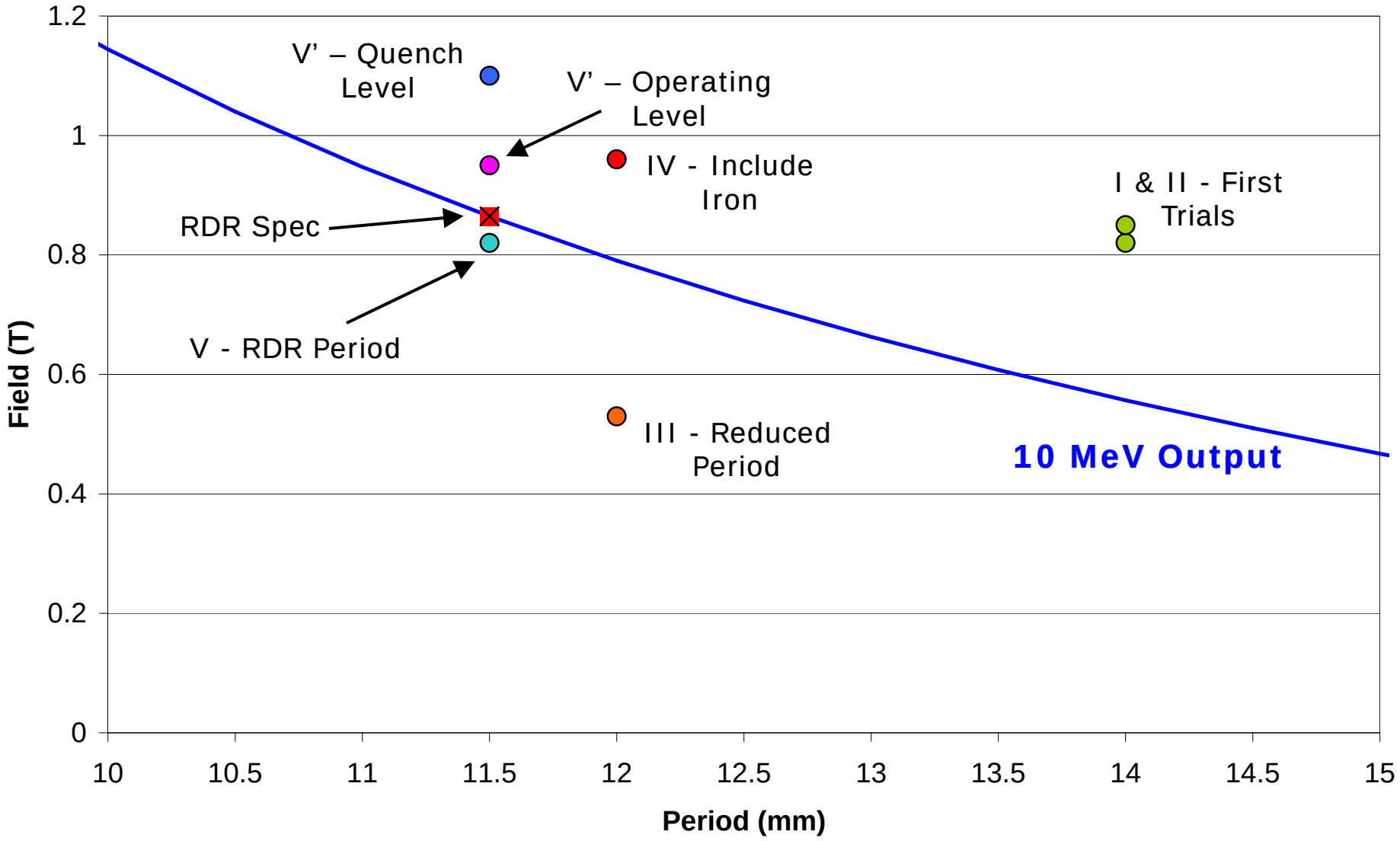
Equates to a field of 1.1 T in bore

RDR value is 0.86 T

80% of critical current (proposed operating point) would be 0.95 T


Quench History for Prototype V and Prorotype VI
Quench current, A
350
300
250
200
150
100
50
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
Quench number
ILC nominal current
Prorotype V
Prorotype V
Prorotype V
Prorotype VI: 17 Apr
Prorotype VI: 25 Apr

Field levels achieved



Technology questions addressed by R & D

- Former manufacture technique
- Continuous winding technique
- Resin impregnation
- Effect of mechanical tolerances

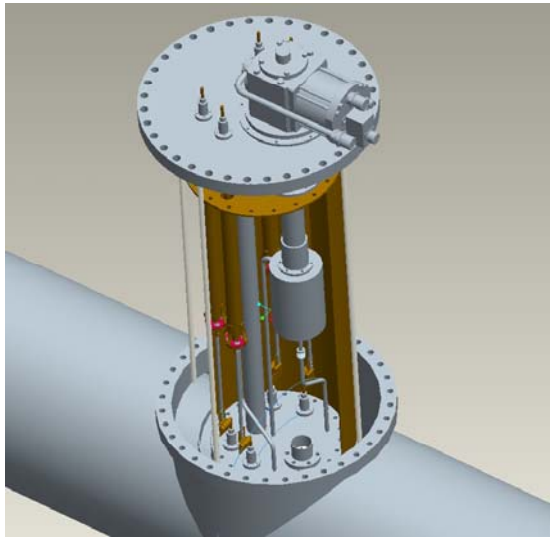
- Achievable field
- Training and quenches
- Measurements at 4K

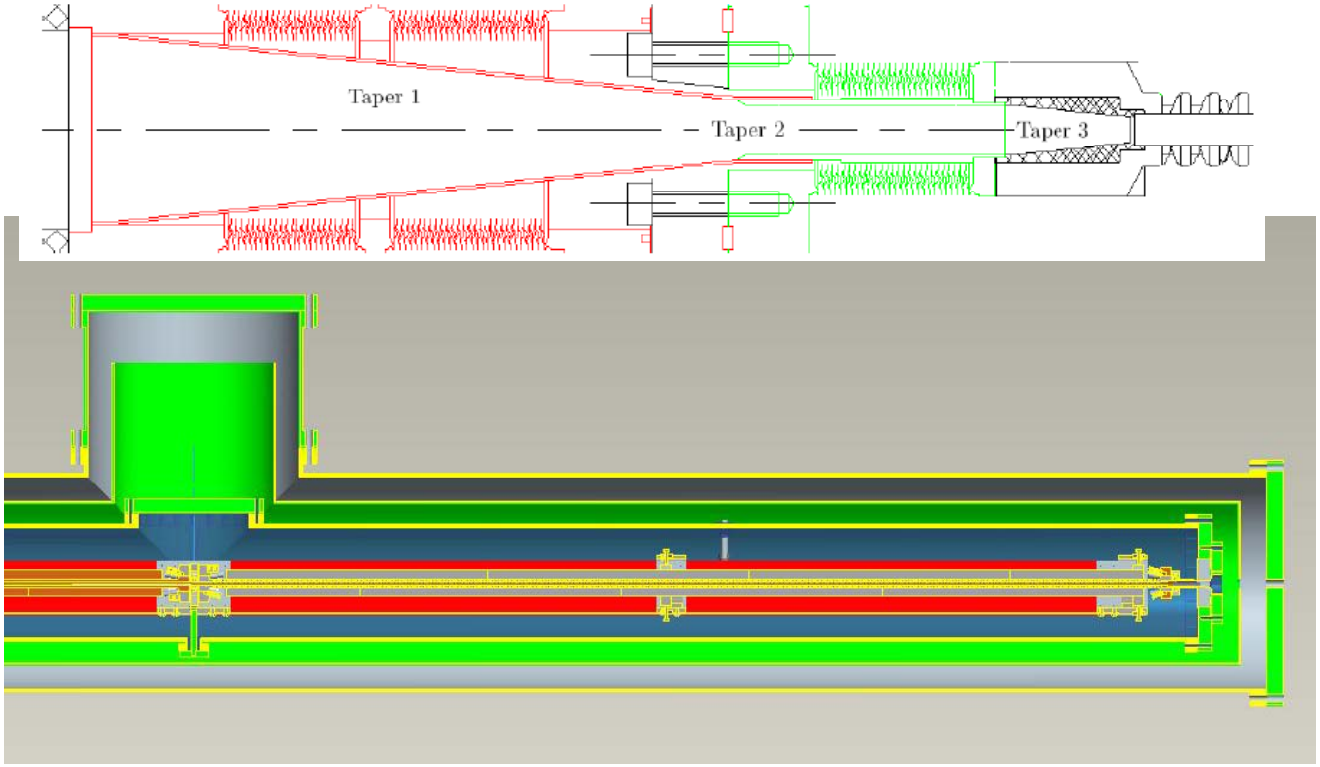
Specification for 4m Undulator Module

On axis field	0.86 T
Peak to peak variation	<1%
Period	11.5 mm
Nominal Current	~250 A
Nominal current as % of Short Sample	80%
SC wire	NbTi 0.4mm dia., SC:Cu ratio 0.9:1
Winding Cross Section	7 wires wide x 8 high
Number of magnets per module	2 (powered separately for tests)
Length of magnetic field	2 x 1.74 m
Cryostat Length	4 m

Undulator Cryomodule

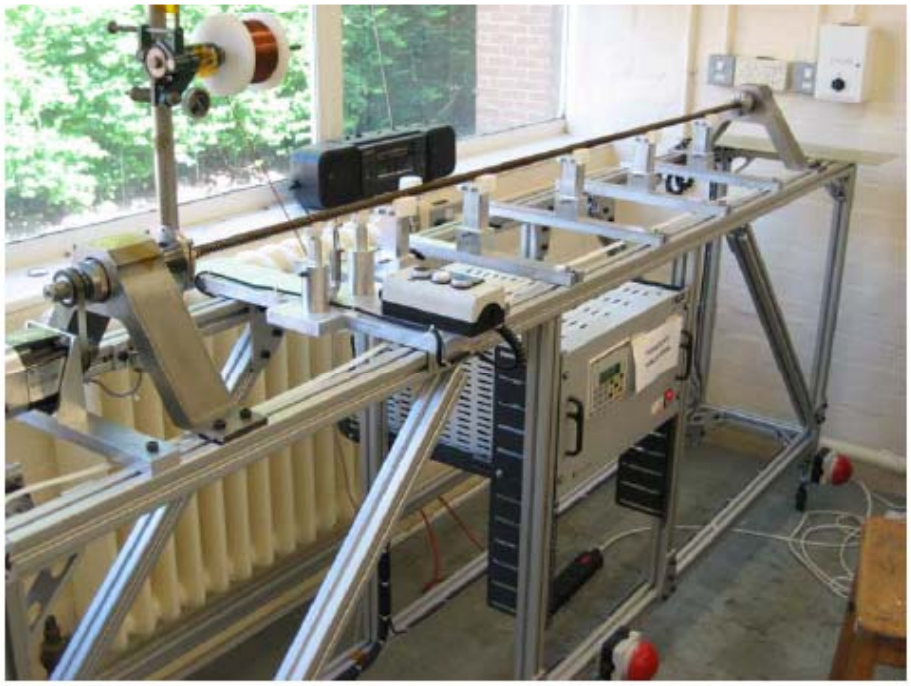
- ‘Full scale ILC cryomodule’ designed and now under construction
- 4m long with ~3.5m active undulator length
- Suitable for electron beam tests

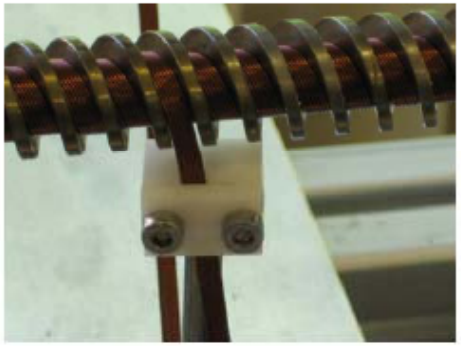




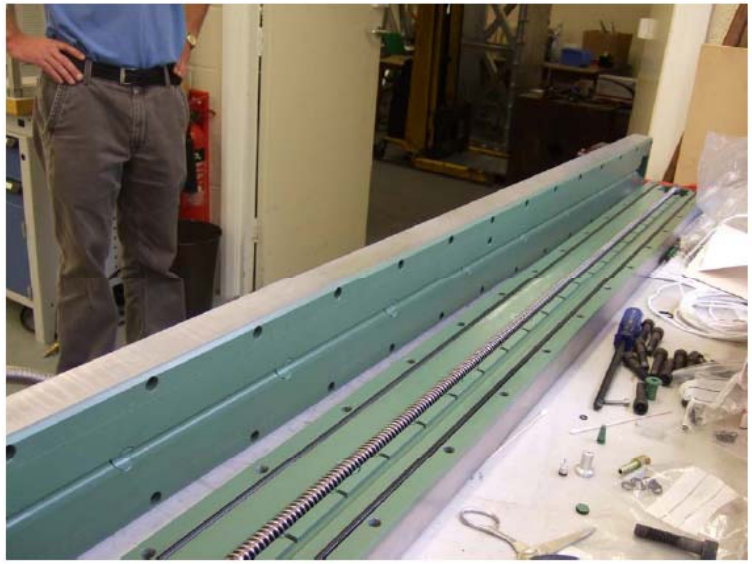
Construction Status of 4m module

Winding undulator on a custom built winding machine





Construction Status of 4m module

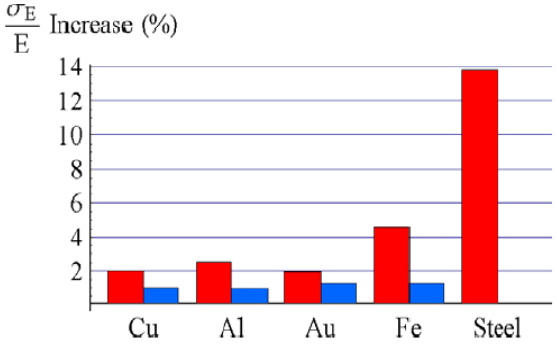


Construction Status of 4m Module

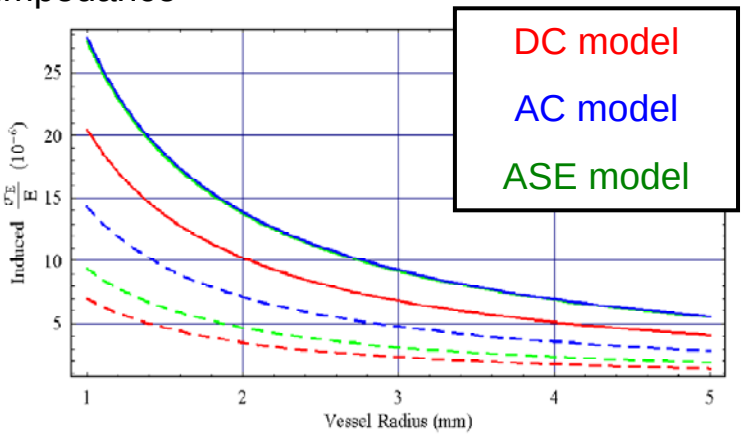
- Both undulators now wound and have passed insulation test
- Magnet tests of first undulator started in December but hampered by cryostat heat leak
- New components manufactured to fix vertical cryostat heat leak – repair this week
- Magnet tests needed for both undulators
- Trial assembly of cryomodule in parallel now
- Assembly of full module by ~end March (?)

Wakefield Studies

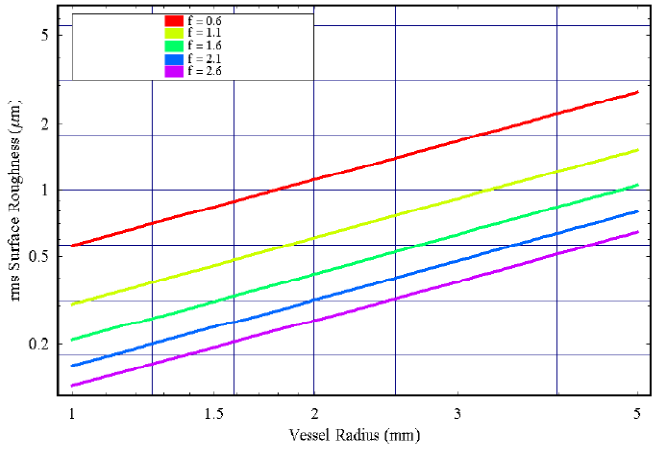
Energy spread increase for 150μm gaussian ILC bunch and 200m long undulator at room and cryogenic temperatures for alternative vessel materials due to **resistive wall** impedance



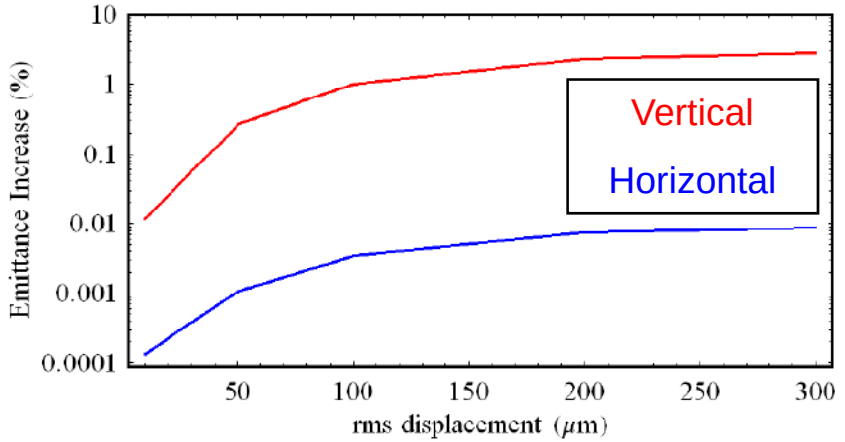
Induced energy spread at room (solid) and cryogenic (dashed) temperatures for copper vessel due to **resistive wall** impedance



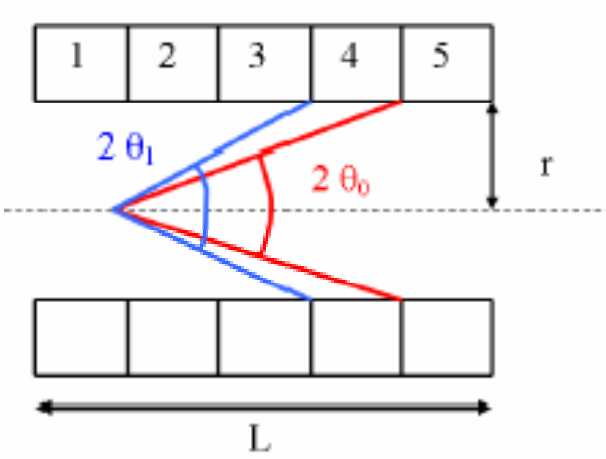
Surface roughness necessary to produce an energy spread of 0.005% (nominal for ILC is 0.05%) for different vessel radii and form factors.



Mean emittance increase due to **geometric wakes** of misaligned taper sections and photon collimators in undulator section.



Undulator Radiation Calculations



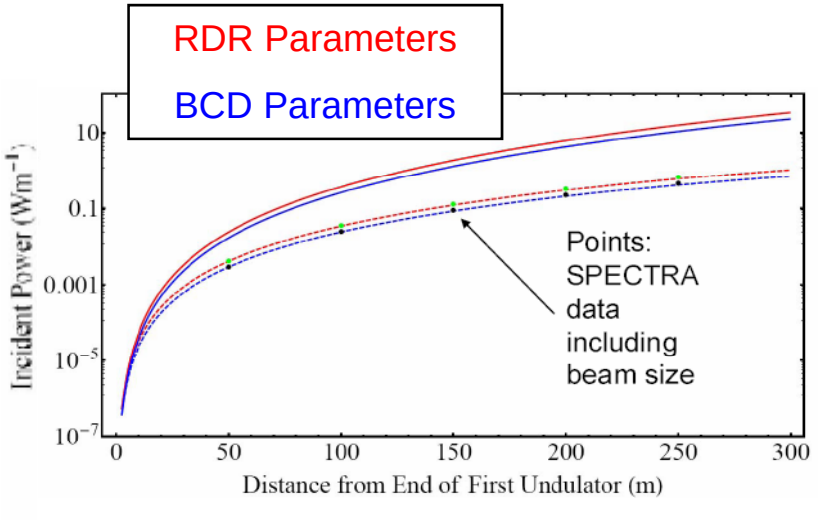
Power per m calculations carried out at relatively large angles (~100/γ)

Beyond the limits of standard undulator codes

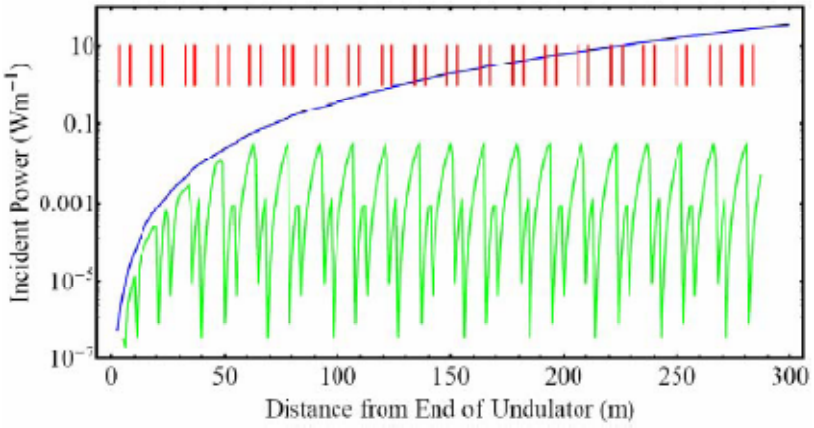
Full ~200m undulator made up of many ~2m sections, each treated separately

Power from undulators enough to quench downstream devices

Power for one 2m undulator and 120 x 2m undulators. Limit is ~1 W/m.



Inclusion of 5mm diameter photon collimators (shown in red) in room temperature sections reduces power level to ~0.05 W/m



Summary

- RDR Undulator parameters now proven (and exceeded) with 500 mm prototype.
- Two 1.75 m undulators waiting for magnet tests.
- Full scale cryomodule in advanced stages of construction – will be completed during 2008.
- Physics studies wide ranging and effects small.