Task 6: Short period helical superconducting undulator

Status of Organisation and Planning

Jim Clarke

HFM Collaboration Meeting

Feb 24th 2009

Institutes

- STFC
  - Daresbury Laboratory (DL)
  - Rutherford Appleton Laboratory (RAL)

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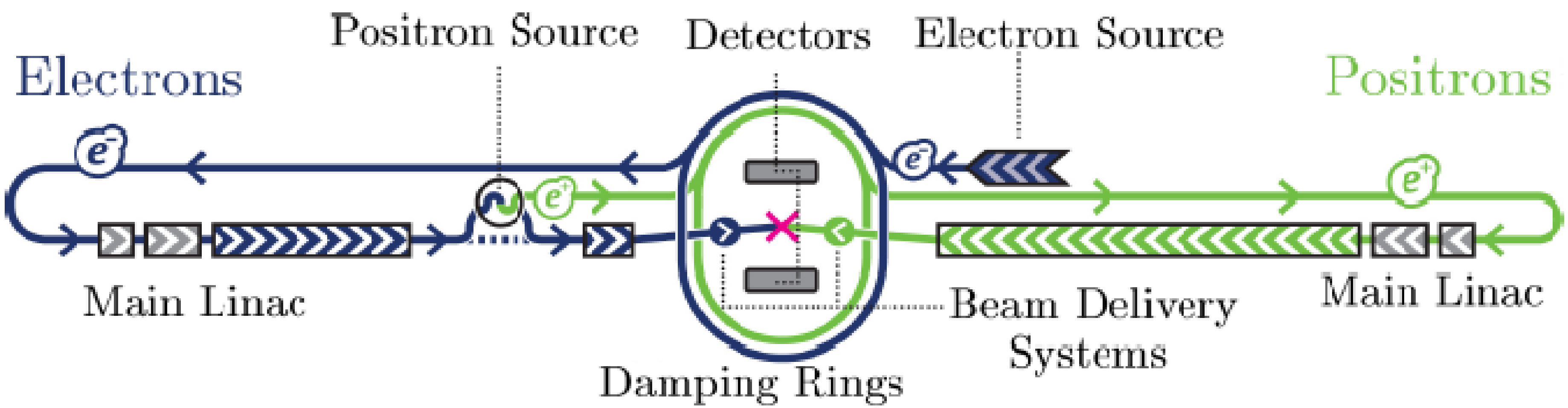
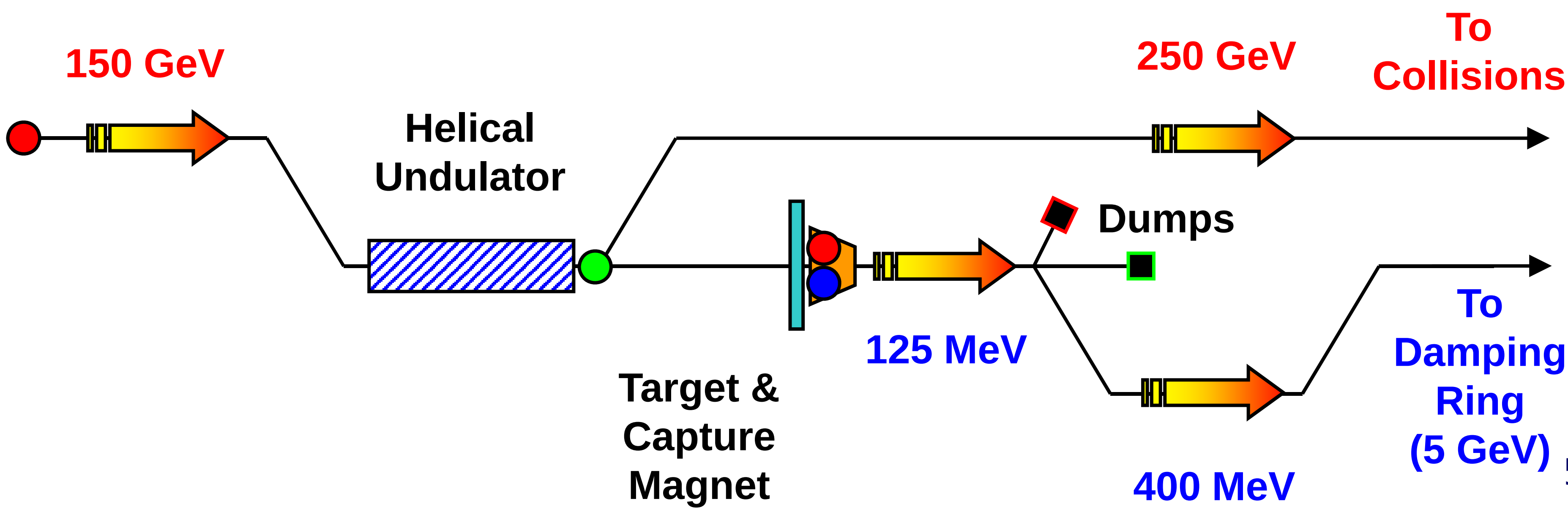
Participants

- Jim Clarke (DL) – Task Coordinator
- Duncan Scott (DL) – Modelling
- Tom Bradshaw (RAL) – Local Coordinator
- Steve Carr (RAL) – Mechanical design
- Jim Rochford (RAL) – Design and testing

Motivation

- **The ILC requires unprecedented numbers of positrons when compared with present day sources**
- **If the positrons can be polarised then the physics reach of the collider can be enhanced**
- **ILC Baseline – Synchrotron radiation from an undulator**
  - **Very high energy electrons**
  - **Short period undulator**
  - **Lots of Periods for high intensity**
  - **Helical undulator → circularly polarised photons**


Positron Source
Detectors
Electron Source
Electrons
Positrons
Main Linac
Main Linac
Beam Delivery Systems
Damping Rings


150 GeV
Helical Undulator
250 GeV
To Collisions
Dumps
125 MeV
Target & Capture Magnet
400 MeV
To Damping Ring (5 GeV)

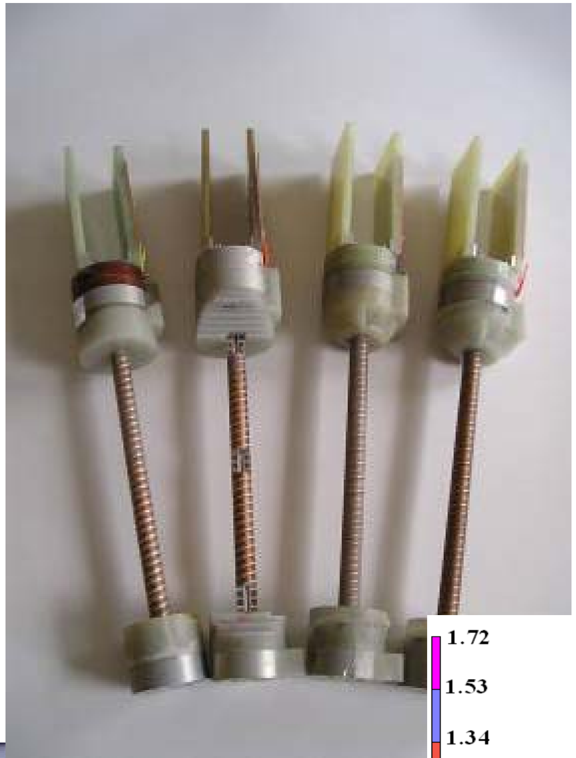
Undulator

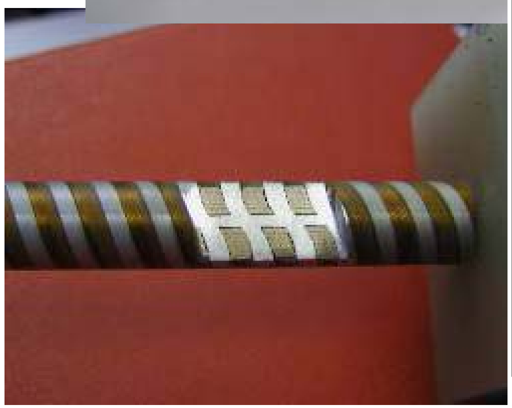
- To generate the photons with a high enough energy (>10MeV) need to use **short period & high field**
- For sufficient positrons undulator must be ~200m
- Short period, high field, only possible with narrow aperture:
  - Resistive wall effects
  - Vessel surface roughness effects
  - Synchrotron radiation power problems
  - Generating a vacuum with difficult aspect ratio
  - Mechanical tolerances
  - Manufacturing issues
- Superconducting technology solution chosen after ‘competition’ with permanent magnet

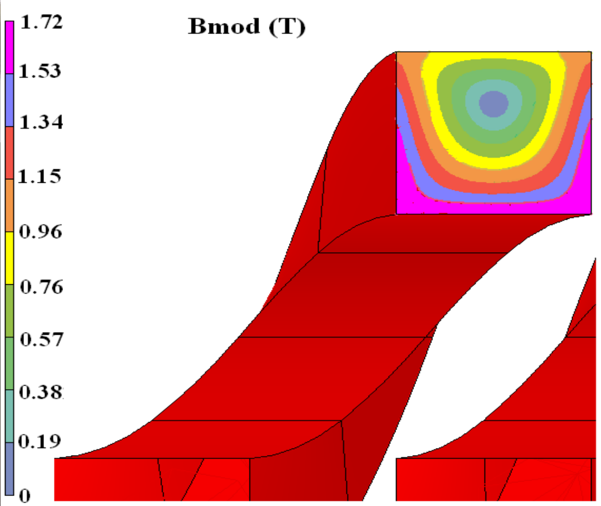
Existing Studies

- Team has been working on superconducting helical undulator development for ILC since 2004 (Supported by STFC & EUROTeV)
- Exclusively NbTi so far
- Several short prototypes have been constructed and tested
- Following this R & D phase a full scale module has been designed and constructed

Prototypes



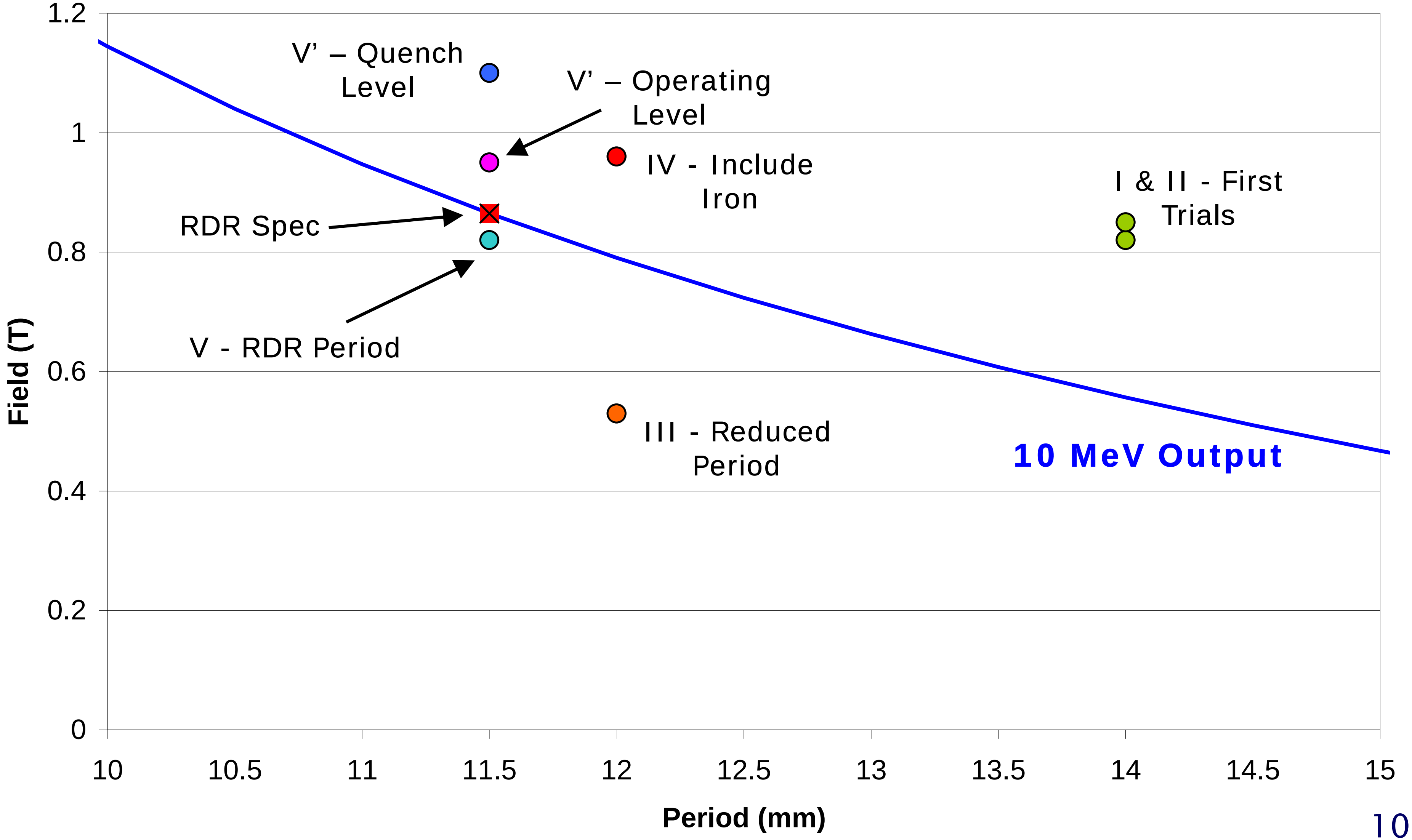




Summary Table

	I	II	III	IV	V
Former material	Al	Al	Al	Iron	Iron
Period, 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

Prototypes Summary

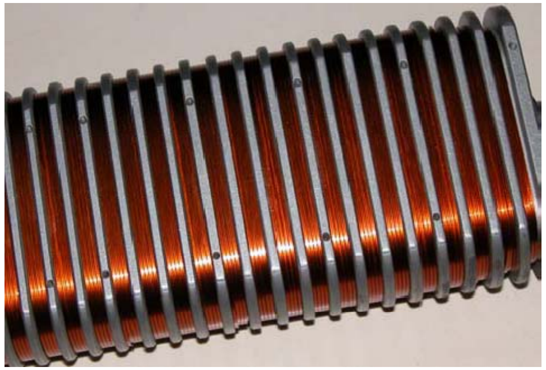


Cryomodule

- **A 4m module containing 2 x 1.75m helical undulators has now been constructed and is being commissioned**

Other Applications

- STFC has taken advantage of this expertise by separately funding the same group to develop superconducting undulators suitable for light sources such as DIAMOND or future FEL facilities.



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Draft Work Plan

- Year 1: Design study with Nb3Sn
  - Geometry selection
  - Wire selection
  - Ribbon or wire?
  - Minimum winding radius?
- Year 1: Familiarisation of working with Nb3Sn
  - Simple winding tests
  - Heat treatment tests
  - Insulation tests
  - Minimum winding radius?

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Draft Work Plan

- Year 2: Construction of prototype 1
  - Magnet Measurements
  - Confirmation of modelling
- Year 3: Iterate design
  - Minimise magnet period
  - Maximise field
- Year 4: Construction of prototype 2
  - Magnet Measurements
  - Confirmation of modelling
  - Direct comparison with NbTi?

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Draft Milestones

- M6 Wire selection & procurement
- M9 Initial winding & activation tests
- M12 Design study complete
- M21 Prototype 1 complete
- M24 Measurements of P1 complete
- M30 Design iterated
- M39 Prototype 2 complete
- M42 Measurements of P2 complete

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Resource Profile

- A relatively flat resource profile is envisaged over the 4 years
- No detailed project plan exists yet

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Collaborations

- We would welcome any others who would like to join in with our efforts
- We are unfamiliar with Nb3Sn and would welcome any advice and assistance