Positron Source

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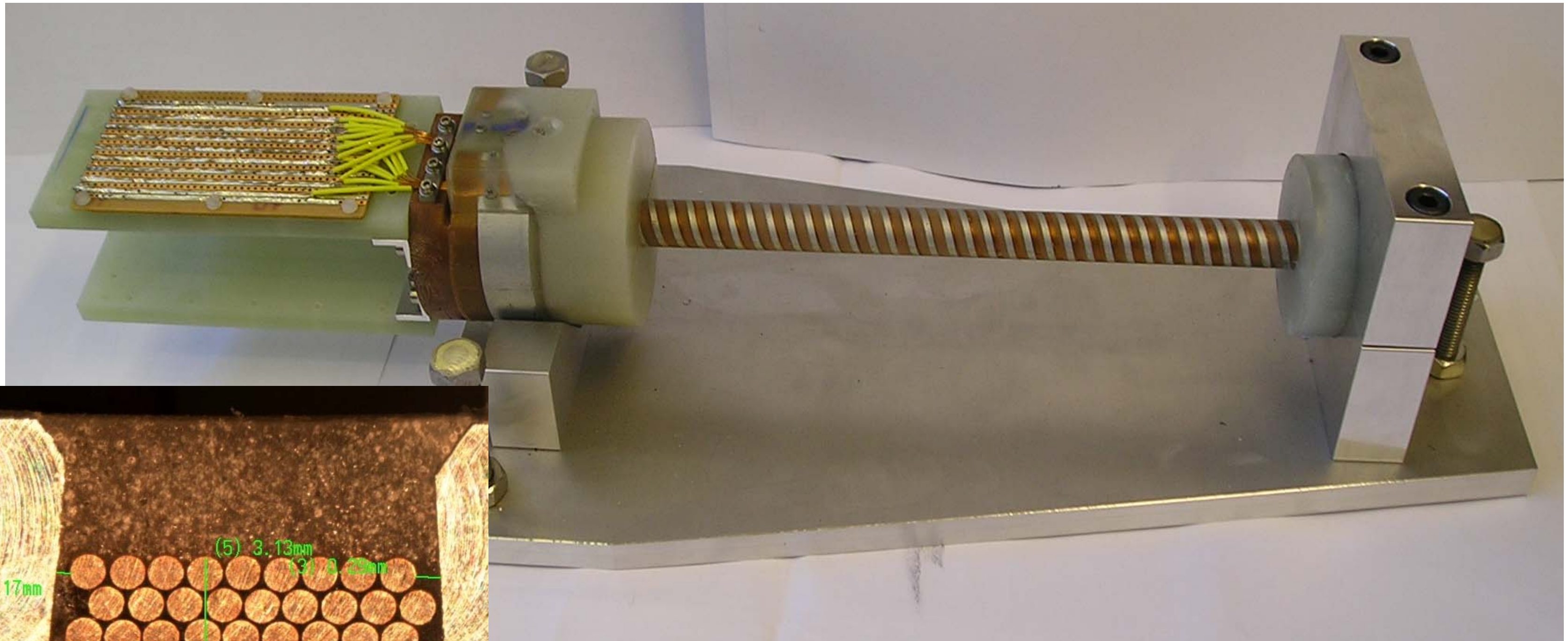
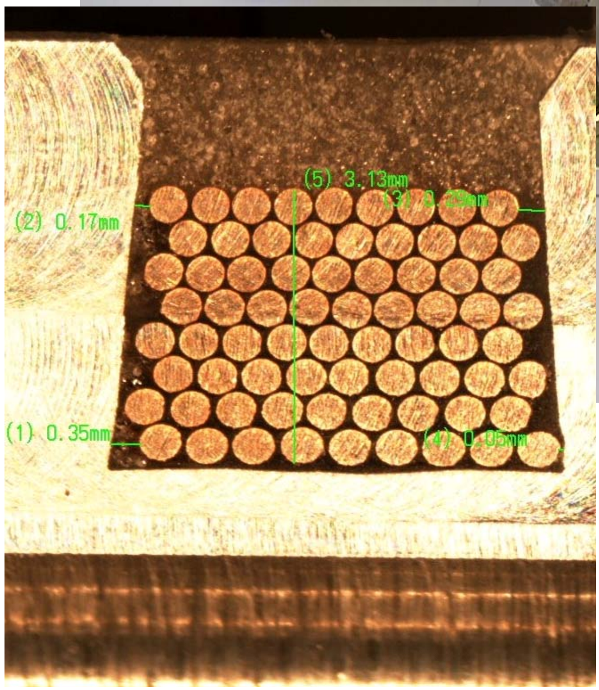
Helical Undulator

- Short test pieces built and tested
  - Superconducting and Permanent Magnet
- Superconducting technology selected
  - Quality high
  - Field strength proven
  - Cheaper
  - Able to vary field levels easily
  - Able to switch off modules
- Further test pieces built and planned for this Summer
- 4m prototype module planned by next Summer
- Parameters reassessed after BCD
  - Intensive 2D and 3D modelling
- Vacuum chamber effects studied
  - Resistive wall wakes – chamber material
  - Surface roughness
  - Fast ion instability
  - Transverse wakes
  - Etc etc……

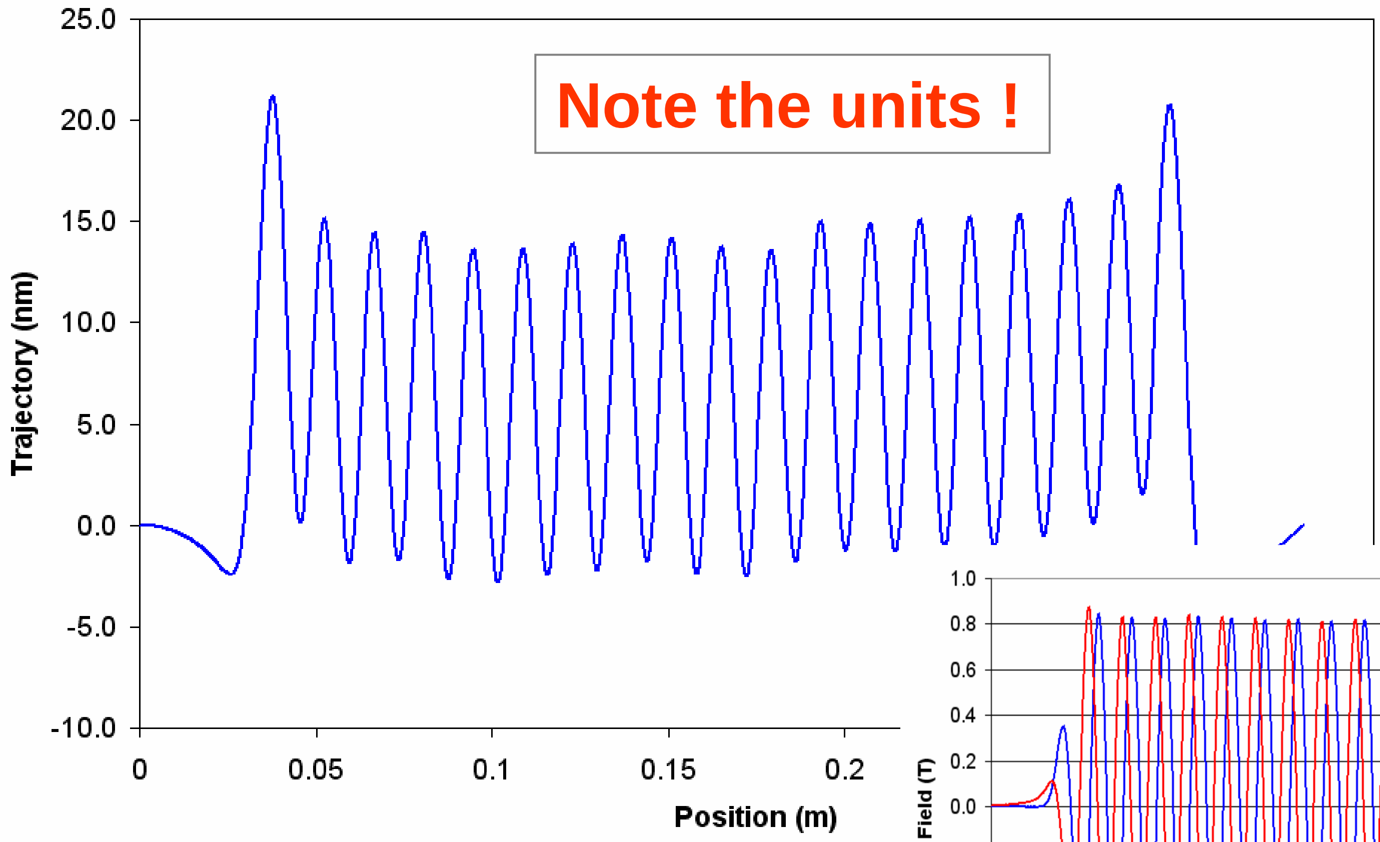
Superconducting Prototypes



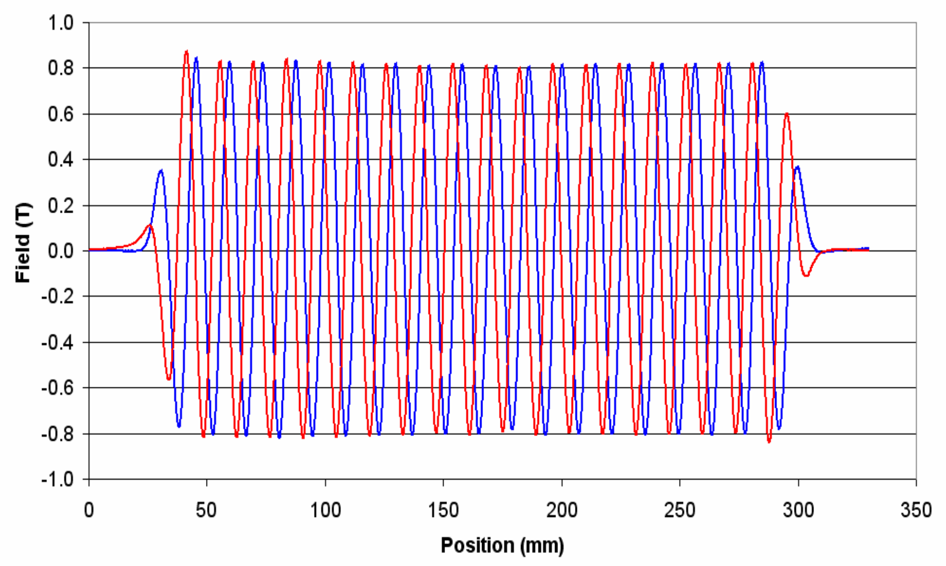


More details of undulator prototypes and measurements in:
Y. Ivanyushenkov et al, Development Of A Superconducting Helical Undulator For The ILC Positron Source, EPAC 06

150 GeV Trajectory



Prototype Measurements
Reached design field of
0.8T without any quenches

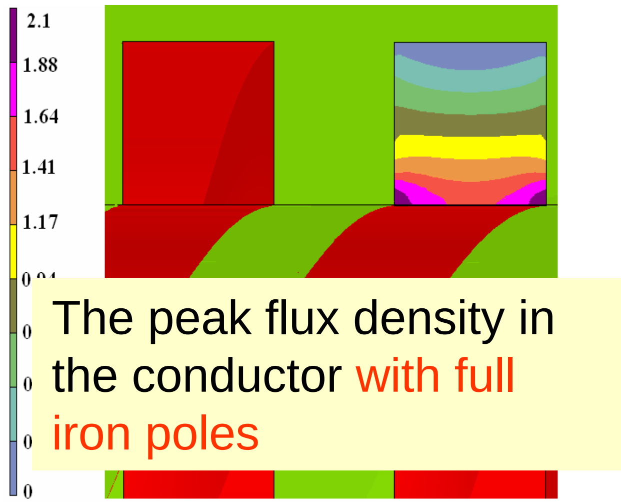


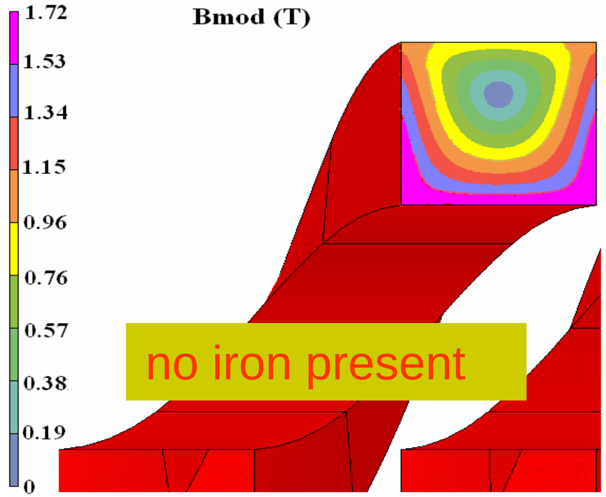
2D & 3D Modelling

Want to reoptimise parameters:

- Undulator now fixed energy of 150 GeV
- Minimise total length
  - short period
- Maximise flux
  - high field
- Accurately determine field in SC wire – high mesh density & no symmetry

Jim Rochford, RAL





Resistive wall impedance and Surface Roughness

Resistive wall impedance

- Modelled with different materials and bunch shapes
- 200 m undulator vessel, at 4K
- Energy spread will increase **by ~1% for Cu, Al or Au and ~10% for steel** (150μm bunch length)

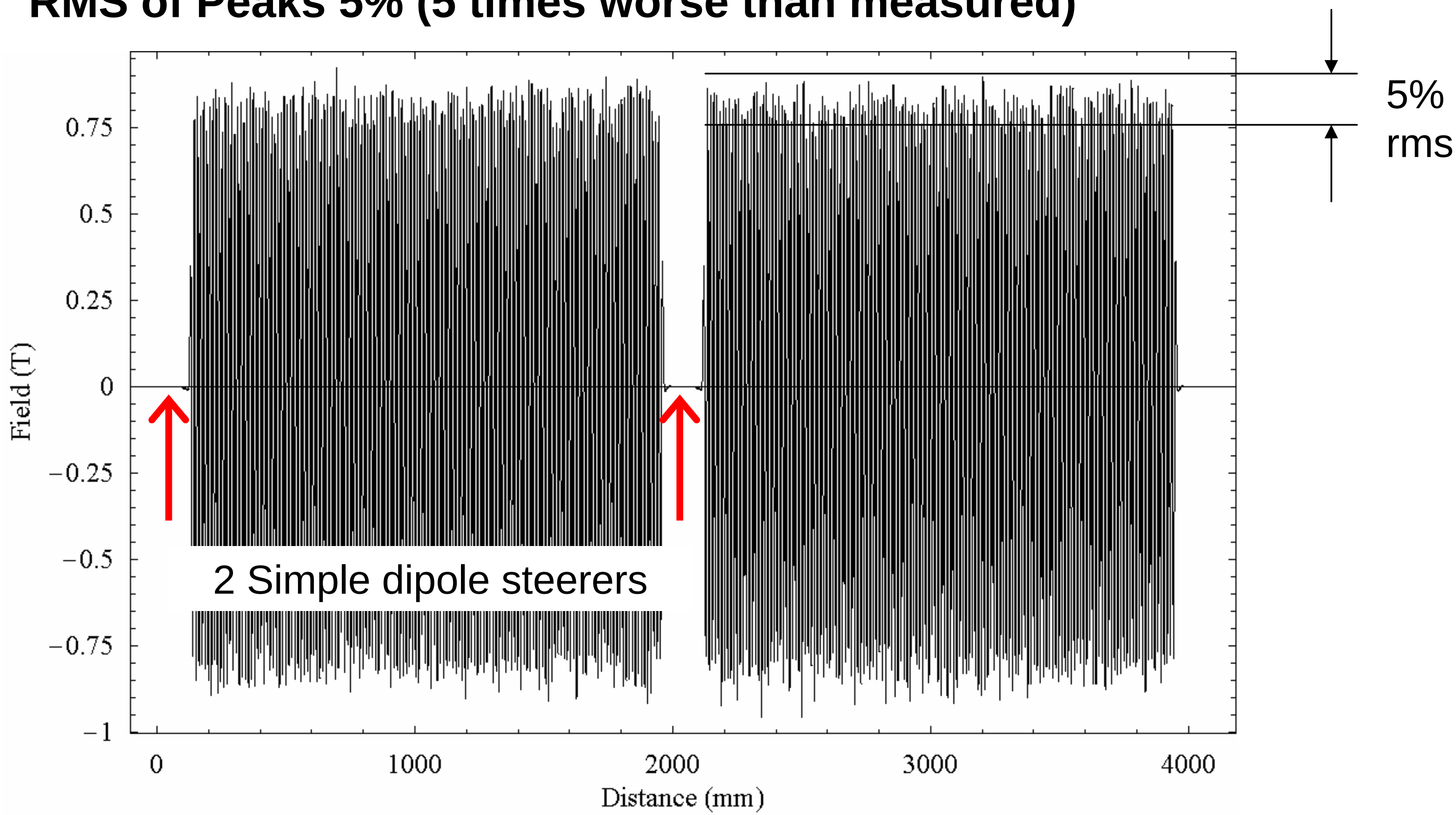
Surface Roughness

- For energy spread increase <10% need roughness **~600nm**
- Cu vessel measured and has roughness **~30nm**
- Energy spread increase **~1%** (pessimistic model)

See J. Clarke et al, Status Of The Helical Contribution To The Polarised Positron Source For The International Linear Collider, EPAC 06

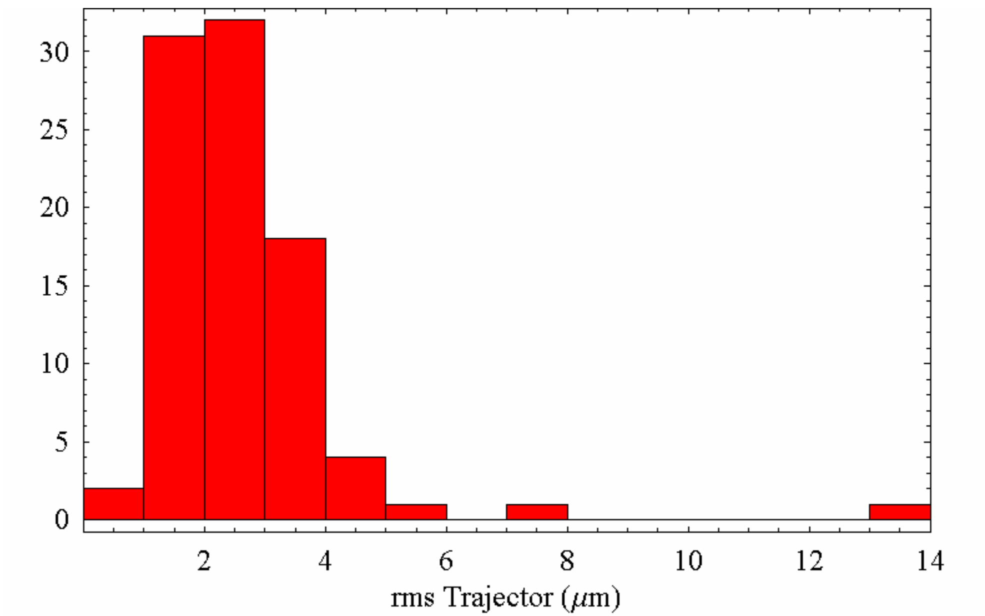
On-Axis field with Random Errors

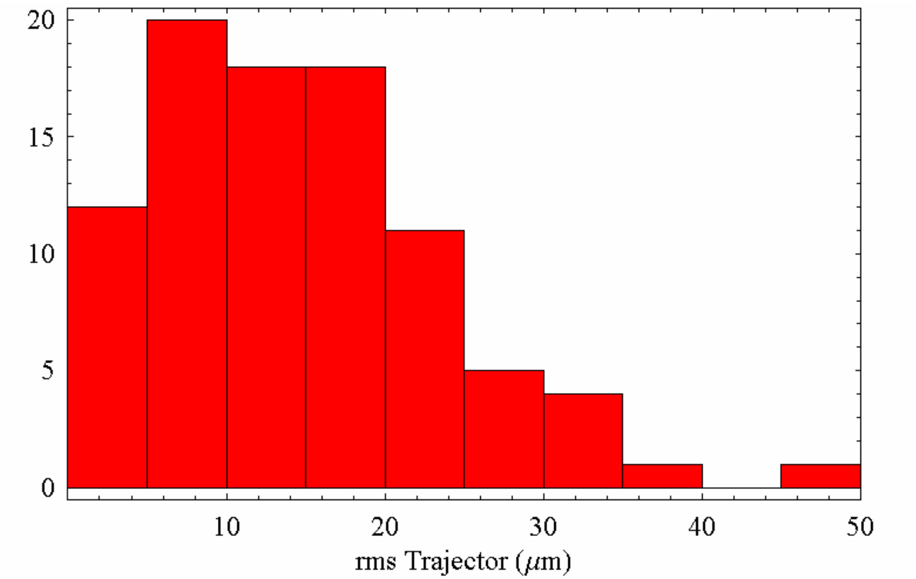
- **2 x 2m undulators per module**
- **RMS of Peaks 5% (5 times worse than measured)**



Results from 100 random seeds

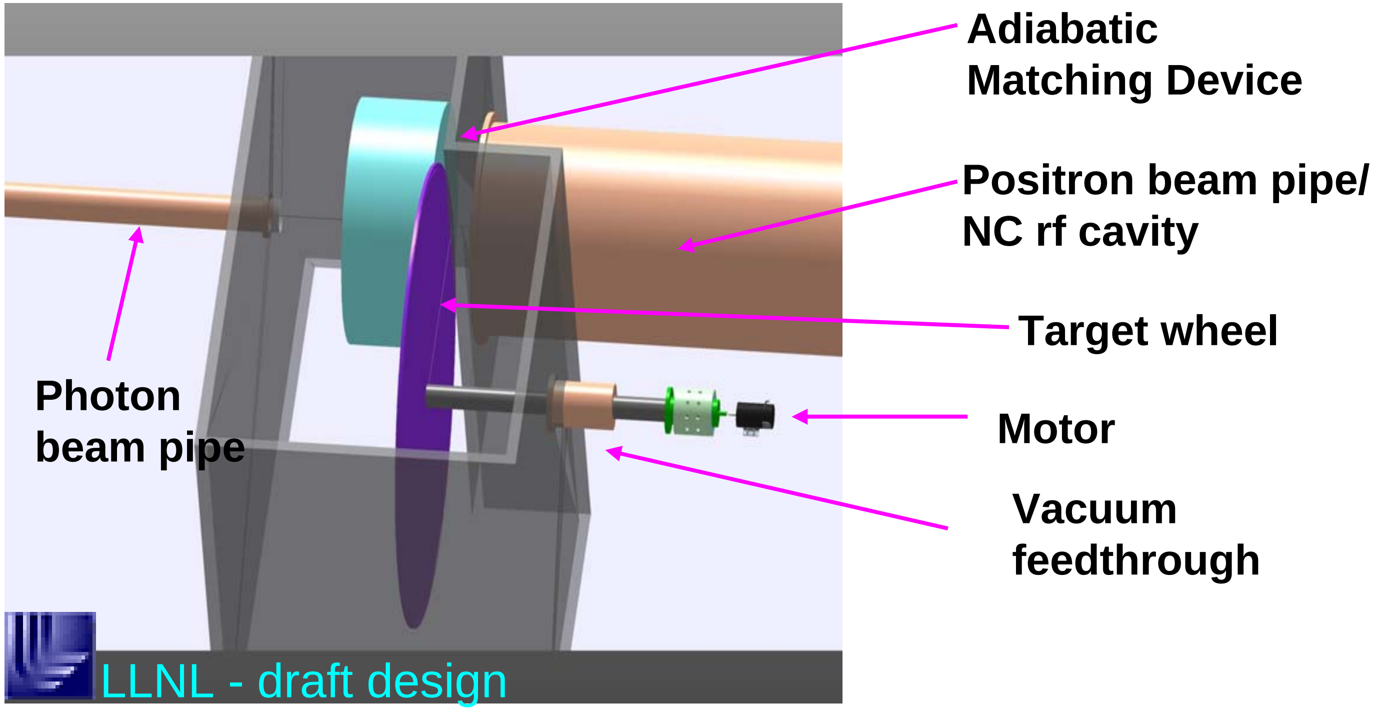
- **The trajectory can be corrected to within a few microns over 4m**
- **No correction may be ok – especially when considering real errors are 5 times smaller**





Conversion Target

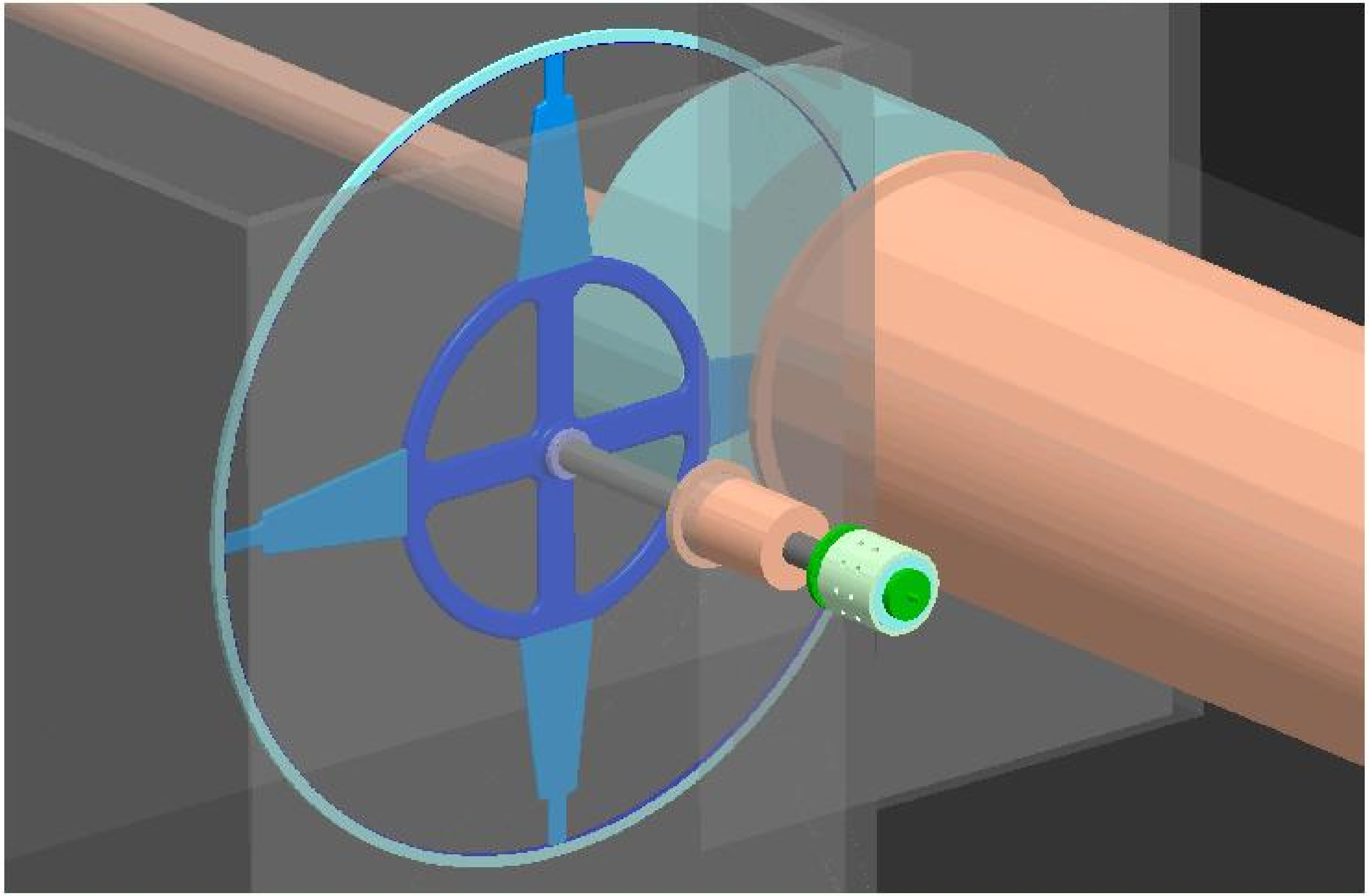
LLNL, SLAC, Liverpool collaboration carry out design studies of the conversion target for the polarised positron source. BINP, Daresbury and Rutherford have recently joined.



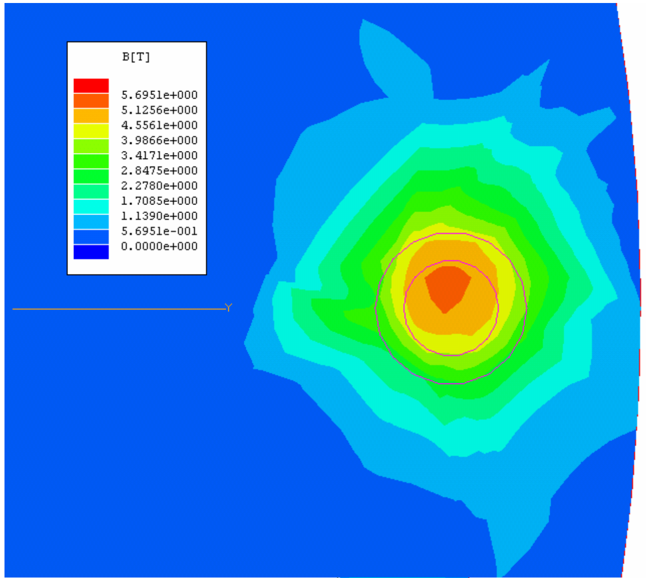
- Developing water-cooled rotating wheel design.
- 0.4 radiation length titanium alloy rim.
- Radius approximately 1 m.
- Target rotates at 1000 rpm.

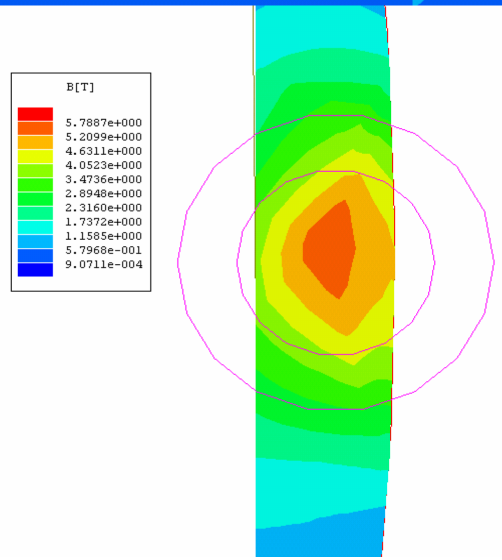
Target Wheel Design

LLNL



Eddy Current Simulations



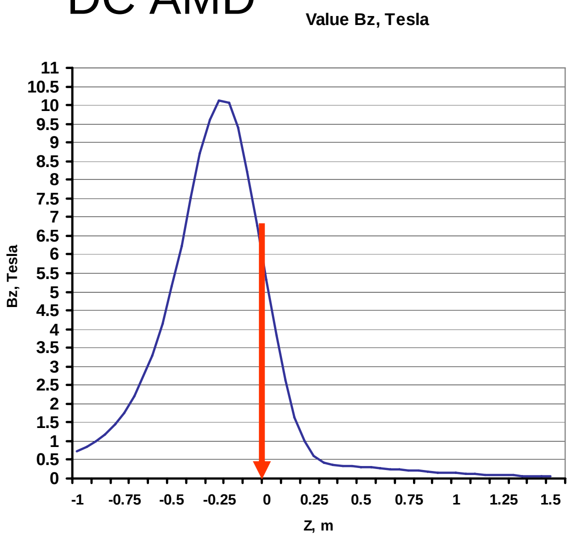


- **Simulations by LLNL indicate:**
- **1m radius solid Ti disc in 6T field of AMD works really well as a magnetic brake (~2MW power loss)**
- **Change to rim design then 14kW power loss – 'comfortable'**
- **Simulations to be calibrated to SLAC rotating disc experiment.**
- **Pulsed AMD design conservatively assumed at present (lower field on target but less positrons captured)**

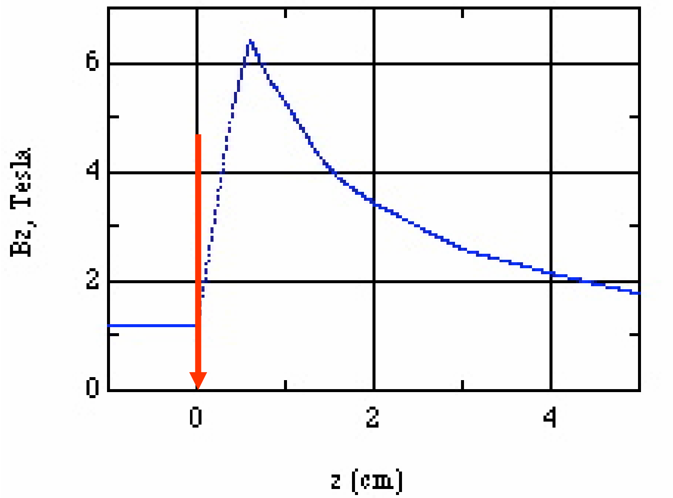
More details of target design in:
I. Bailey et al, Development Of A Positron Production Target For The ILC Positron Source, EPAC 06

Two options under consideration for the AMD

DC AMD



Pulsed AMD



- Option1: DC Superconductor
  - Coil upstream of the target
  - Target sees a full 5T field
  - Spinning metal in magnetic field, we have reinvented the magnetic brake
- Option 2: Pulsed Flux Concentrator
  - Magnet downstream of target
  - Lower field at target
  - Target being hit with a kick at 5Hz
  - Can a pulsed magnet be designed and built?

The pulsed flux concentrator is challenging

- We have an existence proof from a hyperon experiment in the 1960's
  - Liquid nitrogen cooled flux concentrator at 0.3 Hz with long pulse
- We have simulated a similar design with 1ms pulses with 5Hz rate
  - Heat deposition and pulse requirements seem feasible

1532 BRECHNA, HILL, AND BAILEY

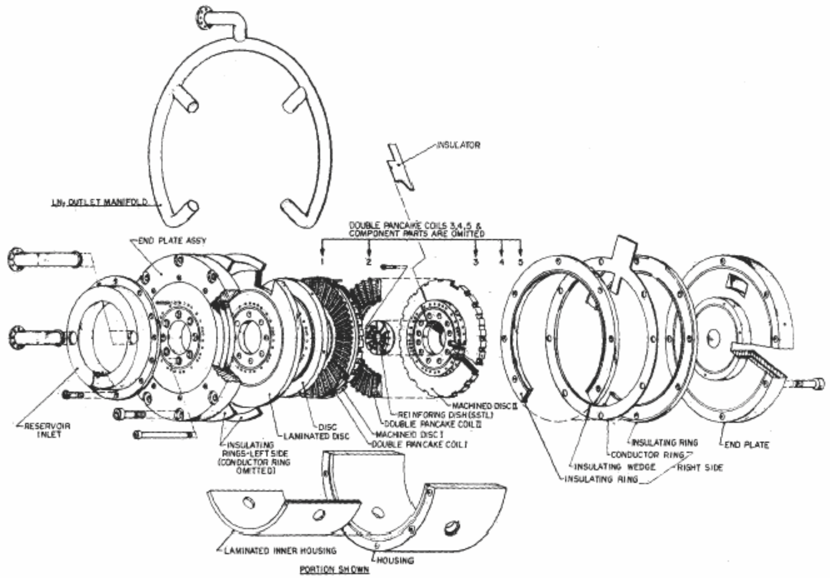
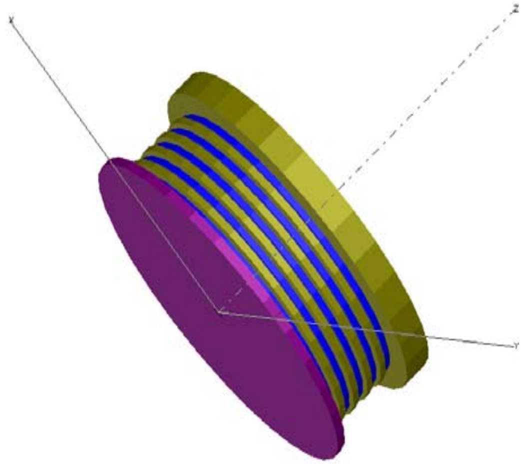
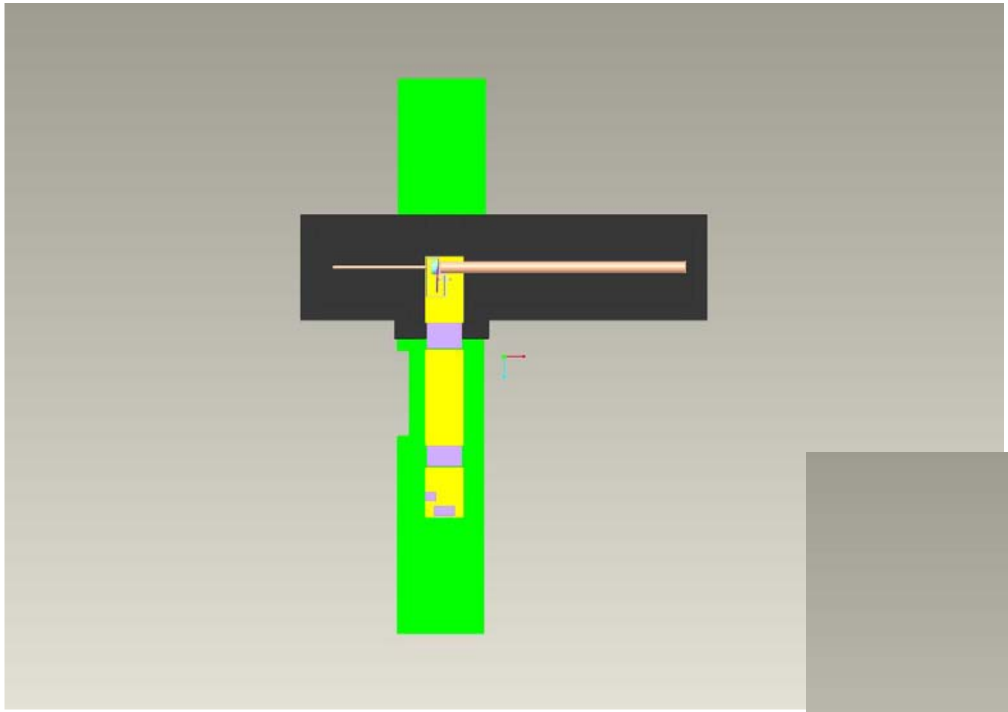


FIG. 5. Exploded view of flux-concentrator assembly.



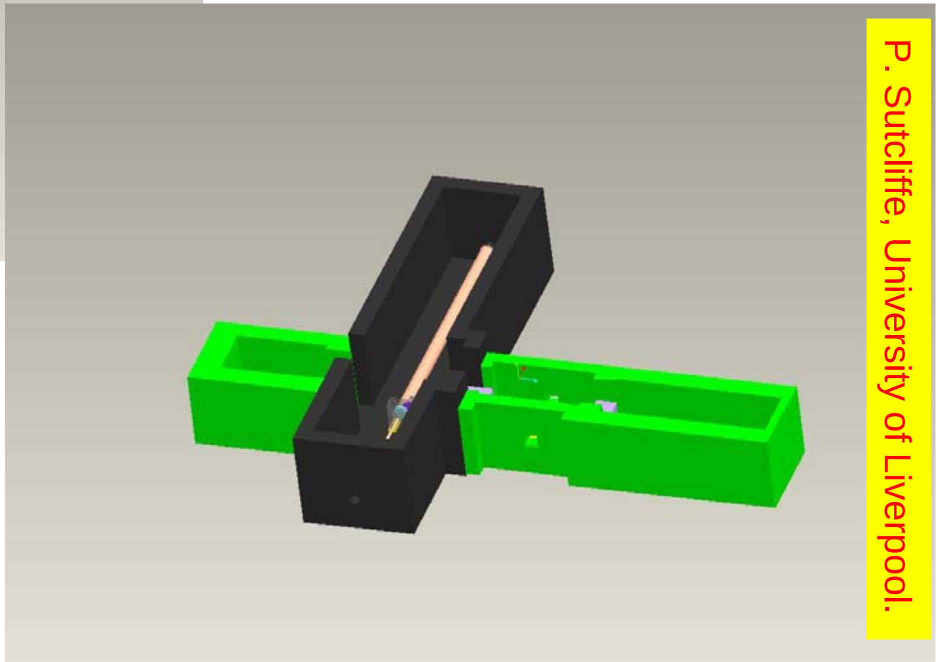
Remote Handling



Cheapest option may be to move any faulty target to a holding cell until ‘cool’ enough to be handled manually. Will depend on component reliability.

Alternative single hot cell design.

Suited to two targets in series.



Target Prototyping

The University of Liverpool and Daresbury propose to further develop the LLNL design and build prototypes of the target systems to determine the reliability.

International positron target meeting was held at BINP May 10th-12th to coordinate ILC target system R&D.

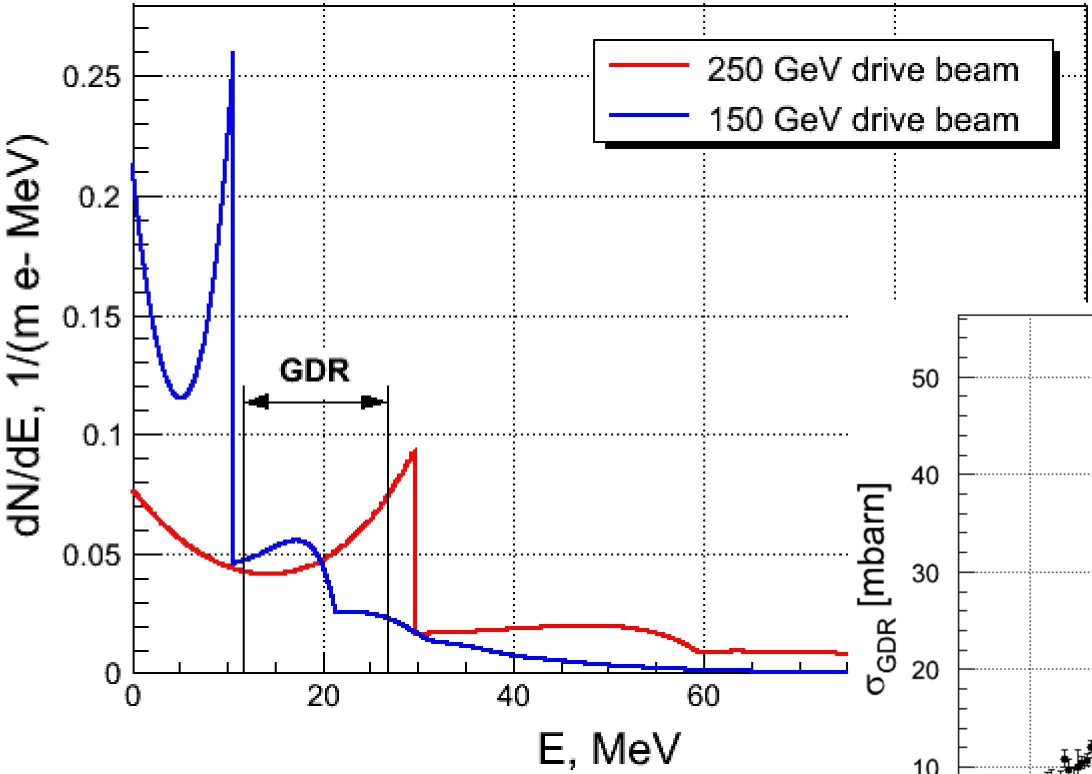
LLNL intend to carry out further mechanical, thermal and vibrational studies that underpin the target design.

SLAC will continue with activation simulations and spinning disc experiment.

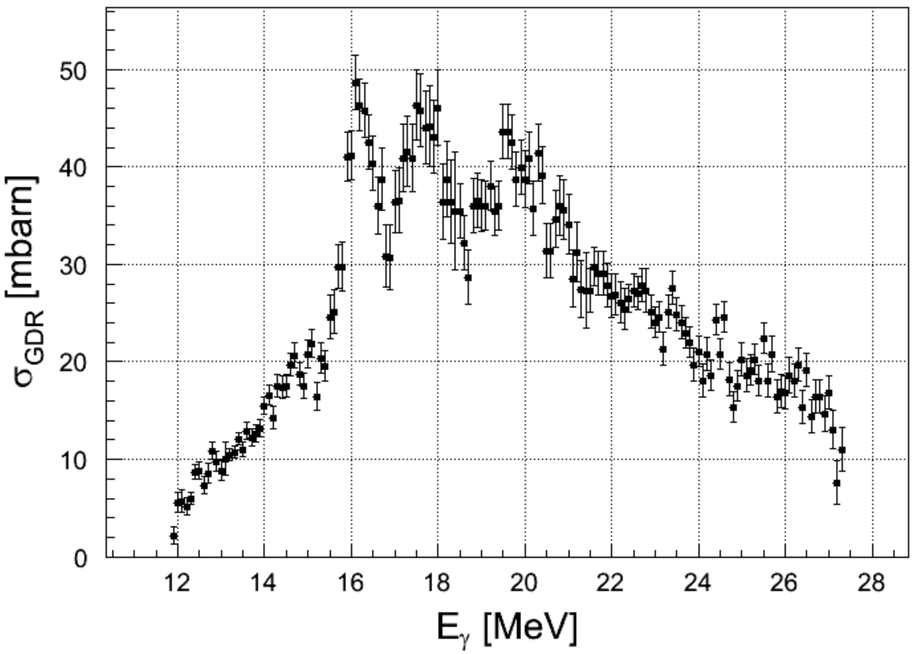
Prototyping to demonstrate:

- **Stability of rotating target**
- **Reliability of drive mechanism and vacuum seals.**
- **Rotation of target in B field of capture optics.**
- **Reliability of water-cooling system for required thermal load**
- **Engineering techniques for manufacture of water-cooling channels.**
- **Radiation hardness of the target systems.**

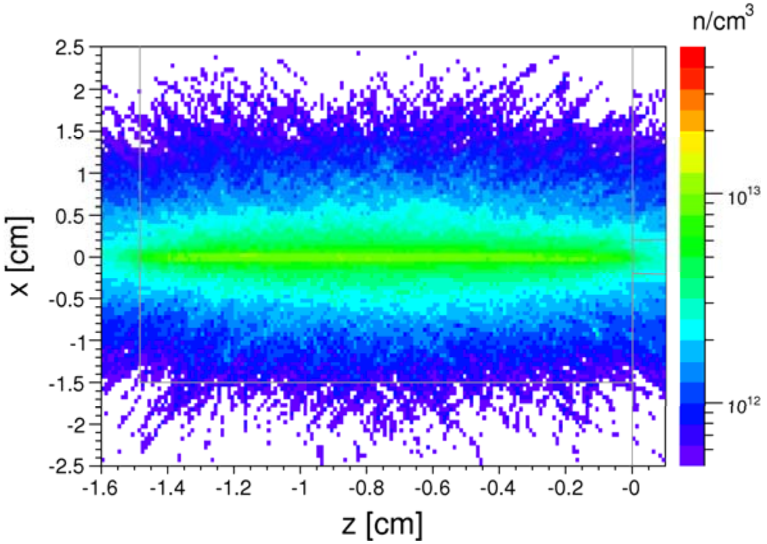
Energy Distribution of Photons

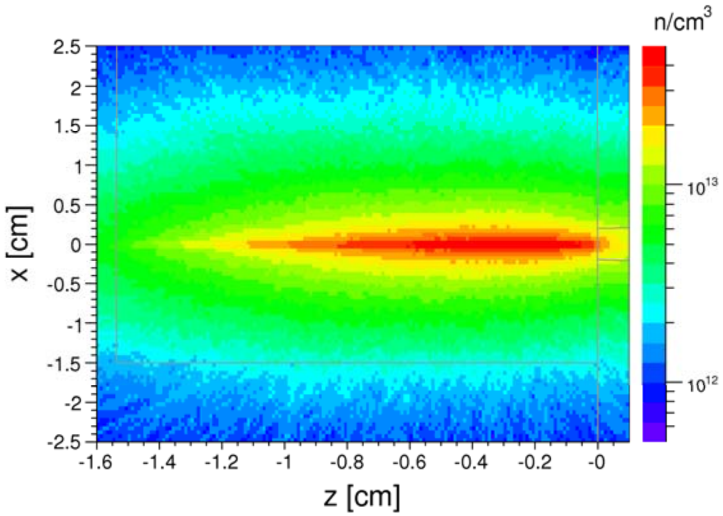


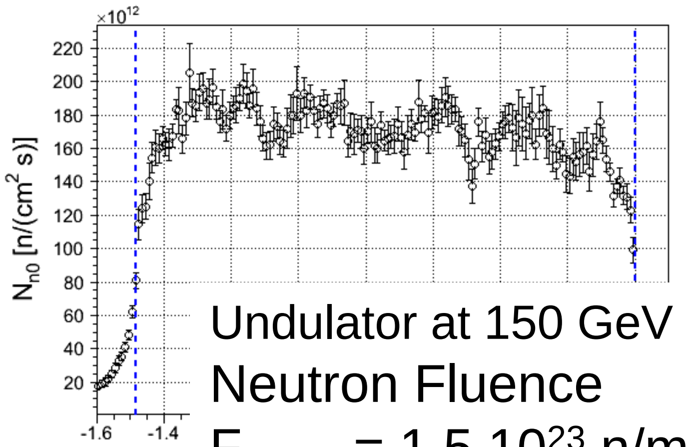
Cross section of Giant Dipole Resonance in ^{48}Ti



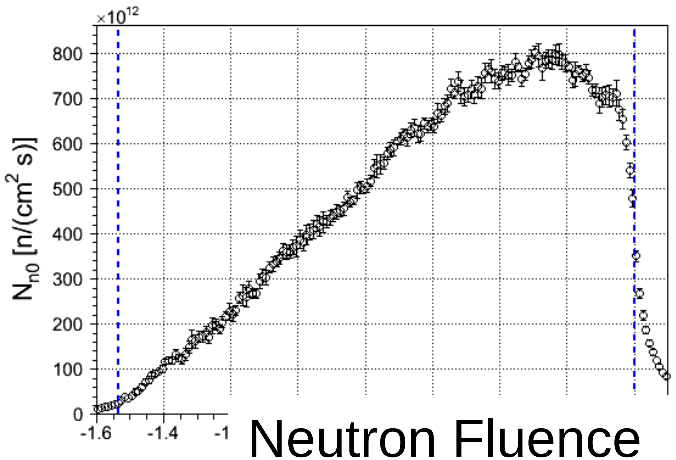
Neutron Irradiation Dose in Target







Undulator at 150 GeV
Neutron Fluence
F_{5000h} = 1.5 10^{23} n/m^2



Neutron Fluence
F_{5000h} = 6.0 10^{23} n/m^2

FLUKA Results

Total Activation and Dose Rate

Source type	A_{5000h} GBq	$\dot{D}_{+1w}$ mSv/h
Undulator based source (150 GeV)	8996	164
Undulator based source (250 GeV)	10849	130
Conventional source	602850	4007

Factor ~67 ~25

Total Number of Neutrons

	Conv.	Ti-6Al-4V Target U150	Ti-6Al-4V Target U250	Ti-5Al-2.5Sn Target U150	Ti-5Al-2.5Sn Target U250
$N_{neutron\ total}$, n/s	$2.71 \cdot 10^{14}$	$3.15 \cdot 10^{13}$	$2.32 \cdot 10^{13}$	$3.02 \cdot 10^{13}$	$2.19 \cdot 10^{13}$

Factor ~10

Beam Power and Deposited Power

	Conventional	Undulator (150 GeV)
Primary Beam Power (kW)	**253.1**	**139.4**
Power Deposited in the Target (kW)	**48.3**	**11.2**
Power Deposited in the AMD (kW)	**49.1**	**7.9**
Power Deposited in the RF Structure (kW)	**85.5**	**1.0**
Power Deposited in the Solenoid (kW)	**8.1**	**0.1**

(assumes 100m Undulator)

More details of target and capture radiation and power studies in:

A. Ushakov et al, Radiation Levels And Activation At The ILC Positron Source, EPAC 06

Target Lifetime

- Maximum neutron dose = 2.2 x 10^{14} n/m^2/s
- After 5000 hours = 3.6 x 10^{25} n/m^2
- Rotation reduces this to = 1.5 x 10^{23} n/m^2 (38cm radius target)
- Damage threshold ~ 2 to 8 x 10^{24} n/m^2
- **Lifetime ~ 50,000 hours, ~10 years of operation**

- Similar calculations at LLNL suggest **~5 year lifetime**

- Target philosophy should be revisited

A. Ushakov et al, Radiation Levels And Activation At The ILC Positron Source, EPAC 06

Source Modelling & Polarimetry

- Ongoing spin tracking studies
  - Damping rings ok, Undulator ok, BDS ok, ….
  - G. Moortgat-Pick, Spin Tracking at the ILC, EPAC06
- New version of GEANT4
  - Polarisation added for target studies
  - Bhabha/Moller scattering being added for polarimetry
  - Official release end of 2006
- Spin Rotators
  - New design developed
  - P. Schmid, A Spin Rotator For The ILC, EPAC 06
- Low energy polarimetry
  - Bhabha selected and under study
  - K. Laihem et al, Study On Low–energy Positron Polarimetry, EPAC 06

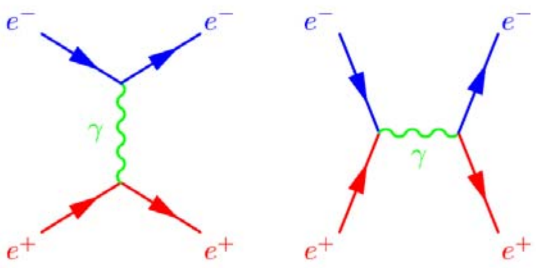
Low Energy Positron Polarimetry

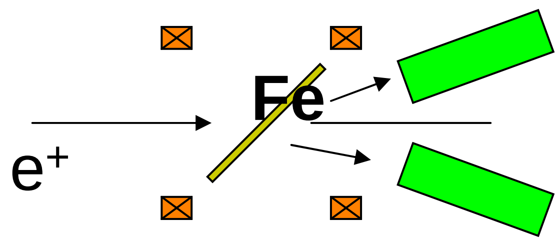
General problem near the source: ⇨ **high beam intensity**
⇨ **typical transverse beam size of ~1cm**

Methods studied	**Main disadvantage**
Laser Compton polarimetry	rate is too low
Compton Transmission Polarimetry	efficient only up to E~50MeV
Mott Scattering	transversely polarised e^+, background
Bhabha Polarimetry	promising, will be studied in detail
Synchrotron Radiation	signal too low

Results:

Bhabha polarimeter; preferably after separation of e+ from e- and γ (E~200 MeV)





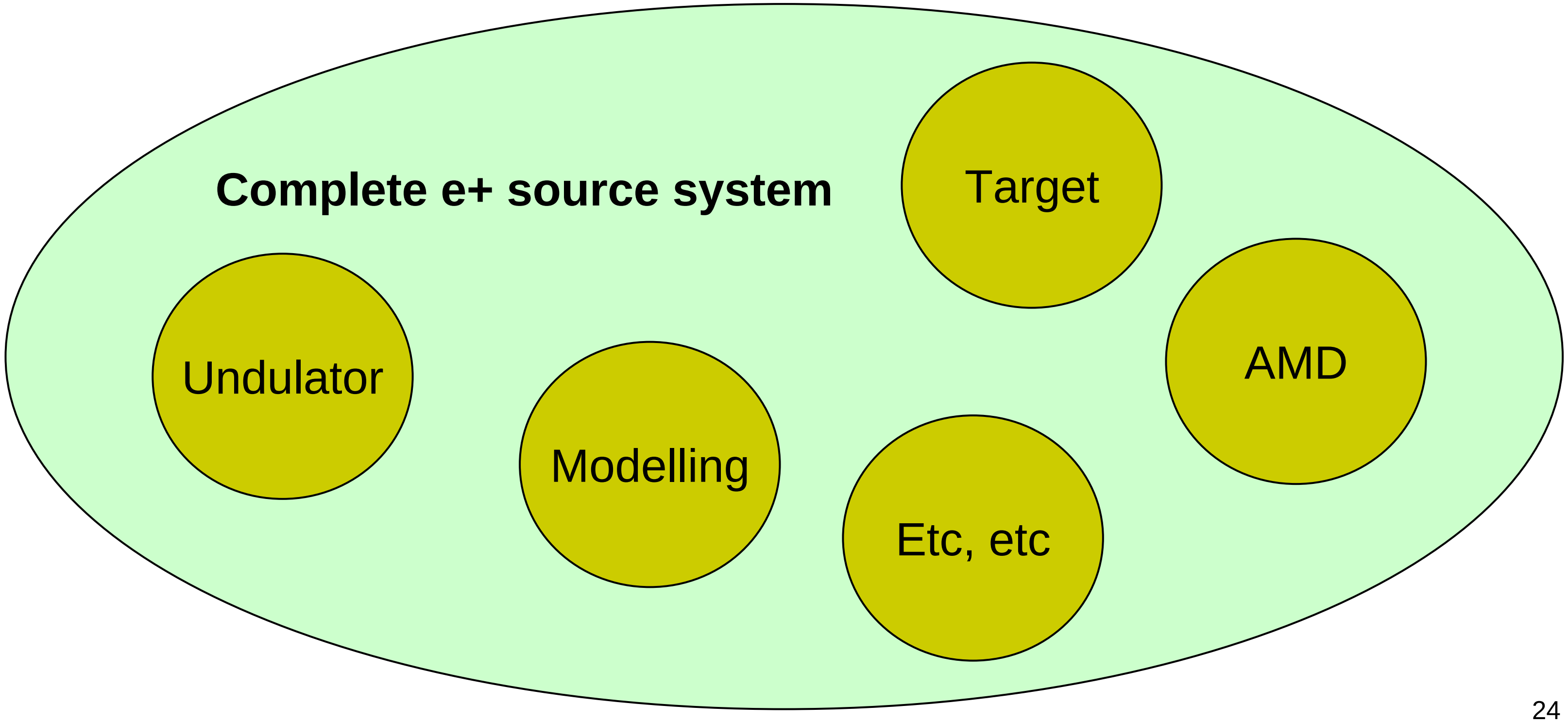
Backup solution: Compton transmission polarimetry after capture section (E~30MeV)

Immediate Costing Priorities

- Assess cost drivers
- Investigate possible cost reductions identified this week
  - e+ bypass tunnel
  - e+ transport line energy
  - Undulator dog-leg instead of chicane
  - Undulator location
  - Positron linac insert
  - Etc, etc
- **Considerable scope for reductions**
- Cost upgrade to polarised positrons
- Cost conventional source (with and without possible upgrade to polarised positrons)
  - Larger error bars since no feasible design

R & D Organisation for Positron Source

- Sub project teams working well
- System integration of parts less effective
- More communication amongst groups planned
- Complete R & D plan needs to be developed



R & D Priorities

- Helical Undulator
  - Build and test (with beam) prototype module
  - Industrialise design – pre production prototype
- Target System
  - Detailed analysis & design of system
  - Start prototyping to confirm design choices
  - Remote handling design
- Adiabatic Matching Device
  - Design choice for the AMD (Pulsed or SC)
  - Engineering design of the AMD
  - Prototype
- Source Modelling
  - Start to end model of e+ source
  - Optimisation of source parameters