Report from WP4: Polarised Positron Source

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2nd EuroTeV Annual Workshop,
Daresbury,
January 2007

Work Areas

- Undulator manufacture
- Impact of undulator
- Photon collimator
- Conversion Target
- Spin Tracking
- Low Energy Polarimetry

Manufacturing prototypes

<table>
<tr><th></th><th>I</th><th>II</th><th>III</th><th>IV</th><th>V</th></tr>
<tr><td>Former material</td><td rowspan="8">2005</td><td rowspan="8" colspan="4">2006</td></tr>
<tr><td>Pitch, mm</td></tr>
<tr><td>Groove shape</td></tr>
<tr><td>Winding bore, mm</td></tr>
<tr><td>Vac bore, mm</td></tr>
<tr><td>Winding</td></tr>
<tr><td>Sc wire</td></tr>
<tr><td>Status</td></tr>
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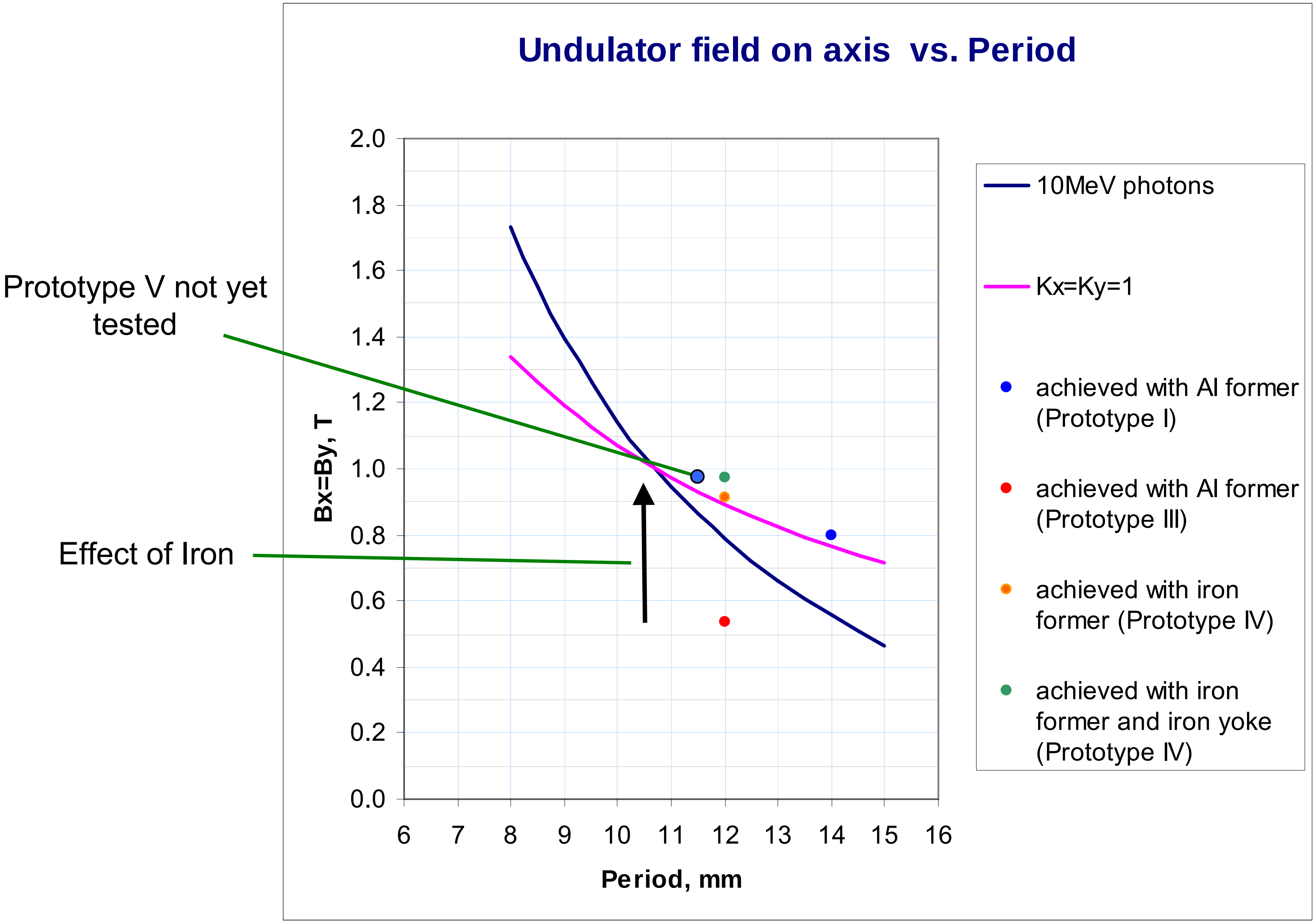
Prototypes family

Short prototypes results summary

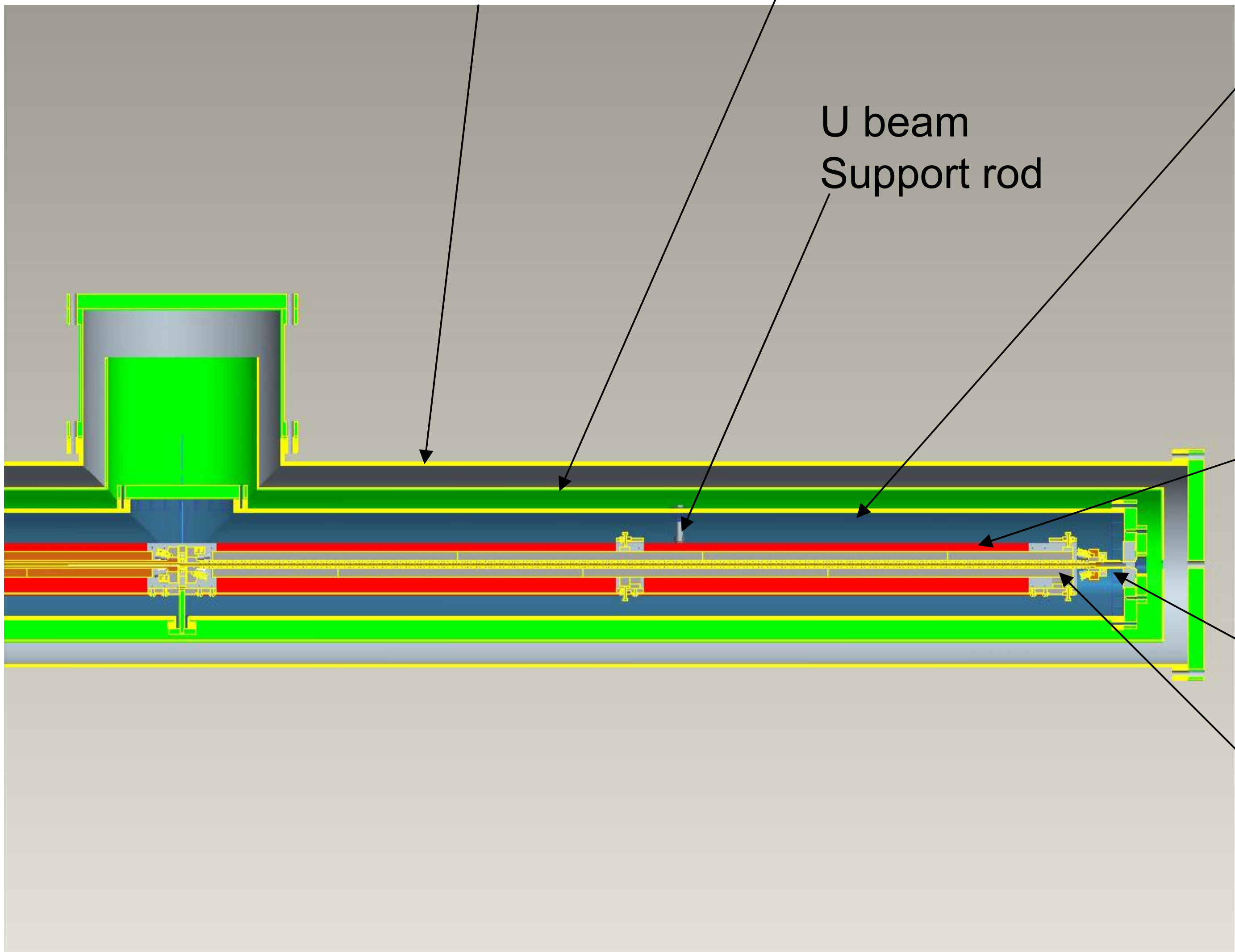


4m Module Overview

Stainless steel vacuum vessel
with Central turret

50K Al Alloy Thermal shield.
Supported from He bath

U beam
Support rod



Stainless Steel He bath contains100L liq He. Supported by 4 rods attached to the vacuum vessel

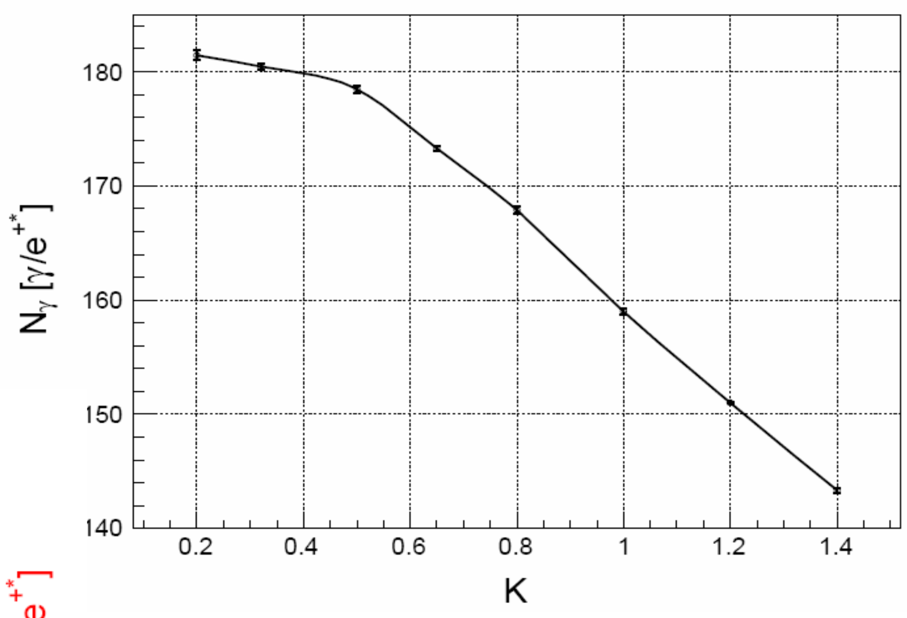
U Beam used to support/align the magnet.

Beam Tube

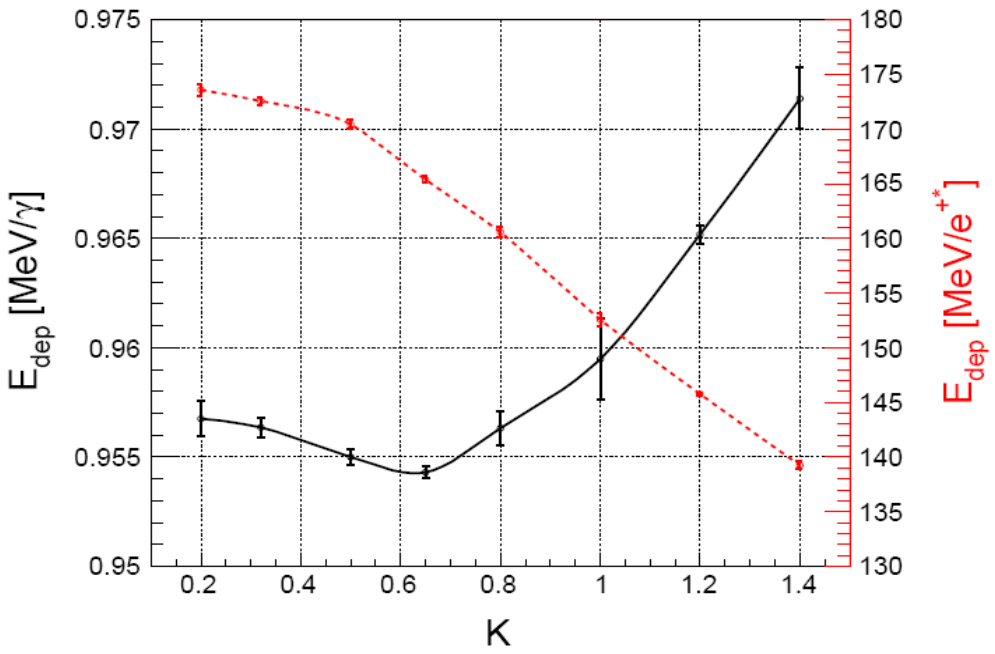
Magnet cooled to 4.5K by liq He in bath.

Undulator Parameter Optimisation with Target

Required number of photons per positron at IP

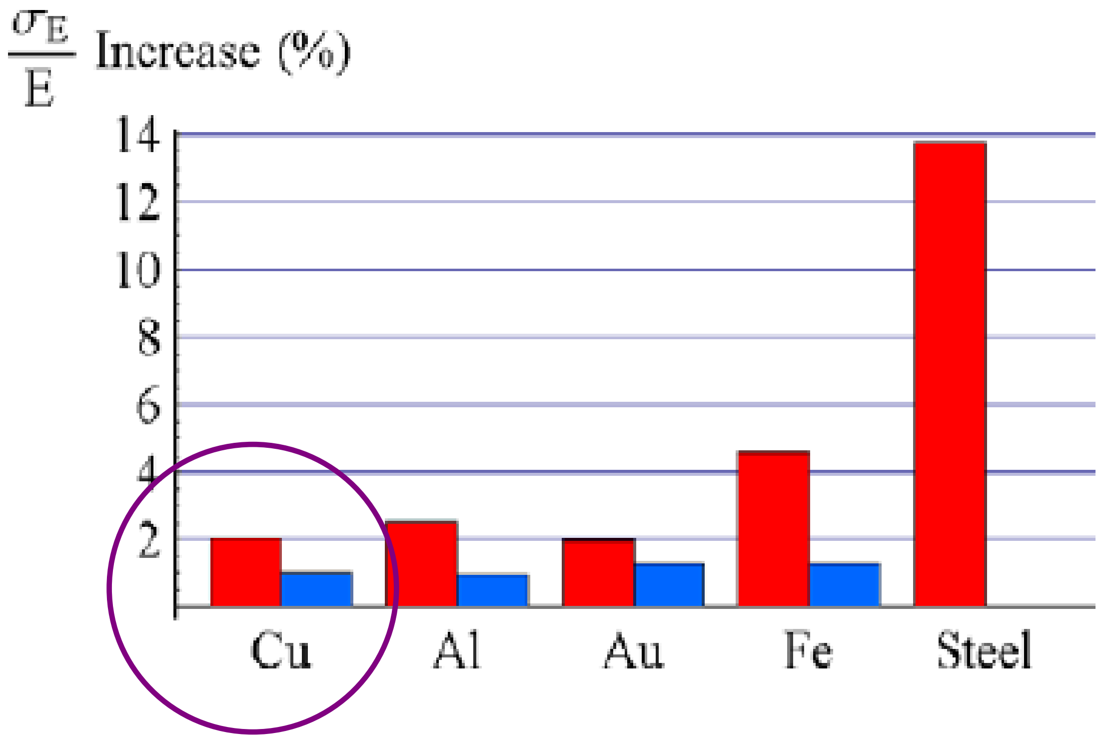


Energy deposition in the target per positron at the IP (red)

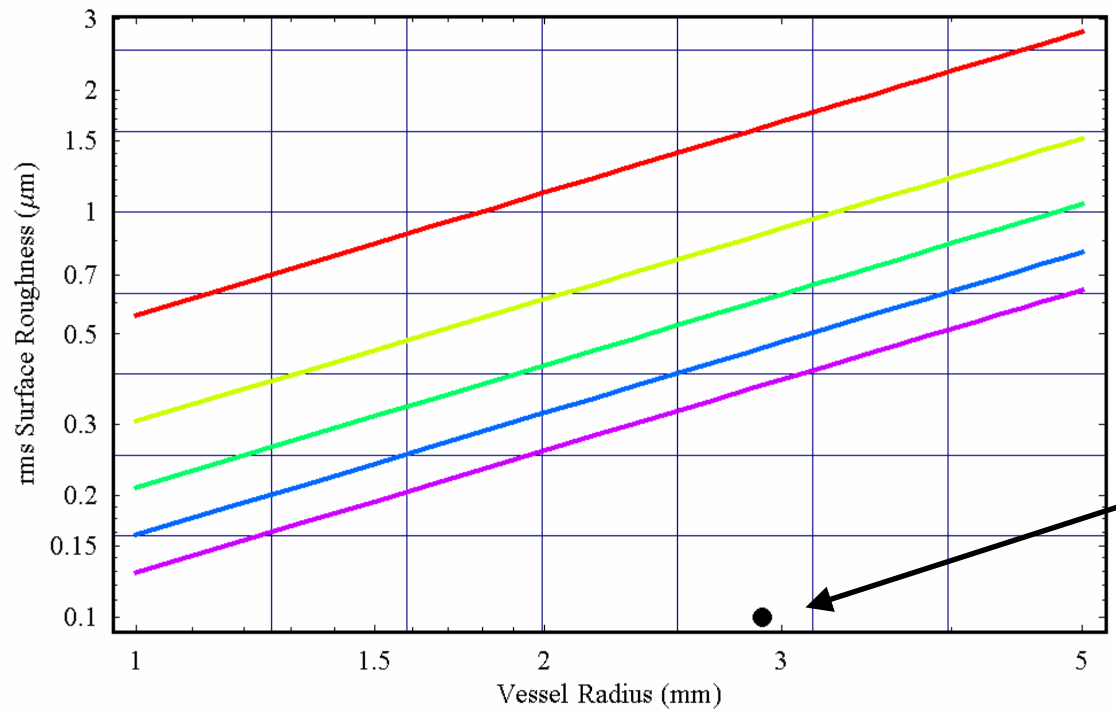


Resistive Wall Results

- Energy spread inrease of nominal, 200m - 5.6mm vessel
- Red is room temperature, blue is at 77K
- Induced energy spread is 5 10^{-6}
- Vessel will actually be at 4K but hard to get reliable material data for modelling – will just get better



Surface Roughness Wakefields



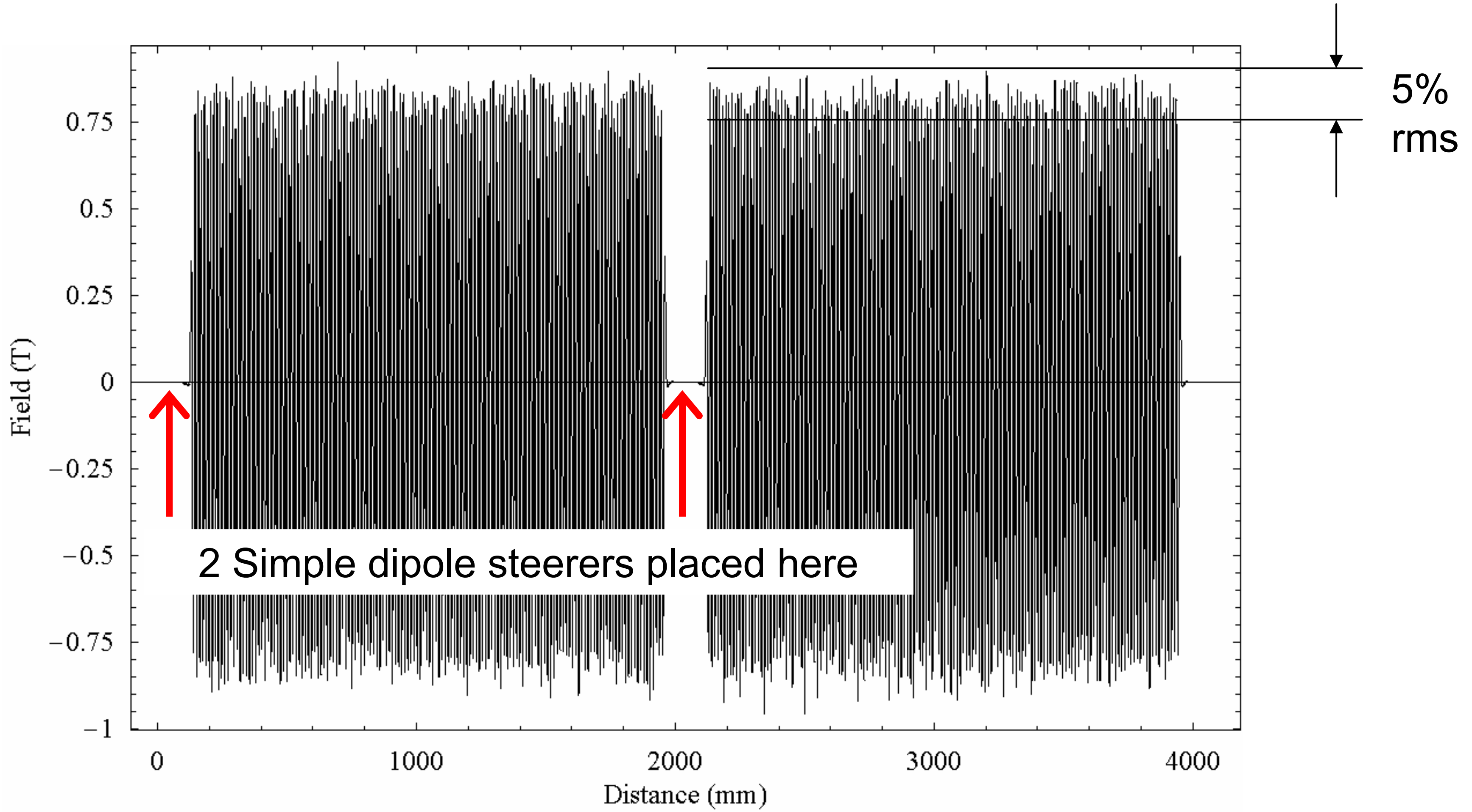
Various Models for surface

A copper pipe with OD 6.35mm, ID 5.8mm and surface roughness R_A~100nm is available from industry today

surface roughness required to produce an energy spread increase of 10% of nominal with 200m long vessel against vessel radius

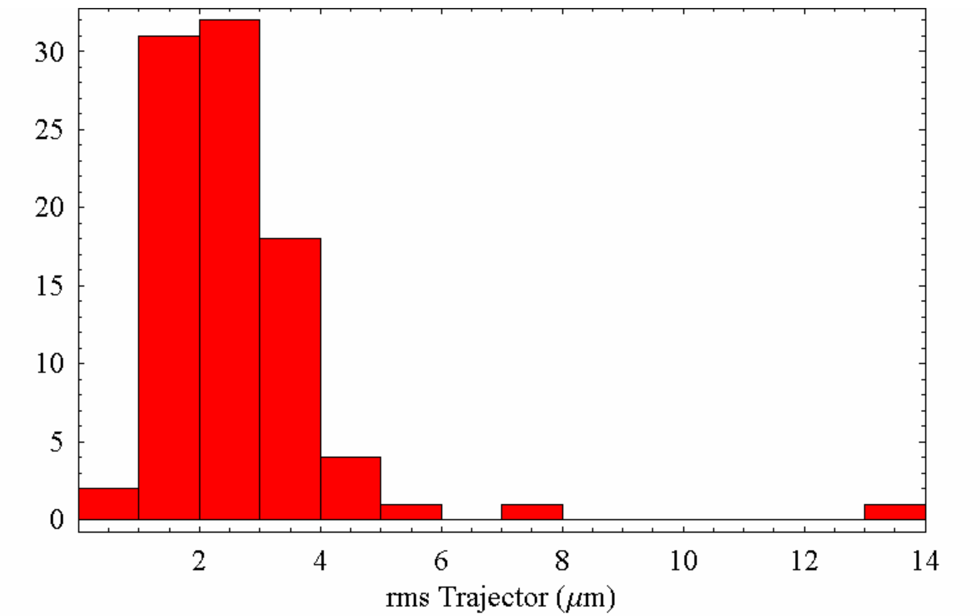
Magnetic Errors & Trajectory Correction

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

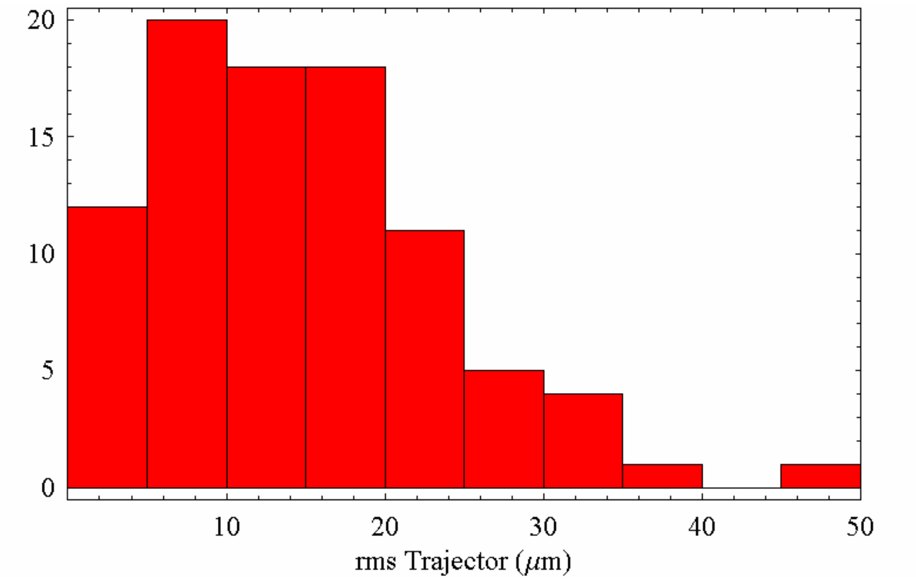


Results from 100 random seeds

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

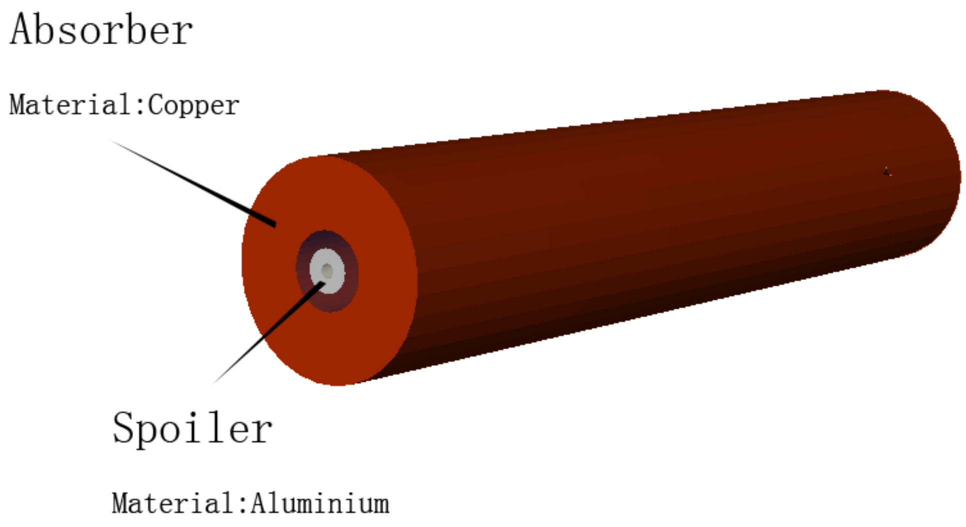


With Correction



Without Correction

FLUKA Photon Collimator Simulations (1)



Starting collimator geometry:

Inner radius of spoiler 1.2mm

Thickness of spoiler 2.3mm

Inner radius of absorber 53.5mm

Thickness of absorber 160mm

Collimator length 1500mm

Assume a 300kW 10 MeV photon beam with Gaussian transverse beam profile (1mm rms):

Power deposited in spoiler: ~2.5 kW

Power deposited in absorber: ~3 kW

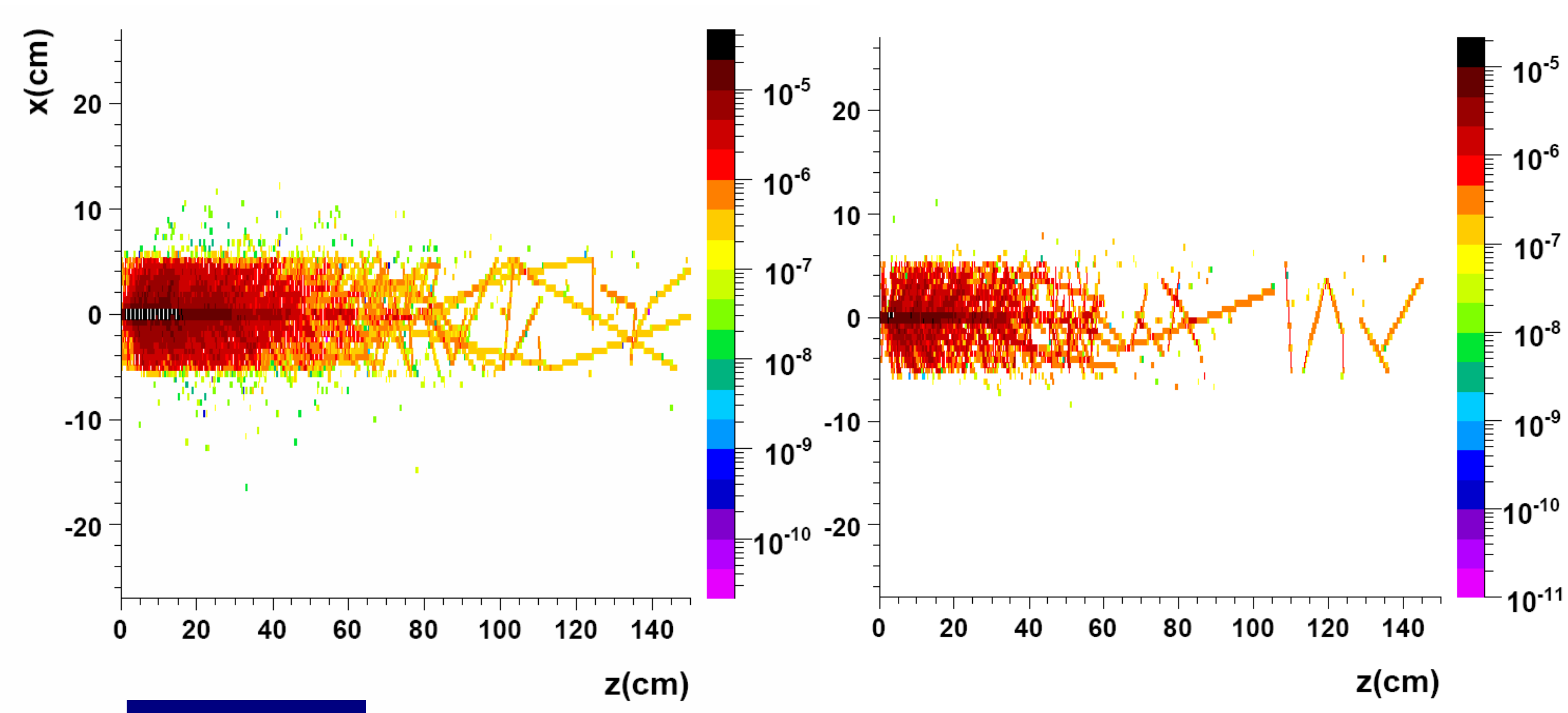
(1.8% of total beam power)

Lei Zang, University of Liverpool

FLUKA Photon Collimator Simulations

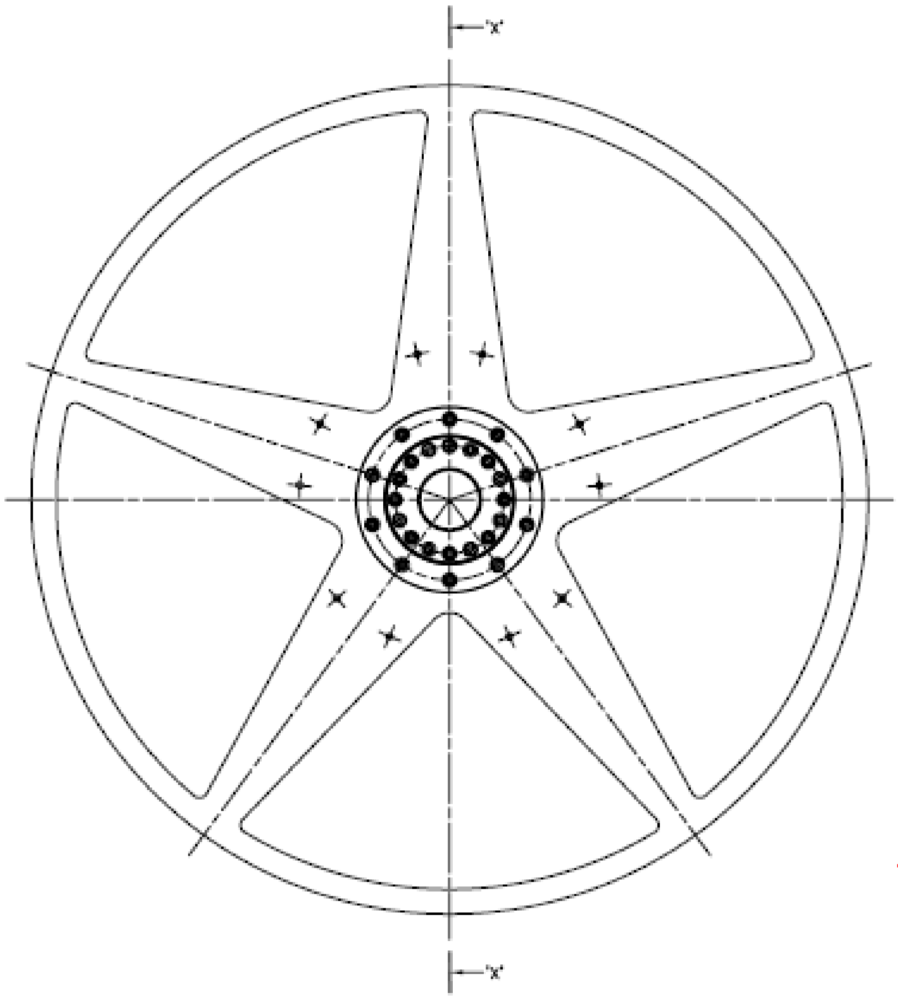
Electron fluence (per primary photon)

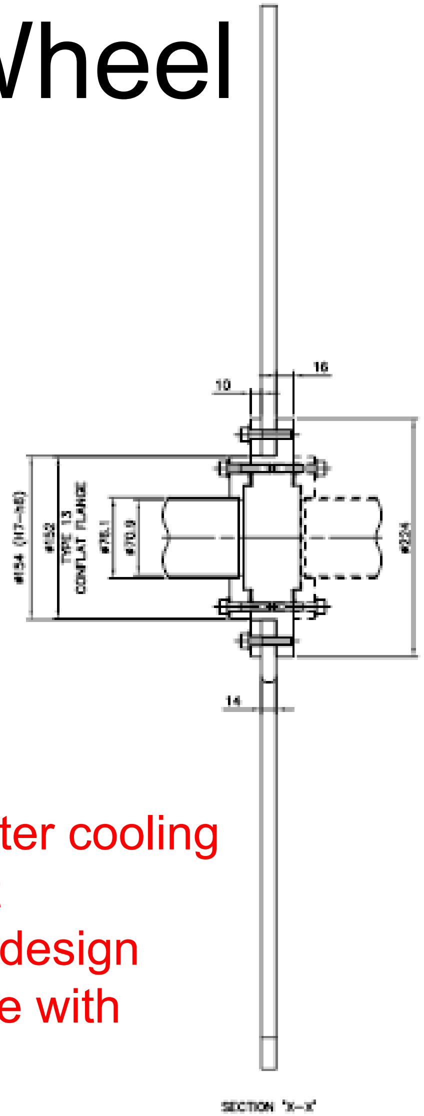
Positron fluence (per primary photon)



10^5 Events

DL Prototype Target Wheel

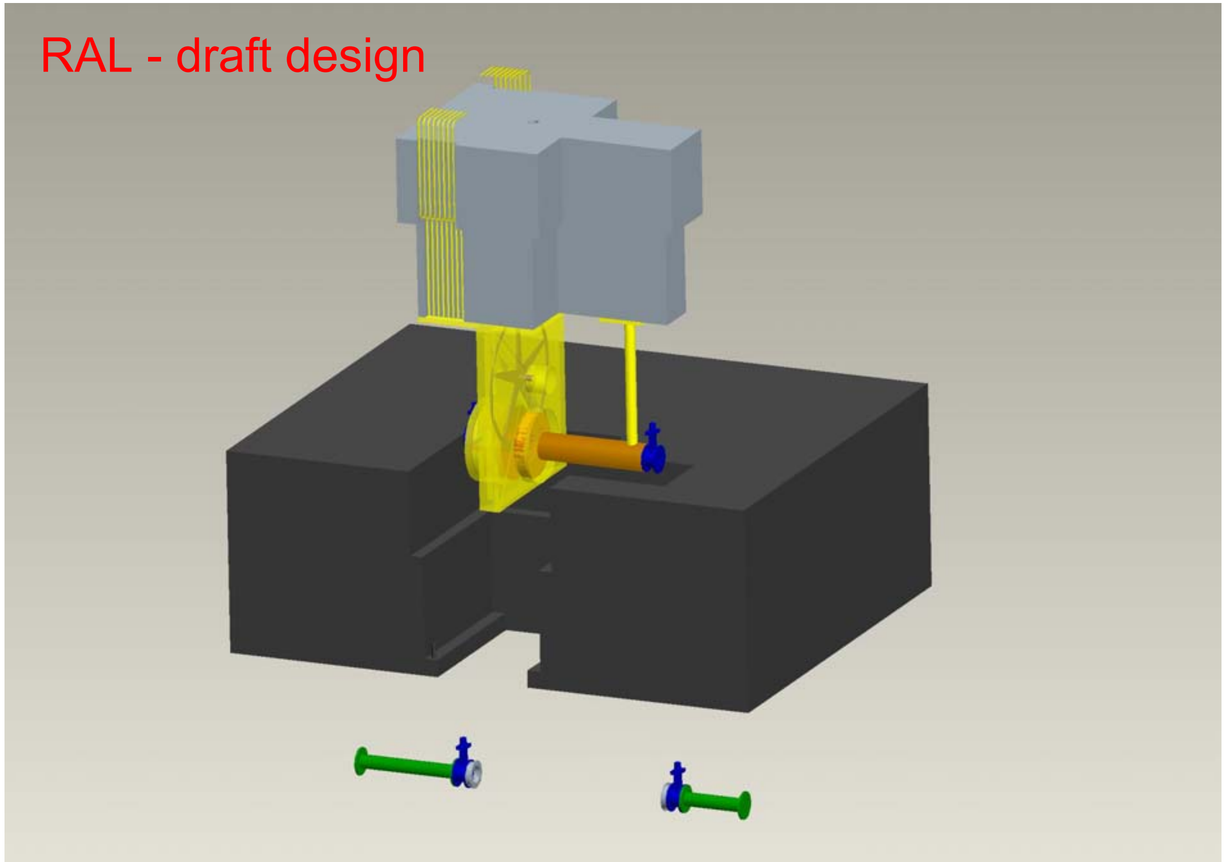




No internal water cooling channel in first prototype, but design fully compatible with channel.

Target Station - Remote Handling

Vertical remote-handling design to mimimise footprint of target hall and therefore minimise civil engineering costs.

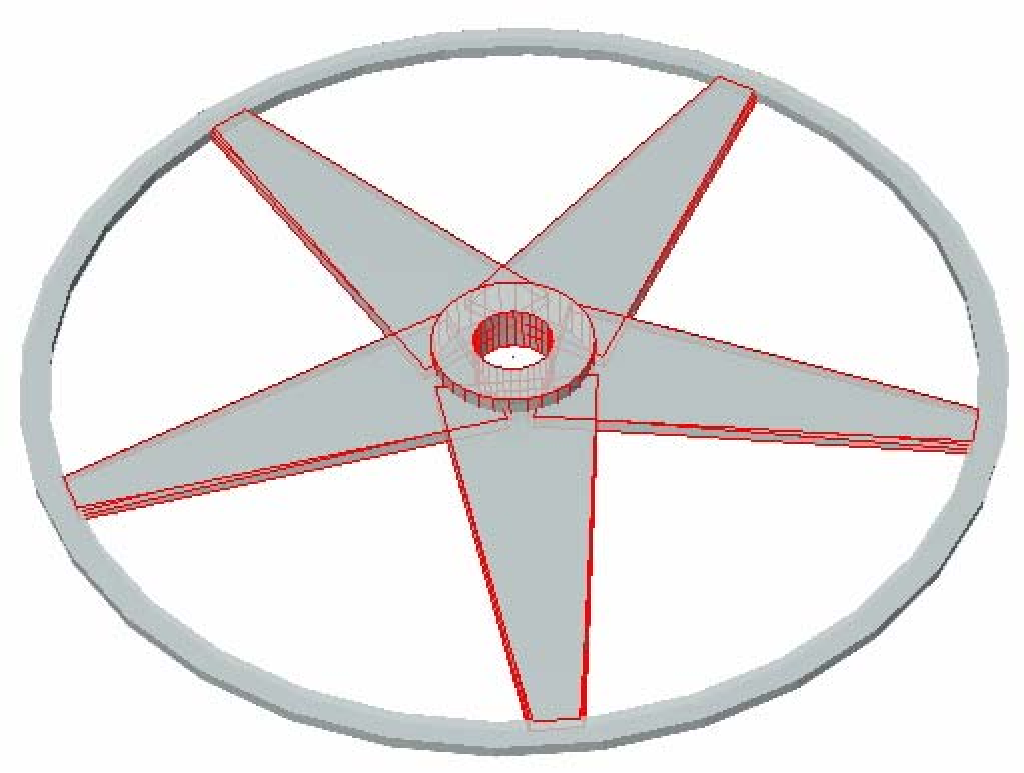


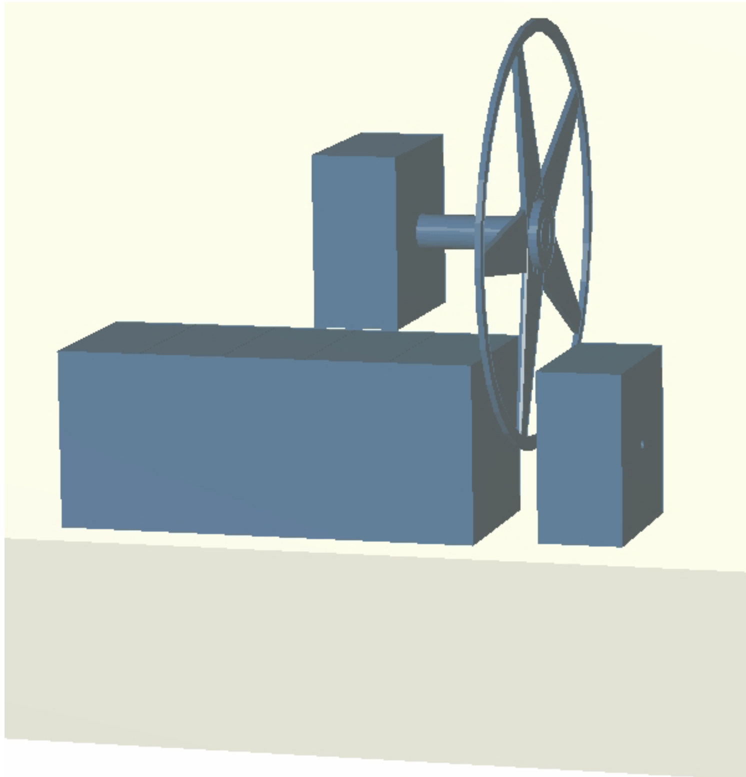
Beam Power and Deposited Power in Target

	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**

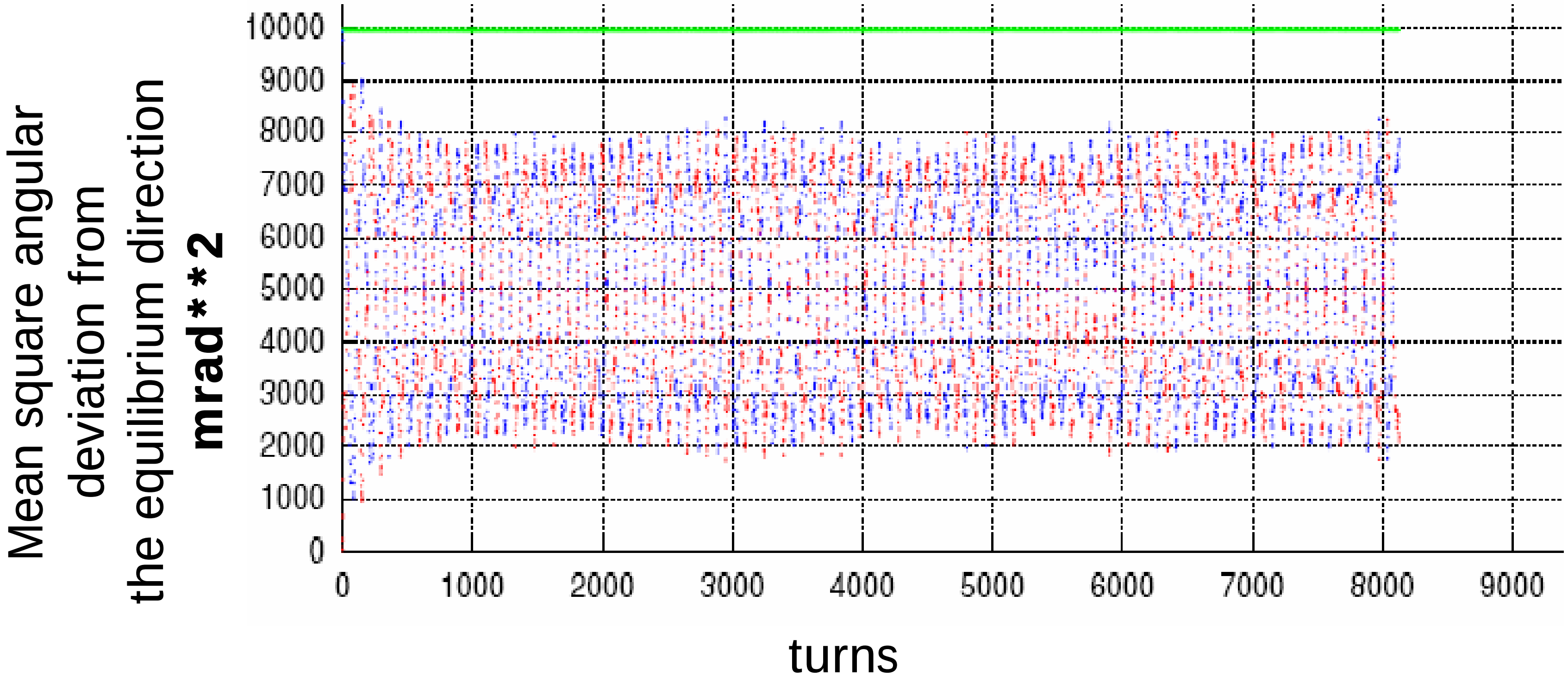
(assumes 100m Undulator)

More Detailed FLUKA Model Being Developed





OCS Spin Diffusion at 5.066GeV for spins initially at 100 mrad from $\hat{n}_0$



No full decoherence of horizontal components of spins

Longitudinal polarisation (some fraction) can survive DR

a) Spin precession

- PPARC review committee: check if used equations in CAIN are applicable!
  - validation of T-BMT equation
- What has been used?

$$\frac{d\boldsymbol{S}}{dt} = -\frac{e}{m\gamma}\left[(\gamma a + 1)\boldsymbol{B}_T + (a+1)\boldsymbol{B}_L - \gamma(a + \frac{1}{\gamma+1})\beta\boldsymbol{e}_v \times \frac{\boldsymbol{E}}{c}\right] \times \boldsymbol{S}.$$

  - 'a' is anomalous magnetic moment of electron $a=(g-2)/2=\alpha/2\pi + \ldots$
  - higher-order effect, radiative corrections to $ee\gamma$ vertex
  - measured up to accuracy of 10^{-11}
- Due to strong fields (beamstrahlung), a is function of field
  - unpublished expression from V. Baier used.....
  - has been checked now

- **Baier derived**

  a) expression for anomalous moment of e in a medium

  → use ansatz in perturbation theory

  → relates spin-dependent part of corrections with magn. moment

  b) get expression valid in beam-beam interactions

  → use this expression for the case that 'no' scattering happens

  → that has been used in CAIN

  c) used approximation: quasi-classical approximation

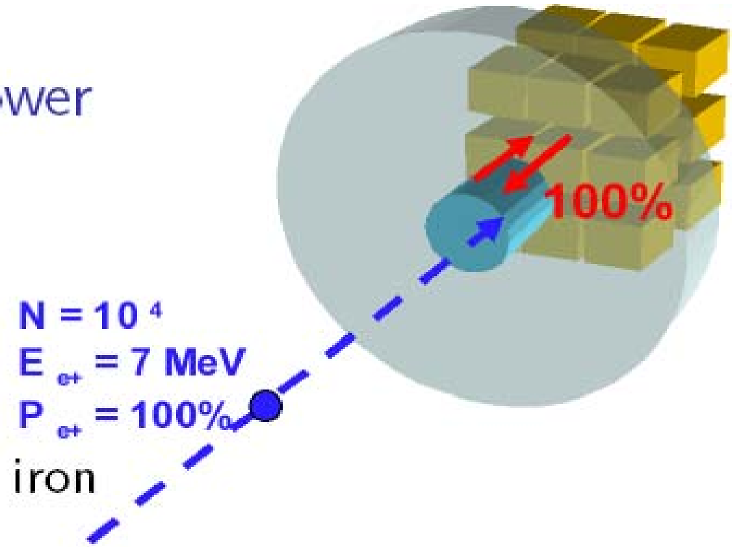
  → (one) condition: change of momentum due to external field has to be slowly

  → applicable if: Larmor radius in magn. field much larger than particle wavelength

  → ok for our case, even although fields are strong

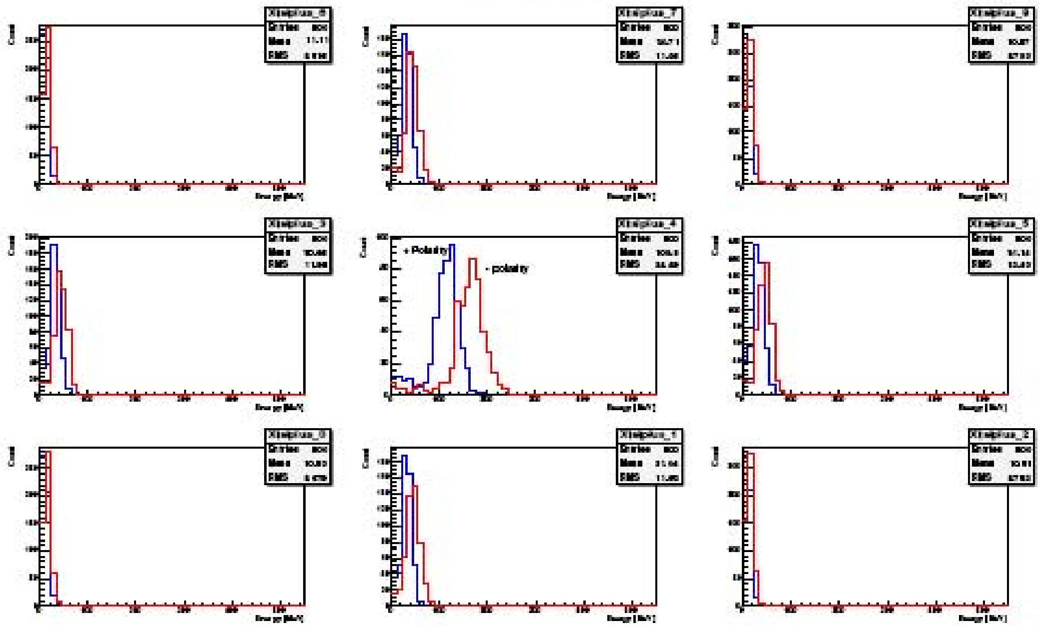
G4 Implementation

Polarimeter – Simulation of Analysing Power



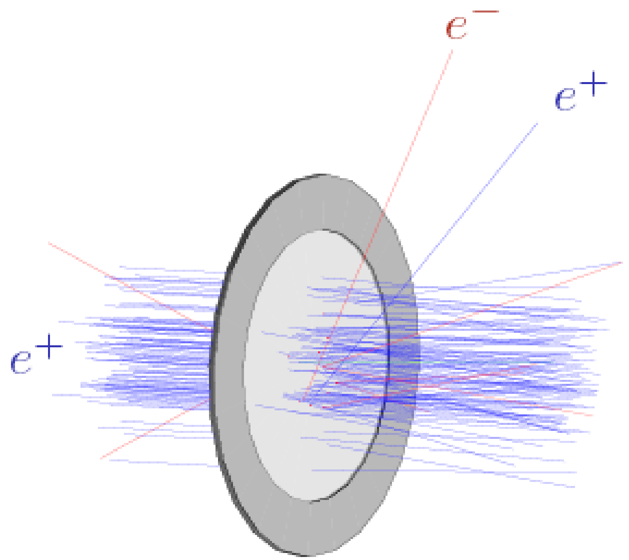
- reconversion of positrons into photons via Bremsstrahlung and annihilation
- transmission of photons through magnetised iron (magnetisation parallel or anti-parallel)
- measurement of transmission in a 9-crystal CsI calorimeter
- polarisation dependence of Compton cross section results in an asymmetry
- simulation gives analysing power (conversion factor between measured asymmetry and polarisation of positrons)

K.Laihem

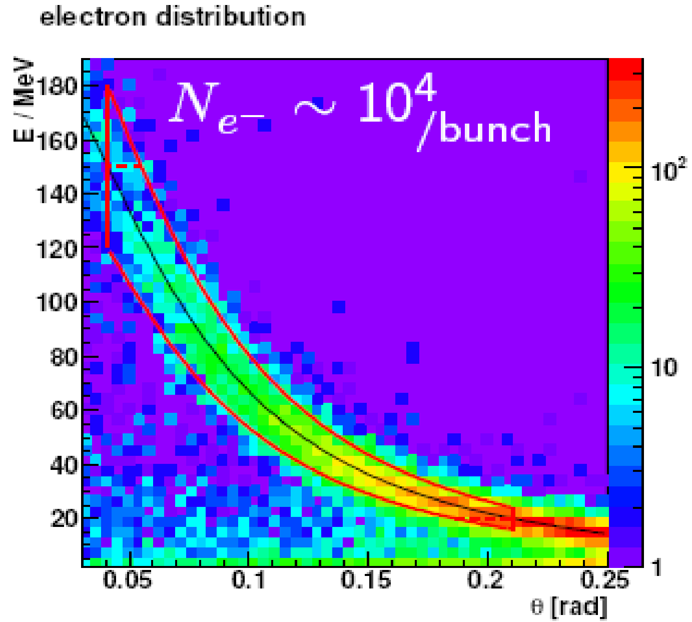


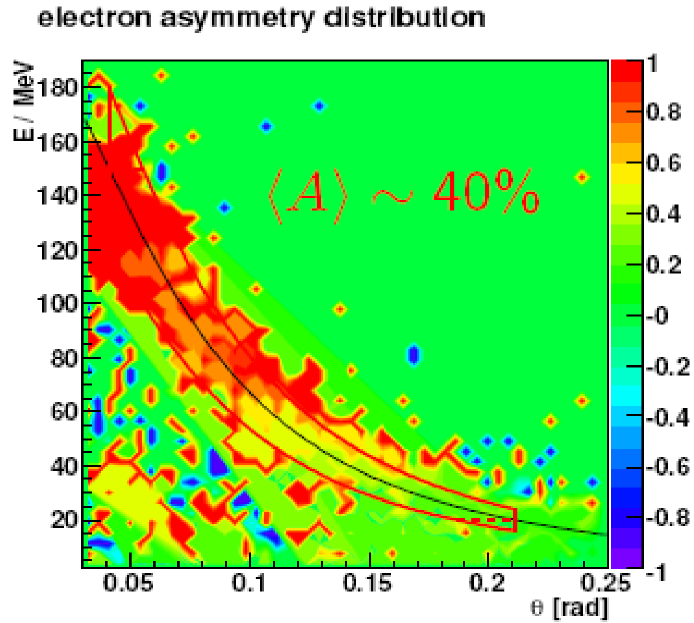
G4 Implementation

Bhabha Polarimeter



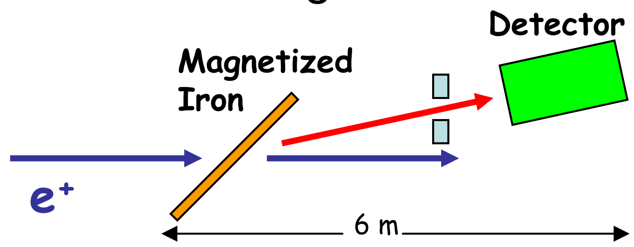
- e^+ beam, $E \approx 200$ MeV
- magnetised iron foil 30 μm
- simulation gives distribution and analysing power for e^+, e^- and γ



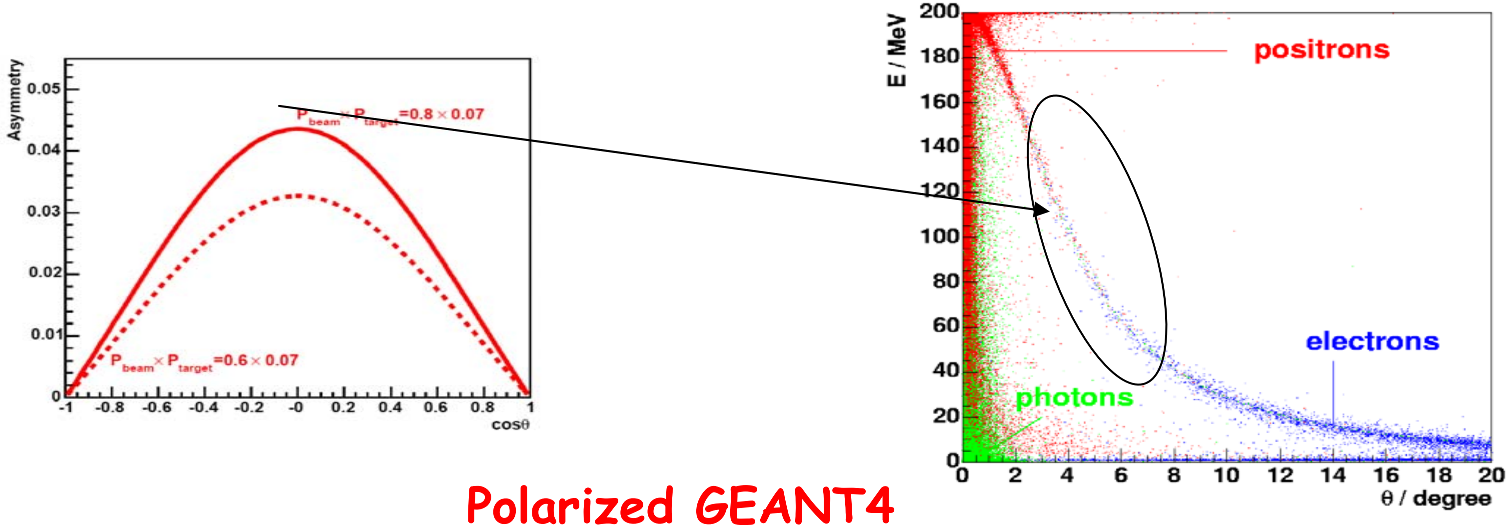


Bhabha Polarimeter

- Measures Asymmetry of scattered particles (e^+,e^-,(γ)) of two magnetization states of the target



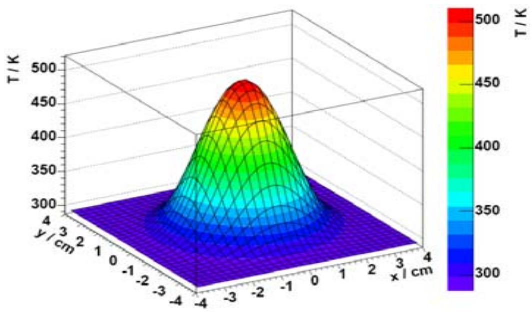
- Mask or shielding selects angular range with max. asymmetry
- Spectrometer -> particle separation, energy selection

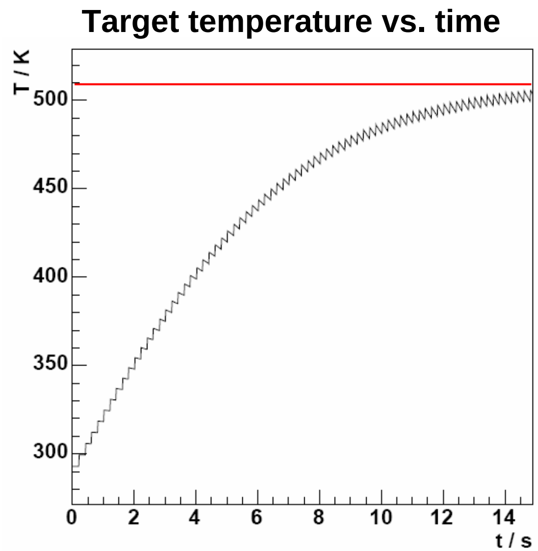


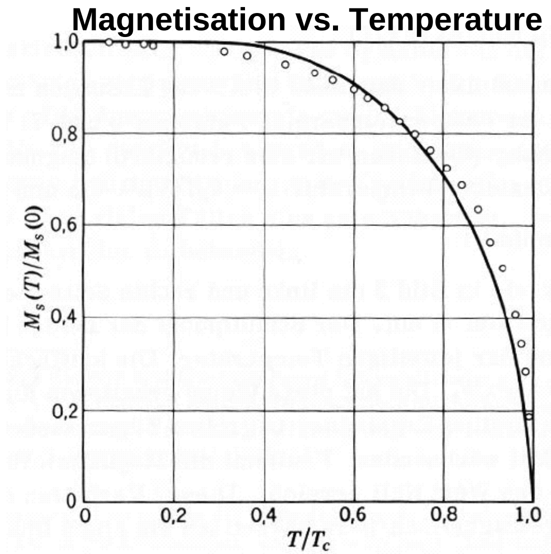
Polarized GEANT4

Bhabha Polarimeter: Target

- Magnetized thin IronTarget
- Heating of the target -> Magnetization decreases
  - Simulation for 30 μm
  - Cooling by radiation
  - T_C (Fe) = 1039 K; melting point 1808 K







- Ongoing considerations on target layout
  - ΔT -> ΔM -> ΔP -> ΔA
  - Magnetic field (tilted or not)
  - Cooling in real
  - Monitoring of magnetization