EUROTeV WP4 Report
Polarised Positron Source

Jim Clarke, on behalf of the WP4 team

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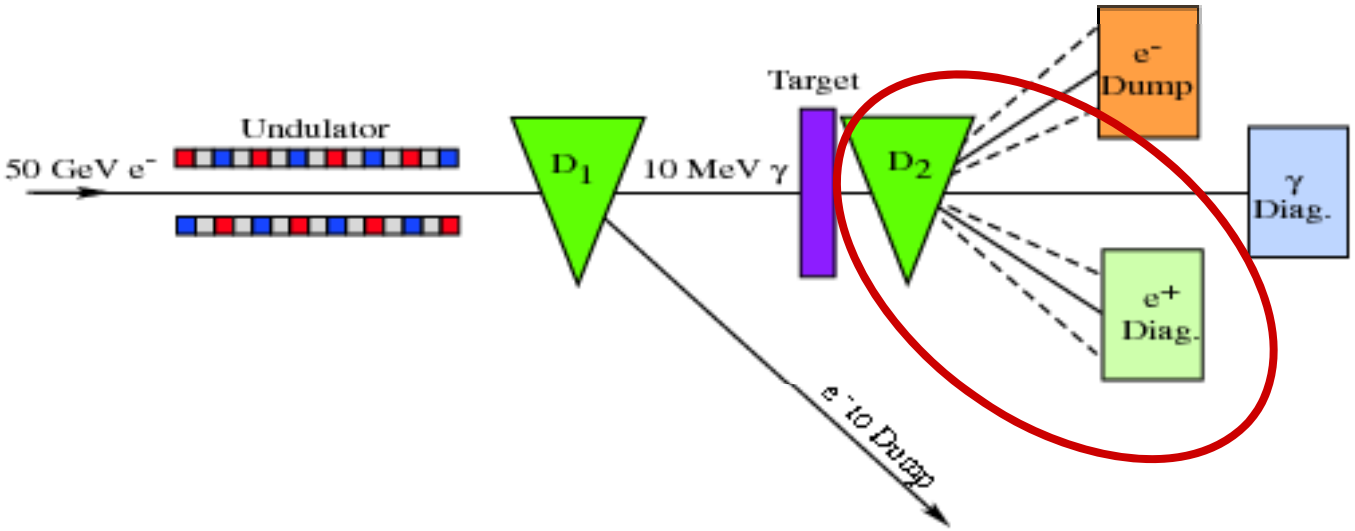
Milestones and Deliverables

Milestone	Milestone name	WP	Lead Contractor	Planned (months)	Achieved (months)
1	Detailed scope and planning report to First Workshop	4	2	6	6
2	Presentation of results and detailed implementation at second workshop	4	2	18	25
3	Computer model/simulations of complete source available	4	2	18	18
4	Presentation of phase 2 results to 3rd Workshop. Plans for GDE input and further R&D	4	2	30	30
5	Low-energy polarimeter prototype complete	4	1	48	48
6	Prototype undulator constructed and measured	4	2	48	48
7	Full engineering design for photon target and collimator complete	4	2	48	48

Deliverable No	Deliverable Name	WP	Lead Contractor	Planned (in months)	Achieved (in months)
1	Fully engineered undulator prototype based on chosen technology	4	2	30	30
2	Report on performance simulations of polarized source system	4	2	18	18
3	Report on conceptual design for spin-flipping system, including estimates of errors	4	1	18	18
4	Fully tested low-energy polarimeter	4	1	48	48

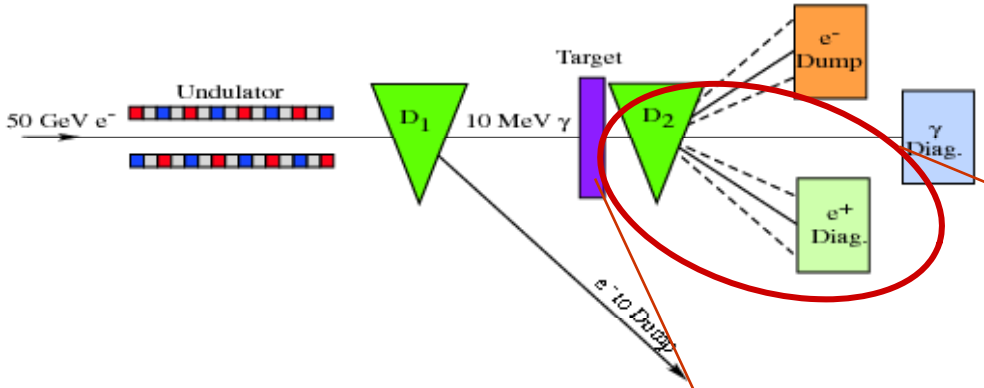
- e+ beam at the source (after capture and first acceleration):
  - 125 MeV < E < 5 GeV
  - beam size ~ cm
- Applicable processes for polarimetry:
  - Compton Transmission (up to energies of ~100MeV)
  - Bhabha polarimetry (E > 250 MeV)
  - Compton polarimetry (after DR, 5GeV)
- **Tested with prototype**
  - Compton Transmission (E166)
- Simulation studies for
  - Bhabha polarimetry
  - Compton polarimetry
- Simulation Tool for polarimetry studies:
  - Geant4 with polarization extension

- E166: prototype for polarized ILC e+ source
  - ➔ Diagnostics for e+, photons, e-

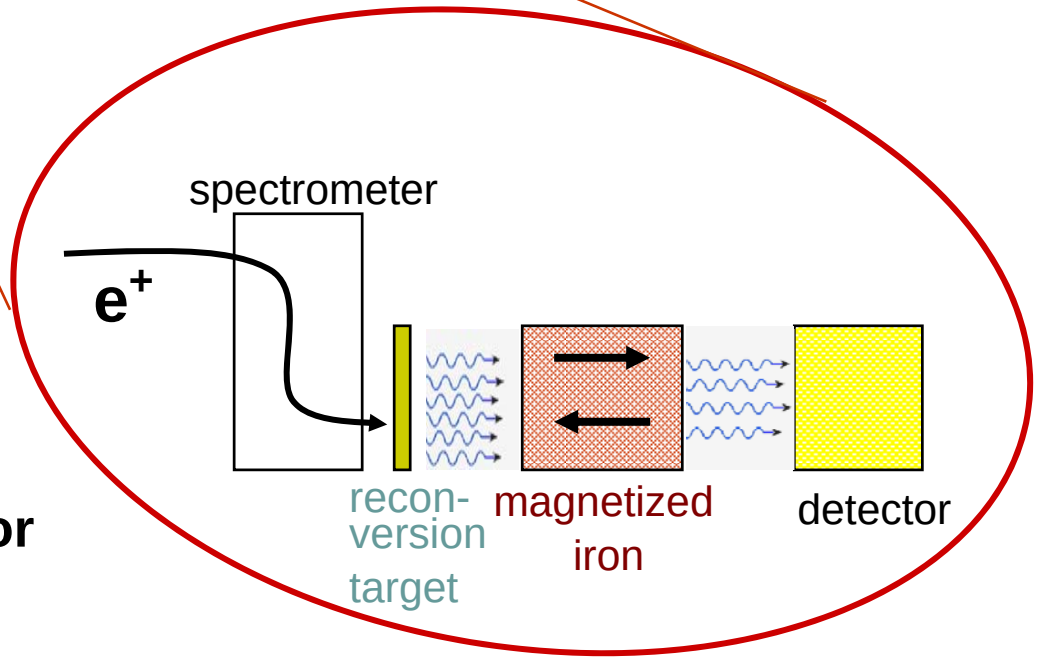


  - ➔ Positron energy: 4.5 MeV – 7.5 MeV

E166 Compton transmission polarimeter



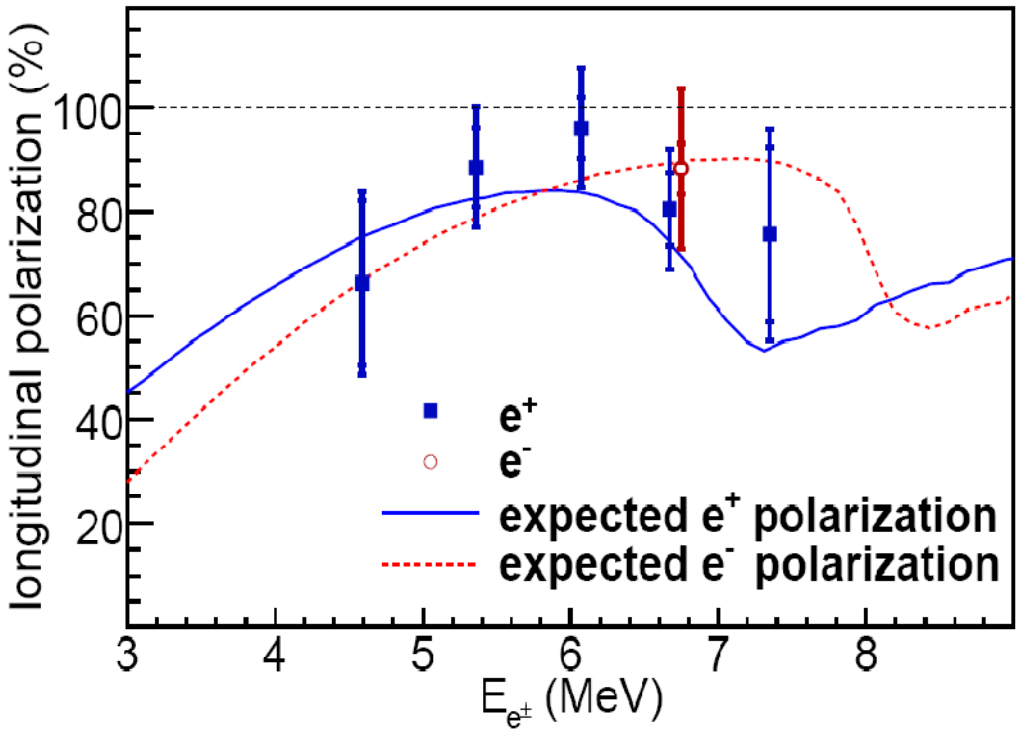
- Reconversion of polarized e+ to polarized photons
- **transmission of photons through iron depends on its magnetization**
- **Measurement of transmission asymmetry for opposite (→ and ←) iron magnetization**



E166 results:

- Good agreement of measurement and prediction
- e+ polarized up to ~90%
- Verification with new GEANT4 – big effort here!

PRL100, 210801 (2008)

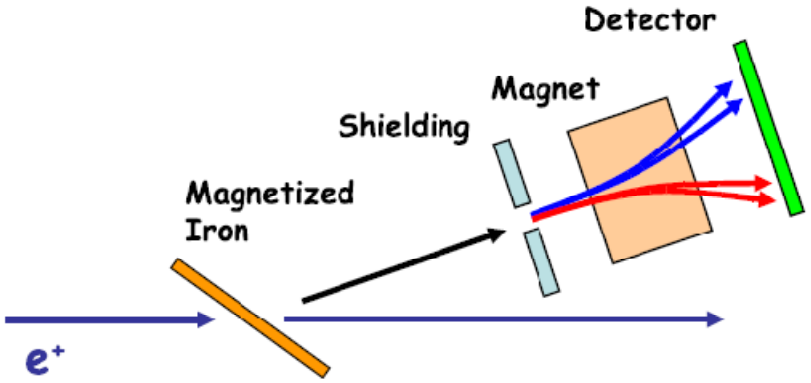


Application at ILC

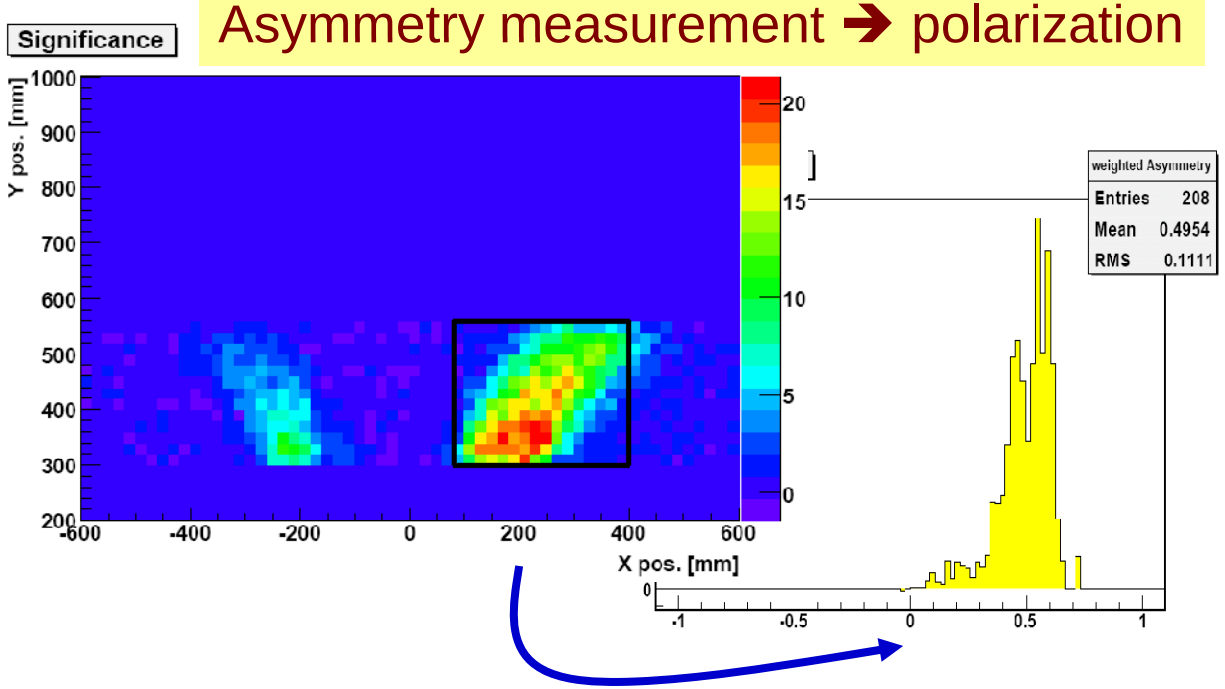
- E_{e+} = 125 MeV
- Method is destructive
  - → only few bunches/pulse,
  - → target heating
- Intense ILC beam → sufficient statistics after few bunches

Bhabha Polarimeter

- Møller polarimeters widely used
- asymmetry of Bhabha scattering for opposite magnetization of target foil measured
- Almost non-destructive due to large transverse e+ beam size
- Intense beam → fast



Asymmetry measurement ➔ polarization



Method	e+ Energy		precision	Delivered
Compton transmission	125 MeV	Destructive → use only few bunches per pulse	Stat: <1% after few pulses, syst. will dominate	**Prototype (E166)** E166 analysis, E166 modelling, design simulations for ILC application
Bhabha	400 MeV	Non-destructive	Stat: ≤1 % after few pulses, syst. will dominate	design simulations
Compton	5 GeV (after DR)	Non-destructive	Stat: ~5% after ~5min	design simulations

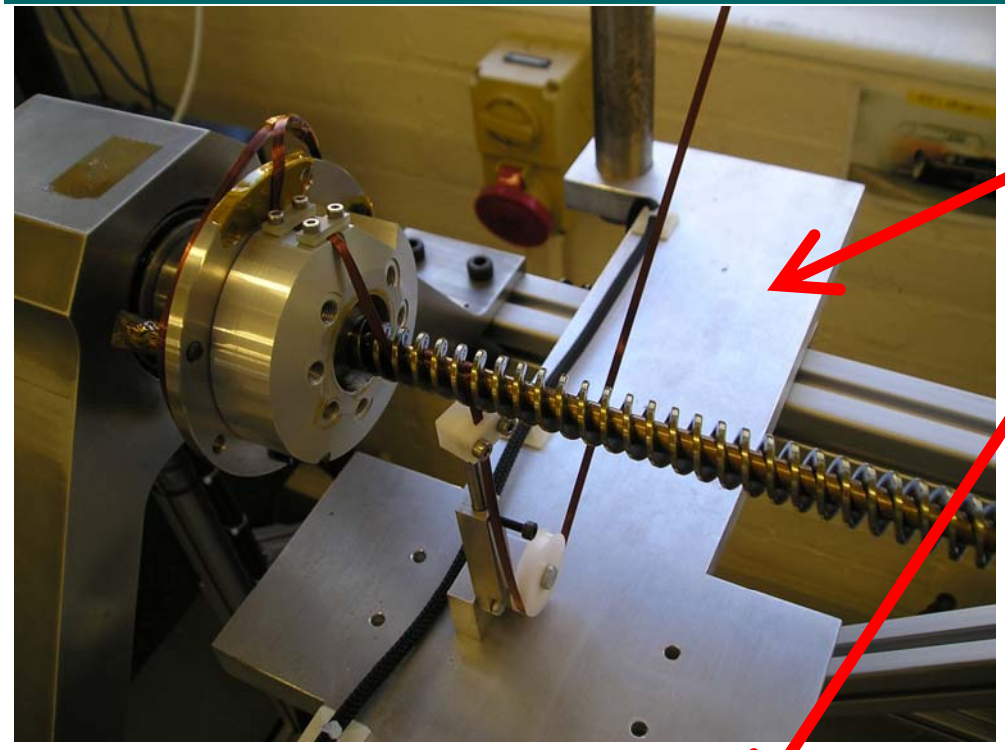
Geant4 with polarized processes

- **Applications:**
  - Polarization transfer (target, E166)
  - Polarimetry (Bhabha/Moller, Compton transmission – in particular E166)
  - ILC polarized positron source modelling

- Polarization is taken into account for
  - Pair-production
  - Bremsstrahlung
  - Compton scattering
  - Moller/Bhabha scattering
  - Positron annihilation into photons
  - Photoelectric effect
- Included since Geant4 release 8.2 (Dec 06)
  - Main focus: longitudinal (or circular) polarization
  - Energy range of interest: MeV … ~5 GeV
- Cross checks with EGS, WHIZARD/O'mega
- Authors: K.Laihem, A. Schaelicke, P. Starovoitov

1.75m Undulator Fabrication

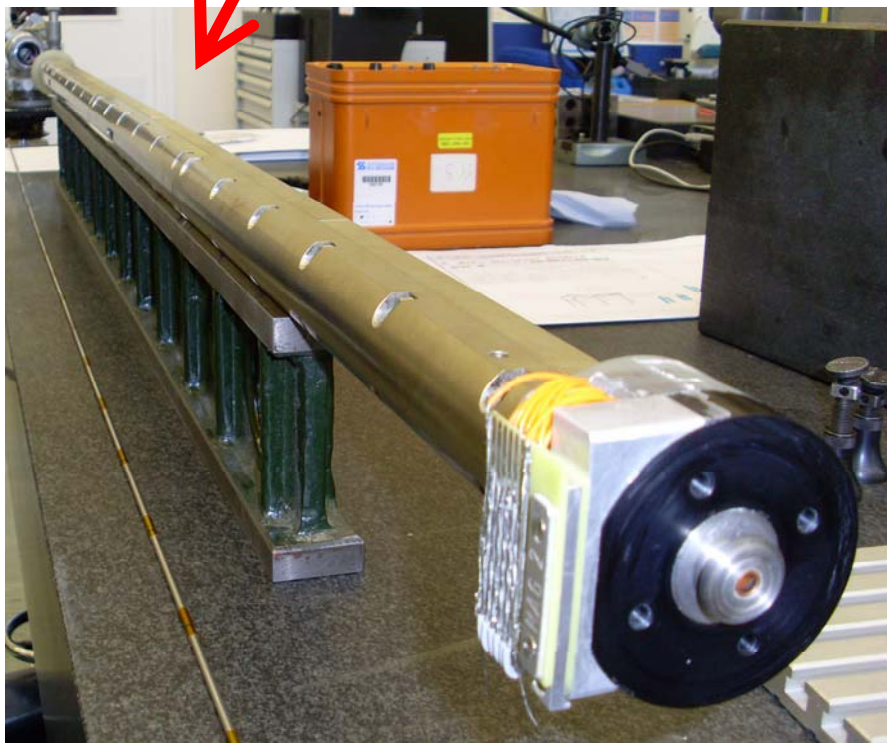
Accelerator Science and Technology Centre



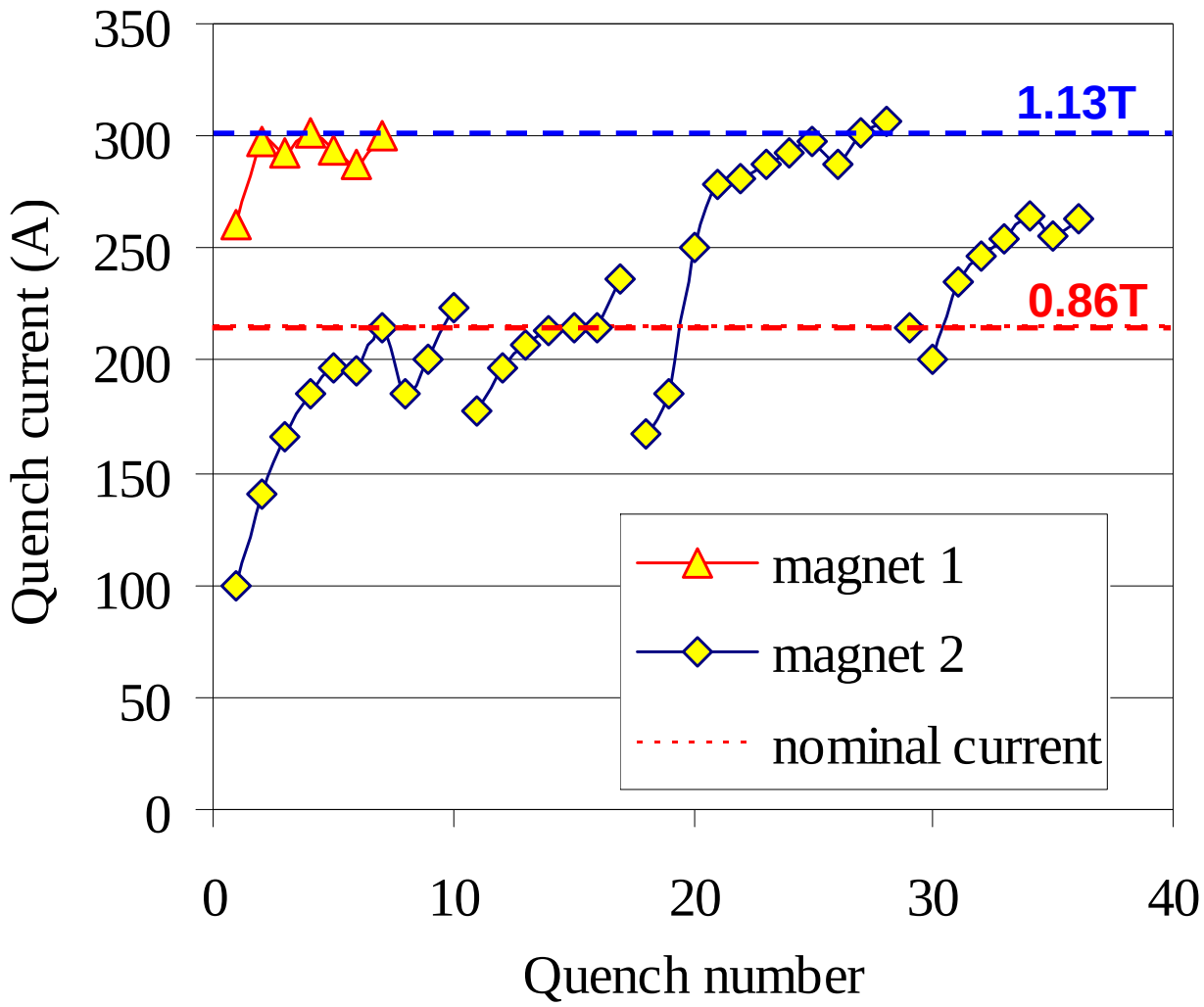
Winding

Potted and in one half of steel yoke

Complete magnet



Quench Training Data

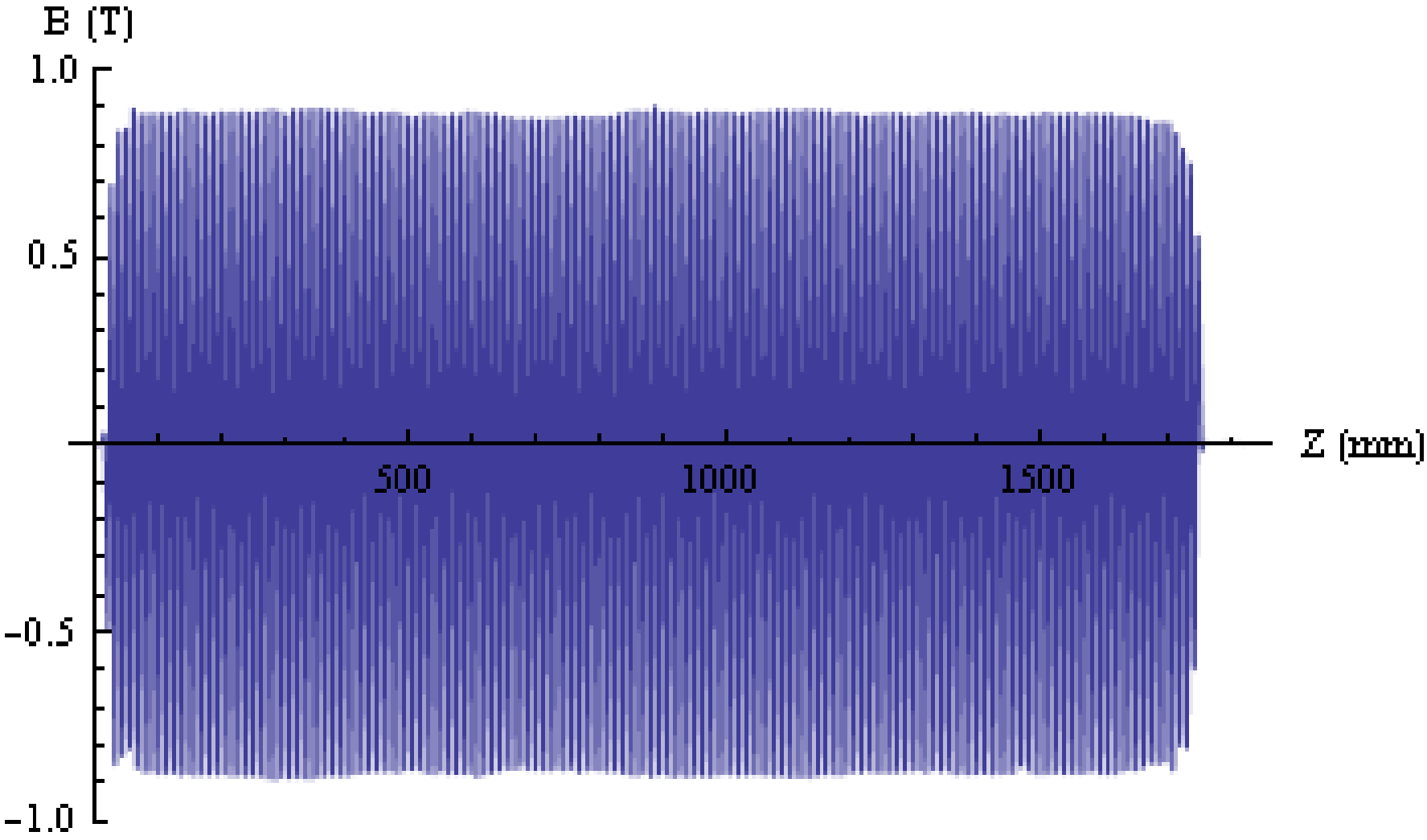


Both long undulators have **exceeded the design current** (216 A) by **~40%.**

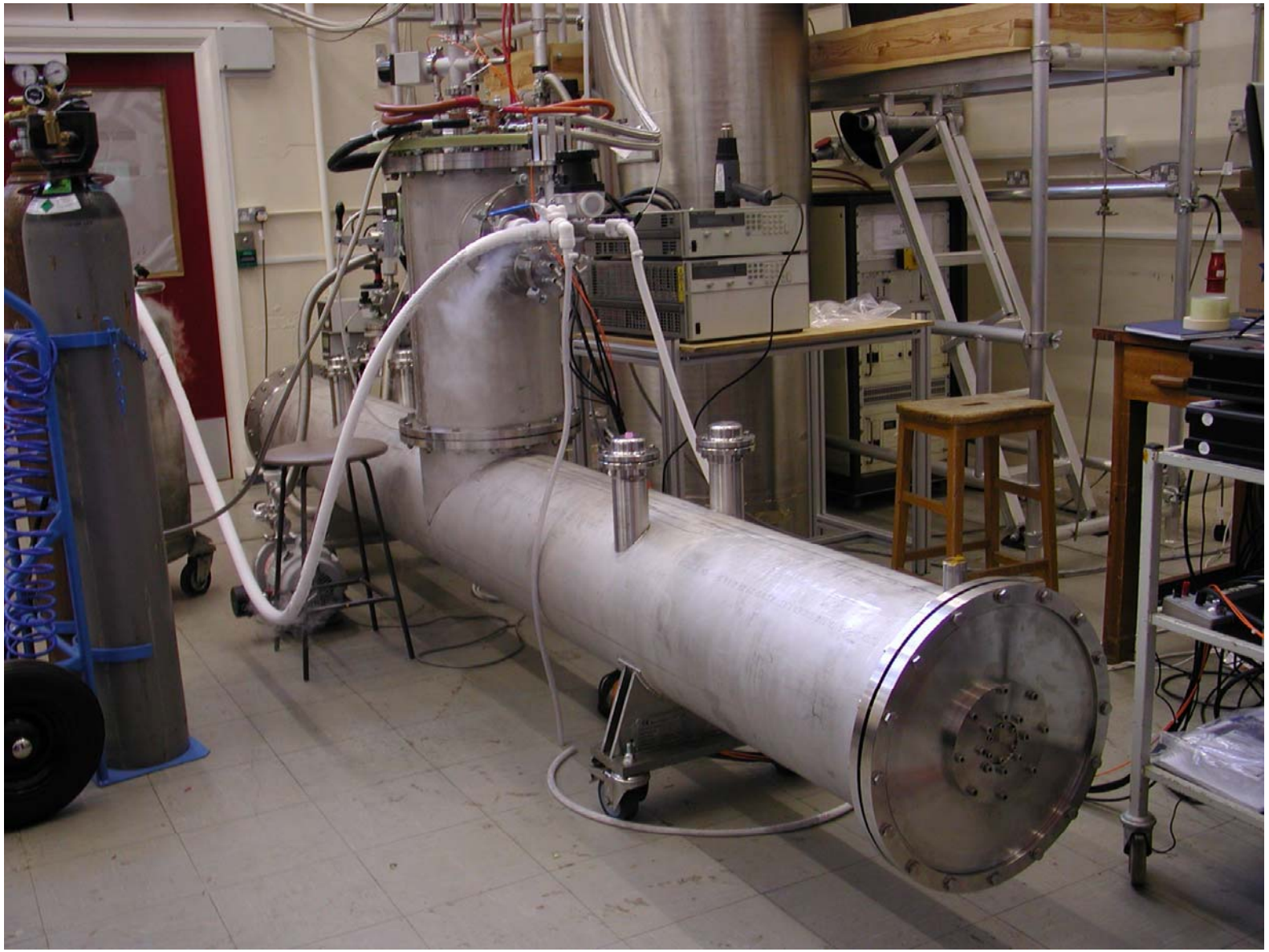
J.A. Clarke et al, EPAC 08

Measurements

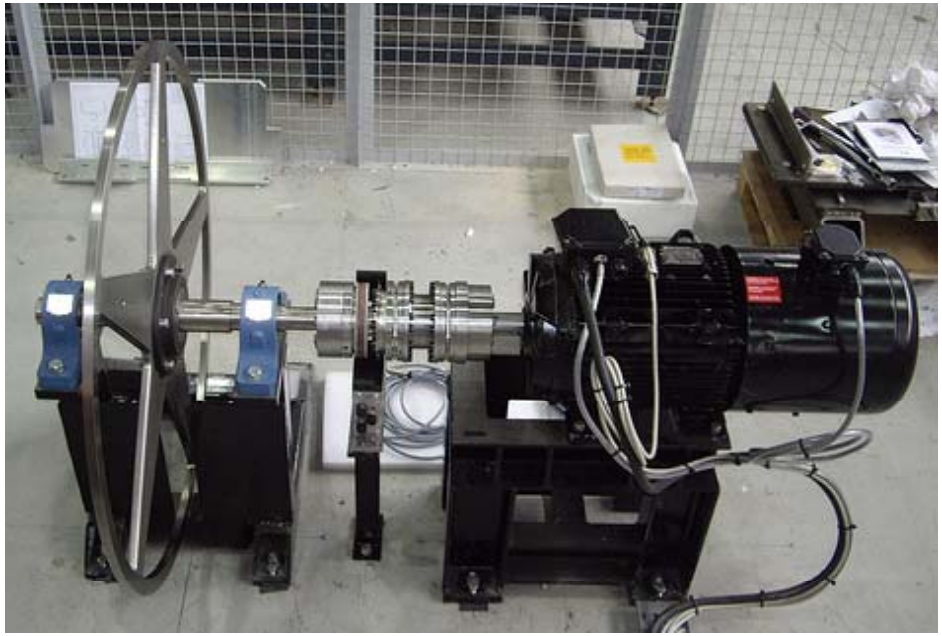
- Measured at the RDR field level

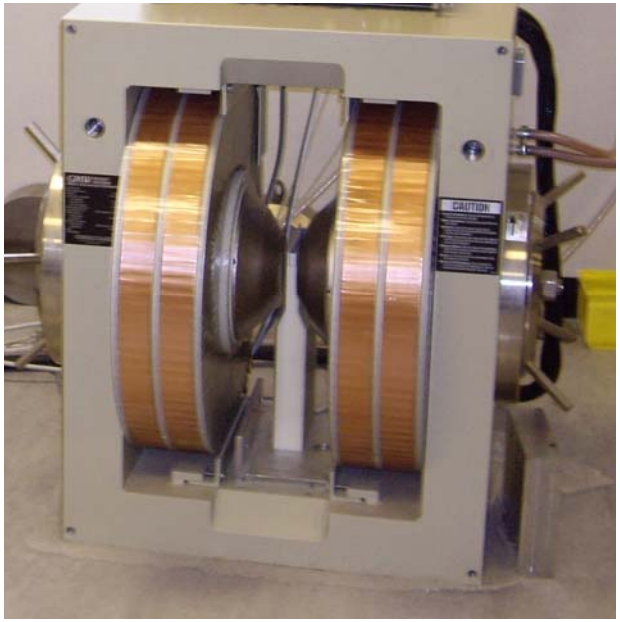


Cryomodule cold tests



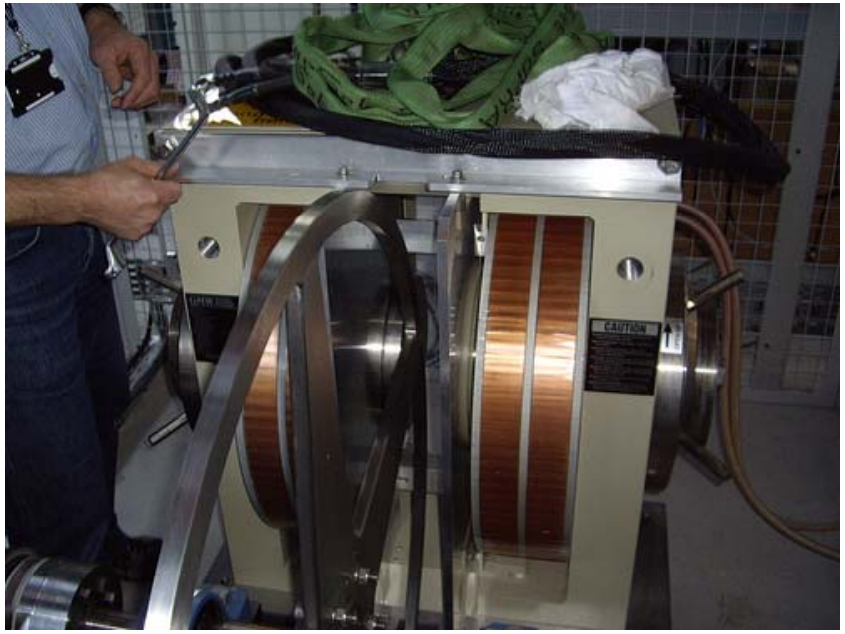
Target Prototype

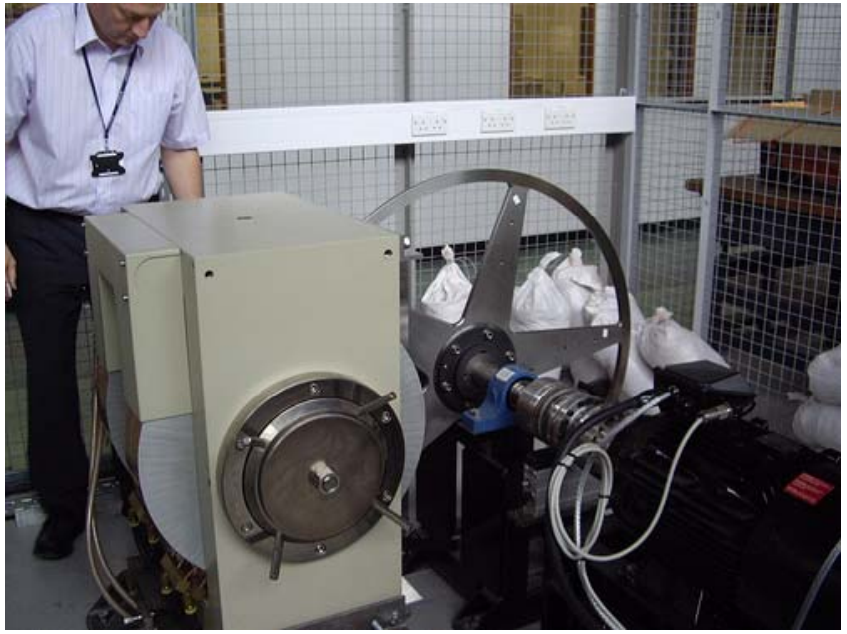




Cockcroft Institute Prototype

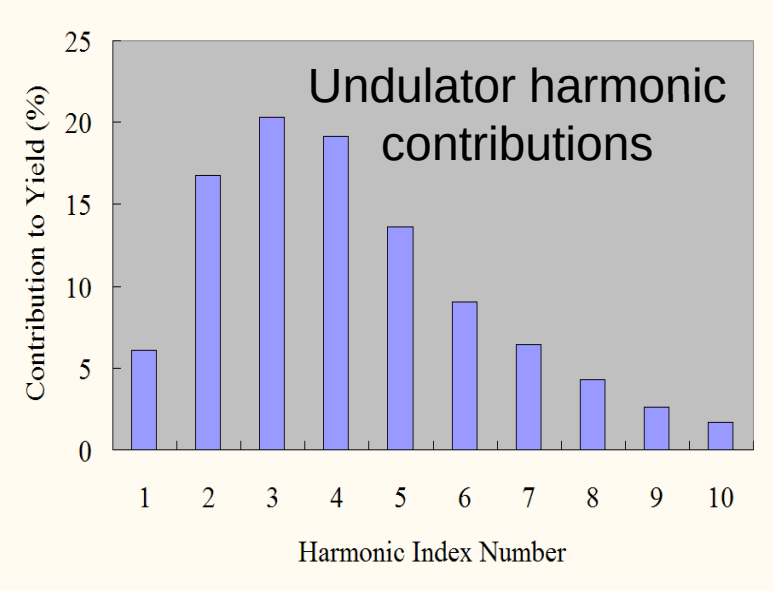
Accelerator Science and Technology Centre

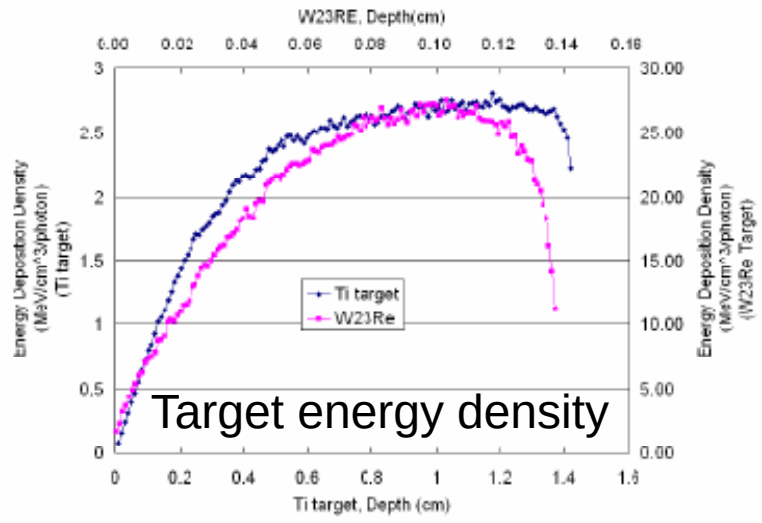




Source Modelling

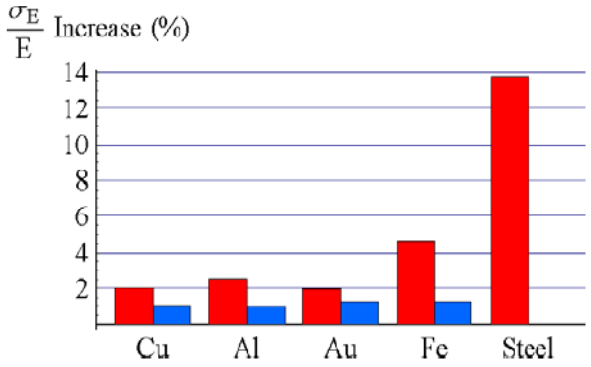
- Extensive modelling of the source has been carried out by several groups
- Used for global optimisation of undulator, target, and capture section parameters
- Yield simulations include undulator, collimation, target, capture magnet, and linacs
- Modelling of *polarisation* of positrons also included



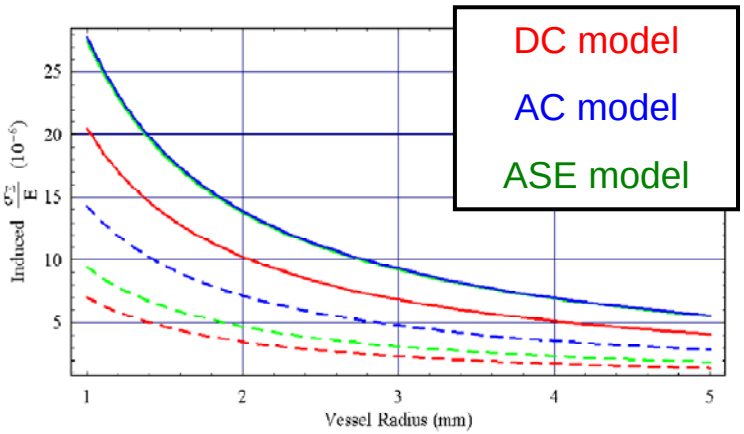


Wakefield Studies

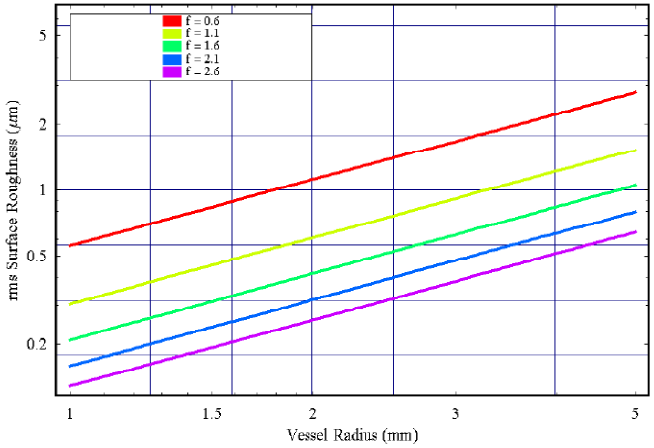
Energy spread increase of electron beam for 200m long undulator at room and cryogenic temperatures for alternative vessel materials due to **resistive wall impedance**



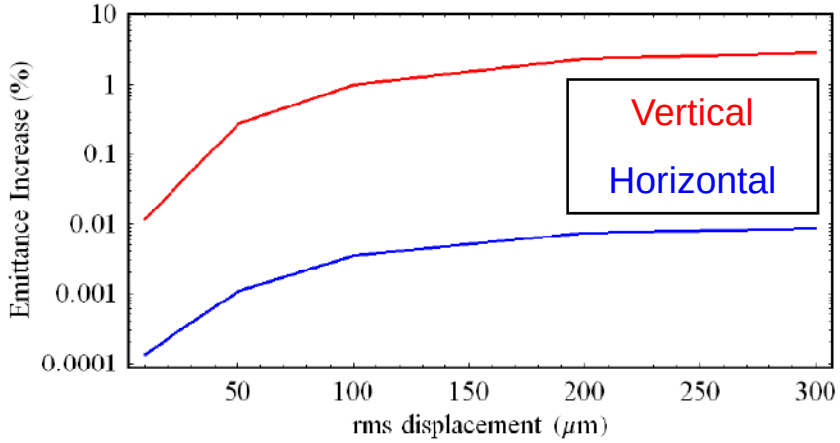
Energy spread increase of electron beam at room (solid) and cryogenic (dashed) temperatures for copper vessel due to **resistive wall impedance**



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.



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Conclusion

- All milestones and deliverables have been met
- A huge amount of progress has been made in the last 4 years
- It has been a very successful and genuine collaboration
- It was a lot of fun as well !

- Key Publications
  - Alexander et al, PRL **100,** 210801 (2008)
  - Scott et al, PR-STAB **10**, 032401 (2007)
  - Duncan Scott thesis
  - Alexander et al, EUROTeV-Report-2008-091
  - Bailey et al, EUROTeV-Report-2008-028
  - Bailey et al, EUROTeV-Report-2008-026
  - Zang et al, EUROTeV-report-2008-029
  - Schmid, EUROTeV-Report-2005-024