Overview of Undulator-Based Sources for LC

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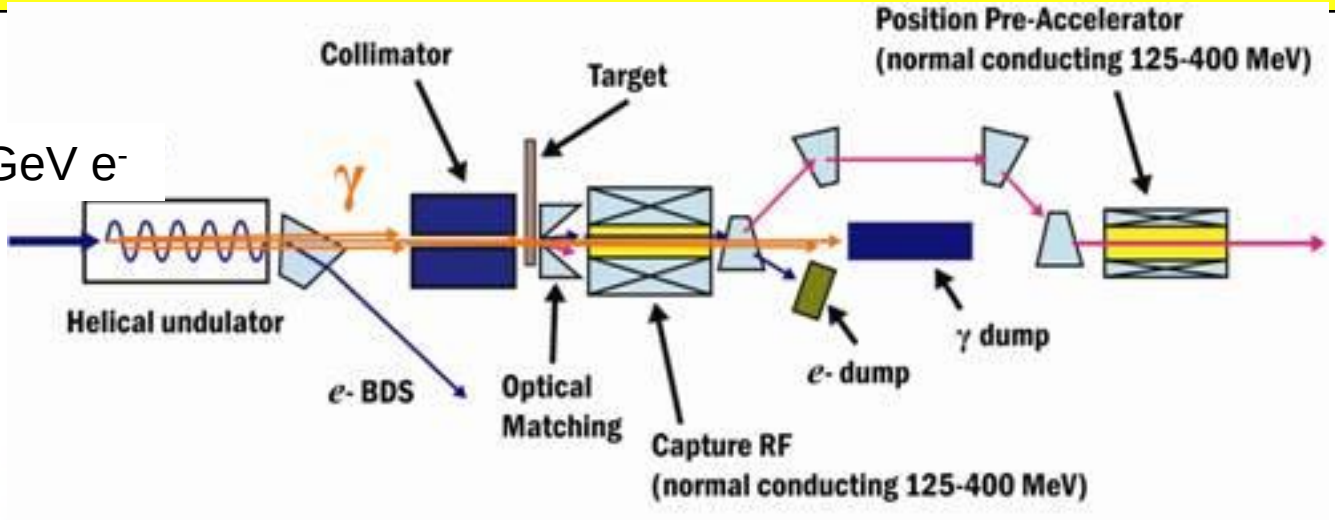
IWLC October 21st, 2010

Outline of Talk

- Undulator positron sources
  - ILC (see Wednesday's talk by J. Clarke)
  - CLIC (see Wednesday's talk by L. Rinolfi)
- Status of rotating target prototype
- Zeuthen LC positron source wiki

Nominal Undulator-based Positron Source Layout

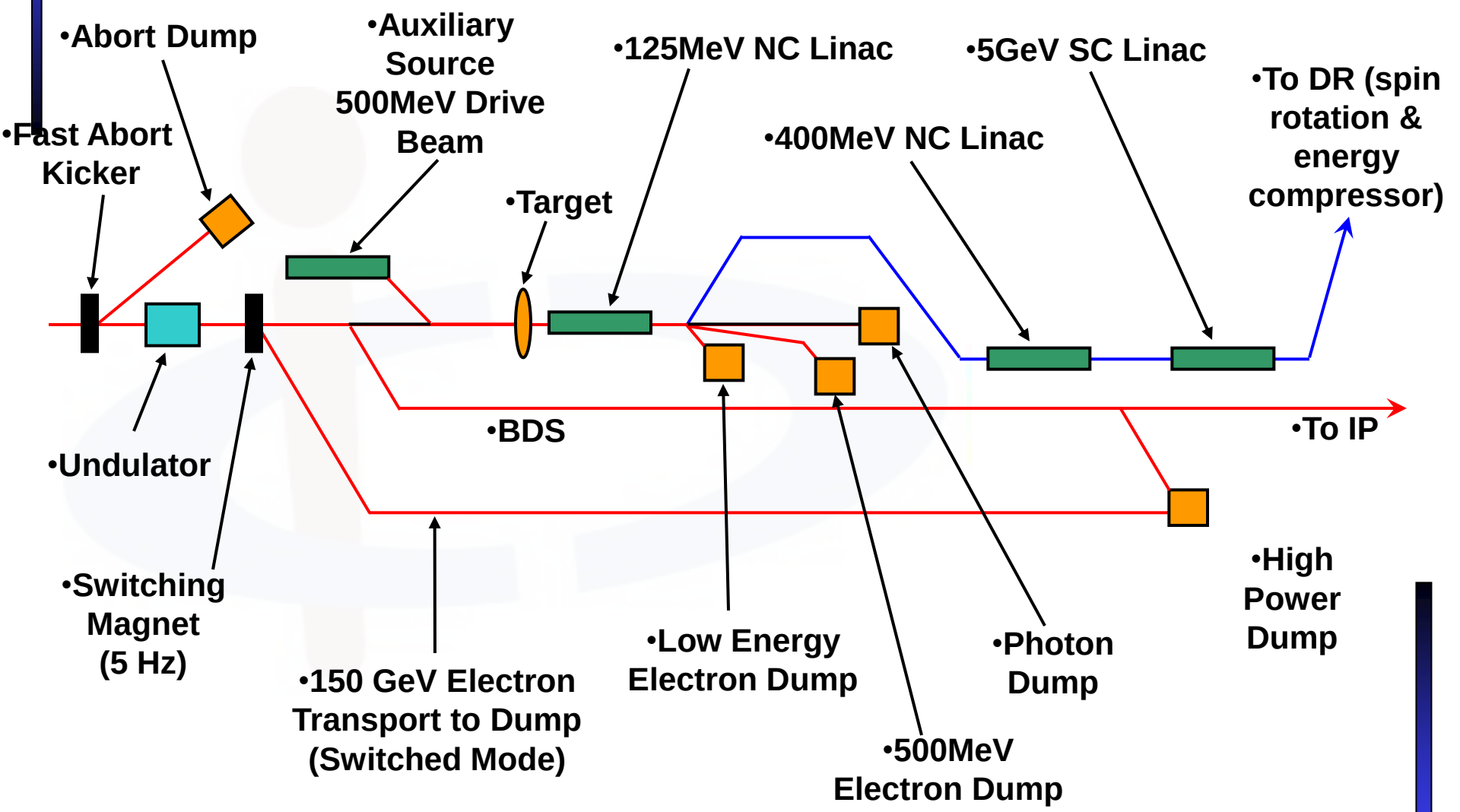


- **Centre of undulator to target: ~500m**
- **Active (K=0.92, period=1.15cm) NbTi undulator length: ~150m → 250m**
  - **Energy losses in undulator ~few GeV**
    - **0.02 GeV/m ILC at 150GeV**
    - **0.05GeV/m CLIC at 250GeV**
  - **Target Power Load ~20kW + eddy current heating ~20kW (assuming 0.4X0 Ti alloy target)**
  - **Beam spot: ~ 1 →2 mm rms**

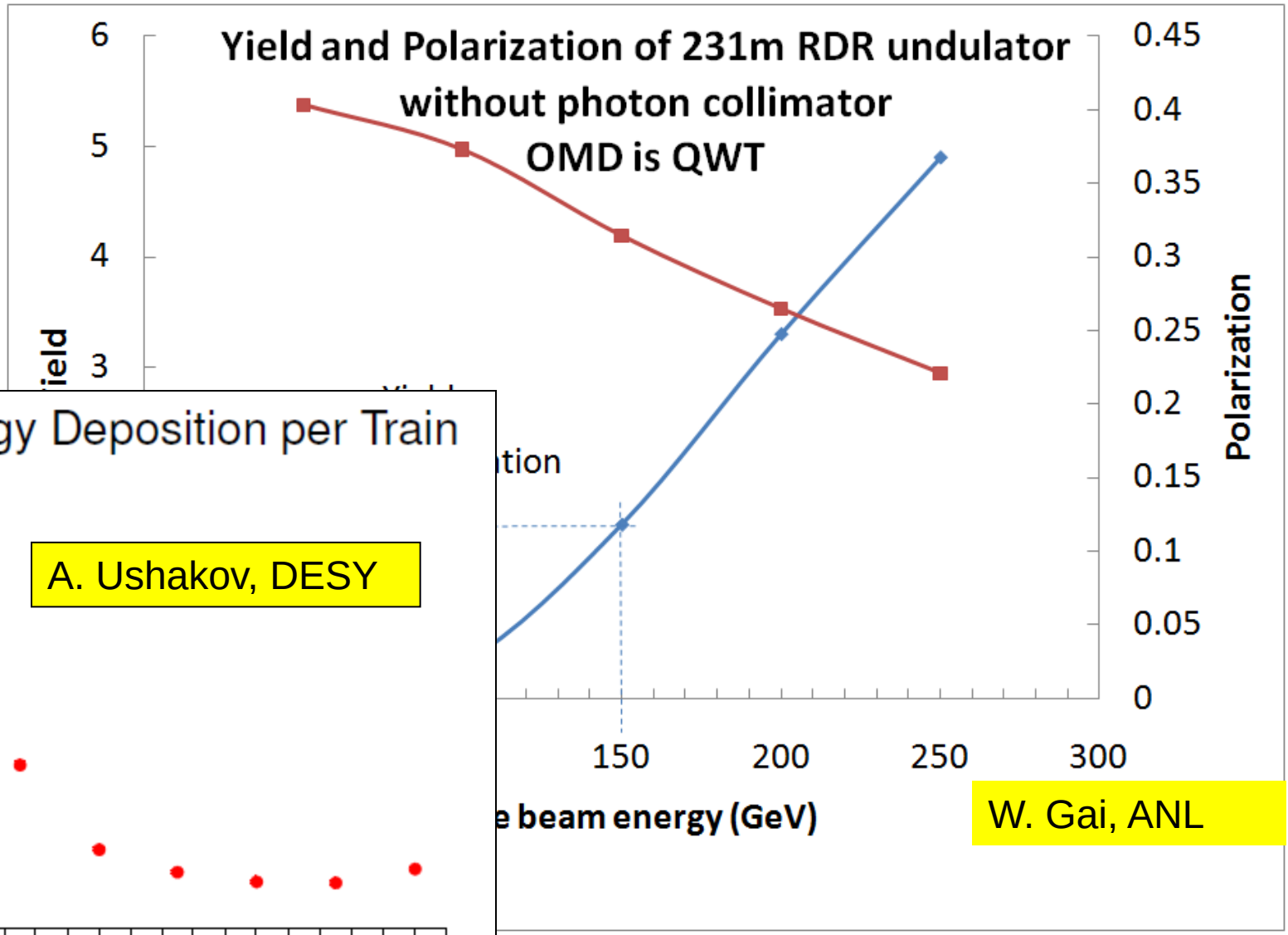
ILC Undulator-Based Source

- Layout
- Undulator
  - Prototype module operated at design current
- Collimator
- Target
- Capture Optics
  - SB2009 undulator length assumes QWT
  - 1ms pulsed FC design under development
  - See Tom Piggott's talk (Thu afternoon)

ILC Schematic Layout for 10Hz Operation



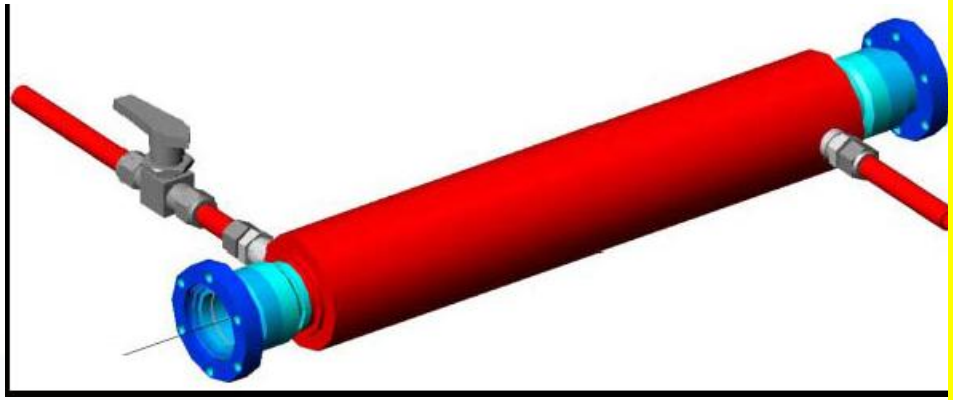
ILC RDR Undulator Positron Yield

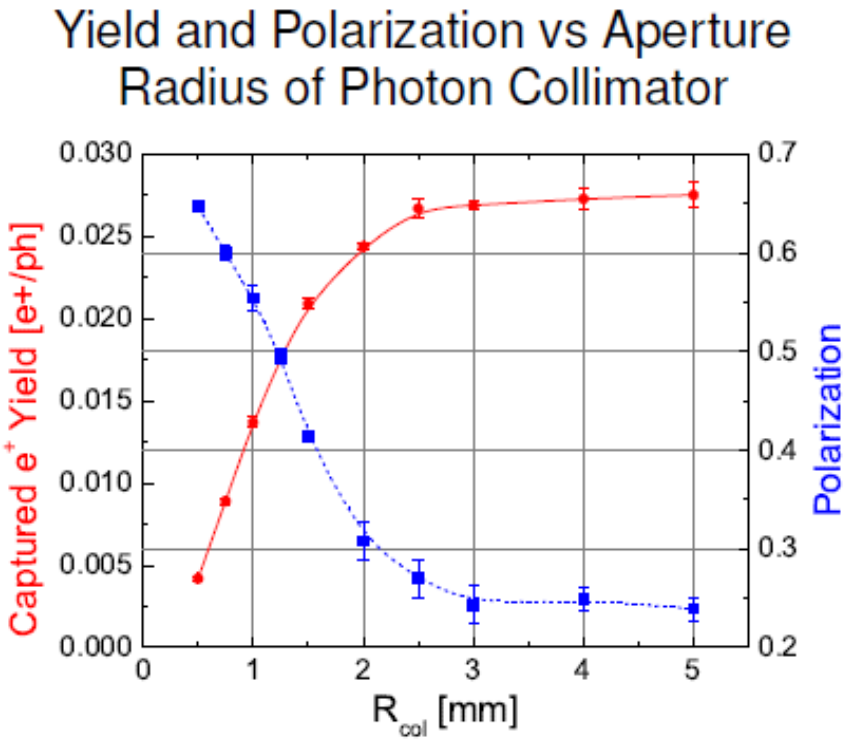


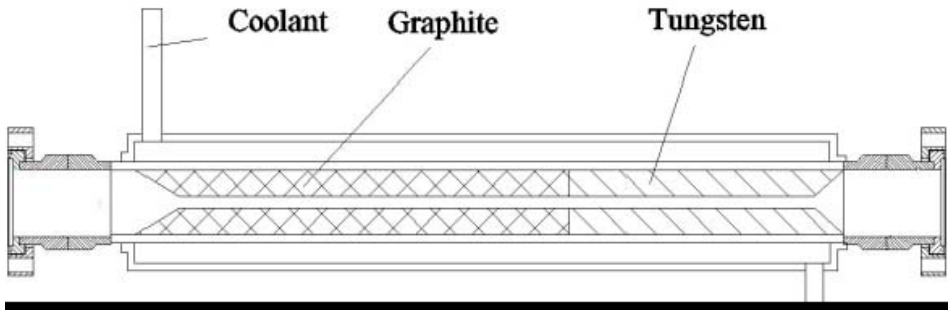
W. Gai, ANL

Photon Collimator

Recommendation from ILC positron source meeting in Durham (2009) was to include a tungsten/graphite collimator of radius 2mm.







Same specification works for SB2009 (2.5kW in collimator)

A. Ushakov, DESY

https://znwiki3.ifh.de/LCpositrons/CollimatorDesign

ILC Target R&D

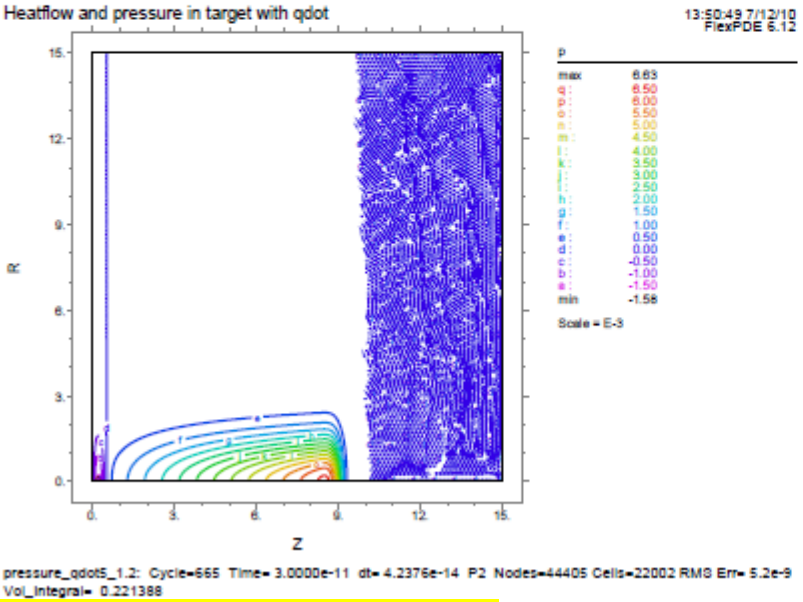
- Eddy currents
  - Daresbury prototype
- Shockwave simulations
  - FlexPDE (S. Hesselbach, Durham → DESY)
  - ANSYS (L. Fernandez-Hernando, Daresbury)
- Shockwave experiments
  - FLASH(?)
  - https://znwiki3.ifh.de/LCpositrons/TargetShockWaveStudy
- Optimising rim design for auxiliary source and 10Hz
  - Machiolate rim?
- Material fatigue

Shockwave Simulation Status

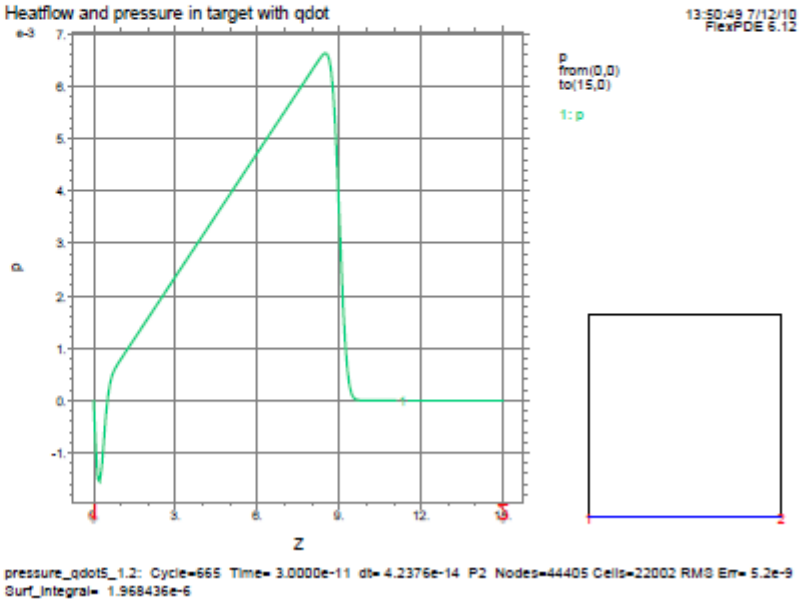
- Large negative pressures on exit face only seen if bunch is made more compact than for ILC RDR
- Even this effects disappears when the time step is smaller than 10^{-14} s

Ti target, RDR bunch size, $t = 3 \times 10^{-11}$ s

Contours of P in MPa



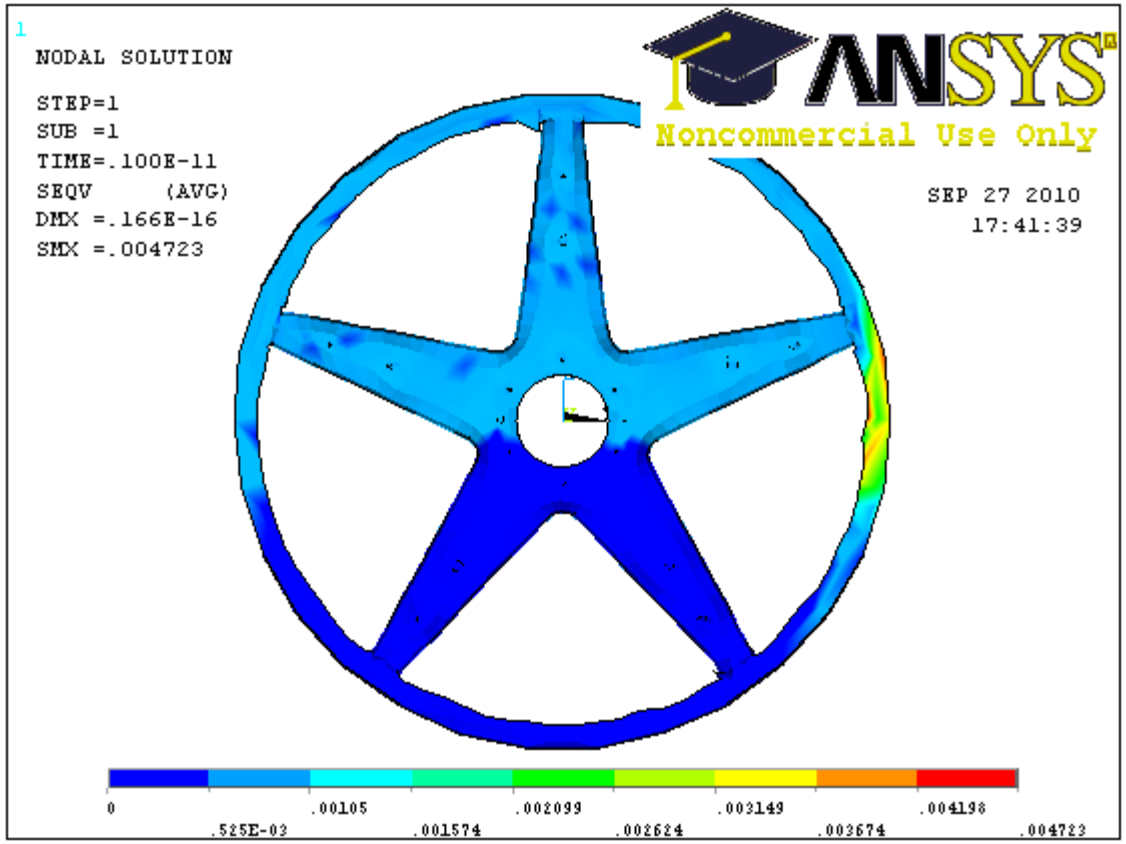
P on beam axis



S. Hesselbach, Durham

Shockwave Simulation Status (2)

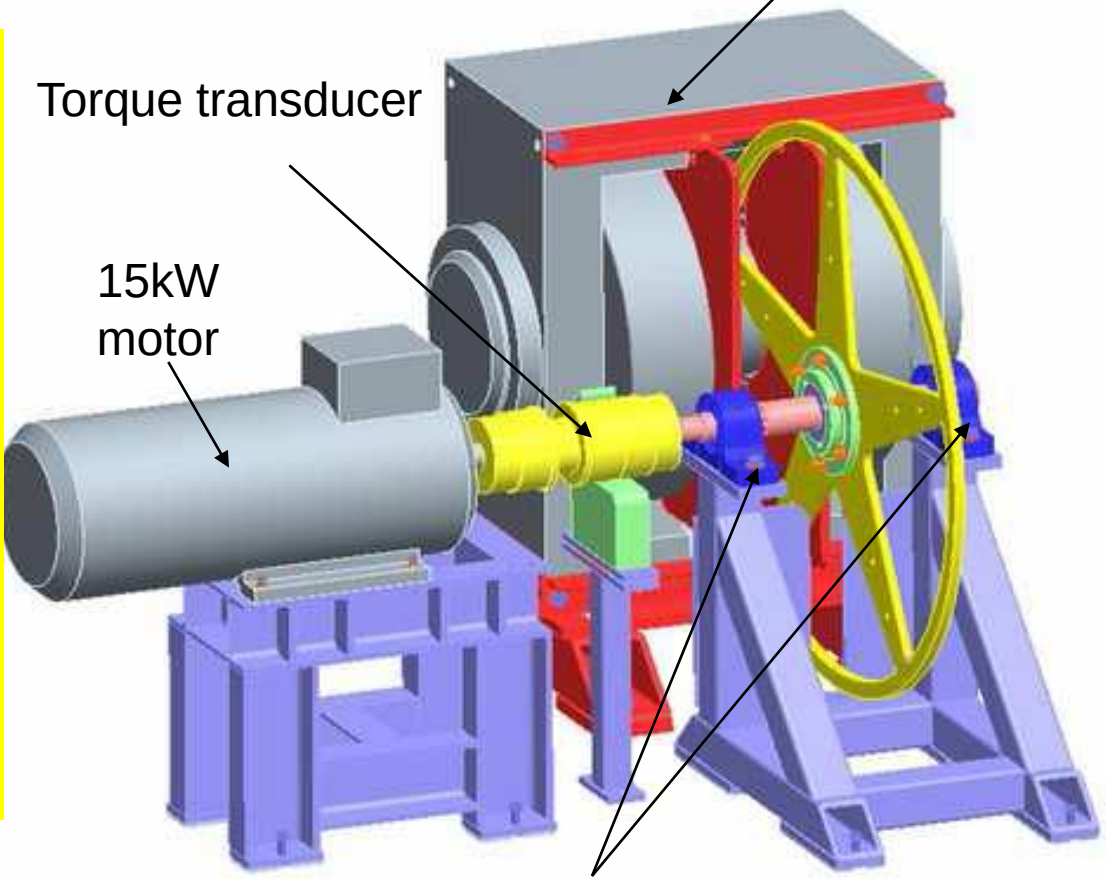
•ANSYS simulations unable to simulate multiple bunches with time steps of 1ps or less

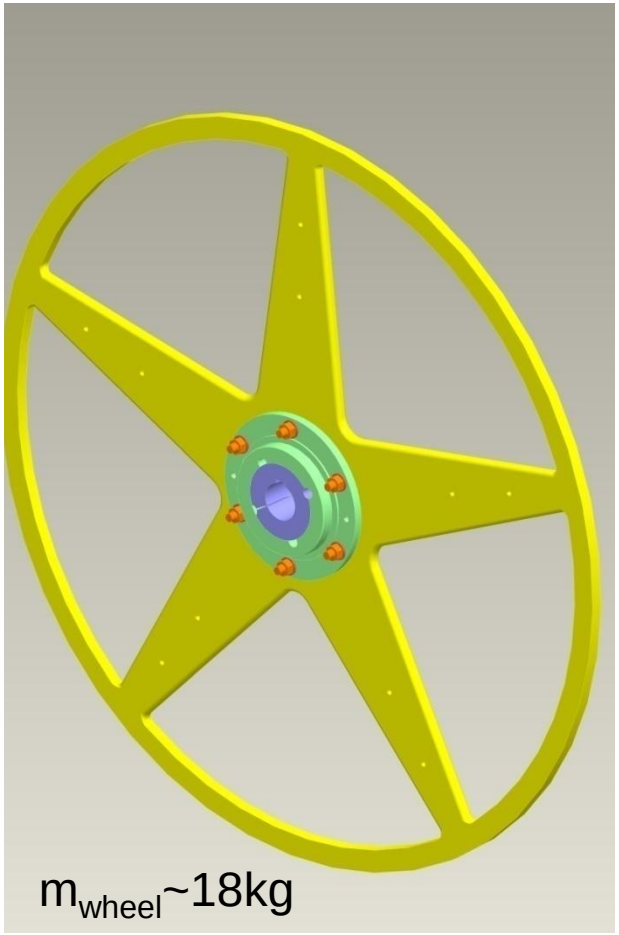


L. Fernandez-Hernando, Daresbury

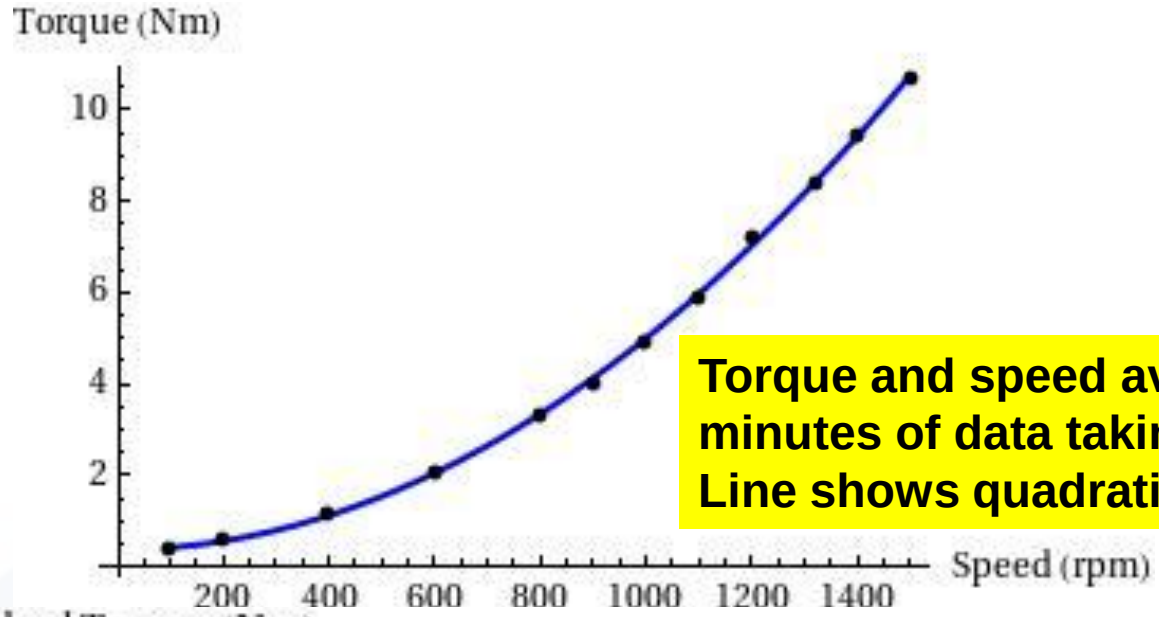
Target Prototype Design

Prototype I - eddy current and mechanical stability

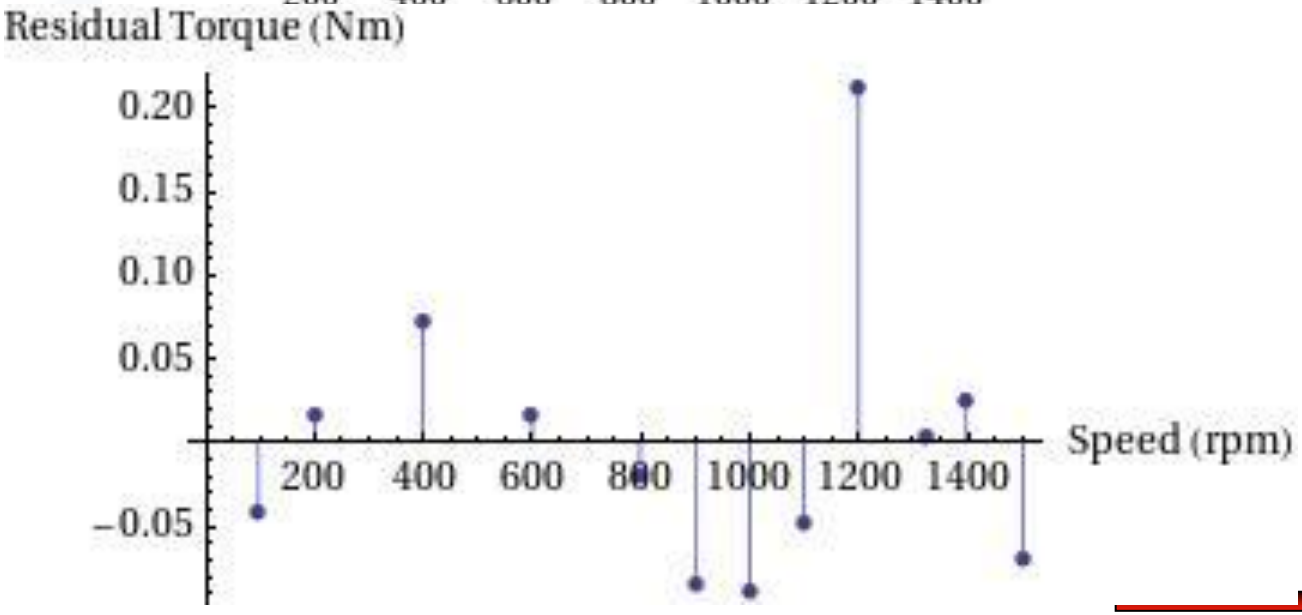




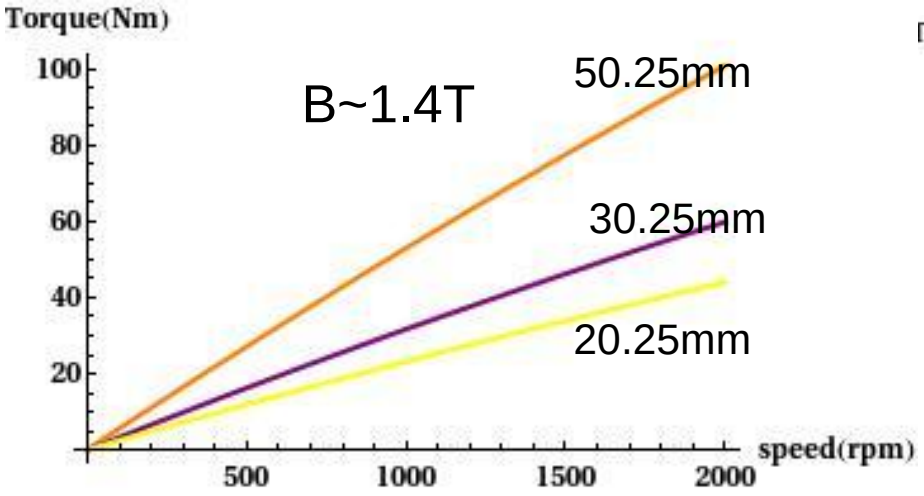
Characterising Frictional Forces

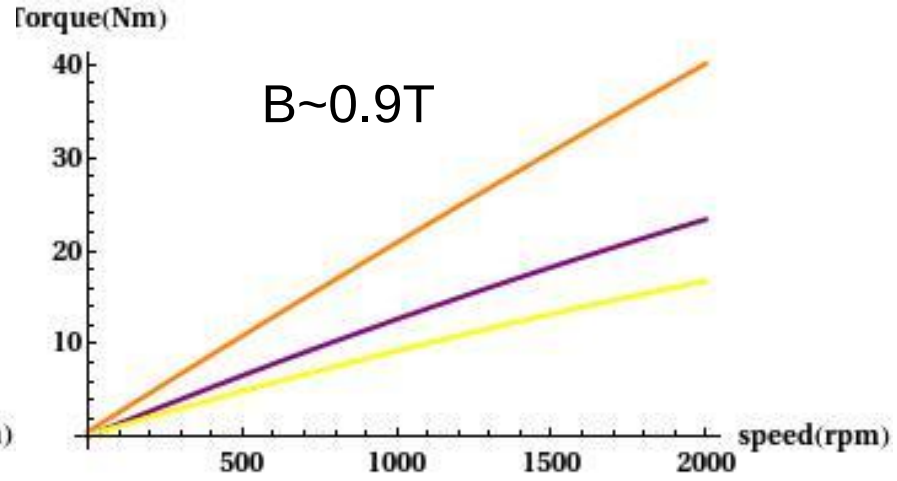


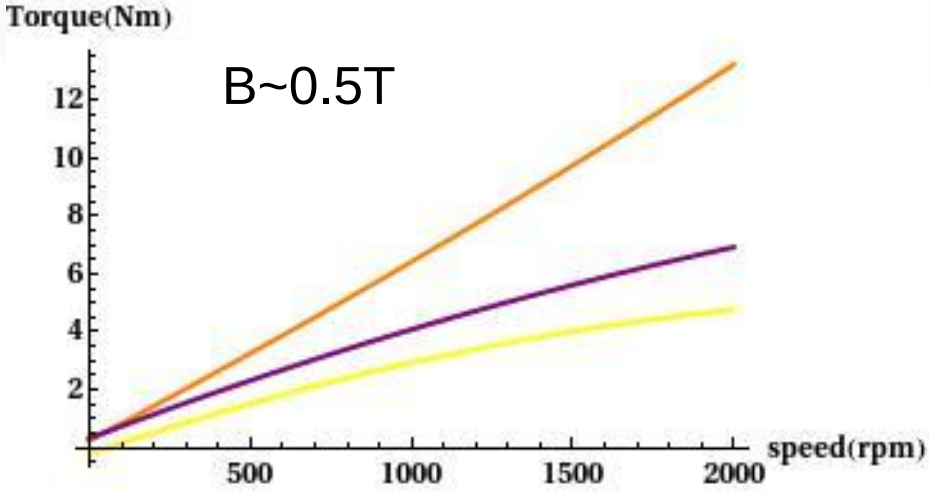
Torque and speed averaged over three minutes of data taking for each data point. Line shows quadratic fit.



Effect of B Field on Average Torque

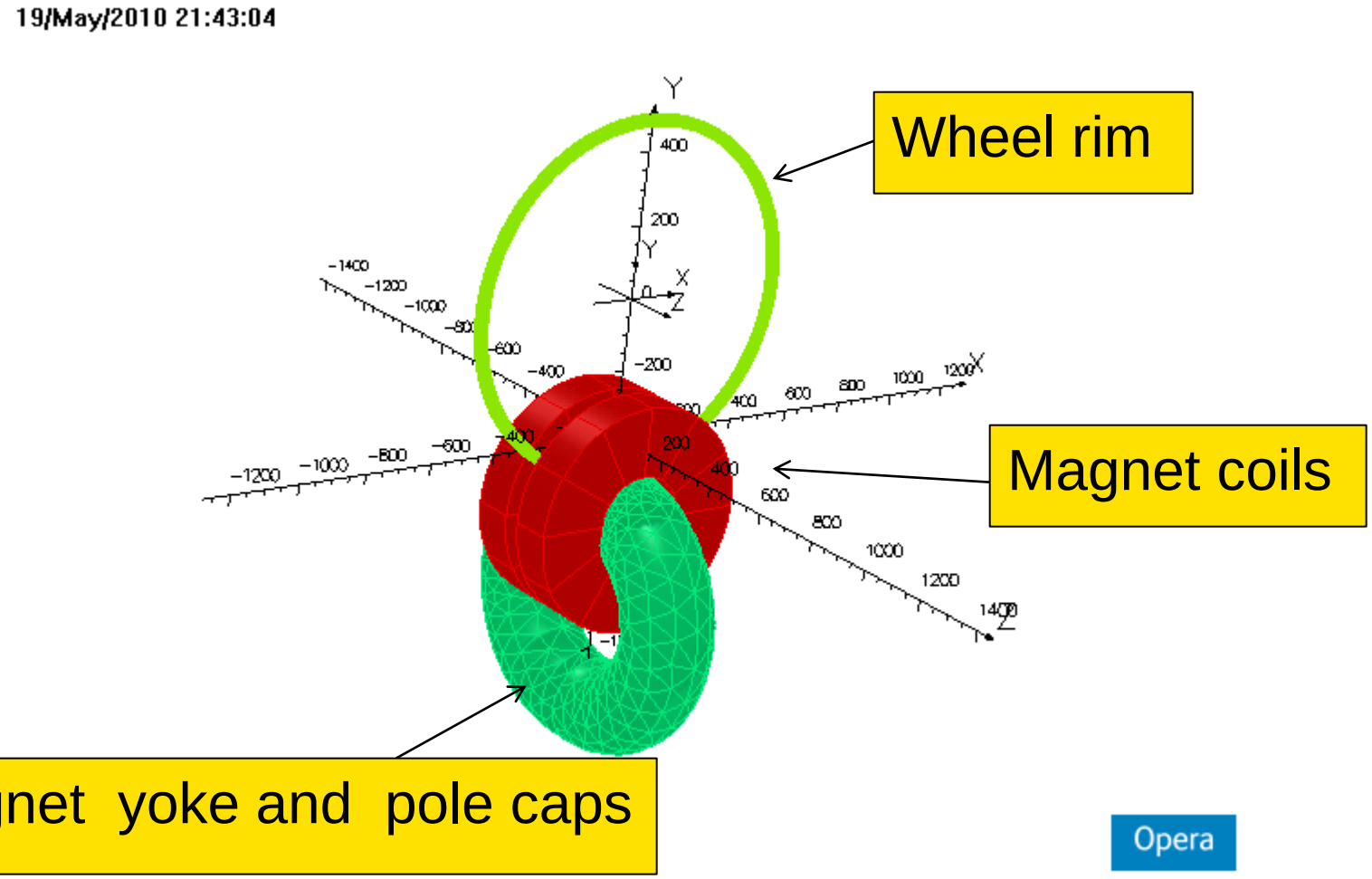




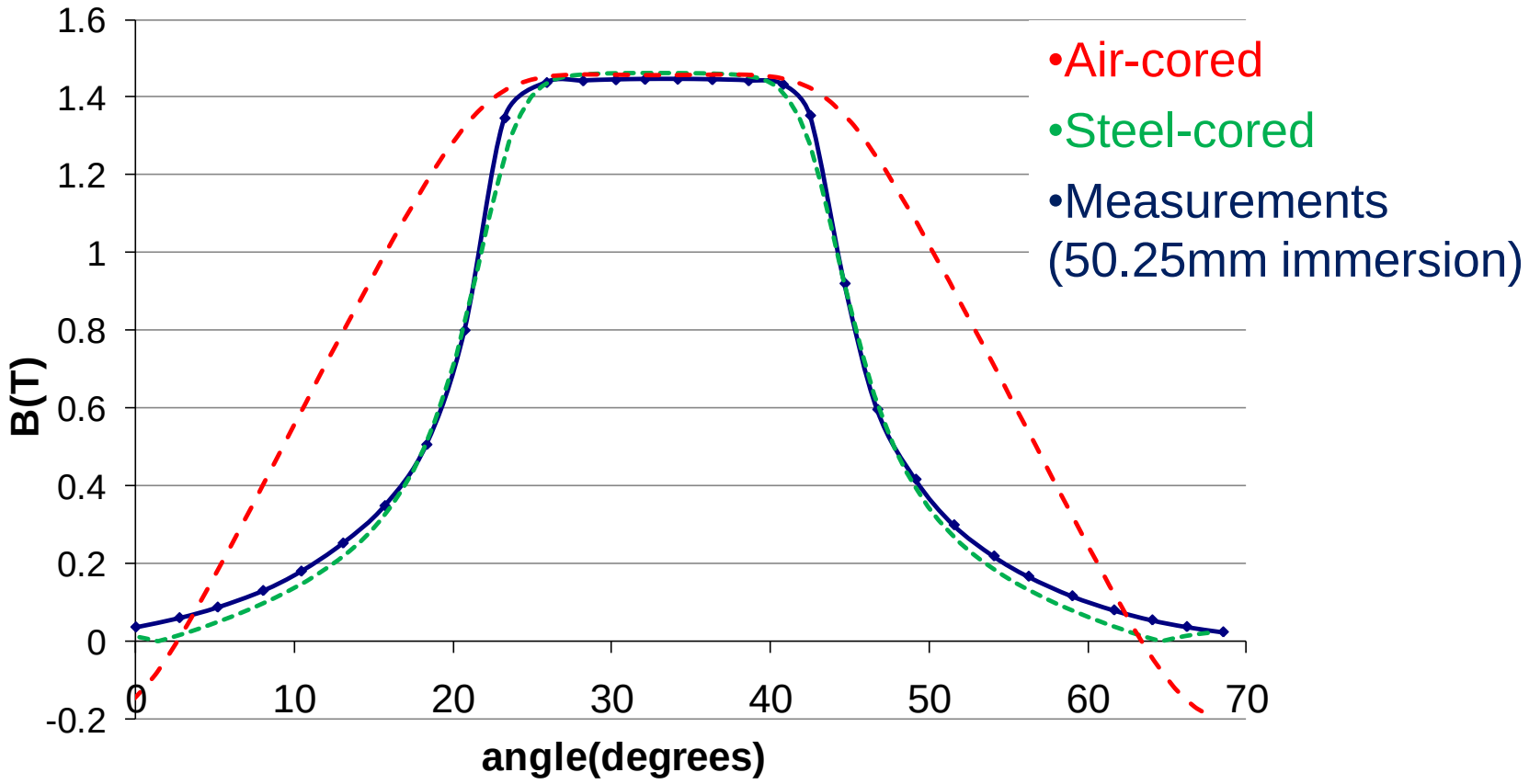


- The plots show a quadratic fit to the measured torques (≤ 1500rpm) where the effects due to bearing friction have been removed.
- The colours represent different immersion depths of the wheel in the field.

ELEKTRA Model

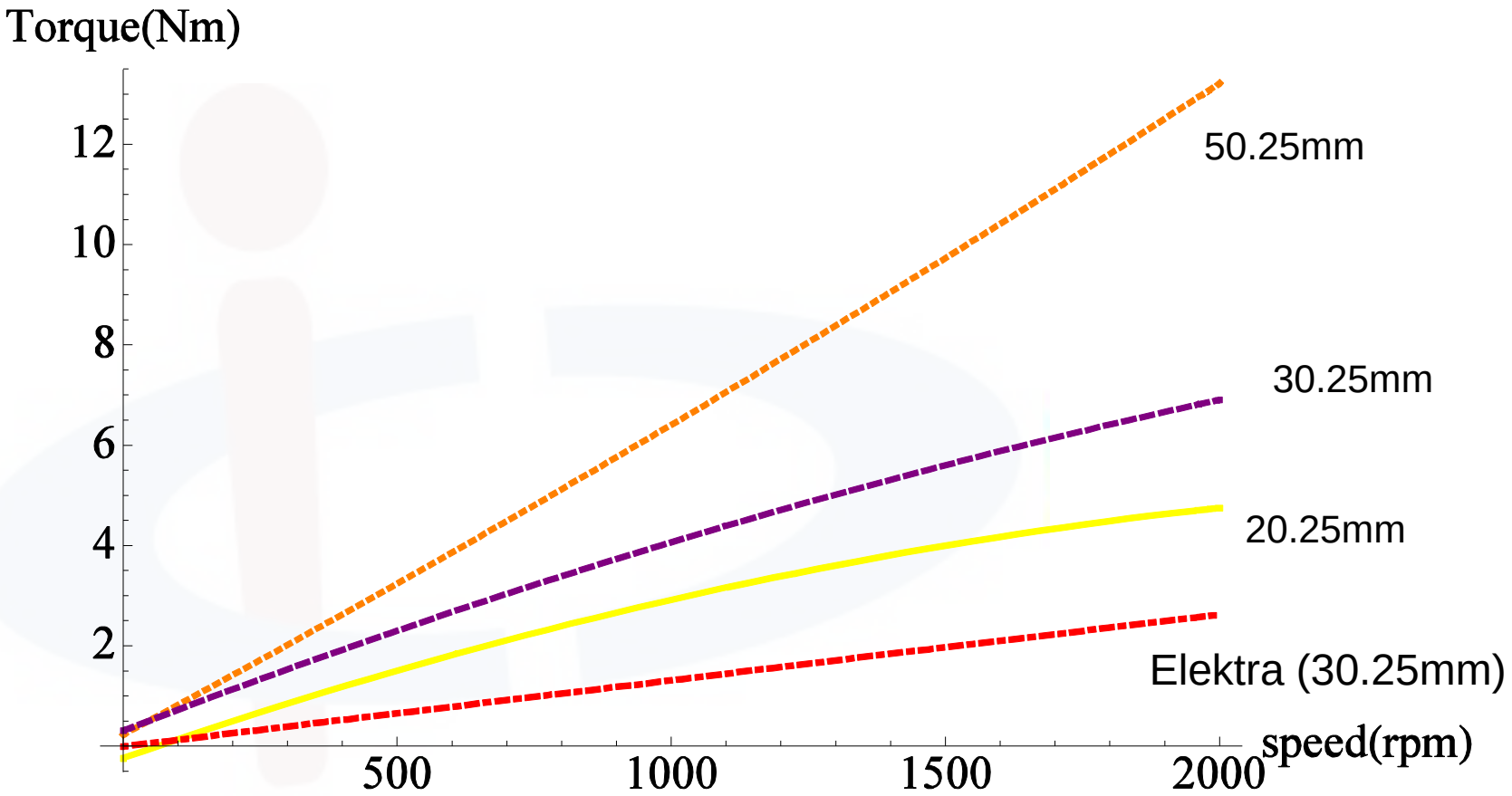


Comparison of air and steel cored ELEKTRA models



•20% increase in predicted torque.

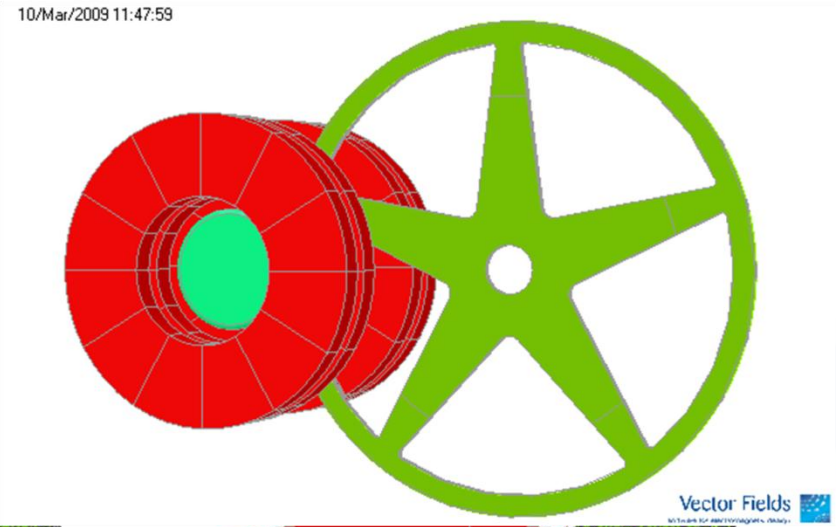
ELEKTRA Model Prediction

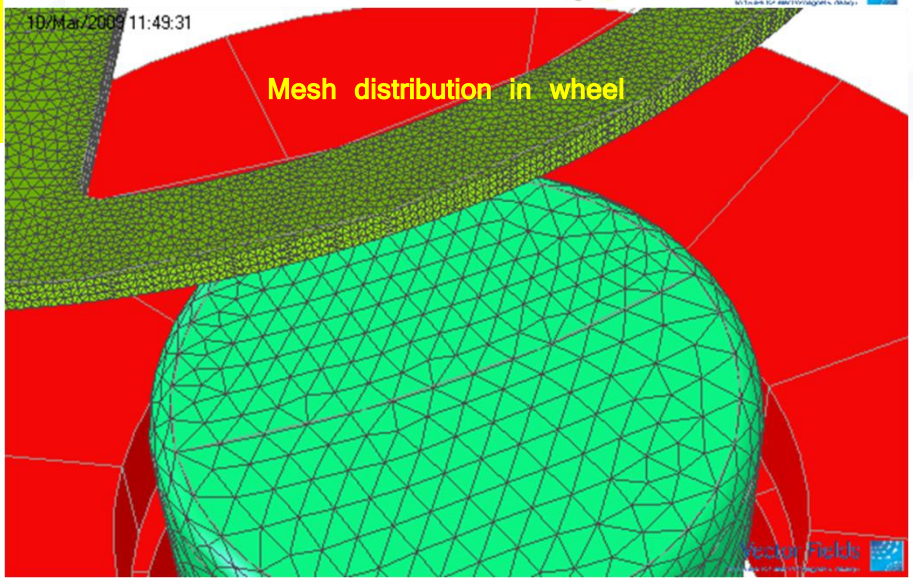


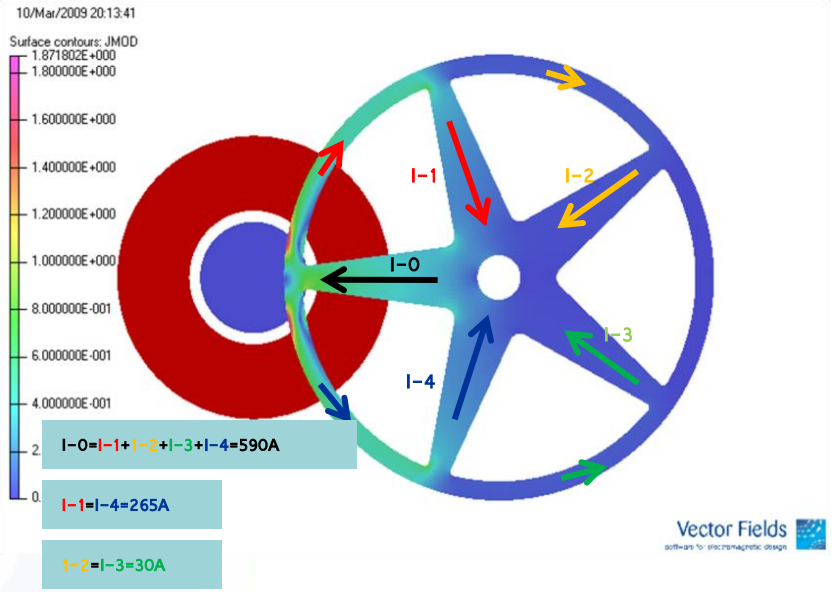
B~0.5T

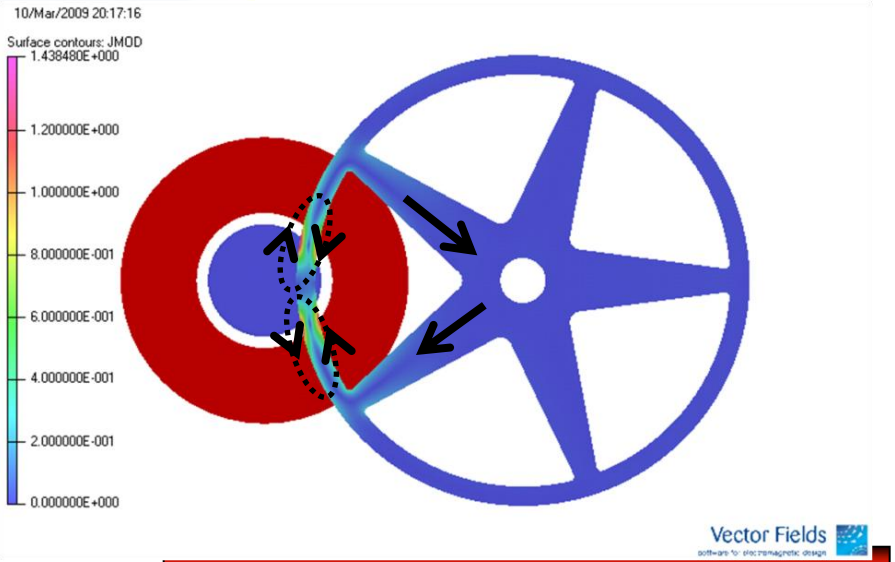
Carmen (spoke) Model Simulations

J. Rochford, RAL

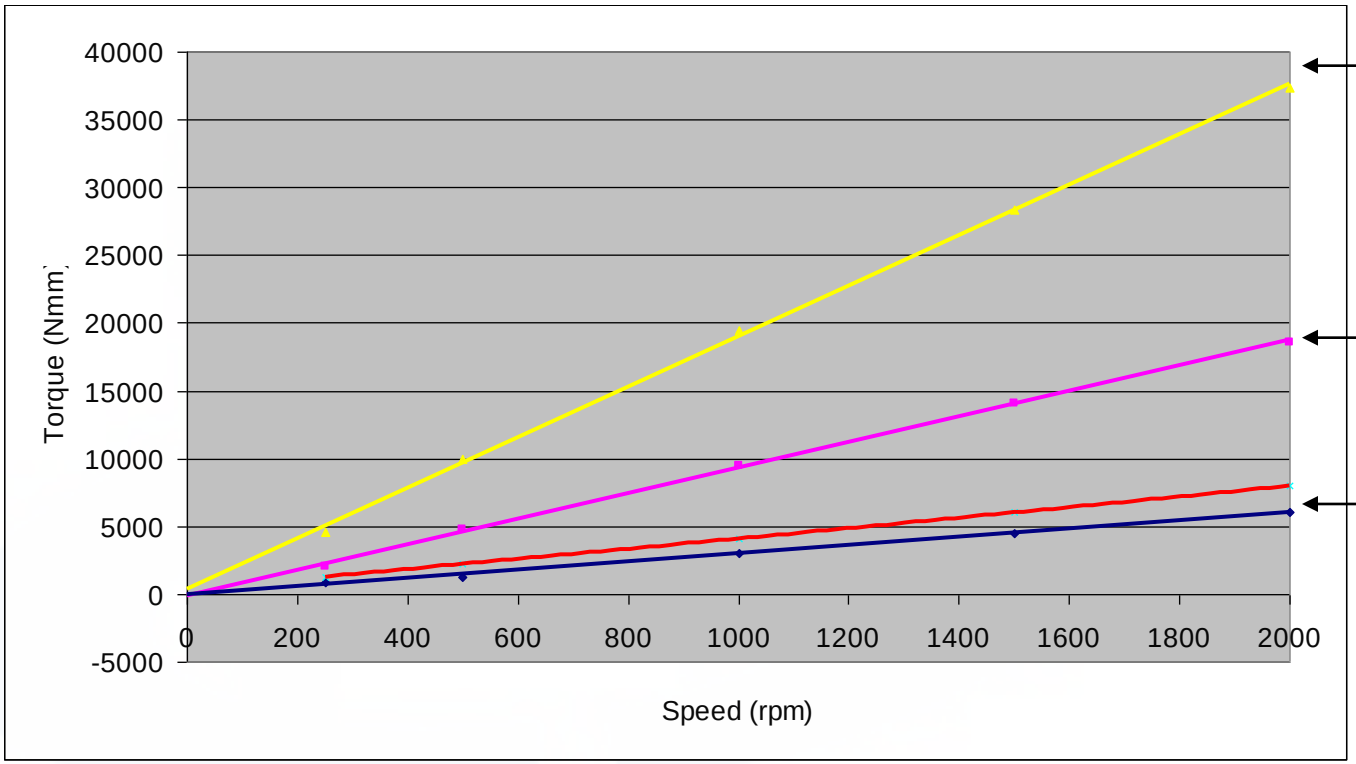








CARMEN Model Prediction



Peak (yellow), average (magenta) and minimum (blue) torques as predicted by the CARMEN model for rim immersed in a field of peak strength ~0.5T. Immersion ~30.25mm (?)

The red line shows the current best fit from the data. Spoke effects appear to be far smaller than indicated by the CARMEN model.

Target Prototype Summary

- Data-taking is ‘complete’
- The rim target can operate in fields ~1.5T (~20kW heating)
  - Fatigue issues?
- ... However, discrepancy between measured and predicted torque is still not fully understood.
- We are checking
  - Torque calibration v power consumption
  - Conductivity of wheel samples
  - Model assumptions (access to CARMEN model)
- Aiming for a paper by the end of 2010...

CLIC Undulator-Based Source

- Reduced beam current $\Rightarrow$ reduced load on target
- Pulse energy deposition in target < 35J/g
- However, short pulse removes advantage of rapid rotation
- Low rotation rate (~50rpm)
  - eddy currents negligible
  - 20kW for ILC at 1.5T $\rightarrow$ 50W for CLIC
- Can use s/c AMD

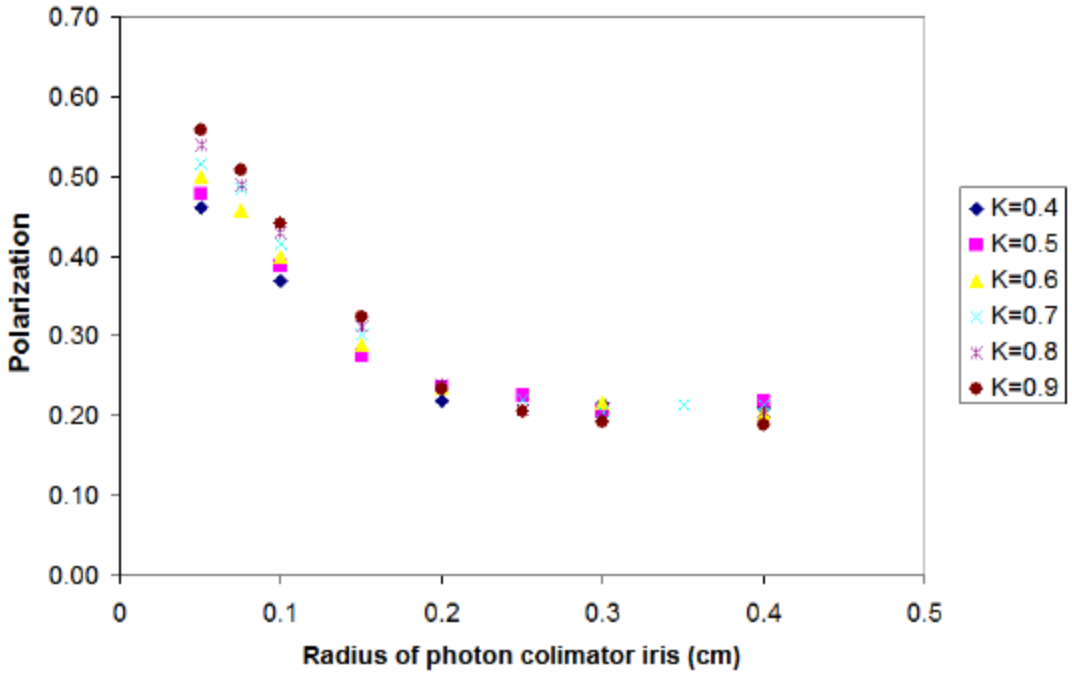
CLIC Undulator-Based Source

- "UNDULATOR BASED POSITRON SOURCE OPTIMISATION FOR CLIC", L. Zang, A. Wolksi, I. Bailey, IPAC10

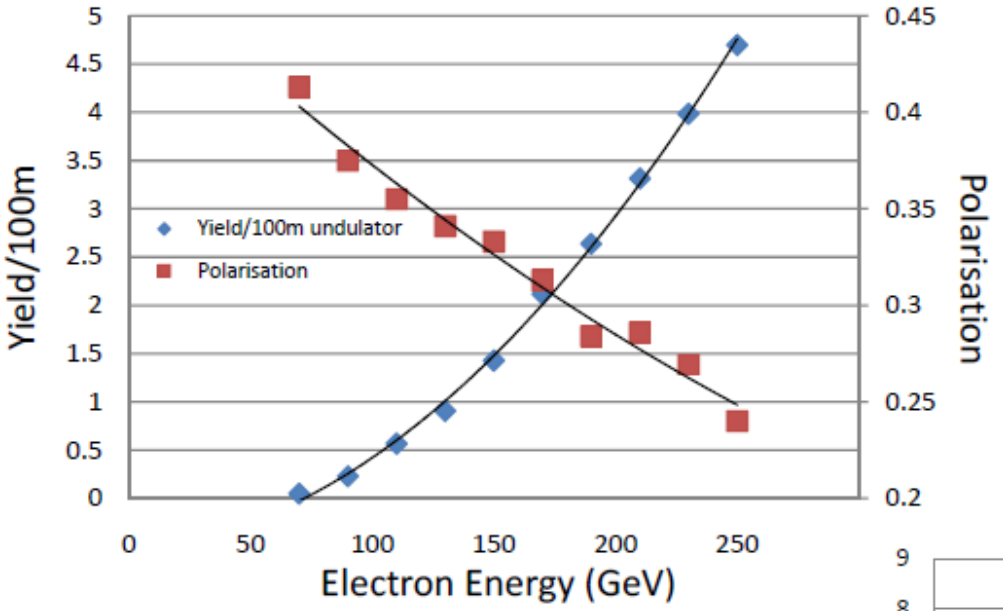
	Option 1	Option 2
Electron energy in undulator	150 GeV	250 GeV
Undulator period	11.5 mm	11.5 mm
Deflection parameter	0.92	0.92
Undulator length	100 m	32 m
Average photon energy	10.5 MeV	29.7 MeV
Power deposition in target	3.3 kW	1.8 kW
Positron yield	1.5	1.5
Positron polarisation	33%	24%

CLIC Undulator-Based Source

- "AN UNDULATOR BASED POLARIZED POSITRON SOURCE FOR CLIC", W. Liu, W. Gai. L. Rinolfi, J. Sheppard, IPAC10

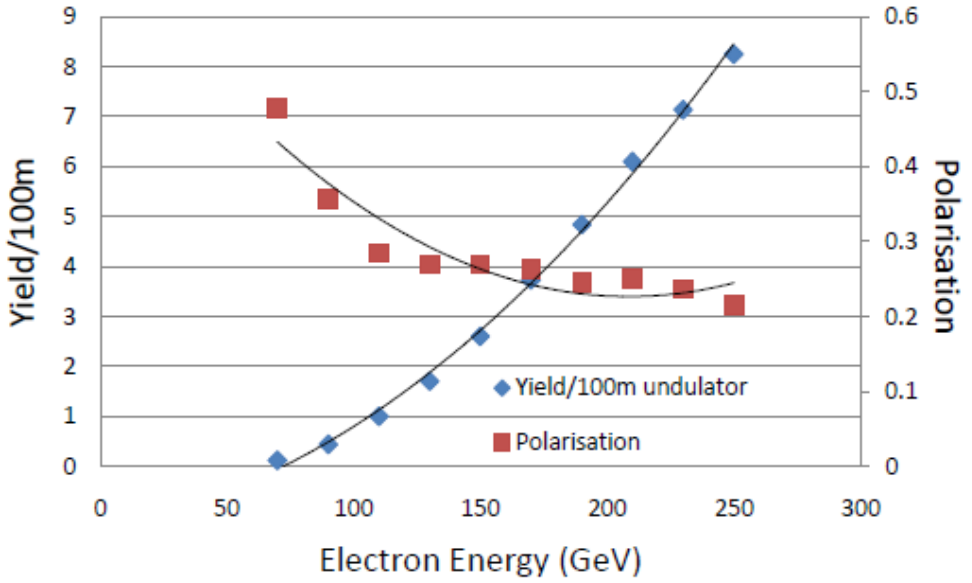


CLIC Undulator-Based Source



- Using ILC DR acceptance

- Using CLIC PDR acceptance



L. Zang, Liverpool

Positron Source Wiki

- Content at the positron source web pages at
  - http://www.ippp.dur.ac.uk/LCsources/index.html

  is being reduced.
- Please consider using the new Wiki.
  - https://znwiki3.ifh.de/LCpositrons/LCpositrons
- It's more accessible than EDMS!
- Current content relates mainly to ILC, but CLIC material could also be added.
- Just click the 'login' button in the top right to create an account.