Magnetic fields of the optical matching devices used in the positron source of the ILC

Richard Pausch
Dresden University of Technology
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Supervisors: Andreas Schälicke, Andriy Ushakov
DESY Zeuthen

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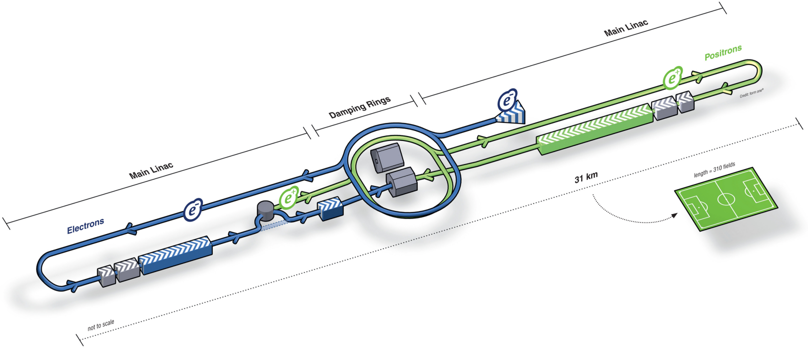
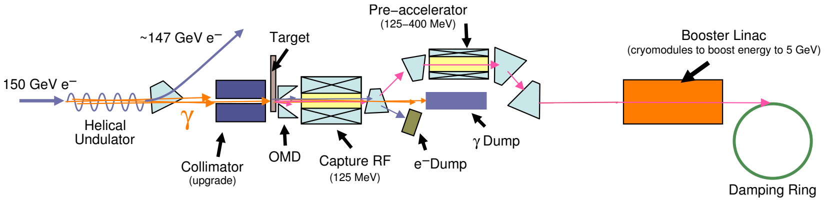
International Linear Collider (ILC)

- proposed counterpart to the LHC
- polarized e^+e^--collisions



The positron source



- aim of the OMD: increase the positron yield
- several **O**ptical **M**atching **D**evices

  Quarter **W**ave **T**ransformer, **A**diabatic **M**atching **D**evise and **L**ithium **L**ens

PPS-SIM

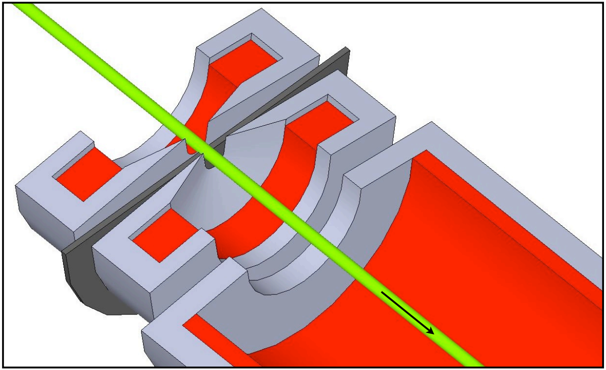
Polarized Positron Source - Simulation

$\rightarrow$ optimize the positron source

- based on Geant4 and ROOT
- simulation of electromagnetic and hadronic showers
- polarisation transfer in physics processes
- particle and spin tracking in electromagnetic fields
- adjustable geometry and GUI
- batch mode for high statistics runs

$\rightarrow$ **only simplified magnetic fields**

Design of the QWT



- QWT: first two solenoids
- Solenoid surrounding the RF-cavity

Simulations

mathematical background:

Maxwell's equations

$$\vec{\nabla} \times \vec{B} = \mu_r \mu_0 \vec{j} \quad \text{and} \quad \vec{B} = \vec{\nabla} \times \vec{A}$$

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$$\vec{A}(\vec{r}) = \int \mathrm{d}^3 r' \, \frac{\vec{j}(\vec{r}')}{|\vec{r} - \vec{r}'|} \quad \longrightarrow \quad \vec{A} = (0, A_\varphi, 0)$$

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Implemented Formula

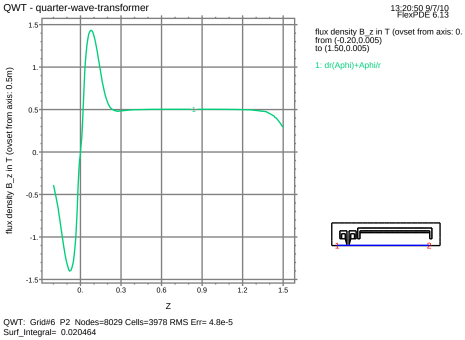
$$\vec{\nabla} \times \left(\frac{\vec{\nabla} \times \vec{A}}{\mu_0 \cdot \mu_r} \right) = \vec{j}$$

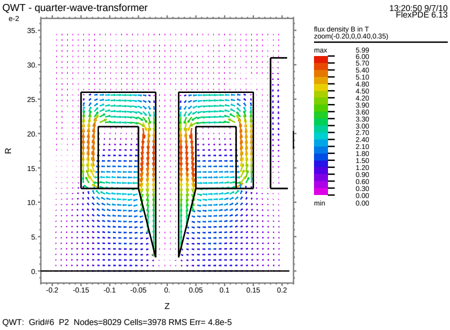
- boundary conditions
- material properties
- current densities

Simulations

Results from FlexPDE

- finite element method
- returns discrete data from the grid points





Function for the fit

FlexPDE gives **discrete data** $\rightarrow$ needs to be fitted
obvious approach: vector potential $\vec{A}$

Gauss's law for magnetism

$$\vec{\nabla} \cdot \vec{B} = 0$$

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Magnetic field from scalar function

$$\vec{B} = \vec{\nabla} \psi(r, \theta, \phi)$$

$\rightarrow$ **spherical harmonics**

Results

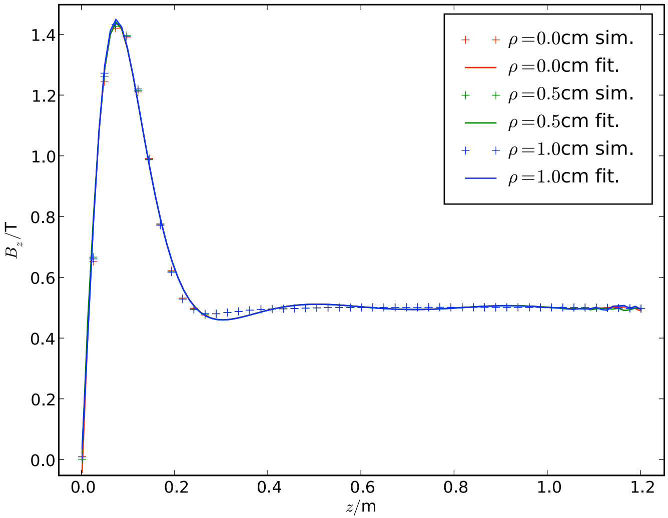
Work:

- simple χ^2 function $\rightarrow \chi^2 = \sum \left(\hat{B}_z(\rho, z) - B_z(\rho, z) \right)^2$
- fit was done using `python` and `minuit2`
- for several different currents

Final results:

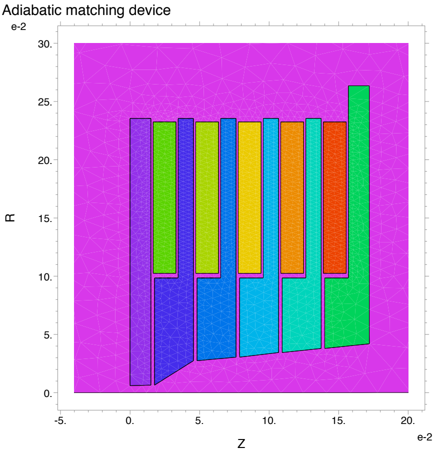
- 39 parameters for the spherical harmonics
- linear relationship between current and parameters
- magnetic flux density is calculable for different currents
- implemented in PPS-SIM

Results



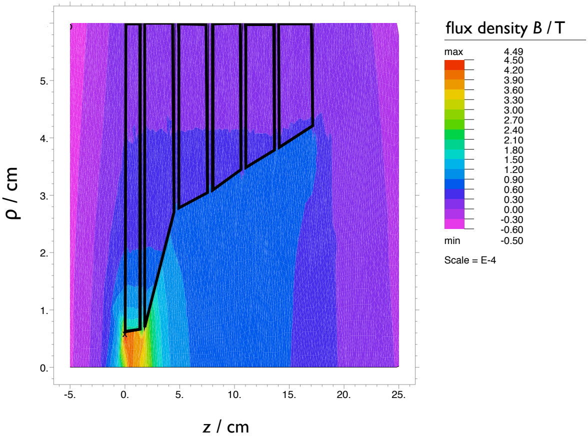
$\rightarrow$ below 10% deviation on main beamline

Design of the AMD



- 6 shaping plates with cuts
- 5 solenoids
- pulsed current
- 2D and 3D model

Results



- not expected magnitude
- still open questions

Conclusions

1. Quarter Wave Transformer
   - working model
   - good approximation by fit
   - relation between current and parameter
   - included in PPS-SIM
2. Adiabatic Matching Device
   - model included in FlexPDE
   - still open questions about physics

Are there any questions?