Polarimeter Design for a LPA Electron Beam

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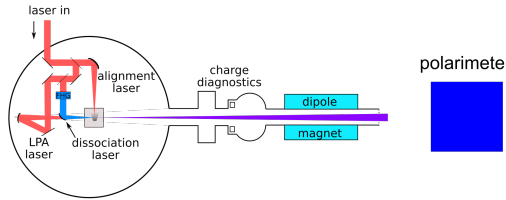
LEAP

Laser Electron Acceleration of Polarized Beams

- Theory suggests that generation possible with pre-polarized plasma target
- Goal: First experimental demonstration of polarized LPA
- Expected Beam Parameters:
  - E_{e-} of 50 -100 MeV
  - beam charge of 10 pC



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- Theory suggests that generation possible with pre-polarized plasma target
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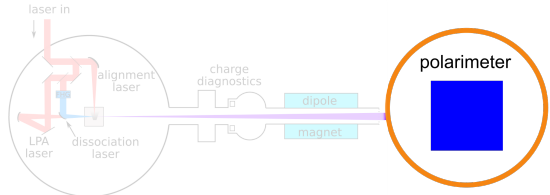
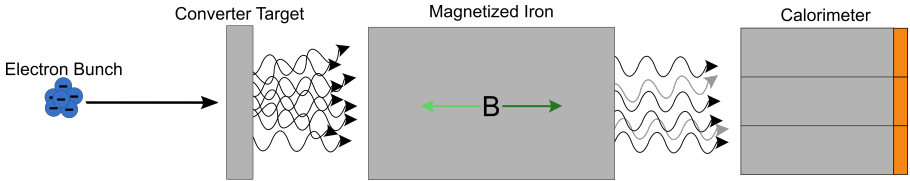
- This talk will focus on the polarimetry



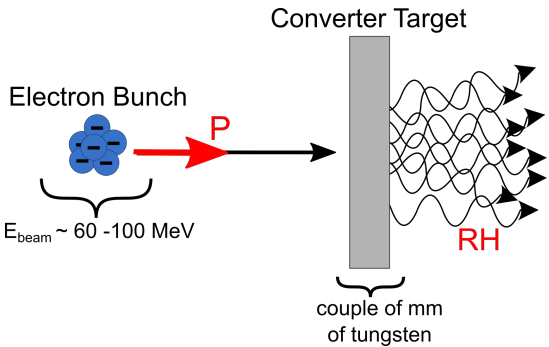
Transmission Polarimetry



- transmission of circularly polarized photons through the iron depends on energy of photons and polarization direction
- magnitude of asymmetry wrt. magnetisation direction is proportional to photon polarization
- ideal for expected energy range of tens to a hundred MeV
- demonstrated for positron polarimetry at the E166 experiment

[G. Alexander et al.: Nucl. Instr. and Meth. A (2009)]

Electron-Photon-Conversion



> creation of circularly polarized photons via Bremsstrahlung

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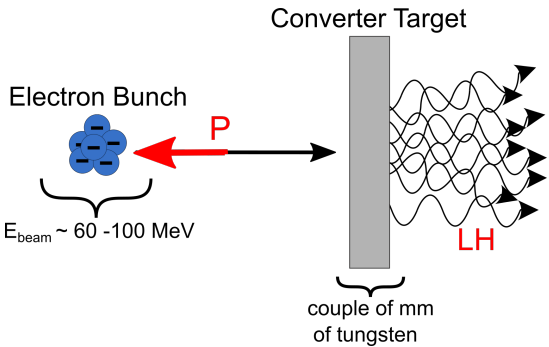

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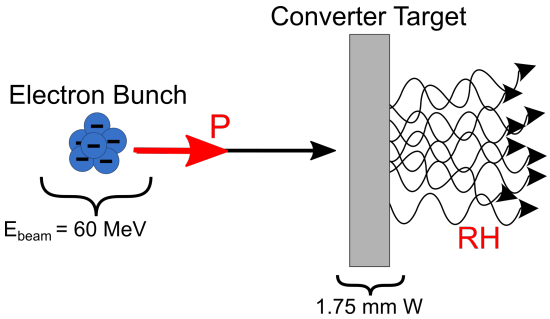
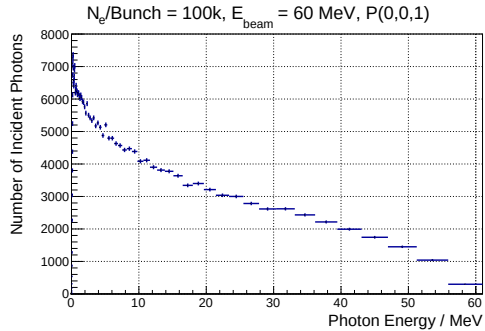
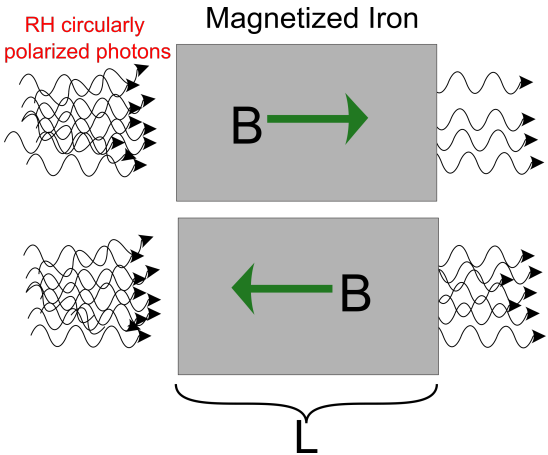




Photon Transmission

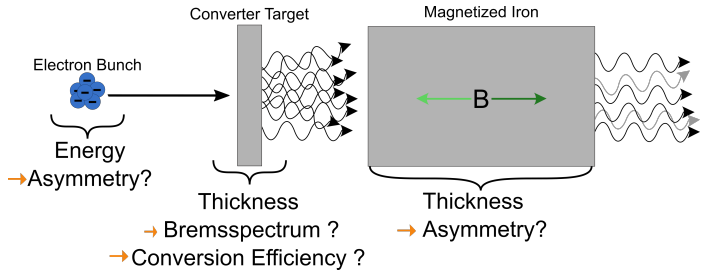


> the transmission of the photons through the iron, depends on polarization direction of both

$$T = N e^{-nL(\sigma_{pair}+\sigma_{photo}+\sigma_{compton})} \cdot e^{-nL\sigma_{pol}P_\gamma P_e}$$

> transmission is higher when polarization of incident e- and iron is antiparallel

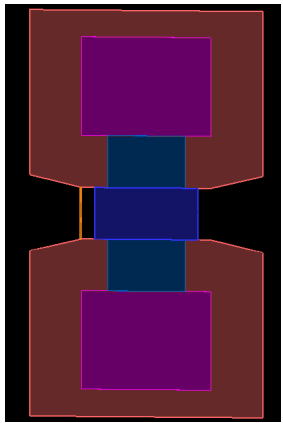
Parameters adjusted for Asymmetry Studies



GOAL:

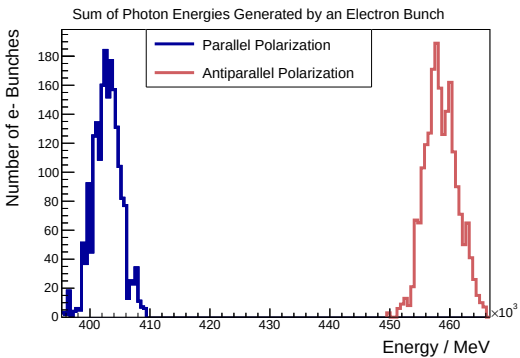
- asymmetry as large as possible
- asymmetry as stable as possible for anticipated beam parameters

Set Up and Specifics of GEANT4 Simulations



- simplified idealistic beam
- e-/iron core polarization of +/- 1
- GEANT4 physicslist including polarized Compton scattering, γ-conversion, ionization, Bremsstrahlung, e+ annihilation and photoelectric effect
- implementation of polarized prozesses in Geant4 by K. Laihem et al. **[arXiv:0712.2336]**

Transmission Asymmetry

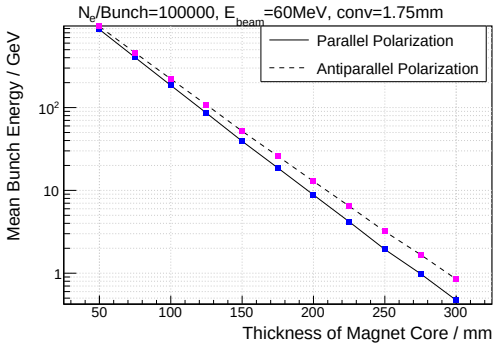


Transmission Asymmetry

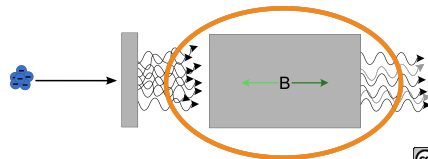
$$\delta = \frac{E^- - E^+}{E^- + E^+}$$

- $E^{+/-}$ is the average photon energy sum per electron bunch
- simulate δ (P_e = 100%) to get analyzing power A_e
- later: $\delta_{measured}/A_e$ yields electron polarization

Analyzing Magnet



- energy sum of transmitted photons per electron bunch decreases exponentially with core thickness
- Difference between energies increases



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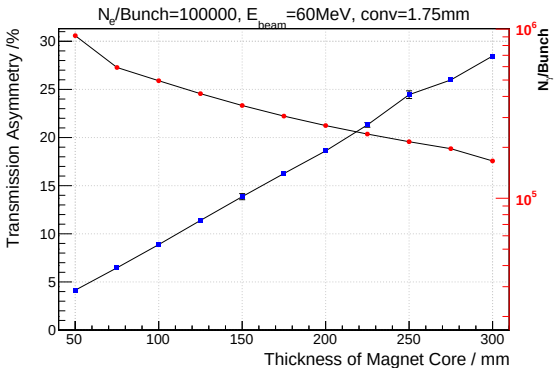
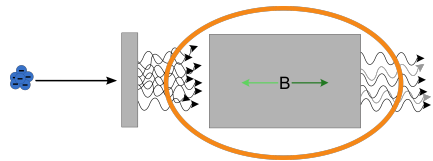
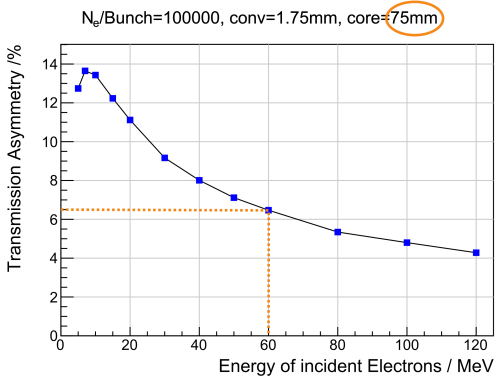
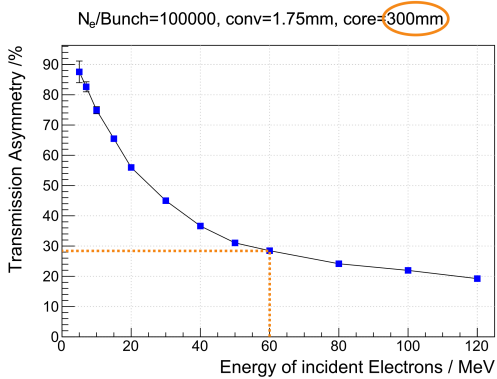


- energy sum of transmitted photons per electron bunch decreases exponentially with core thickness
- Difference between energies increases
- Rate decreases
- Asymmetry increases

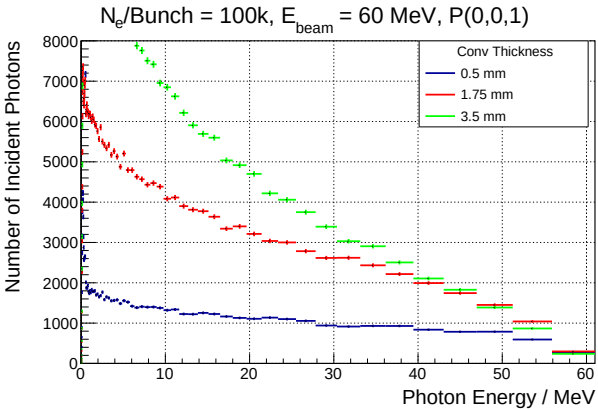


Electron Energy

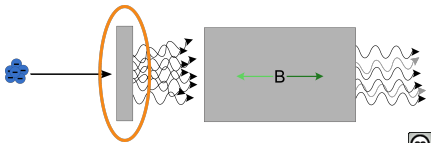




Converter Target



> more high energy photons with thicker converter targets



Conclusion

- LEAP aims to demonstrate creation of polarized electron beams from LPA
- energy range up to ~ 100 MeV
- best method to measure polarization: photon transmission polarimetry
  - polarized Bremsstrahlung
  - spin-dependent transmission through magnetized iron
  - underlying physics process: polarized Compton scattering
- challenge here: wide range of expected electron beam parameters and yet unknown level of stability of beam parameters
- optimization of setup via GEANT4 simulations shows promising results, e.g. asymmetries up to 30 % possible

Thank you!

Contact

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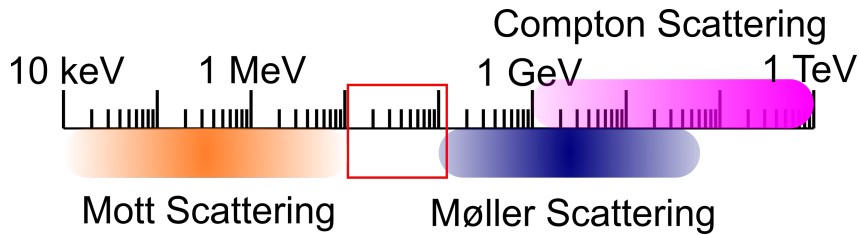
Why not a different Method?



- Mott Scattering: above about 10 MeV scatter probability very small and impractical scatter angles
- Møller Scattering: > 200 MeV to suppress bremsstrahlung background
- Compton Scattering: at few GeV and below the asymmetry is to small

[A.Schälicke et al.: Pramana - J Phys(2007)]