Study on Low-Energy Positron Polarimetry

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DESY, Zeuthen

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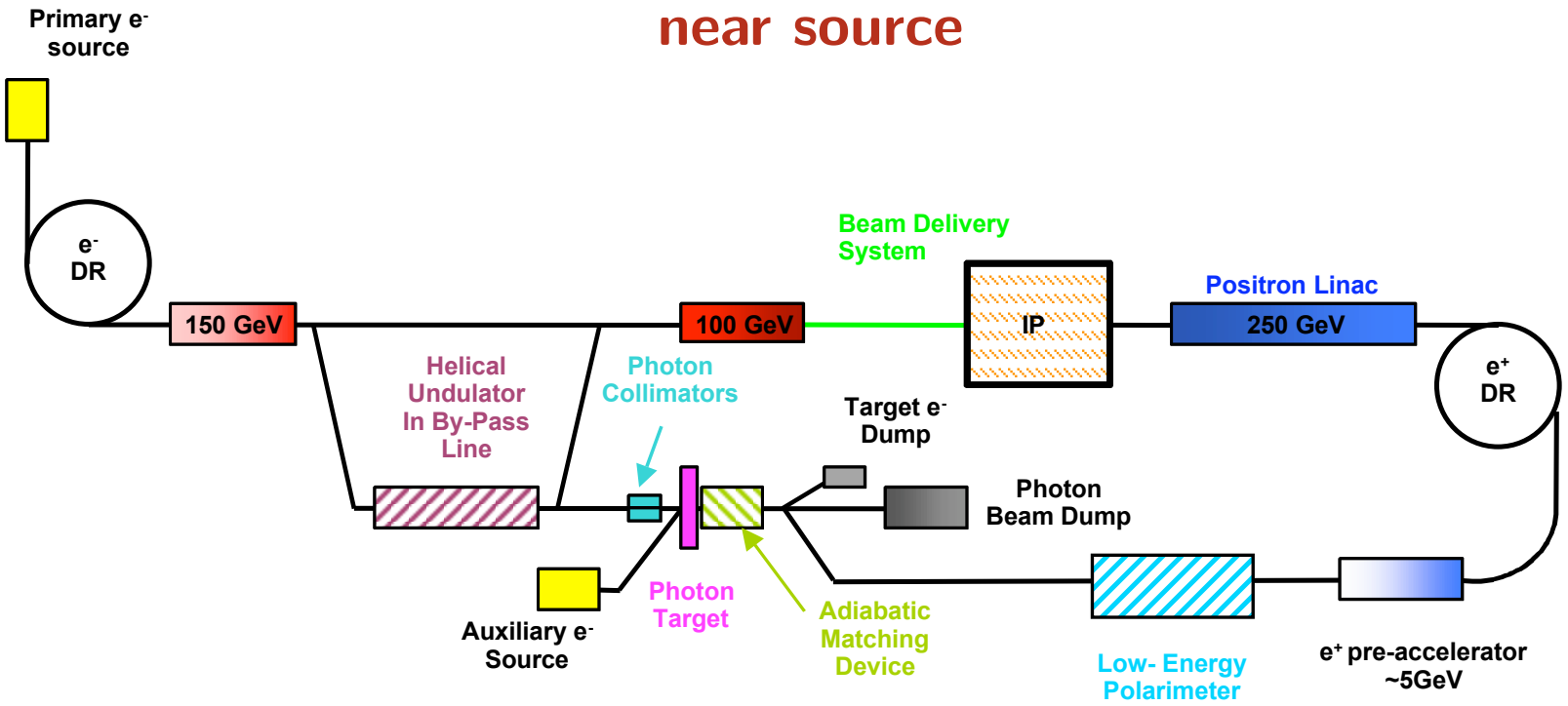
on behalf of the "LEPOL collaboration"

Outline

What is the Low-Energy Polarimeter?

Low-Energy Polarimeter

- measurement of polarization
  near source



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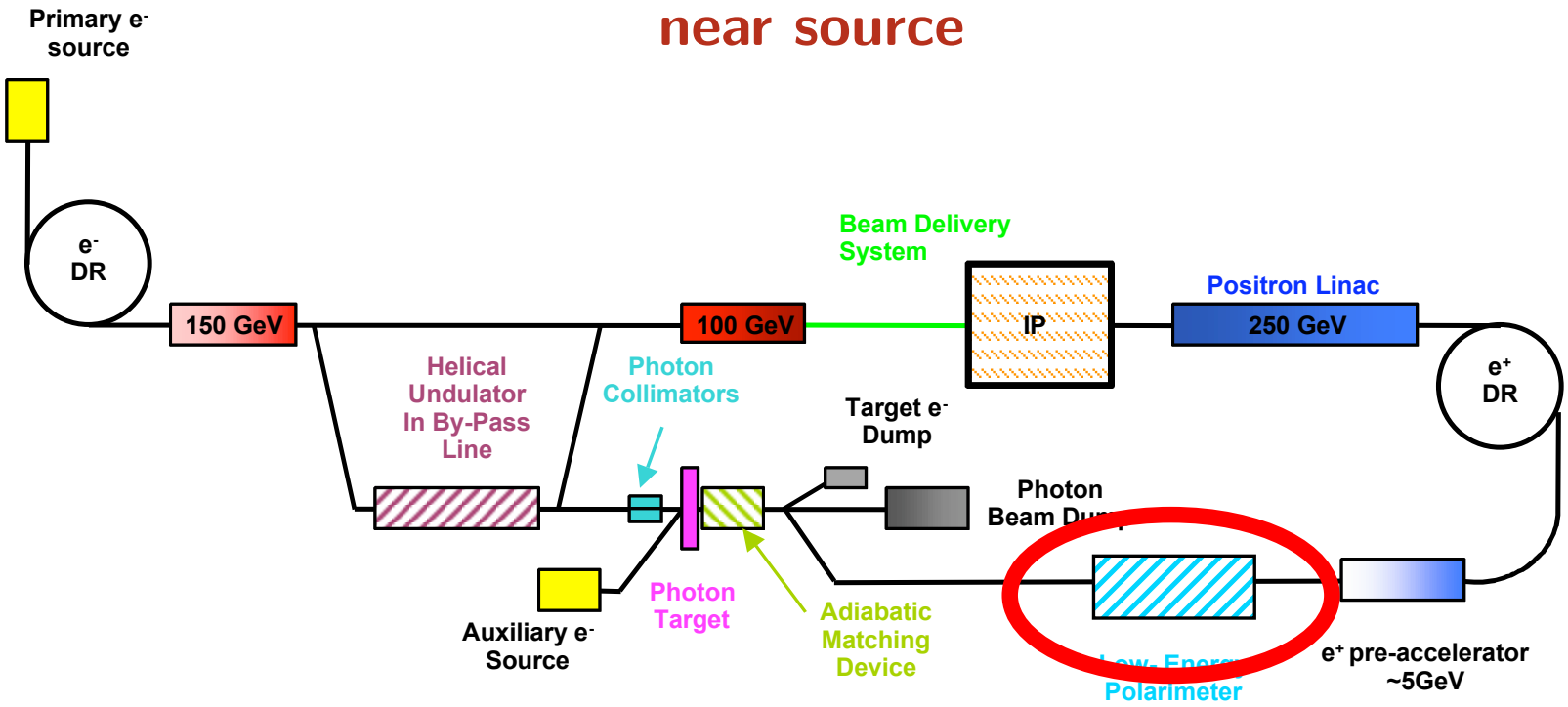
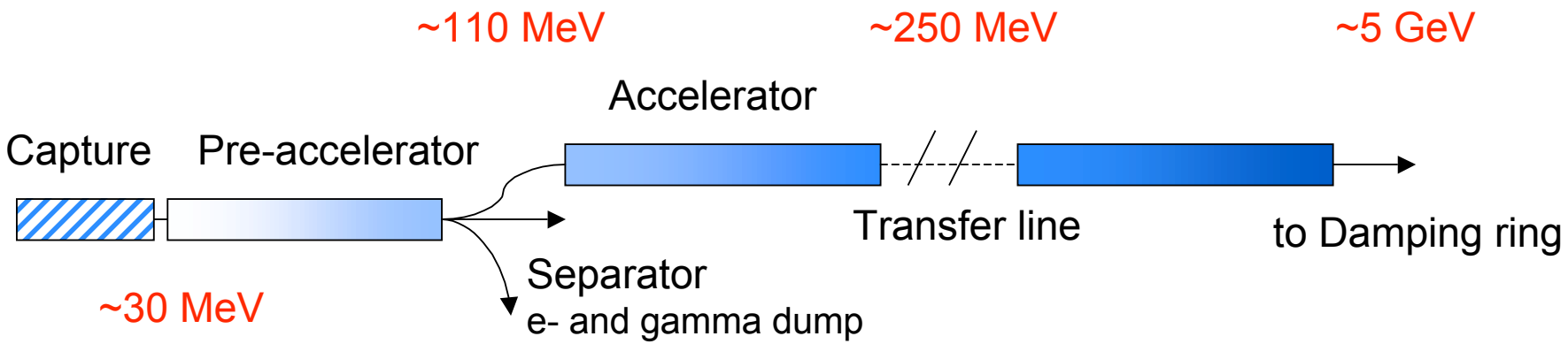


Why do we need a Low-Energy Polarimeter?

- complementary and independent of the polarization measurement at the IP
- important for optimisation of degree of polarization as well as intensity
- control of polarization transport
  polarization maybe lost in
  - damping ring
  - spin rotators
  - transport lines

What are the conditions?



- positions at different beam energies possible
- beam properties provide a *challenge*

Number of e^+ N_{e^+}	$2 \cdot 10^{10}$
Energy E	$30 \ldots 5000$ MeV
Energy spread $\Delta E/E$	~ 10 %
Normalized emittance ϵ^*	~ 3.6 cm rad
typical beam size $\sigma_{x,y}$	~ 4 cm

Overview

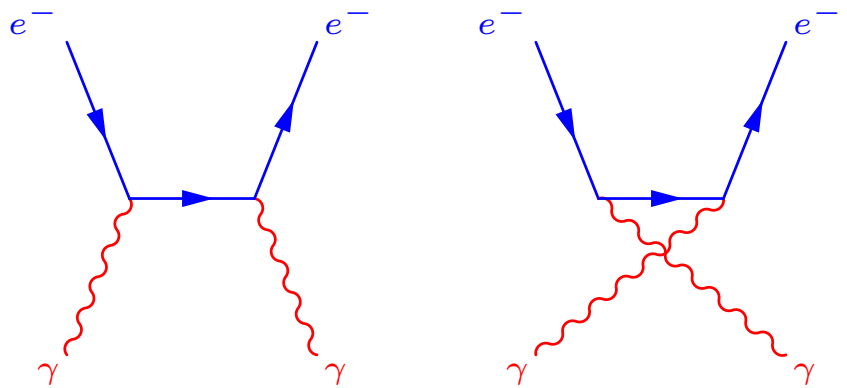
Polarimeter options for positrons (or electrons)

- Laser Compton polarimeter
- Compton Transmission polarimeter (E166)
- Bhabha/Møller polarimeter
- Mott scattering
- Synchrotron radiation

Compton polarimeter

V. Gharibyan, N. Meyners and P. Schüler, LC-DET-2001-047.
M. Woods [SLD Collaboration], arXiv:hep-ex/9611005.
M. Beckmann *et al.*, Nucl. Instrum. Meth. A **479** (2002) 334.

- laser backscattering on beam
- preferred option for the polarimeter close to IP
- high precision achievable
- used at SLC and HERA
- **not** an option for the low-energy polarimeter



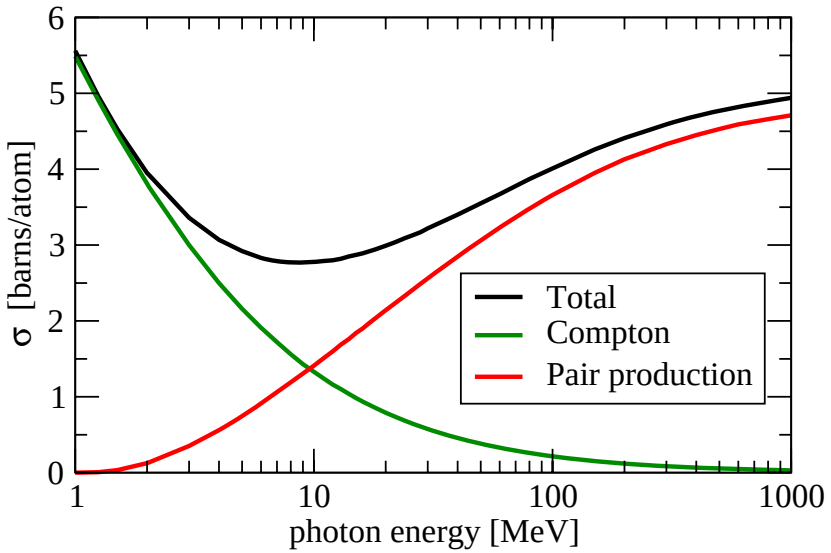
Compton Transmission polarimeter

Principle

- reconversion of positrons to photons in Bremsstrahlung target
- transmission of photons in magnetized iron polarization dependent

Advantages

- simple setup
- can deal with pure beam quality (employed in E166 and ATF)



Disadvantages

- becomes less efficient with higher beam energy
- destructive – complete bunch is dumped
- high energy deposition

Bhabha/Møller polarimeter

Principle

A. V. Grigoriev *et al.*, EPAC-2004-THPLT106.
G. Alexander and I. Cohen, Nucl. Instrum. Meth. A **486** (2002) 552.

- scattering of positrons/electrons in a thin magnetized iron foil

Advantages

- relative simple setup
- non destructive
- used e.g. in SLAC fixed target experiments
- in operation at VEPP-3 storage ring (gas target)

Disadvantages

- small asymmetry
- possible large background (cf. beam properties)

Synchrotron radiation

S. A. Belomestnykh *et al.*, Nucl. Instrum. Meth. A **227** (1984) 173.

Principle

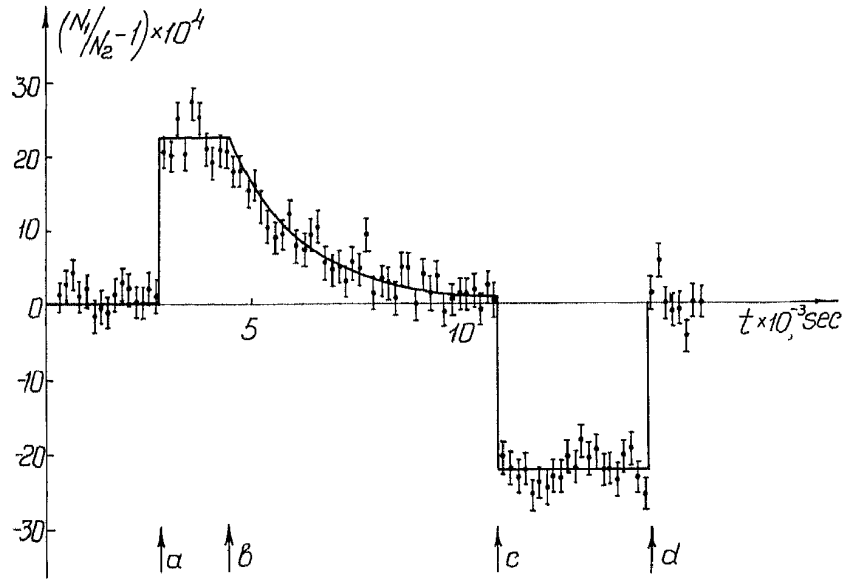
- transverse polarization needed
- angular asymmetries of synchrotron radiation in damping ring

Advantages

- relative simple setup
- non destructive, non intrusive
- in operation at VEPP-4 storage ring

Disadvantages

- very far from source
- very small asymmetry



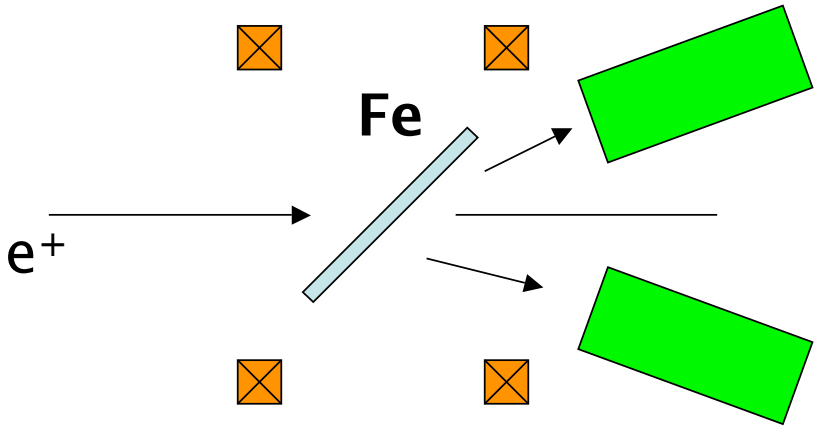
Bhabha polarimeter

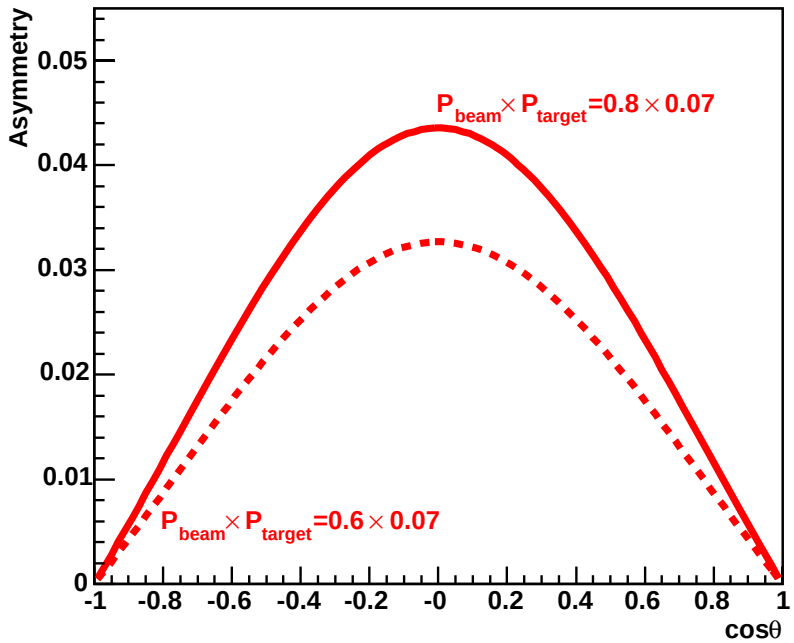
Iron target

- polarization $P_e = 7\%$.
- critical temperature $T_c = 1043$
- radiation damage?

Background

- dominated by Bremsstrahlung
- can be substantially reduced by using final electrons only





G. Alexander *et.al.*, Nonlin. Phenom. Complex Syst. **8** (2005) 180.

G. Alexander and E. Reinherz-Aronis, arXiv:hep-ex/0505001.

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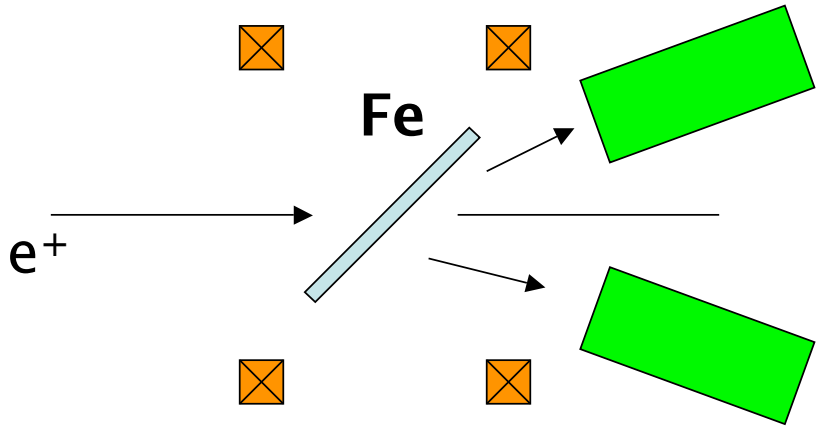

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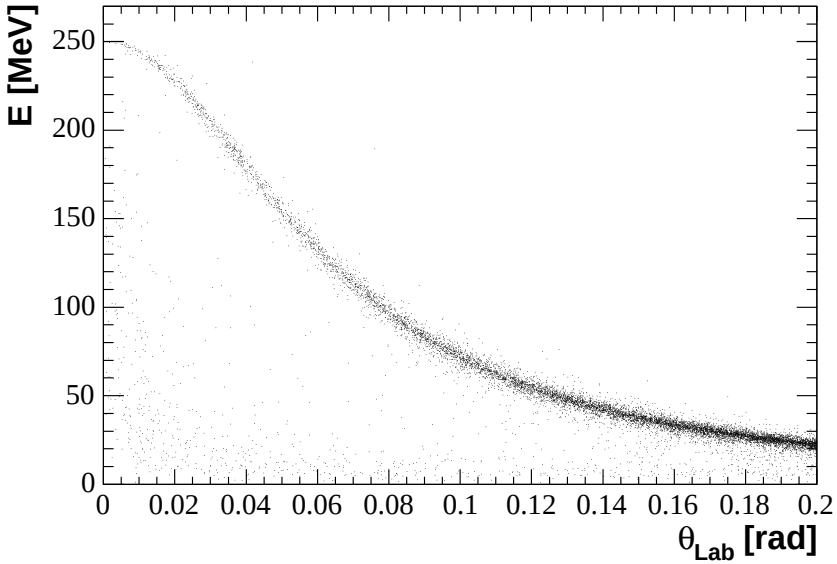

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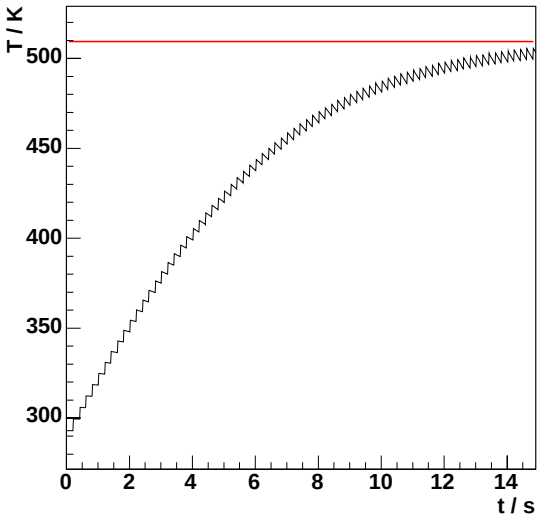
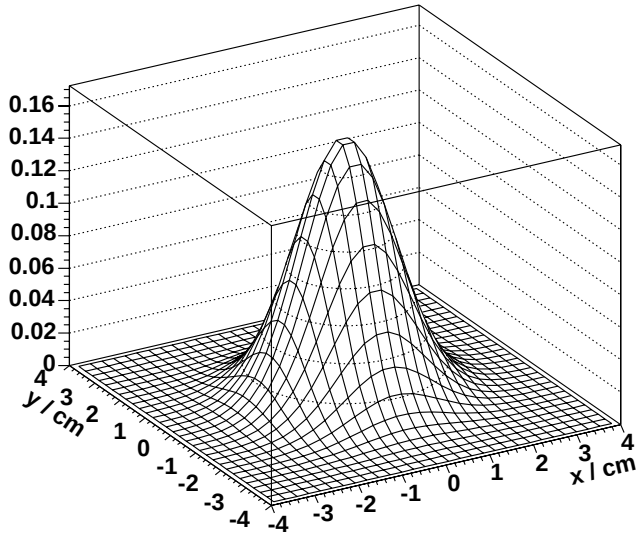
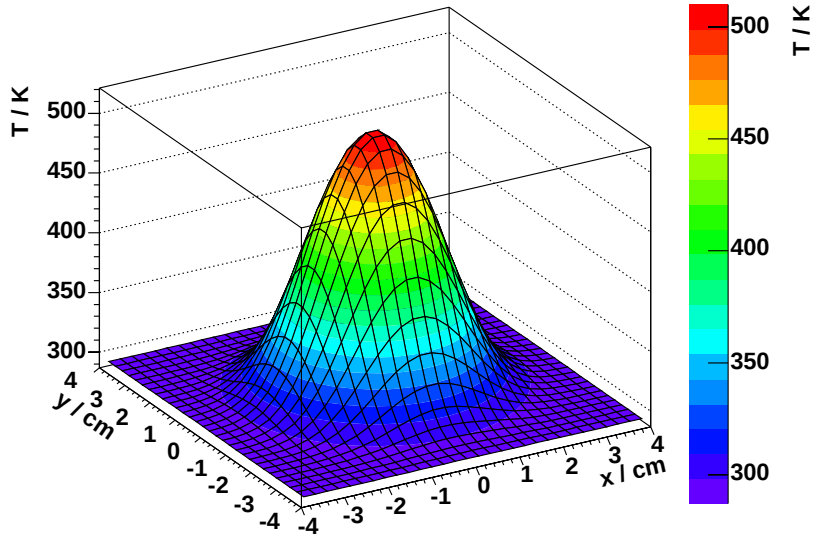
Target temperature

- example $\sigma = 1$ cm, $N_{e^+} = 2 \cdot 10^{10}$
- heat-up per pulse ~ 10 K
- cooling dominated by radiation
- peak equilibrium at ~ 500 K







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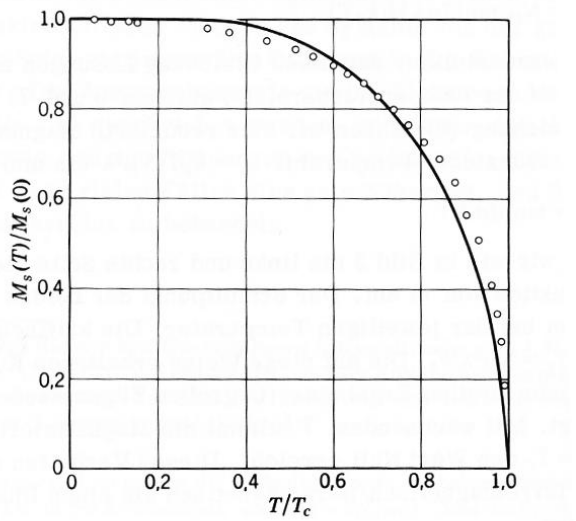
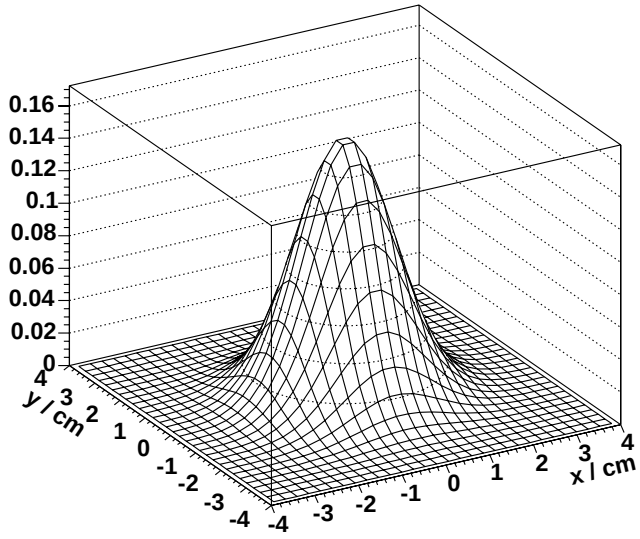
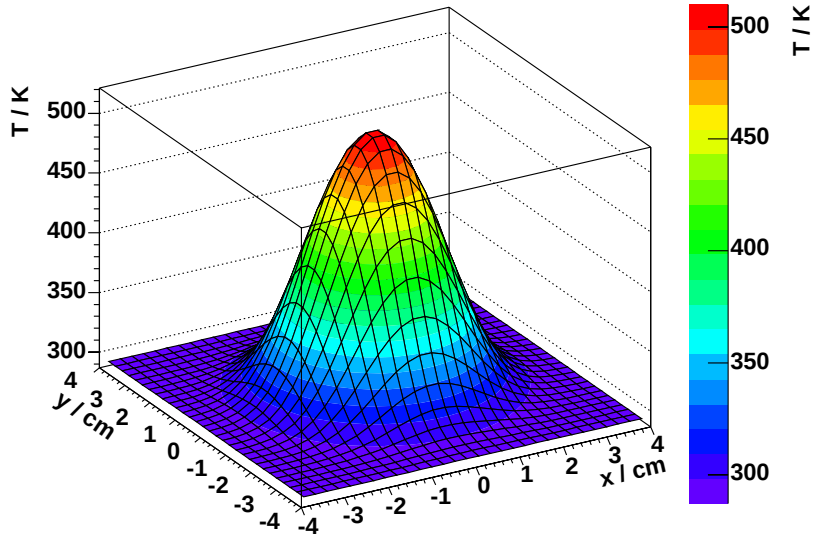






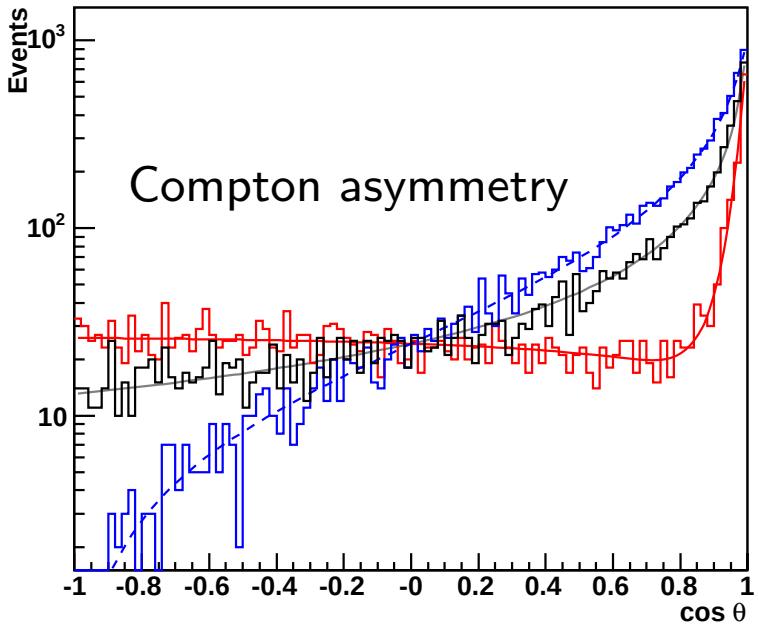
Polarization extension to Geant4

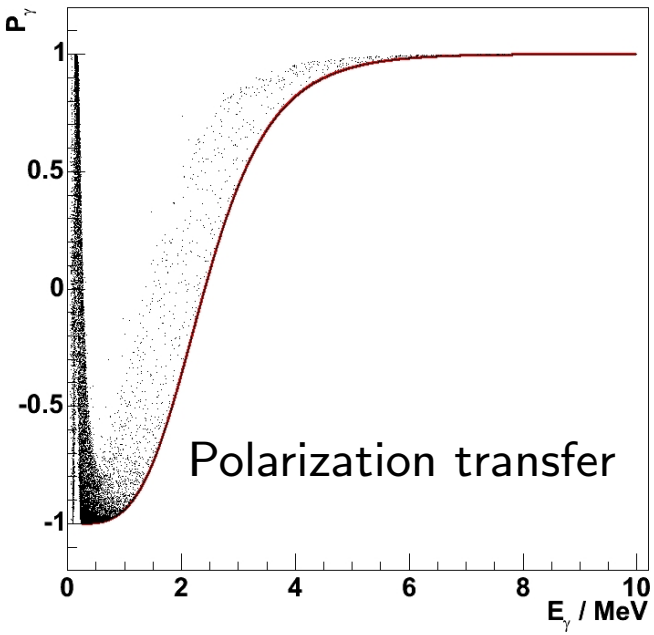
Polarimetry of electrons and positrons

- Compton scattering
- Bhabha/ Møller scattering
- Annihilation into photons

Polarization transfer

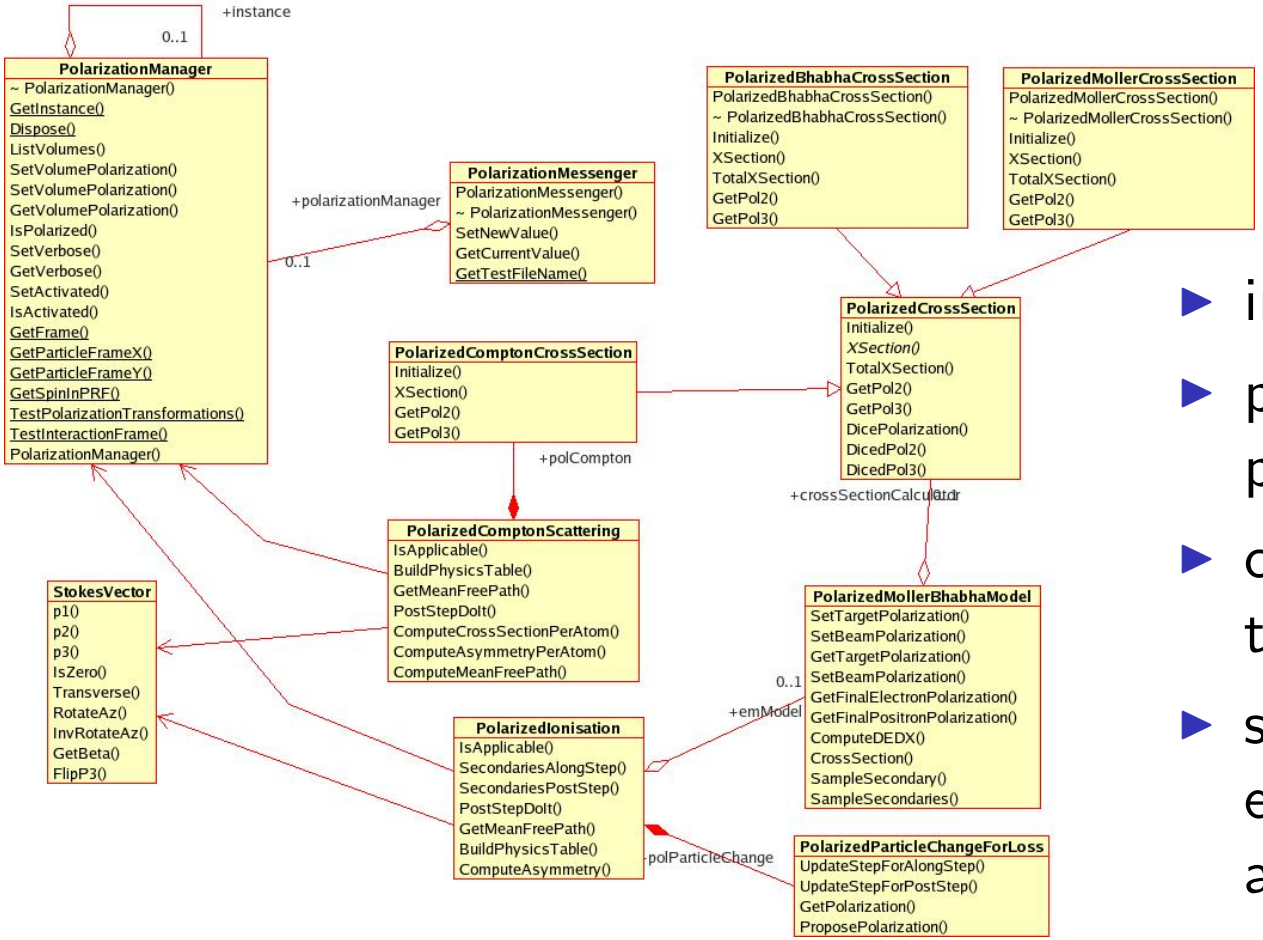
- Bremsstrahlung
- Pairproduction
- ...





R. Dollan, K. Laihem and A. Schälicke, arXiv:physics/0512192.

Polarization Library for Geant4



- independent library
- provides polarized QED process
- can assigns a polarization to any logical volume
- simple to include in existing Geant4 application

Summary & Outlook

- different polarimeter options
- choice of options is difficult
- need detailed simulations (employ the new polarized version of Geant4)
- Bhabha polarimeter under current investigation
- feasibility needs to be demonstrated in prototype experiments

Zeuthen/HU Polarization group:
R. Dollan, H. Kolanoski, K. Laihem, T. Lohse, S. Riemann, A.S.

Cooperation with:
G. Alexander (Tel-Aviv), A. Stahl (RWTH Aachen), P. Starovoitov (Minsk)

"It is remarkable that it is more difficult to think of methods of detecting polarization, which seem apt for realization, than of methods of producing polarization."

H. A. Tolhoek, Rev. Mod. Phys. **28** (1956) 277.