EUCARD workshop ”Spin optimization at Lepton accelerators”

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Book of Abstracts

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A Quartz Cherenkov Detector for Polarimetry at the ILC

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The physics program of the International Linear Collider requires precise knowledge of the luminosity weighted average polarisation at the electron-positron collision point. One crucial element of the ILC polarimetry concept is the use of Compton-Polarimeters measuring before and behind the collision point.

It is foreseen to use Cherenkov detectors to measure the Compton scattered electrons or positrons in the polarimeter chicanes.
In this talk, a possible design for a quartz-based Cherenkov detector for this purpose will be presented.

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Bremsstrahlung polarization correlations and their application for polarimetry of electron beams

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The angular distribution and linear polarization of bremsstrahlung photons is highly sensitive to the spin of the electrons in relativistic electron-atom collisions. While the former effect was well known, the latter one was observed only in the recent years. We report two experimental studies of linear photon polarization with spin-polarised electron beams at 100 keV and 2 MeV. In these measurements Compton and Rayleigh polarimetry techniques were applied to a segmented germanium detector. The spin-dependent tilt angle of the photon polarization plane with respect to the electron beam axis was found to be of the order of a few degrees at 100 keV, and it was enhanced by more than an order of magnitude at the higher energy. This effect can be used for a spin-diagnostics of electron beams. Here a combination of the photon emission asymmetry and linear polarization measurements can fully characterise the spin-polarization state of the beam: all three polarization components can be simultaneously determined. The results of such a test measurement done at 100 keV will be reported.

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Challenges for Polarimetry at the ILC

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At the planned International Linear Collider (ILC), the longitudinal beam polarization needs to be determined with an unprecedented precision. For that purpose, the beam delivery systems (BDS) are equipped with two laser Compton polarimeters each, which are foreseen to achieve a systematic uncertainty of 0.25 %. The polarimeters are located 1.6 km upstream and 150 m downstream of the e^+e^- interaction point (IP). The average luminosity-weighted longitudinal polarization, which is the decisive quantity for the experiments, has to be determined from these measurements with the best possible precision. Therefore, a detailed understanding of the spin transport in the BDS is mandatory to estimate how precise the longitudinal polarization at the IP is known from the polarimeter measurements. The envisaged precision for the propagation of the measurement value is 0.1 %.

The spin transport in the BDS has been simulated, including the simulation of the beam-beam collisions at the IP. This talk discusses the results of this study with focus on the collision effects and the spin transport after the collision.

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Depolarisation at e+e- colliders due to strong fields at the interaction point

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Depolarisation of polarised collider beams, due to the strong electromagnetic fields of the bunch-bunch collision at the IP, is important to understand for the precision physics goals of future e+e- colliders. Beam parameters are generally chosen to maximise the collision luminosity whilst minimising non-linear effects from strong IP fields. Here it will be shown that luminosity can be further enhanced by a judicious choice for the relative longitudinal position of the beam waists. A simulation study of the beam waist optimisation on depolarisation will be presented. The possibility of higher order, non-linear depolarisation effects will be discussed.

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Heat load and stress studies of the collimator materials for the polarized ILC positron source

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An intense polarized positron beam for future linear colliders can be produced using a high power beam of circularly polarized photons which penetrates a thin titanium-alloy target. The degree of polarization can be increased by cutting the outer part of the photon beam generated in a helical undulator using a collimator in front of the target. However, the photon beam induces substantial heat load and stress inside the collimator materials. In order to avoid failure of the collimator components the heat and stress evolution has been simulated. The results as well as the corresponding material arrangements for the photon collimator design are presented.

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ILC Polarized Positron Source at Center-of-Mass Energies of 250 GeV and 1 TeV

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The base-line positron source of the future International Linear Collider (ILC) is polarized and designed for an operation with electron drive beam energies between 150 GeV and 250 GeV (corresponding to 300 GeV up to 500 GeV CM energies). However, running at CM energies below 300 GeV reduces the positron yield substantially; running at Ecm = 1 TeV implies a low degree of positron polarization. The simulation results of yield and polarization at the positron source will be presented for these two "extreme" energies. The possible modifications of the helical undulator will be discussed.

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Phenomenology and calculations for spin polarisation in high energy electron/positron storage rings

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The attainable equilibrium polarisation in electron/positron storage rings depends on a balance between polarisation build-up due to the Sokolov-Ternov effect and depolarisation resulting from the stochastic nature of the emission of photons in the synchrotron radiation. The rate of depolarisation rises faster with energy than the rate of polarisation, with the ratio scaling at least like the square of the energy. It can then be very difficult to obtain high equilibrium polarisation at high energy unless the ring is extremely well aligned. Moreover, the depolarising effects can become prohibitive if the polarisation has been made longitudinal in parts of the ring, unless the optical state of the ring can be arranged appropriately. The beam-beam interaction can also have strong direct and indirect effects on the polarisation.

Thus before a ring is built, the attainable polarisation should be estimated on the basis of well known theory, backed-up by detailed Monte-Carlo spin-orbit tracking simulations.

In this talk I give a brief overview of the theory and illustrate the phenomenology with the results of calculations for various rings including for the ring-ring option of the LHeC.

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Polarized positrons at the ILC - physics goal and source requirements

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At the International Linear Collider (ILC) both beams –electrons and positrons– will be polarized since the positron source is based on a helical undulator. The electron beam passes the undulator which is located at the end of the main linac. So the undulator parameters are strongly coupled to the centre-of-mass energy. The positron polarization has to be optimized for each energy depending on physics
requirements taking into account the acceptable thermal, mechanical and radiation load at the positron source components.
The options are discussed in the talk.

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Possible Approach for Reaching High Energy Polarized Electron and Positron Beams

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The discovery of Higgs has inspired the idea of dedicated higgs factory of high energy electron--positron collisions. Polarization can benefit the physics program not only as an efficient energy calibration, but lso suppress background signals. The experience from high energy electron beams at HERA and LEP has been encouraging, yet also exhibits the great difficulty. The aspect of reaching polarized beams at the beam energy of currently proposed electron--positron collider based on S--T polarization built--up is daunting. Here, we present a scheme to achieve polarized electron and positron beam collisions at high energy.

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Spin asymmetry in high-energy electron-nucleus scattering: bremsstrahlung versus elastic scattering

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The polarization correlations between the incident electron and an emitted bremssstrahlung photon as classified by Tseng and Pratt are extended into the high-energy regime where nuclear structure effects play a dominant role. While electron scattering from spin-zero nuclei is mostly governed by the finite-nuclear-size effects, nuclear bremsstrahlung and magnetic effects come into play when the target carries spin. Theoretical predictions are made for light and medium-heavy nuclei in the energy regime 5-160 MeV by using the PWBA and the higher-order weak-potential approximation (WPA).

For circularly polarized photons near the short-wavelength limit the polarization correlations can be related to the electron-electron polarization correlations from elastic scattering. Their modifications by the nuclear structure effects may, however, be considerably different for the two processes. This is shown by using the PWBA and DWBA theories for the description of elastic scattering.

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Spin treatment at the ILC

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In order to match the precision requirements at the ILC both beams polarized have to be manipulated. In the talk a few aspects in this context are discussed, for instance, helicity flipping and spin tracking at the spin rotator, as well as, resonance depolarization via an RF kicker.

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Status of the Double Scattering Polarimeter for MESA

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The new Mainzer Energy recovering Superconduting Accelerator (MESA) will be used for high precision measurement of the Weinberg angle at low Q^2. In order to be able to measure as precise as desired, the polarisation of the incident electron beam has be know with very low uncertainty. Therefore a Double Scattering Polarimeter (DSP) will be installed at MESA at low energies. In my talk I will present the status of the comissioning and test measurements at a 100 keV test source.

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Sub-percent polarization accuracy for MESA

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The P2 experiment at MESA requires sub-percent accuracy of the beam poalrization measurment. Several polarimeters will be needed to obtain a sufficient redundancy of the experiemnt. The two main polarimeters will be a double scattering device at low energy and a new type of Möller polarimeter. The latter can operate online directly in front of the experiment. The status of the two poalrimeters is presented.

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The spin dynamics simulation suite POLE

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The new spin dynamics simulation suite POLE is designed to perform systematic studies of polarization in circular accelerators with fast energy ramps, or short storage times of up to some seconds. A main application is the investigation of crossing depolarizing resonances depending on arbitrary magnet and optics settings. For instance, many simulations of a single resonance crossing are performed with varying correction schemes.

POLE uses spin tracking and applies frequency filters to the magnetic fields to balance accuracy against computing time. Thus, the step sizes during tracking can significantly exceed the length of a magnet. In order to keep short computing times, synchrotron radiation effects are modeled by a simplified time course of the particles energy. Additionally, multiple spins are tracked simultaneously on multi-core processors. POLE automatically computes the required magnetic field data based on a common lattice file from MAD-X or Elegant.

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Vector polarimetry at MAMI

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Electron/photon tensor-correlation coefficients may allow to design a polarimeter that can measure all components of beam polarisation simultaneously ("vector polarimeter"). Besides its purpose as a beam diagnostic device this would also allow to test theoretical predictions for the correlation coefficients at energies between 1 and 3.5 MeV. As a first step we have set up a measurement of the helicity transfer to the photon as a function of energy which is based on the Compton absorption method. Apparative developments in order to measure photon emission asymmetries caused by transverse and longitudinal electron polarisation are presented. This work was supported by the Deutsche Forschungsgemeinschaft through SFB 443.