A Demonstration of Polarized Positron Production in the FFTB

Thursday, October 3, 2002
R. Pitthan and J. C. Sheppard
Polarized Positron Production Demo Personnel

Y. Batygin, B. Bugg, R. Carr, K. McDonald,
A. Mikhailichenko, K. Moffeit, D. Onoprienko, R. Pitthan,
J. Sheppard, S. Spanier, D. Walz, A. Weidemann, M. Woods

Also

T. Behnke, K. Flöttmann, T. Hirose,
R. Nelson, P. Schuler
NLC Polarized Positron System Layout
The required undulator length for the cut photon spectrum is $L_c$:

\[ N_\gamma = 2.6 \text{ photons/m/e}^-, \quad T_c = 50\%, \quad Y_c = 2.92\%, \quad \xi_c = 20\% \]

\[ L_c = \left( N_\gamma T_c Y_c \xi_c \right)^{-1} = 132 \text{ m}. \]

$S_3 = 59\%$

$L_c$ is the length for a unity gain system, i.e. no overhead factors, hidden or otherwise. This is a preliminary calculation. Optimization with respect to target material, thickness, undulator characteristics, photon cut, beam energy, etc. will be made with simulations as time and priority permit.
FFTBB Exp. Layout
We are proposing an experiment in the FFTB, using a meter-long, short-period, pulsed helical undulator ($\lambda_u = 2.4$ mm, $\kappa=0.17$) and the SLAC low emittance electron beam at 50 GeV, to produce polarized photons in the energy range of a few MeV up to a cutoff energy of about 10 MeV. Photons are converted to polarized positrons in a target which is 0.5 radiation lengths in thickness (targets of both Ti and W will be studied). The goal of the experiment is to measure the yield, spectrum, and polarization of the photons and positrons, and to compare the results to expectations from simulations.
Because of the uncertainty in the level of detector backgrounds, the experiment will likely be done in two parts. The goals for the stages are:

Stage 1. flux, spectra and polarization of undulator gammas

- flux and spectra of positrons
- background measurements for positron polarimetry
- crude positron polarimetry if backgrounds permit

Stage 2. positron polarimetry
This test is a 1% length scale demonstration of undulator-based production of polarized positrons for linear colliders:

• Photons are produced in the same energy range and polarization characteristics as for the collider;

• The same slab target geometry and material are used as in the linear collider;

• The polarization of the produced positrons is in the same range as in the linear collider;

• The simulation tools being used to model the experiment are the same that are being used to design the polarized positron system for the NLC.
This demonstration directly tests the present design approach to the issues of polarized positron production. The test will validate the methodologies and benchmark the design codes: undulator radiation models for photon characterization, undulator design codes for undulator fabrication, POL EGS4 for polarized $e^+$ production, and Beampath for collection and transport. The test will provide full confidence that the NLC design is based on solid, demonstrated principles all working together at the same time.
This demonstration does not test capture efficiency, target thermal hydrodynamics, radiation damage in the target, nor positron polarization diagnostics as envisioned for the actual collider. These issues are being addressed separately. The demonstration does test the photon diagnostics required for a collider.
We expect to empirically demonstrate the validity of the production of polarized positrons for application to linear colliders. The only physics explicitly omitted from the simulations is depolarization of positrons in the target due to multiple scatter and ionization loss. These effects are estimated to be small in comparison with the dominant depolarization of about 10% from bremsstrahlung, which is included in the simulations.
NLC - The Next Linear Collider Project

FFTB Exp. Layout
Double Undulator Scheme, Mikhailichenko

FIGURE 4: General pulsed undulator concept.
Undulator Design, Mikhailichenko

**Figure 1:** Cross-section. StSteel tube has OD diameter of 1.067 mm, ID diameter ~ 0.889 mm, what is >20% however. Wire has diameter ~ 0.6 mm. Two wires separated by gap ~ 0.6 mm. Walls of the case are not in scale, they will be more thick. The case provides good alignment. Coolant liquid is in good contact with wires.

**Figure 2:** Model of pulsed undulator with period of 2.42 mm. G10 rods have length 231.5 mm.
FIGURE 3: Field profile across undulator aperture. Feeding current 2 kA. Calculations from MERMAID for round wire. Wire with rectangular cross section will give ~15% more field for the same current.
Geometry for γ Transmission Polarimetry

Collimator
1mm aperture

Magnetized Fe

Sweep magnet

2mm Pb

Vacuum

Movable table

Pb enclosure

Propane $E_n=11.2$ Mev
Isobutane $E_n=8.1$ Mev
Aerogel $E_n=4.0 - 1.4$ Mev

25 cm

Air (n=1.000273)

K. Moffeit, SLAC
27 August 2002
Positron Polarization

Long. Positron Polarization vs. E; K=0.09, $\gamma_{cut} = $ None

- $P_{zav}(E,E_{max})$
- $P_{zav}(0:E)$
- $1-N_{cum}$
Positron Polarization

Long. Positron Polarization vs. E; $K=0.09$, $\gamma_{cut} = None$

-0.4 -0.2 0 0.2 0.4 0.6 0.8 1

0 1 2 3 4 5 6 7 8 9 10

Positron Energy (MeV)

0.5 r.l. Ti
Budget Requirements

Value of the Experiment: $700k

Collab. Offsets: $300k

On Site Equip.: $40k

NLC Monies, today: $360k

Requested Relief, DESY $140k

NLC Money, FY2003: $220k
Issues

Clarification of Approval Process:
  NLC Video
  MAC
  EPAC (?): responsibility to

Funding:
  NLC
  SLAC RD
  Cornell
  DESY
  UCLC, LCRD
Issues, cont’d

Question of Detector Backgrounds that may adversely affect e\(^+\) polarization measurement, may be okay.

Straightforward cure for stage 2: bring positrons outside of FFTB enclosure.

Rest of measurements look to be very doable.