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# Summary on the POSIPOL workshop for Linear Colliders ILC and CLIC

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## Abstract

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POSIPOL 2006, an international workshop that was held earlier this year at CERN, was dedicated to the production of polarized positrons using the Compton back-scattering of a high-power laser beam by electrons of a few giga-electron-volts. The particular focus was on applications to the two future linear-collider projects, the International Linear Collider (ILC) and the Compact Linear Collider (CLIC). The workshop, which attracted around 50 experts from Europe, Asia and the America, was jointly organized by the CLIC team at CERN, the European CARE-ELAN network, the Japanese high-energy accelerator research organization, KEK, and the Laboratoire de l'Accélérateur Linéaire (LAL) at Orsay. It led to a roadmap and a series of recommendations for future R&D on positron sources for linear colliders.

Polarized positrons (POSItons POLarisés in French, hence POSIPOL) are produced by bombarding a tungsten target with polarized photons. The latter are generated either from a helical undulator or from the scattering of a polarized high-power laser beam with an unpolarized high-energy electron beam. For this second scheme, requirements on the intensity of both the electron beam and the laser beam are significantly relaxed by stacking the laser beam in an optical cavity with an enhancement factor of up to a factor 1000, and by re-using the electrons, which are stored in a so-called Compton ring. This scheme also implies the stacking of the produced positrons in a storage ring. Control of the laser system and of the high-quality optical cavity is crucial, as is the electron-beam dynamics in the presence of electron-laser collisions. The various aspects of this scheme, as well as comparisons with the undulator method, formed the main topics for the sessions at the workshop.

Robert Aymar, CERN's director-general opened the workshop, and was followed by Louis Rinolfi, POSIPOL chair, who set the scene with a look at the state-of-the-art for producing polarized positrons and a reminder of the scope of the workshop. In the first overview session, Gudrid Moortgat-Pick from CERN stressed the importance of positron polarization for future linear colliders. Both a Compton source and an undulator scheme are being considered for the ILC, as described by KEK's Junji Urakawa and John Sheppard of SLAC respectively. Frank Zimmermann of CERN presented a proposal for a Compton source for CLIC (see Figure 1), demonstrating that the pertinent requirements are much less demanding than they are for the ILC. He also emphasized the large synergy with ongoing developments for a Compton ring for medical applications.

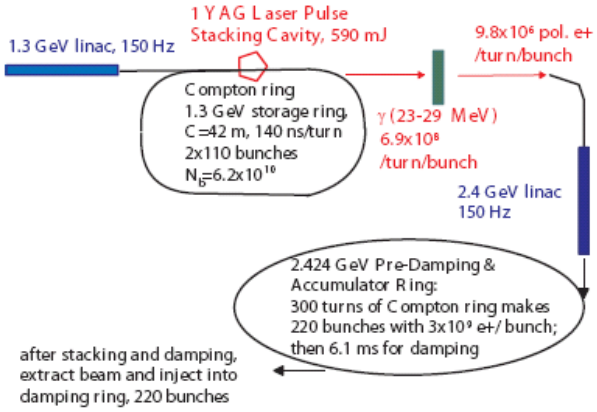


Figure 1: Layout for CLIC scheme

Several talks by Susanna Guidicci of Frascati, Alessandro Variola of LAL and Eugene Bulyak and Peter Gladkikh of the Kharkov Institute for Physics and Technology (KIPT) discussed the beam dynamics and optics designs for Compton rings. One suggestion was to use a pulsed-mode of operation for the Compton ring with a specific technique for radio frequency (RF) phase modulation. Vitaly Yakimenko of Brookhaven National Laboratory described the merits of an alternative single-pass Compton scattering approach involving a high-duty electron linac and a battery of $CO_2$ lasers.

Several talks addressed advances in laser systems, including those by Igor Pogorelsky of Brookhaven, Brent Stuart of Lawrence Livermore National Laboratory, and Sudhir Dixit of Oxford. Yoann Zaouter of Amplitude Systems highlighted the dramatic evolution of fibre lasers over the past decade. Products from Time-Bandwidth, presented by Thomas Ruchti, achieve parameters close to what is needed.

Tsunehiko Omori of KEK presented the first experimental results on polarized positron production using Compton back-scattering at KEK's Accelerator Test Facility (ATF), which have recently been published in *Physical Review Letters*. The E-166 undulator experiment at SLAC also has results, which were described by Andreas Schaelicke of DESY/Zeuthen.

Ian Bailey of the UK's Cockcroft Institute discussed spects of positron production, in particular targets, and described the development of a conversion target. Vladimir Strakhovenko of the Budker Institute for Nuclear Physics presented theoretical calculations of the radiation spectrum and photo-production in a target. Robert Chehab of IN2P3/Lyon and Wei Gai of Argonne National Laboratory addressed the positron production process, in particular matching and capturing positrons downstream of the target. Masao Kuriki of KEK talked about systems considerations for the positron source at the ILC. In partricular construction, commissioning and availability of undulator and Compton schemes.

In the session on equipment and diagnostics, Fabian Zomer of LAL discussed ongoing studies of non-planar optical resonators and Peter Schueler of DESY looked at beam polarimetry issues. A final R&D session focused on optical cavities. Viktor Soskov of IHEP Moscow reviewed R&D on a high-finesse cavity at LAL, and Hiroki Sato of Hiroshima described R&D on an optical cavity for the ILC. Kazuyuki Sakaue of Waseda University, Tokyo, described the experimental plan for X-ray generation using pulse-stacking optical cavity.

At the end of the workshop, POSIPOL participants identified a number of critical issues that still need to be demonstrated, both for positron sources based on an undulator scheme and for the alternative Compton scattering scheme. The two approaches are in principle equivalent, but there are differences in the photon spectrum, photon energies, angular photon spectrum, power on the conversion target, collimation efficiency, operational efficiency, and implementation cost. For the Compton scheme, the photon and positron yields must be simulated with a realistic lattice and energy spread. Many items require further study, including laser systems, 6-D positron distribution, stacking in a pre-damping ring, required RF power, Touschek lifetime, beam instabilities, and the heat-load limit of optical cavities.

The workshop also agreed on a roadmap for future R&D to address the common issues in Compton and undulator sources. Noteworthy common recommendations for the two schemes concern the analysis of the systematic errors in the polarization measurements, the comparison of yields and polarization, the optimization of pre- and post-selection of positrons and the evaluation of the cost.

For the undulator scheme, the main recommendations were the publication of E-166 results, the evaluation of emittance degradation in the undulator and the technical demonstration with an undulator of several metres long. For the Compton scheme, the main recommendations were the publication of the design of a Compton ring with a chicane and with optimization of the energy of the Compton photons, the development of a reliable power laser taking into account the polarization, the simulation of stacking into a damping ring, the comparison of a single-pass scheme with the ring scheme and the comparison of $CO_2$, YAG and fibre lasers.

The workshop also addressed validating design choices and demonstrating feasibility in experiments at KEK's ATF, Brookhaven's ATF and at the DAΦNE storage ring at Frascati. In May, the KEK-ATF Technical Board approved an experimental programme of installing and operating laser pulse-stacking cavities in the ATF damping ring throughout 2006 and 2007. The goal is the simultaneous demonstration of the high enhancement factor that is required by POSIPOL, the small laser spot size, and a small beam-laser collision angle in multi-bunch operation. Optimized optical cavities from LAL may be installed later at the KEK-ATF, enabling the study of high-intensity multi-bunch gamma-ray generation by Compton scattering.

Another new project at KEK would allow accumulation experiments with electron beams. An experimental optimization for the Compton source inside a laser cavity is also foreseen at the Brookhaven ATF, and single-pass Compton collisions could be tested with the drive beam of the CLIC Test Facility 3 at CERN.

Since the POSIPOL workshop, LAL has written a letter of intent concerning R&D activities on polarized positron sources. The idea is to submit a proposal as a Joint Research Activity (JRA-POSIPOL) in the context of the European Framework Programme 7. Several institutes have already expressed their interest: LAL, INFN/Frascati, CERN, DESY Zeuthen, the Institut de Physique Nucléaire de Lyon, the Budker Institute for Nuclear Physics, the National Science Center KIPT, Université-Paris-XI, KEK, Waseda University and Kyoto University,

Further information including all presentations of the POSIPOL workshop can be found at http://www.cern.ch/posipol2006. All detailed recommendations are written in the summary session.

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