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Optimization of an hybrid positron source using channeling

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ABSTRACT

The hybrid positron source made of a crystal-radiator, as a source of channeling radiation, and an amorphous converter is briefly described. Optimization of the heating effects and thermal shocks led to a granular converter made of small tungsten spheres. Simulation results with application to two linear collider projects CLIC and ILC are presented. A test operated with this kind of source at KEK is described and the results gathered last year, reported. Plans for the future are briefly described.

1. Introduction

Needs of high intensity positron sources for future linear colliders lead to important thermal effects due to the high incident powers on the targets [1]. Moreover, the high density of energy deposition in the converter may lead to propagating shocks in the material with, as a consequence, its breakdown: such situation was met for the SLC converter [2]. Solutions to avoid large energy deposition in solid targets consist in separating the generation of photons from the conversion into $e^+ e^-$ pairs. One of them concerns the use of an helical magnetic undulator producing a high rate of polarized photons [3]; the photons are, then, converted in e+e– pairs in a thin amorphous target. If polarization is not foreseen, a planar undulator may be used as a radiator. On the other hand, since many years, theoretical and experimental studies [4–7] have shown the interest to use the large number of photons produced with axial channeling of an ultra-relativistic electron beam in an oriented crystal. It was also possible to reduce the deposited power in the positron converter by using two targets separated by a sweeping magnet; the first one being the crystal-radiator and the second one, the amorphous converter, the so-called *hybrid source* [8,9].

The charged particles exiting from the crystal (e^+e^- pairs) and also what is lasting from the primary e- beam are swept off by the sweeping magnet and do not deposit power in the converter; that is described in reference (8) Further optimization led to the substitution of a granular converter made of small tungsten spheres to the bulk disk [10].

We present, first, a short recall on the main parameters of the hybrid source giving some simulations results; we report also briefly on experimental results at KEK.

2. Main parameters of the hybrid source

The hybrid source (Fig. 1), with a sweeping magnet between radiator and converter taking off the charged particles exiting from the crystal, presents the advantage of lowering the total deposited energy in the converter and its peak maximum density.

Optimization of the parameters of the hybrid source are concerning mainly the choices of the incident electron energy, the crystal and the converter.

The higher the depth of the potential well in the crystal (increasing with Z), the larger would be the radiated energy and the number of photons: the tungsten crystal (W) with an axial

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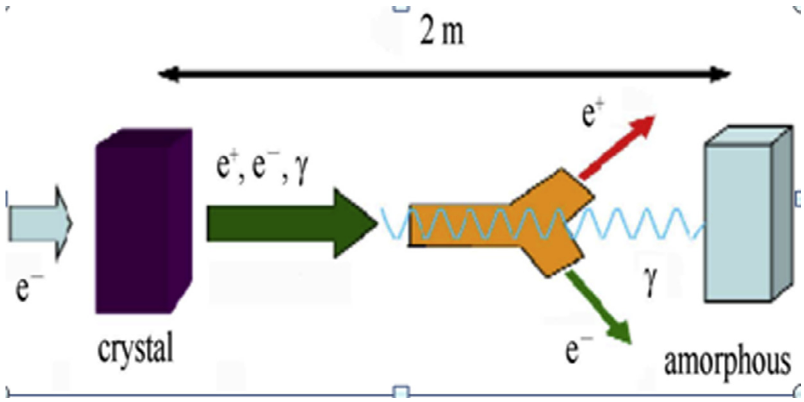

Fig. 1. The hybrid positron source.

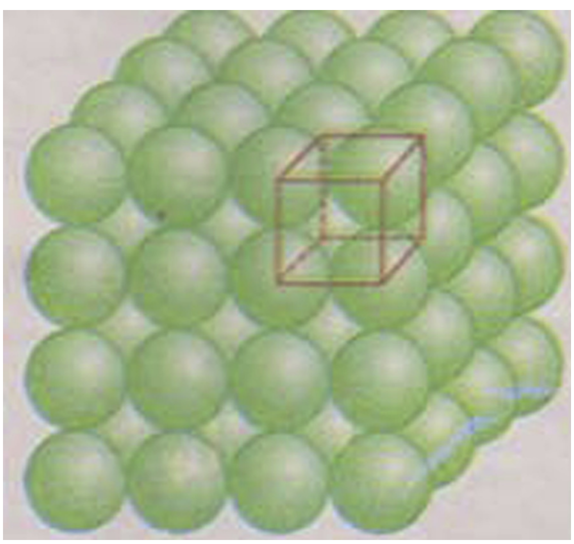

Fig. 2. The granular converter.

potential well of depth Uo ~ 1 kV (for <1 1 1> orientation) at normal temperature (293 K) is our choice. In order to keep the high value of Uo, the deposited energy in the crystal must be limited: so, the crystal is usually thin (~1 mm). The effect of the temperature rise due to the deposited energy is the lowering of the available potential. Simulations have been operated to study this effect [11]. Another important problem is concerning the radiation damages due to the Coulomb scattering of the incident electron beam on the crystal strings. Above a certain fluence displacement of nuclei can occur affecting the crystal structure [12]. The choice of the electron energy is also important: following theoretical studies [13], it is known that for a W crystal there is a threshold for which the radiated energy by channeling I_{ch} is larger than by bremsstrahlung I_{br}, that is, $I_{ch}/I_{br} > 1$ for E = 700 MeV. For other crystals as Si or Ge, this threshold is higher. Concerning the amorphous converter, which is much thicker in order to get a large e+ yield, the heating is more important. In order to mitigate this effect, we may optimize the heat dissipation in the converter and use a rotating target (wheel or pendulum) [14].

We substitute a granular target, made of small spheres (Fig. 2) for which the dissipation in the spheres is proportional to the ratio of the surface on the volume, i.e., proportional to the inverse radius of the spheres, to the amorphous bulk disk.

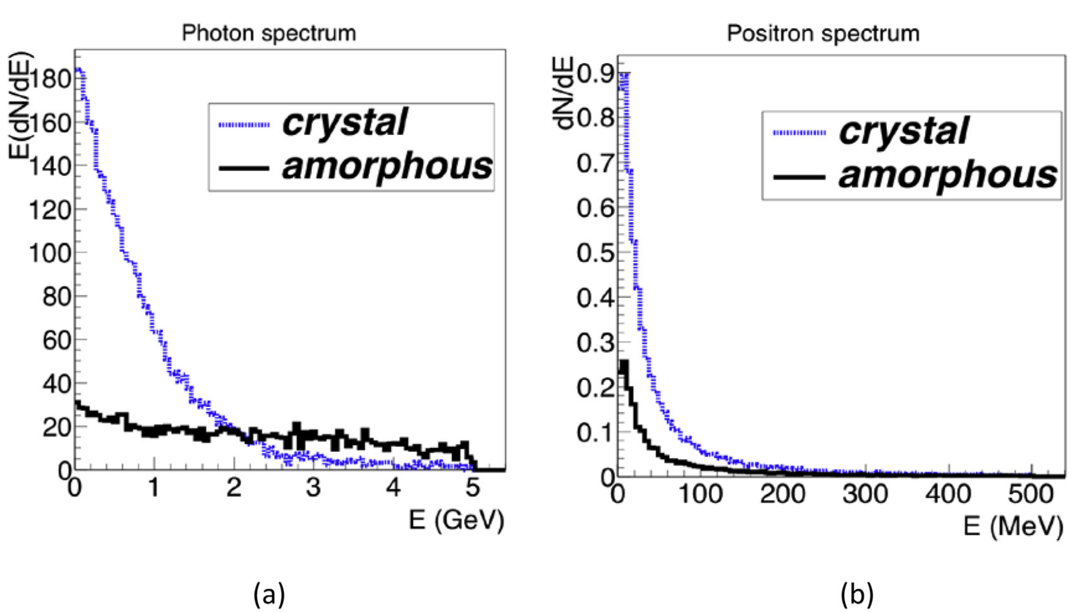

Fig. 3. Photon (a) and positron (b) spectra.