Production of Low Energy Positrons with Synchrotron Radiation

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In the previous report [1] a possibility was pointed out that by installing a high field superconducting wiggler in the SPring-8 storage ring we can generate an intense high-energy γ-ray for the purpose of producing low-energy positrons. In that work the positron yield was estimated with the EGS4 code system [2] and positron emission from a target could not be treated properly. In order to improve this we used a simulation code developed by Kiselev [3] and calculated the positron yield.

A possible configuration of a target-moderator system is shown in Fig. 1. We assumed that (i) the energy of a stored electron beam is 8GeV (ii) the stored current is 100mA (iii) the distance from a superconducting wiggler to a target-moderator system is 35m and (iv) vacuum chamber and magnets are designed appropriately so that one can extract synchrotron radiation (SR) with the horizontal divergence angle of 1mrad. The last two assumptions mean that the horizontal size of the target is set to be 35mm. For the target size we also assumed that the target "depth" in the SR beam direction is 20mm. For the target thickness in the vertical direction, we varied its value from 0.25mm to 2mm. The results of the calculations are shown in Table 1 for a lead target.

Note that the numbers in the last column of this table must be multiplied by a factor that represents the efficiency of moderation. Since typical values of this factor are $(0.1-7) \times 10^{-3}$ [4], we can expect that by using a good moderator system we will obtain about 10^9-10^{10}[slow-e^+/s] for 8–12T wigglers per 1mrad of the orbit arc.

It should be pointed out that the method of using SR has the following advantages: (i) Radiation hazard is drastically reduced and induced radio-activity of a target-moderator system is eliminated. (ii) Cooling of a target is easy. (iii) Life of a target is long. (iv) It is possible to provide 5-10 slow-positron beamlines with a single superconducting wiggler if the vacuum chamber and magnets are designed suitably for extracting a widely spread SR beam. (v) High-energy SR photons can be used not only for positron production but also for other purposes such as γ-ray spectroscopy. (vi) Since SR photons with finite vertical angles are elliptically polarized, it is possible to obtain polarized positron beams by using such photons. For example, photons emitted with a vertical angle of 0.02mrad have a degree of polarization of about 50%. In order to realize a highly-polarized positron beam, however, it is required to select positrons whose energies are near the kinematically allowed maximum value [5], and further studies are necessary for this. (vii) The low-energy positron beam and the SR beam can be used at the same time. This offers us a new and very unique method of analyzing substances [6].

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References

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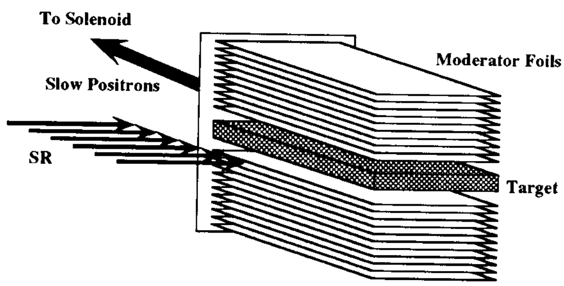

Fig. 1. A possible scheme of positron production and moderation.

Table 1. Positron production efficiency for 8, 10 and 12T wigglers. The target is lead with the size (35mm×20mm×thickness). The third column is the total number of incident photons, and the last column is the total number of positrons emitted from the target. The fourth column is the ratio of the number of positrons produced in the target to the number of incident photons, and the fifth column is the ratio for positrons emitted from the target.

Wiggler field [T]	Target thickness [mm]	Photon number [s^{-1}]	Positrons/Photon (produced)	Positrons/Photon (emitted)	Positron number [s^{-1}]
8	2.0	6.22×10^{14}	1.8×10^{-2}	2.0×10^{-4}	1.2×10^{11}
	1.0	3.83×10^{14}	1.9×10^{-2}	9.7×10^{-4}	3.7×10^{11}
	0.5	2.03×10^{14}	2.1×10^{-2}	2.5×10^{-3}	5.0×10^{11}
	0.25	1.03×10^{14}	1.8×10^{-2}	3.2×10^{-3}	3.3×10^{11}
10	2.0	1.20×10^{15}	2.5×10^{-2}	6.3×10^{-4}	7.6×10^{11}
	1.0	7.15×10^{14}	2.4×10^{-2}	1.3×10^{-3}	9.5×10^{11}
	0.5	3.75×10^{14}	2.6×10^{-2}	3.3×10^{-3}	1.2×10^{12}
	0.25	1.89×10^{14}	2.5×10^{-2}	6.5×10^{-3}	1.2×10^{12}
12	2.0	1.86×10^{15}	3.0×10^{-2}	7.0×10^{-4}	1.3×10^{12}
	1.0	1.08×10^{15}	3.2×10^{-2}	3.0×10^{-3}	3.2×10^{12}
	0.5	5.64×10^{14}	3.0×10^{-2}	4.1×10^{-3}	2.3×10^{12}
	0.25	2.85×10^{14}	3.0×10^{-2}	7.9×10^{-3}	2.2×10^{12}