Slow Positron Target Concepts for the Advanced Photon Source (APS) Linear Accelerator

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Abstract The APS linear accelerator (linac) system [1,2] consists of a 200-MeV, 2856-MHz S-band electron linac, followed by a 450-MeV positron linac. The linac is available for other uses upon completion of the storage ring injection cycle. Nominal linac beam power is 480 W but the power can be increased substantially, making it suitable for production of slow positrons. Simulation studies for the design of a slow-positron target-moderator system that is optimized for operation with the APS linac are presented. Results of simulations of various target configurations indicate that a suitably designed multilayer target can result in a higher positron yield than a single-block target. Use of an integrated, multilayer target moderator is suggested. Some possibilities for extracting slow positrons between target layers by means of electromagnetic fields are discussed. First results from recent accelerator studies aimed at increasing the linac beam power are also presented.

1 Introduction

Slow positrons are valuable tools in atomic physics, materials science, and solid state physics research. They can be used to probe defects in metals, to study Fermi surfaces and material surfaces and interfaces, and to obtain detailed information about the electronic structure of materials. Positrons can be used to obtain information complementary to that obtained by other means. Slow positrons are emitted by some radioactive sources and can also be obtained by moderating the positrons produced by bremsstrahlung when an accelerator beam hits a high-Z target. In our case, an intense electron beam impinges on a tungsten target. The fast positrons are then moderated by a series of foils with a negative work-function for positrons. Positrons emitted from the moderator are captured and transported to an experimental area by electromagnetic fields. The number of positrons that can be delivered to an experiment is a function of the incident accelerator beam power, the target material and geometry, moderator efficiency, and the capture and transport efficiency.

Some initial concepts for the design of a target that is optimized for slow-positron production are discussed, and simulation results are presented. We compare the positron yield obtained from simulations of various target configurations for a fixed beam power and energy. Our integrated target-moderator concept, when combined with an efficient extraction and transport system, can result in a high-intensity slow positron source.

The APS linac beam could be used to produce slow positrons during the hours between storage ring injection cycles or top-up operations. The linac as well as results of the first beam tests aimed at increasing the beam power are briefly described.

2 Simulations

Computer simulations of several target configurations were performed using the electromagnetic shower code EGS4 [3], in order to optimize the target-moderator design parameters. In the simulations, a pencil beam of electrons was incident perpendicular to the basis of a tungsten cylinder. The beam power was fixed at 800 W and the incident electron energy was 400 MeV. We