ANL/ASD/CP97408

A Low-Neutron-Background Slow-Positron Source*

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SEP 28 1999
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Abstract. The addition of a thermionic rf gun [1] and a photocathode rf gun will allow the Advanced Photon Source (APS) linear accelerator (linac) [2] [3] to become a free-electron laser (FEL) driver [4]. As the FEL project progresses, the existing high-charge DC thermionic gun will no longer be critical to APS operation and could be used to generate high-energy or low-energy electrons to drive a slow-positron source. We investigated possibilities to create a useful low-energy source that could operate semi-independently and would have a low neutron background.

I. INTRODUCTION

The APS electron linac was designed to accelerate 30-ns-long pulses containing 50 nC of charge to an energy of 200 MeV. The 500-W beam impinges on a 7-mm-thick water-cooled tungsten converter target and the resulting positrons are further accelerated to 450 MeV. The nominal electron beam power can be increased either by increasing the quantity of accelerated charge or by increasing the beam energy. Slow-positron production rates at the APS linac for a 400-MeV electron beam were estimated to be 3×10^{11} positrons per second with an optimized five-layer target [5], [6]. High-energy drive beams result in high beam power and high positron-production rates at moderate current, thus reducing space charge effects. Accelerator studies indicate that the APS linac could produce up to 35 kW of beam power when run at high energy and in long-pulse mode [7]. The clear disadvantage of high-energy electron beams is the potential for severe component activation near the target. Activation can be reduced if the driving electron beam energy is low but still adequate for electron-positron pair production. Few of the photons will be energetic enough to generate photoneutrons. The neutron yield per incident electron in a high-Z target is low for energies below 14 MeV. The photoneutron cross-section for tungsten is about 400 mb for 14-MeV photons and becomes negligible for photons of energy less than 6 MeV [8]. For one-radiation-length-thick targets, measurements indicate that there are 2.5×10^{-4} neutrons per 14-MeV electron [9].

The linac is being upgraded with a new low-emittance injector to drive an FEL, thus the original injector elements could be used for slow-positron production. Positron yield can be increased by optimizing the target design for a given beam power. A candidate target geometry for 14-MeV electrons was chosen and was optimized by simulation.

* Work supported by U.S. Department of Energy, Office of Basic Energy Sciences under Contract No. W-31-109-ENG-38.