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CONCEPTS FOR A SLOW-POSITRON TARGET AT THE ADVANCED PHOTON SOURCE

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Abstract
The Advanced Photon Source (APS) [1,2] linear accelerator beam could be used to produce slow positrons during the hours between the storage ring injection cycles. Initial concepts for the design of a target that is optimized for slow-positron production are discussed, and simulation results are presented. Some possible ways to increase the nominal linac beam power for improved slow-positron production are also discussed.

1 INTRODUCTION

Slow positrons are valuable tools in atomic physics, materials science, and solid state physics research. Slow positrons can be used: 1) to probe defects in metals, as positrons are repelled by ionized atoms and may be captured at vacancies; 2) to study Fermi surfaces through analysis of photons generated by positron/electron annihilation; and 3) to study surfaces and interfaces of materials through analysis of energy losses, diffraction, and reemission of positrons from surfaces or interfaces.

Slow positrons can be emitted by radioisotope sources or they can be obtained by moderating the positrons produced by accelerator beams. Normally, an intense electron beam impinges on a target made of a high atomic number material, such as tungsten or tantalum. Positron production occurs as a result of bremsstrahlung interactions, and the positrons are then moderated by a series of foils that have a negative work-function for positrons. Positrons emitted from the moderator are then 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 beam power, target material and geometry, moderator efficiency, and slow positron capture and transport efficiency.

The APS linac beam could be used to produce slow positrons during the hours between storage ring injection cycles or top-off operations. The linac and some possible ways of increasing its beam power are discussed.

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. Finally, we present an integrated target-moderator concept that will result in a high-intensity slow positron source, when combined with an efficient extraction and transport system.

2 THE APS LINAC

The APS electron linac accelerates 30-ns-long pulses containing 50 nC of charge to an energy of 200 MeV. The resulting 500-W electron beam impinges on a 7-mm-thick water-cooled tungsten target that serves as a positron converter. Pair-produced positrons and electrons are refocused by a 1.5-T pulsed coil and directed into the positron linac where, during normal operation, they are captured and accelerated to 450 MeV. Linac design parameters are listed in Table 1, together with achieved performance values.

The nominal electron beam power of 500 W can be increased for slow positron production purposes by increasing the nominal pulse length of 30 ns and by increasing the effective repetition rate.

The upstream accelerating structure in each linac is directly powered by a 35-MW klystron, while the remaining structures are powered in groups of four by a klystron and SLED (SLAC Energy Doubler) cavity assembly. The SLED cavities can be detuned, thereby allowing the full klystron pulse, nominally 5 μs, to be used. The beam energy with SLEDs detuned but without heavy beam loading was measured to be about 400 MeV. Measurements to determine the maximum accelerated pulse length with reasonable energy spread are scheduled. A new pulser design that allows re-firing of the gun 1 μs after the end of the first beam pulse is under consideration.

The linac repetition rate is limited to 60 Hz by the present modulator's resonant-charging system design; however constant-current power supplies that could also allow a faster rate are presently being tested [3].

Table 1: Linac Performance Summary

	Design	Achieved	Units
Energy on Target	200	240	MeV
Gun Pulse Length	30 ns	> 1 μs	
Current on Target	1.7	> 2	A
Rf Rate	60	60	Hz
e^- Energy Spread	± 8	≤ ± 8	%
e^+ Emittance	≤ 1.2	≤ 1.2	mm mrad
e^+ Energy	450	458	MeV
e^+ Current	8	14	mA
e^+ Energy Spread	± 1	≤ ± 1.6	%