STATUS OF THE UCLA PEGASUS LABORATORY*

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Abstract

The PEGASUS laboratory is a versatile radiation facility dedicated to the advancement of novel concepts in beam physics. The installation of a new LaB_6 cathode will allow for both thermionic emission and photoinjection operation. The PEGASUS plane wave transformer injector has been conditioned to 20 MW of RF power. Recent operations show a 15 MeV dark current beam that will be used for beam radiation studies. An upgrade to the drive laser system has been explored and will be realized shortly. This paper will describe and report the status of the various subsystems of the PEGASUS laboratory and outline the experiments underway, such as innovative beam instrumentation, surface effects in optical transition radiation, Thomson scattering, and waveguide SASE FEL.

INTRODUCTION

The PEGASUS (Photoelectron Generated Amplified Spontaneous Radiation Source) beam-radiation laboratory has been commisioned at UCLA. The long-term goal of PEGASUS is the study of SASE FEL physics and other beam-radiation interactions. The current experiment in progress at PEGASUS is the study and imaging of optical transition radiation from various surfaces. Thomson Scattering, and other radiative processes, will be examined at PEGASUS in the following months.

PEGASUS is a linac-based electron beam radiation laboratory. The present injector consists of the Plane Wave Transformer (PWT) Injector [1]. The existing design of the cathode supports the opertion of thermionic emission and photoinjection. Table 1 shows the relevant beam parameters for the photoinjection mode.

Table 1: Pegasus Design Parameters (Photoinjection mode)

Parameter	Value
Energy	12-18 MeV
Energy Spread	0.15%
Emittance	$\leq$ 4 mm-mrad
Bunch Charge	1 nC
Bunch Length	1 mm
Beam Size	150 μm
Undulator Parameter	1.05
Undulator Period	20.5 mm

* Work supported by DOE grant DE-FG03-98ER45693

LABORATORY DESCRIPTION

RF Injector

The PWT gun is a novel standing-wave S-band electron source that is designed to provide 1 nC, 17 MeV electron beams. The peak gradient is expected to be 60 MV/m. The PWT has a compact design, allowing a simple emittance compensation solenoid. At present, a LaB_6 cathode serves as the electron source via thermionic emission. Other cathodes to be tested at PEGASUS will include OHFC copper, single crystal copper, and Cs_2Te.

Thermionic Emitter The PWT allows for insertable and removable cathodes. The current cathode assembly entails a LaB_6 thermionic cathode heated conductively by a UHV substrate cartridge heater. Thermionic cathodes are desirable for high (accumulated) charge applications, such as transition radiation [2]. The thermionic cathode provides a quick and cost efficient method of generating beam charges up to the 1 nC level. Initial observations show that the heater has achieved operating temperatures between 1000°C - 1200°C, corresponding to an operating power of 5-6 Watts and an operating thermionic DC current of approximately 400 μA [3].

Photocathode Drive Laser

A drive laser system has been designed and will be procured from commercial sources in the near term. The laser is based on Ti:S to allow for femtosecond beam - laser interactions. A terawatt class amplifier is envisioned as an eventual extension for Thomson scattering and other radiative processes. The drive laser and terawatt system are further described in these proceedings [1].

RF Power System

The RF system is designed to supply 20 MW of power to the PWT injector. A small amount of the 89.25 MHz mode-locker RF from the laser oscillator is fed into a phase locked oscillator running at 2.856 GHz. Final amplification of the signal is made by a SLAC XK5 klystron. The 20 MW of RF power is transported to the PWT by a SF_6 filled Al waveguide system. Large reflected voltages, from the standing wave PWT structure, are absorbed by a high power ferromagnetic isolator [4].

Undulator

The PEGASUS undulator is available for FEL and undulator studies. The device a tapered, 2m long, planar magnet

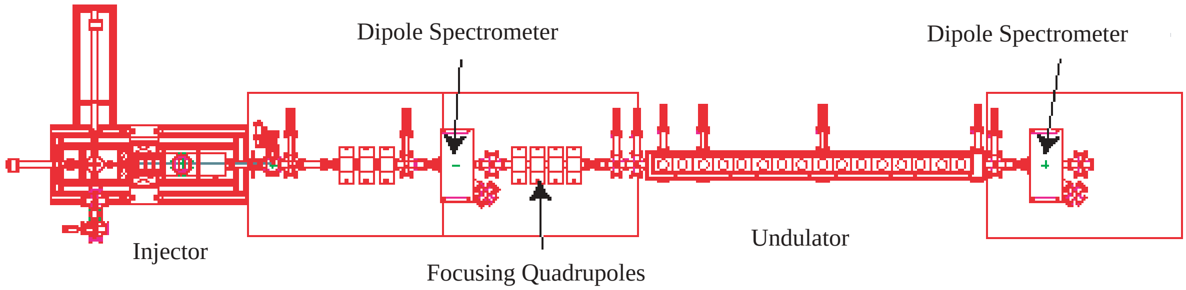

Figure 1: CAD Drawing of the PEGASUS Beamline.

undulator with a 20.5 mm period and K = 1.05. The undulator was constructed in collaboration with the Kurchatov Institute. SASE was first observed with it at LANL [5]. A pulsed wire apparatus developed at UCLA was used successfully in the UCLA/LANL experiment. This apparatus allows for multipole B-field measurements, and thereby facilitates alignment and quantification of the undulator parameter.

Experimental Diagnostics

Beam energy and energy spread are measured in the dispersive section after the dipole spectrometer. Beam charge is determined using impedance matched stripline sum-signals and Faraday cup beam dumps. Both charge and energy measurements are made in two locations, before and after the undulator. Throughout the beamline, beam position and size are monitored using YAG crystals imaged with CCD cameras. Intra-undulator measurements are conducted in a similar fashion. Emittance measurements are made via the quadrupole scanning technique. The focusing quadrupoles and dipole spectrometers were designed, fabricated and characterized at UCLA to meet laboratory specifications.

EXPERIMENTS

Optical Transition Radiation

An extended analytical model for optical transition radiation (OTR) has been developed [6]. Of particular interest is OTR from non-standard generic surfaces, which include arbitrary modulated surfaces in a limited plane. The results for a 17 MeV beam will be compared with the predicted analysis for parabolic, grating, and Fresnel surfaces. A thermioinic emitter is advantageous for this study since it provides the required high integrated charge beams to be intercepted by the various targets. A high resolution, color digital camera is used for spectral analysis. In the initial runs, rough ($\geq 2\lambda$) and smooth ($\lambda/4$) aluminum and copper surfaces were used to intercept the beam, where λ is the radiation wavelength ($\approx 1\mu$m) .

SASE FEL Physics

SASE FEL studies will revolve around the 2m IR FEL undulator. Although the beam provided by the PWT would not drive the FEL to saturation, GENESIS 1.3 simulations show that the addition of a 1 mm square waveguide will significantly enhance gain and reduce the saturation length by about 30 % [7]. Insertion of a commercially available waveguide in the undulator has been investigated. The waveguide will enhance FEL performance by compensating for diffractive effects, eventually yielding saturation. Of particular interest is the purity of the waveguide mode as well as the power losses of the proposed hollow glass waveguide [8].

Thomson Scattering

The installation of an upgraded drive laser system will facilitate the study of electron beam - laser beam interactions. Calculations show that with existing PEGASUS parameters, and a UV pulse length of 100 fs and peak power 1TW, the tunable x-ray pulse will have a photon flux of up to 10^8 photons per pulse (at 180° incident angle) and radiation wavelength of 2.2 Å[9].

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