OPERATION OF THE APS PHOTOINJECTOR DRIVE LASER SYSTEM

Yuelin Li

December 2004

Abstract

The APS photoinjector drive laser system has been in operation since 1999 and is achieving a performance level exceeding the requirement of stable operation of the LEUTL FEL system. One remarkable number is the UV energy stability of better than 2% rms, sometimes less than 1% rms. This report summarizes the operation experience of the laser system and the improvements made along the way. We also outline the route of upgrade of the system and some frontier laser research and development opportunities in ultrabright electron beam generation.

I. Introduction

A photoinjector is the only way to generate the high-brightness beams required by fourth-generation light sources. However, most of the existing photoinjector drive laser systems, the starting point of everything, are obsolete flash-lamp-pumped systems [1], including the GTF drive laser at SLAC and the ATF drive laser at BNL. Funding constraints limit the near-term possibility of replacing these lasers with diode-pumped drivers, hence it is important to understand the common pitfalls and maintain these systems so they can efficiently support the research on high-brightness beams and future light sources.

The APS photoinjector drive laser (APSPDL), in particular, is a glass laser that has significant thermal lensing effects associated with the poor thermal conductivity of the glass, which limit the achievable performance. Despite all the problems we encountered in the past few years, the APSPDL has been a workhorse for the operation of the LEUTL FEL system, leading to the demonstration of optical SASE FEL [2], demonstration of saturation operation of a SASE FEL [3], thorough characterization of the SASE FEL pulse [4-7] and some exciting applications [8]. The system is operating with a performance exceeding the requirement of the FEL operation.

II. The APS Laser System

2.1 The laser system

The APS laser system, consisting of a Time-Bandwidth Product GLX-200 oscillator and a Positive Light flash-lamp-pumped Nd:Glass amplifier, is a generic chirped-pulse amplification (CPA) system. In a CPA system, the short pulse from the oscillator is first stretched and then amplified and recompressed. The recompressed infrared (IR) pulse at 1053 nm is subsequently frequency-quadrupled to obtain the ultraviolet (UV) pulse at 263 nm. The UV pulse is relayed to the cathode of the photoinjector to generate the electron beam.

A block diagram of the APSPDL is shown in Fig. 1. The basic operational parameters of the system are listed in Table 1.