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GUI DEVELOPMENT FOR THE DRIVE LASER AT FERMILAB'S ASTA FACILITY*

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Abstract

A comprehensive set of graphical user interfaces is being developed for the drive laser of the Advanced Superconducting Test Accelerator (ASTA) facility at Fermilab. These interfaces have been designed in Synoptic, a Java-based GUI development platform with credential-dependent access to the Fermilab accelerator controls network. Such implementation facilitates the user's ability to monitor and control many aspects of the drive laser system in an intuitive environment, as well as timely updates on the part of the developers made necessary by the evolving drive laser system. Furthermore, the current interface hierarchy readily allows integration into the larger pool of Synoptic applications being developed for other subsystems at ASTA.

CONTROLS AND SYNOPTIC

As with most accelerator systems at Fermilab, ASTA relies upon ACNET, the Fermilab accelerator controls platform, to coordinate operations between the various subsystems. Upon completion of installation, ASTA facility subsystems will include the drive laser, the normal-conducting RF gun, a number of super-conducting RF structures, various beamline components, and support utilities including low-conductivity water and cryogenics. As a prototypical accelerator facility, ASTA has been and will continue to be subject to constant change as development requires. This, in turn, requires flexibility in the controls applications to provide an adequately comprehensive overview while avoiding short-term obsolescence.

Synoptic [1], a Java-based GUI platform similar to DESY's JDDD [2], was chosen to address this concern in the development of controls interfaces used at ASTA. Written at Fermilab to interface with ACNET, Synoptic is able to interact with all subsystems through the basic control object, or ACNET device. Devices can include any of the following properties: analog control and readback, digital control and readback, digital status, and digital or analog alarms. The front-end (VME, VXI, Linux PC, etc) hosting a given device will either use any inputs internally or it will act as a bridge, executing commands on an external instrument. This saves an applications programmer from writing the command interface for each of these instruments. In addition, Accelerator Command Language [3] (ACL) scripts can be executed through synoptic displays allowing for more complex, adaptive, or persistent logic.

DRIVE LASER SYNOPTICS

The ASTA drive laser system is no exception to the challenge presented by rapid development, and as such the associated Synoptic displays have undergone frequent updates to remain useful as a tool for both reference and control. Most of the changes made throughout the development process have been made to the main optics table, a 16'-long optical bench that hosts the Infrared (IR) seed lasers, IR amplification sections, IR to Ultraviolet (UV) conversion section, and various beam diagnostics. Other minor changes have also been made to the laser transport and cathode optics sections. As seen in Fig. 1, the 1054 nm IR laser originates from either a Calmar Yb-FA laser, or a Time-Bandwidth GE-100 Nd:YLF laser. These act as seed lasers, intensified through several YLF-crystal amplification stages before frequency conversion, first to green at 526 nm before conversion to UV at 263 nm, transport, and impinging on the Cs_2Te-coated Mo cathode of the photoelectron gun. [4]

Changes made to this display since its inception include addition of the Time-Bandwidth seed laser, replacement of a YLF-based, multipass-amplification cavity section with three YLF-based, single-pass stages with common timing referred to as the preamplifier, and various beam path changes to accommodate adjustments in the optics (including lenses, isolators, and diagnostics such as photodiodes and the radiometer). Each of the display changes started with adjustments to the background image. Created as an SVG graphic in Inkscape and exported to a PNG image, work is underway to allow the import of SVG graphics directly into the Synoptic development environment. This would allow for a much higher degree of dynamic content, providing a mechanism, for example, to make portions of the beam to be visible or invisible when shutters are open or closed. Once the background is updated, active components- including readbacks, digital status, and buttons- are updated, adding, changing, or removing each as necessary before the display is committed.

Existing Display Features

The main display (Fig. 1) in particular hosts a number of unique controls made possible by recent developments in the Synoptic platform and ACNET, namely the ability to launch ACL scripts directly from synoptic displays as well as launching ACL scripts based

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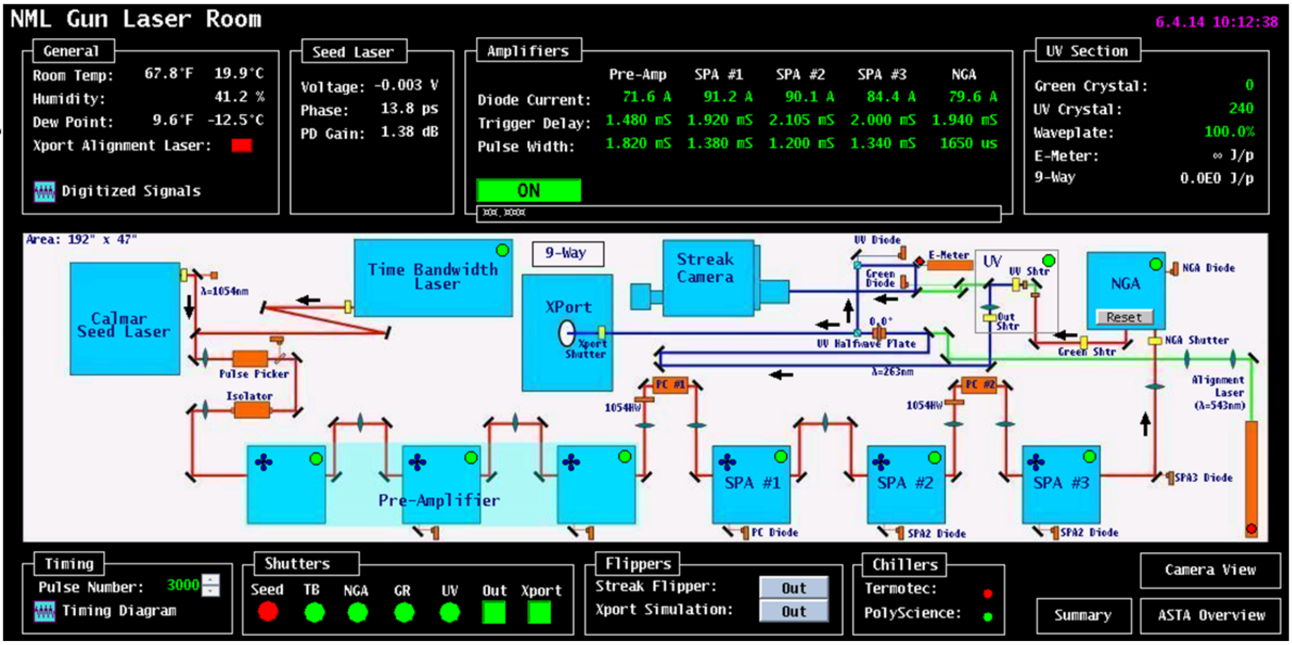

Figure 1: The Main Laser Synoptic for the ASTA electron gun drive laser.

on ACNET device settings. These controls include the laser toggle ('on' button), the alignment laser button, and the bunch number control, each of which rely on ACL to perform a number of steps. The laser toggle triggers an ACL script directly, which checks for status on the amplifier water chiller before turning on and setting appropriate currents for each of the single-pass amplifiers. By triggering the ACL script directly, feedback is given on whether the script completed or if there was an error, indicative of a controls issue. The alignment laser script spawns a persistent script, which waits one hour before turning the alignment laser back off to prevent the alignment laser from being left powered, unused, for extended periods of time.

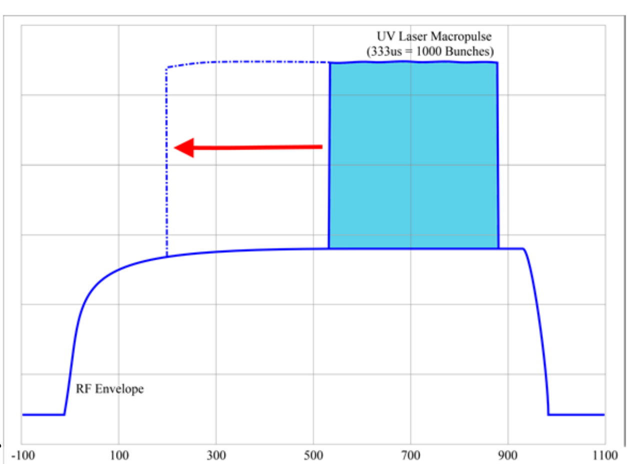

Figure 2: A schematic showing placement of the UV laser with respect to the Gun RF envelope in time with a scale of μs. The UV macropulse is fixed near the end of the gun pulse and the timing of the leading edge is adjusted towards the front of the gun pulse as more bunches are requested.

The bunch selection control adjusts an ACNET device, N:LGPN. Changing this device to the desired number of bunches triggers a script in turn to adjust a number of devices that control laser timing. Once the number of pulses is limited by the programmed flattop period of the gun RF, the pulse controller timing is adjusted, setting the number of 3 MHz bunches allowed through the first and second 'Pulse Cleaner' Pockels cells (PC #1 and #2), as seen in Fig. 1. The various amplifier diode timer widths are then adjusted to limit free-lasing and maximize diode lifetime for each of the amplification stages. Finally the overall laser timing with respect to the gun RF pulse is adjusted to impinge the laser onto the cathode such that the pulse train ends a fixed period from the end of the gun flattop to ensure stability, as seen in Fig. 2.

Other, more-rudimentary controls and status readback on the main page include status summations for each of the amplification stages and a summation of the shutters to provide at-a-glance verification that each of these are prepared for nominal operation. The wave plate control, is a somewhat more involved expression according to Equation 1, that converts the ACNET device N:LGUVW from degrees to a percentage of the UV transmitted through the first polarized cube following the UV halfwave plate ($W_{\%}$) in Fig. 1. This conversion is not currently one of the default transformation types allowed for ACNET devices, so it was created using two expression components in order to make the necessary conversions to read and set the device.

$$W_{\%} = \frac{1}{2} + \left[\frac{1}{2} \times cos\left(\frac{\pi}{180} \times N\!:\!LGUVW\right)\right] \quad (1)$$

Display Interconnectivity

Flow is provided by interconnecting a number of synoptic displays using hyperlinks within the display

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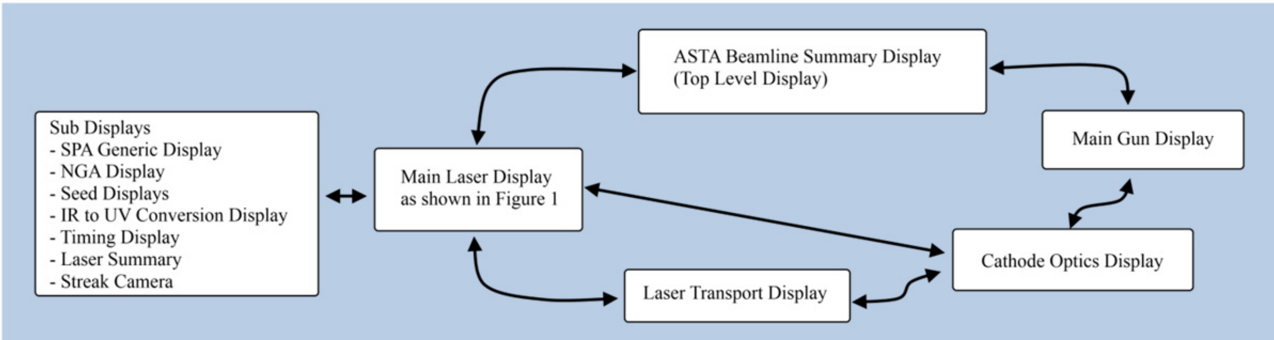

Figure 3: A block diagram of links between the various laser synoptic displays and associated systems. The links are URIs that connect the various displays shown in either the Java or HTML display environments. The Main Gun Display controls the Photoelectron Gun, representing the next major beamline component, with its own set of Synoptic displays.

environment. This streamlines the control process, making operation more intuitive to a non-expert user. From the main ASTA summary page, selecting the laser opens the main display shown in Fig. 1. From there displays to show more detail can be launched for each of the amplification sections (a generic display based on the ACNET device nomenclature for each of the amplifiers), the seed lasers, the frequency-conversion section, the streak camera, and a summary display. From the main display, the user can follow the beam path from its source seed laser to the UV laser transport, which is launched into a display of its own and likewise on to the cathode optics section, located in the ASTA cave at the 9-way cross roughly one meter downstream of the gun. This general flow is detailed in Fig. 3. Each of these displays can be launched either through the ACNET controls system or with a web browser to allow for remote monitoring.

A prime example of a single-purpose display, the streak camera display, offers control over the most commonly-used functions of the Hamamatsu streak camera on the main laser table, including control of the MCP gain, locking and setting the range of the synchroscan unit, and

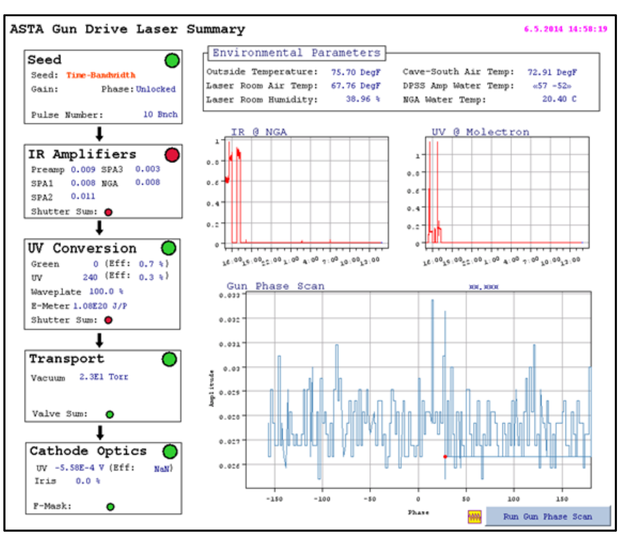

Figure 4: The summary display shows selected information to indicate overall health of the laser system.

toggling power to the unit, as well as offering logical loops to protect the streak tube. It is planned that this display will be converted to a general display, like the single-pass amplifier display, making it suitable for use with either the ASTA laser lab streak camera, or the planned 50 MeV experimental beam-line streak camera.

Also unlike the main laser page, or any of the other associated laser synoptic displays, the summary display (Fig. 4) shows selected information for the entire laser system to give a complete overview of laser health. This includes sampled maxima from photodiodes monitoring the IR, Green, and UV sections as well as shutter status, amplifier status, transport vacuum, and other subsystems that could potentially prevent the laser from reaching the gun photocathode.

CONCLUSION

As ASTA commissioning continues, Synoptic is expected to play a vital part by allowing for rapid and flexible updates to controls applications, not only for the laser system but for ASTA in its entirety. By keeping pace with improvements made to the laser system, more-informed decisions can be made with regards to the gun drive laser, as well as downstream beamline components as the suite of synoptic displays continues development.

ACKNOWLEDGMENTS

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REFERENCES

[1] Synoptic Webpage: http://synoptic.fnal.gov/
[2] DESY JDDD Webpage: http://jddd.desy.de/
[3] ACL Introduction Webpage: http://www-ad.fnal.gov/help/ul_acl/intro_acl.html
[4] P. Garbincius et al., "Proposal for an Accelerator R&D User Facility at Fermilab's Advanced Superconducting Test Accelerator (ASTA)," Fermilab-TM-2568, 2013.