Gemini control system

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Introduction

During the last year as Gemini has come on line it has been necessary to upgrade the control system from its fundamental single target area condition, to supply high power pulses to two target areas. This has introduced some conflicting operational modes and included the adding the ability to smoothly switch between single and double passing the stretcher, integrating control of the Quantel pump lasers, adding controls to the wireless pad, integration with the diagnostics to ensure the data is saved with correct shot number etc. The basic infrastructure was described in last year's report [1]. This article outlines the main work undertaken to upgrade the system in readiness for Gemini.

Single and double stretching

To amplify pulses to their full energy without unwanted non-linear effects the optical system was redesigned to 'double stretch' the Gemini pulses by building the stretcher into an optical cavity and switching the pulses out after two passes with a Pockels cell [2]. Pulses for TA2 would only be stretched once. Thus it is necessary for the control system to retime the switch-out Pockels cell to give either a single or double pass.

However, this gives a conflict of interest since both TA2 and Gemini users would prefer to receive pulses of the correct pulse length. The software was initially written to prioritize the correct pulse length for laser shots, but during simultaneous low power setup in both areas then a compromise has to be made with only one area receiving the correct stretch. This approach was found impractical for everyday operations and an alternative was needed. Thus to allow both areas to obtain pulses of the correct stretch a compromise had to be made, namely the loss of 10 Hz operation. To minimize the need for operator intervention the software was changed so that when the target area reprate dropped to 1 shot in 4 (2.5 Hz) then the correct pulse length was automatically given. An additional mode allowing the laser operator to alternate between pulse lengths was also added.

Originally the single/double pass retiming was achieved using a GHz relay, however due to their limited lifetime and the new 2.5 Hz switching it was redesigned using TTL technology so that pulse length could be selected on a shot by shot basis. To simplify the electrical system the acousto-optic modulator (Dazzler) used to compensate for high-order spectral phase changes in the laser chain was linked to the pulse stretch.

The automatic alignment system was originally set to align on both singly and doubly stretched pulses. However if the stretcher cavity is misaligned then the alignment system is unable to correct for this and the two corrections fight against one another. To avoid this the system is now aligned on either the single or double stretched pulses and this is selected manually from the laser room.

Shot control/numbering and energy control

The Astra drive system was duplicated for use in Gemini. An additional form was added to allow the users to request and control the energy on target shots. To give a wide range of energies it was necessary to control both the input energy (via the waveplate) and the pump energy. This was done by adding a single slider for each amplifier. At the lower end of the scale the Quantels are run at half energy and the input reduced by turning down the waveplate. To increase the power the waveplate is first rotated to increase the input from amp 3 and then the Quantel energy is ramped up.

To cope with High Power, Full Power and Quantel shots the control system was written to use two separate shot numbers, Quantel shot and Laser shot number. High power and Full Power have a Laser shot number, whilst Full power and Quantel shots have a Quantel shot number. Thus different shot types require different shot numbers to be incremented. These numbers are saved locally and sent to the diagnostic PCs just before every shot.

When a shot is fired it is important to keep a record mapping the corresponding shot numbers as well as other laser parameters that may affect the laser performance. e.g. Quantel settings and waveplate position. These are integrated into the Gemini/eScience project [3] to be automatically saved in the Gemini database. Initially this was done locally with the control PC generating the necessary XML metadata files and copying them across to the data server. However this process increased the software cycle time over the 100 mS limit needed to keep in sync with the 10 Hz laser. Thus a separate UDP (User Datagram Protocol)-metadata conversion program was written and run on a second PC. This enabled the shot metadata to be rapidly sent as UDP packets within the 100 mS limit.

Much of the users data is in the form of parameter scans where the laser parameters are kept constant and one variable is gradually altered. To speed these scans they are increasingly being computerised with a shot sequence being taken on the touch of a button. To allow this to be fully automated the control system was modified to accept external 'fire' commands over the network.

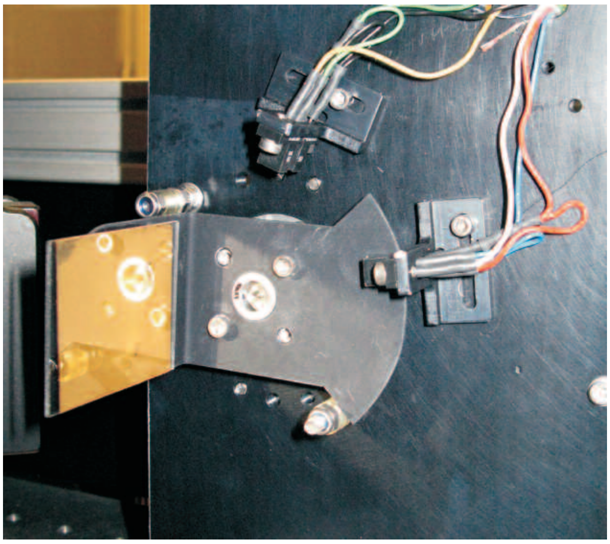

Figure 1. Low inertia blade with gold reflector capable of selecting a single 10 Hz pulse.

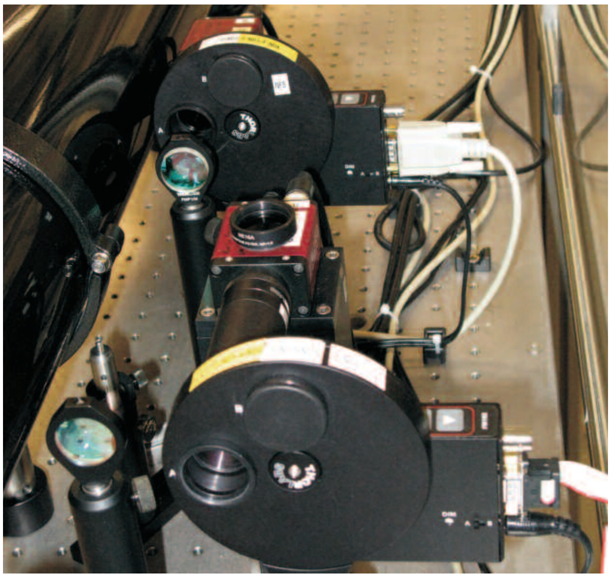

Figure 2. Filter wheels installed to automatically attenuate pulse on high power shots.

Additional control hardware

Since the last report the fast shutter has been redesigned to be lighter by simply bending the blade at ninety degrees to reduce its moment of inertia and lessen the vibrations (figure 1).

The original design featured an anodized blade to block the beam. This was found to over heat and cause turbulence problems in the transmitted beam when the shutter heated up and was opened for a single shot. Tests with a polished stainless steel blade were initially promising, but the metal was tarnished within a few days. An eventual solution was obtained by gold coating a thin glass slide and gluing it onto the blade. These mirrors were produced by the target fabrication group.

Gemini shots can span a wide energy range (<10mJ to >10 J), thus it is important to correctly attenuate the diagnostics to keep the signal on scale. To do this RS232 controlled filter wheels from ThorLabs were installed in front of key diagnostics. These were preloaded with an increasing range of ND filters and connected to the control PC via remote Ethernet to RS232 converters (figure 3). The control software was modified to automatically adjust the filters dependent on which energy mode is selected (figure 2).

Additional pneumatic slides were installed in the south amplifier to slide in ‘tissue’ attenuators to further reduce the energy for alignment in the target area. Control for these was given from the LA3 wireless pad and TA3 control room. They were also interlocked into the firing procedure.

Quantel pump lasers

The Quantel lasers require external 5 Hz, and 20 second Flash and Q-Switch trigger pulses in synchronicity with the rest of Astra. No external ‘start charge’ pulse is given. Once the Quantel lasers are run in external mode they automatically charge every 20 seconds. An external trigger is necessary to fire them and initiate the next 20 second cycle. These external triggers are automatically generated by the control system. To control the pump energy the control software communicates with the Quantel PC to retime the laser by specifying which lamp delay file is used. An array of preset lamp delays was set up in advance to cover the energy range required. Other commands to start and stop the pump lasers exist, but have not been needed since the lasers are started manually and run continually to maintain the heads in a state of thermal equilibrium. To give the option of reducing the number of Quantel shots the cycle time can be increased in to 40 seconds or 1 minute. This would increase the lamp lifetime, but would only be practical for experiments where a slower shot rate is not a hinderance.

Once selected the control system generates Quantel triggers regardless of whether the Quantel lasers are actually running or not. To save generating diagnostic triggers and capturing and storing blank data the status of the Quantel lasers is monitored, i.e. whether capacitor banks and Q-switches are enabled. The shot number is only increased when everything is running. The control system also has a link back from the Rogowski diagnostic.

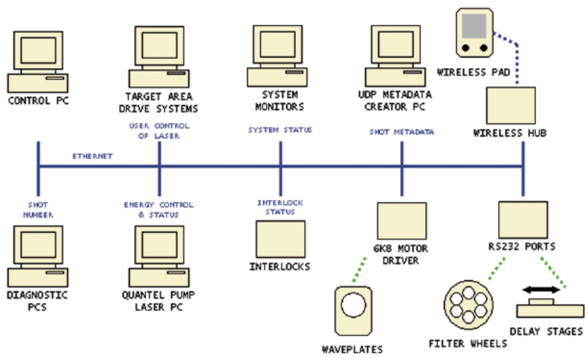

Figure 3. Gemini Control Network. The Ethernet has become a straightforward way to connect remote controllers and hardware to the control PC.

If any of the traces are missing this is indicative of a lamp failure and the laser can be stopped.

Conclusion

The Gemini control system has been modified to allow simultaneous operation in TA2 and Gemini to be as smooth as possible. Work has also been carried out to ensure shot data is only captured on an actual shot and that control system metadata is saved to the Gemini database.

References

1. E. Divall, CLF Annual Report 2006-07. p168 to 170.
2. A. J. Langley *et al*., CLF Annual Report 2004-05, p 214.
3. eCLF Project Progress. CLF Annual Report 2008, p229.