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CTF3 Note 036 (Min.)
(Laser)

REPORT ON THE PHOTO-INJECTOR WORKSHOP, CERN, 24-25TH SEPTEMBER 2001

Summarized by S. Hutchins

Abstract

The photo-injector development studies at RAL, Strathclyde and CERN started in March 2000, and the resulting conclusions are expected at the end of 2002. This meeting was to called to review the current status, identify any changes and plan for system tests in 2002.

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Agenda:

- Welcome and Introduction*, I. Wilson*
- Status reports
    1. Oscillator Development at the Institute of Photonics, *G. Valentine*
    2. Amplifier and System Studies at RAL*, I.N. Ross*
    3. Photo-cathode Developments CERN*, H. Trautner*
    4. Harmonic conversion and pulse manipulation CERN, *S.C. Hutchins*
- Planning for the PILOT test
    1. Probe beam line, *H.H. Braun*
    2. Location and infrastructure for the test, *S.C. Hutchins*
- Changes to the CTF3 laser specification
- Report of the meeting to the CTF3 Working Group, *I.N. Ross*

Transparencies used in the presentations are available on the CTF3 web pages.

Summary of the current status reports:

G. Valentine:
A Nd:YLF Quasi-CW oscillator has been constructed at Strathclyde with one 300W diode pump array, a second could be added. The output power from the oscillator is >60W during the 2-300μs pump pulse (peak power). Transient relaxation oscillations are actively suppressed in 10μs using an acousto-optic modulator. The cavity is currently 24cm long, when the saturable absorber mode locker is added 500MHz pulse rate will be achieved, the cavity can be shortened to 750MHz, but 1.5GHz will not be possible with the available material. It is expected that the oscillator will output >50W (peak) when mode locked.

I.N. Ross:
The RAL 5kW amplifier section continues its test programme, one Nd:YLF rod has broken as a result of a power supply fault, where the pulse length increased beyond the

specified maximum. The laser diodes proved to be more robust than expected and were undamaged. Single pass small signal gain (ssg) of 10 is observed, and saturated gain of 3-4. The intensity variation of the fluorescence distribution in the rod is 30%, due to different absorption performance with the polarisation angles due to the geometry of the pump chamber. The absorption changes with temperature, polarisation, doping concentration and wavelength, improvements to the distribution are possible if these are optimised.

H. Trautner:
Testing in the CTF has confirmed the good Quantum Efficiency (QE) of cathodes produced using the co-evaporation process, in place of alternative Cs-Te layers. Cathode #137 was produced with an initial QE of 11% on a new plug, extensive testing in the laboratory indicated that the efficiency stabilised at 8%, 4x higher than previous "layered" cathodes. It has been installed in the CTF RF gun and used to produce high charge pulses; the QE has now dropped to 4%. A second plug (#139) has been prepared with the Ion Controlled Etching (ICE) cleaning process and has an initial efficiency of 15%.

S.C. Hutchins
Improvements to the efficiency of Harmonic conversion have been carried out on the CTF2 laser system. There are two cascaded conversions, IR to Green light and Green to UV, the first is achieved with >50% efficiency, which is expected for pulses which are Gaussian in profile and time, further tests will be performed with beam simulating the "flat top" distribution expected from the power amplifier. The second conversion process is limited to 25% efficiency; study of the available literature has shown that at these wavelengths, it is not possible to improve upon this, as there is a two-photon absorption process that is not well understood. Better results have been reported using CLBO in place of BBO; some authors have suggested that this is due to the simultaneous absorption of one UV and one Green photon, an equivalent wavelength of 175nm, which is beyond the transparency range of BBO (cutoff at 180nm) but not of CLBO (cutoff at 170nm). Tests will continue with CLBO to improve the Green to UV efficiency.

A HV Pockels cell driver has been purchased to test the phase switching method proposed in the photo-injector scheme. The electrical switching time is 25ns, due to the non-linear nature of the Pockels effect this results in an optical switching time of 12ns. Material fatigue, acoustic effects and heating of Pockels cells with this mode of operation will be tested in the laboratory starting in December, the driver unit will also be studied by the PS-PO group to evaluate possible improvements to the switching time.

Synopsis of the PILOT test planning discussions

H.H. Braun:
The Photo Injector Long Train tests are an attempt to bring together the various elements under study in order to demonstrate their operation as a laser photo-injector, using the CTF2 probe beam line. The tests must be performed in 2002 as the CTF2 machine will be permanently closed down in December 2002.

The integration of the optical parts of the system; oscillator, amplifier(s) and harmonic conversion to UV, is proposed to be made at RAL in March 2002, which has the best diagnostic equipment. The Strathclyde oscillator is already committed for other tests in 2002, and would have to be duplicated in order to be available for PILOT tests. Work at Strathclyde on the synchronisation of the oscillator to an external RF source can only be started late in 2002. An alternative oscillator (CTF spare) and amplifier(s) could be used for the PILOT tests. A decision on these options will be taken at the end of October when mode-locked performance of the oscillator, and the costs of duplication and amplification are known.
The aim of the tests will be to show reliable production of a long pulse train, having pulse intensity variation of 1%, or better, and similar shot-to-shot variation. The limitations of the beam diagnostics, beam loading in the RF Gun, Photocathode efficiency (0.3%) and available laser power from the 5kW amplifier, leave the possibility of producing a 250MHz frequency, 0.2nC/bunch, 1.4uS pulse train of 350 pulses. The equipment should be installed at CERN in September 2002, for use on the CTF2 probe beam line during October/November. A second optical table would be installed in the CTF laser room, leaving the existing laser undisturbed for Drive beam operation. The laser room has power, cooling, 250MHz RF synchronisation signal and timing pulses available.

Digest of the Review of CTF3 Laser System Design discussion

Given the dramatic increase in Photo-cathode efficiency that has been reported, the availability of diode pumping efficiency measurements and the need to include a 20MHz bandwidth feedback loop to achieve 0.1% stability in the pulse train, the estimated laser diode power of the final amplifier was reviewed. After examining all of the information available, it was agreed that the amplifier power required could be reduced by a factor 2.4, if the Photocathode results are confirmed on a larger sample. The introduction of a fast feedback amplitude control adds a significant loss to the system if a linear operating point is considered, and a high voltage, 20MHz bandwidth feedback system must be developed, this could be undertaken at RAL, if funding is available. No other changes to the system are foreseen at this time.

Participants:
RAL, Didcot, UK: I.N. Ross, M. Csari,
Institute of Photonics, Strathclyde, UK: G. Valentine,
RHUL, London, UK: G. Blair
CERN: H.H. Braun, E. Chevallay, V. Fedosseev, G. Geschonke, S.C. Hutchins, T. Lefevre, L. Rinolfi, G. Suberlucq, H. Trautner, I. Wilson