Report of the Planning meeting for CLIC Photo-injector Study 23rd March 2000

CTF3 Tech. Note 2000-5
Laser

Present:
Ian Ross , (RAL, UK)
I.Wilson, H.Braun, G.Suberlucq, S.Hutchins, L.Rinolfi, H.Trautner, P.Legros (CERN)

G.Suberlucq and H.Trautner reported the status of the “millicoulomb” test of photocathodes. A suitable laser is sought, a pulse length of 100mS at 0.5-1W CW power, 266nm wavelength is needed to be compatible with the DC cannon perveance and power supply. This will allow the generation of electron currents of 10A, 100ns at 1KHz repetition. A higher current (10mA) high voltage supply is planned. A potential laser has been identified; a diode-pumped, Q-switched UV laser from Quantronix, which can generate 200ns pulses. It is hoped to rent this laser in June/July in order to perform the tests.

H.Braun reported that there were no major obstacles to produce an RF Gun for CLIC parameters, the difficulties experienced with the current photo-injectors are aggravated by the high frequency of operation, 3GHz, where the CLIC injector will be operated at 1GHz. This will allow better cooling and vacuum conditions that are a limitation to the lifetime of the photocathodes.

Ian Ross presented a schematic diagram of the CLIC laser system (annex 1). He is in the process of finalising the feasibility report which should be available at the end of April 2000. There appear to be no major obstacles to the construction, but several points need confirmation before a cost and production schedule can be produced with confidence.

The preferred material is Nd:YLF, due to its thermal properties and the 10ps pulses that are required. The amplifiers are all operated in a saturated mode, producing an IR stability of less than 1/1000. In addition, the pulse output energy is directly proportional to the pump power, with a response time of a few microseconds, which allows the possibility of feedback systems to compensate for external effects during the pulse train. The system assumes efficient pumping, extraction and harmonic conversion, which is possible with a super-Gaussian transverse profile which can achieve an 85% “fill factor” in the amplifiers. The final amplifier requires 60kW of optical pump power, the current cost is about $6.7/watt, reduced from $20/watt in 1998. The cost of the system at todays prices is then estimated at 750kCHF for the diodes and the same amount for all other equipment and optics. The cost of the CTF3 laser system would be less, currently 750kCHF.

The areas that are uncertain due to the unique nature of the beam energy and structure were listed and discussed, this represents a two-year program of work;

1. Fourth harmonic conversion efficiency	pulse train, high average power, max. efficiency
2. Amplifier gain control	system normally stabilised by beam loading
3. Gain saturation	gain saturation to achieve stable output
4. Pumping efficiency	pump chamber, max stored energy, wavelength
5. Extraction efficiency	beam dia. = rod dia., Uniformity of intensity
6. Feedback stabilisation of the diode drivers	pulse to pulse, fast feedback, safety
7. Optical or beam intensity feedback systems	e-beam to UV, photocathode and gun compensation
8. Programmed feed-forwards systems	“pulse train” compensation, thermal, conversion
9. Fracture limit of Nd:YLF	Thermal shock
10. Synchronisation drift during pulse train	material heating effects, esp. in pulsed power osc.
11. Synchronisation to external signal.	CW osc. ok, (300fs); pulsed osc. ??
12. 1.5GHz oscillator.	Cavity size/power, multiple pulses in cavity?
13. UV/visible fast switching/pulse manipulation	RF cycle shift, absorption, electrical damage
14. Optical measurements	energy meas. at 1/1000, 1us response times
15. Thermal distortion compensation	generate & maintain the super-Gaussian profile

Some of these items will be addressed in current projects, H.Trautner outlined the amplifier tests that he is initiating (annex 2) which will investigate amplification of pulse trains(items 3,4 &5).

S.Hutchins proposed that the CTF3 Probe-Beam laser development (CTF Note 99/37) can also serve as a test bed for several of the subjects of interest. The Nd:Glass oscillator and regenerative amp. could be used to evaluate:

- High frequency oscillators (11,12)
- Fast feedback control of diode pumping (6,7)
- Programmed diode pump control (8)
- Optical switching/manipulation (13)
- Optical measurements (14)

S.Hutchins also proposes to use the CTF2 laser to perform initial studies of the Harmonic conversion efficiency (item1).

It was noted that E.Bente, (Institute of Photonics, Strathclyde, UK) has recently received approval for his project to develop a high-frequency, high power oscillator, these studies will directly address items 10,11and 12. It is hoped that he will visit CERN in the near future.

Ian Ross will propose to RAL, the development of a high-power amplifier section, in order to study:

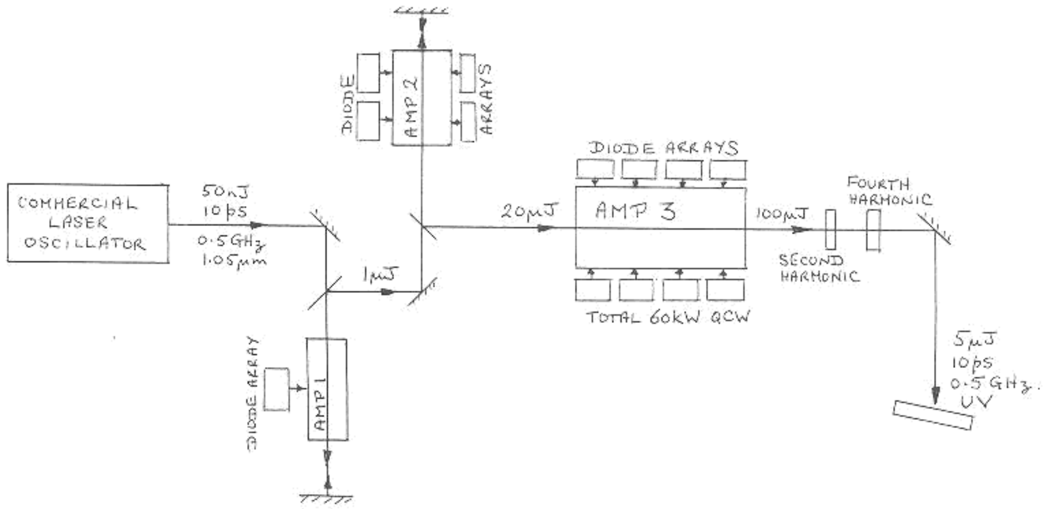
- Amplifier parameters (2,3)
- Pump chamber development (4,5)
- Fracture limit of Nd:YLF (9)
- Thermal distortion compensation (15)

Several Optical Institutes, Universities and manufacturers have expressed an interest in the CLIC laser development, we will now renew these contacts and encourage any involvement in the various aspects of the study.

Reported by S.Hutchins

Distribution:
All present plus:
J-P Delahaye
J-P Potier
K.Schindl
E.Bente, Institute of Photonics, Strathclyde, UK.

PHOTO-INJECTOR LASER SYSTEM FOR 'CLIC' DRIVE BEAM



Annex1

Annex 2:

Memorandum

Heiko Trautner

Experiments to be conducted in the "Laserlab":

1) Amplification of a puls train

As a source to be amplified, it is foreseen to use the Lightwave 130. Three different amplifiers will be used:
The two former BMI pump chambers, both flashlamp-pumped.
The to be constructed, diode-pumped amplifier (see below).
This should give a sound basis to compare with theory, allowing to extrapolate to the CLIC laser, if necessary.

For these tests, a puls picker system, capable of extracting at least 50 pulses, if possible more, has to be installed. This might also serve for testing the fast pockels-cells foreseen to use in the CLIC laser.

2) A diode pumped amplifier

To conduct tests of a diode pumped amplifier, a stack of diodes, with max. power of 480 W is ordered (peak wavelength 797nm). As a first test, an elliptical pump-chamber is foreseen (see Fig.1).

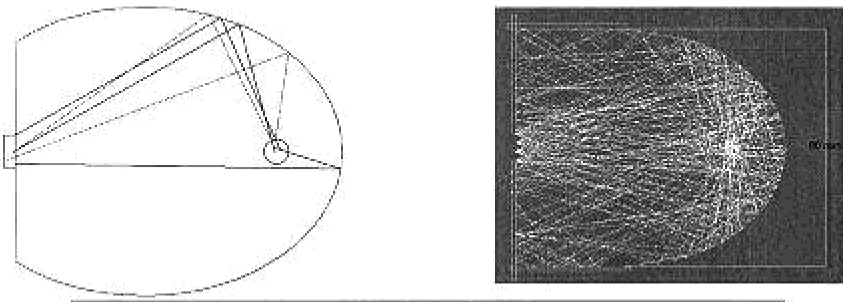


Figure 1 First "simulation" of an elliptical chamber, half axes 30x40mm

Left: Raytracing done "by hand".
Right: Simulated a more complete ellipse with two additional mirrors, the rod is not included (=> no absorption)

For evaluation of different designs, a more detailed raytracing should be done. For the moment, is is foreseen to buy a 40mm long rod of 6mm diameter. If it is possible to concentrate more energy in a smaller space, a smaller diameter might be better.
Transverse shaping might be tried at this installation, since a rectangular shape is preferred by the users.

3) Shortest possible amplified pulses with Nd:YLF

As above, with a fiber/grating stretcher/compressor system. The mechanical support for coupling into a monomode fiber is available.