Report on the CTF3 Photo-injector Workshop, 24-25th September 2001

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Selection of transparencies from the workshop for the CTF3 working group

CLRC

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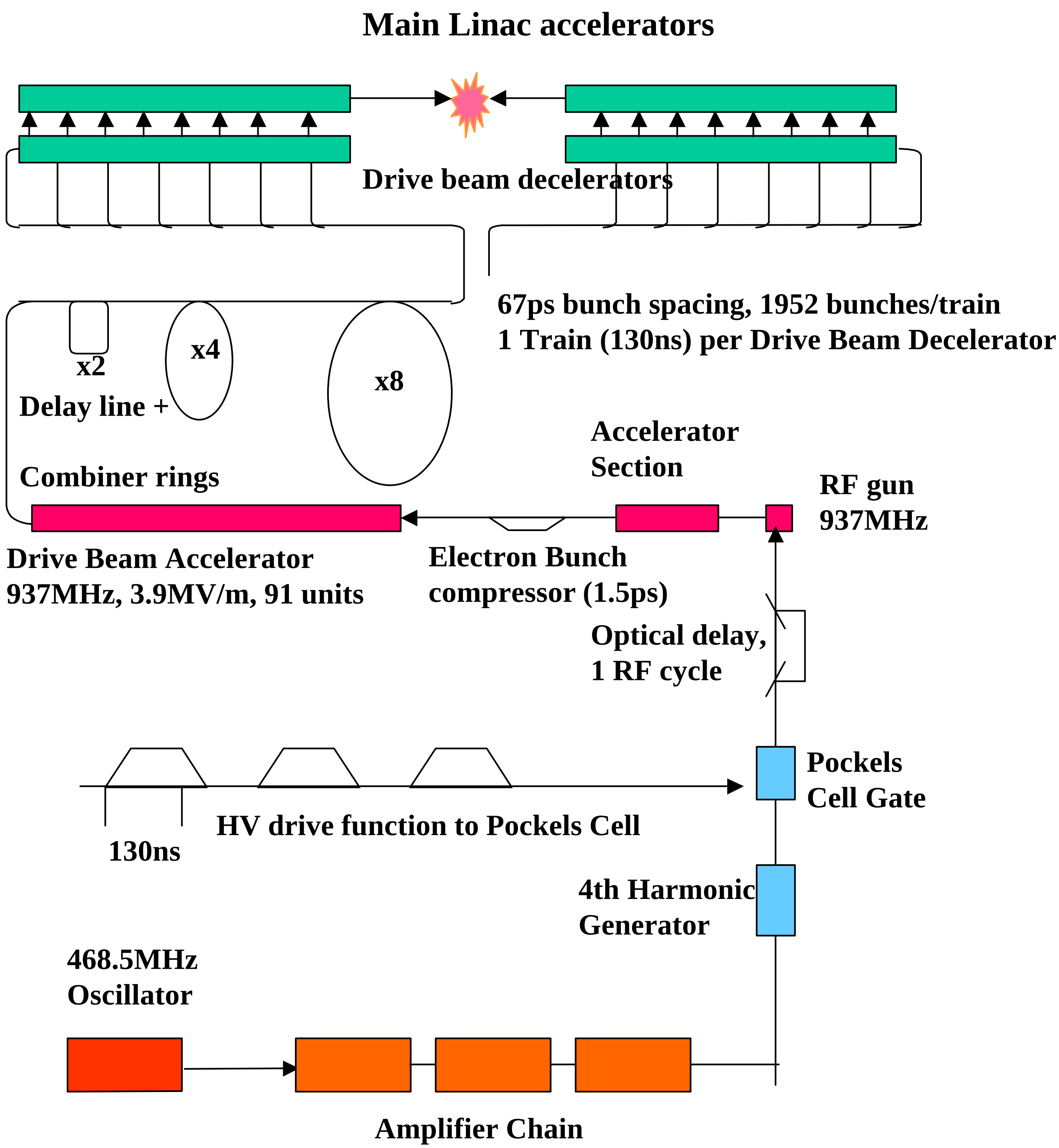
Summary and Outlook

- No technological problem for RF gun
- Laser is feasible with some technical challenges
- Cathodes are able to produce the required current density
- Cathodes resist the laser intensity

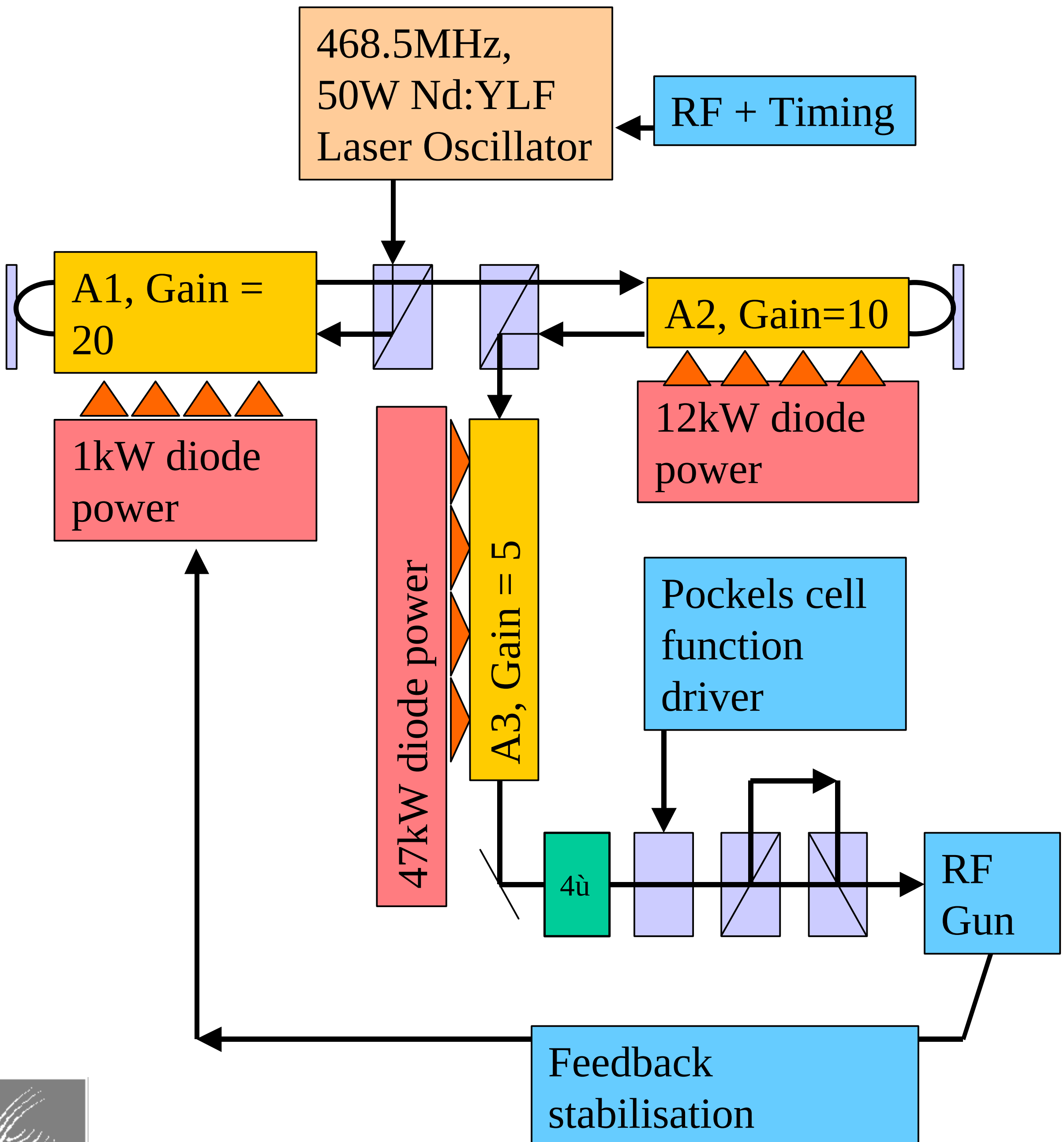
A photoinjector seems to be feasible and to be a good technical solution:

- Better emittance
- No satellites
- Lower costs
- Less Radiation

CLIC DRIVE BEAM PHOTO-INJECTOR



THE CLIC PHOTO-INJECTOR LASER SYSTEM



State of the Art

Commercial Systems

10W cw TEM_{00}	Nd:Vanadate	- for pumping TiS (eg Millenia)
1kW cw	Nd:YAG	-for engineering applications
1J/100Hz	Nd:YAG	-for engineering applications

Demonstrated Systems

Oscillators-
5kW multimode
200W cw TEM_{00}
50W cw modelocked TEM_{00}

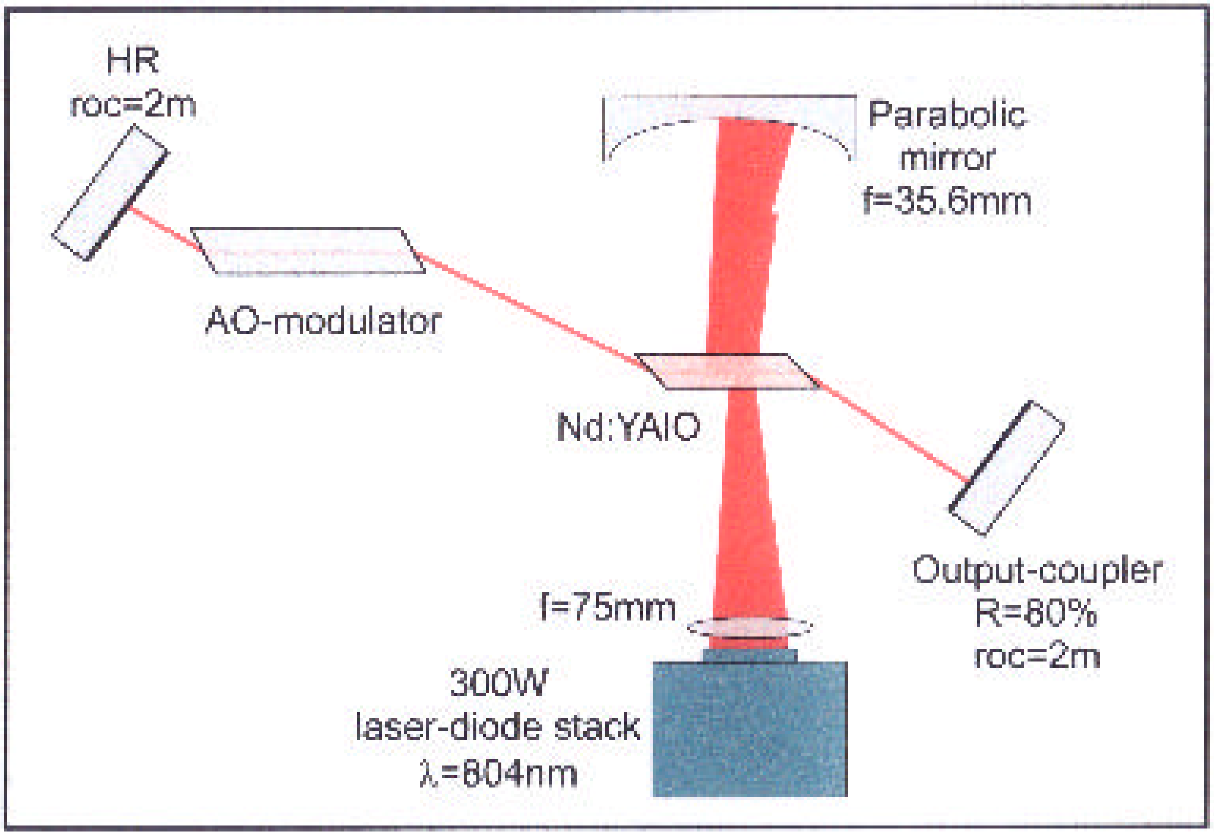
MOPA-
10J/100Hz
10mJ / 15 fs/ 1kHz

Designed Systems

Oscillators- >10kW

MOPA - >100kW

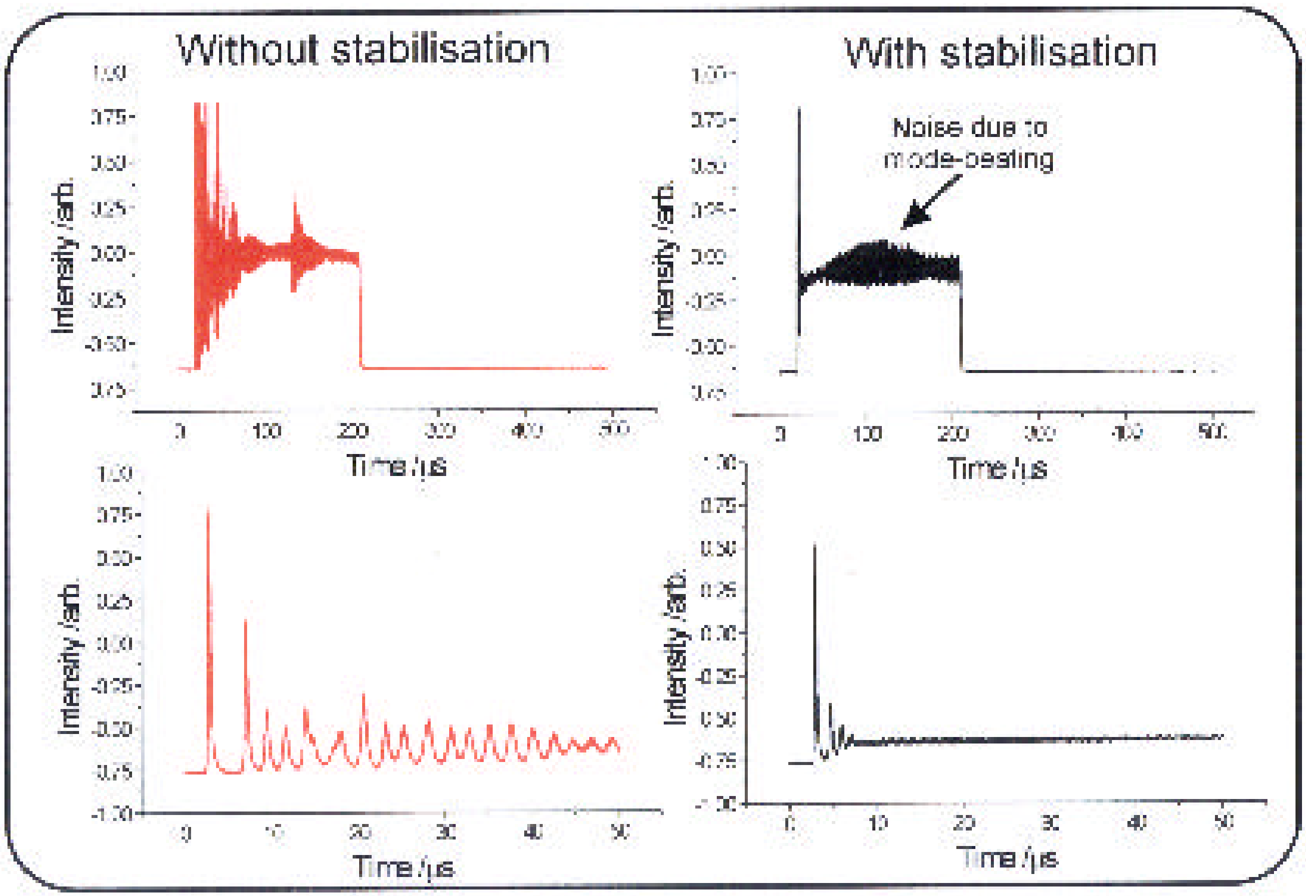
Schematic of laser



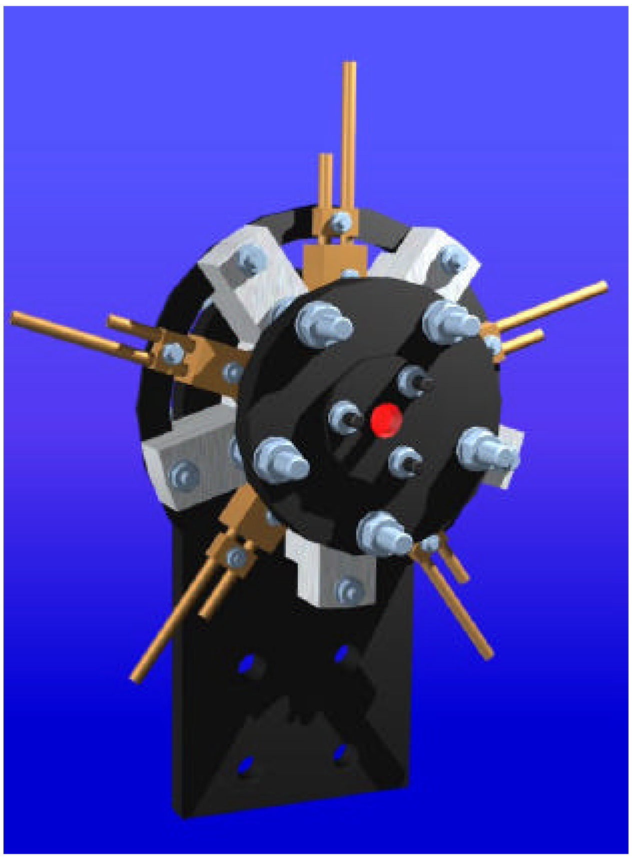
- Pump diodes operated at 300W quasi-CW: 200μs pulse at 100Hz
- Cavity length: 24 cm

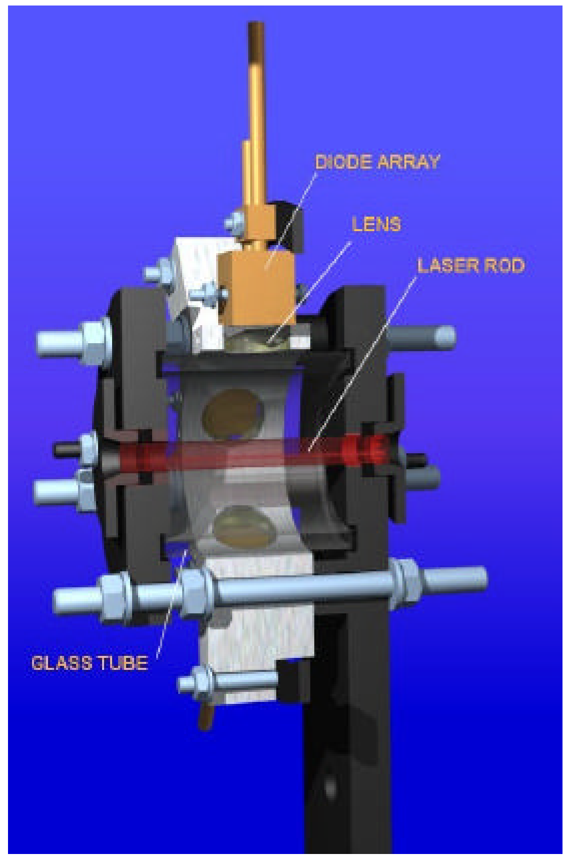
Combined differential+proportional stabilisation of quasi-cw Nd:YLF laser

- Peak power after stabilisation(in 200μs) = 60W (300W pump)



5kW DIODE-PUMPED TEST AMPLIFIER





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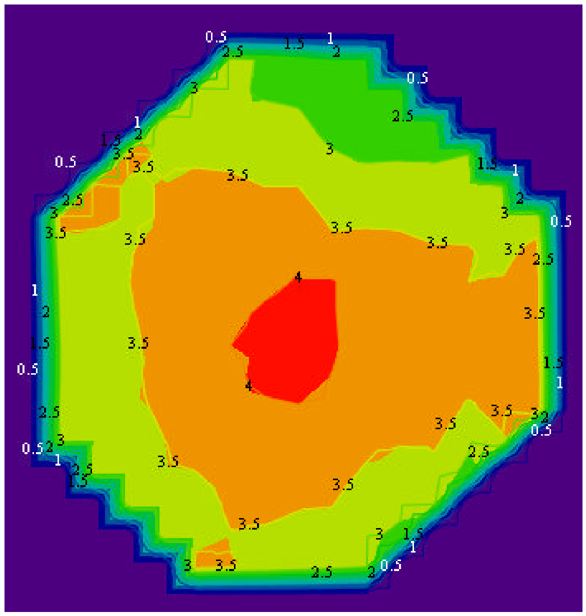
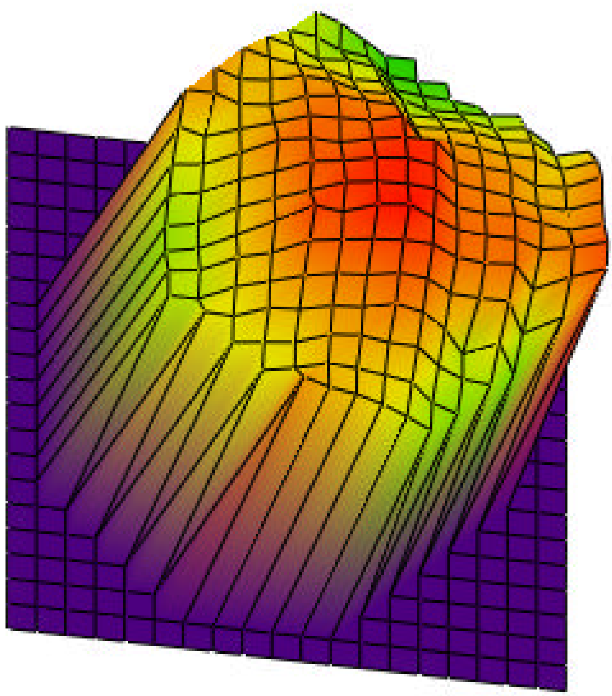
Saturated gain-distribution at single pass amplification

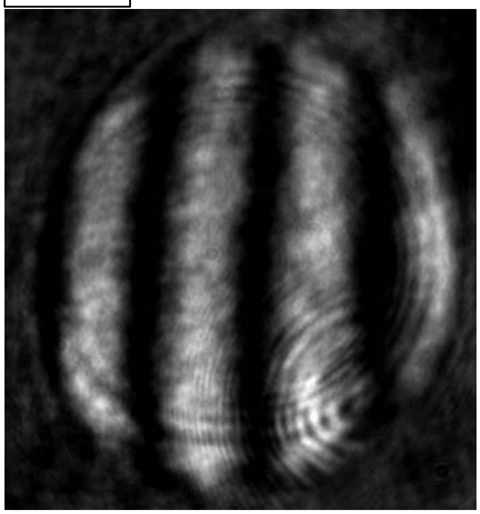




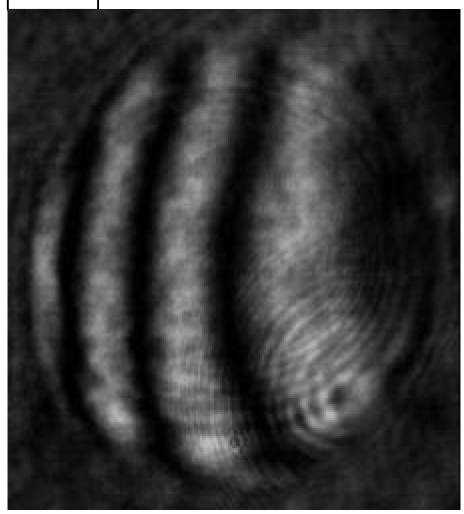
Thermal-lensing effect in the Nd:YLF rod

Vertical fringes:

Nonpumped

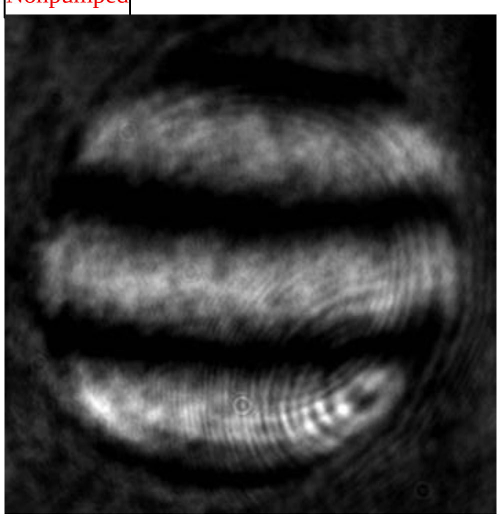


100 Hz

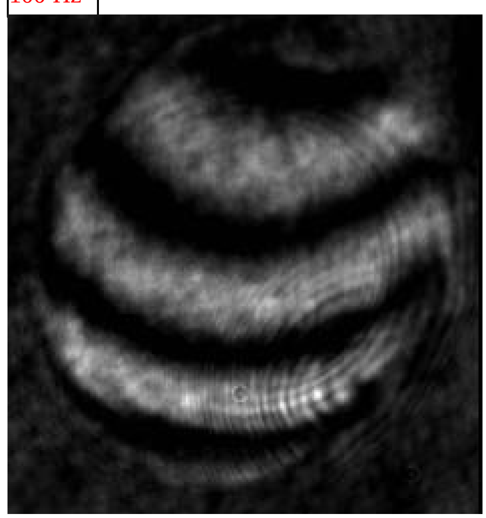


Horizontal fringes:

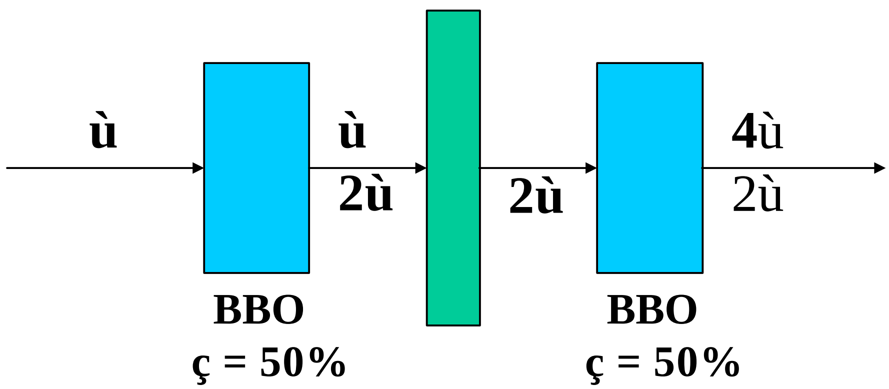
Nonpumped



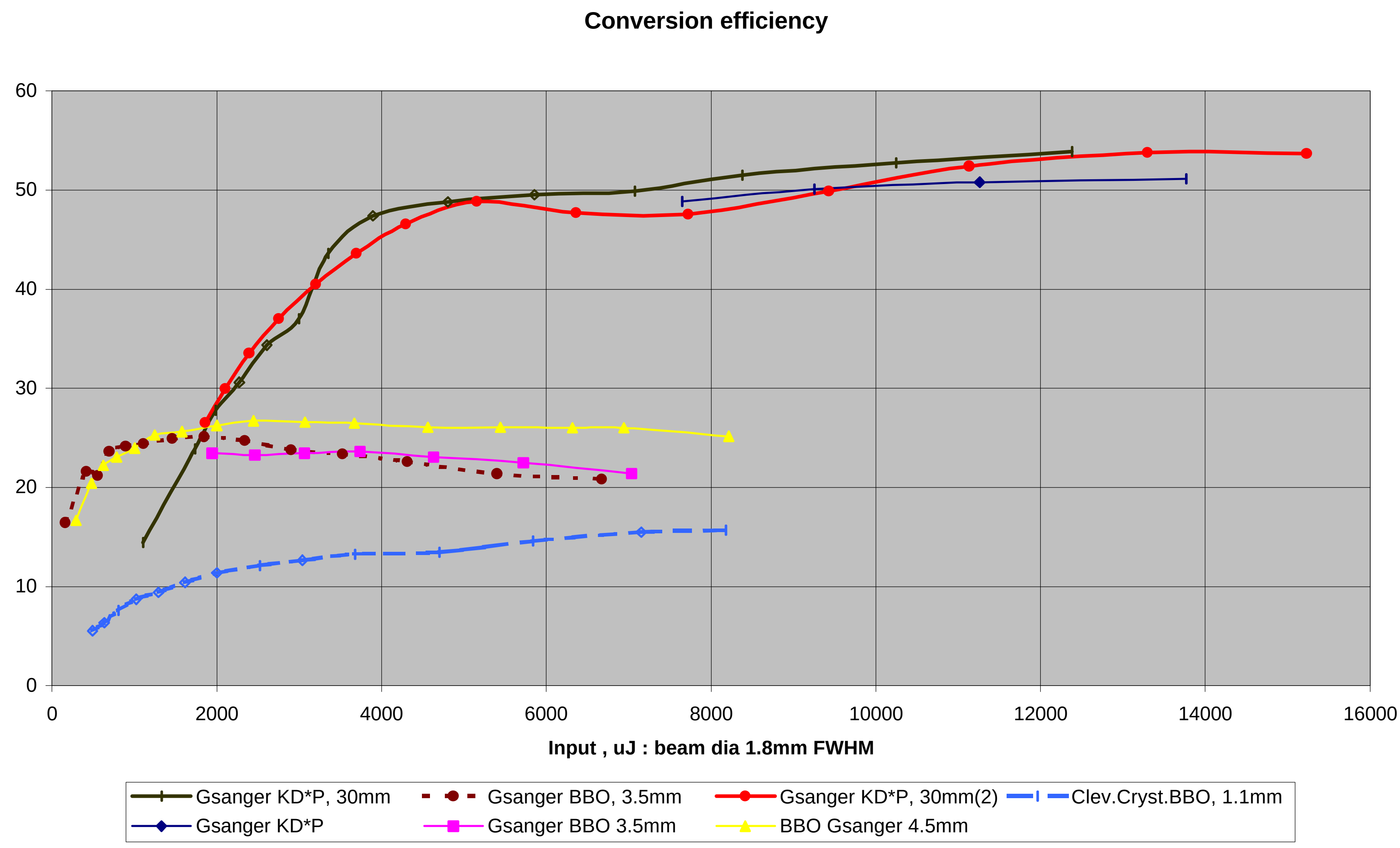
100 Hz



FOURTH HARMONIC GENERATION



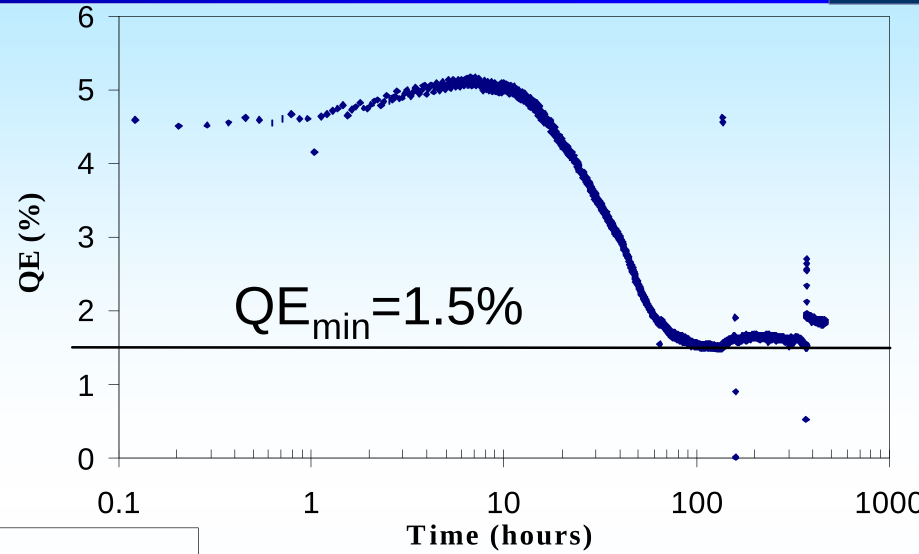
- Predicts 25% efficiency overall
- Literature reports 25% efficiency
- Requires optics to give square flat-top beam
- Design assumed 10% - achievement of say 20% would substantially cut the cost of laser.

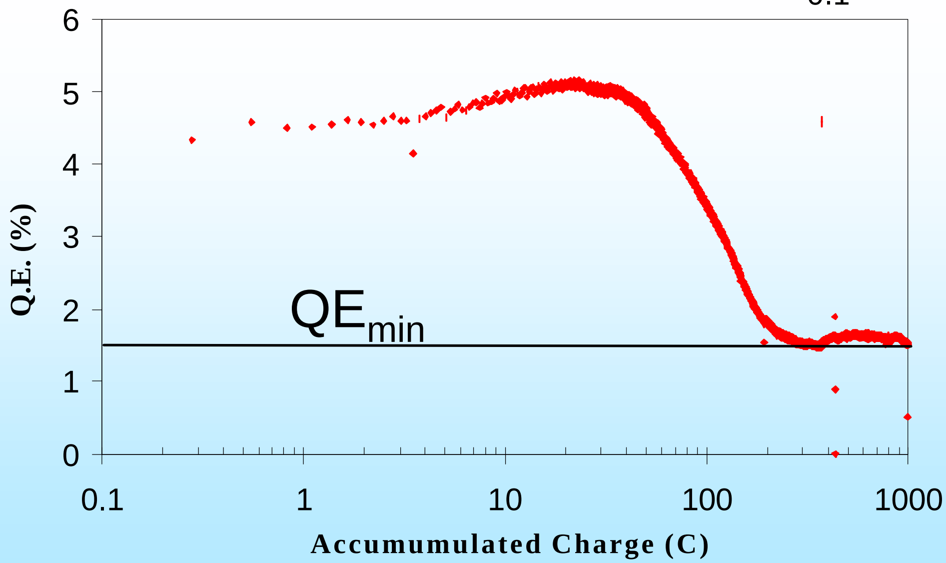

Conversion efficiency
0
10
20
30
40
50
60
0
2000
4000
6000
8000
10000
12000
14000
16000
Input , uJ : beam dia 1.8mm FWHM
Gsanger KD*P, 30mm
Gsanger BBO, 3.5mm
Gsanger KD*P, 30mm(2)
Clev.Cryst.BBO, 1.1mm
Gsanger KD*P
Gsanger BBO 3.5mm
BBO Gsanger 4.5mm

Cathode test for high average current I

Reminder for CLIC:
1mC per macropulse,
75 mA on average
For CTF 3: 5.2 μC,26 μA

Cathode plug was cleaned by Ar^{+} bombardment
Thickness Te: 10nm
Thickness Cs: 8nm



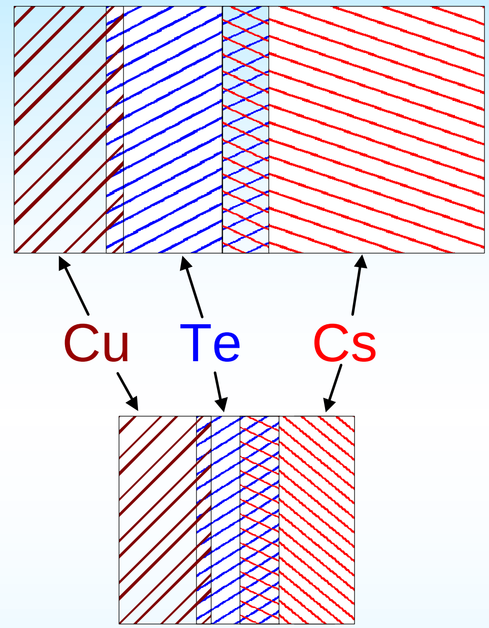


Average current: **750 μA**
Total charge: **1.2 kC**
Current density: **21** $\frac{mA}{cm^2}$
Laser power density: **6** $\frac{W}{cm^2}$

Riddles of Cesium Telluride

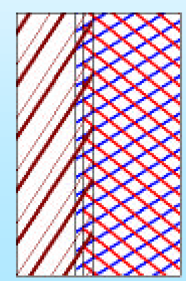
Experiences:

Cs-Te cathodes with
10nm Te,15nm Cs:
Qe ≈10% → ≈1.5%



Cs-Te cathodes with
2nm Te, 6nm Cs:
Qe ≈ 10% → ≈1.5%

Only a thin (some nm) active interface really consisting of photoemitting Cs_2Te ?



Solution:

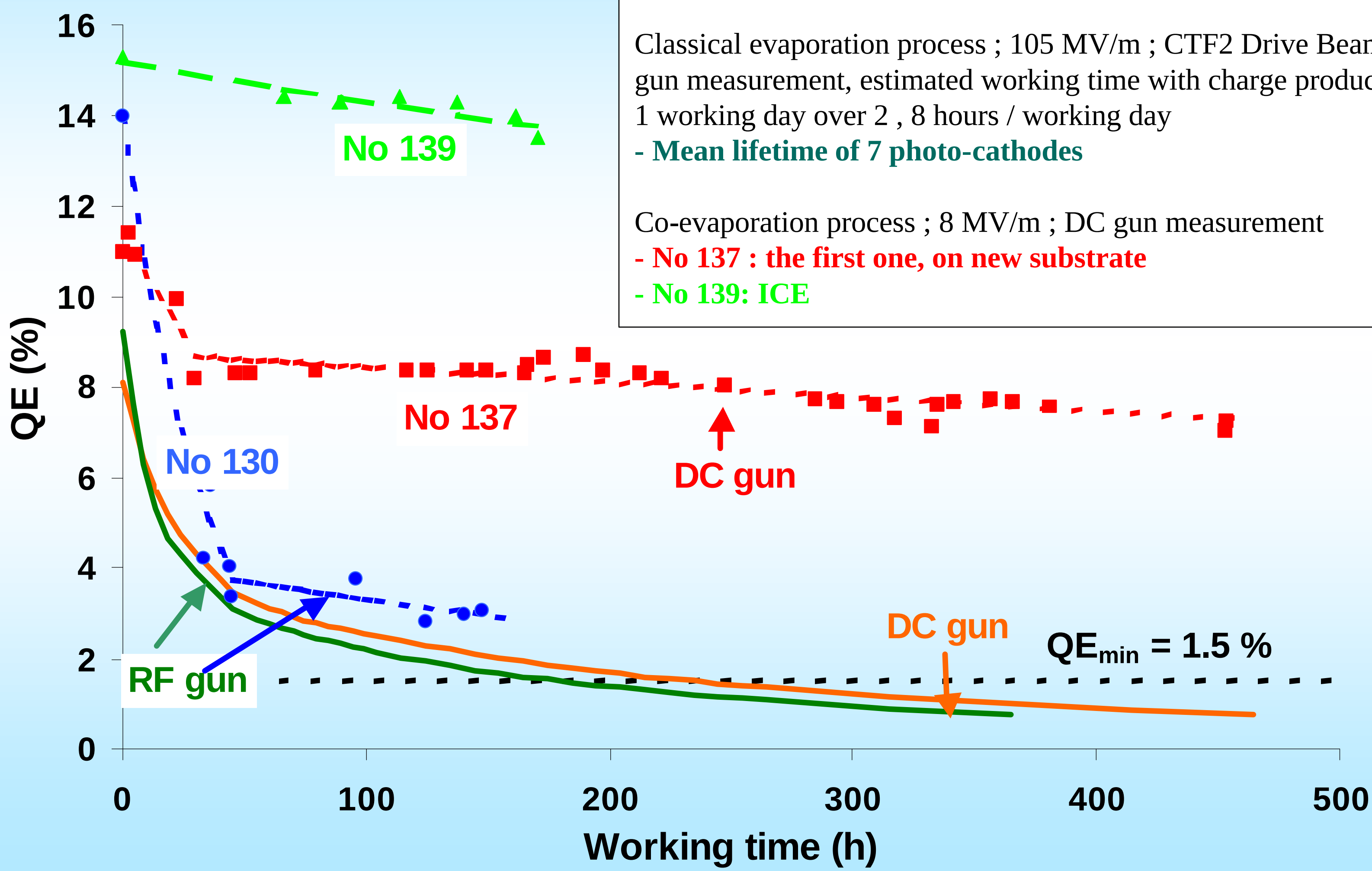
Evaporate both elements at the same time

Gain in QE

Classical evaporation process ; 8 MV/m ; DC gun measurement
- **Mean lifetime of 6 photo-cathodes, including high charge test**

Classical evaporation process ; 105 MV/m ; CTF2 Drive Beam RF gun measurement, estimated working time with charge production : 1 working day over 2 , 8 hours / working day
- **Mean lifetime of 7 photo-cathodes**

Co-evaporation process ; 8 MV/m ; DC gun measurement
- **No 137 : the first one, on new substrate**
- **No 139: ICE**



CTF II, configuration for PILOT experiment

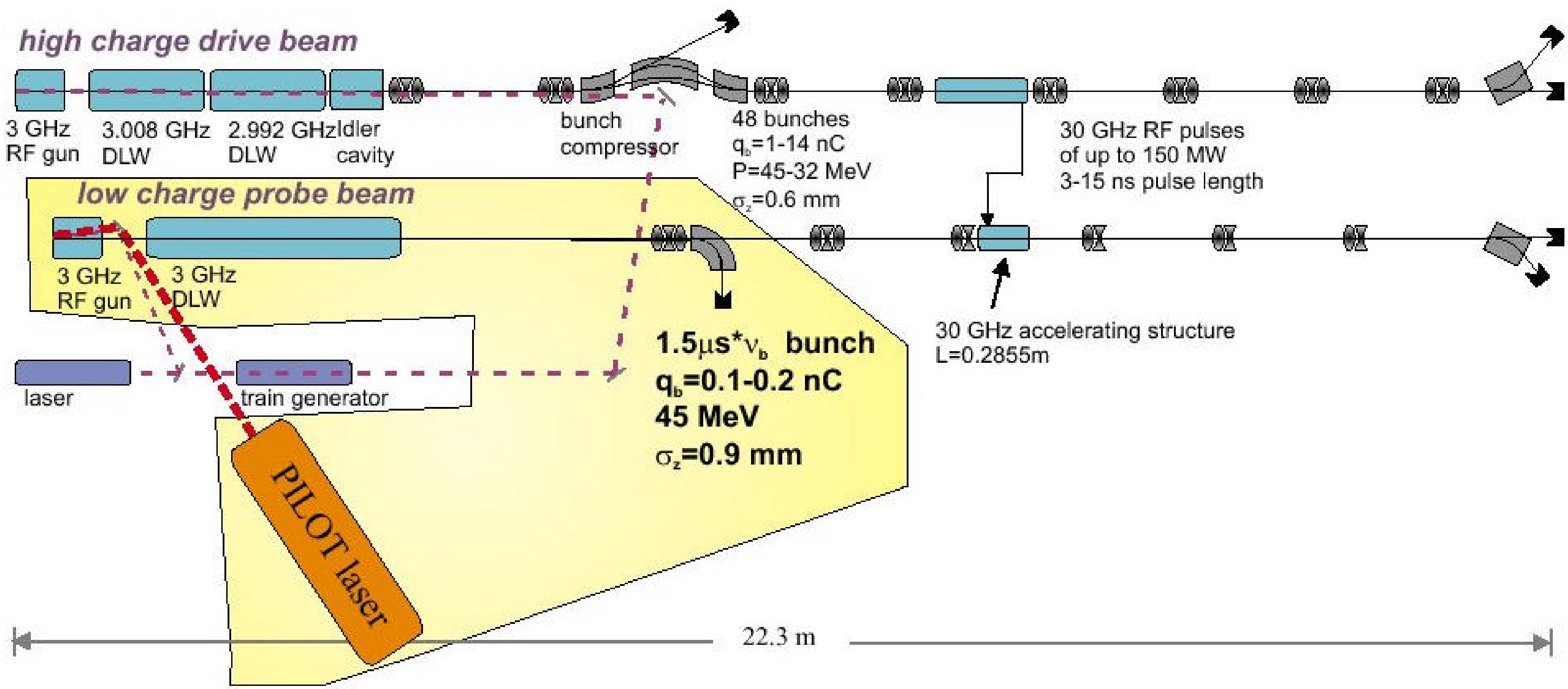


Photo injector option needs a convincing proof of principle experiment for the laser system.

The most convincing experiment is a working photo-injector demonstrating the main features on a reduced scale.

Those features are (in order of importance)

- **long bunch train phase locked with RF**
- **reliable operation for many hours**
- **laser power stability during train & stability pulse to pulse**
- **phase switching every 140 ns**

If this can be shown the photo-injector option for CTF3 will be followed up.

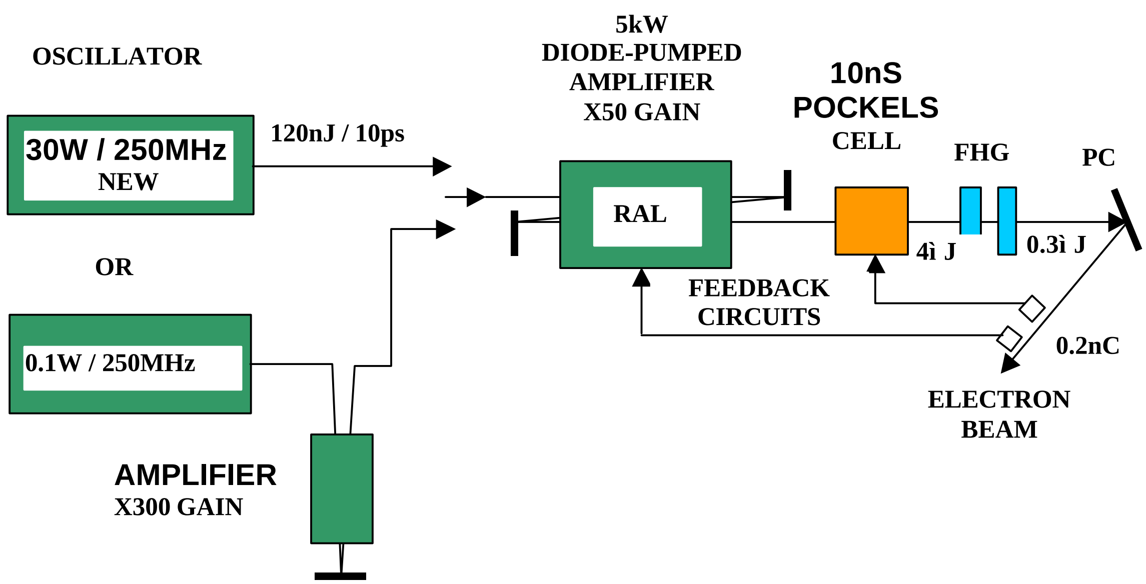
The injector variant which will be most successful in CTF3 will be the one for the CLIC drive beam

These constraints imply for the PILOT experiment:

- **installation on the CTF II probe beam**
- **impact on the operation of CTF II laser system has to be minimised**
- **experiment has to be ready for October 2002 at the latest**
- **parameters for the laser system**

		A	B
ν_B	MHz	249.88	499.76
q_B	nC	0.2	0.1
W_B on cathode @264 nm	μJ	0.32	0.16
P_{LASER} on cathode @264 nm	W	80	
ν_{REP}	Hz	5	
T_{PULS}	μs	1.5	

PHOTO-INJECTOR LASER FOR 'PILOT' TESTS



‘PILOT’ CTF2 TESTS

AIMS

Demonstrate stable pulse train operation yielding 0.2nC per electron bunch from the photo-cathode at a frequency of 250MHz and for a train length of 1.5ì s.

Demonstrate optical feedback stabilisation of the optical pulse train to 1%.

Demonstrate beams on the photo-cathode spatially uniform to 30%.