



CCLRC
Rutherford Appleton Laboratory

Photo-injector laser development

PILOT Test/ CTF3 Design

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PILOT TEST

Target parameters

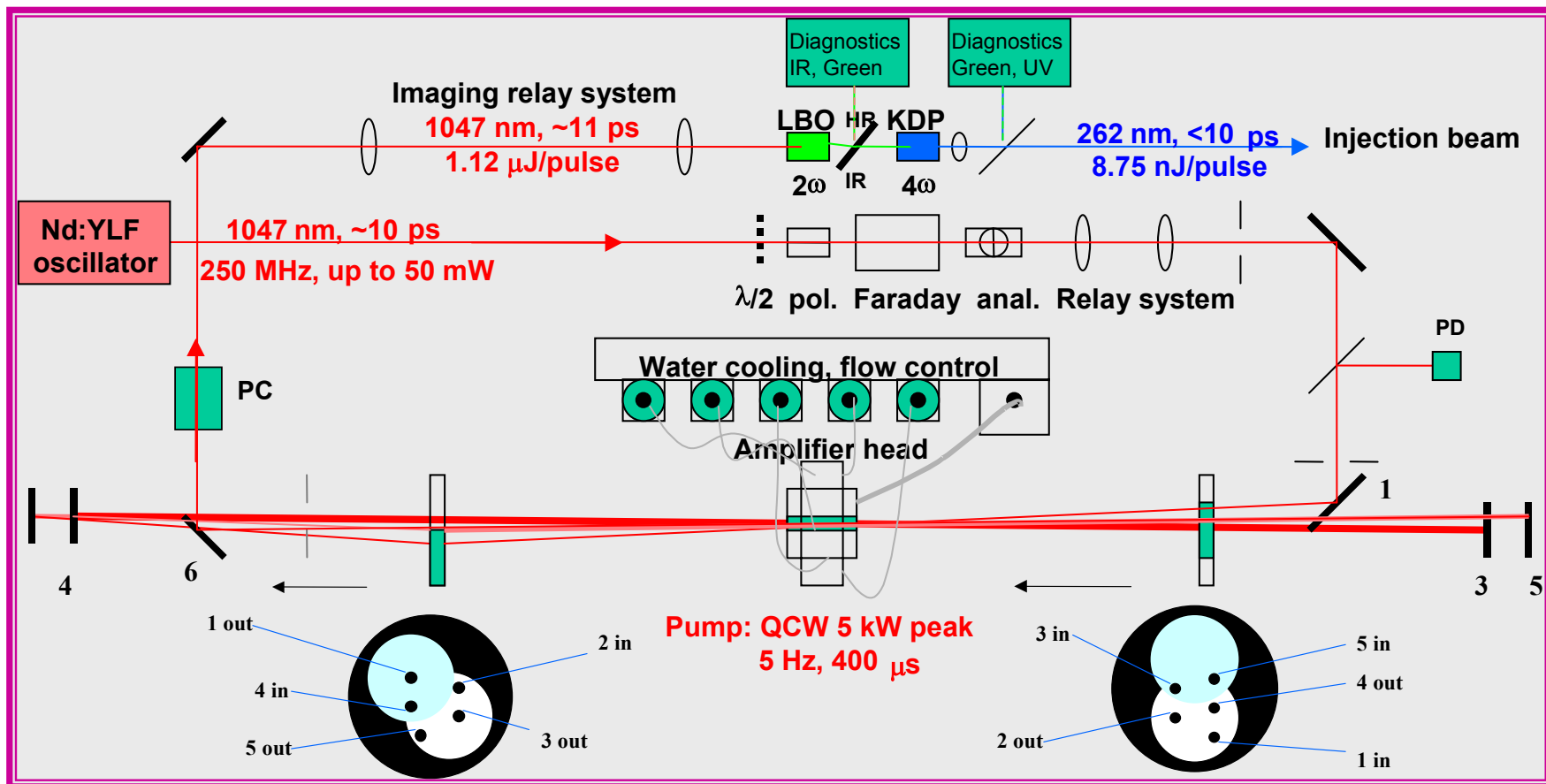
Target Parameters	Units	Nominal values
Charge / pulse	nC	0.15
Number of pulses	-	350
Oscillator repetition frequency	GHz	0.25
Macro-pulse width	μ s	1.4
QE _{min}	%	5
Wavelength	nm	262
W _{cathode} / pulse	nJ	30
Optical path transm.	%	50
IR/UV conversion eff.	%	5
Stabilization transm.	%	80
W _{OUT} / pulse (Amplifier)	μ J	1.5
Total Amplifier Gain	-	=6000x
W _{OUT} / pulse (oscillator)	nJ	0.4

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PILOT TEST

System layout



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PILOT TEST

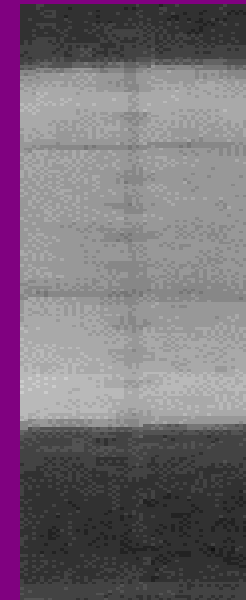
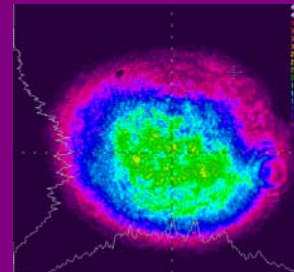
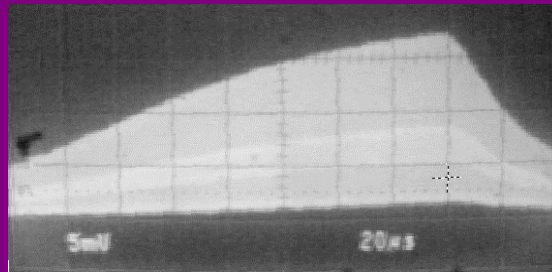
Performance at RAL

Developing pulsetrain

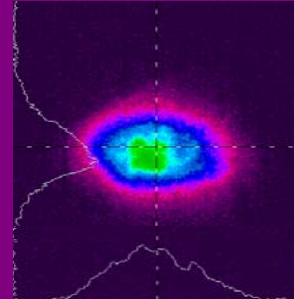
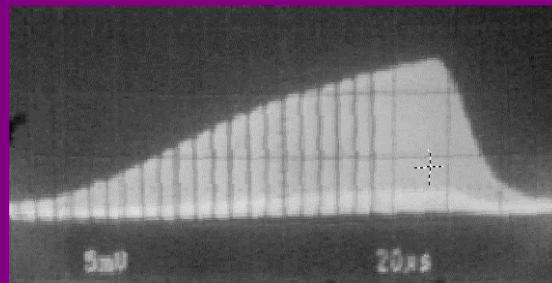
Near-field
picture

The used 1 μ s
train

IR (1047 nm)



UV (262 nm)



	IR	Green	UV
Max. energy/micropulse	2.6 μ J	0.56 μ J	148 nJ
Energy stability (rms)	1%	1%	1.3%
Pumping: 5Hz, 400 μ s, 5kW (peak)			

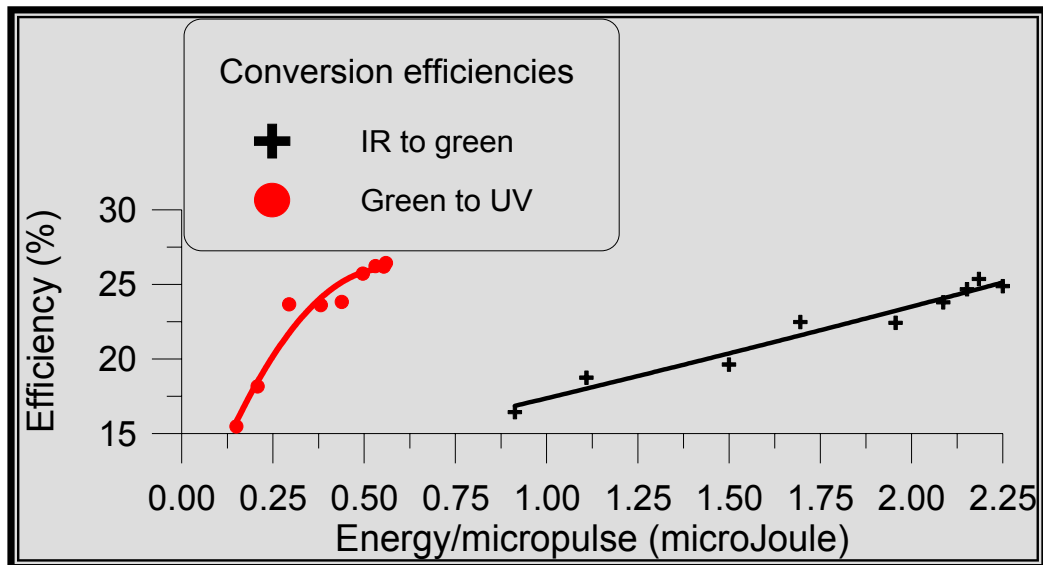
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Harmonic generation at RAL

LBO type I 2cm for 2ω
KDP type I 2cm for 4ω

5% overall efficiency with $2 \mu\text{J}$, $\sim 7.5\text{ps}$ IR pulses



Relay imaging of the end-surface of the amplifier crystal

Same image for both crystals:

- less space

- smaller transmission losses

Heating effects:

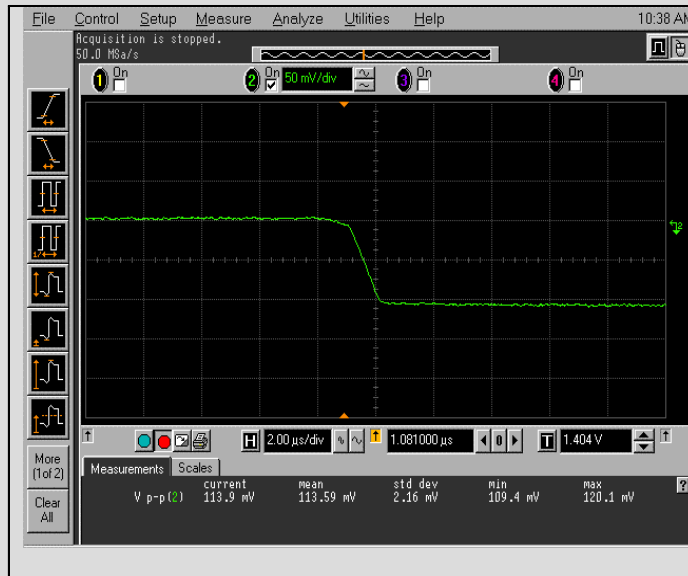
- can be suppressed by cutting the pulsetrain before the crystals

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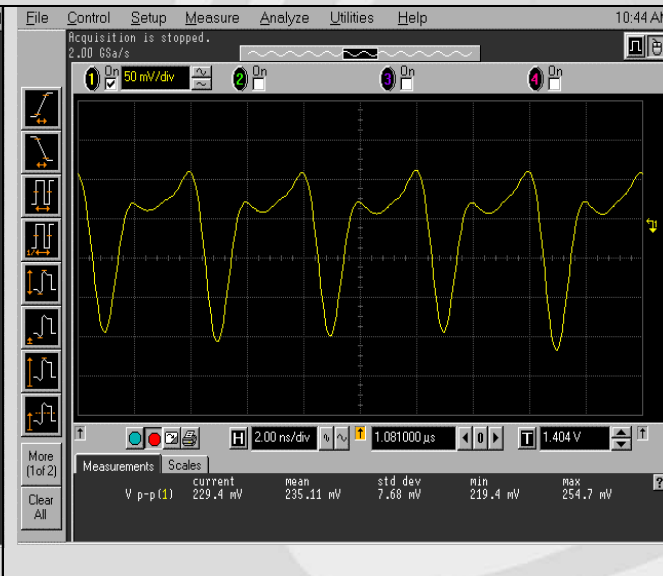
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Sample electron bunch train charge measurements - PILOT



Faraday Cup



Wall current monitor

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Achieved parameters in CERN

	Target	Actual
IR Energy/pulse	1.5uJ	1.2uJ
UV Energy/pulse	30nJ	16.8nJ
WCM Charge/pulse	150pC	70pC
Stability	<1%	1.9% rms

5-Pass amplification:

- More sensitivity to alignment
- Difficult beam size control over the passes

Low input power from oscillator:

- Less saturated amplifier causing higher sensitivity to input variations

Damaged pump diodes:

- Lower pumping power, causing less gain and saturation
- Non-uniform pumping distribution causing poor conversion to UV

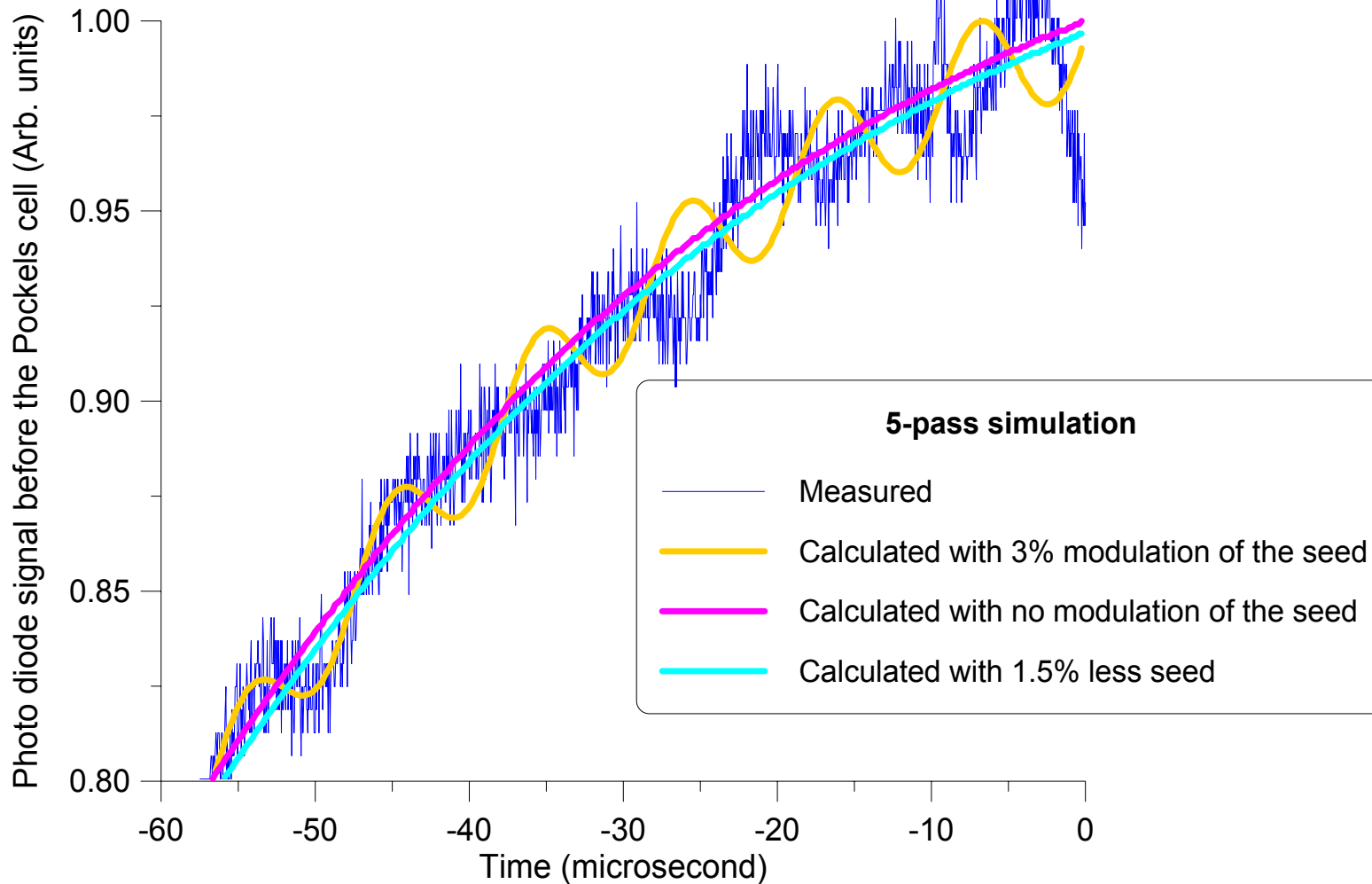
Damaged second harmonic crystal:

- Optical feedback causing instability

Oscillations on LWE output (1.5%rms) at 10uS period:

- Oscillations on the output of the amplifier

Modulation of the oscillator



PILOT to CTF3

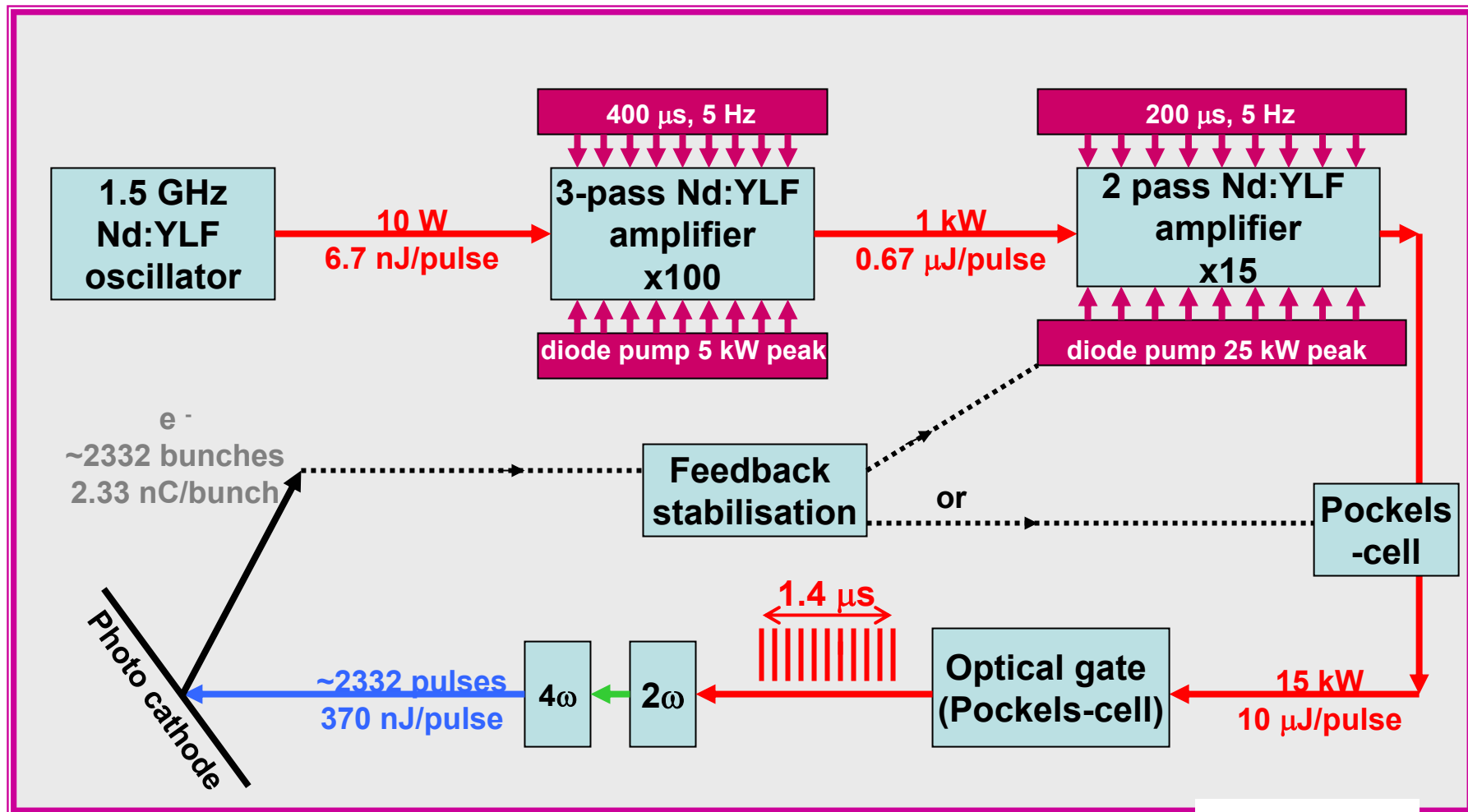
Target parameters

Target Parameters	Units	PILOT (achieved)	CTF3
Charge / bunch	nC	0.07	2.33
Number of pulses	-	250	2332
Oscillator repetition frequency	GHz	0.25	1.5
Macro-pulse width	μ s	1	1.548
QE _{min}	%	4	3
Wavelength	nm	262	
W _{cathode} / pulse	nJ	8.75	370
Optical path transm.	%	52	70
IR/UV conversion eff.	%	1.5	7.4
Stabilization transm.	%		70
Repetition rate	Hz	5	
W _{OUT} / pulse (Amplifier)	μ J	1.12	10
Pulse train mean power	kW	0.28	15
Average power (UV)	mW	1.4	116
W _{OUT} / pulse (oscillator)	nJ	0.4	6.7

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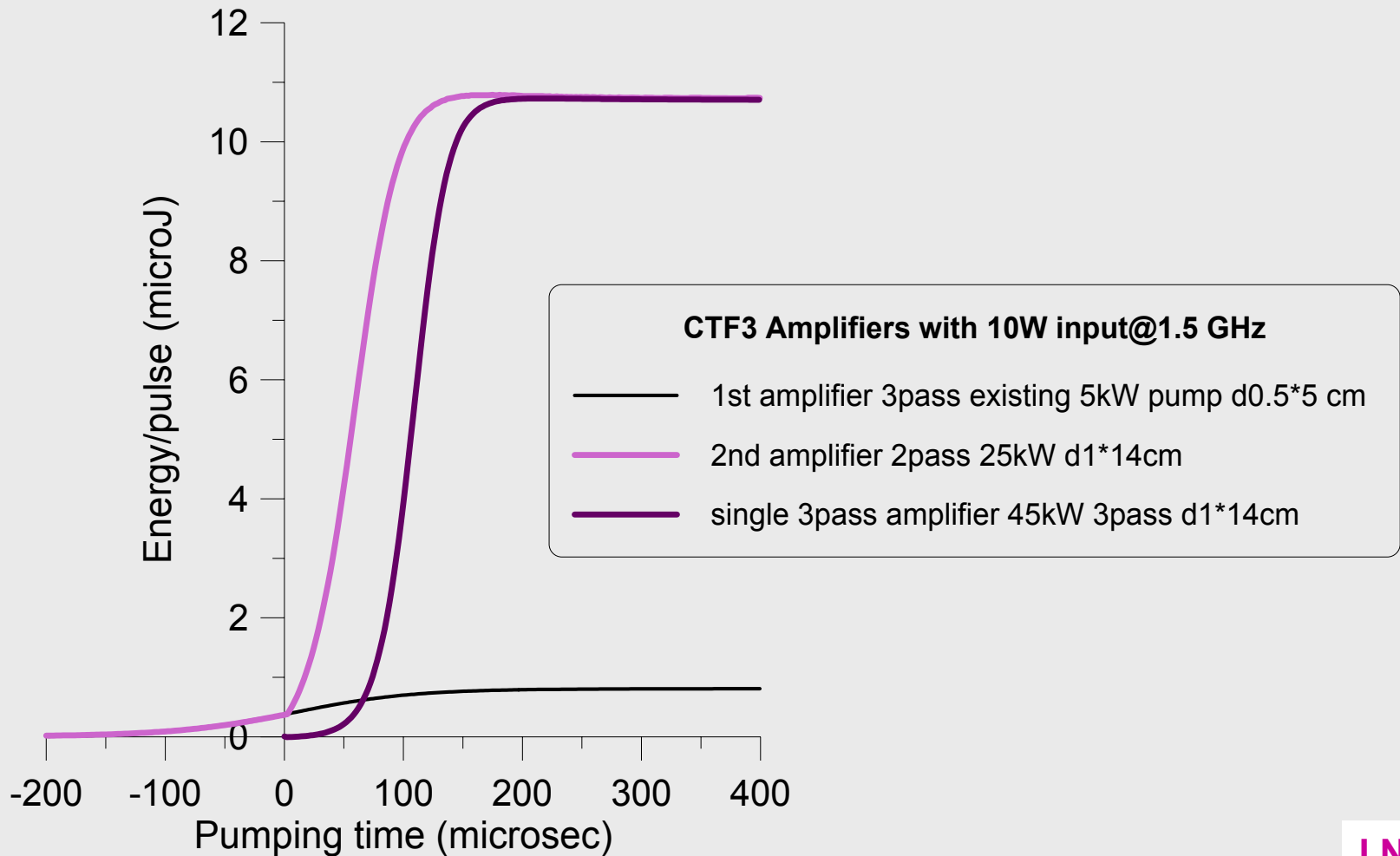
PILOT to CTF3 System layout



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CTF3 amplifiers Modelling



Summary

Pilot Tests

Laser System set up and tested at RAL - gave satisfactory performance.

Pilot tests at CERN - OK but not as good as expected

because

- non-ideal design**
- equipment imperfections**
- noise**
- no feedback control**

but all these can be resolved

CTF3

New designs proposed and some modelling work in progress