STF Laser Status

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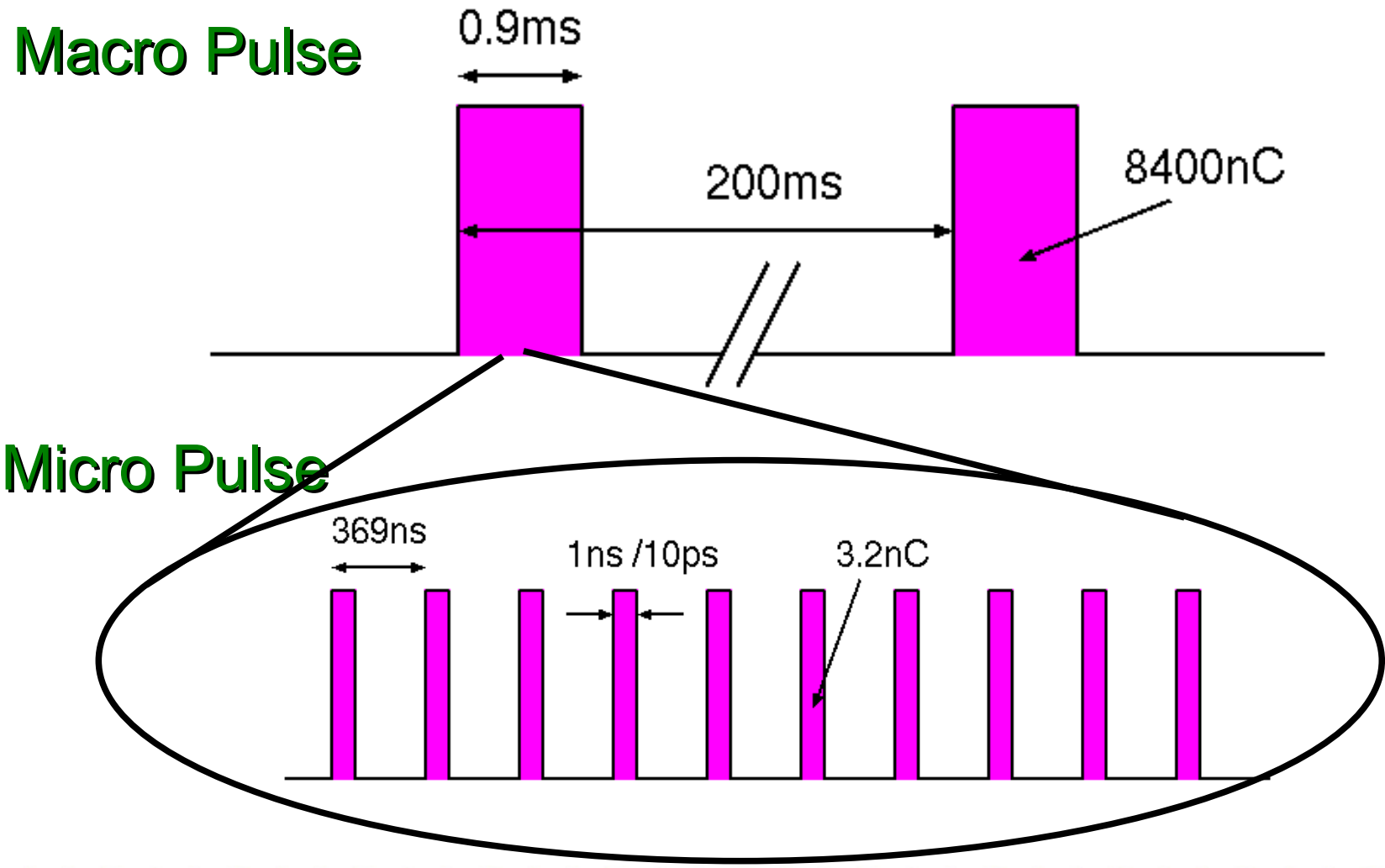
ILC/STF Requirements

Parameters	
Pulse length	0.9ms
Pulse reputation	5Hz
# of micro bunches in a pulse	2625 (5120)
Bunch separation	369(189)ns
Bunch charge	3.2(1.6)nC
Micro bunch length at source	10ps(1ns)
Peak current	320A(3.2A)
Electron Polarization	None(80%)

Pulse structure



ILC/STF beam parameter

	Symbol	STF1	STF2	STF3	ILC
Operation mode		5Hz MP	5Hz MP	5Hz MP	5Hz MP
Macro pulse length (μs)		969.23	969.23	969.23	969.23
Micro Pulse reputation (M Hz)	f_μ	2.71	5.42	10.83	2.71
Bunch spacing (ns)	Tb	369.23	184.62	92.31	369.23
Number of μ pulses in MP	Nb	2625	5250	10500	2625
Cathode Material		CsTe	CsTe	CsTe	NEA GaAs
Laser Wave length (nm)	λ	263	263	263	780
Quantum efficiency (%)	η	1.00	1.00	1.00	0.50
Average current in MP (mA)	I_{avg}	8.67	8.67	8.67	8.67
μ Pulse Charge (nC)	Q_μ	3.20	1.60	0.80	3.20
Laser Micro Pulse Energy (μJ)	E_μ	1.51	0.75	0.38	1.02
μ Pulse length (ps)	t_μ	10.00	10.00	10.00	1000.00
Laser MP Average Power (W)*	Pm	4.08	4.08	4.08	2.75
Laser Average Power (mW)**	P_λ	19.77	19.77	19.77	13.33
Laser μ Pulse Energy (μJ) @ FM	$E_{\mu 1053}$	6.03	3.01	1.51	–
Laser MP Average Power (W) @FM		16.32	16.32	16.32	–
Laser Average Power (mW) @FM		79.08	79.08	79.08	–

TTF Laser (1)

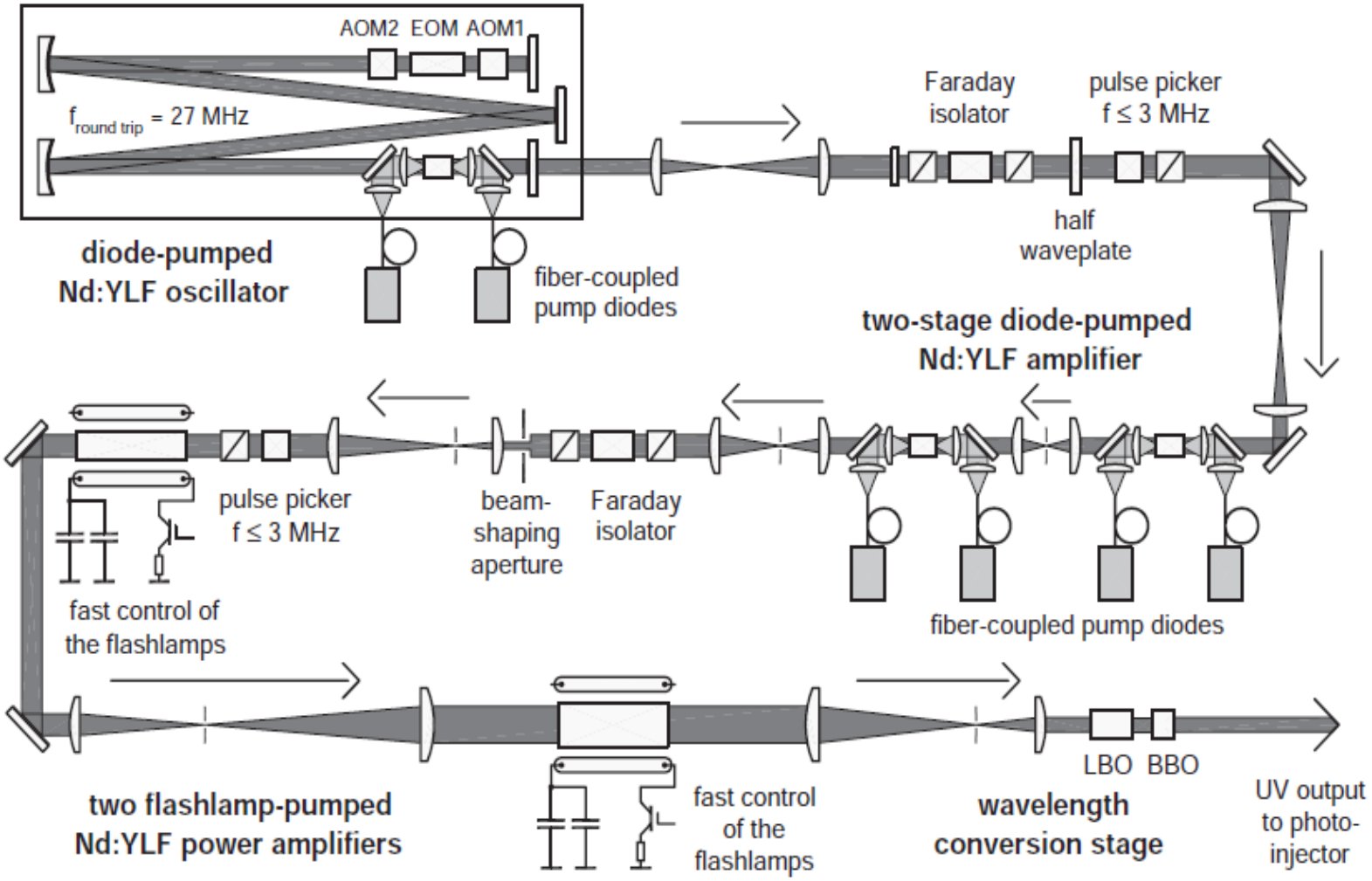
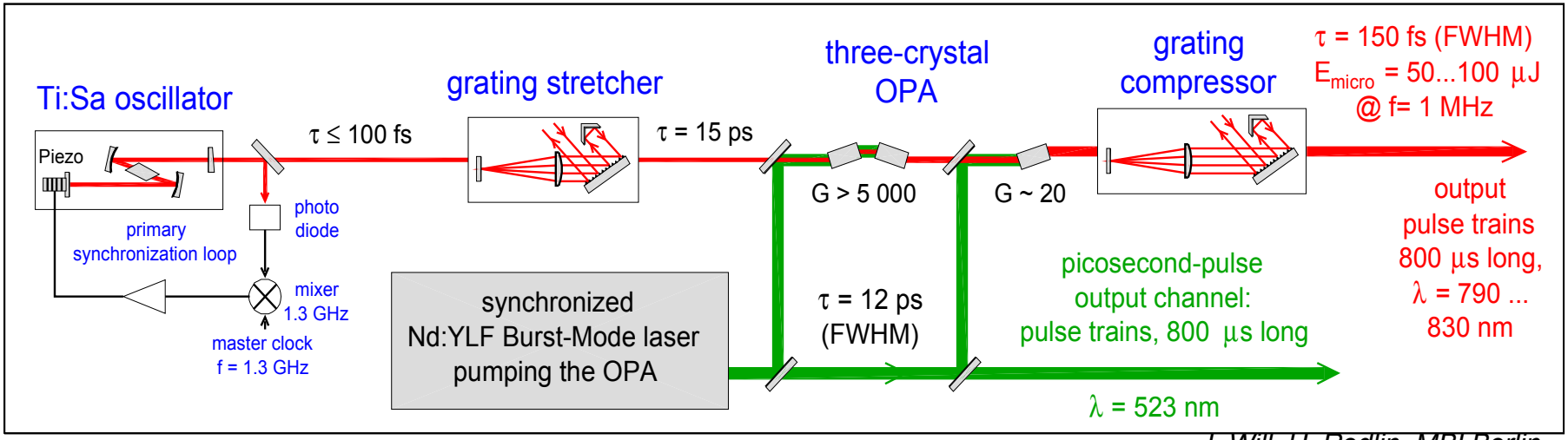


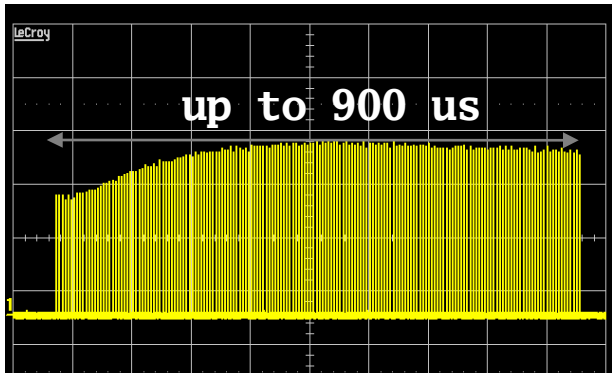
Fig. 1. Optical setup of the Nd:YLF photocathode laser. NIMA 541(2005)467-477

ILC Laser proposed by DESY



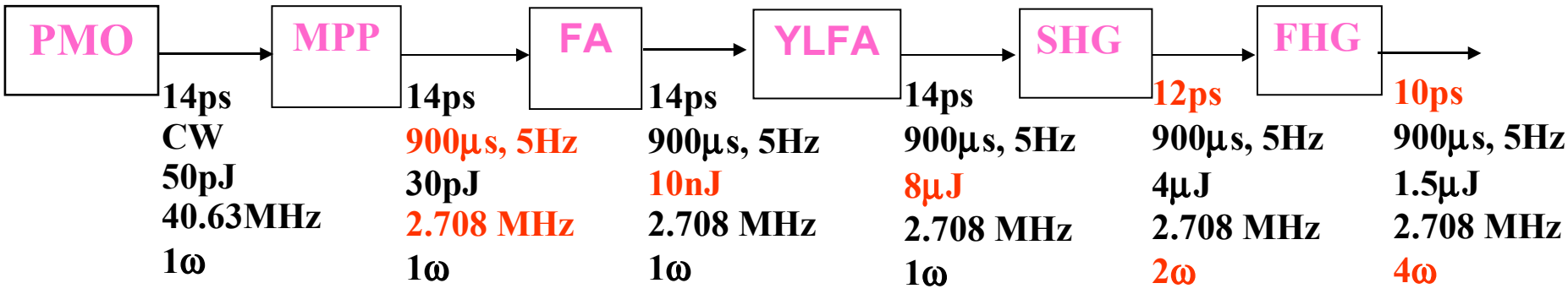
I. Will, H. Redlin, MBI Berlin

- OPCPA (Optical Parmetric Chirped Pulse Amplification) system generates trains with a wide range of pulse length, 150 fs .. 20 ps (FWHM)
- Pulse energy: E_{micro} = 50 ~ 100 uJ
  E_{train} = up to 80 mJ
- Available wavelength: = 790 ~ 830 nm
- Pulse train: up to 0.9ms



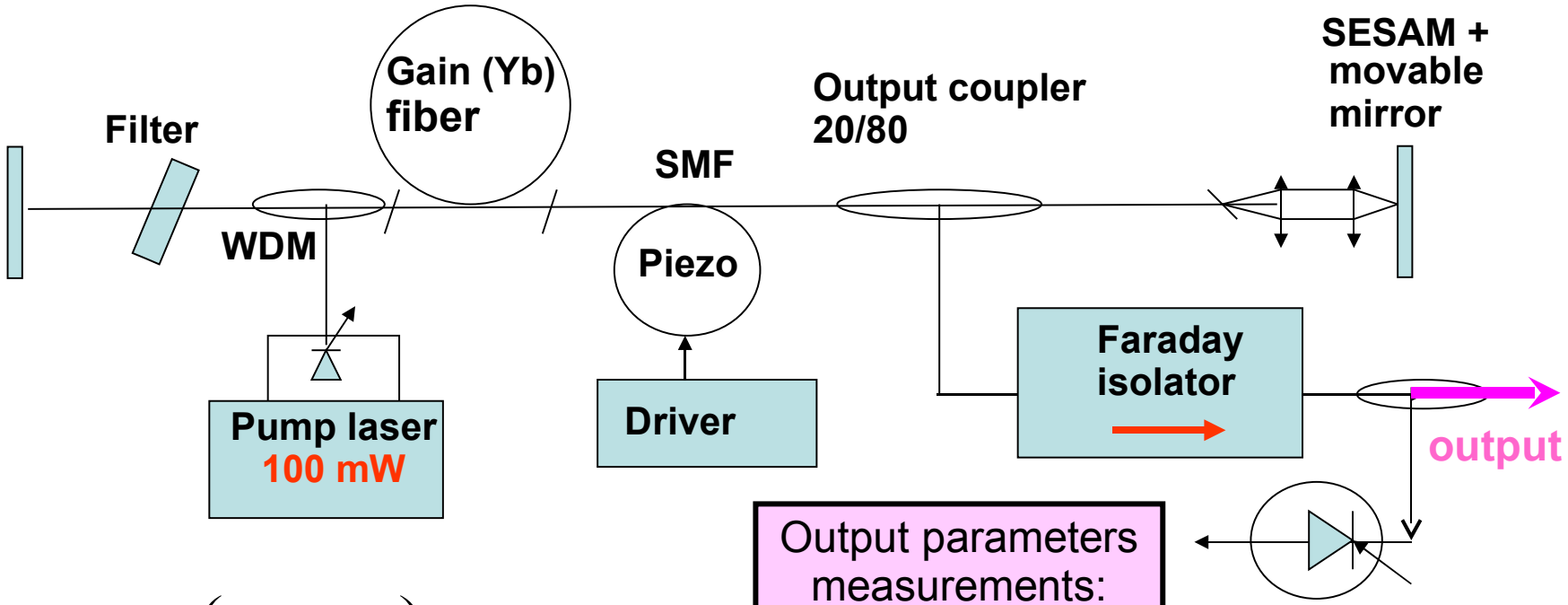
Output pulse train of the OPCPA

Basic Configuration

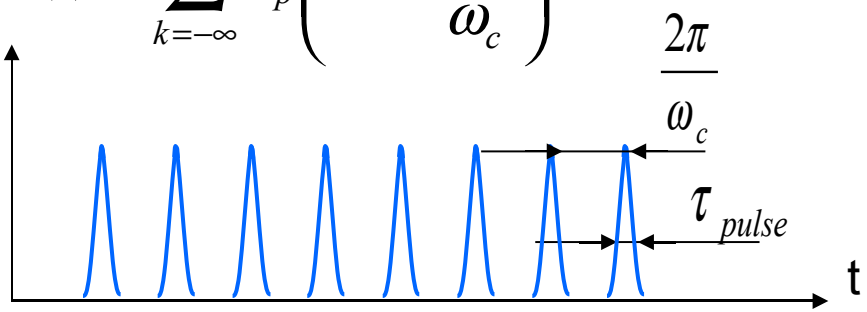


Macro pulse duration	900 us
Leading and tail duration	0.3us from 0.1 to 0.9 level
Contrast ratio	500
Micropulse duration	8-12ps
RMS of micropulse duration	1%
Micropulse rep. Rate	2.708MHz +/- 1.3kHz
Macro pulse repetition	5Hz
Number of micropulses in macropulse	2437
Wavelength	266nm
Micropulse energy	1.4uJ
RMS of micropulse energy (10 consequence pulses)	3%
RMS of micropulse energy (within whole macropulse)	10%

Picosecond Master Oscillator (PMO)



$$I(t) = \sum_{k=-\infty}^{\infty} I_p\left(t + k\frac{2\pi}{\omega_c}\right)$$



Output parameters measurements:

- W = 50 pJ
- P_{pic} = 5 W
- P_{aver}=2 mW
- λ = 1047 nm
- τ = 14 ps
- F = 40.63 MHz
- (2.708=40.63/15)

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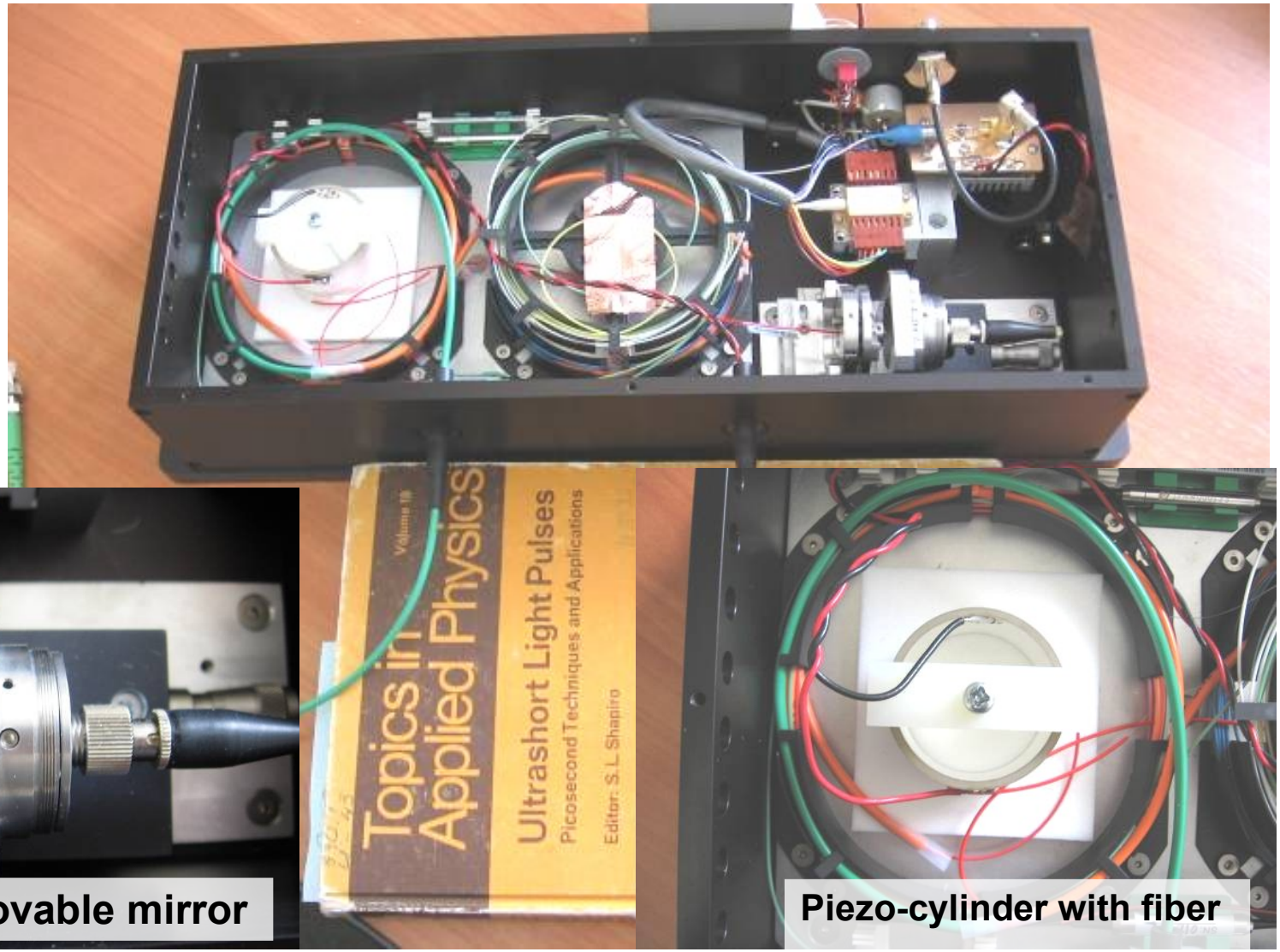
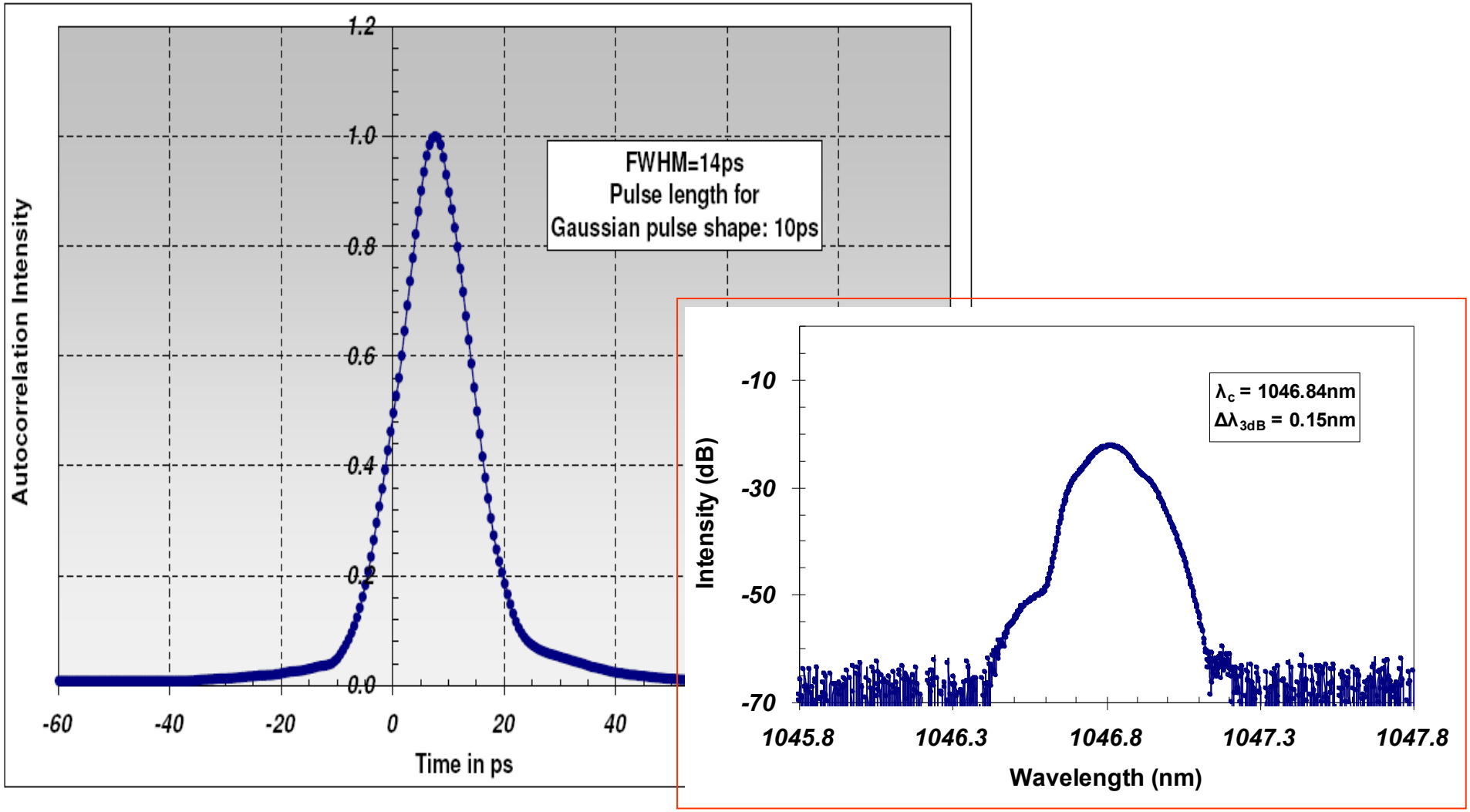
PMO: Pictures



PMO:Wave Length and Pulse duration



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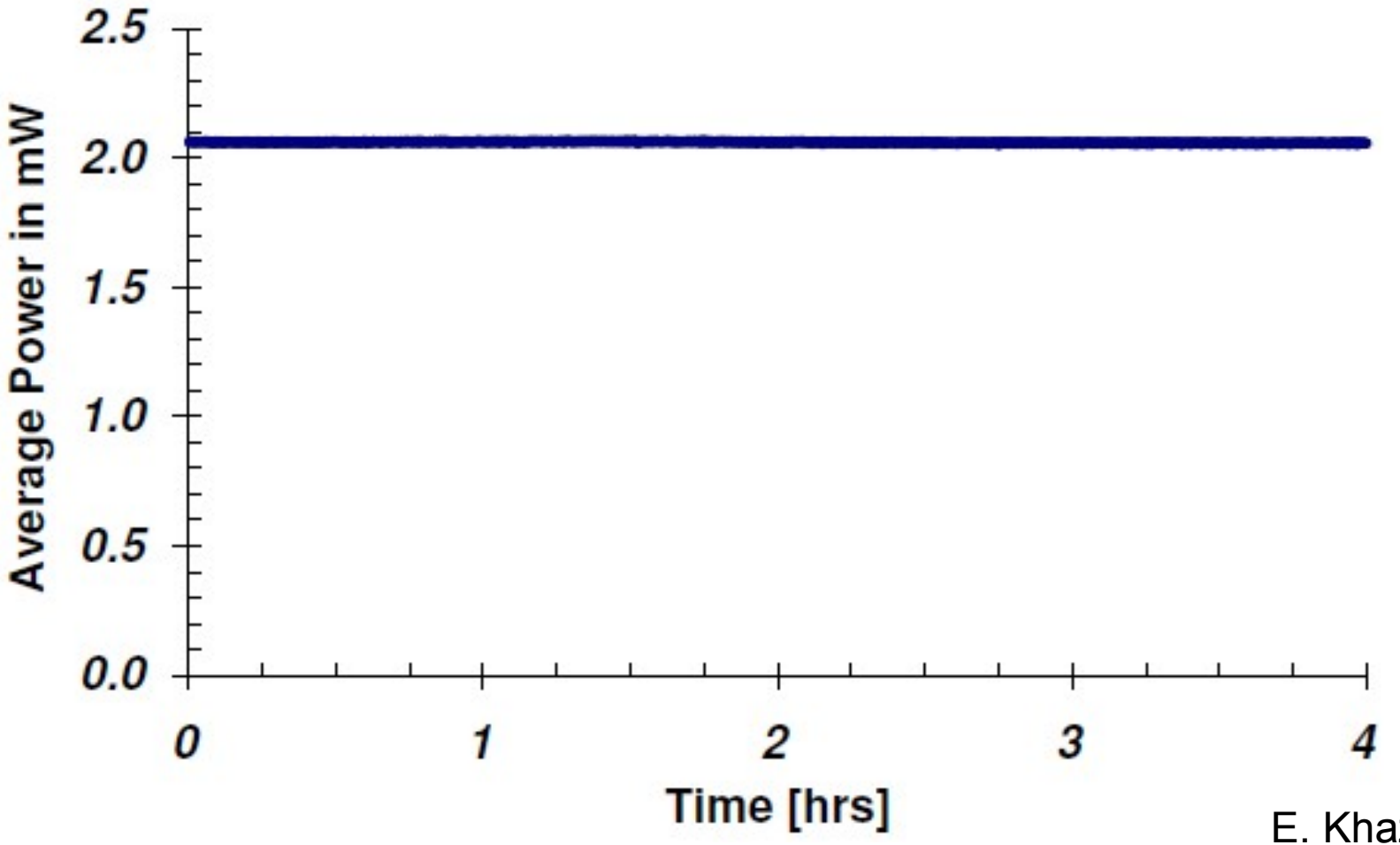
PMO:Power stability
+/- 0.5% @4hours



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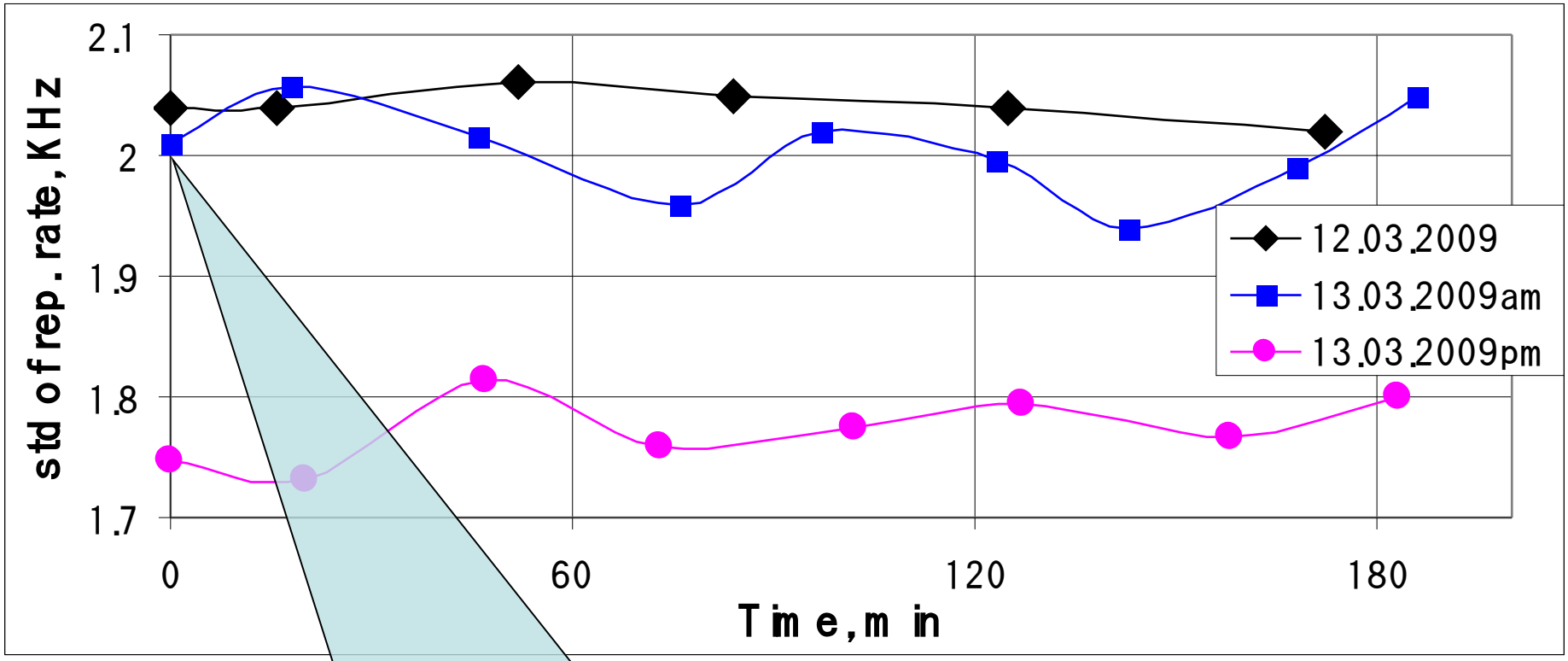
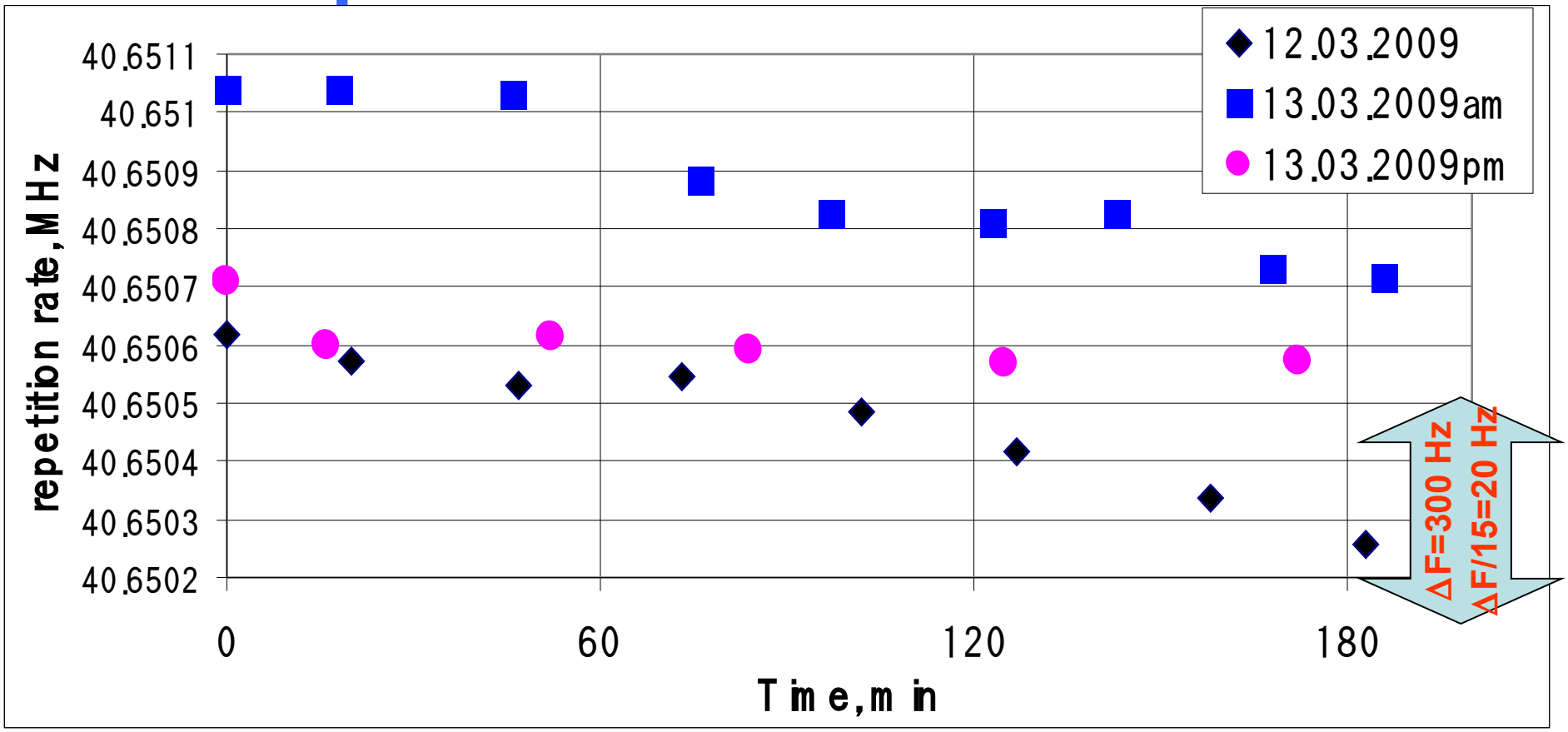
Picosecond master oscillator (PMO). Repetition rate jitter <100Hz @3hours



δF=2 KHz δF/15=130Hz

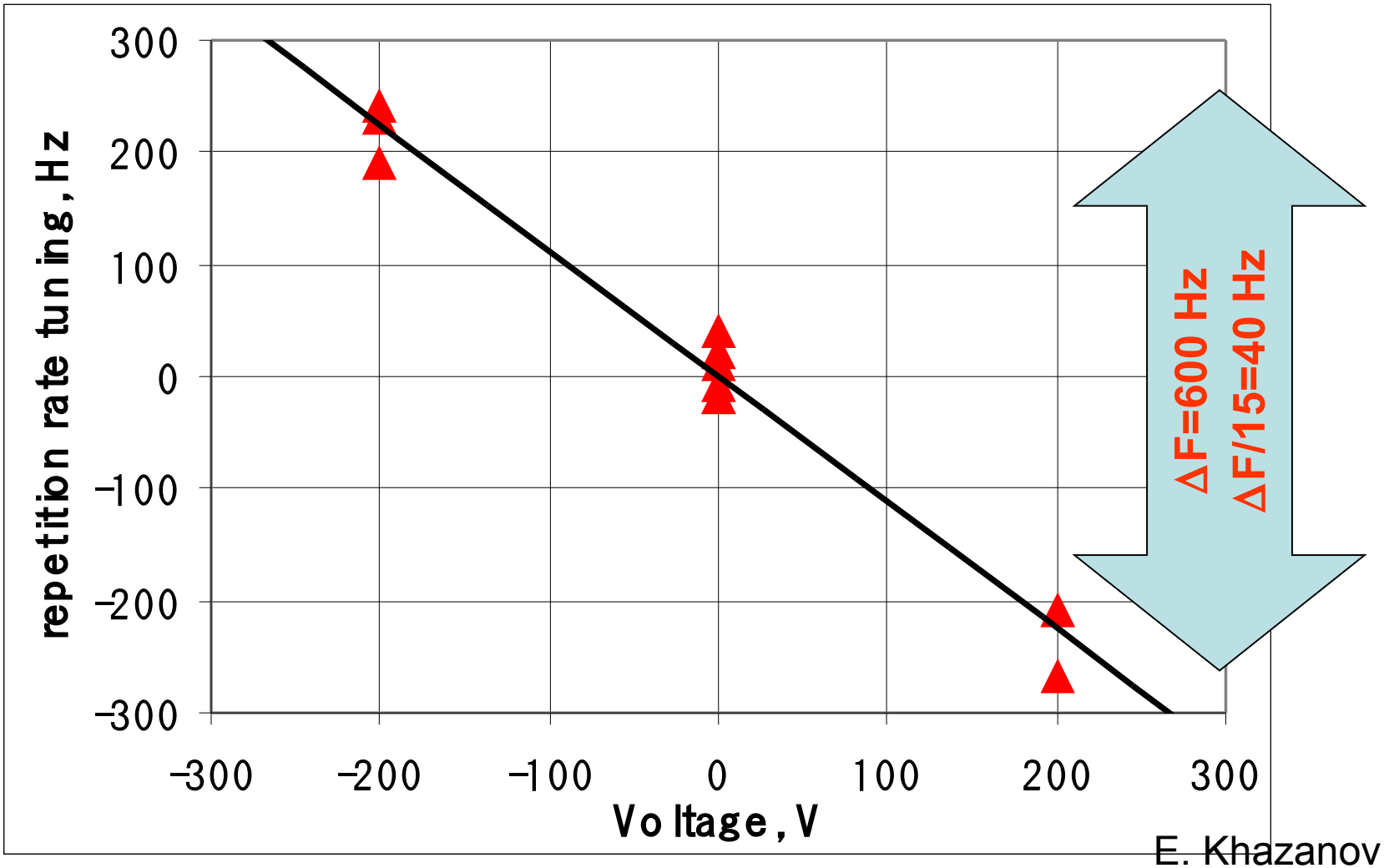
Limited by @4GHz 20GSa oscilloscope

Picosecond master oscillator (PMO).
Repetition rate drift <10Hz/hour



Maximum dF/dt=120Hz/hour
Maximum (dF/dt)/15=8Hz/hour

PMO:Repetition rate *fine* tuning



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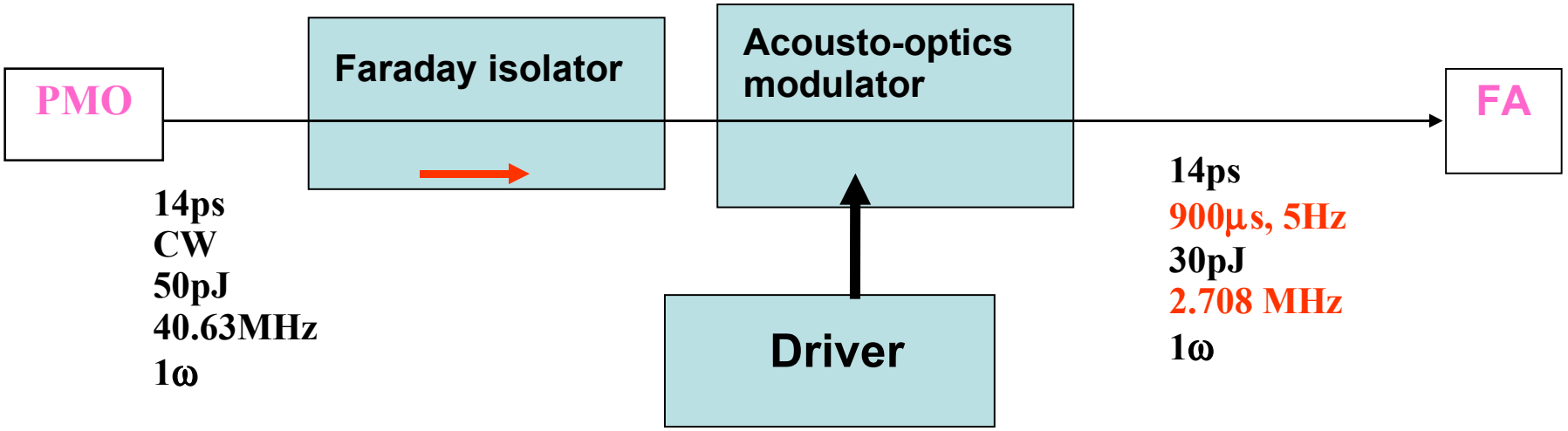
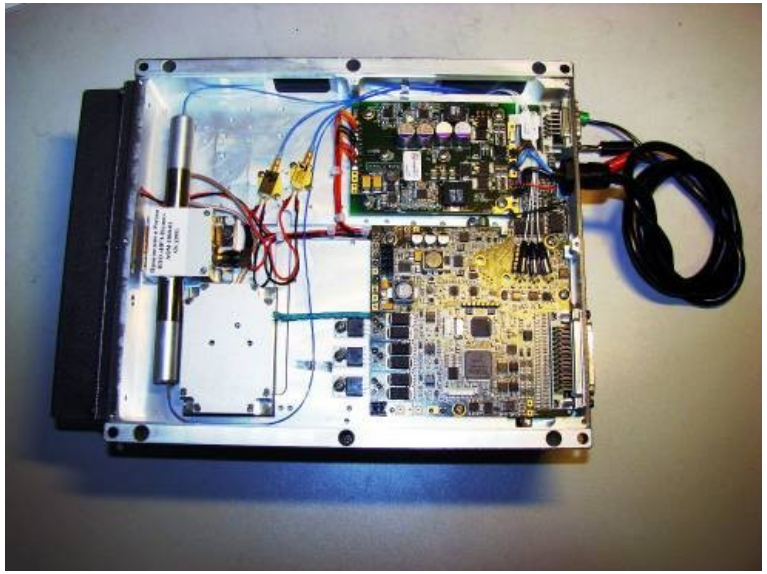
Macropulse profiler (MPP)





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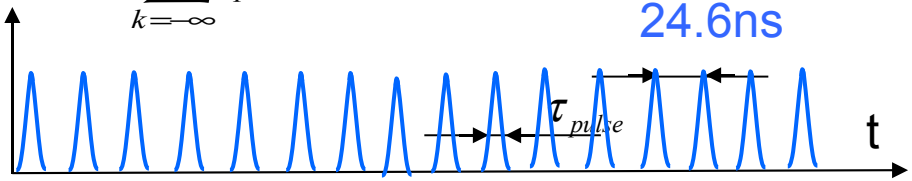
MPP: Functions

1. Transmits only 1 of 15 micropulses

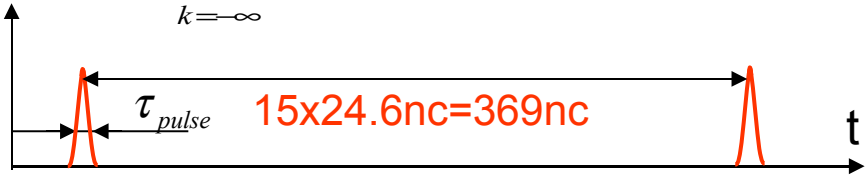
input

$$I(t) = \sum_{k=-\infty}^{\infty} I_p(t + k \cdot 24.6ns)$$

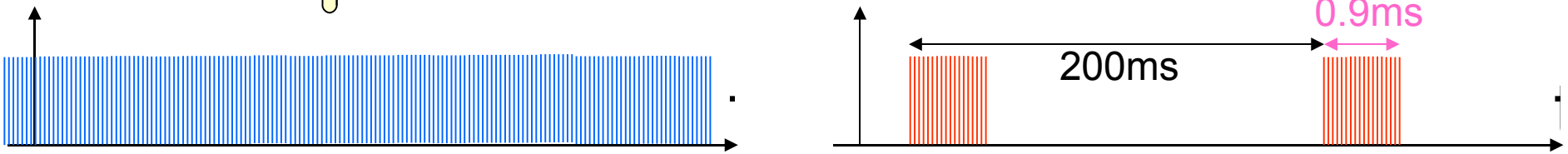


output

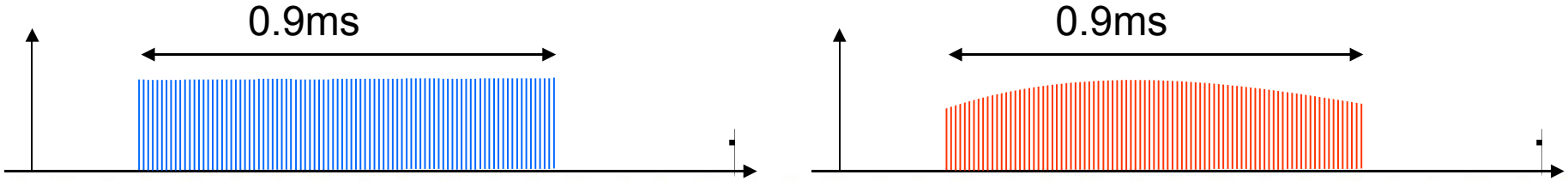
$$I(t) = \sum_{k=-\infty}^{\infty} I_p(t + 15 \cdot 24.6ns)$$



2. Transmits 900μs macropulse @5Hz

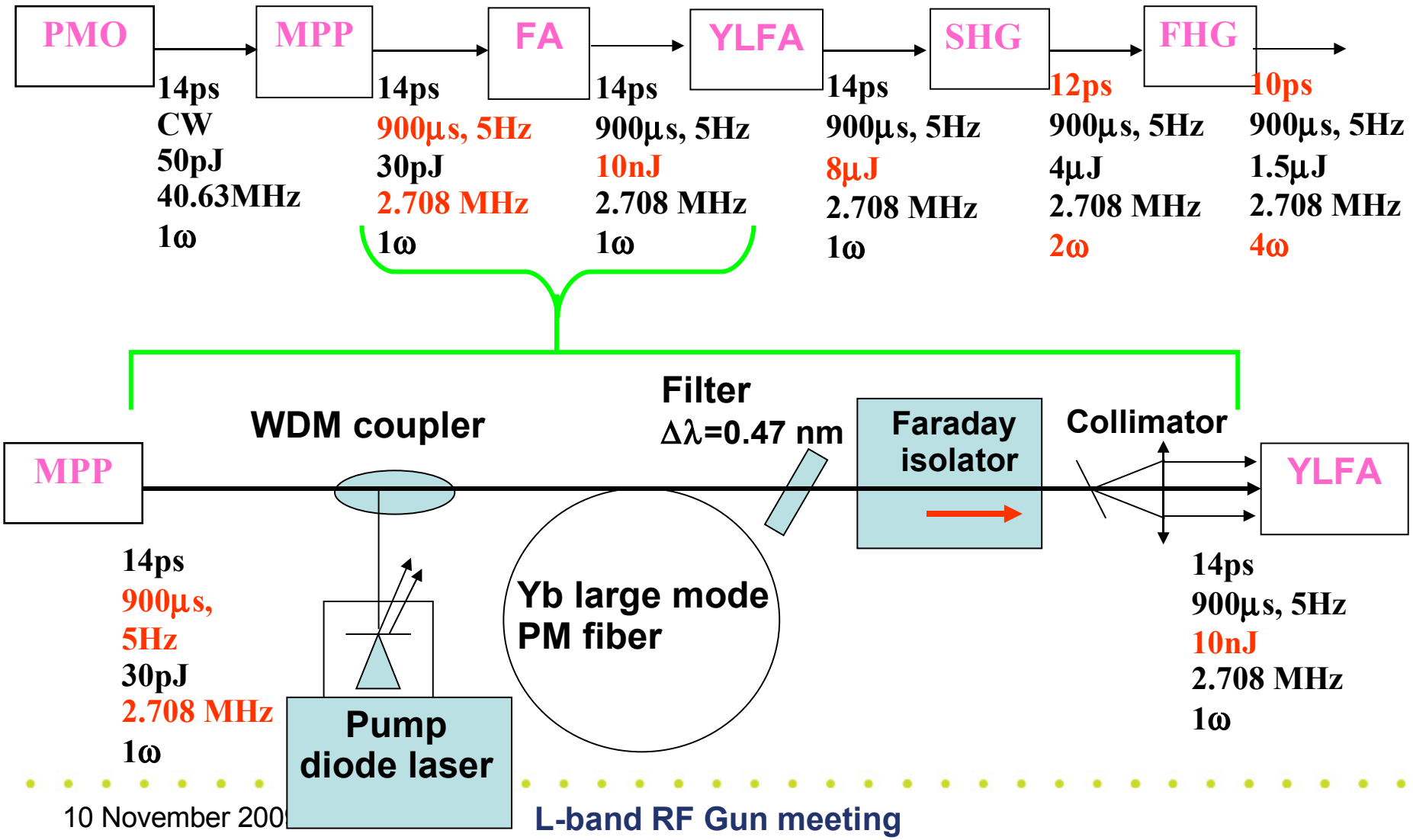


3. Pre-shapes macropulse to compensate gain time dependence



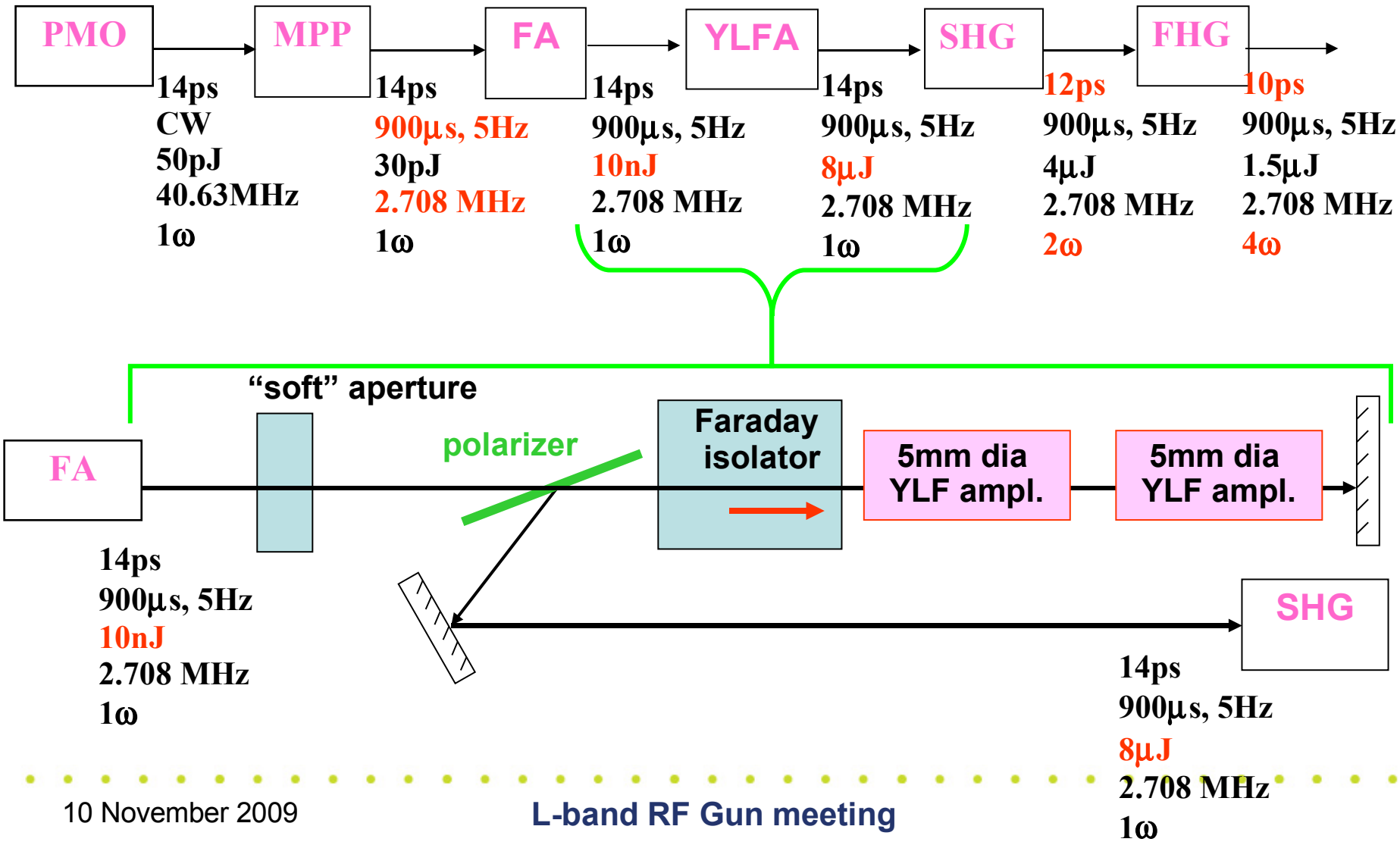
Preliminary fiber amplifier (FA).

Optical scheme.



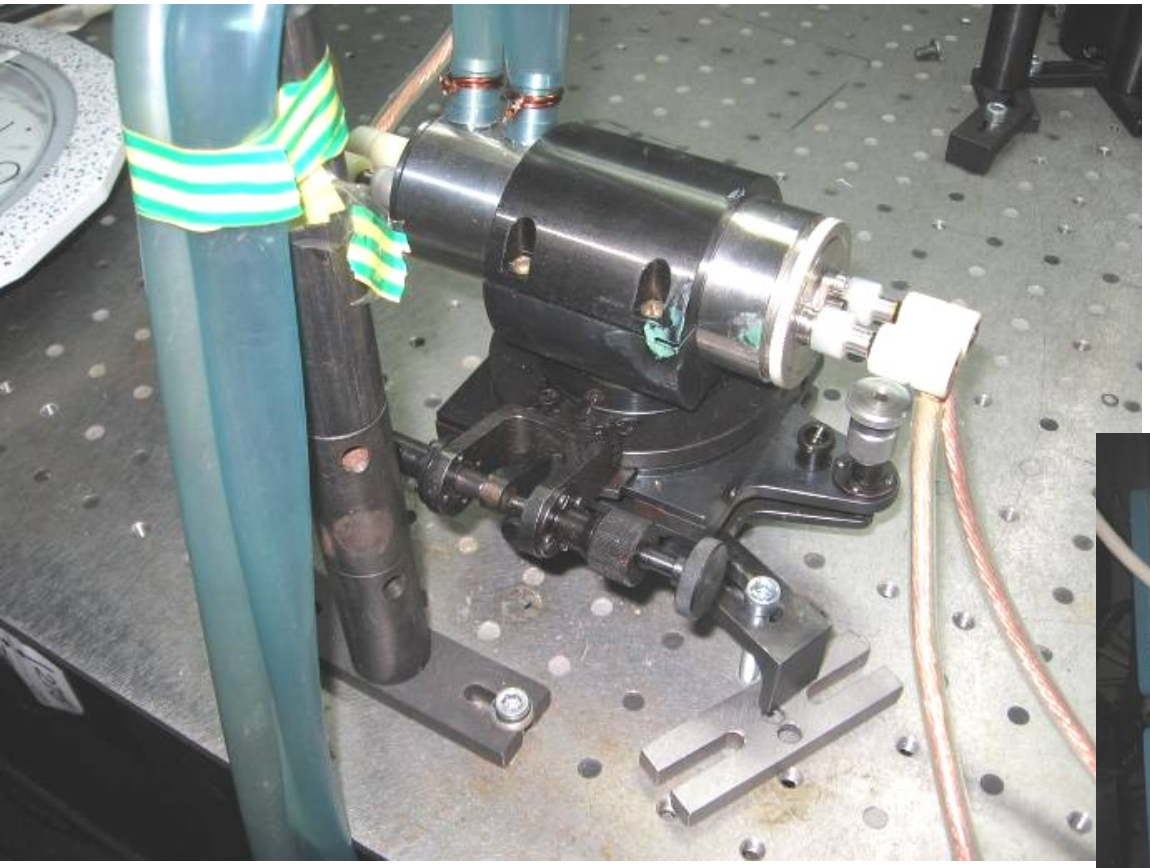
Power Nd:YLF crystal amplifier (YLFA)

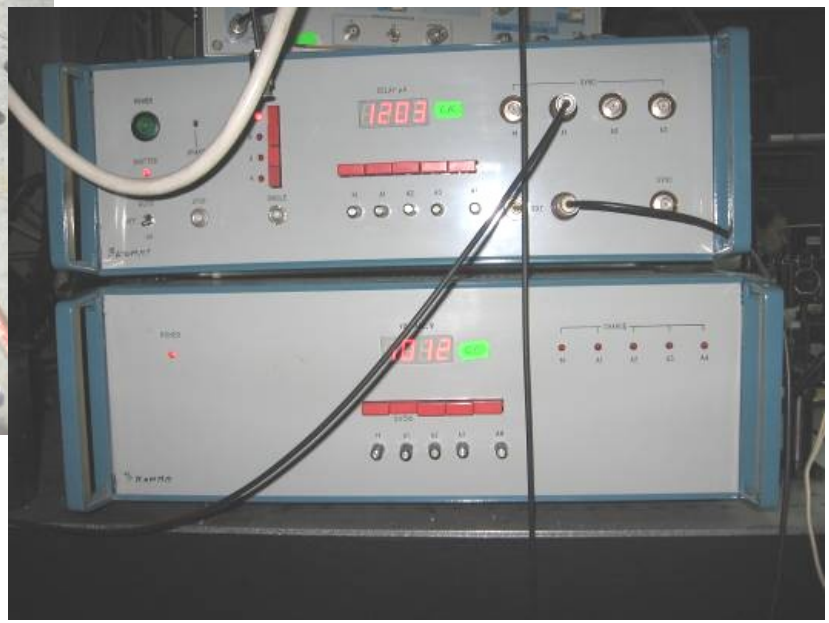
Optical scheme.



Power Nd:YLF crystal amplifier (YLFA)

Picture.





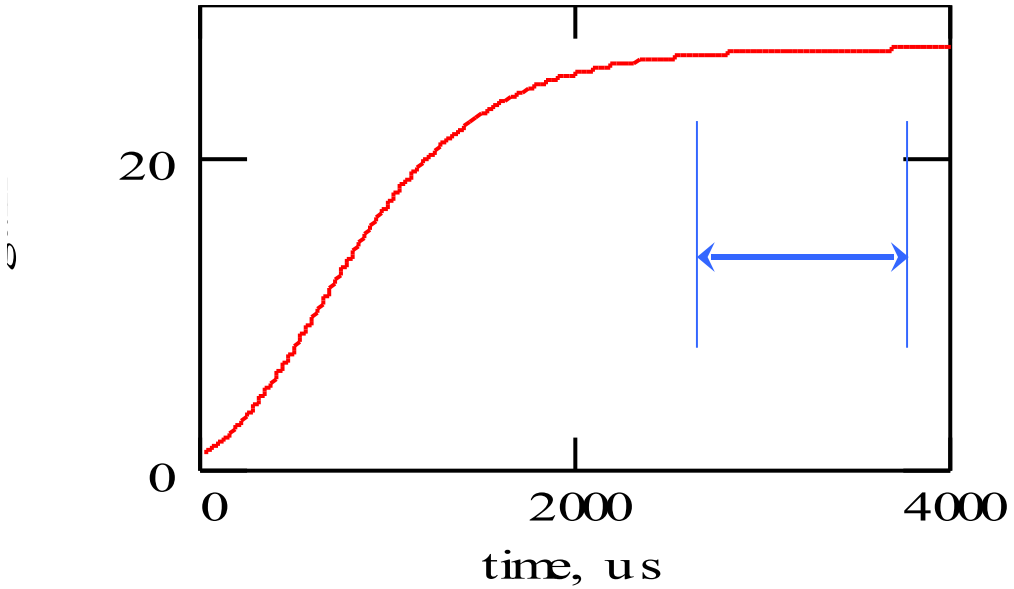
Power Nd:YLF crystal amplifier (YLFA)

Idea of two *short-pulse* YLF amplifiers.

more or less flat gain during 900μs

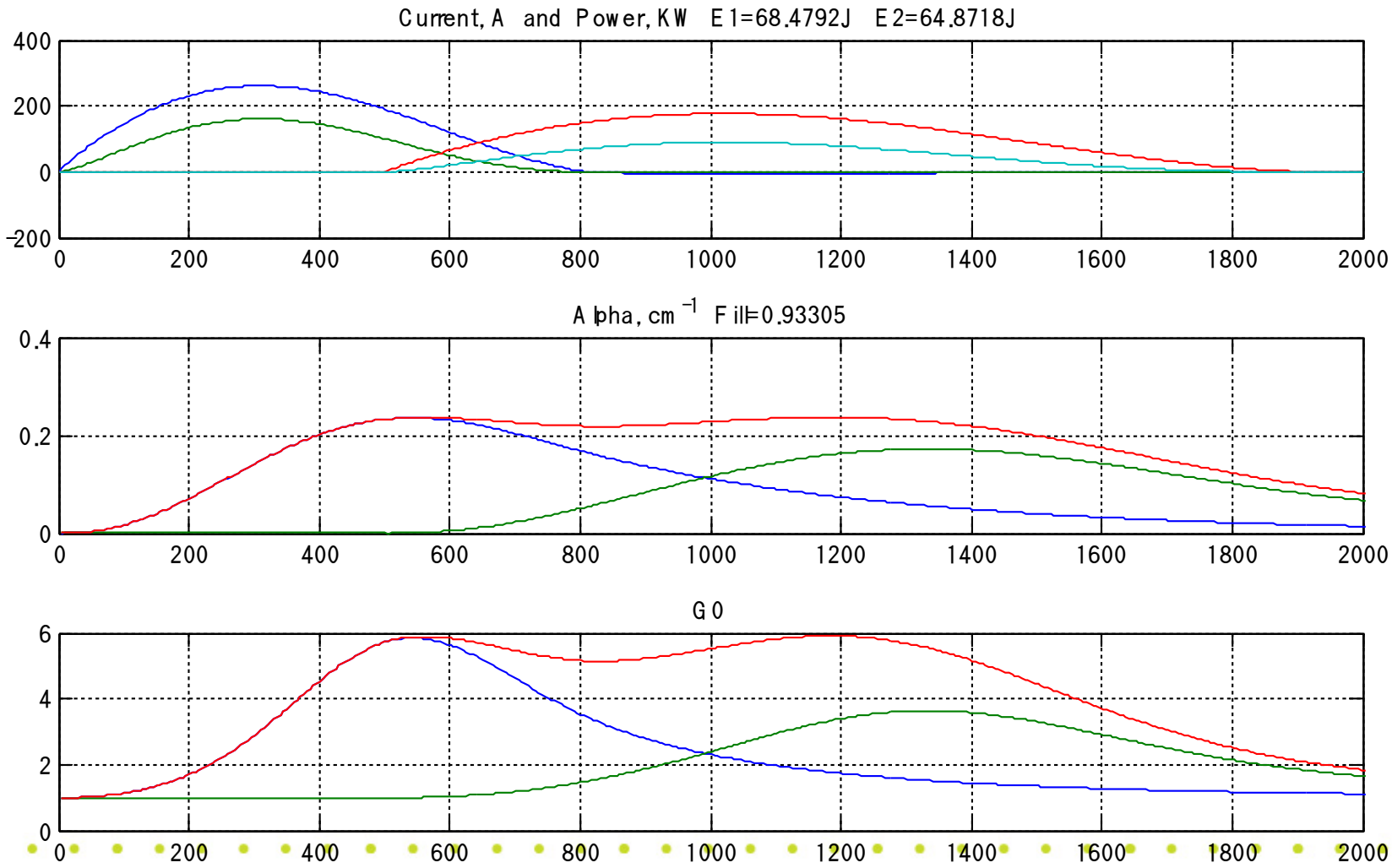
Population inversion lifetime is 500μs

With one amplifier we need very long (2-3ms) pump pulse



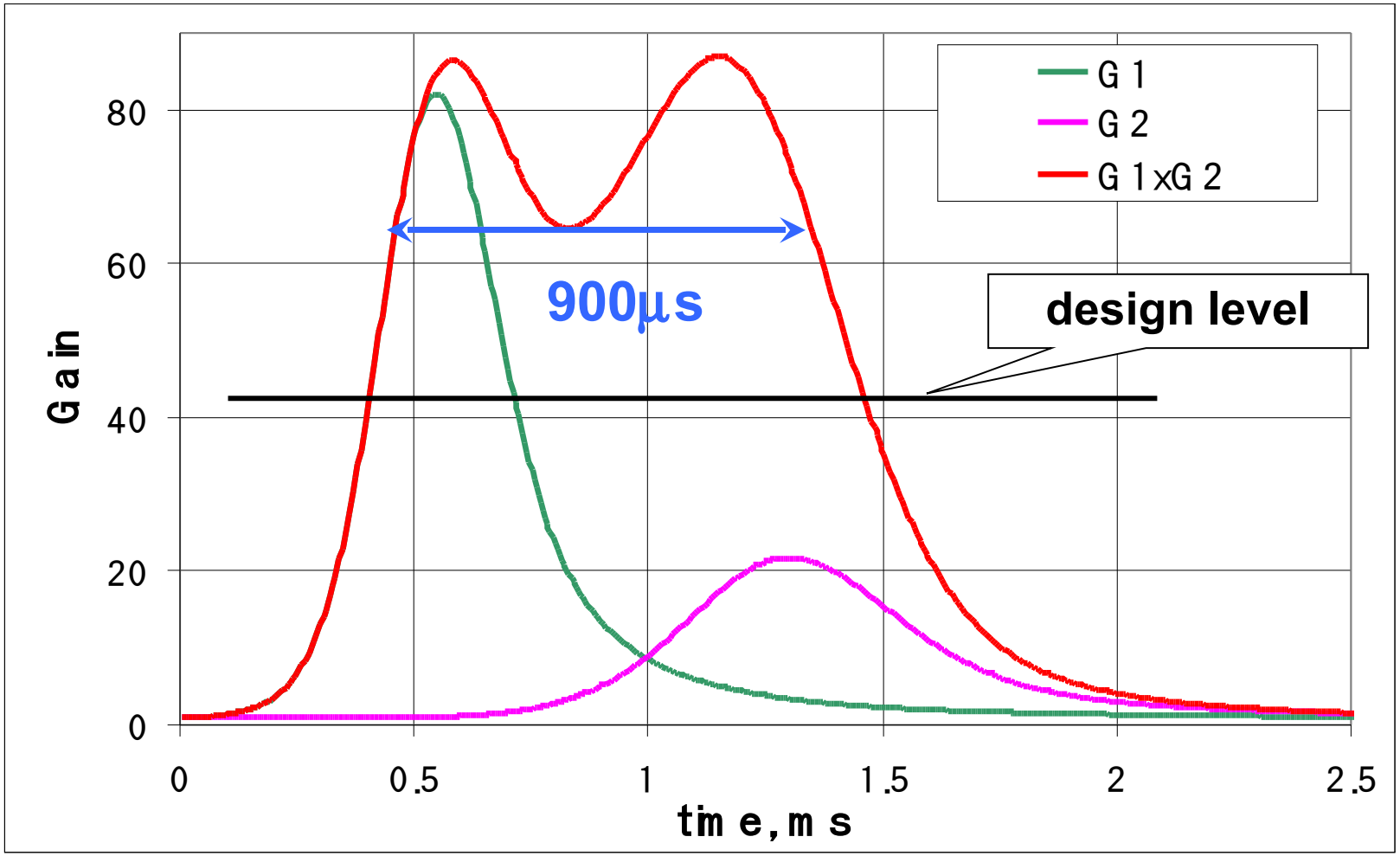
Power Nd:YLF crystal amplifier (YLFA)

Idea of two *short-pulse* YLF amplifiers.



Power Nd:YLF crystal amplifier (YLFA)

Optimal gain temporal profile.

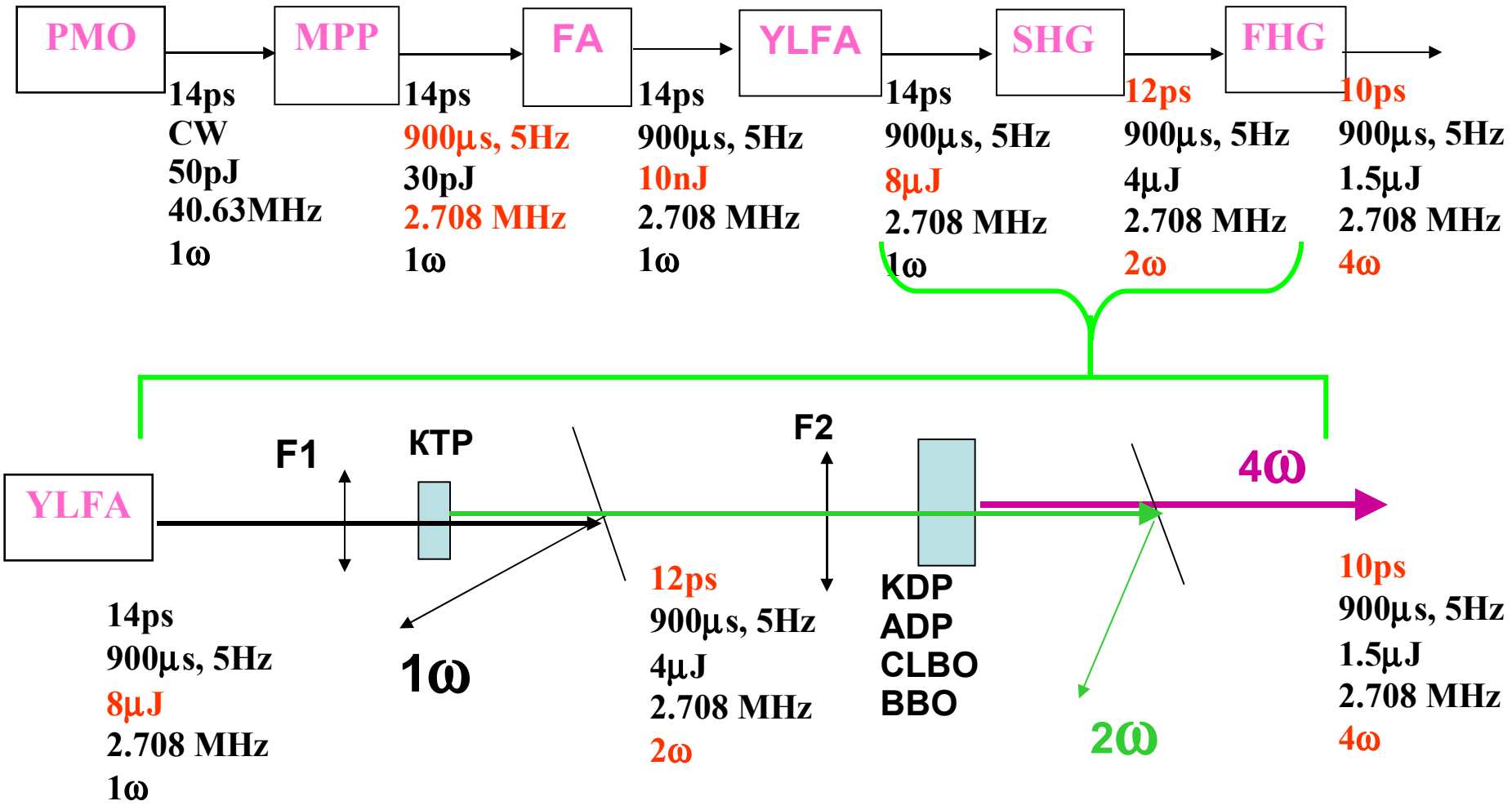


Fundamental mode Status

- 10% standard deviation of the micro pulse energy for whole Macro Pulse is achieved.
- 3% for 10 subsequent pulse is already done.
- Output energy (fundamental mode) is 8uJ/micro pulse, what is expected.

Second and forth harmonic generation

Optical scheme.



SHG and FHG

- UV laser (263nm) is obtained as consequence of SHG and FHG by non-linear crystals.
- HG generation is achieved by birefringence of non-linear crystal for phase-matching condition.
- Phase matching (phase velocity matching) , High efficiency, and less walk-off (group velocity matching) are feasible for HG crystals.

SHG

- KTP has the largest figure of merit in HG.
- 10uJ pulse, 10ps pulse duration, spot size 330um, 0.6cm length; expected conversion efficiency 80%.
- Less breakdown limit 5-10 GW/cm^2.
- 50 % efficiency is achieved experimentally.

	d_{eff} , pm/V	w, mrad	d_{eff} /w
KTP	3.59	4.09	0.88
LBO	0.831	6.93	0.12
BBO	2.01	55.86	0.036

FHG

- KTP and LBO are excluded due to non-transparency and difficulty on phase matching.
- Choice will be made among ADP, DADP, and KDP.
- KDP case: 1uJ pulse, 10ps pulse duration, spot size 200um, 2.5cm length; expected conversion efficiency 60%.
- Pulse length will be shorten down to 8.6ps after HG.

	d_{eff} , pm/V	w, mrad	d_{eff} /w x 100
ADP	0.678	8.36	8.11
DADP	0.624	7.69	8.11
KDP	0.469	12	3.91
CLBO	0.798	32.2	2.48
BBO	1.74	85.34	2.04
DLAP	0.45	46.6	0.97
KBBF	0.426	53.6	0.79
KABO	0.271	49.57	0.55
LB4	0.132	28	0.47
LFM	0.461	100	0.46

Summary

- Pico-second Master Oscillator, Macropulser profiler, YLF amplifier, SHG are almost completed.
- Study to finalize the system with FHG is on-going.
- The final status will be examined by our visit to IAP in December.
- Synchronization to RF is a big issue. Feed back loop to cavity length synchronizing to RF signal should be made.