



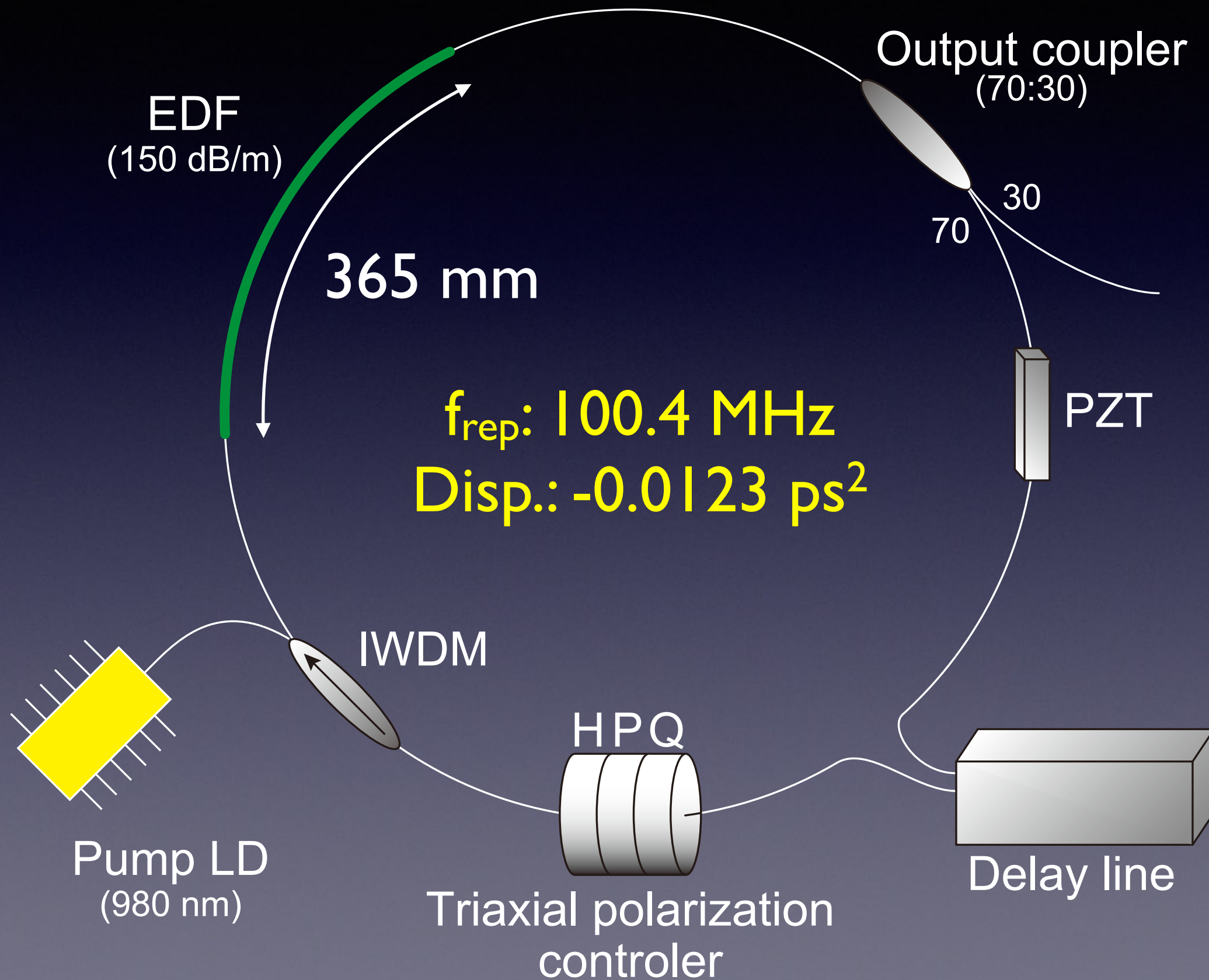
Development of Piezo-EOM dual-comb system

Takeo Minamikawa

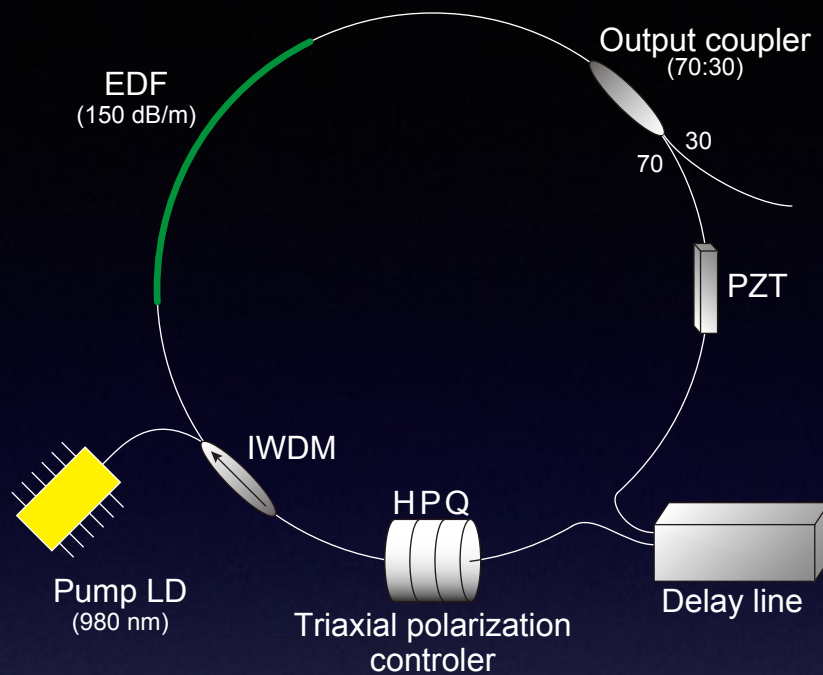
Institute of Technology and Science, Tokushima Univ.
JST/ERATO Minoshima Intelligent Optical Synthesizer Project

Contact: minamikawa.takeo@tokushima-u.ac.jp

Fiber laser setup

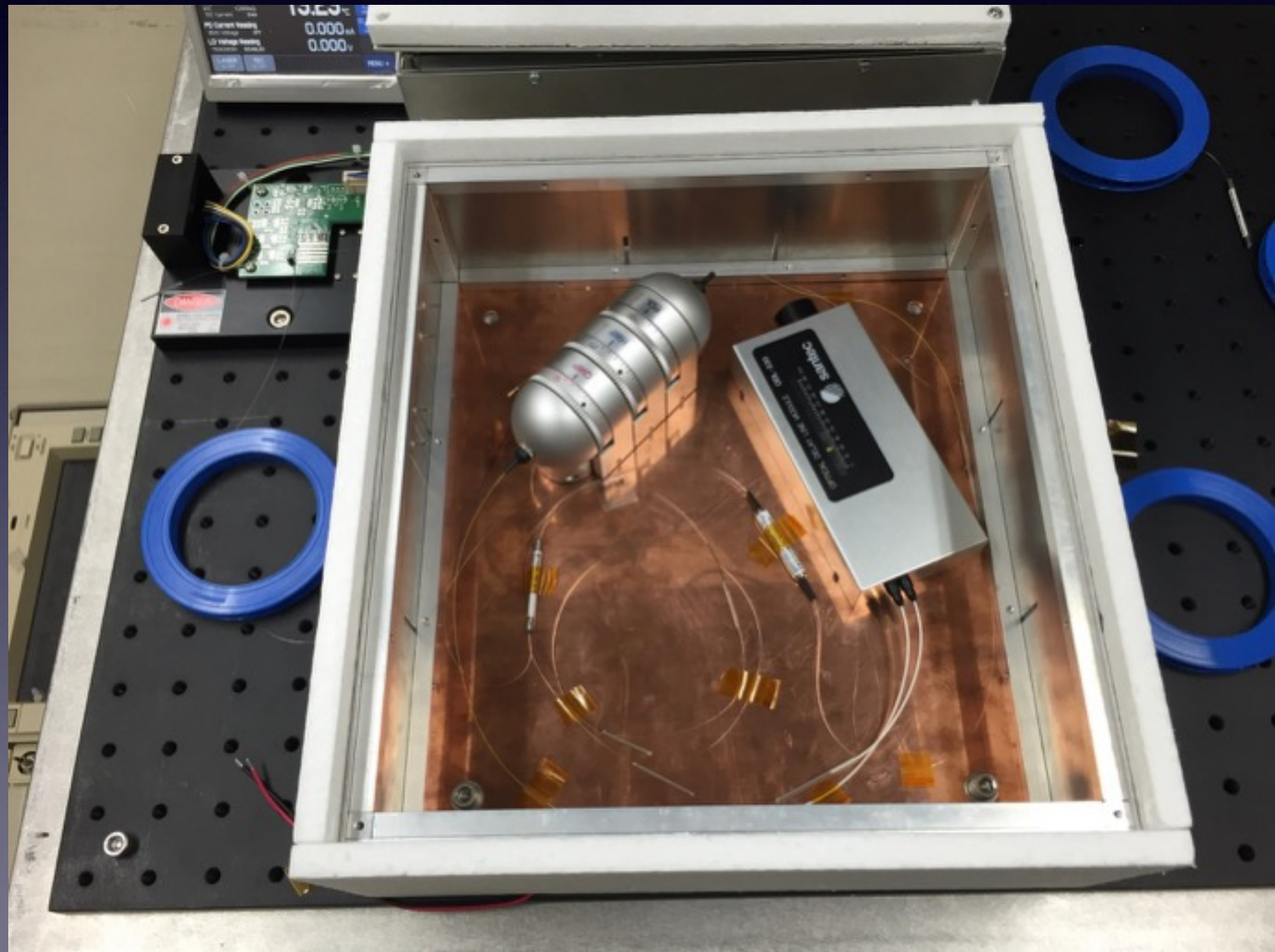


Fiber laser setup in chamber

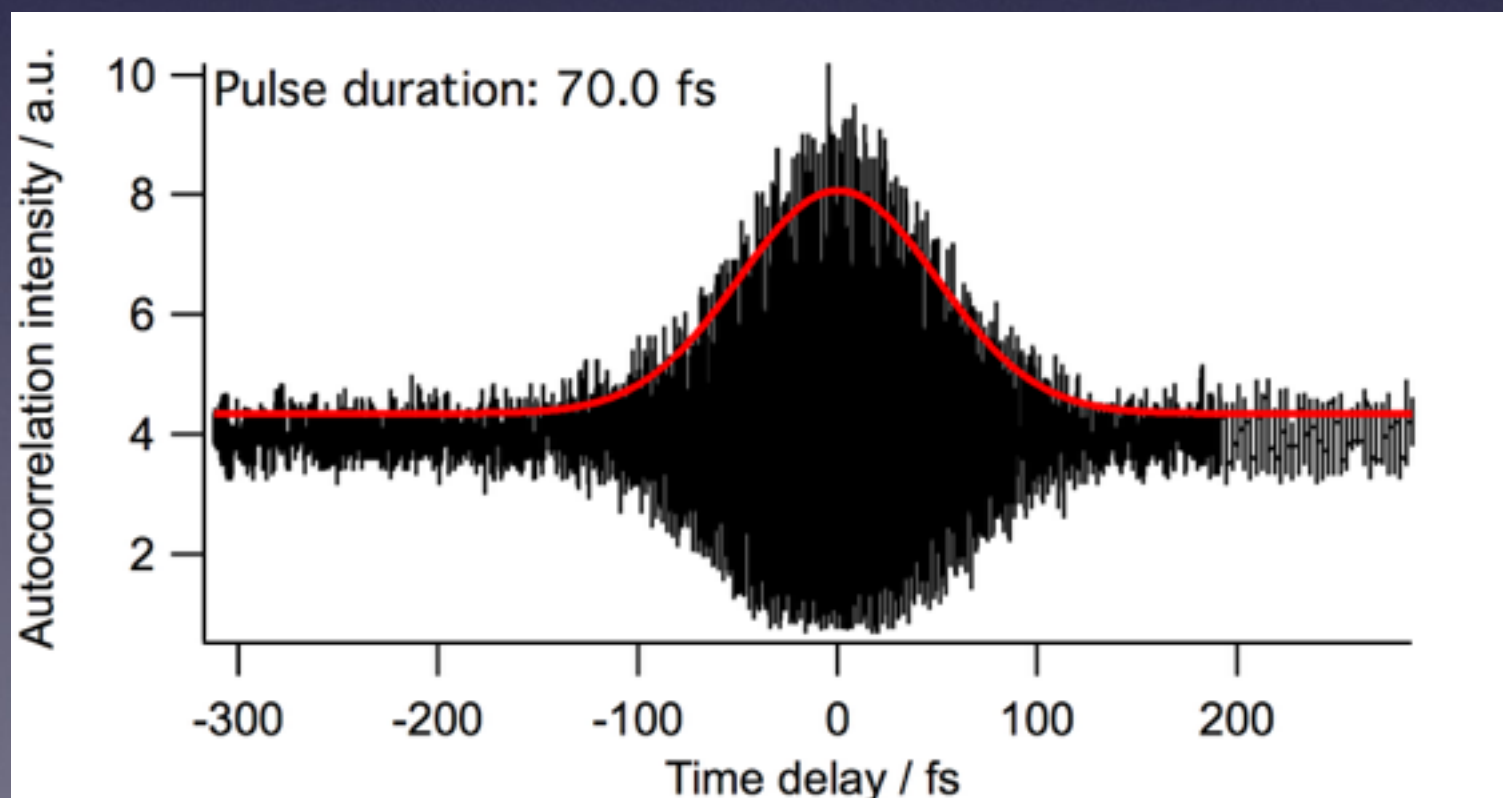
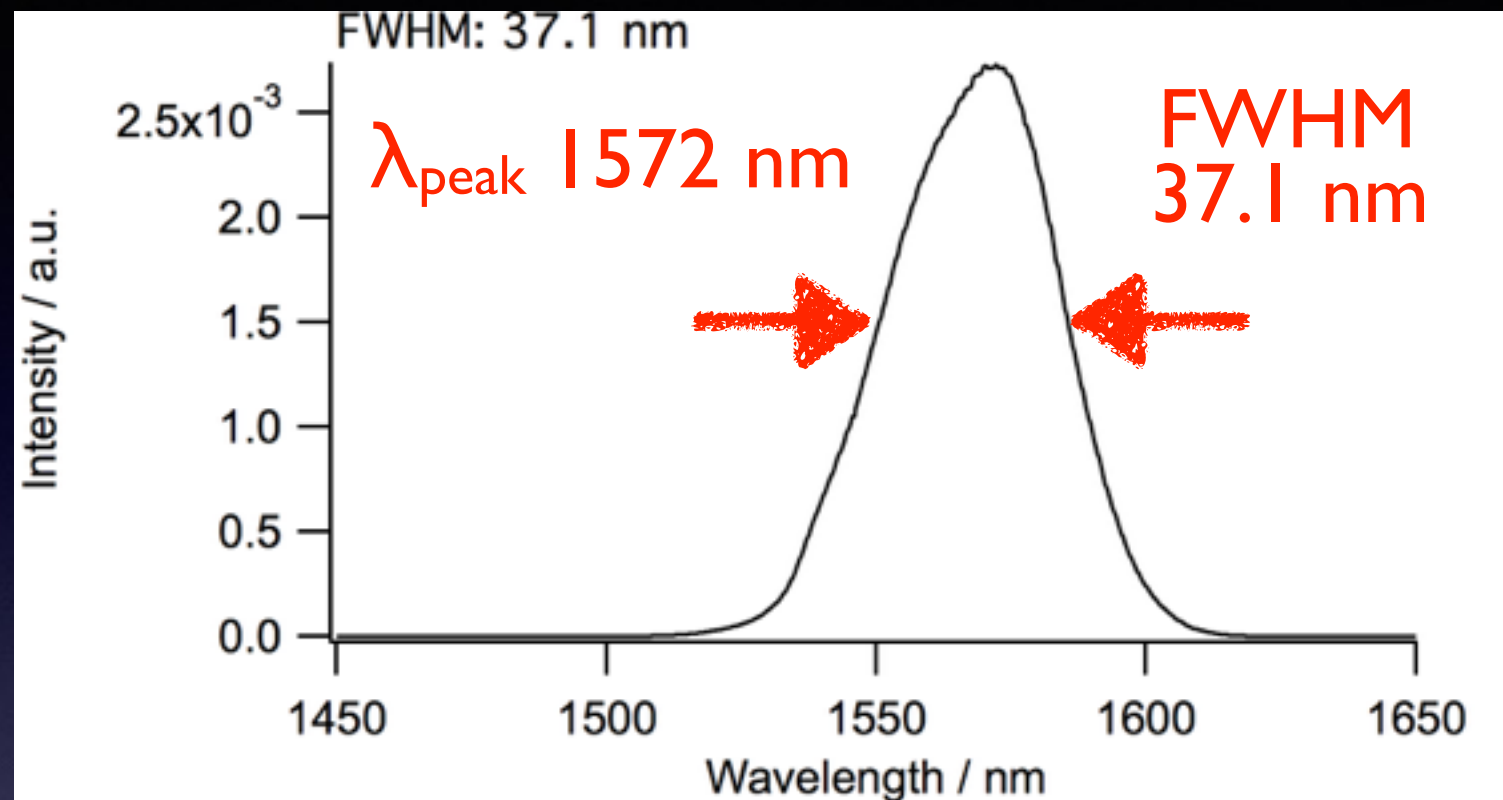


Laser power
9.49 mW

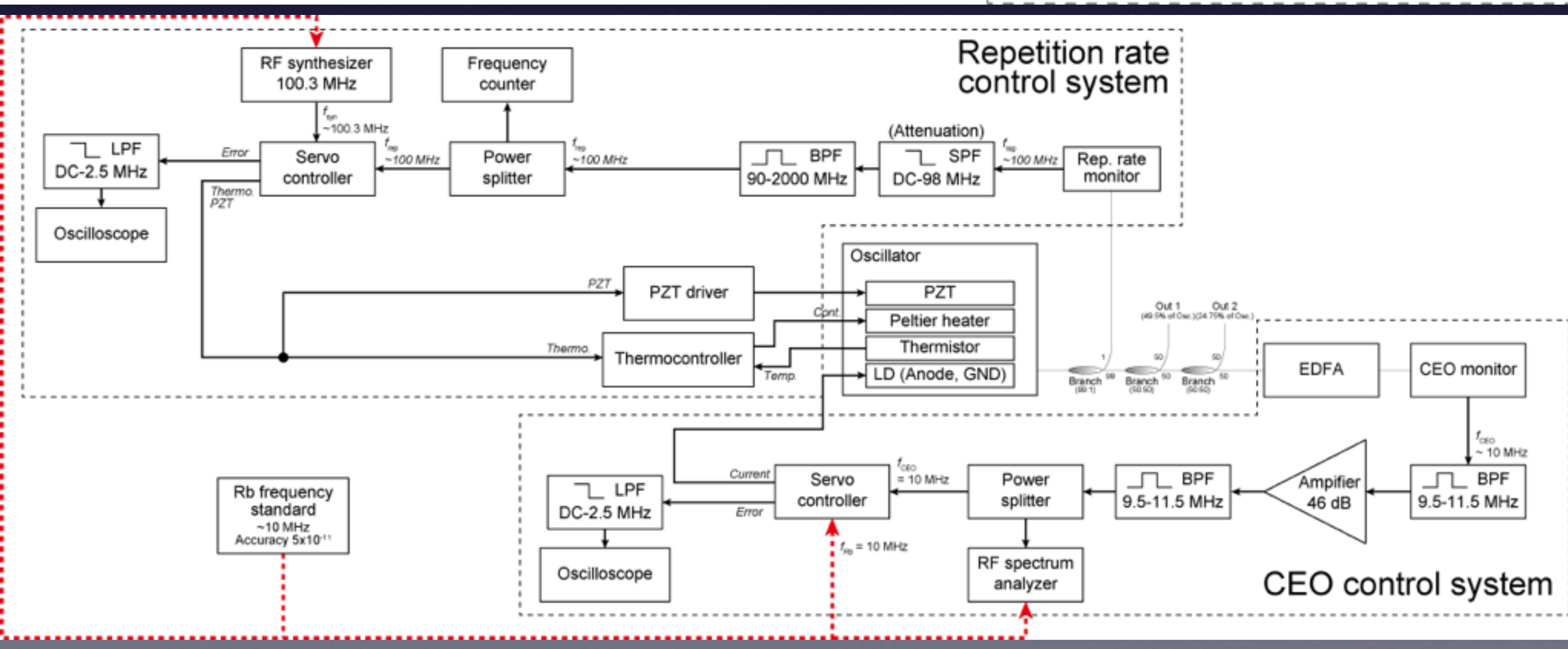
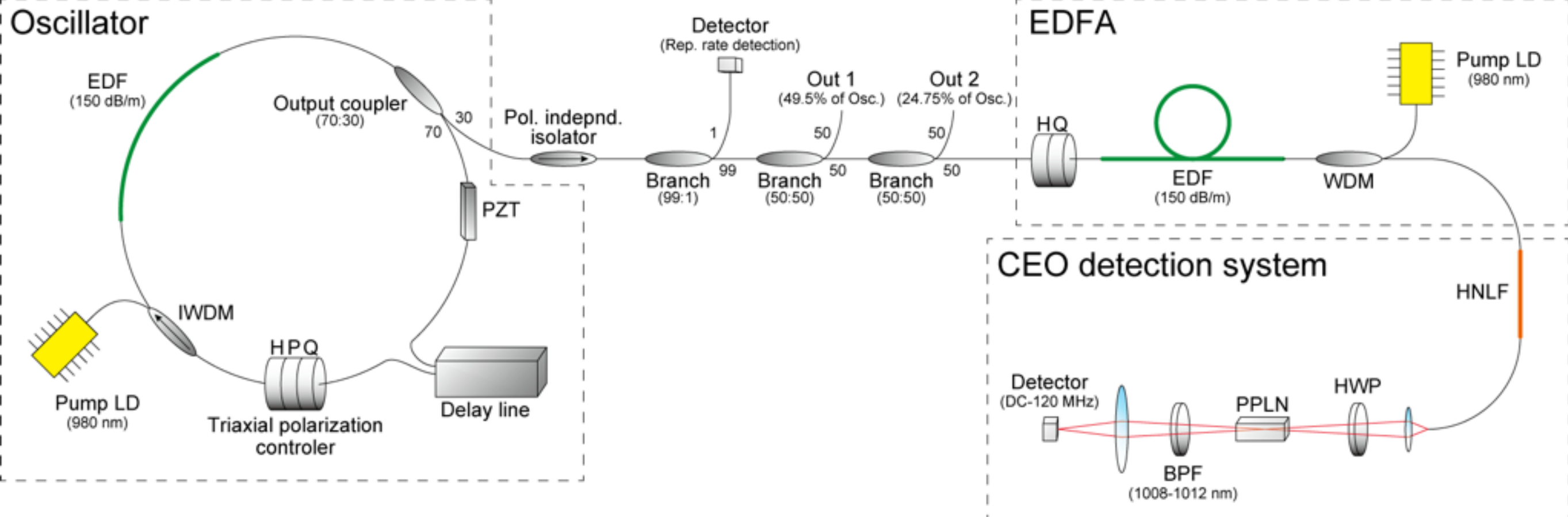
LD current: 360 mA@ 21.0 °C

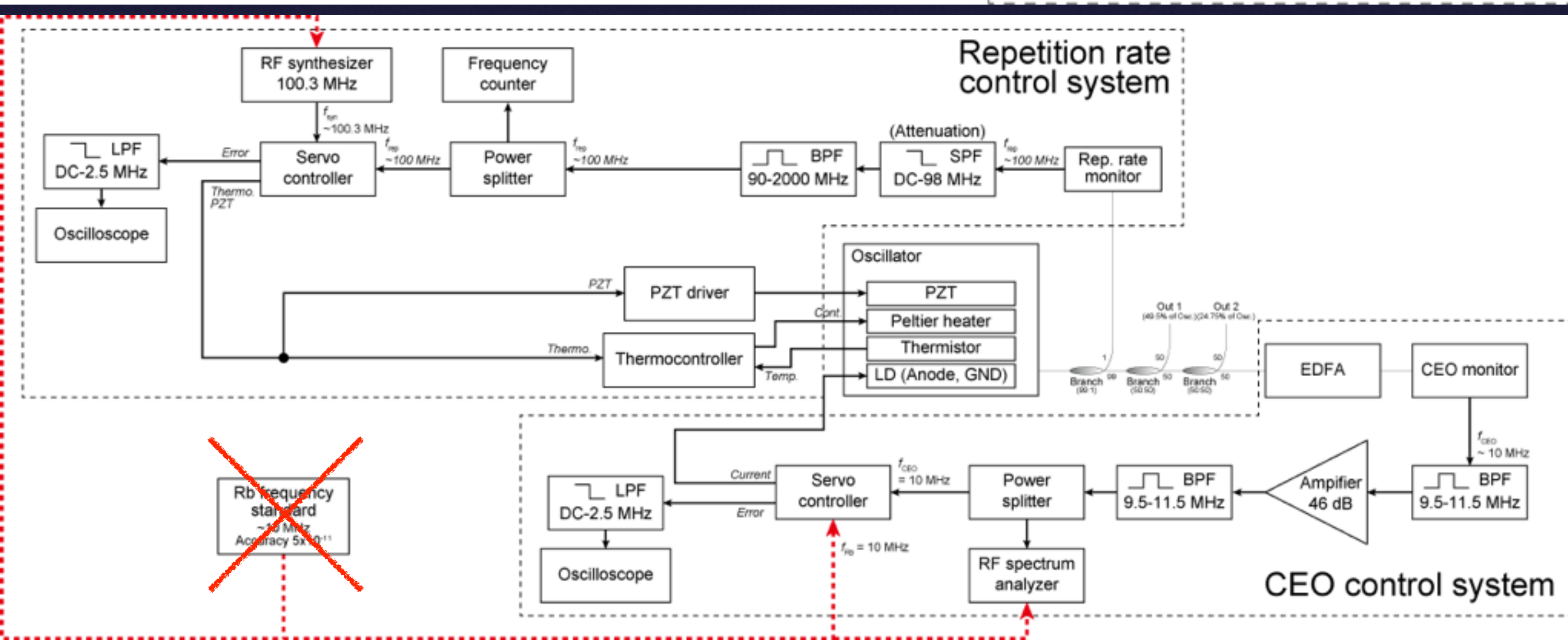
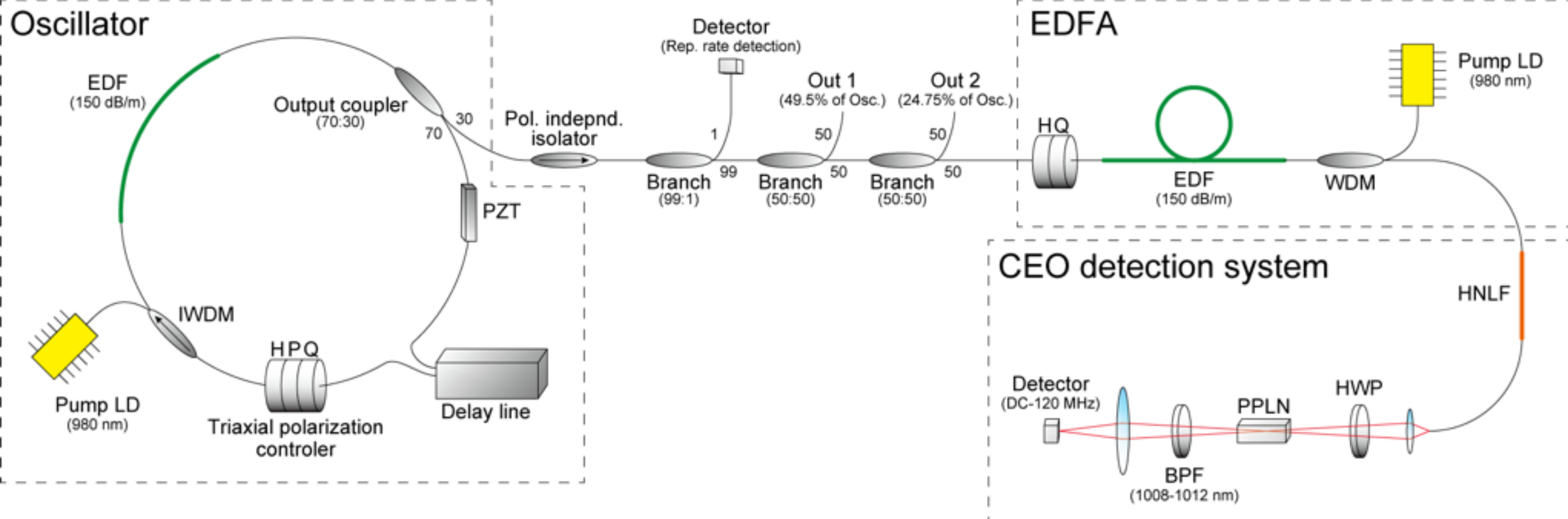


Fiber laser spec. - Wavelength -



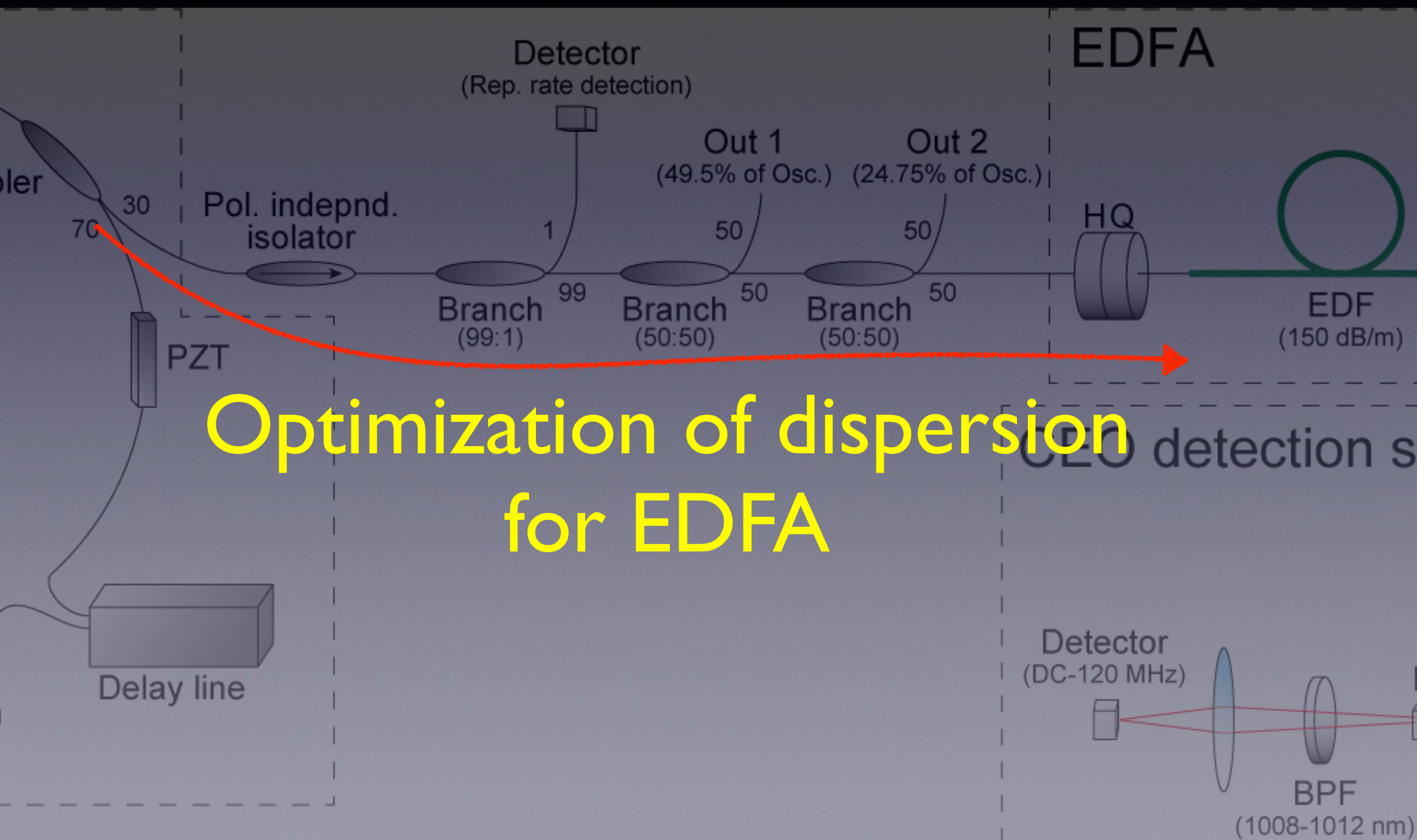
Progress



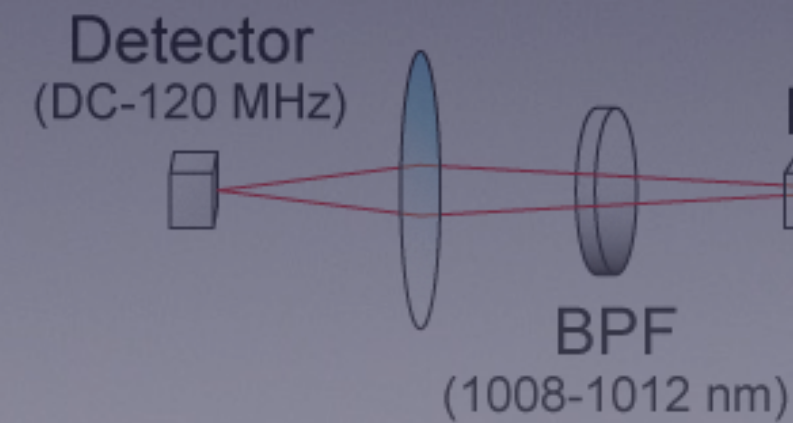
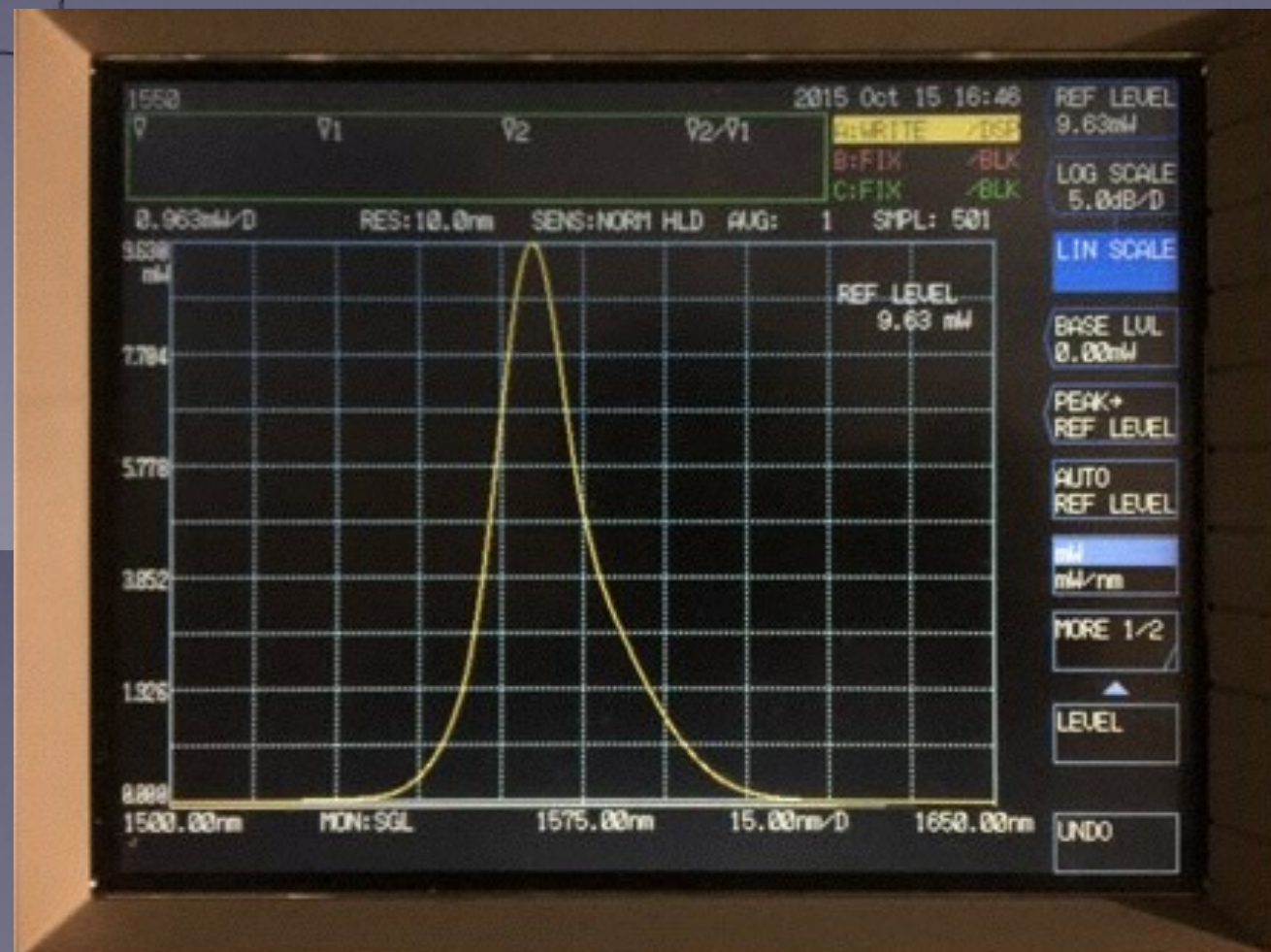
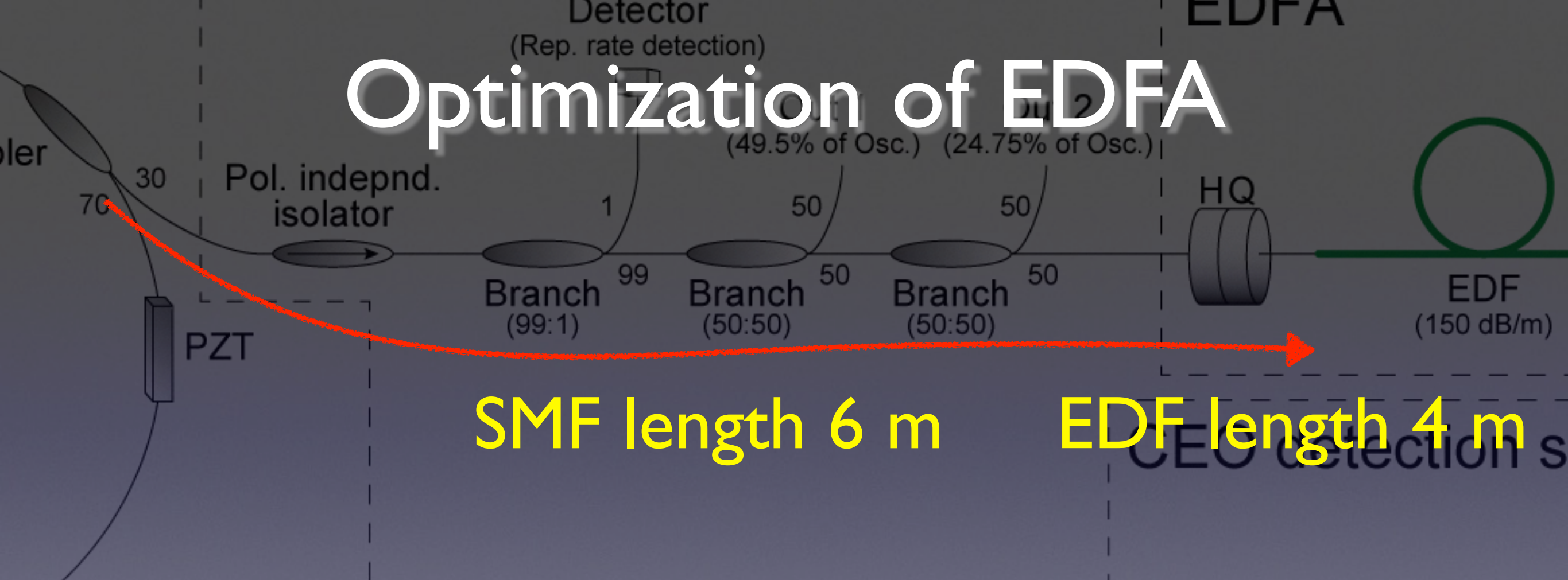


f_{ceo} stabilization

Optimization of EDFA



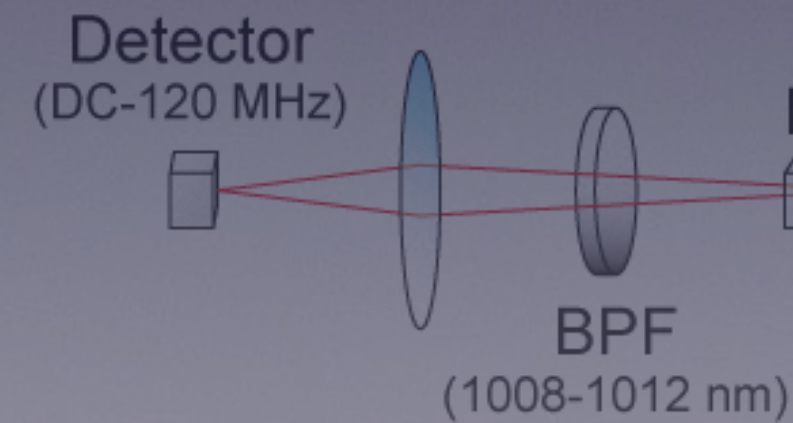
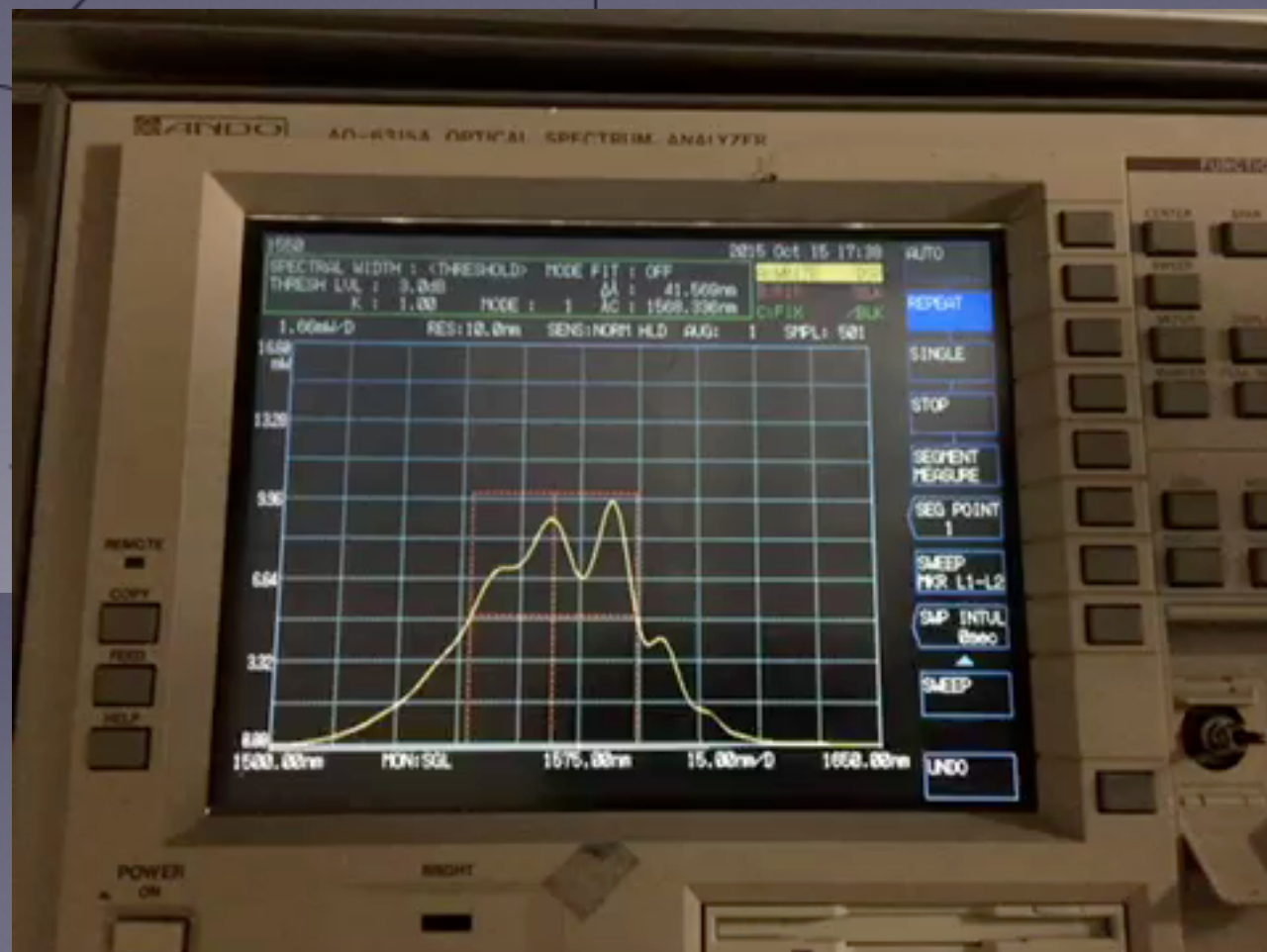
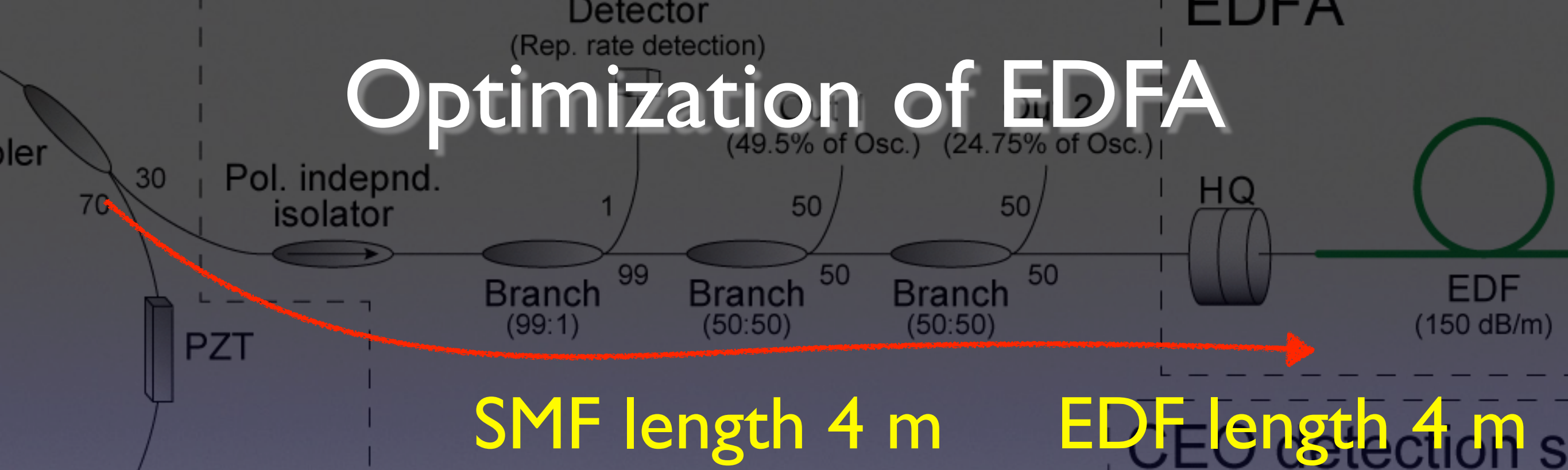
Optimization of EDFA



No change

by tuning HWP and QWP

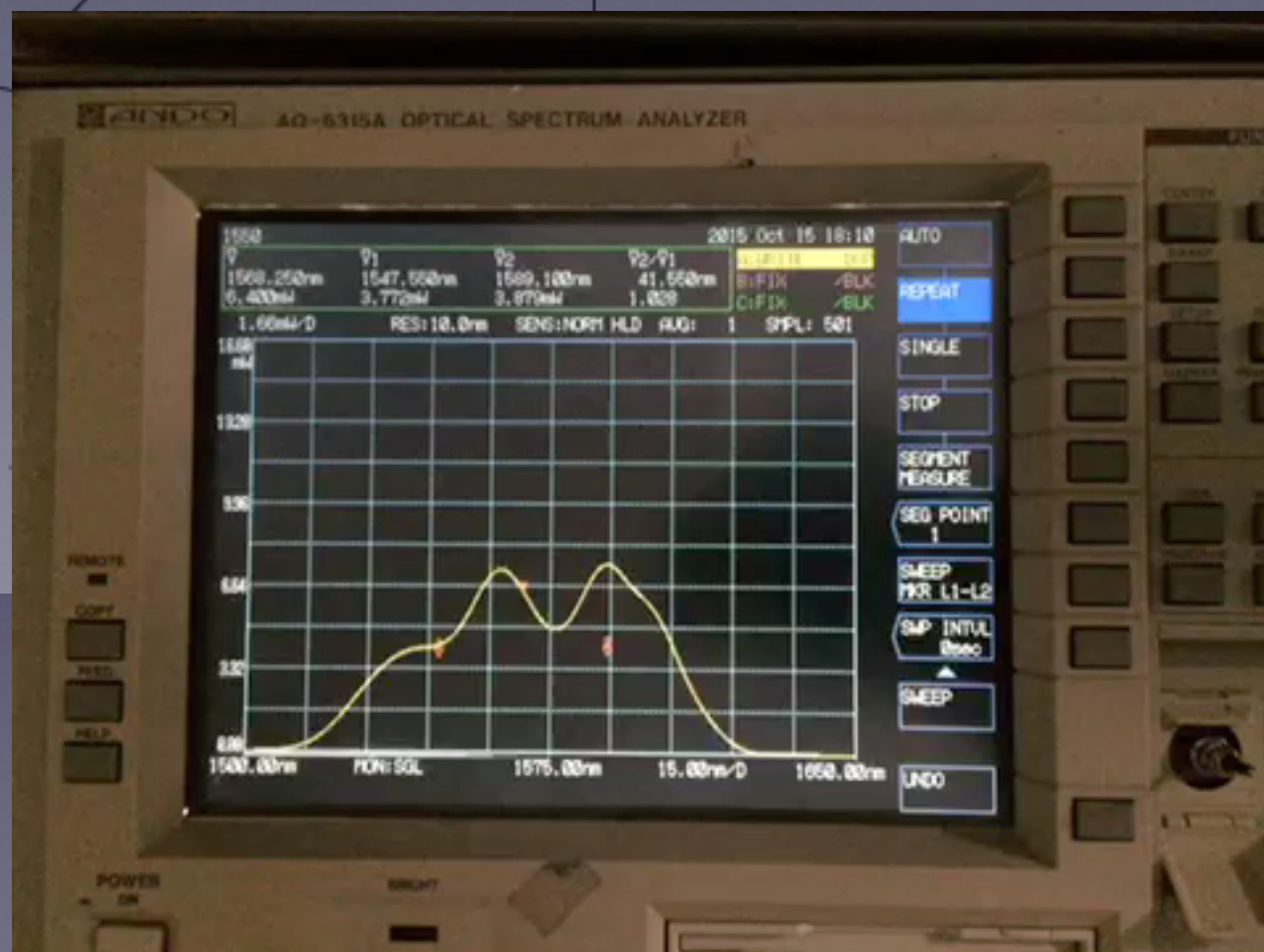
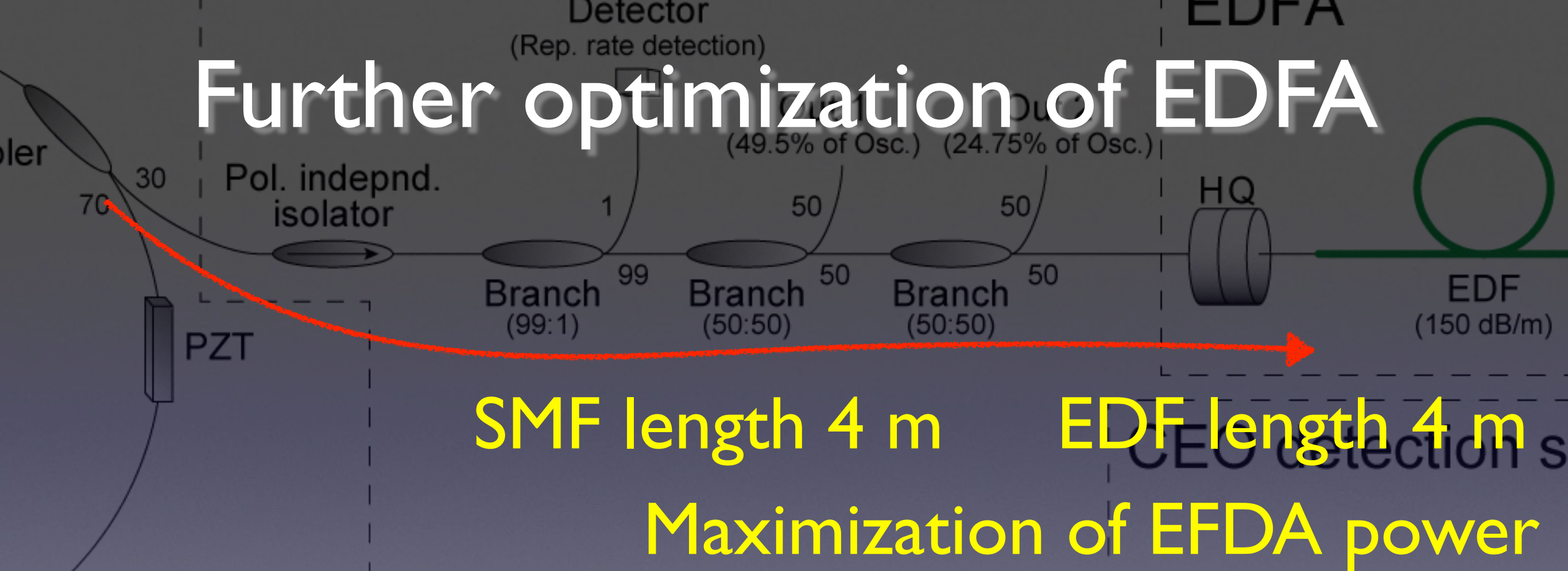
Optimization of EDFA



Changed

by tuning HWP and QWP

Further optimization of EDFA

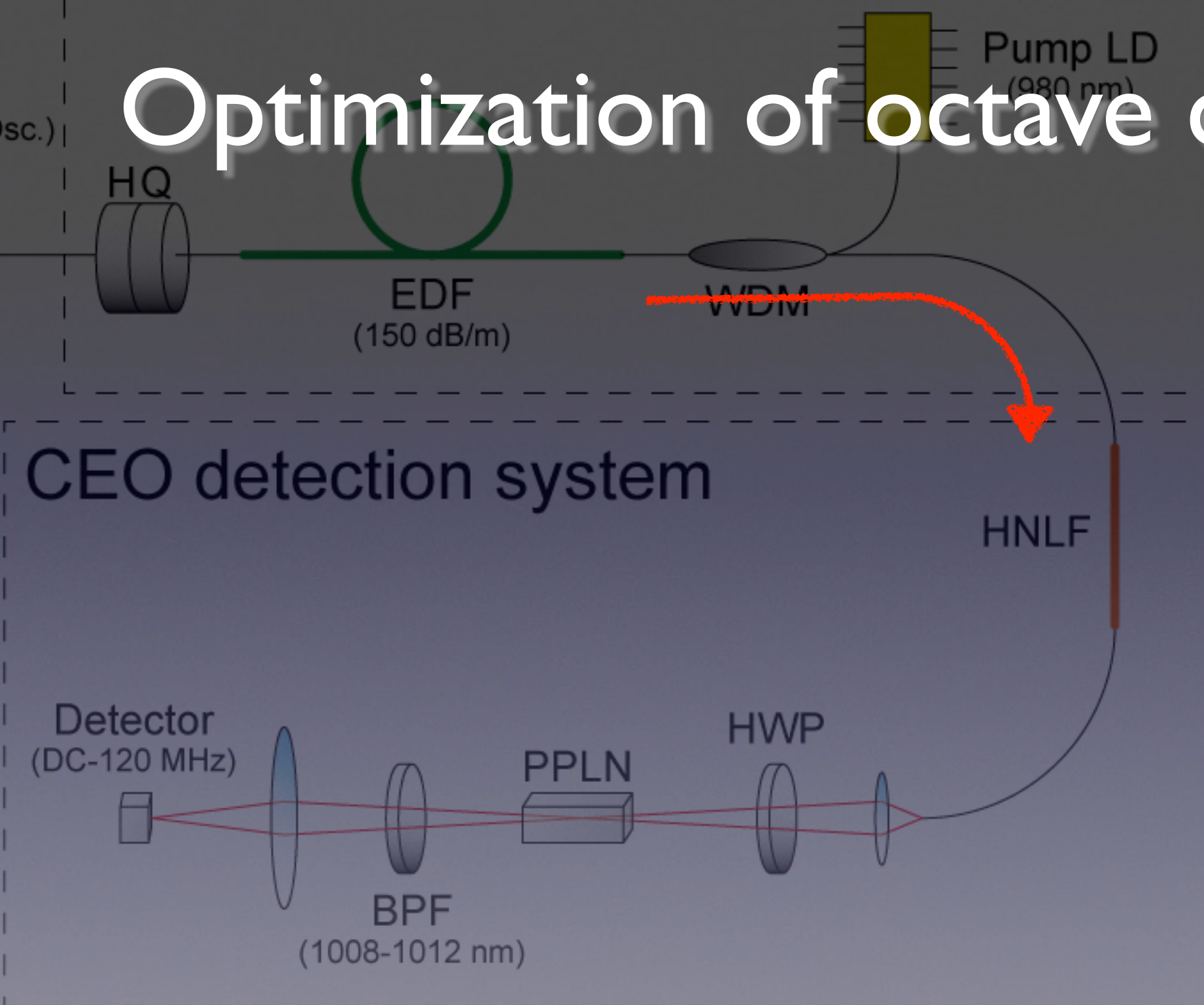


Output power of EDFA

Initial	51.0 mW
10 cm shorter	53.5 mW
10 cm shorter	54.5 mW
10 cm shorter	55.0 mW
10 cm shorter	55.0 mW

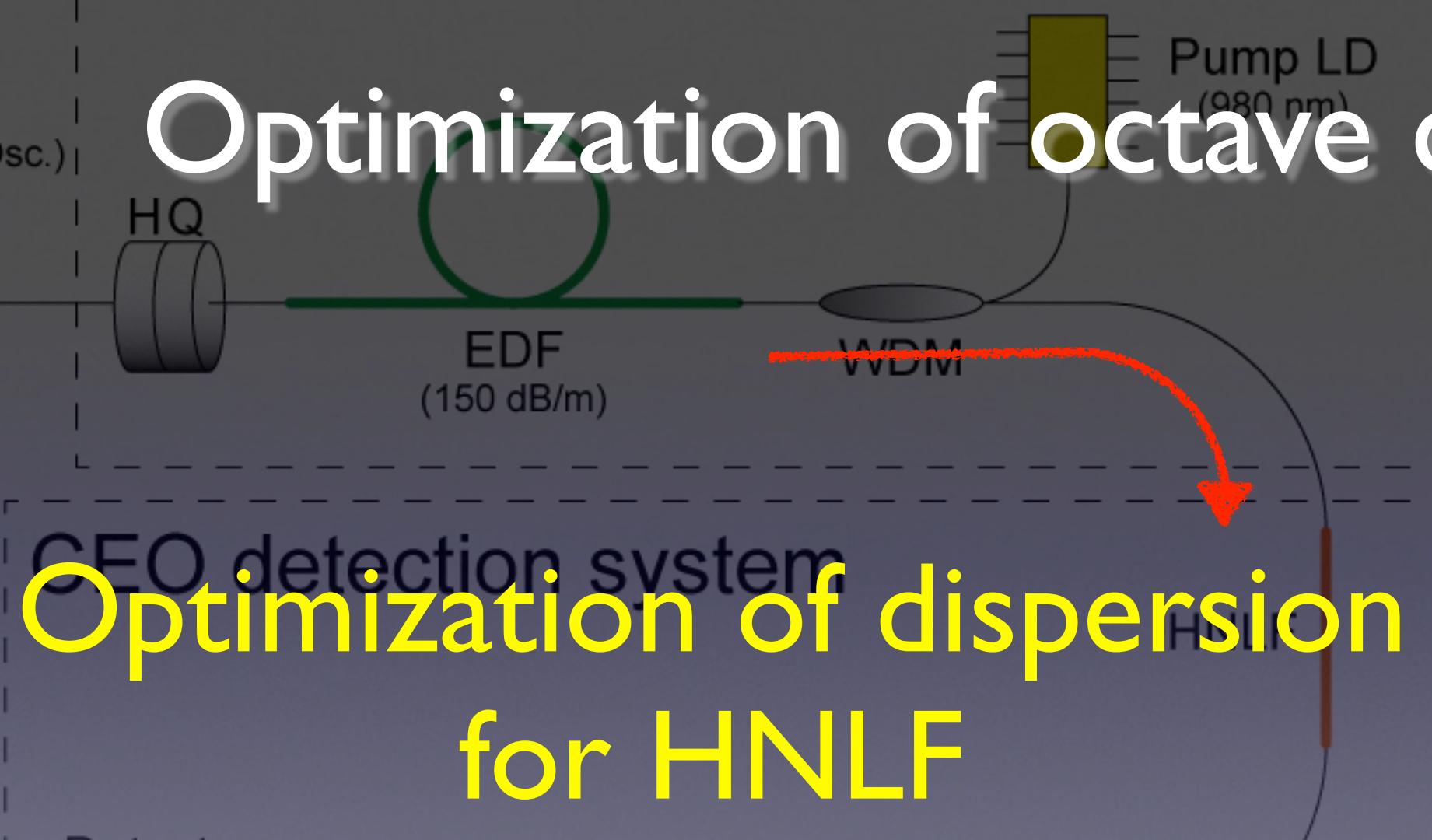
@LD 800 mA

Optimization of octave continuum



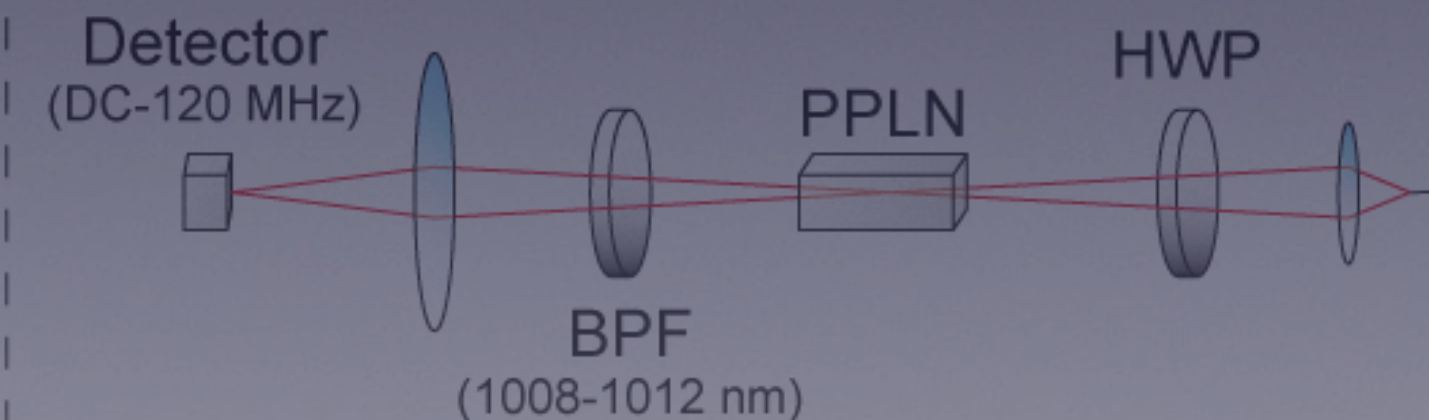
Optimization of dispersion
for HNLF

Optimization of octave continuum

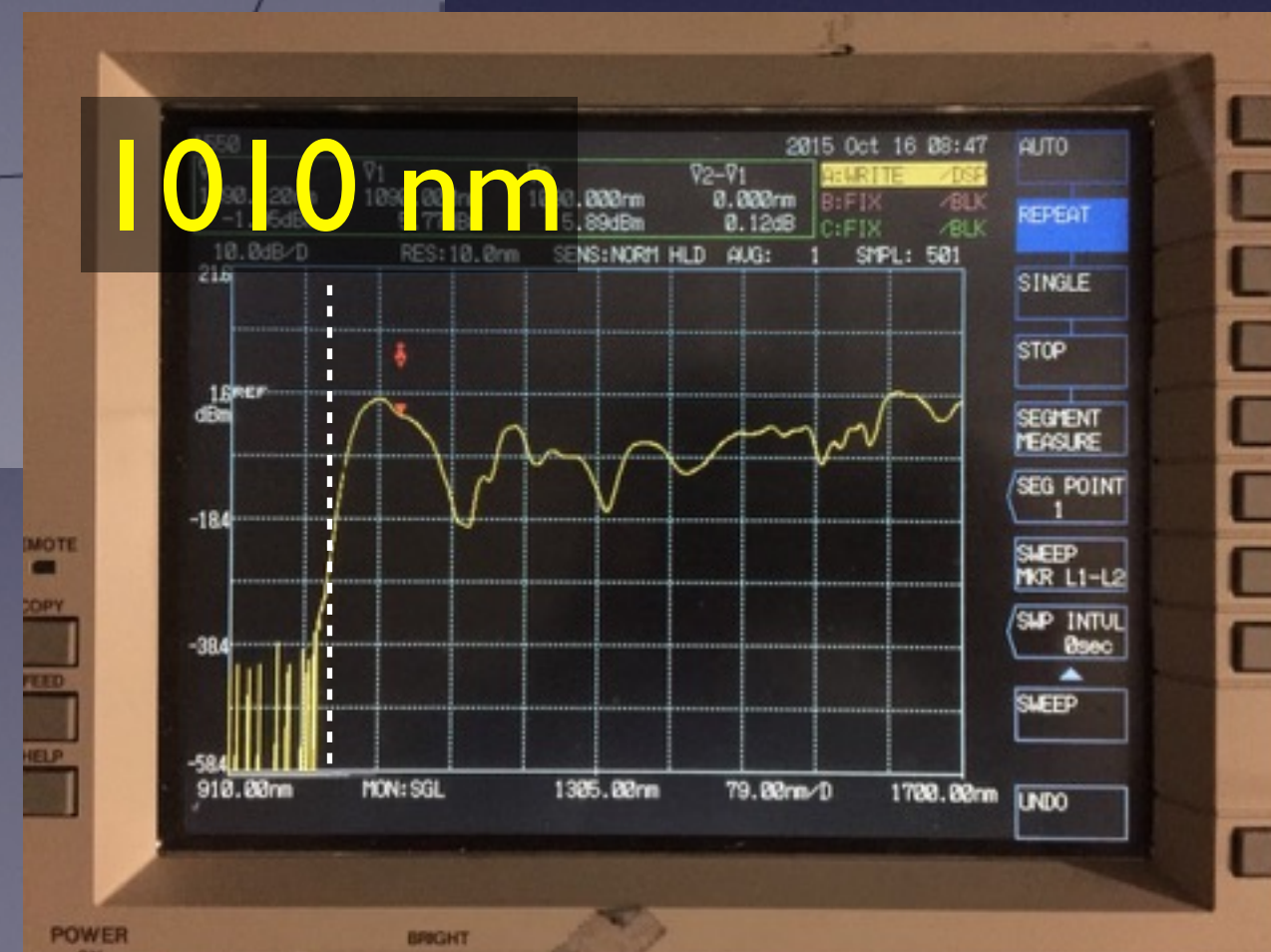


HNLF length
20 cm

Optimization of dispersion for HNLF



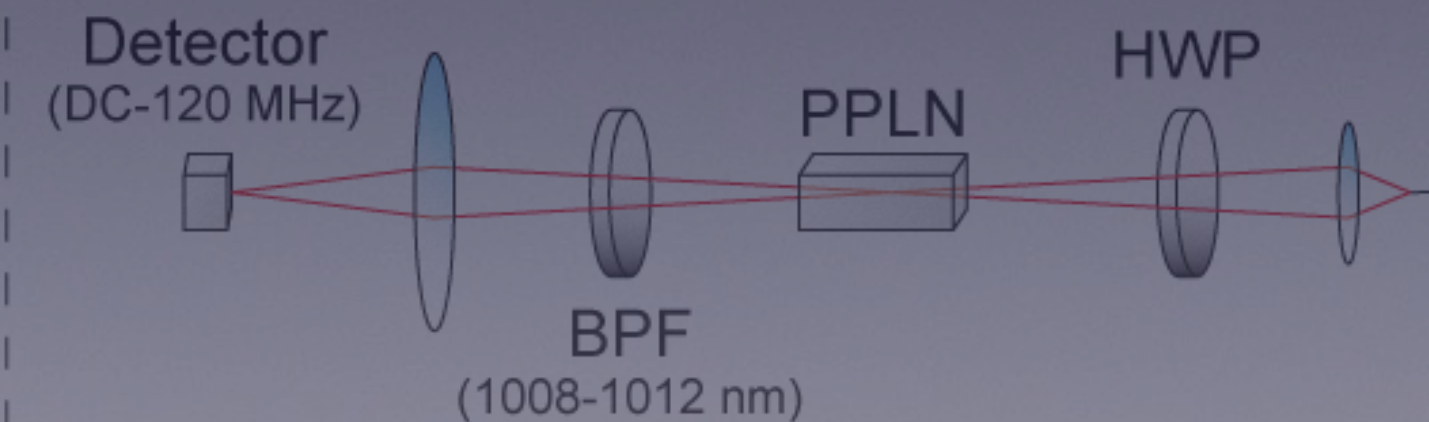
Initial
SMF length 2.4 m
(WDM 40 cm)



Optimization of octave continuum



CEO detection system Optimization of dispersion for HNLF



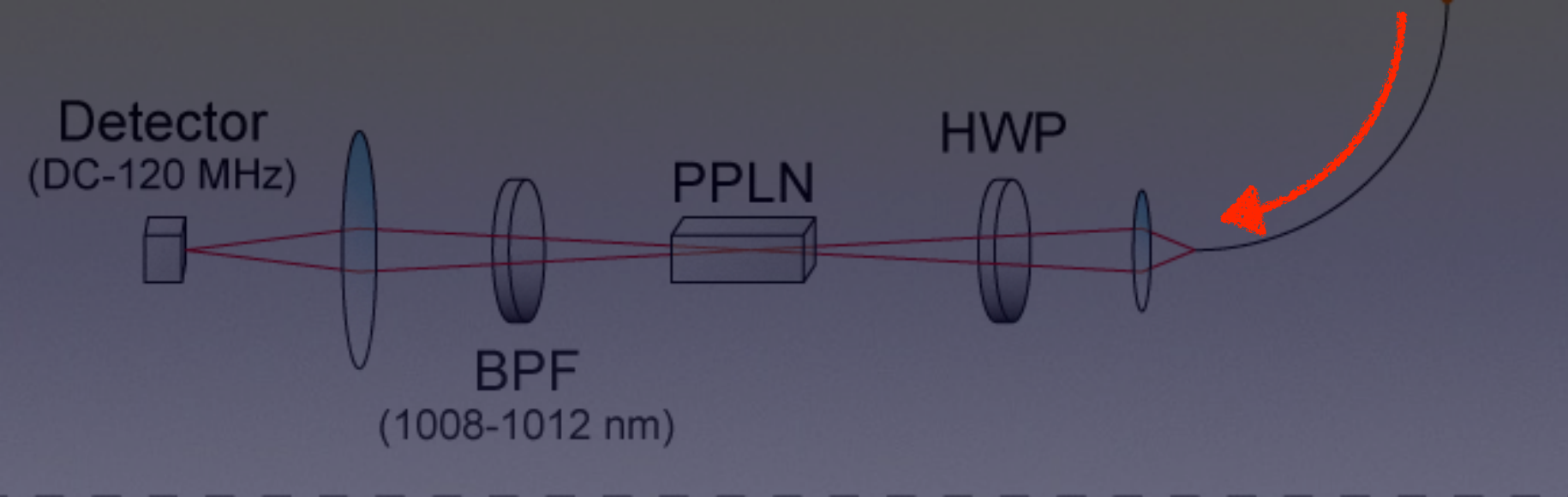
Maximize spectral intensity at 1010 nm

Optimized
SMF length 30 cm

1010 nm



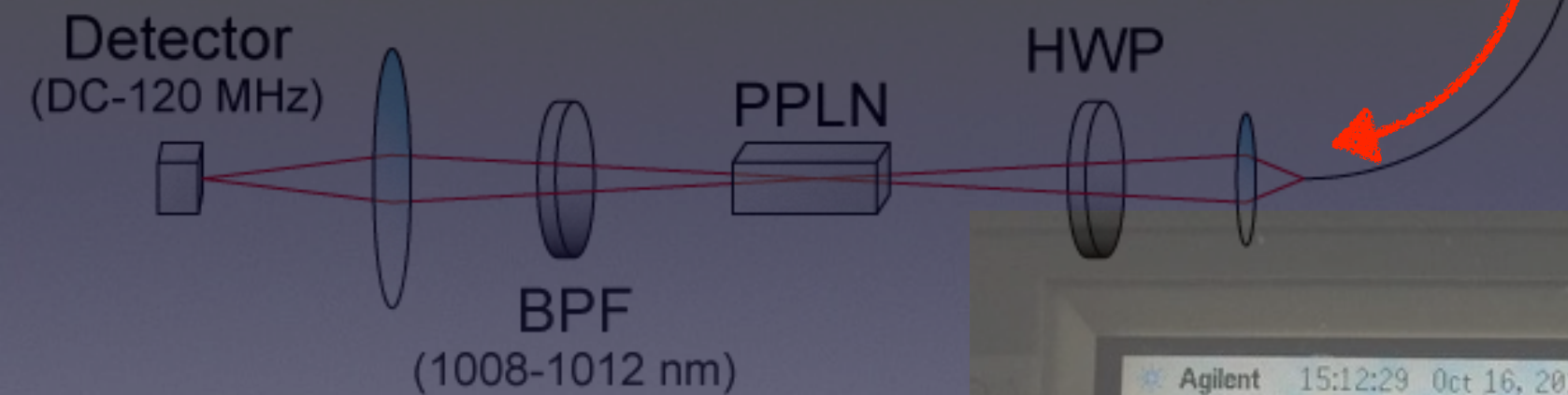
Optimization of beat signal f-2f interferometer



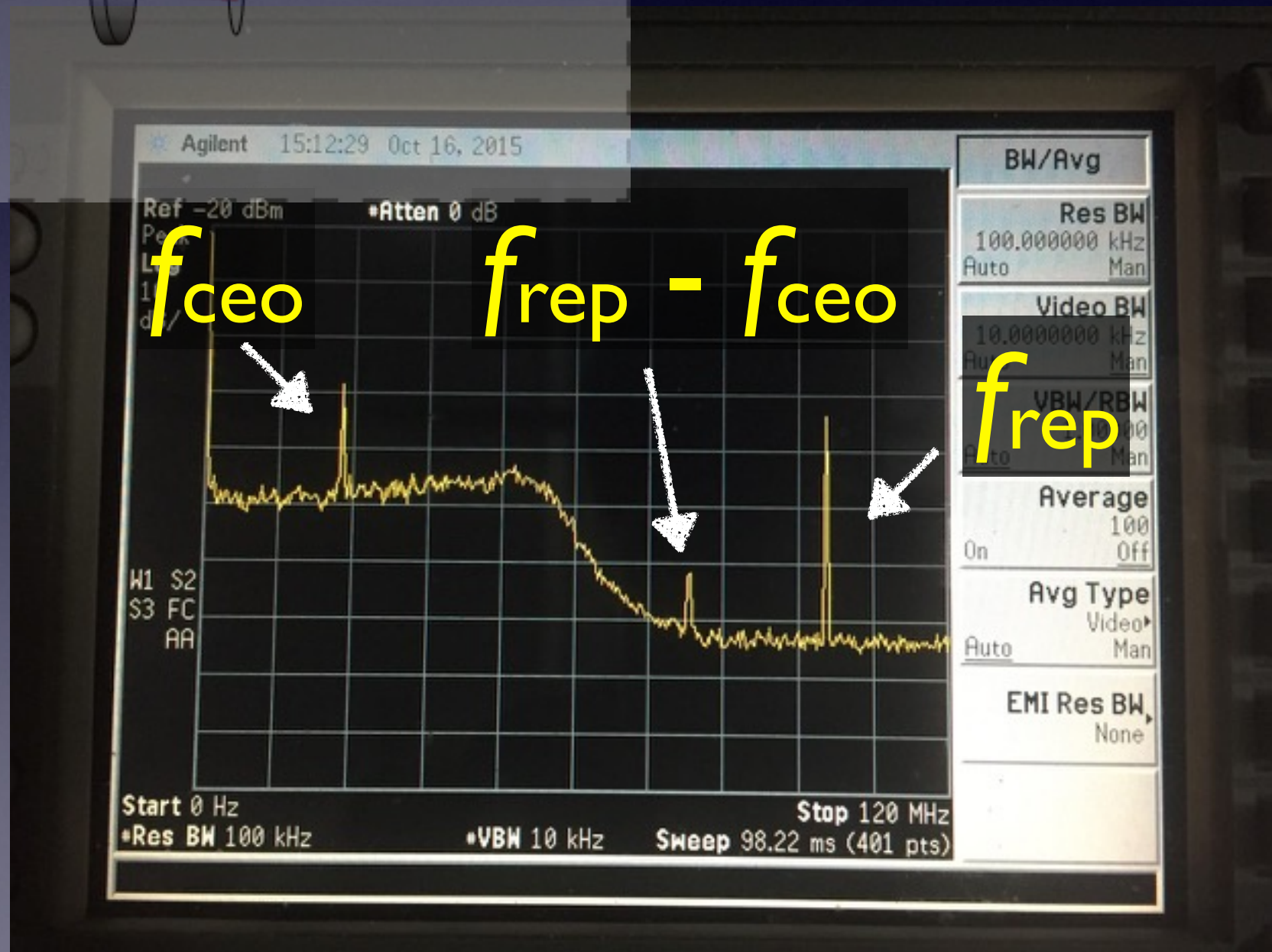
Optimization of dispersion
for beat signal
(1010 nm and SHG of 2020 nm)

Optimization of beat signal

CEO detection system

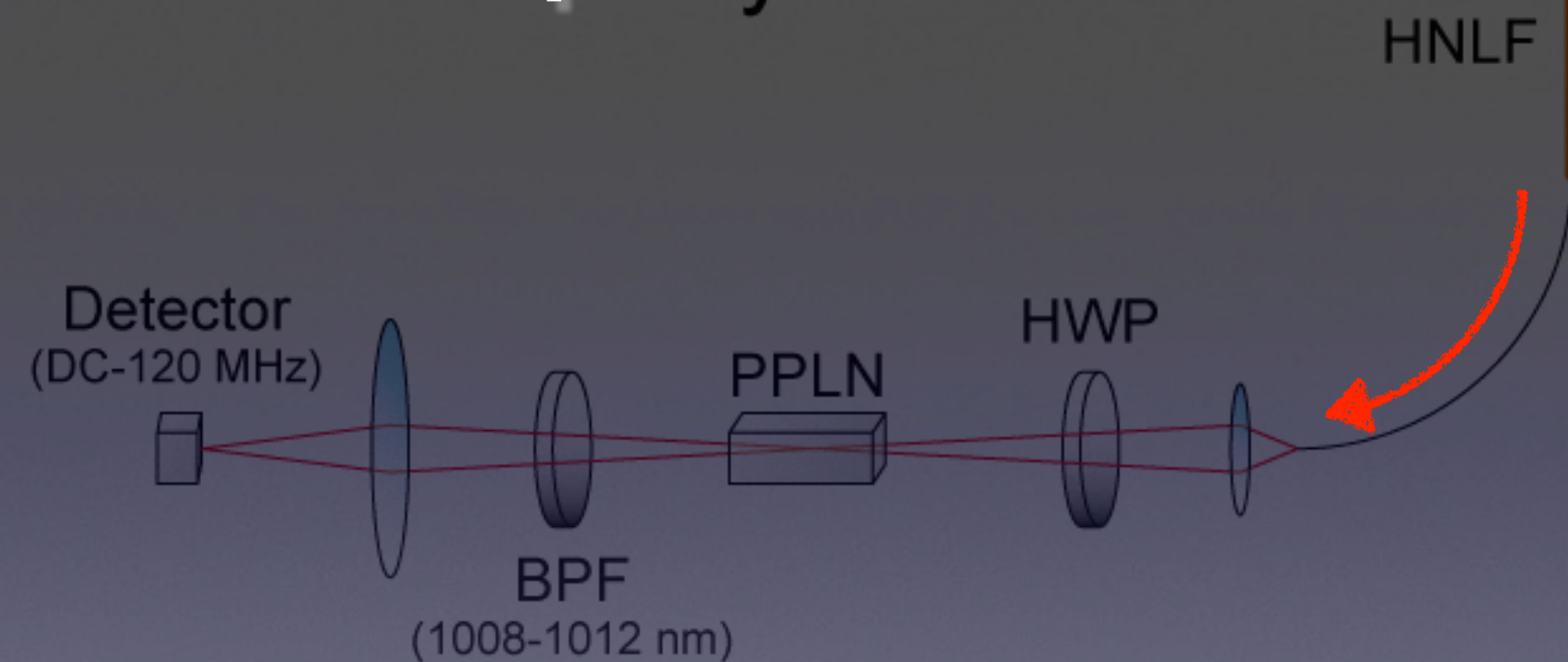


w/ SPF
(DC-48 MHz)



Optimization of beat signal

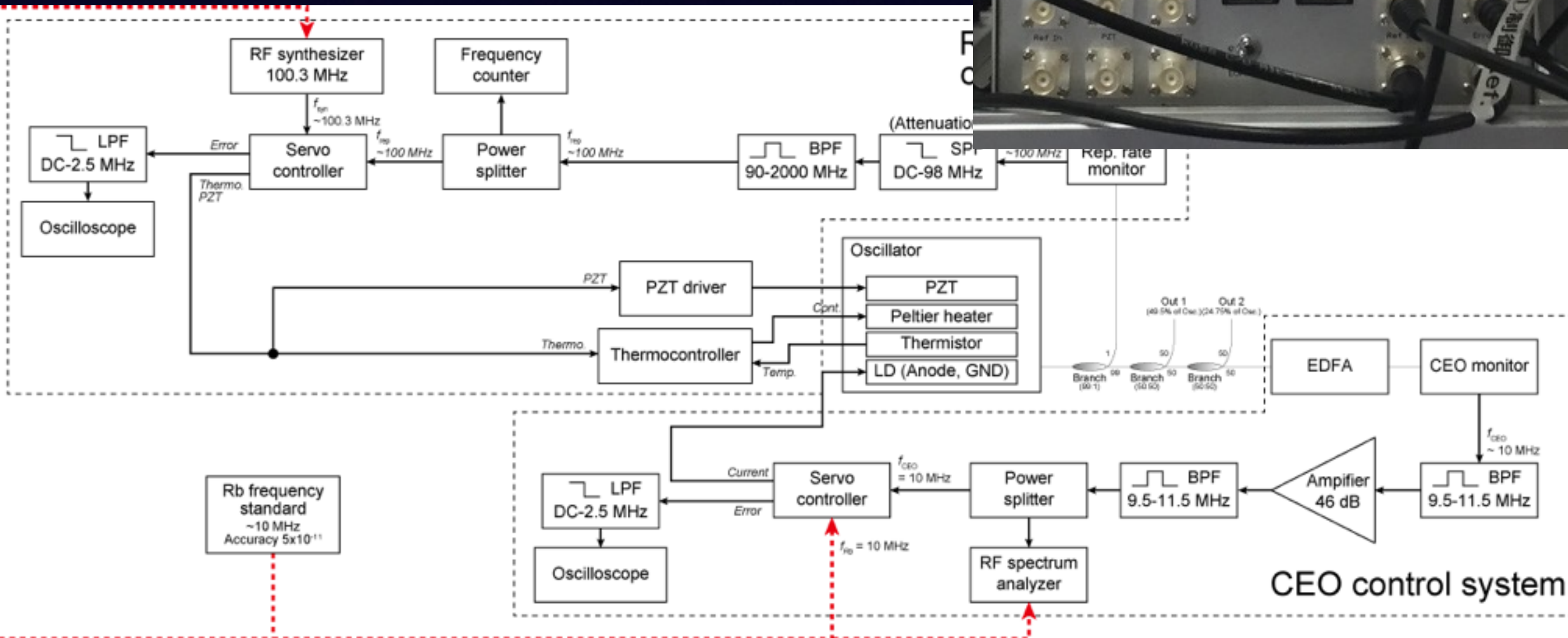
CEO detection system



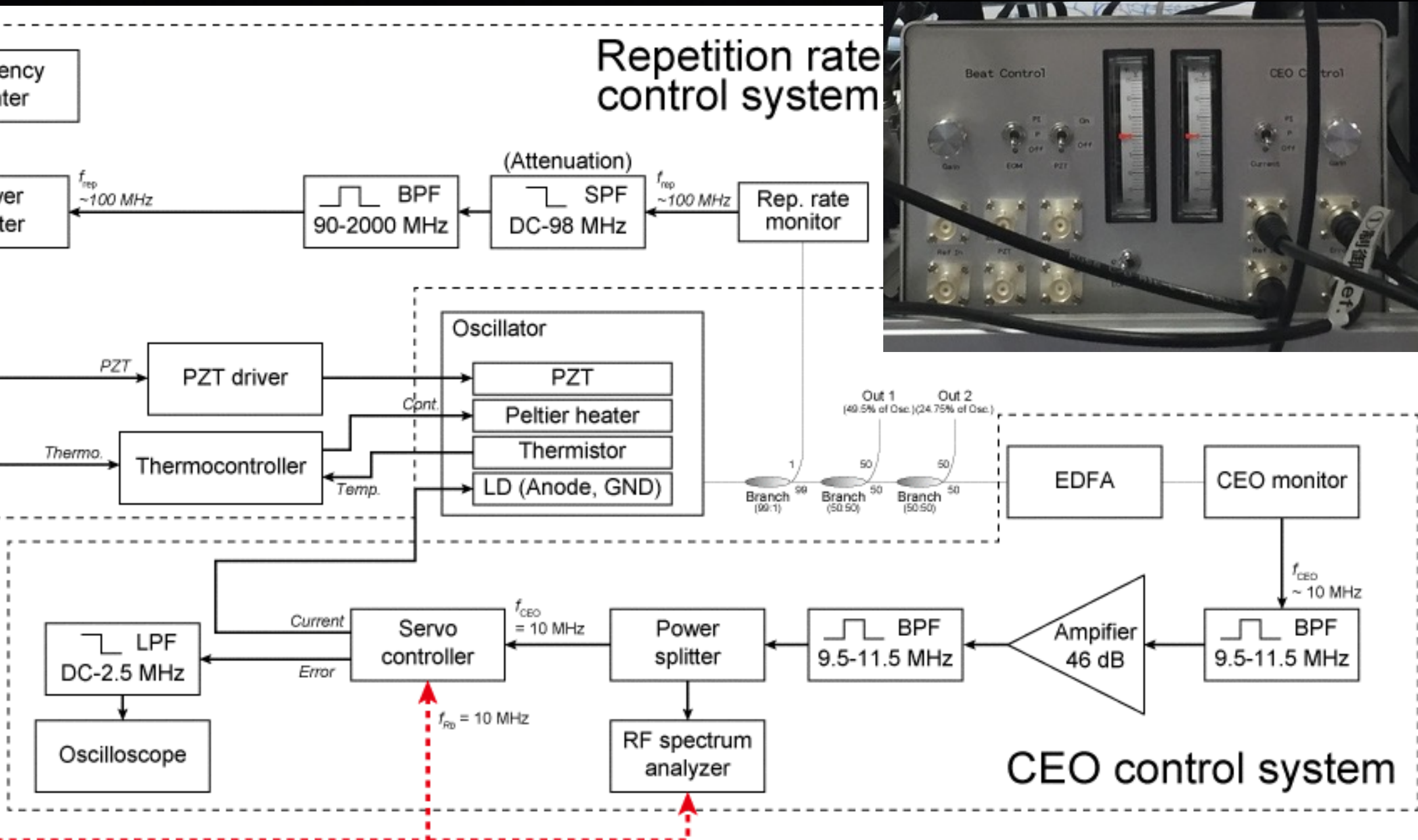
w/ BPF
(9.5-11.5 MHz)



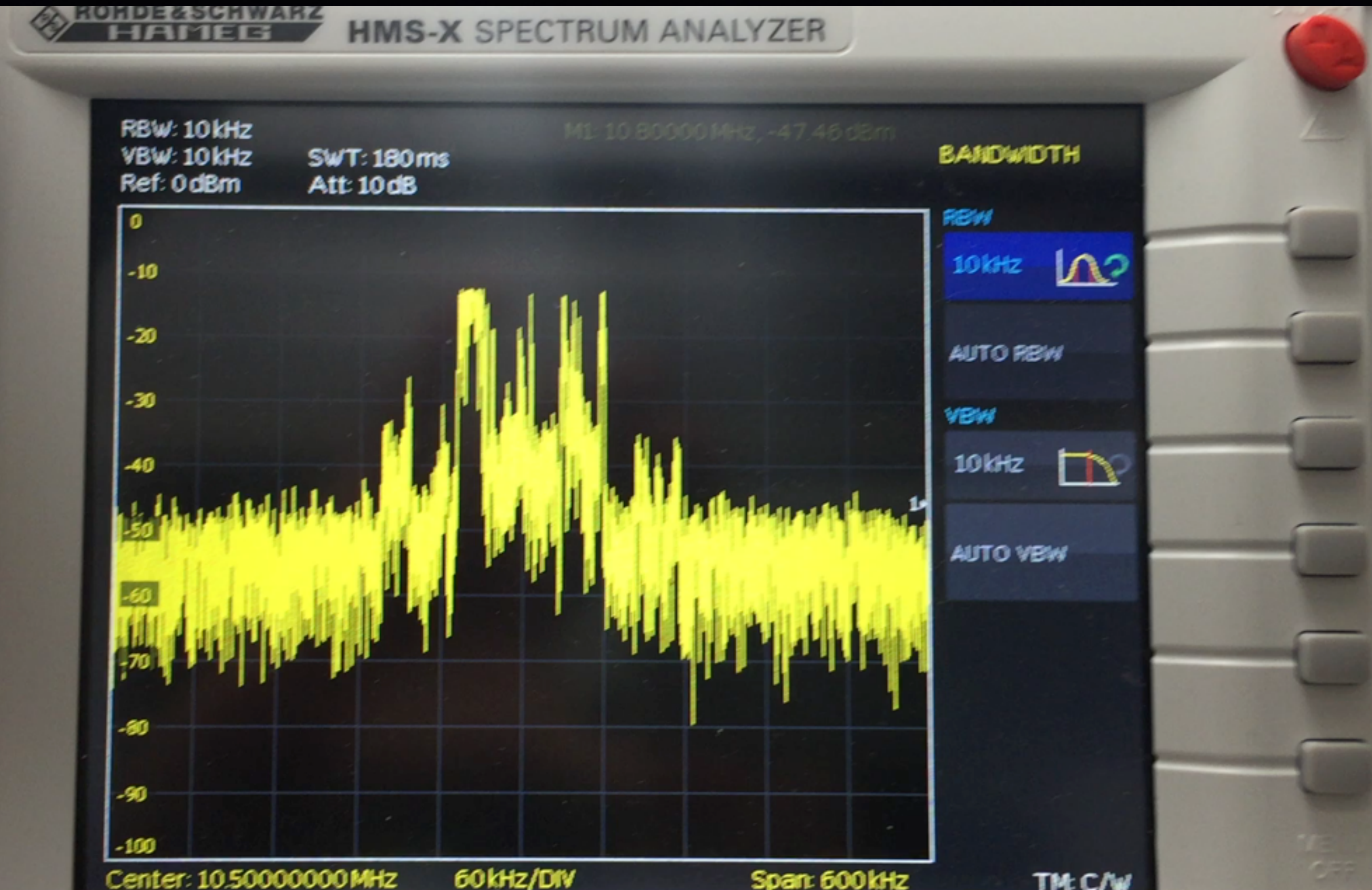
f_{ceo} stabilization



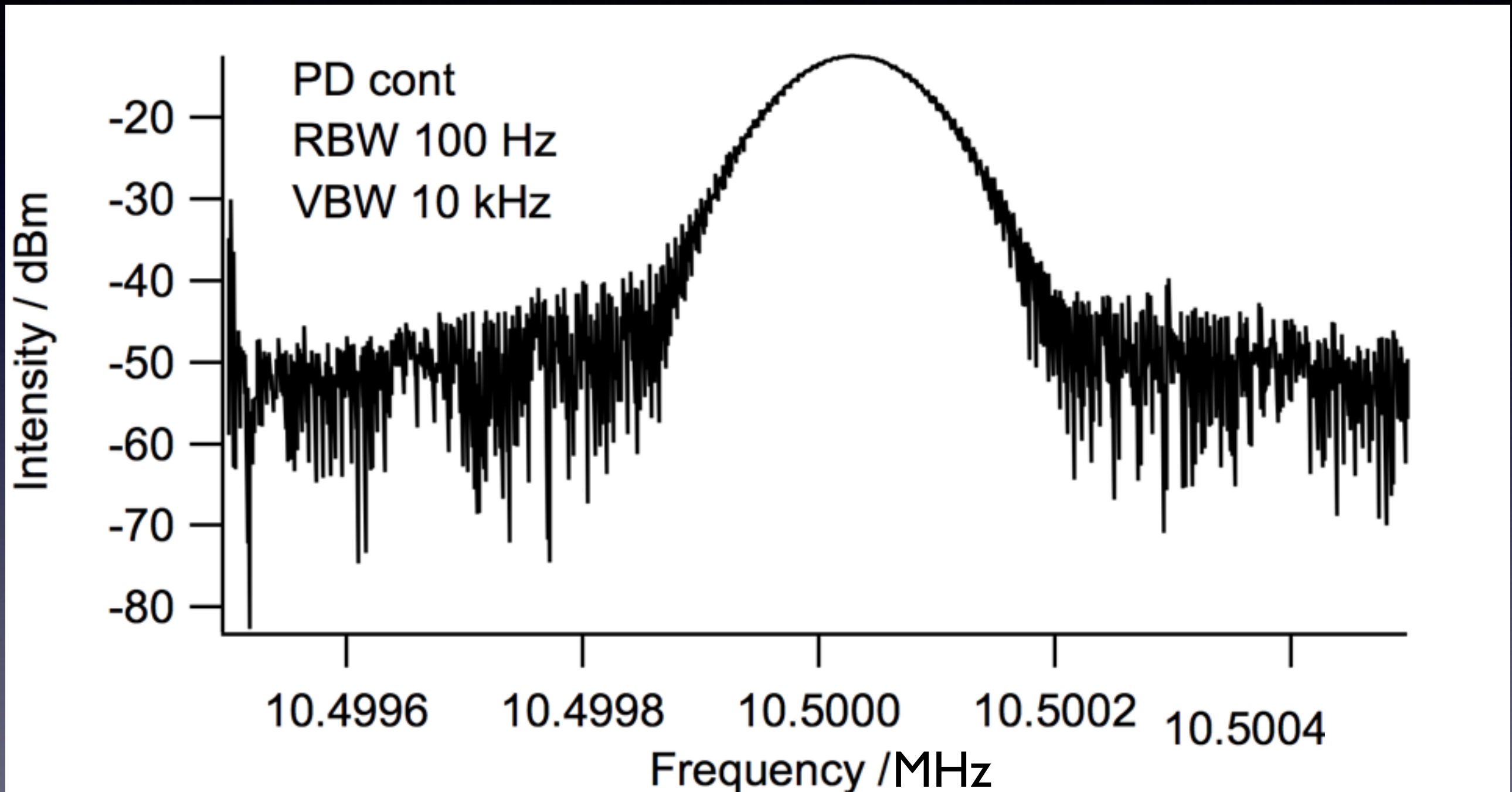
f_{ceo} stabilization



f_{ceo} stabilization

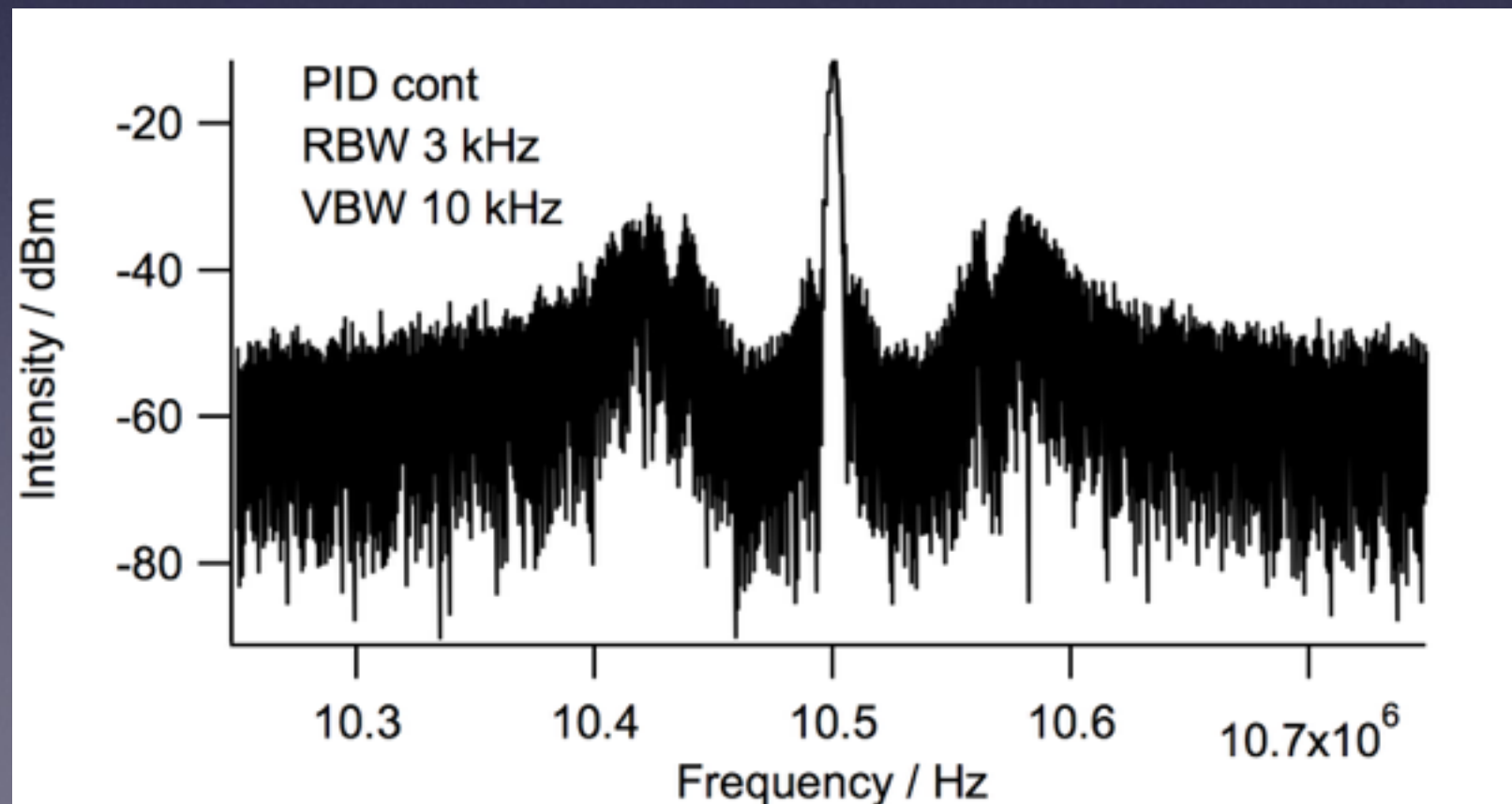
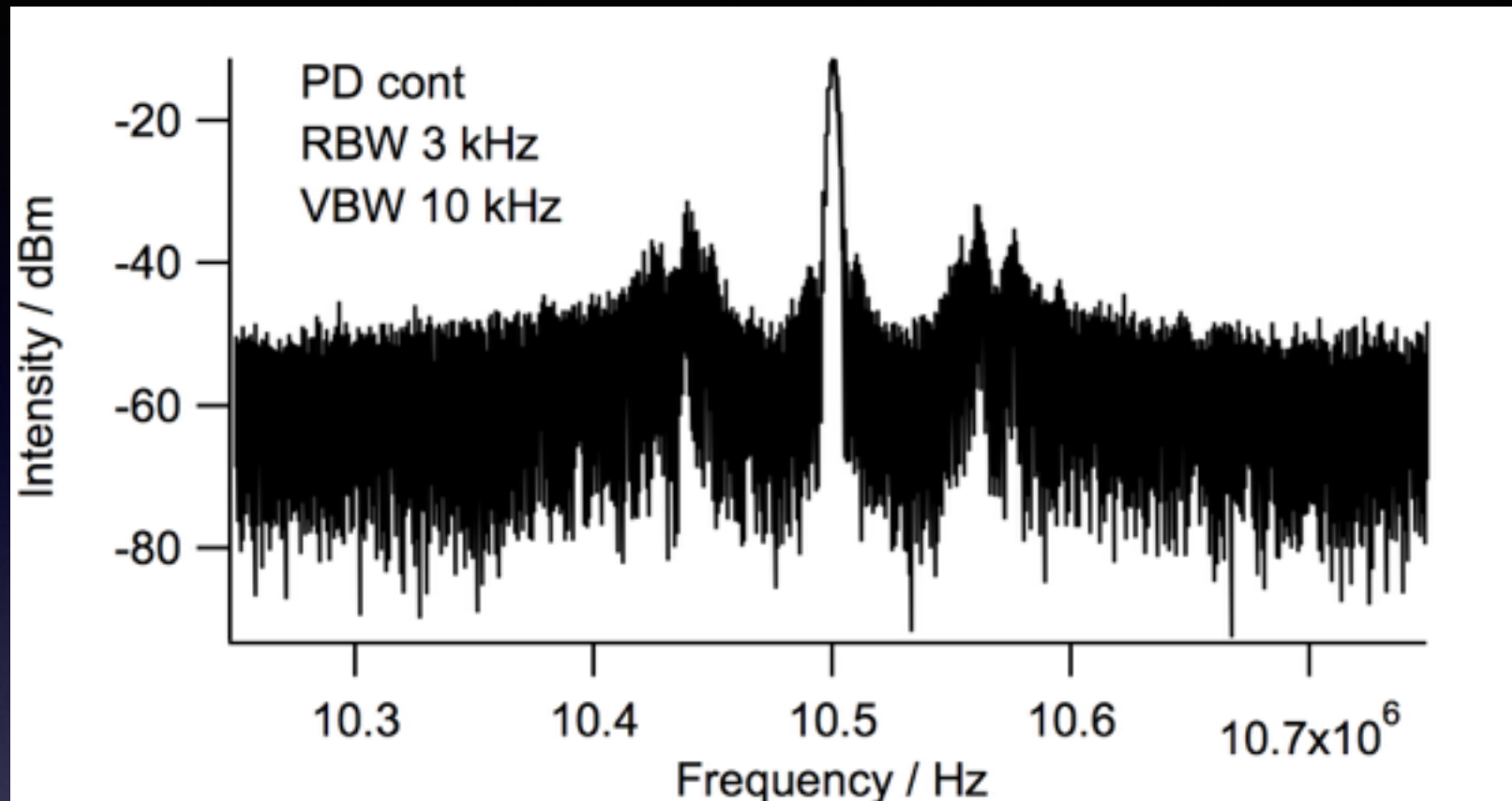


f_{ceo} stabilization

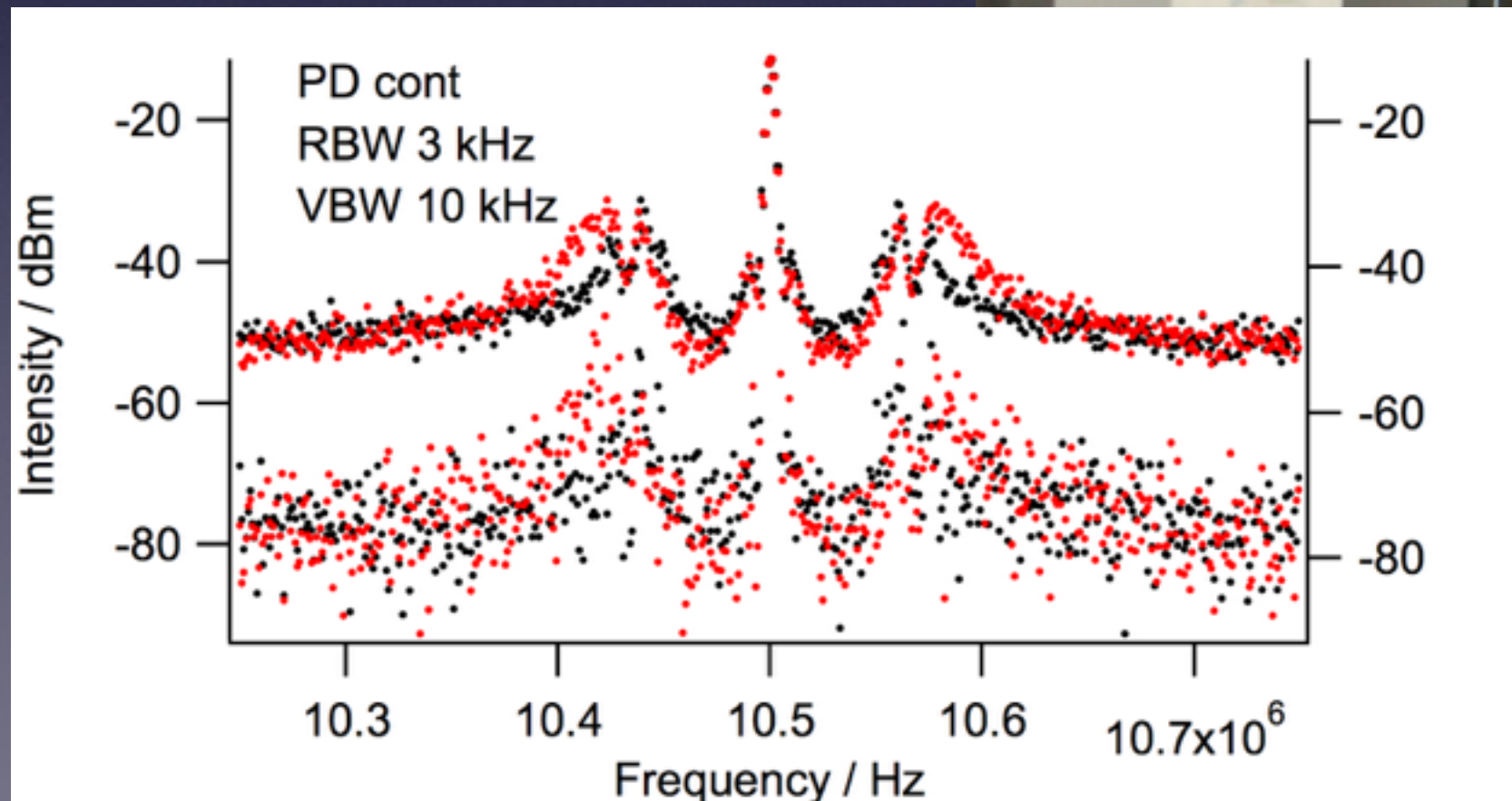
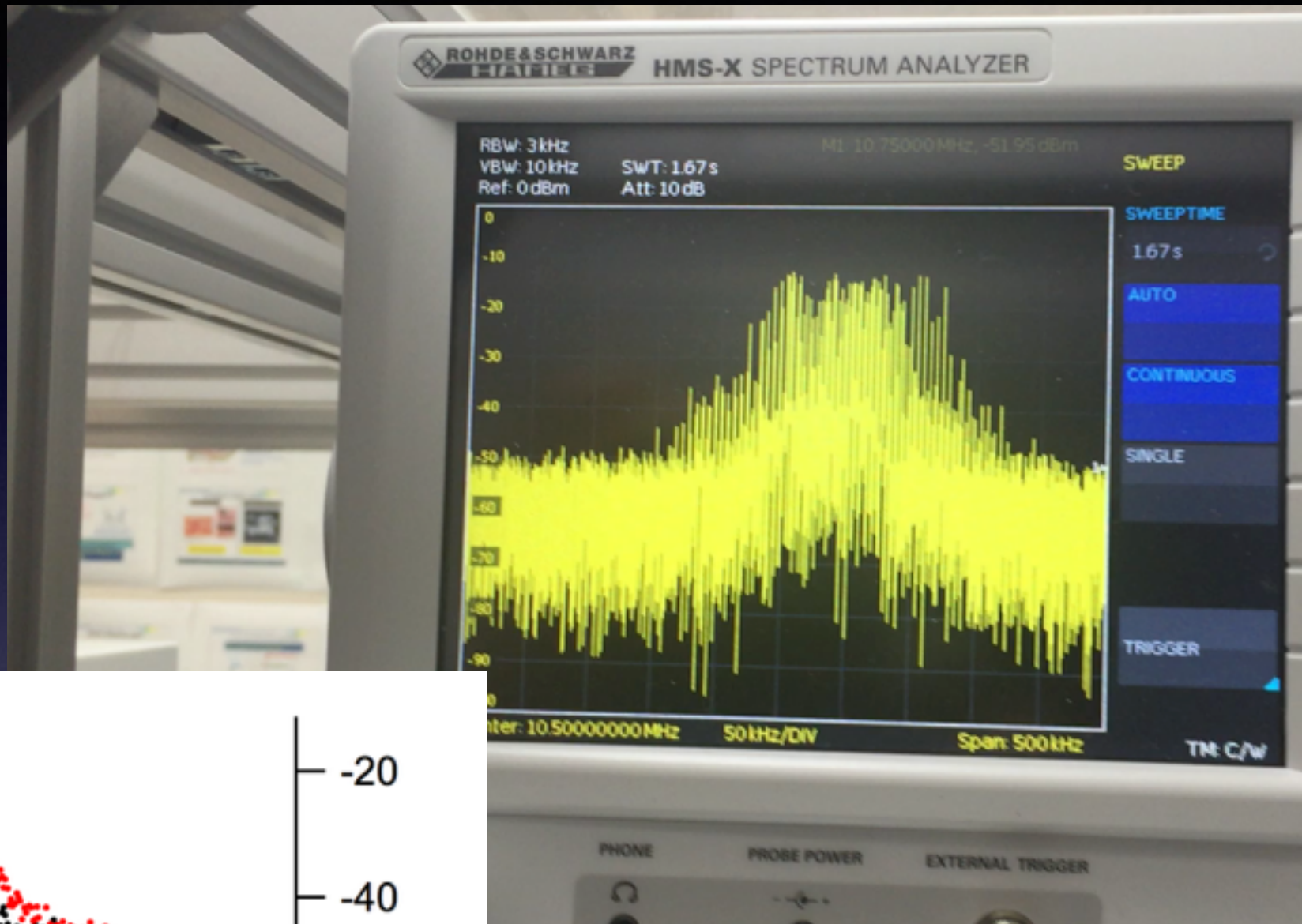


FWHM was less than 100 Hz

f_{ceo} stabilization



f_{ceo} stabilization

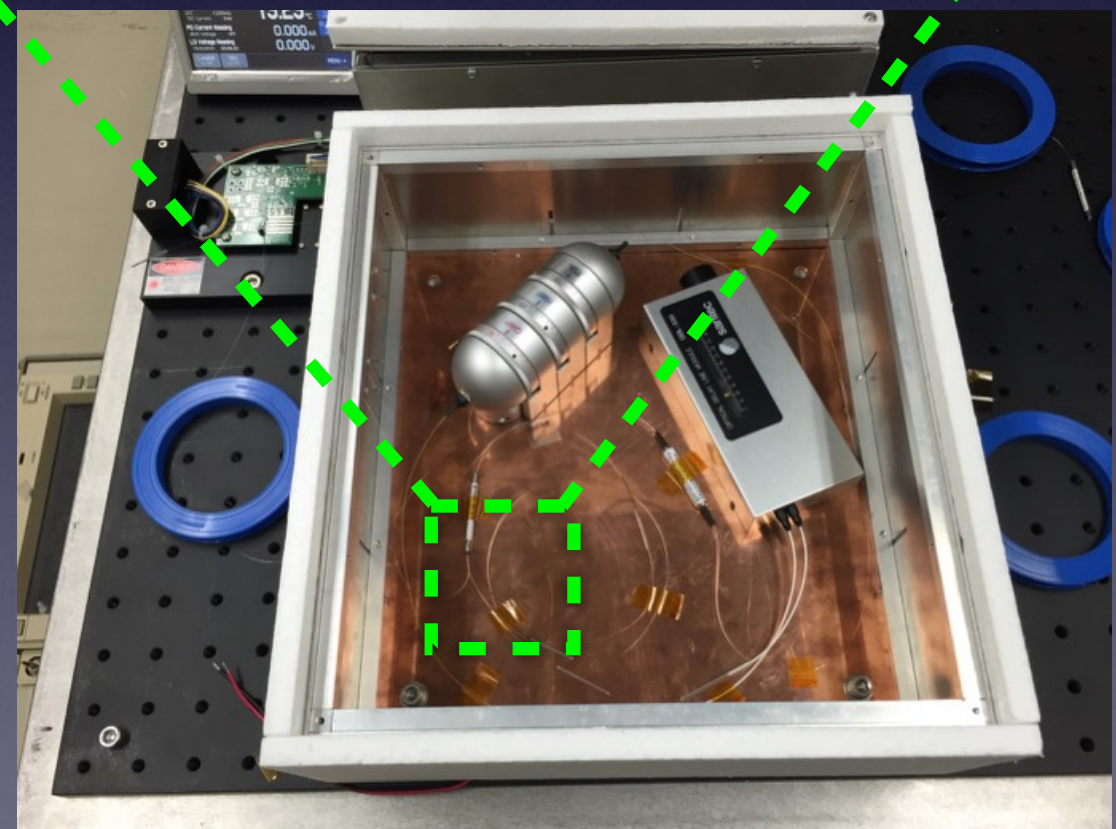
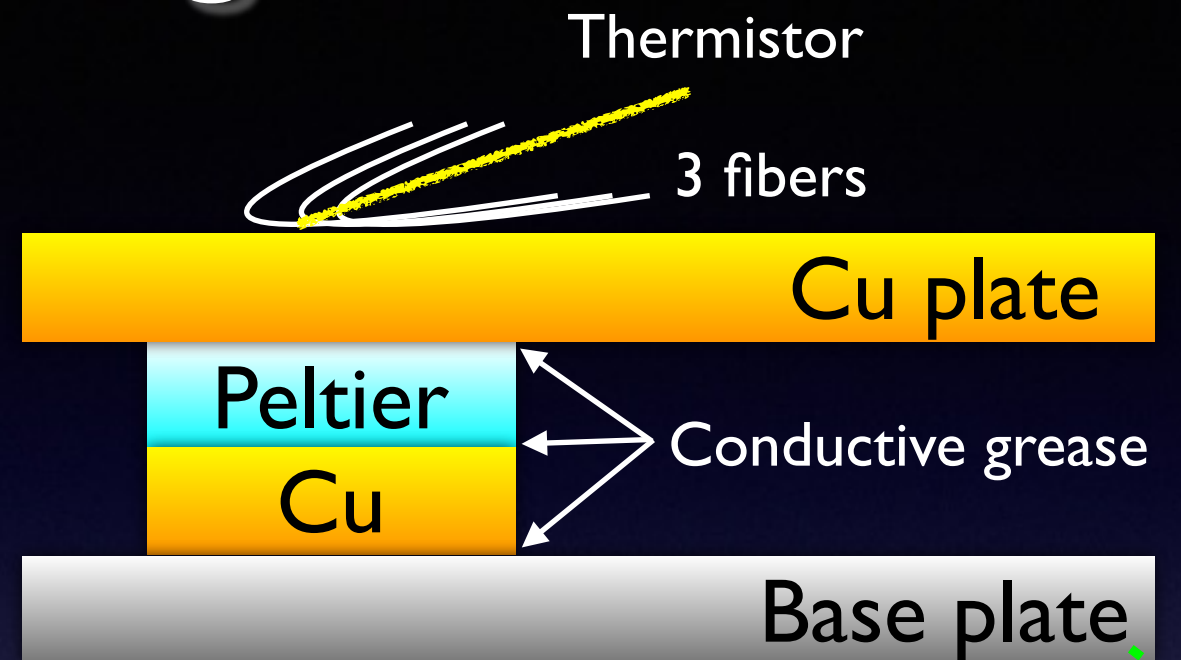
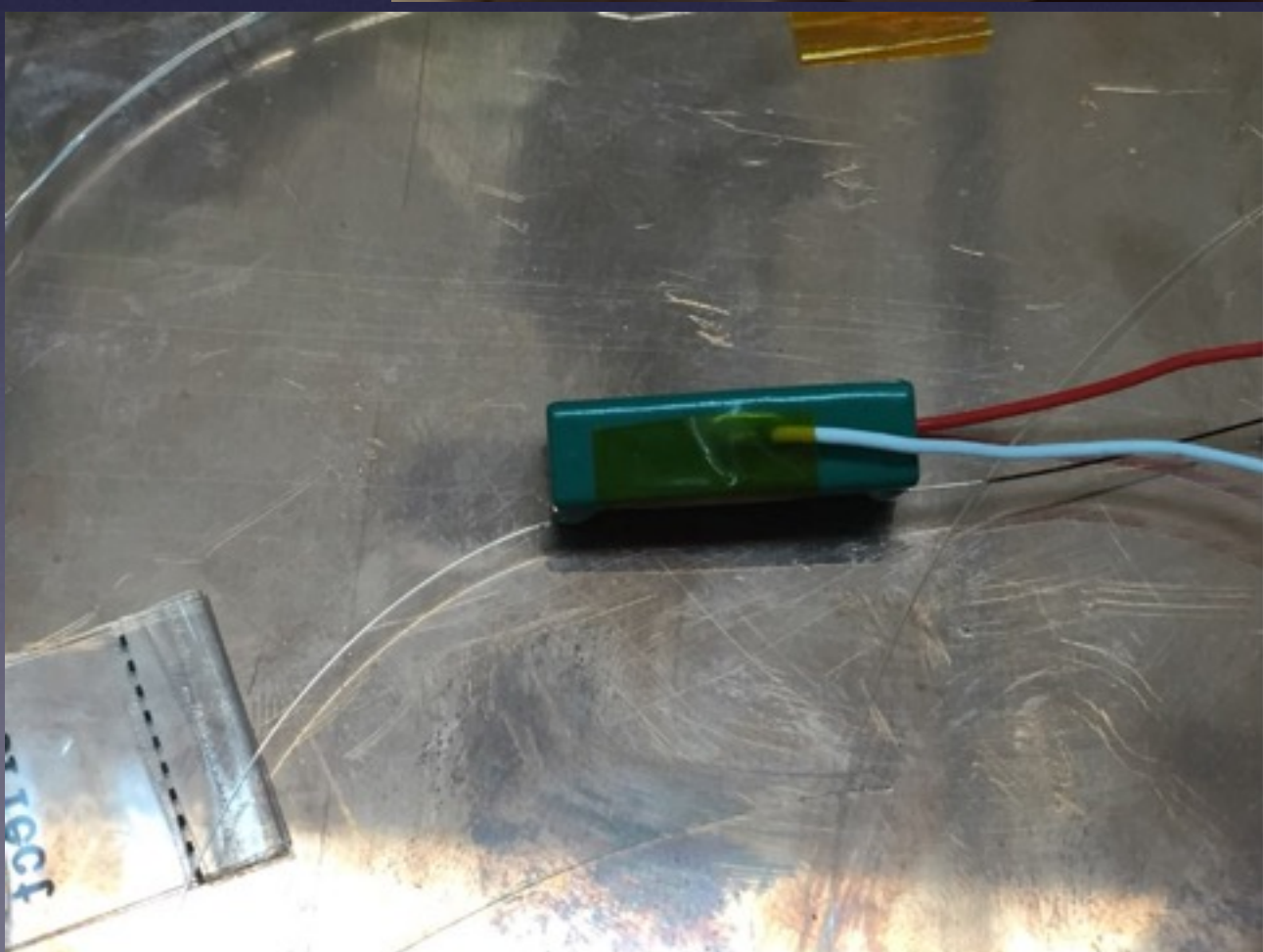


w/o cont
↓
PD cont
↓
PID cont

f_{rep} stabilization

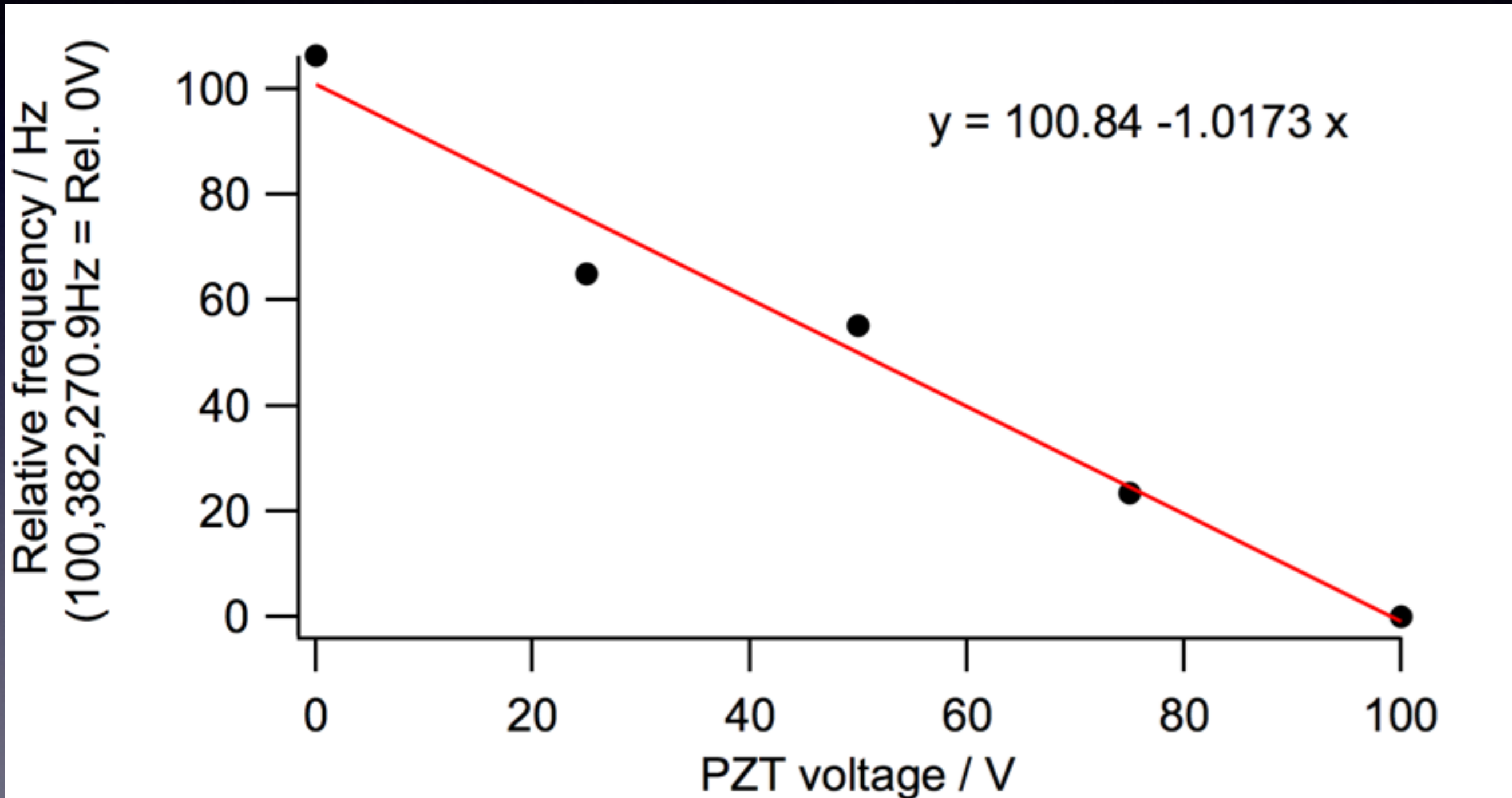
f_{rep} tuning

PZT



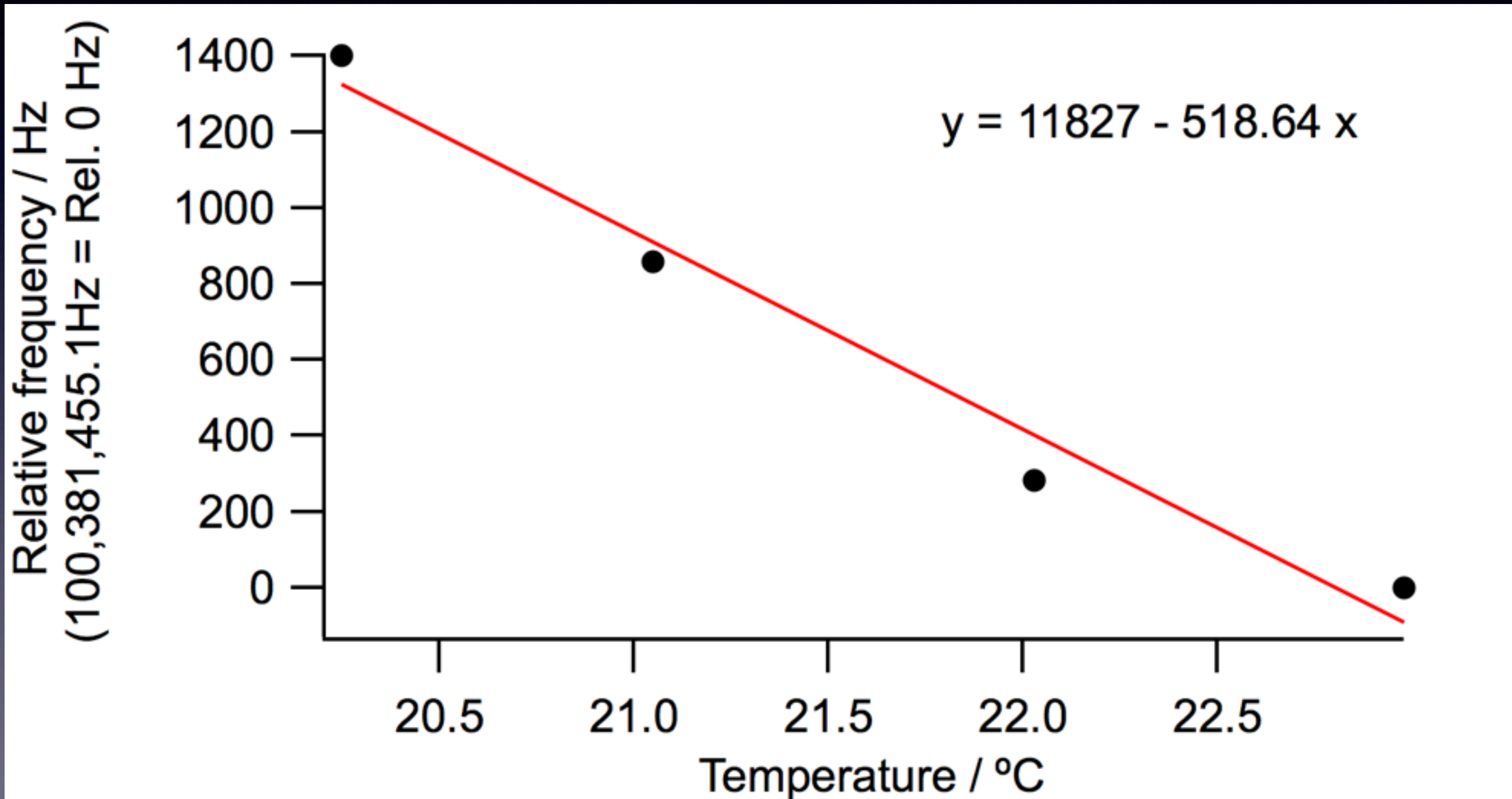
Peltier

f_{rep} tuning - PZT -



$\Delta f = 100 \text{ Hz} \longrightarrow \Delta L = 2.98 \text{ } \mu\text{m}$ (Spec. 11.6 $\mu\text{m}@100\text{V}$)

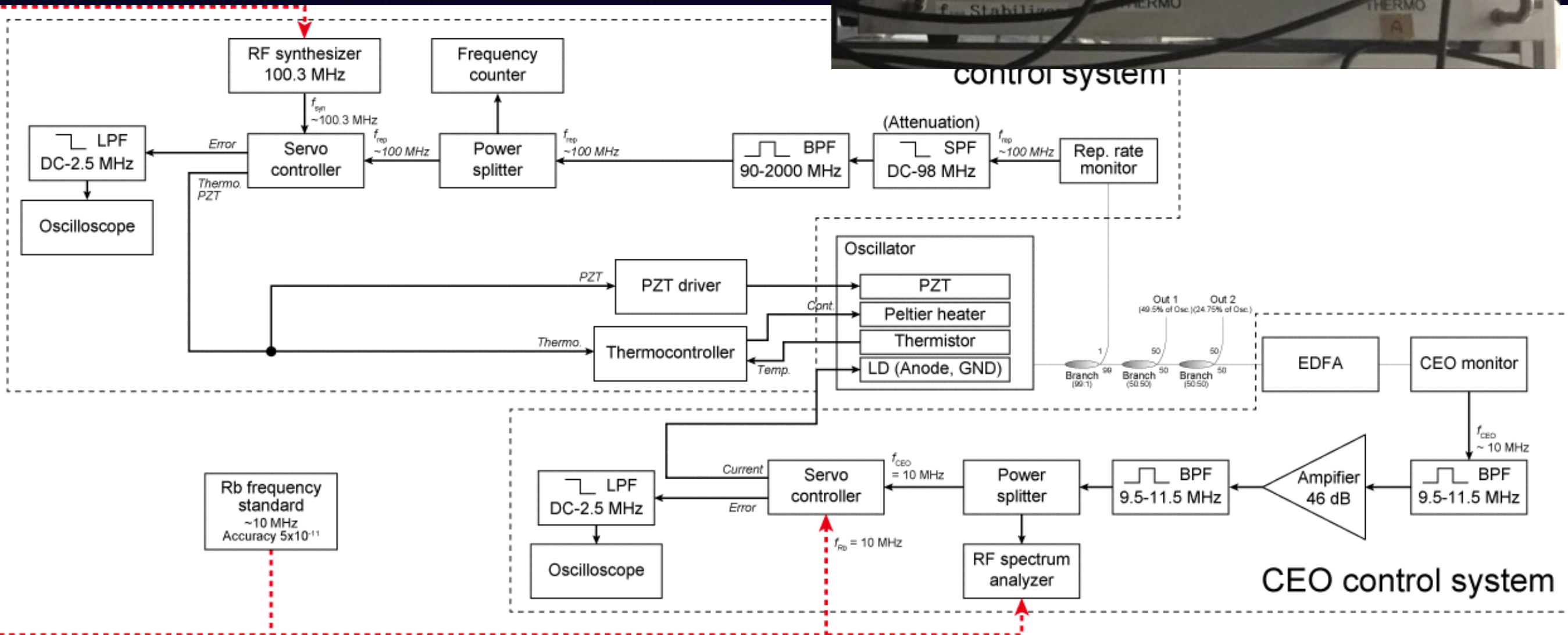
f_{rep} tuning - Peltier -



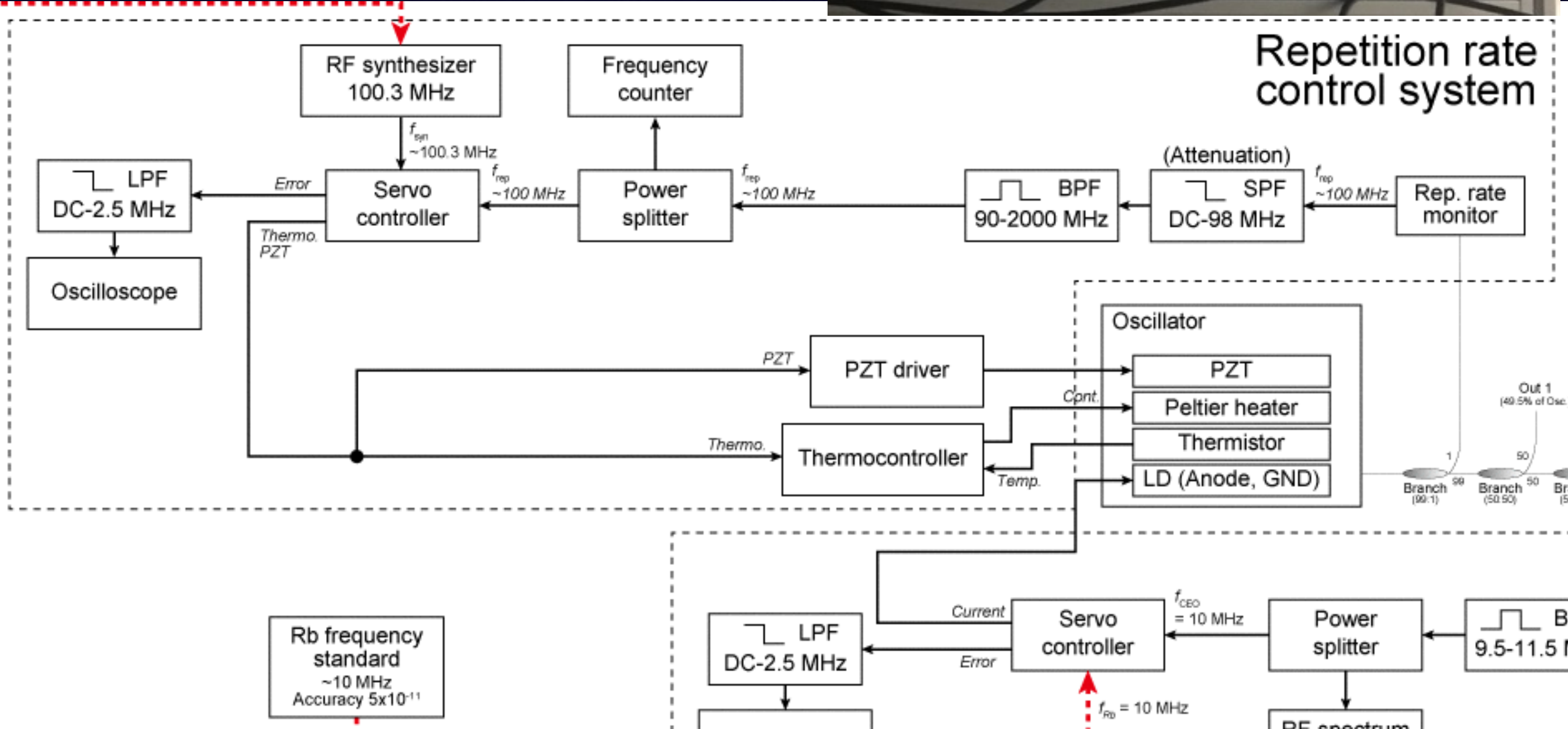
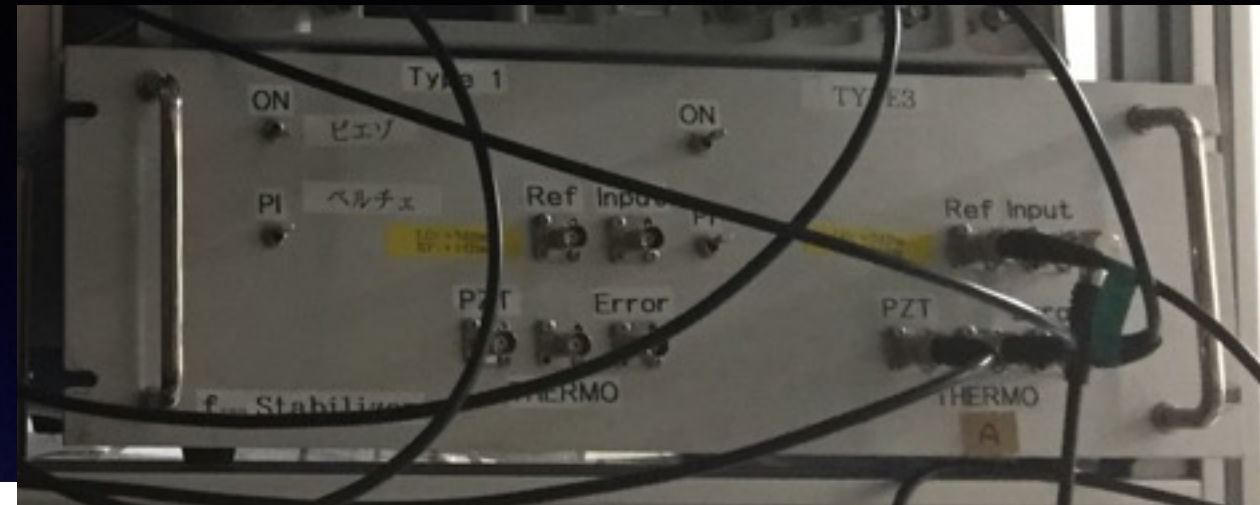
f_{rep} stabilization



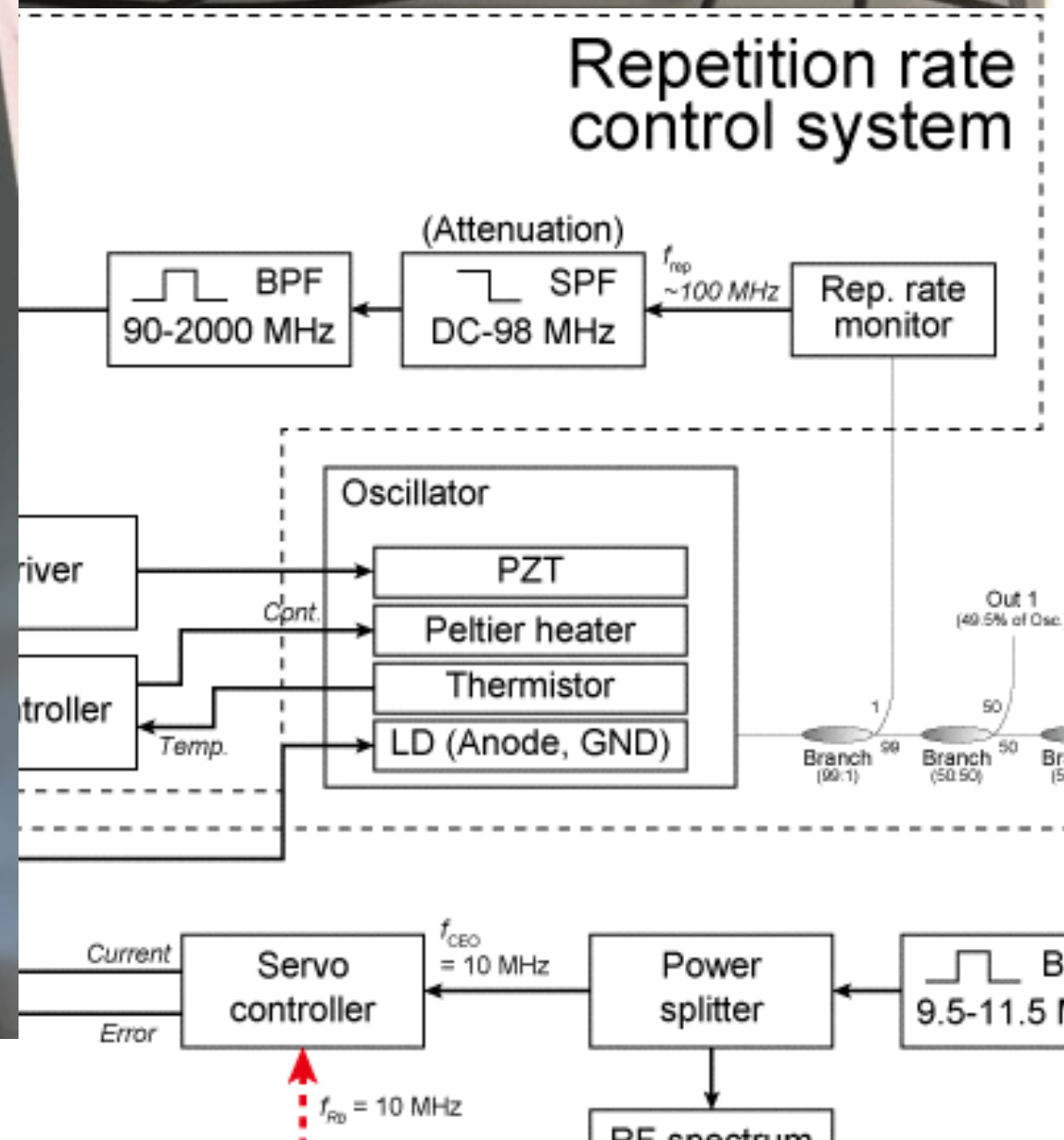
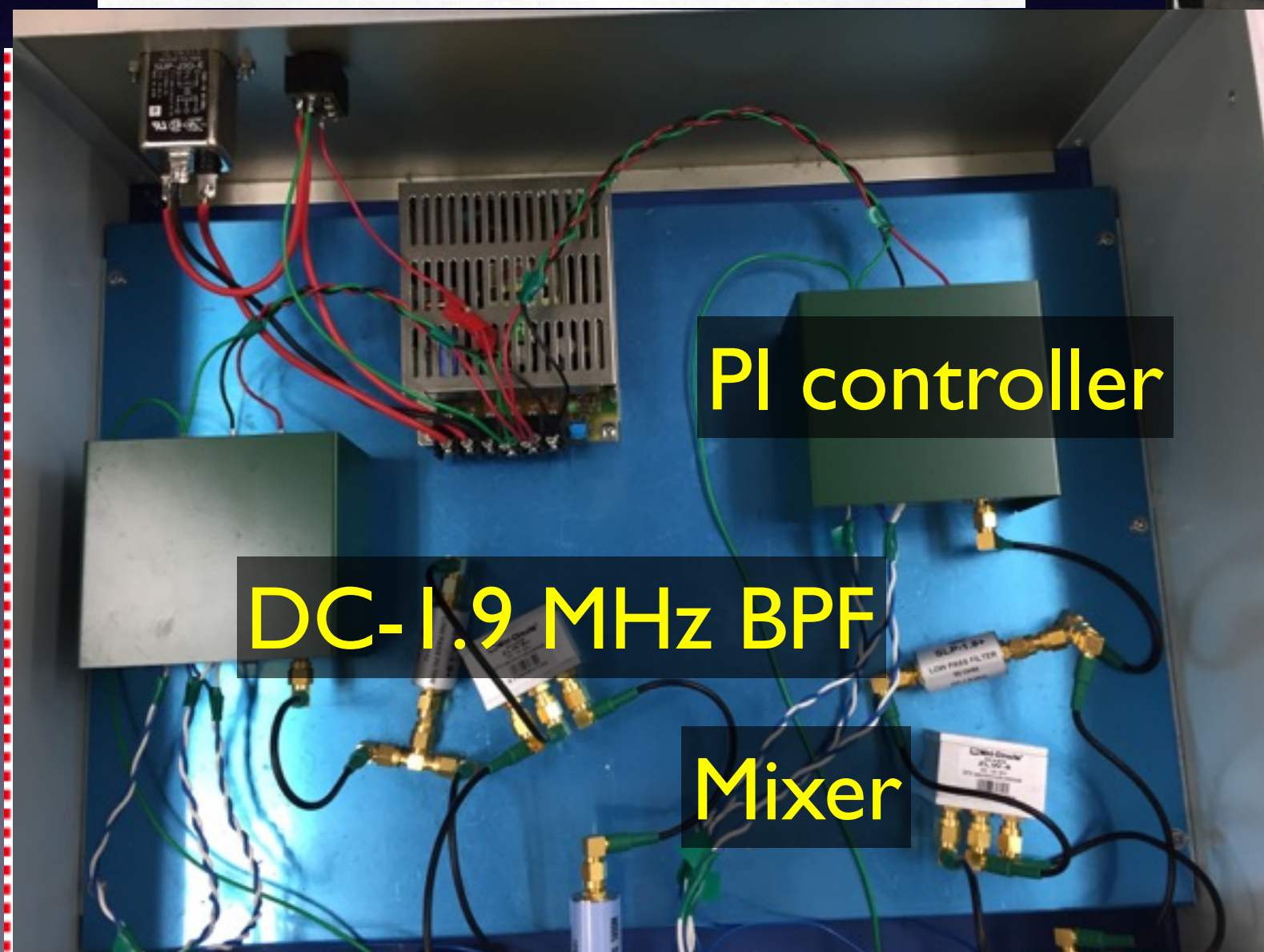
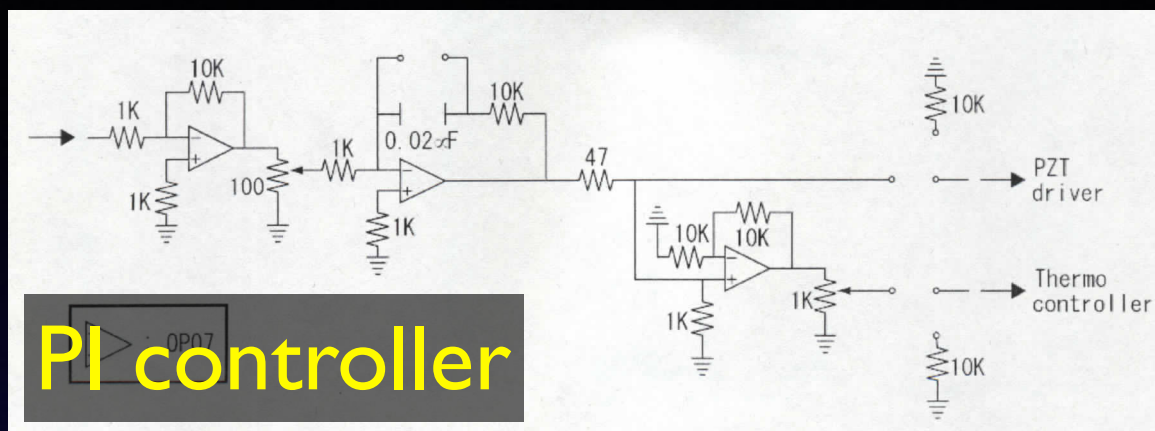
control system



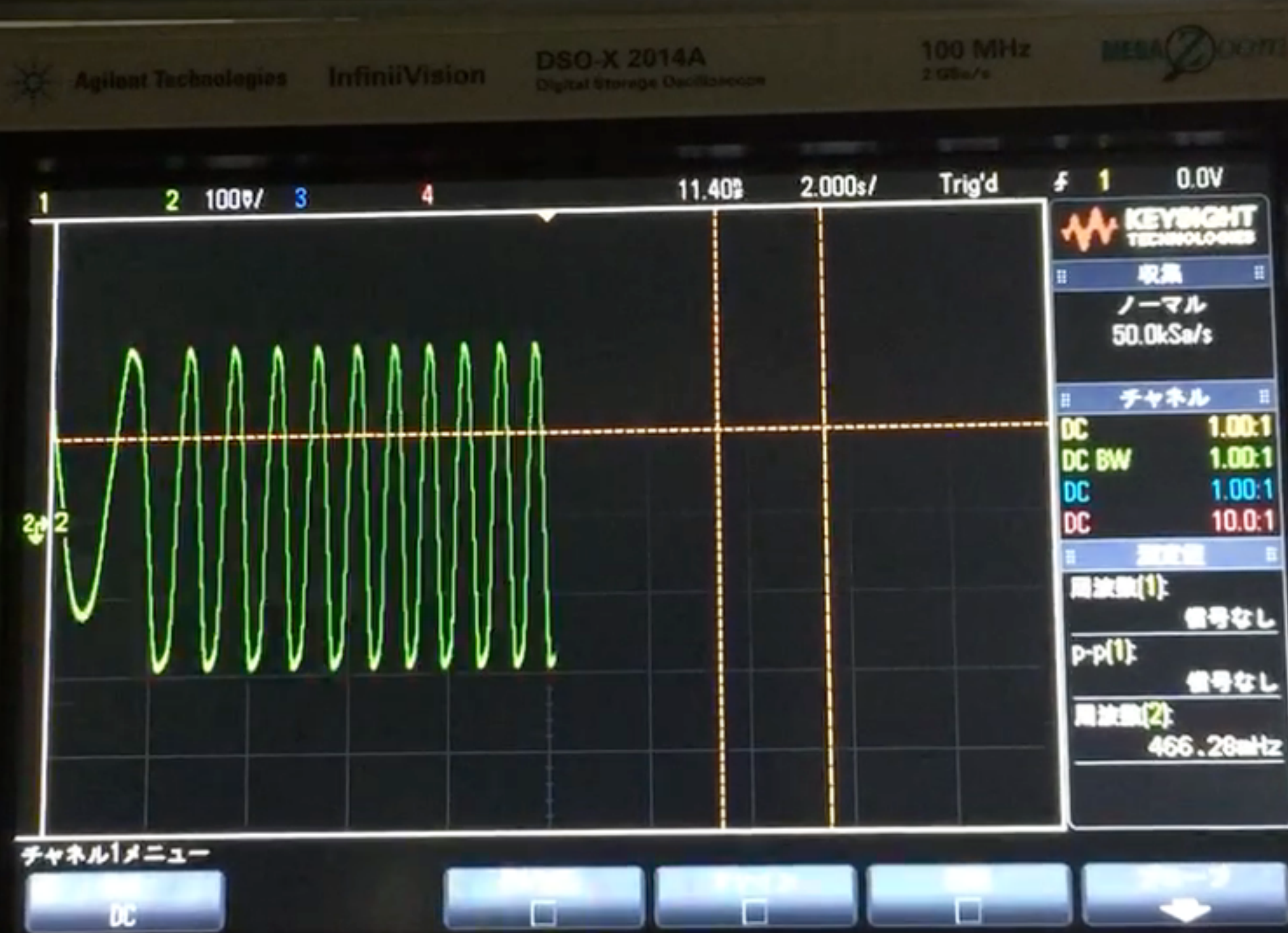
f_{rep} stabilization



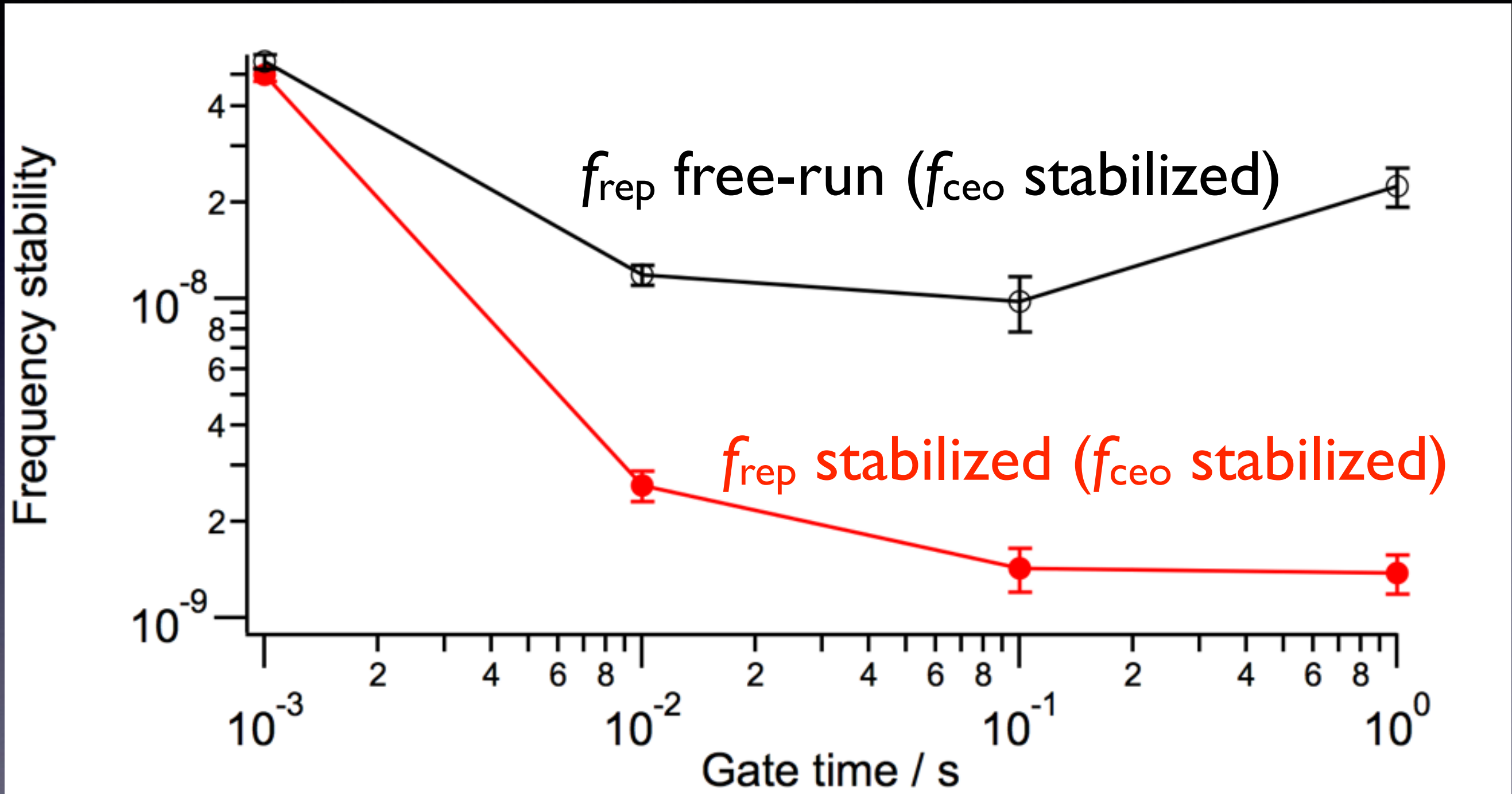
f_{rep} stabilization



f_{rep} stabilization



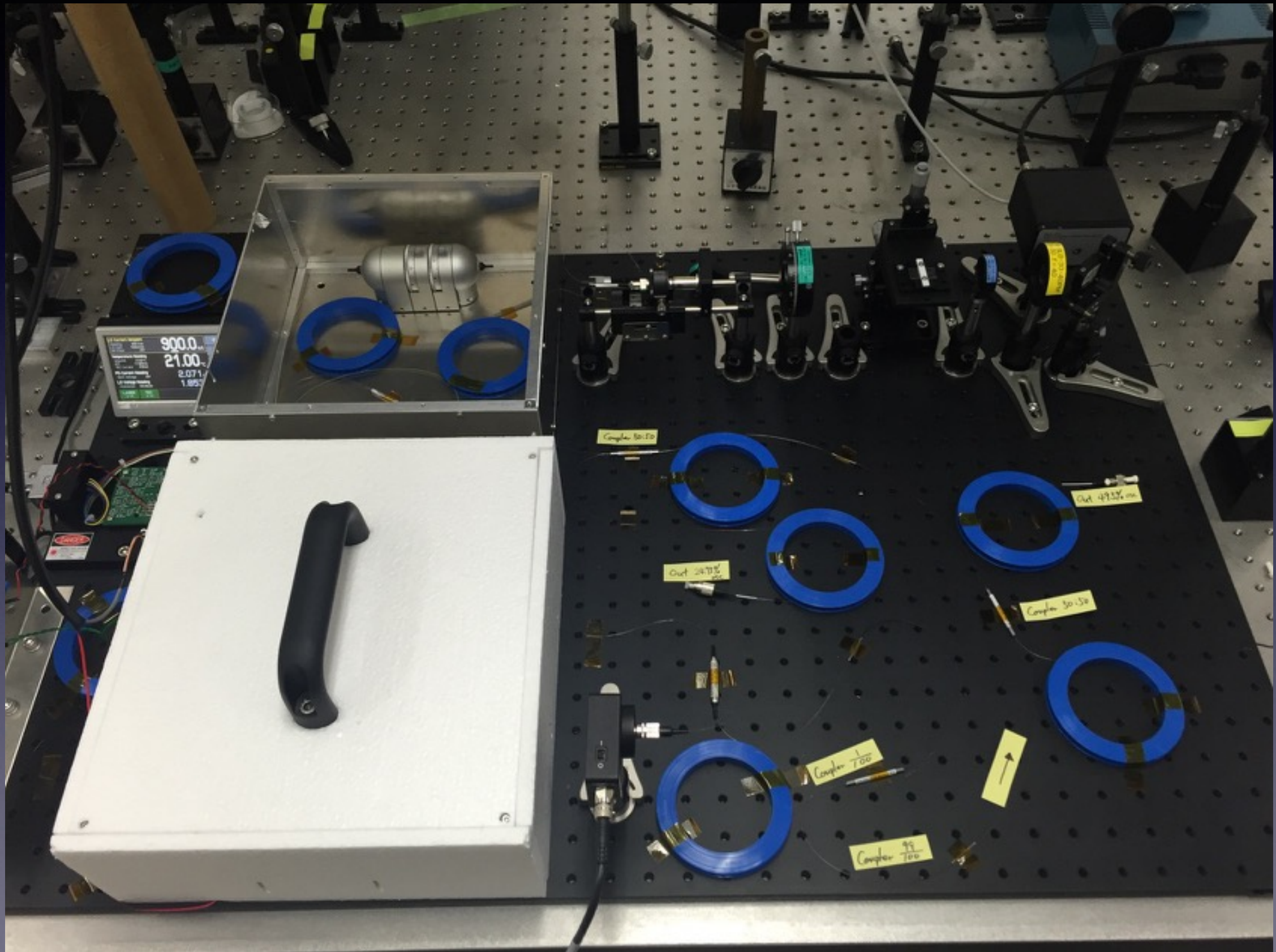
f_{rep} stabilization



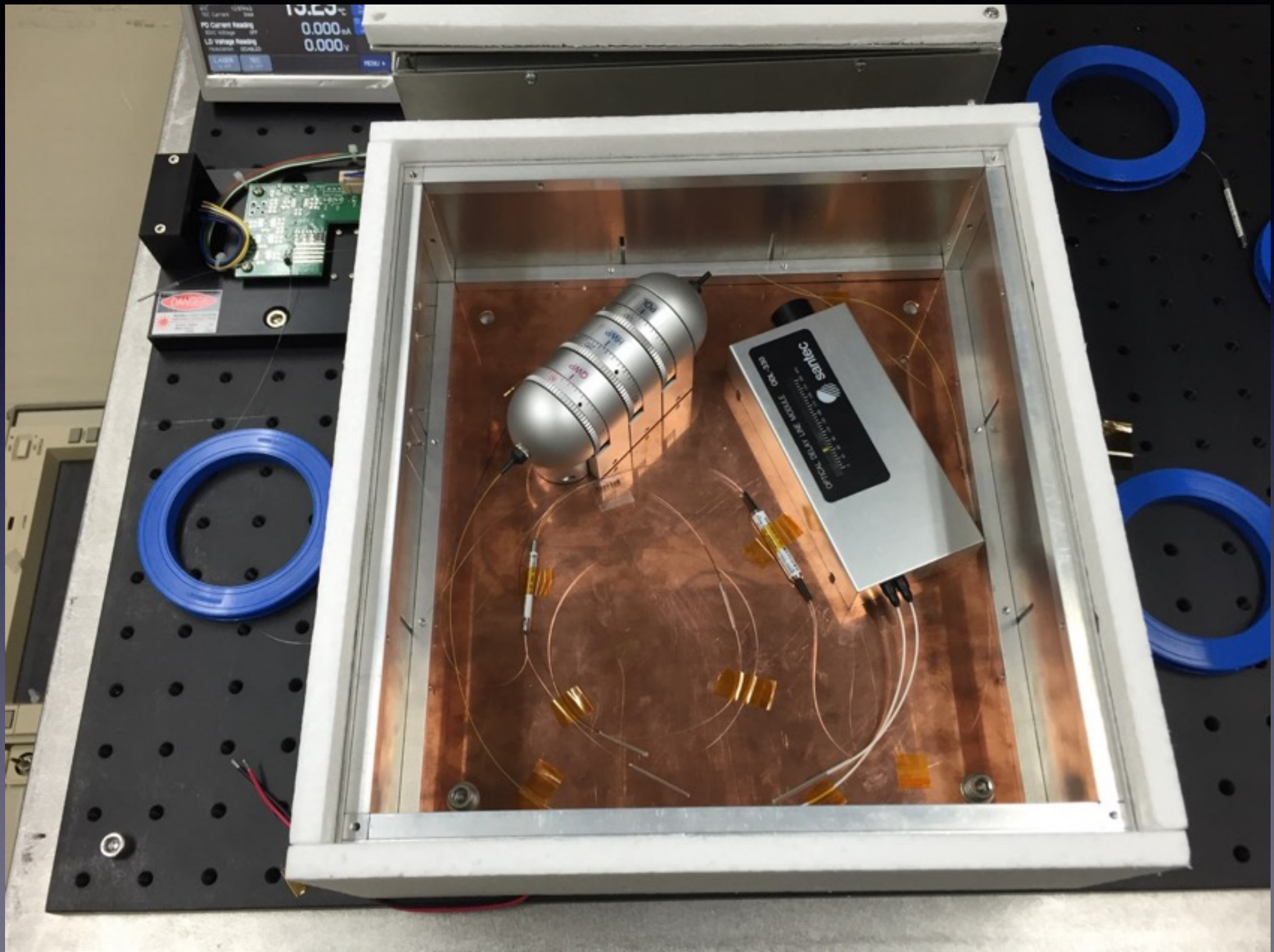
of counts for calculate S.D.: 100
w/o Rb standard for all equipments

Optical setup

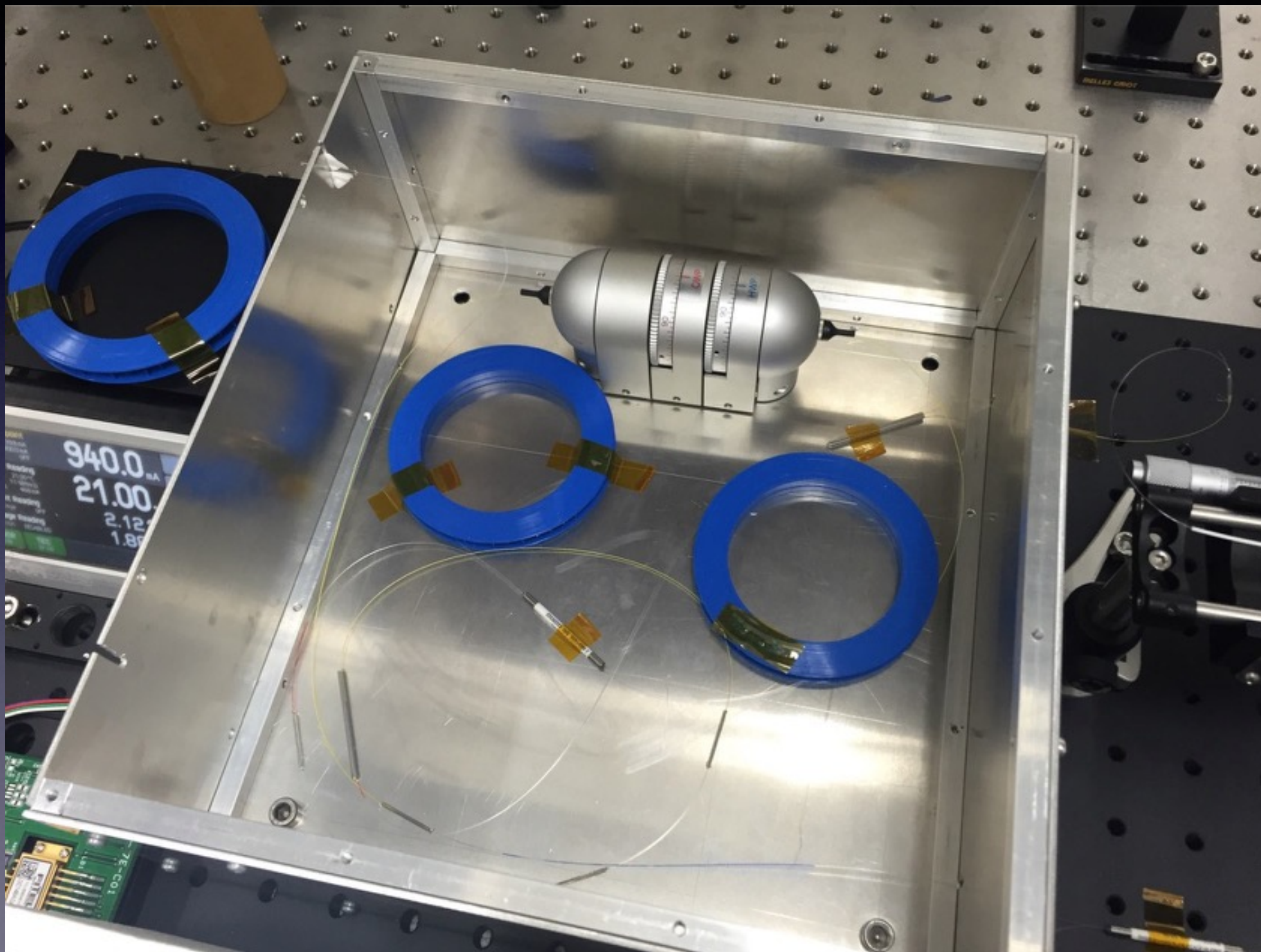
Optical setup



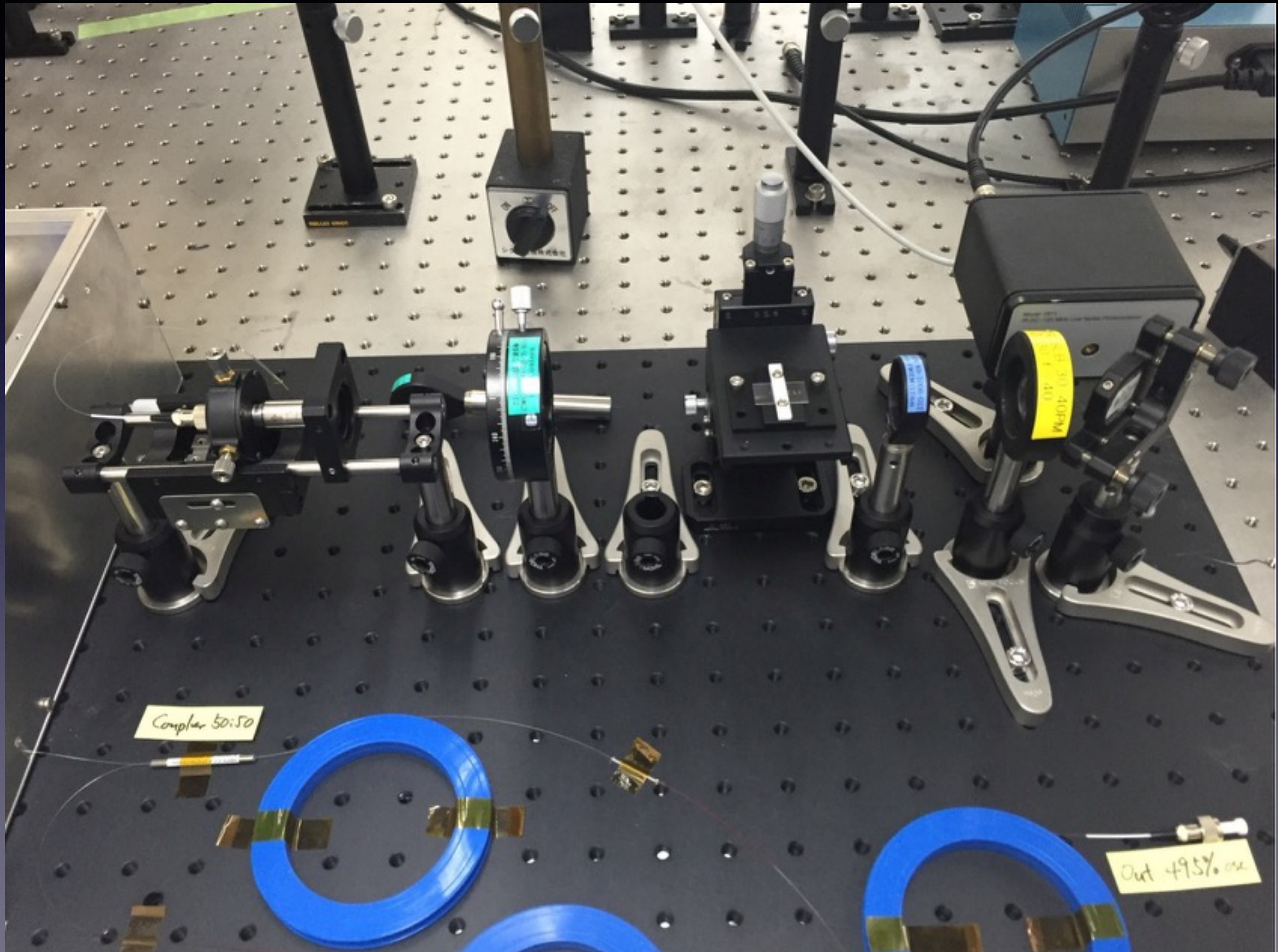
Oscillator



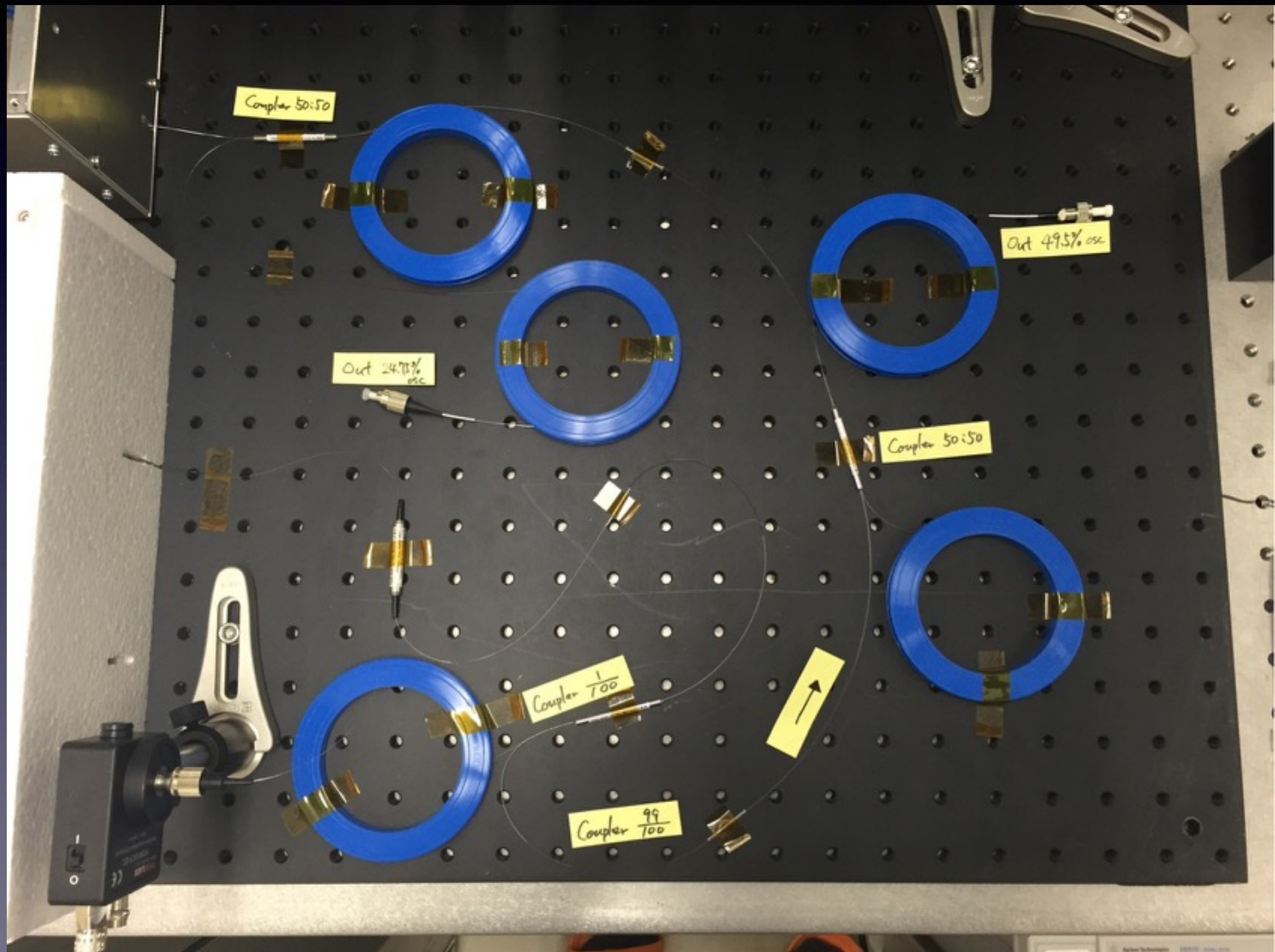
EDFA + HNLF



f - $2f$ interferometer



Branches



Branches

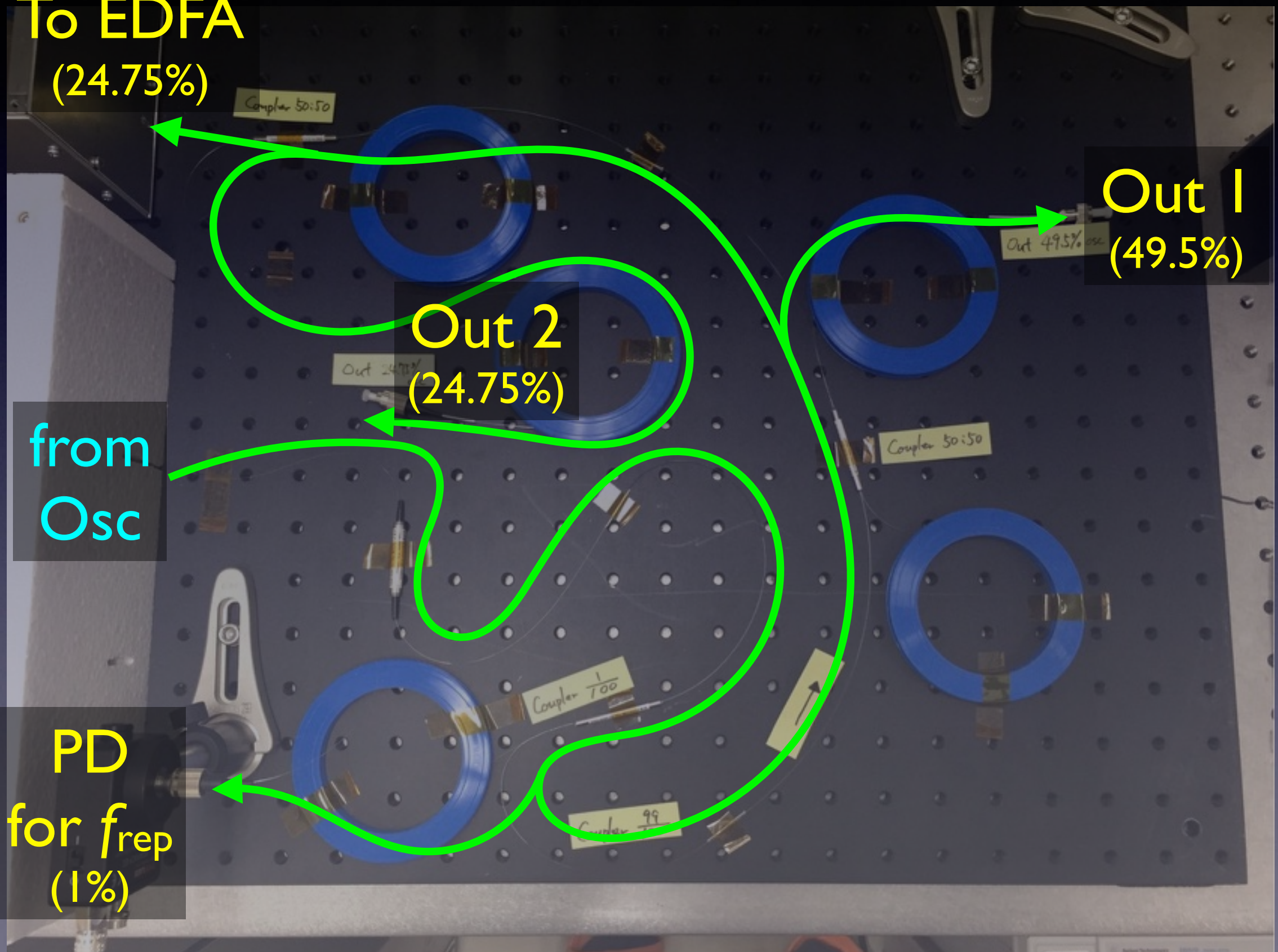
To EDFA
(24.75%)

Out 1
(49.5%)

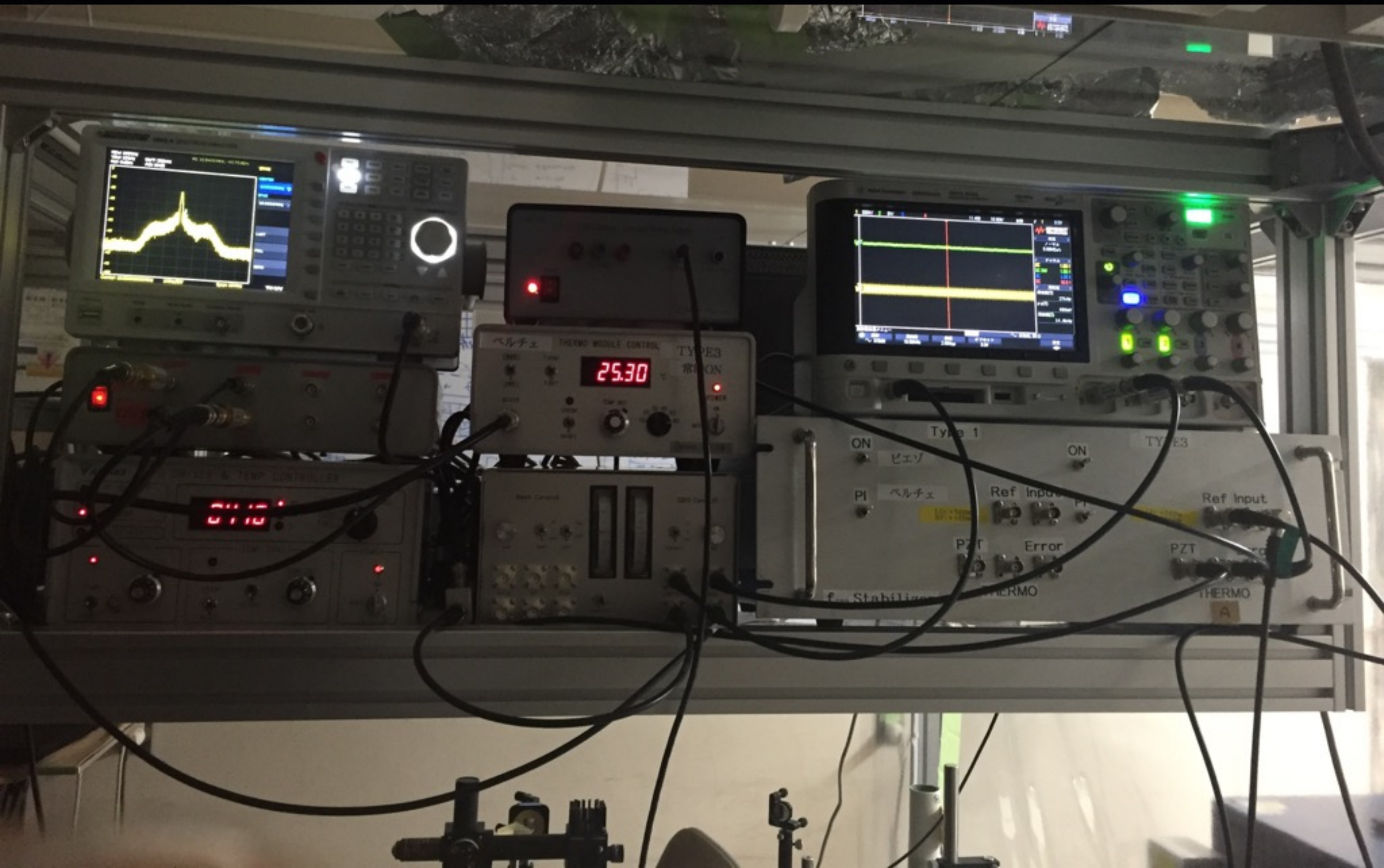
Out 2
(24.75%)

from
Osc

PD
for f_{rep}
(1%)



Controllers



Controllers

PZT controller

RF spectrum analyzer

Power supply for f_{ceo} PD

Oscilloscope
(w/ wave generator for f_{ceo})

RF amplifier

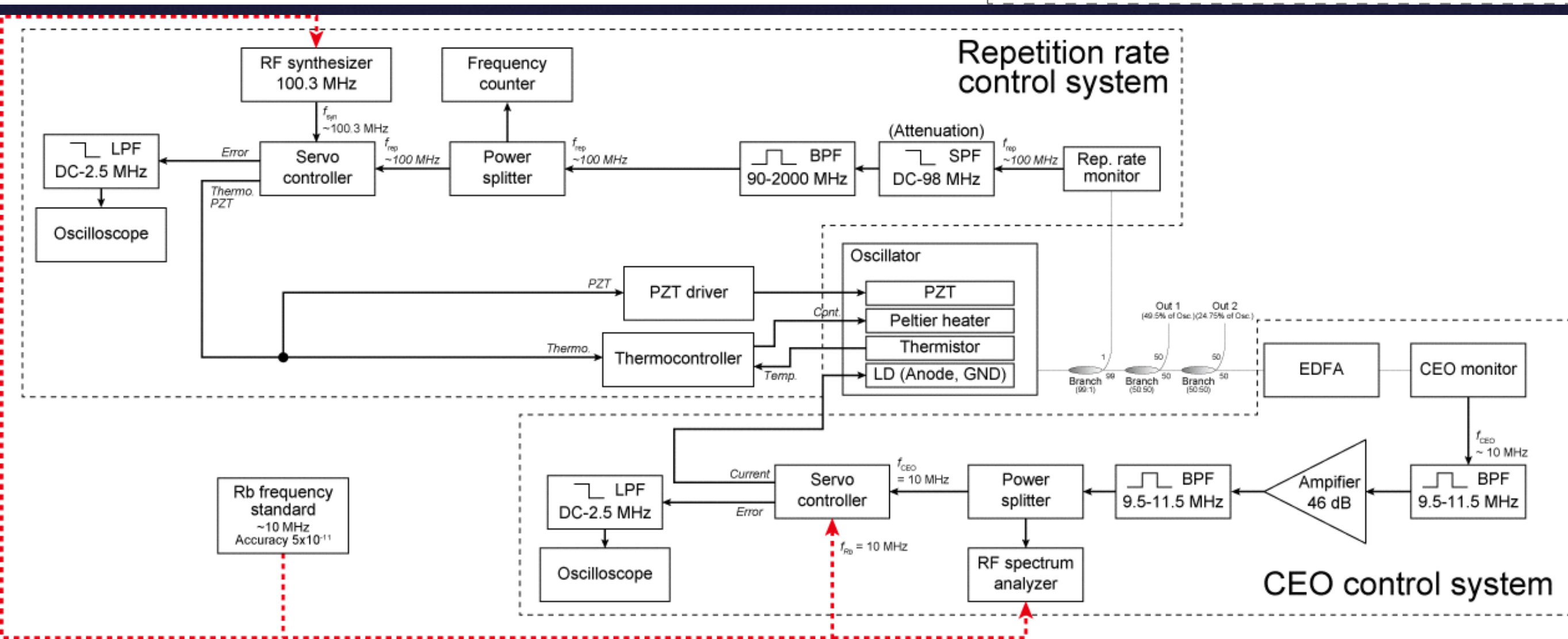
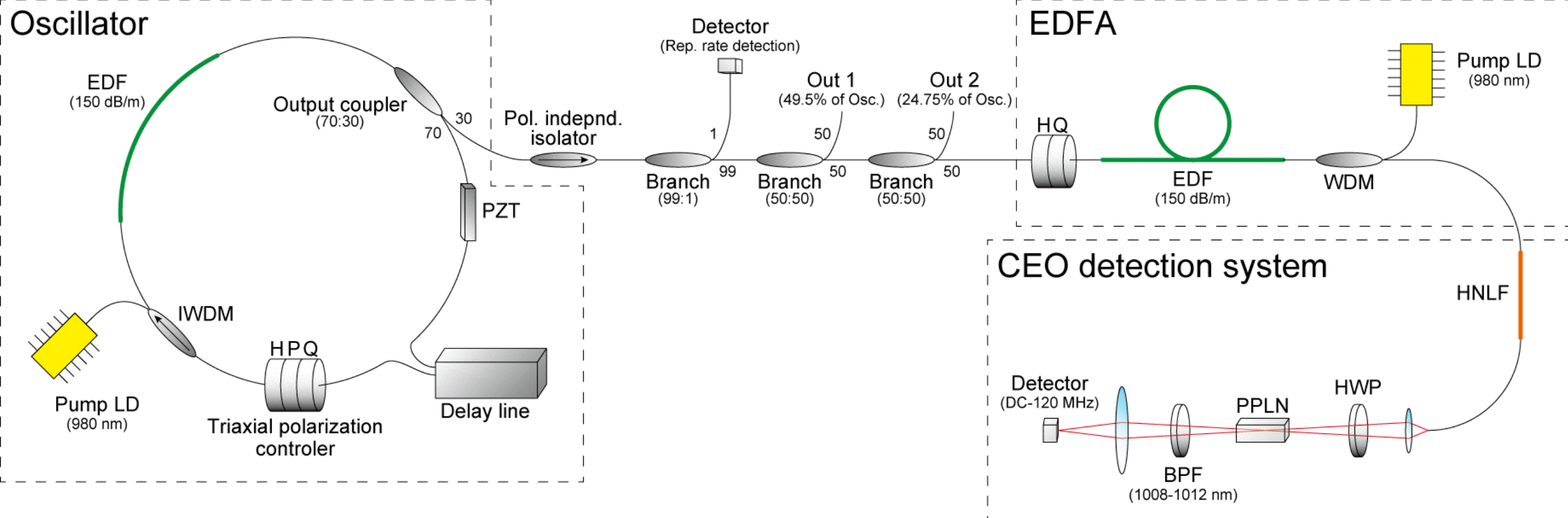
Peltier controller

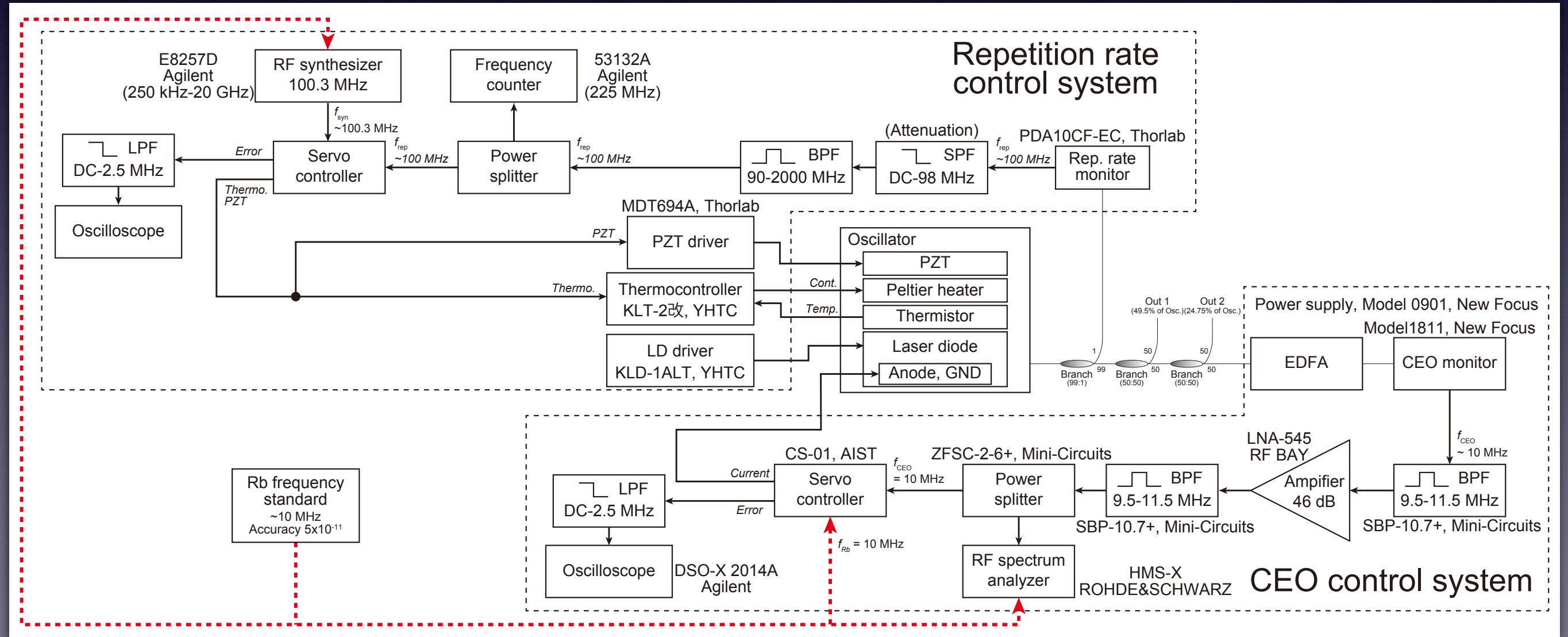
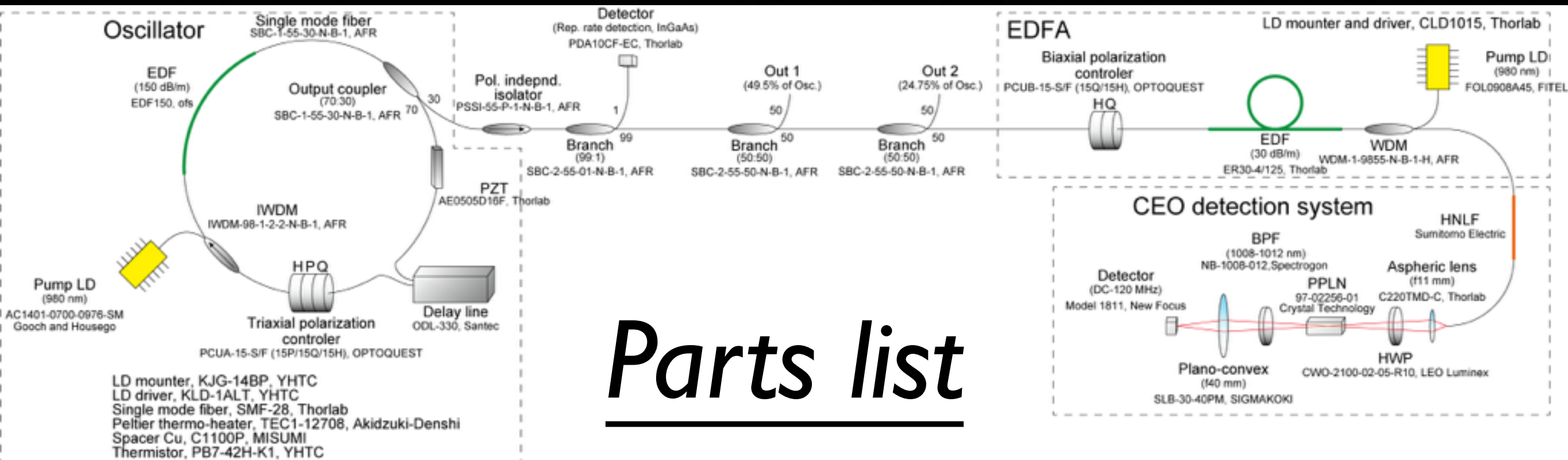
LD controller

f_{ceo} servo controller

f_{rep} servo controller

Rf synthesizer for f_{rep}





Oscillator

Specification

LD power	>360 mA @ 21.0 °C
Wavelength	1572 nm (peak), FWHM 37.1 nm
Pulse width	70.0 fs (not optimized)
f_{rep}	100,382,270.9 Hz $\pm$ 0.15 Hz @ stabilized (w/o Rb)
f_{ceo}	BW <100 Hz @ stabilized ($\sim$ 100 kHz @ free run)
Power	9.49 mW (Out1, 4.7 mW; Out2=2.4 mW)
Notes	Delay line ($\Delta f_{\text{rep}} \sim 3.3$ MHz @ $\Delta 330$ ps) PZT ($\Delta f_{\text{rep}} \sim 100$ Hz @ $\Delta 100$ V) Peltier ($\Delta f_{\text{rep}} \sim 1$ kHz @ $\Delta 2^\circ\text{C}$)

EDFA for f_{ceo} detection

LD power	800 mA @ 21.0 °C
EDFA length	4 m
Output	55.0 mW @ 2.4 mW input

Future work

Move to M306 room

Construction of dual-comb system

- ✓ Confirmation of EOM comb system
- ✓ Construction of EDFA system (x2)
- ✓ Synchronization of PZT-comb to RIO
- ✓ Synchronization of RIO to EOM-comb
- ✓ Evaluation of relative-line width between PZT- and EOM-combs
- ✓ Enclosure for EOM comb?