31/October/2015
Dr meeting

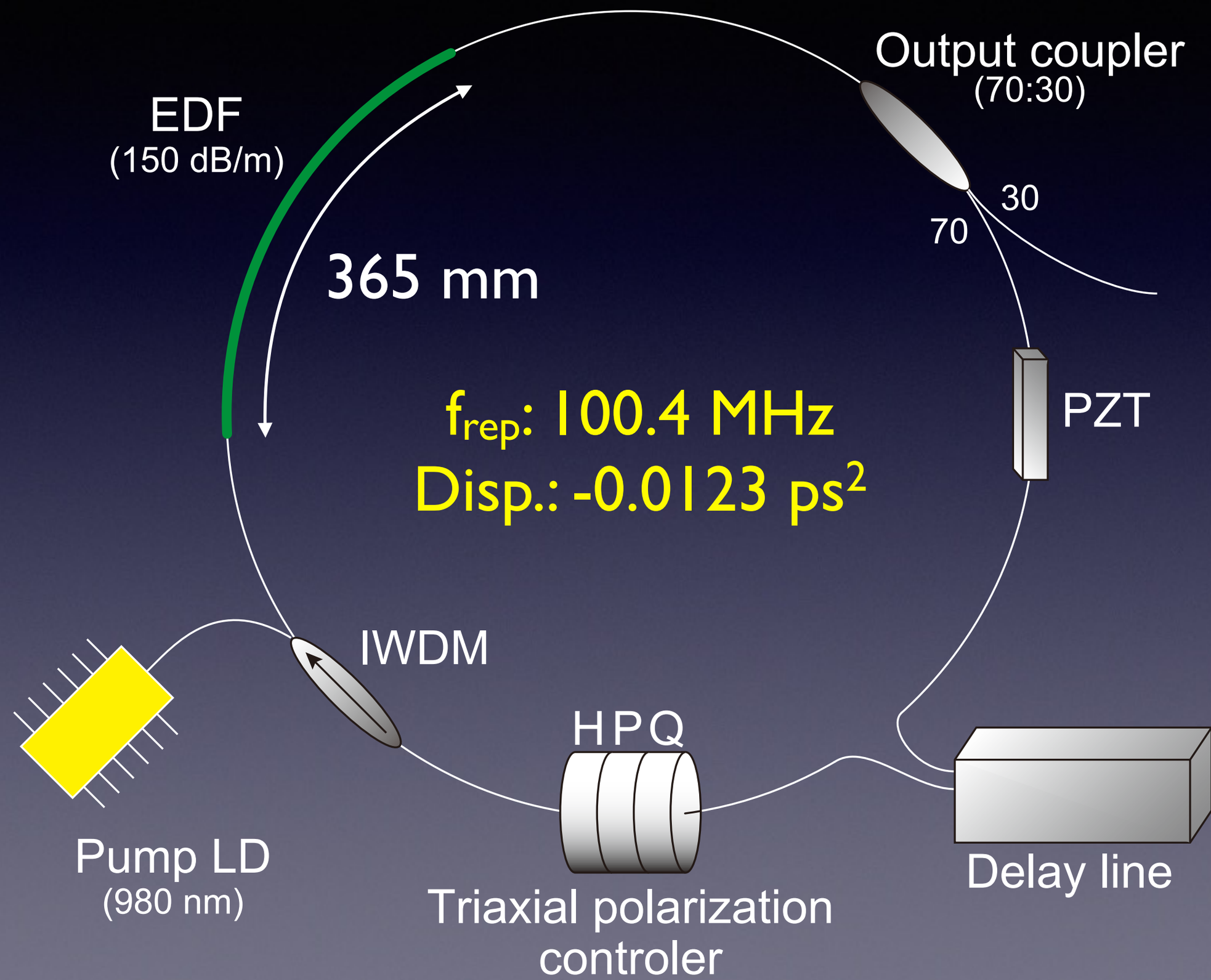
Development of Piezo-EOM dual-comb system

Takeo Minamikawa

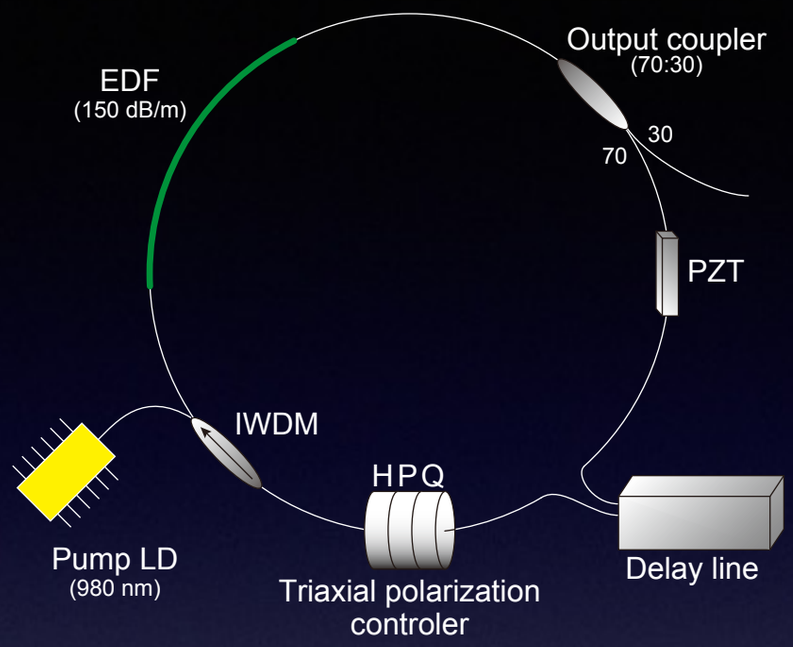
Institute of Technology and Science, Tokushima Univ.
JST/ERATO Minoshima Intelligent Optical Synthesizer Project

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

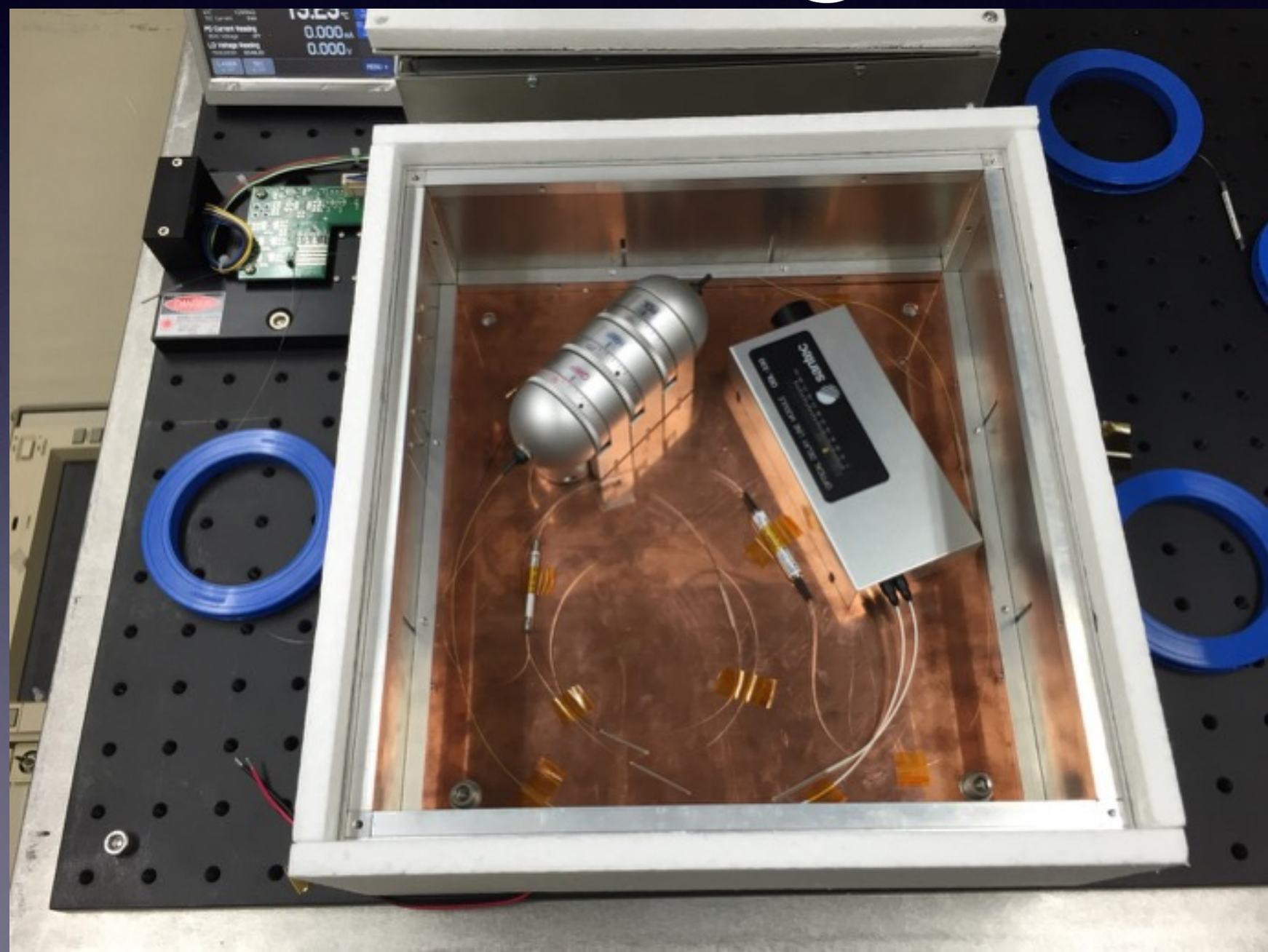
Fiber laser setup



Fiber laser setup in chamber

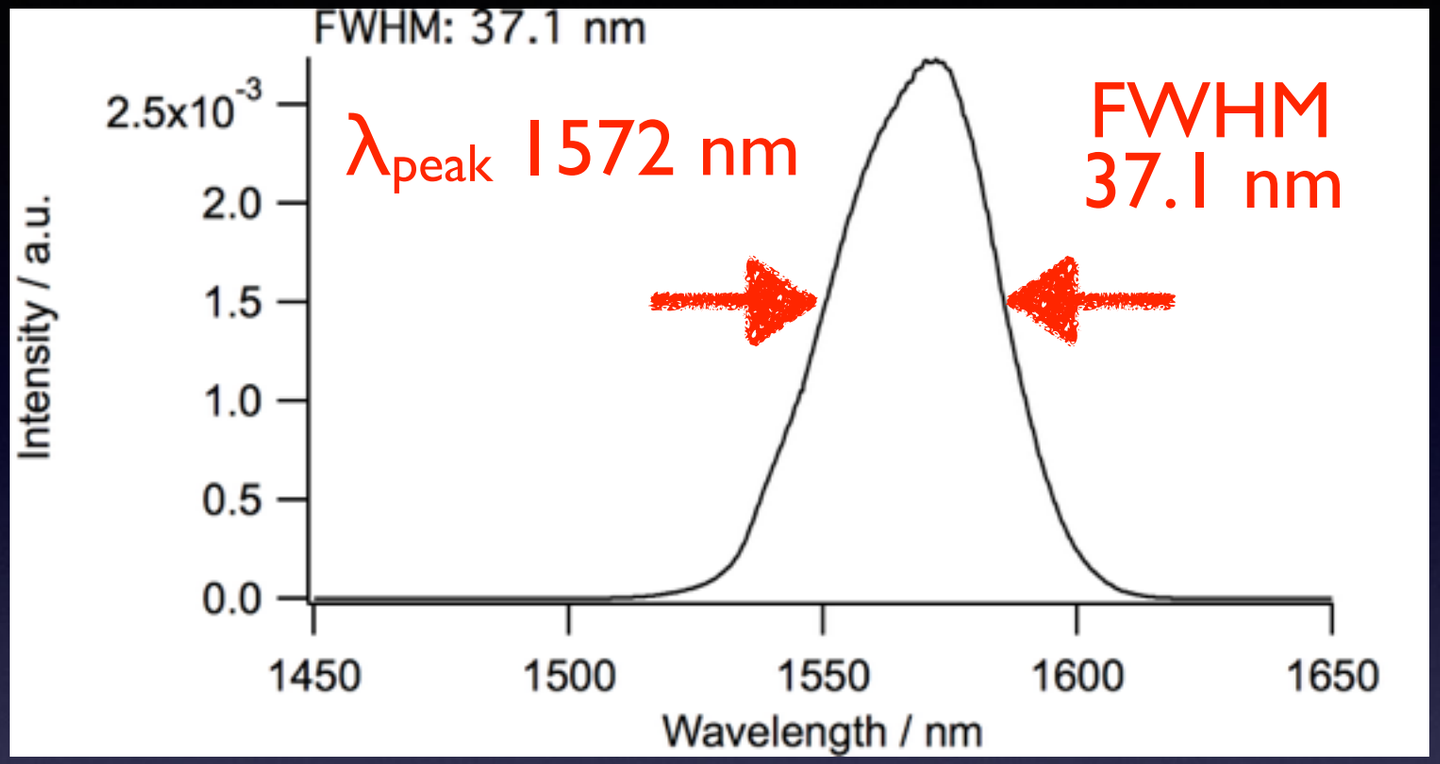


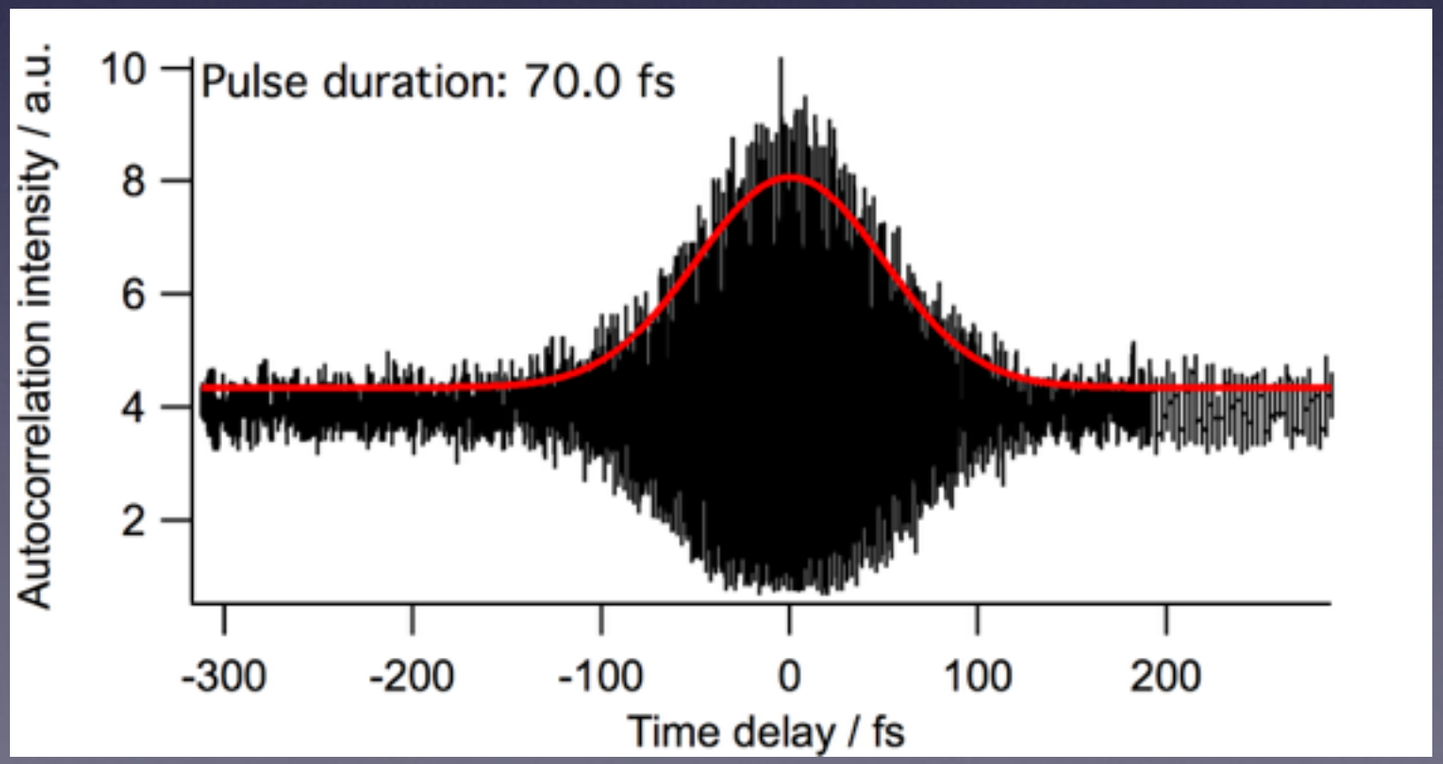
LD current: 360 mA@ 21.0 °C



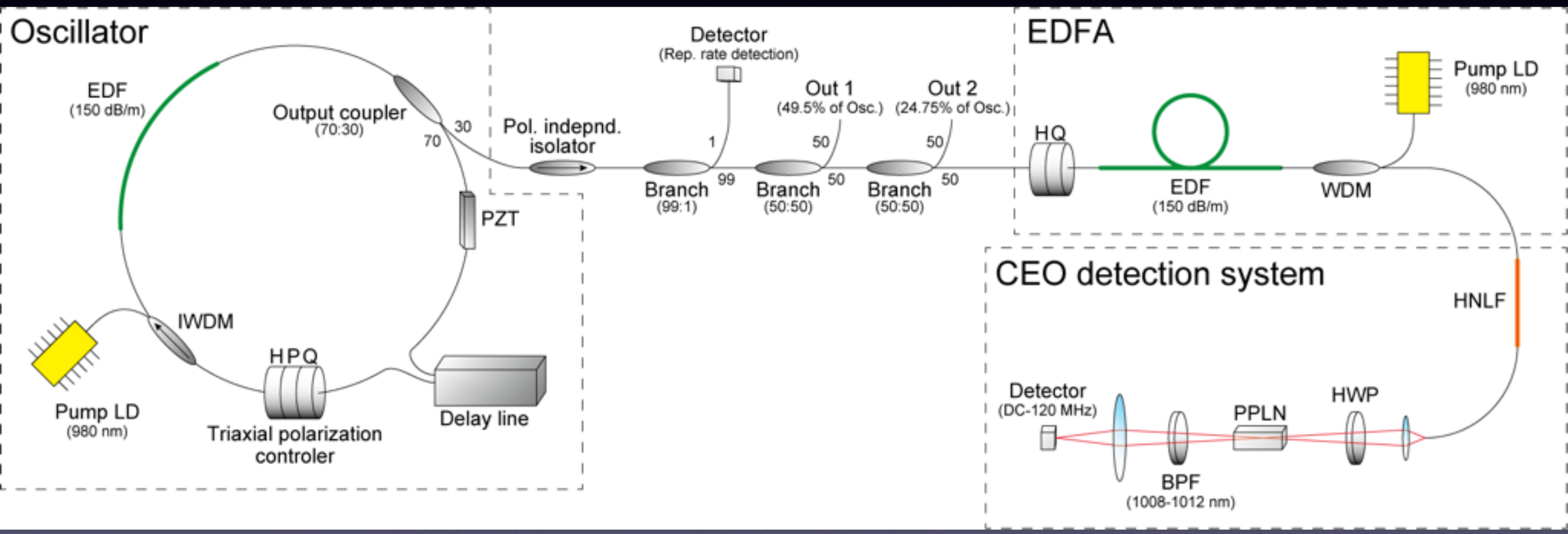
Laser power
9.49 mW

Fiber laser spec. - Wavelength -



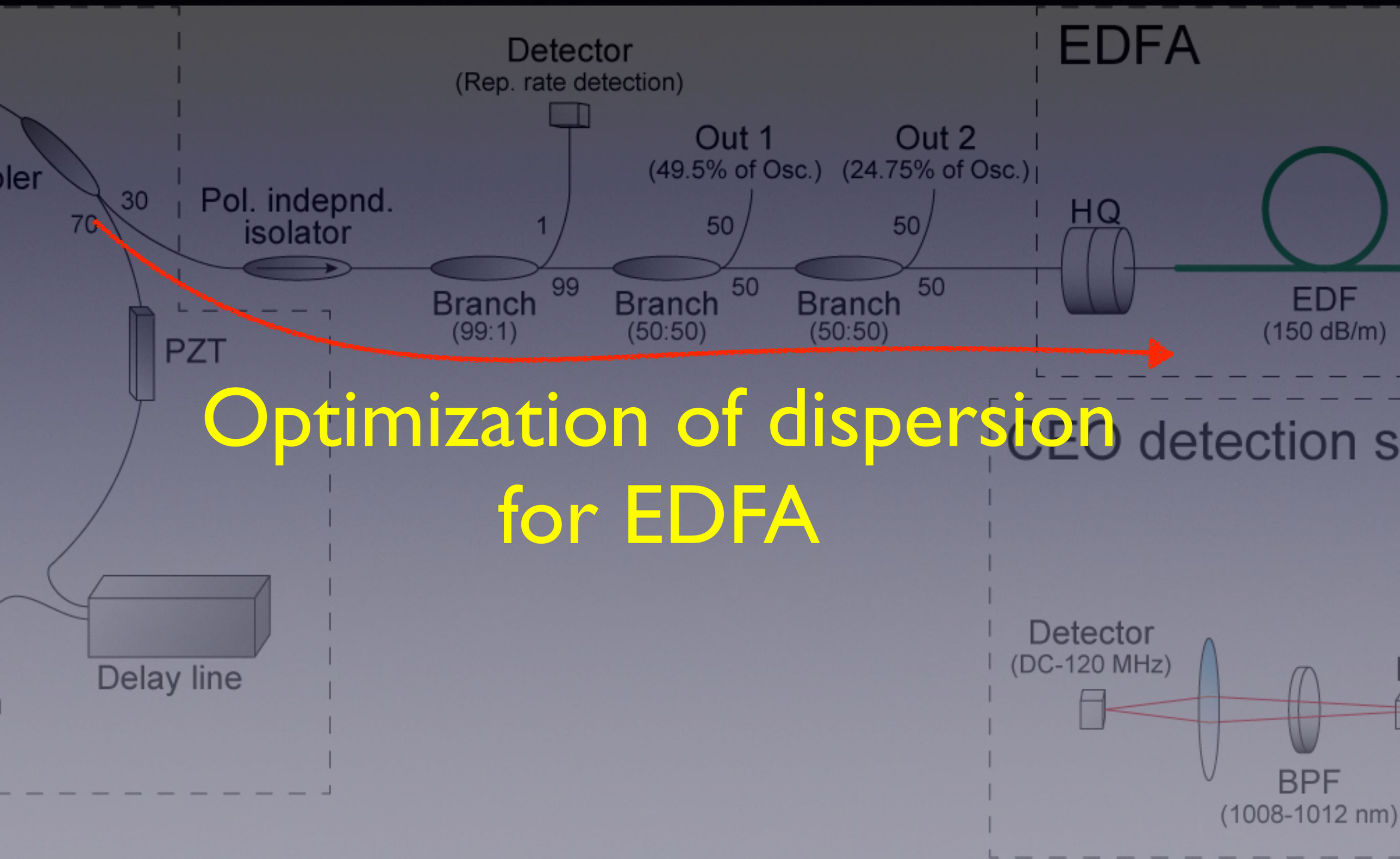


Progress


Oscillator
EDF
(150 dB/m)
Output coupler
(70:30)
30
70
PZT
IWDM
HPQ
Pump LD
(980 nm)
Triaxial polarization
controler
Delay line
Pol. indepnd.
isolator
Detector
(Rep. rate detection)
1
99
Branch
(99:1)
Out 1
(49.5% of Osc.)
50
50
Branch
(50:50)
Out 2
(24.75% of Osc.)
50
50
Branch
(50:50)
EDFA
HQ
EDF
(150 dB/m)
WDM
Pump LD
(980 nm)
CEO detection system
HNLF
Detector
(DC-120 MHz)
BPF
(1008-1012 nm)
PPLN
HWP

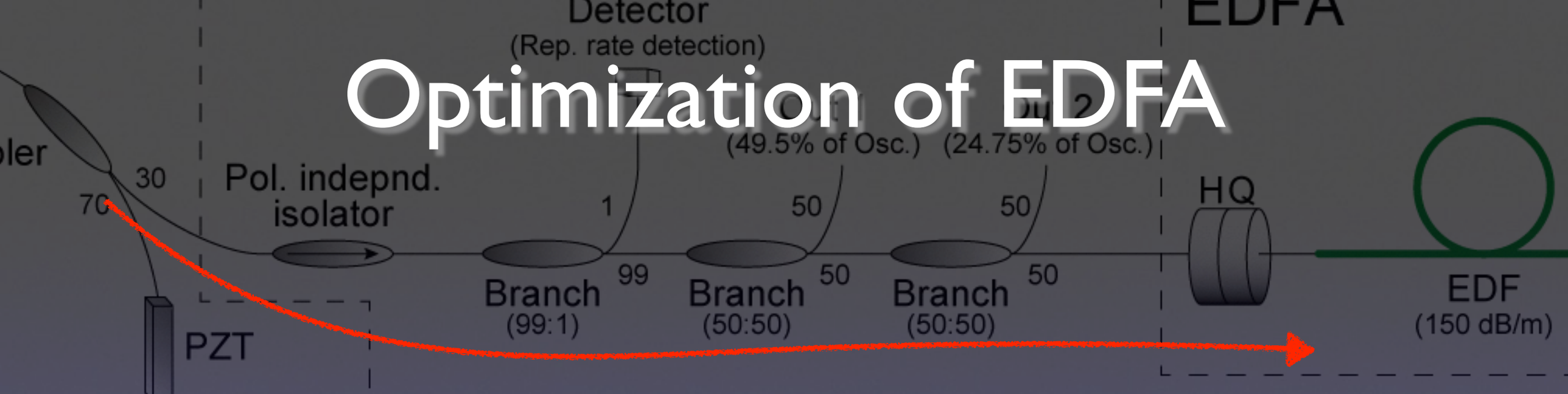
f_{ceo} stabilization

Optimization of EDFA

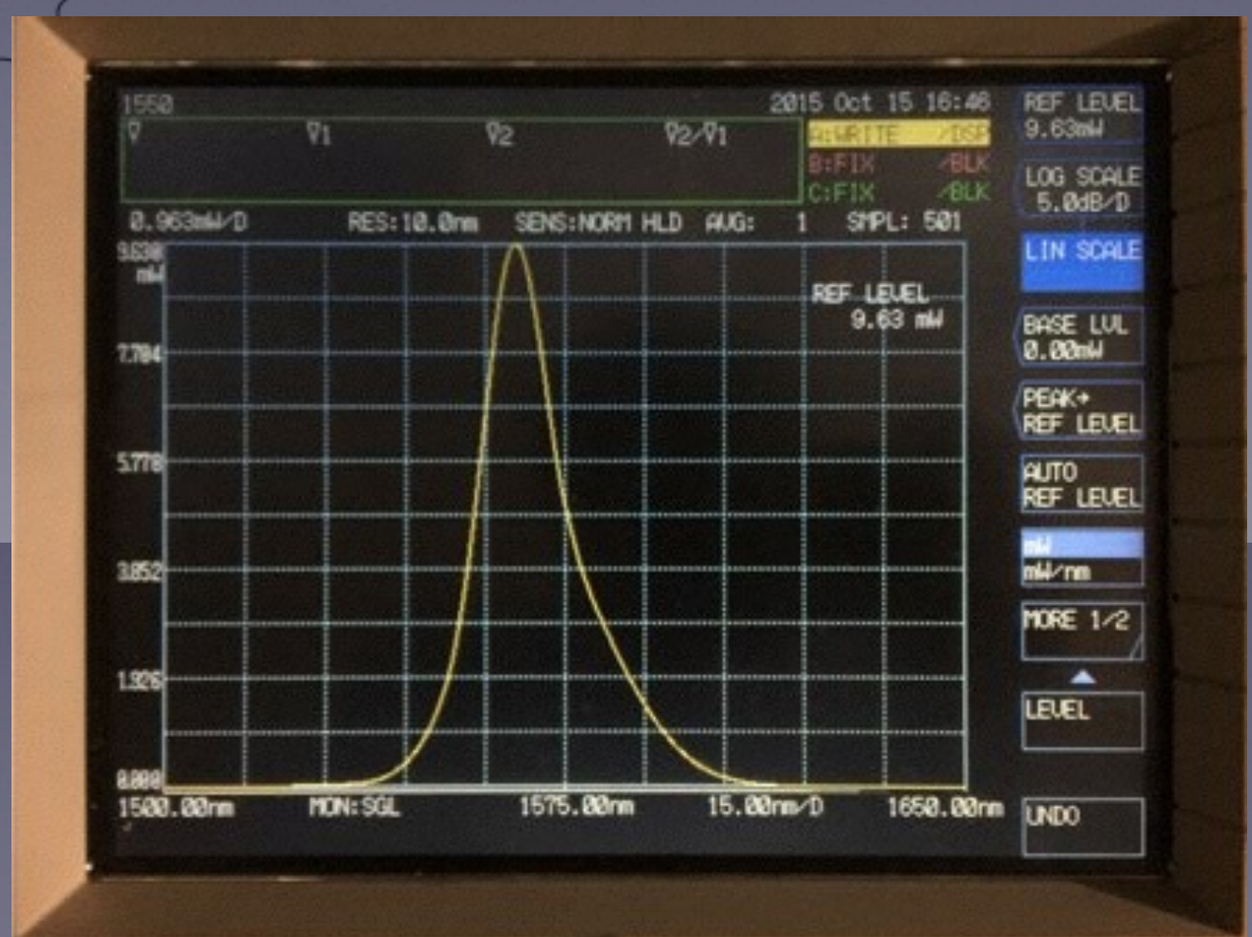


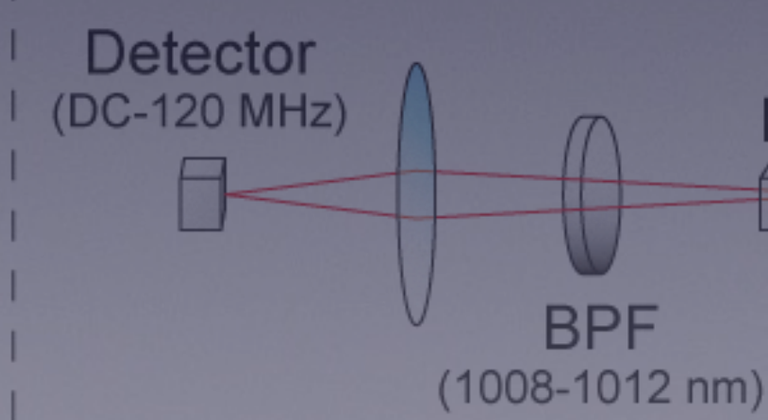
Optimization of dispersion for EDFA

Optimization of EDFA



SMF length 6 m EDF length 4 m

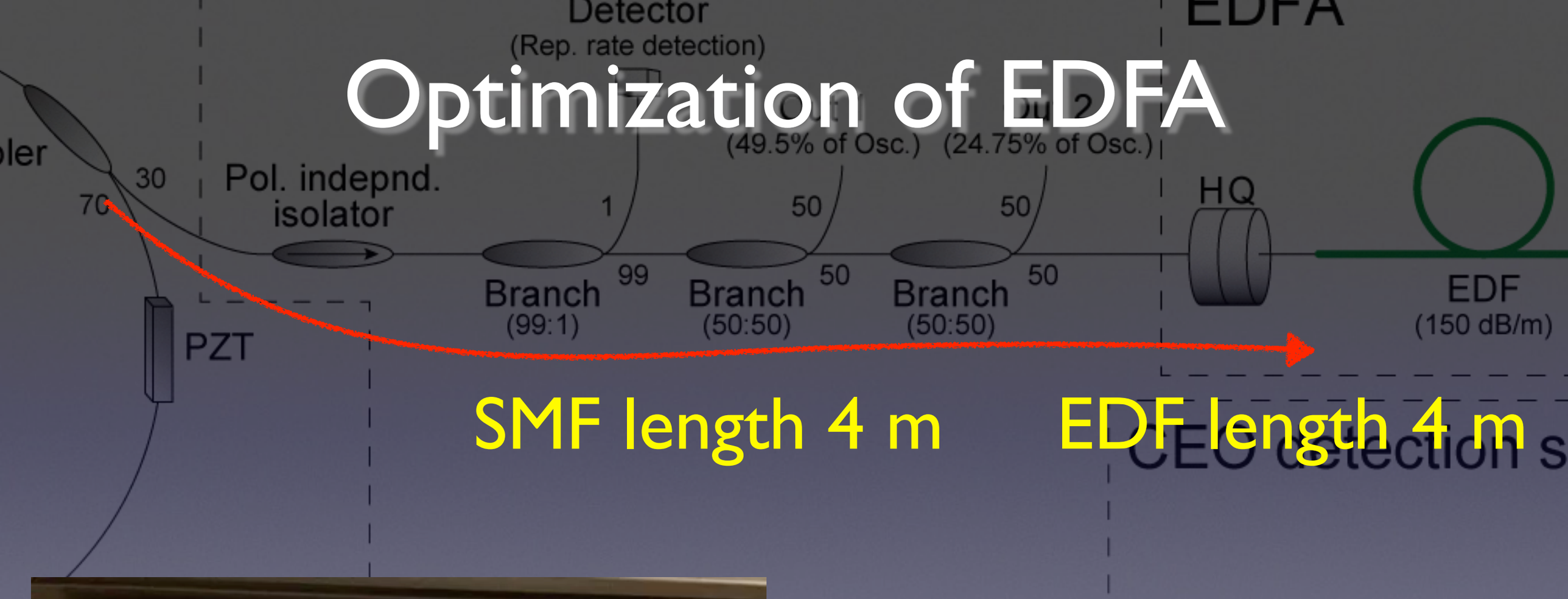




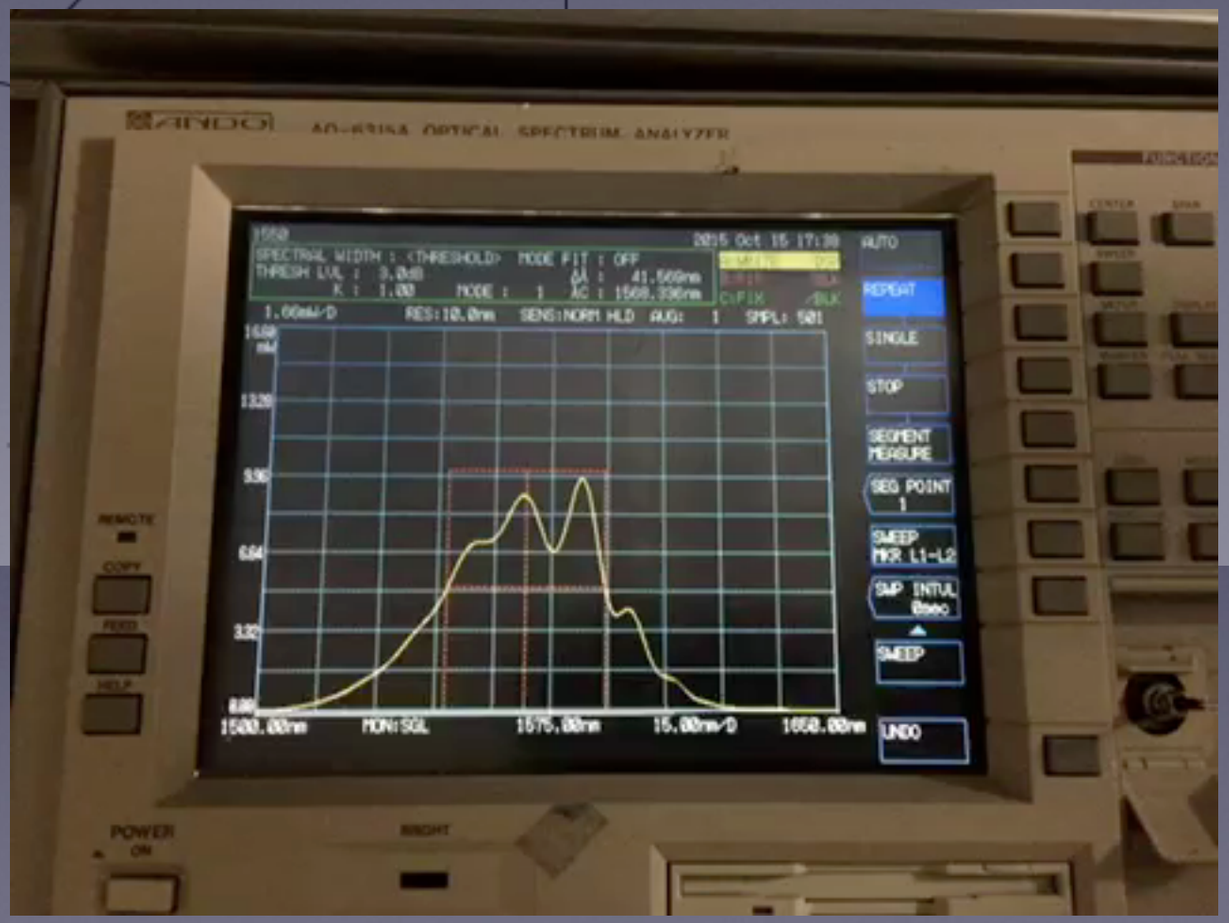
No change

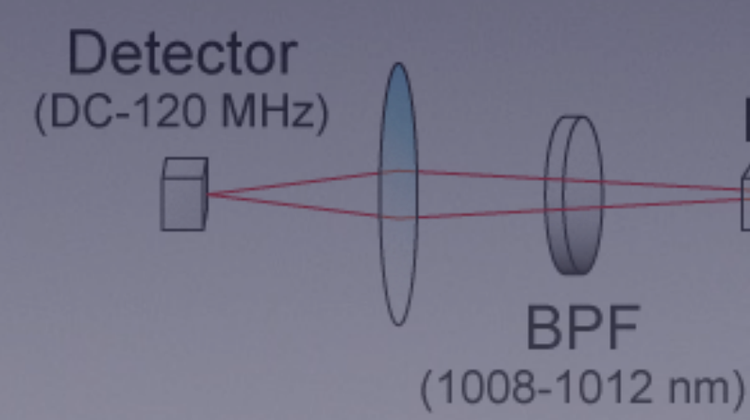
by tuning HWP and QWP

Optimization of EDFA



SMF length 4 m EDF length 4 m

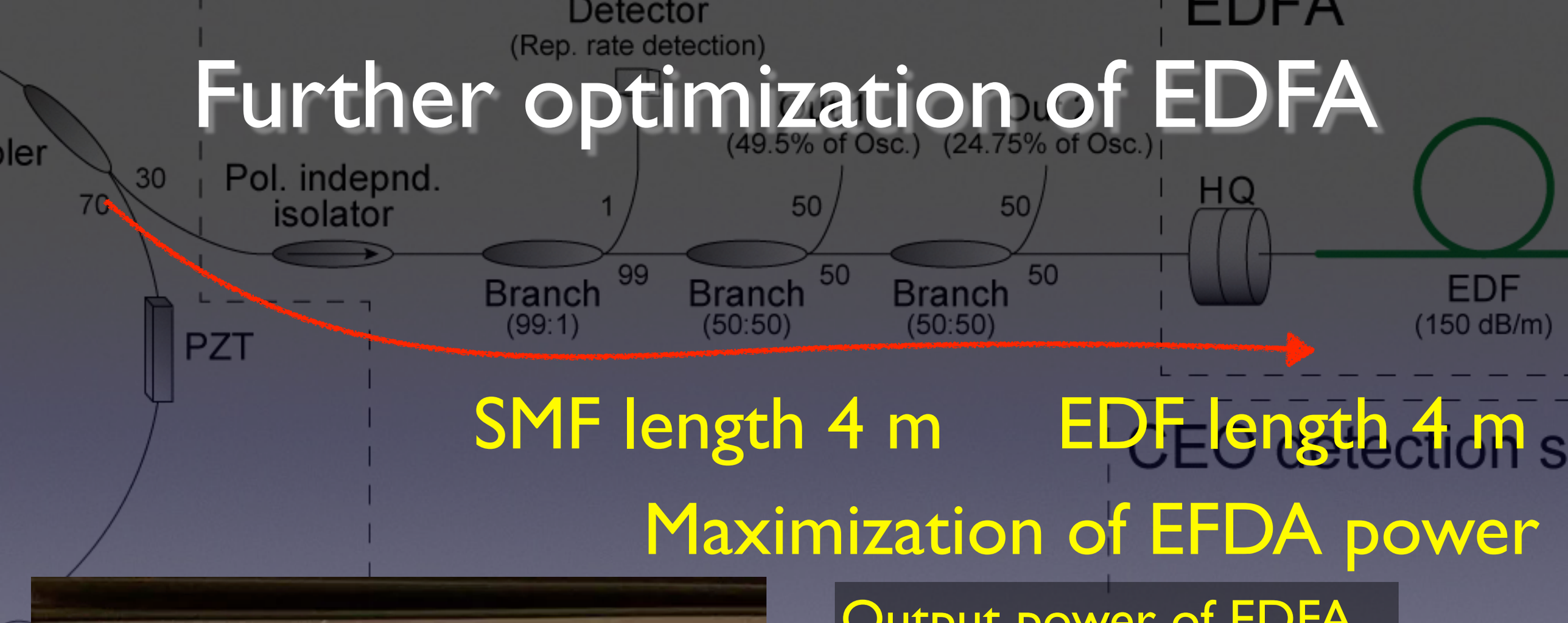




Changed

by tuning HWP and QWP

Further optimization of EDFA



SMF length 4 m EDF length 4 m

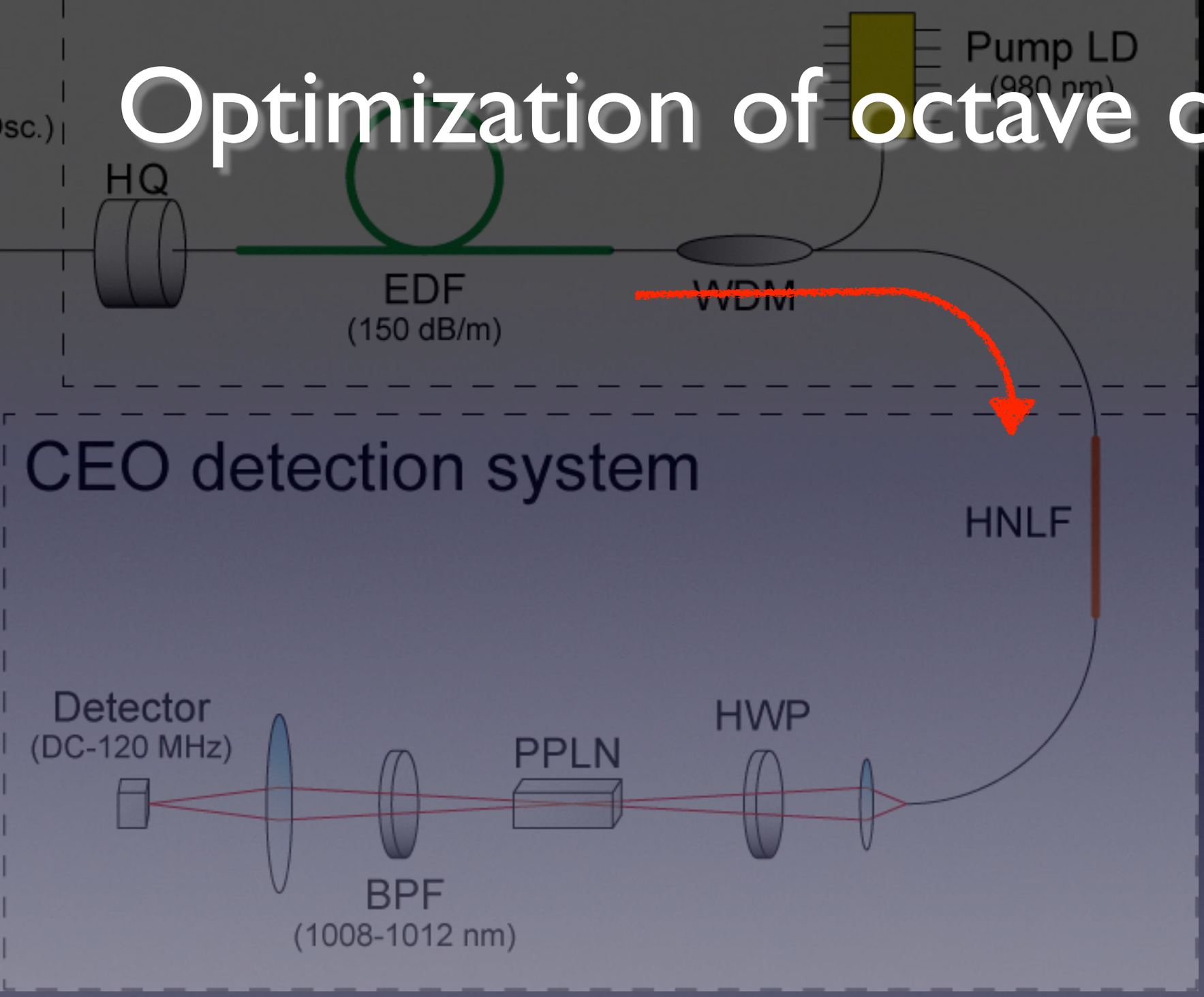
Maximization of EFDA power

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

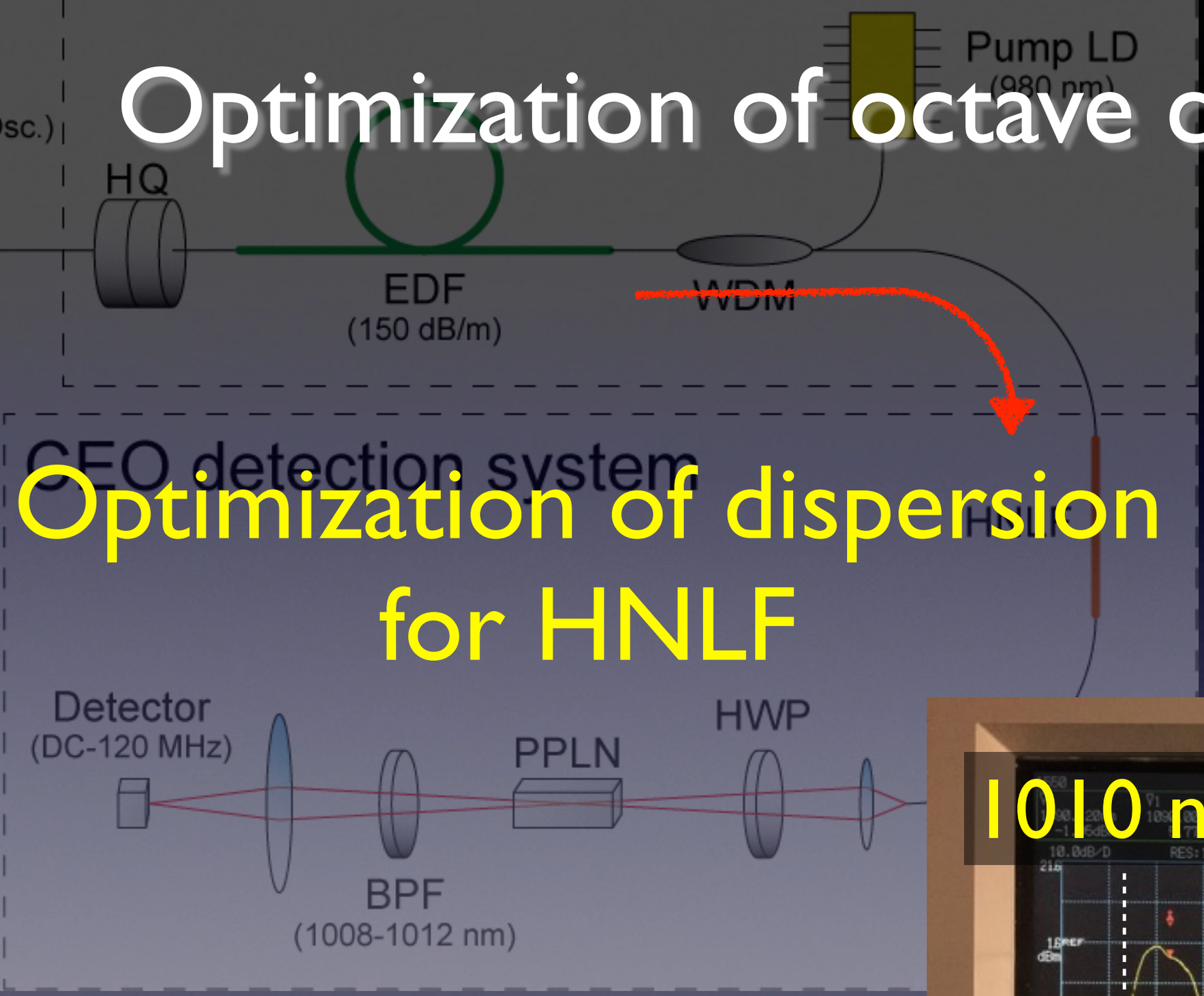
@LD 800 mA

Optimization of octave continuum



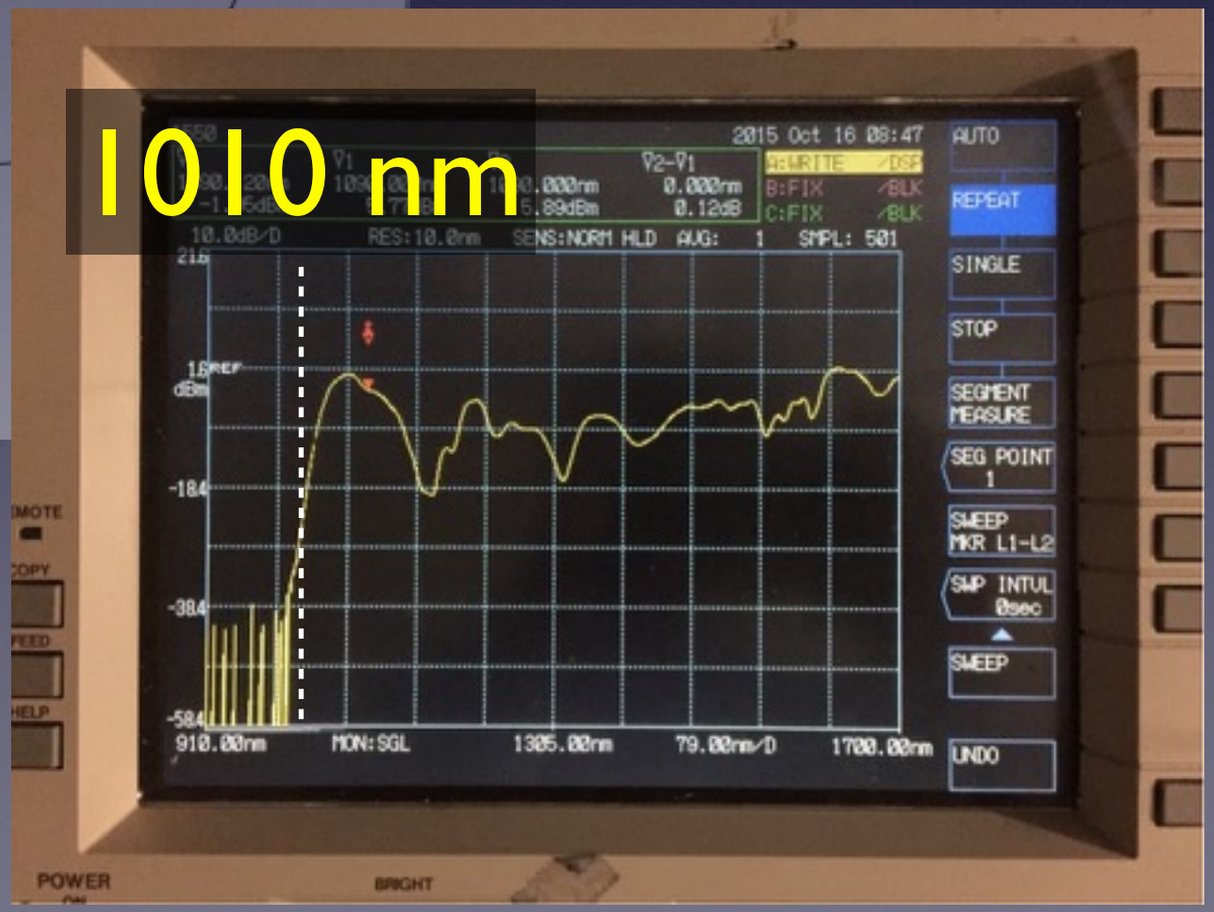
Optimization of dispersion for HNLF

Optimization of octave continuum



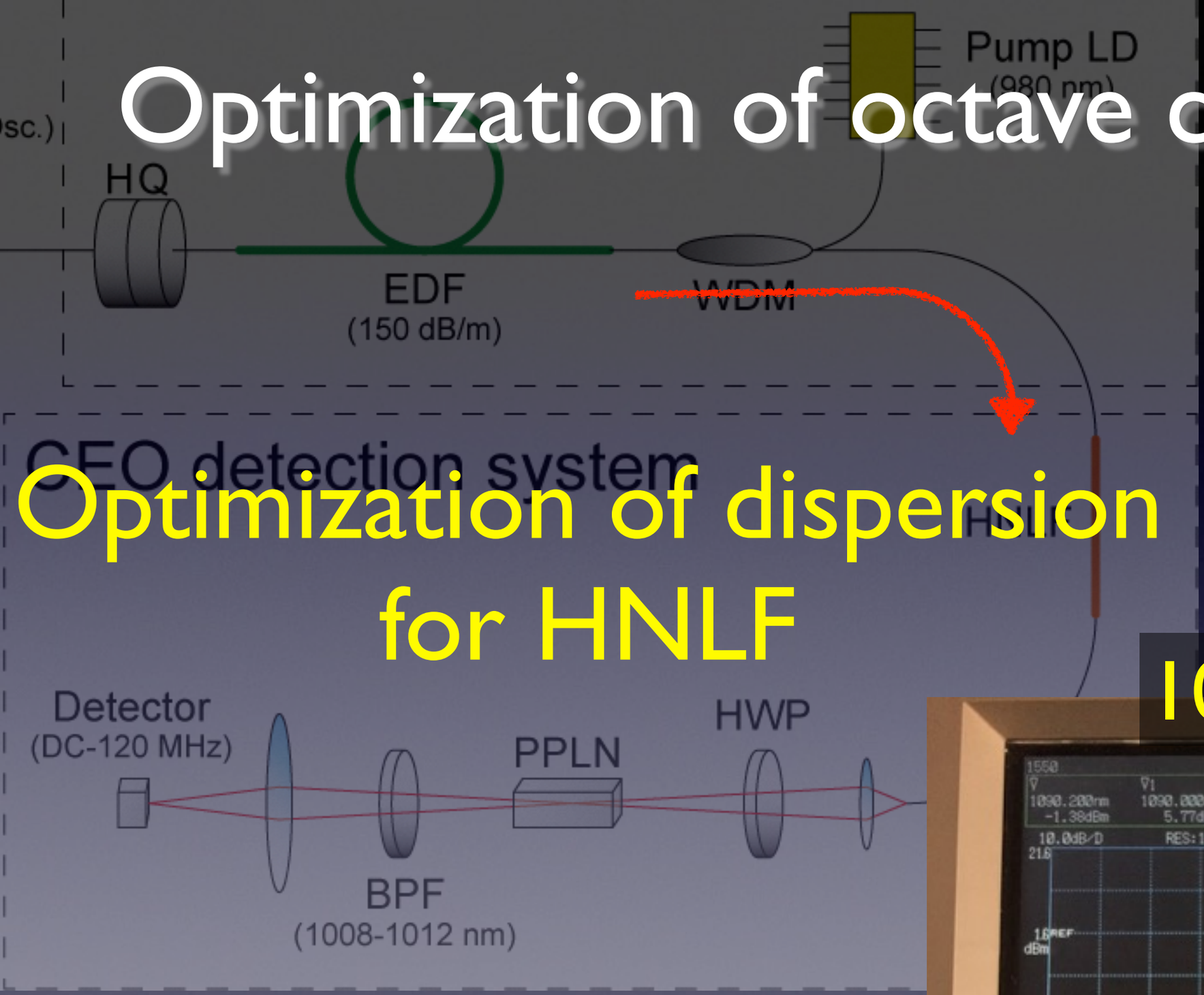
HNLF length
20 cm

Optimization of dispersion for HNLF



Initial
SMF length 2.4 m
(WDM 40 cm)

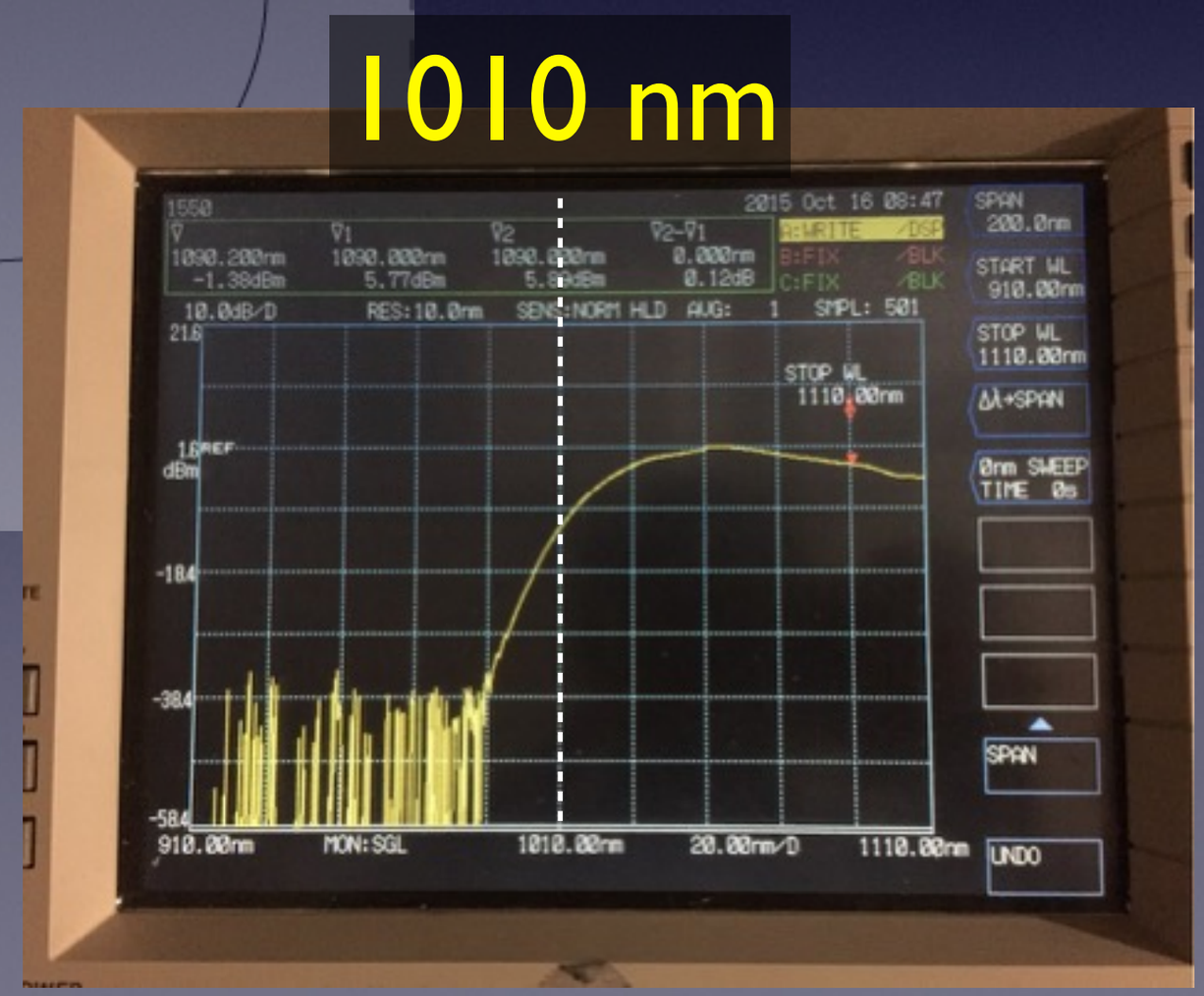
Optimization of octave continuum



Optimization of dispersion for HNLF

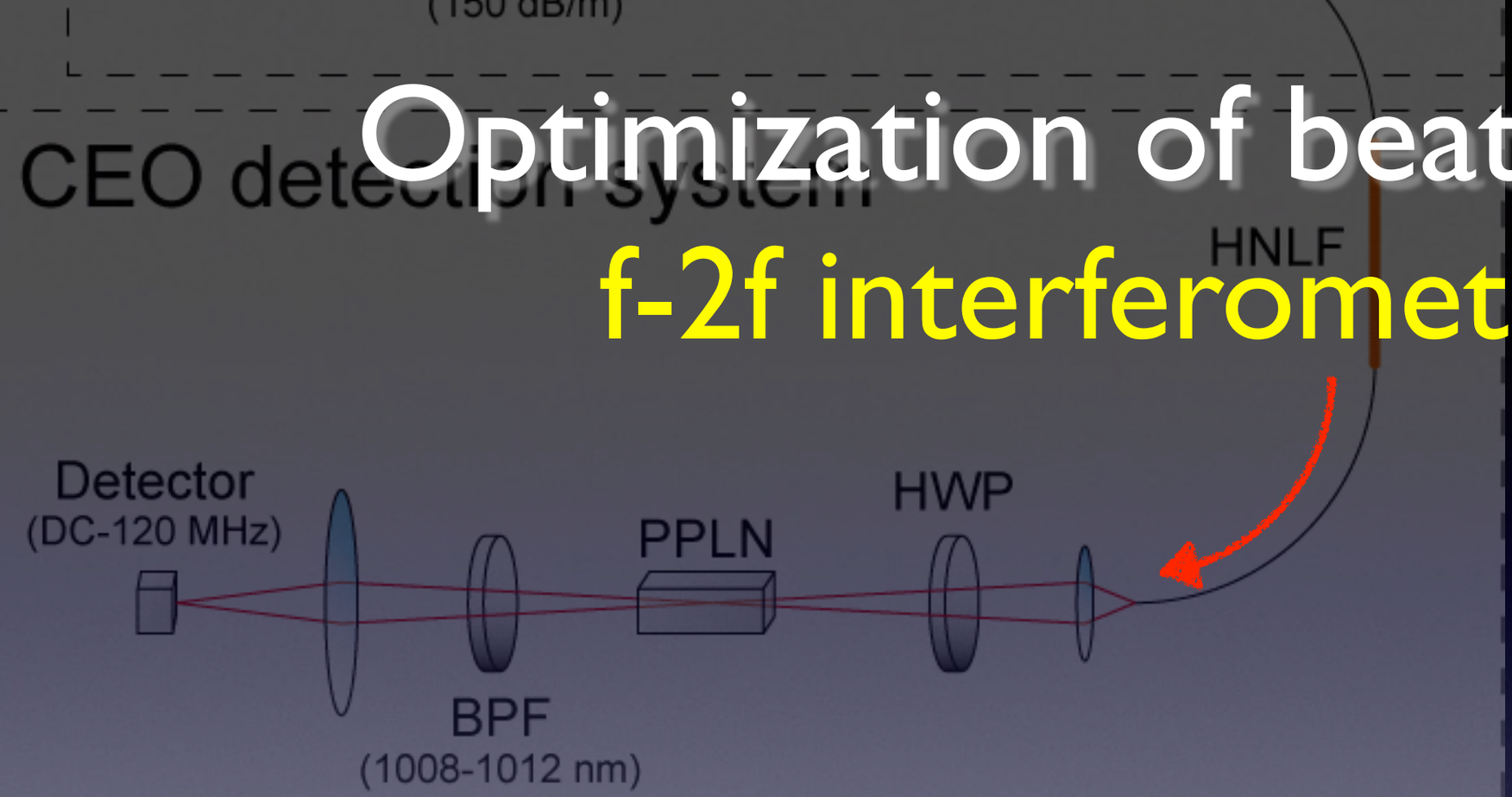
Maximize spectral intensity at 1010 nm

Optimized
SMF length 30 cm



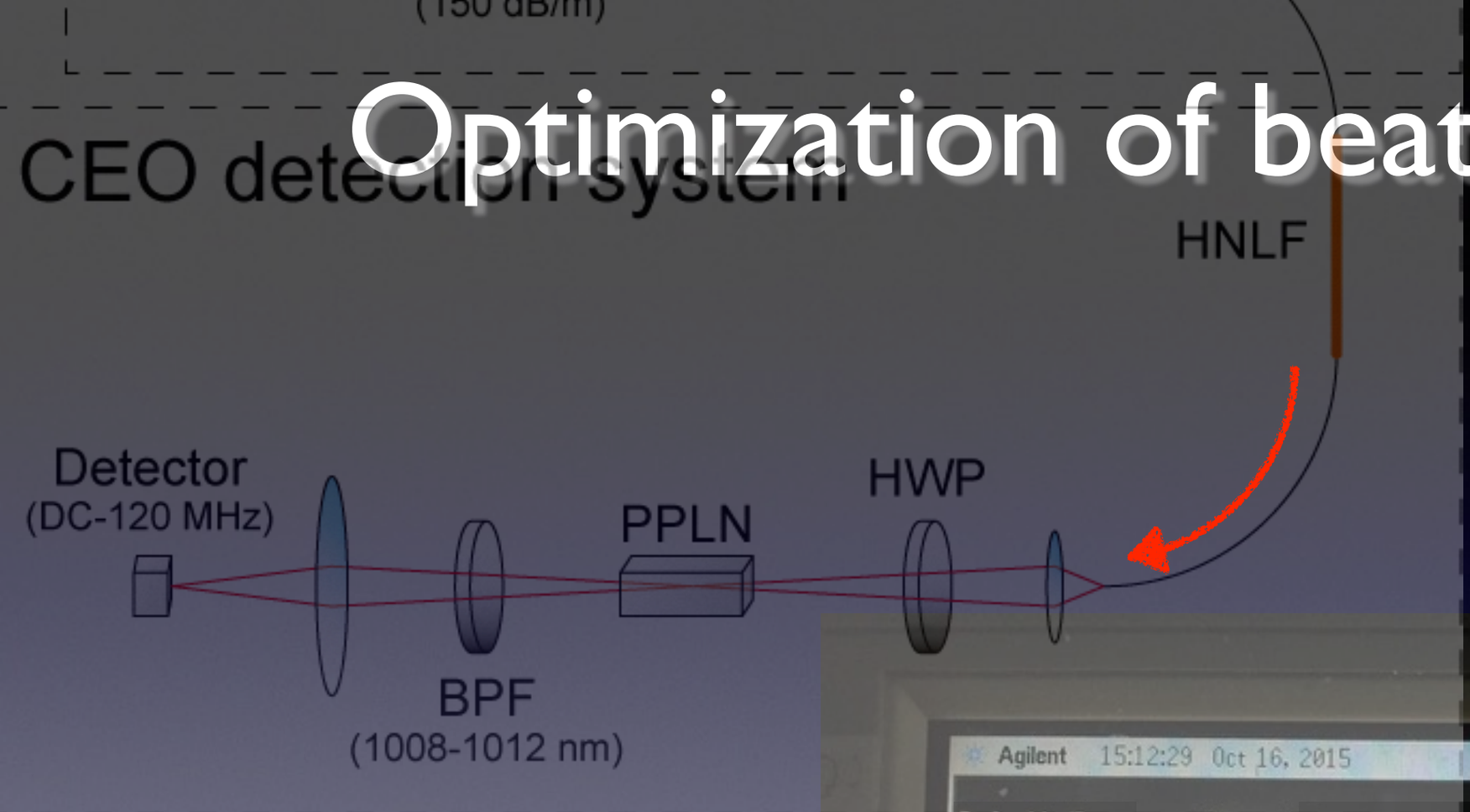
Optimization of beat signal

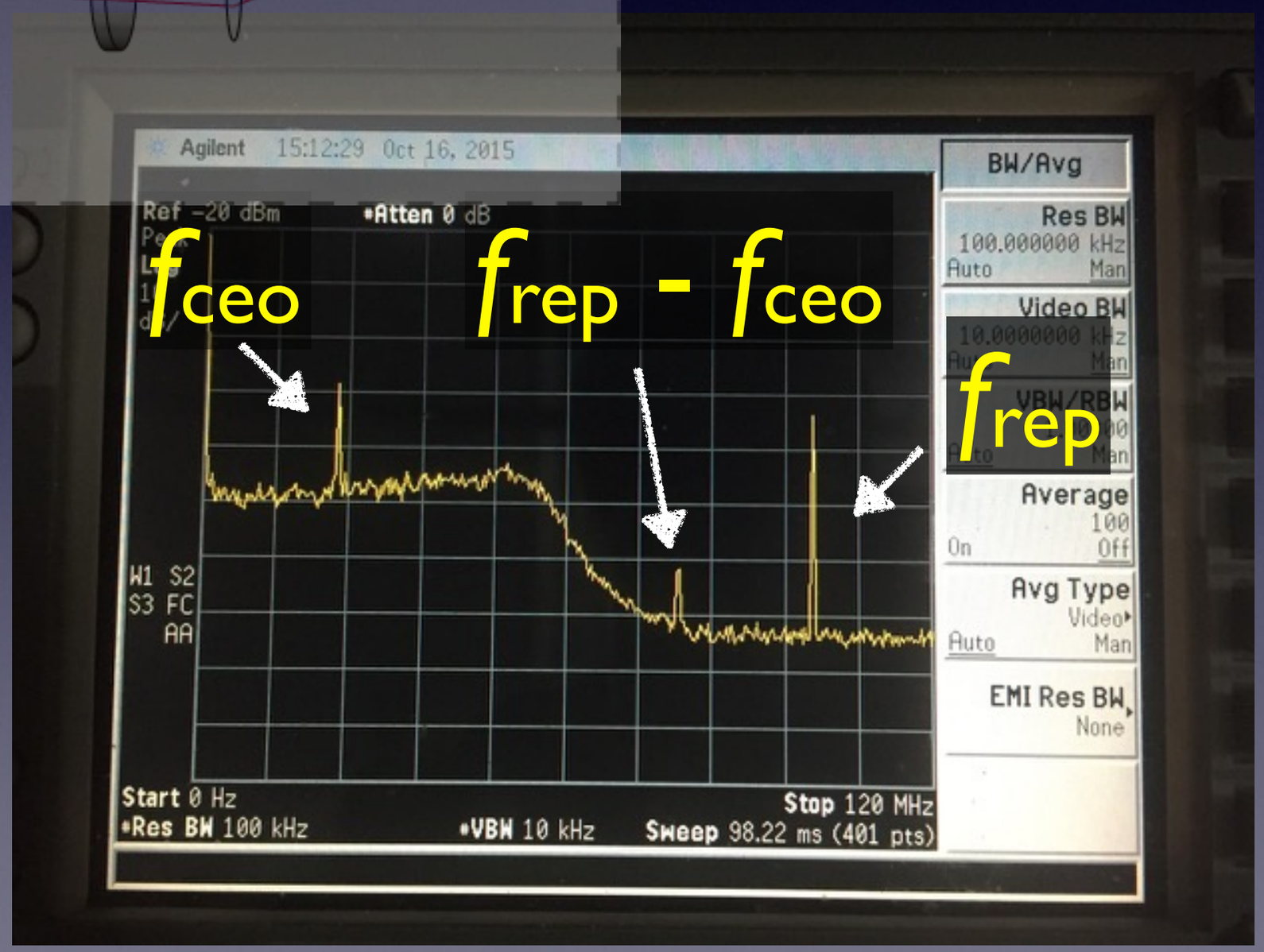
f-2f interferometer



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

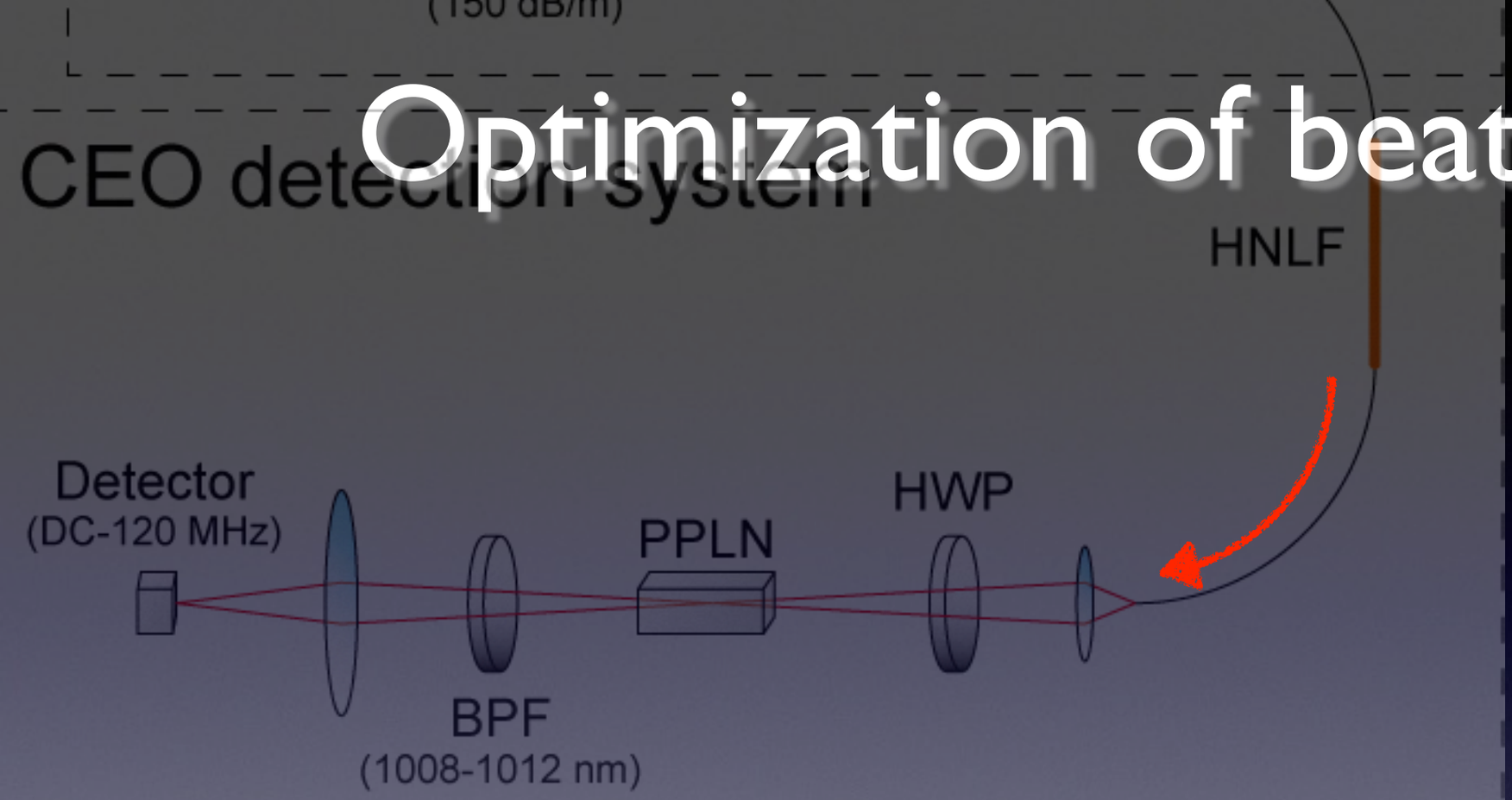
Optimization of beat signal





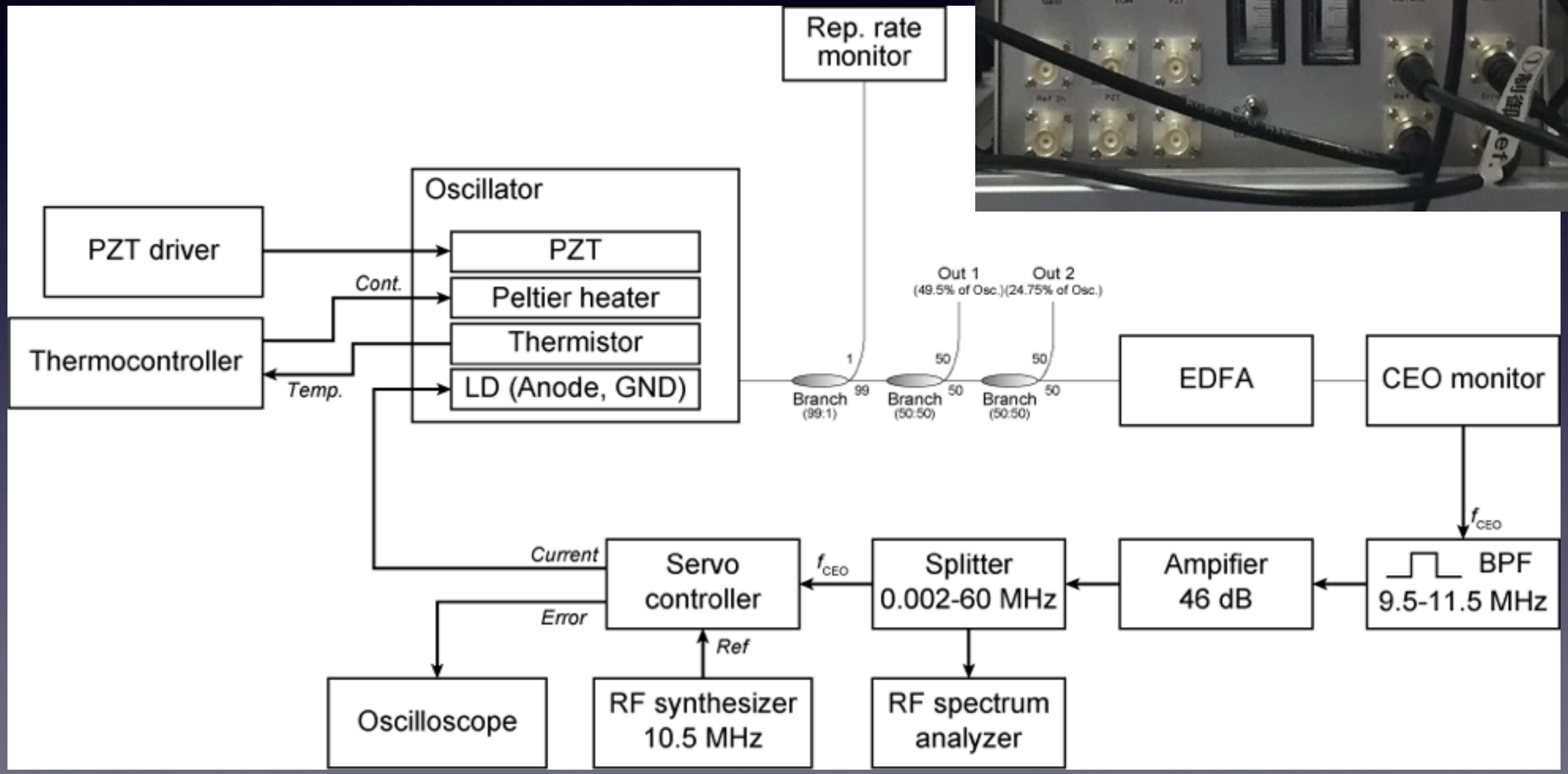
w/ SPF
(DC-48 MHz)

Optimization of beat signal

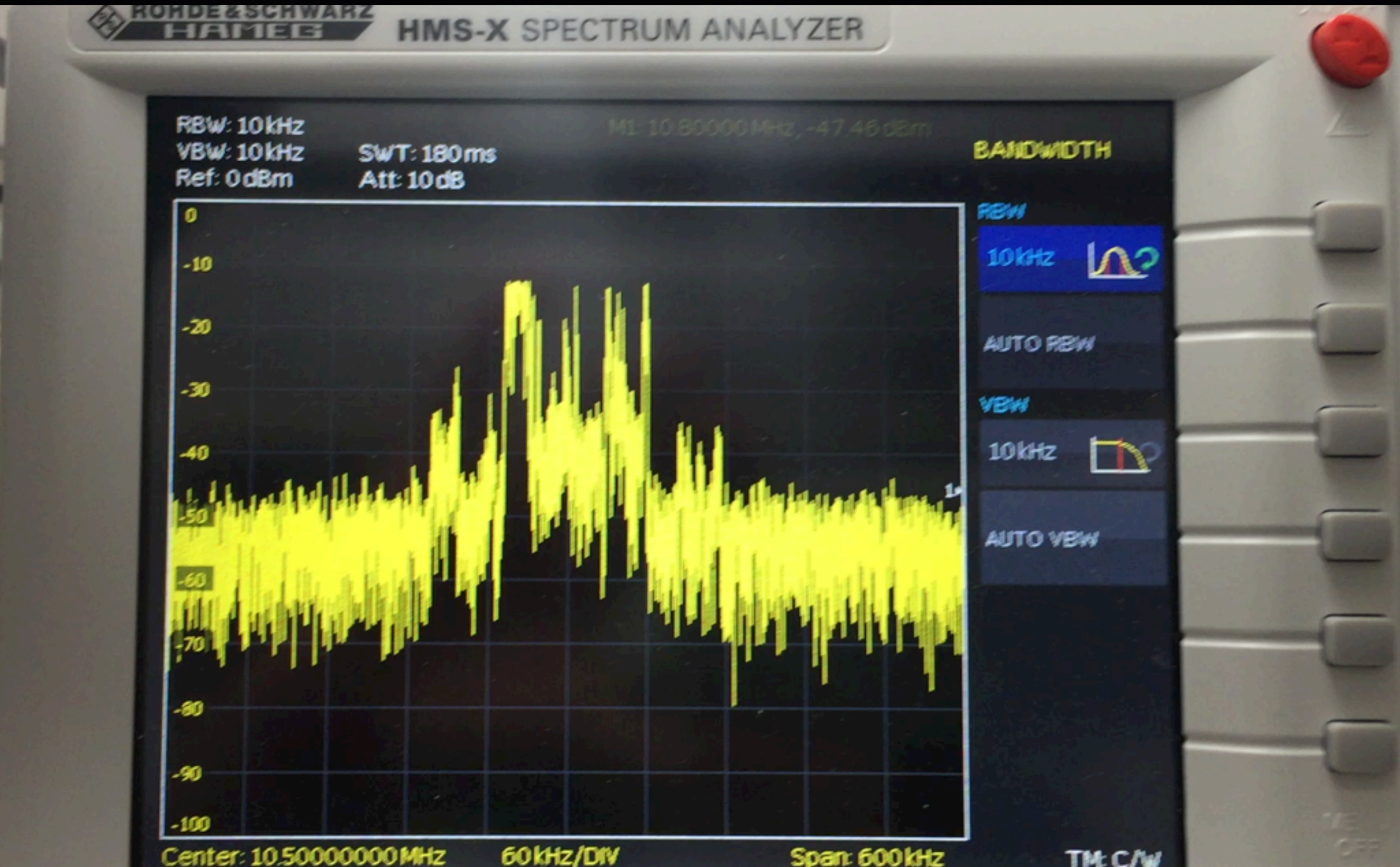


w/ BPF
(9.5-11.5 MHz)

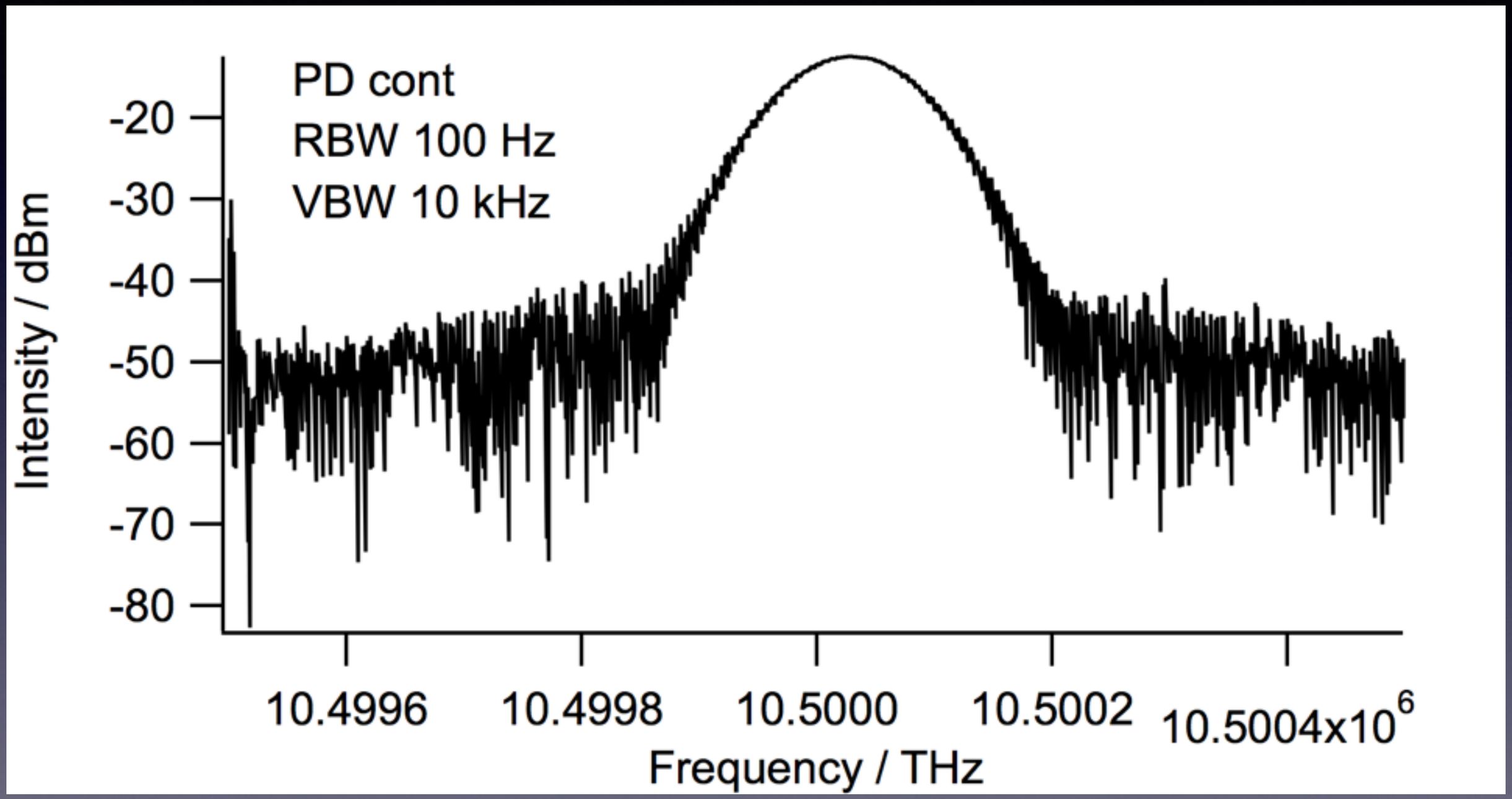
f_{ceo} stabilization



f_{ceo} stabilization

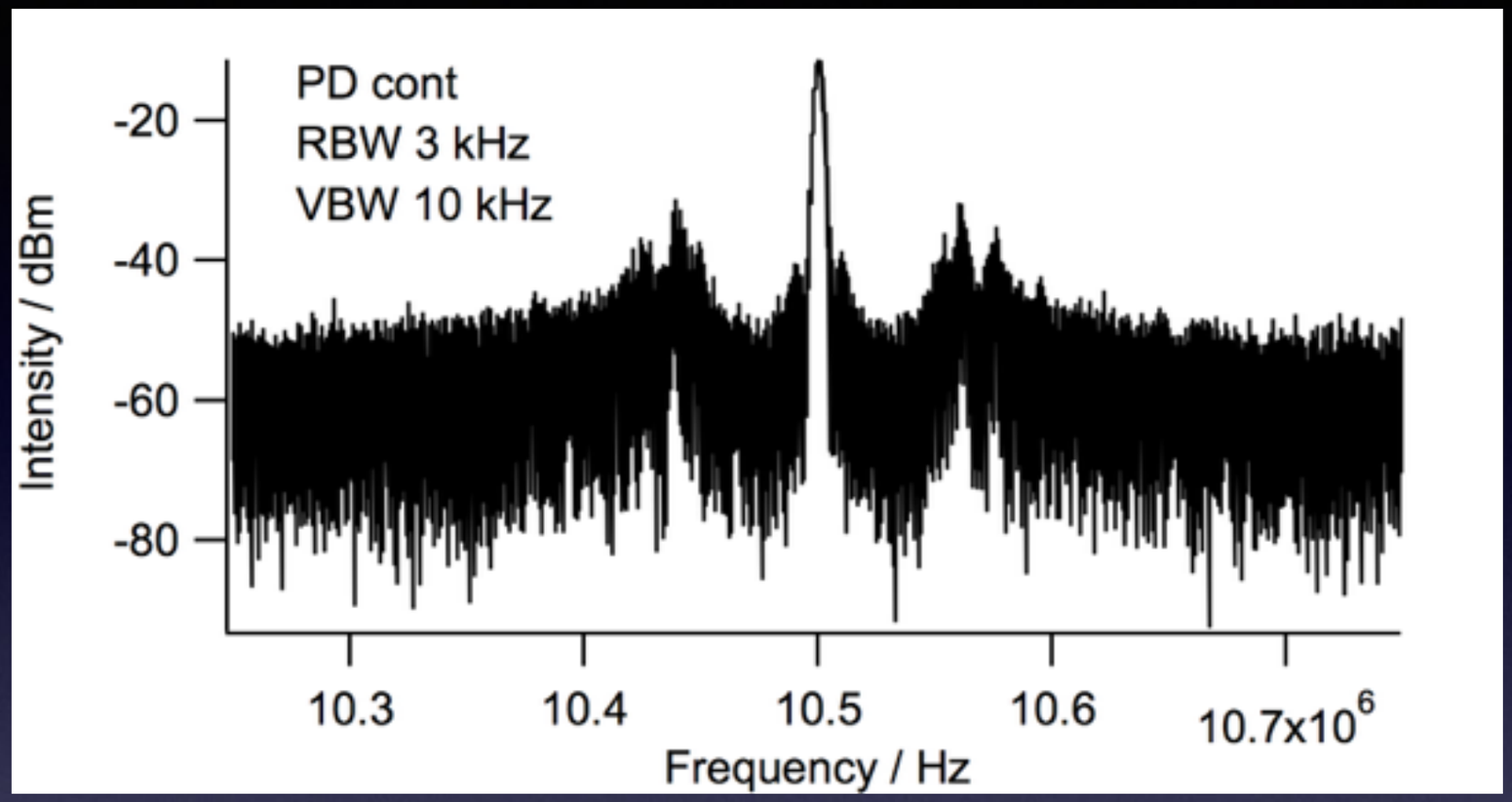


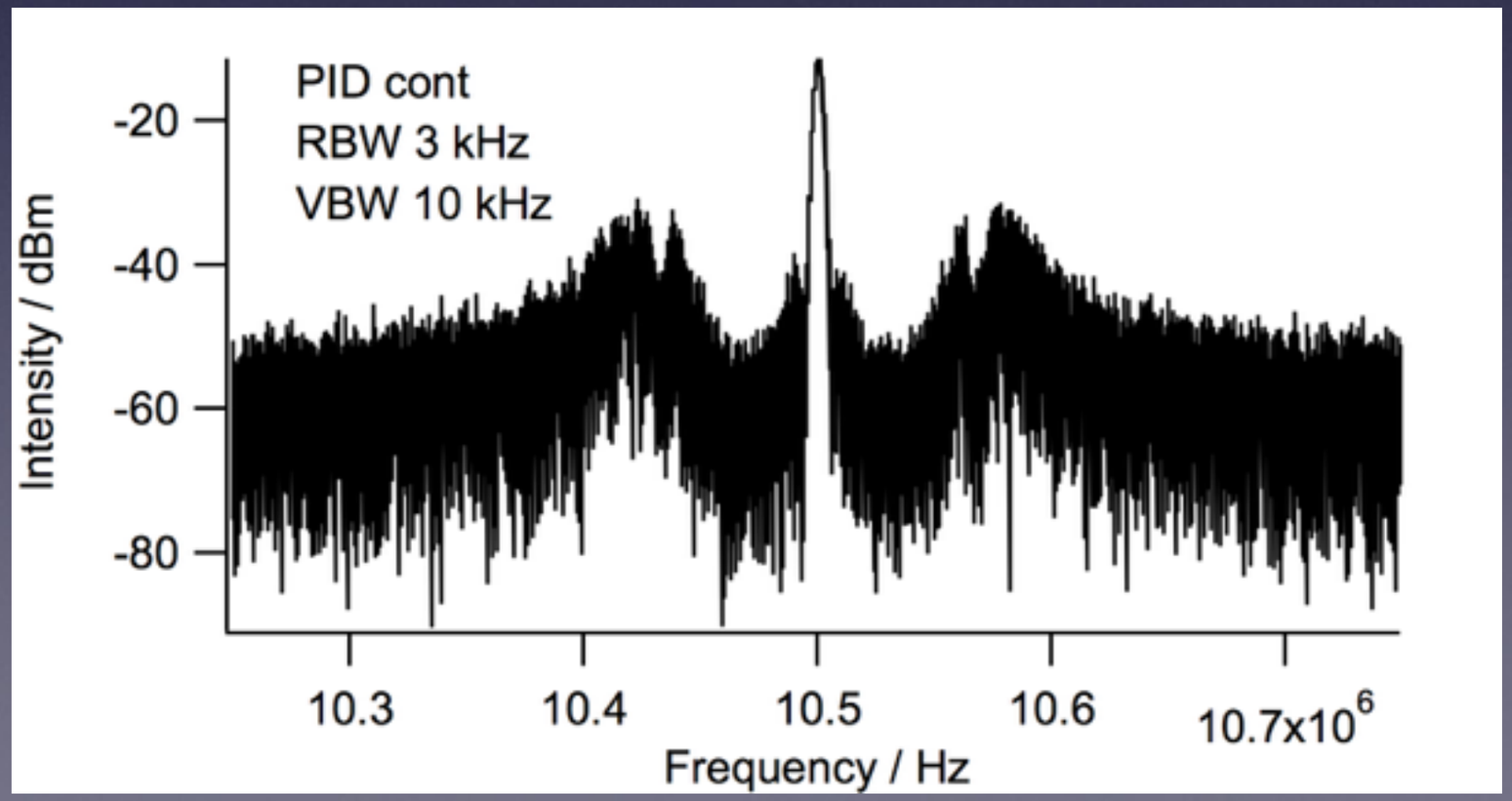
f_{ceo} stabilization



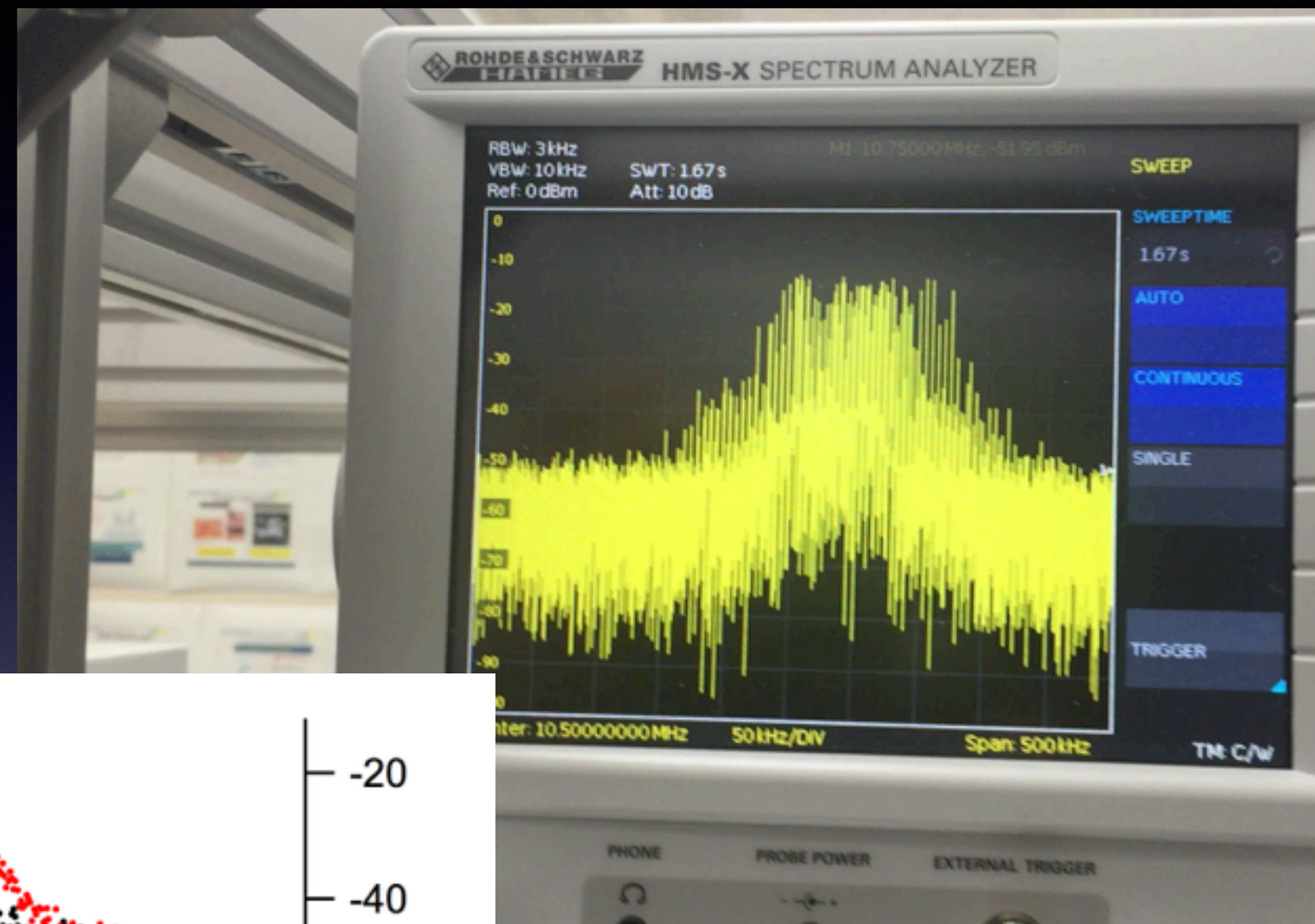
FWHM was less than 100 Hz

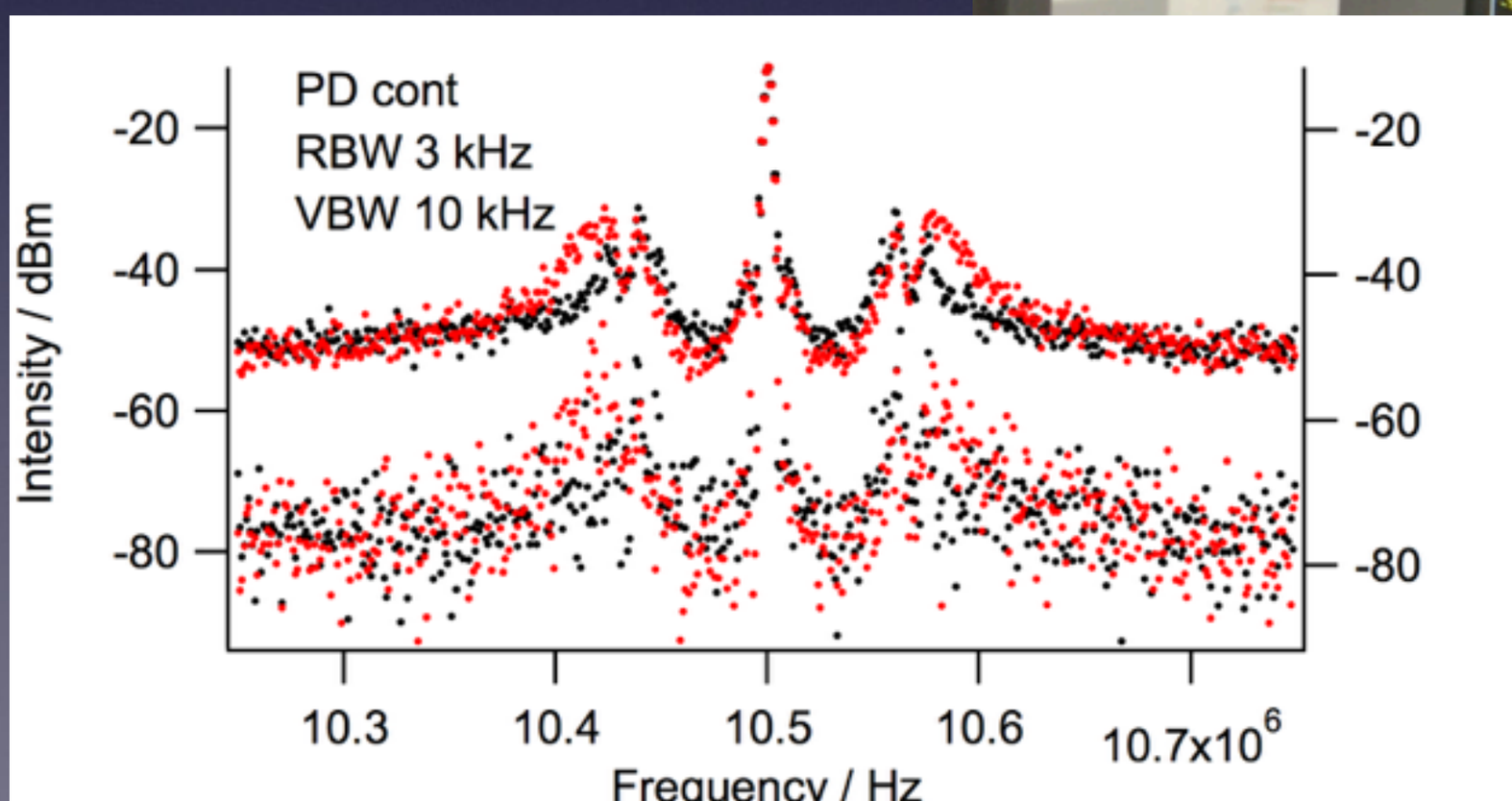
f_{ceo} stabilization





f_{ceo} stabilization





w/o cont

↓

PD cont

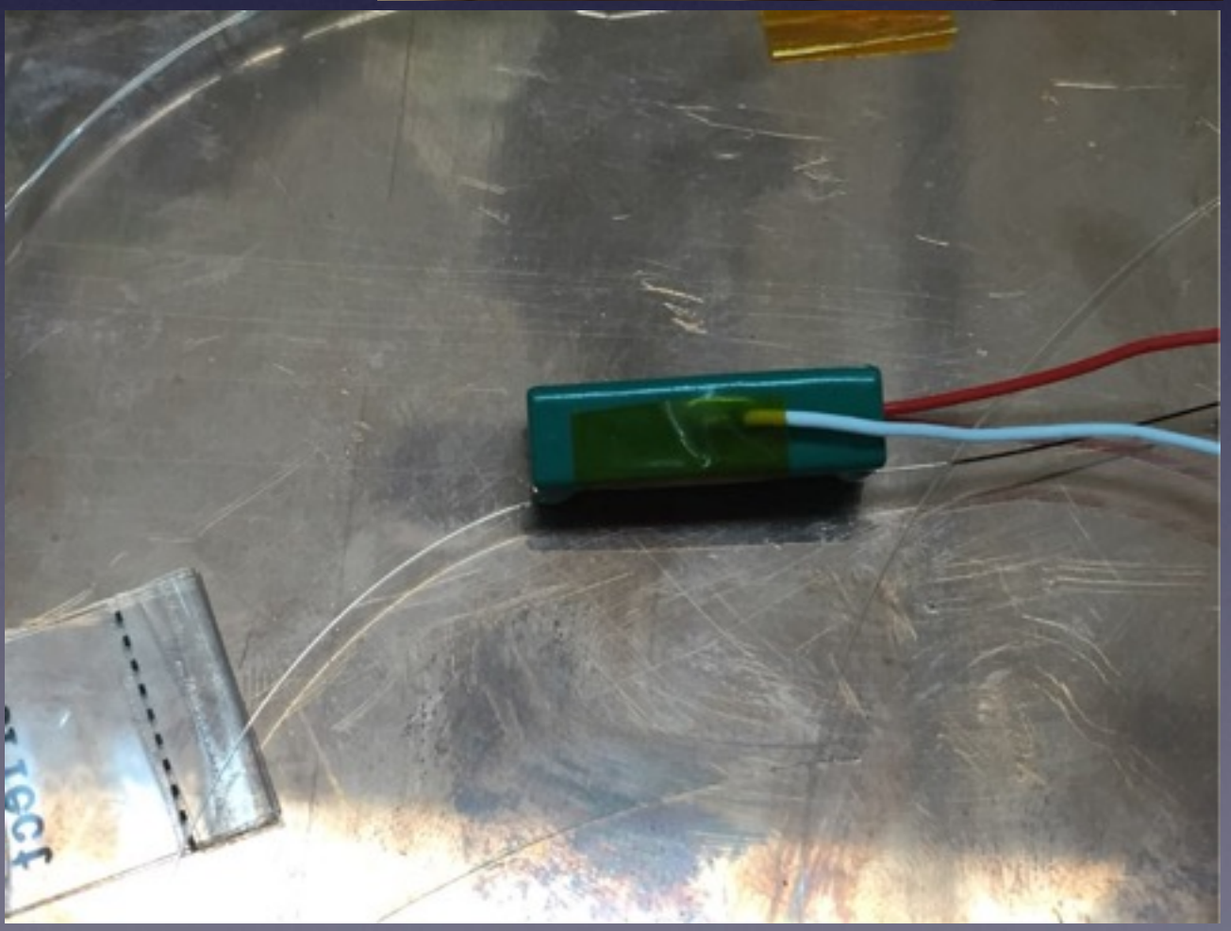
↓

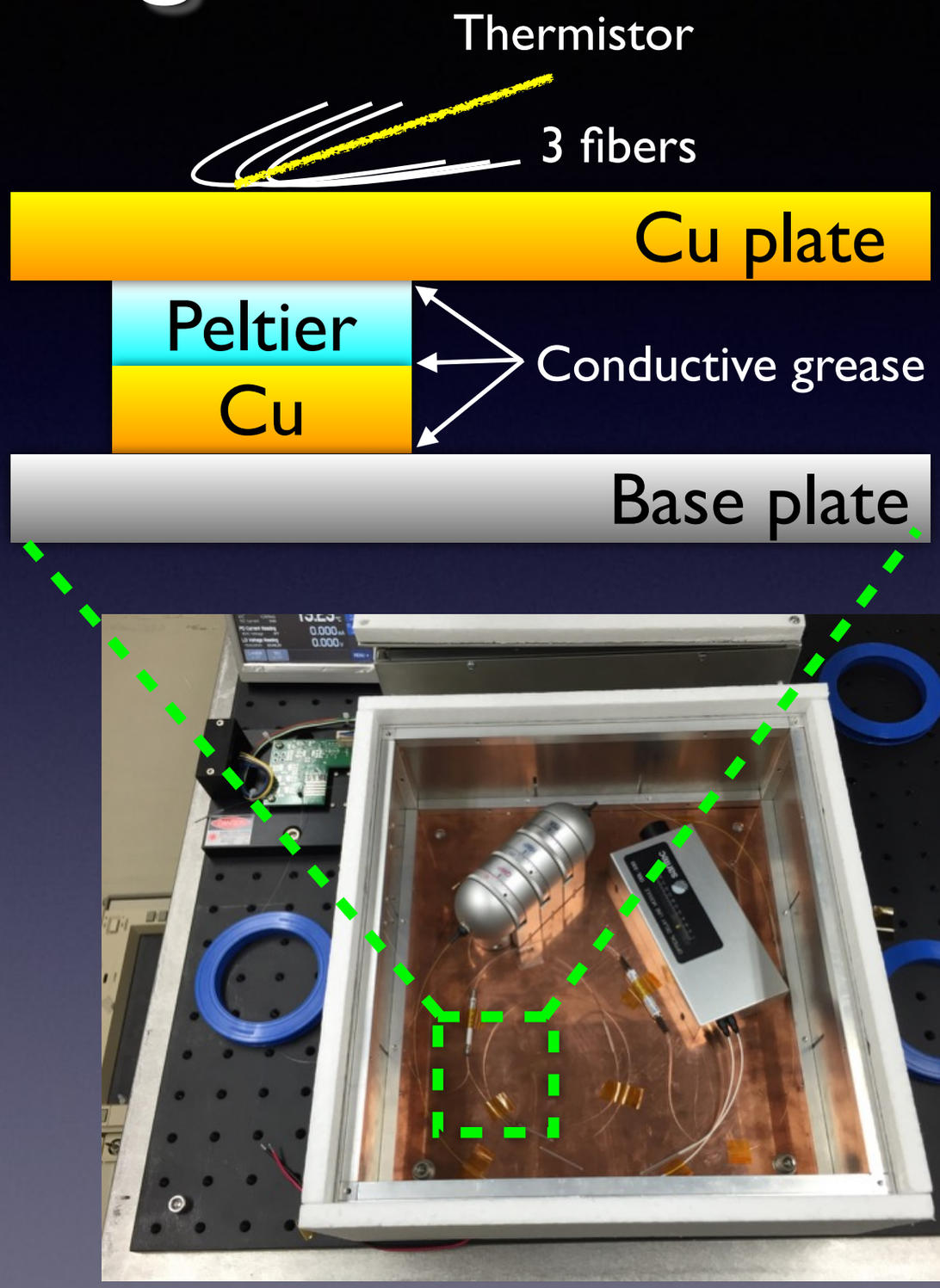
PID cont

Towards f_{rep} stabilization

f_{rep} tuning

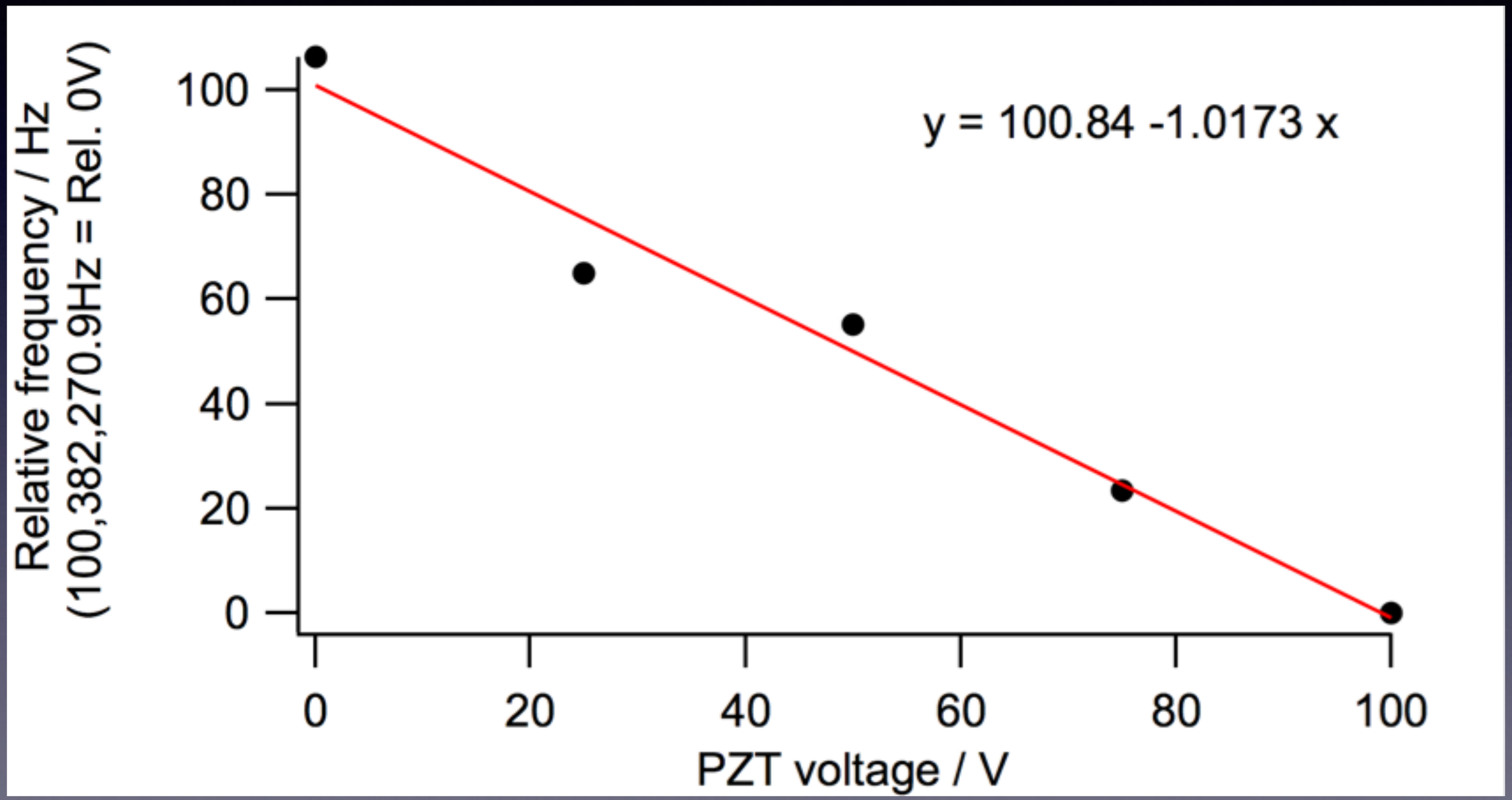
PZT





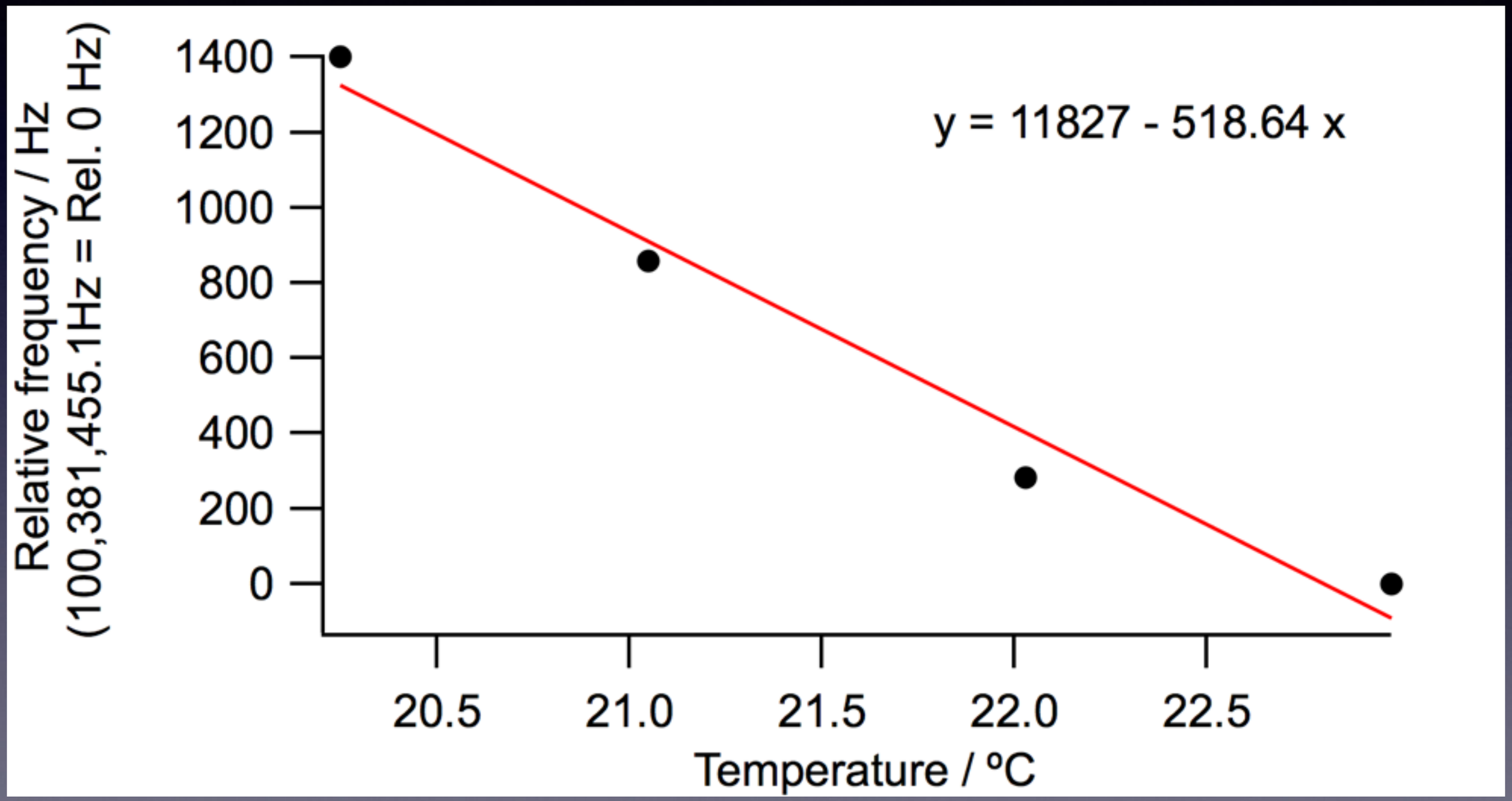
Peltier

f_{rep} tuning - PZT -

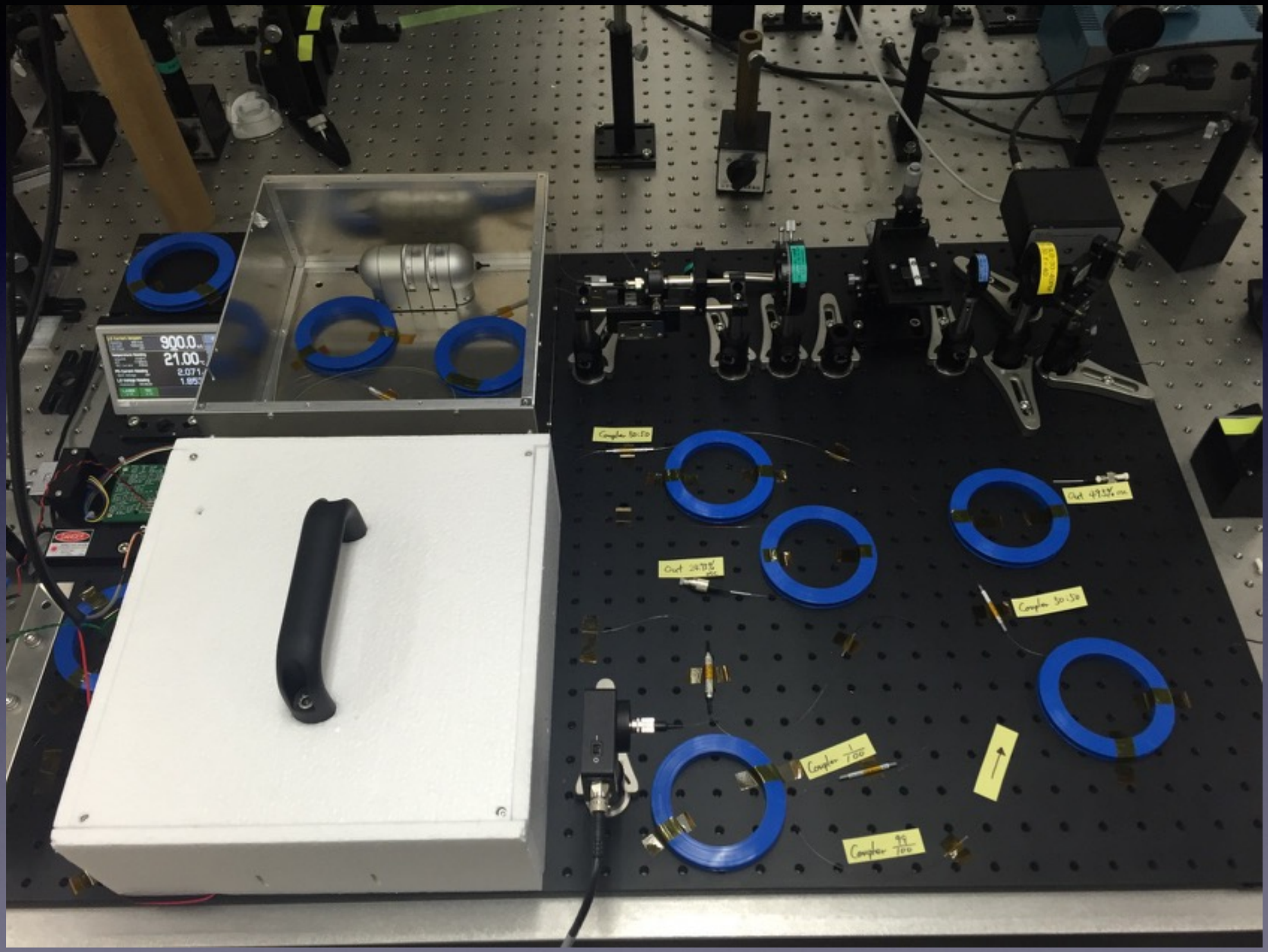


Δf = 100 Hz → ΔL = 2.98 μm (Spec. 11.6 μm@100V)

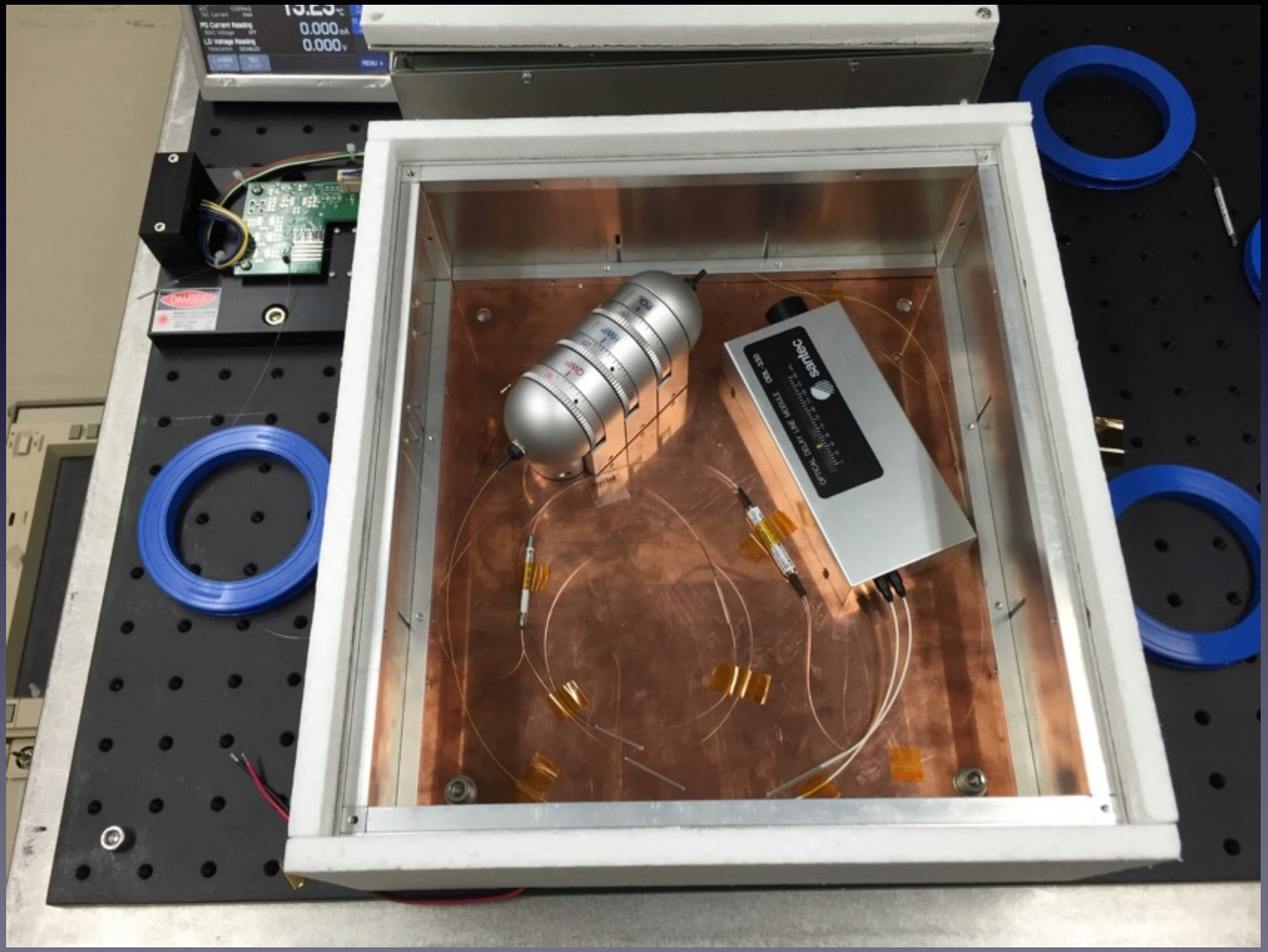
f_{rep} tuning - Peltier -



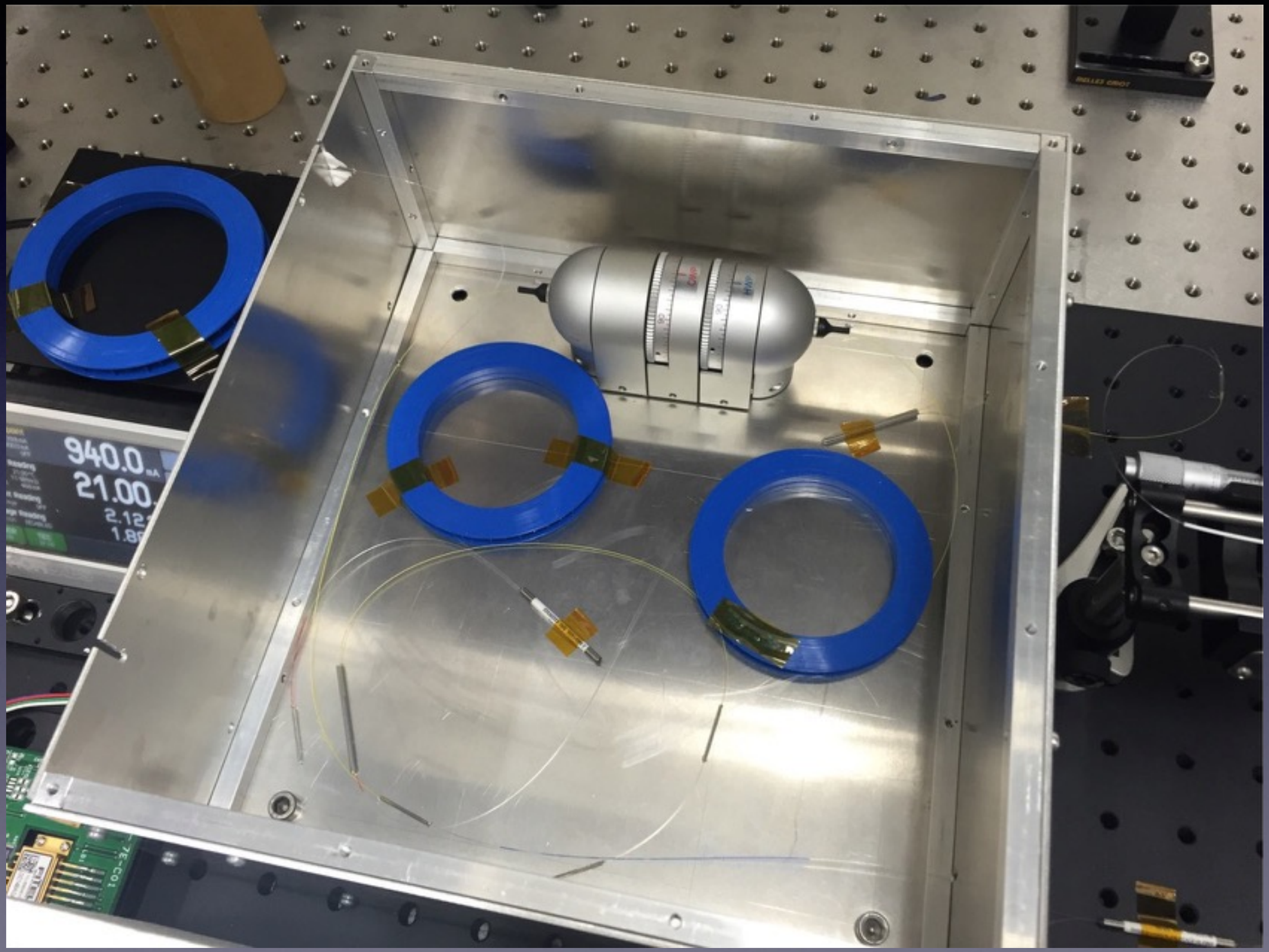
Optical setup



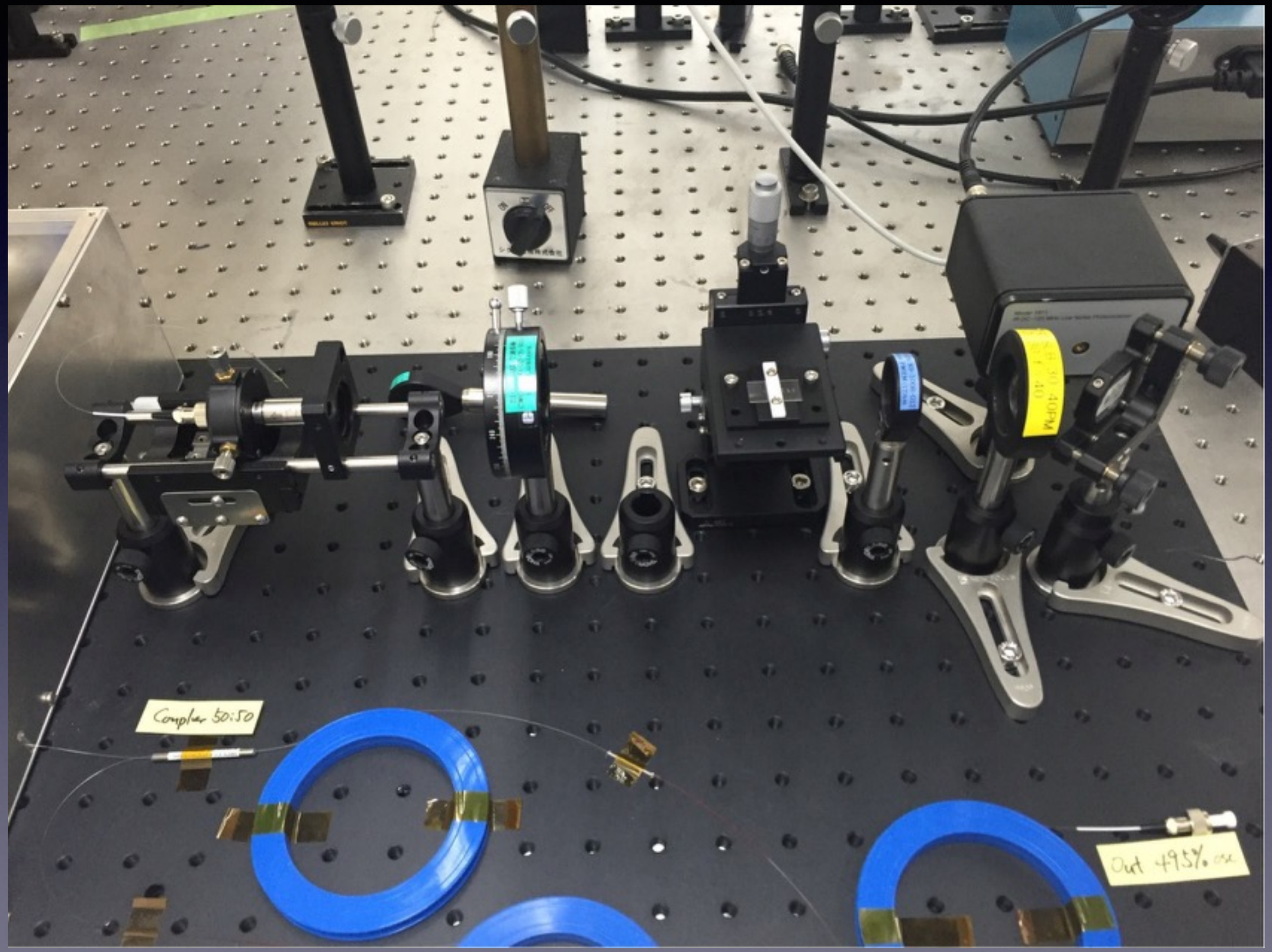
Oscillator



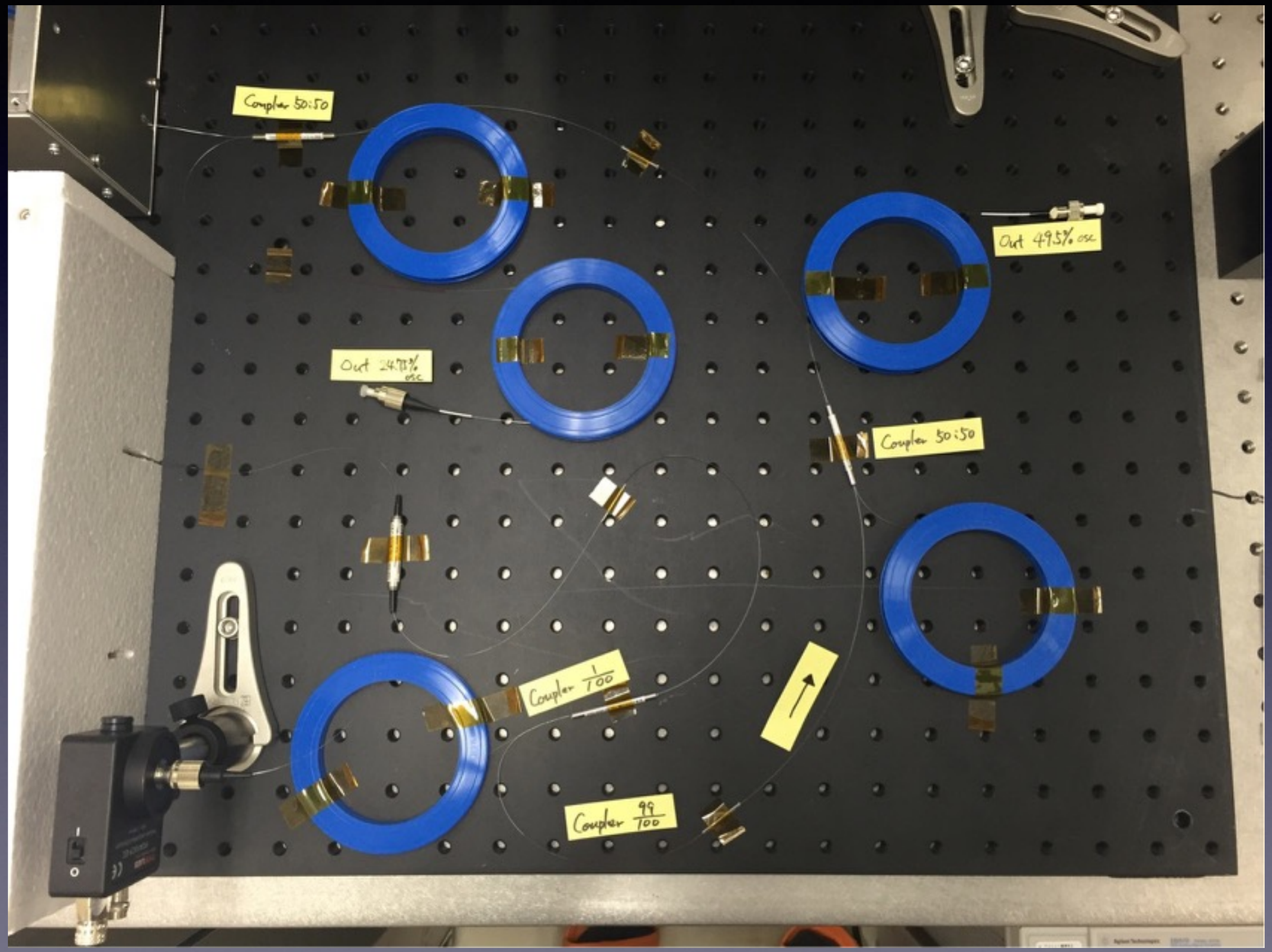
EDFA + HNLF



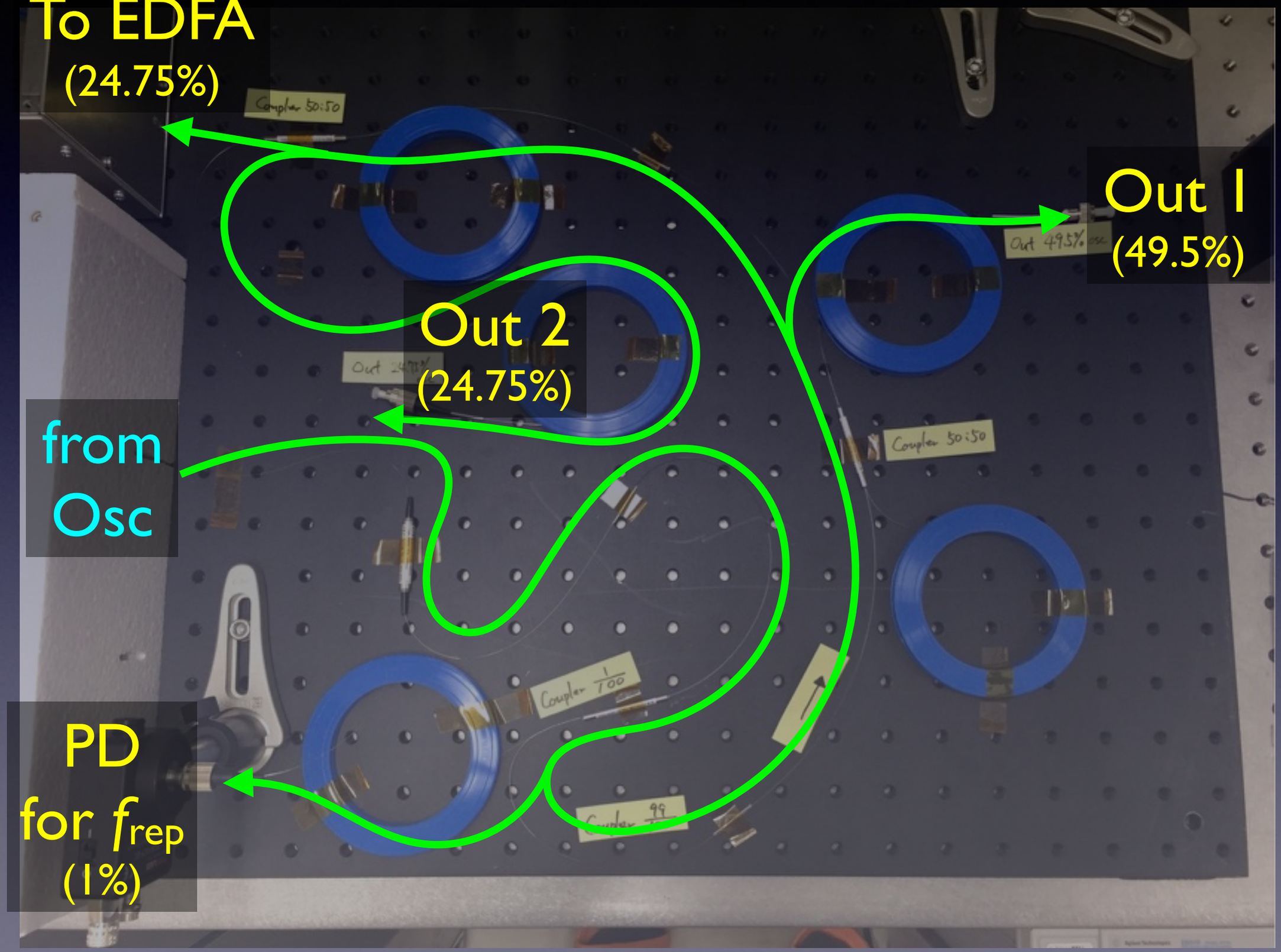
f-2*f* interferometer



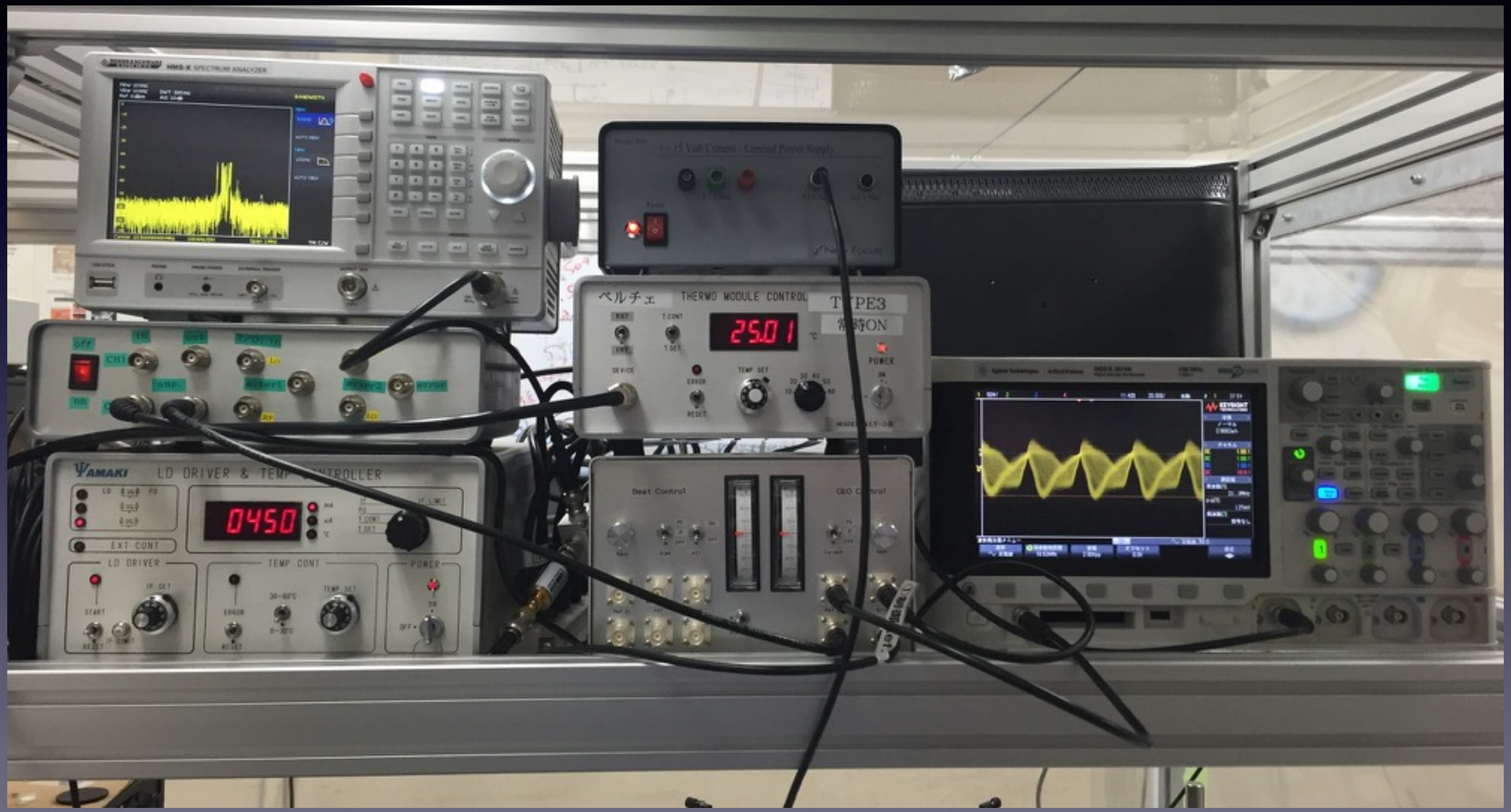
Branches


Coupler 50:50
Out 49.5% osc
Out 24.7% osc
Coupler 50:50
Coupler 1/100
Coupler 99/100

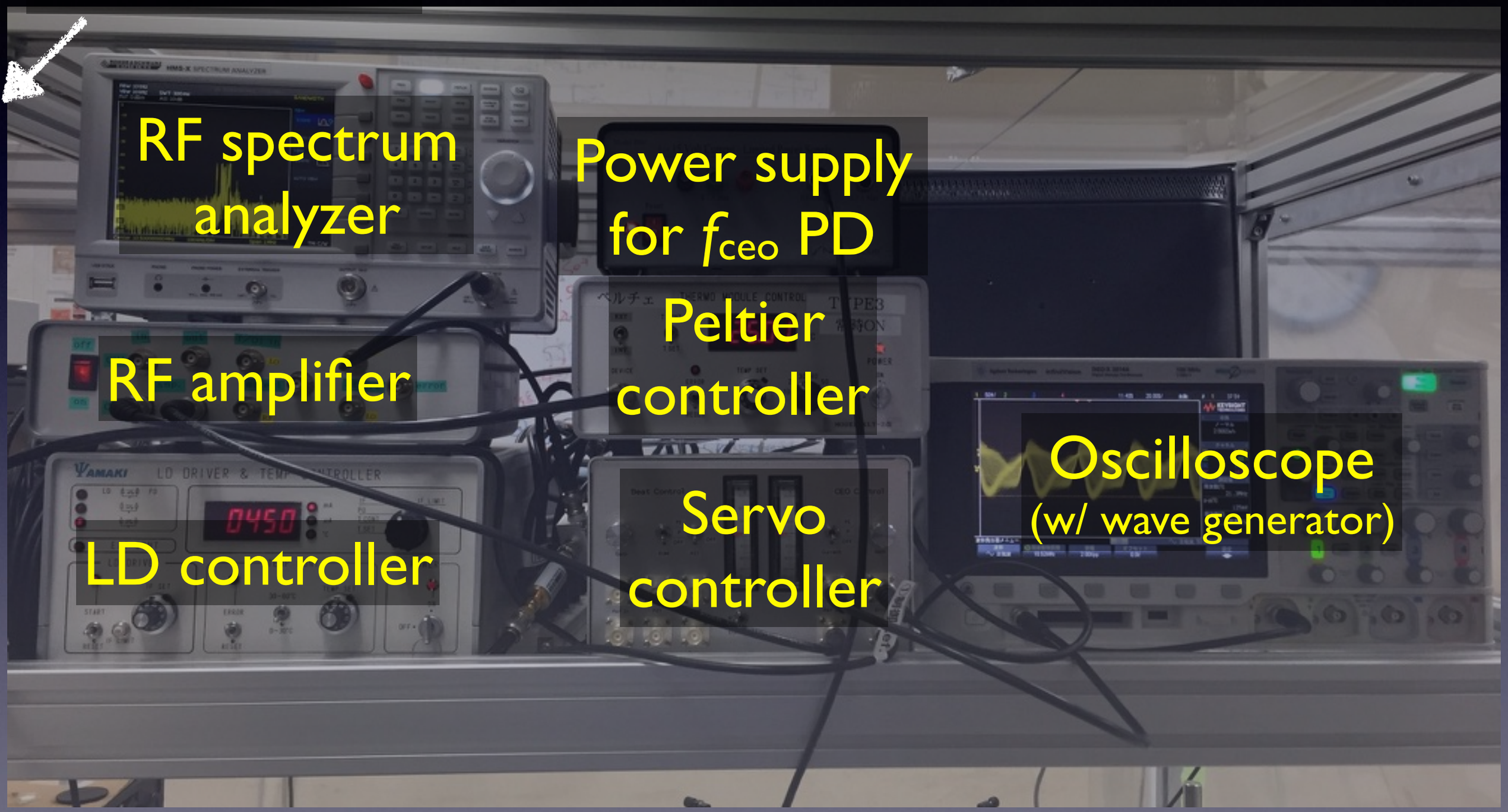
Branches


To EDFA
(24.75%)
Out 1
(49.5%)
Out 2
(24.75%)
from
Osc
PD
for f_{rep}
(1%)
Coupler 50:50
Coupler 50:50
Coupler 1/100
Coupler 99/1

Controllers



Controllers



Specification

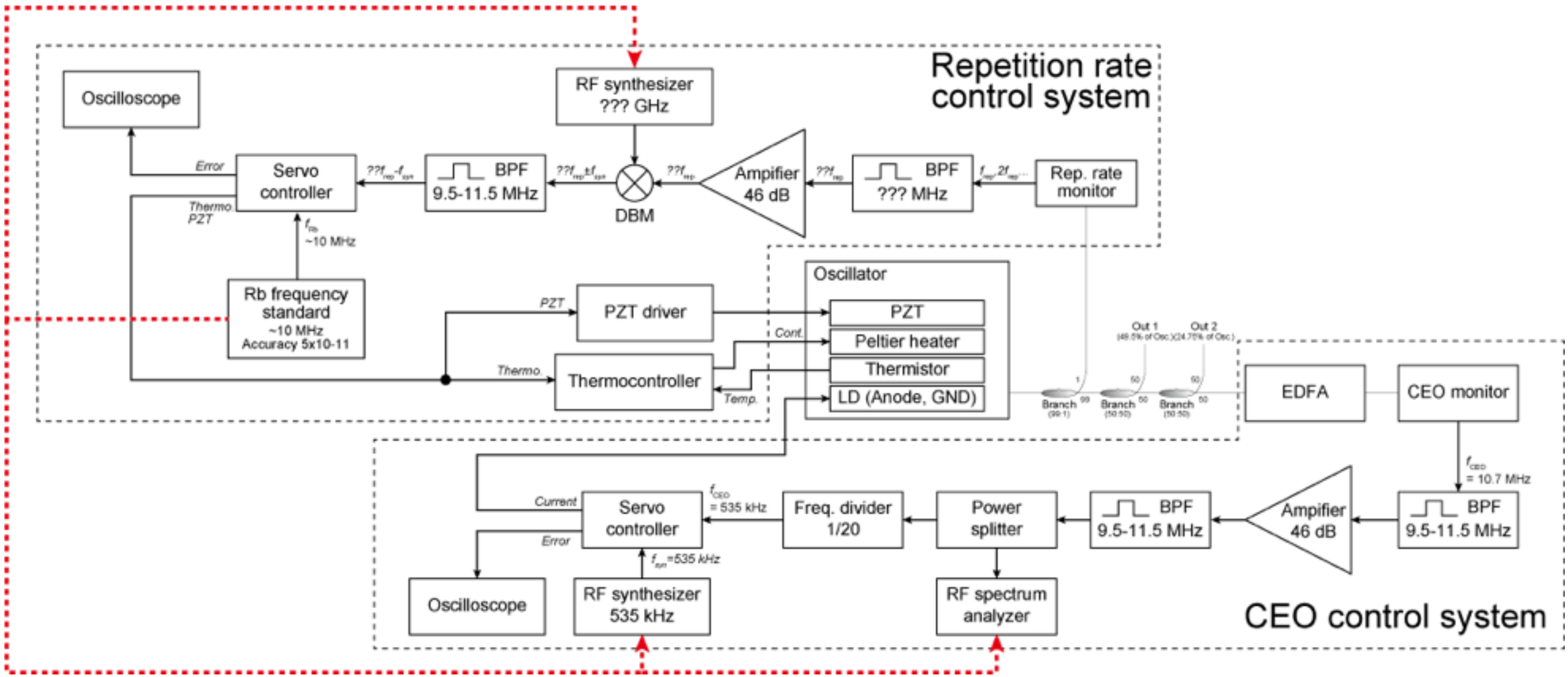
Oscillator

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 ± about 0.5 Hz @ free run
f_{ceo}	BW <100 Hz (~100 kHz @ free run)
Power	9.49 mW (Out1, 4.7 mW; Out2=2.4 mW)
Notes	Delay line (Δf_{rep}~97 MHz@Δ330 ps) PZT (Δf_{rep}~100 Hz@Δ100V) Peltier (Δf_{rep}~1 kHz@Δ2°C)

EDFA

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

Future work


Repetition rate control system
Oscilloscope
RF synthesizer ??? GHz
Error
Servo controller
BPF 9.5-11.5 MHz
DBM
Ampifier 46 dB
BPF ??? MHz
Rep. rate monitor
Thermo. PZT
~10 MHz
Rb frequency standard
~10 MHz
Accuracy 5x10-11
PZT
PZT driver
Oscillator
PZT
Peltier heater
Thermistor
LD (Anode, GND)
Cont.
Thermo.
Thermocontroller
Temp.
Out 1
Out 2
Branch
EDFA
CEO monitor
= 10.7 MHz
BPF 9.5-11.5 MHz
Ampifier 46 dB
BPF 9.5-11.5 MHz
Power splitter
Freq. divider 1/20
= 535 kHz
Current
Servo controller
Error
=535 kHz
Oscilloscope
RF synthesizer 535 kHz
RF spectrum analyzer
CEO control system