Calibration of laser for thermal shock measurement

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Motivation

- Unknown particles are expected to have a major impact on cosmology. ex)Q-ball
- Can be found with high probability by using a large detector
  → Would like to search with IceCube experiments
- Light emission in ice has not been sufficiently investigated, so we will study thermal shock in ice in the laboratory.

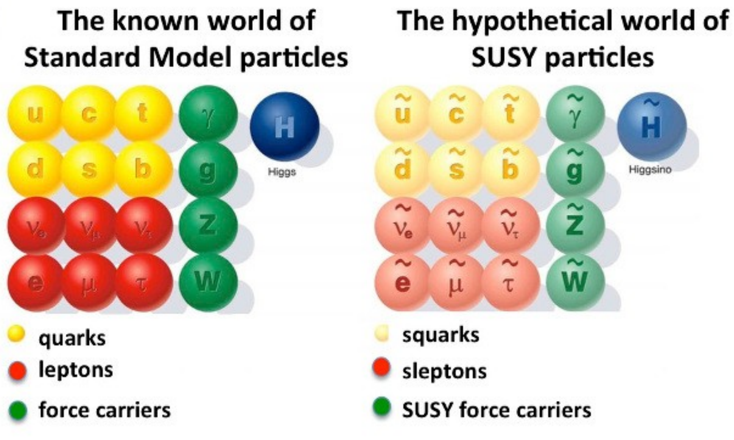
Qball

- Supersymmetric particles that are supposed to fill in the theoretical gaps in the Standard Model.

- The Q-ball is composed of such supersymmetric particles.

- But we haven't found a Q-ball, or even a supersymmetric particle.

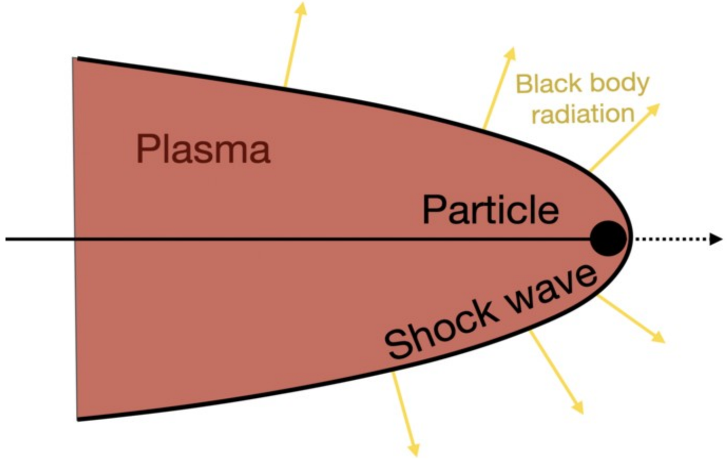
→We want to confirm the existence of supersymmetric particles by finding Q-balls.



Thermal shock

- When the Q-ball hits a material, a plasma is generated and a thermal shock develops

- I want to observe light from this plasma with a large detector like the IceCube experiment.



→we know it is black body radiation (like the Sun).
But we don't know how much light, because the plasma might be opaque.

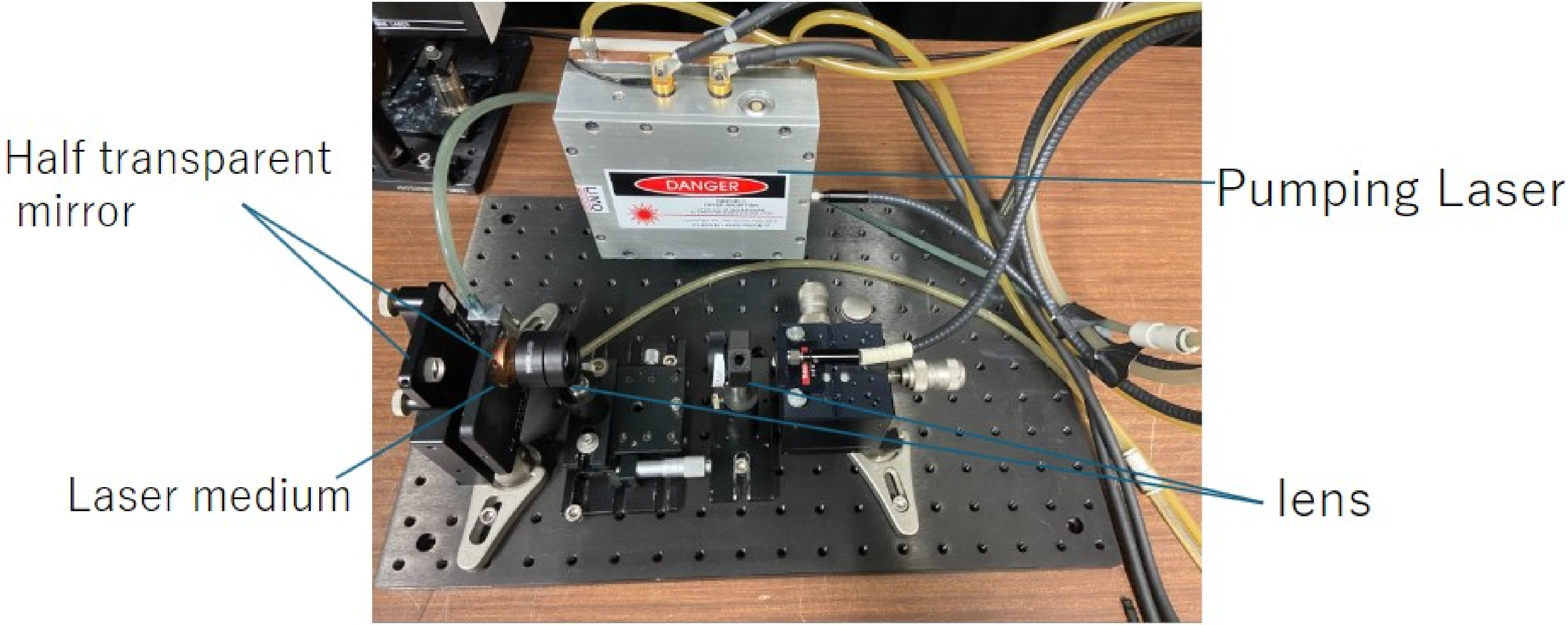
→I want to generate plasma on a laboratory scale by irradiating ice with a strong laser and measure the light of the plasma in the ice.

Goal

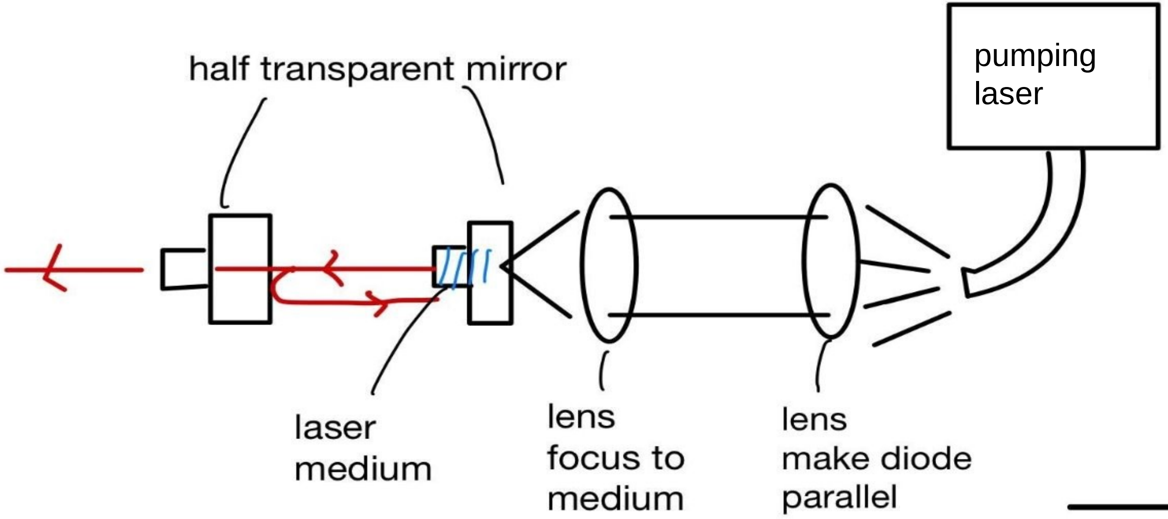
I would like to calibrate laser for these purpose.

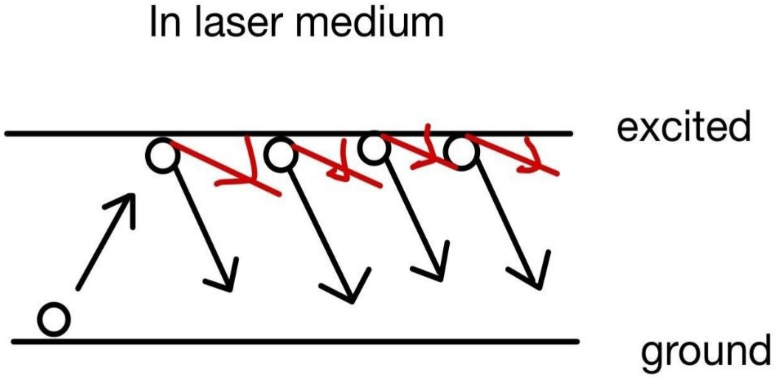
Especially we need to predict the power of the laser over long time, because we cannot measure the laser power during irradiation of the ice

Laser setup

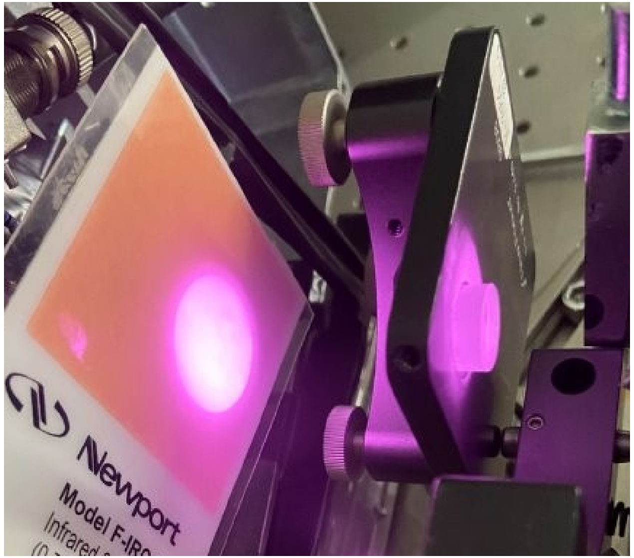

Half transparent mirror
Pumping Laser
DANGER
Laser medium
lens

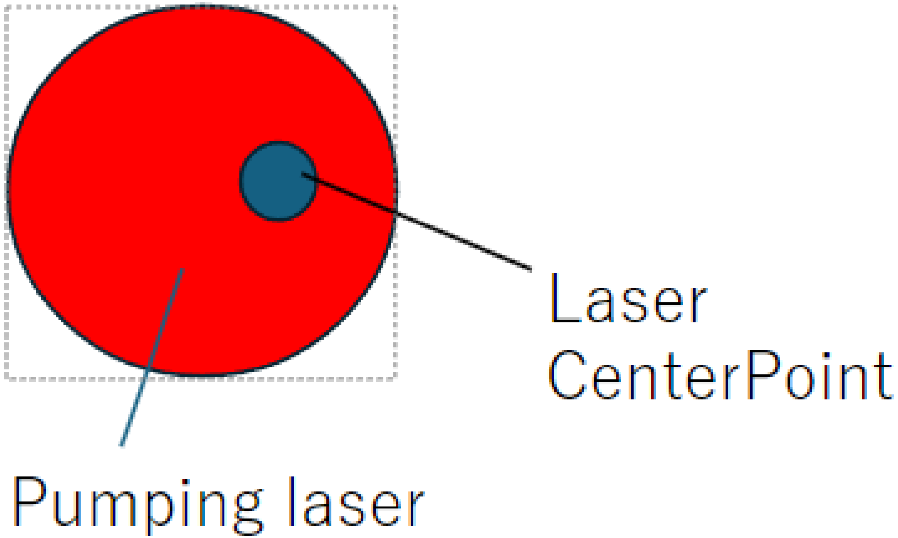
Laser Mechanism





How the laser actually looks





measurement setup

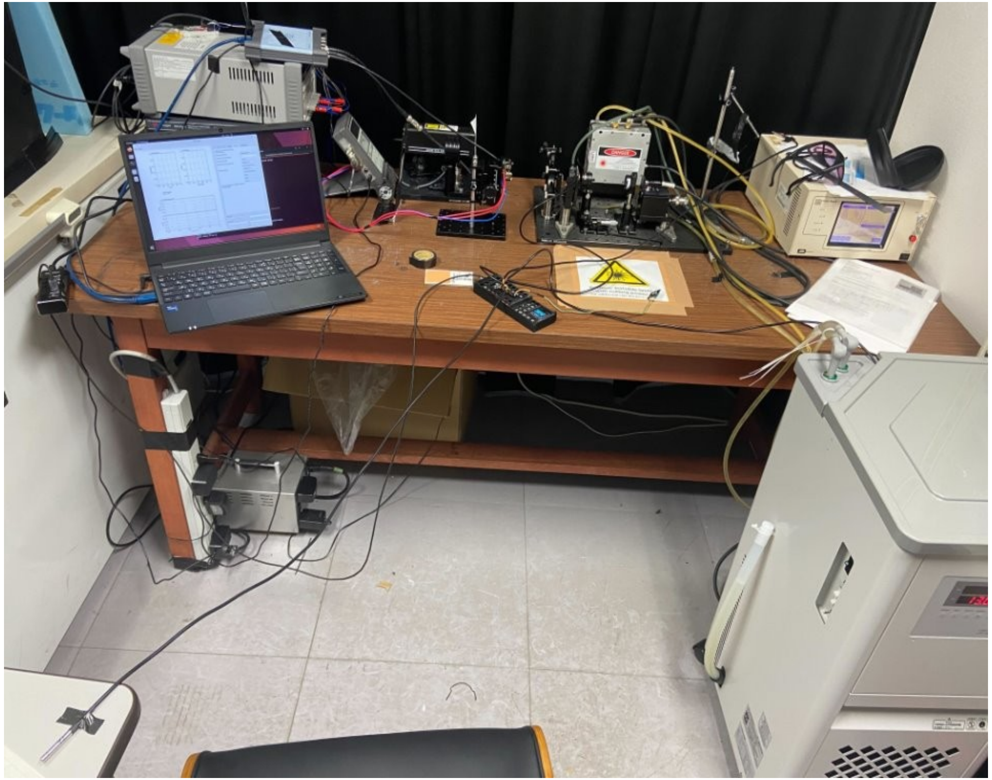
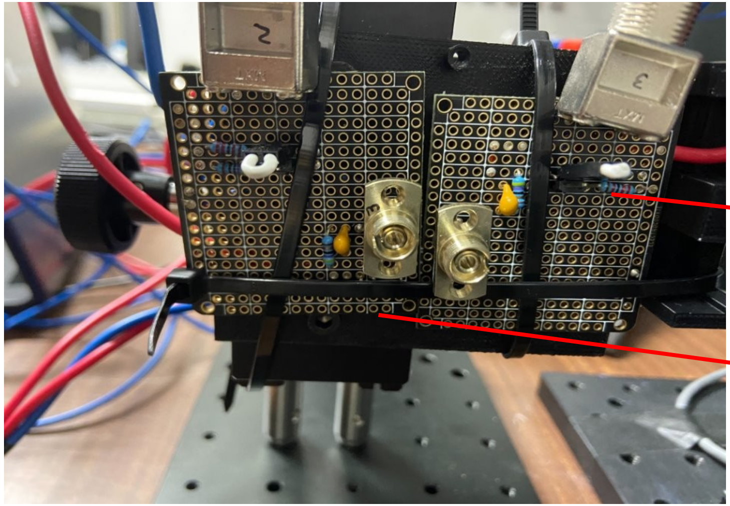


Photo diode



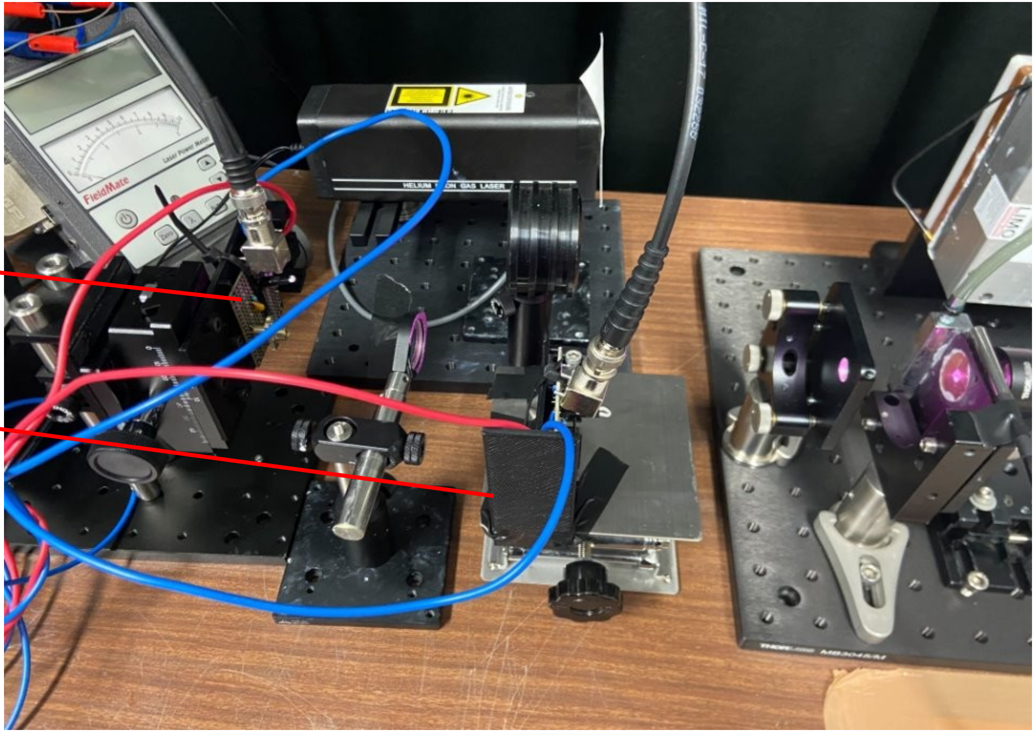
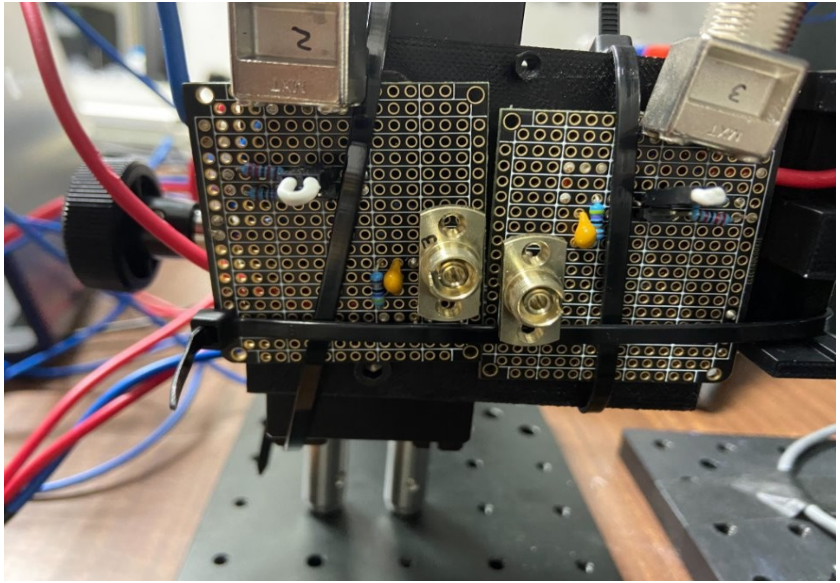


Photo diode

- FCI-InGaAs-120
- Active area diameter 120μm
- Responsive 1100 -1620 nm

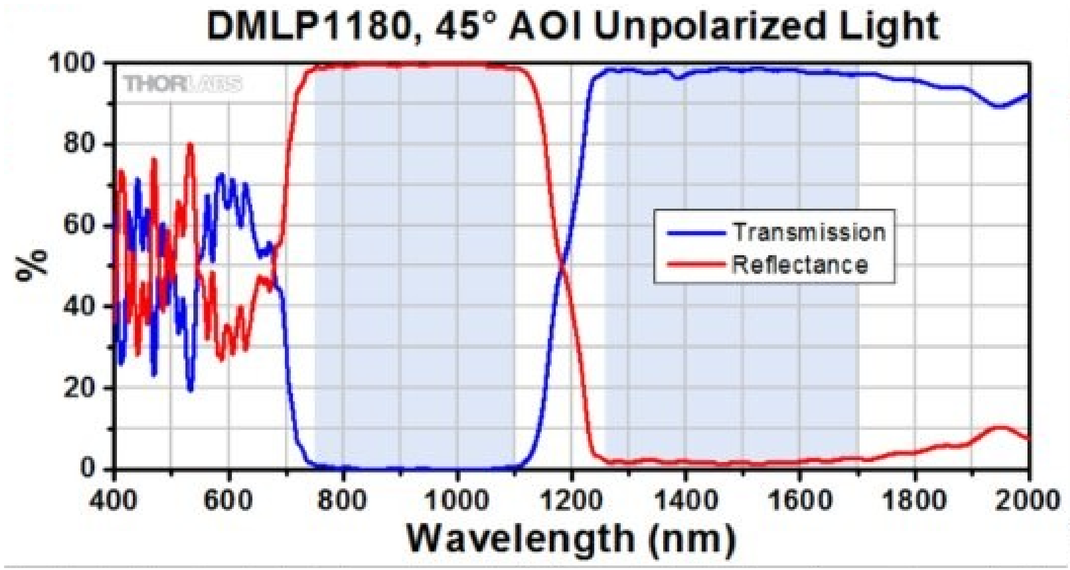


filter lens

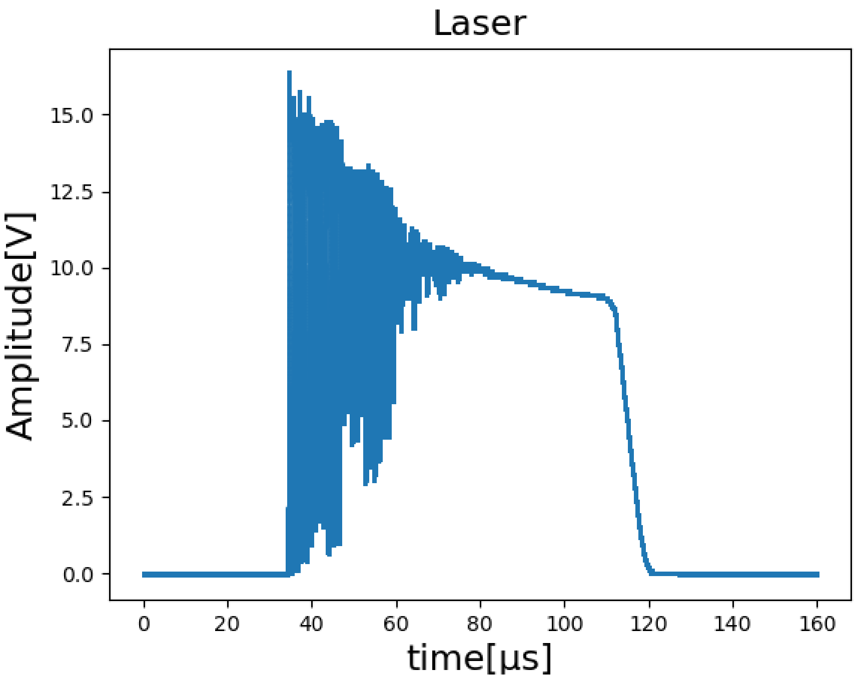
DMLP1180

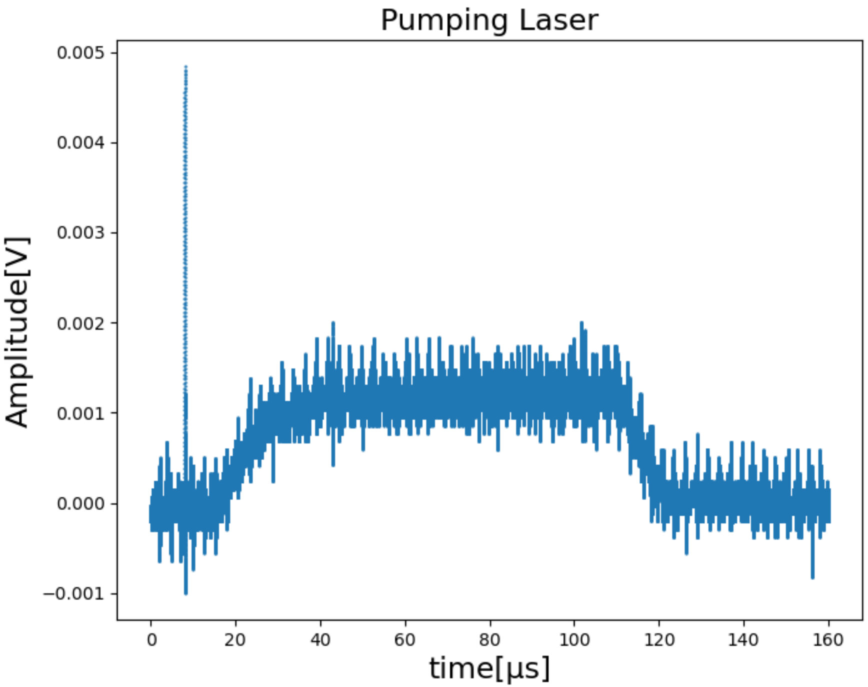
- laser(1350 nm) 99.5% transmit

- Pumping laser(840 nm)99.5% reflect

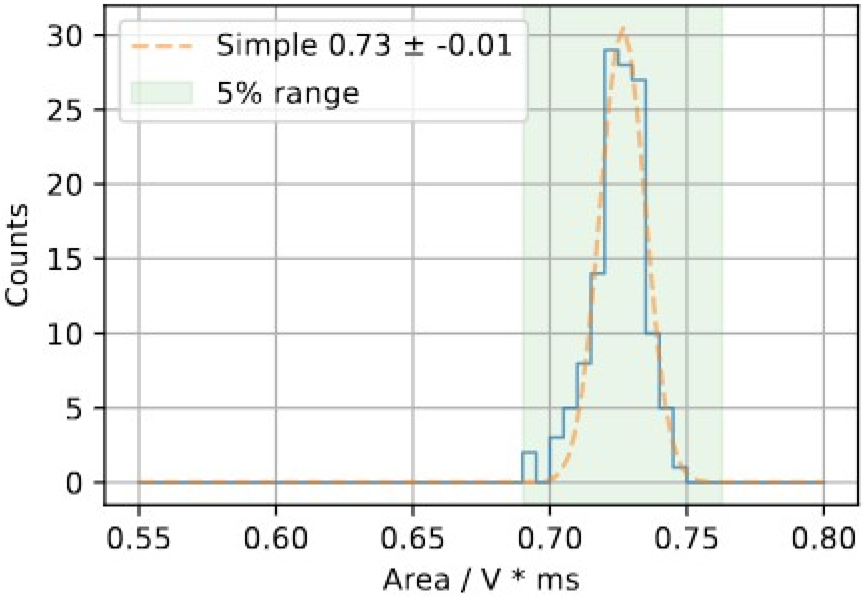


Waveform with photodiode

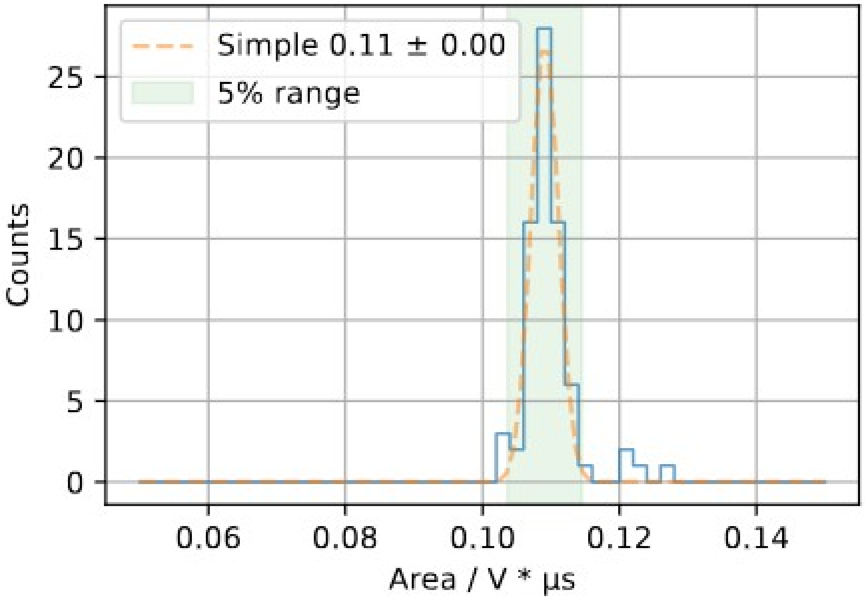




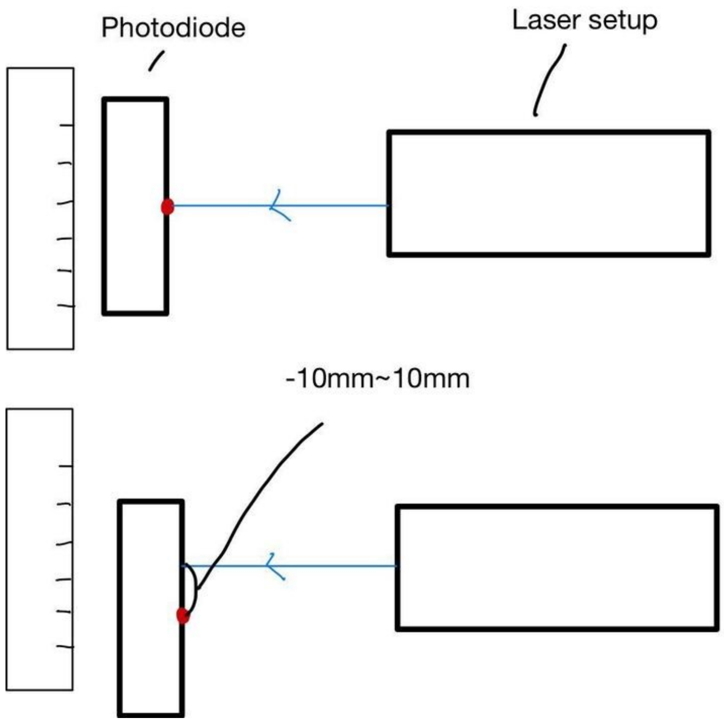
Laser

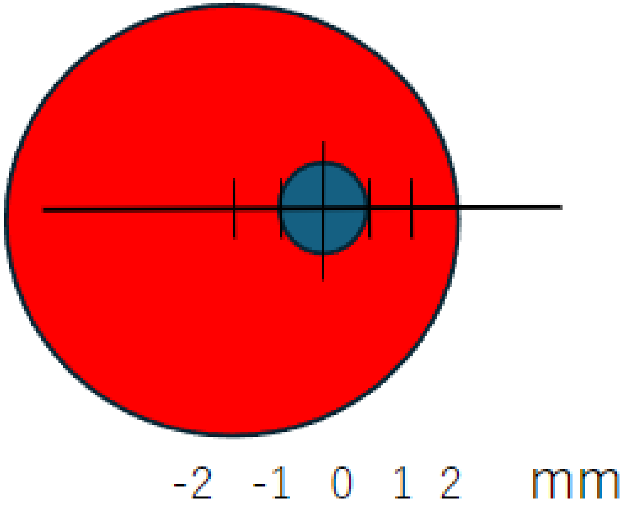


Pumping laser

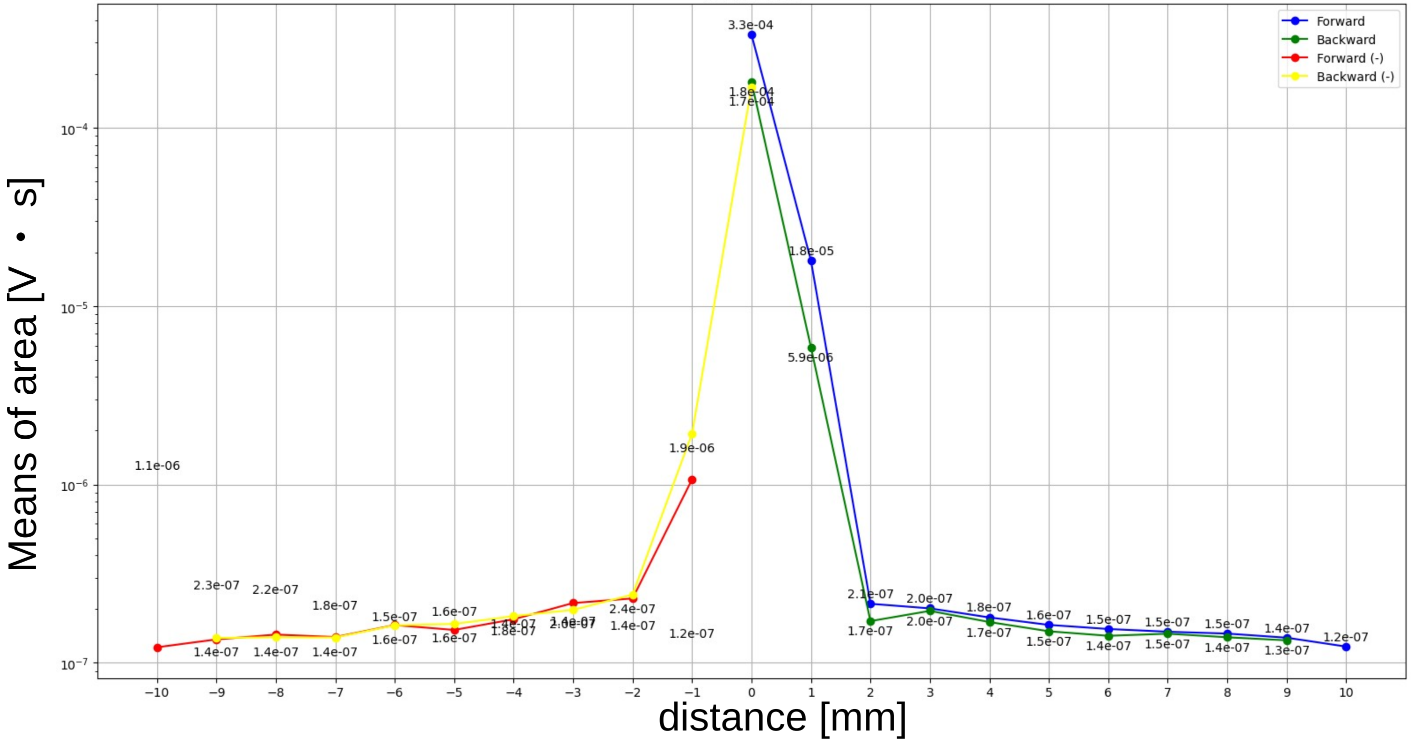


Laser profile measearment

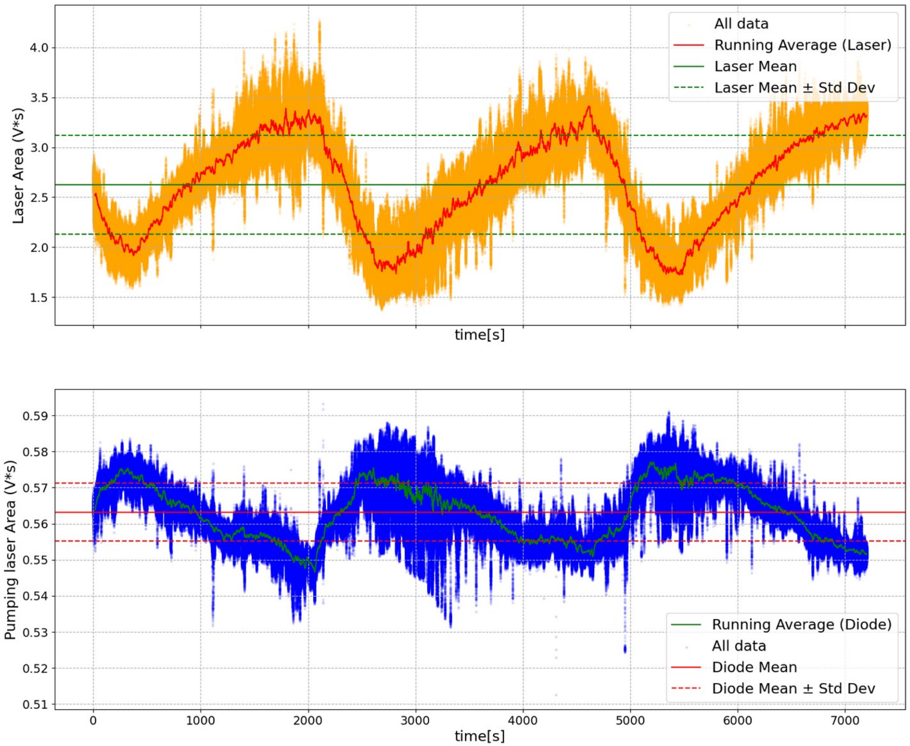




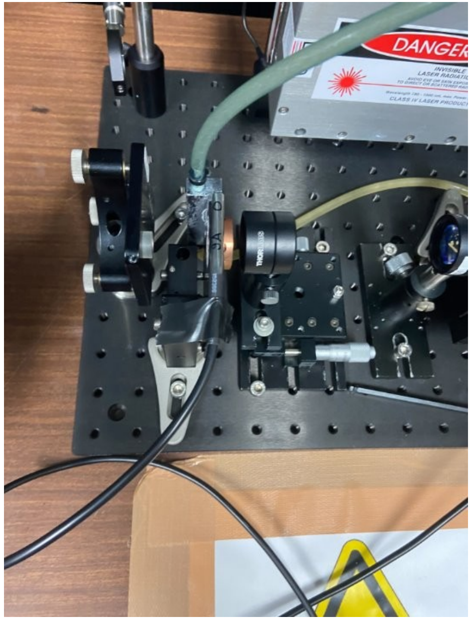
Laser beam profile

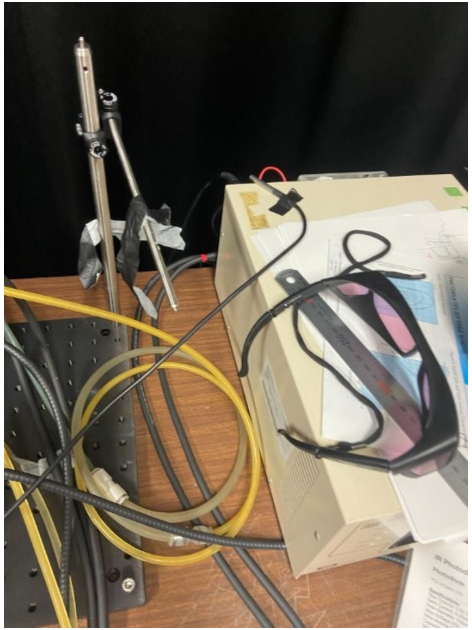


Laser area over long time

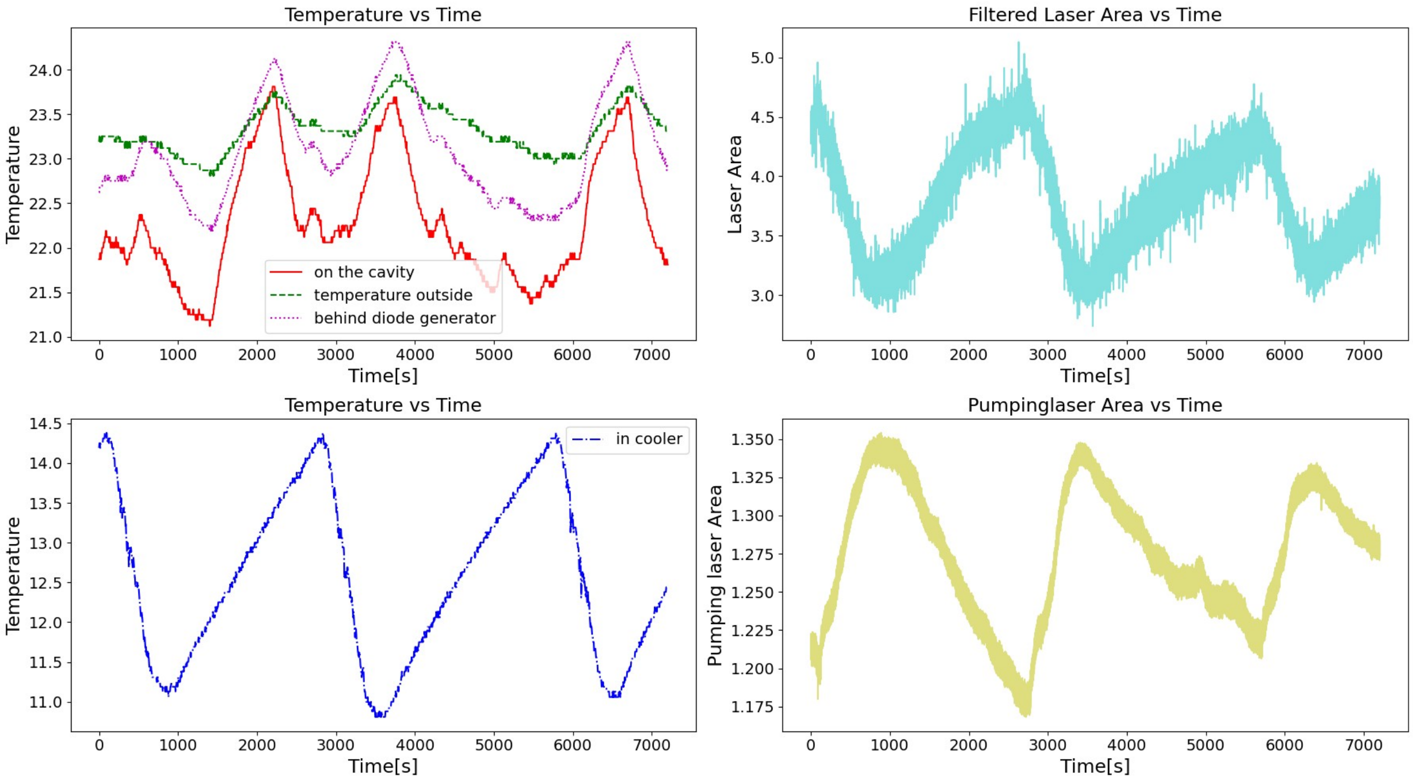


Temperature sensors

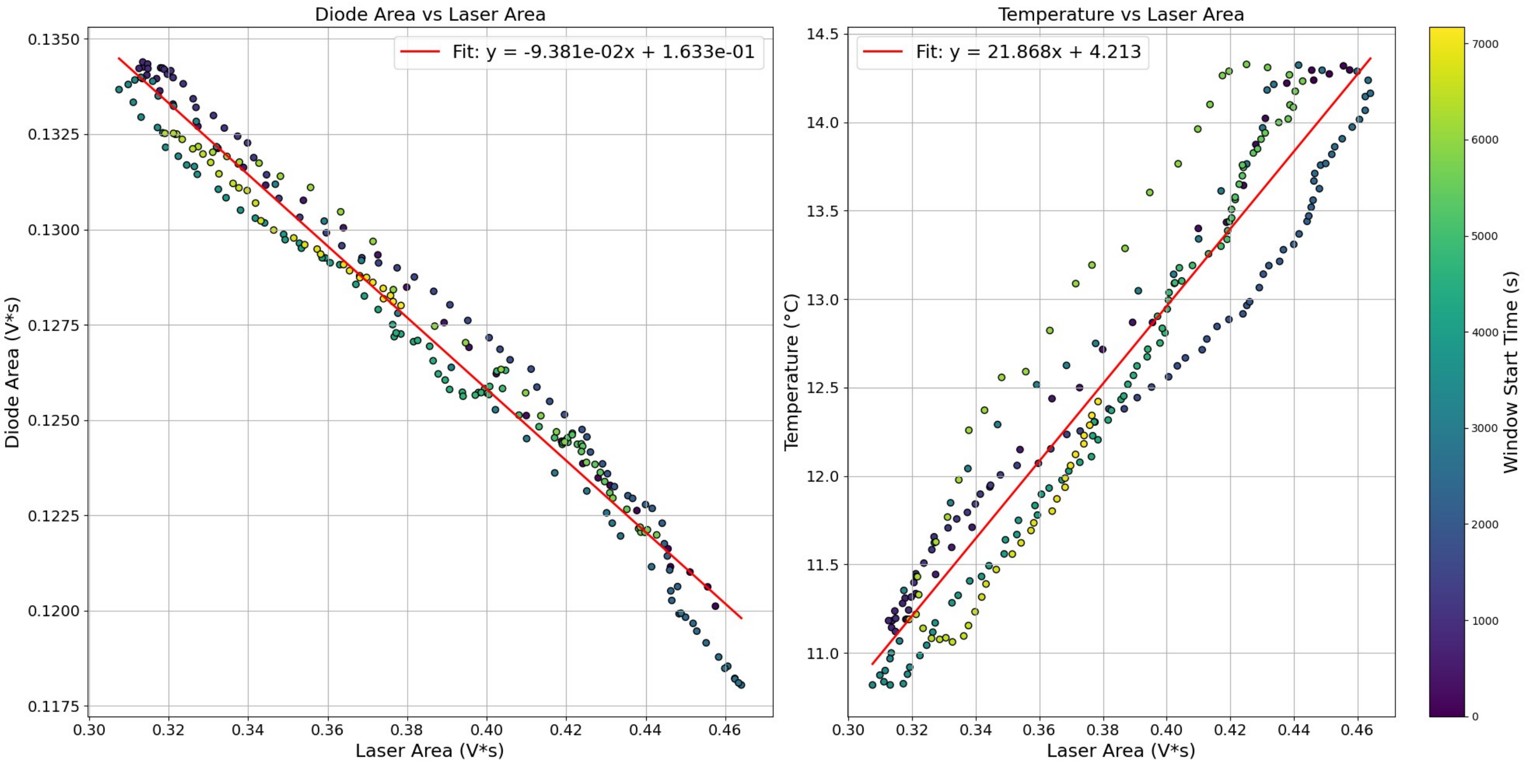




Laser pumping laser temperature plots



Correlation between areas and temperature



other evaluation in this data

- chiller temperature period: 46 ± 3min
- searched for correlations of linear fit values a and b with laser power,

  but no relationship

  → I use power meter instead of photodiode
- photo diode only gives relative values and no linear response the power

  meter gives
  absolute values

power meter

ICECUBE
SOUTH POLE NEUTRINO OBSERVATORY

PM3 1098336

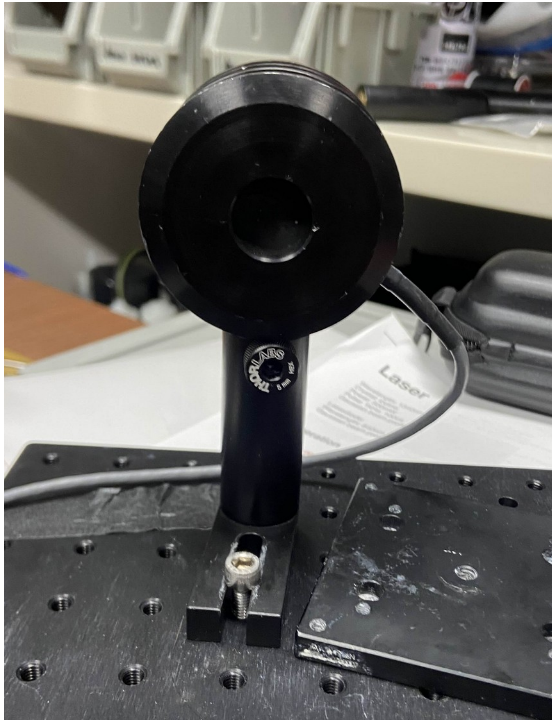
active area: 19 mm

power range: 500μW-2W

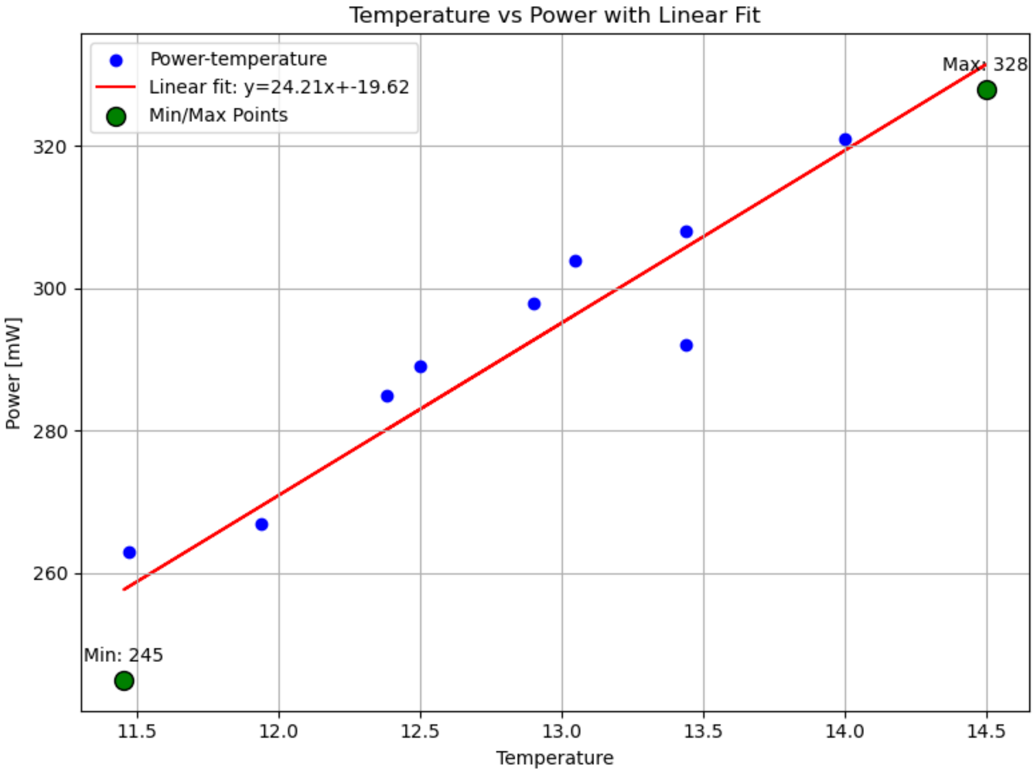
wavelength range: 300-11000 nm

response time: 2 seconds

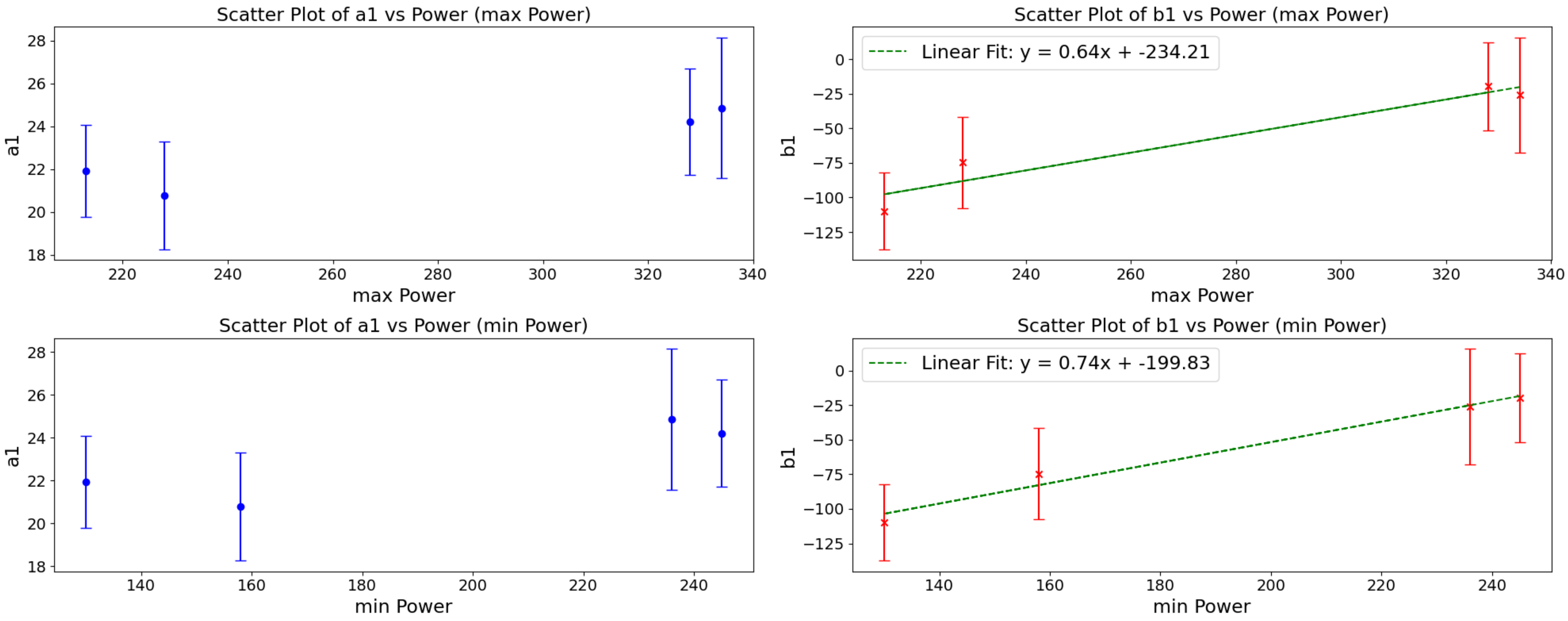
power uncertainty: 50 μW resolution
+ 1mW thermal drift + calibration
1%



Absolute power in dependence of chiller temp



Fit values in dependence of laser power

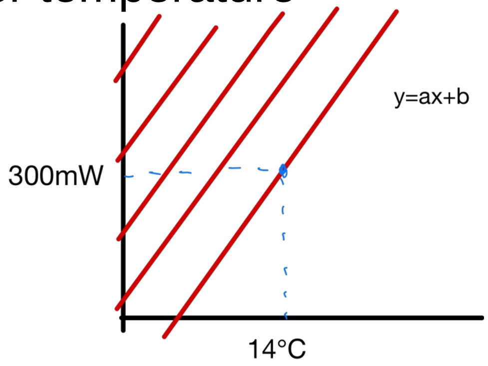


How I predict actually use

Slope is almost constant so linear is defined with intercept

Take few minutes measurements 2 or 3 minutes then define intercept from temperature and power

predict power from equation and number of chiller temperature



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Summary

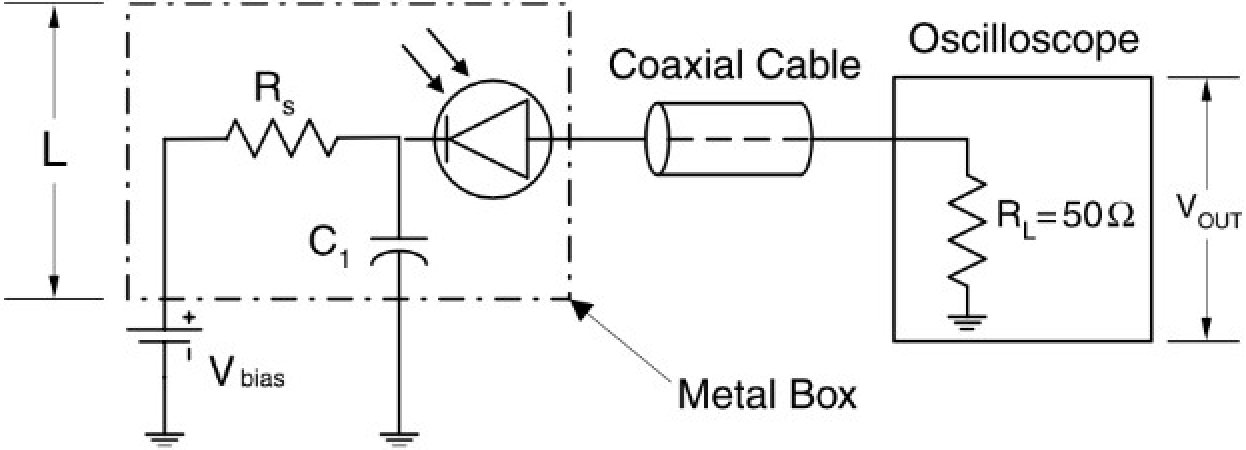
- Laser gives 80μs of beam and has gaussian profile with 1mm diameter
- laser oscillation due to chiller
- chiller has stable period at stable room temperature
- laser power development over time can be predicted using chiller temperature
- For short time 3% uncertainty for long time 20% uncerrtainty

next

- Take more data and plot it so that you can make more accurate predictions
- Irradiate actual ice and measure

back up

circuit



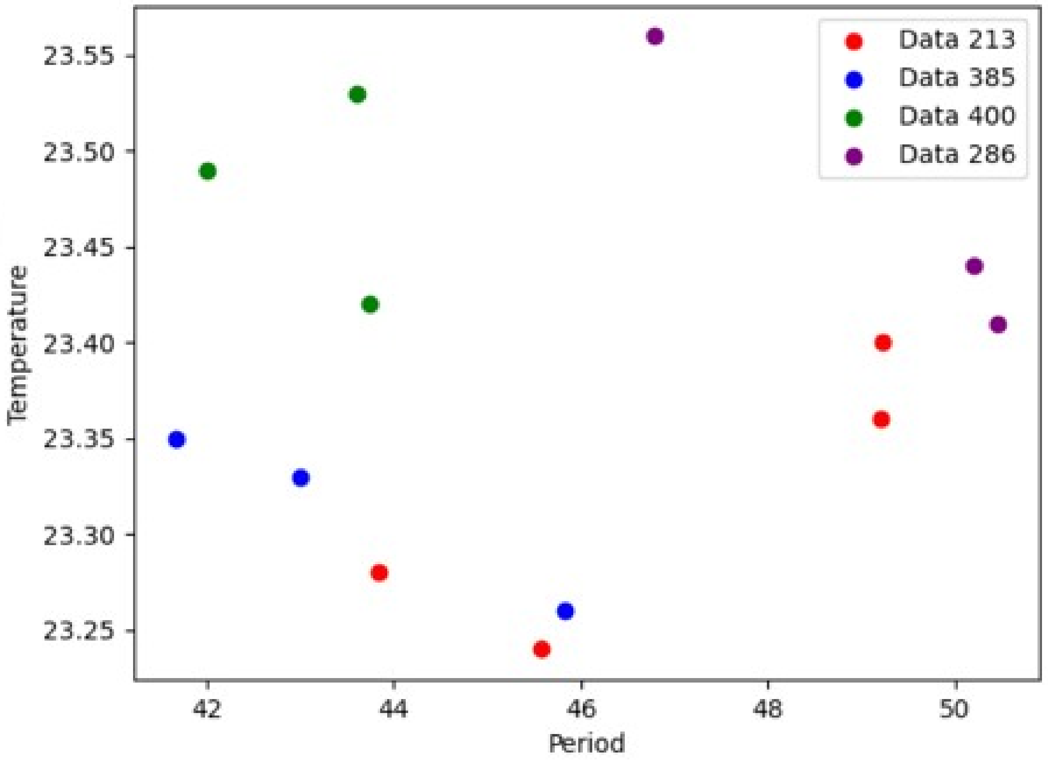
L
R_s
C_1
V_{bias}
Coaxial Cable
Oscilloscope
$R_L=50\Omega$
V_{OUT}
Metal Box

measureway

- measure laser and pumping laser waveform
  → We may know stability by looking at these area
  → Two plots show oscilation

using temperature sensors correlation with chiller temperature
predict from area datas → no relationship
plots from power and temperature → maybe pridict

chiller period and out temperature



power- liner value