

# Dark matter Axion search with riNg Cavity Experiment DANCE:

Development of automated cavity locking system

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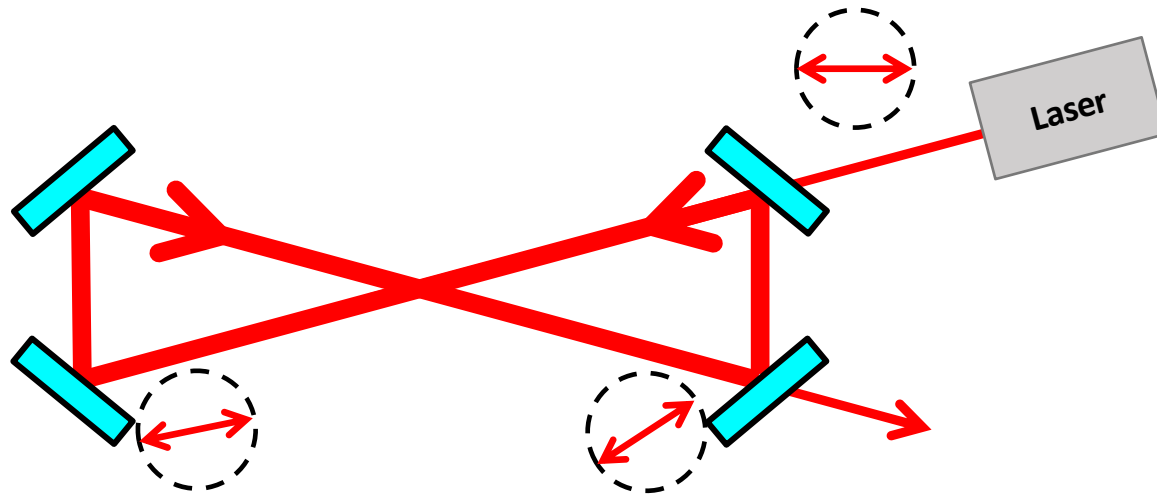
# Overview

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- DANCE searches for axion dark matter with ring cavity
- The cavity needs to be locked to resonance during observation
- Developed the **automated cavity locking system** to deal with the unlock during the long-term observation

# Resonance of optical cavity

DANCE cavity amplifies the rotation angle of linear polarization



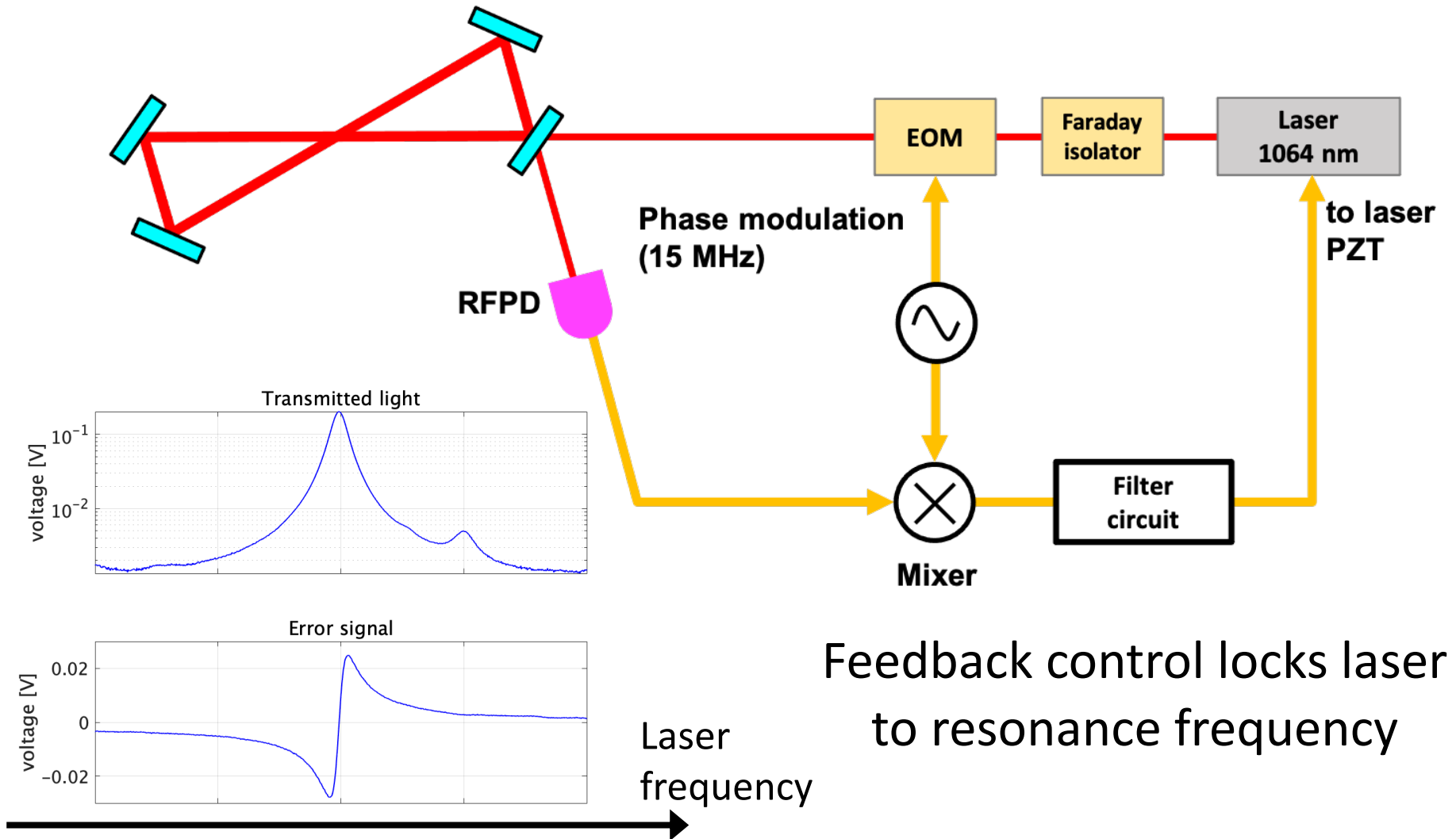
Condition for resonance:  
Round-trip length  $L = m\lambda$



Wavelength  $\lambda$  (or frequency  $\nu$ )  
needs to be controlled

# Feedback control of DANCE

With PDH technique, error signal can be obtained



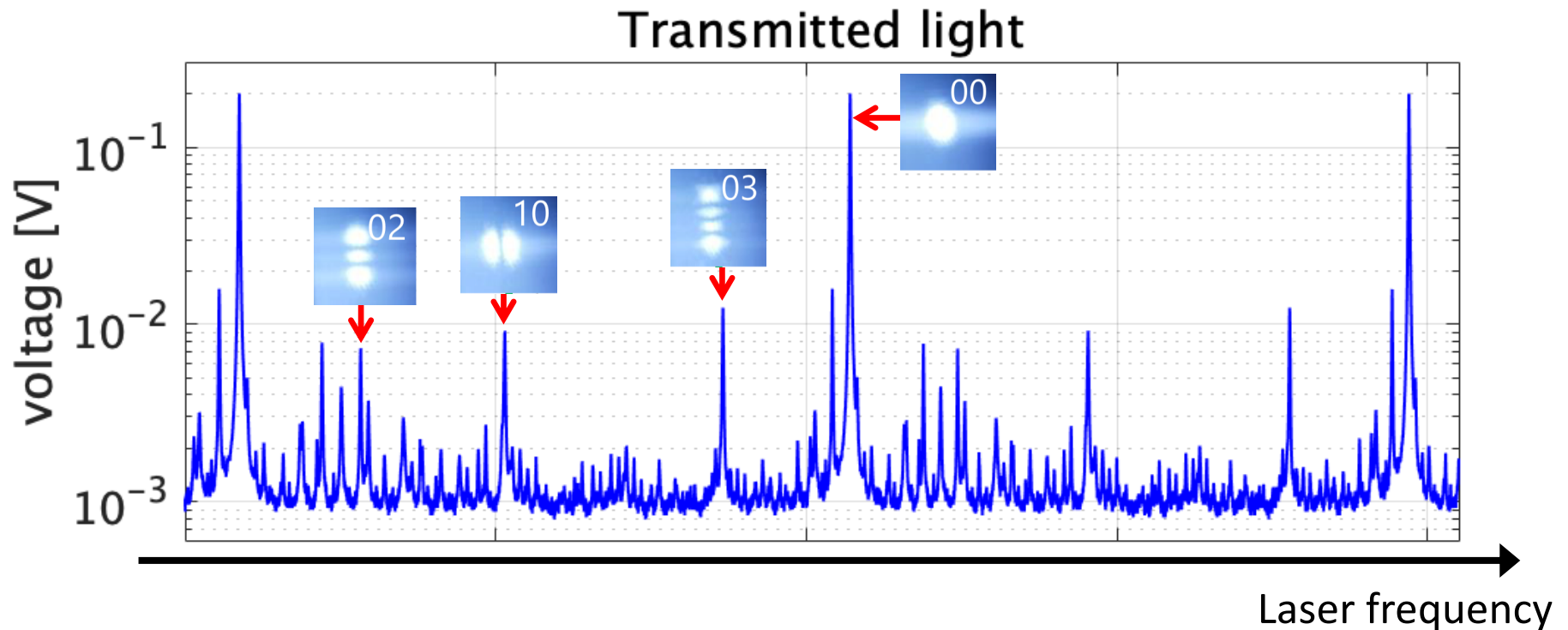


# Procedure for locking a cavity

There are many higher order resonant modes



Need to adjust Laser frequency to TEM00 mode manually



# Issues in current DANCE

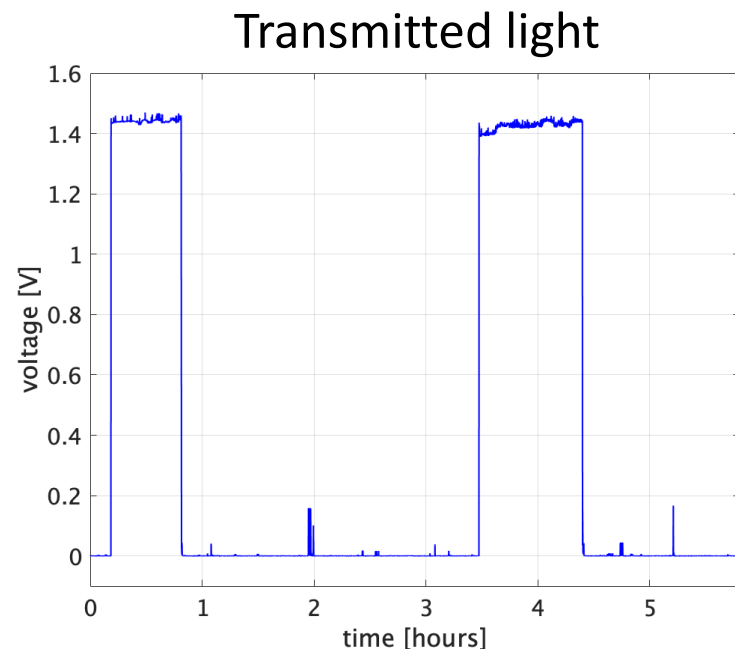
SNR grows with the observation time  $T_{obs}$

$$\text{SNR} \propto \begin{cases} T_{obs}^{1/2} \\ T_{obs}^{1/4} \end{cases} \quad (\text{depending on axion mass})$$

Long-term observation (e.g. 1 year) is planned

Current DANCE

- Cavity lock continues for around 1 hour
- Long off-duty time



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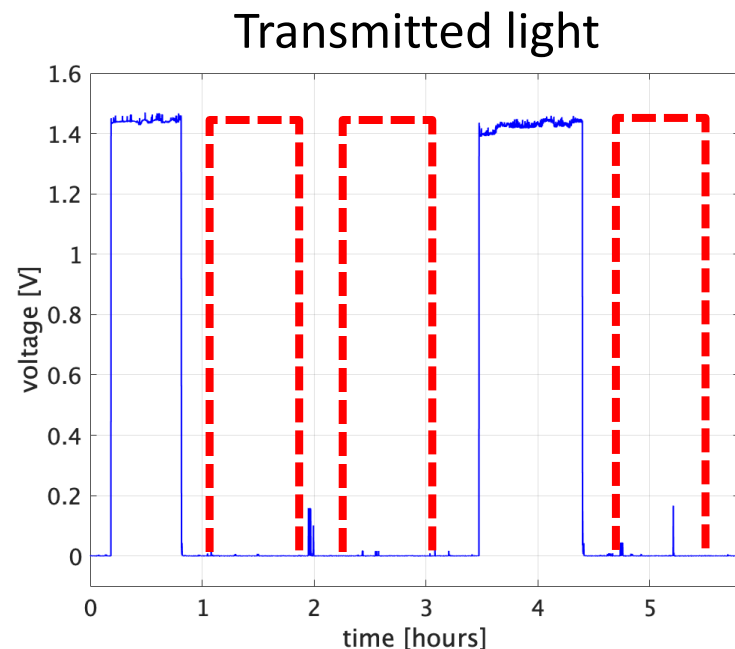
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Current DANCE

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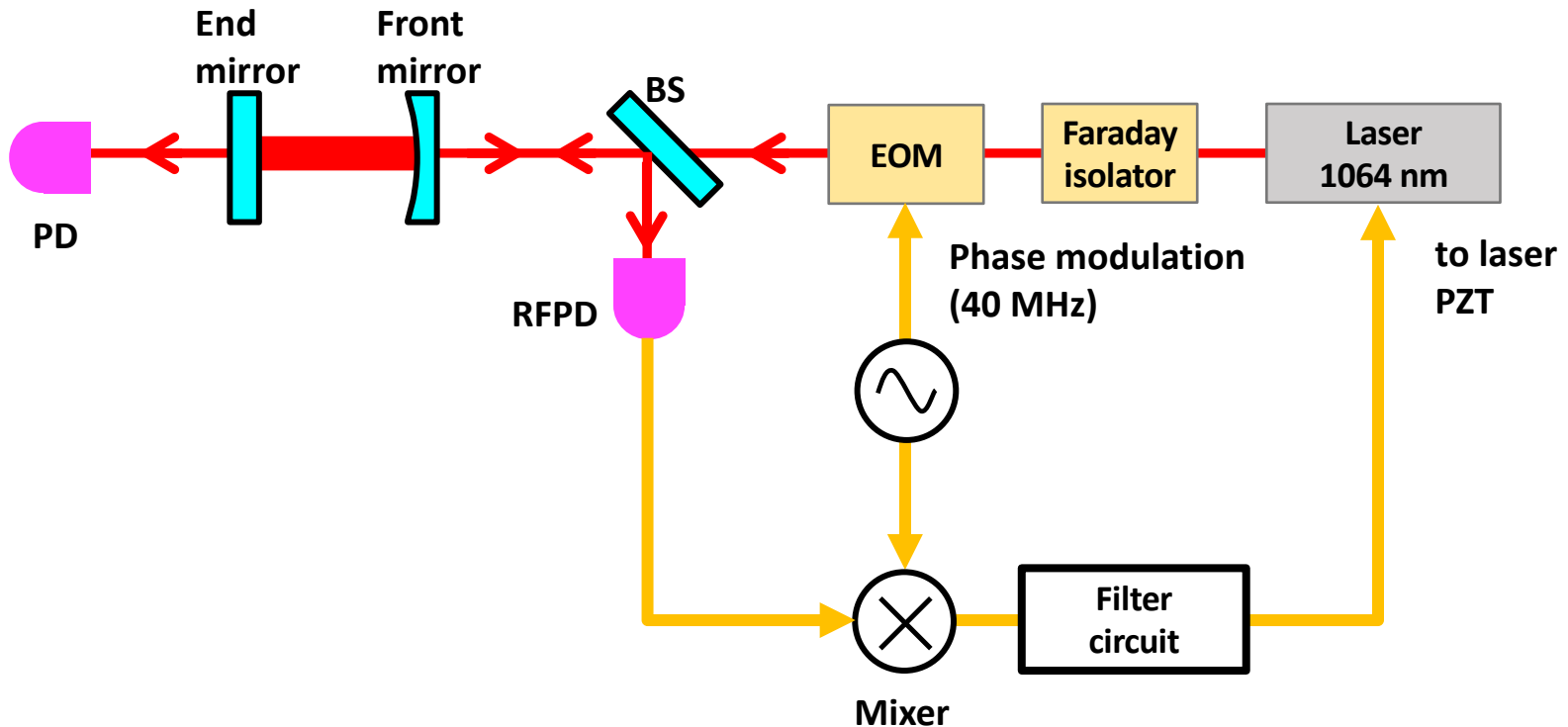


Developed the automated cavity locking system to improve duty cycle



# Cavity for demonstration experiment

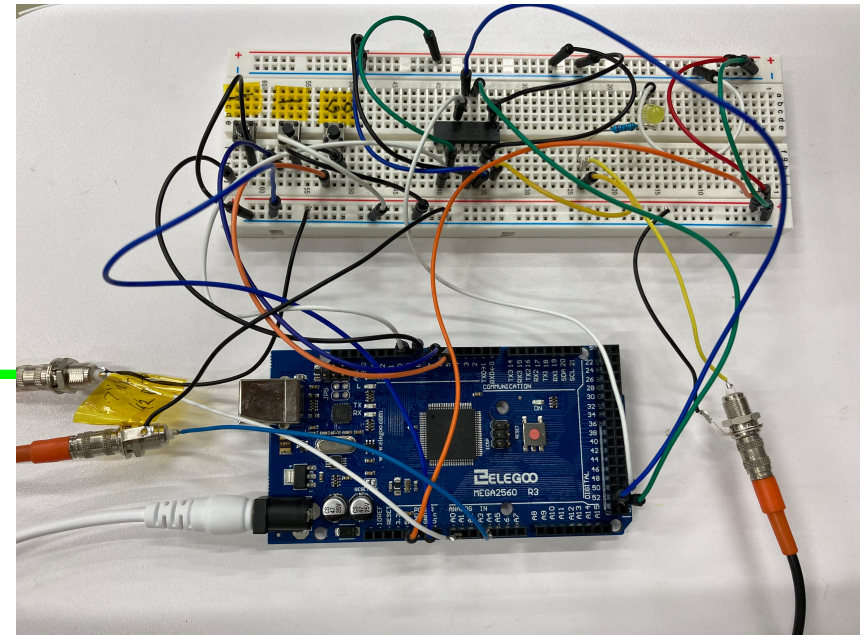
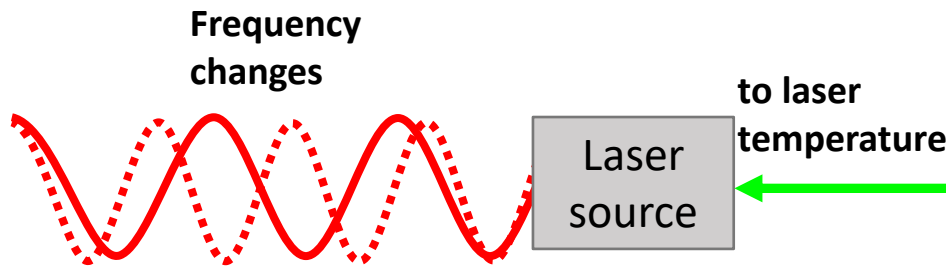
Linear cavity (Finesse  $\approx 100$ ) was used for demonstration experiment



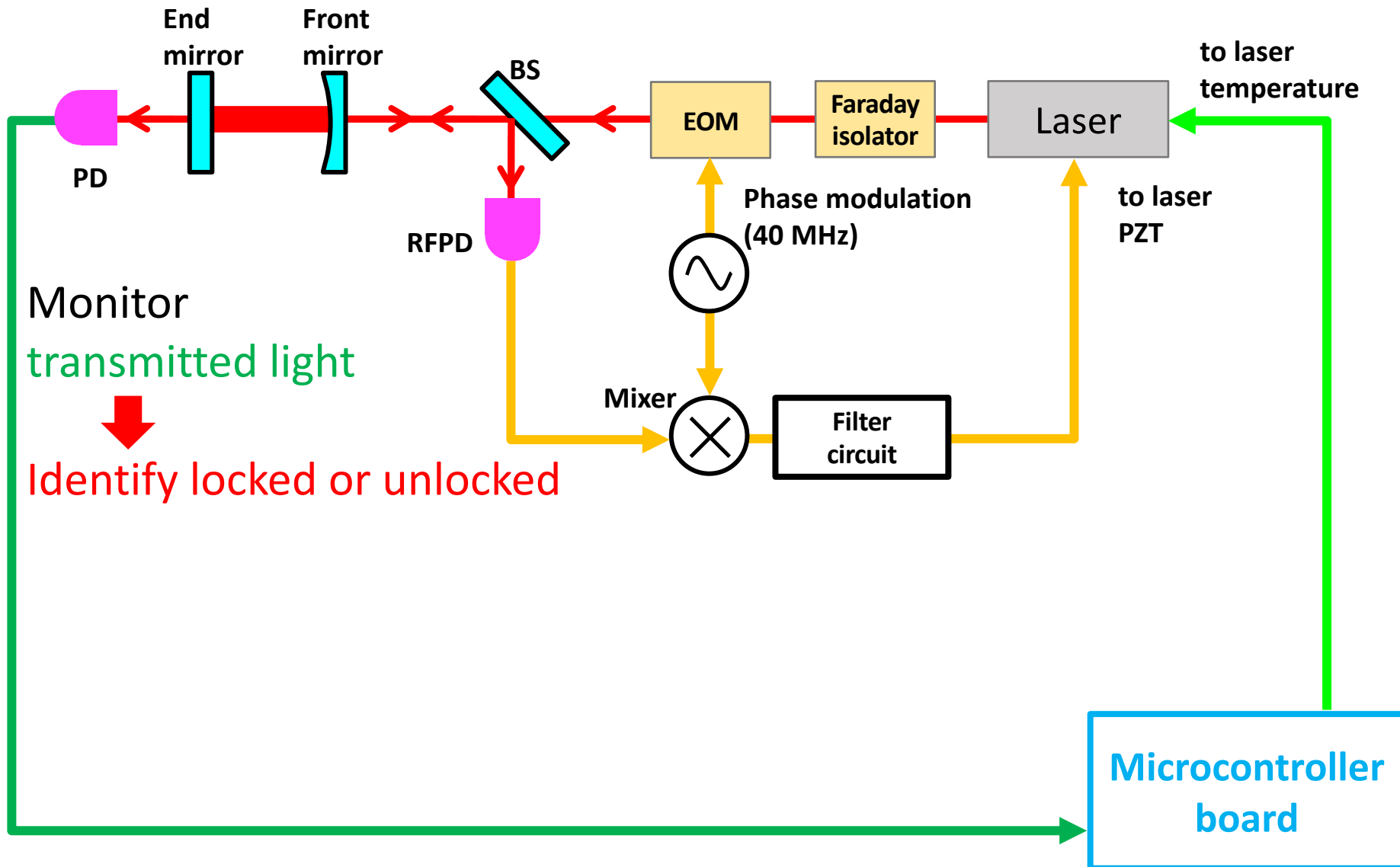
# Automated cavity locking system

Use a microcontroller board

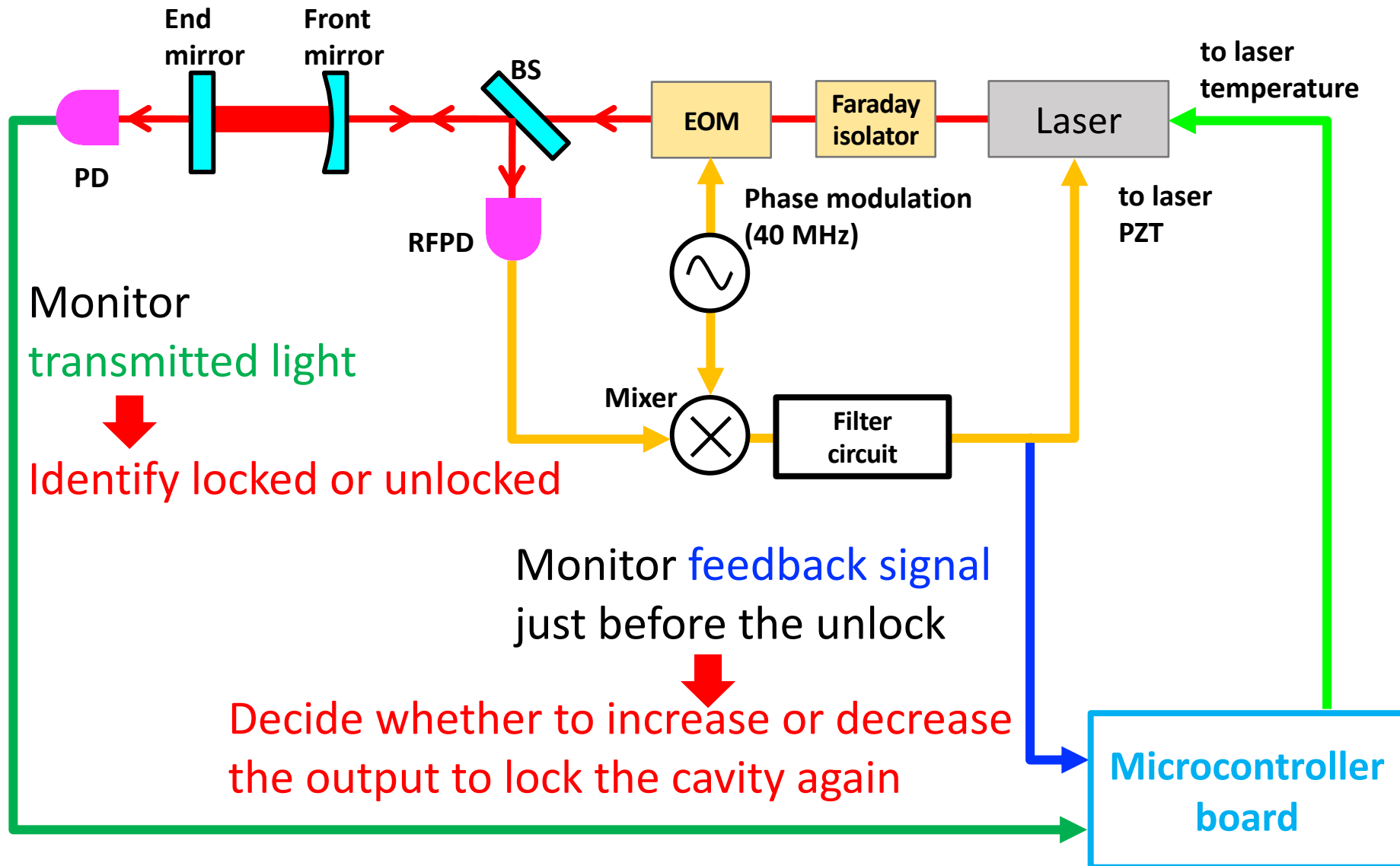
Adjust laser frequency by changing the temperature in the laser source



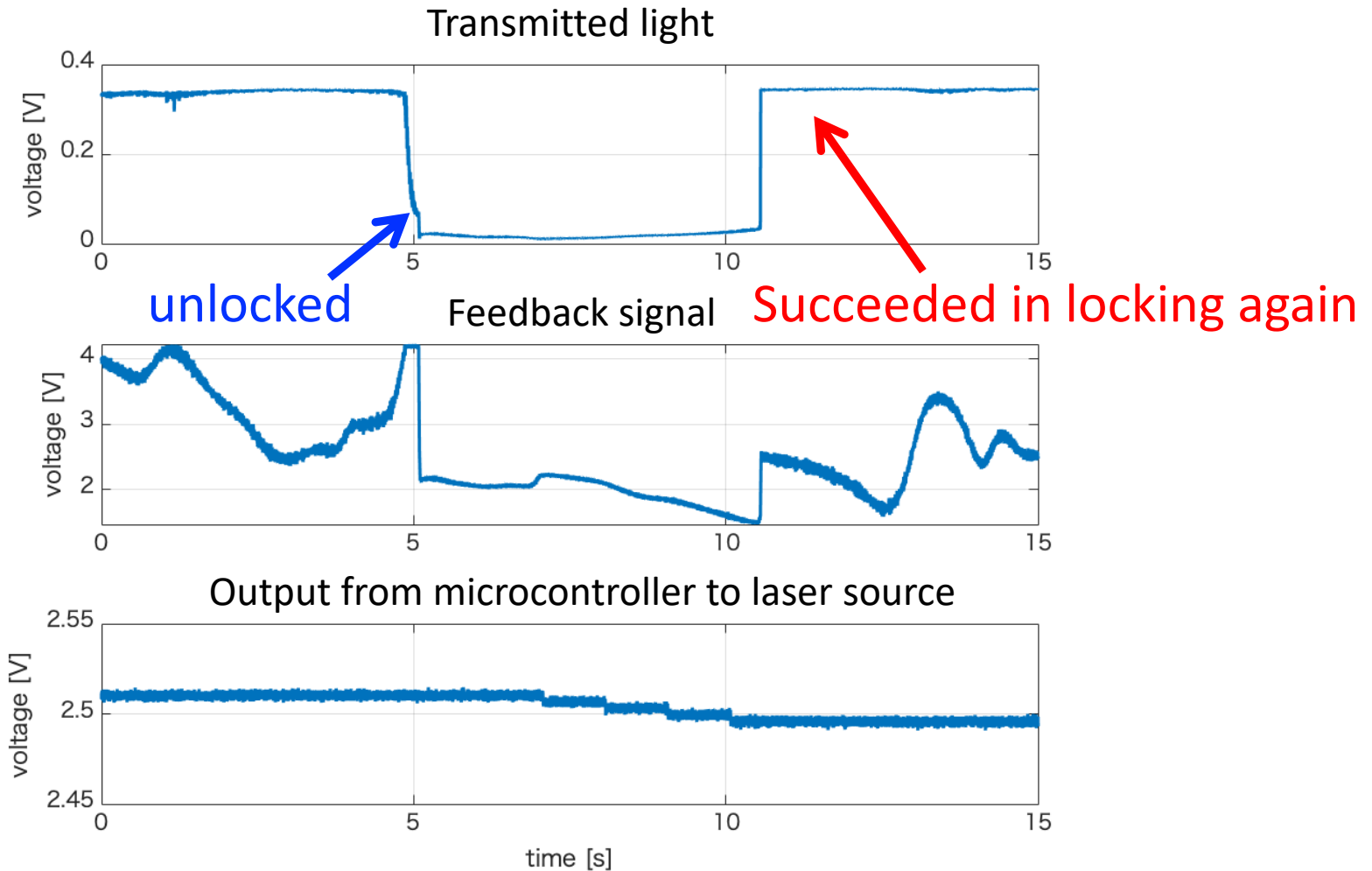
# Automated cavity locking system



# Automated cavity locking system



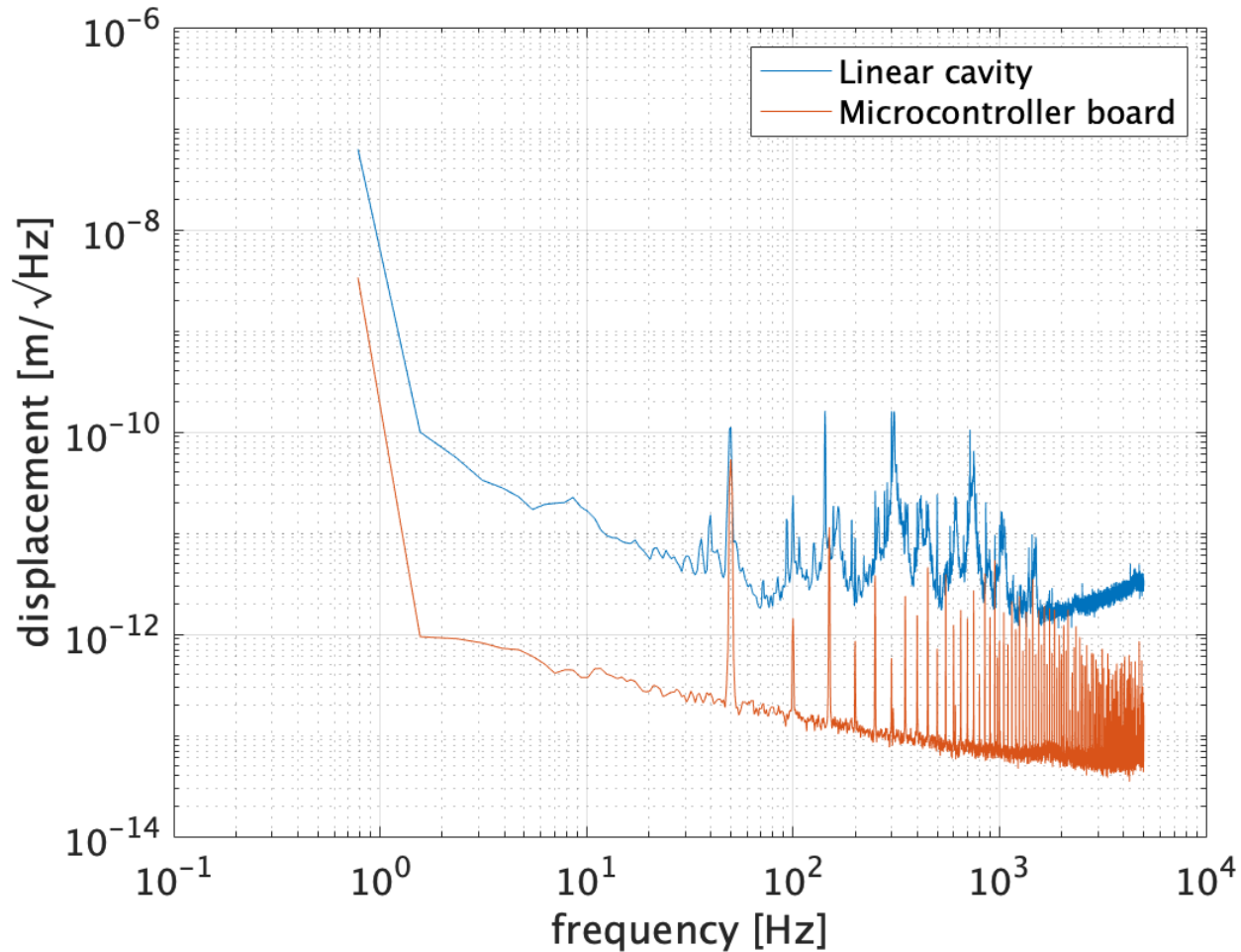
# Result



Off-duty time  $\approx 6$  sec  Duty cycle in DANCE  $\approx 99.8\%$



# Noise of Microcontroller board



# Summary & Future plans

- Long-term observation is planned for the future DANCE
- The automated cavity locking system succeeded in recovering the resonance automatically

## Future plans

- Apply the automated cavity locking system to New DANCE
- Develop double-loop feedback control system to improve the duration of the lock

