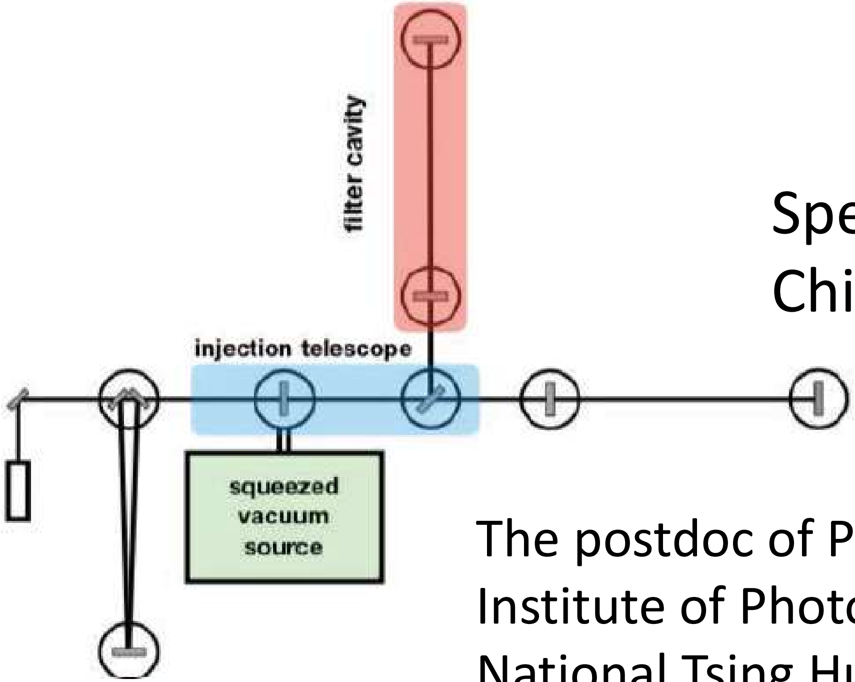
# Report some work of filter cavity and squeezed light generation in NAOJ

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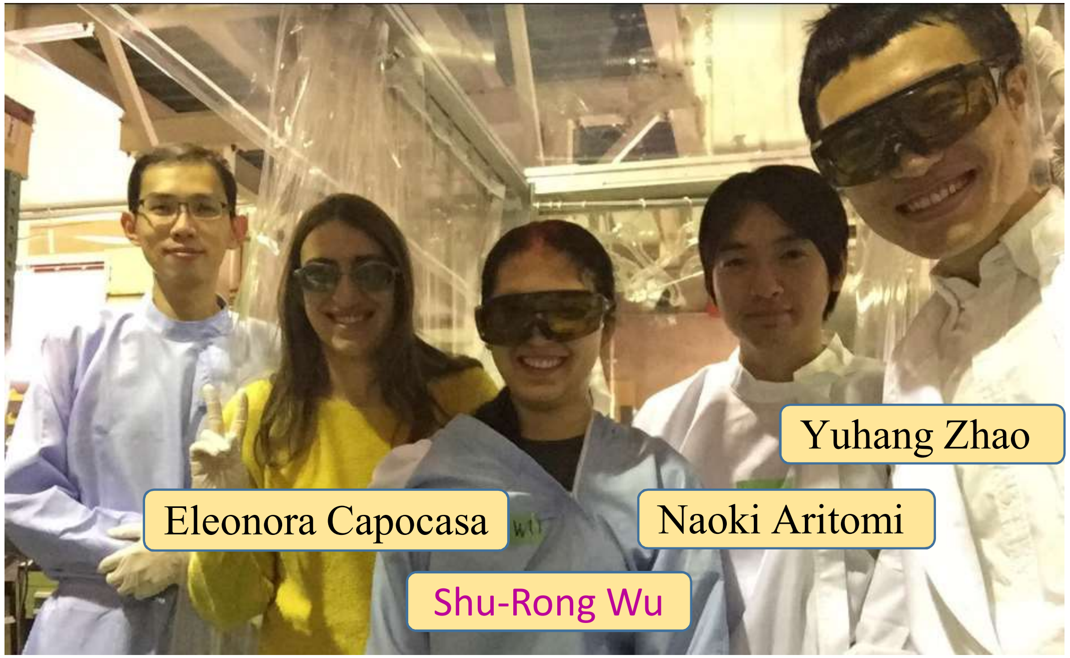
Prof. Ray-Kuang Lee's experimental team


With Prof. Matteo Leonardi's team

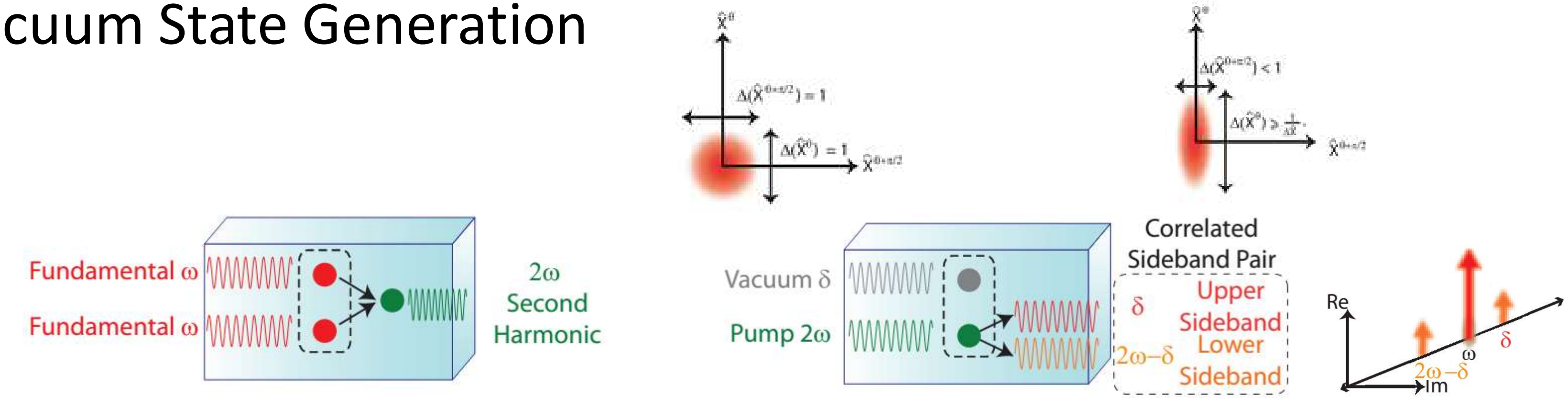


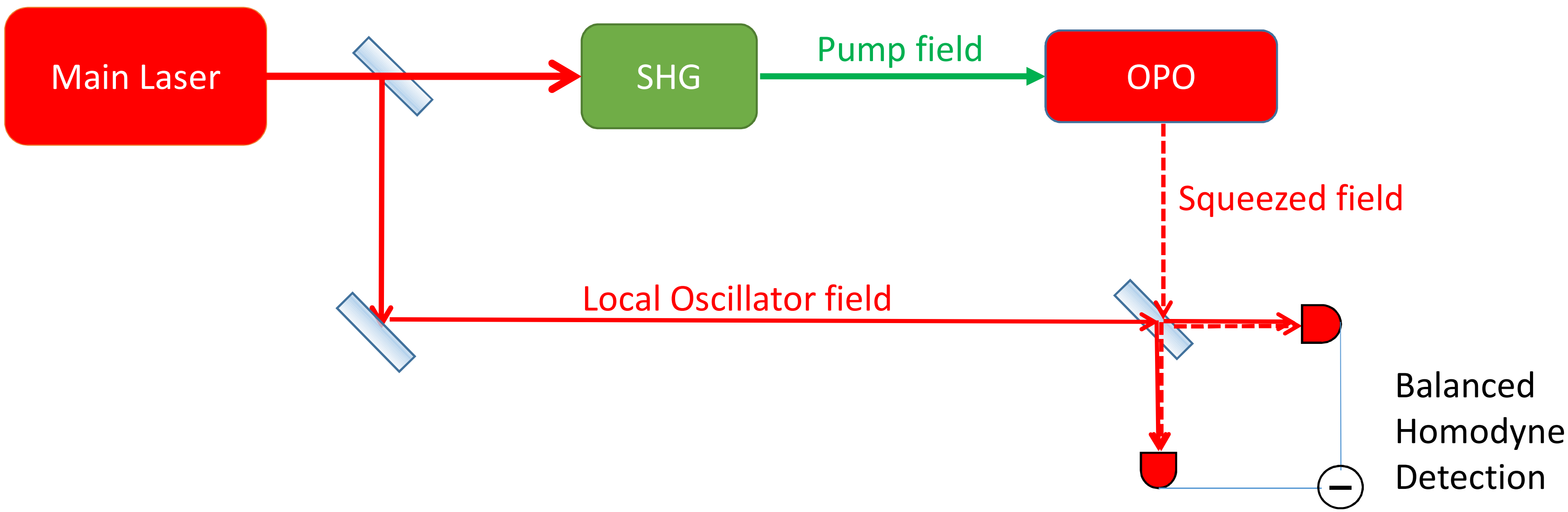

**Chien-Ming Wu**

- 10 dB squeezing in MHz region
- Two-mode squeezed stat generation
- Wave Function Metrology
- Quantum optics and Quantum Information theory

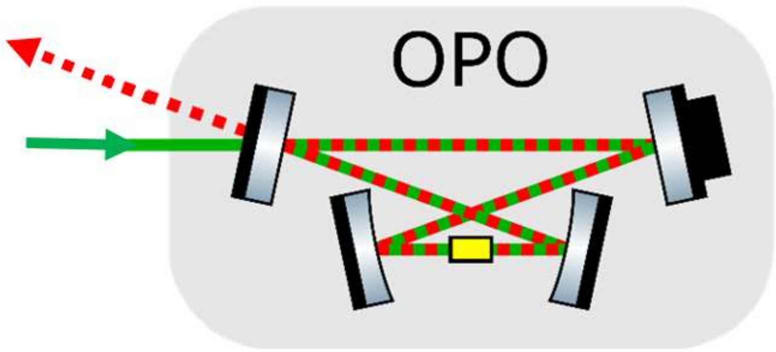
- Quantum enhanced sensing for GWD
- Audio-frequency and high squeezing level
- Frequency-dependent squeezing via filter cavity

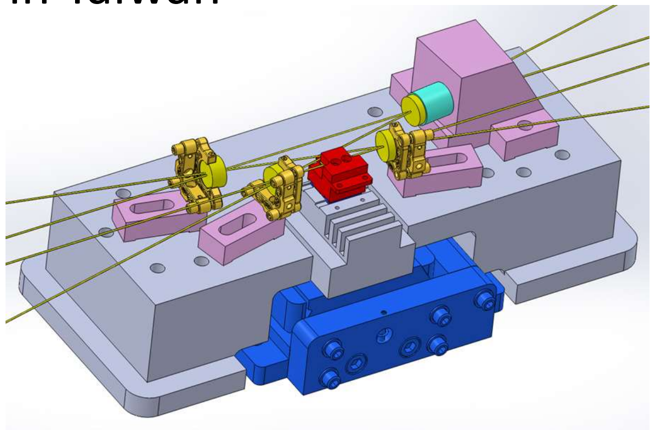
# Squeezed Vacuum State Generation



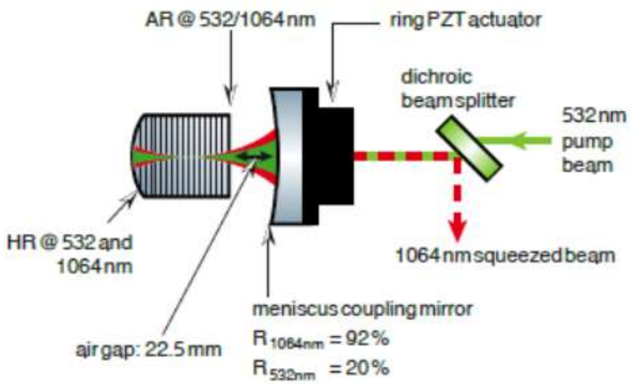
Bow-tie traveling-wave Squeezer in Taiwan

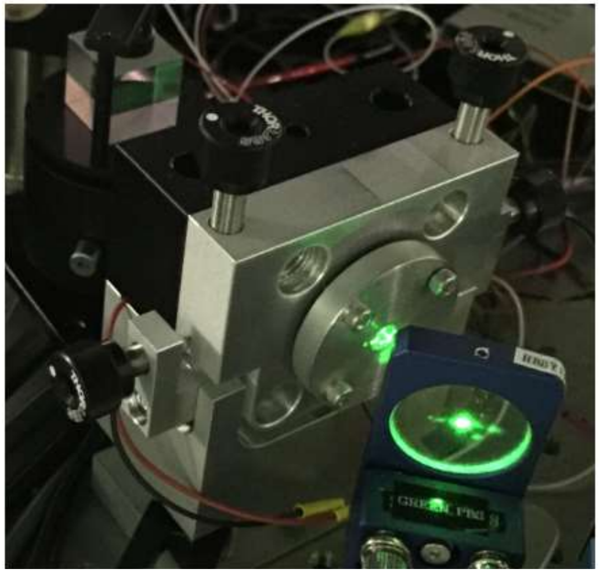


- Flexibility
- Isolation to backscatter

Hemilithic standing-wave Squeezer in NAOJ

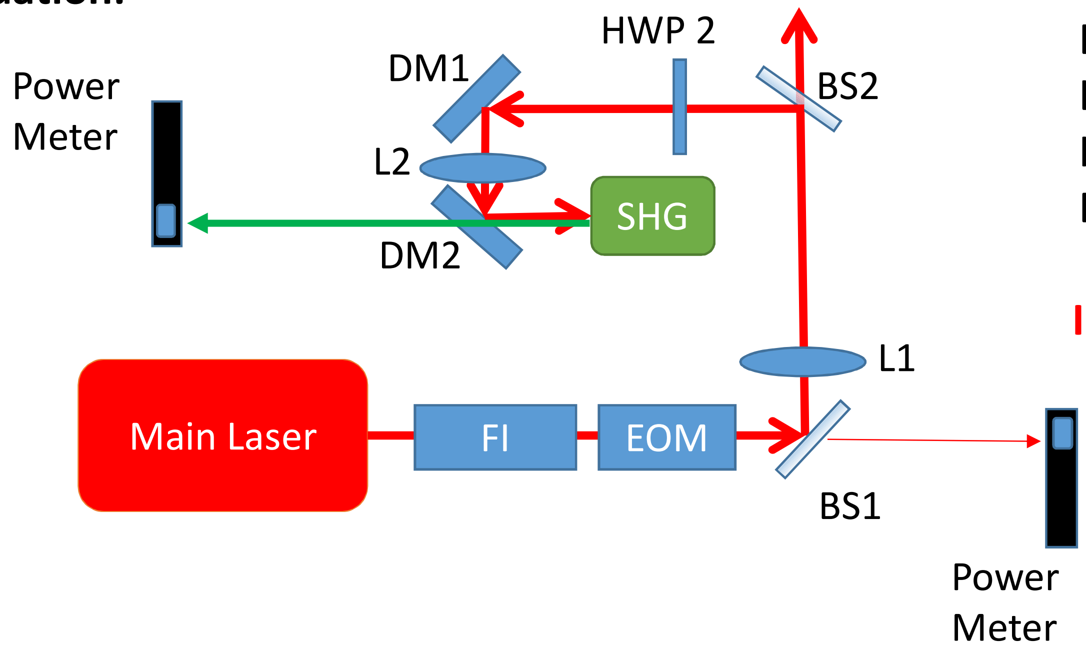


- Compact
- Robust against mechanical vibrations
- Less intracavity loss

- Improving the SHG Power Fluctuation

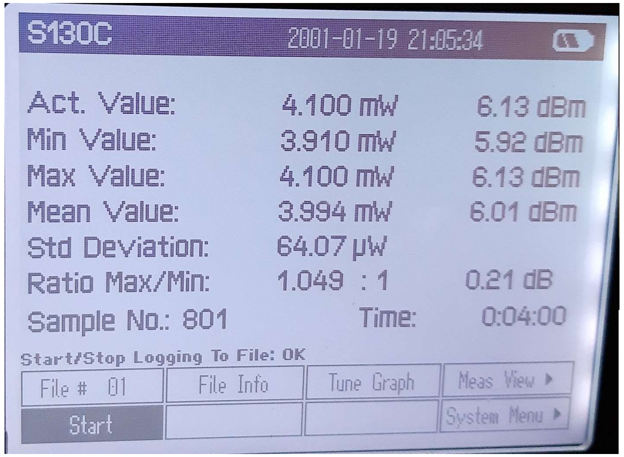
**Green Power fluctuation:**
**8.34%**




FI : Faraday Isolator
EOM : Electro-Optic Modulator
L: Lens
HWP : Half-Wave Plate
DM: Dichroic Mirror

**IR Power fluctuation:**
**4.76%**

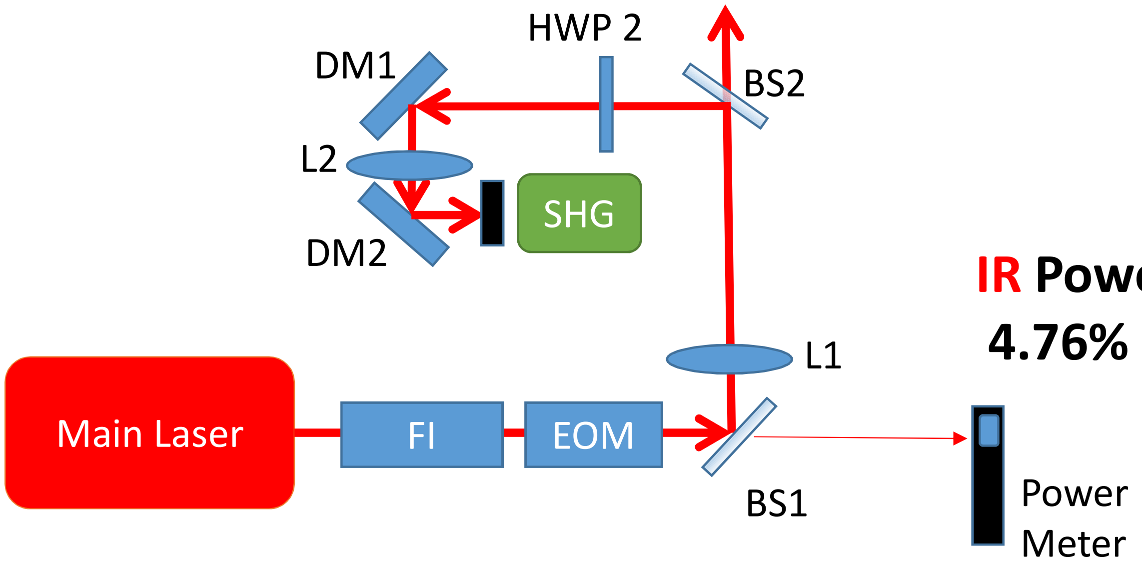

Power fluctuation was measured by using the statistic mode of Thorlabs PM 100D power meter with S130C - Slim Photodiode Power Sensor Si, 400 - 1100 nm, Response Time < 1 µs




Sampling rate: 3.3Hz

- Improving the SHG Power Fluctuation

When blocking the IR beam into the SHG



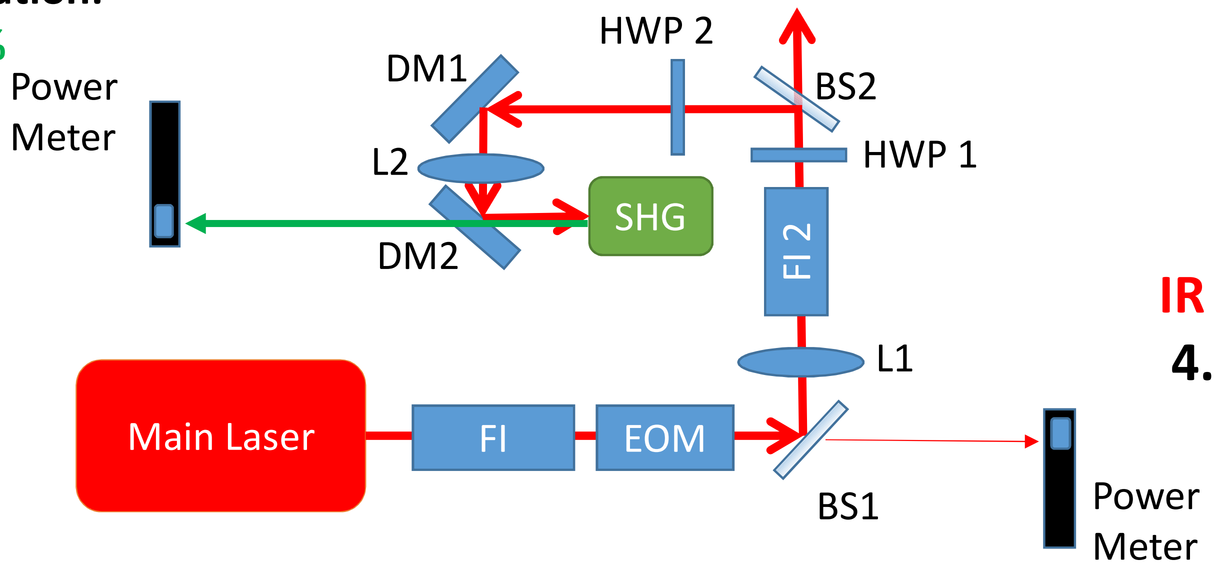

**IR Power fluctuation:**

**4.76% -> 0.2%**

- Improving the SHG Power Fluctuation

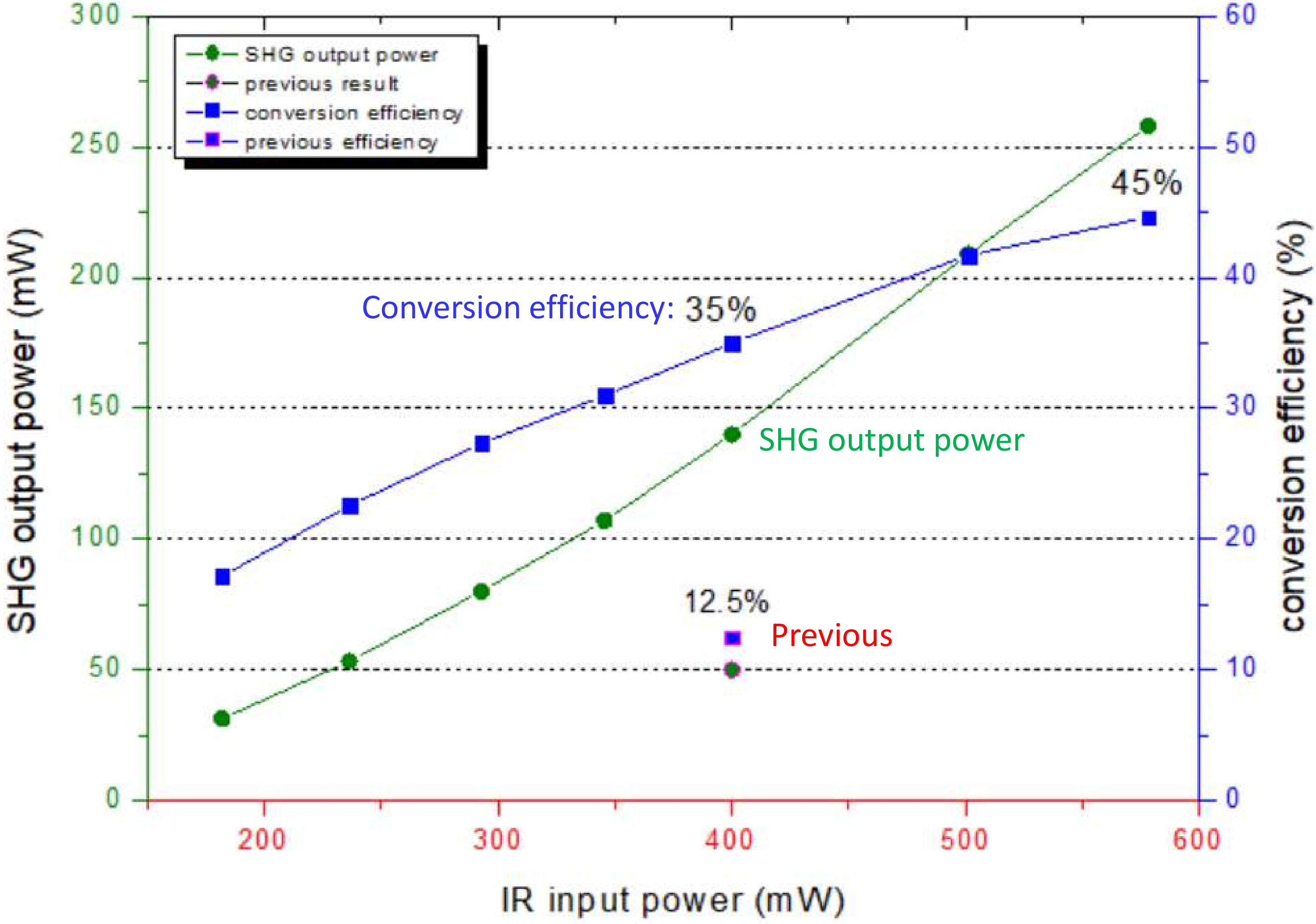
Adding a second Faraday isolator

**Green Power fluctuation:**
**8.34% -> 0.74%**

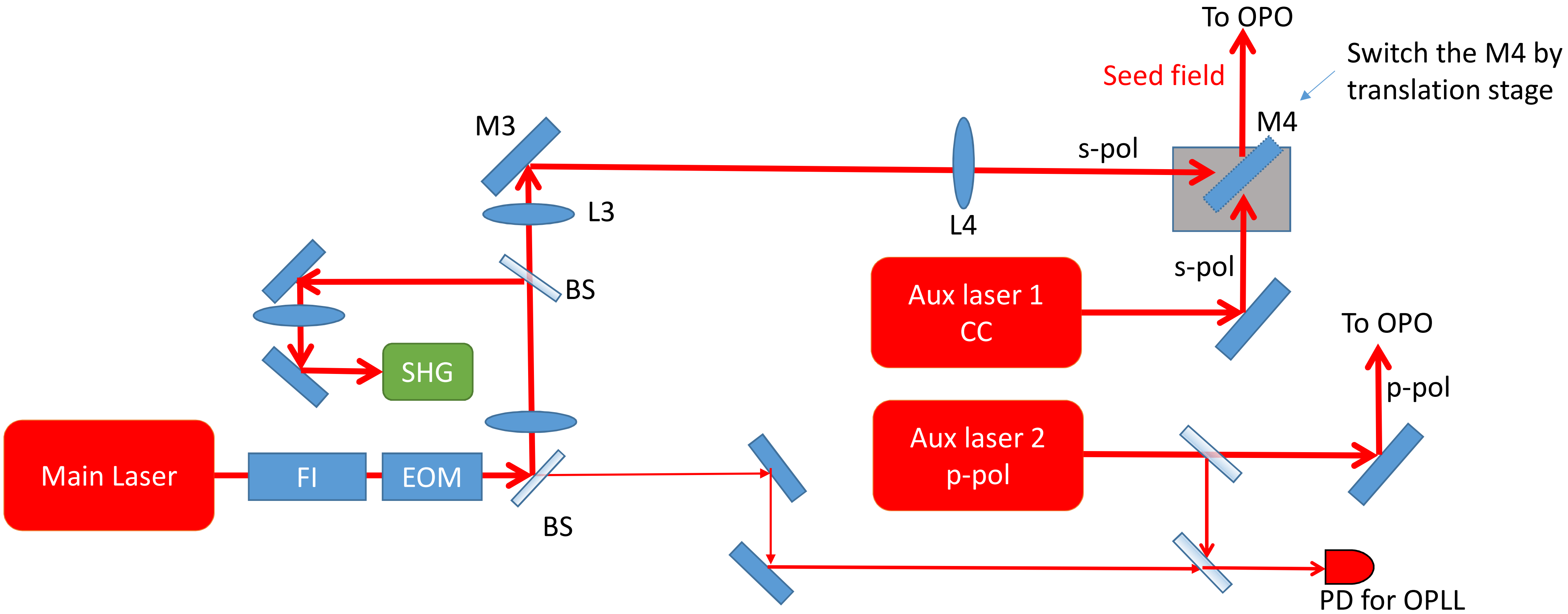



**IR Power fluctuation:**
**4.76% -> 0.97%**

- Improving SHG mode-matching to increase SHG conversion efficiency

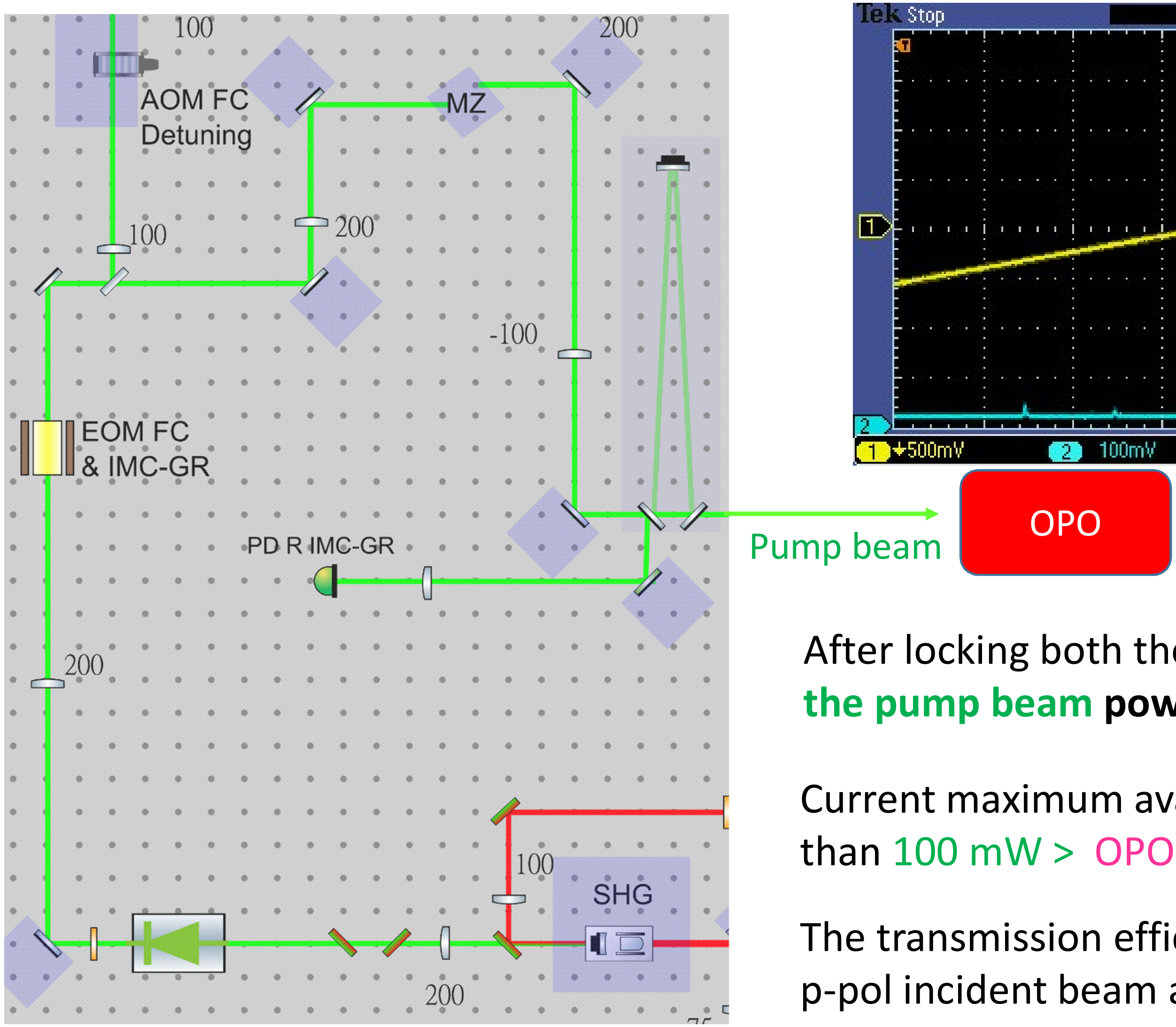


- Set up the Bright Alignment Beam to swap the Coherent Control light
  for seeding the OPO => No need to lock the phase between Aux laser 1 and Main laser




- **5 MHz to 400MHz optical phase locked between s-pol and p-pol was achieved**

- Recover the green mode cleaner (GRMC) and Mach–Zehnder interferometer (MZ)




SHG green power fluctuation: 0.74%

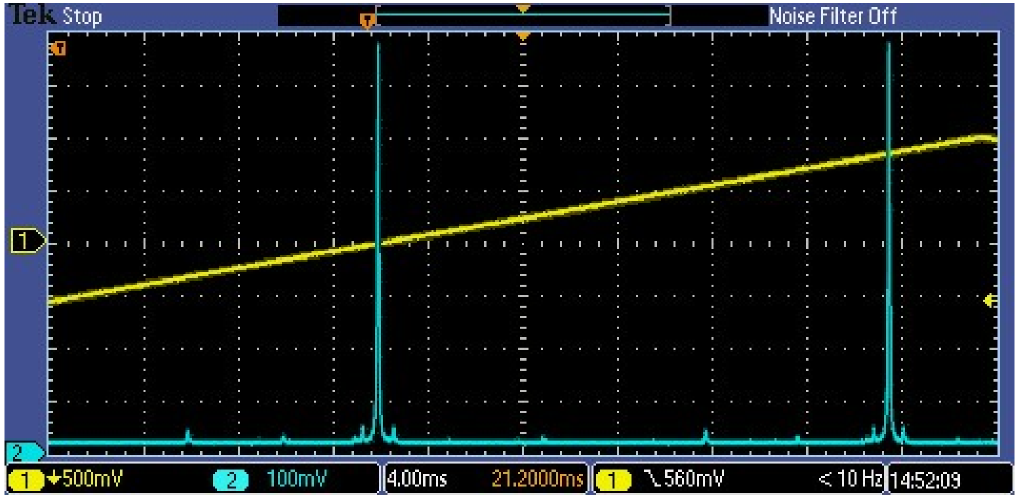



Fig. The GRMC transmission spectrum of injecting the s-pol beam

After locking both the GRMC and the MZ,
**the pump beam power fluctuation: 0.03% @ 95mW**

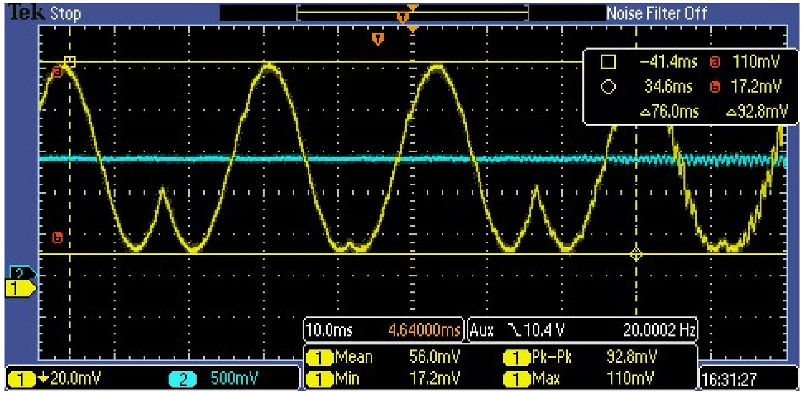
Current maximum available pump power is higher than 100 mW > OPO threshold power( 80mW )

The transmission efficiency of the MC is 77.7% when using p-pol incident beam and 54% when using s-pol beam

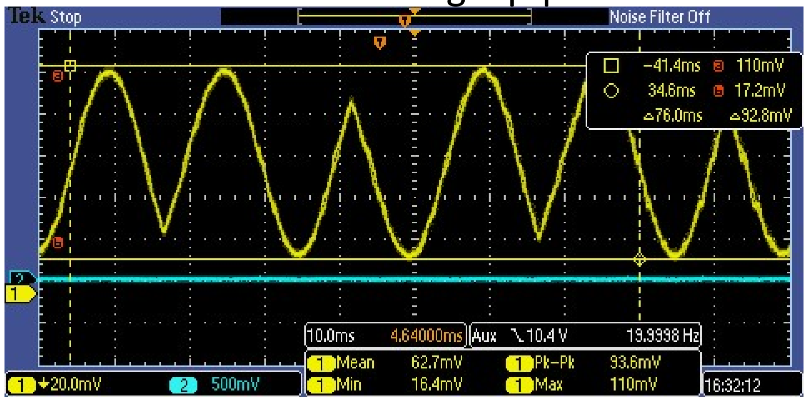
- Parametric Gain Measurement

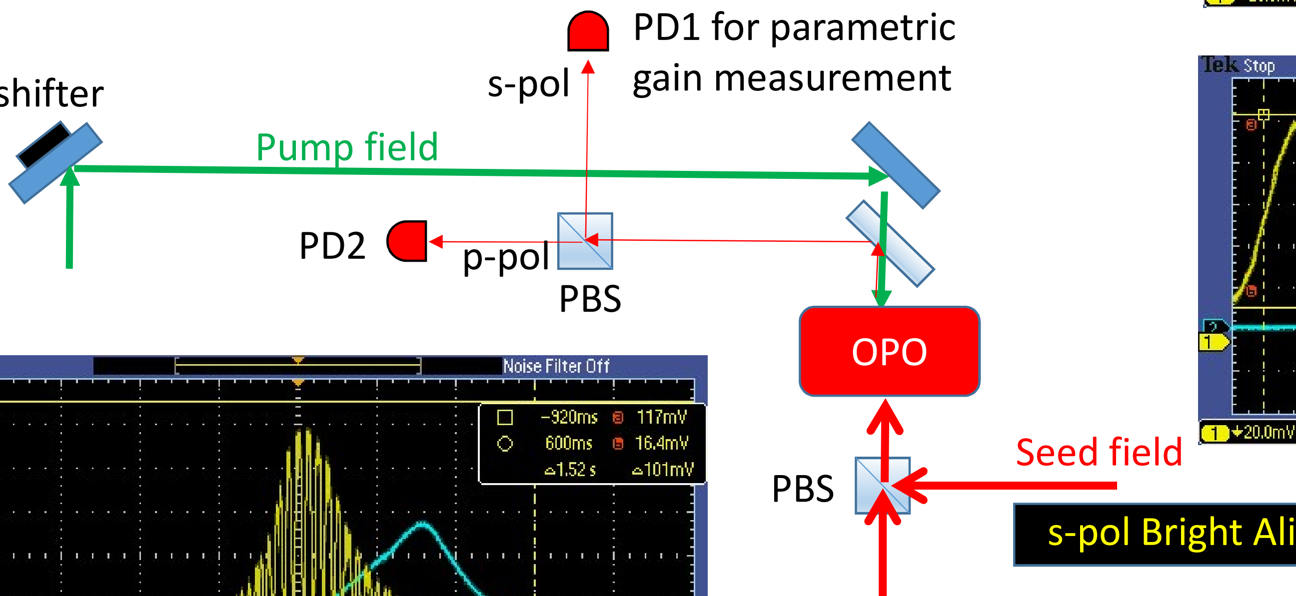
investigation of the amplification and de-amplification of seed field to determine the threshold power of the OPO system

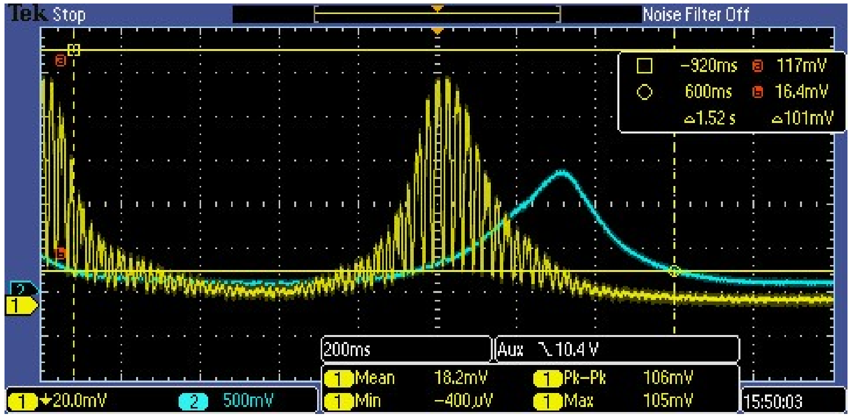
Upper Fig. : p-pol on resonance




Bottom Fig. : p-pol off resonance



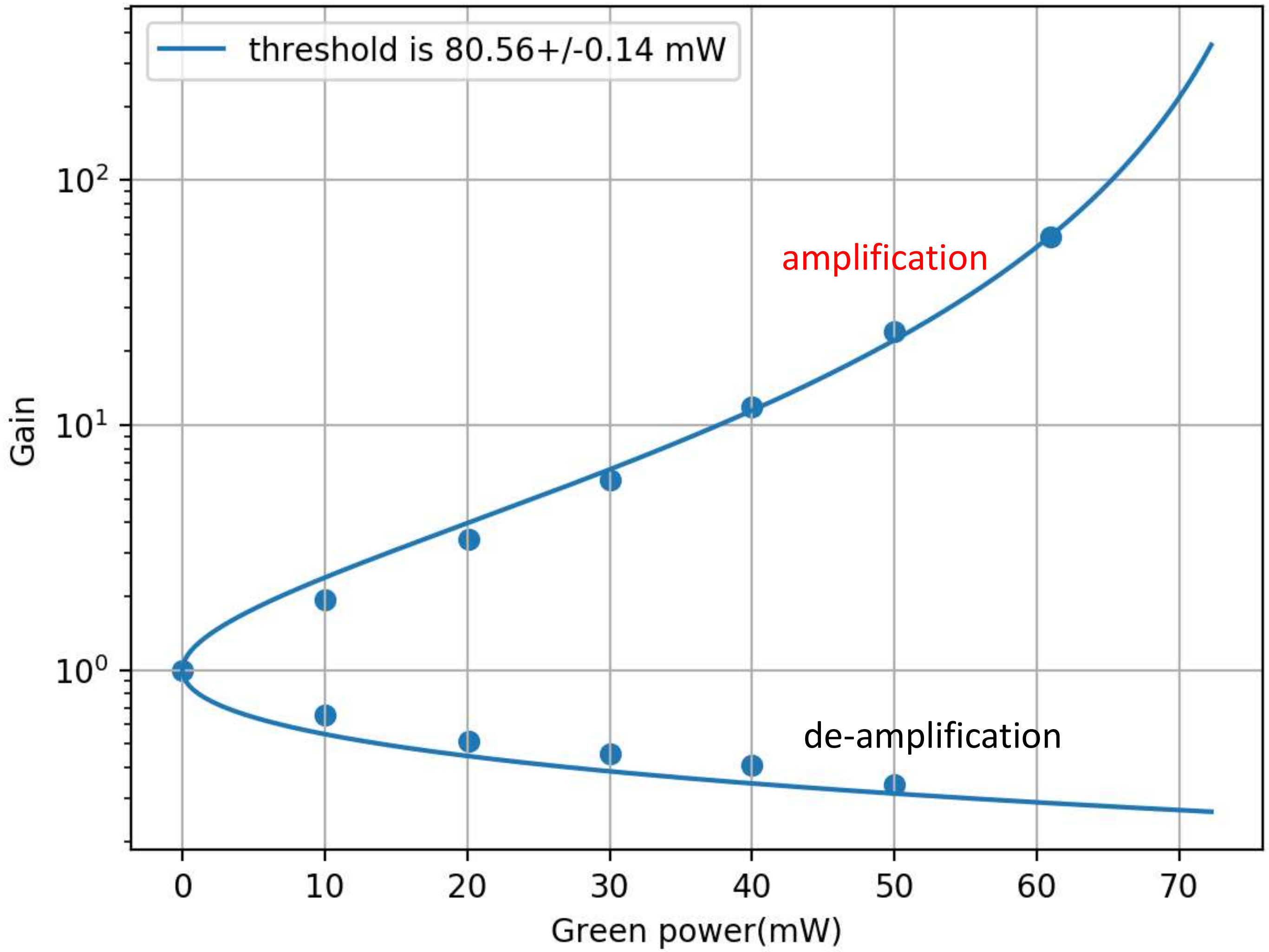




The p-pol and s-pol beam can both stabilize at the OPO resonance via optical PLL

Fig. The OPO transmission spectrum of injecting the p-pol and s-pol beam when scanning the phase of pump field

- Parametric gain measurement



Next steps: 1. complete the setup of Balanced Homodyne Detection

2. measure the squeezing and inject it into the filter cavity

3. obtain the frequency-depend squeezing