

Stable Narrow-line VECSEL Operation for Sodium Guide Star Generation

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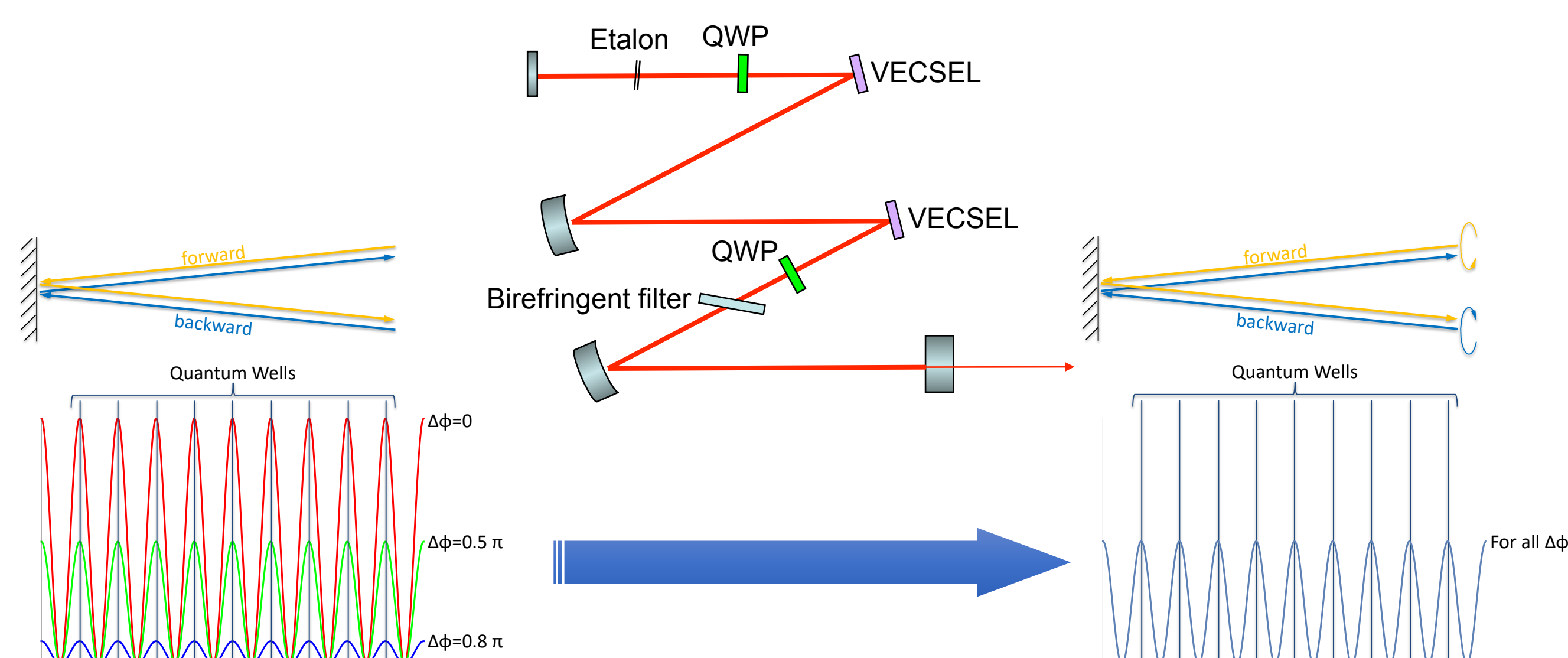
Approach to Sodium Guide Star Laser

VECSEL as Sodium LGS

- VECSEL = Vertical External Cavity Surface Emitting Laser (aka OPSL)
- Attractive candidates for guide star lasers because they are SIMPLE!
- Scalable power output to **tens of watts** with multiple VECSEL devices in one cavity
- Na LGS required to be at 589 nm; challenging to make a VECSEL at this wavelength; instead, run at 1178 nm and frequency double
- GaInNAs devices used

The Scaling Challenge

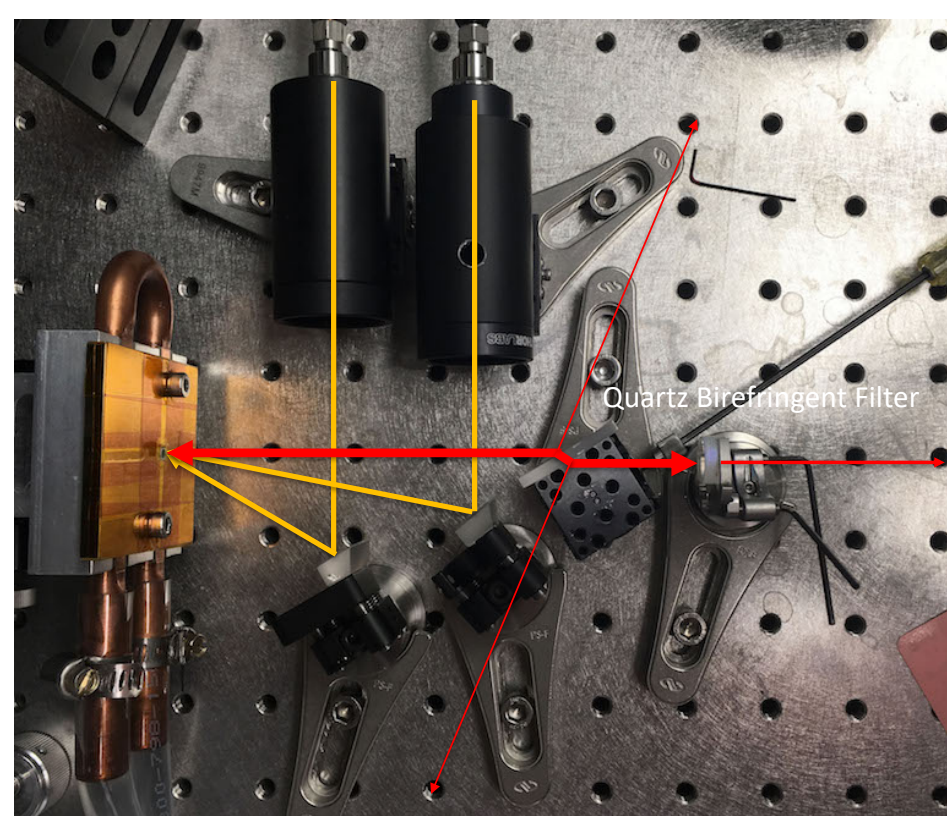
- To maintain stable single-frequency oscillation, forward and backward propagating waves in the cavity **cannot be allowed to interfere** at the VECSEL folds
- Achieved by imposing opposite circular polarization with quarter-wave plates (the “twisted mode”) inserted into an otherwise linearly polarized cavity



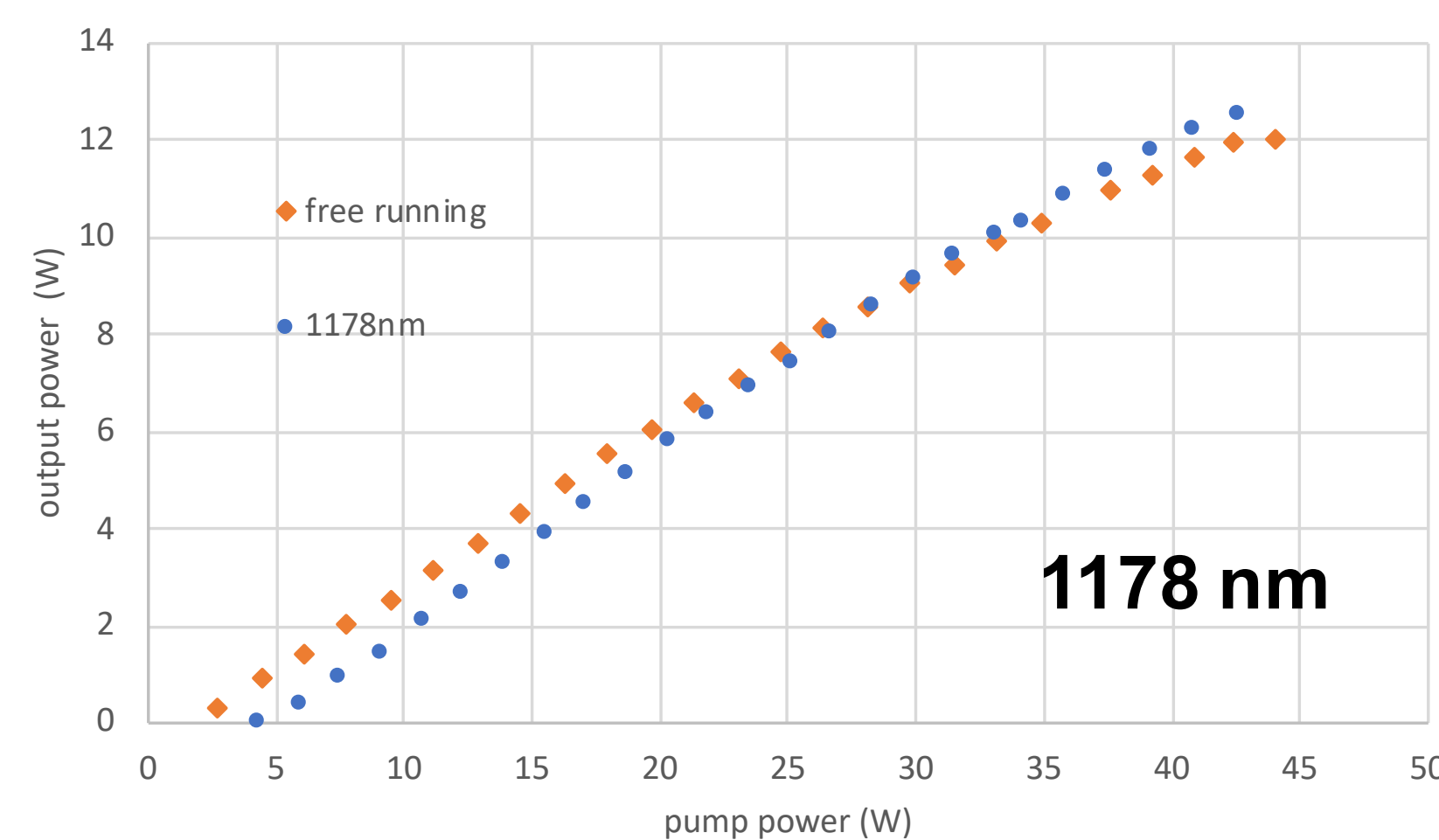
Twisted mode configuration and its standing wave pattern

Power Output from Single VECSEL at 1178 nm

- Power output of free-running VECSEL measured with no frequency selection or polarization elements in the cavity
- Power also measured with birefringent filter in beam to enforce 1178 nm
- Total all-mode power exceeded 12 W



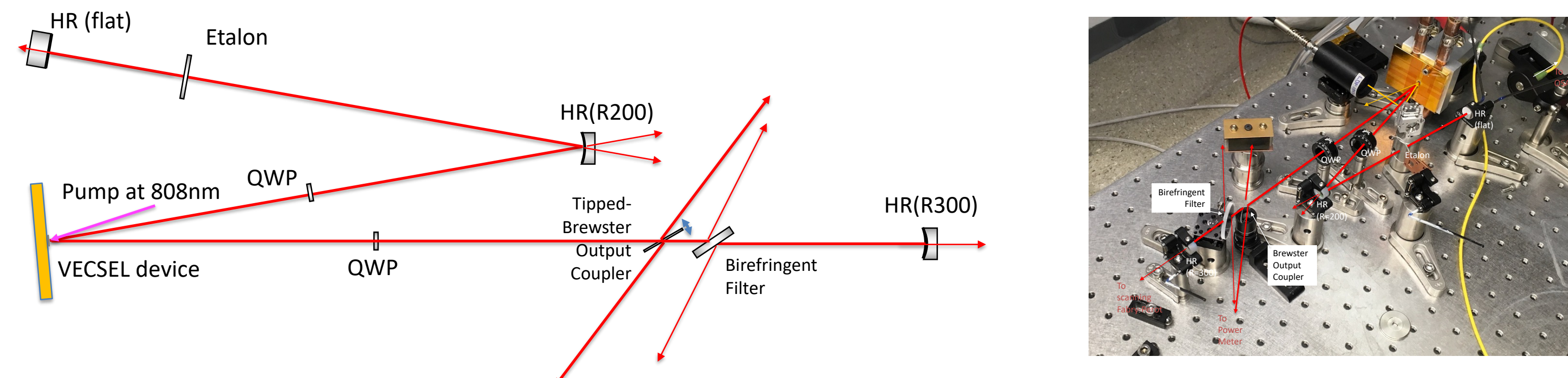
Pump arrangement at 808 nm for single VECSEL test



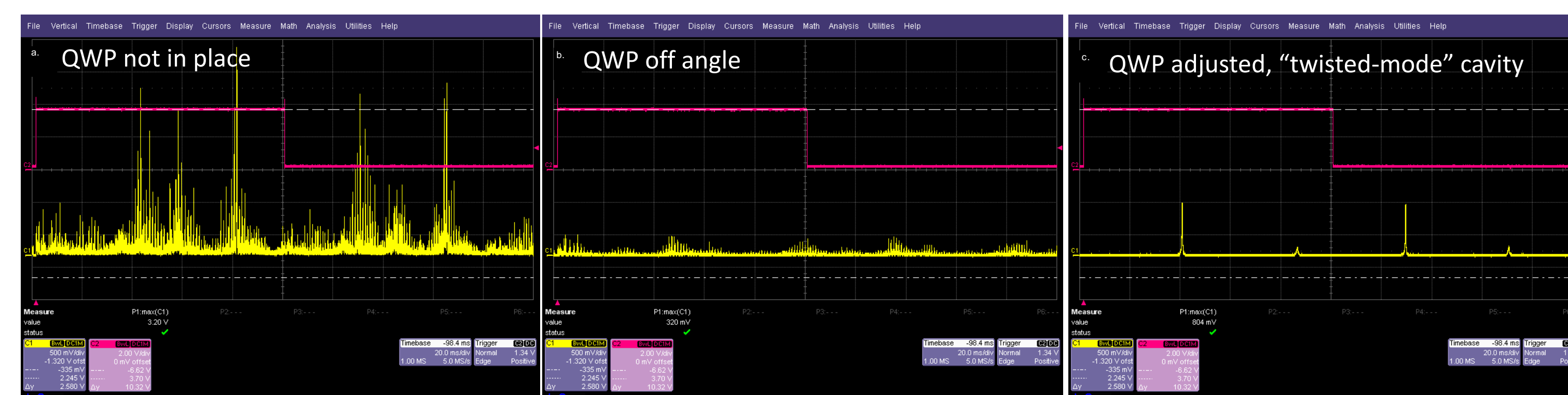
Output power of a single-device VECSEL

Single Frequency Operation: Results

- Z-fold cavity with etalon and BRF to impose wavelength and polarization constraints, and adjustable Brewster window as variable output coupler



Spectra Measured with a Fabry-Perot Interferometer



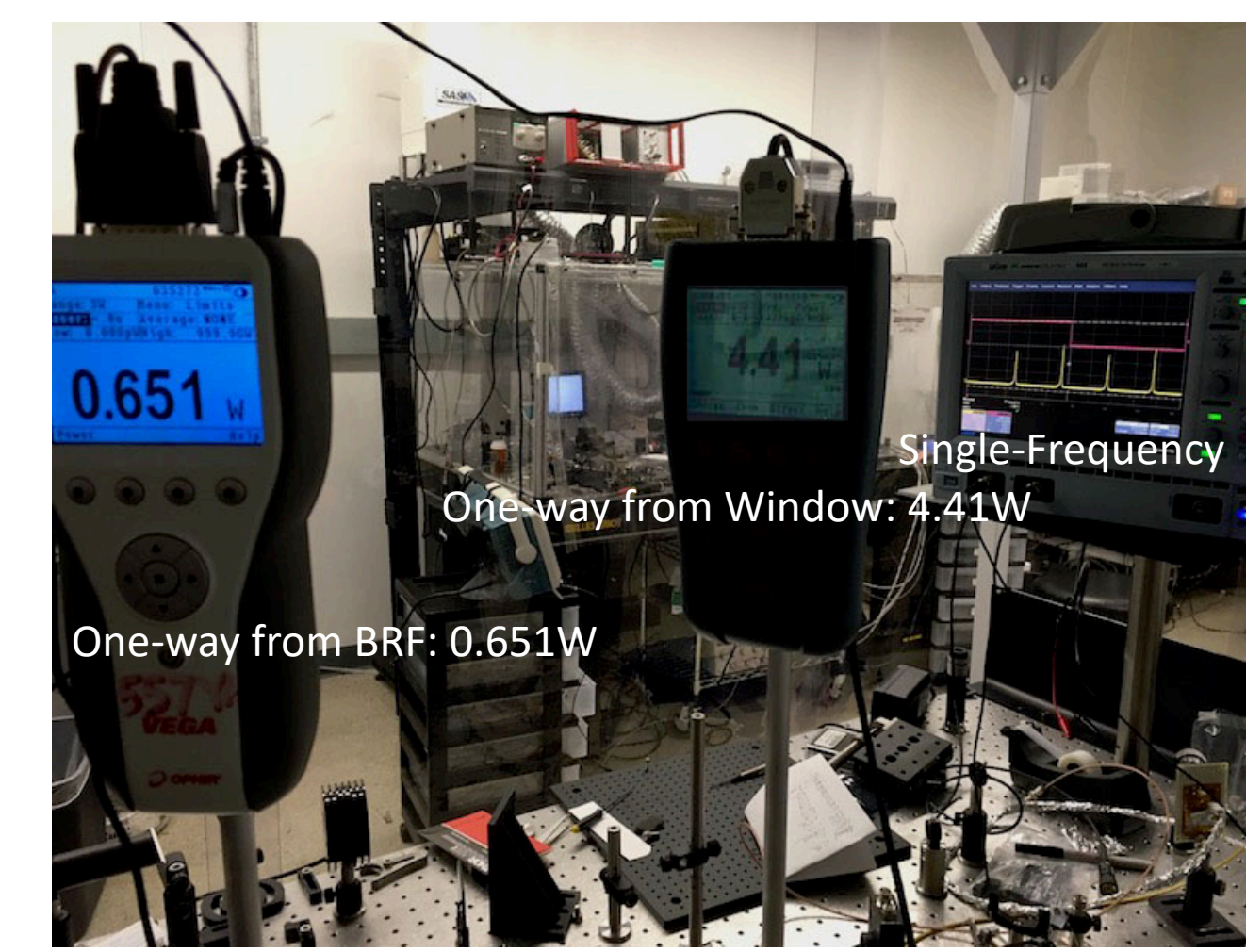
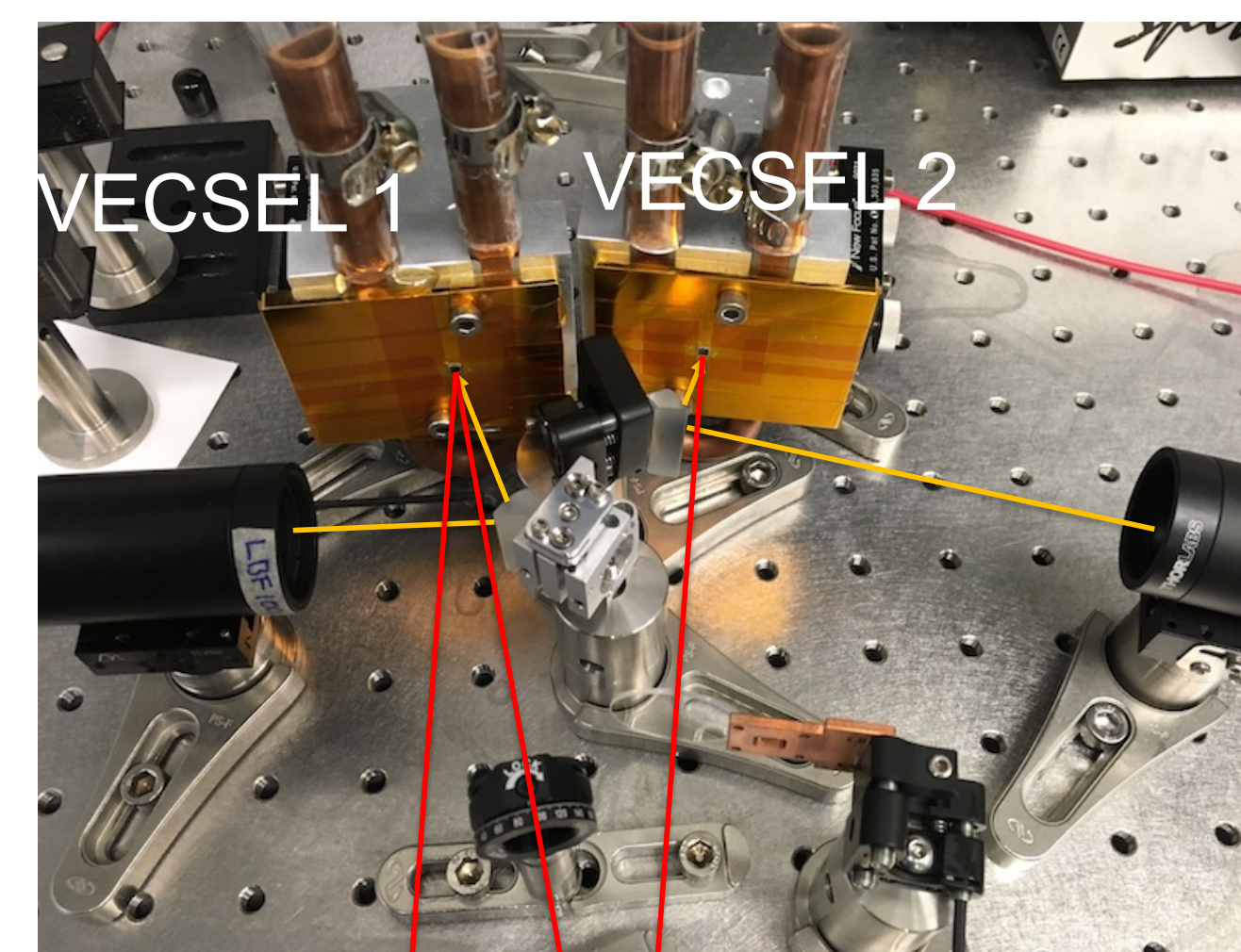
A hideous mess

Still a mess, and low power

Single frequency!

With Two VECSELs in the Cavity

- HR flat replaced with second VECSEL for more power
- **Total power output exceeded 10 W single frequency**
- No special precautions taken in laboratory environment (e.g. thermal control, air flow, vibration)
- Stable single-frequency operation observed for periods > 15 minutes



Conclusions and Next Steps

- Demonstrated twisted-mode stable single-frequency operation
- Demonstrated single-frequency output from a two-device VECSEL cavity of 10.12 W at 1178 nm
- Next step: expand cavity to include four VECSEL devices
- Install conventional output coupler with 6% transmission
- Add frequency-doubling external cavity to 589 nm based on PPLT crystal