ECE558 Course Project

Photonic Testbed for E-O-E Neuron Characterization

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Outline

Introduction & Motivation

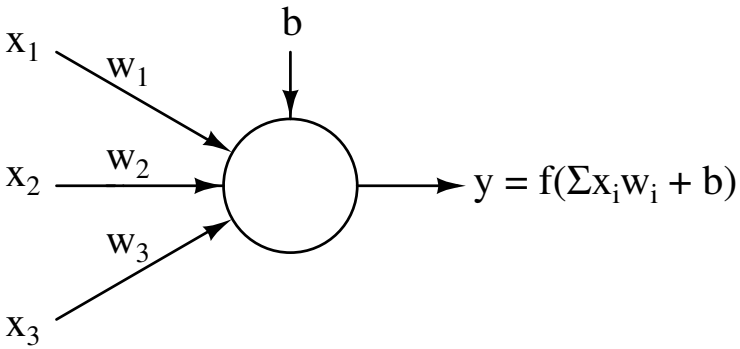


Figure: Neuron functional model

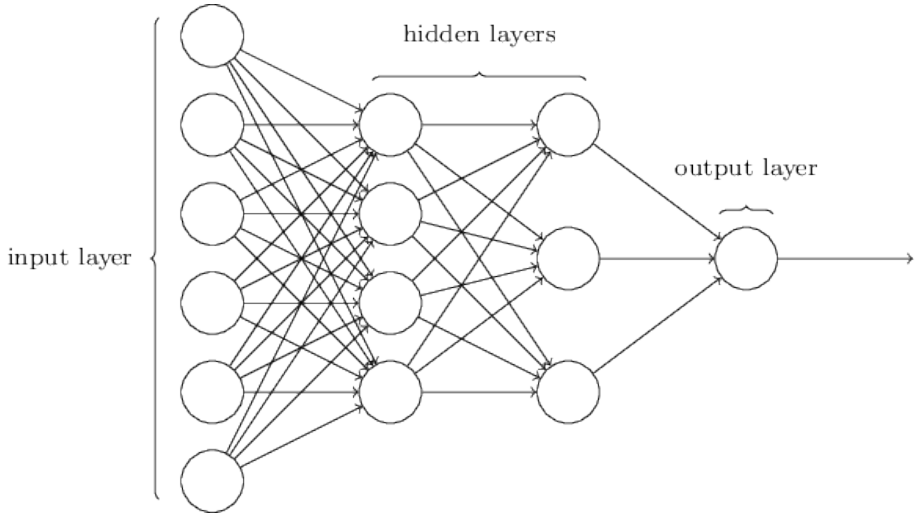


Figure: Neural Network example

- Photonic systems have the following advantages over electrical systems:
  - High operational bandwidth
  - Lower cross-talk between multiplexed channels
  - Lower power dissipation
- This motivates research into photonic integrated circuits for performing neural network computations

Photonic Neural Networks

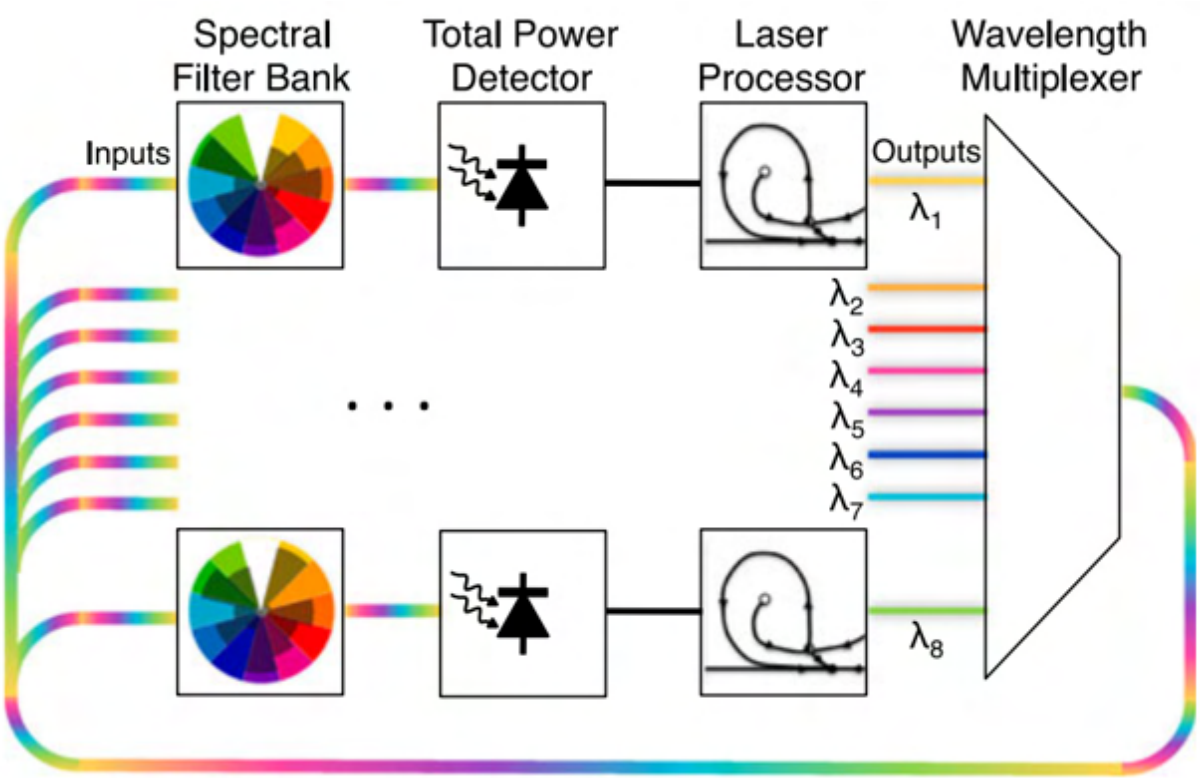


Figure: Optical broadcast and weight network

A. N. Tait, M. A. Nahmias, B. J. Shastri and P. R. Prucnal, "Broadcast and Weight: An Integrated Network For Scalable Photonic Spike Processing," in Journal of Lightwave Technology, vol. 32, no. 21, pp. 4029-4041, 1 Nov.1, 2014, doi: 10.1109/JLT.2014.2345652.

Photonic Neural Networks

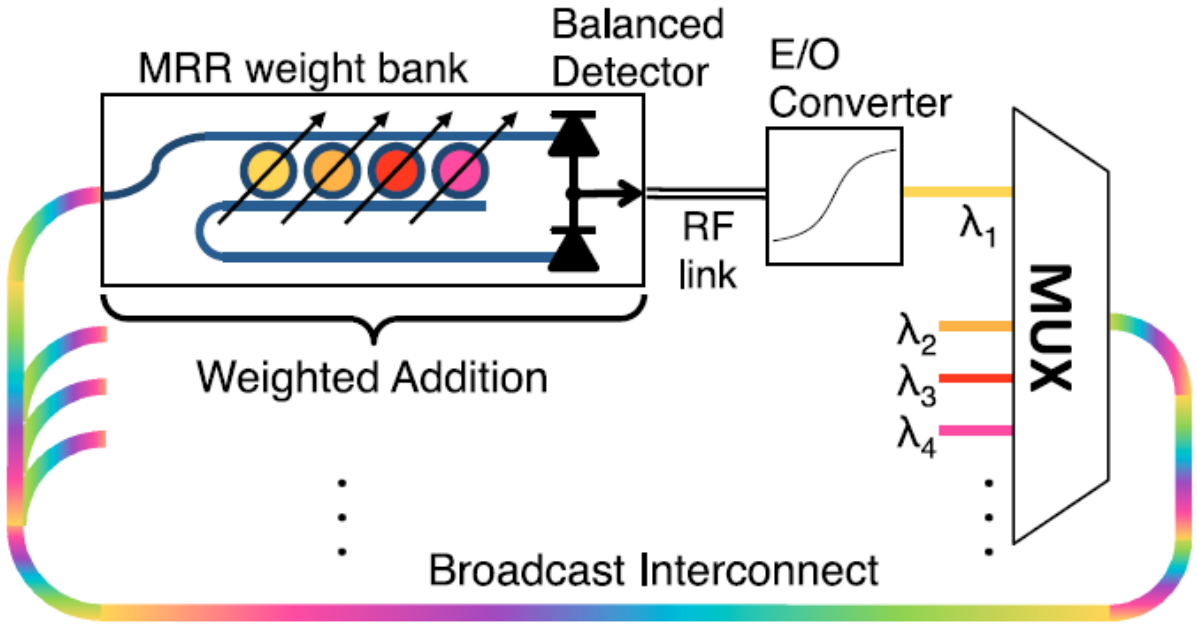


Figure: Microring Resonators (MRR) used as tunable spectral filters in an optical broadcast and weight network

A. N. Tait et al., "Microring Weight Banks," in IEEE Journal of Selected Topics in Quantum Electronics, vol. 22, no. 6, pp. 312-325, Nov.-Dec. 2016, Art no. 5900214, doi: 10.1109/JSTQE.2016.2573583.

Lionrock Chip & Test Setup

Figure: Layout of Lionrock chip designed by Lightwave Lab

Lionrock Chip & Test Setup

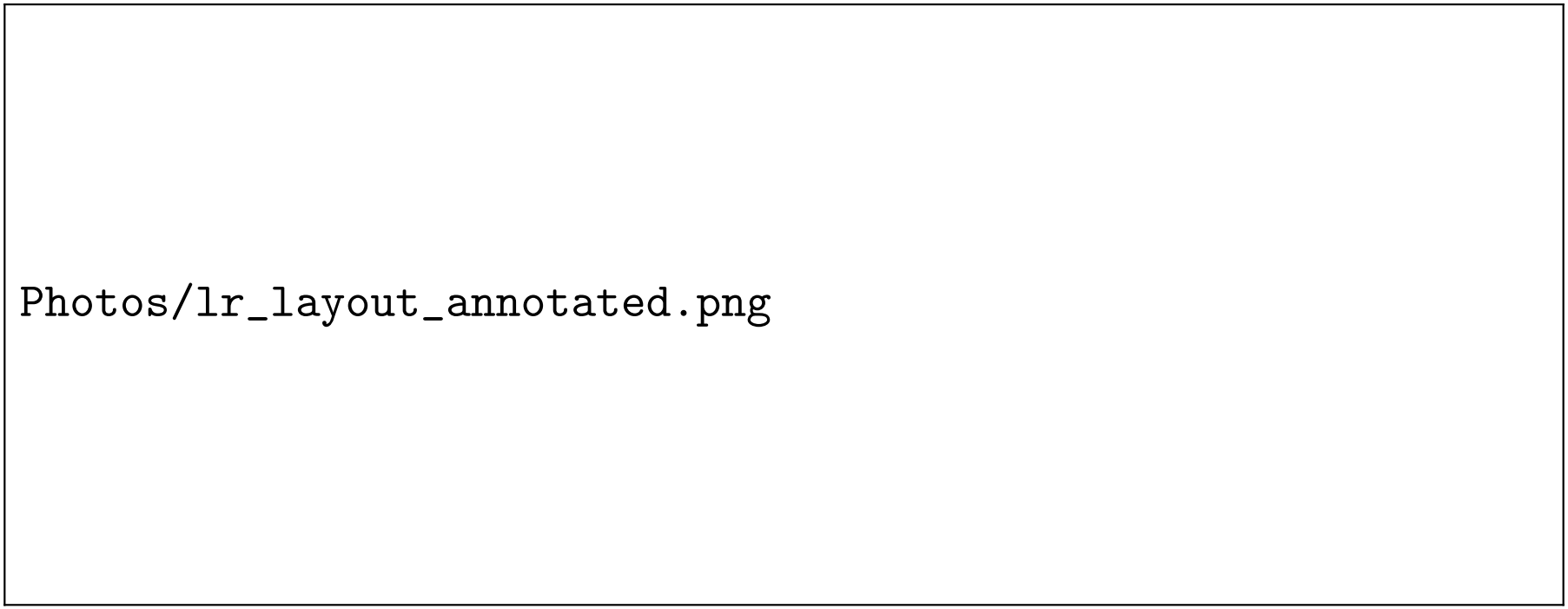


Figure: Layout of Lionrock chip designed by Lightwave Lab

Lionrock Chip & Test Setup

Figure: Test setup for E-O-E Neuron Characterization

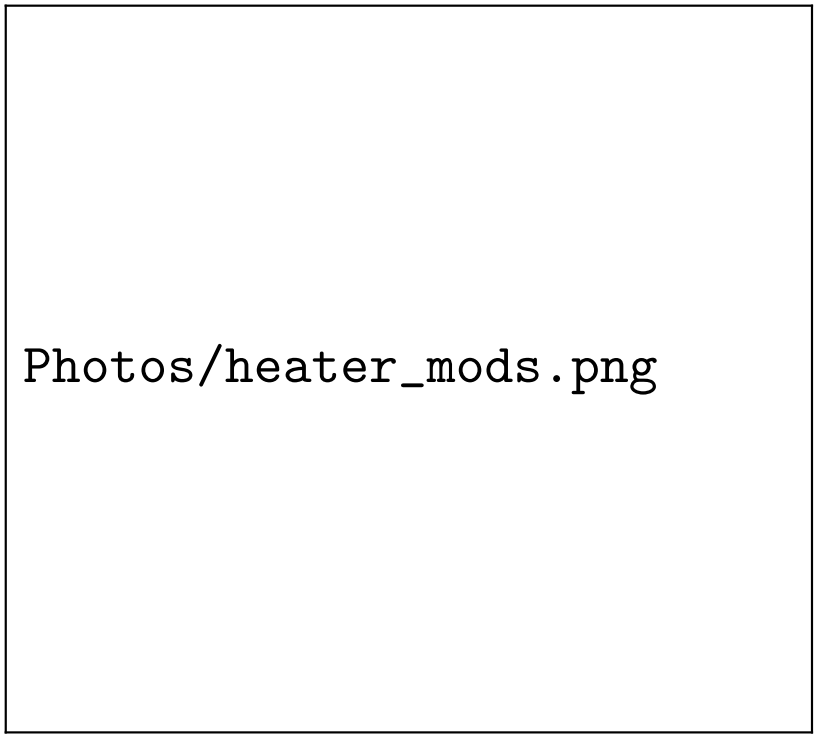


Figure: MRR_2 with heater modulator

Lionrock Chip & Test Setup

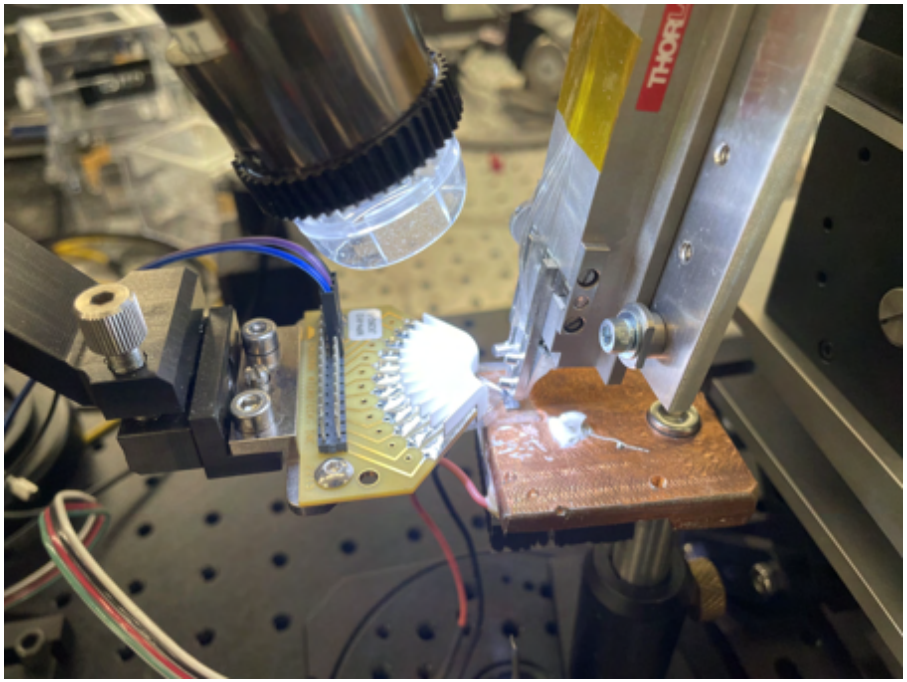


Figure: Test setup side view

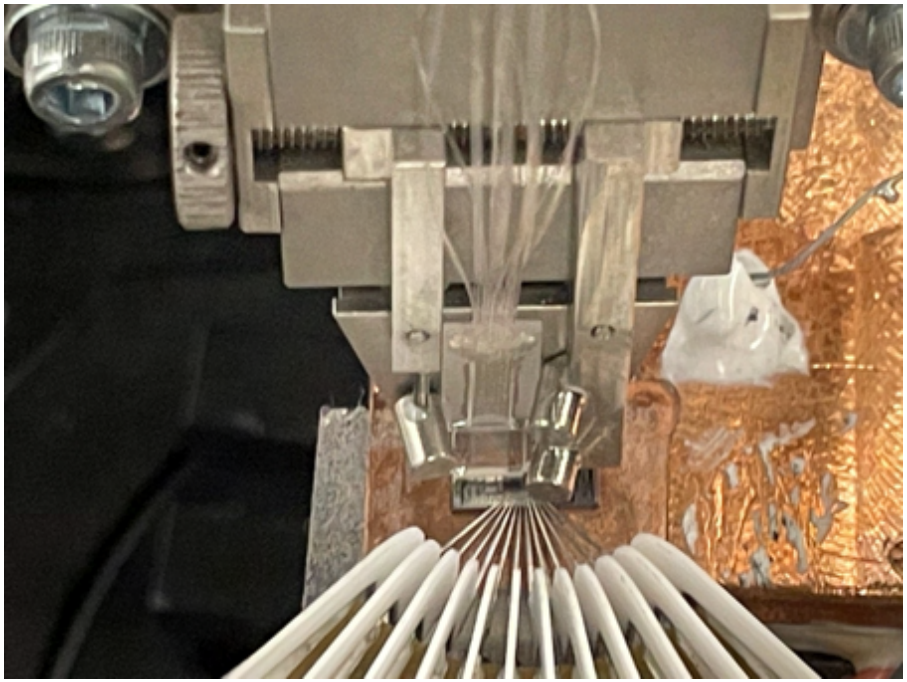


Figure: Test setup top view

Lionrock Chip & Test Setup

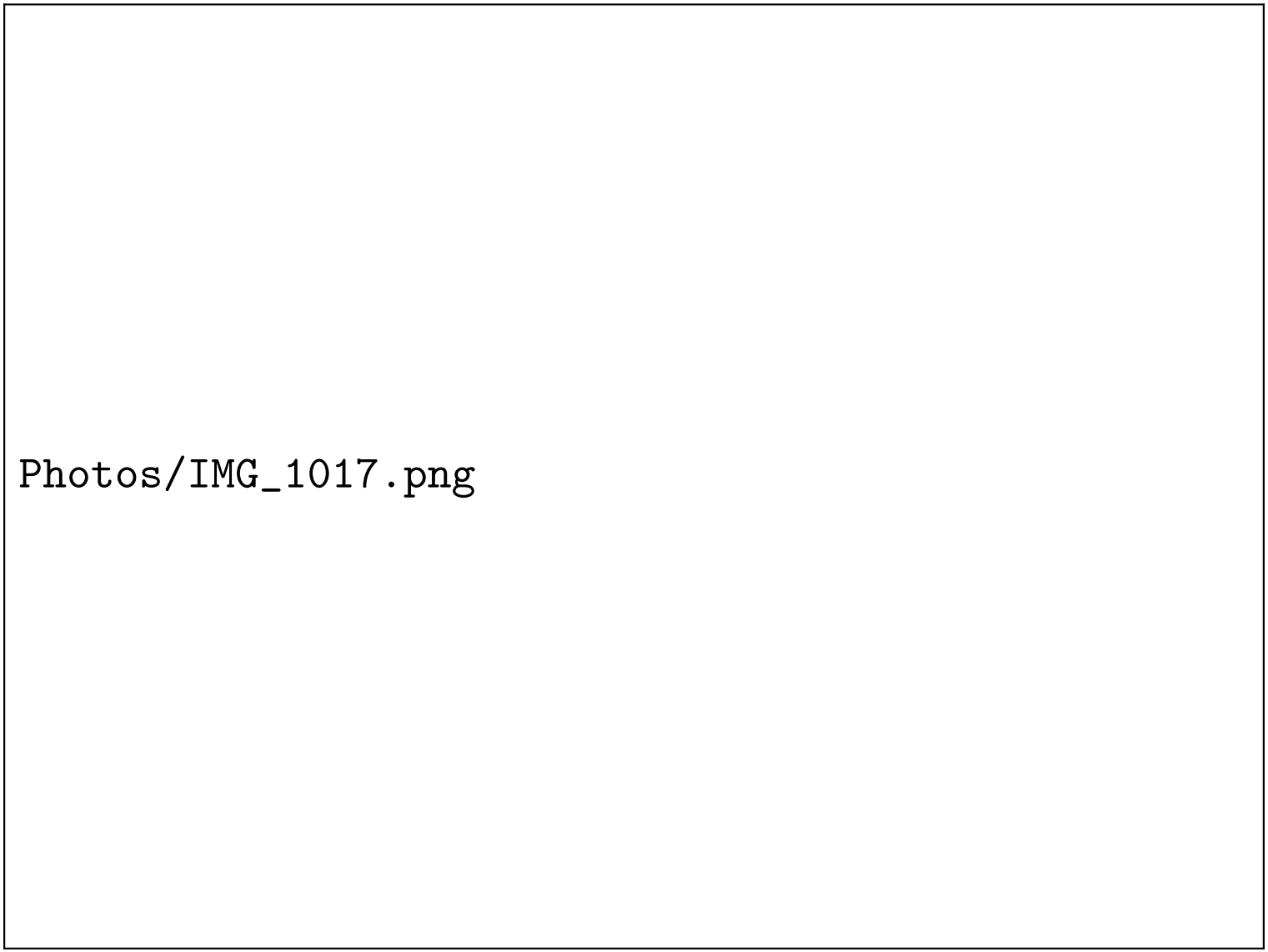
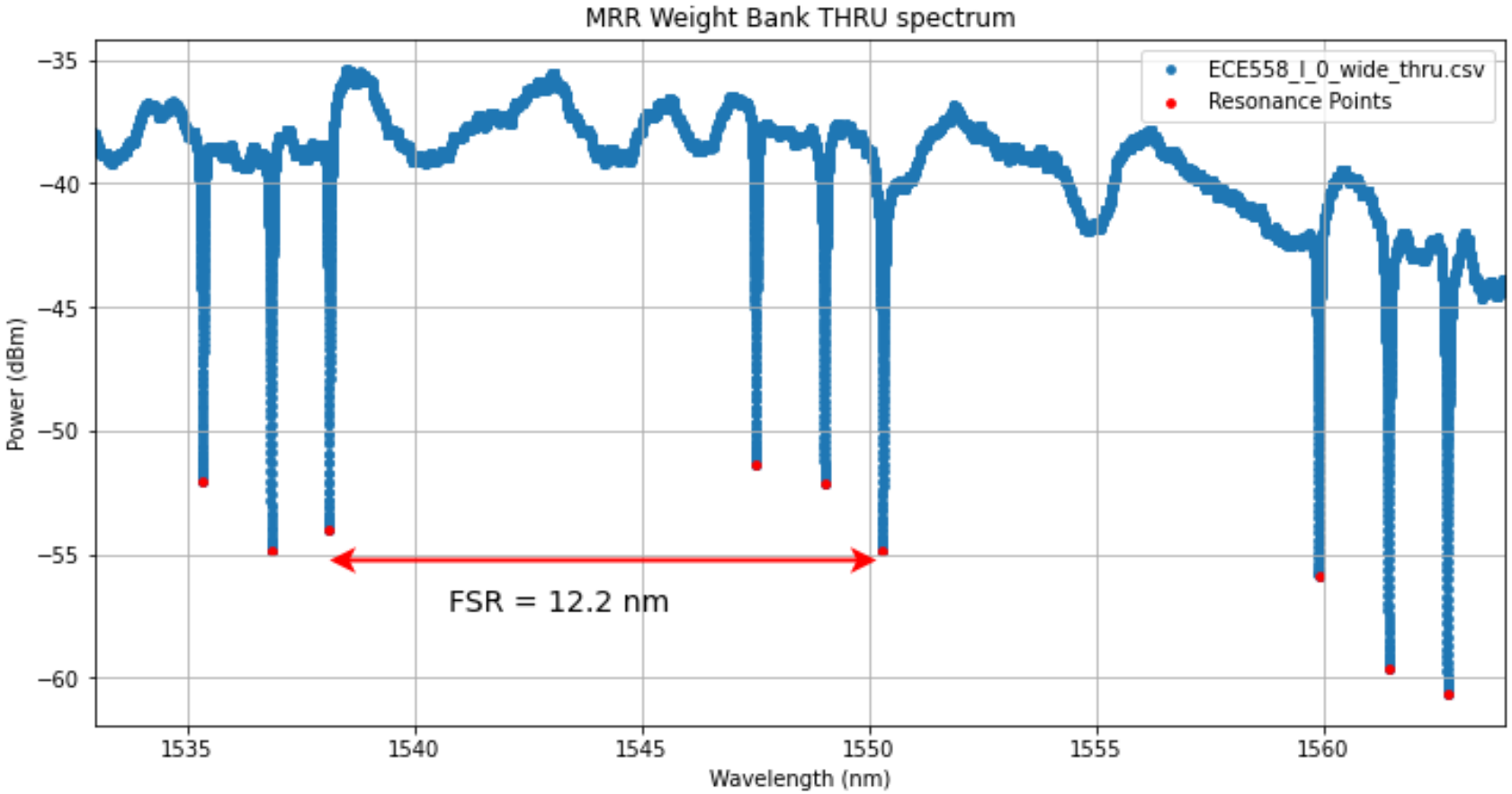


Figure: Complete test setup

THRU Port Measurements



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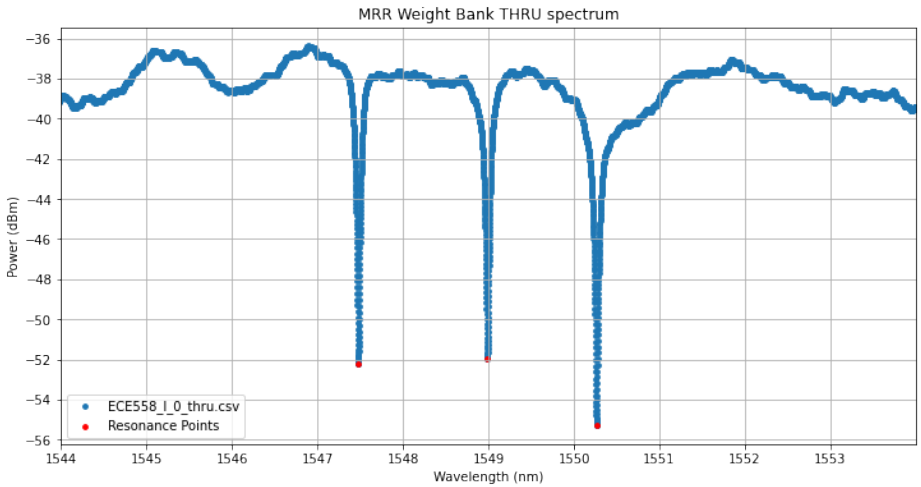

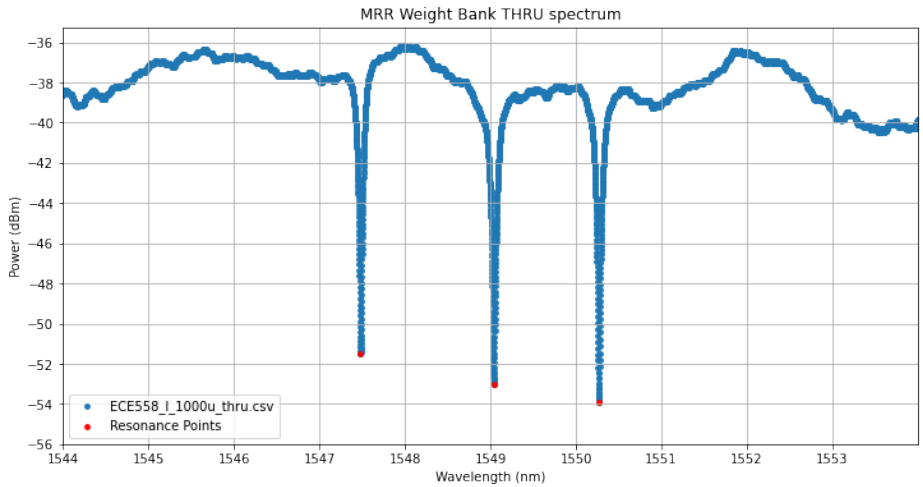

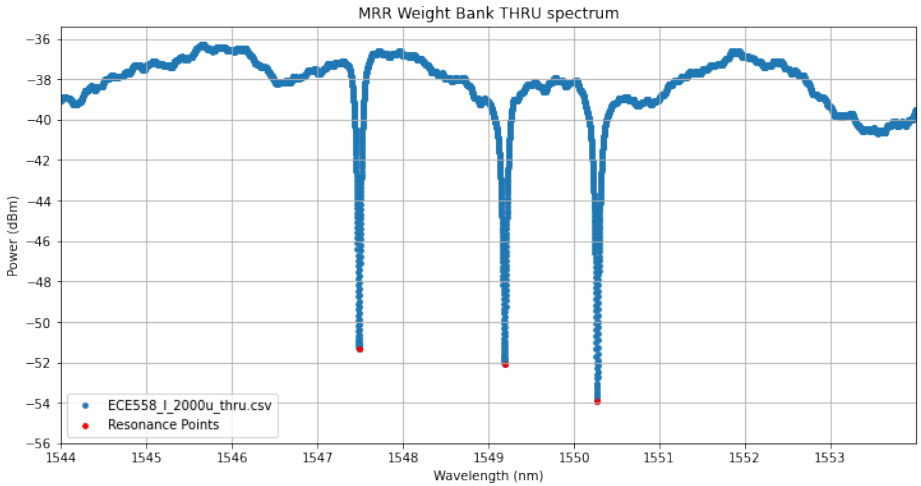

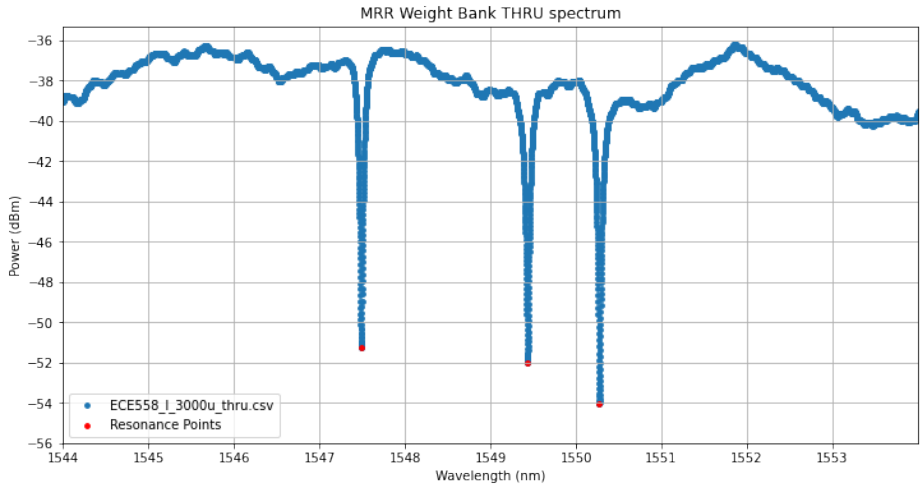

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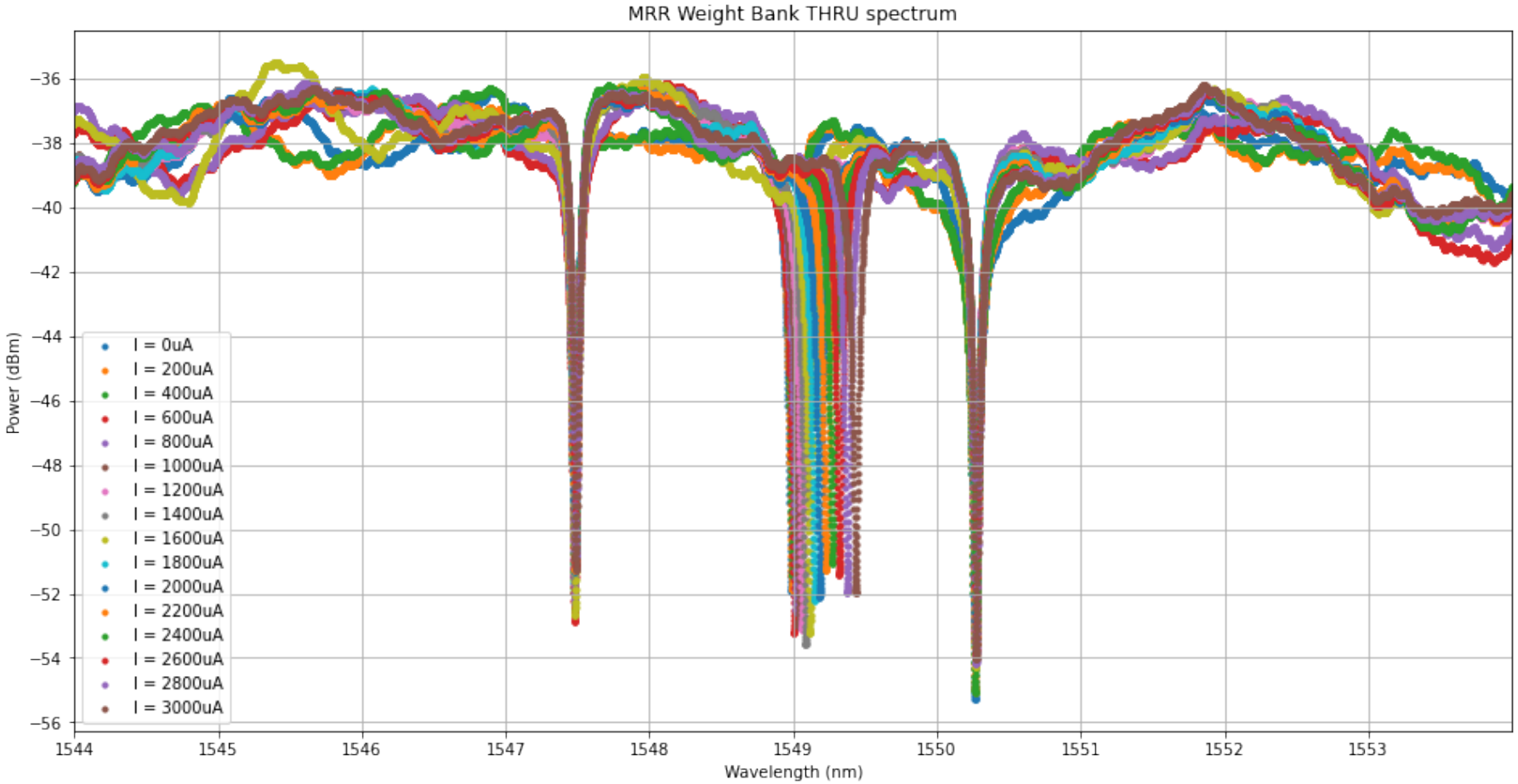
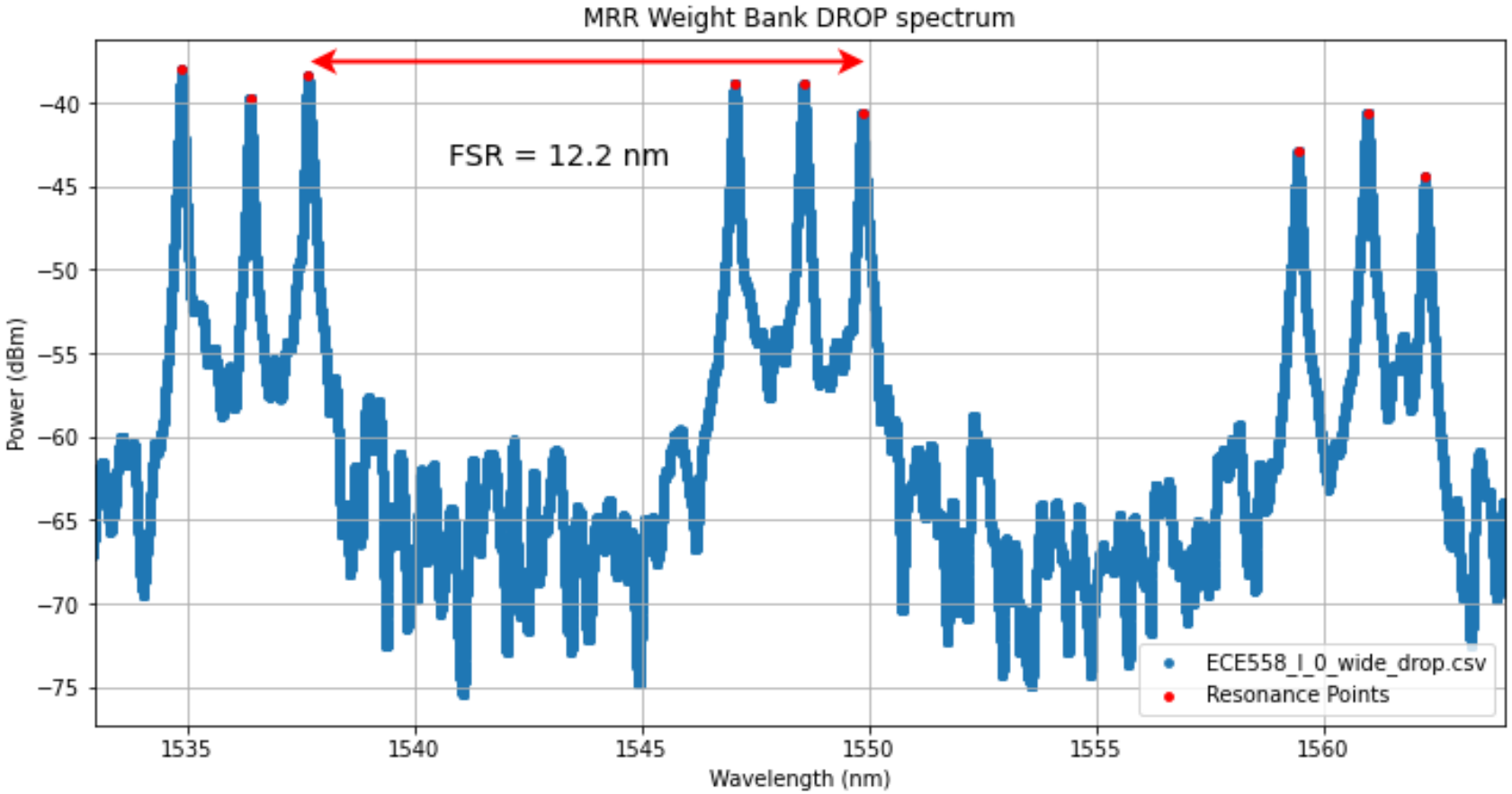


DROP Port Measurements



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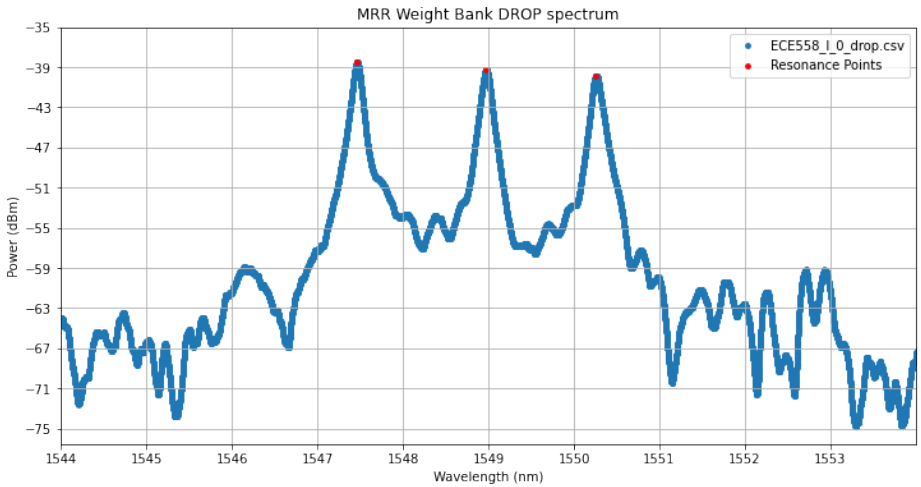

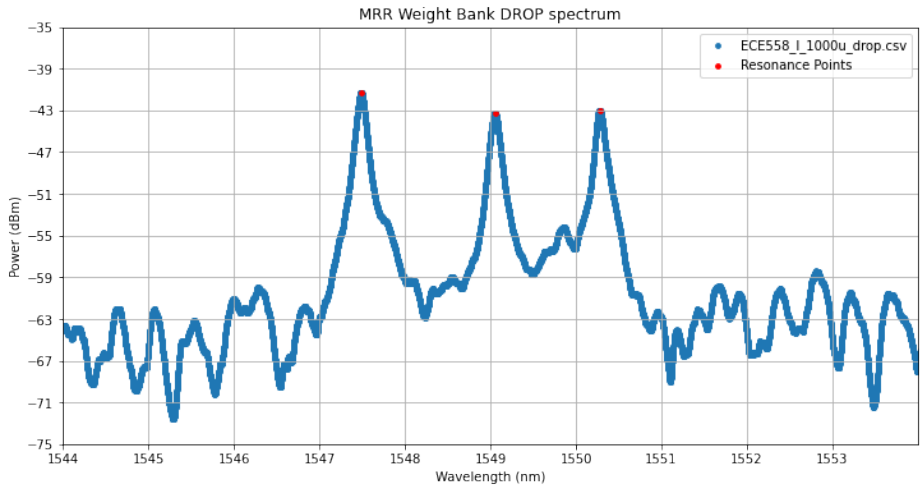

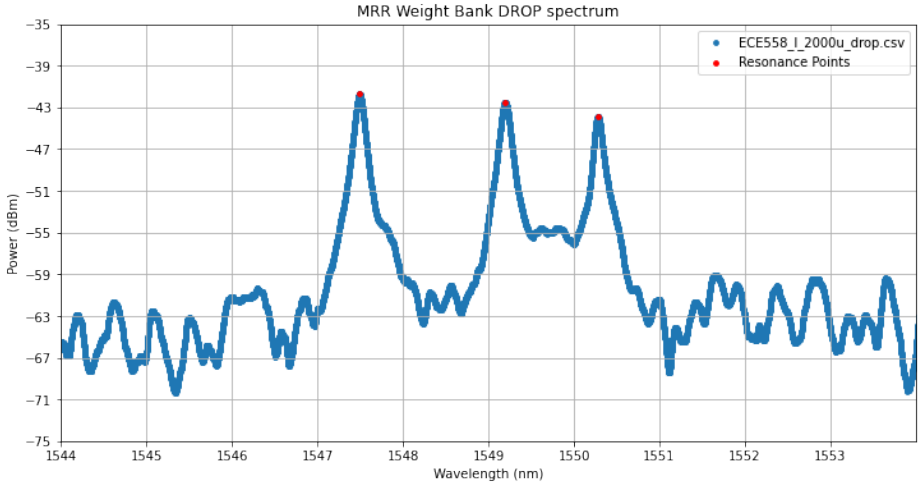

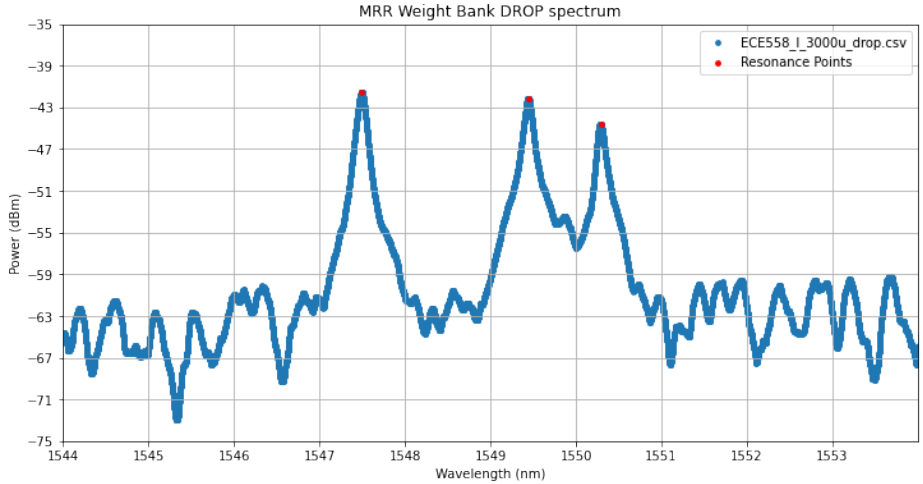

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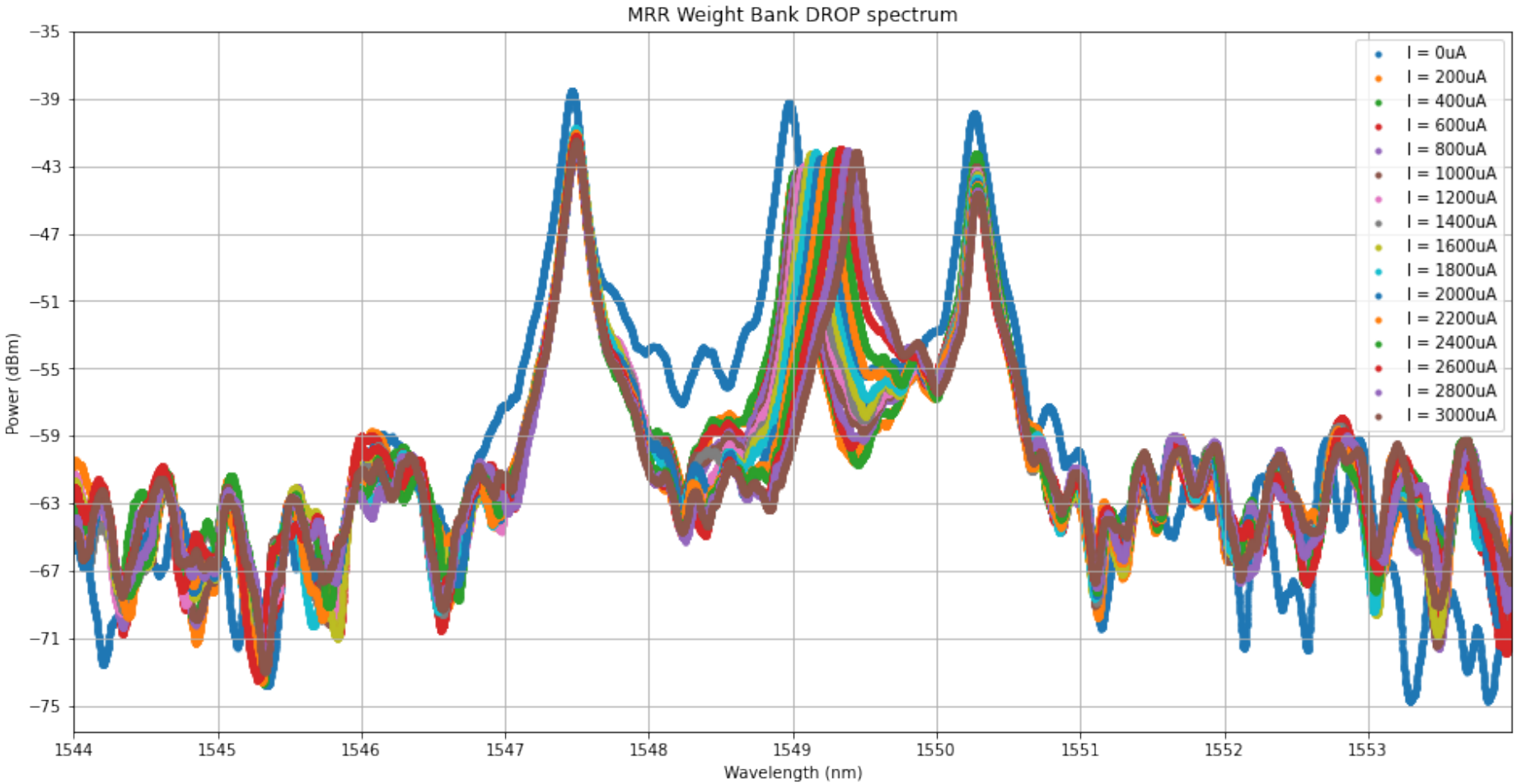
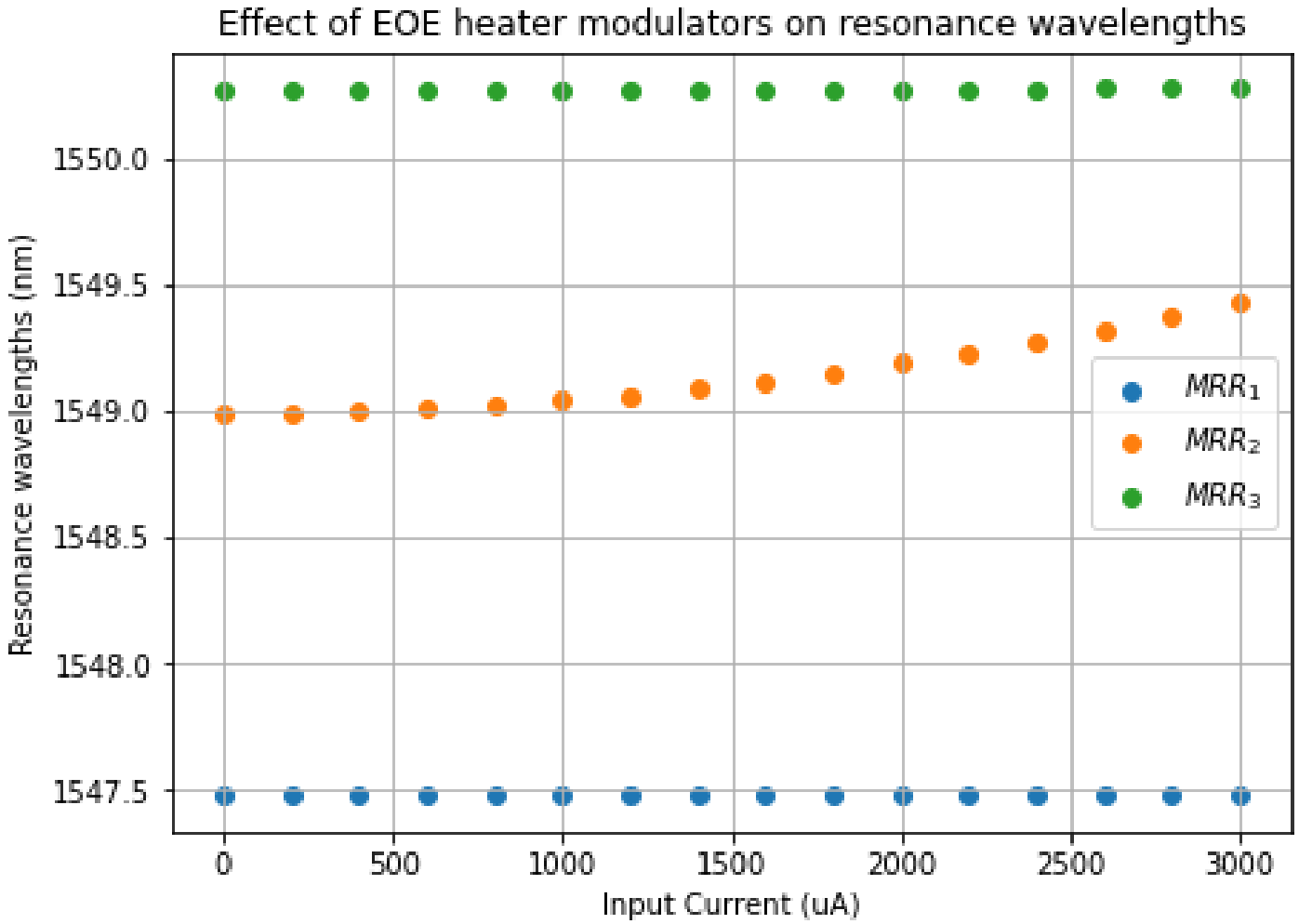


Combined Results



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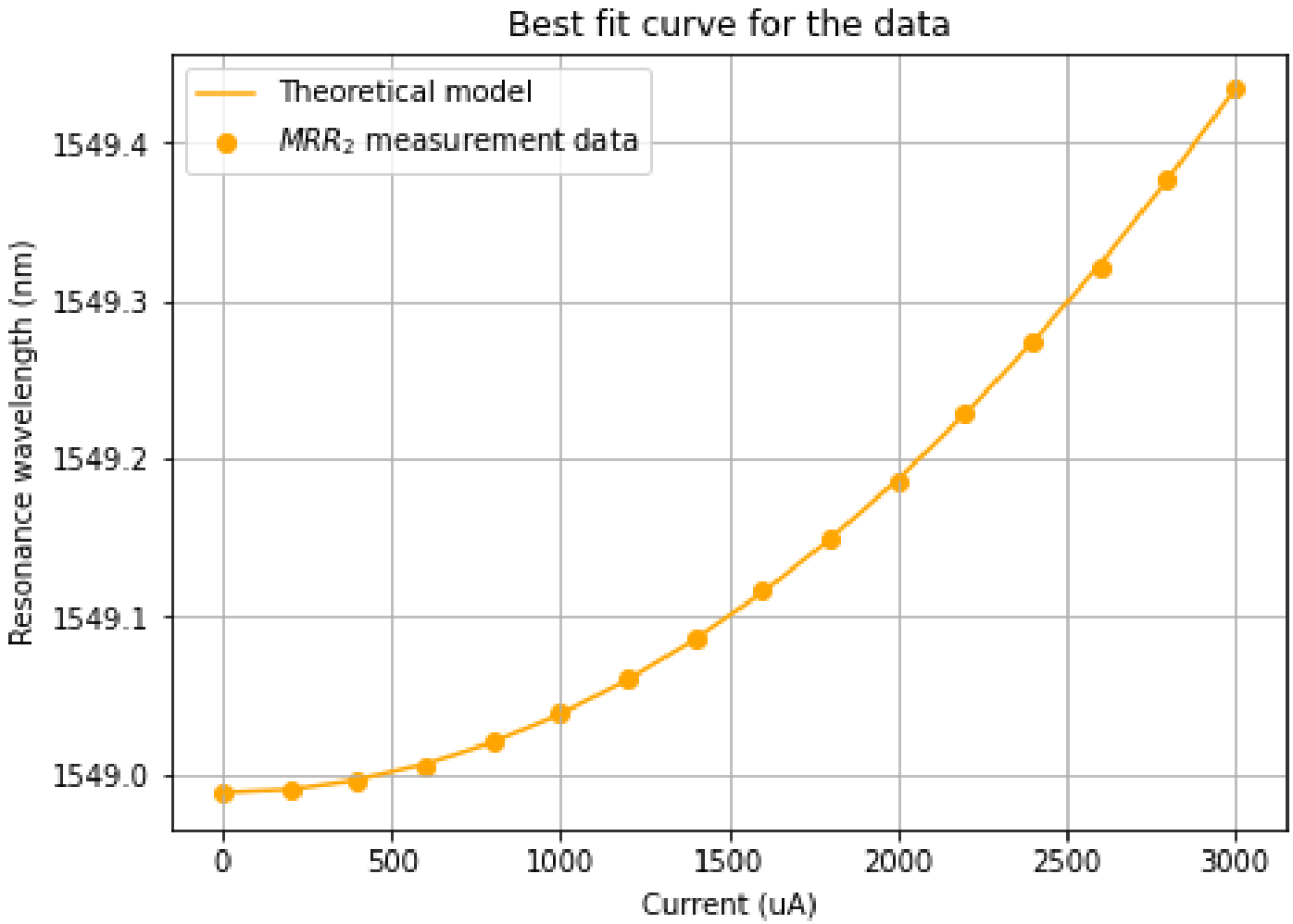
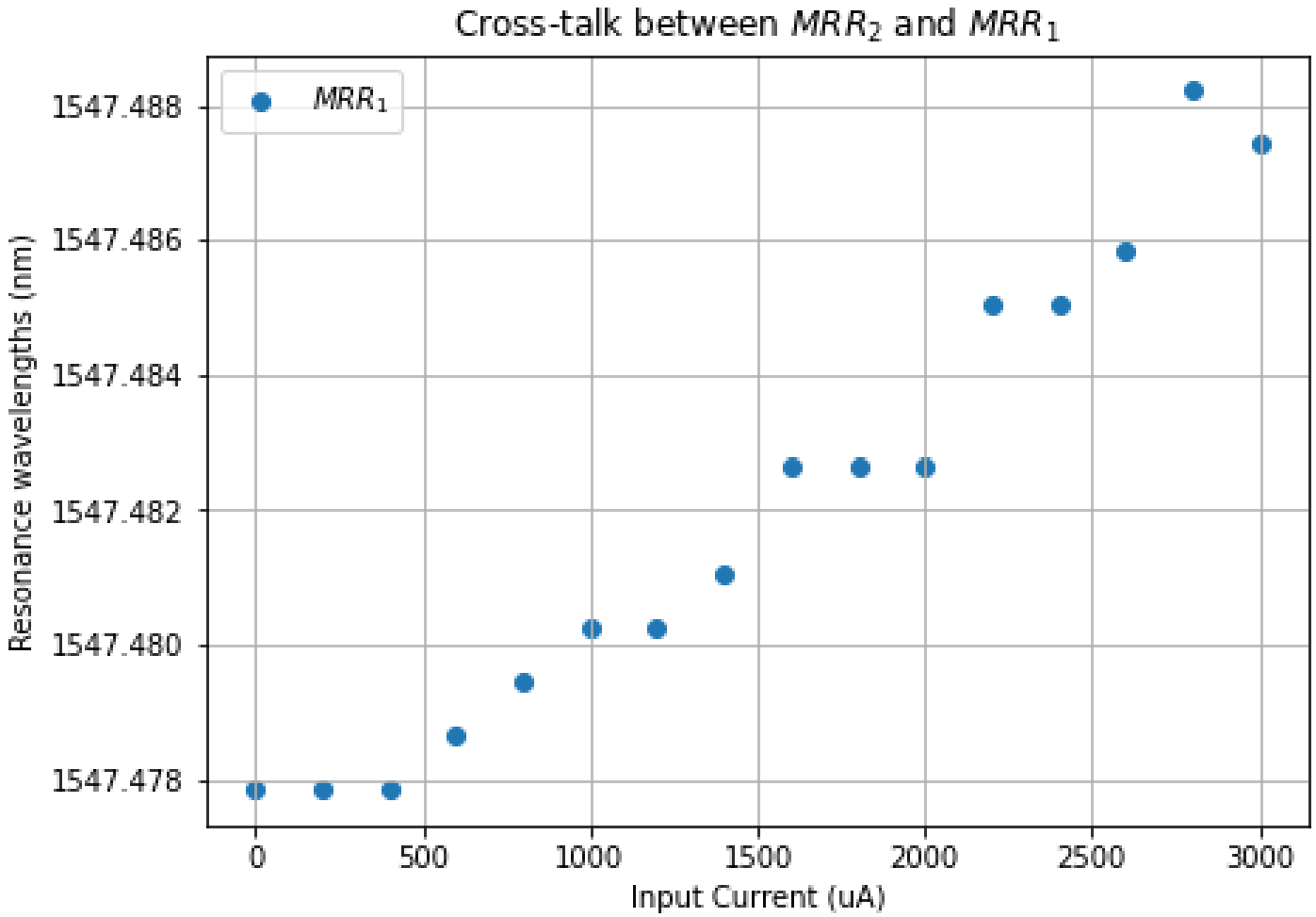


$$\lambda_0\ (nm) \approx 1548.99 + 4.945 \times 10^{-8} \times (i\ (\mu A))^2$$

Combined Results



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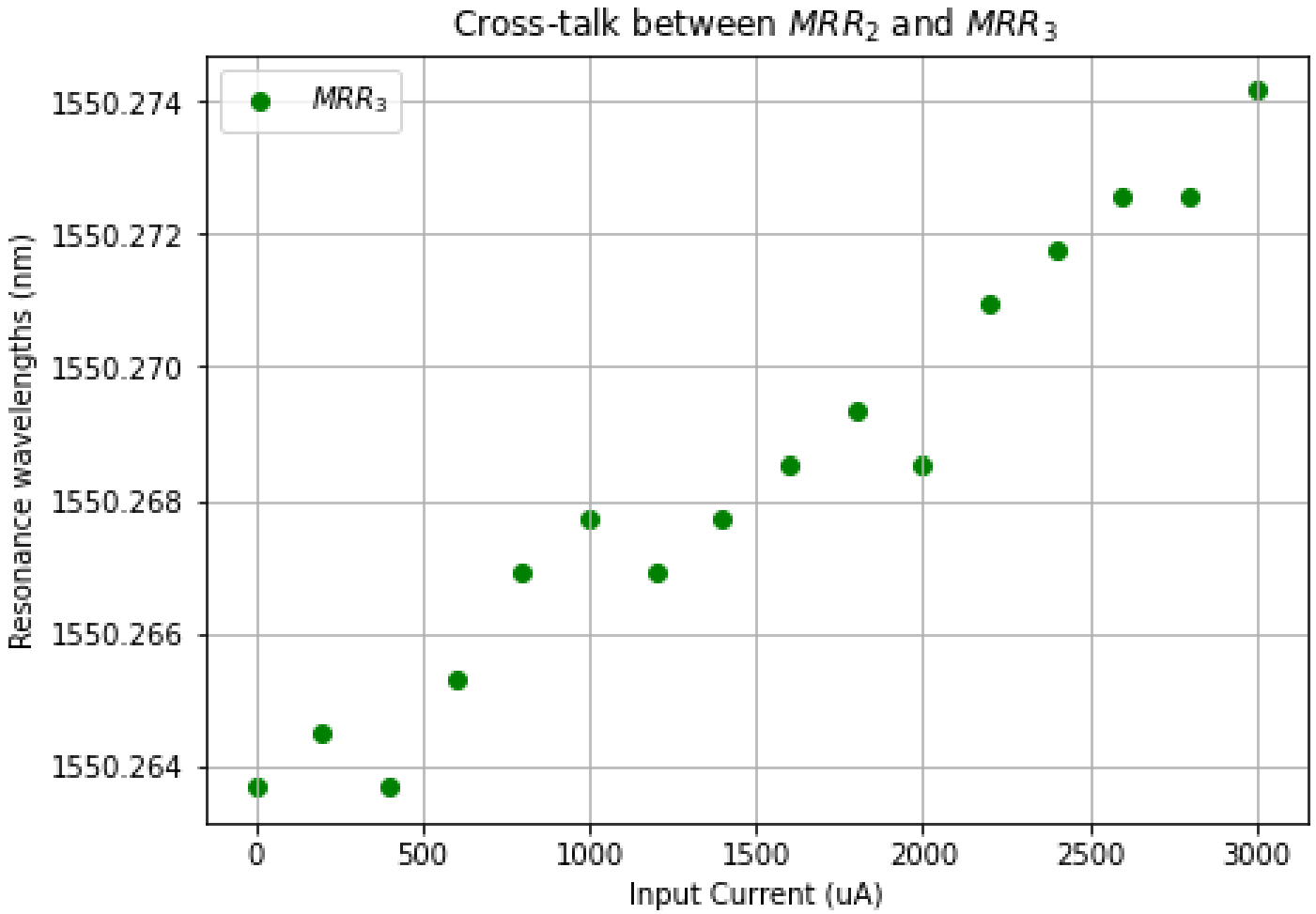

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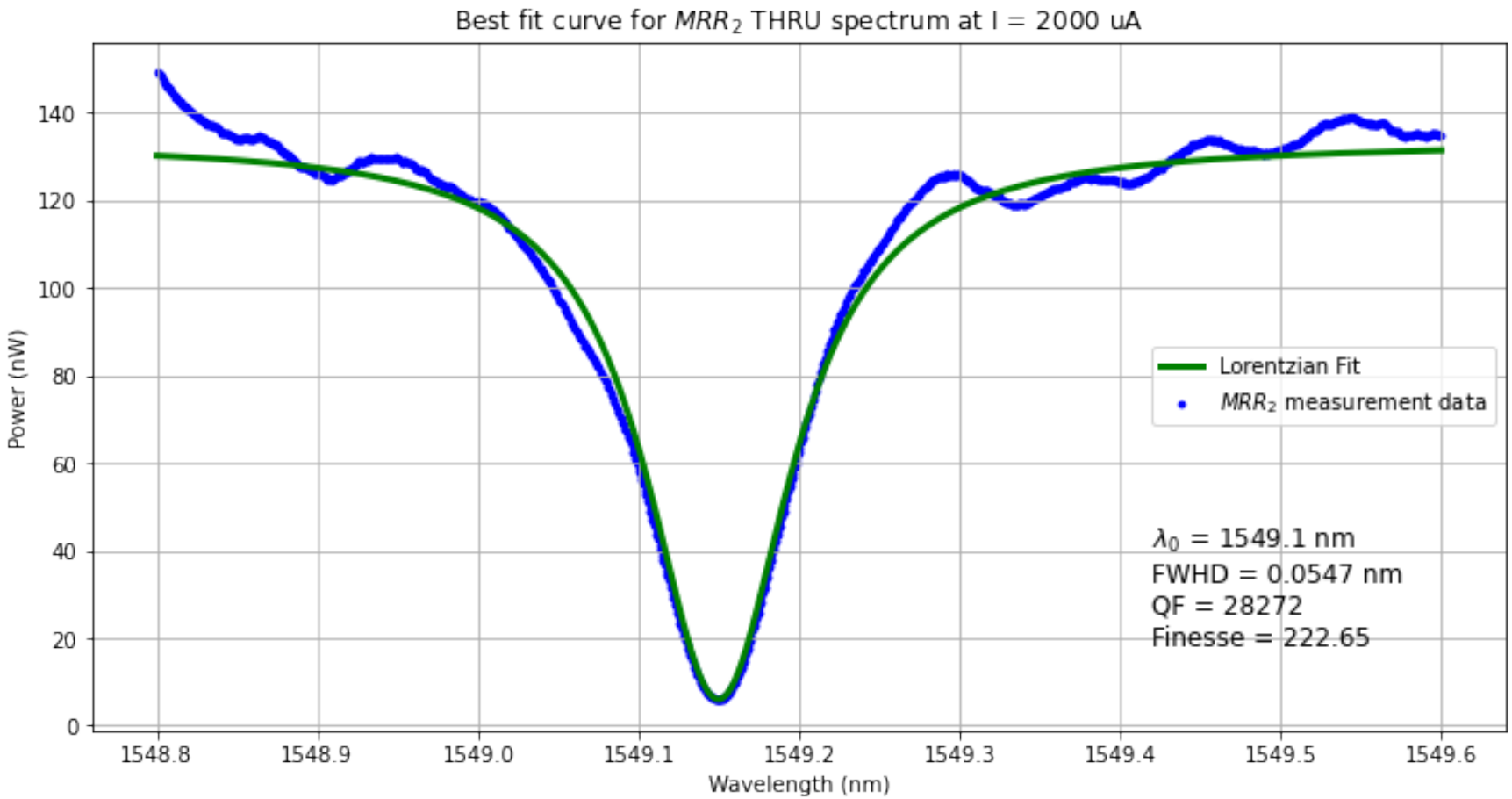
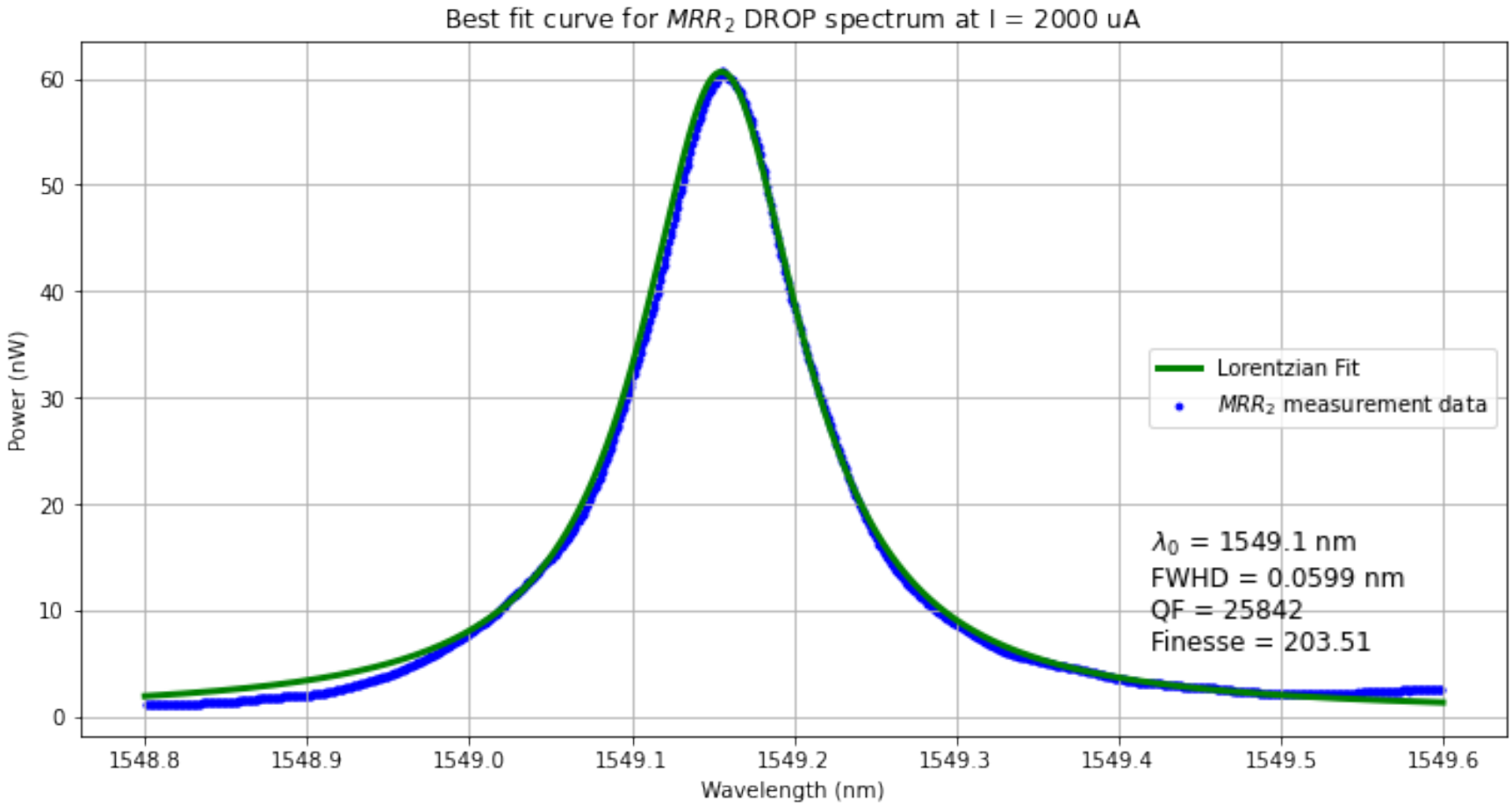


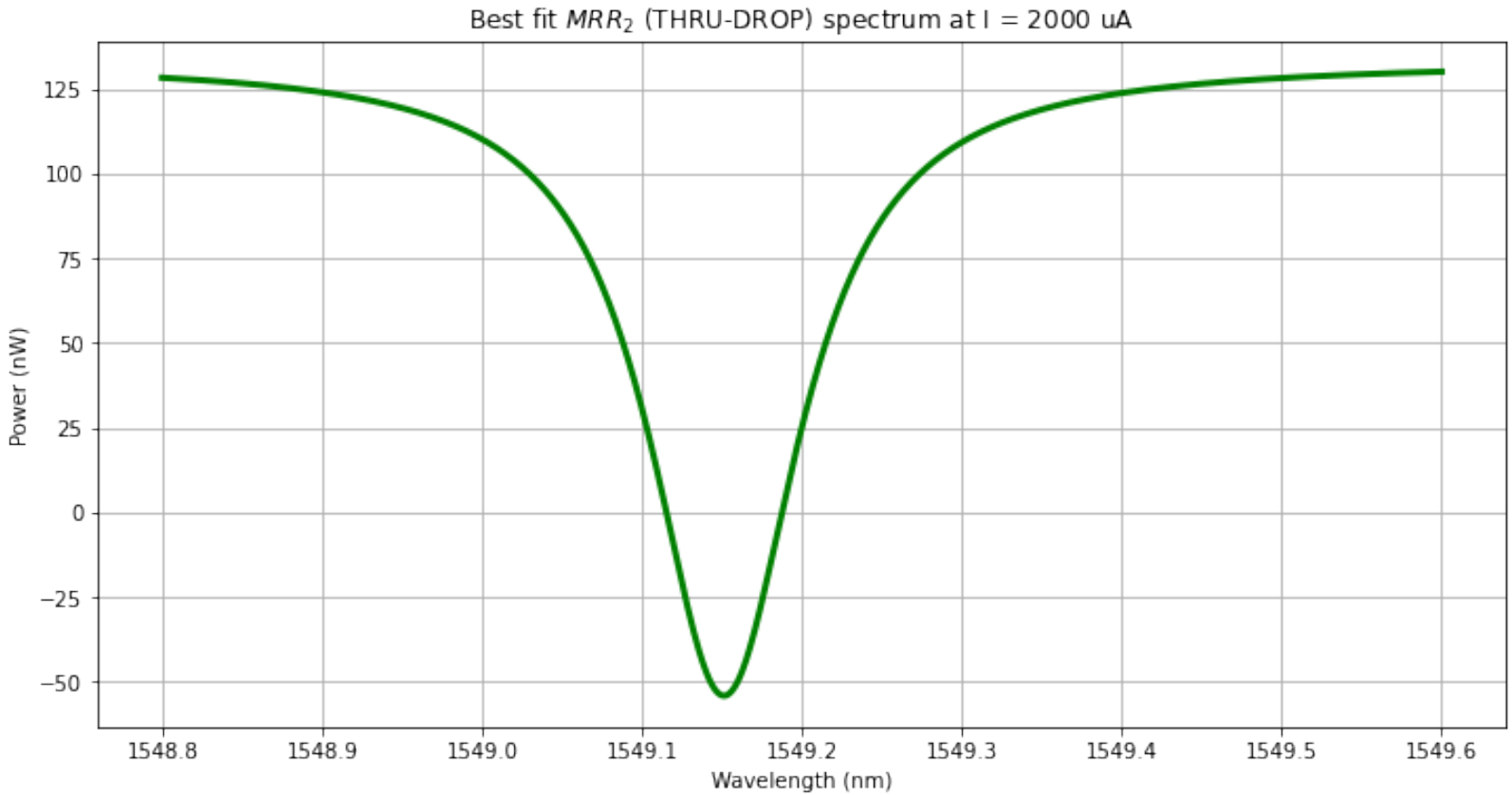
$$P(\lambda, \lambda_0) \approx P_{max} - \frac{P_{max} - P_{min}}{1 + \left(\frac{QF \times (\lambda - \lambda_0)}{\lambda_0}\right)^2}$$

Combined Results



$$P(\lambda, \lambda_0) \approx P_{min} + \frac{P_{max} - P_{min}}{1 + \left(\frac{QF \times (\lambda - \lambda_0)}{\lambda_0}\right)^2}$$

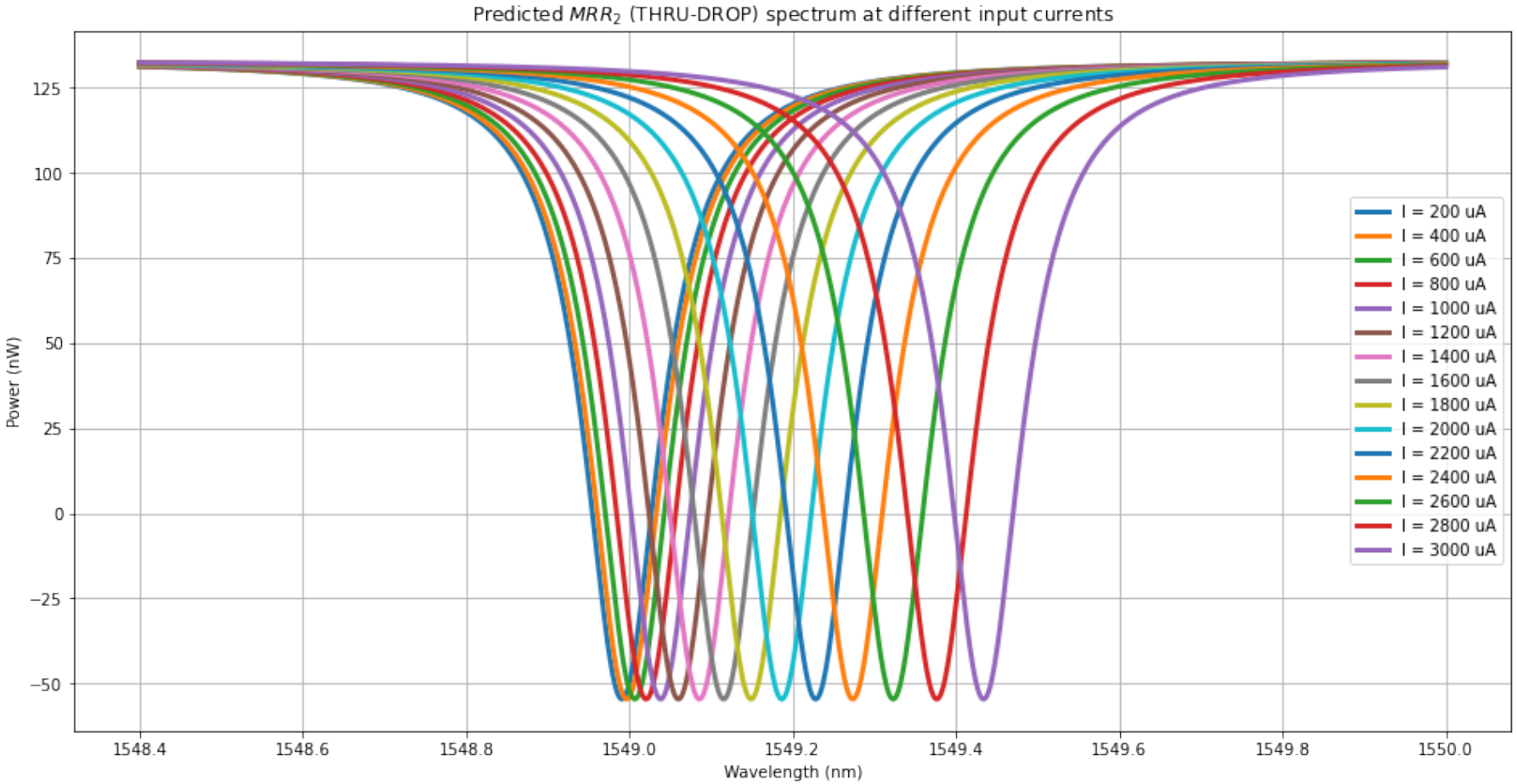
Combined Results



$$P(\lambda, \lambda_0) \approx a - \frac{b}{1 + \left(\frac{QF_{THRU} \times (\lambda - \lambda_0)}{\lambda_0}\right)^2} - \frac{c}{1 + \left(\frac{QF_{DROP} \times (\lambda - \lambda_0)}{\lambda_0}\right)^2}$$

$$\lambda_0\ (nm) \approx 1548.99 + 4.945 \times 10^{-8} \times (i\ (\mu A))^2$$

Combined Results



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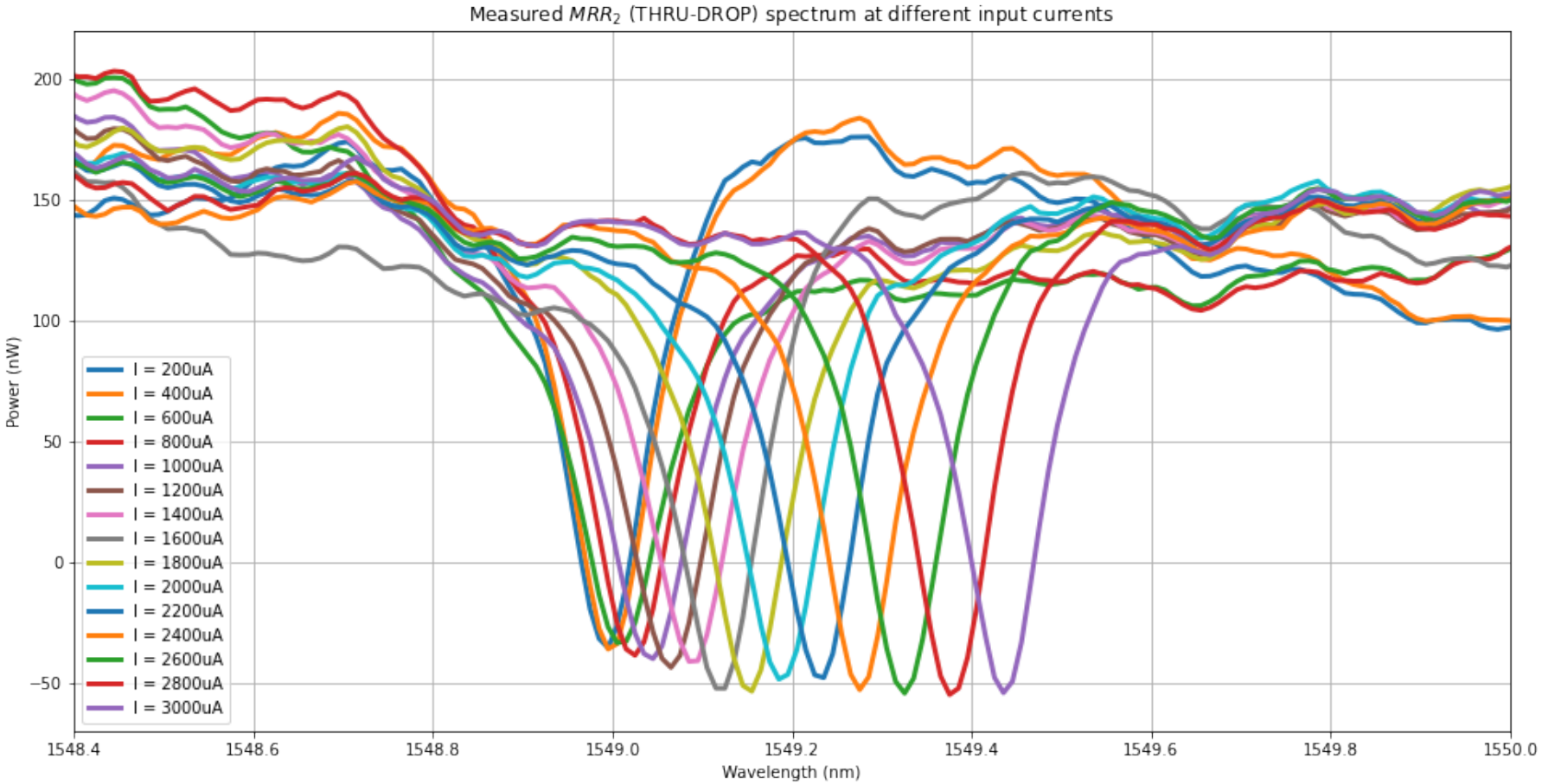

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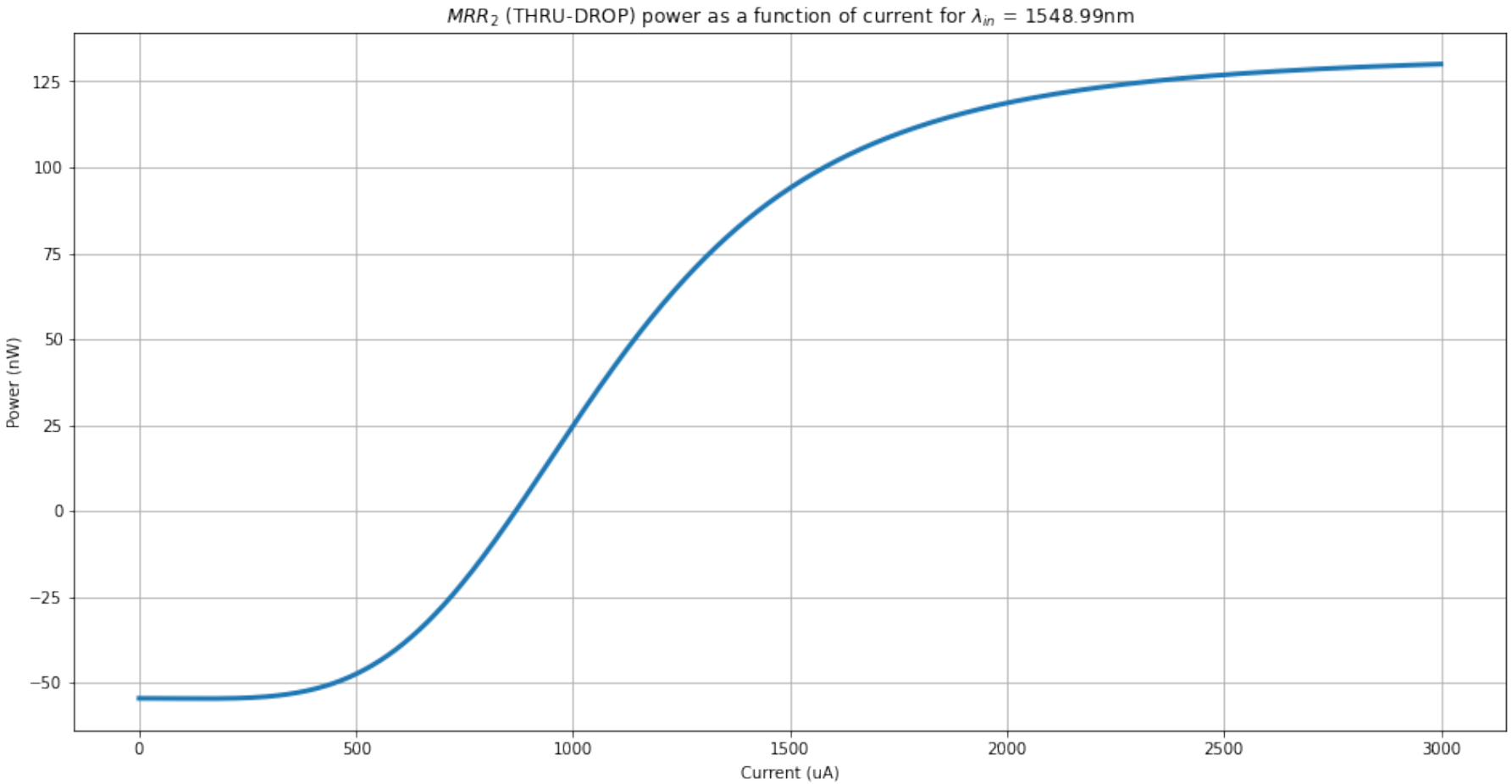

Fixing $\lambda = 1548.99nm$ and sweeping over the input current to vary λ_0 (and thus control $P(\lambda, \lambda_0)$). This represents the weighting performance of E-O-E heater modulators.

Conclusion & Future Work

- Weighting performance of E-O-E heater modulators was characterized by setting up the photonic testbed

- Future work includes:
  - Characterize the weighting performance of E-O-E PN modulators
  - Determine the frequency performance of both modulators
  - Determine the noise figure of both the modulators
  - Enable remote operation of OSA with GPIB Ethernet controller