Characterization of Wavelength Selective Photonic Switches for Scalable Data Center

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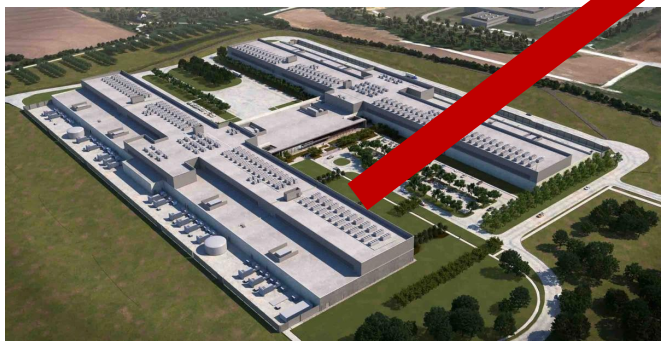
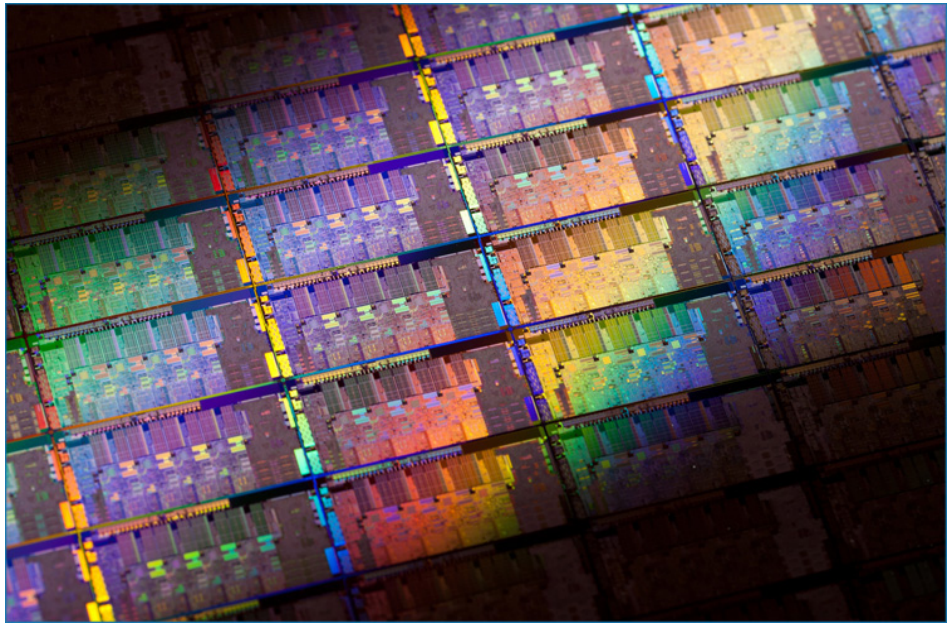


- In 2014, data centers in USA consumed 70 billion kWh ~2% of total energy![1]

Microsoft tests underwater data center

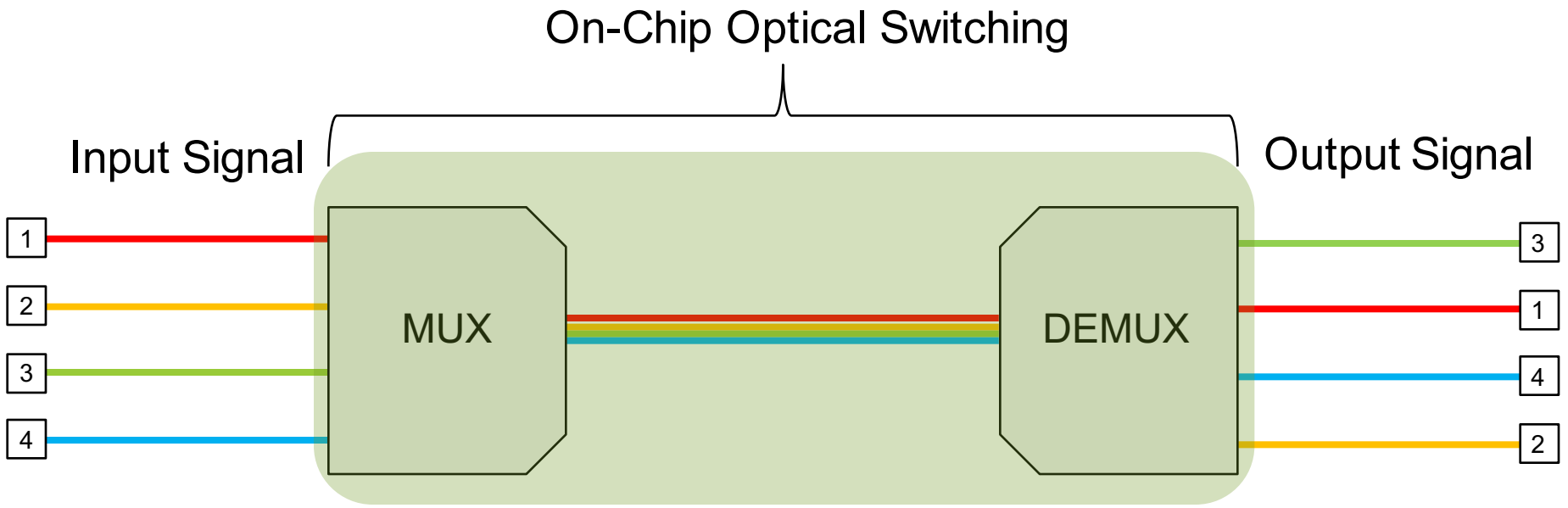
Photonics

- Secure communication
- Faster data processing
- Energy efficient!



1. https://eta.lbl.gov/publications/united-states-data-center-energy
2. https://news.microsoft.com/features/under-the-sea-microsoft-tests-a-datacenter-thats-quick-to-deploy-could-provide-internet-connectivity-for-years/

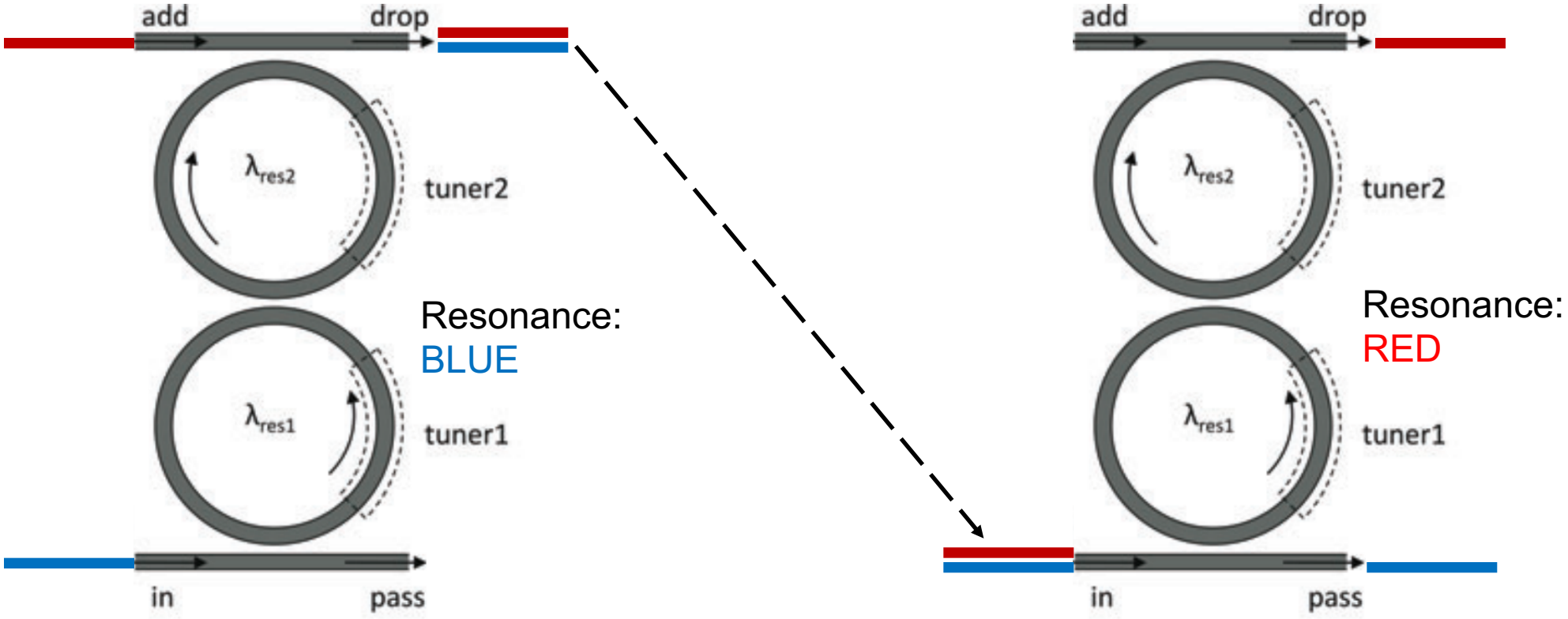
Wavelength Division Multiplexing



- Signals are combined (MUX) into one fiber
- Signals are re-routed from one channel to another and separated out (DEMUX)
- This process can be scaled down with integrated photonics

Wavelength Selective Switch

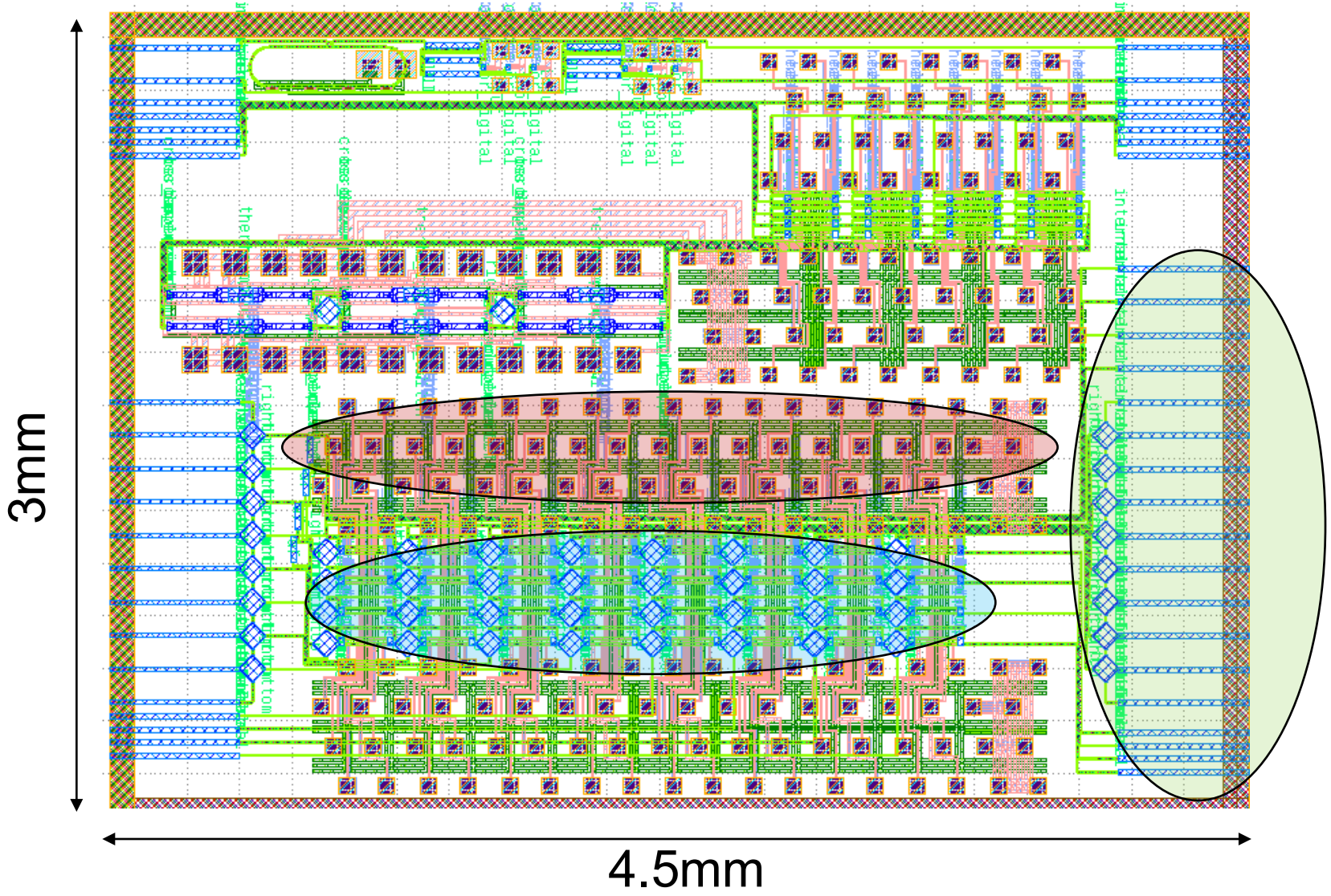
Second Order Microring Resonator



- Resonant wavelengths are thermally tuned
- One signal can be added to the same path of another signal

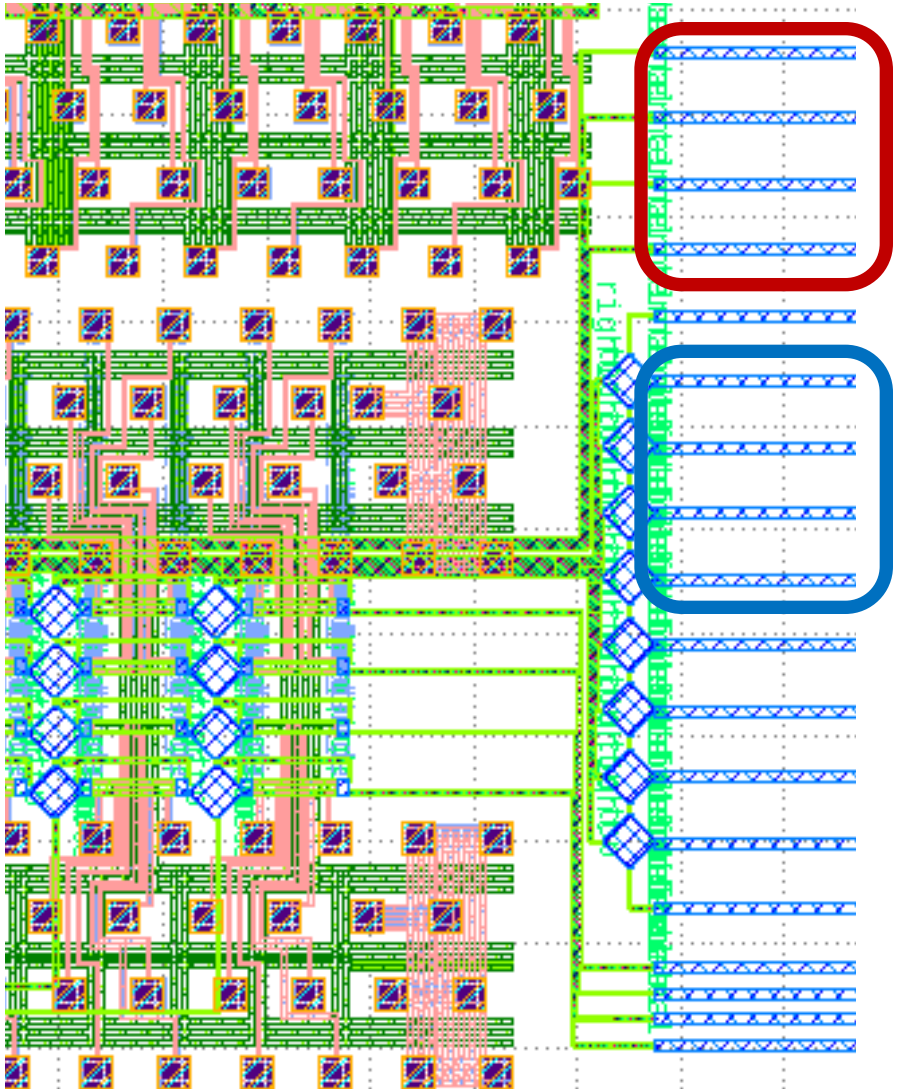
- Input signal can also be dropped off to another path

Integrated Photonics Switch Design

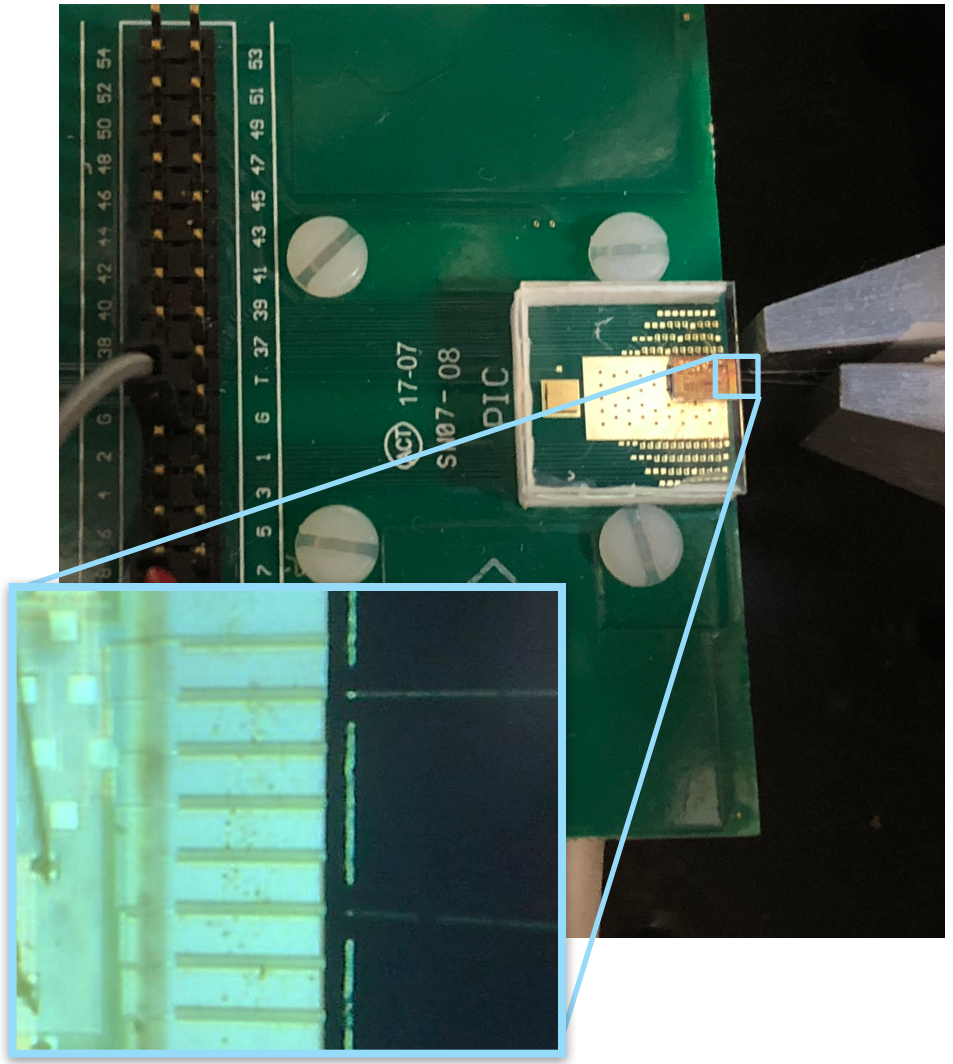


- Electrical-Pads
- Optical-Switches
- Optical-Edge Couplers
  - Fabricated through the AIM Photonics foundry

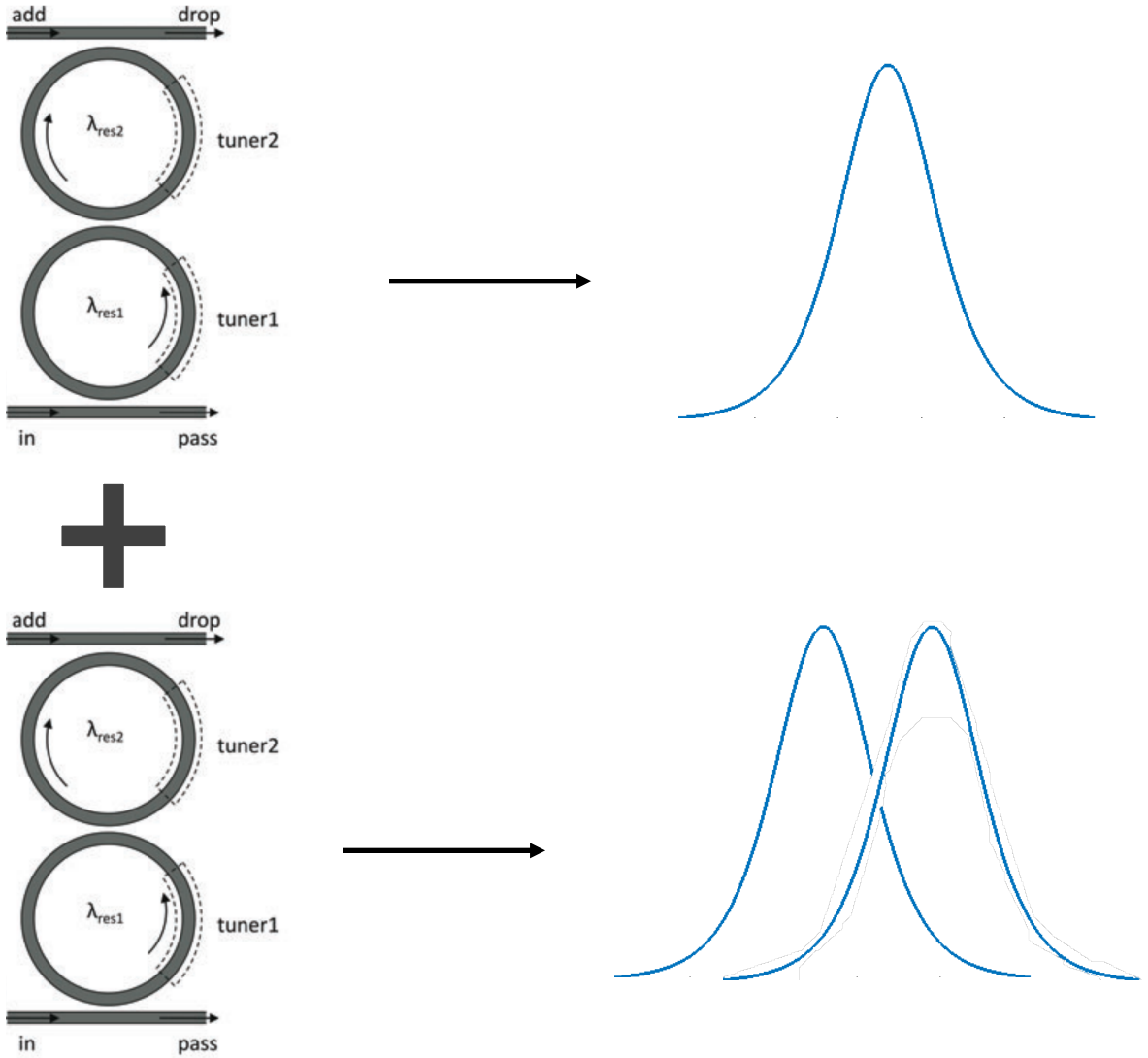
Coupling to Channels



- 4 Output channels
- 4 Input channels

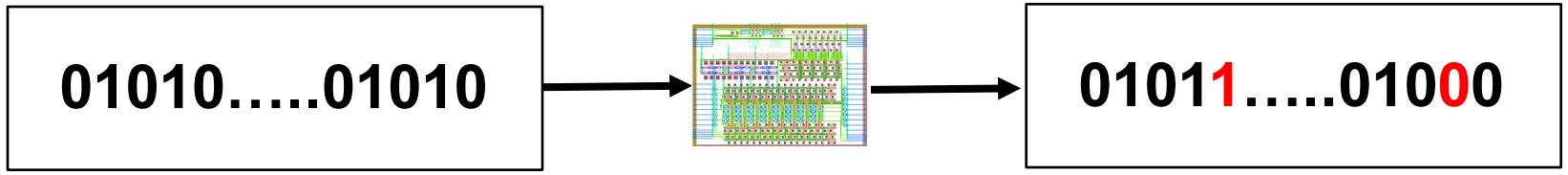


1. Maximizing the Transfer Function of Switches

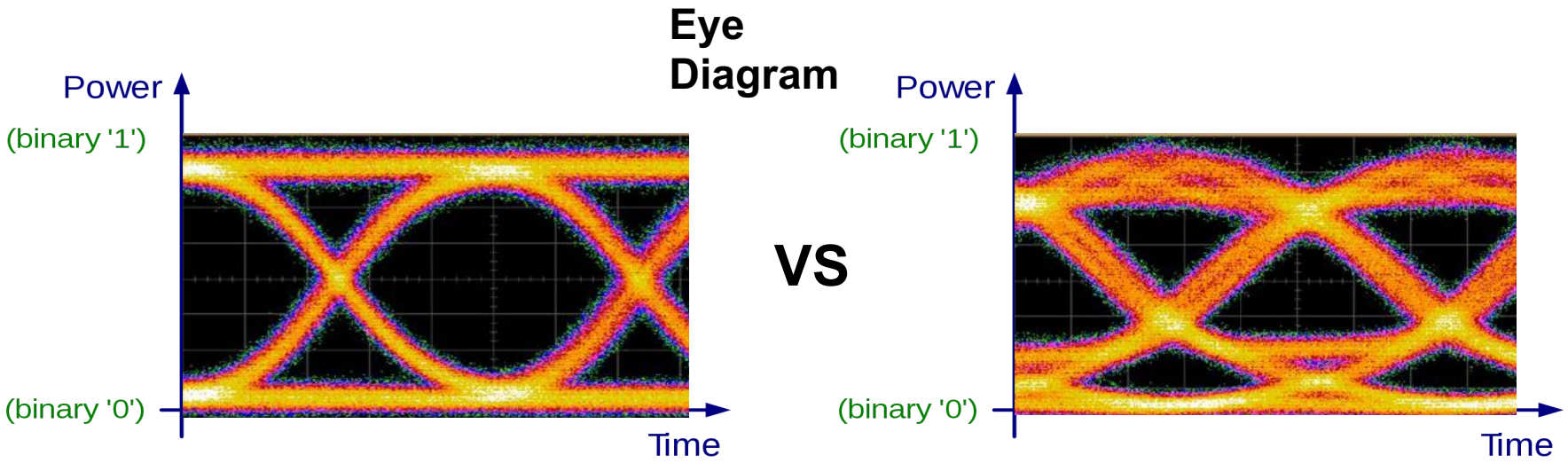


- Transfer function is measured from the drop port
- Goal is to maximize coupling into 2 sets of second order rings
- Create 3.2 nm separation between resonant peak
- Working in the telecommunication wavelength (C-band: 1530 nm – 1565 nm)

2. Bit Error Rate Test

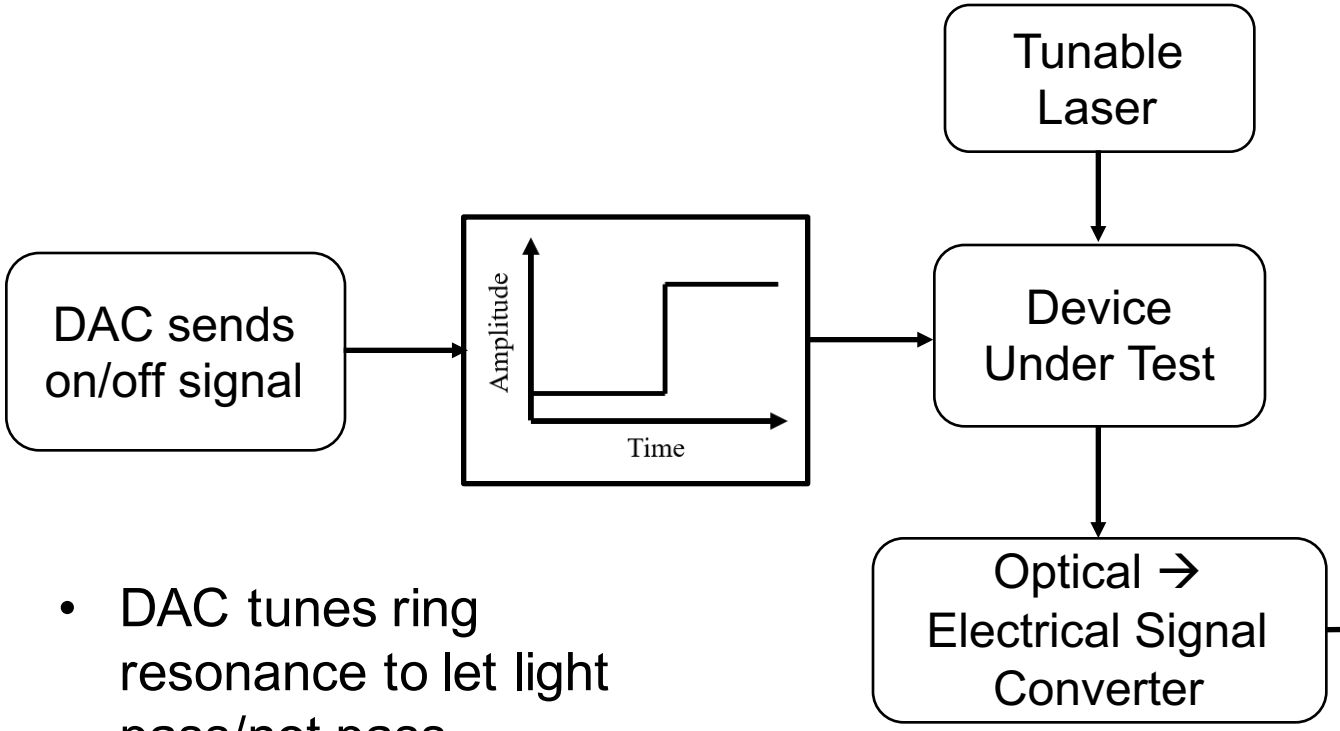


- Modulated signal is sent at the resonant wavelength of one pair of rings
- Inability to distinguish signal correctly generates errors
- Known bits of signal is compared with to determine number of errors



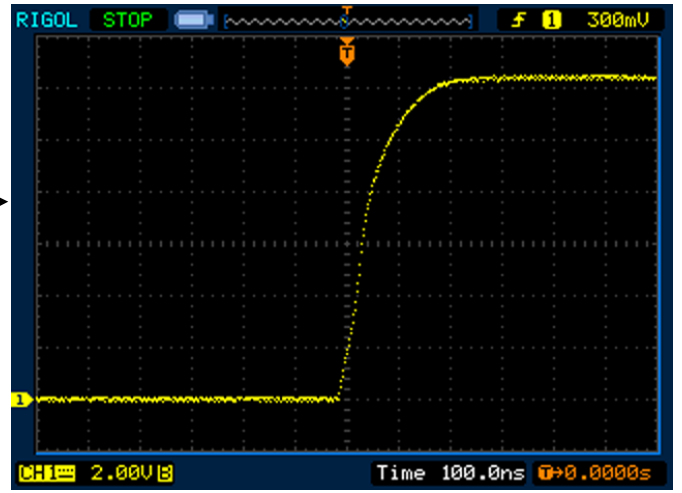
- Distinguishable lines: Low noise and jitter
- Symmetric open eye: wide bandwidth and high signal

3. Switching (Rise/Fall) Time

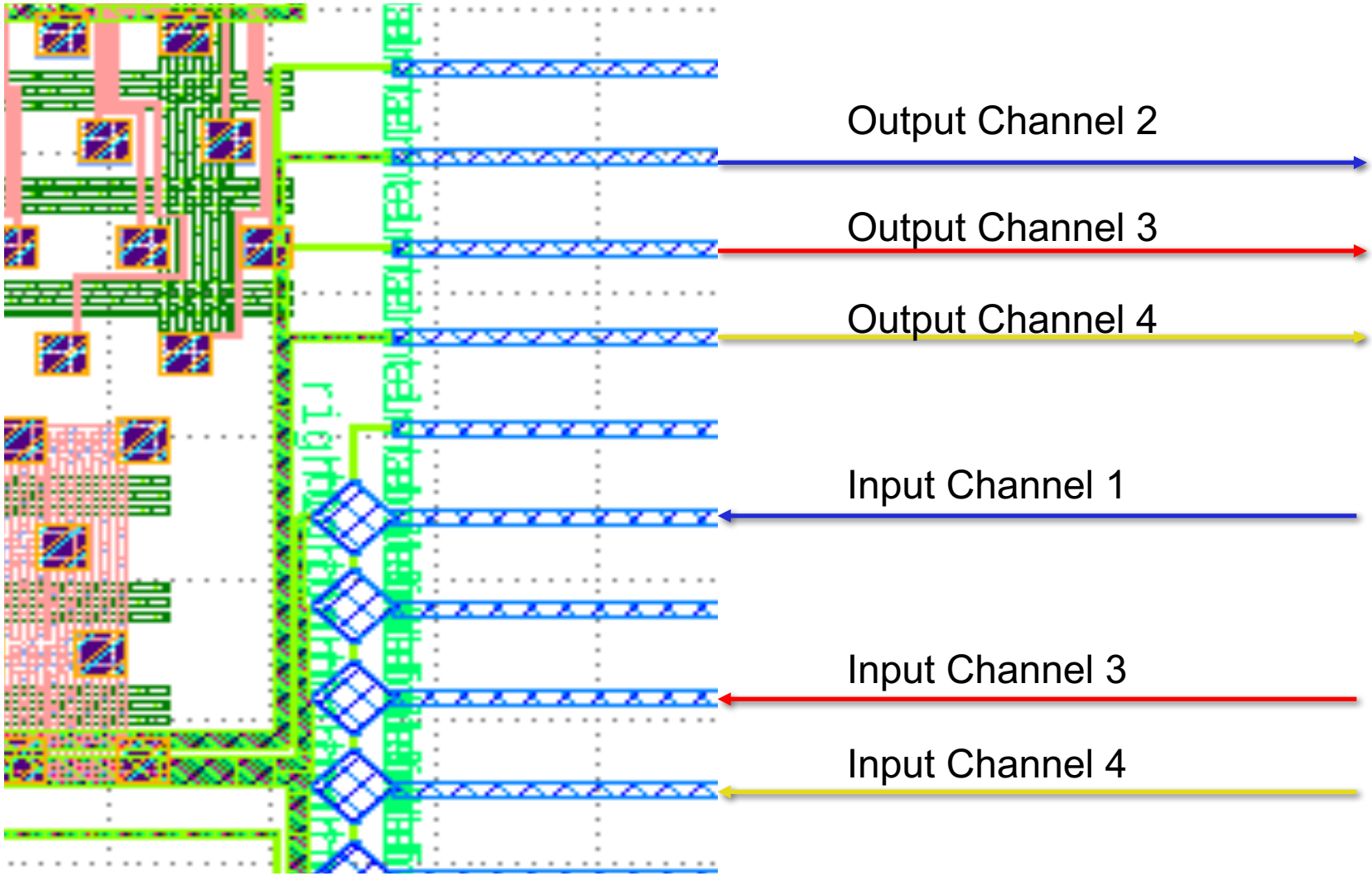


- DAC tunes ring resonance to let light pass/not pass

- Heat/Energy takes time to transfer
- Electrical signal is obtained through oscilloscope



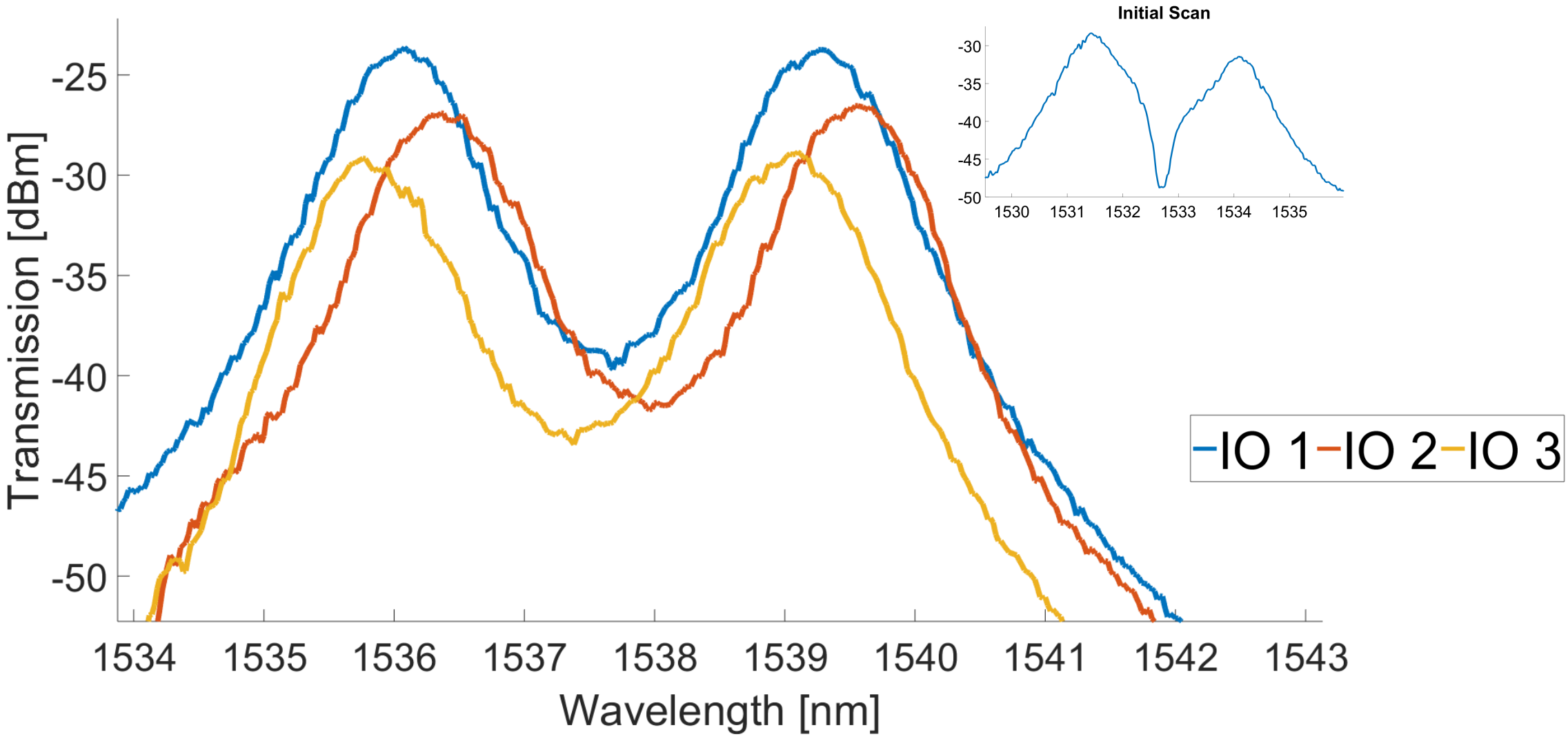
Ports Under Test



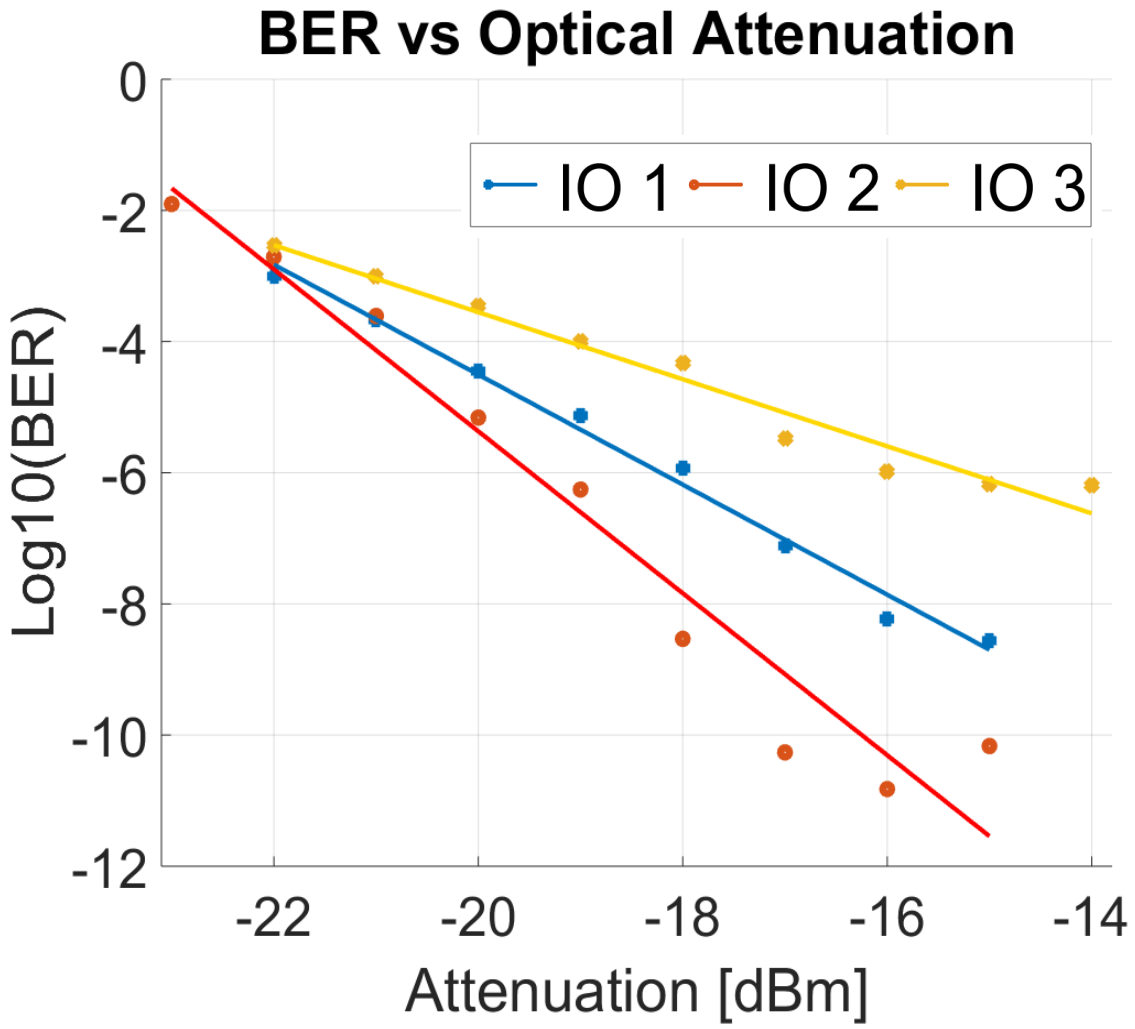
Port Sets:

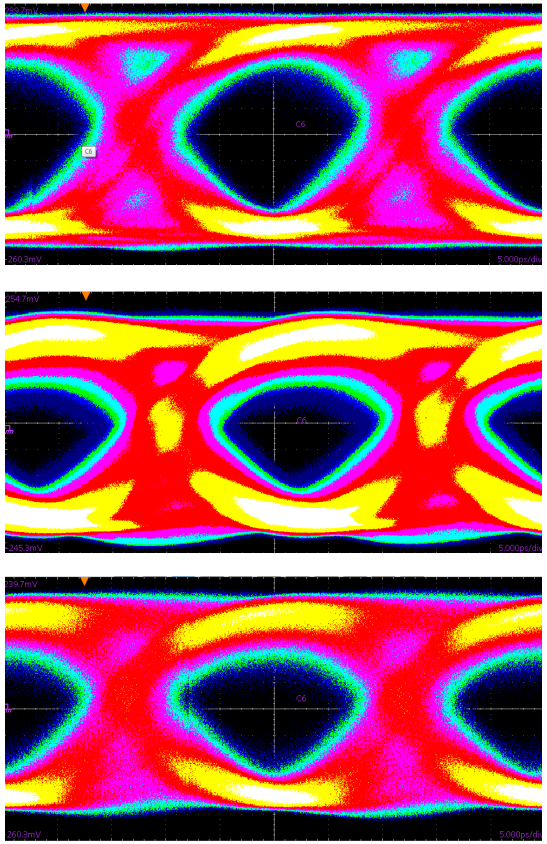
- IO 1 = Input 1 & output 2
- IO 2 = Input 3 & output 3
- IO 3 = Input 4 & output 4

Transfer Function



Bit Error Rate Test



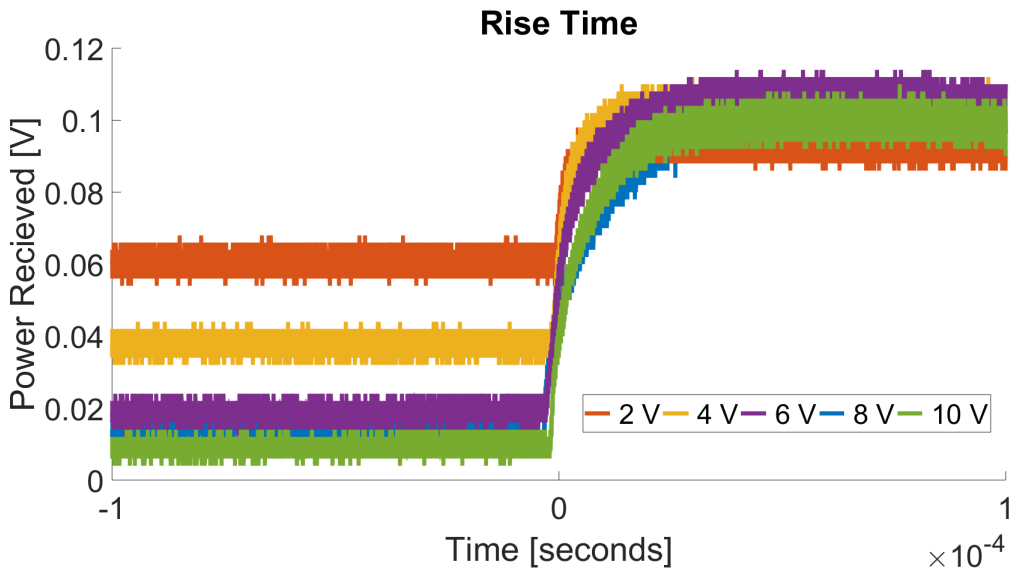


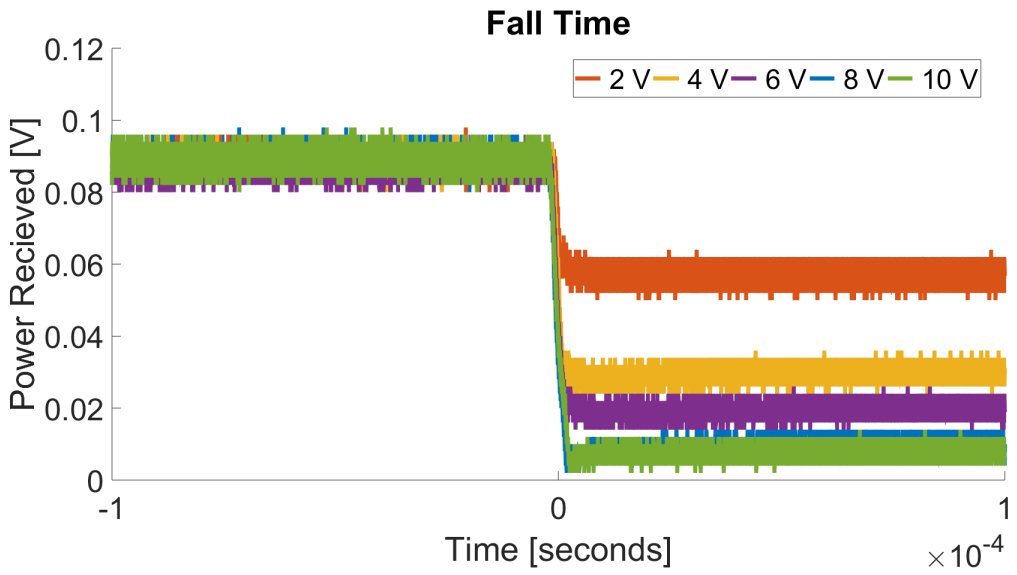
IO 1

IO 2

IO 3

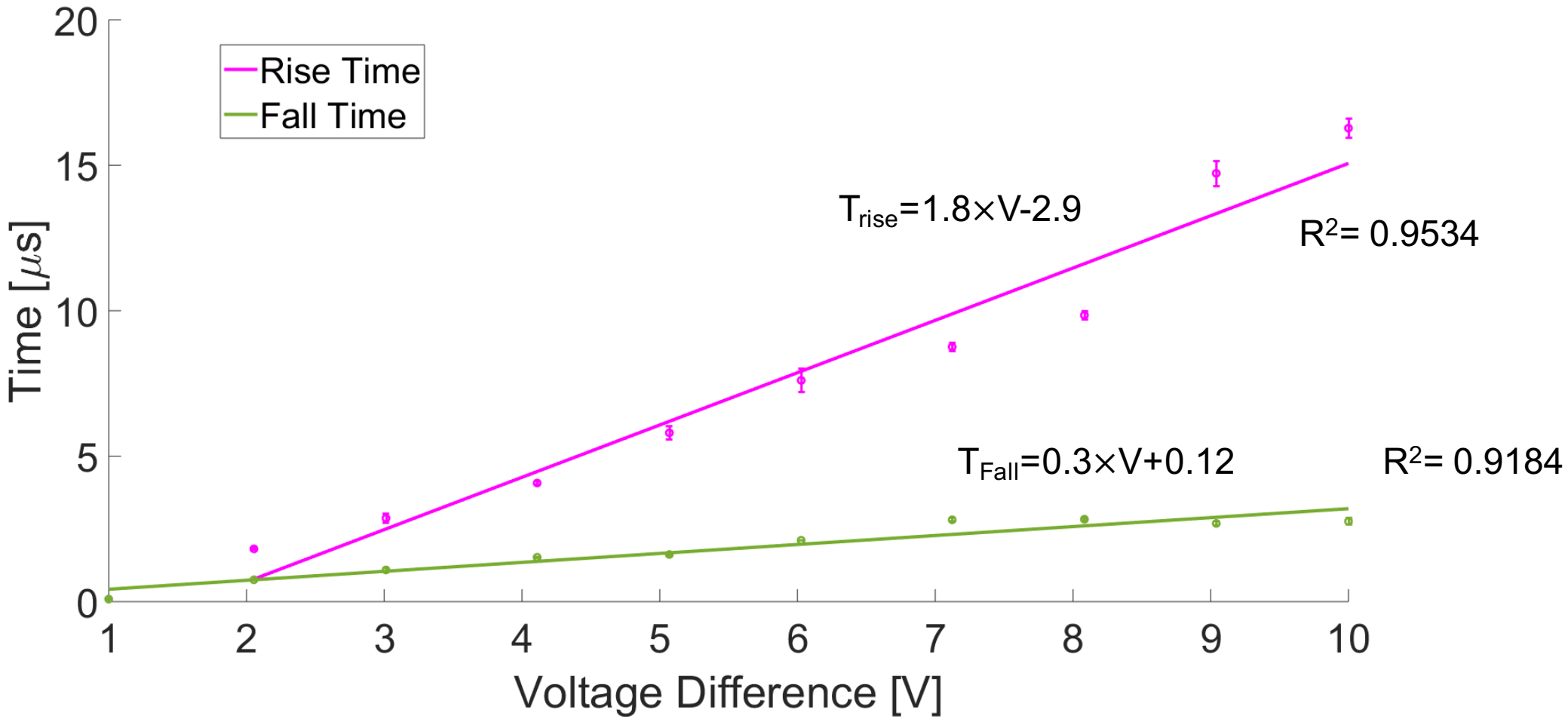
Switching Time Oscilloscope





- Switching time is shown for a thermal tuner in IO 1
- Time axis includes negative value because oscilloscope set t=0 when triggered

Switching Time



Conclusion

- Able to simultaneously switch 2 wavelengths and separate local maxima by 3.2 nm to reduce optical cross talk
- BER test demonstrates a low error rate of 10^9 for IO1 @ 15 dBm optical attenuation but needs to be repeated
- Coupling decreases with increasing I/O #, resulting in lower signal to noise ratio (SNR)
- Eye diagram show high noise and jitter but wide bandwidth
- Optical power is reduced by >50% at 4 V difference, which requires less than 5 us switching time

Future Work

- BER test needs to be repeated for all the I/O
- Repeat the above experiments with a fiber array
- Reduce noise and measure optical crosstalk
- Decrease switching time with a material that allows electro-optic tuning (i.e. lithium niobate) or through carrier depletion

Acknowledgement

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