

Enabling Optical Technologies for Optical Ethernet

WOCC 2004

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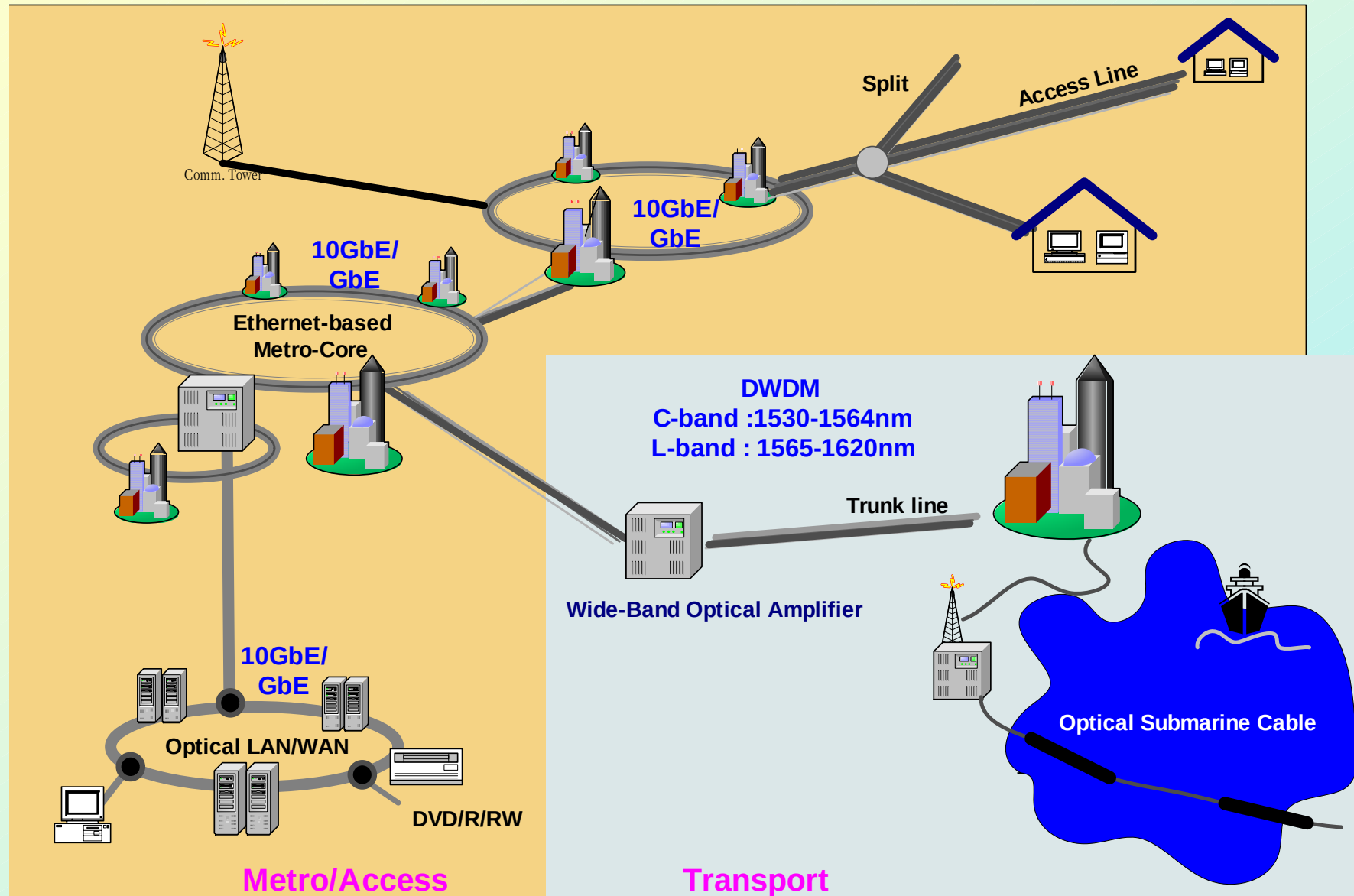
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- **Optical Ethernet**
- Enabling Optical Technologies
 - Optical Label Switches
 - Tunable Lasers
 - Wavelength Converters
 - Fixed wavelength
 - Broadband
 - Multicast
- Conclusions

Optical Ethernet



Before:

- Ethernet was a LAN technology
- SONET, ATM, and MPLS provide the necessary traffic management and SLA verification capabilities for service provider networks

Now:

- Metro Ethernet are offered by service providers for
 - Ease of use
 - Low cost
 - Flexibility
- Extending beyond metro and across transport networks

- **Low latency and jitter**
- **Survivability:** SONET-like, support multiple grades of restoration, varying levels of priority, and optical layer automatic protection switching.
- **Reach:** Metro networks often span 100km or more. Today 40km reaches are being specified for 10-gigabit Ethernet
- **Traffic and congestion management:** ATM-like
- **Security**
- **Standard:** Metro Ethernet, and 10 GbE

Why Optics?

- Huge carrier frequency (~ 200 THz)
 - Large signal modulation bandwidth
- Huge transmission bandwidth (> 60 THz, wired)
 - No need of spectral efficient coding
 - Simple signal encoding/decoding, → allow high speed
- Nearly perfect channel (fiber)
 - Abundant in material
 - Low-loss, low dispersion, and no interference
- Short wavelength ($\sim 1 \mu\text{m}$)
 - Small waveguide dimension
 - Small antenna (laser and detector)



Why Optics? (cont')

- Additional dimension of signal encoding
 - **Wavelength**, frequency, time, code
 - Allow hierarchical data encoding
 - Allow flexible bandwidth aggregation and management
- Fast switching???
 - Propagating in light speed, not switching in light speed
 - **Excellent line speed**. All optic devices work at the huge carrier frequency and has large bandwidth
 - **Photons run faster**, but electronics jump over shorter gates
 - Usually need electronic switching circuits
 - Lack of optical computing and memory
 - Not necessarily rapidly switchable

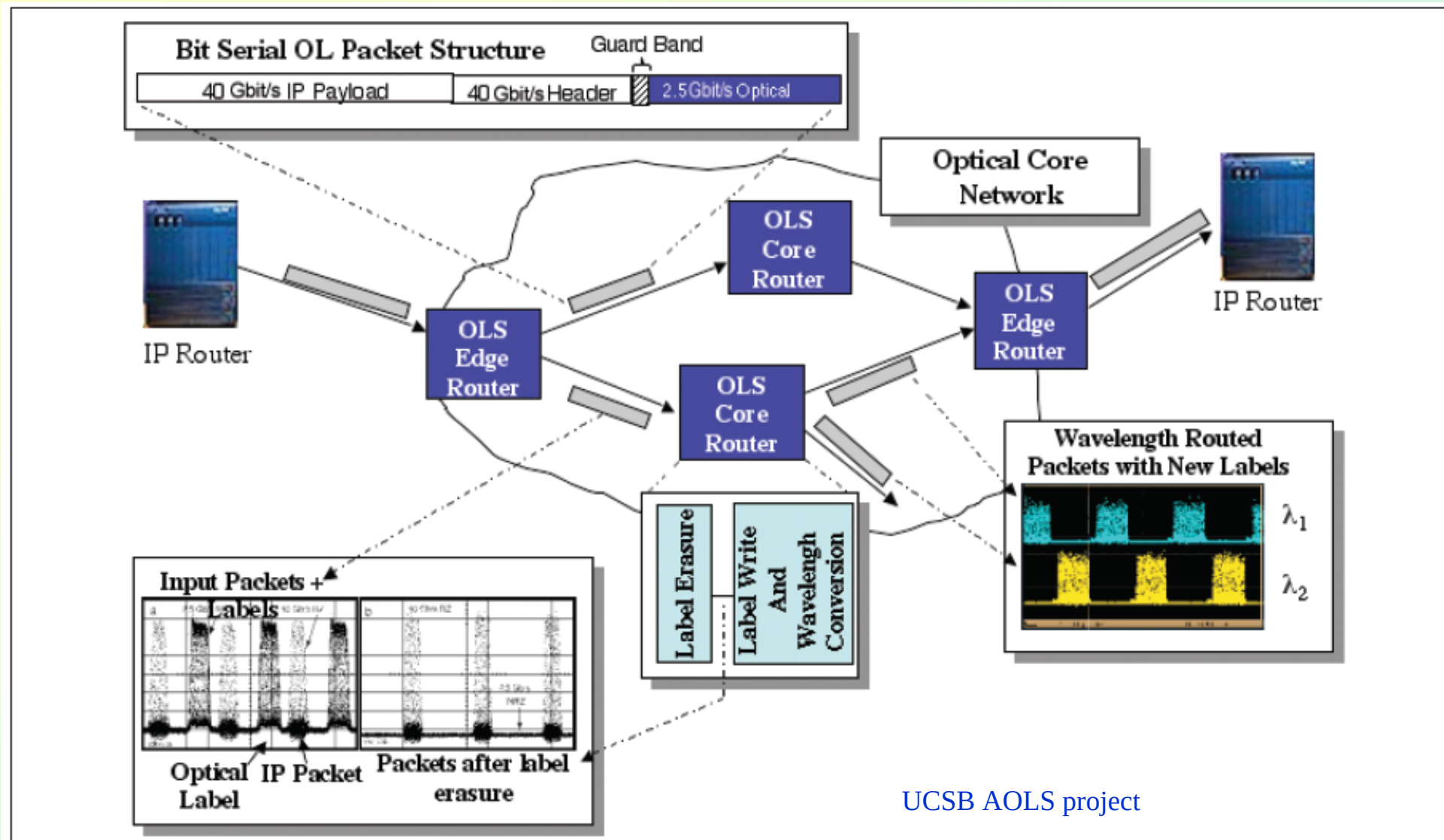


Optics for Ethernet

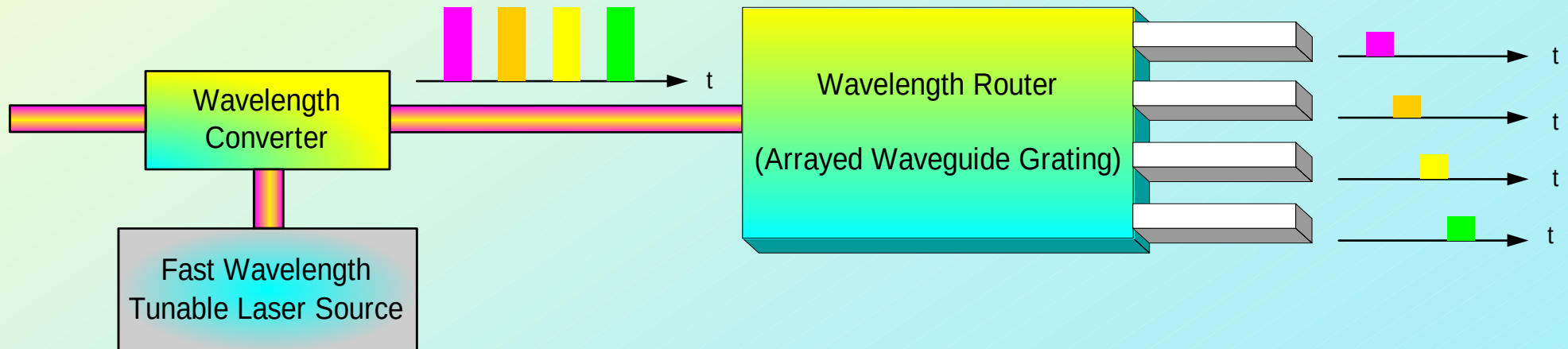
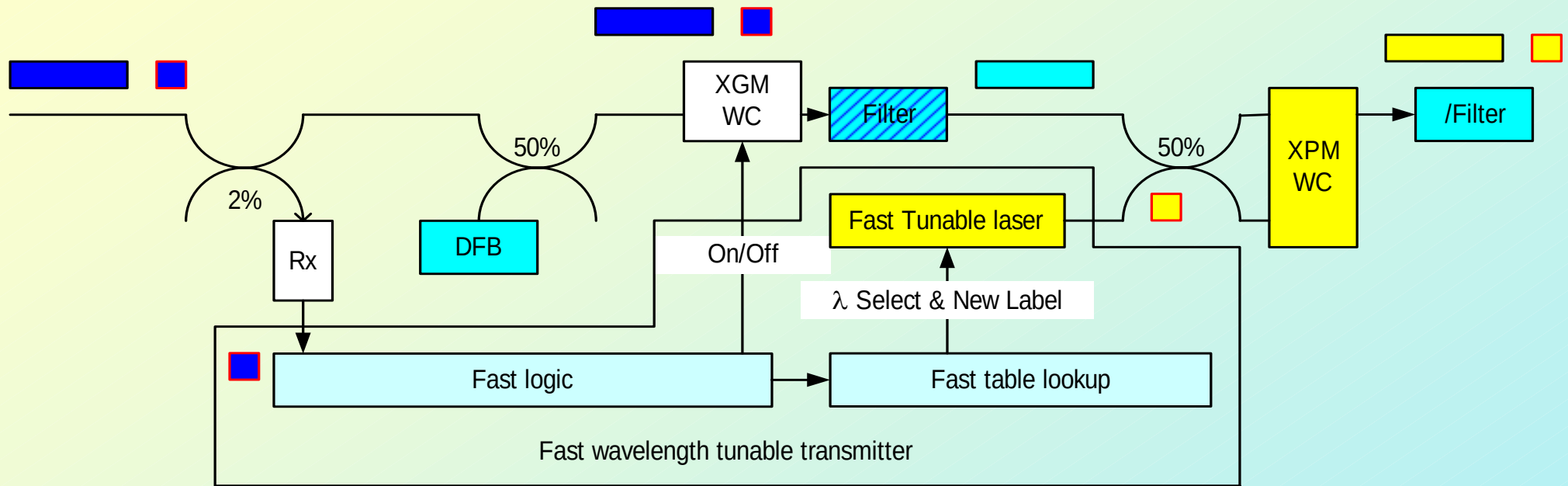
- 10 GbE transceivers (mature now!)
- **Agile modules**: flexibility, fast switching
- **Data routing**: label swapping, lambda switching
- **Performance monitoring**: restoration and class of service
- **Wavelength conversion**: reduce # of wavelengths



Label Switched Networks

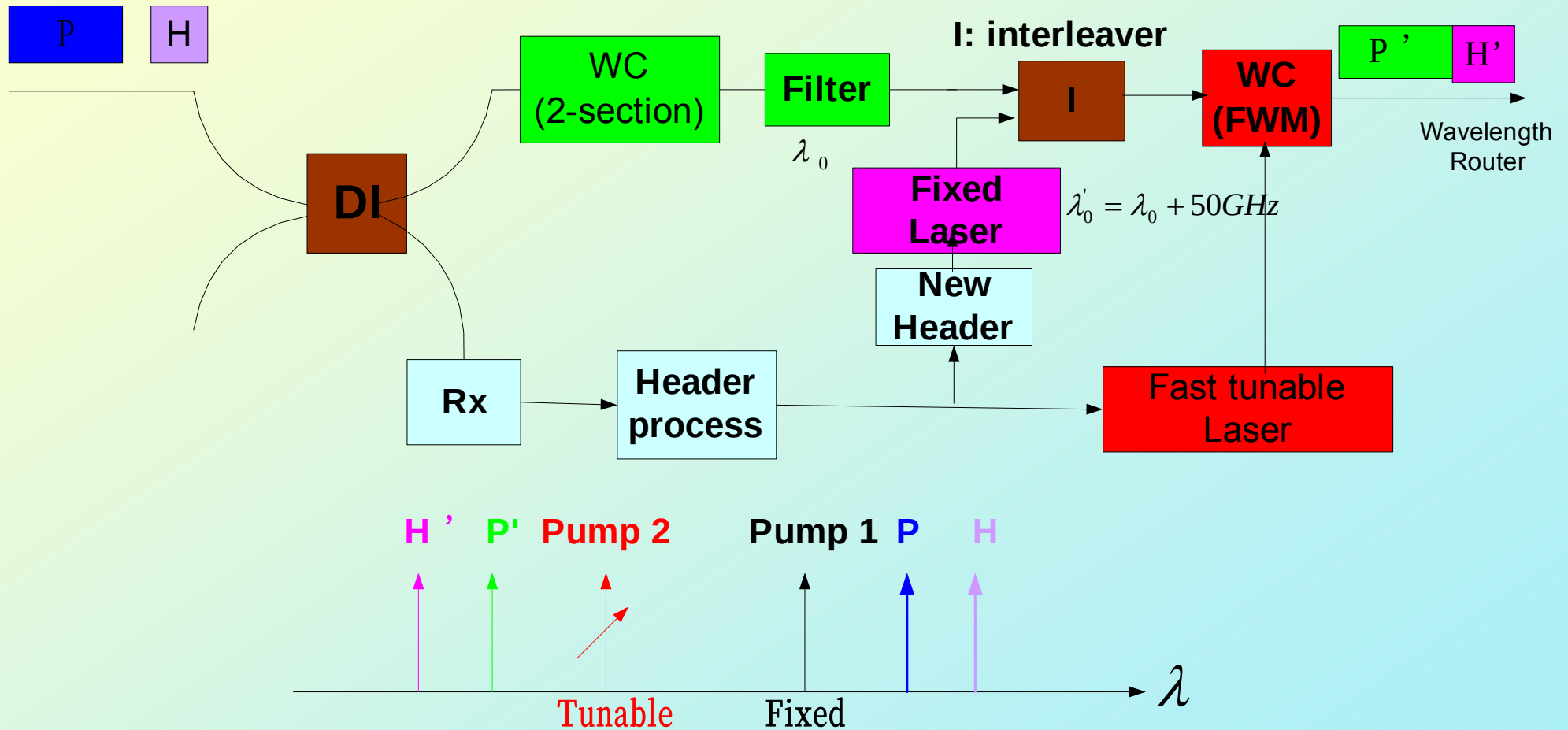


Optical Router in AOLS

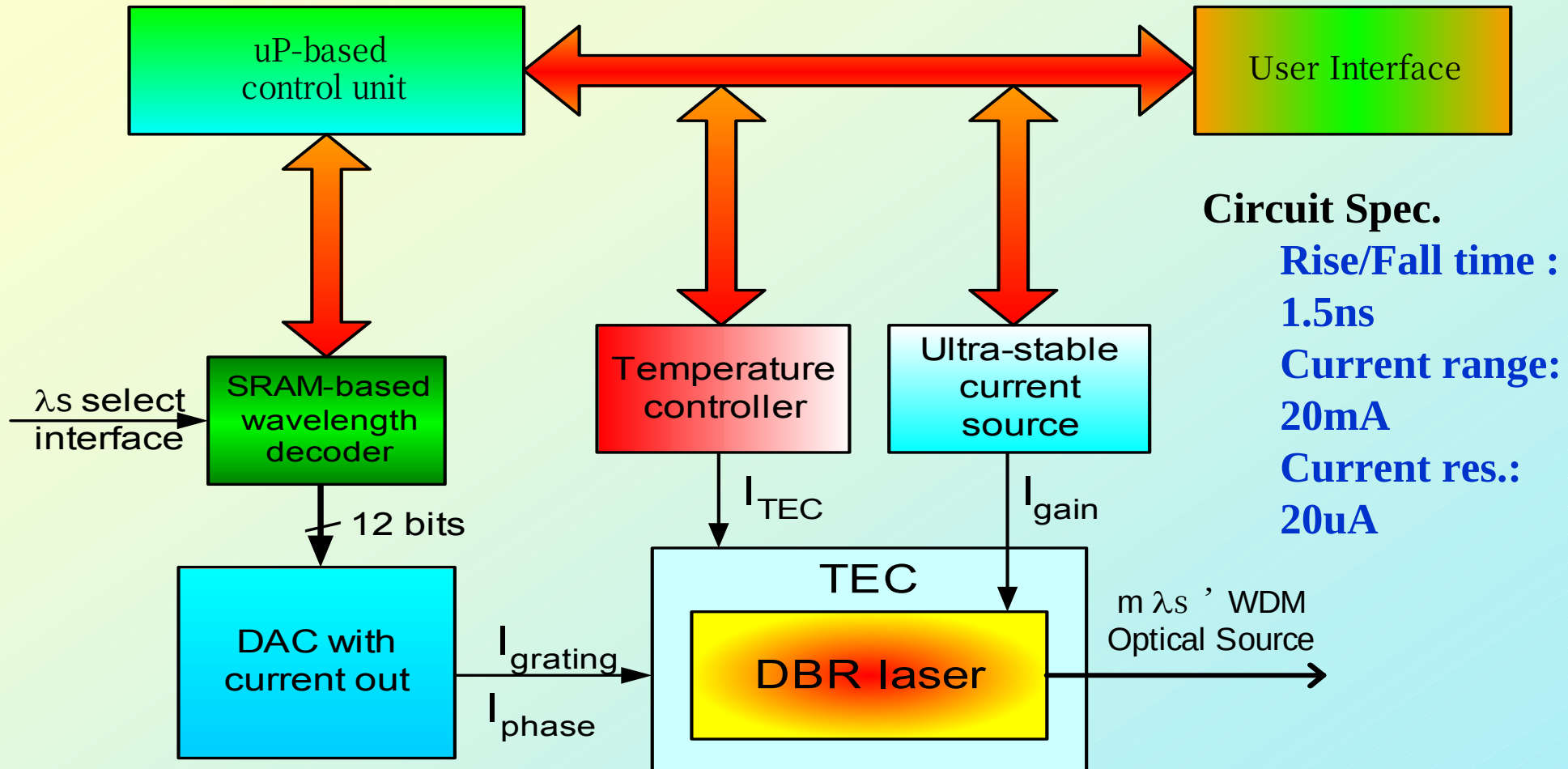


NTUST Label-Switched Router: proposal

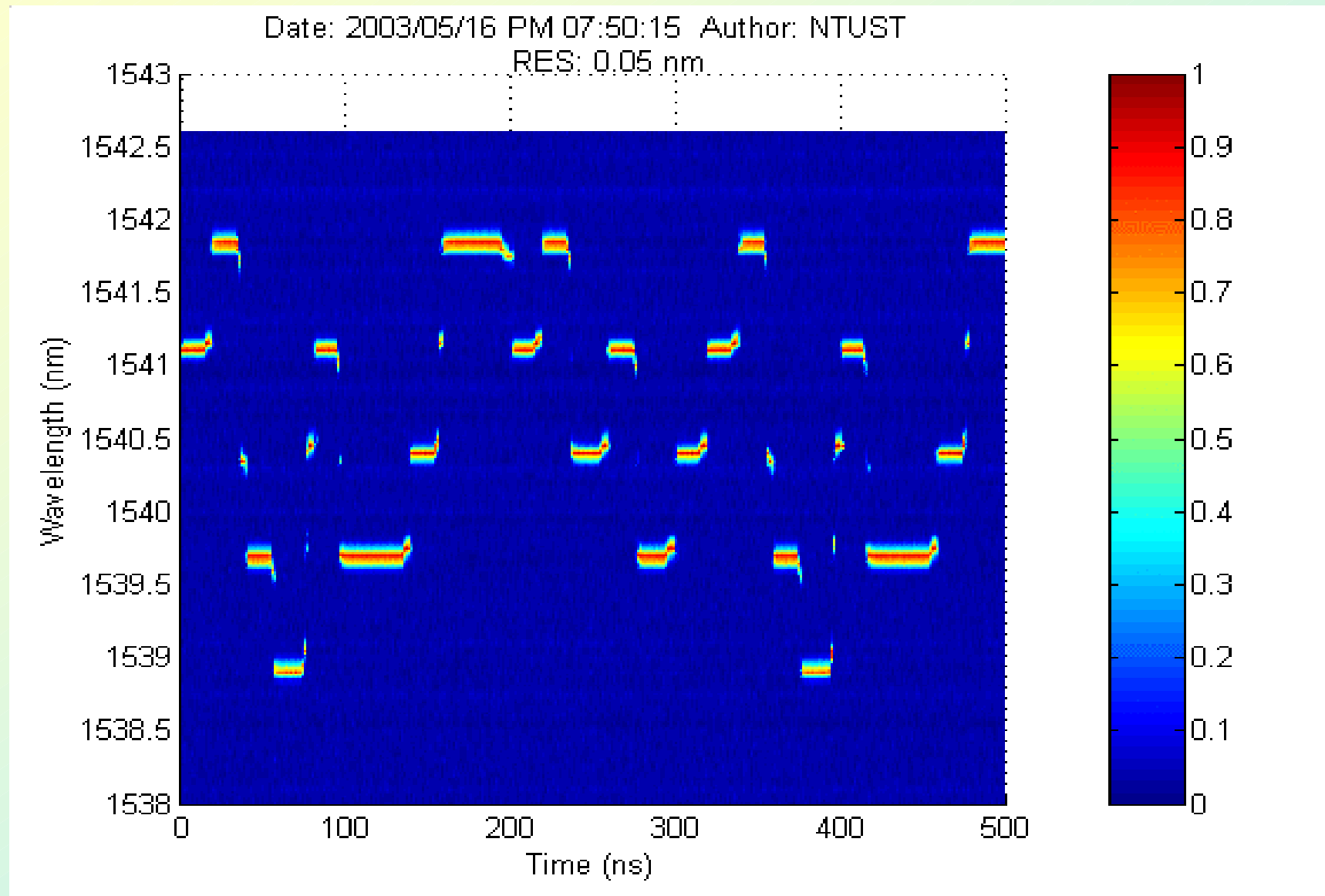
- Encode the data and payload on different wavelengths
- Allow for using low-cost lasers and wavelength converters



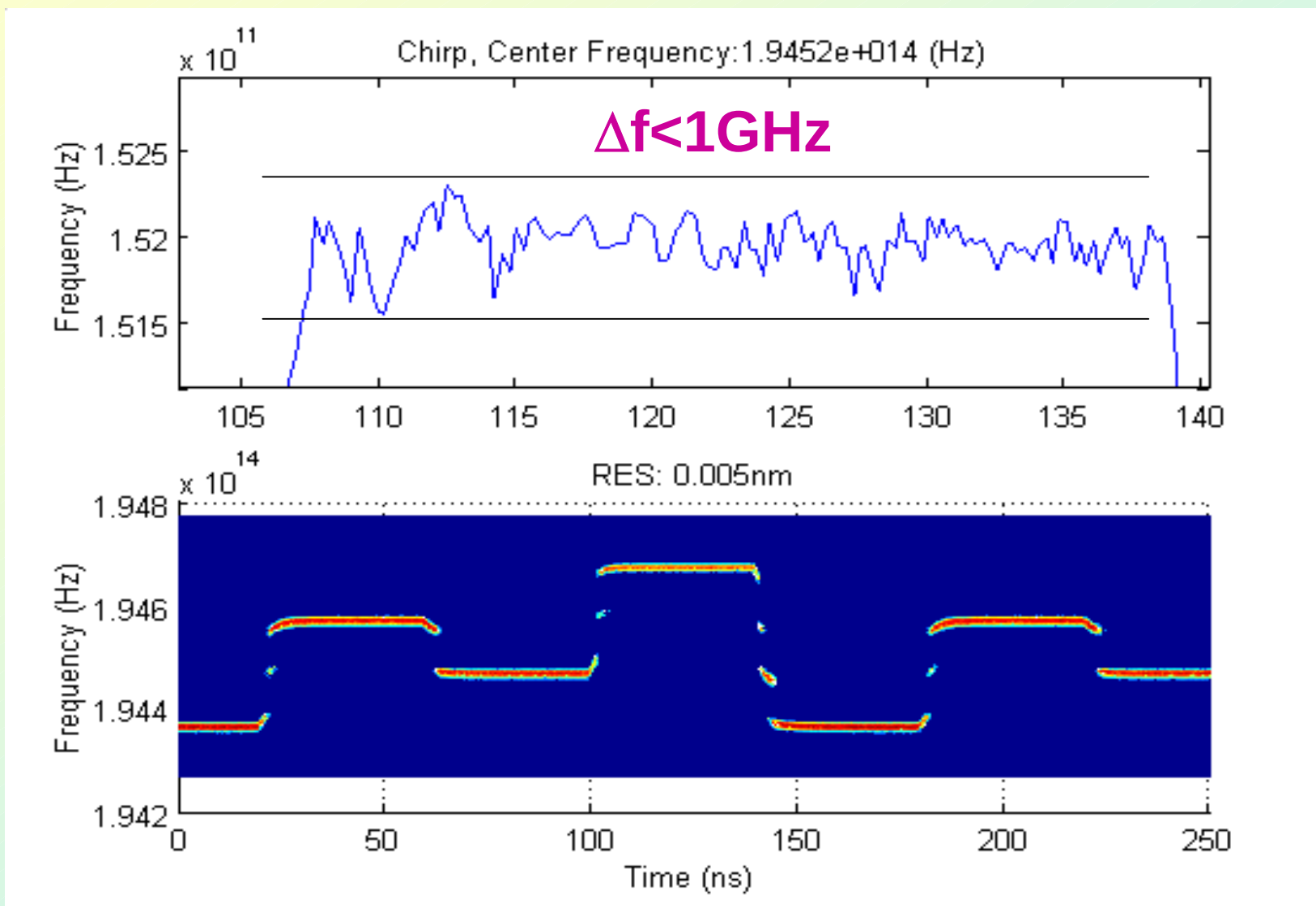
Fast Tunable Lasers for Data Routing

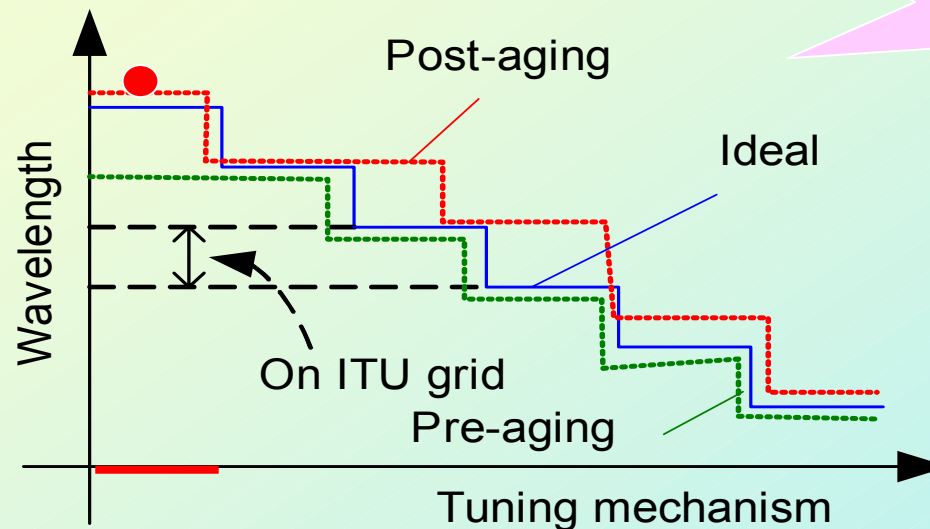


DBR Lasers



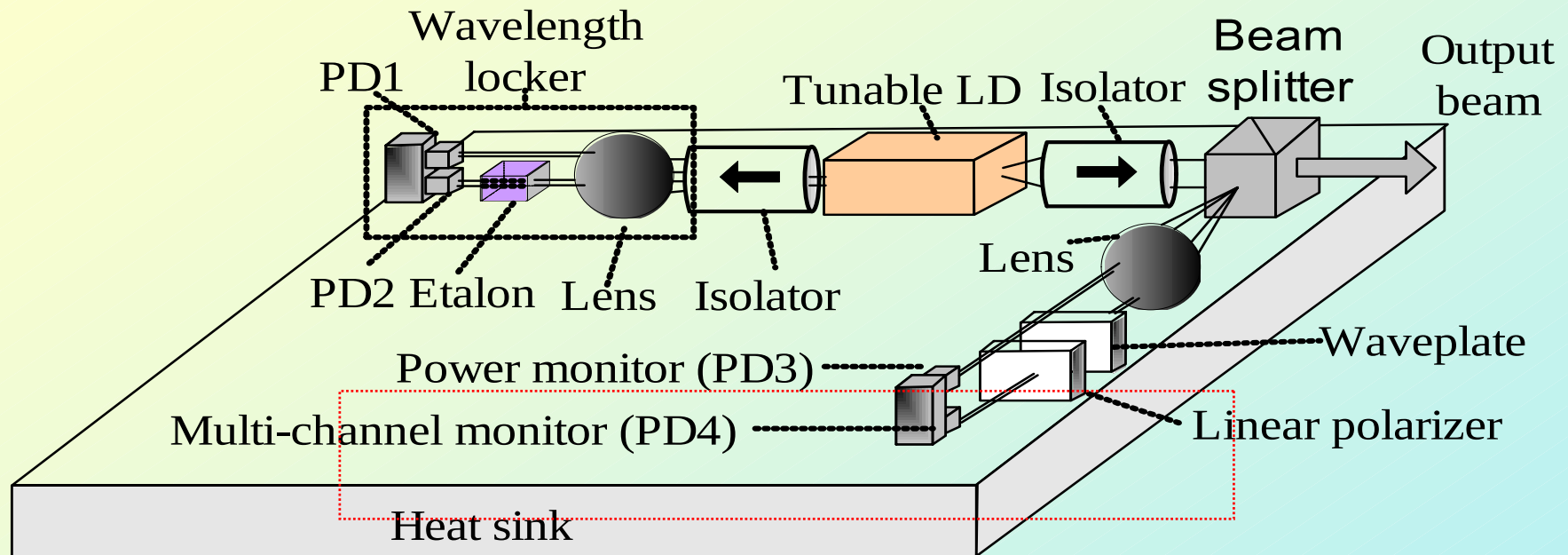
Wavelength Stability During Tuning



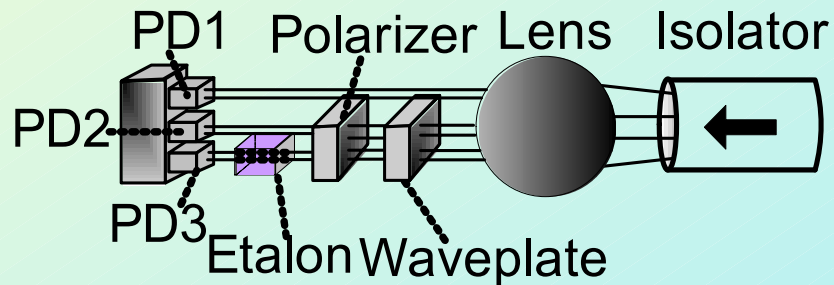


Tuning curve of a tunable laser varies with the aging process or temperature fluctuation.

Channel Monitoring + λ -Locker



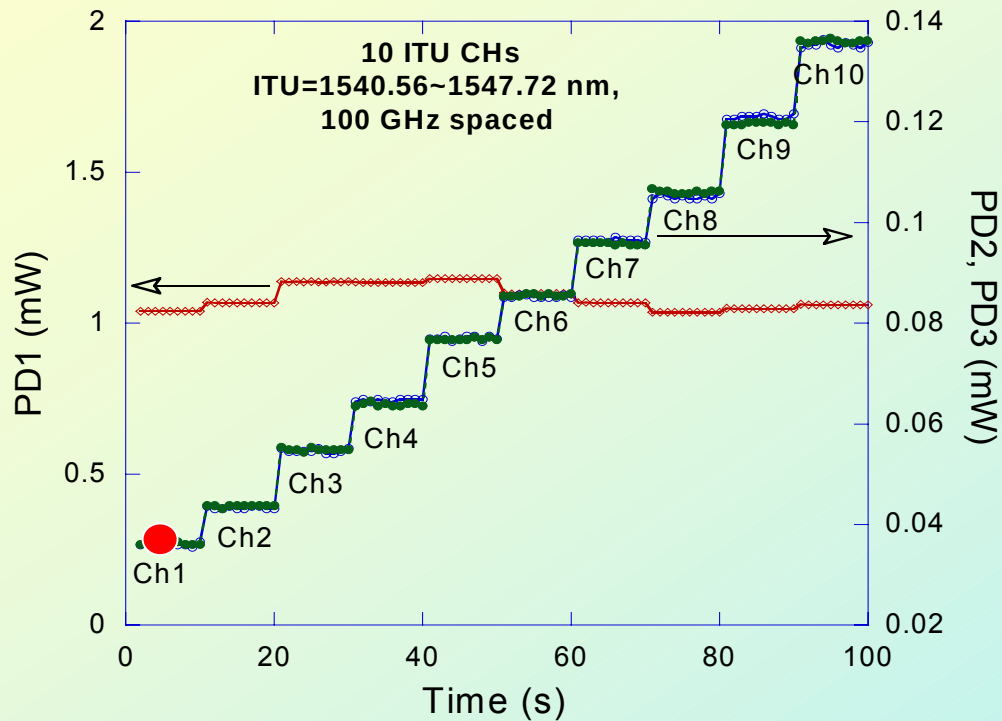
Compact module



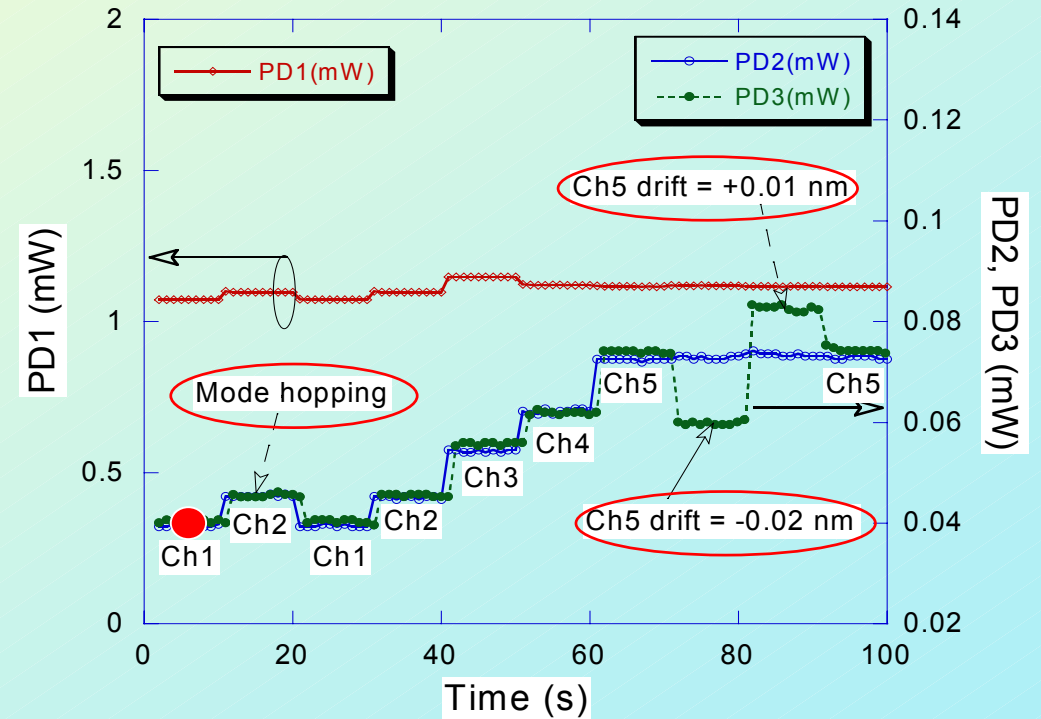
Power: PD1
Wavelength: PD3/PD2
Channel: PD2/PD1

Tunable Laser monitoring

Proper tuning



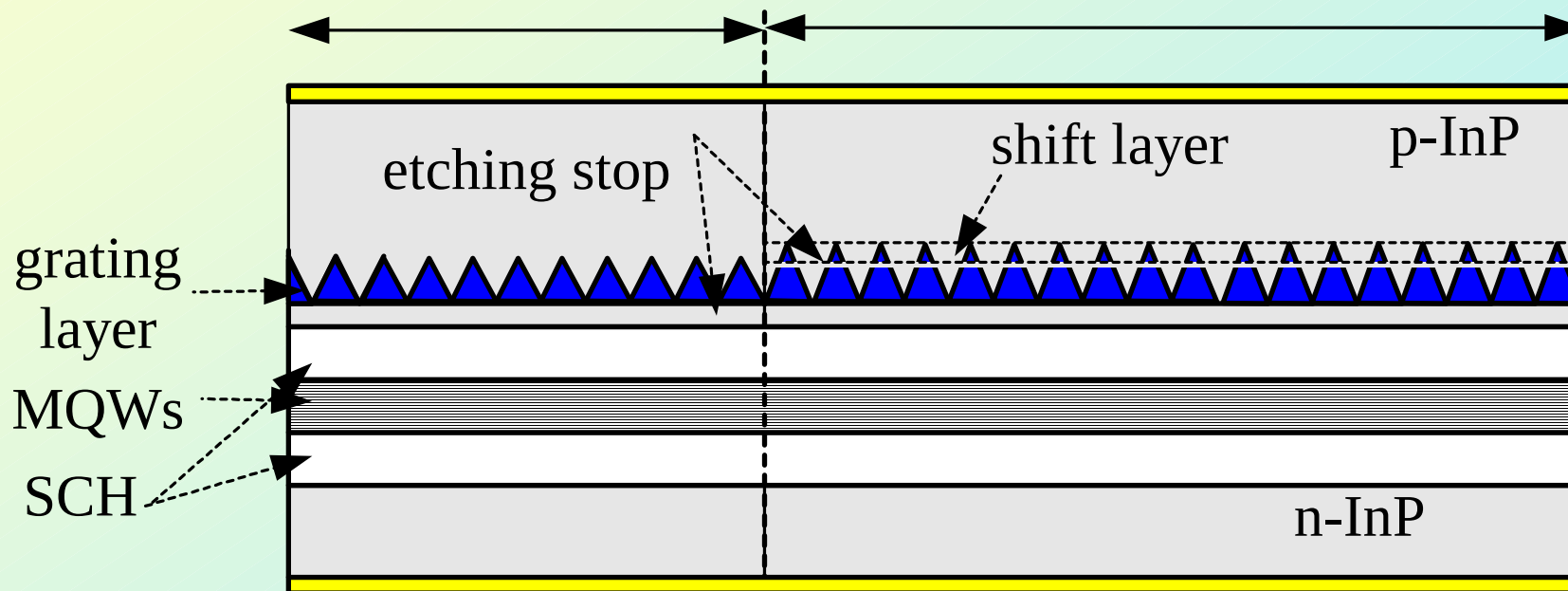
Mode hopping and wavelength drift



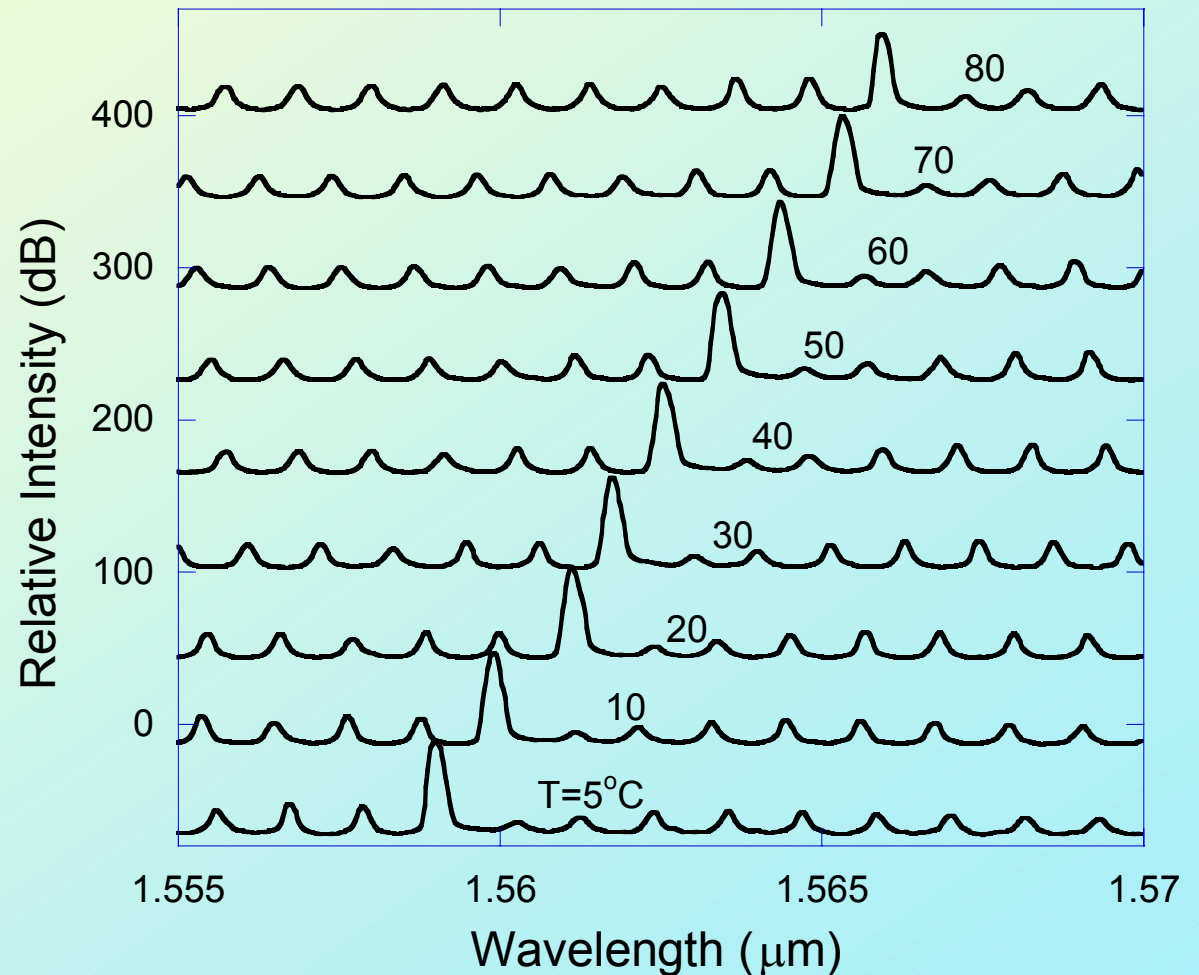
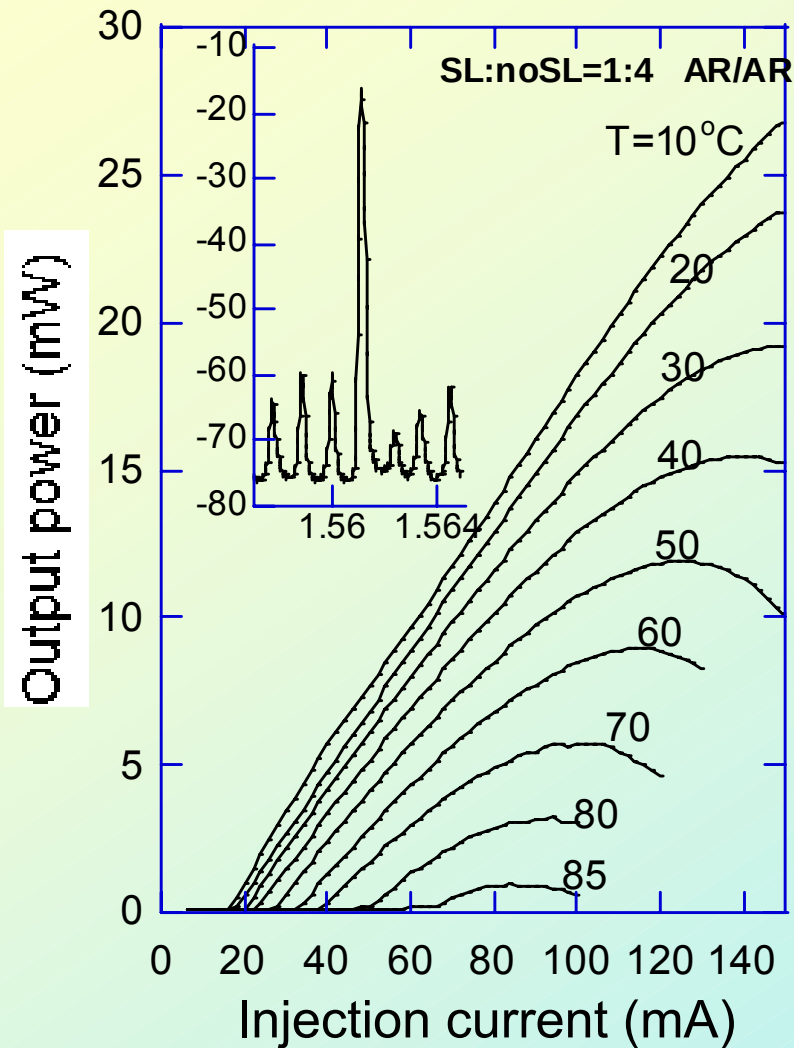
PD2≠PD3 → wavelength drift

Two-Section DFB Lasers

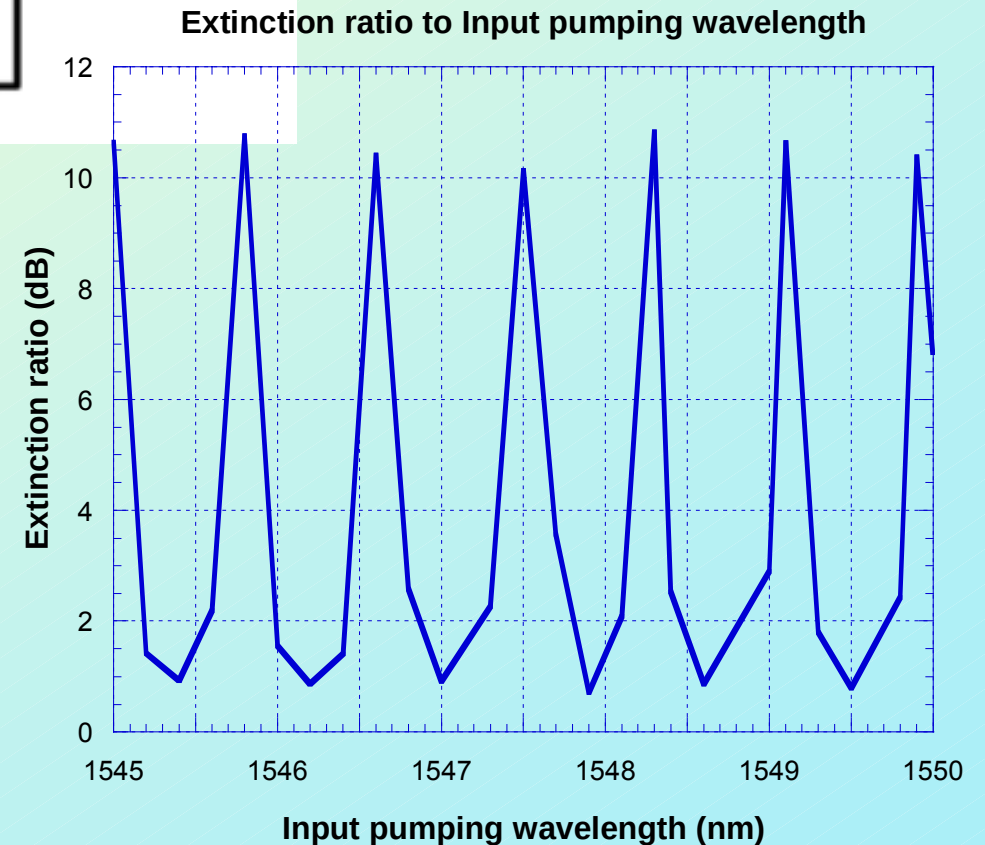
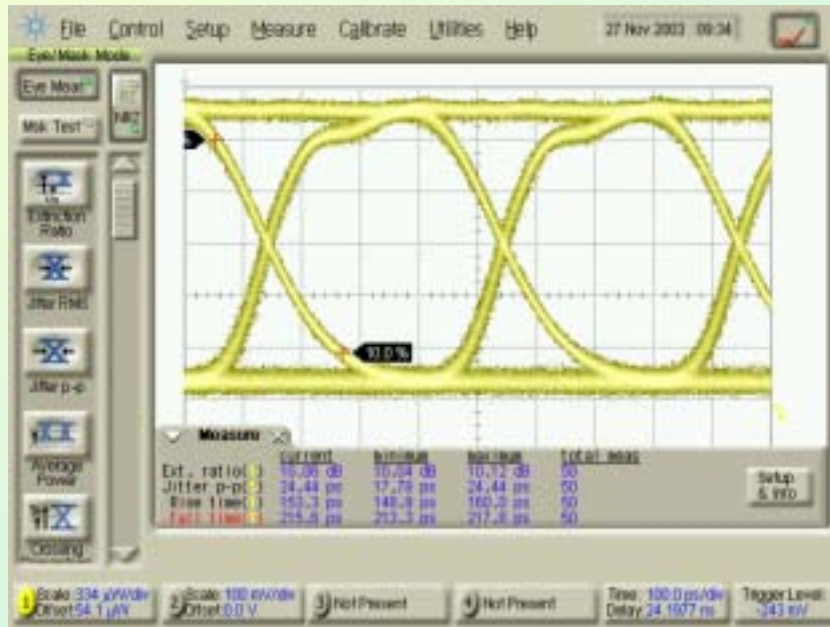
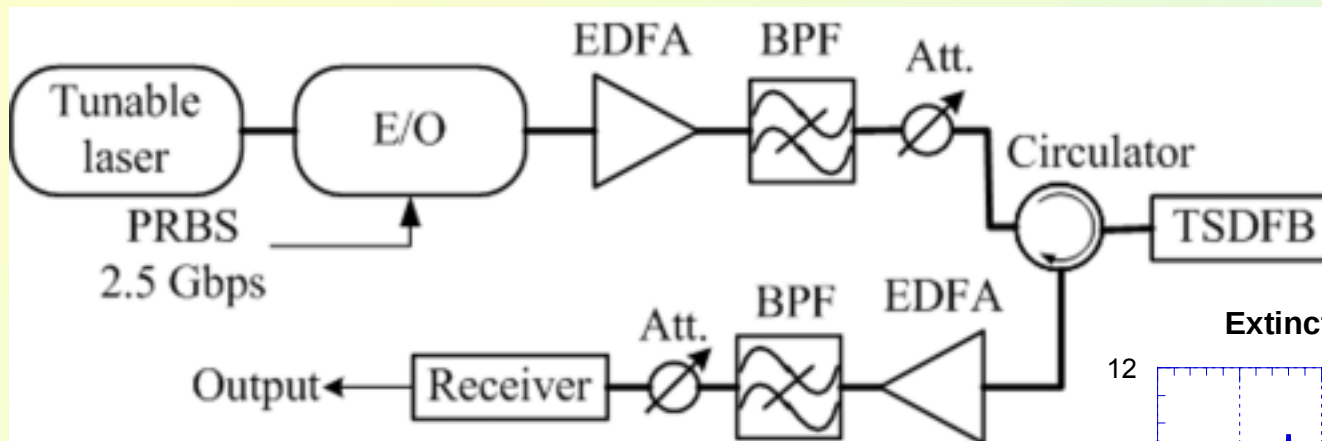
- Use a thin shift layer to obtain stable single- λ output
- Low-cost sources
- Can be used for λ -conversion with fixed output λ



Two-Section DFB Lasers (cont')

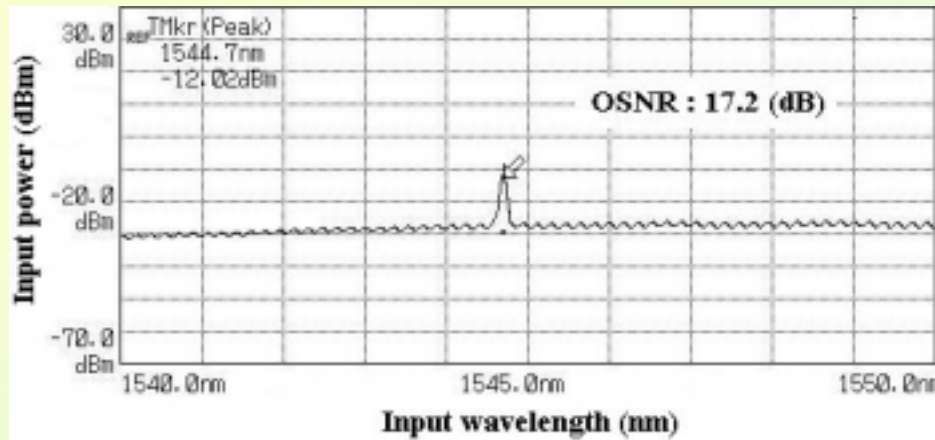


TS-DFB as Wavelength Converters

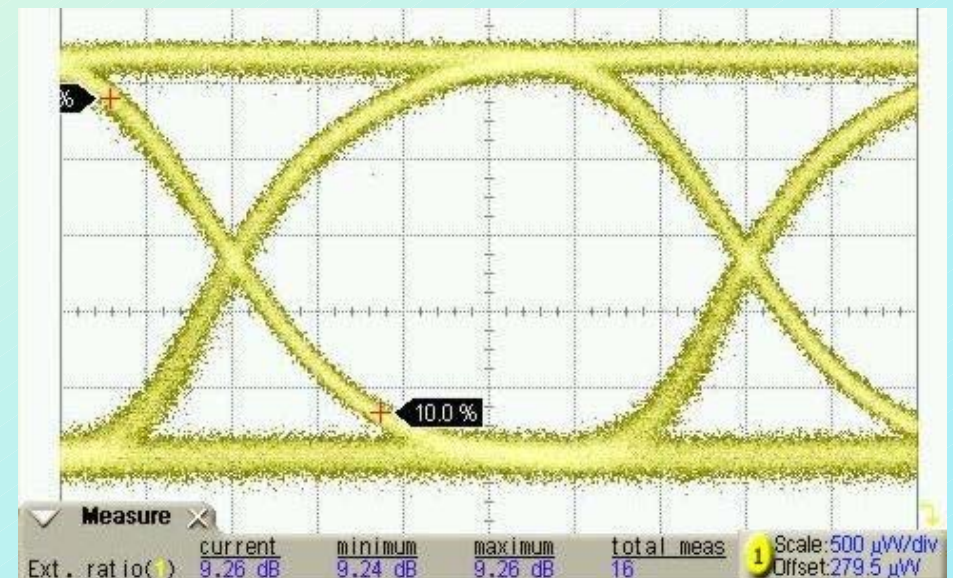
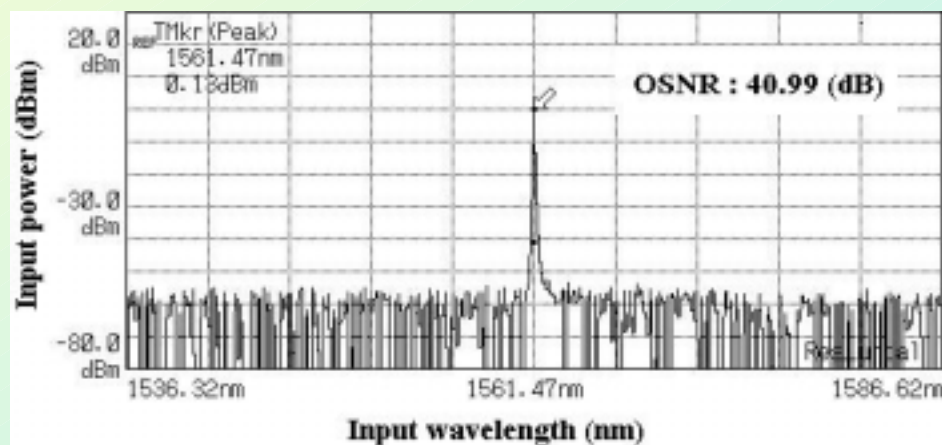


Reshaping and ASE Immunity

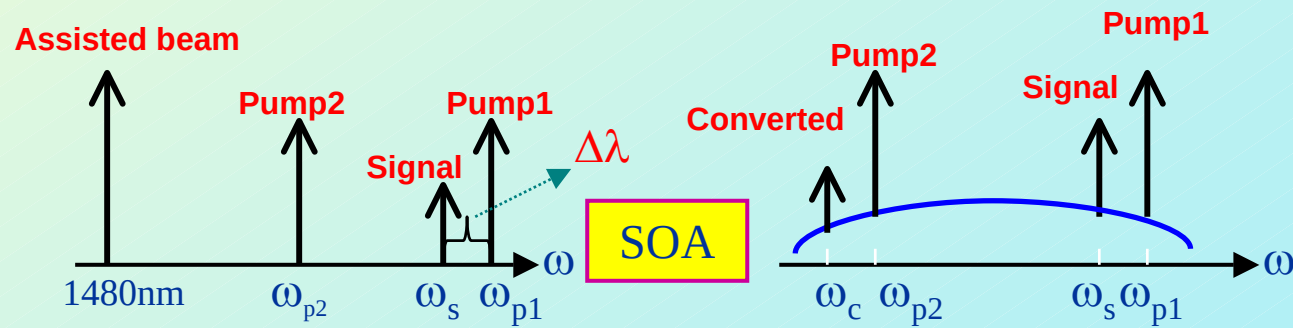
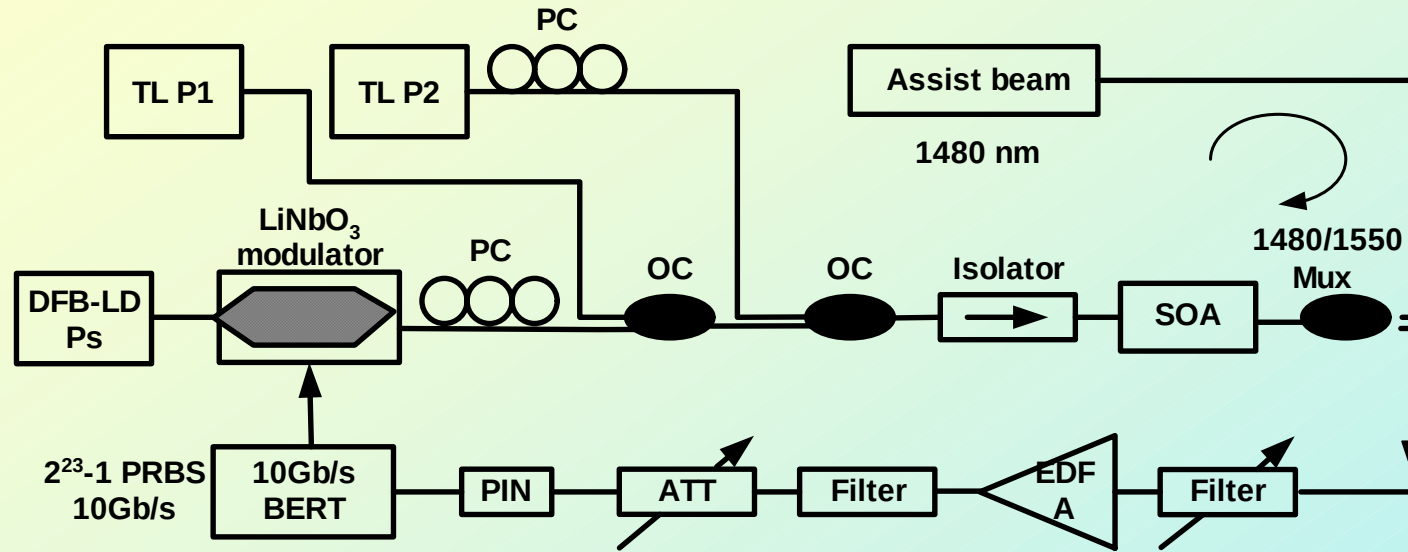
Input



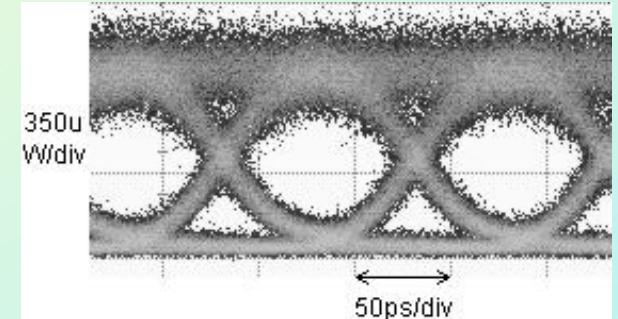
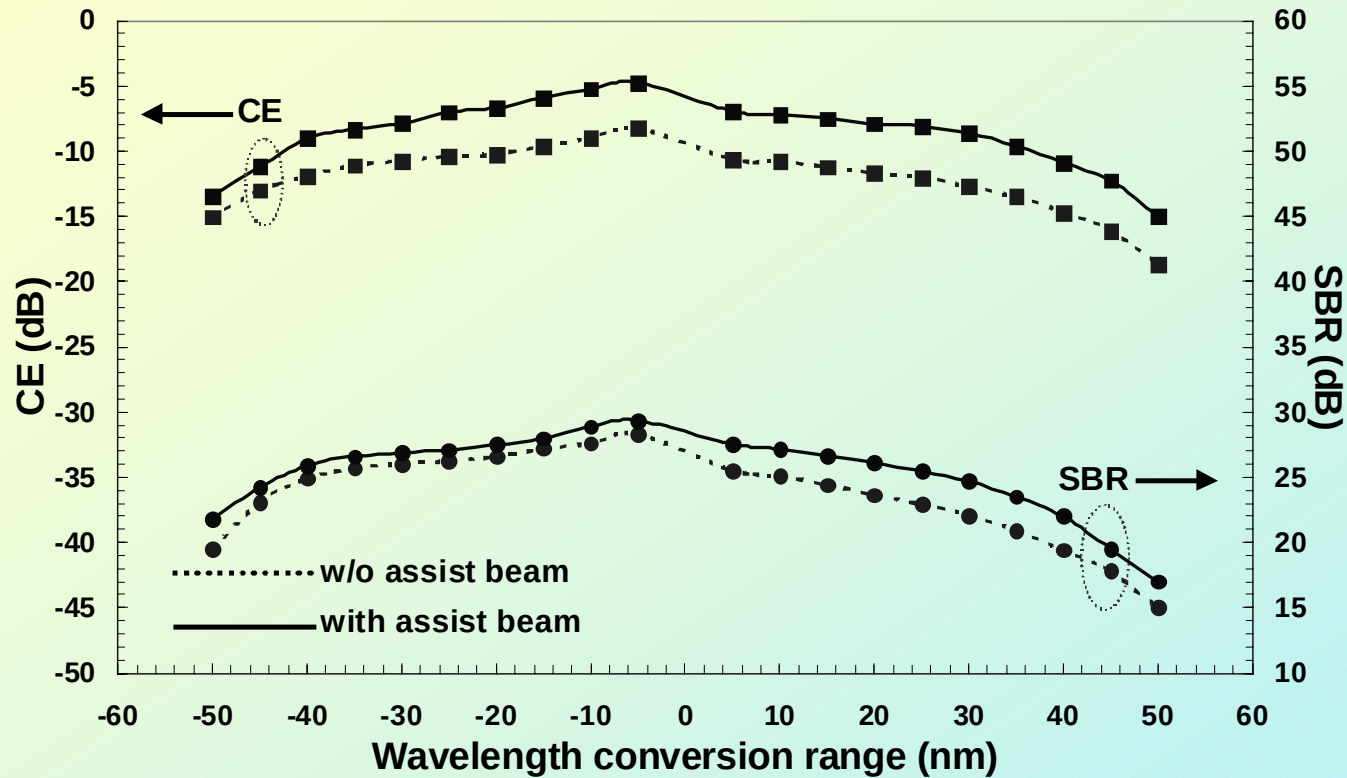
Output



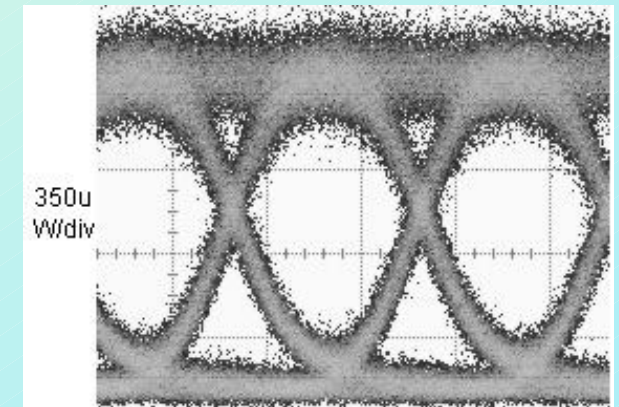
FWM-SOA Broadband Wavelength Converters



FWM-SOA Wavelength Converter (cont')

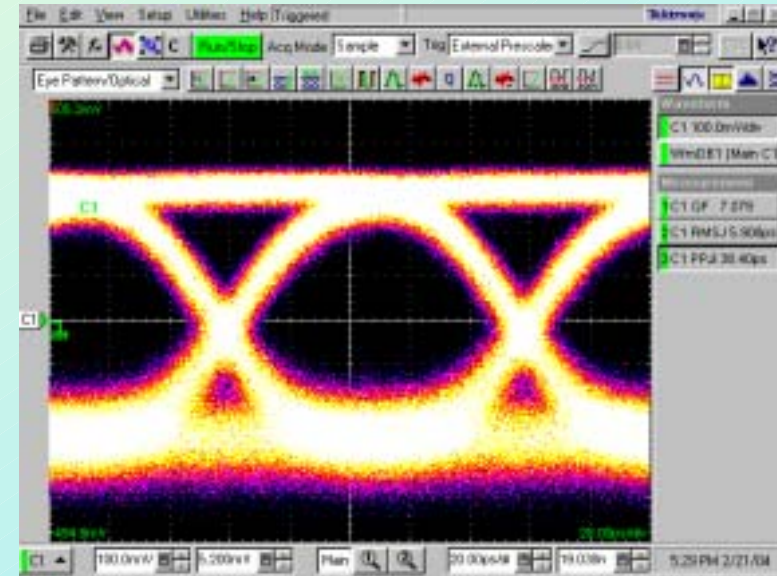
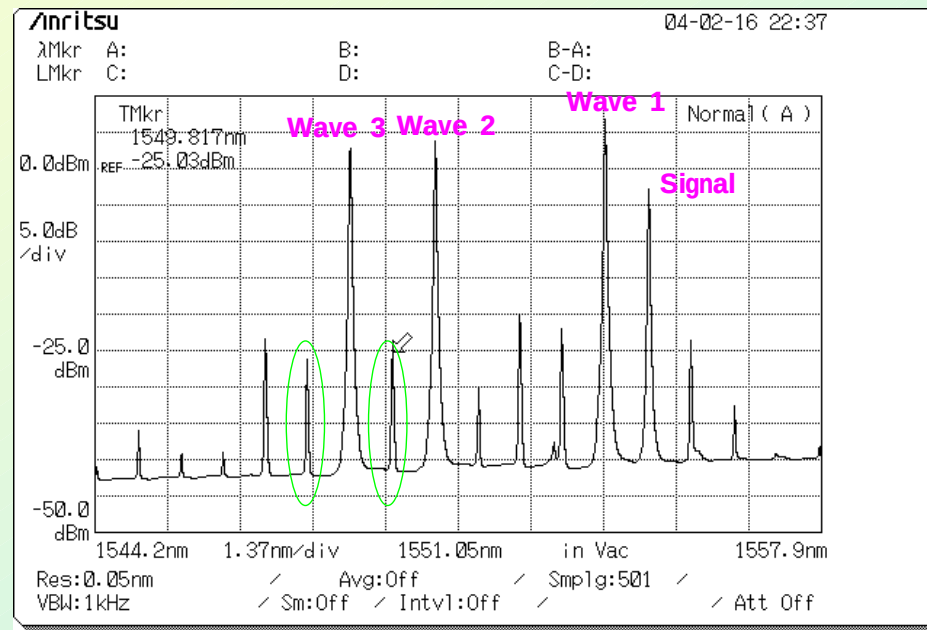
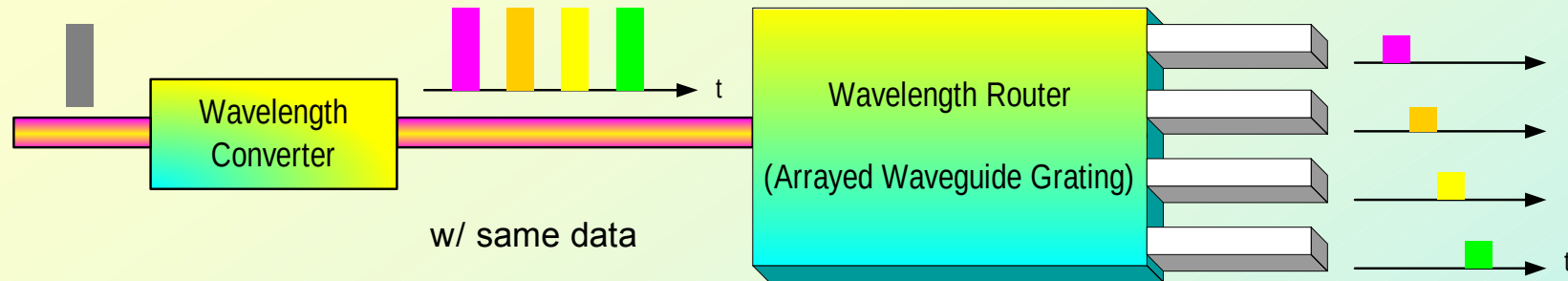


w/o A-beam



w/ A-beam

Multicast Wavelength Converters



Summary

- Optics can provide Ethernet-based networks w/
 - **More flexibility and re-configurability**
 - **Survivability**
 - **Fast data routing**
 - **Class of service**
 - **Multicast**
- A label-switched router is proposed for best use of the strength of optics
- Optical technology can be cost-down further from integration and mass production

Acknowledgment

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