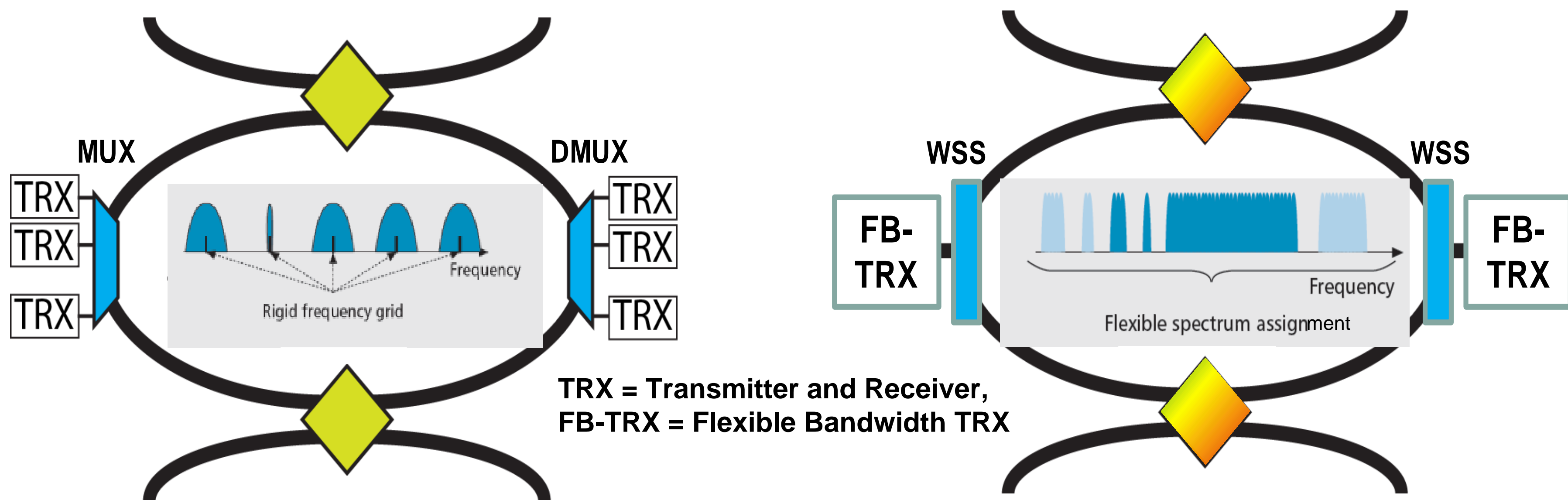


Abstract: We investigated several key techniques in software-defined elastic optical networks, with successful testbed and multi-domain UCD-COTN-ESNet demonstration.

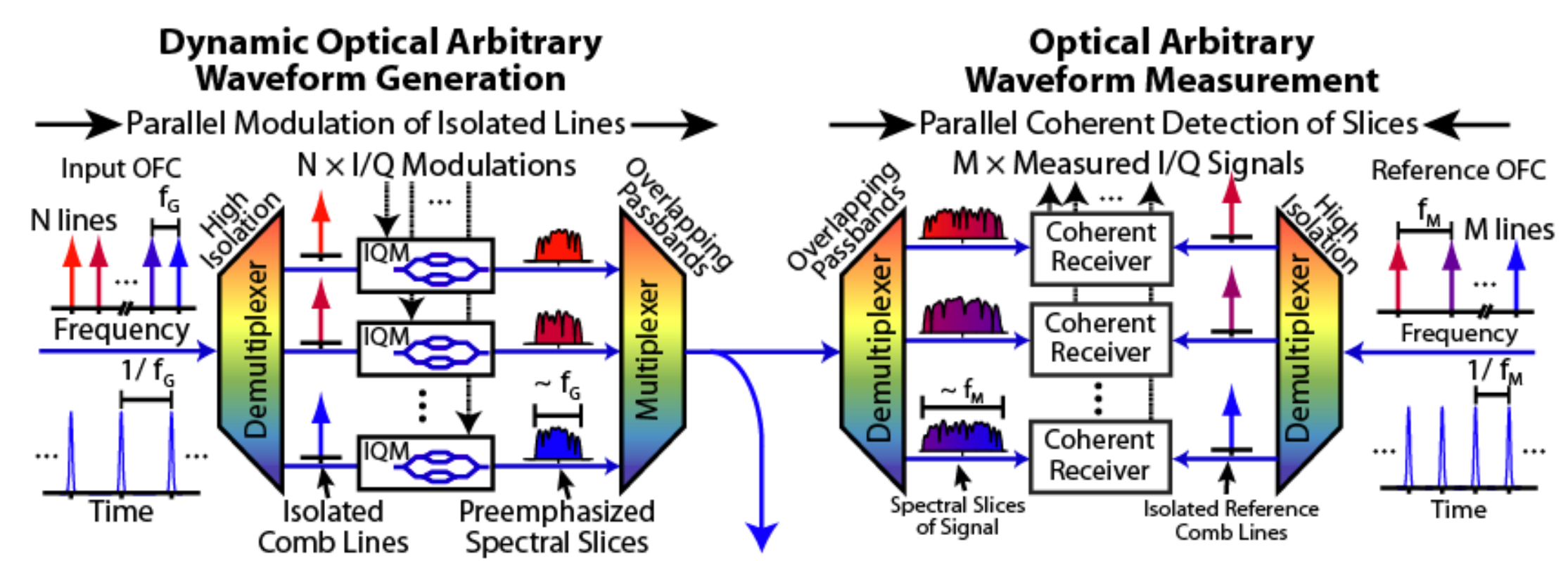
Conventional DWDM vs Flexible Bandwidth



- wasted stranded spectral bands
- wavelength management
- wavelength routing
- fixed capacity per wavelength determined by transponder
- subwavelength granularity difficult
- multiwavelength granularity difficult
- efficient use of spectrum
- bandwidth management
- bandwidth routing
- flexible capacity per flow
- assign mini-capacity below standard WDM channel
- assign large-capacity above standard wavelength channel capacity

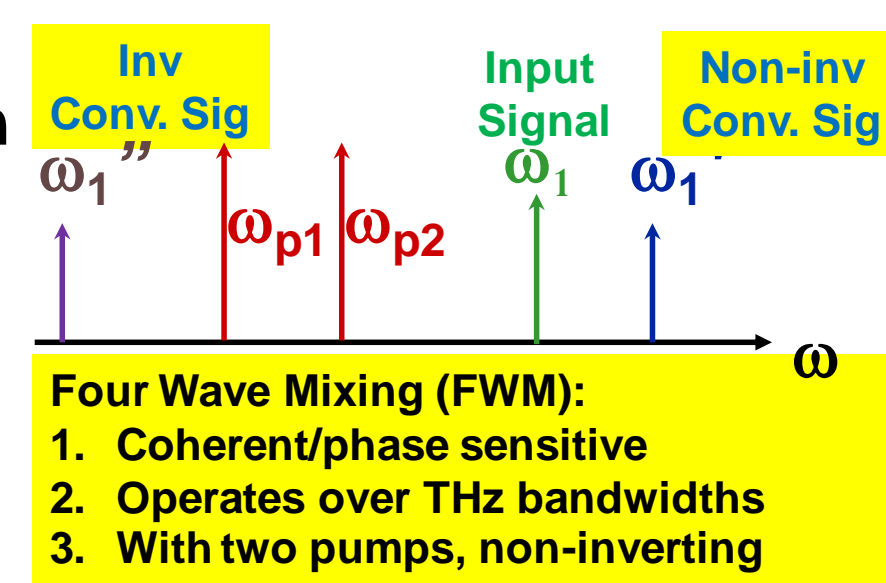
Key Techniques for Elastic Optical Networks

Bandwidth-Scalable THz Rate Optical Arbitrary Waveform Generation and Measurement

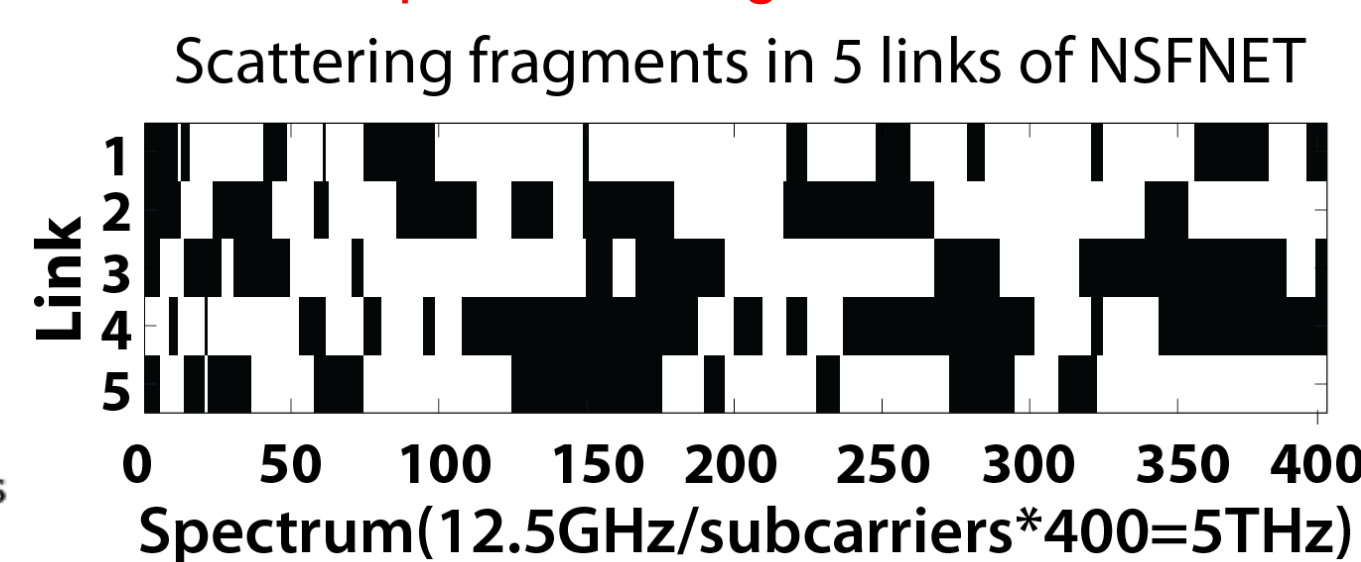


- Fourier Synthesis of Arbitrary Waveforms scaling to Terahertz BW using simple CMOS speed electronics
- Flexible spectrum & modulation format assignments
- Flexible grid spacing
- Low PAPR and Pre-Comp/Post-Comp
- Photonic Integrated Circuit construction

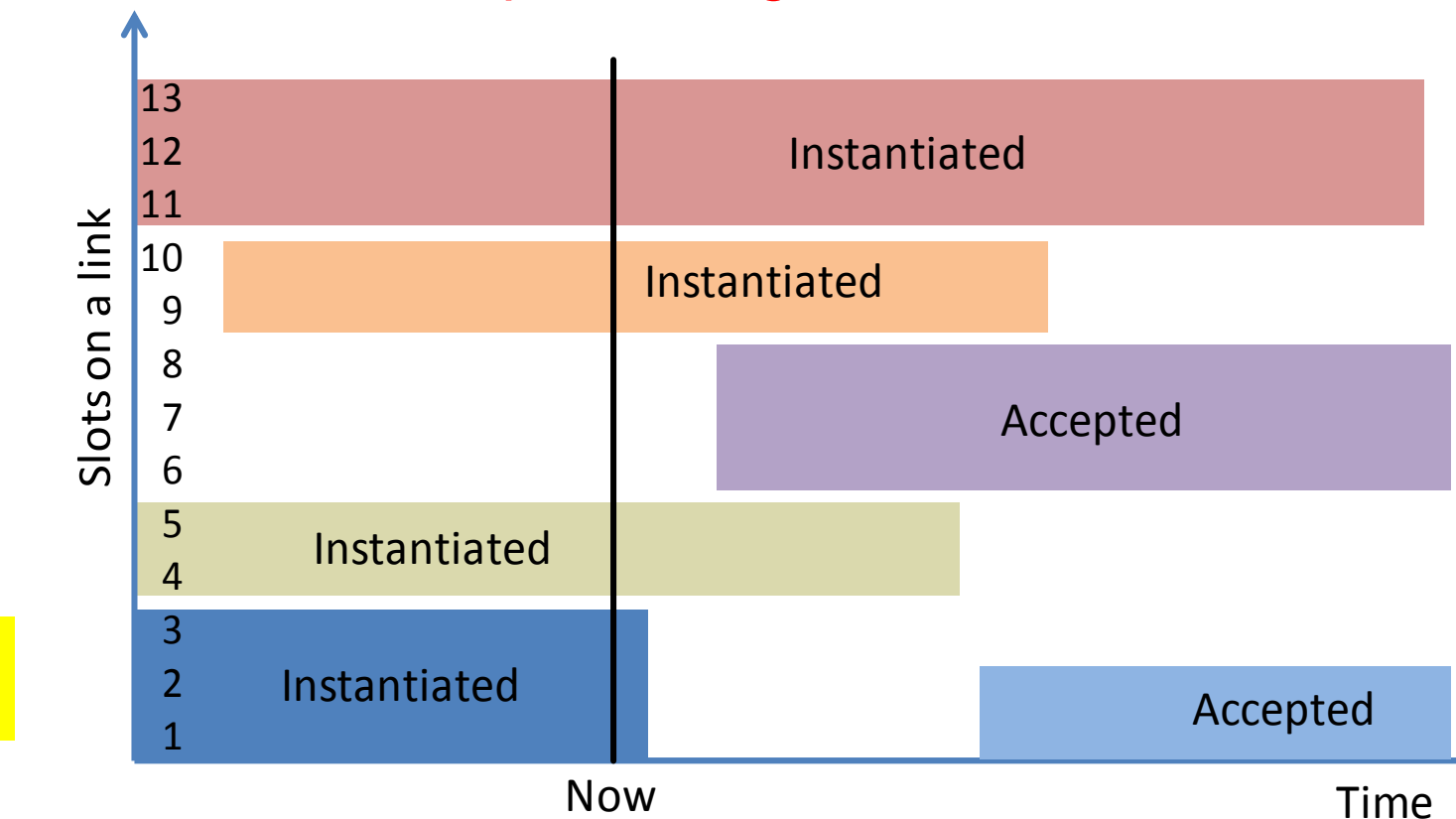
- Fragmentation is a new challenge in Flexible Bandwidth Networks
- FWM can be used to defragment
- Defragmentation is about moving the existing connections
- Defragmentation can be mapped to MIS problem in an auxiliary graph



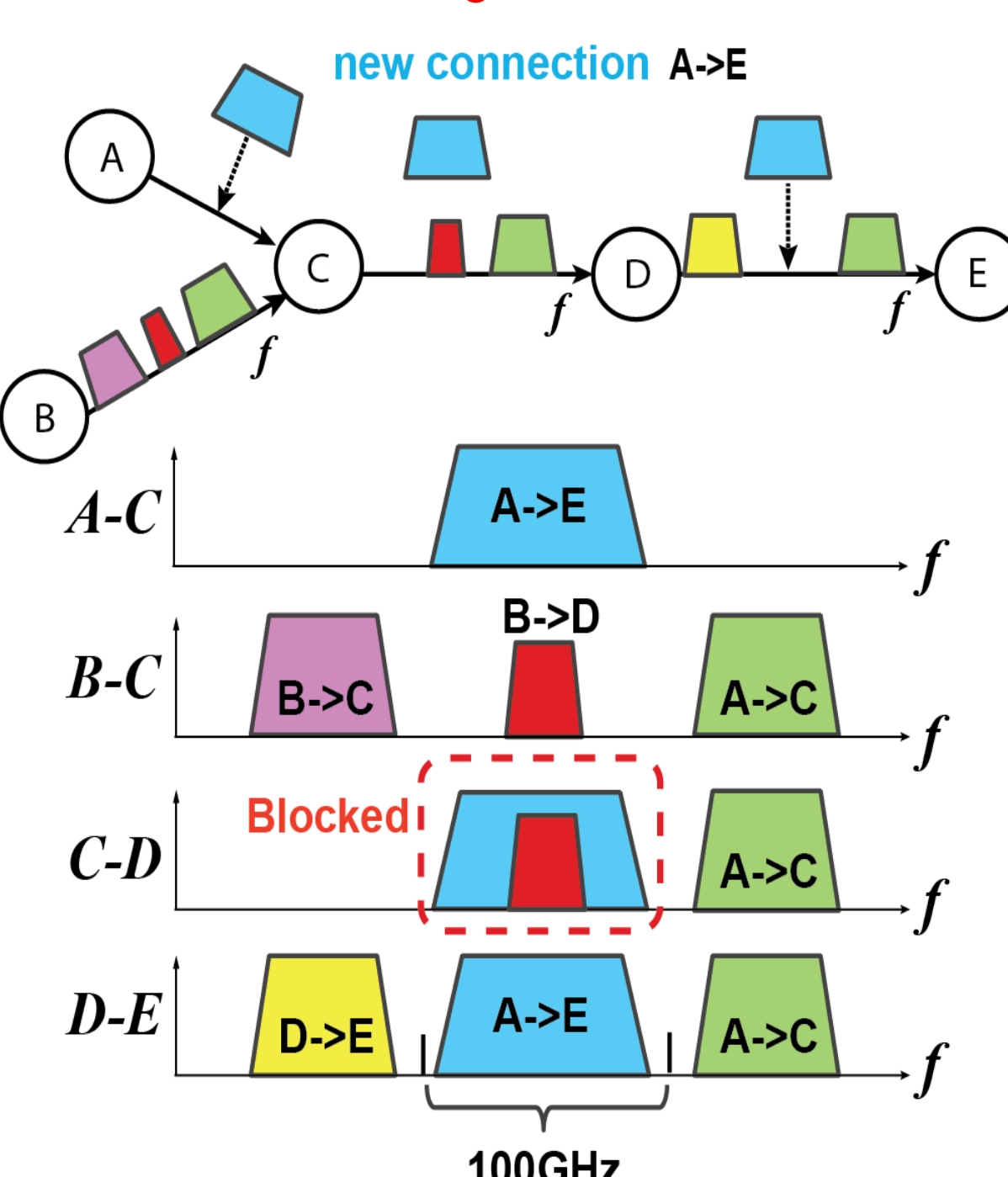
Spectrum Fragmentation



Temporal Fragmentation

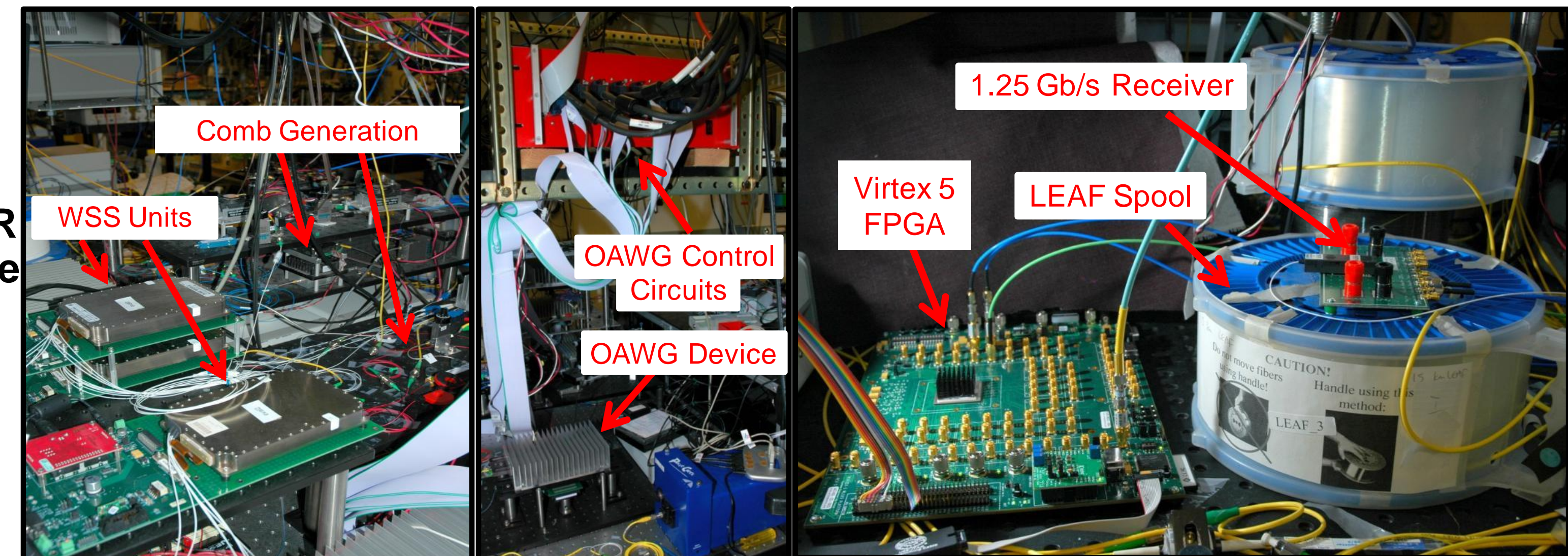


Defragmentation



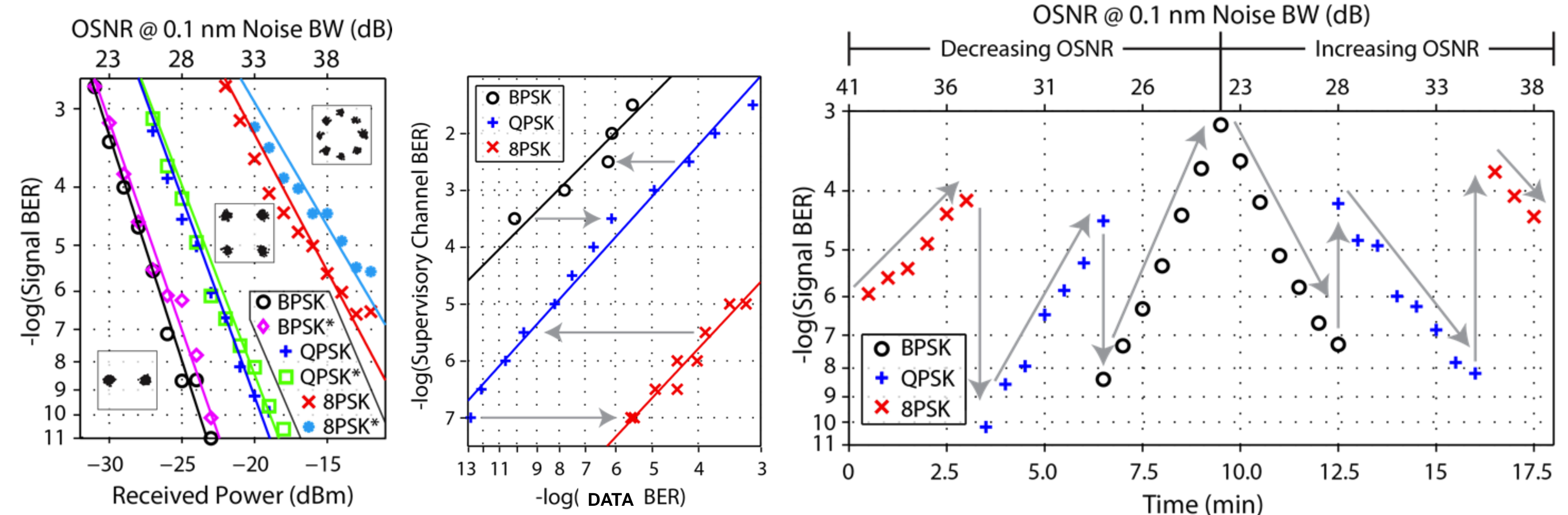
EON-Flexible Bandwidth Network Testbed

(a) FPGA based low-speed over-modulation

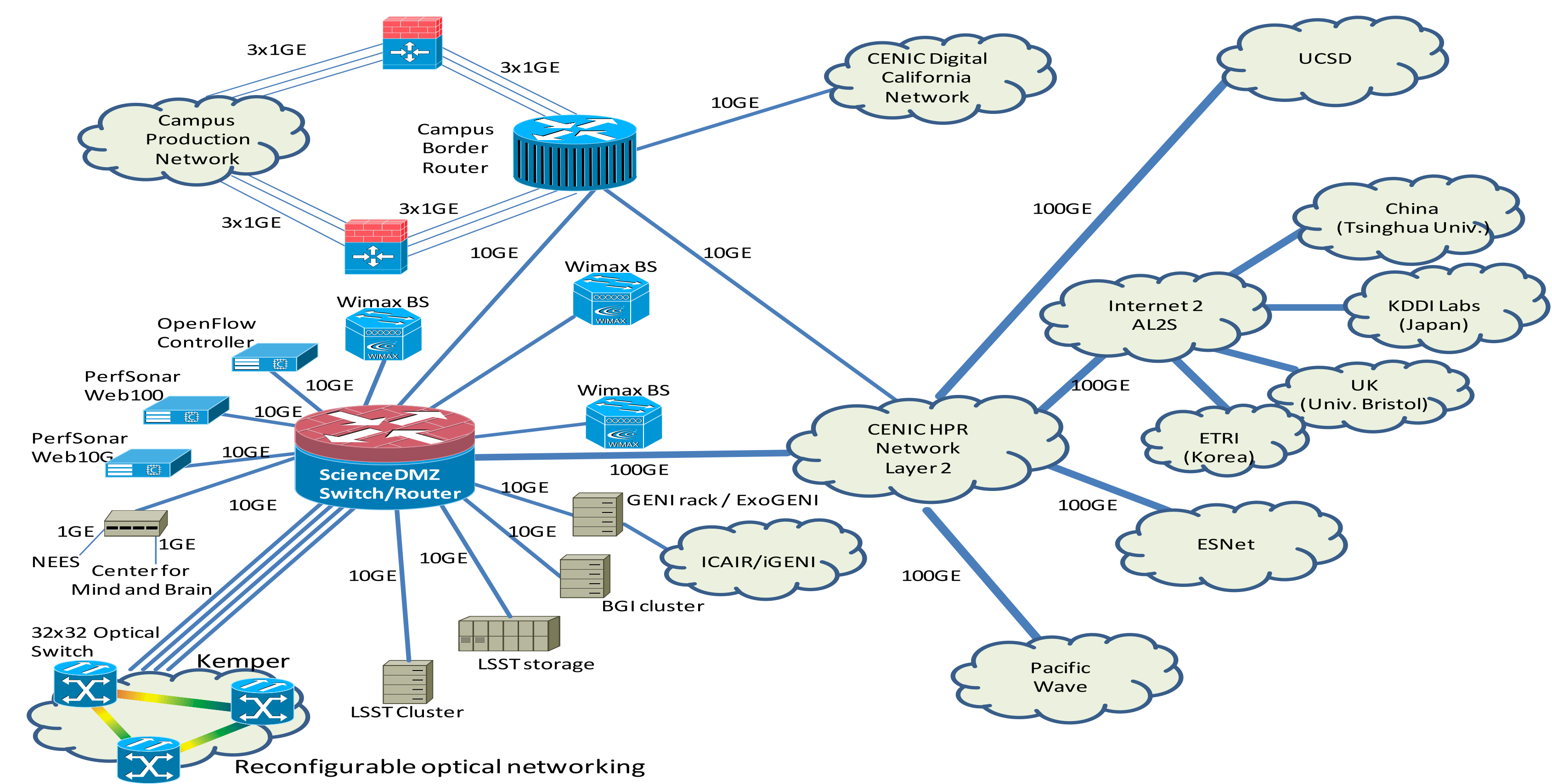


(b) Correlation between the BER of the SC and the data

(c) Automated adjustment of modulation format to maintain BER

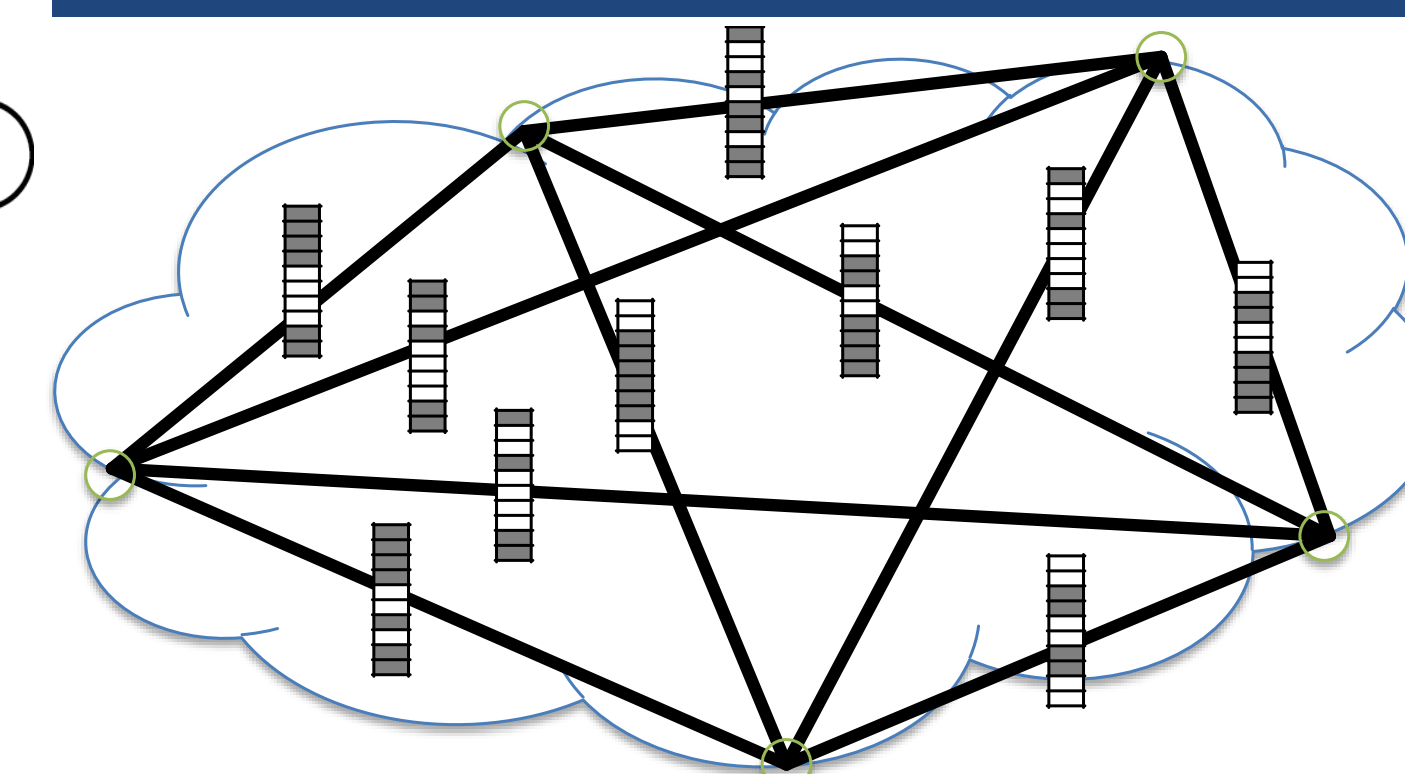


UC Davis Campus Testbed



We have successfully conducted multi-domain SDN experiments with COTN and ESNet from UC Davis Campus Networks

Domain Virtualization for FlexGrid



- Domain controller**
 - Defines virtual links between gateway pairs
 - Finds path between each pair of gateways
 - Determines the slots available on each virtual link path for that interval
 - Reports slot availability on a per-virtual link basis
- Virtualization**
 - Blocking probability decreases with number of paths evaluated for each virtual link
 - However overhead increases with number of paths

Our Selected Publications related to this topic:
[1] S. J. B. Yoo, et al., "Software defined elastic optical networking in temporal, spectral, spatial domains," Photonic Network Communications (Invited), Vol. 28, No. 1, pp. 19-33, August, 2014.
[2] X. Cai, et al., "Experimental demonstration of adaptive combinational QoT failure restoration in elastic optical networks," IEEE/OSA Journal of Lightwave Technology, Vol. 31, No. 4, pp. 664-671, February, 2013.

This work was supported by DOE

Software-defined Elastic Optical Networking by OpenFlow

