
Time-Stretch Oscilloscope Insertion in CIAN Cross-Layer Network Test-Bed

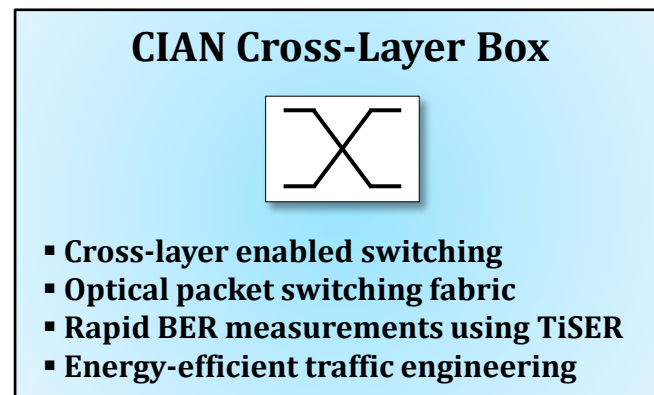
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Goals

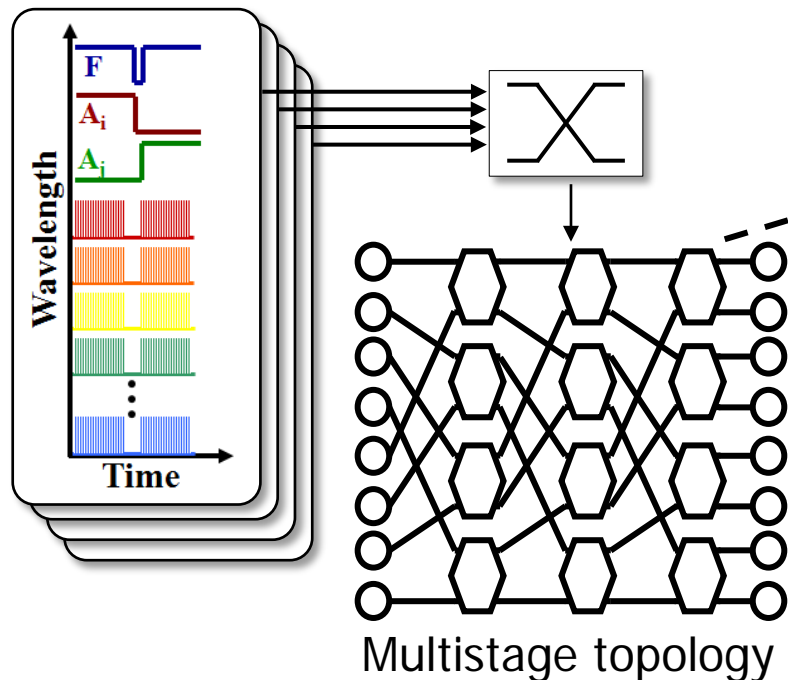
- Key goals: the development and insertion of bit-error rate measurements using Time-Stretch Enhanced Recording (TiSER) oscilloscope in the test-bed.
 - Apply BER algorithm to 10-Gb/s and 40-Gb/s wavelength-striped optical packets supporting by the Columbia CIAN test-bed
 - Use the extrapolated BER measurements to actuate fast packet switching
- Ultimately, the aim is to have TiSER be inserted in a *CIAN cross-layer box* to allow integrated switching and BER measurement capabilities



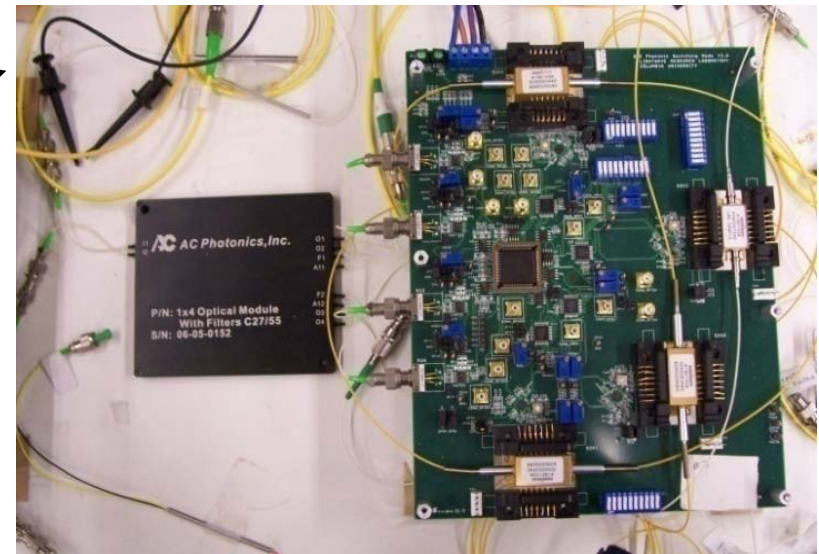
CIAN Cross-Layer Network Overview

Implemented test-bed to demonstrate switching fabric in one *CIAN cross-layer box*

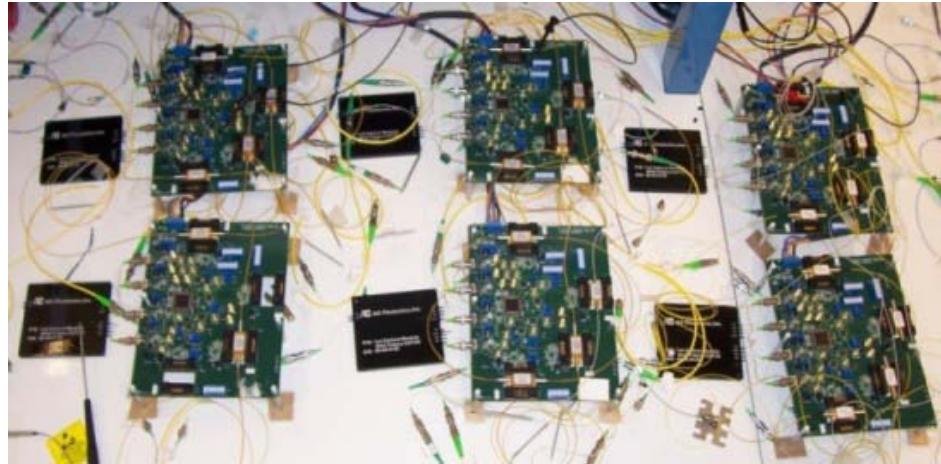
- Multistage optical switching fabric with distributed routing control logic
- High-bandwidth, wavelength-striped packets
- 2×2 SOA-based programmable wideband switching nodes



2×2 photonic switching node

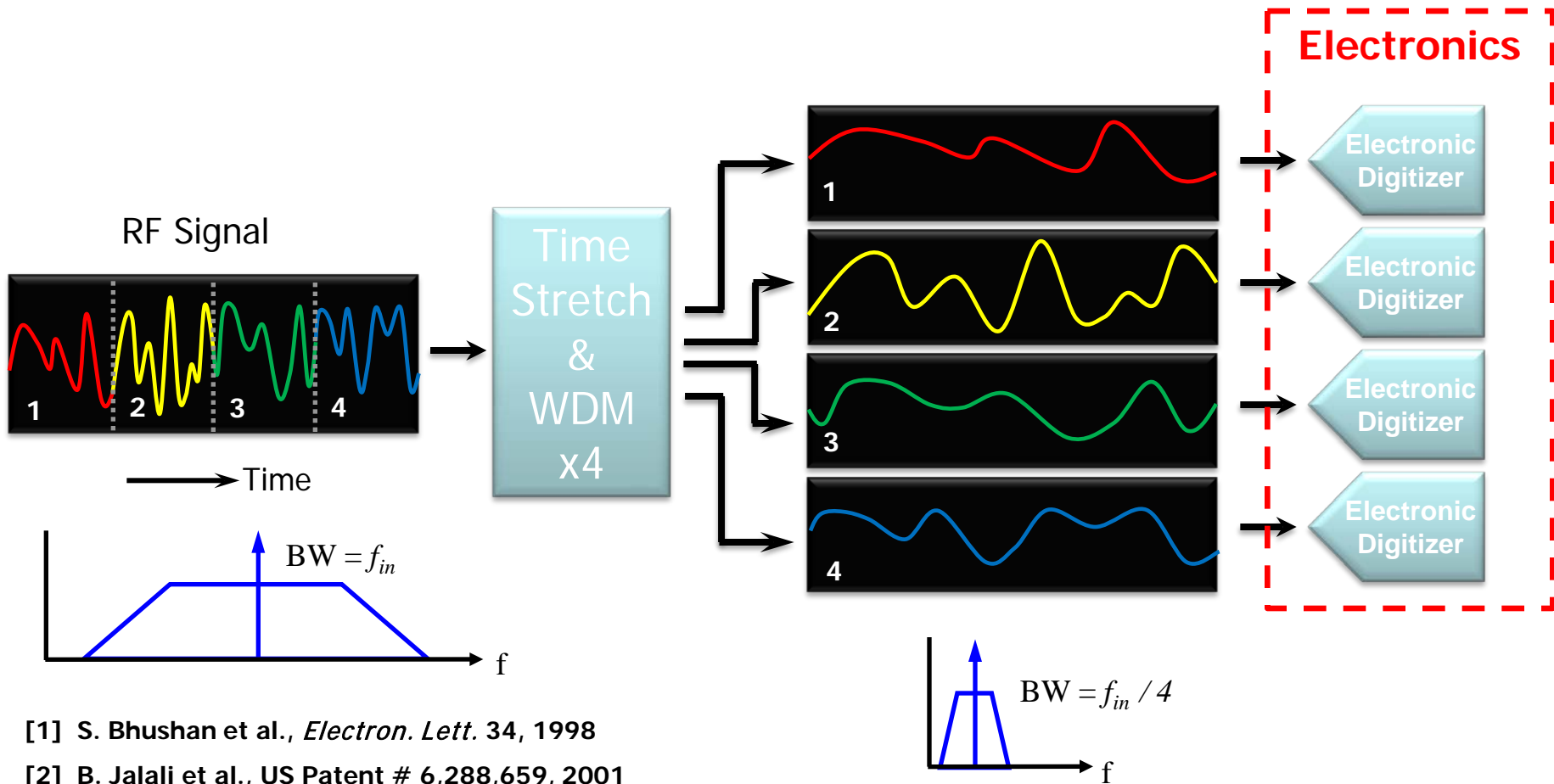


CIAN Cross-Layer Network Overview



- Photograph of test-bed
 - Implemented with commercially available components
 - Individually packaged elements (SOAs, passive optics, optical receivers, digital electronics)
- Serves to demonstrate critical network and cross-layer concepts
 - Error-free transmission of wavelength-striped messages
 - Cross-layer infrastructure: monitors optical packets and proactively discards degraded high-priority packets

Photonic Time-Stretch ADC



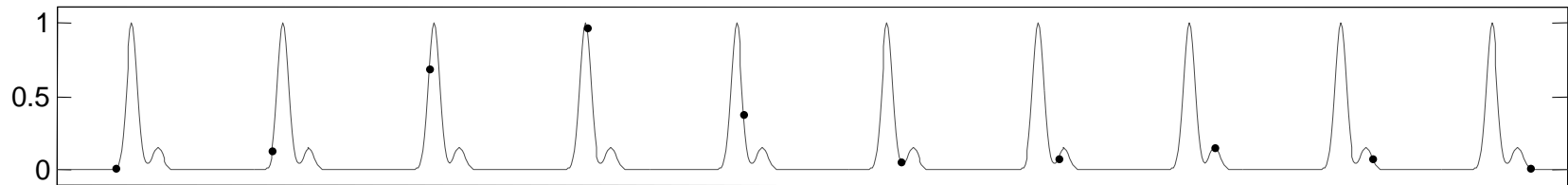
[1] S. Bhushan et al., *Electron. Lett.* 34, 1998

[2] B. Jalali et al., US Patent # 6,288,659, 2001

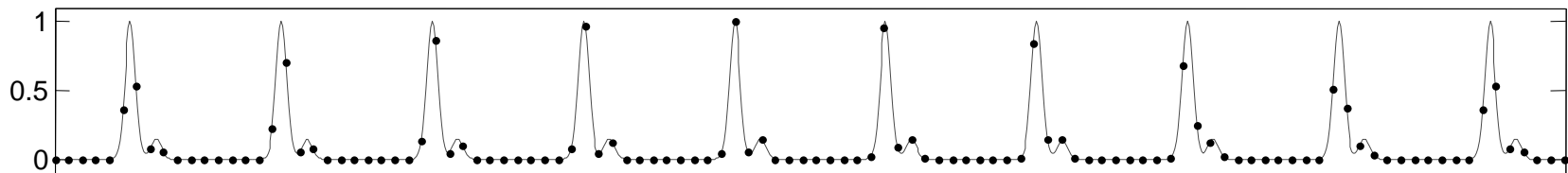
Real-Time Burst Sampling

Real-time Burst Sampling (RBS) technique records **bursts of samples** in **real-time** in each sampling period.

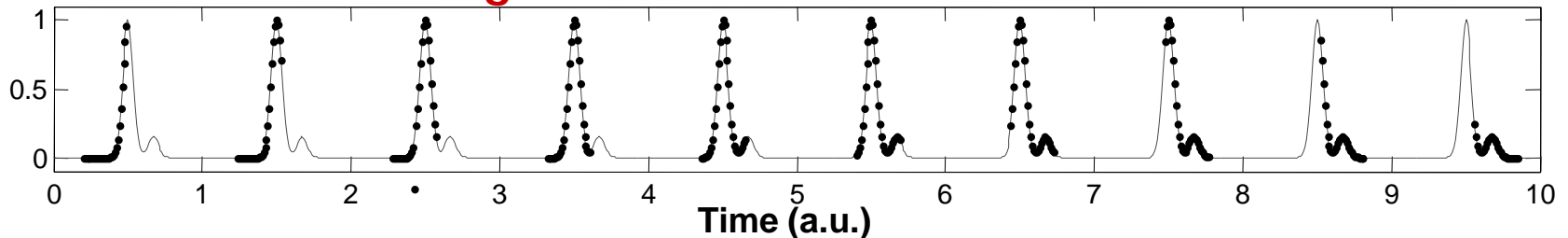
Equivalent-time sampling (using sampling oscilloscope) – repetitive signals



Real-time sampling (using real-time digitizer) - single shot signals but limited bandwidth



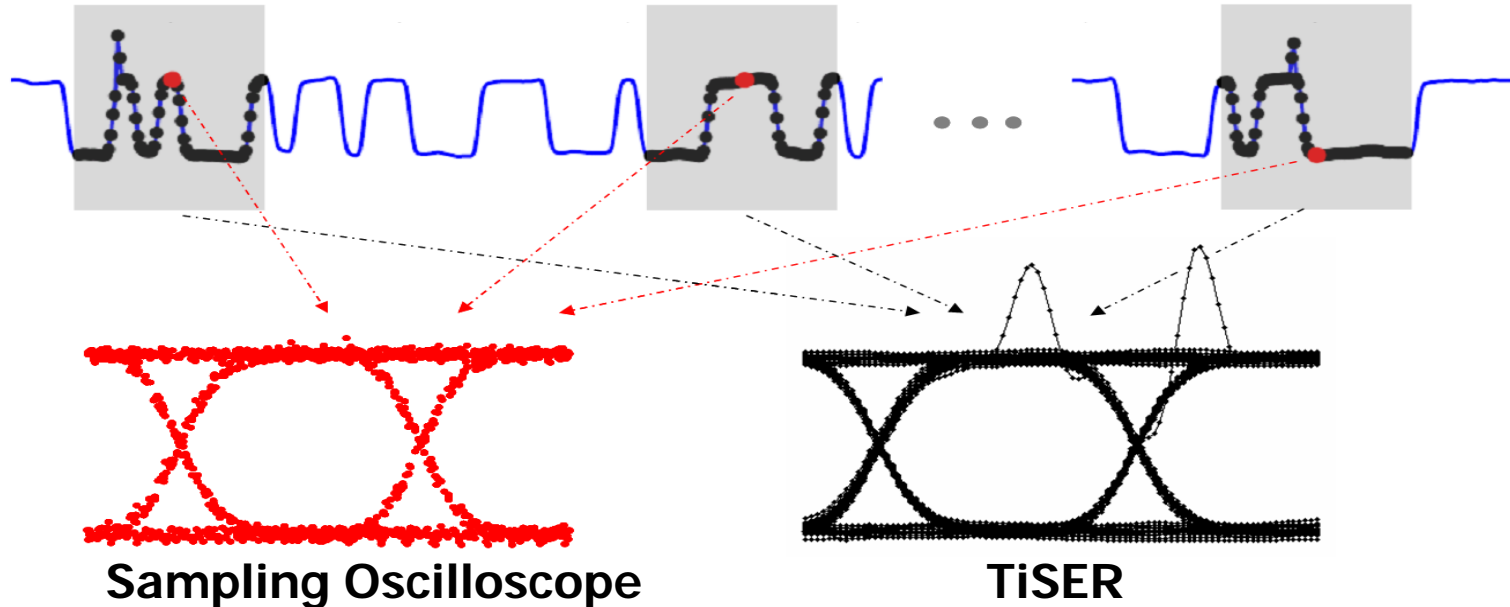
RBS (using TiSER - Time Stretch Enhanced Recording oscilloscope) – Ultrahigh bandwidth and real-time within bursts



S. Gupta and B. Jalali, *Appl. Phys. Lett.* 94, 041105 (2009)

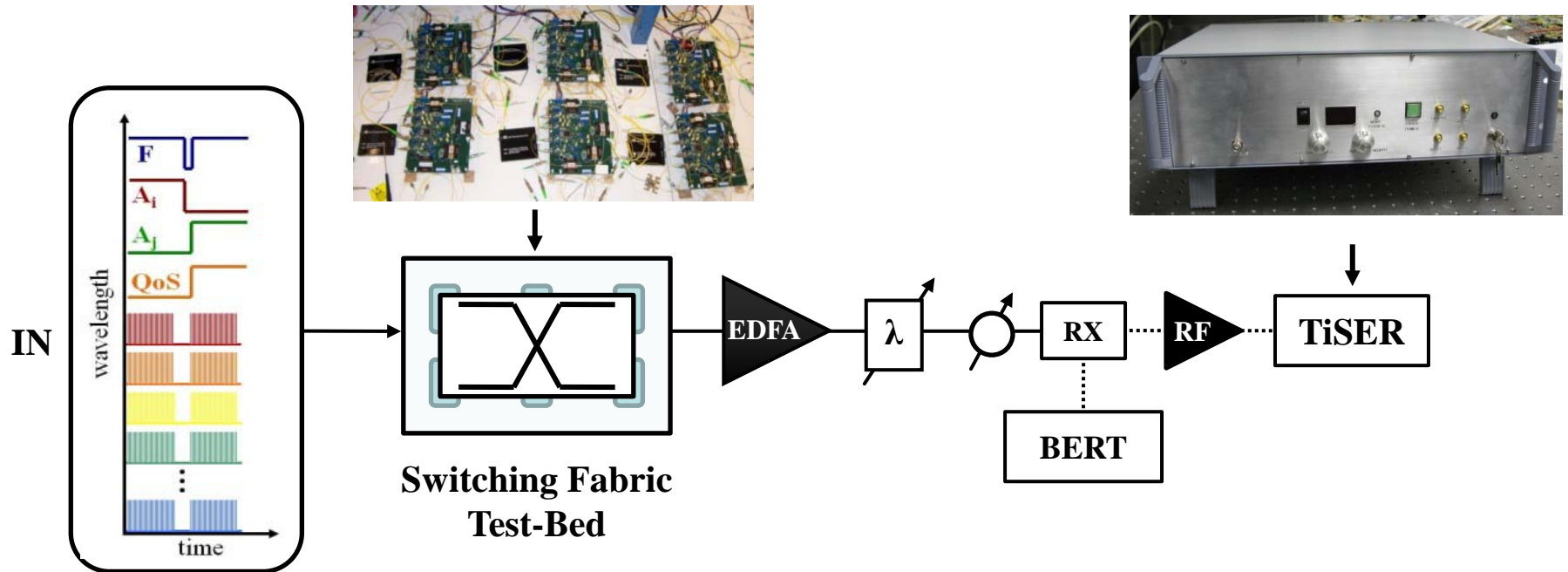


TiSER Can Capture Ultrafast Transients



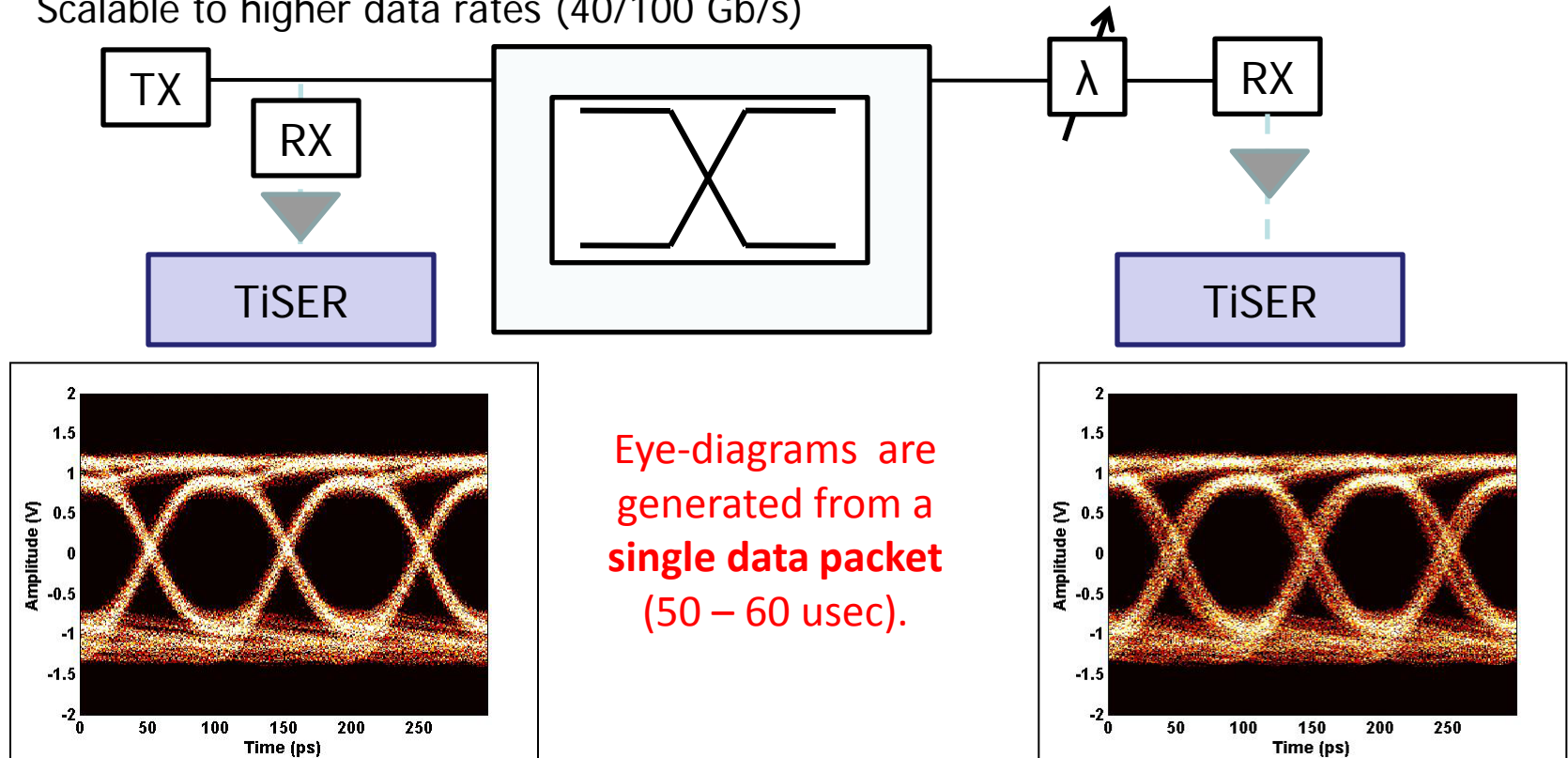
- Unlike conventional scope, TiSER can capture **fast repetitive**, **non-repetitive dynamics** and **rare events**. Real-time digitizers and sampling oscilloscopes do not provide these features because they either lack sufficient bandwidth or lack real-time capability.
- TiSER records more samples in certain time interval compared to sampling oscilloscope, resulting in **shorter test time**.

10-Gb/s Experimental Setup



10-Gb/s Measurements

- Insertion of UCLA's TiSER scope in Columbia cross-layer optical access network testbed
 - First step: generate eye diagrams at 10 Gb/s ($\lambda=1556.6\text{nm}$)
 - Scalable to higher data rates (40/100 Gb/s)



C. P. Lai, A. Motafakker-Fard, B. Buckley, B. Jalali, K. Bergman, Photonics Society Annual meeting, Nov 2010

Future Work

- Apply devised BER algorithm to the existing 10-Gb/s data
- Insert TiSER in CIAN cross-layer box, in order to capture 40-Gb/s eye diagrams
- Extrapolate the BER from the 40-Gb/s wavelength-stripped packets and use the measurements to actuate packet switching

