Fermilab

Optical Data Transmission Workshop
Aug. 19, 2010
Fermilab

Fermilab Activities and Planning

Alan G. Prosser

Optical Data Transmission Workshop
Fermilab Activities

Outline:

Versatile Link Common Project

Free Space Optical Transmission

CMS Pixels Phase 1 Upgrades

Versatile Link Common Project

Goal: “Development of a general purpose optical link which can cover all envisioned transmission applications: a versatile link”.

Participating Institutions and Organization (by Work Packages):

Work Package 1.1 (Southern Methodist University)
Point to Point Architecture and System Engineering

Work Package 2.1 (CERN)
Front End Components (Versatile Transceiver)

Work Package 2.2 (Fermilab)
Back End Components

Work Package 2.3 (Oxford University)
Passive Components

Schedule: (Phased Approach, Nominally 18 Months/Phase)

Phase 1: Proof Of Concept (Completed Sept. 2009)
Phase 2: Feasibility Demonstration (Completion Date March 2011)
Phase 3: Preproduction Activities (subject for review at TWEPP 2010)

Versatile Link Common Project

Work Package 2.2 (FNAL, joined in Sept. 2008):

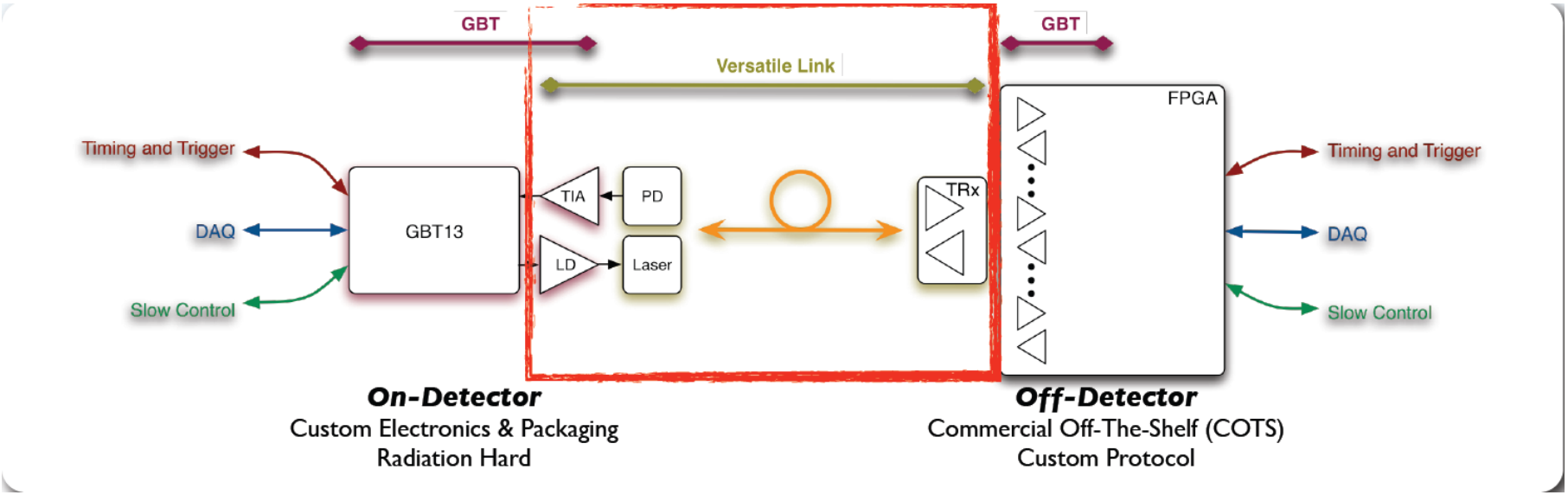
Responsible for Evaluation of Back End Components:

- Single Channel SFP+ TRx (850 nm and 1310 nm)
- Parallel Optical Modules (SNAP12, QSFP, Optical Engines)
- High Power Transmitters

Activities Include:

- Testing of candidate components
- Selection of reference components for Versatile Link Team
- Procurement of samples of reference components
- Specifications for qualified components
- Preproduction support for back end components

Versatile Link Components



Source: "Versatile Link Status Report"
Jan Troska
CMS Tracker Upgrade Meeting
April 24, 2009

Versatile Link Common Project

Test Equipment Includes:

Tektronix DSA8200 Digital Signal Analyzer
- 80C12-10G Optical Head
- 80A06 Pattern Sync Module
- 80E04 Electrical Sampling Module
- JNB Jitter Analysis Software

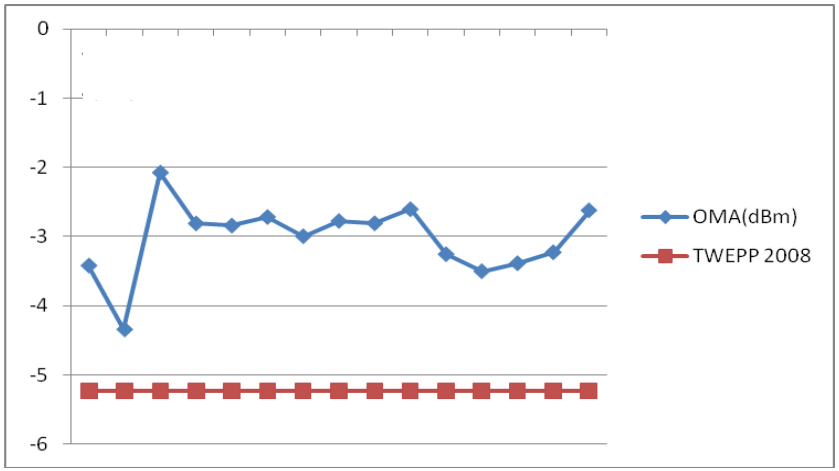
JDSU MAP-200 Multi Application Platform
- 850 nm Variable Optical Attenuator
- 1310 nm Variable Optical Attenuator

Altera Stratix II, Stratix IV GT Signal Integrity Kits (up to 10 Gbps)

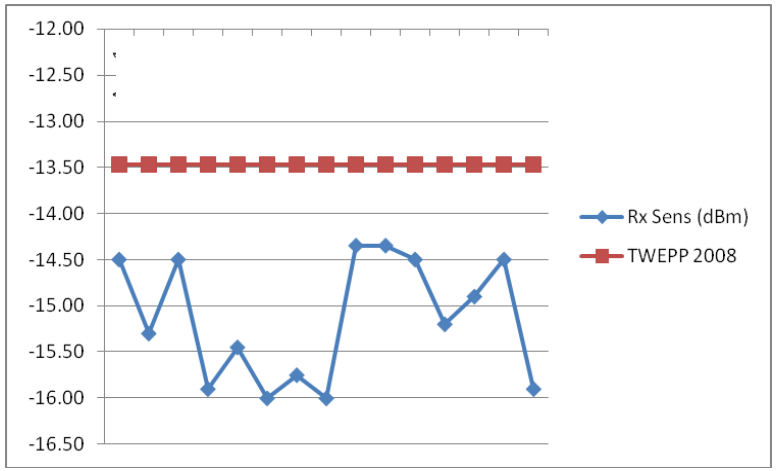
SFP+ Evaluation Boards from SMU

VBERT Test System from SMU

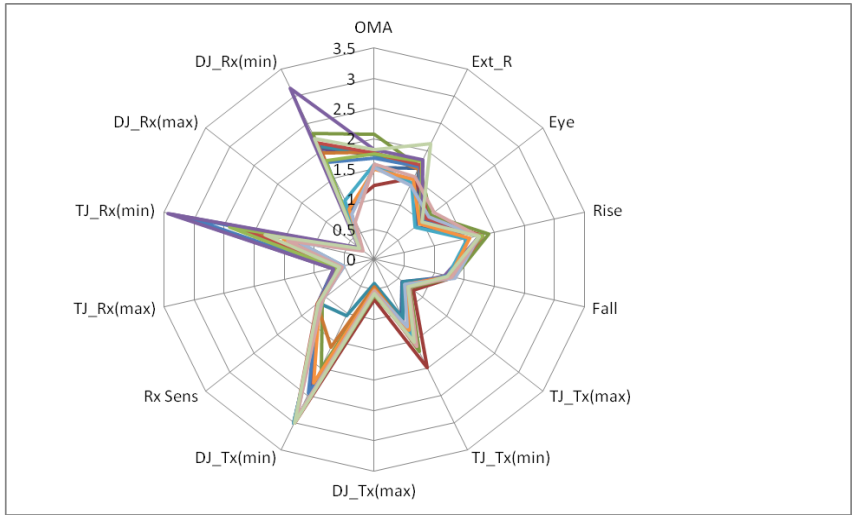
Versatile Link SFP+ Transceiver Measurements



Transmitter Measurements



Receiver Measurements



Radar Plots

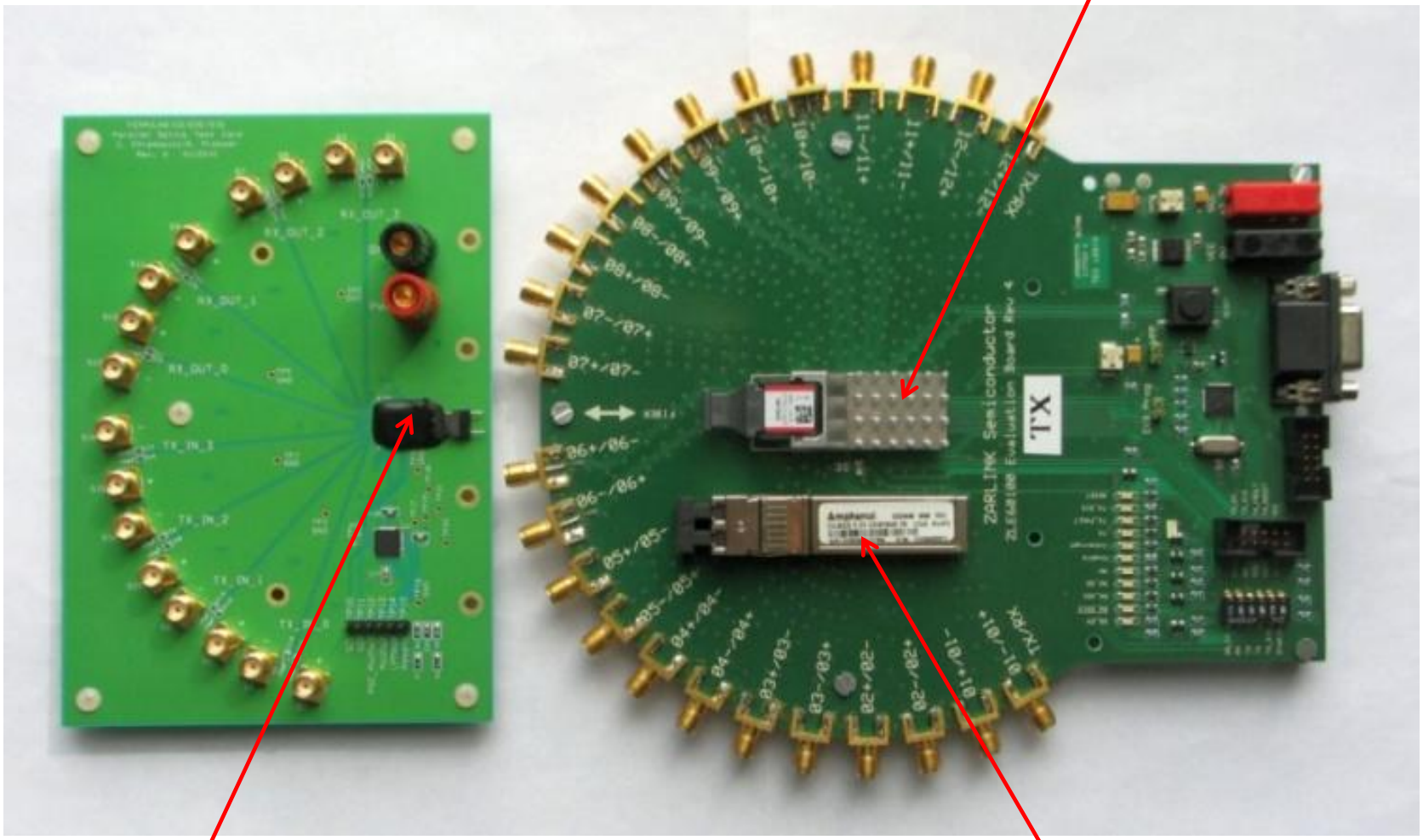
Data Collected at:

5 Gbps
6.25 Gbps
10 Gbps

Parallel Optics – Package Evolution

- Off the shelf and prototype devices
- High speed, parallel communications

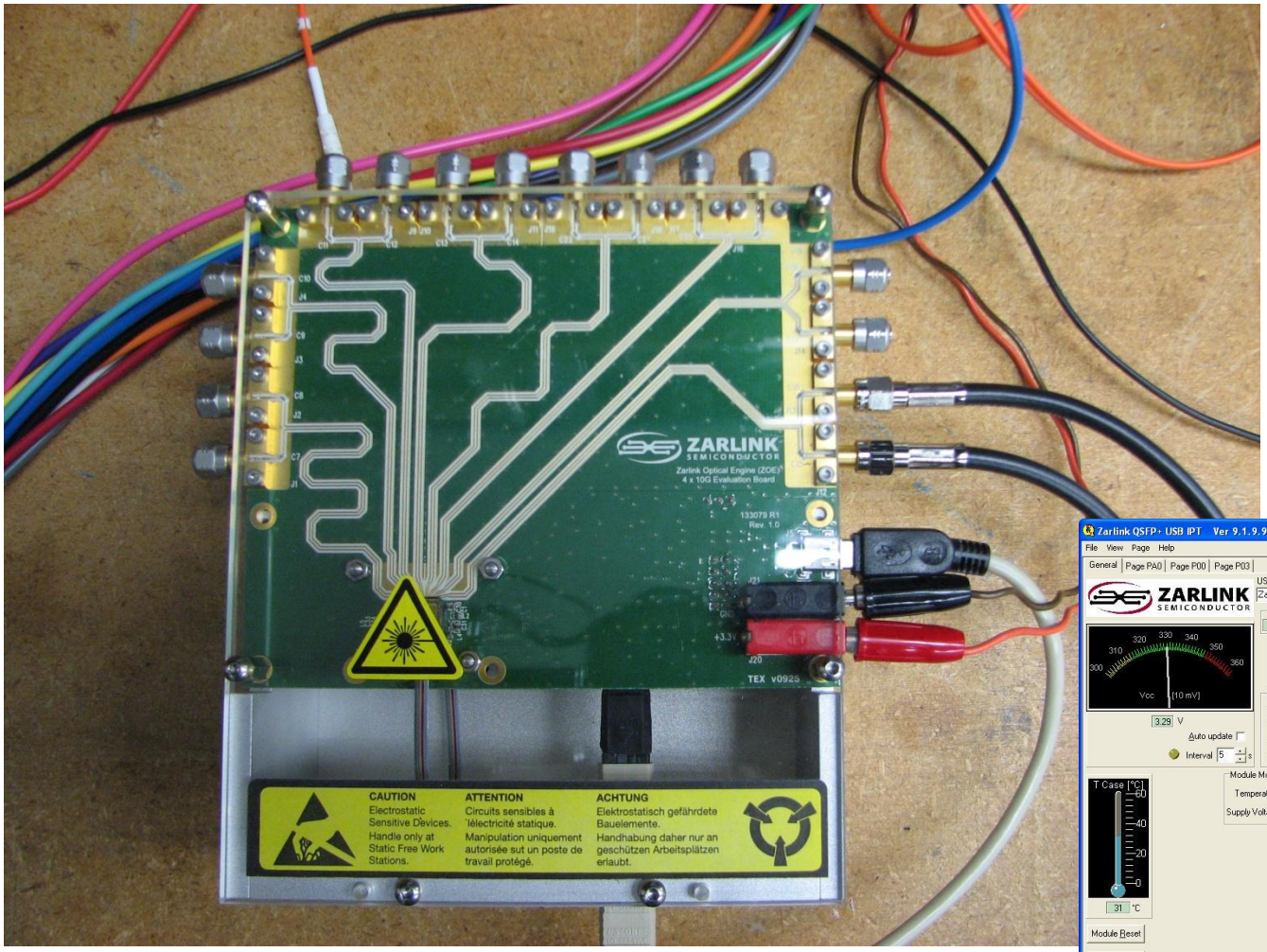
SNAP12 Transmitter
(12 channels, 2.7 Gbps/channel)

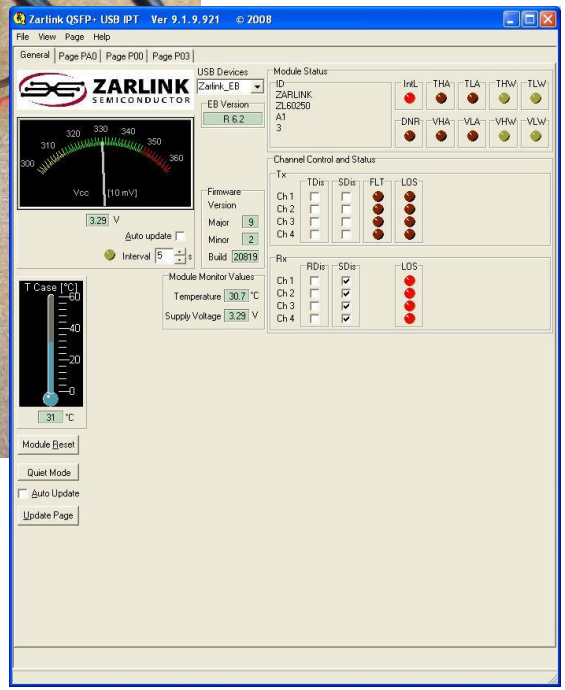


Parallel Optical Engine Transceiver
(4 channels, 6.25 Gbps/channel)

SFP+ Single Channel Transceiver
(10 Gbps)

Parallel Optics @10 Gbps/Channel





4 Channel TRx Parallel Optical Engine Evaluation Kit from Tyco (Zarlink)
Successfully tested at 10 Gbps on each channel

Versatile Link Common Project

Next Steps:

SFP+

- Develop detailed specifications for SFP+ TRx
- Additional testing (thermal, noise)

Parallel Optics

- Continue Evaluation of Evolving Technology
- Develop demonstration hardware with FPGA (μTCA platform)
- Develop specifications for candidate devices

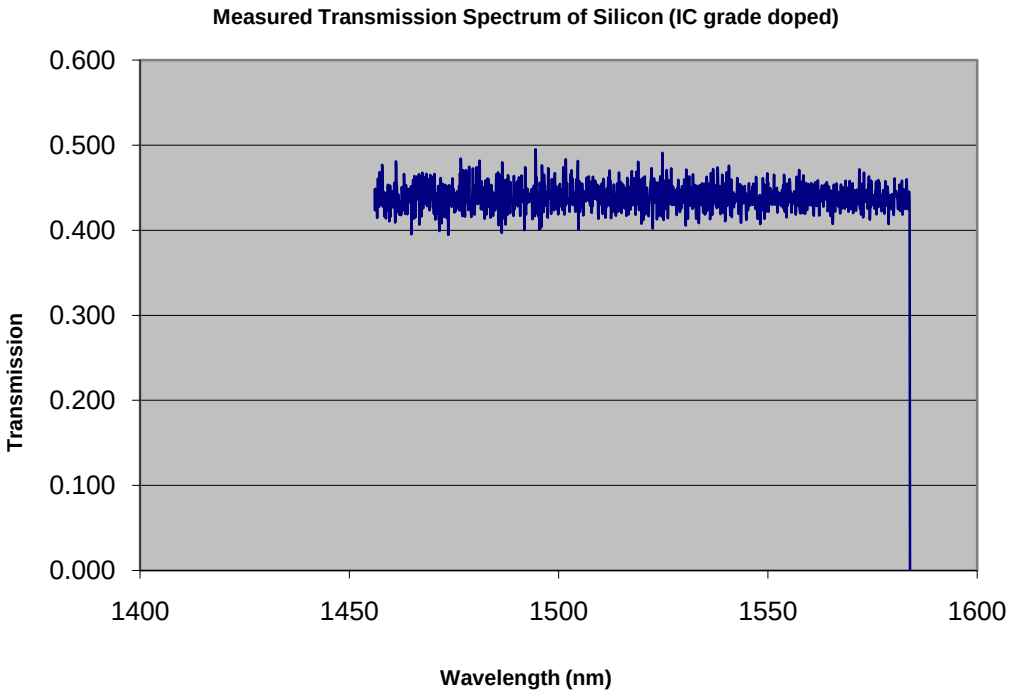
High Power Transmitters

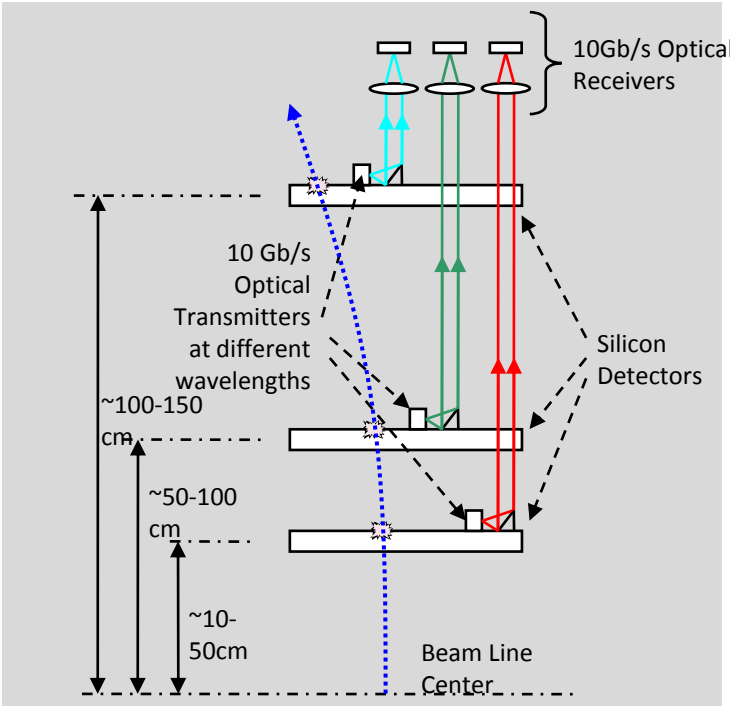
- Investigate higher power options in commercially available components

Phase III

- Topic for discussion at TWEPP 2010 (next month)

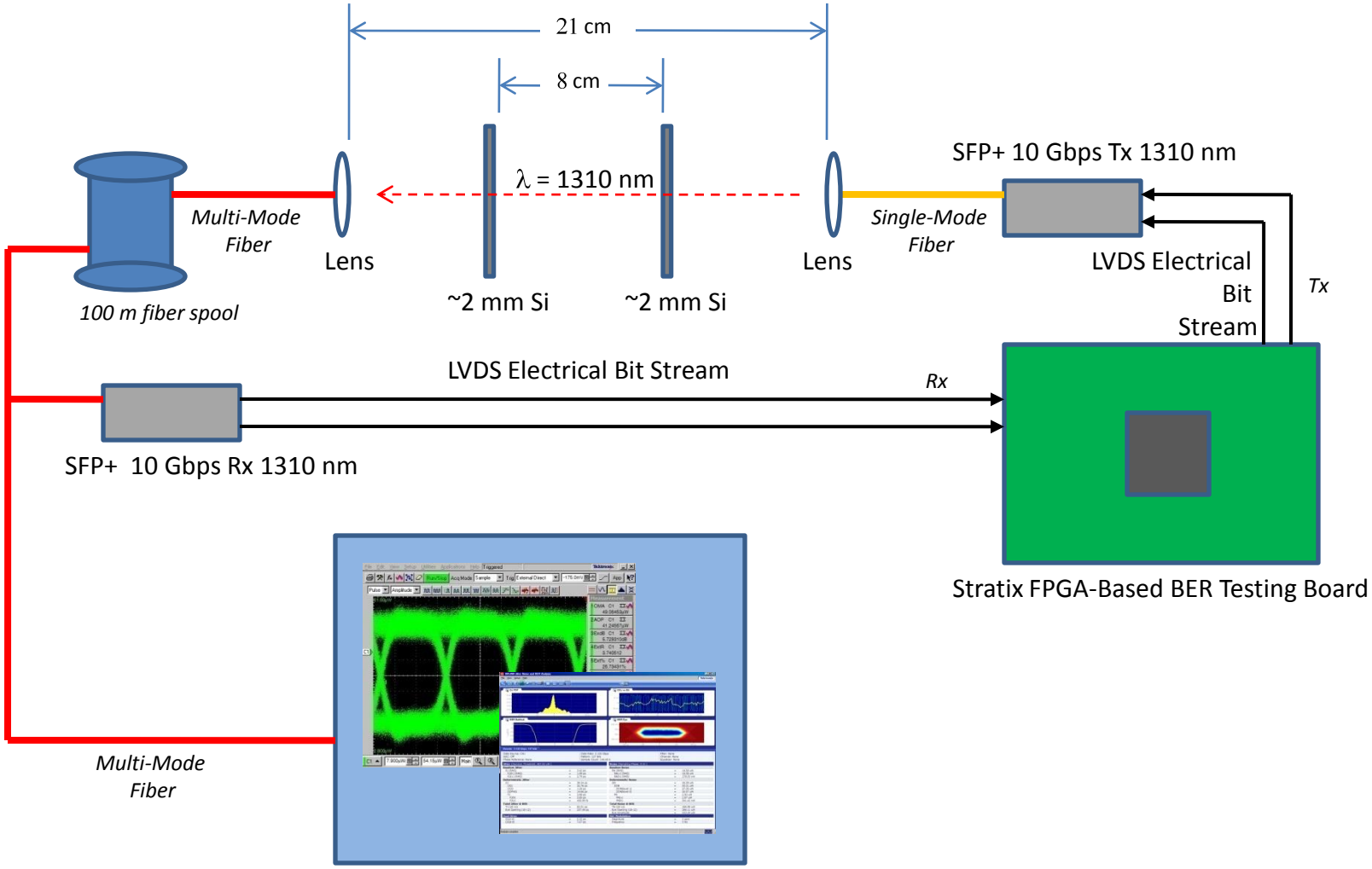
Cable-less Free Space Optical Data Transmission



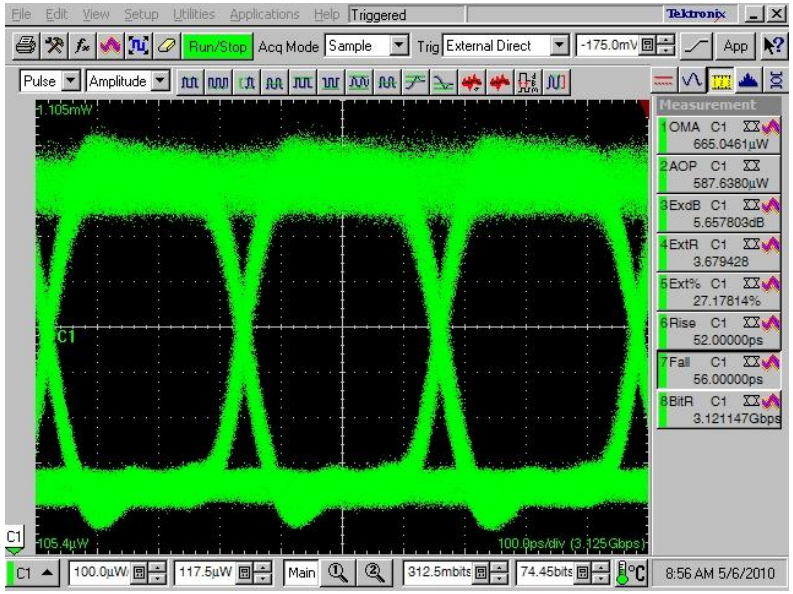


- Optical fibers removed from detector volume
- Transmission through free space or silicon

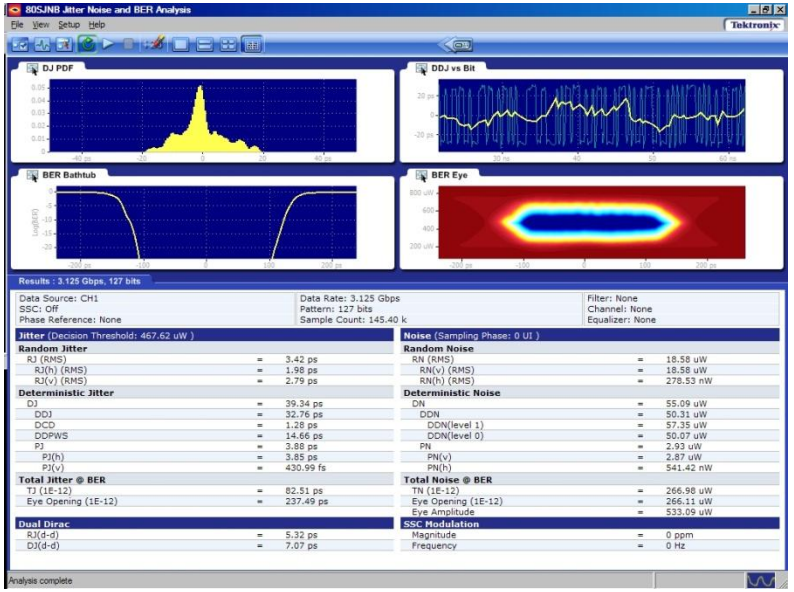
Single Wavelength Free-Space Transmission Testing

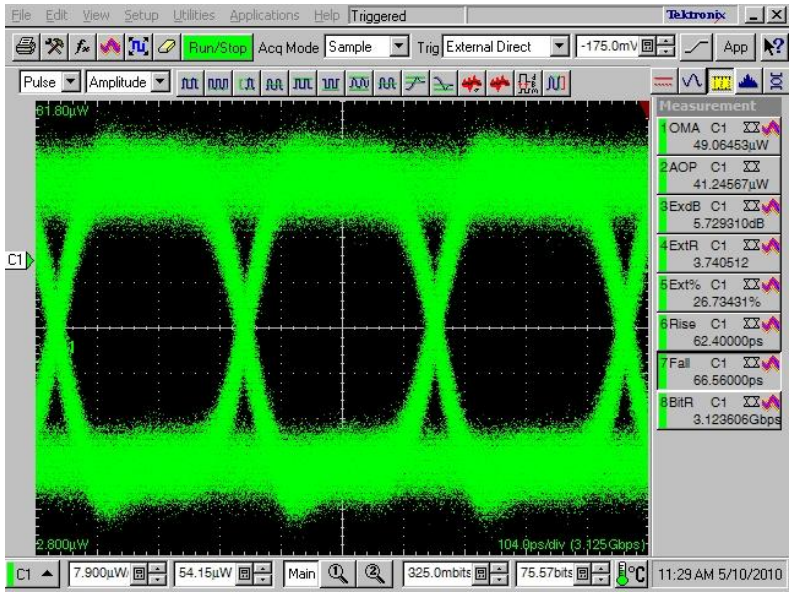


Single Wavelength Free-Space Transmission Testing

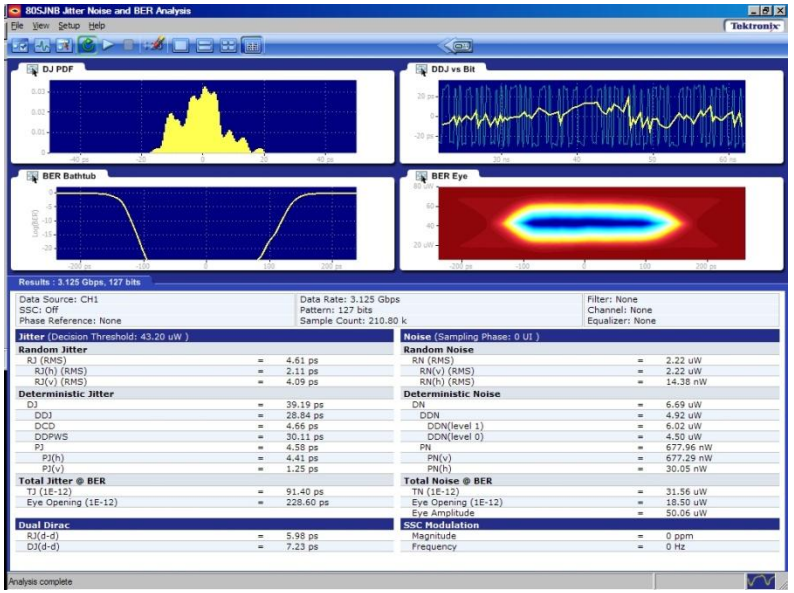


Output of SFP+ Transceiver



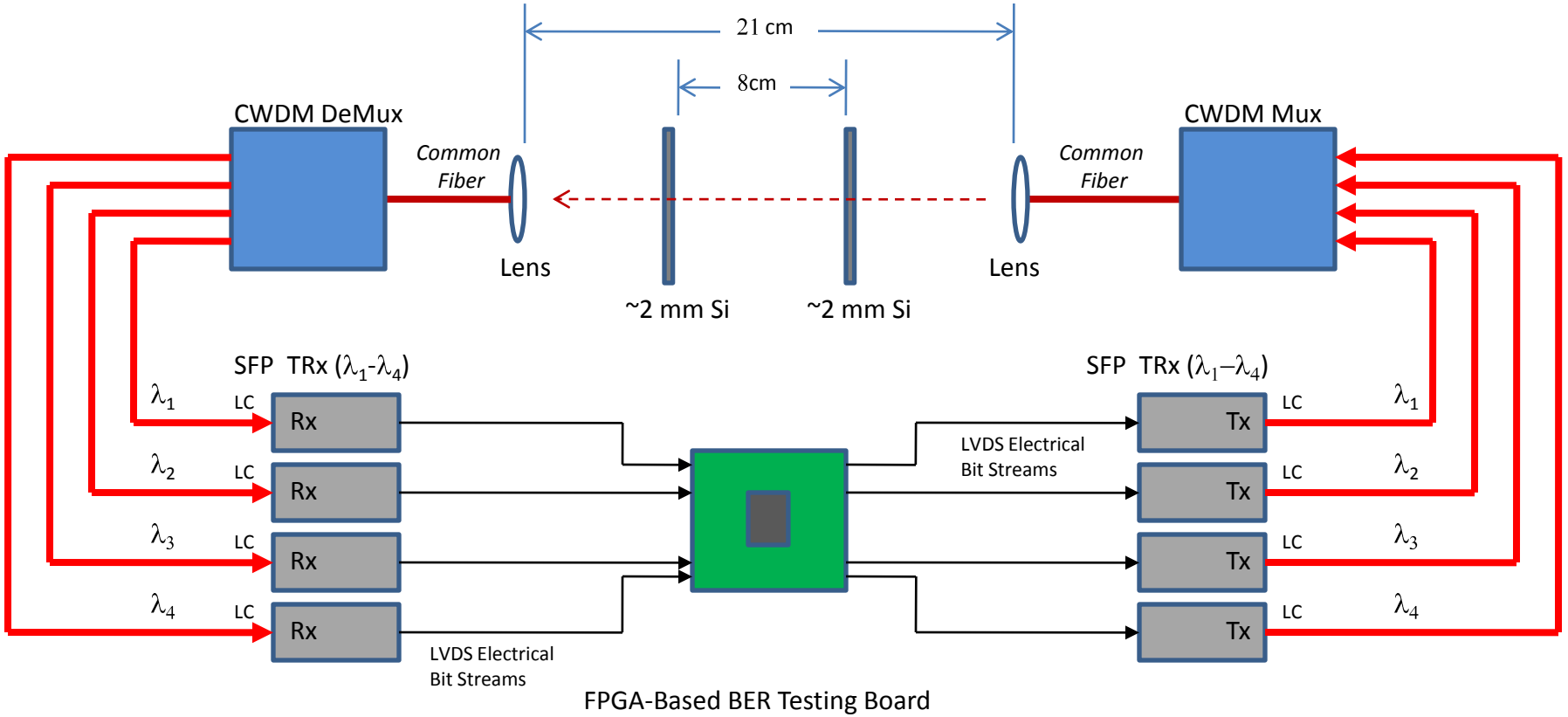


Output of 100 m Multimode Fiber after Free Space link Through Si



Operated error free for over 48 hours at 10 Gbps

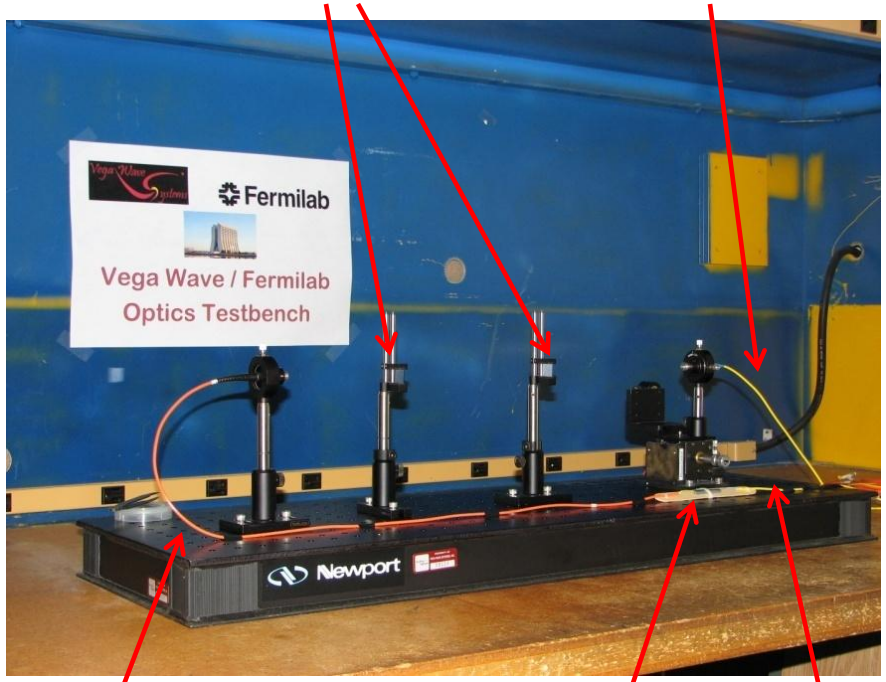
CWDM/Free-Space Bit Error Rate Testing



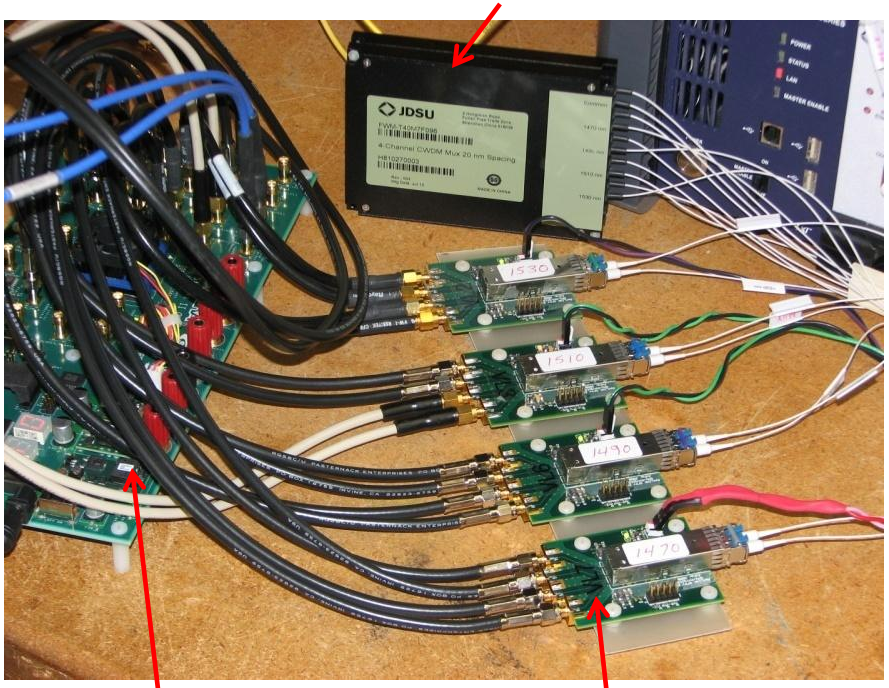
λ_1 = 1470 nm
λ_2 = 1490 nm
λ_3 = 1510 nm
λ_4 = 1530 nm

CWDM/Free-Space Optics Lab Test

Free-Space Optics Lab Test Bench



Free-Space Optics TRx Group



Operating error free for over 48 hours at 1 Gbps on all 4 four channels

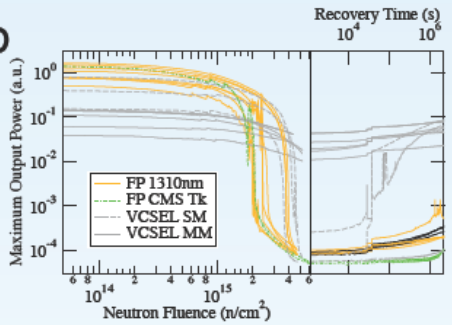
Fermilab

Moving towards new Pixel OH

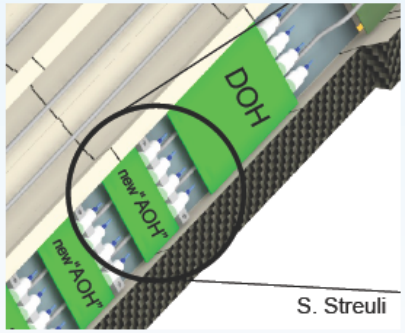
CERN Fermilab SMU Versatile Link

CERN

- Profit from work within Versatile Link project to identify a sufficiently radiation resistant packaged Laser (TOSA)
  - Present Laser die no longer produced and not available



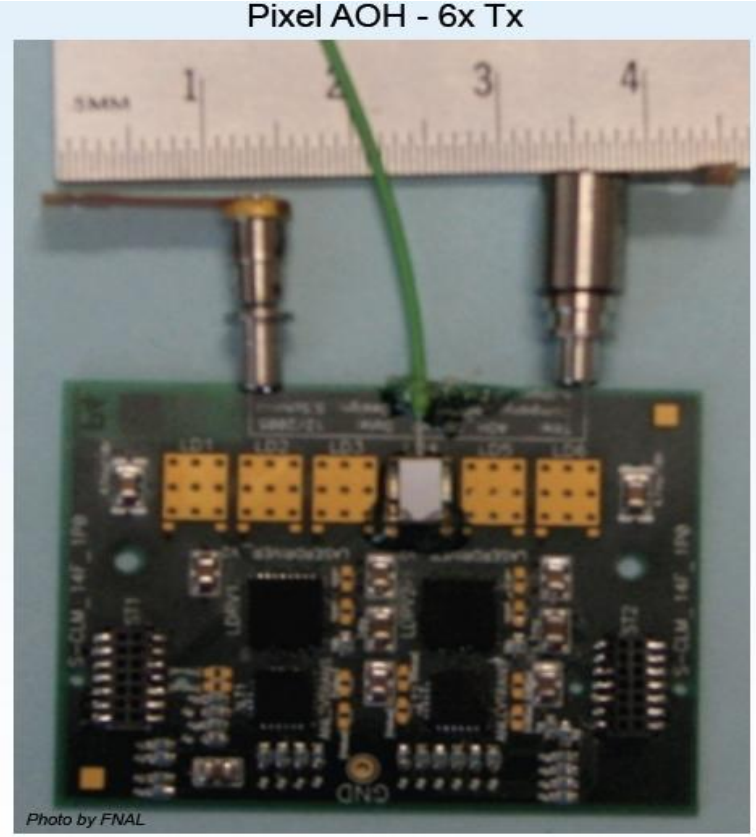
- Design and build a prototype OH to check signal integrity, matching of new laser to existing laser driver (LLD)
  - Dimensionally compatible with current mechanical design
  - Include ALT?

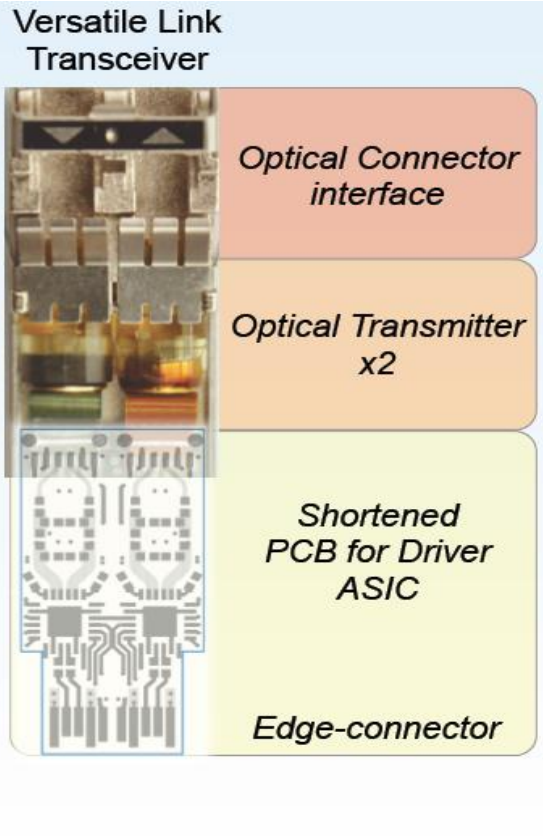


FNAL

- Fully characterize design inc. system test, thermal management
- Produce, Test, QA

CMS Pixels Phase One OptoHybrid Approach





Space Requirements Appear to Be Met with Existing Commercial TOSA Technology

Additional Devices Being Considered (Smaller Form Factor)

Plan is to Leverage Expertise From Versatile Links

CMS Pixels Phase One OptoHybrid Test Program

Characterization of:

1. **Optical Performance**
2. **Electrical Performance**
3. **Thermal Characteristics**
4. **Magnetic Field Tolerance**
5. **Irradiation Test Results**

Optical And Electrical Characterization Results**

	Specs			TOB/TEC Measured			TIB/TID Measured		
	min	typ	max	min	typ	max	min	typ	max
Gain [µW/mV] (LLD gain=0)	0.13	0.20	0.29	0.14	0.20	0.27	0.15	0.19	0.22
Gain [µW/mV] (LLD gain=1)	0.19	0.30	0.43	0.20	0.29	0.39	0.22	0.28	0.33
Gain [µW/mV] (LLD gain=2)	0.26	0.40	0.58	0.27	0.39	0.53	0.31	0.38	0.44
Gain [µW/mV] (LLD gain=3)	0.32	0.50	0.72	0.34	0.48	0.65	0.37	0.46	0.55
Input Referred Noise [mV]		2.4	3.0	0.9	1.2	1.8	0.6	1.0	2.5
Integral Lin. Deviation [%]			3.0	0.2	0.7	1.7	0.4	0.7	1.8
Input Resistance [Ω]		200		218	223	228			
Decoupling Capacitance [µF]				2.2	2.3	2.5			
Bandwidth [MHz]	90			131	143	152	116	127	136
Jitter [ps]			500		73		43	56	71
Skew [ps]			1500		250		0	55	240
Crosstalk [dB]	-54			-66	-73		-59	-67	-77
Power Supply [V]	2.25	2.50	2.70	1.85	2.50	2.75			
Power Supply Rejection [dB]	30			32			30	45	62
Power [mW] (LLD bias=1)		35		28	31	34			
Power [mW] (LLD bias=127)		260		187	195	204			
Output Power Range [mW]	1.44	2.00	3.10	1.44	2.00	2.75			

***From "Qualification Test Results for the CMS Analog Optohybrids", M. Friedl et. al., 16 July, 2004*

CMS Pixels Phase One OptoHybrid Approach

Other Activities:

Testing of SNAP12 Format 1310 Array Receivers (FED Interface)

Evaluation of 1310 nm VCSEL TOSAs