Fermilab Optical Links
Activities for Optical Modulator Program

Fermilab
Computing Division/Electronic Systems Engineering

FNAL Interests in Low Power High Speed Transmission

Technical Challenge: High speed data transmission (on-detector components)

- Must be reliable (frequent access to detector components is impossible)
- High data rates needed for enabling future readout architecture advances
- Radiation and magnetic field tolerance required
- Low power (cooling), low mass (scattering) components needed

Optical modulators may be a promising alternative to on-detector lasers

HEP Application: Track triggering

- High speed, low power data transmission between layers of a tracker
- High speed, low power data transmission off detector

FNAL Possible Contributions

Test Engineering Activities:

- **High Speed Electrical and Optical Signal Characterization**
- **Environmental Testing**
- **Radiation Testing**

Design for Test:

- **High Speed Printed Circuit Board Design and Assembly**
- **Low Noise Flexible Circuit Design**

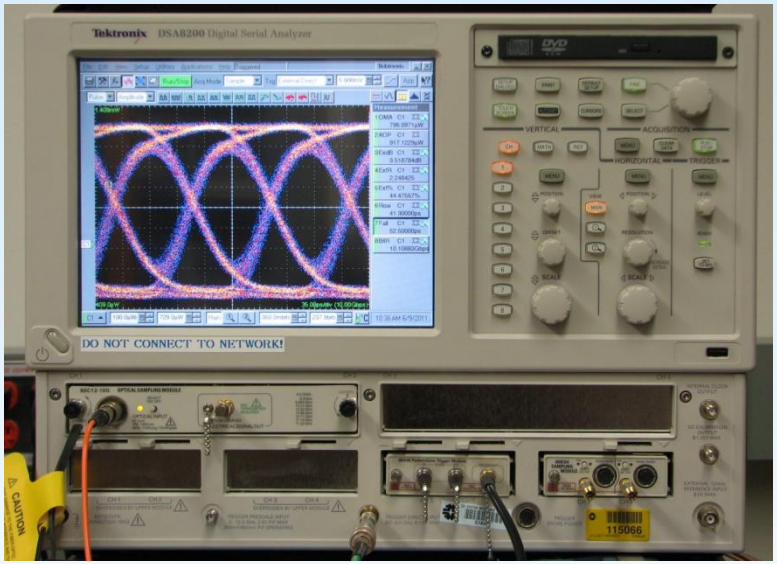
Modulator System Test Engineering

FNAL/CD/ESE Facilities

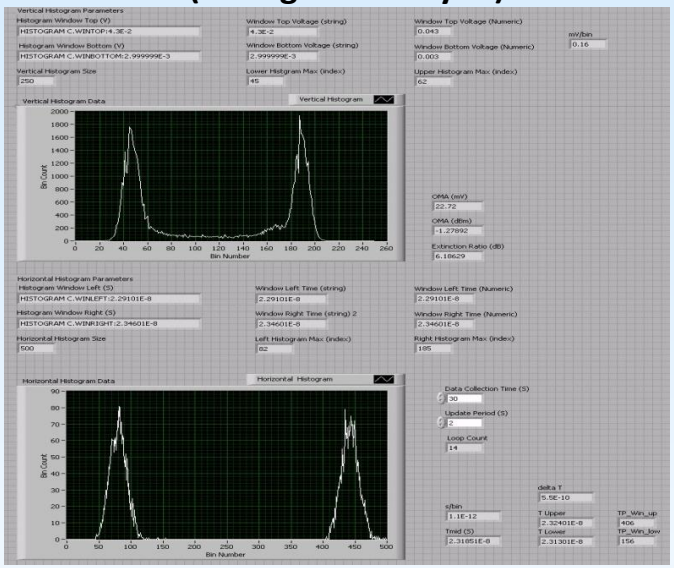
Modulator System Test Engineering

FNAL/CD/ESE Test Equipment and Methods

Digital Signal Analyzer (Eye Patterns, Jitter)

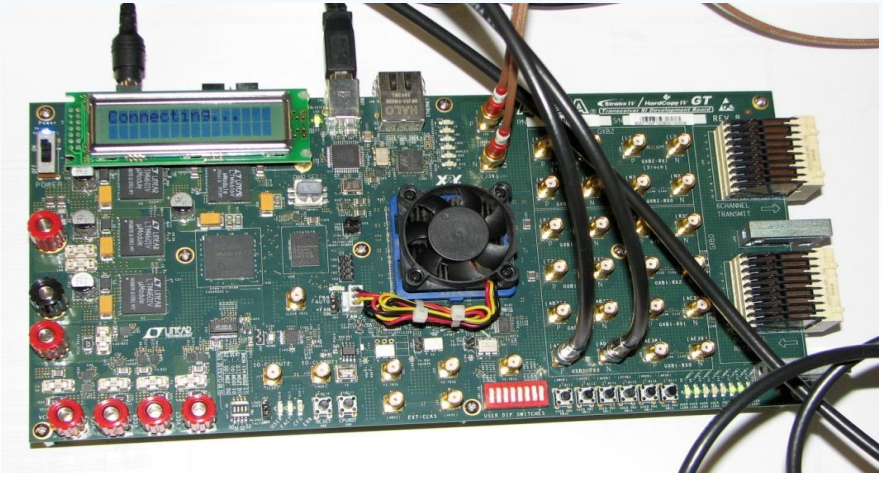


Labview VIs (Histogram Analysis)



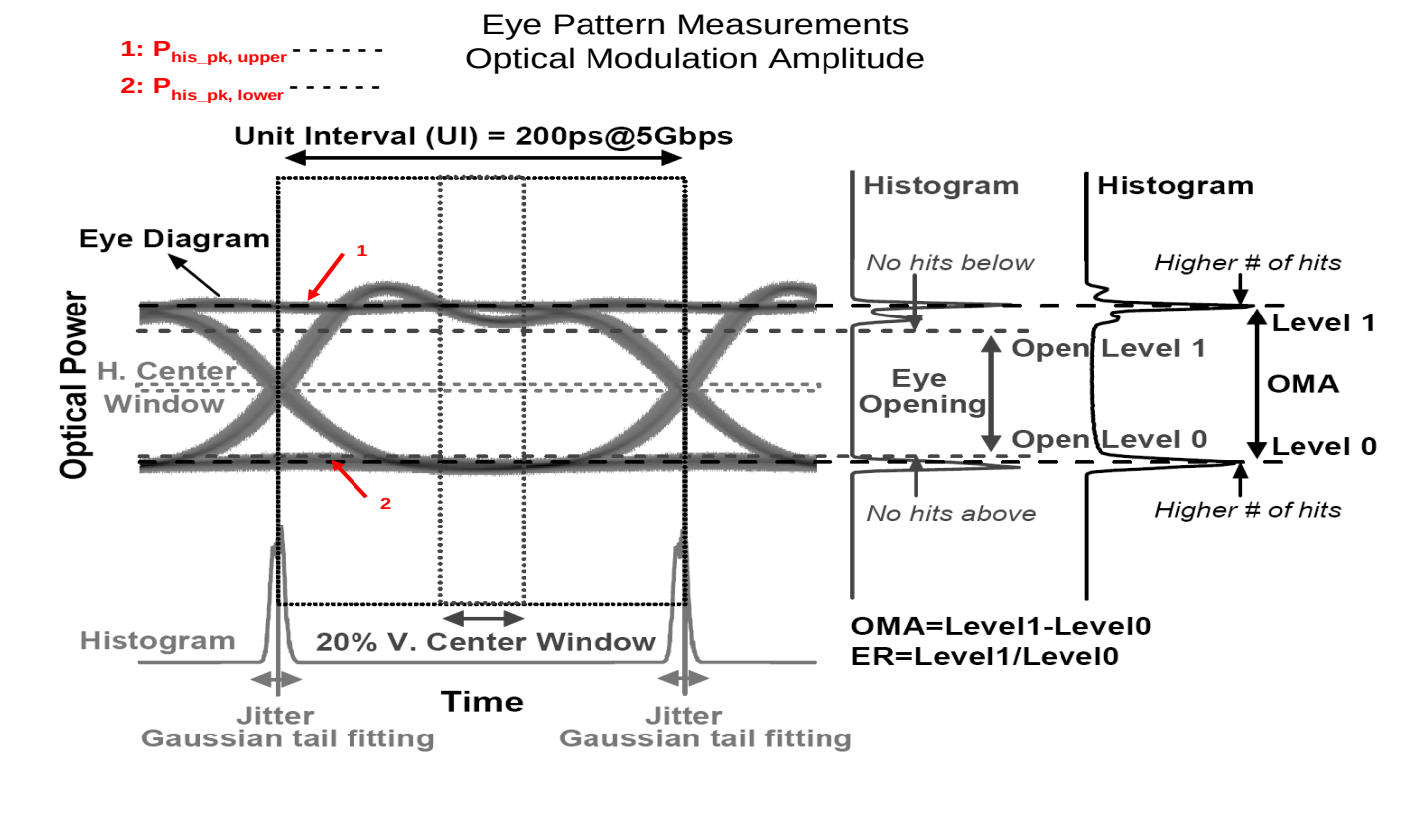
Variable Optical Attenuators (Receiver Sensitivity)

FPGA Signal Integrity Kit (BERT, PRBS Generation)



Modulator System Test Engineering

Eye Pattern Measurements and Analysis



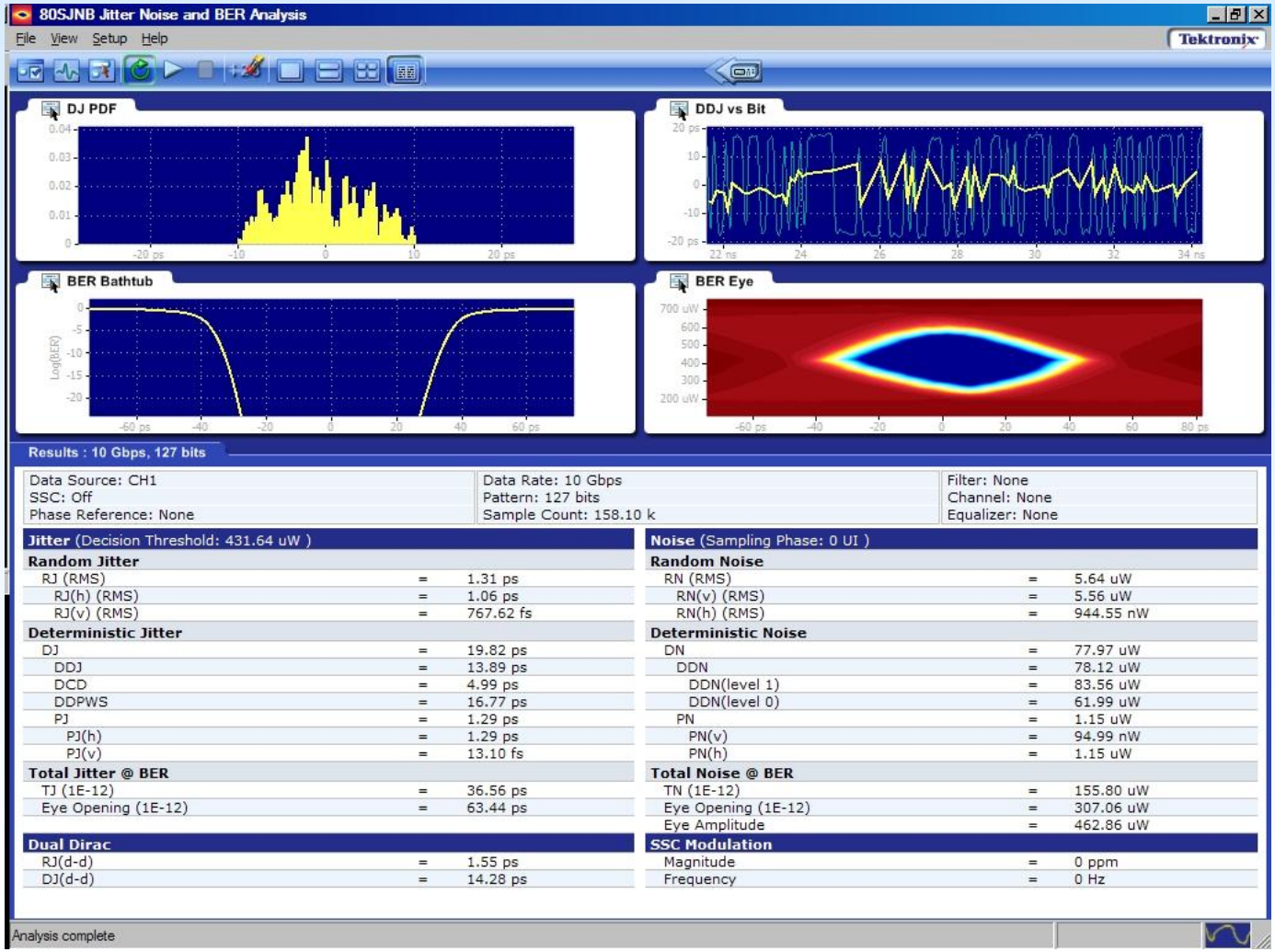
"Standard" Transmitter Measurements	Units
Optical Modulation Amplitude (OMA)	dBm or μW
Transmit Eye Extinction Ratio	dB
Transmit Eye Opening	% of OMA
Transmitter Rise Time	ps
Transmitter Fall Time	ps
Transmitter Total Jitter	Fraction of UI
Transmitter Deterministic Jitter	Fraction of UI

Other Modulator Measurements

Bandwidth = (f_{upper} – f_{lower}) *(50% reduction in modulation amplitude)*
Insertion Loss
Reflectance
Power Consumption

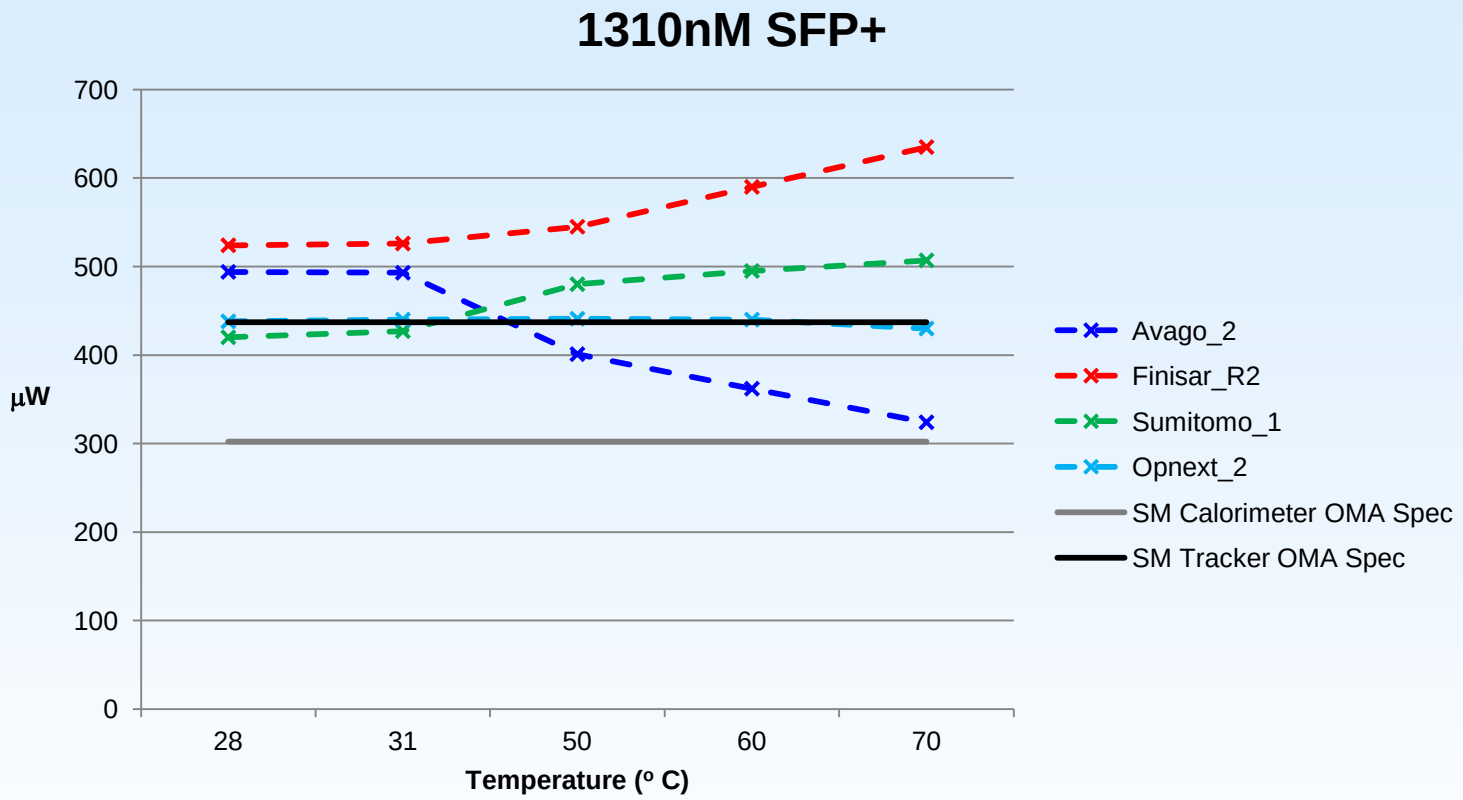
Modulator System Test Engineering

Optical and Electrical Jitter Decomposition and Analysis

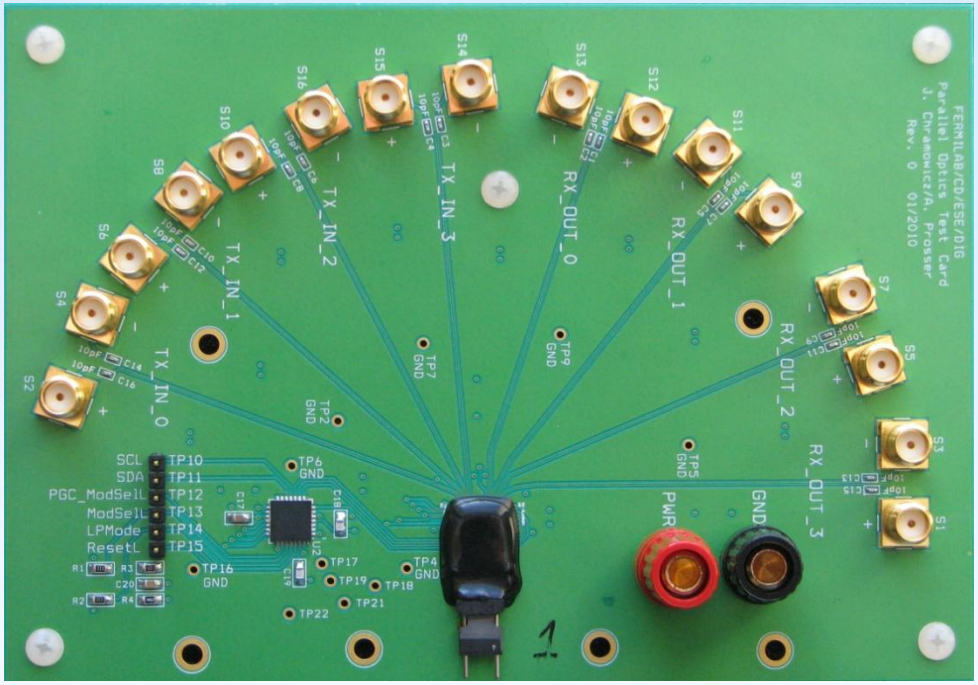


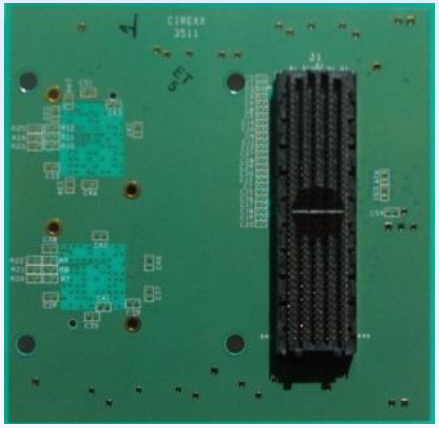
Modulator System Test Engineering

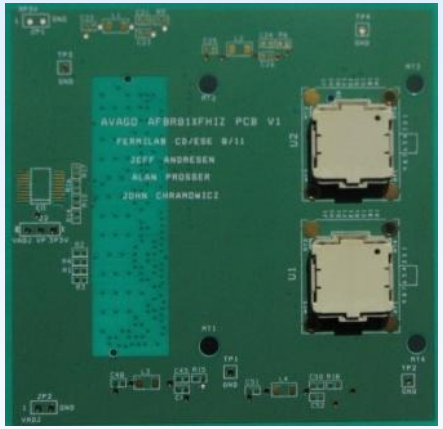
Temperature Dependence for Electro-Optical Measurements



Design for Modulator Test







High Data Rate Evaluation Boards

Compact High Data Rate Application Boards

Design for these speeds (10 Gbps and greater) requires careful engineering:

- ***Precisely balanced and matched traces***
- ***Control of impedance discontinuities***
- ***Use of low loss PCB materials***
- ***Design for low emissions and susceptibility***

Design for Modulator Test

Other expertise:

- **Test stand development for SEU testing of ASICs**
- **Testing of irradiated devices**

We have recently taken delivery of a CSZ Environmental Test Chamber for:

- **Temperature Testing**
- **Humidity Testing**
- **Accelerated Aging Testing**