AUTOMATING TESTING OF OPTICAL LINKS FOR THE CMS

BY BEN HAWKS (OSWEGO HIGH SCHOOL)

SPECIAL THANKS TO:
ALAN PROSSER
JOHN CHRAMOWICZ

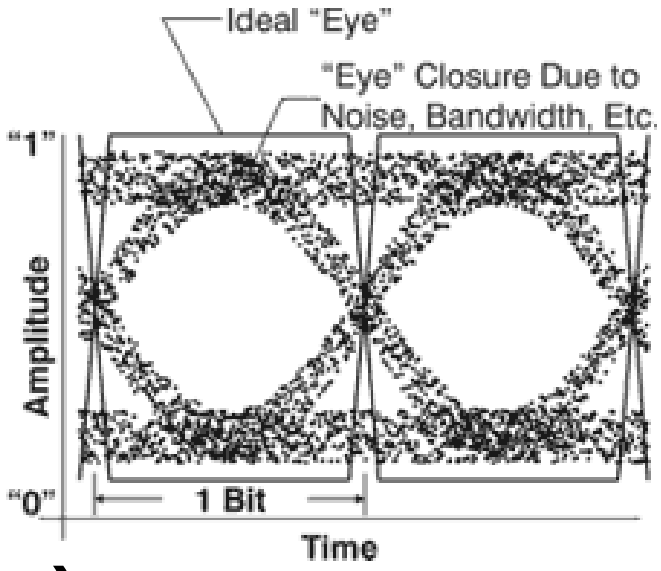
OPTICAL COMMUNICATIONS?

Optical Signals, not electrical

(really tiny) Lasers!

Electrical (Tx) -> Optical (Fibers) -> Electrical (Rx)

Capacity for extremely high speeds

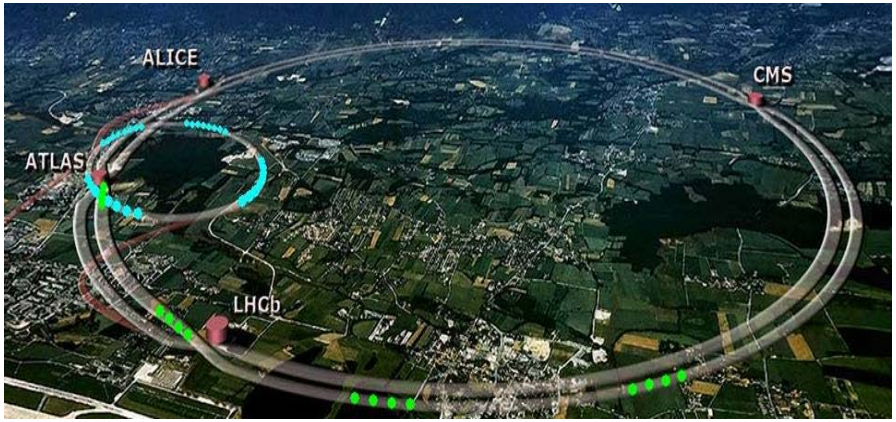


THE LHC

The Large Hadron Collider

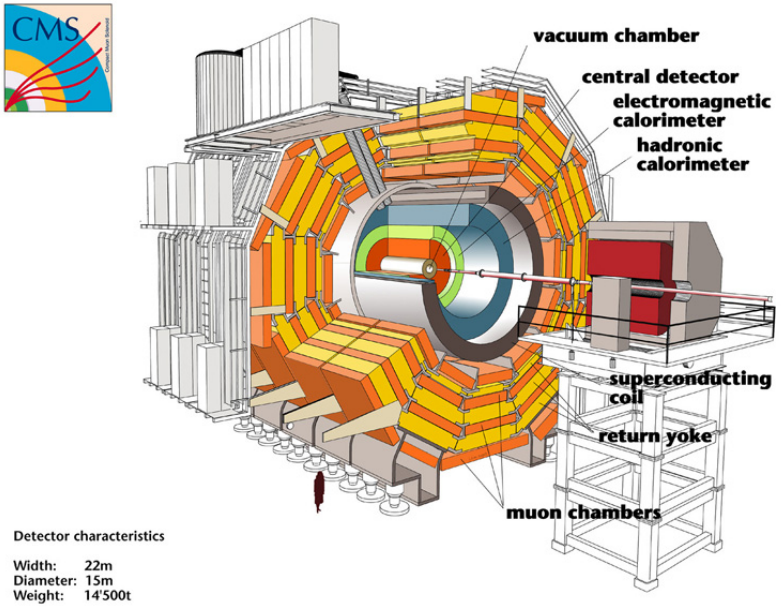
CERN

Proton Beams



ALICE, ATLAS, LHC-b, CMS

THE CMS



Compact Muon Solenoid

Very large detector that's

Part of the LHC at CERN

Higgs Boson

Pixel Detector

THE POH

Pixel OptoHybrid

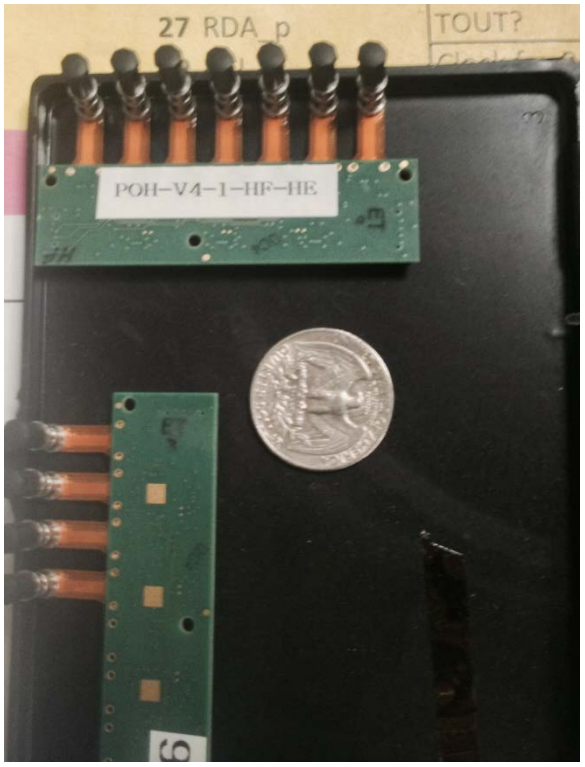
Designed for use in the CMS

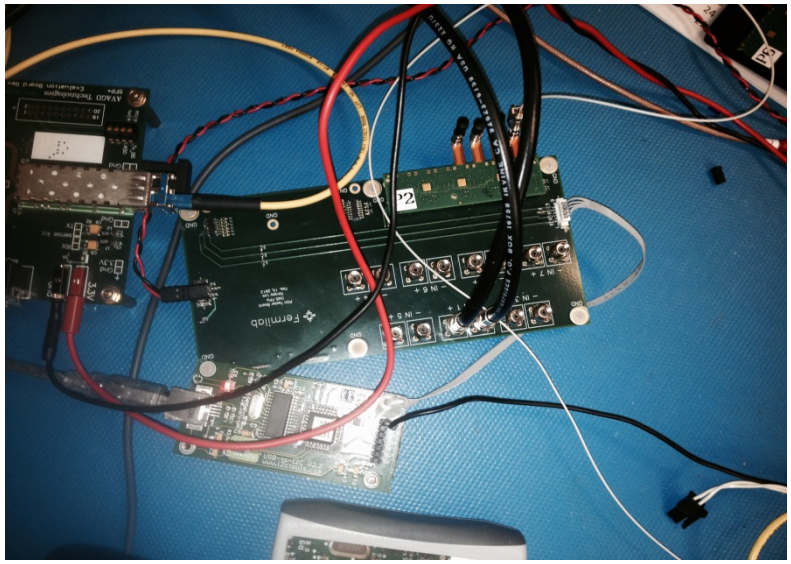
Has to be Radiation Hardened

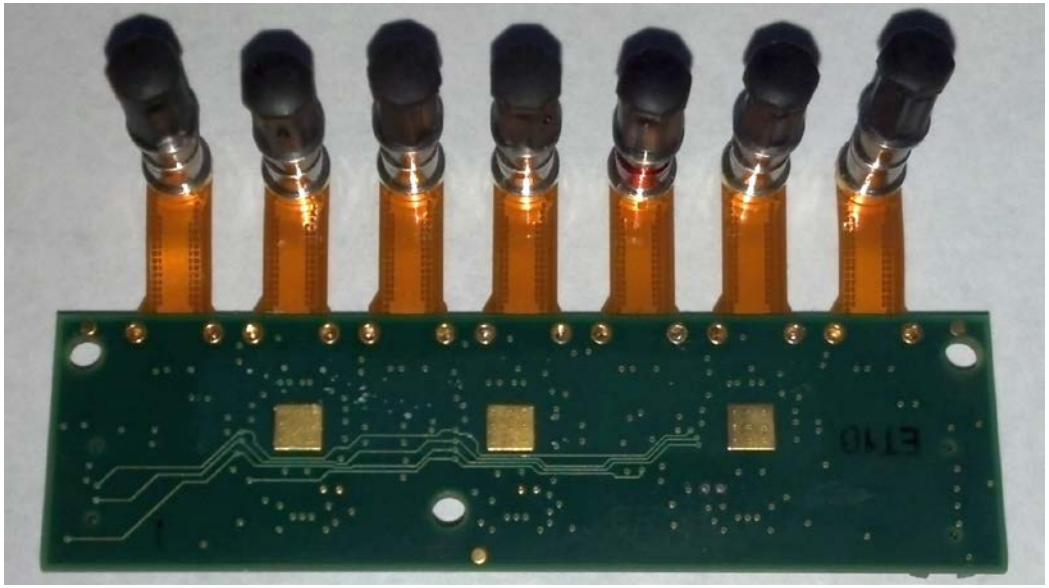
Part of the Phase 1 Upgrades

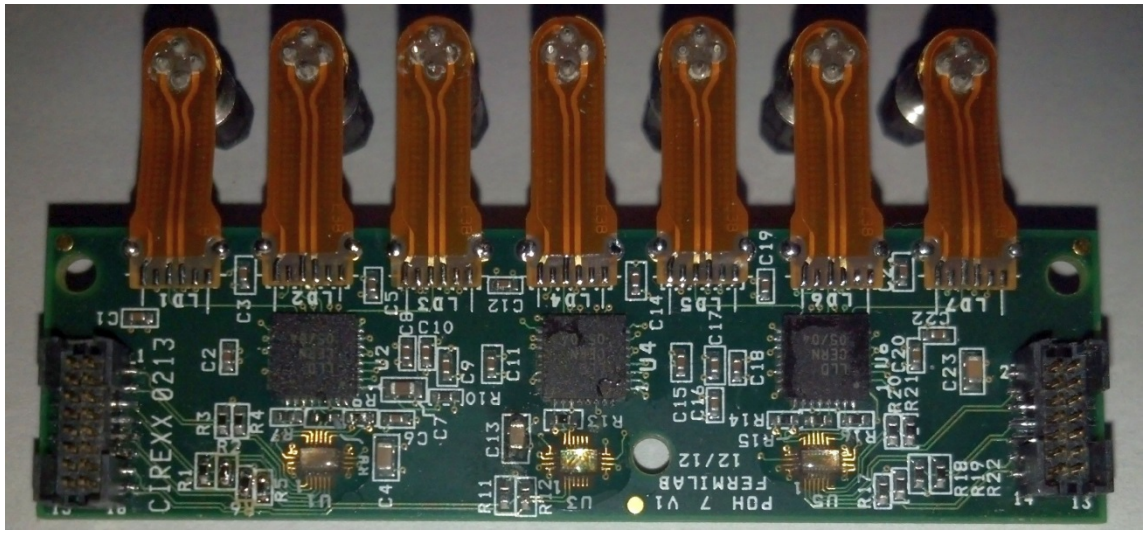
Runs @ 1310nm

Spec calls for 400Mb/s








CIREXX 0213
FERMILAB
POH 7 V1
12/12

BER TESTING

Bit Error Rate

PRBS-7 Pattern (PN7)

PNX/PRBS-X, where X is the number of bits being permutated in the sequence (e.g. PN7 = 2^7 - 1 or 127 bits)

Attenuating signal artificially

Radiation, Fiber Length, and unaccountable events causes signal decay in actual conditions

BER TESTING

BER's for common systems:

(IEEE 803.2ah) 100/1000BaseT Ethernet – 10^{-10}

Solid State Drive – Generally around 10^{-15} or 10^{-16} (Consumer vs Enterprise)

Cell Phone Calls – 10^{-2} (Packets)

Streaming Videos over Cellular Data – 10^{-5} (Packets)

BER TESTING

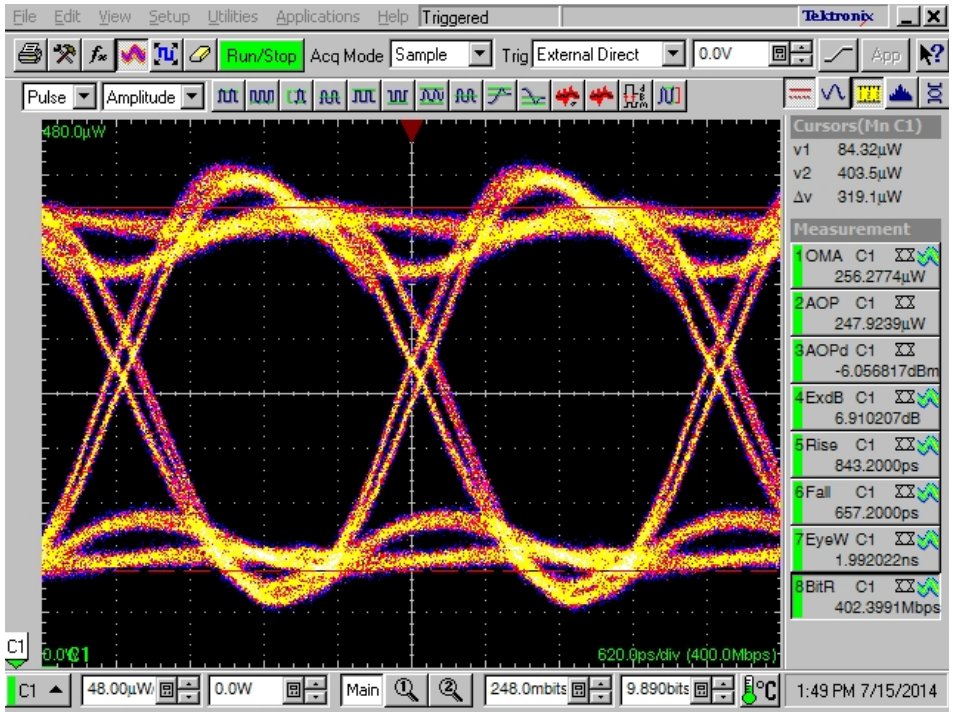
“Attenuation is the gradual loss in intensity of any kind of flux through a medium”

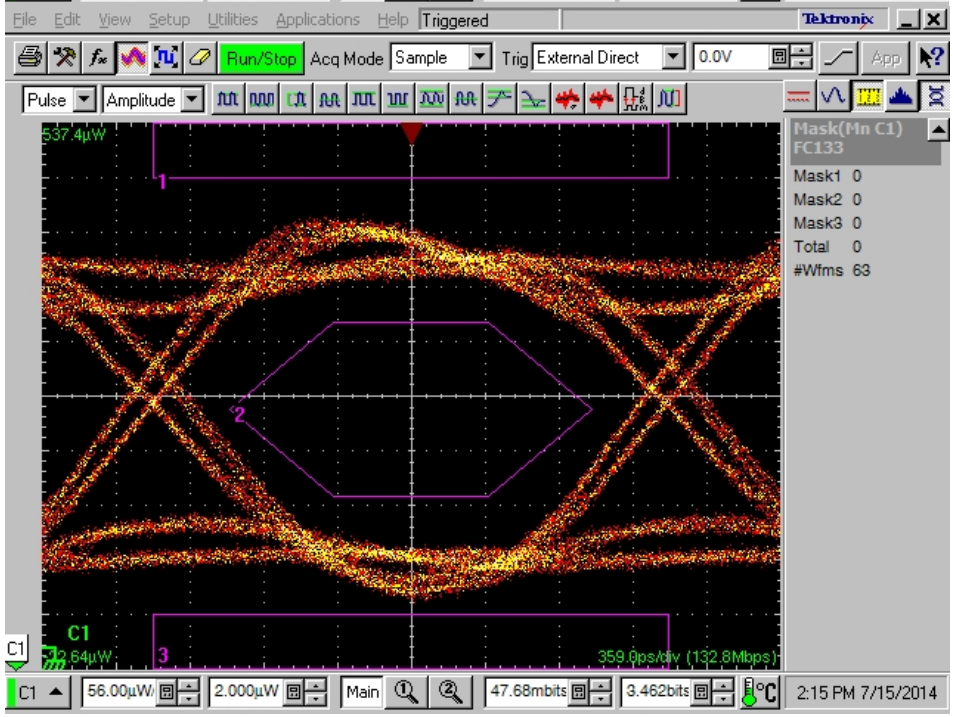
“Attenuation in fiber optics, also known as transmission loss, is the reduction in intensity of the light beam (or signal) with respect to distance travelled through a transmission medium.”

Using an Attenuator to simulate component decay due to radiation, fiber length, or other unaccountable events

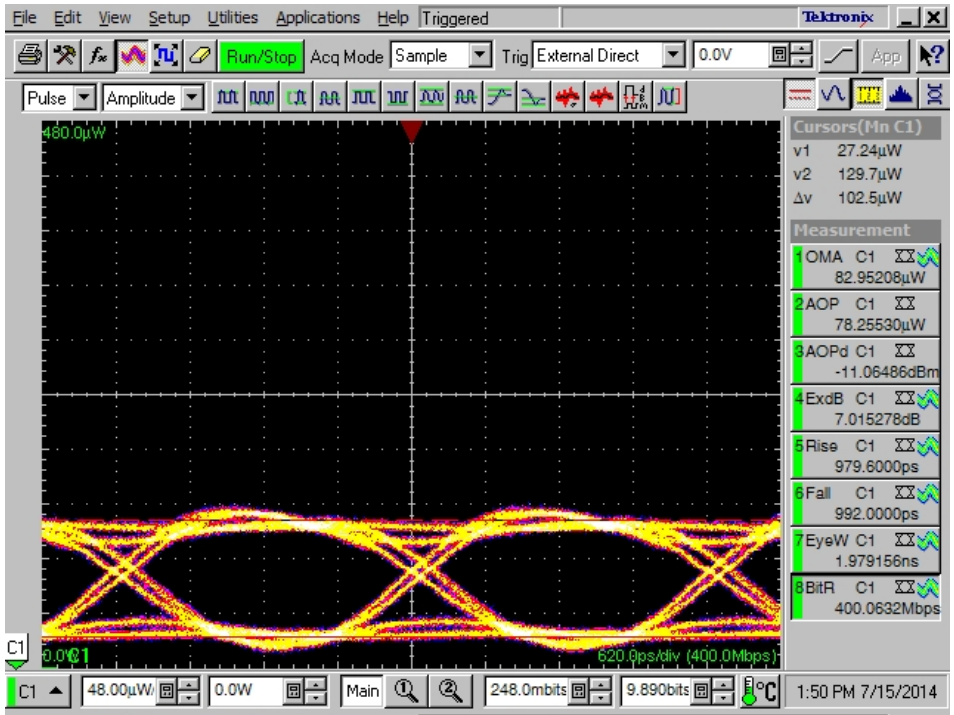
$$\text{Attenuation (dB)} = 10 \times \log_{10}\left(\frac{\text{Input intensity (W)}}{\text{Output intensity (W)}}\right)$$

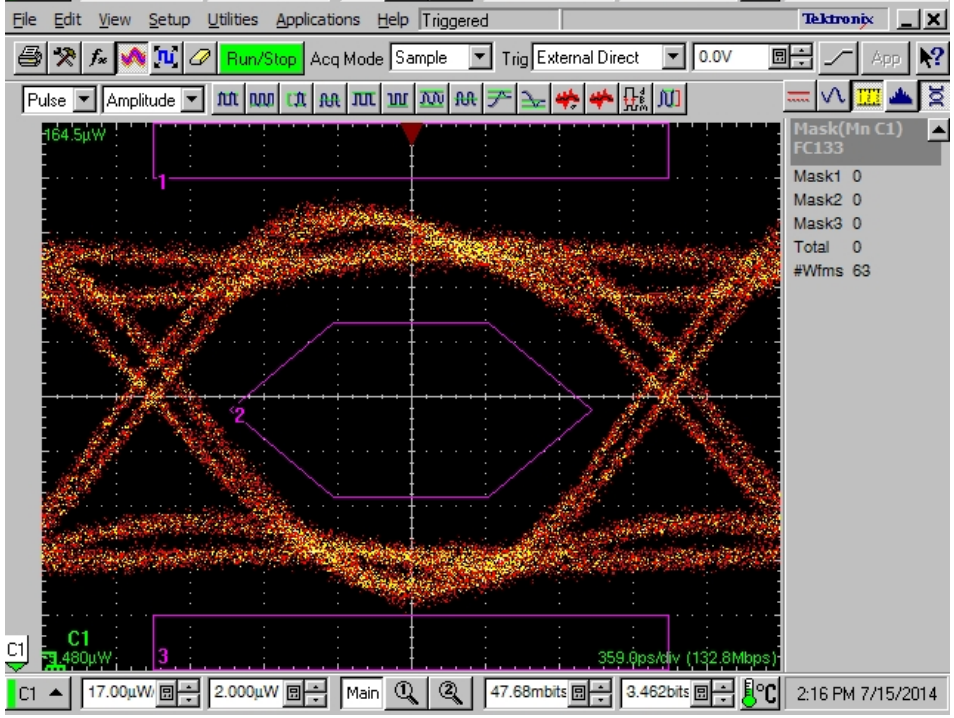
0 dB of Attenuation



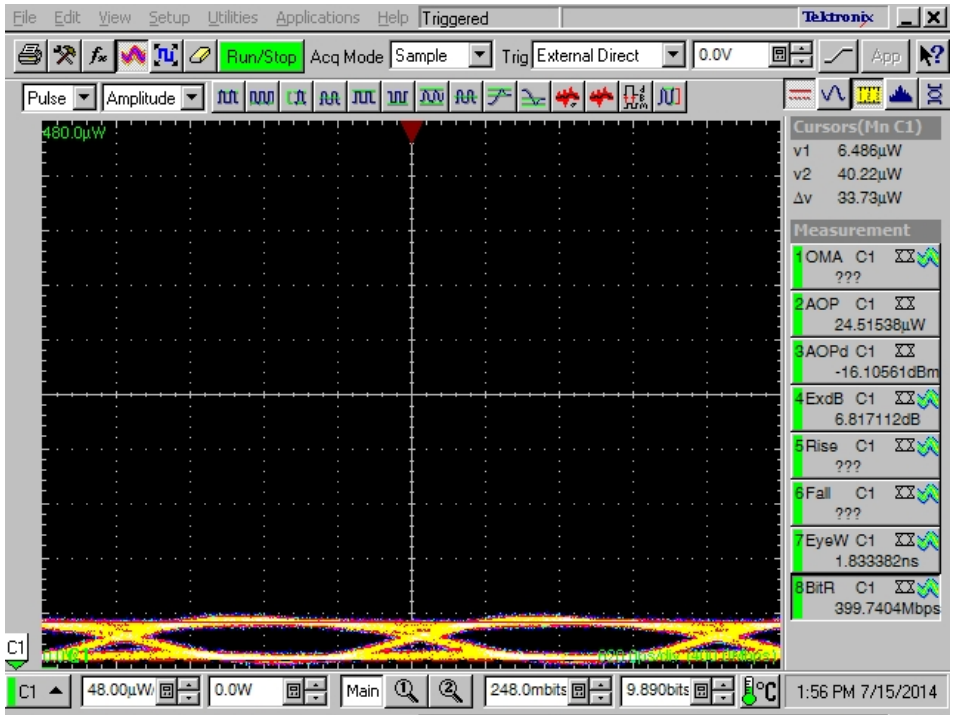


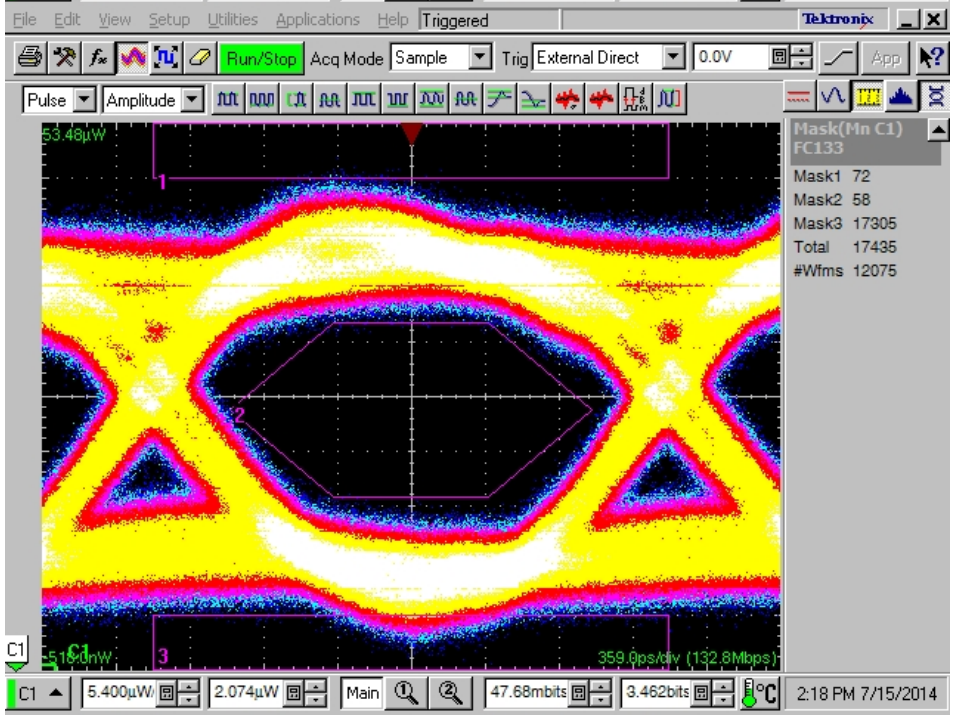
5 dB of Attenuation

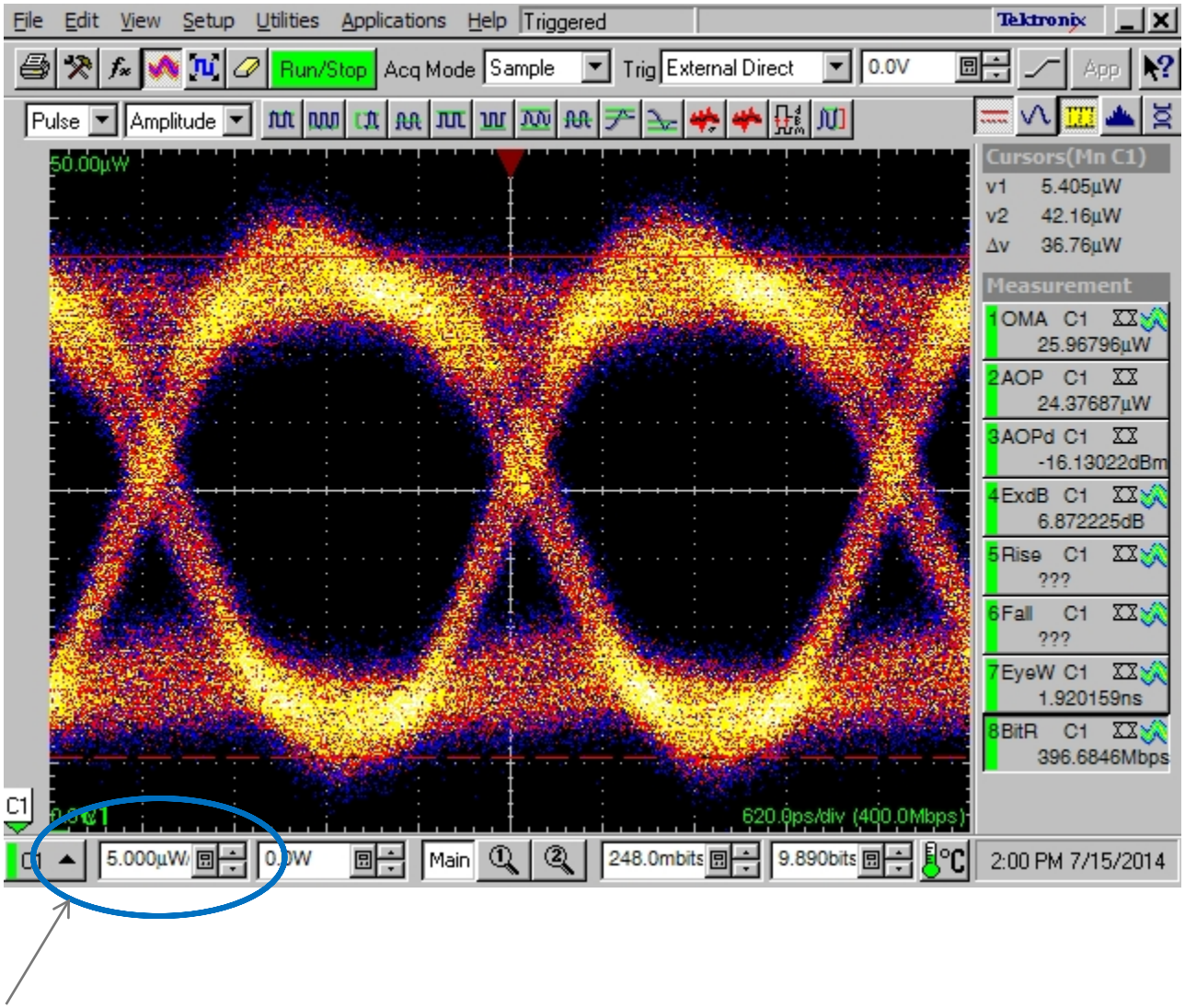




10 dB of Attenuation

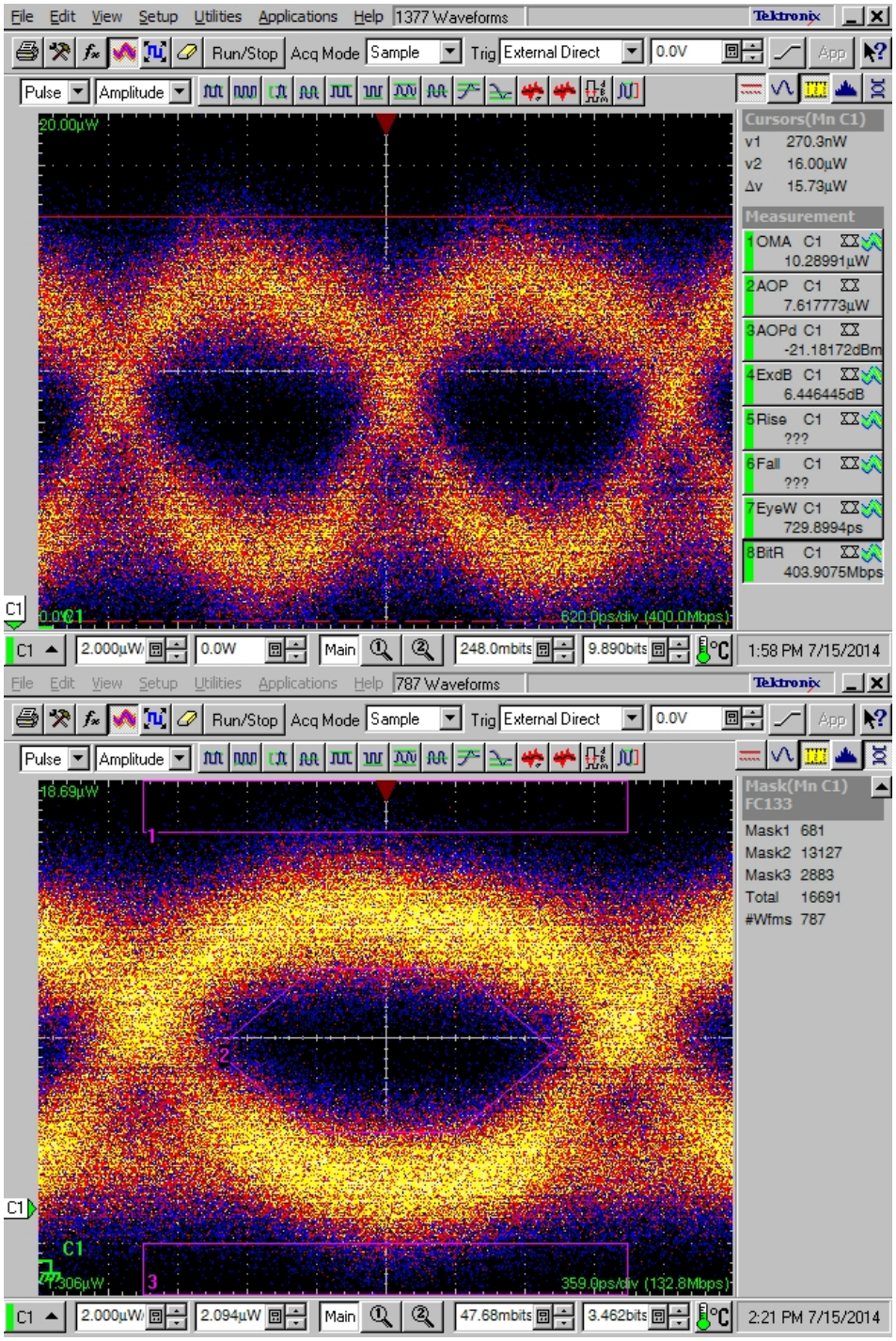




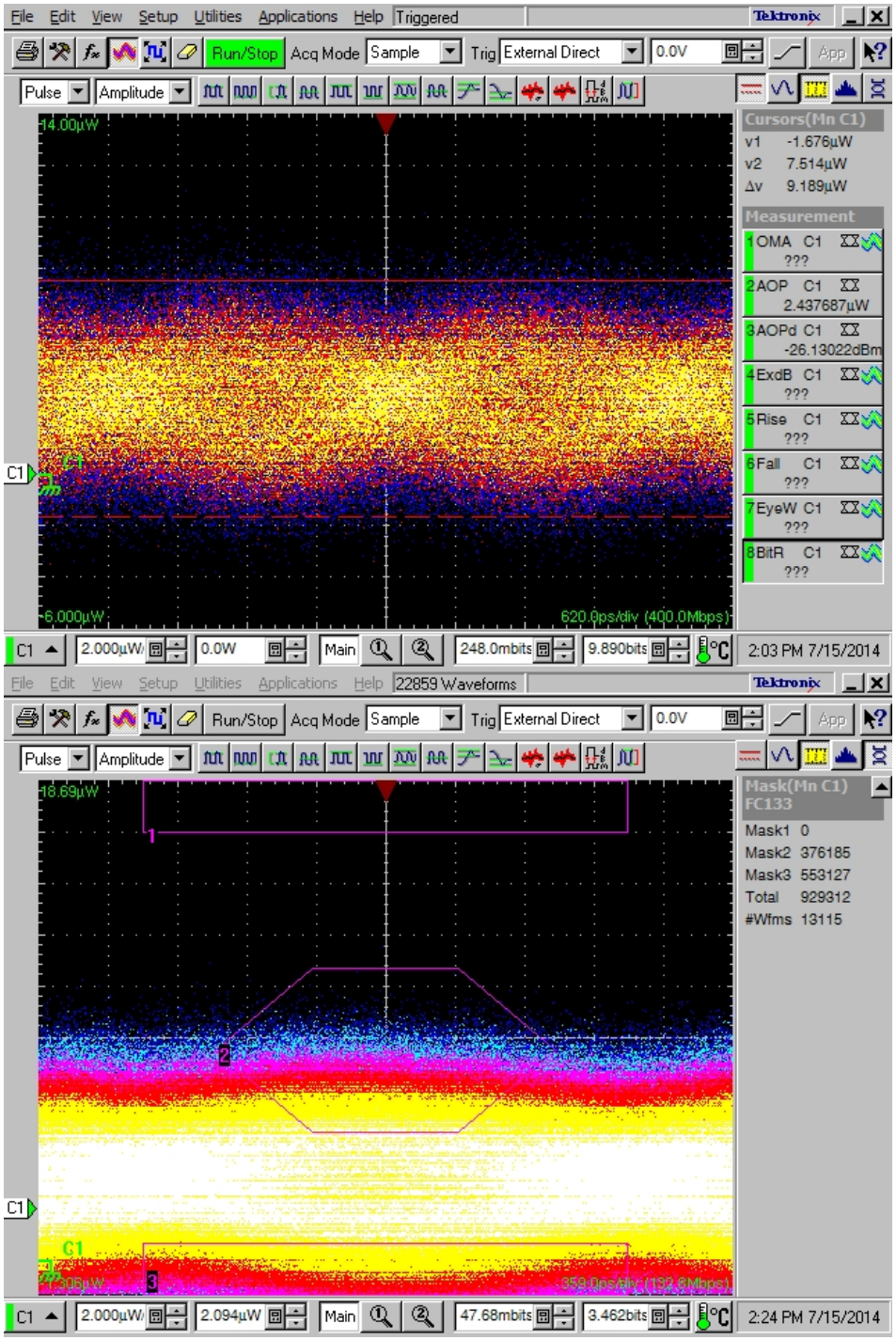

File Edit View Setup Utilities Applications Help Triggered
Tektronix
Run/Stop
Acq Mode
Sample
Trig
External Direct
0.0V
App
Pulse
Amplitude
50.00µW
Cursors(Mn C1)
v1 5.405µW
v2 42.16µW
Δv 36.76µW
Measurement
1 OMA C1
25.96796µW
2 AOP C1
24.37687µW
3 AOPd C1
-16.13022dBm
4 ExdB C1
6.872225dB
5 Rise C1
???
6 Fall C1
???
7 EyeW C1
1.920159ns
8 BitR C1
396.6846Mbps
C1
620.0ps/div (400.0Mbps)
5.000µW/
Main
248.0mbits
9.890bits
2:00 PM 7/15/2014

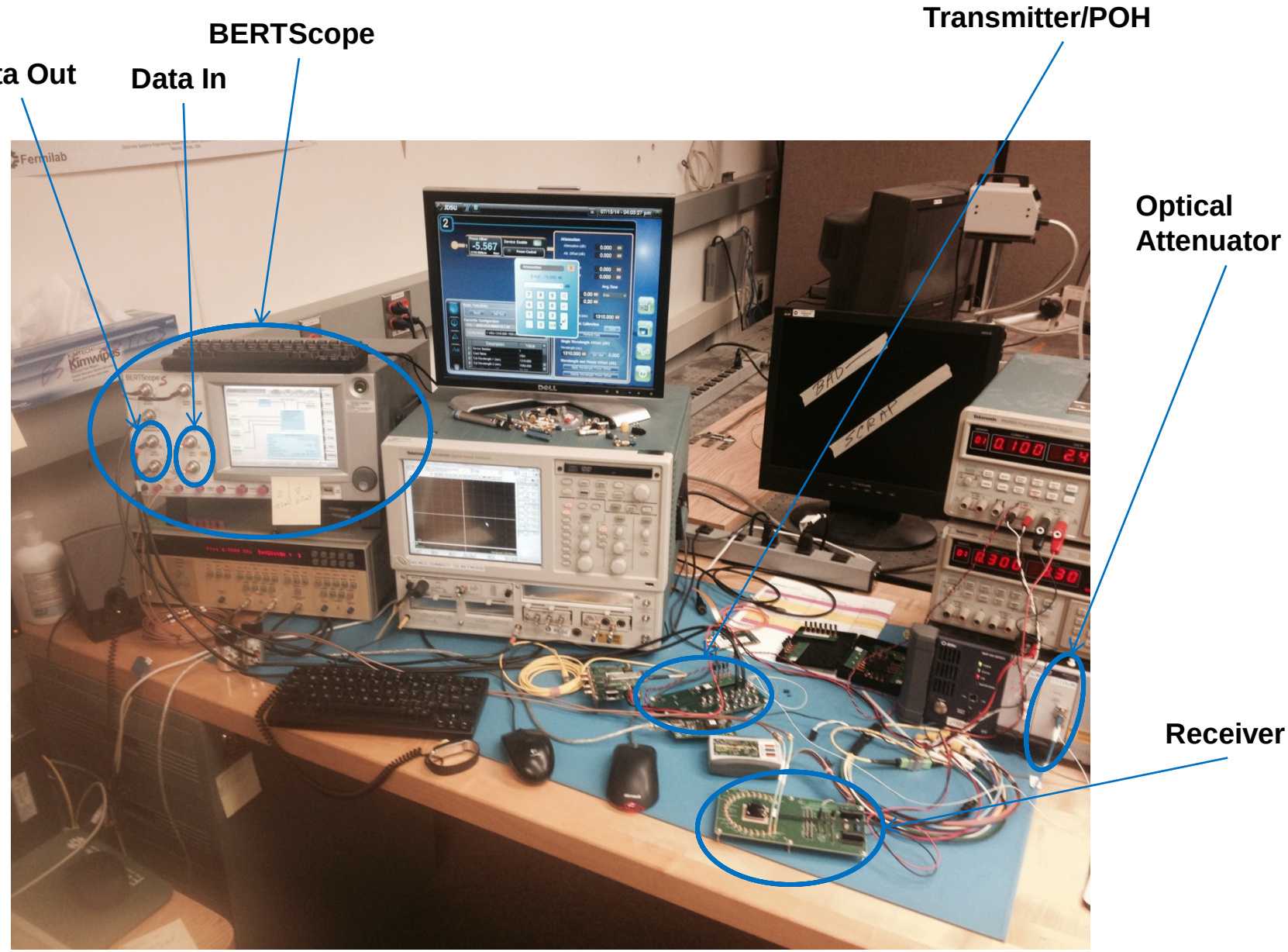
Scale

15 dB of Attenuation



20 dB of Attenuation




Data Out
Data In
BERTScope
Transmitter/POH
Optical Attenuator
Receiver
Fermilab
BAD
SCRAP

AUTOMATING THE PROCESS

Previously conducted and recorded all by hand

Time Consuming

Human Element to data

Had to “Babysit” the equipment while running

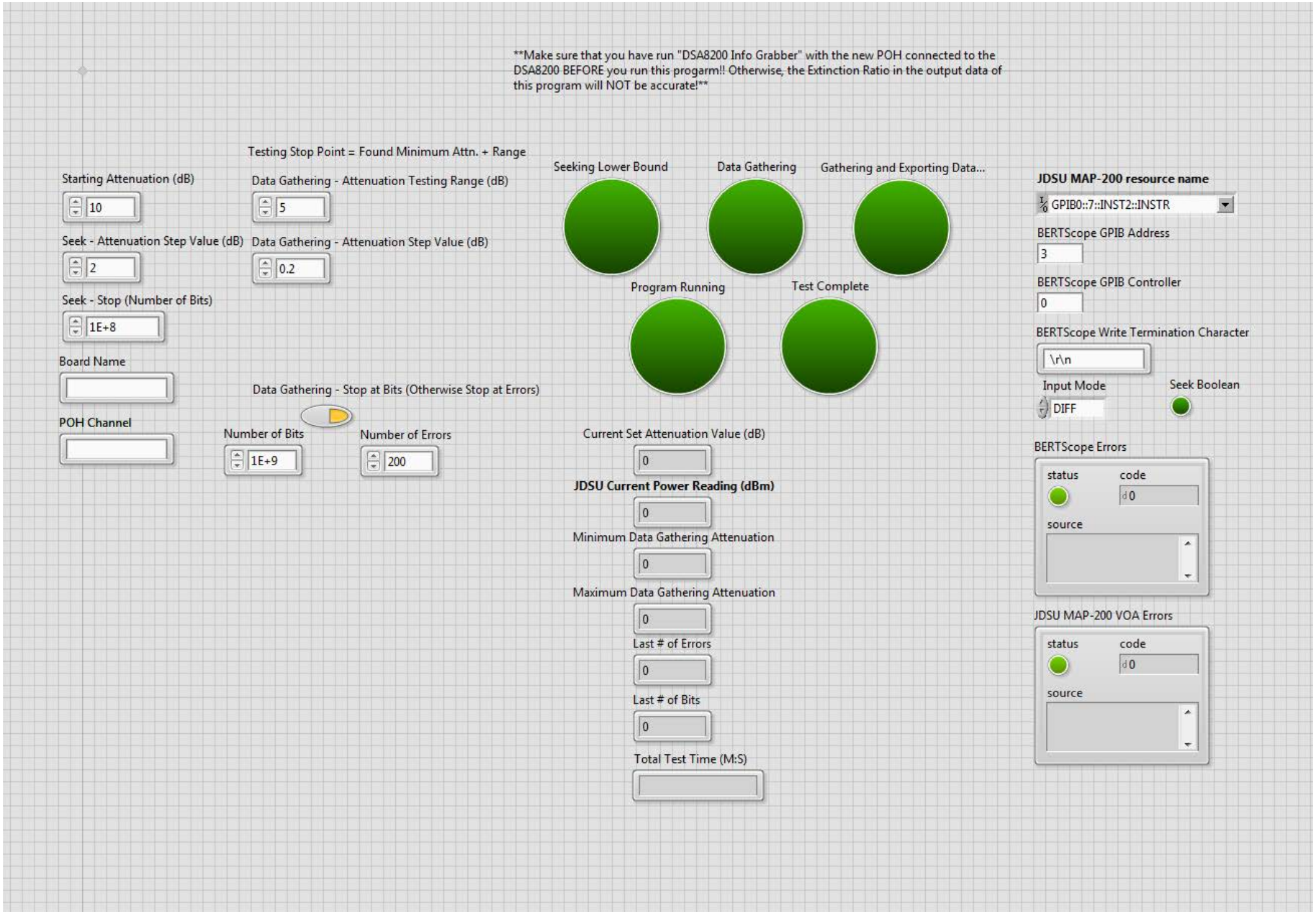
Due to time required, few data points gathered

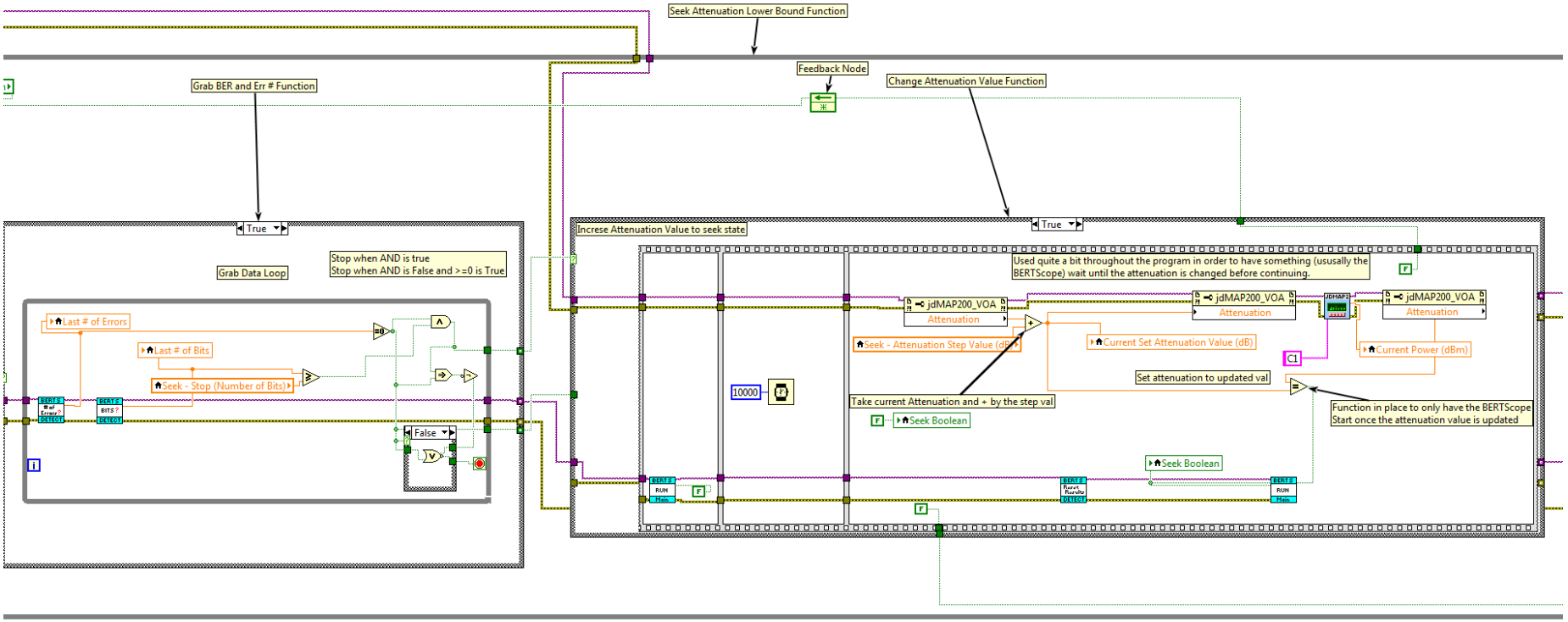
AUTOMATING THE PROCESS

NI Labview 2013

GPIB Interface

Instrument Specific Drivers


Make sure that you have run "DSA8200 Info Grabber" with the new POH connected to the DSA8200 BEFORE you run this progarm!! Otherwise, the Extinction Ratio in the output data of this program will NOT be accurate!
Testing Stop Point = Found Minimum Attn. + Range
Starting Attenuation (dB)
10
Data Gathering - Attenuation Testing Range (dB)
5
Seek - Attenuation Step Value (dB)
2
Data Gathering - Attenuation Step Value (dB)
0.2
Seek - Stop (Number of Bits)
1E+8
Board Name
POH Channel
Data Gathering - Stop at Bits (Otherwise Stop at Errors)
Number of Bits
1E+9
Number of Errors
200
Seeking Lower Bound
Data Gathering
Gathering and Exporting Data...
Program Running
Test Complete
Current Set Attenuation Value (dB)
0
JDSU Current Power Reading (dBm)
0
Minimum Data Gathering Attenuation
0
Maximum Data Gathering Attenuation
0
Last # of Errors
0
Last # of Bits
0
Total Test Time (M:S)
JDSU MAP-200 resource name
GPIB0::7::INST2::INSTR
BERTScope GPIB Address
3
BERTScope GPIB Controller
0
BERTScope Write Termination Character
\r\n
Input Mode
DIFF
Seek Boolean
BERTScope Errors
status
code
0
source
JDSU MAP-200 VOA Errors
status
code
0
source


Seek Attenuation Lower Bound Function
Feedback Node
Grab BER and Err # Function
Change Attenuation Value Function
True
Grab Data Loop
Stop when AND is true
Stop when AND is False and >=0 is True
Last # of Errors
Last # of Bits
Seek - Stop (Number of Bits)
=0
False
Increse Attenuation Value to seek state
True
Used quite a bit throughout the program in order to have something (ususally the BERTScope) wait until the attenuation is changed before continuing.
jdMAP200_VOA
Attenuation
Seek - Attenuation Step Value (dB)
Current Set Attenuation Value (dB)
Current Power (dBm)
C1
10000
Set attenuation to updated val
Take current Attenuation and + by the step val
Seek Boolean
Function in place to only have the BERTScope Start once the attenuation value is updated

AUTOMATING THE PROCESS

“Fix and Forget”

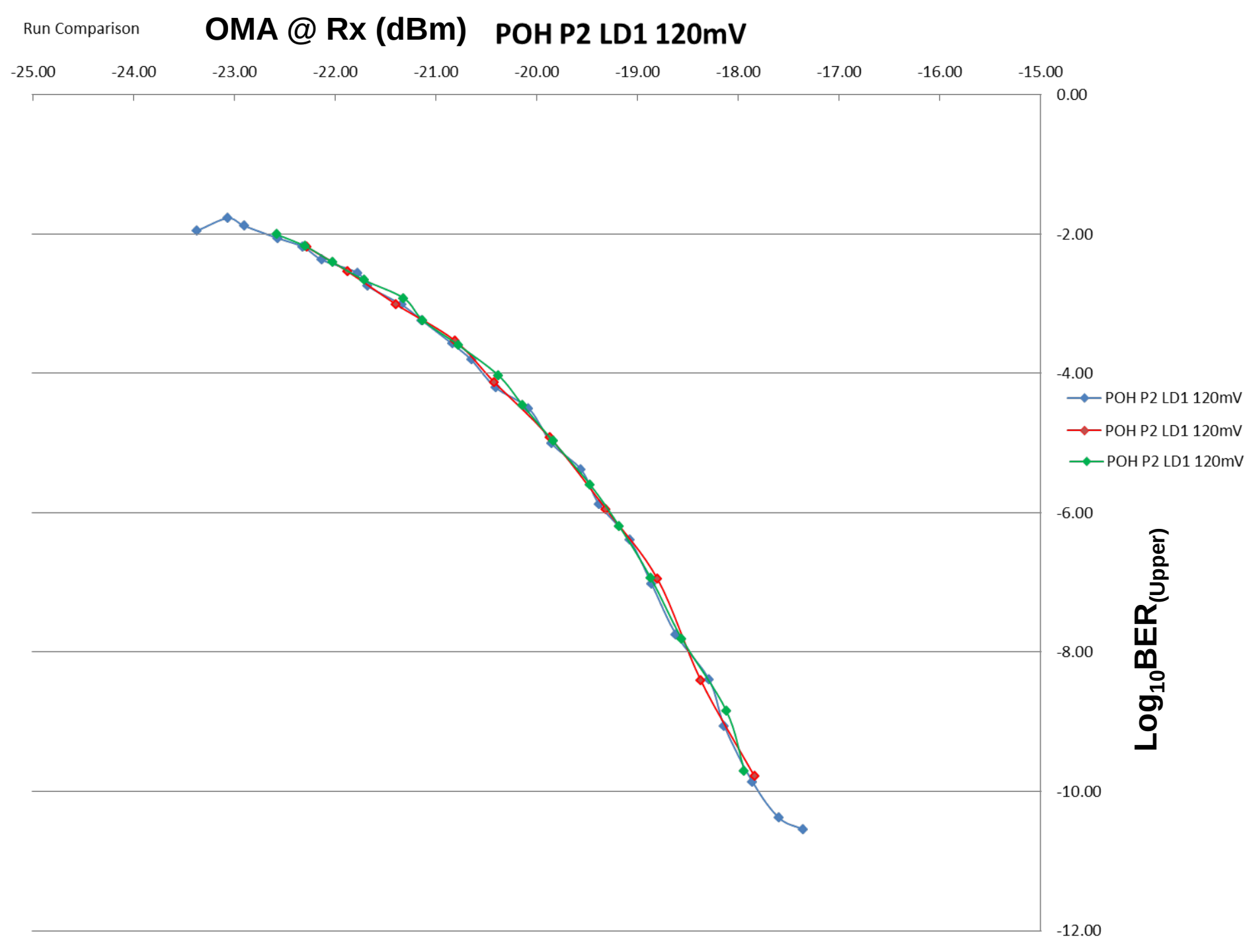
Data Exported into a CSV file

Consistent parameters

Removal of human element in data

More Data points

Other small related tasks automated


Run Comparison
OMA @ Rx (dBm)
POH P2 LD1 120mV
-25.00
-24.00
-23.00
-22.00
-21.00
-20.00
-19.00
-18.00
-17.00
-16.00
-15.00
0.00
-2.00
-4.00
-6.00
-8.00
-10.00
-12.00
POH P2 LD1 120mV
POH P2 LD1 120mV
POH P2 LD1 120mV
Log10BER(Upper)

MY EXPERIENCES

Overall Awesome

Improved LabVIEW Skills

Learned about Optical Communications

Able to make something that’s actually going to be used

Didn’t set anything on fire

SPECIAL THANKS TO

Alan Prosser and John Chramowicz, and the rest of ESE

Chris Stoughton, George Dzuricsko, and Ian McNair

All of the 2014 Quarknet Students!