Irradiation Results and Transmission on Small Cables/Fiber

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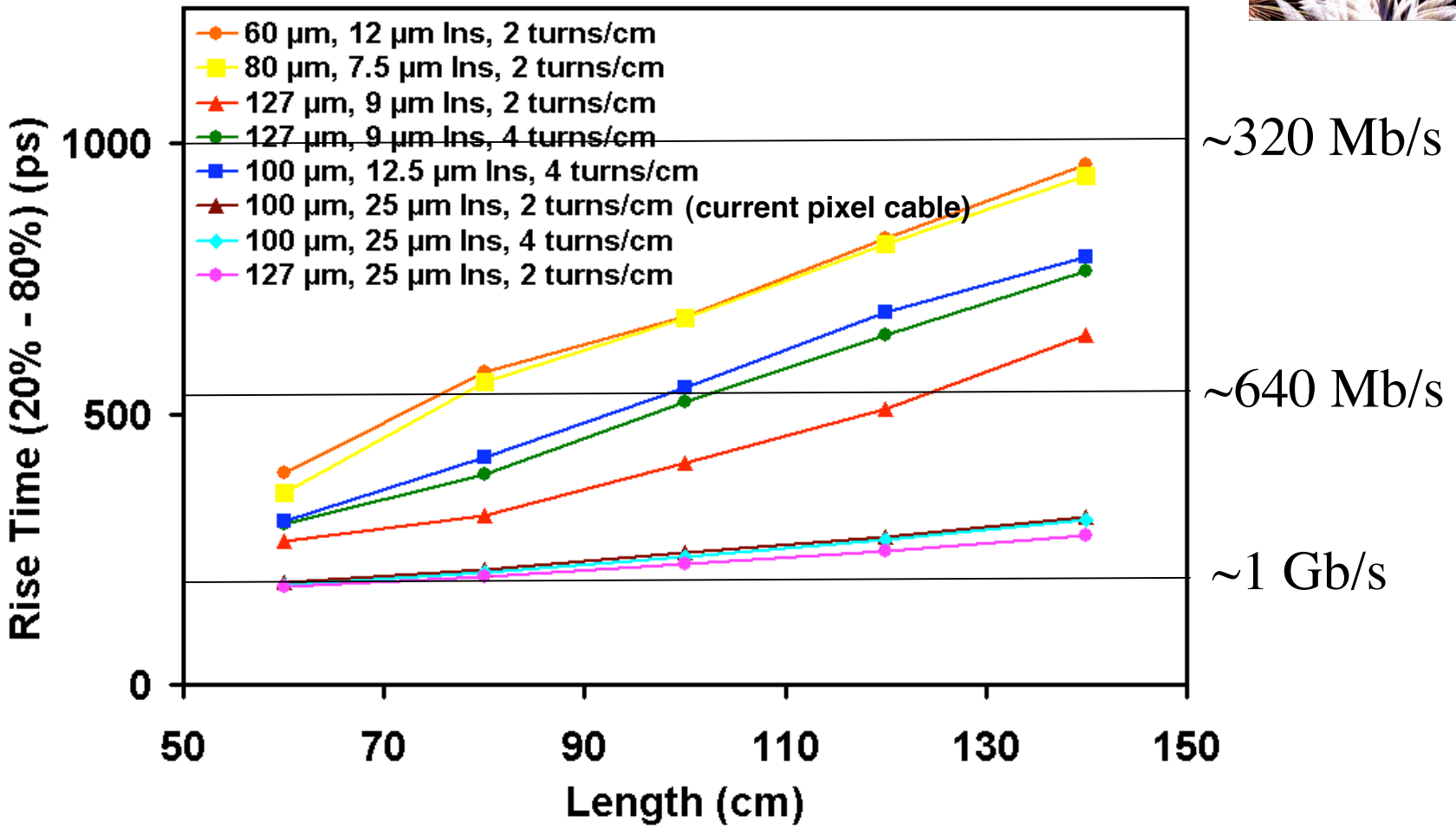
Outline

- Introduction
- Bandwidth of micro-twisted pairs
- Bandwidth of fiber
- Radiation hardness of VCSEL arrays
- Radiation hardness of PIN arrays
- Results on compact MT-style opto-packs based on BeO
- Summary

Current Pixel Opto-Link Architecture

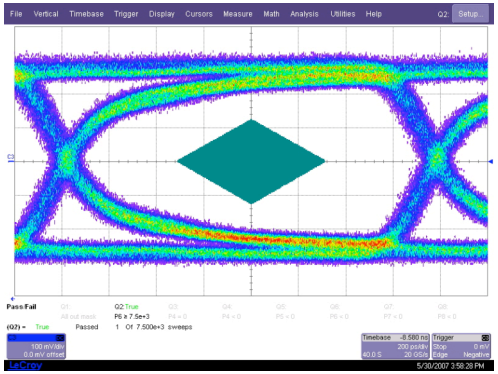
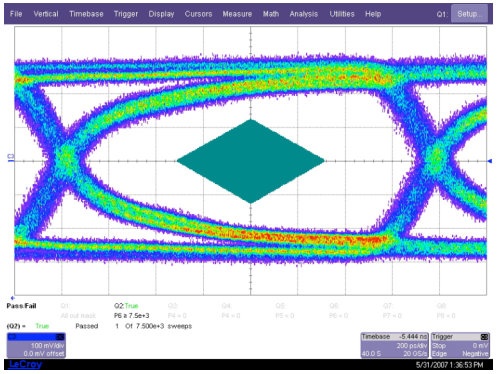
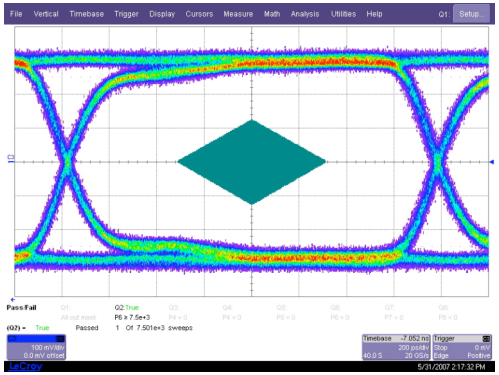
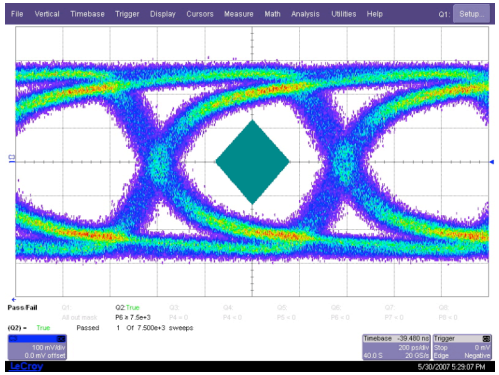
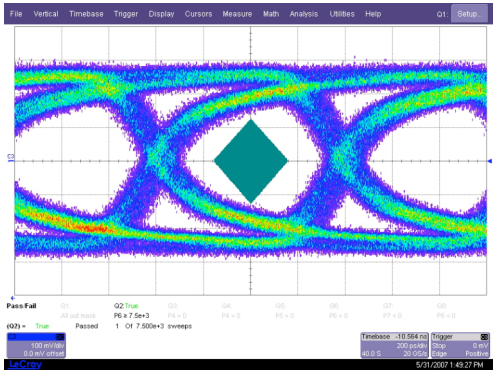
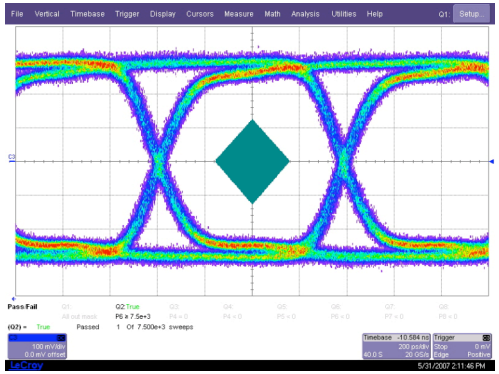
- Optical link of current pixel detector is mounted on patch panels:
  - ⇨ much reduced radiation level
- use micro-twisted pairs for transmission between pixel and opto modules
  - ⇨ simplified the design/production of both types of modules
  - ⇨ what is the bandwidth of the micro cables?
- use rad-hard/low-bandwidth SIMM fiber fusion spliced to rad-tolerant/medium-bandwidth GRIN fiber
  - ⇨ what is the bandwidth of the fiber?

Bandwidth of Micro Twisted Pairs



- current pixel cable with thick insulation is quite optimum!

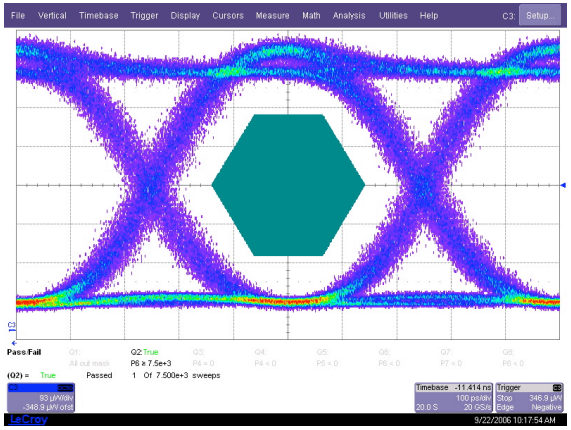
Eye Diagrams

	127 μm cable 140 cm	100 μm current pixel cable 140 cm	100 μm current pixel cable 60 cm
640 Mb/s			
1280 Mb/s			

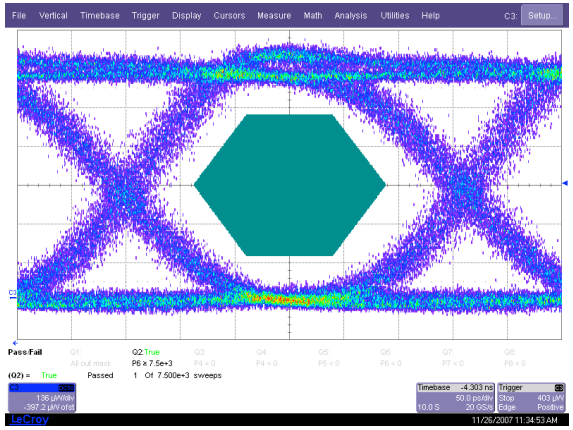
- transmission at 640 Mb/s is adequate
- transmission at 1280 Mb/s may be acceptable
- 127 μm cable is slightly better

Bandwidth of Fiber

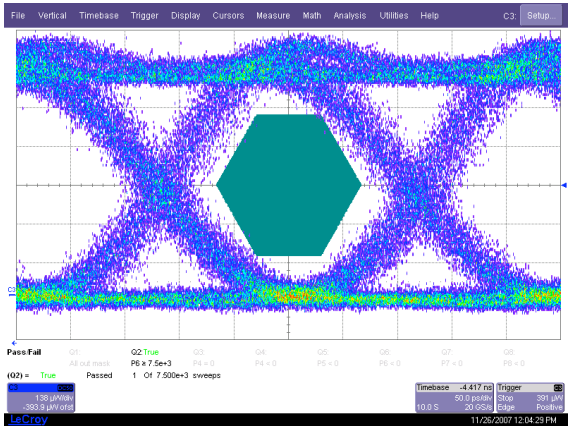
Preliminary



2 Gb/s



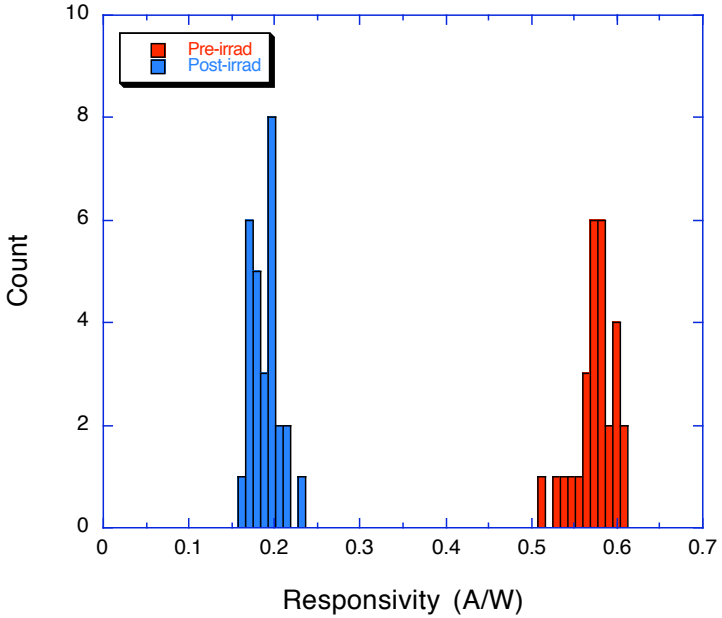
3.2 Gb/s

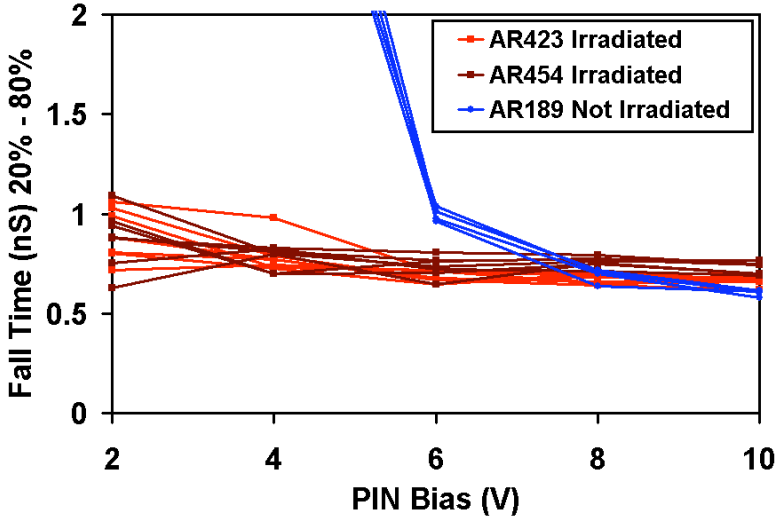


4.25 Gb/s

- transmission at 3.2 Gb/s is probably adequate

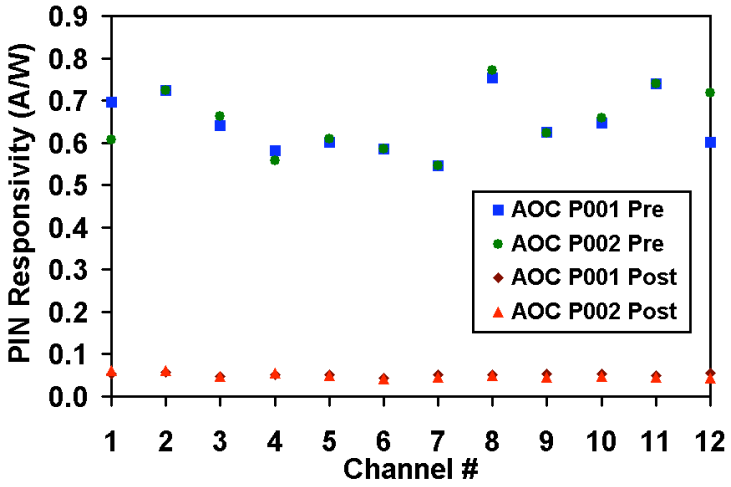
Radiation-Hardness of Silicon PIN

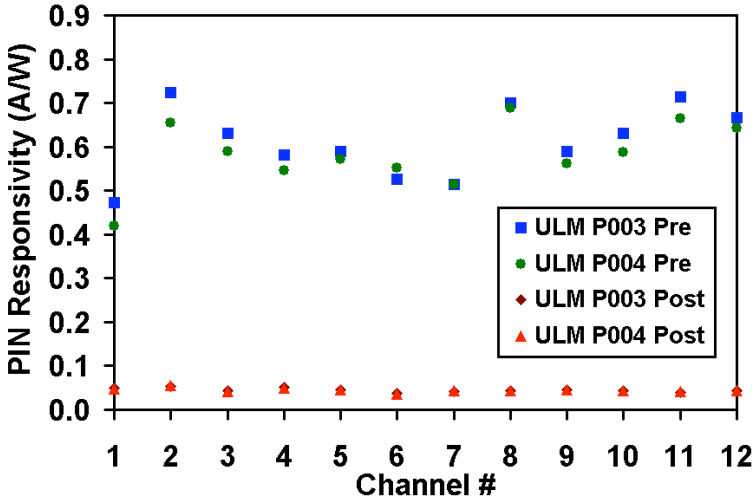


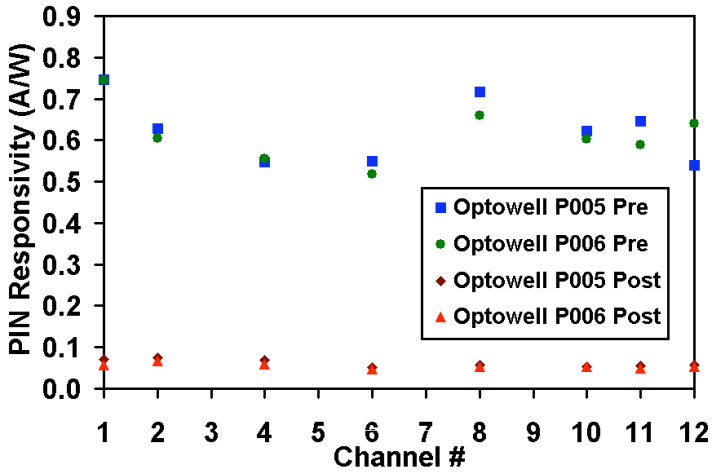


- PIN responsivity decreases by 3x at 114 Mrad (SLHC: 69 Mrad)
- no degradation of rise/fall time
  - ✔ operation at 160 MHz is OK

Radiation-Hardness of GaAs PIN

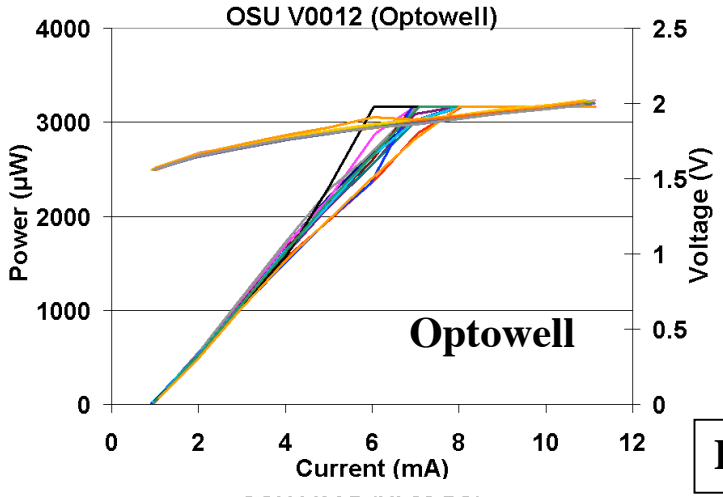




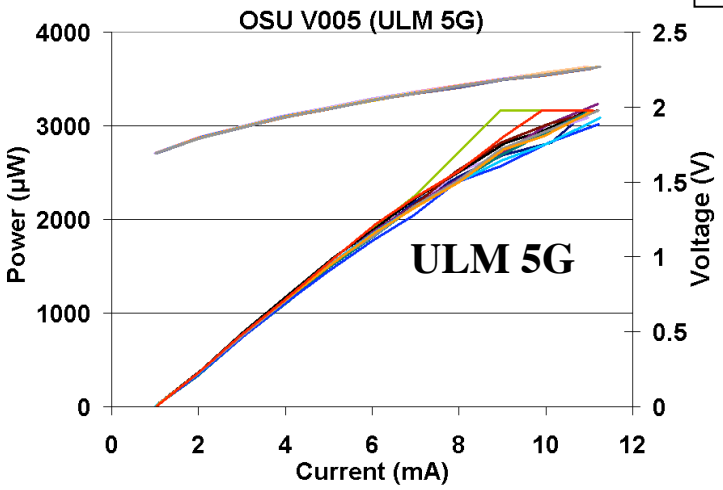


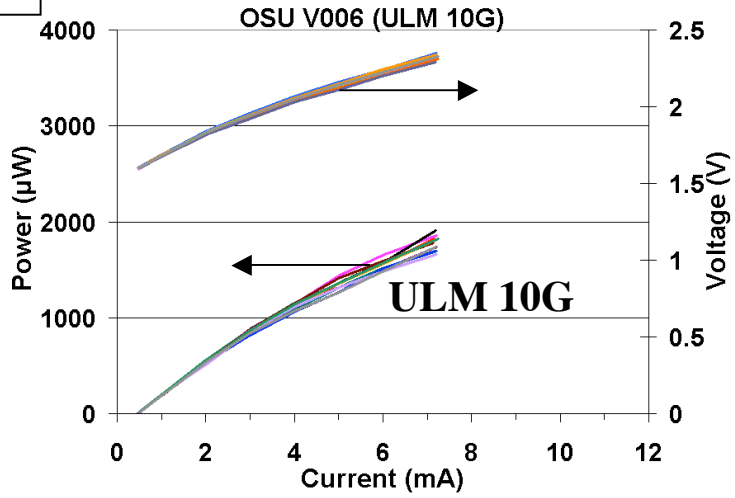
- all arrays are front side illuminated
- PIN responsivities decrease by ~10x at 53 Mrad
- should repeat irradiation to SLHC dosage of 34 Mrad

VCSEL LIV Characteristics



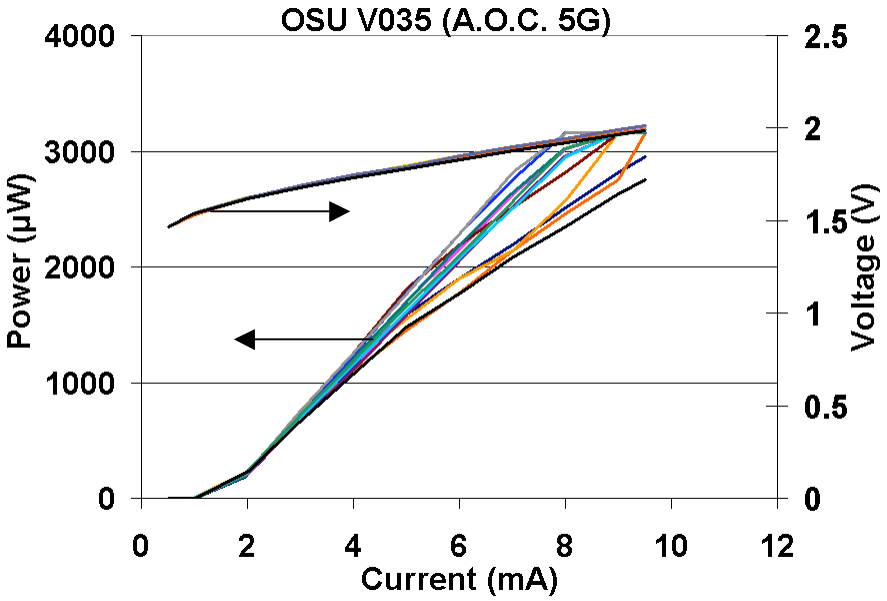
Pre-irrad

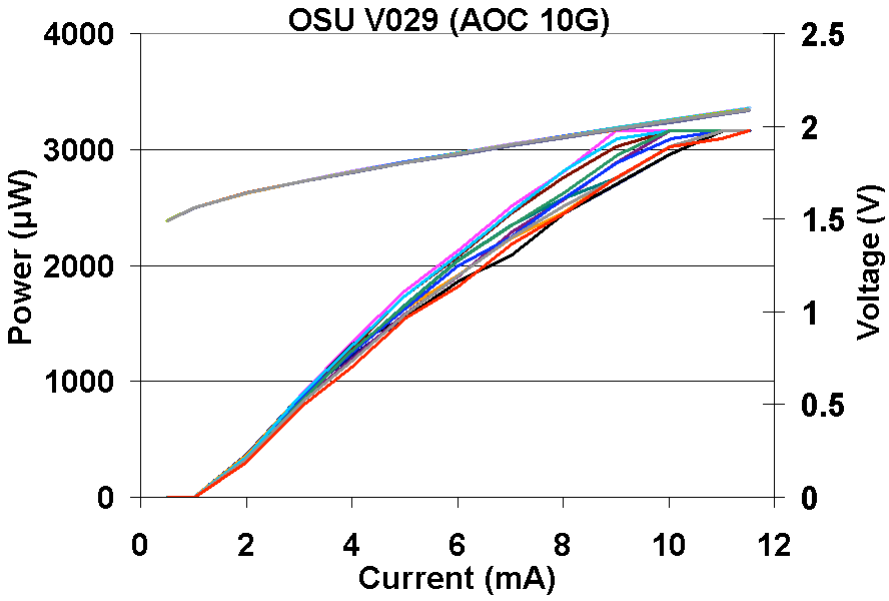




- ☹ ULM requires higher voltage to operate
- ● all arrays have very good optical power

VCSEL LIV Characteristics

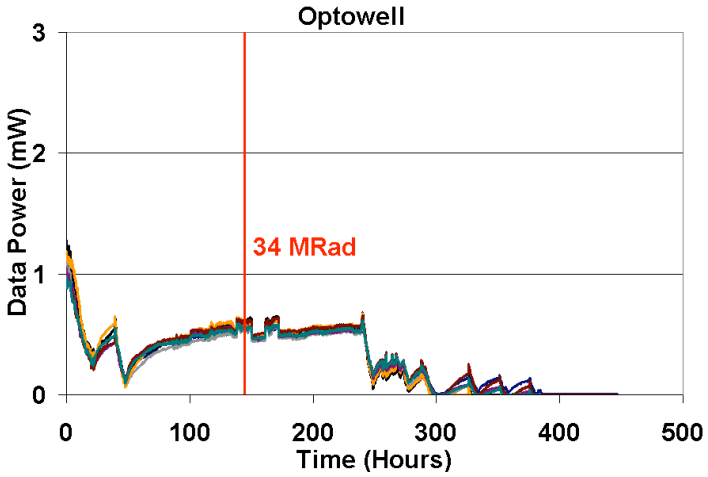


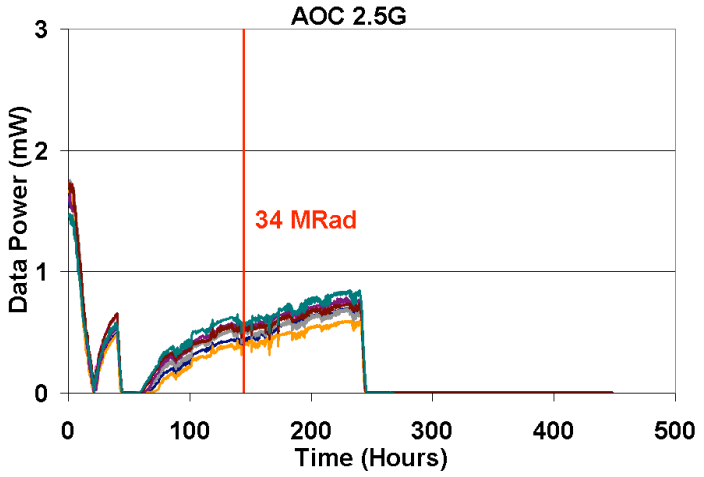


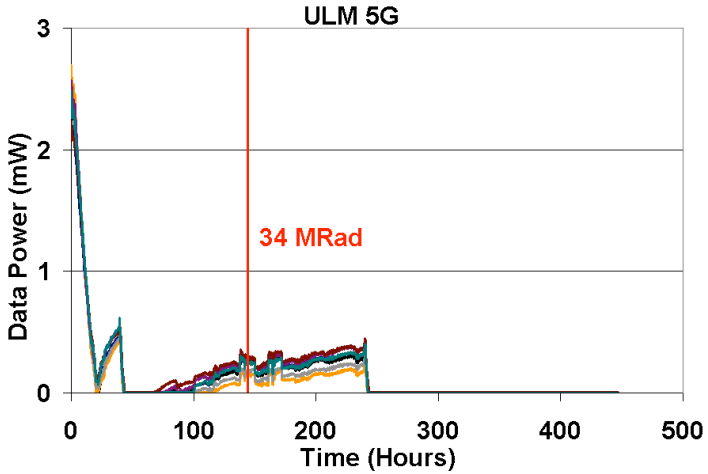
Pre-irrad

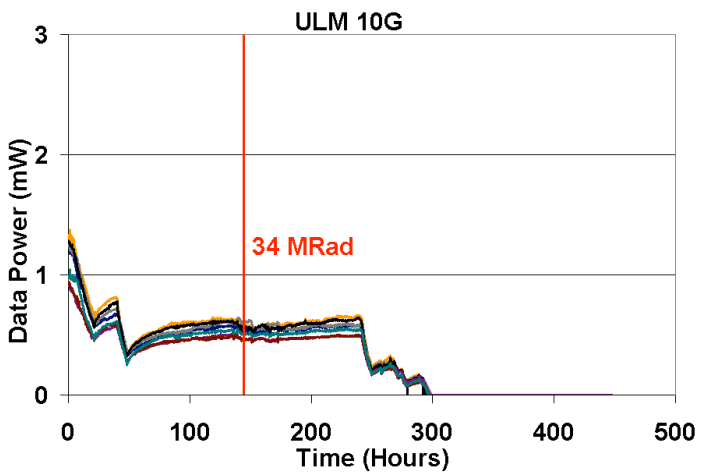
- both arrays have very good optical power

VCSEL Power vs Dosage





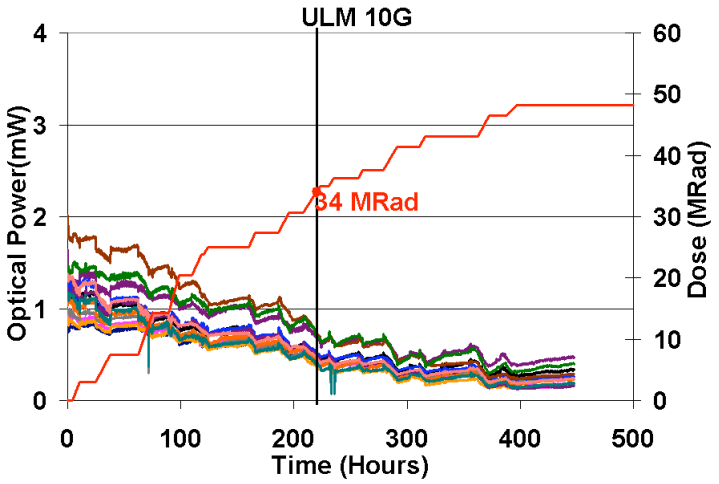


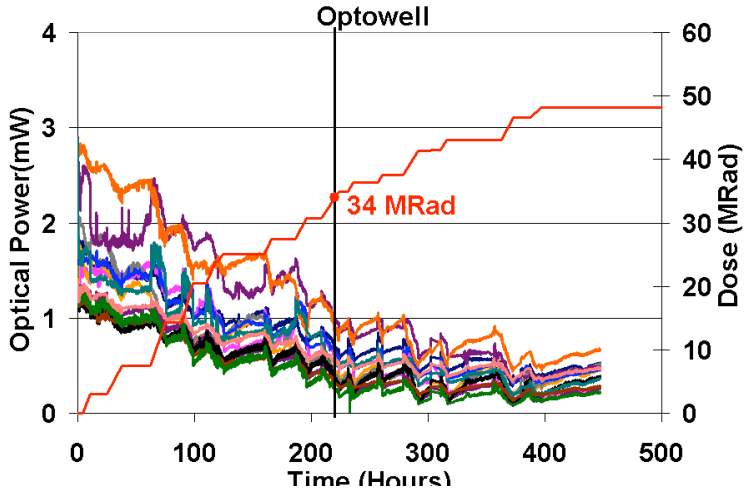


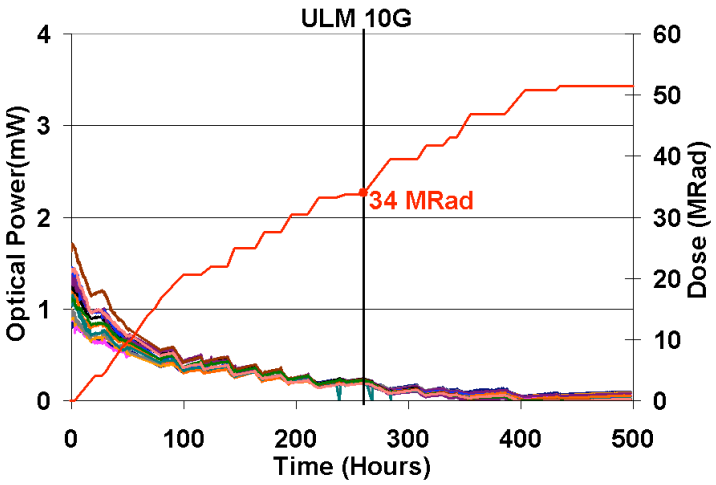
2006:
Two arrays each
(2 x 7 channels)

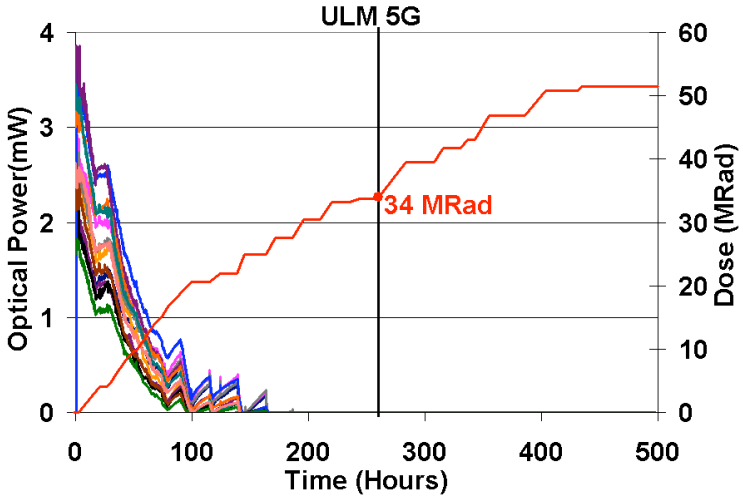
- all VCSELs still produce optical power at SLHC dosage
- should irradiate at lower intensity and have more time for annealing

VCSEL Power vs Dosage









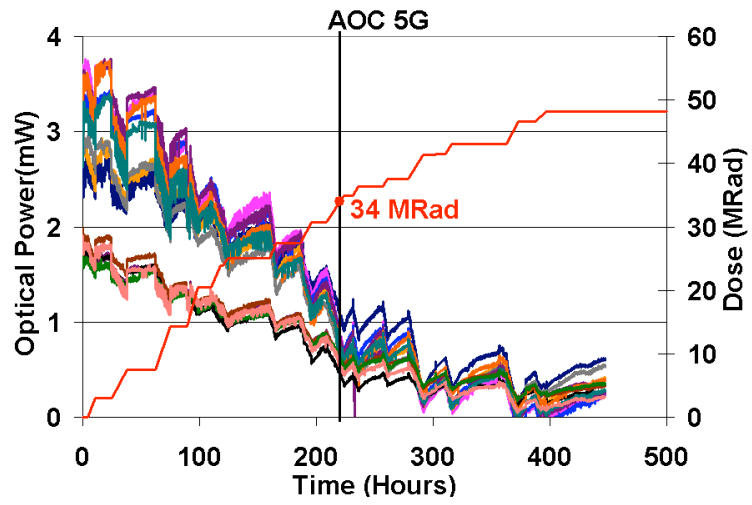
1st irradiation period

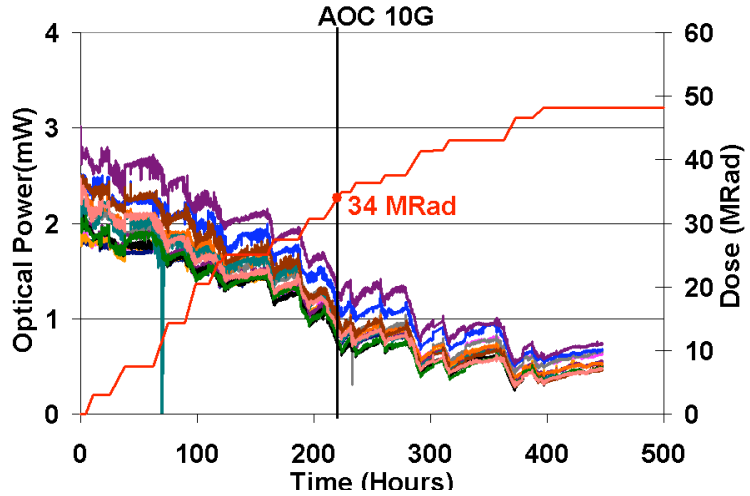
2007: Two arrays each (2 x 7 channels)

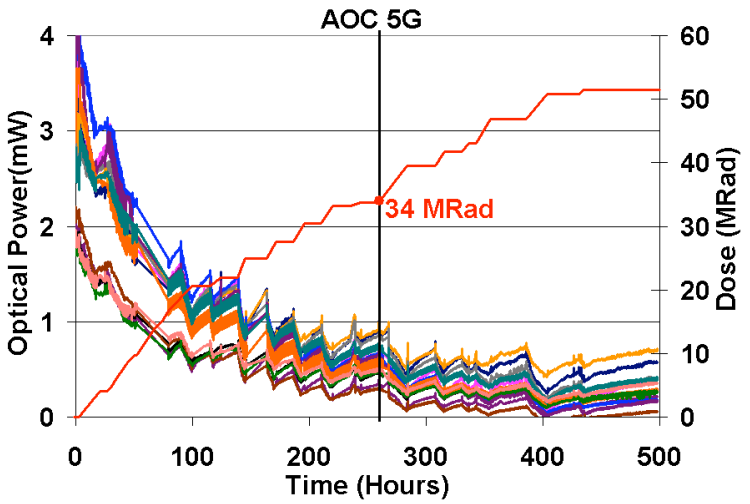
2nd irradiation period

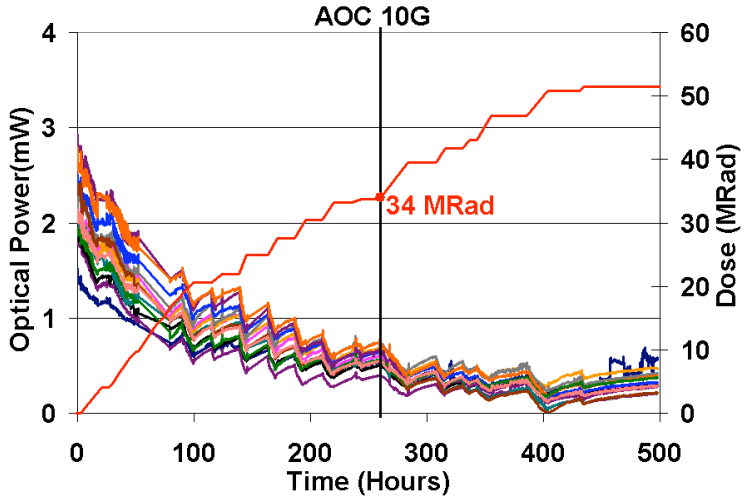
- Optowell & ULM (10 Gb/s) survive to SLHC dosage

VCSEL Power vs Dosage









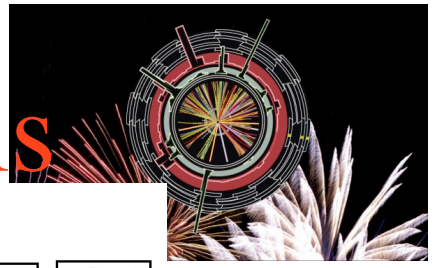
1st irradiation period

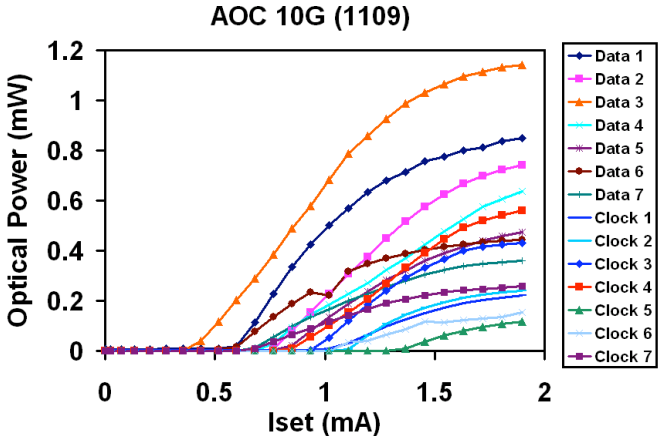
2007: Two arrays each (2 x 7 channels)

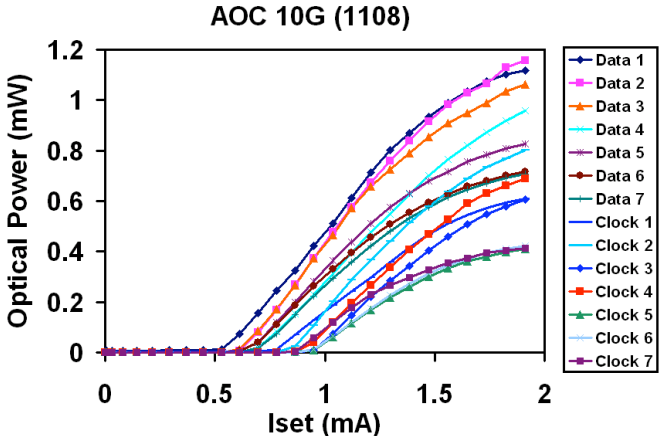
2nd irradiation period

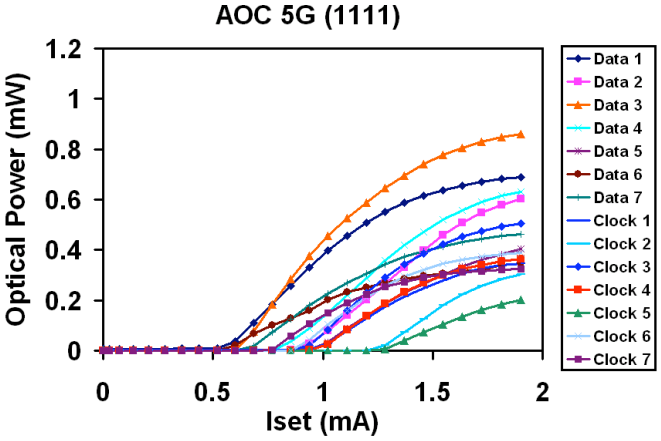
- AOC (5 & 10 Gb/s) survive to SLHC dosage

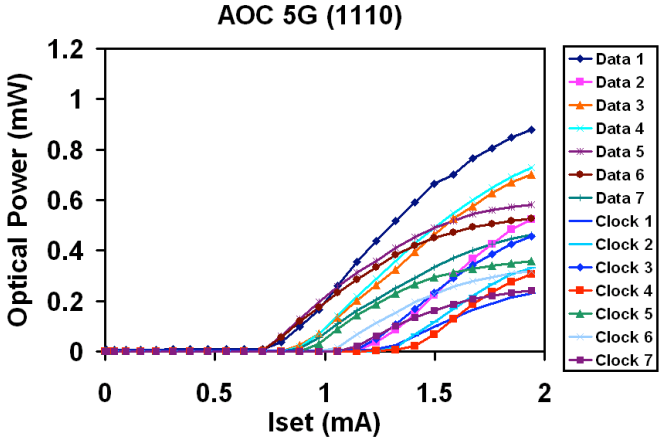
Post-Irradiation Analysis









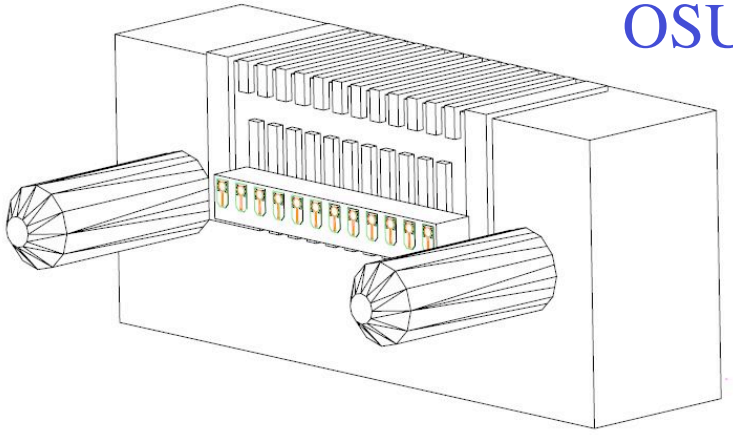


- all arrays except ULM 5 G still produce optical power
- post-irradiation analysis (including annealing) in progress…

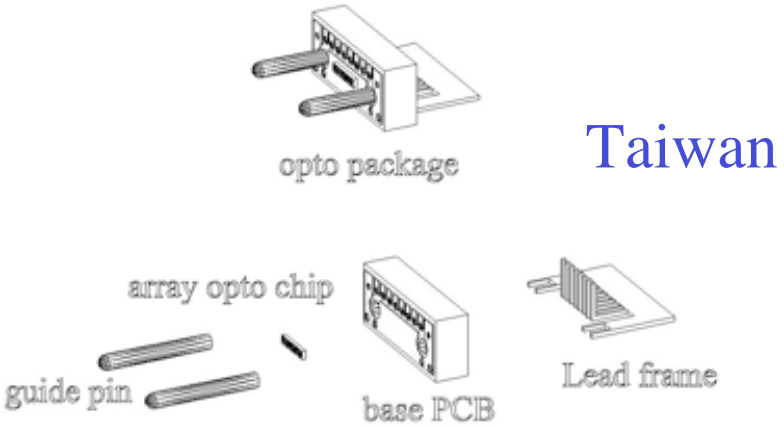
Opto-Pack Development

- current pixel detector uses Taiwan optical packages
  - ☹ VCSEL mounted on PCB with poor heat conduction
  - ☹ micro soldering of 250 μm leads is difficult
- Ohio State develops new opto-pack for SLHC
  - uses BeO base with 3D traces for efficient heat removal
  - wire bond to driver/receiver chip

OSU

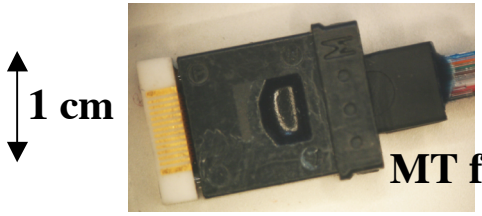


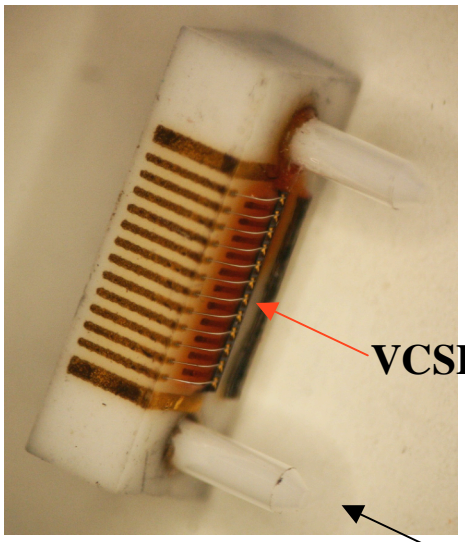
Taiwan

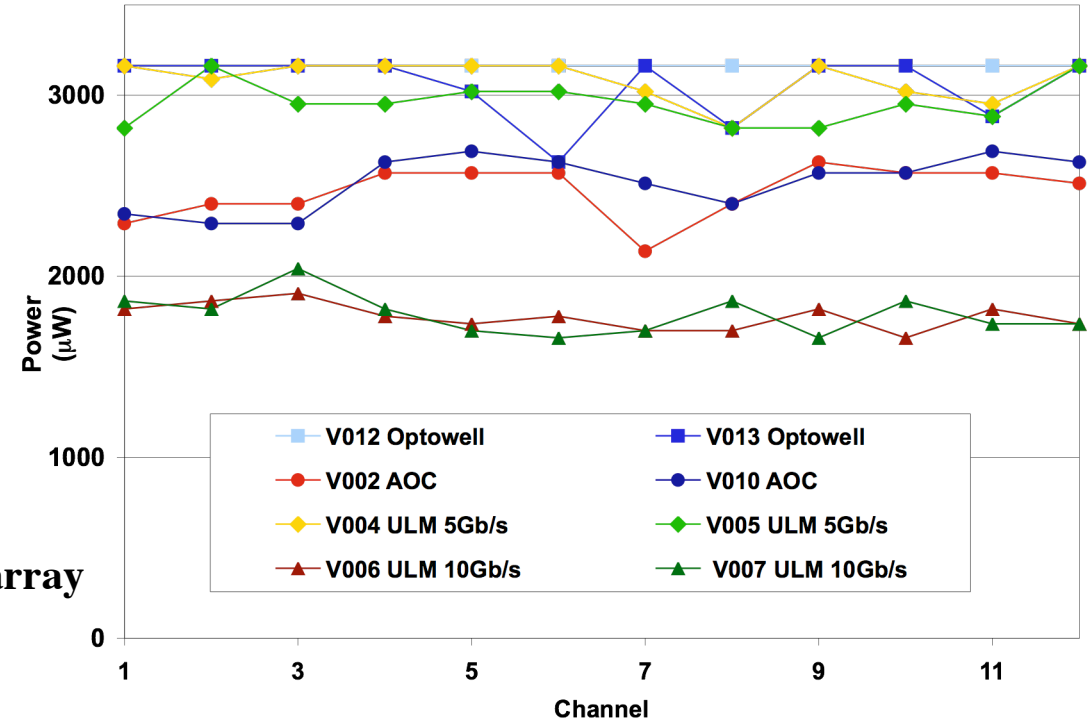


Results on Opto-Packs

- 35 VCSEL & 6 PIN opto-packs have been fabricated
  - all VCSEL opto-packs except one have good coupled power
- ⇨ principle of new opto-pack has been demonstrated







Summary

- micro twisted-pair cable of current ATLAS pixel detector can be used for transmission up to 1 Gb/s
- fusion spliced SIMM/GRIN fiber can transmit up to 3 Gb/s
- Si PIN responsivity is ~3x smaller at 114 Mrad (SLHC: 69 Mrad) :
  - Si PIN can be operated up to 160 MHz
- GaAs PIN responsivity is ~10x smaller at 53 Mrad (SLHC: 34 Mrad)
- high speed VCSELs from 3 vendors can survive to SLHC dosage
- compact MT-style opto-pack based on BeO has been developed