



Radiation-Hard Optical Link for SLHC

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Outline

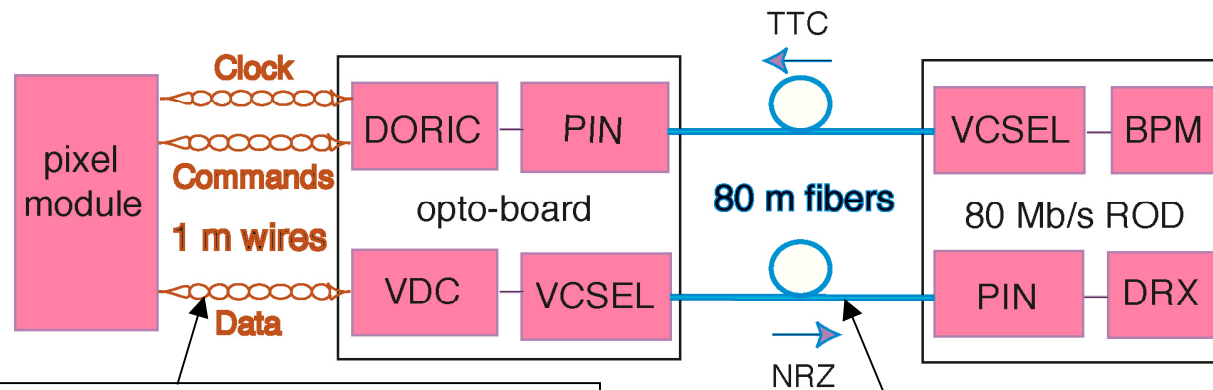


- Introduction
- Bandwidth of micro twisted-pair cables
- Bandwidth of fusion spliced SIMM-GRIN fiber
- Radiation hardness of PIN/VCSEL arrays
- Results on MT-style optical packages based on BeO
- Summary



ATLAS Pixel Opto-Link Architecture

- ATLAS is a detector studying pp collisions of 14 TeV at CERN
 - ◆ pixel detector is innermost tracker
 - ◆ detector upgrade planned for Super-LHC in 2015



micro twisted pairs decouple
pixel and opto module production
⇒ simplify both production

8 m of rad-hard/low-bandwidth
SIMM fiber fusion spliced to 70 m
rad-tolerant/medium-bandwidth
GRIN fiber

⇒ upgrade based on current pixel link architecture
to take advantage of R&D effort and production experience?



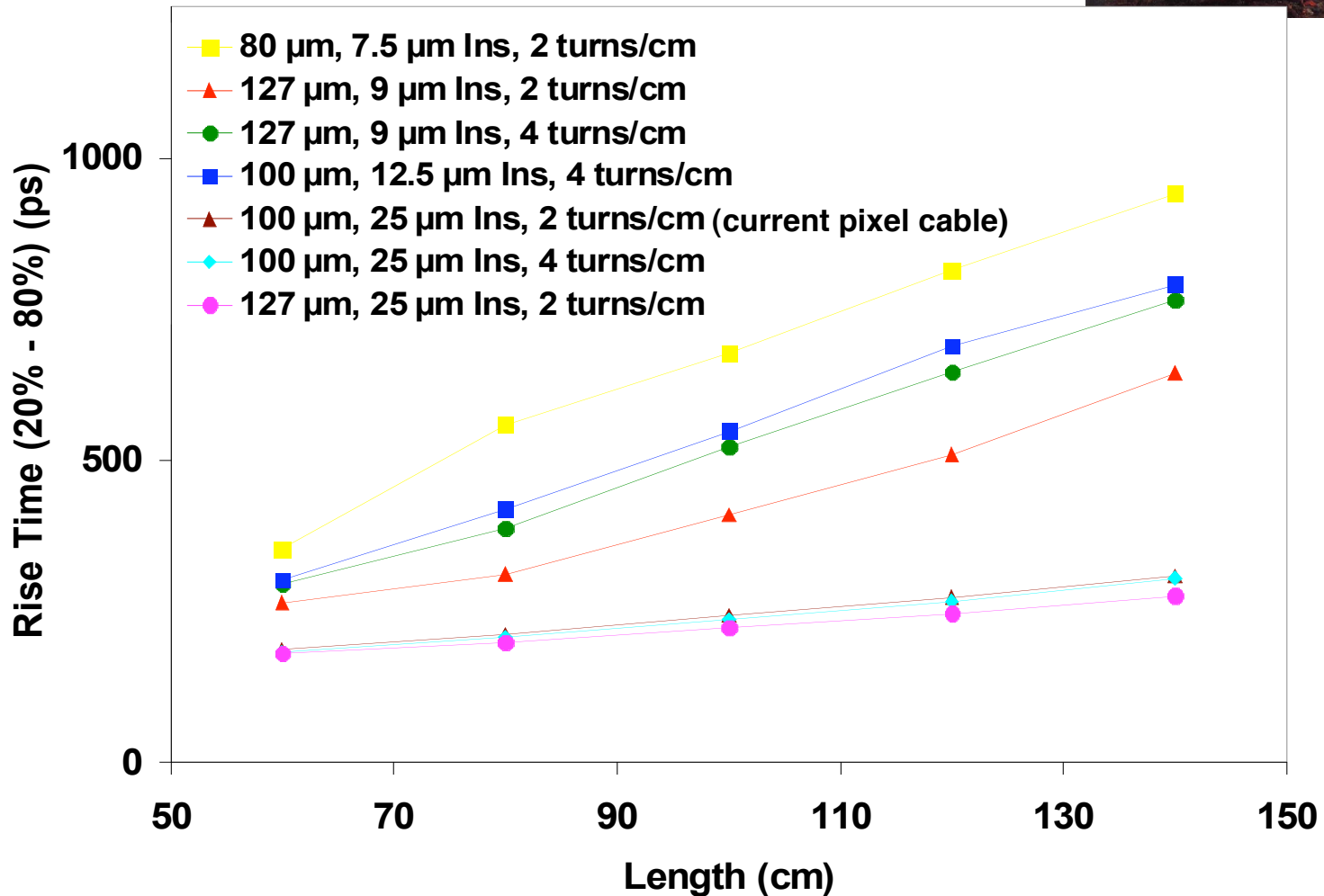
R&D Issues for SLHC



- bandwidth of ~ 1 Gb/s is needed
 - ◆ can micro twisted pair transmit at this speed?
 - ◆ can fusion spliced SIMM/GRIN fiber transmit at this speed?
- can PIN/VCSEL arrays survive SLHC radiation dosage?



Bandwidth of Micro Twisted Pairs



● current pixel cable with thick insulation is quite optimum!



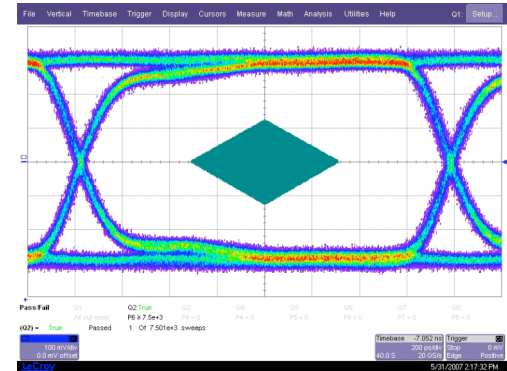
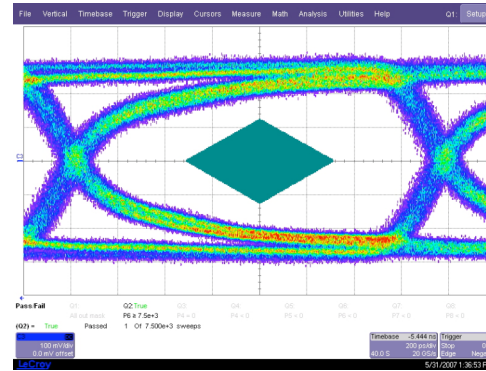
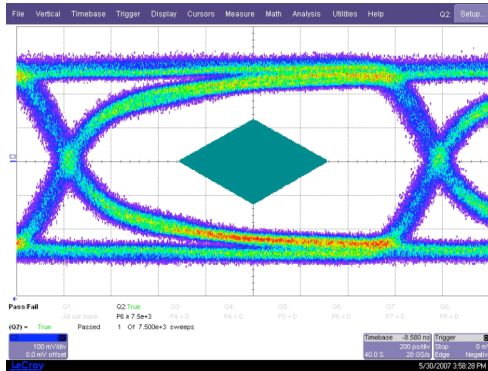
Eye Diagrams

127 μm cable
140 cm

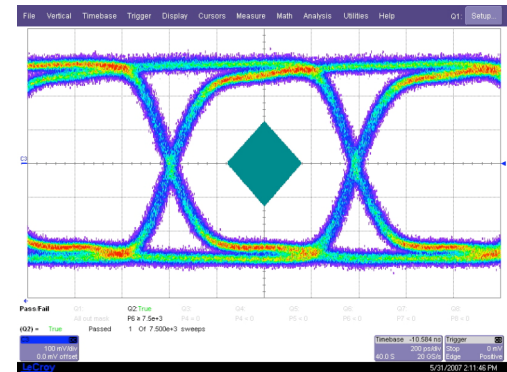
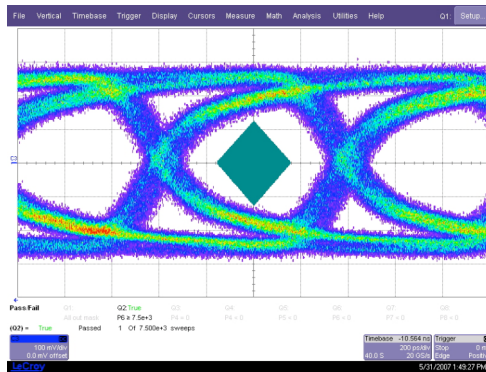
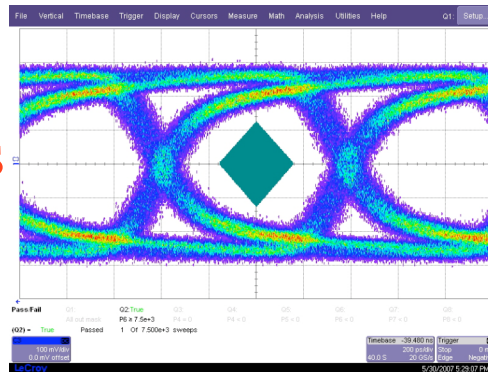
100 μm current pixel cable
140 cm
60 cm



640 Mb/s



1280 Mb/s



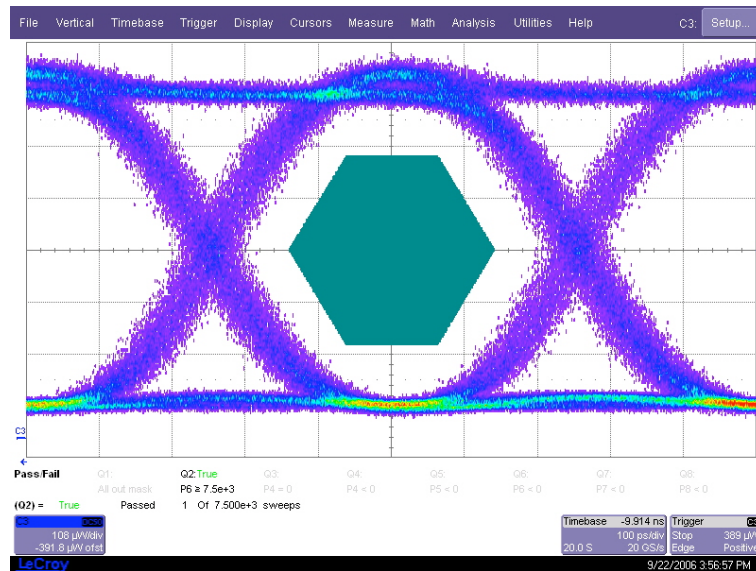
- transmission at 640 Mb/s is adequate
- transmission at 1280 Mb/s may be acceptable
- 127 μm cable is slightly better



Bandwidth of Fusion Spliced Fiber

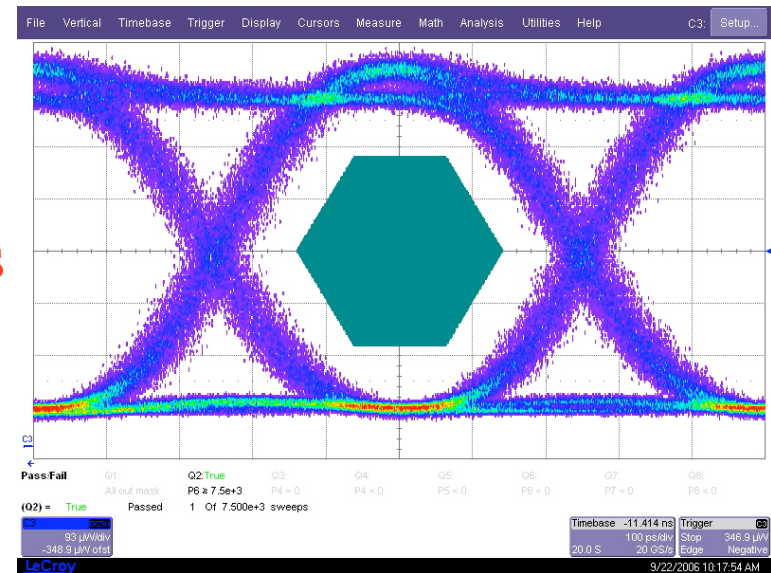


1 m GRIN fiber



2 Gb/s

8 + 80 m spliced SIMM/GRIN fiber



- transmission up to 2 Gb/s looks adequate



Radiation Level at SLHC



- Optical link of current pixel detector is mounted on patch panel:
 - ⇒ much reduced radiation level:
 - ◆ Si (PIN) @ SLHC:
 - 2.5×10^{15} 1-MeV n_{eq}/cm^2
 - 4.3×10^{15} p/cm² or 114 Mrad for 24 GeV protons
 - ◆ GaAs (VCSEL) @ SLHC:
 - 14×10^{15} 1-MeV n_{eq}/cm^2
 - 2.7×10^{15} p/cm² or 71 Mrad for 24 GeV protons
 - ◆ above estimates include 50% safety margin



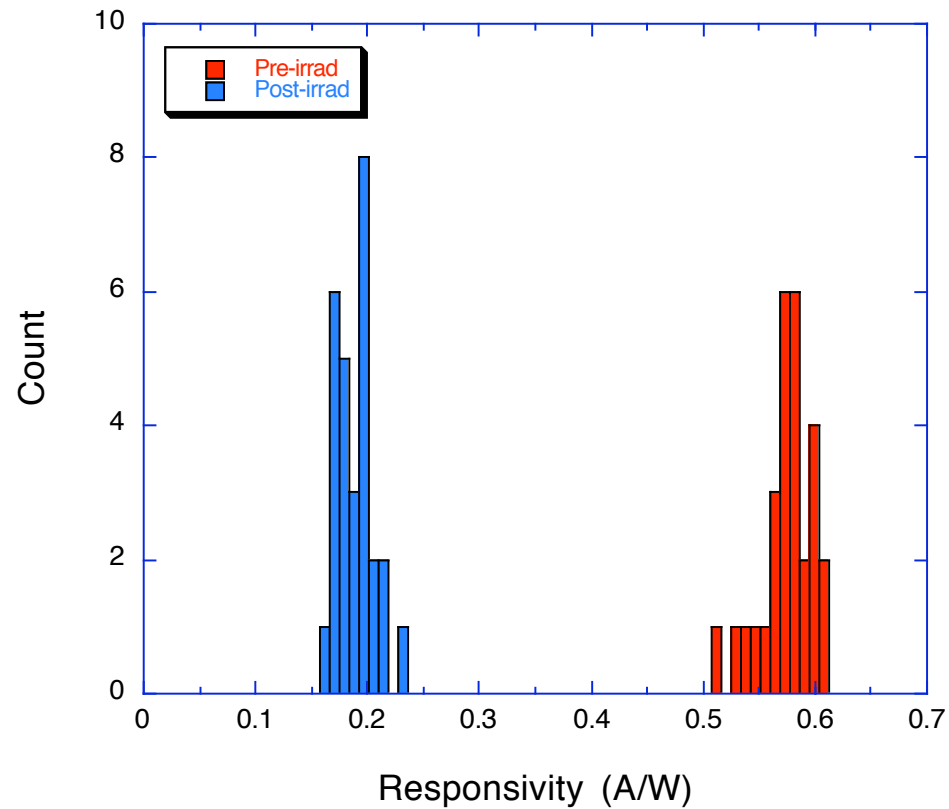
Requirements for PIN/VCSEL



- PIN:
 - ◆ What is responsivity after irradiation?
 - ◆ What is rise/fall time after irradiation?
- VCSEL:
 - ◆ driver chip most likely be fabricated with 0.13 μm process
 - nominal operating voltage is 1.2 V
 - thick oxide option can operate at 2.5 V
 - ⇒ VCSELs must need < 2.3 V to produce 10 mA or more
 - ◆ What is rise/fall time after irradiation?
 - ◆ What is optical power after irradiation?
 - ◆ What current is needed for annealing?



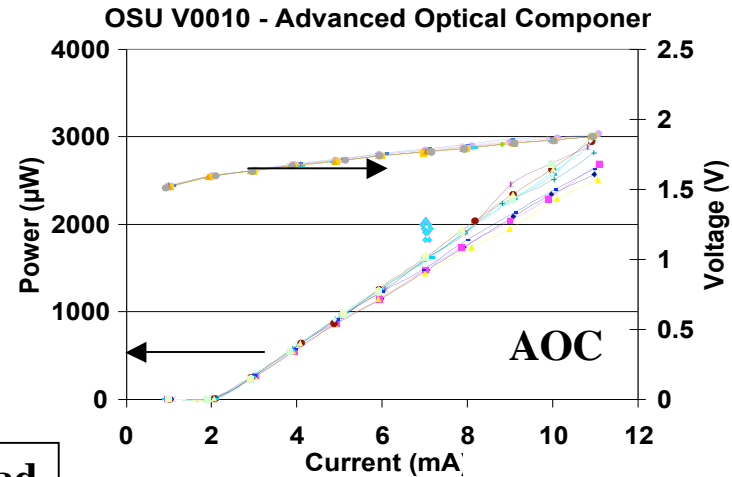
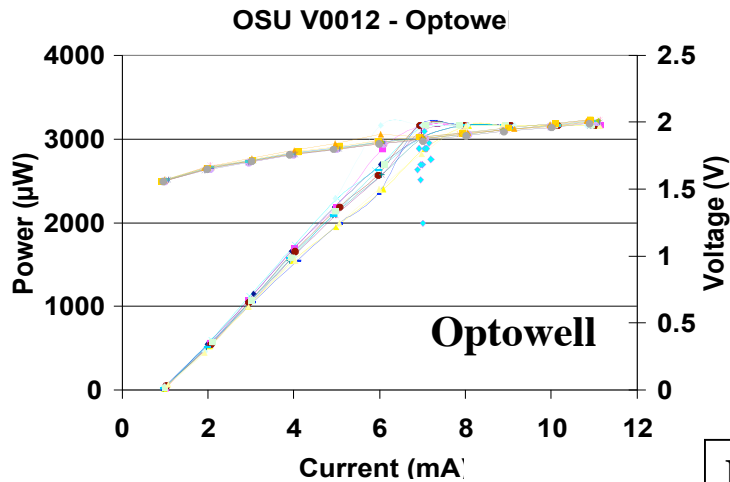
PIN Responsivity



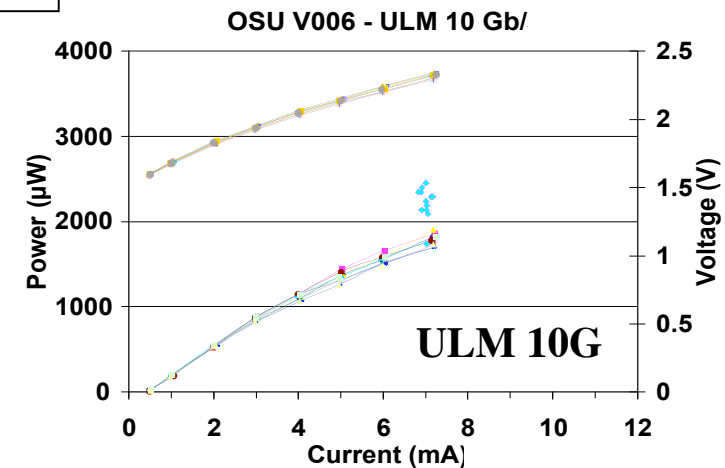
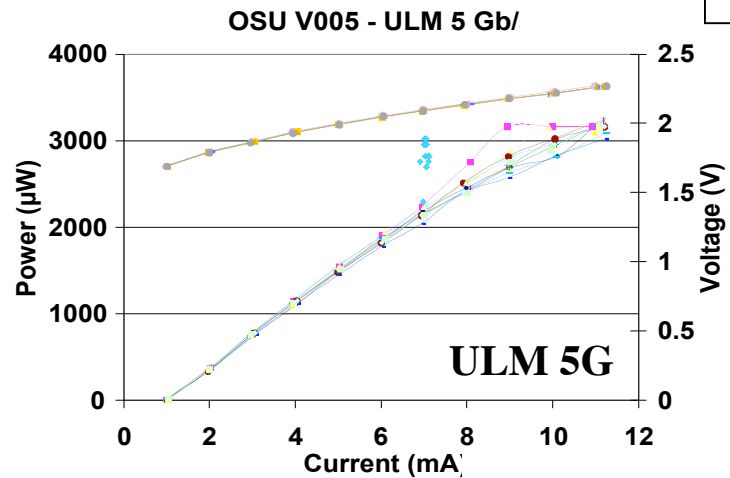
- responsivity decreases by 65% after SLHC dosage



VCSEL LIV Characteristics



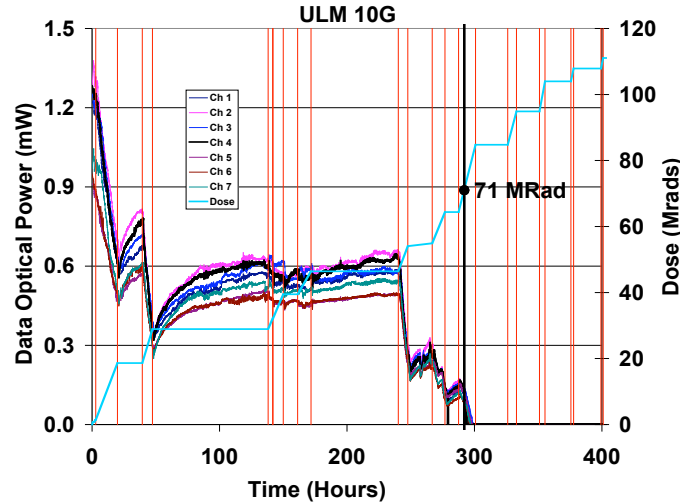
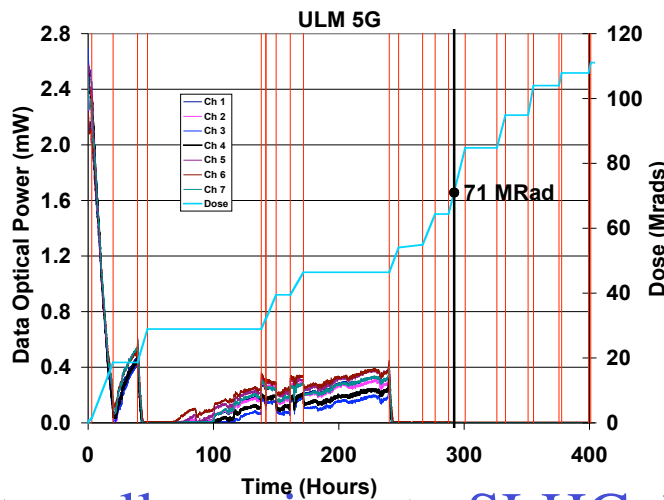
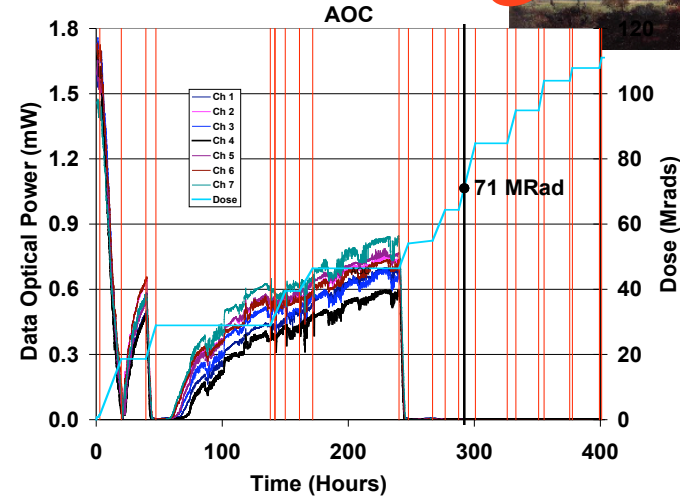
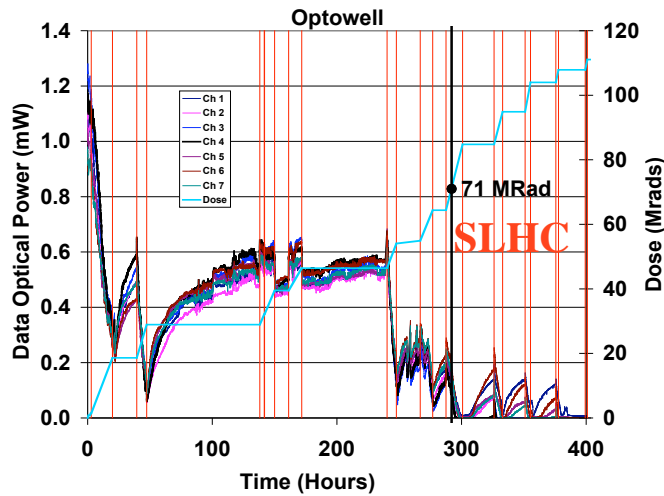
Pre-irrad



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



VCSEL Power vs Dosage



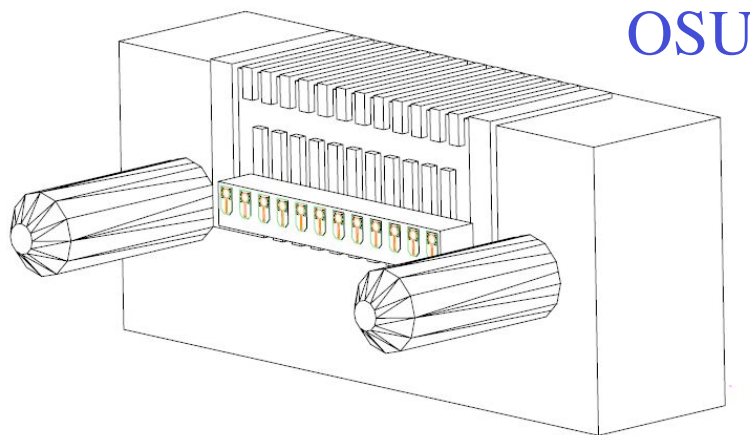
- Optowell survives to SLHC dosage
- more VCSELs might survive with more annealing during irradiation



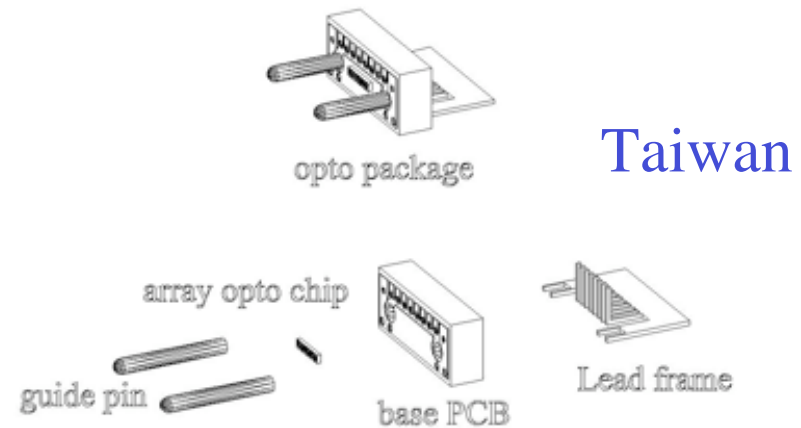
Opto-Pack Development



- 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

RD07

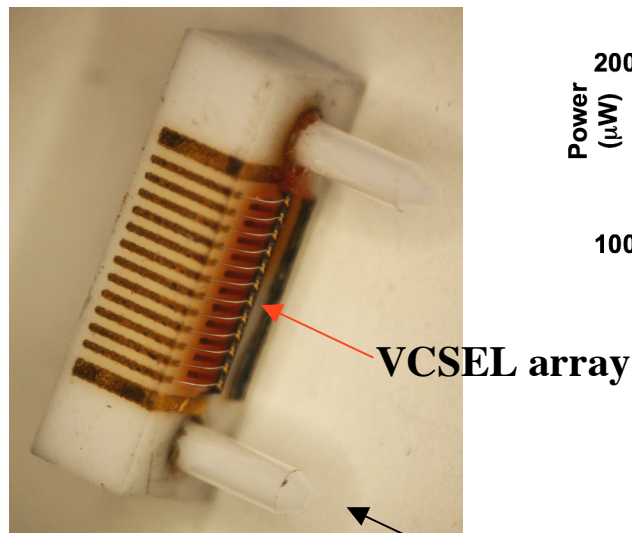
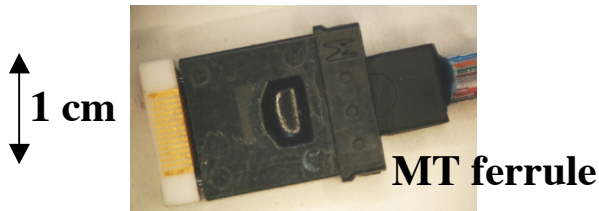
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Results on Opto-Packs

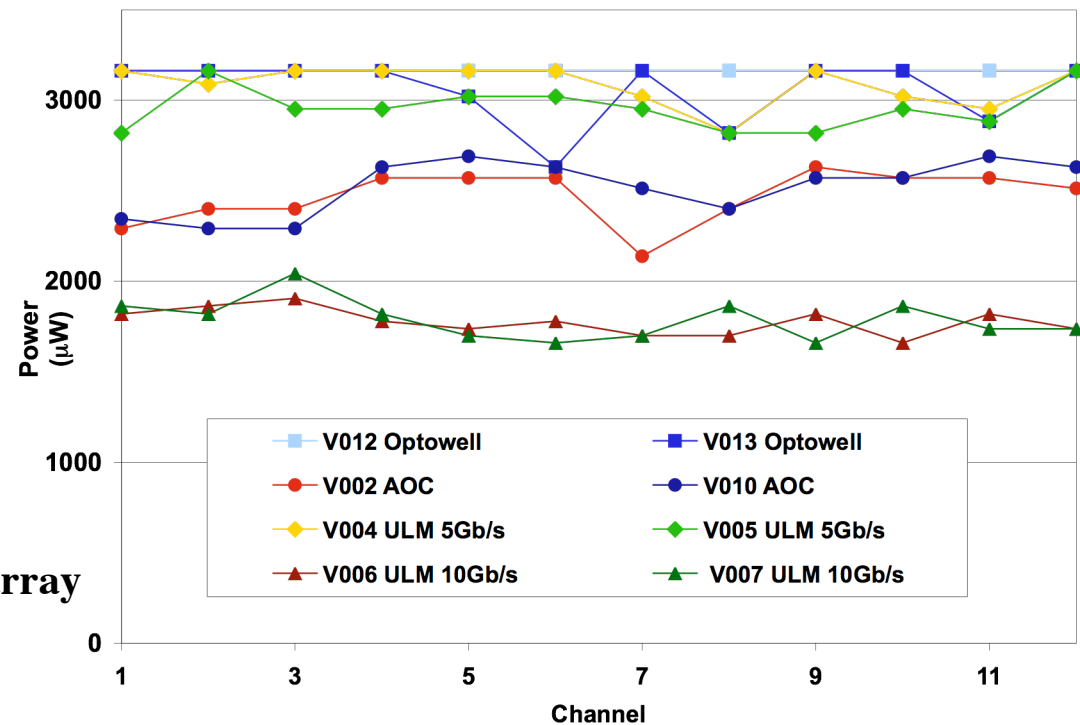


- 30 VCSEL/PIN opto-packs have been fabricated
- ◆ all VCSEL opto-packs have good coupled power
- ⇒ principle of new opto-pack has been demonstrated



K.K. Gan

Ceramic guide pin



RD07

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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 2 Gb/s
- PIN responsivity decreases by 65% after SLHC dosage
- Optowell VCSEL survives SLHC dosage
- ⇒ current opto-link architecture satisfies SLHC requirements
- compact MT-style opto-pack based on BeO has been developed