



Bandwidths of Micro Twisted-Pair Cables and Fusion Spliced SIMM-GRIN Fibers and Radiation Hardness of PIN/VCSEL

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Outline

- Introduction
- Bandwidth of micro twisted-pair cables
- Bandwidth of fusion spliced SIMM-GRIN fibers
- Radiation hardness of PIN/VCSEL arrays
- 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
- current optical link of pixel detector transmits signal at 80 Mb/s
- opto-link production is decoupled from module production
 - ◆ transmit signal to/from modules with micro twisted pairs
- use PIN/VCSEL arrays coupled to robust fiber ribbon
- use 8 m of rad-hard/low-bandwidth SIMM fiber fusion spliced to 70 m rad-tolerant/medium-bandwidth GRIN fiber
- ⇒ simplify opto-board production
- ⇒ upgrade based on current pixel link architecture to take advantage of R&D effort and production experience?



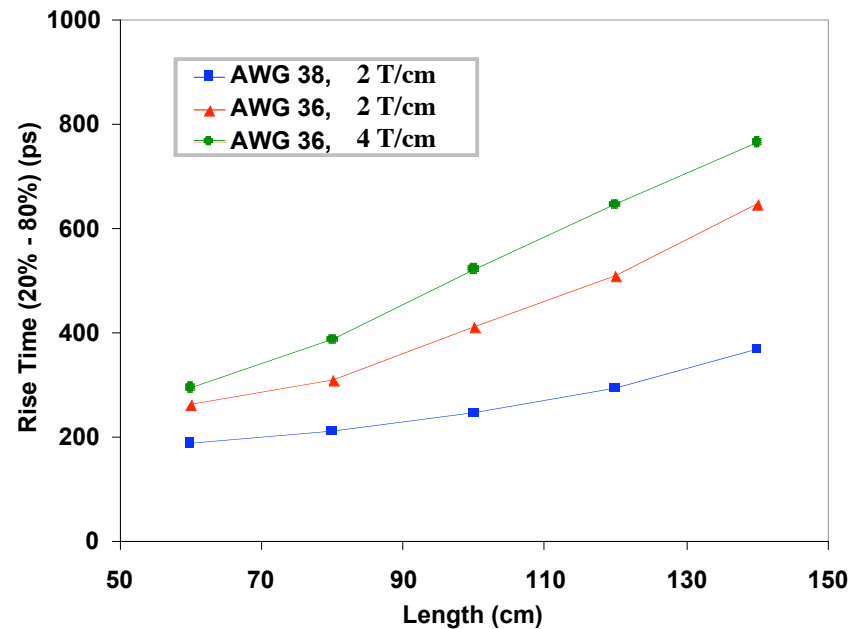
R&D Issues for SLHC

- bandwidth of ~ 640 Mb/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

- bandwidth of 3 micro twisted-pair wires were compared:
 - ◆ 38 AWG/100 μm , 2 turns/cm (current pixel cable)
 - ◆ 36 AWG/127 μm , 2 turns/cm
 - ◆ 36 AWG/127 μm , 4 turns/cm

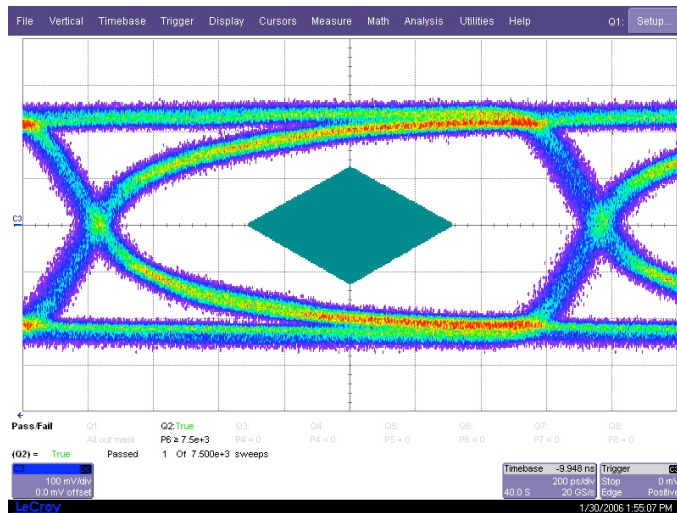


- current pixel cable is the best!

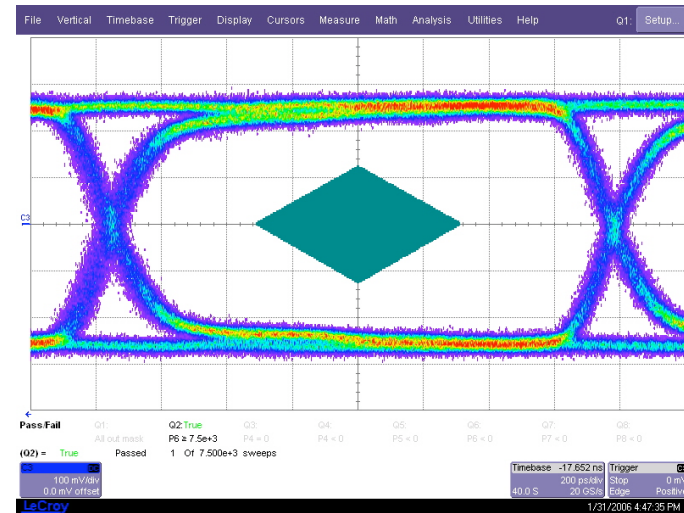


Eye Diagrams at 650 Mb/s

140 cm pixel cable



60 cm pixel cable

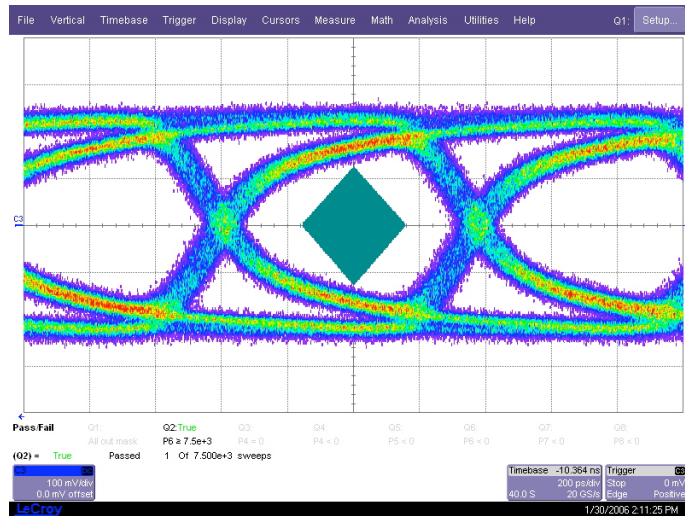


- transmission at 650 Mb/s is adequate

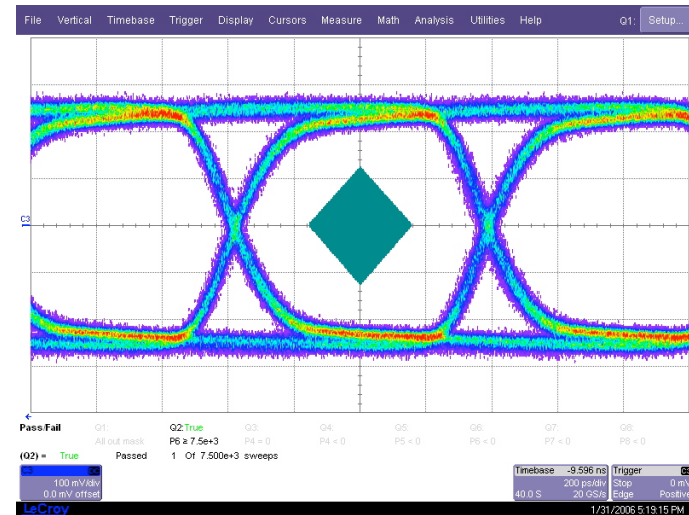


Eye Diagrams at 1.3 Gb/s

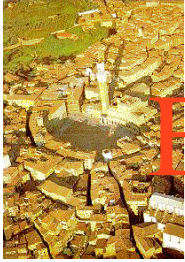
140 cm pixel cable



60 cm pixel cable

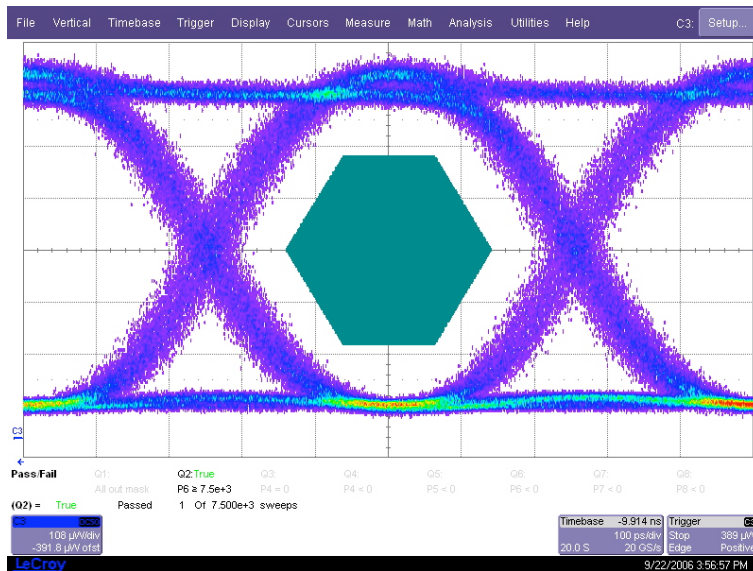


- transmission at 1.3 Gb/s may be acceptable



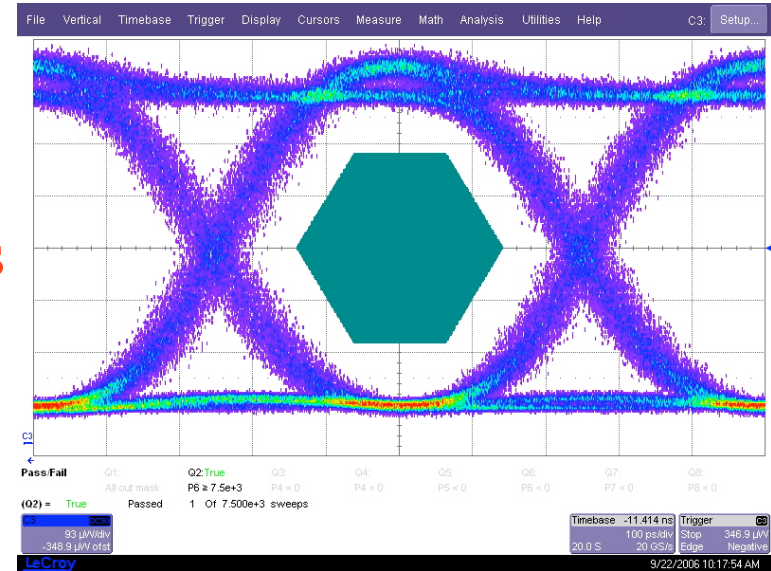
Bandwidth of Fusion Spliced Fiber

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

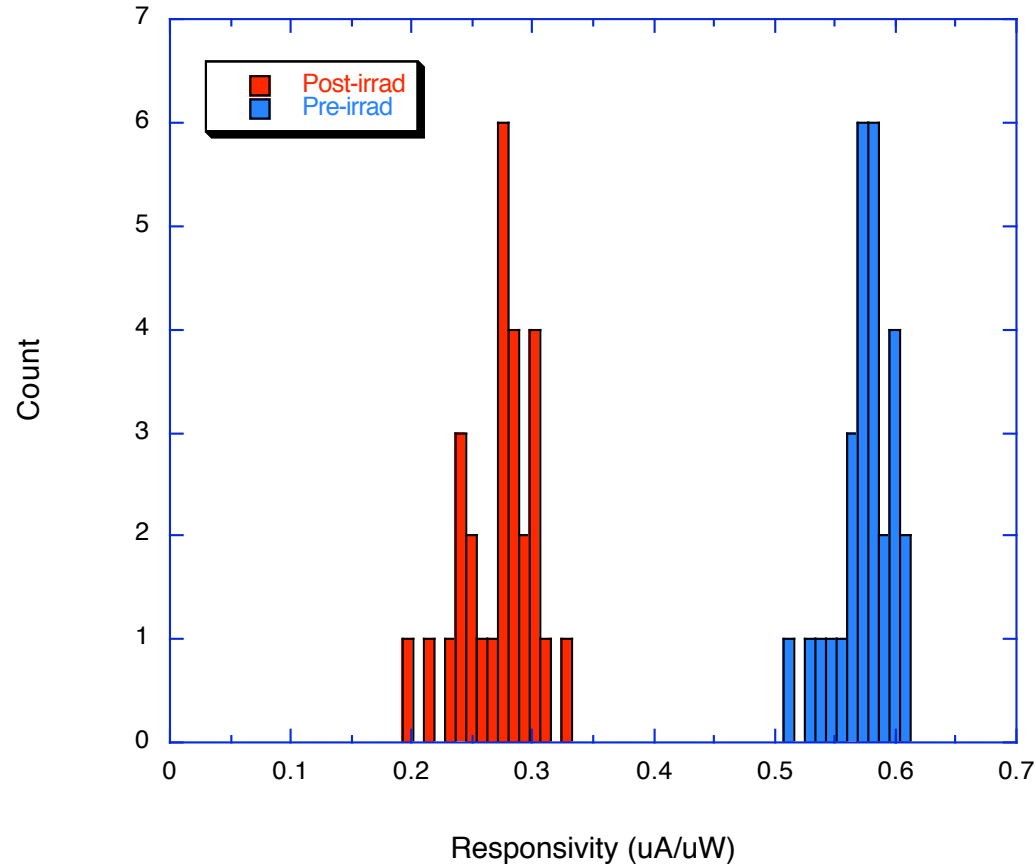


Requirements for PIN/VCSEL

- 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
 - operating voltage is 1.2 V
 - thick oxide option can operate at 2.5 V
 - ⇒ VCSEL 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?



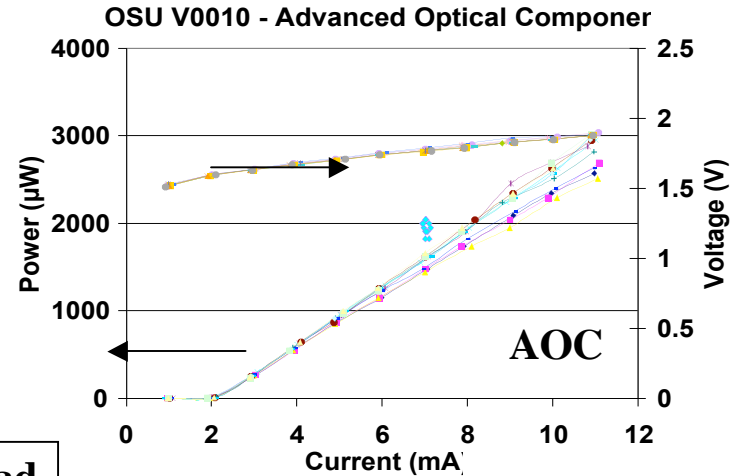
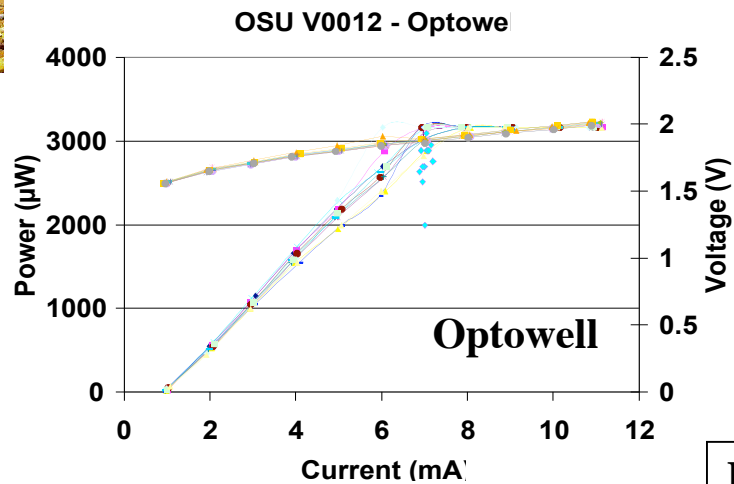
PIN Responsivity



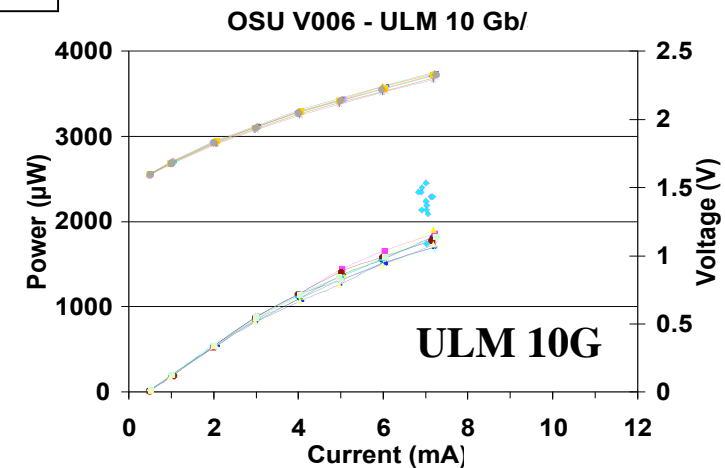
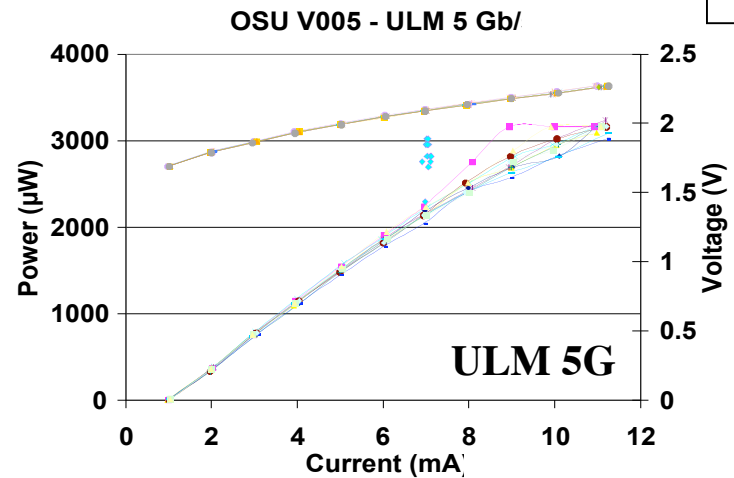
- responsivity decreases by ~50% after SLHC dosage



VCSEL LIV Characteristics



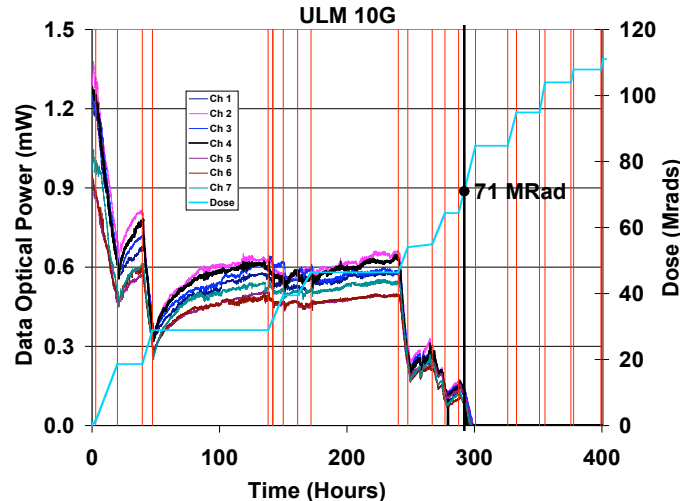
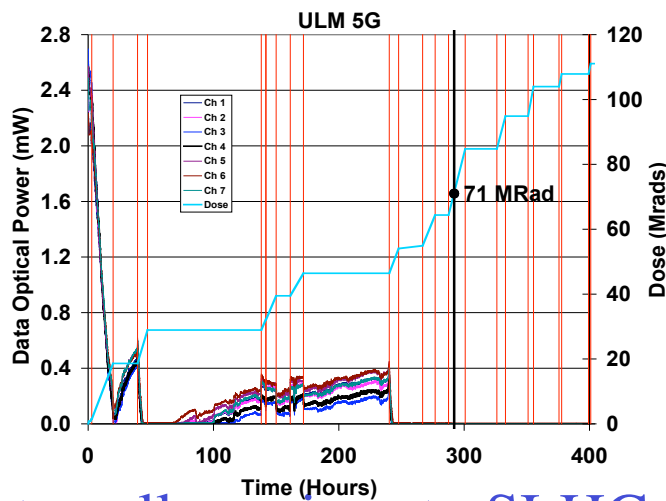
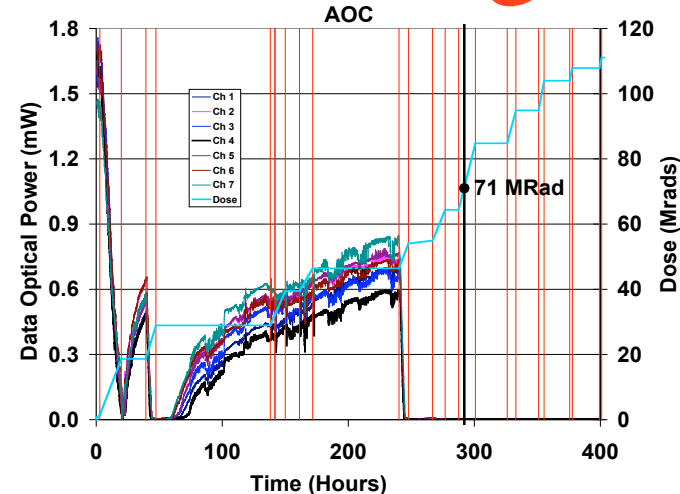
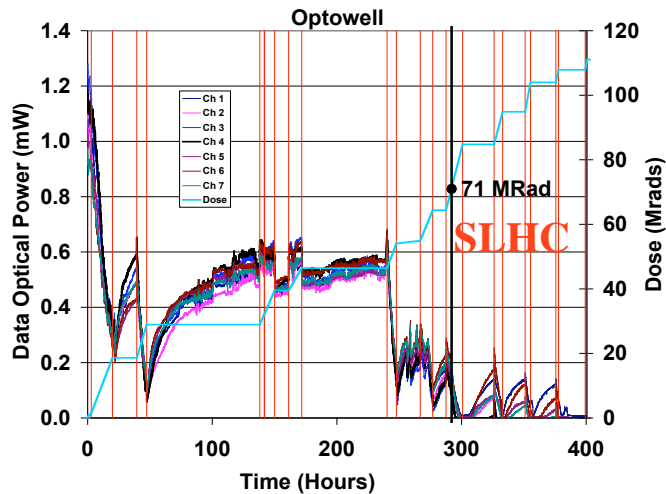
Pre-irrad



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



VCSEL Power vs Dosage



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



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 50% after SLHC dosage
- Optowell VCSEL survives SLHC dosage
- ⇒ current opto-link architecture satisfies SLHC requirements