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

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Outline

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- 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

- opto-link production is decoupled from module production
  - transmit signal to/from modules with micro twisted pairs

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

REW: simplify opto-board production
REW: 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

- Transmission at 650 Mb/s is adequate
- Transmission at 1.3 Gb/s may be acceptable
Bandwidth of Fusion Spliced Fiber

1 m GRIN fiber

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:
      - $2.5 \times 10^{15} \text{ 1-MeV } n_{eq}/\text{cm}^2$
      - $4.3 \times 10^{15} \text{ p/cm}^2$ or 114 Mrad for 24 GeV protons
    - GaAs (VCSEL) @ SLHC:
      - $14 \times 10^{15} \text{ 1-MeV } n_{eq}/\text{cm}^2$
      - $2.7 \times 10^{15} \text{ p/cm}^2$ 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

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

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VCSEL Power vs Dosage

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

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