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

- Upgrade based on current pixel opto-link architecture to take advantage of R&D effort and production experience?
- Can current pixel link infrastructure be operated at higher speed?

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
R&D Issues for SLHC

- bandwidth of ~ 640 Mb/s (= 8 x 80 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?
- upgraded version of driver/receiver chips are needed
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!

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Eye Diagrams

140 cm pixel cable

- transmission at 650 Mb/s is adequate
- transmission at 1.3 Gb/s may be acceptable

60 cm pixel cable

- 650 Mb/s
- 1.3 Gb/s
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:
      - $2.5 \times 10^{15}$ 1-MeV $n_{eq}/cm^2$
      - $4.3 \times 10^{15}$ p/cm$^2$ or 114 Mrad for 24 GeV protons
    - GaAs (VCSEL) @ SLHC:
      - $14 \times 10^{15}$ 1-MeV $n_{eq}/cm^2$
      - $2.7 \times 10^{15}$ p/cm$^2$ 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
    - 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 ~65% 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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VCSEL LIV Characteristics

- large shift in IV after 1.6 x SLHC dosage
- SLHC dosage already includes 50% safety margin
- some optowell VCSEL still producing optical power
  - will irradiate to SLHC dosage only in 2007
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 as a possible upgrade option