Radiation-Hardness of Optical Components

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Outline

● Introduction
● Radiation hardness of fibers
● Radiation hardness of PIN arrays
● Radiation hardness of VCSEL arrays
● Summary
Optical Data Transmission

- SCT and Pixel detector use optical links for data transmission
  - 850 nm VCSELs are used to convert electrical signal into optical signal for transmission over fiber
  - PINs convert optical signal into electrical signal
  - VCSEL/PIN of Pixel detector are mounted on patch panel PP0 instead of directly on the FE’s
    - much reduced radiation level
    - VCSEL/PIN for SLHC are expected to be mounted at a location with relative radiation no higher than PP0
    - study degradation of VCSEL/PIN at SLHC dose
    - study degradation of fiber with routing that begins at various possible locations for opto components
Collaborating Institutions

- **Fibers irradiation:**
  
  T. Hoffman, C. Issever, A. Weidberg  
  Oxford University  
  J.B. Ye  
  Southern Methodist University

- **VCSEL/PIN irradiation:**
  
  The Ohio State University  
  M.R.M. Lebbai, P.L. Skubic  
  University of Oklahoma  
  B. Abi, F. Rizatdinova  
  Oklahoma State University
Optical Fiber Irradiation

- Corning Infinicor GRIN fiber irradiated with $\gamma$'s from Co$^{60}$
- Attenuation parameterized to calculate losses along fiber routing
Optical Fiber Irradiation

- assume $L = 3,000 \text{ fb}^{-1}$
  - including safety factor of 1.5 for $r < 110 \text{ cm}$ and 5 for $r > 110 \text{ cm}$
  - worst total attenuation for Infinicor GRIN fiber is 0.33 dB from 5 possible locations for opto components of pixel detector
  - attenuation for SIMM is much smaller
  - 2 of the 3 Ericsson fibers tested well
  - no significant degradation in passive connectors and fused taper splitters
  - PLCC splitters seem more susceptible to ionizing radiation
Radiation-Hardness of Silicon PIN

- Irradiate PIN with 24 GeV protons at CERN
  - SLHC dosage: $2.6 \times 10^{15}$ p/cm$^2$ ($1.5 \times 10^{15}$ 1-MeV n$_{eq}$/cm$^2$)
  - Assume $L = 3,000$ fb$^{-1}$, including 50% safety factor
  - Post-irradiation analysis of aluminum foils indicates the devices received only half the expected dose
  - Hamamatsu devices are more radiation hard
Radiation-Hardness of GaAs PIN

- Irradiate PIN with 24 GeV protons at CERN
  - SLHC dosage: $2.6 \times 10^{15}$ p/cm$^2$ ($8.2 \times 10^{15}$ 1-MeV n$_{eq}$/cm$^2$)
    - Assume $L = 3,000$ fb$^{-1}$, including 50% safety factor
  - Post-irradiation analysis of aluminum foils indicates the devices received only half the expected dose
    - Significant decrease in responsivity
Radiation-Hardness of GaAs PIN

Preliminary

- Hamamatsu device is more radiation hard
Degradation of PIN @ SLHC

<table>
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<tr>
<th>Material</th>
<th>Gb/s</th>
<th>Responsivity (A/W)</th>
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<th>Post</th>
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</table>

- Hamamatsu devices are more radiation hard
850 nm VCSEL Power vs Dosage

- 2007 irradiation with 1.6 x SLHC dose, after 1.5 safety factor:
  - close to zero power on some channels
- 2008 irradiation with SLHC dose:
  - AOC(5 & 10 G) have good power
1310 nm VCSEL

- 1310 nm VCSELs are becoming available
  - radiation tolerance looks encouraging
  - readily available radiation-hard fiber
  - single mode laser is easier to understand
    - no mode hoping as in multi-mode laser
- Need to keep an eye on this development
Summary

- Degradation of Infinicor GRIN fiber at SLHC is small
- Potential 850 nm PIN candidates identified for SLHC opto-link
- Potential 850 nm VCSEL candidates identified for SLHC opto-link