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:

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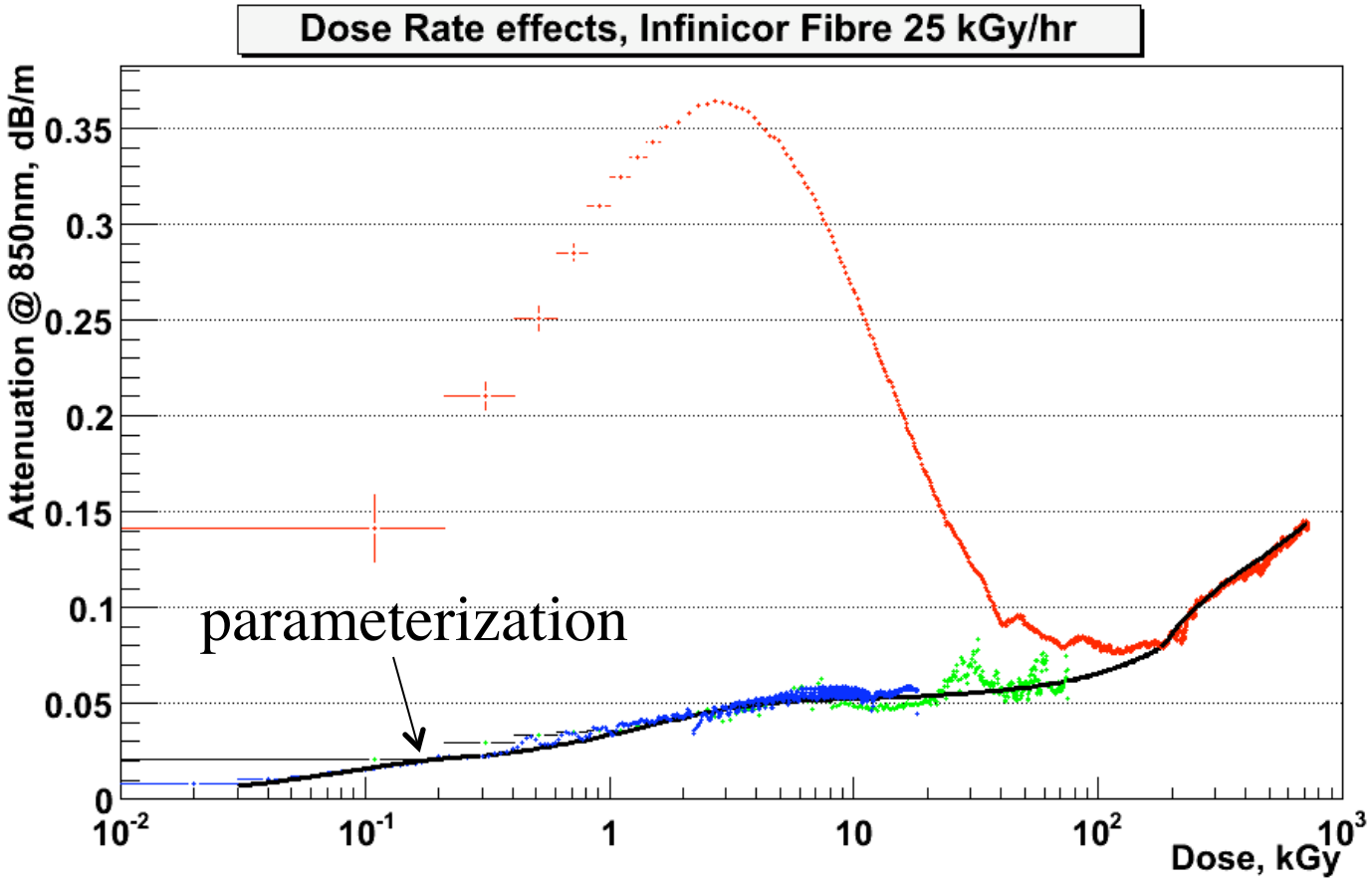
Optical Fiber Irradiation

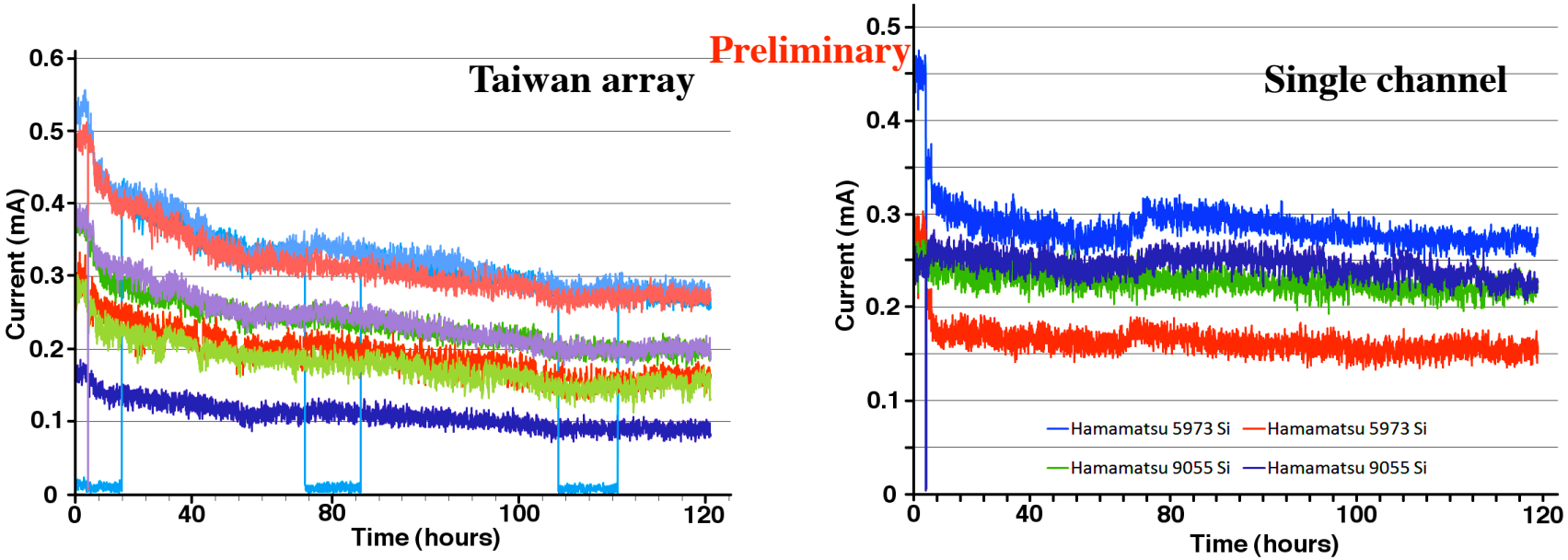


- Corning Infinicor GRIN fiber irradiated with γ's from Co^{60}
- Attenuation parameterized to calculate losses along fiber routing

Optical Fiber Irradiation

- assume L = 3,000 fb^{-1}
  - including safety factor of 1.5 for r < 110 cm and 5 for r > 110 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

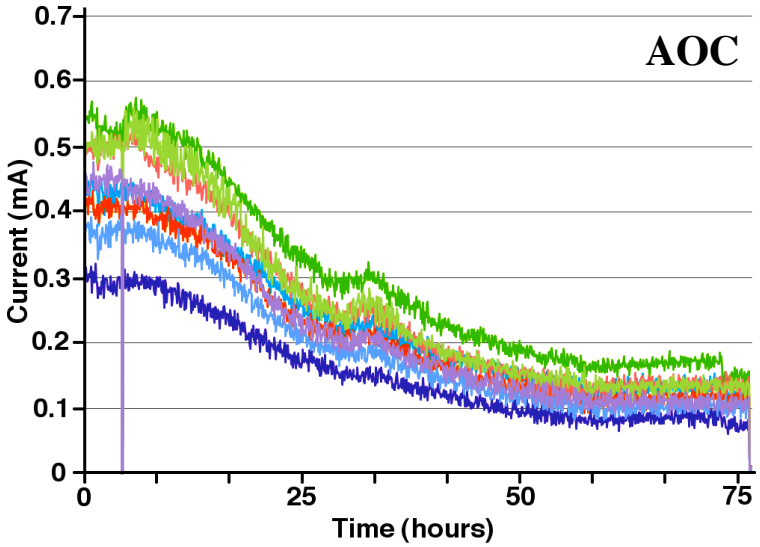
Radiation-Hardness of Silicon PIN

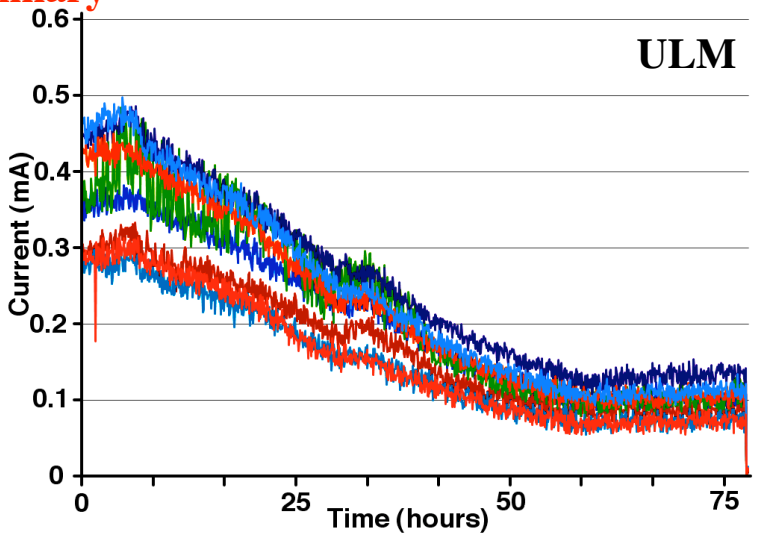


- irradiate PIN with 24 GeV protons at CERN
  - SLHC dosage: 2.6 x 10^{15} p/cm^2 (1.5 x 10^{15} 1-MeV n_{eq}/cm^2)
    - assume L = 3,000 fb^{-1}, including 50% safety factor
  - post-irradiation analysis of aluminum foils indicates the devices received only half the expected dose
    - Hamamatsu devices are more radiation hard

Radiation-Hardness of GaAs PIN

Preliminary

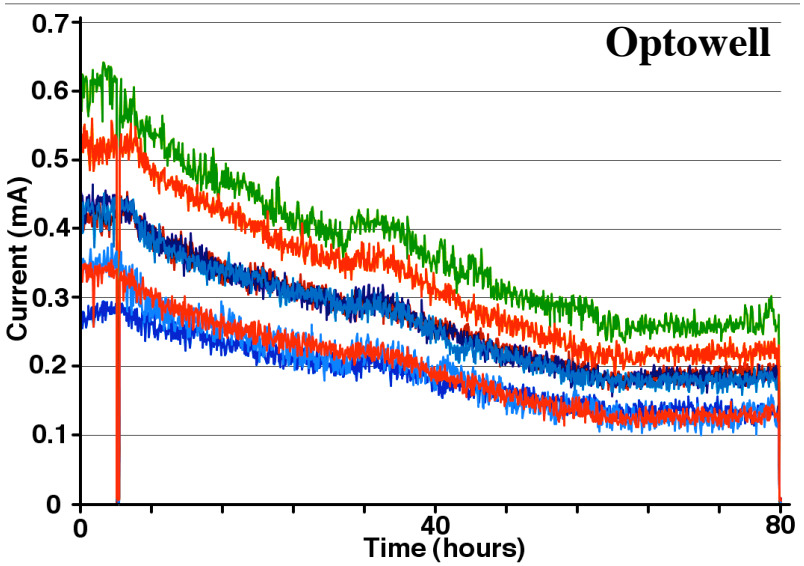


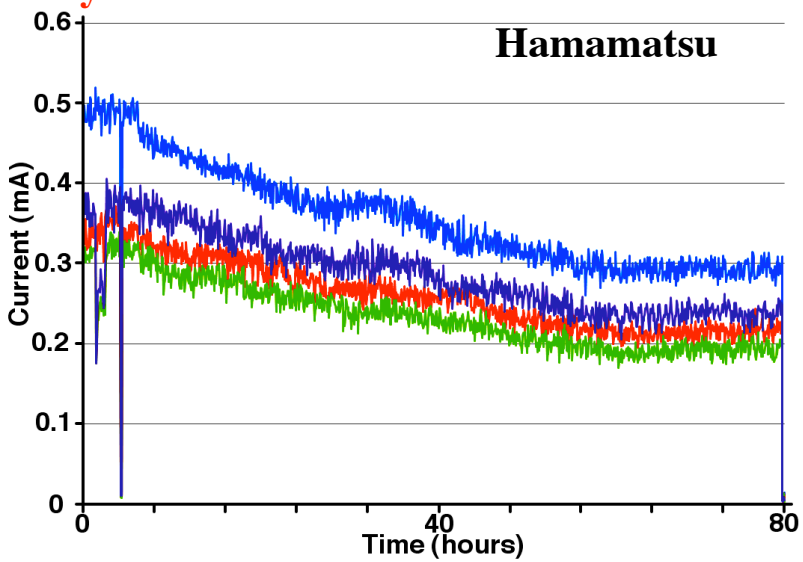


- irradiate PIN with 24 GeV protons at CERN
  - SLHC dosage: 2.6 x 10^{15} p/cm^2 (8.2 x 10^{15} 1-MeV n_{eq}/cm^2)
    - assume L = 3,000 fb^{-1}, including 50% safety factor
  - post-irradiation analysis of aluminum foils indicates the devices received only half the expected dose
    - significant decrease in responsivity

Radiation-Hardness of GaAs PIN

Preliminary





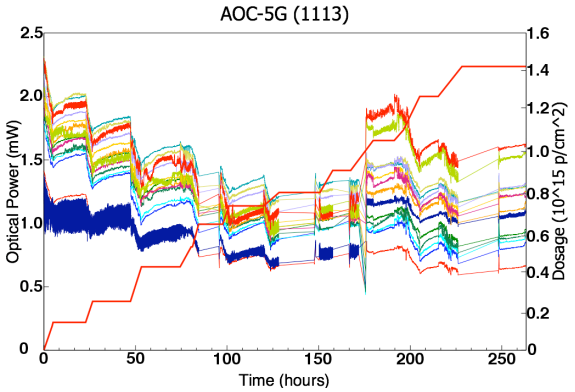
- Hamamatsu device is more radiation hard

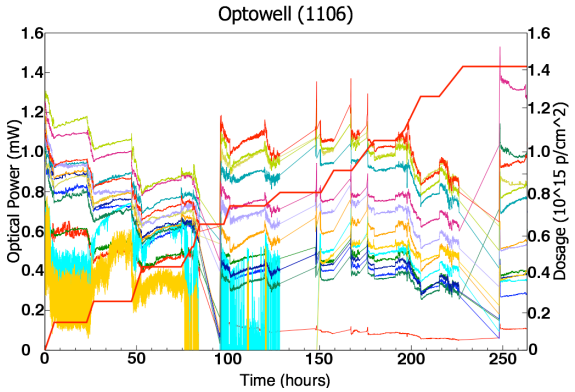
Degradation of PIN @ SLHC

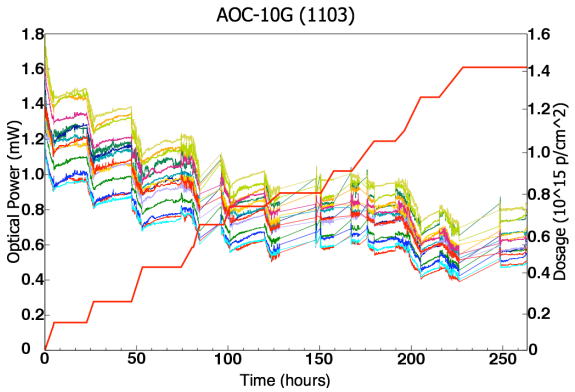
	Gb/s	Responsivity (A/W)	
GaAs		Pre	Post
ULM	4.25	0.50	0.03
AOC	5.0	0.60	0.04
Optowell	3.125	0.60	0.10
Hamamatsu G8921	2.5	0.50	0.20
Si			
Taiwan	1.0	0.55	0.19
Hamamatsu S5973	1.0	0.47	0.29
Hamamatsu S9055	1.5/2.0	0.25	0.18

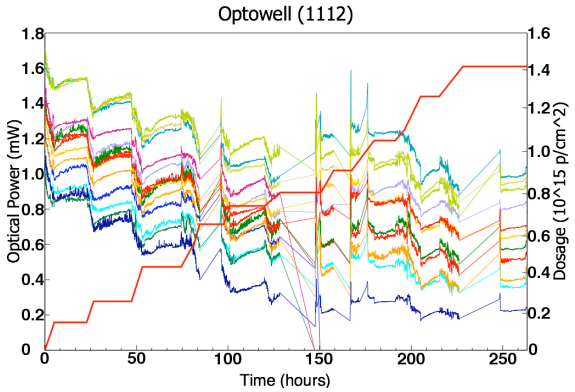
- Hamamatsu devices are more radiation hard

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