Radiation-Hardness of VCSEL/PIN

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Outline

- Introduction
- Radiation hardness of PINs
- Radiation hardness of VCSELs
- Summary

Radiation Dosage at SLHC

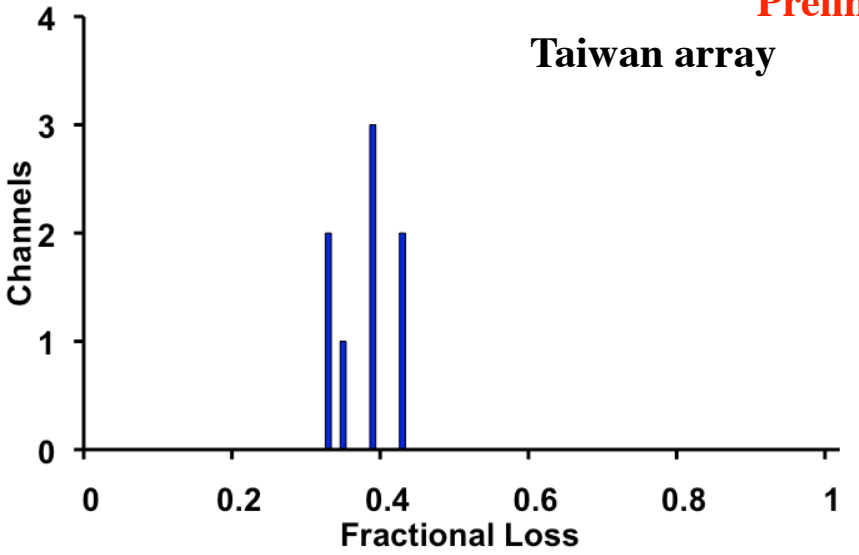
- VCSEL/PIN of current pixel detector are mounted on patch panel PP0 instead of directly on the FE's
  - ⇨ much reduced radiation level
  - ⇨ VCSEL/PIN at SLHC are expected to be mounted at a location no closer than PP0 to the interaction region
  - ⇨ study degradation of VCSEL/PIN at "PP0"
  - ⇨ expected dosage at 3,000 fb^{-1} with 50% safety factor:
    silicon: 1.5 x 10^{15} 1-MeV n_{eq}/cm^2
    GaAs: 8.2 x 10^{15} 1-MeV n_{eq}/cm^2
    - ◆ assuming radiation damage scales with Non-Ionizing Energy Loss (NIEL)

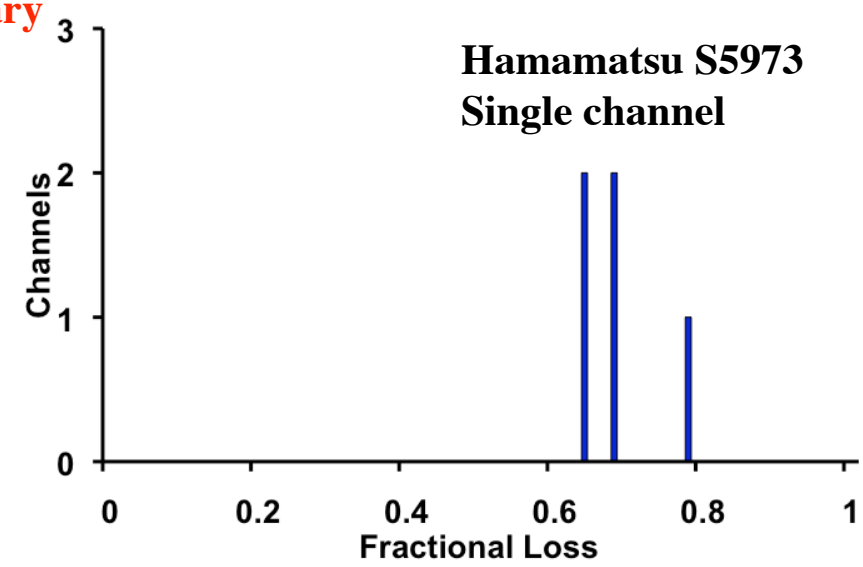
Irradiation Program in 2007/8

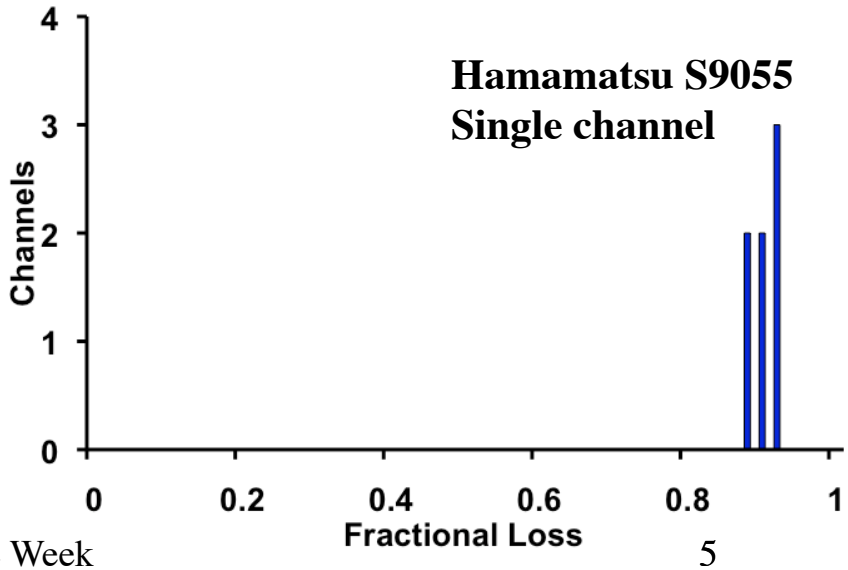
- 2007: VCSEL/PIN irradiated to 5,000 fb^{-1} with 50% safety factor
  - ◆ very significant damage in VCSEL/PIN
  - ⇨ 2008: irradiated to "official" 3,000 fb^{-1} with 50% safety factor
    - ✘ beam profile changed after initial calibration (SEC factor)
      - ⇨ received ½ of the target dosage
      - ⇨ damage extrapolate to 3,000 fb^{-1} with 50% safety factor

Radiation-Hardness of Silicon PIN

Preliminary



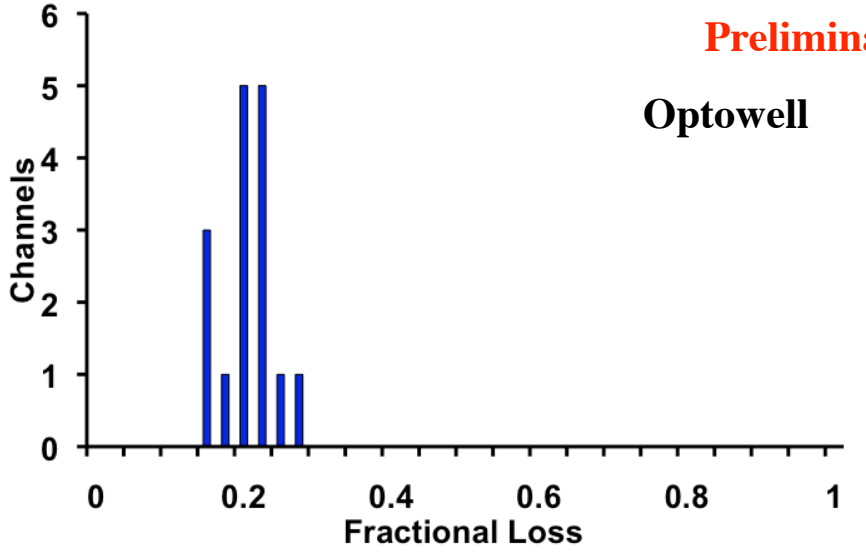


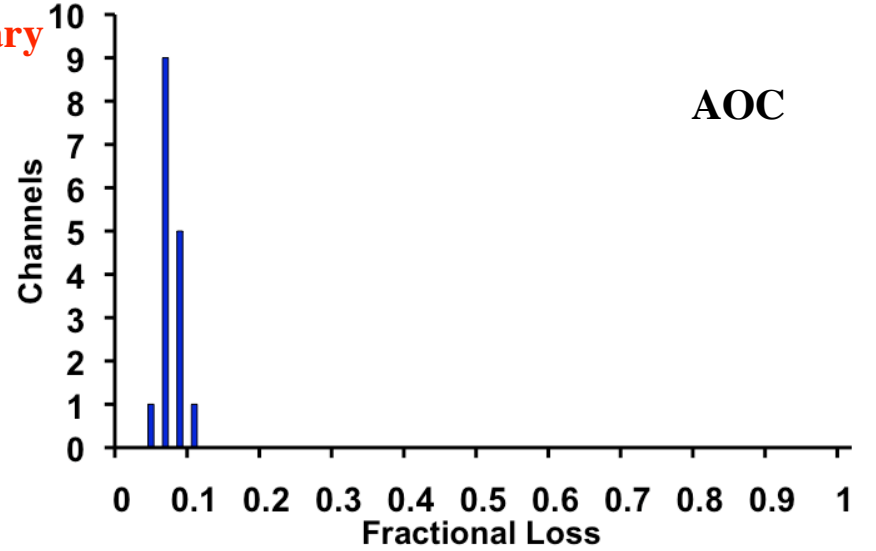


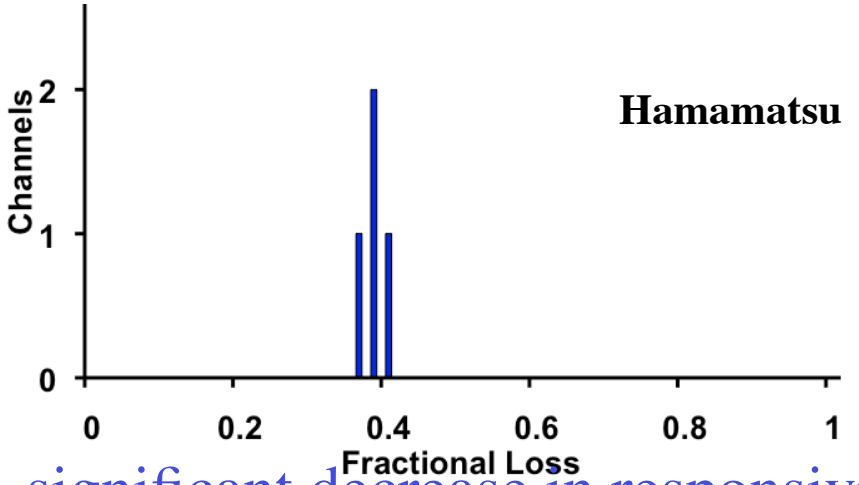
- Silicon PINs are quite radiation-hard as expected
- Hamamatsu PINs are more radiation-hard

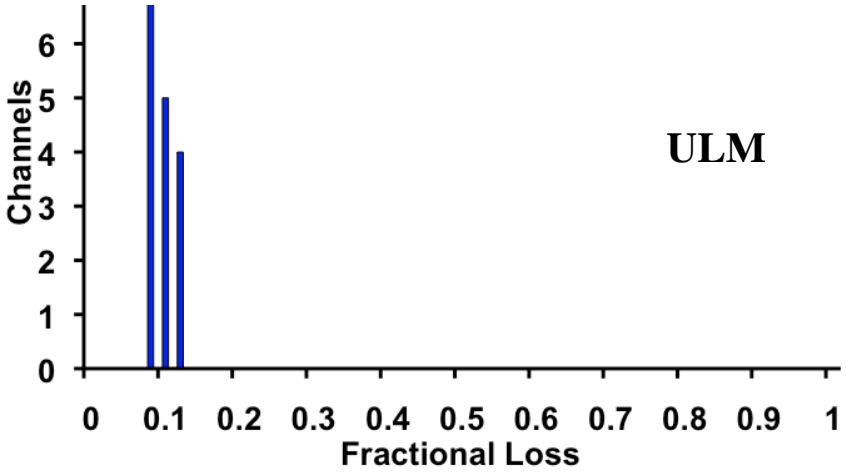
Radiation-Hardness of GaAs PIN

Preliminary









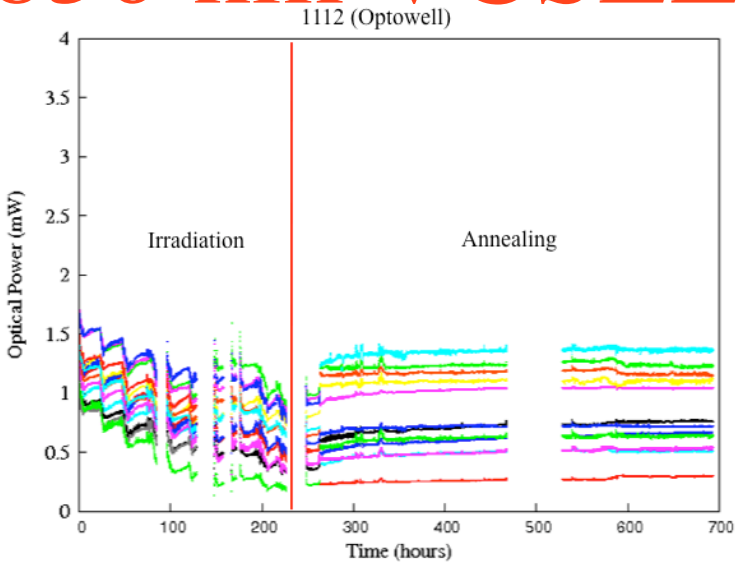
- significant decrease in responsivity
- Optowell is more radiation hard

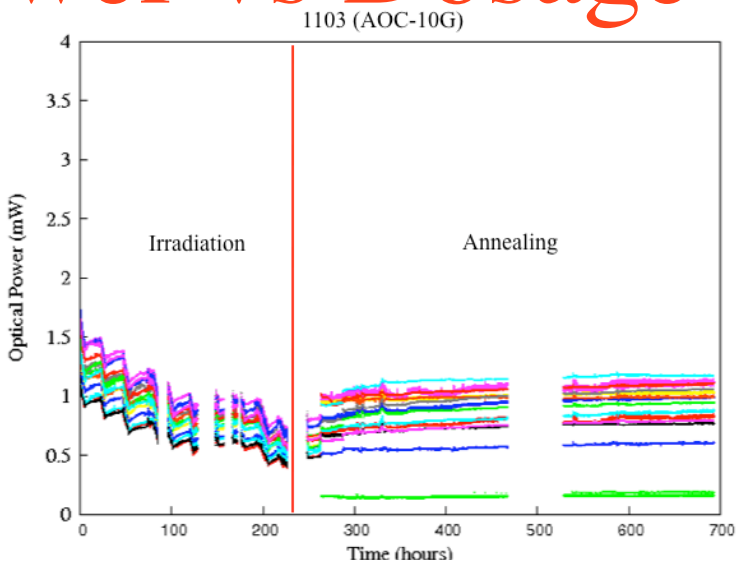
Degradation of PIN @ SLHC

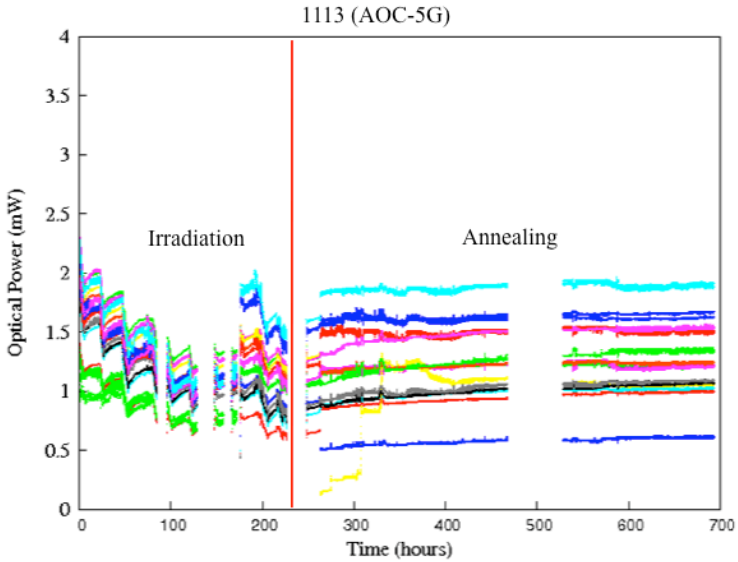
	Gb/s	Responsivity (A/W)	
GaAs		Pre	Post
ULM	4.25	0.50	0.04
AOC	5.0	0.60	0.04
Optowell	3.125	0.60	0.11
Hamamatsu G8921	2.5	0.50	0.20
Si			
Taiwan	1.0	0.55	0.20
Hamamatsu S5973	1.0	0.47	0.33
Hamamatsu S9055	1.5/2.0	0.25	0.19

- Hamamatsu devices are more radiation hard

850 nm VCSEL Power vs Dosage







- Very slow annealing of optical power
- AOC 5G has good power at SLHC dosage

Summary

- Hamamatsu and Optowell PINs are more radiation hard
  - Need to repeat irradiation in 2009 to SLHC dose
- AOC 5 G arrays have good power after SLHC dose
  - Need to repeat irradiation with large sample in 2009