Summary of Optical Link R&D

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Outline

- Introduction
- Plan for insertable B-layer
- Status of Versatile Link Project
- Radiation hardness of fibers
- Radiation hardness of VCSEL/PIN
- Single event upset in PIN
- Summary

Optical Data Transmission

- SCT and Pixel detector use optical links for the transmission of data, clock, and commands between FE and counting room
  - 850 nm VCSELs are used to convert electrical signal into optical signal for transmission in fibers
  - PINs convert optical signal into electrical signal
- Plan for the detector upgrade is to operate optical link at higher speed

Plan for Insertable B-layer

- A new insertable pixel barrel with r = 3.7 cm is planned for 2013
  - ~2 x 450 links (data & TTC)
- Two possible opto-link upgrade paths:
  - build more current links
    - modest effort: 1/3 of the current system
  - build a modern version with modest improvements in speed and functionalities

IBL On-Detector Opto-Link Upgrade

- Use Corning Infinicor GRIN fibers
  - total attenuation due to radiation is ~ 0.1 dB
- Use 850 nm VCSEL/PIN arrays evaluated for SLHC
- Design faster versions of VCSEL driver and PIN receiver
  - double the speed of data transmission to 160 Mb/s
  - first prototype chips fabricated in IBM 130 nm process
    - chips irradiated in August 2008
    - next prototype iteration: winter 2009
    - new functionalities will be added:
      - individual control of VCSEL drive current
      - redundancy: bypassing of bad VCSEL/PIN channel

IBL On-Detector Opto-Link Upgrade

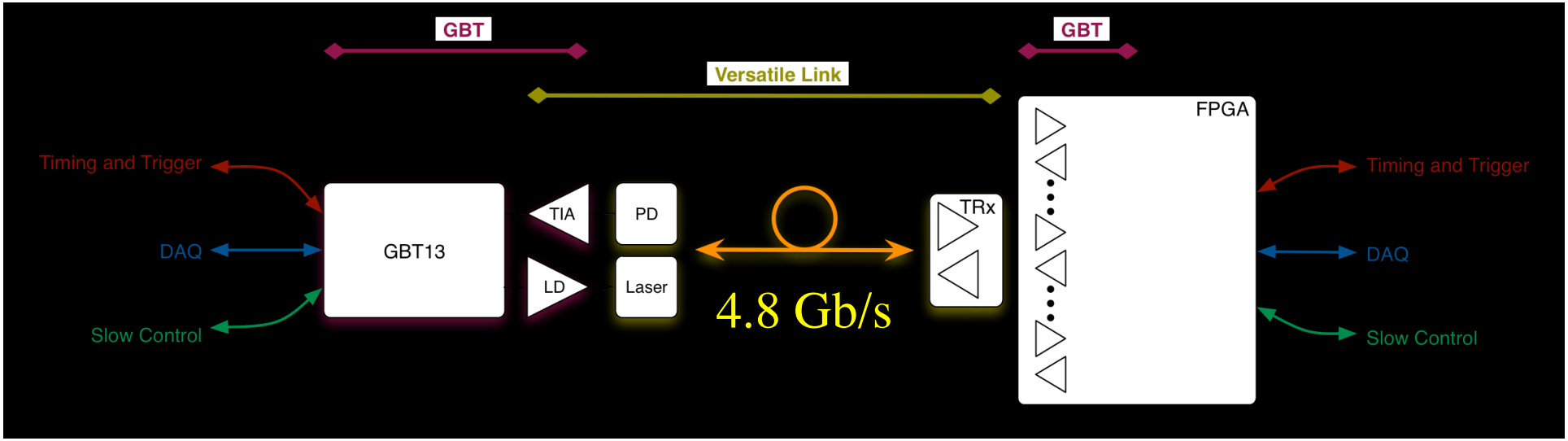
- Use BeO based optical package for housing VCSEL/PIN
  - replace current FR4 based package with difficult soldering
  - 55 VCSEL/16 PIN opto-packs have been built for irradiation
- Replace current custom/fragile connector housing with commercial MPO connector
- Preserve current opto-board concept for integrating VCSEL/PIN arrays + ASICs + fiber ribbon
  - 64 boards needed
  - compact design + ease of handling
  - plan to keep the opto-board concept as an option for the pixel detector at SLHC, including the possibility of adapting driver/receiver of GBT/VL into arrays

IBL Off-Detector Opto-Link Upgrade

- New 64 Back-of-Crate (BOC) cards needed
  - BOC splits 160 Mb/s stream into four 40 Mb/s streams
  - current BOC splits 80 Mb/s stream into two 40 Mb/s streams
- Need 64 Read-Out-Drivers (ROD)

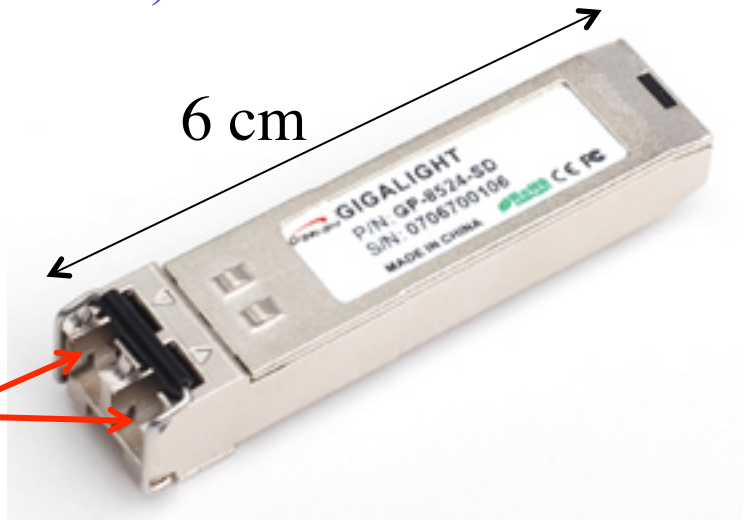
Versatile Link Project

- Institutes: CERN, Fermilab, Oxford, SMU, Taiwan
- Goal: develop opto-link between front- and back-end electronics
- Fully characterized devices and ready for production by end of 2011



Status of Versatile Link Project

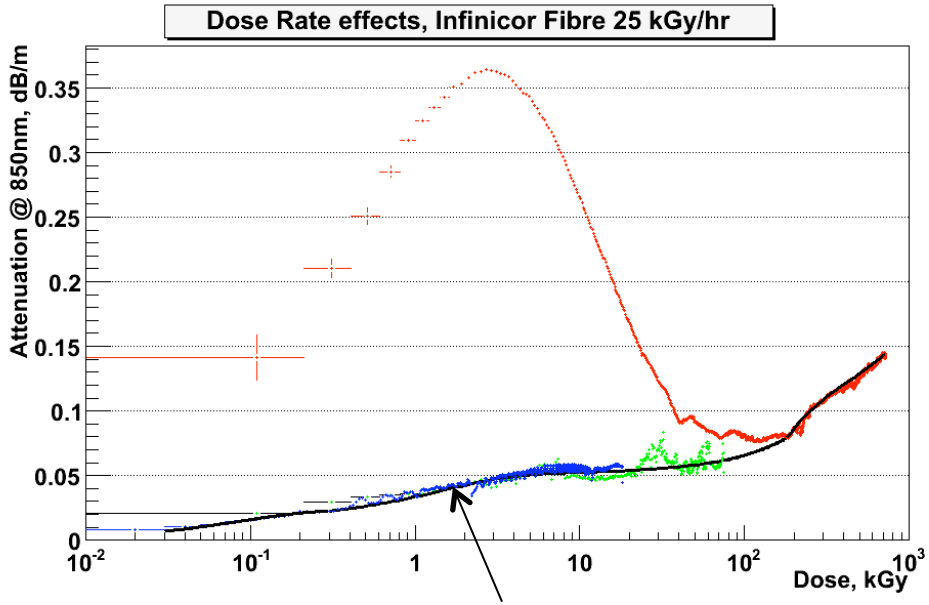
- SFP+ identified as an integrated solution for driver/receiver and PIN/VCSEL
  - industrial partner identified
- Development of test system in progress
- Radiation hardness of fibers studied (next slides)
- Single event upset in PIN studied (next slides)
- Phase 1: proof of concept by Oct. 09



One uplink and one downlink fibers

Radiation-Hardness of Optical Fiber

- Corning Infinicor GRIN fiber irradiated with γ's from Co^{60}
- Attenuation parameterized to calculate losses along fiber routing
- Attenuation is estimated to be 0.33 dB for the possible opto-link location with highest radiation



Oxford/SMU parameterization

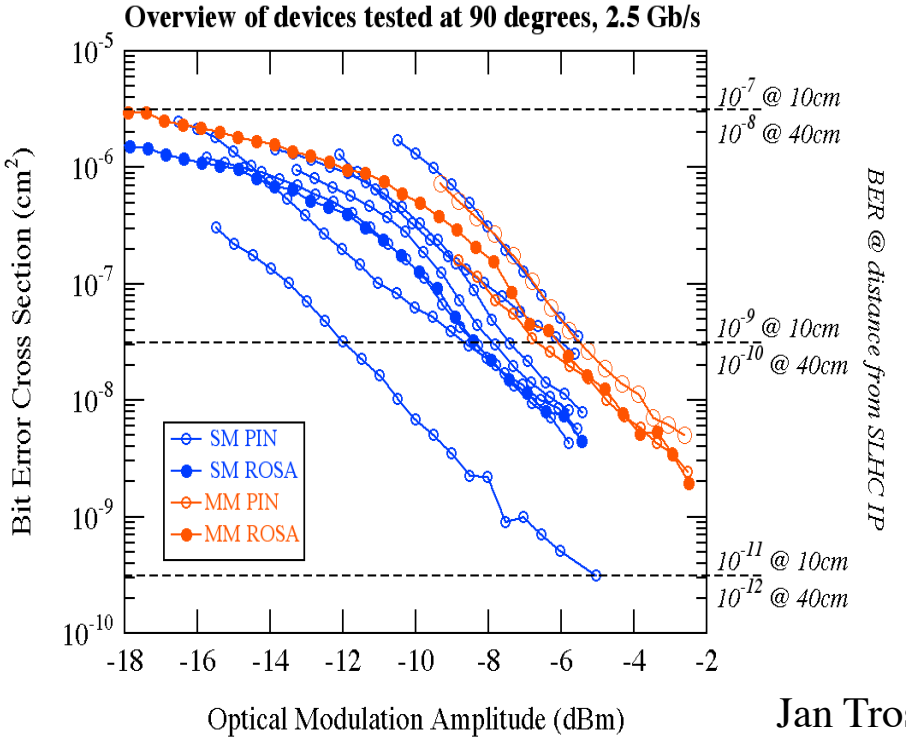
Radiation Hardness of VCSEL/PIN

- Radiation hardness of 850 nm VCSEL/PIN has been studied
  - based a sample of ~ 2 devices for each variety
  - Si PIN candidate:
    - Hamamatsu degradation ~40% (1 Gb/s)
  - GaAs PIN candidate:
    - Hamamatsu degradation ~60% (2.5 Gb/s)
    - Optowell degradation ~80% (3.125 Gb/s)
  - VCSEL candidates: AOC (5 &10 Gb/s), Optowell (2.5 Gb/s)
  - plan to irradiate larger sample (20) of best candidates in 2009
  - continue need of irradiation of new/higher speed devices
- Need a similar program for 1310 nm VCSEL/PIN

Ohio State/Oklahoma/Oklahoma State

Single Event Upset in PIN

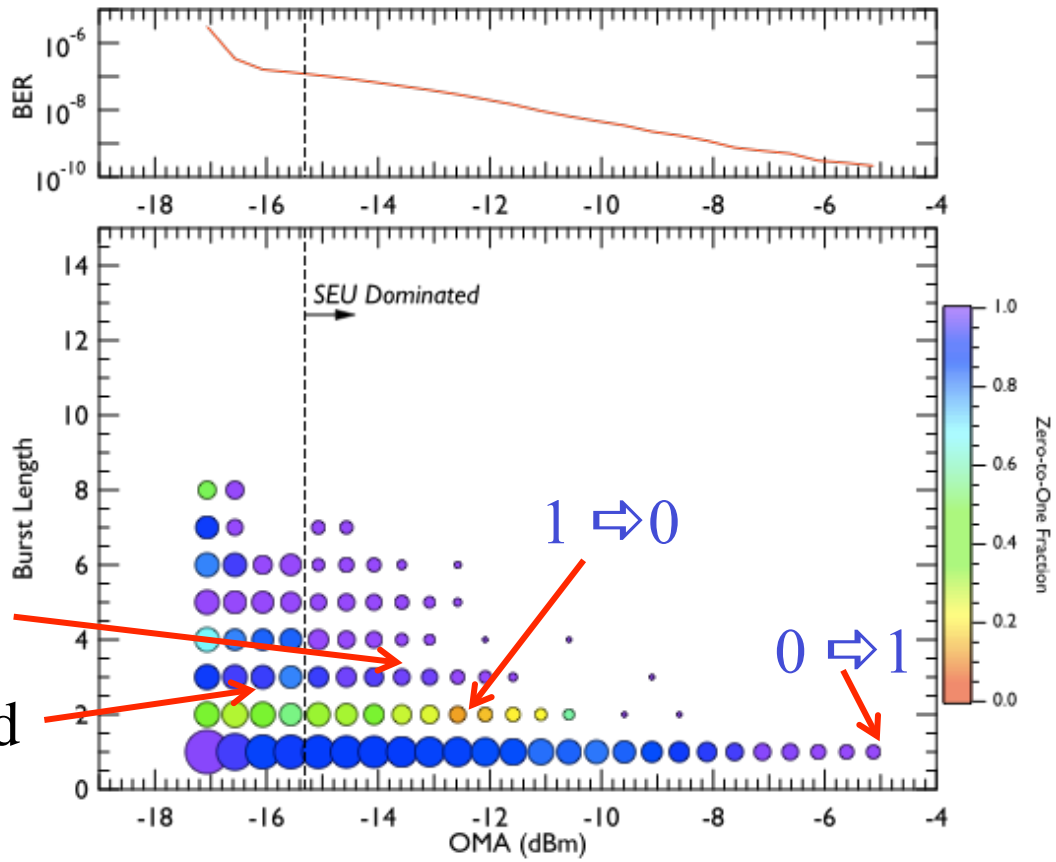
- expect single event upset in PIN due to nuclear interactions
  - SEU rate depends on electronics coupled to PIN
  - SEU rate decreases with higher PIN current



Jan Troska et al., Versatile Links group

Single Event Upset in PIN

- high PIN current (OMA): only see single bit errors 0 ⇨1 transitions
- Low PIN current (OMA): longer burst of errors up to ~ 10 bits
  - also see 1 ⇨0 transitions
    - interaction between PIN and electronics?
- ⇨ electronics need to correct for burst of errors



Summary

- modest upgrade proposed for insertable B-layer
- good progress by Versatile Link Project in developing high-speed link
- radiation-hard fiber identified
- 850 nm VCSEL/PIN candidates identified
  - electronics needs to correct for burst of errors in PIN