Radiation-hard high-speed fiber-optical data links for HEP experiments

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The current and future collider experiments require radiation-tolerant high speed fiber-optical interconnects to readout the innermost tracking detectors for full-detector track triggering. These interconnects should have low power consumption, high reliability, small foot-print, low mass, low bit-error-rate, and low cost. Therefore, it is highly desirable to perform the electical to optical conversion right in the sensor readout ASICs. In many ongoing experiments, the sensor readout ASICs transmit data using electrical cables away from the beamspot to perform the electrical to optical conversion. The long electrical cables add undesired mass to the tracker, require high power to transmit data, limit the data transmission speed (1Gbps), and take considerable amount of space (the cable routing is challenging). The optical fibers offer much higher bandwidth, lower mass volume, and power consumption in comparison to the contemporary electrical interconnects.

The Silicon Photonics technology promises the fiber-to-chip readout. Silicon Photonics is a mature commercial technology. It offers low power consumption, high-reliability, small footprint, low cost, and customizable radiation tolerance. Si-Pho allows fabrication of optical circuits in the same wafer together with the electrical circuits using a conventional CMOS process. Commercial Si-Pho devices have been evaluated for radiation tolerance if HEP experiments and the optical circuits themselves were found to have promising radiation tolerance. One of the commercial devices was found to have limited radiation tolerance because of the slow-speed electrical interface needed for configuration and control [1].

Contemporary commercial Si-Pho products offer about 50 Gb/s per fiber with power consumption of about 1.5W to drive the fiber (that includes power for the laser). If radiation tolerance of lasers is an issue, the laser can be remote to deliver light to the optical chip through a fiber. There is already a variety of approaches how to couple single-mode fiber to the optical chips. The target radiation tolerances should be TID 3 Mrad and NIEL 1e17 n/cm^2.

The HEP community would benifit from a multi-directional approach to strengthen the high-speed interconnect program by:

- partnering with commercial companies to take advantage of the recent progress in Si-Photonics optical transceivers,
- more active cooperatin with the CERN [2] and the European HEP community who are already actively exploring the technology, and
- developing local expertise in optical circuits and devices. The Si-phonics device libraries are widely available.

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References

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