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New Optical Technology for Low Mass Intelligent Trigger and Readout

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We describe a number of new electro-optical technologies which would enable data transmission with very low mass and power. Extremely small optical modulators which can be integrated into CMOS chips would allow the mass and power of lasers to be displaced outside the tracking volume. These modulators could be used to pass data between tracking layers of order cm apart rather than mm, enabling very fine resolution on an angle trigger with silicon pixels. This might implemented be as follows: External lasers would provide light which would be transmitted into the tracker by fiber or perhaps beams in air. The data from one layer would be imposed by the modulator, which might be incorporated into a multiplexer or processor chip. The data would be passed to the adjacent layer by beams in air, perhaps directly or with extremely small fixed mirrors. Photodiodes of the same SiGe technology as the modulators in processors on the second layer would receive the data. The modulators themselves use extremely low power, of order 50 fJoule/bit in one case. Versions which might be suitable for HEP are being developed by MIT and IBM. They could also be used to pass data out of a tracker at over 1 to 5 Gbit/sec with very low mass and power. In general these could be useful for data transmission on staves,
between staves,and out of staves. There is an ATLAS study of the radiation hardness of SiGe materials in CMOS electronics which is relevant to these modulators, and indicates that the materials would be suitable for use in an LHC upgrade. We refer to a group at MIT which has expertise at all levels of these optical issues from materials to devices to system aspects.

Another technology which looks promising is the use of light beams with no fibers. The technology will be different on different distance scales. Over distances of microns, communication between chips might be done directly with no external lensing. Over distances of cm, the use of MEMS mirrors for steering and switching has been demonstrated by Lucent. Over longer distances, the use of the MEMS mirrors with feedback loops which may or may not involve extra optical paths is being investigated
at Argonne. Low mass MEMS mirrors are also being developed at Argonne. Over the longer distances, some very low mass rad-hard lenses would be used. In all these cases, the mass of optical connectors is eliminated, and there is no fiber to be radiation damaged.

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