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Evaluation of high-speed single fiber communication using Wavelength Division Multiplexing.

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There are many reasons for keeping the number of communication fibers in a data acquisition system to a minimum. We are therefore evaluating different schemes for using Wavelength Division Multiplexing (WDM) techniques. WDM is a useful tool for achieving high data bandwidths when up scaling current systems and to allow fiber sharing between multiple data sources. Different strategies such as single fiber single wavelength (SFSW), diplex transceivers and modulation using off board laser sources are investigated.
While the primary target is related to the ATLAS upgrade, the work can also have more general applications. Key concepts are cost, size, ruggedness and scalability.

Summary

The present TileCal digitizer system in ATLAS comprises 256 drawers with up to 8 quasi-independent digitizer boards per drawer. A patch panel at the end of the drawers is the only access point for power and communication. The current digitizers preprocess the data and send only accepted events off the detector. The maximum readout bandwidth is 80 Mbps per board, transmitted over a single fiber per drawer.
In the maximal SLHC upgrade scenario, calorimeter data for every bunch crossing would be read out, increasing the bandwidth of the digitizer system by a factor of 60 to up to 50 Gb/s per drawer. It would be advantageous to use the existing fiber plant to avoid laying new fibers. This could be achieved using Wavelength Division Multiplexing (WDM) technology. Using WDM will also open up for high speed duplex communication over a single fiber, either by using diplex electro-optical modules, Single Fiber Single Wavelength (SFSW) modules or standard passive WDM multiplexers.
Four options are being evaluated for the ATLAS TileCal digitizer application using WDM. The first option is to use standard lasers with the same wavelength on all boards. This scheme is less expensive than the other options, but requires an electro-optical/opto-electrical interface card at the patch panel to produce the different wavelengths for the WDM output.
The second option is to use lasers with fixed but different wavelengths for each board. This would only need a passive WDM MUX module at the patch panel, but the replaced boards must have a laser wavelength matching the originals. Using pluggable lasers (XFP standard) solves this, but pluggable lasers are more susceptible to poor environmental conditions, and may not be the best choice for the TileCal application.
The third option is to use tunable lasers on the boards and a passive WDM MUX at the patch panel. Here, boards can be replaced without regard to wavelength order. Tuneable lasers with sufficient speed are currently expensive, as they are just beginning to become available. As prices go down, though, they present us with a flexible upgrade path with a wide range of use.
The fourth option is to feed the digitizers with an off board laser source and use modulation techniques. This saves on PCB complexity inside the drawer but introduces more fiber connectivity points. Using 16 (or 32 for redundancy) signals, half is used as feeds and the other half for output. Since reflections and crosstalk are significant in this solution, the topology is critical when attempting to achieve single fiber operation.

Primary author: Mr ERIKSSON, Daniel (Department of Physics-Stockholm University)

Co-authors: Prof. BOHM, Christian (Department of Physics-Stockholm University); Dr SILVERSTEIN, Sam (Department of Physics-Stockholm University)

Presenter: Mr ERIKSSON, Daniel (Department of Physics-Stockholm University)

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