Proposal WDM-based Optical Links for Next Generation HEP

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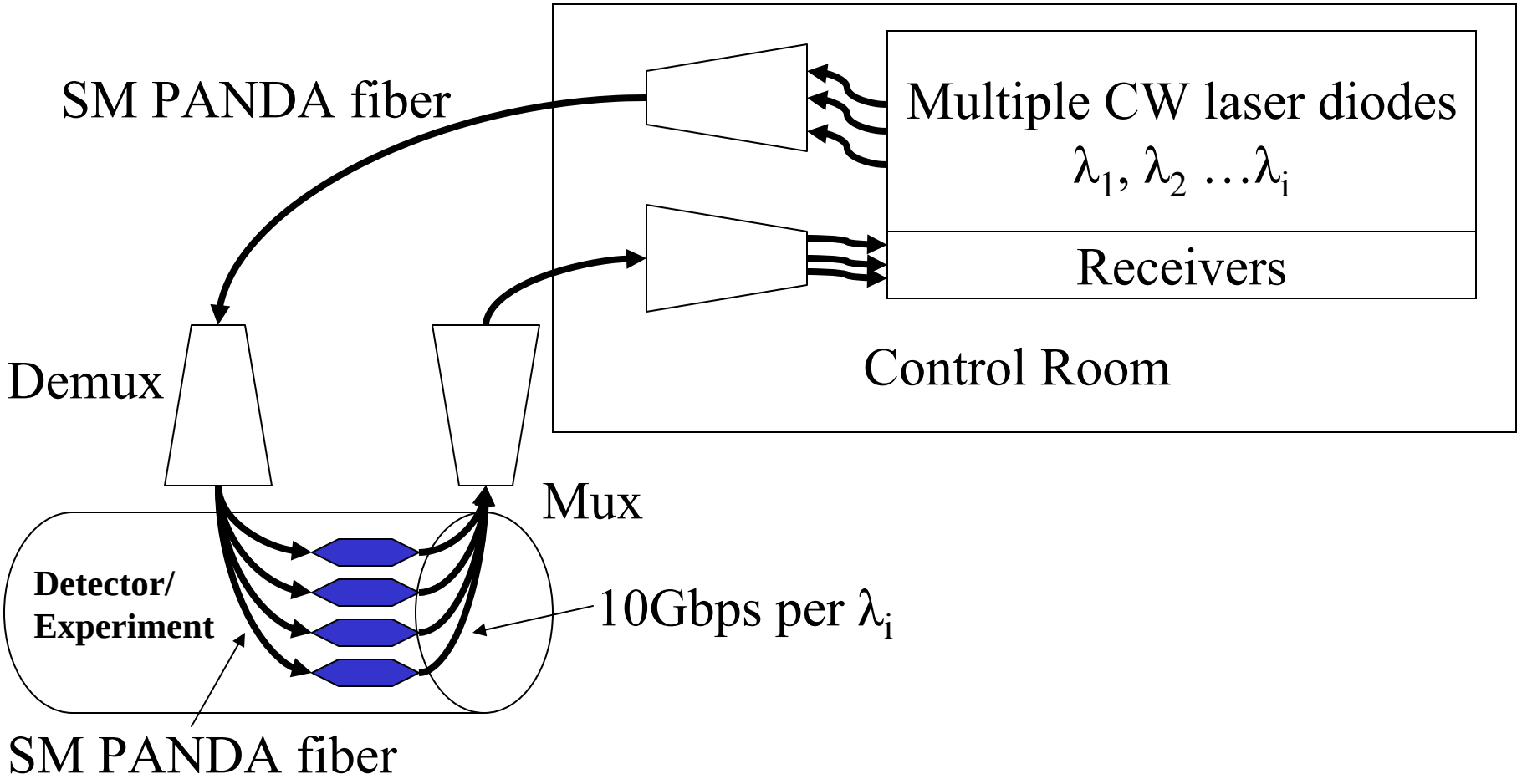
General Link Requirements

- Next generation HEP experiment requirements:
  - Flexible data rates (10Gbps up to 200Gbps).
  - High reliability in a range of radiation environments.
  - Low power consumption
  - Small size (≤2-3cm^2)
  - Moderate cost:
    - Part cost – COTS where possible (use industry standards – Ethernet, ITU, etc.)
    - Design and testing cost- low capital equipment (Test equipment cost becomes prohibitive with speed >10Gbps).
    - Installation and maintenance costs – low fiber count, small connectors/devices

Proposal



Wavelength Division Multiplexing (WDM) at 10Gbps/channel with external CW laser sources and modulators at the experiment.

WDM

- Several choices for the WDM specification:
- All wavelength channel spacings are defined by industry standards in a wavelength range of 1270nm through 1610nm.
  - CWDM (20nm spacing) (1270nm-1610nm, ITU G.694.2)
  - WDM (100GHz- 0.8nm, or 200GHz channel spacing ITU G.694.1, 1528.38nm-1622.25nm)
  - DWDM (25-50GHz, ITU G.671)

Advantages/Features

- **Lower Capital Costs:** Test equipment costs lower for 10Gbps channel data rates.
- **Minimized Cable/Infrastructure:** WDM minimizes cabling from the control room.
- **Channel Speed Upgrade:** Modulators could upgrade speeds to 25Gbps 'easily' – drive electronics are the limitation.
- **Reliability:**
  - Channel redundancy possible for improved reliability.
  - External modulators
- **Reduced Size:**
  - Demux at the detector outer layers, distribute fibers to various layers/locations on the detector.
    - Demux size is less critical if located outside the detector
    - Integrated modulators possible.
- **COTS Components:**
  - Lasers, receivers could be easily modified COTS parts.
  - Modulators may need some customization
  - Demux/mux could be COTS.

Design Issues

- How to mux/demux the wavelength channels within the size and power budget?
  - Demux is more difficult, depending upon power budget.
  - Demux Options
    - WDM:
      - Arrayed Waveguide Grating (AWG)
        - Big if SiO_2 is used. (150mm x 60mm)
        - Needs stable temperature – usually incorporates a heater/TEC, otherwise it is a passive device.
        - Could use Si (<2cm^2), or InP. – Not COTS, but could be custom manufactured.
    - CWDM
      - Bulk filters
      - Can be compact if placed on Si Optical Bench (commercial parts available for 4-channel LX4 10Gbps Ethernet).
      - Needs no temperature control
- Modulator:
  - Type (MZ most likely)
  - Material (Si, InP?)
  - Level of integration (single channel, multiple channels)
  - Wavelength range.
- Drive Electronics

Suggestions

- Use WDM at 100GHz or 200GHz channel spacing.
  - 1550nm wavelength range
  - Better match for modulator wavelength range.
- Use silicon-based AWG
  - Smaller size.
  - Need to test temperature stability, may need moderate temperature control.
- Modulator choice:
  - InP Mach-Zehnder or
  - Si Mach-Zehnder using current injection (not depletion mode).
- Laser diodes – 50-100mW external FBG stabilized Fabry-Perot laser diodes.
  - FBGs readily available