Analysis of the Failures in the On-Detector Opto-Links of ATLAS Pixel

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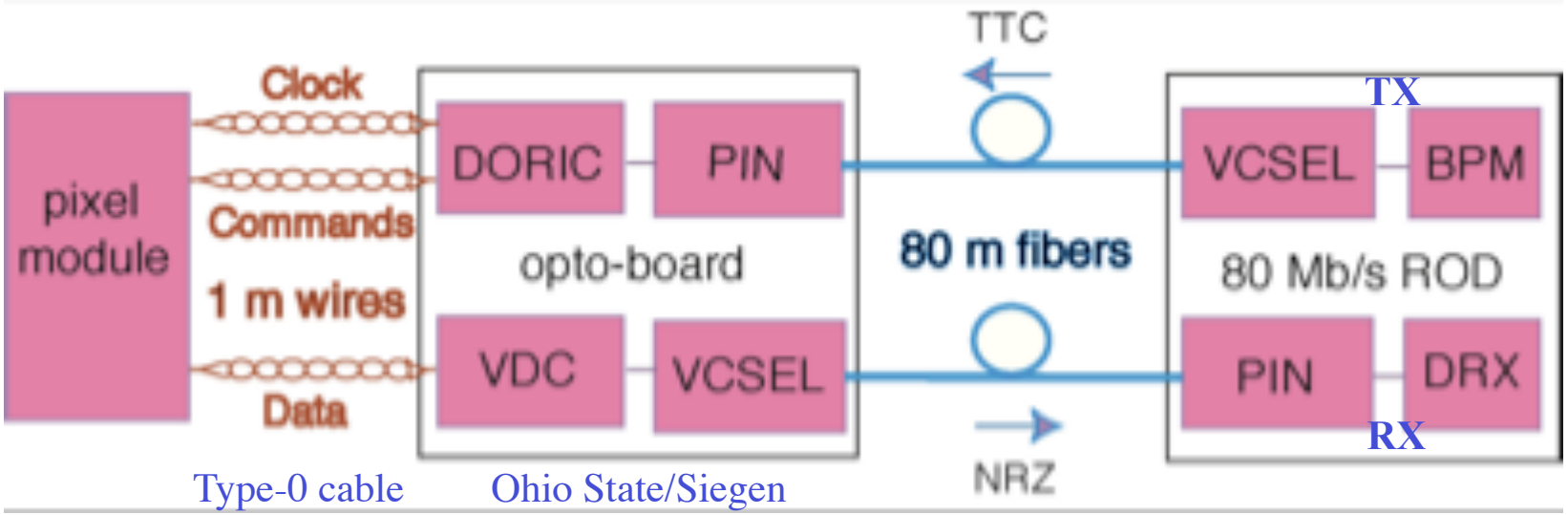
ATLAS Pixel Opto-link



VCSEL: **Vertical Cavity Surface Emitting Laser diode**

VDC: **VCSEL Driver Circuit**

PIN: **PiN diode**

DORIC: **Digital Optical Receiver Integrated Circuit**

Status of On-Detector Opto-Links

- ~49 of 1744 pixel modules cannot be properly operated:
  - high or low voltage shorts
  - dead, shorted, or noisy front-end (FE) chips
  - 20 optical link related "failures"
    - how many of these actually opto failures?
    - date of last "failure": June 2010

PIN Array Problems

- 10 pixel modules receive no clock or cannot be configured
  - 7 PIN channels on opto-boards have currents
    - will discuss later possible cause of failure
  - 2 PIN channels on opto-boards have no current
    - most likely due to a cold solder between the PIN array optical package (opto-pack) and the opto-board
      - soldering micro leads to opto-board is very challenging
        - difficult to supply sufficient heat to leads due to excellent conductivity of BeO board
        - difficult to clean flux used in soldering
          - cold solder masked by flux
          - new opto-packs will use wire bonds for connection
  - 1 PIN channel has no current information

VCSEL Array Problems

- 10 pixel modules: no operating point for the off-detector opto-electronics to properly receive the data from the modules
  - 2 channels: light output not yet measured
  - 7 channels have no light
    - cold solder?
      - expect equal contribution to PIN failures:
        - 2 PIN channels have no current
    - ESD?
    - TX type failure?
    - a breakage in the electrical cable?
  - 1 channel has light

Type-0 Cables

- opto-board is connected to pixel modules using Type-0 cables
  - pixel modules on outer layer use old, less reliable cables
    - ⇨ look for correlation between opto "failures" and cables:
      - old cables: 12/594 = (2.02 +/- 0.58)%
      - new cables: 4/1194 = (0.34 +/- 0.17)%
      - ⇨ failure rate associated with the old cables is much higher
      - ⇨ many opto "failures" might actually be broken electric connections in the Type-0 cables

TX Problem and Opto-board VCSELs

- VCSEL arrays on opto-boards of current pixel detector were fabricated using the same process as the TX arrays
  - current accumulated live time ~ 0.05 months
  - TXs start to fail after 6 months of live time
    - ⇨ expect failures on opto-board VCSEL arrays in the future

Lifetime Test of Truelight VCSEL

- Siegen is performing test of four opto-boards
  - transmitting clock (50% duty cycle) at room temperature
    - Wuppertal will measure optical spectrum monthly
- similar study of 7-8 boards planned on test system at CERN
  - transmitting clock at all times

Lifetime Test of Truelight VCSEL

- Ohio State has found ~50 VCSEL array from original production
  - 400 channels will be monitored
    - represent a significant fraction of final system: 1,788 channels
    - no need to use thermal acceleration
  - ~50% have improperly cured epoxy
  - will mount VCSEL on BeO board to emulate detector environment
  - will transmit pseudo random data (50% duty cycle)
  - will keep chamber at ~20^0 C flushed with N_2
  - still waiting for funds from US to acquire optical spectrum analyzer (OSA) to monitor degradation of spectrum with time
  - if some VCSELs in opto-boards/opto-packs fail within 6 months
    - ⇨ need to extract pixel detector to replace opto-boards

Summary

- ~1% of on-detector opto-links of Pixel detector are not working
- Major contributors to failures are probably:
  - Type0 cable problems
  - cold solders
- Failure rate is low so far
  - last failure: June 2010
- High statistics lifetime study of old VCSEL arrays planned