# Opto-Link Upgrade

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# Outline

- Upgrade requirements/wishes
- Bandwidth of micro twisted-pair cables
- Bandwidth of fusion spliced SIMM-GRIN fibers
- Radiation hardness of PIN/VCSEL arrays
- Opto-Link Working Group/common projects

# Need New Opto-Link for B Layer?

- opto-boards are located in radioactive area
  - cannot remove/reinstall service panels in 8 months
  - need new opto-boards + service panels: 2 MCHF?
- do we really need new opto-link for B layer?

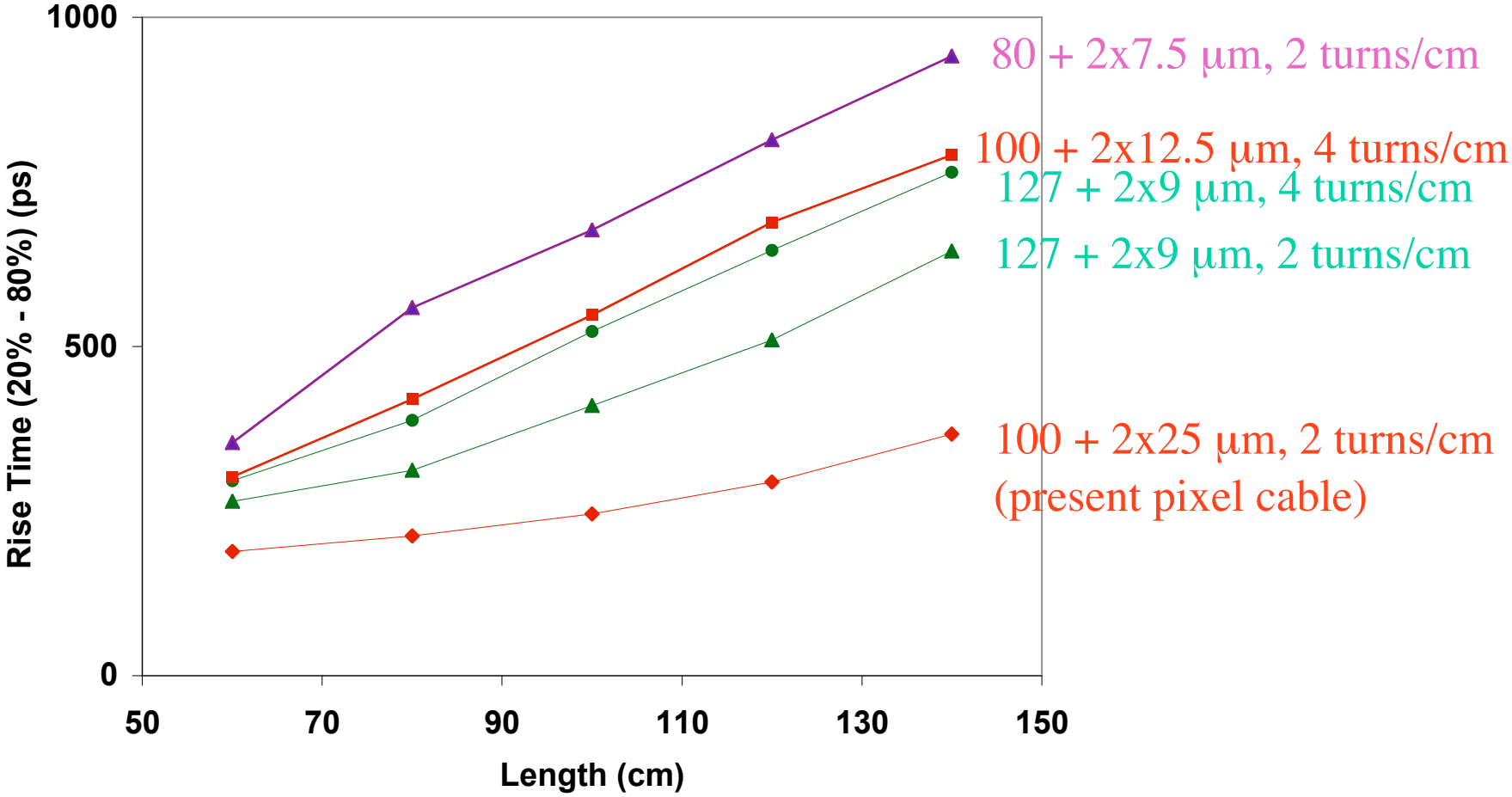
# Upgrade Requirements/Wishes

- bandwidth of ~ 500 Mb/s is needed
- services must fit within current space allocation
  - current system uses 6-7 channels in 8-channel array/ribbon
  - can almost double the number of links using 12-channel array/ribbon as most fiber volume is in the cladding
- preserve as much as possible current pixel opto-link architecture to take advantage of R&D effort and production experience

# Upgrade Feasibility with Present Infrastructure

- can micro twisted pair transmit at ~ 1Gb/s?
- can fusion spliced SIMM/GRIN fiber transmit at ~ 1 Gb/s?
- can PIN/VCSEL arrays survive SLHC radiation dosage?

# Bandwidth of Micro Twisted Pairs

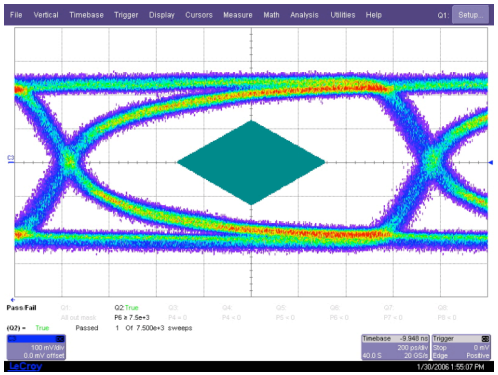



- current pixel cable is the best!
- more cables with thicker insulation being ordered

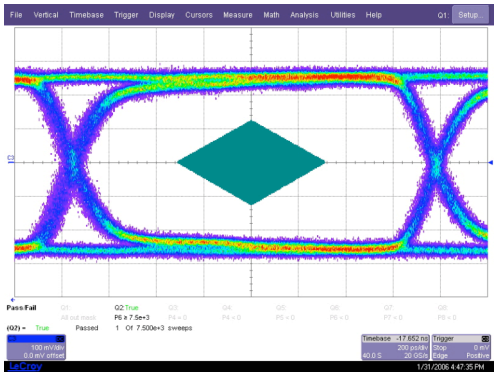
# Eye Diagrams

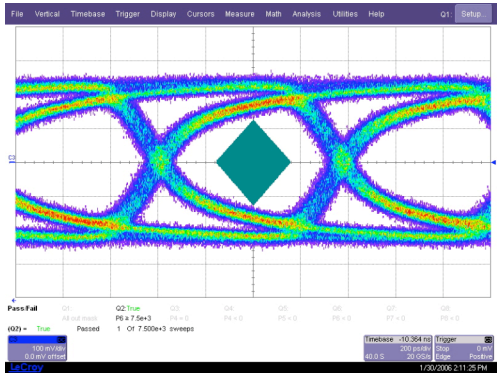
140 cm pixel cable

60 cm pixel cable

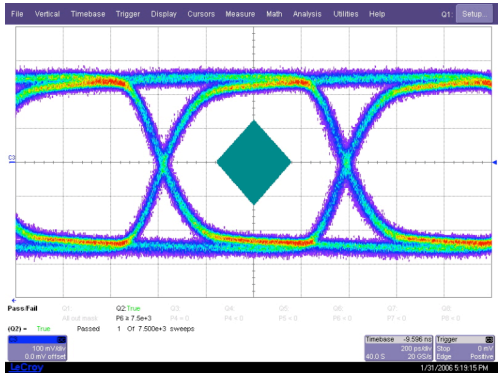


650 Mb/s





1.3 Gb/s

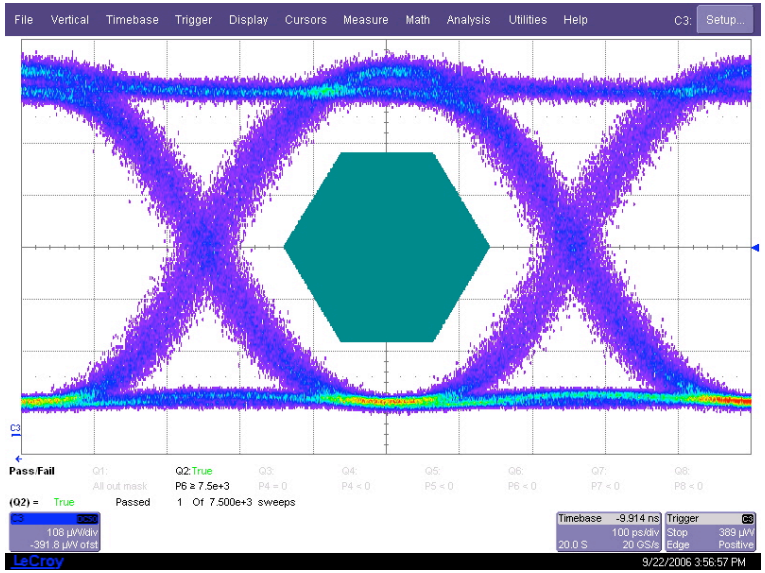


- transmission at 650 Mb/s is adequate
- transmission at 1.3 Gb/s may be acceptable

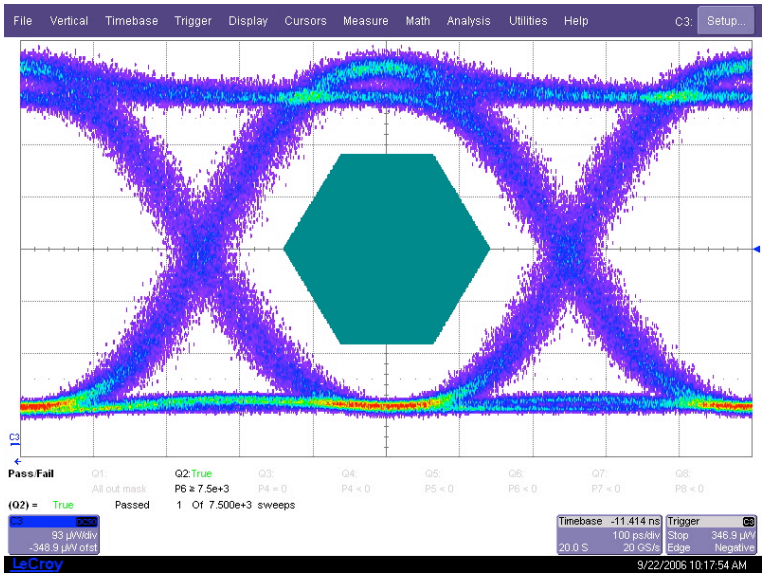
# Bandwidth of Fusion Spliced Fiber

1 m GRIN fiber

8 + 80 m spliced SIMM/GRIN fiber




2 Gb/s

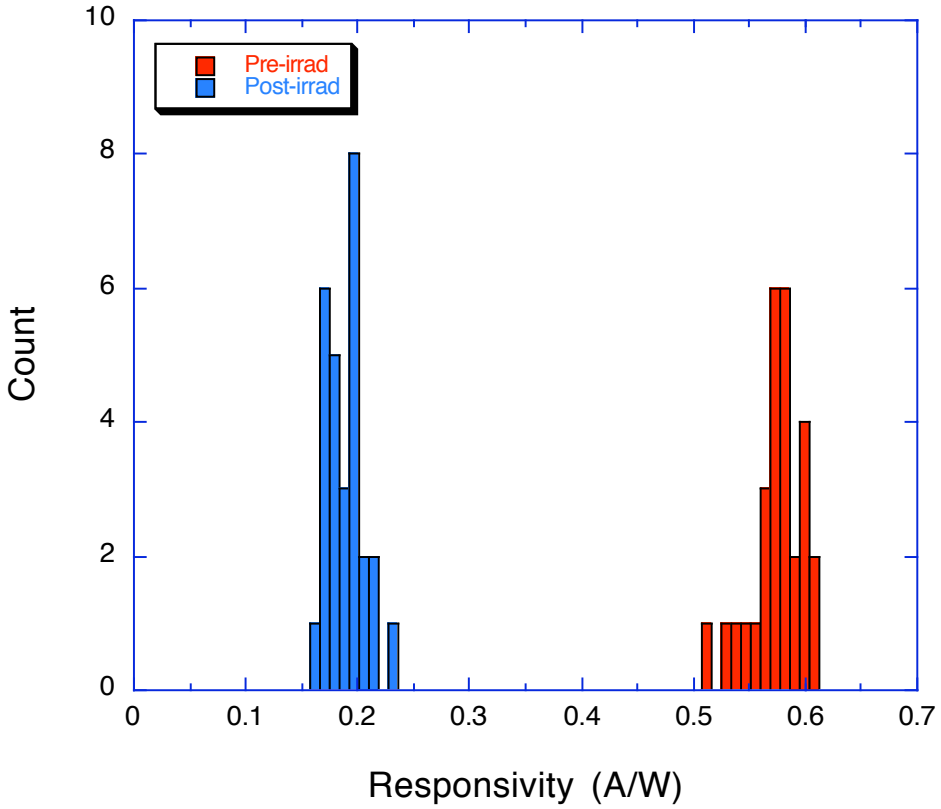



- transmission up to 2 Gb/s looks adequate

# Radiation Level at SLHC

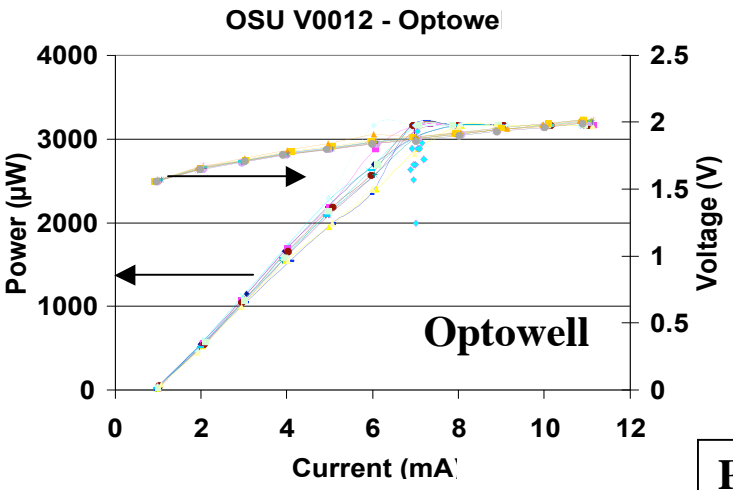
- Optical link of current pixel detector is mounted on patch panel:
  - ⇨ much reduced radiation level:
    - Si (PIN) @ SLHC:
      - $2.5 \times 10^{15}$ 1-MeV $n_{eq}/cm^2$
      - $4.3 \times 10^{15}$ $p/cm^2$ or 114 Mrad for 24 GeV protons
    - GaAs (VCSEL) @ SLHC:
      - $14 \times 10^{15}$ 1-MeV $n_{eq}/cm^2$
      - $2.7 \times 10^{15}$ $p/cm^2$ or 71 Mrad for 24 GeV protons
    - above estimates include 50% safety margin

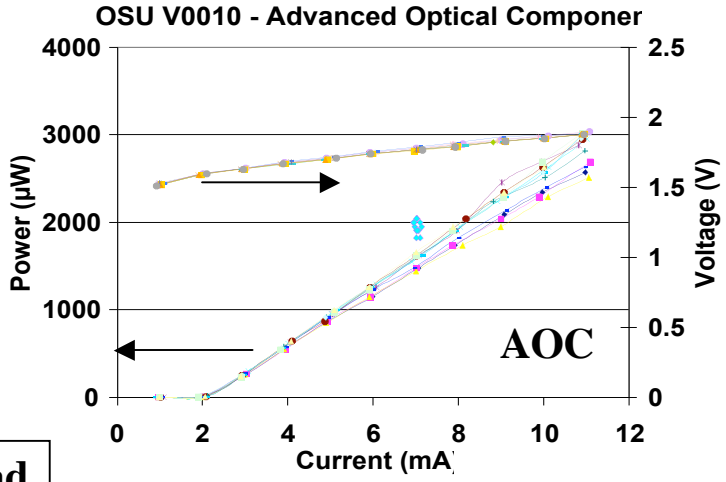
# PIN Responsivity



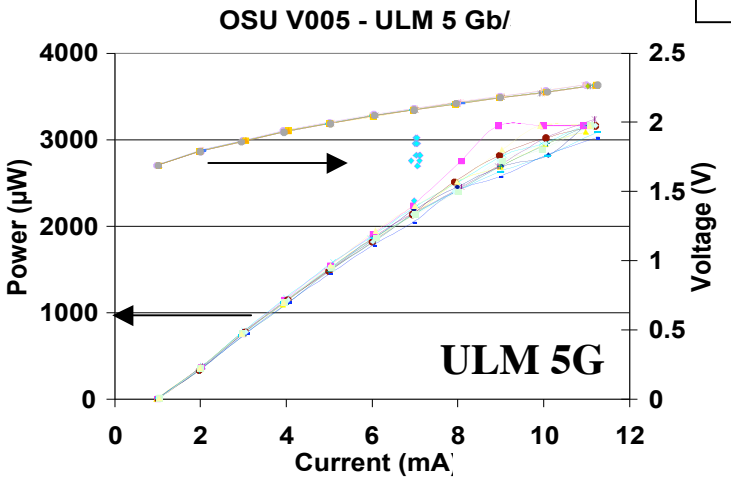

- responsivity decreases by ~65% after SLHC dosage

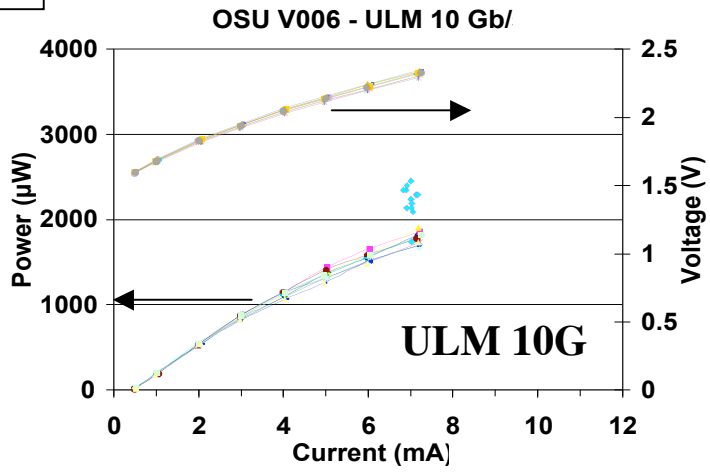
# VCSEL LIV Characteristics



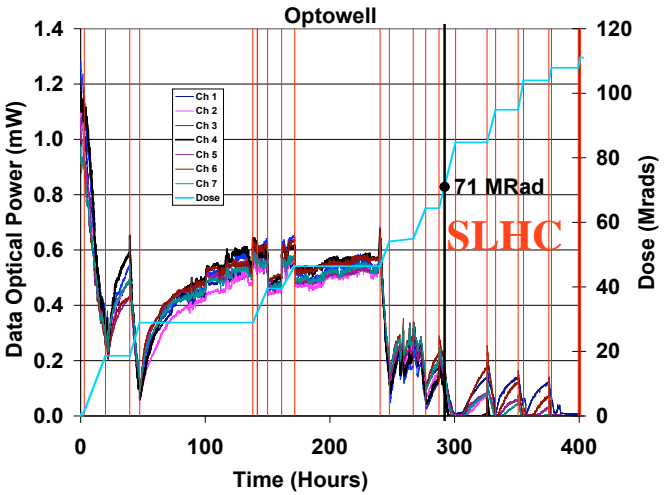

**Pre-irrad**

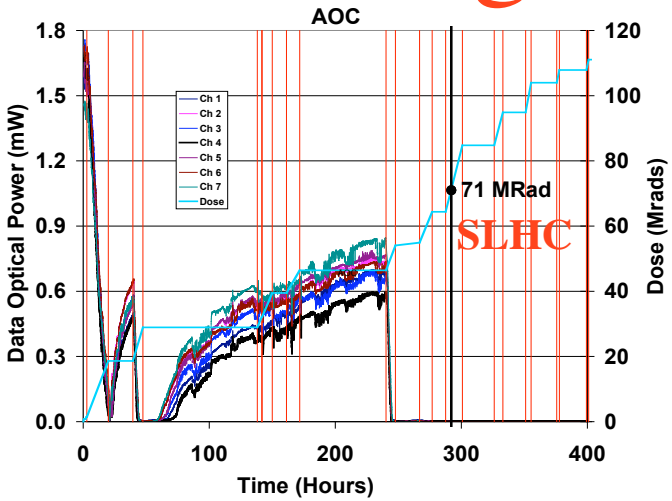


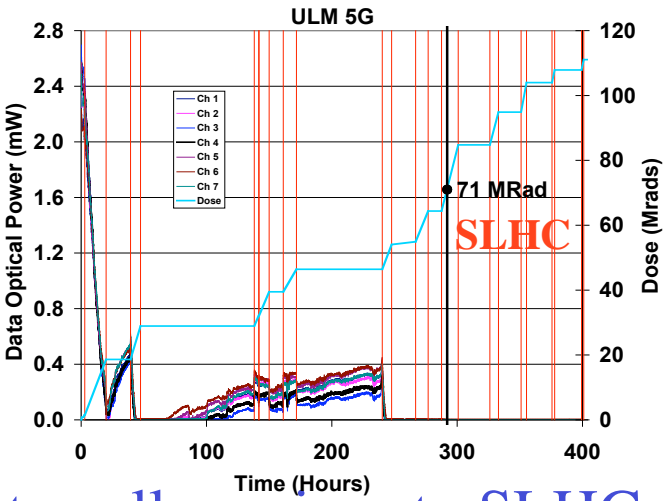



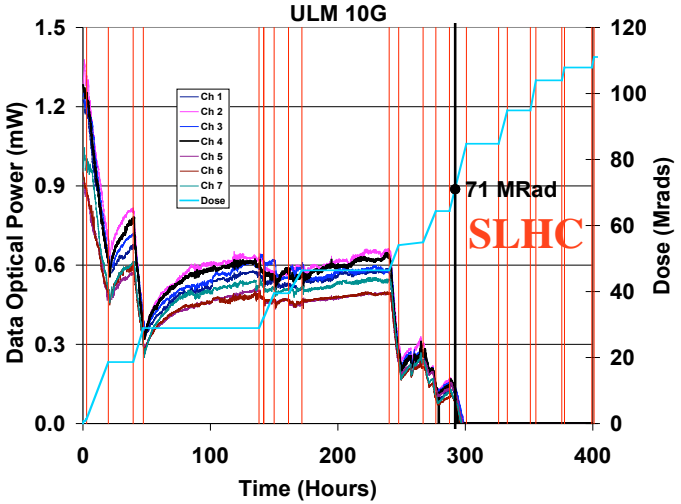

- ULM requires higher voltage to operate
- all arrays have very good optical power

# VCSEL Power vs Dosage




- Optowell survives to SLHC dosage
- more VCSEL might survive with more annealing during irradiation

# Opto-Link Working Group/Common Projects

- CMS/ATLAS Opto-Link Working Group has been formed to share test results and plan future activity
  - biannual meetings: CERN + LECC
- two common projects proposed by CERN:
  - GBT
  - versatile link project
    - most groups prefer 2-5 Gb/s at the expense of micro twisted pairs and fiber ribbons
    - ⇨ pixel must appoint a representative to ensure compatible with lower bandwidth link

# Future Directions

- complete evaluation of bandwidth of micro twisted pairs
- continue irradiation of PIN/VCSEL arrays
- should DORIC/VDC be converted to operate at high speed with 0.13 μm technology as an upgrade option?
  - VDC has been converted at schematic level
- design of a concentrator of several ~500 Mb/s data into 2-5 Mb/s output?