Rad-Hard Opto-Link Upgrade

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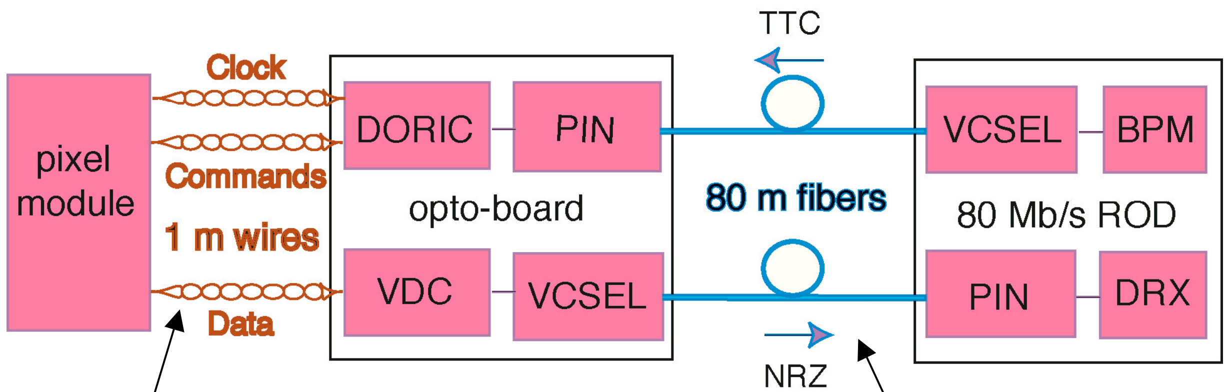
Outline

- Upgrade plan/requirements
- Bandwidth of micro twisted-pair cables
- Bandwidth of fusion spliced SIMM-GRIN fibers
- Radiation hardness/speed of PIN/VCSEL arrays

Current Opto-Link Architecture

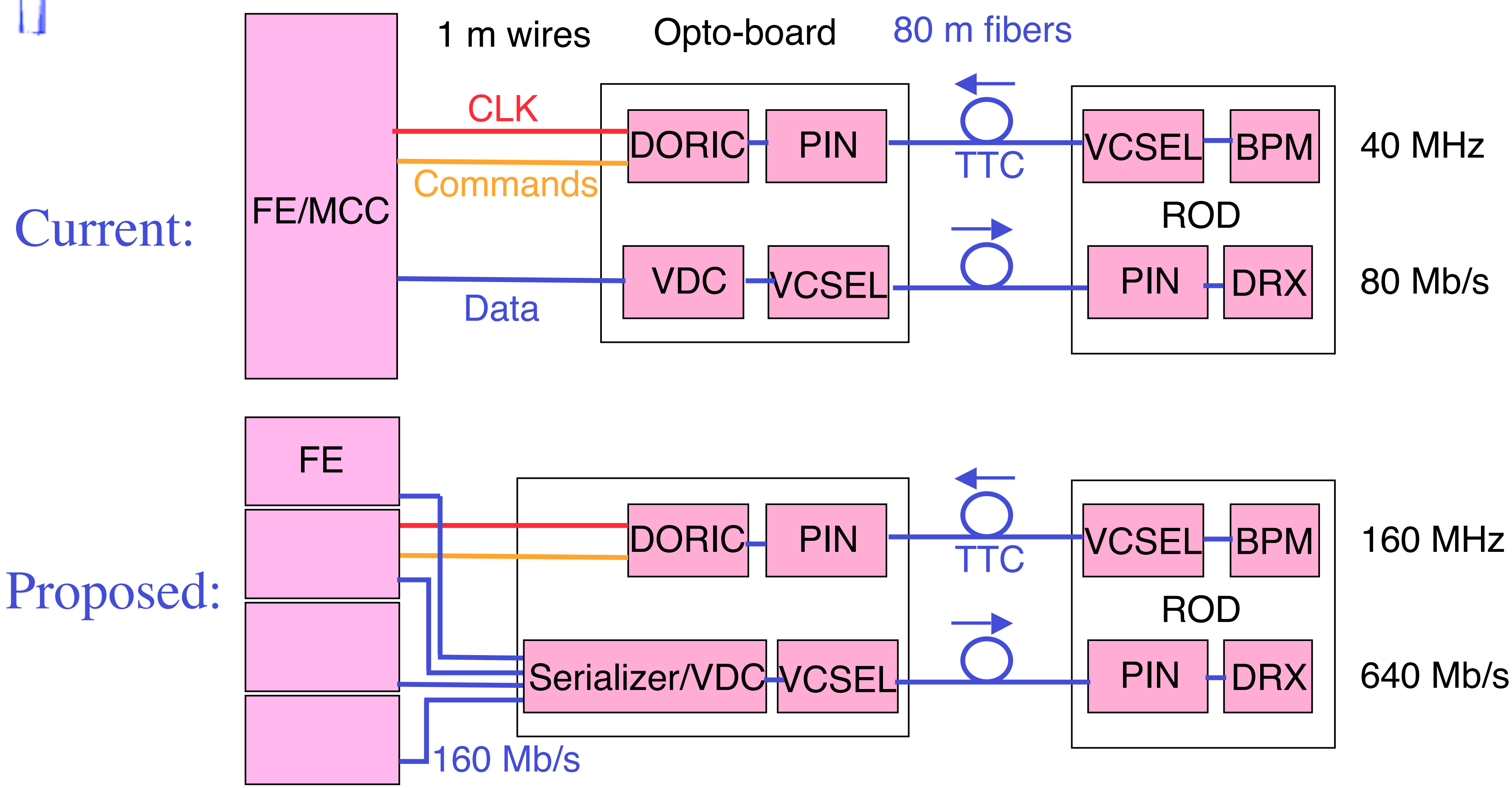


micro twisted pairs decouple pixel and opto module
⇨ simplify both design/production

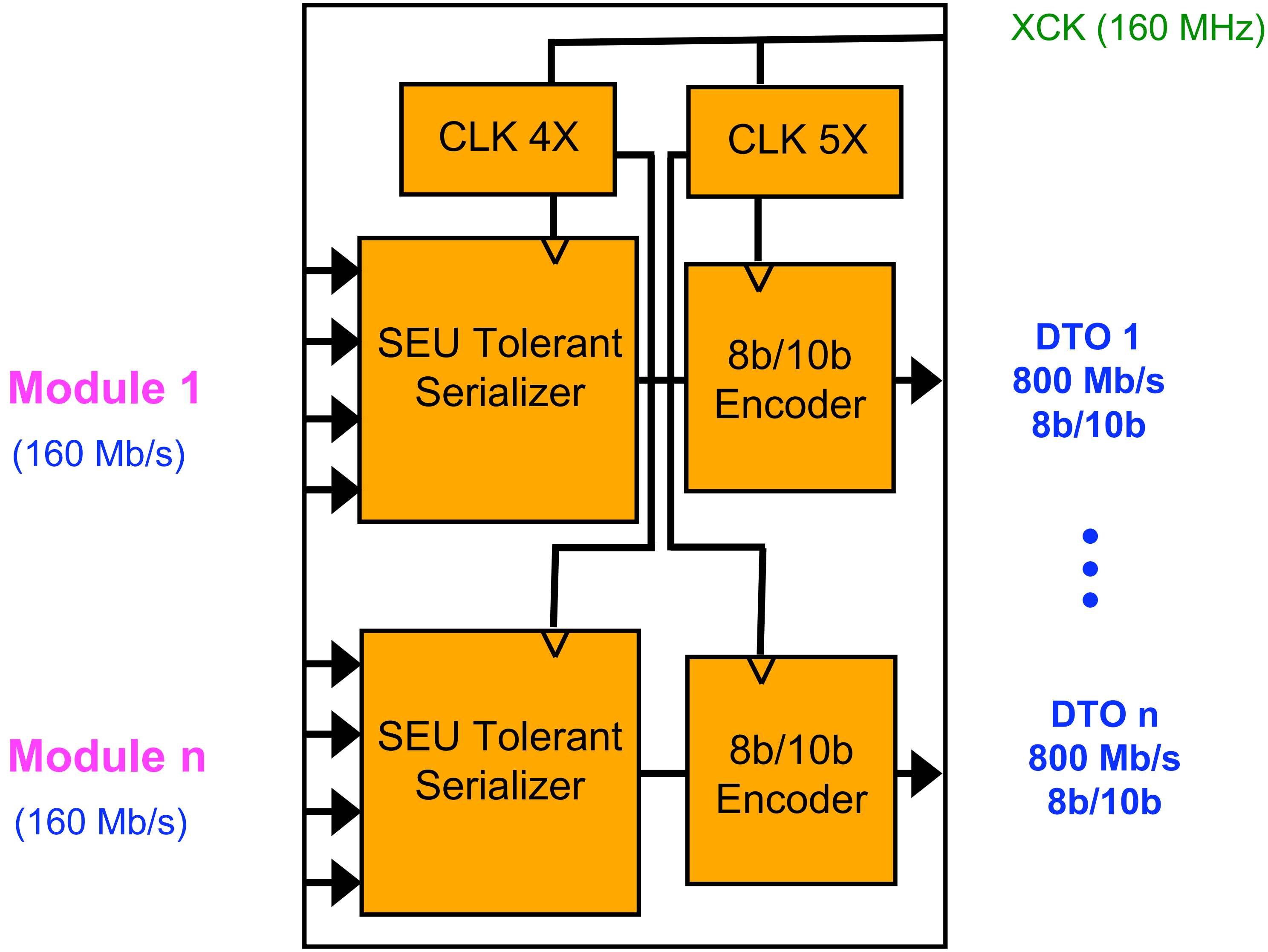
8 m of rad-hard/low-bandwidth SIMM fiber fusion spliced to 70 m rad-tolerant/medium-bandwidth GRIN fiber

- Plan: upgrade based on current pixel link architecture to take advantage of R&D effort and production experience

Proposed Opto-Link Architecture



Possible GBT-Lite Architecture



Case for DC Balancing in Opto-Link

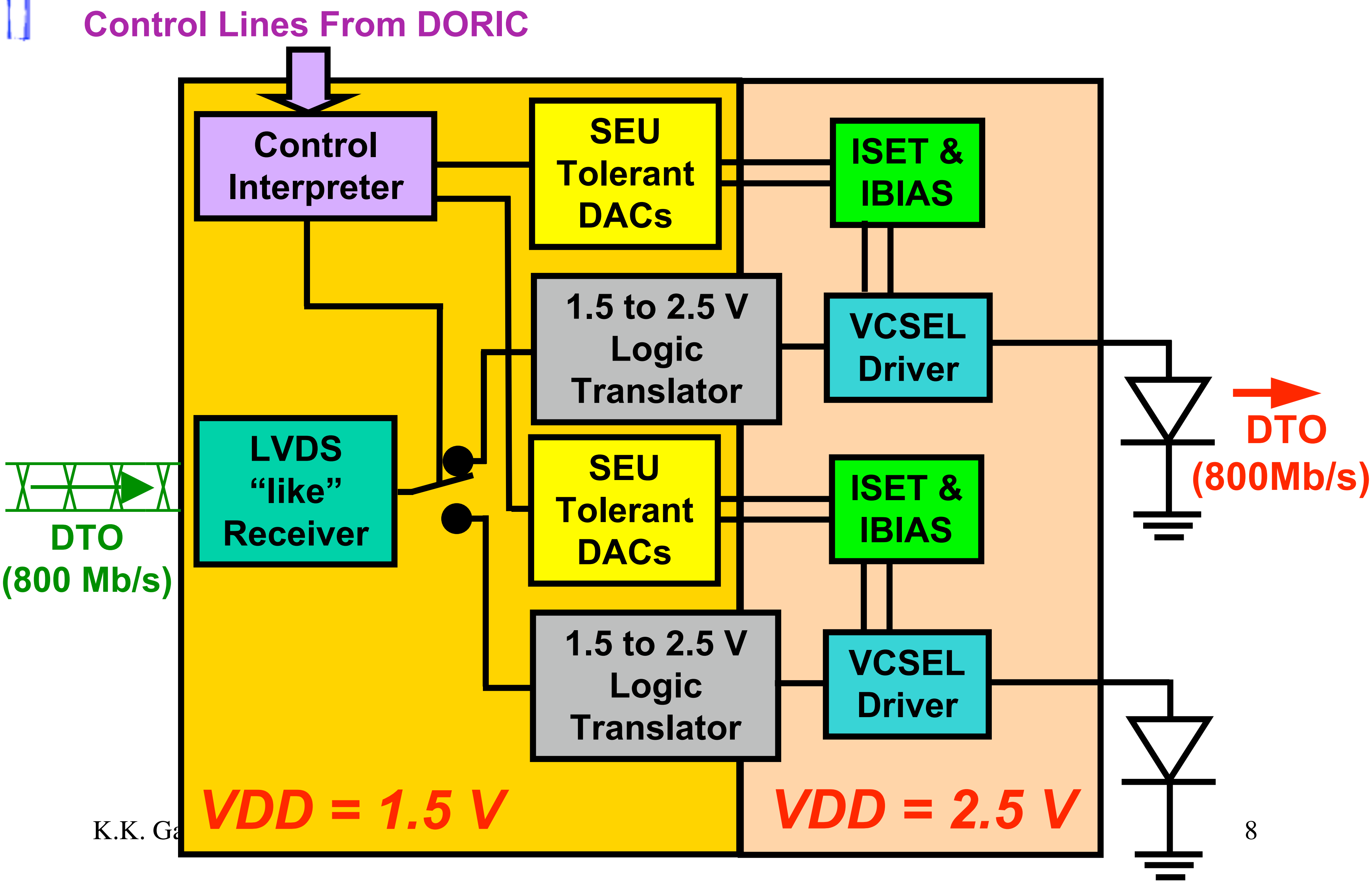
- some VCSELs require μs to produce full optical power
- Pixel TTC opto-link has been quite easy to operate
- commercial high speed opto links are mostly DC balanced

⇨ DC balancing will likely make a more robust uplink!

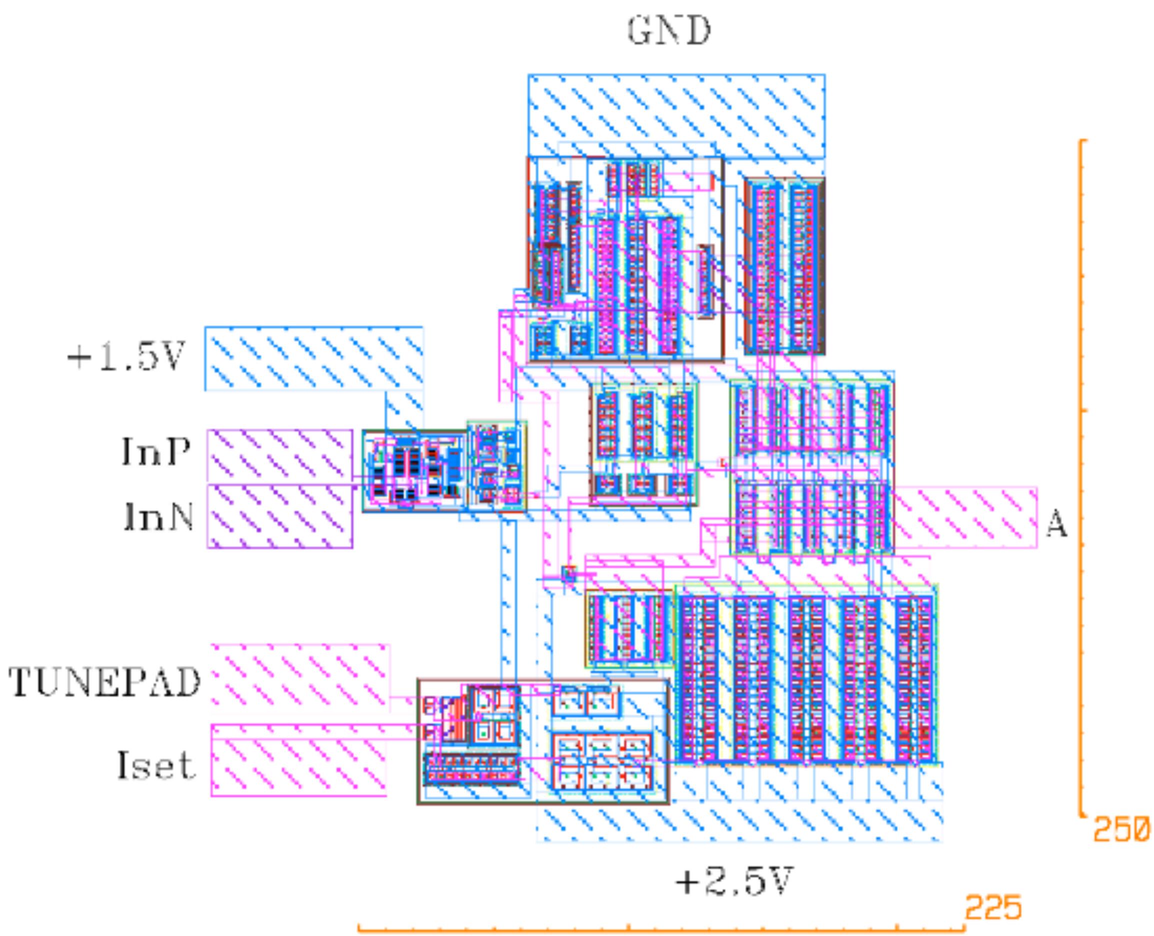
Increasing Functionality in VDC?

- lost of VCSEL:
  - add capability to reroute data in VDC to spare VCSEL?
- difficult to operate present data links due to optical power spread in VCSEL arrays:
  - add current adjustment for each VCSEL channel?

VDC with Rerouting Capability?

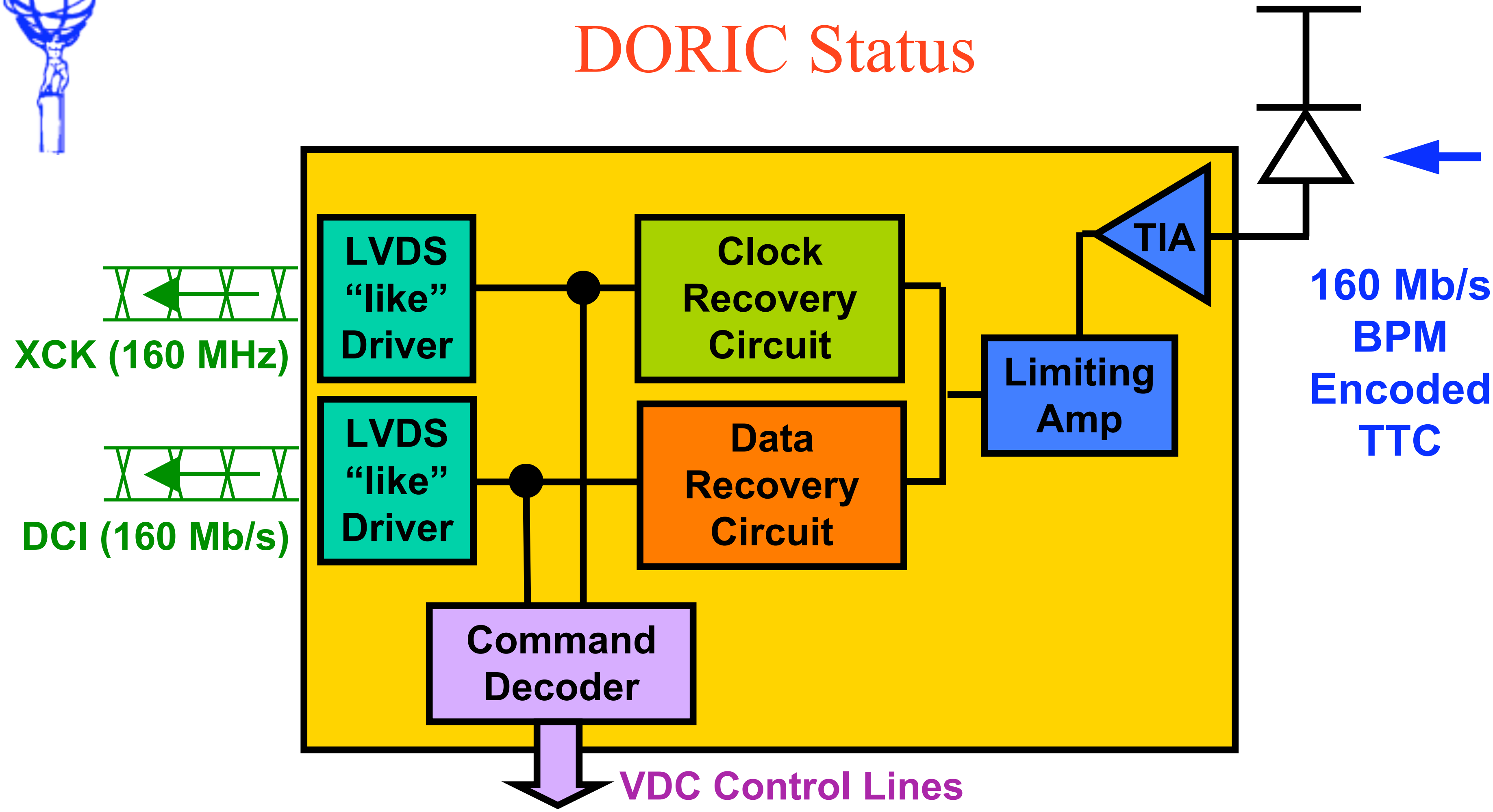


VDC Status



- thick oxide (2.5 V) transistors are enclosed devices
- extracted simulations indicate bandwidth > 1 Gb/s

DORIC Status

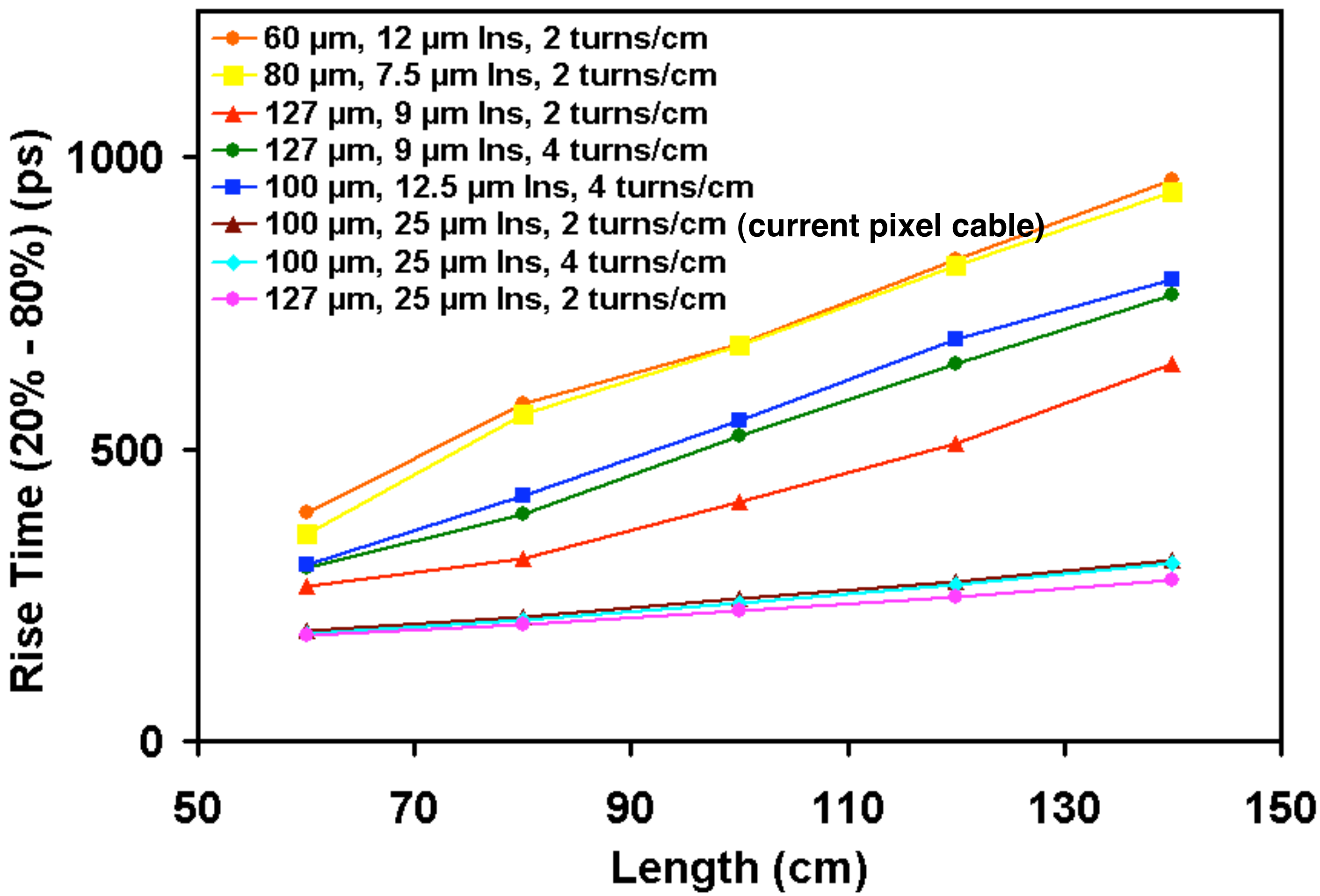


- simulations of transimpedance amplifier + limiting amplifier yield 50% duty cycle for input current of 20-1000 μA
- preliminary simulations of LVDS "like" driver promising

Upgrade Feasibility with Present Infrastructure

- can micro twisted pair transmit at 160 MHz?
- can PIN operate at 160 MHz?
- can PIN array survive B-layer radiation dosage?
- can high-speed VCSEL array survive B-layer radiation dosage?
- can fusion spliced SIMM/GRIN fiber transmit at 640 Mb/s?
- we already know some of the answers from SLHC R&D

Bandwidth of Micro Twisted Pairs



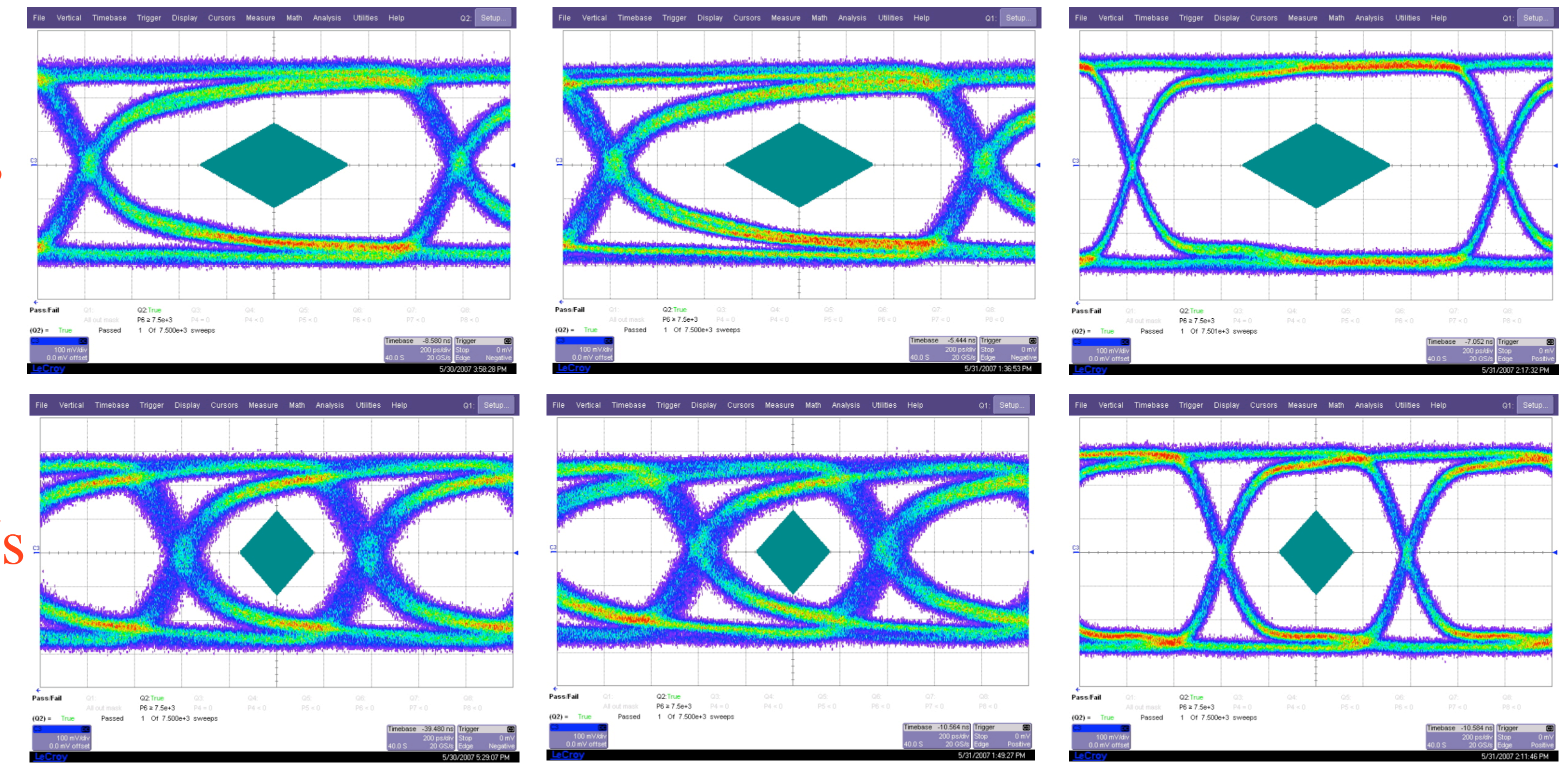
- current pixel cable with thick insulation is quite optimum!

Eye Diagrams

127 μm cable 140 cm | 100 μm current pixel cable 140 cm | 60 cm

640 Mb/s

1280 Mb/s

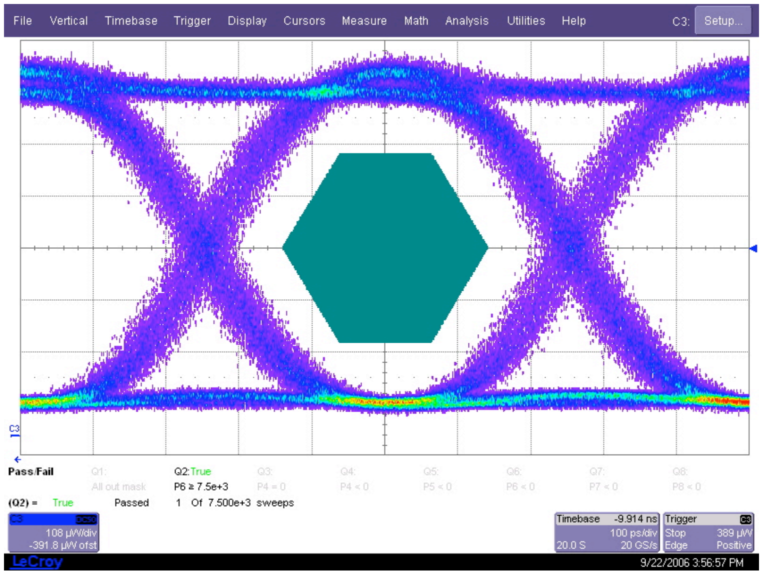


- transmission at 640 Mb/s is adequate
- transmission at 1280 Mb/s may be acceptable
- 127 μm cable is slightly better

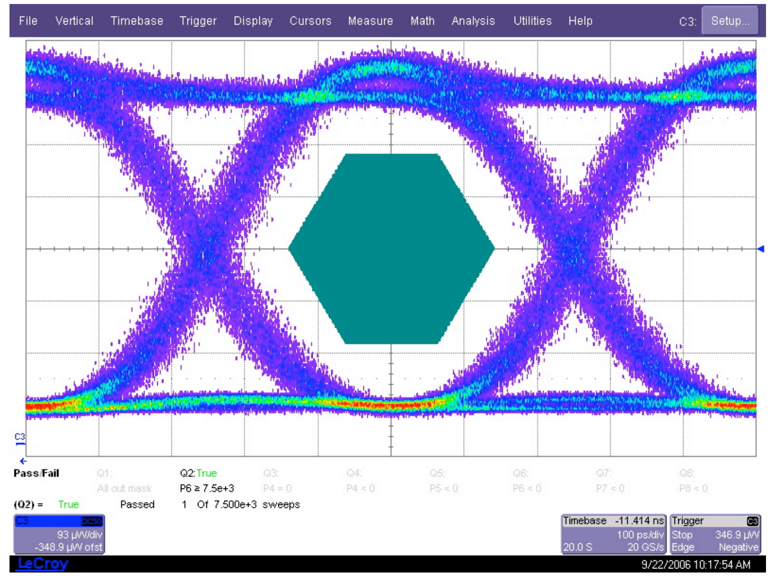
Bandwidth of Fusion Spliced Fiber

1 m GRIN fiber

8 + 80 m spliced SIMM/GRIN fiber

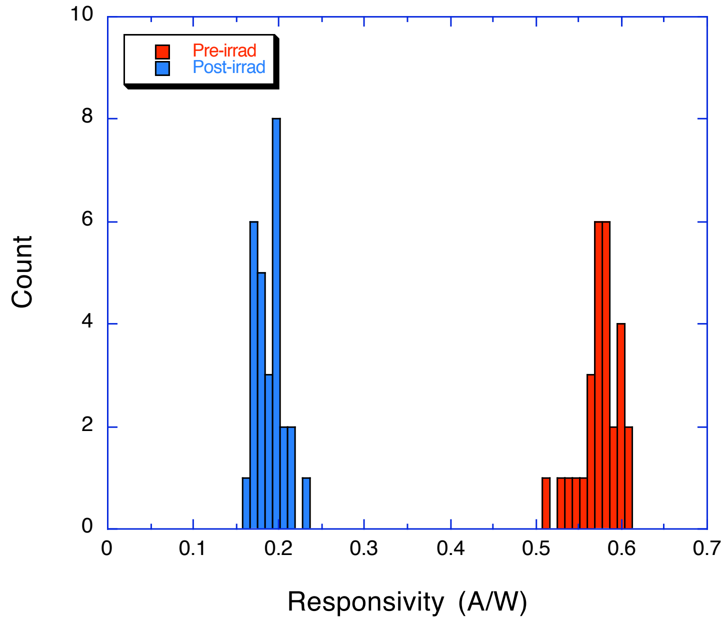


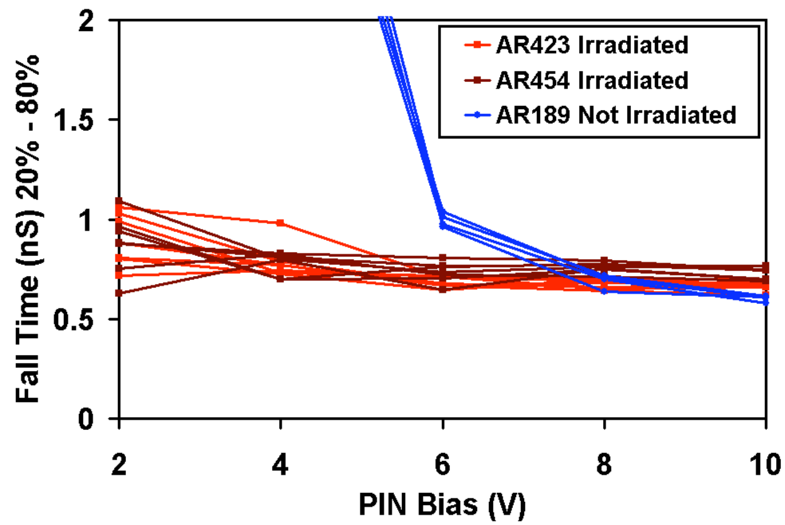
2 Gb/s



- transmission up to 2 Gb/s looks adequate
- ⇨ current fibers can be reused
- current system uses 6-7 channels in 8-channel array/ribbon
- some spare ribbons were installed
- ⇨ can have modest increase in # pixel modules

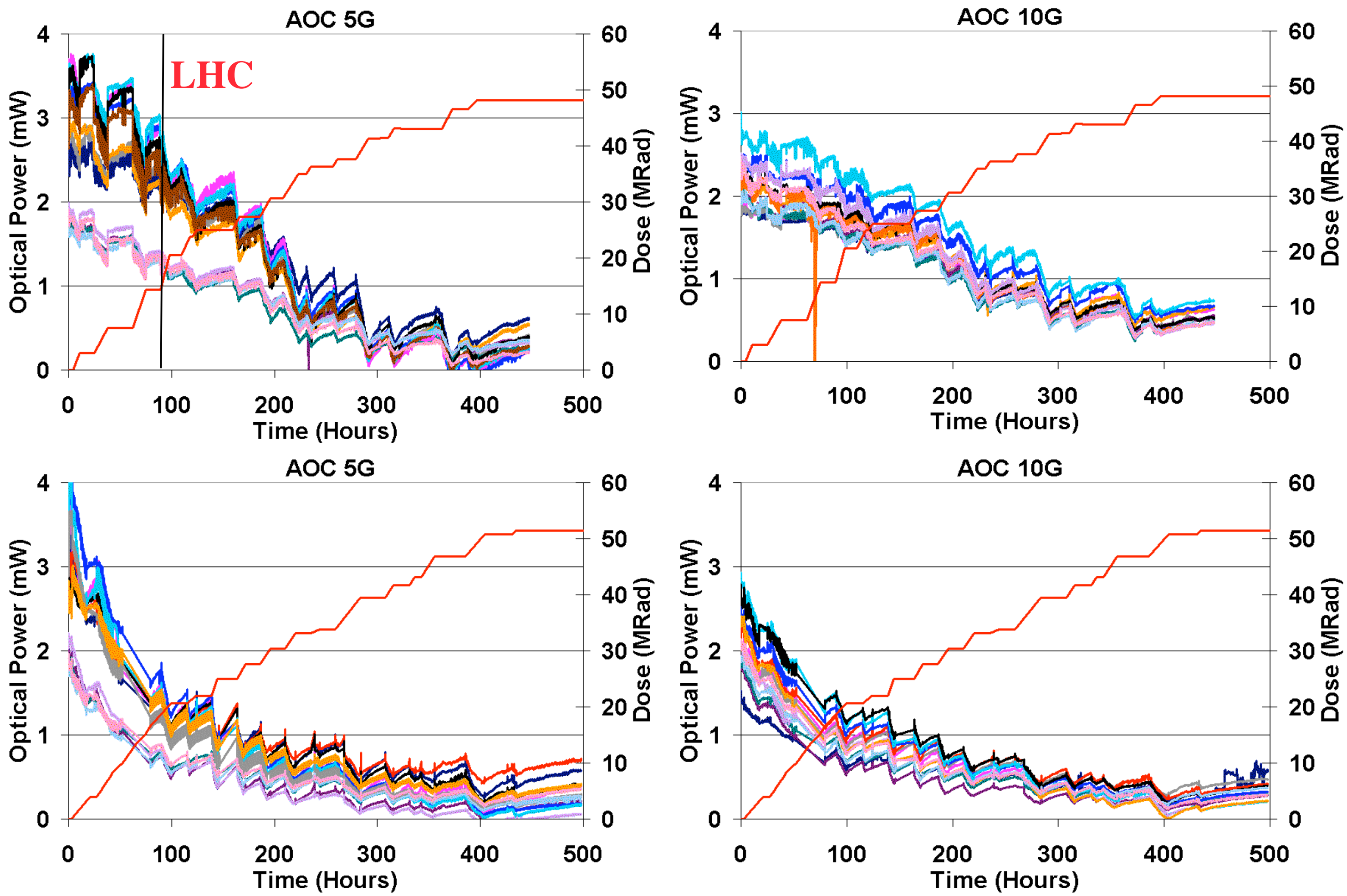
PIN Responsivity





- Si PIN responsivity decreases by 65% after SLHC dosage
- operation at 160 MHz is OK
- completed irradiation of GaAs PIN from 3 vendors:
  - Optowell, AOC, ULM
  - responsivities will be measured soon

VCSEL Power vs Dosage



1st irradiation period

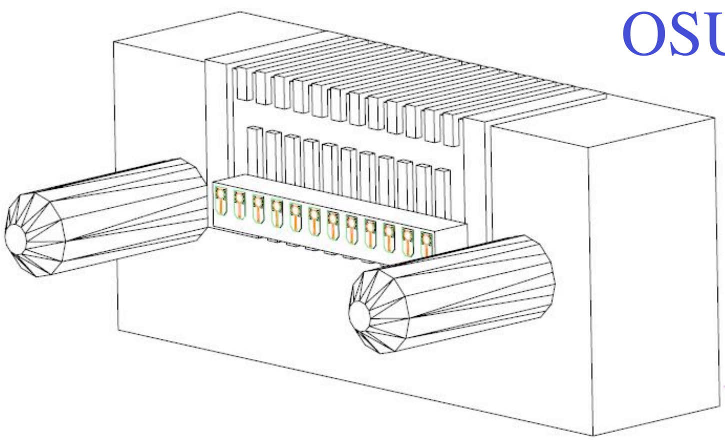
2007 preliminary Two arrays each (2 x 7 channels)

2nd irradiation period

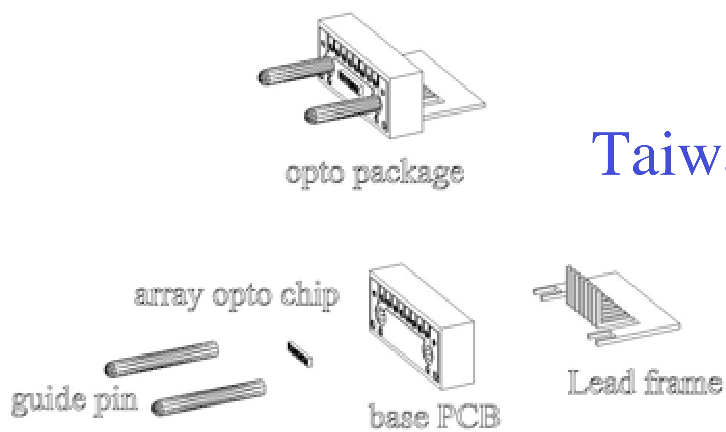
- irradiated VCSELs from 3 vendors to SLHC dosage
- all are acceptable for B layer replacement

Opto-Pack Development

- current pixel detector uses Taiwan optical packages
  - ☹ VCSEL mounted on PCB with poor heat conduction
  - ☹ micro soldering of 250 μm leads is difficult
- Ohio State develops new opto-pack for SLHC
  - uses BeO base with 3D traces for efficient heat removal
  - wire bond to driver/receiver chip



OSU

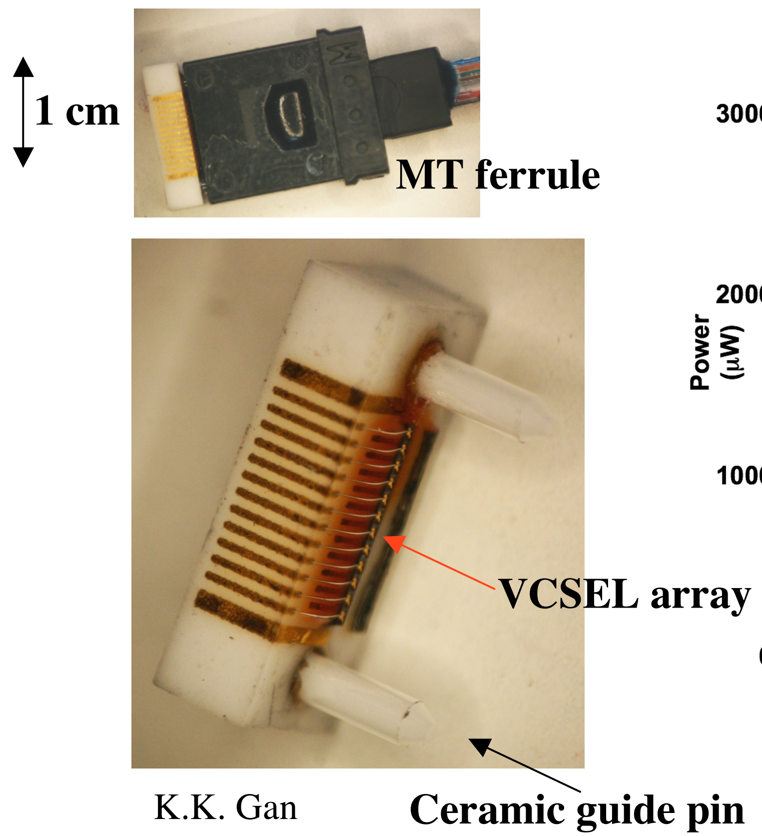


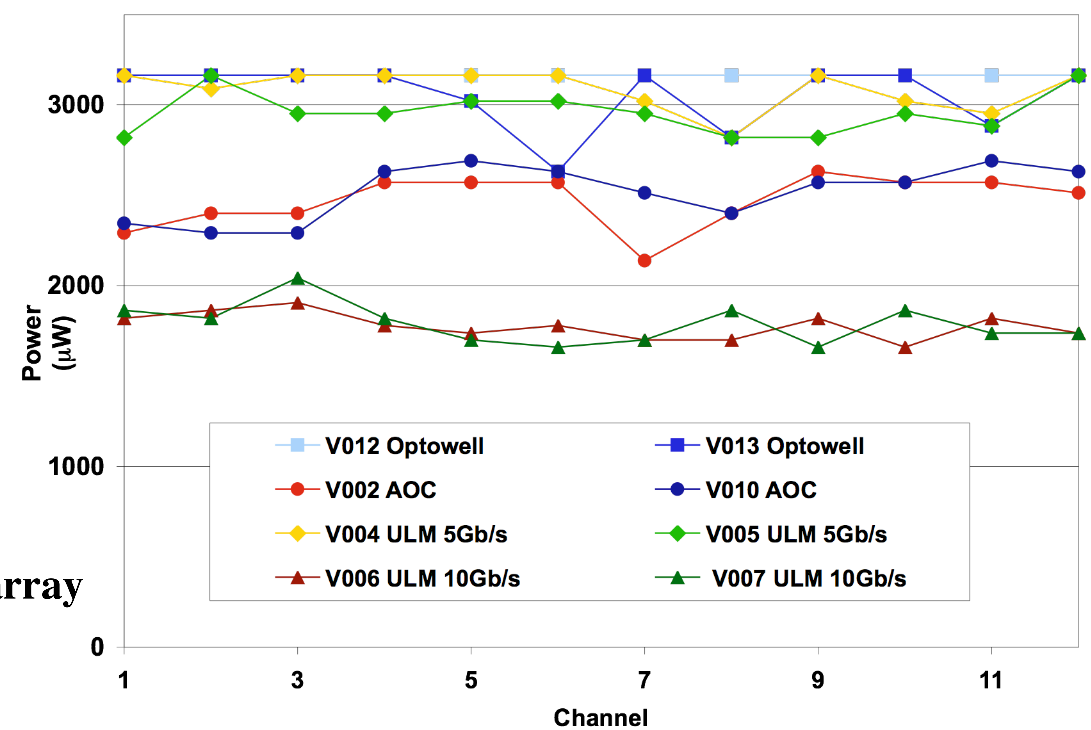
Taiwan

Results on Opto-Packs

- 35 VCSEL & 6 PIN opto-packs have been fabricated
  - all VCSEL opto-packs except one have good coupled power

⇨ principle of new opto-pack has been demonstrated





Summary

- Simple VDC design completed
  - ❑ VDC with more functionality proposed
- DORIC design in progress
- ✔ micro twisted-pair cable of current ATLAS pixel detector can be used for transmission up to 1 Gb/s
- ✔ fusion spliced SIMM/GRIN fiber can transmit up to 2 Gb/s
- ✔ Si PIN can be operated up to 160 MHz
  - ❑ GaAs PIN evaluation in progress
- ✔ good high speed VCSELs from 3 vendors
- ✔ compact MT-style opto-pack based on BeO has been developed
- ⇨ current opto-link architecture satisfies B-layer requirements