Bandwidths of Micro Twisted-Pair Cables and Fusion Spliced SIMM-GRIN Fibers

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Outline

- Introduction
- Bandwidth of micro twisted-pair cables
- Bandwidth of fusion spliced SIMM-GRIN fibers
- Measurement of VCSEL characteristics
- Summary

ATLAS Pixel Opto-Link Architecture

- ATLAS is a detector studying pp collisions of 14 TeV at CERN
  - pixel detector is innermost subsystem
  - detector upgrade planned for Super-LHC in 2015
- current optical link of pixel detector transmits signal at 80 Mb/s
- opto-link production is decoupled from module production
  - transmit signal to/from module with micro twisted pairs
- use PIN/VCSEL arrays coupled to robust fiber ribbon
- use 8 m of rad-hard/low-bandwidth SIMM fiber fusion spliced to 70 m rad-tolerant/medium-bandwidth GRIN fiber

⇨ simplify opto-board production

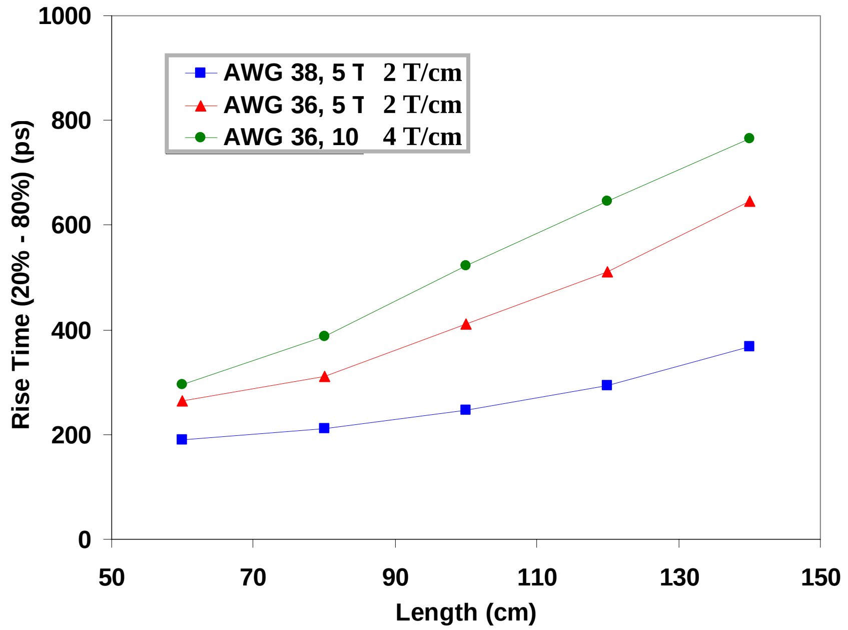
⇨ upgrade based on current pixel link architecture to take advantage of R&D effort and production experience?

R&D Issues for SLHC

- bandwidth of ~ 640 Mb/s is needed
  - can micro twisted pair transmit at this speed?
  - can fusion spliced SIMM/GRIN fiber transmit at this speed?
- can PIN/VCSEL arrays survive SLHC radiation dosage?

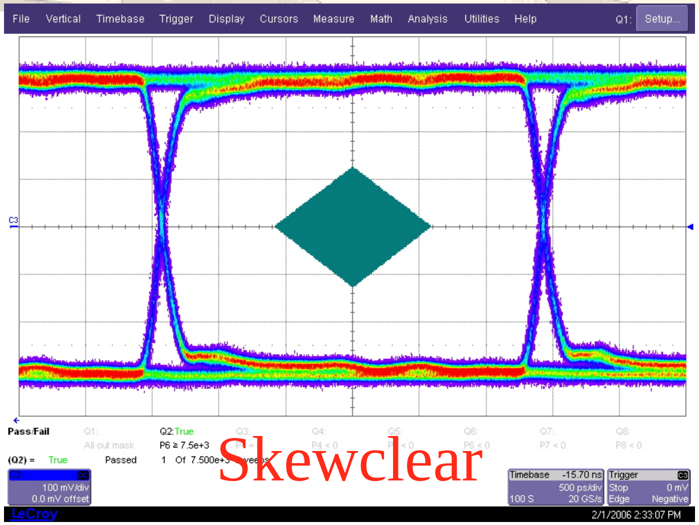
Bandwidth of Micro Twisted Pairs

- bandwidth of 3 micro twisted-pair wires were compared:
  - 38 AWG/100 μm, 2 turns/cm (current pixel cable)
  - 36 AWG/127 μm, 2 turns/cm
  - 36 AWG/127 μm, 4 turns/cm

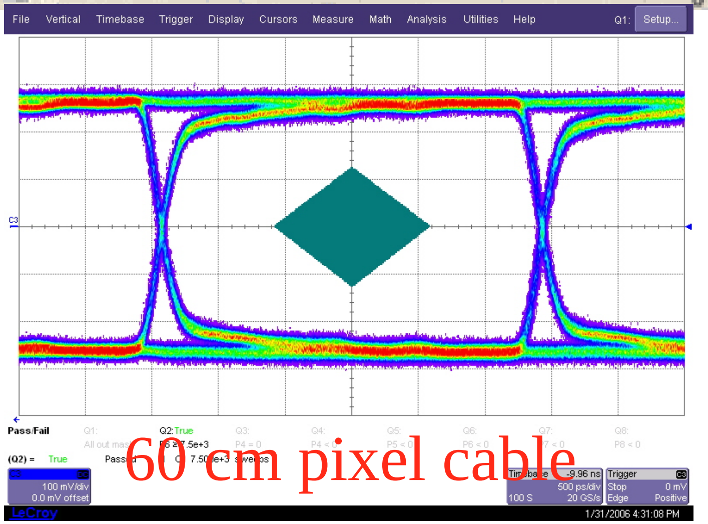


- current pixel cable is the best!

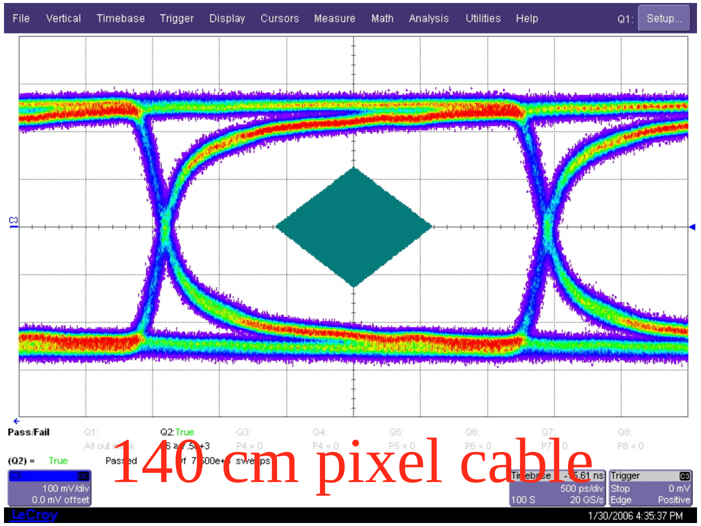
Eye Diagrams at 350 Mb/s



Skewclear

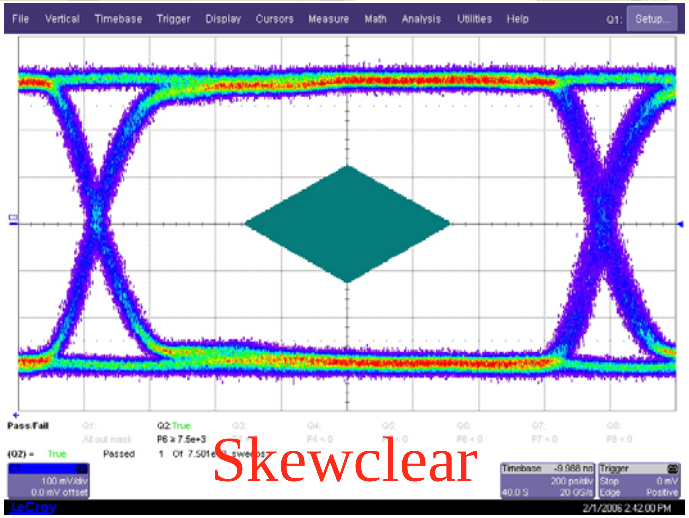


60 cm pixel cable

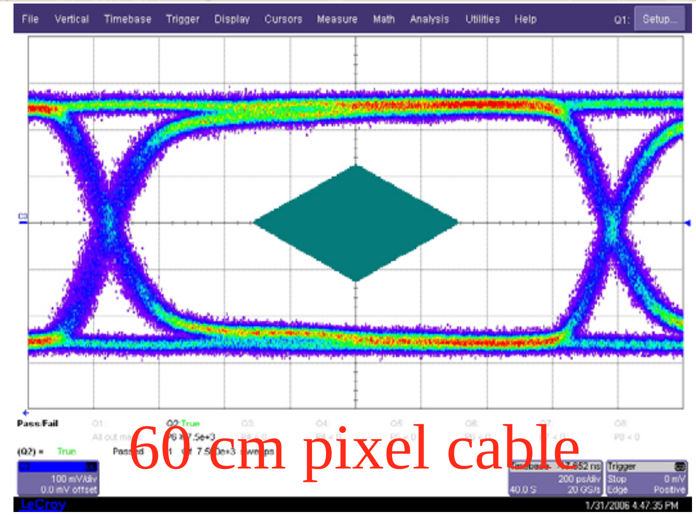


140 cm pixel cable

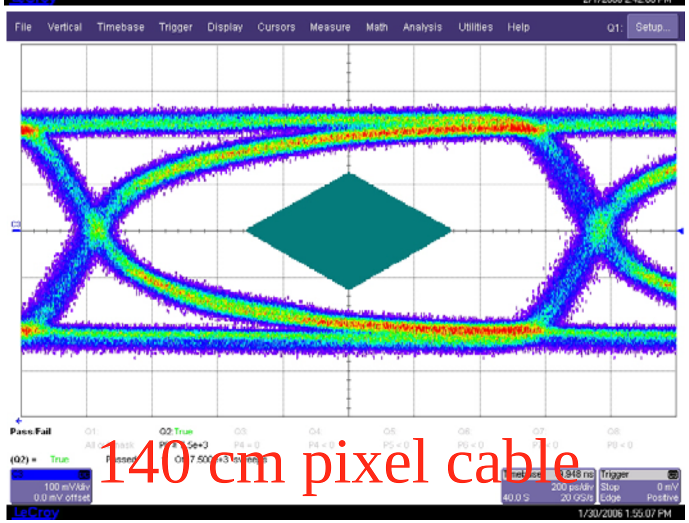
Eye Diagrams at 650 Mb/s



Skewclear



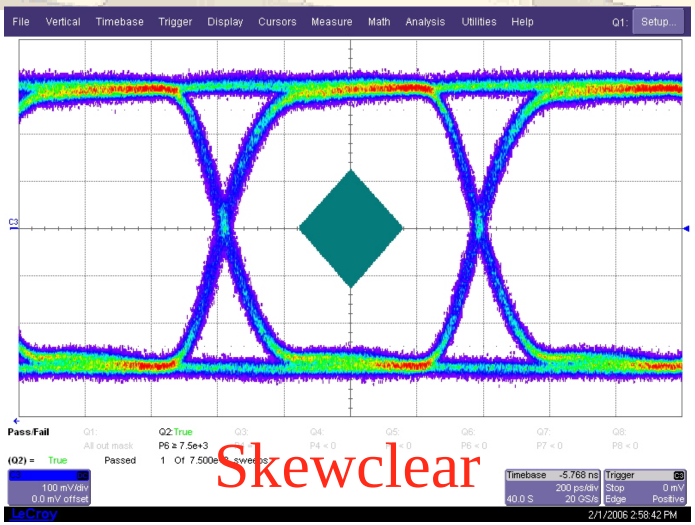
60 cm pixel cable

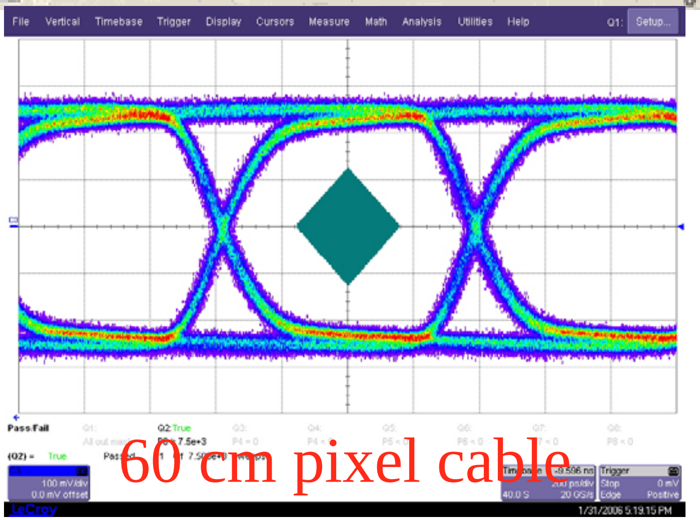


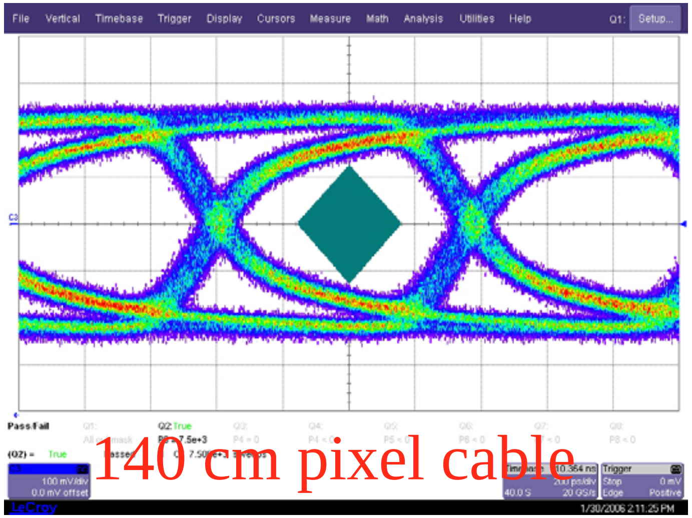
140 cm pixel cable

- transmission at 650 Mb/s is adequate

Eye Diagrams at 1.3 Gb/s


Skewclear

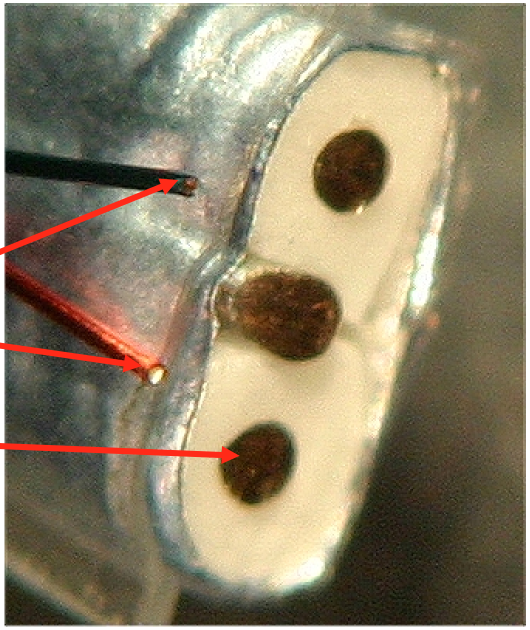

60 cm pixel cable


140 cm pixel cable

- transmission at 1.3 Gb/s is marginal

Using Skewclear in Pixel Detector?

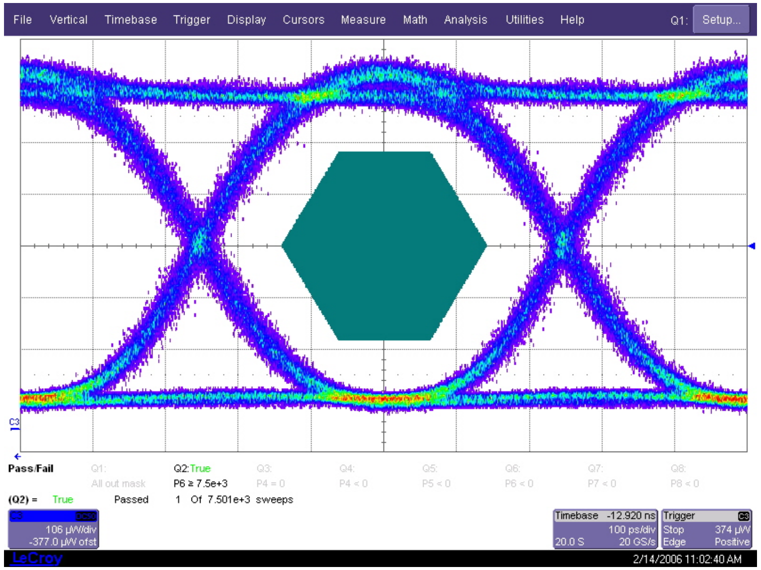
A picture is worth a thousand words…



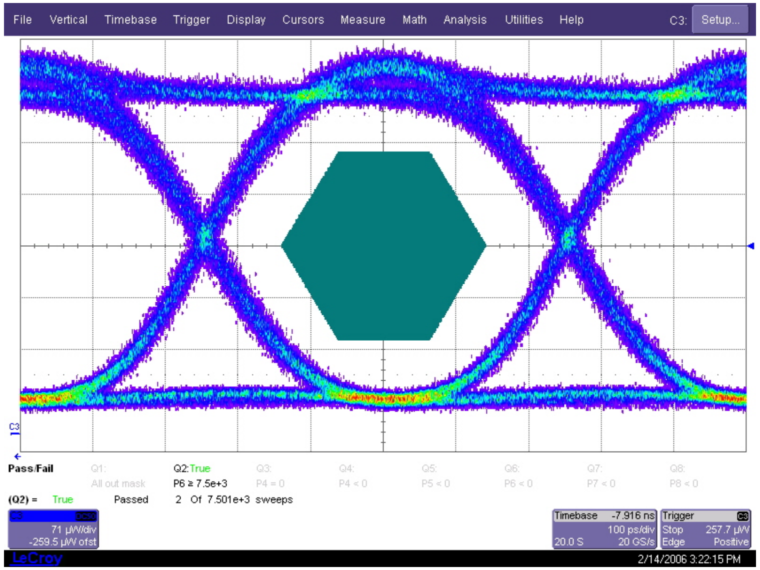
- Skewclear is too big for pixel detector

Bandwidth of Fusion Spliced Fiber

20 m GRIN fiber



29 m spliced SIMM/GRIN fiber



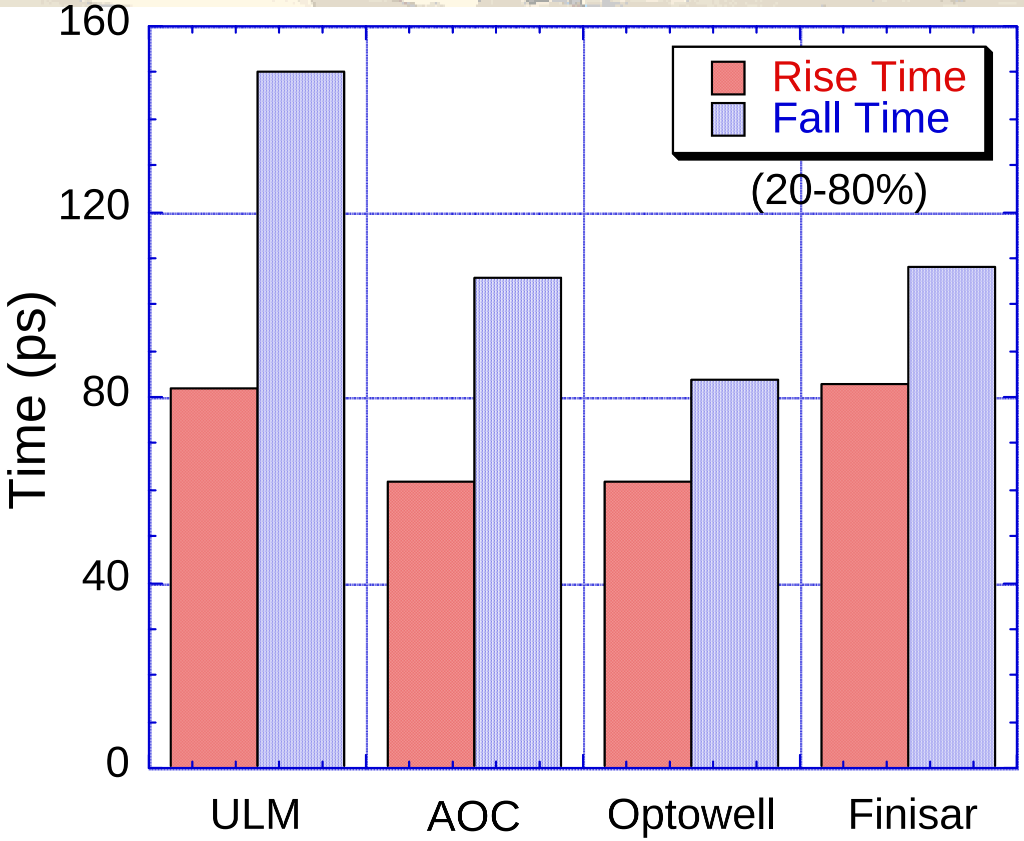
2 Gb/s

- transmission up to 2 Gb/s looks adequate

Requirements for VCSEL

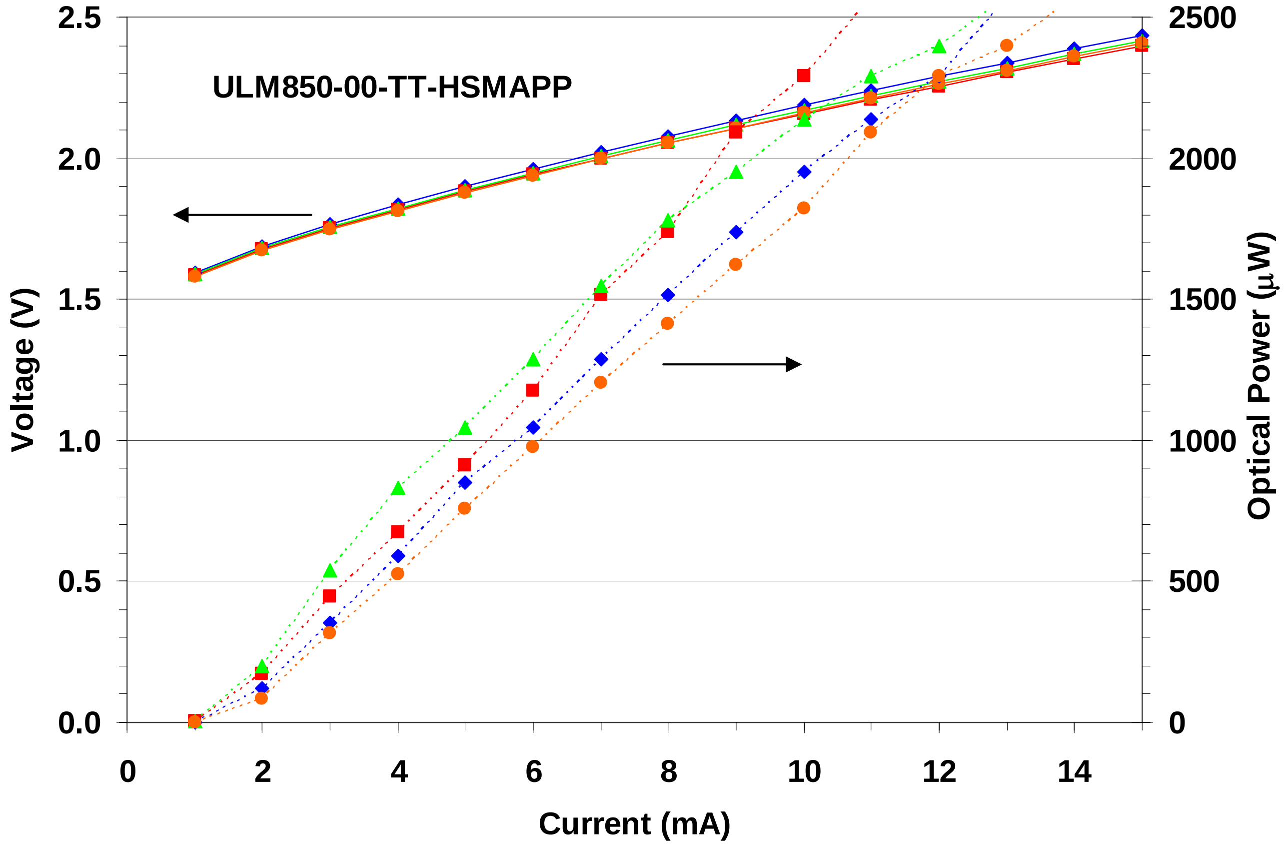
- VCSEL driver chip most likely be fabricated with 0.13 μm process
  - operating voltage is 1.2 V
    - thick oxide option can operate at 2.5 V
    - ⇨ VCSEL must need < 2.3 V to produce 10 mA or more
- What is VCSEL optical power after irradiation?
- Can VCSEL be annealed after irradiation?
  - What VCSEL current is needed for annealing?

Rise/Fall Time of VCSELs



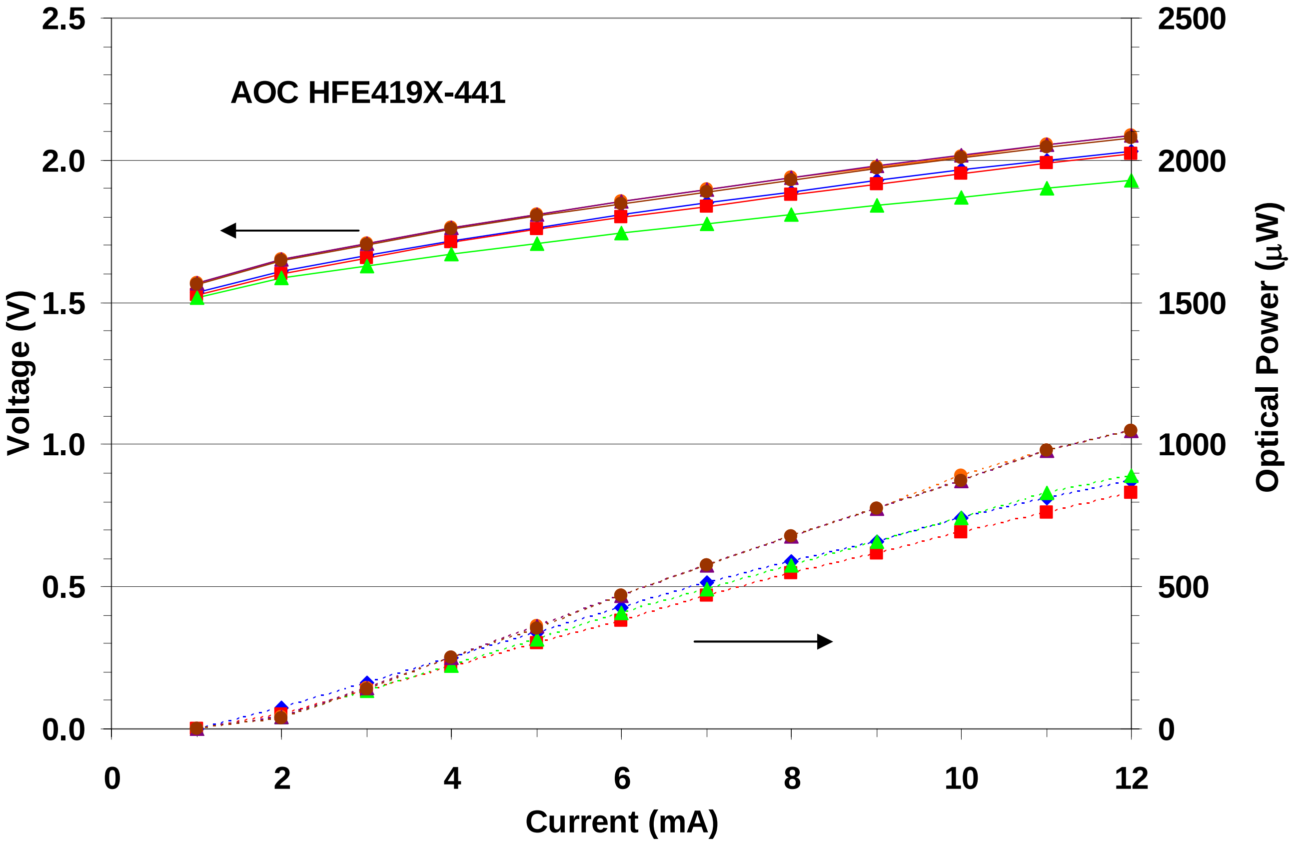
- all VCSELs have similar rise time
- ULM has somewhat slower fall time

I-L and I-V Characteristics



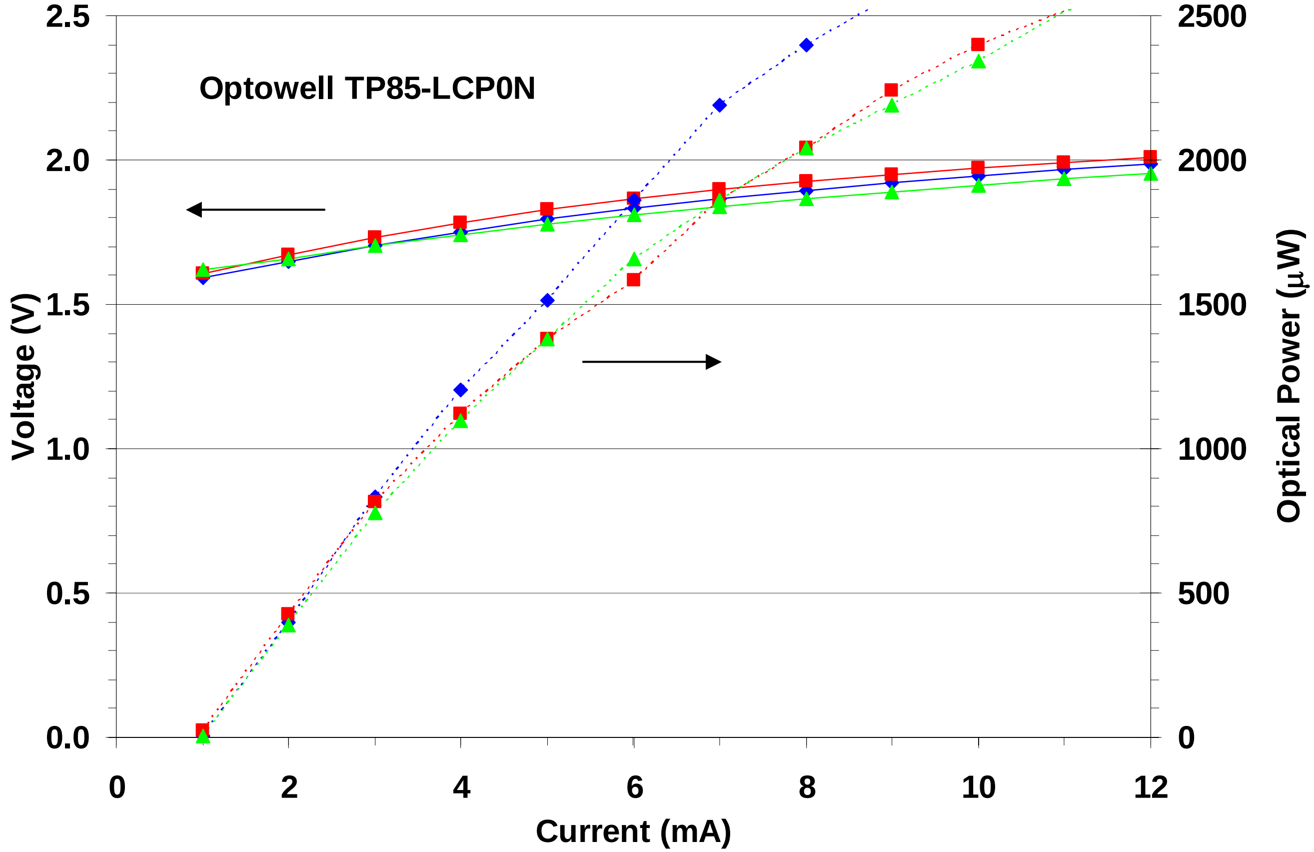
- somewhat high voltage needed to drive VCSEL
- very good optical power

I-L and I-V Characteristics



- good optical power
- candidate for irradiation study

I-L and I-V Characteristics



- very good optical power
- candidate for irradiation study

Summary

- 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

  ⇨ current opto-link infrastructure satisfies SLHC requirement
- two VCSEL candidates identified for irradiation with 24 GeV protons at CERN this August