

Radiation-Hard Optical Link for SLHC

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Outline

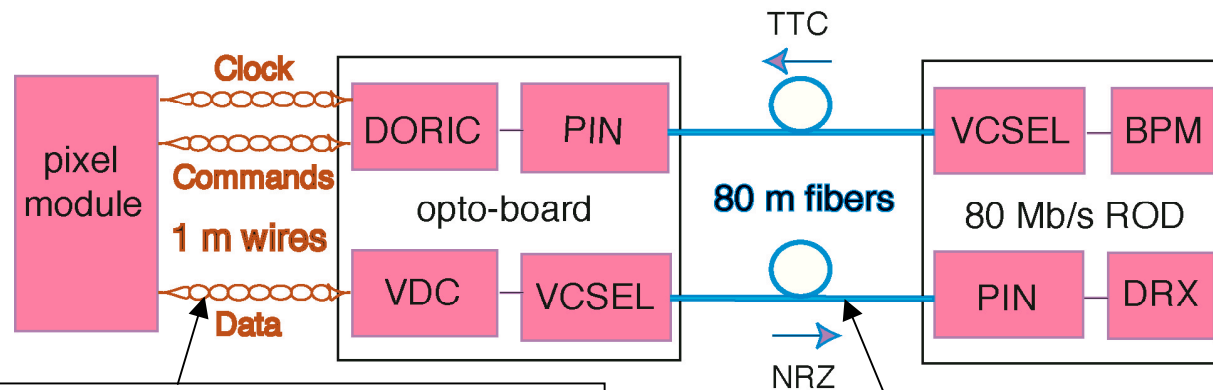


- Introduction
- Bandwidth of micro twisted-pair cables
- Radiation hardness of PIN/VCSEL arrays
- Results on MT-style optical packages based on BeO
- Summary



ATLAS Pixel Opto-Link Architecture

- ATLAS is a detector studying pp collisions of 14 TeV at CERN
 - ◆ pixel detector is innermost tracker
 - ◆ detector upgrade planned for Super-LHC in 2015



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

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



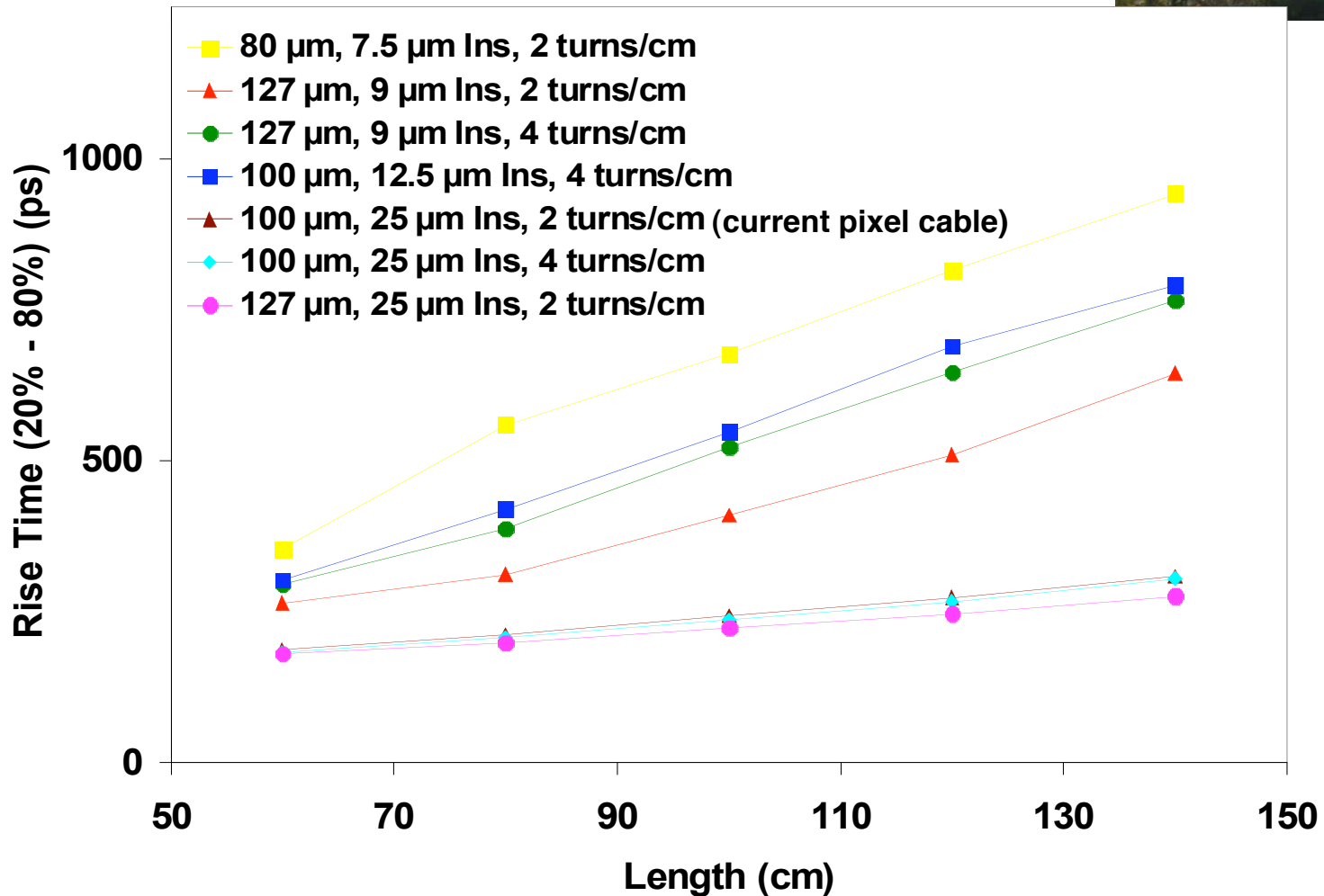
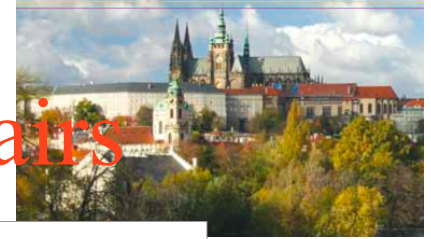
R&D Issues for SLHC



- bandwidth of ~ 1 Gb/s is needed
 - ◆ can micro twisted pair transmit at this speed?
 - ◆ can fusion spliced SIMM/GRIN fiber transmit at this speed?
 - ✓ measured bandwidth ~ 2 Gb/s (see LECC06 talk)
- can PIN/VCSEL arrays survive SLHC radiation dosage?



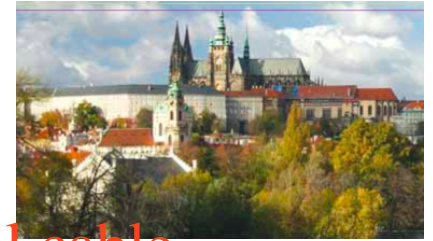
Bandwidth of Micro Twisted Pairs



● current pixel cable with thick insulation is quite optimum!



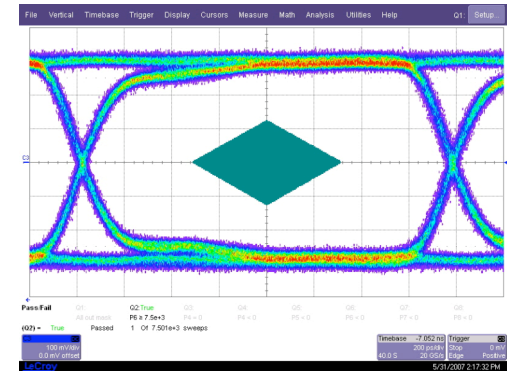
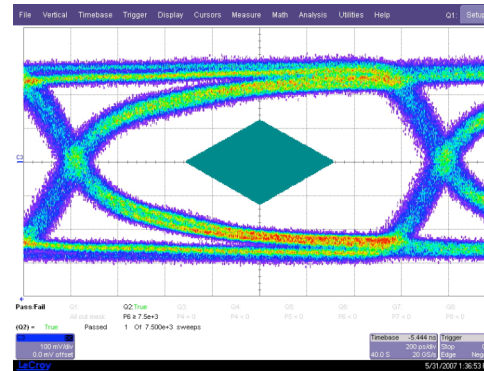
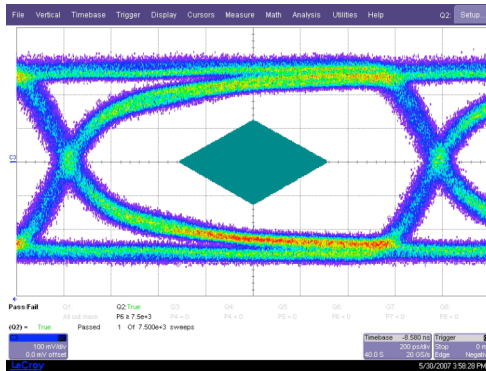
Eye Diagrams



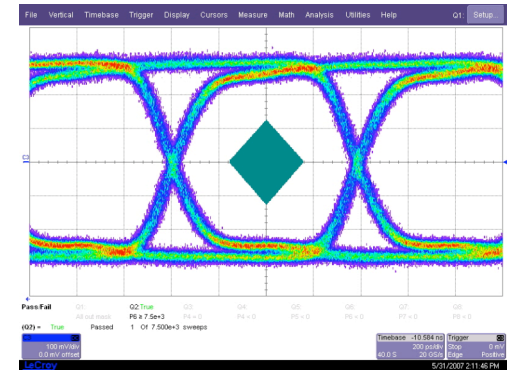
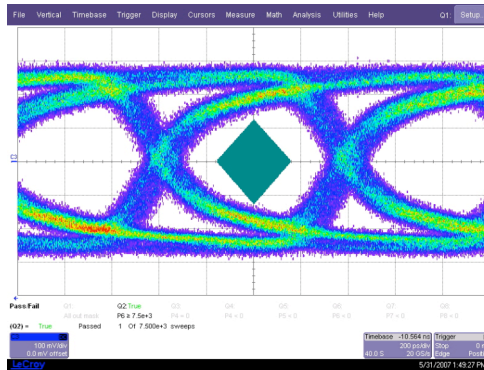
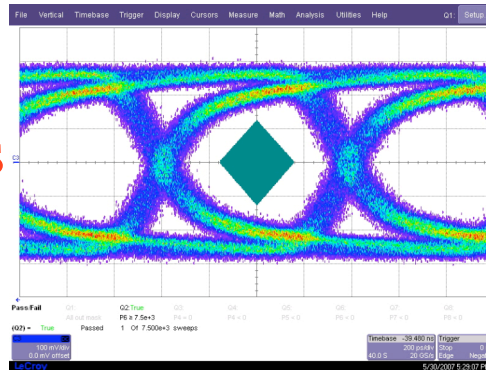
127 μm cable
140 cm

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



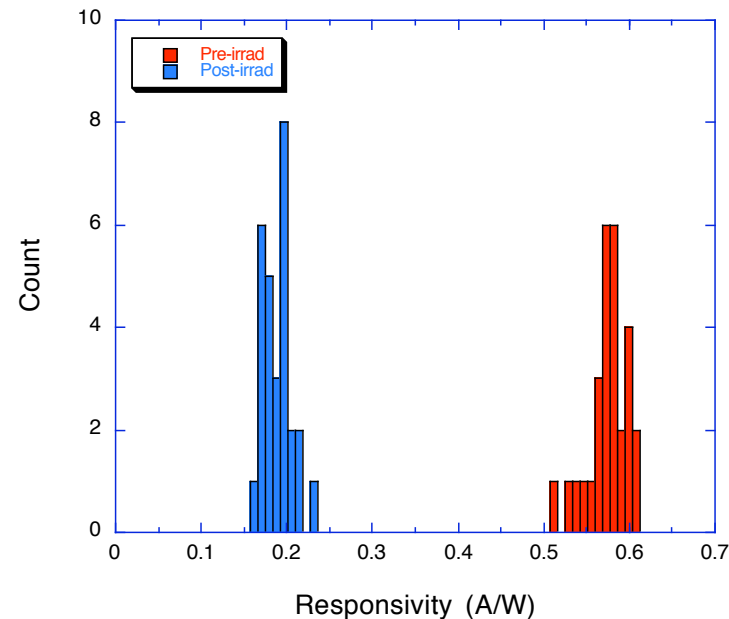
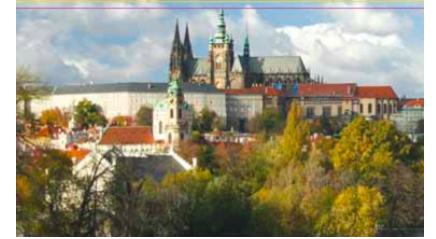
Radiation Level at SLHC



- Optical link of current pixel detector is mounted on patch panels:
 - ⇒ much reduced radiation level:
 - ◆ Si (PIN) @ SLHC (5,000 fb⁻¹):
 - 2.5×10^{15} 1-MeV n_{eq}/cm^2
 - 4.3×10^{15} p/cm² or 114 Mrad for 24 GeV protons
 - ◆ GaAs (VCSEL) @ SLHC:
 - 14×10^{15} 1-MeV n_{eq}/cm^2
 - 2.7×10^{15} p/cm² or 59 Mrad for 24 GeV protons
 - ◆ above estimates include 50% safety margin



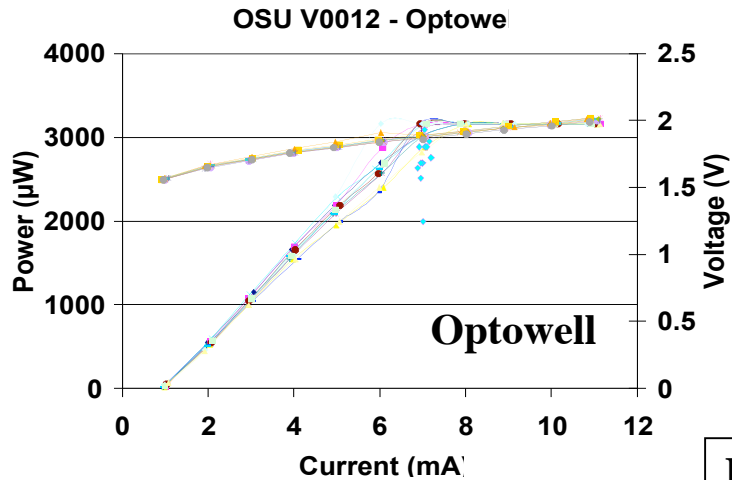
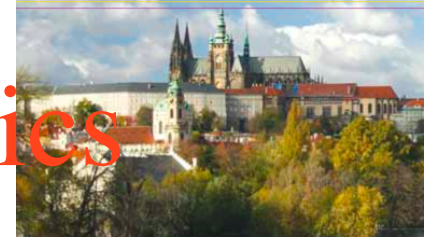
PIN Responsivity



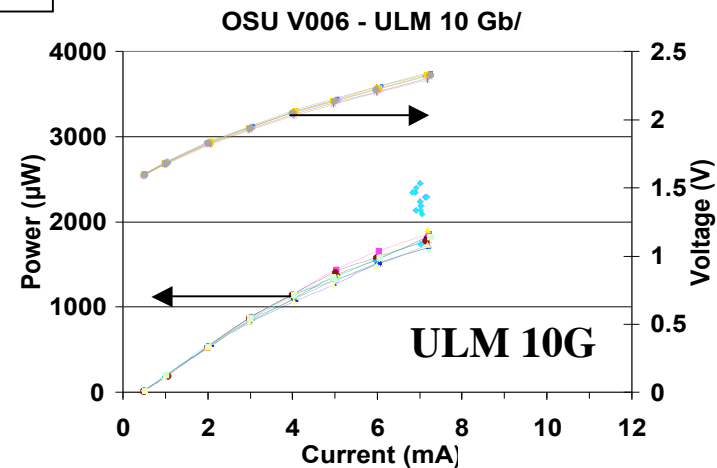
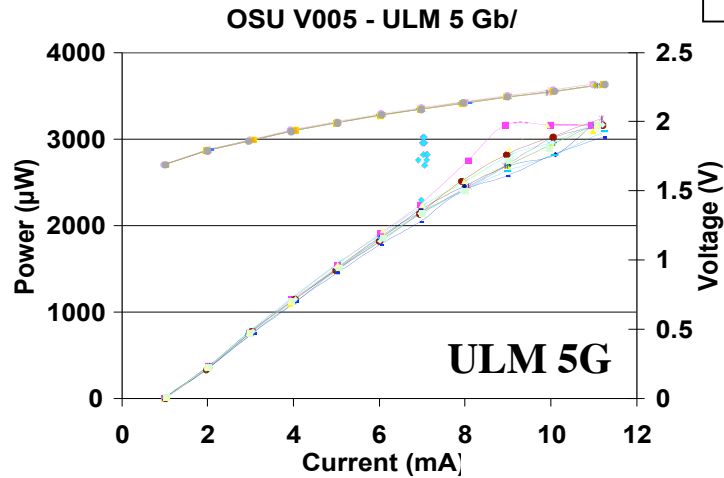
- Si PIN responsivity decreases by 65% after SLHC dosage
- completed irradiation of GaAs PIN from 3 vendors:
 - Optowell, AOC, ULM
 - responsivities will be measured next month



VCSEL LIV Characteristics



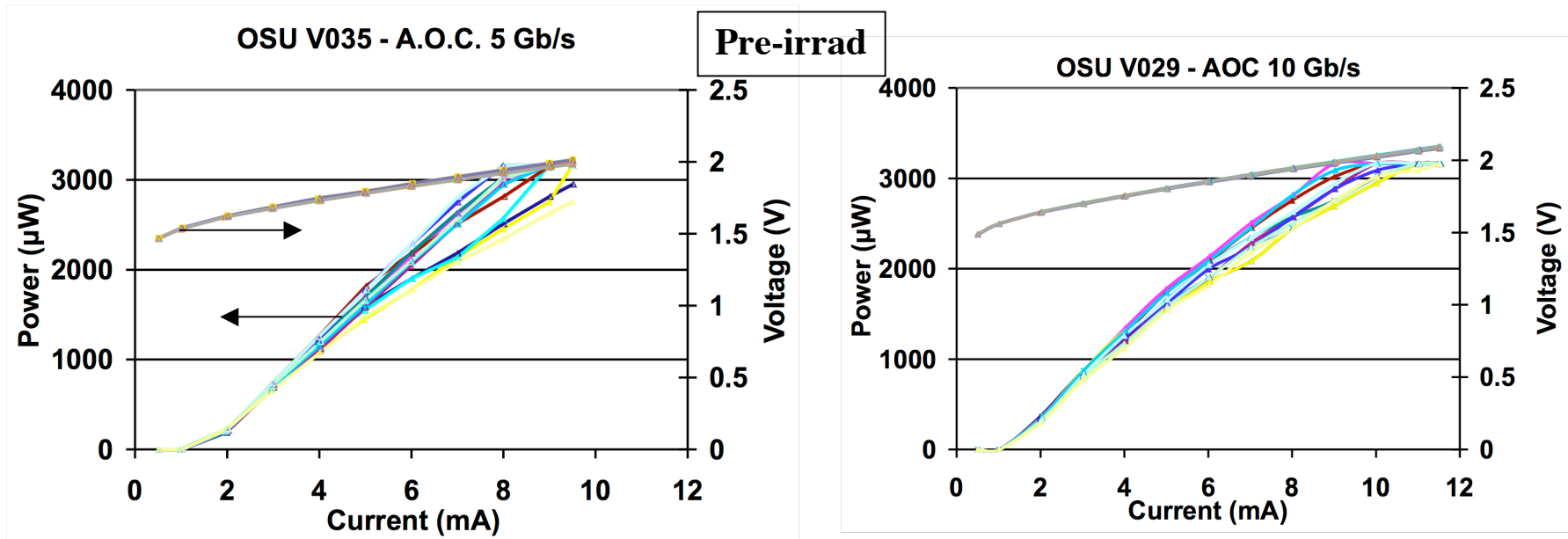
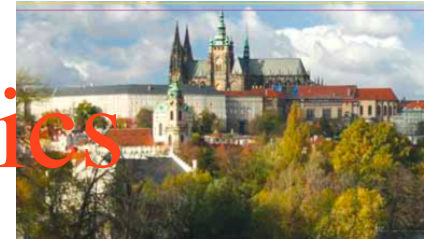
Pre-irrad



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



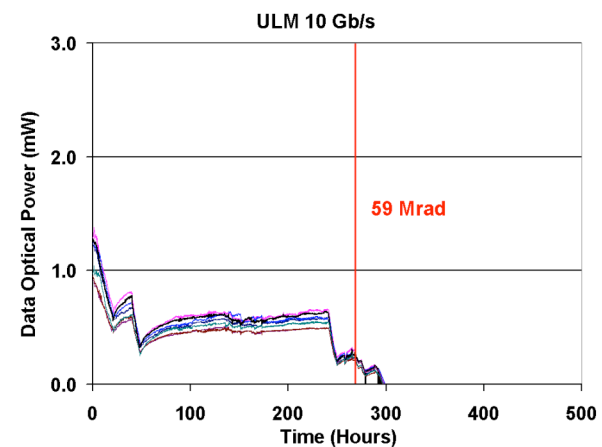
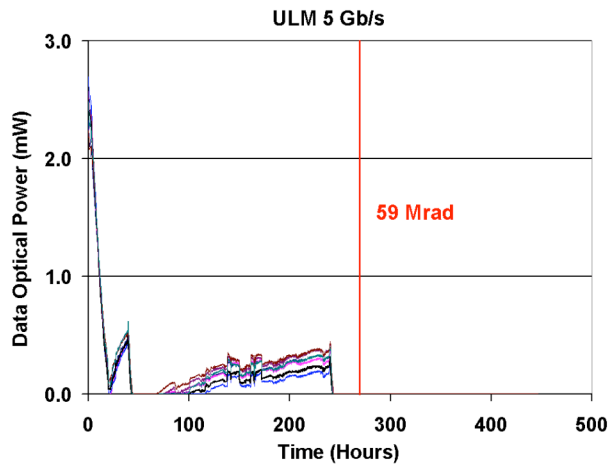
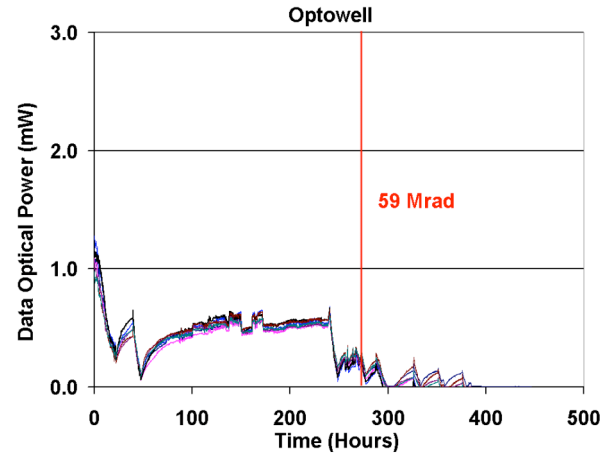
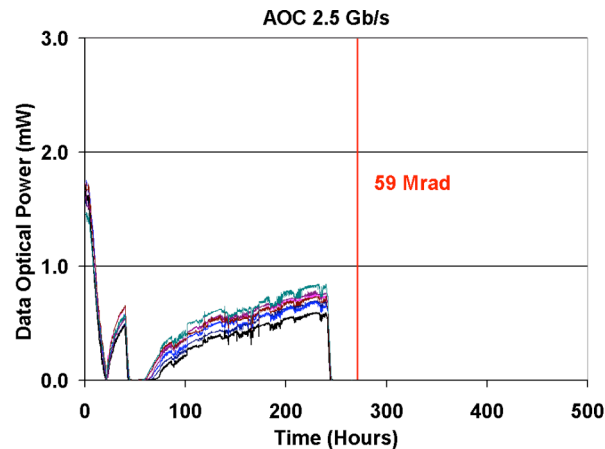
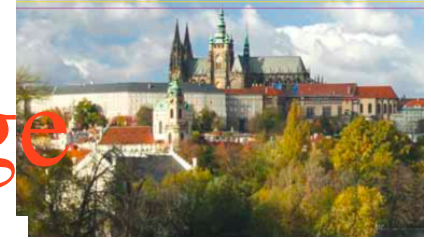
VCSEL LIV Characteristics



- both arrays have very good optical power



VCSEL Power vs Dosage

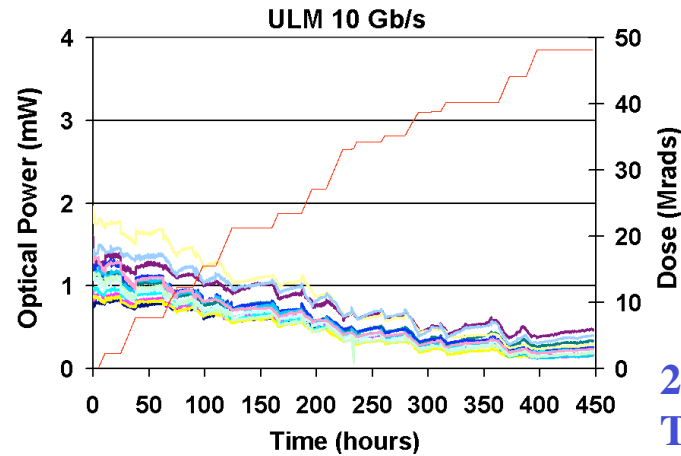
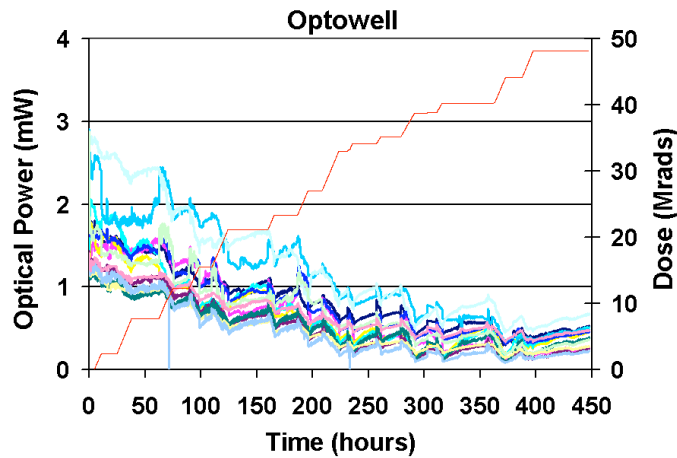
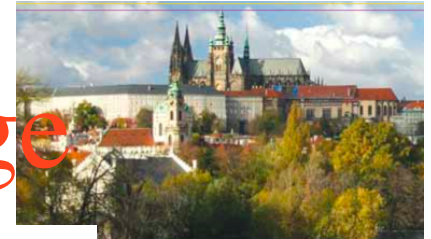


2006:
Two arrays each
(2 x 7 channels)

- Optowell & ULM (10 Gb/s) might survive to SLHC dosage
- more VCSELs might survive with lower intensity/more annealing

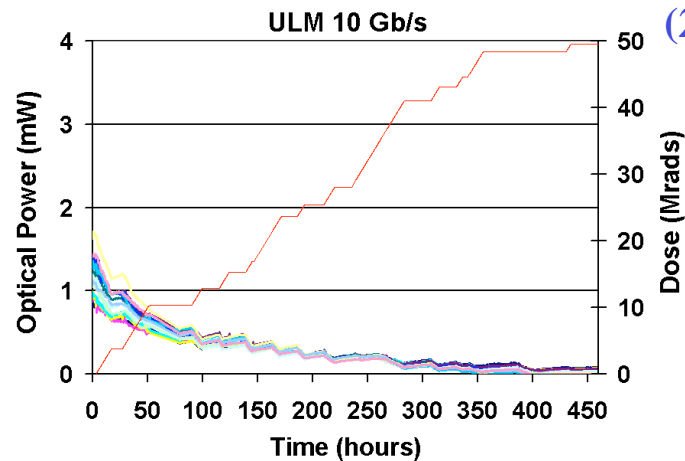
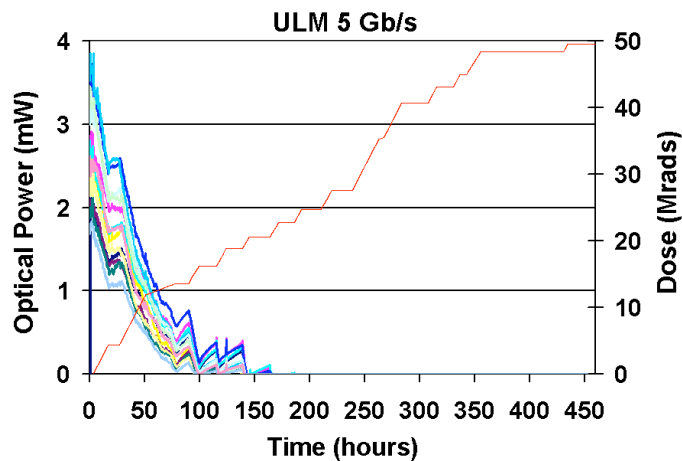


VCSEL Power vs Dosage



1st irradiation period

2007 preliminary
Two arrays each
(2 x 7 channels)

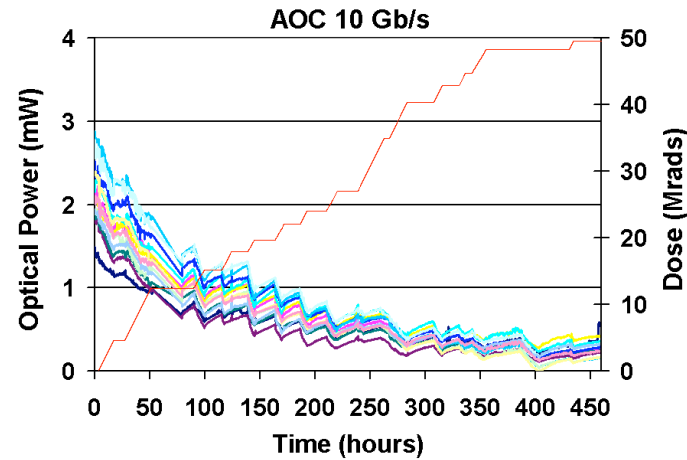
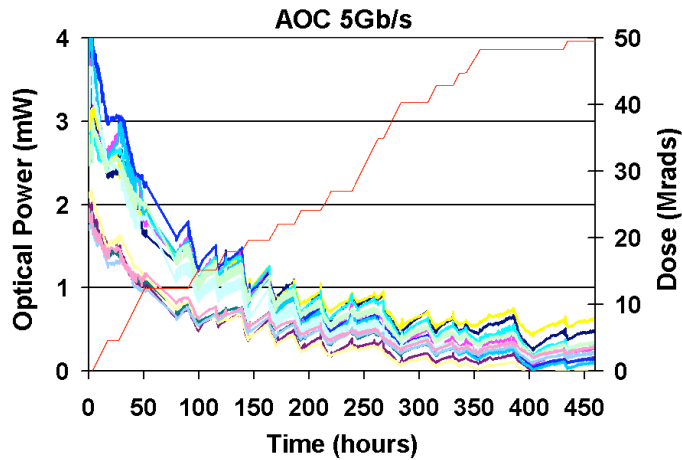
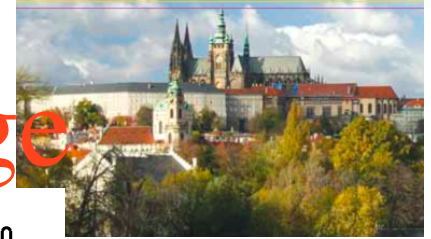


2nd irradiation period

- Optowell & ULM (10 Gb/s) might survive to SLHC dosage

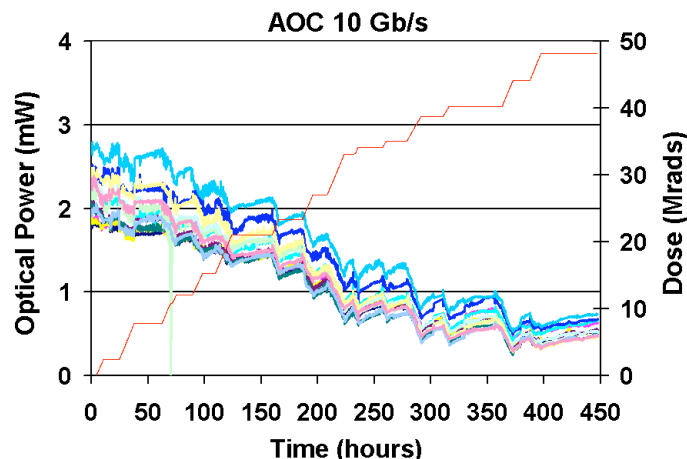
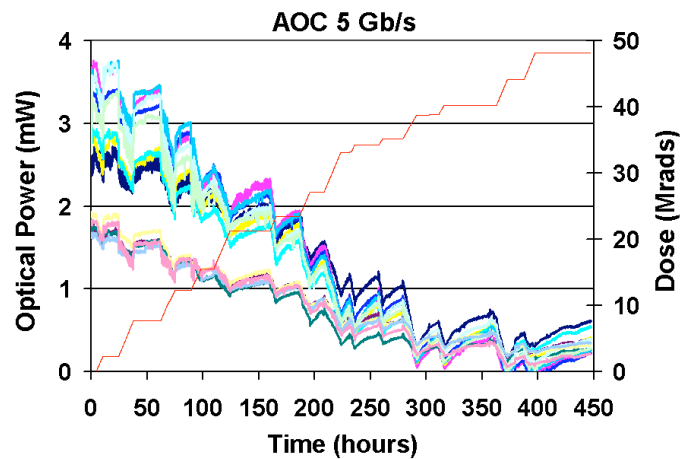


VCSEL Power vs Dosage



1st irradiation period

2007 preliminary
Two arrays each
(2 x 7 channels)

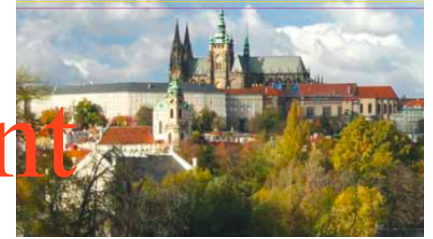


2nd irradiation period

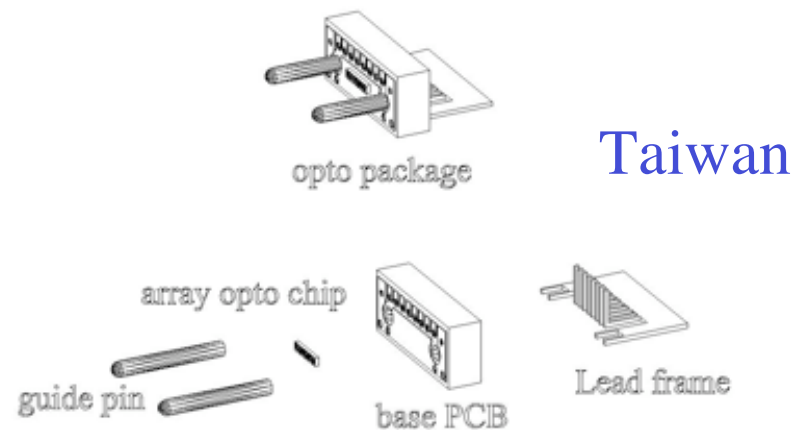
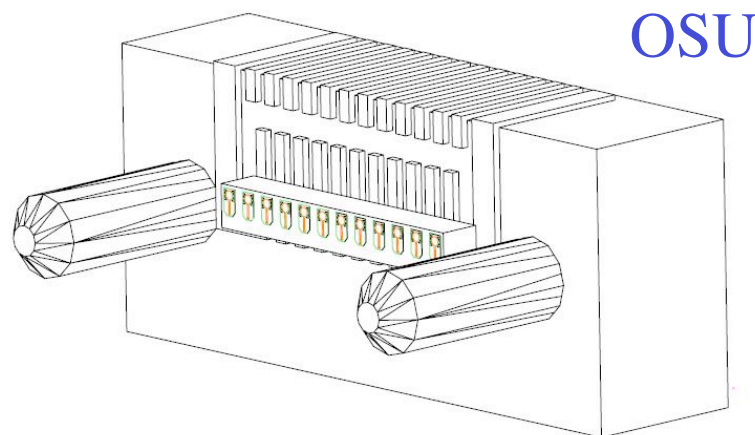
- AOC (5 & 10 Gb/s) might survive to SLHC dosage
- need further analysis after radiation cool down...



Opto-Pack Development

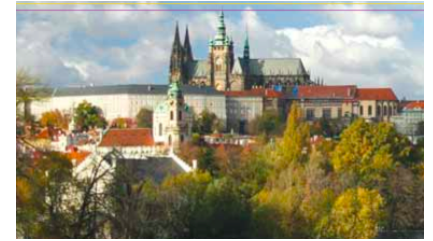


- current pixel detector uses Taiwan optical packages
 - ☹ VCSEL mounted on PCB with poor heat conduction
 - ☹ micro soldering of 250 μm leads is difficult
- Ohio State develops new opto-pack for SLHC
 - uses BeO base with 3D traces for efficient heat removal
 - wire bond to driver/receiver chip

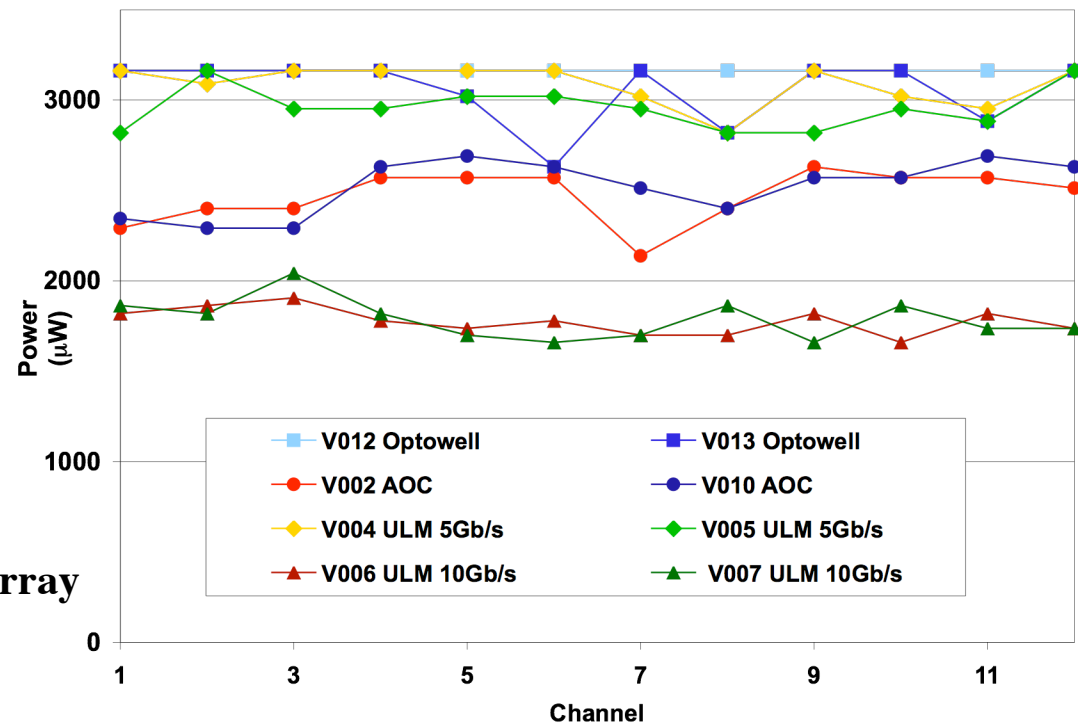
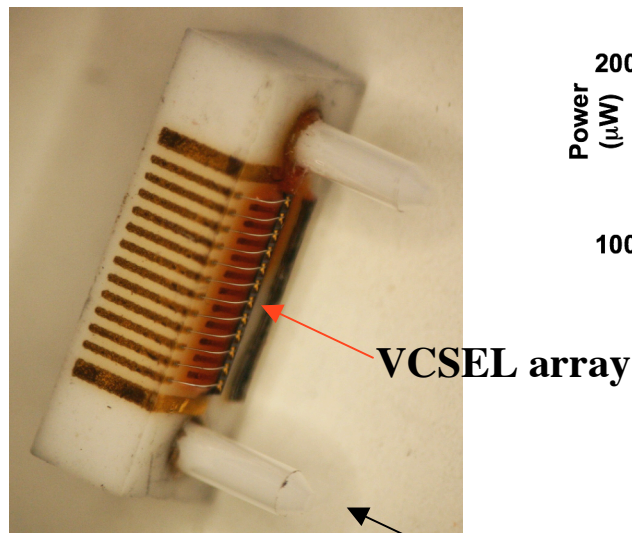
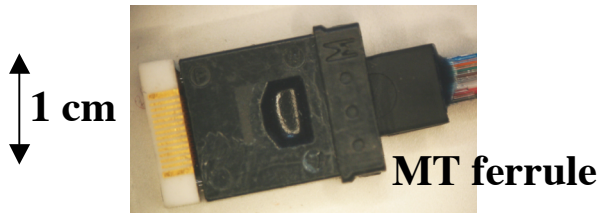




Results on Opto-Packs



- 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



- 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 responsivity decreases by 65% after SLHC dosage
- VCSEL from 3 vendors might survive to SLHC dosage
- ⇒ current opto-link architecture satisfies SLHC requirements
- compact MT-style opto-pack based on BeO has been developed