New Results on Opto-Electronics

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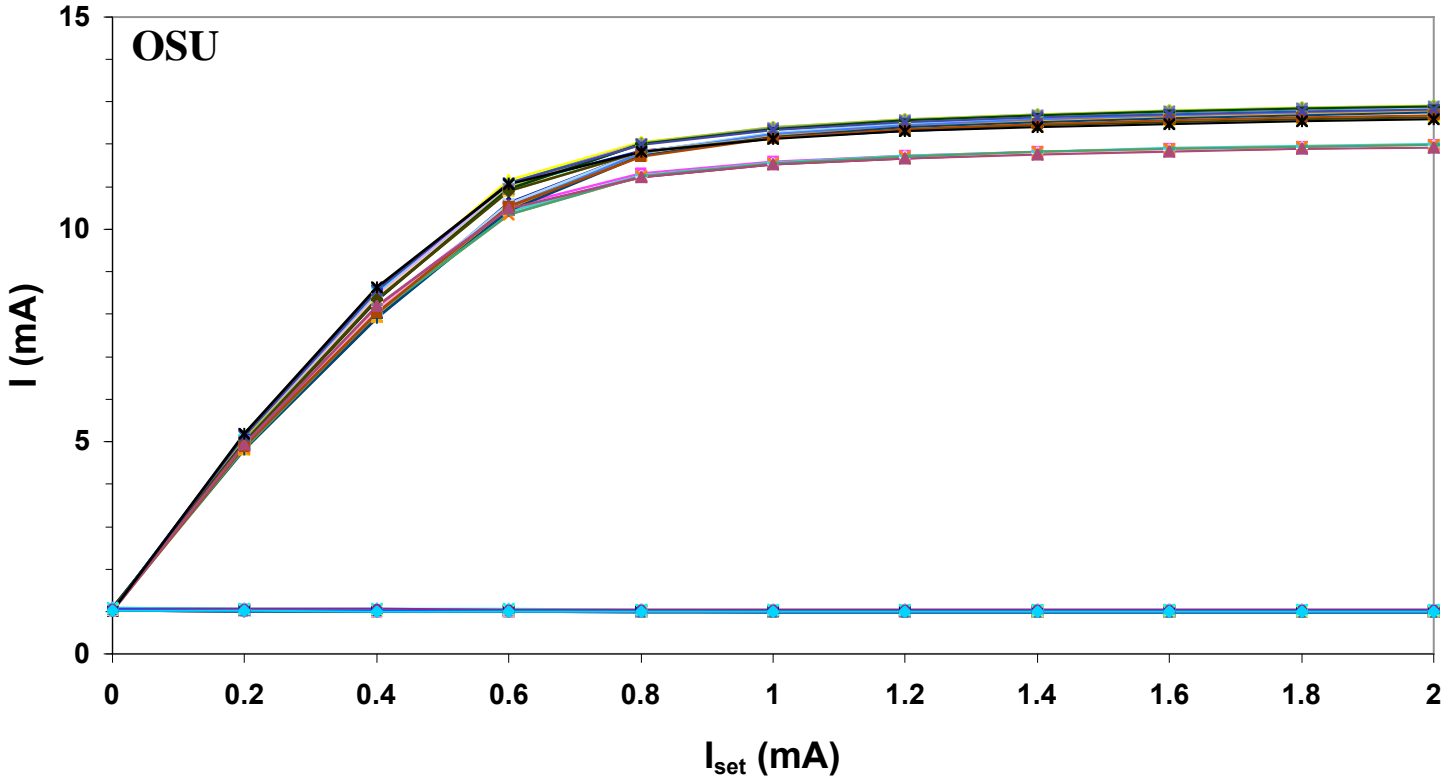
Outline

- Packaged VDC-I5e Results
- Opto-board Results with VDC/DORIC-I5e
- summary

VDC/DORIC-I5e: Engineering Run

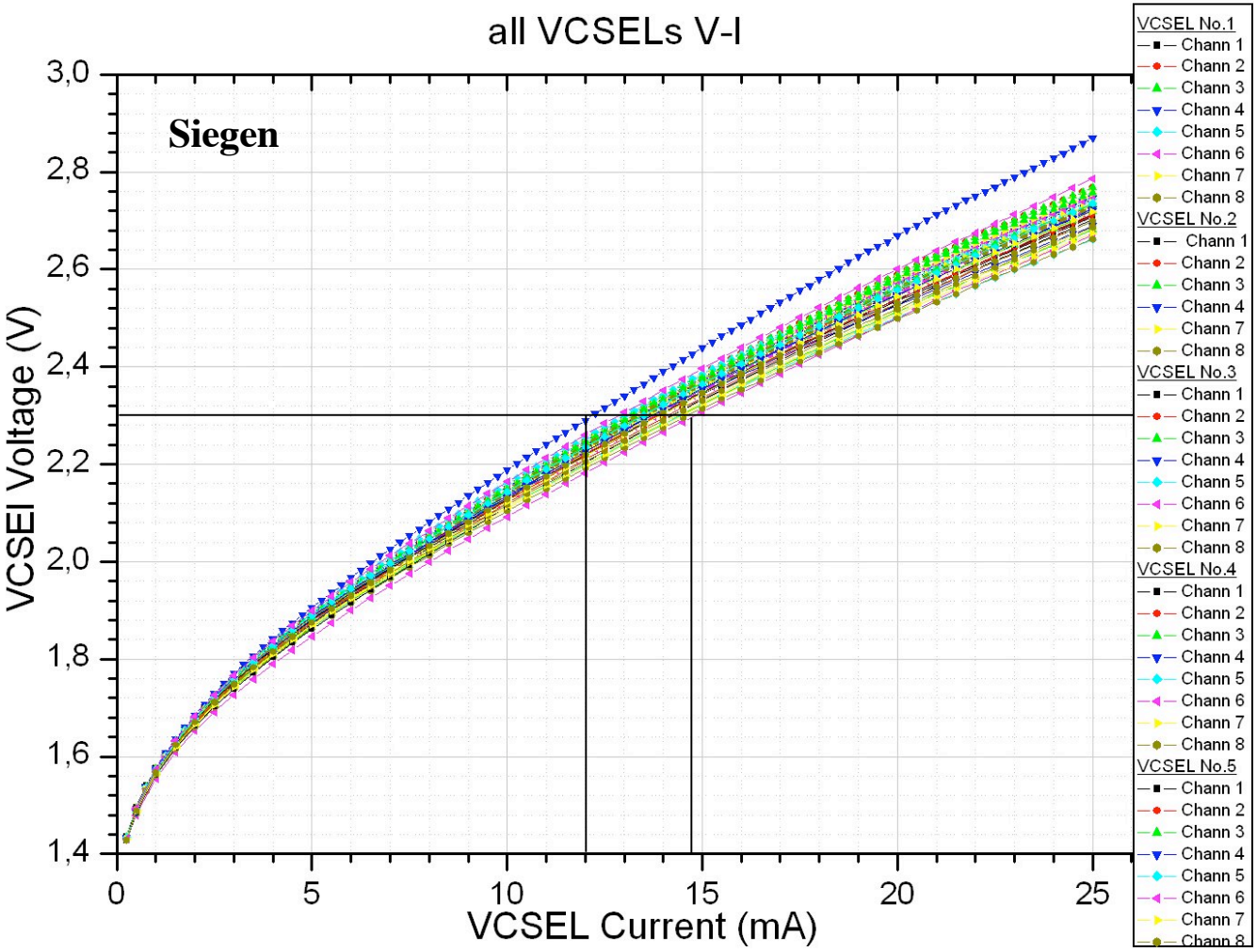
- convert from 3-metal to 5-metal layout
- minor improvements in DORIC
- submitted with MCC in April 2003
- dice delivered in June 2003
- this will be production run if successful

VDC-I5e: Bright and Dim Currents vs. I_{set}



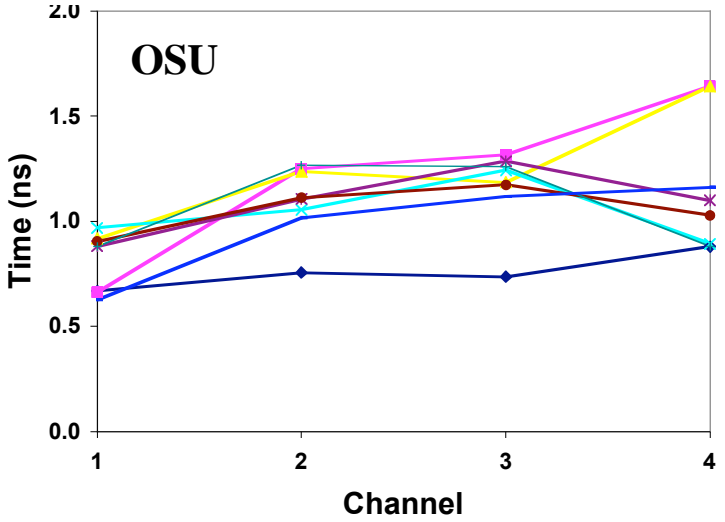
- dim current is ~ 1 mA as expected
- bright current measured with 1 Ω in series
- maximum bright current is ~ 13 mA

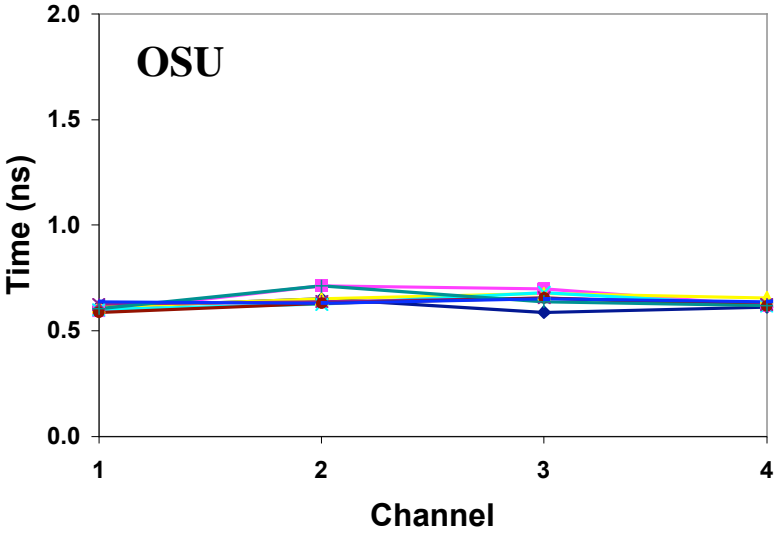
VDC-I5e: Maximum Bright Currents

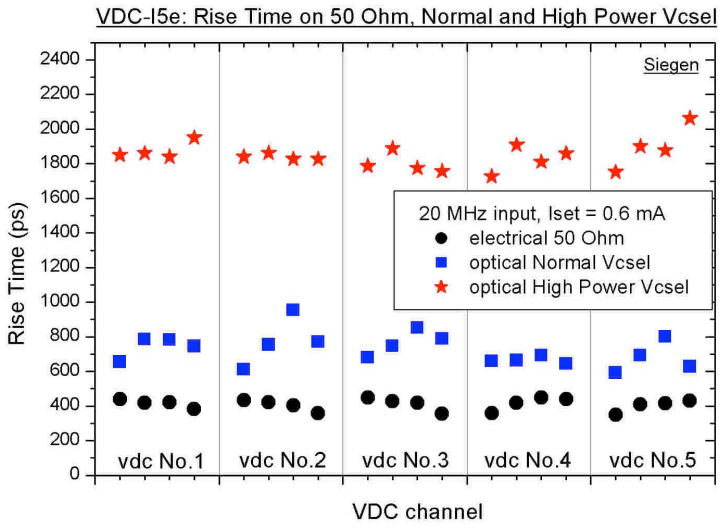


- maximum bright current is ~ 12-15 mA

VDC-I5e: Rise/Fall Time

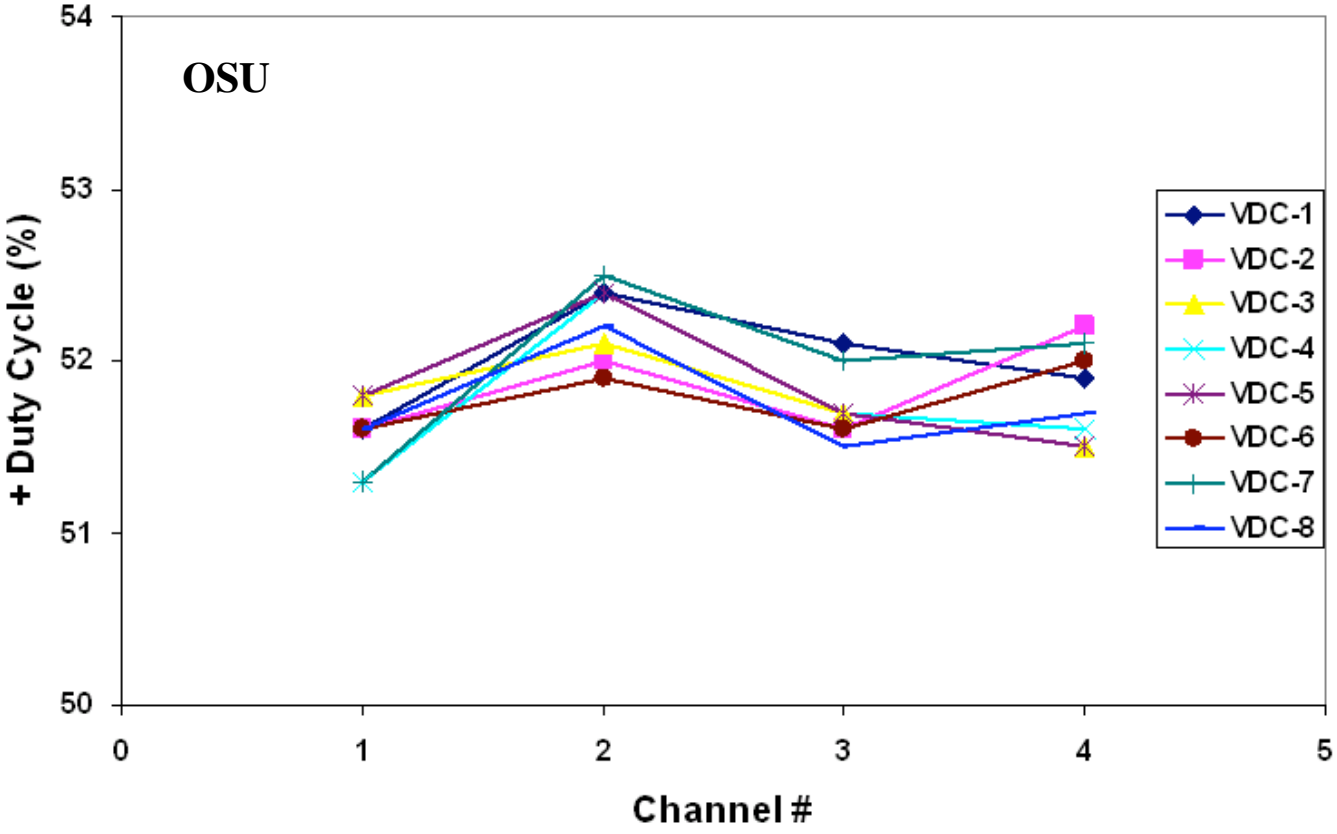






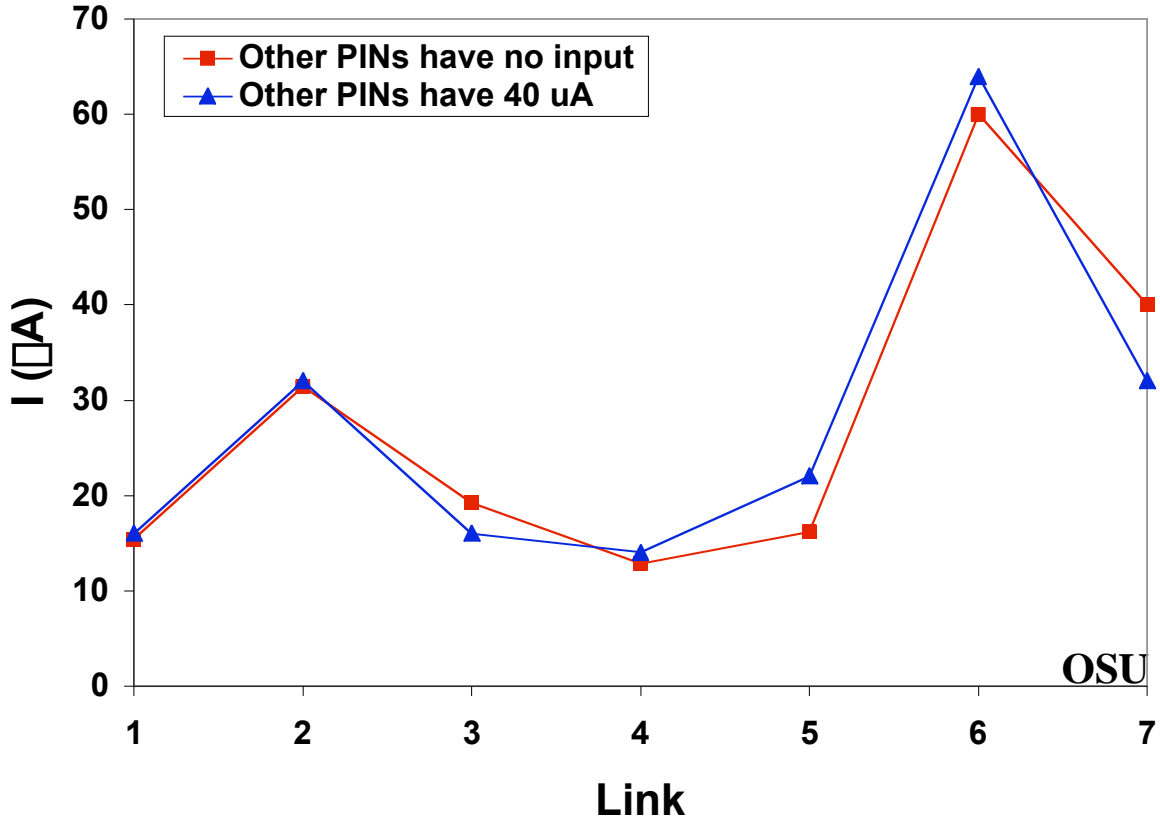
- fast rise/fall time:
  rise time < 2 ns
  fall time < 1 ns

VDC-I5e: Clock Duty Cycle



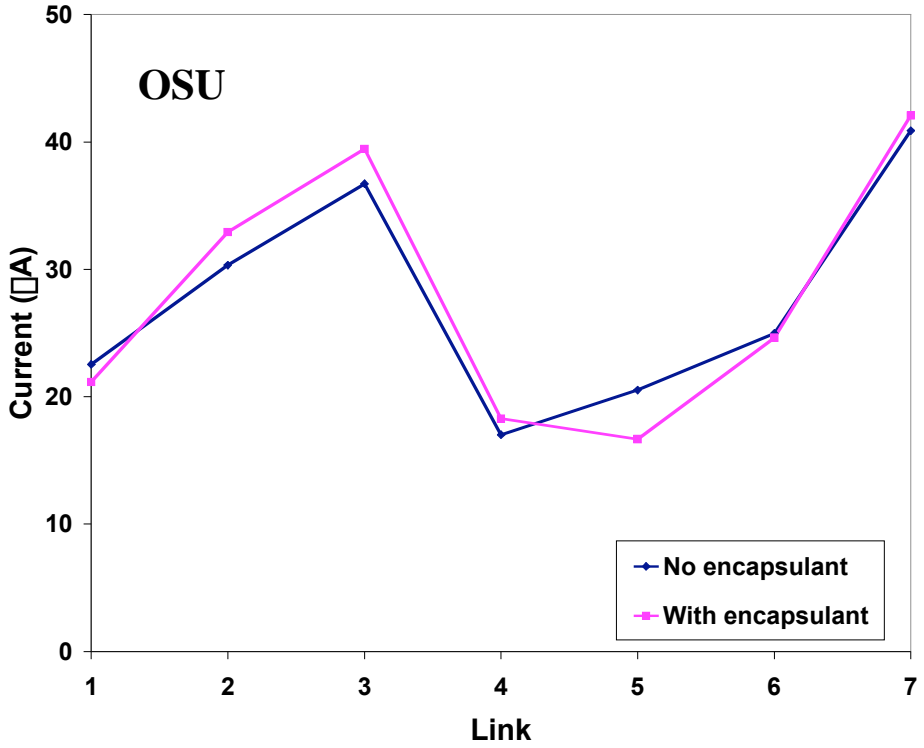
- clock duty cycle is close to 50%

PIN Current Thresholds with No Bit Errors



- thresholds measured with VDC/DORIC-I5e on BeO opto-board
- thresholds are independent of activity in adjacent channels
- channel with high threshold can be reduced to ~ 40 □A with 2 pF at noise-canceling input channel of PIN

PIN Current Thresholds with Encapsulant



- Epotek 353ND used as optical epoxy to encapsulate wire bonds on VCSEL/PIN arrays and irradiated with 24 GeV to ~ 30 Mrad in last few years
- use same epoxy to encapsulate wire bonds on VDC/DORIC
  - ⇨ no degradation in PIN current thresholds for no bit errors
  - ⇨ no degradation observed in this year irradiation (see later talk)

Summary of VDC/DORIC-I5e

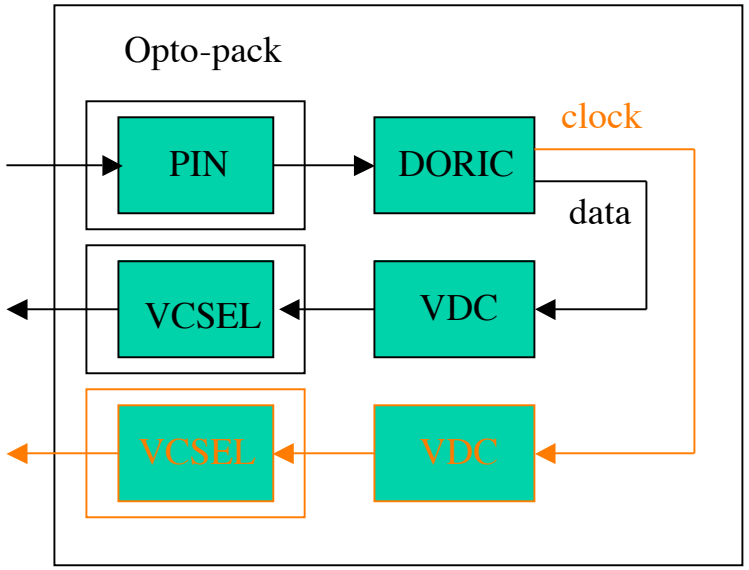
- VDC and DORIC from engineering run are acceptable for use in opto-board production

Status of BeO Opto-board

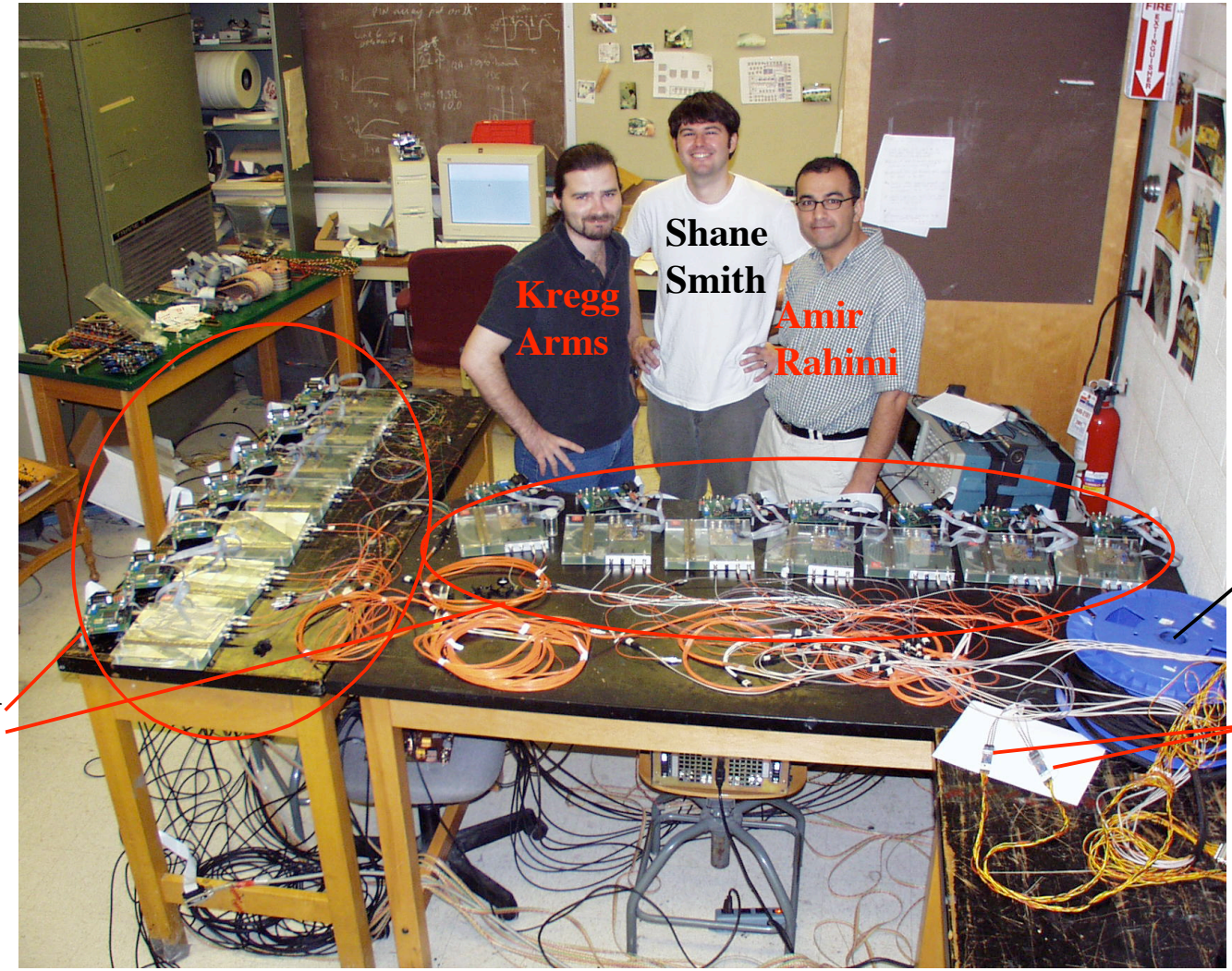
- CPT has been chosen as new vendor
- layout is now in progress
- prototype submission: early next week
- delivery: November

Proton Irradiation at CERN

- use 24 GeV protons at T7
- cold box: irradiate 4 VDC-I5e and 4 DORIC-I5e with no optical components
- shuttle: irradiate 4 opto-boards

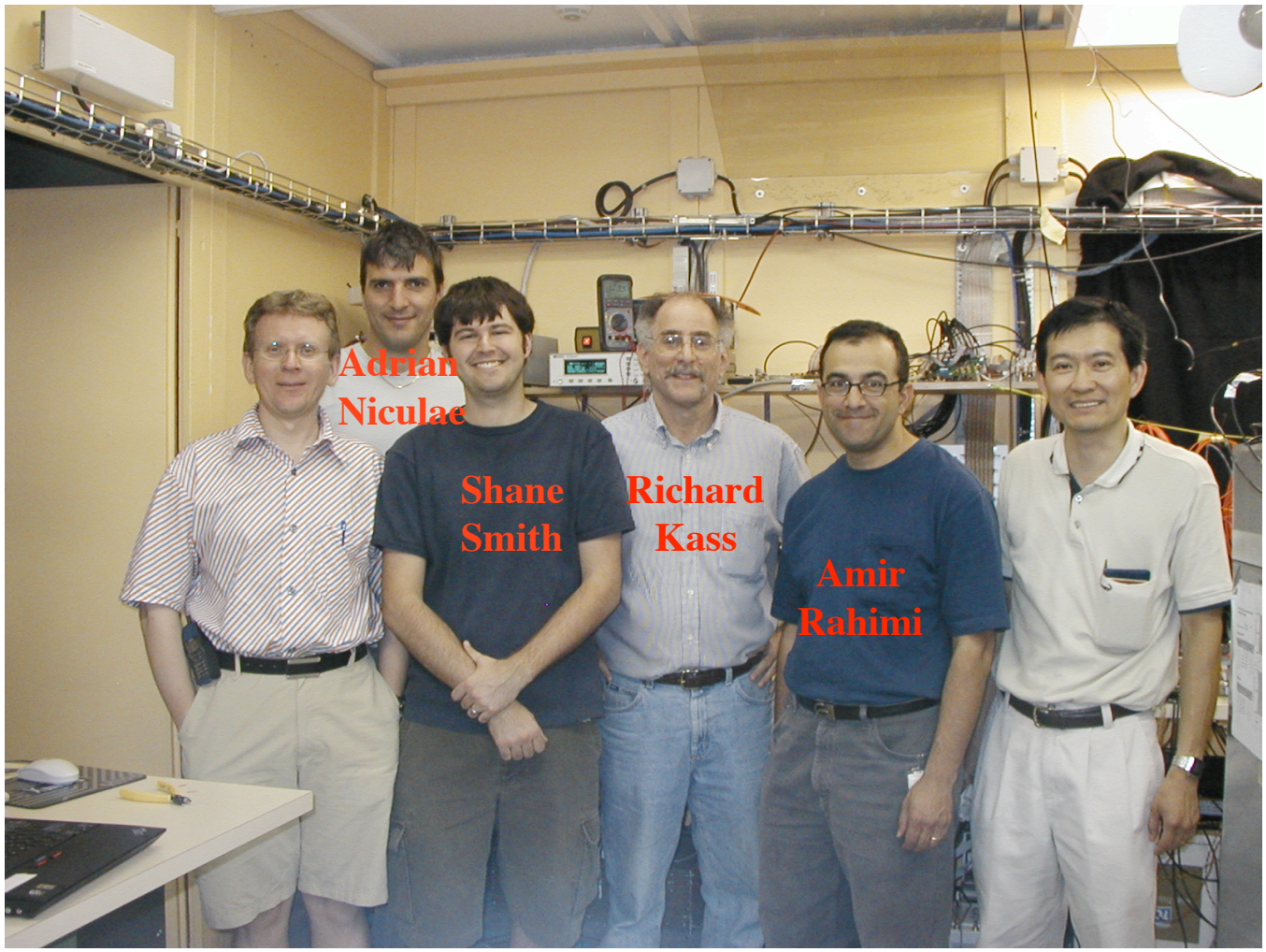


Shuttle Test System



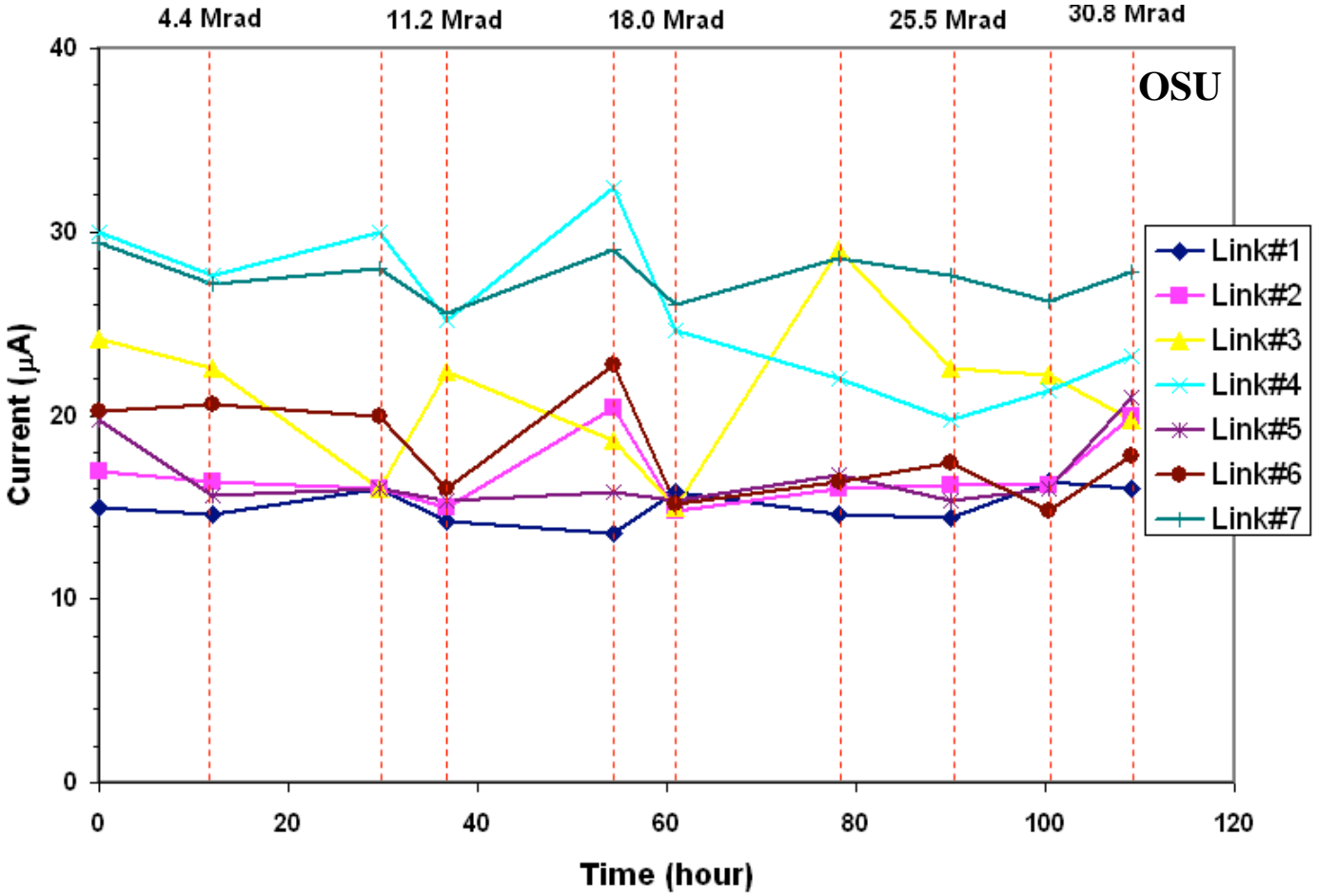
It took 15 man-hours to pack the cold box and shuttle test systems for CERN…

Irradiation Crew



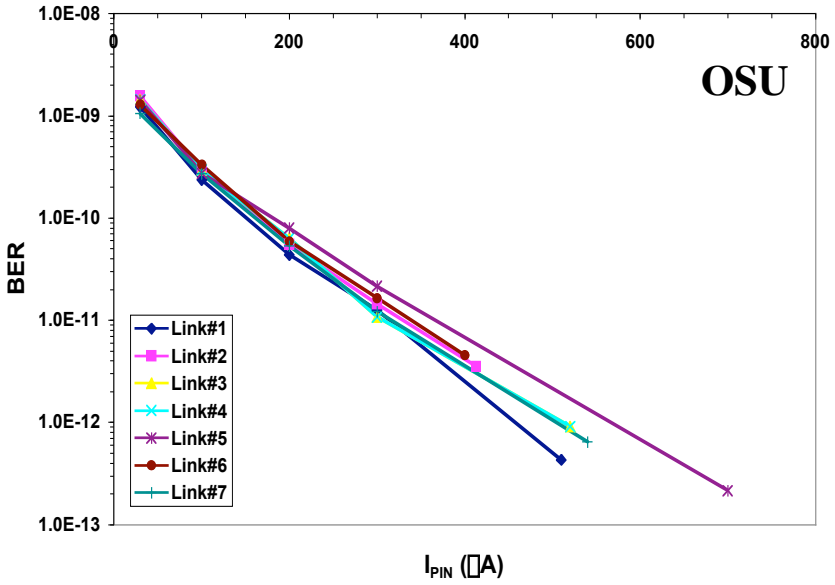
With special thanks to Petr Schio and Maurice Glaser…

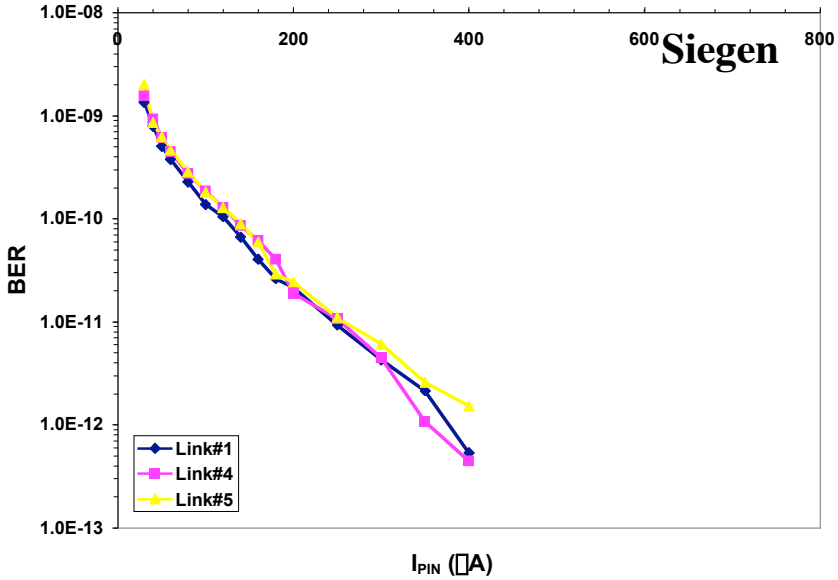
PIN Current Threshold vs Dosage



- PIN current thresholds for no bit errors remain constant

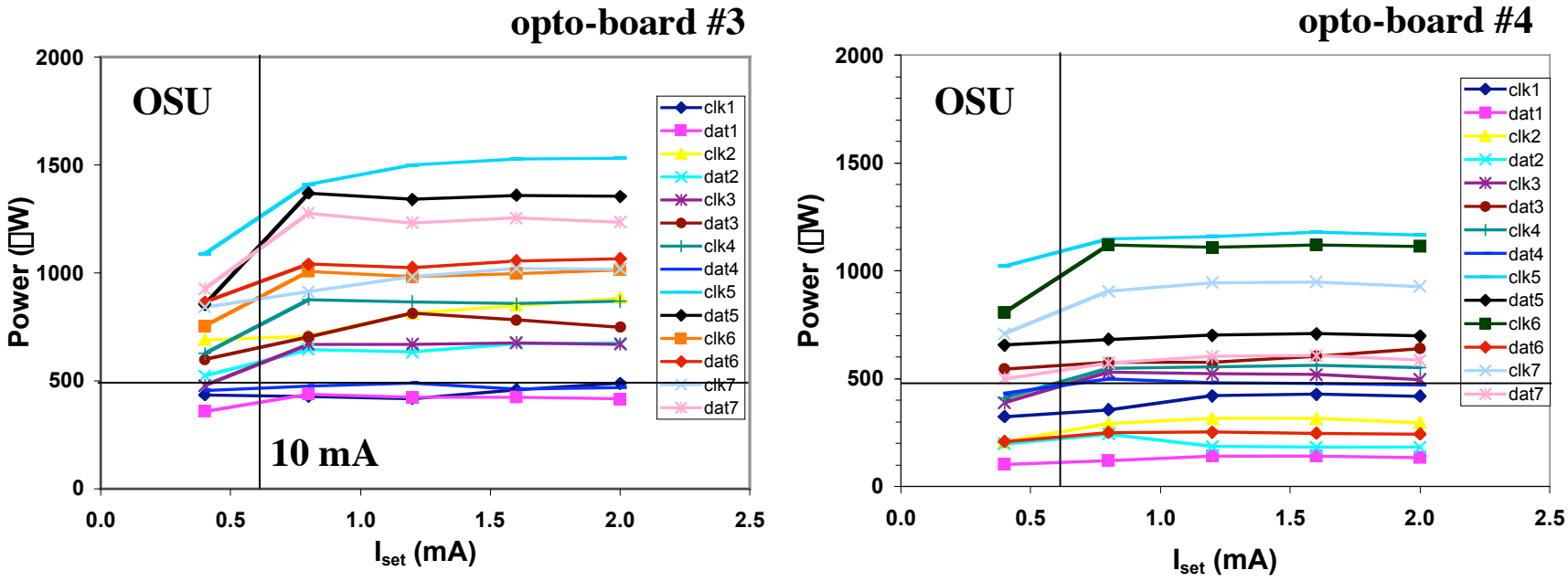
Proton Induced Bit Errors in PIN





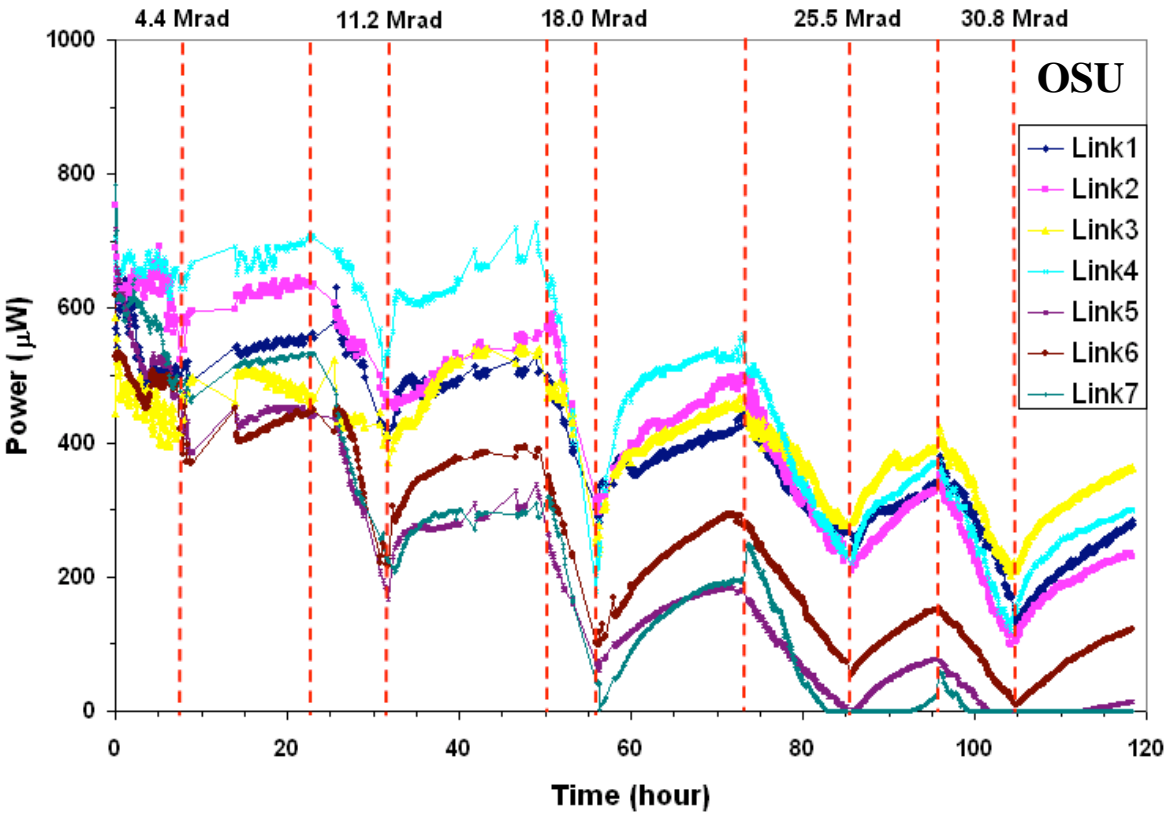
- observed bit errors has been converted to above bit error rate for PP0
- bit error rate decreases with increasing PIN current as expected
- bit error rate ~ 3 x 10^{-10} at 100 μA
  - DORIC spec: 10^{-11}

Optical Power vs I_{set} before Irradiation



- significant number of links have power below 500 □W
- some links have power as low as 100 □W
- higher VCSEL current yields 10-30% higher power

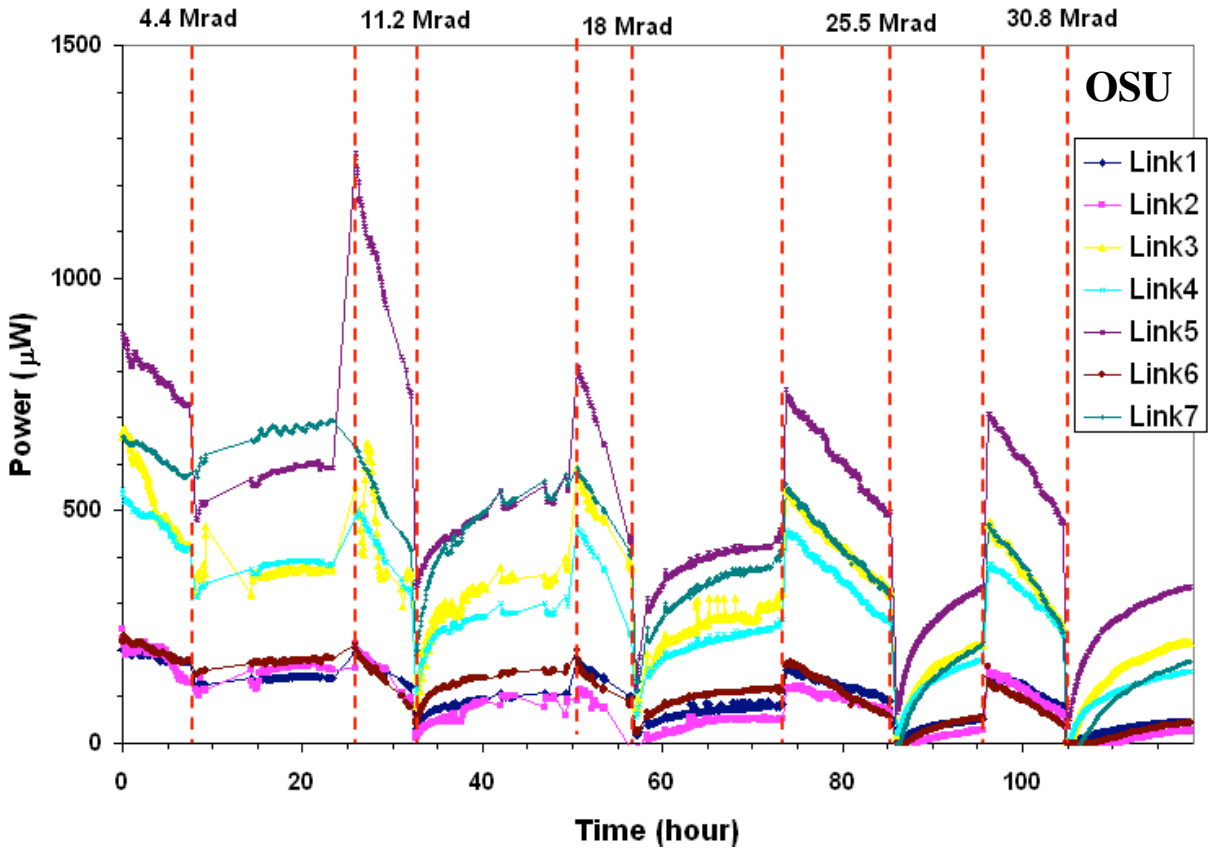
Clock Optical Power vs Dosage



BeO #3

- power decreases with dosage as expected
- annealing at ~ 13 mA recovers some lost power

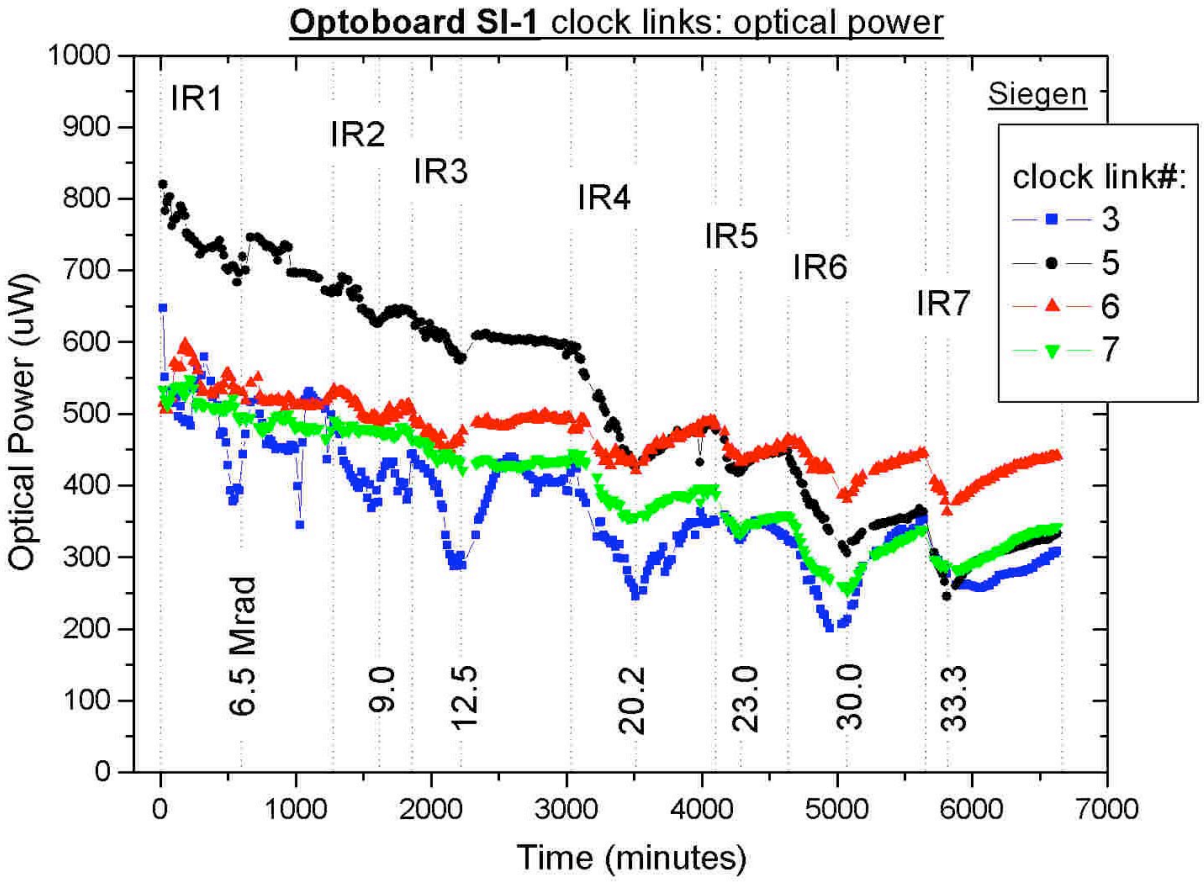
Data Optical Power vs Dosage



BeO #4

- some links lost all power after ~ 11 Mrad

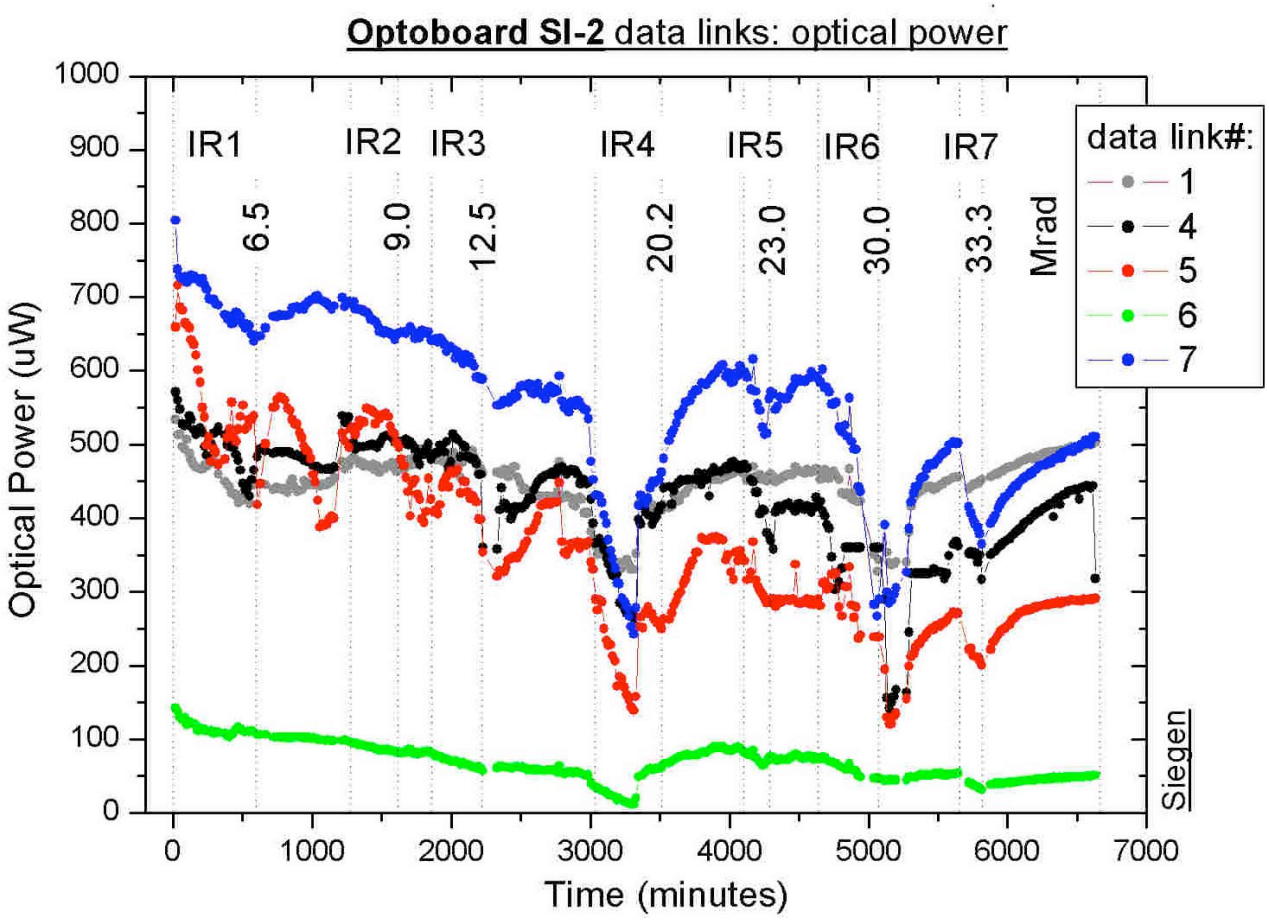
Clock Optical Power vs Dosage



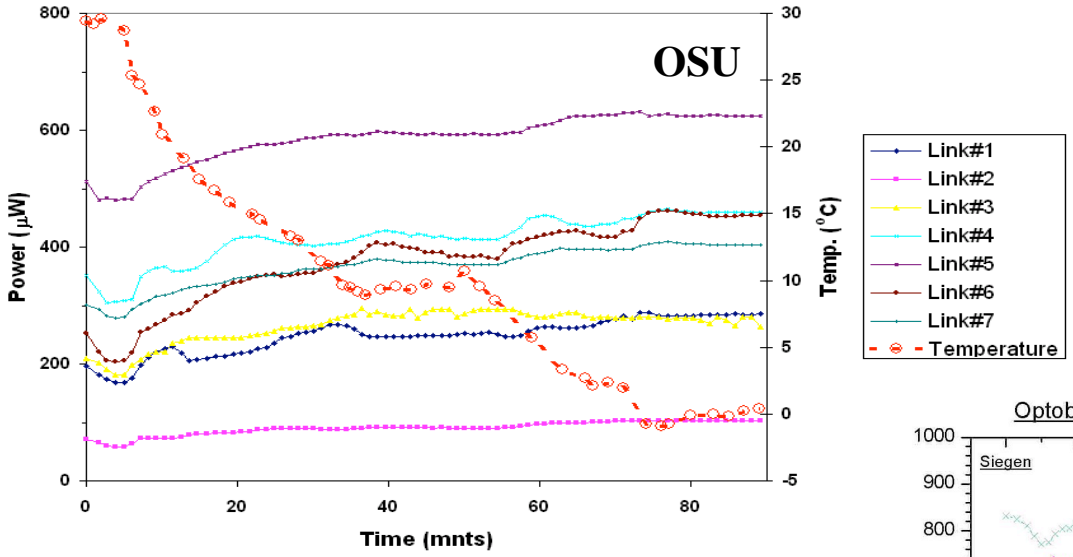
- sent all high data to Siegen opto-boards vs pseudo-random data to OSU opto-boards during irradiation

⇨ lower rate of power lost in Siegen opto-boards

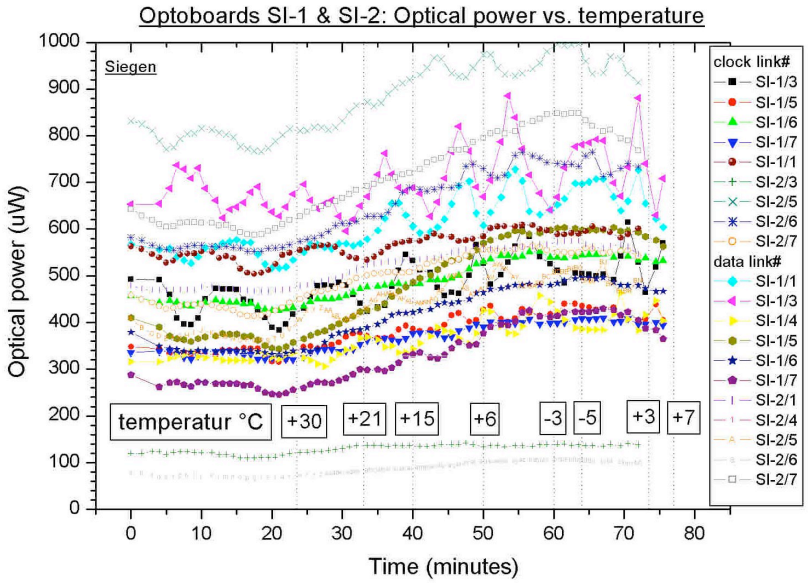
Data Optical Power vs Dosage



Optical Power vs Temperature

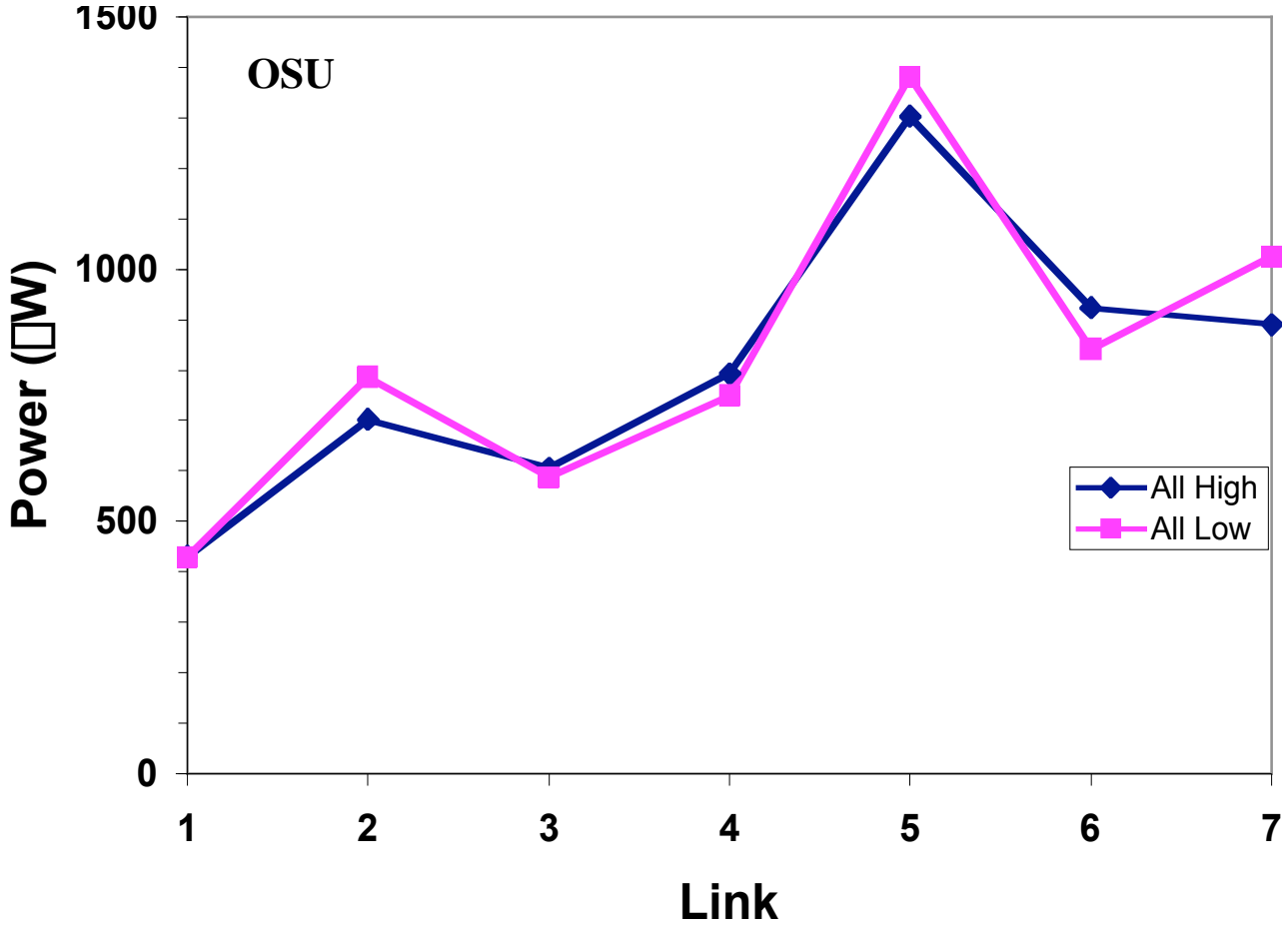


Siegen



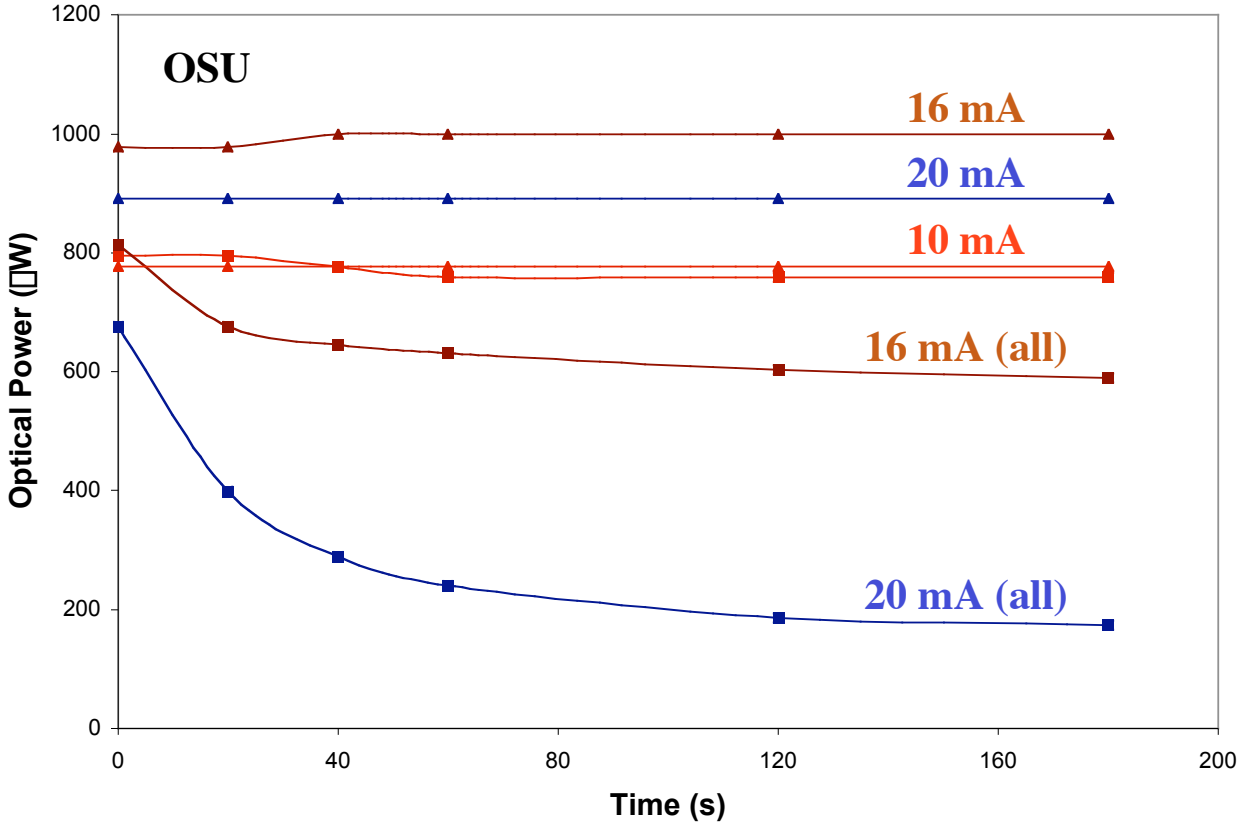
- cooling opto-board increases optical power by 10-30%

Optical Power with All Channel On or Off



- total current in VCSEL array differs by ~ 3 x between all on and off but no difference in power is observed

Optical Power vs Time



- VCSEL connected to power supply via resistor instead of VDC
- optical power with all channels powered decreases with time due to heating
- good power at 10 mA in above test with opto-pack attached to FR-4
- low power at 10 mA on opto-board with opto-pack attached to BeO

Optical Power Crisis/Plan

- all four BeO opto-boards have links with power below 500 μW
  - some links have power as low as 150 μW
  - power lost due to heating of VCSEL array?
- need more systematic study of heating/cooling
  - any correlation between IV curve and optical power???
  - what is the temperature on VCSEL array?
  - correlation between optical power and unirradiated opto-board temperature
  - can optical power be increased with thermal conductive gel on VCSEL array?
  - any correlation of optical power before and after mounting on opto-board?
  - need to build ~ 10 opto-boards to understand acceptant criteria/yield
- optical power spec of 500 μW minimum on opto-board is probably unachievable

  ⇨ go back to spec of 300 μW before the era of high-power VCSEL array?

Summary

- no significant degradation of VDC/DORIC-I5e up to 55 Mrad
- PIN current threshold for no bit errors remains constant up to 30 Mrad
- observed significant optical power lost during irradiation
  - need more time for annealing to see if VCSEL can fully recover
- minimum power requirement of 500 □W on opto-board is difficult to achieve
  ⇨ need more systematic study of heating/cooling