Status of Opto-board Production

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Outline

- History
- Prototype results
- Status of opto-boards production
- 2004 irradiation results
- Summary

History

- Fabricated with BeO for heat management
  - initial prototype with FR4 for fast turn around and cost saving
- Two prototype runs with Hybrid Source:
  - 1st run: open vias
  - 2nd run: shorts due to overfilled vias
    - No known design error in the layout

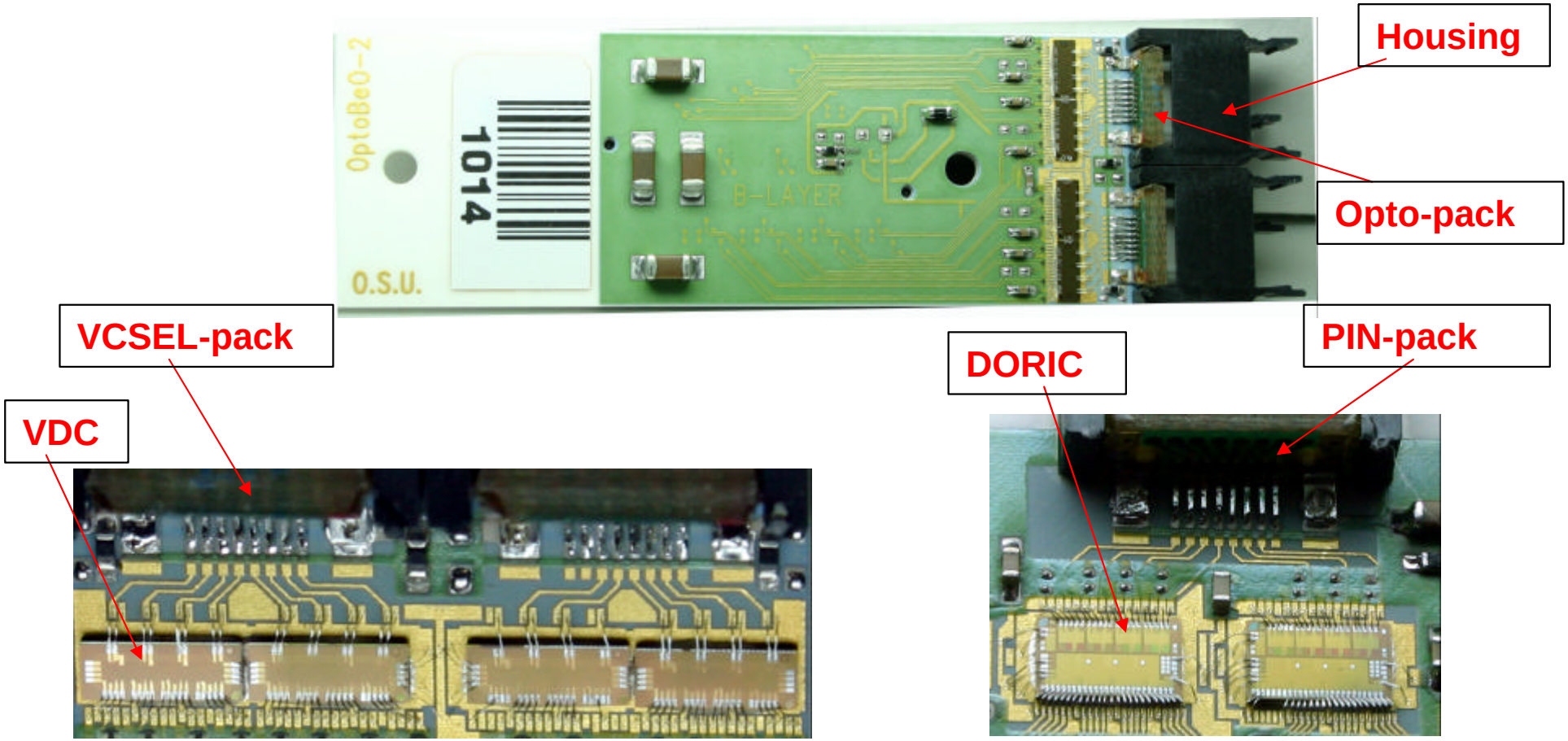
➢Use more experienced/expensive vendor (CPT)

Summary of 1st CPT Prototype

- 28 boards were delivered
  - Equal number of B and Disk layers
  - Populated opto-boards have low noise and good optical power
    - no known circuit design error
  - Very important for improving assembly procedure
    - Decided to solder one lead at a time
    - **Built the last seven boards with 100% yield**
  - A few SMD's detached from three boards
    - Removed the wire-bondable gold under the solderable pads in the next proto-type run
    - Decided to order a production run instead of another proto-type run
      - Would save ~$5K if successful

BeO Opto-board

- 80 B-layer opto-boards were delivered in October

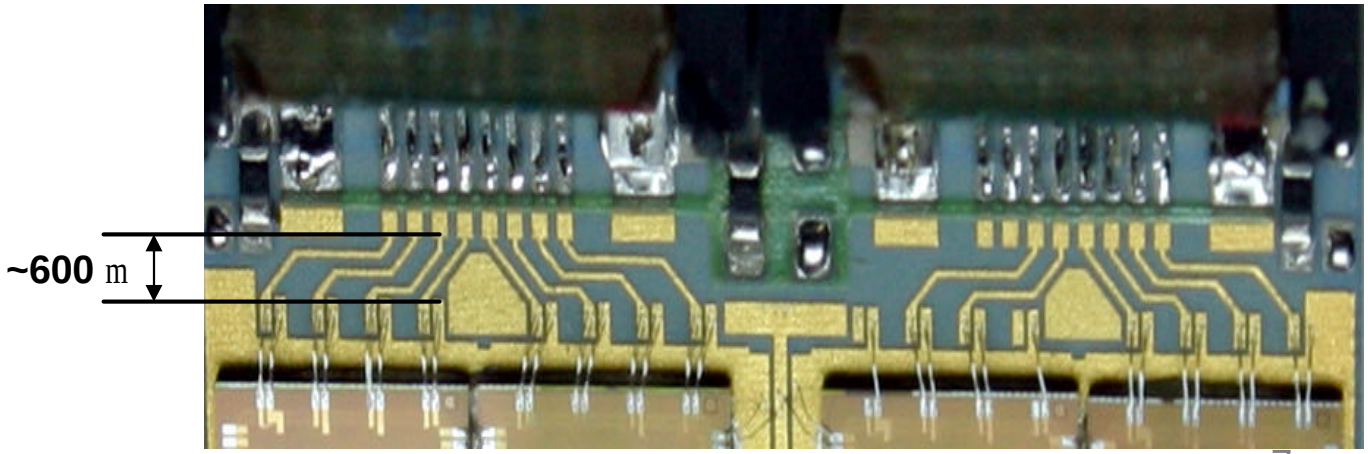


Big Improvement in Quality of Solder Joints

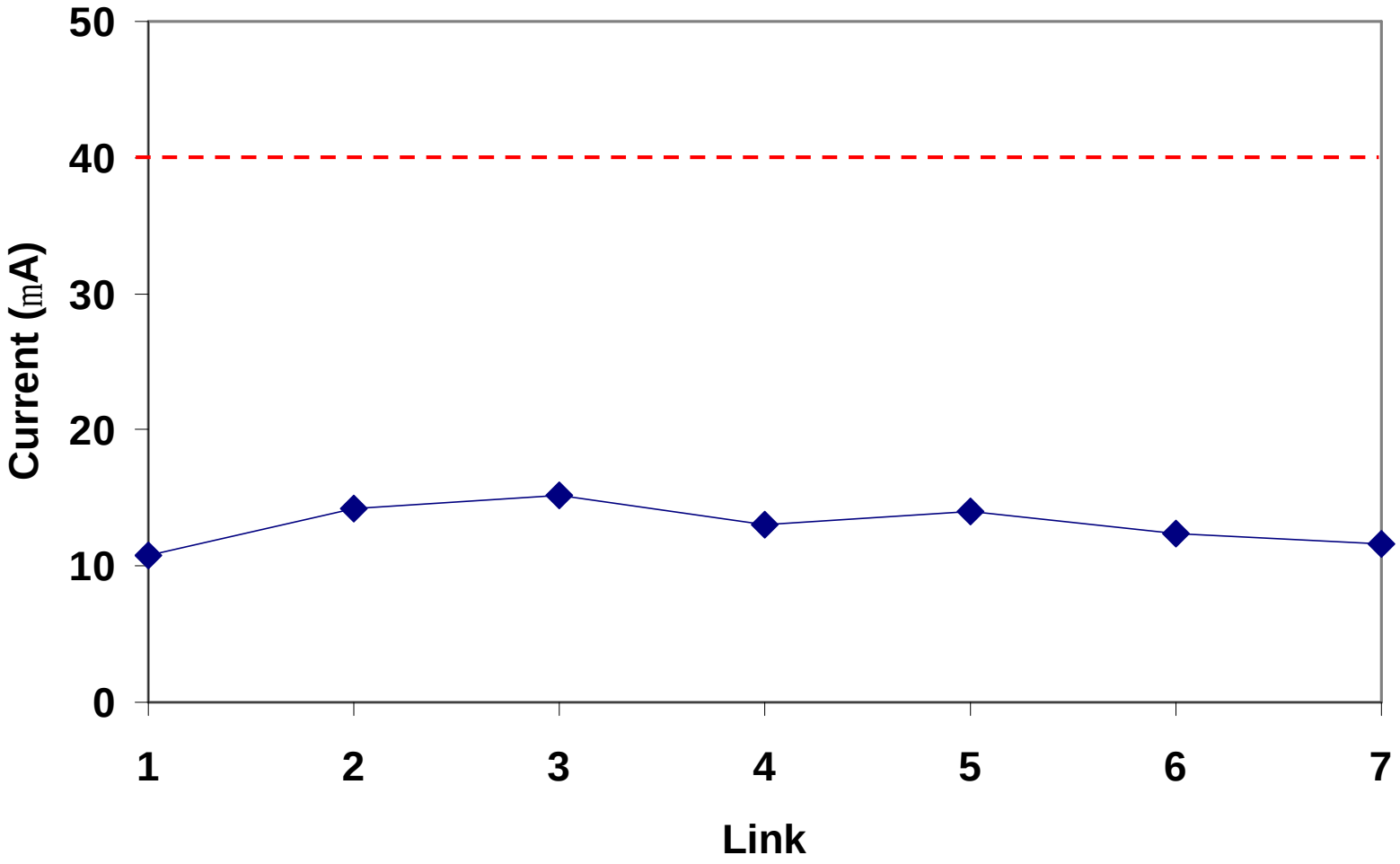
- No peeling of opto-pack solder traces
- The quality of SMD solder joints were greatly improved
  - The quality of solder joints of the 80-pin connector now looked poor in comparison
    - Decided not to remove the wire-bondable gold under the solder pads because at the time the solder joints looked acceptable
  - ➢ Will remove wire-bondable gold in the production run

How We Solve the Masking Residue Problem

- **Problem**: Occasionally some residue remains after we peel off the mask used for protecting the VDC's, DORIC's and wire-bond traces, even with the recommended high power UV light/short curing time
- To achieve required wire-bond surface cleanliness, remove the residue using isopropyl alcohol and DI water
  - But, first apply a thin layer of mask on the opto-pack leads to prevent remaining soldering flux seeping over the wire-bond pads
  - Clean the residue mask/flux on the chips and wire-bond pads
  - Remove the mask on the opto-pack leads
  - Wire bond
  - ➢ **Excellent pull strength**

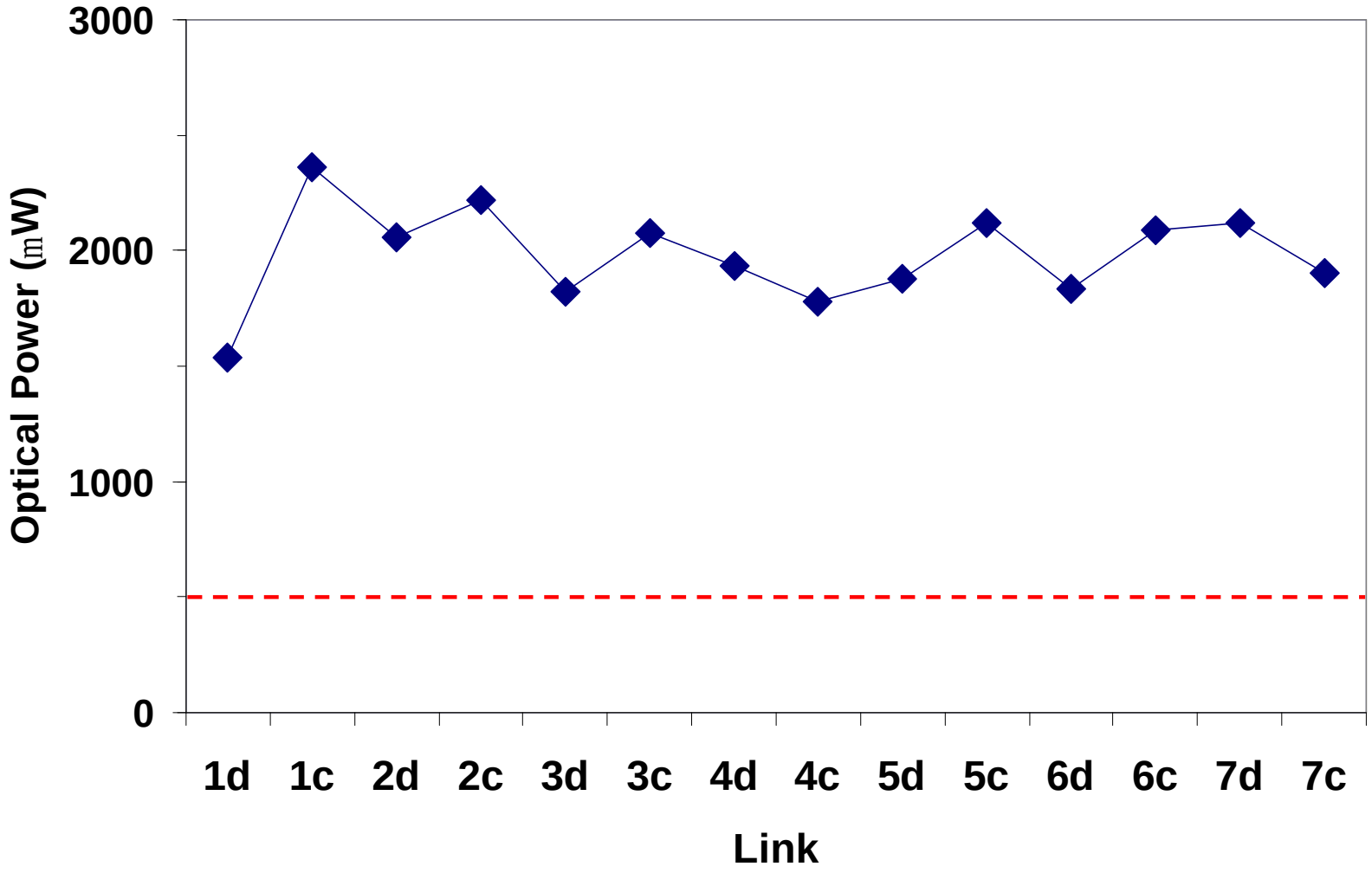


Minimum PIN Current for No Bit Error



- Minimum PIN current for no bit error is significantly below the spec. of 40μA

Optical Power



- Excellent optical power
  - Significantly above the minimum requirement of 500μW

Test of Production Procedure

- Ten boards were populated by AA and constructed at OSU
  - **All boards burned-in/thermal cycled and passed QA**
    - **Excellent power and low noise**
    - **Yield = 100%**

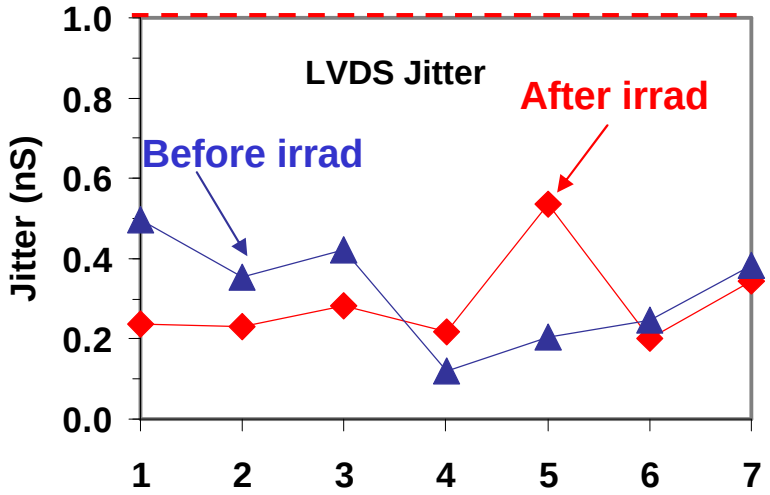
Status of Opto-board

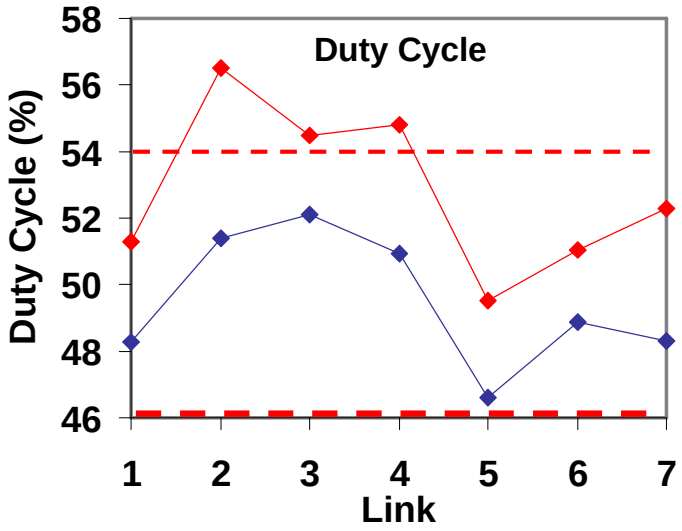
- We have established a reliable assembly procedure with single opto-pack lead soldering
  - 100% yield on the 7 boards from the 1st proto-type
  - 100% yield on the 10 boards from the 2nd proto-type
  - Assuming ~70% yield for the production
    - Order 300 D boards now
    - Order 60 B boards later

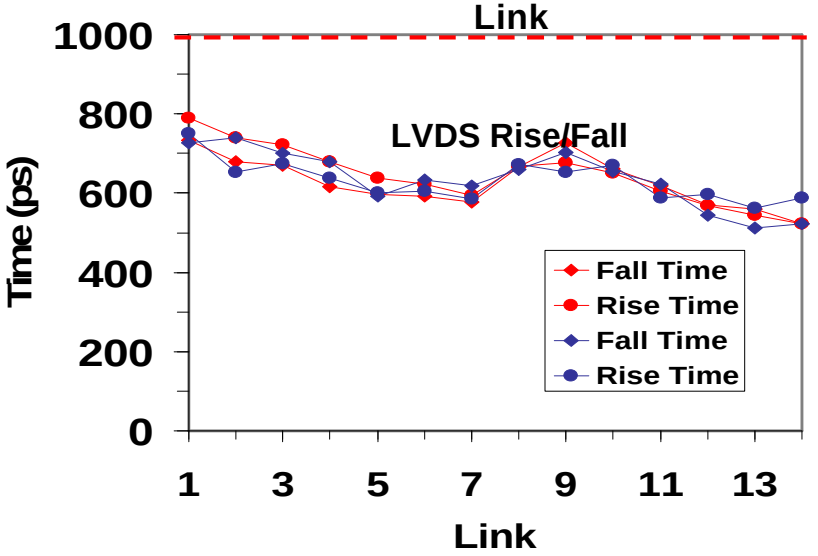
Radiation Hardness Measurements of Opto-boards

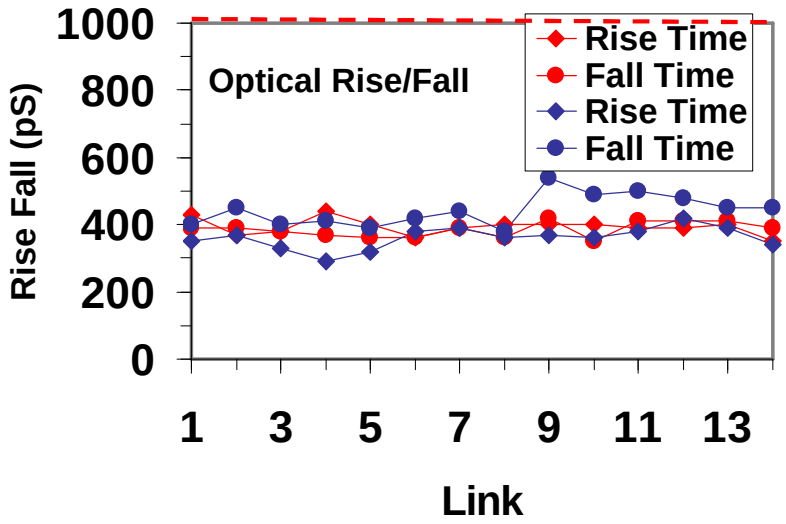
- Use CERN's T7 beam (24 GeV Proton) for radiation hardness
  - T7 shuttle setup
    - Can be moved in and out of beam remotely for annealing
  - Real time testing of opto-board system using loop-back setup
    - Compare transmitted and decoded data
    - measure minimum PIN current for no bit errors
    - Measure optical power
- Last irradiation in June 2004
  - Four BeO opto-boards were irradiated with up 32 Mrad

Rise/Fall Times, Duty Cycle and Jitter



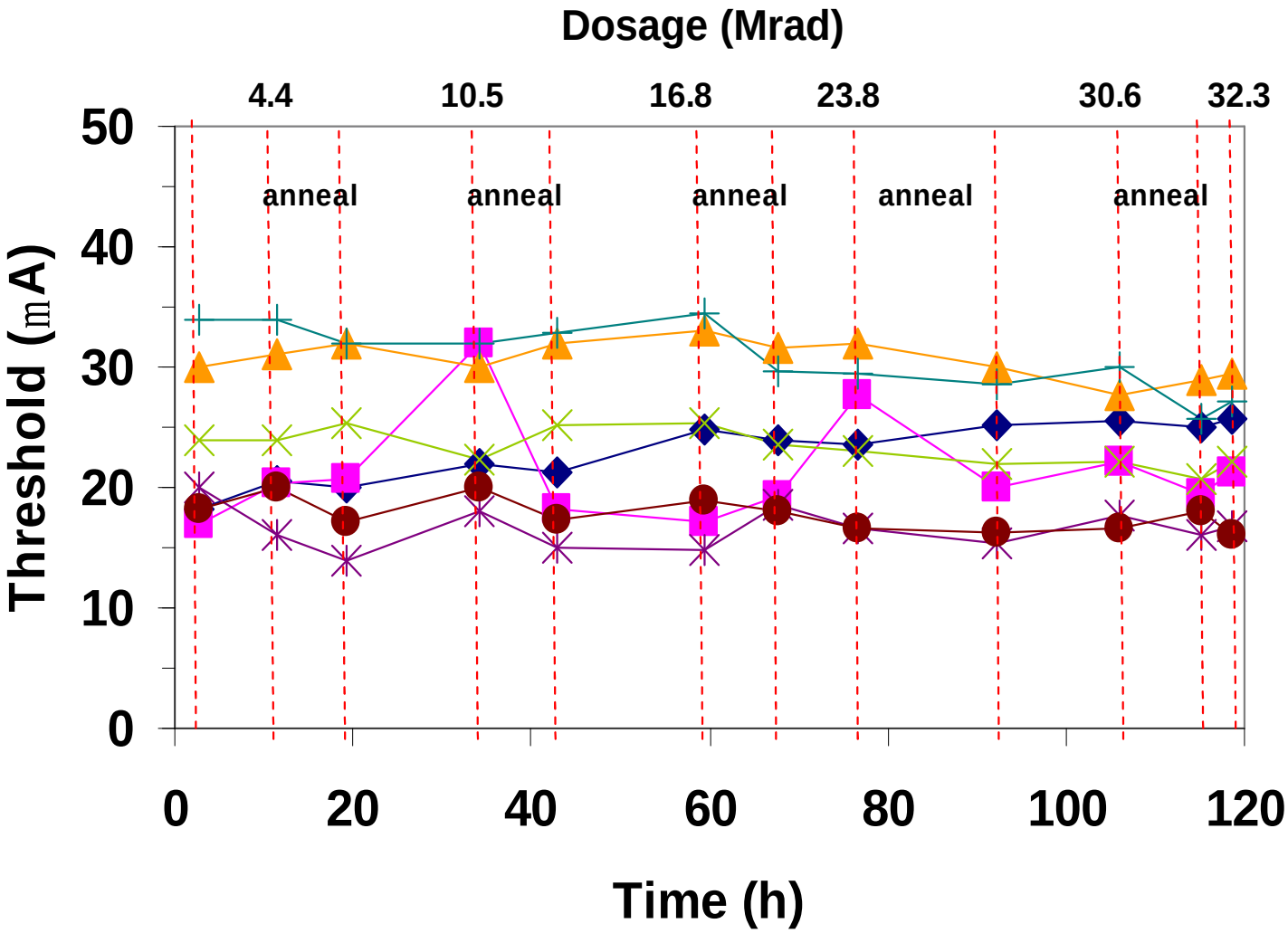






- Jitter, and rise and fall times are within the spec
- Duty cycle slightly higher than 54% in three of the links

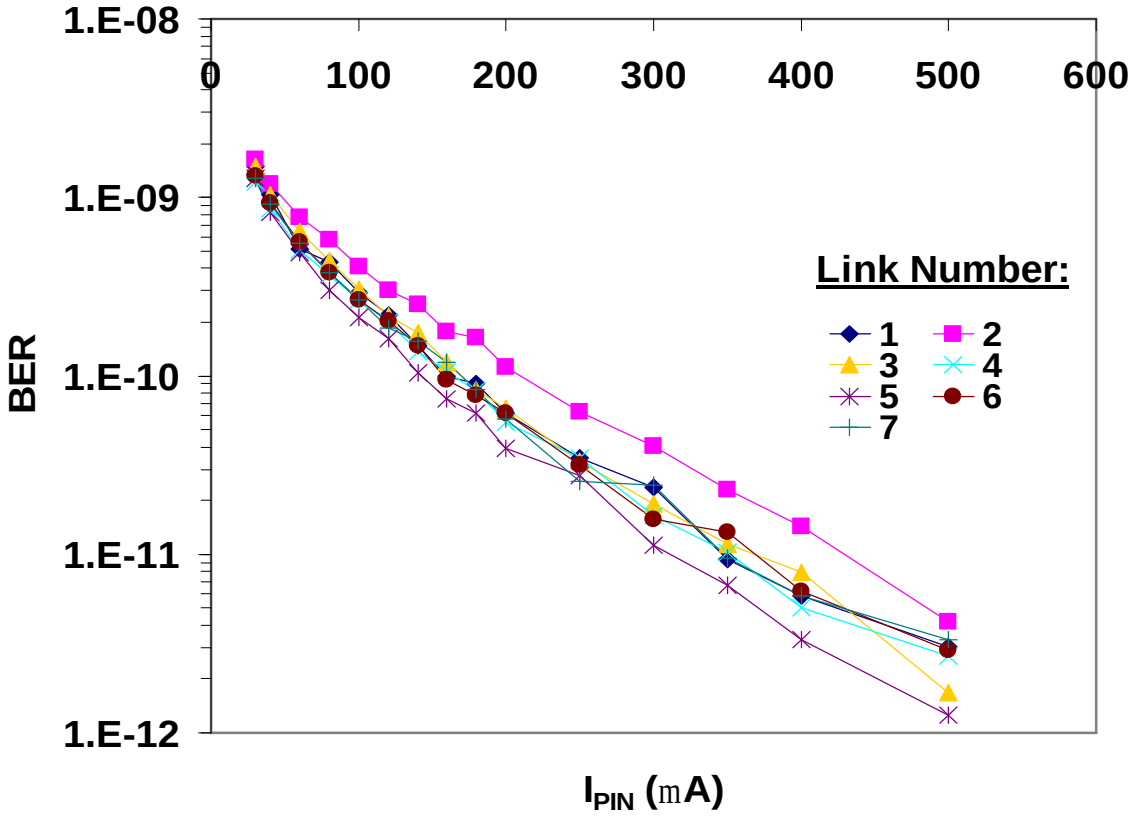
PIN Current Threshold vs Dosage



- PIN current thresholds for no bit errors remain constant

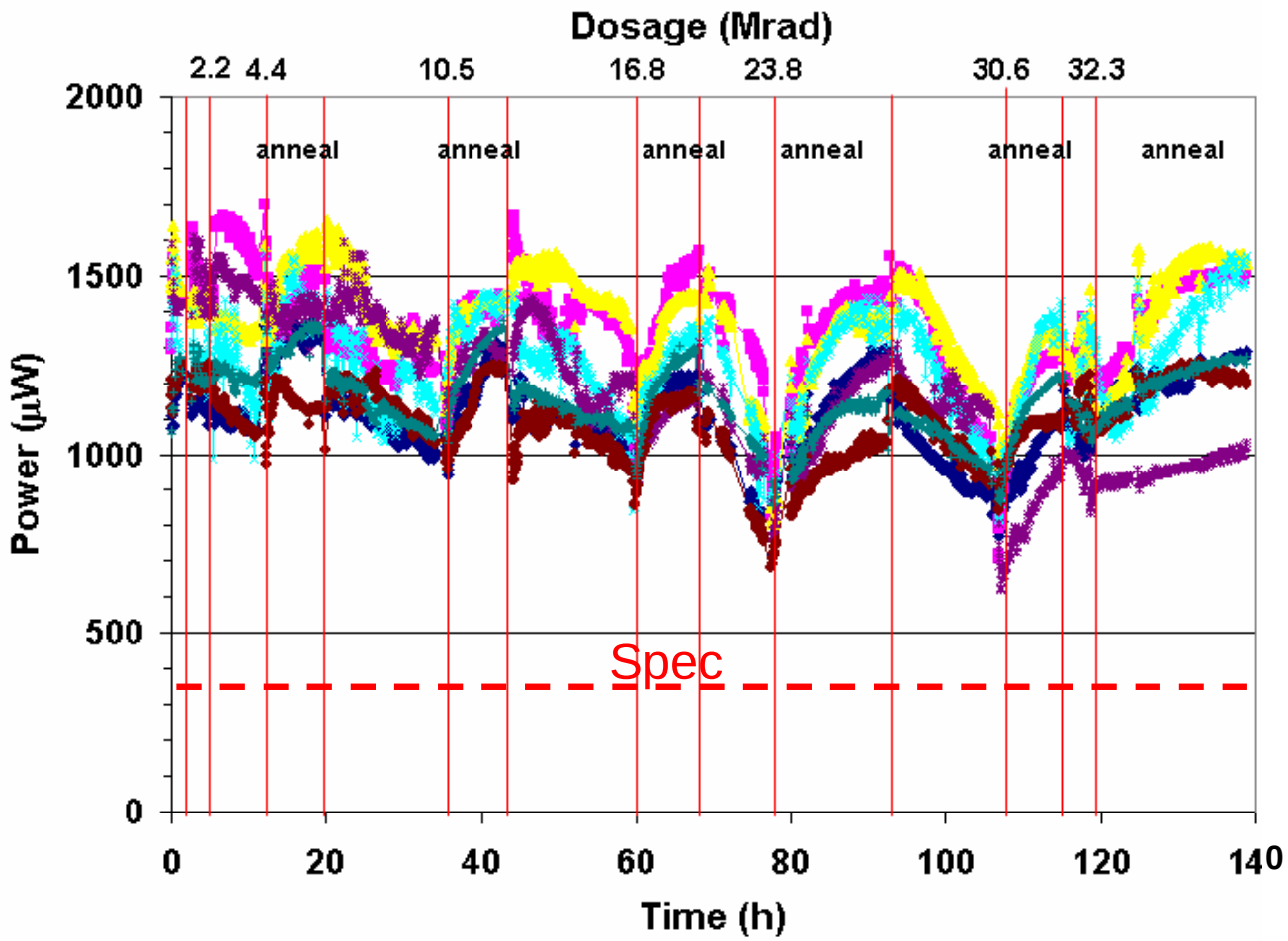
Proton Induced Bit Errors in PIN

- Convert bit errors to bit error rates at opto-link



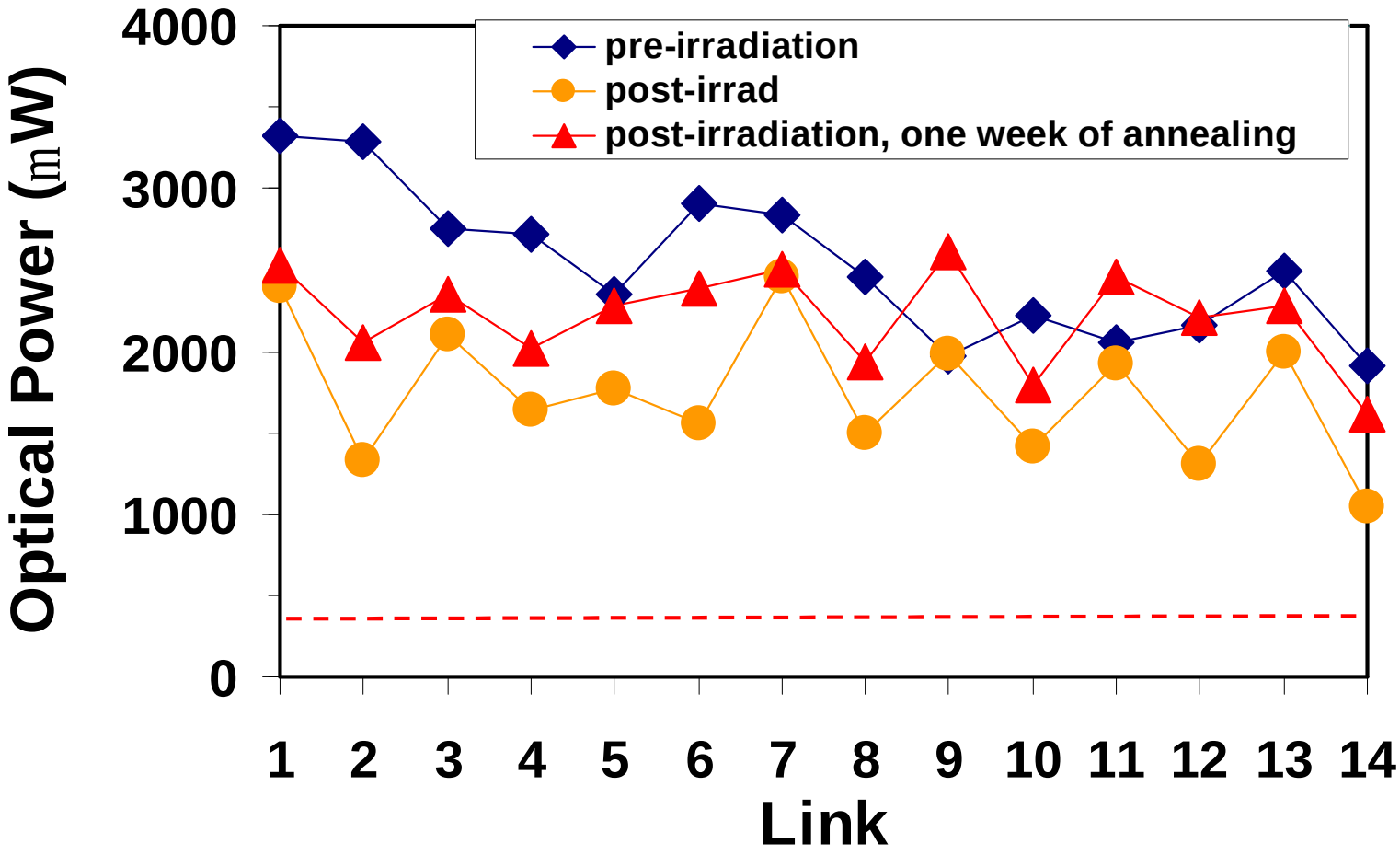
- Bit error rate decreases with PIN current as expected
- Bit error rate: ~3 x 10^{-10} at 100 μA (1.4 errors/minutes)
  - DORIC sepc: 10^{-11}
  - Opto-link error rate is limited by SEU

Optical Power vs. Dosage



- Irradiation procedure: ~5 Mrad/day (10 hours) with annealing rest of the day
- Optical power decreases with dosage as expected
- Limited annealing recovers some lost power
- Still good power after 30 Mrad

Optical Power



- Some degradation in power after irradiation
  - Power is significantly above the minimum required ~350 μW
- Annealing recovers some of the lost power

Production Plan

- Today: Submit D board layout to CPT
- Feb.: Receive D boards from CPT
- March: Submit B board layout to CPT
- June: Receive B boards from CPT
- Sept.: Complete production if BOTH OSU and Siegen can produce 10 boards/week

Summary

- No degradation in performance with up to 32 Mrad proton irradiation
  - Low PIN current for no bit errors
  - Excellent optical power after irradiation
- 17 pre-production opto-boards have been fabricated
  - Meet all the pixel detector requirements
  - Excellent optical power and low noise
  - Yield = 100%
- Assuming ~70% yield
  - ➢ order 300 D boards now and 60 B boards later