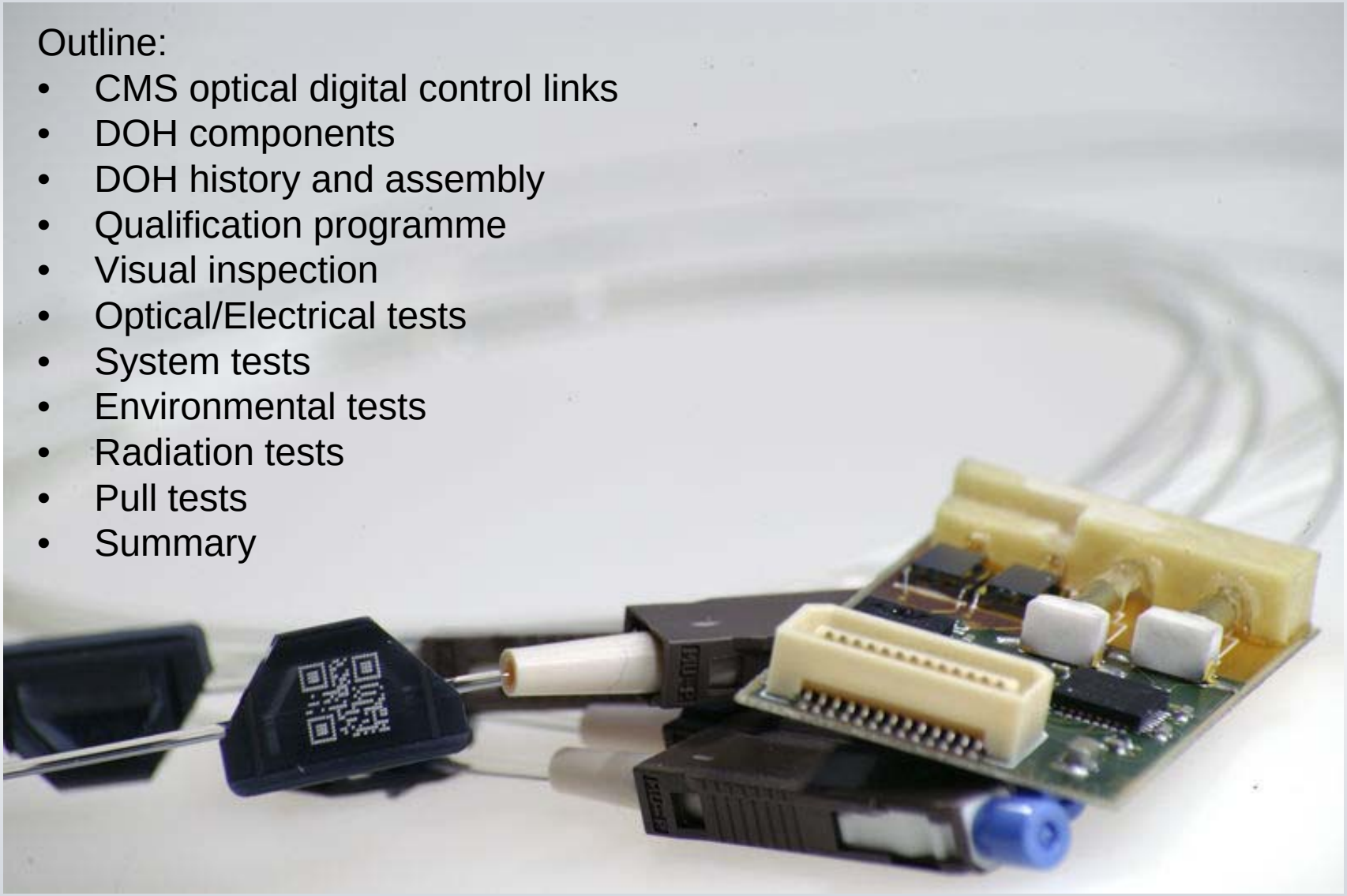
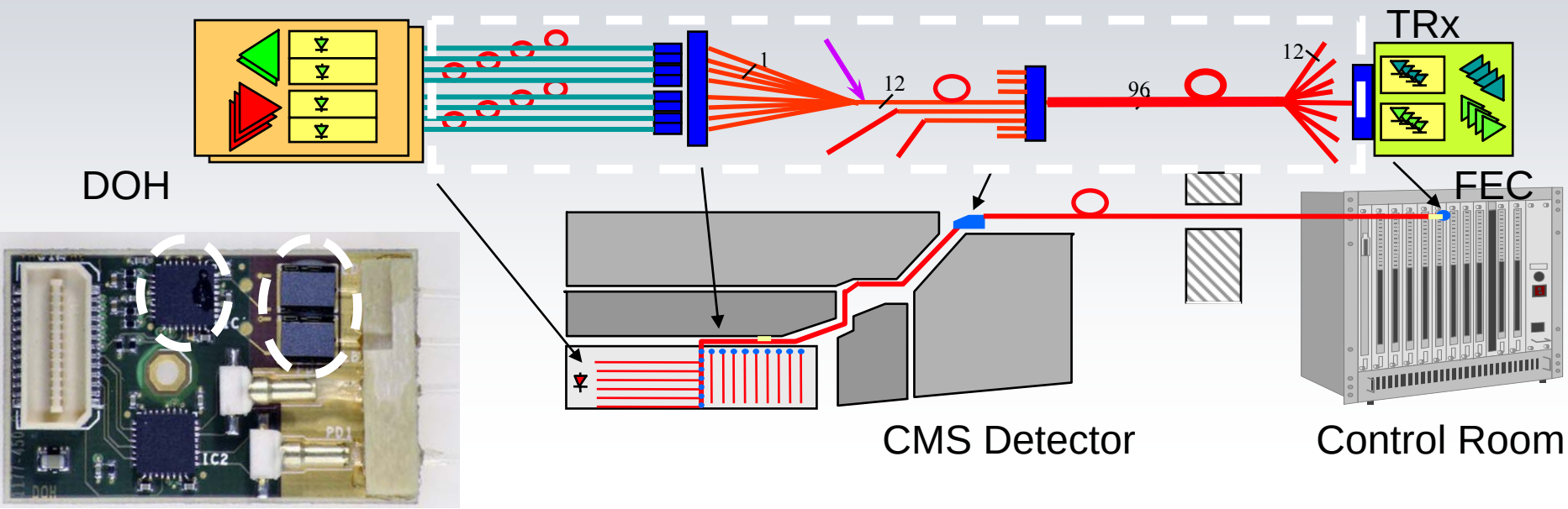
Qualification of the CMS Digital Optohybrid

Outline:

- CMS optical digital control links
- DOH components
- DOH history and assembly
- Qualification programme
- Visual inspection
- Optical/Electrical tests
- System tests
- Environmental tests
- Radiation tests
- Pull tests
- Summary



CMS Control Link Digital Optohybrid (DOH)

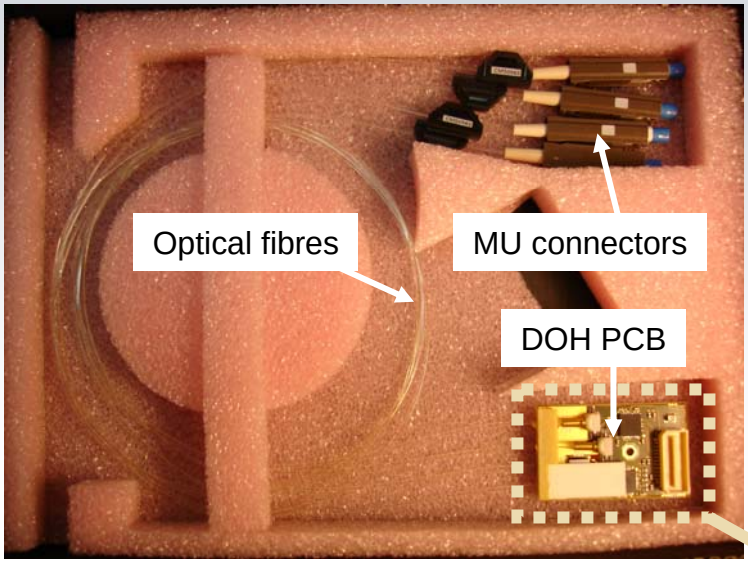


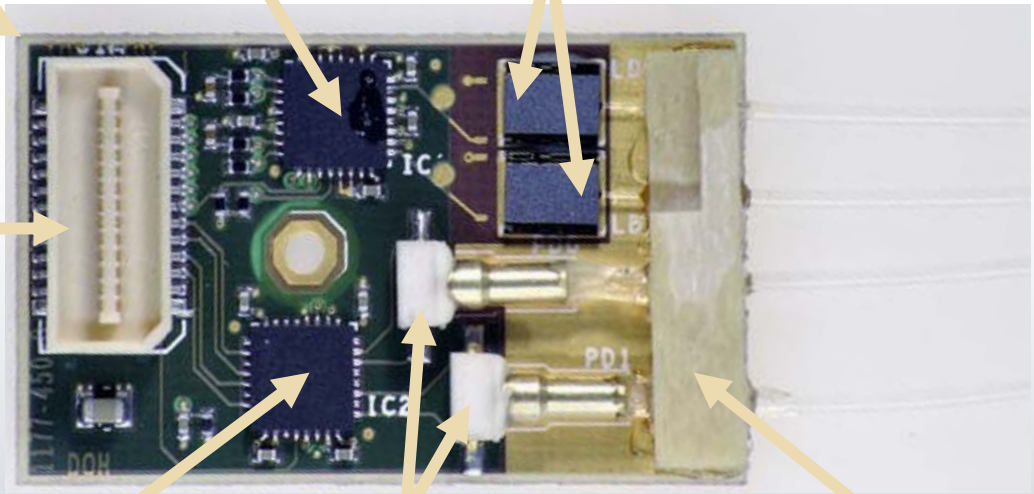
CMS Tracker Optical Digital Control Links

- Bi-directional
- Extreme environment
  - High radiation levels
  - High magnetic field
  - Restricted access for repair
- Derived from analogue readout links
- Adopted by other CMS sub-detectors

CMS Sub-detector	Rings	DOHs
Pixels	64	128
Tracker	350	700
ECAL	368	736
Preshower	52	104
RPCs	28	28
Total	*862*	*1696*

DOH Components



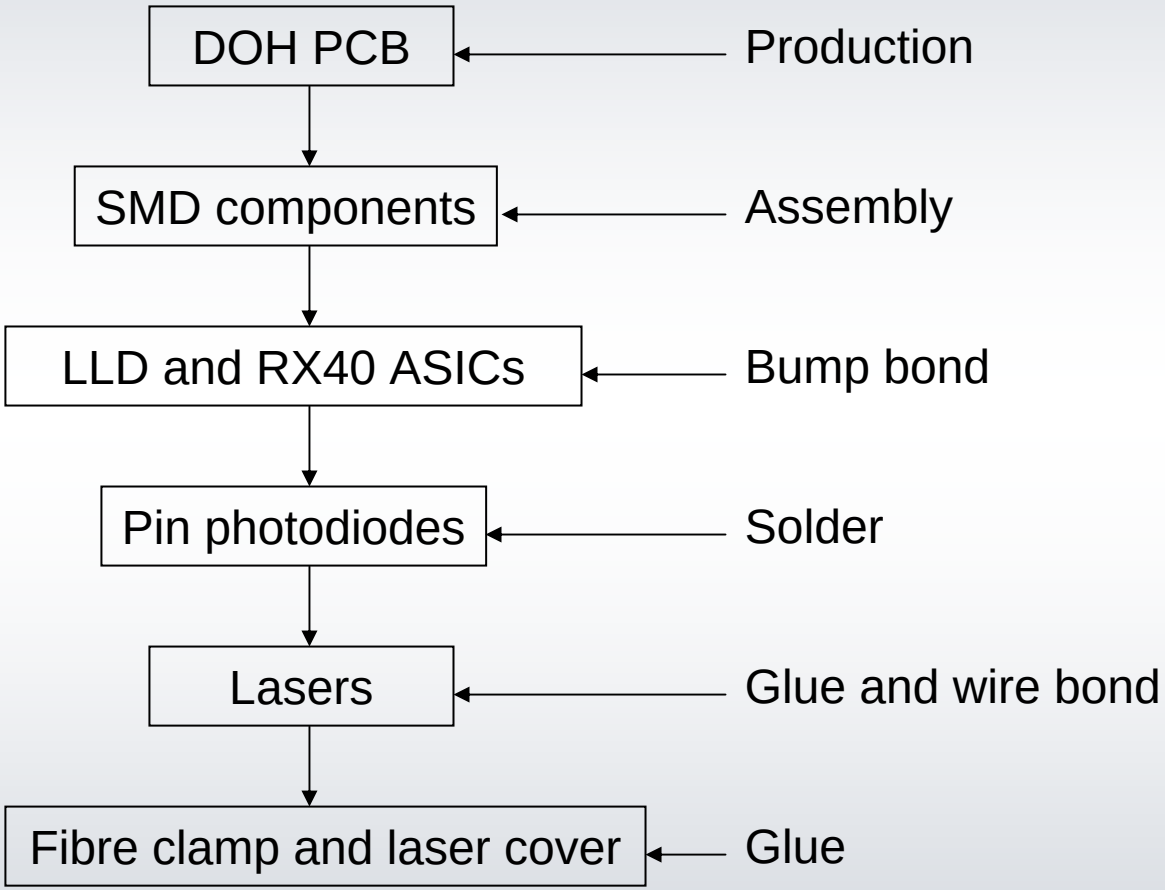


26-way NAIS
Electrical connector:
- CK/DA to/from CCUMs
- Reset to CCUM
- I^2C to/from CCUM

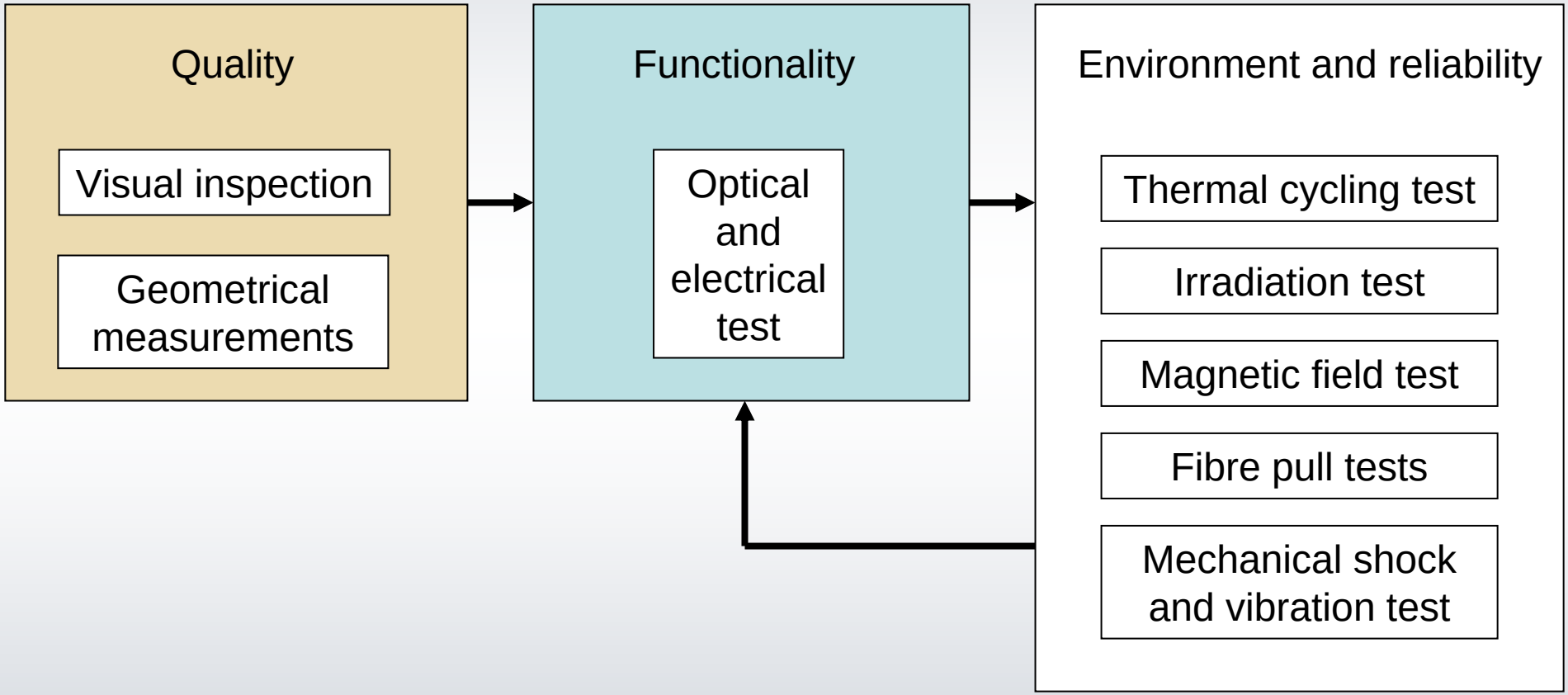
DOH Production History

- 2001-3 Preliminary specs/prototypes
- 10/03 Order placed with Kapsch
- 12/03 Specifications frozen
- 03/04 Pre-production batch (40 pcs)
- 04/04 Rejection
- 06/04 Re-qualification batch (37 pcs)
- 07/04 Acceptance
- 08/04 Start of final production

DOH Assembly Sequence

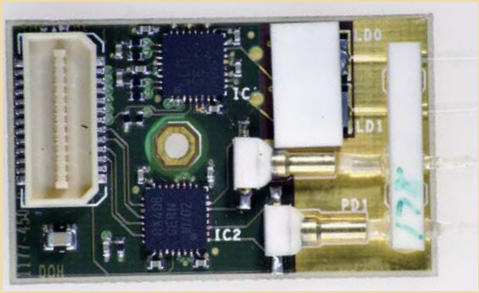


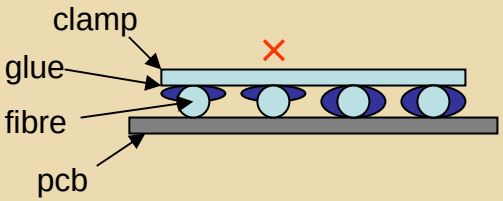
Qualification Programme



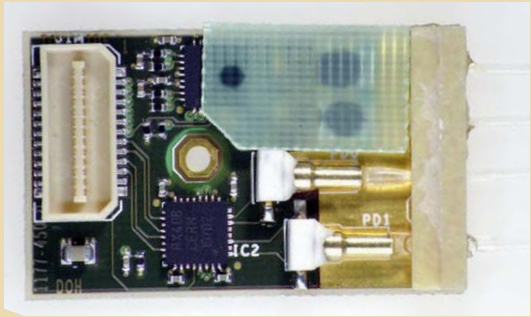
Visual Inspection

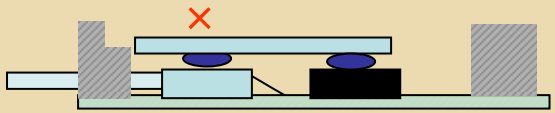
Kapsch fibre clamp

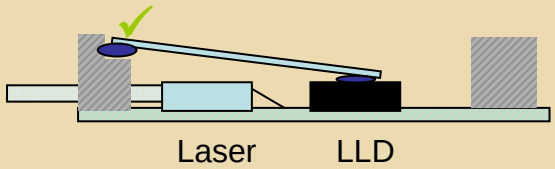




CERN fibre clamp



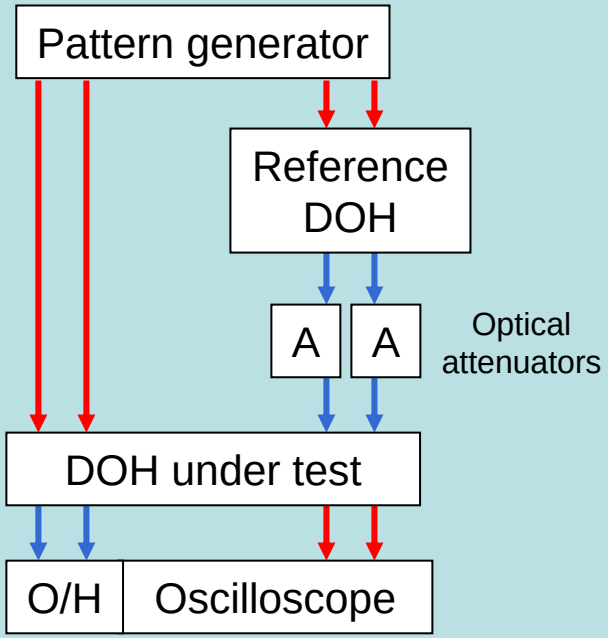




Buffer rupture

Inspection test	# failures
Fibre clamp	10
Laser cover	20
QR code	2
Soldering	12
Fibre buffer rupture	5

Optical/Electrical Test Setup



Rx Tests:

- Receiver sensitivity
- Receiver saturation
- Output voltage swing
- Reset generation

Tx Tests:

- Optical modulation amplitude (OMA)
- Average launch power (ALP)
- Input impedance
- I^2C check
- L-I characteristics

System Tests:

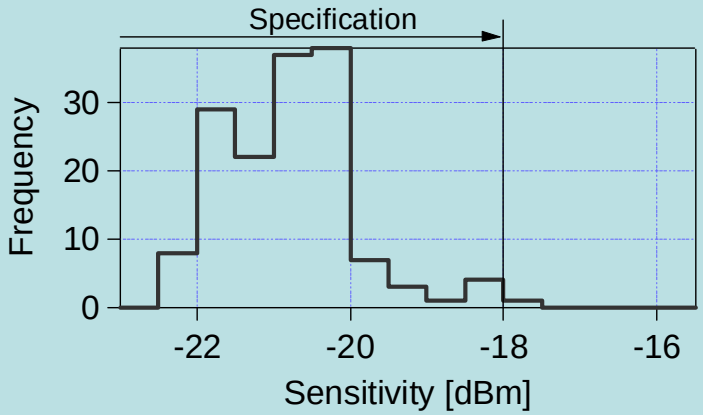
- Power supply
- Eye pattern
- Skew
- Jitter

Func.

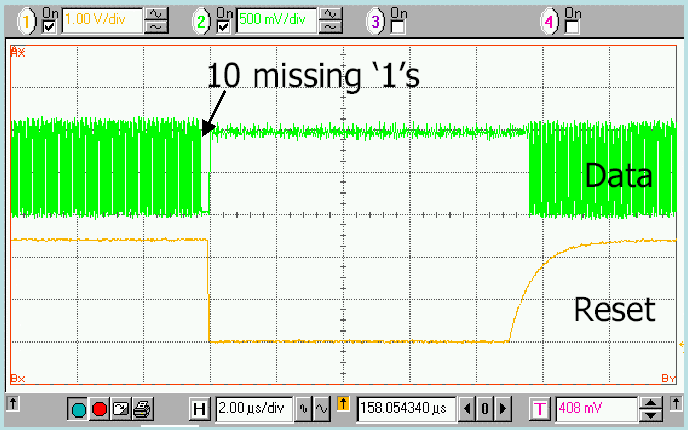
Optical/Electrical Tests

RX40 and PHOTODIODES

Sensitivity

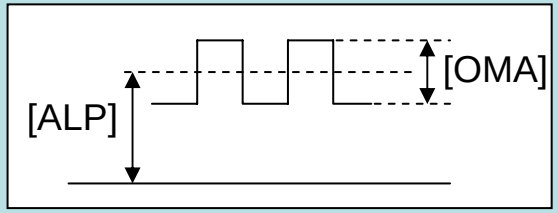


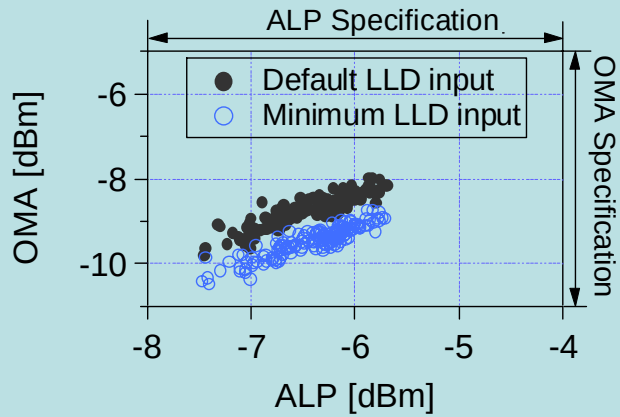
Reset generation



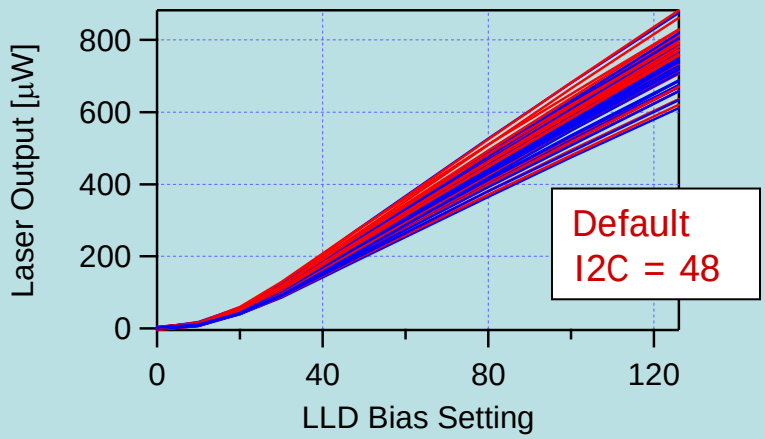
LLD and LASERS

OMA & ALP



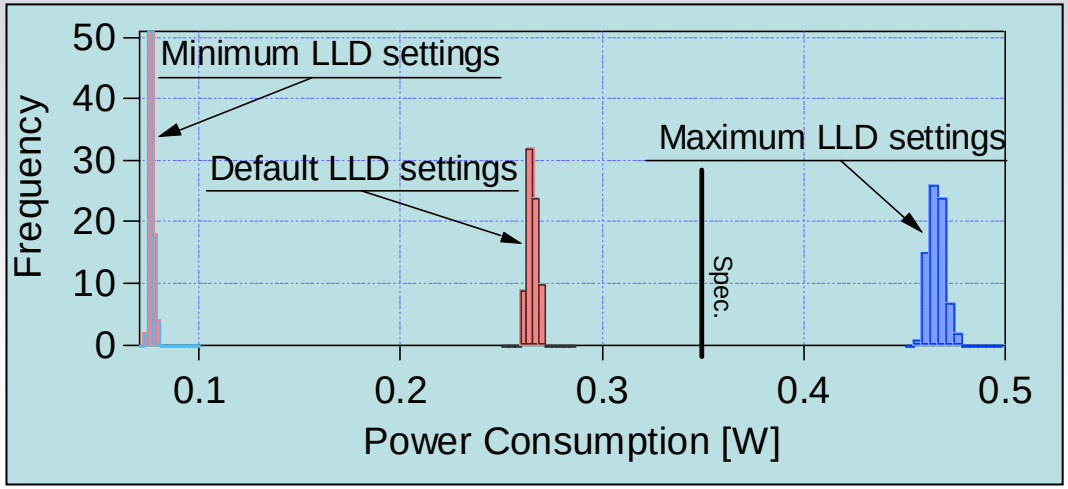


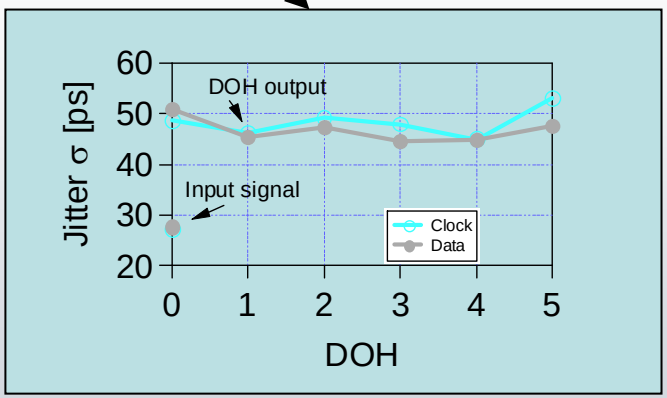
I2C check and L-I char.

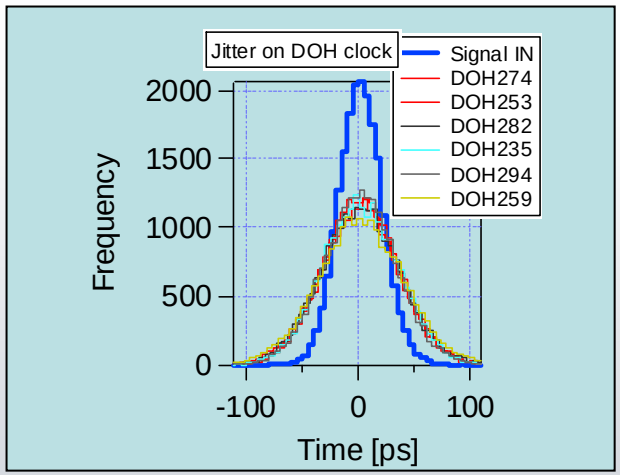


System Tests

- Power consumption within 350mW spec.
- Bit Error Rate, $<10^{-12}$
- Skew <1ns
- Jitter well within 250ps rms spec.

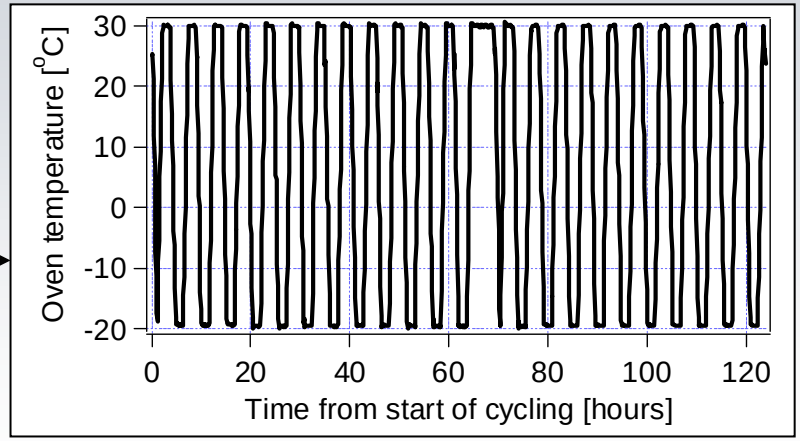




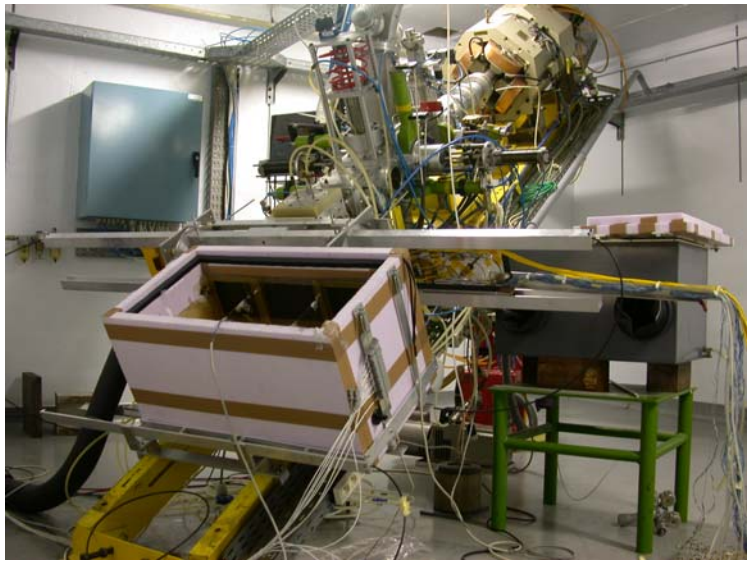


Environmental Tests

- Temperature cycling (CERN)
- B-field (CERN)
  - 2 DOHs, 3 orientations, 2.4 T
- Shock test (Kapsch)
  - 6 DOHs, 20G
- Vibration test (Kapsch)
  - 6 DOHs, 10Hz-500Hz
- All DOHs were functional after above tests

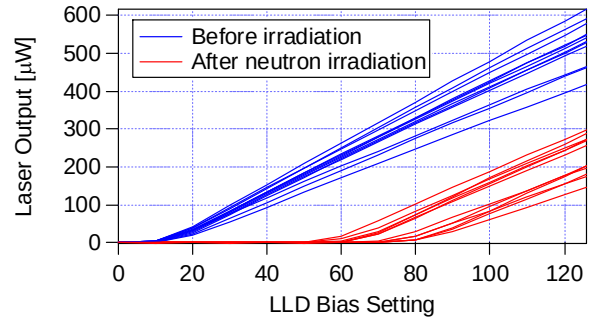


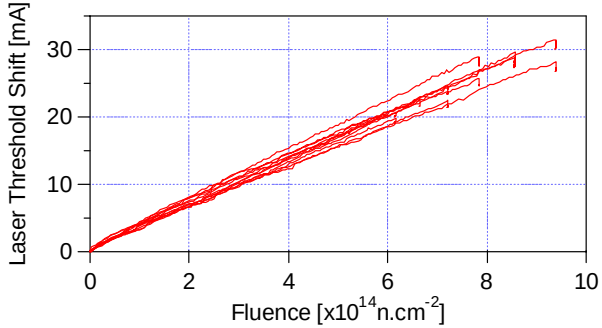
Radiation Tests



- Irradiation (6 DOHs)
  - 100kGy Co-60 gamma
  - Up to 9.4x10^{14}n/cm^2 (UCL ~20MeV)
- Expected laser and photodiode damage
- Final system laser threshold shift should be less:
  - ~6mA (LLD bias shift =13)

LASERS

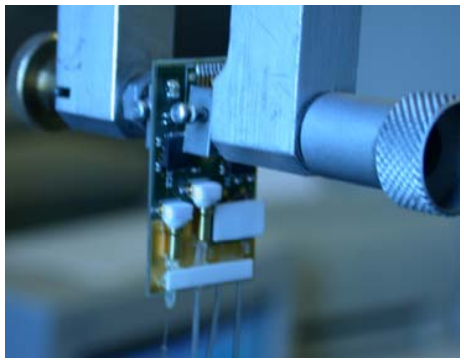




PHOTODIODES

Sensitivity	Clock	Data
Prerad avg. [μW]	8.7	9.1
Prerad-gamma [%]	-5	-1
Prerad-neutron [%]	-29	-32

Pull Tests



Non-destructive pull tests:

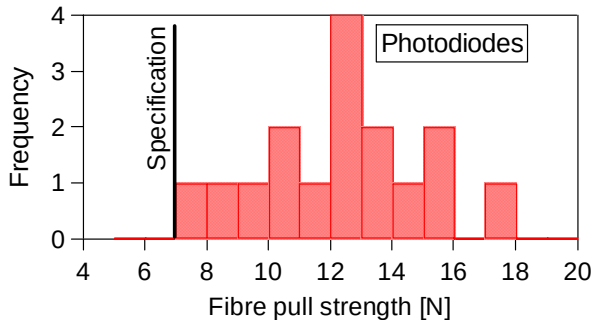
- Attach 700g to fibre
- 3/40 fibres failed (all lasers)

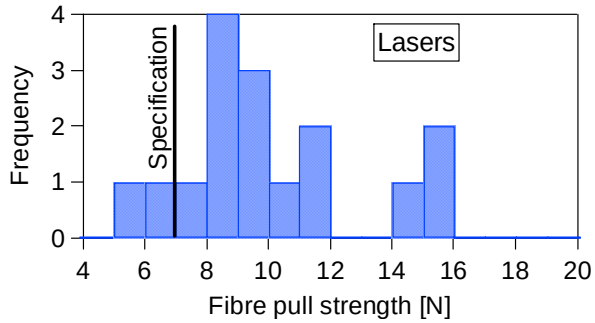
Destructive pull tests:

- Pull fibre until it fails
- 2/36 fibres below spec (all lasers 5.5N & 6.7N)

In Summary

- Fibre strength reasonably good
- Revise DOH pull strength specification





Summary

- DOH has undergone an extensive series of tests
  - Good functionality
  - Quality of assembly
    - 1st Pre-production failed visual inspection
    - 2nd Pre-production much better:
      - Redesigned fibre clamp
      - Redesigned assembly jig
- Remaining issues
  - Buffer ruptures on fibres
  - Soldering of photodiodes onto DOH pcb
- Production phase
  - 100 DOHs in August 04
  - Expect to reach production rate of ~200 DOHs/month