Fibre optic connectors – a different “view”

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with thanks to

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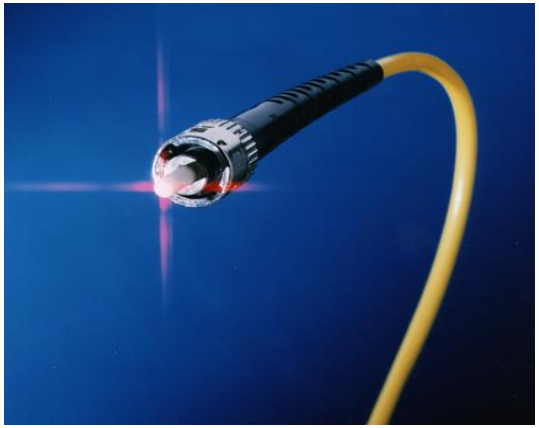
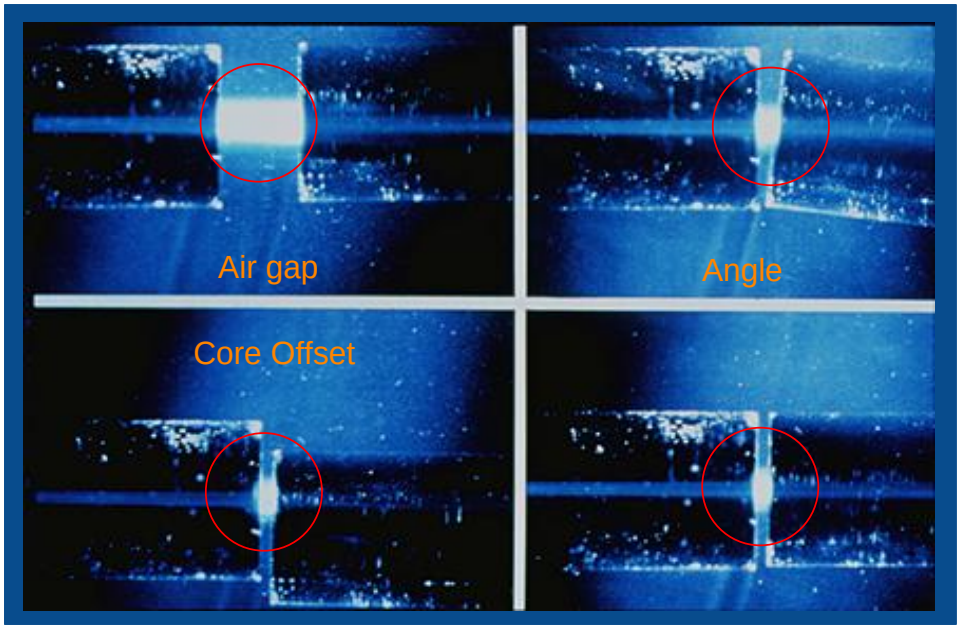
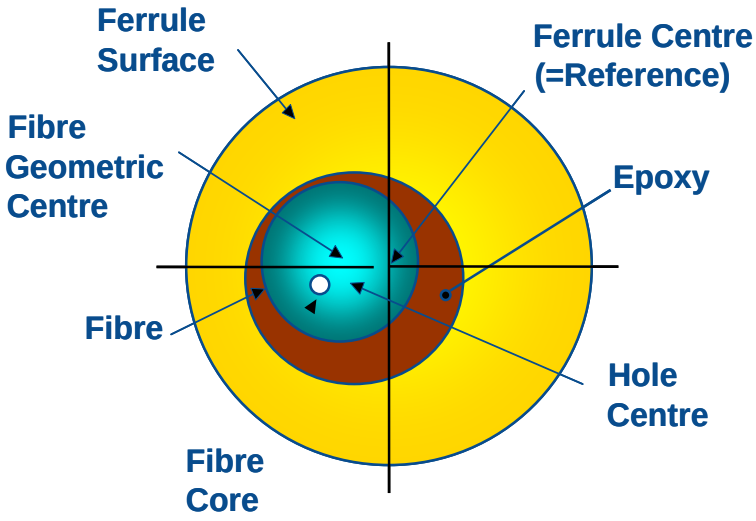
Presentation Outline

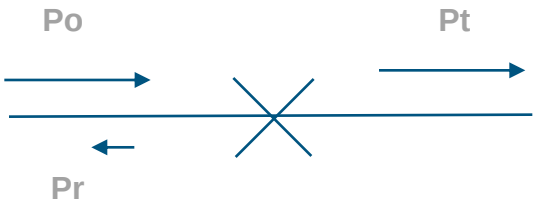
1. Alignment and Insertion Loss
2. Overview of Optical Fibre Connectors
   - Standard connectors
   - Multiple fibre connectors
   - Rugged connectors
   - Active optical cable assemblies
3. Active multiple channel connectors

Attenuation









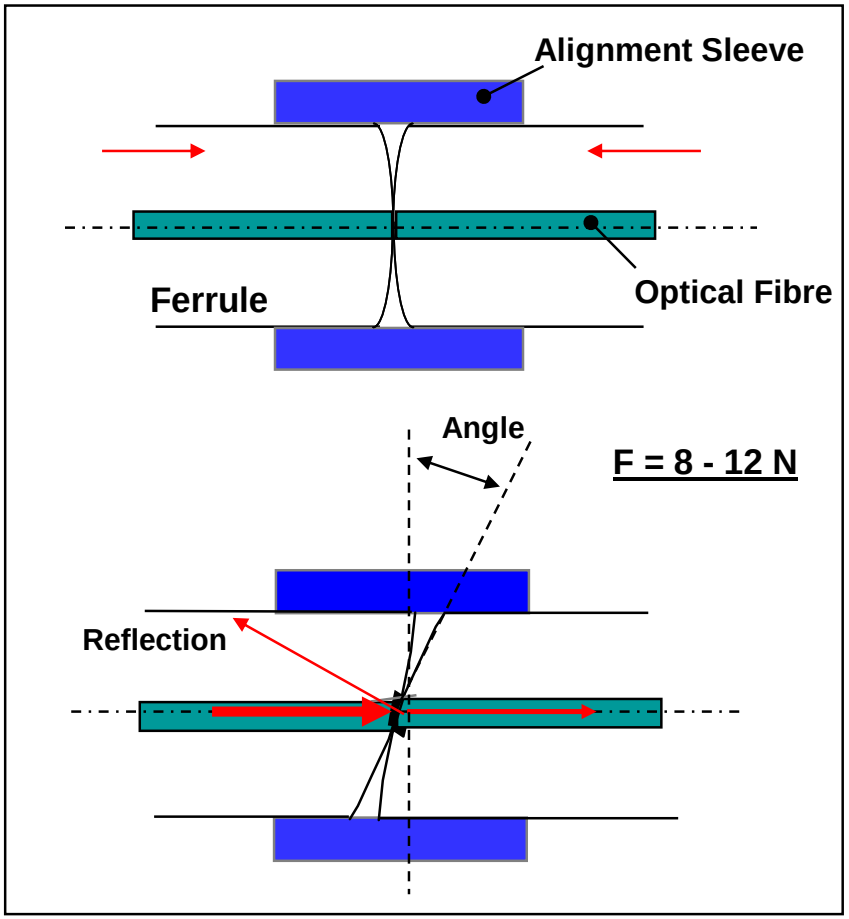
Insertion Loss = $-10 \times {}^{10}\log \{ P_t / P_o \}$

Return Loss = $-10 \times {}^{10}\log \{ P_r / P_o \}$

Return Loss

- **PC (Physical Contact):**
  - Low Insertion Loss (0.2 dB typ.)
  - Return Loss:
    - Mated > 45 dB
      > 55 dB (Ultra PC)
    - Un-mated ~ 15 dB

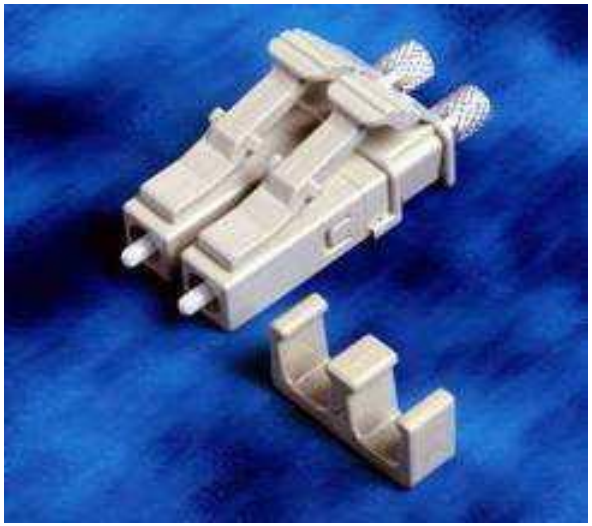
- **APC (Angled Physical Contact):**
  - Low Insertion Loss (0.2 dB typ.)
  - Return Loss:
    - Mated: 70..80 dB typ.
    - Un-mated: > 60 dB



SC Connector

- Subscriber Connector, Square Connector, Standard Connector
- Push pull connector
- Pre-Radiused, Full 2.5 mm Ceramic Ferrule
- Tuneable, 4 positions for Lowest Losses
- PC or APC end facet
- Multimode or Single mode
- Simplex & Duplex Versions
- Wide Range of Cable Diameters
- 900 µm buffer
- 1.6 - 2.0, 2.4 & 3 mm
- Polymer and Metal rear body design
- Standards IEC 61754-4, TIA/EIA 568B & GR326
- Applications: Telecom, Datacom, CATV, Industrial

LC Connector



- Lucent Connector or Local Connector
- Small Form Factor (SFF), push pull connection
- Reduces equipment space by 50%
- Full 1.25 mm Ceramic Ferrule
- RJ 45 based design
- PC or APC end facet
- Multimode or Single mode
- Simplex & Duplex Versions
- Field installable duplex clip
- Secure Versions (Colour & Key coded)
- Standard IEC 61754-20
- Applications: Computer & Transmission Equipment Manufacturers, Telecoms, Industrial, High-density connections, SFP transceivers, XFP transceivers.

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Ultra-short LC

- Ultra Short LC design (37 mm) when standard LC is 52 mm
- Accommodating cable diameter 1.8 - 2 mm
- Shortest design
- Single mode and Multimode
- Separate Simplex & Duplex thumb latch
- Bend Limiting Boot
  - Preventing signal losses due to sharp cable bends / kinks
- Applications
  - Front I/O cabling
  - Racks with Front doors
  - Restricted Space Areas

Variety of designs for all applications

Short 42 mm boot

Bend Limiting

Low Cost

3.0 mm Cable

Angled

Right Angle

Short Buffer

Bend Limiting Buffer

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MU Connector

- Miniature Unit
- Half the size of the SC Connector
- Push Pull design
- Full Ceramic 1.25 mm Ferrule
- PC end facet
- Single mode
- Tuneable
- Primarily used in Asia
- Standard IEC 61754-6
- Applications: Telecom, CATV, Data

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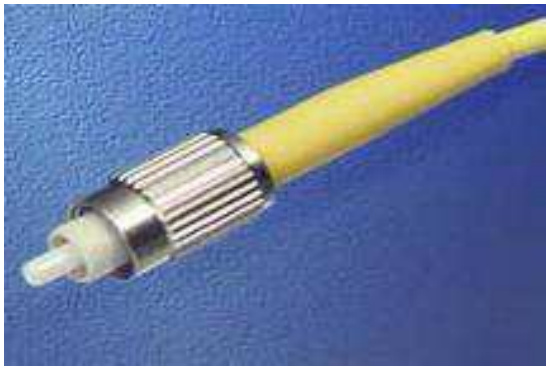
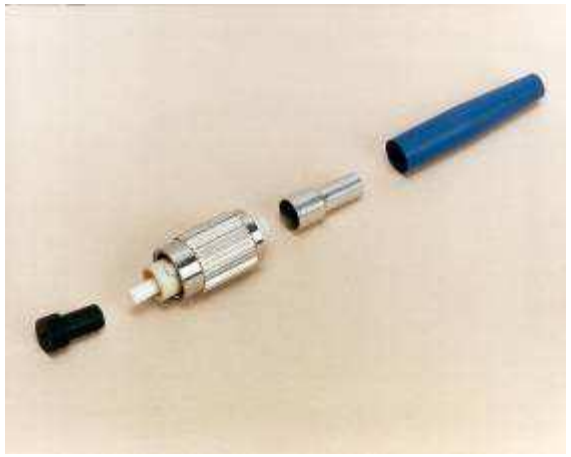
FC Connector



- Ferrule Connector or Fibre Channel
- Threaded coupling nut for secure connection
- Single Piece Rugged Connector Body
- PC or APC end facet
- Full Ceramic Ferrule, 2.5 mm
- Single mode or Multimode
- Standard IEC 61754-13
- Applications: Datacom, Telecom, single-mode lasers, CATV, Instrumentation, Widely used eg. UK & Indian Telecom Networks



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ST Connectors

- Straight Tip
- Bayonet connection
- Only PC end facet
- Multimode or rarely Single mode
- Ferrule options: Full Ceramic, Stainless Steel (SS), Polymer
- Different Hole size options in SS :
- – 125, 140, 231, 240, 280 µm
- Nut options: Stainless Steel, Polymer
- Standard IEC 61754-2
- Applications: Industrial, Military, Medical

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MT Connector

- Mechanical Transfer
- Push pull connection
- 2.5 mm × 6.4 mm
- Two alignment pins
- Available in pre-terminated cable assemblies
- Applications: outdoors

MPO/MTP and MPX Multi-Fibre Interconnects

- Multiple Fibre Push On/ Pull Off
- Push pull connection
- Free floating for system reliability
- Based on industry proven MT technology
- Blindmate backplane solution
- Both multimode (62.5/125 µm or 50/125µm) and single mode (9 µm) fibre
- Standard IEC-61754-7
- Applications: indoor interconnects

PARA-OPTIX™ Higher Density Ferrules
6 rows of 12 fibres = 72 positions

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PARA-OPTIX™ Cable Assemblies

- Industry Standard MTP/MPO Connector
- Up To 72 Fibres
- Multimode Only
- Use Anywhere MPO Is Used:
  - Backplane
  - Front-panel I/O
- Telcordia Testing
  - 108-2175 Product Spec.
  - 501-626 Test Report

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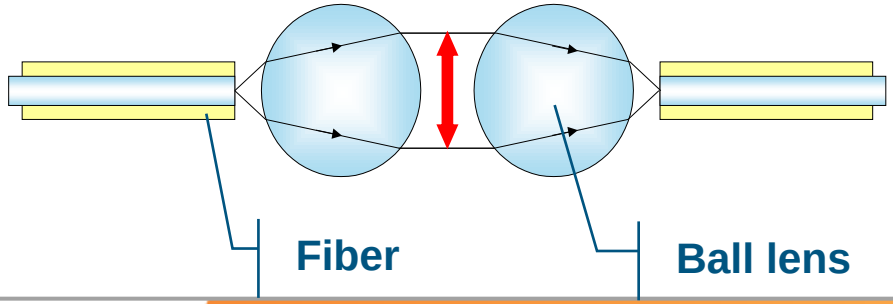
Rugged Fiber Optic Connectors



Expanded Beam Connector

Sealed Industrial Rugged ODVA Compliant Duplex LC

- IP67 Rated - Protection from dust and water immersion
- LC qualified to Telcordia GR-326 and TIA/EIA 568B.3
- Temperature – 40 to 85°C
- Bayonet-style mechanical lock
- Flame retardant UL 94 V-0
- Redundant interfacial, cable, and panel seals
- Single mode and multimode fibre

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Outdoor Connector

- Fibre Optic Cable assembly with an industry standard copper interface
- Easy to Install
- One hand blind mating possible
- Easy to clean
- Waterproof
- Dustproof
- Corrosion resistant
- EMI Shielded.
- IP 68
- Light Weight
- Low Cost
- Low Insertion Loss
- Longer Reach

Duplex Version

Quad Version

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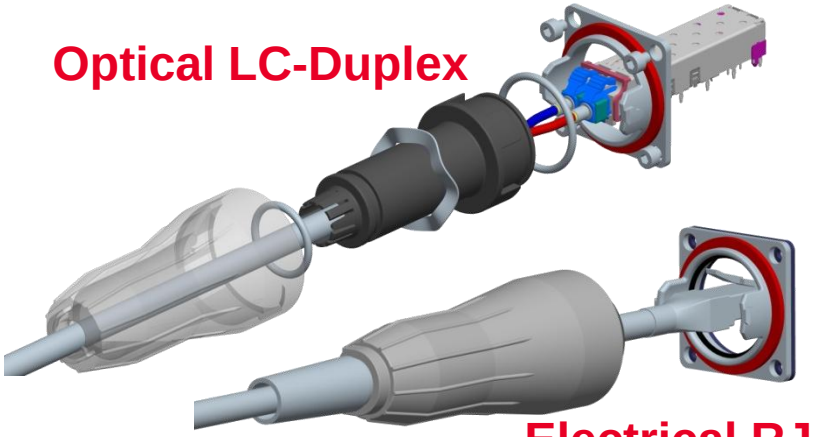
Outdoor IP67 Sealing System: FULLAXS



Applications
- Fiber To The Antenna
  - Remote Radios
  - BTS
- Industrial
- Other Outdoor applications

Features & Benefits
- „Open“ Bulkhead: Easy direct access to SFP access for repair or upgrade
- Bayonet Locking, IP 67 Sealing: Quick & Easy handling returns Low Applied Cost
- No internal pigtail required for coupling to SFP: Reduces Sytem Cost
- Based on standard LC platform: Proven interface & wide range of SFP TxRx‘s
- Free Z-Axis with full float: Accepting all known SFP‘s, No stress on Fibers & Cable
- Easy Bulkhead (X-Y) Positioning : Allows wide tolerance on SFP position
- Will also accomodate RJ45 etc.: One System fits all

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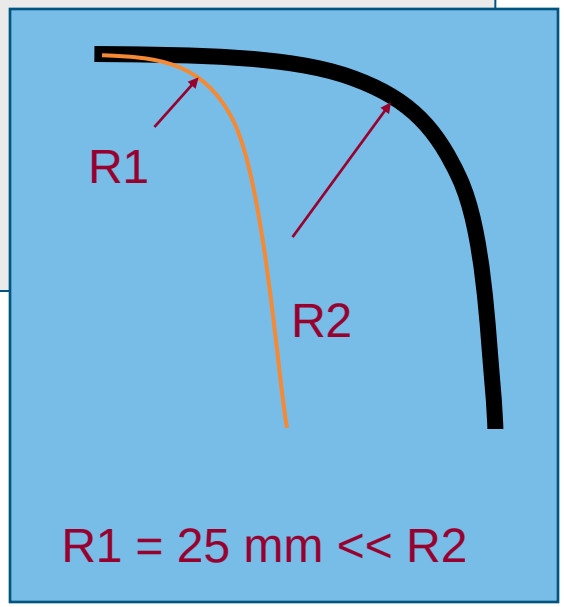
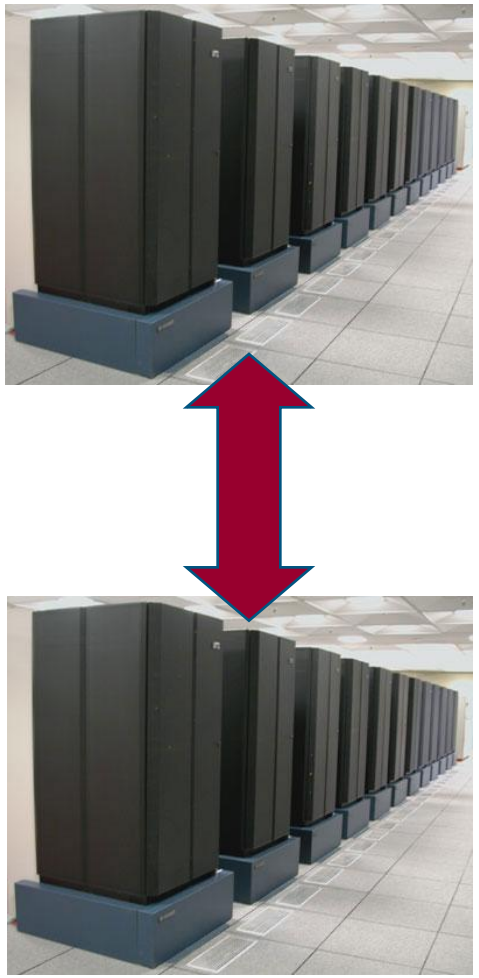
Imagine…. Having one of the following problems

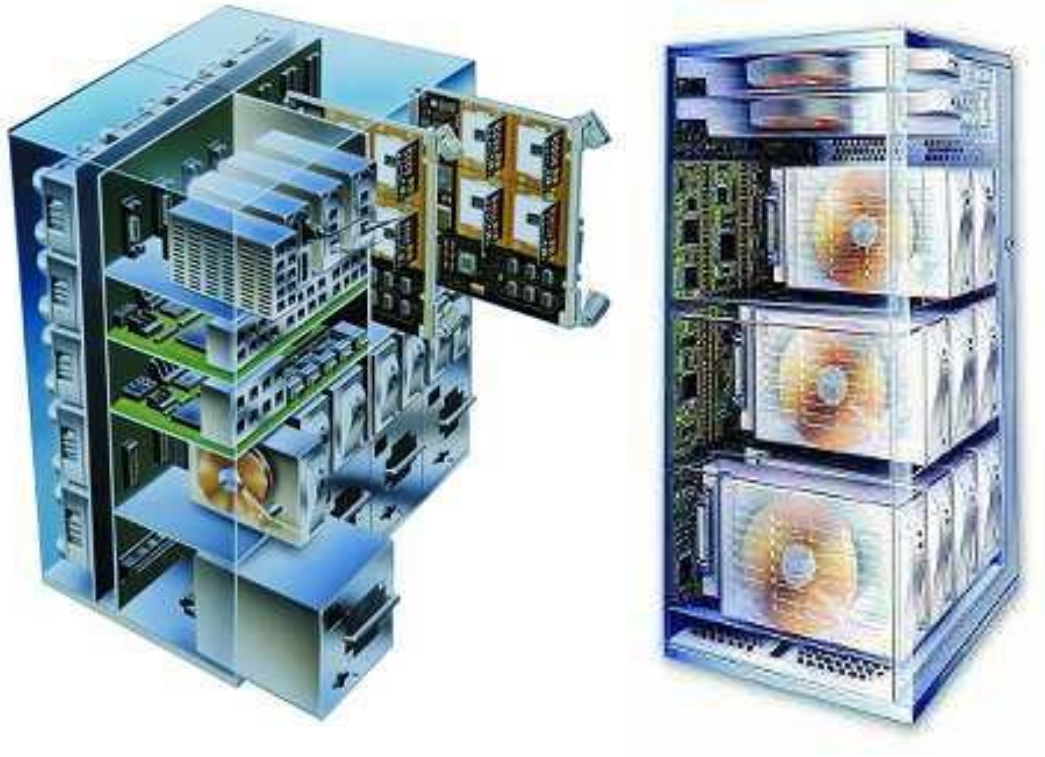
- Real estate of present location is full and needs to be expanded
- Cable lengths would need to exceed 50 m
- Costs for new real estate would be too high
- EMI of all cables would exceed limits
- Too much cable weight
- Air flow problems
- Forced cable bending





Active Optical Cable Assemblies

- Applications:
- Super Computers
- Cluster Computers
- High End Servers
- Mass Storage
- Metro Network Switch / Cross Connect
- High End Carrier Class Routers



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PARALIGHT Active Optical Cable Assemblies

- Optical Fibre with electro-optic components
- No Equipment Upgrades
- Functions like a Standard Electrical Cable
- 100 Metres Plus Reach
- Low Latency
- No EMI
- Hot Pluggable
- 1/3 Size of Copper Cable
- 1/10th weight copper cable
- 3.0 mm O.D. Round: flexible
- Low Power!
- Increased Air Flow

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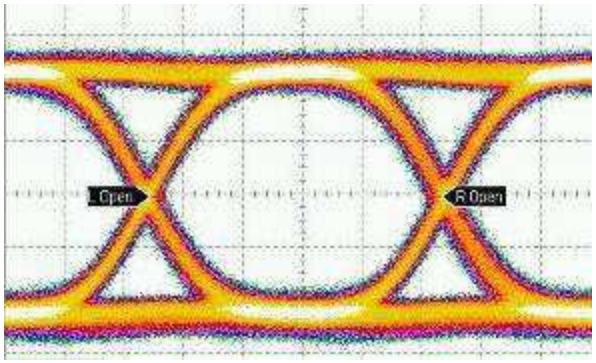
PARALIGHT Active Optical Cable Assemblies

- 2.5 to 10 Gbit/s per channel
- 0.8 Watt power dissipation
- BER 10^{-12}
- For sequence length 2^7-1
- Total Jitter 0.42 UI



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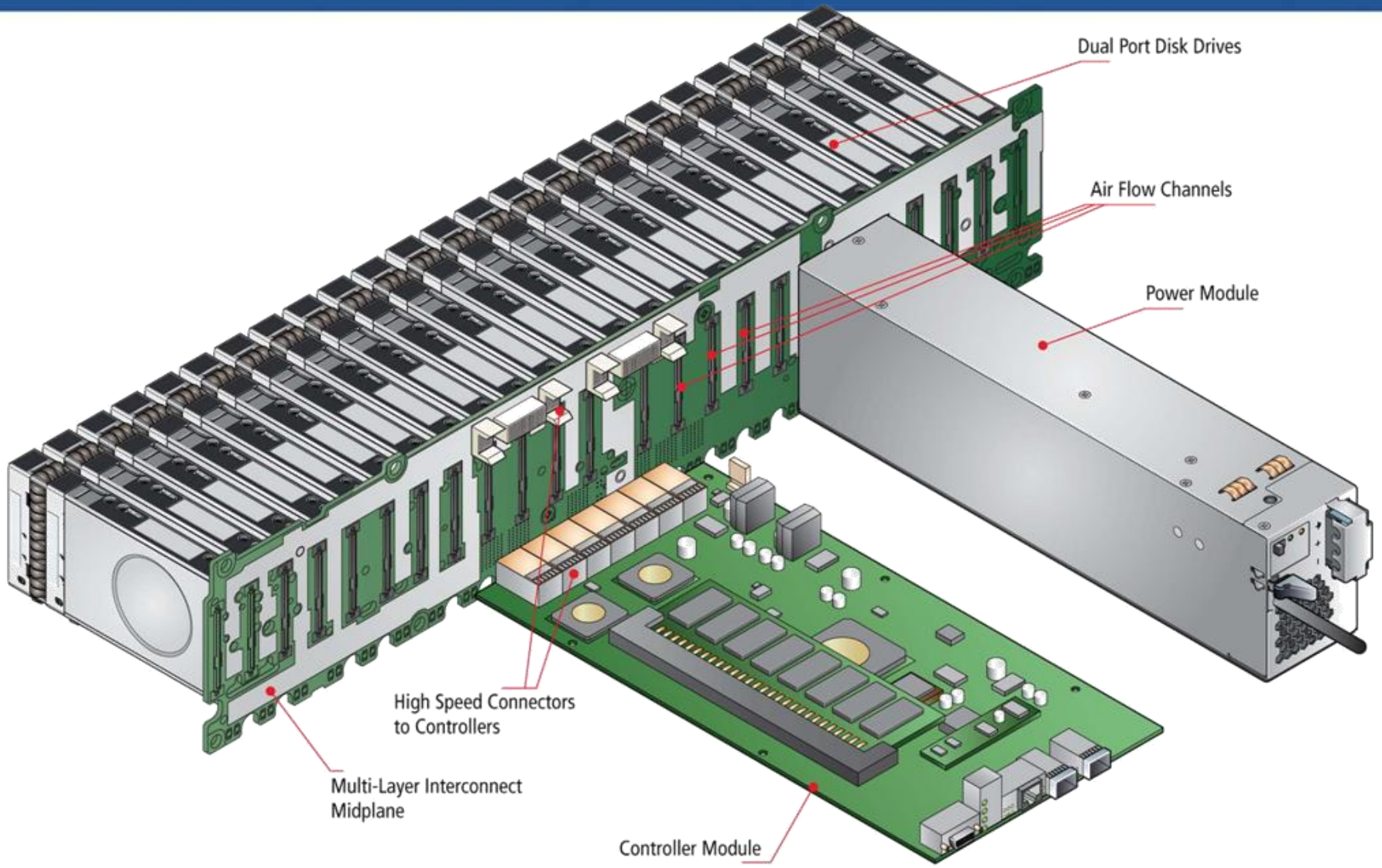
Design and performance constraints



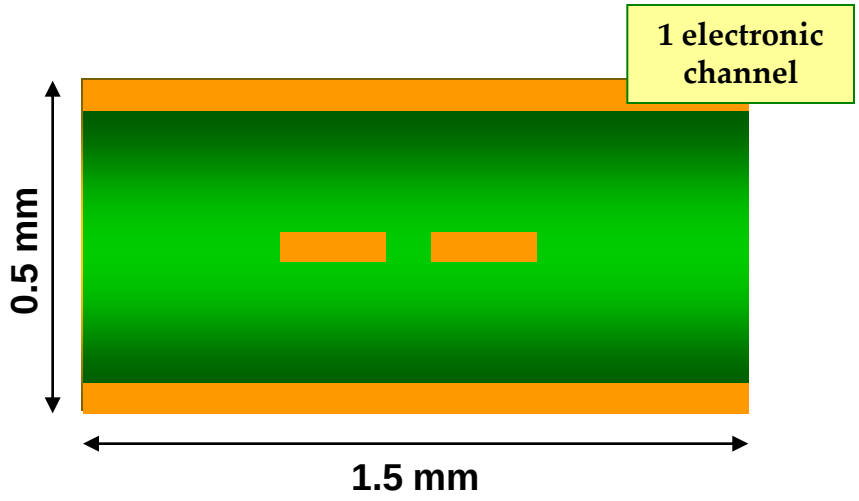
Interconnect density comparison

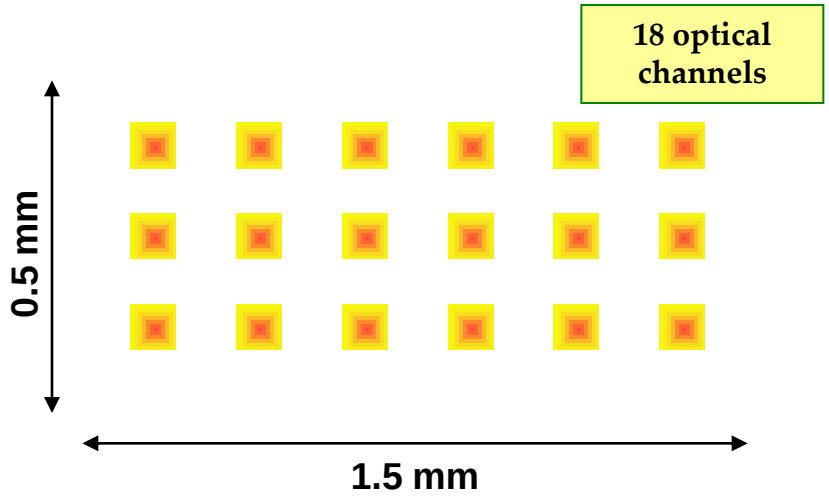
Density of copper interconnect

- Based on design rules for 10 Gb/s
- 1.5 mm horizontal spacing
- 0.5 mm vertical spacing

Density of optical interconnect

- Based on MTP standard
- 250 µm horizontal and vertical spacing
- 18 fold density increase

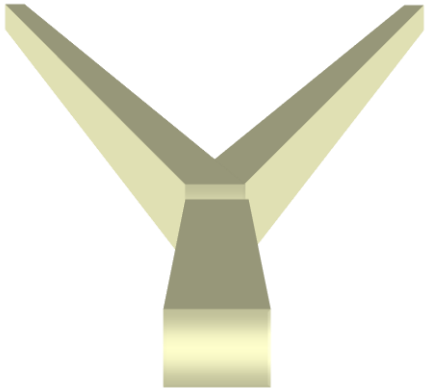




Optical layout advantages

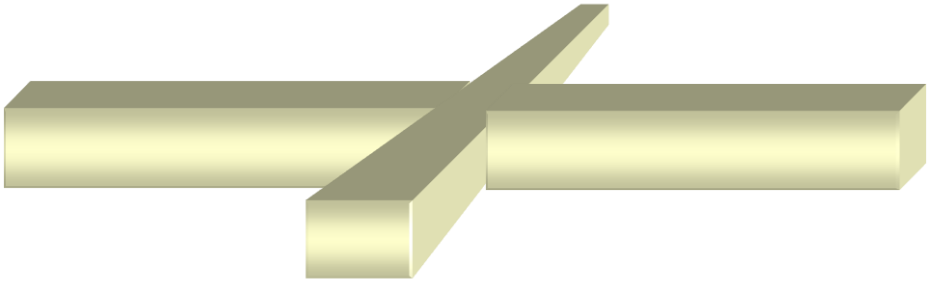
Splitters

- Optical power splitters
- Branch number dependent on link budget

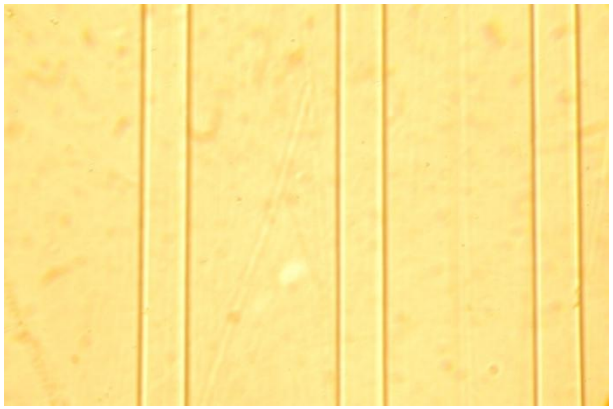


Crossovers

- Signal crossovers on one layer
- Different crossover angles possible

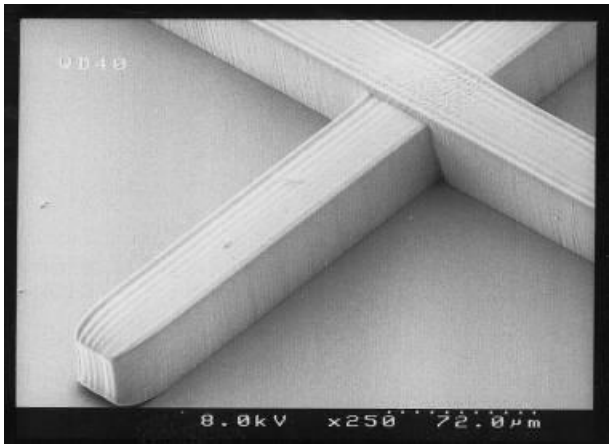


Polymer Multimode Waveguide Interconnects

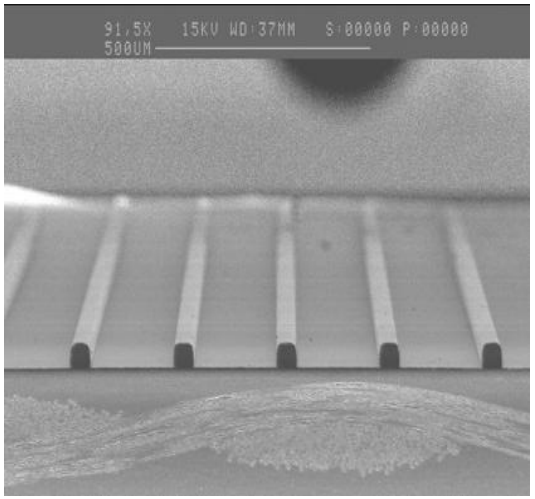


Straight waveguides – Optical InterLinks

90° Crossings – Dow Corning



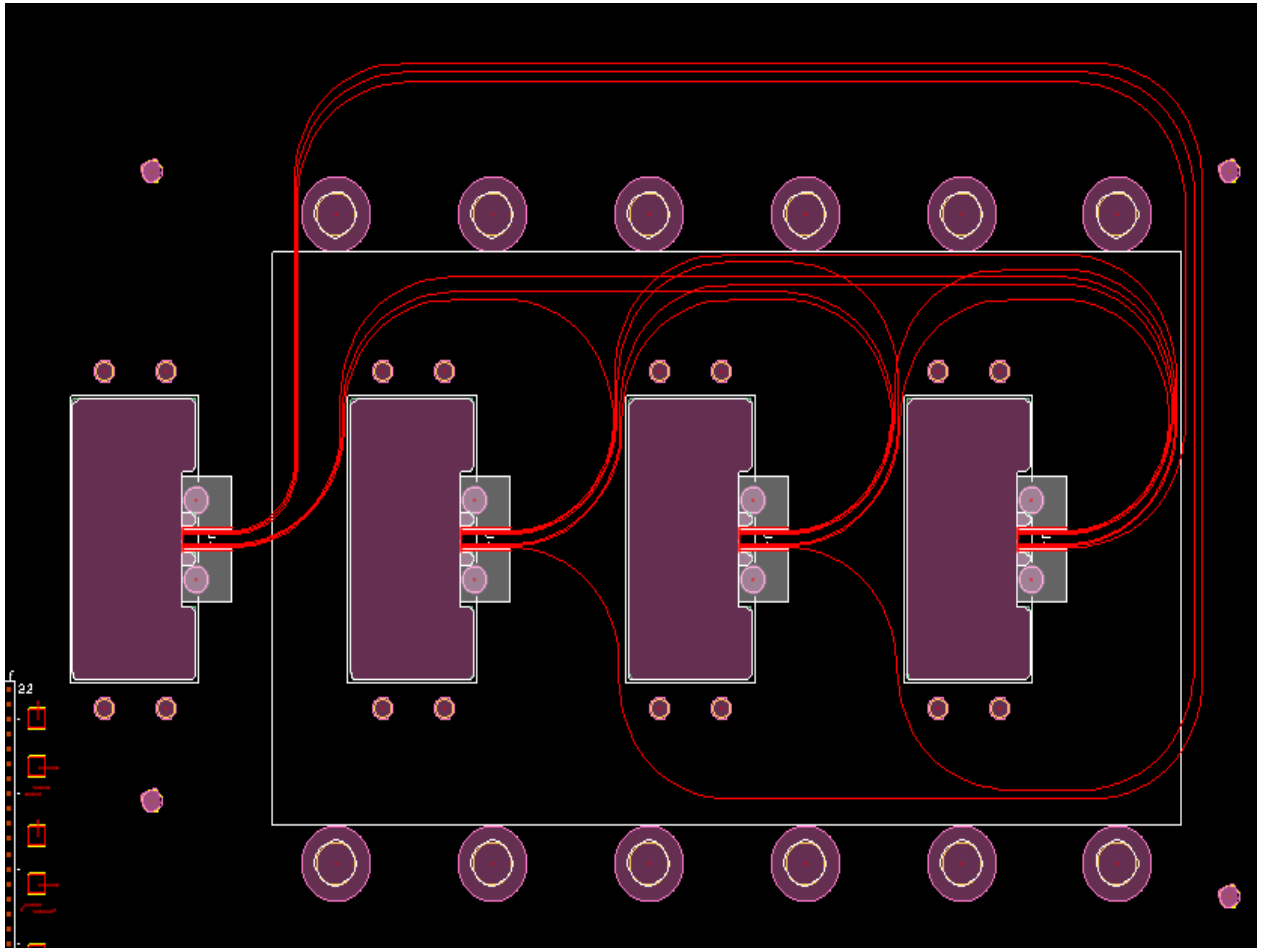
90° Crossings – Heriot Watt University



Waveguide cores – Exxelis

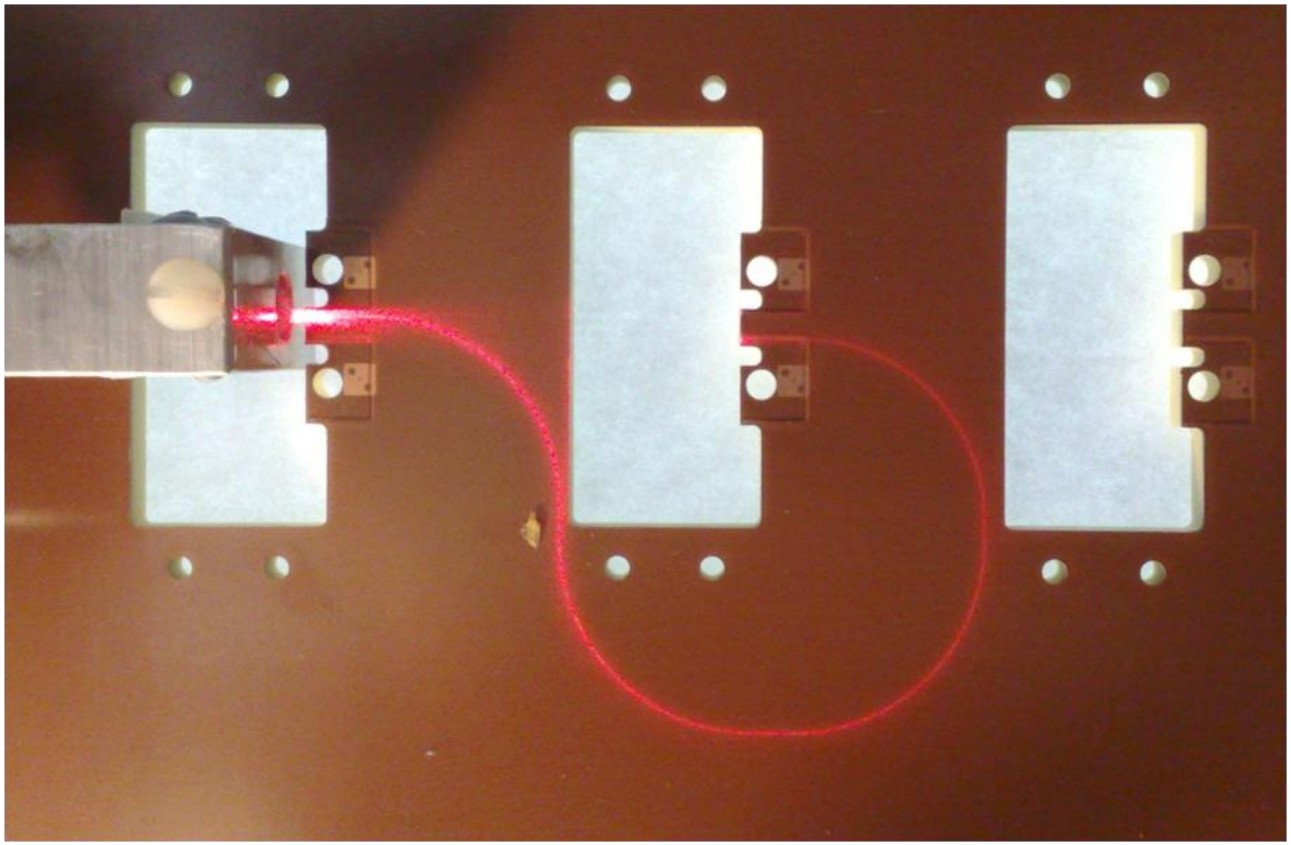
50° Crossings – Exxelis

Fully Interconnected System Demonstrator

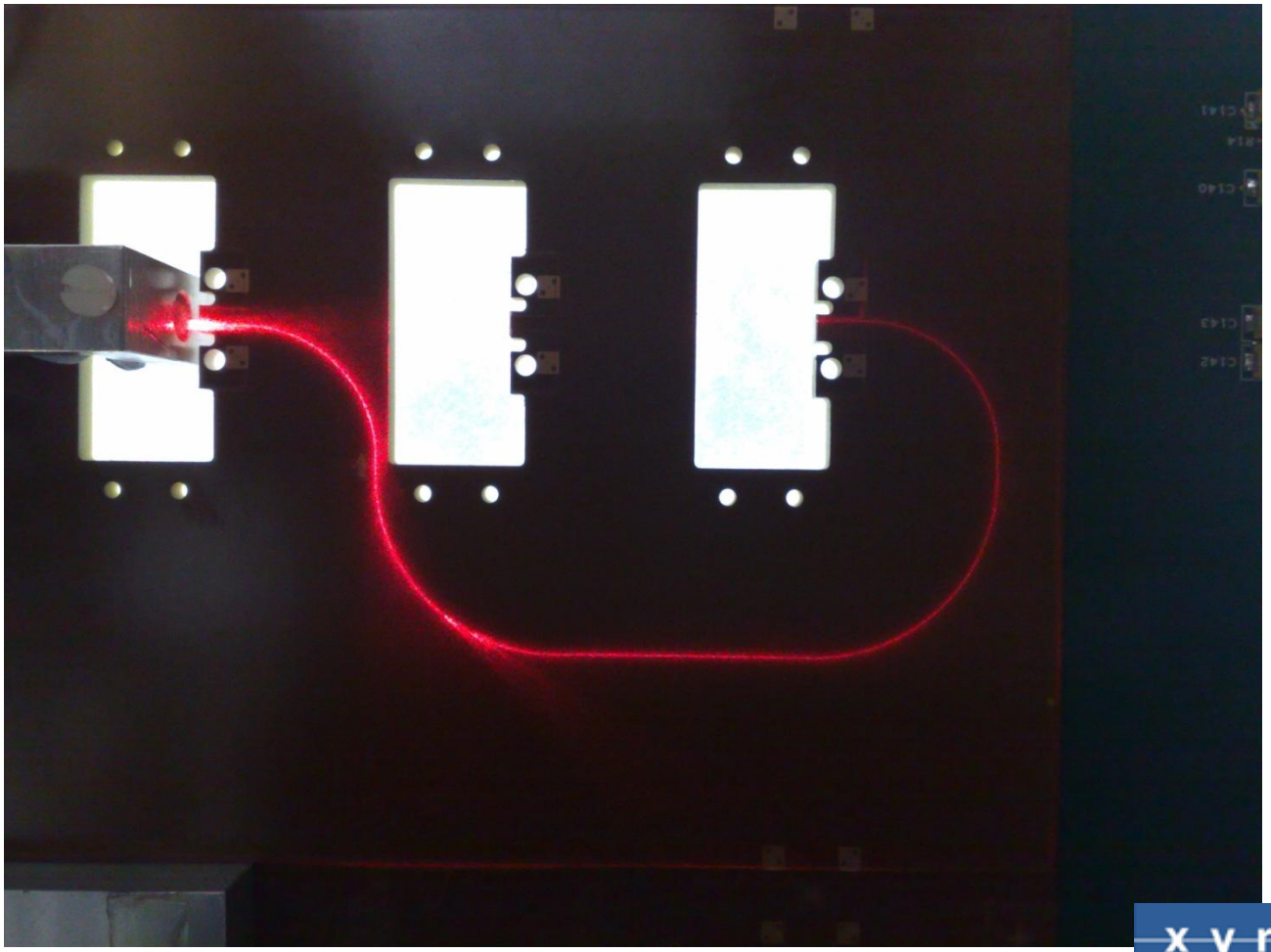


Fully connected waveguide layout using design rules

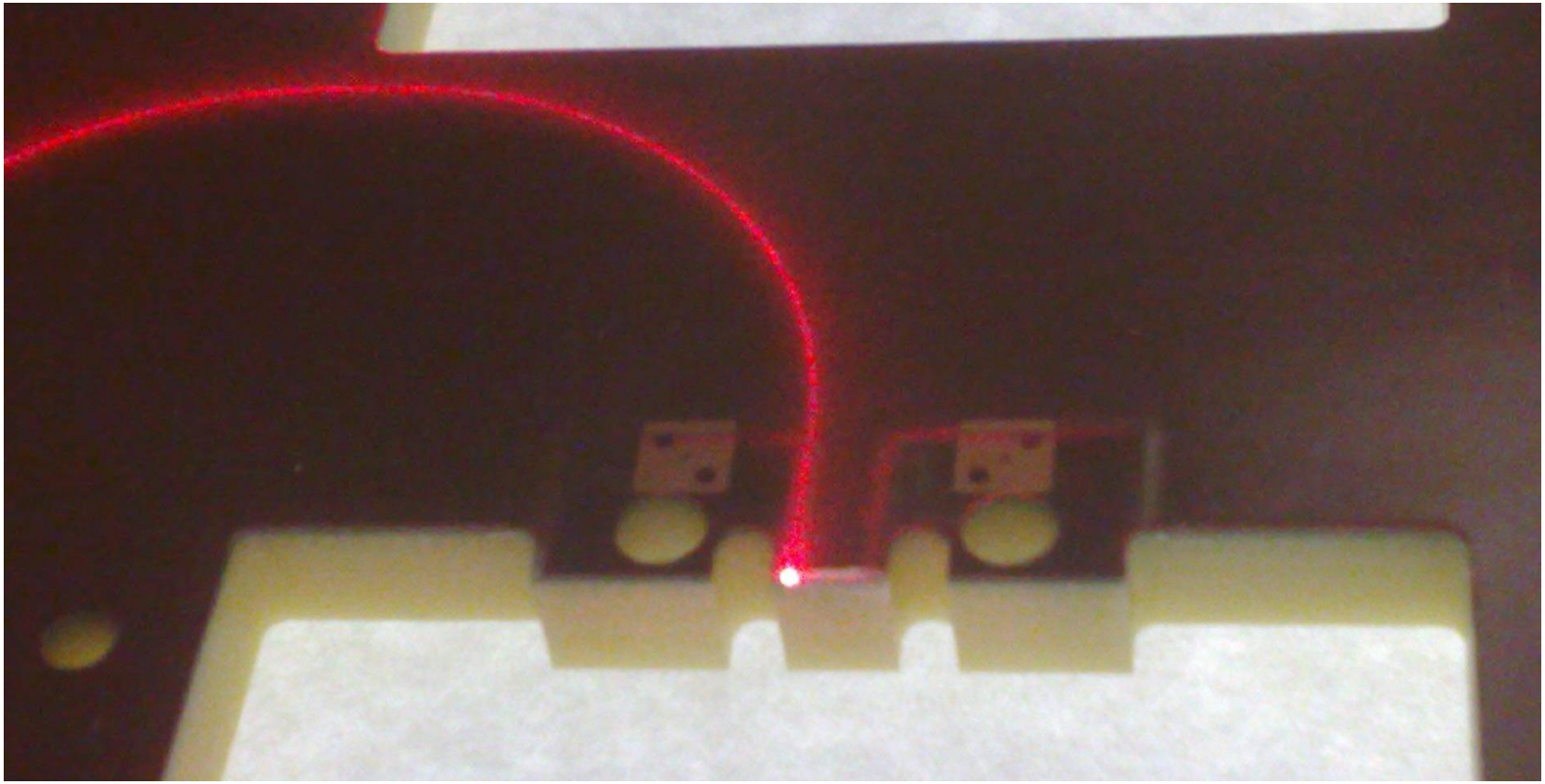
The Shortest Waveguide Illuminated by Red Laser



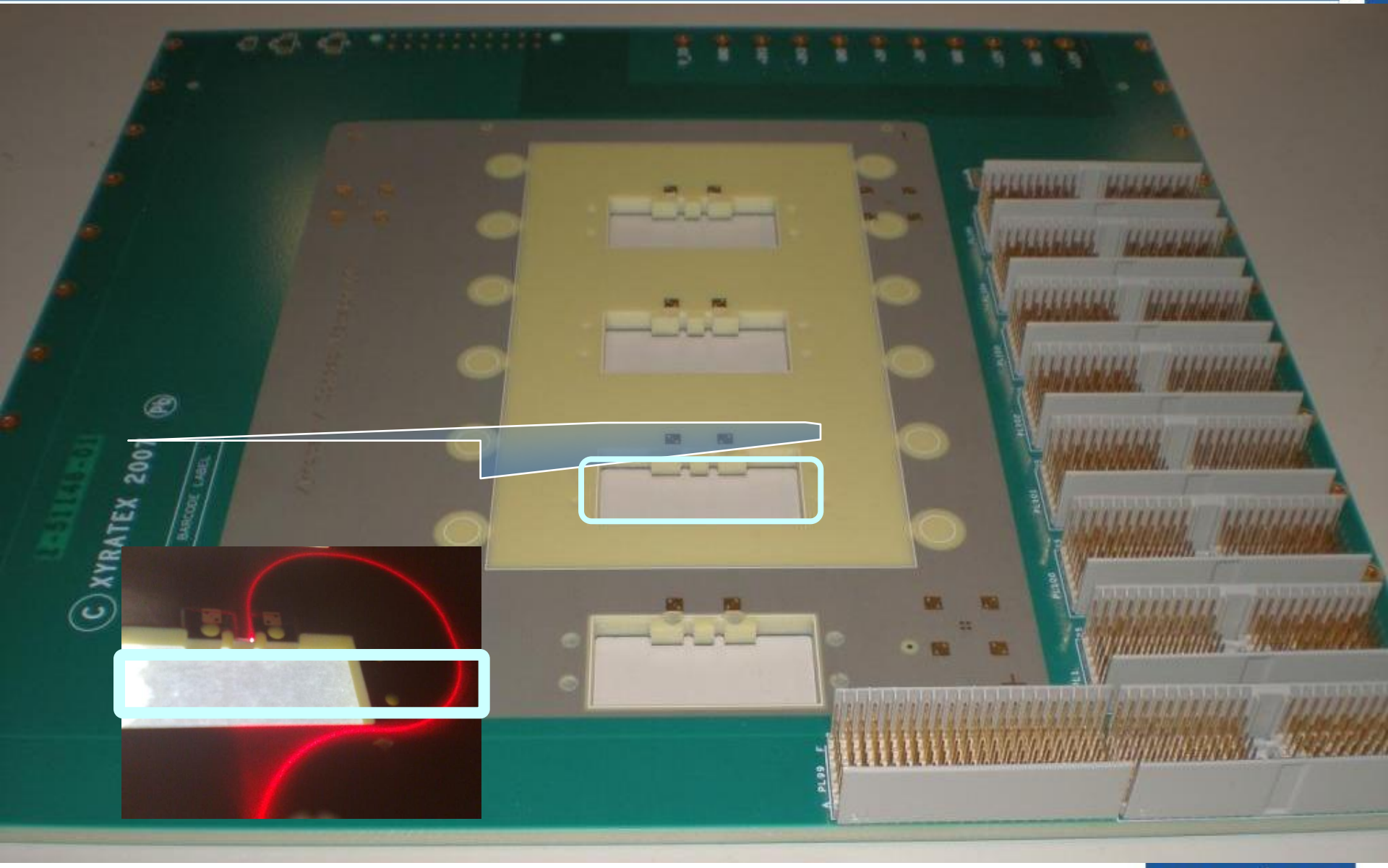
Waveguide with 2 Crossings Connected 1st to 3rd Linecard Interconnect



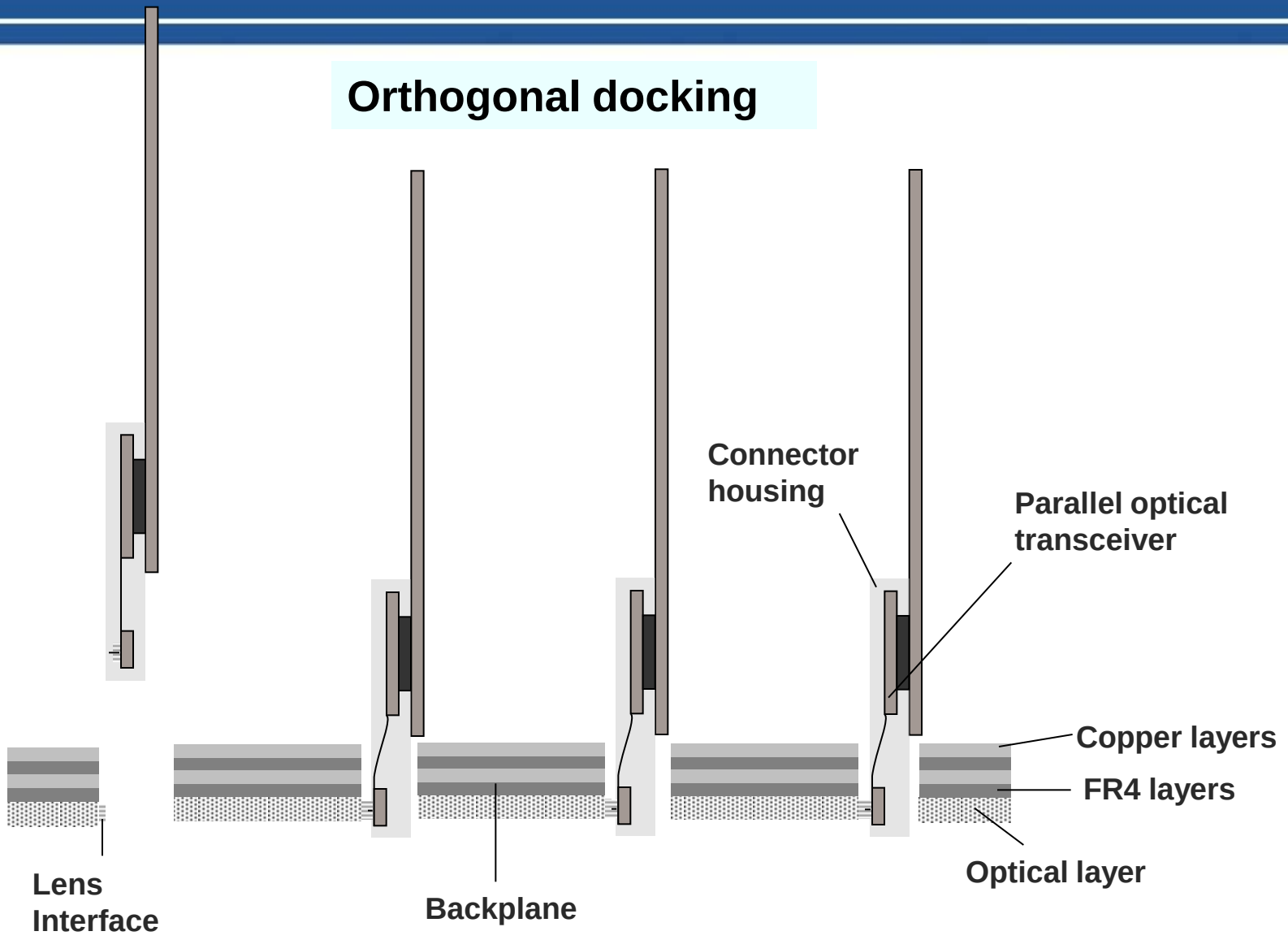
Output Facet of the Waveguide Interconnection



Xyratex Electro-Optical Midplane

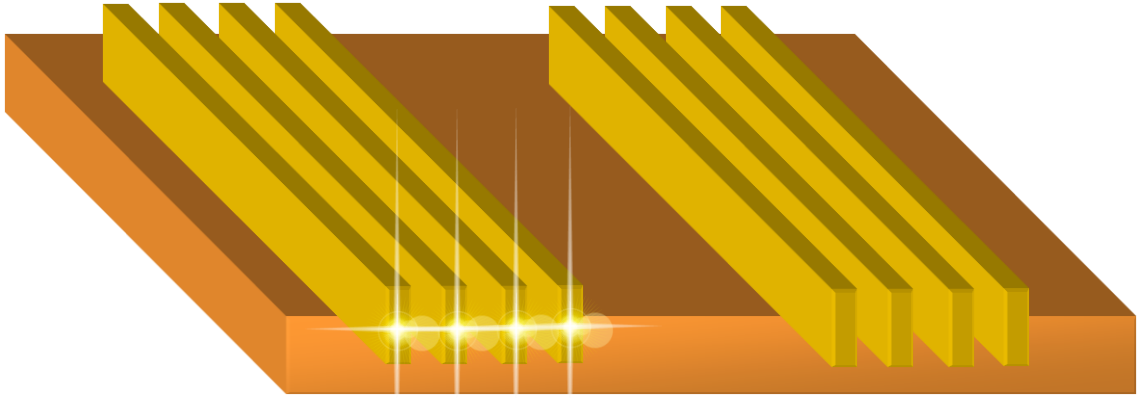


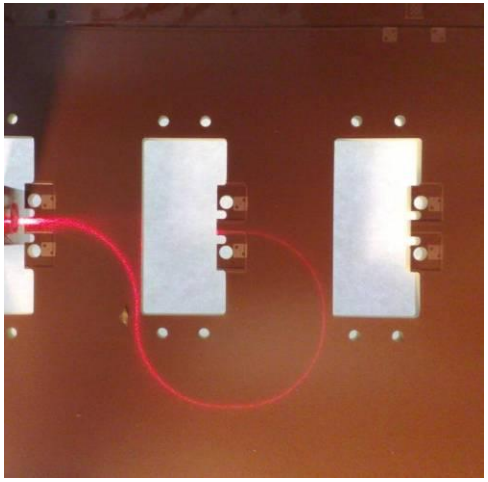
Optical backplane connection architecture



Optical backplane connection architecture

Butt-coupled in-plane connection

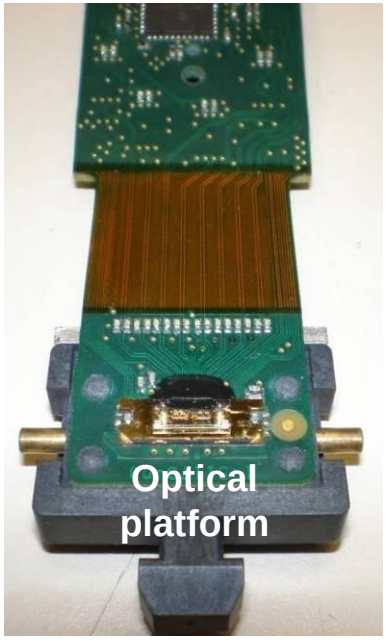


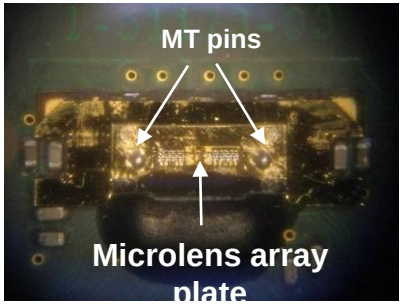


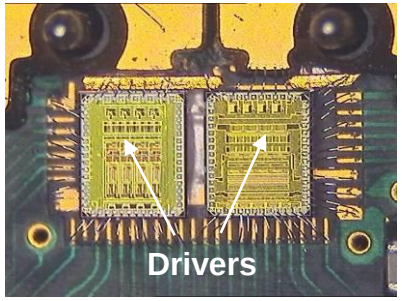
Single waveguide illuminated

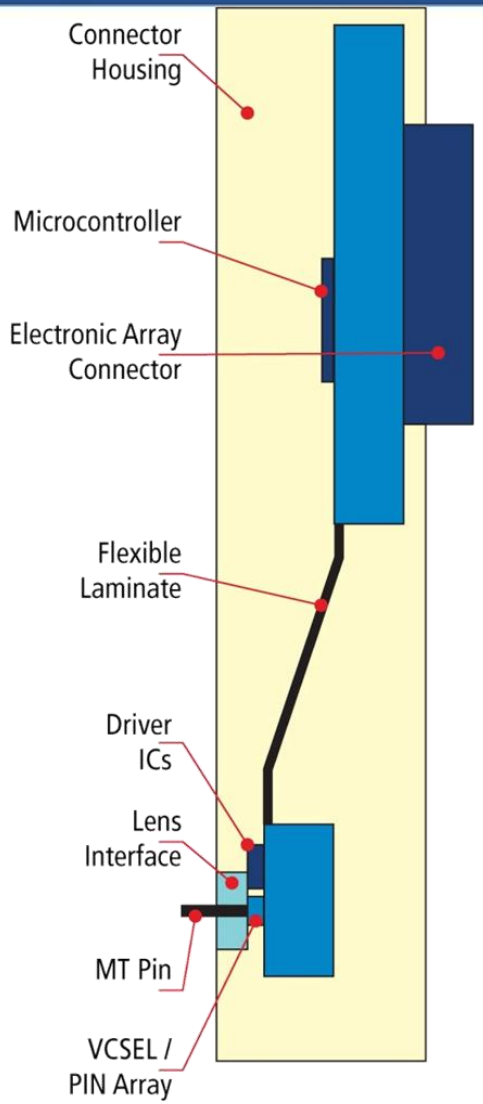
Parallel optical transceiver

- Mechanically flexible optical platform
- MT compatible optical interface
- Geometric microlens array
- Quad VCSEL driver and TIA/LA
- VCSEL / PIN arrays on pre-aligned frame







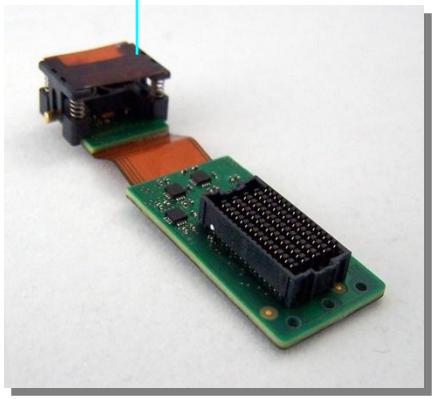


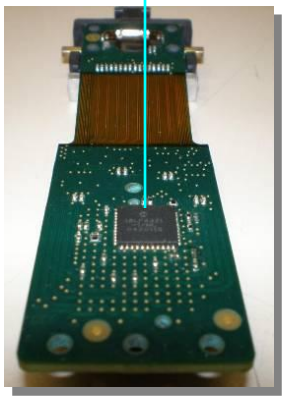
Active pluggable connector

Parallel optical transceiver

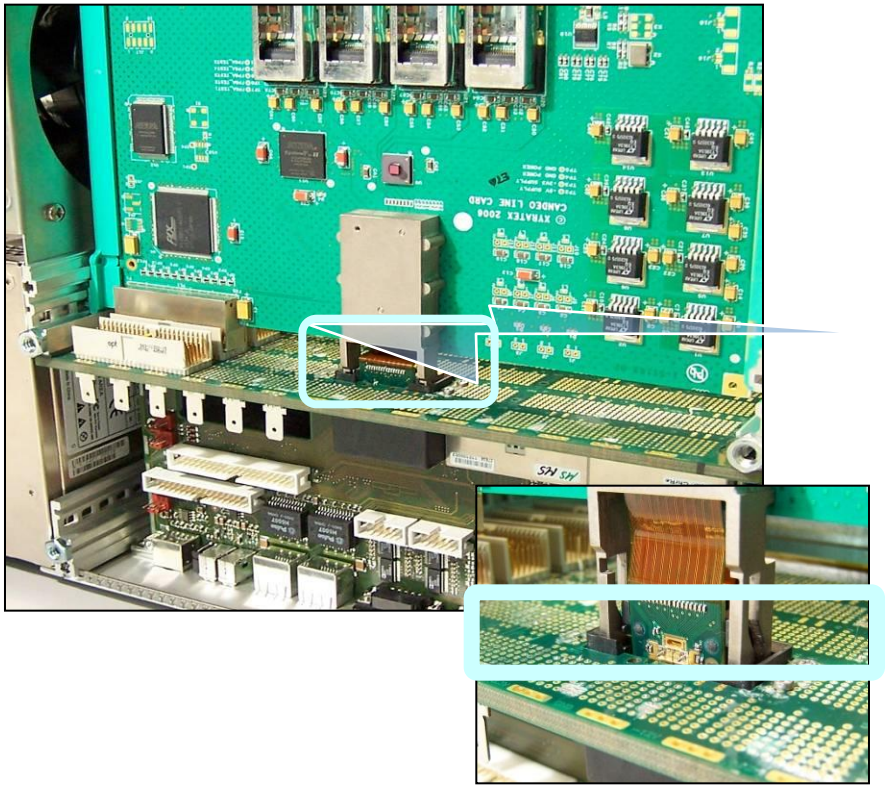
Spring loaded platform

Microcontroller





Connector module



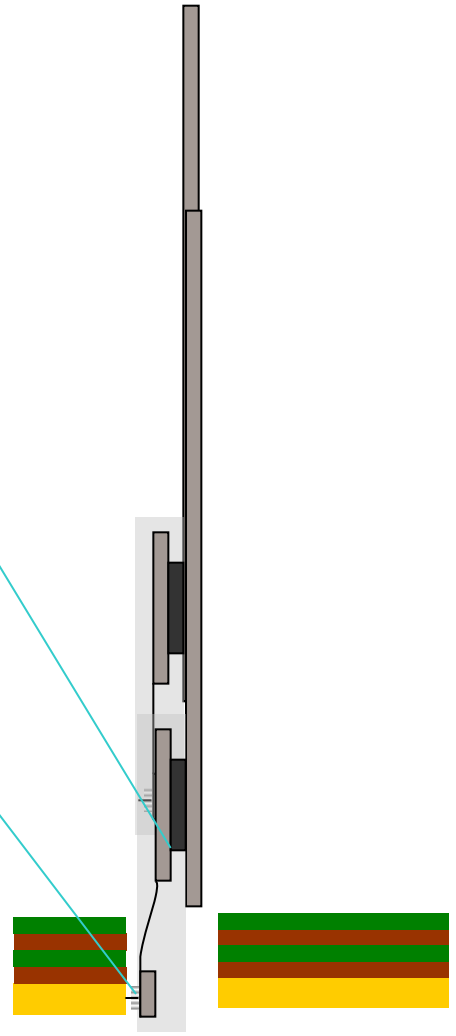
Two stage connection mechanism

First stage

- Peripheral card inserted into midplane

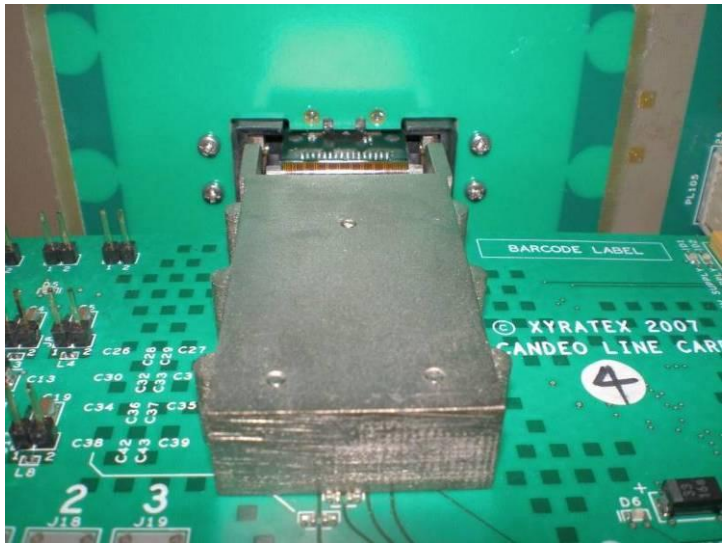
Second stage

- Optical platform pushed forward
- Butt-coupled in-plane interface

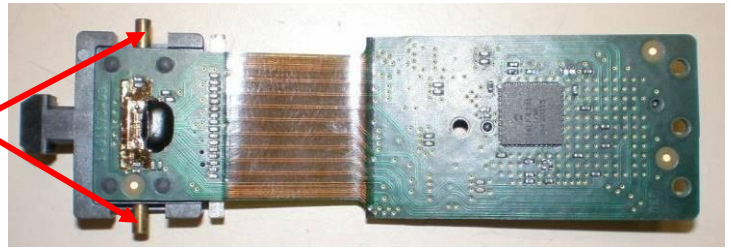


Connector engagement mechanism

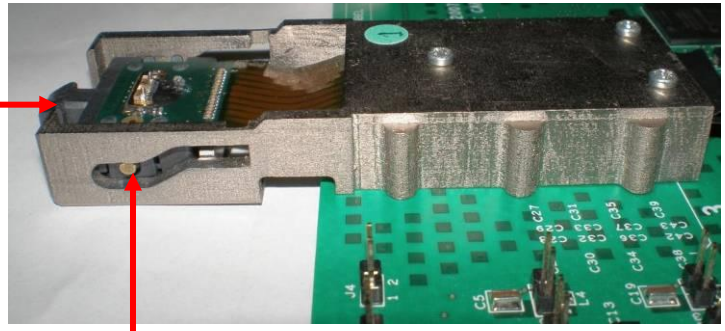
Docked



Cam followers



Ramped plug



Cam track

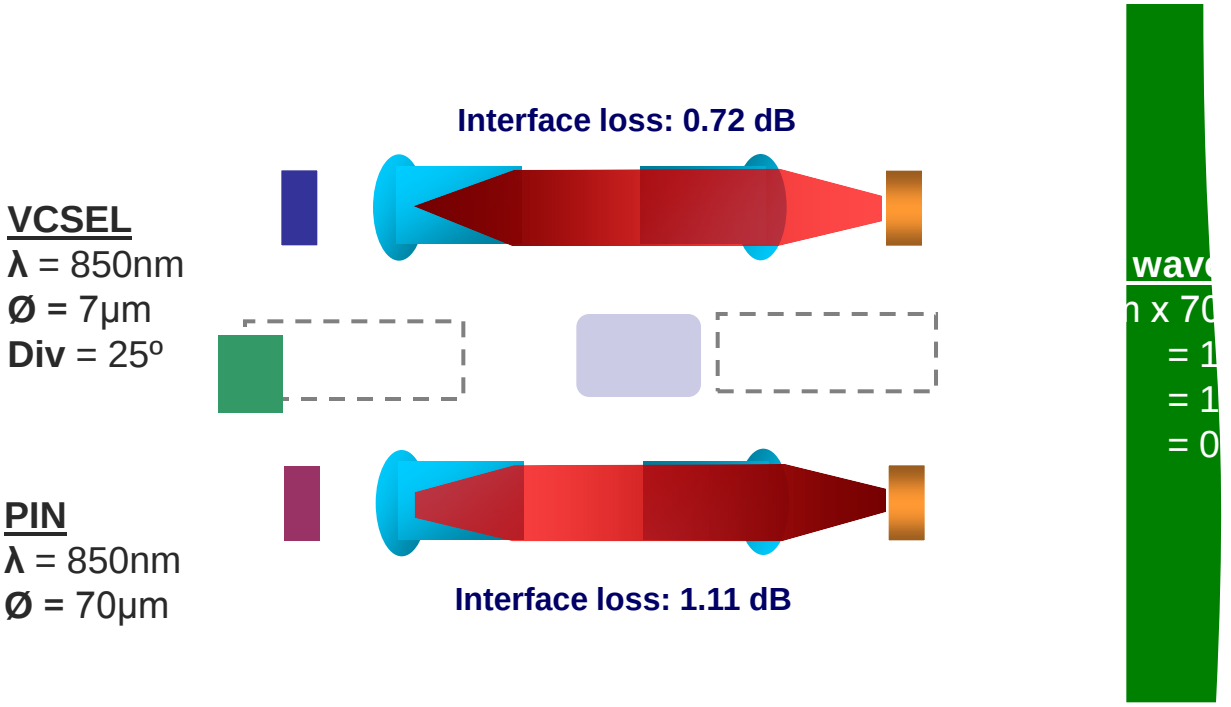
Dual lens coupling interface

Free space coupling

- Optimised for loss minimisation
- Maximum beam expansion

Dual lens coupling solution

- Beam expansion at coupling interface
- Reduces susceptibility to contamination



Electro-optical midplane

Optical polymer

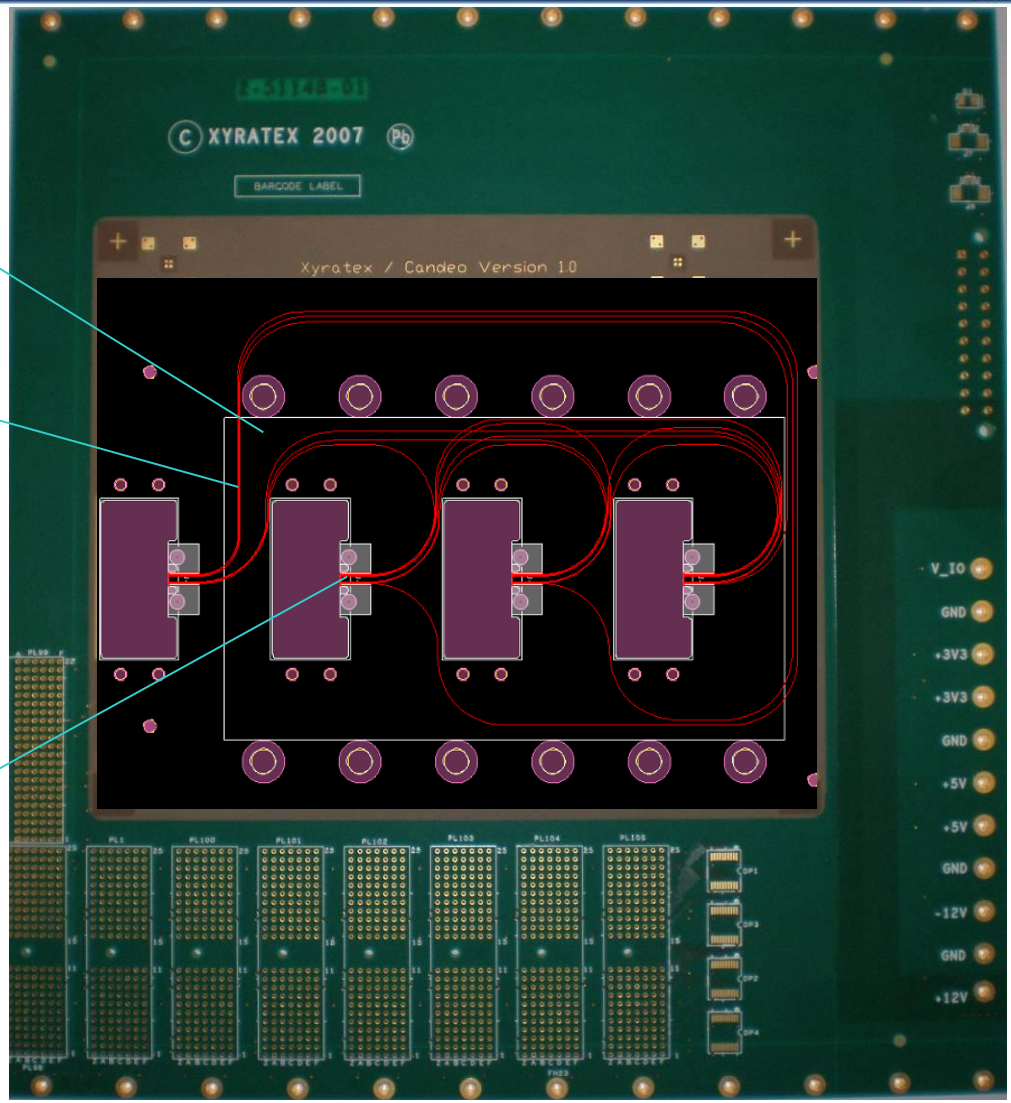
- Low loss at 850 nm

Waveguide characteristics

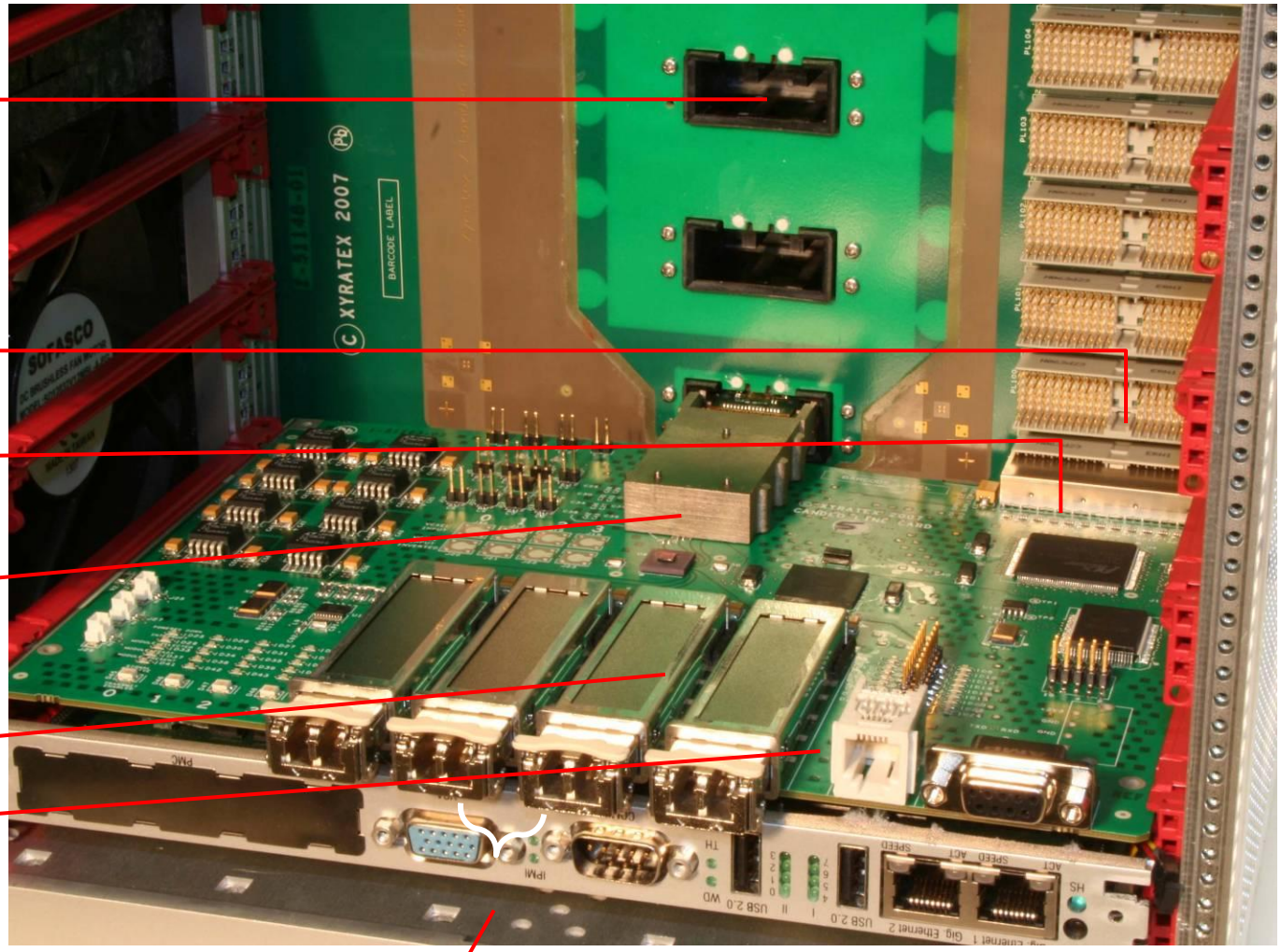
- n_{core} = 1.56
- $n_{cladding}$ = 1.524
- Δn = 2.3%
- N.A. = 0.33

Core dimensions

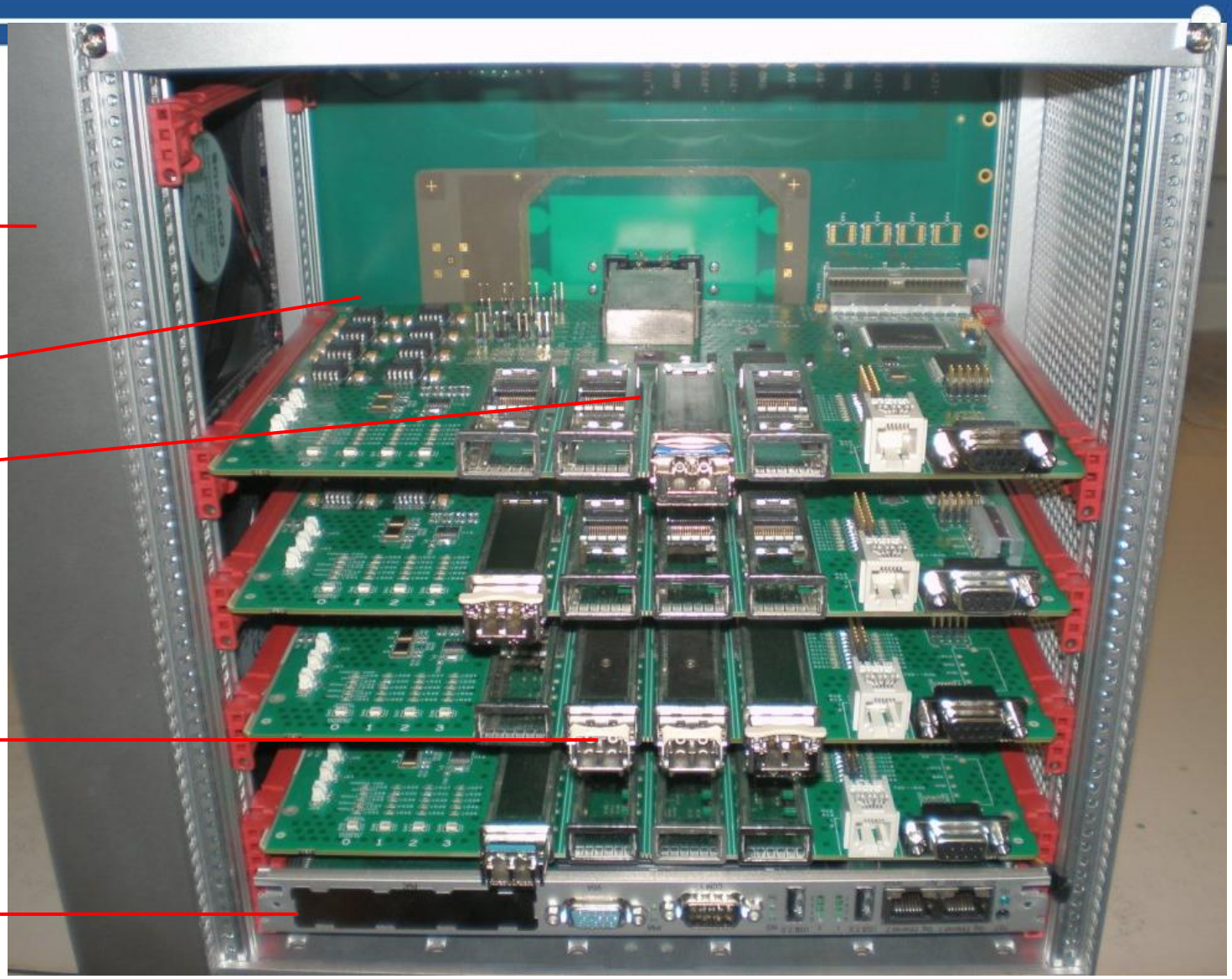
- Ø = 70 µm x 70 µm



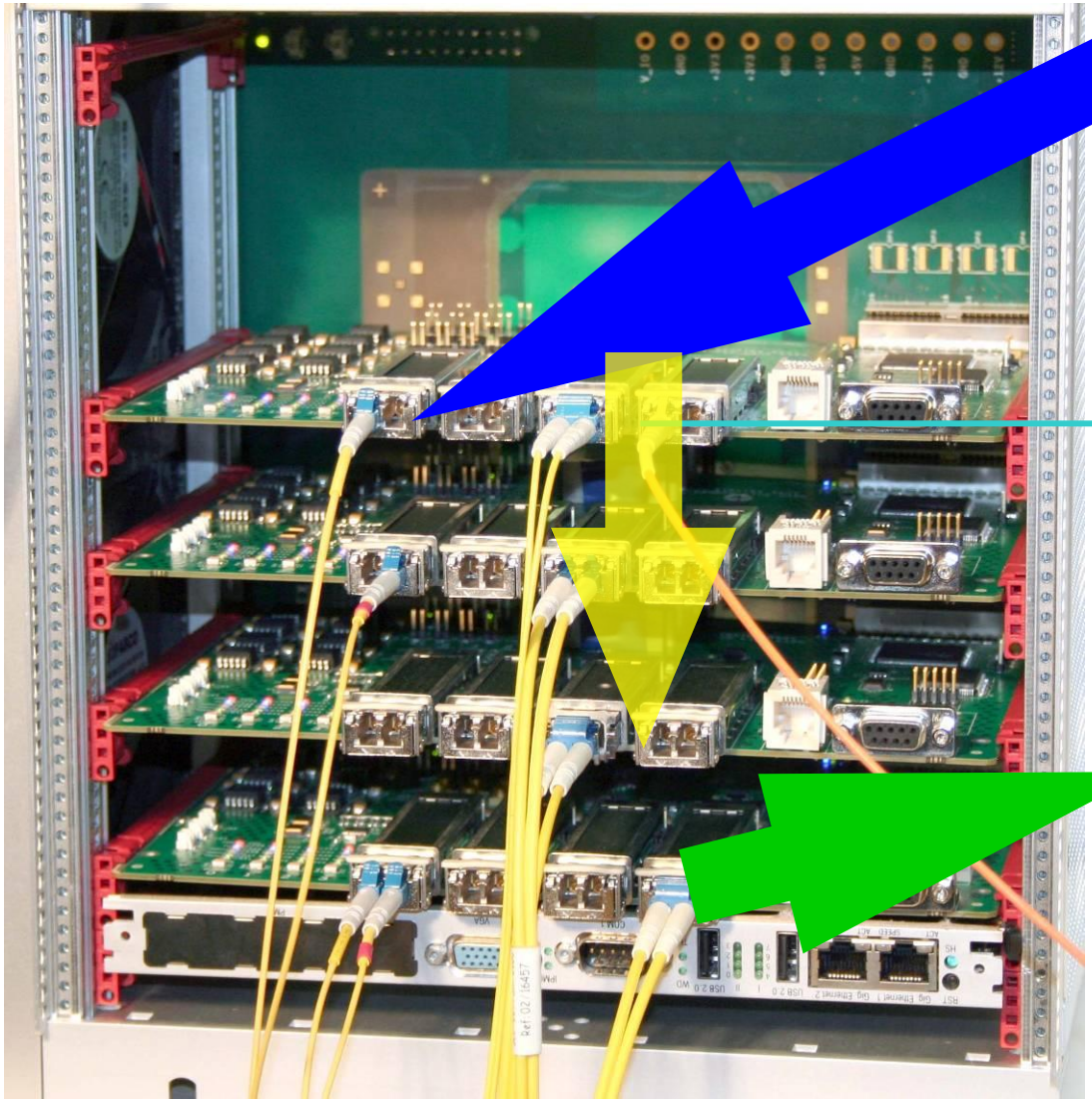
Peripheral test cards



Demonstration platform



High speed data transmission measurements

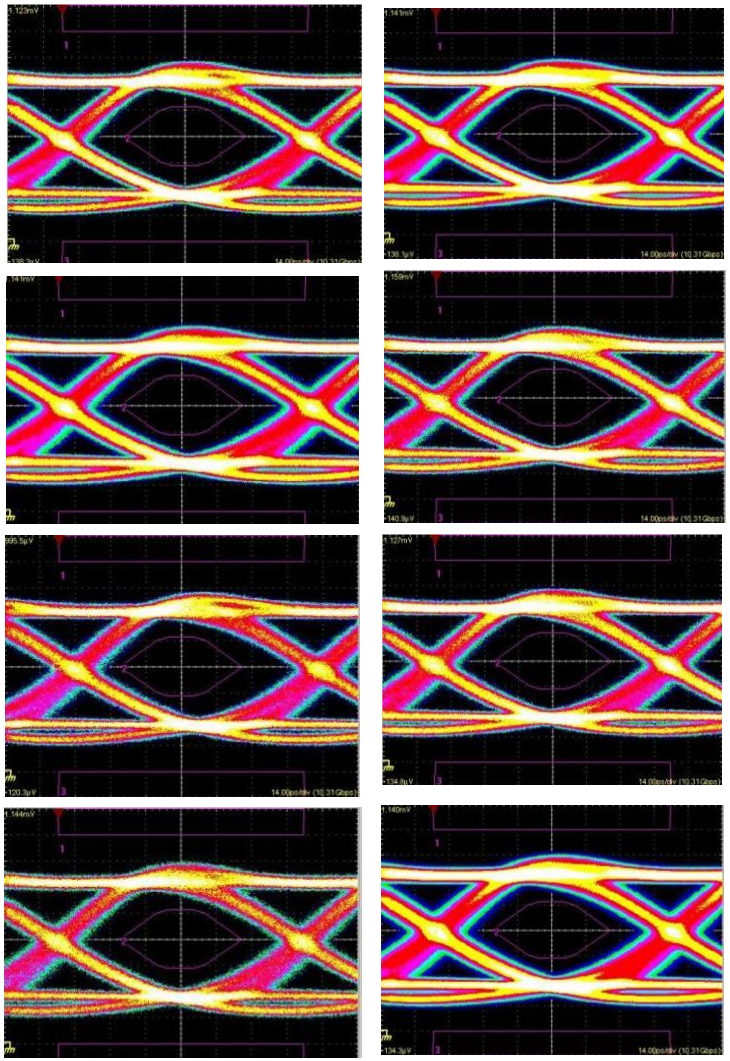


- **1st test card**
  - 10 GbE LAN test data
  - Injected into front end
- **Electro-optical midplane**
  - Pluggable connectors
  - Polymer waveguides
- **Target test card**
  - Retrieved through front end
  - Signal integrity measured

High speed data transmission measurements

Test data captured on 8 waveguides

- Data rate: 10.3 Gb/s
- Typical Pk to Pk jitter: 26 ps



BERT on waveguides

- Measured on all waveguides
- BER less than 10^{-12} measured

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