

Design and implementation of an electro-optical backplane with pluggable in-plane connectors

Speaker:

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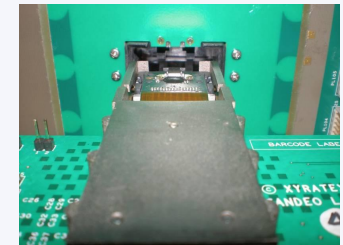
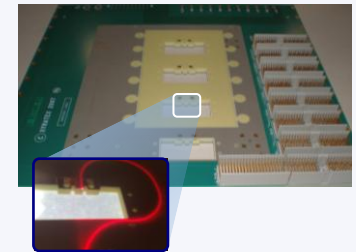
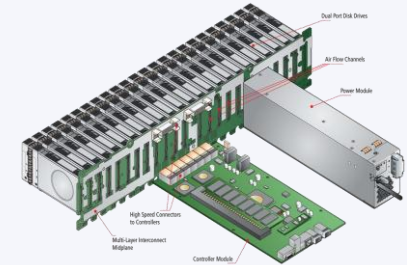
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Tuesday 26th January 2010

R. Pitwon, K. Hopkins
K. Wang, D. R. Selviah, H. Baghsiahi,
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M. Halter, Max Gmür

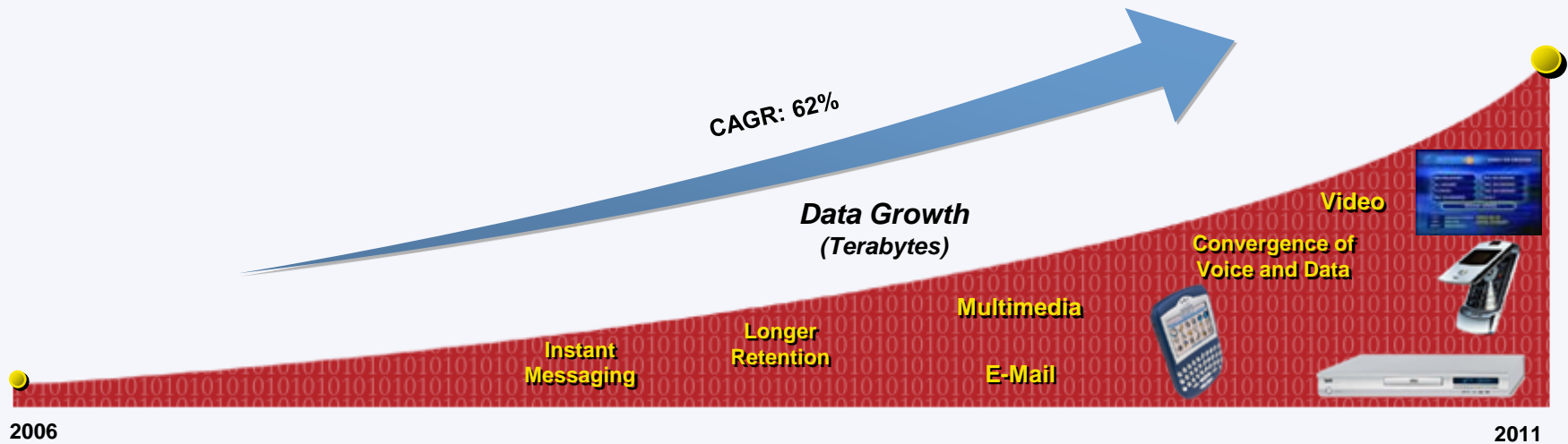
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University College London
IBM Zürich
Vario-optics AG

Overview

- ❑ Design challenges in data storage systems
- ❑ Electro-optical backplane with polymer waveguides
- ❑ Active in-plane optical backplane connector
- ❑ Demonstration platform



Design challenges in modern data storage systems



Source: IDC, 2007



Data storage protocol and form factor trends

Disk drive form factors decreasing

3.5" HDD



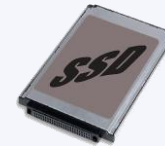
2.5" HDD



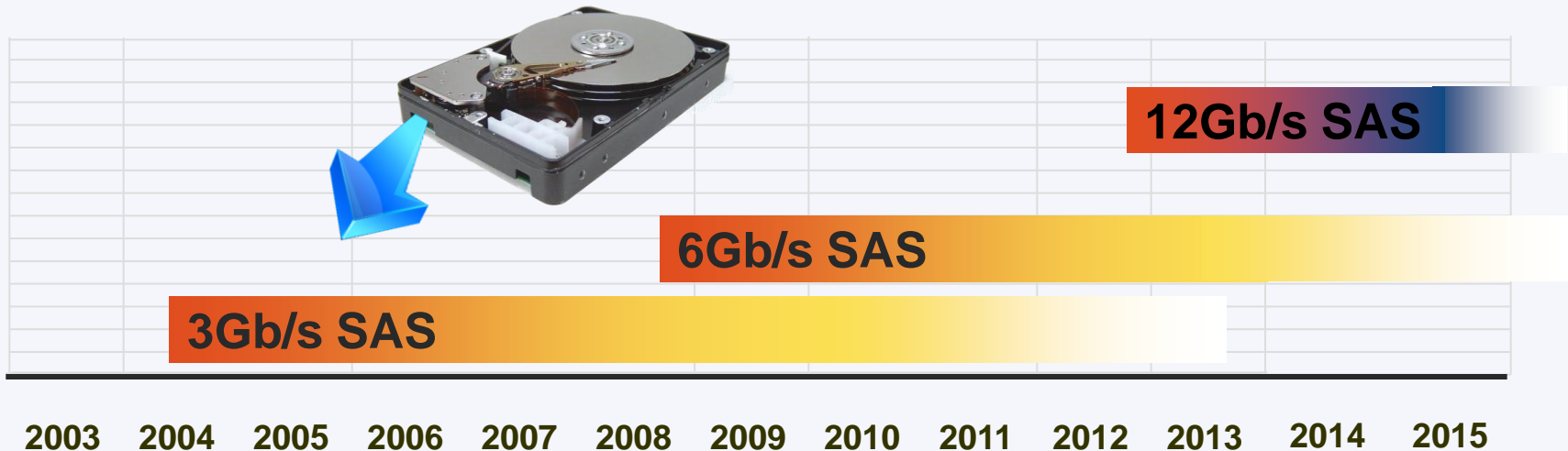
2.5" SSD



1.8" SSD



Data storage interconnect speeds increasing



Source: SCSI Trade Association Sep 08

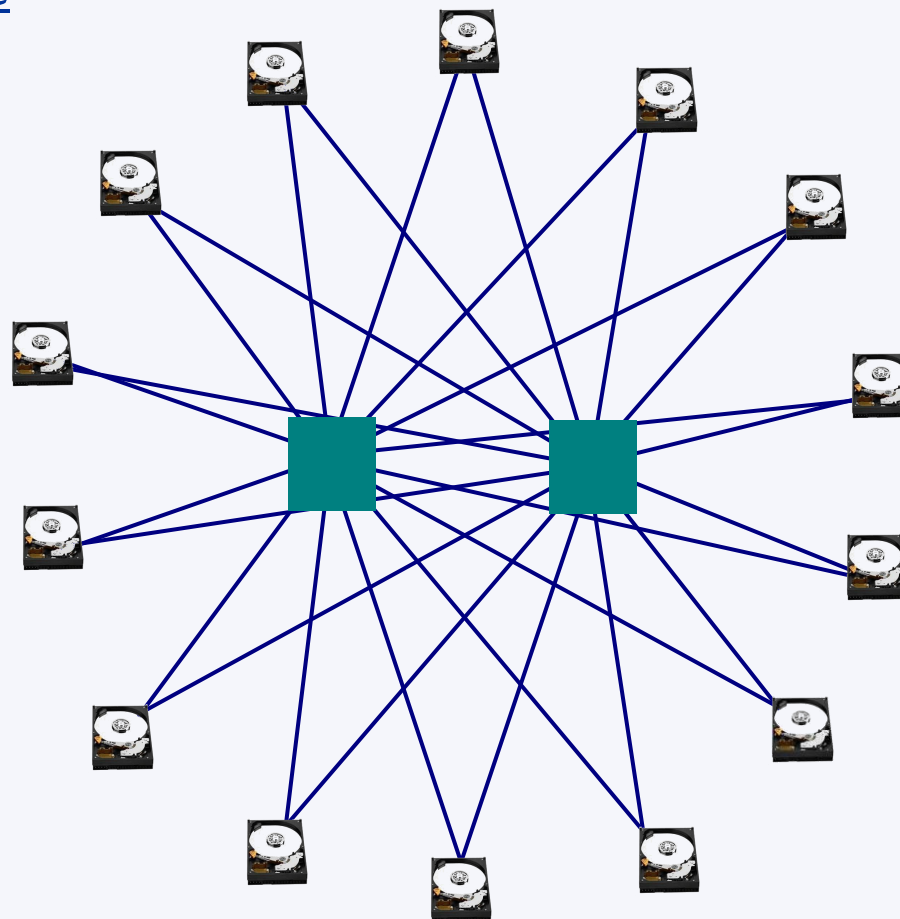
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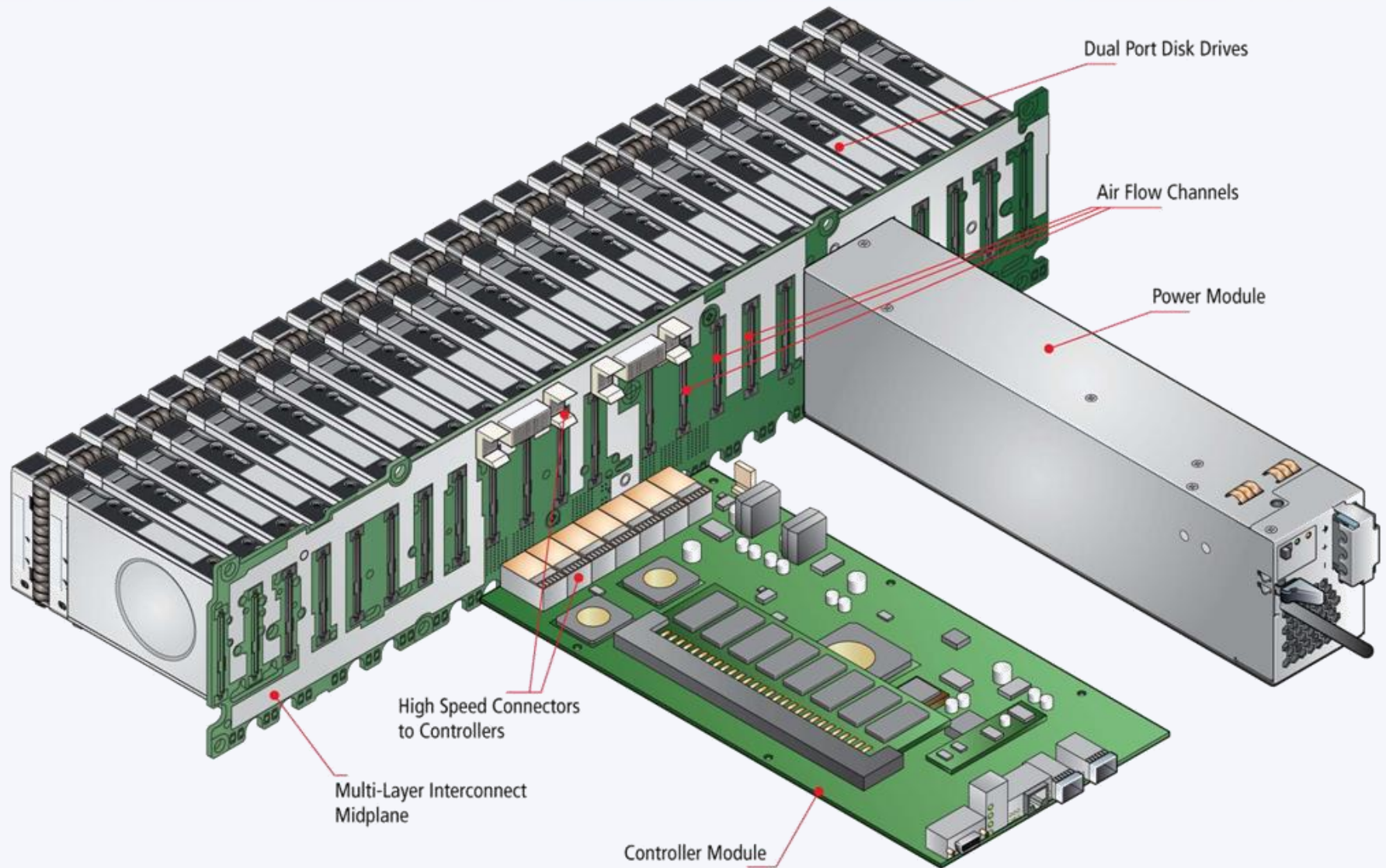
Data storage array backplane topology

Redundant dual star architecture

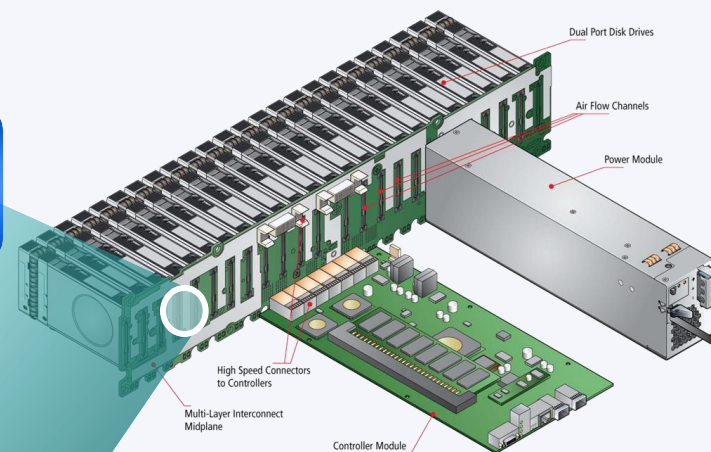
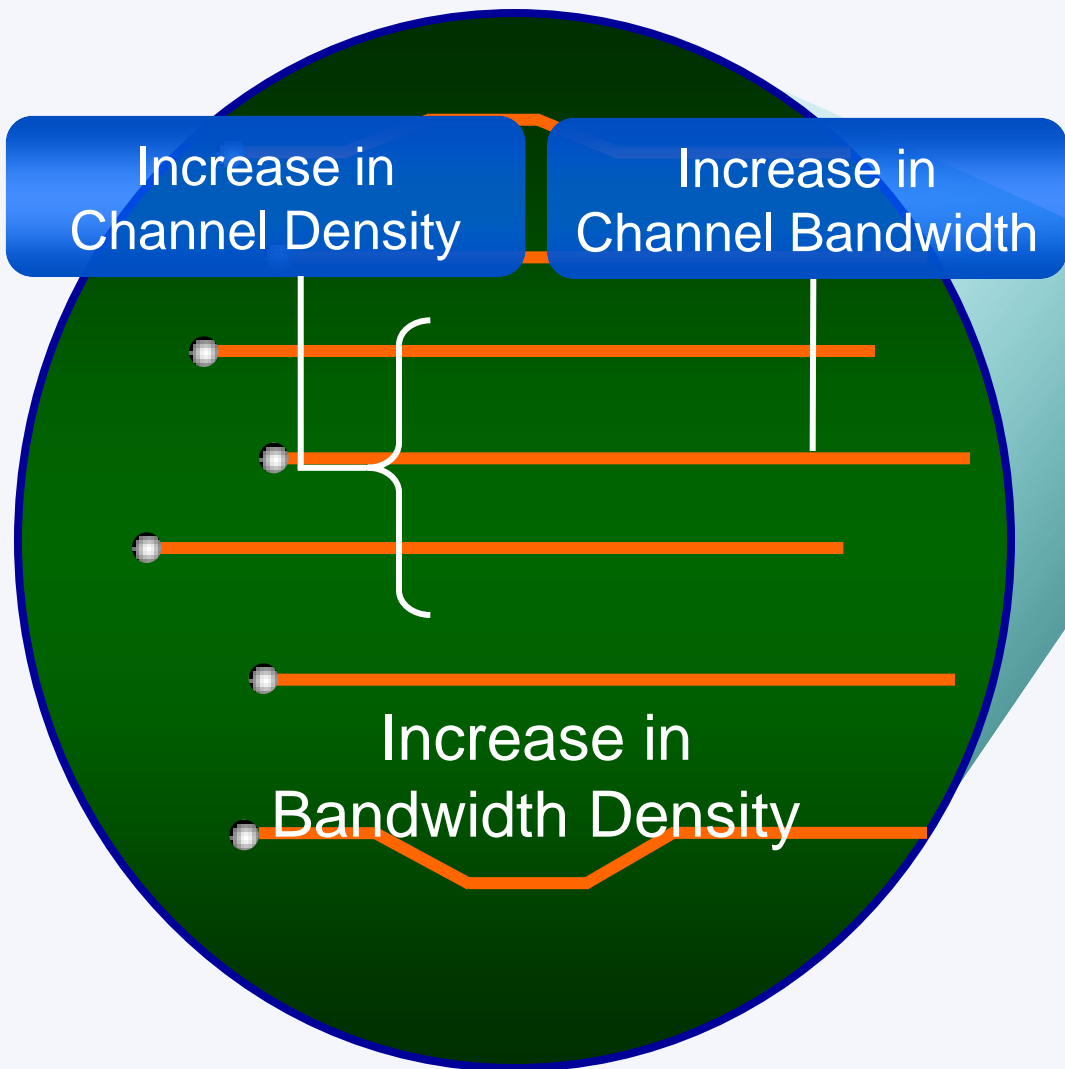
- ❑ Data storage devices
- ❑ Controller modules
- ❑ Midplane interconnect



Design and performance constraints



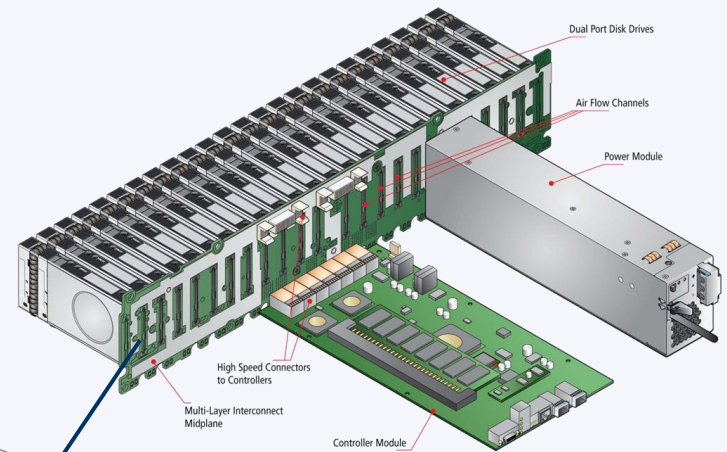
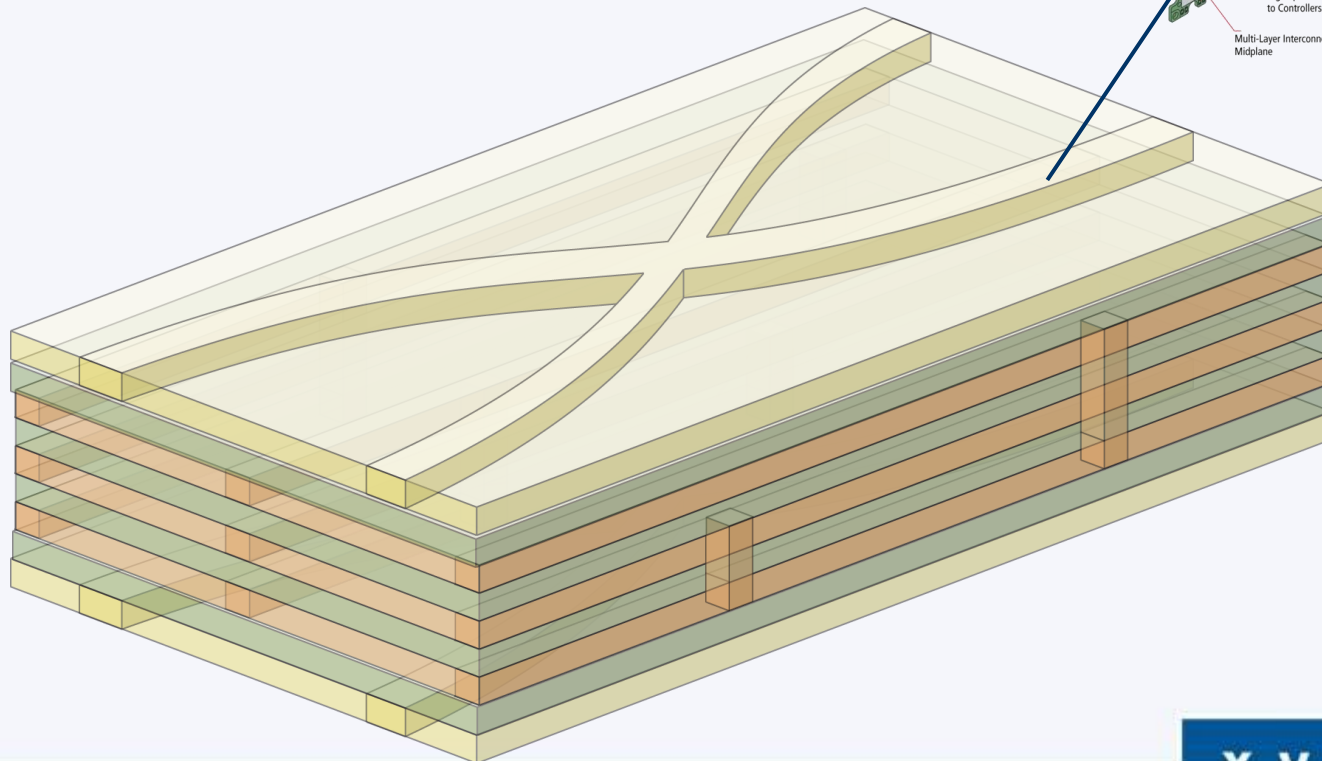
Design and performance constraints



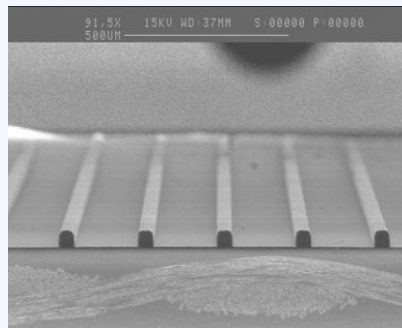
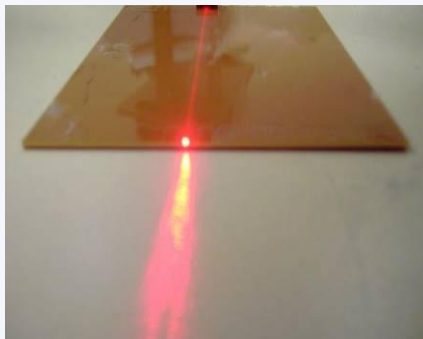
- ❑ Decreasing form factors cause increase in density
- ❑ Increasing interconnect data rates on midplane

Design and performance constraints

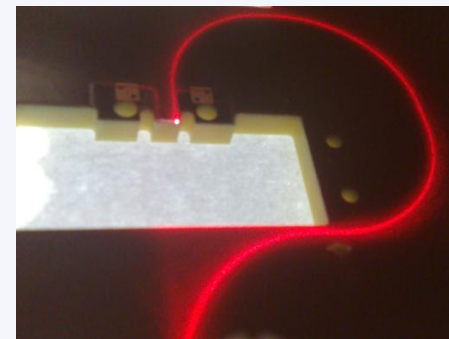
- ❑ Copper layers for power distribution
- ❑ Copper layers for low speed communication
- ❑ Optical layers for high speed communication



Electro-optical backplane with polymer waveguides



Source: Exxelis



Polymer optical waveguide layer

Optical polymer

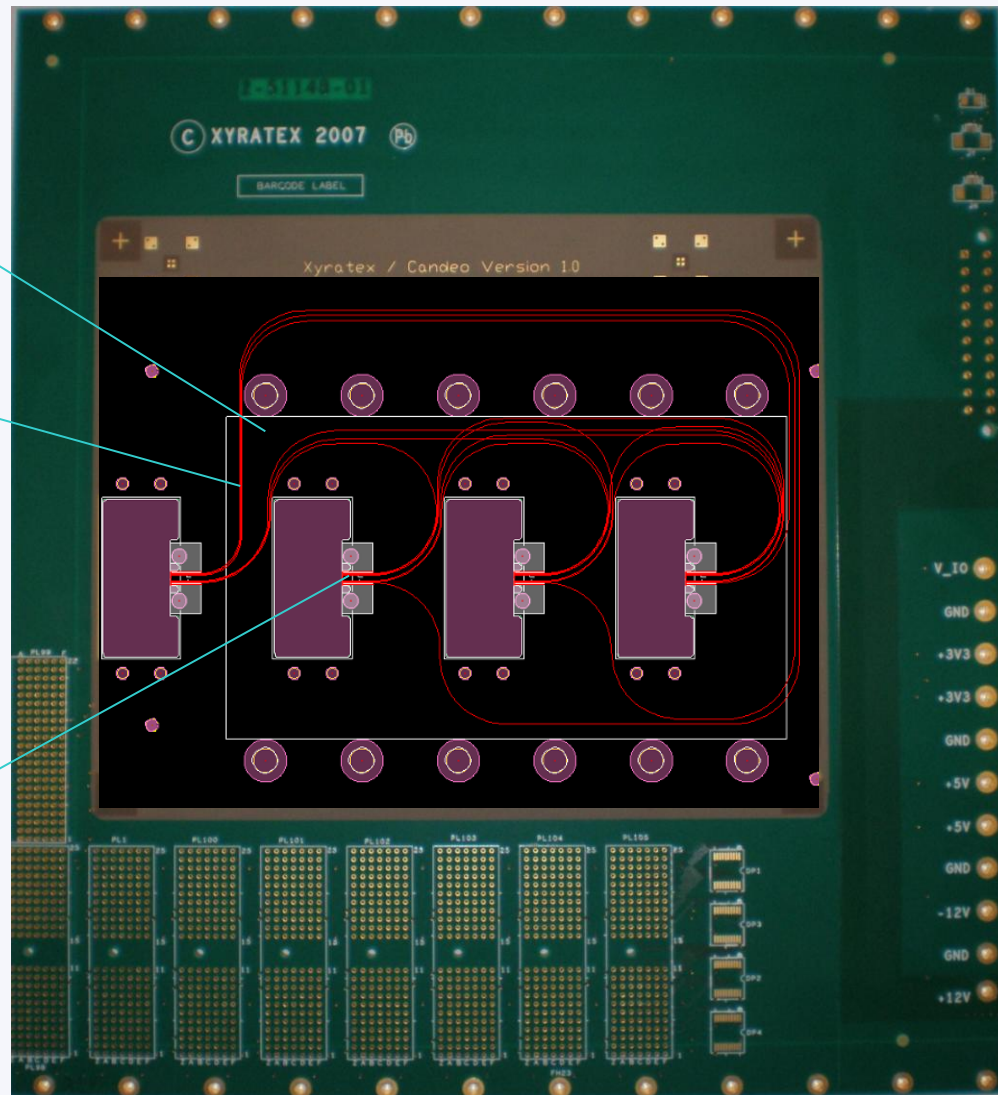
- ❑ Low loss at 850 nm

Waveguide characteristics

- ❑ $n_{\text{core}} = 1.56$
- ❑ $n_{\text{cladding}} = 1.524$
- ❑ $\Delta n = 2.3\%$
- ❑ N.A. = 0.33

Core dimensions

- ❑ Cross-section = $70 \mu\text{m} \times 70 \mu\text{m}$
- ❑ Pitch (centre) = $250 \mu\text{m}$



Optical interconnect design

Waveguide layout

- ❑ UCL
- ❑ Xyratex
- ❑ IBM Zurich

Crossovers

- ❑ Non-orthogonal
- ❑ 130° to 160°

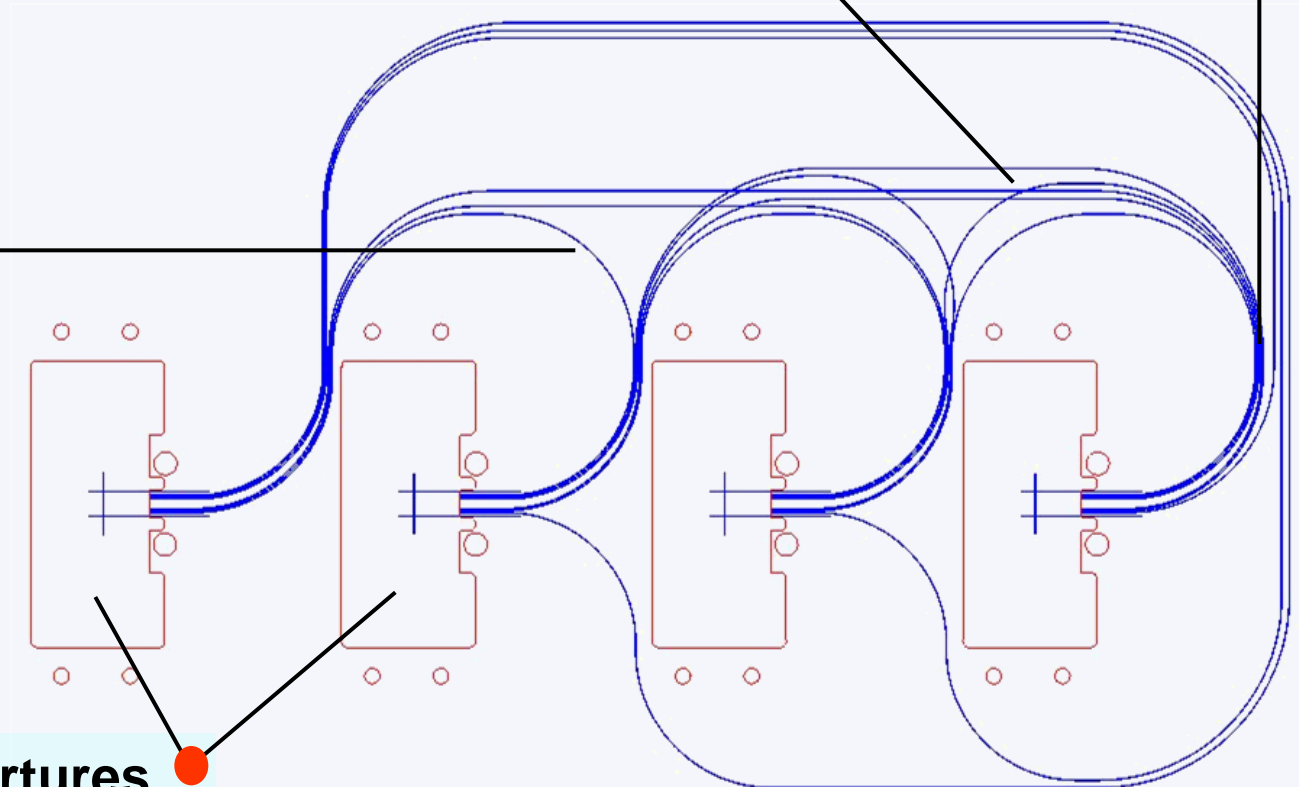
Min. Pitch

- ❑ $250\ \mu\text{m}$

Bends

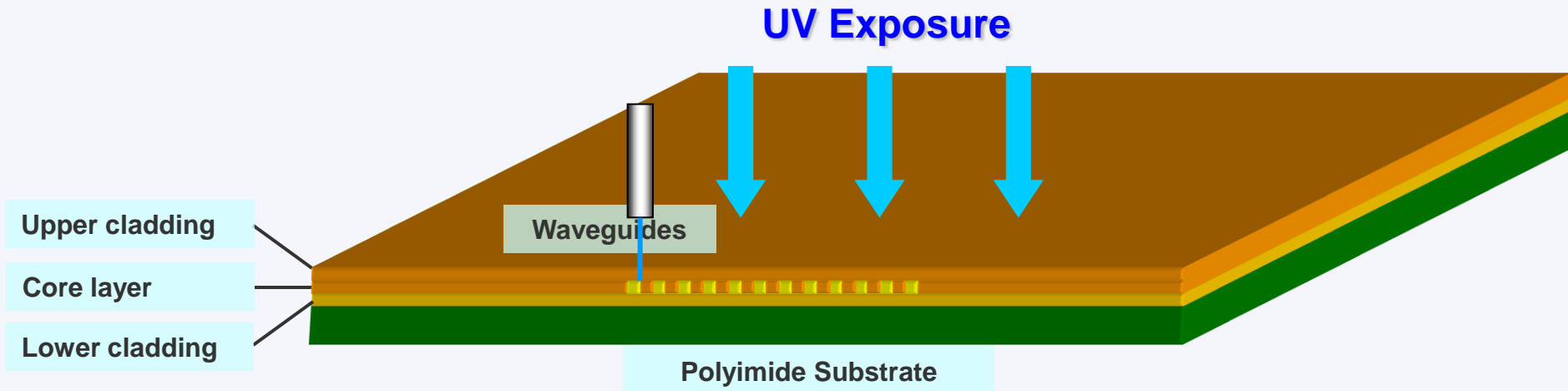
- ❑ RoC = 17 mm
- ❑ Negative and positive cascades

Engagement apertures



Electro-optical PCB fabrication process

1. Deposit lower refractive index polymer (cladding) onto substrate surface
2. Cure polymer layer with exposure to ultra-violet light to harden
3. Deposit higher refractive index (core) polymer onto lower cladding layer
4. Align UV laser write head into position
5. Activate laser and move write head to pattern waveguide features in core layer
6. Remove uncured portions of the core layer
7. Deposit lower refractive index polymer onto patterned core layer
8. Cure upper cladding layer with UV light

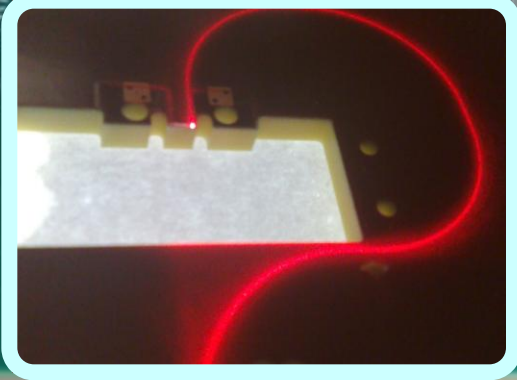


Electro-optical midplane

Multilayer electro-optical PCB

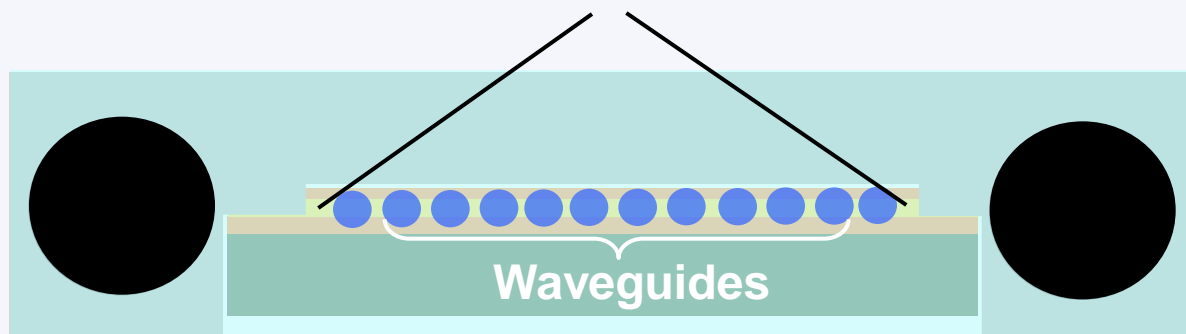
Compact PCI bus connectors

Optical connector sites

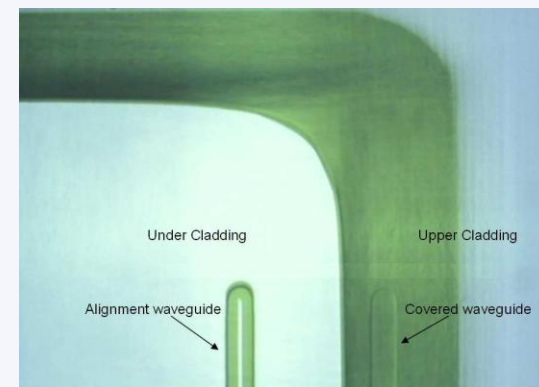
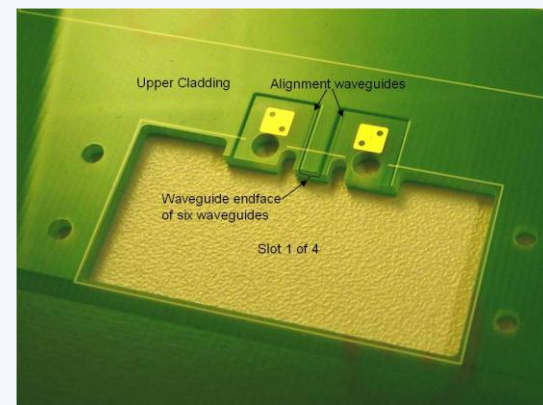


Passive alignment and assembly

Mechanical registration features



- Deposit lower cladding layer
- Deposit core layer
- Pattern core layer including registration waveguides
- Deposit upper cladding layer
- Remove part of upper cladding for mechanical access
- Align MT compliant receptacle with microlens array



Optical connector receptacles

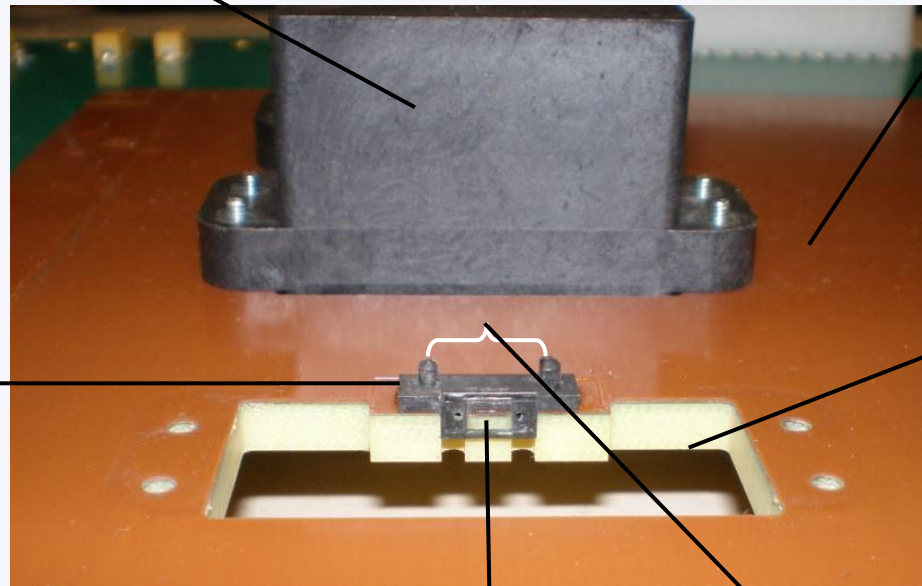
Primary receptacle

- Low tolerance
- Pluggable connector

Secondary receptacle

- High tolerance
- Lens holder
- MT compliant

Electro-optical midplane



Micro lens array

- MT compliant

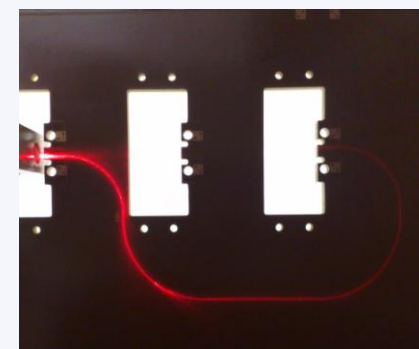
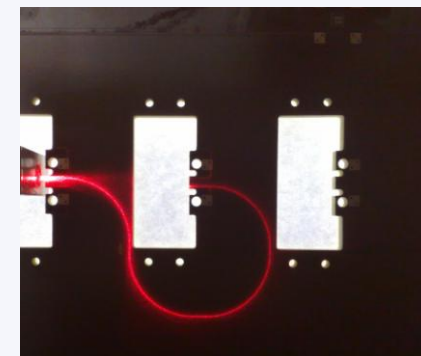
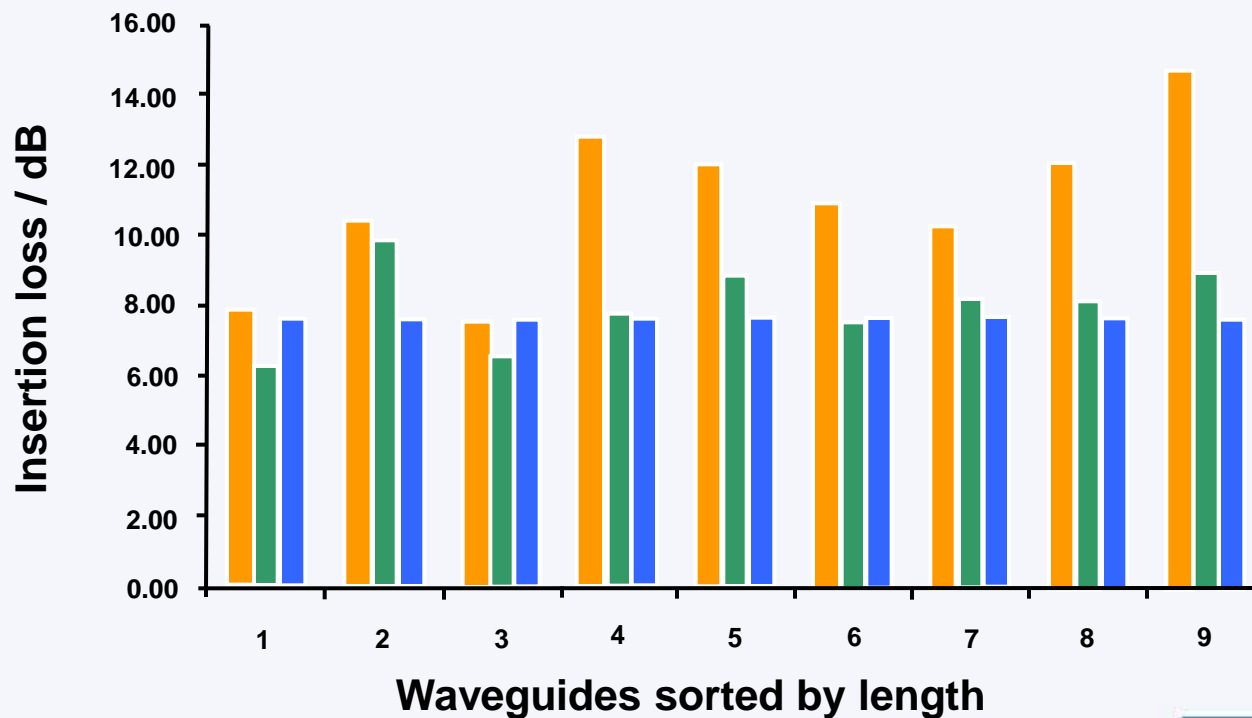
Connector site

Alignment stubs

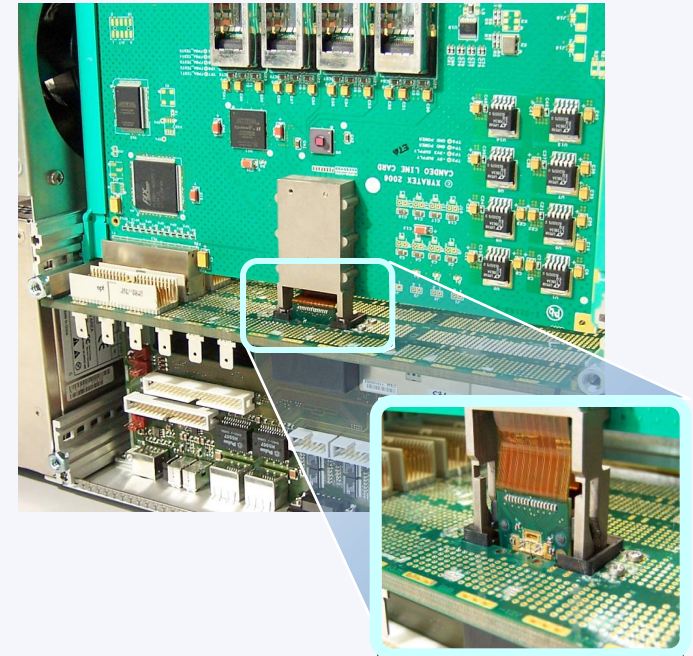
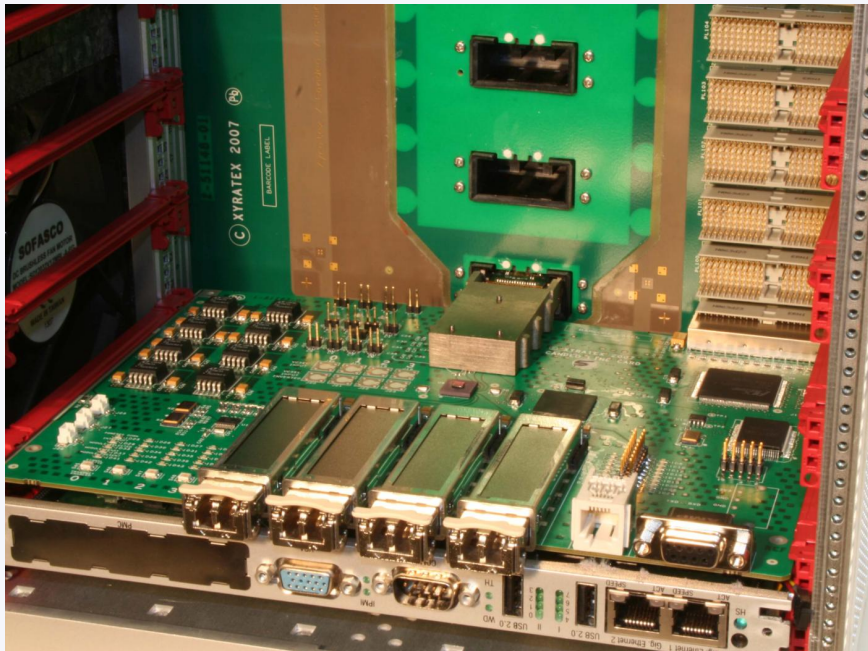
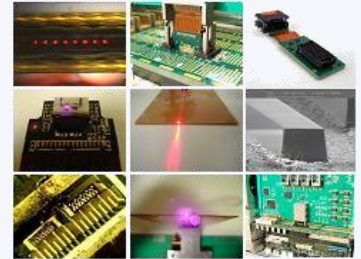
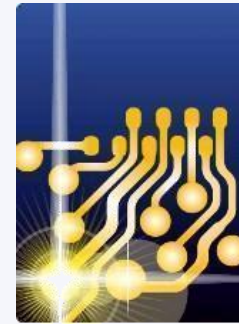
Waveguide insertion loss measurements



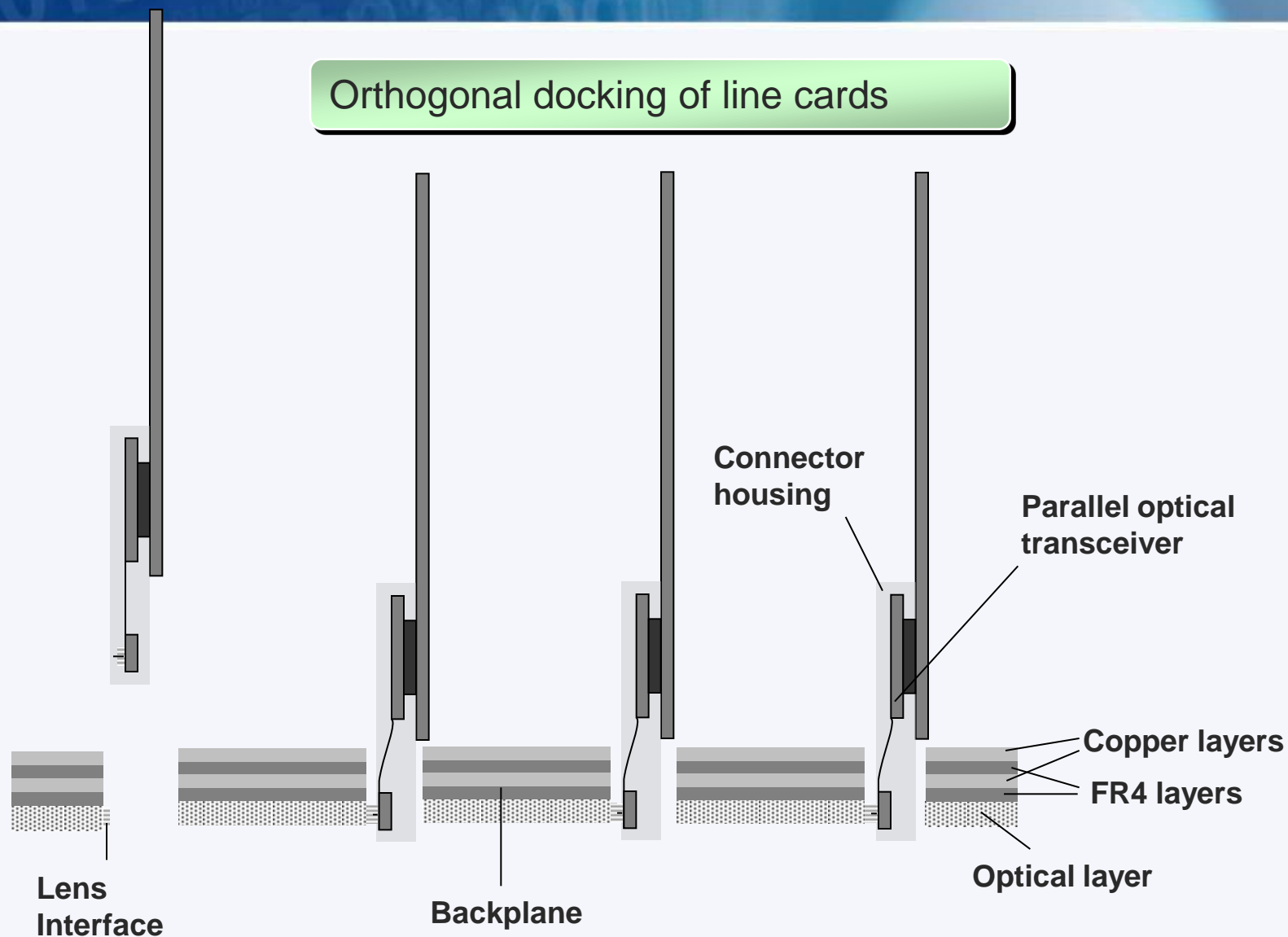
- Measured loss without index matching fluid
- Measured loss with index matching fluid
- Calculated loss



Active optical backplane connector

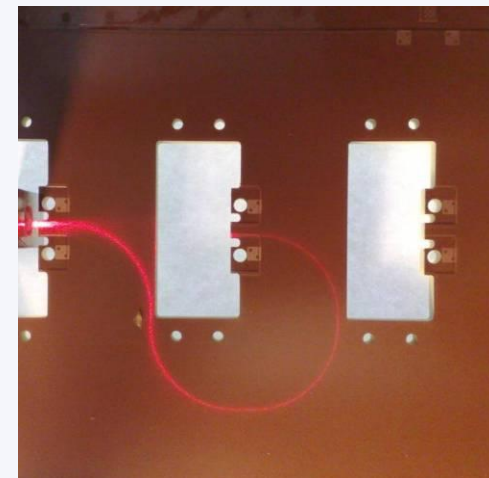
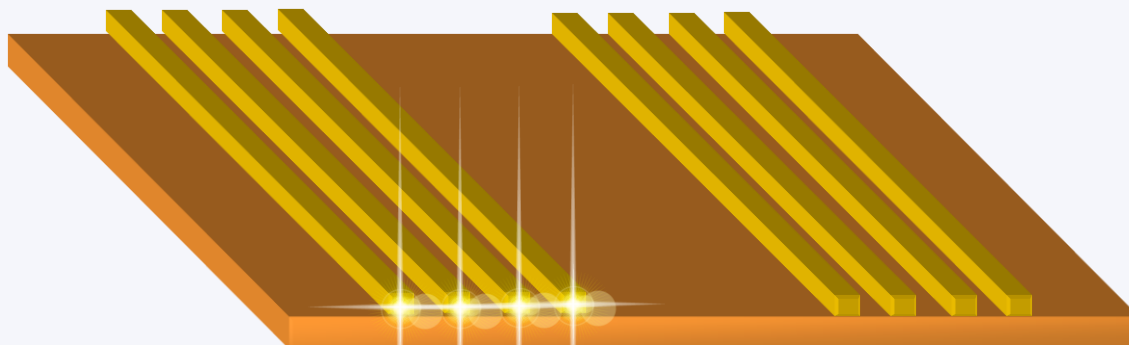
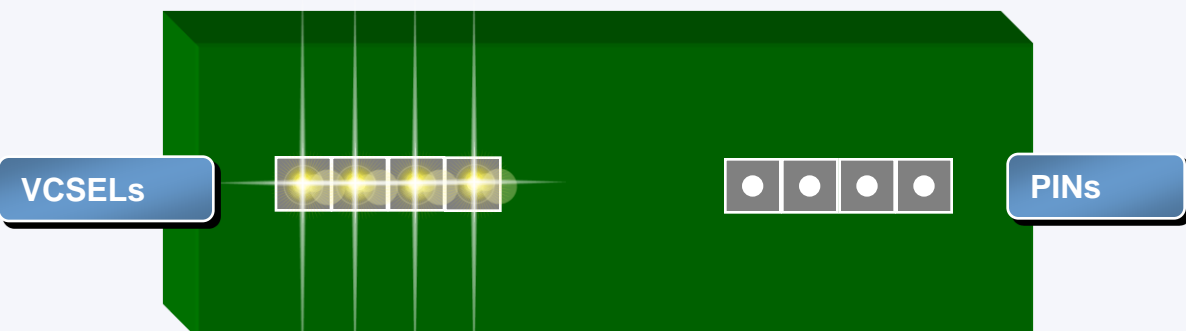


Optical backplane connection architecture



Optical backplane connection architecture

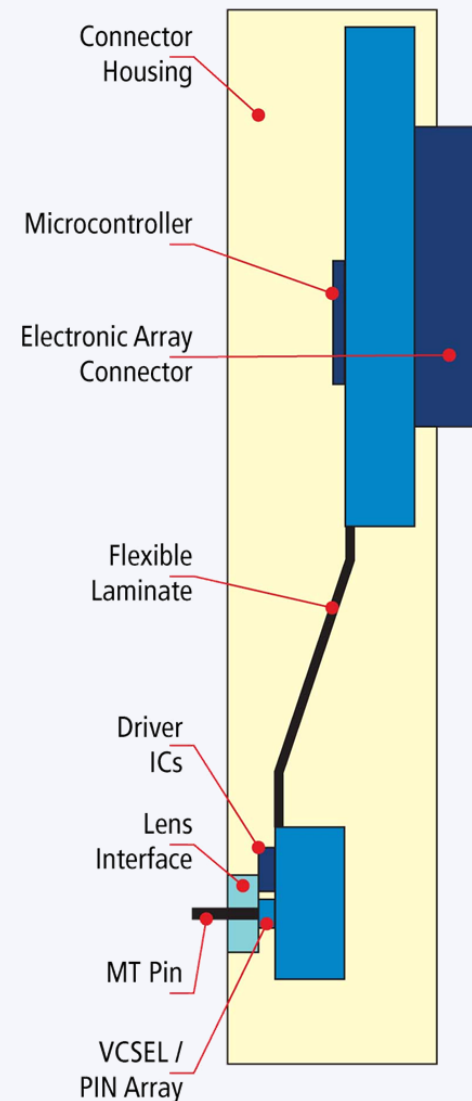
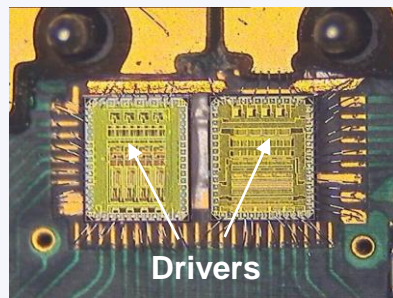
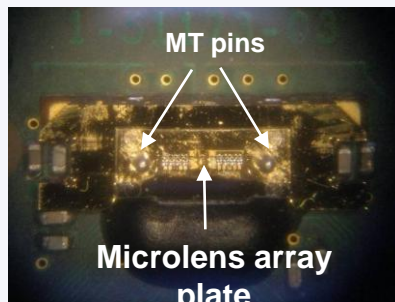
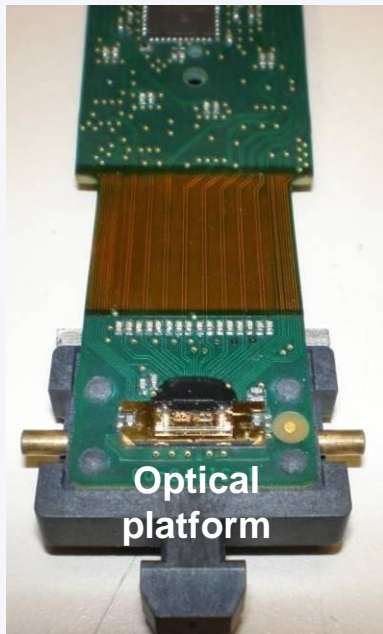
Butt coupled connection without 90° deflection



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



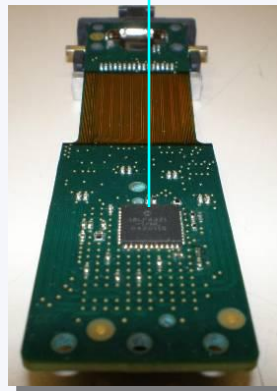
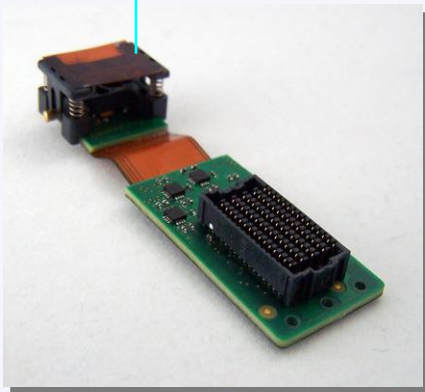
ACTIVE PLUGGABLE OPTICAL CONNECTOR

Parallel Optical Transceiver

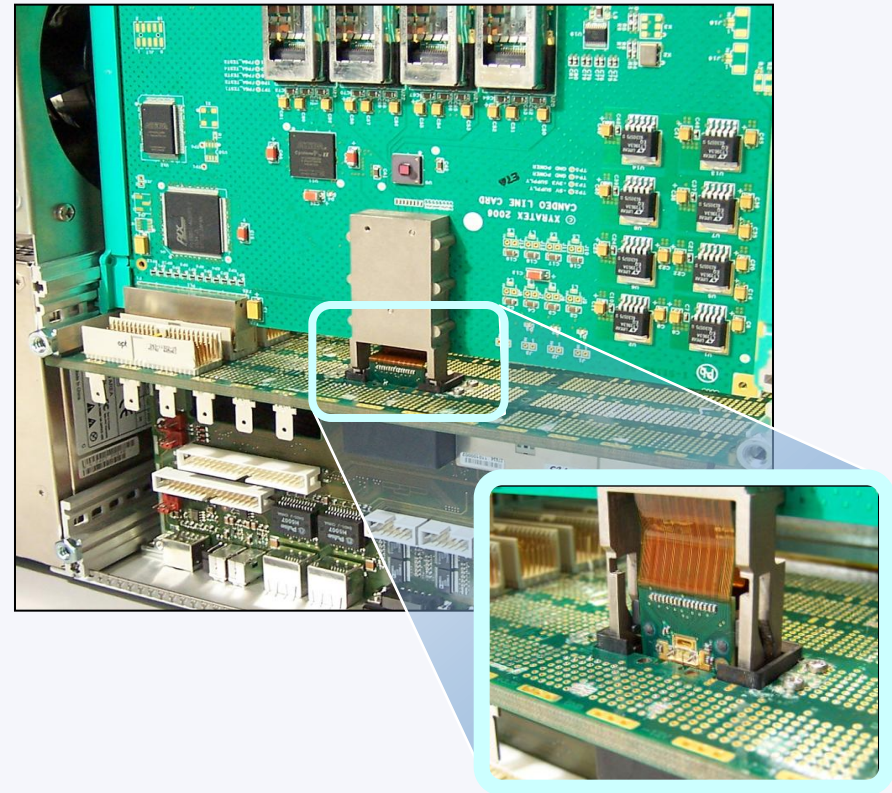


Spring loaded platform

Microcontroller

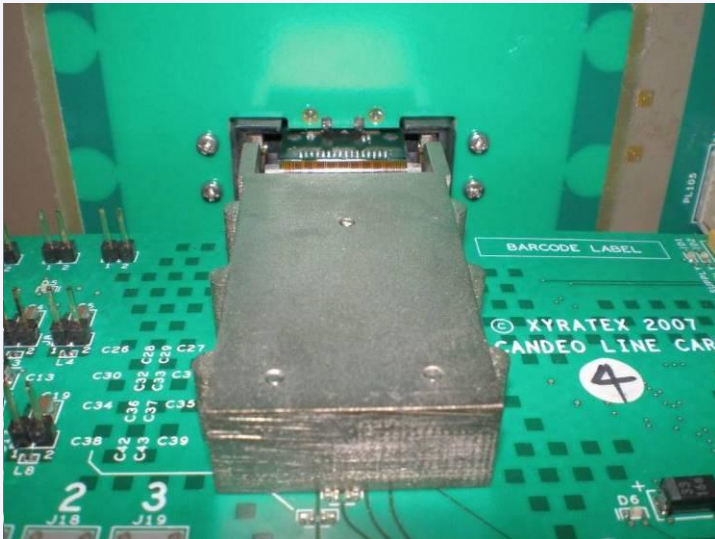


Connector Module

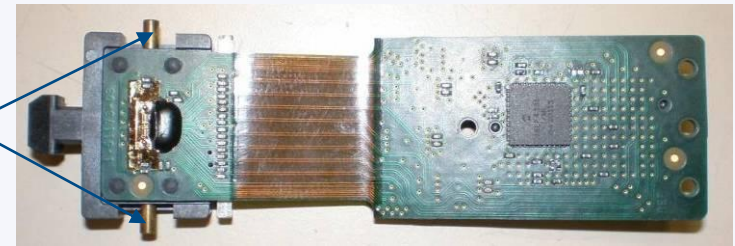


- ❑ Cam followers guided along cam track
- ❑ Allows for orthogonal movement of optical platform
- ❑ Ramped plug for reversible connection

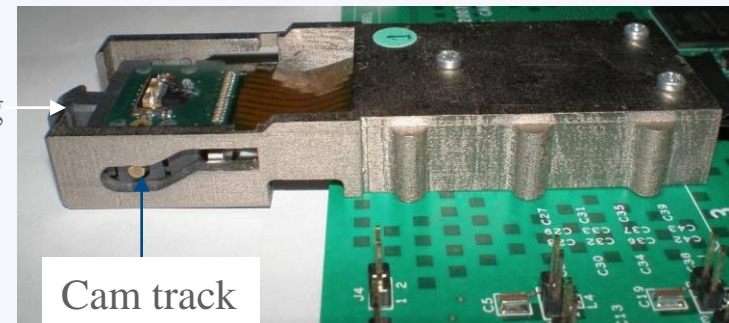
Docked



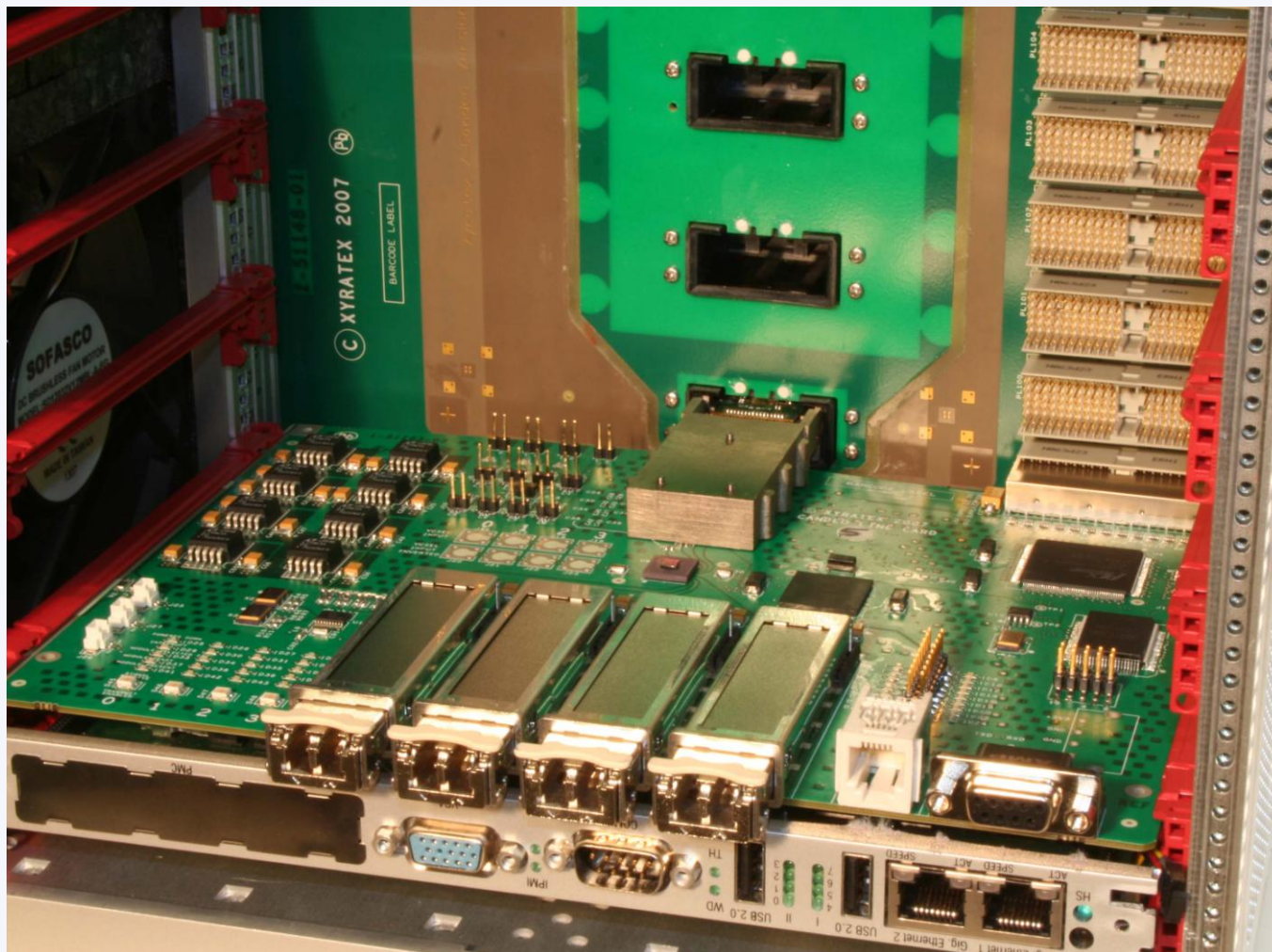
Cam followers



Ramped plug



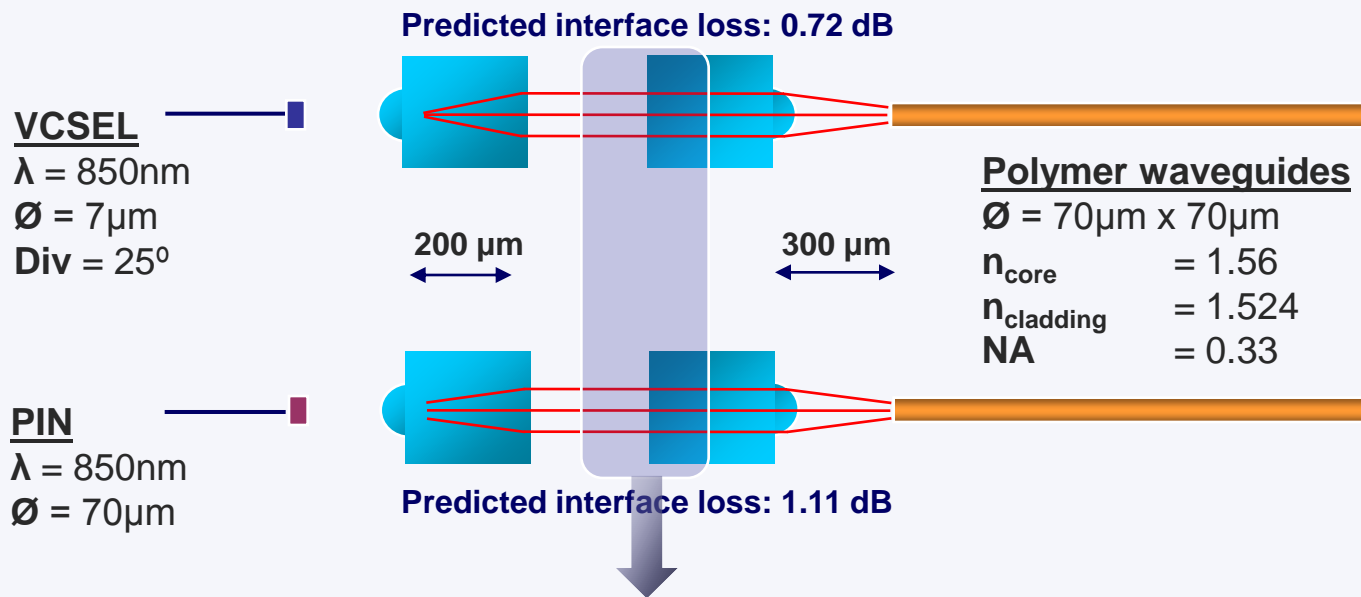
Optical backplane connection architecture



Dual lens coupling interface

Free space coupling arrangement

- ❑ Optimised for loss minimisation
- ❑ Maximum beam expansion



Dual lens coupling solution

- ❑ Beam expansion at coupling interface
- ❑ Reduces susceptibility to contamination

Demonstration assembly

Demonstration platform with peripheral test cards

Electro-optical
backplane

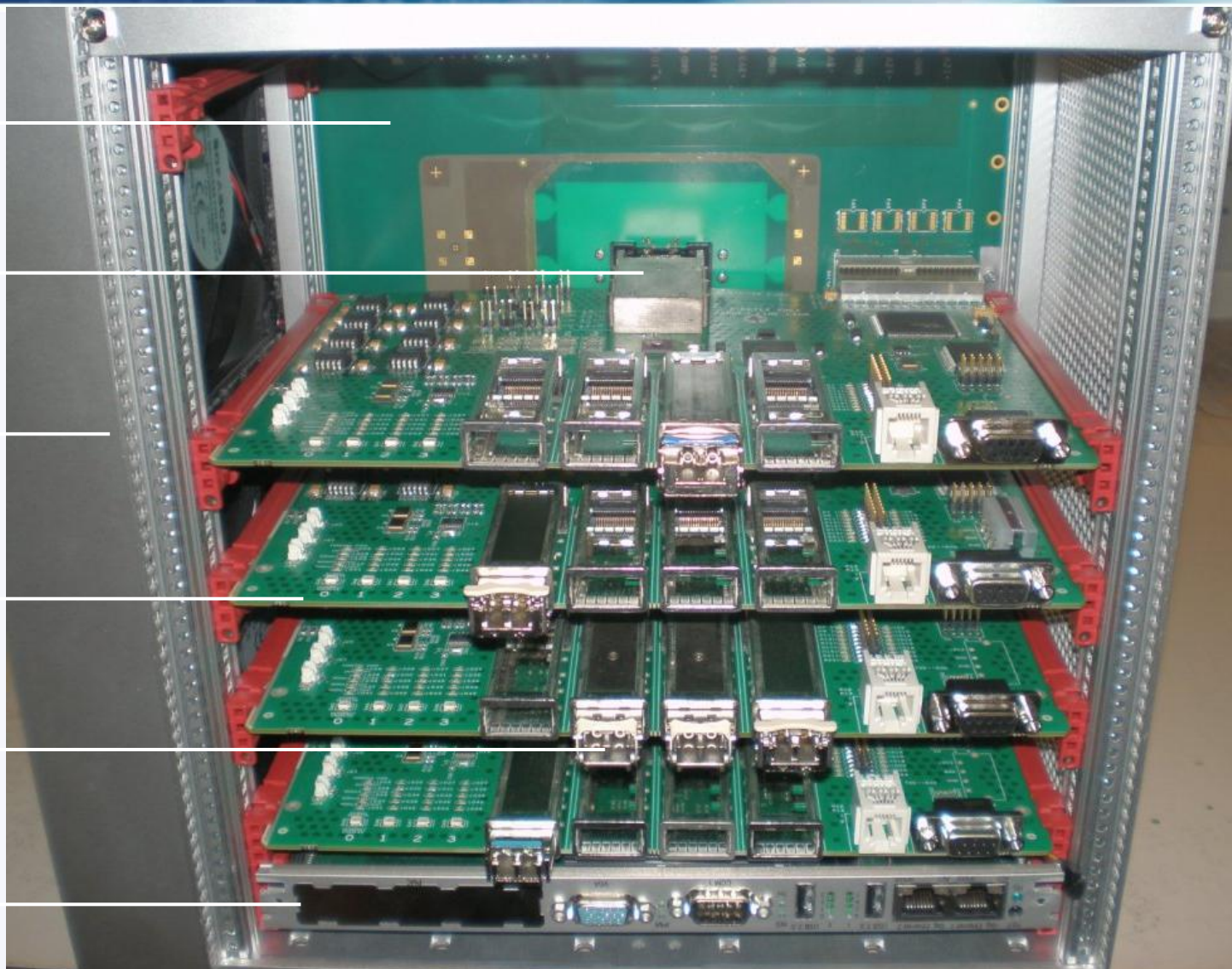
Pluggable optical
connectors

Compact PCI
chassis

High speed
switch line cards

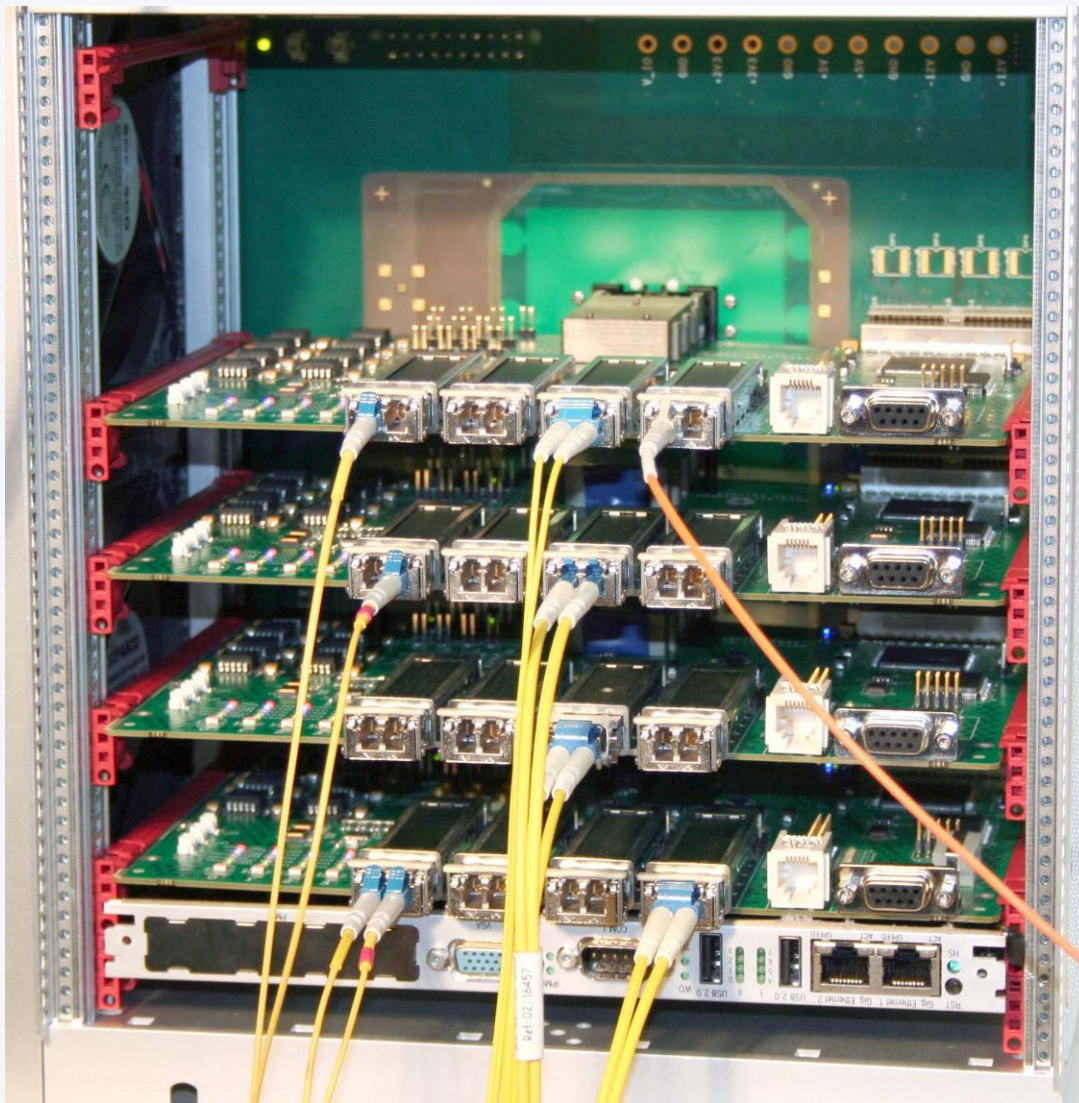
XFP front end

Single board
computer



xyratex

Demonstration assembly



Procedure

- ❑ 10 GbE LAN test traffic @ 10.3 Gb/s into demo front end (1st line card)
- ❑ Data passed across pluggable connectors and optical backplane
- ❑ Data retrieved through front end of 2nd line card

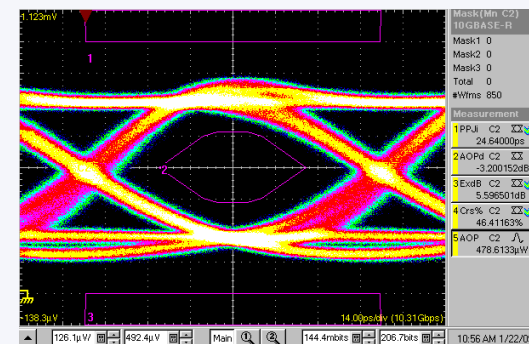
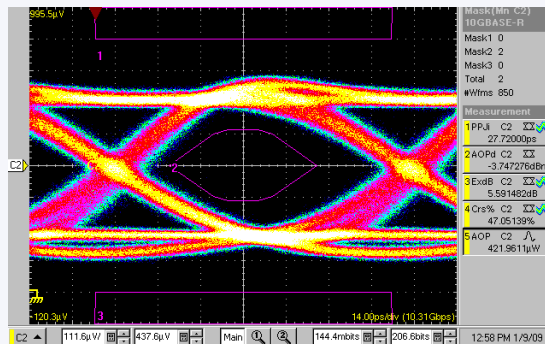
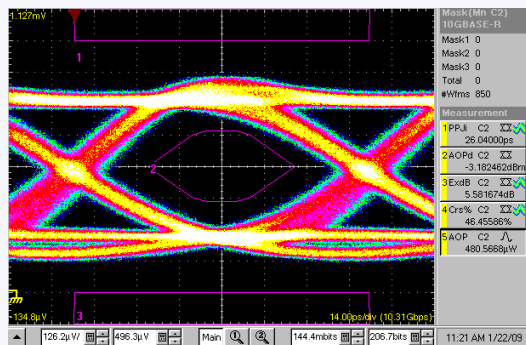
High speed data transmission measurements

Procedure

- ❑ 10 GbE LAN test traffic @ 10.3 Gb/s into demo front end (1st line card)
- ❑ Data passed across pluggable connectors and optical backplane
- ❑ Data retrieved through front end of 2nd line card

Results

- ❑ Test data captured with typical peak to peak jitter ~30ps (after front end CDR)
- ❑ Total optical waveguide interconnect loss ranges from -6 dB to -13 dB



Acknowledgements

Will write something here

EPSRC

DTI

Samtec

Thank you for your attention

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