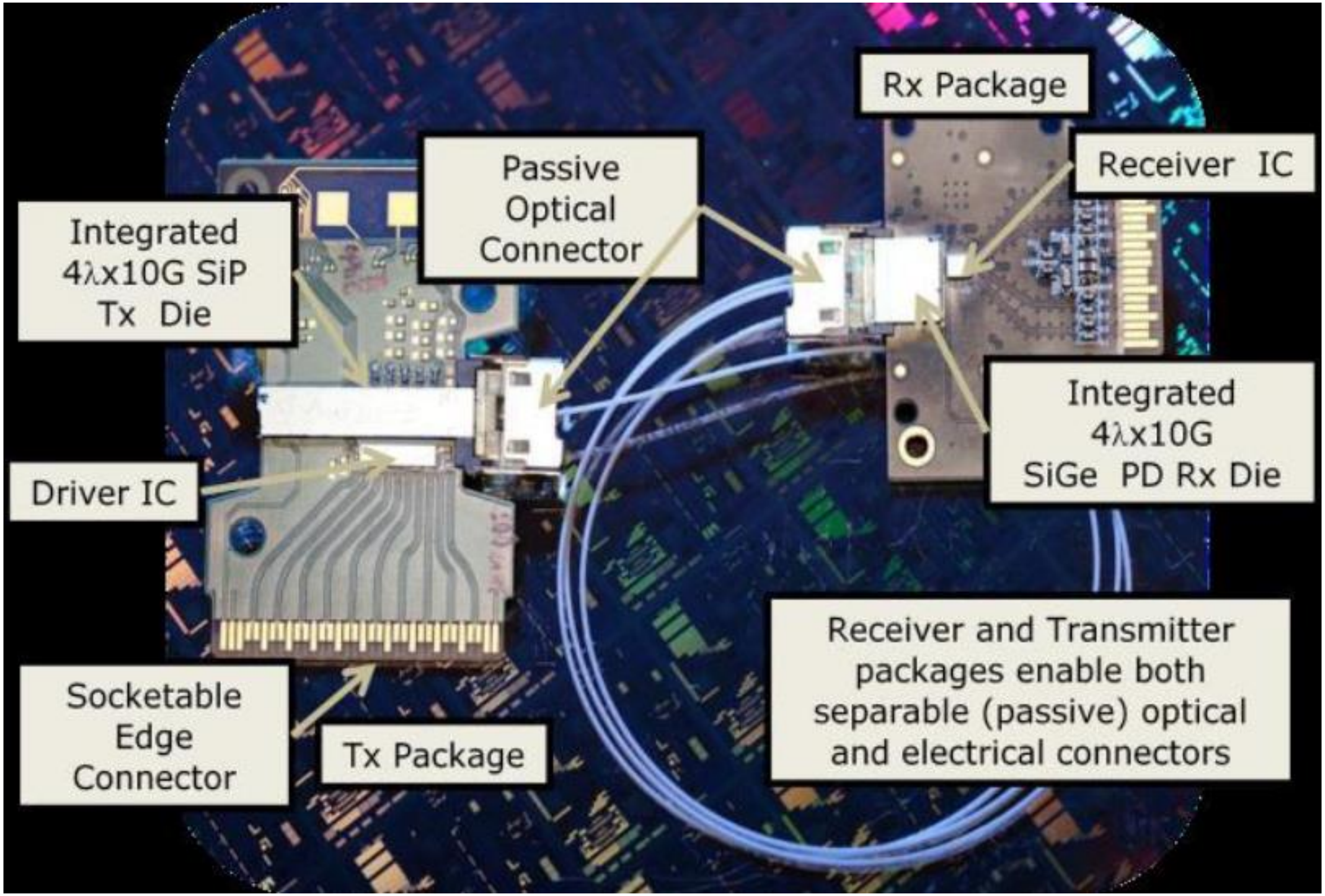
Optical Fiber Communications

Chapter XX

Silicon Photonics

Intel Si-Photonics



Ref) OFC (Optical Fiber Communication Conference) Mar, 201

Intel Si-Photonics

4λ x 12.5 Gb/s CWDM link :

(1291 nm, 1311 nm 1331 nm, and 1351 nm).

The integrated silicon photonic transmitter

- 4 hybrid s lasers
- 1 x 4 Si modulator array
- optical multiplexer

The integrated receiver

- an optical demultiplexer,
- 1 x 4 array of high speed SiGe photodetectors,
- 4-channel 10 Gb/s BiCMOS receiver IC.

Ref) OFC (Optical Fiber Communication Conference) Mar, 201

Intel Si-Photonics

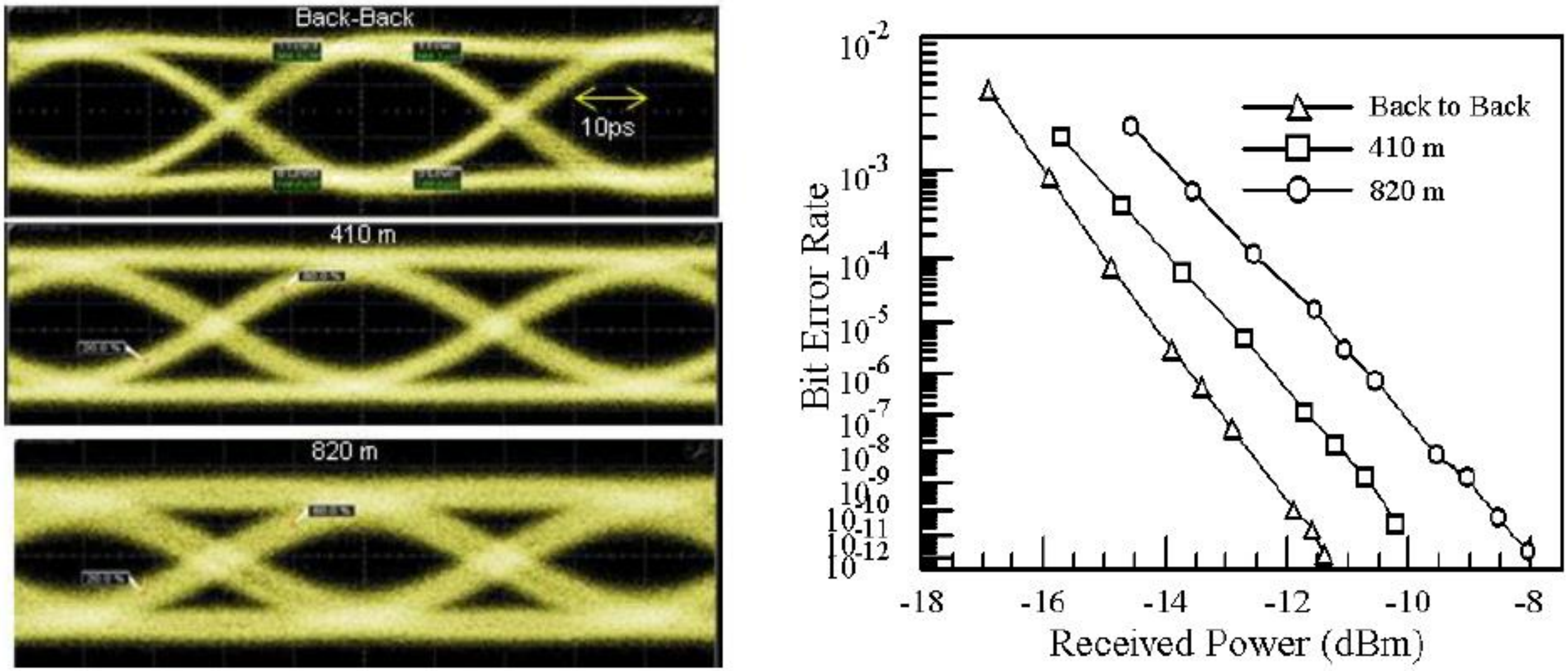


Fig.2 Eye diagrams (left) and measured BER vs. average received power (right) of the 25Gb/s signal over 410m and 820m MMF compared against the back-to-back configuration.

Ref) OFC (Optical Fiber Communication Conference) Mar, 201

Exponential Growth in Supercomputing Power

- 33% of all FLOPs are IBM
- 196 of 500 are IBM Systems
- 3 Systems in top 10 (3,5,9)

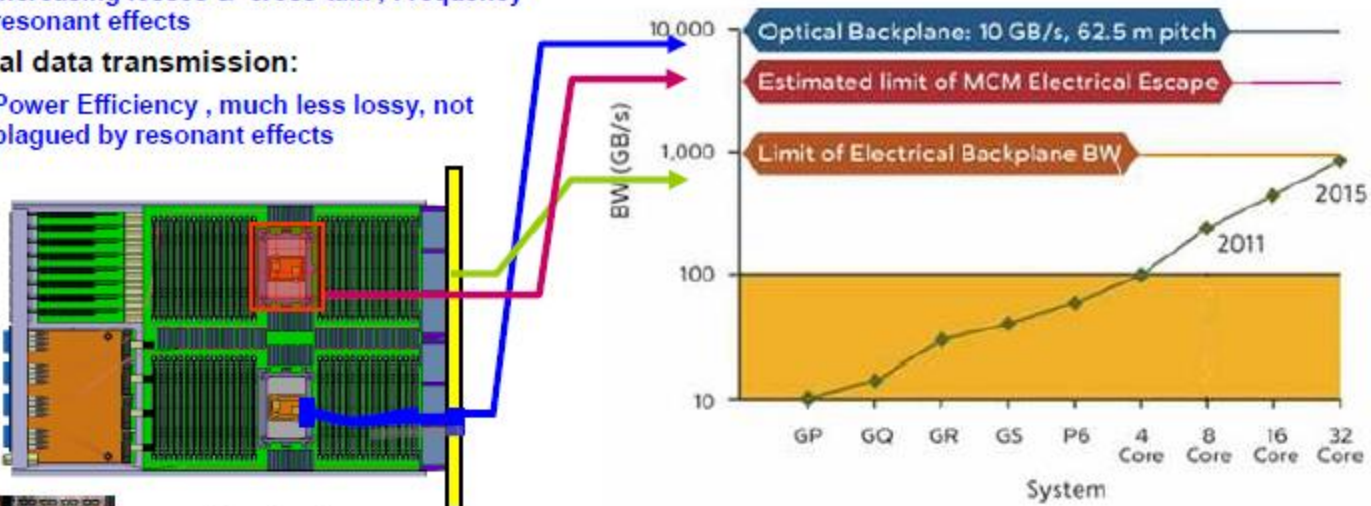
- Performance increase
  Factor 10 every 4 yrs
- Exascale Systems by 2020
  3 Orders increase
  compared to today!!!

Demands new technologies

- BW requirements must scale with System Performance, ~1B/FLOP (memory & network)
- **Requires exponential increases in communication bandwidth at all levels of the system** → Inter-rack, backplane, card, chip

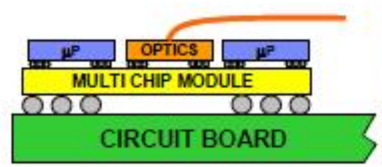
Electrical BW Bottlenecks – Optics opportunities

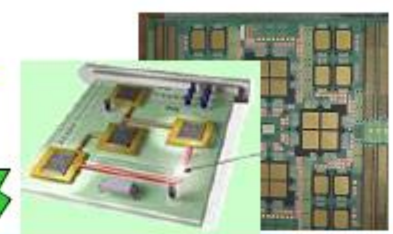
- **Electrical Buses become increasingly difficult at high data rates (physics):**
  - Increasing losses & cross-talk ; Frequency resonant effects
- **Optical data transmission:**
  - Power Efficiency , much less lossy, not plagued by resonant effects



Rack

Backplane





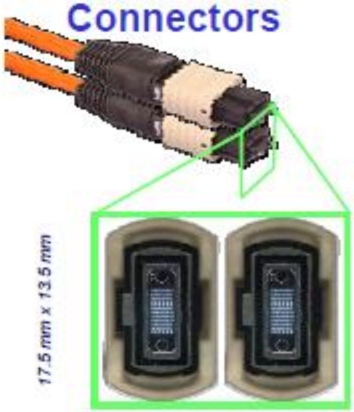
Density advantage of optics

Cables

1 m cable

IBM

Connectors

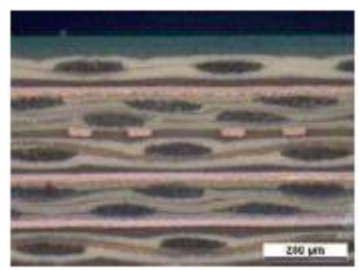


144 x 10+ Gbps

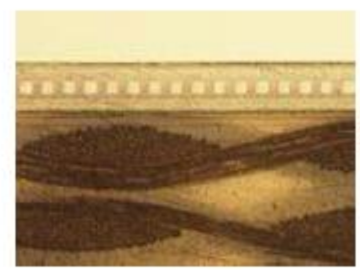
ERNI

21 x 10 Gbps

PCB-Tracks



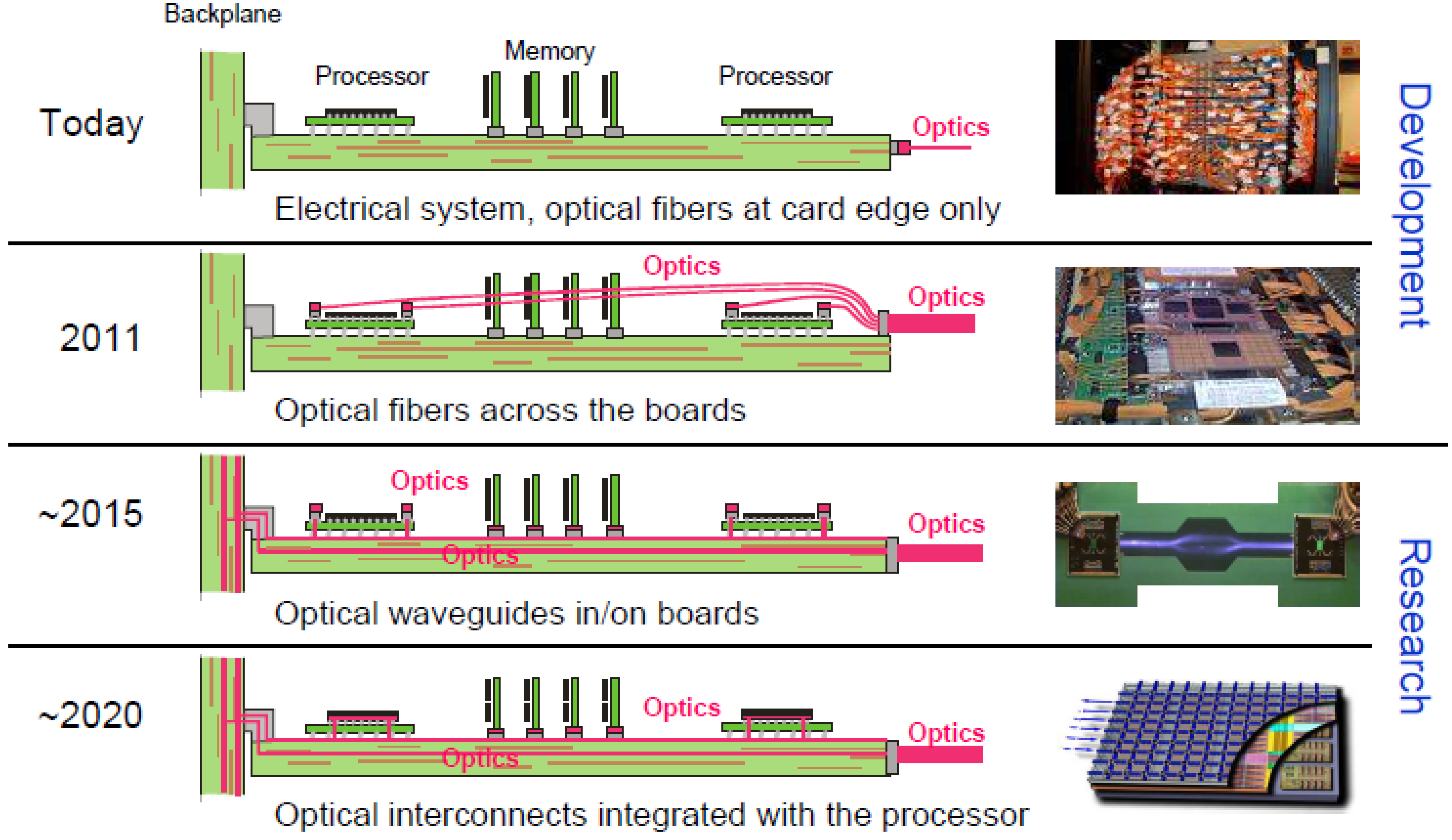
differential striplines
2 x 10 Gbps
80x17 µm tracks @ 460 µm pitch



IBM

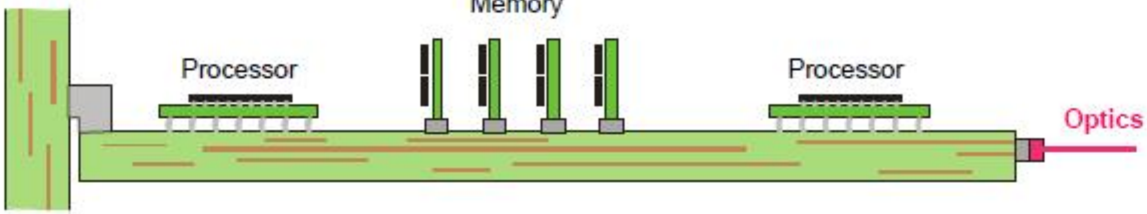
optical waveguides
16 x 10+ Gbps
35x35 µm cores @ 62.5 µm pitch

Photonics Roadmap – Optical Interconnects in Supercomputing



Optical interconnects will be applied for shorter and shorter links to fulfill bandwidth and power efficiency requirements. Integration will increase bandwidth density and reduce cost.

2008: Roadrunner – 1 PetaFlop

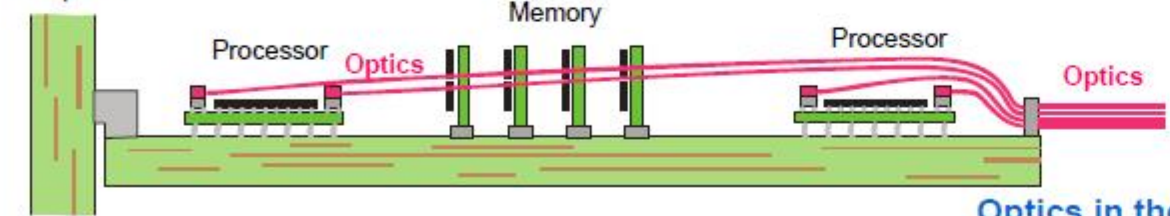


Optics at the board-edge:

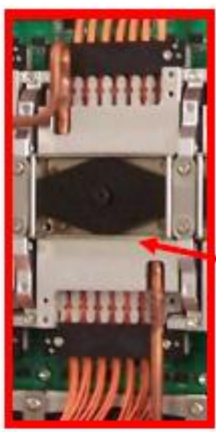
Performance increase
Based on existing assembly concepts

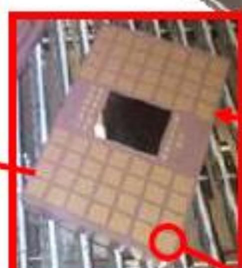
Total ~48000 Fibers

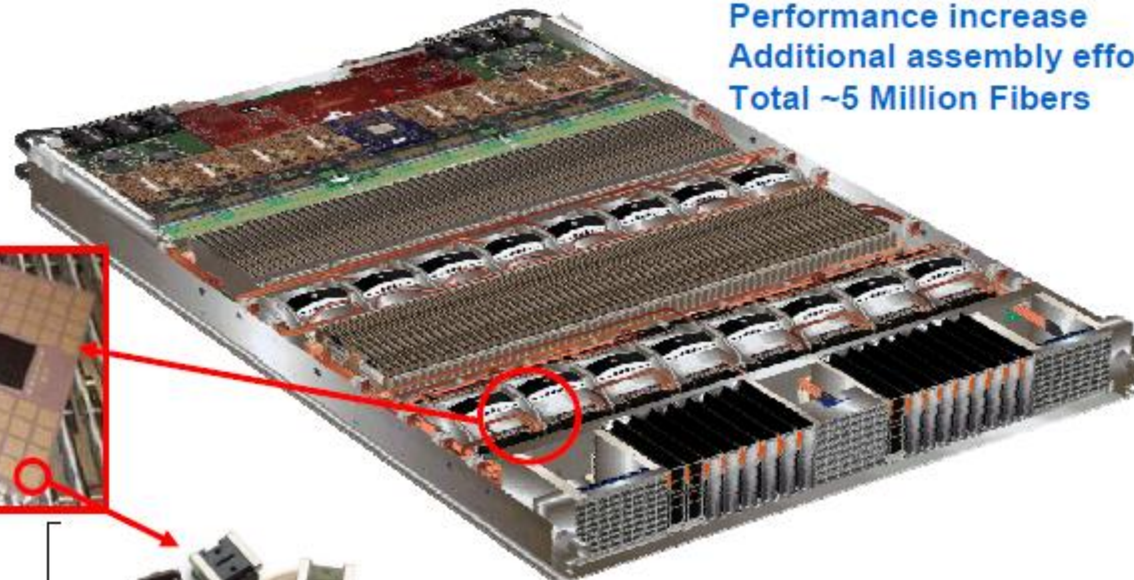
2011: Blue Waters – 10 PetaFlop



Optics in the system
Performance increase
Additional assembly effort
Total ~5 Million Fibers







Processor Package

Avago MicroPOD™

How much optics will be required?

- 10x performance increase every 4 years
- 10x performance increase costs 1.5x as much
- 10x performance increase requires 2x more energy

	2008	2020
Performance	1 PetaFlop	1 ExaFlop
Cost	150 M$	500 M$
Energy consumption	2.5 MW	20 MW
Optical bandwidth	0.012 PB/s	400 PB/s
# Optical signals	48000 @ 5 Gb/s	320×10^6 @ 25 Gb/s
Optics efficiency	50 mW/Gb/s	1 mW/Gb/s
Cost of optics	10$ /Gb/s	0.025$ /Gb/s

Based on existing trends, not a product plan

Optics must become
- More efficient
- Cheaper
- Simpler