1st Detector Readout Link Topical Workshop of the Helmholtz Alliance

14 - 15 February 2011
Bergische Universität Wuppertal

Experience, developments and perspectives on high bandwidths data transmission in HEP experiments will be discussed:

- Requirements of future HEP experiments
- Perspectives of optical data transmission
- New technologies (wireless transfer)

André Schöning
Physikalisches Institut
Universität Heidelberg

PHYSICS AT THE TERA SCALE
Helmholtz Alliance

Workshop on Fast Readout Data Links

Motivation

Why Workshop on Data Links!

- **Bandwidth limitations of data links mainly determine design of readout / trigger systems**
- **Existing workshops and conferences focus on**
  - detector R&D,
  - electronics
  - computing (IT)
  - and other system aspects
- **Considering the importance of data links for future high rate experiments we have to put more focus on data link issues and new technologies**

Data Links in Industry and HEP

Industry

off-the-shelf solutions optimised for industrial needs:

- reliability
- cost effective
- flexibility
- high bandwidth
- mass production

HEP

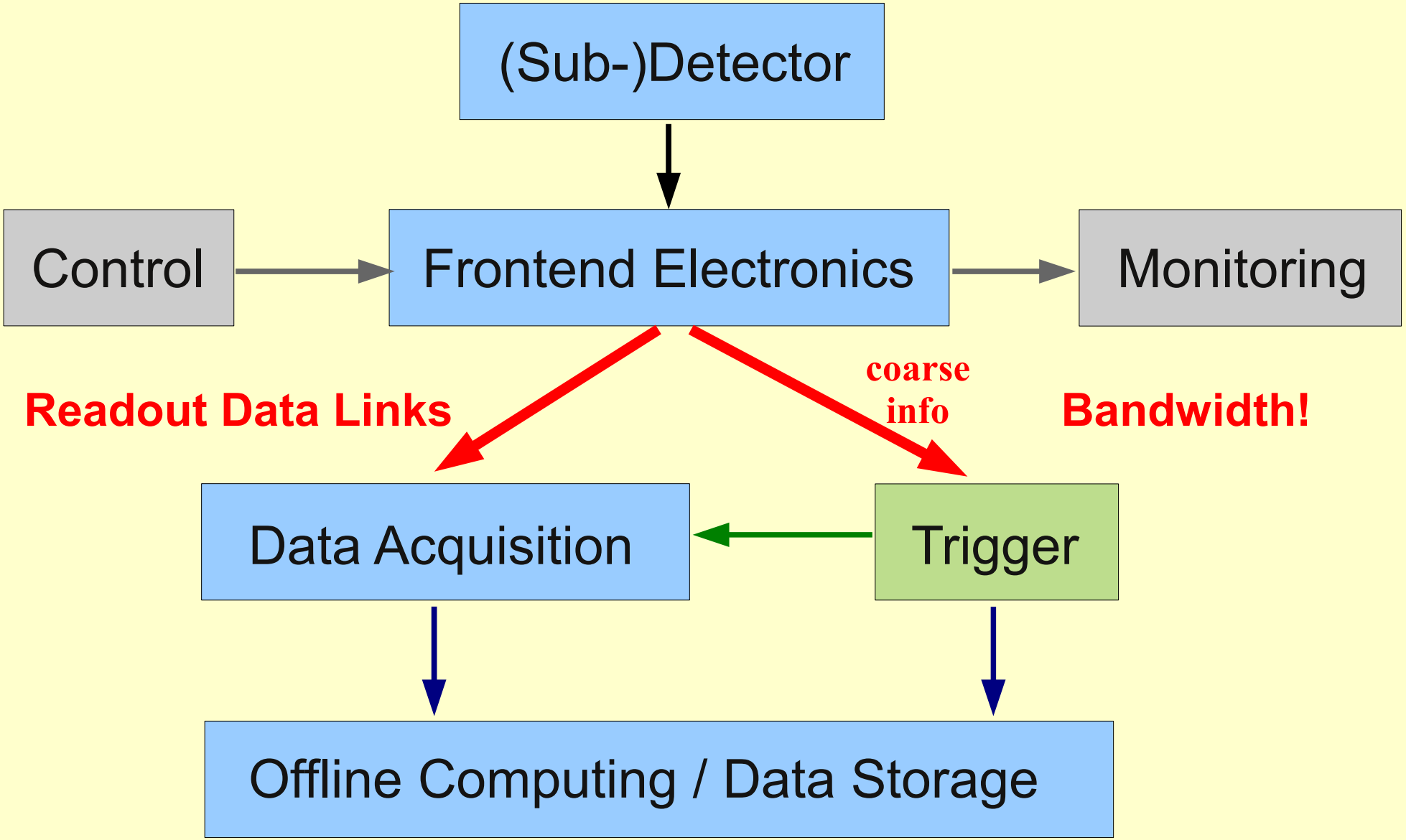
specialised solution at technology frontiere in “difficult” environments

- high bandwidth
- small form factors / low mass
- radiation tolerant
- specific solutions
- prototypes

- **different priorities**
- **additional efforts needed**

The Critical Task

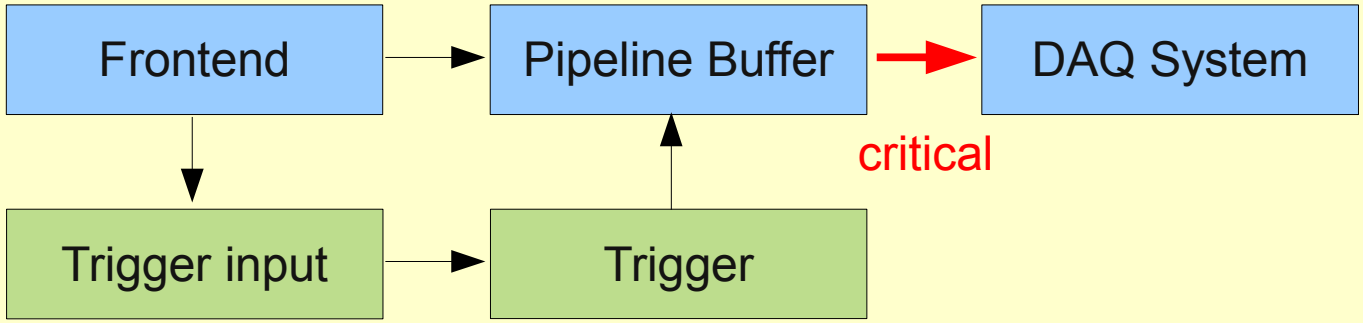
Detector Readout Model



Readout/Trigger Concepts

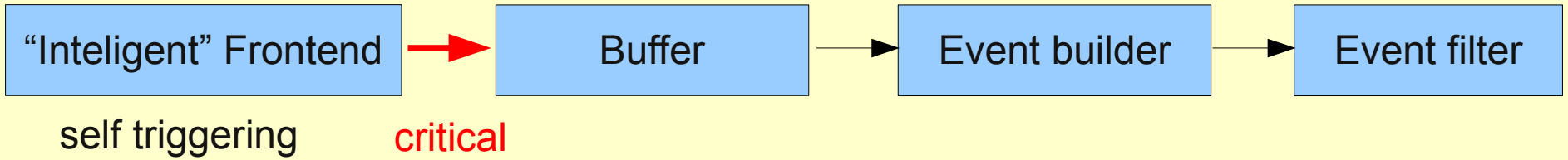
“Traditional: Solution”

multi-trigger level system with pipelined frontend buffers



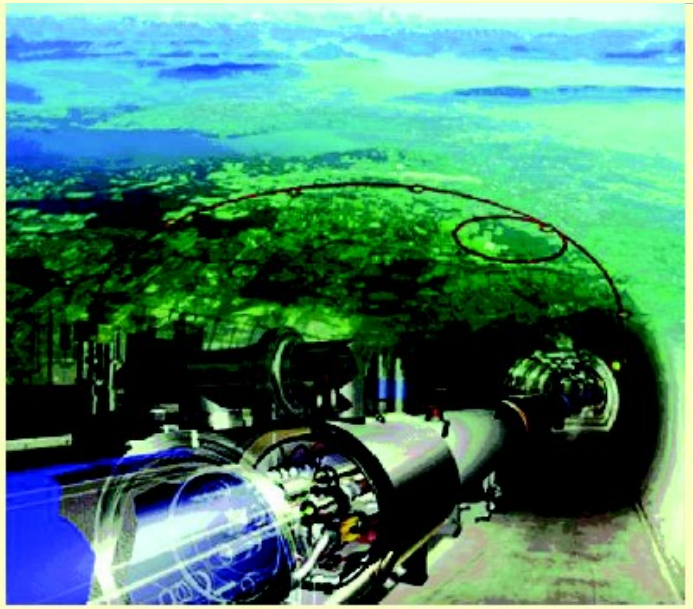
“Modern concept”

self-triggered frontends with event buffers for event building

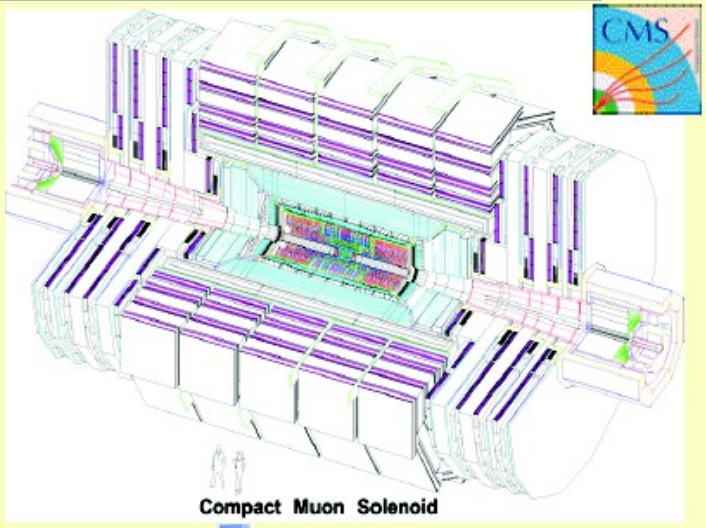


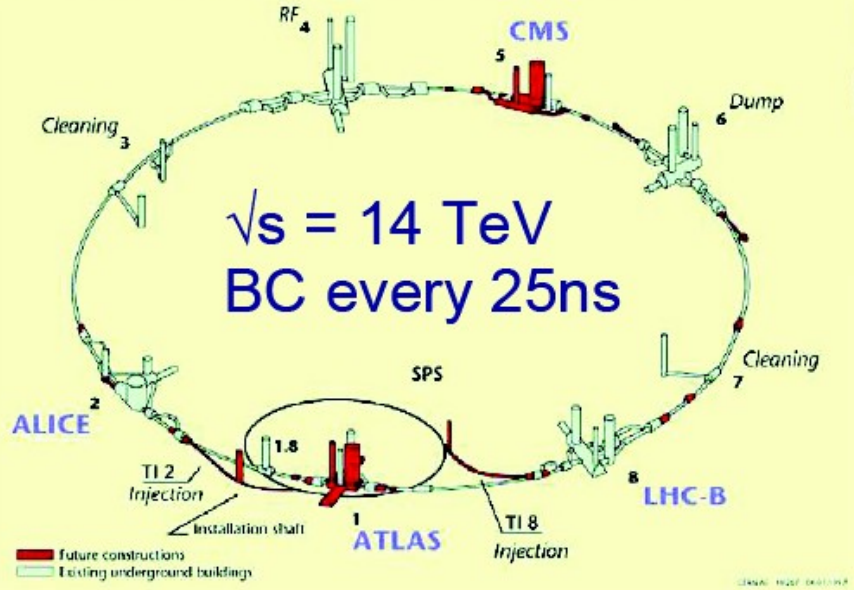
The Challenge

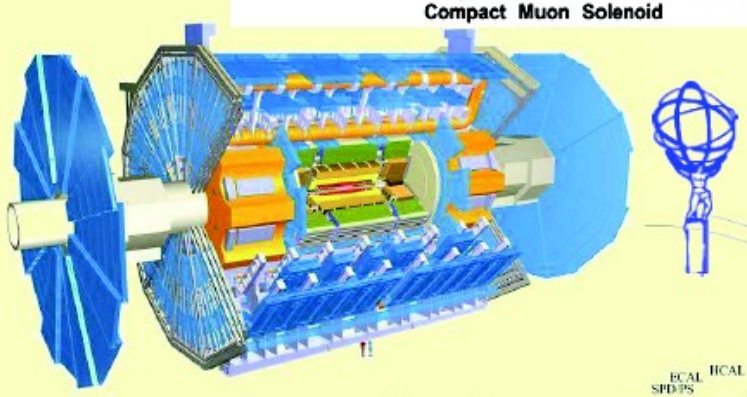
Technology Frontier LHC

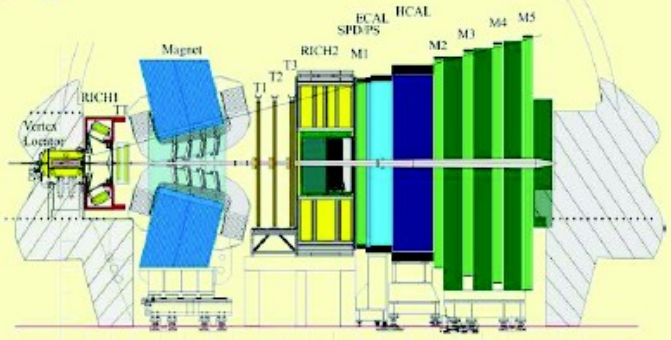


at CERN

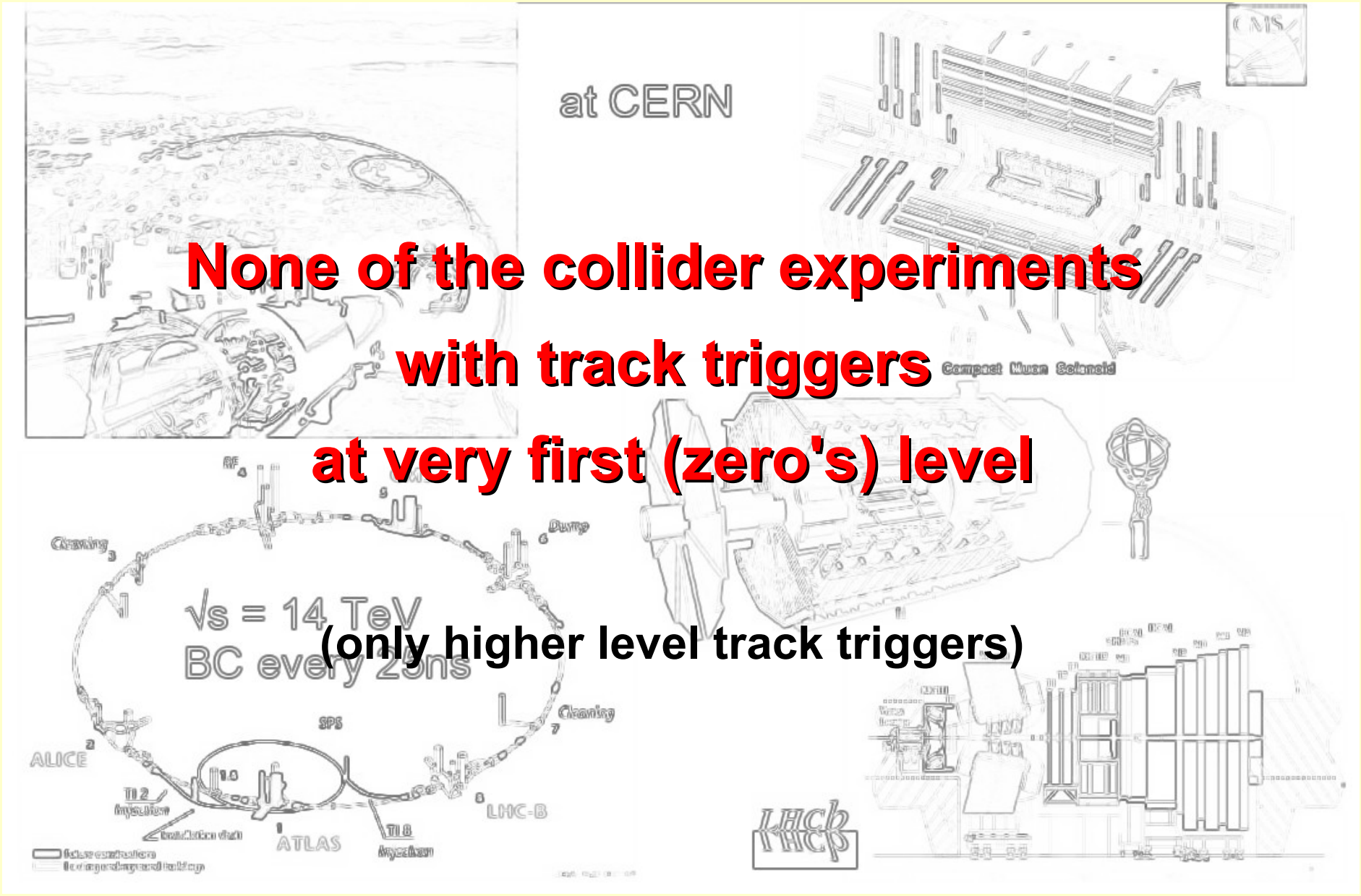








Technology Frontier LHC



High Precision Tracking Detectors

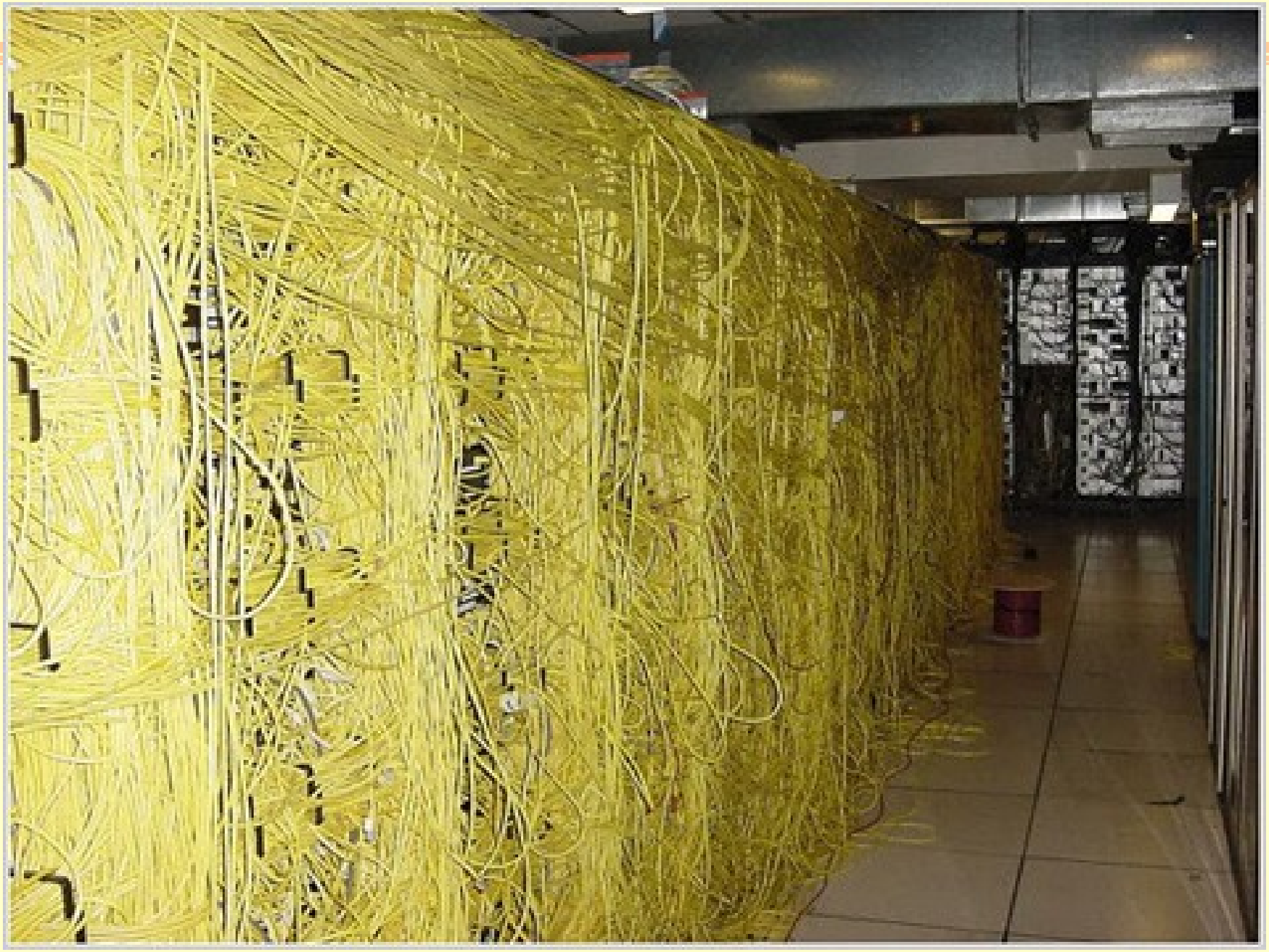
Example pixel detector: highest density of channels

- high density: 10^4 channels / cm^2
- high event rates: f = O(100) MHz
- high particle densities: occupancy=1%

- **data rate of 10^{10} signals / second / cm^2 per layer!**

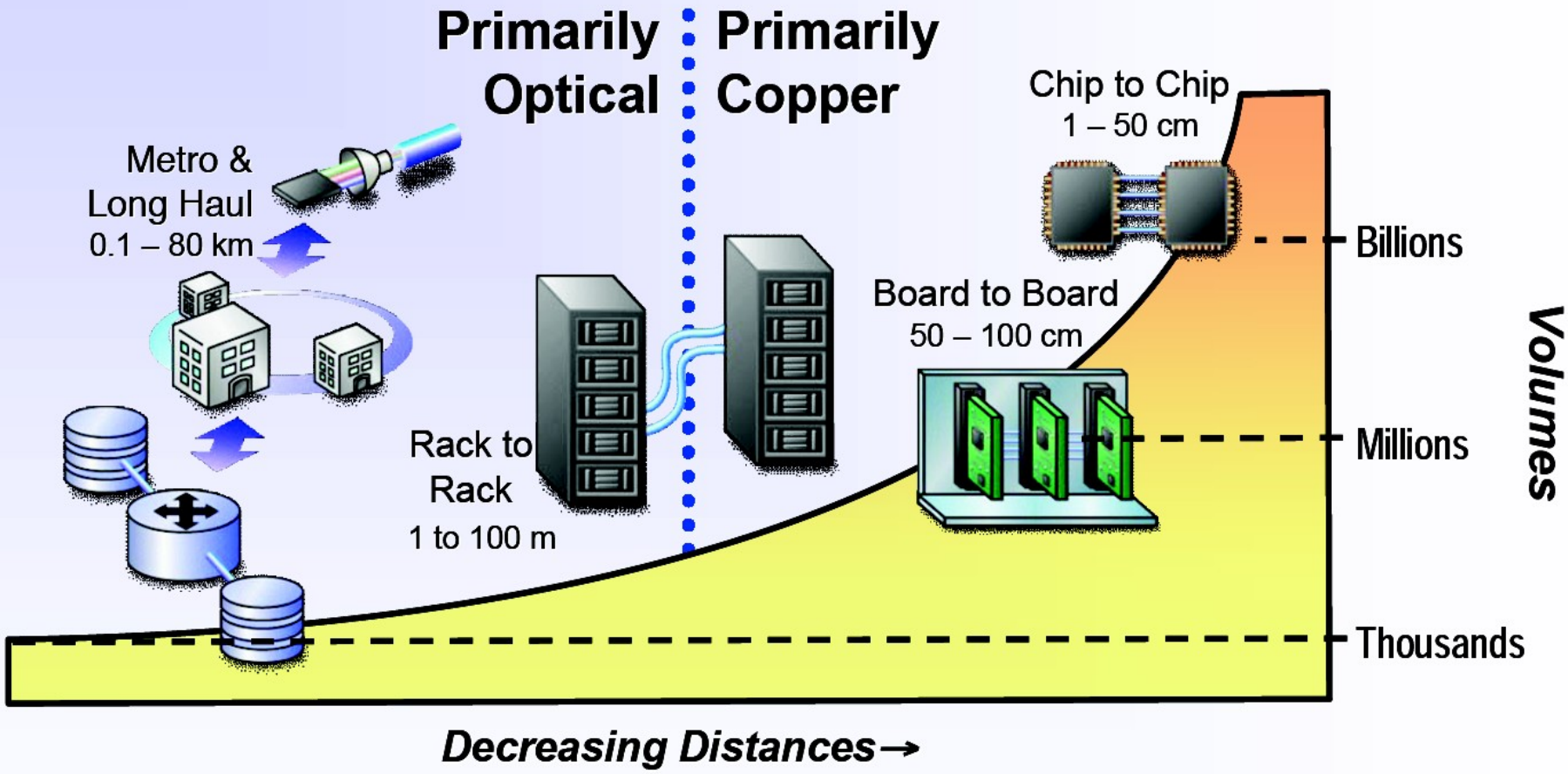
Strip Detectors:

- factor 10-100 smaller signal rate!
- **readout for 10^8 signals / second / cm^2 per layer** ↪



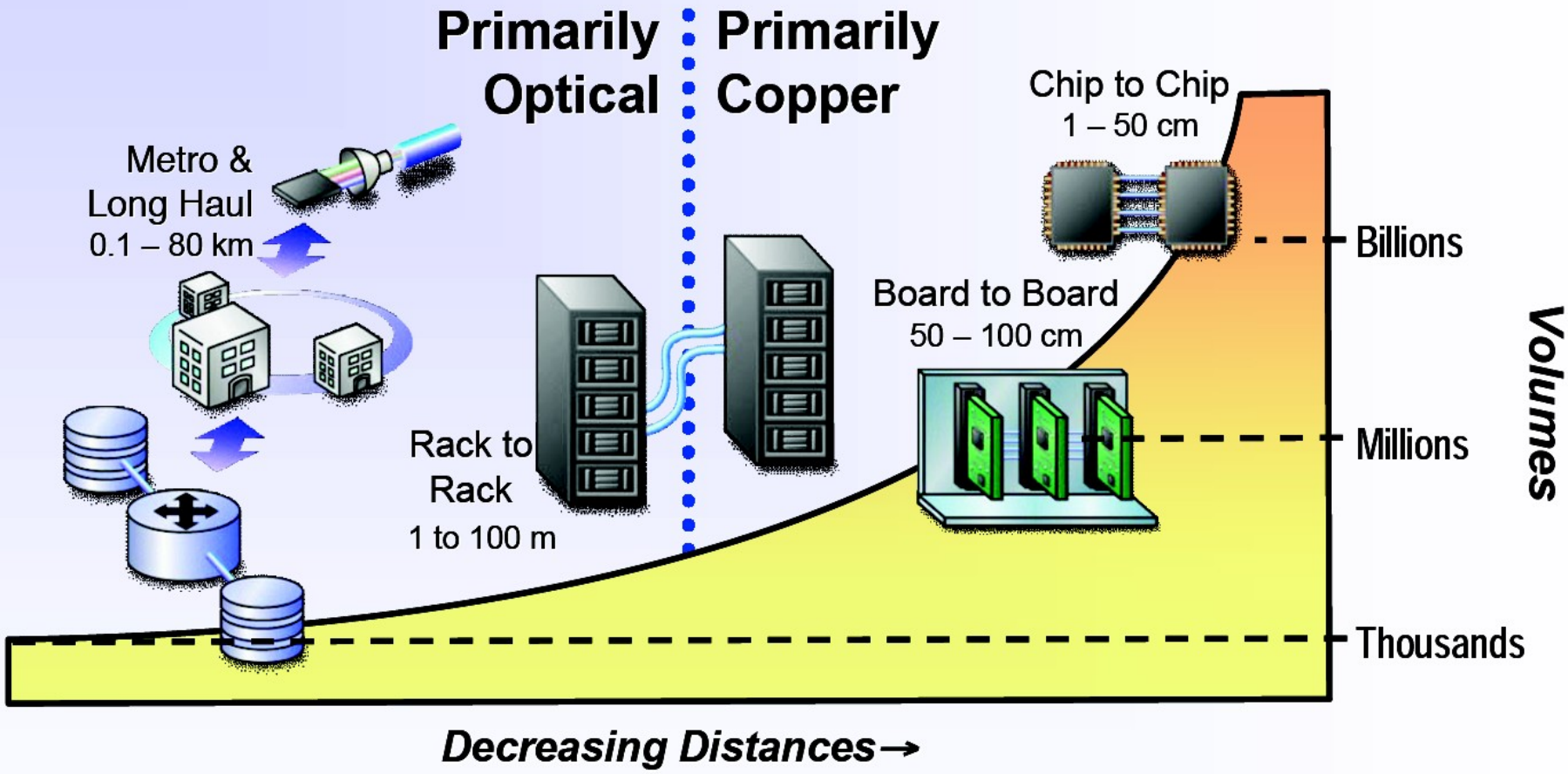
Todays Technologies

Today's High Speed Interconnects



Courtesy of Mario Paniccia, Intel

Today's High Speed Interconnects



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typical detector size ~ 100m

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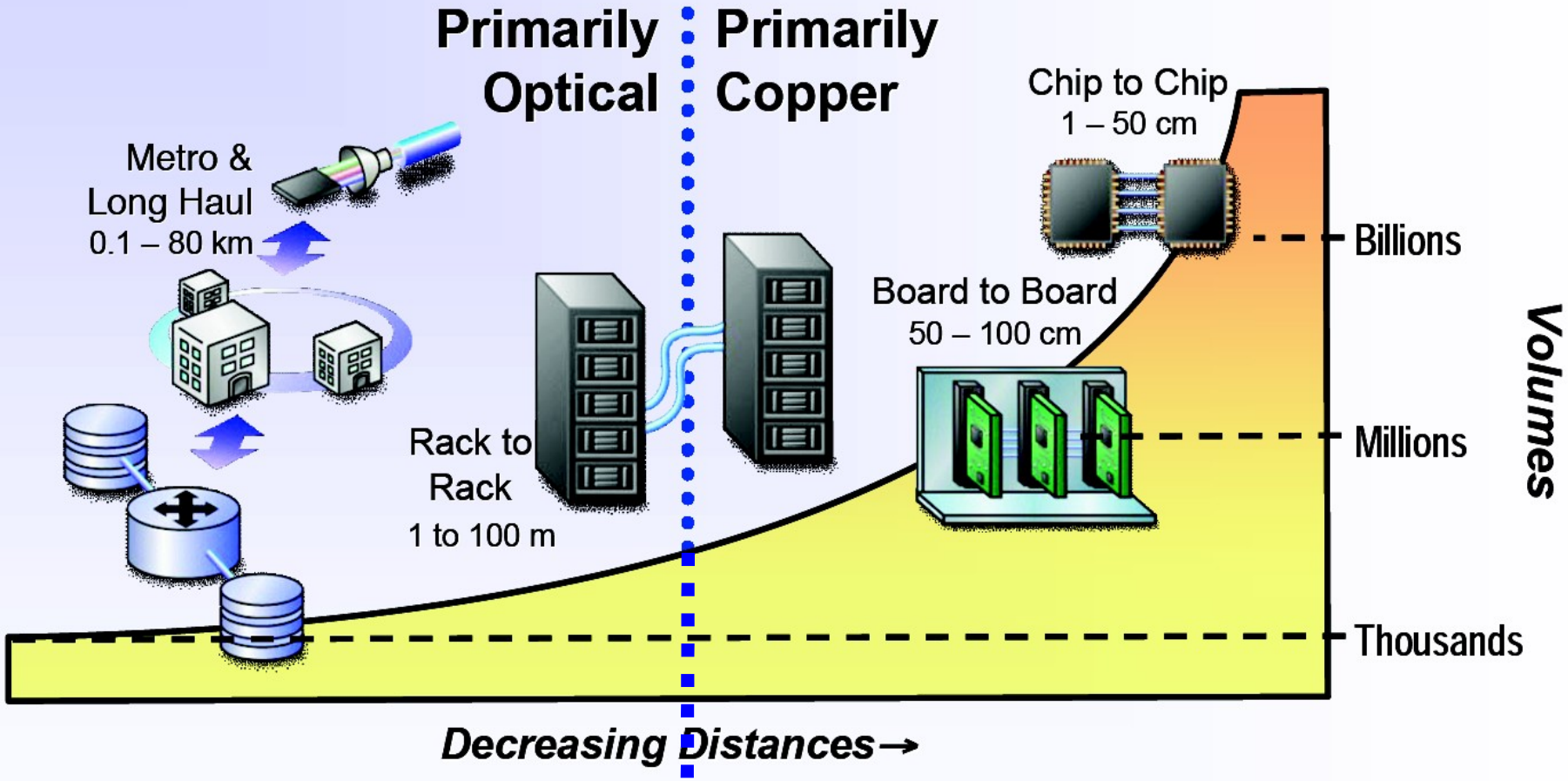

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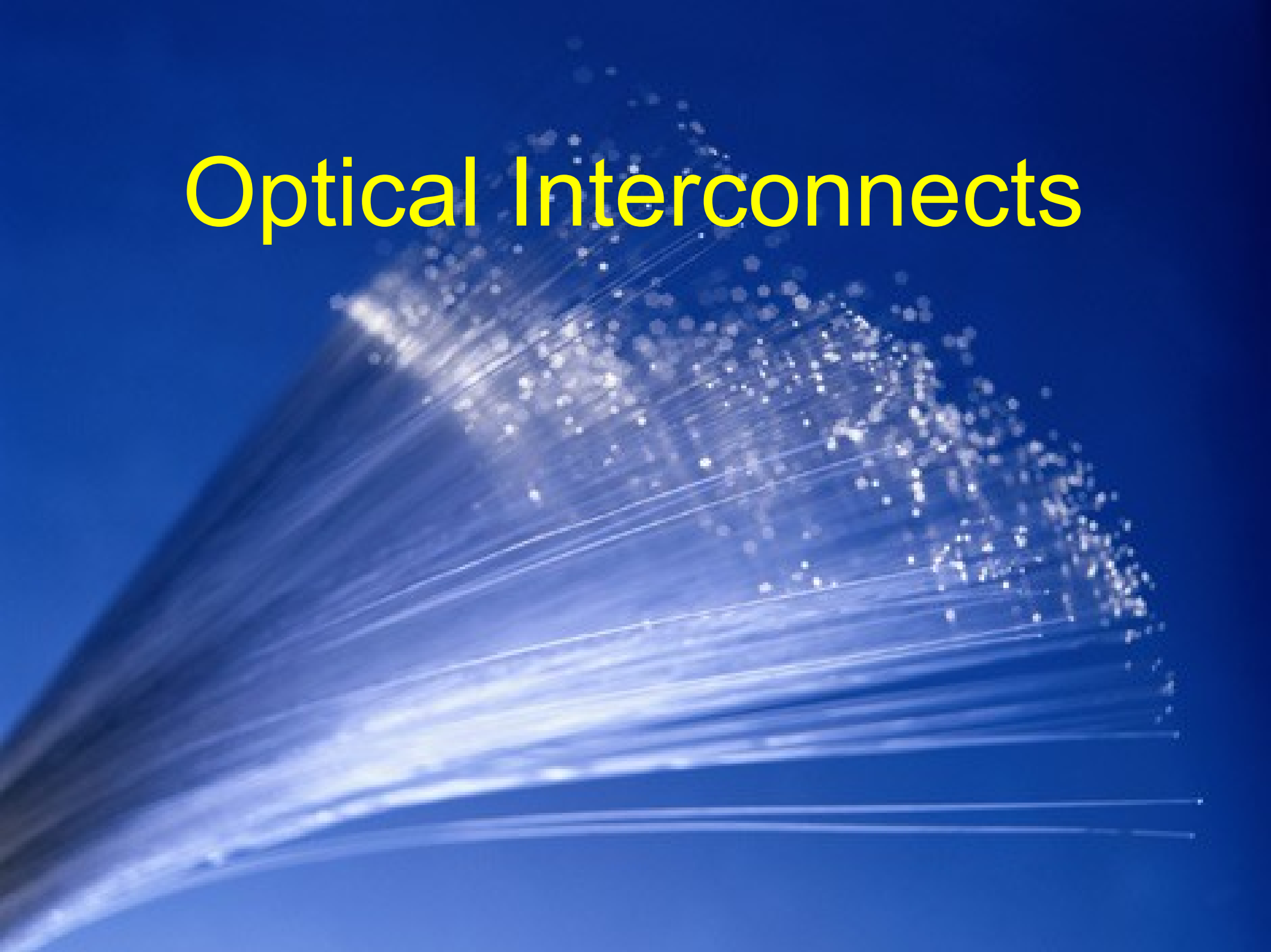
Optical Interconnects



Optical Components

e.g. 75 Gbit/s per multifiber cable connector!

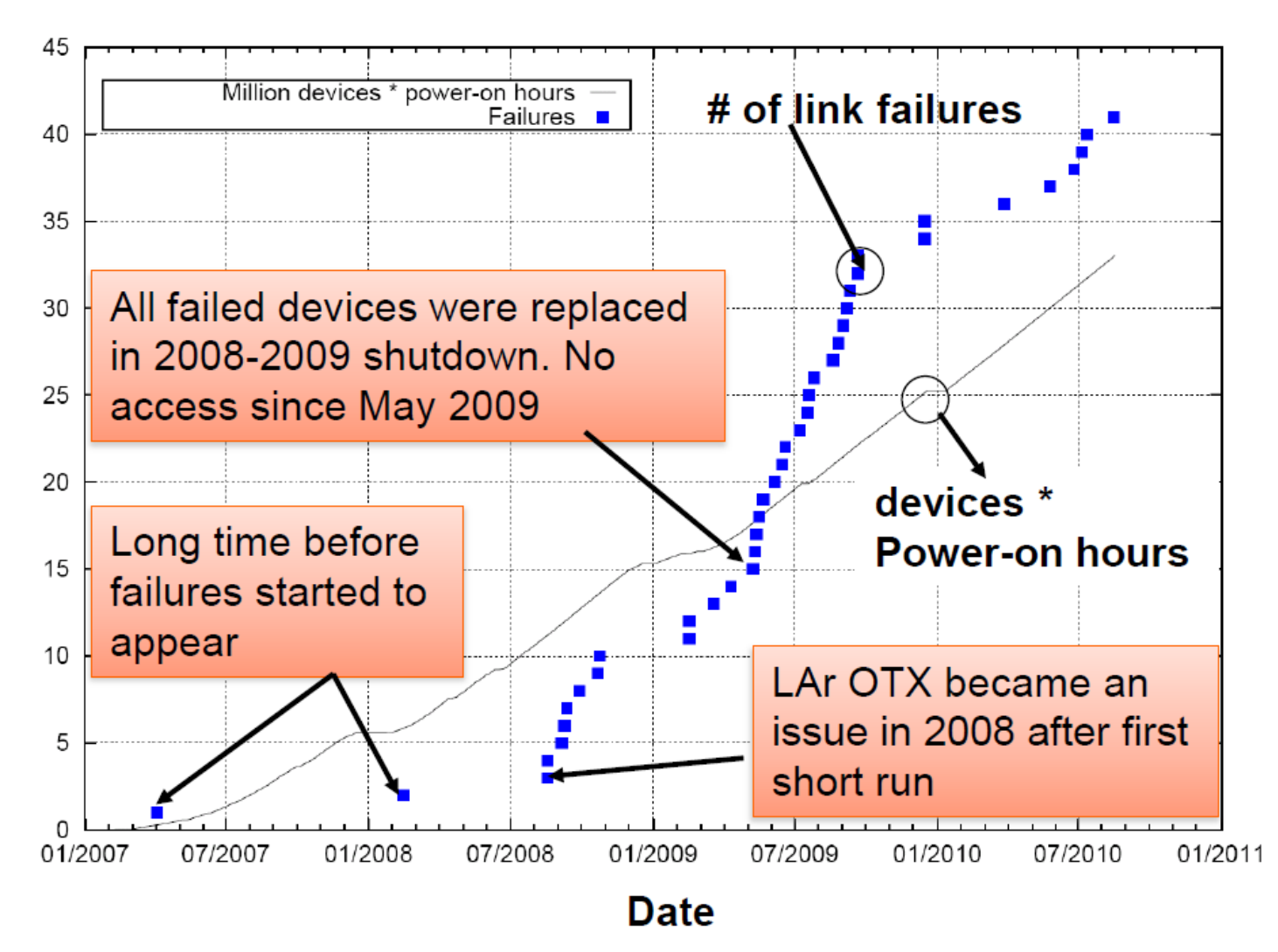
but kit with problems ↪

fiber optical cords

optical adapters

receivers/
transceiver

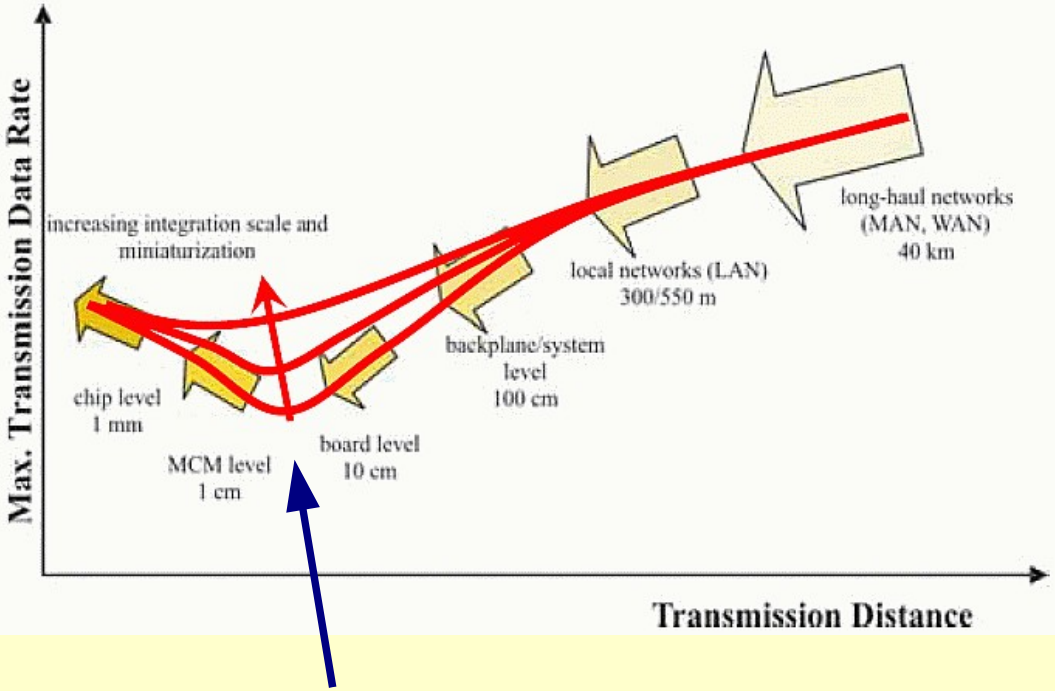
ATLAS VCSEL Failures



from S.Simion

New Technologies

The “Technological Gap”



iNEMI 2004 Roadmap

- optical interconnects will integrate all levels of packaging
- may be reached for high performance systems **2010..2015**

R&D program in Industry and Academia

Predictions iNEMI (2005):

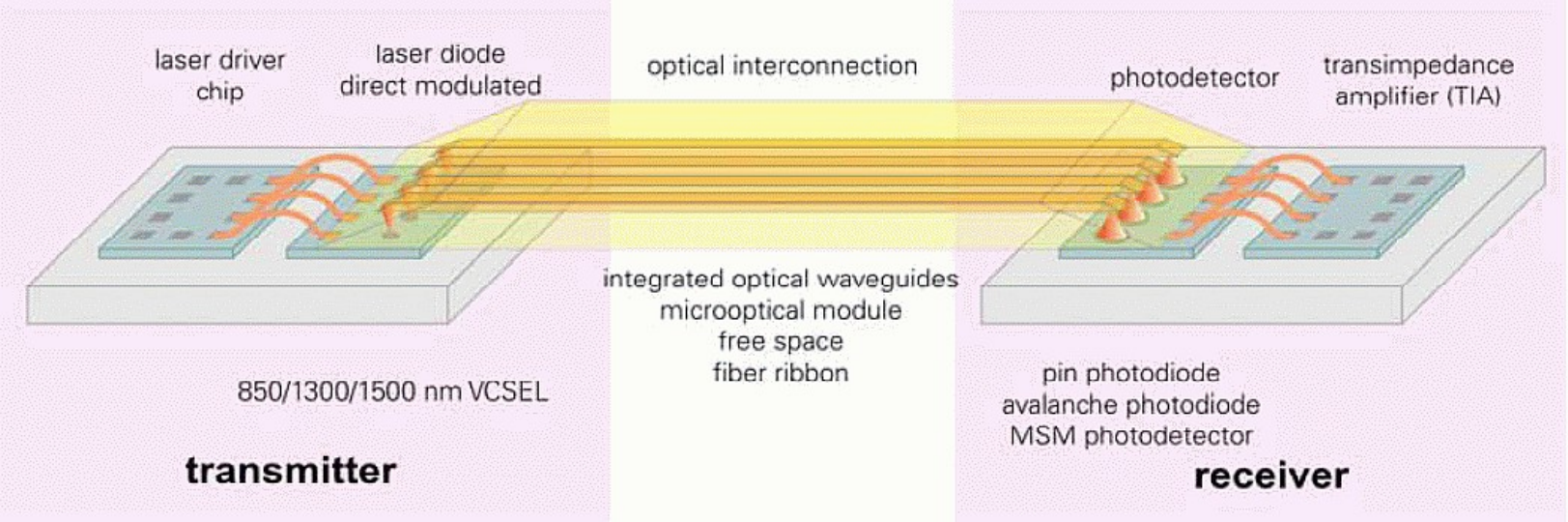
optical interconnect will compete against copper interconnect technology

for backplane and board applications at **data rates 10-15 Gbps and higher**

Bridging the “Technological Gap”

One Solution:

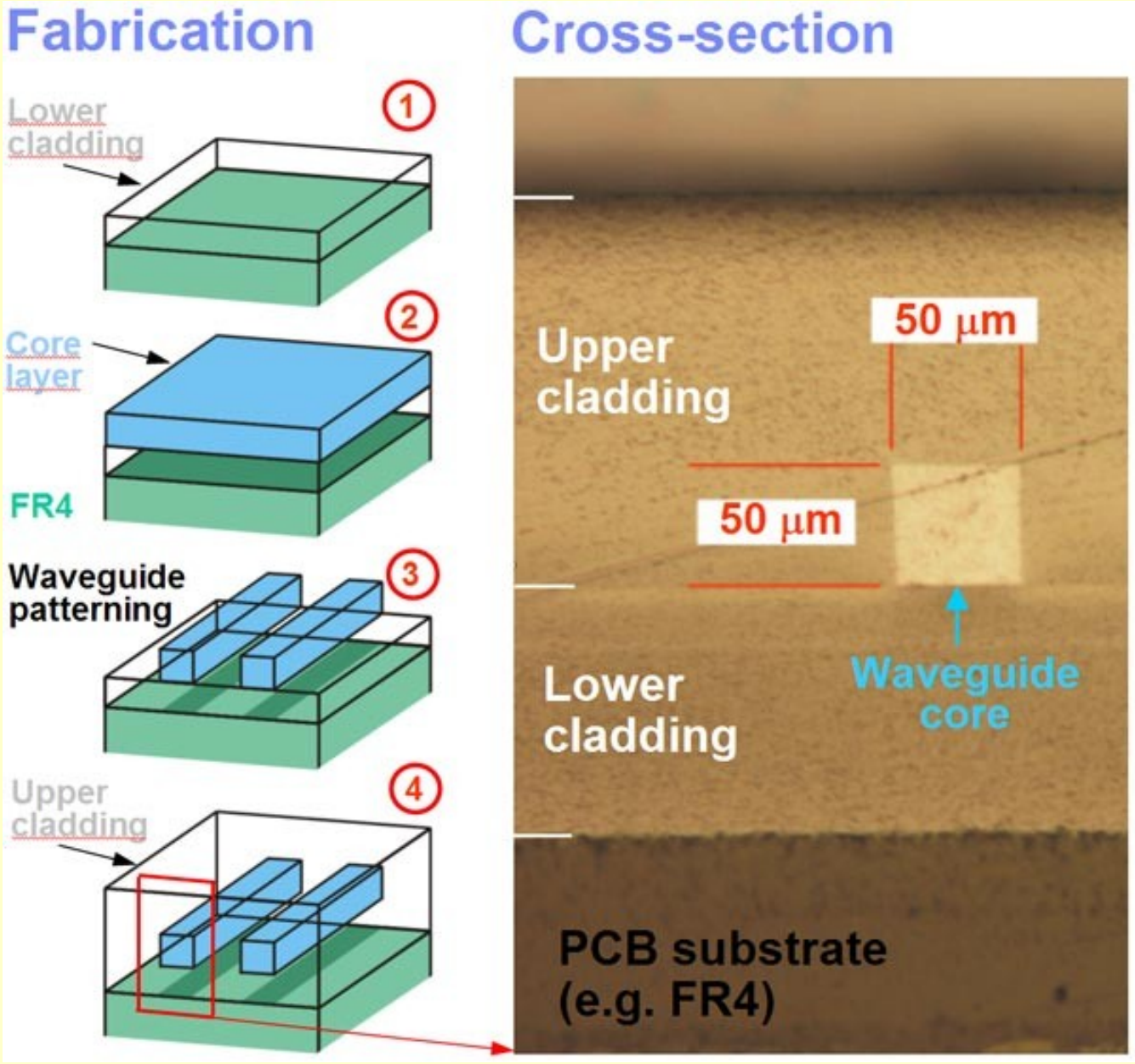
Institut für Aufbau- und Verbindungstechnik der Elektronik (IAVT), TU Dresden



Optical Interconnects

IBM Zurich

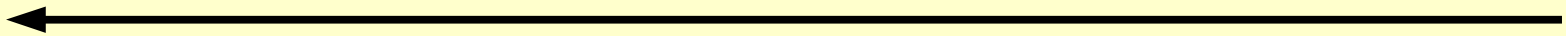
- electro optical PCB

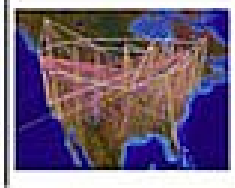
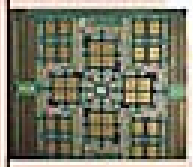


Scaling of Optical Fiber Technology

IBM Zurich

distance



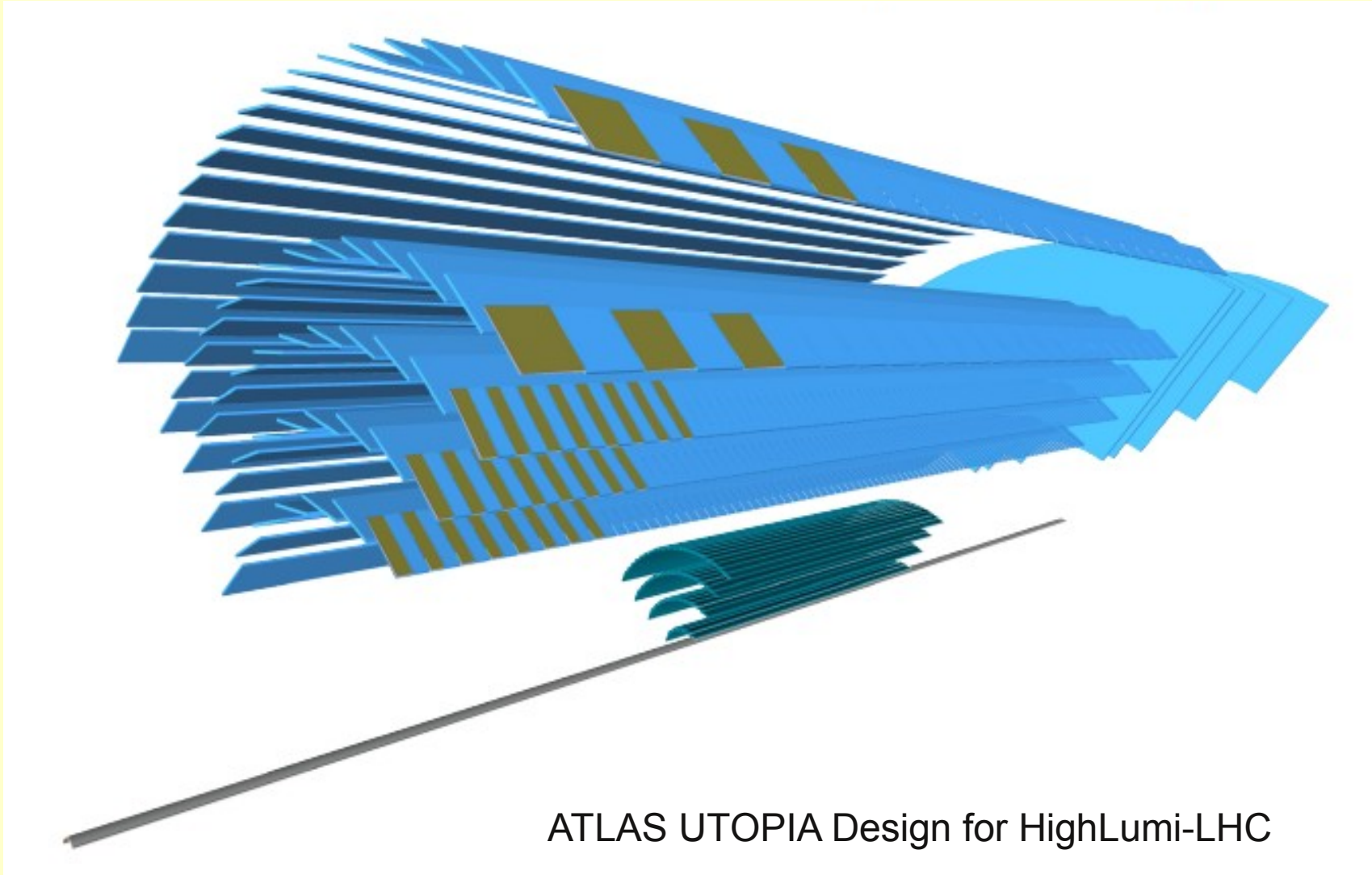
	Internet, Wide Area Network	Local Area Network	Rack-to-Rack	Card-to-Card	On-Card	On- MCM	On-Chip
							
Distance	multi-km	10 - 2000 m	30+ m	1 m	0.1 - 0.3 m	5 - 100 mm	0.1 - 10 mm
Number of lines	1	1 – 10	~100	~100-1000	~1000	~10'000	~100'000
Use of optics	Since the 80s and the early 90s	Since the late 90s	Now	2010+	2010-2015	Probably after 2015	Later, if ever

Our Focus

future

The "Technology Gap" in HEP Experiment

BW Limitations in Inner Detectors



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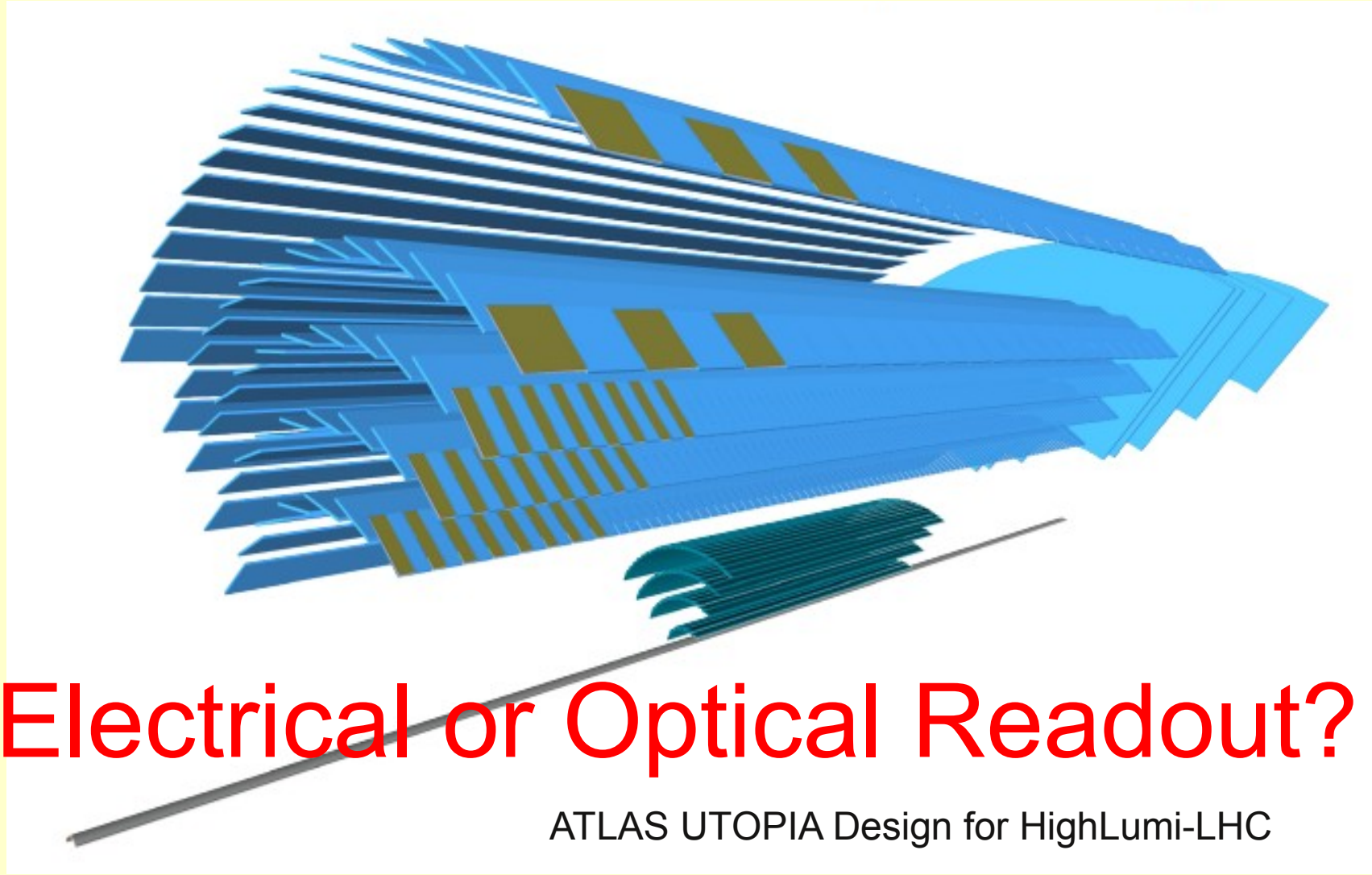
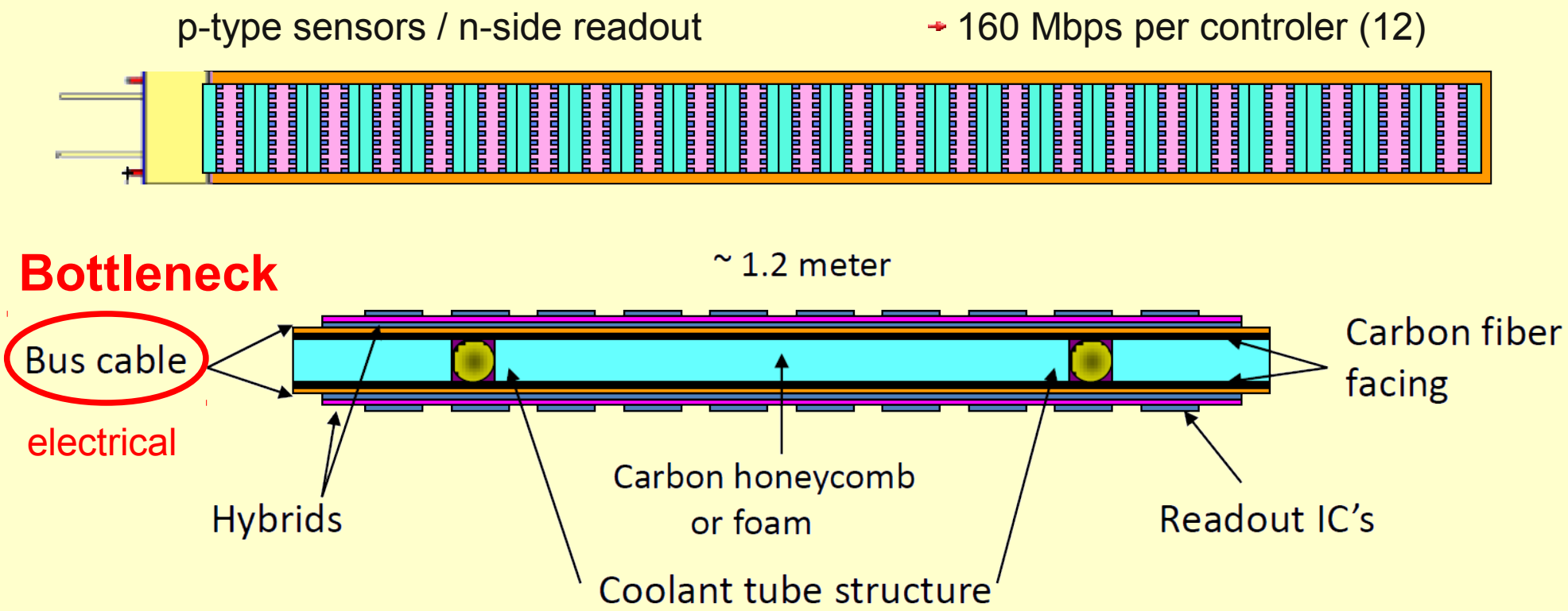


The “First Meter” Bottleneck

example:

Upgraded ATLAS Barrel Strip Detector to be used as first level trigger

Stave Design:



Critical Parameters

The frontend readout data rate can be characterised by 3 numbers:

$$\text{Gbps} / \text{cm}^2$$

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Gbps / cm^2

Gbps / g

Gbps / W

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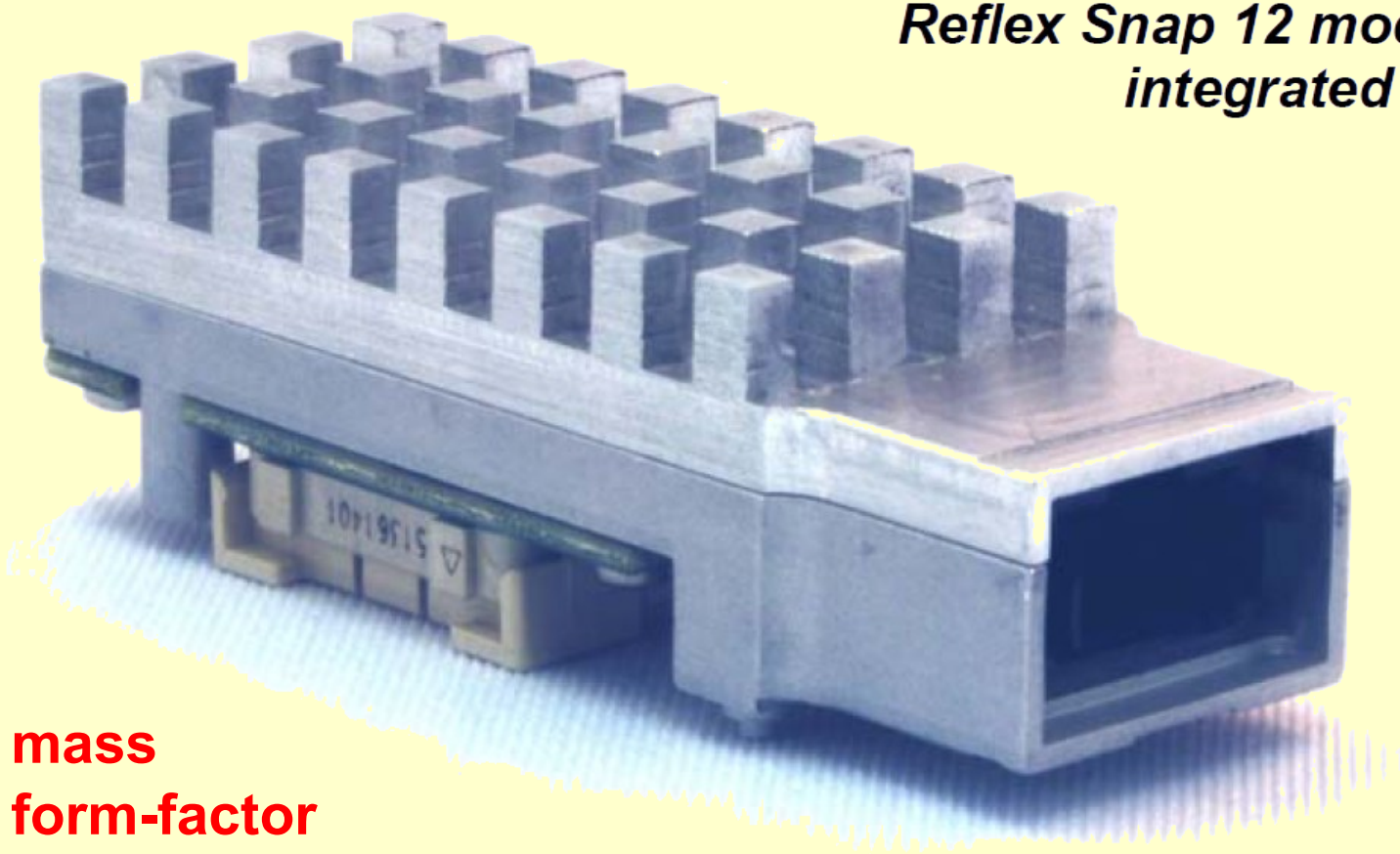
Gbps / W

new technologies will push these numbers up!

Optical Components ?

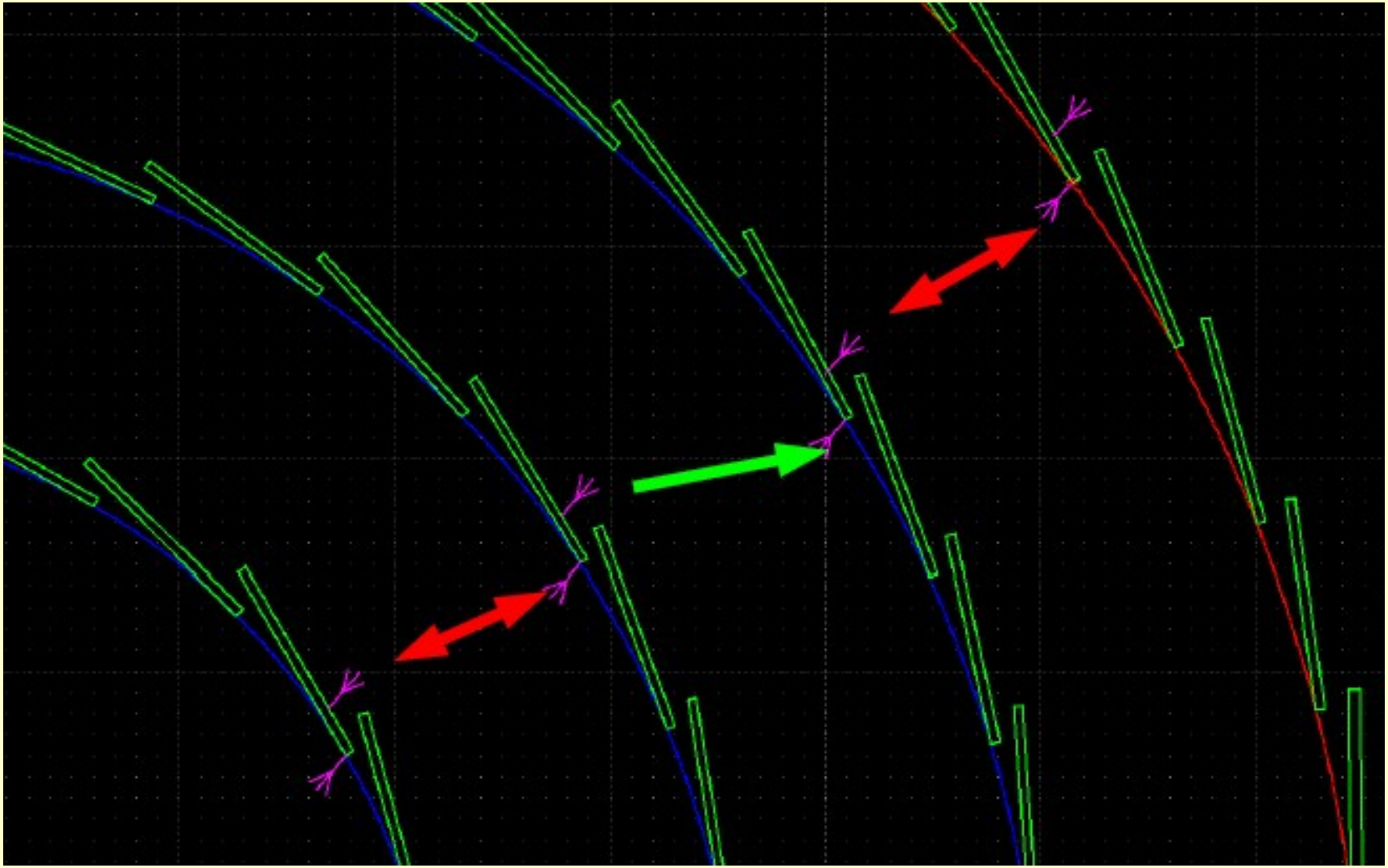


Reflex Snap 12 module with integrated heatsink

- **mass**
- **form-factor**
- **radiation tolerance**

The Third Way

Wireless Readout?



talks by → Richard Brenner
→ Hans-Kristian Soltveit

Opportunities in Germany?

global efforts in the area of data links exist:
- e.g. GBT link (→next page)
- how much do we contribute or gain from these efforts?

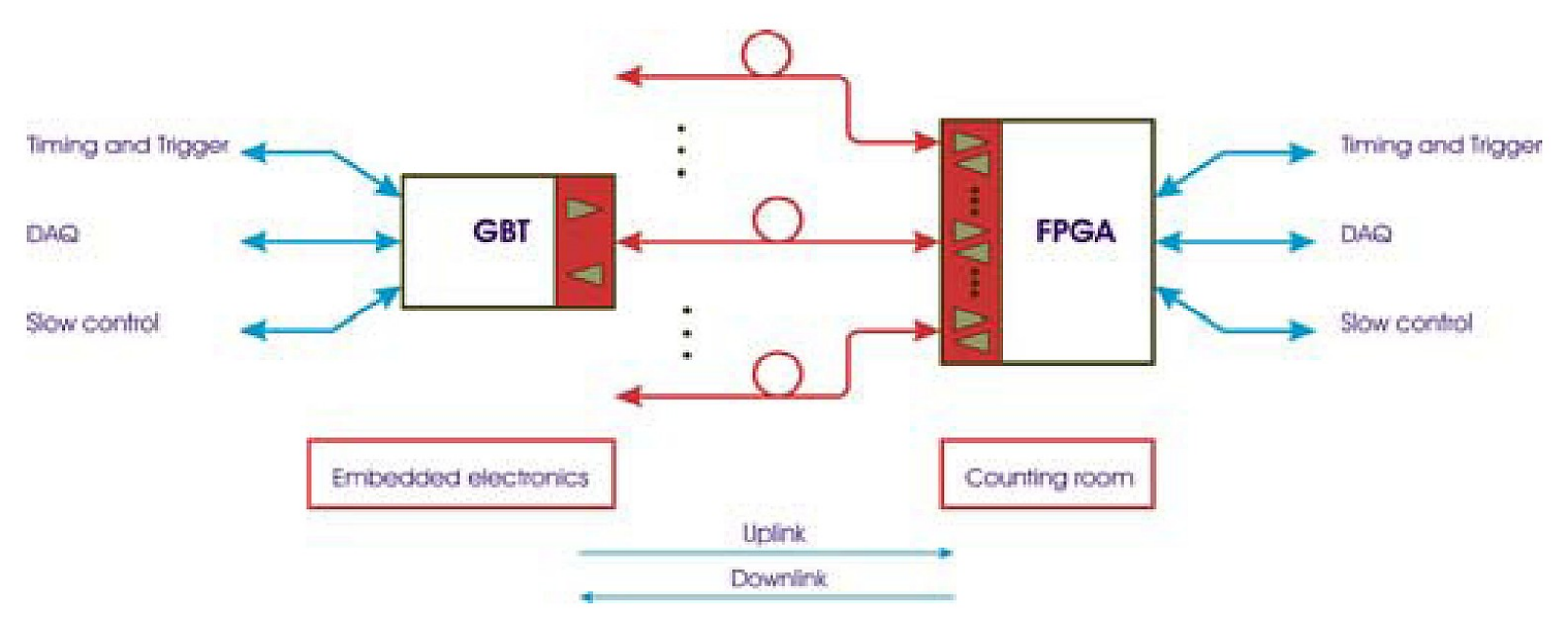
sharing of experience
- different experimental groups in Germany with often identical challenges
- sharing of information
- knowledge database?

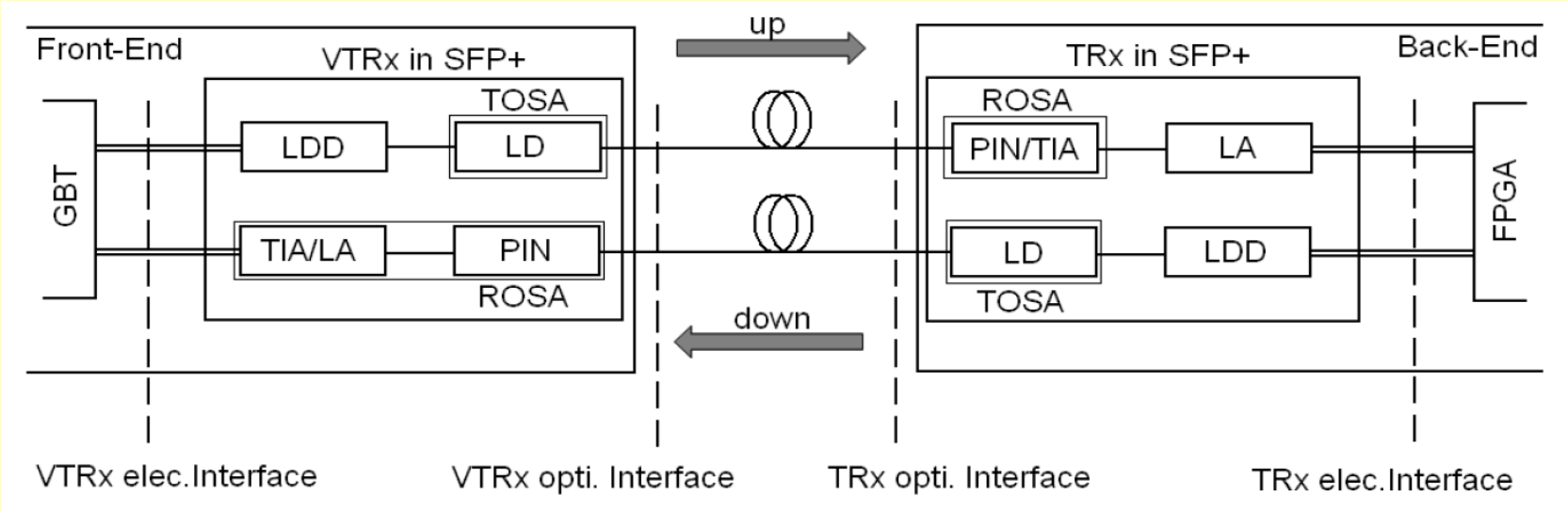
field relies heavily on industry
- contacts to industry?
- co-operations with industry?

new technologies are evolving quickly
- issue: customization for particle physics applications
- common projects?

resources and projects?
- who is active in R&D for data links in Germany?
- launch new projects in new areas (e.g. wireless)?

GBT Versatile Link






Vietnam 2010
Bright prospects for new interconnect technologies in particle physics (HEP)
Wish you a successful workshop in Wuppertal