

POF Standards 2010 what do we need next ?

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**POF Standards Workshop: Discussion and
Strategy on the Development of POF Standards**
- March 23, 2009

2:00 p.m. - 5:00 p.m.

Content

- Application of POF
- Consequences
- next steps for standardization
- the optical interface - mainly required for Gigabit transmission
- Simulation

Applications

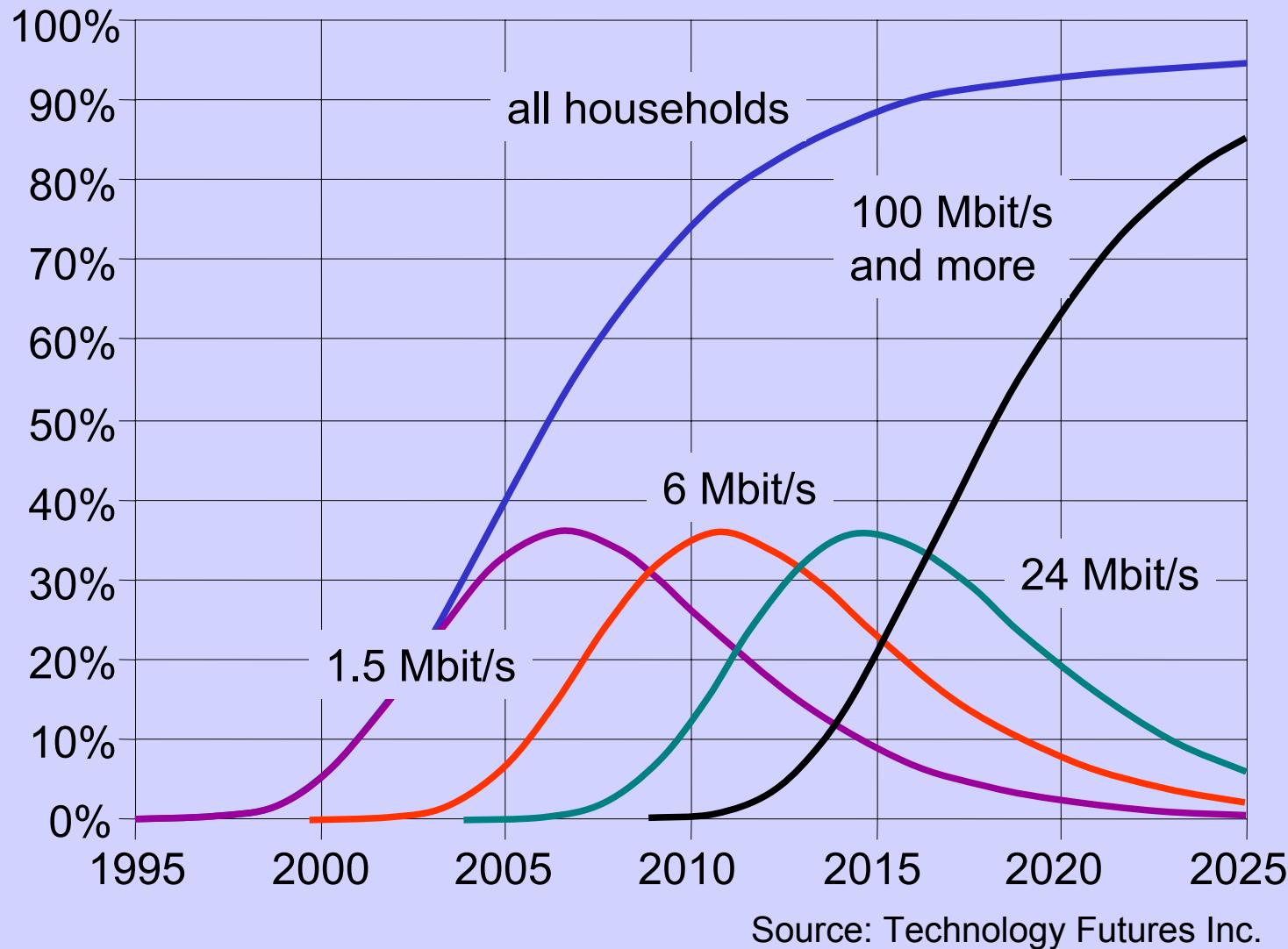
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Use of standard SI-POF:

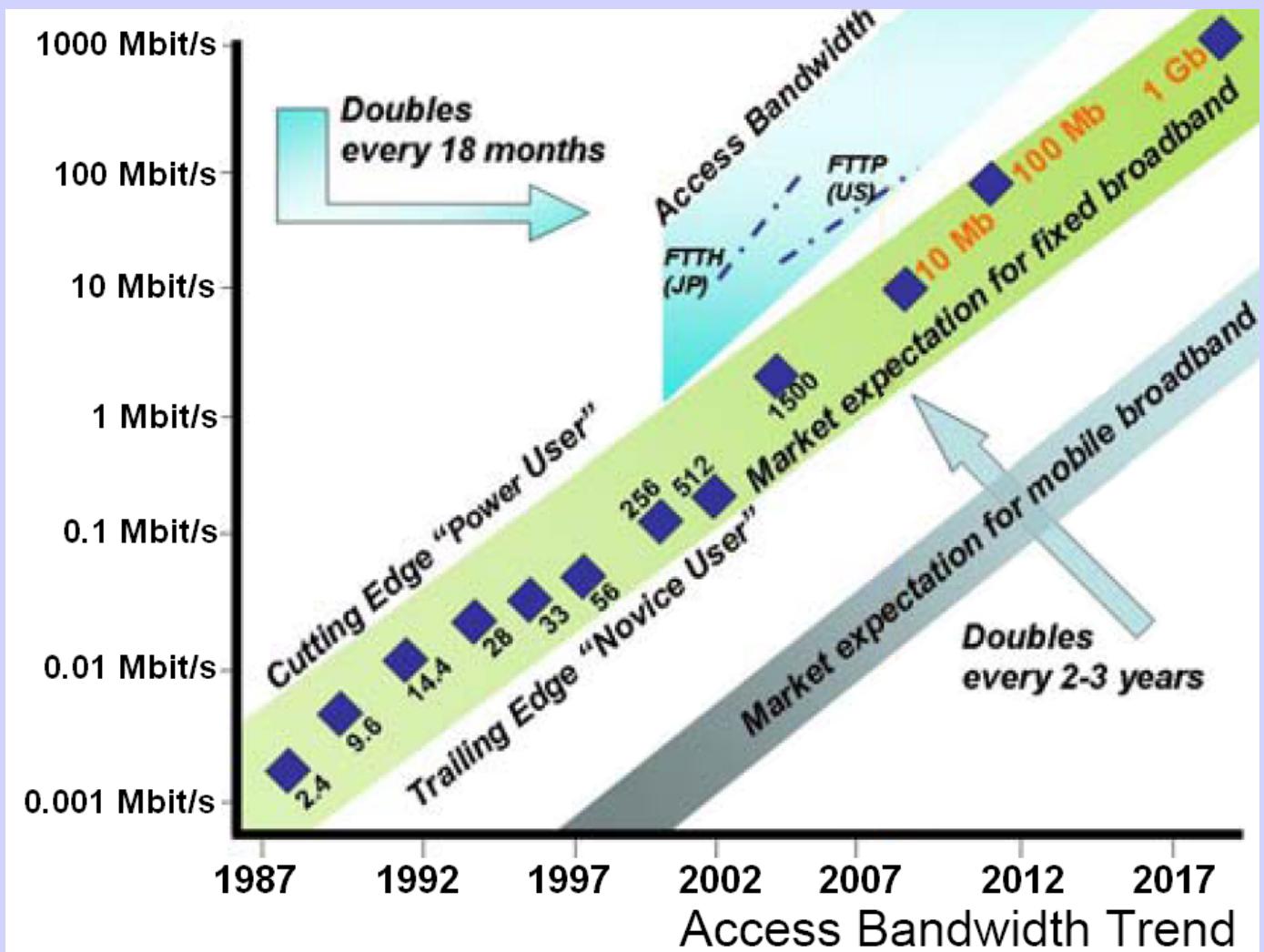
- **Automation**: change from field bus applications to Fast Ethernet
- **Car networks**: higher speed required (from 25 Mbit/s - 150 Mbit/s - 1000 Mbit/s ?); passive star networks for Flexray ?
- **Home networks**: Gigabit Ethernet required, optical interface standard
- **Interconnection**: multi channel parallel transmission, speeds up to 10 Gbit/s, low power consumption

Home networking market

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bandwidth expectations



Home network requirements:

- 1 Gbit/s will be required in the next years
- simple installation techniques for home networks
- professional installation techniques for building (backbone) networks
- first step: definition of cables, fibers and connectors required
- second step: definition of an optical POF interface required

Next steps of POF standard activities

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New VDE/VDI working group

First meeting in Jan. 2009:
4 main Topics identified

- Fibers and cables
- Connectors for POF home/apartment networks and other application
- Measurement technologies and devices
- standardized optical POF interfaces

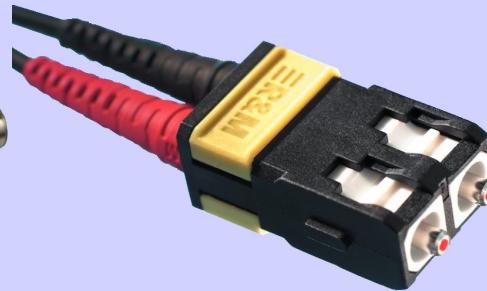
Example I: connectors

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present available connectors:



EM-RJ

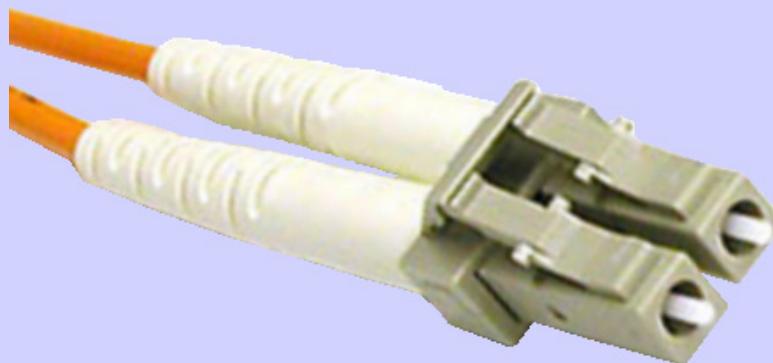


SC-RJ



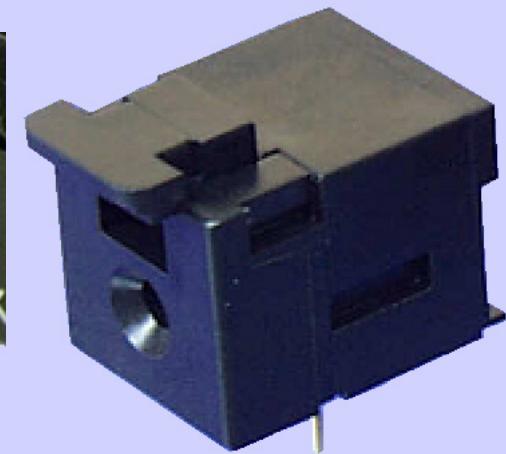
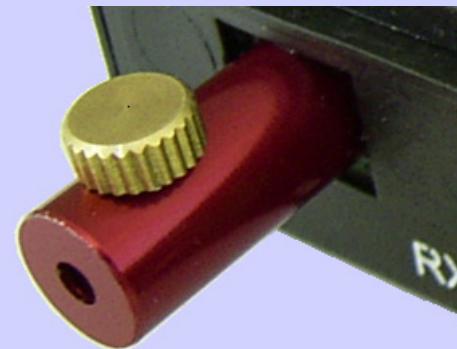
SMI

The IEC view:



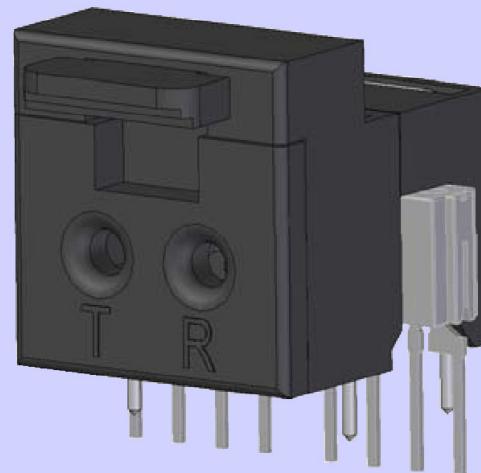
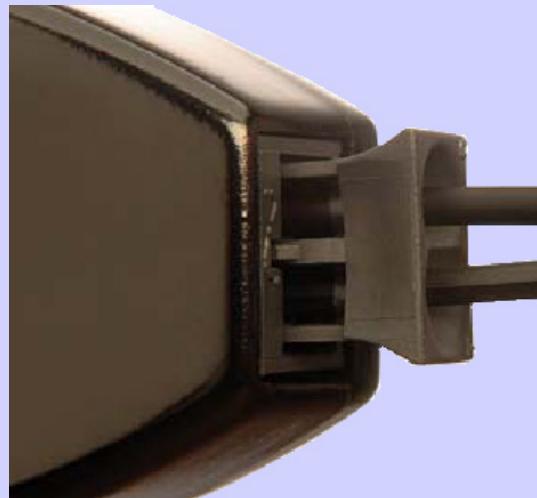
Installation without connectors !!

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DieMount

Ratioplast



Firecomms

Siemens

possible directions

- use of connector less installation in the apartment by the customer (fiber spec is the connector spec)
- use of standard connector in (structured) building networks
- different connectors for GOF and POF ! - make it impossible to connect the wrong cable; profit from the more relaxed tolerances; create an individual POF image (see *RJ45 is Ethernet*)

The POF-SFP idea

- installation “Link on demand”
- free choice of transmission medium
- 100/1000 Mbit/s upgrade possible
- connector less or standard connectors



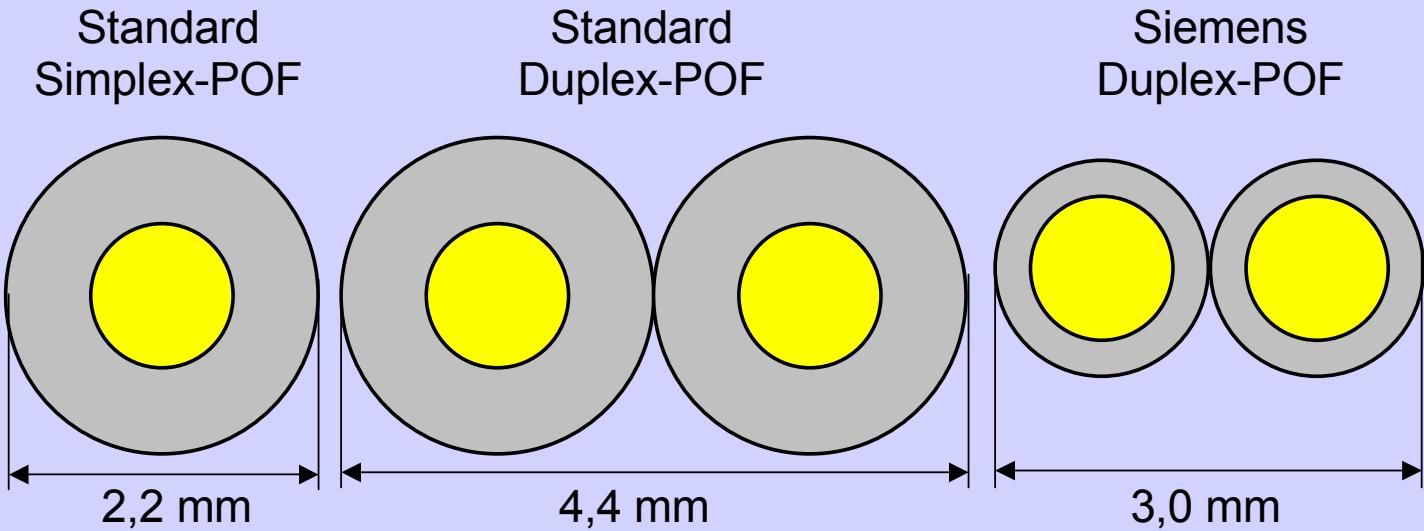
Decision in 2008: A4a.2

but what about A4b .. A4h ?

- **GI-POF:** what diameter, NA ?
- **MC-POF:** how many single cores, NA, diameter, loss ?
- **PF-GI-POF:** 50 µm, 62½ µm, 80 µm, 120 µm, 200 µm ? present bandwidth specification is 1880 - 5000 MHz · 100m
- **PF-GI-POF:** Mode mixing is important for the bandwidth: spec of coupling length ?
- t.b.c.

Example III: Cable

Simplex or Duplex
1.5 or 2.2 mm jacket



Identification of POF type:

- by color, colored dots or rings
- by printed code
- by different jacket diameter

Example IV: measurement

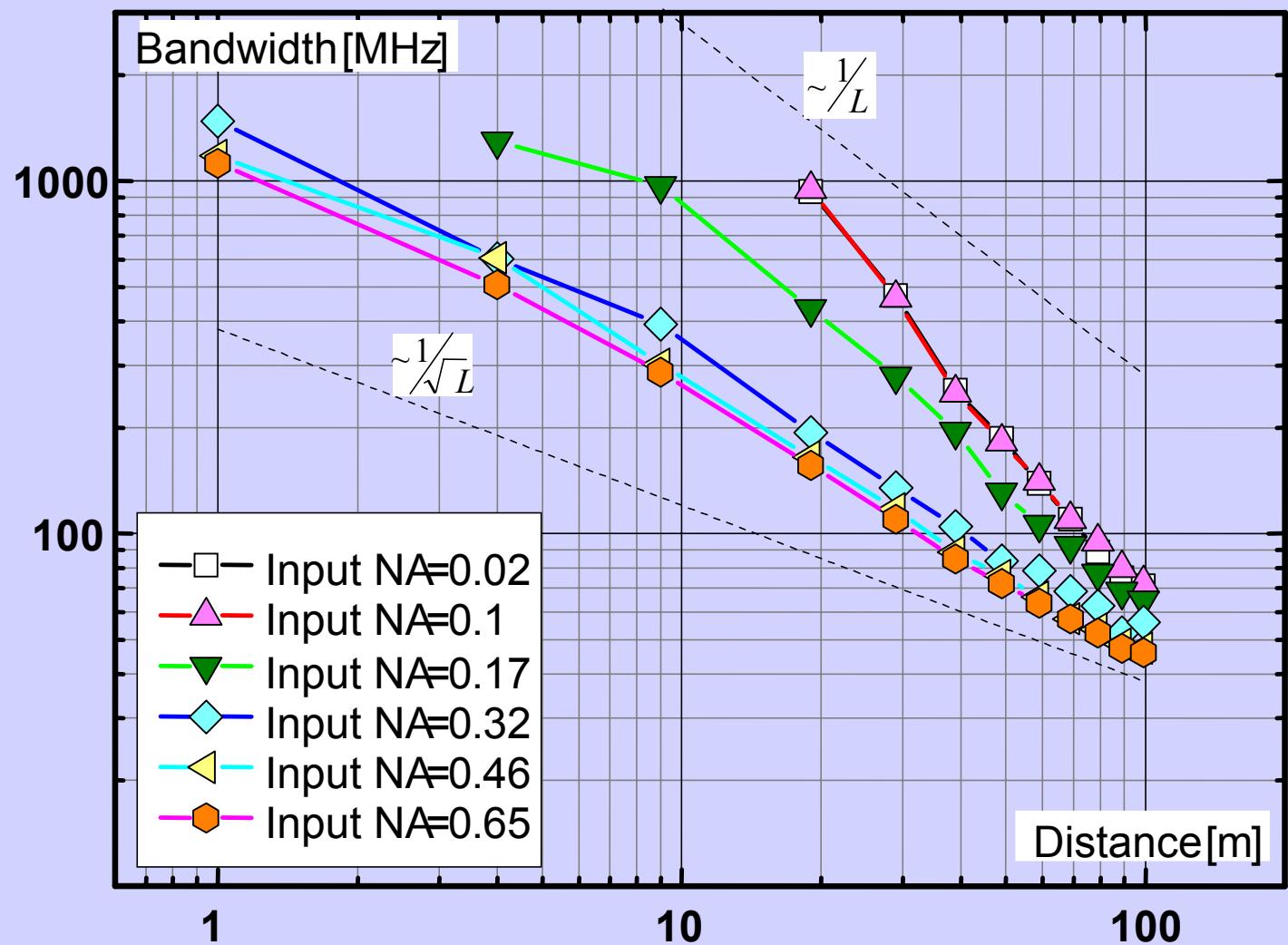
we have a standard for attenuation measurements on the A4a.2 fiber

we are still missing:

- standard for fiber bandwidth
- standard for connector loss (e.g. OTDR)
- loss measurements on A4d, A4e
- mode mixers for A4d, A4e and PCS
- specification of optical properties for modulated signals (e.g. eye diagram mask with standard equalizer)
- ...

SI-POF bandwidth

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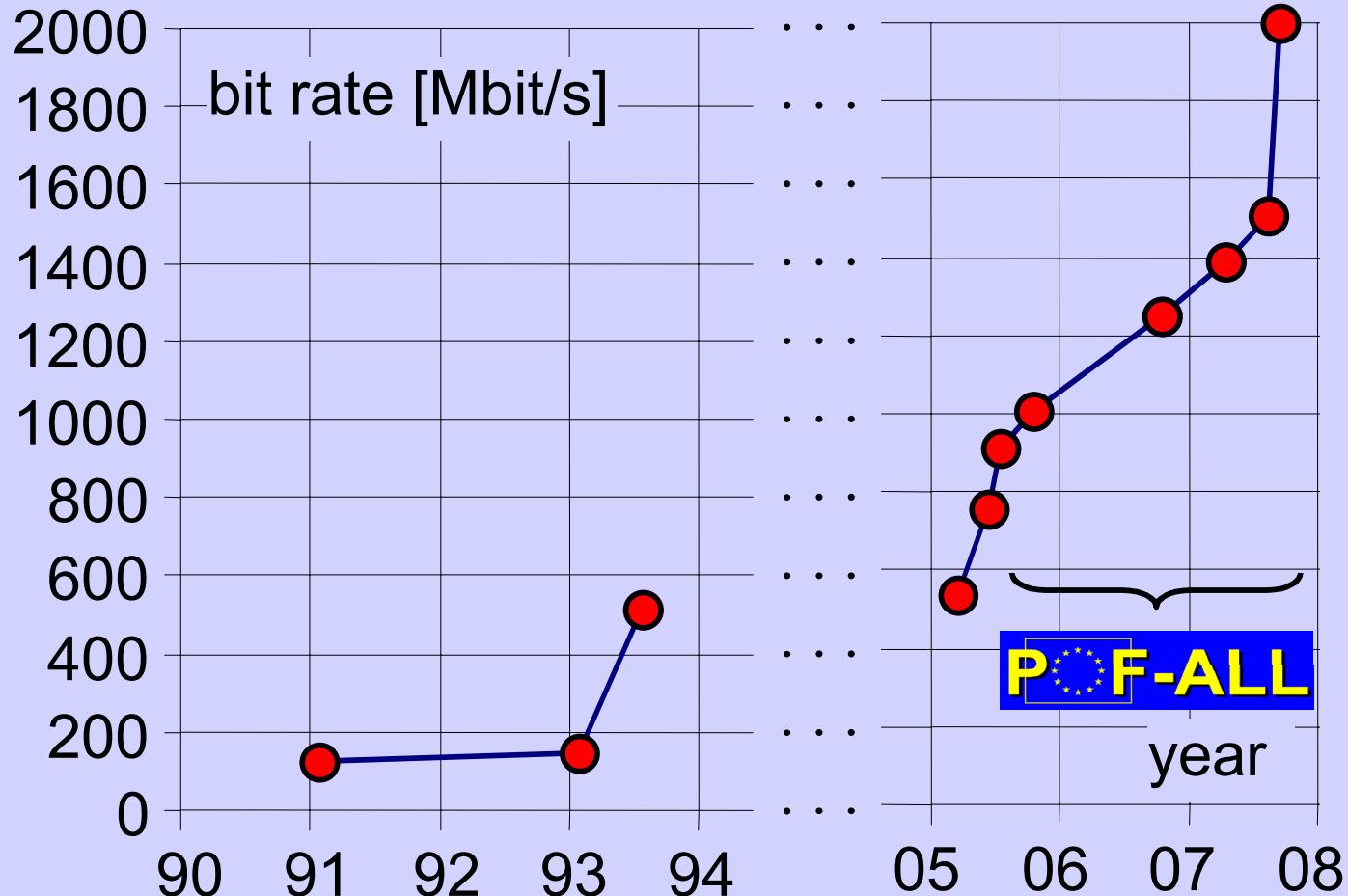
the optical interface
- mainly required
for Gigabit
transmission

1 Gbit/s over 100 m POF ?

- Typical SI-POF bandwidth is 40 MHz
- but: Bandwidth of a Cat 6 cable is 3 MHz
- 1 Gbit/s over 100 m POF have been realized with:
 - passive equalizing (POF-AC)
 - OFDM (Siemens)
 - DFE/FFE filter (TU Munich/Siemens)
- there is still place for improvements (e.g. integrated receivers)

How fast is a 1 mm POF over 100 m 20

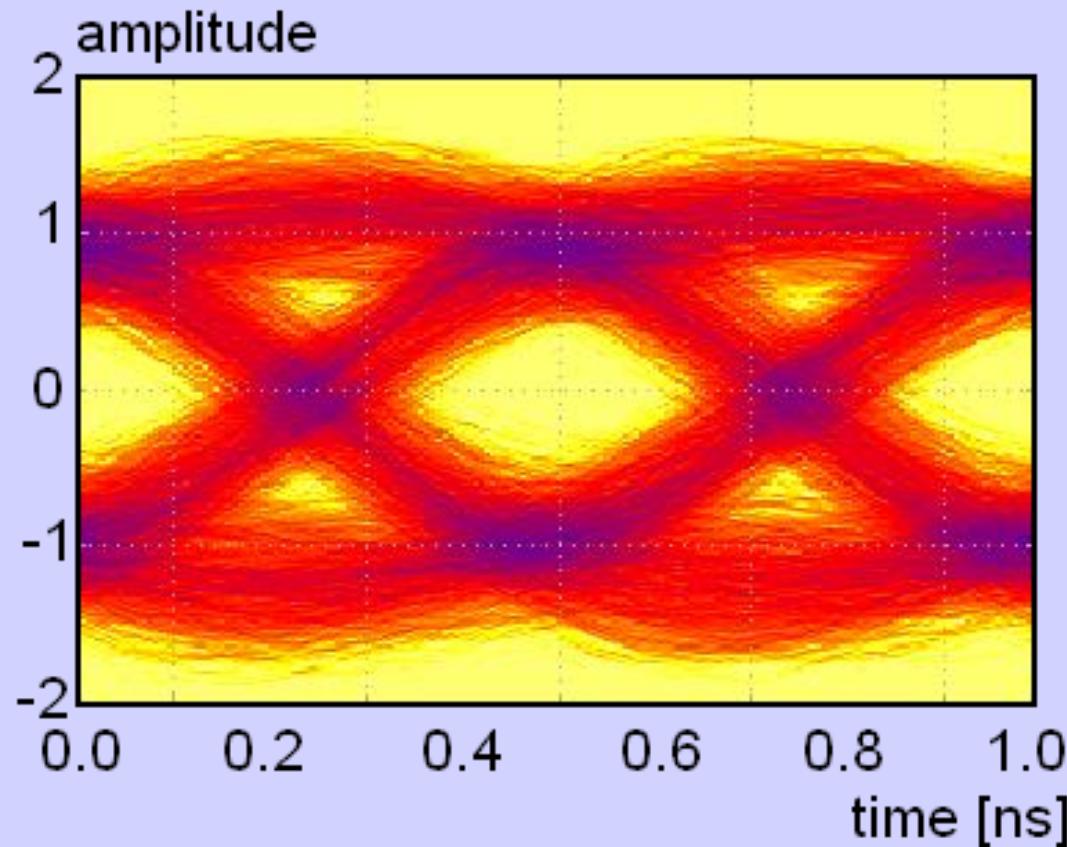
100 m standard POF (A4a.2), NA = 0.50



last result (TU Munich)

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- Laser : Union Optronics
- sequence : PRBS7, 2000 Mbit/s
- fractionally-spaced DFE offline processed (Matlab)
- offline measured BER: $2 \cdot 10^{-5}$



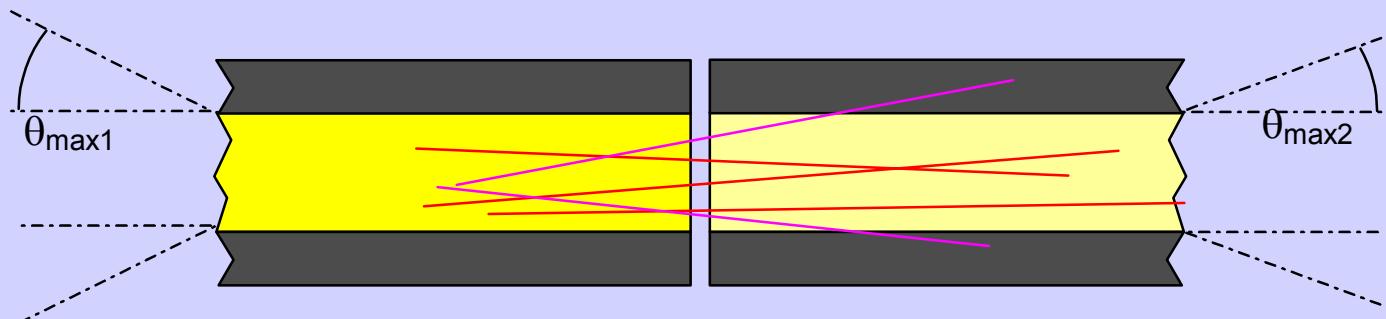
Simulation of optical Systems - basis of standards

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POF-SC: the POF Simulation Center

- started in Jan. 2009 in Nürnberg
- international speaker: Prof. Bunge
(Telekom University Leipzig)
- Goal: coordination of all European POF simulation activities
- create basic data for standards
- running project: physical model for connector losses
- ready: simulation of Gbps links with NRZ, DMT and FFE/DFE
- **see Juri's presentation at the POF-Day**

Example POF connector loss



connector loss in theory:

Solid angle for input fiber: $\theta_{\max 1}^2 \cdot \pi$

Solid angle for output fiber: $\theta_{\max 2}^2 \cdot \pi$

Attenuation:

$$\begin{aligned}\alpha &= 10 \cdot \log (\Omega_1 / \Omega_2) \\ &= 10 \cdot \log (\theta_{\max 1}^2 / \theta_{\max 2}^2)\end{aligned}$$

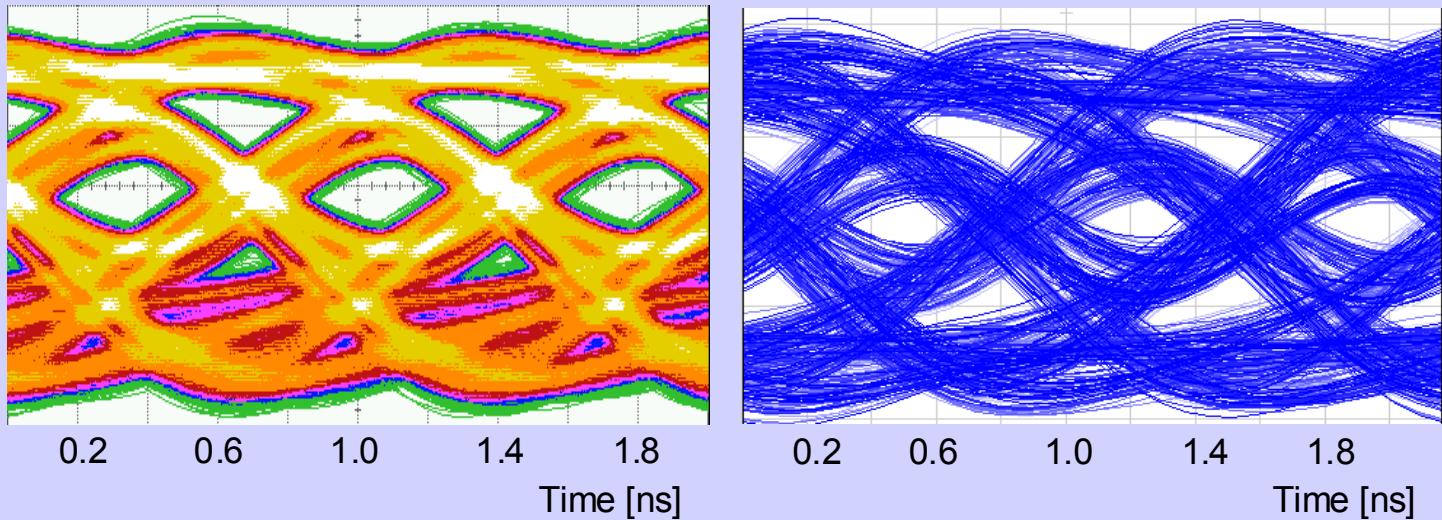
Expressed by NA:

$$\alpha = 10 \cdot \log (A_{N1}^2 / A_{N2}^2)$$

but: how is the loss under EMD conditions ?

approach: statistical model for light distribution

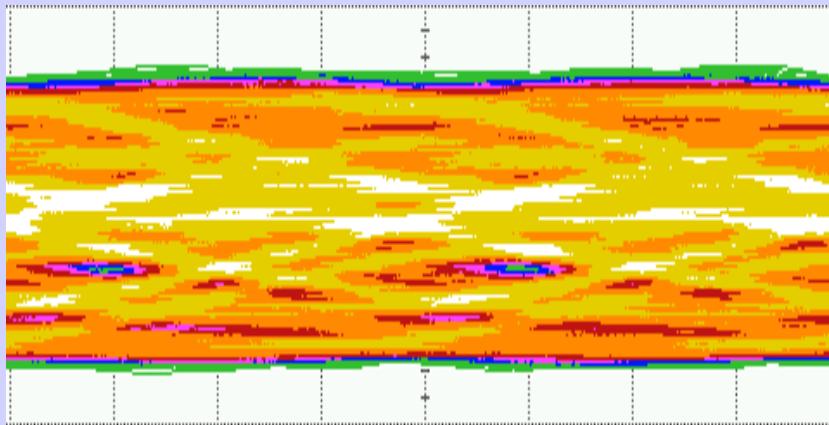
Measured and simulated eye diagram



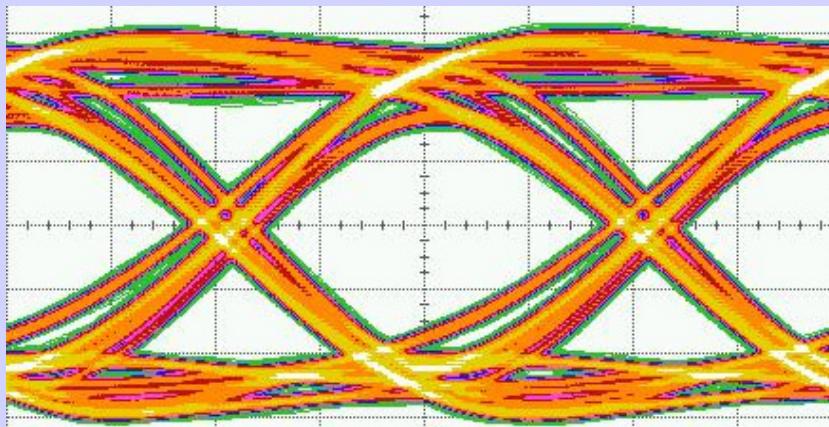
650 nm Laser diode, +6.5 dBm fiber coupled
received power: -11 dBm after 100 m POF
 $\text{BER} \approx 10^{-9}$

the eye problem

at the PD, the eye is completely closed,
how can I specify the optical input signal ?
one option: reference equalizer



1.25 Gbit/s
50 m POF
no equalizer

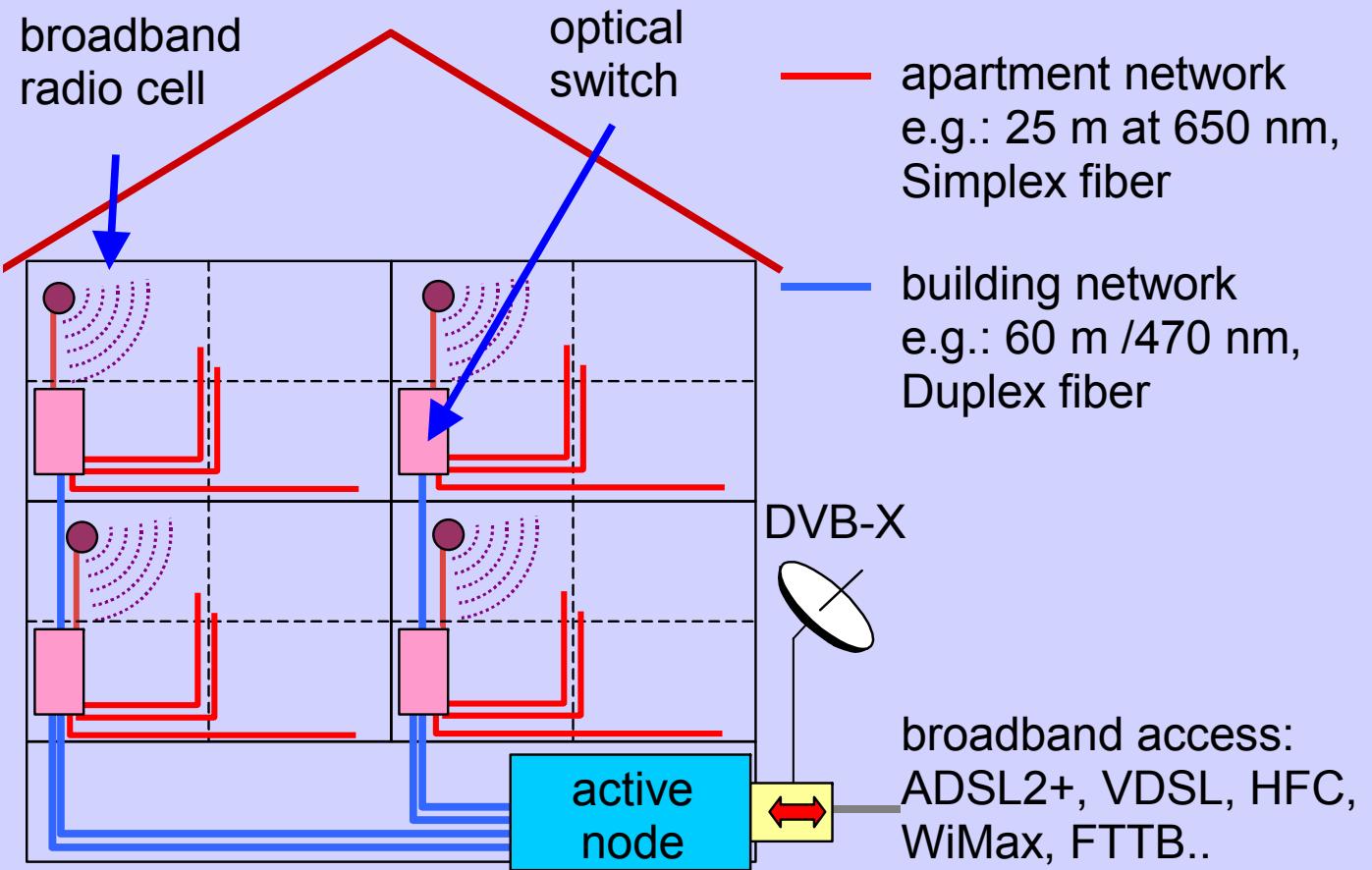


1.25 Gbit/s
50 m POF
optimized
equalizer

Conclusion outlook

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combination radio and POF



the vision of the POF future

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