

# Experimental Verification of Mode Group Diversity Multiplexing over GI-POF at 21.4 Gb/s without Equalization

Stefan Schöllmann, Werner Rosenkranz

University of Kiel, Germany

Chair for Communications  
Kaiserstr. 2, 24143 Kiel, Germany  
Email: sts@tf.uni-kiel.de

# Motivation

Initial Point: High speed LAN over POF

## Plastic Optical Fibre

- Easier handling compared to silica fibres
  - Bending
  - Connectors
- Short reach at high speed
  - Low bandwidth distance product



**Research Topic:** Increase of bandwidth distance product

### Existing

- New fibre types
- Coarse (C)WDM
- Equalization

### Alternative

- Mode Group Diversity Multiplexing

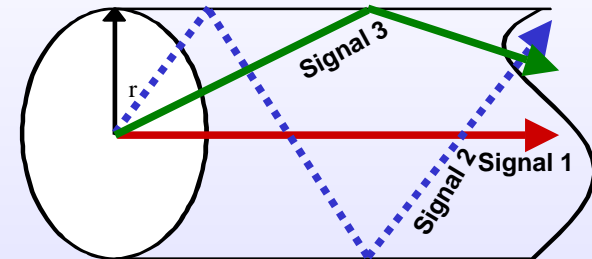
# Outline

- Motivation
- Introduction
  - Transmission Characteristics of POF
  - Mode Group Diversity Multiplexing
- Experimental Setup
  - Transmitter
  - Receiver
- Experimental Results
- Outlook & Conclusion

# Introduction (1)

## Plastic Optical Fibre (POF)

- Large core diameter (62.5 – 1000  $\mu\text{m}$ )
  - Multi mode character
    - Mode dispersion
    - Mode coupling



### Impulse Response

$$h(t) = \sum_{m=0}^{M-1} P_m \delta(t - \tau_m)$$

$M$  = Number of excited mode groups

$P_m$  = Power of mode group  $m$

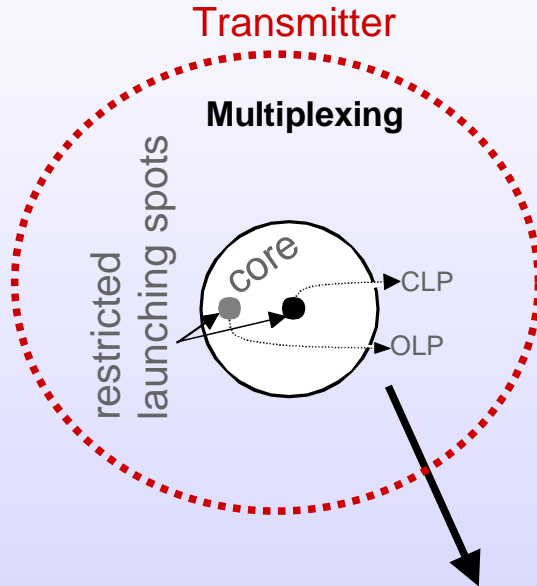
$\tau_m$  = Time delay of mode group  $m$

With the effect of mode coupling

$$P_m = \sum_{n=0}^{N-1} \gamma_{n,m} \cdot P_n$$

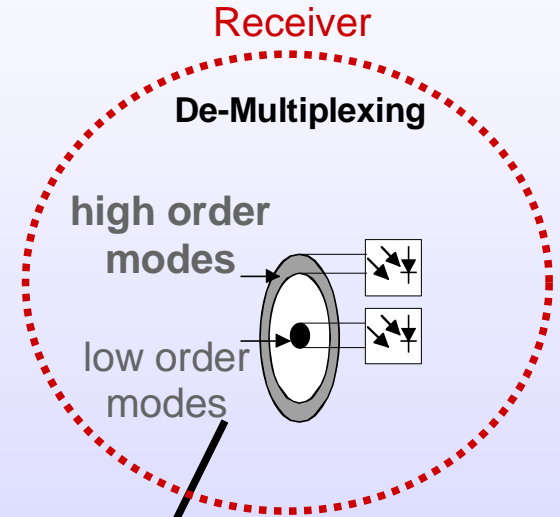
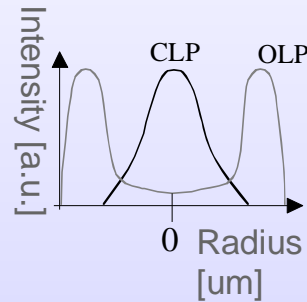
# Introduction (2)

## Principle of Mode Group Diversity Multiplexing



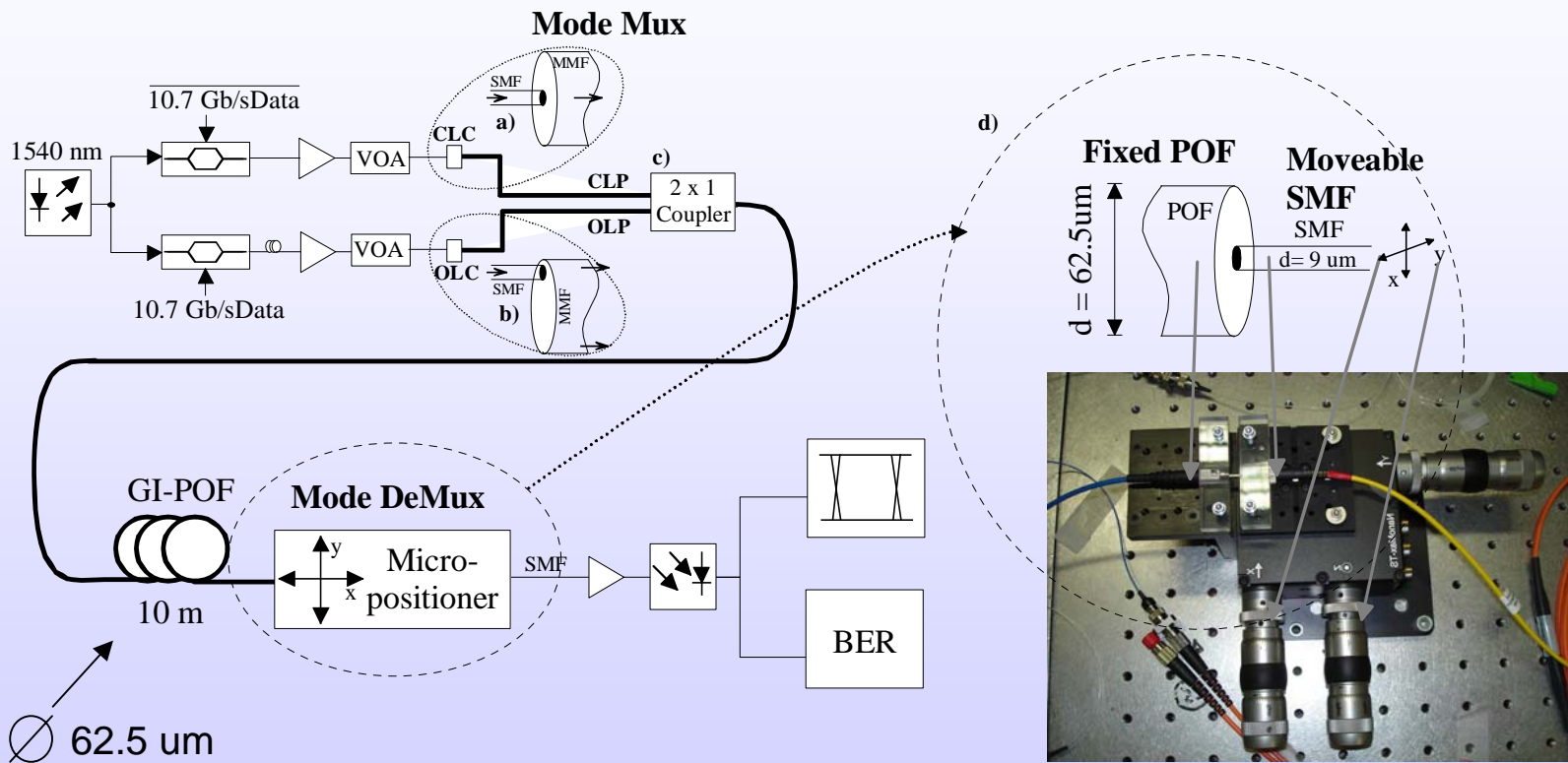
Assignment of different signals to different mode groups

**Power distribution in the POF**



Separation of different mode groups

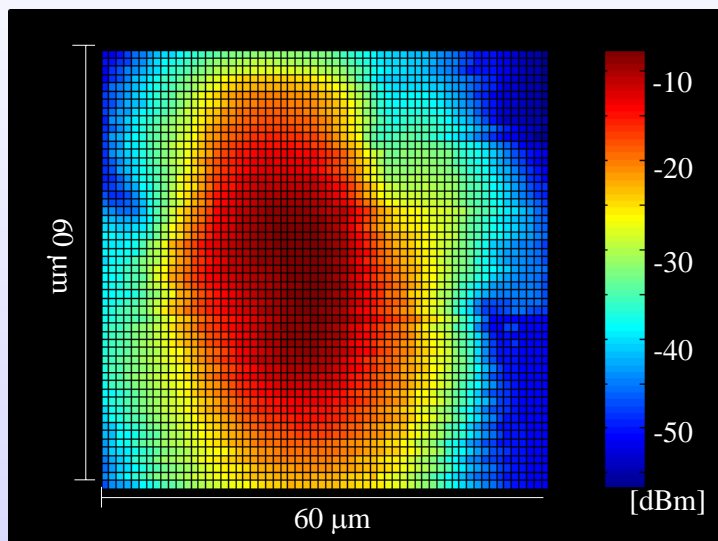
# Experimental Setup (1)



# Experimental Results (1)

## Intensity distributions for different launching positions on MMF

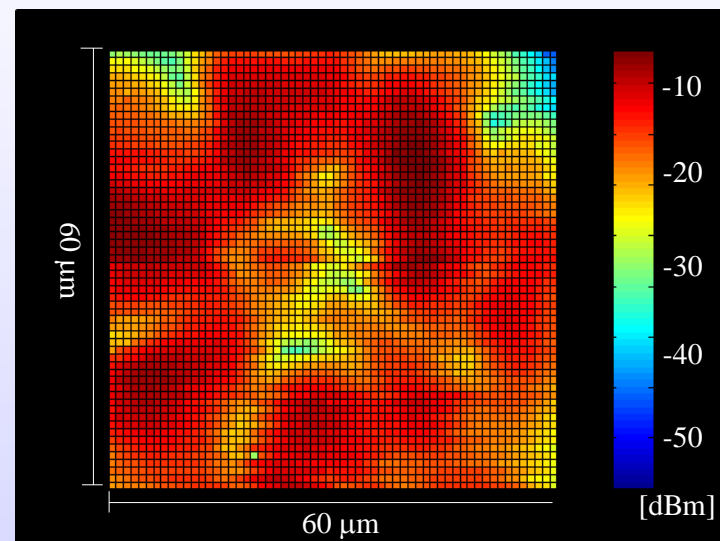
CLP



### Centre Launch Position

- Concentration of power in the centre of the core

OLP 20 μm



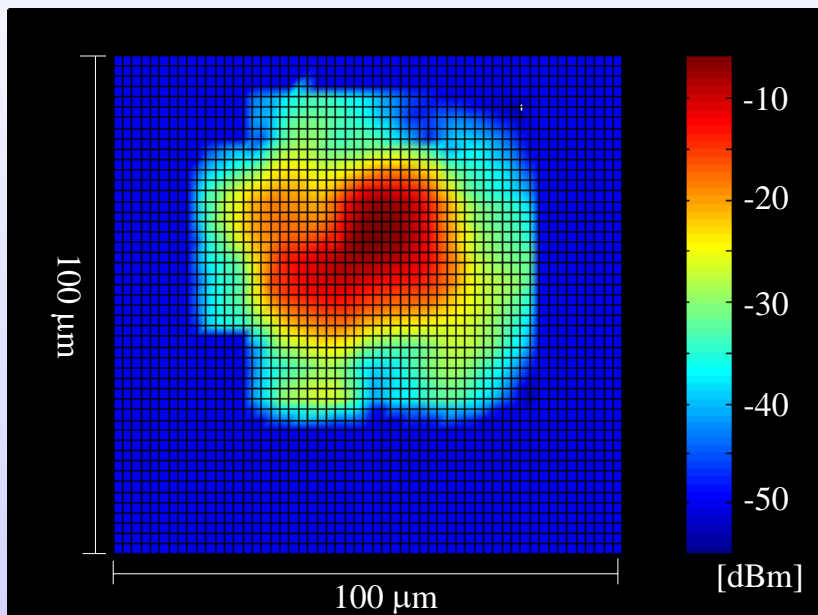
### Offset Launch Position

- Power is more distributed over the core radius (closer to core cladding)

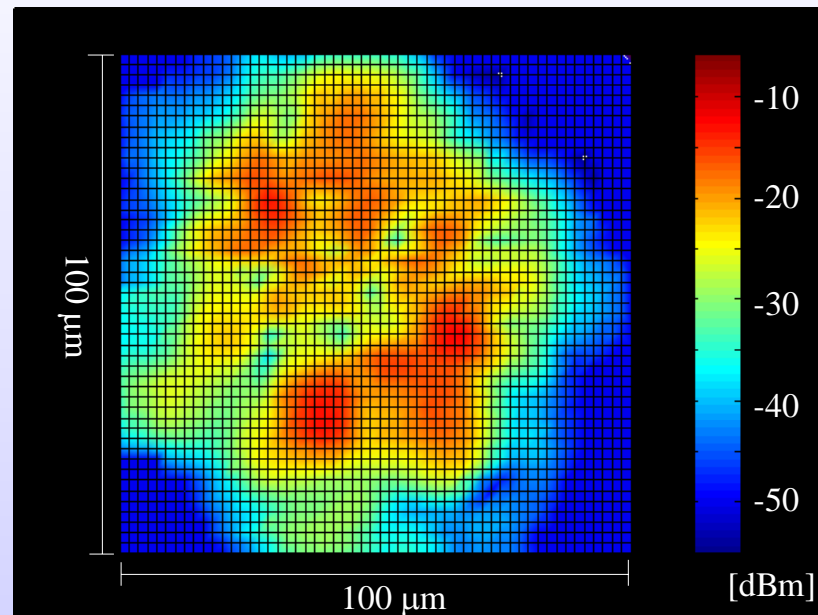
## Experimental Results (2)

### Intensity distributions **after 10m GI-POF**

CLP



OLP, 20 μm



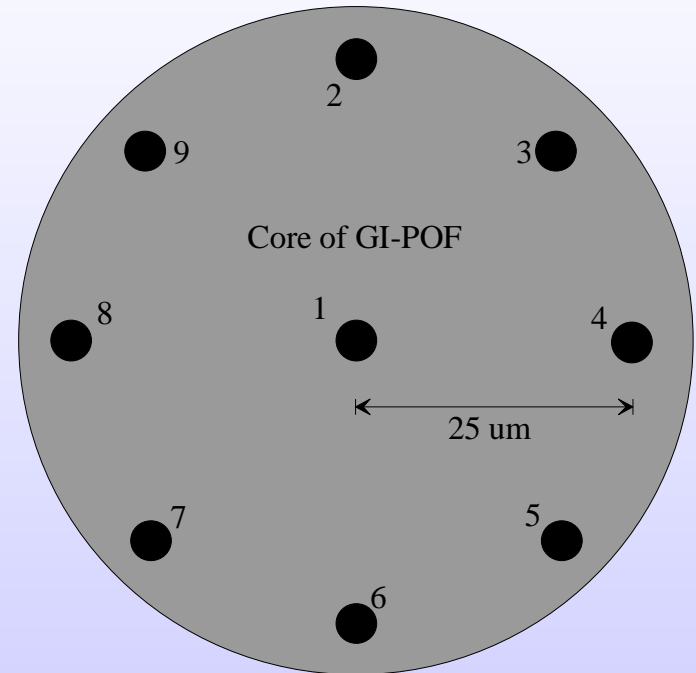
**No significant change** in the intensity distributions for CLP and OLP

# Experimental Results (3)

## Detection of the different signals

Two different detection areas:

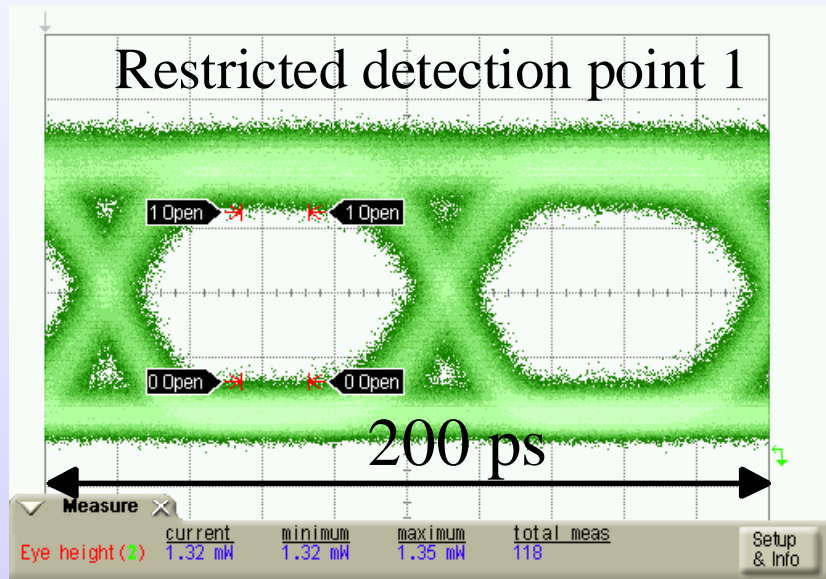
- Centre of the core for detecting low order modes
- Detection area formed as a ring close to core cladding edge
- Realized with the detection points 2 - 9
- Realized with the detection point 1



## Experimental Results (4)

### Detection of signal 1 (CLP)

#### CDP

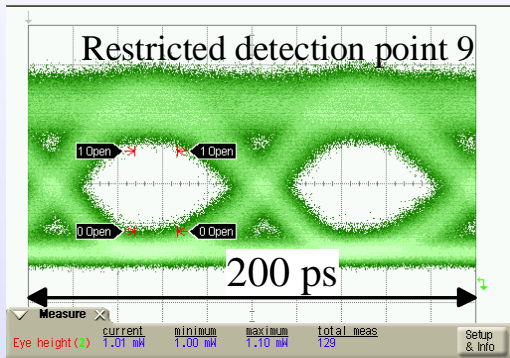


- Wide open eye for restriction area 1
  - low influence of mode dispersion
  - low interference from second channel

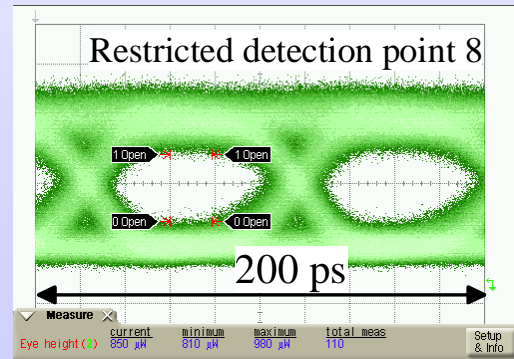
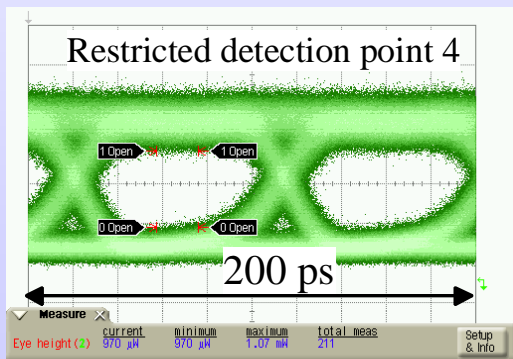
# Experimental Results (5)

## Detection of signal 2 (OLP)

### ODP



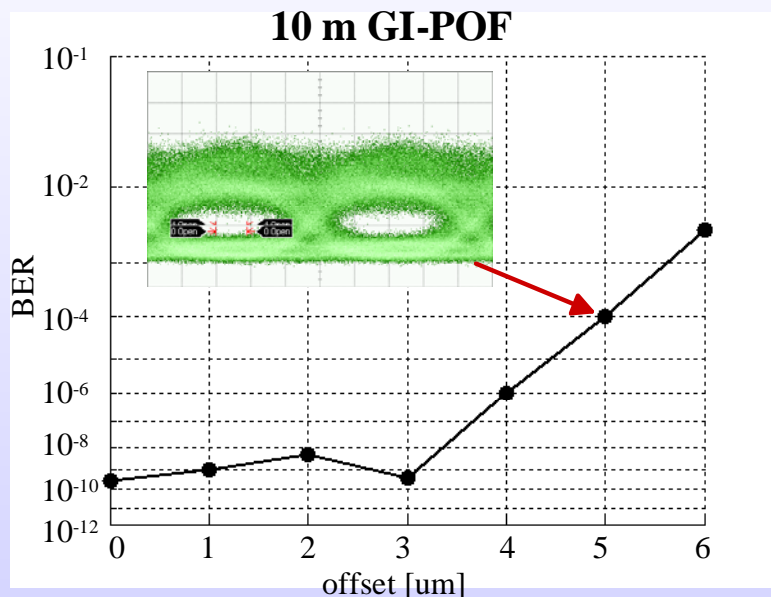
- Wide open eye for points 4, 8, 9
- more distorted due to
  - Mode dispersion
  - High scattering from second signal





## Experimental Results (6)

### Influence of slight variations at CLP



- 0 um to 3 um offset
  - no significant performance change
- 4 um and 5 um offset
  - significant performance reduction to a BER of  $10^{-4}$
- 6 um offset
  - BER of  $3 \cdot 10^{-3}$  → Correction by standard FEC is not possible

# Conclusion & Outlook

- Experimental Verification of Mode Group Diversity Multiplexing over 10 m GI-POF @ 21.4 Gb/s
  - Multiplexing was realized by different launching positions and mode preserving coupler
  - Intensity distribution after transmission was analysed
  - Successful demultiplexing was realized with different detection areas
  - Crosstalk from low order modes to high order modes was analysed for varying launching positions (0  $\mu\text{m}$  to 6  $\mu\text{m}$ ) at CLP