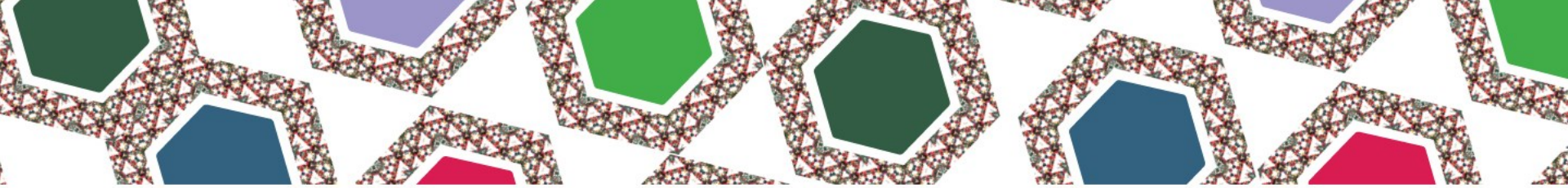


ITU Kaleidoscope 2013
Building Sustainable Communities

Non-Directed Indoor Optical Wireless Network with a Grid of Direct Fiber Coupled Ceiling Transceivers for Wireless EPON Connectivity

D. R. Kolev[1], T. Kubo[2], T. Yamada[2], N. Yoshimoto[2], K. Wakamori[1]
[1]GITS, Waseda University, Japan
[2]ANSL, NTT Corporation, Japan
dkolev@fuji.waseda.jp

Kyoto, Japan
22-24 April 2013

Outline

- Research motivation
- Proposed system
  - EPON standard
  - Theoretical model
  - Synchronization
- Results and discussion
- Conclusion and future work

Research Motivation

Expanding market of portable devices and applications → High capacity mobile access network

Goal: high-speed, secure and power efficient indoor communication system for mobile users

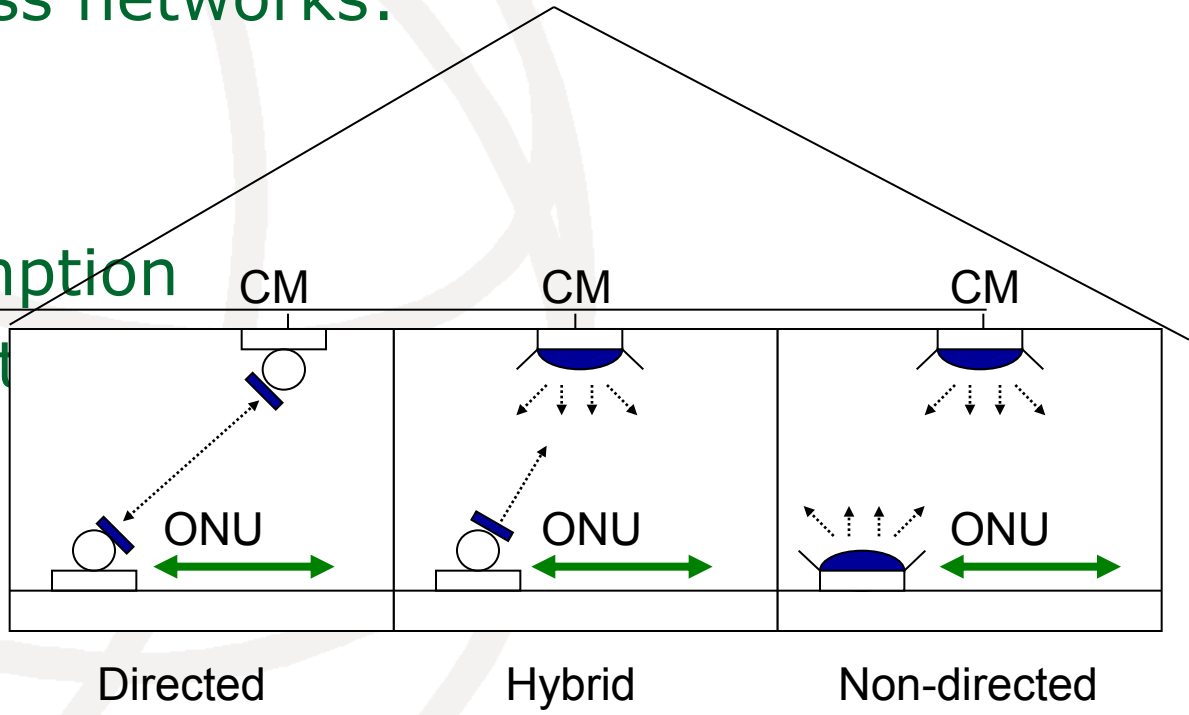
Indoor optical wireless networks:

- High speed
- Diffuse
- Line of sight (LOS)
- Low power consumption
- Electromagnetic int

OLT - optical line terminal

ONU – optical network unit

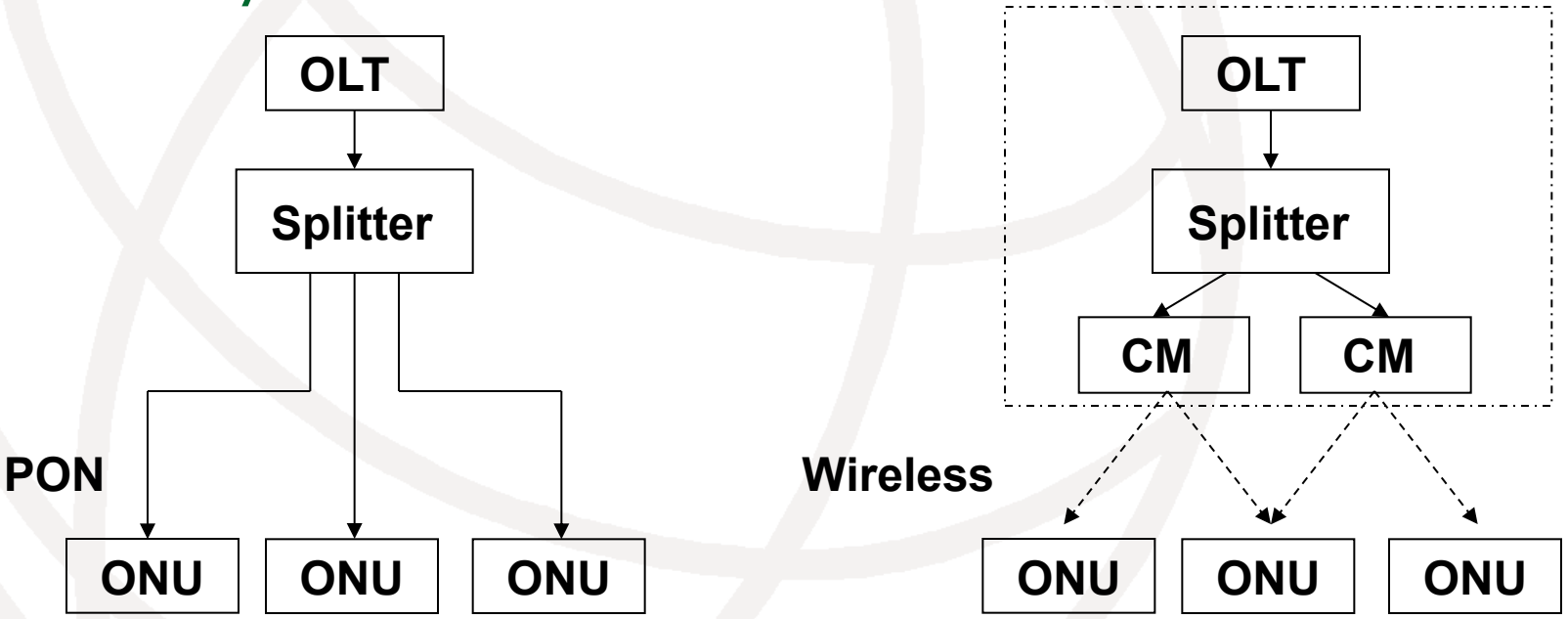
CM – ceiling module



Proposed System - EPON

New standards or compatibility with current fiber standards – EPON (802.3ah)

- Provides seamless connectivity for IP-based communications
- Scalable bit rates for the users
- Widely used and cost effective



Proposed system – Theoretical Model[1]

G_{OA} – Optical gain

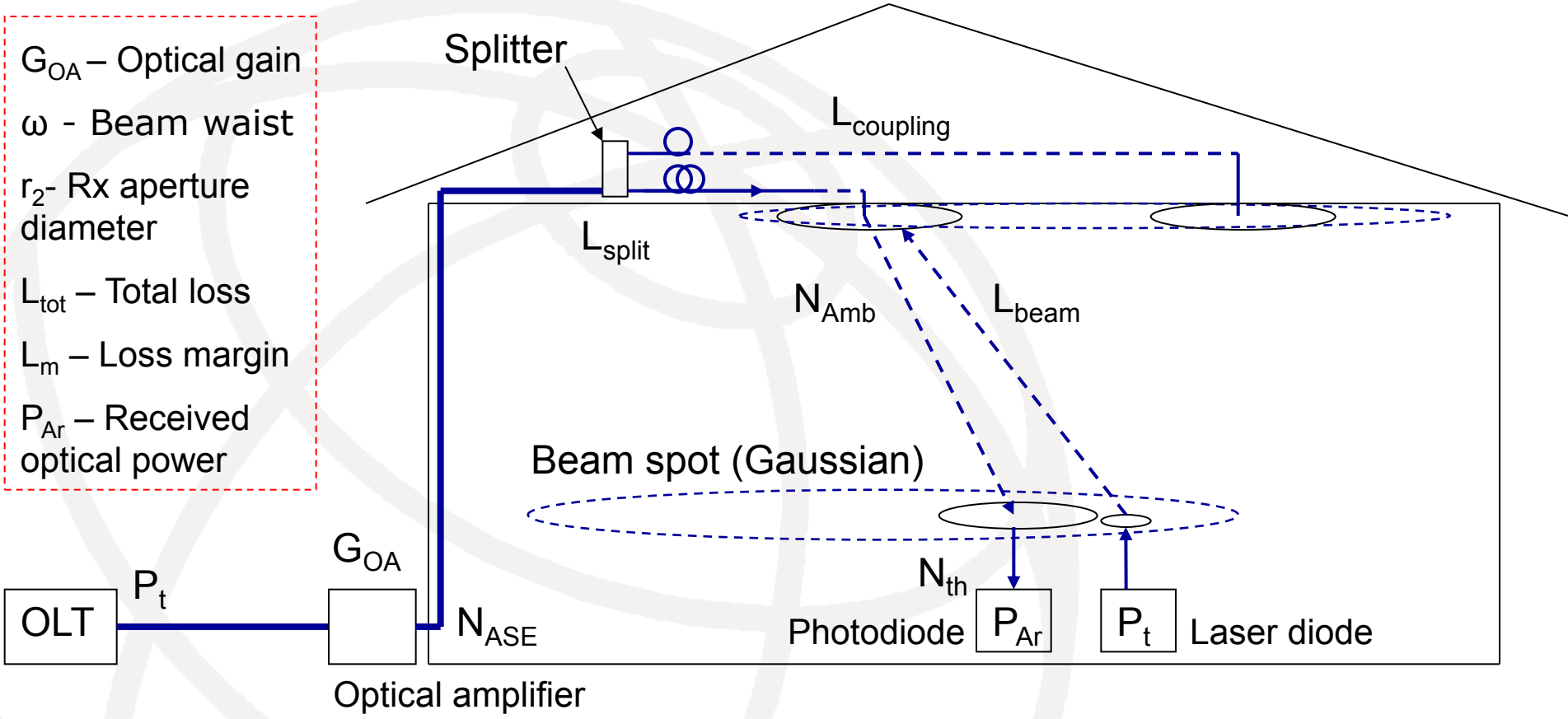
ω - Beam waist

r_2- Rx aperture diameter

L_{tot} – Total loss

L_m – Loss margin

P_{Ar} – Received optical power



$$L_{tot} = L_{split} L_{coupling} L_{beam} L_m$$

$$P_{Ar} = P_t L_{tot} G_{OA}$$

ω=1m, r_2=20mm:
L_{beam}=45dB

Proposed system – Theoretical Model[2]

$$SNR_d = \frac{\left(P_{Ar}\rho_{RX}\right)^2}{\left\langle i_{ase}^2\right\rangle + \left\langle i_{bn}^2\right\rangle + \left\langle i_{th}^2\right\rangle} = \frac{\left(P_{t,d}L_{tot}G_{OA}\rho_{RX}\right)^2}{4I_sG_{OA}I_{ASE}L_{tot}\frac{B}{\Delta\nu_f} + 2e\rho_{RX}P_{bn,d}B + \frac{4kTB}{R_{in}}}$$

$$SNR_u = \frac{\left(P_{t,u}L_{tot}G_{OA}\rho_{RX}\right)^2}{4I_sG_{OA}I_{ASE}L_{tot}\frac{B}{\Delta\nu_f} + 2e\rho_{RX}P_{bn,u}BG_{OA} + \frac{4kTB}{R_{in}}}$$

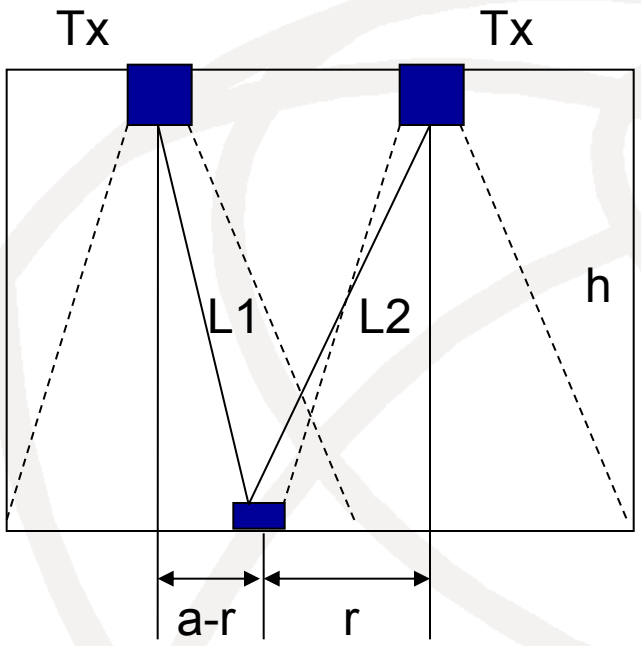
- ρ_{RX} – PD responsitivity
- I_s – signal current in the PD
- I_{ASE} – ASE current in the PD
- B – bandwidth
- $\Delta\nu_f$ –band pass filter bandwidth
- e – elementary charge
- P_{bn} – ambient noise power
- R_{in} – feedback resistance
- k – Boltzmann's constant
- T - absolute temperature

Eye safety

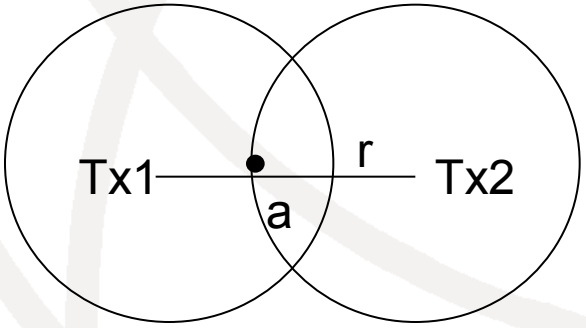
The transmit power in the wireless part is under 10dBm;

(Class 1 laser product: IEC 60825-1)

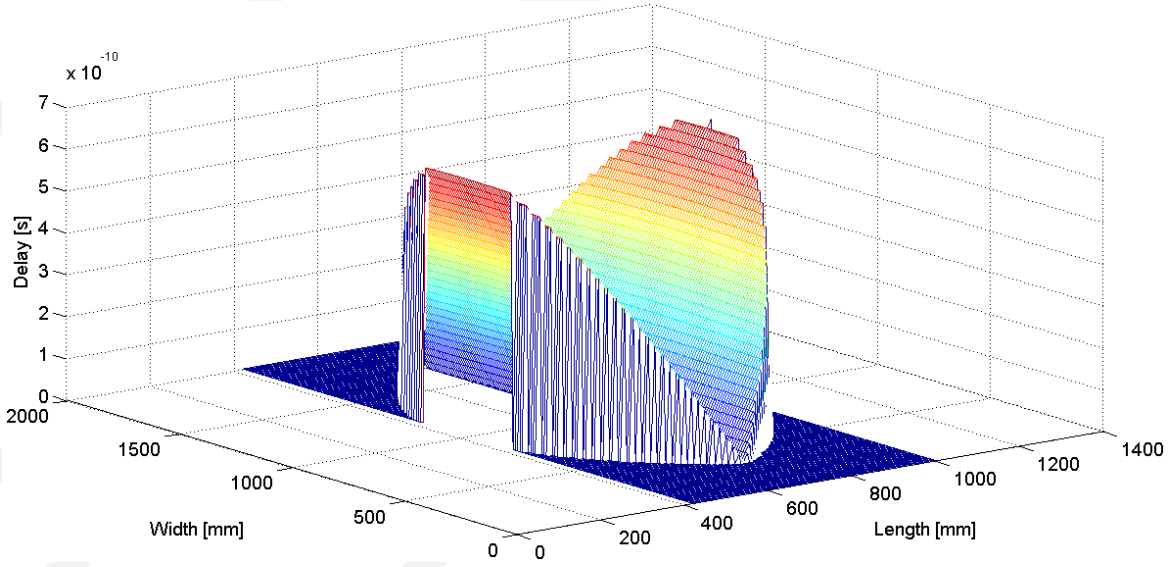
Proposed system - Synchronization



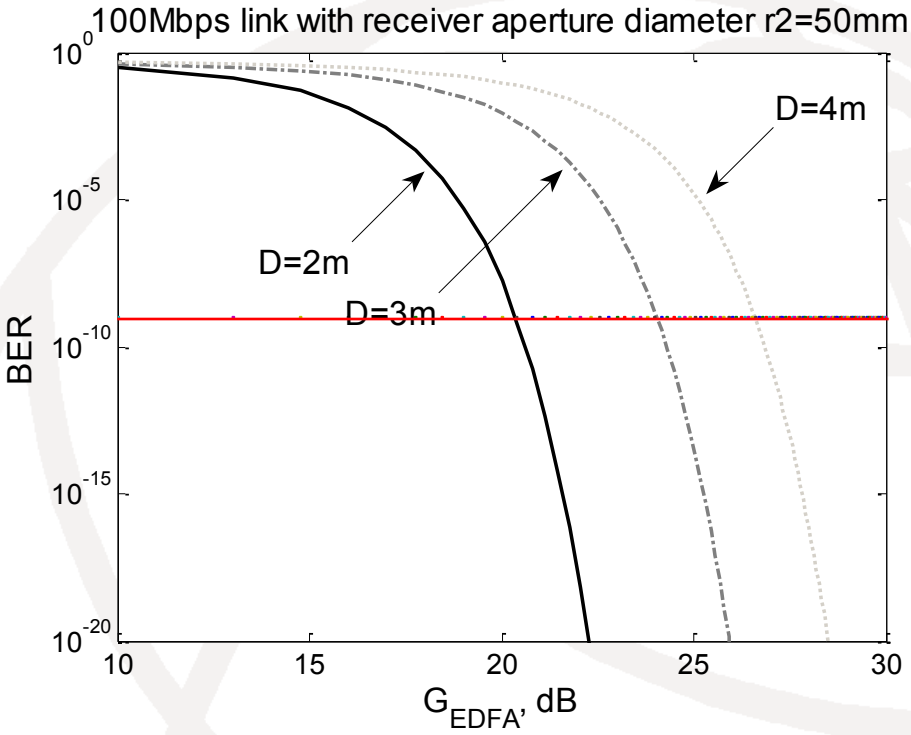
- Synchronization in the fiber part can be achieved by path equalizing
- In wireless part the mobile device is mobile with random location – only the biggest delay can be estimated

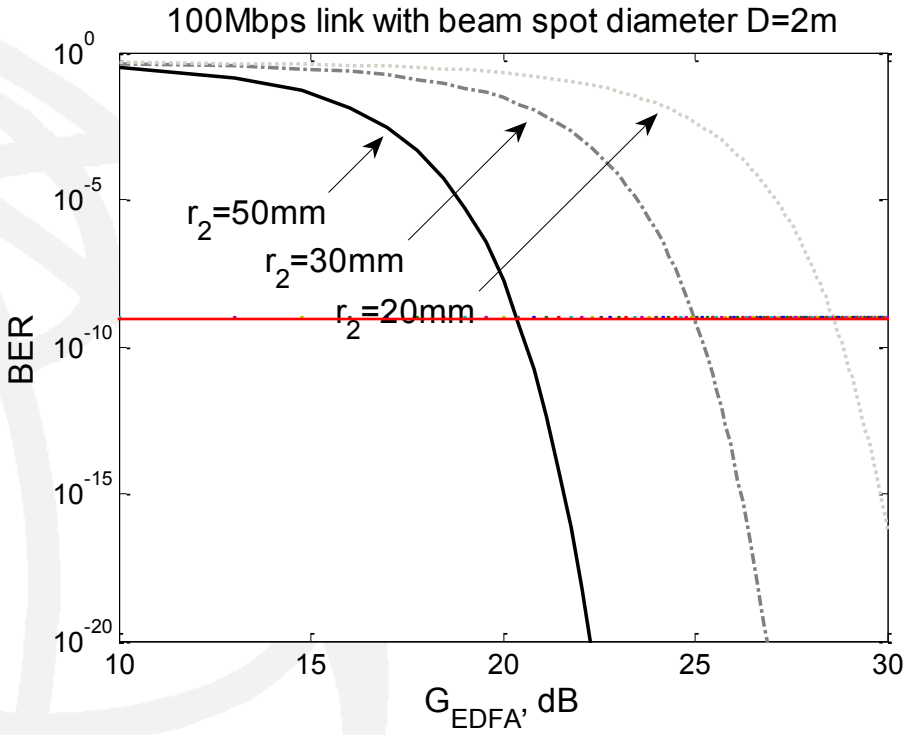


h=2m, r=1m, Δt=0.64ns



Results – Downlink



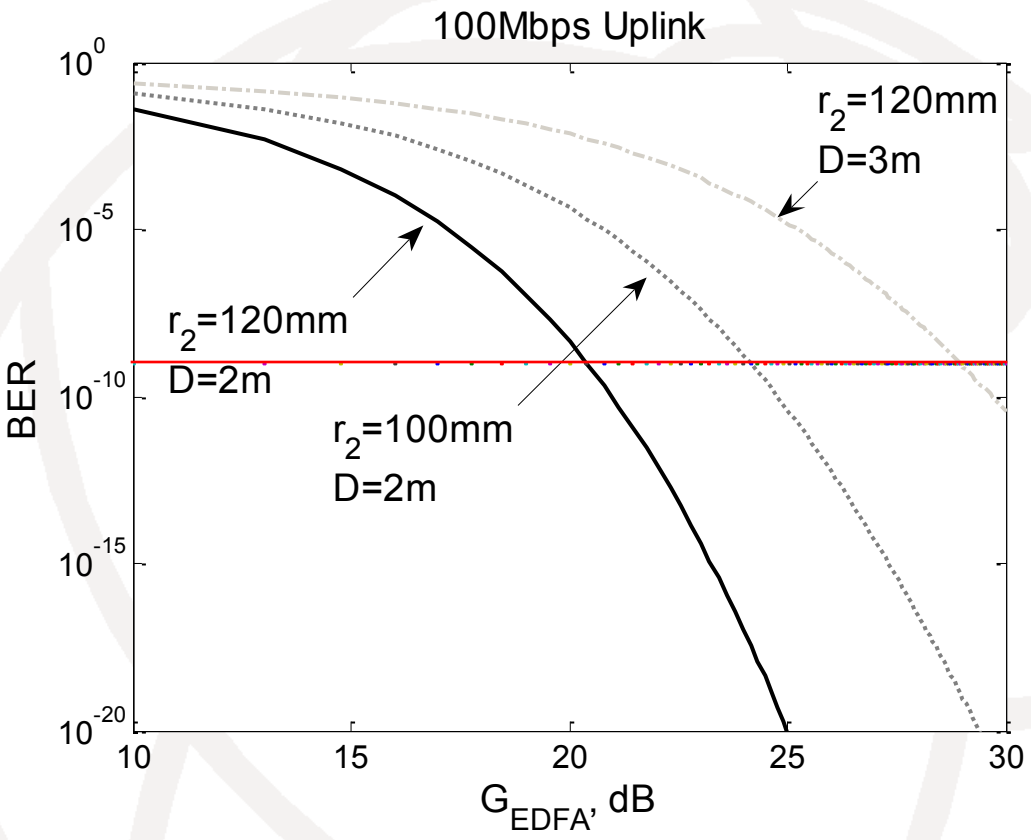


- 0dBm transmit power
- Big indoor coverage
- Reliable high speed link (100Mbps)

PD responsitivity: 0.8A/W

PD load resistor: 50Ω

Results - Uplink



- LD with transmit power $P_{t,d}$=0dBm
- Reliable high speed uplink (100Mbps)
- Lower speed will further increase the system performance

Conclusion

- Proposed system - Sustainability:
  - Compatible with EPON standard;
  - High-speed communication for mobile users;
  - Low power consumption compared to RF;
  - High security;
  - Free RF spectrum (interference immunity)
    - lower human exposure to electromagnetic waves;
    - free resources for other applications;
  - Eye safety regulations considered;

Future work

- Proposed system:
  - Better theoretical model;
  - Enhanced performance:
    - Transimpedance amplifier implementation;
    - Gigabit links;
  - Prototype;
- Standardization:
  - Update of EPON standard for wireless networks;
  - Propose for change in the uplink wavelength;

Thank you for your attention!

Dimitar R. Kolev

Waseda University, Japan

dkolev@fuji.waseda.jp