IEEE MTT-S 2006 International Microwave Symposium

IEEE Microwave Theory and Techniques Society
San Francisco, California
June 11-16, 2006
Workshops and Tutorials

WFC - New Optical Approaches for Microwave, High-Speed Signal Transmission

AGENDA

8:00 AM *Welcome and Introductory Remarks*
T. Berceli, Budapest University of Technology and Economics, Hungary

Speakers:

8:10 AM *High Performance Coherent Fiber-Optic Link*
P. R. Herczfeld et al., Drexel University, Philadelphia, USA

8:35 AM *Recent Advances in Microwave Signal Processing: The LABELS Project*
J. Capmany, Polytechnic University of Valencia, Spain

9:00 AM *Novel Techniques for Enabling High Performance Optical Links for Fiber Radio Communications*
D. Novak et al., University of Melbourne, Australia

9:25 AM *Novel Lithium-Niobate Based Optical Devices for Microwave/Millimeter Wave Photonics*
M. Izutsu et al., National Institute of Information and Communications Technology, Tokyo, Japan

9:50 AM Coffee Break

10:10 AM *Radio-over-Fiber Multi-Service MM-Wave Interconnection with Photonic Up-conversion*
Dual Band Remote Delivery and Photonic Envelope Detection
Javier Marti et al., Polytechnic University of Valencia, Spain

10:35 AM *All-Optical A/D Conversion Based upon Nonlinear Fiber-Optic Switch and its Applications*
K.-I. Kitayama et al., Osaka University, Osaka, Japan

11:00 AM *High-Speed InP Transistors for Microwave-Photonic Signal Transmission*
W.-Y. Choi, Yonsei Univerity, Seoul, S. Korea

11:25 AM *Combined Optical-Wireless Indoor Communications System*
T. Berceli, Budapest University of Technology and Economics, Hungary

11:50 AM Closing Remarks
P. R. Herczfeld, Drexel University, Philadelphia, PA, USA

Organizers:
T. Berceli, Budapest University of Technology and Economics, Hungary
P. R. Herczfeld, Drexel University, Philadelphia, USA

Sponsors:
MTT-3: Microwave Photonics

Abstract:
The optical technology offers advantageous new approaches for the transmission of microwave, high speed signals. The optical fiber signal transmission has a very l loss (0,2 dB/km) and a very wide bandwidth. It is capable to transmit any kind of modulation format. Its properties can be well utilized mainly in mobile networks bo for outdoor and indoor systems. The workshop presents an overview of these new methods in the framework of invited talks presented by experts in the field.
In the program several new approaches will be presented which offer more advantageous transmission properties. Complete systems will be reported like coherent optical transmission, routing high-speed packet switched signals, distribution system with both wireless and wireline nodes, combined wireless-optical indoor system Some other presentations will cover new results on components for advanced systems. The speakers come from four continents: America, Europe, Asia and Australia Their achievements are complementary.

WFC-7

High-Speed InP Transistors for Microwave-Photonic Signal Transmission

Woo-Young Choi

wchoi@yonsei.ac.kr

Dept. of Electrical and Electronic Engineering,

Yonsei University, Seoul, Korea

Outline

- Introduction
- InP HBT as high-speed photo-detector
- InP HBT optoelectronic mixer
- Optically injection-locked self-oscillating optoelectronic mixer (OIL-SOM) based on InP HBT
- Summary

Millimeter-wave wireless networks

High-speed
Wireless LAN
(WLAN)

Service Provider

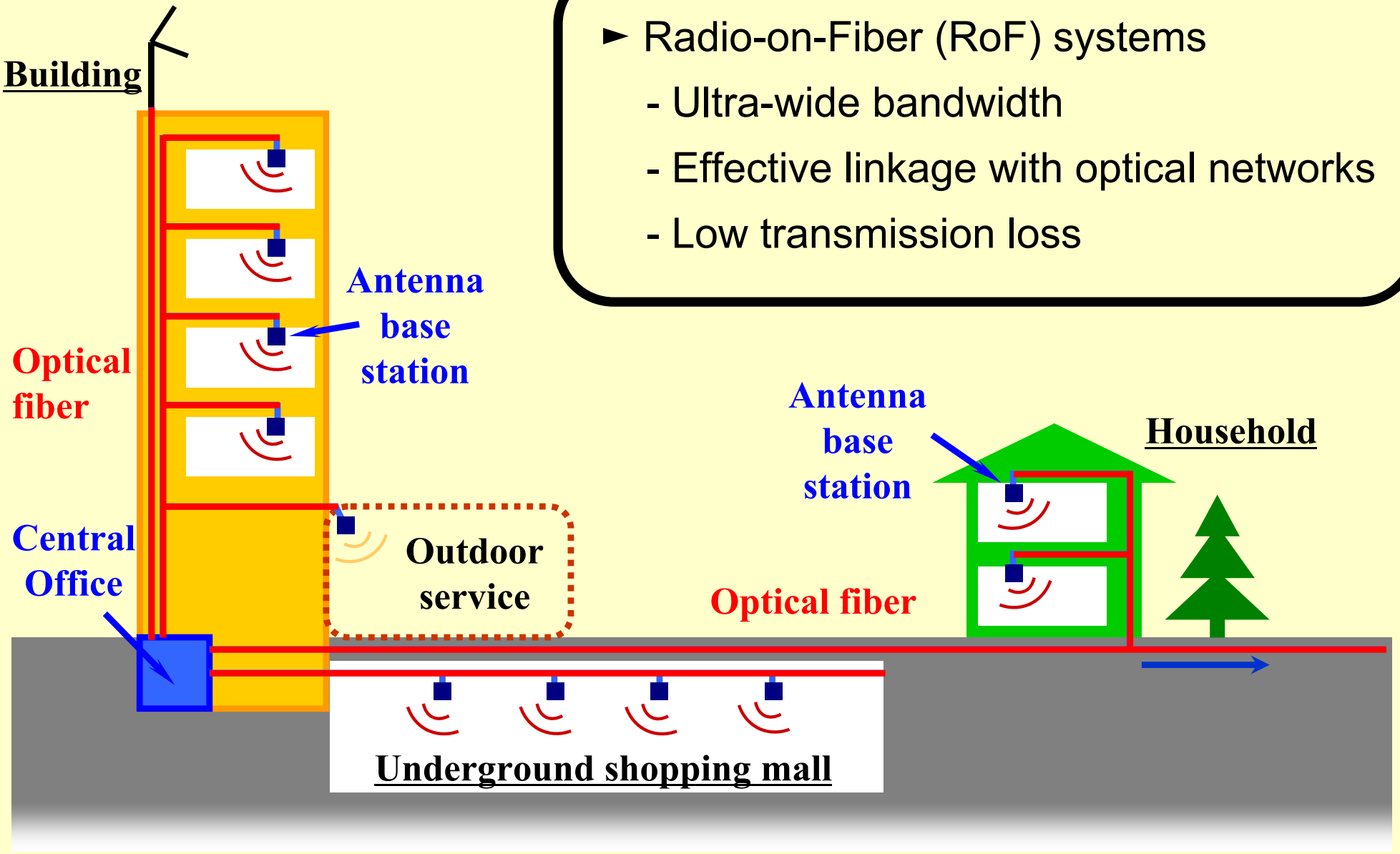
Wireless Broadband Networks

Wireless Personal
Area Network (WPAN)

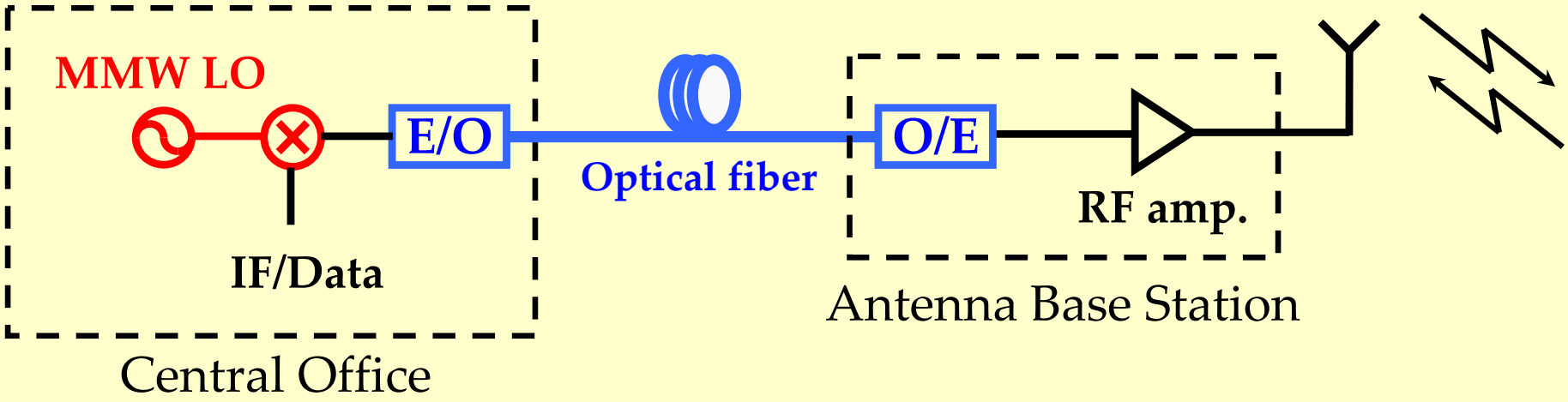
- Wide bandwidth
- High transmission loss
  (4~15dB/km at 60GHz)
- Frequency re-use
- Directivity
- Unlicensed band (59-64GHz)

RoF systems

- Radio-on-Fiber (RoF) systems
  - Ultra-wide bandwidth
  - Effective linkage with optical networks
  - Low transmission loss



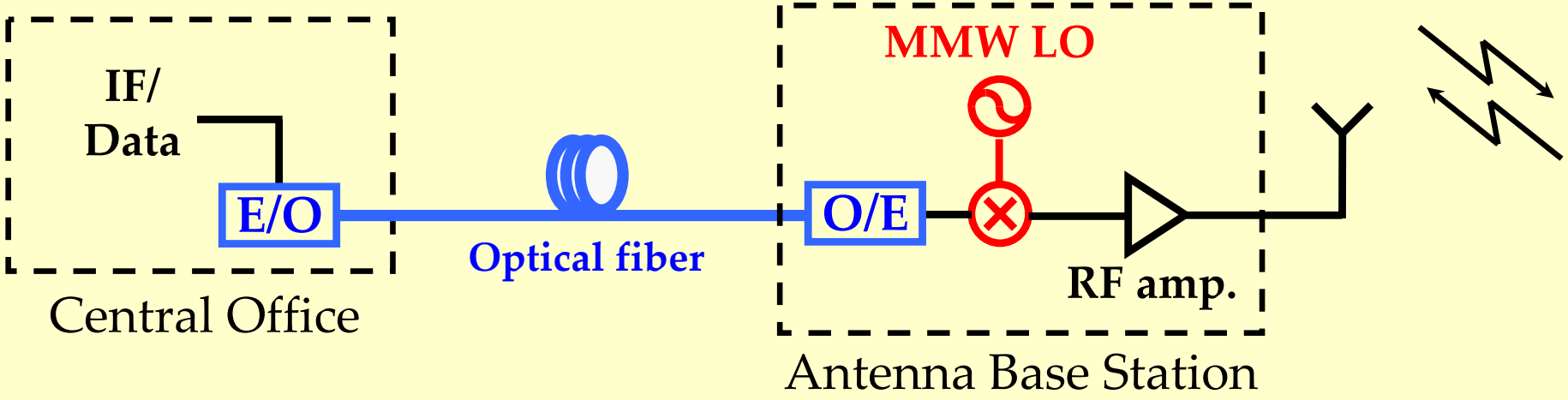
Optical millimeter-wave transmission



- Advantages
  - Straight-forward architecture
  - Simple receiver

- Disadvantages
  - Chromatic dispersion
  - High-speed optical modulators and photo-detectors

Remote up-conversion system

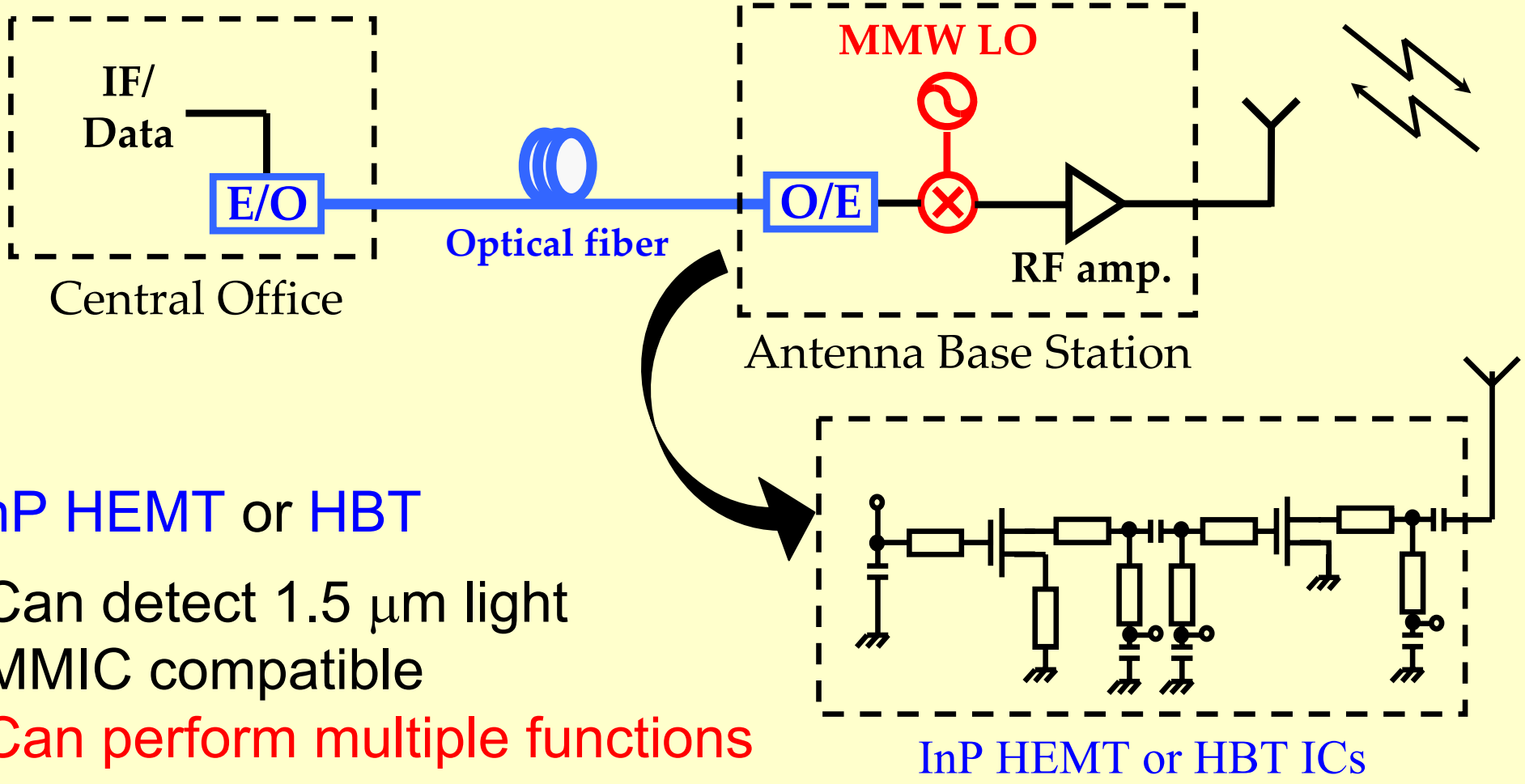


- Advantages
  - Chromatic dispersion immunity
  - Not expensive optical modulators and photo-detectors

- Disadvantage
  - Complex receiver

➔ System on Chip approach?

High-speed InP transistors for RoF System



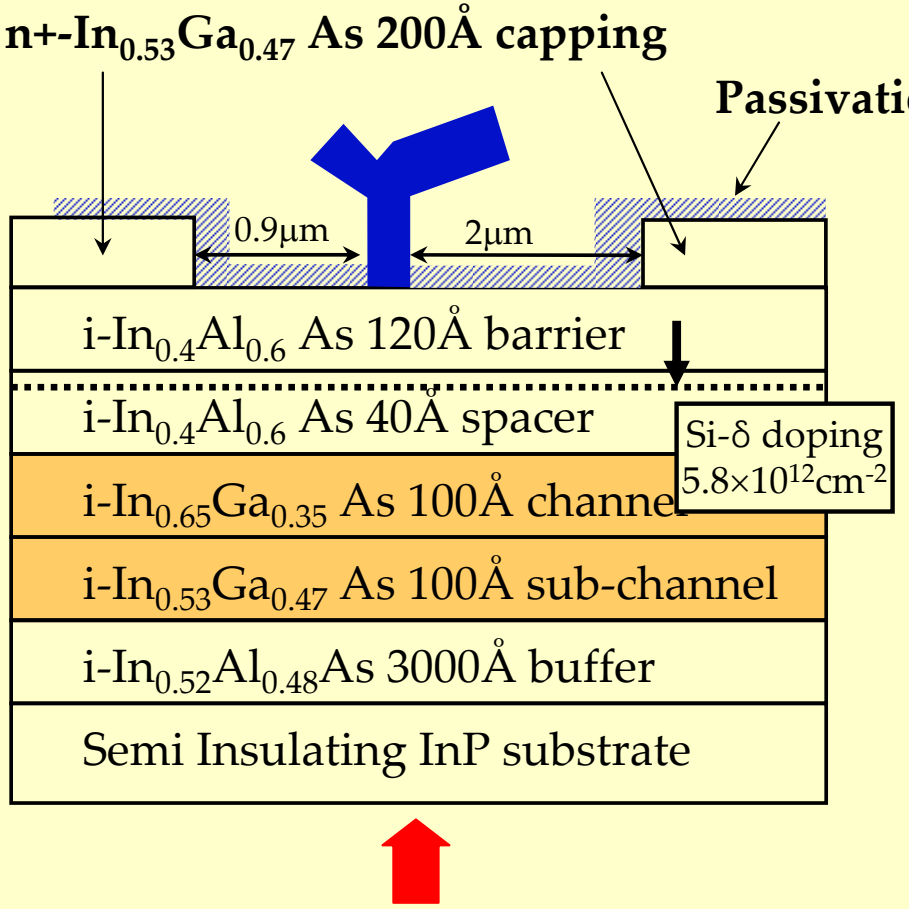
InP HEMT or HBT

- Can detect 1.5 μm light
- MMIC compatible
- Can perform multiple functions

- Optoelectronic mixer (PD + mixer)
- Optically injection-locked self-oscillating O/E mixer (PD + phase-locked oscillator + mixer)

High-speed InP Transistors

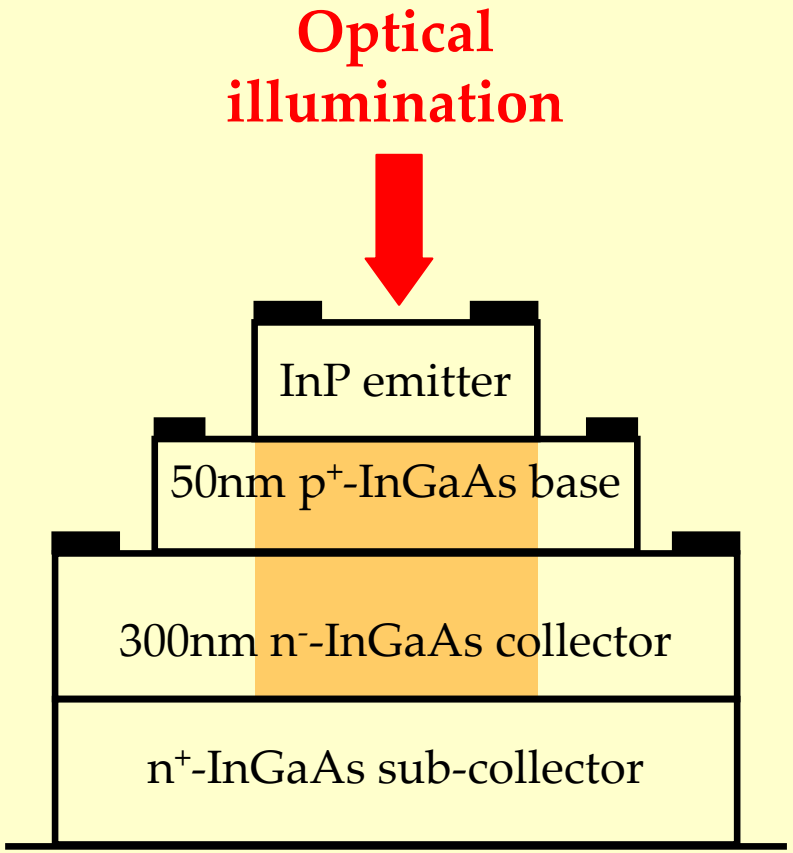
InP HEMT



Optical illumination

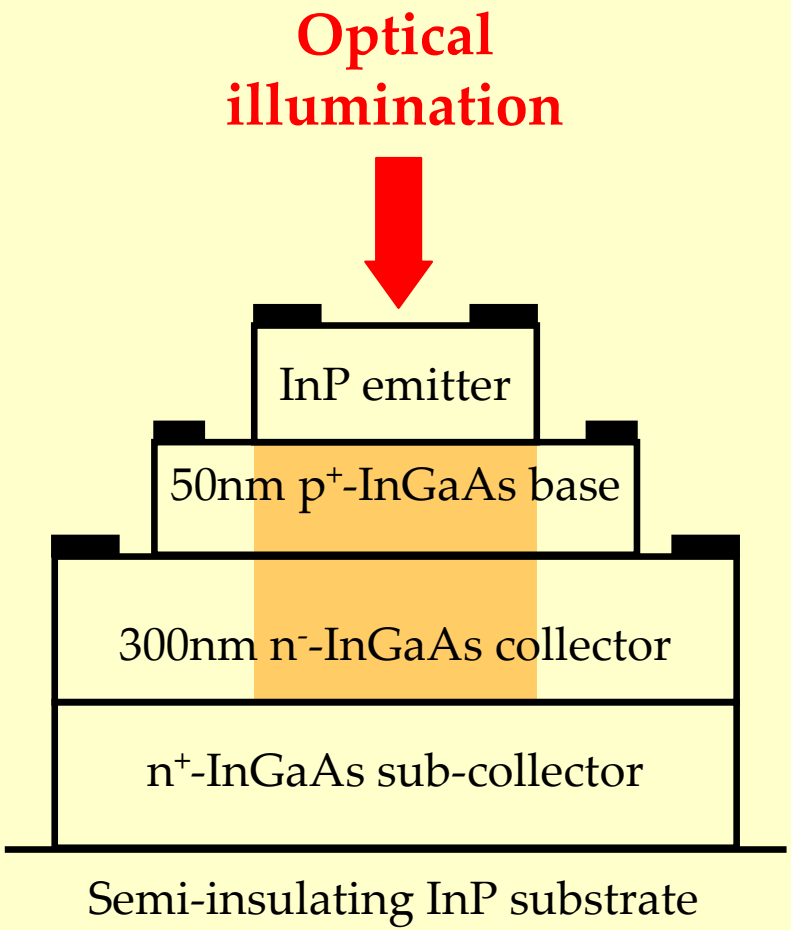
IEEE Trans. MTT. Jan. 2005

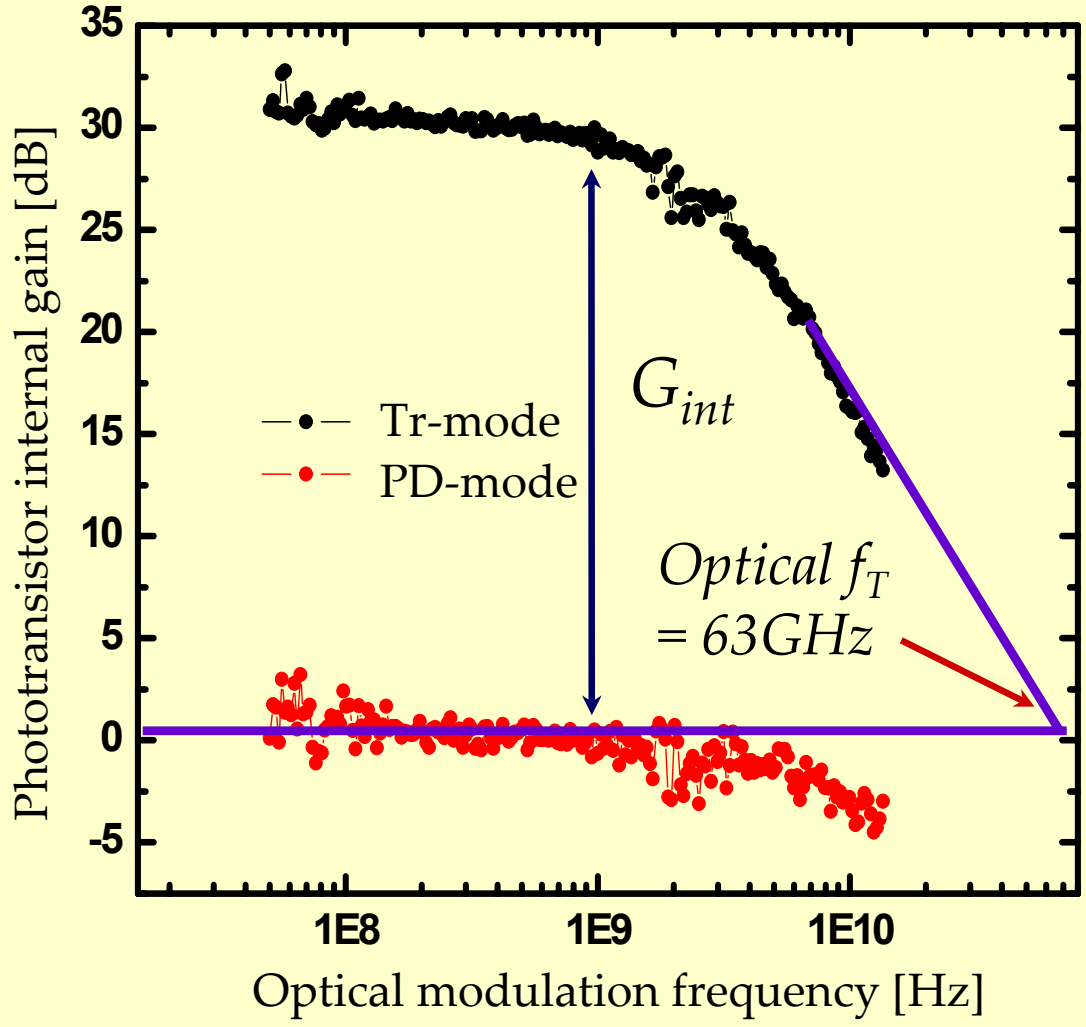
InP HBT



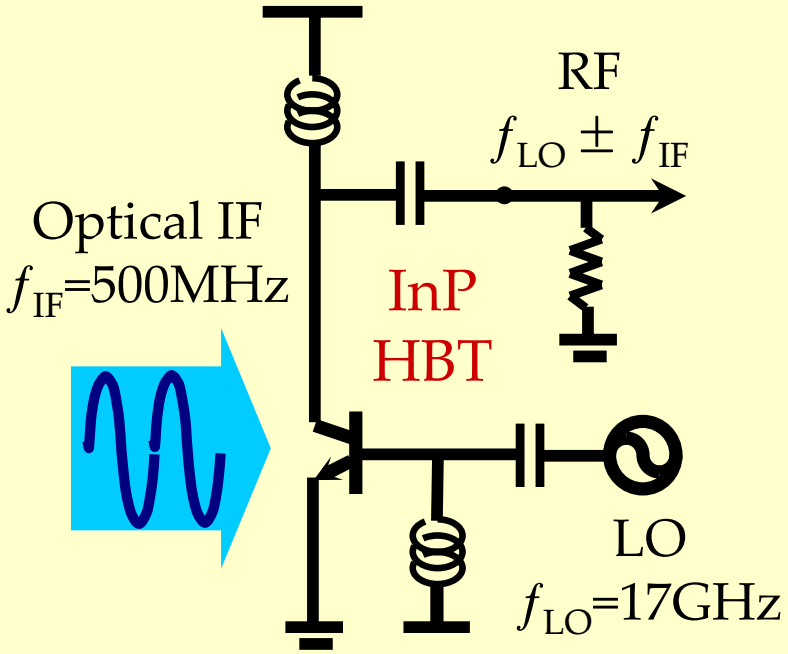
(Fabricated by NTT Photonics Laboratories, Japan)

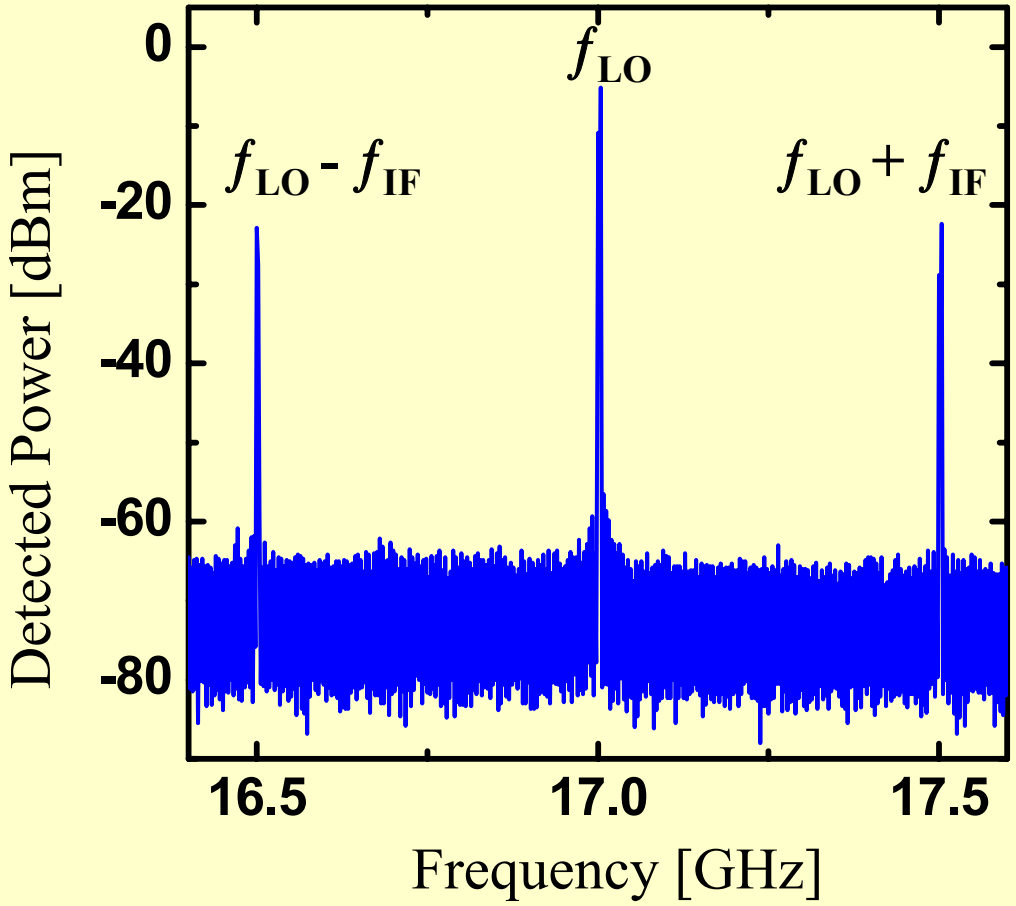
Photo-detection Characteristics of InP HBT





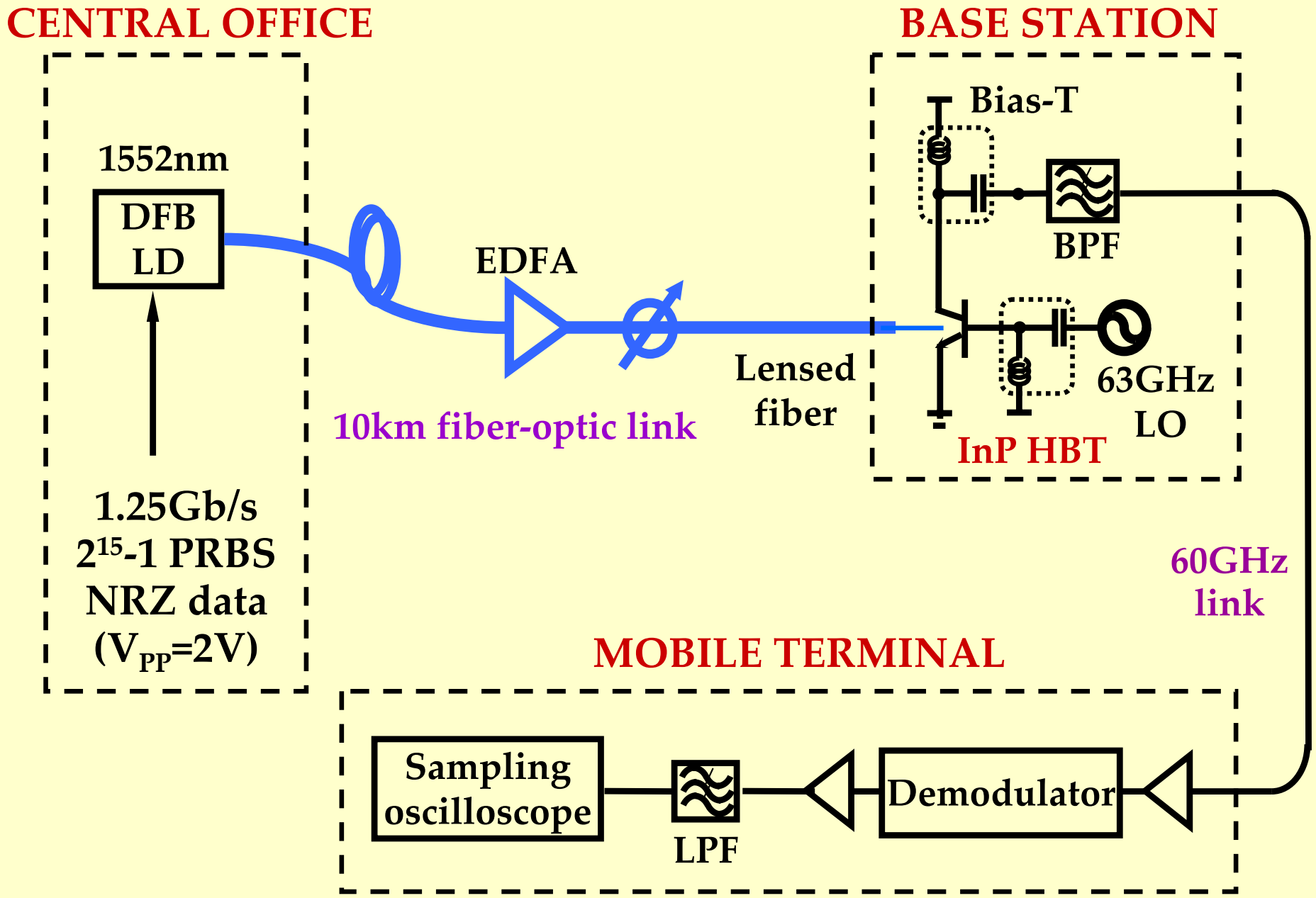
HBT optoelectronic mixer



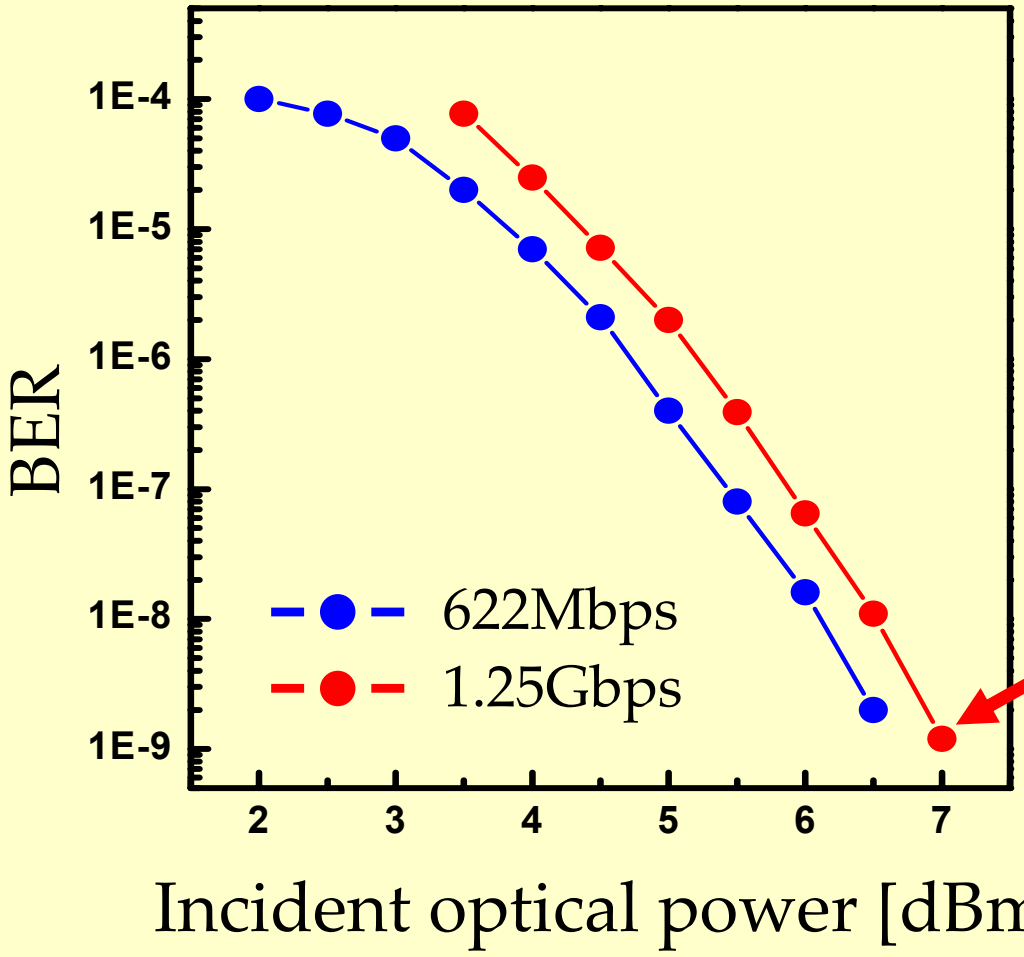


- Photodetector + Frequency mixer
  → Optoelectronic mixer

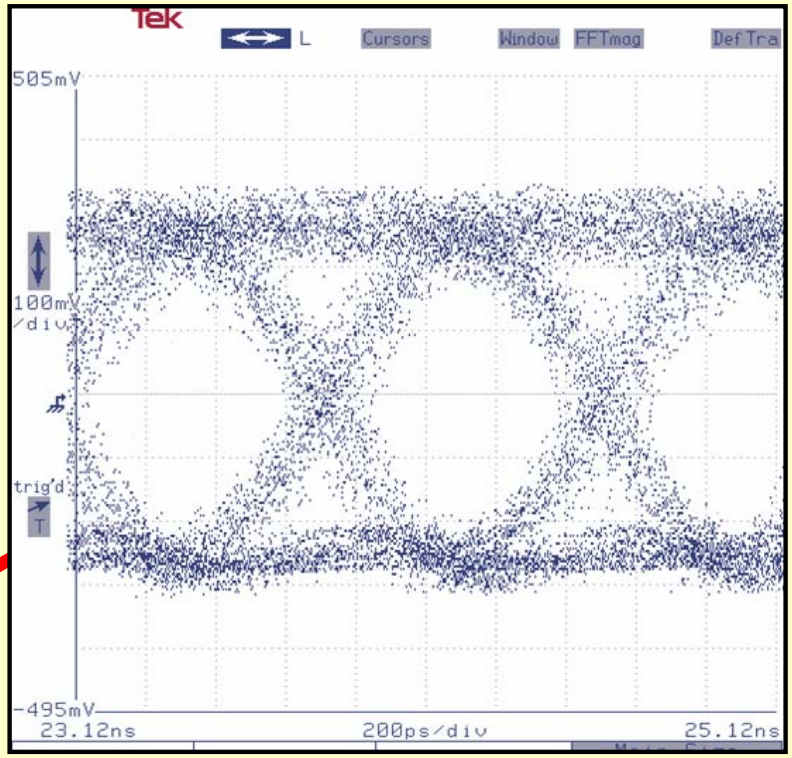
1.25Gbps data Tx. in 60GHz band using O/E mixer



Transmission results

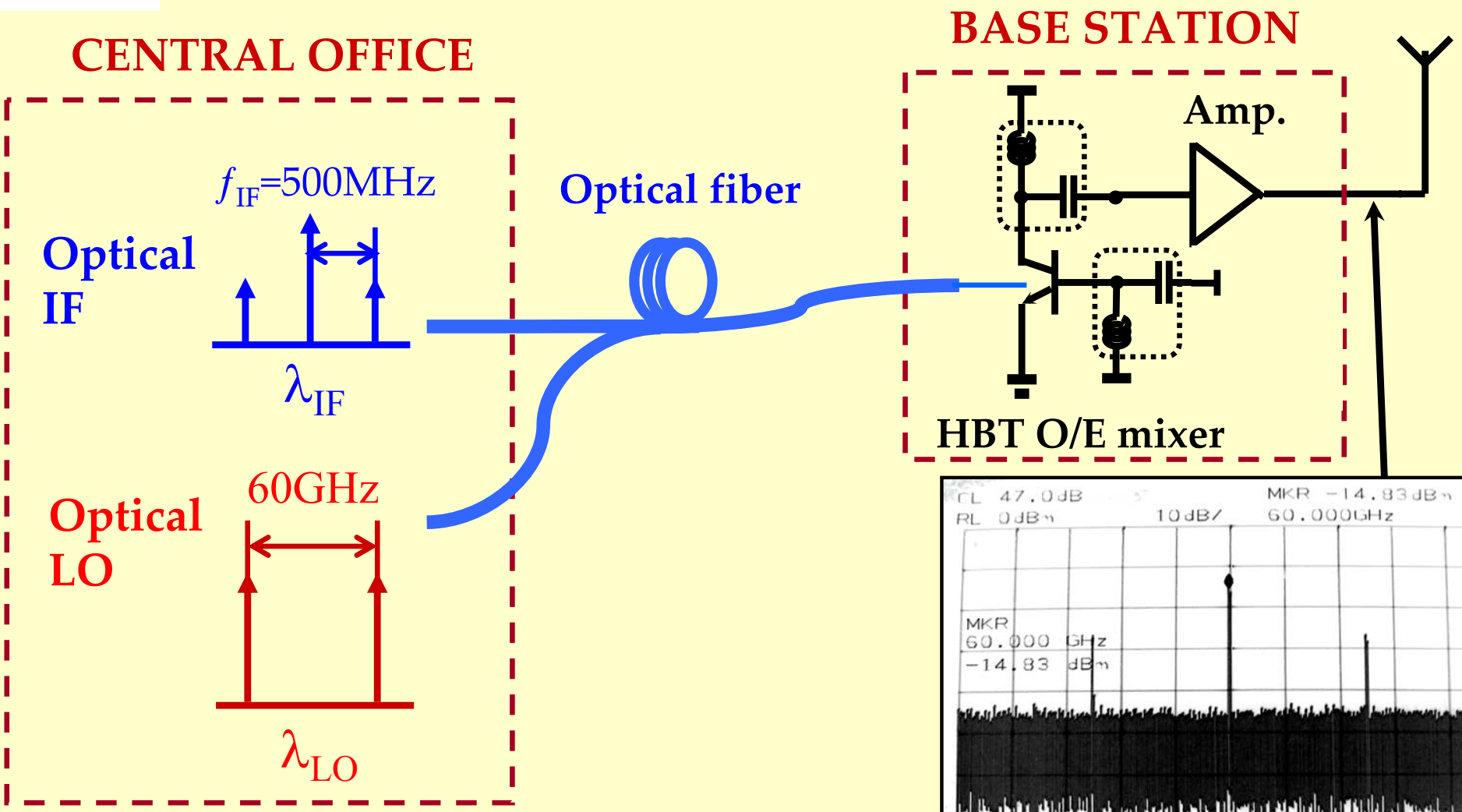


1.25Gbps eye-diagram



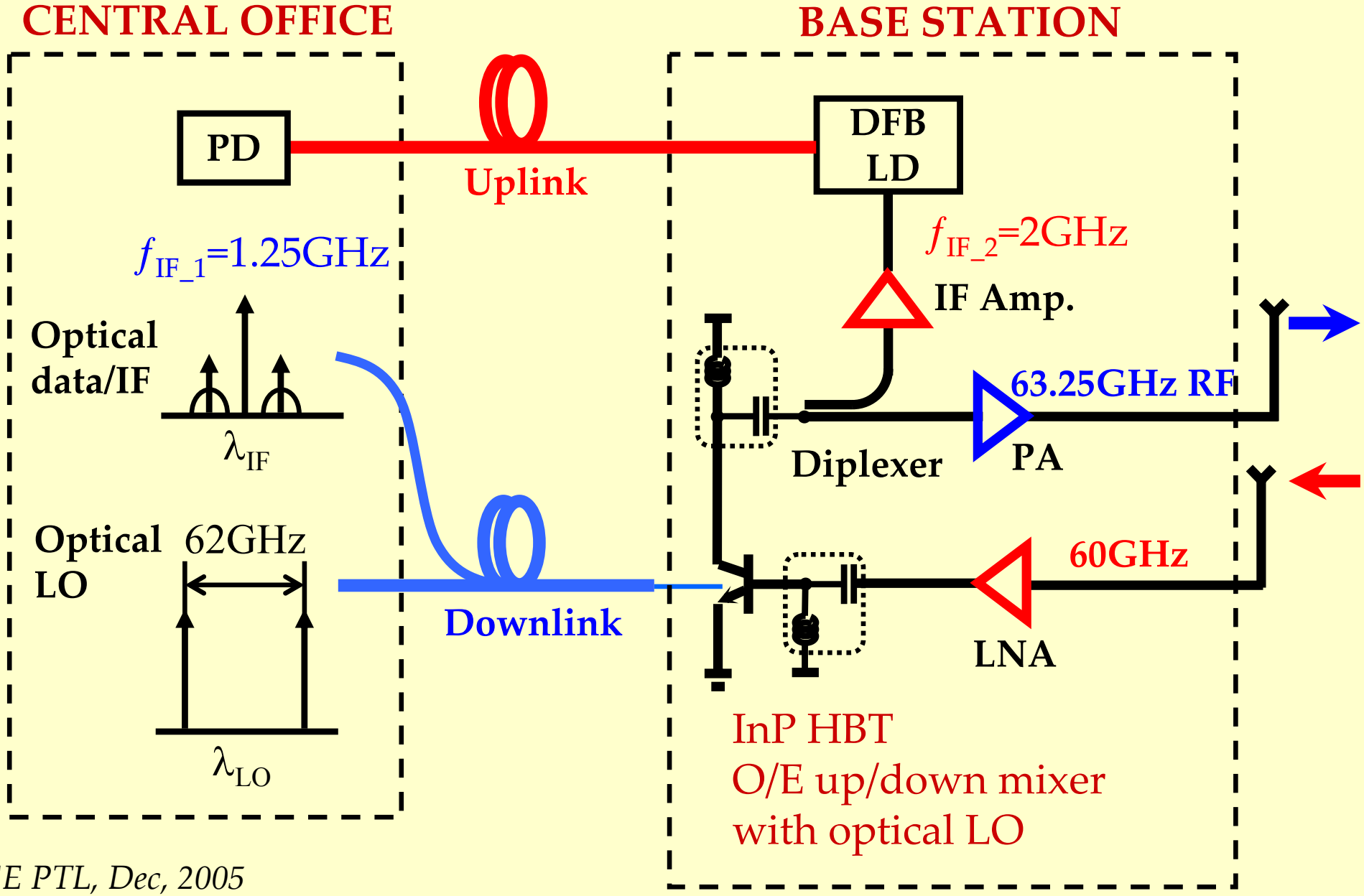
- Gigabit data transmission in 60GHz
- LO required in BS

HBT optoelectronic mixer with optical LO



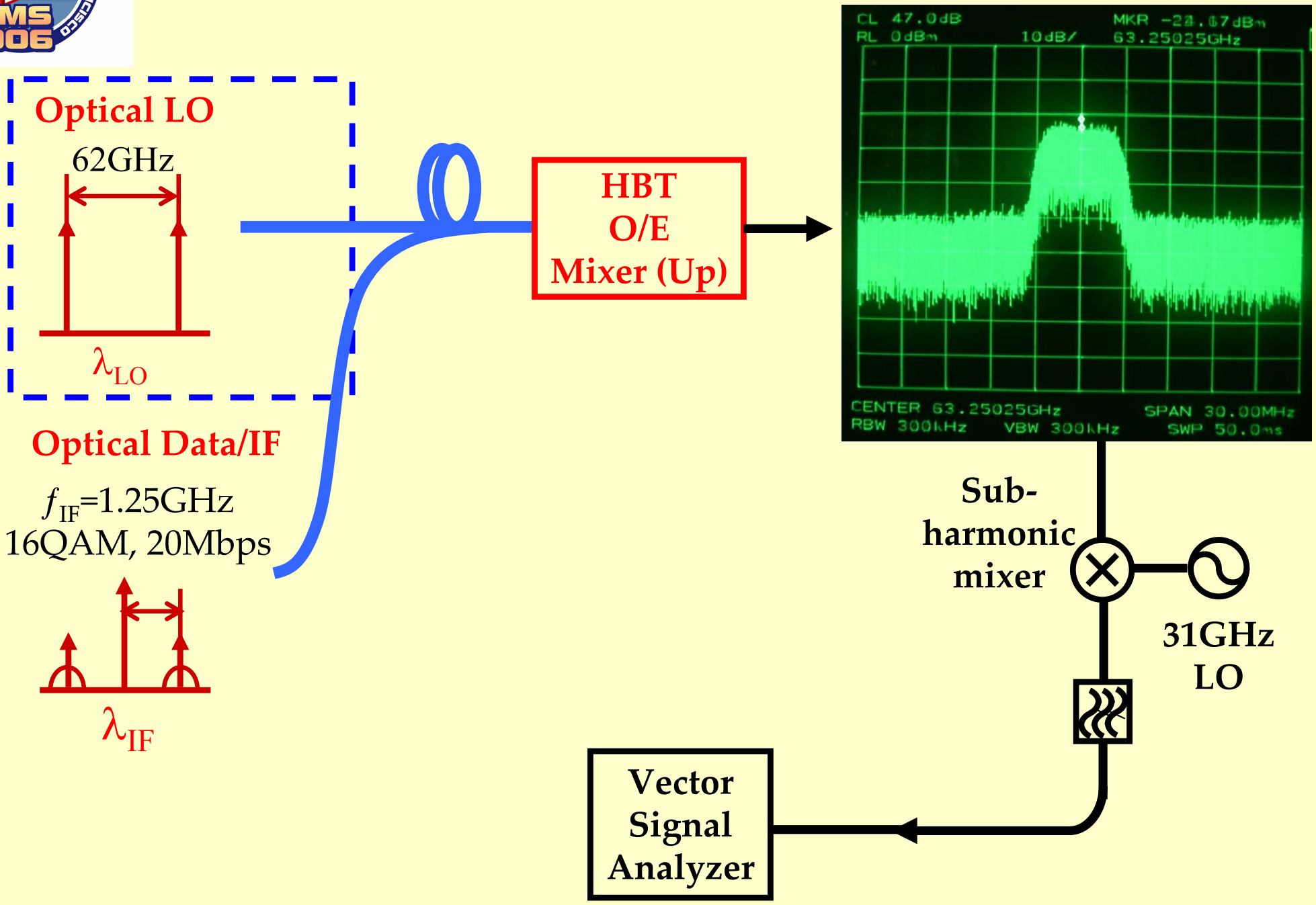
- Optical LO distribution
- Elimination of LO in base stations

60GHz bi-directional link based on HBT



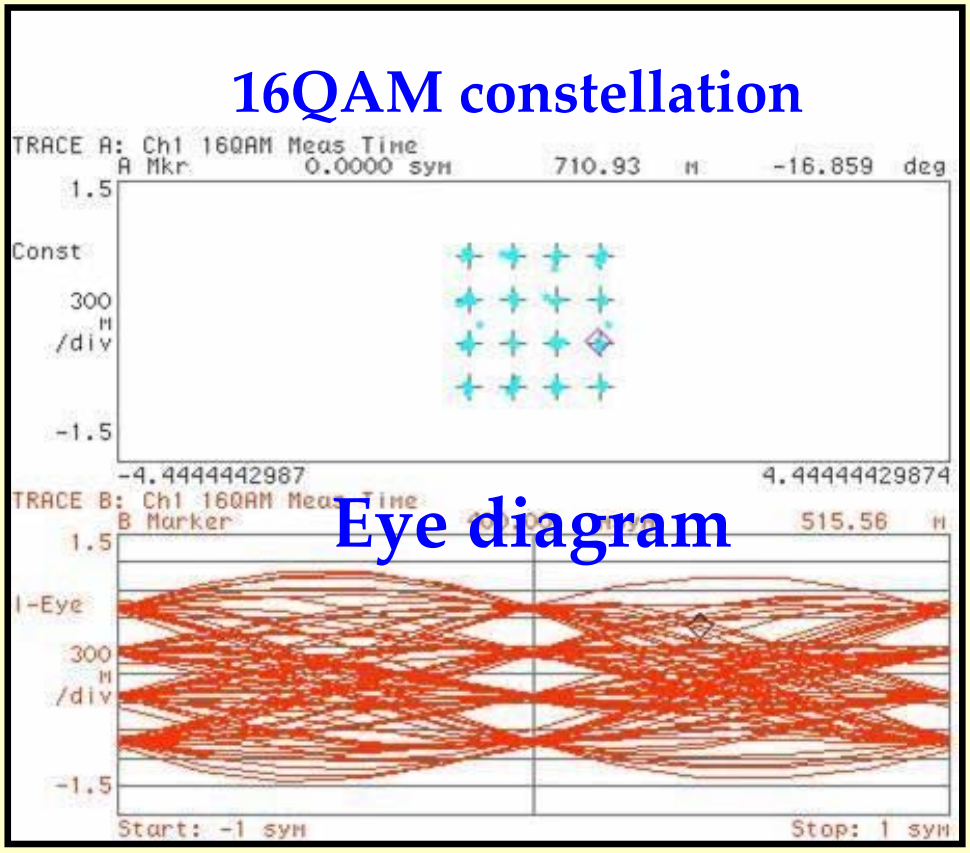
IEEE PTL, Dec, 2005

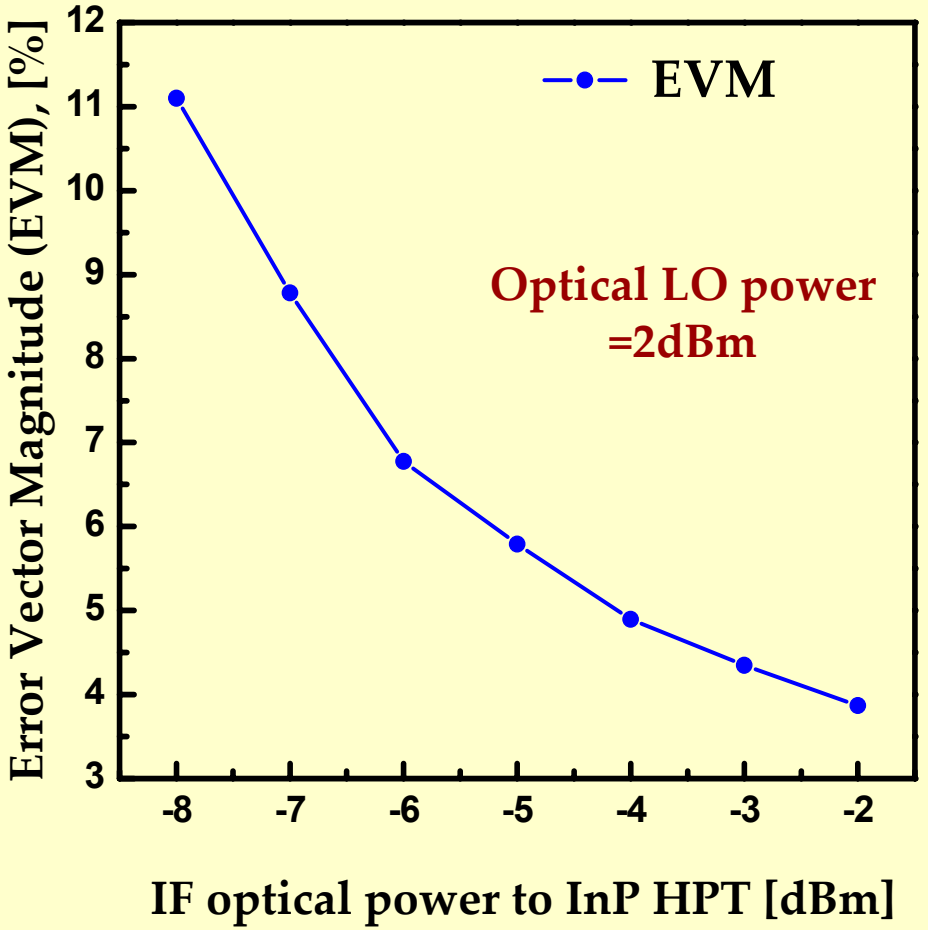
60GHz downlink Transmission



Downlink transmission results

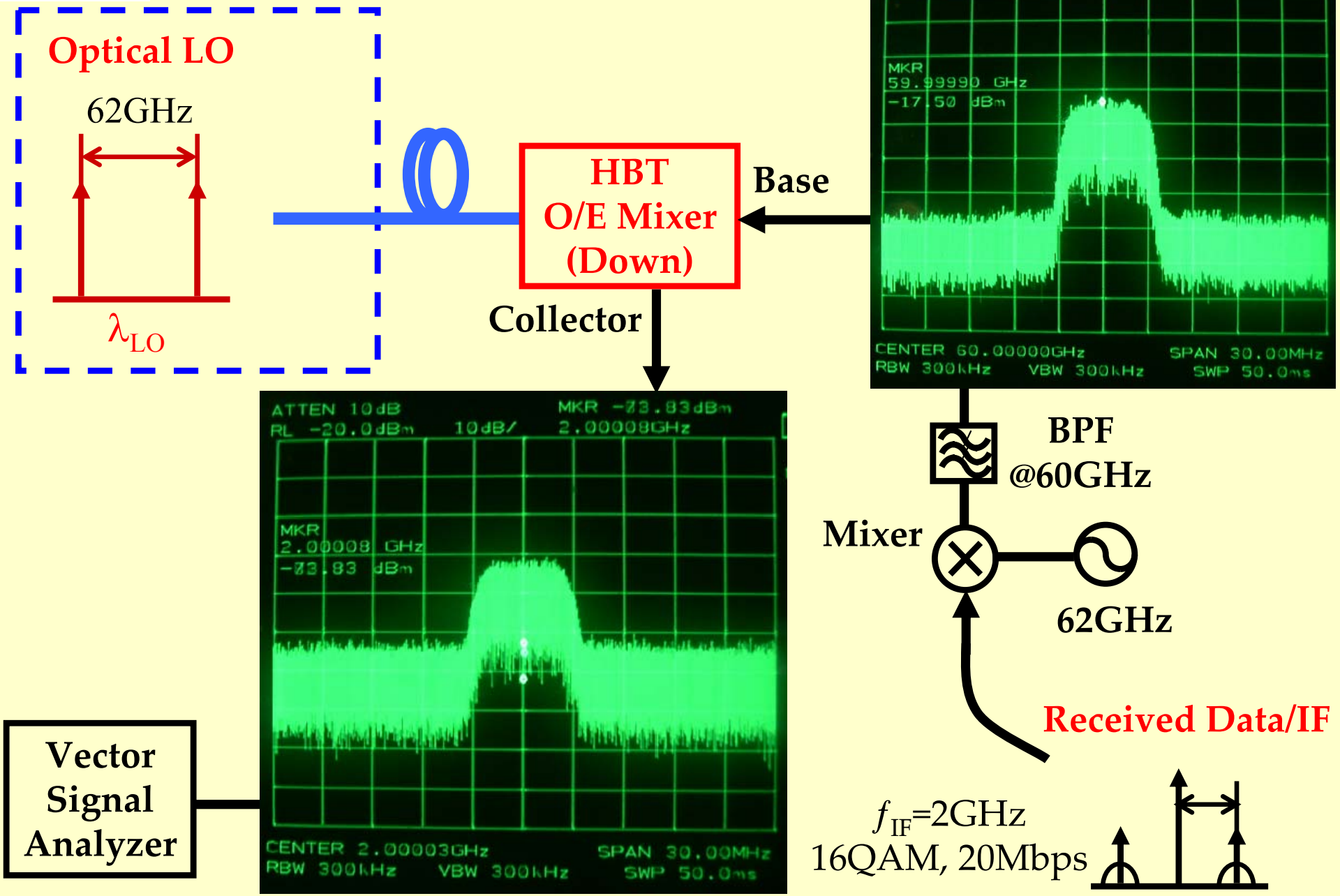
After demodulation





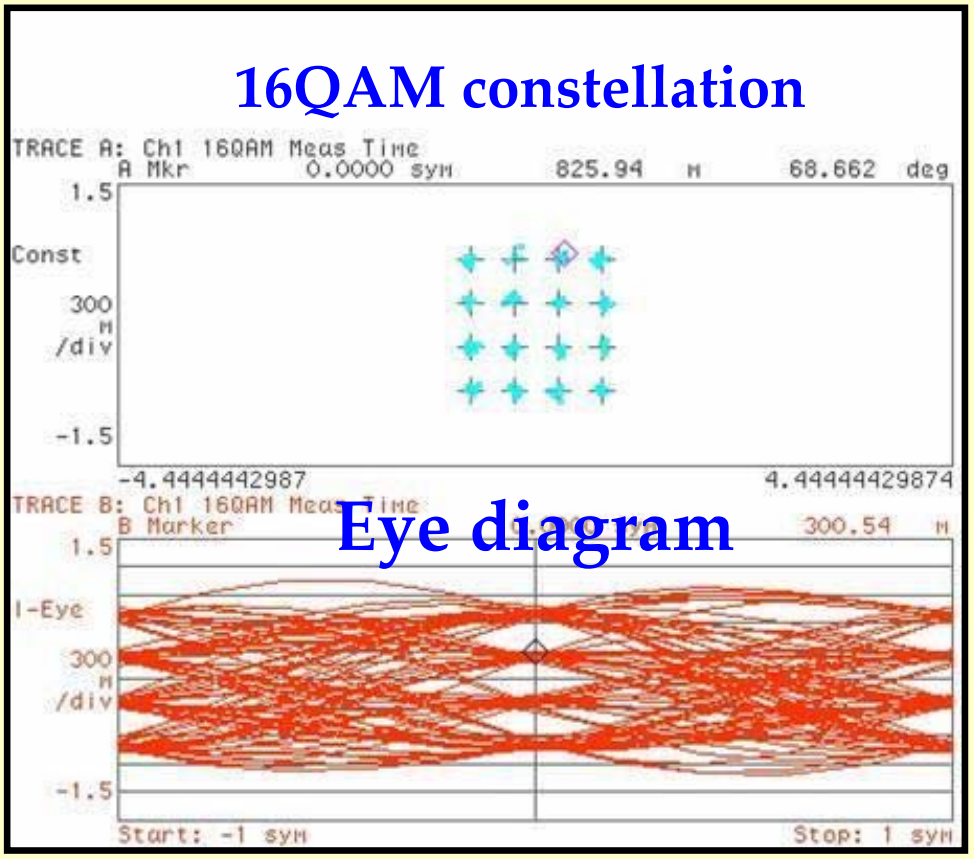
- EVM=4.53%
- 16 QAM transmission is possible

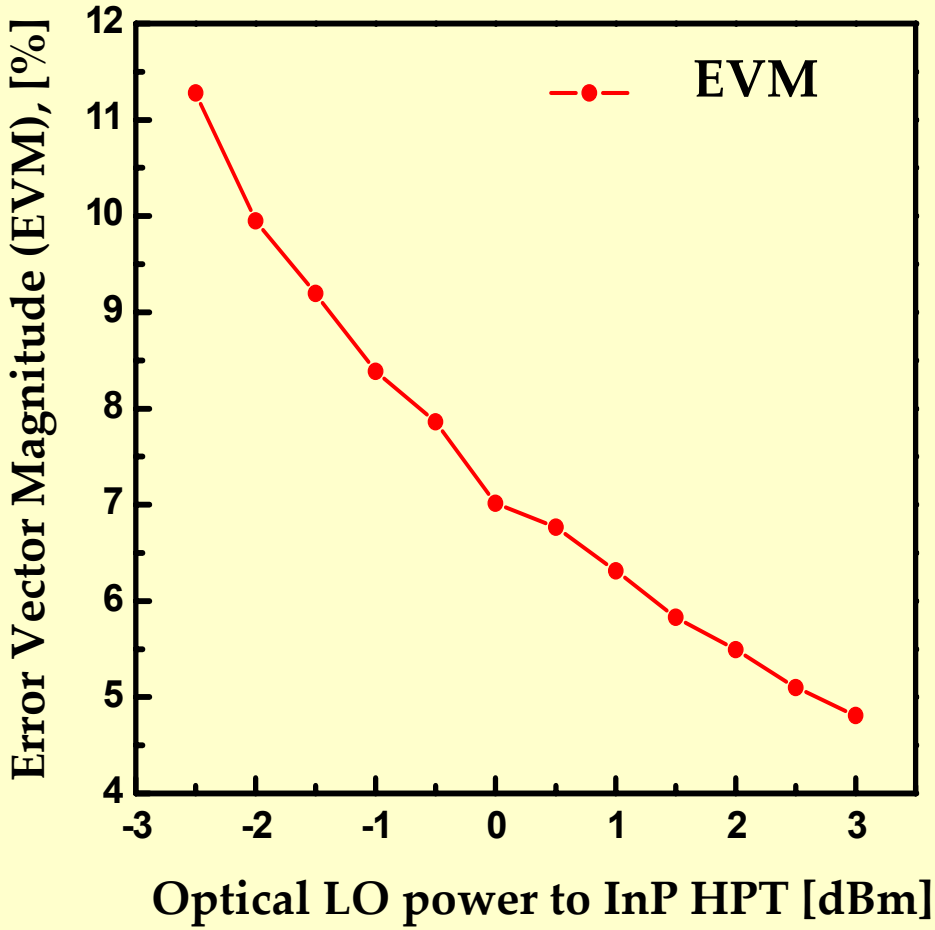
60GHz uplink transmission



Uplink transmission results

After demodulation

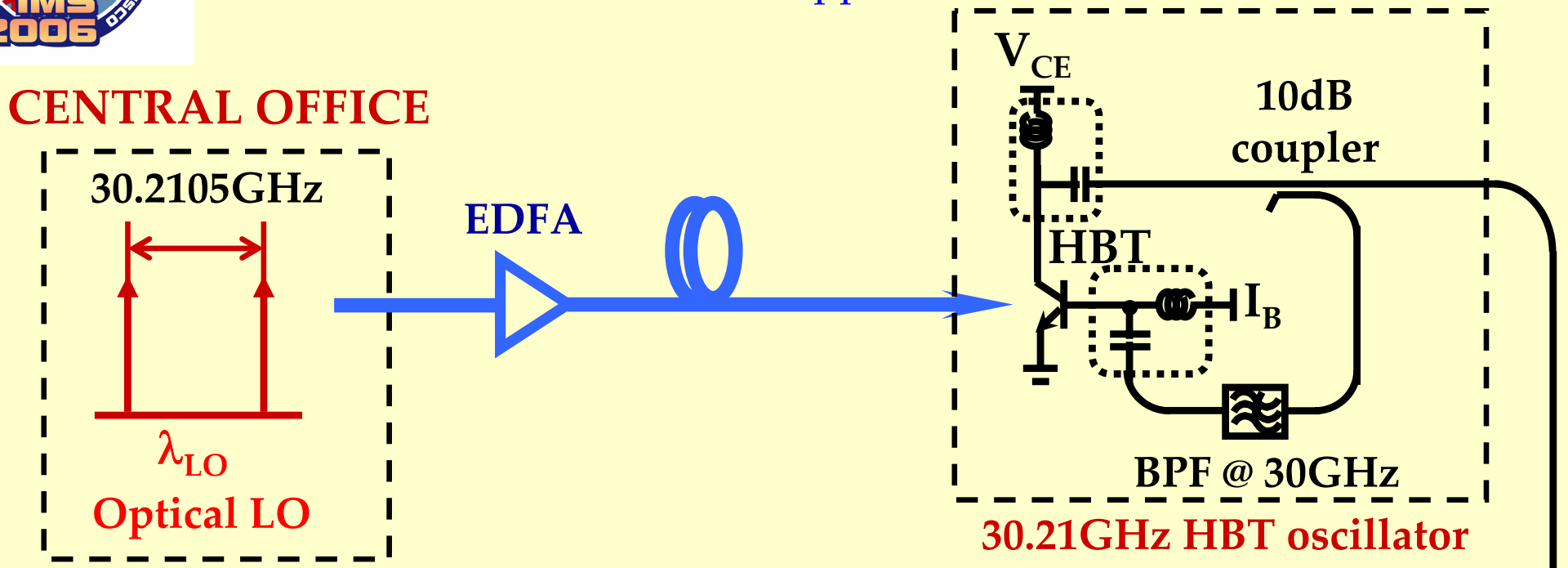


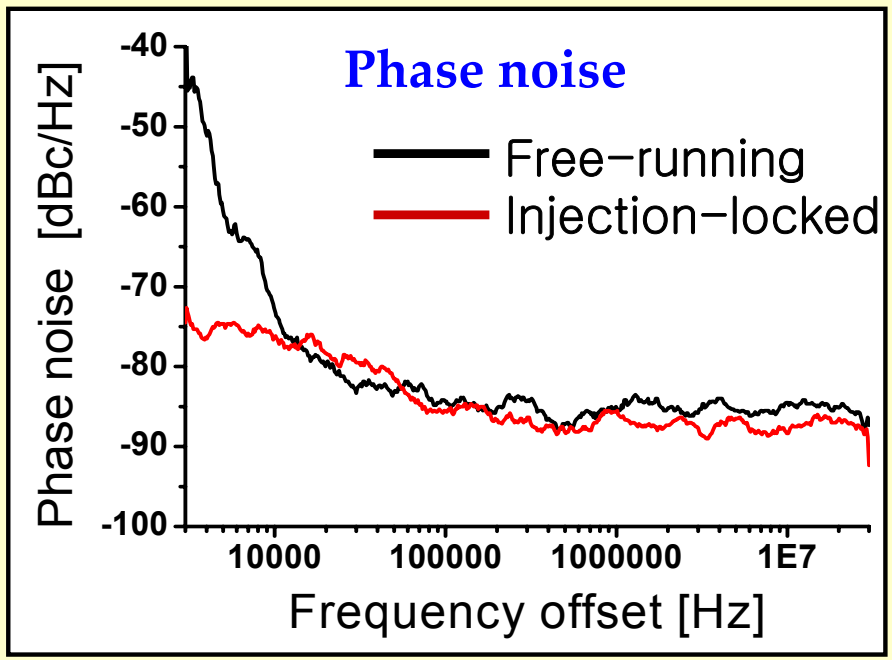


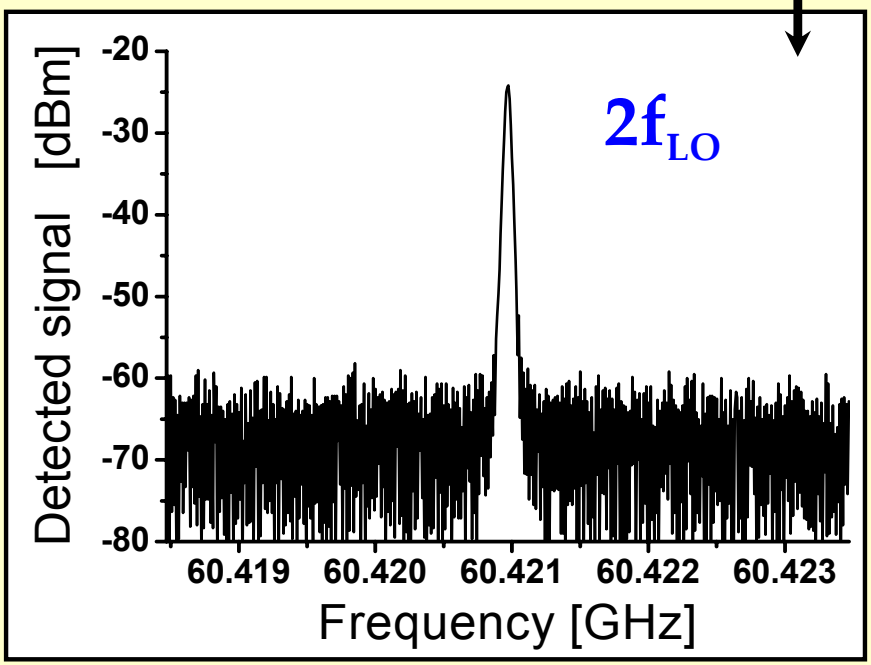
- EVM=4.67%
- 16 QAM transmission is possible

Optically injection-locked OSC

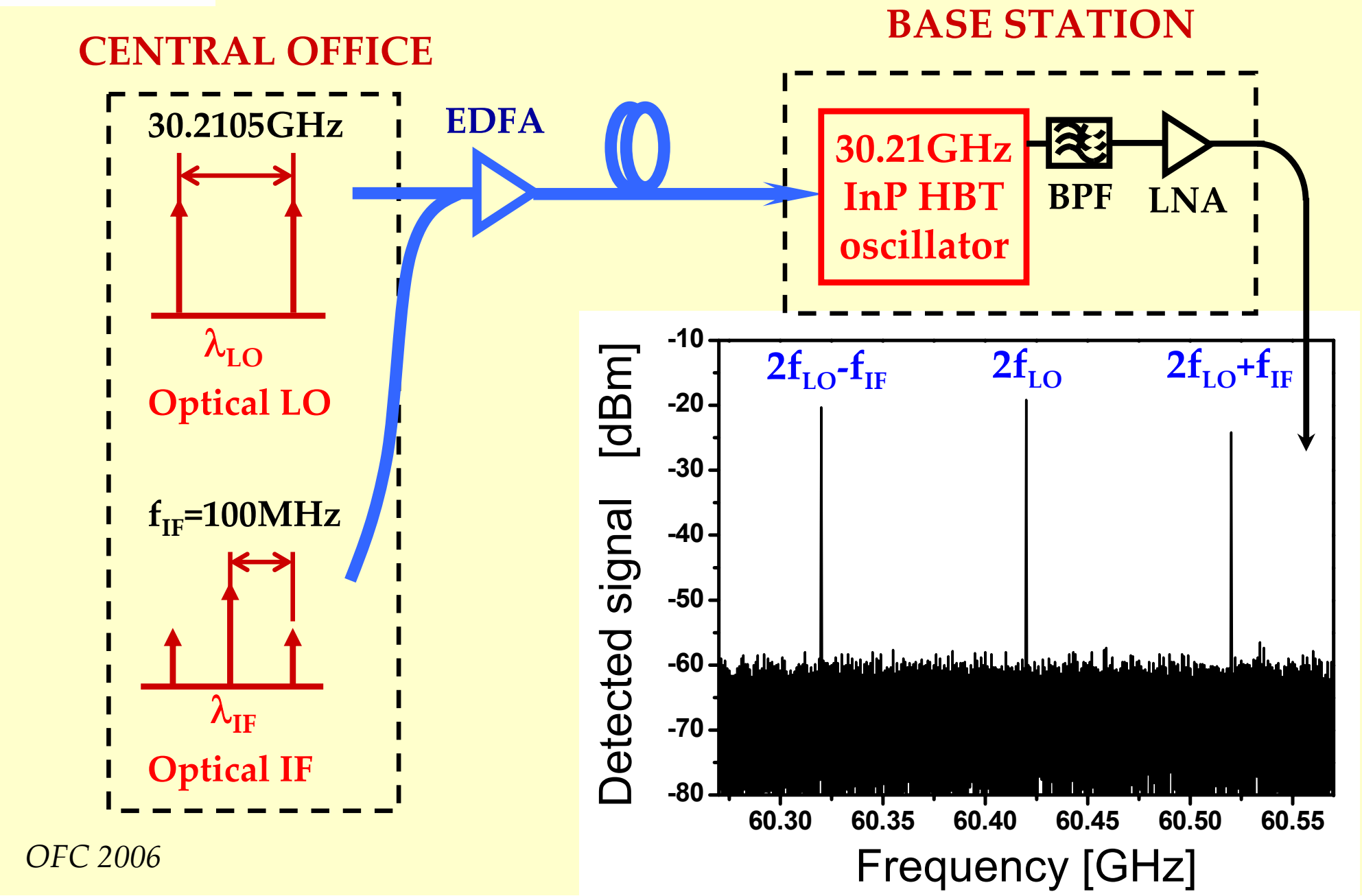
- Use 2nd harmonic for 60GHz applications





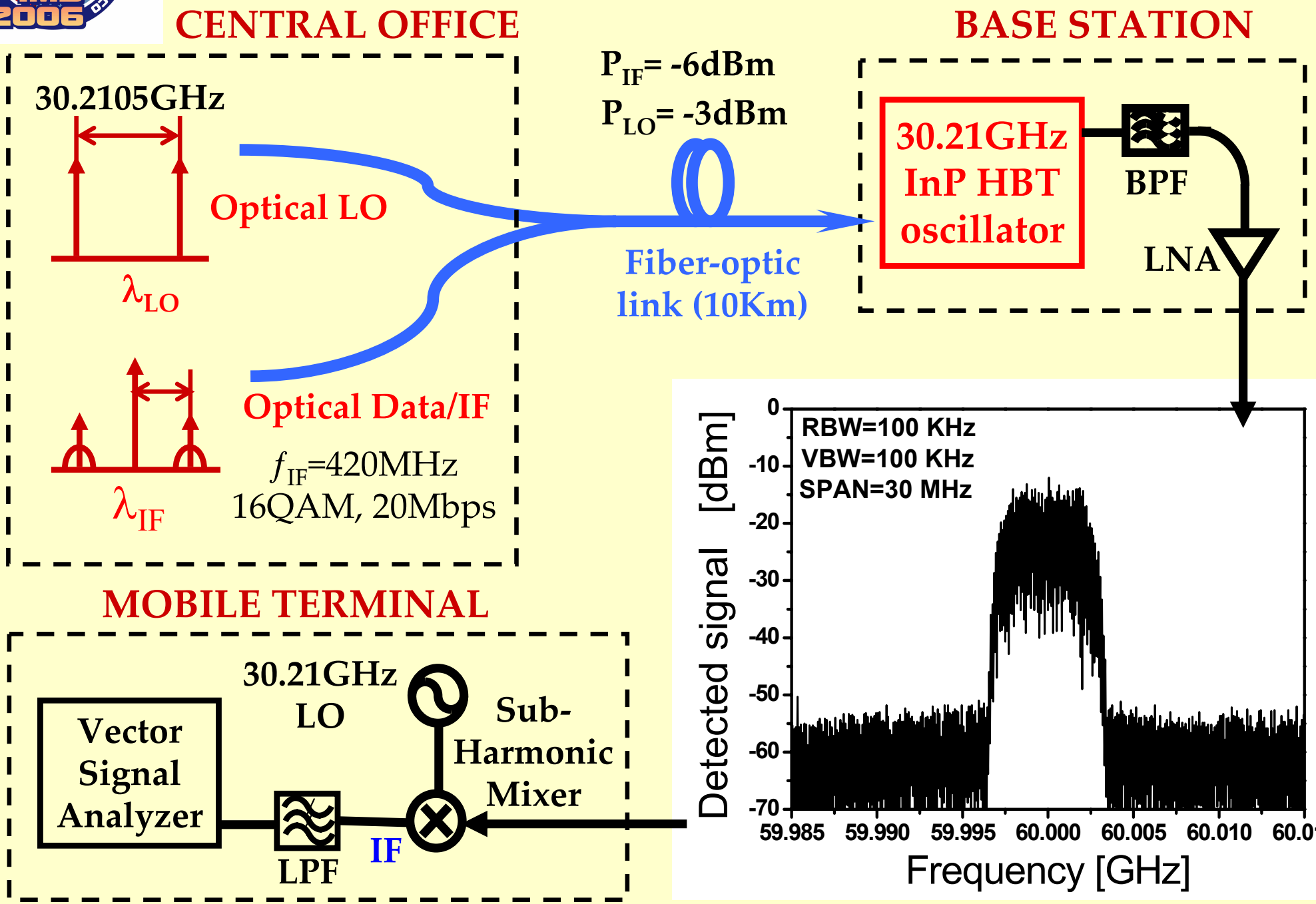


Optically injection-locked self-oscillating O/E mixer

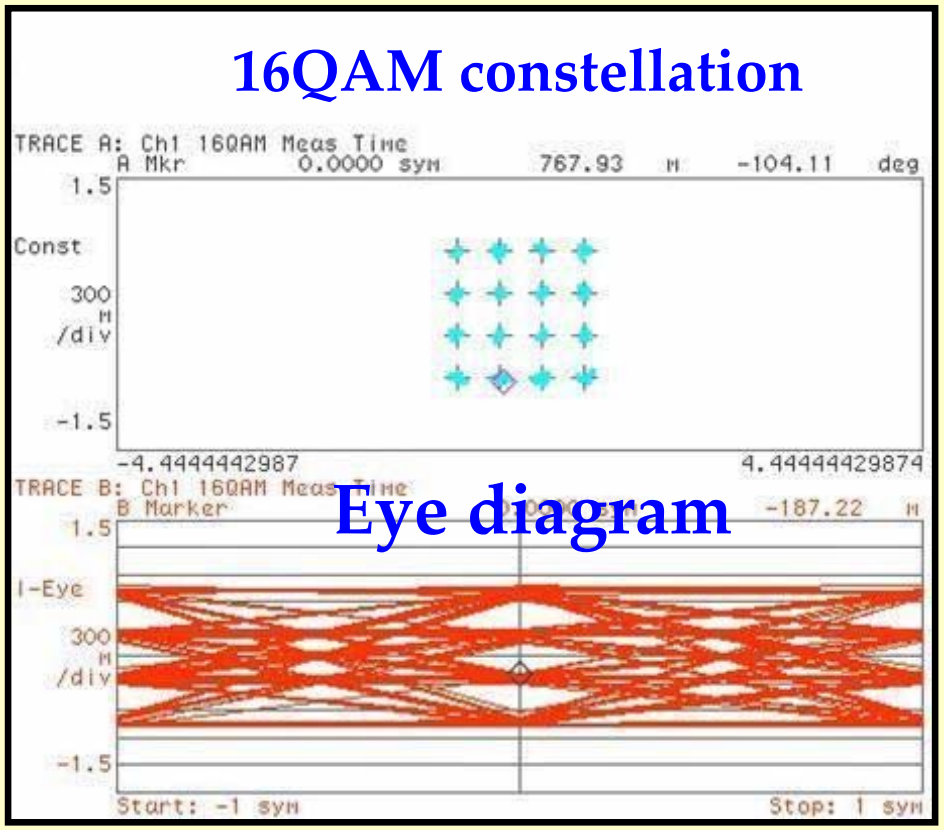


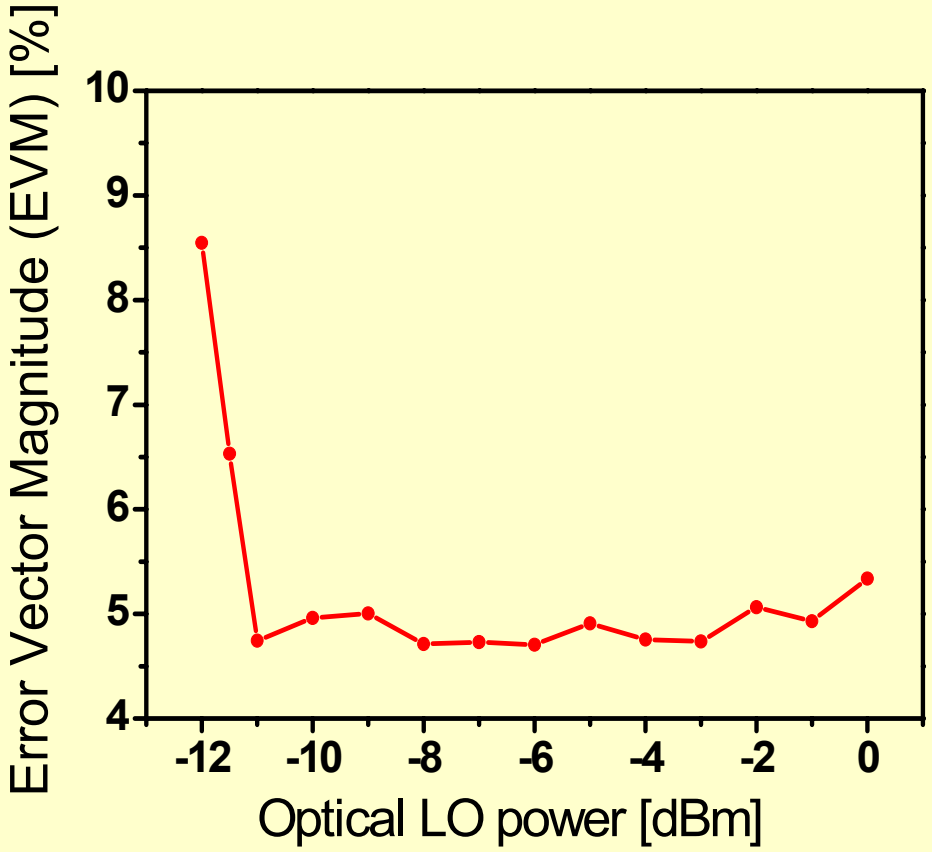
OFC 2006

60GHz downlink using OIL-SOM



Downlink transmission results





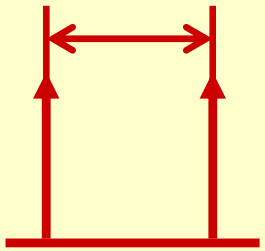
- EVM=4.74% corresponding to 26.5dB SNR (Error-free transmission)
- Insensitive link performance over optical LO power

MMIC OIL-SOM

BASE STATION

CENTRAL OFFICE

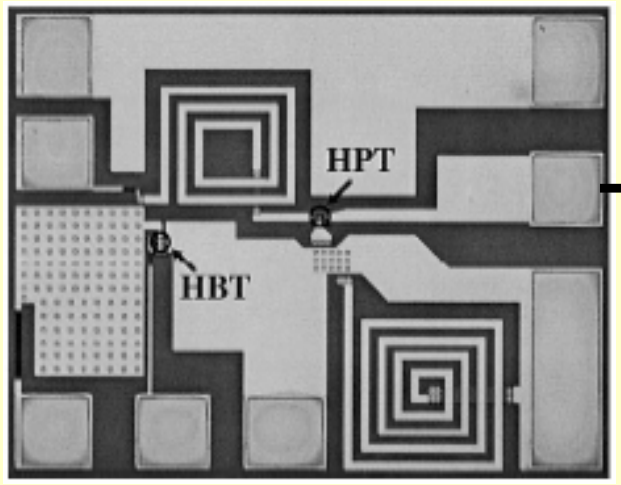
30.2105GHz



λ_{LO}

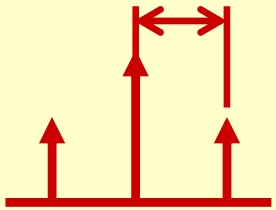
Optical LO

EDFA



10GHz MMIC oscillator

f_{IF}=100MHz

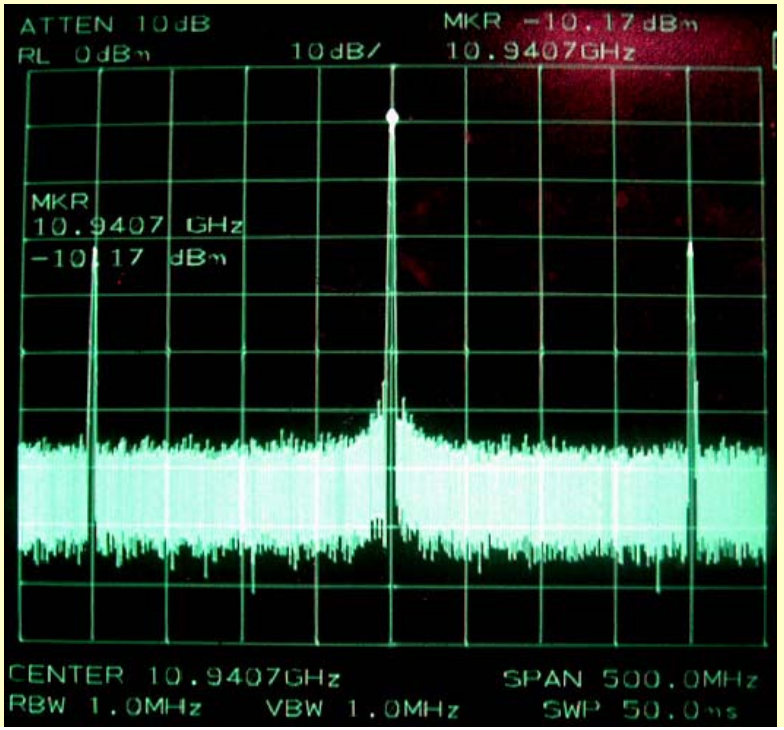


λ_{IF}

Optical IF

- One chip base station is possible!

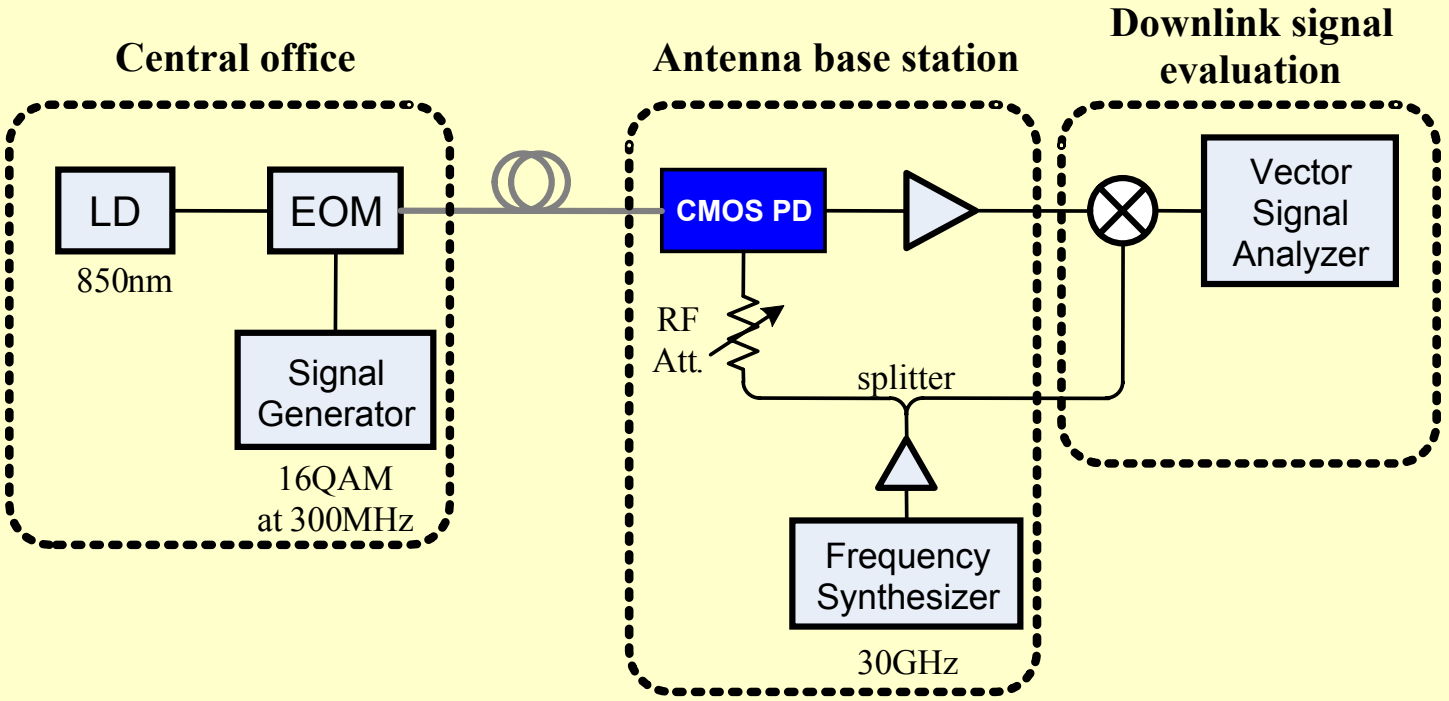
- Much wider locking range
  (3MHz → 1.4GHz at P_{opt}=2dBm)



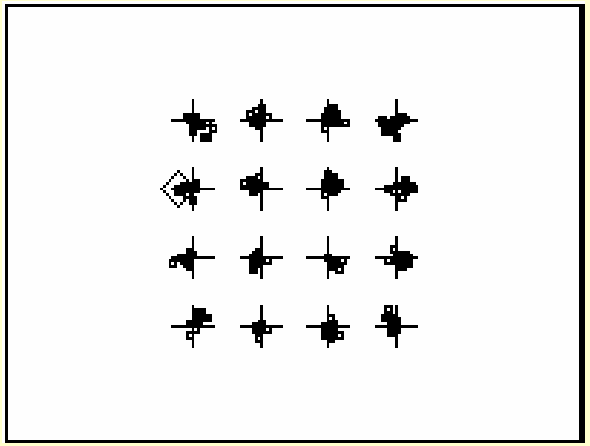
IEEE PTL, Nov, 2005

CMOS compatible O/E mixer

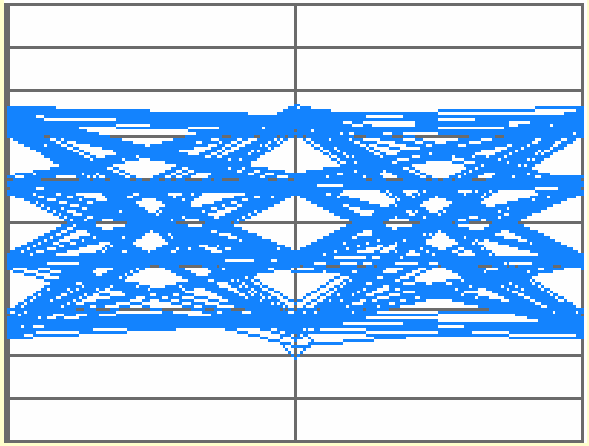
- Si photodiode fabricated by standard 130nm CMOS process



16QAM constellation



Eye diagram



-EVM = 6%

Summary

- High-speed InP transistors (HEMT, HBT) are useful for RoF systems
  - Photo-detectors
  - Optoelectronic mixer
  - Optically injection-locked self-oscillating O/E mixer

➔ More power systems with HBT/HEMT MMIC

➔ Possibility for high-speed Si circuits

- Acknowledgements
  - Jae-Young Kim, Chang-Soon Choi in Yonsei Univ.
  - Dr. Kamitsuna at NTT Photonics laboratory, Japan