2008 IEEE Radio and Wireless Symposium

Incorporating WAMICON

WORKSHOP WM2 NOTES

Radio Over Fiber Technologies

Monday, 21 January 2008
8:30 am – 5:00 pm

Organizers:
Dr. Yongxin Guo, *I2R, Singapore*
Prof. Jianping Yao, *University of Ottawa, Canada*

Speakers: Masayuki Izutsu, *NICT, Japan*
Prof. Beatrice Cabon, *INPG, France*
Dr. Thas A Nirmalathas, *University of Melbourne, Australia*
Xiupu Zhang, *Concordia University, Canada*
Prof. Jianping Yao, *University of Ottawa, Canada*
Woo-Young Choi, *Yonsei University, South Korea*
Michael Sauer, *Corning, USA*
Nathan Gomes, *University of Kent, UK*
Dr. Jianjun Yu, *NEC Labs, USA*
Dr. Yongxin Guo, *I2R, Singapore*

2008 IEEE RADIO AND WIRELESS SYMPOSIUM

Orlando Florida

22 – 24 January, 2008

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Fiber-fed wireless systems based on remote up-conversion techniques

Jae-Young Kim and Woo-Young Choi

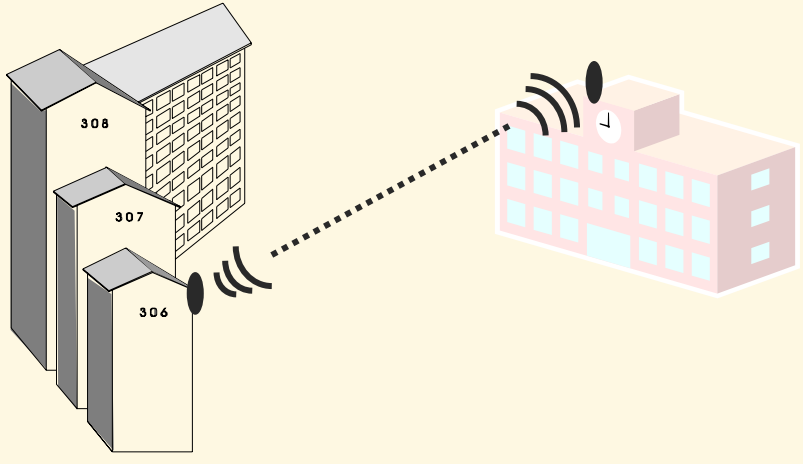
Dept. of Electrical and Electronic Engineering,
Yonsei University, Seoul, Korea

Outline

1. Radio over Fiber for 60GHz WLAN
2. Remote up-conversion techniques
3. Optoelectronic mixer based on InP HBT
4. Optically injection-locked self-oscillating optoelectronic mixer (OIL-SOM) based on InP HBT
5. Summary

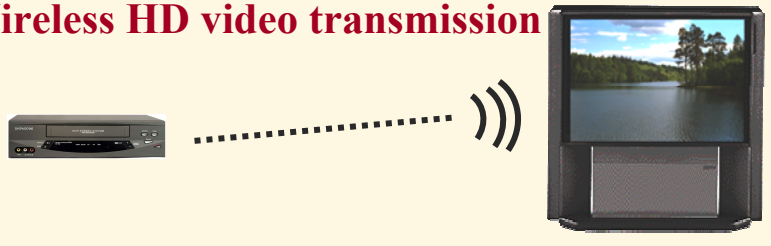
60GHz for Wireless Networks

Broadband Wireless Access



High-speed Wireless LAN

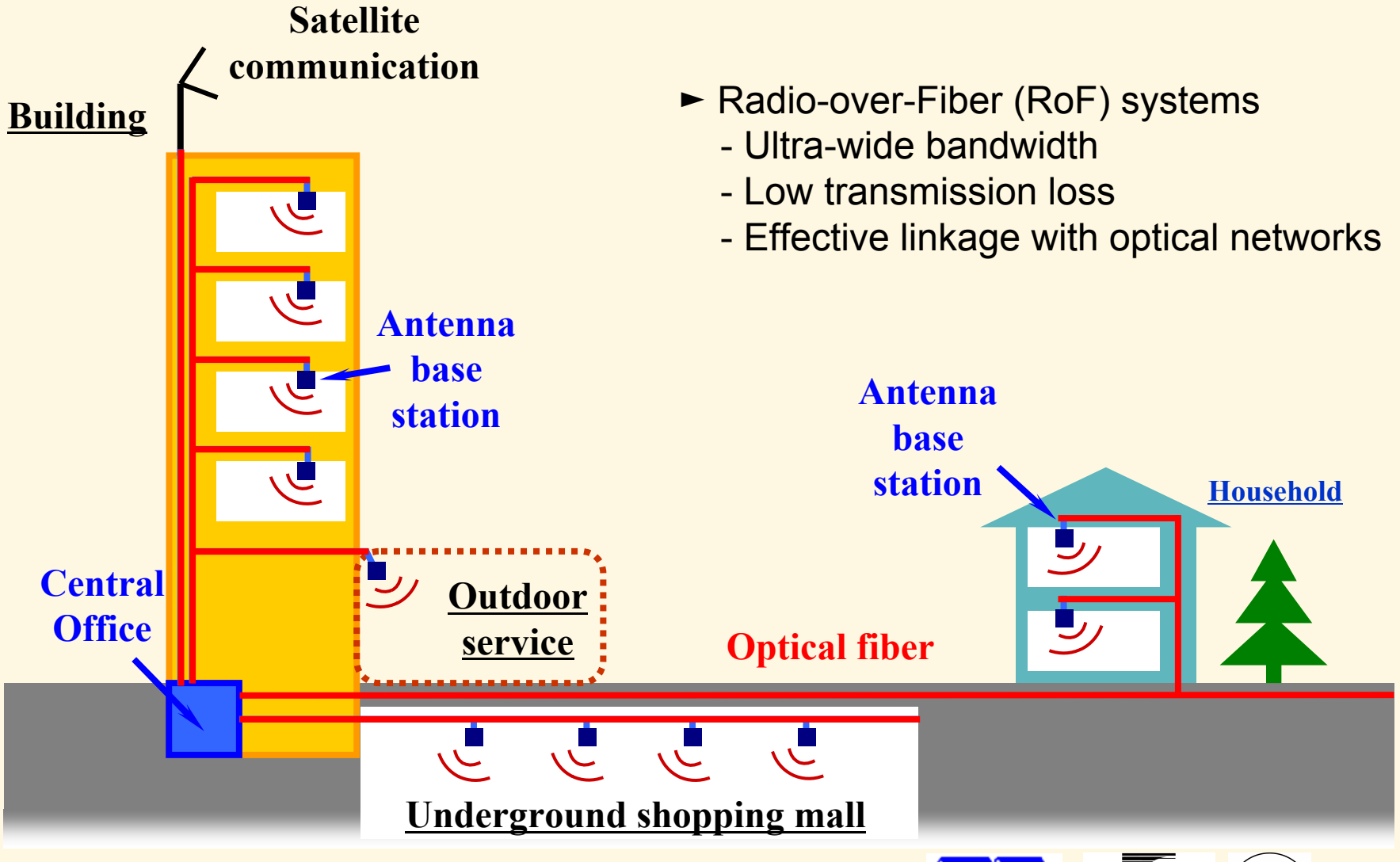
Wireless HD video transmission



Wireless Personal Area Network (WPAN)

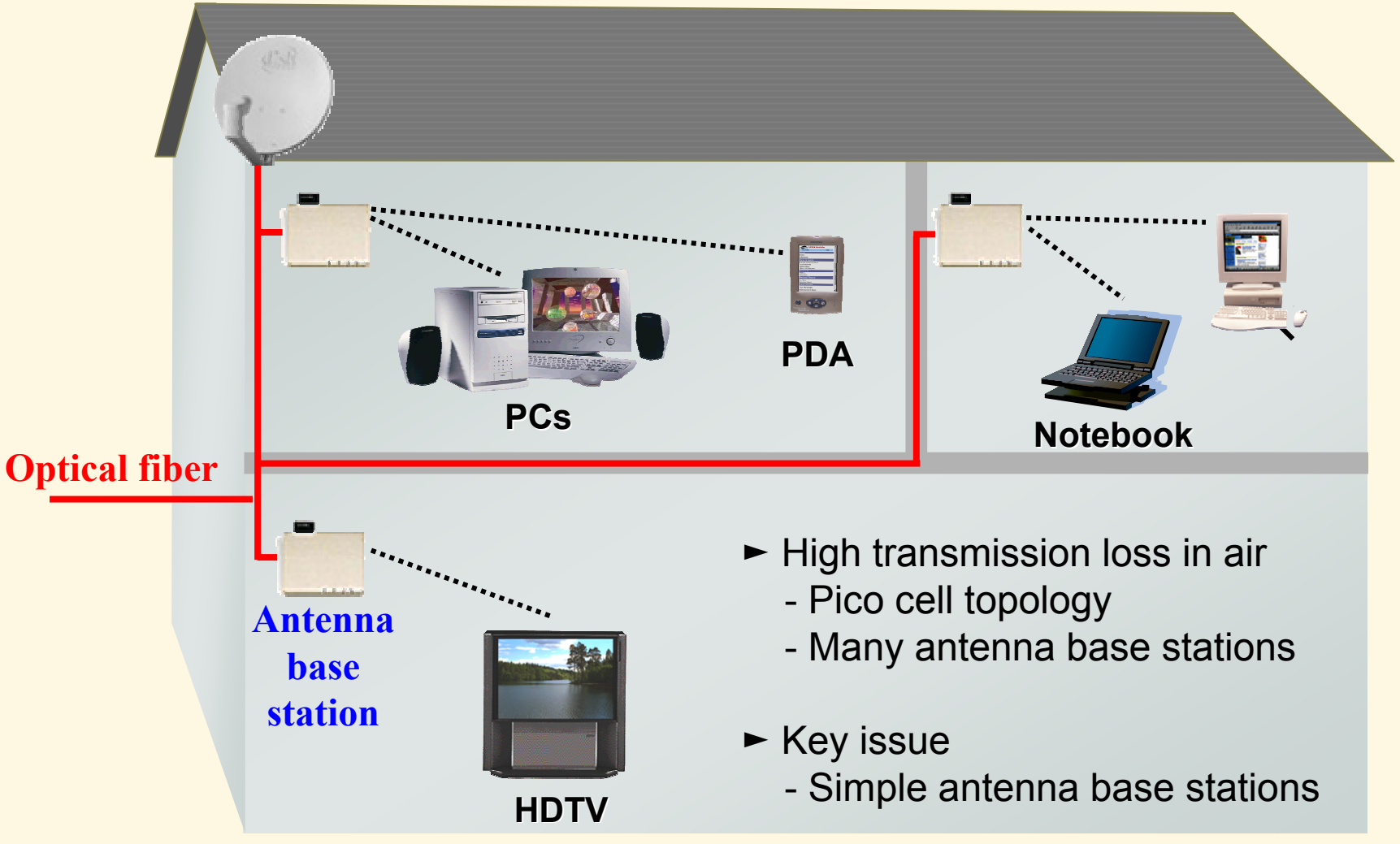
- **Growing interest in 60GHz**
  - 60GHz as unlicensed band
  - IEEE 802.15.3C explores 60GHz band for WPAN

Fiber-Fed wireless system for wireless networks



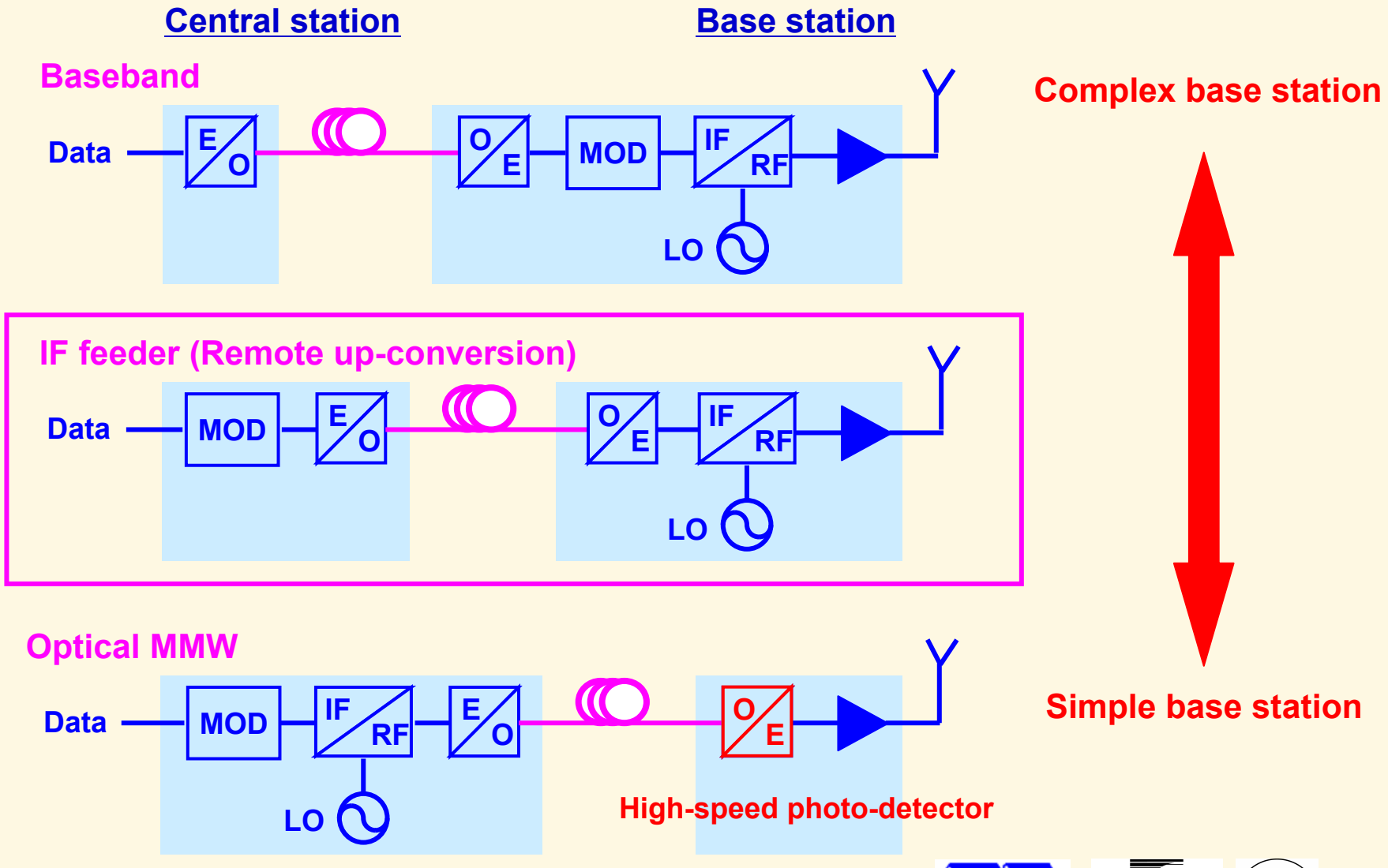
- Radio-over-Fiber (RoF) systems
  - Ultra-wide bandwidth
  - Low transmission loss
  - Effective linkage with optical networks

Fiber-Fed wireless system for wireless networks

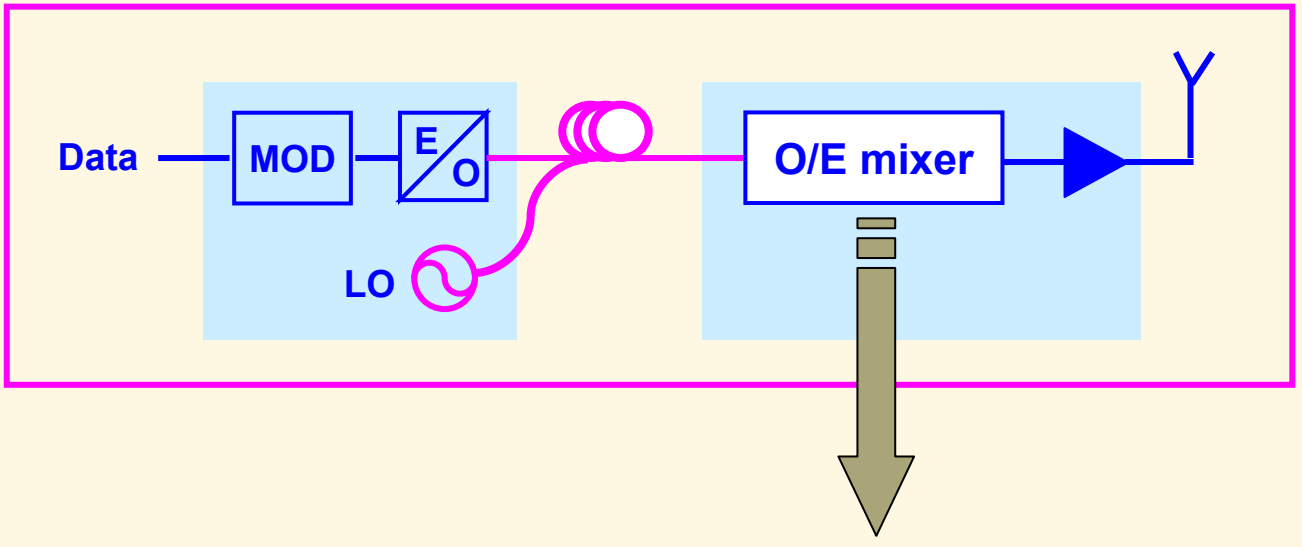


- High transmission loss in air
  - Pico cell topology
  - Many antenna base stations
- Key issue
  - Simple antenna base stations

Architectures for Fiber-Fed Wireless Systems



IF feeder with optical LO distribution



Why InP HBT?

- Optoelectronic mixing
- High optical responsivity
- High-speed operation
- MMIC-compatibility

SOA + EAM

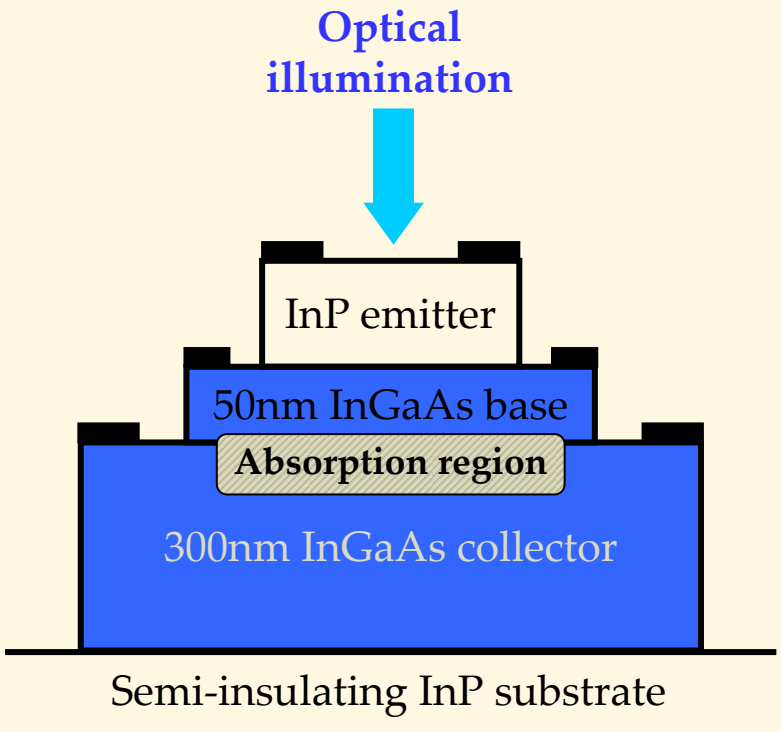
- J. S. Seo, etc, IEEE MTT, Feb 2006

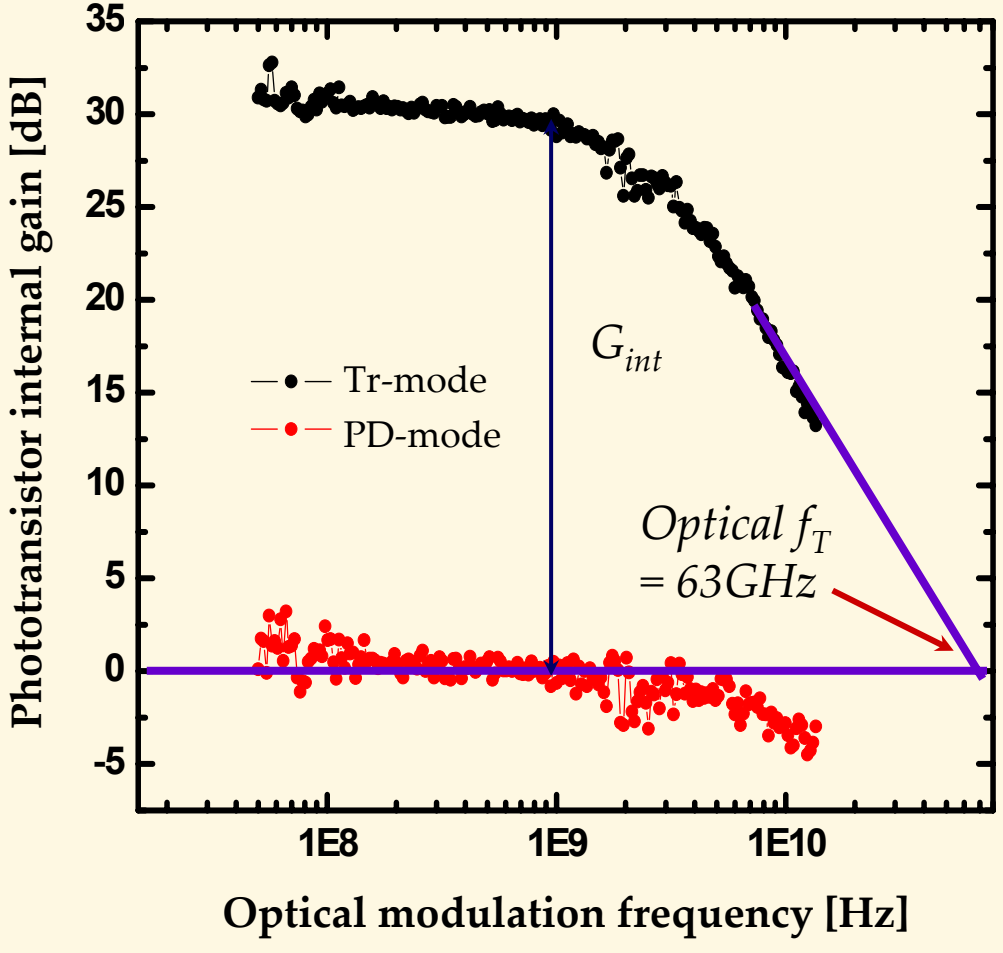
InP HEMT O/E mixer

- C. S. Choi, etc, IEEE MTT, Nov 2004

InP HBT O/E mixer

InP Heterojunction Bipolar Transistor



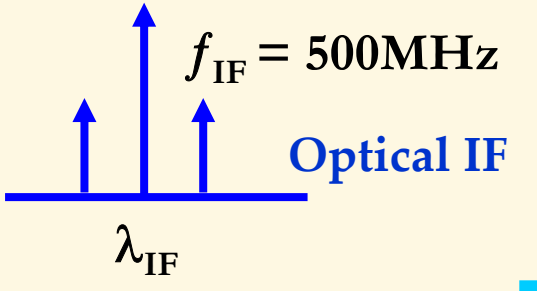


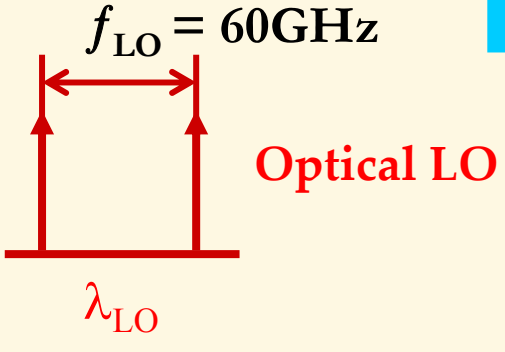
- Optical BW $_{3dB}$ = 1.7GHz
- f_T = 153GHz, f_{max} = 94GHz

Fabricated in NTT Photonics Laboratories, Japan

Operation Principles and Characteristics of HBT O/E mixers

HBT Optoelectronic Mixer with optical LO





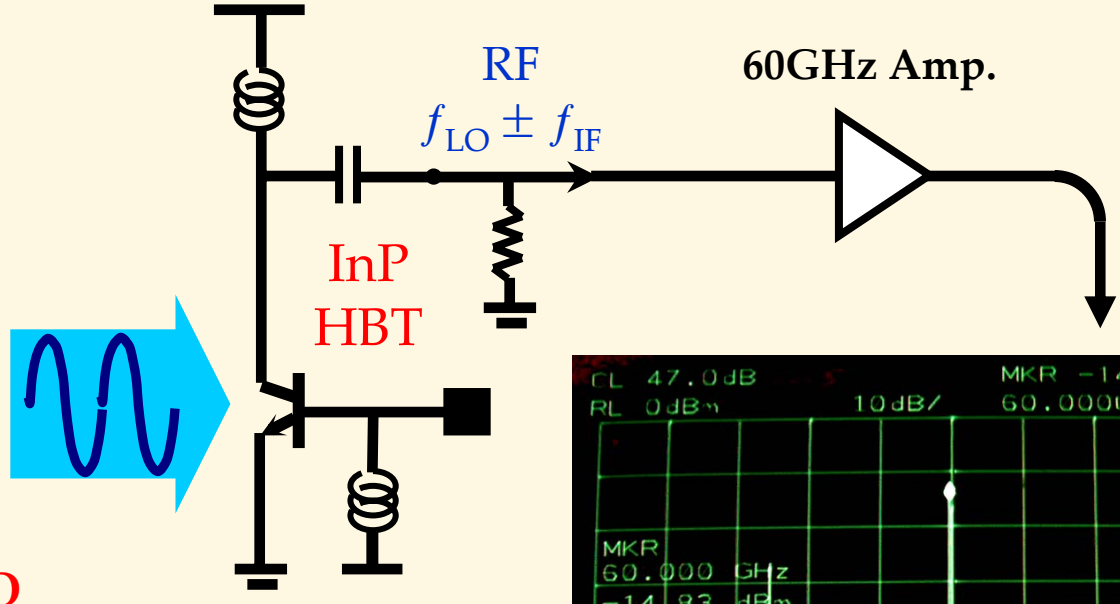
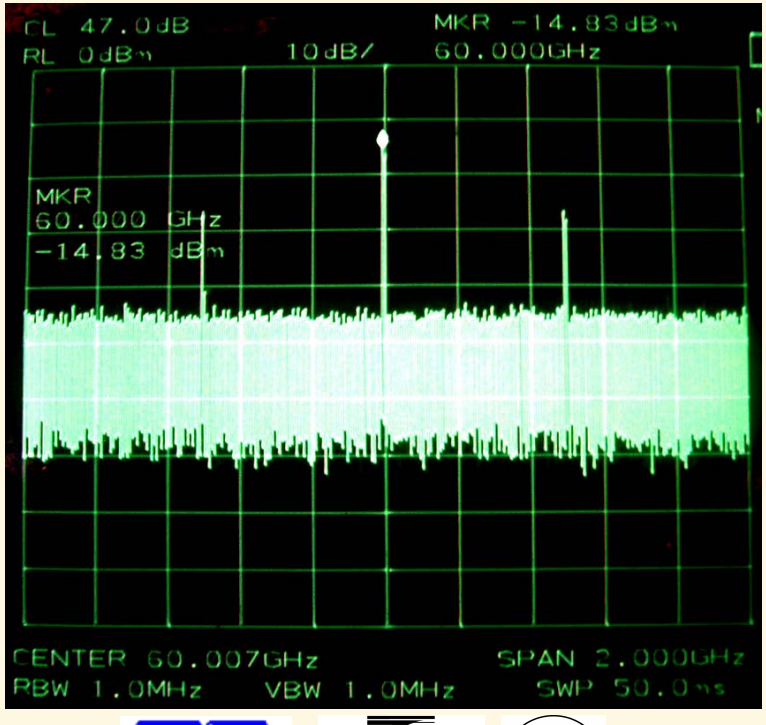
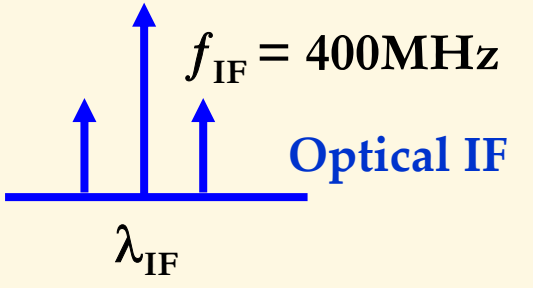


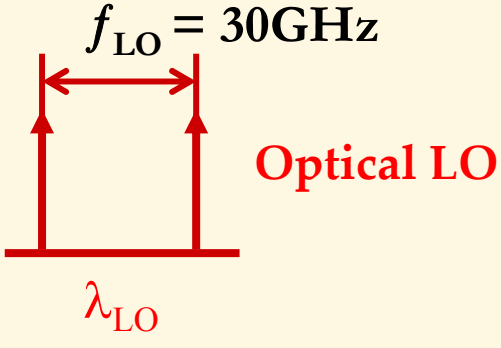
Photo-detector + mixer
→ O/E mixer

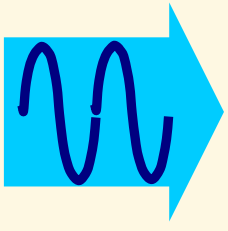


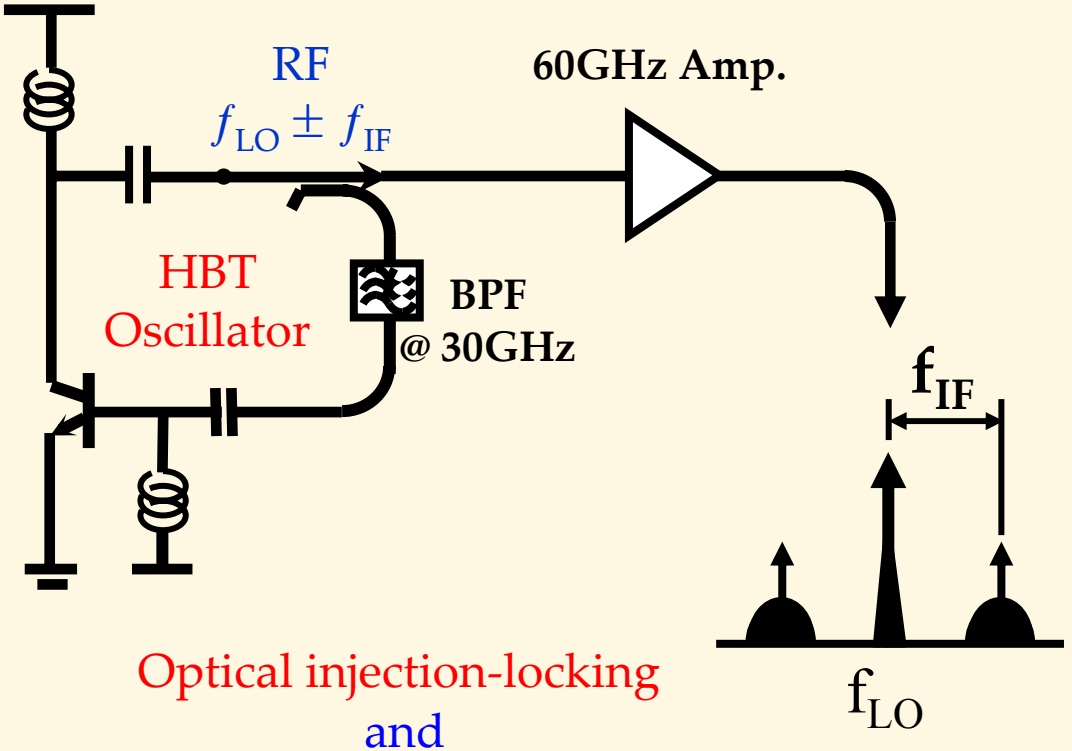
- Optical LO distribution
- Elimination of LO in many ABSs
- But, low conversion efficiency

HBT Self-oscillating optoelectronic Mixer







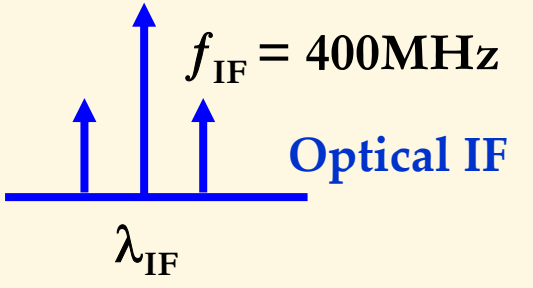


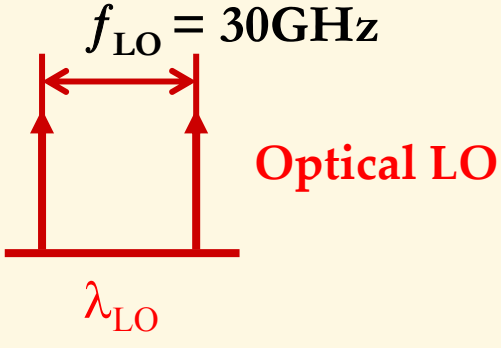
Optical injection-locking
and
Self-oscillating mixing

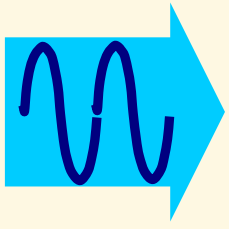
(OIL-SOM)

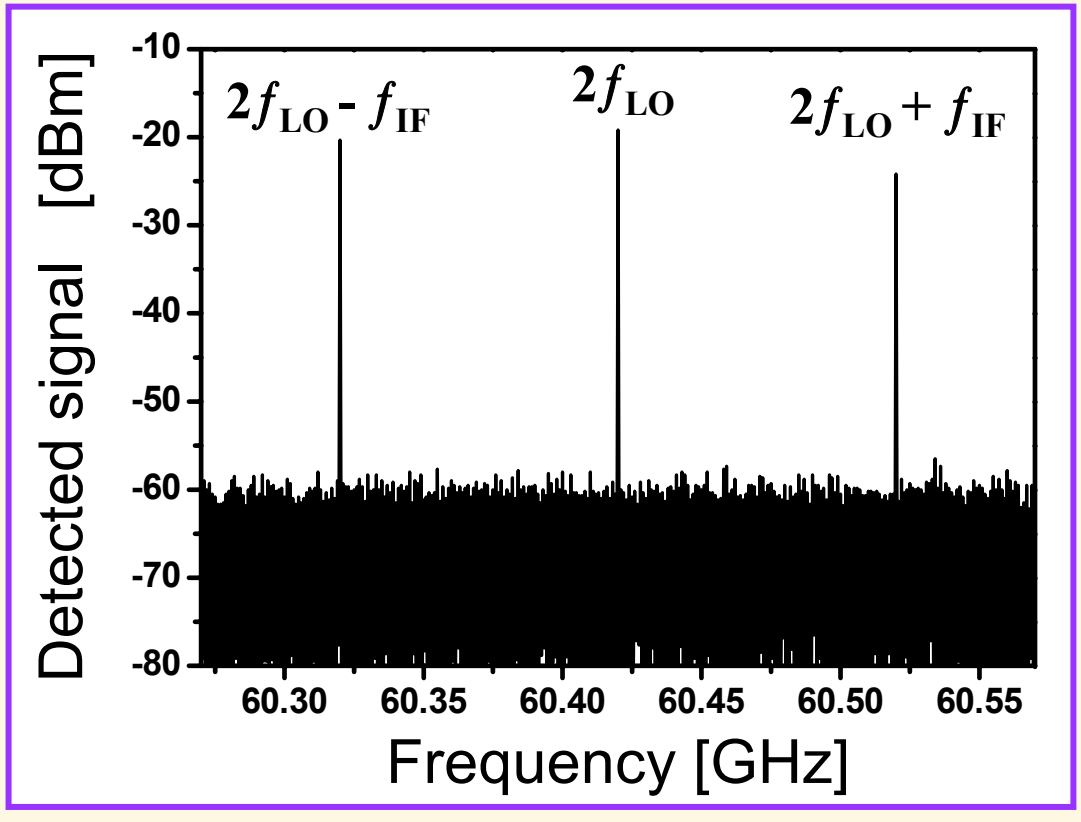
- High power LO generation
- Improved conversion efficiency
- Integrated Oscillator also possible

HBT Self-oscillating optoelectronic Mixer





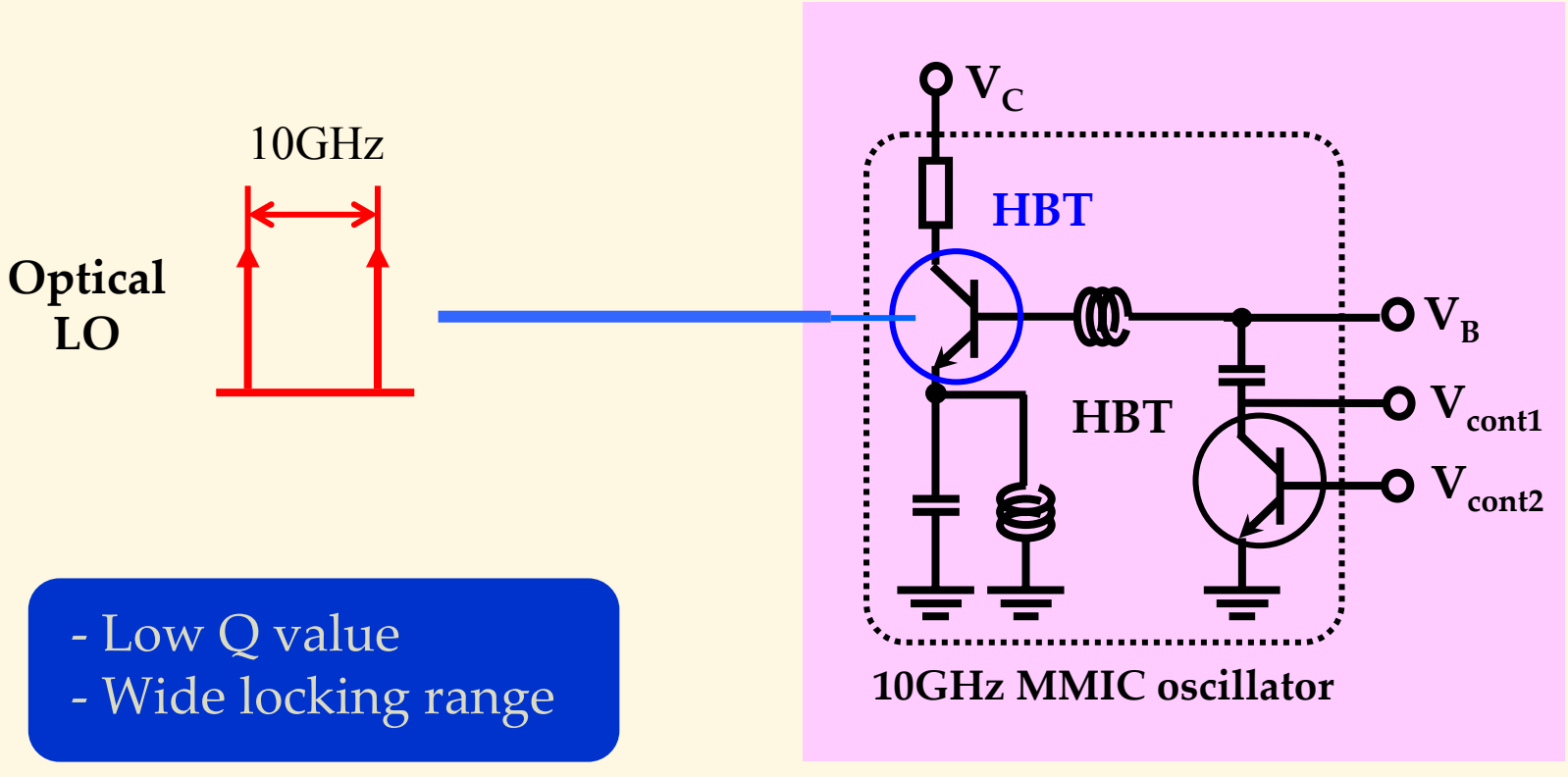




(Used 2nd harmonic for 60GHz applications)

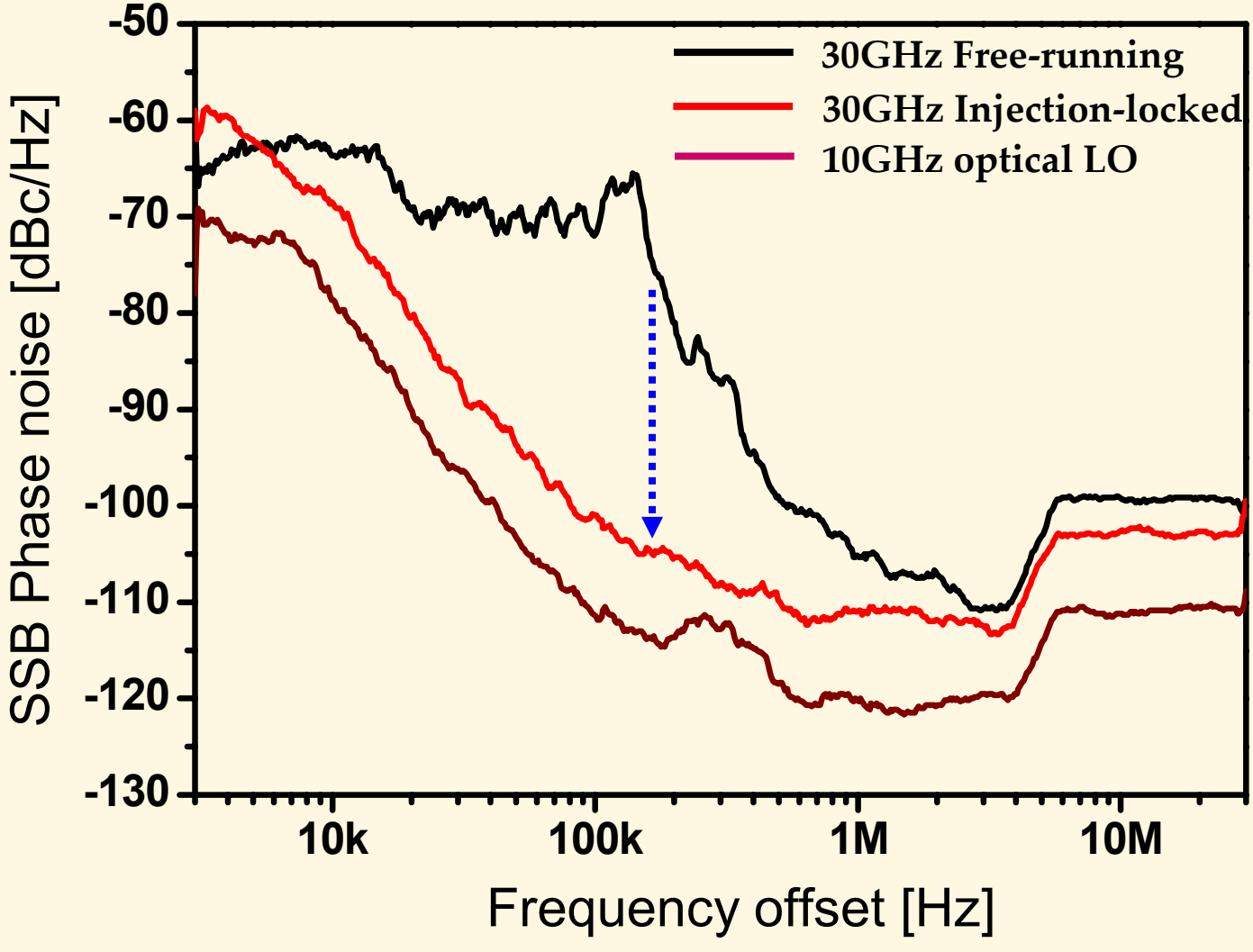
- High power LO generation
- Improved conversion efficiency
- Integrated Oscillator also possible

HBT MMIC self-oscillating mixer

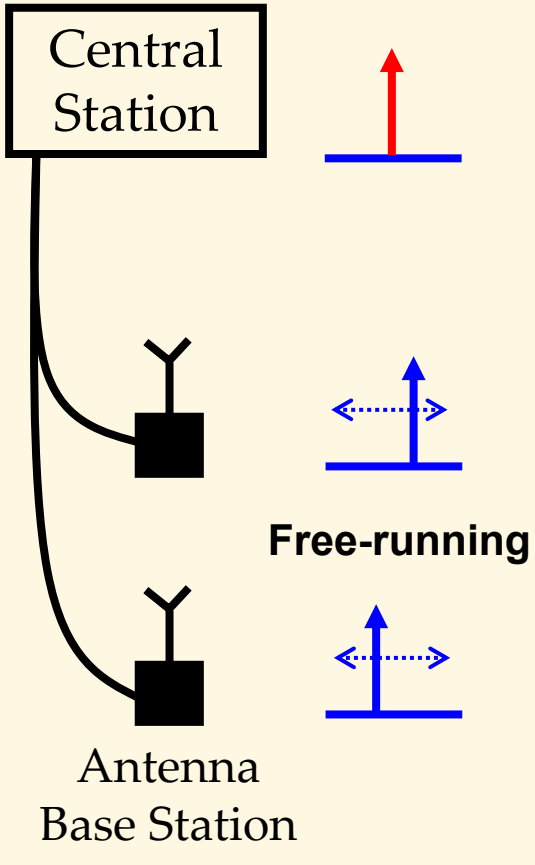


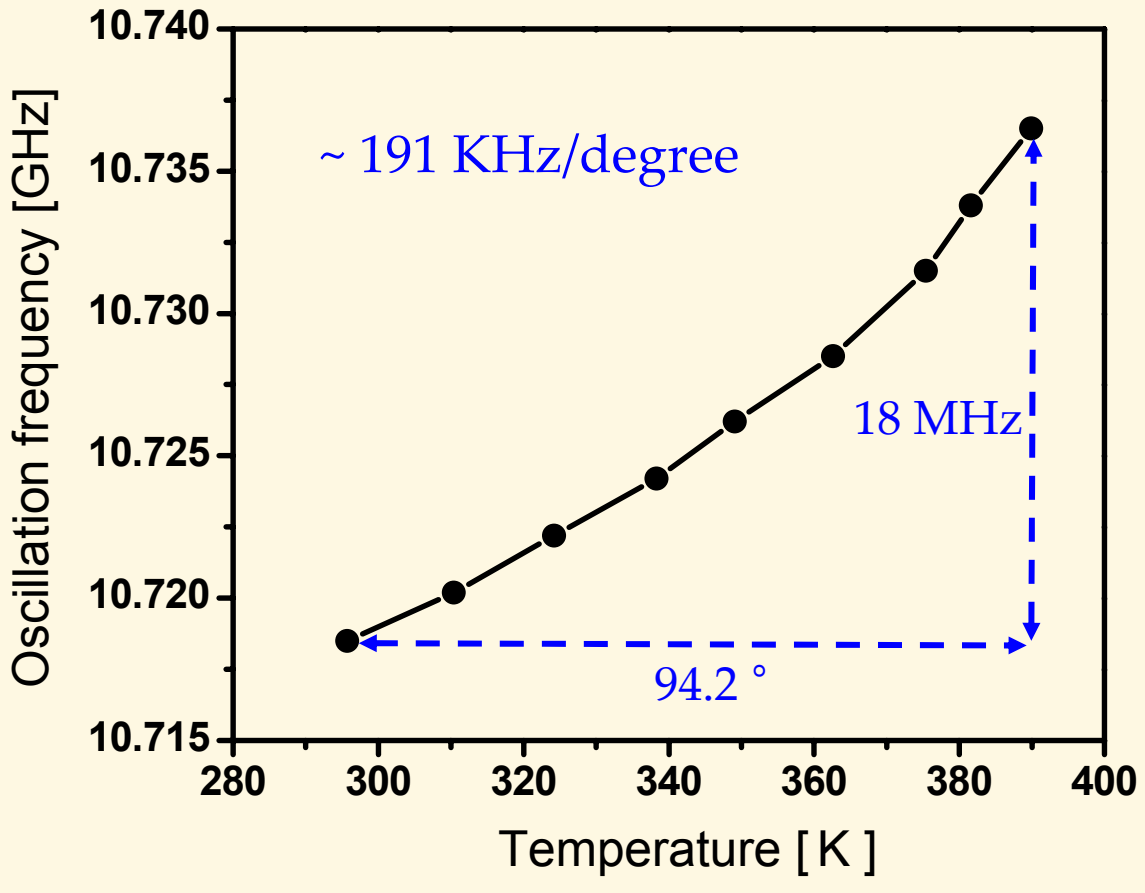
- Low Q value
- Wide locking range

Phase noise reduction by optical injection-locking



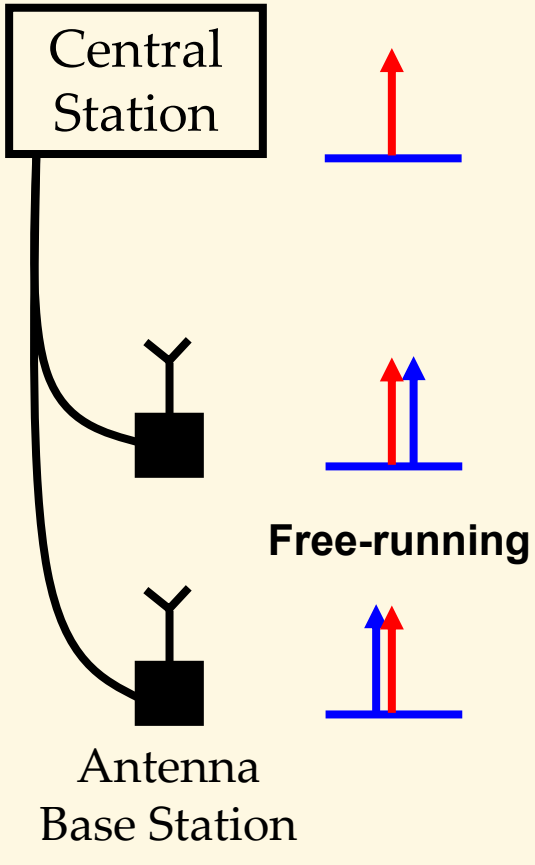
Thermal variation of oscillation frequency

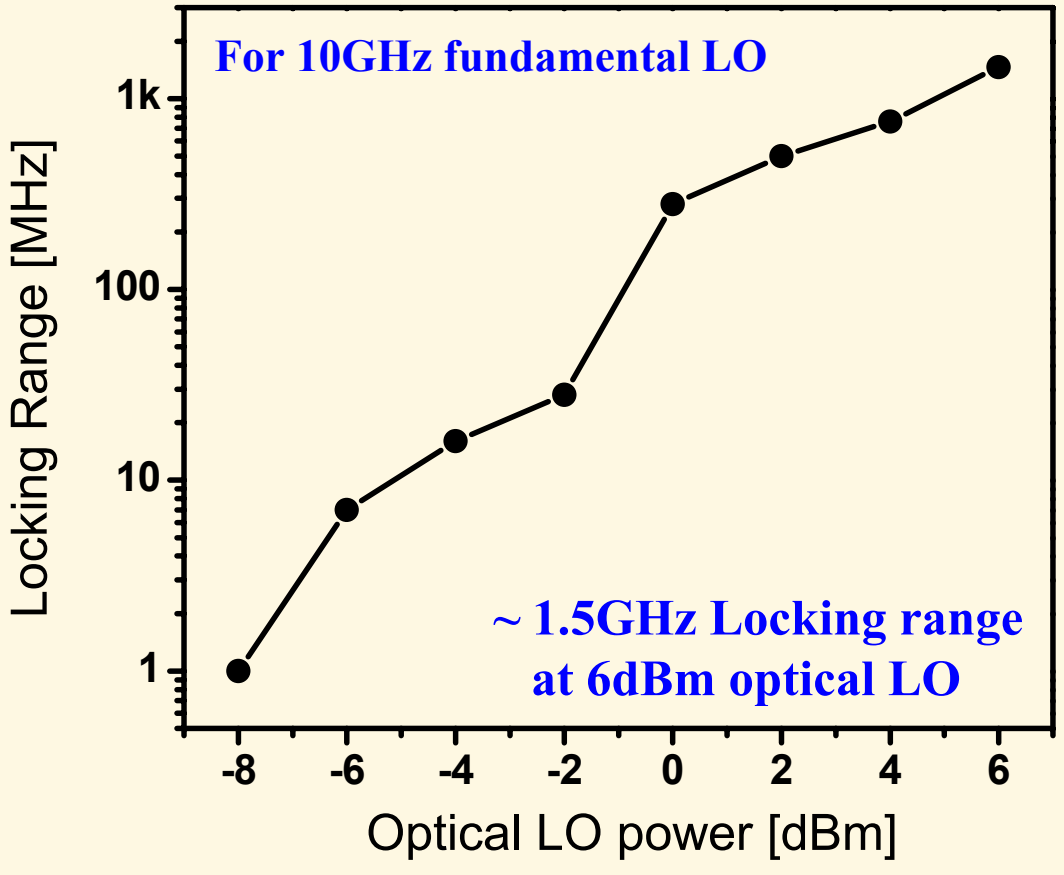




- The self-oscillating frequency varies with temperature

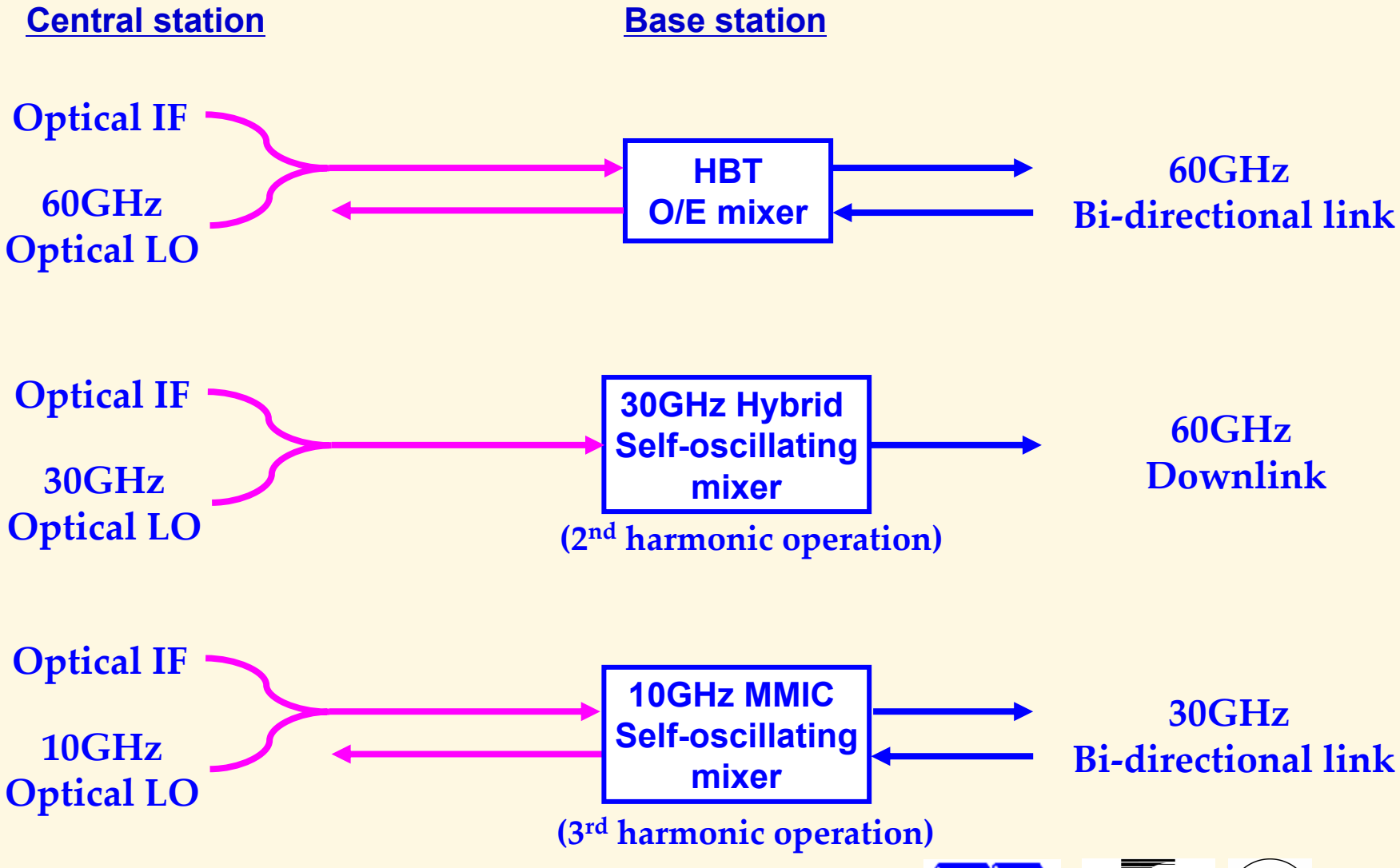
Wide optical injection-locking range



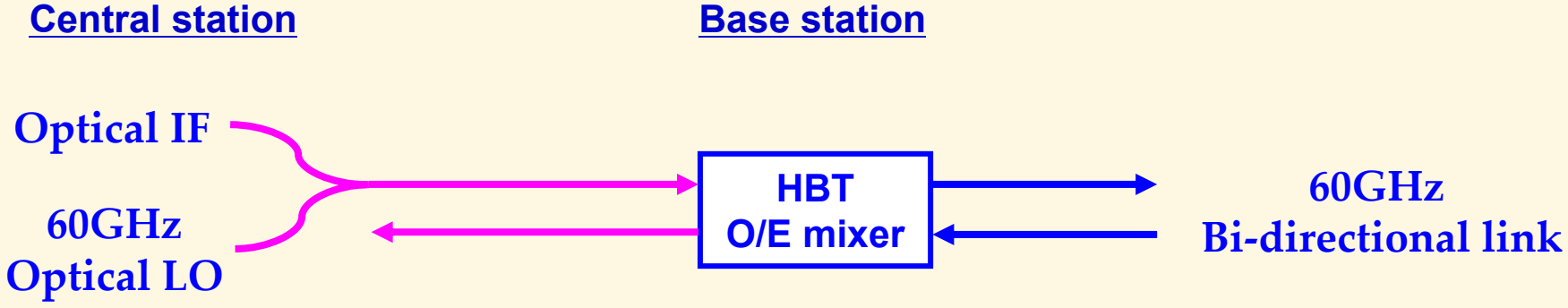


- Wide locking range for maintaining injection-locking in ABS

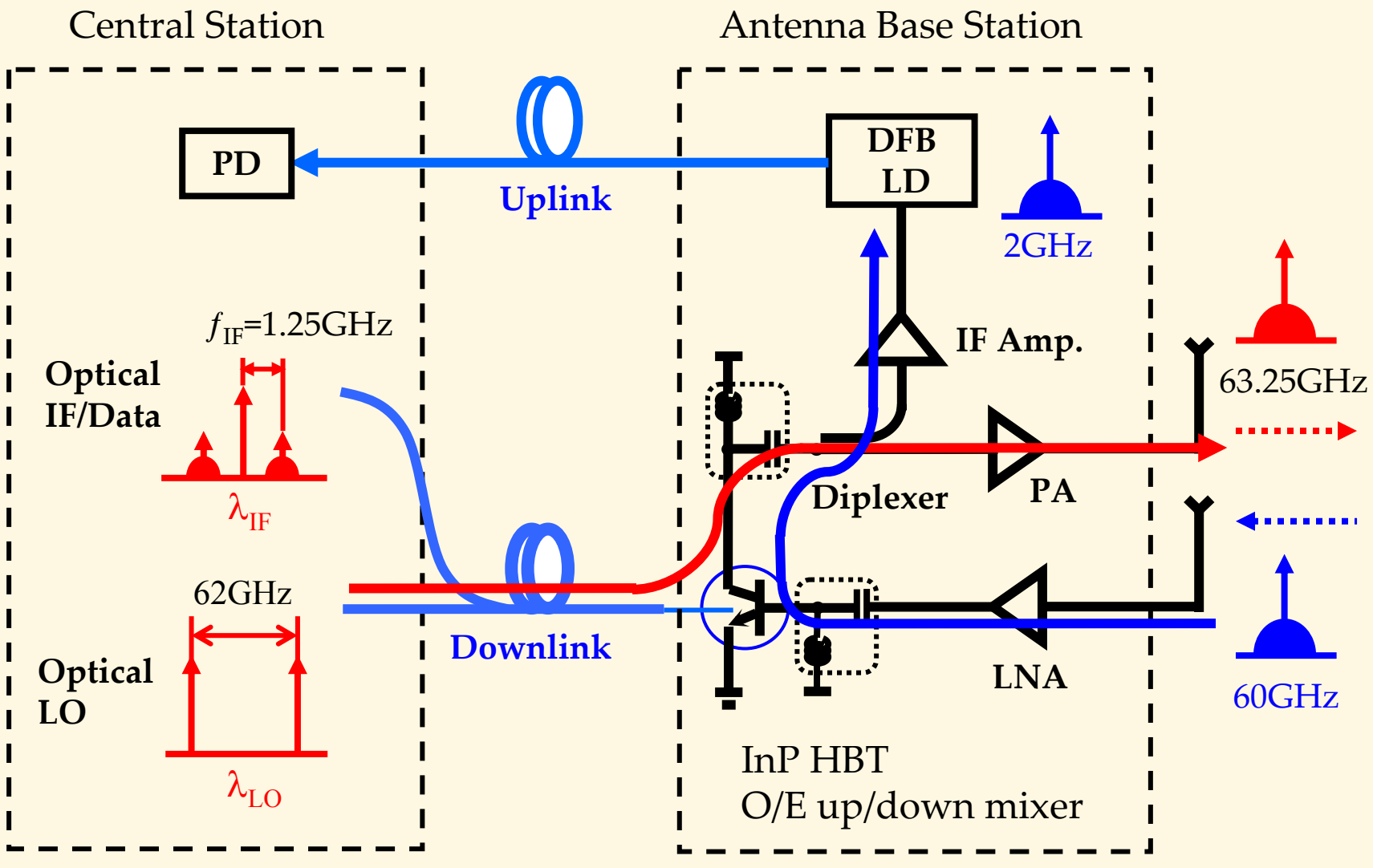
Link demonstrations using O/E mixers



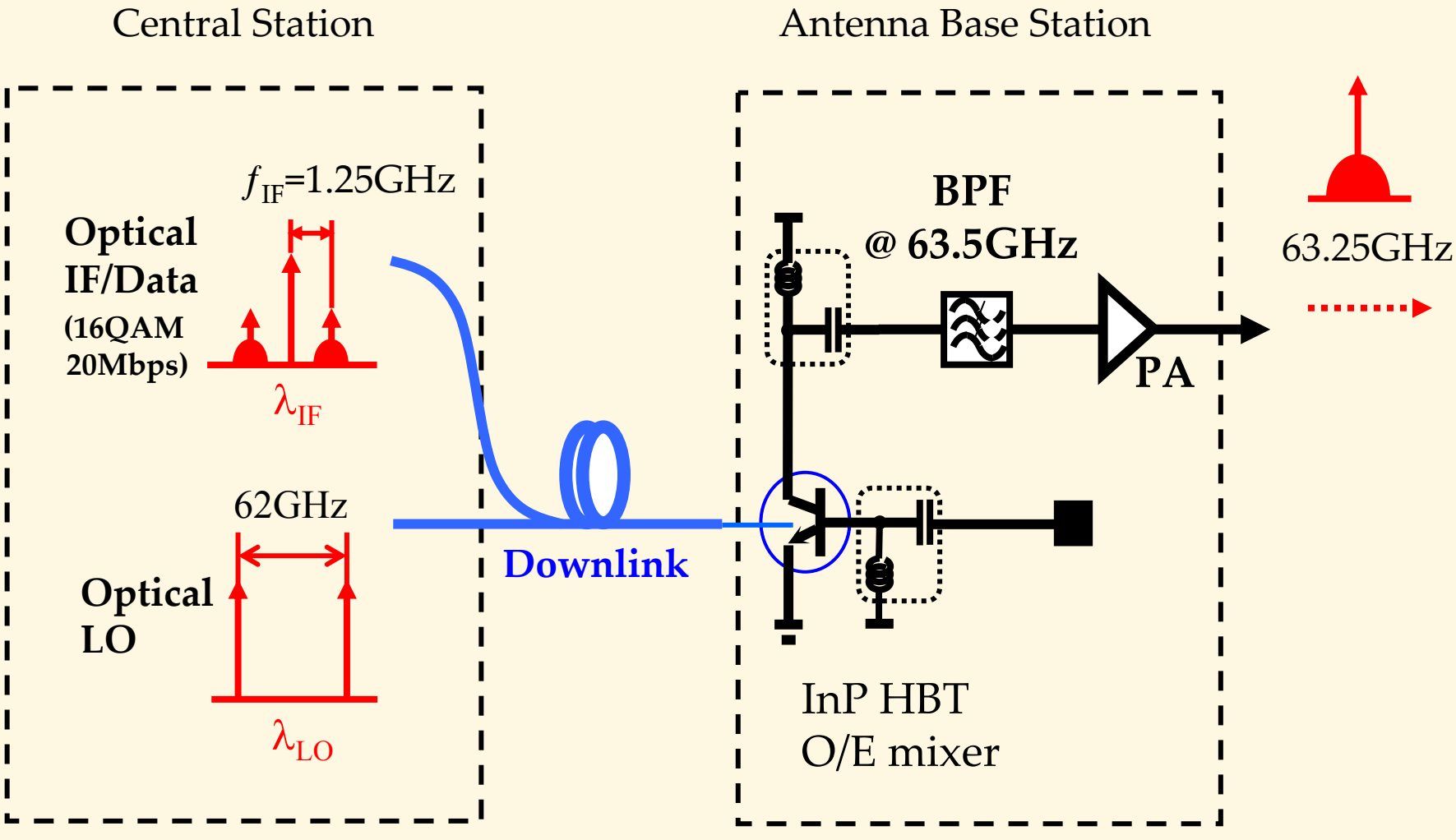
60GHz Bi-directional link using HBT O/E Mixer



60GHz bi-directional links based on HBT

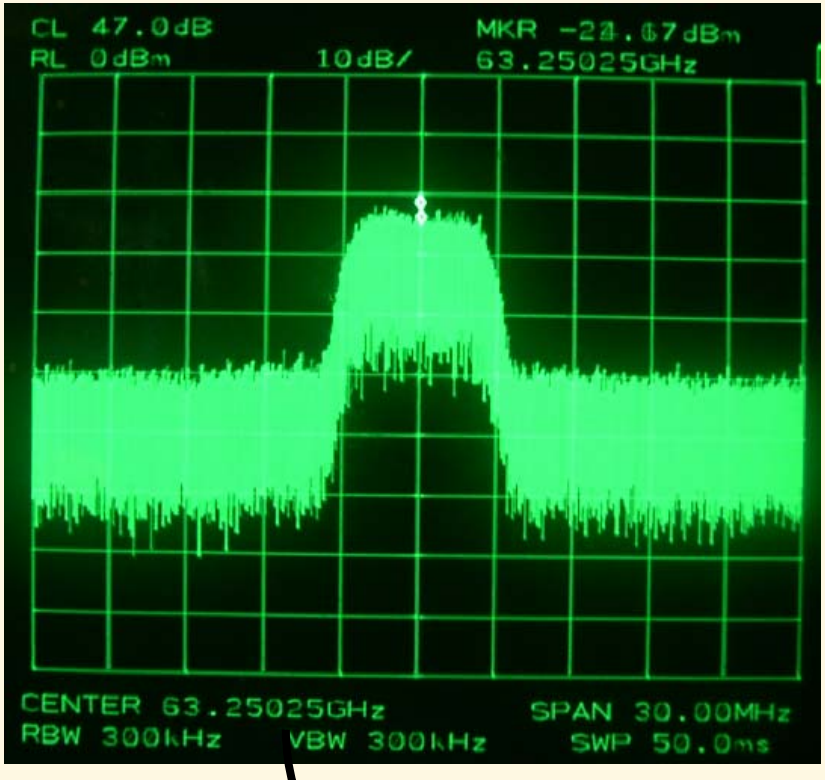


Downlink transmission (Up-conversion)

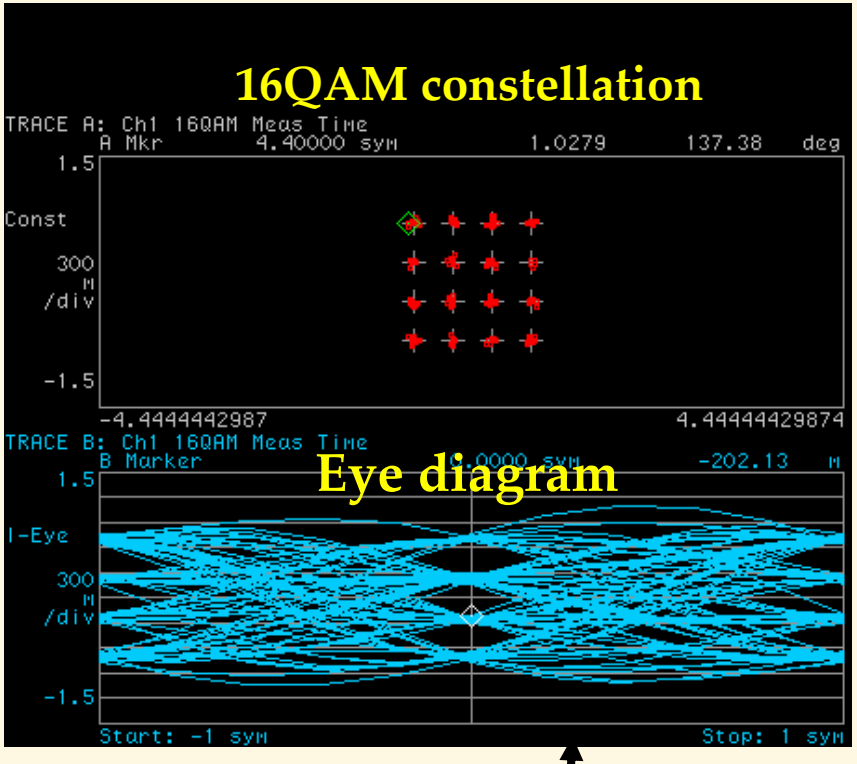


Downlink transmission results

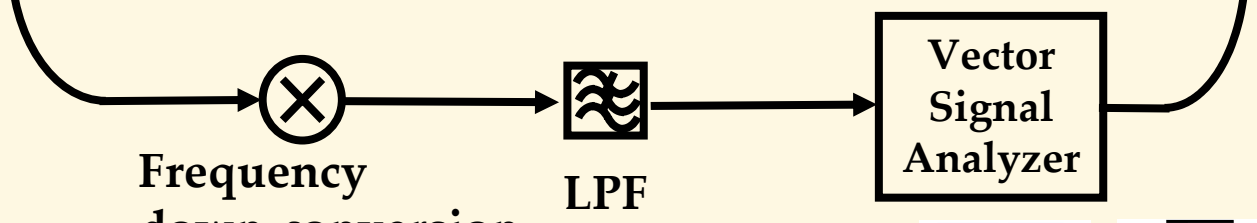
Frequency up-converted spectrum



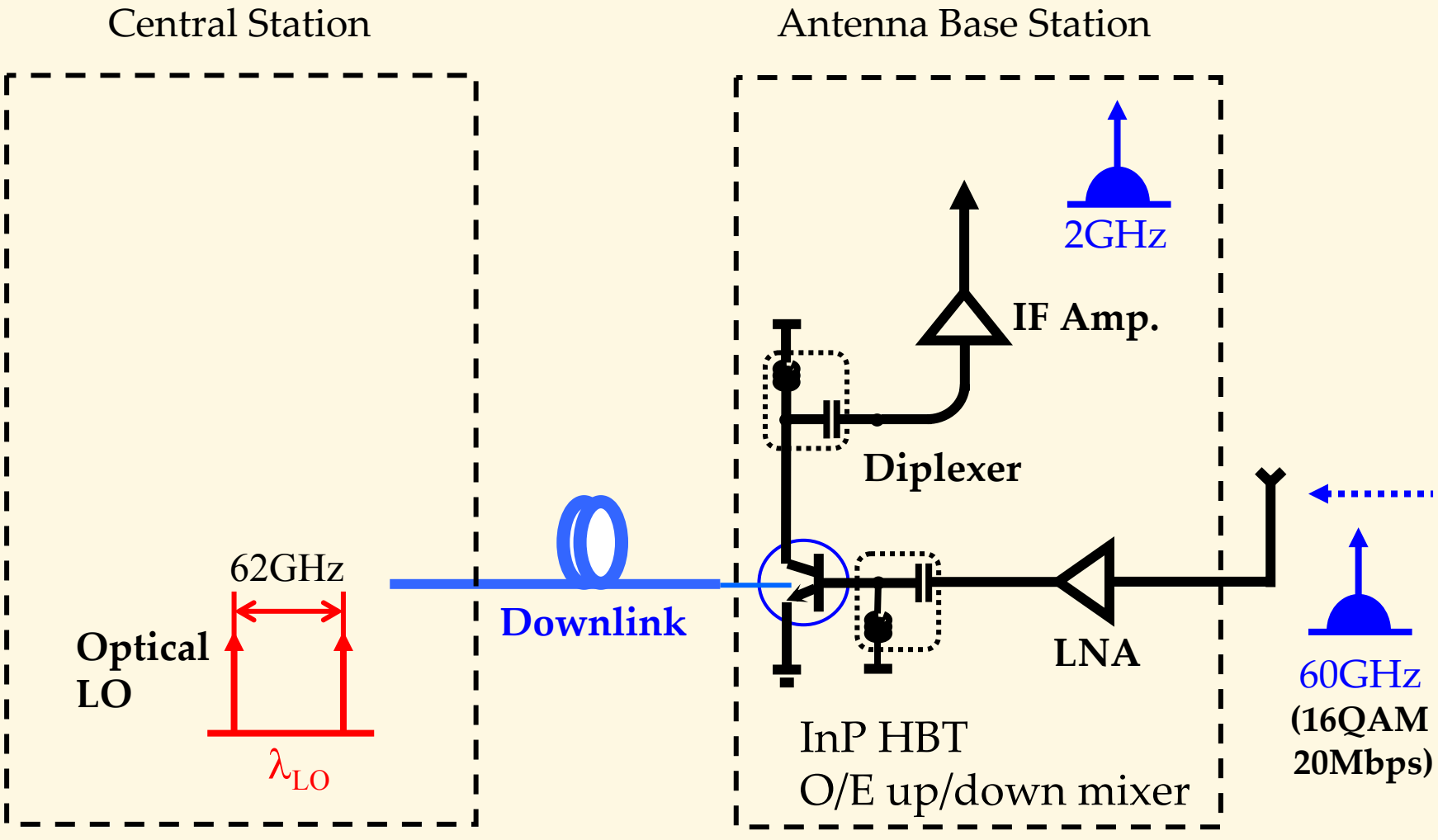
Eye-diagram and constellation



EVM =4.53%

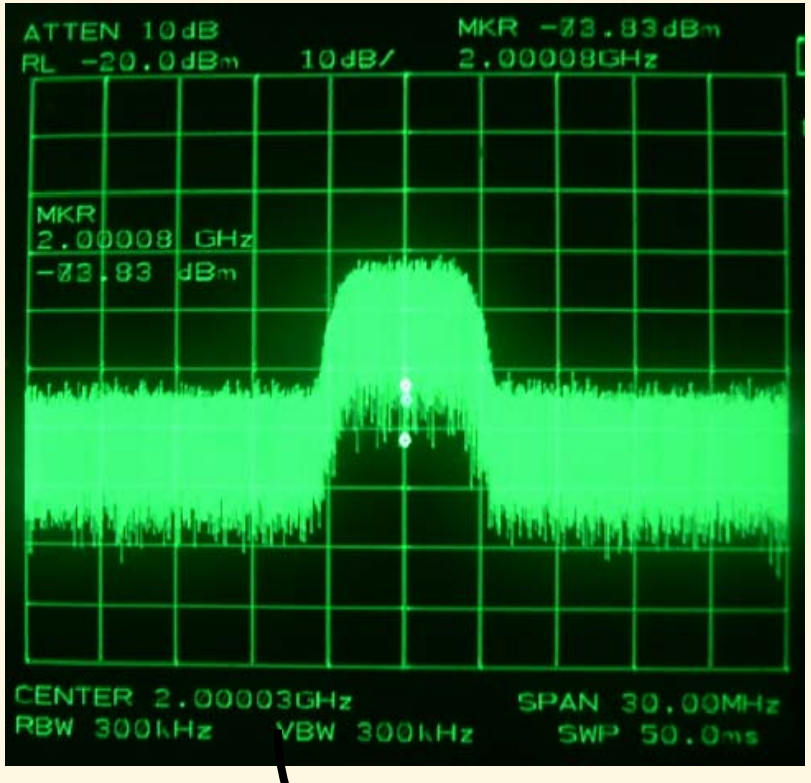


Uplink transmission (Down-conversion)

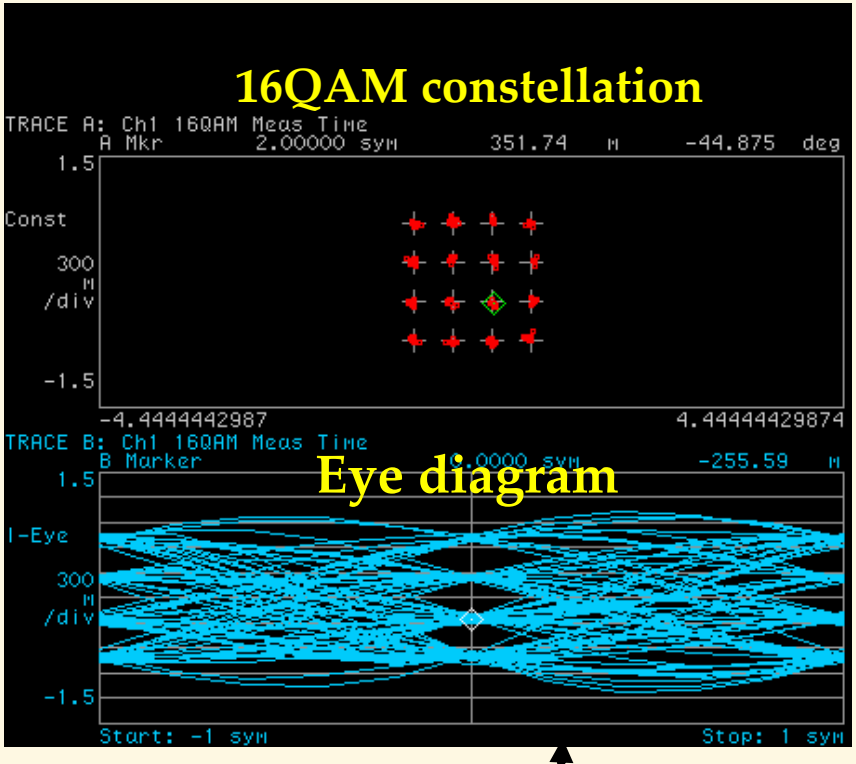


Uplink transmission results

Frequency down-converted spectrum



Eye-diagram and constellation



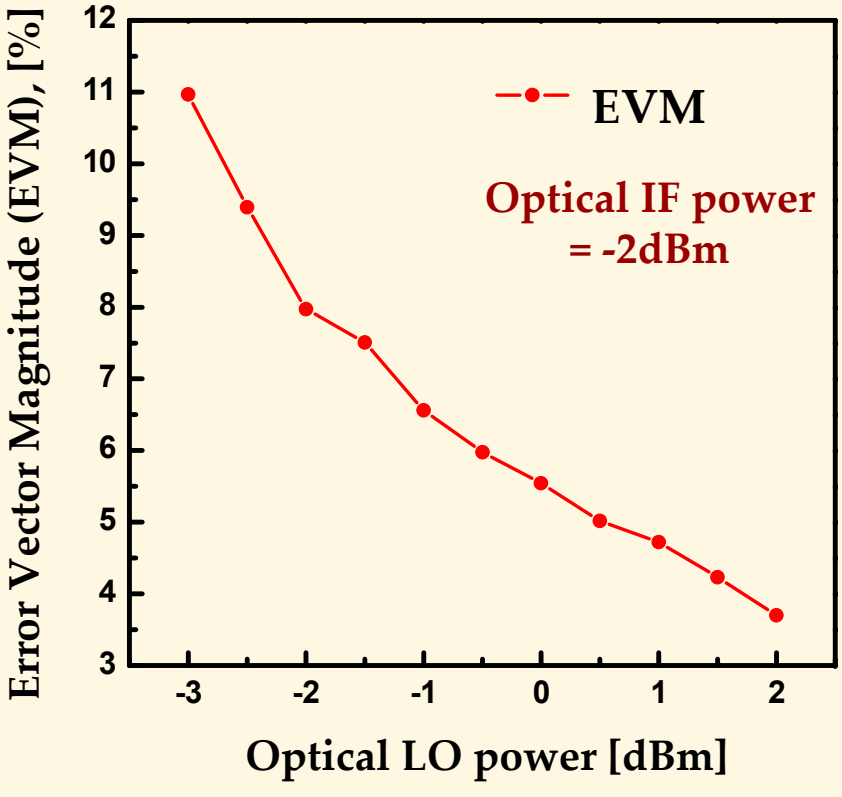
EVM =4.67%

LPF

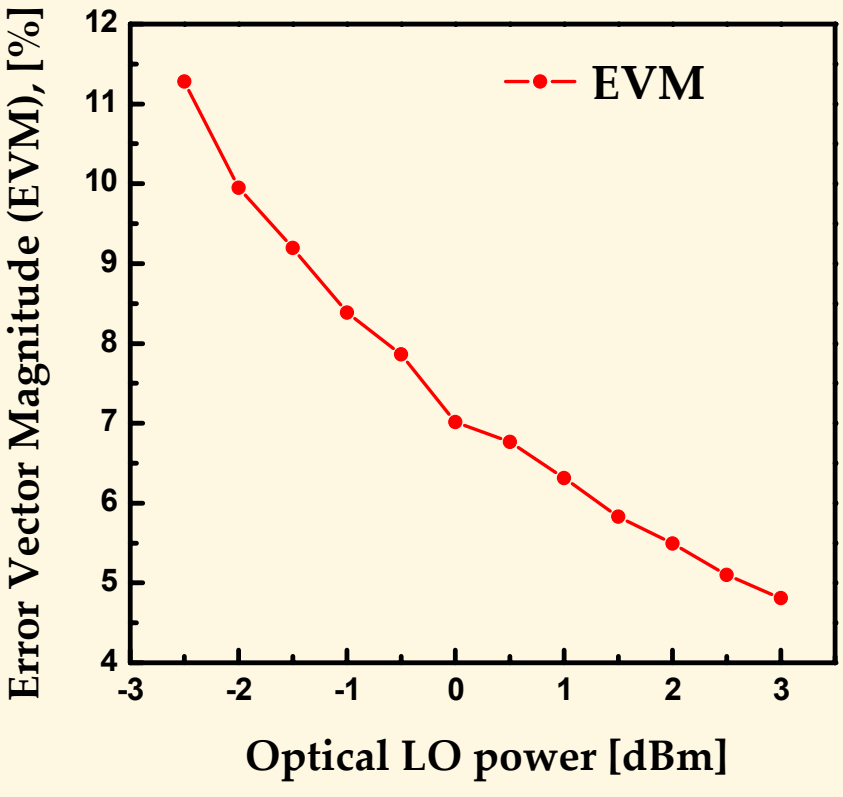
Vector Signal Analyzer

Resulting EVM VS optical LO power

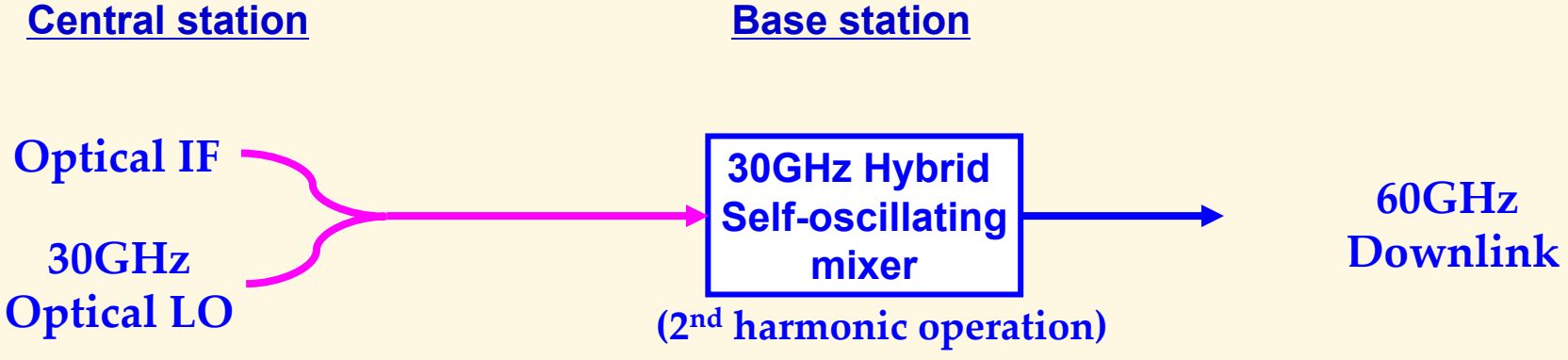
Downlink



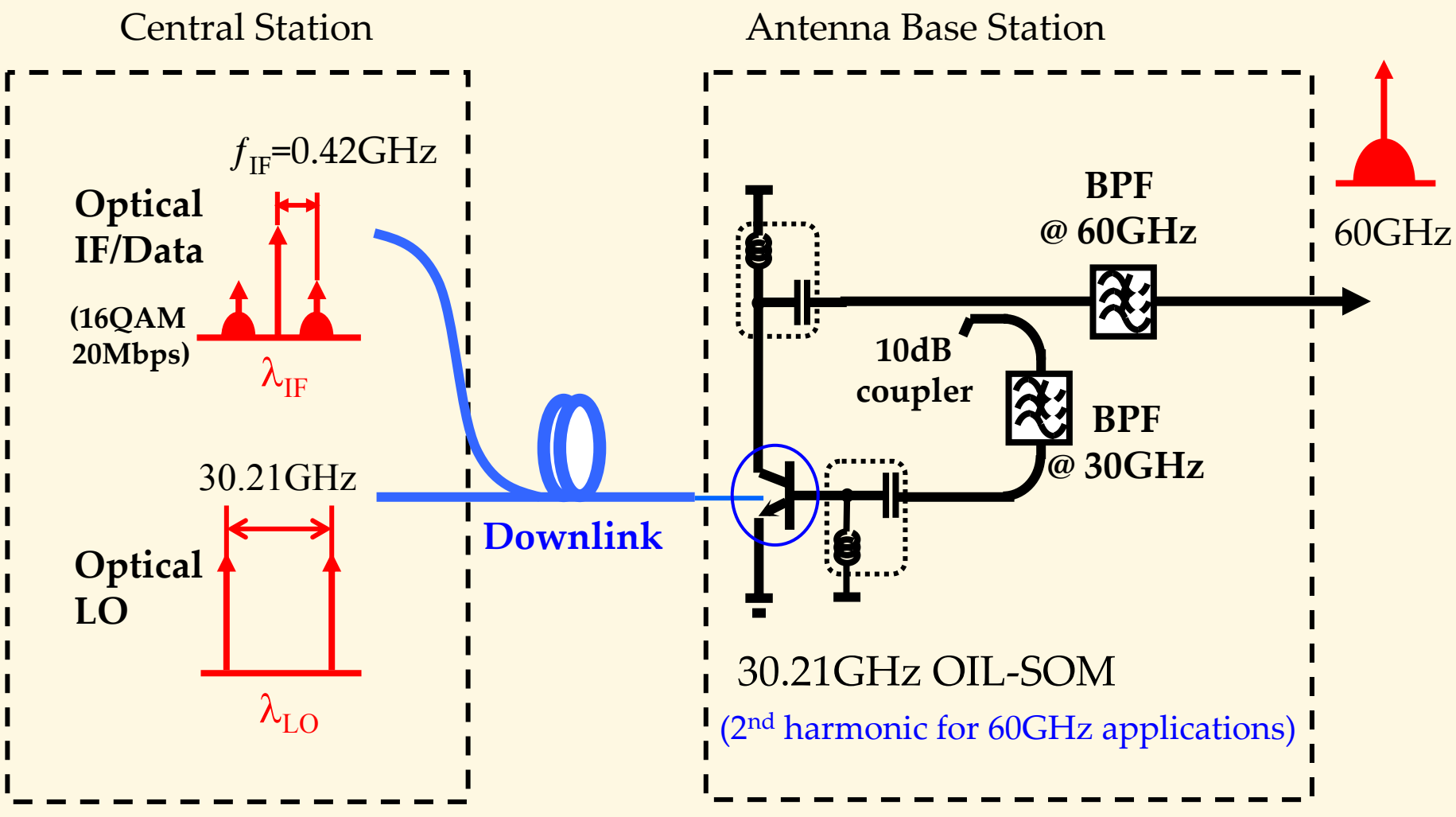
Uplink



60GHz Downlink using HBT Self-oscillating Mixer

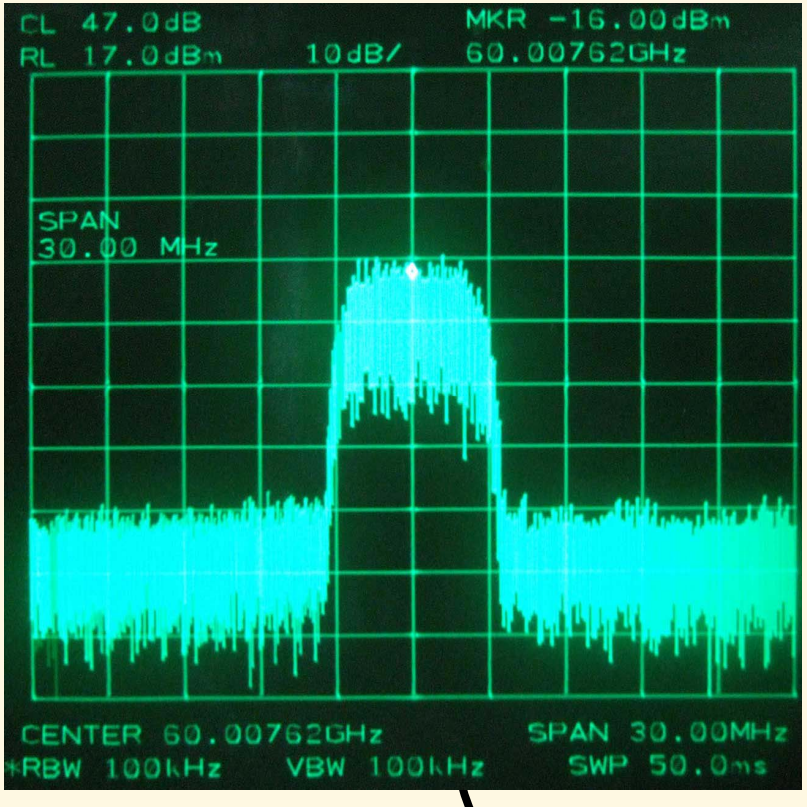


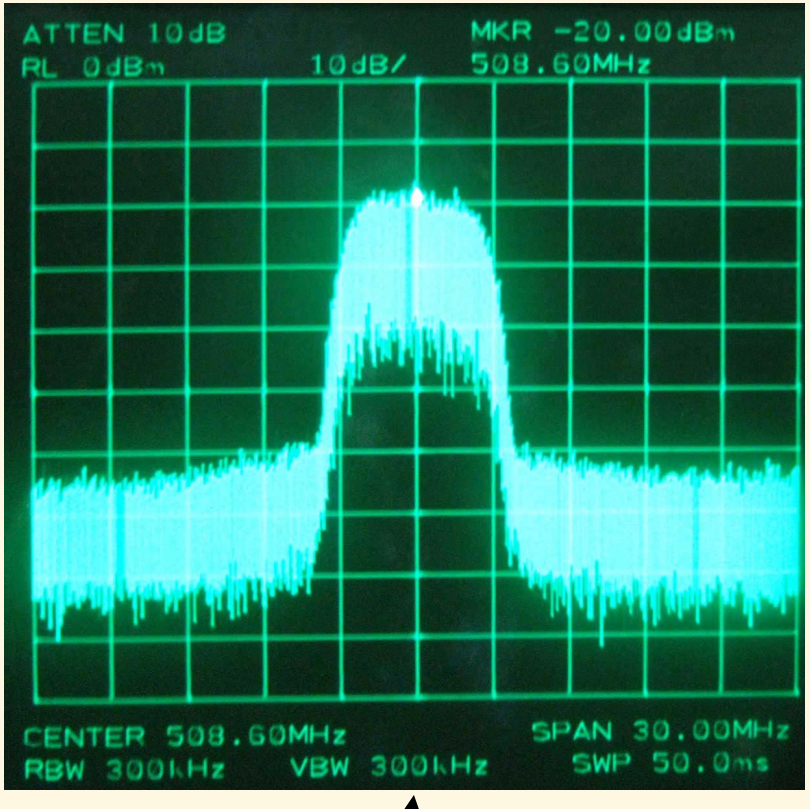
Hybrid OIL-SOM for 60GHz downlink

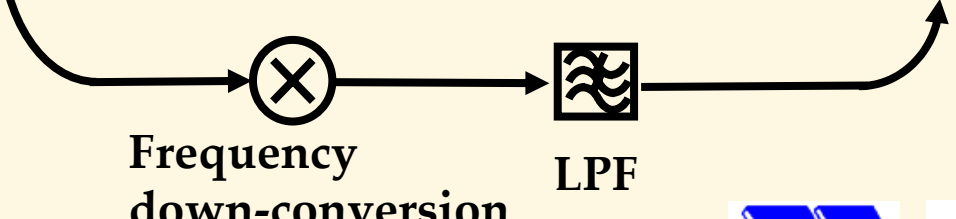


Downlink transmission results

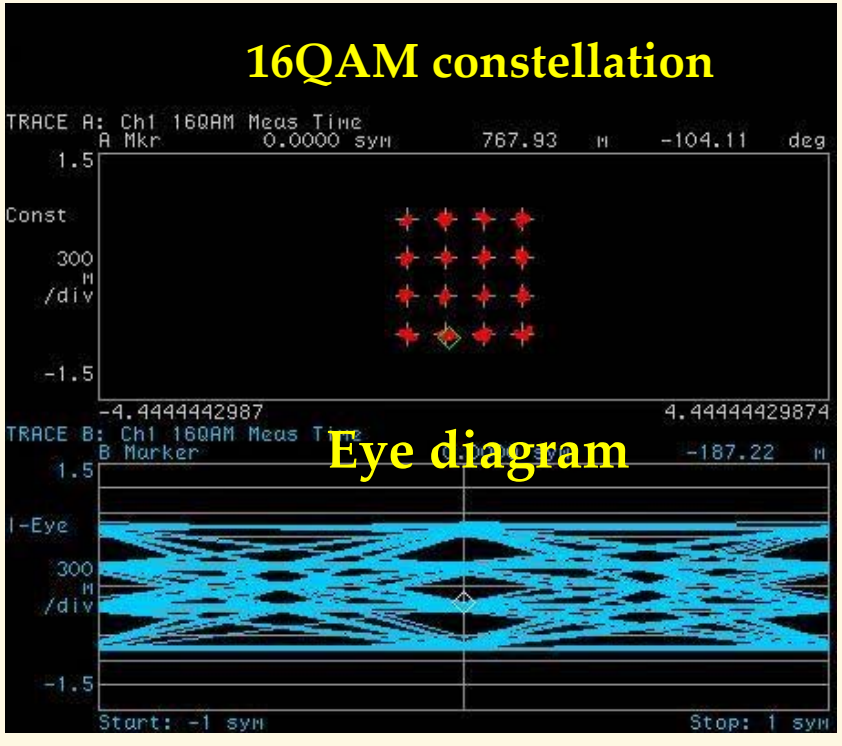
Frequency up-converted spectrum





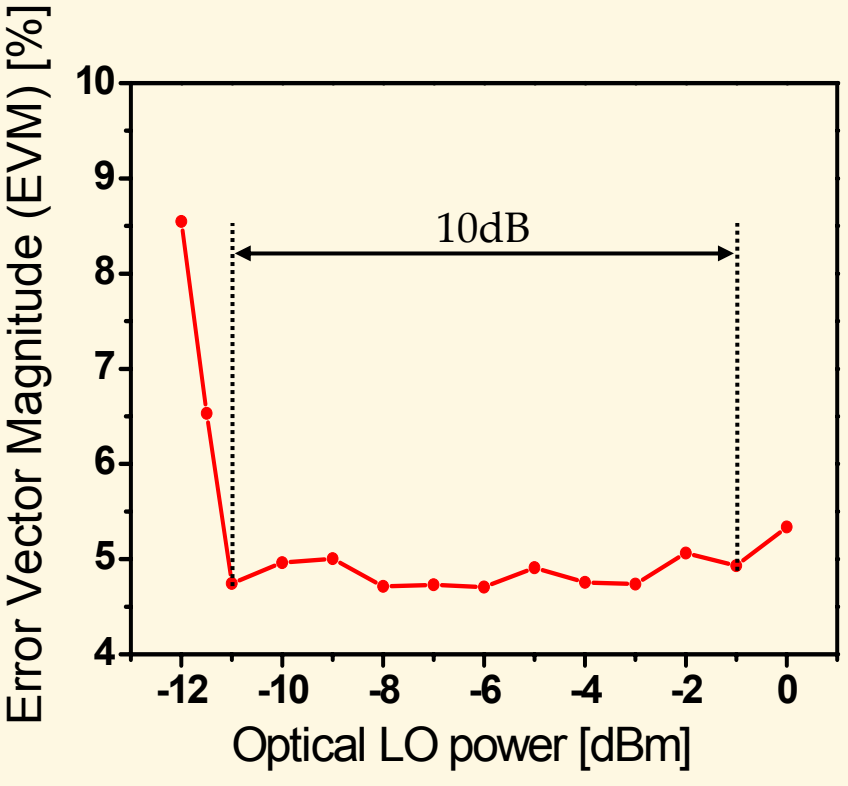


Resulting constellation and EVMs



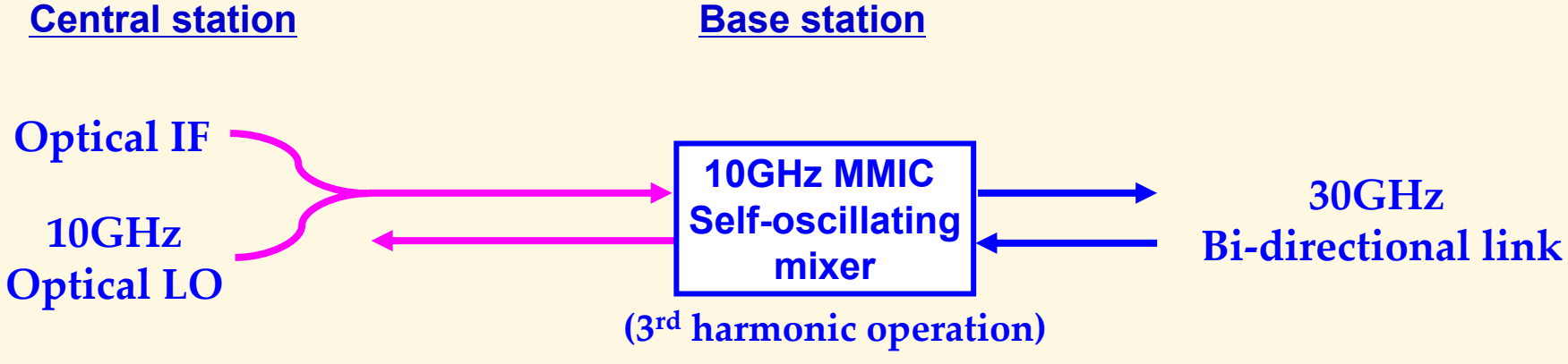
EVM =4.74%

Optical LO power = -3dBm

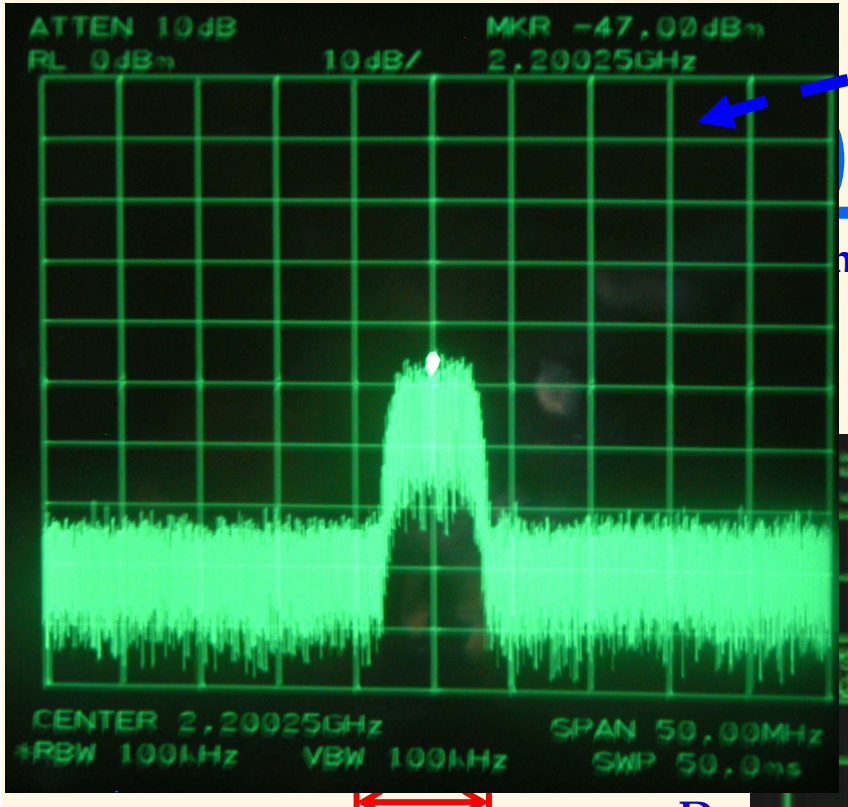


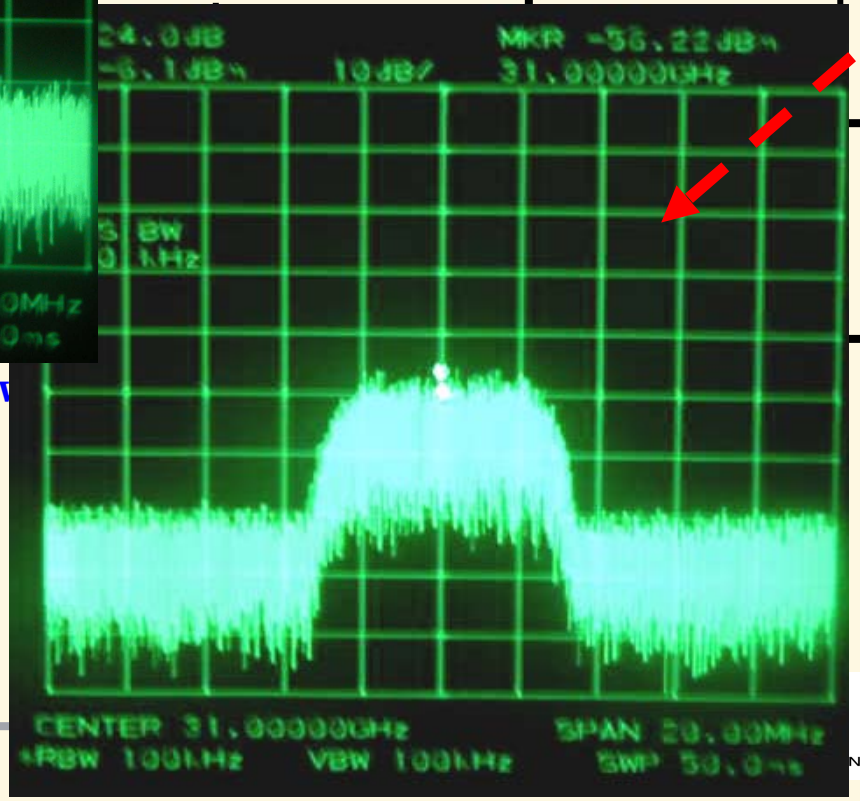
- Insensitive link performance on optical LO power

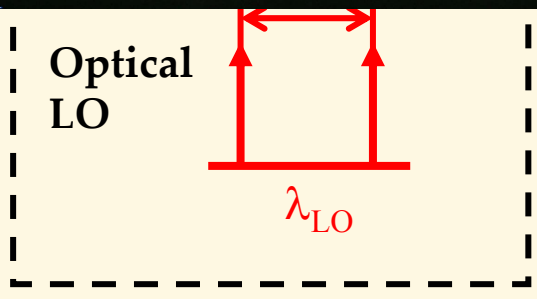
30GHz Bi-directional link using HBT Self-oscillating Mixer



MMIC OIL-SOM for 30GHz bi-directional link

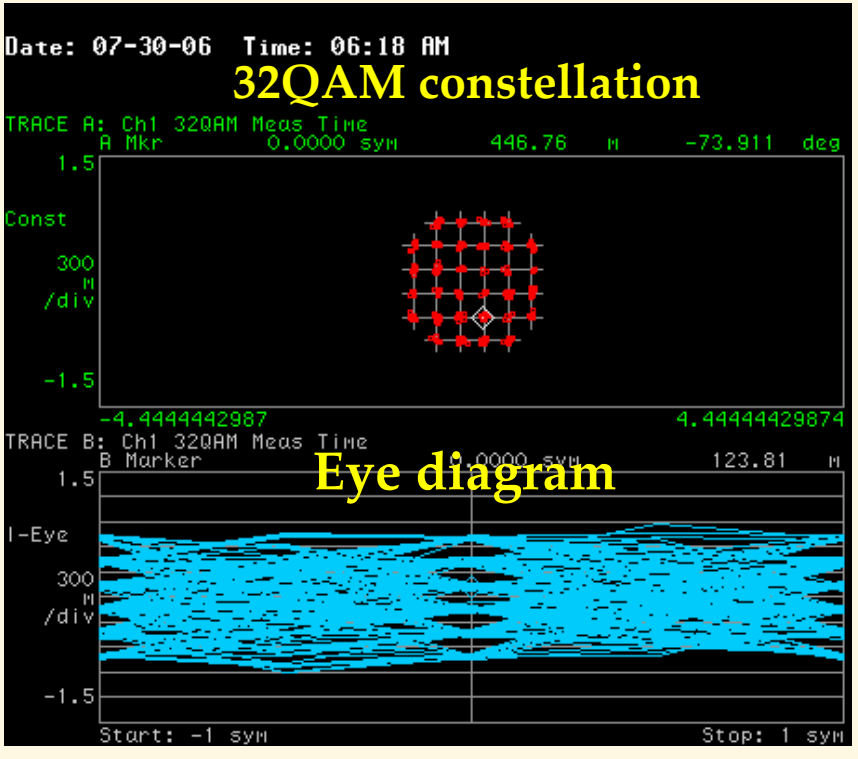






Resulting constellation and eye-diagram

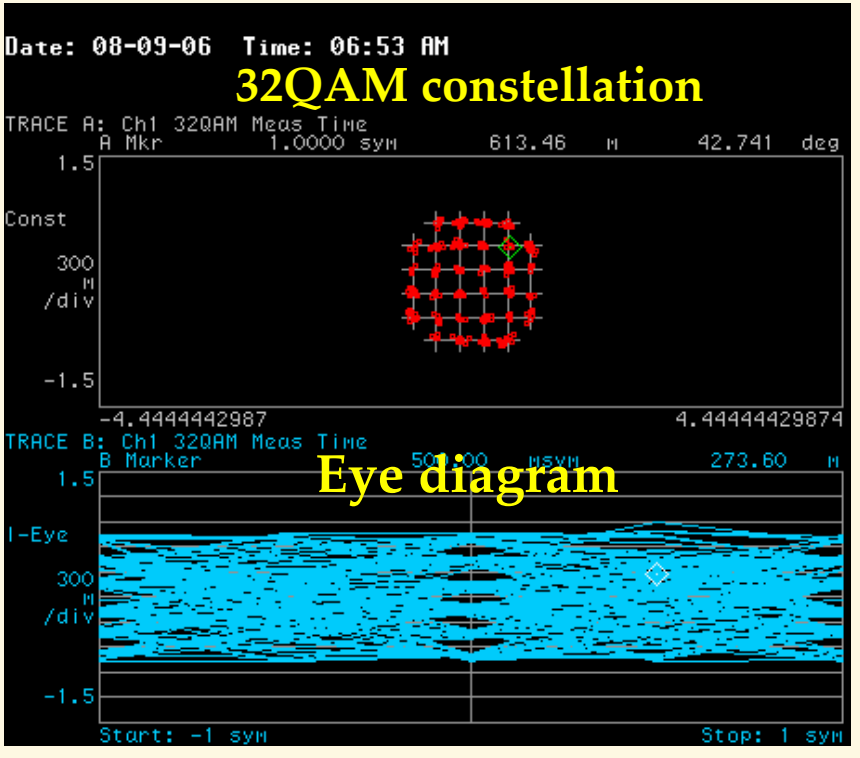
Downlink



EVM =4.34%

Optical LO power = 0dBm
Optical IF power = 0dBm

Uplink

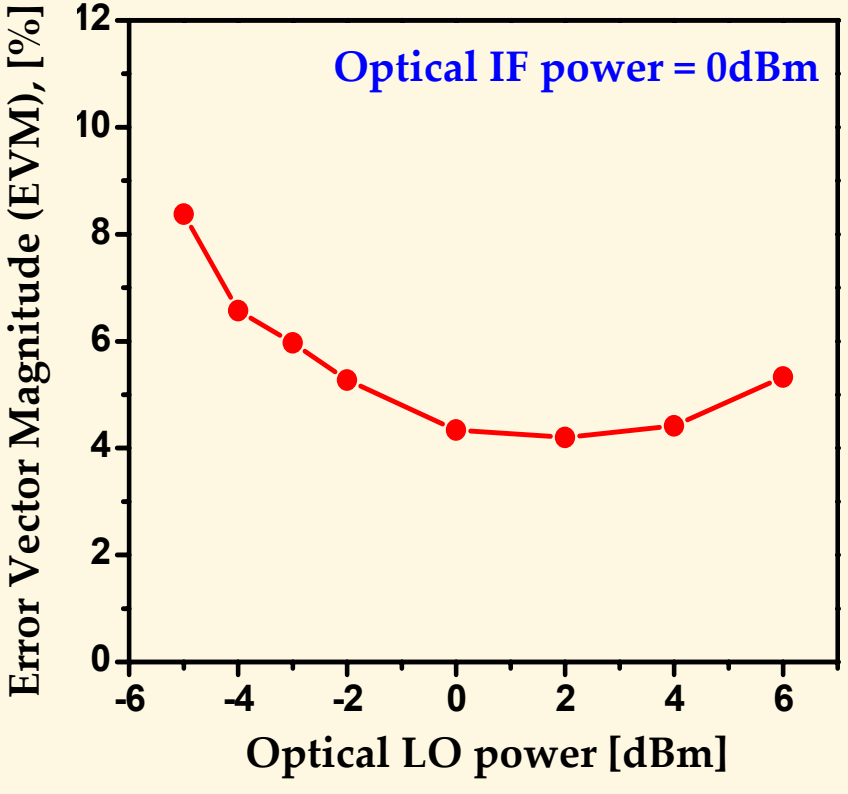


EVM =5.47%

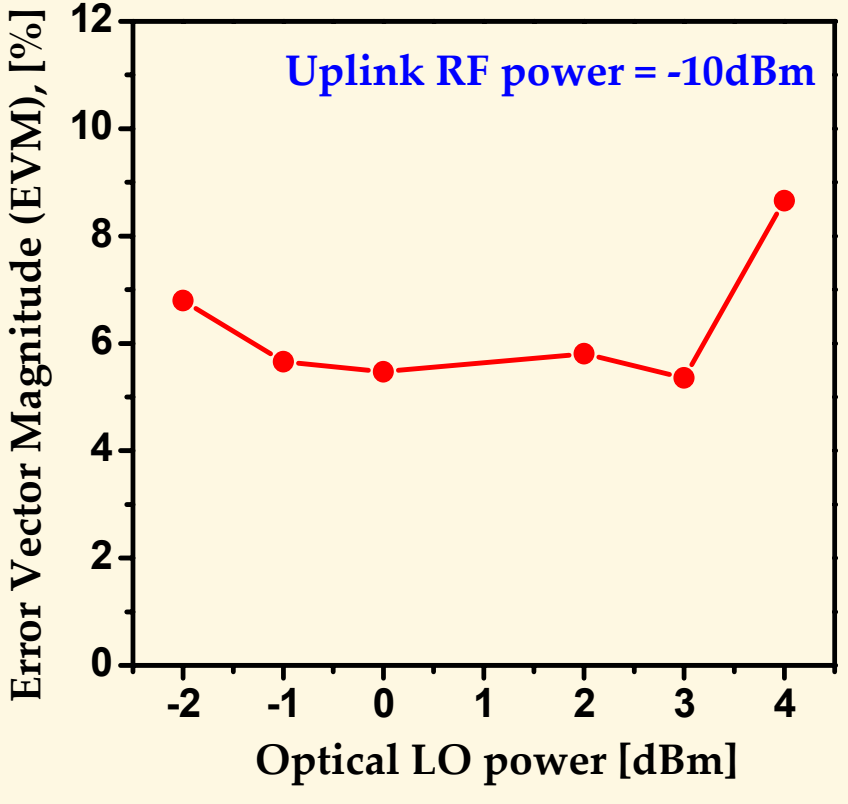
Optical LO power = 0dBm

Resulting EVM VS optical LO power

Downlink



Uplink



Summary

- InP HBT/oscillator-based optoelectronic mixers
  - For effective fiber-fed wireless systems
  - Support simple base station architecture
  - Possibility of integrated antenna base station with RF circuits
  - Effective frequency conversion with low power optical LO

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Q & A