The Ariel University Center of Samaria

The Israeli FEL Knowledge Center

P.O.Box 3, Ariel – 44837, Israel

Millimeter Waves Sensing Behind Walls - Feasibility Study with FEL Radiation

B.Kapilevich, M.Einat, A. Yahalom, M.Kanter, B.Litvak, (AUC, Ariel),

A.Gover (University of Tel-Aviv, Tel-Aviv)

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“THE REAL VOYAGE OF DISCOVERY CONSISTS NOT IN SEEKING NEW LANDSCAPES, BUT IN HAVING NEW EYES.”

-MARCEL PROUST-
a French novelist

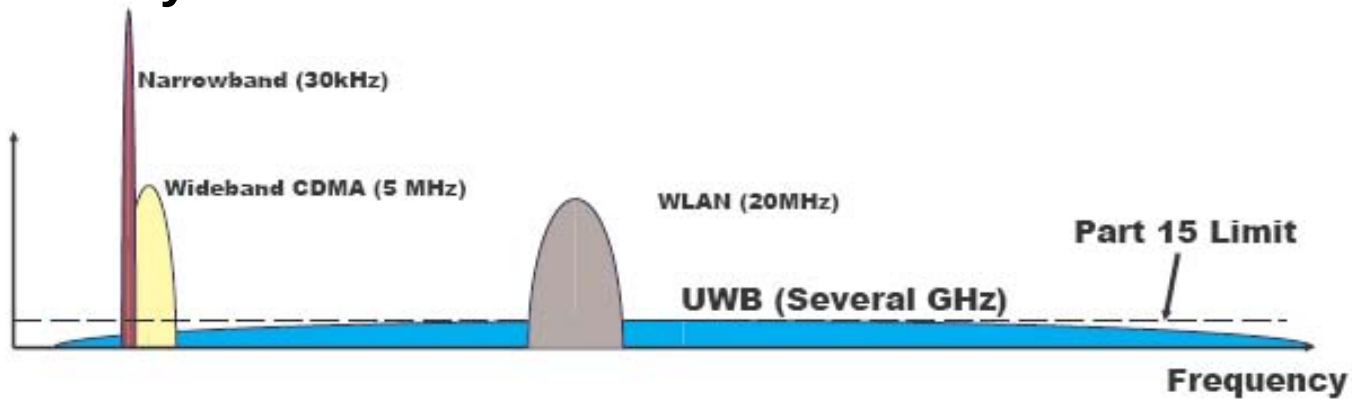
TOPICS FOR DISCUSSION

- ***INTRODUCTION;***
- ***EXPERIMENTAL SETUP;***
- ***CHARACTERIZATION OF BULDING MATERILAS USING MM-WAVE PULSE RADIATION OF THE FEL;***
- ***CHARACTERIZATION OF BULDING MATERILAS USING MM-WAVE QUASI-NOISE ILLUMINATION;***
- ***DISCUSSION AND CONCLUSIONS.***

Introduction

FCC Regulatory Issues for UWB Systems

- **Ground penetrating radar: below 960 MHz or in 3.1 to 10.6 GHz;**
- **Through-wall imaging systems: below 960 MHz or in 1.99 to 10.6 GHz;**
- **Surveillance systems: in 1.99 to 10.6 GHz;**
- **Medical systems: in 3.1 to 10.6 GHz.**

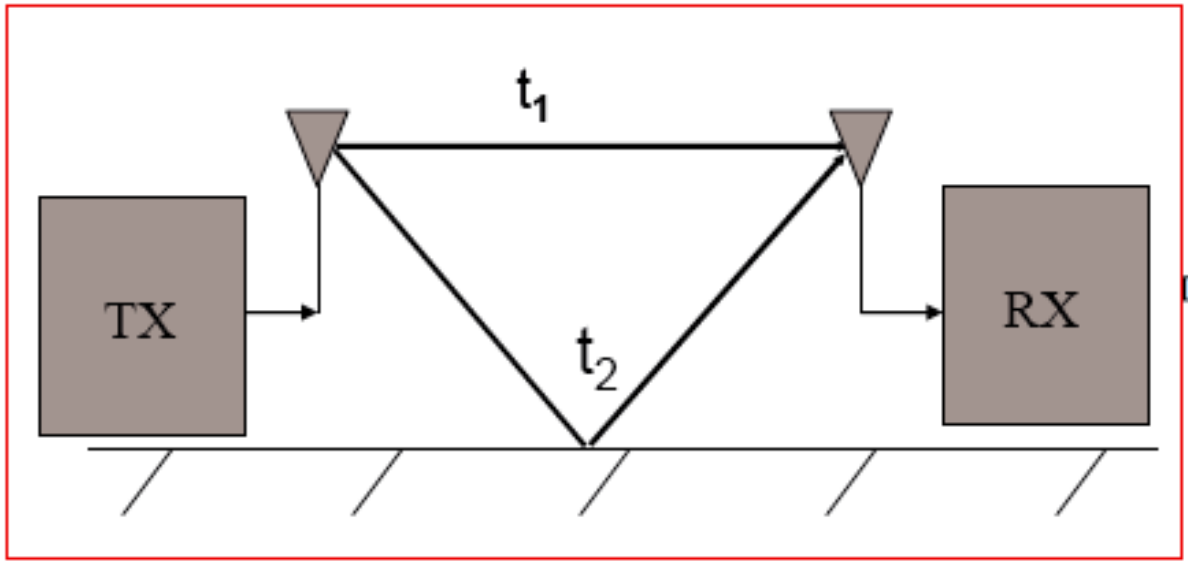


- UWB is a form of extremely wide spread-spectrum
- RF energy is spread over several GHz of spectrum

Unique Characteristics

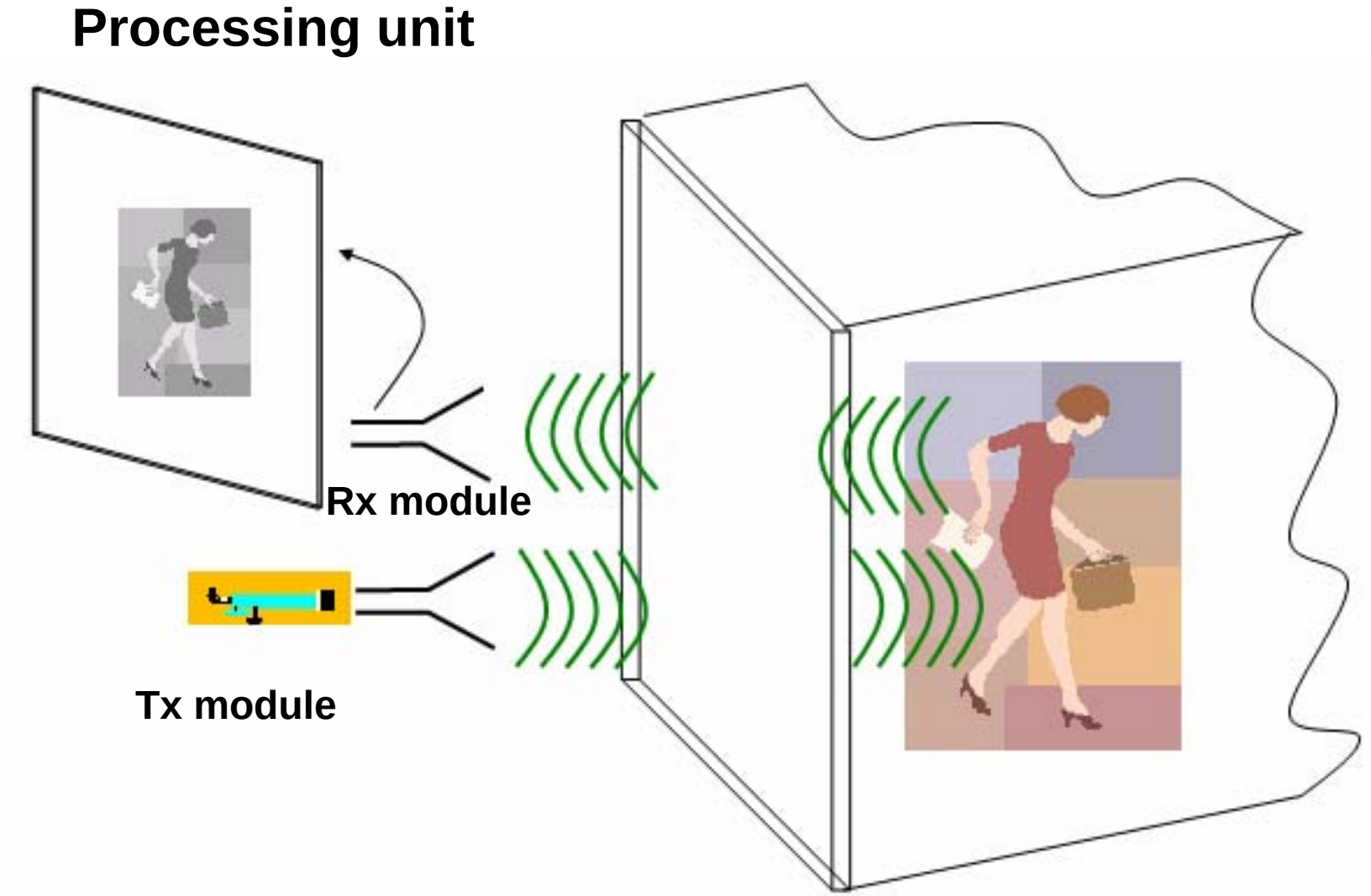
Robust Multipath Performance

- Very short pulse duration prevents destructive interference from multipath signals



Even for short distances, $t_2 - t_1$ will be much larger than the received pulse width

Typical TWI's scenery



FEL mm-wave Pulse Generation: Advantages and Questions to be answered

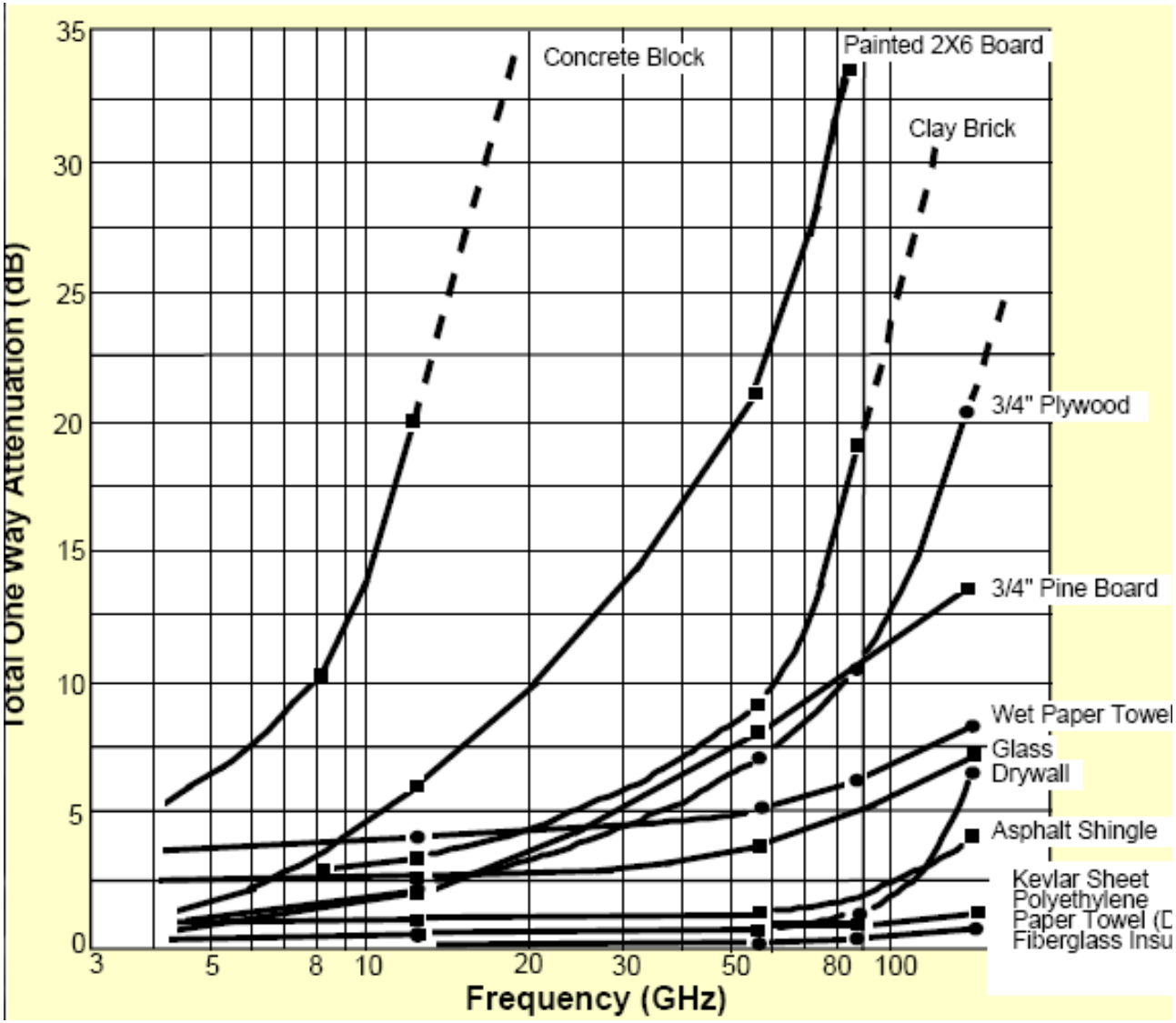
Advantages:

- Suitable for high power applications;
- Improved overall antenna performance;
- Beam forming possibility;
- Improved spatial resolution;

Questions to be solved:

- Propagation Characterization?
- Link Budgets?
- Diversity Receiver Design?
- Spatial Resolution?
- Antenna Characterization?

Wall Penetration Capability



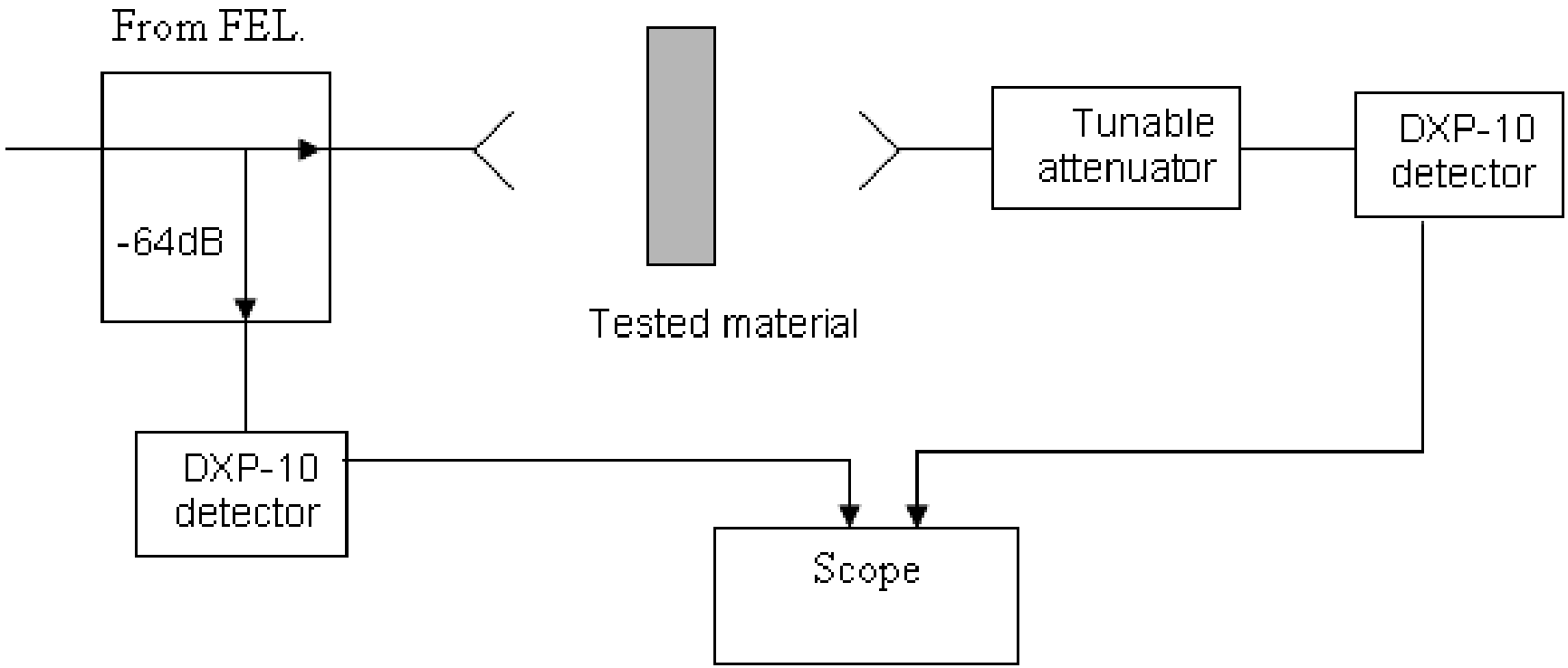
See: L. M. Frazier, "Radar Surveillance through Solid Materials,"

SPIE Photonics East Conference, Boston, MA, November, 1996.

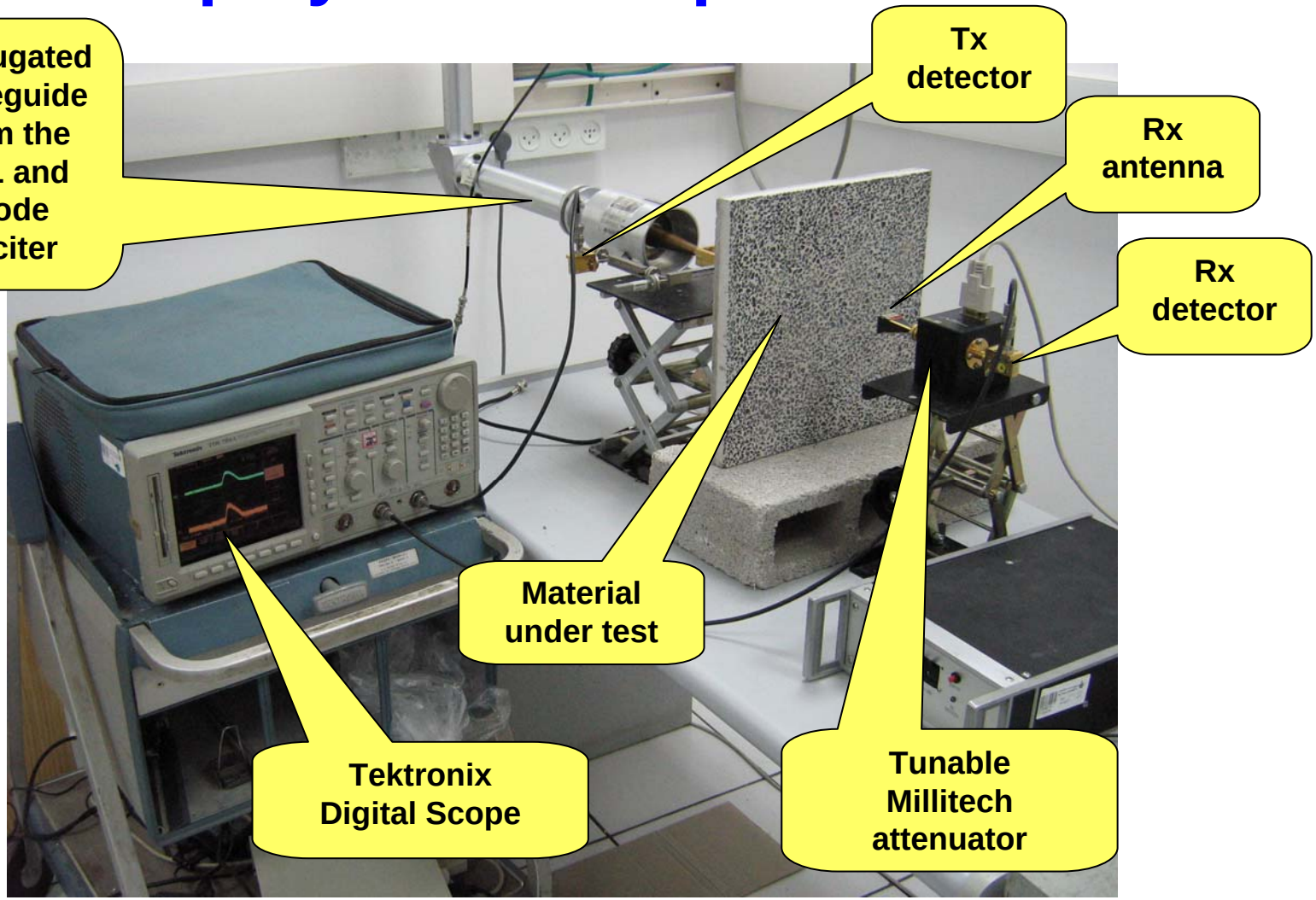
(Paper 2938-20)

Experimental setup and calibration

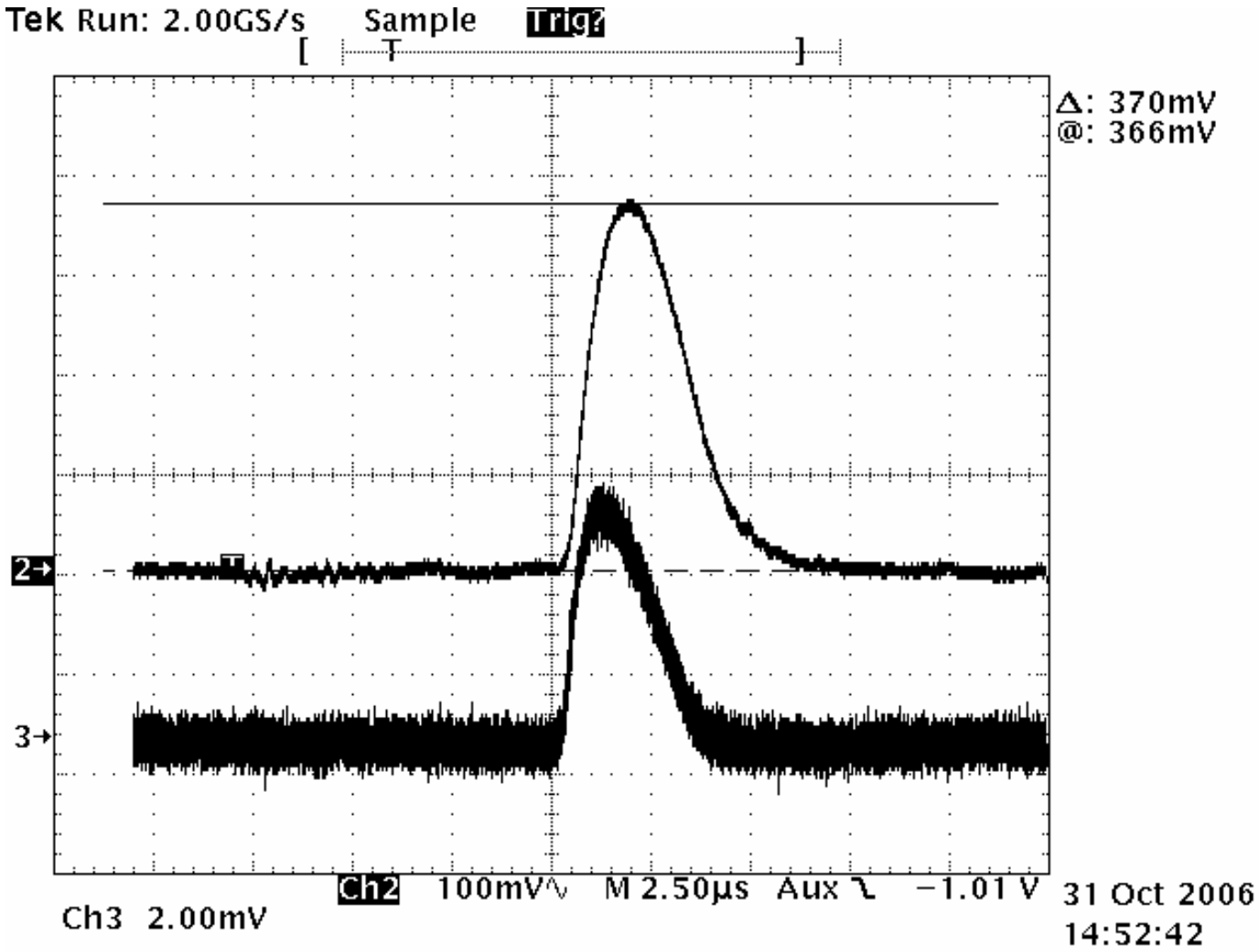
The schematic of experimental setup employed FEL experiments



General view of experimental setup employed FEL experiments



Recorded signals of Rx (channel 2) and Tx (channel 3) detectors



Coherent Characterization

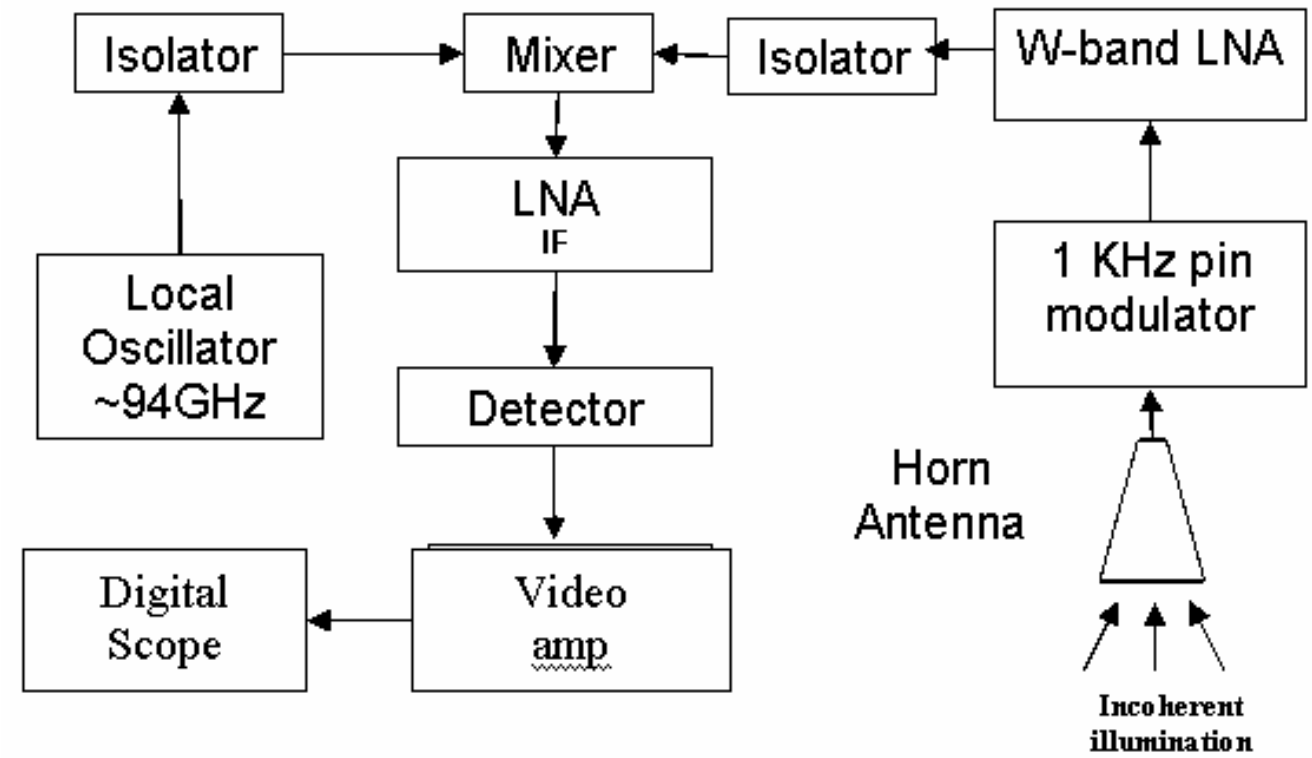
Measured attenuation of different building materials

Type of the material	Effective attenuation [dB]	Comments
one layer of wood board, 2cm	-19	Horizontal polarization
one layer of wood board, 2cm	-20.4	Vertical polarization
two layers of wood board, 4cm	-41.6	Both in Vertical polarization
one layer of gypsum board, 1.2cm	- 3.5	- - -
one plate of cement tile, 2.5cm	-39.3	Vertical polarization
one plate of cement tile, 2.5cm	-39.5	Horizontal polarization

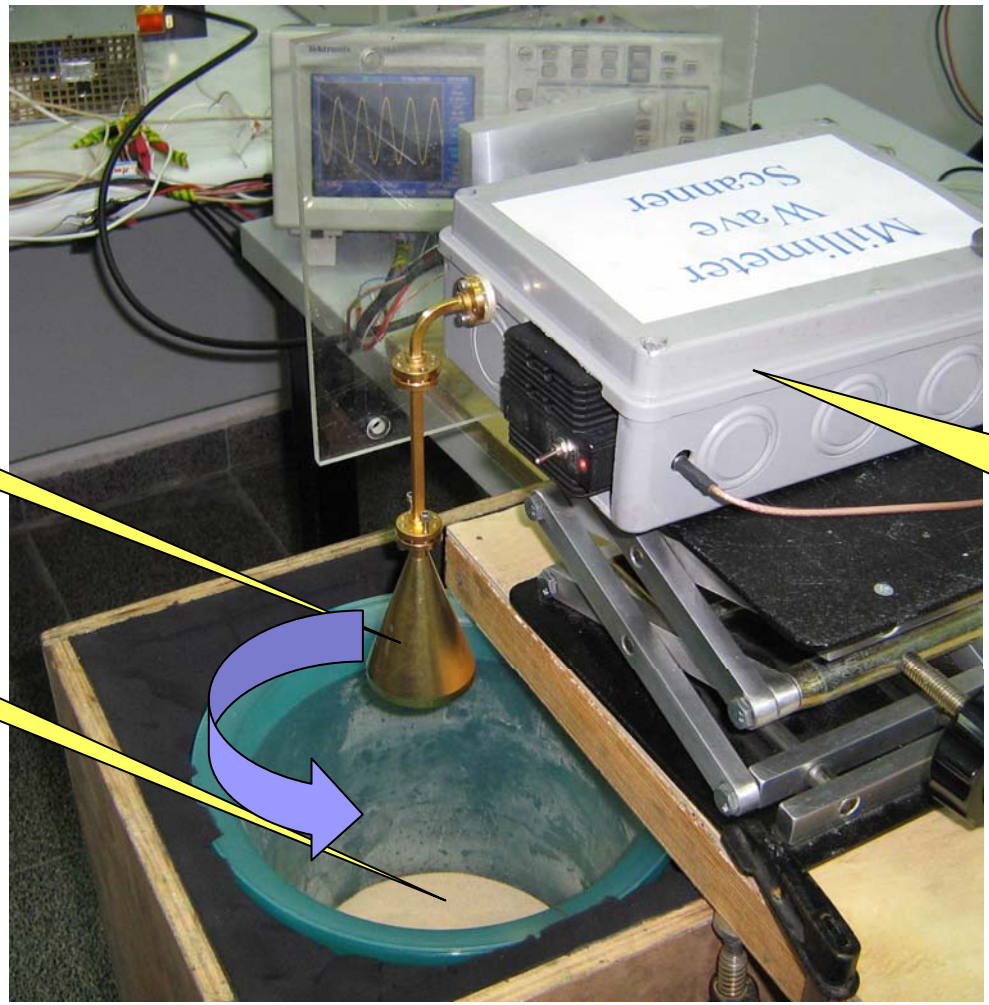
Quasi-noise Characterization

Block-diagram of the W-band sensor designed for incoherent experiments

S/N = 9 dB and BW = 12 GHz



General view of the experimental setup assembled for quasi noise experiments



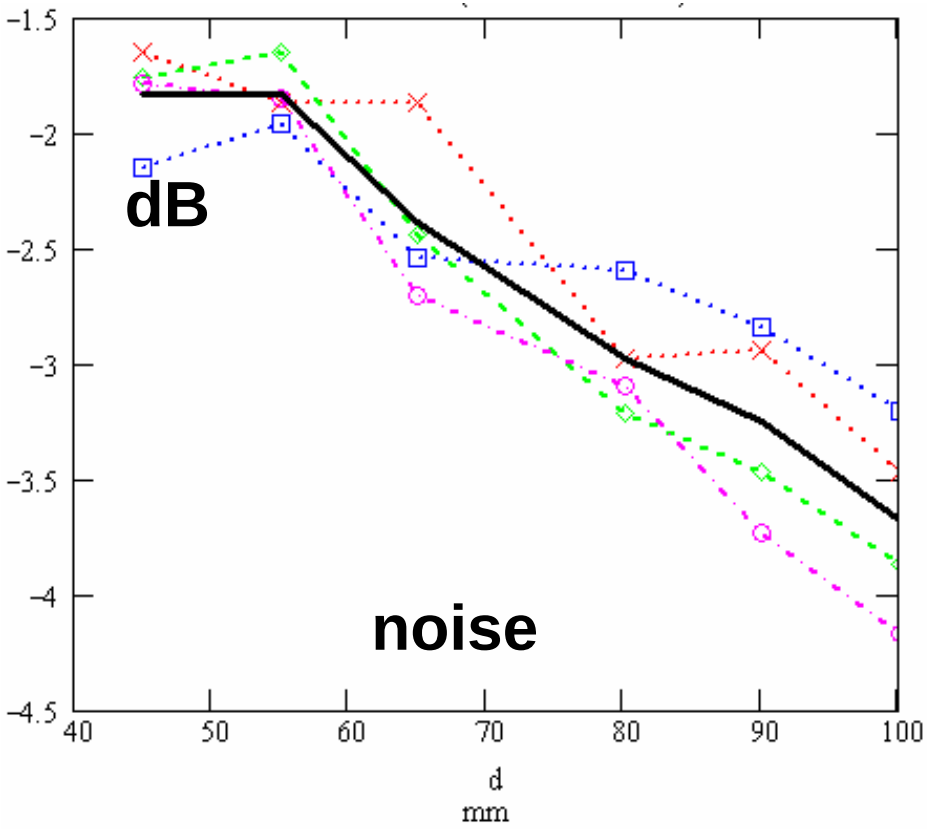
Rx antenna

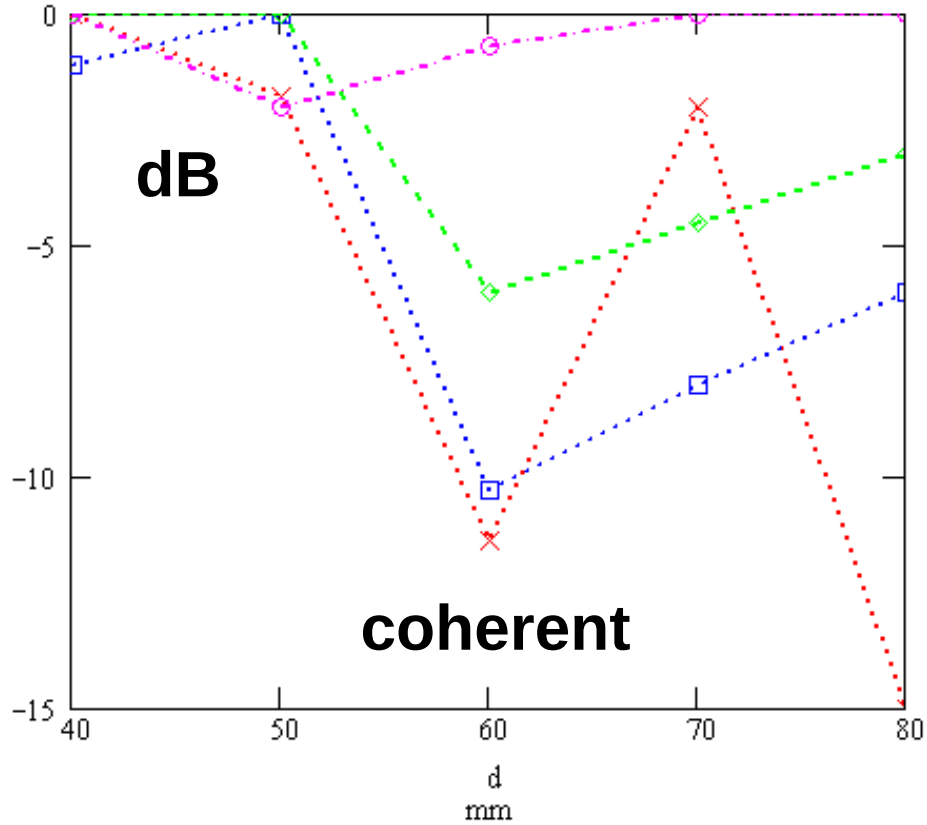
Sand under test

W-band quasi-noise sensor

Comparison results measured with quasi noise and coherent illuminations of sand for

0, 90, 180, and 270 deg. of E-field





Discussion and conclusions

1. Characterization of the selected building materials was performed using pulse FEL mm-wave radiation and quasi-noise illumination;
2. Depolarization and interference effects play important role;
3. We can expect 1 order better resolution on mm-wave in comparison with TWI system operating within microwave range;
4. Due to higher attenuation the realization of mm-wave TWI systems need more powerful sources. The mm-wave FEL is one of candidates for such purpose.

Acknowledgements

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Thank You

Q &A