The photoconductive antenna - A new device for spacegeodetic applications

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ABSTRACT

Emerging from Terahertz technology, photoconductive antennae (PCAs) are usually applied to generate terahertz radiation out of short optical laser pulses in a rather instantaneous way. As PCAs can be constructed for custom applications, this paper outlines the application of a PCA for generating microwave pulses out of picosecond laserpulses capable of being detected by VLBI systems. This could serve as an independent calibration signal for the internal VLBI signal path from feed horn to data registration. Further customization of PCAs for the relatively low VLBI frequency domain can lead to very interesting applications starting from verification of local ties up to intersystem timetransfer between SLR and VLBI systems, giving way to an experimental approach of combination of space geodetic measurements in the GGOS sense.

1 Introduction

Photoconductive antennae (PCA) are devices emerging from terahertz technology. Being a bidirectrional device, as the name antenna suggests, it is capable of transmitting an electromagnetic pulse preferable in the terahertz frequency domain, on excitation with short optical laser pulses and, vice versa, detecting a terahertz pulse in temporal coincidence with an optical laser pulse. The customized design of a PCA leads to lower frequency output in order to access the microwave region, the frequency domain where VLBI observations are carried out. Thus PCAs constructed for the operation in the microwave region can be used as a link device between microwave and optical space geodetic techniques in a variety of ways, e.g. the verification of local ties between SLR and VLBI systems, the optical to microwave time transfer and even the replacement of the existing phase calibration device.

2 Experimental setup

A first experiment was set up in order to do a phase noise measurement of a laser pulse induced microwave pulse train using the existing Ti:Sa laser system of the Satellite Observing System Wettzell (SOS-W). The laser consists of an oscillator which can be synchronized to a frequency standard by means of an external frequency synthesizer providing the nominal pulse repetitive frequency of 73MHz. This frequency synthesizer can in turn be synchronized as well to a stable reference frequency provided by a maser for time transfer experiments. For nominal SLR operation, the oscillator output is amplified at a repetition rate of 1kHz. This option hasn't been used throughout this experiment due to the fact that the phase noise analysis of 73MHz is much more comfortable with the equipment in use. Figure 1 illustrates the setup with the laser head on the right side. The output is guided by two steering mirrors onto the PCA where the optical pulses are converted to microwave pulses. These are detected by a comercial satellite TV receiver (LNB) at a bandwidth of 11GHz. Next to a schematic setup of the experiment the inlet of figure 1 shows the signals displayed with a 50GHz sampling oscilloscope. The upper pink trace corresponds to two adjacent optical laser pulses.

3 Phase noise analysis

For the phase noise analysis, the laser oscillator is operated synchronously with the 73MHz output of a frequency synthesizer, which is also used to provide a 10MHz reference signal for the phase noise analyzer. The phase noise analyzer (Rhode&Schwarz) is connected to the output of the LNB mentioned in the experimental setup section. To give an overview on the frequency bandwidth of the obtained LNB output an electrical spectrum was recorded from 10MHz up to more than 13GHz. The obtained frequency comb with equidistant spacings of the 73MHz pulse repetition frequency is displayed in figure2. The slope of the spectral power corresponds to a gaussian pulse shape of 40ps width.

The phase noise measurement shown in firgure 3 is performed on the signals first harmonic. The signal starts at a carrier normalized level of -40dBc for 1Hz offset frequency and reaches the noise floor at -130dBc and an offset frequency of 300kHz. The slope shows some volatile peaks of spurious signals as well as some residual phase noise arising from the laser oscillator length stabilization.

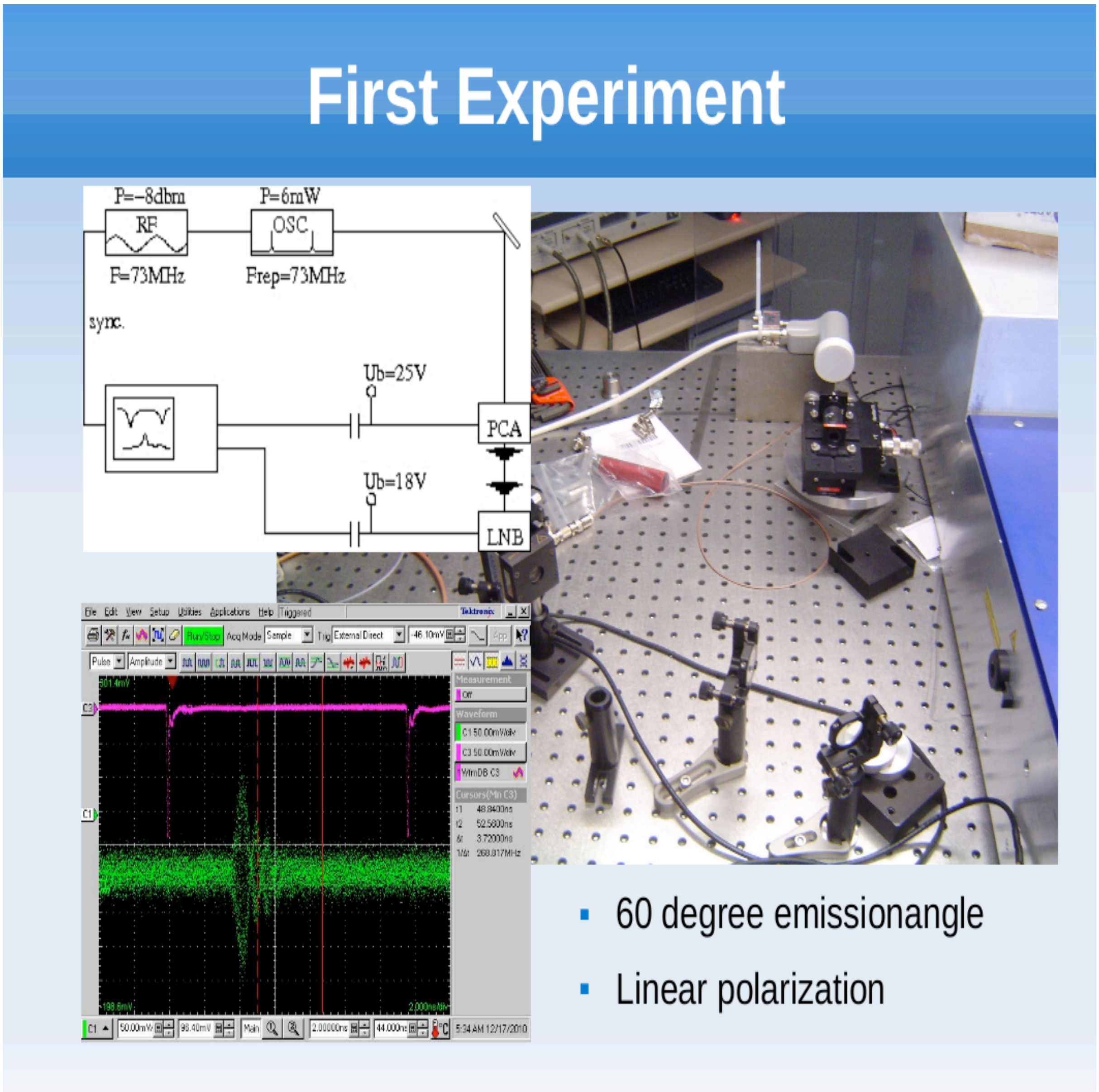

Figure 1 Basic schematic setup, illustration and oscilloscope traces of the first photoconductive antenna experiment.

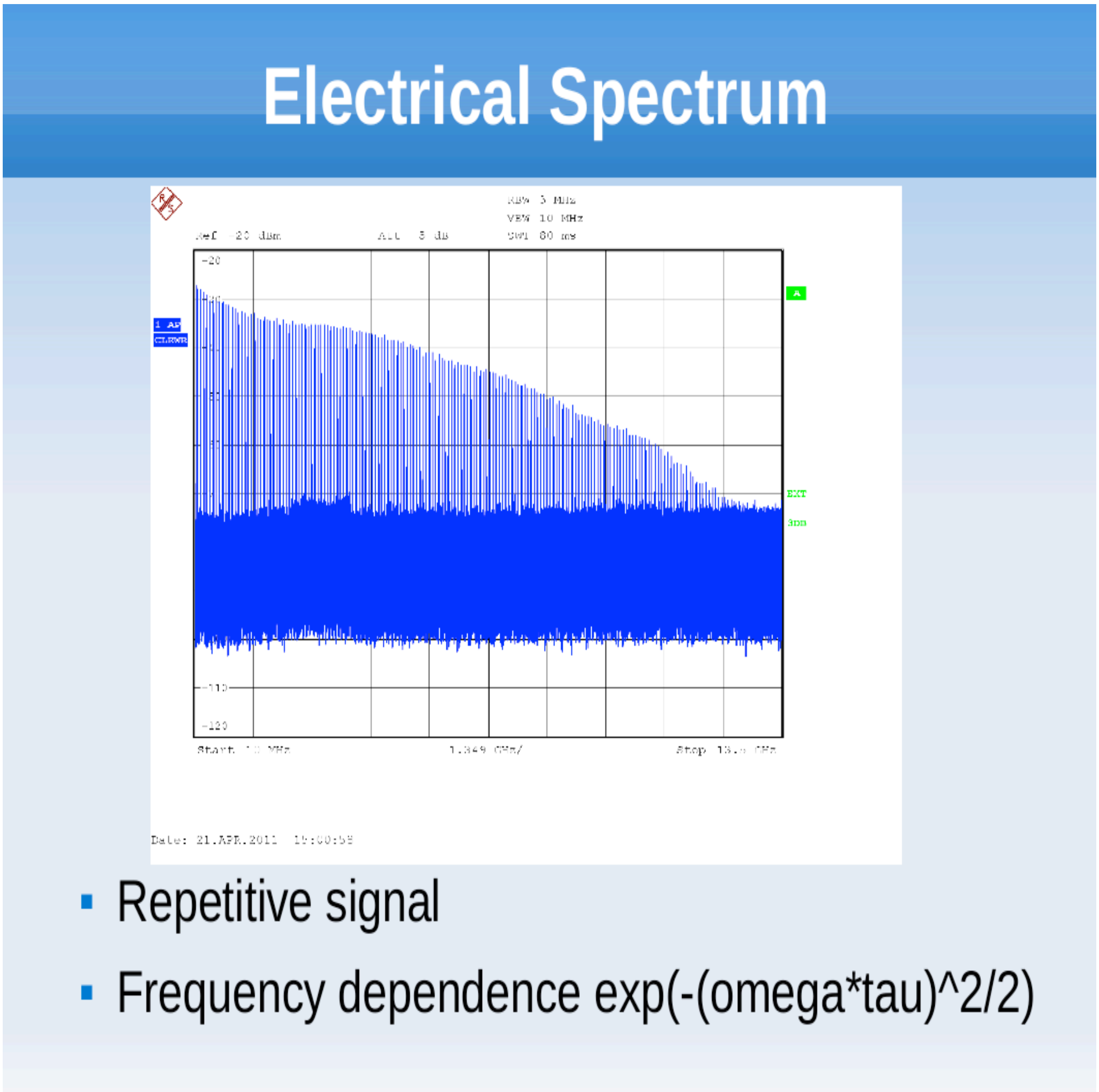

Figure 2 Frequency comb obtained from electromagnetical signal of a photoconductive antenna detected by an LNB and recorded by an electtrical spectrum analyzer

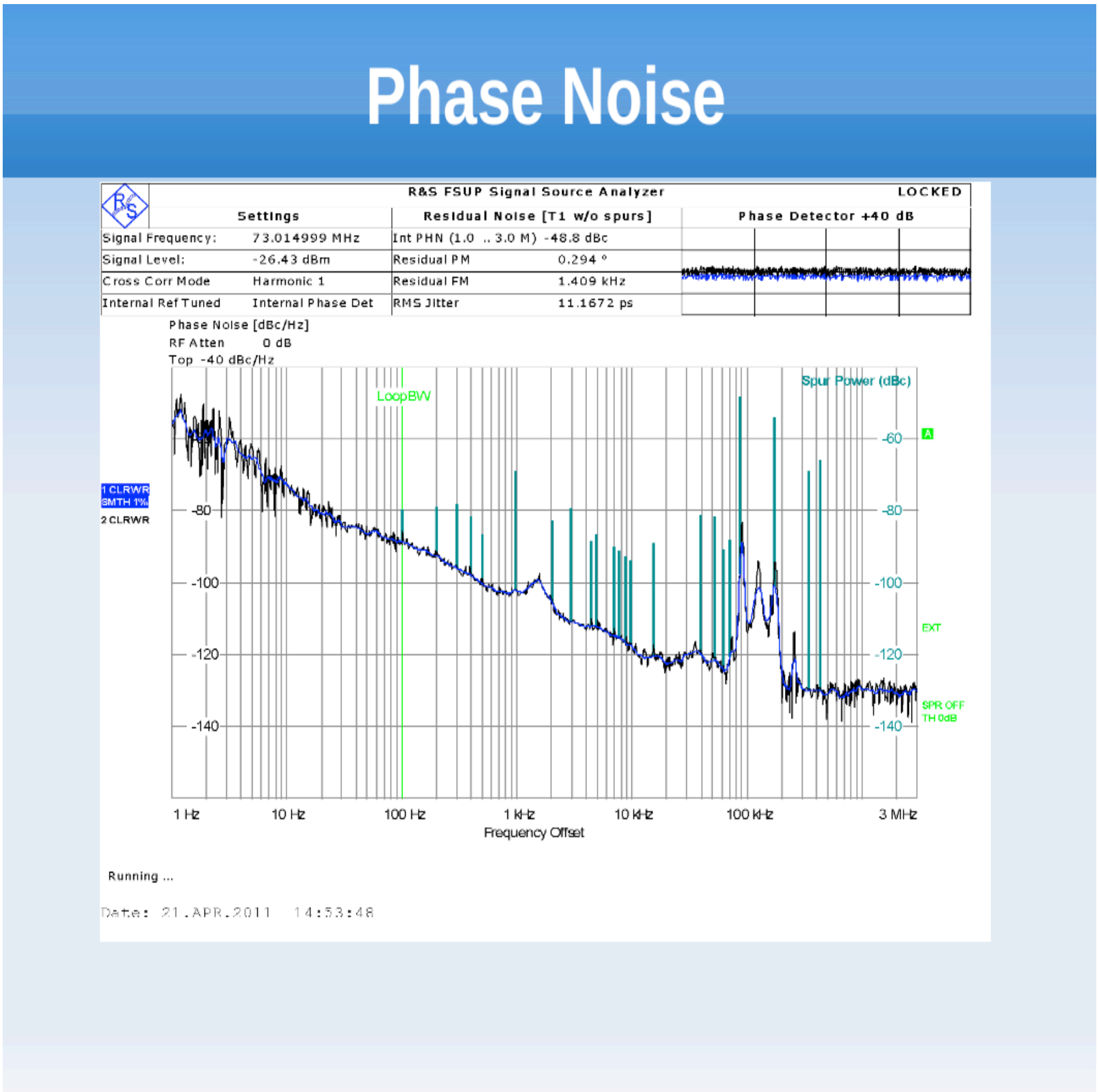

Figure 3 **Frequency comb obtained from electromagnetical signal of a photoconductive antenna detected by an LNB and recorded by an electtrical spectrum analyzer**

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