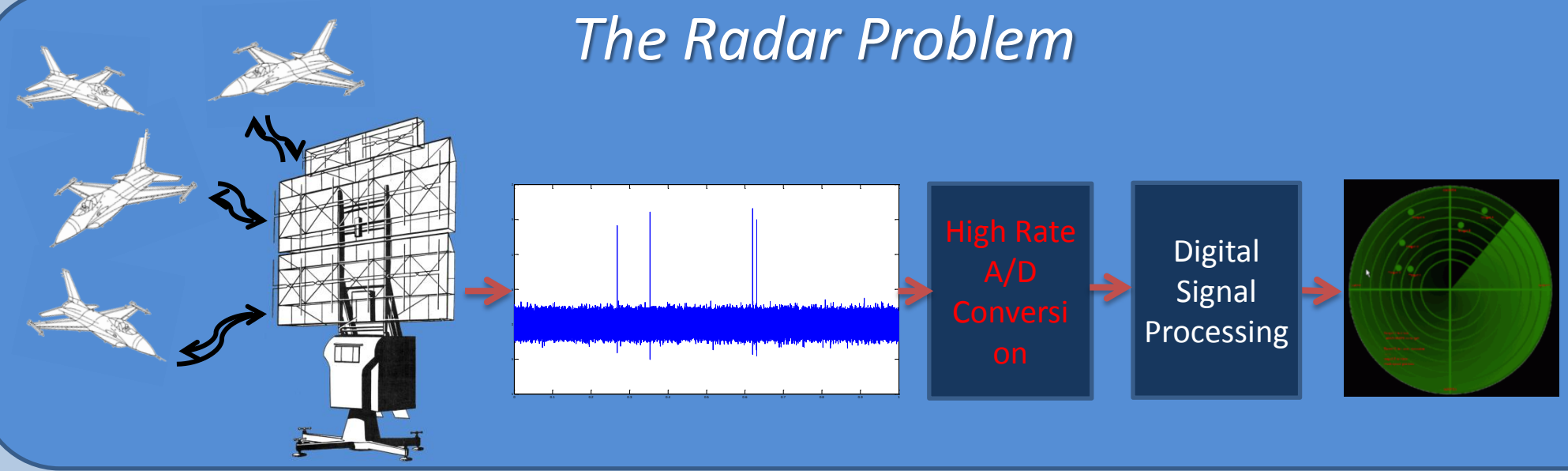
Technion Israel Institute of Technology
High Speed Digital Systems Lab
Electrical Engineering Department
HS DSL
NATIONAL INSTRUMENTS

Sub-Nyquist Radar Sensing

Front-End and Algorithm

Omer Bar-Ilan, Eliahu Baransky, Gal Itzhak, Noam Wagner, Idan Shmuel, Rolf Hilgendorf and Prof. Yonina Eldar

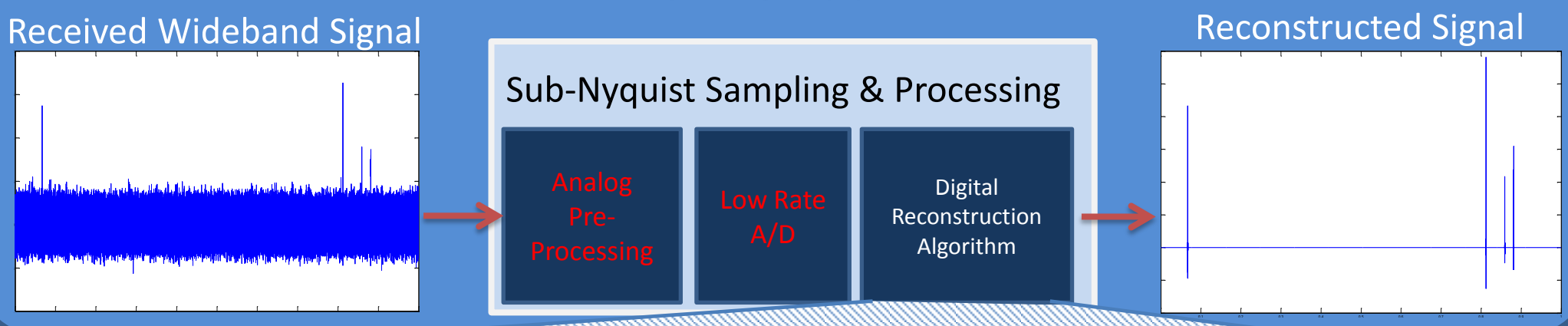
The Radar Problem



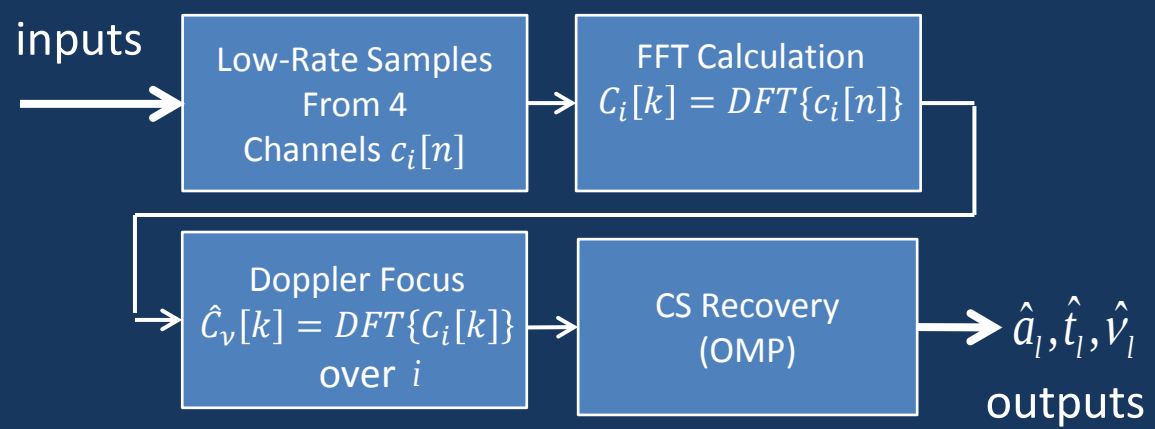
Doppler Focusing

Doppler focusing processing technique uses target echoes from consecutive pulse-transmissions to create a single superimposed pulse. It implicitly estimates targets' Doppler frequencies in the process of estimating target delays and amplitudes. The recovery is based on the Xampling framework, which allows reducing the number of samples needed to accurately represent the signal, directly in the analog-to-digital conversion process. After sampling, the entire digital recovery process is performed on those low rate samples without ever having to return to the Nyquist rate. When sampling at one tenth the Nyquist rate, and for SNR above -25dB, Doppler focusing achieves results almost equal to classic recovery working at the Nyquist rate.

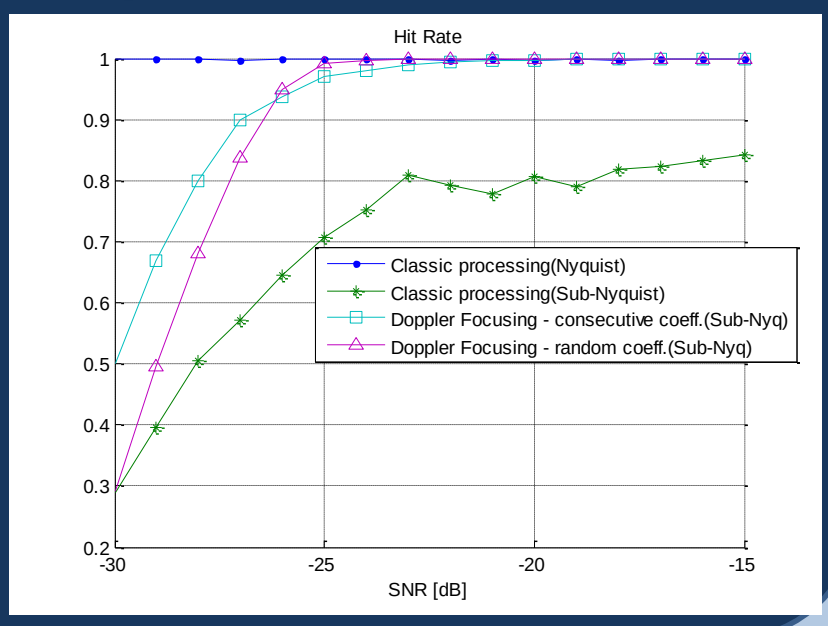
Xampling approach



Flow of Reconstruction Algorithm



A/D rate is 1/20 of Nyquist rate, while actual number of samples used for recovery is 1/3 of A/D rate



References

[1] O. Bar-Ilan and Y. C. Eldar, "Sub-Nyquist Radar," SCC'2013, Jan. 2013.
[2]G. Itzhak, E. Baransky, N. Wagner, I. Shmuel, E. Shoshan and Y. C. Eldar, "A Hardware Prototype for Sub-Nyquist Radar Sensing," SCC'2013, Jan. 2013.
[3] R. Tur, Y. C. Eldar, and Z. Friedman, "Innovation rate sampling of pulse streams with application to ultrasound imaging," Signal Processing, IEEE Trans. on, vol. 59, no. 4, pp. 1827–1842, 2011.
[4] K. Gedalyahu, R. Tur, and Y.C. Eldar, "Multichannel sampling of pulse streams at the rate of innovation," Signal Processing, IEEE Trans. on, vol. 59, no. 4, pp. 1491–1504, 2011.

http://webee.technion.ac.il/people/YoninaEldar/index.html

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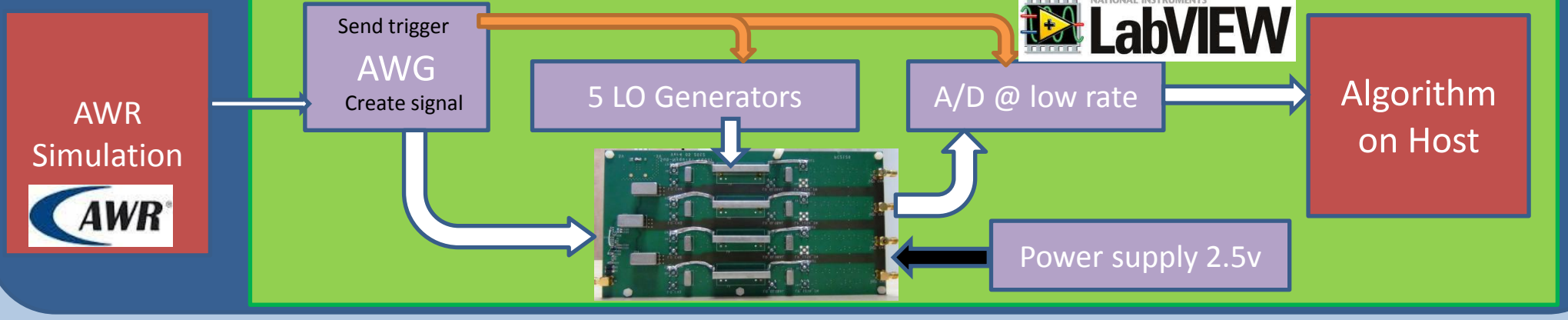
Hardware and Supporting System

Idan Shmuel, Rolf Hilgendorf, Eli Shoshan and Prof. Yonina Eldar

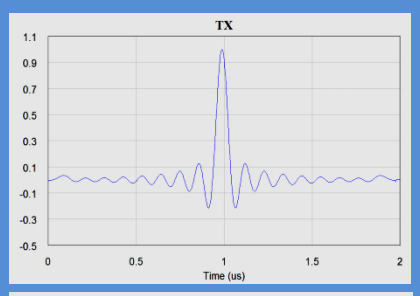
Demo System Top Level

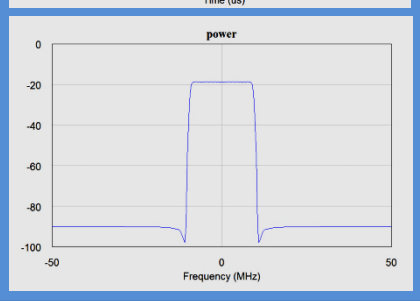


AWR RF Medium simulation

Pulse in time domain

Pulse in frequency domain



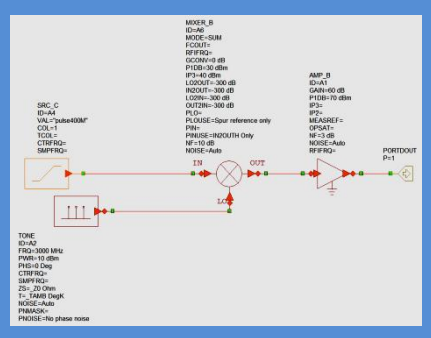


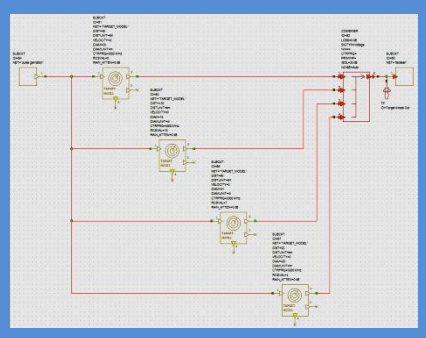
medium and targets

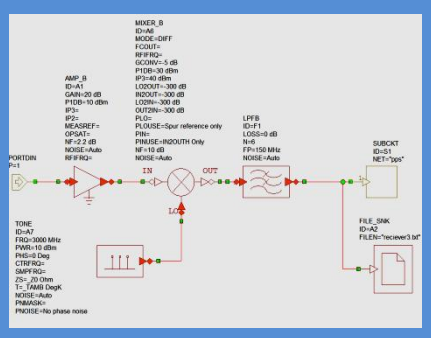
transmitter

speed, distance, cross section

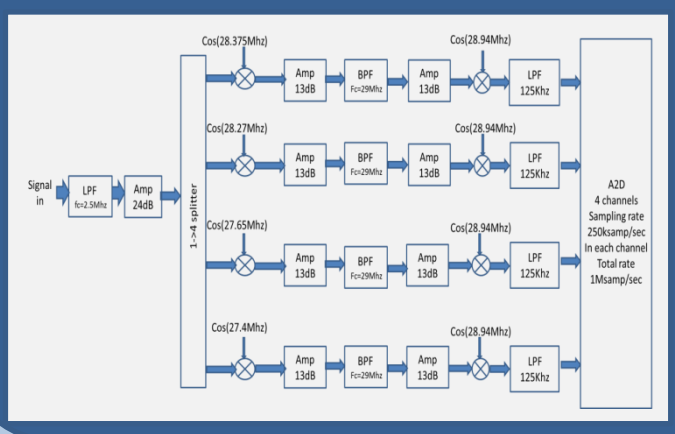
receiver front end







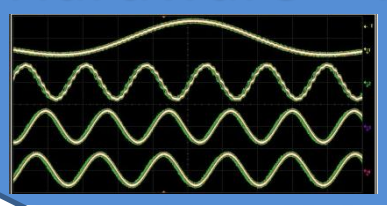
PPS- Pulse Pre Sampler



- Input signal BW< 150MHz
- Crystal filter BW 70KHz
- Modular and flexible design
- Dynamic range 65dB

Supporting Hardware – NI System

3 NI Flex Rio 7965R FPGA and NI 5781 Baseband transceiver create 5 local oscillators waveforms with constant starting phase



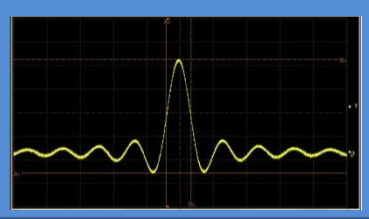
NI 6672 timing and synchronization module distribute clock and trigger signals

NI 6123 4 channels simultaneous A/D @ 250Ksamp/sec per channel

System Challenges:

- Start all devices at the same time with skew less then 1nsec
- Good synchronization- Low clock jitter and small clock drifts between devices
- Connectivity- AWR RF simulation environment to LabView

NI 8133 I7 controller
Run AWR , LabView and MATLAB script



NI 5451 Arbitrary Waveform Generator transmits pulse waveform

NI 5690 RF amplifier

NI 4130 Power supply to PPS