Project: IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)

Submission Title: Direct and Directed NLOS Channel Measurements for Intra-Device Communications

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Source: Alexander Fricke, Thomas Kürner, TU Braunschweig
Address Schleinitzstr. 22, D-38092 Braunschweig, Germany
Voice:+495313912416, FAX: +495313915192, E-Mail: fricke@ifn.ing.tu-bs.de/t.kuerner@tu-bs.de

Re: n/a

Abstract: Channel measurements based on a vector network analyzer are presented for the operational modes direct transmission and directed non-line-of-sight transmission.

Purpose: Contribution towards developing an intra-device channel model for use in TG 3d

Direct and Directed NLOS Channel Measurements for Intra-Device Communications

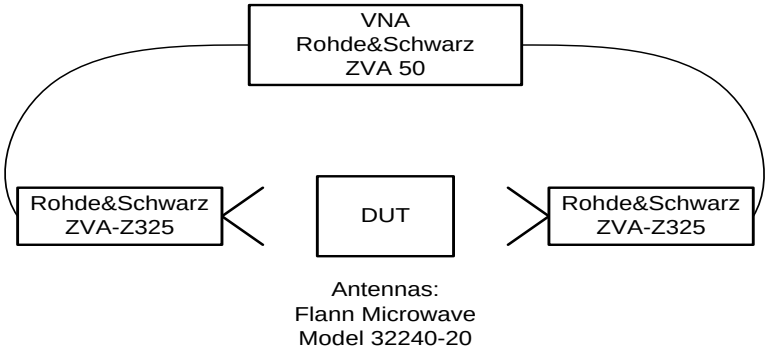
Alexander Fricke, Thomas Kürner
TU Braunschweig

Outline

- Measurement Approach
- Scenario Definitions
- Results for Direct Transmission
- Results for Directed NLOS Transmission

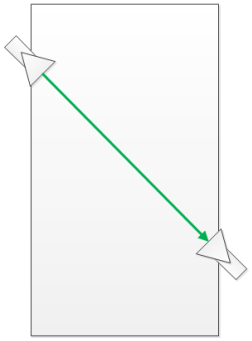
Measurement Approach (Setup)

– **Frequency domain measurements** using a vector network analyzer with frequency extensions have been performed as described in [1]

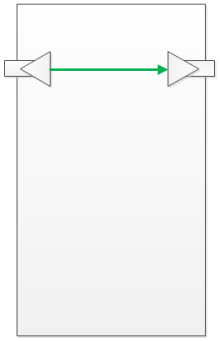


Scenario Definitions (1)

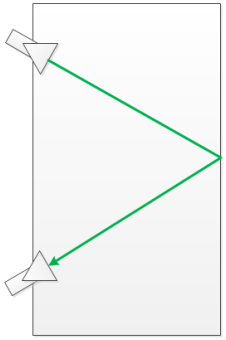
Scenario direct_1: Diagonal Alignment



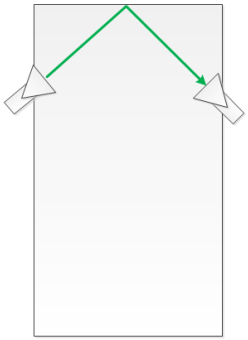
Scenario direct_2: Opposing Alignment



Scenario dNLOS_1: Neighbouring Position, Specular Alignment

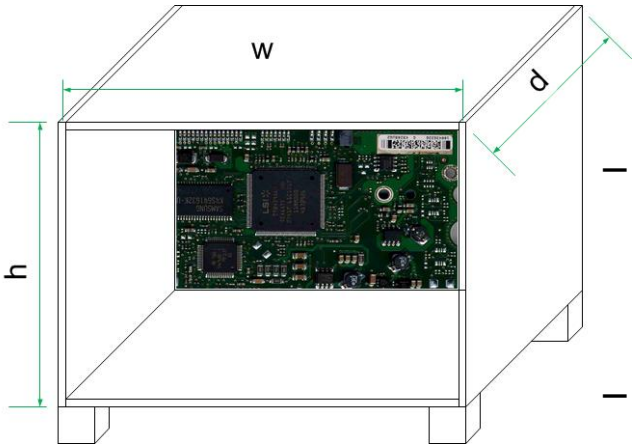


Scenario dNLOS_2: Opposite Position, Specular Alignment



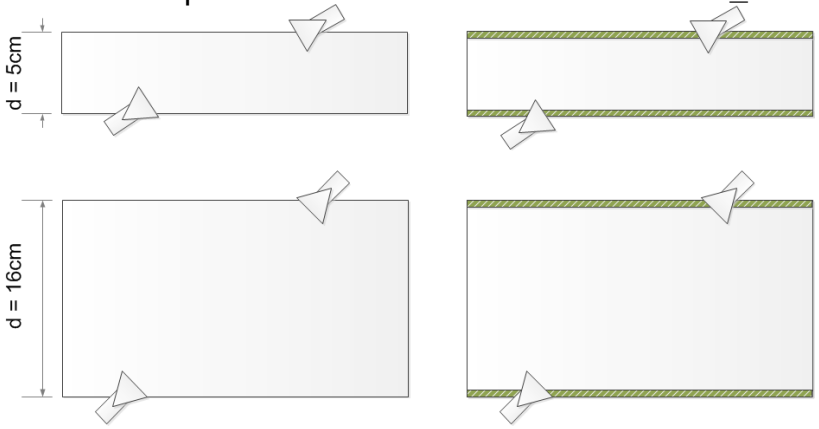
- Four measurement scenarios comprising **two different operational modes** have been defined and measured
- The operational mode **direct transmission** corresponds to communiction via a line-of sight connection between Tx and Rx
- In the case of **directed NLOS transmission**, the signal is guided via a reflection inside the device due to the missing possibility of aligning the antennas
- These two operational modes are examples for two **different** intra-device **use-cases** that require **different statistics** as input for the stochastic channel model
- The analysis of these operational modes will also be presented at this year‘s **ICEAA** in Torino, Italy [1]

Scenario Definitions (2)



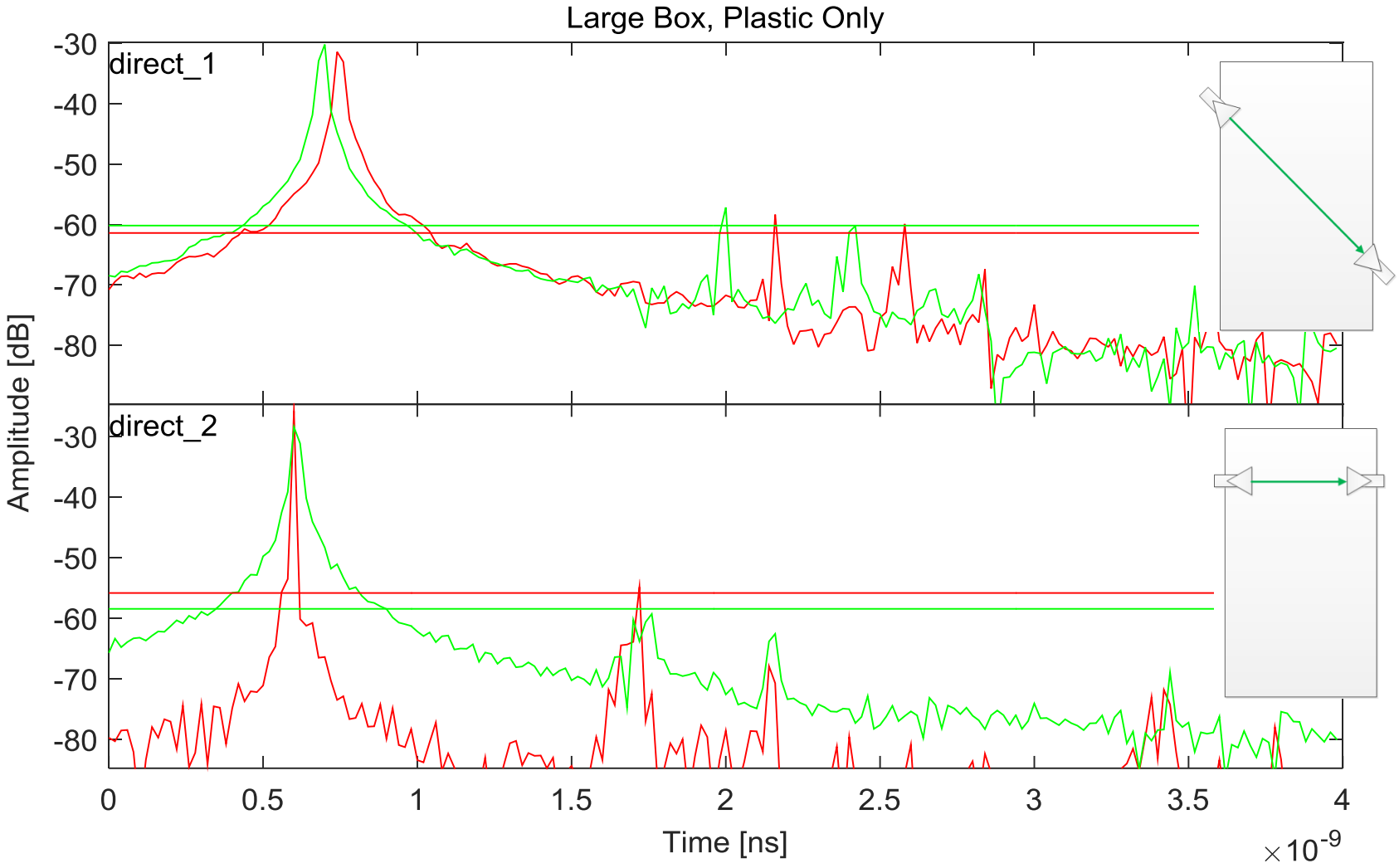
- Analogous to the campaign presented in [2], **each scenario** has been measured for **two different box sizes** „S“ and „L“
- The lateral dimensions are w = 26cm and h = 21 cm. The distance between front- and backside d is 5cm for the S- and 16cm for the L-sized box
- Moreover, each scenario has been measured inside a **plastic-only surrounding** and in a box equipped with **printed circuit boards on front- and backside**

Example: Four realizations of scenario *direct_1*

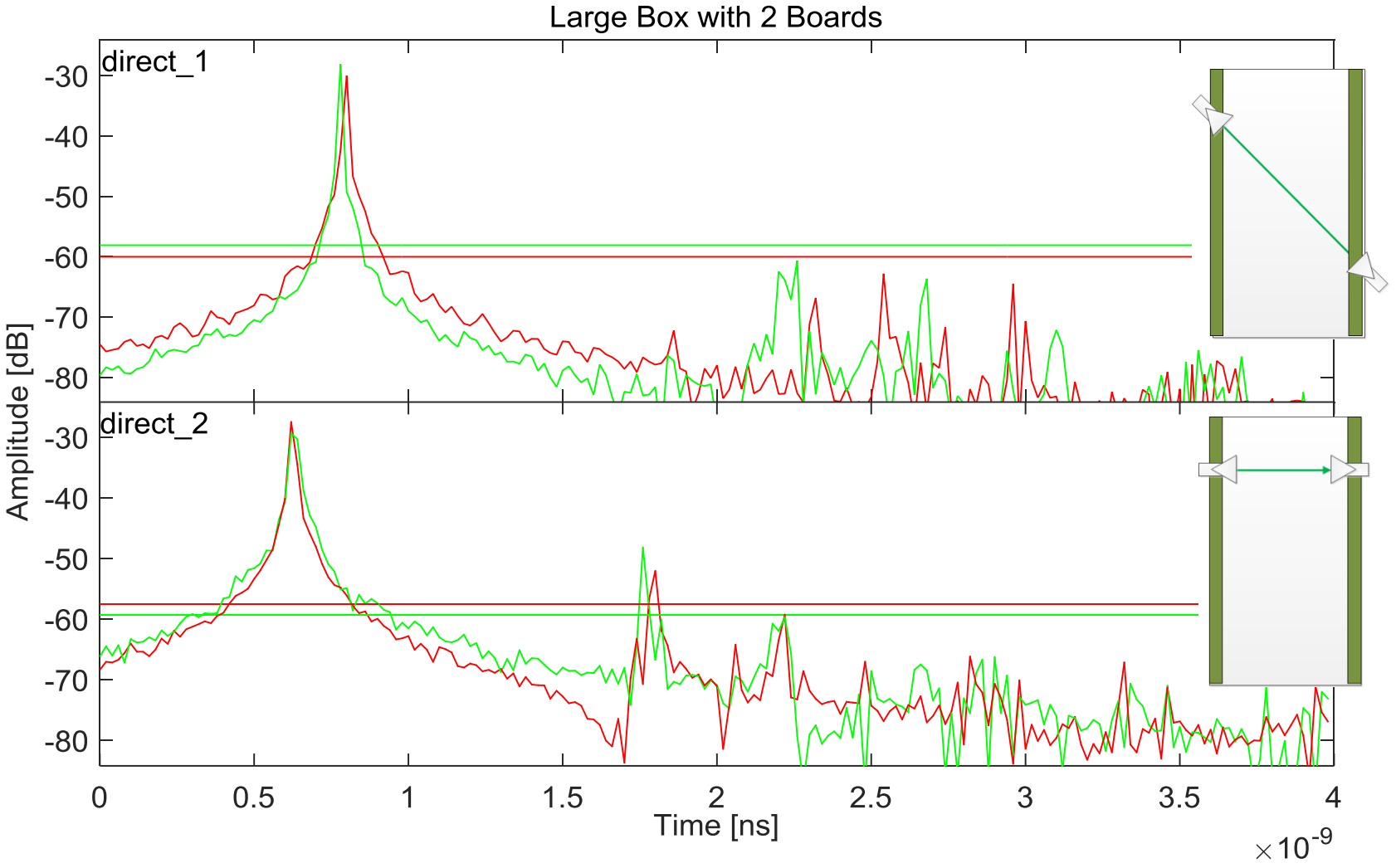


- The above considerations lead to a total of **four realizations** per scenario definition

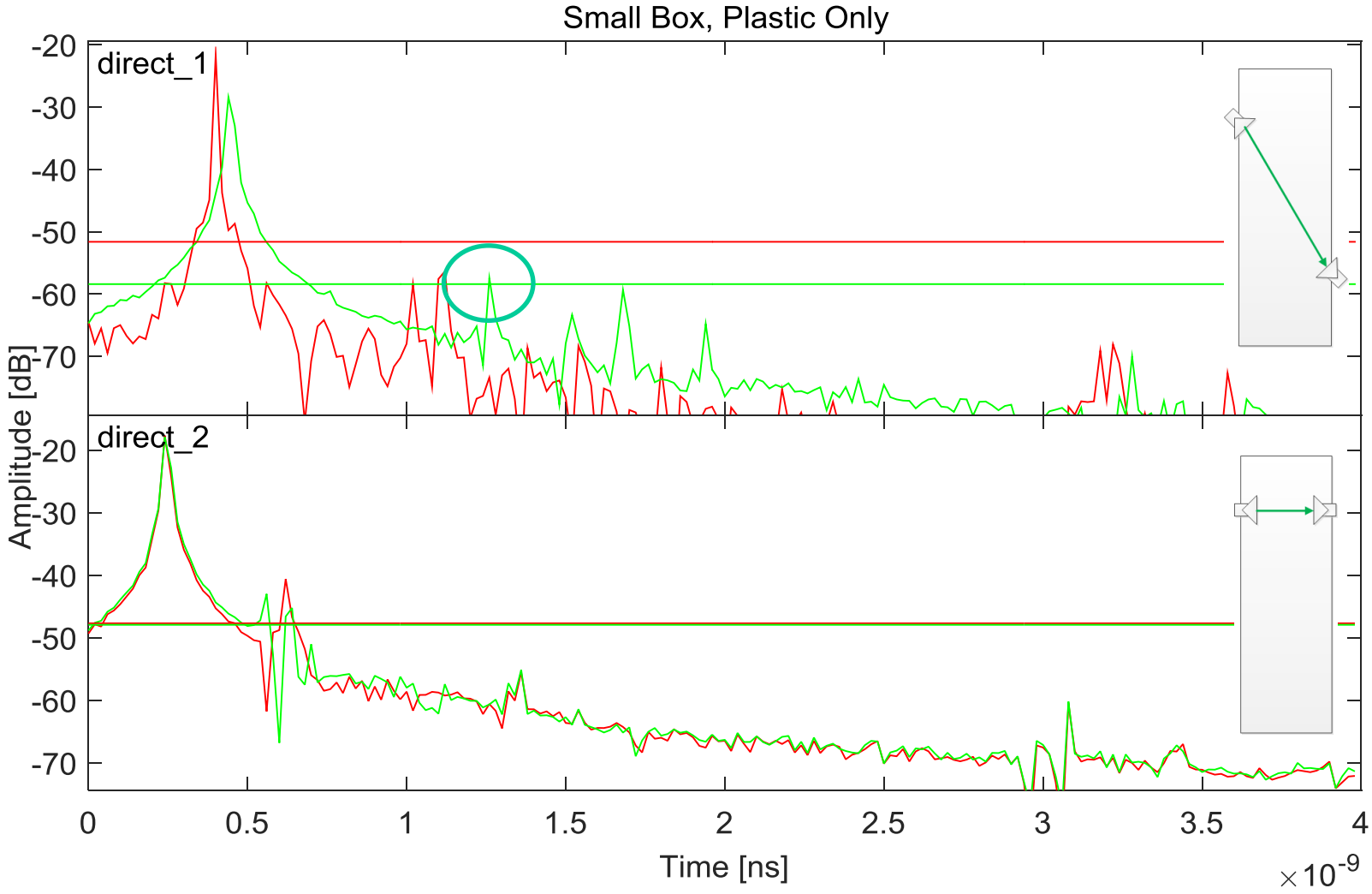
Results for Direct Transmission (1)



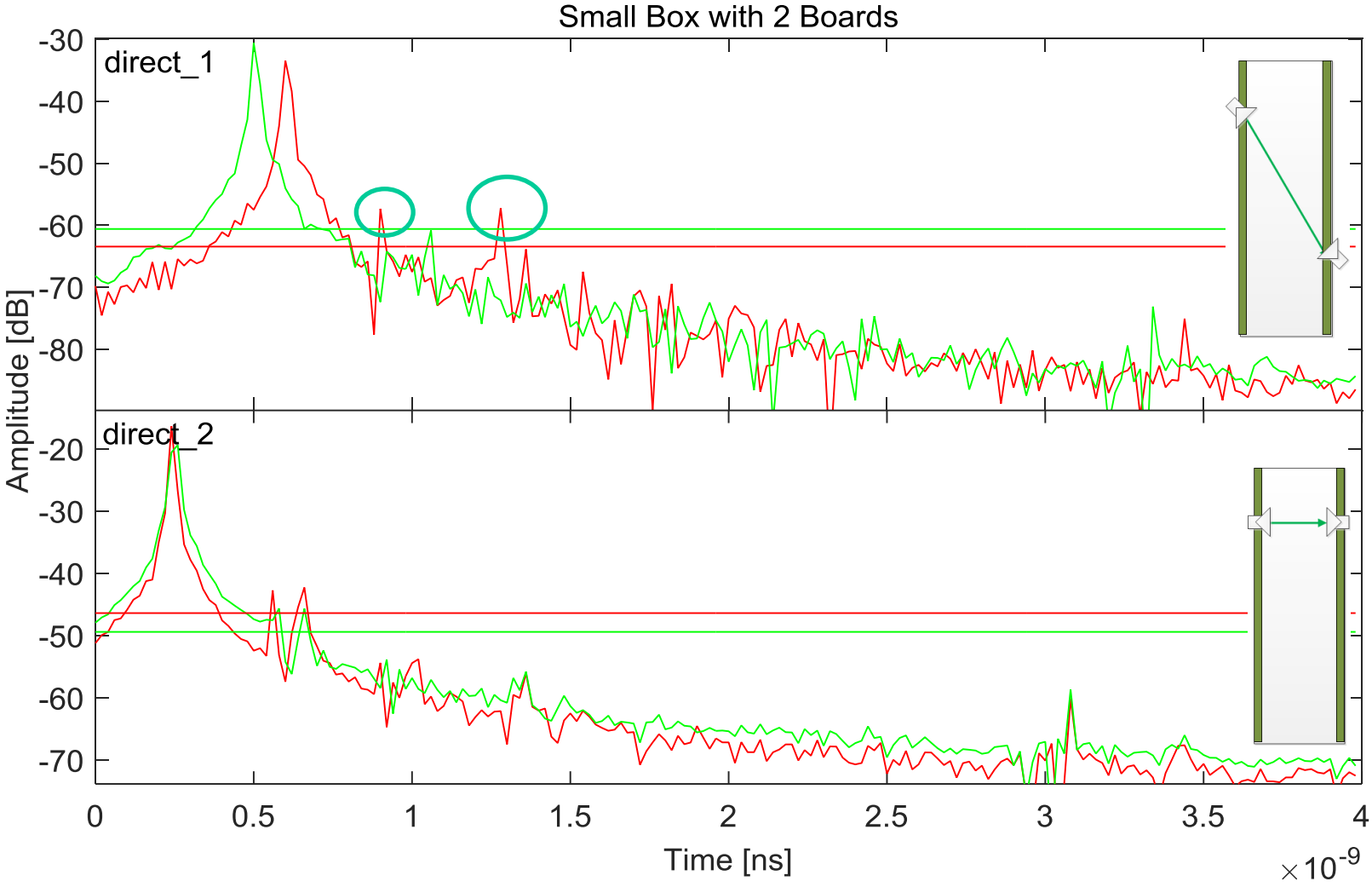
Results for Direct Transmission (2)



Results for Direct Transmission (3)



Results for Direct Transmission (4)



Results for Direct Transmission (Conclusion)

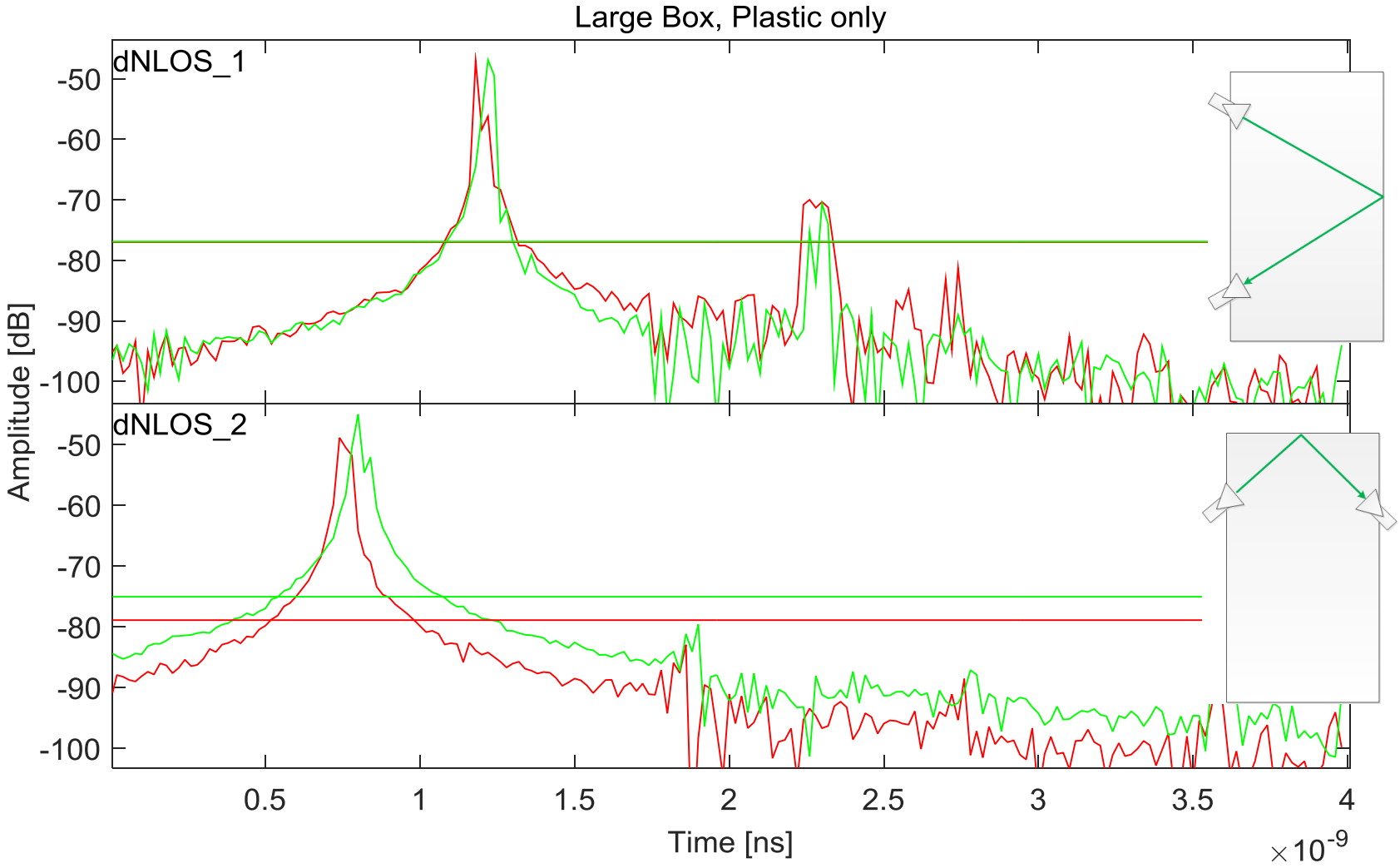
- One **distinct main pulse** followed by a series of **echoes at least 20dB weaker** than the main signal
- The amplitude of the **main signal might be degradated** when building parts (partly) **block the line-of-sight connection**

- **No additional multipath** components are generated **from the PCBs**; the multipath amplitudes remain rather constant
- A **narrower propagation environment** leads to a more compact signal with temporally **closer multipath components**

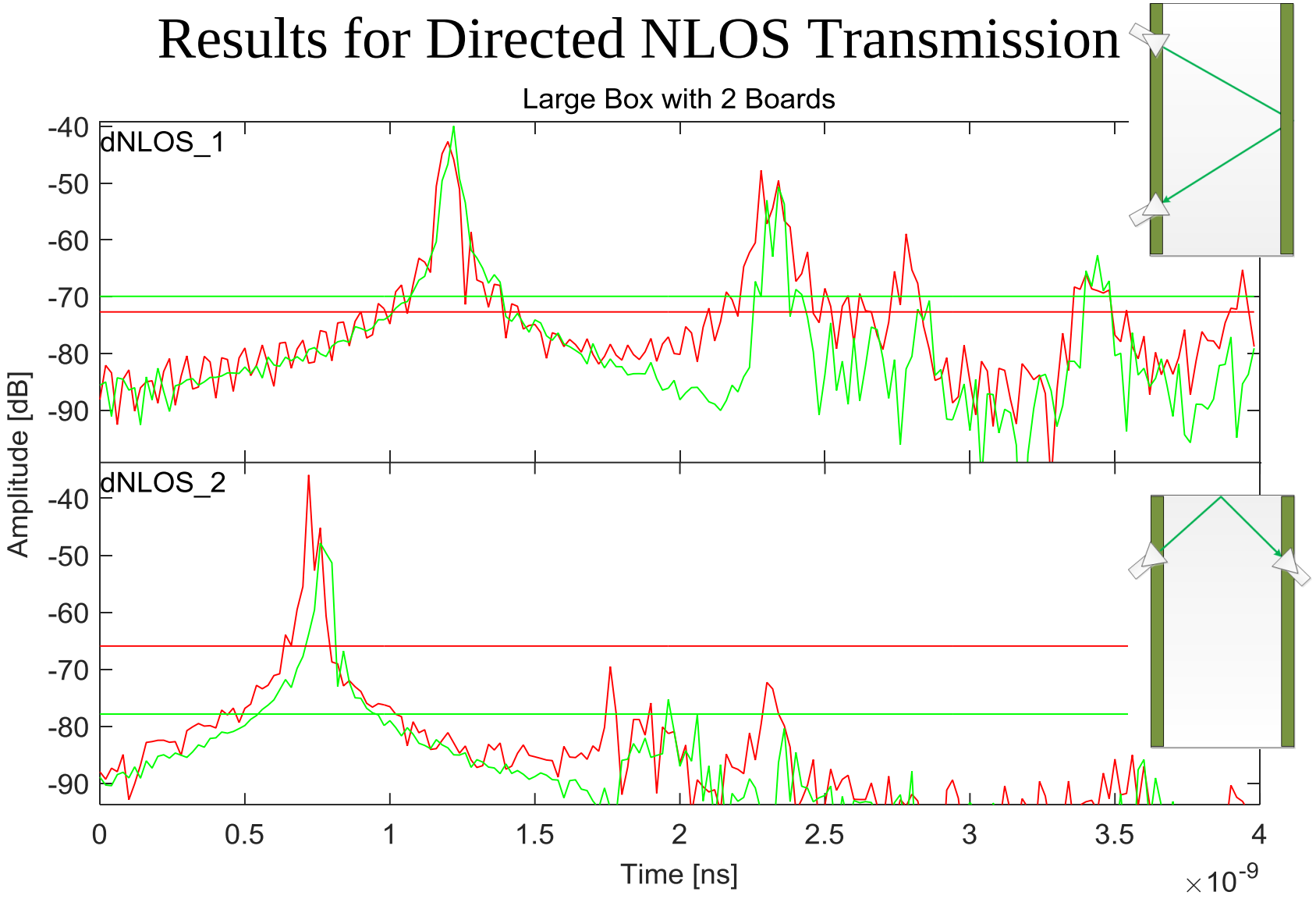
Temporal Analysis: RMS Delay Spreads

	Large ABS	Small ABS	Large PCB	Small PCB
direct_1, red	0.241 ns	0.019 ns	0.036 ns	0.126 ns
direct_1, green	0.164 ns	0.113 ns	0.020 ns	0.065 ns
direct_2, red	0.197 ns	0.097 ns	0.215 ns	0.099 ns
direct_2, green	0.089 ns	0.107 ns	0.225 ns	0.110 ns

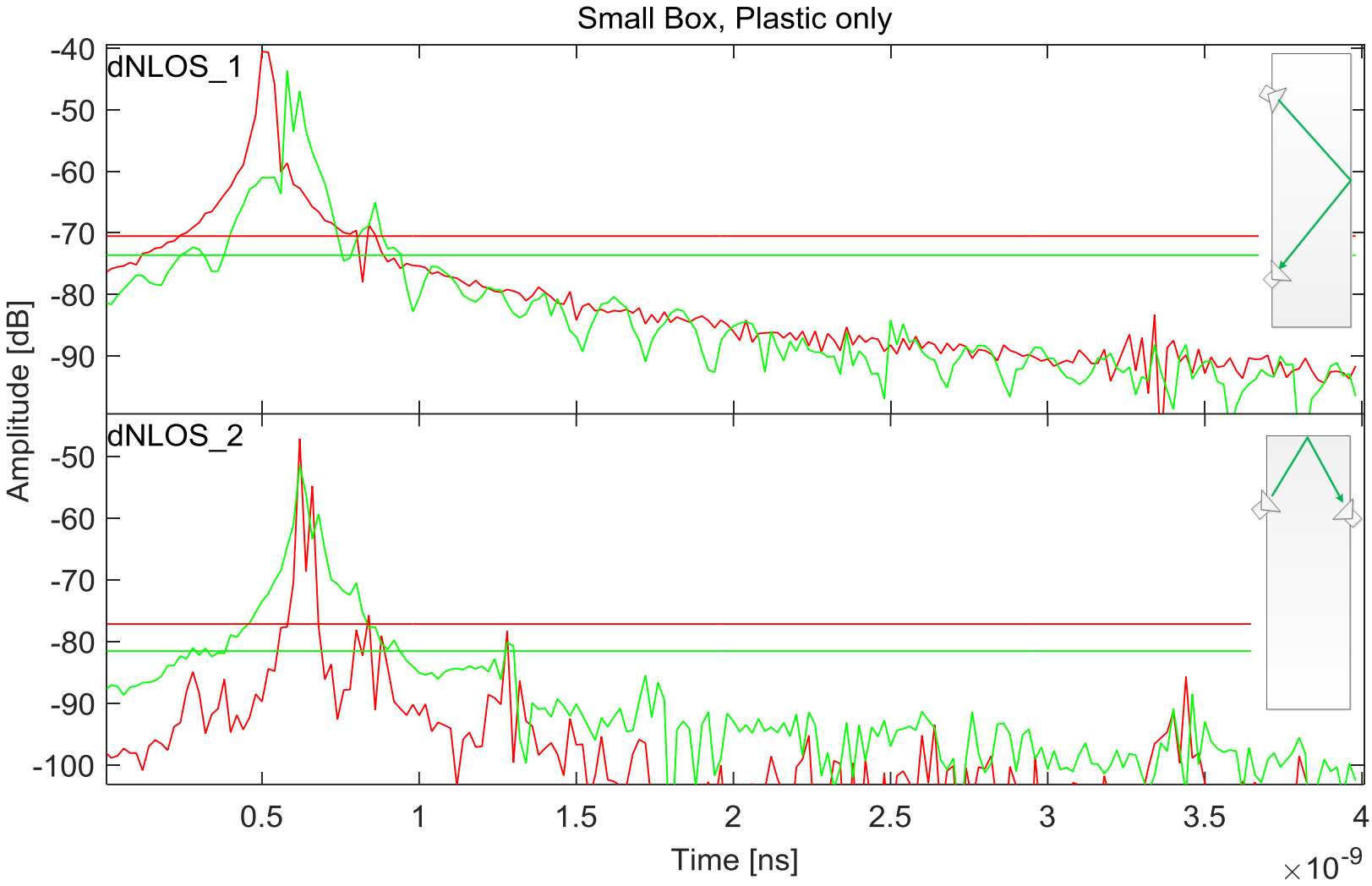
Results for Directed NLOS Transmission (1)



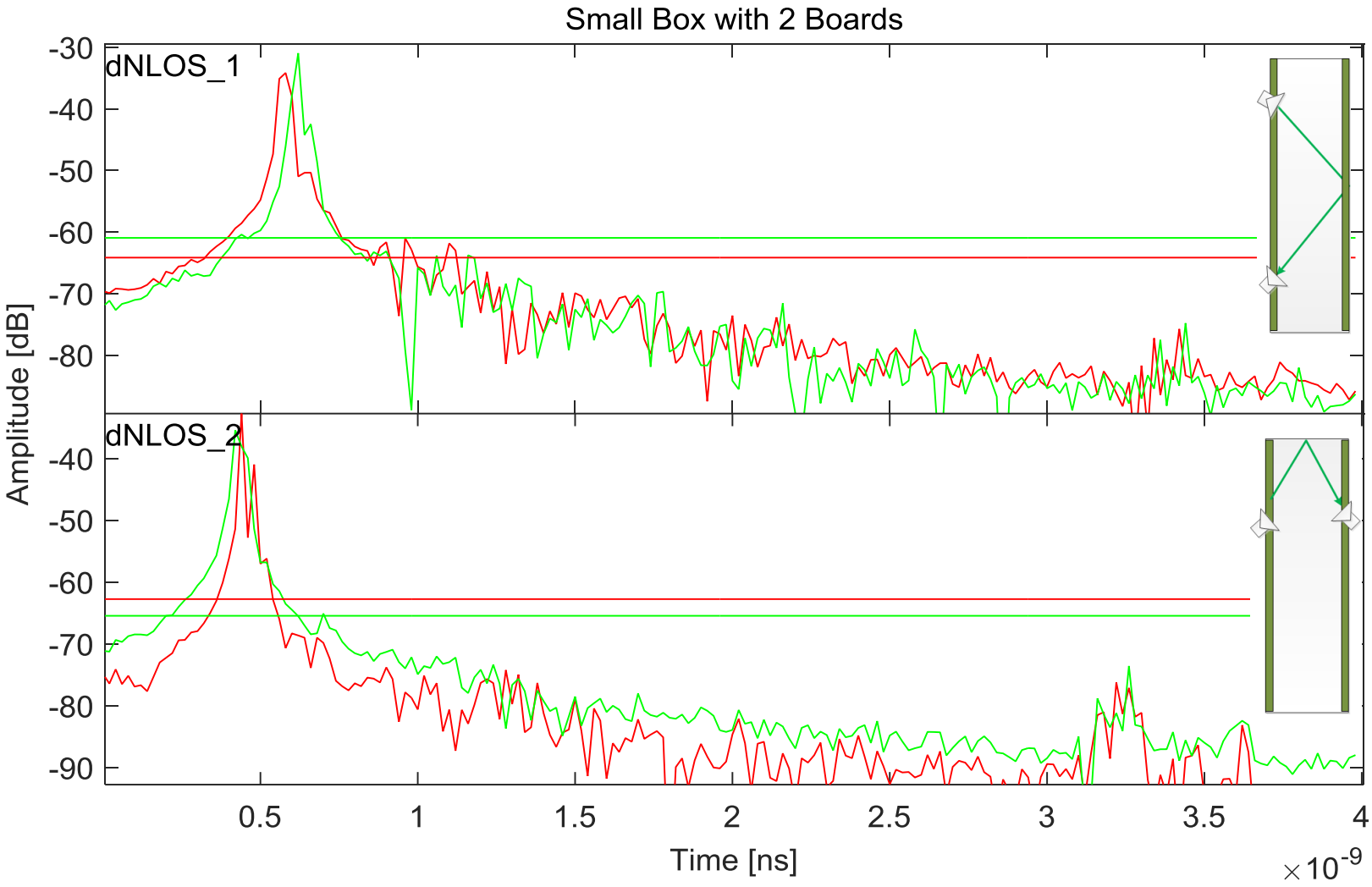
Results for Directed NLOS Transmission



Results for Directed NLOS Transmission (3)



Results for Directed NLOS Transmission (4)



Results for directed NLOS Transmission (Conclusion)

- **Main pulse might be broadened** by both ABS or PCB reflection; **echoes up to 5dB** below the main pulse
- In spacious environments, the **insertion of PCBs** leads to **improved number and strength of MPCs**

- Again, **a narrower environment leads to a reduced multipath richness**; however, it might broaden the main pulse further due to a larger reflection angle

Temporal Analysis: RMS Delay Spreads

	Large ABS	Small ABS	Large PCB	Small PCB
dNLOS_1, red	0.367 ns	0.099 ns	0.758 ns	0.122 ns
dNLOS_1, green	0.245 ns	0.115 ns	0.650 ns	0.047 ns
dNLOS_2, red	0.072 ns	0.036 ns	0.026 ns	0.027 ns
dNLOS_2, green	0.085 ns	0.129 ns	0.139 ns	0.069 ns

Thank You
for Your Attention

References

[1] A. Fricke et al., „Characterization of Transmission Scenarios for Terahertz Intra-Device Communications“, International Conference on Electromagnetics in Advanced Applications (ICEAA), September 7-11 2015, Torino, Italy

[2] doc.: IEEE 802.15-15-0166-00-003d: „Measuring the THz Intra-Device Propagation Channel“