

Modular Ground Penetrating Radar Tomography System with a Combination of Star and Daisy Chain DAQ and Trigger Topologies with Picosecond Accuracy

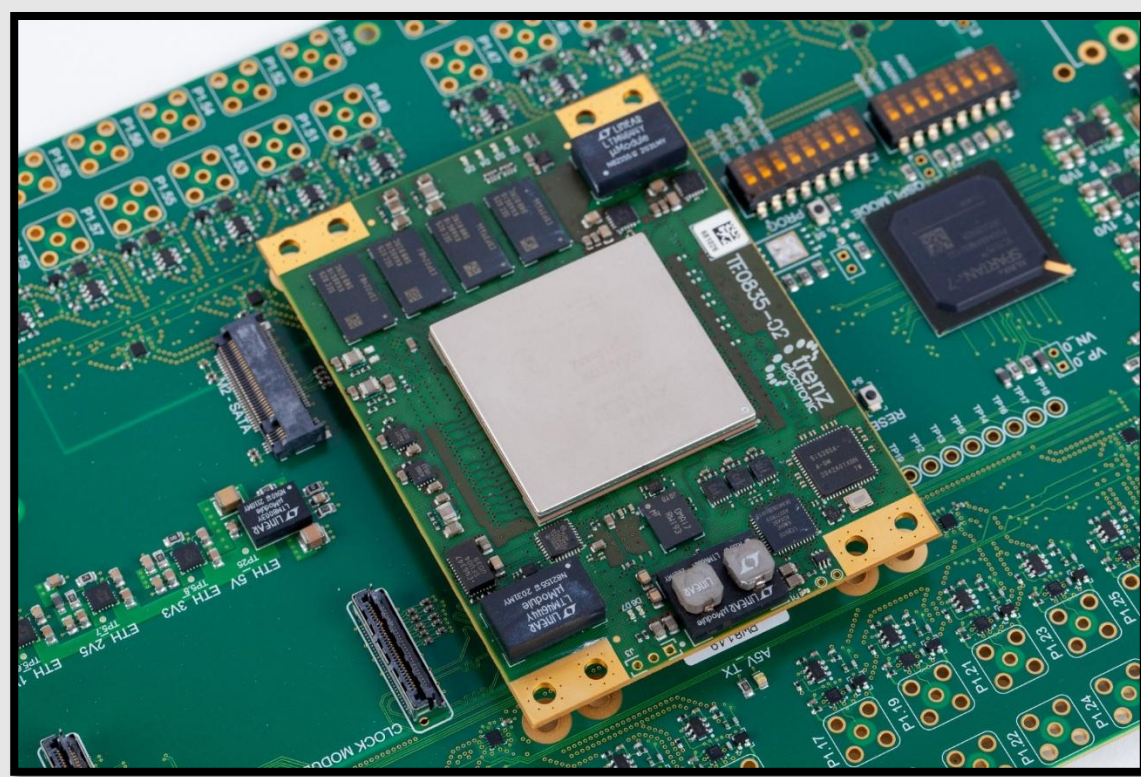
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- DAQ-system with 39 RF-SoMs and 312 4-GS/s ADC channels
- HMC7044 based clock distribution network with less than 40 ps jitter
- Visualizing root growth, flow and transport processes in soils

KEY REQUIREMENTS

- Non-invasive 3D monitoring of permittivity and conductivity
- Resolution: spatial: 5 cm³, temporal: 10 seconds
- Modular and scalable DAQ system for the simultaneous operation of 2496 antennas
- Timing accuracy: < 25 ps, Frequencies: 0.5 – 1.5 GHz



DAQ

- System-on-Module
- AMD/Xilinx ZU25DR
- 39×8 4.0 GS/s ADC
- 39×8 6.5 GS/s DAC
- 24 GB / tomogram
- HMC7044 jitter attenuator

Figure: RF System-on-Module with integrated ADC and DAC units.

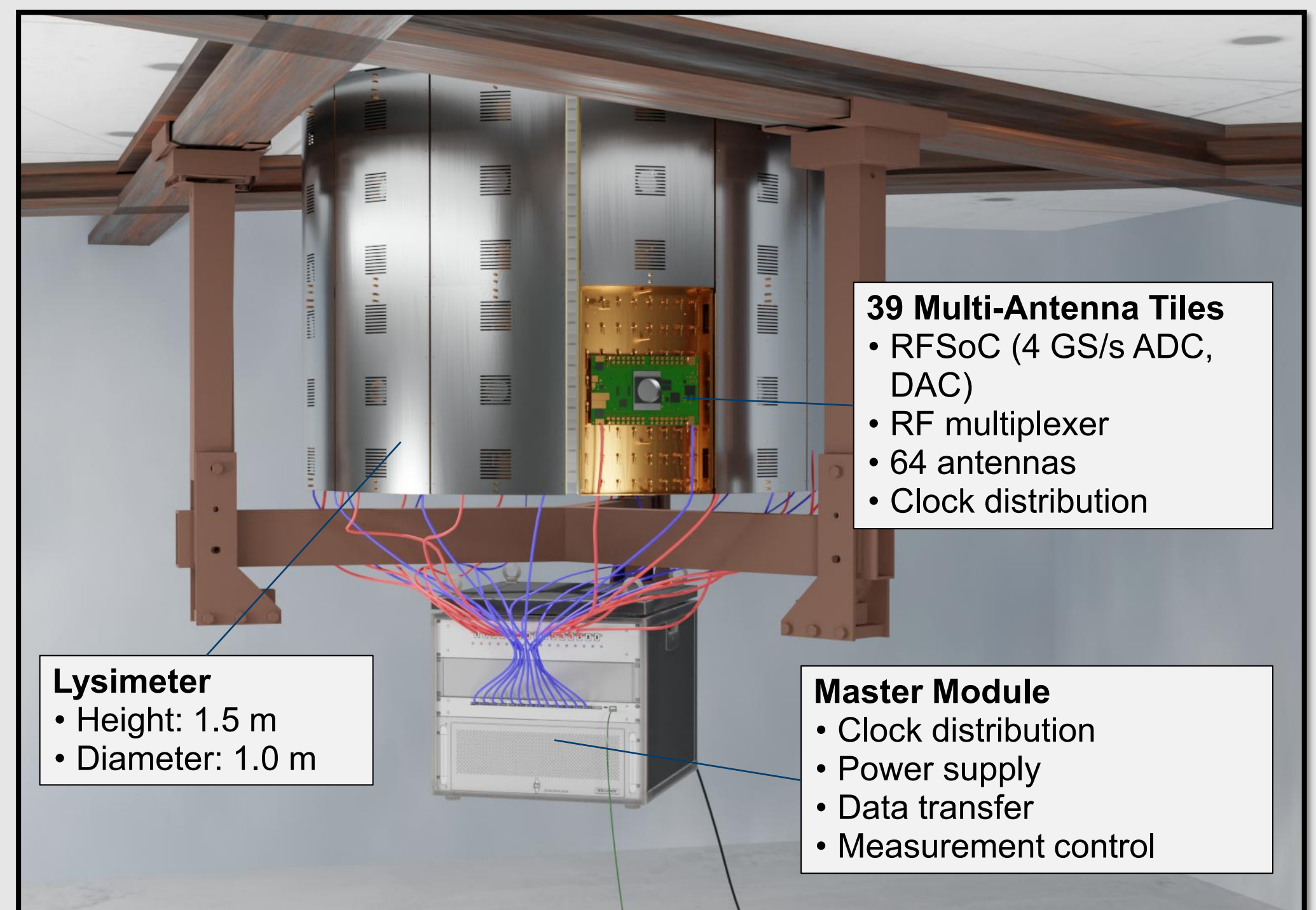


Figure: Sketch of the full GPR system. One tile cover is removed to show the DAQ board.

SYSTEM ARCHITECTURE

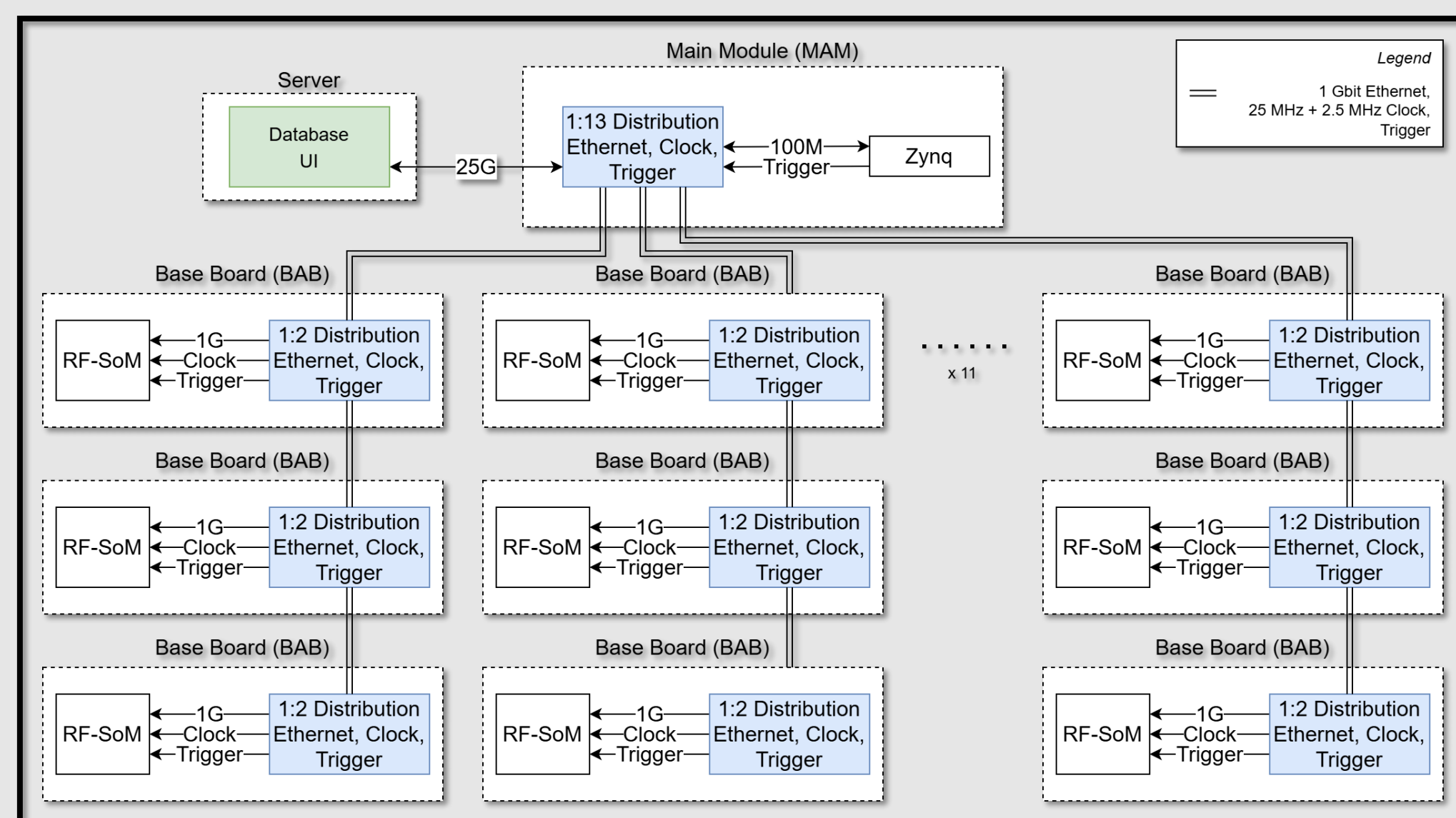


Figure: Distribution of data and synchronization via daisy chain and star shape structure.

BASEBOARD PROCESSING

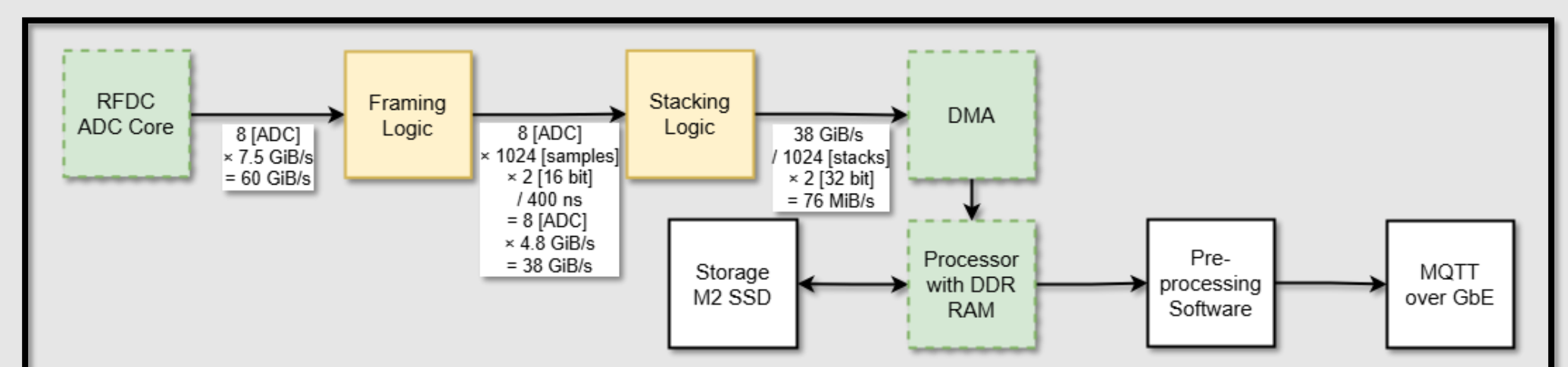


Figure: Data acquisition and pre-processing architecture.

- 2.5 MHz clock → 400 ns/frame with 1024 samples/frame
- Subdivide frame in 256 ns measurement + 144 ns pause
- Stacking of 1024 frames & extension to 32 bit → 76 MiB/s
- For all 39 baseboards: 2.9 GiB/s
- Overall measurement time: 2496 (antennas) × 8 (RX multiplexing) × 1024 (stacks) × 400 ns = **8.2 s**

RESULTS

- ✓ Synchronization accuracy better than 40 ps
- ✓ Signal-to-noise (SNR) with 1024 stacks sufficient to transilluminate soil
- ✓ Unexpected couplings on PCB filtered out

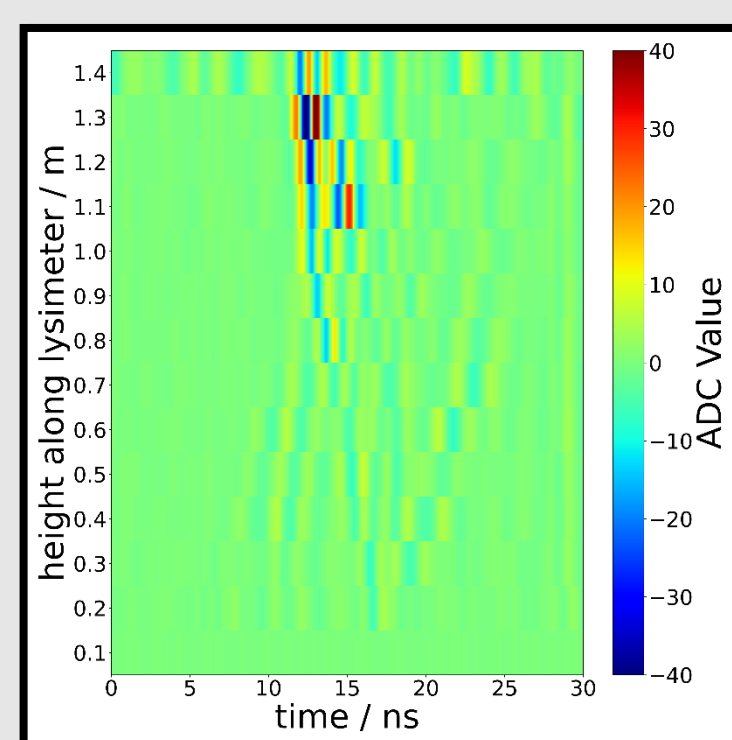


Figure: B-scan of a demonstration measurement at a lysimeter.

OUTLOOK

- Optimization of SNR
- Optimization of antenna
- Setup a prototype system with two antenna "bars"
- Build full system



Figure: Mock-up of a 3D GPR data visualisation for a soil lysimeter.

