

Introduction

Localization has gained significant traction in 5G networks. Meanwhile, LEO satellite mega-constellations are already delivering broadband Internet via Non-Terrestrial Networks (NTNs).

Within the GERMINAL project, we envision 6G as a key technology not only for communication but also for positioning.

This work presents the ongoing development of a testbed designed to evaluate both TN and NTN signals.

Methods

Our testbench is implemented through the **OpenAirInterface** (OAI) open-source software.

- The **TN** is based on the Palamà et al. [1] testbench.
- The **NTN** platform is based on simulated direct satellite access using a transparent payload architecture [2].

In Figure 1, a high-level architecture of our 5G TN-NTN testbench is shown.

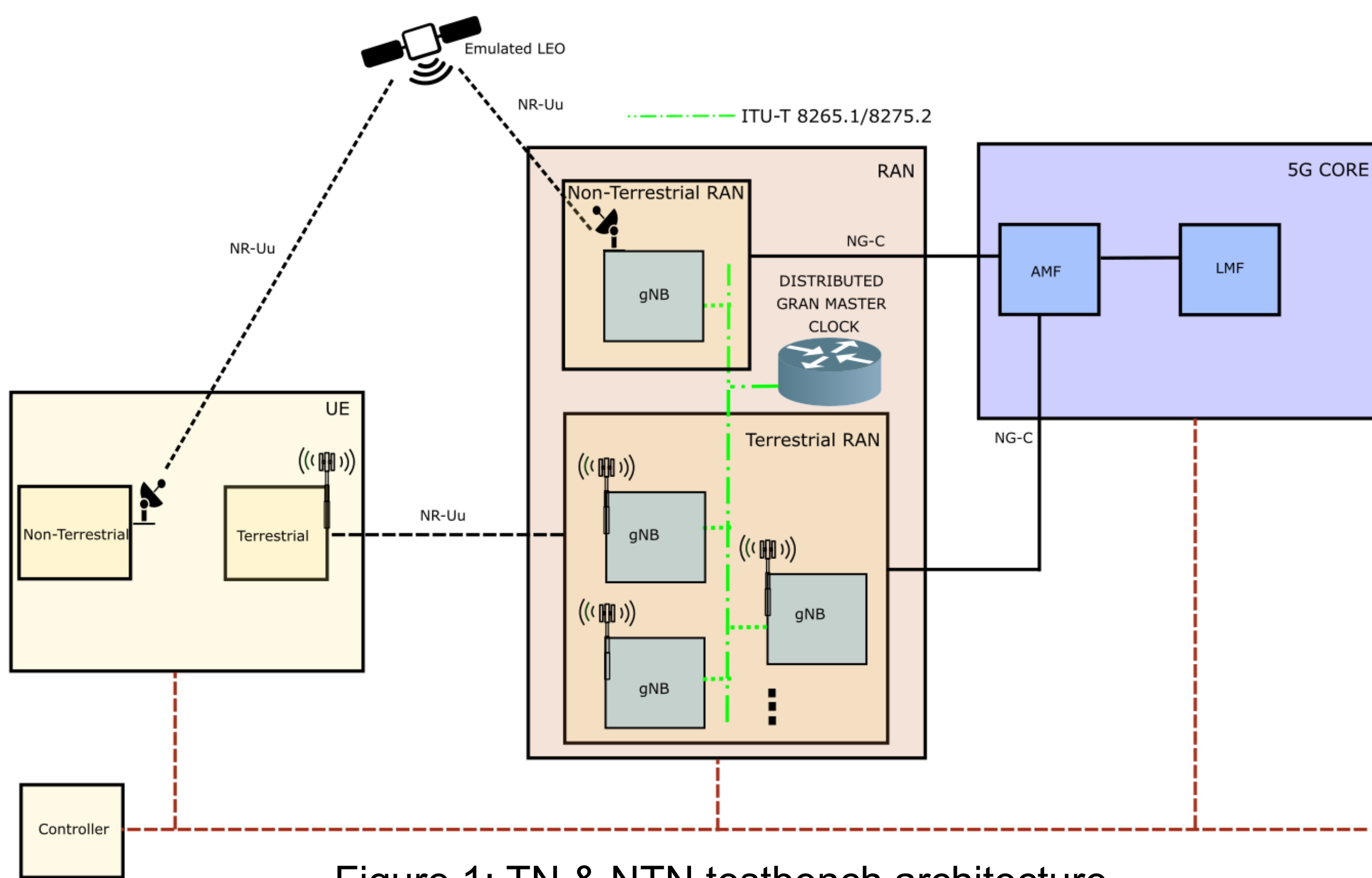


Figure 1: TN & NTN testbench architecture.

To perform positioning, we use Down Link Time Difference of Arrival (**DL-TDoA**) technique [3], which leverages:

- The Positioning Reference Signal (PRS)
- A set of Base Stations (BSs, gNBs in 5G)
- The user equipment (UE) to measure the TDoA between each pair of gNBs.

Reference

- [1] I. Palamà, Y. Lizarribar, L. M. Monteforte, G. Santaromita, S. Bartoletti, D. Giustiniano, G. Bianchi, N. B. Melazzi, 5G positioning with software-defined radios, Computer Networks, 2024
- [2] 3GPP TS 38.101-5: User Equipment (UE) radio transmission and reception; Part 5: Satellite access Radio Frequency (RF) and performance requirements.
- [3] 3GPP TS 38.305: NG Radio Access Network (NG-RAN); Stage 2 functional specification of User Equipment (UE) positioning in NG-RAN

Results

Indoor preliminary tests with the TN at 40 MHz of bandwidth are performed. Figure 2 showcases 8 Resource Elements (RE) with the received PRS symbols from 3 gNBs:

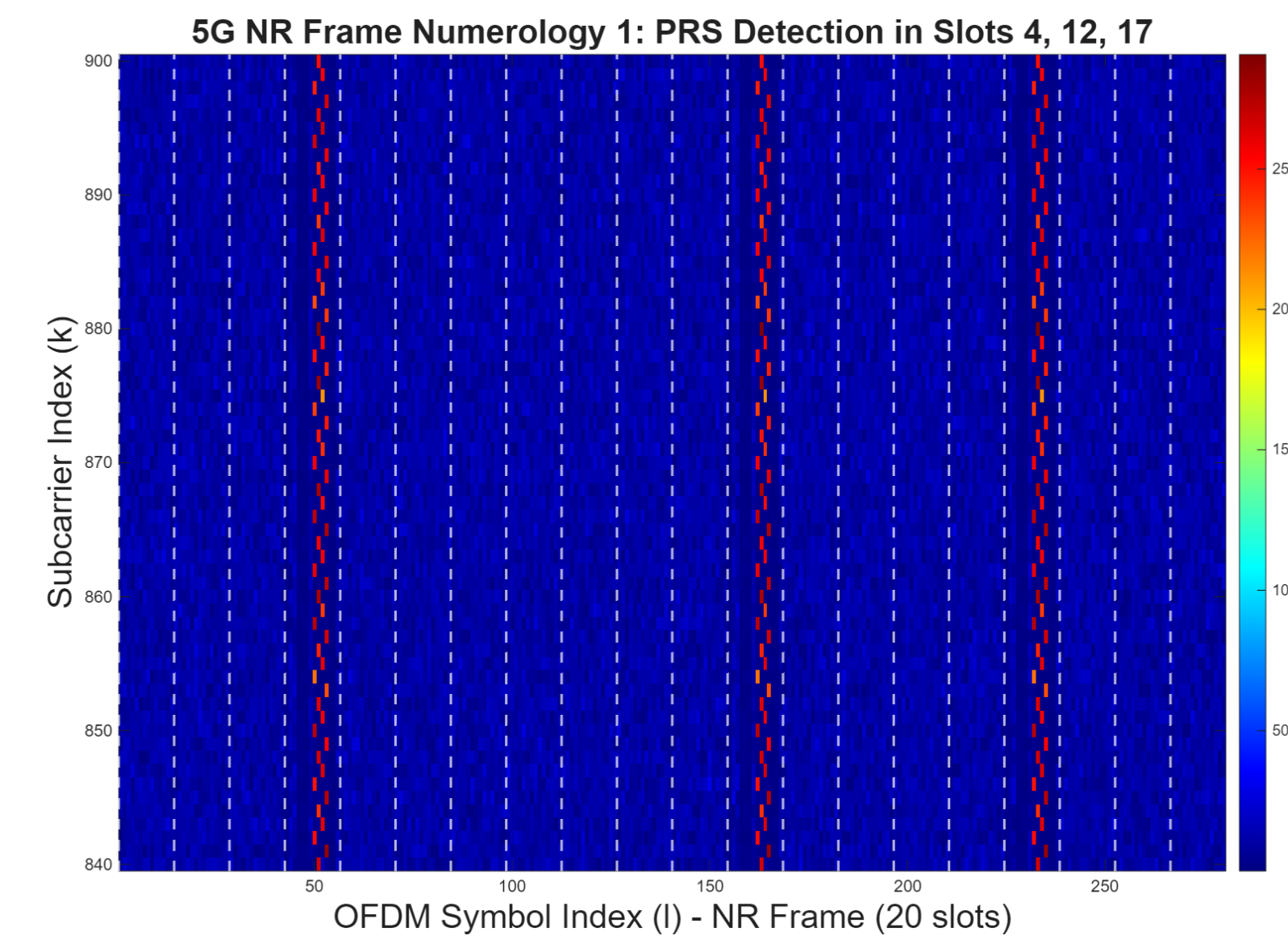


Figure 2: Resource Grid with PRS.

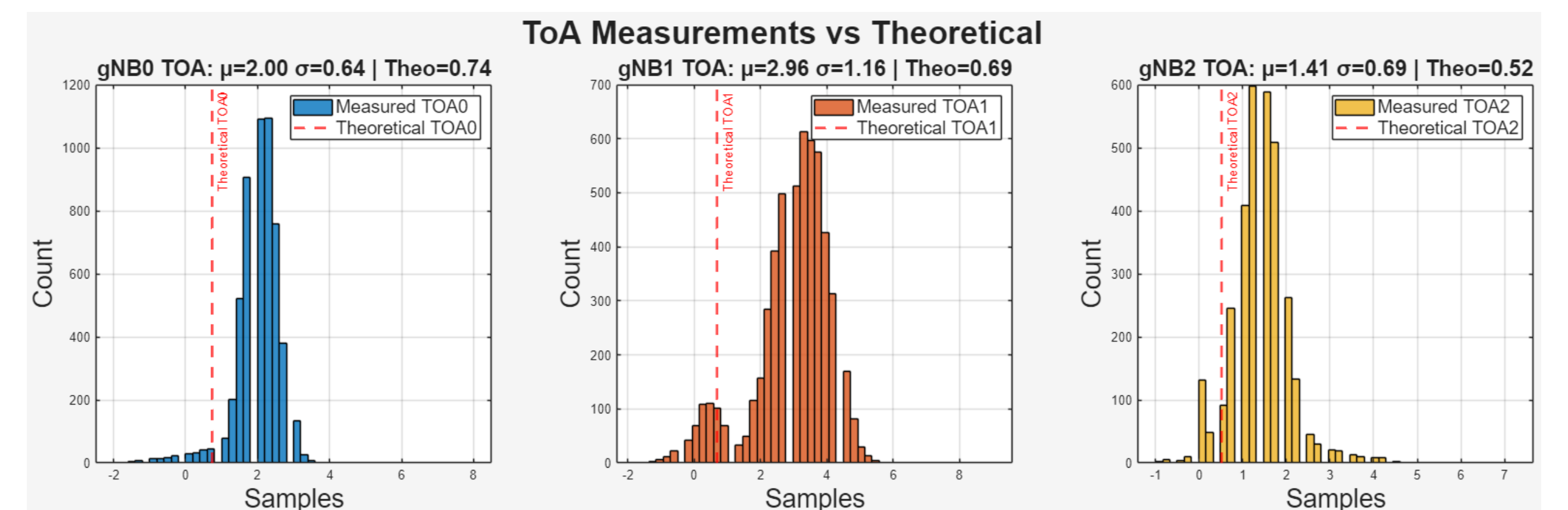


Figure 3: Statistics of computed ToA values.

In Figure 3, we denote:

- Higher σ of gNB_1 ToA suggests **multipath**.
- Constant shift of the Gaussian bells w.r.t. to the expected value (red line) is due to the **synchronization offset** and compensated by DL-TDoA.

The localization estimates of the UE are computed by the NLS algorithm and plotted in Figure 4.

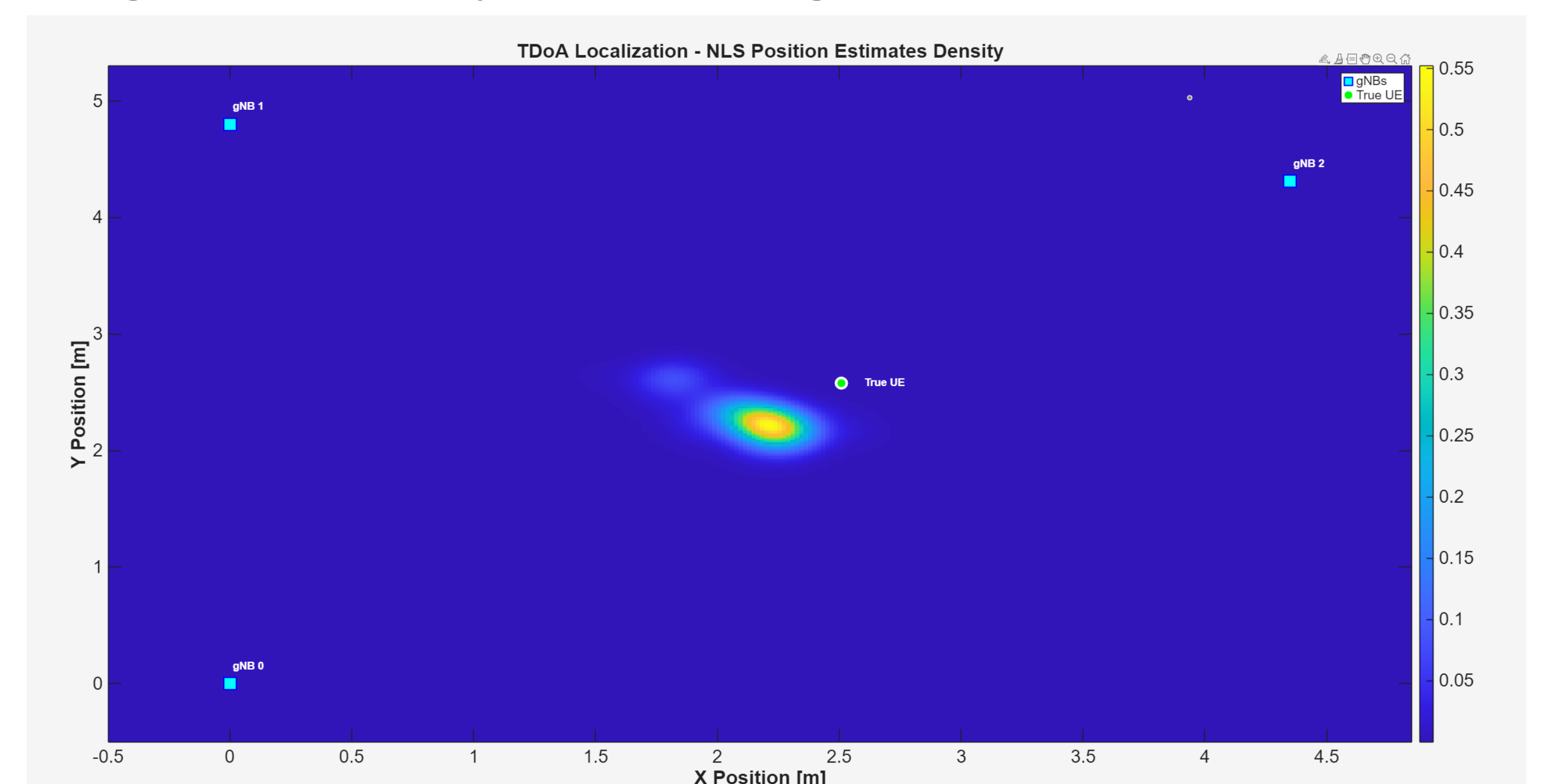


Figure 4: Gaussian-smoothed density plot of localization results.

Results of **0.5m error for 80%** of the samples can be compared with Palamà et al. [1], where they could obtain a 0.7m error in 80% of the cases.

Future Work

These are ongoing tests. The next steps include conducting TN tests with 80 and 100 MHz of bandwidth for comparison, performing position estimation in LOS, NLOS, and outdoor scenarios, comparing results before and after the integration of NTN, and using different synchronization equipment for the gNBs.