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CELEBRATING 25 YEARS OF SECURE & ROBUST GNSS POSITIONING

GNSS receiver LEO-PNT technology & impact on applications

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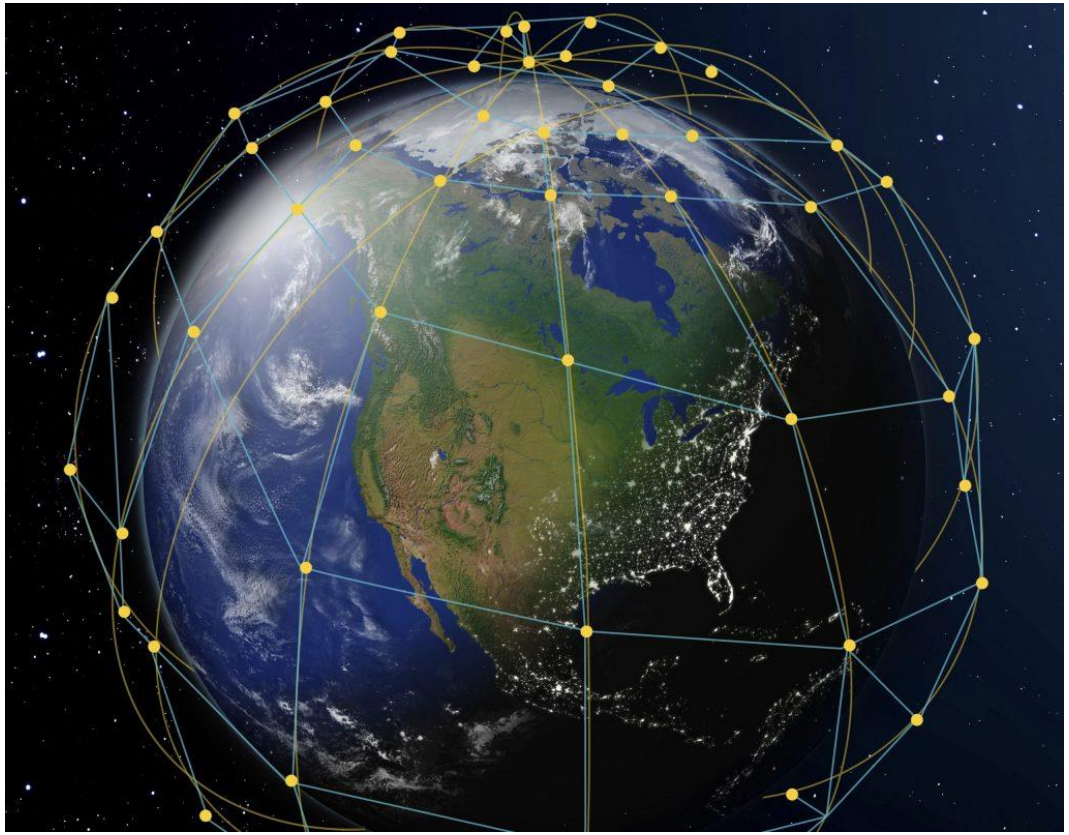
& Frank Boon

NETHERLANDS SPACE SOCIETY

LEO-PNT at Septentrio



- **LEO-PNT benefits to Septentrio applications**
  - Increased **availability** and **integrity** through further increased redundancy of the “system of systems”
  - Better multipath characteristics
  - Better fit for Precise Point Positioning technology making possible **trustable centimeter fix in seconds, globally, without local infrastructure**
  - **Modern correction distribution** channel
  - Modern signal security

- **R&D activities**
  - **1 Post-Doctoral** fellow with **KUL** co-funded by **VLAIO**
  - **Close collaboration with commercial LEO partners for LEO-PNT tracking PoC**
  - **ESA FutureNav**

Septentrio participation to the ESA FutureNav program

Space Segment

- Provide on-board high precision GNSS receiver for IOD payload to OHB through RAKON (LEGION Project)

User Segment

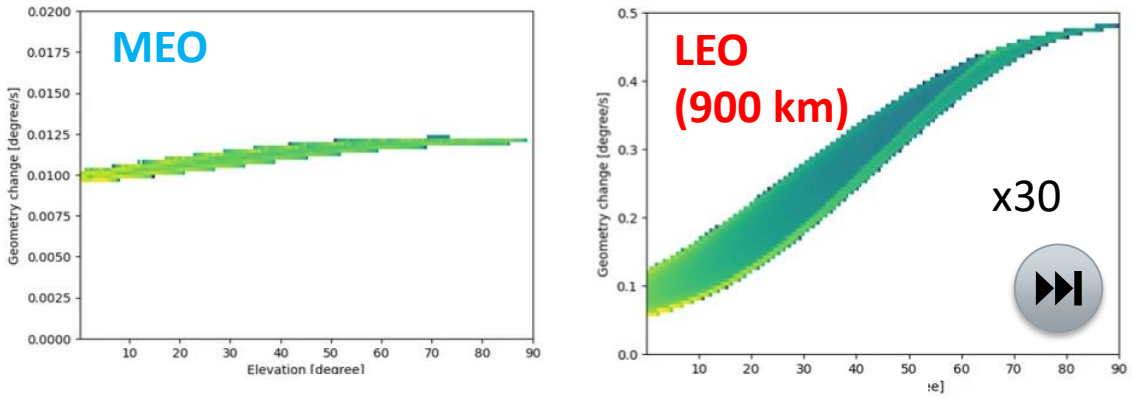
- Provide User Equipment Breadboard to GMV (LEGION Project)

Eager to contribute to IOV phase

LEO can drastically improve high-precision navigation

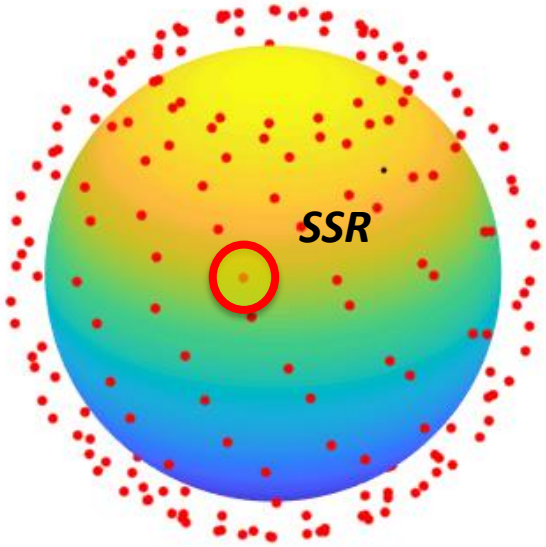
- **Rapid Geometry Change**
  - **Key parameter for PPP/SSR convergence**
    →10 minutes becomes 20 seconds
  - **More Robust Navigation**

Geometry Change (degrees/second)



- **Higher Power because Closer**

  → Higher Data Rate per Satellite
  + Many more satellites
  = Superior Space-based Augmentation Services



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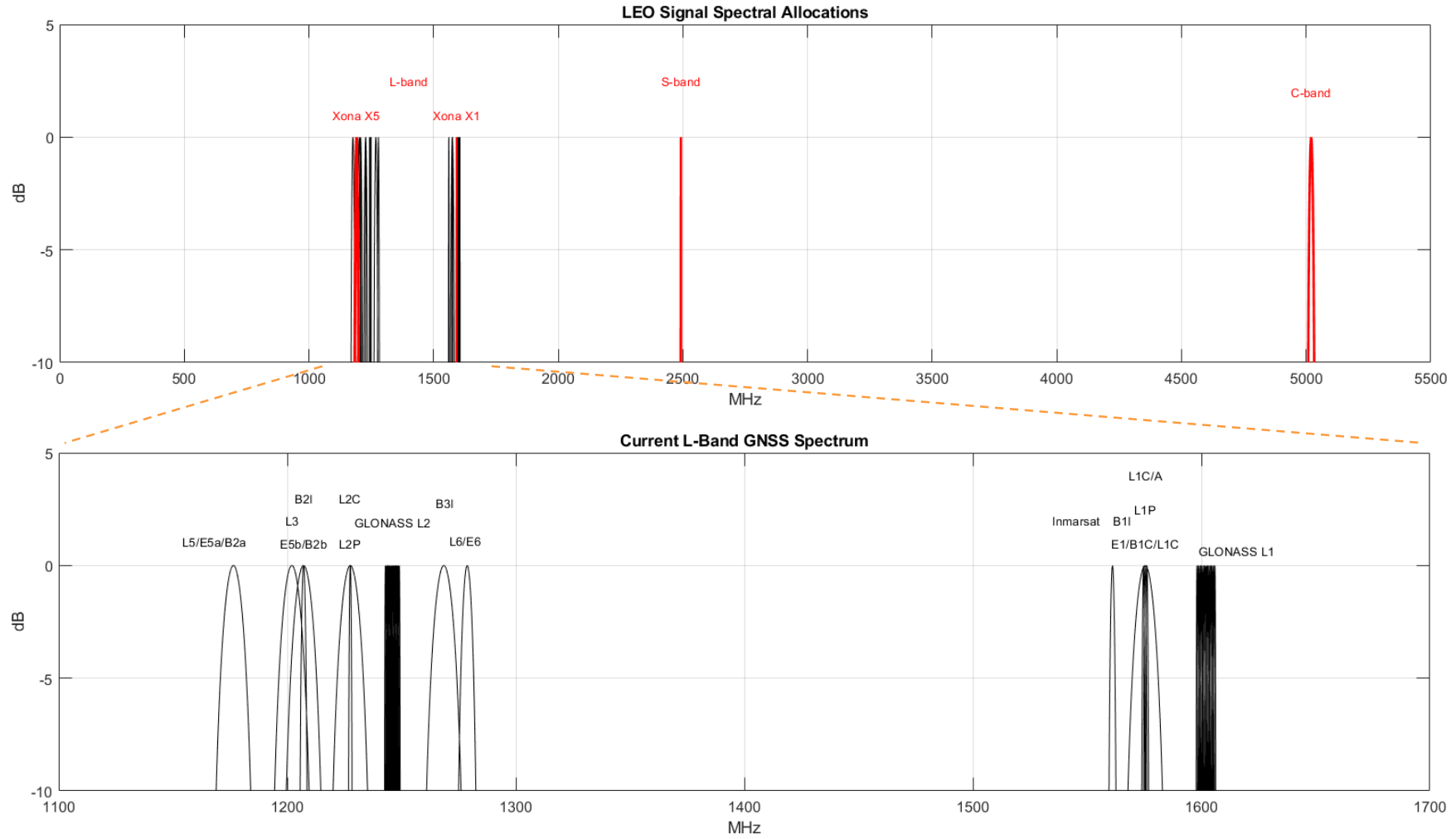
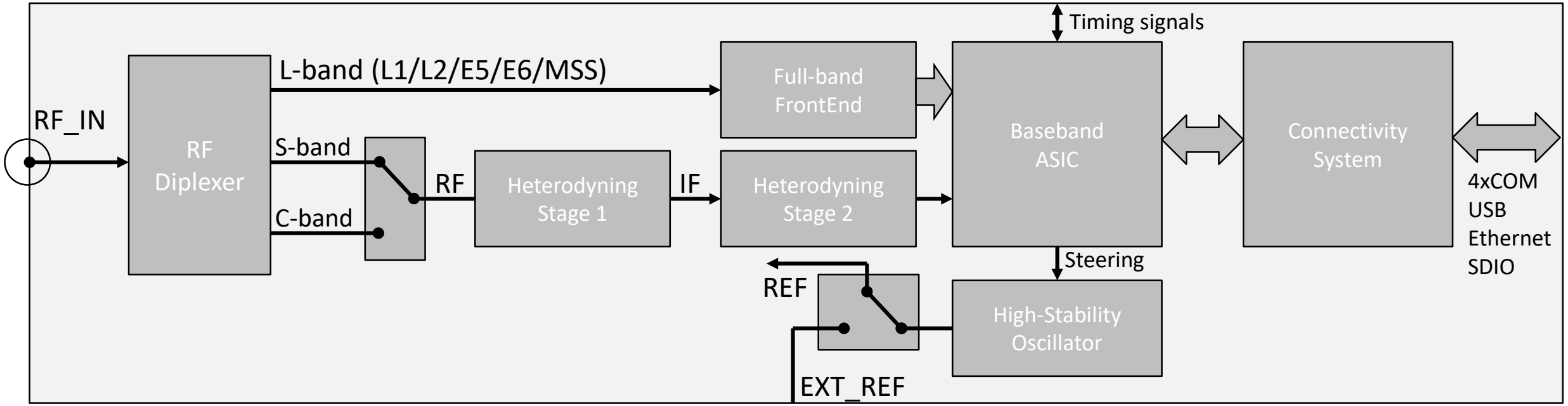
LEO-PNT Receiver Prototyping

Xona Test Signals & Satellite Navigation Spectrum



L/S/C-Band Receiver Prototype



Smaller than a Credit Card

LEO-PNT RF & Data Simulator

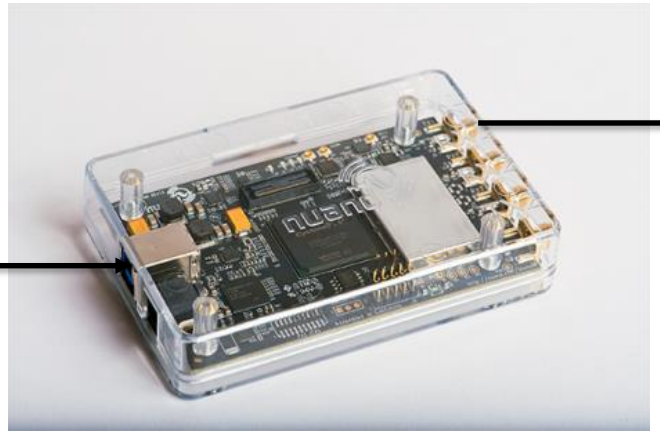
Full-Band GNSS Antenna

Septentrio PULSAR™ GNSS Receiver Prototype

Software Defined Radio

Play samples at X1 or X5 Frequencies

Loop *Samples from Satellite Pass*

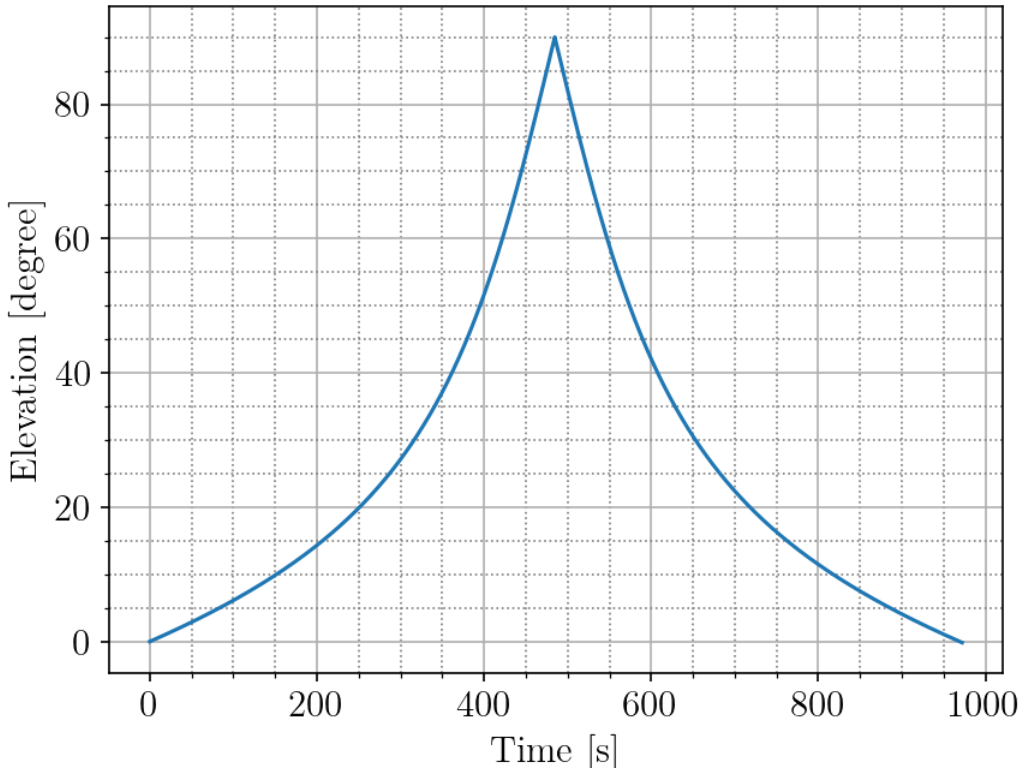


6 GHz BladeRF micro 2.0

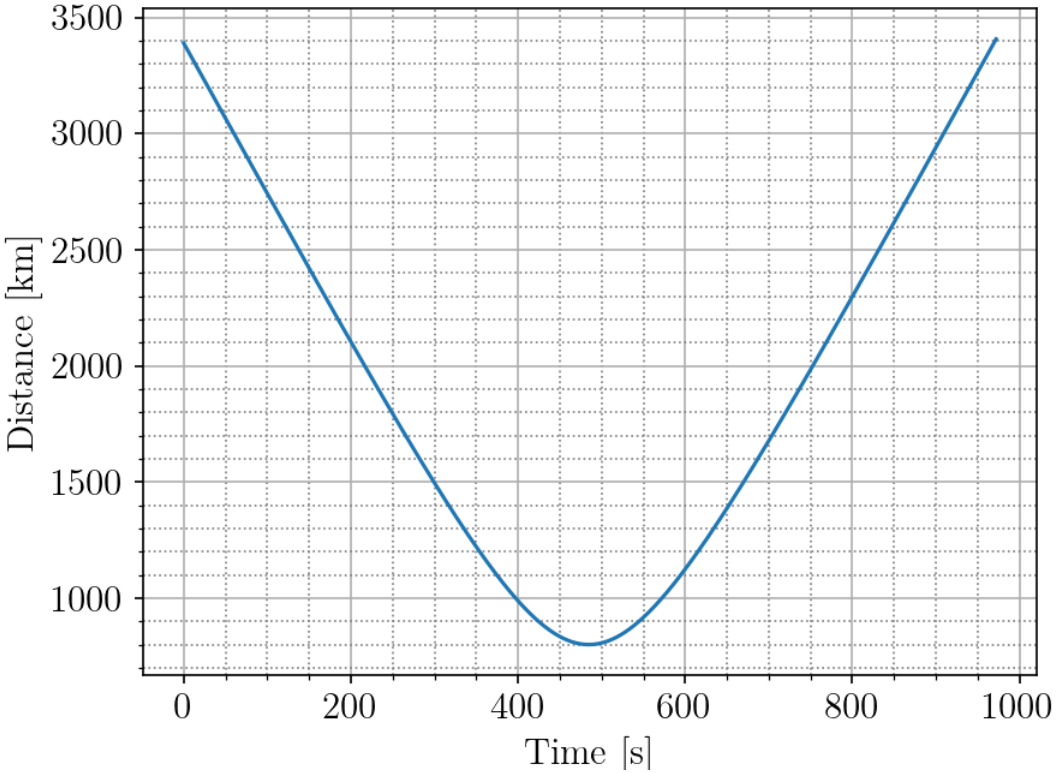
Baseband Signal I/Q File

LEO-PNT Signal Tracking results

LEO orbit @ 800 km



Very short pass (~15 min),
Only a short time at high elevation



Large difference in distance:

- High power difference
- High Doppler

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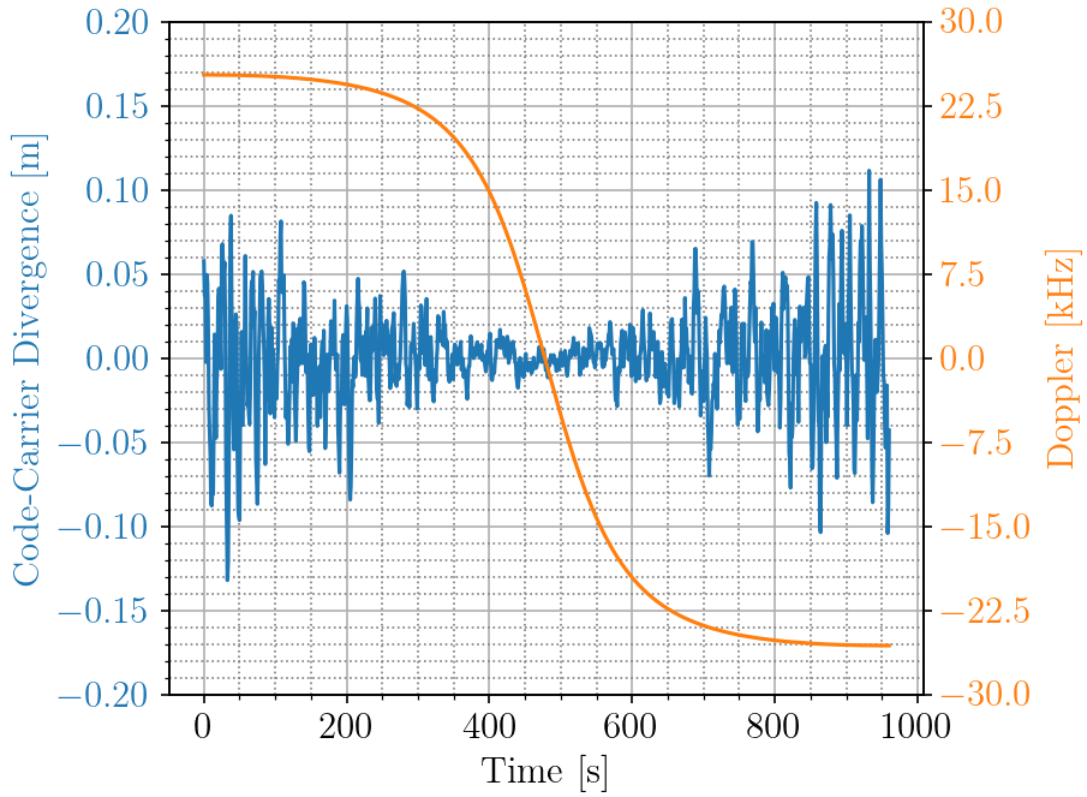
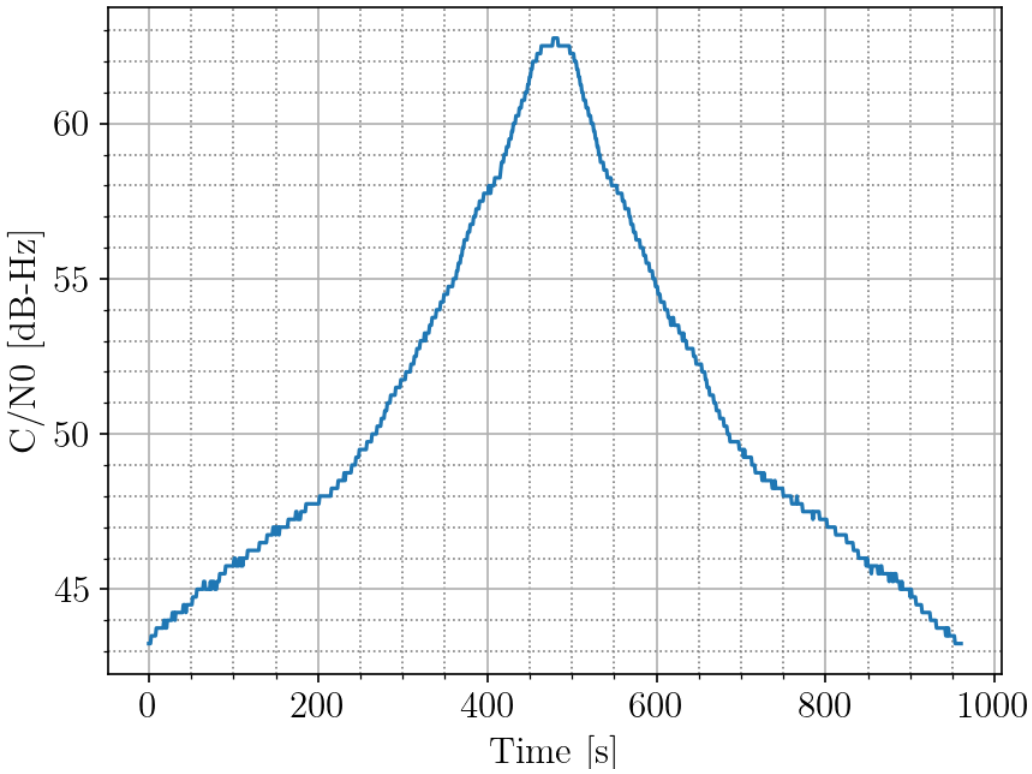
L-band: 1176.45 MHz, E5a signal





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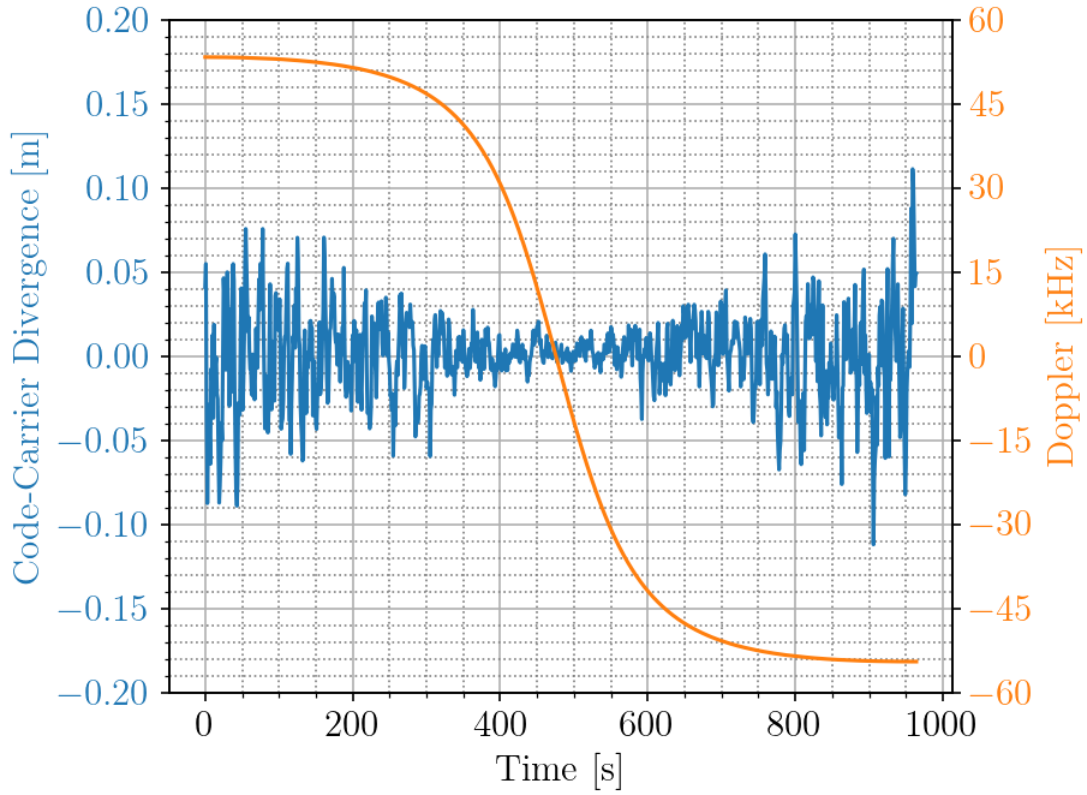
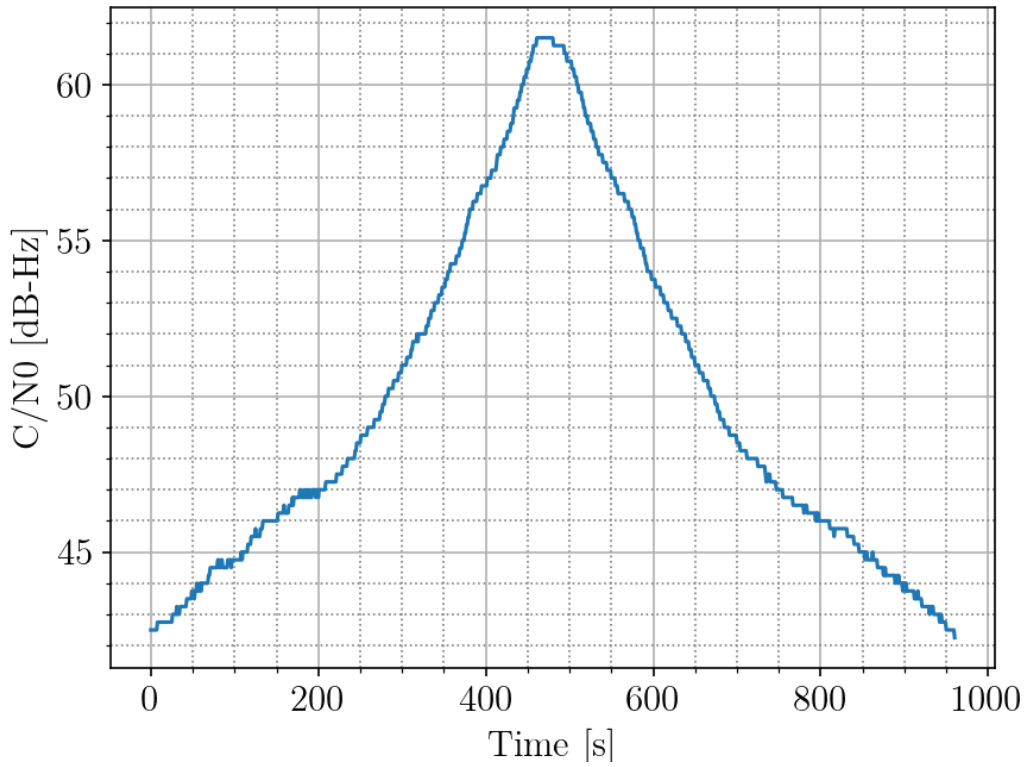
S-band: 2492.028 MHz, E5b signal





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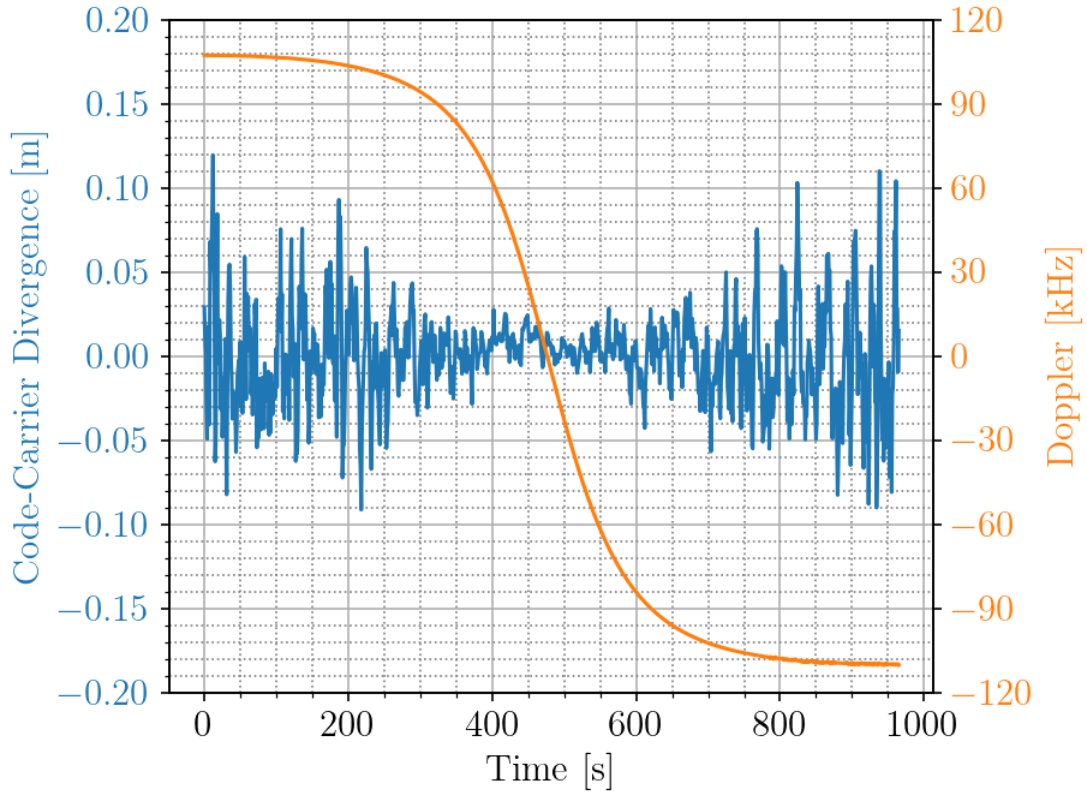
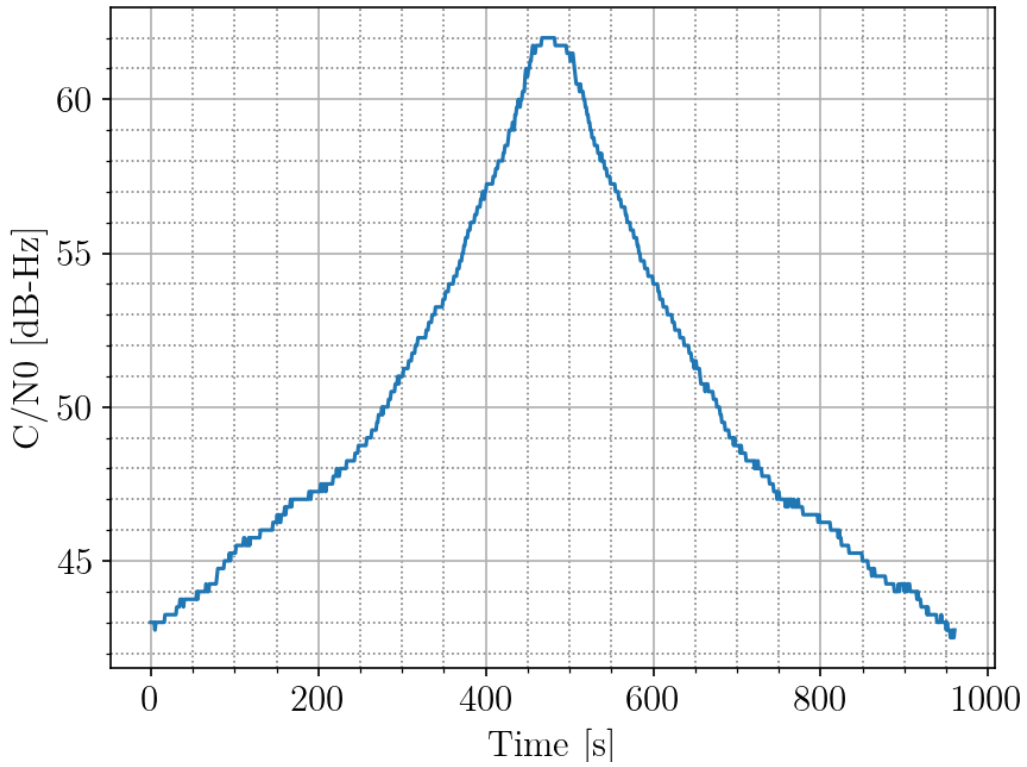
C-band: 5019.861 MHz, E5b signal





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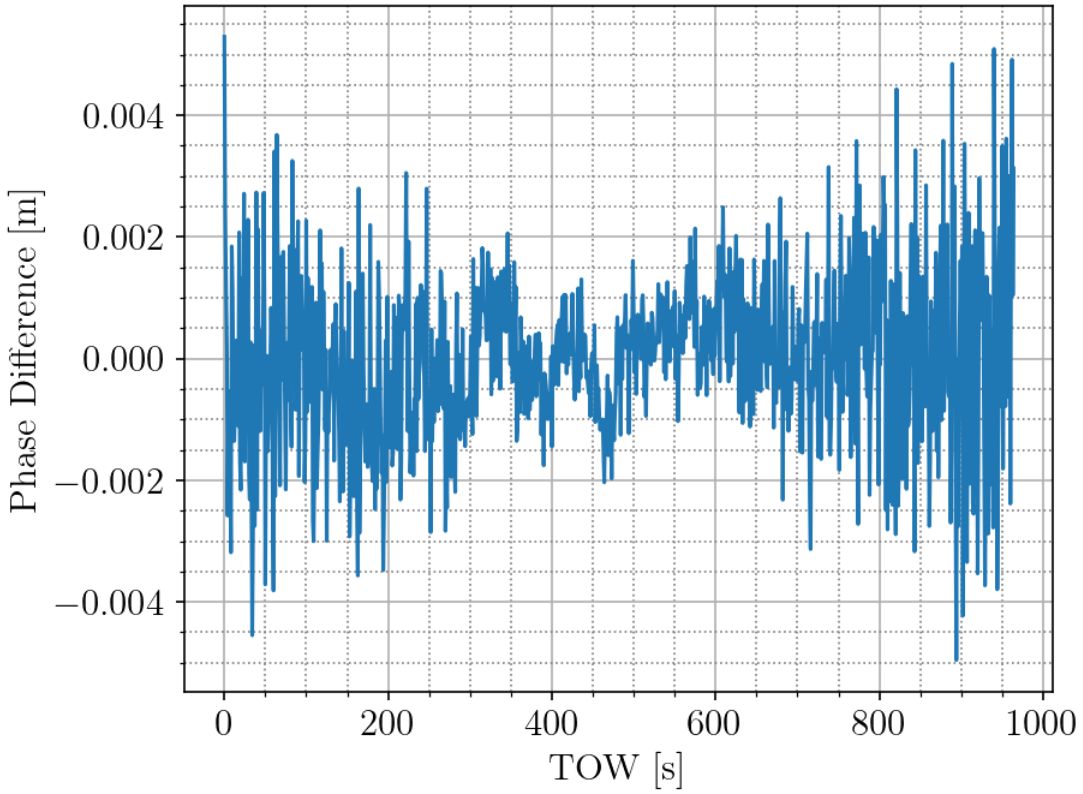
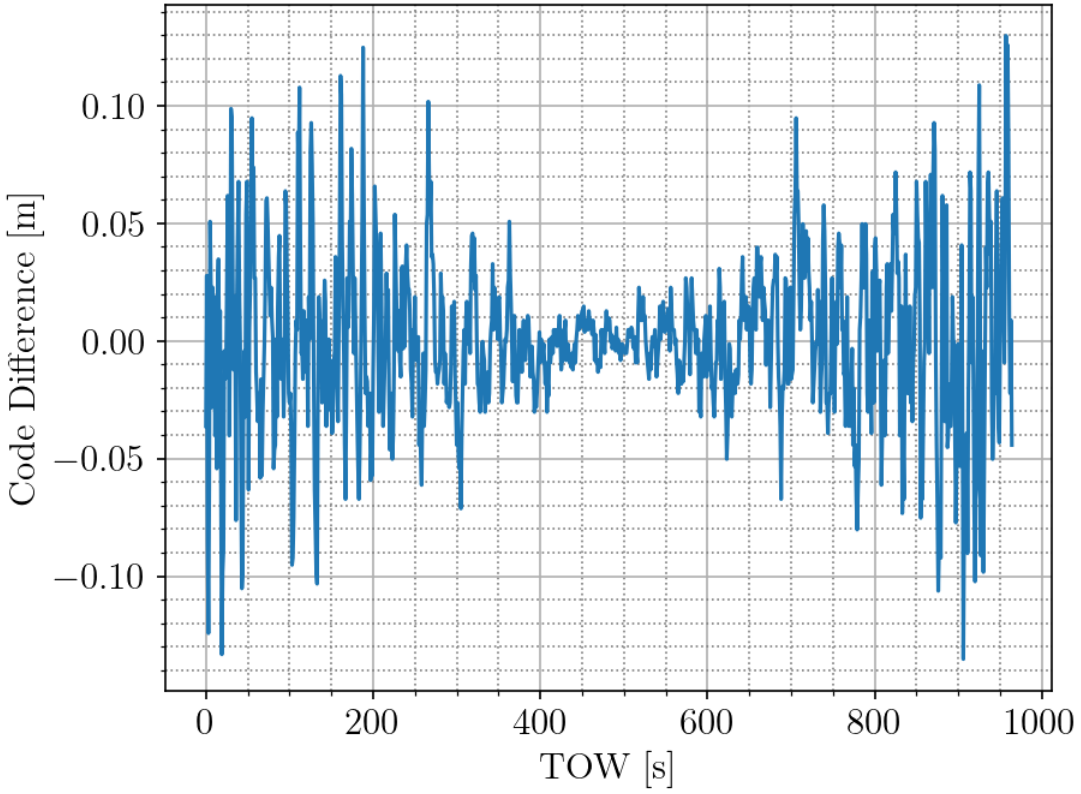
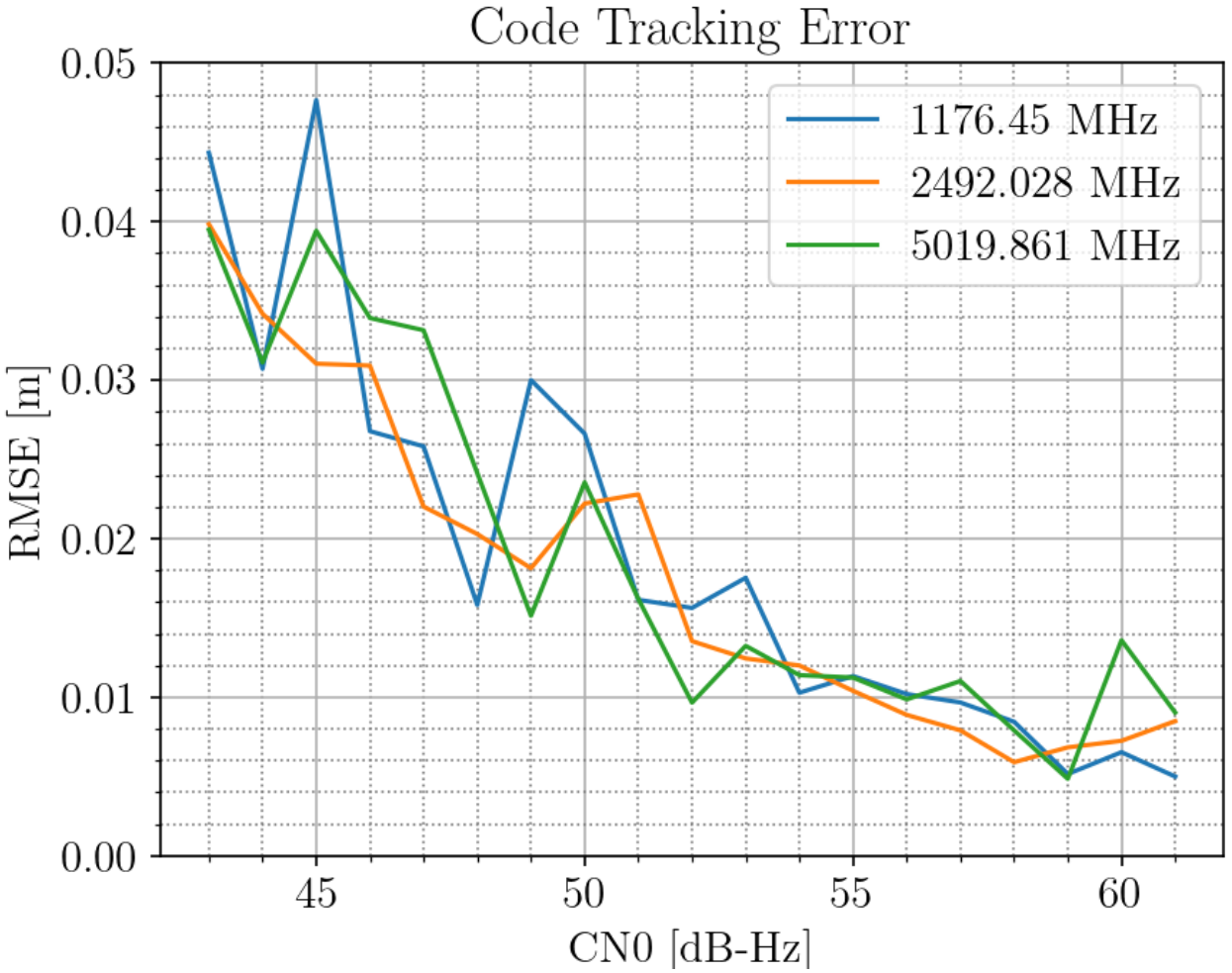
Dual frequency combinations: L-band vs S-band



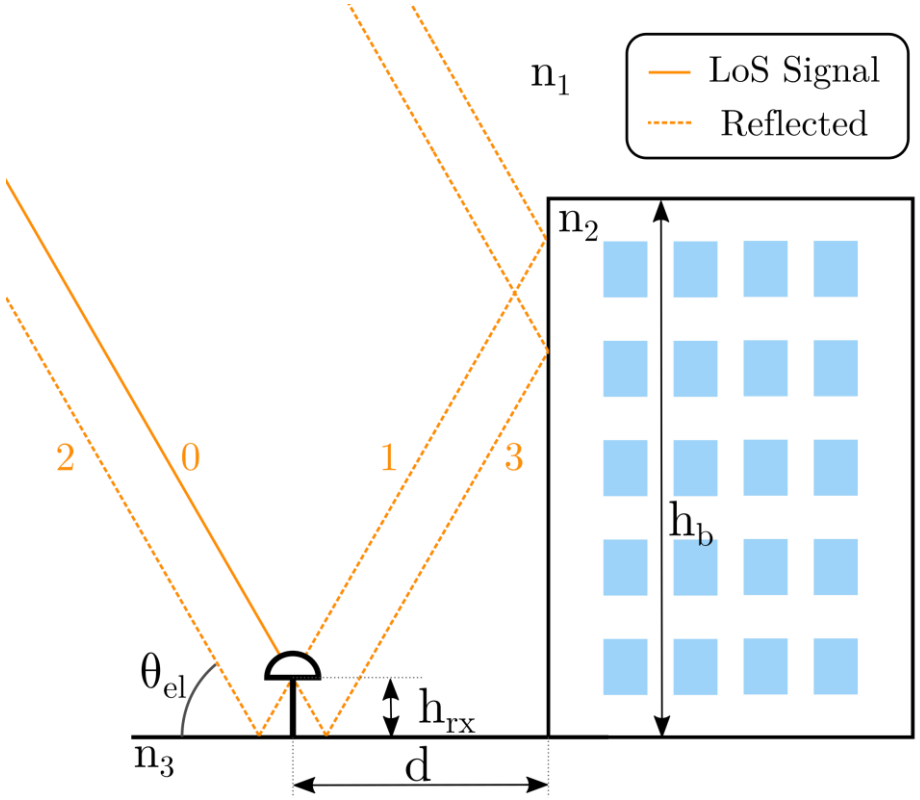


Carrier frequency does not influence code tracking error

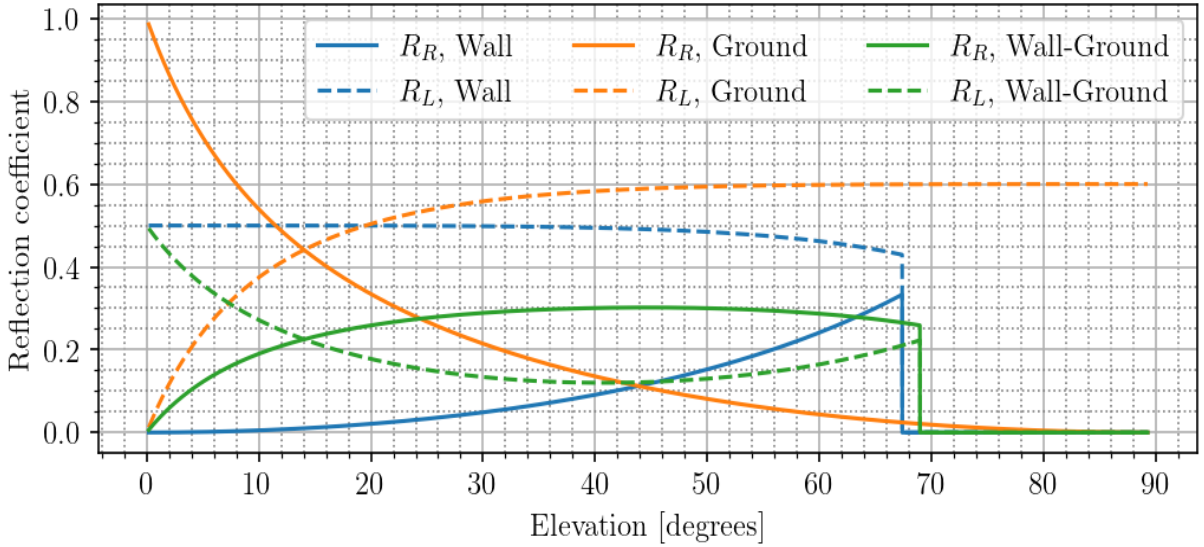


LEO-PNT Multipath Scenario

Multipath scenario overview



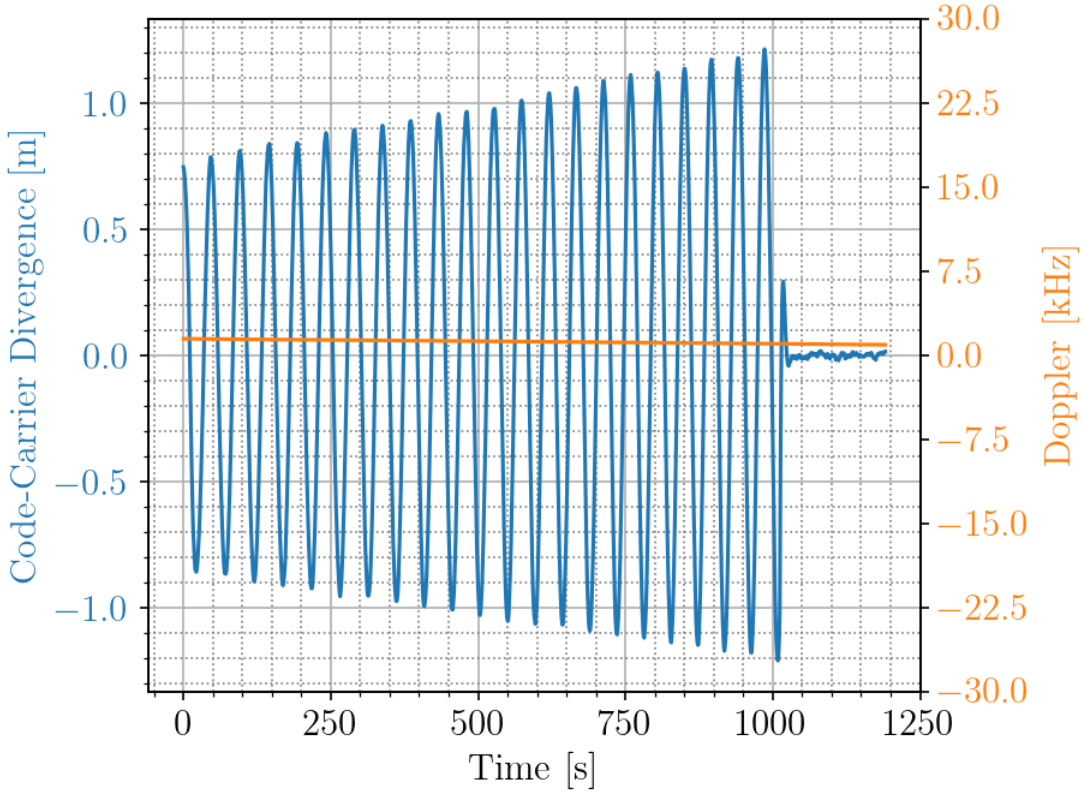
- **Static** RX at height of 2m above ground
- High concrete building (50m) at 20m distance
- Wall reflection is severe around 65 degrees elevation



De Bast, Sibren, Jean-Marie Sleewaegen, and Wim De Wilde. "Analysis of Multipath Code-Range Errors in Future LEO-PNT Systems." *Engineering Proceedings* 54.1 (2023): 34.

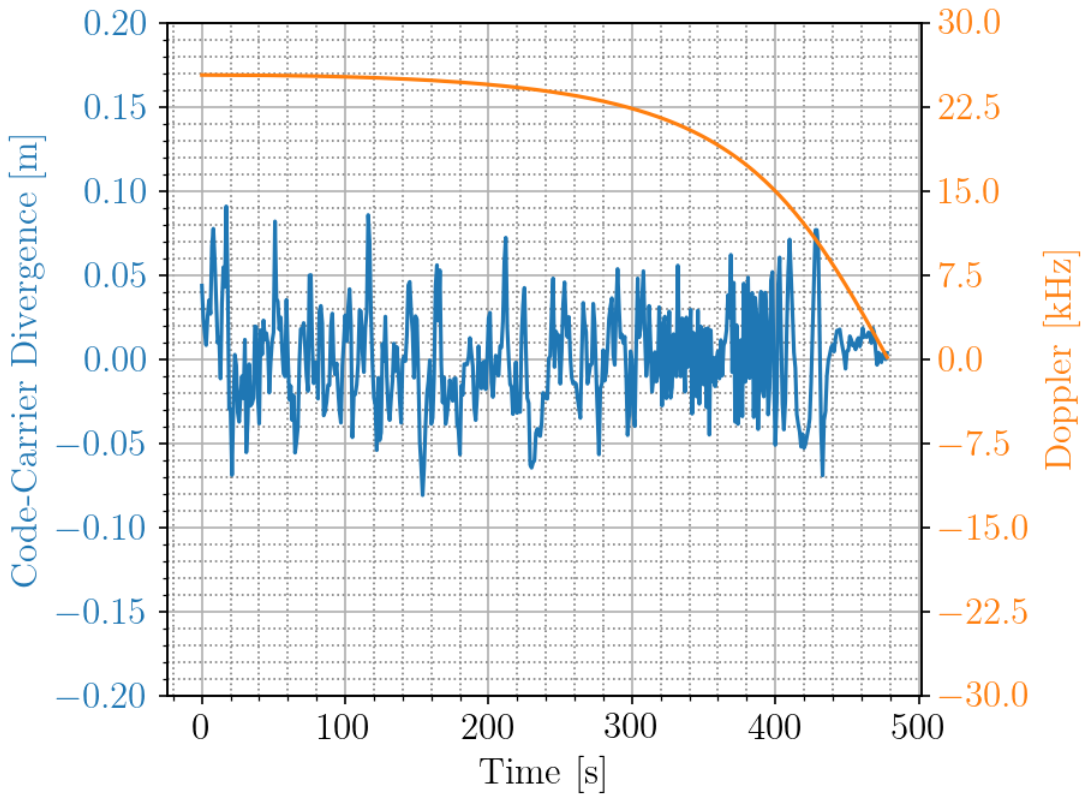
MEO vs LEO

23 222 km, elev: 65 -> 68 degrees



MP Error ~ 1.2 m

800 km, elev: 0 -> 90 degrees



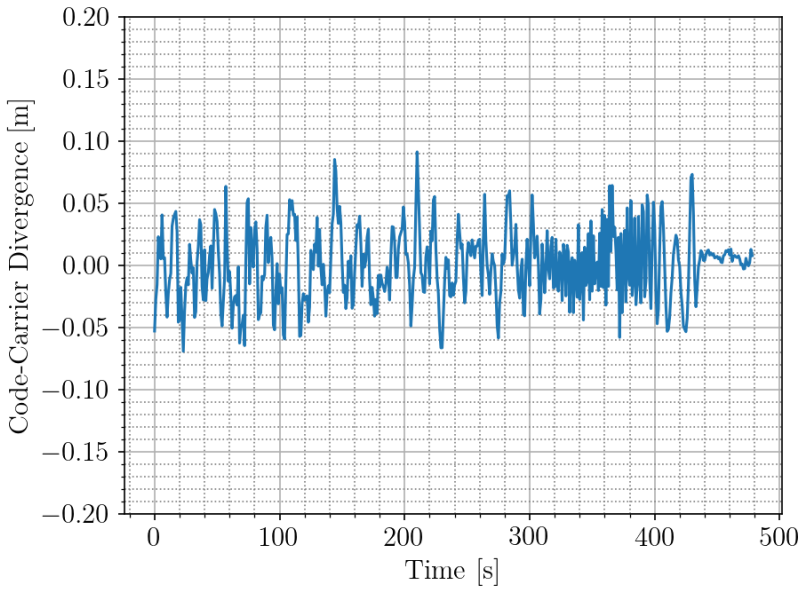
MP Error ~ 0.08 m

In both cases, MP mitigation was turned off in the receiver

Carrier frequency influences code multipath error

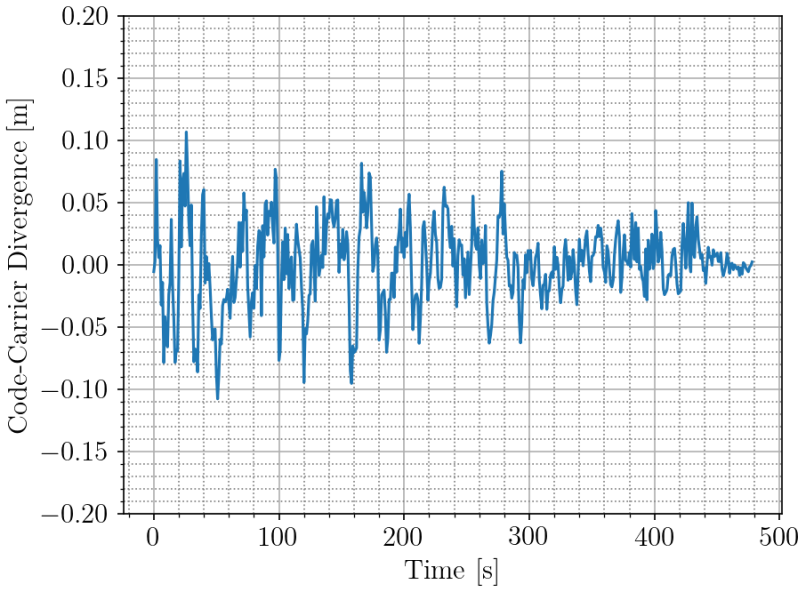
Half pass: Elevation: 0 -> 90 degrees

L-band



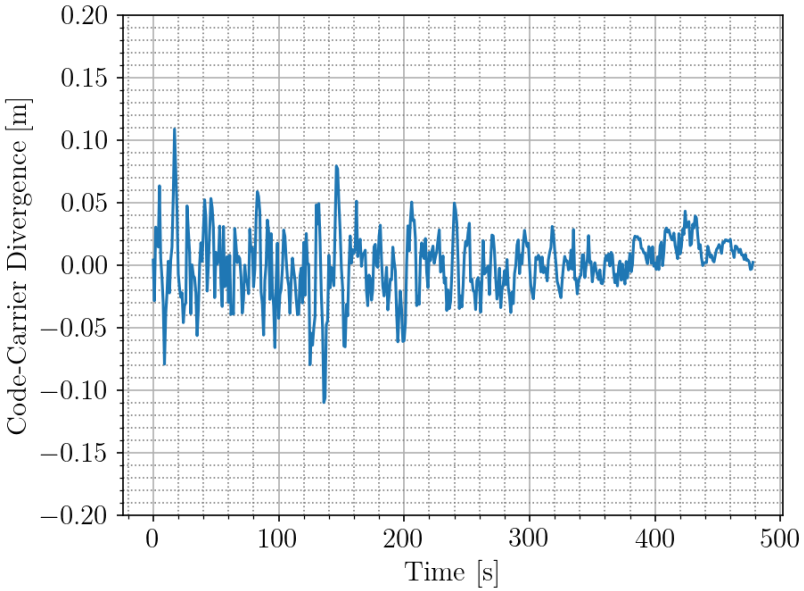
MP error: 8 cm

S-band



MP error: 5 cm

C-band



MP error: 3 cm

Summary

- Septentrio focuses both on Space- & User Segment
- LEO-PNT has a big promise towards robustness, availability & resilience
- Rapid prototyping and breadboarding succesfull
- HIL simulation results are very promising

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