GPS Performance with the GRANDProto FEB

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Experimental Setup

- A GRAND “Box” with a Trimble (now Protempis) single-frequency GNSS receiver
- A Septentrio high-grade GNSS receiver PolaRx5TR
- A high-quality GNSS antenna PolaNt Choke Ring
- One “low-cost” u-blox F9T (dual-frequency) receiver
- A GNSS 4-way splitter
- A White Rabbit switch connected to the T-REFIMEVE network for an accurate PPS time reference (±1 ns from UTC(OP))
- A high-quality 4-channel oscilloscope

High-quality GNSS reveiver **PolaRx5TR**

- **High-quality GNSS receiver PolaRx5TR from Septentrio (~$15,000)**
  - **Connected to a high-quality GNSS antenna via a GNSS splitter.**
  - **This receiver provides a very precise position (better than 1 cm), which is used as a reference.**

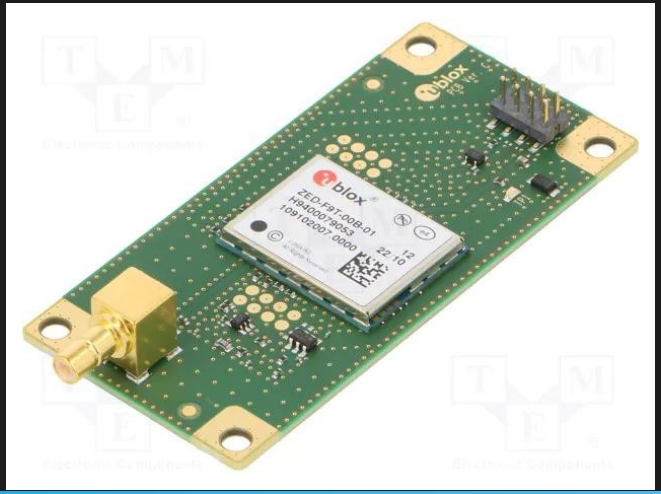
High-quality GNSS reveiver **PolaRx5TR**

Figure – Le récepteur Septentrio PolaRx5TR

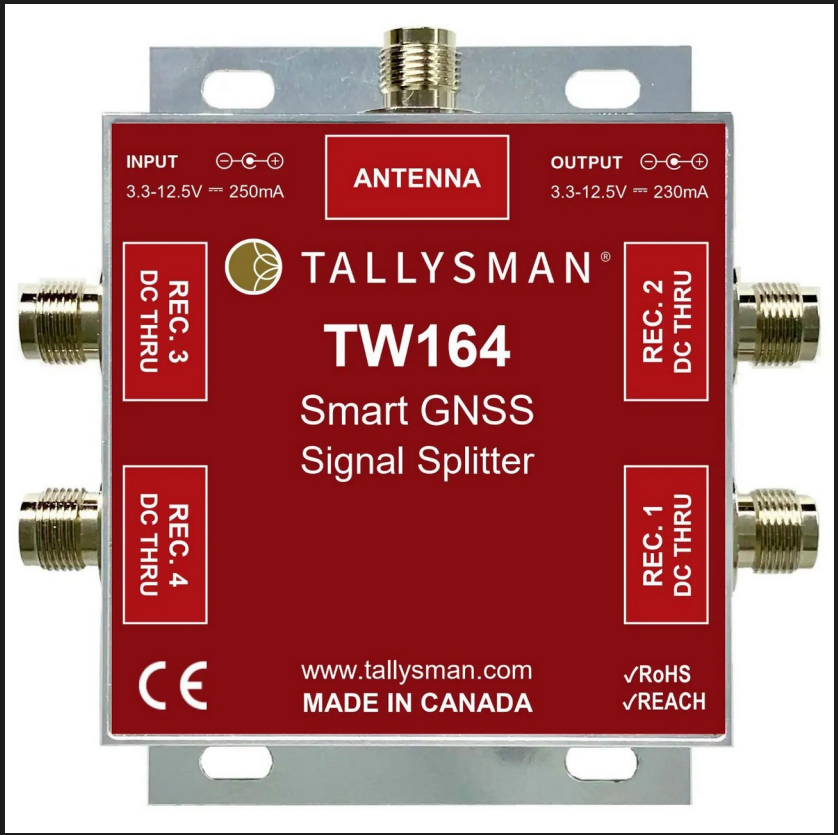
“Low cost” Ublox F9T (Dual Frequency)

- “Low Cost” GNSS receiver Ublox F9T **from Ublox**

  - **Connected to the same High Quality GNSS antenna using the same GNSS splitter**

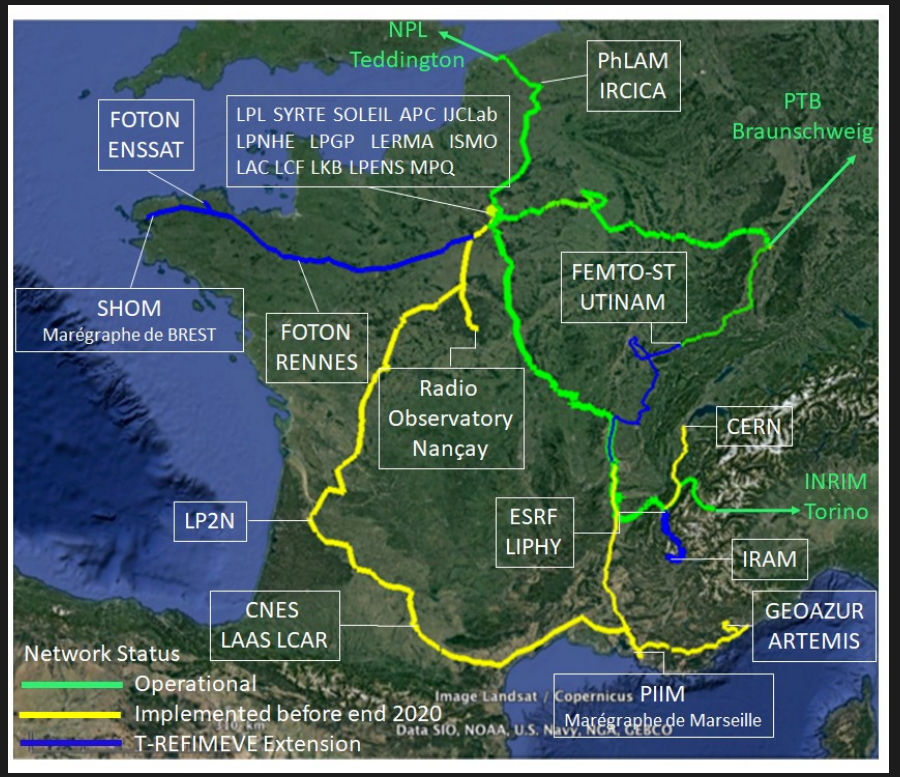


4 ways GNSS splitter



White Rabbit switch connected to the T-REFIMEVE Network

- LPNHE is a member of the T-REFIMEVE Network
- T-REFIMEVE distribute a very precise Time Reference base on UTC(OP) using the WHITE RABBIT protocol
- The precision is about 1-2ns



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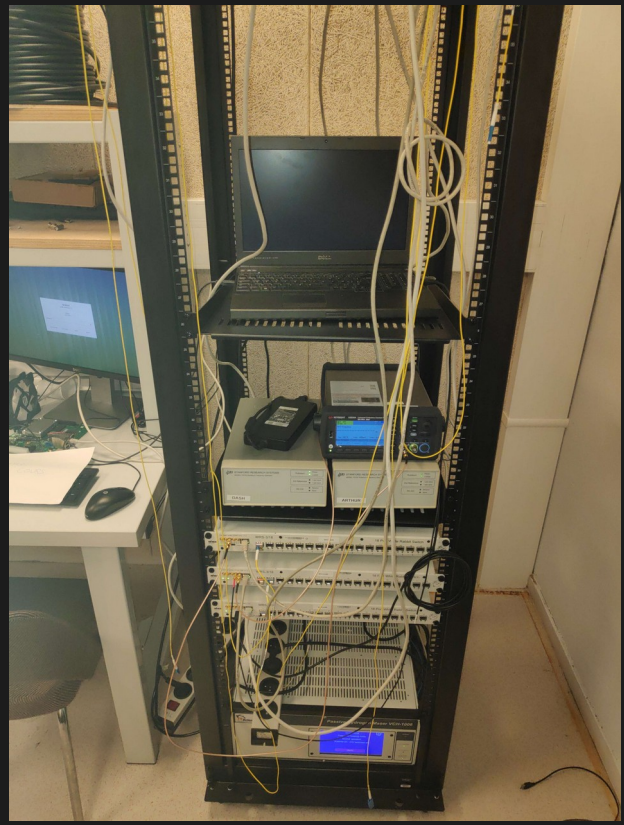
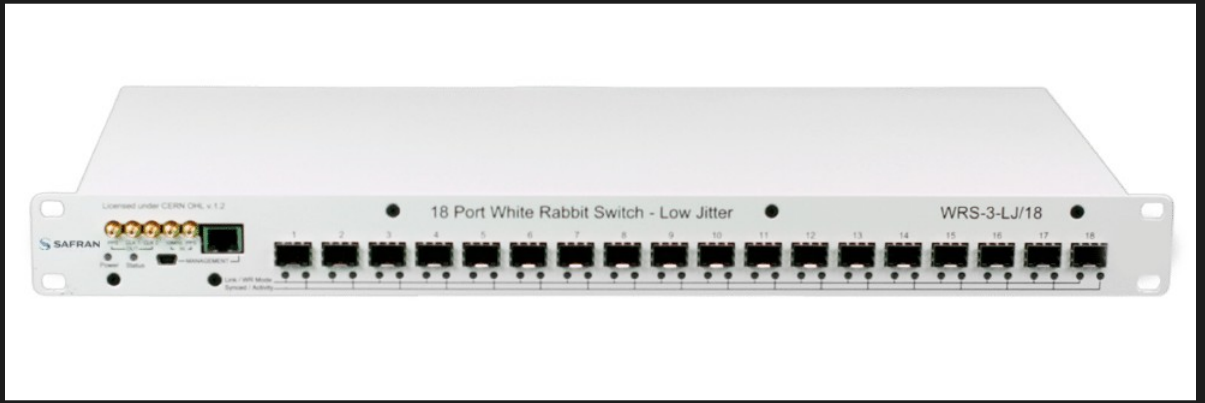


White Rabbit switch connected to the T-REFIMEVE Network

- **The WHITE RABBIT Switch connected to the T-REFIMEVE network give a Pulse Per Seconde synchronize with the UTC (OP) with a precision about 1-2ns**



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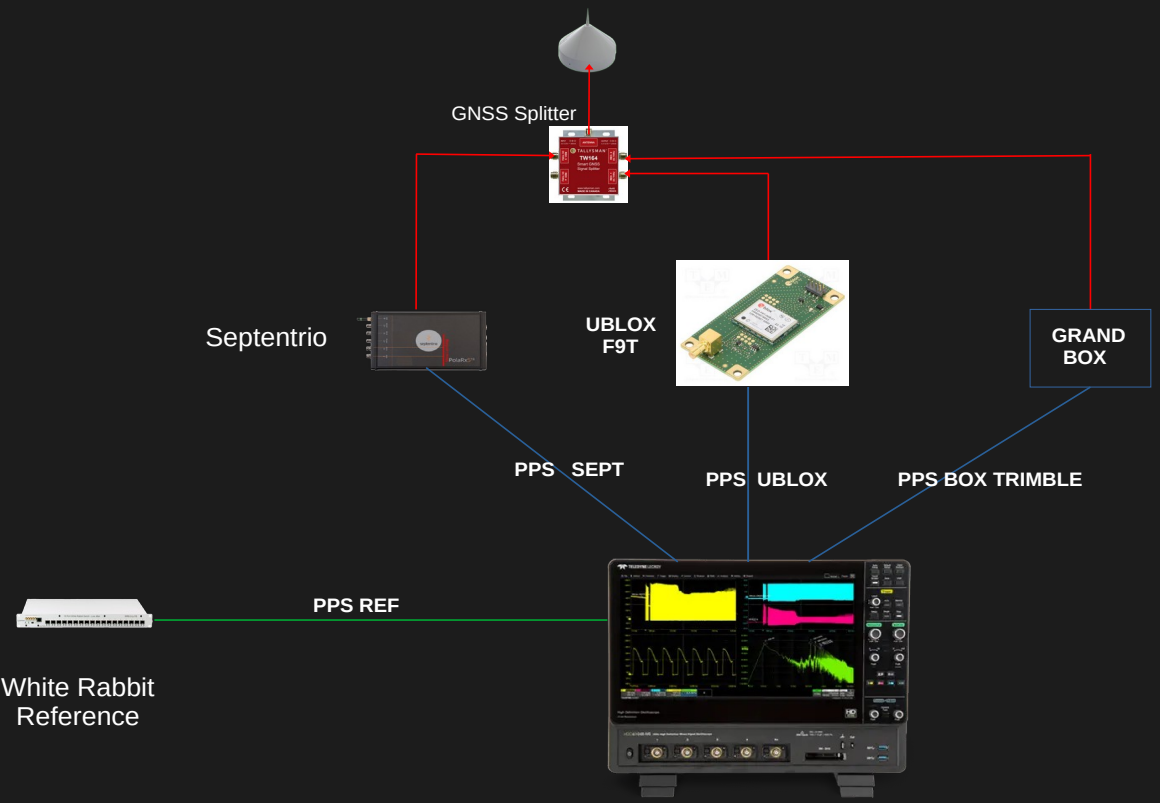
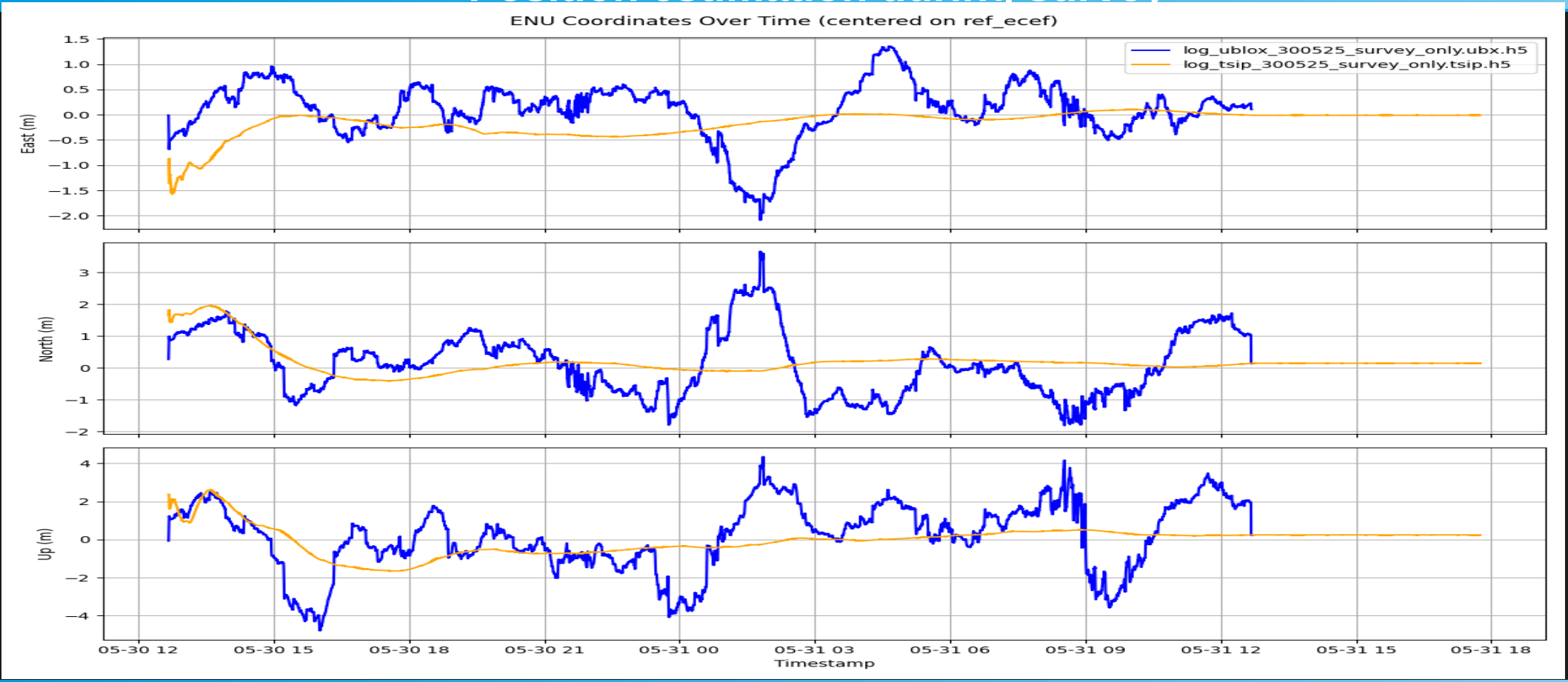


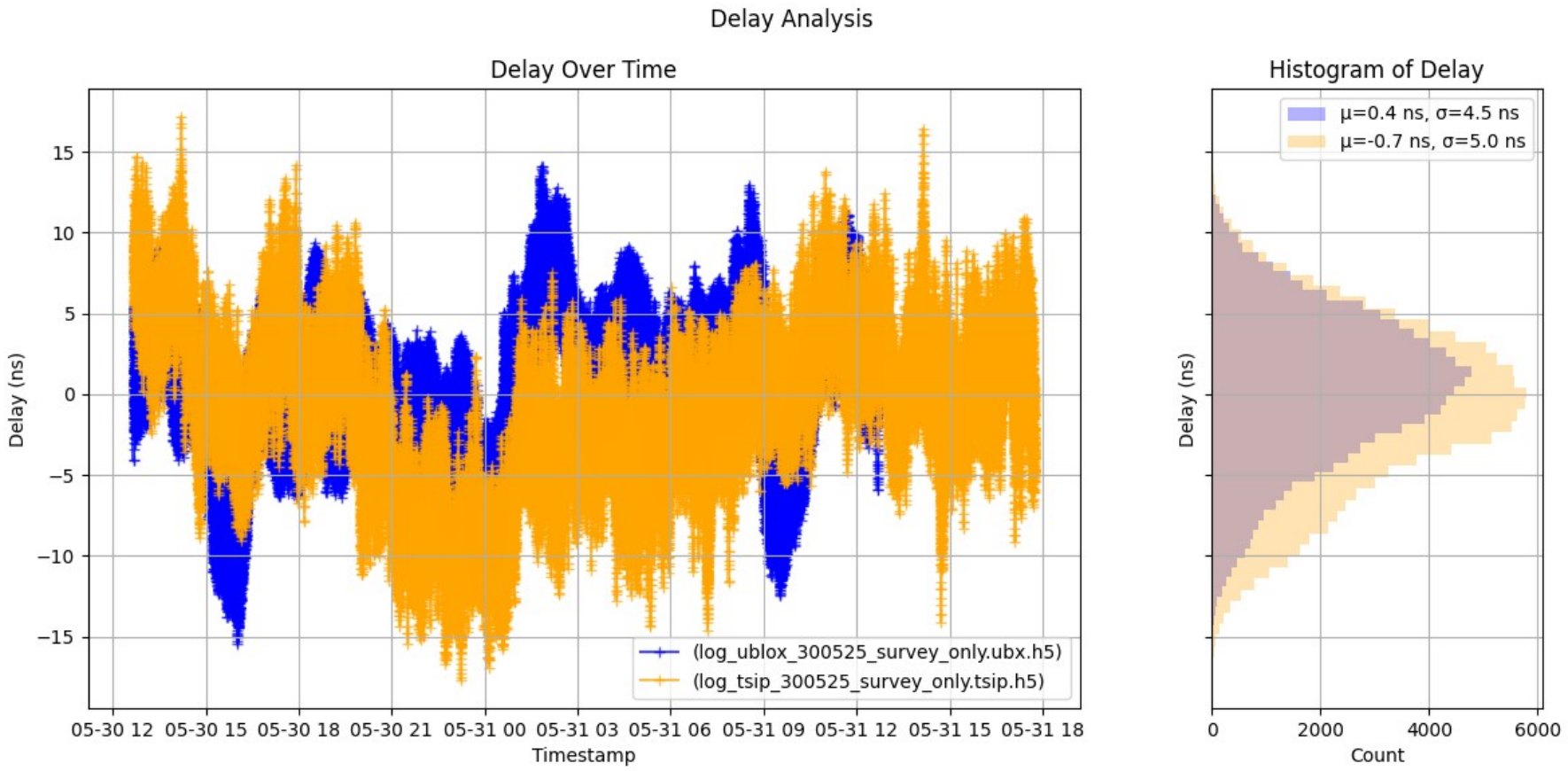
Study on the behavior of the survey mode

- For GNSS dedicated to timing applications, there is a “survey” mode.
  - To have correct time, the receiver must know its position accurately.
  - In survey mode, the receiver computes its position over a configurable duration, until a standard deviation estimate becomes lower than a configurable threshold.
  - After this process, the position is considered “fixed”, and this increases the precision of the time.
  - To avoid this survey process, if the position of the antenna is well known, this position can be directly provided to the receiver.

Study on the behavior of the survey mode
Position estimation during survey



Study on the behavior of the survey mode
PPS variation during survey



GNSS PPS time relative to WhiteRabbit Time Reference (1-2ns from UTC(OP)) before calibration

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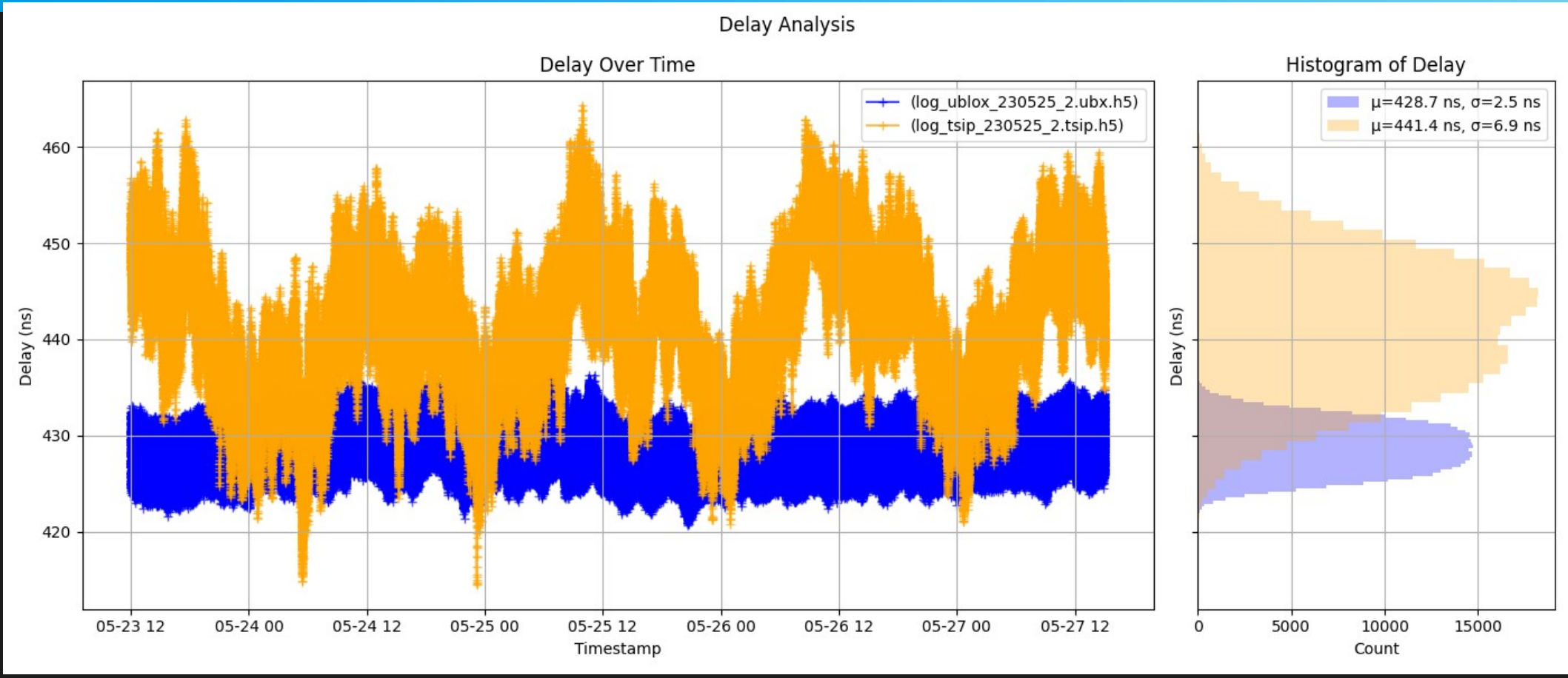
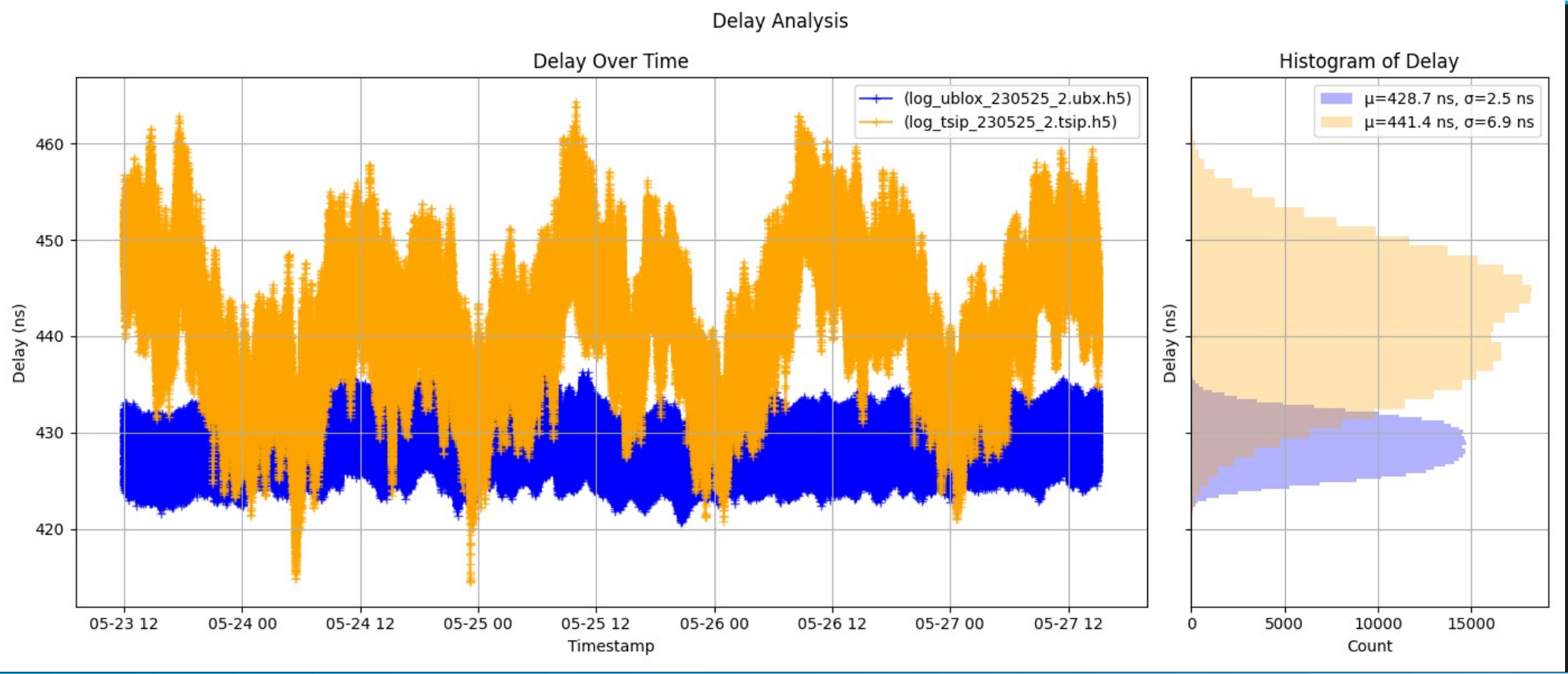
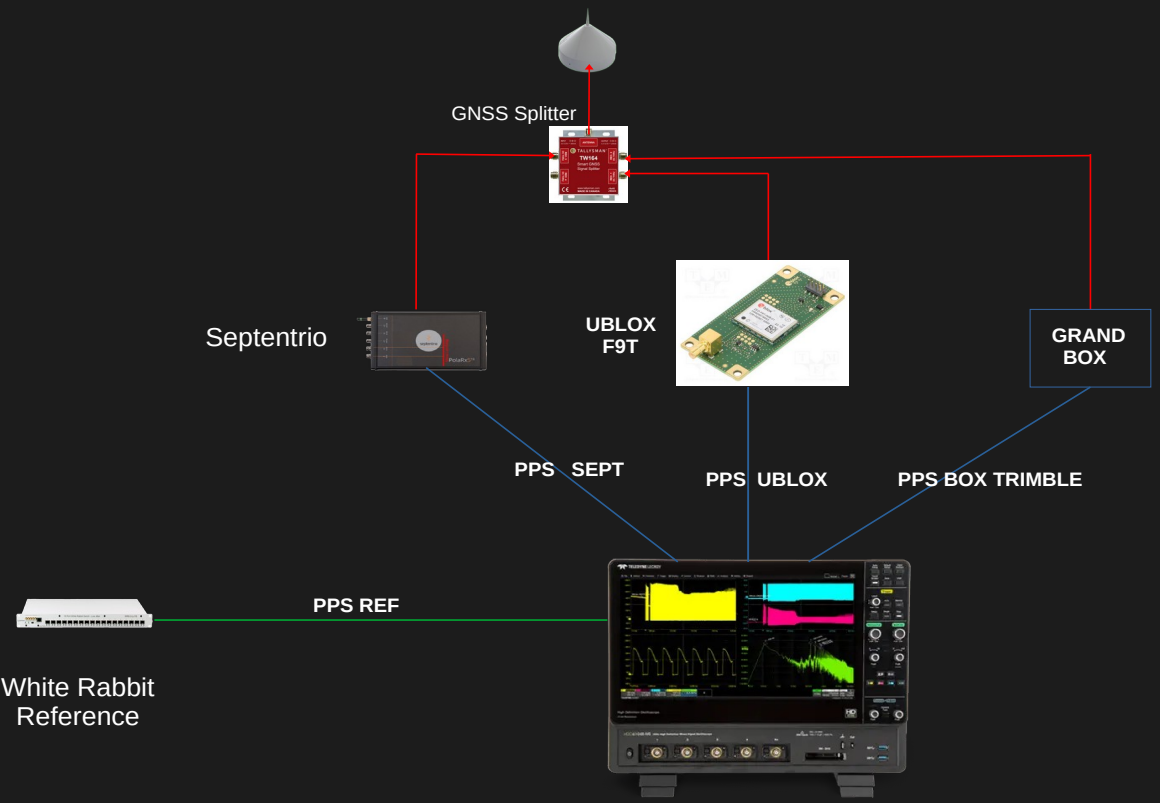


Results without any calibration of delays (antenna cables, PPS cables, GNSS internal delays)



Delays in antenna cables, PPS cable



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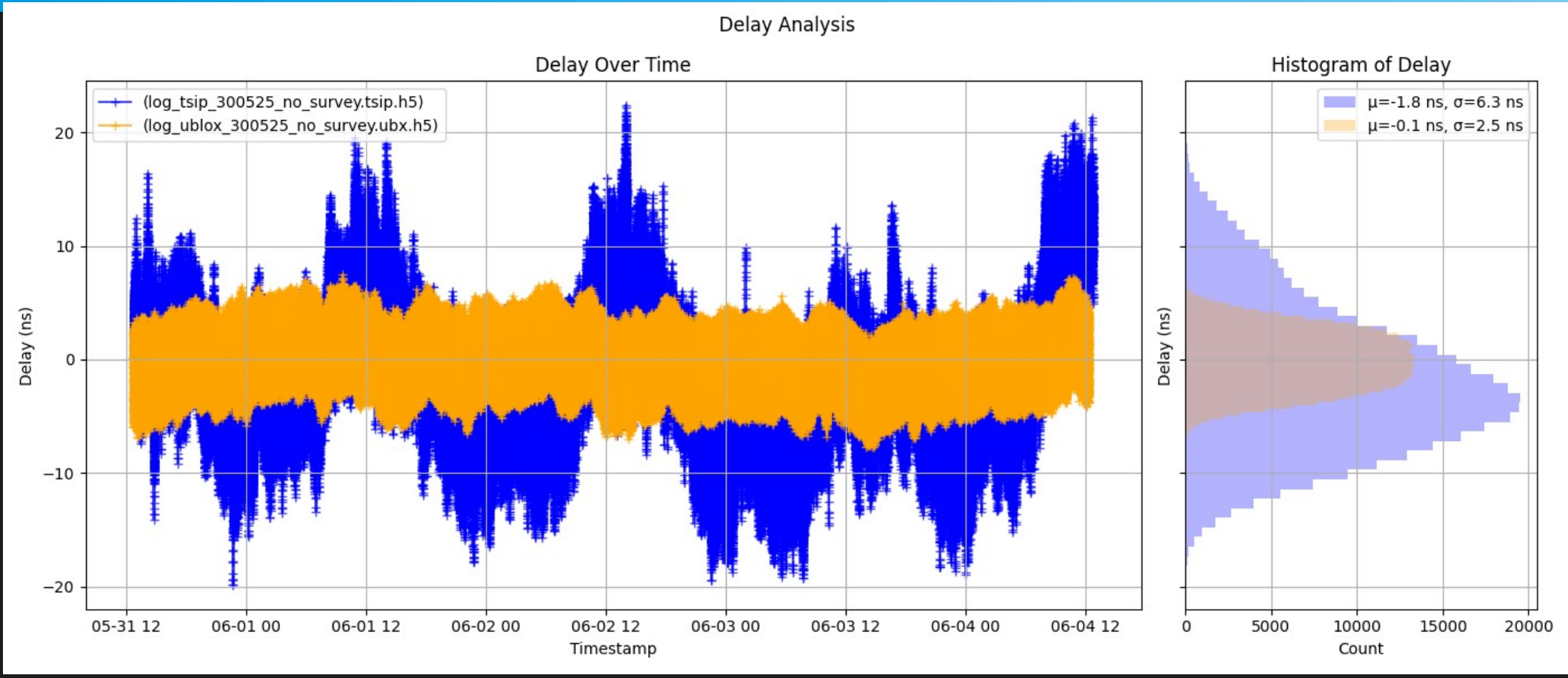

Open Reflections and Proposals for the Future

Open Reflections and Proposals for the Future concerning GNSS

- Use of a Dual or Triple Frequency GNSS Receiver, (still “quite” low cost
  - Ublox F9T (Dual)
  - Setptentrio Mosaic-T (Triple)
  - Novatel (Dual and Triple)

- But the cost must be evaluate

Open Reflections and Proposals for the Future concerning GNSS

- Global (UTC based) timestamping of events are important

  But relative timestamping precision between beacons are maybe more important ?

  - Technique like Differential GPS (in real time or in post-processing) allows a better RELATIVE precision of timestamping by reducing common errors between nearby receivers

Open Reflection and Proposal for the Future concerning the electronics

- Some GNSS dedicated to Timing have a 10MHz Output
  - Maybe I could me a good idea to “clock” ADC with a 10 MHz for a better timestamp of samples ?

- For the moment the time-stamping of the PPS in the FPGA is based on counter
  - Maybe I could be interesting to use TDC (Time to Digital Converter) in the FPGA for a more precise timestamping of the PPS ?