T2K GPS Status and Upgrade Plans

Haowei Zheng
(for the T2K-GPS group)
Stony Brook University

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T2K GPS Status

T2K GPS Receivers

GPS system in Tokai NU1 Hall and SK used to keep Time sychronisation at beam and far detector

Currently 3 GPS receivers are used in each subsystem:

- ND: GPS1 = CNS Clock II (now tertiary)
- SK: GPS1 = TrueTime (old primary, now tertiary)
- GPS2 = Motorola (secondary)
- GPS3 = Septentrio (primary, T2K data analysis)

Also a Rubidium clock at each site as back-up

T2K GPS Upgrade Status

GPS upgrade work was performed during May - August 2022 at Tokai NU1 Hall (by H. Berns and K. Sakashita)

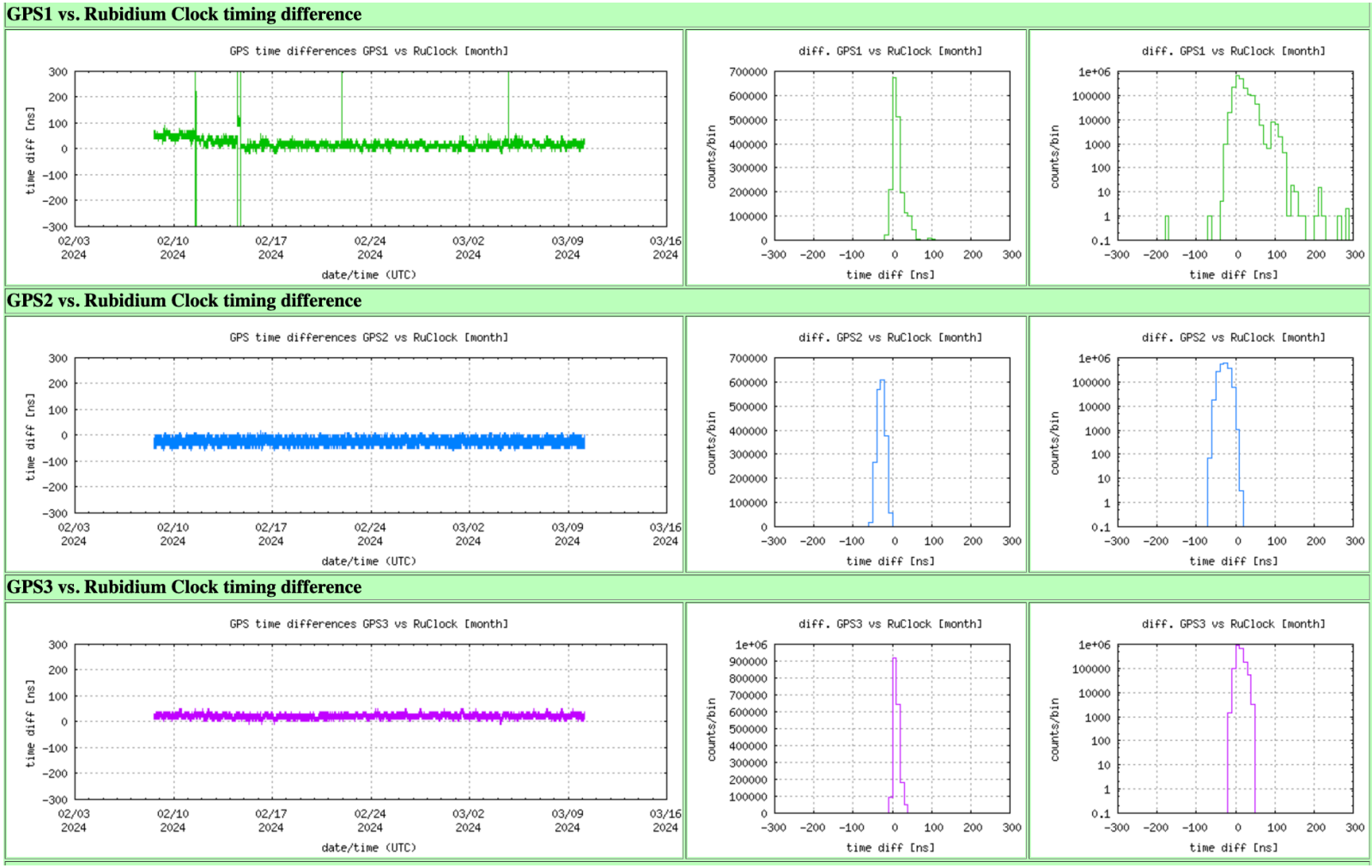
- Now both primary and backup GPS1s are working smoothly

A new CNS Clock II has been sent to Kamioka from Tokai since the last CM, and is currently awaiting installation (as the new SK GPS I)

T2K GPS Status Beam site

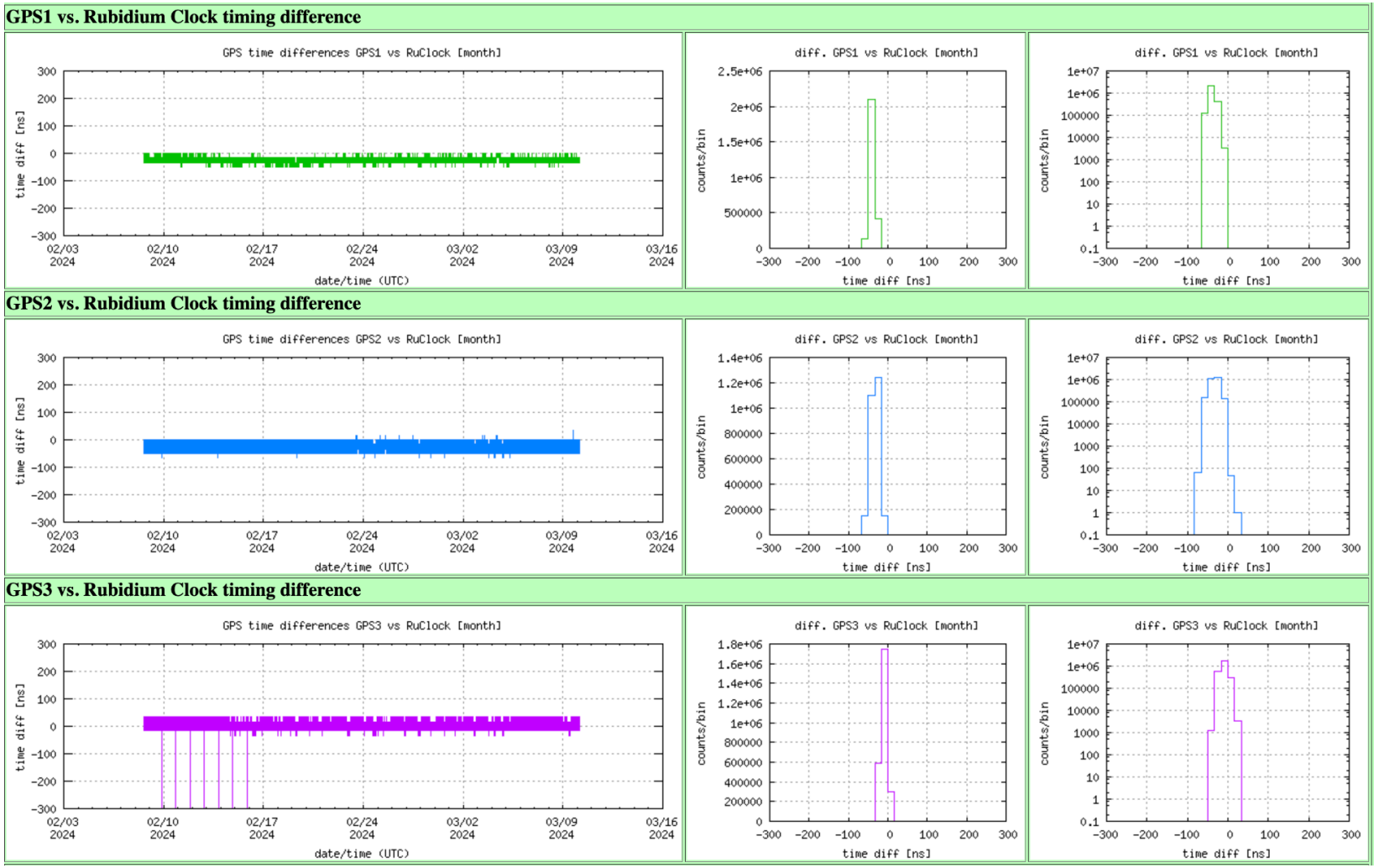
- Time stamp measurement by GPS is stable at ND site.
- Reminder:
  - GPS1 = CNS Clock II (tertiary)
  - GPS2 = Motorola (secondary)
  - GPS3 = Septentrio (new primary)

GPS 1 is currently slightly unstable after an issue occurred in January

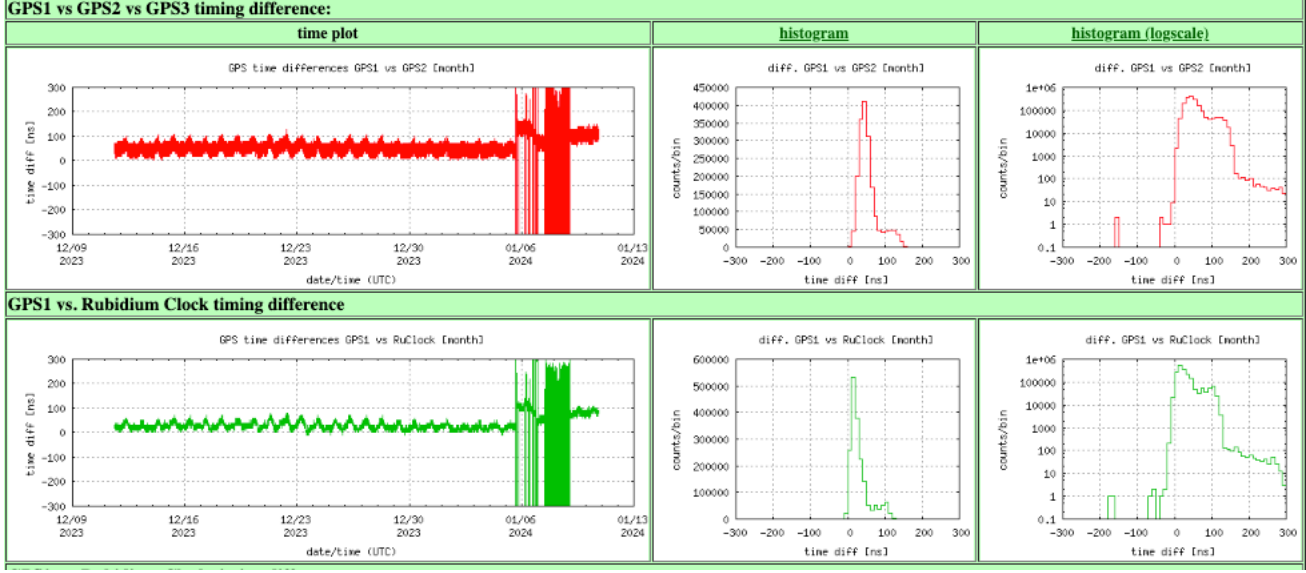


T2K GPS Status SK site

- Time stamp measurement by GPS is currently stable at SK site.
- Reminder:
  - GPS1 = TrueTime (tertiary)
  - GPS2 = Motorola (secondary)
  - GPS3 = Septentrio (new primary)



Beam Site GPS 1 Jump



- On Jan 11 2024, GPS 1 in Tokai NU1 hall had reading offset of 100ns when compared to other GPS receivers and Rd Clock
- This was a similar issue to one occurred Nov 2023, which was solved after a power reset
- Sakashita-san power-cycled CNS-Clock II and the gps collector
- The offset was gone for 1~2 days but reappeared
- Offset disappeared by itself on Feb 14th 2024, Tokai GPS I returned to relative normality

Backup

T2K GPS Upgrade Status

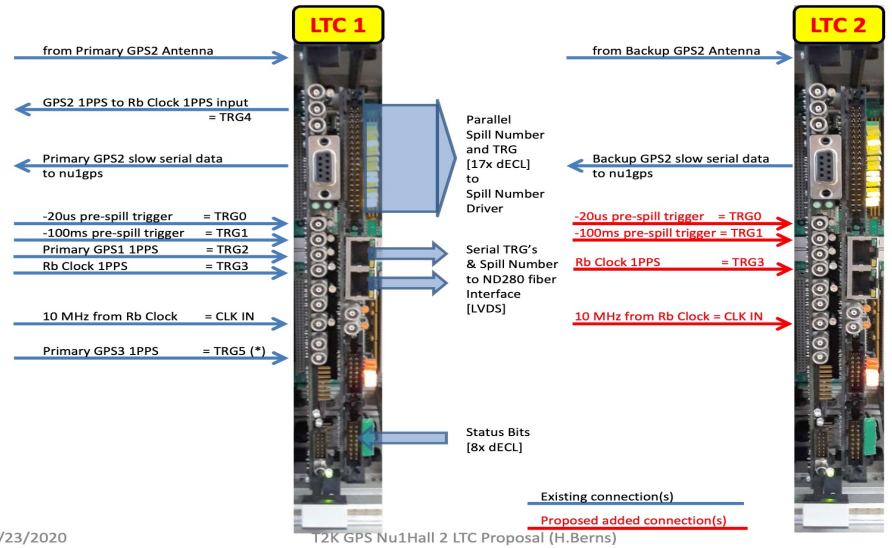
- 2 new Rubidium Clocks (SRS FS725) as spares for both JPARC and Super-K GPS system have been purchased and shipped to Tokai
  - The Ru clock at Tokai site was replaced with the existing spare one on 3/18/2019 due to clock drifting issues

- Redesign of Local Time Clock (LTC) module is in progress: aim at finishing in 2023
  - H. Berns is now designing a new FPGA board with a Xilinx-based module which will be the central logic unit for the new LTC board
  - In a DUNE related project, H.Berns found a better Xilinx-based module comparing to the previous one he had tested.
  - Design work of new LTC board's PCB is almost finished. Plan to produce a prototype of new LTC board after the Xilinx-based module check

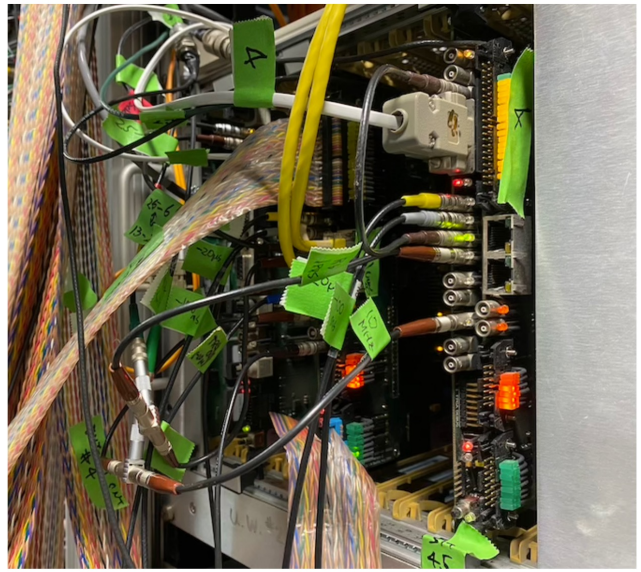
LTC1 and LTC2 Running in Parallel

- LTC1 clock counter had bug (bit 31th sometimes stuck)
- Current configuration: Using the backup LTC in parallel with the primary LTC
  - Primary LTC had been modified in Sep. 2018 for adding GPS3 to the system (which introduced the 48-bit counter problem for TRG0 input)
  - Backup LTC module was available in the VME crate, with original firmware and hardware configuration
  - Backup LTC module is used actively in parallel to the primary LTC in the gps_collector VME access
  - Connect a few signals (10 MHz rubidium reference clock, rubidium 1PPS, the ~100ms trigger and ~20µs trigger) to get the correct and accurate timing of the ~20µs trigger, and still keep all 3 GPS receivers active as well
  - Sakashita-san implemented this idea on Nov. 17th, 2020
  - H. Berns modified the gps_collector, and it's works well now by using both LTC#1 and LTC#2 to get the -20µs spill times right

Two LTC module connection diagram



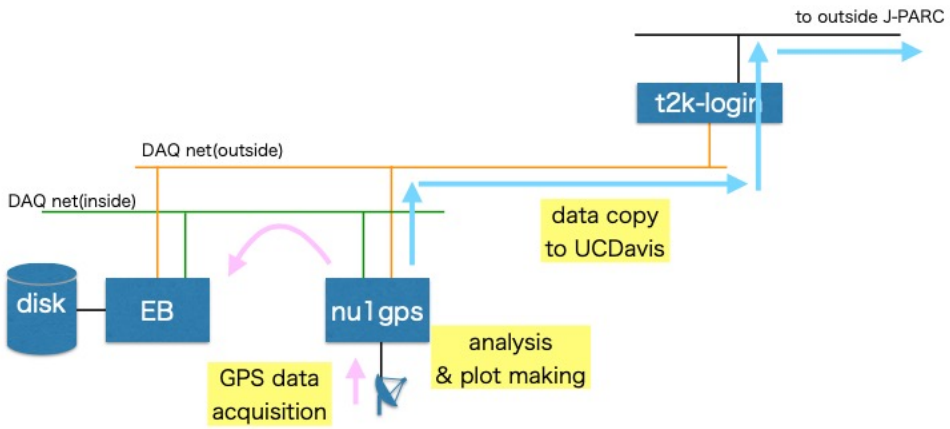
LTC#2 status (after)



Missing -100ms Pre-spill Signal and PC Upgrade

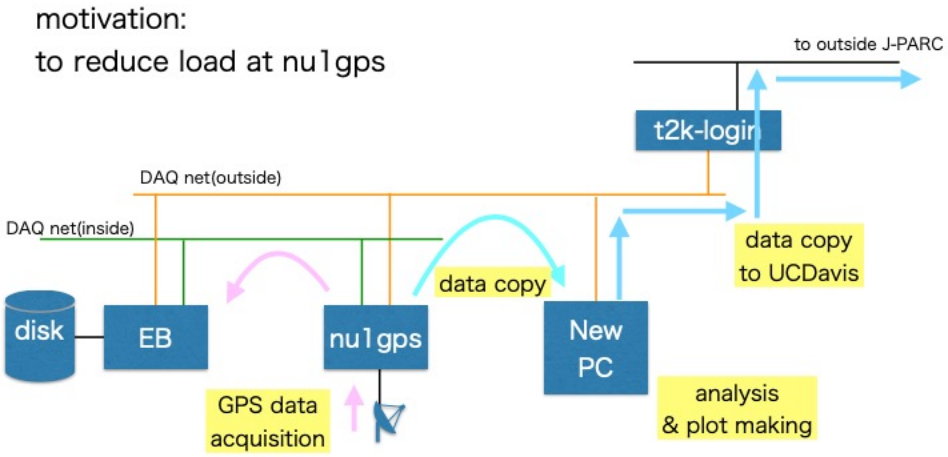
- There were some events with wrong GPS Time Stamp, which was caused because of missing -100ms spill trigger, which was caused by slow response of nu1gps (details in backup slides)
- K. Sakashita: Proposed and added a new PC to analyze and plot GPS data
  - nu1gps: only utilized for data acquisition of GPS data, and copying GPS data to gpsana01 (new PC)
  - gpsana01: analyze and plot GPS data
- This has been implemented on Feb. 17, 2021. nu1gps has also been upgraded to a PC with better CPU and memory. No missing -100ms trigger event has been observed since then.

Previous configuration



K. Sakashita

Current configuration

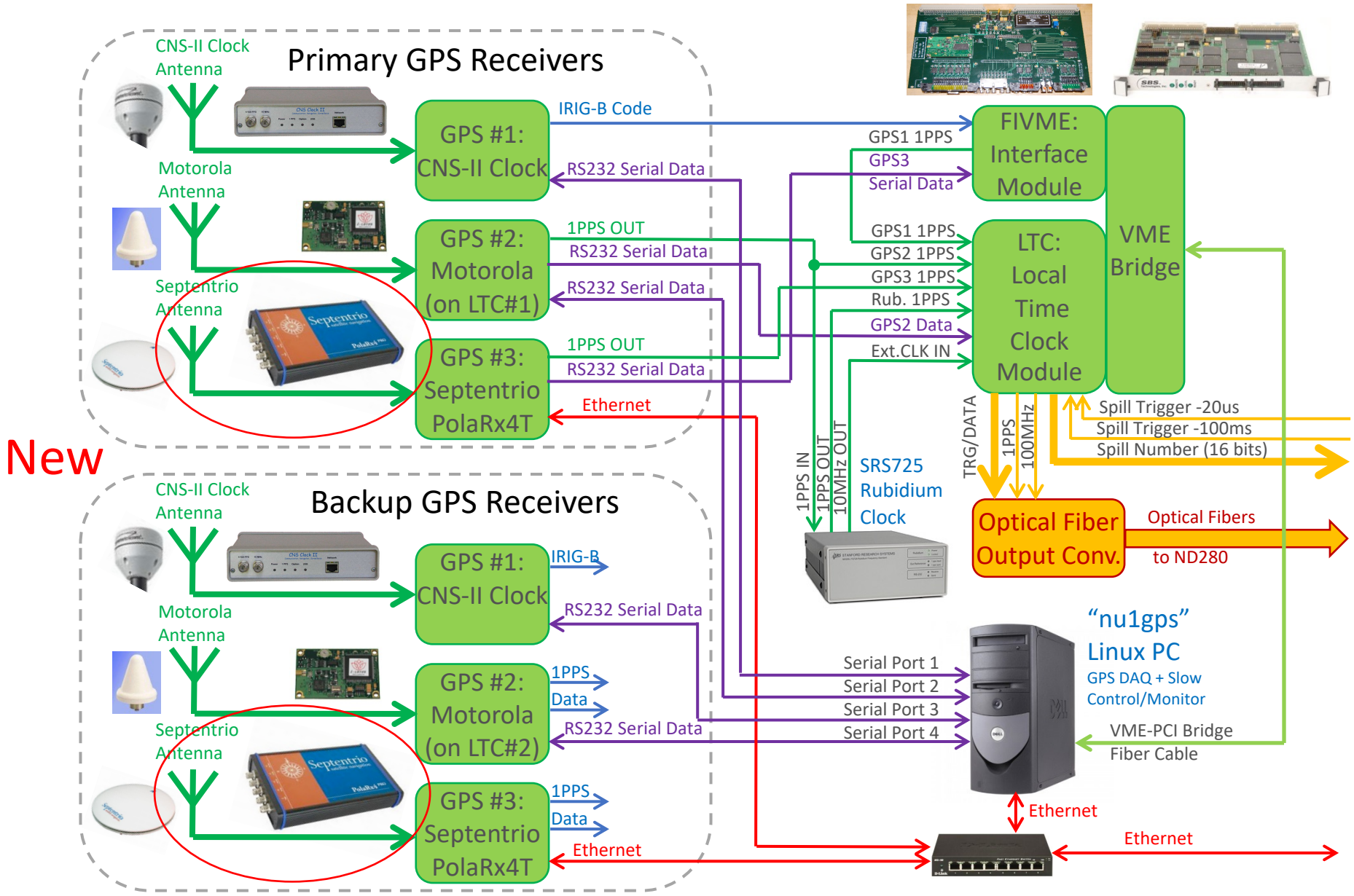


K. Sakashita

GPS Upgrade Proposal

- Need to upgrade the current T2K GPS system after ~10 years of running since the start of T2K
- This GPS upgrade is intended for T2K (and T2K-II) and not HK
- New GPS system should be robust against data loss etc. in short term as well as long term operation
- Improvement: Use Ethernet instead of VME bus to communicate between Local Time Clock module, Serial-IO boards and GPS DAQ PC
- Chang Kee submitted new 4-year T2K US Common Funds Proposal to DOE and it has been approved. Sufficient funds are guaranteed

T2K GPS at J-PARC NU1 Hall



Two LTC module connection diagram