Time Resolution for 1PPS difference of the new Trigger/GPS module

A. Corvaglia, M. Panareo, M. P. Panetta

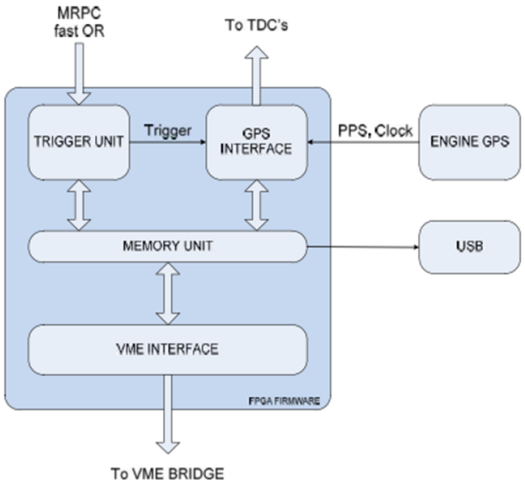
The new Trigger/GPS Module the EEE Project

The Trigger Unit

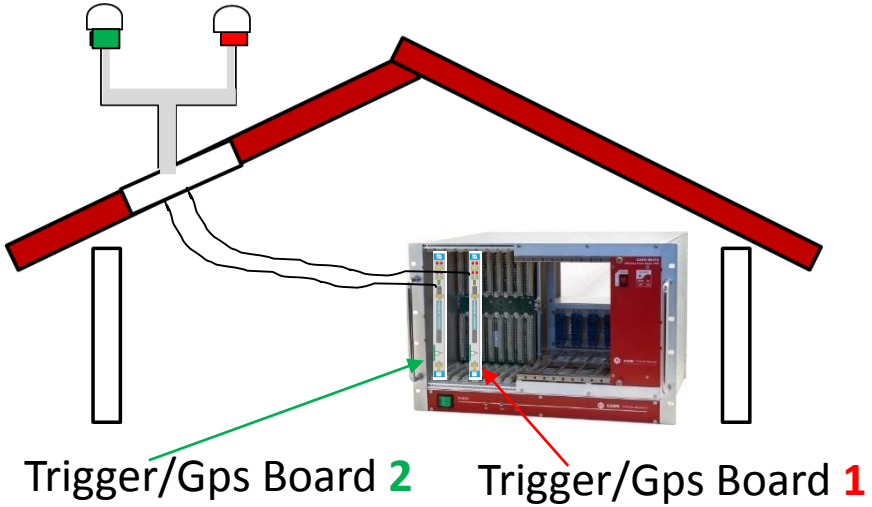
- A 6-fold coincidence (within a 500 ns window) of both FRONT-END cards of the 3 MRPCs, generates the data acquisition **Trigger**
- The trigger unit performs the count values of the triple (Trigger) chambers coincidences, the 3 doubles, the 3 single, and 6-FRONT-END outputs for testing purpose (efficiency measurements)

The GPS Interface

- The GPS unit feds both the TDCs with its **clock disciplinated** to the one pulse per second signal (1PPS) to synchronize the TDCs internal counters
- At each 1PPS pulse the internal counters are resetted
- Every time an event trigger occurs, the module feds into each TDC a signal to stamp its event time. The **absolute time** of an event is built as the **TDC event time plus the GPS timestamp for each 1PPS**.
- The LabView DAQ system directly sorts out and puts the data from the two TDCs into single events, read out the module at appropriate times and insert the GPS time values within the data stream at the correct record.



New Trigger/GPS module Test



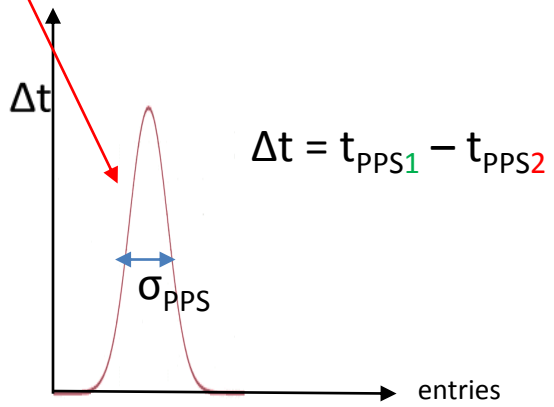
Time Stamp jitter Δt measurements beetwen 2 different boards with the aim of evaluate the PPS resolution σ_{PPS}

(the Trimble GPS Engine time resolution is ~15 ns accord the data sheet).

The Global Time Stamping resolution of the cosmic ray events σ_{GTS} should be the sum of :

- σ_{HITS}, which depends on the signals from the MRPCs and TDC resolution (100 ps)
- σ_{1PPS}, time resolution for 1PPS:

$$\sigma_{GTS} = \sigma_{HITS} + \sigma_{1PPS}$$



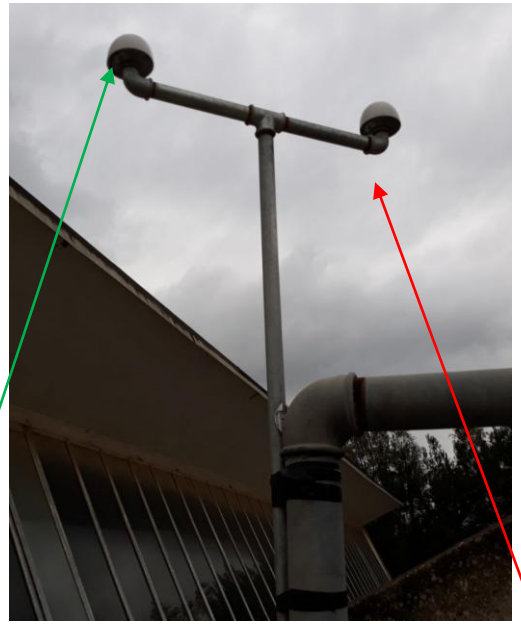
$$\Delta t = t_{PPS1} - t_{PPS2}$$

A new Trigger/GPS Unit for the EEE Project

Time Stamp jitter

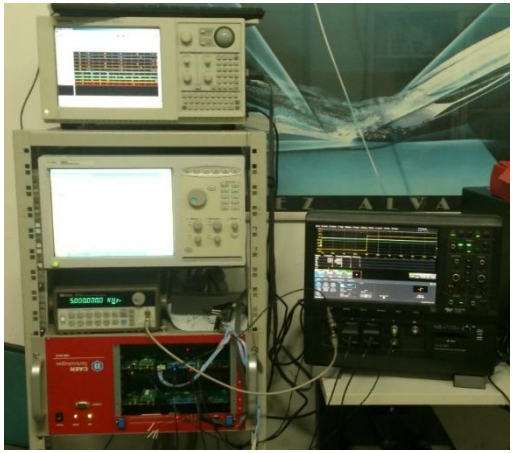
Set-up

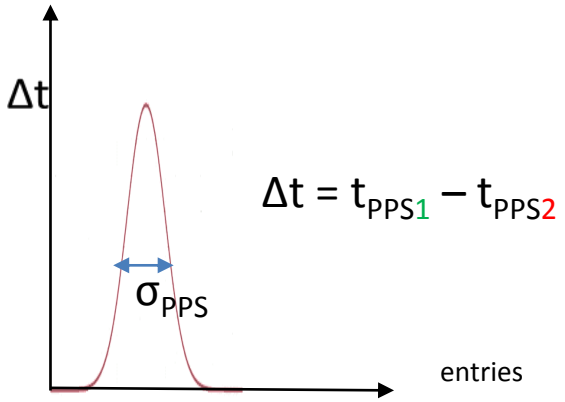
- The couple of boards are supply in the same VME crate
- The couple of antenna are mounted on the roof above our laboratory, at a distant of 40 cm to the opposite ends of an alluminium arm. It is placed far from walls to avoid any GNSS signal reflections
- There is a cables length difference = 2,7m (v_{cable} =0,66c → Δt = 15.93 ns)
- 20 Trigger/GPS Boards in the Electronic Lab. at Lecce
- 17 already tested



Gps Antenna **1**

Gps Antenna **2**

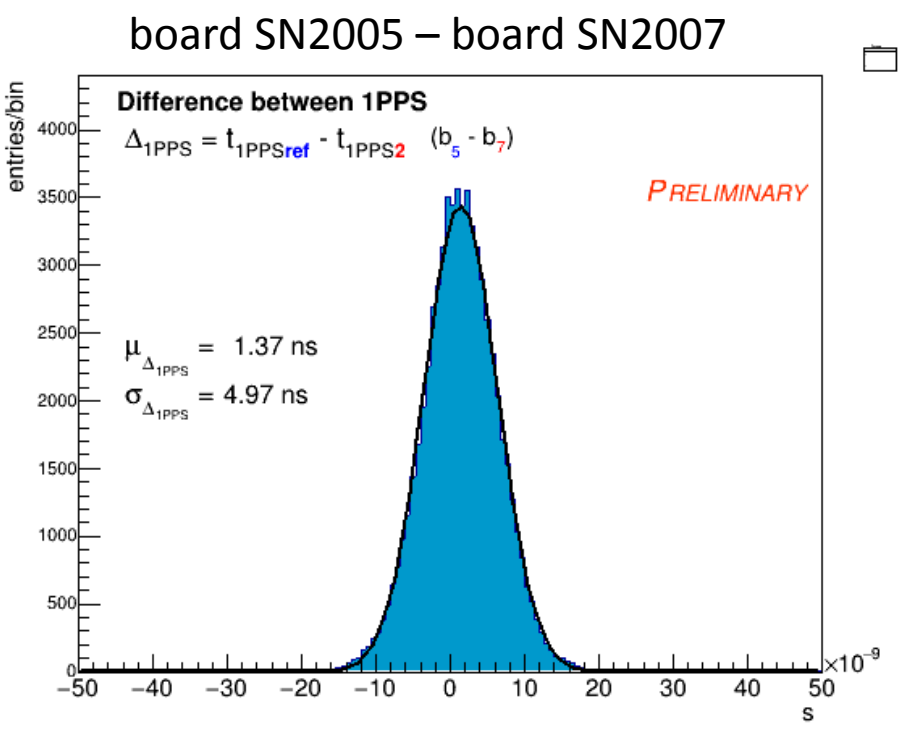


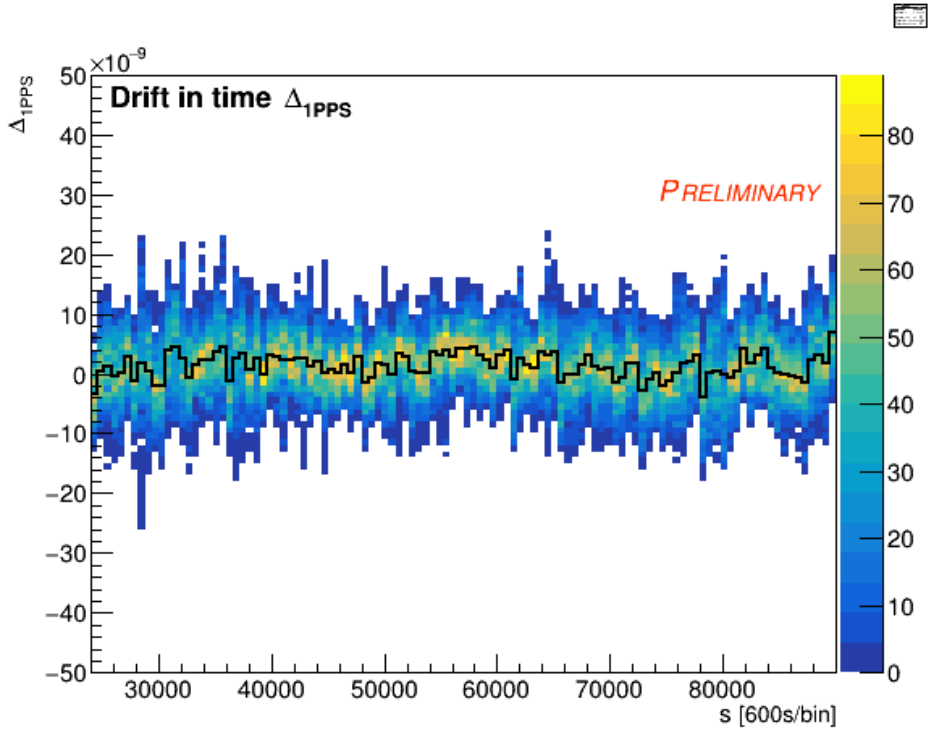


$\Delta t = t_{PPS1} - t_{PPS2}$

We measured the time stamp jitter for the 1PPS as the difference between the 1PPS signals for a couple of boards, between a **reference** module ($1PPS_{ref}$ SN=005) and the other modules ($1PPS_{\text{board serial Number}}$) with the oscilloscope

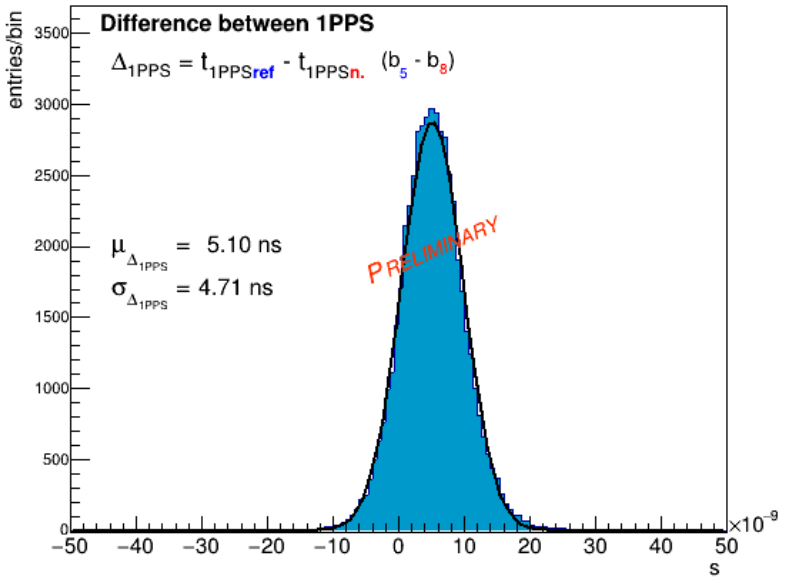
board SN2005 – board SN2007

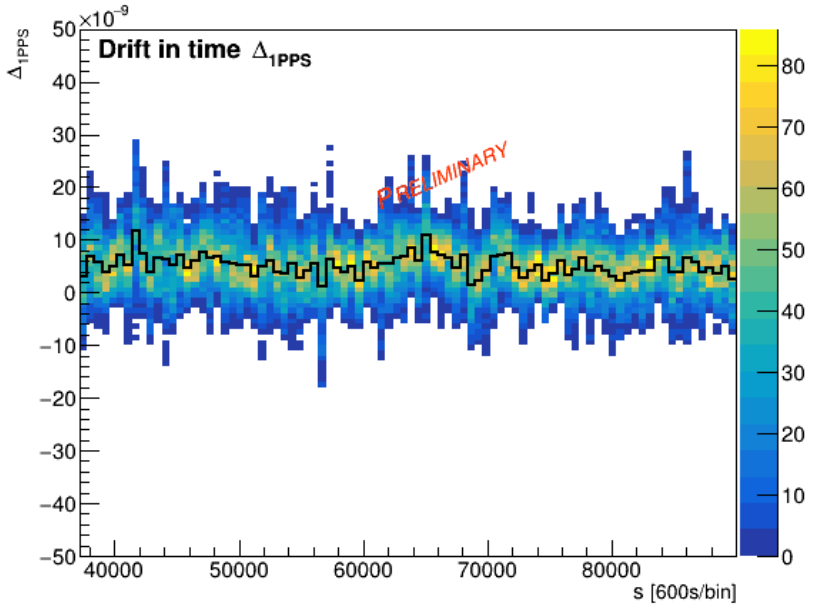




Corrected for the cables length difference.

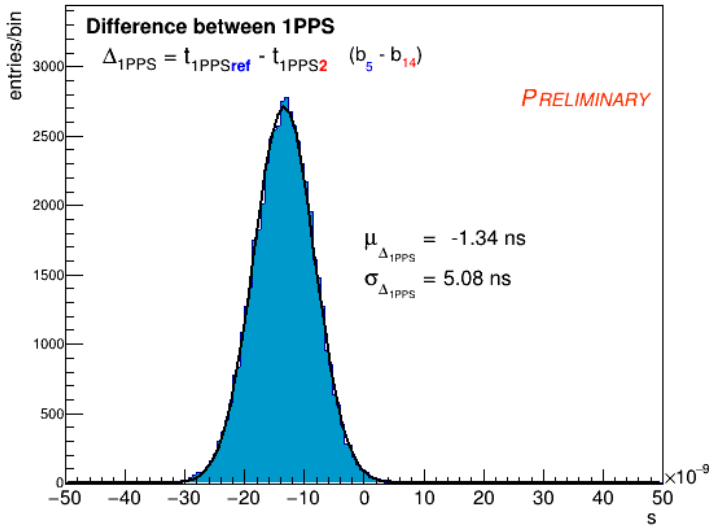
board SN2005 – board SN2008

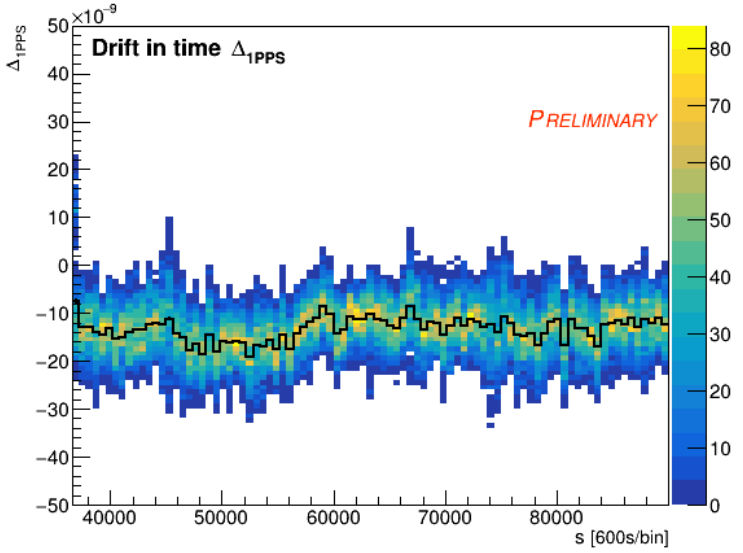




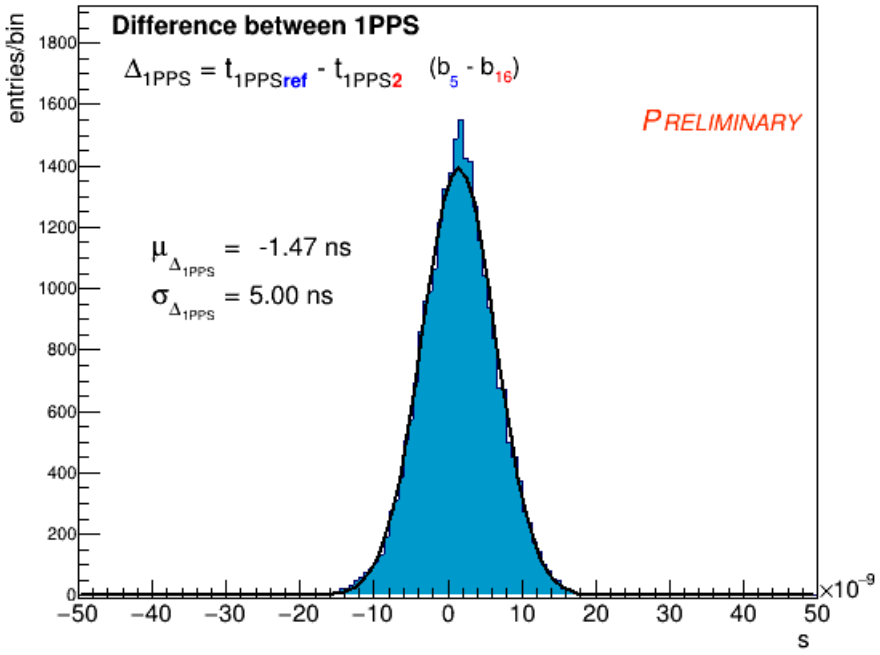
board SN2005 – board SN2014

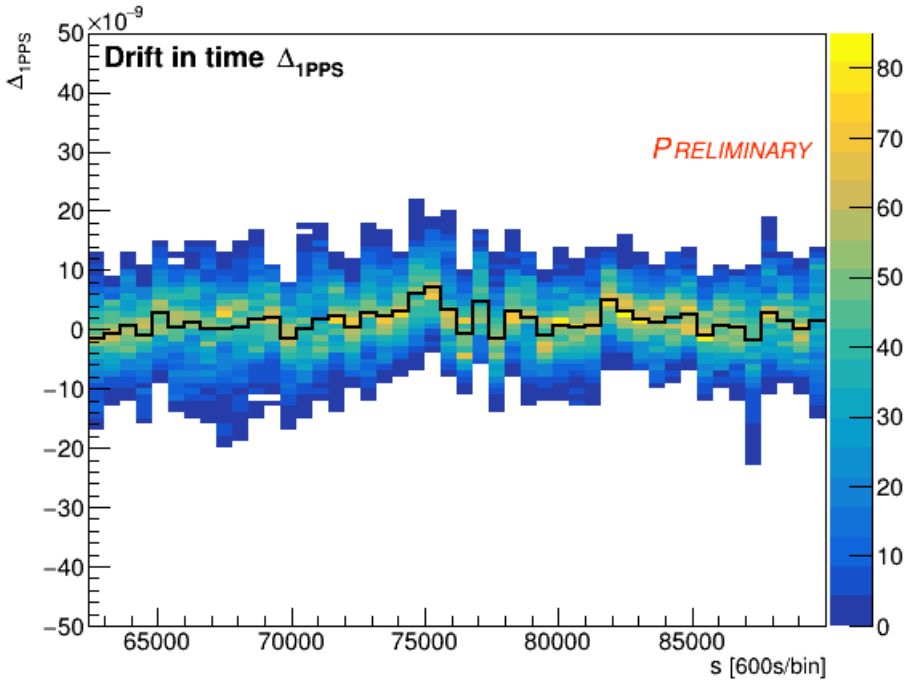
Corrected for the cables length difference.



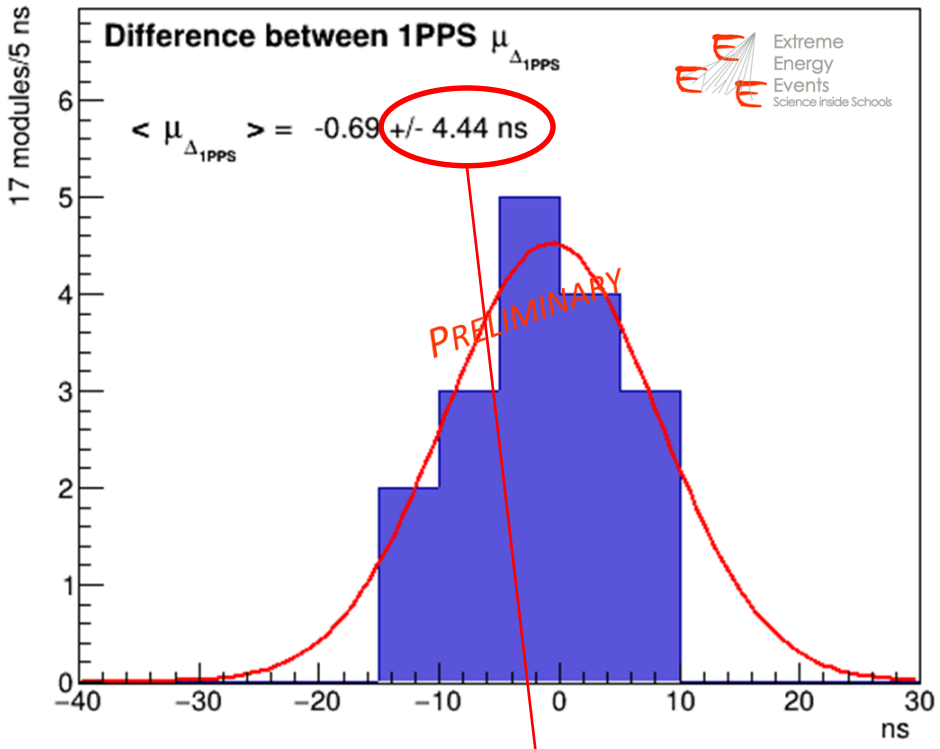


board SN2005 – board SN2016

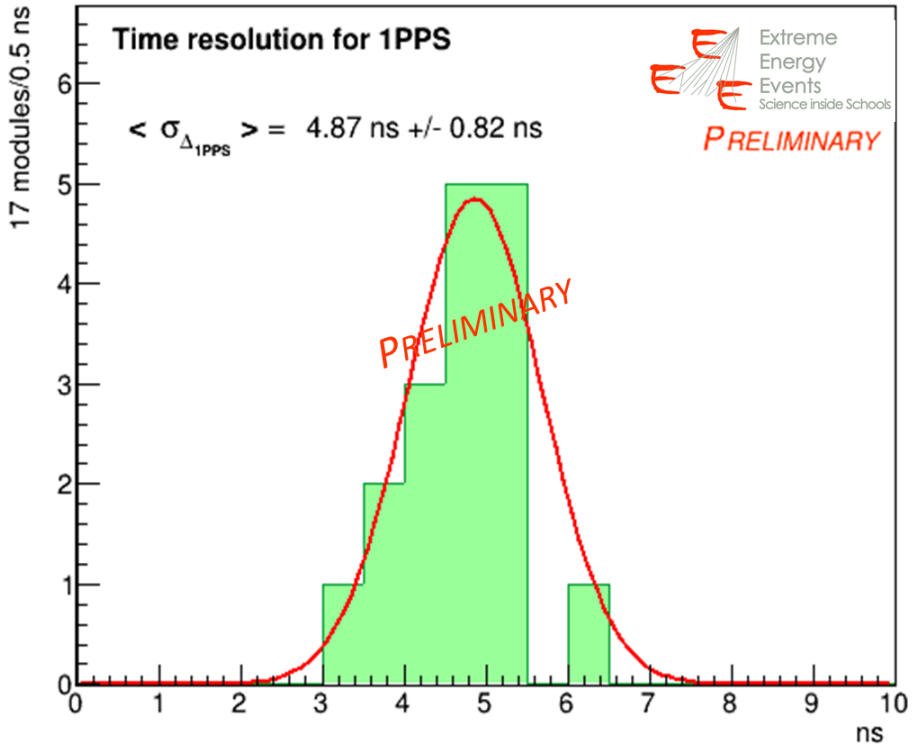




Mean 1PPS difference Δ_{1PPS} distribution for all the module tested

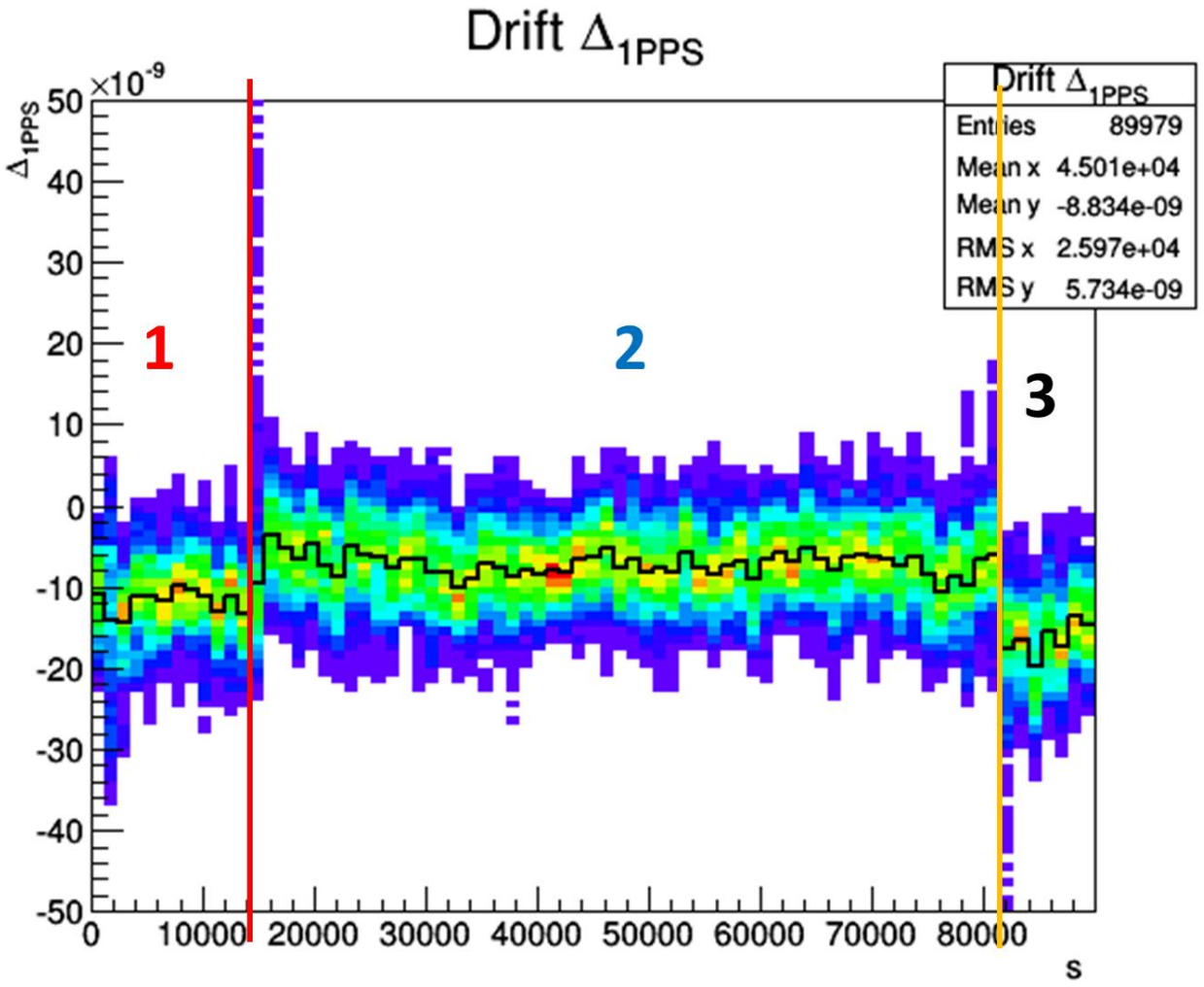


Time resolution σ_{1PPS} distribution for all the module tested

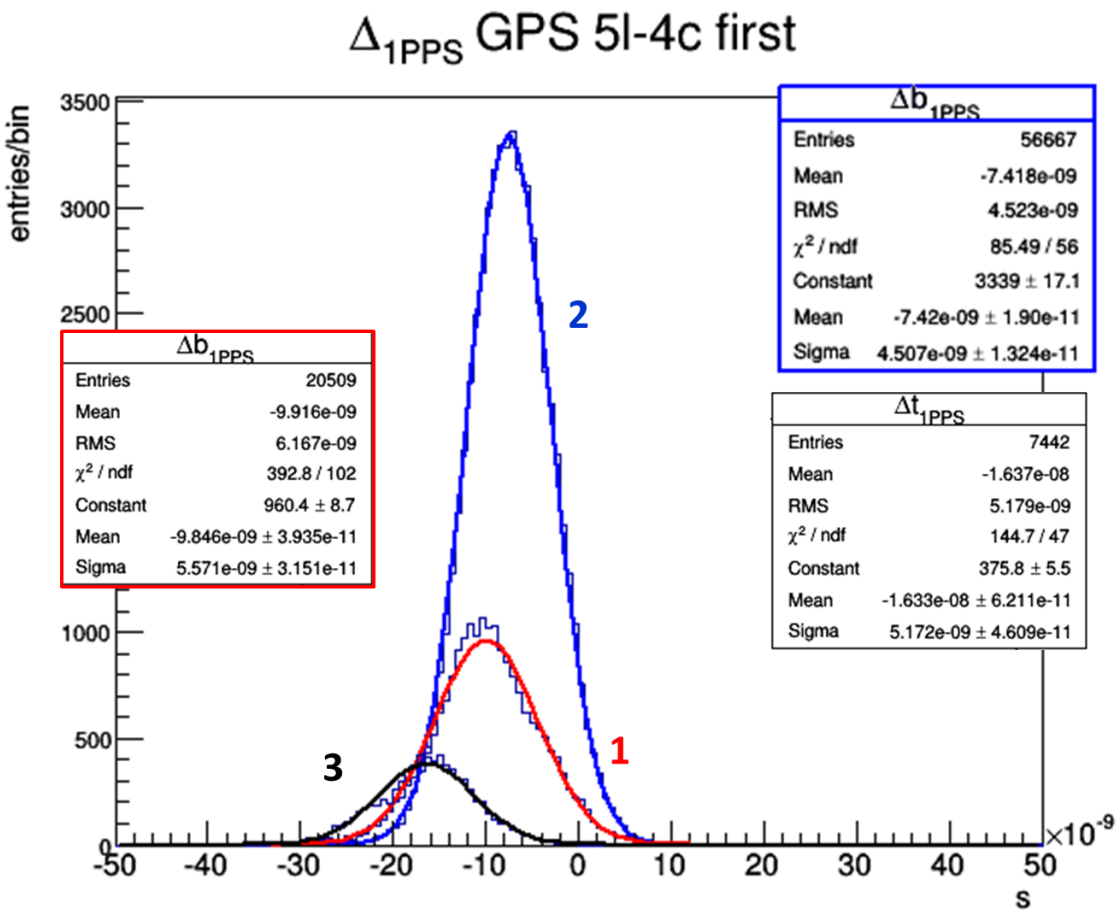


Time resolution measurements for the 1PPS exibit adequate stability in time.

The Distribution of the mean $\mu_{\Delta 1PPS}$ shows a larger variability, probably due to the different satellite constellation connected to the GPS engine



Signal drift in time: VME crate was turned off for a few minutes (1-2 minutes), after 14000 s, and after 80000 s.

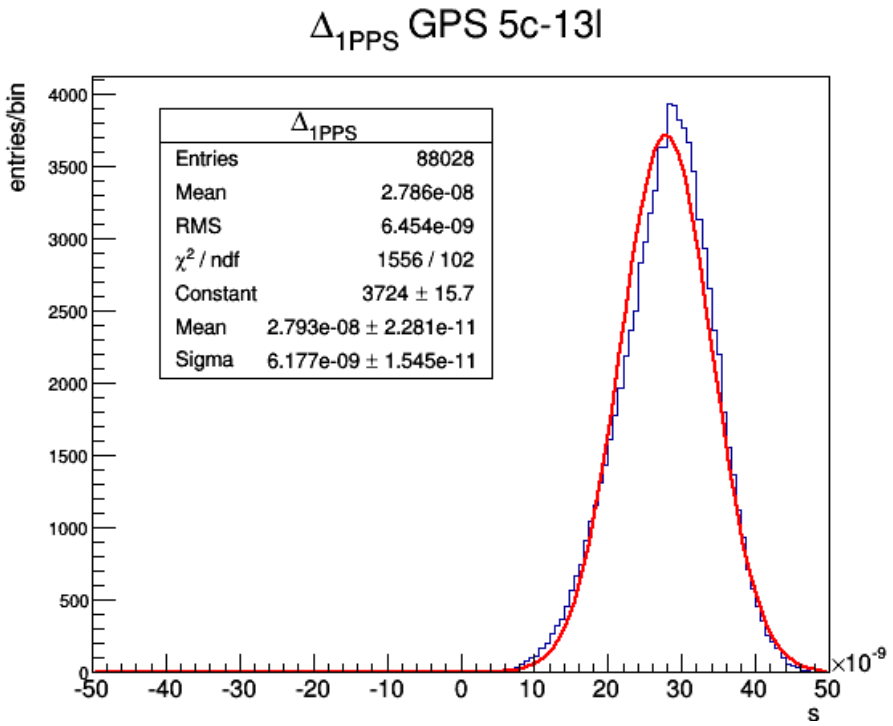


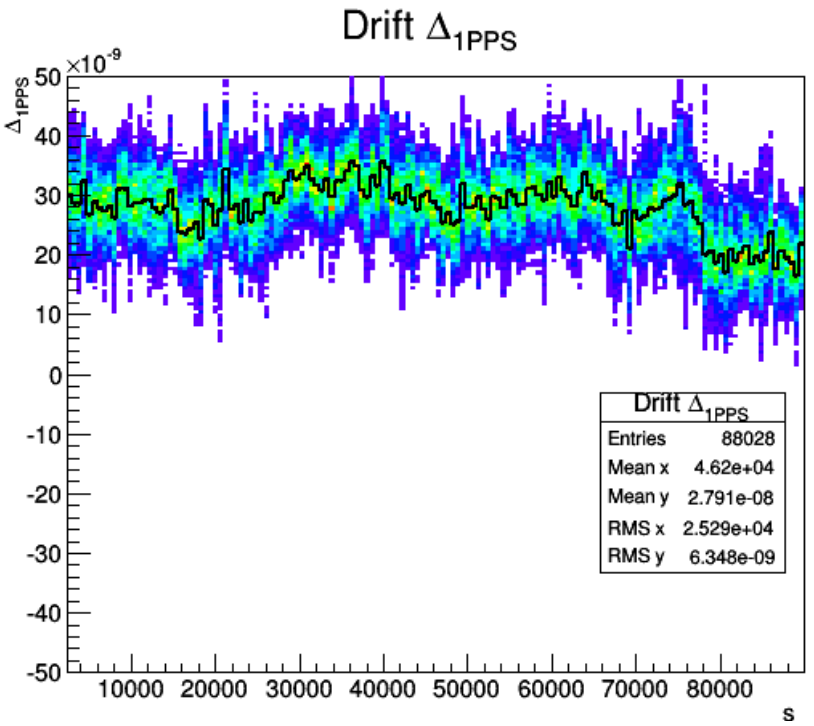
For each interval (first 1800 s are not plotted because the GPS engine needs 20 minutes at least for syncronization and for building its GPS constellation) we observe a different gaussian distribution, obtained from the same modules couples, with a different Δt_{1PPS} mean value

When the board power supply is turned off obviusly there is a reset of the GPS satellite costellation.

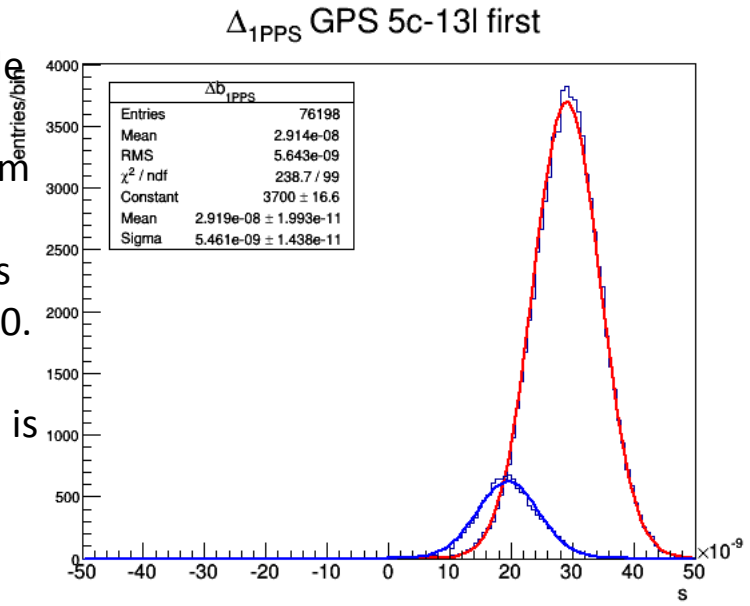
Larger variability for the average distribution Δ_{1PPS}

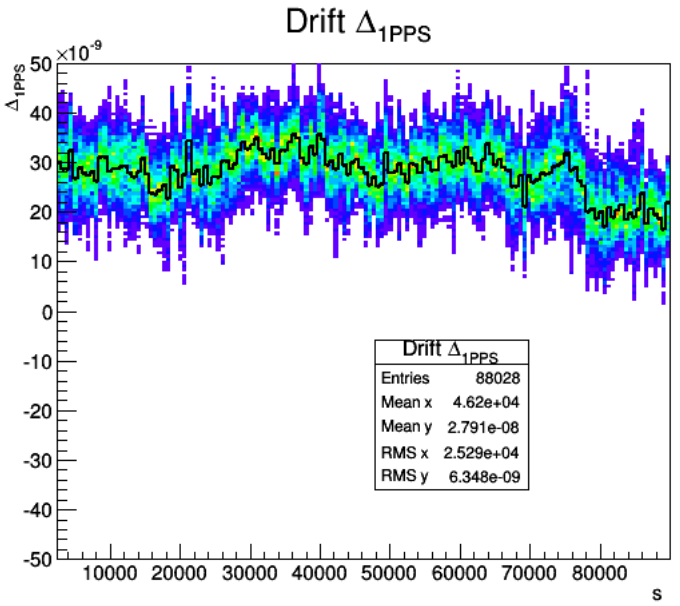
- It is probably due to the differece in the satellite constellation built by the GPS engine
- It is probably not due to any caracteristic of the board itself.

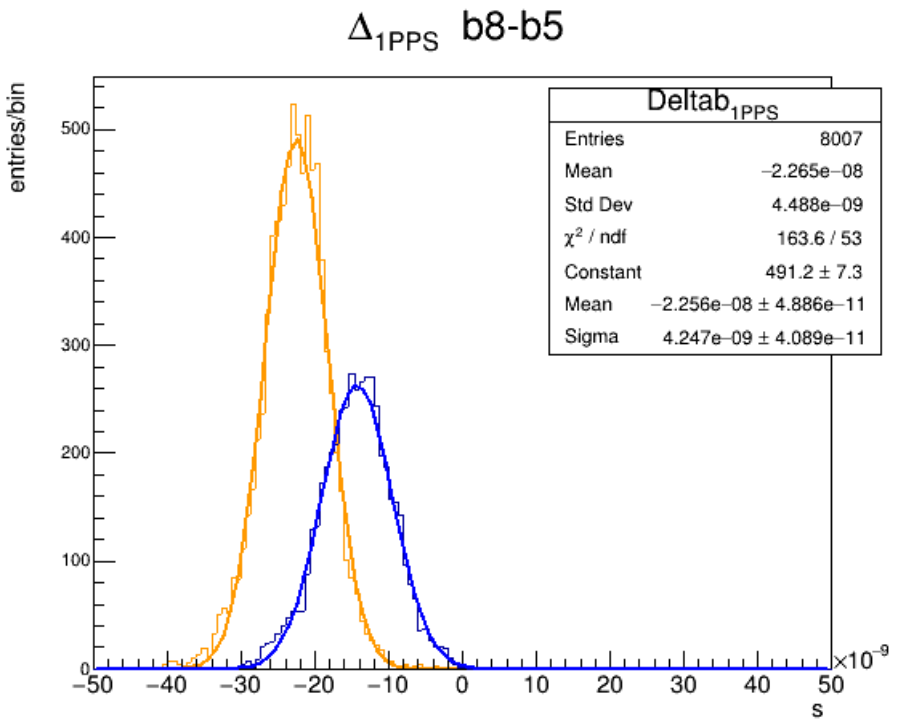


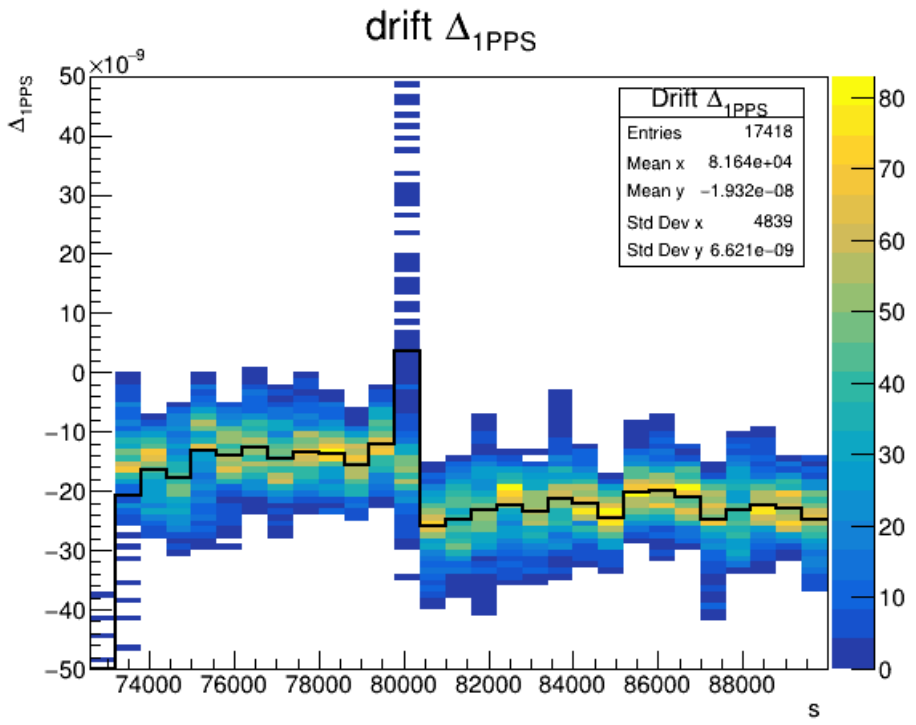


The antenna cable has been disconnected from the tested board for some minutes at second = 78000. A new different 1PPS distribution is generated





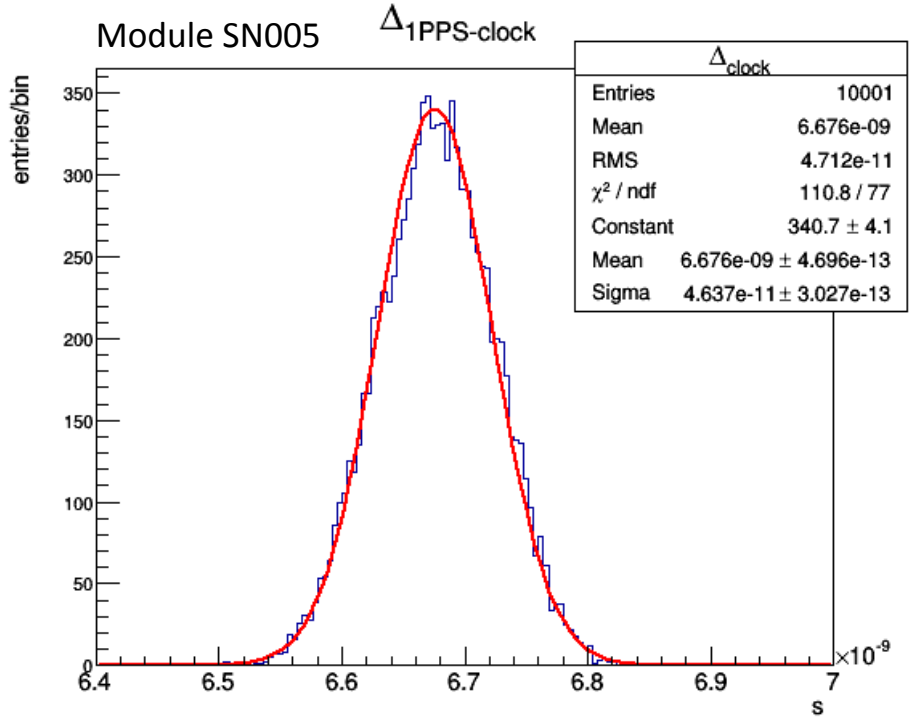


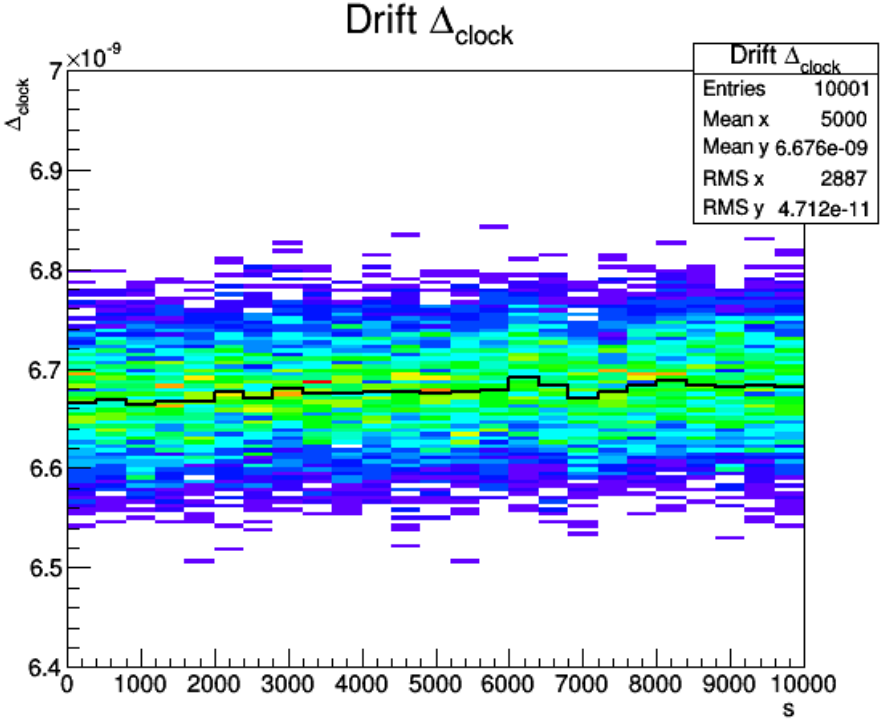


The board power supply is turned off at second = 78000. After this GPS satellite costellation reset, a different gaussian distribution is obtained from the same modules couples, with a different Δt_{1PPS} mean value

Clock Difference form the 1PPS

The GPS unit feeds both the TDCs with its **clock disciplinated with the 1PPS** to synchronize the TDCs internal counters



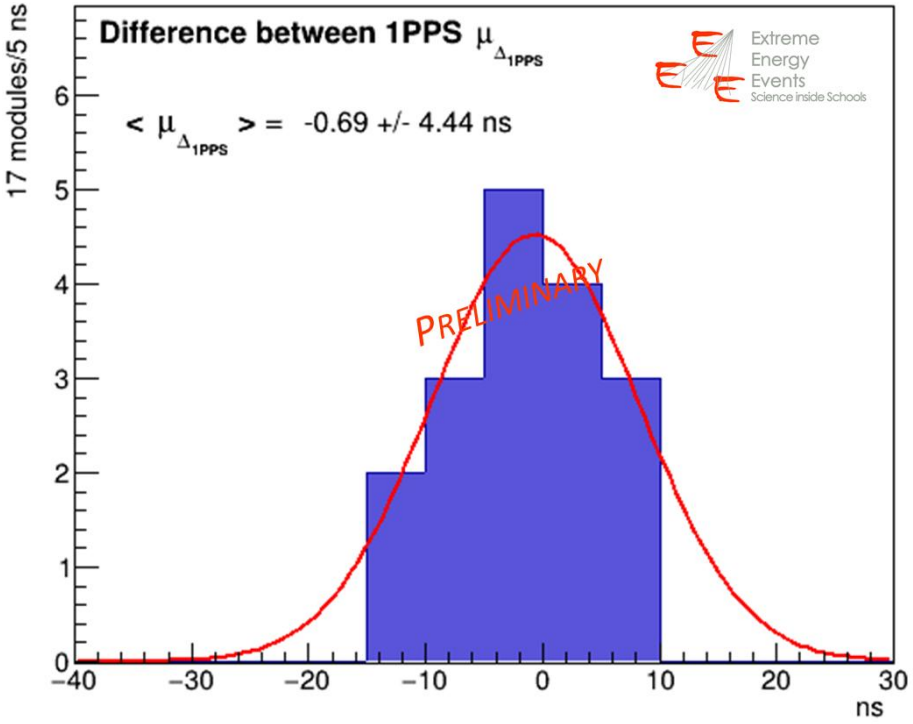


Δt_{clock} = 6.67 ns

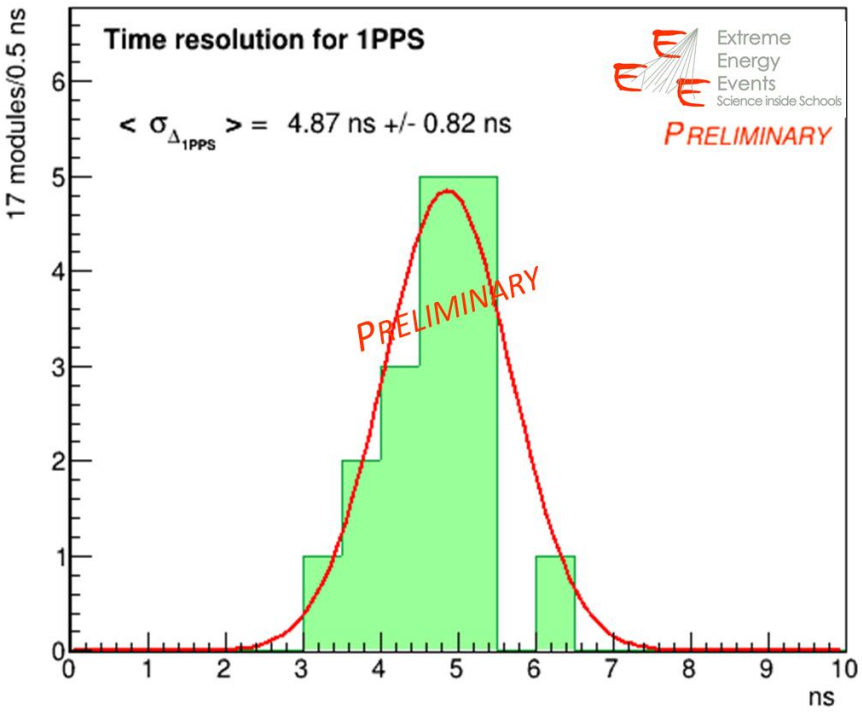
σ_{clock} = 46 ps

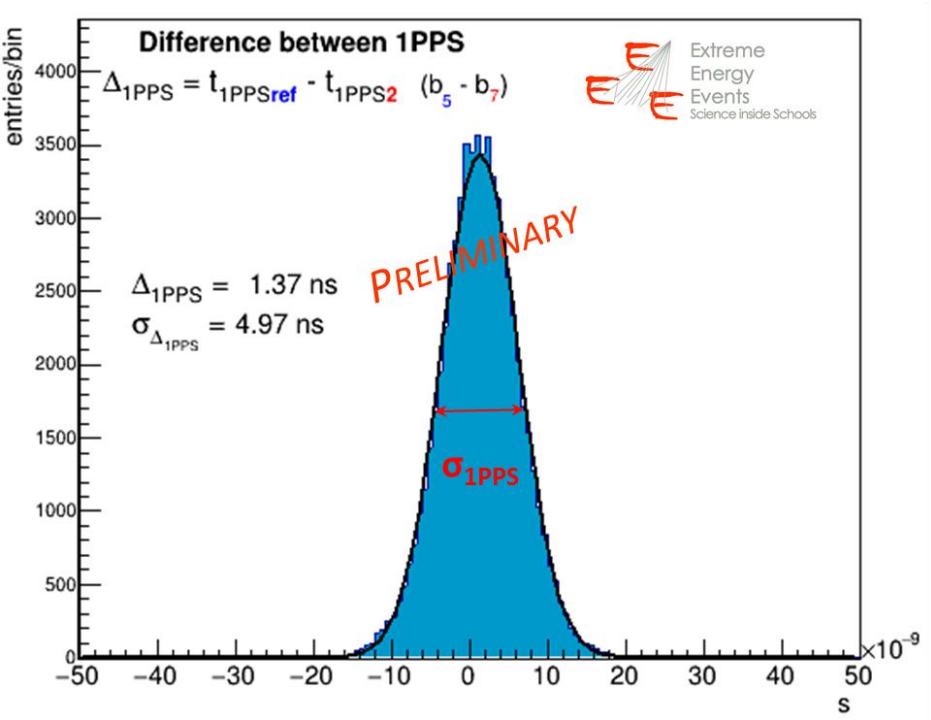
Plot for PISAMEETING 2018

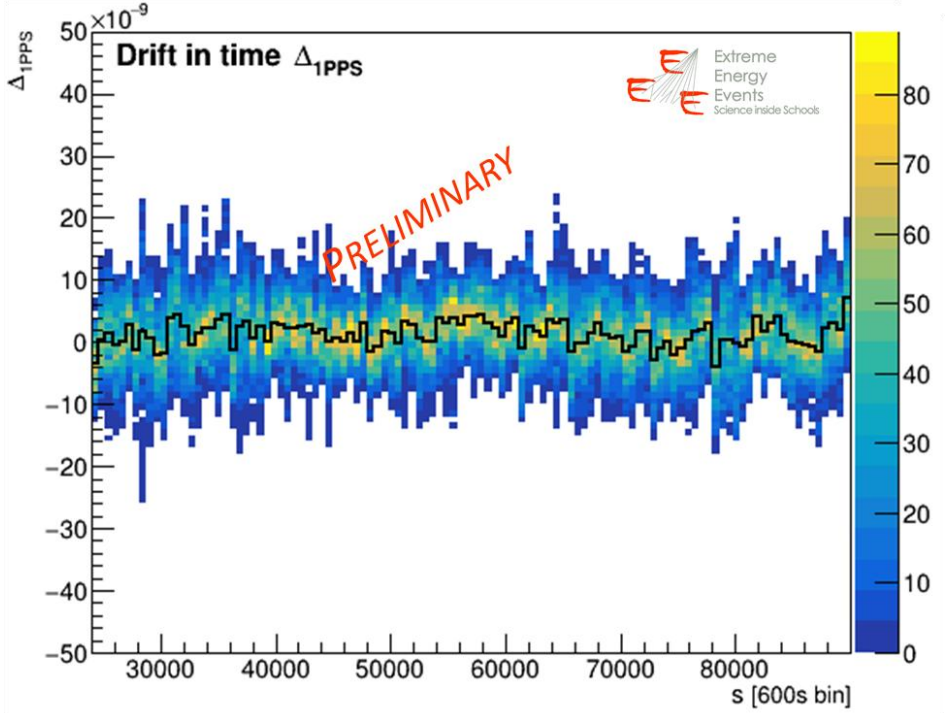
Mean 1PPS difference Δ_{1PPS} distribution for all the module tested

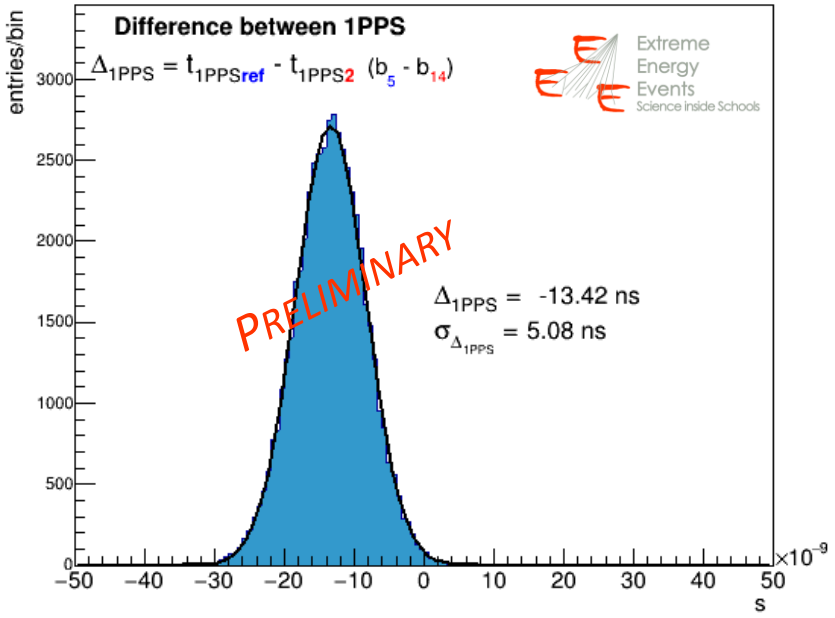


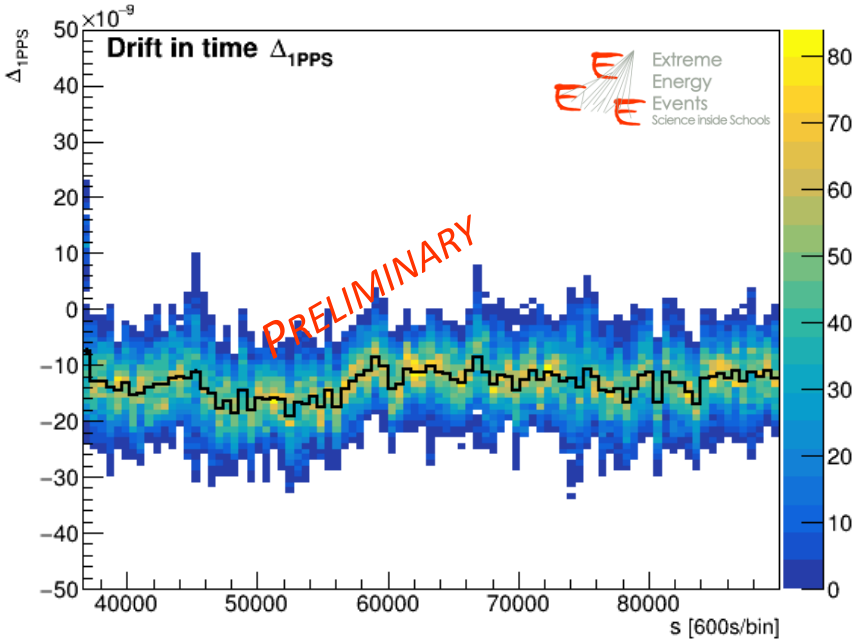
Time resolution σ_{1PPS} distribution for all the module tested




Difference between 1PPS
$\Delta_{1PPS} = t_{1PPSref} - t_{1PPS2}$ $(b_5 - b_7)$
Extreme Energy Events
Science inside Schools
PRELIMINARY
Δ_{1PPS} = 1.37 ns
$\sigma_{\Delta_{1PPS}}$ = 4.97 ns
σ_{1PPS}
entries/bin
s
$\times 10^{-9}$


Drift in time Δ_{1PPS}
Extreme Energy Events
Science inside Schools
PRELIMINARY
Δ_{1PPS}
$\times 10^{-9}$
s [600s bin]


Difference between 1PPS
$\Delta_{1PPS} = t_{1PPSref} - t_{1PPS2}$ $(b_5 - b_{14})$
Extreme Energy Events
Science inside Schools
PRELIMINARY
Δ_{1PPS} = -13.42 ns
$\sigma_{\Delta_{1PPS}}$ = 5.08 ns
entries/bin
s
$\times 10^{-9}$


Drift in time Δ_{1PPS}
Extreme Energy Events
Science inside Schools
PRELIMINARY
Δ_{1PPS}
$\times 10^{-9}$
s [600s/bin]