UUB in Auger Prime

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Outline

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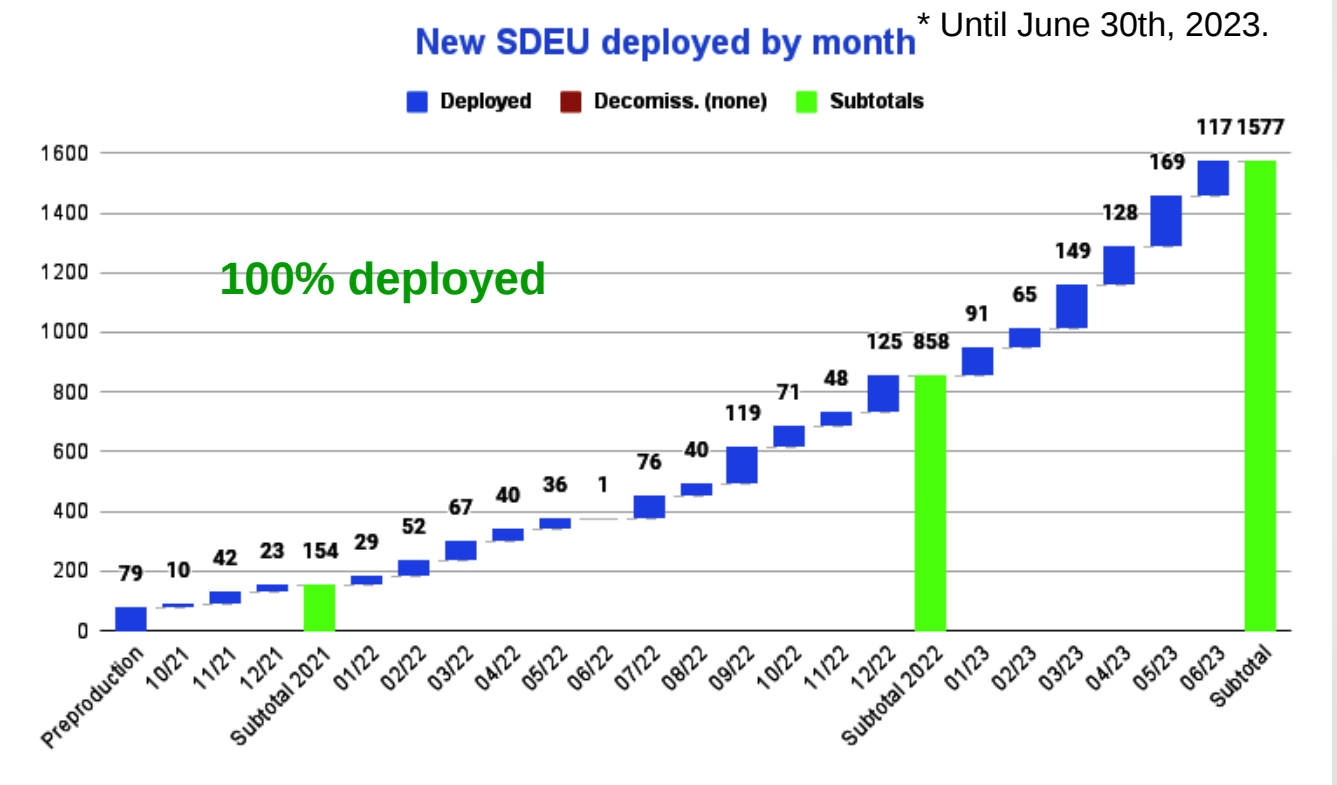
- UB vs UUB characteristis
- Commissioning
  - Down-sampling and reduction
  - Errors
    - FPGA
    - Logic & Timing
    - Triggers (Lightening, TOTD, etc)
  - Actions
    - FPGA
    - CDAS
    - DAQ

Status of Deployment

Thanks to A. Travaini

Status of Deployment

Deployment Progress



* Until June 30th, 2023.

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Only accessible stations

https://www.auger.org.ar/SDEU/statistics/index.html

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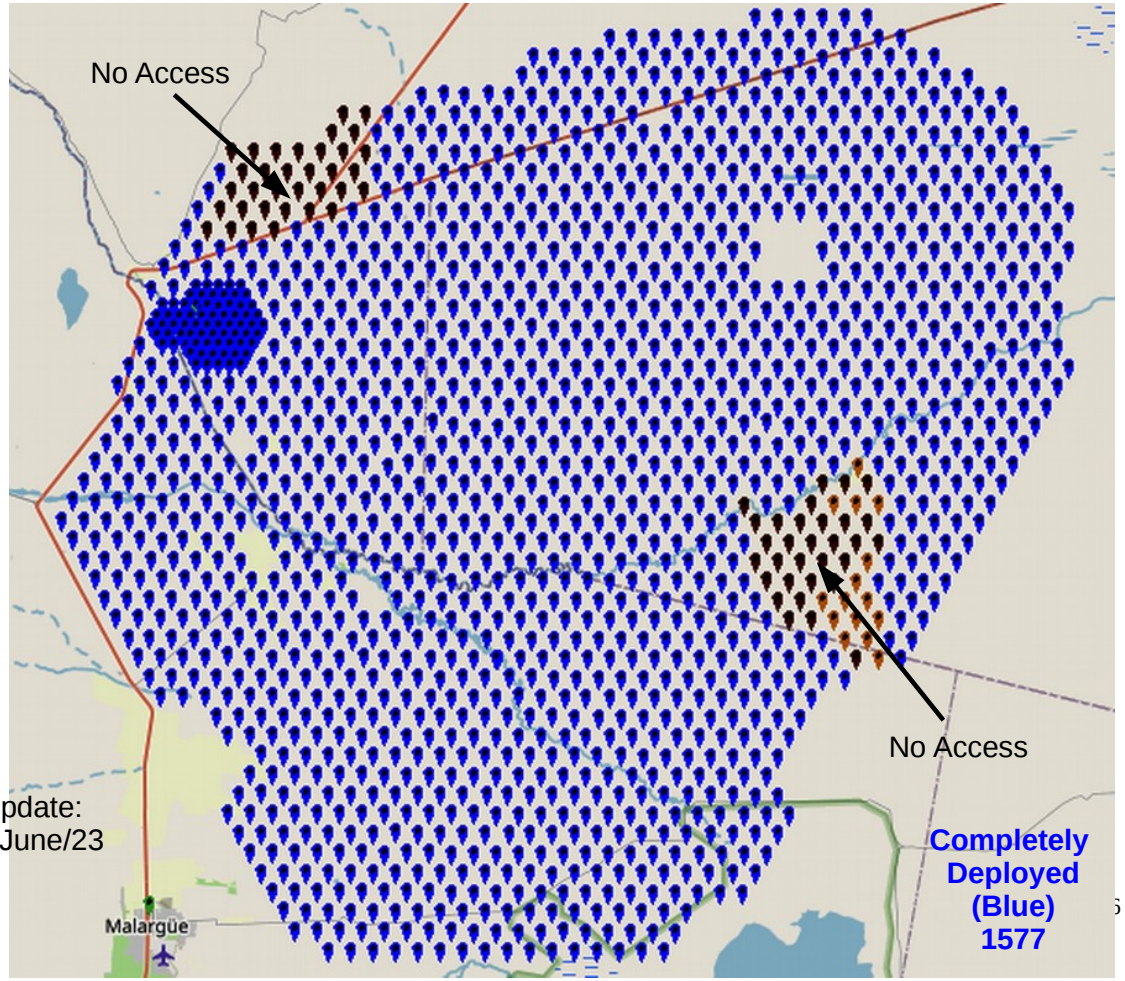
Thanks to A. Travaini

Status of Deployment



Thanks to A. Travaini

Status of Deployment

After deployment work in progress

- Replace some unstable UUB/SPMT/SSDPMT → **Doing this!**.
- Replacement of UUB w/o AMIGA conn (Southern Infill) → **Done**.
- UUB visual inspections, testings and/or repairs → **Doing this!**.
  - Goal is to end the task with the 2000 boards analyzed and repaired whenever is possible → **Waiting next shipment**
- Do the TPCB modifications for the entire array → **Doing this!**.
- GPS reprogramming of all the units → **Done / Doing this!**.
- SPMT testing of all units → **Finishing this!**.
- Others (DB, Docum., SPMT testing, etc)... → **Doing this!**.

Thanks to A. Travaini

UB vs UUB Characteristics

- **Old electronics:**
  - ADC Resolution = 10 bit
    ADC Range (Voltage) = 0 – 2 Volts
    ADC Range (Counts) = 210 = 0 – 1024 ADC Counts
    1 ADC Counts = (2 V) / (1024 ADC Counts) = 1.953 mV
  - ADC sampling = 40 MHz

    ADC time bin = 25 ns

    Time Window = 750 samples = 18,750 us
- **New electronics:**
  - ADC Resolution = 12 bit
    ADC Range (Voltage) = 0 – 2 Volts
    ADC Range (Counts) = 212 = 0 – 4096 ADC Counts
    1 ADC Counts = (2 V) / (4096 ADC Counts) = 0.488 mV
  - ADC sampling = 120 MHz

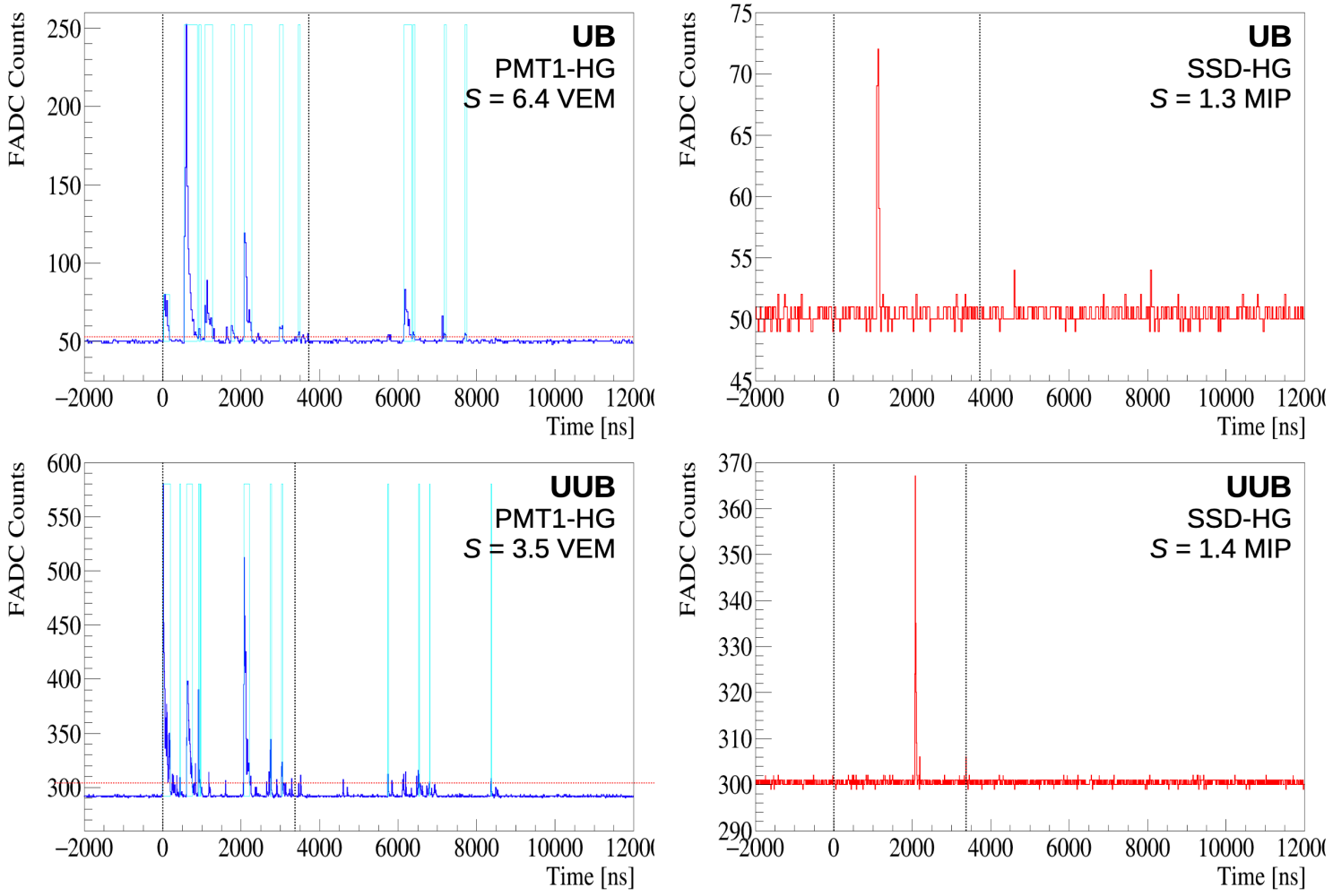
    ADC time bin = 8,33 ns

    Time Window = 2048 samples = 17,059 us

UB vs UUB Characteristics

Example

Small signals extraction



Thanks to Q. Luce

UB vs UUB Characteristics

- Another very important aspect:
  - UB -> HG is the extracted signal from last Dynode and amplified X40
    HG vs LG have a phase due to capacitive extraction and amplification of last Dynode
    Specific calibration needed in Lab
  - UUB -> same signal in HG and LG, same circuit, no phase between HG and LG
    HG/LG can be calculated directly by data

Commissioning

- Since September 2021 an intense activity for the commissioning has started involving SDEU, CDAS, MONITORING and FOUNDATION tasks.
- In particular SDEU is organizing beweekly meetings to present and discuss in detail the behaviour of the new electronics installed in the field, including SPMT and SSD. You can find detailed reports and presentation on the SDEU site (https://www.auger.unam.mx/AugerWiki/SDEU_Front_Page)
- Also CDAS is organizing periodic meetings

  (https://www.auger.unam.mx/AugerWiki/CDAS-DAQ/Meetings)

Recently also Foundation and Calibration are giving important contributions

https://www.auger.unam.mx/AugerWiki/FoundationsGeneralMeetings

https://www.auger.unam.mx/AugerWiki/Calibration_analysis/SD/Meetings

Commissioning

The commissioning activity has involved:

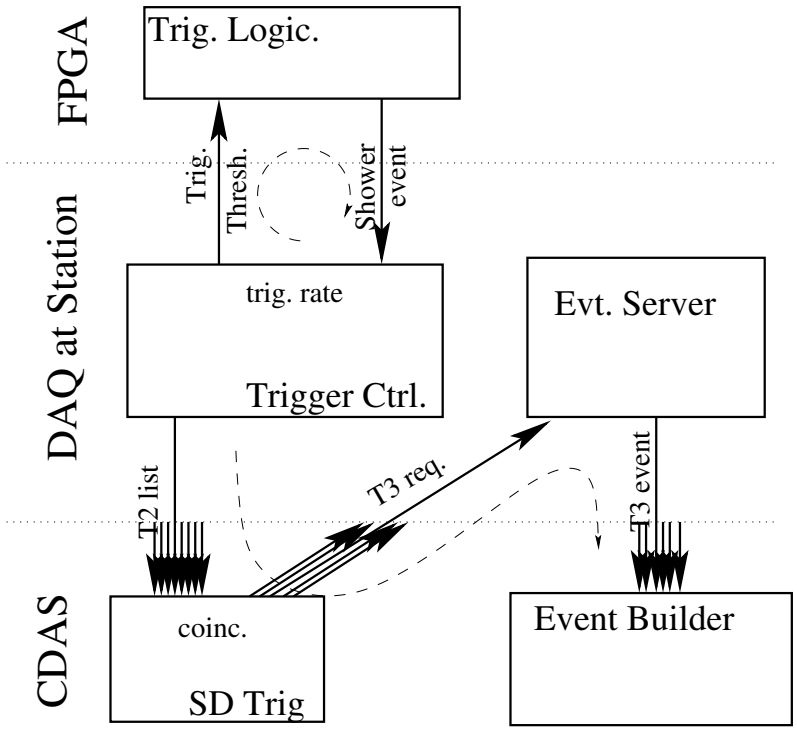
- SDEU
  - UUB DAQ (New devices and calibration procedure)
  - TRIGGER (New functionalities and update)
- CDAS
  - DAQ (New Data format and actions)
  - Monitoring (New parameters and format)

In order to make «adiabatic» the transition, keeping into account that for long time both electronics have been working together, a great effort has been done to reduce the UUB signals to UB characteristics (Down-sampling and reduction).

Commissioning

or ... General view

General DAQ view.



Commissioning

Old and upgraded DAQ

Old and upgraded DAQ

- CDAS
  - all modification need to be need to be backward compatible (old and new electronics work simultaneously).
  - Most of modifications are due to different data format (internal data organization, additional channels and detectors).
  - implement process to handle small PMT data
- At SD Station Electronics
  - Adapt the DAQ from OS9000 operating system to LINUX
  - include "sPMT" process to extract signal amplitude, area of big signal and transmit to CDAS.
  - introduce an additional data structure, which is only exchanged between internal processes. It make much easier to make whatever development, since it does not require changes in all DAQ.
  - "Msg. Server"
    - Join the two processes ("Msg. Server In" and "Msg. Server Out" in the old electronics), in just one process.
    - identify available communication system to be used. In the old electronics, it could only use one protocol. This feature was needed due to bigger amount of data with new electronics and also to manage the T3 transmission in the INFILL region.
    - Data transmission order: in the old electronics, the message order are associated with shared memory between "Msg. Server Out" and some other process. In the upgraded DAQ, the priority are set by the process which send the message to "Msg. Server". Which make easier for whaever process manage which message should be transmitted first.

Commissioning

STATEMENTS: (we want to make)	**(Known) Open problems**	**Required Analysis**	**DAQ changes** (incl. merging) (Needed/planned) (Possibly needed)
Stable operation w/ near 100% uptime / duty cycle	High lightning sensitivity in UUB Transient spikes in trigger rates at two times of the day resulting in significant downtimes	Cause? Uptime + aperture?	Suppression of triggers in response to anomalous high rates or fix source of problem Testing setup for new triggers that can not cause unwanted spike in T3 rate Upgrade CDAS DAQ to supported OS Further automated checking and resolution procedure (as intermittent solution while lacking firmware fix)
Physics-ready data on large scale		Higher level validation of data from Foundations/Physics tasks	
UUB triggers understood and properly interfacing	Remaining UB/UUB discrepancies in • T1 & T2 Thr rates • ToT rates • ToTd & MoPS rates Spatial non-uniformities in trigger rates Populations in ToT rates	T3 rates and purities compatible? Why? (e.g. noise/digitization related?) Impact on downstream analysis acceptable? Proper interfacing with FD trigger?	
Full DAQ functionality for enhancements to Phase I hardware			Completion of WCD-SSD coincidence histogram pipeline Refinements to SPMT HV setting procedure Incorporation of SPMT calibration constants into merged data Identify / send status of SSD PMT Online estimation of the MIP peak/charge / VEM charge
Demonstrate capabilities for enhanced triggering		Detailed/implementable proposals for new triggers	

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Commissioning: examples of noise studies

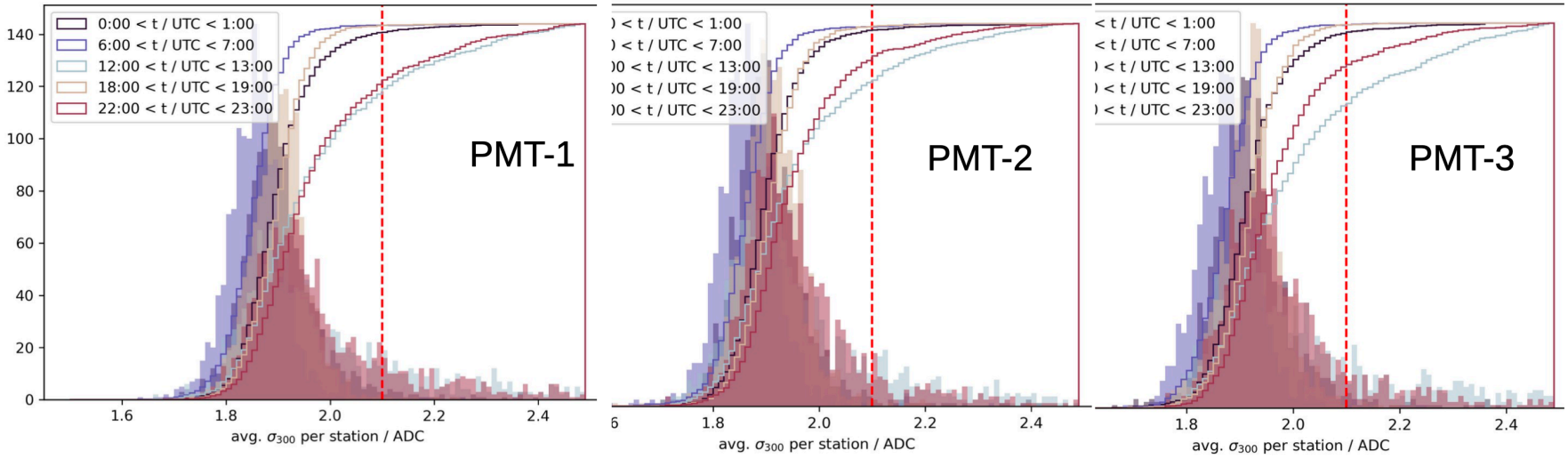
Reminder: Comparing PMTs

- PMT 1 vs PMT2/3 asymmetry expected from cabling

- sunrise: PMT1/3 similar at ~20% of stations

- sunset: PMT1 more affected

→ today: confirm with with more data: use 01 July – 16 August 2023

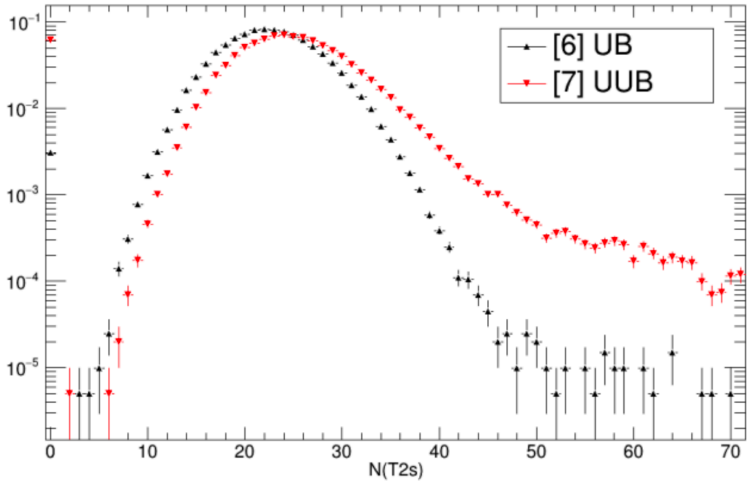


Commissioning: Lightning

- High T3 rates. At least 2 problems:
  - New threshold and trigger algorithm
  - Reset buffer of T3 proposal when high (CDAS)

High rate for UUBs

- Higher T2 (and thus T3) rate in UUBs on 03/02/2022. [5]
- In the following we try to address this problem to UUBs higher resolution.

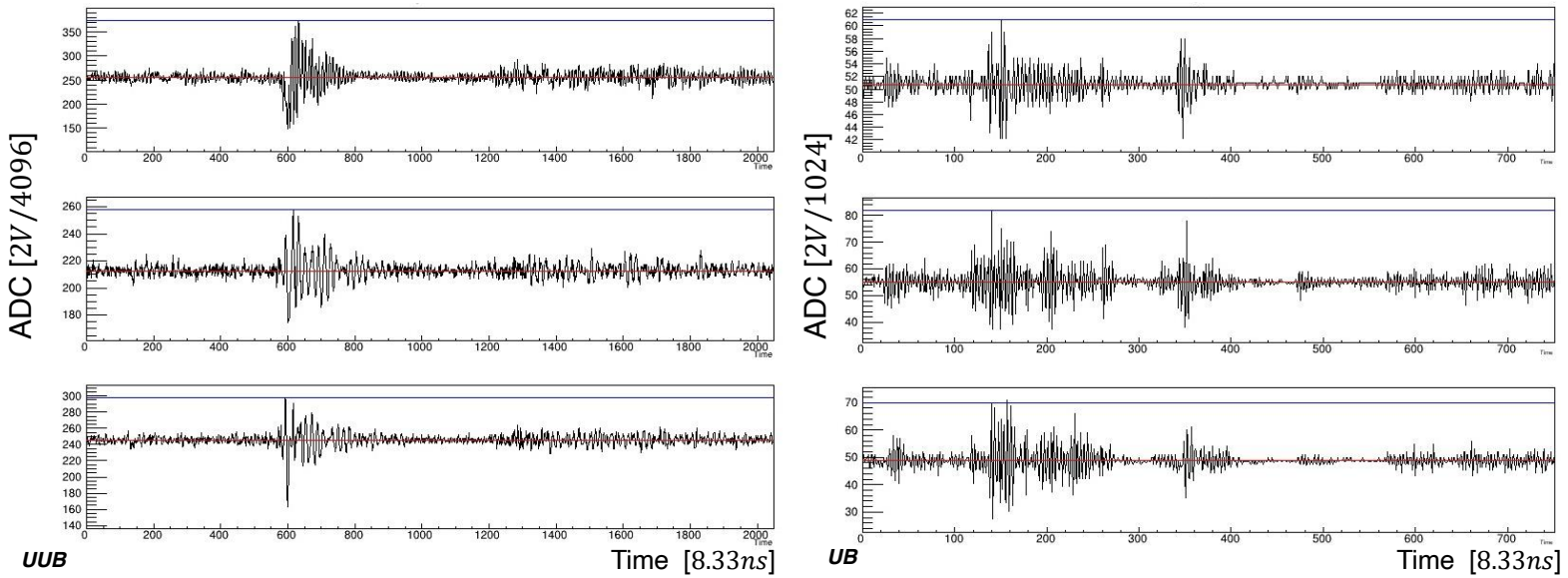


Normalized histogram of T2 rate per GPS second (averaged) on 03/02/2022 16:00-23:59:59 UTC. [5]

Commissioning: Lightning

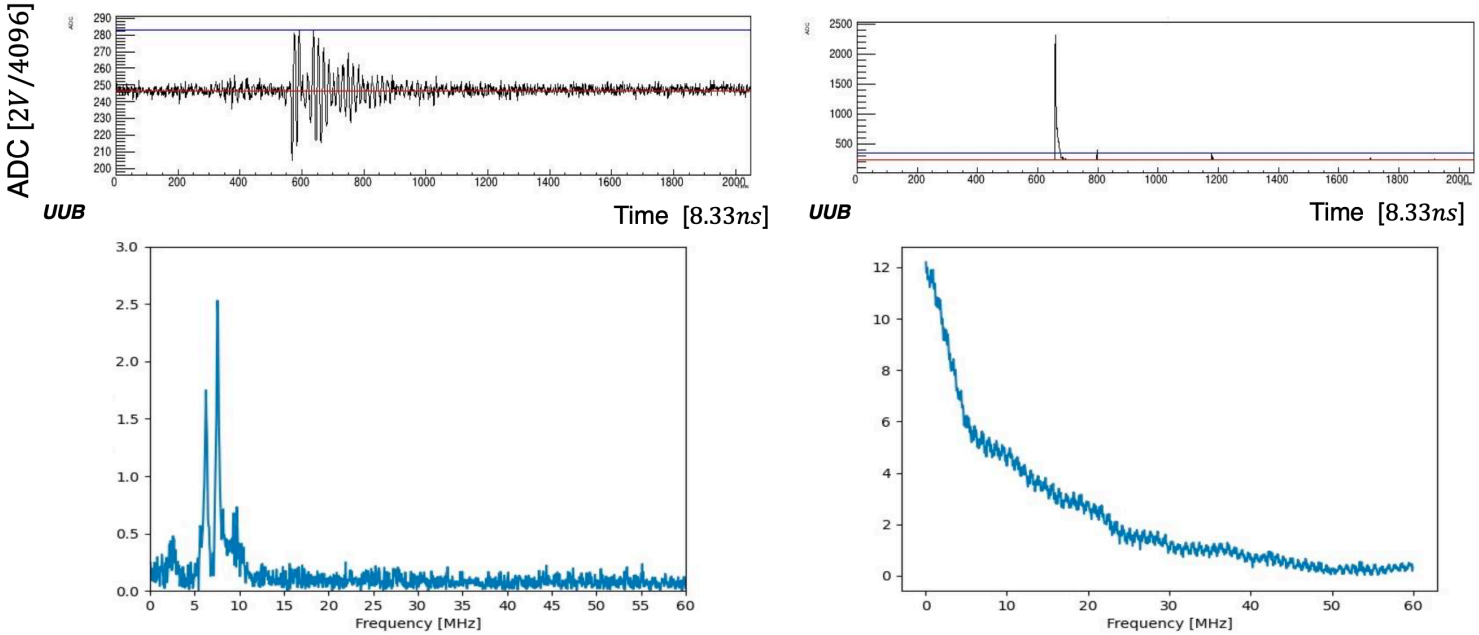
Example of a lightning noise trace

- Damped oscillations around the baseline.
- Signal drops significatively under the baseline.



Commissioning: Lightning

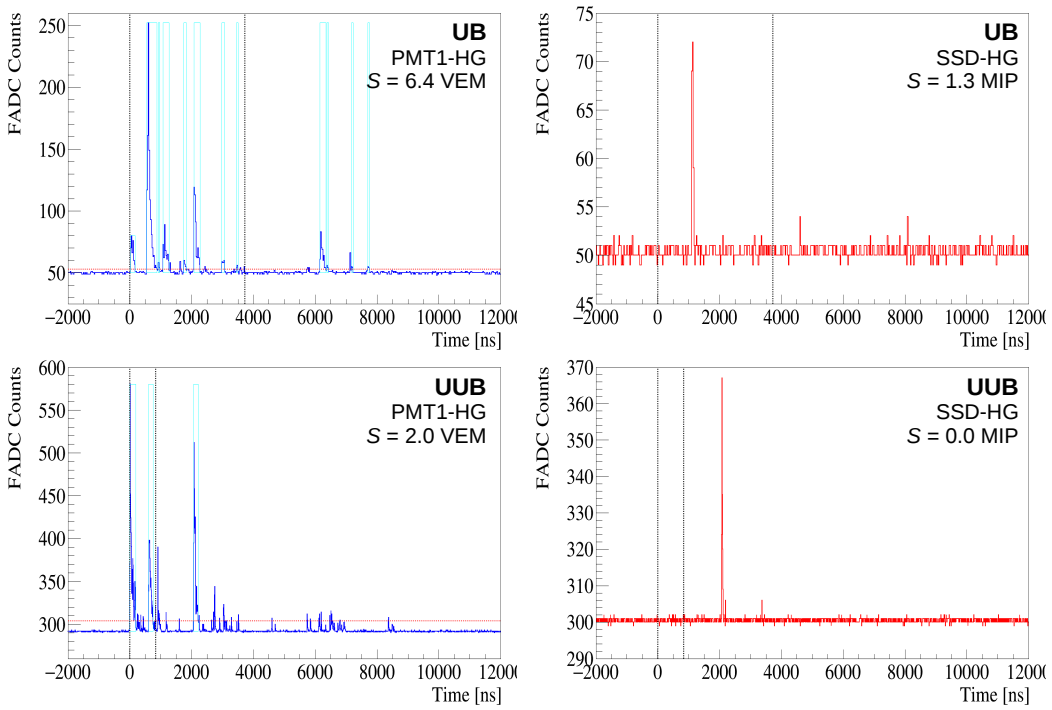
- Possible solution:
  - Lightning event identification
  - Implementation of a filter in FPGA to discard such events
  - We are testing algorithms on field data



Commissioning

- Actually, the comparison on science activities show a good behaviour of the new electronic.
  - Many errors have been determined

Small signals extraction in simulation



See Quentin Luce studies

Actions

- Actions are studied on:
  - FPGA
    - Corrected the filtering of the signal and studies on new triggers for UUB to enhance performances using the new CPU and electronics potentialities
  - CDAS
    - Implementing new functionalities to better perform with the new electronics
  - DAQ
    - New routines, new calibration, management of new devices

In Palermo we are developing a dedicated DAQ system for noise studies based on Raspberry