



Assembly, Optimization, and Noise Characterization of the TAMBO-4 Detector Panels: Toward the Identification of the MIP peak

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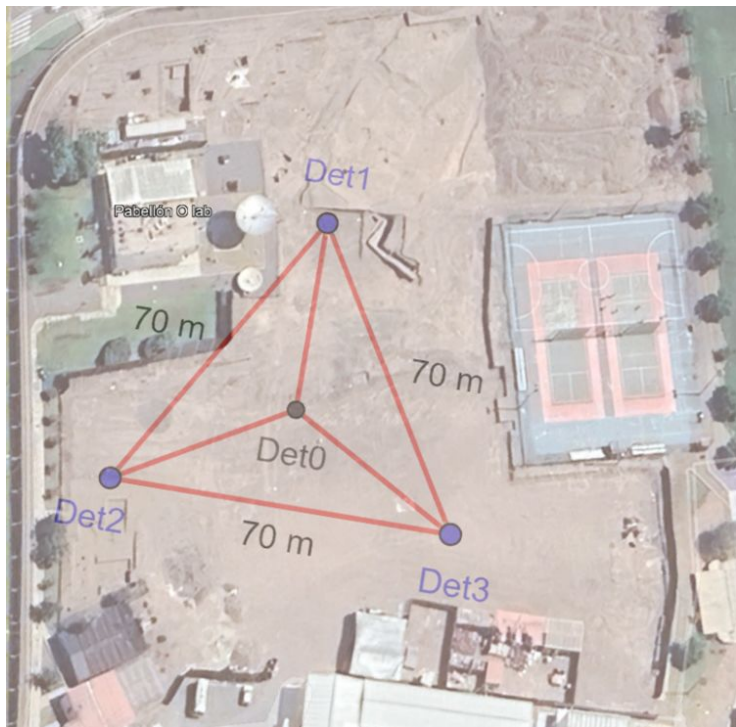
HEP Group - PUCP

TAMBO Collaboration Meeting Fall 2026

August 2026

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- A horizontal bar with a teal segment on the left and an orange segment on the right.
- I. Brief overview of TAMBO-4
 - II. Panel assembly and data acquisition system development
 - III. Initial tests and results
 - IV. Hardware and software enhancements
 - V. Latest results
 - VI. Ongoing work

I. Brief overview of TAMBO-4

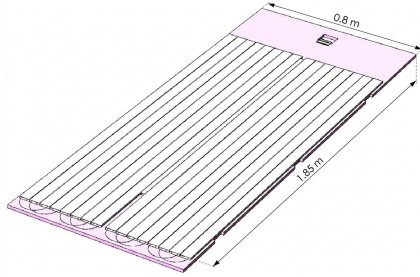


TAMBO-4 Design

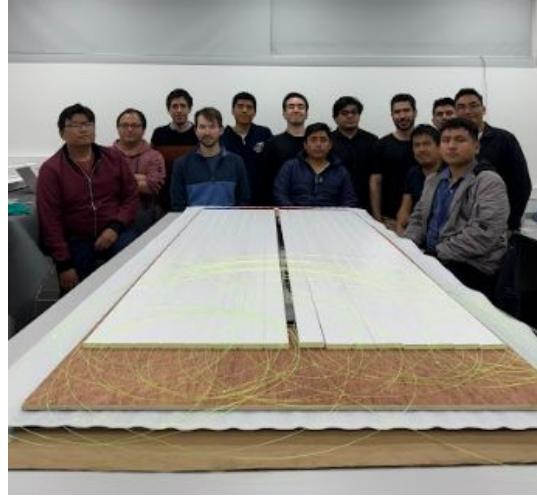
- Located at PUCP Campus near INRAS
- Array configuration, equilateral triangle with central node (~70m side)
- Components: Four detection stations + one central station as data hub
- Data post processing to get shower features
- Aim to compare results with Red Pitaya and uDAQ working in parallel

II. Panel assembly and data acquisition system development

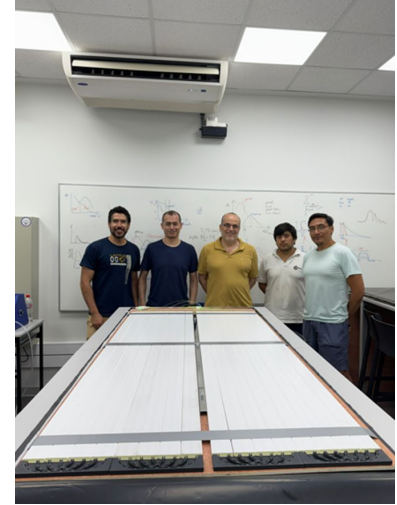
TAMBO



1st Panel



2nd Panel



3rd Panel



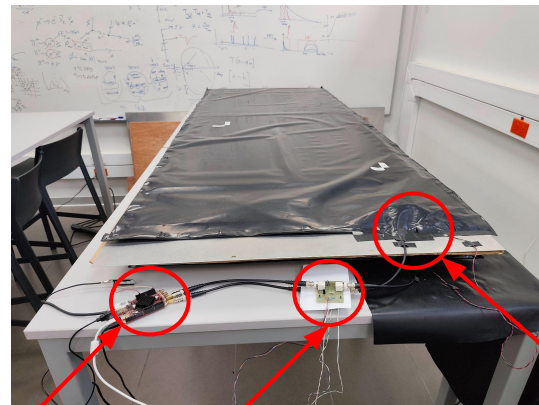
4th Panel

II. Panel assembly and data acquisition system development



The Red Pitaya platform

- Red pitaya stemlab 125-14In7020 (**Low noise version**)
- FPGA + ARM + peripherals (**High-speed data rate**)
- 14 bit ADC (**122uV sensitivity**)
- 125 Msps (**8ns resolution**)
- GPIO ports (**For PPS sync**)
- Own linux distro (**Data and network management**)
- The 4-input channel version would be used

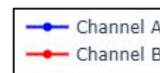
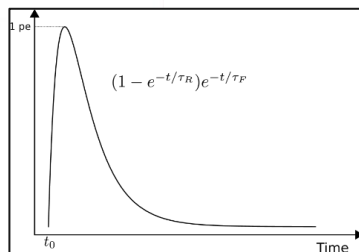
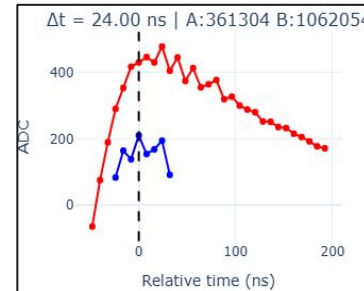
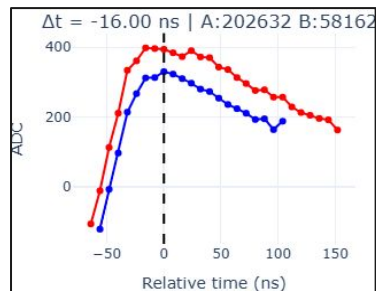
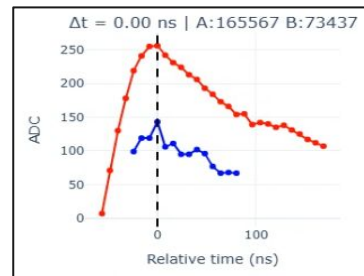
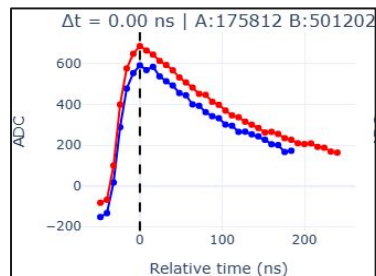
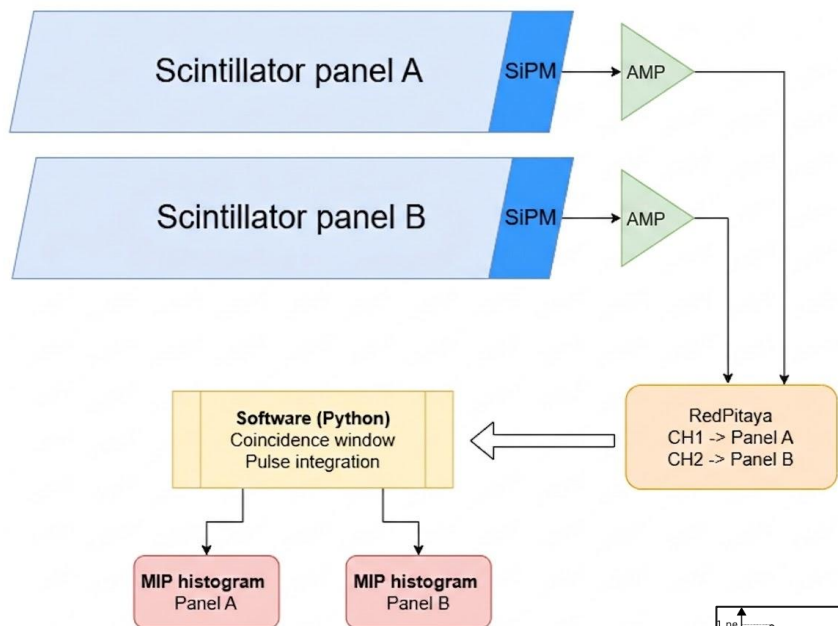


Red Pitaya with 2
input channel (ADC)

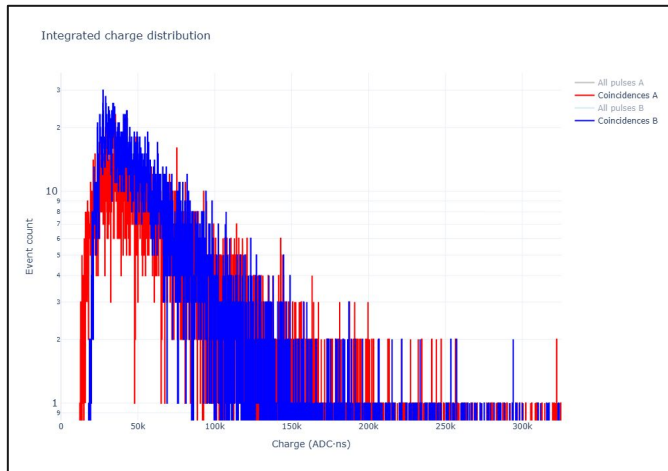
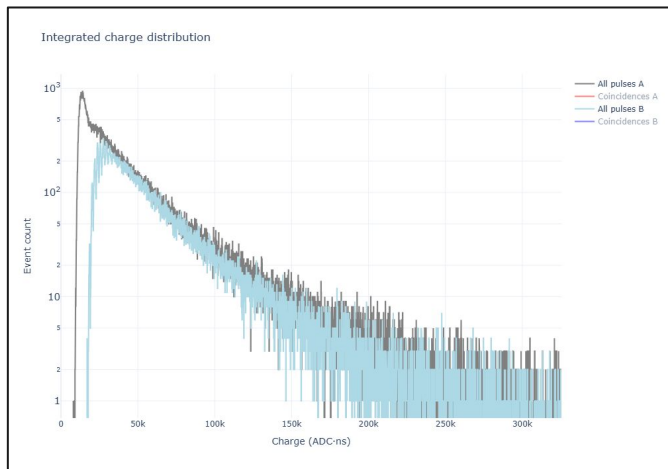
Transimpedance
amplifier (TIA) x2

Scintillator panel
with SiPM attached
x2

III. Initial tests and results



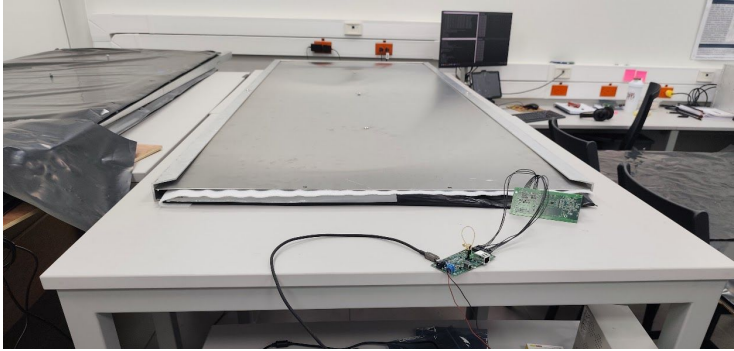
III. Initial tests and results



Analysis of integrated charges and coincidences

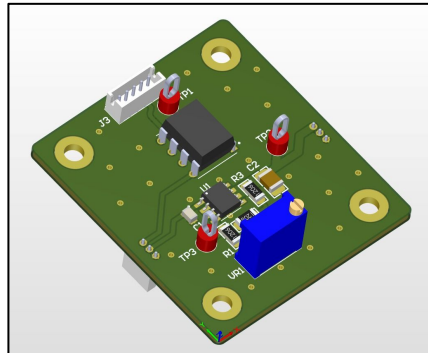
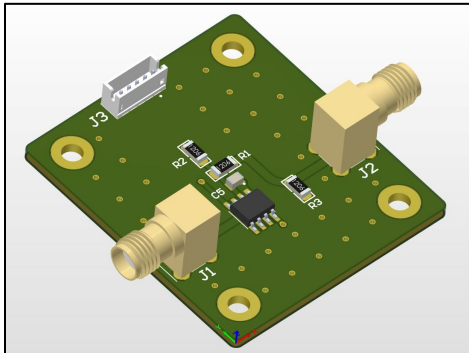
- The environment was electromagnetically noisy
- Panels were affected by light leakage
- Many pulse shapes could not be easily classified
- The thresholds differ from channel to channel which caused difference in the data rate
- Baseline information for each channel was unavailable
- The integrated charge distributions across channels were not similar
- The coincidence rate was lower than expected (2-4Hz)

IV. Hardware and software enhancements



Hardware improvements

- Frequency analysis was conducted on the SiPM signals
 - 30 Mhz bandwidth
 - Big AM radio stations interference (around 2Mhz)
 - Interference coming from the amplifiers themselves and the bias voltage generator
- The 4 panels have been sealed in their aluminum enclosures.
- New and better amplifiers were built (x10, 60MHz)
- Battery banks and linear regulators were chosen to reduce noise from power supplies and the bias voltage generator

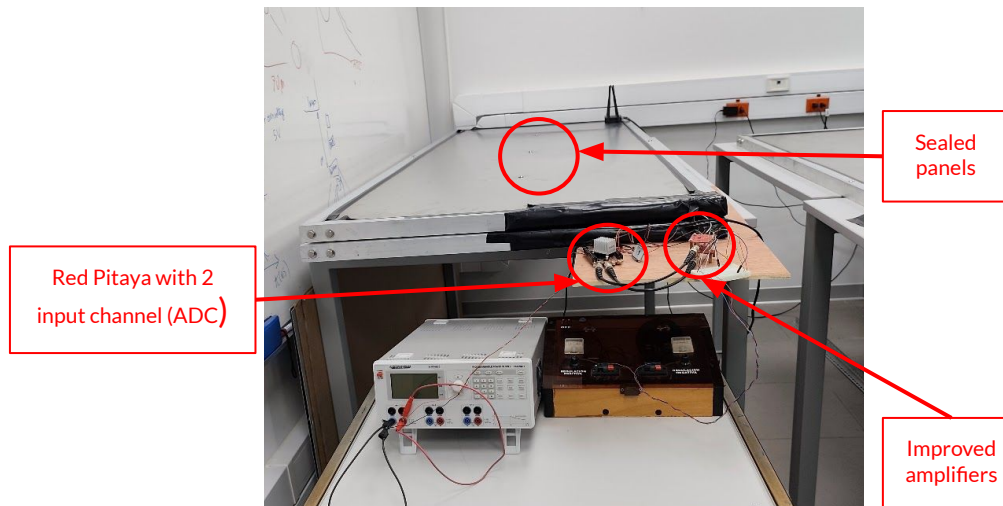
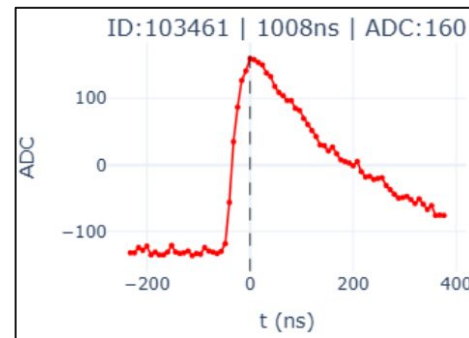
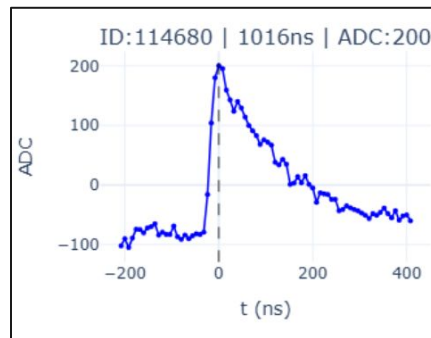


IV. Hardware and software enhancements

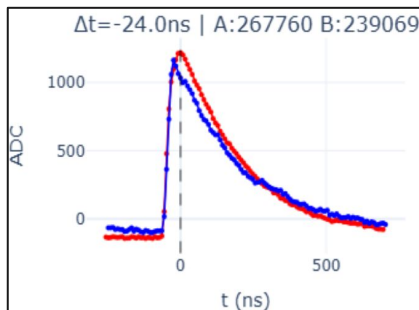
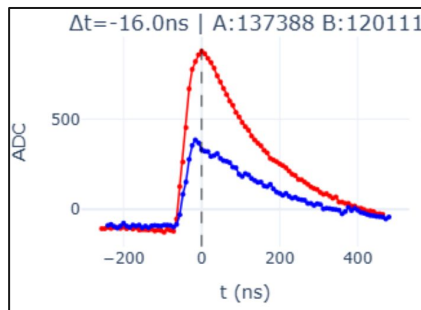
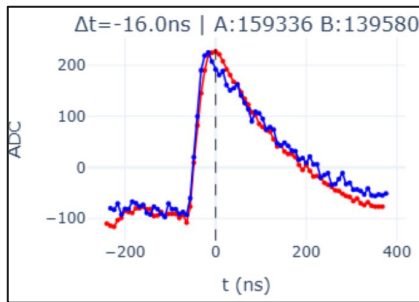
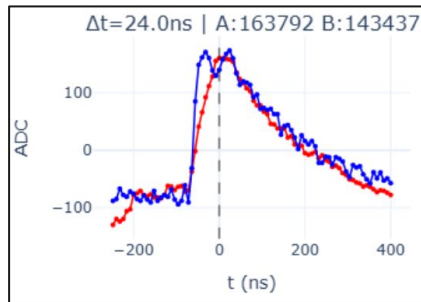


Software improvements

- Additional pre-rising threshold and post-falling threshold sampling was implemented on the Red Pitaya platform
- Now it is possible to get baseline information for each channel
- The offset of each ADC channel was determined, this helped to balance the data rate
- The coincidence detection algorithm was optimized



V. Latest results



Higher-quality data

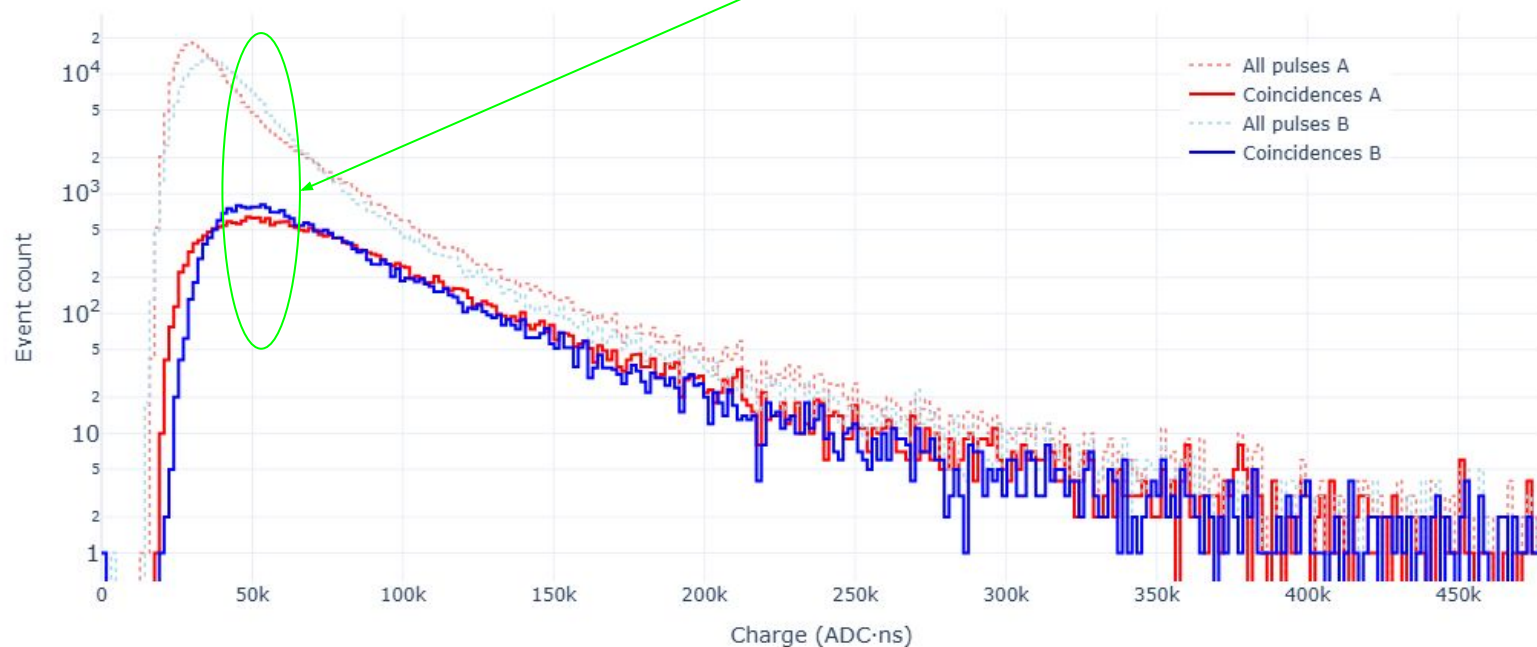
- The noise level was substantially reduced
- The pulses are now easily distinguishable
- Data rate is balanced
- Baseline is calculated automatically
 - Ch A -> -121.05 ADC (-14.768mV)
 - Ch B -> -78.59 ADC (-9.587mV)
- The coincidence rate is better ($\sim 87\text{Hz}$)

V. Latest results

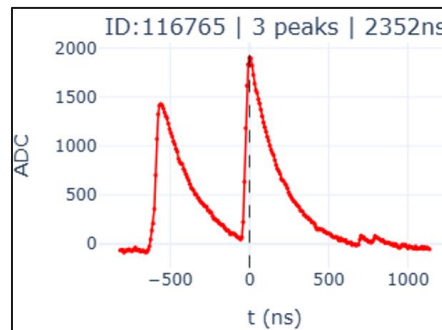
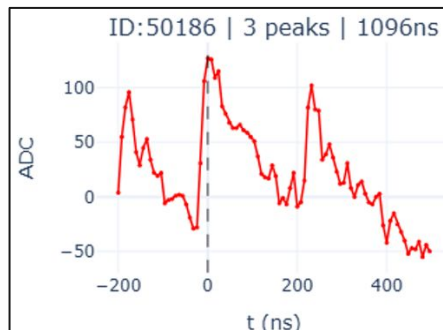
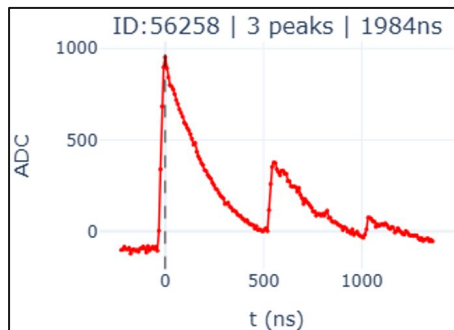
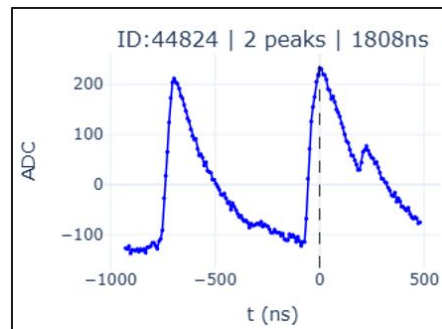
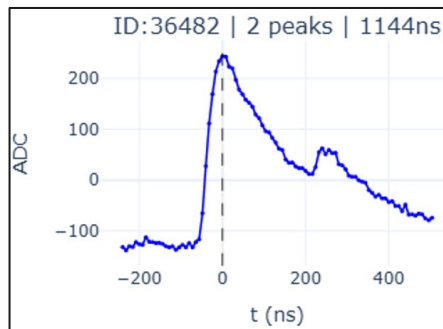
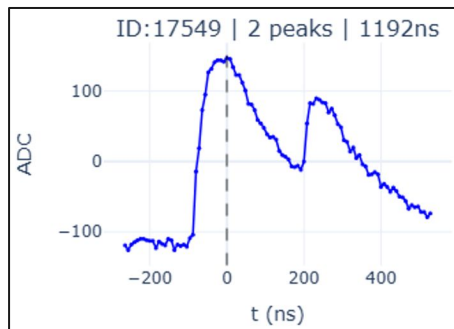


Integrated charge distribution — all vs coincident pulses

MIP?



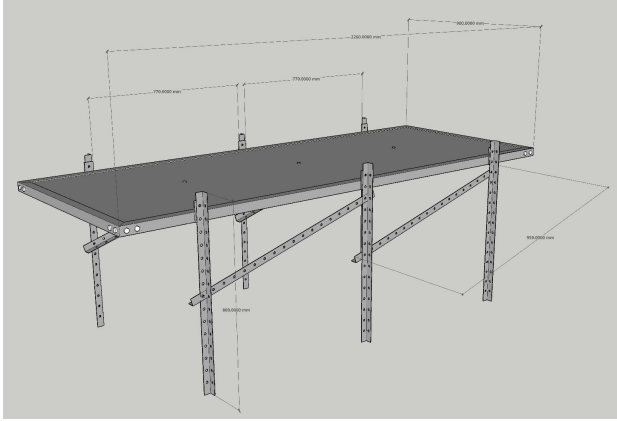
V. Latest results



Additional interesting findings

- Two or more consecutive pulses were detected in both channels
- Crosstalk? After pulse? Shower?

VI. Ongoing work



Panel implementations

- Prototype for placing panels outdoor (INRAS)
- Adapter for the Red Pitaya and uDAQ systems to work together is installed
- Waterproofing and dustproofing are currently in progress





Thanks for your attention!
Questions?