

PMT signal treatment for triggering

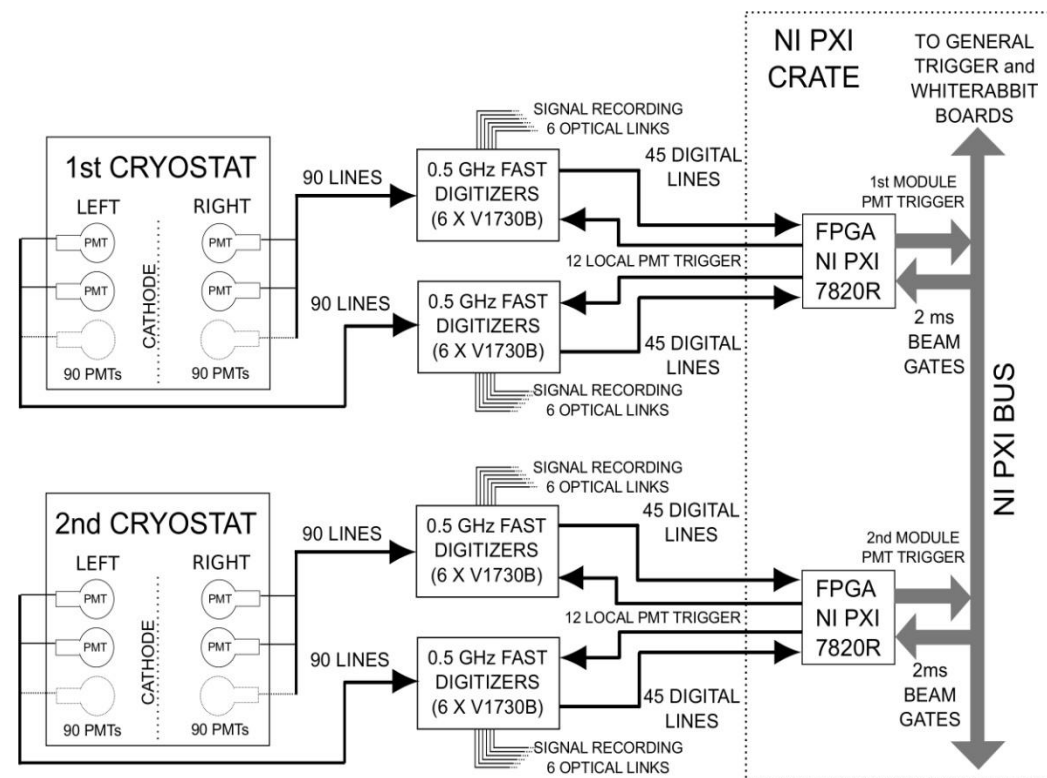
*Gian Luca Raselli
INFN - Pavia*

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PMT Trigger scheme

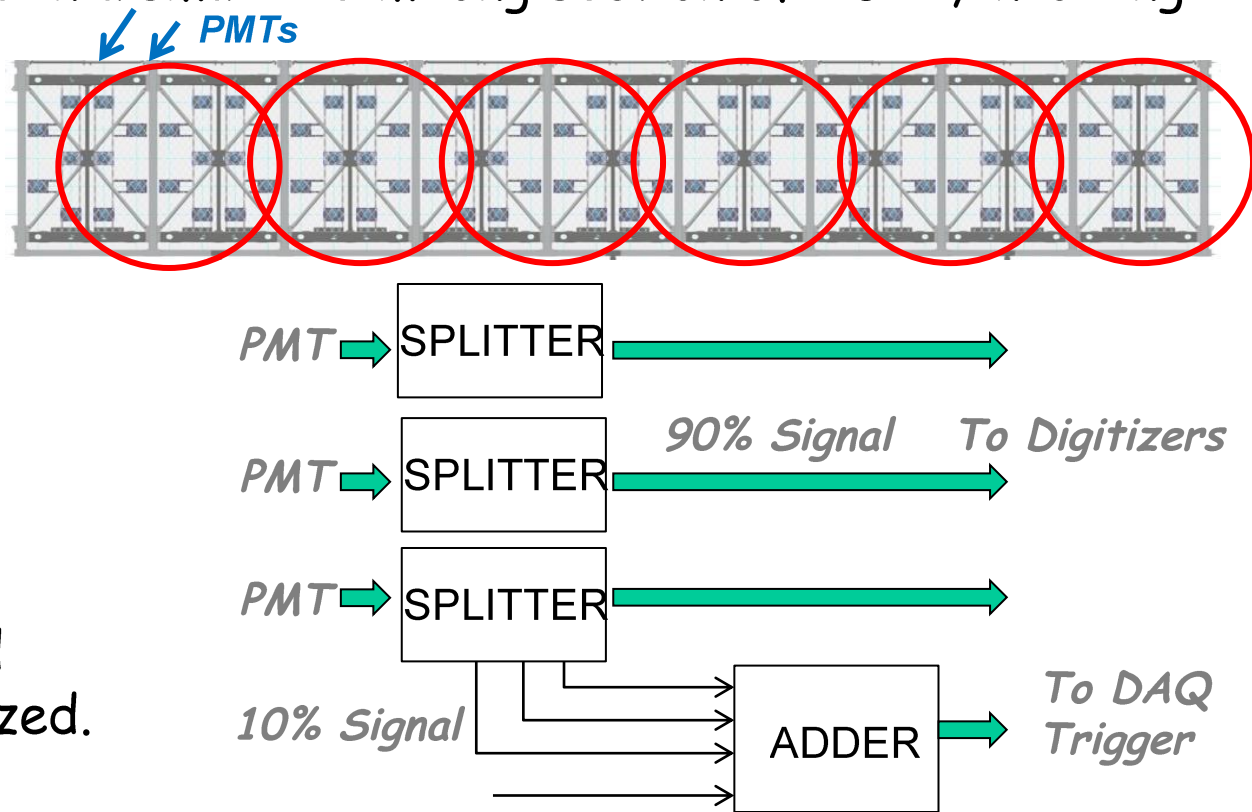
- 90 PMTs/TPC are connected to 6 CAEN V1730B boards which generate a set of discriminated signals in terms of OR/AND of pairs of adjacent PMTs.
- These 45 signal outputs from a single TPC chamber are processed by a programmable logic unit FPGA (NI-PXIe 7820, one for each T300 module).
- A PMT-TRIGGER signal defined by majority or coincidence patterns, will enable the fast PMT digitizers:

- If this occurs inside a 2 ms gate in coincidence with BNB/NuMI extractions to record all PMT activity during the TPC drift time window.
- Each PMT pulse is stored in a $10 \mu\text{s}$ window to record both fast/slow components of the LAr scintillation.
- This signal will be also used to generate the GENERAL TRIGGER in coincidence with BNB/NuMI beam spill to enable the event read-out.



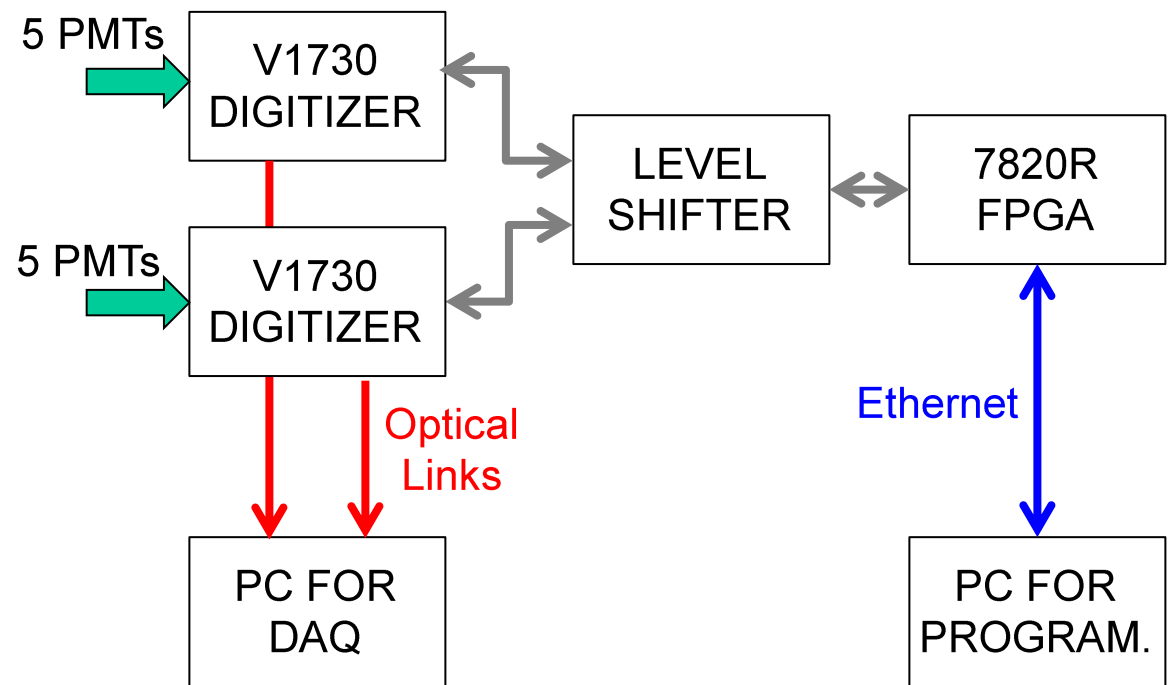
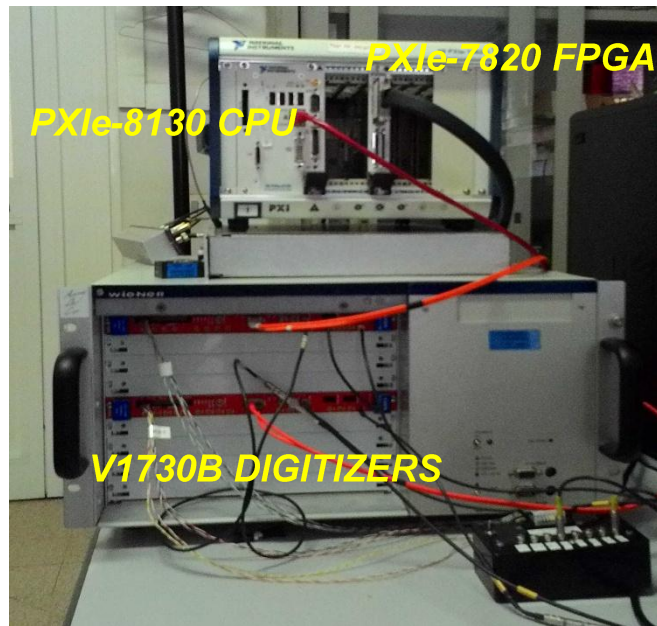
ICARUS Trigger system

- Following the ICARUS experiment at LNGS with CNGS beam, the previous scheme can be complemented by the exploitation of the analog sum signal of fired PMTs in the event to further reduce the electronic noise in the detector.
- According to the low energy of BNB/NuMI beams, ν interactions are expected to be mainly spatially confined in a small ~ 3 m long section of T600, involving ~ 15 neighboring PMTs.
- Therefore the analogue sum of 15 PMT signals in a ~ 3 m slice can be included in the trigger scheme to identify the neutrino interaction
- Each PMT line can be split to feed both the digitizers and 15 signal adder where the waveform are summed up and then discriminated and digitized.



The proposed PMT clustering would allow to increase the event recognition capability of Trigger system, possibly identifying the interested detector region.

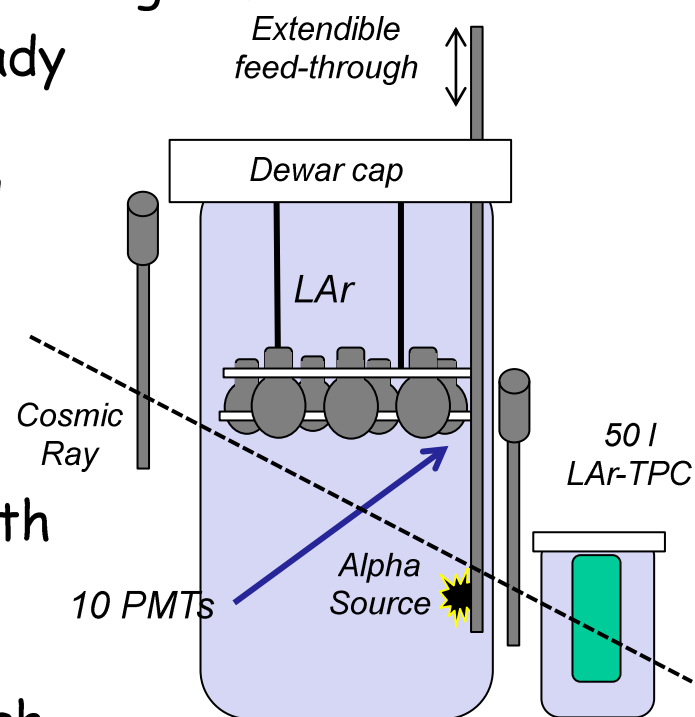
PMT DAQ/Trigger test bench



- A test bench has been instrumented to test digitizers and FPGA programming, the same used for the T600 trigger and DAQ system:
 - A VME crate hosts two V1730B digitizers.
 - A NI-PXIe 1062Q crate host one 7820 board + 8130 CPU
- FPGA programming is carried out by means of LabVIEW tools.
- Digitizers programming by means of CAEN library.
- The test bench, used to learn the programming and synchronization of the system, has been transferred to CERN for test facility triggering/DAQ.

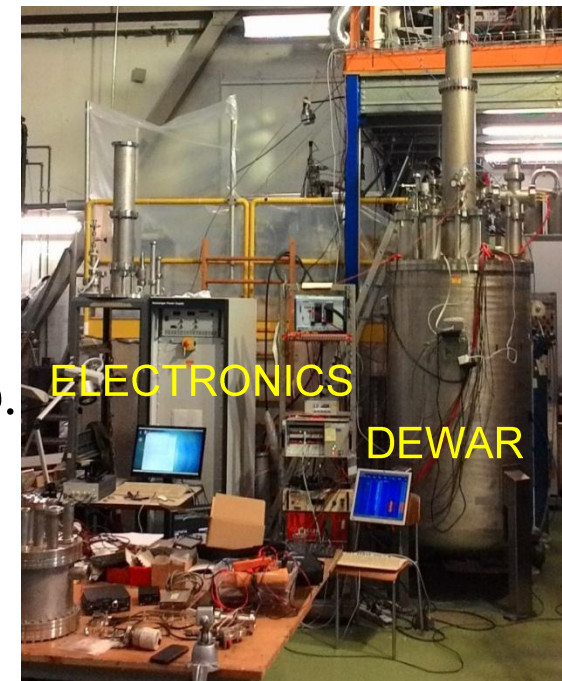
LAr test facility to test DAQ/ Trigger systems (CERN)

- A small scale LAr test facility is has been prepared at CERN to test trigger configuration logics, laser calibration, DAQ, on-line and define electronic synchronization (trigger/wire/PMT) and timing.
- 10 R5912 Hamamatsu PMTs equipped with laser calibration system are arranged into an existing ~1600 liters LAr cryostat exposed to c-rays and an α source inserted in LAr to initially calibrate PMT response.
- The DAQ/Trigger scheme is a subset of the general design of ICARUS T600.
- The PMT array is complemented aside with the already operational ICARUS 50 l LAr-TPC which is provided by LAr recirculation/filtering system, to performing synchronous DAQ programming for both PMTs and Wire Signals.
- Cosmic muons crossing both TPC dewars will be selected by external plastic scintillators.
- The PMT waveform recording, initially performed with CAEN software, will later be based on ArtDAQ.
- The 10-PMT facility is also a test bench for prototypes or components of the trigger system, such as analog adders, level shifters and laser components.



Trigger Programming Status with the 10-PMT facility

- Test facility is presently operational with Liquid Argon, after argon gas tests to check the PMT working and the electronics layout aiming to:
 - Check of PMT working at cryogenic temperature;
 - Calibrate and equalize the PMT gain;
 - Implement trigger logics
- PXIe-7820 FPGA are programmed using the LabVIEW tools, implementing simple logics of the input signals (coincidence, majority...) to perform counting and recording the frequencies of the input pattern.
- First results indicate that the light produced in this system is very high. Different situation with respect to the T600 detector that can contribute to a high light production: no drifting electric field, PMTs closed each other, limited active volume, visible light reflected by stain steel.
- Test with cosmic ray will continue the full month of Sep. also using the external scintillator telescope.
- In Oct. data will be acquired with an internal a source and the 50 l LAr-TPC will be activated for sync. DAQ.

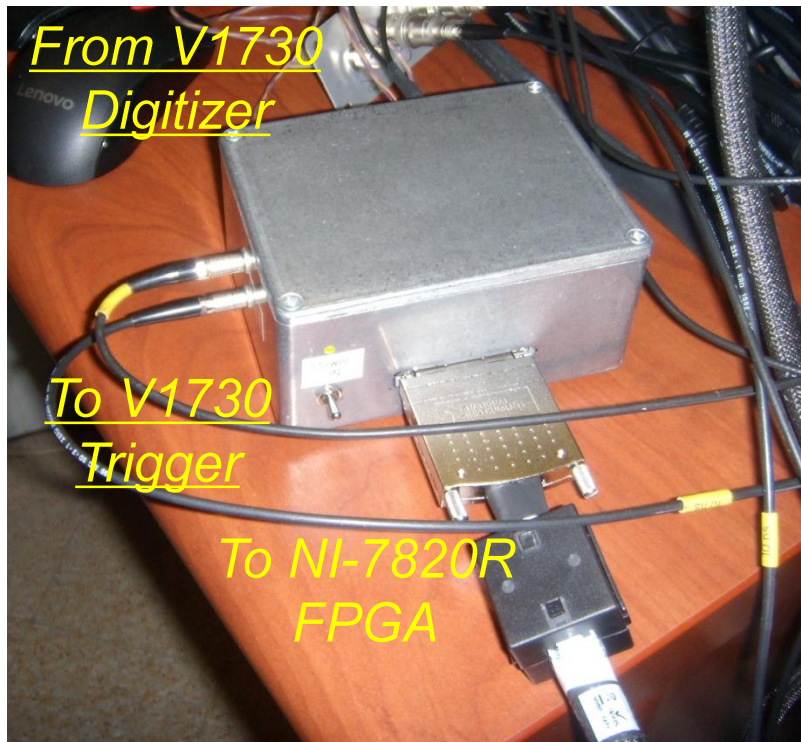


Test fo electronic prototypes

- The 10-PMT test facility at CERN is also an important test bench for some components and prototypes of the trigger system.

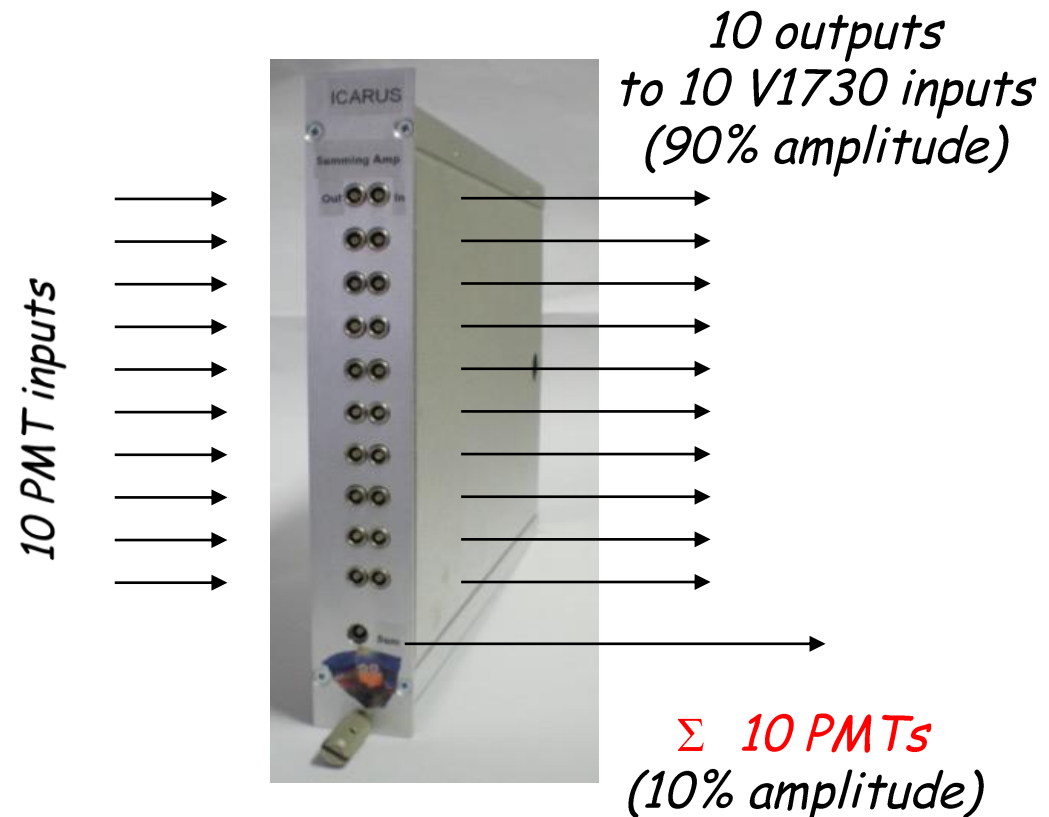
LVDS-to-TTL Prototype

Used to convert the discriminated output signals from the V1730 digitizers (LVDS) to the FPGA 7820 inputs.



Analog Adder Prototype

Used to exploit and test a 10-PMT analog sum.



- In addition some parts of the Laser calibration system (Laser, splitters...) will be tested.