# A NEW CONCEPT ANALOG SYSTEM TO READOUT MULTI-CHANNEL PHOTODETECTORS


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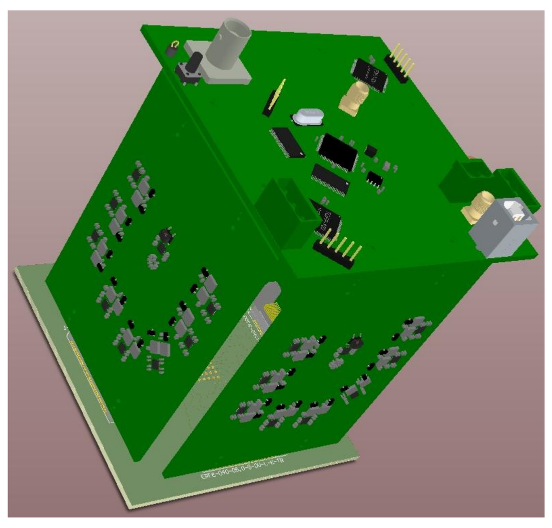
**Granularity is a fundamental parameter for electromagnetic and hadronic calorimeters. While the granularity of electromagnetic calorimeters can be improved using pixeled silicon detectors, other solutions are necessary for hadronic ones. Increasing granularity allows for higher definition of hadronic jets and for studying the substructure of overlapping jets. One proposal to increase the readout granularity of hadronic calorimeters involves using multi-channel photodetectors, such as Multi-Anode PhotoMultiplier Tubes (MAPMTs). In this poster, an innovative readout prototype for multi-channel photodetectors will be presented. This readout concept is based on the equalization and on the analog sum of a programmable number of channels. A configurable sum of individual channel signals allows for a reduction in the number of digitized channels, lowering the costs of the granularity enhancement project. A potential application of this new readout is in ATLAS-like hadron calorimeters.**


## Prototype description



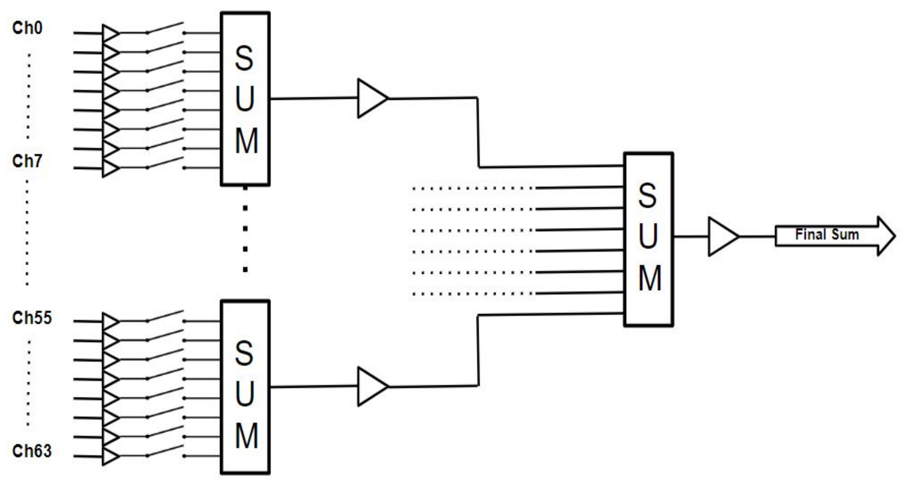
The new readout prototype for multi-channel photodetectors consists of 6 printed circuit boards with high-bandwidth Integrated Circuits, designed to host a 64-channel MAPMT with a sensitive area of 18 × 18 $mm^2$ and an anode pitch of 2.54 mm.

The boards are connected by high-speed board-to-board connectors arranged to form the faces of a parallelepiped. As a prototype used for a first proof of feasibility, no constraint on system dimensions, nor on power consumption (25 W) was applied.

The characteristics of this new readout concept are:

- ➡ **equalization** of the 64 individual MAPMT channels;
- ➡ configuration of the **analog signal sum** of an arbitrary number of channels;
- ➡ a three stage amplification of the single output signal. In the first stage the 64 amplified signals are first fed to 8-channel resistive summing networks each receiving 8 inputs. The output of the 8-channel networks is amplified before being fed into a resistive network for the final sum. The total sum can be further amplified to match the dynamic range of the ADC used for signal digitization. The gains of the three steps are configurable in a range from -6 to 26 dB.

The selected channels and all amplifications can be set through a GUI, allowing to establish USB connection with the prototype and to upload the selected configuration for the final sum.

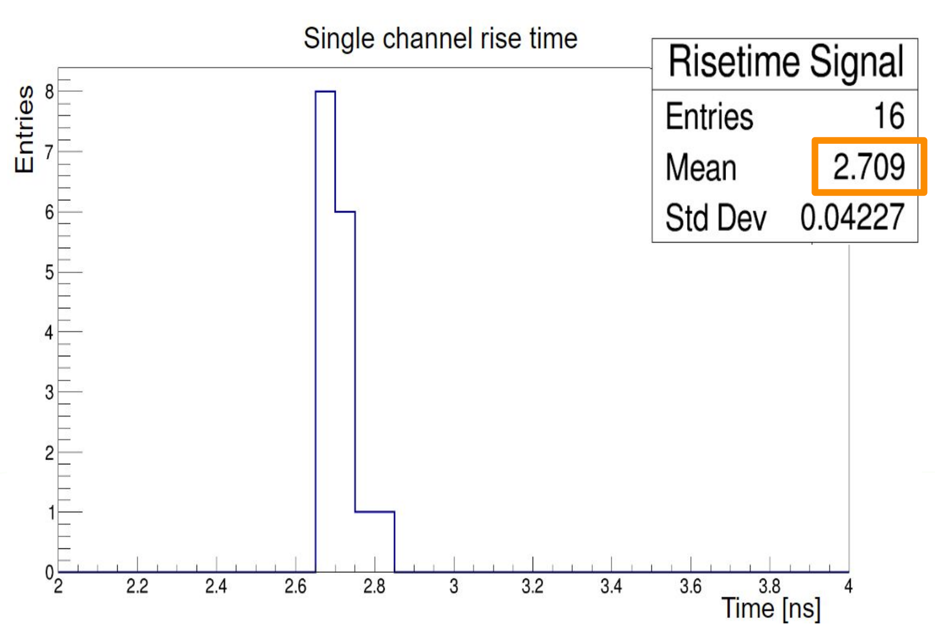


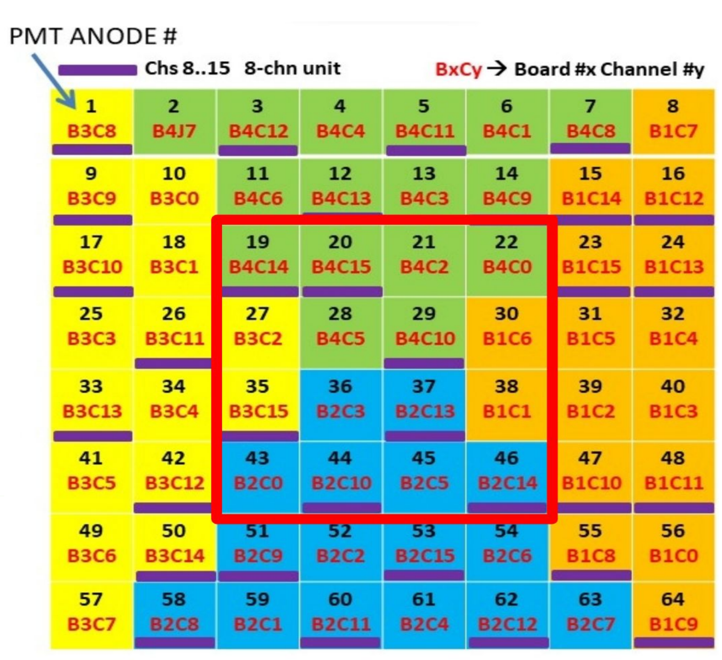

The prototype was tested in the ATLAS-Pisa laboratories in terms of pulse shape stability and of linearity of the analog sum for an arbitrary number of channels.

**↓ Prototype tests →**

## Pulse shape stability

The prototype was tested by injecting a known input signal into the 16 central readout channels. The input signal has been generated by differentiating a square pulse, in order to mimic a typical PMT signal (rise time < 2 ns). The characteristics of the output signals were analyzed with a digital oscilloscope. The rise time of the 16 output signals is ~ 2.7 ns, with a statistical uncertainty of ~ 40 ps and a systematic uncertainty of ~ 60 ps due to the fit procedure.

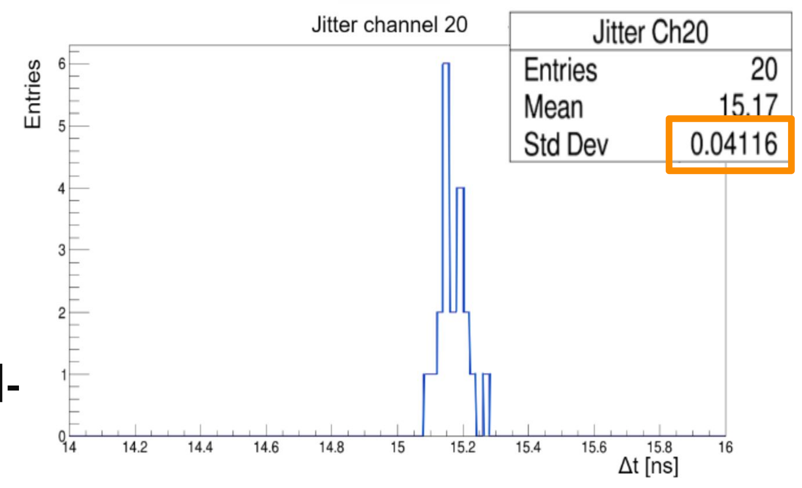



➡ **All channels exhibit consistent behavior. The prototype ensures the stability of the output signal pulse shapes.**

## Jitter time

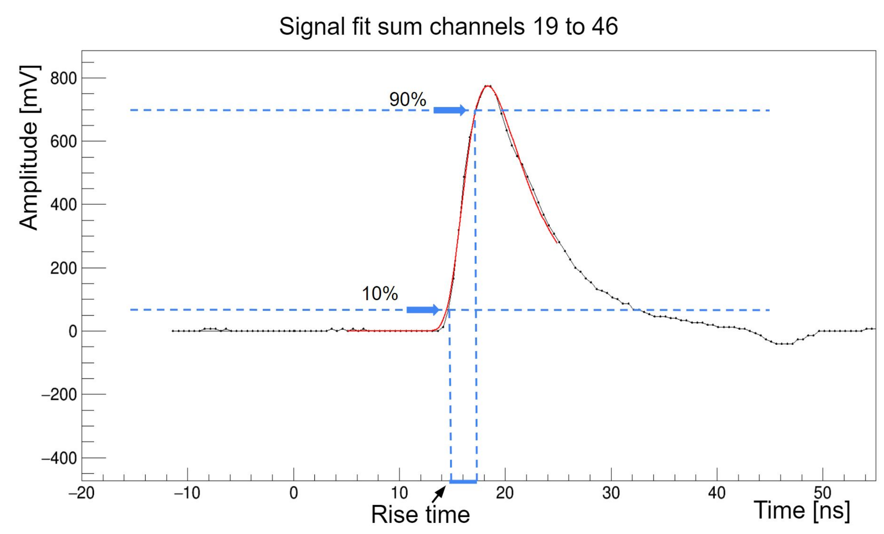
The jitter time of the prototype is defined as the variation in the time delay between input and output. The prototype jitter time is ~ 40 ps. This jitter value ensures good temporal stability for this type of read-out system.

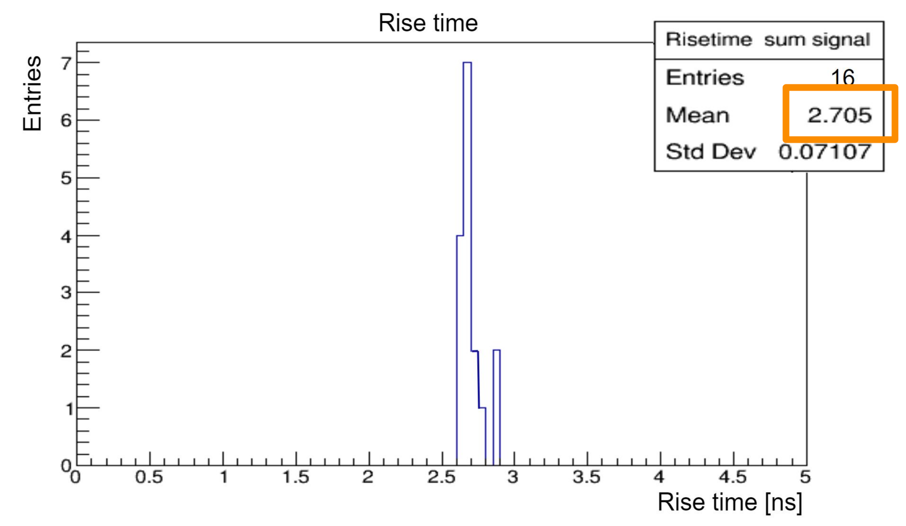



➡ **Good data transmission through the readout prototype.**

## Linearity of the analog sums

The stability of the signal pulse shape and the linearity of the analog sum were tested by analyzing the signal sums of an arbitrary number of channels (from a single channel up to the sum of all 16 tested channels).



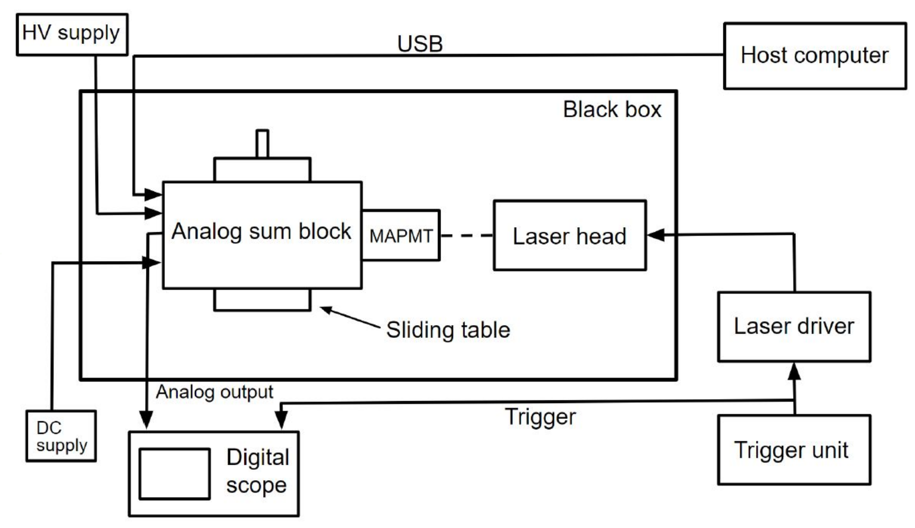




The rise time of the analog sums are consistent within one standard deviation with the rise time of the individual channels.

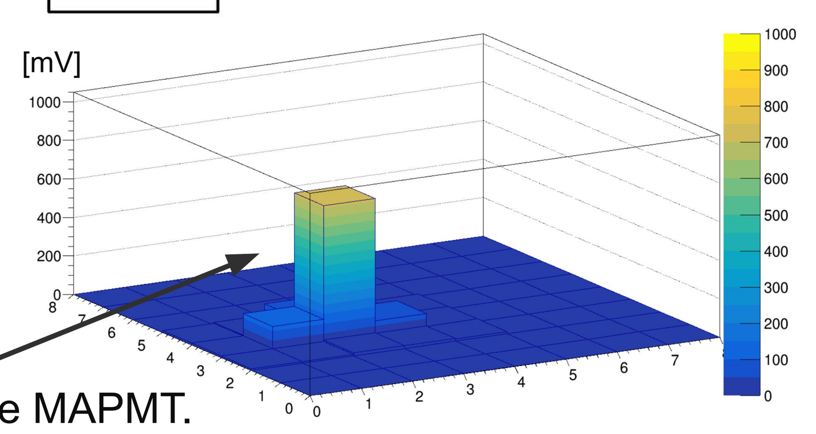
➡ **The operation carried out by the resistive networks to sum the analog signals does not alter the shape of the outputs. The prototype guarantees the linearity of the analog sums.**

## MAPMT active area scan

The performance of the readout prototype was tested using a HAMAMATSU R7600-300-M64 multi-anode PMT and a laser beam incident on the photodetector.




The scan of the MAPMT active area allowed us to identify minimal effects of optical cross-talk and coupling between adjacent channels that do not alter the correct functioning.




Laser spot centered on a given anode pixel of the MAPMT.

## Conclusion and plans

The readout prototype guarantees pulse shape stability of the output signals and linearity of the analog sums. The resistive summing networks do not alter the shape of the analog sum outputs. The jitter time is ~ 40 ps and ensures good data transmission through the readout. Prototype results demonstrate the feasibility of this project.

Encouraged by the promising results of the tests, next step will be the design of a similar device using ASIC technology.

The **new ASIC chip** can be tested in ATLAS-like experimental setups. Thanks to its **versatility**, the chip can be used in any environment that involves the use of multi-channel photodetectors, both in the field of particle physics and in industrial applications.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