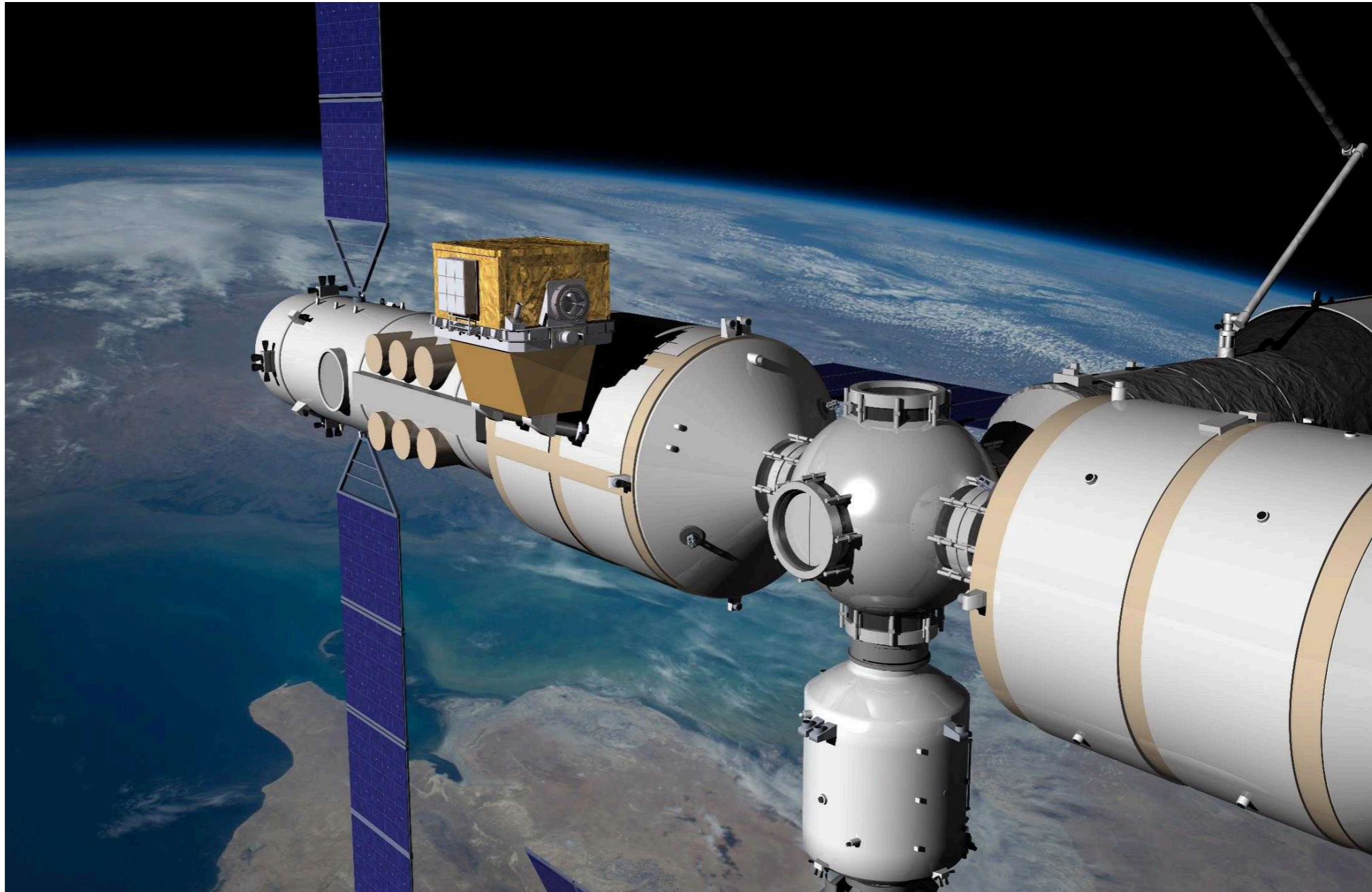


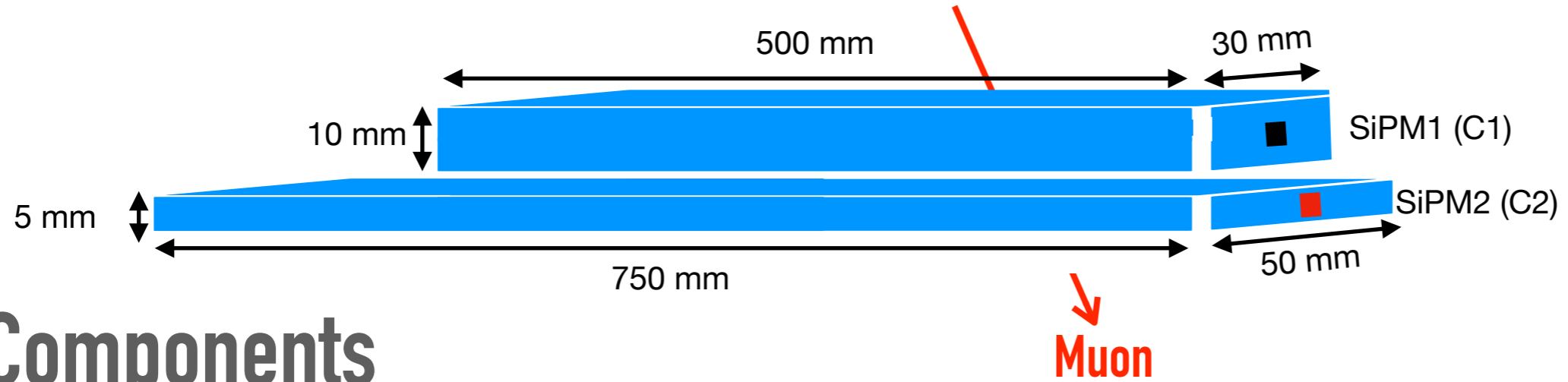
The HERD Space Mission



Timing resolution checks

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Goal: to assess the intrinsic timing properties of bar+SiPM only



Components

SiPM 1, SiPM 2: Hamamatsu S13360 – 3025CS

Scintillator coupled to SiPM1: Eljen (EJ 200)

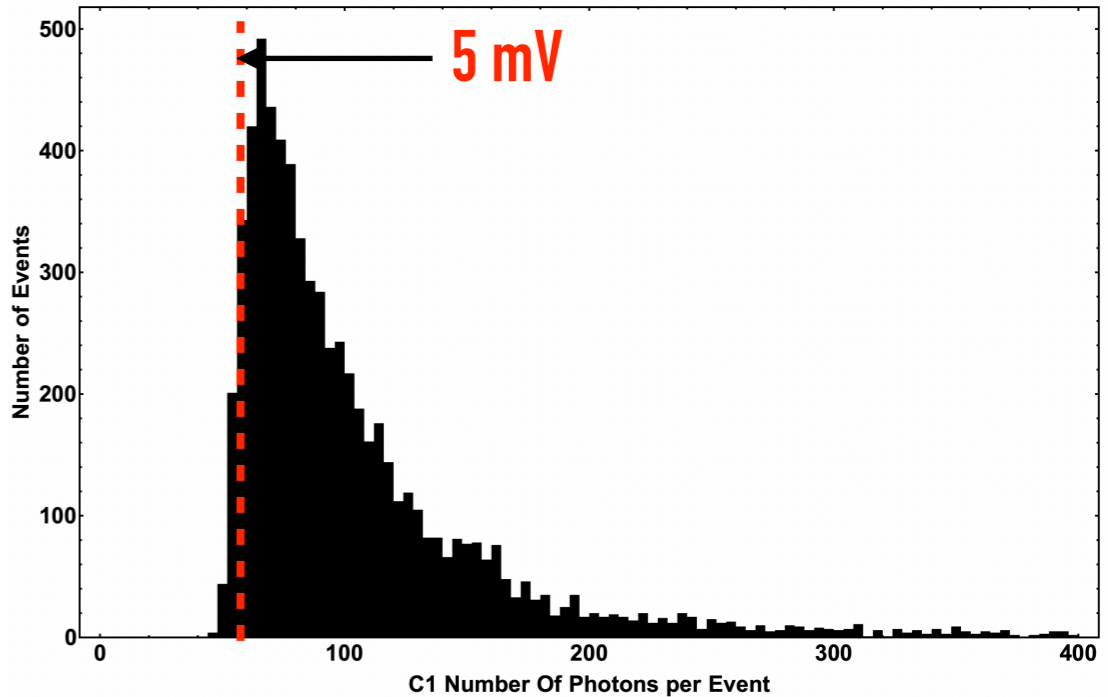
Scintillator coupled to SiPM2: Saint-Gobain (BC-404)

Linear LV Power Supply to operate the SiPMs

Both SiPMs are readout by means of a Lecroy HD06104 oscilloscope (1 GHz bandwidth, 2.5 GS/s*)

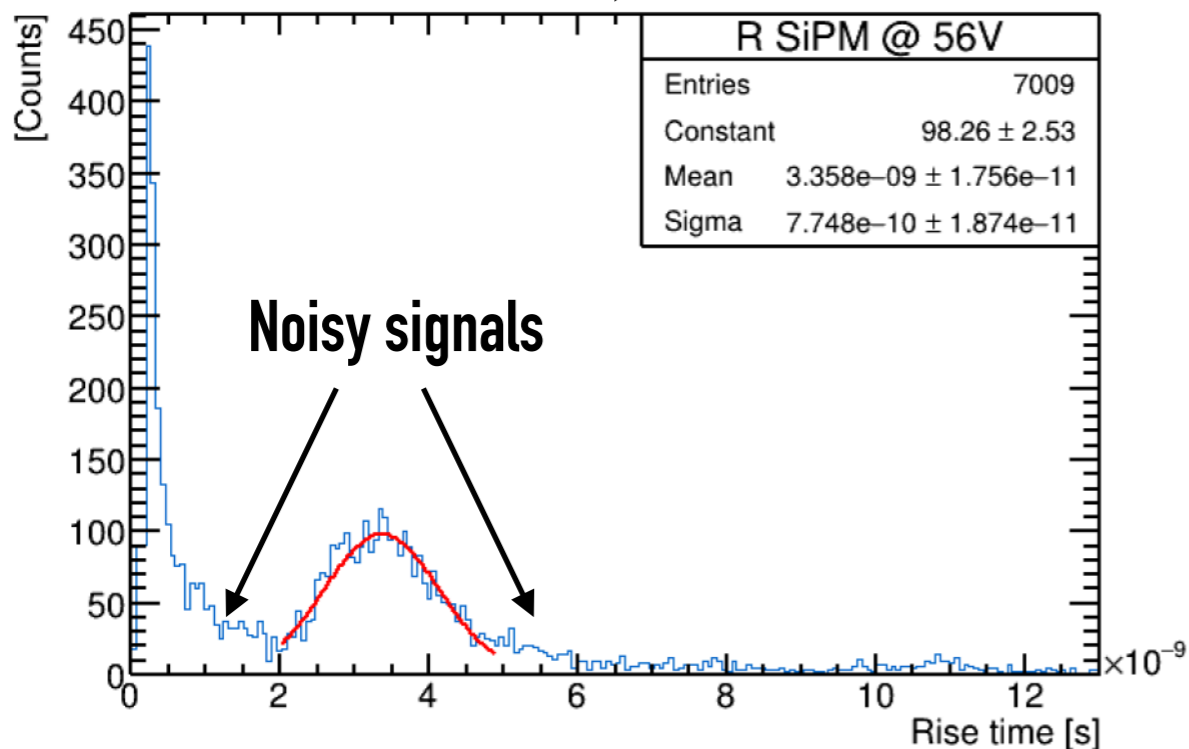
NB:

- SiPM 1 and SiPM 2 are operated at same gain (from previous measurements, 5×10^5 @ 56V, ~room T)
- The trigger is active when both SiPM 1 and SiPM2 produce a signal ($V_{thr} > 5 \text{ mV}$) in a time window of 200 ns

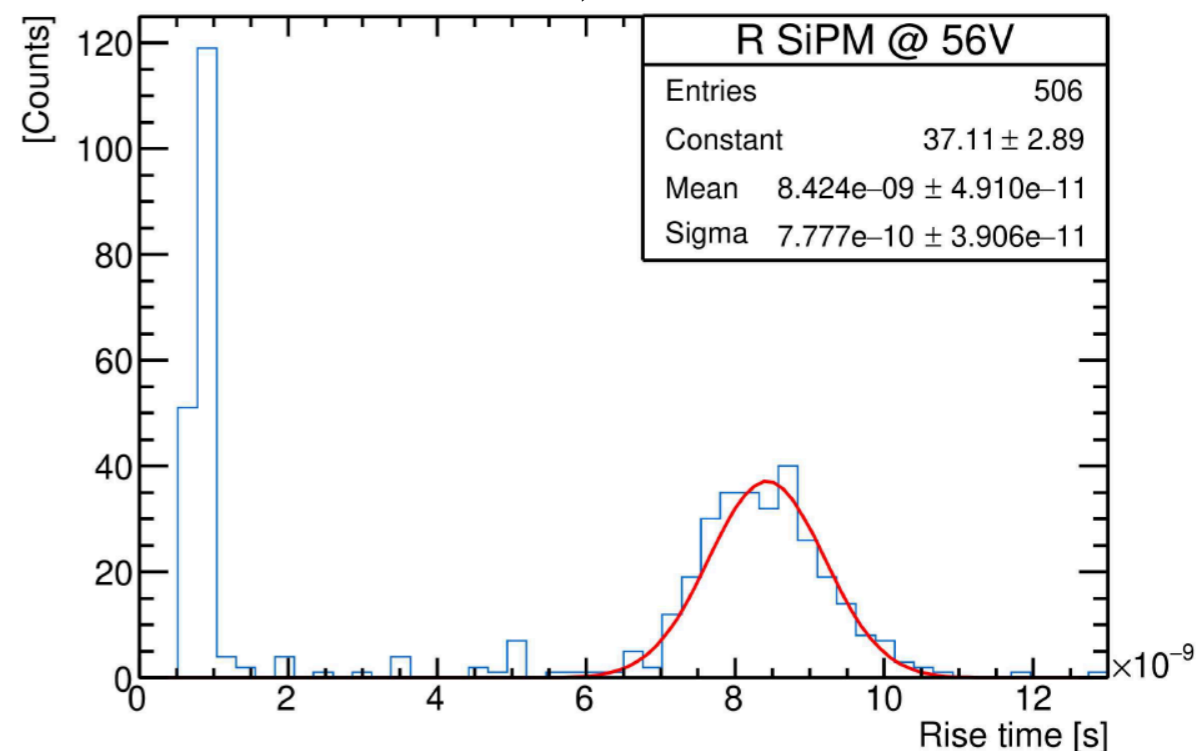


Preliminary test: measuring the rise time

Rise Time SiPM2, Full Bandwidth

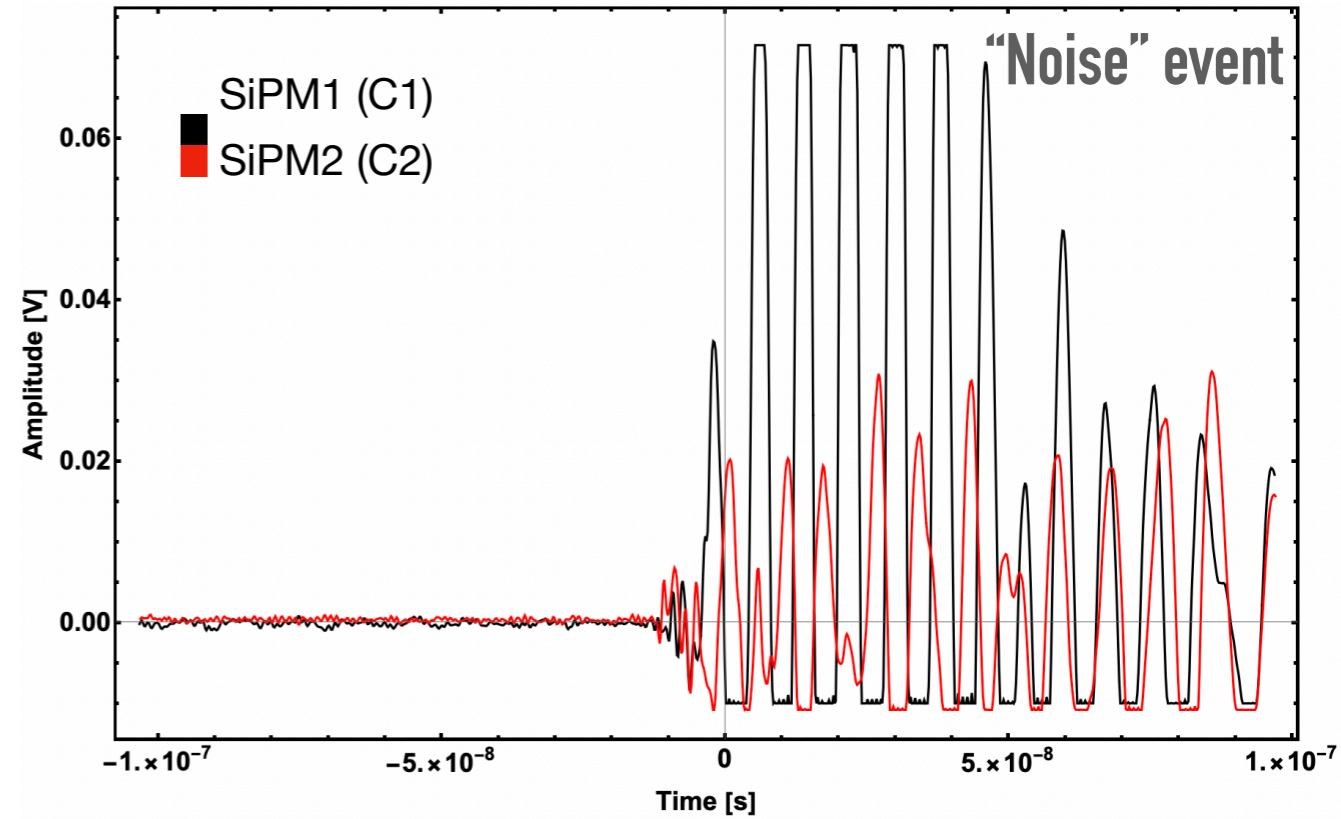
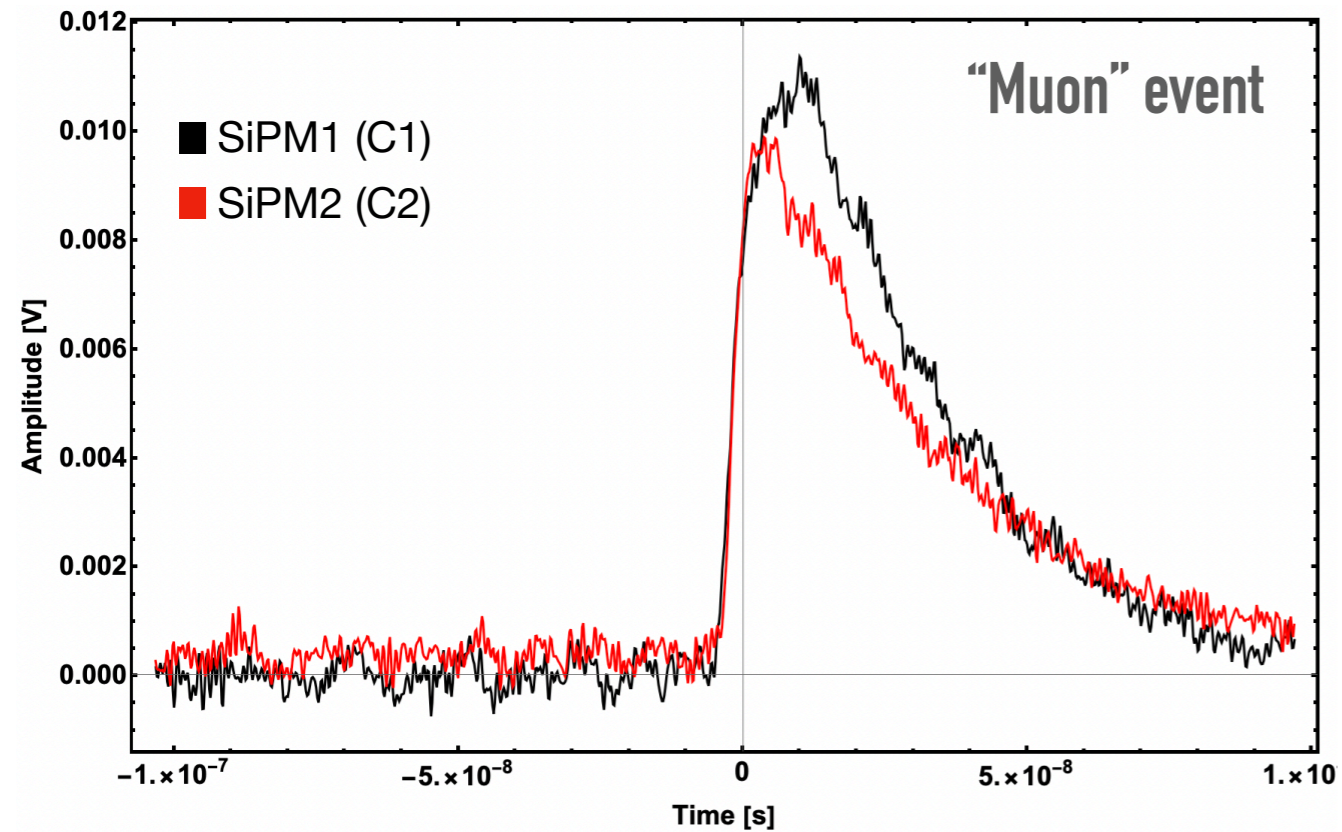


Rise Time SiPM2, 20 MHz Bandwidth



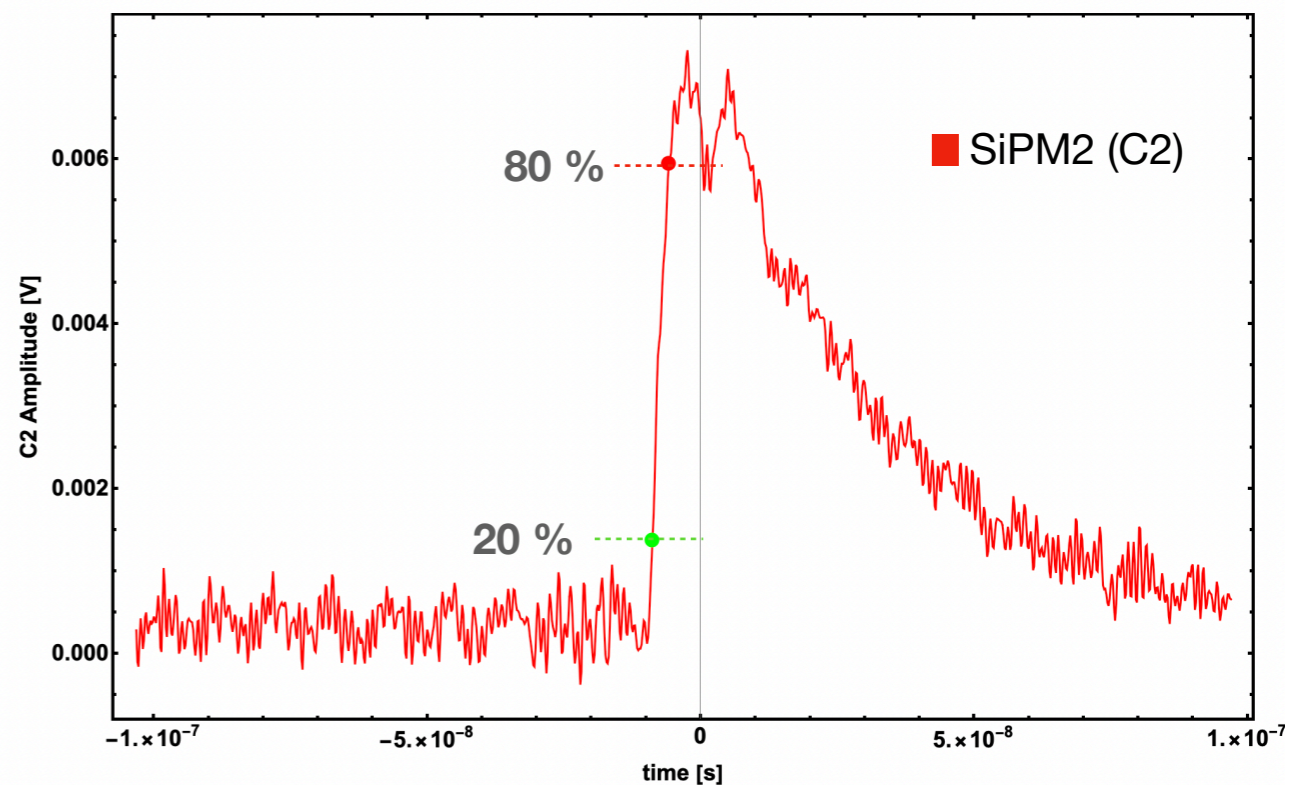
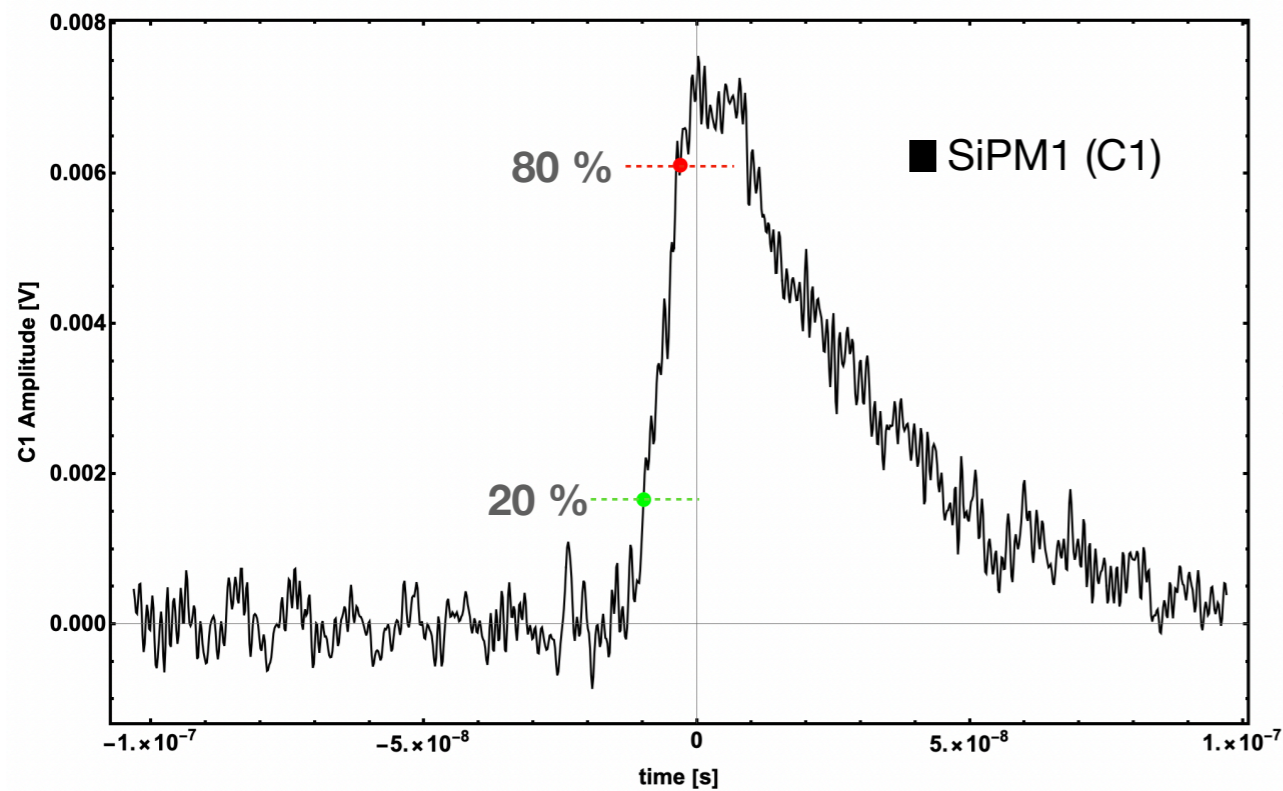
- We implemented an online analysis on the HD06104 and collected the rise time of each signal.
- Working at very low thresholds exposes the system to EM noise.
- A filter might be used: the SNR will improve, however this would affect the shape of the signal, especially the fastest component.
- We decided to perform a more refined analysis at the waveform level.

Waveform analysis



200 ps/bin (in oversampling mode)

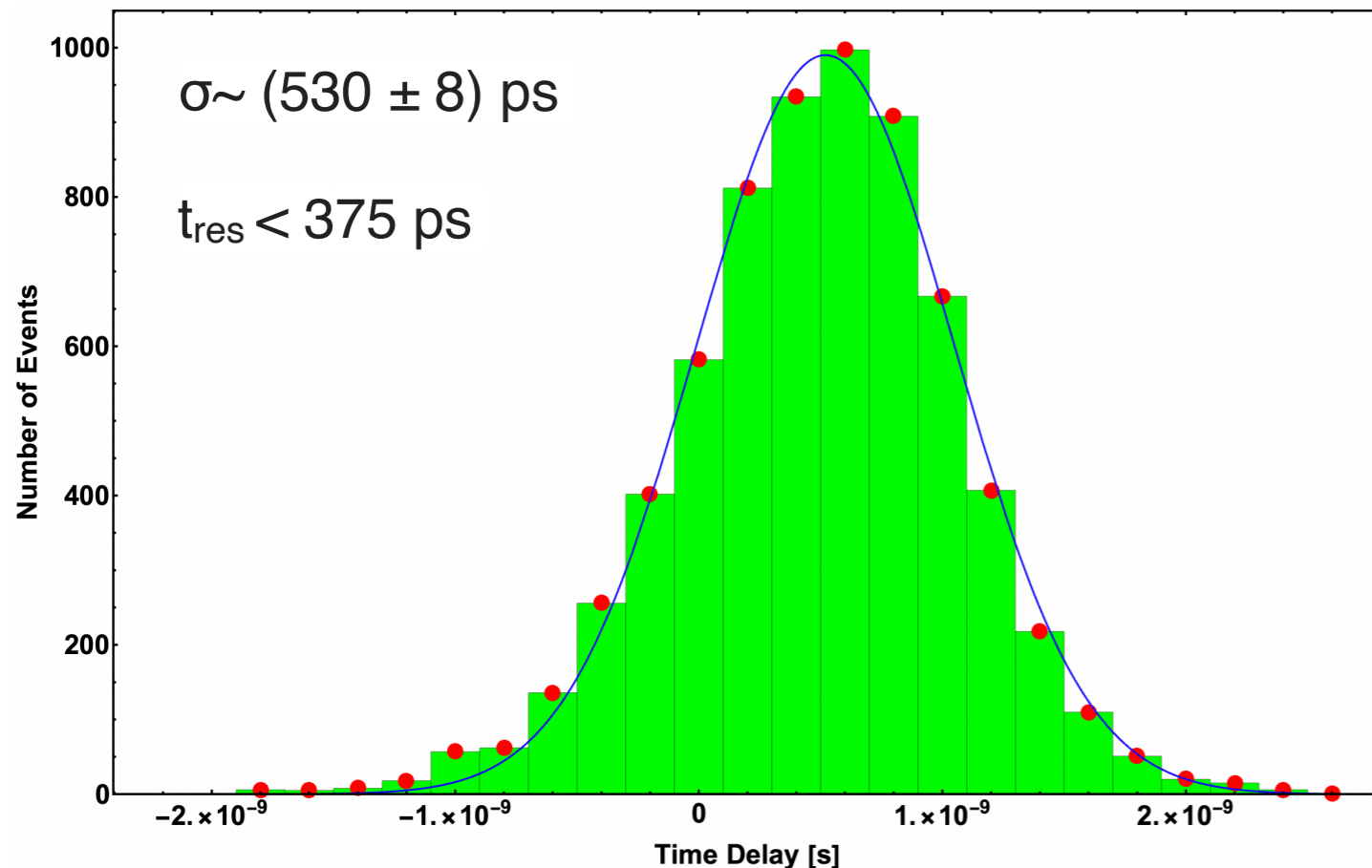
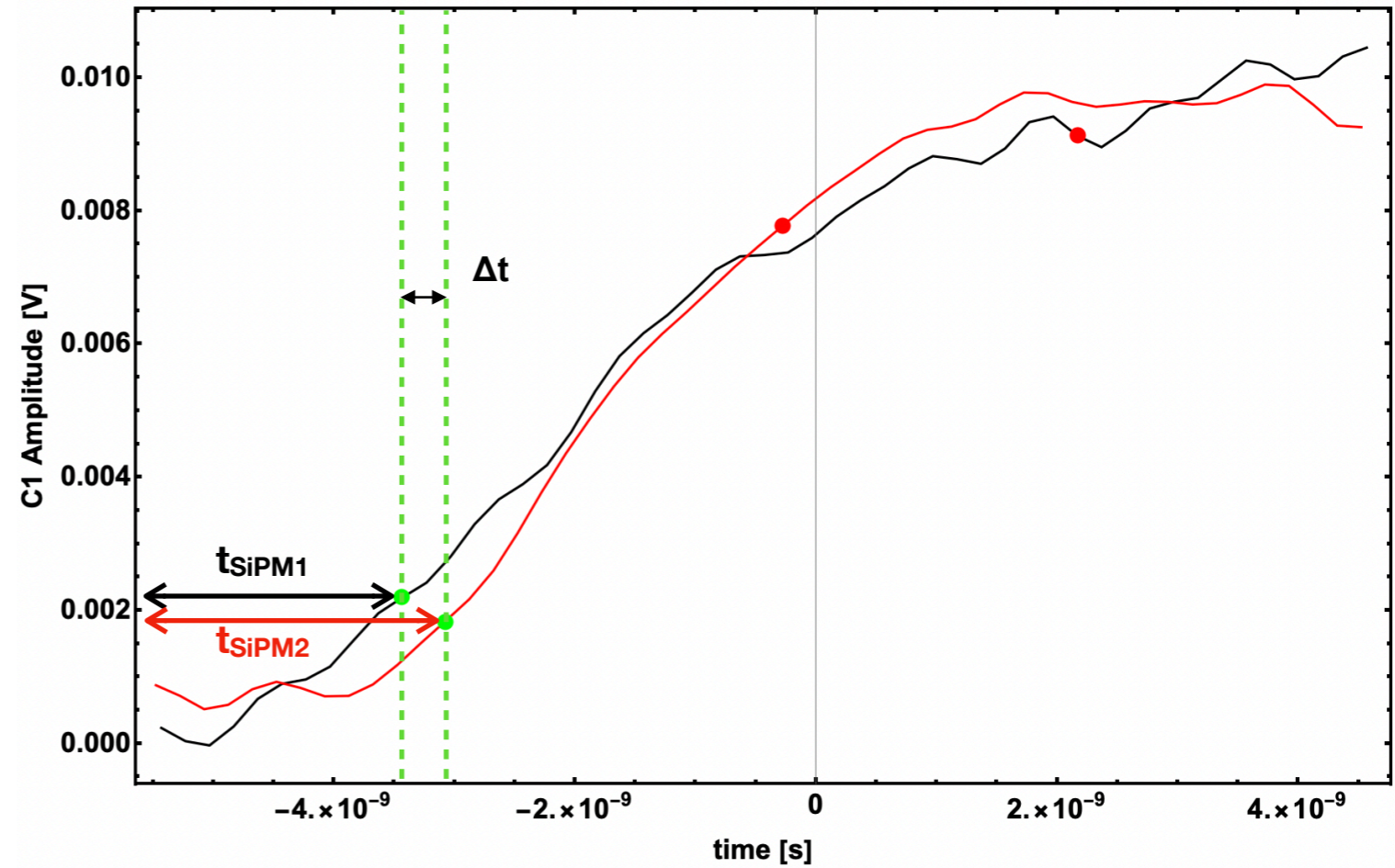
The analysis is performed at the waveform level by measuring relevant parameters (Rise Time (20%-80%), Max Amplitude, Baseline)



Time delay: a good estimator for the time resolution

Time delay Δt between SiPM1-SiPM2 (using the position of the 20% of max amplitude)

$$\Delta t = t_{\text{SiPM1}} - t_{\text{SiPM2}}$$



Next steps:

- Software implementation of a Constant Fraction Discriminator
- Hardware implementation of a Constant Fraction Discriminator
- In general, improve the experimental setup

Considerations and conclusions

- The timing measurement of “scintillator bar + SiPM” is dominated by the instrumentation performance and the experimental setup. In this preliminary test we have collected SiPM signals in correspondence of crossing muons through a HD06104 Lecroy oscilloscope.
- The oscilloscope bandwidth (1 GHz) and sampling rate (2.5 GS/s) seem not to be adequate to perform a precise measurement.
- The absence of a preamplifier demands for a configuration in which the minimum discrimination threshold imposed is > 4 mV over 50Ω @ a SiPM gain of 5×10^5 .
- 5 mV threshold corresponds to ~ 60 photons (and, due to the SiPM structure, the larger is the signal, the slower is the rise time).
- We could set an upper limit for the timing to about 400 ps (compatible with the actual sampling rate of the oscilloscope, 1 sample every 400 ps).

Room for improvement

- Move from analog to digital using Constant Fraction Discriminator and fast TDC
- Use identical scintillator bars, equalise finely the gain of the SiPMs, improve the optical coupling, clean the setup.
- Implement an external trigger logic to lower the threshold on the SiPM.