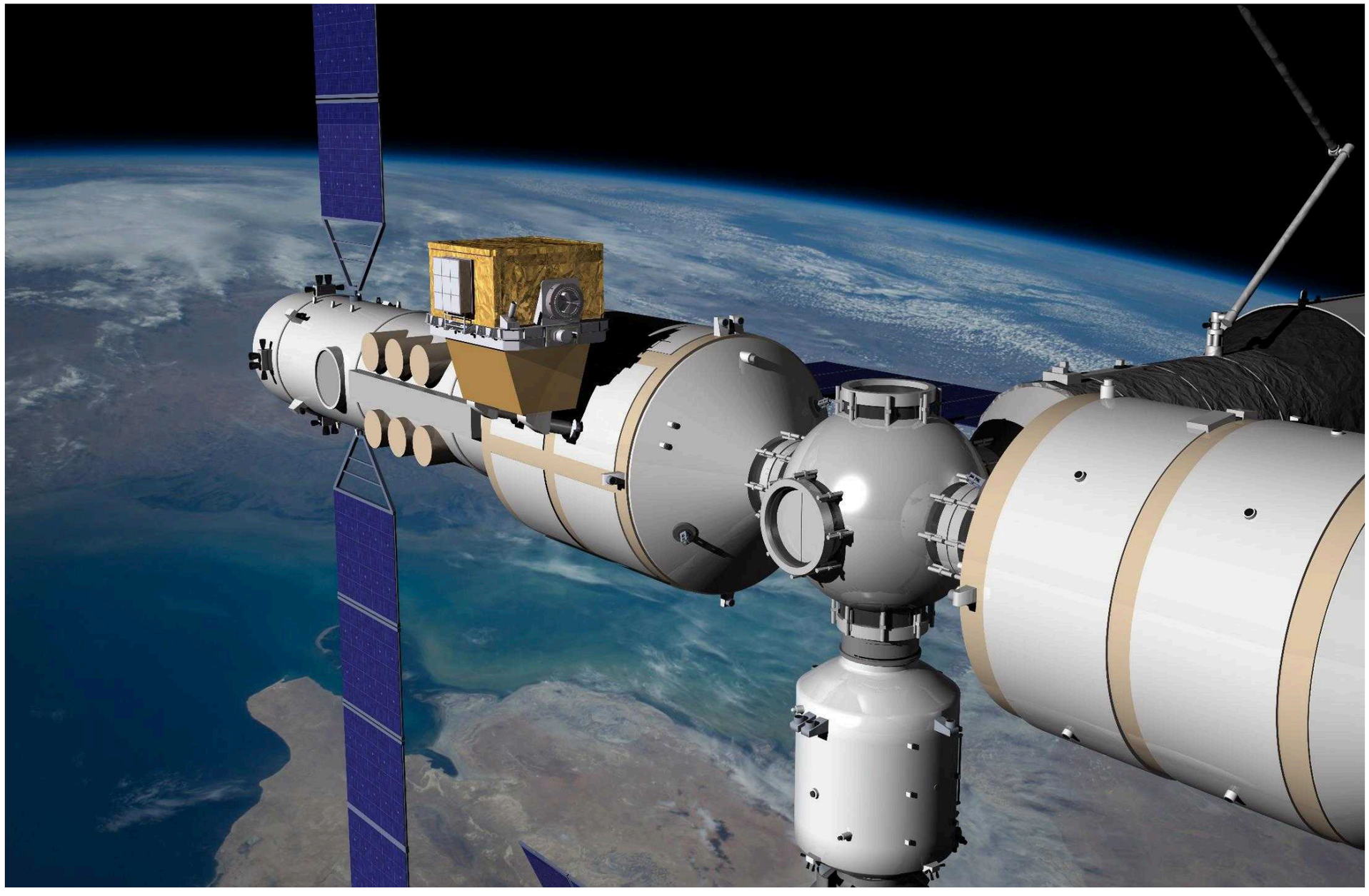
GRAN SASSO SCIENCE INSTITUTE
SCHOOL OF ADVANCED STUDIES
Scuola Universitaria Superiore

INFN LNGS

The HERD Space Mission



Timing resolution checks at GSSI

Contents

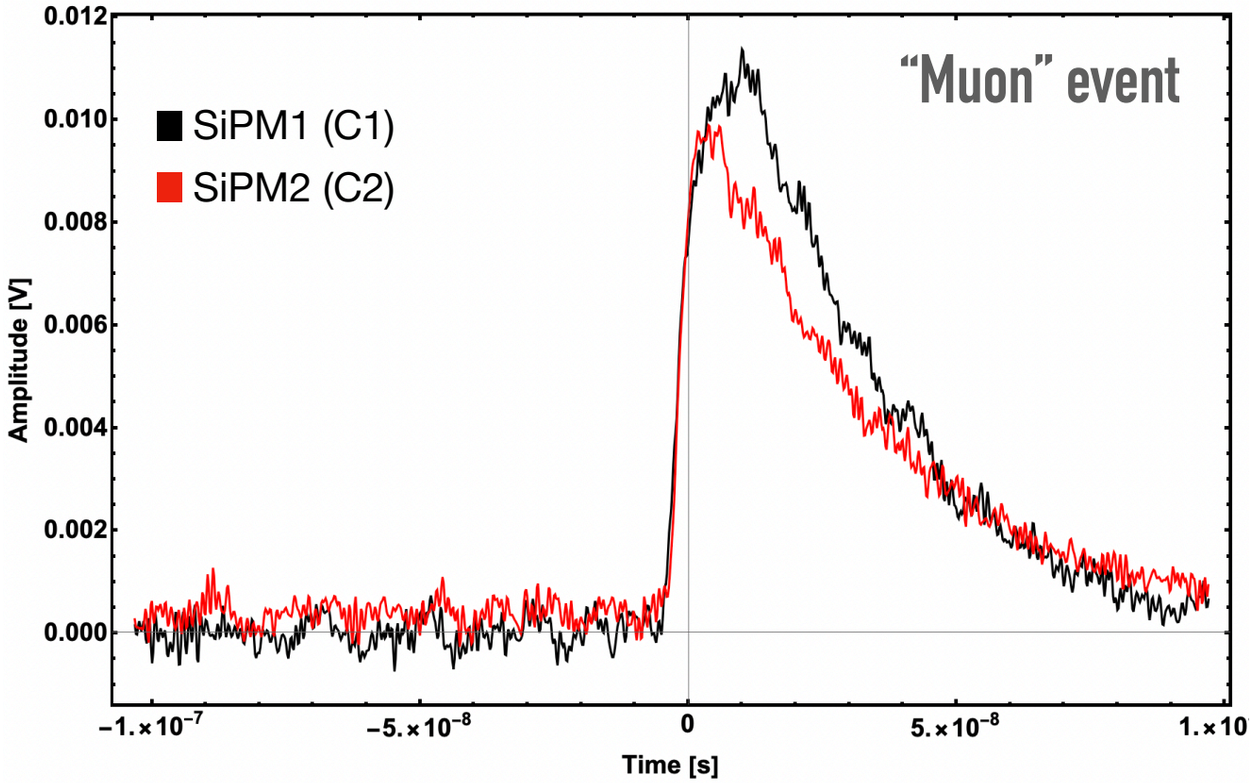
Goal: to assess the intrinsic timing properties of bar+SiPM only

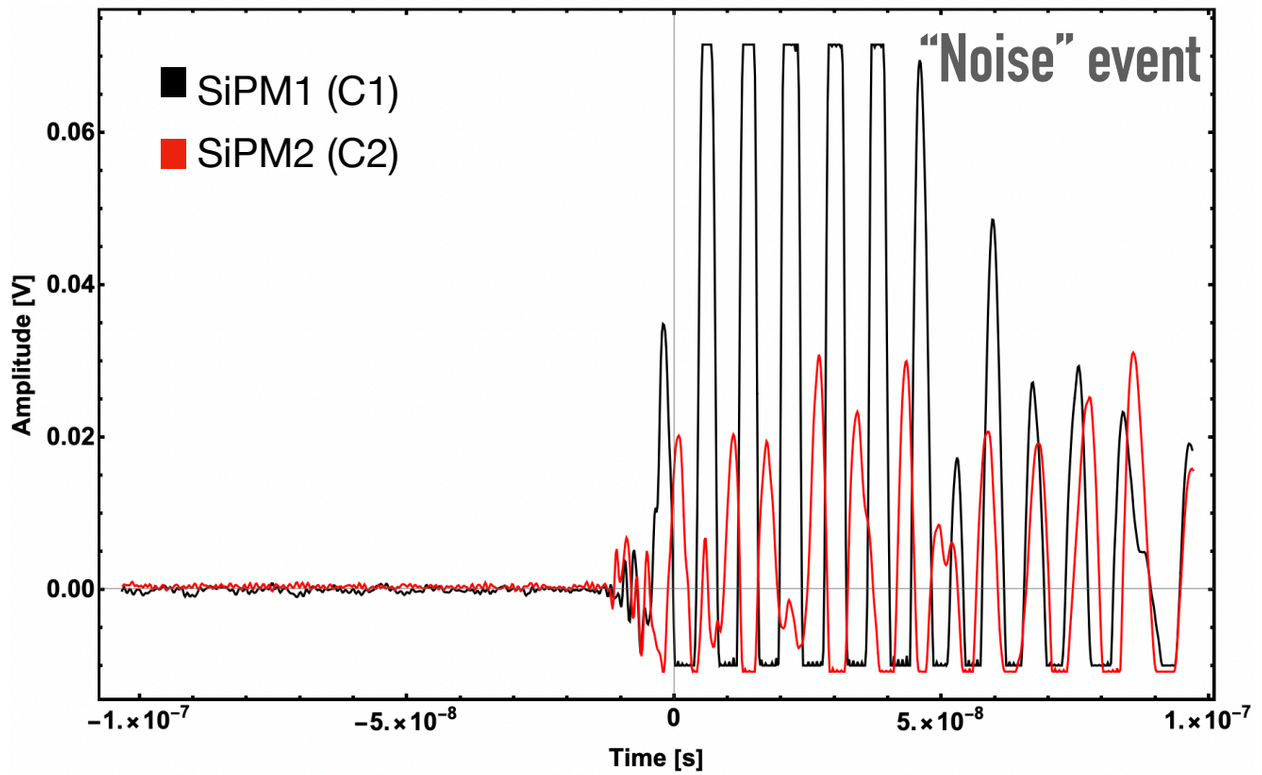
Waveform Analysis

Timing Tests at GSSI:

- Two bars (the 10&13 assembled in XY in the prototype tested at CERN, two SiPMs per bar, readout in OR) tested in January;
- Two bars (different in size and material, superimposed, one SiPM per bar), tested in December 2021 (reported already at the PSD meeting);
- Two bars (same size and material, superimposed, two SiPMs per bar, readout in OR), tested this week.

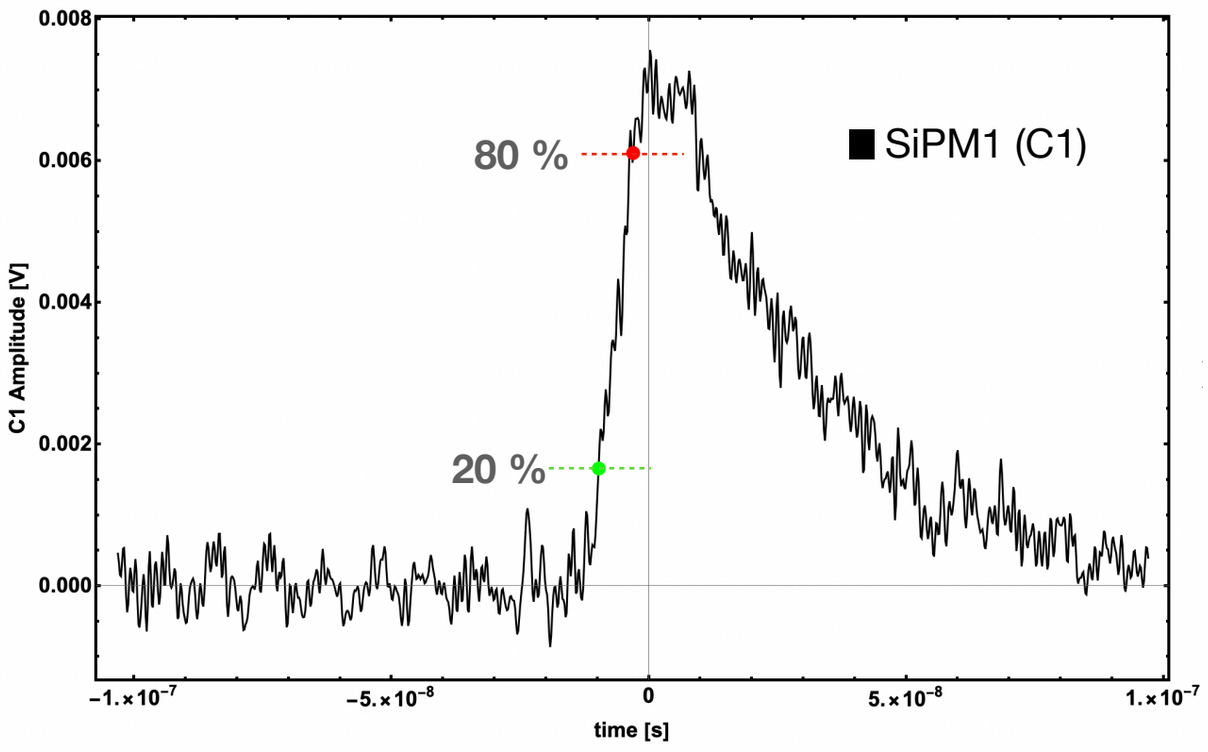
Waveform analysis

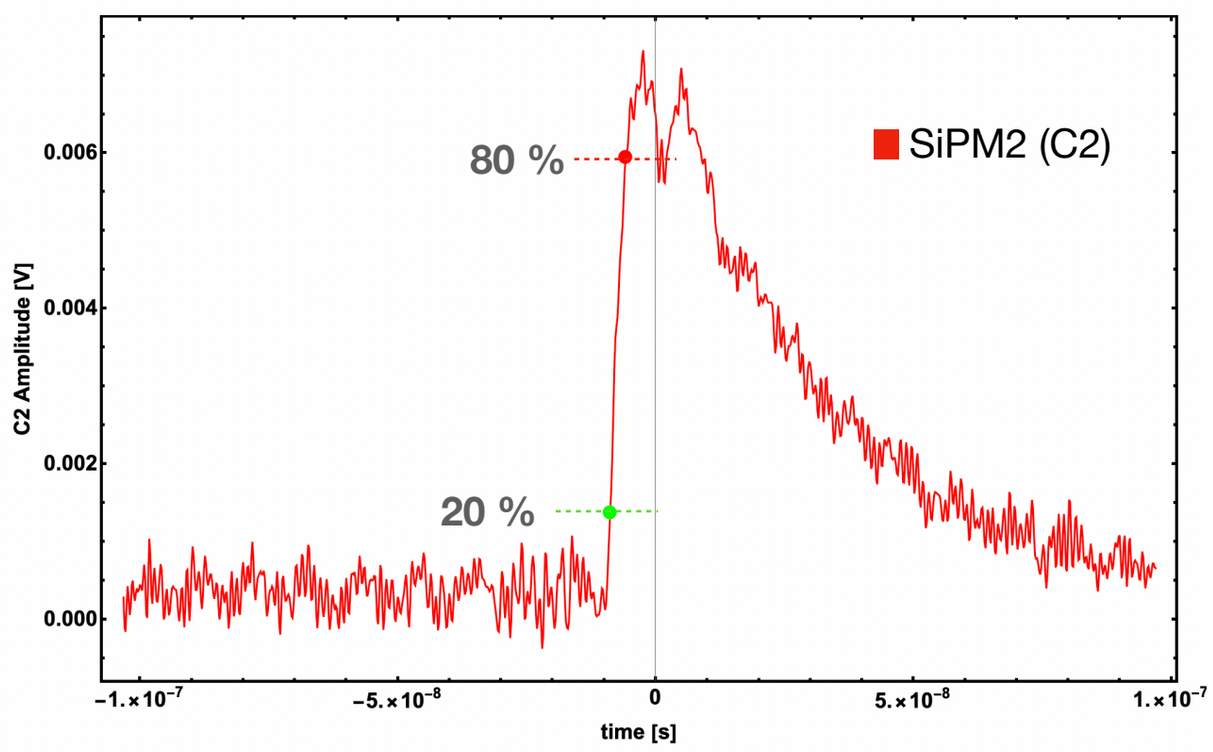




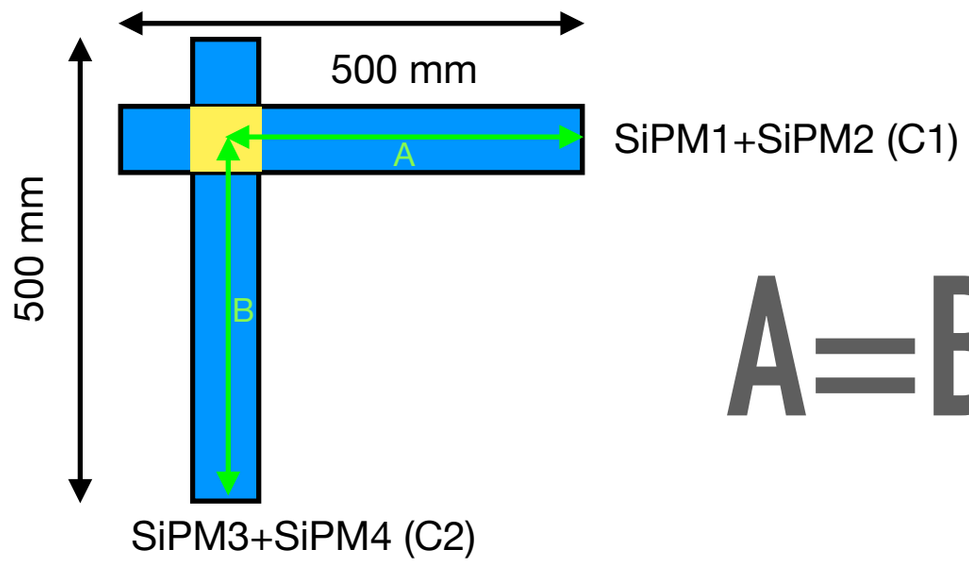
200 ps/bin (in oversampling mode)

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





Timing properties of the system composed of two orthogonal scintillating bars 10 & 13 embedded in the prototype tested at CERN



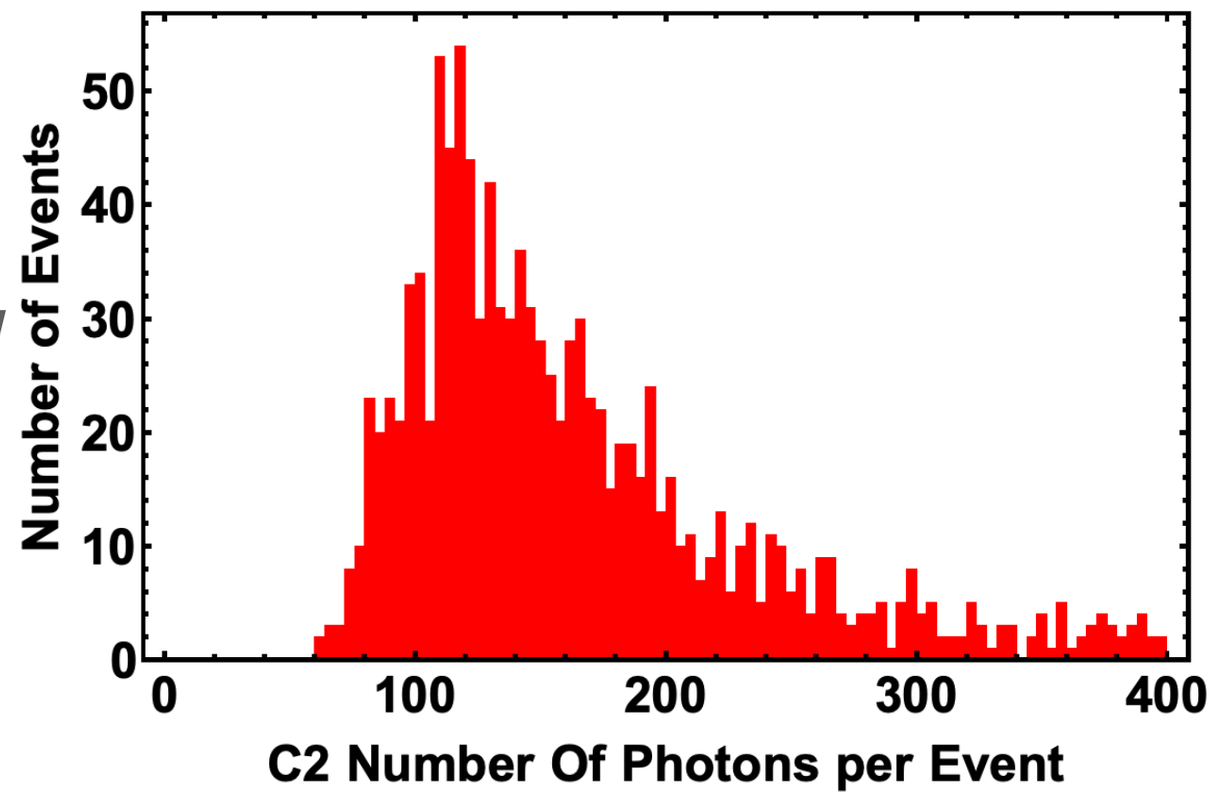
A=B

Components

- SiPM1 and SiPM2 are readout in OR, same for SiPM3 and SiPM4 (Vbias~ 45 V)
- Linear LV Power Supply to operate the SiPMs
- Both SiPMs are readout by means of a Lecroy HDO6104 oscilloscope (1 GHz bandwidth, 2.5 GS/s)

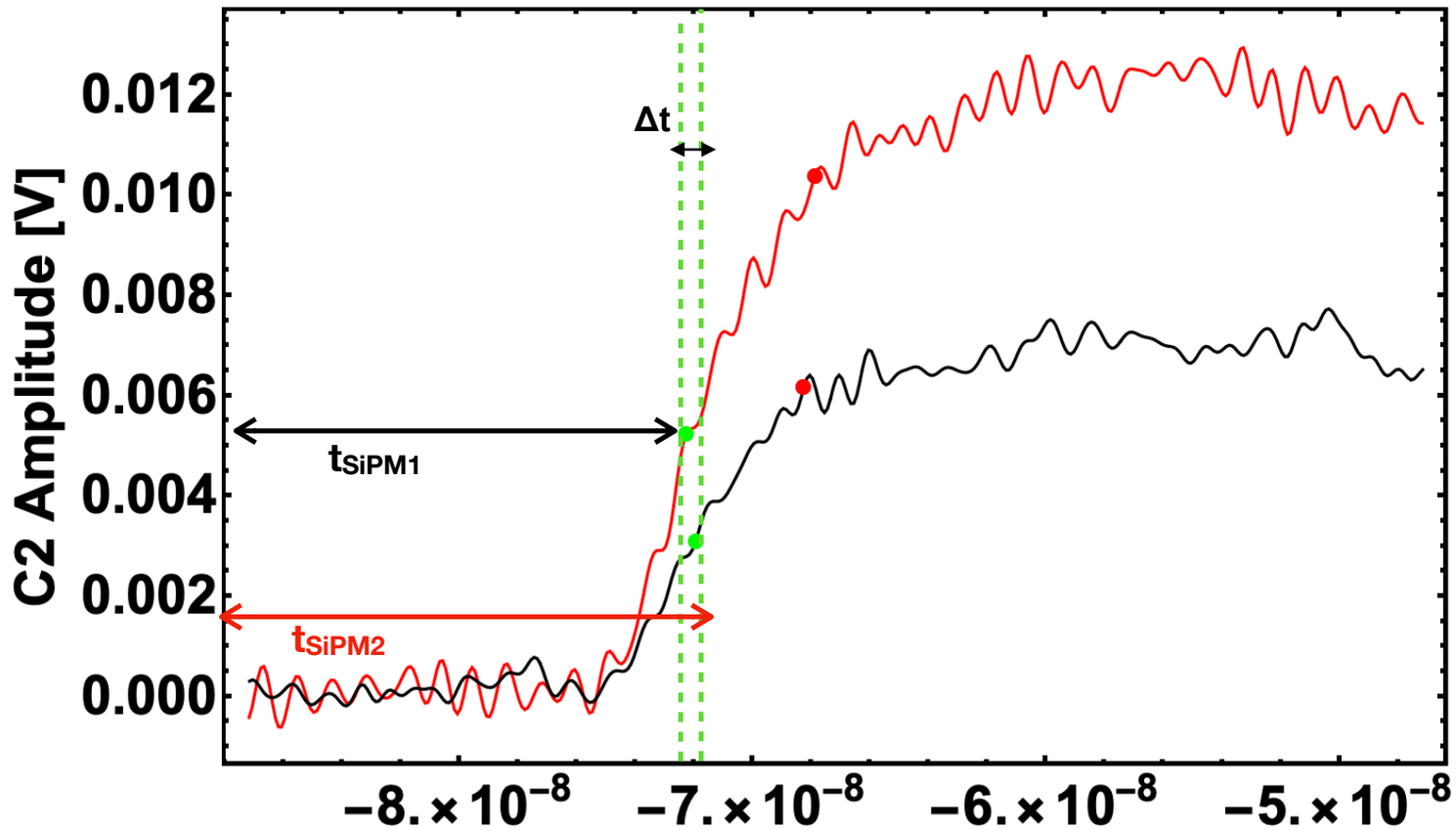
NB:

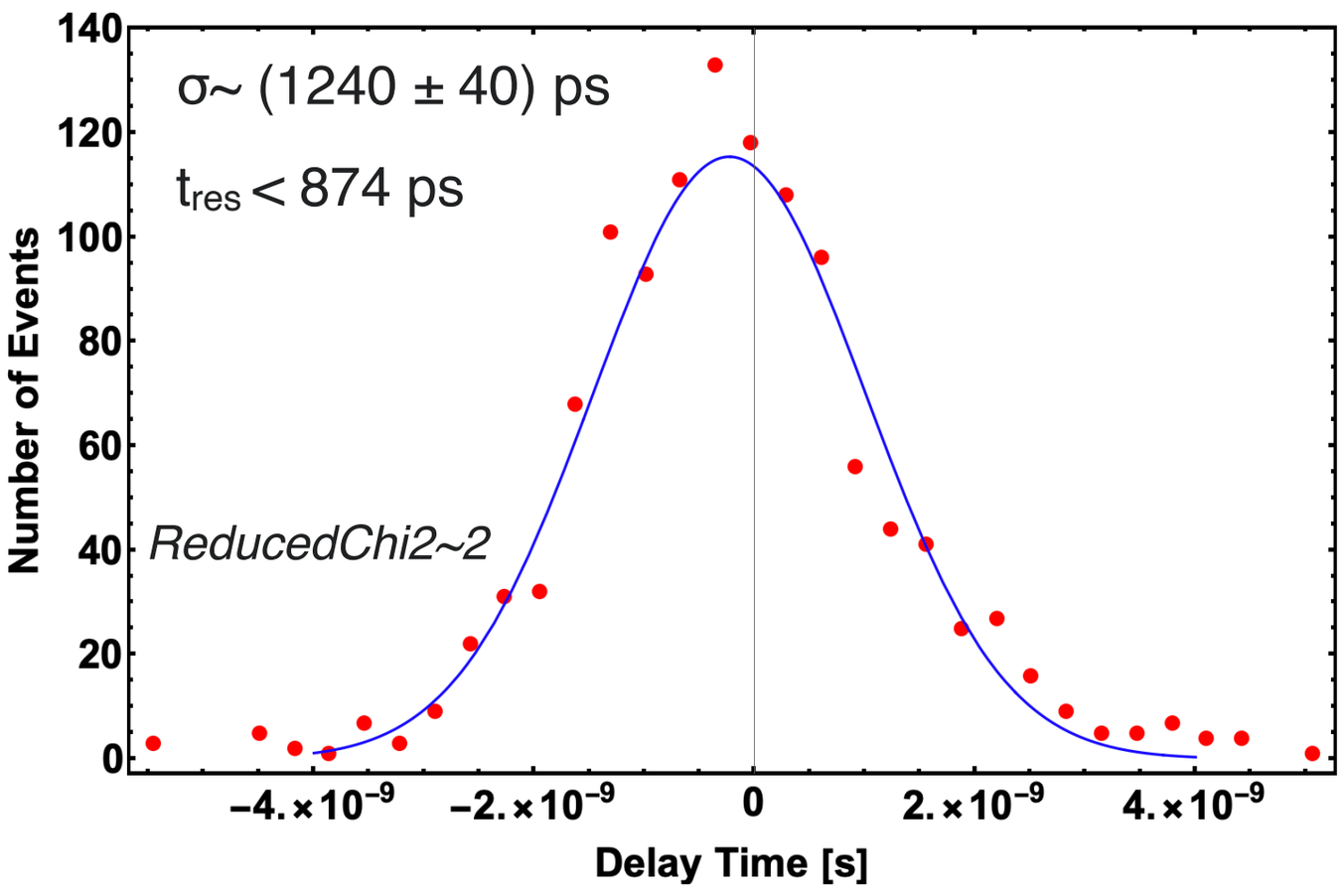
- The OR mode brings in the effect of gain non uniformity and the intrinsic jitters of the two SiPMs in each bar.
- High intensity scintillation light regime (assuming an average gain of $5x10^5$ (TBC))



Time delay Δt between SiPM1–SiPM2 (using the position of the 40% of max amplitude)

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

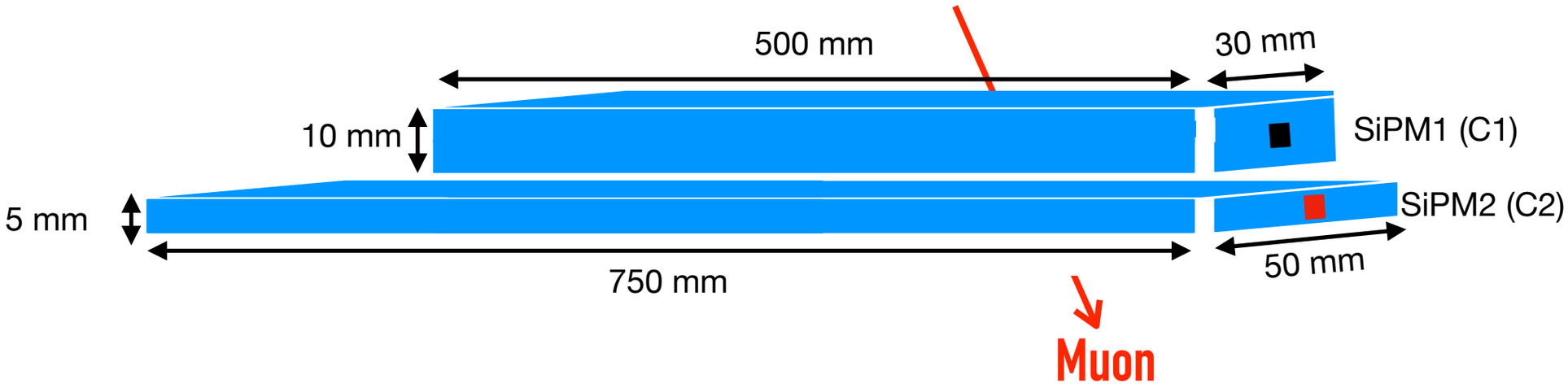




Possible improvements:

- Use one SiPM only per each bar;
- Noise Hunting (challenging);
- Faster electronics (or HDO with higher performance, i.e. higher sampling rate);
- Cleaner setup (always possible).

Timing properties of the system composed of two superimposed scintillating bars different in dimensions and material



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

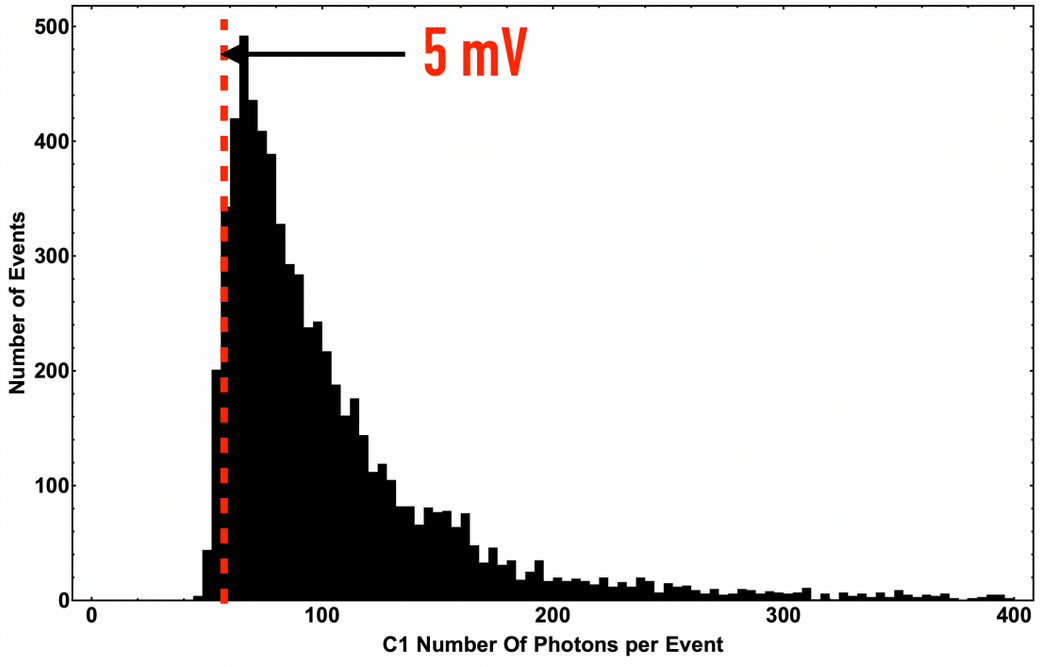
Both SiPMs are readout by means of a Lecroy HDO6104 oscilloscope (1 GHz bandwidth, 2.5 GS/s)

Presented in December

NB:

- SiPM 1 and SiPM 2 are operated at same gain (from previous measurements, $5x10^5$ @ 56V, ~room T)

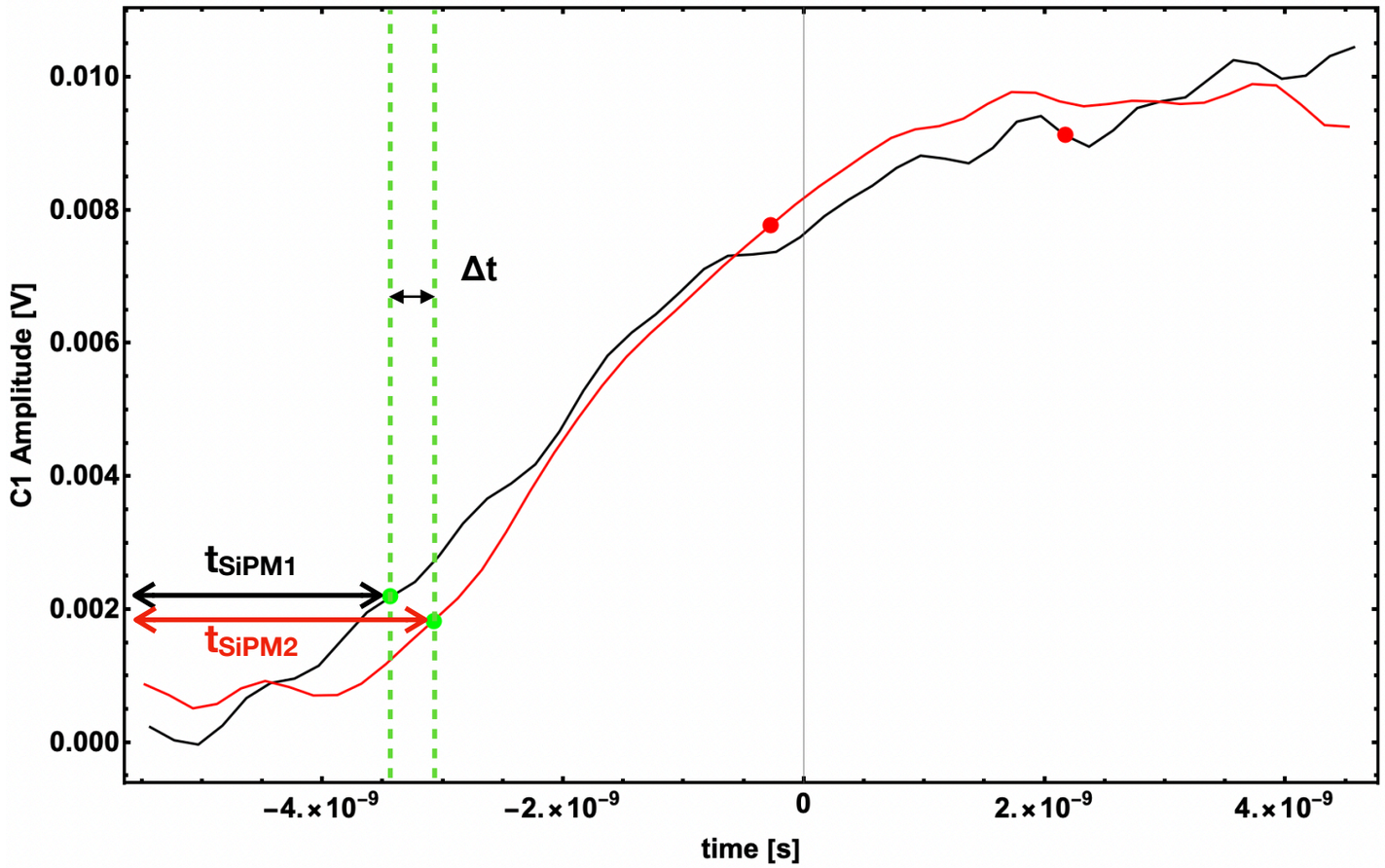
- The trigger is active when both SiPM 1 and SiPM2 produce a signal ($V_{thr} > 5$ mV) in a time window of 200 ns

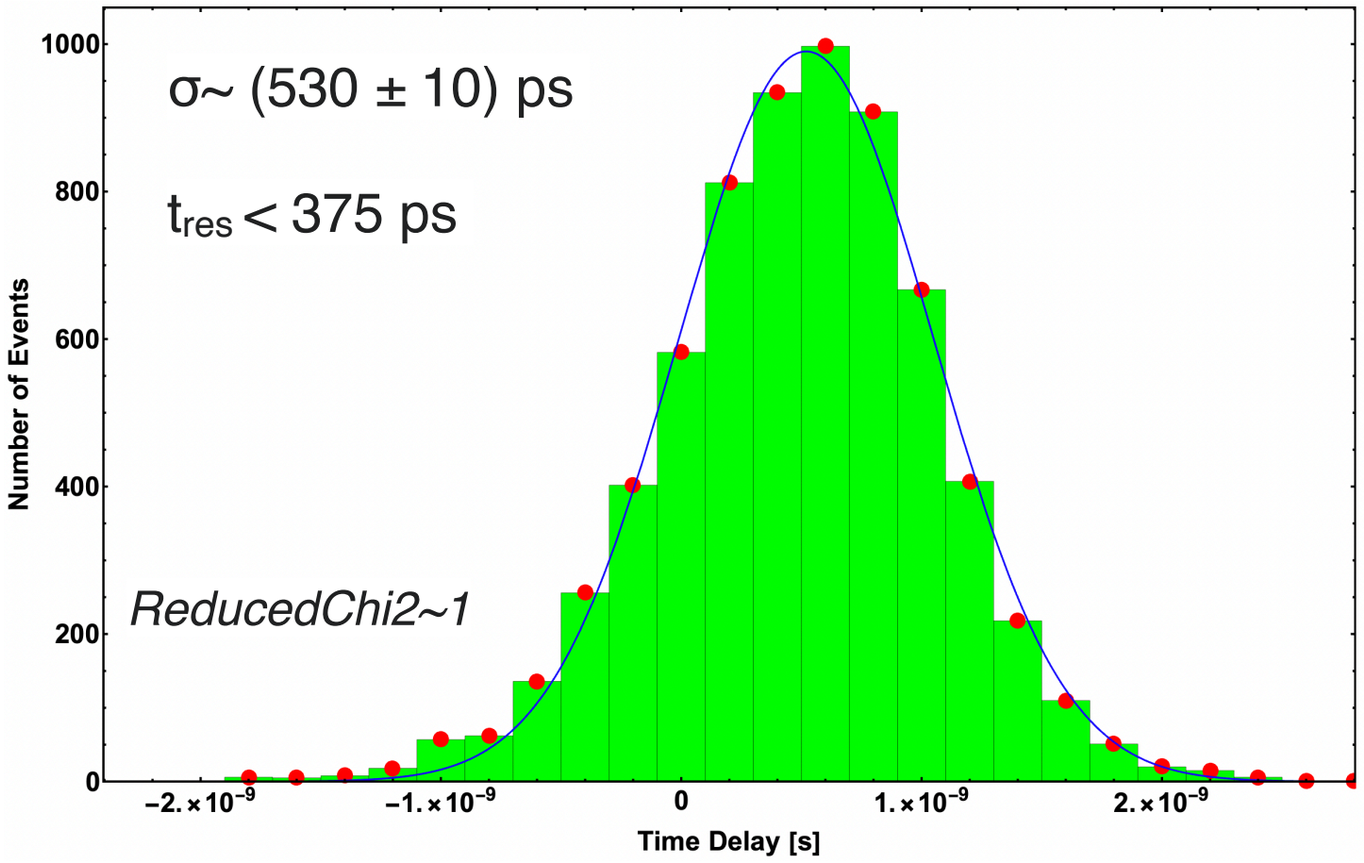


Time delay: a good estimator for the time resolution

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

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

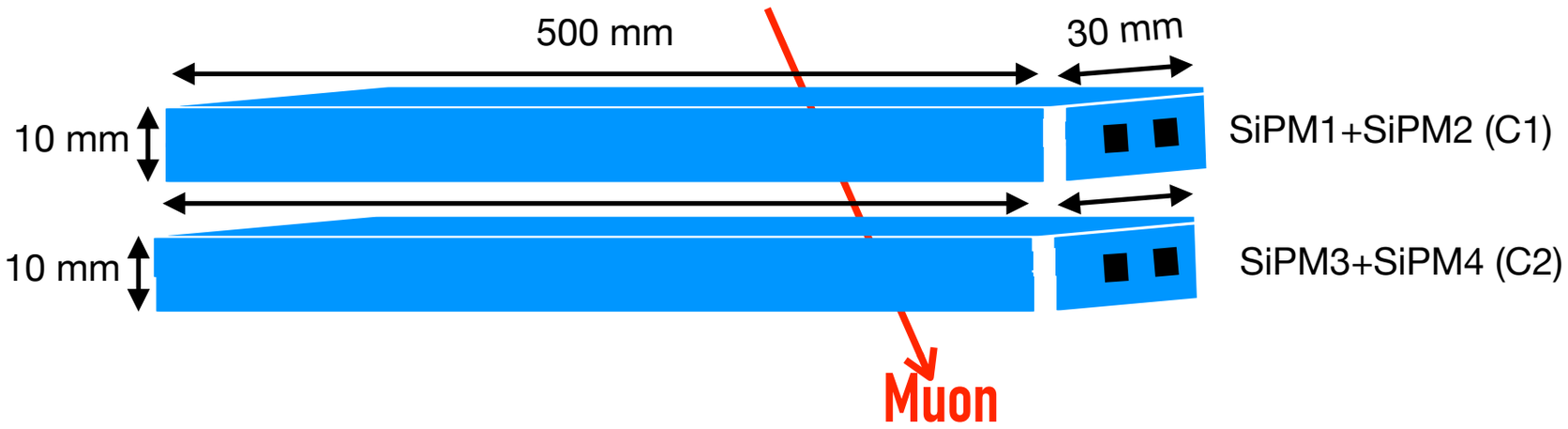




Possible improvements:

- Use identical scintillating bars, same coupling, equalisation of SiPM gains;
- Hardware implementation of a Constant Fraction Discriminator;
- Faster electronics (or HDO with higher performance, i.e. higher sampling rate);
- Cleaner setup (always possible)

Timing properties of the system composed of two superimposed identical scintillating bars



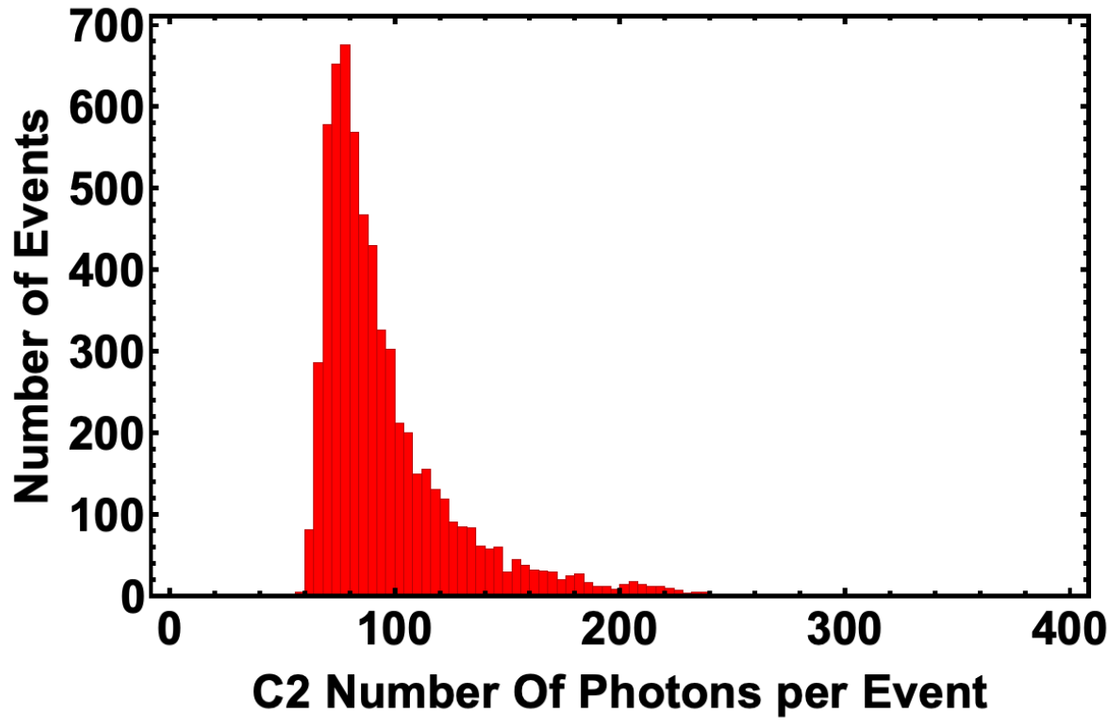
Components

- SiPM1 and SiPM2 are readout in OR, same for SiPM3 and SiPM4 (Vbias~ 45 V)
- Linear LV Power Supply to operate the SiPMs
- Both SiPMs are readout by means of a Lecroy HDO6104 oscilloscope (1 GHz bandwidth, 2.5 GS/s)

Measured last Monday

NB:

- The OR mode brings in the effect of gain non uniformity and the intrinsic jitters of the two SiPMs in each bar.
- High intensity scintillation light regime (assuming an average gain of $5x10^5$ (TBC))

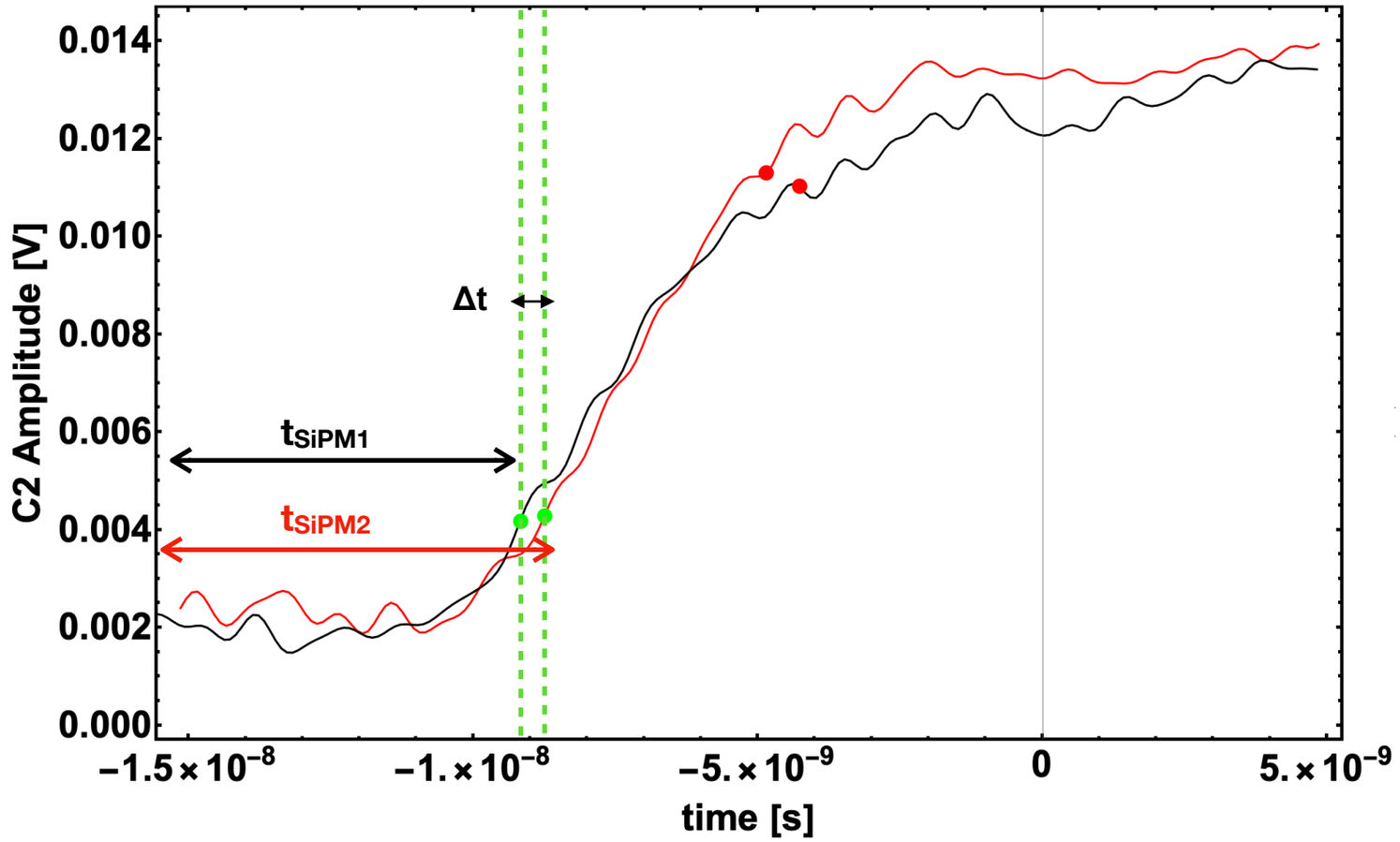


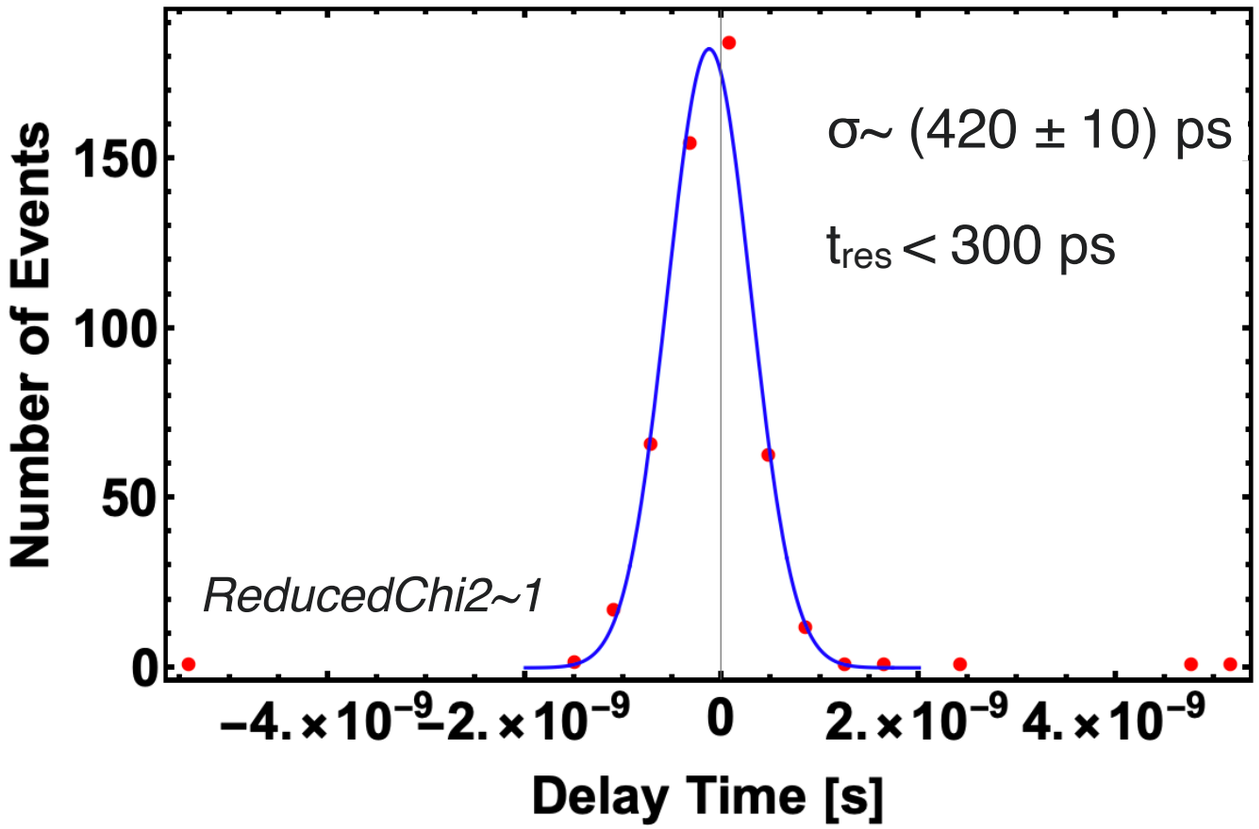
Time delay: a good estimator for the time resolution

Time delay Δt between SiPM1-SiPM2 (using the position of the **30% of max amplitude**)

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

Selected Sample:
<TimeDelay>±2.65 STD





Possible improvements:

- Use one SiPM only per each bar;
- Noise Hunting (challenging);
- Faster electronics (or HDO with higher performance, i.e. higher sampling rate);
- Cleaner setup (always possible).

Conclusions

We have tested the time features of three different systems:

1. Two bars (the 10&13 assembled in XY in the prototype tested at CERN, two SiPMs per bar, readout in OR);
2. Two bars (different in size and material, superimposed, one SiPM per bar);
3. Two bars (identical, superimposed, two SiPMs per bar, readout in OR).

The best timing response has been obtained for option 3 (t_{res}<300 ps)

Currently, the t_{res} measurement (option 3) seems to be dominated by:

1. the readout electronics being used (HDO6104 Lecroy oscilloscope, 1 GHz BDW, 2.5 GS/s);
2. the two SiPM readout in OR (intrinsic jitter, gain difference, larger capacitance);
3. operations at high intensity light regime (no pre-amp stage in use).

Room for improvements:

1. Faster readout;
2. External Trigger;
3. SiPM individually operated and read out;
4. Cleaner setup and noise hunting.