

# Timing performance of a **single tile**

## Final results

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# Outline

- Introduction
- Laboratory test
  - serial connection of the SiPMs
  - hybrid connection of the SiPMs
- Beamtime test
  - serial connection of the SiPMs
- Discussion

# Introduction

## single tile

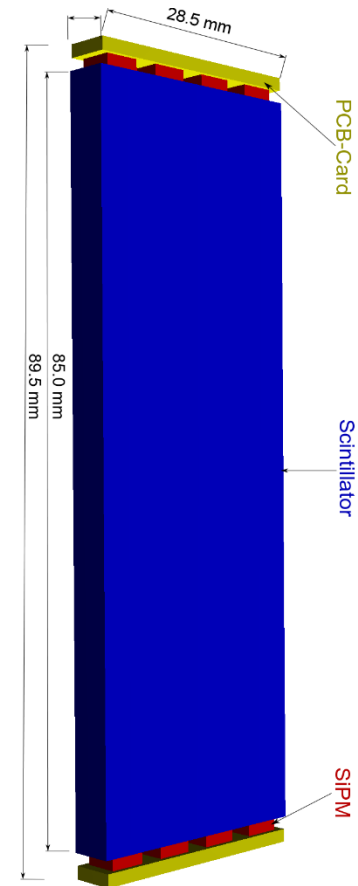
- Design

- 85x29× 5 mm<sup>3</sup> scintillator
- 4 SiPMs per side

- Condition

- time resolution <100 ps

After optimizing scintillator material, sensors, wrapping, etc. the timing performance of a single tile will be presented



single tile

# Laboratory test

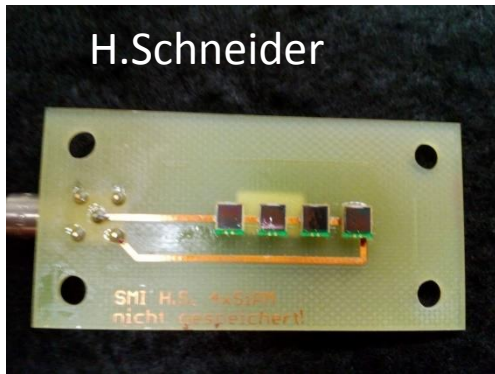


Fig.1: serial connection

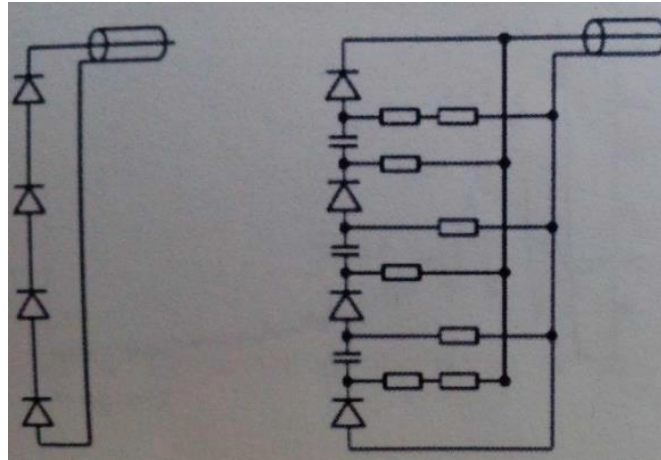


Fig.2: schematic of the series and hybrid connections

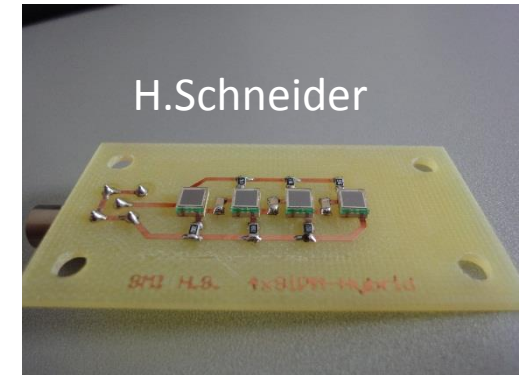


Fig.3: hybrid connection

	Serial connection	Hybrid connection
Signal line	series	series
Bias line	series	parallel

# Laboratory test

## Serial connection

SiPMs : **HPK S13360-3050-PE**

Scintillator: **EJ-232, 90x30x5**

Wrapping: **Aluminised mylar**

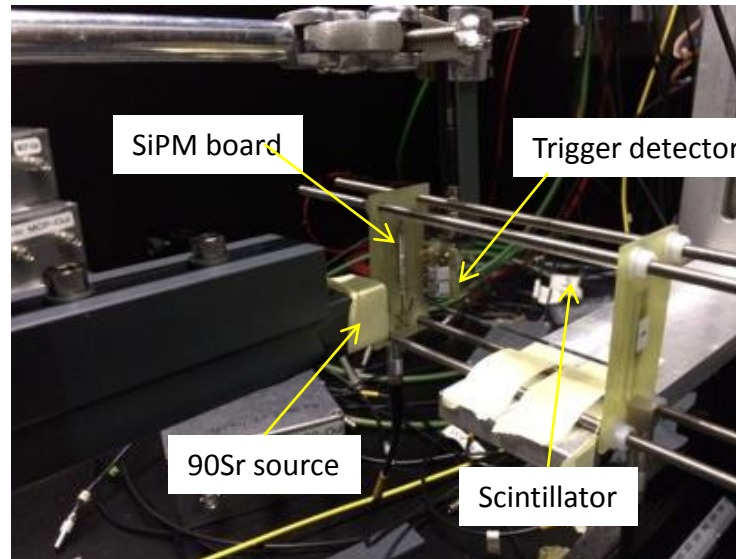


Fig.5: Experimental setup,  
Trigger detector and source are  
mounted together



Fig.6: wrapping

# Laboratory test

## Serial connection, performance

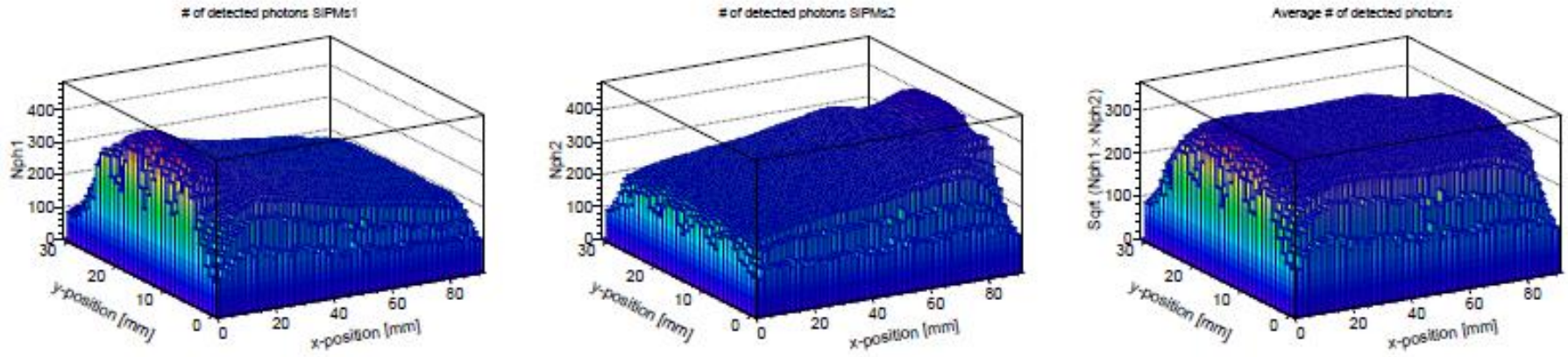


Fig.7: Number of detected photons, position scan with 1 mm steps for 90x30x5 mm<sup>3</sup> EJ-232 scintillator

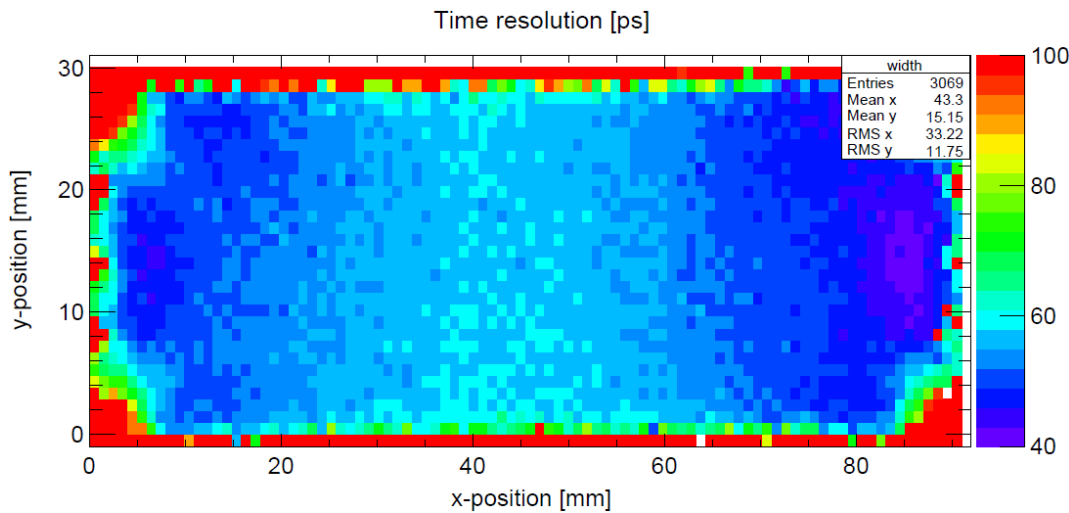


Fig.8: Time resolution from position scan with 1 mm steps, 3069 points

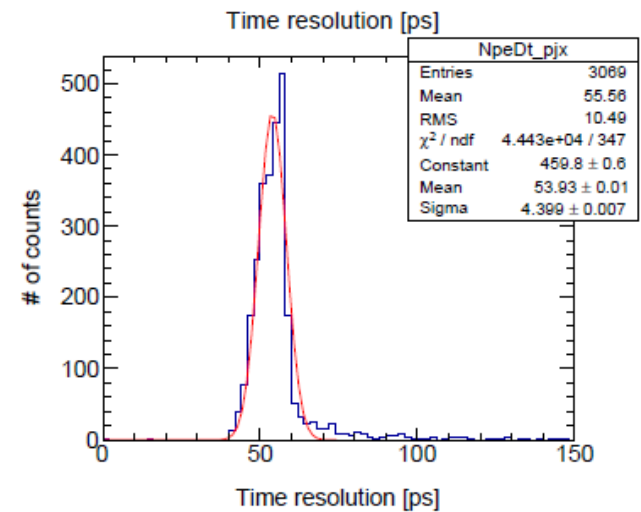
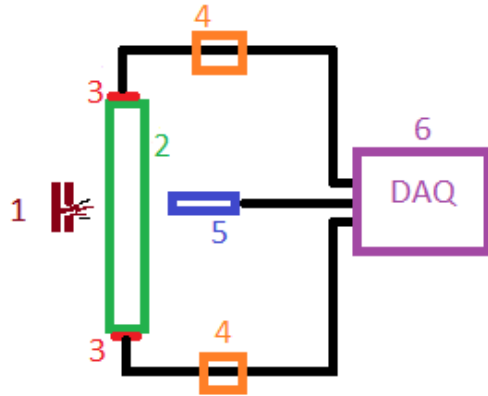


Fig.9: Mean time resolution **54 ps**

# Laboratory test

## Hybrid connection



- 1... Sr90 source (highly collimated electrons)
- 2... Scintillator EJ-232, EJ-228
- 3... Hybrid boards (HPK SiPM, up channel 1, down channel 2)
- 4... PSI-SMI preamplifiers
- 5... Hamamatsu PMT (trigger)
- 6... DAQ-Lecroy waverunner 625zi

Fig.10: Experimental setup

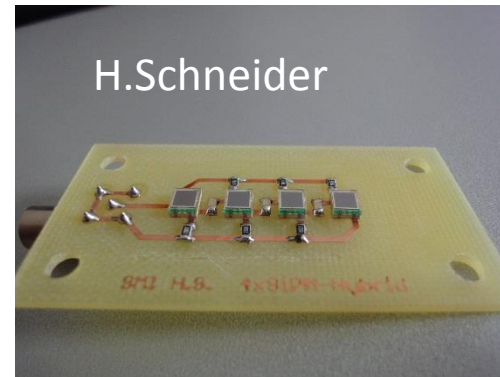


Fig.3: hybrid connection

SiPMs : HPK S13360-3025-PE

$V_{BR}=52\text{ V}$  ;  $V_{OP} = V_{BR} + 5\text{V}$   
recommended by HPK

R= 10 kOhm

C= 10 nF

# Laboratory test

## Hybrid connection, performance

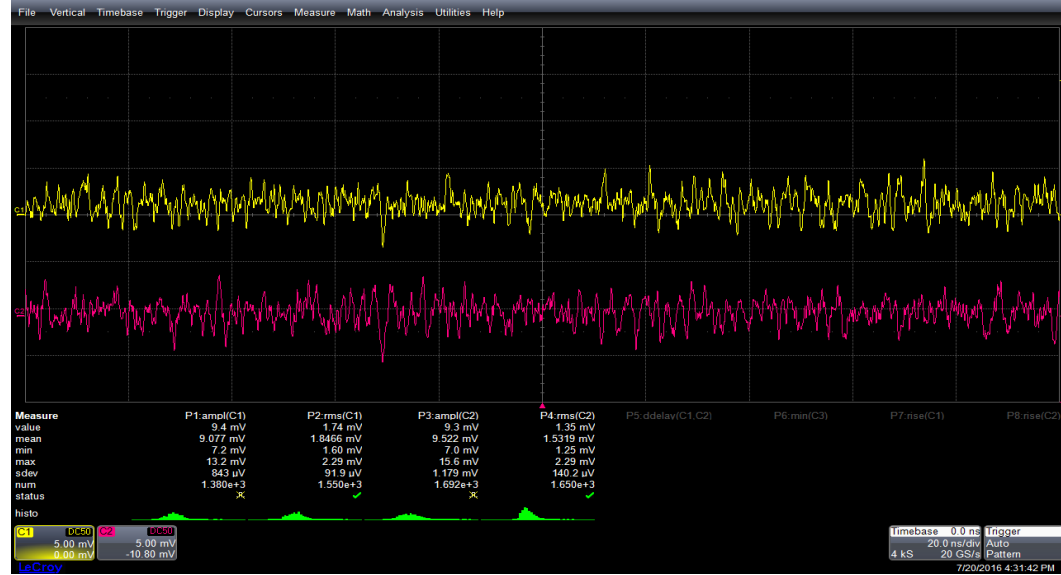
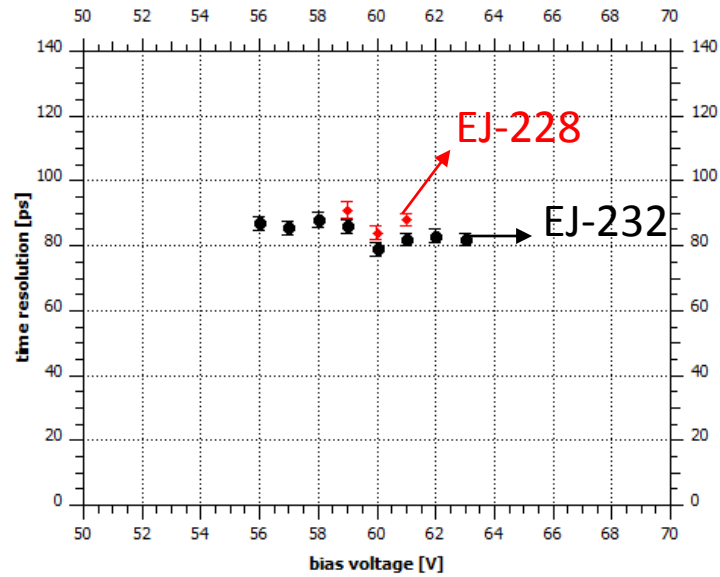
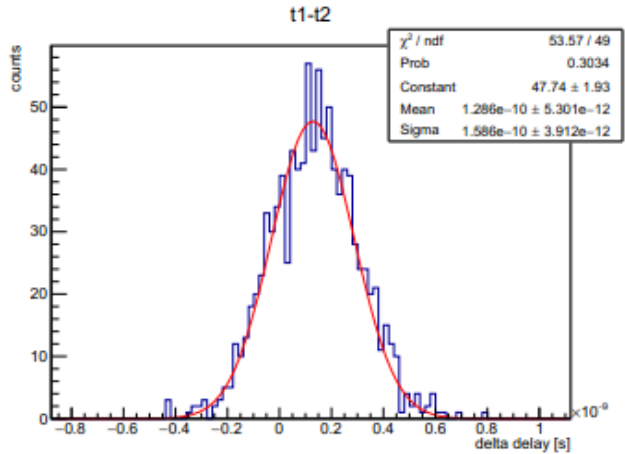


Fig.11: Time resolution at different voltages

Fig.12: Noise level about 10 mV peak to peak and a RMS value of 1.8 mV (which is high)



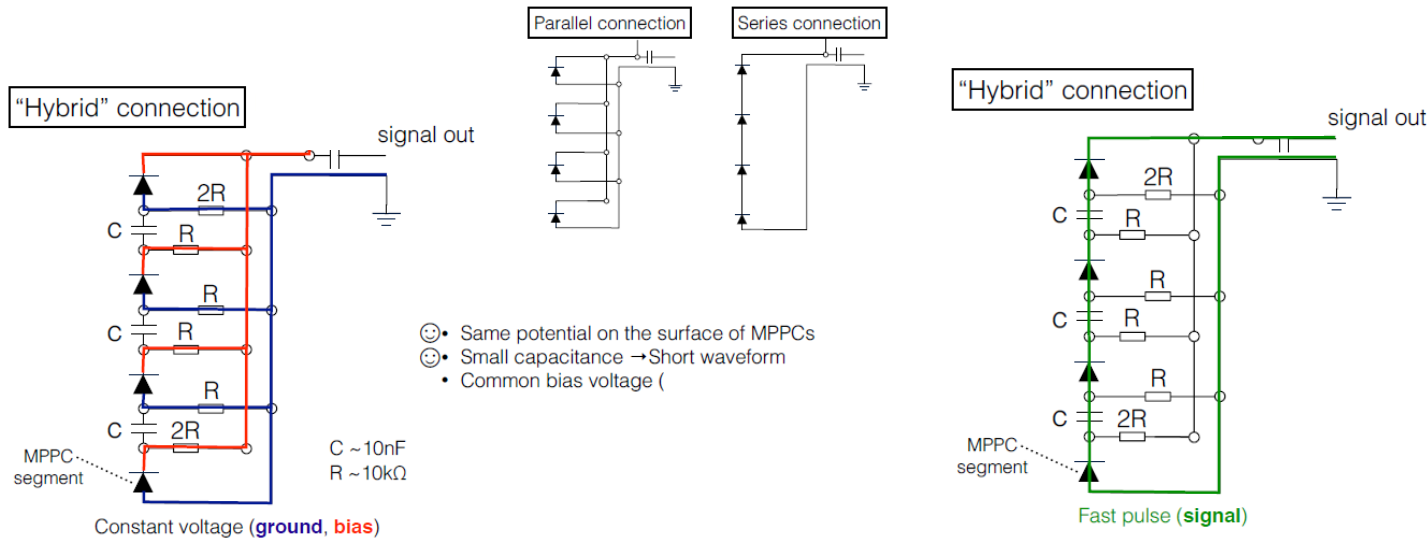
time difference resolution = 158 ps  
time resolution of detector  $\cong$  79 ps

Fig.13: Time difference resolution



# Laboratory test

## Hybrid connection/Serial connection comparison



Ryu Sawada,  
 Upgrade of MEG  
 Liquid Xenon  
 Calorimeter

Single values, time  
 resolution worse  
 because of noise  
 (10mV)

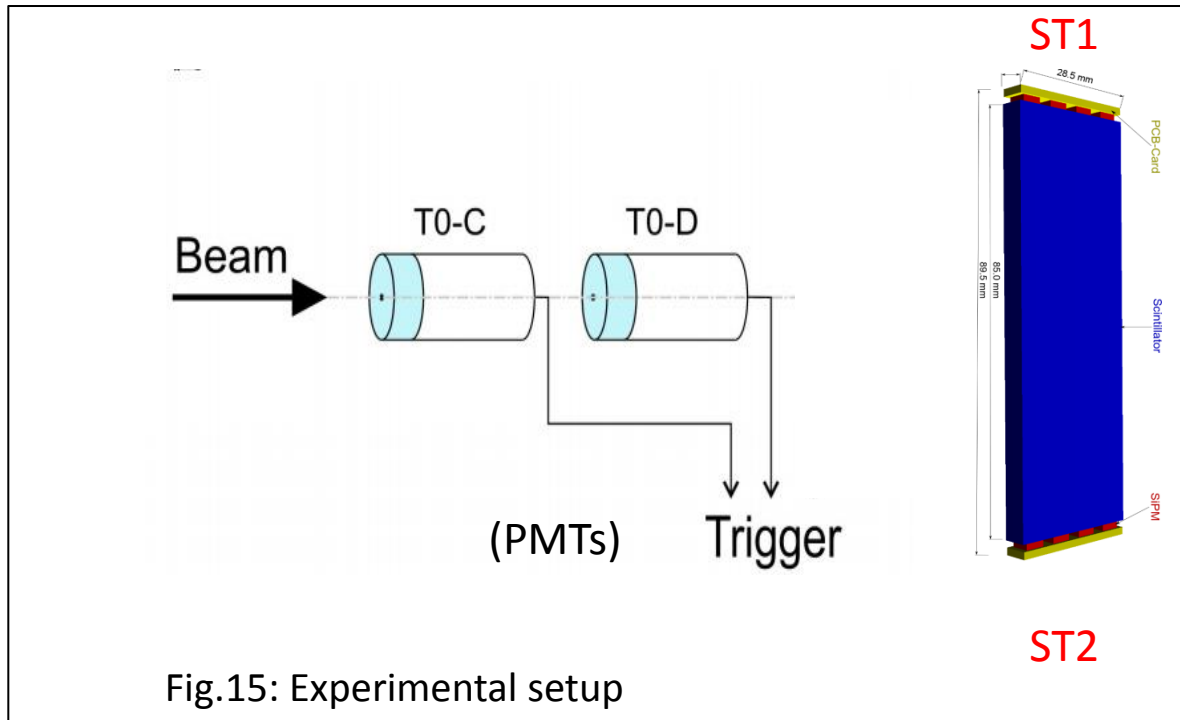
Fig.14: SiPMs connected in series, parallel and hybrid

SiPM connection	Serial (Erlangen)	Serial (Vienna)	Hybrid (Vienna)
Voltage applied	240 V	240 V	60 V
Signal rise time	~ 1.3 ns	~ 1.3 ns	~ 1.3 ns
Time resolution	54 ps	76ps	79ps
Noise level	~3 mV	~10 mV	~10 mV

Table 1: SiPMs connected in series and hybrid

mean time res.  
 from 3069 points

# Beamtime test (CERN east counter hall T10 ALICE, June 2016)



SiPMs :HPK S13360-3050-PE

Scintillator: EJ-232, 90x30x5

Wrapping: aluminised mylar

SiPMs conencted in series

→ Detectors → FE electronics → CAEN  
Digitizer → DAQ program → Binary files  
→ Waveform analysis → Root file →  
Final analysis

Maciej Slupecki

The beam is a mixture of different particles:  $\bar{p}$ ,  $K^{+/-}$ ,  $\pi^{+/-}$ ,  $\mu^{+/-}$ ,  $e^{+/-}$  etc.. @ 6GeV/c, but this does not have an influence on the time resolution estimation -> contamination effect can be ignored

# Beamtime test

## Data analysis results

$$\left(\frac{ST1+ST2}{2}\right) - \left(\frac{T0.C+T0.D}{2}\right)$$

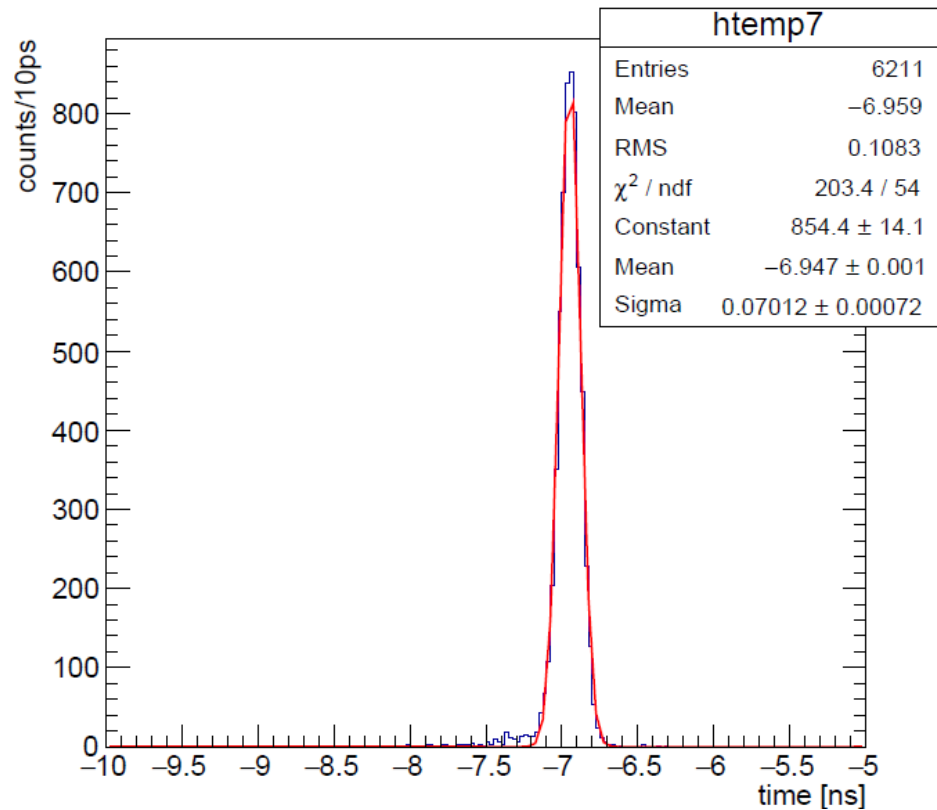
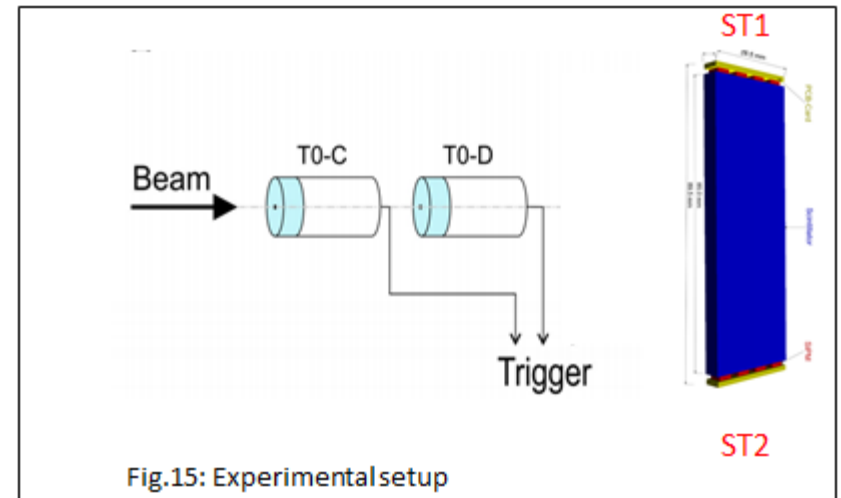


Fig.16: Time resolution **70 ps**



# Discussion

Best time resolution obtained with 4 SiPMs connected in series (54ps).

The hybrid connection does not deteriorate the signal output.

The main reason why we are interested in the hybrid connection, is because the TOF-PET chip cannot provide necessary bias voltage for 4 SiPMs in series.

A first beam test was done with our prototype resulting in 70 ps time resolution.

Outlook:

New scintillator almost ready to be tested.

“**EJ-232Q** (Benzophenone) plastic scintillator is a quenched variant of EJ-232 specifically formulated for ultra-fast counting applications. “ <http://www.eljentechnology.com/>