

# SciTil new prototype tests

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# Outline

- New SciTil geometry introduction

- Serial SiPM connection
- Laser tests
- Tests with scintillator

- Summary and outlook

# New SciTil geometry

As an alternative to SciTils and SciRods we plan to use wider bars read-out by a larger number of SiPMs connected in series.

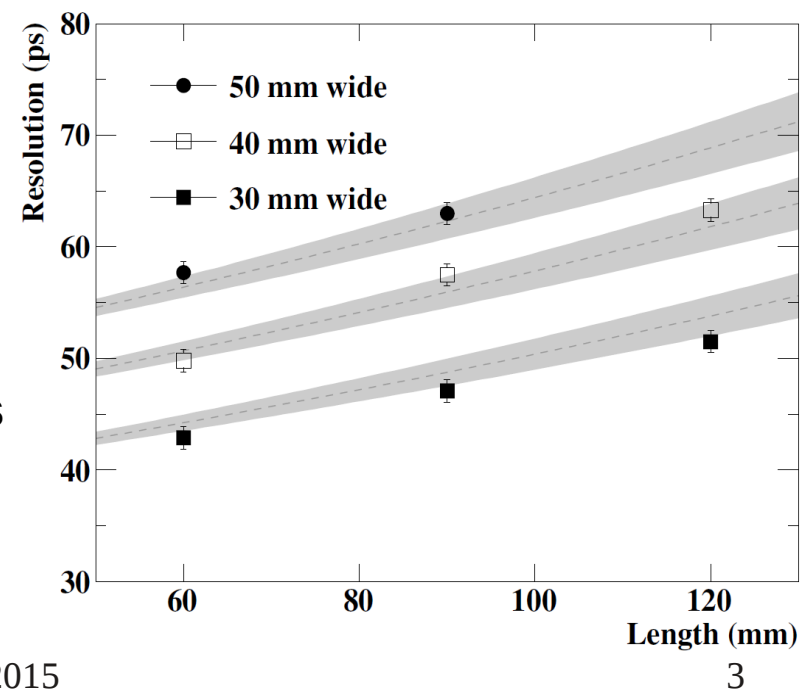
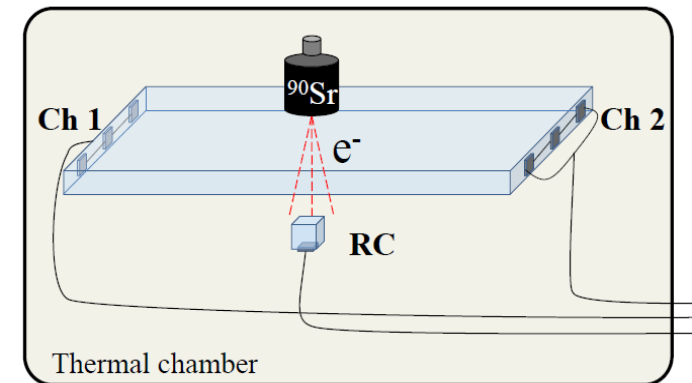
- improve time resolution
- decrease number of channels
- sustain position resolution

## High precision timing counter for the MEG experiment

Paolo W. Cattaneo et al.,  
“Development of High Precision Timing Counter Based on Plastic Scintillator with SiPM Readout”,  
*IEEE Trans. Nucl. Sci.*, Feb. 2014,  
*arXiv: 1402.1404v1*

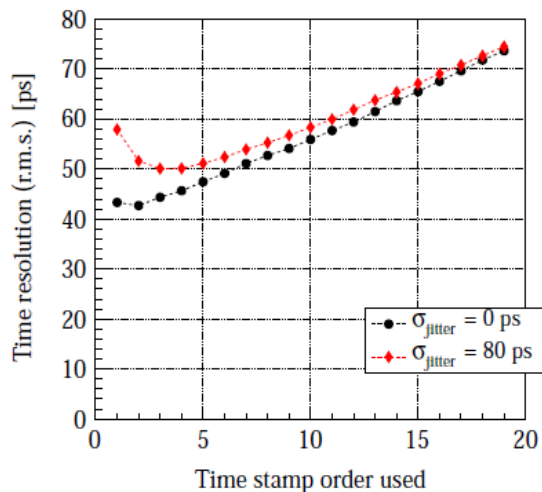
Time resolution below 50 ps reached with  
 $90 \times 30 \times 5 \text{ mm}^3$  scintillators with 4 SiPMs in  
series.

The current MEG II layout foresees scintillator bars  
with dimensions of  $120 \times 40 \times 5 \text{ mm}^3$  read-out by  
6 SiPMs on each side connected in series.

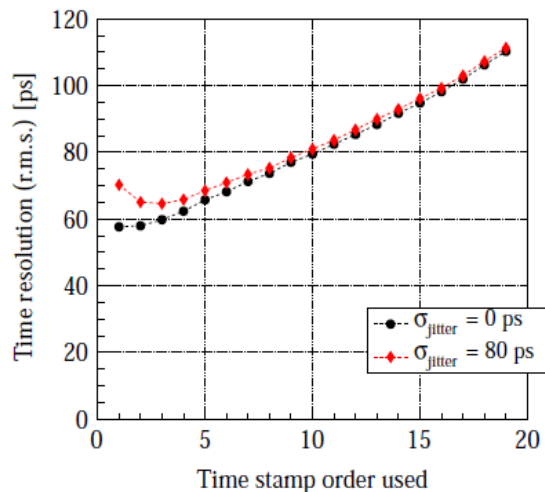


# New SciTil geometry simulation

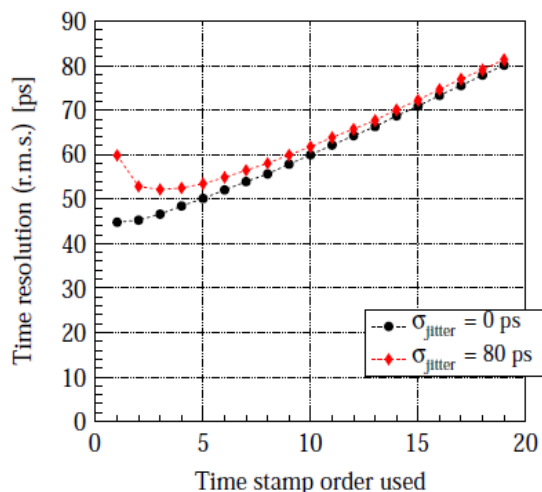
From Panda TOF meeting Dec 2014



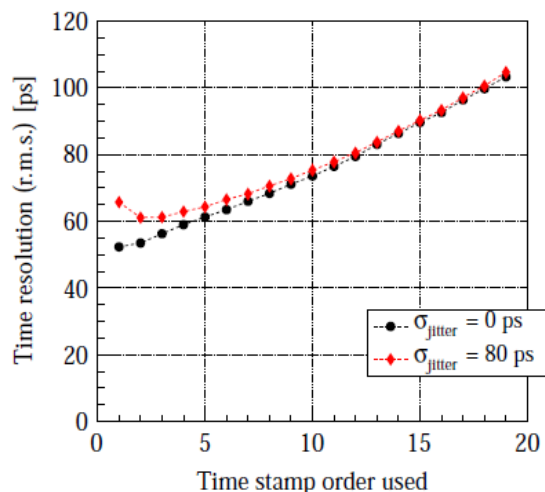
(a) Geo1



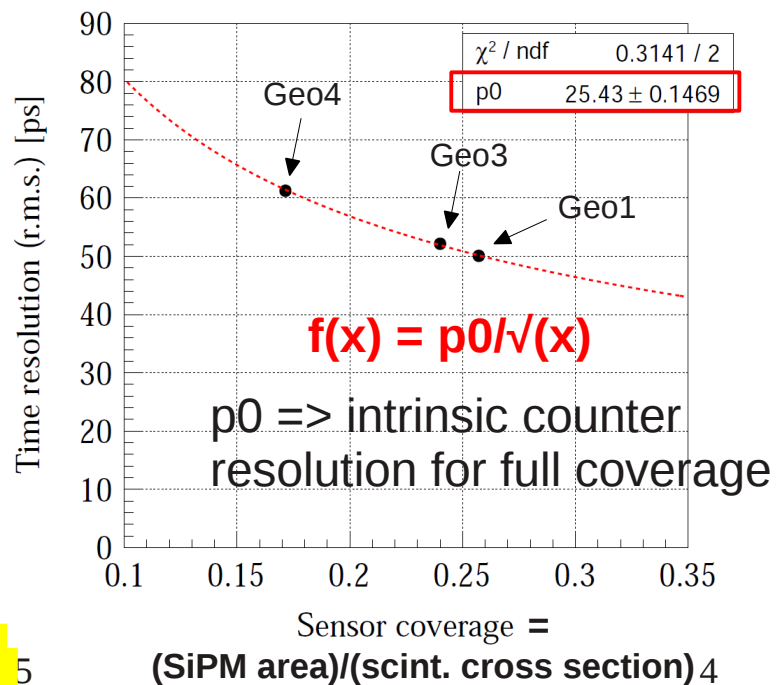
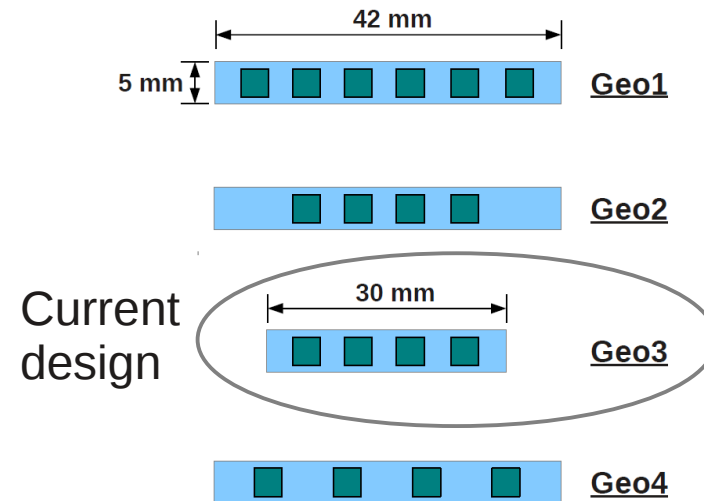
(b) Geo2



(c) Geo3



(d) Geo4

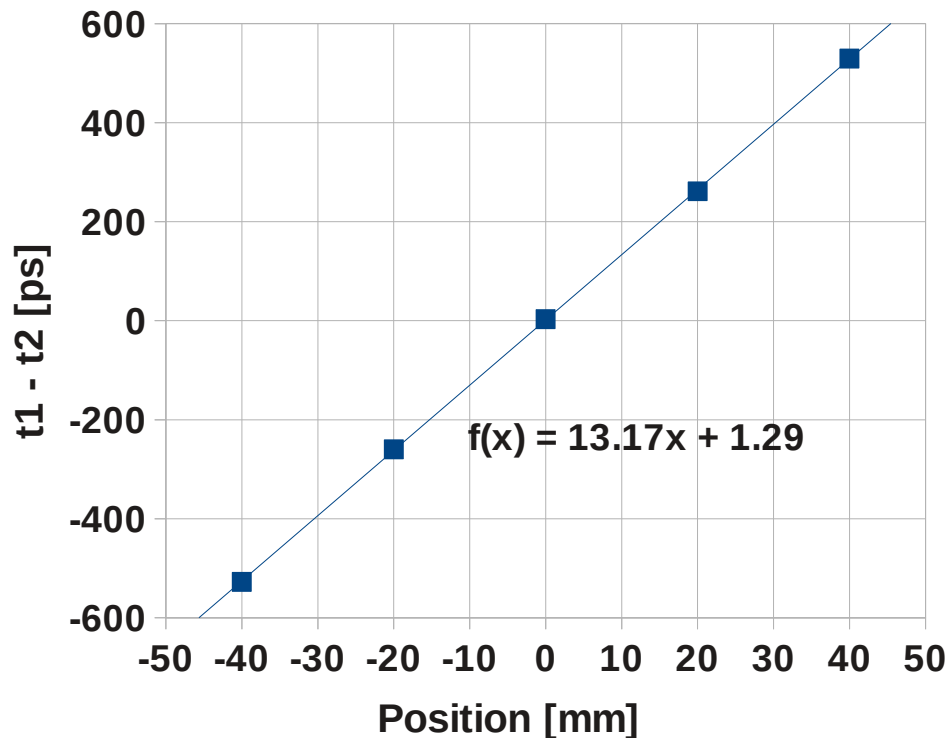


• The larger the sensor coverage the better the timing.

# Position resolution simulation

From Panda TOF meeting Dec 2014

Relation between time difference and hit position from simulation:



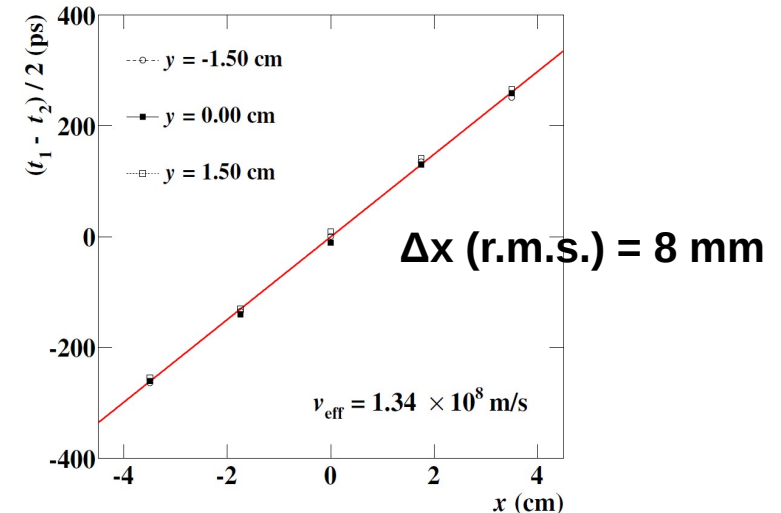
From the slope we can estimate the effective speed of light:  $v_{\text{eff}} = 7.6 \times 10^7$

Position resolution with  $\sigma(t_1 - t_2) = 90$  ps:  
 $\Delta x$  (sigma) = 6.8 mm  
 $\Delta x$  (FWHM) = 16.1 mm

## Comparison with experiment:

Paolo W. Cattaneo et al., arXiv: 1402.1404v1

MEG geometry (90 x 40 x 5 mm<sup>2</sup>)



A. Lehmann, SciTil Meeting, July 24, 2014

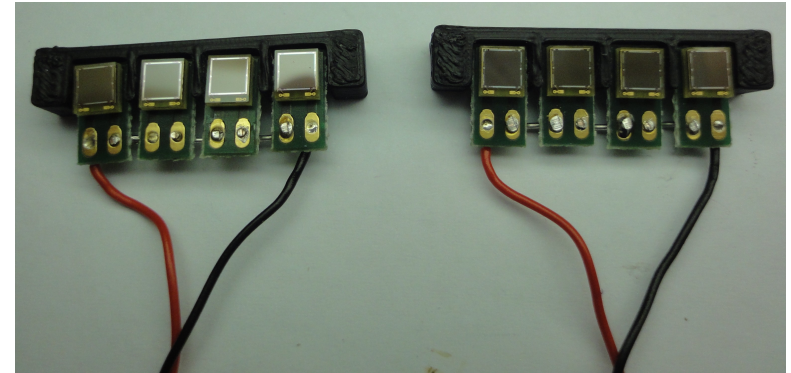
SciRod geometry (120 x 5 x 5 mm<sup>2</sup>)

$\sigma(t_1 - t_2) = 100$  ps  $\rightarrow$   $\Delta x$  (FWHM) = 13 mm

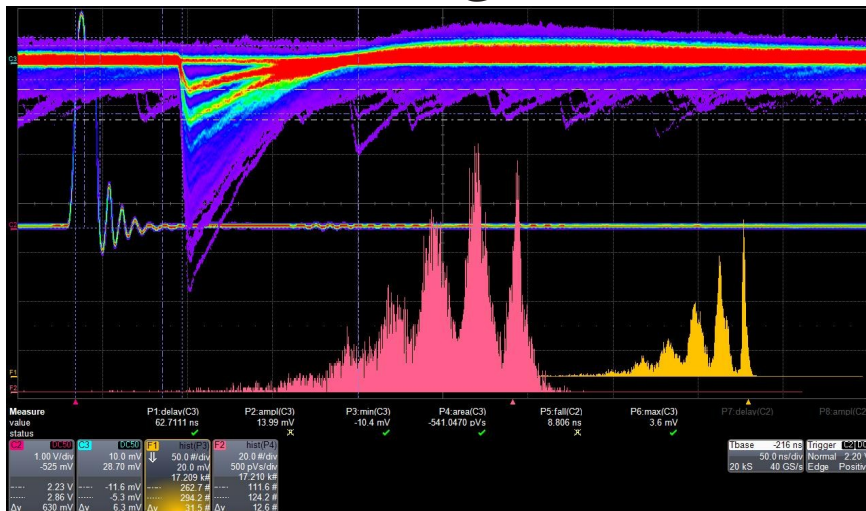
# SiPM serial connection

Serial connection of SiPMs (Ketek PM3350):

- + Automatic adjustment of over-voltage
- + Signal becomes narrower
- + Fast rise time
- + Better time resolution
- Higher bias voltage
- Reduced pulse height (but photon counting capability remains)

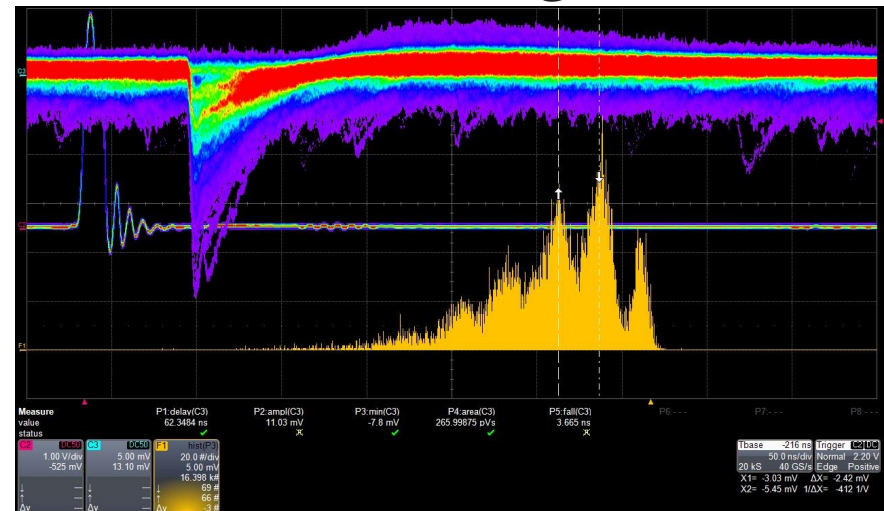


1 SiPM @ 29V



1 p.e. ~ 6.2 mV

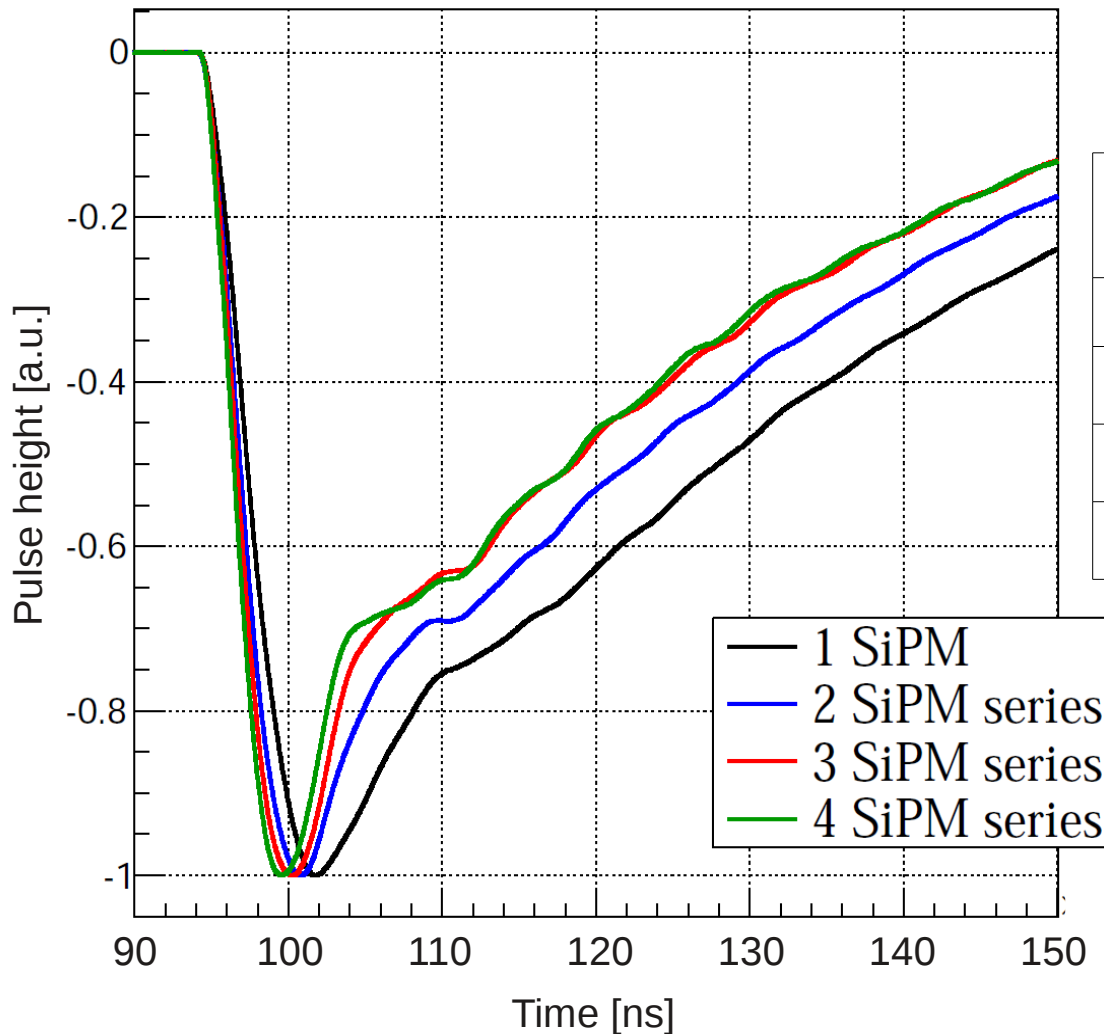
4 SiPM series @ 116V



1 p.e. ~ 2.4 mV

# Laser test

Picosecond laser (30 ps width) on Ketek PM3350 (1 – 4 in series) amplified with Photonique preamp. Plot shows an average of 1000 recorded waveforms.

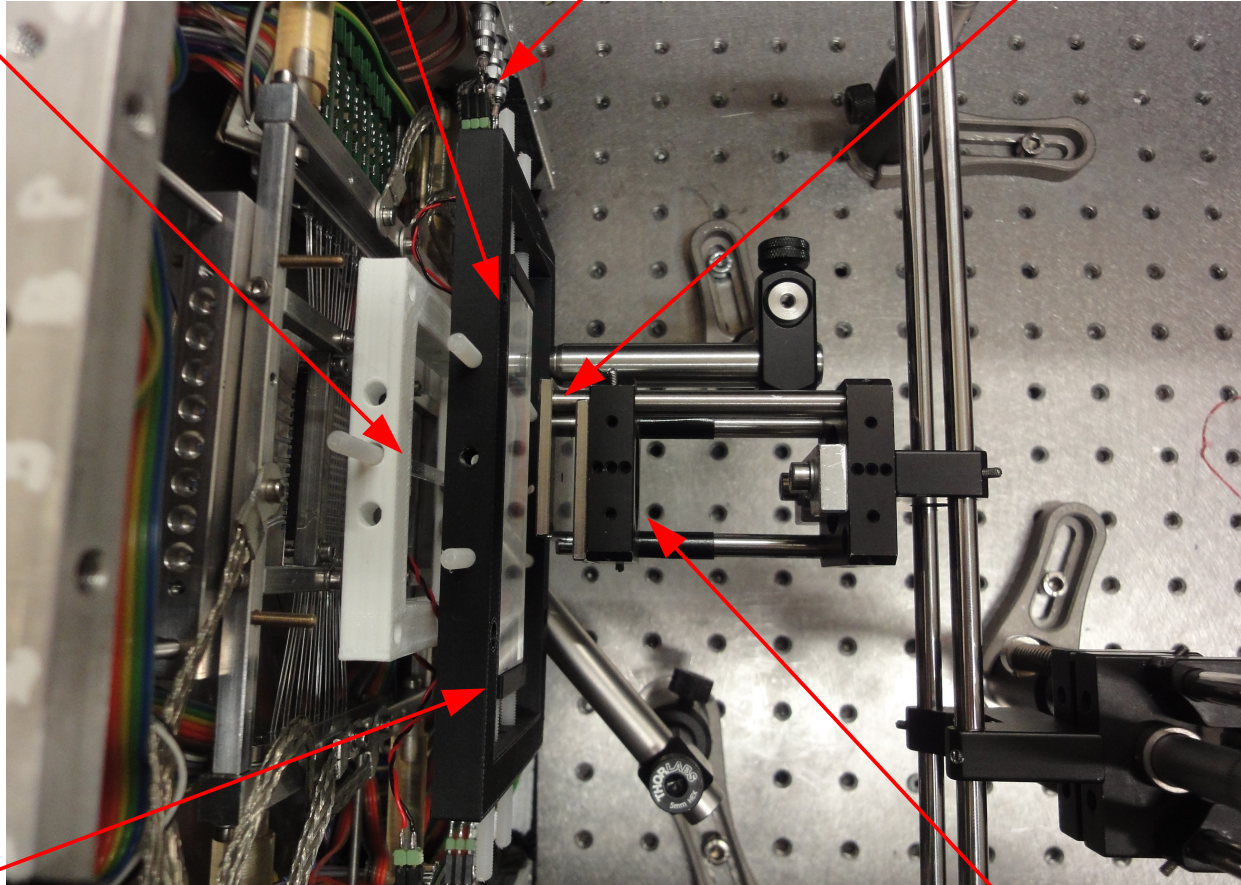


	Rise time [ns] (10% – 90%)	Width [ns] @ 50% level
1 SiPM	4.6	30.6
2 SiPM series	3.875	25.375
3 SiPM series	3.375	21.875
4 SiPM series	3.125	21.85

**~ 32% faster signal rise time**  
**~ 30% smaller signal width**

# Test setup with scintillator

Trigger counter      SciTil (90 x 30 x 5 mm<sup>3</sup>)      Preamplifier      Pinhole collimator



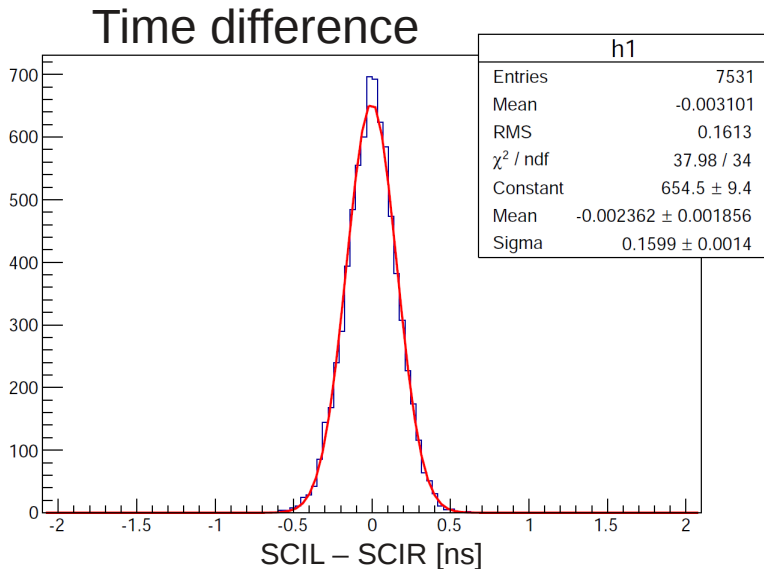
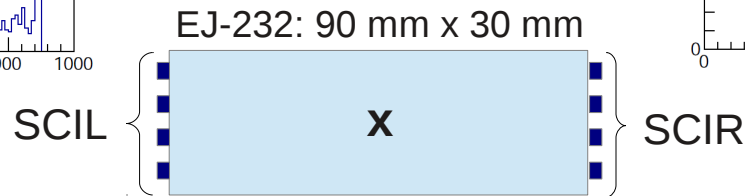
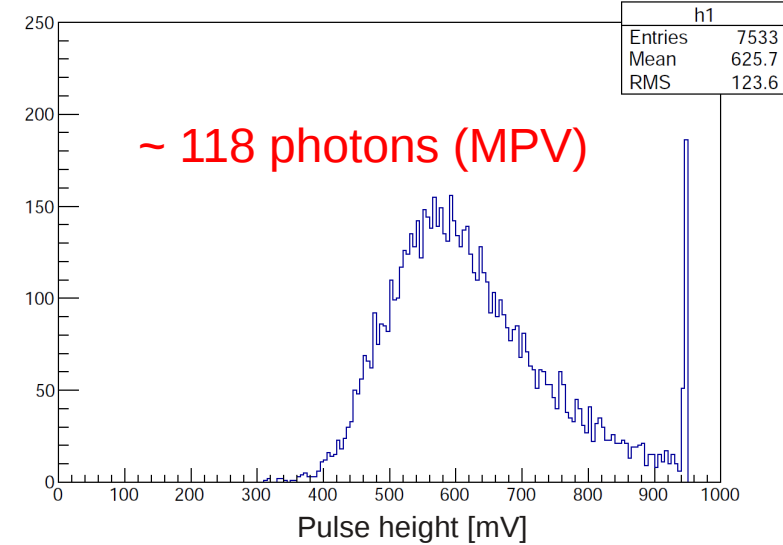
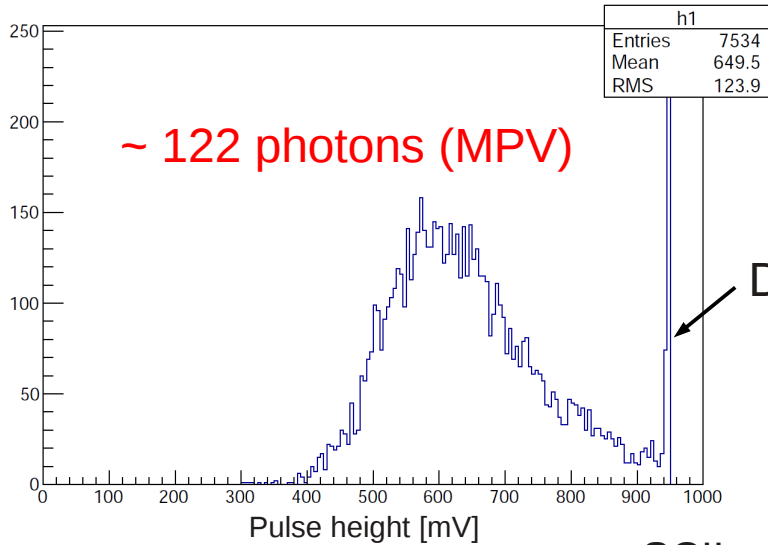
4 SiPM in series on each side  
Ketek 3350

<sup>90</sup>Sr source (not on the photo)

 to CAEN waveform digitizer (5GS/s)



# First results with EJ-232



**Time difference resolution  $\sigma_{\text{diff}} \sim 160 \text{ ps @ 120V}$**   
**Time difference resolution  $\sigma_{\text{diff}} \sim 148 \text{ ps @ 124V}$**   
**Time difference resolution  $\sigma_{\text{diff}} \sim 154 \text{ ps @ 128V}$**   
**Estimated tile time resolution  $\sigma_{\text{tile}} \sim 74 \text{ ps @ 124V}$**

**Already better than best results with 30 x 30 mm<sup>2</sup> tiles although results are preliminary and no fine tuning and optimization done.**

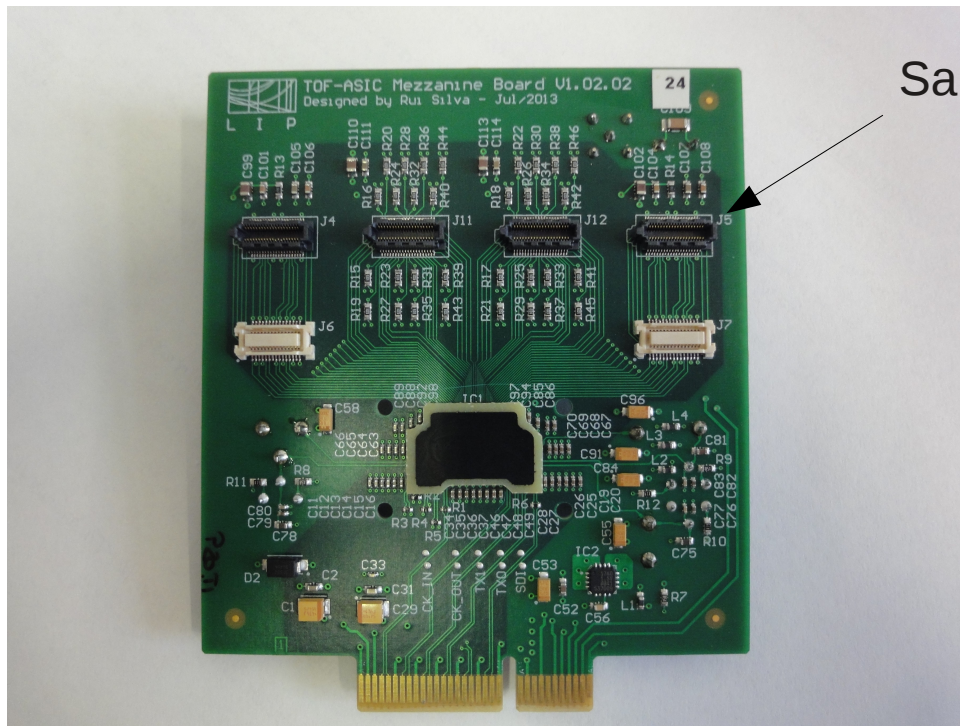
**More systematic measurement will follow + estimation of position resolution.**

Thank you !

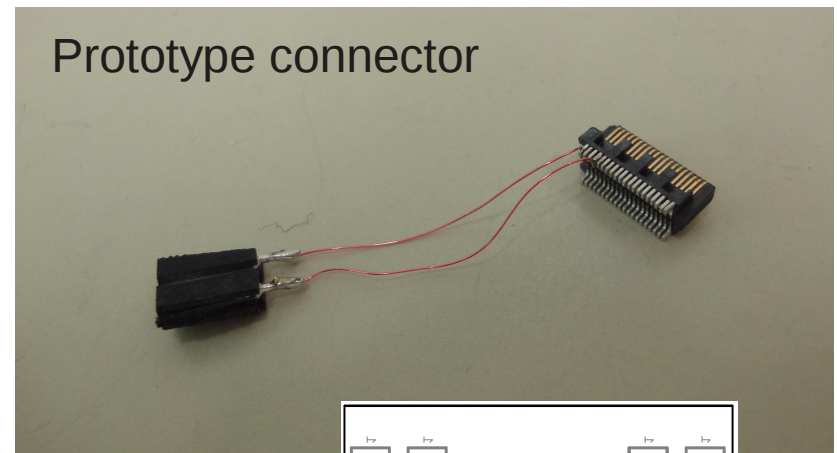
# Spare

# SiPM connection

- The mezzanine board connects to 4 Hamamatsu 16 channel arrays
- We need an adapter to connect single SiPMs

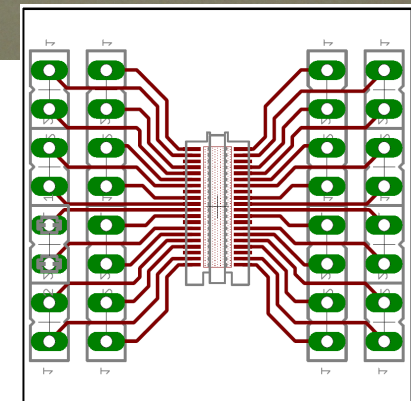


Samtec SS4 connector fits to ST4



Prototype connector



We are preparing a print board with ST4 on one side and connectors for SiPMs on the other side.



# Summary and outlook

- Results are preliminary
- Time resolution of about 30 – 35 ps using test pulses
- Time resolution of about 45 ps with laser and SiPM
- Time resolution of about 120 ps with Hamamatsu 050C and EJ-228
- Time resolution of about 180 ps with Ketek 3360TS and EJ-228

## To do:

- Update firmware and software (new release available) 
- Redo calibration (TDC, amplifier) – some channels show worse resolution? 
- More systematic measurements needed → **started using pulse generator**
- Some results not yet fully understood (timing, ToT spectra, coincidences, ...)
- Improve SiPM connection (Samtec connector) → **in preparation**
- Use new SiPMs (current SiPMs have been used at test beam) → **SiPMs have arrived**
- Noise on signal? Connection? (high  $v_{th\_E}$  needed) → **new connector should improve**
- Test with scintillator bar geometry → **scintillators (90 x 30 x 5 mm<sup>3</sup>) have arrived**