Study of scintillator detectors time resolution with different SiPM readout on T10 test beam at June 2012

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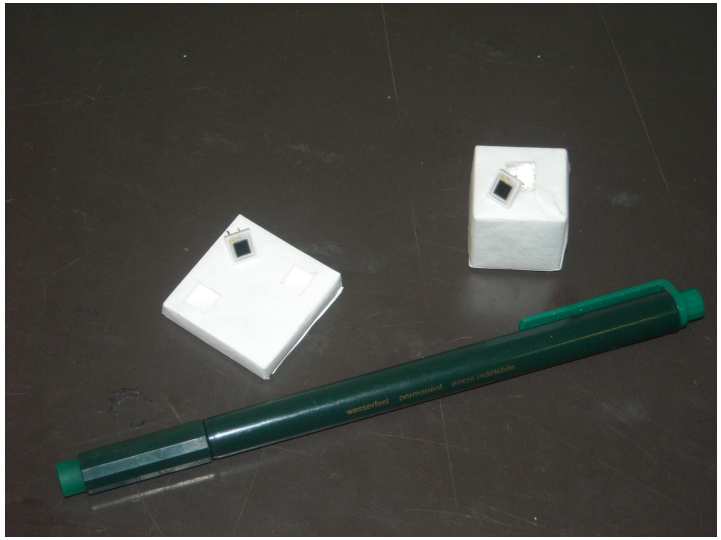
- The goal of measurements.
- Scintillator detectors with different SiPMs readout.
- T10 test beam facility.
- Results of measured time resolution for different SiPMs readout.
- Conclusion

Goal of the test

To measure time resolution and amplitude spectra of scintillator detectors with SiPMs produced by HAMAMATSU, KETEK and ZECOTEK.

Dimensions of scintillators are optimized for TOF systems of PANDA experiment at FAIR. Additional test have been done for scintillators optimized for central part of forward CBM TOF, HADES FW….

Scintillator detectors with different SiPMs readout



Scintilators – BC-408
Two sample:
-28 x 28 x 5 mm
-30 x 30 x 10 mm
Scintillators have been overlapped by TYVEK

Used SiPMs – sensitive area 3 x 3 mm:
- **PM3350 (KETEK)**
- **MPPC S10362-33-100C (HAMAMATSU)**
- **MAPD-3N (Zecotek)**

Method of light readout:
Scintillator 28 x 28 x 5 mm by two SiPMs from one surface.
Scintillator 30 x 30 x 10 mm by two SiPMs from opposite rear surfaces.

Properties of used SiPMs

MPPC S10362-33-100C (HAMAMATSU)

Active Area 3 x 3 mm^2
Pixel Size 100 x 100 um
Number of Pixels 3600
Peak Wavelength 440 nm
Operating Voltage 70±10 V
Gain 750 000

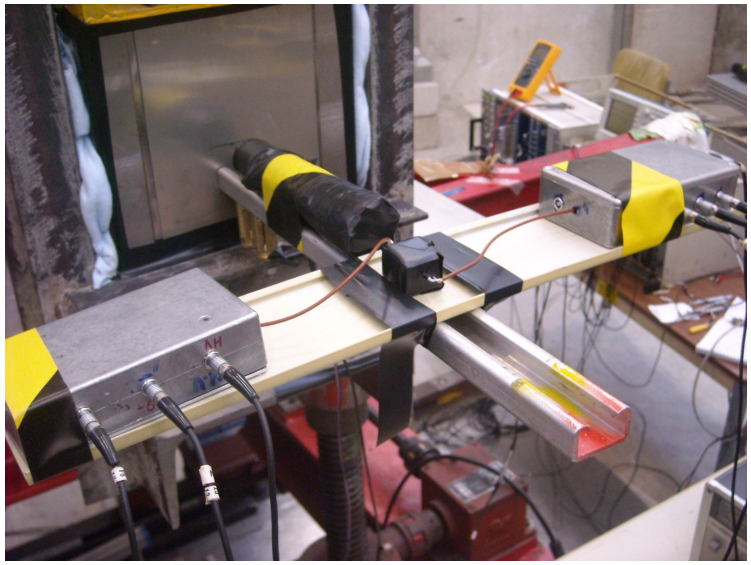
PM3350 (KETEK)

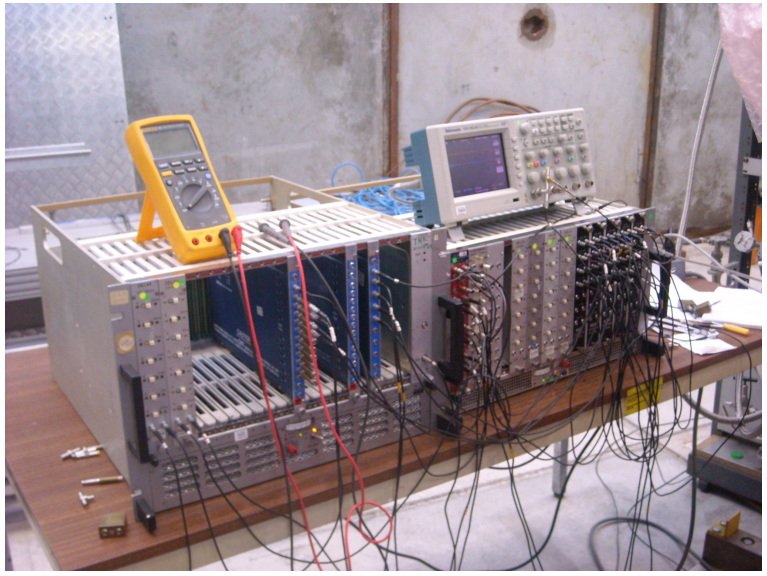
Active Area 3 x 3 mm^2
Pixel Size 100 x 100 um
Number of Pixels 3600
Peak Wavelength 420 nm
Operating Voltage 28 - 41 V
Gain ~2 000 000

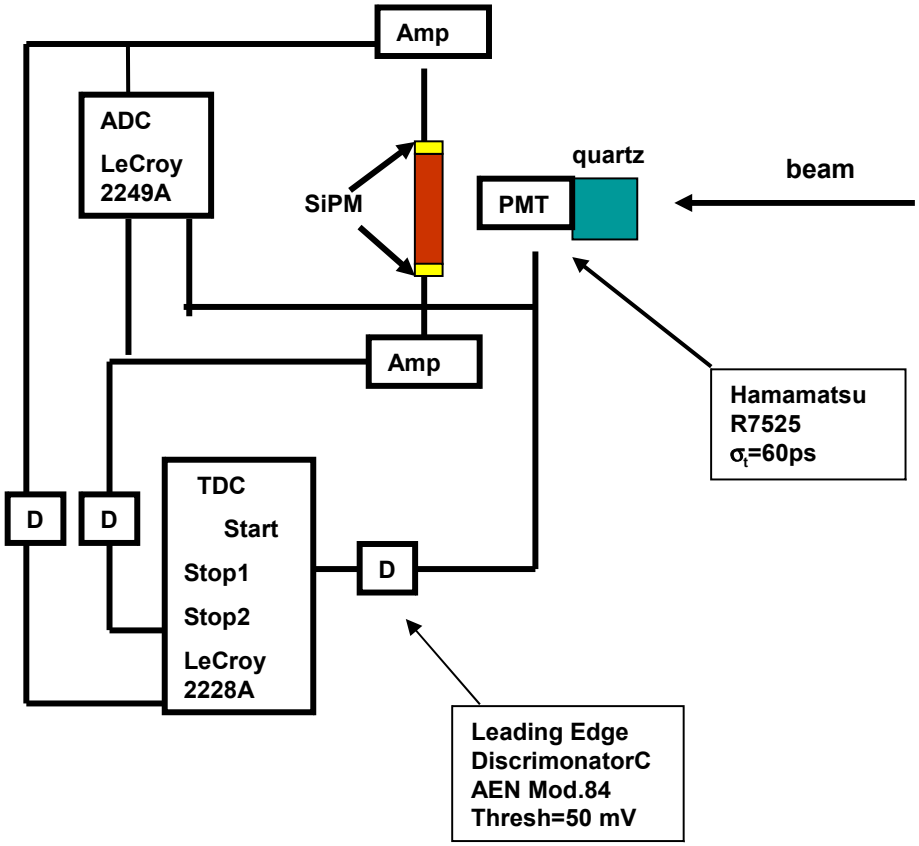
MAPD-3N (Zecotek)

Active Area 3 x 3 mm^2
Number of Pixels 135 000
Peak Wavelength 450 -500nm
Operating Voltage ~90 V
Gain 50 000

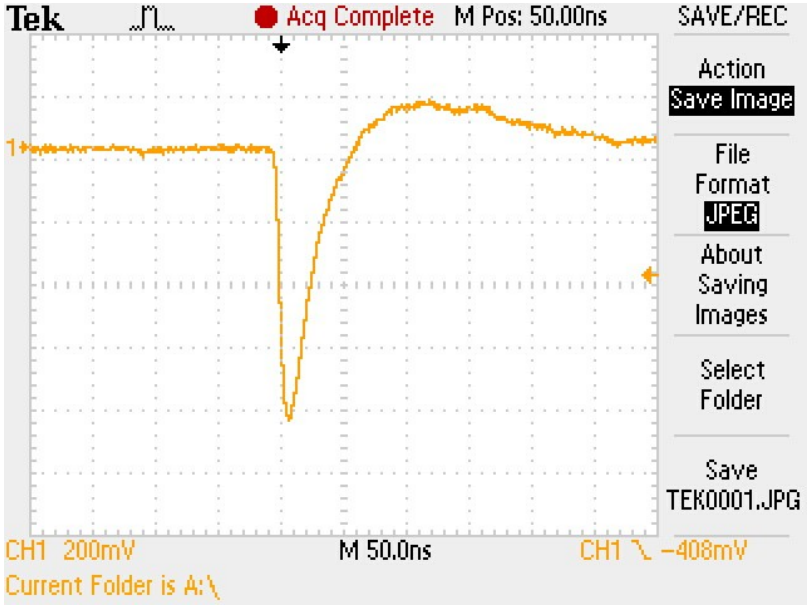
Experimental Setup







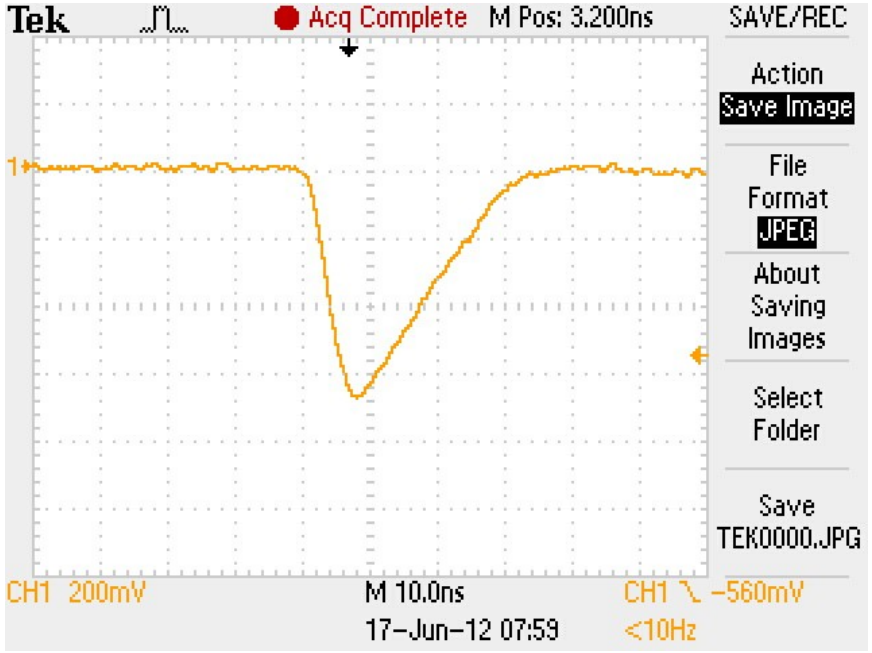
Two different amplifiers were used



Differential amplifier provided by H.Orth

(positive overshoot is visible)

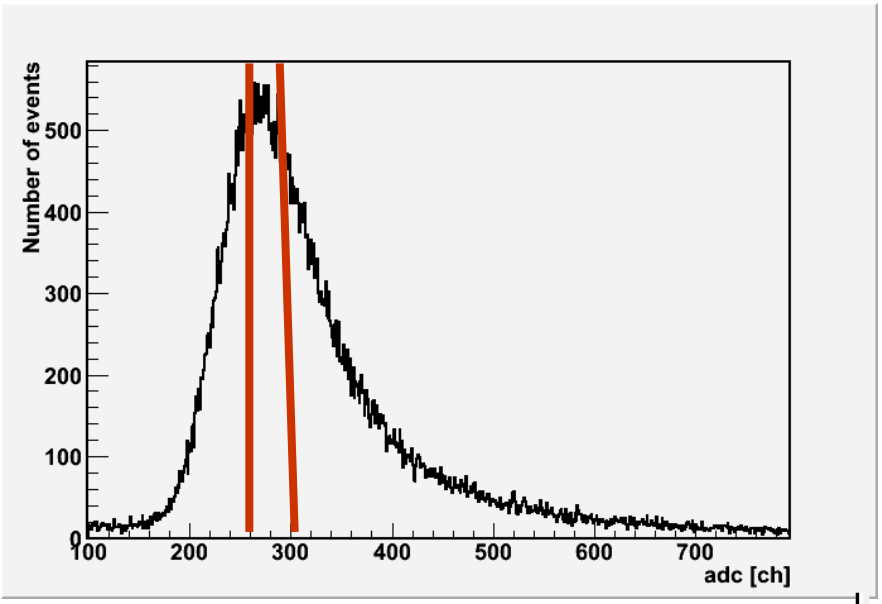
Amplifier with Pole Zero Compensation

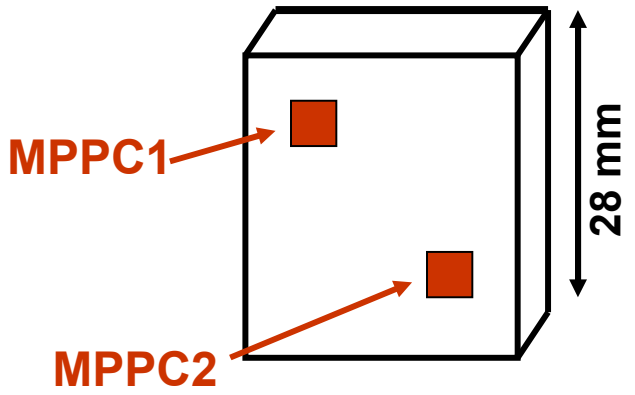


The time and amplitude resolutions for PZC amplifier are slightly better and the measurements were done for second type.

Test results for scintillators with HAMAMATSU MPPC S10362-33-100C

Amplitude spectra for one of MPPC at large side



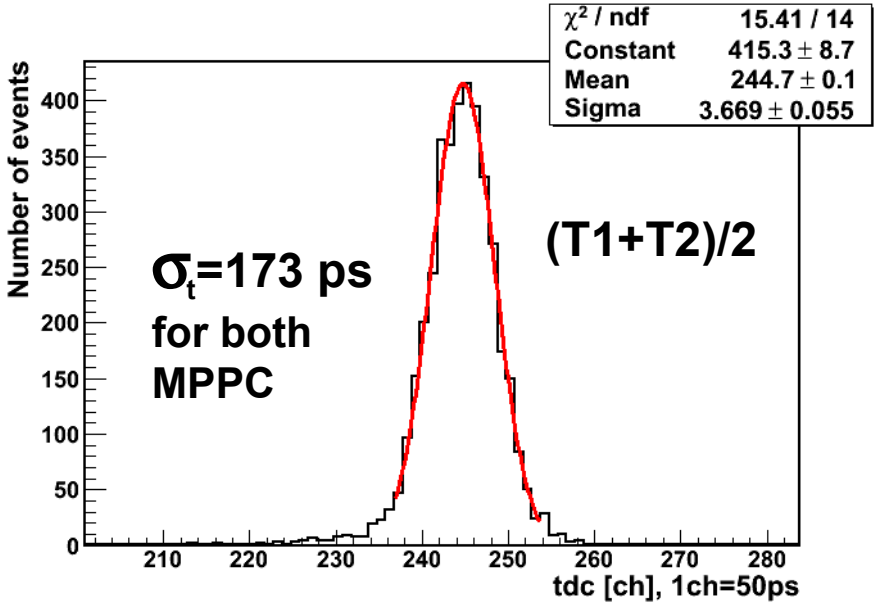


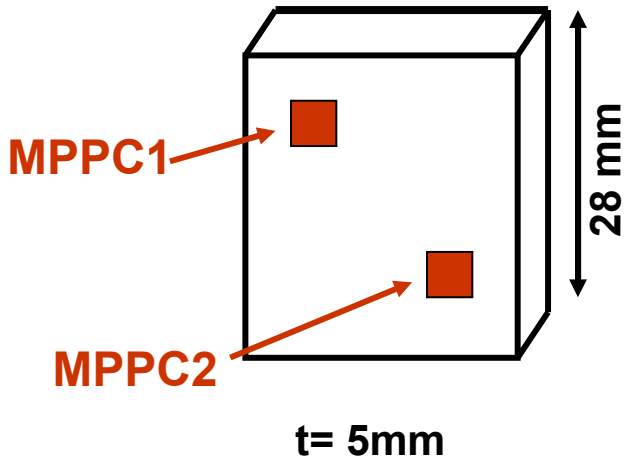
t= 5mm

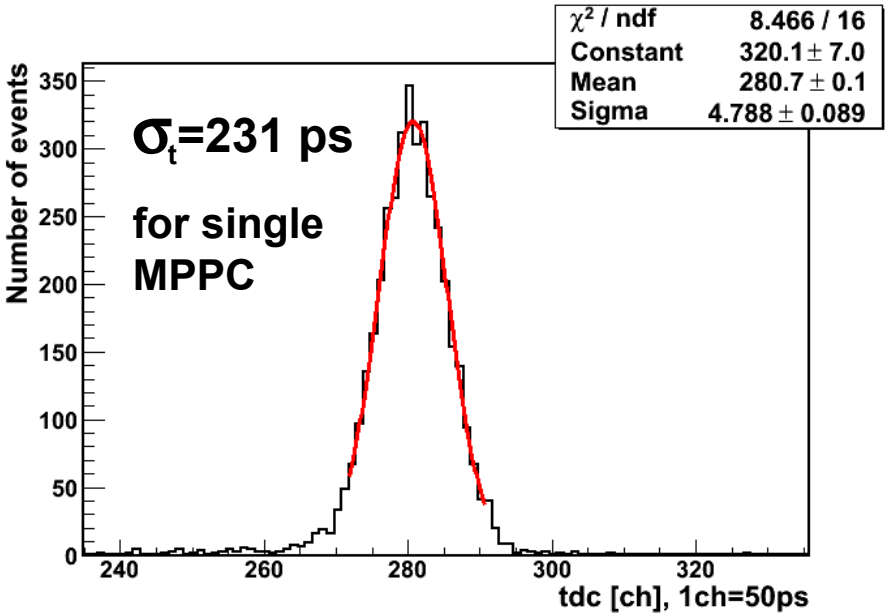
At present analysis the time resolution was determined for narrow ADC bin to avoid T-A walk

Time-amplitude walk

Time spectra for MPPCs from large side





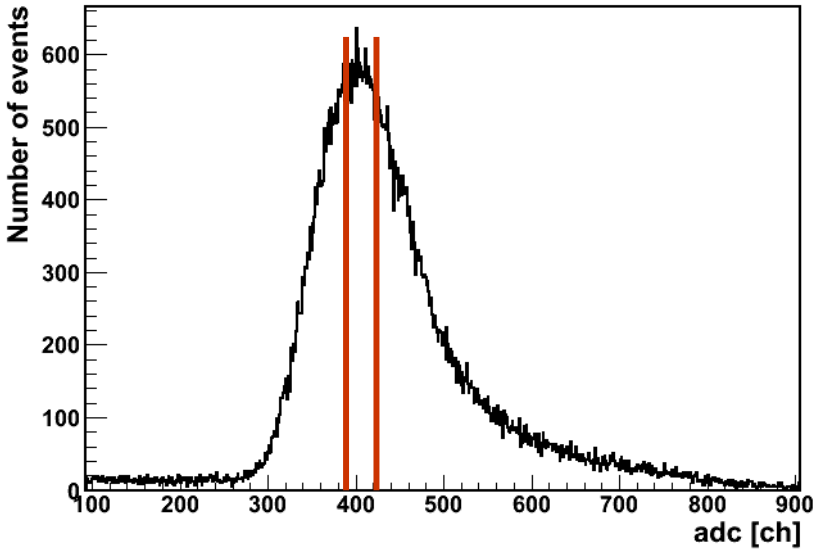


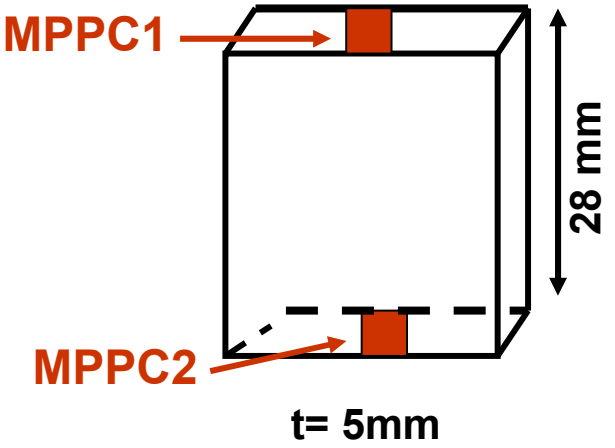
Time resolutions were calculated for narrow ADC bin= 40 ch

Time resolution of start quartz detector (σ_t=60ps)

Is taken into account

Amplitude spectrum for MPPC at small side

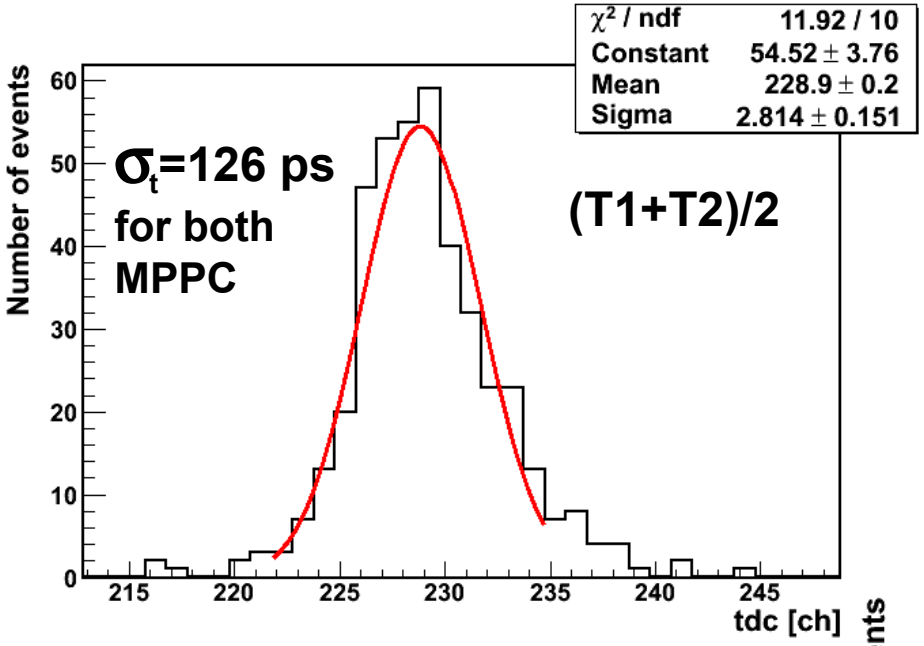


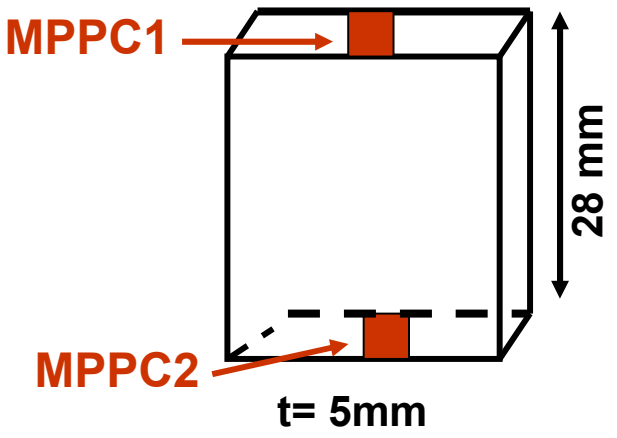


Amplitude at small side is ~1.5 times larger comparing to large side

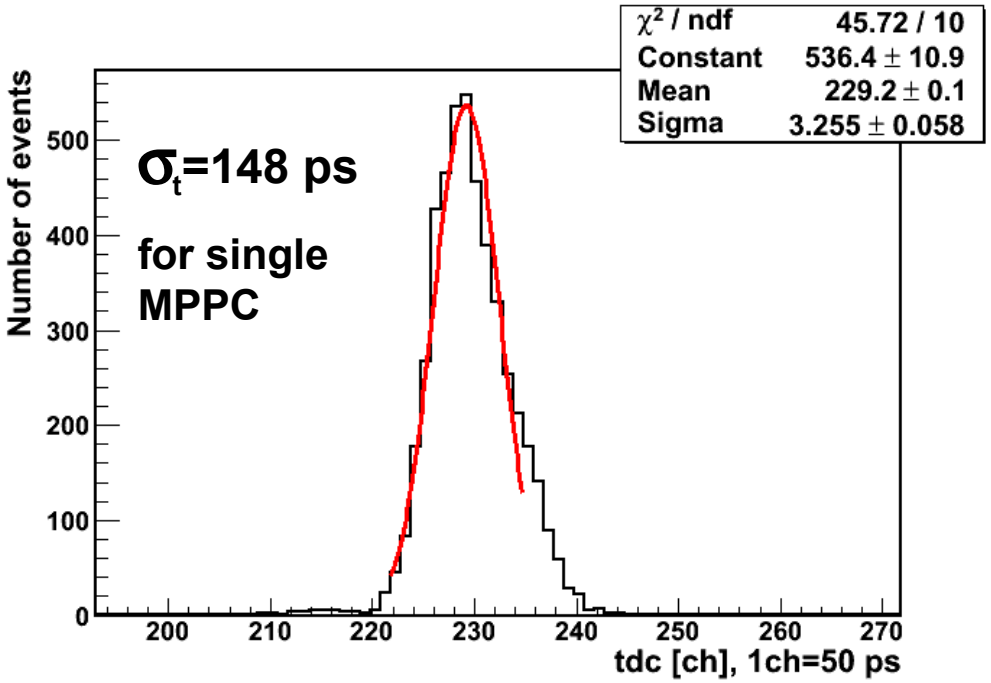
Time resolution were calculated for narrow ADC bin ~ 40 ch to avoid T-A walk

Time spectra for MPPCs at small opposite sides

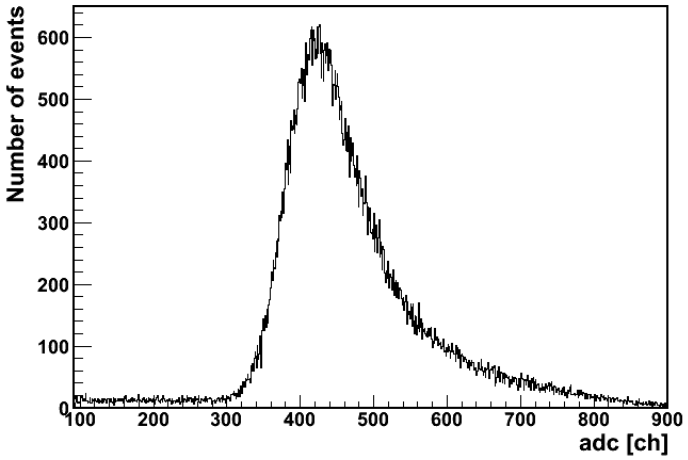


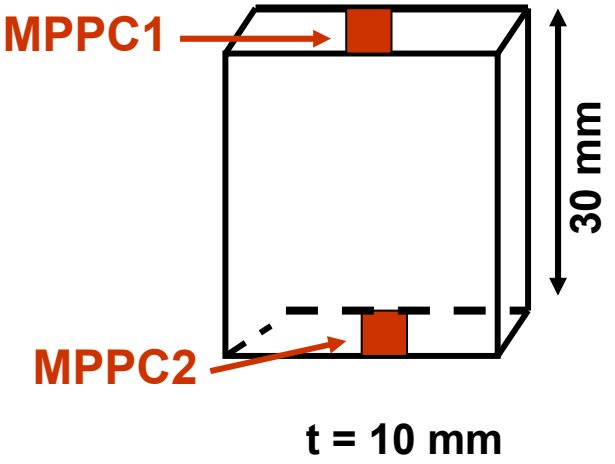


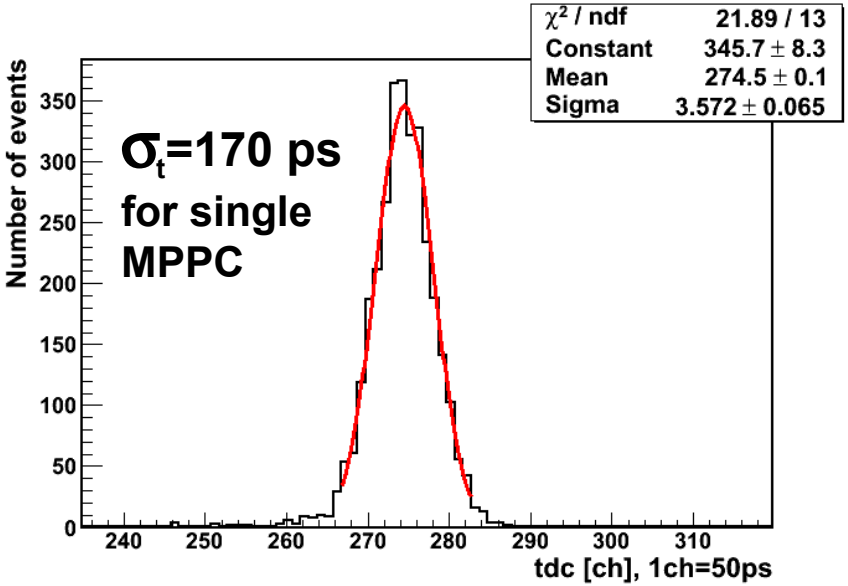
Calculation were done for narrow ADC bin= 40 ch

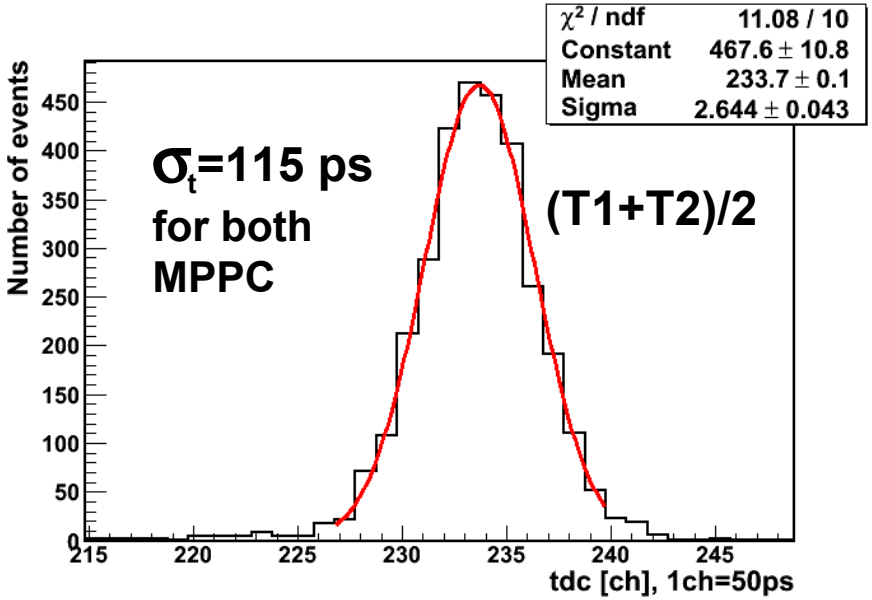


Spectra for MPPCs from scintillator 30 x 30 x10 mm





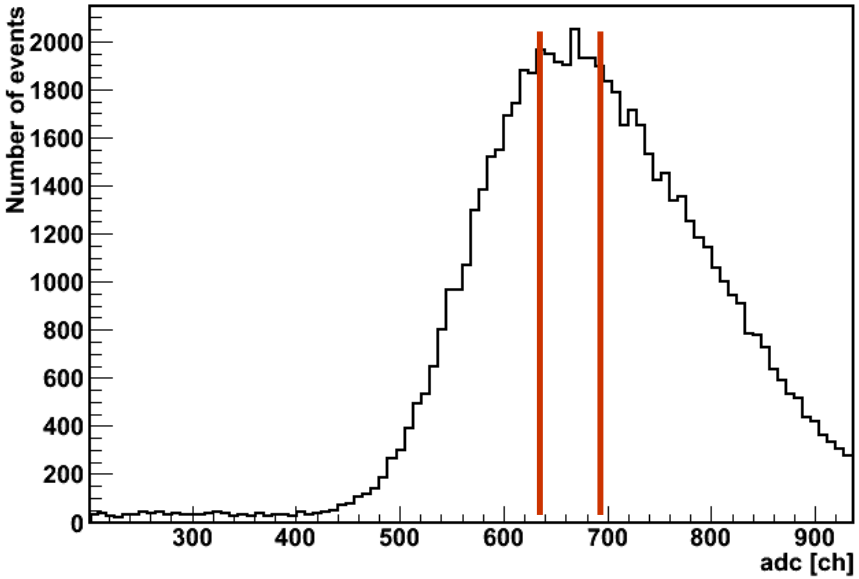


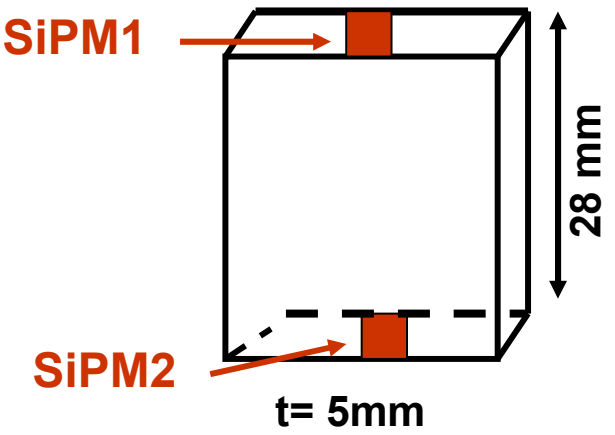


Calculation were done for narrow ADC bin= 40 ch

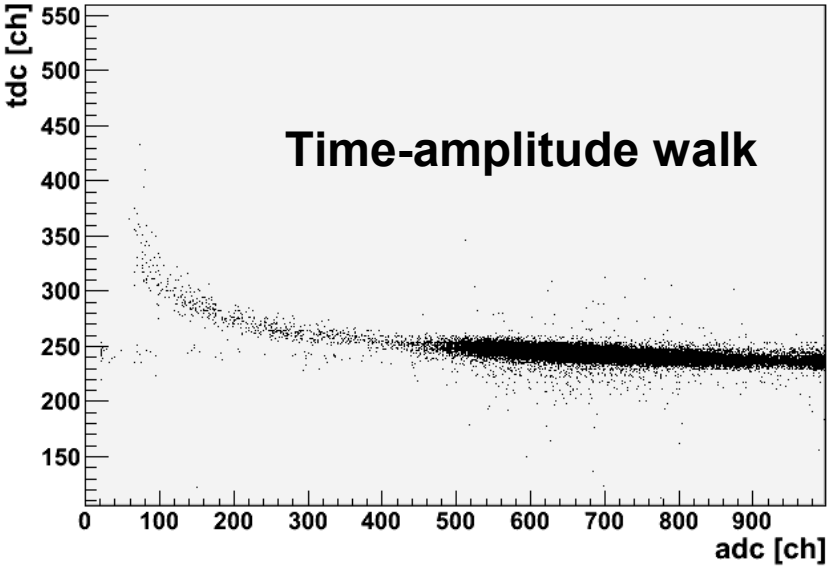
Test results for scintillators with PM3350 (KETEK)

Amplitude spectra for KETEK SiPMs at small side

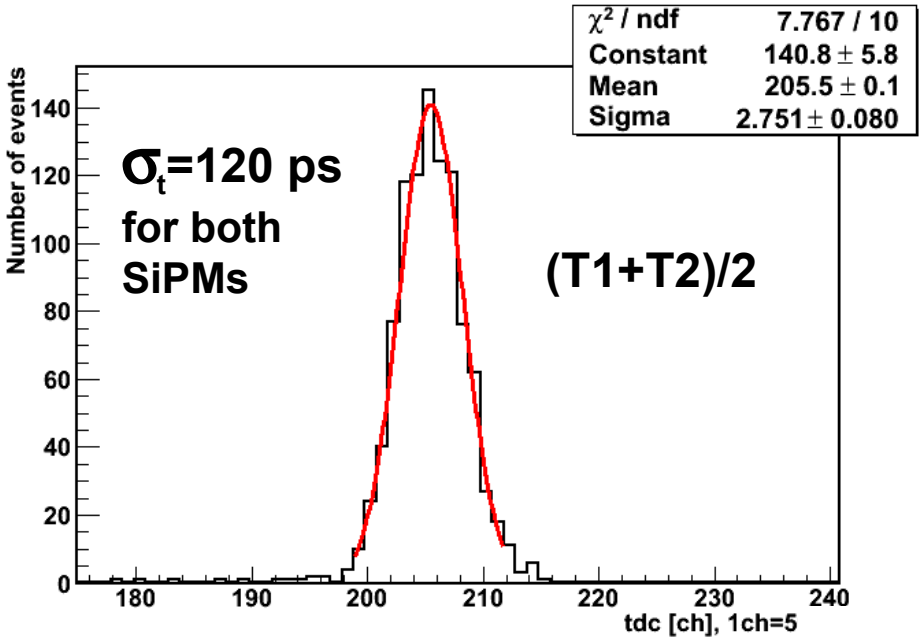


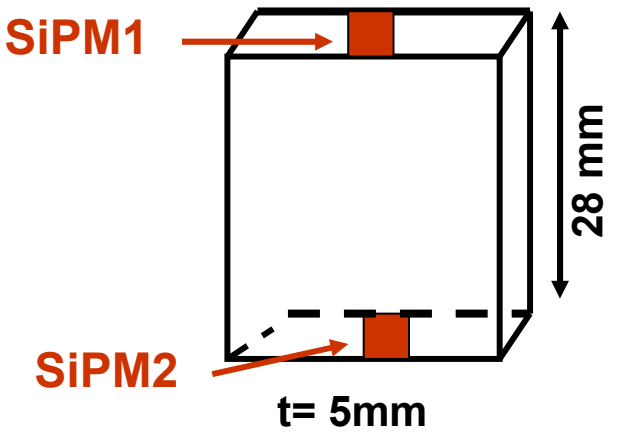


Time resolution was calculated for narrow ADC bin to avoid T-A walk

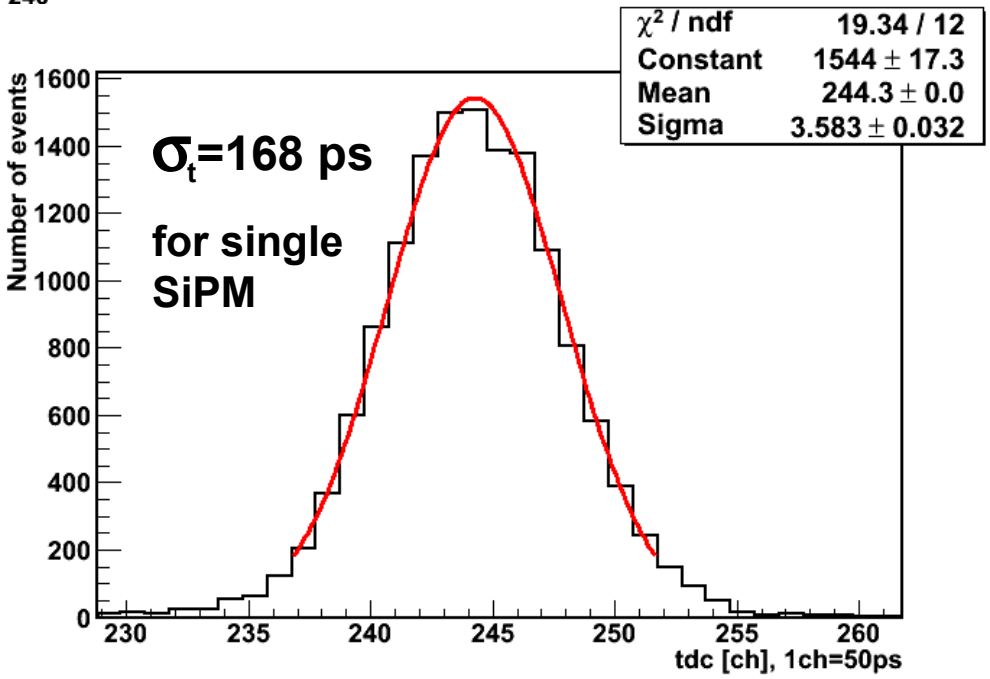


Time spectra for KETEK SiPMs at small sides

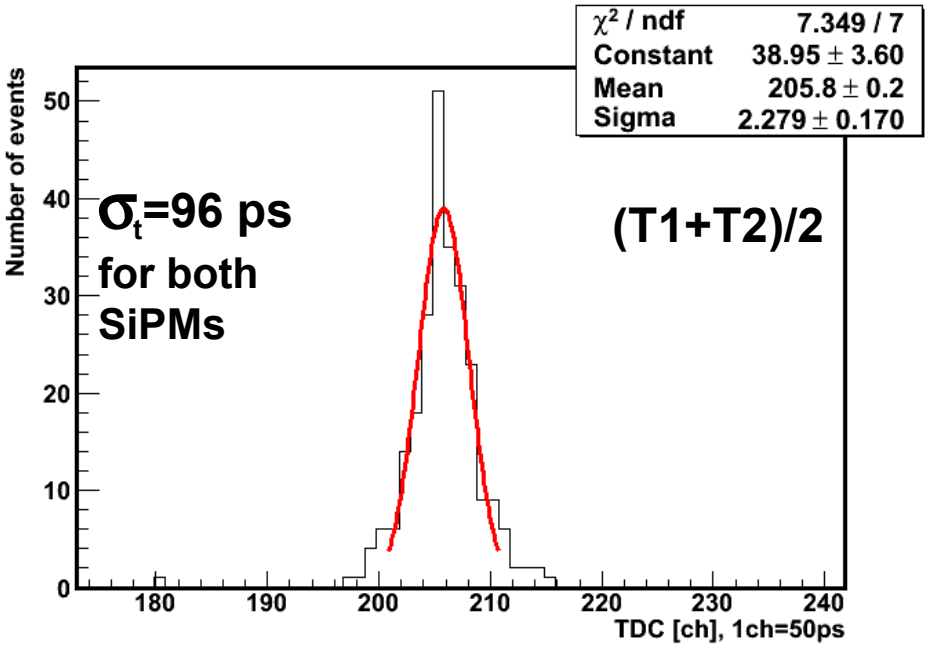


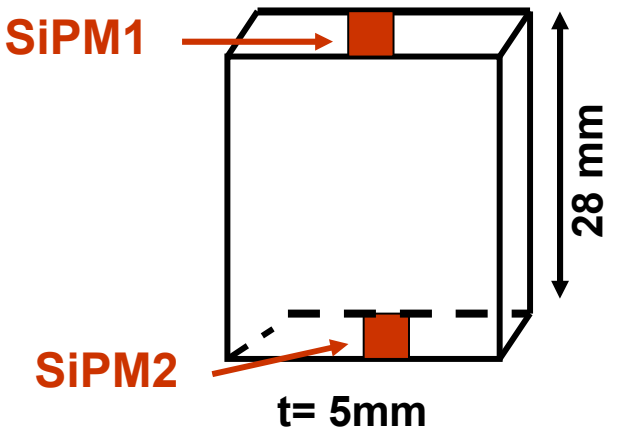


Calculations were done for narrow ADC bin= 50 ch

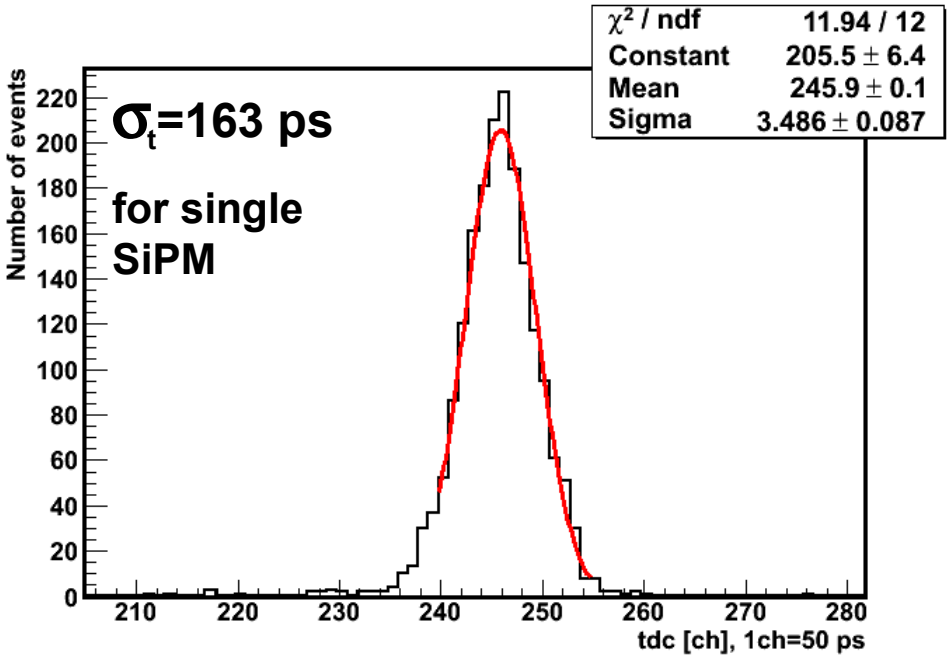


Time spectra for KETEK SiPMs at small sides for very narrow ADC bin=20 ch



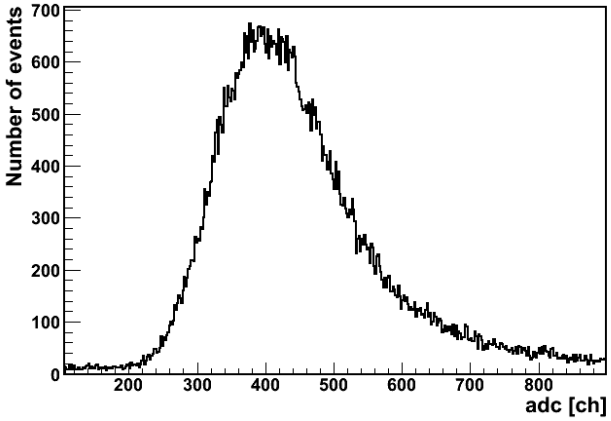


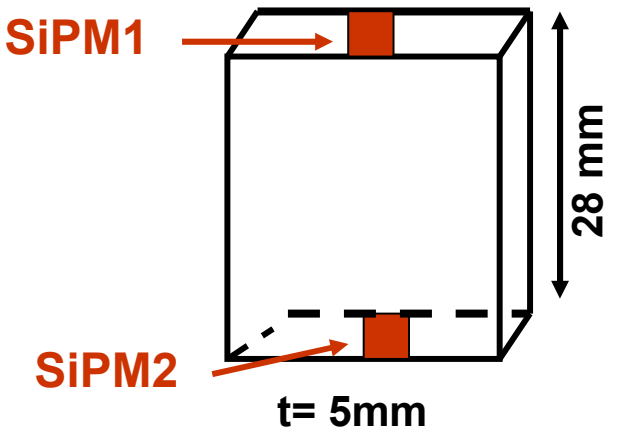
Measurement were done for very narrow ADC bin= 20 ch

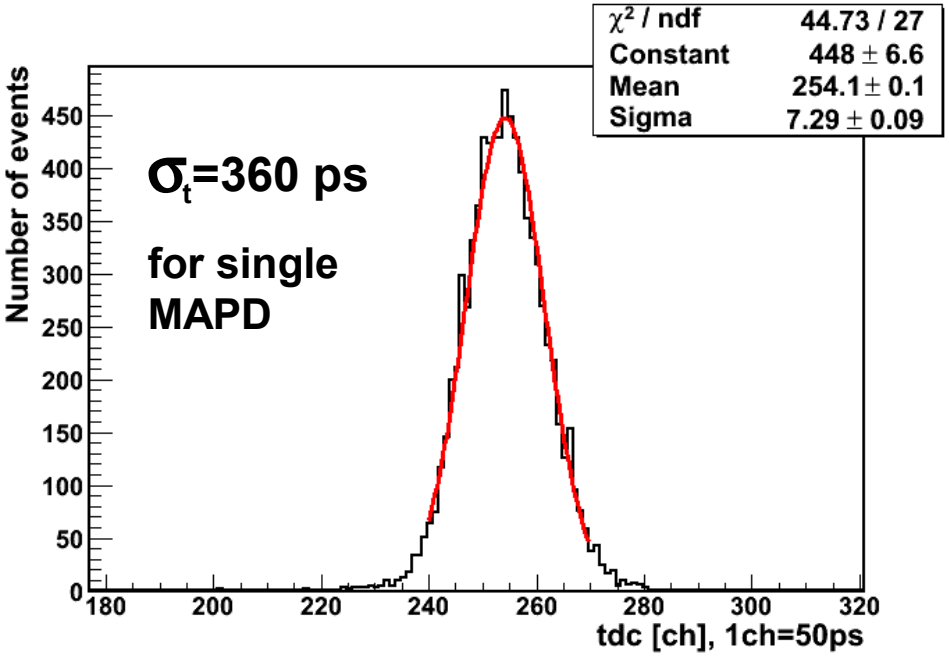


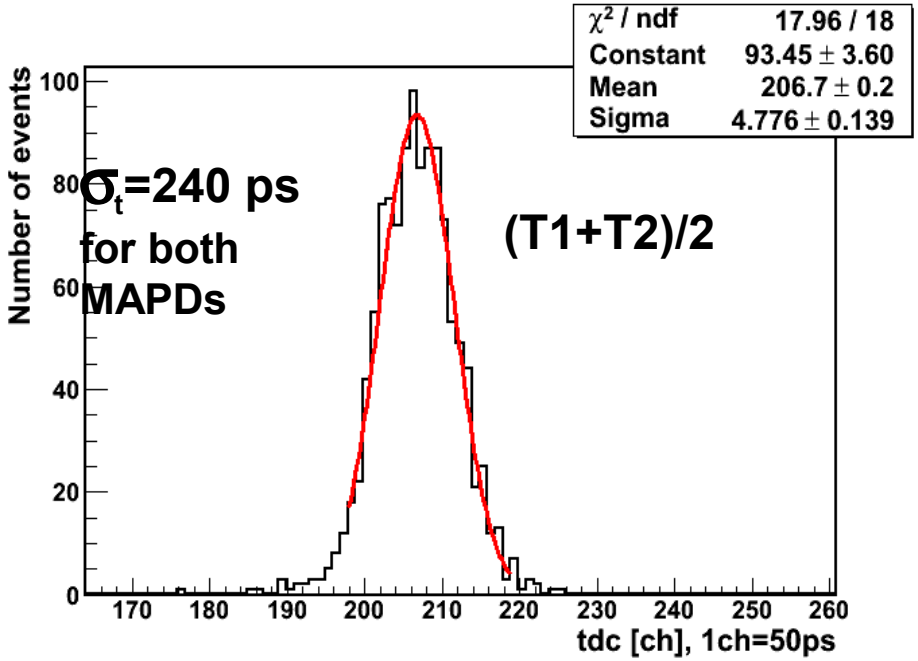
Test results for scintillators with MAPD-3N

Spectra for Zecotek MAPD-3N









Summary

- A measurements of 28x28x5 mm^3, 28x28x10 mm^3 and 30 x 30 x 10 mm^3 scintillator tiles were performed for a few types of SiPMs.
- The best time resolution is obtained in case of SiPM position at opposite small sides of the tile.
- Time resolutions for single Hamamatsu MPPC and KETEK SiPM are very similar and about 150-160 ps.
- Averaged time resolution with two SiPM readout is about 120 ps.
- For very narrow ADC bin widths the time resolution could achieve 100 ps. But it is worser probably for wide ADC range. The effect of time-amplitude walk should be account properly.
- Further optimization of the measurements is required. Namely, the discriminator threshold, signal amplification, SiPM voltage and noise affect the time resolution.