

# Time Resoulution Improvement of Single Scintillator Tile for PANDA Barrel TOF

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# Outline

1 Overview

2 Setup

3 Outlook

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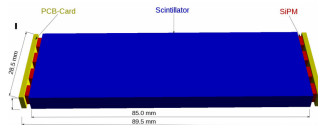
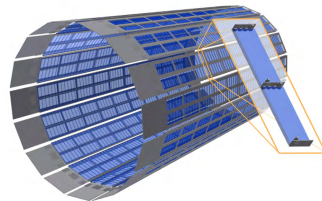
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# Geometry

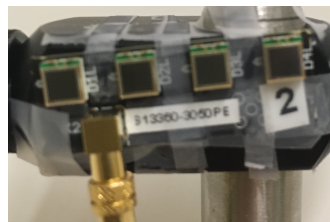
- Barrel TOF consists out of 16 Super-Module
- Each Super Module consists out of 2x60 Single Tile Scintillator (SciTil)
- SciTil Size: 85x28.5x5 mm<sup>3</sup>
- Read out with Silicon Photomultiplier (SiPM)



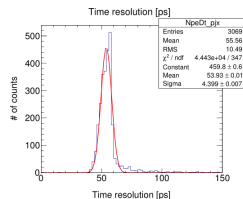
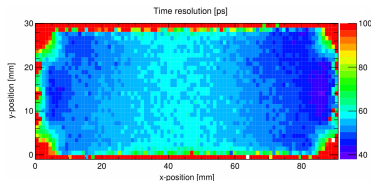
# Results until now → SciTil & SiPM

- Tile Size tested:  $30 \times 30 \times 5$  mm<sup>3</sup>,  $120 \times 5 \times 5$  mm<sup>3</sup>, optimization with current design
- Plastic Scintillator: EJ-232 or EJ 228
- 4 SiPM are on each end of the SciTil, forming one channel
- connection: serial, parallel, hybrid
- Hamamatsu, eg. S13360,  $3 \times 3$  mm<sup>2</sup>

Properties	EJ-228	EJ-232
Scintillation Efficiency (photons/1MeV e <sup>-</sup> )	10200	8400
Light Attenuation Length (cm)	-	10
Rise Time (ns)	0.5	0.35
Decay Time (ns)	1.4	1.6
Wavelength of Maximum Emission (nm)	391	370
Pulse Width, FWHM (ns)	1.2	1.3
Density (g/cm <sup>3</sup> )	1.023	1.023



# Results until now → Wrapping of SciTil



Time resolution with different wrapping EJ-232 (top), EJ-228 (bottom)

Wrapping material	Time resolution [ps]	Number of detected photons
No wrapping	$55.0 \pm 0.3$	$288 \pm 2$
Aluminised Mylar foil	$52.7 \pm 0.3$	$352 \pm 2$
Tyvek hardstructure 1057D	$55.0 \pm 0.3$	$394 \pm 3$
Enhanced specular reflector (ESR)	$55.2 \pm 0.3$	$355 \pm 3$
Teflon tape	$59.4 \pm 0.3$	$408 \pm 4$
aluminium foil	$54.2 \pm 0.3$	$344 \pm 3$

Wrapping material	Time resolution [ps]	Number of detected photons
No wrapping	$61.3 \pm 0.3$	$371 \pm 2$
Aluminised Mylar foil	$59.7 \pm 0.3$	$445 \pm 3$

# Motivation for further work

- Scan shows some inhomogeneity of time resolution; only for EJ-232 available.
- Thickness of SciTil not tested yet. (SiPM 3 mm, SciTil 5 mm)
- Fixing the SiPM to SciTil can be improved (see scan)
- Decide how to connect SiPM (serial or hybrid)
- Test time resolution with PET-TOF chip

## Timetable:

- Submission of the TDR to FAIR ✓
- until 2018: Radiation hardness test; development of front end electronics, final beam test of the TOF prototype
- 2019: Industrial fabrication of components

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1 Overview

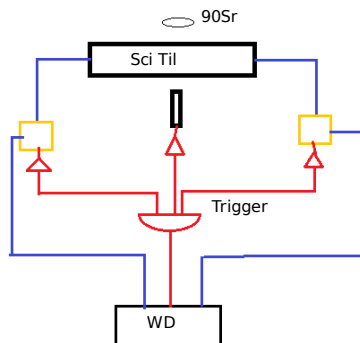
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3 Outlook



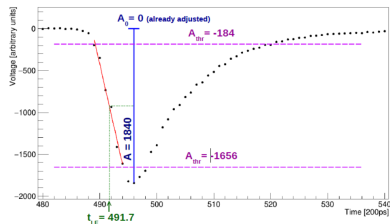
# Experimental Setup

- Strontium 90 produces  $e^-$  with kinetic energy up to  $2.28 \text{ MeV}$
- Energy is high enough for  $e^-$  to go through SciTil and hit Scintillator of photomultiplier tube (PMT)
- $3 \times 3 \text{ mm}^2$  Trigger Scintillator behind the SciTil
- Signal read out on both ends and Trigger signal of PMT

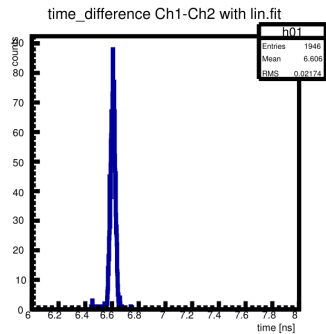
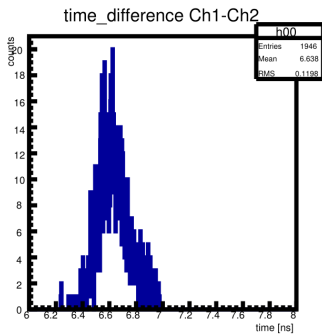


# Data processing

- In Vienna only used WavePro 735Zi 3.5 GHz Oscilloscope [40 GS/s]
- Timing was set at absolute threshold value.
- Now CAEN Desktop Digitizer [5 GS/s]
- For timing make a linear fit of the falling slope, works on relative threshold value.



# Date processing (2)



# Outline

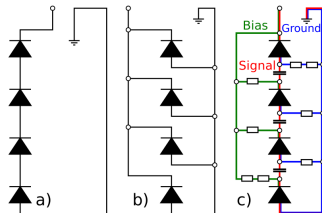
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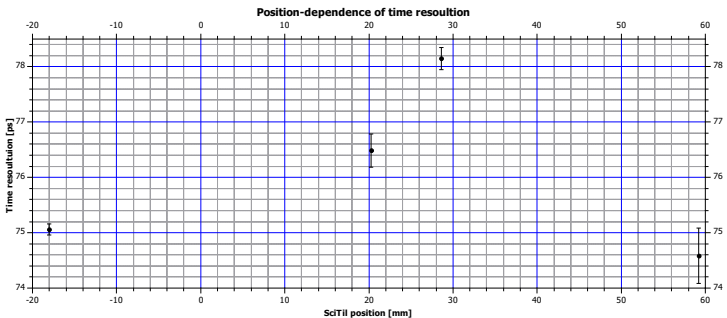
# SiPM

- Decide which connection to be used: serial (Bias= $4 \times 55 \text{ V}$ ), hybrid (Bias= $55 \text{ V}$ )
- Fixing (glueing?) SiPM to SciTil has to be improved
- SiPM size  $3 \times 3 \text{ mm}^2$ ; adjust to SciTil size



# SciTil

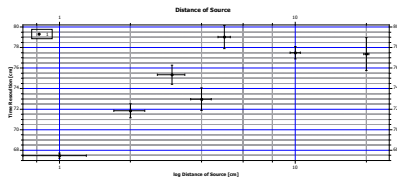
- Thickness of SciTil to be tested with same size as SiPM
- Homogeneity of time-resolution to be improved
- Scan for EJ-228 to be done



# Setup improvement

- For Trigger 3x3 mm<sup>2</sup> Scintillator is used.
- Effective velocity inside SciTil  $\approx c/3$
- 3 mm  $\rightarrow$  30 ps resolution
- $\sigma_{measured}^2 = \sigma_{SciTil}^2 + \sigma_{Detector}^2$

- Distance of Sr90 Source should be close to SciTil



# Conclusion

- Still time for improvement and testing various components
- SciTil/ SiPM type, size, connection
- Transition to Waveform Digitizer gives more flexibility therefore better chance for precise timing