

A SiPM based Organic Scintillator Detector for the Bonn Teststation

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The Forward Endcap of the PANDA-EMC

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The Forward Endcap

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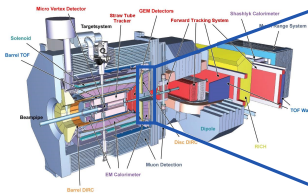
The Trigger Detector

Efficiency Tests

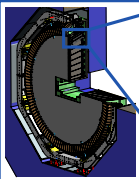
Testsetup Results

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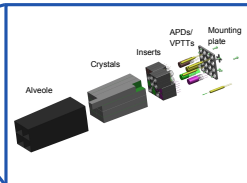
Panda Experiment



Forward Endcap



Detector Submodule



- 260 detectorsubmodules with each 16 or 8 crystals
- Test and pre-calibration of all modules at the final working condition is necessary before the final assembly
→ a teststation for tests and precalibration has to be built

Design Ideas of the Bonn Teststation

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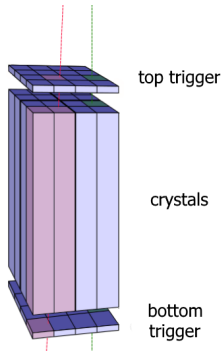
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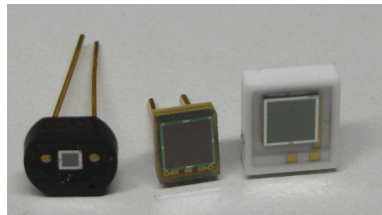
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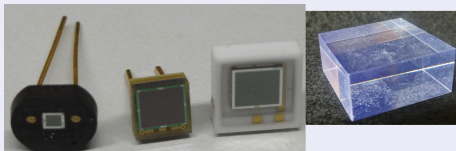


- detection of MIPs penetrating a crystal
→ 16 square-cut organic scintillators
- spatial resolution matching the geometry of the crystal $2,3 \times 2,3 \text{ cm}^2$
- inactive area as small as possible → compact readout of the scintillators

- trigger ability and compactness needed
→ SiPM readout suitable
- EMC working temperature -25°C



Which SiPM is suitable?

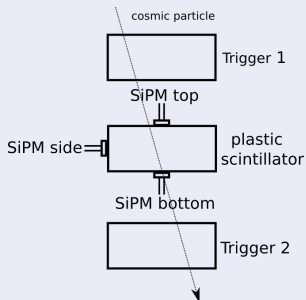


- EJ-200 plastic scintillator
- wavelength of peak emission 425 nm

SiPM	Hamamatsu S12571			Hamamatsu S12572			Ketek
	25C	50C	100C	25C	50C	100C	PM3350
V_{Bias}	70V	70V	70V	70V	70V	70V	25V
Active area	1mm ²	1mm ²	1mm ²	9mm ²	9mm ²	9mm ²	9mm ²
Pixels	1600	400	100	14400	3600	900	3600
Pixel pitch	25μm	50μm	100μm	25μm	50μm	100μm	50μm
Fillfactor	65%	62%	78%	65%	62%	78%	63%
PDE	35%	35%	35%	35%	35%	35%	40%
λ at max.	450nm	450nm	450nm	450nm	450nm	450nm	420nm

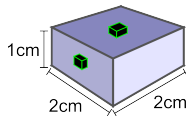
- EJ-200 plastic scintillator dimensions: (2 × 2 × 1) cm
→ select SiPM with best signal to noise ratio

Testsetup



plastic scintillator:

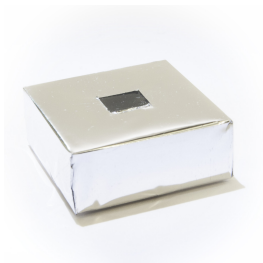
EJ-200



- time-consuming test with MIPs
→ quick rule out of SiPMs

Results

SiPM	efficiency	time resolution
PM3350 Top	94,2%	570ps
S12572 Bottom	76%	2,0ns
S12572 Side	75%	2,1ns
S12571 Side	62,3%	2,2ns



Tested coating:

- without coating
- tin foil
- teflon foil
- mylar foil

Results

SiPM	efficiency	efficiency (mylar)
PM3350 Top	94,2%	98,1%
PM3350 Side	95,4%	98,2%
S12572 Bottom	76%	85%
S12572 Side	75%	85%

→ most suitable SiPM: Ketek PM3350

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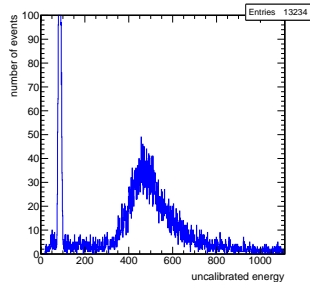
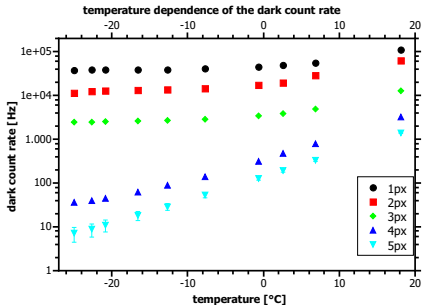
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Results:

at -25°C , 20% rel. Overvoltage and threshold 50 mV

- mean detected photons ≥ 100
- dark count rate 1 Hz
- efficiency of 97%
- temperature dependence of $21,5 \pm 0,3 \frac{\text{mV}}{\text{K}}$

The Trigger Detector

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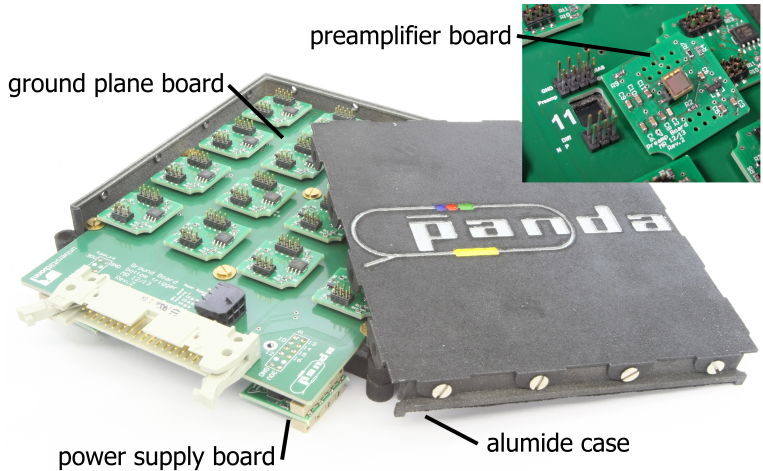
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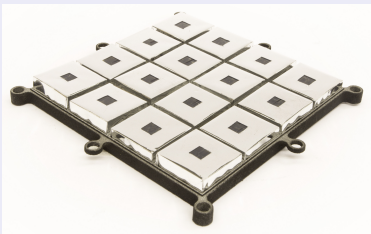
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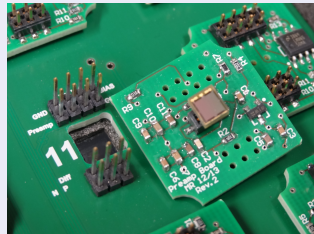
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Array of 16 scintillators

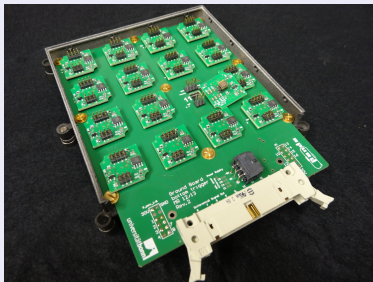


Preamplifier and SiPM

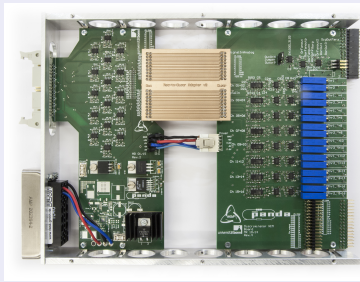


- 3D-printed case out of alumide
- SiPMs directly connected to scintillators (with air gap)
- Trans-impedance amplifier based on Photonique design
- differential output

Ground plane board



NIM discriminator



- Differential signal transmission to the NIM discriminator
- Signal splitter
- Discriminator threshold adjustable 5 – 100 mV
- ECL outputs
- logic or output for trigger

Efficiency with the final testsetup

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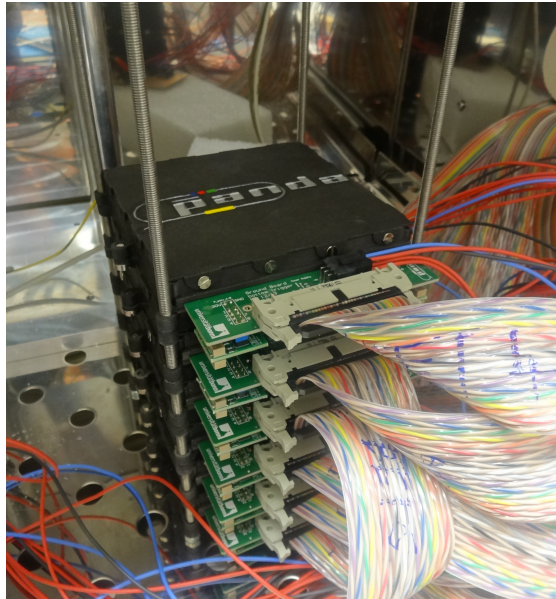
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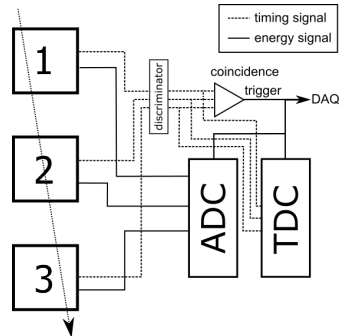
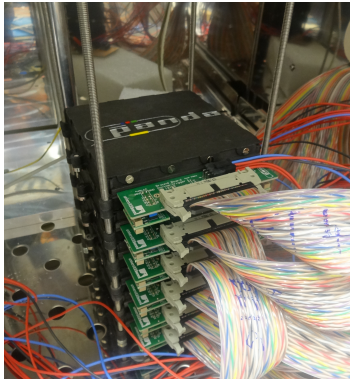
The Trigger Detector

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- Test of all build trigger detectors
- Stack of 6 trigger detectors
- Cosmic particles used to determine the efficiencies
- Coincidence 2 out of 3 will start the DAQ

Example for ADC and TDC spectra

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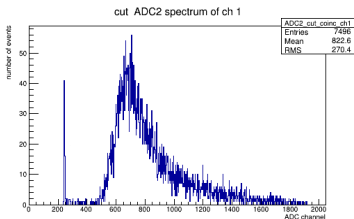
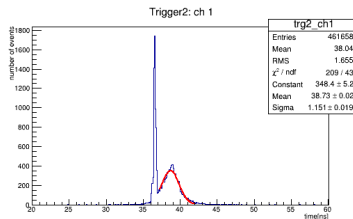
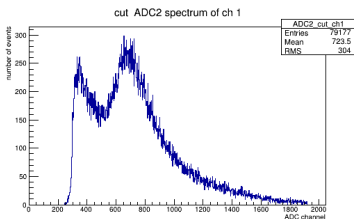
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- at -25°C
- 20% rel. Overvoltage
- threshold 50 mV
- mean detected photons ≥ 100
- dark count rate 1 Hz



Efficiencies

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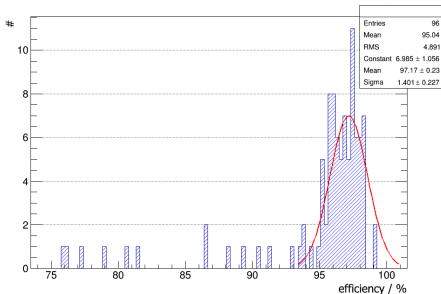
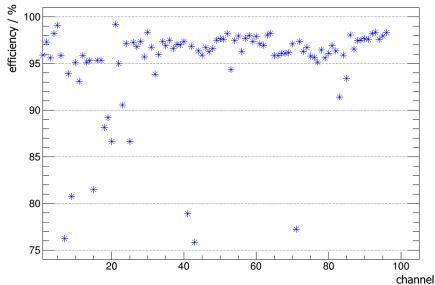
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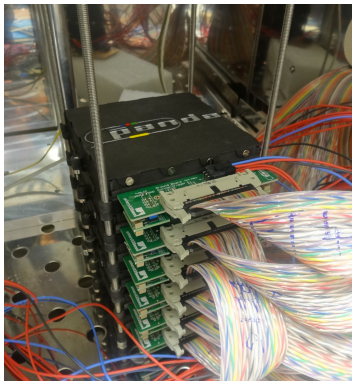
Efficiency

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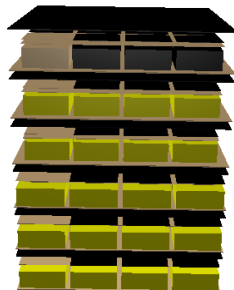
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Simulation Setup



- Simulation to check the observed cosmic distribution
- Stack of 6 ideal trigger detectors (threshold 1MeV)
- Used cosmic-ray library (CRY)^a for particle generation
- Same trigger condition

^a<http://nuclear.llnl.gov/simulation/>

Comparison simulation - measurement

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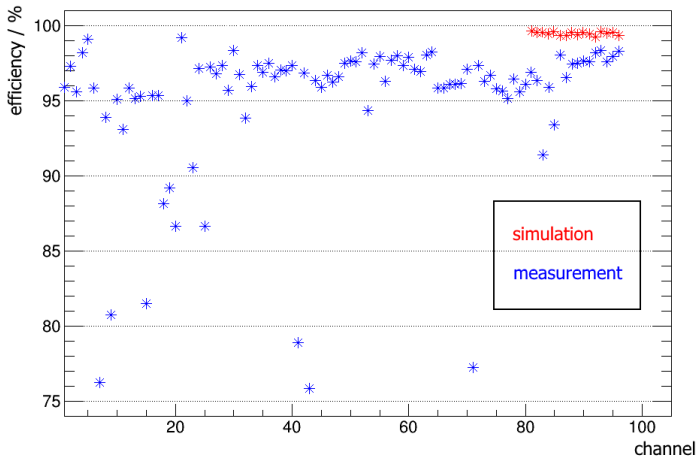
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- Mean of simulated efficiencies 99.54%
- yield to a small correction for the measured efficiencies

Summary:

- Suitable SiPM for readout selected ✓
- 8 detector successful built ✓
- 81% of all channels have efficiencies $> 95\%$
- First Forward Endcap detector submodul successful tested ✓

Outlook:

- Fix channels with efficiencies $< 95\%$
- Investigate difference between simulation and measurement
- Test and pre-calibration of the 260 detector submodules

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**Efficiency
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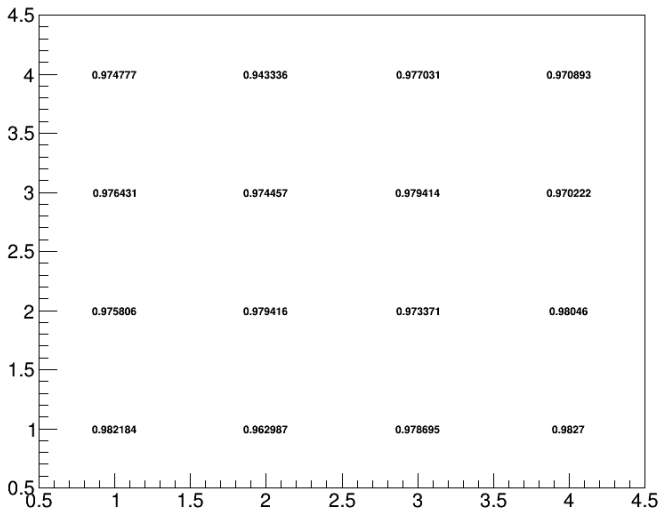
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Thank you for your attention

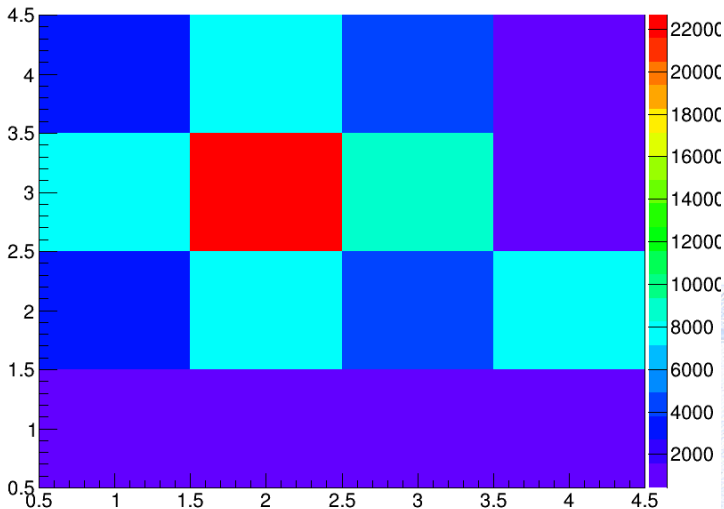
Efficiencies triggerdetector 5

efficiency of the trigger detector 5 for each channel



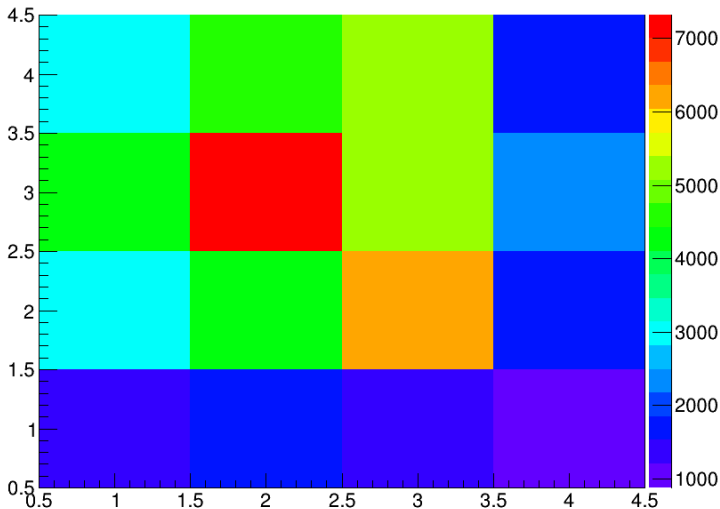
Hits in triggerdetector 2

Hits in trigger 2 if hit in trigger 1_5



Hits in triggerdetector 3

Hits in trigger 3 if hit in trigger 1_5



Multiple hits in triggerdetector 1

Multihits in trigger 1 ch6

