Scintillators with Silicon Photomultiplier readout

Silicon photomultipliers

An alternative to the readout of scintillation crystals with photomultiplier tubes is the use of so-called silicon photomultipliers (SiPms)

- Low voltage operation (25-30 V)
- Insensitive to magnetic fields
- High gains ($10^6$)
- Mechanically compact
- Elements 3x3 of 6x6 mm

SiPm elements can be combined into matrices. SiPms can be operated up to 60 degrees C.

Disadvantages of SiPms are:

- Linearity of pulse height spectrum strongly depending on bias and scintillator speed
- Temperature dependent gain
- Noise at higher temperatures
- Cost per cm$^2$

For applications where small size and low voltage operations are required, SiPm readout of scintillators can be a good choice.

SiPms behave totally different from classical photomultiplier tubes, as well with respect to signal processing as to spectroscopic behavior.

The gain of SiPms is a very strong function of the bias voltage which should be chosen carefully depending on the actual application of the detector.

The number of SiPms needed on a scintillation crystal depends on the requirements.

SCIONIX has developed a range of sensors equipped with SiPms for a great variety of applications.
The energy resolution and noise level achievable with SiPm readout depends on the crystal dimensions, type of scintillator and area covered by the SiPm; some examples:

<table>
<thead>
<tr>
<th>Crystal size and type</th>
<th>Energy resolution (662 keV)</th>
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<tbody>
<tr>
<td>NaI(Tl) 32 x 25 mm</td>
<td>&lt; 8.0 %</td>
</tr>
<tr>
<td>CsI(Tl) 25 x 25 mm</td>
<td>&lt; 7.0 %</td>
</tr>
<tr>
<td>CsI(Tl) 35 x 51</td>
<td>&lt; 7.5 %</td>
</tr>
<tr>
<td>CsI(Tl) 48 x 35 mm</td>
<td>&lt; 7.5 %</td>
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</tbody>
</table>

**Signal shapes**

The signal of a SiPm detector depends very strongly on the termination resistor. A typical example of a bare NaI(Tl) SiPm signal is shown below.

SCIONIX has developed bias generator / preamplifier modules for SiPm scintillation detectors. The gain drift as a function of temperature is internally corrected. Such modules operate at voltage 5.2 – 16V and consume less than 30 mW.