

## INTRODUCTION

The purpose of this Technical Note is to give recommendations that improve the performance of scintillators readout with SensL's Silicon Photomultiplier detectors.

SPMs (Silicon Photomultipliers) have been shown to be a valuable alternative to traditional vacuum PMTs, especially for the readout of (<10 - 20mm) scintillator crystals for gamma, particle and X-ray spectroscopy. The performance of scintillator-SPM detector assemblies is characterized by the FWHM energy resolution and the achievable low energy threshold. Such performance is highly dependent on the light collection efficiency from the scintillator on to the SPM. With the proper set-up, SPMs outperform vacuum PMTs, and offer the ability to develop next generation medical and hazard and threat detection systems.

## SCINTILLATION CRYSTALS AND THEIR RECOMMENDED SHAPING TIMES

The ScintPack-SL contains samples of the following scintillator crystals:

- **CsI(Tl)** (3mm & 6mm)
- **BGO** (3mm)
- **LYSO** (3mm)

One should note that these three crystals have different scintillation times and therefore different shaping times should be used for optimum performance. Generally, a delay line shaper or gated integrator gives the best performance, but CR-RC or semigaussian shapers are more widespread. In addition, for the best performance the preamplifier should be configured as an integrating preamplifier. The SensL Technical Note "*SensL Preamp Conversion*" gives instructions for how to convert the standard SensL preamplifier (part of the Micro-EVB, and included in the ScintPack-SL) into an integrating preamplifier.

Scintillator	Characteristic decay time	Recommended integration time for delay line shaper or gated integrator	Recommended shaping time for CR-RC or semigaussian shaper
CsI(Tl)	Two components: can be approximated as single 1 $\mu$ s	3 - 4 $\mu$ s	4 - 5 $\mu$ s
BGO	300ns	1 $\mu$ s	500ns
LYSO	40ns	200ns	250ns

## COUPLING THE SCINTILLATION CRYSTAL TO THE SPM

For good light collection efficiency one has to take the following measures:

1. The crystal size and SPM active area should match each other. That typically means that the size of output face of the crystal is coupled to a SPM of the same dimension ( $3 \times 3 \text{mm}^2$  or  $6 \times 6 \text{mm}^2$ ).
2. Optical coupling grease such as Bicon BC-630 should be applied between the SPM and the crystal. For permanent mounting, one should use special transparent glues or cements like the Meltmount™.
3. The remaining five scintillator crystal surfaces that are not coupled with the SPM should be covered with a diffuse light reflector. One of the best and most easily available materials for that is teflon tape.

## RECOMMENDED REFLECTOR MATERIAL

One of the best and most easily available materials for crystal wrapping is teflon tape, particularly the white teflon (PTFE) tape used for household plumbing. It is important to note that generally there are two types of such tape available:

1. Thin, used mostly for water tube joints.
2. Thick (so called gas quality tape), used mostly for gas tube joints.

We recommend type 2 (gas quality) as it has demonstrated significantly better performance. In addition, it is easier to use. The example of such tape is pictured on the following page, and commonly found in shops for household appliances, e.g:

<http://radionics.rs-online.com/web/p/products/231-964/>

[http://www.homedepot.com/h\\_d1/N-5yc1v/R-202280370/h\\_d2/ProductDisplay?langId=-1&storeId=10051&catalogId=10053](http://www.homedepot.com/h_d1/N-5yc1v/R-202280370/h_d2/ProductDisplay?langId=-1&storeId=10051&catalogId=10053)

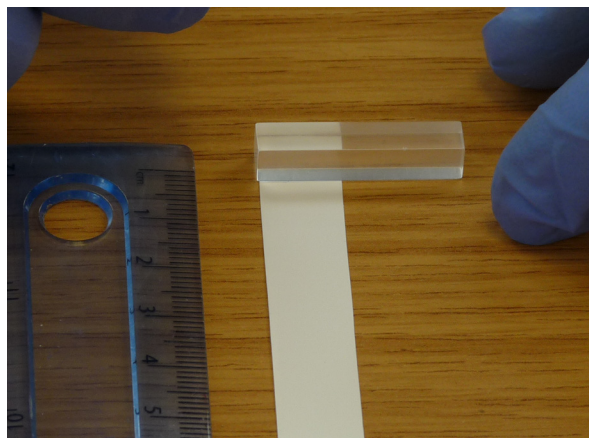


## APPLYING THE REFLECTOR MATERIAL

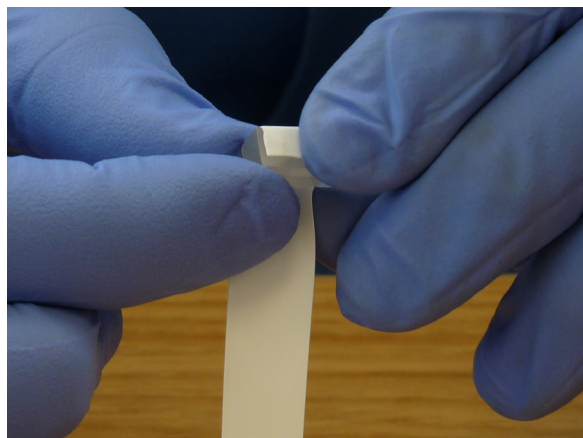


An undamaged length of the Teflon tape should be carefully unwound from the reel, and laid on the work surface. To determine the typical length of tape required to wrap the crystals from the ScintPack-SL, please refer to the table below.

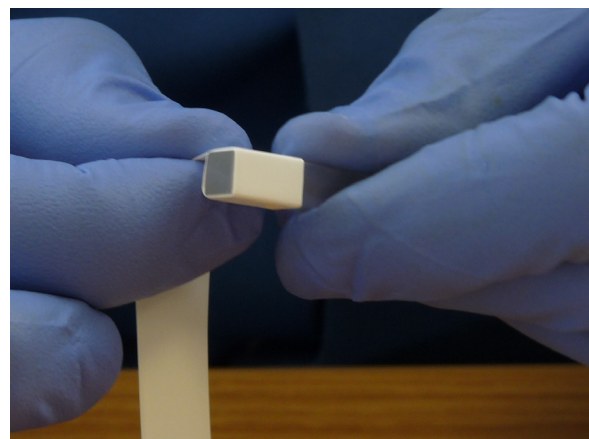
Crystal Size	Length of Teflon Tape
3 x 3 x 15 mm <sup>3</sup>	13cm
6 x 6 x 30 mm <sup>3</sup>	42cm



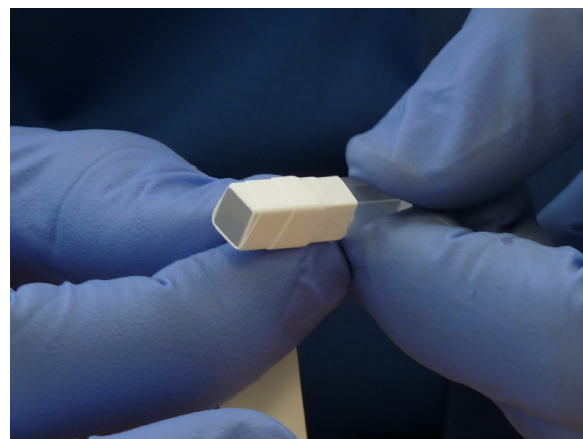
1) Ensure that the crystal is clean and free of marks from finger-prints etc. Carefully lay the crystal onto the tape, ensuring that the exit face is aligned to the edge of the tape.



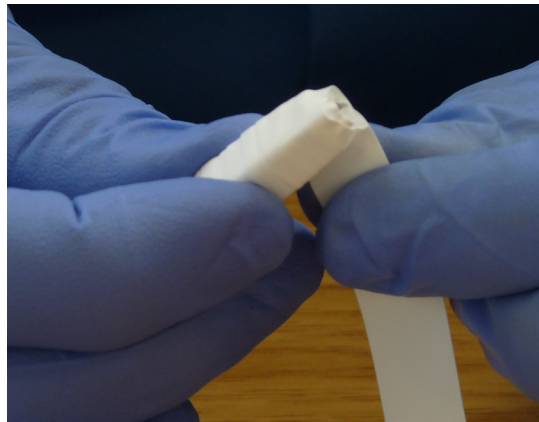
2) Start to carefully wrap the teflon around the crystal, ensuring that the first wrap neatly aligns the tape edge with the edge of the crystal. Take care to avoid covering any of the exit surface with the tape.



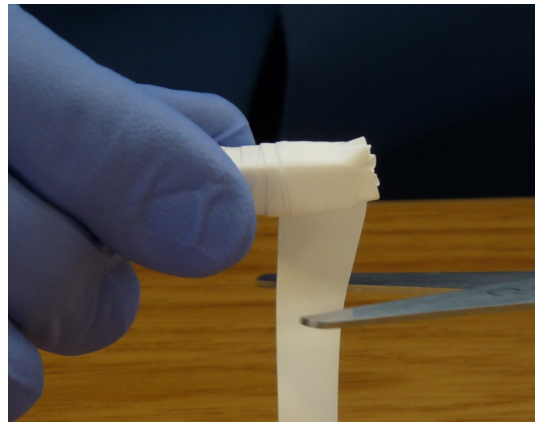
3) After the first wrap, cover this same area with at least another two layers. You should aim to have 3 layers of teflon tape covering the five non-exit surfaces of the crystal.



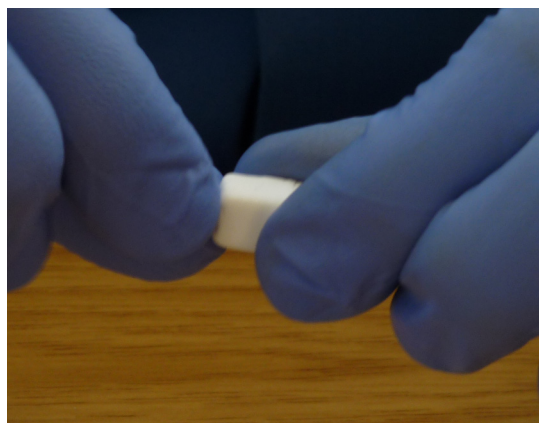
4) Continue to wrap up the length of the crystal, avoid wrinkles or damage to the tape. Aim for 3 layers of teflon coverage.



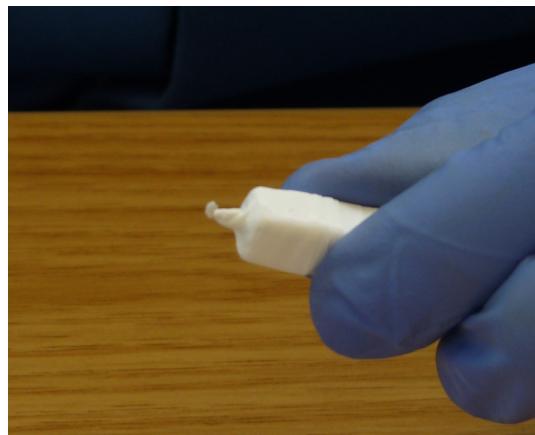
5) Continue to wrap until the tape is generously overlapping the end. Ensure there are 3 layers of this overlap.



6) Cut off any excess tape and wrap the tape end around the crystal. The teflon tape adheres to itself well enough that it should stay in place by itself.



7) Pinch together the overlapping ends of the teflon tape to seal the face opposite the exit surface of the crystal. Ensure that it is done tightly so that it remains secure.



8) The end will look like this. The point can be trimmed off if desired. The wrapped crystal is now ready for use.

One should note that over time optical grease may get partially absorbed by the teflon tape causing noticeable deterioration of light reflectance. Therefore, SensL recommends re-wrapping the crystal after every measurement to ensure the best light collection.