Investigation of SiPMs for use at a Pulsed Muon Source

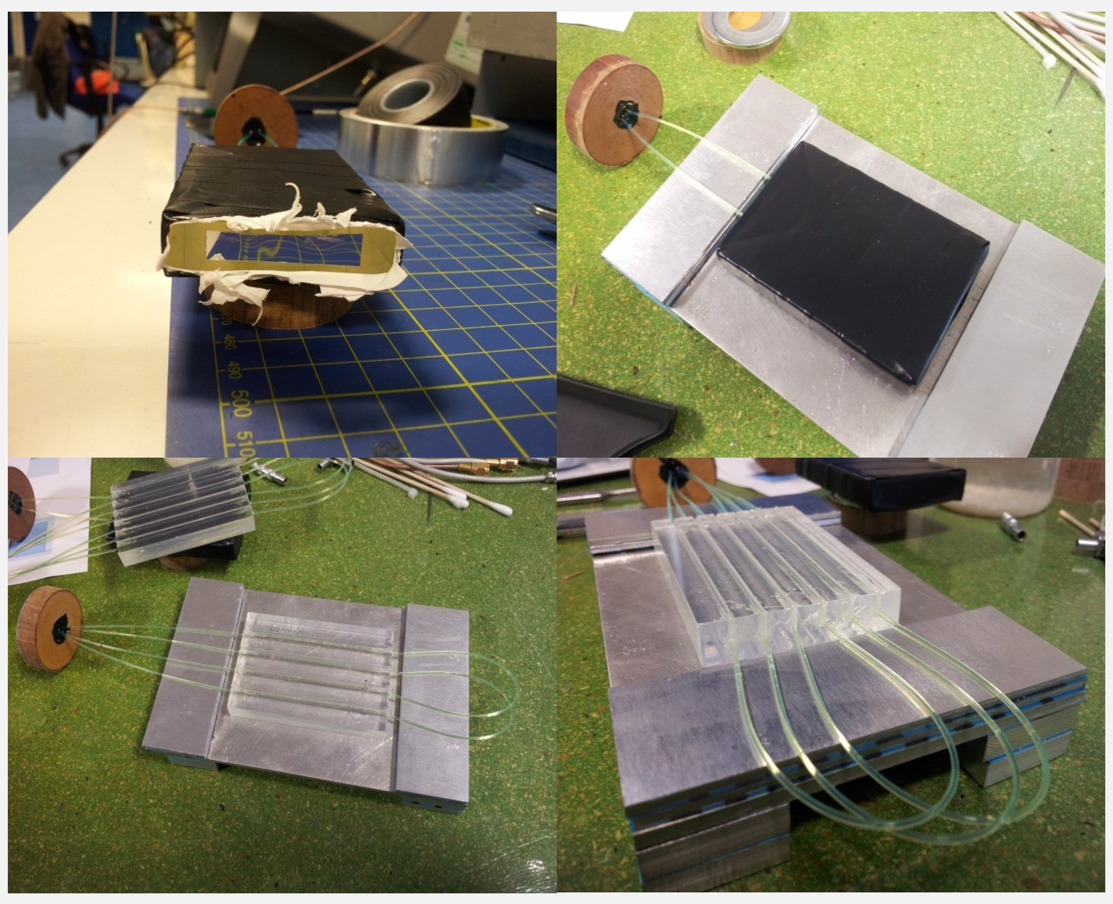
D.E Pooley, L Pollastri, E.M Schooneveld, N.J Rhodes, J.N.T Peck, S.P Cottrell, A.D Hillier
ISIS, STFC, Rutherford Appleton Laboratory, Harwell Oxford, UK

1. Motivation

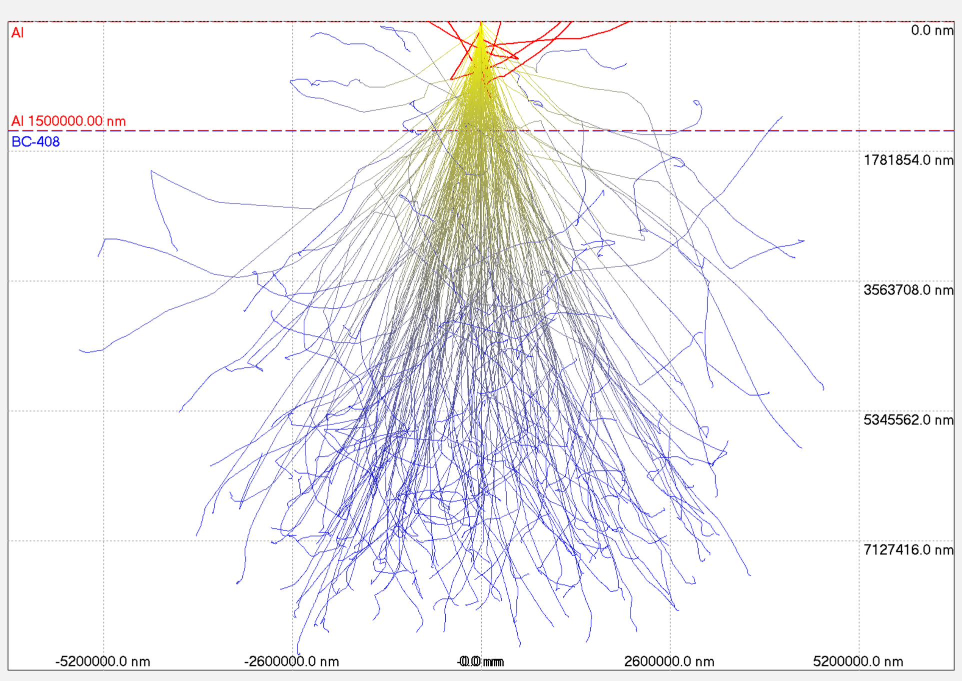
As part of the Neutron and Muon I3 (EU FP7) we have been evaluating the application of SiPMs for use at pulsed muon sources. For this application, fast detectors are required to avoid significant dead time distortion of the µSR spectra.

2. Build and Characterisation

The optical coupling of WSF and the BC400 plastic scintillator was investigated. Parameters investigated included: fibre type, number of fibres per volume, fibre position, fibre depth and fibre termination efficiency, where light was collected from one or both ends of the fibre.



Each test element was evaluated using a calibrated beta source (^{90}Sr). To be sure that that the scintillator was of adequate thickness CASINO simulations were run, which show all ^{90}Sr electrons are stopped in 10mm of plastic scintillator.

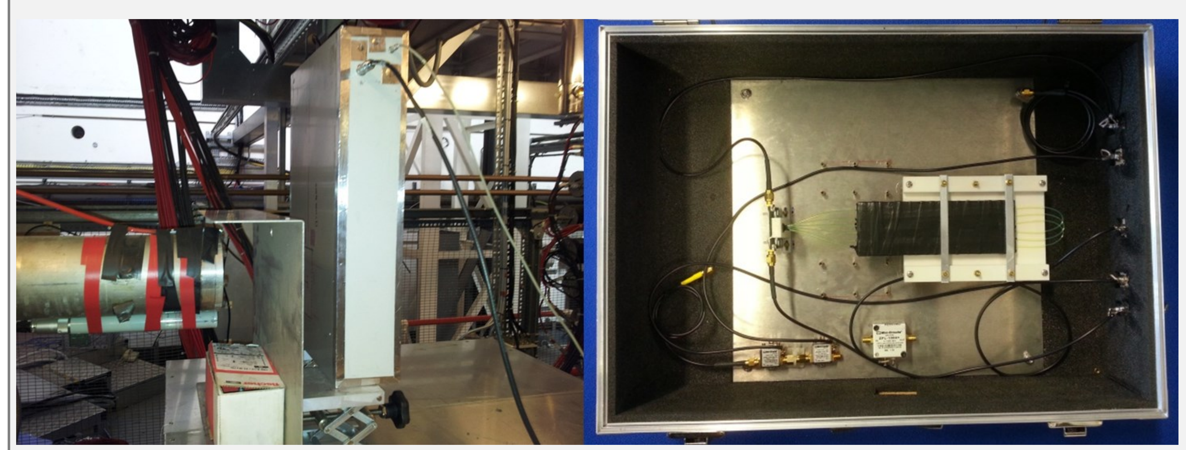


Silicon SiPMs used in this investigation:

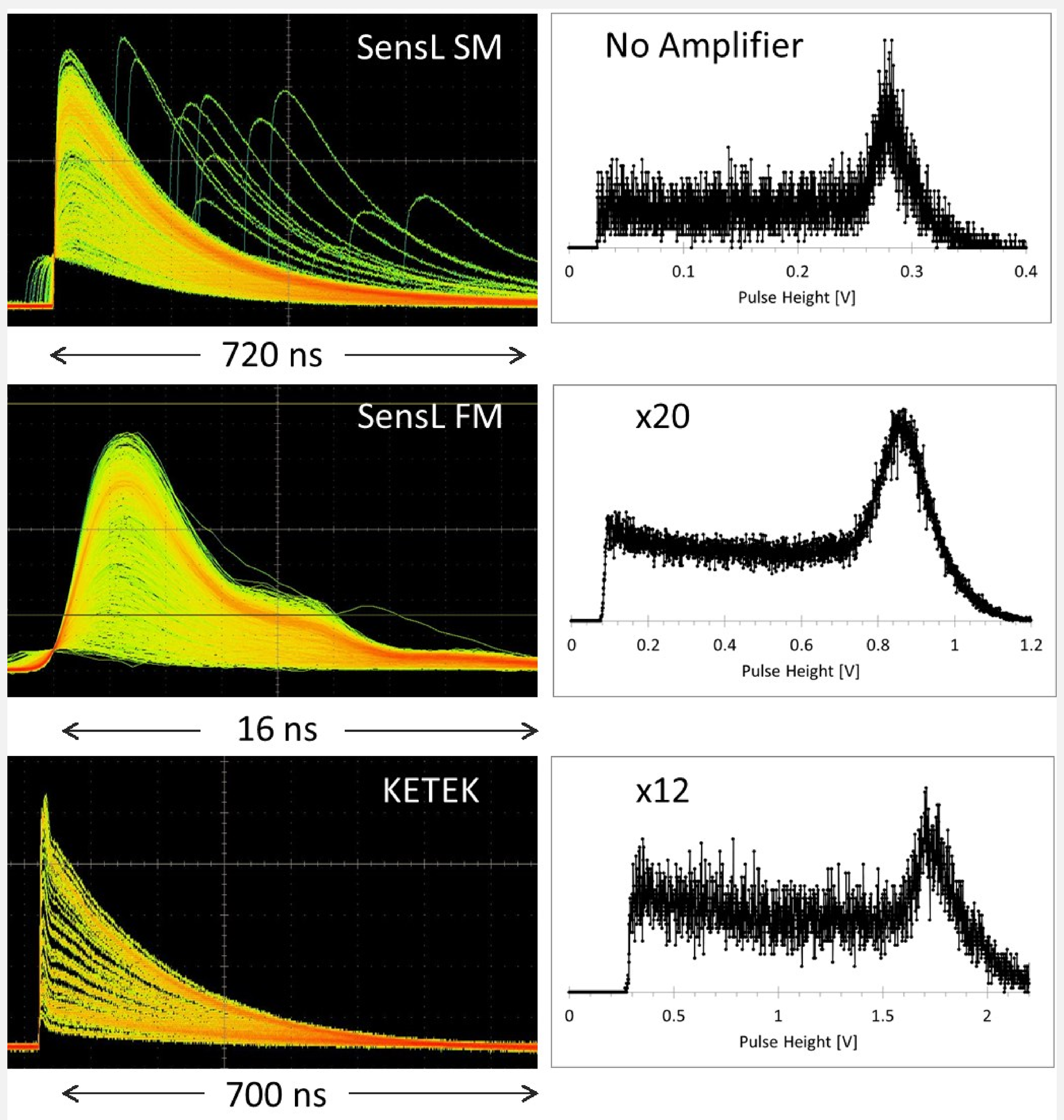
Manufacturer	Name	Product	Pixel Size [um]	Sensor Size [mm]
SensL	MicroFM	SMA-30050	50	3 x 3
SensL	MicroSM	30050-X13	50	3 x 3
KETEK	Optical Trench Isolation	PM3350TS-SB0	50	3 x 3

3. Muon Beam Evaluation

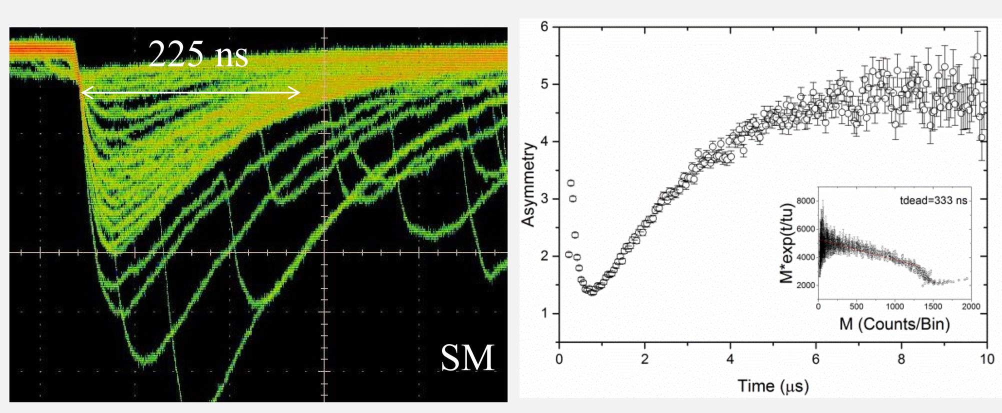
µSR spectra were recorded for muons stopped in an Al target. A scintillating element was coupled to the SiPM, positioned downstream of the sample.



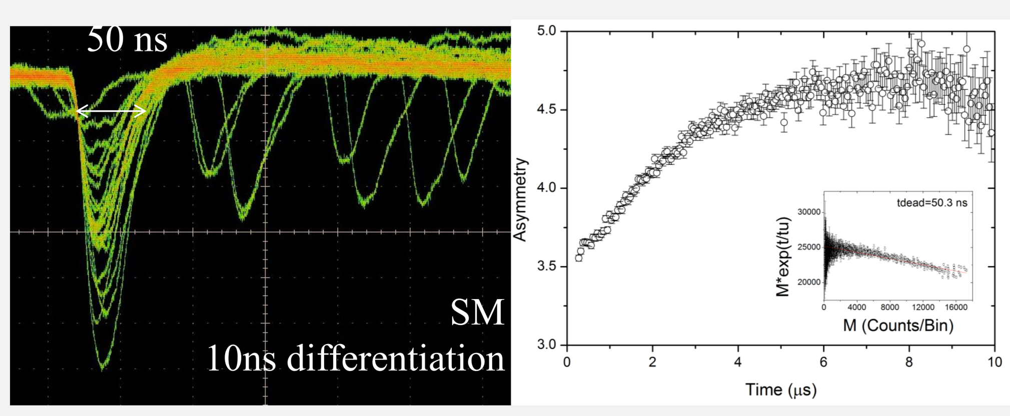
The three SiPMs were characterised on the MuSR beam line at ISIS. Typical signals are shown, alongside their pulse height spectra.



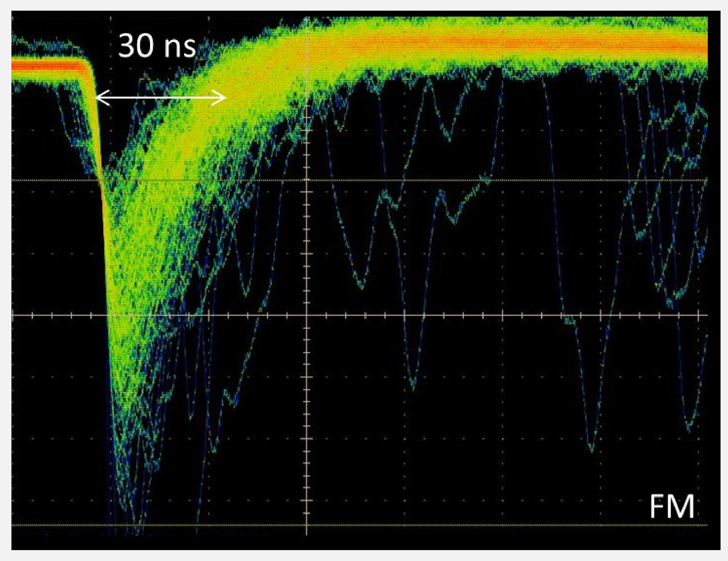
Initially the SensL slow mode SiPM was measured as it gave the biggest signals. The long decay time of the signal is reflected in the asymmetry plot by significant distortion at short times.



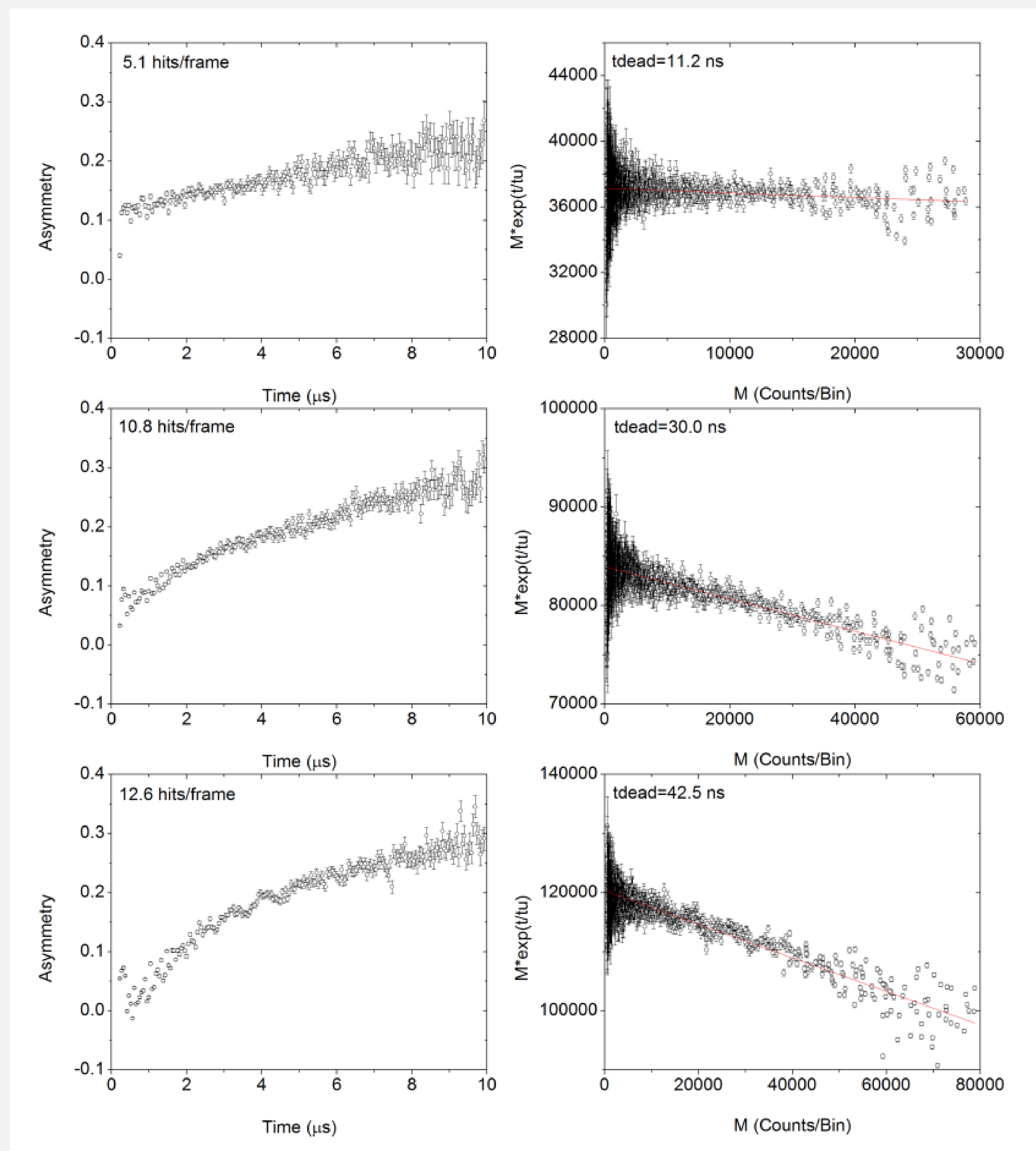
The situation is greatly improved by signal processing. Differentiated signals are shown with the corresponding improvement in the asymmetry plot.



The SensL fast mode device, which provided on chip differentiation, was therefore investigated. The signal decay times were further improved.



To characterise dead time performance, µSR spectra were recorded at various count rates typical for µSR experiments.



Dead time was investigated by fitting to the non-paralysable model [1]. The values are significantly longer than the ~10ns measured for PMTs, limiting high rate performance. Unexpectedly the fitted values for dead time appear to be rate dependent.

4. Conclusion and Outlook

While SiPMs are excellent for use in fast timing applications and high magnetic fields [2] they appear to be limited in their application at pulsed muon sources where high instantaneous counting rates are typical.

Results presented here will form a larger investigation into SiPM dead time, complementing work at J-PARC [3].

[1]W. R. Leo, Techniques for Nuclear and Particle Physics Experiments: A How-To Approach, Springer-Verlag, 1994. [2] A. Stoykov *et.al.* NIM A, vol. 610, p. 374, 2009. [3] R. Kadono and Y. Miyake, Rep. Prog. Phys., vol. 75, p. 026302, 2012.