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Detector Technologies for Pulsed Muon Sources – Part Two

Work within this Task is focussed on understanding how APD detector technologies might be applied at pulsed muon sources, where the need to measure very high instantaneous data rates following muon implantation presents a unique challenge for detector systems.

Early project planning highlighted the need for an APD test array to allow a systematic study of the performance and operating parameters of APD-based detectors, enabling them to be properly characterised and compared to equivalent PMT-based systems. The requirements of this test array together with the methodology for the study was described in the document 'Detector Technologies for Pulsed Muon Sources – Design of an APD Test Array (part 1)', part satisfying JRA deliverable D17.8.

Following from this document, a modular test system was implemented to allow on-beam evaluation of a number of alternative APD devices and pre-amplifiers. Large area scintillation elements were designed to allow devices to be tested at realistic data rates, the absolute rate being controlled both by adjusting both the beam collimating slits and the sold angle covered by the detector. Detailed reporting will form part of deliverable D17.10; however, preliminary results suggest that while these devices have excellent signal/noise characteristics for use in muon instrument detector arrays, their performance at very high data rates is currently not ideal because of their extended dead time.

A programme of work focussed on developing APD-based detectors for pulsed muon instruments is on-going at the J-PARC pulsed muon source (see http://j-parc.jp/MatLife/en/index.html# for background information on the facility). Discussions during a recent visit by ISIS staff suggested that both the J-PARC and ISIS groups have encountered similar performance issues with APD-based detectors on pulsed beam instruments, with the J-PARC group reporting a pulse pair resolution in excess of 100ns and a rate dependent distortion of typical μSR spectra.

The Muon JRA project within FP7-II originally envisaged the development of a prototype APD-based detector for the ISIS HiFi spectrometer, designed as a transverse detector for pulsed RF measurements. However, early results obtained from the test system have highlighted the need for further basic research to understand how to properly characterise the dead time of these devices and to develop methods for minimising the distortions that are currently seen in μSR signals. Development of a complex APD-based detector is clearly premature, and work within the remaining period of the JRA will instead focus on establishing operating parameters and an optimised design for using APD devices at high data rates.

The project will therefore continue as follows:

- Develop on-beam measurements using a refined APD test array with a particular focus on understanding and reliably quantifying the dead time of various APD-based detectors. Recent work has highlighted the need to study both SensL and Hamamatsu devices, while trends in the dead time with device pixilation may also merit investigation.

- Develop off-beam measurements to provide an efficient method for systematically calibrating dead times of these devices and to investigate timing resolution. This setup will

also provide an essential method of ‘quality control’ for systems intended for beamline experiments.

On-going discussions with the group at J-PARC are envisaged. The APD test programme is resource intensive both in terms of beam time and staff effort, and a wider collaboration is likely to be highly beneficial to the project.

The equipment developed to complete this research programme (including the existing modular test system) will form deliverable D17.9 (prototype APD detector array for an ISIS spectrometer). Results of this extended research programme will be reported as part of deliverable D17.10 (results of on-beam evaluation) scheduled for month 48 of the project.

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