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Fast Detectors and Electronics for Nuclear Resonant Scattering of Synchrotron Radiation

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In nuclear resonant scattering (NRS) experiments the nuclear decay following the excitation of the sample by a synchrotron radiation pulse is monitored by fast avalanche photo diodes (APD) [1]. In this presentation we focus on recent developments on a 16 element APD detector, the application of a fast time to digital converter (TDC) [2] for enhanced pulse detection, and a fast digitizer for time resolved pulse shape analysis.
The 16 element APD detector consists of 16 single Hamamatsu APDs (type S5444LC, 3 mm diameter and 30 µm thickness), yielding a time resolution of 0.3 ns each. By inclining and stacking all modules one is able to accept variable beam size, the beam intensity is distributed on all APDs, resulting in a reduced load on each APD and the performance especially at early times after the intense prompt pulse is significantly improved. In this arrangement we achieved an efficiency of about 15% and a time resolution below 0.8 ns at a photon energy as high as 73 keV at the 193Ir resonance.
Classical NIM-based timing electronics requires a veto region up to 8 ns after the prompt pulse. The TDC (FAST Comtec MCS6A, up to 5 input channels) can operate veto-free, with 100 ps time resolution up to 8 MHz event rate. It allows fitting of data already 2.5 ns after the prompt pulse. Moreover, the TDC provides the capability to count multiple events per excitation, a feature, which is, e.g., important for NRS experiments at free electron lasers.
The fast digitizer based on commercial electronics from SP devices [3] allows for time resolved pulse height and shape analysis with a sampling rate of 4 GHz. This allows one to time and count multiple events per excitation, and in Nuclear Inelastic Scattering the digitizer provides the possibility to separate the time dependencies of the 6.4 keV x-ray fluorescence and 14.4 keV gamma fluorescence recorded simultaneously.
References
1) A.Q.R. Baron, S. Kishimoto, J. Morse, J.-M. Rigal, JSR 13, 131 (2000)
2) https://www.fastcomtec.com/
3) https://www.spdevices.com/

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