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Field-programmable gate array (FPGA) TDC module for Fermilab SeaQuest (E906) experiment

We develop a field-programmable gate array (FPGA) TDC module for Fermilab SeaQuest (E906) experiment. This 64-channel TDC is made of a 6U VMEbus unit equipping with a Microsemi ProASIC3 Flash based FPGA of low power and high radiation tolerance. The TDC firmware could digitize multiple hits of both polarities and possesses a multiple-hit elimination functionality which could be turned on to remove after-pulses in the wire chambers and proportional tubes. A scaler module is implemented to record the number of hits for each channel. The TDC resolution is determined by internal cell delays of 450 ps, and a measurement precision of 200 ps has been achieved. Furthermore we demonstrate the way of constructing the Wave Union TDC using the current multi-hit TDC with an external wave union launchers. Based on a four-edge wave union the measurement precision is improved by a factor of 2, 108 ps. Even more significant improvement of measurement precision up to 69 ps is achieved by combining the approaches of Wave Union TDC and multiple-channel ganging.

Primary author: Ms WANG, Su-Yin (IPAS/Fermilab/NKNU)

Co-authors: SU, Da-Shung (IPAS, Taiwan); CHRISTIAN, David (Fermilab); YAO, Hsi-Hung (IPAS,Taiwan); WU, Jin-Yuan (Fermilab); CHANG, Wen-Chen (IPAS, Taiwan)

Presenter: Ms WANG, Su-Yin (IPAS/Fermilab/NKNU)