Contribution ID: **16** Type: **POSTER**

A User-friendly Fully Digital TDPAC-Spectrometer

The new user-friendly fully digital TDPAC spectrometer consists of 6 detectors (38 mm diameter x 38 mm height LaBr3(Ce) scintillators mounted on XP2020URQ photomultipliers; energy resolution DE/E = 3% at 662 keV) arranged in a cube (see fig.1), a PXI system with 3 digitizer cards of the type AC240 (each card has 2 channels and one FPGA, see fig.1), and a single PC with a special PCI card to communicate with the PXI system.
Each digitizer channel runs with a sample rate of 1GS/s and for every digitizer channel there is an independent data stream. These 6 data streams are fed into 3 FPGAs. The task of the FPGA is to process the data streams by real parallel digital hardware. The FPGA has 2 main tasks: (i) search for pulses and calculate the pulse area for the energy histogram (takes 265 ns); (ii) search for pulses and calculate their timestamps by the CFD method (takes 1354 ns).
To calculate a timestamp in the FPGA a 5 stage pipelined digital circuit is used: 1) Detection of pulse by a threshold comparison in order to filter uninteresting data. 2) Summation of the digitized data stream for the energy determination. 3) Classification of the pulses by the calculated energy area from stage 2. This is done by a comparison with a given energy window. 4) Fitting a polynomial of degree 3 by 4 points around the CFD level. 5) Finding the CFD timestamp with a binary search algorithm by comparing the CFD level with the values of the polynomial.
After stage 5 the calculated timestamp is saved into a FIFO inside the FPGA. The FIFO is built by FPGA internal BRAMs. Stage 5 is the bottleneck with a throughput of 1.05 million timestamp per second. The spectrometer creates a timestamp data stream of 8.4 MByte/s per channel, i.e. a 50.4 MByte/s data stream from the digitizers to the PC. In a typical application we have a pulse rate of 5 kHz per channel, i.e. a data stream of only 240 kByte/s from the digitizers to the PC.
The PC with Windows XP executes the spectrometer software which collects the datasets from the digitizers via PCI DMA transfers (85 MByte/s).
The software runs on an Intel Core2Duo CPU with 1.8GHz. For the time spectrum the software executes a coincidence search, the critical part of the spectrometer software. The coincidence search has a throughput of 7 million timestamp comparisons per second.

Fig.1 Left: 6-detector cube with conventional analog electronics and cable delays Right: 3 digitizer car

Poster presentation

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Track Classification: New Directions and Developments in Methodology