Real Time Event Building for a Pixel Tracking Telescope Using an Advanced Mezzanine Card and MicroTCA

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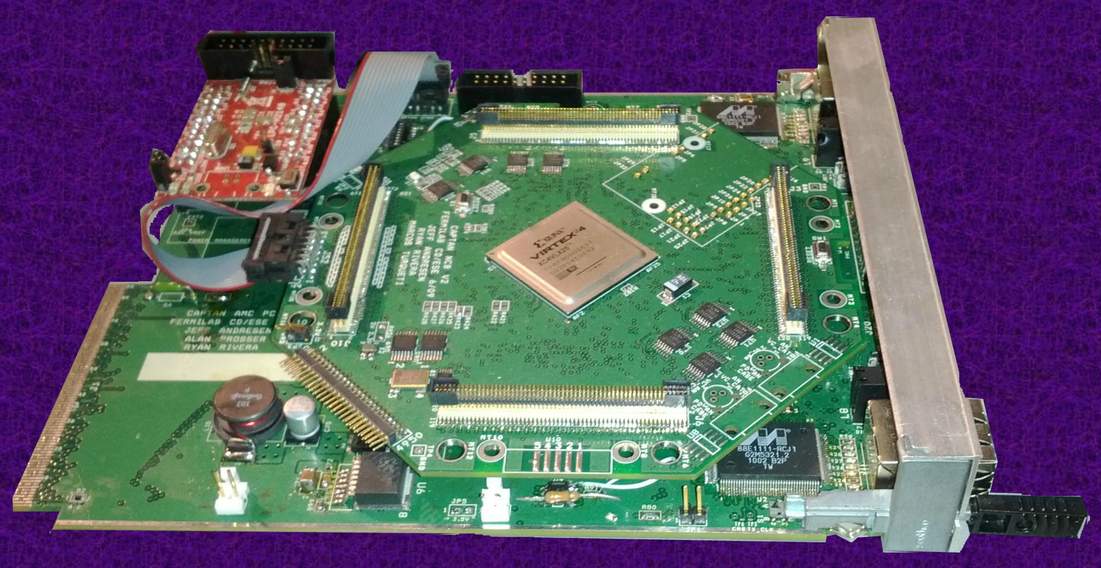


Abstract – The Electronic Systems Engineering Department of the Computing Sector at the Fermi National Accelerator Laboratory has designed a pixel tracking telescope which is part of the Fermilab Test Beam Facility (FTBF). In the data path between the telescope, data acquisition components, and a PC is a commercial MicroTCA crate which houses an Advanced Mezzanine Card (AMC). This AMC receives, buffers, and processes the data from the tracking telescope, transmitting complete assembled events to the PC in real-time. This approach makes possible the rapid assessment of the data and pixel telescope alignment and improves the efficient use of the beam. In earlier versions of this system, the telescope would push all of its data to a PC where the data was stored to disk. Then event assembly, geometry inference, and particle tracking were all done at a later time. This approach made it difficult to efficiently assess the quality of the data as it was being taken, at times resulting in wasted test beam time. The real time event building is the first step towards a system which will provide real time track reconstruction of test beam data. This poster includes the details of the design approach and the results achieved when the MicroTCA hardware was employed for the first time during a test beam run at the Fermi Test Beam Facility in 2012.

~ System Overview ~

The pixel telescope system layout is shown to the right. The telescope is located within the beam enclosure at the Fermi Test Beam Facility at FNAL. There is a gigabit Ethernet switch that negotiates the network traffic between the three Compact And Programmable daTa Acquisition Node (CAPTAN) stations, the MicroTCA crate, and the PC in the control room. The pixel planes generate data tagged with a trigger number each time a particle passes through the pixel planes and through a scintillator downstream of the telescope.

Prior to this project, all of the raw data from the pixel stations was pushed to the PC where the individual data streams were stored to disk in separate directories. Then an off-line application scanned the separate directories, merged the station data into events based on matching trigger number, and saved the resulting merged data file to disk.

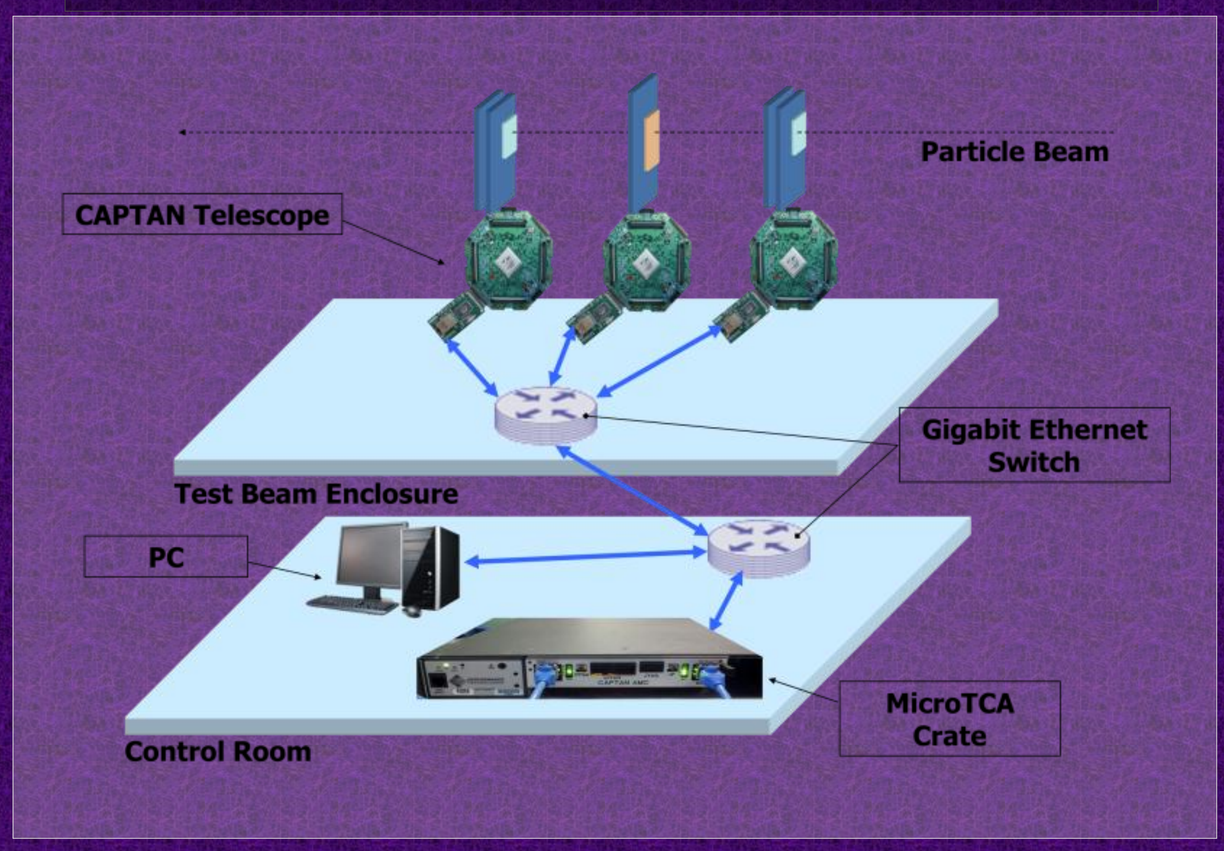
With the addition of the MicroTCA crate and our AMC, the event building occurs in real-time thus bypassing the need for the intermediate storage of the raw data. The PC receives only completed events for storage, and the analysis of the runs can begin with geometry inference, followed by track reconstruction.

~ Real-Time Event Assembly ~

The MicroTCA card which handles the real-time event assembly was designed by the Electronic Systems Engineering Department at FNAL and is shown above. It meets the physical specifications for a full-size, double width Advanced Mezzanine Card (AMC). It relies on two daughter cards to provide the functionality: one daughter card to act as the Module Management Controller (MMC) that is required under the MicroTCA standard, and one to conduct the event assembly.

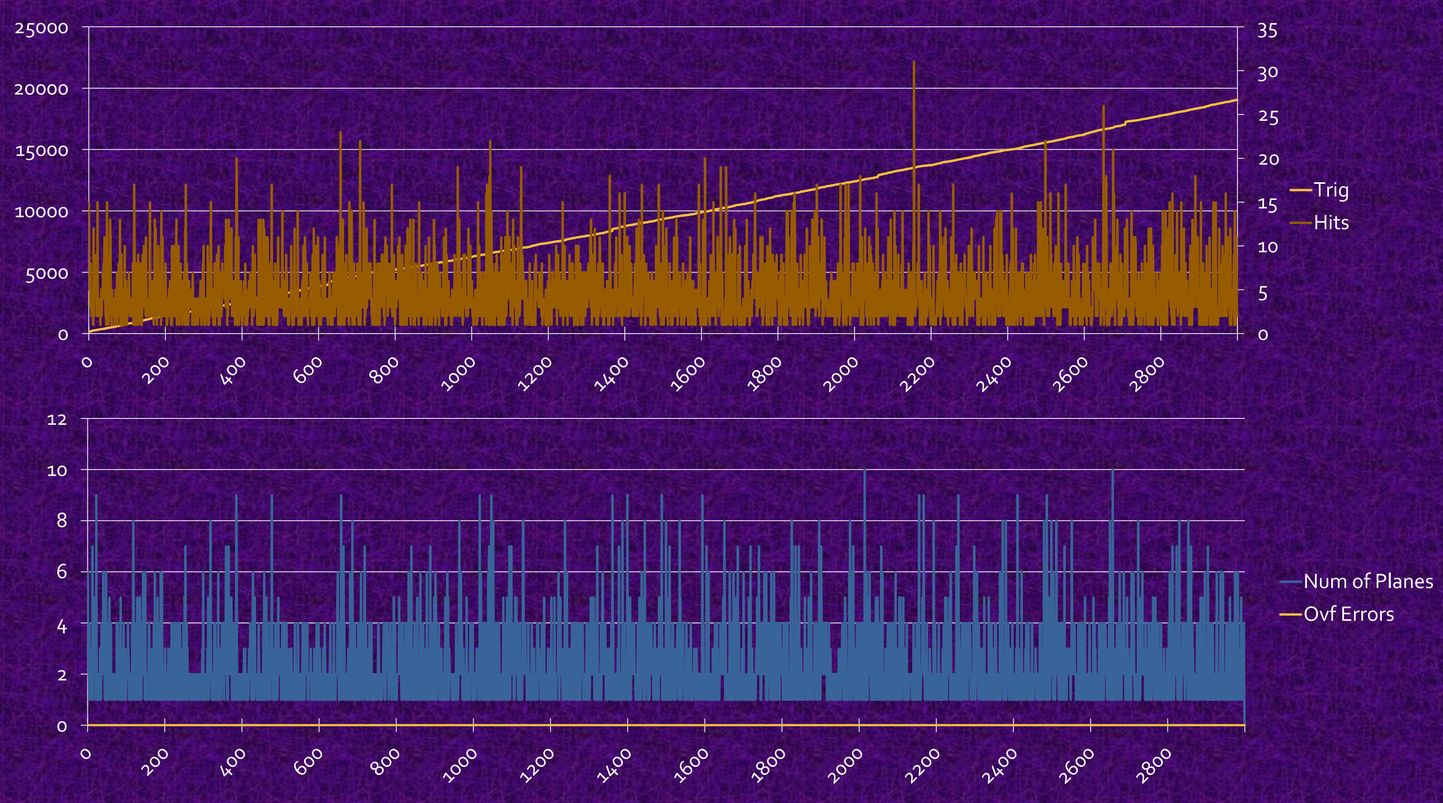
The MMC daughter card is the LPC-H2148 from Olimex. It utilizes the LPC2148 microcontroller and is programmed with C code. The MMC orchestrates communication with the shelf manager of the MicroTCA crate to request power, respond to status requests, and access crate resources.

The event assembly daughter card is an additional CAPTAN – identical to the hardware used in the tracking telescope. We already possessed CAPTAN boards with Virtex-4 FPGAs, so compatible connectors were designed into the AMC to leverage the hardware already on hand. The CAPTAN on-board FPGA affords the processing power and memory for the event assembly algorithm.



Run 1117 - Running parasitically

(3378 events total)



~ Results ~

Due to the 2012 accelerator complex shutdown at Fermilab, the Fermi Test Beam Facility beam time was in high demand when this project was ready to acquire data. However, we were able to take several good runs while running parasitically with another test beam experiment. These runs lent confidence to our real-time event assembly algorithm.

In order to assess the event assembly algorithm, the data from the telescope was forwarded, both to the PC, as had been done in the past, and to the AMC in the MicroTCA crate. Then the merged file from the PC was crosschecked with the assembled events generated by the AMC. Results from a run where complete agreement was found are shown on the left.

Above, the combined hit count (right Y-axis) from all the telescope pixel detectors is shown for each assembled event. The telescope had 10 pixel planes of varying size and orientation, and was situated off-axis with respect to the beam center. The off-axis position accounts for the <10 average hit value. On the same graph, the sequential trigger number (left Y-axis) is present. The scintillator was noisy, so the small vertical discontinuities arise from the time (~60 seconds) between beam spills.

Below, the number of telescope pixel planes present is shown for each assembled event. Although rare, there are events in which all 10 planes report a hit. On the same graph, the number of overflow errors is shown coinciding with each event. These errors would be due to an internal memory overflow detected in the FPGA configware. During this run there were no overflow errors for the duration of the 3,378 assembled events.

~Future Work~

The results presented here represent an encouraging first step towards a system which includes real time track reconstruction capability. A new AMC, known as FIONA (Fast Input/Output Networked AMC) is now being designed at Fermilab. FIONA will include a more powerful FPGA with DDR3 memory for track data storage and high speed parallel optics. The design will be a mid-size, double width MicroTCA format including a rear transition module (RTM) for the optical interfaces.

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