Crate Distribution and Trigger Processing Module for the KOTO Experiment

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This paper introduces a new Crate Distribution and Trigger Processing Module (CDT) designed for the KOTO Experiment at J-PARC, Japan. The CDT Module will work in the existing KOTO-ADC crates. Each 6UVME Crate includes 16 ADC Modules which require an 8ns sampling clock and two trigger pulses. This new Module receives these signals from the System Master and distributes them to the ADCs via CAT6 Interconnects. In addition to this Fan-Out Function, the new CDT Modules collect high speed serial LVDS Data from the ADC modules, representing Cluster Bits of the Cesium Iodide Calorimeter elements from each ADC Channel. This new feature doesn't require new ADC hardware and the Cluster Data are recorded via the same CAT6 cables that are used for Fan-Out. All local Cluster Bits from the KOTO CsI Crates are gathered into one place, a Decision Making CDT (DM-CDT), where a system Cluster Map is generated. Communication between the Crate CDT and the DM-CDT is done via optical Links at 2.5Gbps data rate. Cluster Numbers, calculated inside the DM-CDT, are sent to Master via a CAT6 cable. Currently in the KOTO Experiment, the Level-1 Trigger decision is made based on the Total Energy of the Calorimeter. The Cluster Numbers collected with the new CDT, will be used in combination to the Total Energy values for an enhanced Level-1 Trigger decision. The full design and final test results are presented.

ARCHITECTURE

The CDT Module was designed to work in the existing KOTO-ADC Crates. Each crate includes 16 ADC Modules, which require a clock and two trigger pulses: Level One Accept Trigger (L1A) and LIVE. The CDT Module receives these signals from the System Master and distributes them to the ADC Modules.

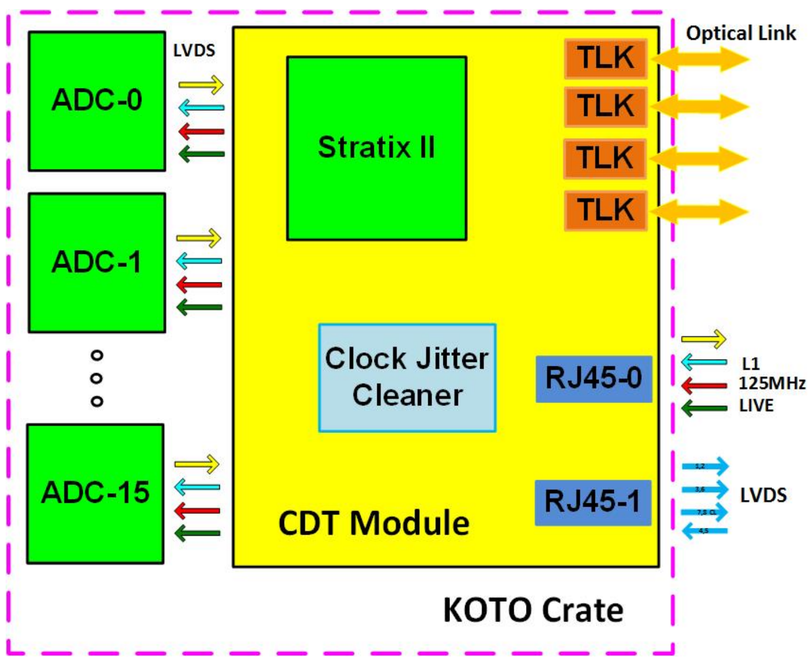

Figure1. Block Diagram of the Crate Distribution and Trigger Processing Module.

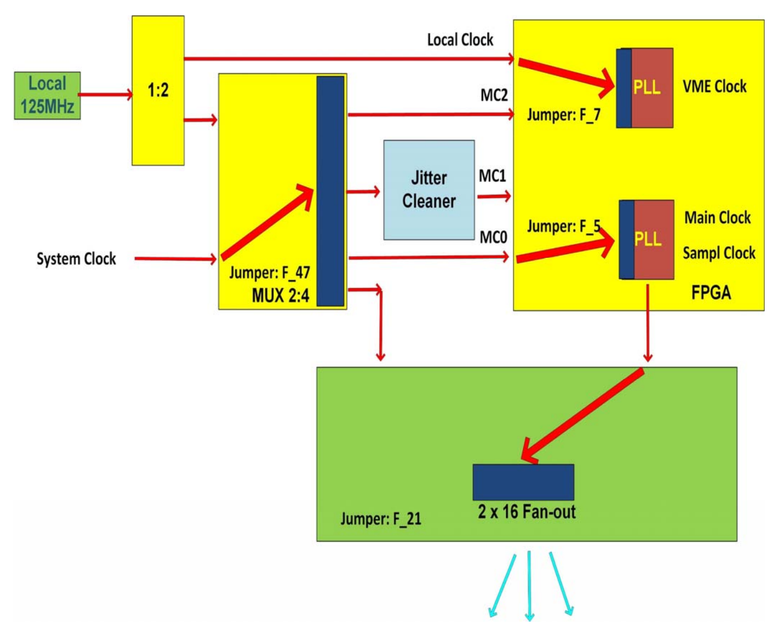

Figure2. Block Diagram of the Clock Distribution Block.

Figure 2 presents the Block Diagram of the Clock Distribution Block inside the CDT. Many clock combinations are possible by changing internal jumpers and/or by VME Commands.

The Block Diagram of the CDT Module installed in a KOTO CsI Crate, is presented in Figure 1. All ADC Modules in KOTO run on the same 8ns sampling clock.

Cluster Bits are continuously generated inside the ADCs each time a recorded sample is above a preset threshold.

In addition to this Fan-Out Function, the CDT Modules located in the 16 KOTO CsI Crates collect serial LVDS Data from the ADC modules, representing Cluster Bits for each ADC Channel.

This new feature doesn't require new ADC hardware and the Cluster Data are recorded via the same CAT5 cables that are used for Fan-Out.

KOTO CLUSTER TRIGGER

Using the new CDT Module, a Cluster Map of the entire CsI Detector can be created for each L1A event. Before each L1A, Cluster Bits from CsI ADCs are collected by the Crate's new CDT, via the existing CAT6 cables. Eventually, all Cluster Bits from the CsI Crates are gathered into one place, where the Cluster Map is generated, and Cluster Numbers are calculated and sent to Master. Based on these numbers, a final L1A decision is made inside Master.

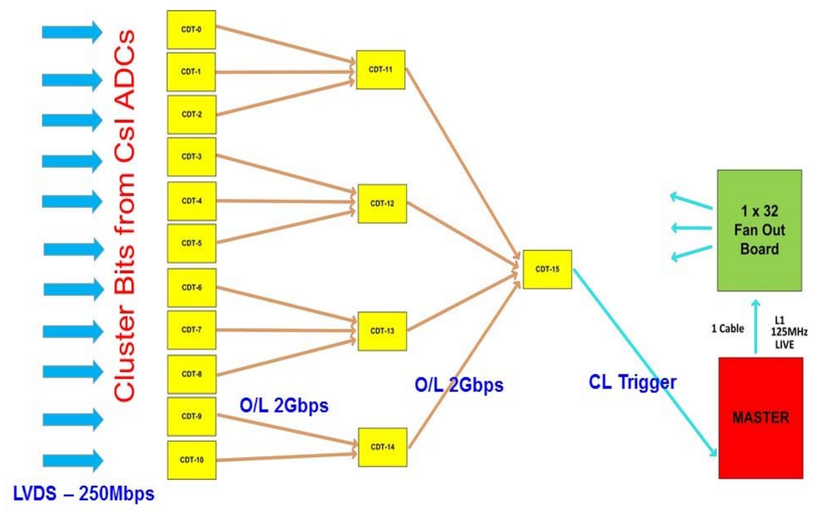

Figure 3. KOTO Cluster Trigger with the new CDT Module. To generate the Cluster Trigger, all of the system Cluster Bits are collected into one place. In this configuration, the same CDT Module performs three different functions, based on the loaded firmware.

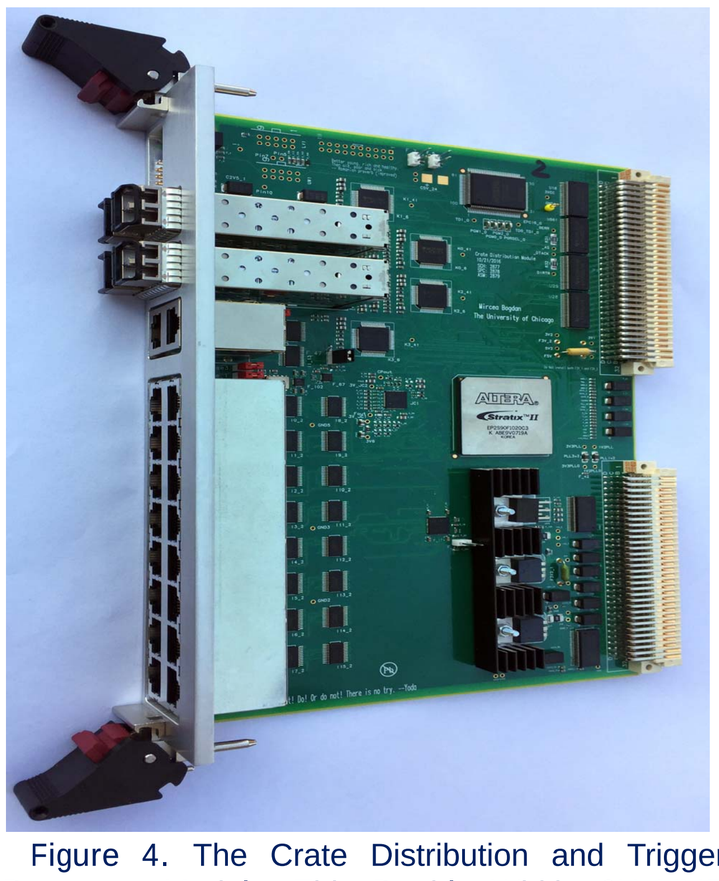

Figure 4. The Crate Distribution and Trigger Processor Module. This Double Width, 6U VME Module can service up to 16 ADC Boards.

Since the Cluster Trigger function is separated from the Fan-Out function, the CDT was designed such that it can collect Cluster Bits from the ADCs and send them out on the Optical Links (OL), or it can merge data from 3 OLs into one, or it can create the full Cluster Map and calculate the Cluster Numbers.

These functionality modifications are made by changing firmware in the same PCBs. Figure 3 present the Cluster Trigger structure in which the CsI CDTs are collecting the Cluster Bits, and the non-CsI CDTs are performing the above mentioned functions.

CONCLUSIONS

18 pieces CDT Module were installed at J-PARC and successfully tested with Beam.

This new module allows the counting of final state photon clusters within a few microseconds and opens up additional kaon decay channels to be studied.

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