Data acquisition system based on fast waveform digitizers for large neutrino detectors

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DAQ system requirements

For modern large volume neutrino and antineutrino detectors it is crucial to have an efficient data acquisition system with following characteristics:

- Ability to process data from hundreds or thousands of detection channels
- Zero dead time acquisition
- Complex and configurable trigger logic
- Remote control and configuration “on the fly”

General DAQ system architecture

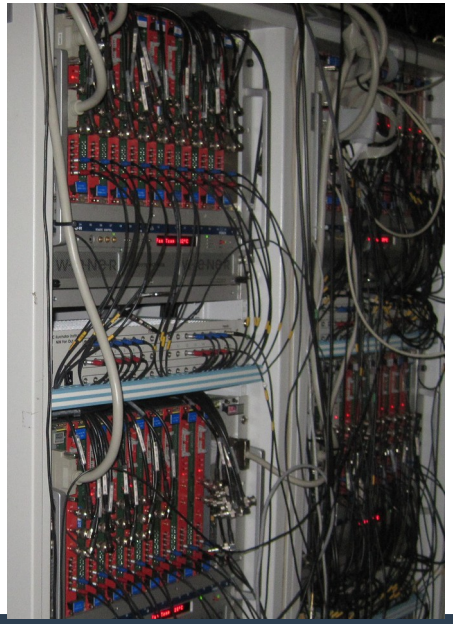
- **Based on flash ADCs (fast waveform digitizers).**
- **Trigger signal generation is based on programmable logic (FPGA) unit for maximum flexibility and performance.**
- **Digital trigger source signals are provided by programmable discriminator to allow remote trigger tuning.**
- **Could be easily adapted for usage in different particle physics detectors with large number of channels.**

CAEN V1495 prog. logic unit with VME interface used in Borexino FWFD system.

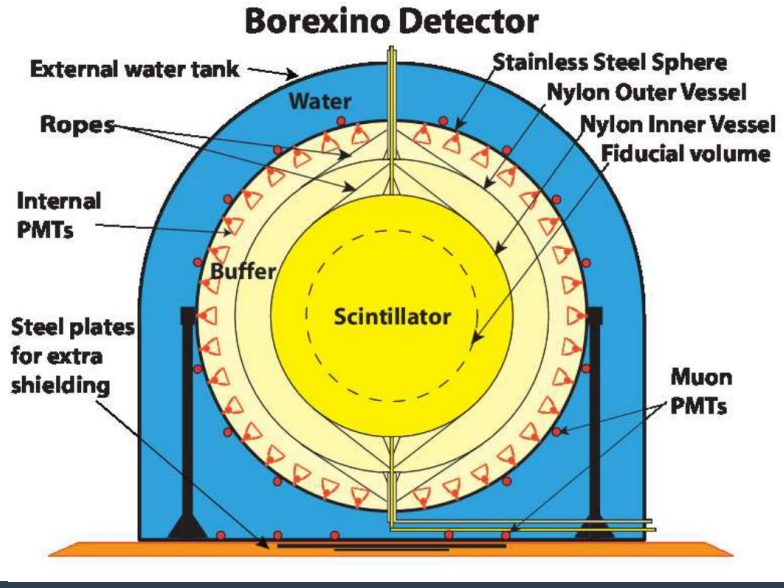
Custom built FPGA-based trigger unit hardware for iDream experiment.

Borexino FWFD DAQ system

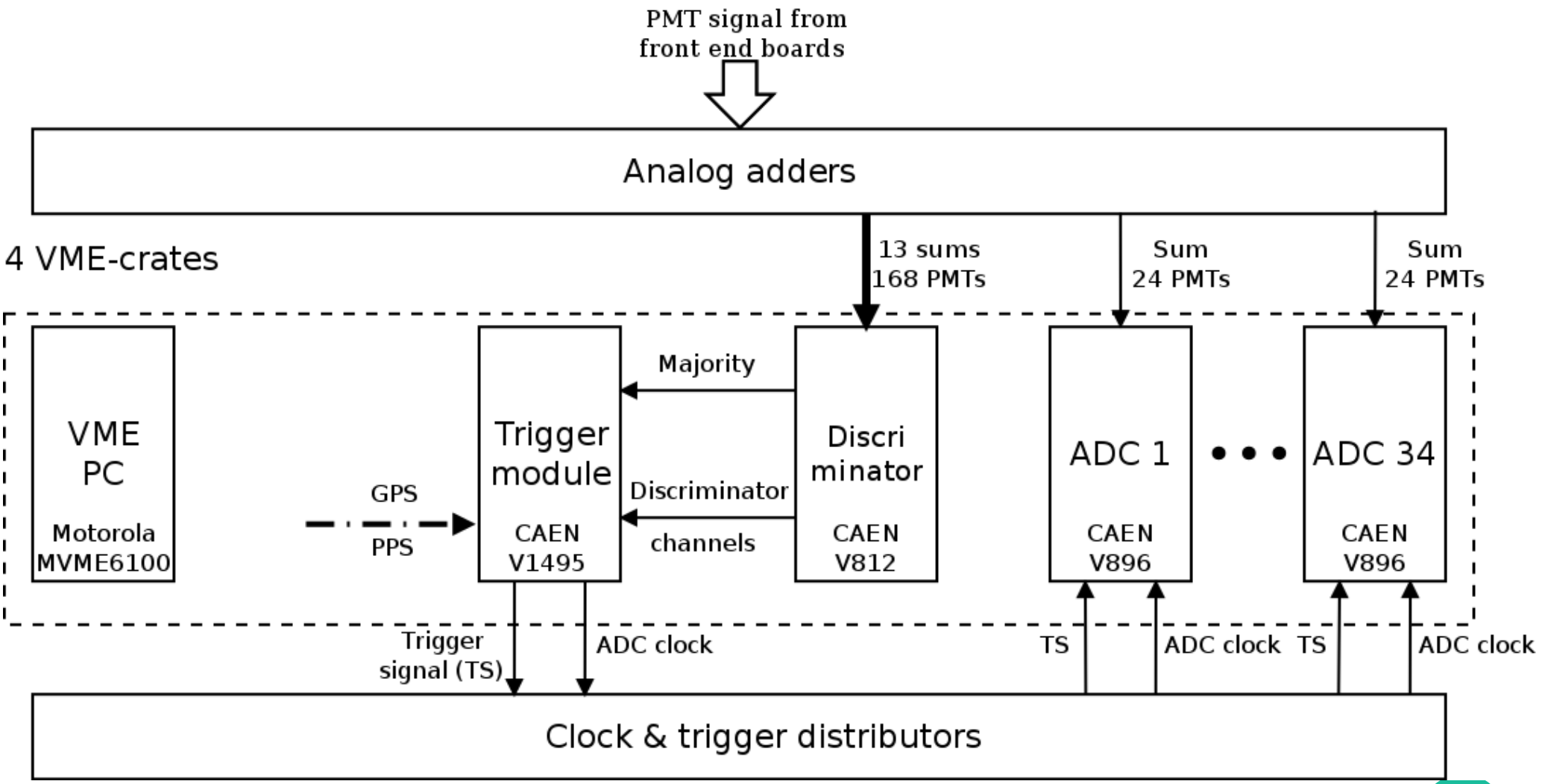
- **Borexino is an ultra low background neutrino scintillation detector located in underground Laboratori Nazionali del Gran Sasso (Italy) on the depth of 3800 mwe. The target is 278 tons of pseudocumene-based liquid organic scintillator. Scintillations in target are registered by 2212 PMTs.**
- **FWFD DAQ subsystem is based on fast ADCs and is designed to be used for no dead time spectroscopy in energy range 1-100 MeV.**
- **The system is taking data. The data is being used to study cosmogenic backgrounds in Borexino and to search for rare high energy events such as GRB-correlated neutrino flux, DSNB neutrinos and (possibly) SN neutrinos.**



Functioning FWFD DAQ subsystem in Borexino

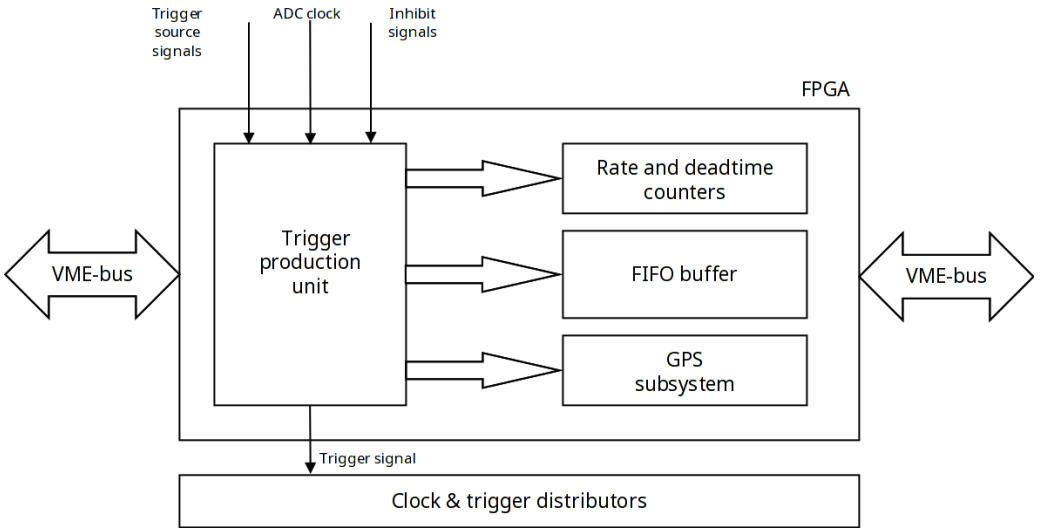


Borexino FWFD system structure



Versatile trigger unit

- **Trigger logic is realised on FPGA programmable logic chip.**
- **All trigger configuration parameters could be adjusted without FPGA reprogramming.**
- **Trigger unit subsystems:**
  - Trigger production
  - Trigger info storage buffer (FIFO)
  - External bus interface
  - Additional functionality modules

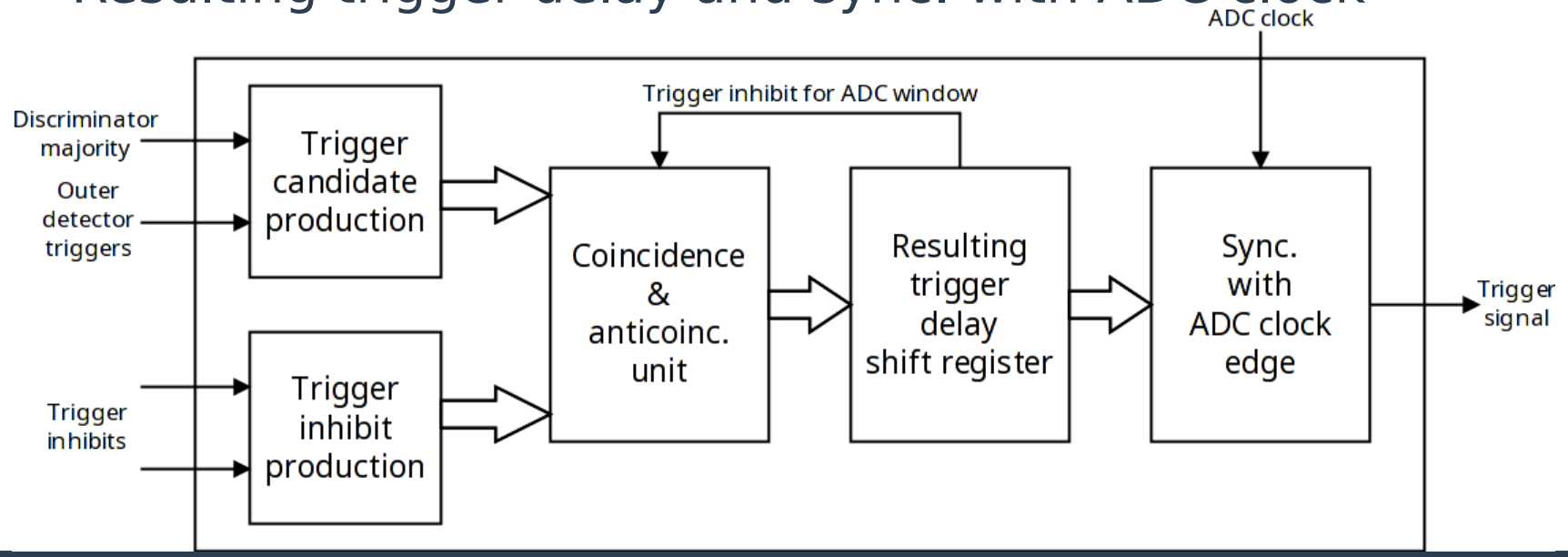


Borexino FWFD trigger unit structure

Trigger production logic

Trigger production stages:

- Trigger sources & inhibits form and delay
- Trigger candidates production from sources and inhibits
- Coincidence/anticoincidence of trigger candidates to generate trigger of one of defined types
- Resulting trigger delay and sync. with ADC clock



Borexino FWFD system additional trigger functionality & performance

Additional trigger unit features:

- GPS time tagging from GPS PPS signal
- Dead/live time counters
- Event rate counters for each trigger type, source and inhibit
- Synchronization with main low-energy DAQ system

Total DAQ system performance:

- 102 8-bit 400 MHz ADC channels
- 16 channel constant fraction discriminator with majority output
- Up to 16 trigger sources and inhibits
- Trigger signal timing jitter less than 10 ns
- Average event readout rate up to 15 Hz (limited by VME configuration)
- Up to 512 events in burst without dead time

Conclusion

A DAQ system architecture built on fast waveform digitizers and FPGA-based trigger was presented. This system is capable of processing data from particle physics detectors with large number of channels and currently its implementation provides data for rare neutrino event analysis in Borexino detector and is being integrated into new iDream detector.