Introduction

The India-based Neutrino Observatory (INO) collaboration is planning to set up a magnetised Iron-Calorimeter (ICAL) to study atmospheric neutrino oscillations. We present here an overview of the R&D for electronics & DAQ for ICAL.

ICAL Parameters

- 3 modules each of size 16m x 16m x 14.5m.
- 150 layers of RPCs interleaved by Iron plates of thickness 56mm.
- 64 (8 x 8) RPCs per layer per module.
- Total of 28,800 RPCs of size 1.95m x 1.84m x 0.024m, with 64 strips (30mm pitch) on either read-out planes.
- Magnetic field of 1.3 Tesla.
- Total of 3,686,400 electronic channels.

ICAL Electronics

Front-end to RPC-DAQ bus

- 8 LVDS pairs of comparator signals.
- Amplified & multiplexed RPC pulse on 50Ω.
- 3-bit channel address bus for multiplexer.
- Power supplies & threshold control (d.c./DAC bus).

RPC DAQ Block Diagram

Front-end specifications

- Process: AMSC3516C5 (0.35µm CMOS).
- Input dynamic range: 18fC–13.6pC.
- Input impedance: 45Ω @ 350MHz.
- Amplifier gain: 8mV/µA.
- 3-dB Bandwidth: 274MHz.
- Rise time 1.2 ns; Comparator sensitivity 2mV.
- LVDS drive 4mA & Power per channel < 20mW.

Specifications for ICAL TDC device

- Either 8 or 16 number of channels TDC with Least Count 200ps used in Common Stop mode.
- Dynamic range: 2 (essential) and 32 (desirable).
- Number of bits: 14 (essential) and 18 (desirable).
- Hits: single hit (essential) and multi hit (desirable).
- Double hit resolution: 5–10ns.
- Readout buffer size: 128 words (maximum).
- Signal & control inputs: LVDS & TTL respectively.
- DNL/INL: 100ps (typical).
- Power rail: 3.0 to 3.6 Volts (suggested).
- Control & readout interface: SPI (essential) & SPI + Parallel (desirable).

Data Interface

- FPGA
- NOS II (with TDC/1P1T chip in software)
- MAC
- PHY
- Ethernet PHY
- RJ45 Jack
- RJ45 Jack

Integration Schematic

Pulse Shape Monitor

- Inverter “Domino” ring chain
- Clock
- “Time stretcher” GHz → MHz
- Waveform stored
- Shift Register

Data Networking

- RPCs designed as network device
- Each RPC will have Embedded FPGA + Linux + TCP/IP
- Forward DAQ by RPC modbus global trigger
- On board desk control monitoring

Advantages of VME: Elegant, compact, components that keep getting better and cheaper, standard protocols and software, future proof, stand-alone device

Figure 1: The 50kton Iron Calorimeter.

Figure 2: The functional diagram for electronics.

Figure 3: Block Diagram for Front End ASIC.

Figure 4: Package CLCC48, Chip area 13mm²

Figure 5: Ref: Stefan Ritt, Paul Scherrer Institute, Switzerland.

Figure 6: RPC DAQ board

Figure 7: Proposed scheme for Network interface

Figure 8: Alternative network based DAQ for INO-ICAL

Figure 9: RPC DAQ and its placement.

Figure 10: Ref: Stefan Ritt, Paul Scherrer Institute, Switzerland.