Electronics and Data Acquisition Systems for the RPC based INO-ICAL Detector

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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.

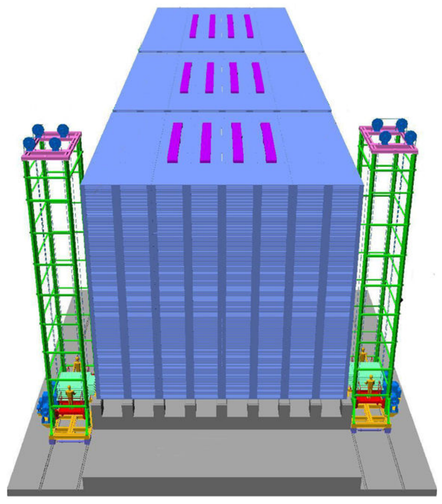

Figure1: The 50kton Iron Calorimeter.

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 (8×8) 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

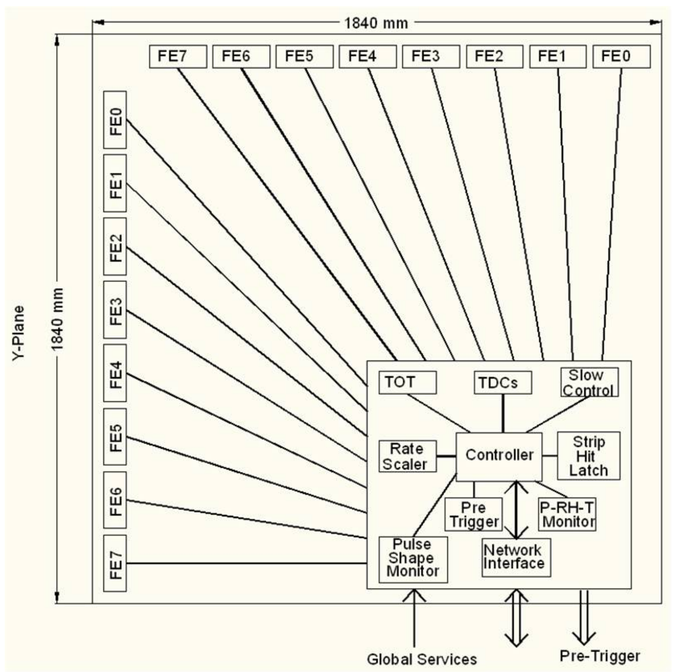

Figure2: The functional diagram for electronics.

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).

Software Requirements

RPC-DAQ controller firmware | Backend online DAQ system | Local & remote shift consoles | Data packing & archival | Event & monitor display panels | Event data quality monitors | Slow control & monitor consoles | Database standards | Plotting & analysis software standards etc.

Front End Electronics

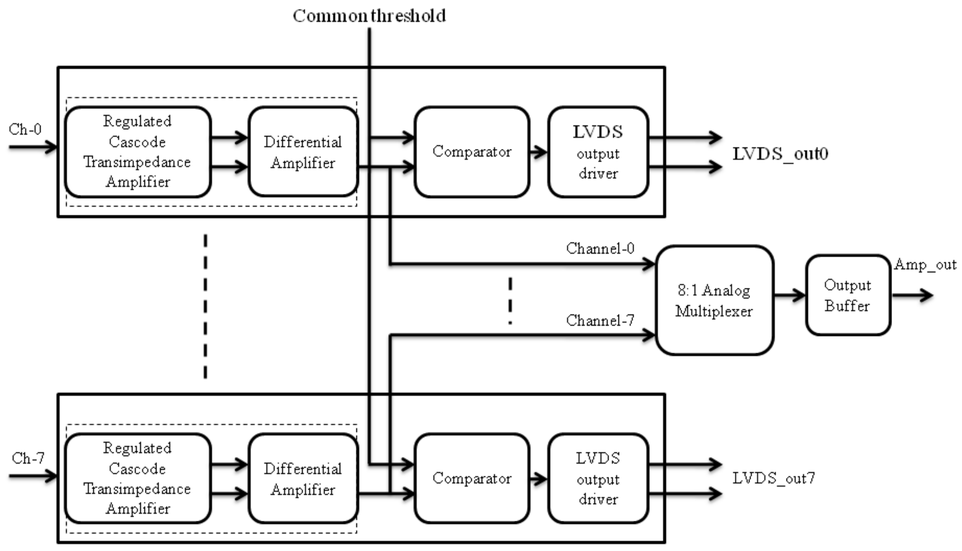

Figure3: Block Diagram for Front End ASIC.

Front-end specifications

- Process: AMSc35b4c3 (0.35μm CMOS).
- Input dynamic range: 18fC–13.6pC.
- Input impedance: 45Ω @ 350MHz. .
- Amplifier gain: $8mV/\mu A$.
- 3-dB Bandwidth: 274MHz.
- Rise time 1.2 ns; Comparator sensitivity 2mV.
- LVDS drive 4mA & Power per channel <20mW.

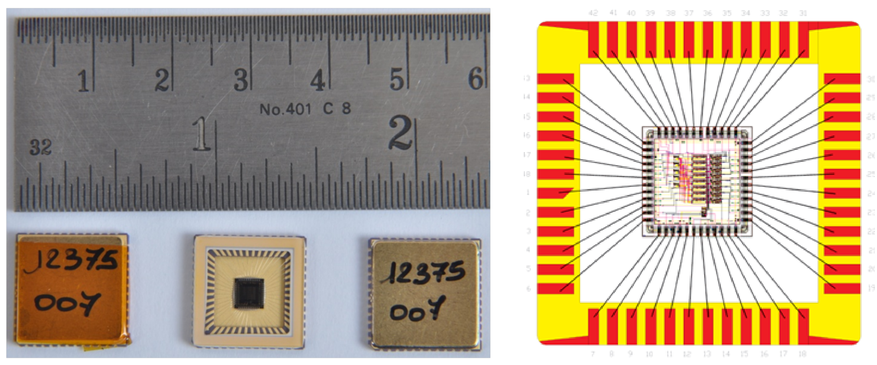

Figure4: Package CLCC48, Chip area 13mm^2

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 onputs : LVDS & TTL respectively.
- DNL/INL : 100ps (typical).
- Power rail : 3.0 to 3.6 Volts (suggested).
- Control & readout interface : SPI (essential) & SPI + Parallel (desirable).

Pulse Shape Monitor

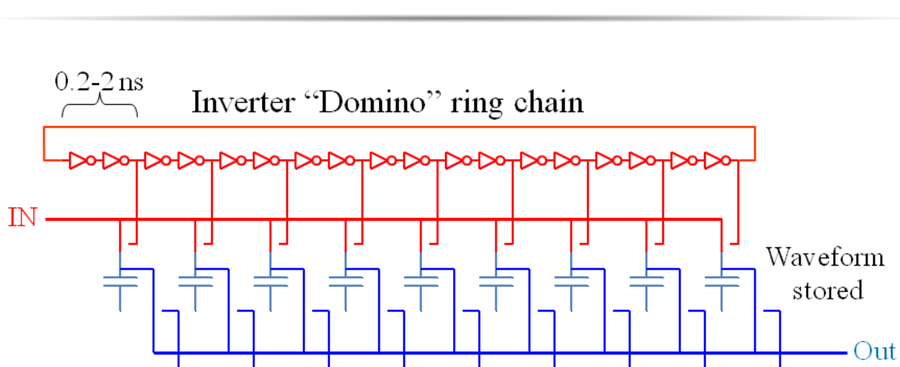

Figure5: Ref: Stefan Ritt, Paul Scherrer Institute, Switzerland.

RPC DAQ Block Diagram

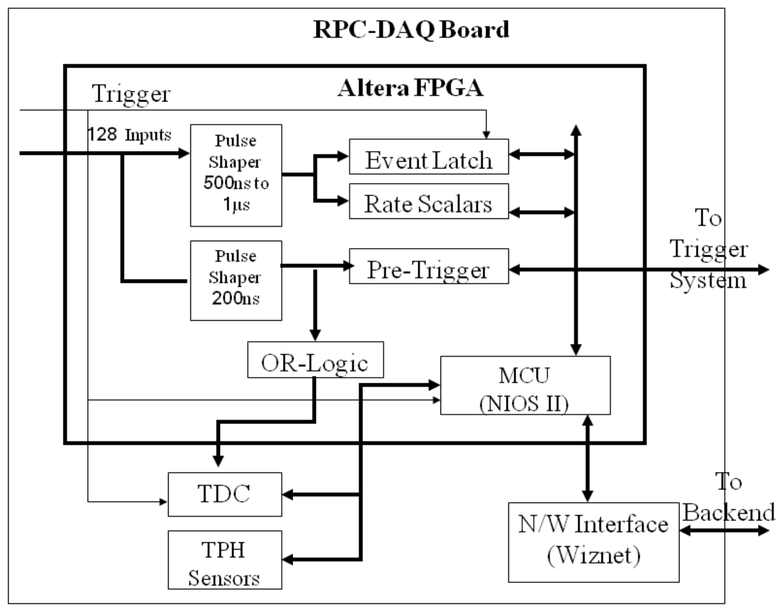

Figure6: RPC DAQ board

Data Interface

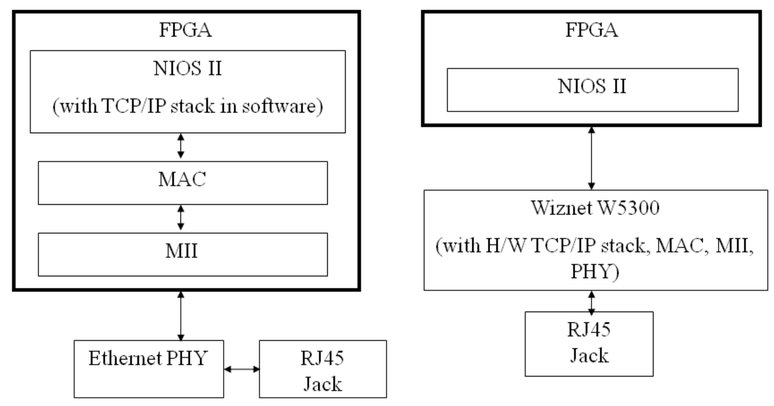

Figure7: Proposed scheme for Network interface

Data Networking

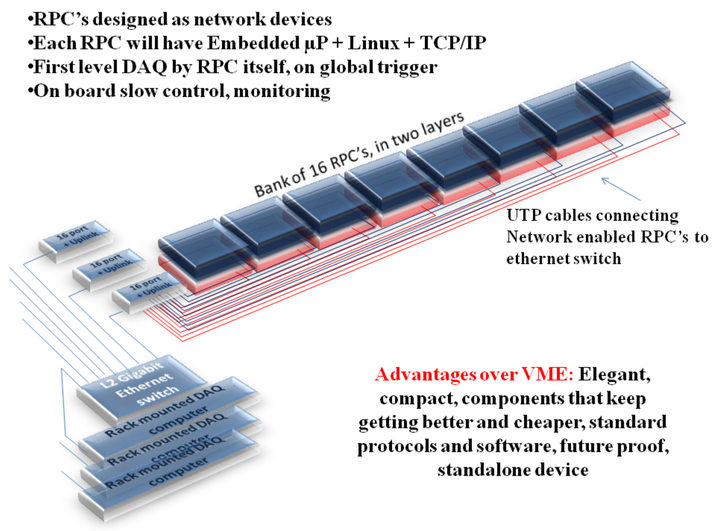

Figure8: Alternative network based DAQ for INO-ICAL

Integration Schematic

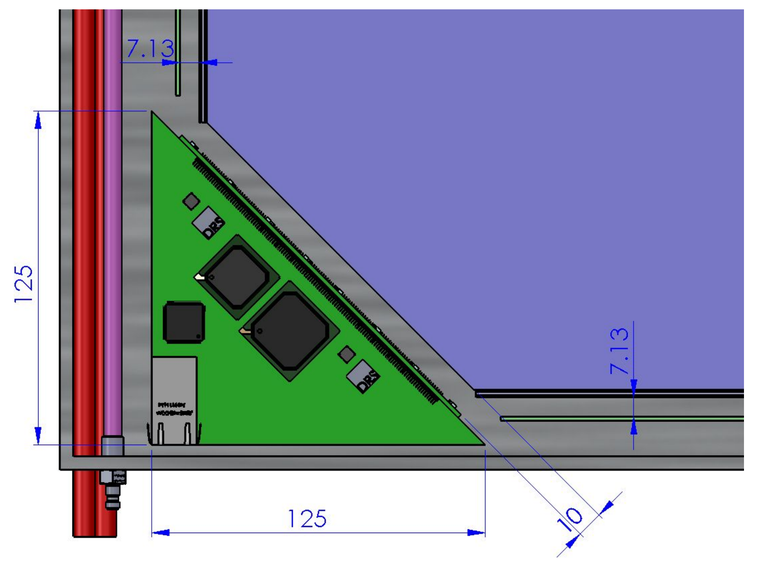

Figure9: RPC DAQ and its placement.