The Juno Experiment Central Detector readout electronics

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The Jianmeng Underground Neutrino Observatory

The Jianmeng Underground Neutrino Observatory (JUNO) [1] [2]will be the largest, ever built, liquid scintillator (LS) underground neutrino experiment. JUNO is under construction in the South of China and its main purpose is to measure the neutrino mass hierarchy. Thanks to its large mass, 20 kton of LS, it will perform several important measurements, from the precise measurements of oscillation parameters to the detection of neutrinos coming from SuperNovae. The central detector is made of a sphere of 20kt LS surrounded by about 18000 20" (large) and 25000 3" (small) photomultipliers and is aiming at measuring electronics anti-neutrinos issued from nuclear reactors at a distance of 53 km.

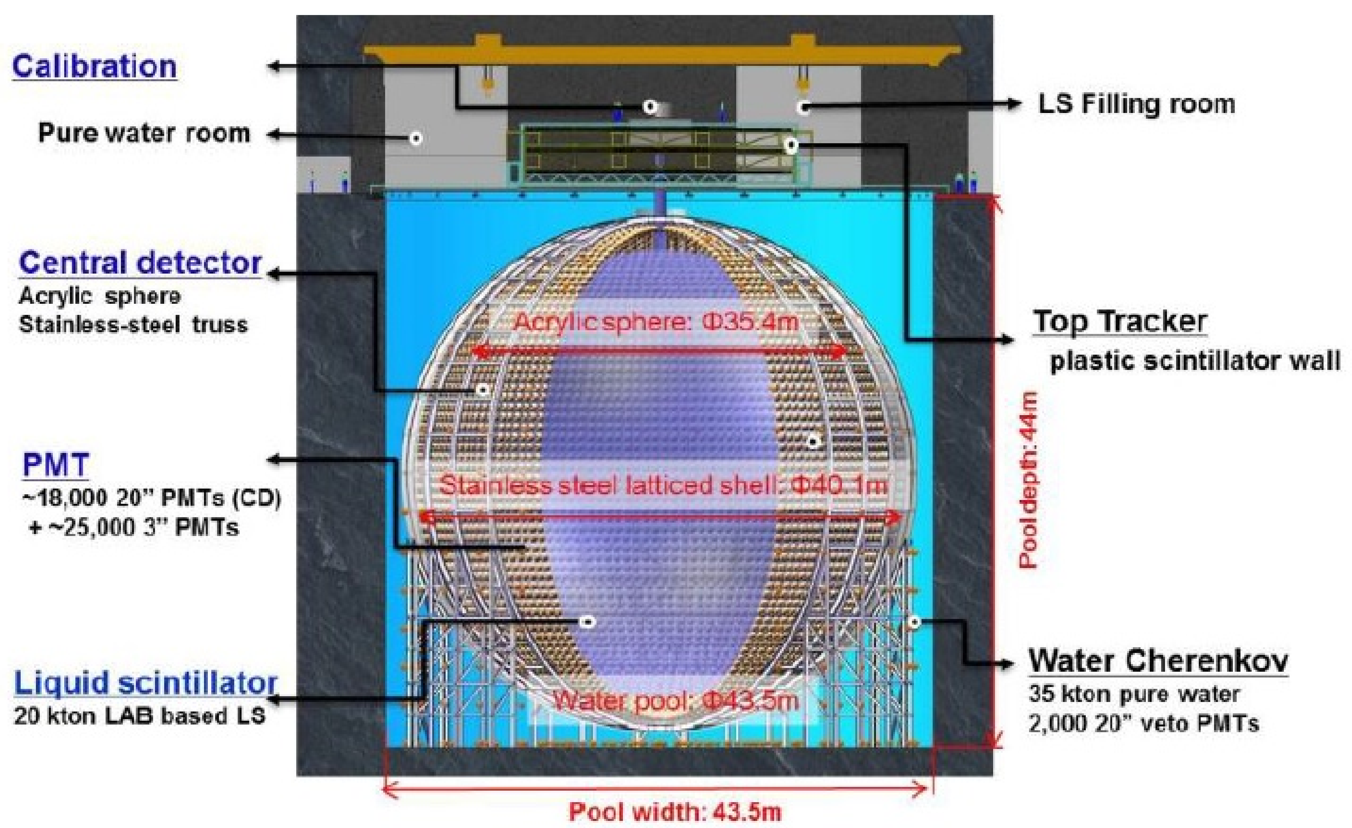

Figure 1. JUNO central cetector sphere

Inverse Beta Decay reaction

The reactor electron antineutrino interacts with proton via the inverse β-decay:

$$\bar{\nu} + p = e^{+} + n \ [3]$$

The positron quickly annihilates with an electron, yelding two $\gamma - rays$ at the energy of 511KeV; The Neutron scatters, gets thermalized and then it will get captured by a proton releasing a 2,2 MeV γ-ray. Good events are characterized by the prompt-delayed signal pair. The expected reactor neutrino event rate is ~60 events/day. JUNO will also detect other neutrinos (i.e: geoneutrinos and supernovae neutrinos).

Detector performances

The Juno detector should have excellent energy (3% at 1 MeV) and time resolutions. These requirements will be satisfied thanks to :

- full PMT waveform acquistion with a large dynamic range (from 1 to 1000 photo-electrons);
- 14 bits Flash ADC, 2 per channel to accommodate the large signals dynamic;
- wide use of reprogammable electronics (FPGA);
- dedicated synchronization and trigger system.

The front end electronics will be placed underwater (wet electronics). The 'dry' electronics will be located in the electronics rooms.

Detector and electronics block diagram

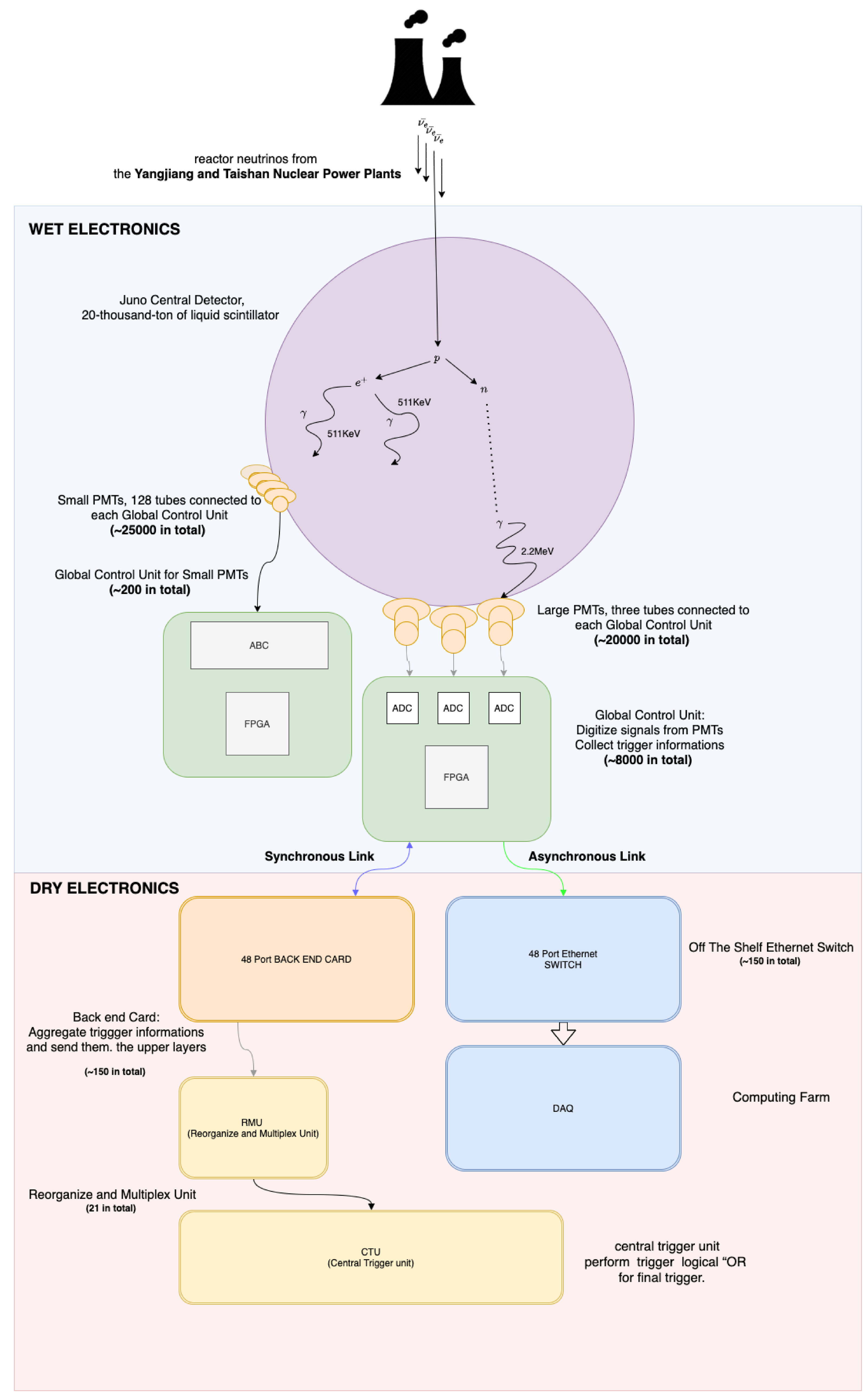

Figure 2. JUNO Electronics scheme

Global Control Unit

The Global Control Unit (GCU)[4] is at the origin of all the information needed by the experiment: the full PMT waveforms are acquired by the ADCs, together with time-charge informations, are sent to the upper electronics layers. Here are the main characteristics of the board:

- All GCUs clocks are synchronized inside a 16 ns window;
- Global Clock received from BEC and recovered on-board;
- Perform a first online data processing, generating the local trigger requests;
- Storage capability up to 1 s of raw data thanks to the on-board 2 GB DDR RAM;
- Guarantee remote FPGA reconfiguration and recovery thanks to a second FPGA on-board.

Asynchronous link

Each of the 8000 Global Control Units can send the complete ADC data frames to the DAQ system thanks to a 1Gb/s ethernet link. This link is also used for Slow control, parameter setting, and allows to perform a complete reconfiguration of the FPGA firmware. The IPBUS protocol is used for both control ad readout[5].

Synchronous link

The Back end electronics layer is connected to the Global Control Units by a custom Synchronous copper Link. The GCUs are synchronized using a reduced version of the IEEE 1588 protocol [6]. Trigger requests/accepts are delivered synchronously to/from the Front End electronics. The back-end card are used as a concentrator and the incoming trigger request signals will pass an equalizer for compensating the attenuation due to the long cables

Trigger system

The event time information is collected by the trigger system which could base decision on the number of PMTs that have generated signals (multiplicity trigger), or base on the total charge information[7].

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