



# multi-PMT electronics system for Hyper-Kamiokande

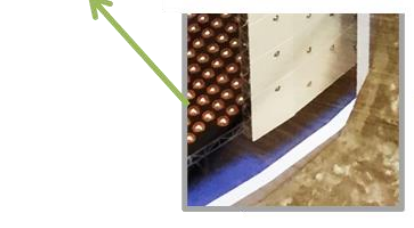
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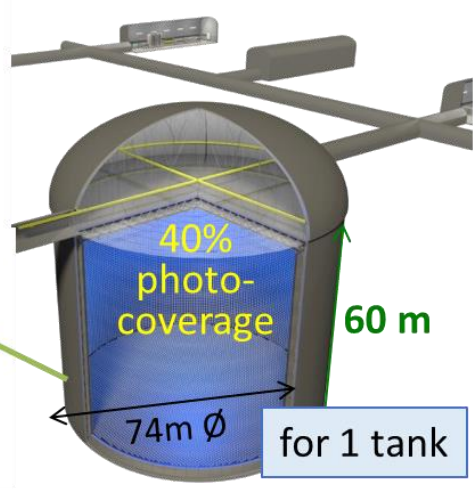
Hyper-Kamiokande



About 7,000 PMTs  
for Outer Veto Detector

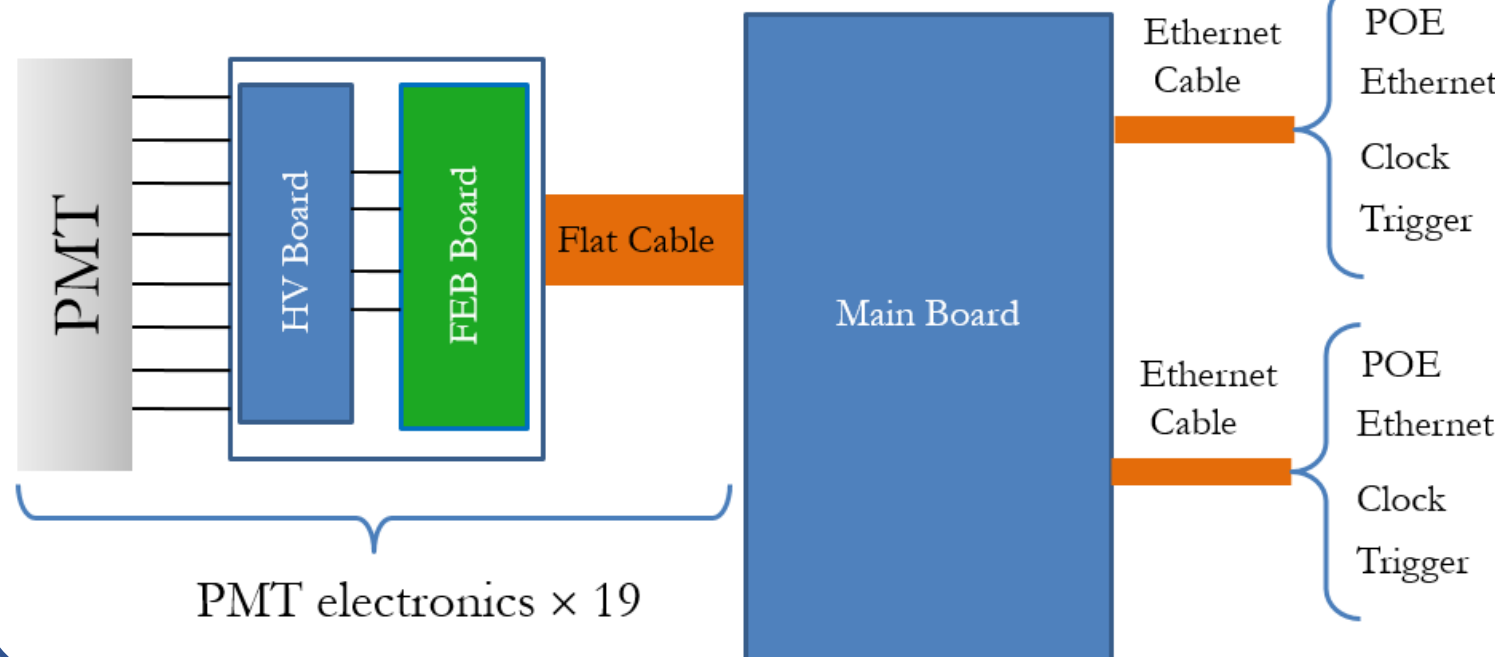
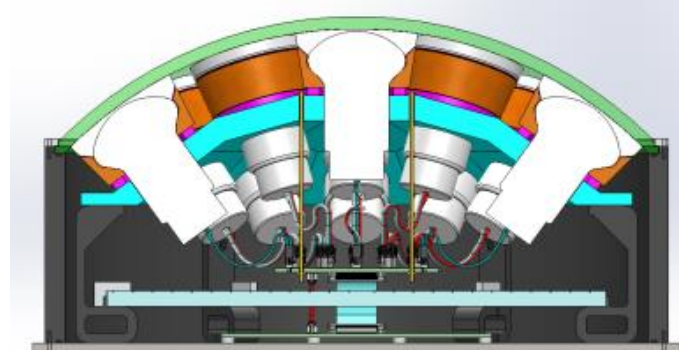


Fiducial volume: 188 kt



Hyper-Kamiokande is a next generation underground water Cherenkov detector designed to study neutrinos from astronomical sources, reactors and accelerators, nucleon decay, and with a focus on the determination of leptonic CP violation.

A system of small photomultipliers, the so called multi-PMT (mPMT) module, is considered to improve the Hyper-Kamiokande physics capabilities. mPMT system introduces intrinsic directional sensitivity, improves the timing resolution and improves the reconstruction performance, particularly for events with vertices near the photosensor plane. A mPMT module consists of 19 3" PMTs, installed inside a mechanically safe pressure vessel, with its electronics, readout and calibration system integrated.



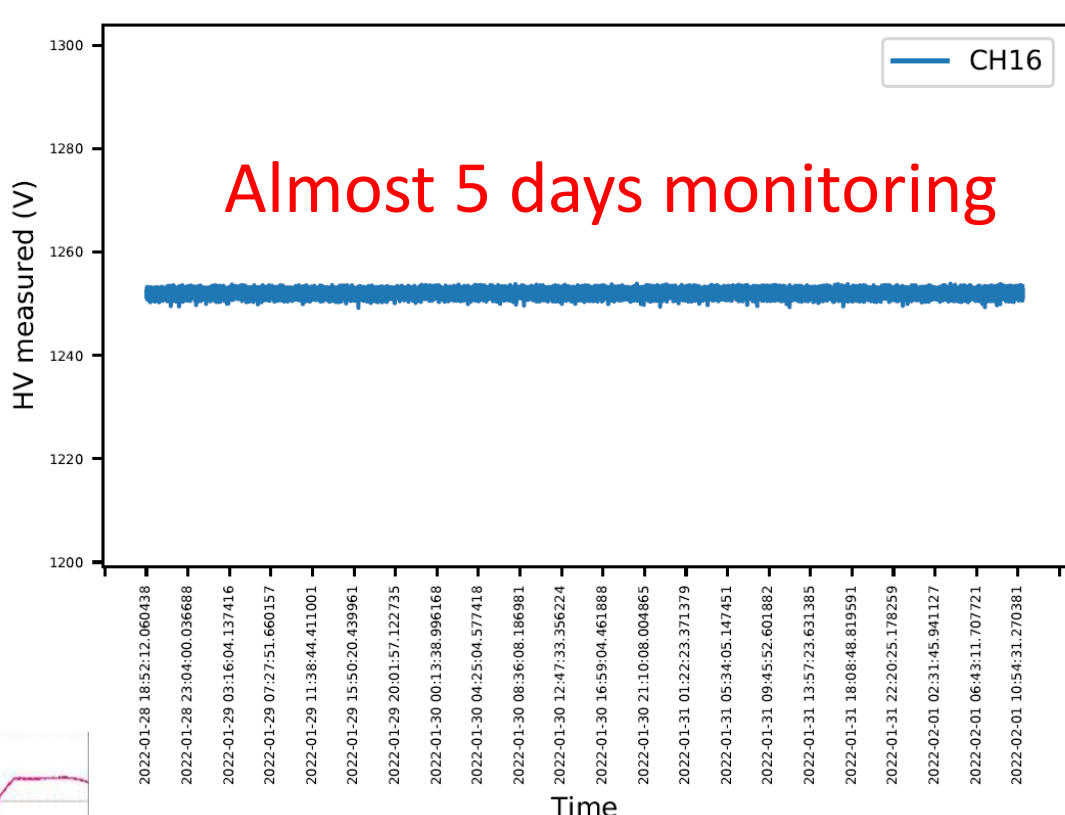
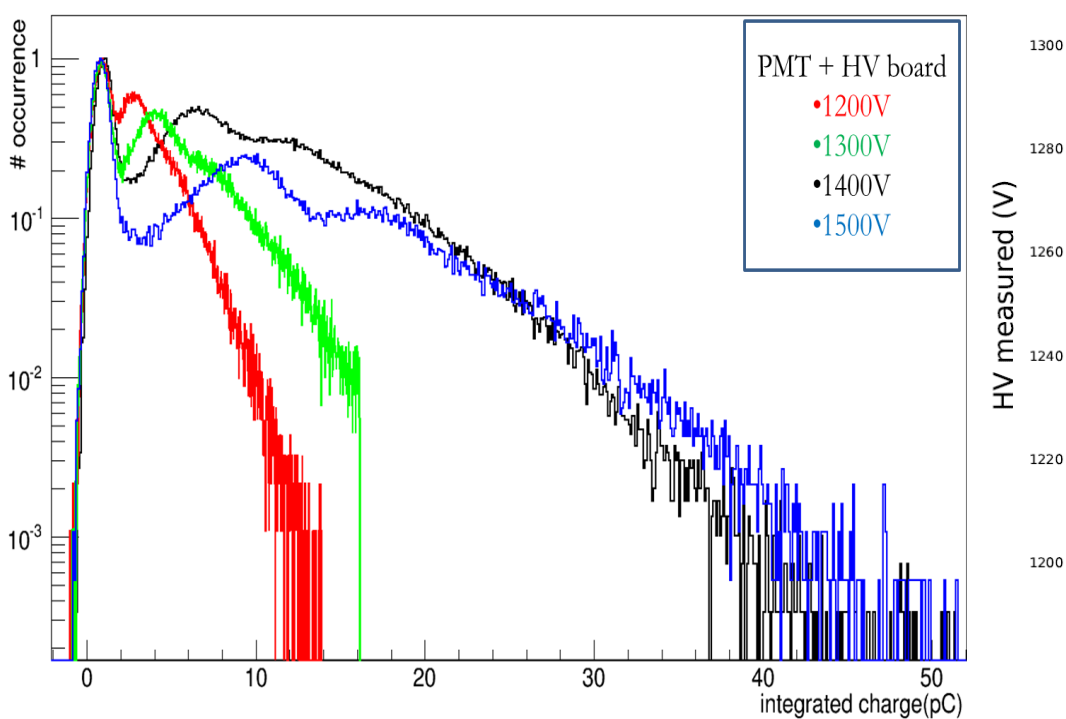
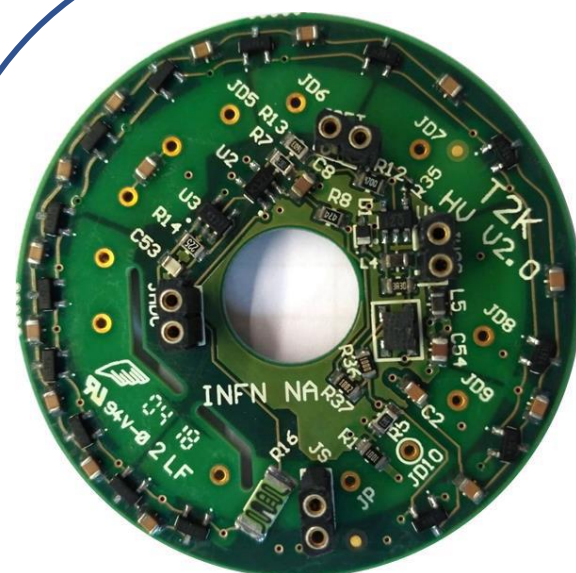
Electronics system requirement:

- 4 W power budget for the whole system
- 19 HV channels up to 1500 V with less than 1% noise
- 19 FE board with 0,1 PE charge resolution and 60 PE of dynamic range
- 300 ps timing resolution
- 100 ns absolute timestamp precision
- 20 years of operation without maintenance

Every component of the system is custom designed

## HV board

- Crockett-Walton Multiplier for LV-HV converter up to 1500V
- 0,3% stability in monitored voltage
- **3.2 mW power consumption @ 1500 V**
- Suitable also for critical application with 350 years of MTTF with SN29500

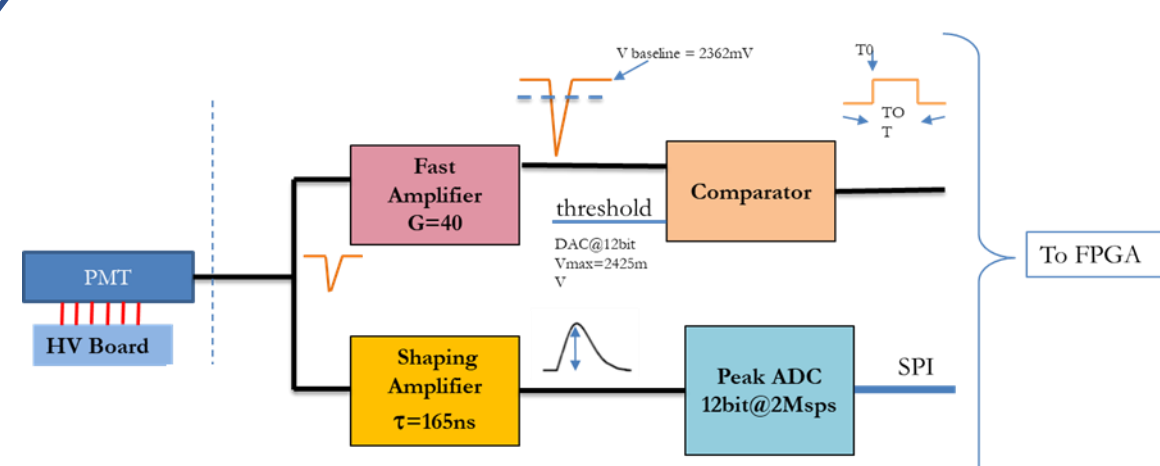


500  $\mu$ V peak noise,  
equivalent to 0,15 PE  
threshold

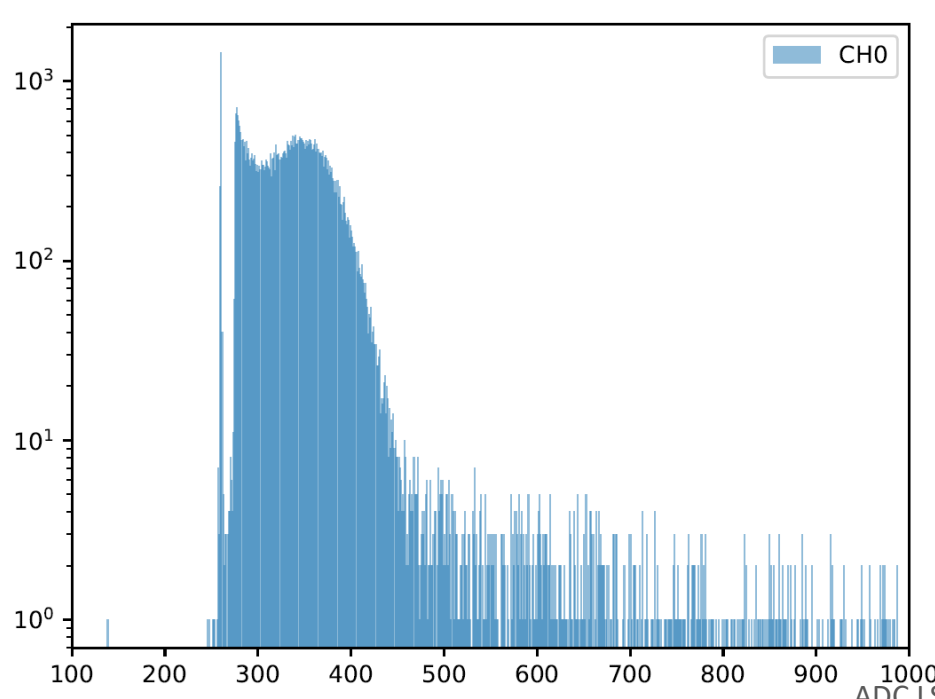


In purple the HV switching signal, in yellow  
the induced noise on the signal

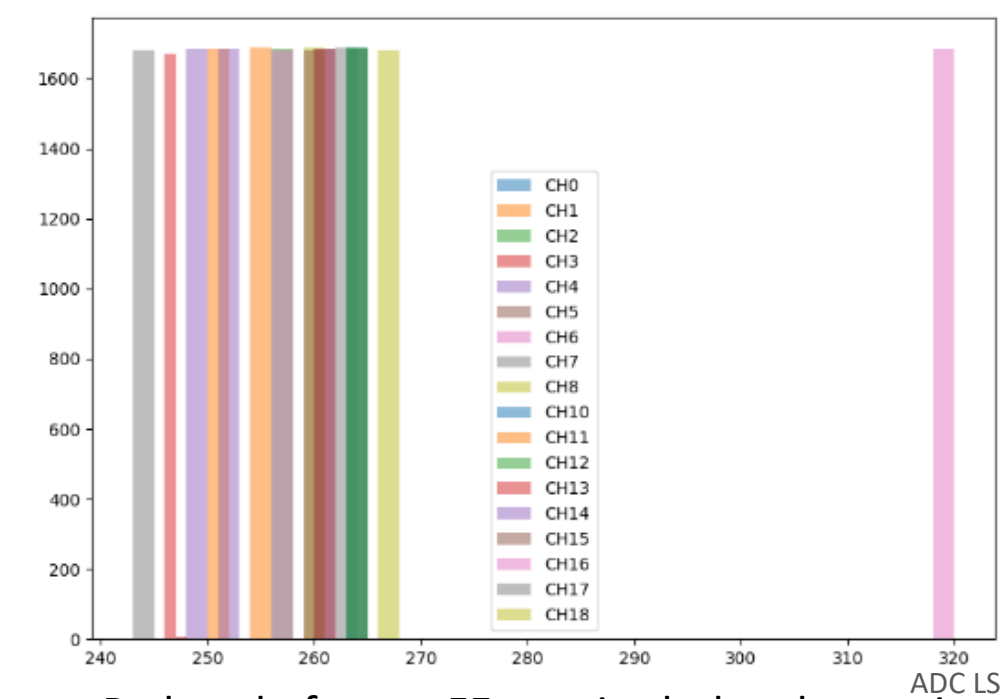
## FE board



- Fast amplifier with Trigger output and SPI for a 12 bit ADC
- 40 mW of power consumption
- 1 MHz acquisition rate up to 60 PE with 0,1% FWHM/ch
- STM32L0 processor to control HV and FE parameter via ModBus
- 650 years of MTTF with SN29500 standard



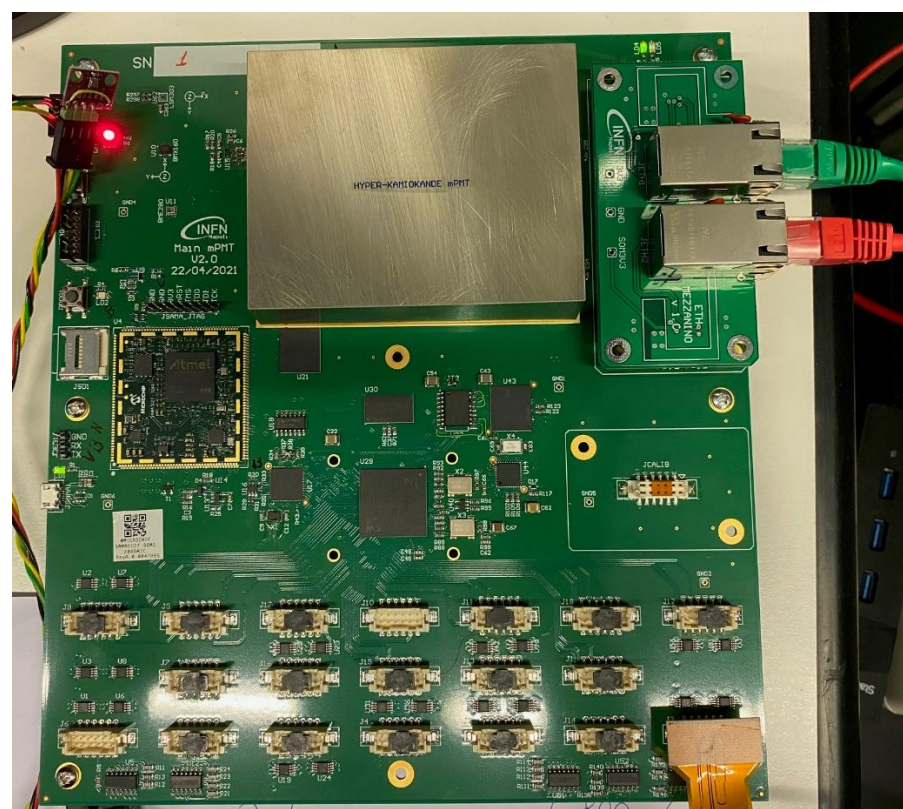
Acquisition of a 3" PMT spectra with the  
FE and the HV board



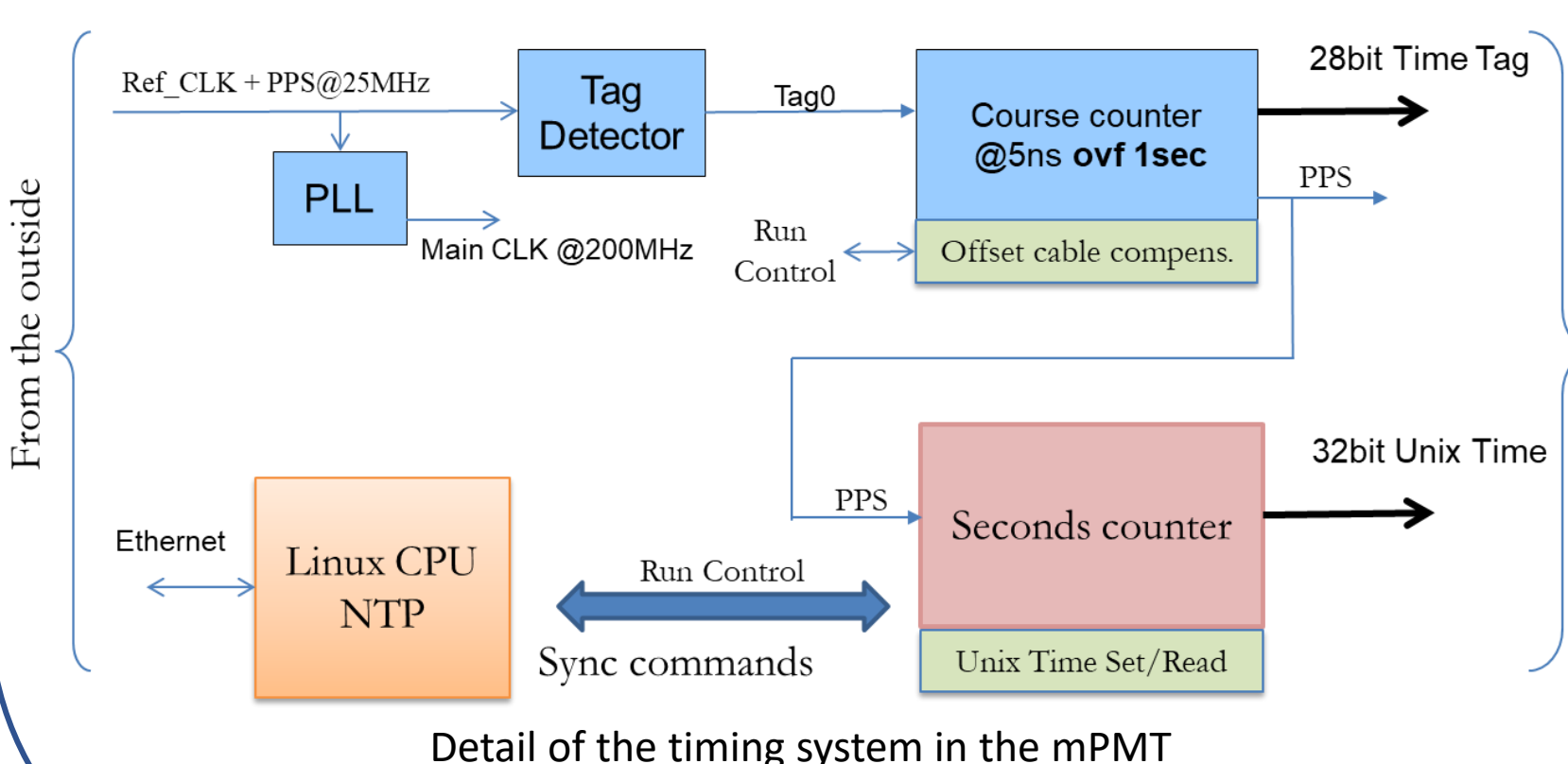
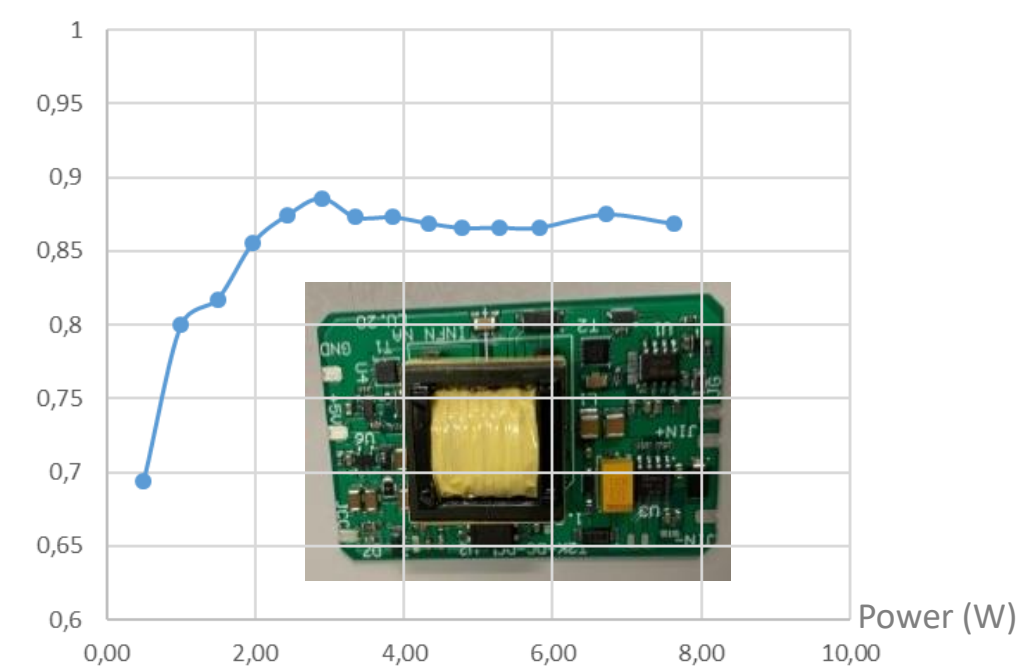
Pedestal of many FE acquired, the electronic  
noise is 1 LSB. Pedestal taken triggering with  
no signal on the input

## Main board and Acquisition

- System with redundant CPU and power supply
- **2.5 W power consumption at maximum load**
- **87% POE Power supply efficiency @ 4 W**
- 270 ps LSB TDC based on multiphase clock and carry delay lines
- 100 ns precision absolute timestamping based on PPS transmission over clock line
- 100 years of MTTF with SN29500 standard

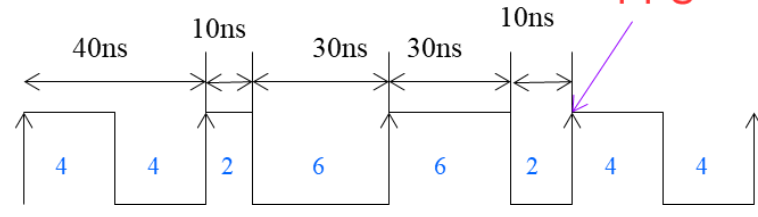


POE Optimized efficiency

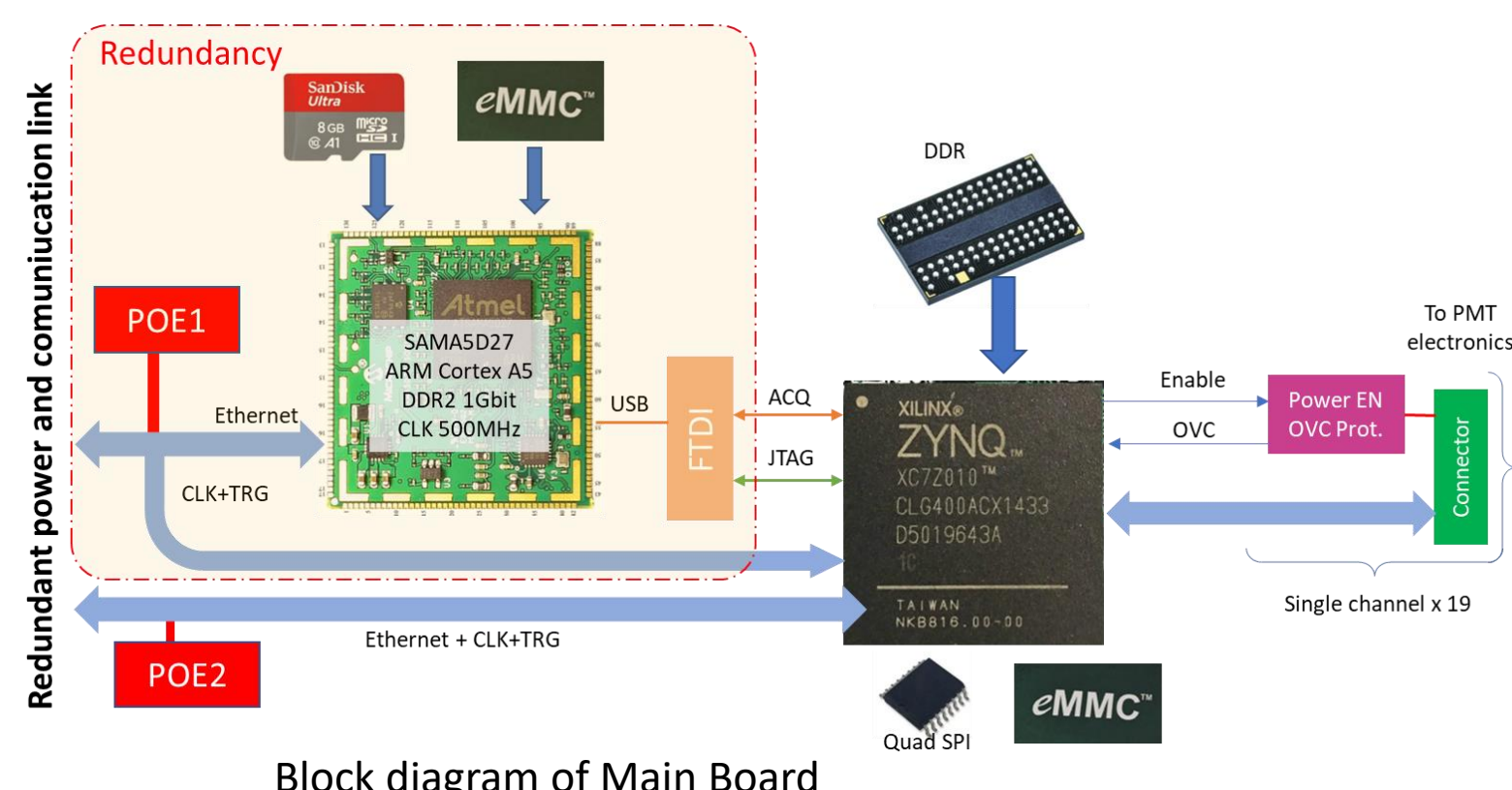


Detail of the timing system in the mPMT

Ref\_CLK @25MHz with PPS



Demo for the timing and data link aggregator



Block diagram of Main Board