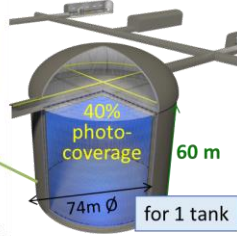
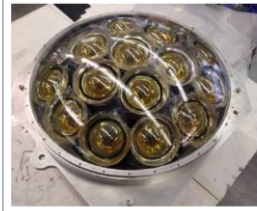


About 7,000 PMTs for Outer Veto Detector



Fiducial volume: 188 kt

Hyper-Kamiokande will use both the new 20" B&L PMT and the mPMT, an underwater vessel composed of 19 3" PMT to increase the granularity

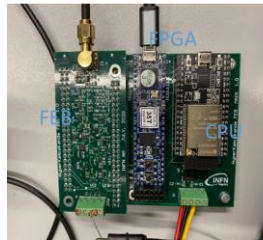
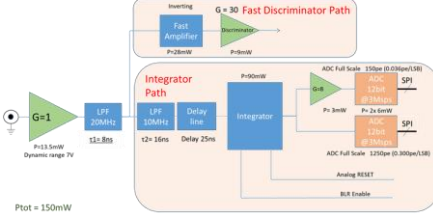


- 20" PMT requirements:
- 0.2 pC charge resolution
 - up to 2500 pC
 - 100 ps timing resolution
 - Max 1Mhit/s/channel and 8B/hit < 200 mW/channel

- mPMT requirements:
- 0.1 pe charge resolution
 - up to 25 pe for each PMT
 - 300 ps timing resolution
 - MAX 4 W for whole system

Same concept for 20" and mPMT electronics: a fast path for trigger generation and time measurements and an integrator path for charge measurements.

20" PMT

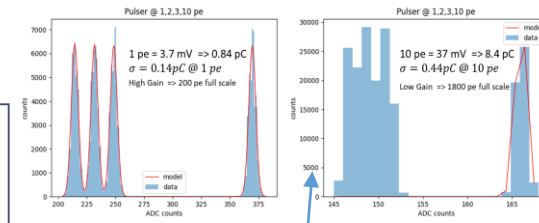
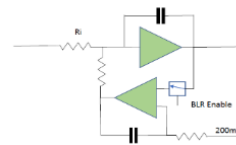


Under optimization

- Promising charge resolution (0.15 pC)
- Stable fast chain up to 1MHz rate

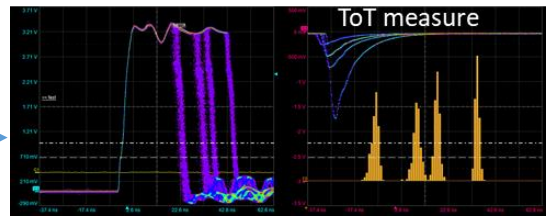
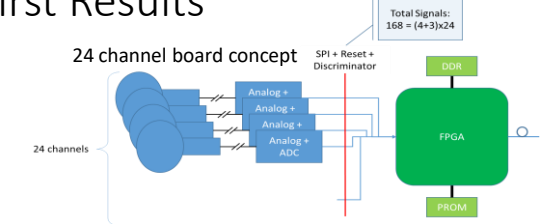
A classical integrator with a Baseline restore system is used, while the discriminator is a chain of Operational amplifiers and a diode baseline restore for rate compensation.

Integrator and Discriminator: First Results

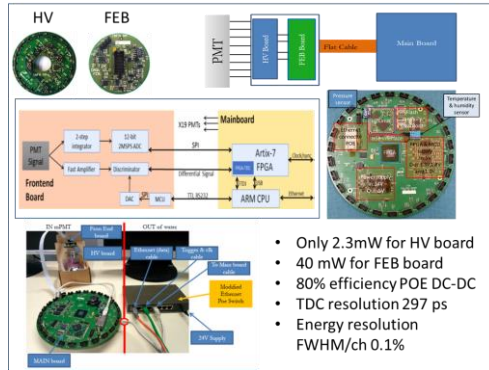


Preliminary results:

- charge resolution: 0.14 pC
- Power consumption: 210 mW/channel.
- Max time walk for trigger: 6 ns
 - 300 ps TDC under development to test time resolution.

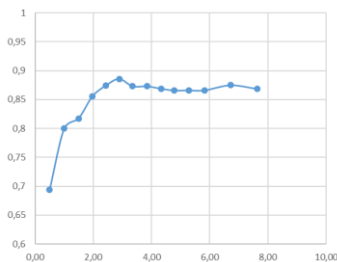


mPMT

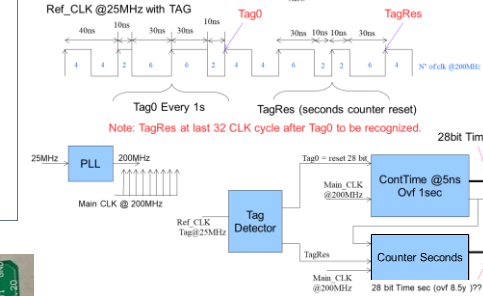
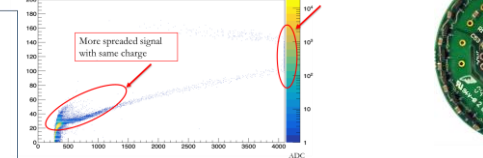


- Only 2.3mW for HV board
- 40 mW for FEB board
- 80% efficiency POE DC-DC
- TDC resolution 297 ps
- Energy resolution FWHM/ch 0.1%

POE Optimized efficiency



ToT vs Energy



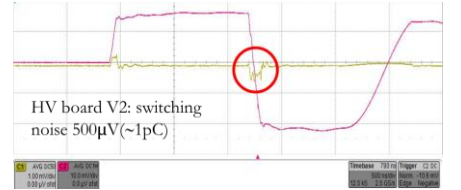
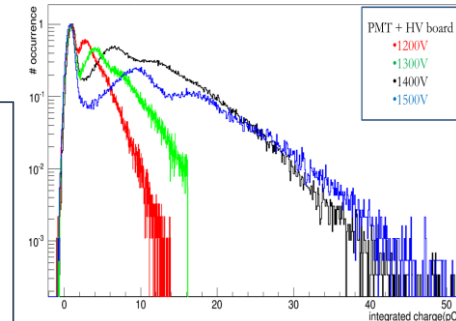
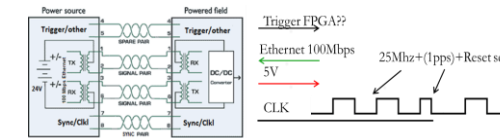
Analog FE is similar to the 20" one, but here we also design a custom POE power supply with 87% efficiency @4W and we use an Artix 7 FPGA and an ARM-based Atmel system for data acquisition. This solution meets all the requirements. Upgraded version will be based on Zynq FPGA.

Basic Cockcroft-Walton (CW) voltage multiplier circuit designed for -HV up to 1500V



Last upgrade:

- Induced signal noise reduction
- Switching output and signal output protection diode
- Reflector ring supply
- Power consumption reduction



A clock modulation is used to generate the PPS and the Reset signal for the acquisition, to avoid phase ambiguity.

Two weeks long underwater tests revealed really stable gain and HV for the PMTs, resolution to 0.1% FWHM/channel and 100ps time resolution.