

# The 3-inch Photomultiplier System of the JUNO Experiment



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On behalf of the JUNO Collaboration



In addition to the 18,000 20-inch photomultipliers, 25,600 3-inch photomultipliers and their readout electronics will be deployed as a complementary photodetectors array in the Jiangmen Underground Neutrino Observatory.

## STATUS

- 26,000 Photomultipliers already produced
- Delivery of the full electronics in 2021

➤ Complementary independent readout

- Systematics disentanglement
- Precision calorimetry

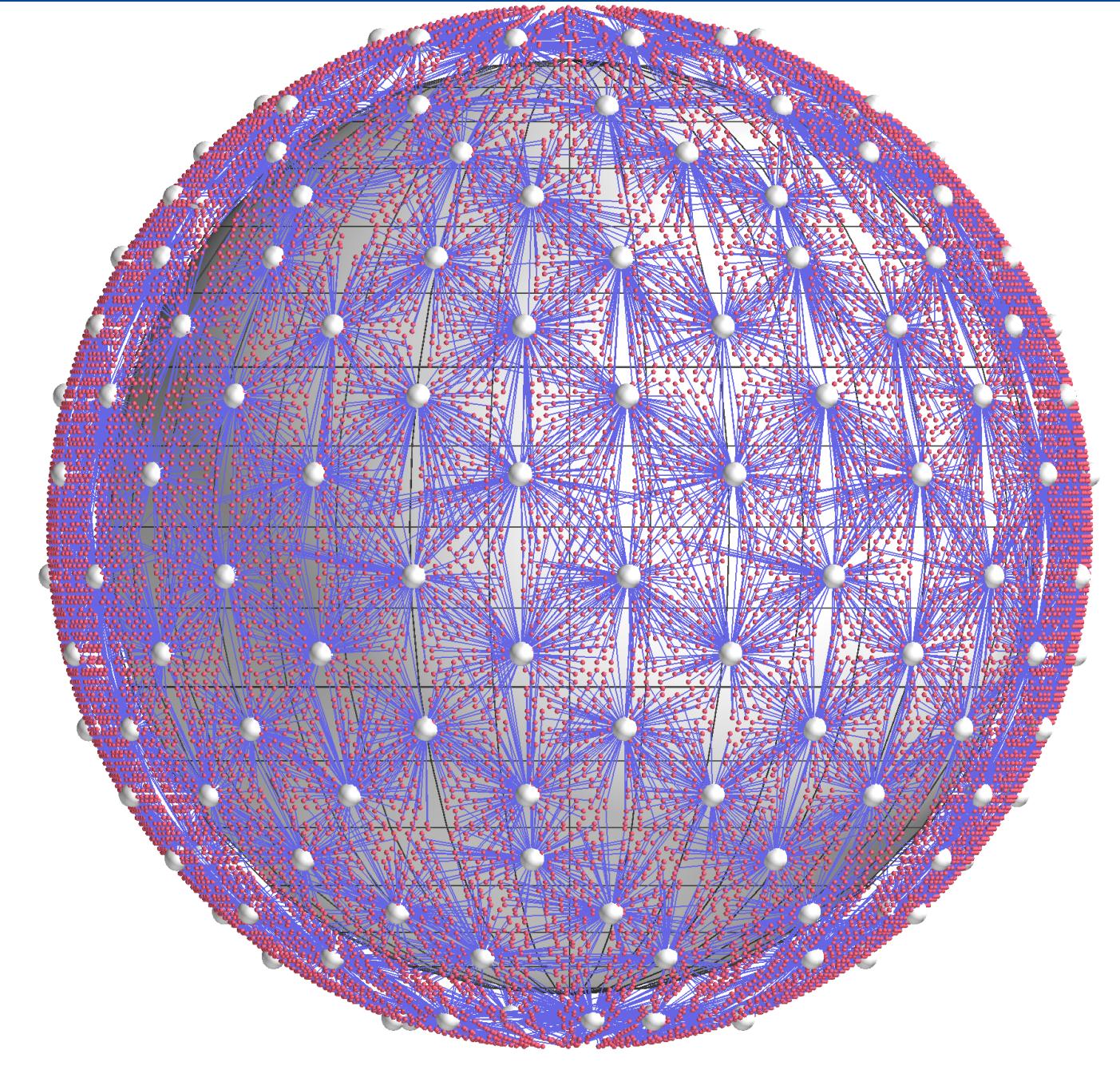
➤ Improve inner-detector  $\mu$ -reconstruction resolution

- After- $\mu$  neutrons catching

➤ Standalone measurement of solar parameters

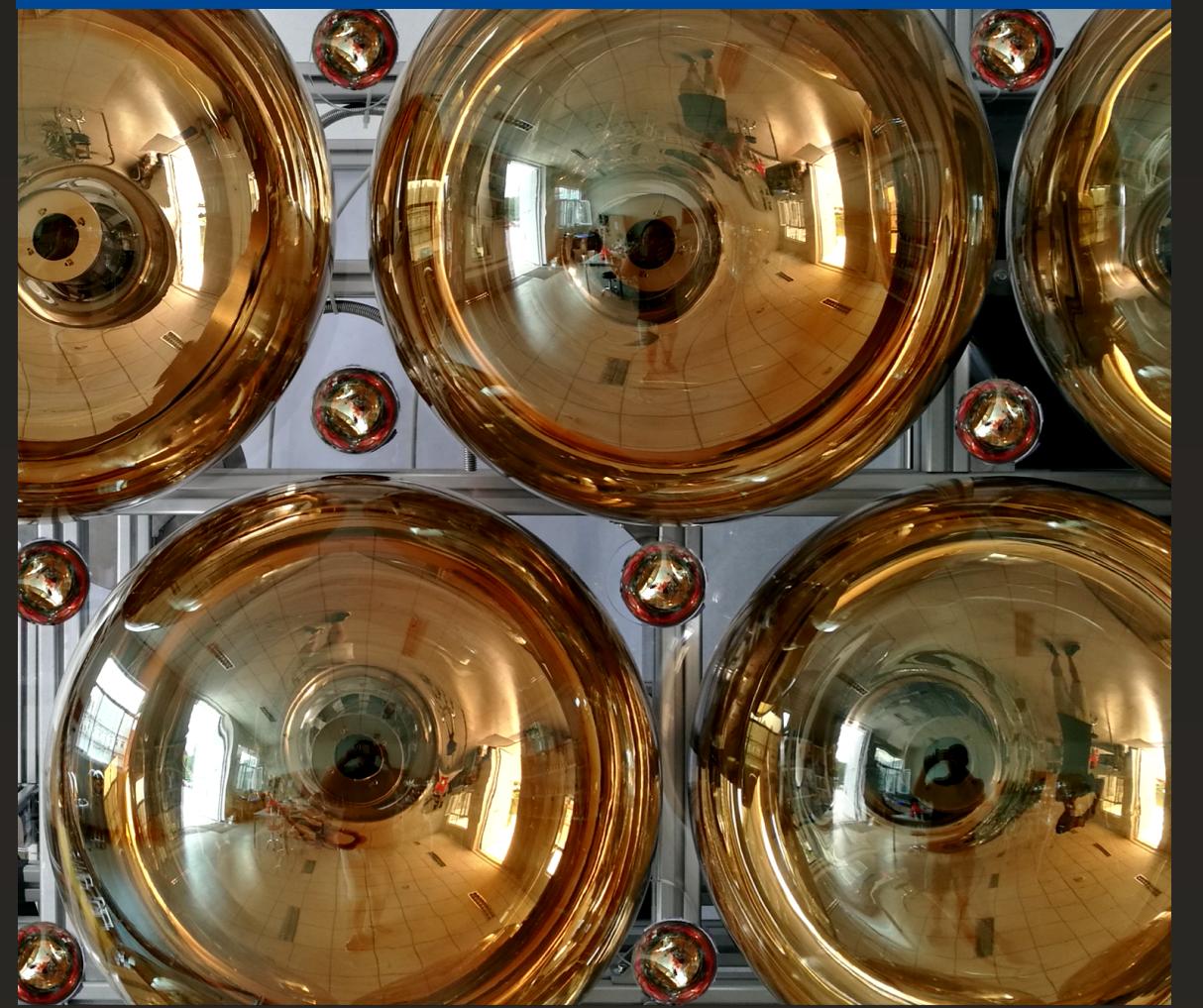
➤ Measurement of supernova high events rate

## 25,600 Photomultipliers = 200 x 128 PMTs

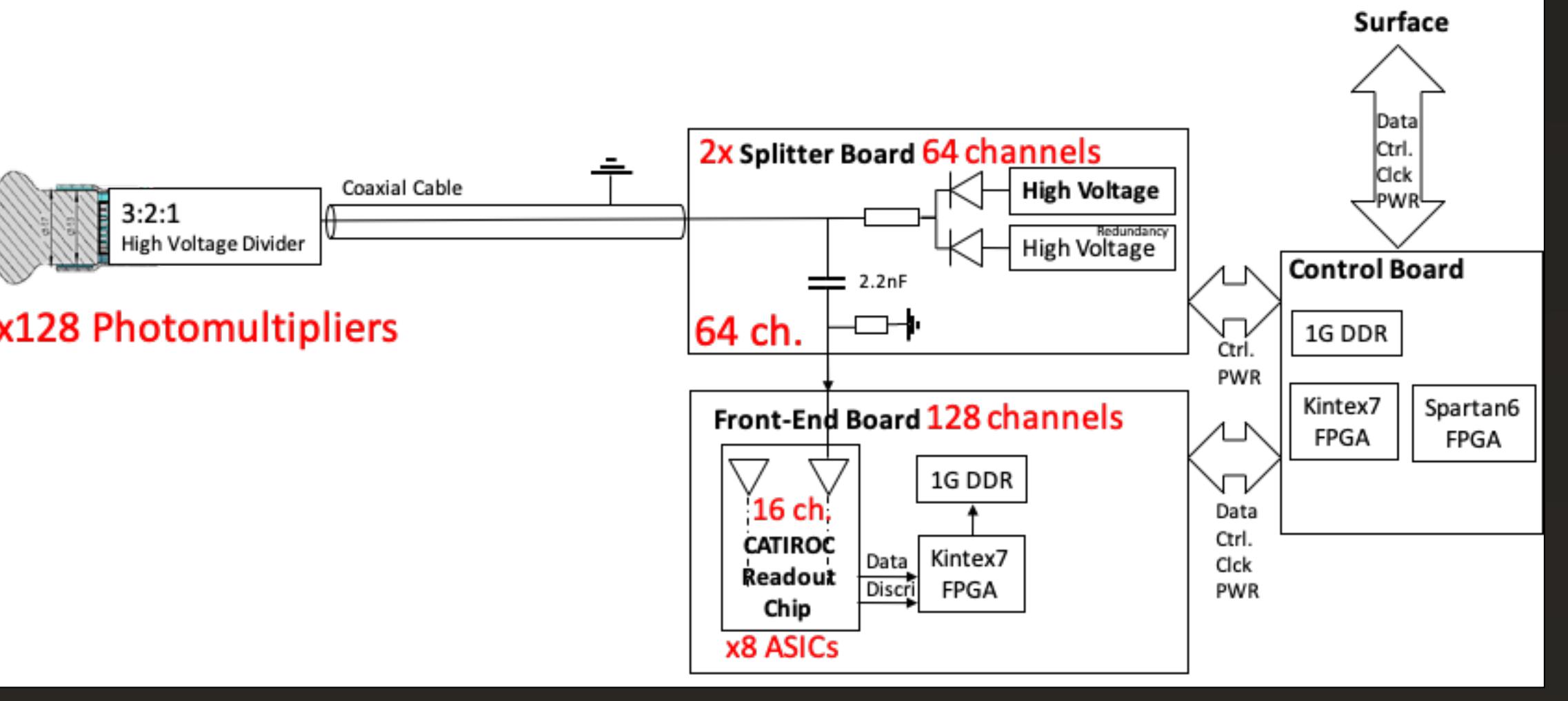


The 200 Underwater Boxes positioning and their cabling to the 25,600 Photomultipliers

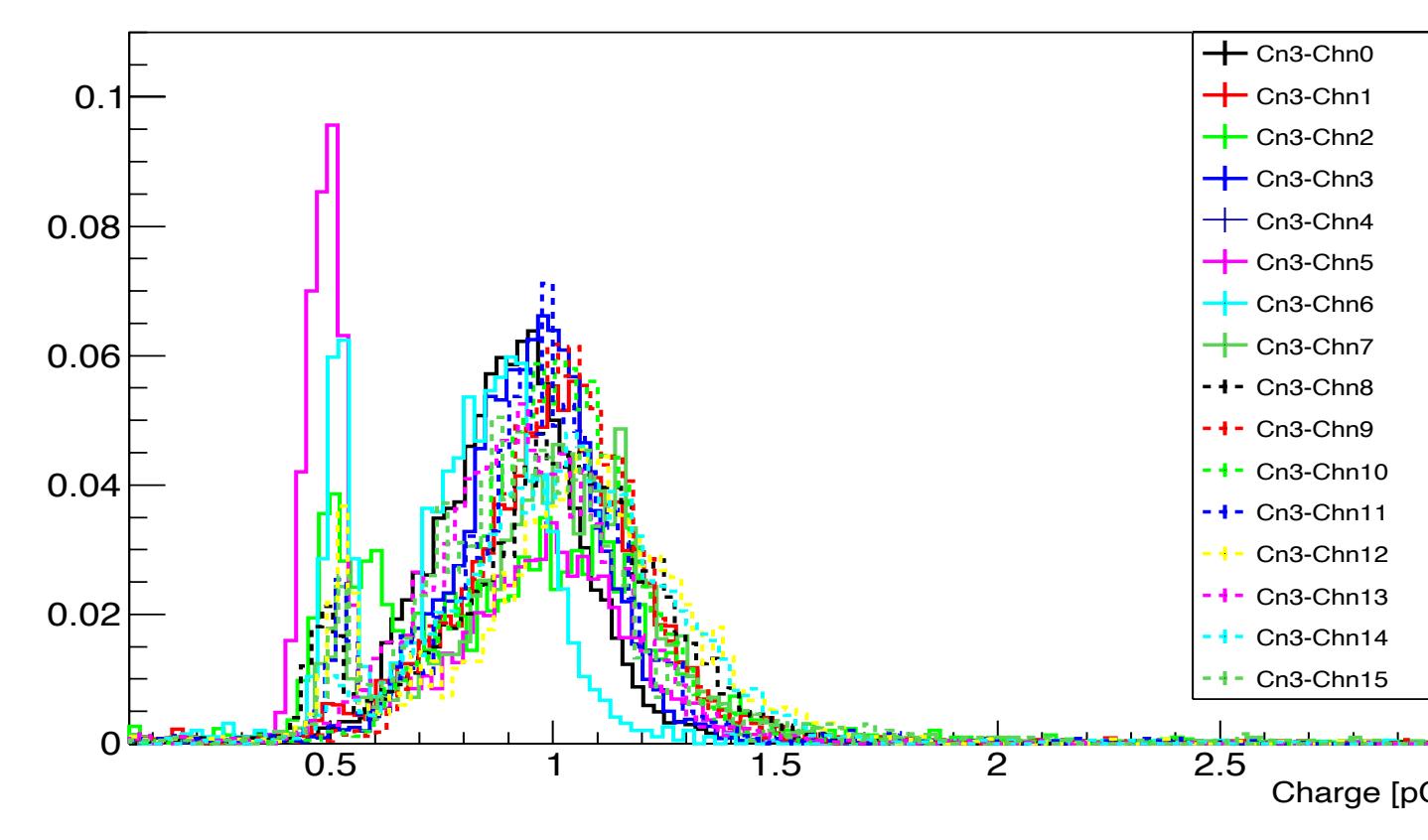
## 20" and 3" PMTs interleaving



## Readout of 128 photomultipliers in a single Underwater Box



Single Photo-Electron (SPE) charge spectra obtained from 16 XP72B22 3-inch photomultipliers using the whole prototype front-end electronics with 1 CATIROC chip

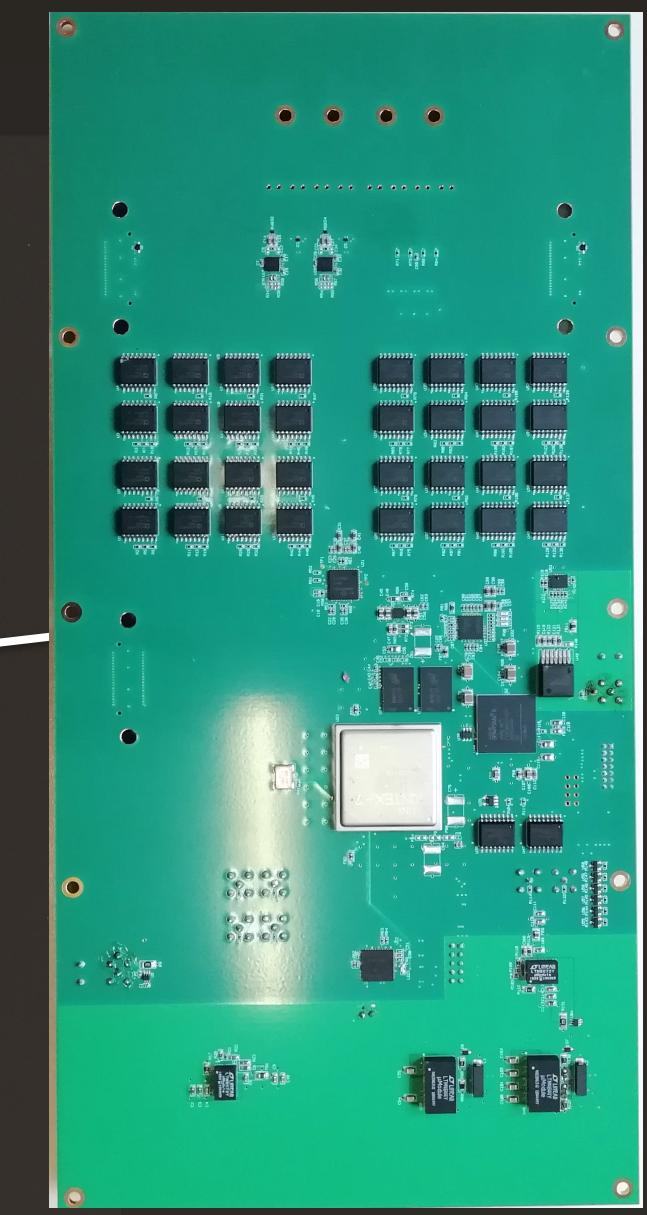


## UnderWater Box

50 cm x 10" diameter  
Stainless Steel 304L  
Electronics junction box  
Heat exchanger with JUNO water pool  
1 to 8 bars High reliability

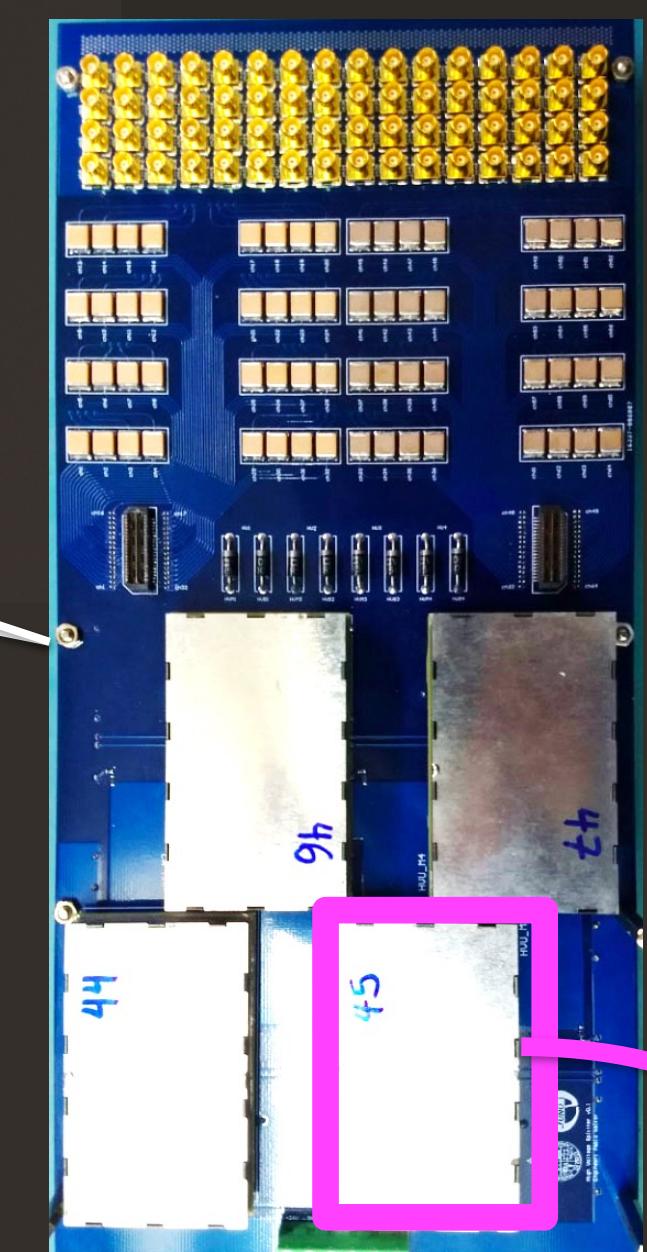
## Global Control Unit

Link to surface  
DAQ link  
Clock distribution  
LV Power Supply  
2 FPGA  
- Kintex 7  
- Spartan 6



## High Voltage & Signal Splitting

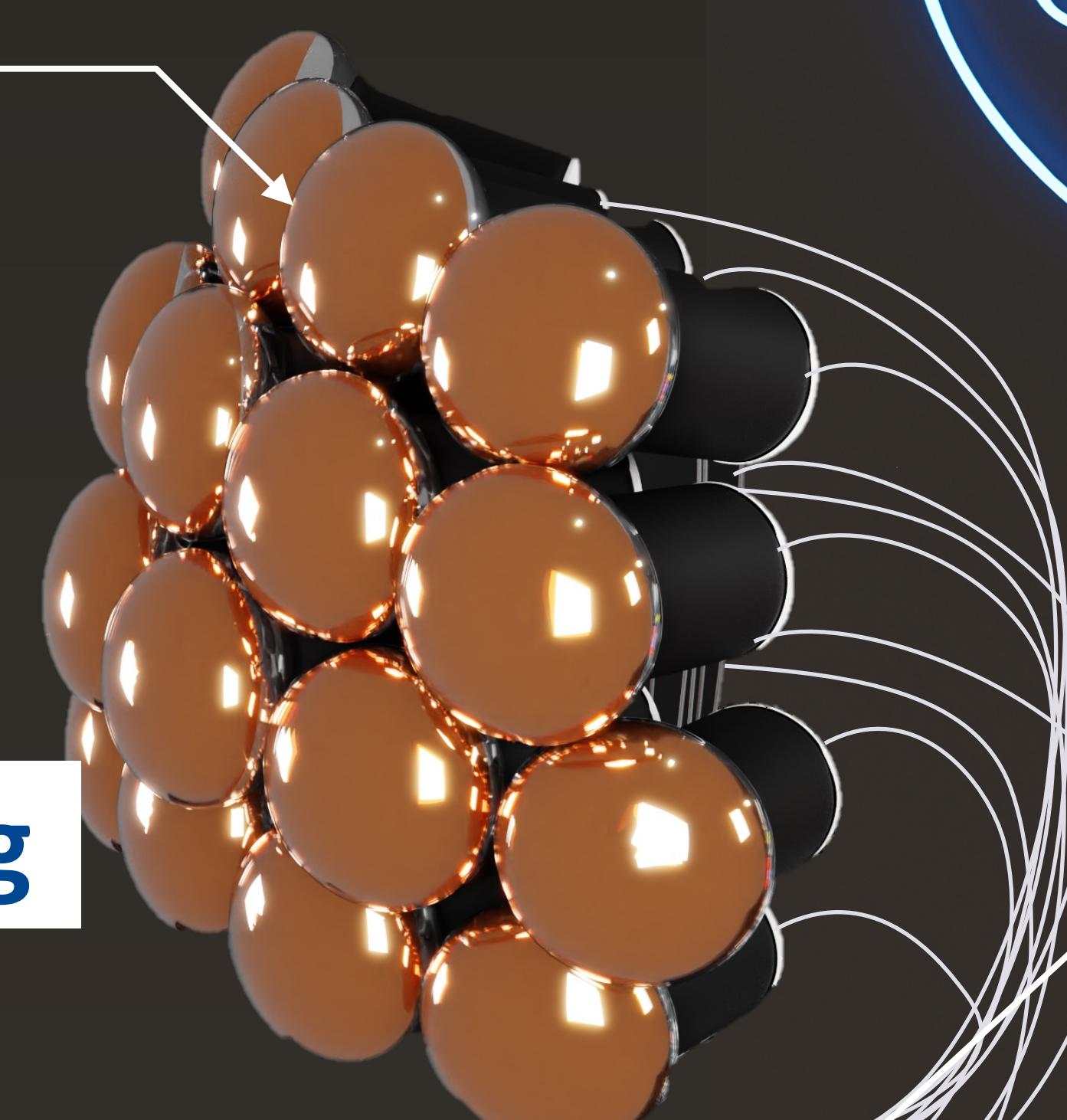
2 boards / 64 channels each  
Signal to High Voltage separation  
Signal integrity / No crosstalk  
High Voltage power supply



16 PMTs to 1 HV channel  
[800-3000]V / 300 $\mu$ A max.  
10 mV ripple  
0.05% long term stability

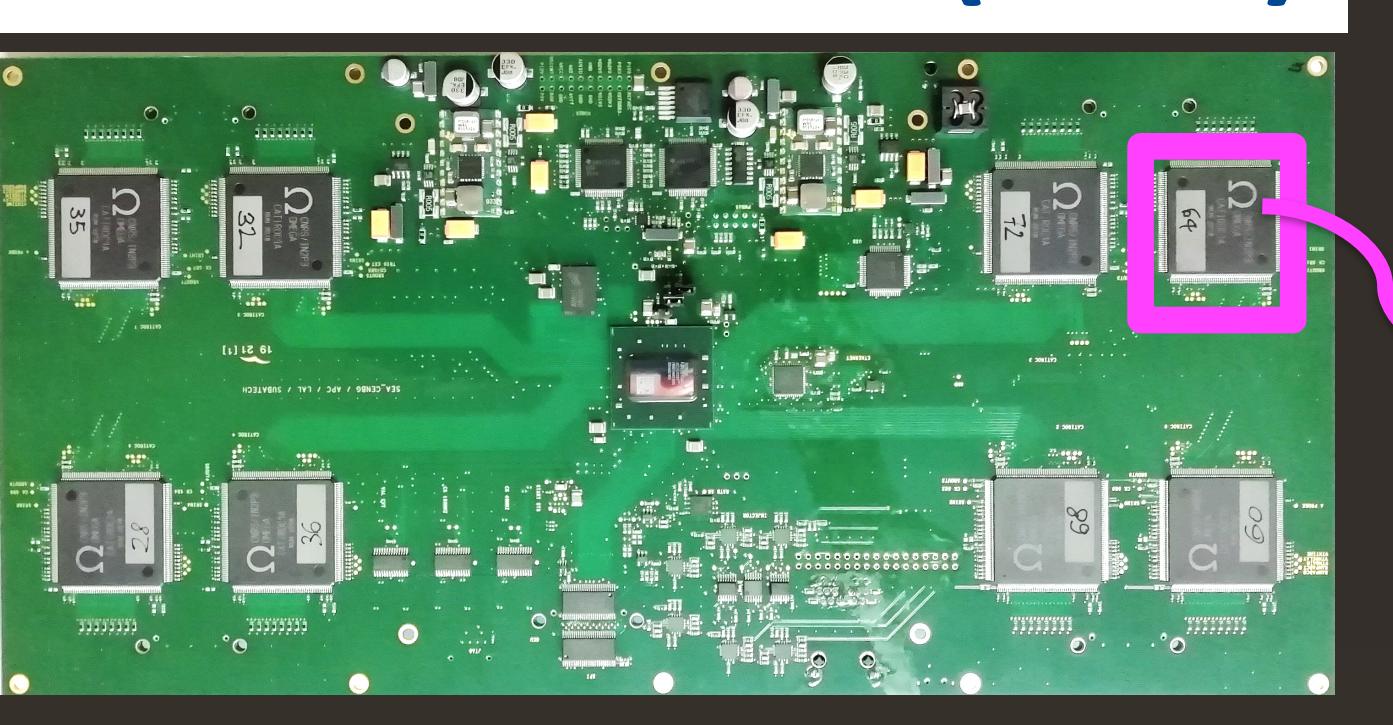
## 3-inch Photomultipliers

Company: HZC Photonics  
Model: XP72B22  
Designed for JUNO  
10 dynodes  
QE 24.9%  
SPE  $\sigma$  33.2%  
TTS 1.6ns  
DCR 0.5kHz @ 0.25 PE



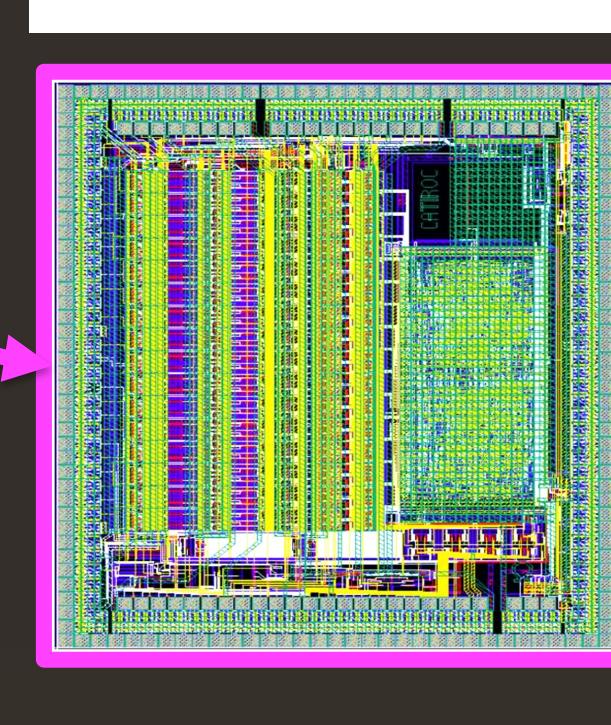
## Front-End Readout Board (ABC)

128 channels  
Charge and Time  
Triggerless  
8 CATIROC ASICs  
1 FPGA Kintex 7  
1Gb DDR



## CATIROC Readout ASIC

Designer: Omega - Weeroc  
AMS SiGe 0.35 $\mu$ m  
16 negative input channels  
[160 fC – 100 pC] Charge range  
200 ps RMS time resolution  
Triggerless acquisition



## Underwater cabling

Company: Axon Cables  
Designed for JUNO  
16 channels harness  
High voltage

High frequency, High reliability  
RG178 coaxial cable

Transport signal & high voltage

