Testing and Assembling of the 20-inch PMTs for the JUNO Experiment

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On behalf of JUNO collaboration

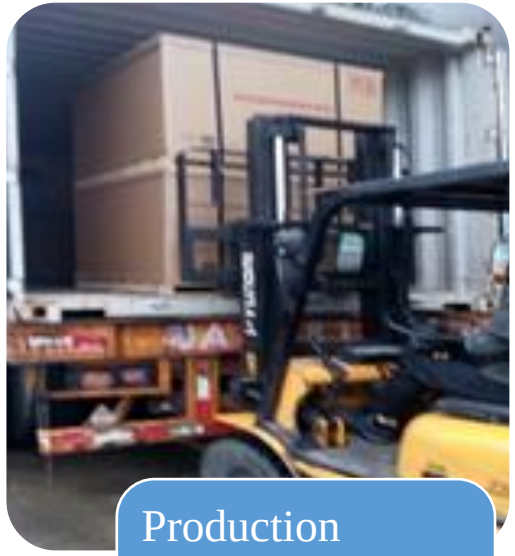
2023-09-05

Outline

- 1. PMTs at Pan-Aisa
  - Overview
  - Bare PMT test
  - Potting PMT test
  - Protection Cover Assembling
- 2. PMTs at JUNO SAB
  - PMT assembling on Modules
  - PMT test in SAB
  - PMT DCR study in SAB
- 3. PMT at JUNO Underground
  - PMT Module assembling progress
  - PMT Test on JUNO Detector

1. PMTs at Pan-Aisa

1.1 Overview:



Production

- PMTs are produced by Northern Night Vision Technology Co. and Hamamatsu Photonics K. K.
- PMTs are sending to Pan-Asia Co.

Acceptance Test

- PMTs have a detailed acceptance test by container PMT test system at PMT test and Potting station

Potting

- PMTs passed acceptance test are send to potting station

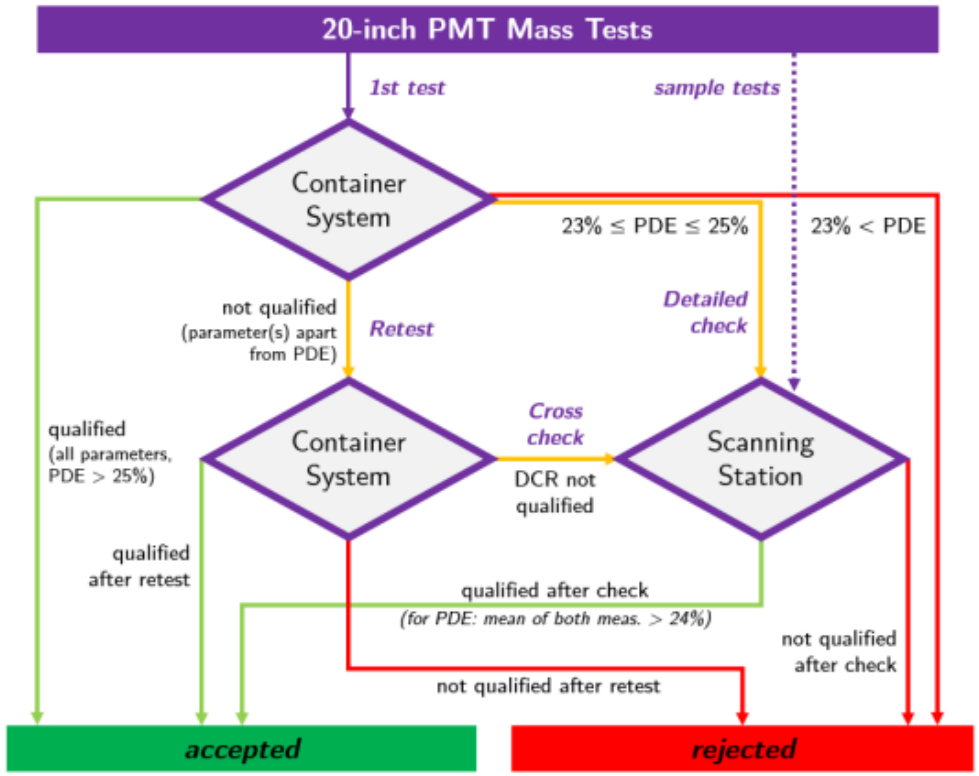
Protection Cover Installation

- Potted PMTs are installed in protection covers

1. PMTs at Pan-Aisa

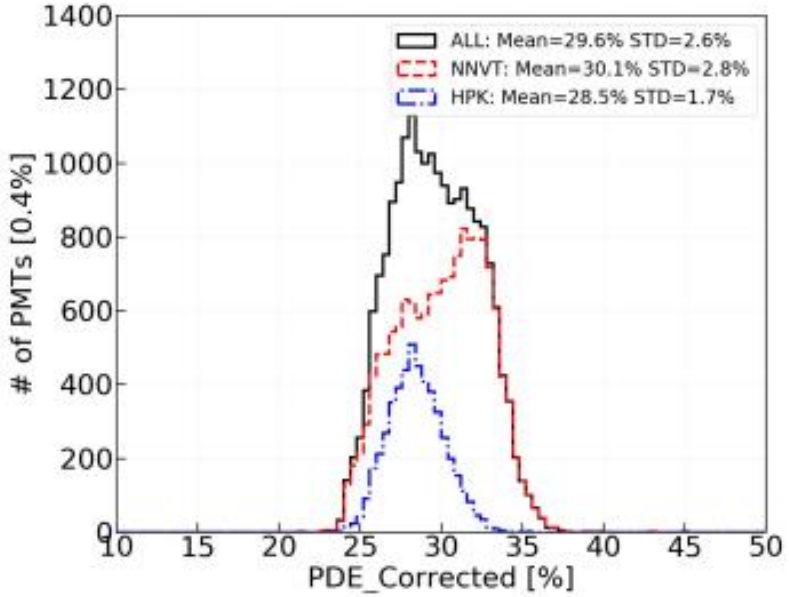
1.2 Bare PMT test: Container PMT mass test system

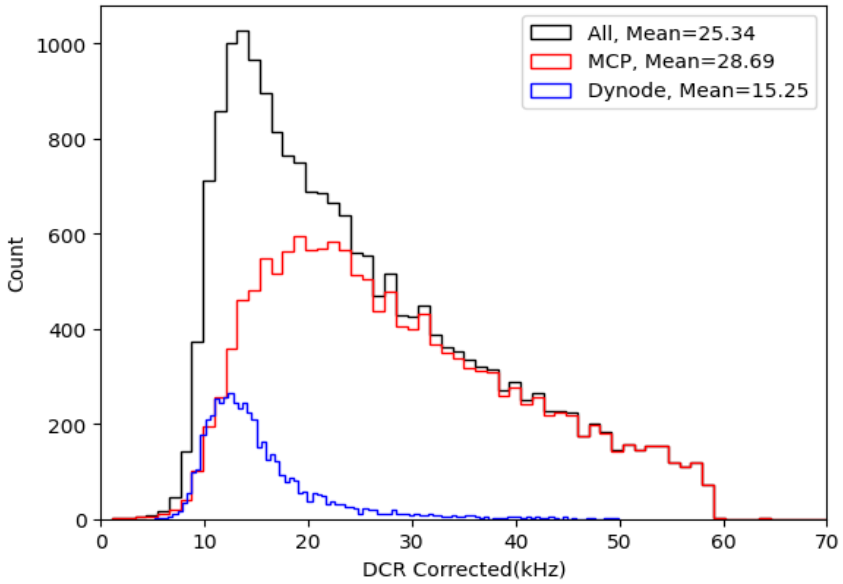
- Measurement and classification procedure for PMTs with the container and scanning station systems



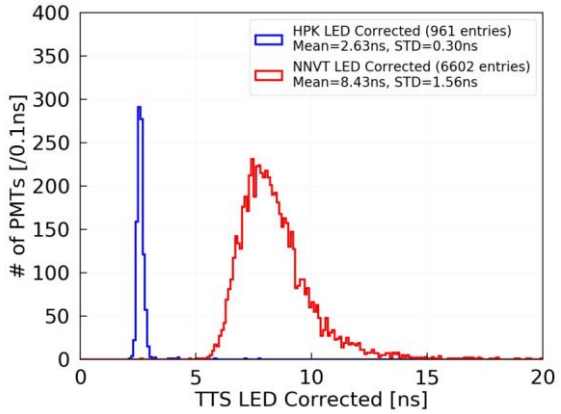
1. PMTs at Pan-Aisa

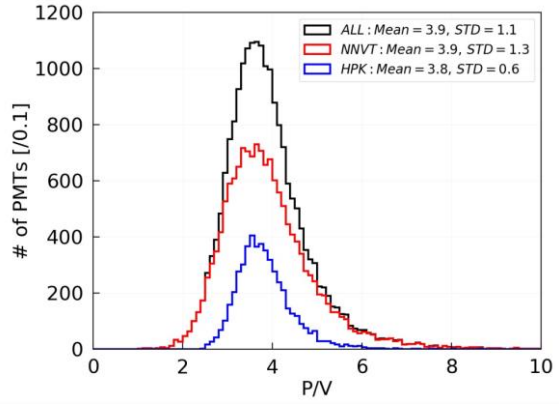
1.2 Bare PMT test: Results

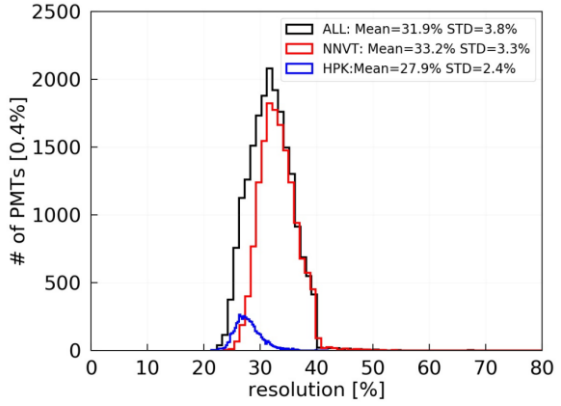


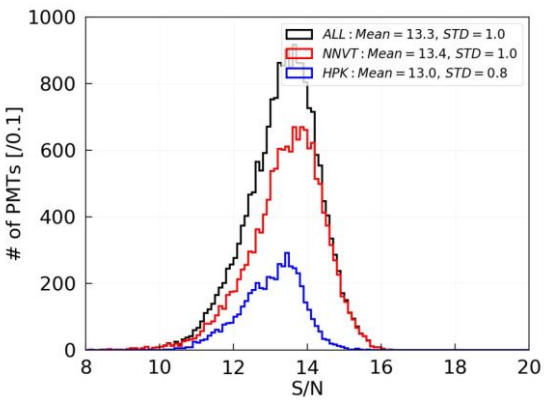


Parameters	HPK	NNVT
HV(V)	1863	1736
Gain	1.00E+07	1.03E+07
PDE(%)	28.5	30.1
DCR(%)	15.3	28.7
Resolution(%)	27.9	33.2
P/V	3.8	3.9
S/N	13.0	13.4
TTS(ns)	6.3	9.7









1. PMTs at Pan-Aisa

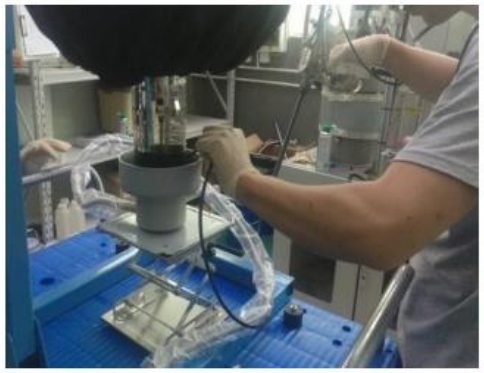
1.3 PMT Potting

Base soldering to PMT

Soldering quality check

Test after soldering

Sealing of base



Sealant filling

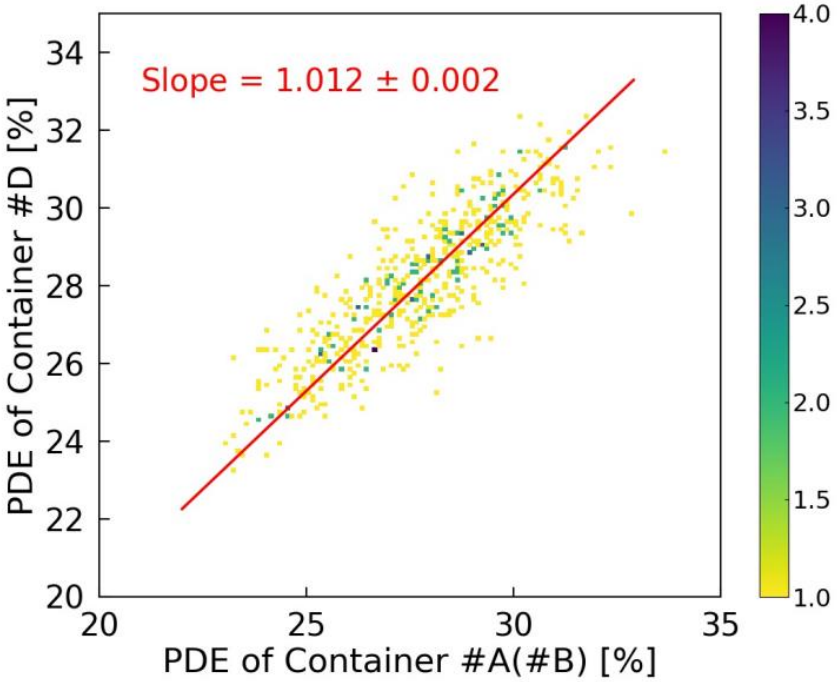
Butyl tape wrapping

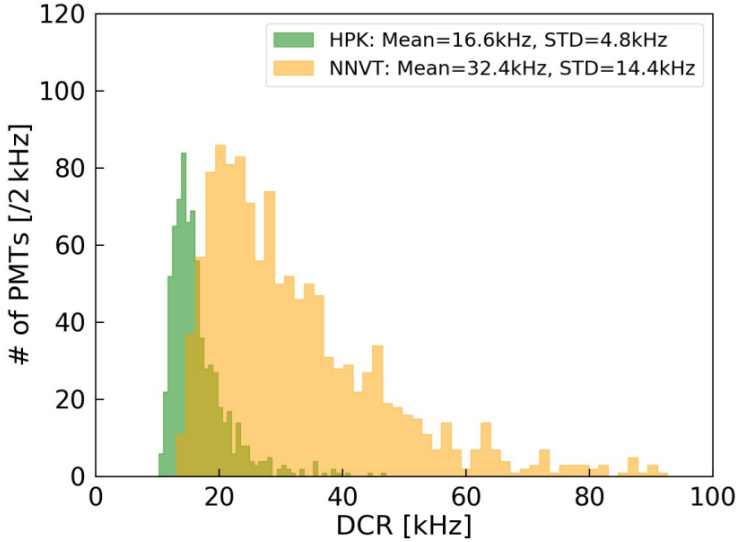
Shrinkable tube heating

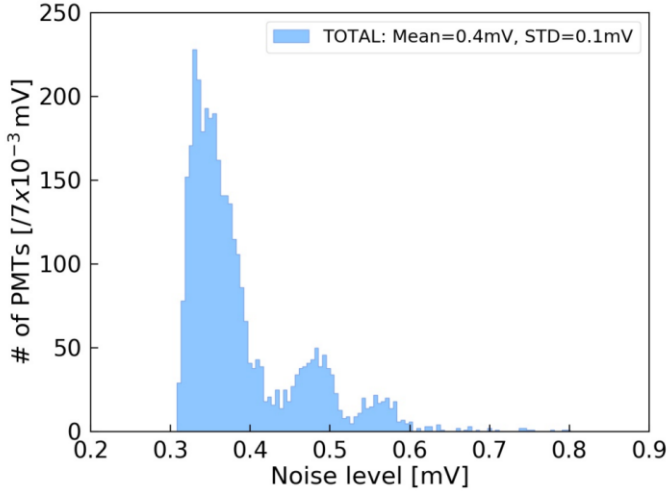
Leak test

1. PMTs at Pan-Aisa

1.3 PMT Potting: Test results with 1F3 Electronics(Container #D) after potting







1. Test results are corresponding to each other in Container A/B and Container D.
2. Noise level on JUNO 1F3 electronics are lower than expected.
3.Typical parameters of dynode and MCP PMTs in container #D.

Parameters	All PMT	Dynode PMT	MCP PMT	High-QE PMT	Low-QE PMT
HV /V	1799	1929	1722	1701	1745
Gain /10^6	10.0	9.9	10.0	9.9	10.1
PDE /%	27.4	27.7	27.2	29.0	25.1
DCR /kHz	26.5	16.6	32.4	31.0	33.9
Resolution /%	30.5	28.0	32.0	32.7	31.2
P/V	3.8	3.6	3.9	3.9	3.9
FWHM /ns	10.5	10.8	10.3	10.4	10.1
S/N	14.3	14.2	14.3	14.2	14.4
RT /ns	4.8	6.4	3.9	4.0	3.9
FT /ns	11.9	8.9	13.6	14.1	13.1
HT /ns	314.0	285.4	331.1	331.8	330.2
Relative TTS /ns	8.8	6.2	10.3	10.3	10.4
Amplitude /mV	8.1	7.9	8.1	7.9	8.4

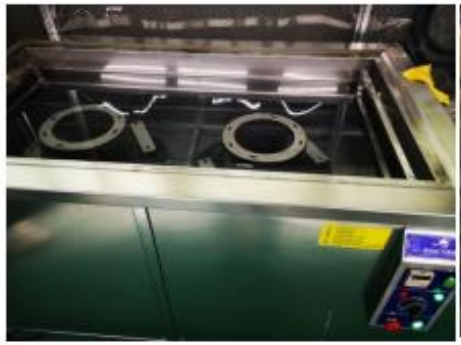
1. PMTs at Pan-Aisa

1.4 PMT Protection Cover Assembling

PMT cleaning

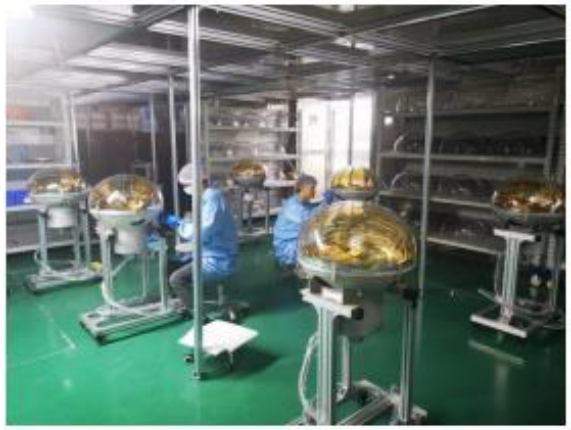
acrylic cover cleaning

acrylic cover disinfection by O_3



SS cover cleaning

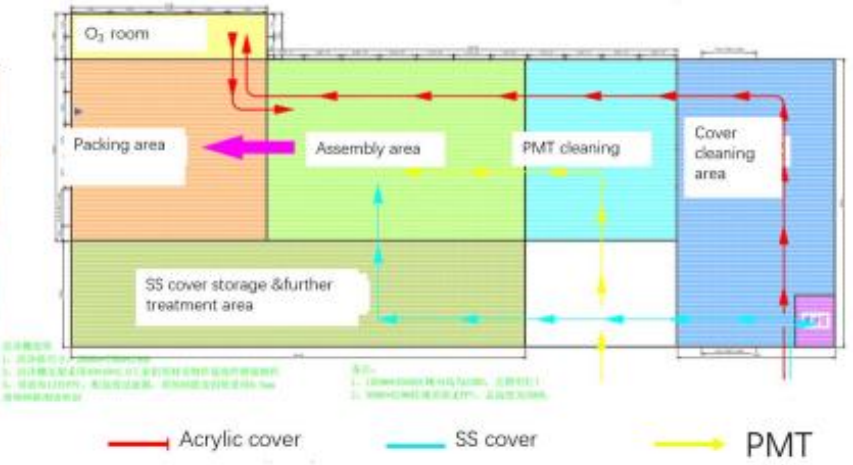
Parts installed to SS cover



Cover assembling

Protection film attached

Packaging



overall procedures

2. PMTs at JUNO SAB

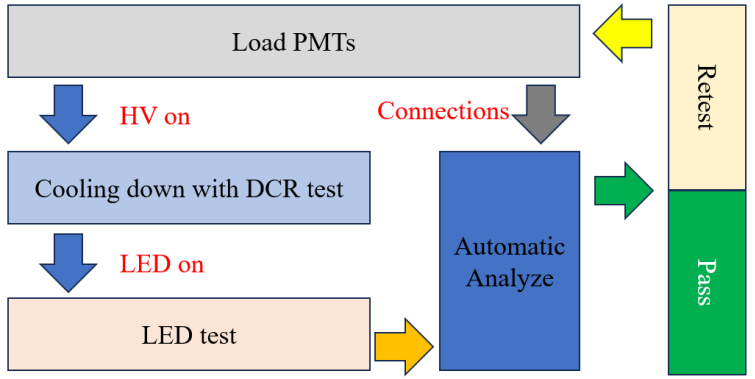
2.1 PMT Assembling on Modules

- After assembling PMTs in Protection Covers, PMTs are packing and delivering to JUNO Onsite, stored in Surface Assembling Building(SAB)

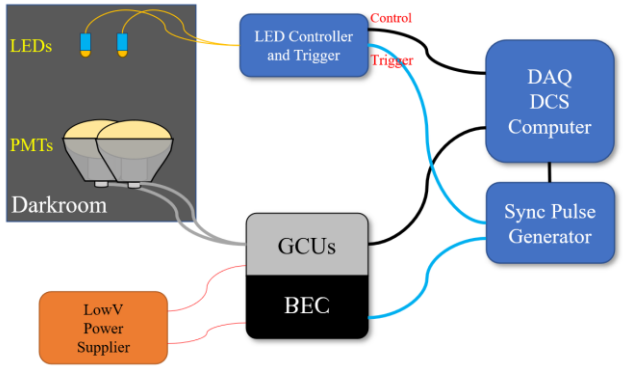
Storage

Testing

Assembling



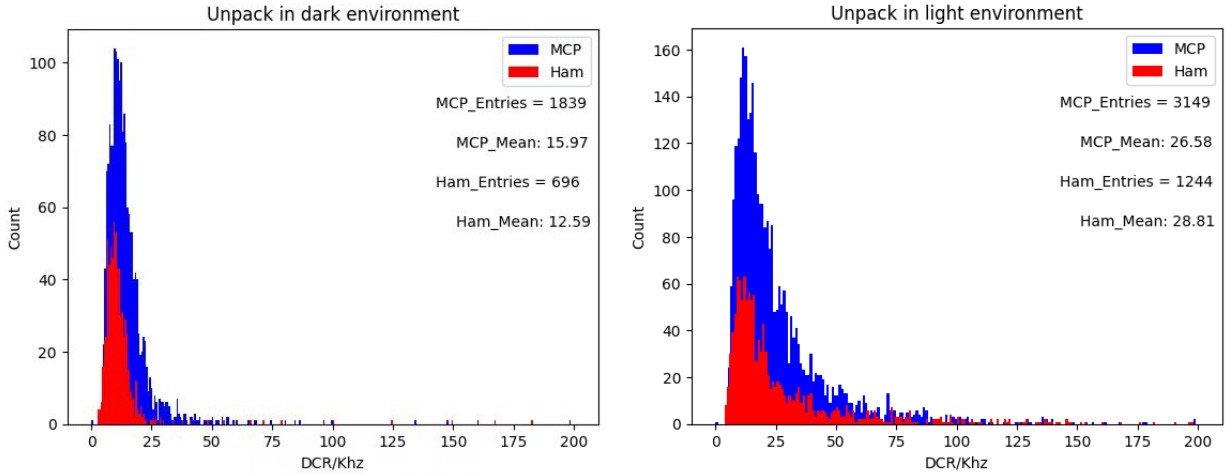
SAB PMT Test Procedure

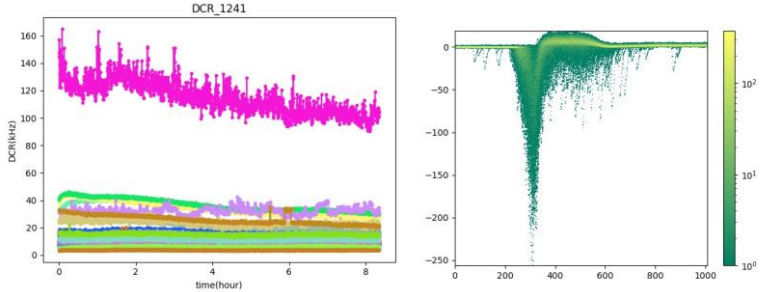


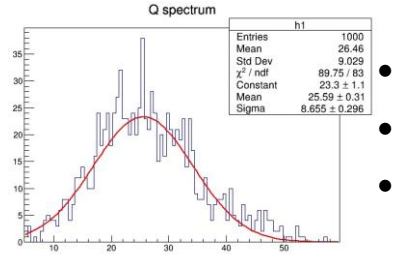
SAB PMT Test System

2. PMTs at JUNO SAB

2.2 PMT Test in SAB



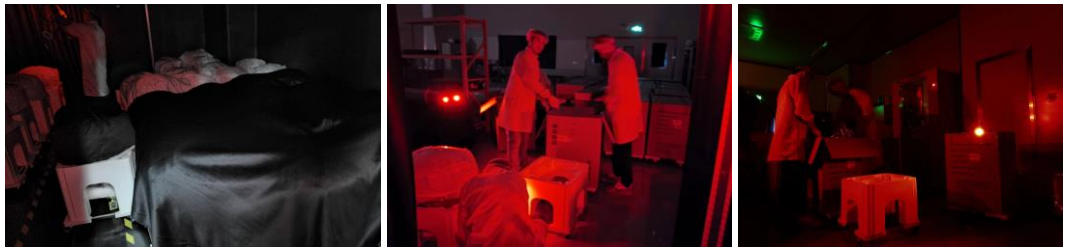




- One DCR test run
- Response waveform of light
- Calculated charge distribution

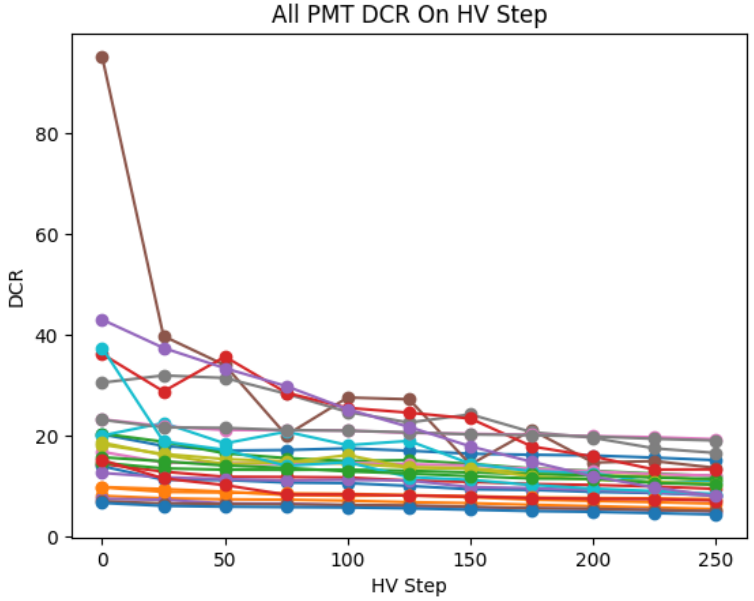
Unpack PMT in dark or light environment, DCR shows different.

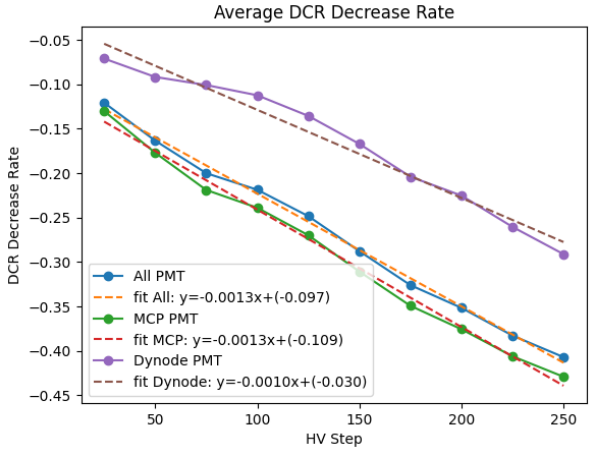
Dark	Entries	DCR (kHz)	Light	Entries	DCR (kHz)
MCP	1839	15.97	**MCP**	3149	26.58
Ham	696	12.59	**Ham**	1244	28.81

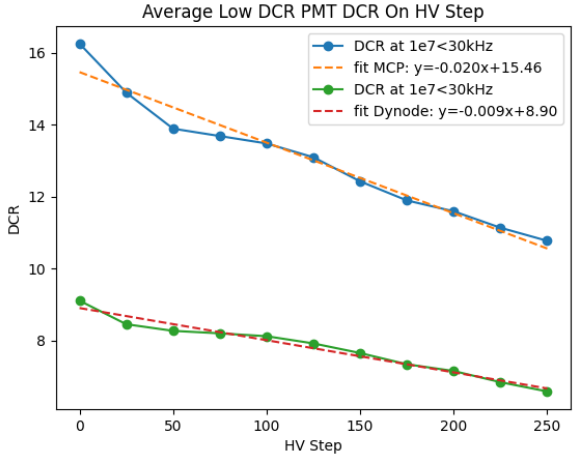


2. PMTs at JUNO SAB

2.3 PMT DCR Study in SAB: DCR HV-scan Test







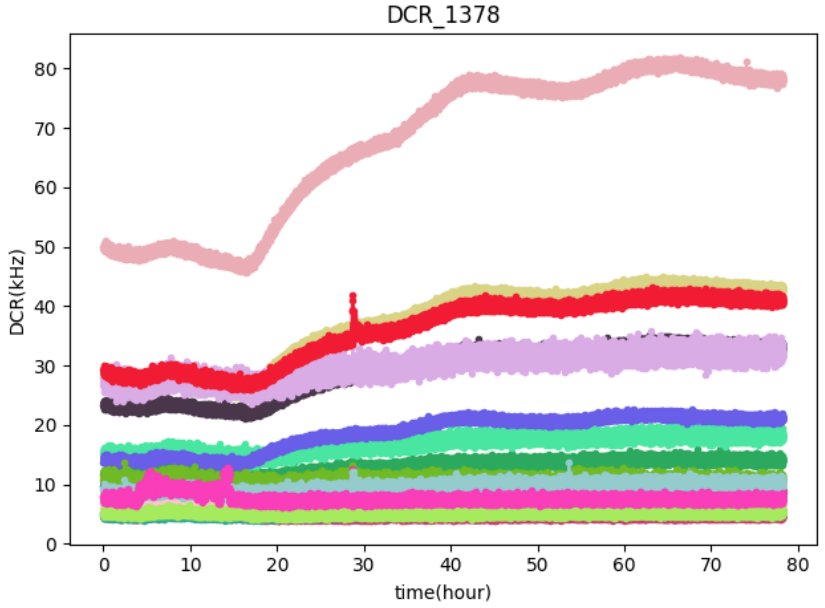
Up Pictures:
HV decrease from
HV@1E7 to
HV@1E7 -250V
Step=25V

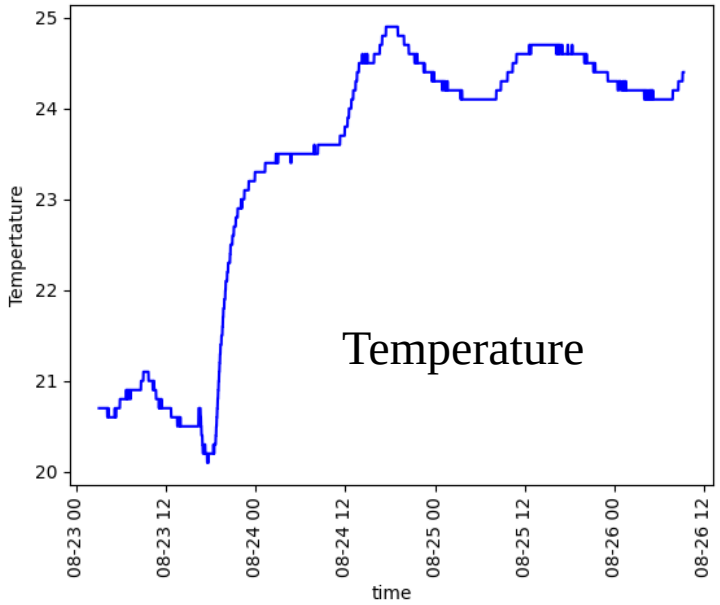
For PMTs with low DCR,
DCR of MCP PMTs decreases about
1 kHz every 50V;

DCR of Dynode PMTs decreases about
0.5 kHz every 50V;

2. PMTs at JUNO SAB

2.3 PMT DCR Study in SAB: DCR Temperature Test

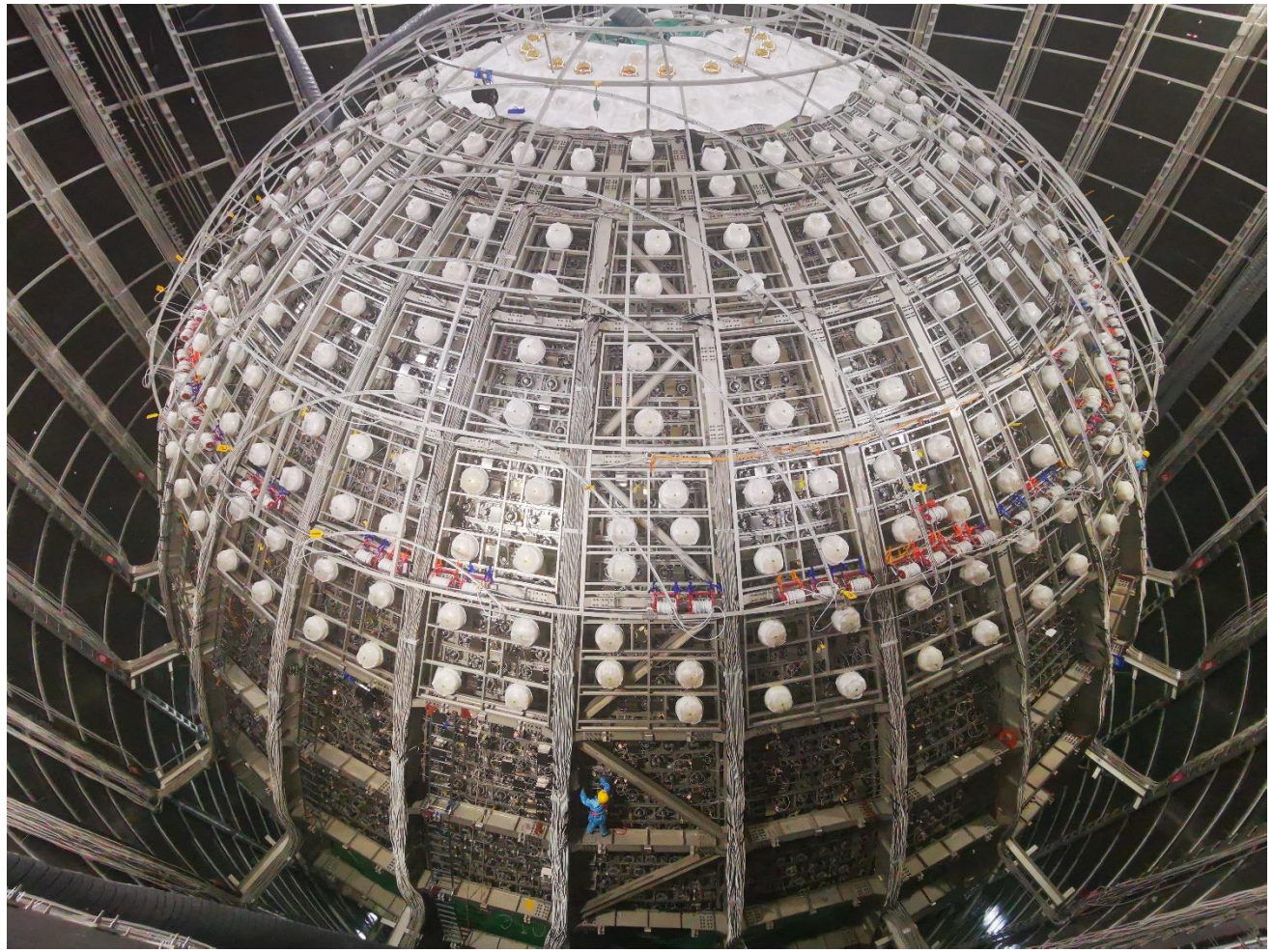


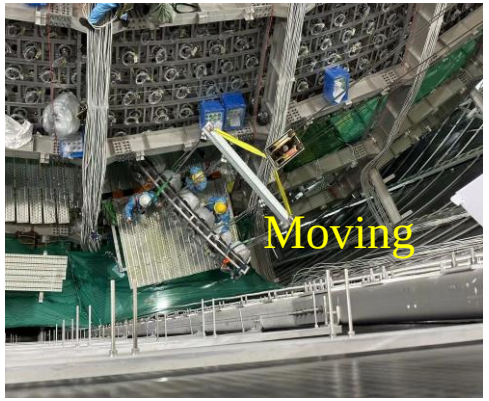


- The DCR of most of PMTs is not sensitive to temperature.
- Mean time of lowest DCR is 220 minute later lowest temperature.
- Keeping temperature at a low level is benefit to big detector performance.

3. PMT at JUNO Underground

3.1 PMT Module Installation on Truss

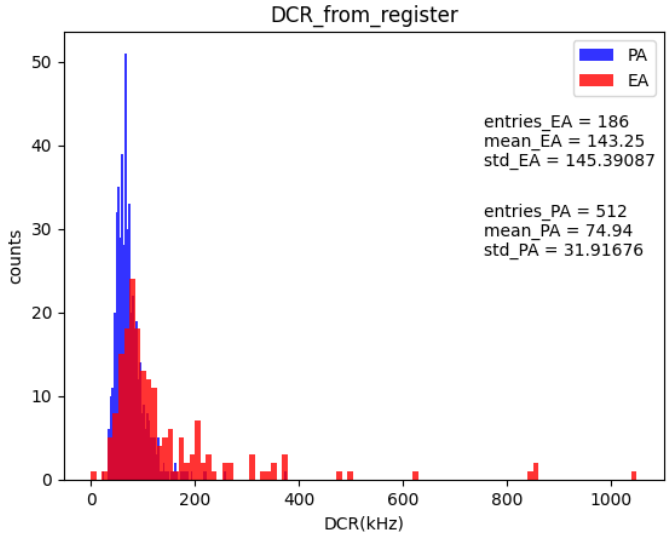


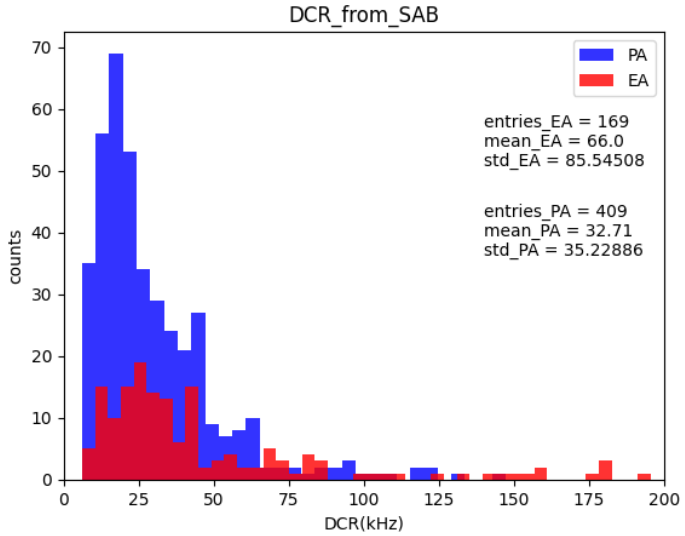


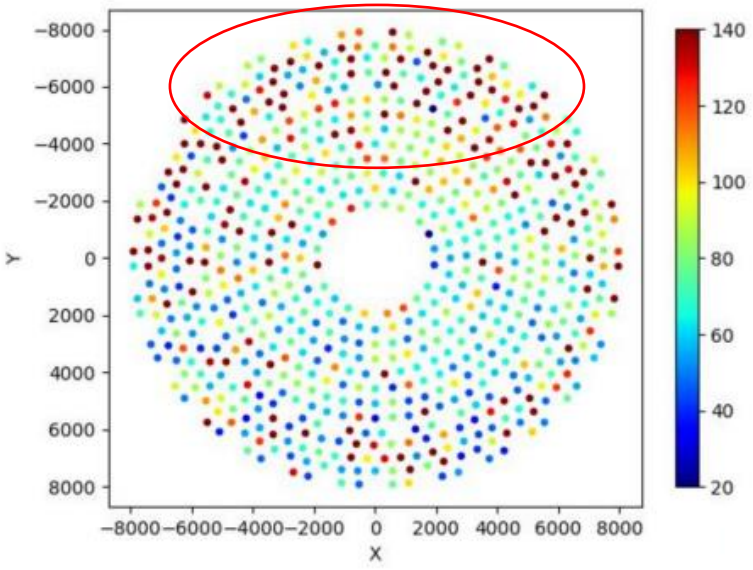
LPMT module:
+11 to +3 finished,
+2 in progress 1430 modules;
(41% of 3460) ;
6647 PMTs
(38% of 17612);

3. PMT at JUNO Underground

3.2 PMT light off Test on Detector



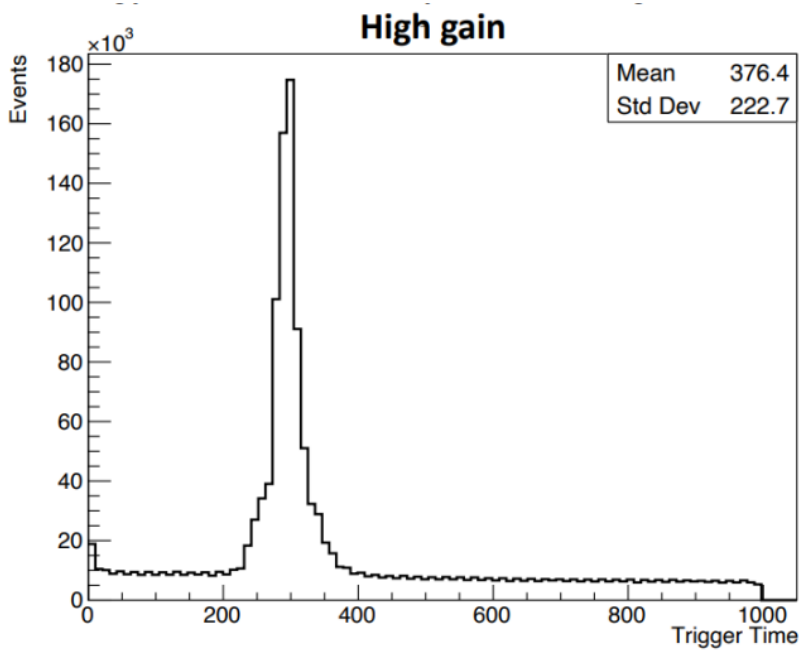




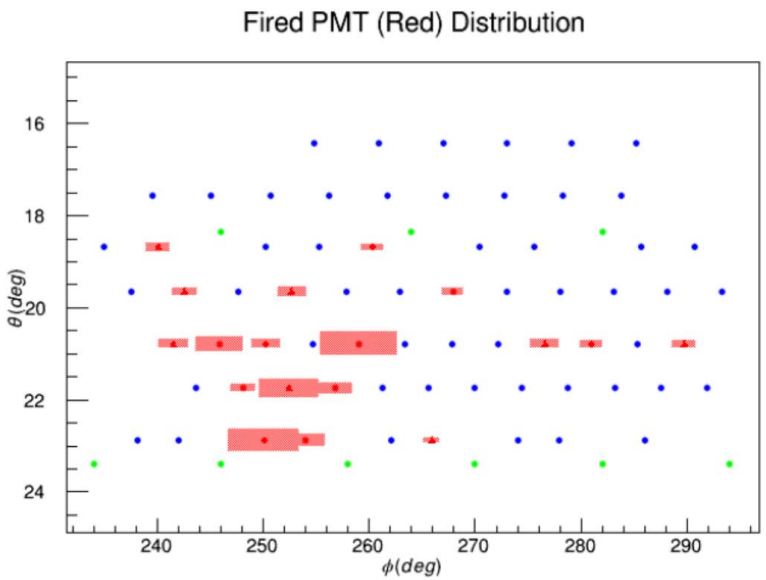
The DCR tests and retests show a acceptable DCR value for all PMTs.
High DCR PMTs are Hamamatsu PMTs, they take a longer time to Cooling down.
The concentrating DCR distribution shows a leakage of light.

Good news for PMT installation!

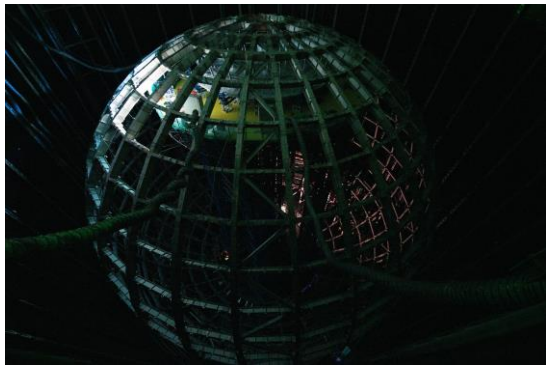
3. PMT at JUNO Underground



Hit time distribution of BEC nhit events



Hit pattern



Turning light off in the Experiment Hall

- Understanding PMT hit patterns ongoing.
- Light leakage could due to holes near the connection bars of SS structure

The 3rd Light off test is ongoing!!!

4. Summary

- PMT testing and assembling is ongoing.
- PMT performance meets to the requirement of JUNO.
- Further PMT testing on Detector is planned.

That’s all, thank you!!

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