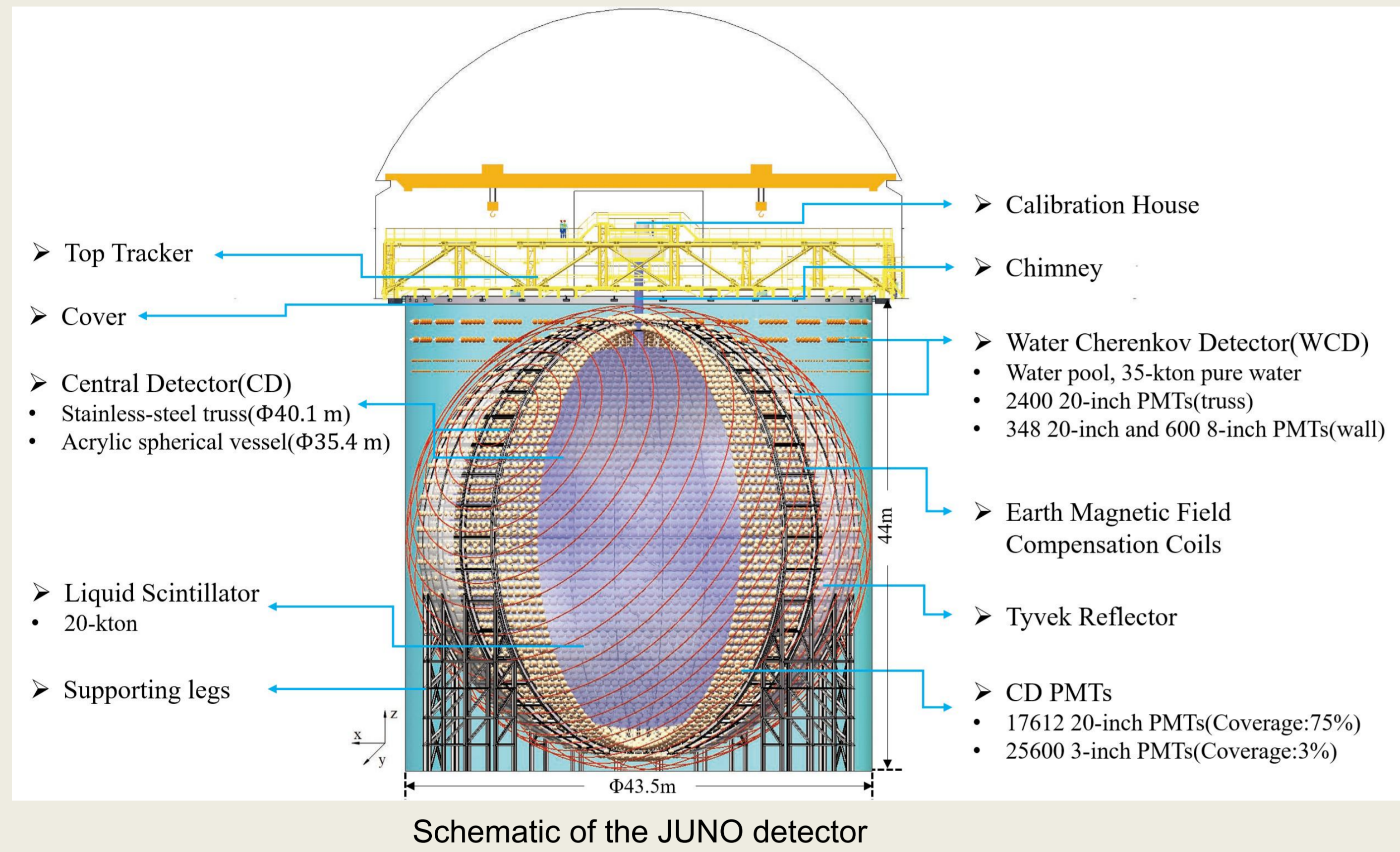


### Introduction of the JUNO detector

The JUNO detector is designed with a 35.4 m-diameter acrylic vessel and a 40.1 m-diameter stainless steel truss, which holds 20 kt liquid scintillator, 20,012 20-inch PMTs and 25,600 3-inch PMTs. The total coverage of all PMTs is ~78%, with 75% from 20-inch PMTs and 3% from 3-inch PMTs. In addition, 348 20-inch PMTs and 600 8-inch PMTs have been installed on the side wall of the water pool.

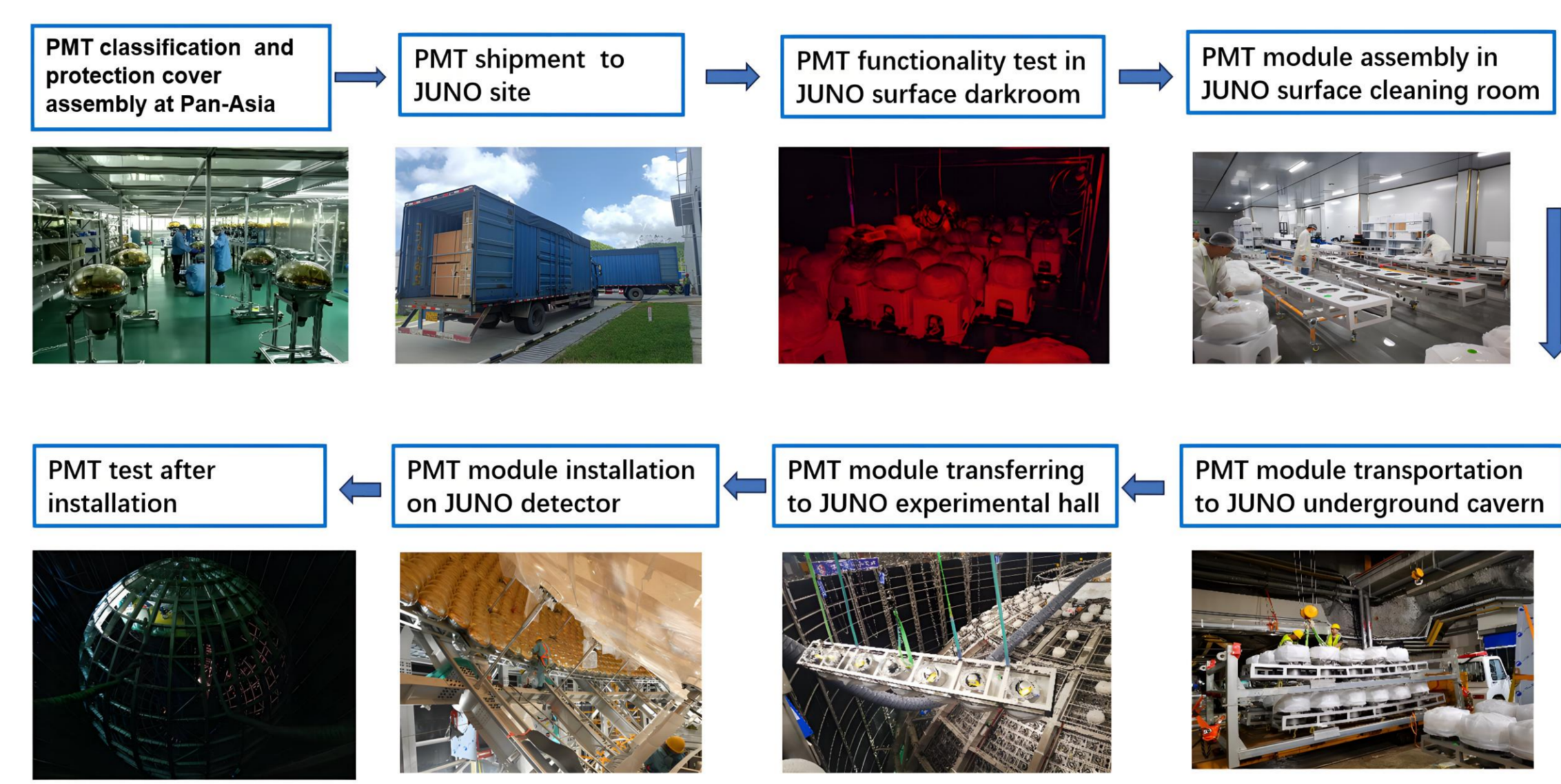
JUNO's construction has been fully completed, and data taking started on August 26, 2025.



### Overview of the 20-inch PMT instrumentation status

JUNO's 20-inch PMT instrumentation covers mass testing & characterization, high-voltage divider design, waterproof potting, underwater implosion protection, and final PMT installation. This poster centers on the recently completed PMT installation work; all other instrumentation tasks were finished previously and introduced elsewhere.

Figure below illustrates the workflow for 20-inch PMT installation. Upon completion of PMT processing at the Pan-Asia workstation, all PMTs are delivered to the JUNO site for functional testing. Subsequently, the tested PMTs are integrated into modules, which are then transferred to the underground JUNO experimental hall. The final step consists of mounting these PMT modules onto the stainless-steel truss, with periodic performance tests conducted throughout the entire installation process.

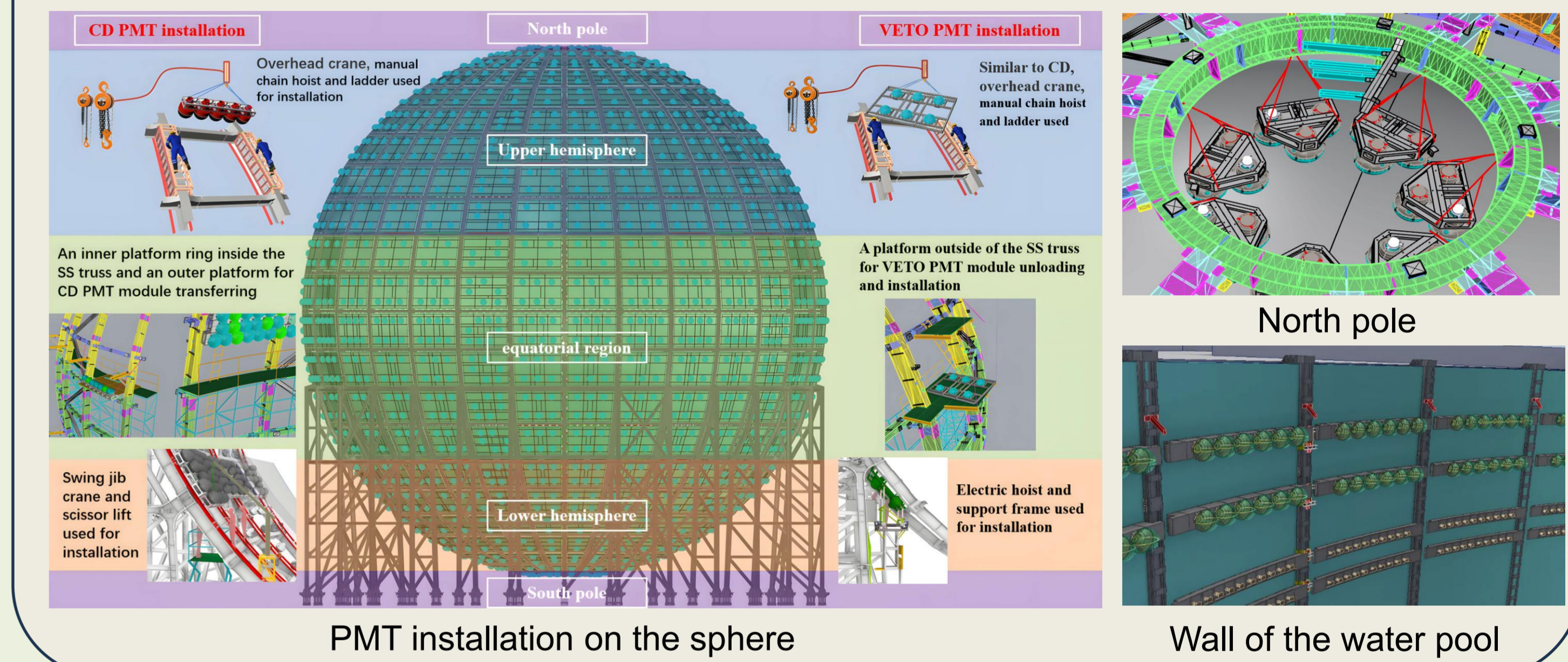


Workflow of 20-inch PMT installation

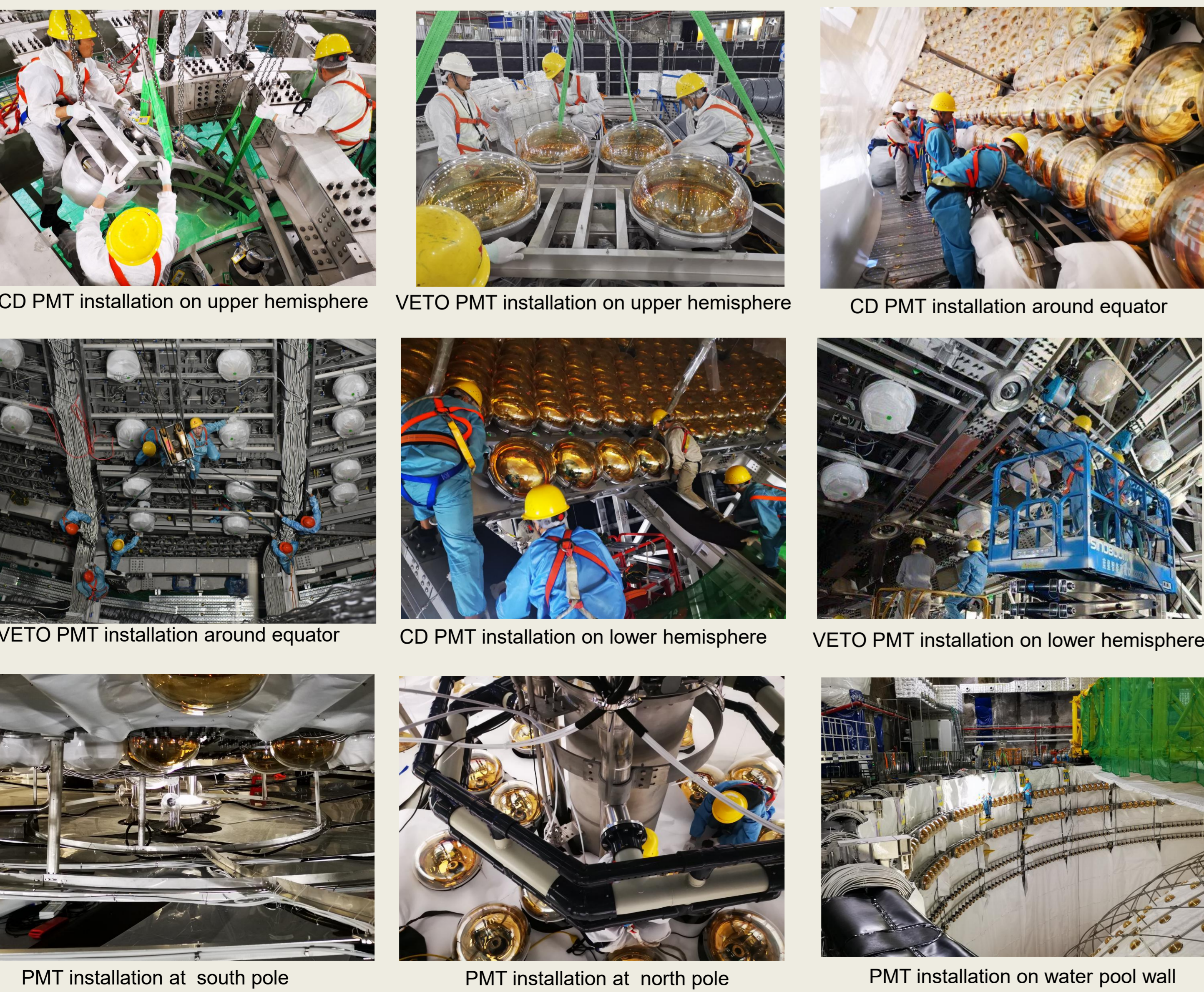
### Design of the 20-inch PMT installation

Due to differing platforms and installation techniques, the spherical detector's PMT installation area is split into five regions: upper hemisphere, equatorial region, lower hemisphere, polar areas, and the water pool wall. The PMT numbers for each region are presented below, and the diagrams show region-specific PMT installation design.

Region	CD PMT			VETO PMT	
	Ring Numbers	Module Numbers	PMT Numbers	Module Numbers	PMT Numbers
Region 1 (Layer +11 to Layer +2)	54	1545	7493	280	850
Region 2 (Layer +1 to Layer -4)	31	930	6374	150	960
Region 3 (Layer -5 to Layer -11)	35	976	3703	190	560
Region 4 (Layer -12 and Layer +12)	4	14	42	20	30
Region 5 (Wall of water pool)	-	-	-	58	348
Total	124	3465	17612	698	2748

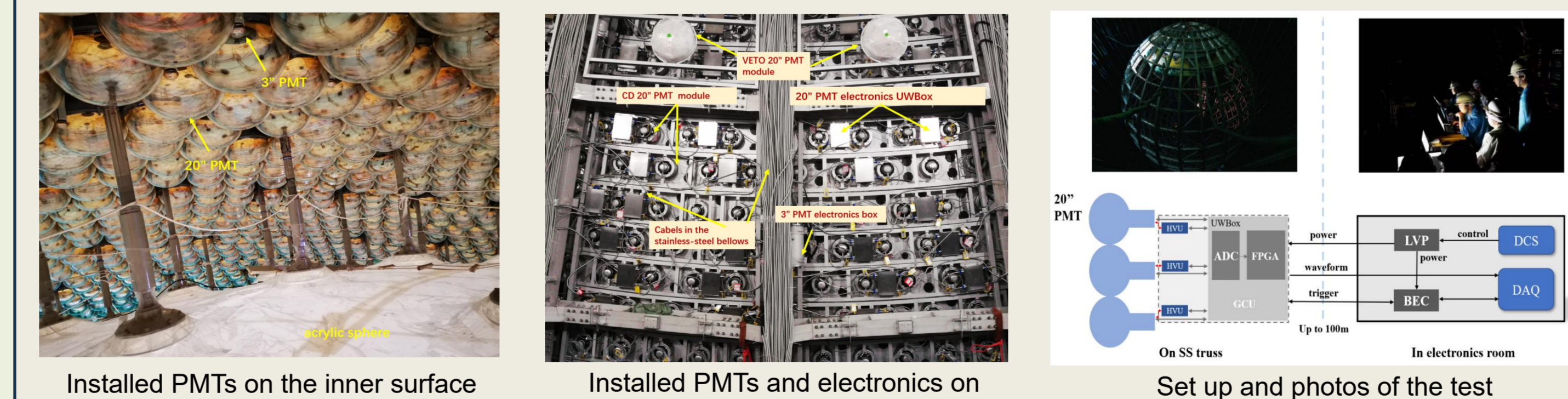


### Photos of the 20-inch PMT installation

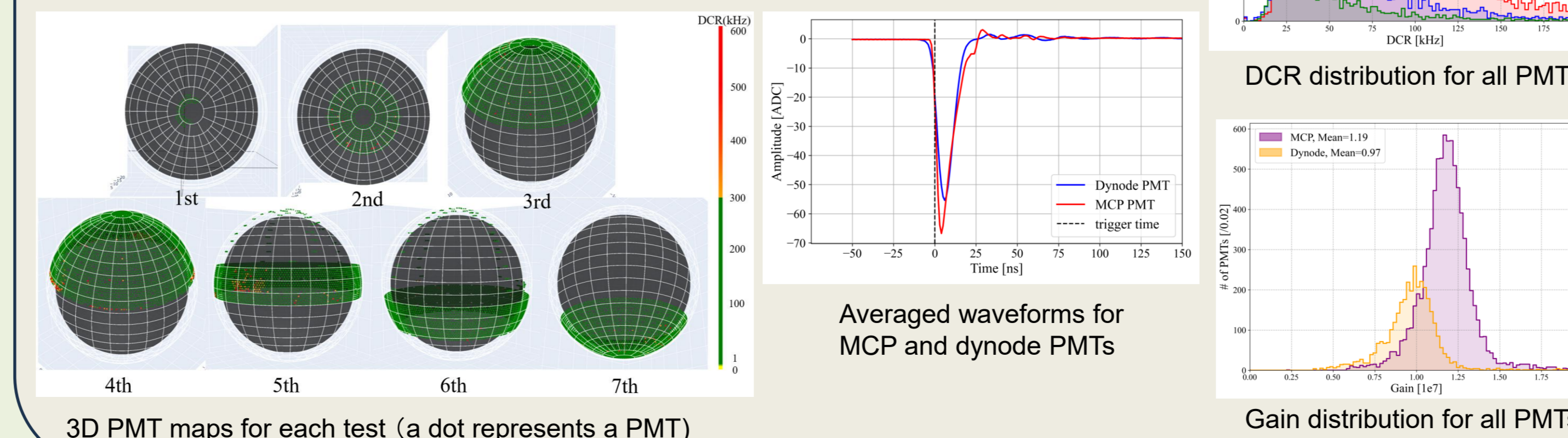


### Test during the 20-inch PMT installation

To verify PMT functionality and installation quality, regular tests were performed during the installation. PMT Dark Count Rate (DCR), gain and waveform were measured. These procedures also serve as joint tests integrating PMTs, electronics and the DAQ system.



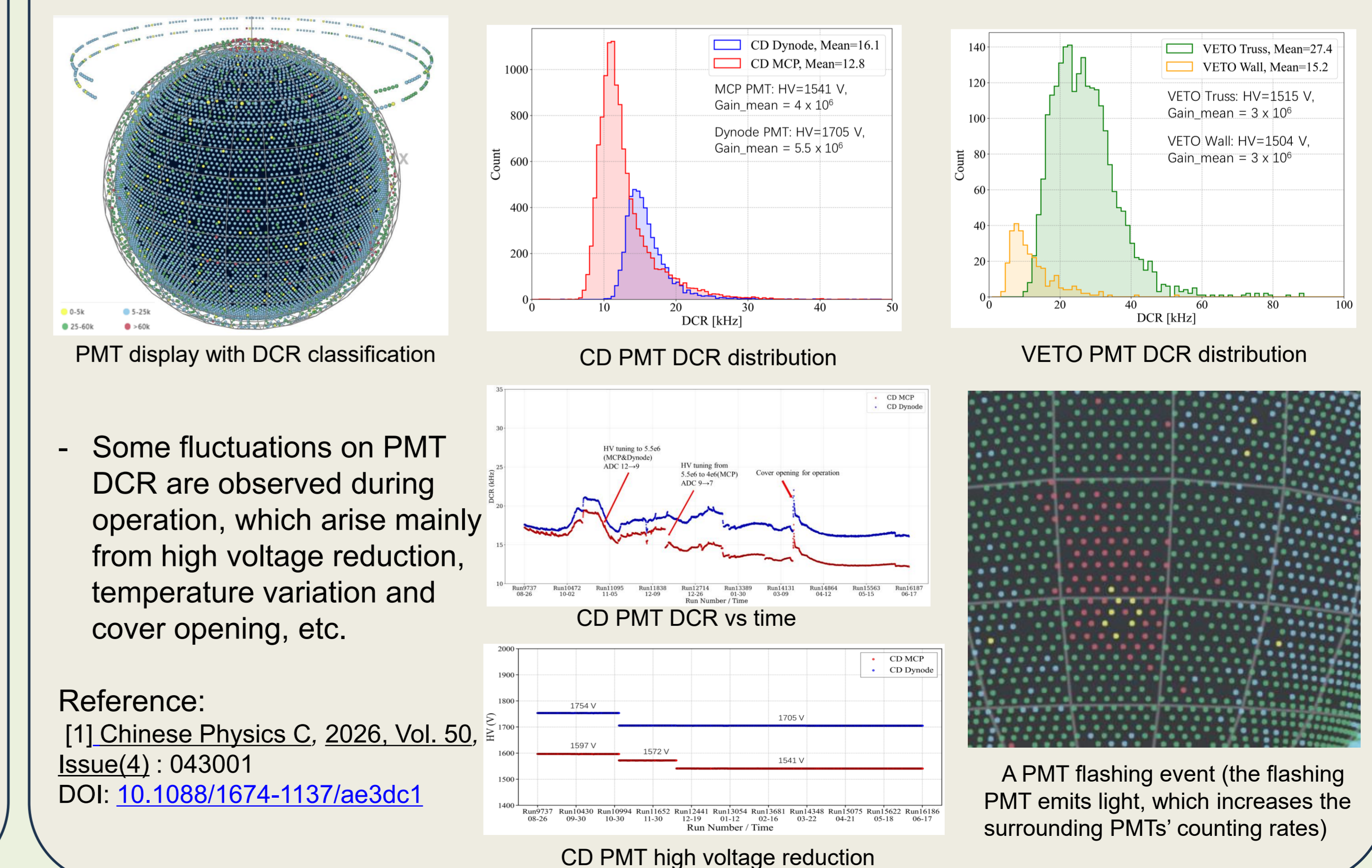
Test results indicate that all installed 20343 PMTs (17596 for CD and 2747 for VETO) operate normally; only two PMTs exhibited no signal after power-up. The elevated DCR and gain values relative to prior Pan-Asia test arises from differences in test conditions such as light shielding and cool-down time.



### Operational status of the 20-inch PMT

Following JUNO's official operation launch in August 2025, the 20-inch PMTs have operated steadily and show good performance in general<sup>[1]</sup>:

- PMT DCR is gradually decreasing. DCR of MCP PMTs in CD is now ~13 kHz (acceptance test: 31 kHz); DCR of dynode PMT is ~16 kHz
- Only ~40 channels (PMTs + electronics) are dead since water filling began (December, 2024)
- Extensive efforts have been done to mitigate PMT flashing, including HV reduction, periodic PMT restarts, and automatic shutdown of PMTs with high DCR. ~600 PMTs are turned off



Reference:  
[1] Chinese Physics C, 2026, Vol. 50, Issue(4) : 043001  
DOI: [10.1088/1674-1137/ae3dc1](https://doi.org/10.1088/1674-1137/ae3dc1)