



Status of JUNO

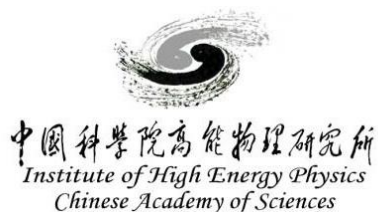
Zhimin Wang (王志民)

(IHEP, Beijing)

On behalf of JUNO collaboration

wangzhm@ihep.ac.cn

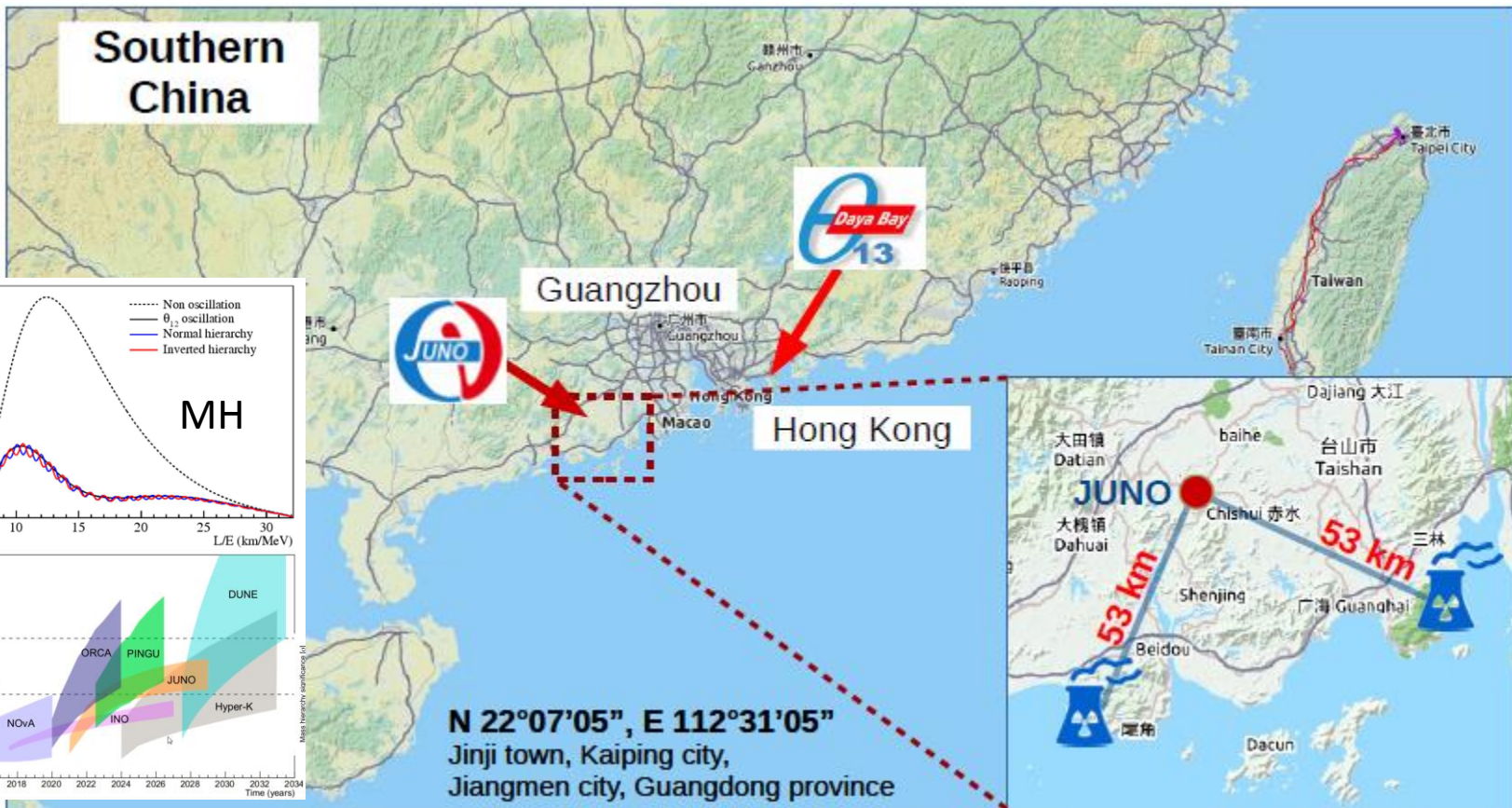
Neutrino, 27 July 2017, TAUP17, Sudbury, Canada



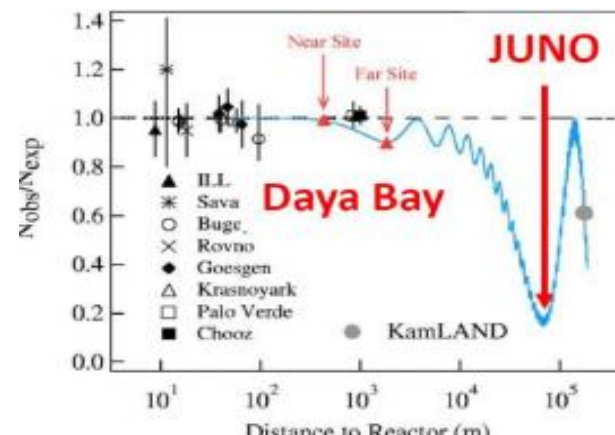
Jiangmen Underground Neutrino Observatory

the multi-kton liquid scintillator detector

NPP	Daya Bay	Huizhou	Lufeng	Yangjiang	Taishan
Status	Operational	Planned	Planned	Under construction	Under construction
Power	17.4 GW	17.4 GW	17.4 GW	17.4 GW	18.4 GW



A multi-purpose detector: precision oscillation parameters and multi- neutrinos



	Δm_{21}^2	$ \Delta m_{31}^2 $	$\sin^2 \theta_{12}$	$\sin^2 \theta_{13}$	$\sin^2 \theta_{23}$
Dominant Exps.	KamLAND	MINOS	SNO	Daya Bay	SK/T2K
Individual 1σ	2.7% [20]	4.1% [25]	6.7% [6]	10% [21]	14% [23, 24]
Global 1σ	2.6%	2.7%	4.1%	8.6%	11%

**Probing the unitarity of U_{PMNS} to $\sim 1\%$
more precise than CKM matrix elements !**

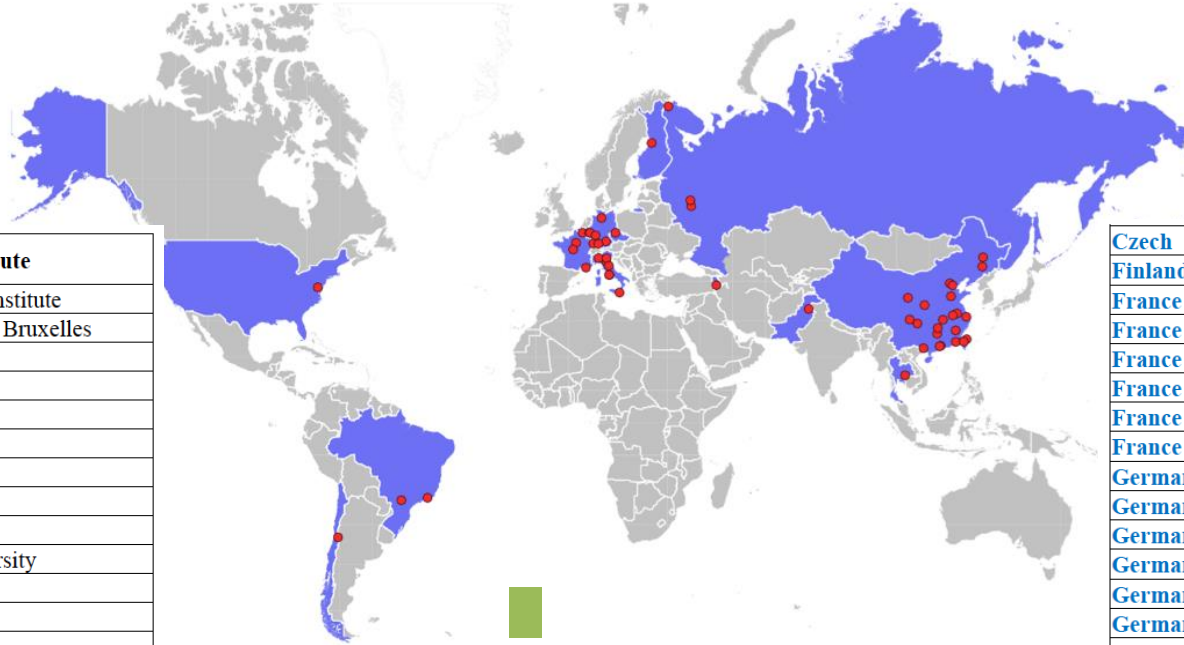
	Statistics	+BG +1% b2b +1% EScale +1% EnonL
$\sin^2 \theta_{12}$	0.54%	0.67%
Δm_{21}^2	0.24%	0.59%
Δm_{ee}^2	0.27%	0.44%

New physics tests in low-energy oscillation phenomena:

- Light sterile neutrinos 1405.6540
- Non-standard neutrino interactions 1310.5917, 1408.6301
- Lorentz and CPT violation 1409.6970
- Other Neutrino s: Geo, Super Nova,...



JUNO collaboration



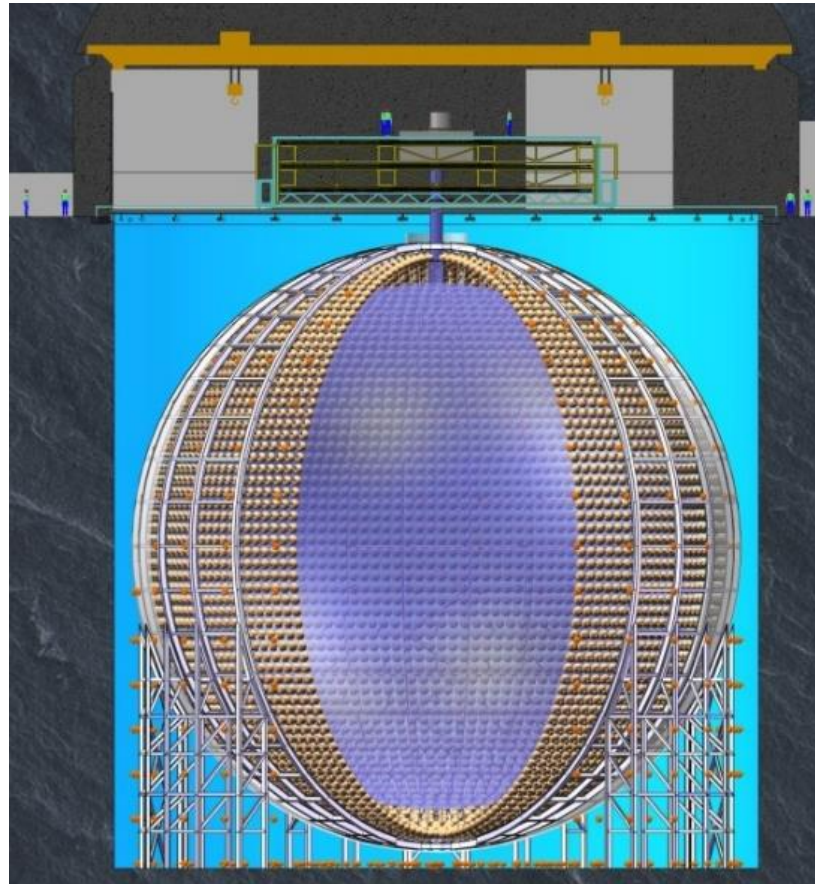
Country	Institute
Armenia	Yerevan Physics Institute
Belgium	Universite libre de Bruxelles
Brazil	PUC
Brazil	UEL
Chile	PCUC
Chile	USM
China	BISEE
China	Beijing Normal U.
China	CAGS
China	ChongQing University
China	CIAE
China	DGUT
China	ECUST
China	Guangxi U.
China	Harbin Institute of Technology
China	IHEP
China	Jilin U.
China	Jinan U.
China	Nanjing U.
China	Nankai U.
China	NCEPU
China	Pekin U.
China	Shandong U.
China	Shanghai JT U.
China	IMP-CAS
China	SYSU
China	Tsinghua U.
China	UCAS
China	USTC
China	U. of South China
China	Wu Yi U.
China	Wuhan U.
China	Xi'an JT U.
China	Xiamen University
China	NUDT



Czech	Charles U.
Finland	University of Oulu
France	APC Paris
France	CENBG Bordeaux
France	CPPM Marseille
France	IPHC Strasbourg
France	LLR Palaiseau
France	Subatech Nantes
Germany	FZJ ZEA2
Germany	RWTH Aachen U.
Germany	TUM
Germany	U. Hamburg
Germany	IKP FZJ
Germany	U. Mainz
Germany	U. Tuebingen
Italy	INFN Catania
Italy	INFN di Frascati
Italy	INFN-Ferrara
Italy	INFN-Milano
Italy	INFN-Milano Bicocca
Italy	INFN-Padova
Italy	INFN-Perugia
Italy	INFN-Roma 3
Pakistan	PINSTECH (PAEC)
Russia	INR Moscow
Russia	JINR
Russia	MSU
Slovakia	FMPICU
Taiwan	National Chiao-Tung U.
Taiwan	National Taiwan U.
Taiwan	National United U.
Thailand	NARIT
Thailand	PPRLCU
Thailand	SUT
USA	UMD1
USA	UMD2

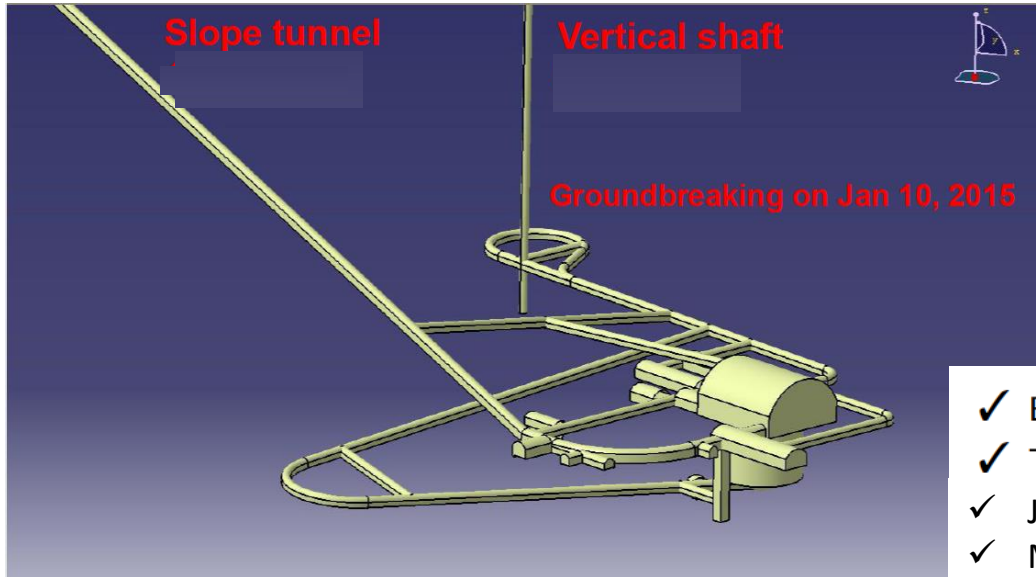
Established in July 2015
71 institutions/Universities
571 collaborators

JUNO detector challenges

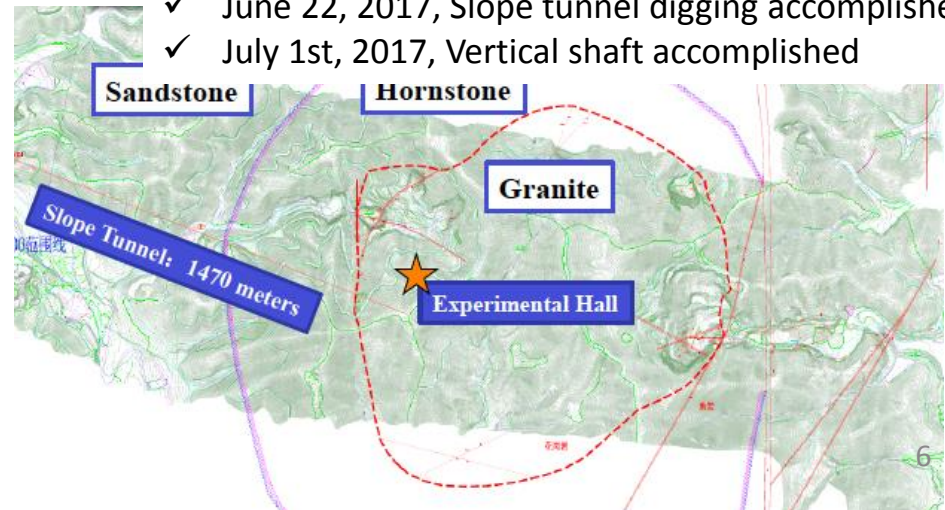


Experiment	Daya Bay	BOREXINO	KamLAND	JUNO
LS mass	20 ton	~300 ton	~1 kton	20 kton
Coverage	~12%	~34%	~34%	~80%
Energy resolution	~7.5%/√E	~5%/√E	~6%/√E	~3%/√E
Light yield	~ 160 p.e. / MeV	~ 500 p.e. / MeV	~ 250 p.e. / MeV	~ 1200 p.e. / MeV

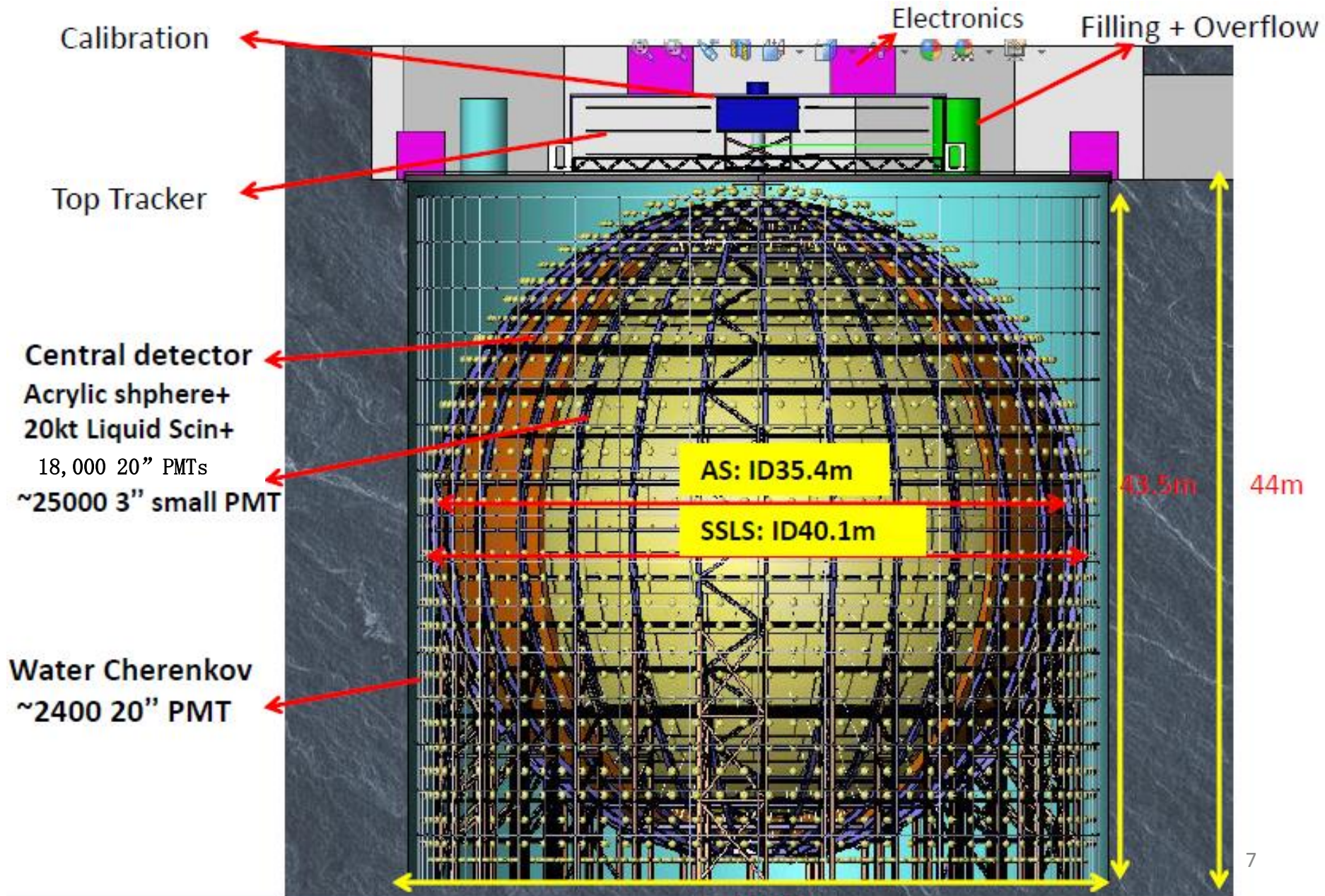
Going 720 m underground



- ✓ Experimental Hall overburden: 720 m (1900 mwe)
- ✓ Two access to experimental Hall
- ✓ Jan 10, 2015, Civil construction kick-off
- ✓ May 26, 2015, Vertical shaft digging started
- ✓ June 22, 2017, Slope tunnel digging accomplished
- ✓ July 1st, 2017, Vertical shaft accomplished



JUNO detector

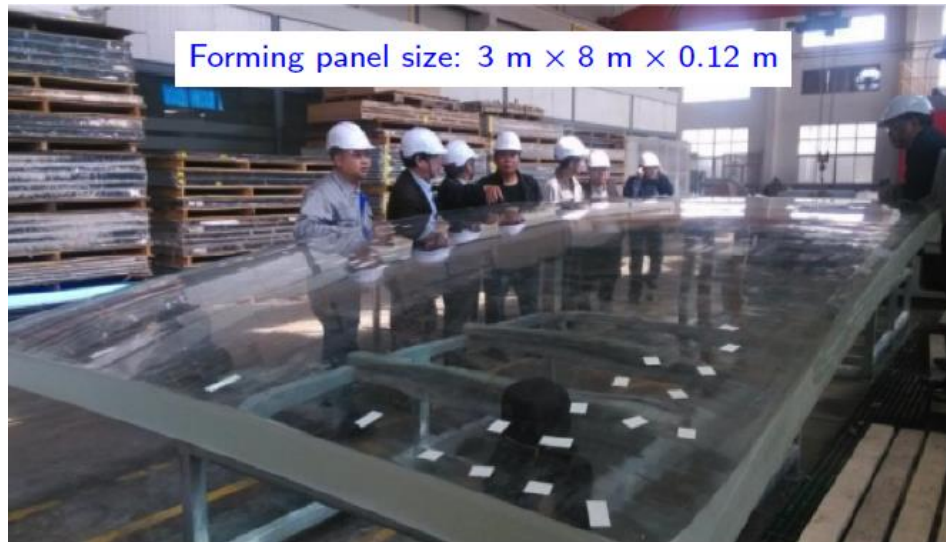
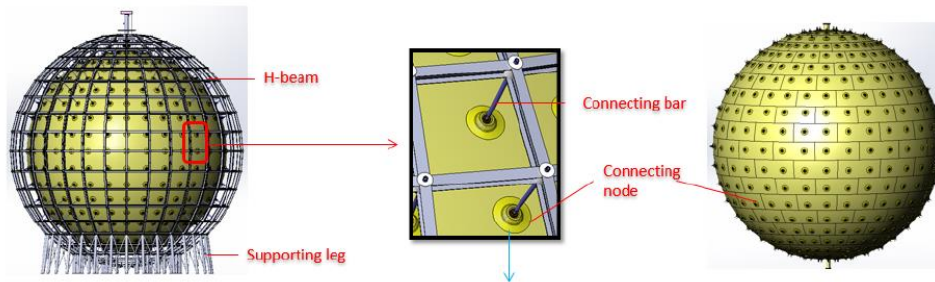


JUNO Central Detector

For more detail please refer to Yuekun and Boxiang's talk.

Acrylic Sphere and Stainless Steel truss

- ✓ safety was given a priority
- ✓ 260 acrylic panels of 12 cm thickness
- ✓ Total weight: ~600 t of acrylic and ~600 t of steel



Worst stress case: the total vertical load is ~2600t up, ~560 connecting nodes will carry it

Central detector: acrylic vessel bidding signed

MMA storage

Cleaning workshop

Cleaning room for making Polymerization container

Polymerization container flat setting in the water pool

- **Thermoforming & annealing** In heating room: staged temperature control
The shape of the spherical panel is good in forming practice

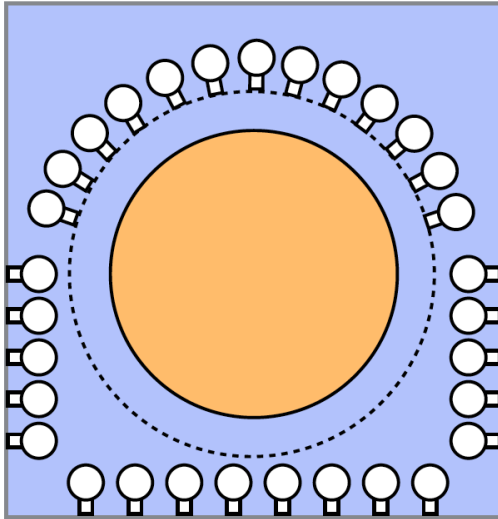
Forming mold and jig

Forming in heating room

Annealing

JUNO Muon Veto

Refer to Poster 139 by
Christoph Genster



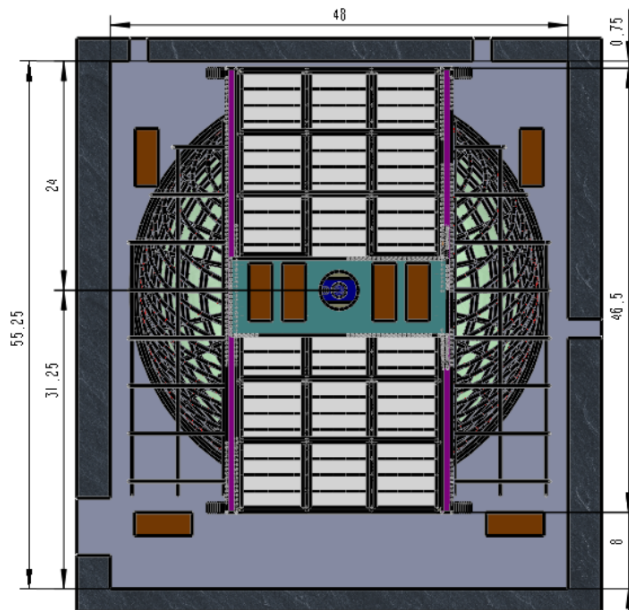
Water Cherenkov

20~30kt ultra-pure water

Water acting as moderator &
pool instrumented to detect Cherenkov light

2000 20" PMTs located as in the picture

Maximise detection efficiency of Cherenkov light



Top Tracker

Arrived at China

Using **OPERA** plastic scintillator (49m²/module)

Three layers to ensure good muon tracking

Partial coverage due to available modules

- **Reject ~50% muons**
- Provide tagged muon sample to study reconstruction and background contamination with central detector

Optimizing light collection

- **Optical coverage: ~78%**

→ 18,000 large PMTs (20") → 75%

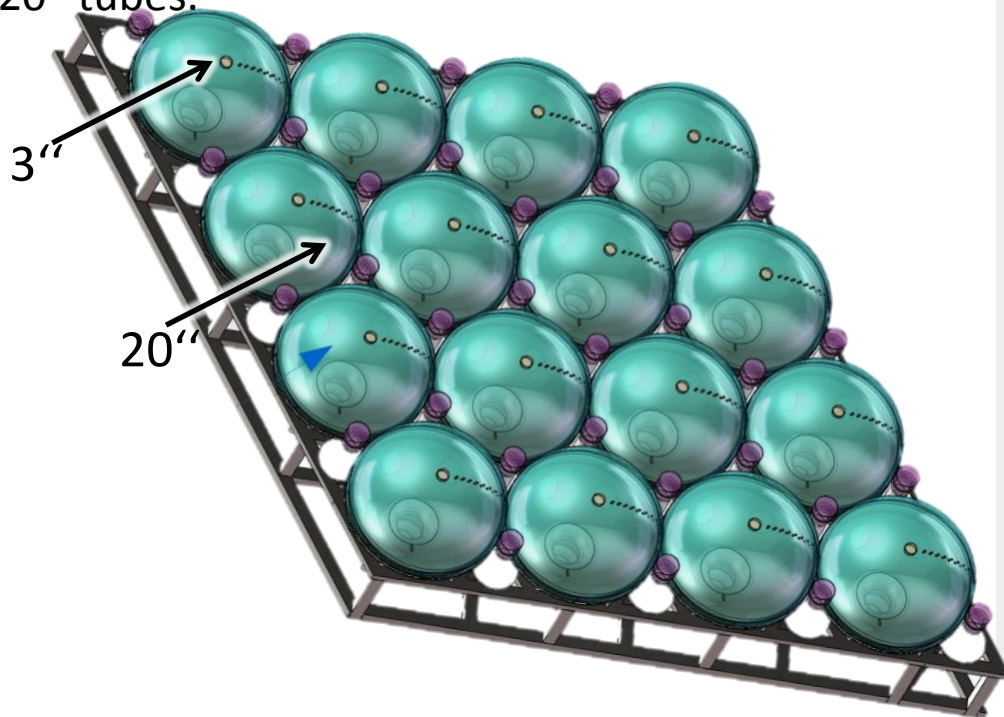
- 15K NNVT MCP 20" PMT

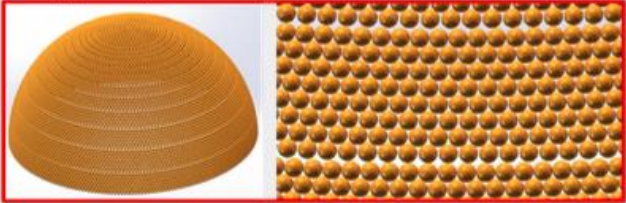
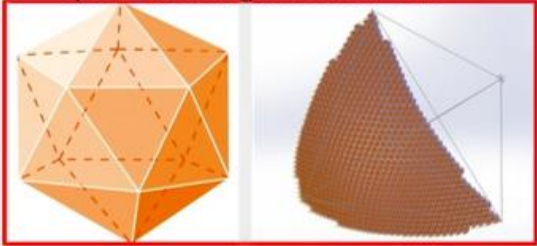
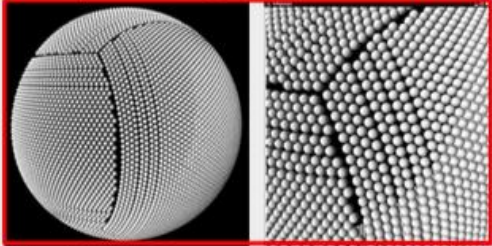
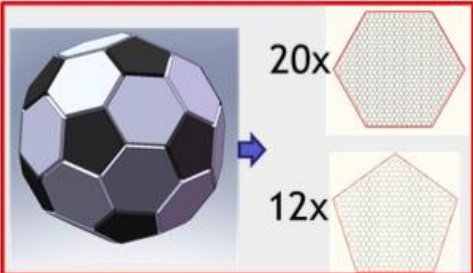
- 5k Hamamatsu 20" PMT

→ 25,000 small PMTs (3") → 2.5%

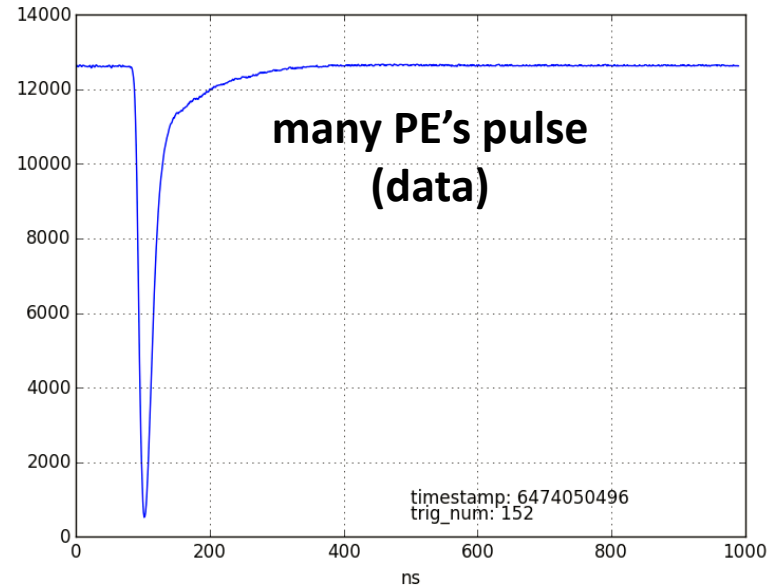
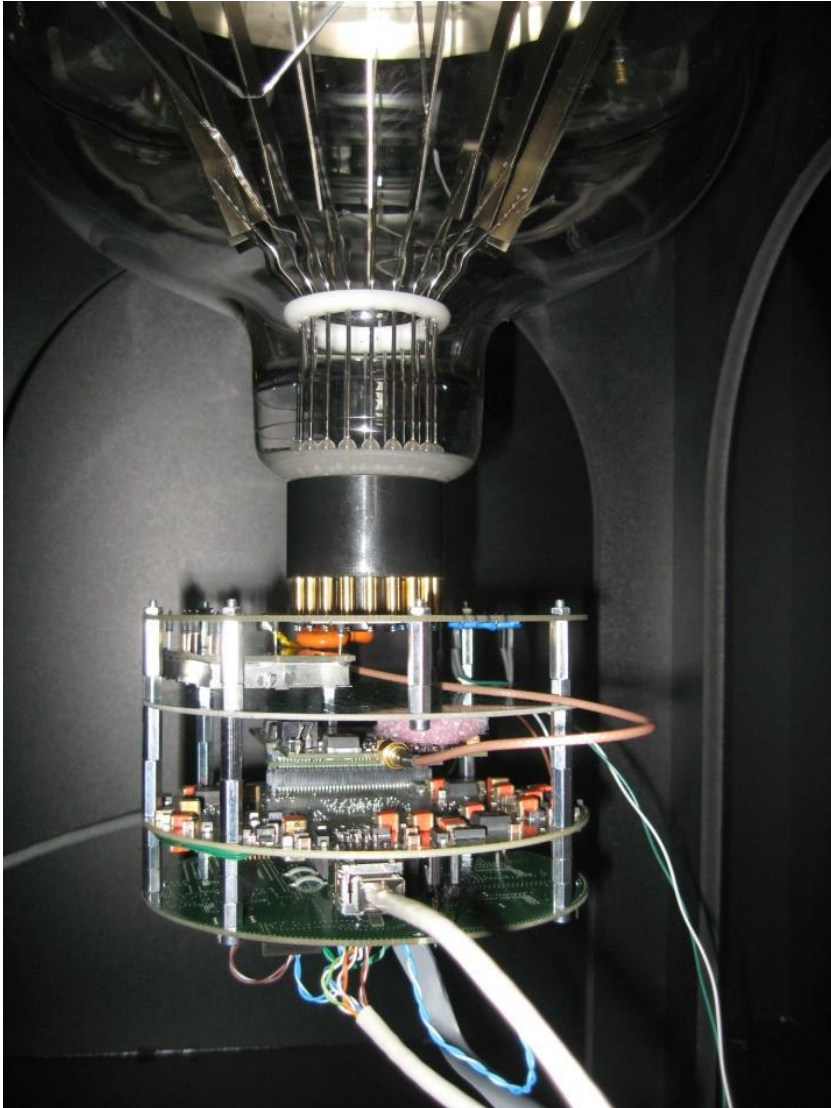
(double calorimetry + timing)

All the bidding signed (20", 3"), and receiving 20" tubes.



1	<p>Supper layer arrangement method 77.8%</p> 	SELECTED
2	<p>Spherical triangle method 72%</p> 	
3	<p>Volleyball arrangement method 75.96%</p> 	
4	<p>Football arrangement method 74.08%</p> 	

Electronics and Integration test with PMT



1st prototype demonstration...

- **analogue front-end...**
 - baseline, noise, no ringing/overshoot, etc
- **digital front-end...**
 - FADC sampling, data handling
- **connectivity (underwater-surface)...**
 - cabling, interfaces, etc
- **Digital back-end...**
 - DAQ, clock, data-collection, etc

1st 20" PMT Receiving/storage

MCP-PMT



Hamamatsu



May 17th: 1st NNVT 20" MCP-PMT arriving at Pan-Asia, total 336 tubes in 28 packages
May 20th: 1st Hamamatsu 20" PMT arriving at Pan-Asia, total 160 tubes in 40 packages

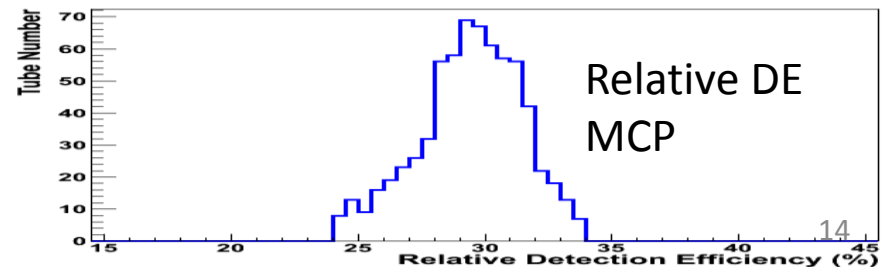
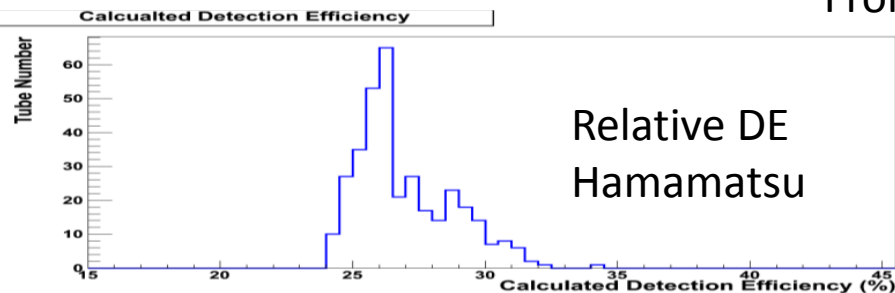
At Zhongshan Pan-Asia PMT testing station

JUNO Received tubes

@Pan-Asia station

- Totally 2784 tubes
 - MCP: 4 batches (1344 tubes)
 - 1st: 336 tubes
 - 2nd: 312 tubes
 - 3rd: 360 tubes
 - 4th: 336 tubes
 - Hamamatsu: 7 batches (1440 tubes)
 - 1st: 160 tubes (batch #5)
 - 2nd: 320 tubes (batch #6)
 - 3rd: 800 tubes (batch #1~#4)
 - 4th: 160 tubes (batch #7)

From vender Data sheet



Testing 20" PMT

- JUNO PMT acceptance test systems are under commissioning
 - all with earth magnetic field shielding
- Testing system commissioning going on

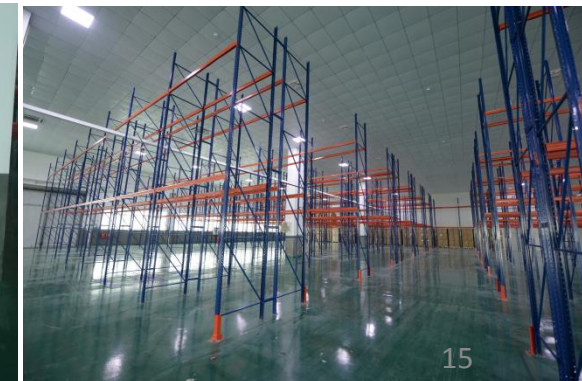
Visual check



Container test system

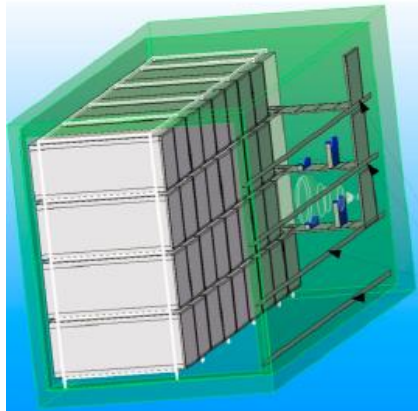


Sample scan station system

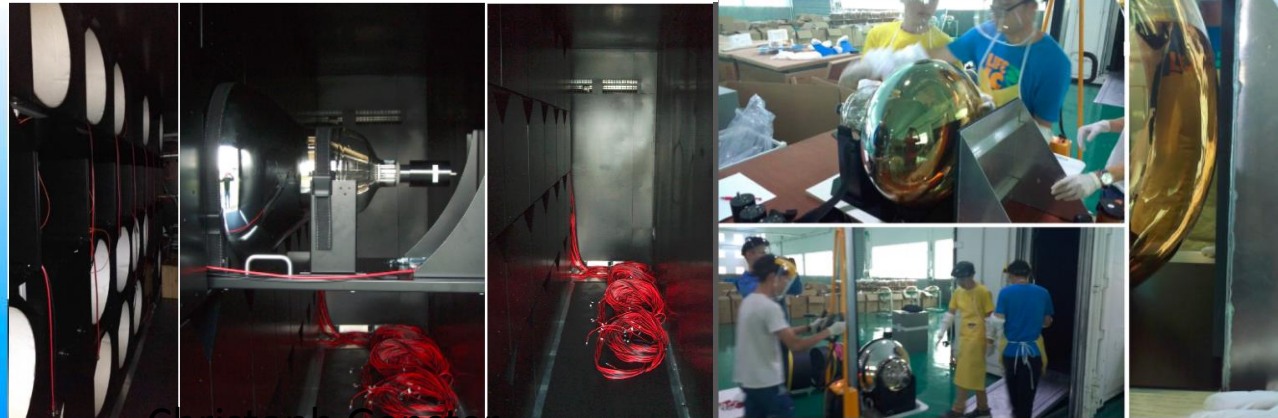


Testing systems

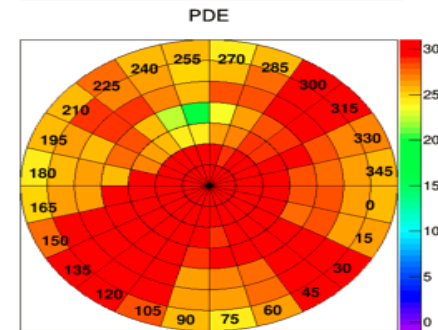
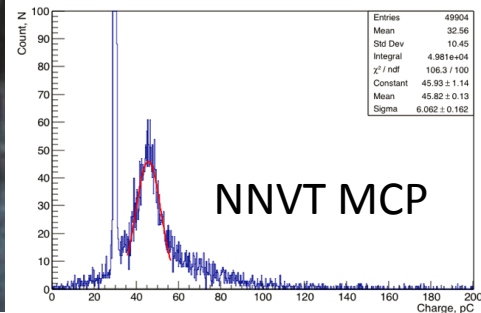
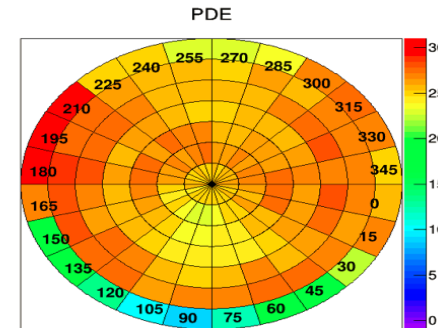
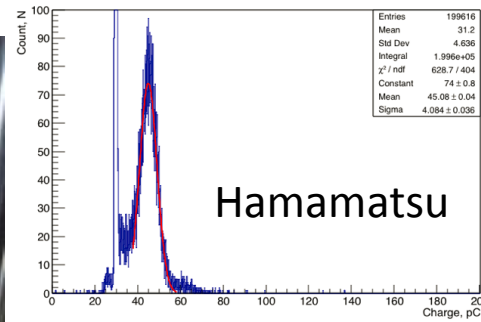
Commissioning/Testing



Holder to support weight of drawers during loading



Christoph Genster



***Thanks for your
attention!***

Backup



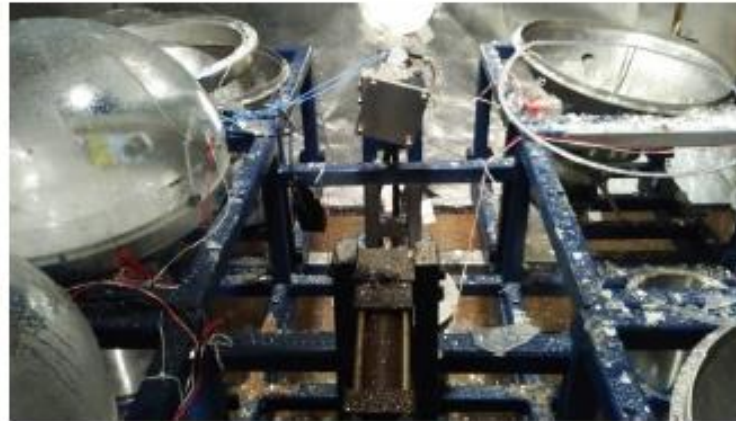
Underwater implosion tests

6 times of protection tests under 0.5MPa water since 2016

1st test



2nd test



3rd test



4th test



5th test



6th test



JUNO calibration system

Goals

- ✓ Overall energy resolution : $3\%/\sqrt{E}$
- ✓ Energy scale, non linearities : $< 1\%$

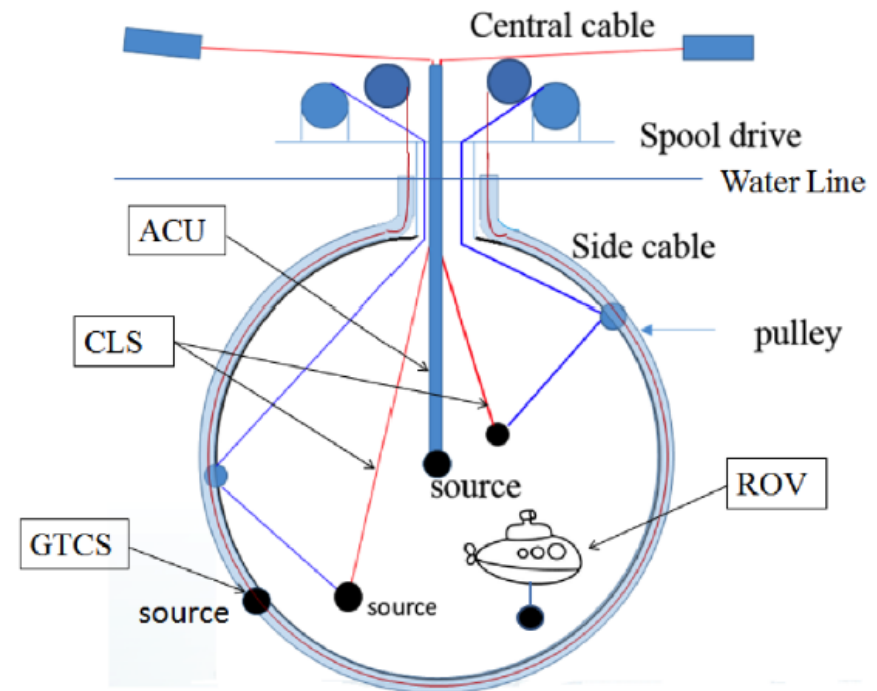
Four Complementary Systems

- ✓ 1D : Automatic Calibration Unit ACU for central axis scan
- ✓ 2D : Cable Loop System CLS for vertical planes scan and Guide Tube Calibration System GTCS for CD outer surface
- ✓ 3D : Remotely Operated under-liquid-scintillator Vehicles ROV for whole CD scan

Method	System
Rope Length Calculation	CLS, ACU and GTCS
Ultrasonic receiver	ROV, CLS
CCD(Independent)	ROV, CLS

Radioactive Sources

- ✓ photons : ^{40}K , ^{54}Mn , ^{60}Co , ^{137}Cs
- ✓ positrons : ^{22}Na , ^{68}Ge
- ✓ neutrons : $^{241}\text{Am-Be}$, $^{241}\text{Am-}^{13}\text{C}$
 $^{241}\text{Pu-}^{13}\text{C}$, ^{252}Cf



JUNO schedule

