Jiangmen Underground Neutrino Experiment (JUNO)

Project Status

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On behalf of JUNO Collaboration

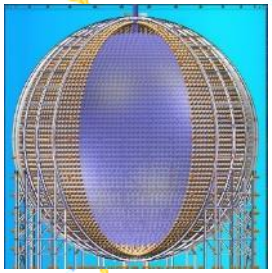
Location of JUNO and JUNO-TAO

77 Institutions, 600 collaborators

- China (34), Taiwan, China (3), Thailand (3), Pakistan, Armenia
- Italy (8), Germany (7), France (5), Russia (3), Belgium, Czech, Finland, Slovakia, Latvia
- Brazil (2), Chile (2), USA (3)

20 kton LS detector

700 m underground



Guang Zhou

•Daya Bay

•Hong Kong

JUNO

•53 km

•53 km

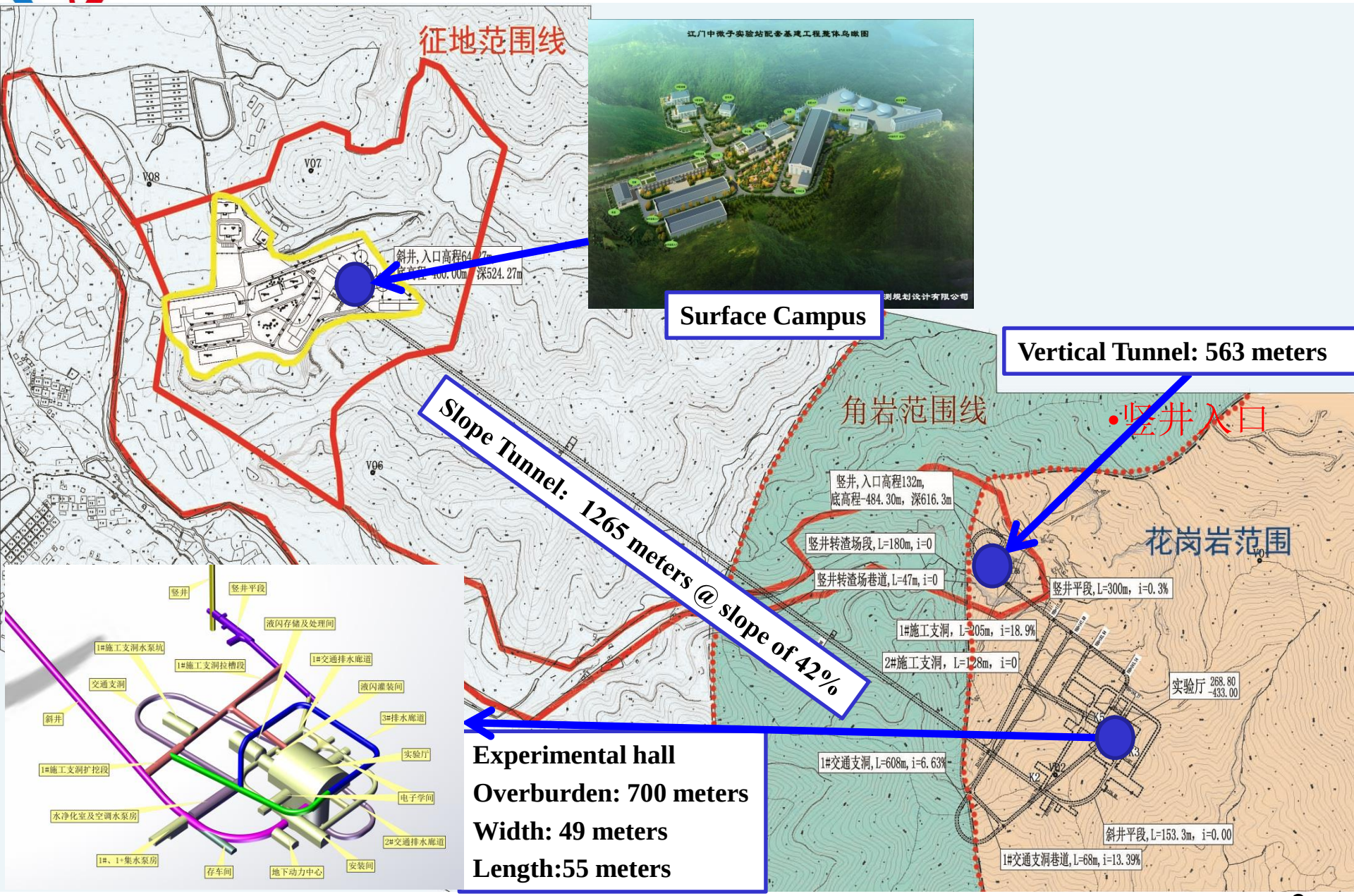
•TAO

•Taishan NPP

•Yangjiang NPP

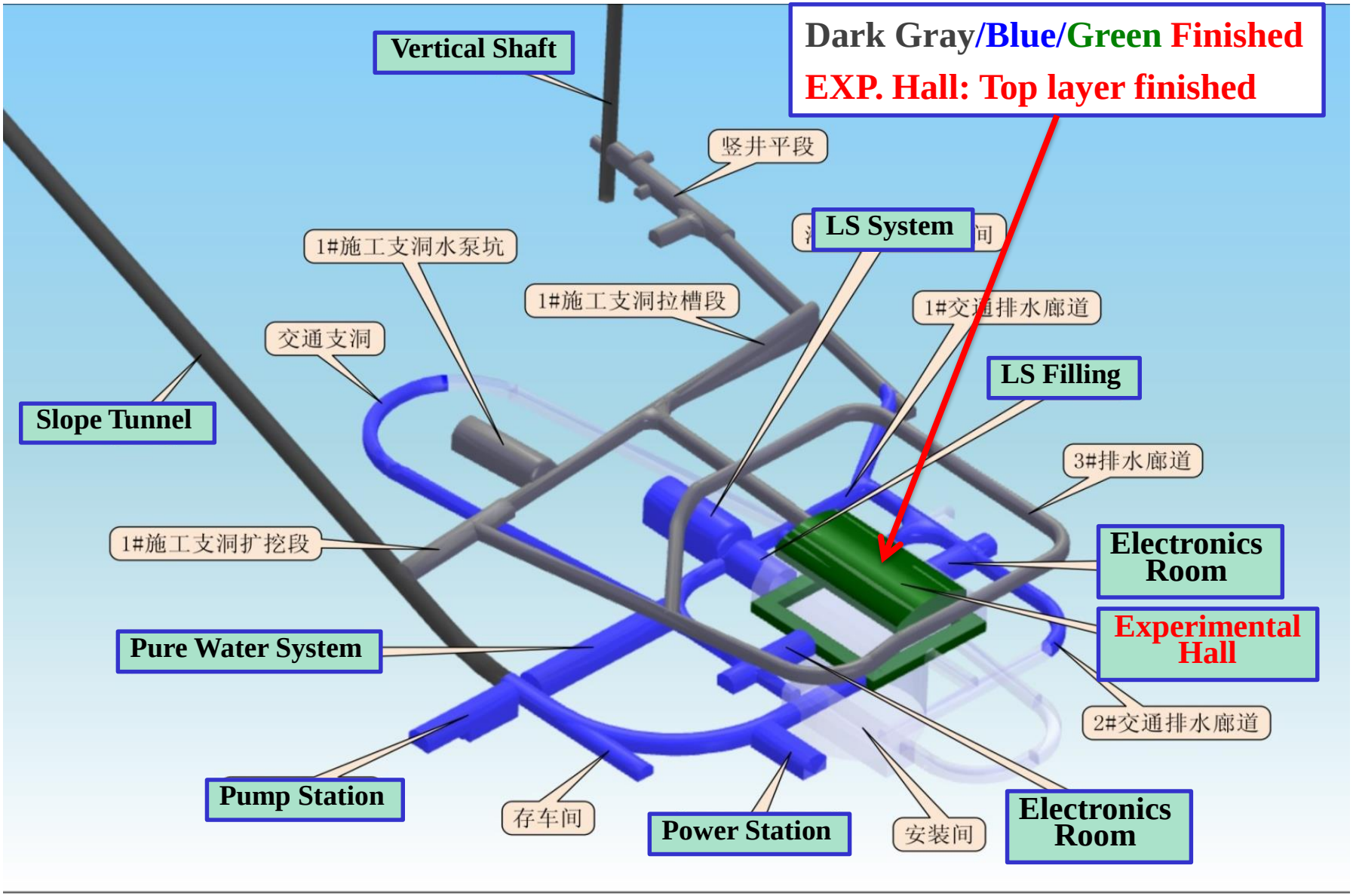
Yangjiang	Taishan
17.4 GW	9.2 + 9.2 GW

JUNO Site Facility



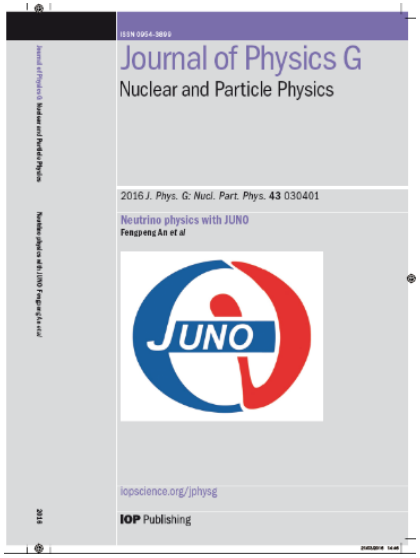
Experimental hall
Overburden: 700 meters
Width: 49 meters
Length:55 meters

Underground Construction Status



Neutrino Physics with JUNO

- **Mass Hierarchy** w/ reactor: 3-4σ in 6 years
- Precision w/ reactor: $\sin^2\theta_{12}$, Δm^2_{21}, Δm^2_{31} to <1%
- **Supernova Burst**: 5k events + Neutral current
- **Diffuse SN Background**: Discovery potential
- **Geo-neutrino**: Determine Geo-physics model
- **Proton Decay**: Best in K channel
- **Solar neutrinos**
- Atmospheric neutrinos
- Sterile neutrinos
- Neutrinos from Dark Matter
- Exotic searches with neutrinos



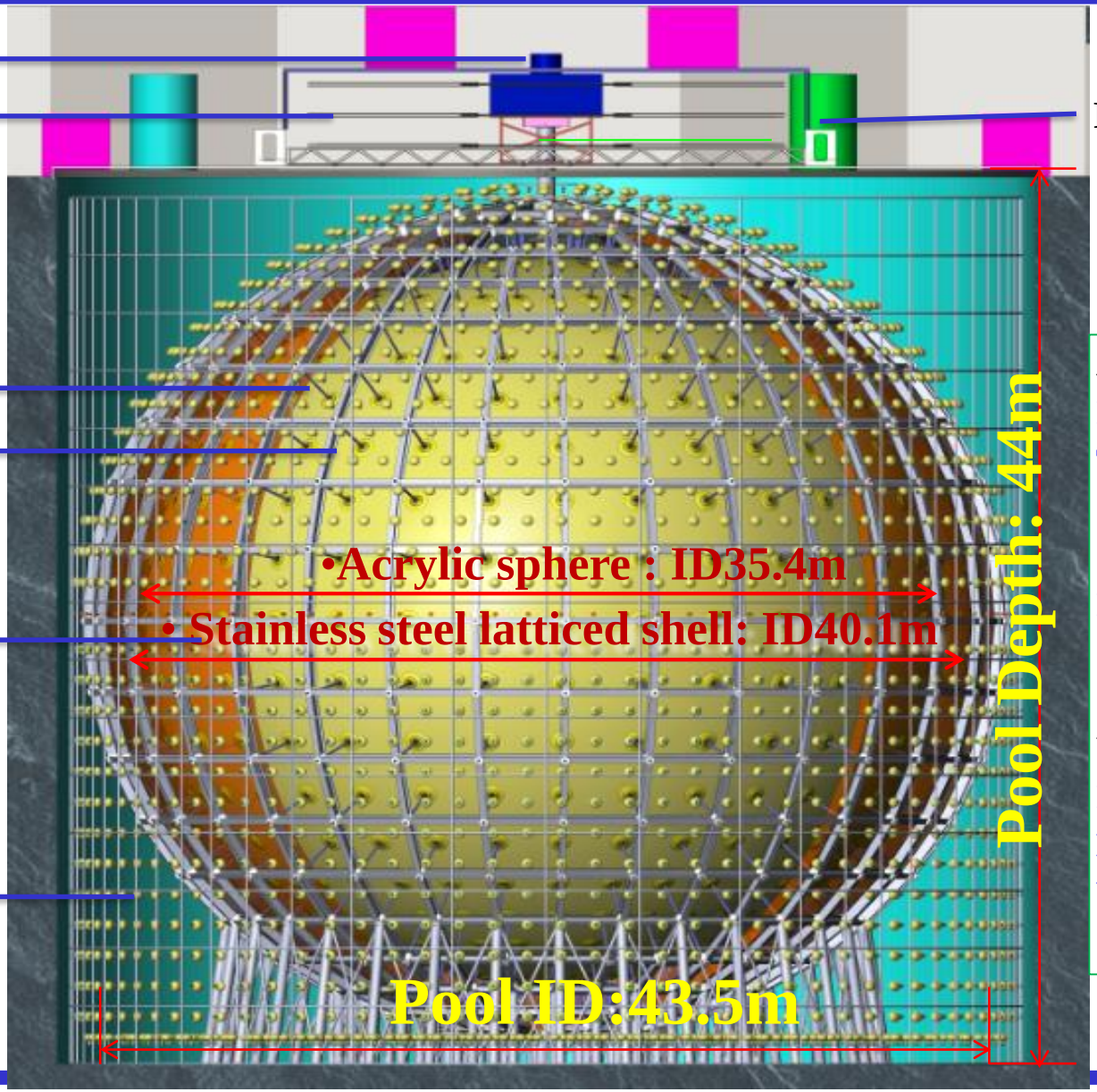
JUNO Yellow book
J. Phys. G 43, 030401 (2016)

State-of-Art LS Detector

	Daya Bay	BOREXINO	KamLAND	JUNO
Target Mass	~20 t	~300 t	~1 kt	~20 kt
Photoelectron Yield (PE/MeV)	~160	~500	~250	~1200
Photocathode Coverage	~12%	~34%	~34%	~78%
Energy Resolution	~7.5%/√E	~5%/√E	~6%/√E	<3%/√E
Energy Non-linearity	~1.5%	~1%	~2%	<1%

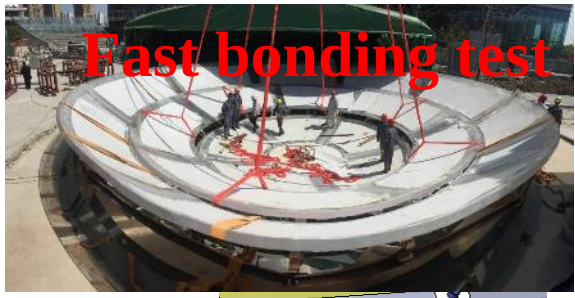
- **Titanic detector**
- **Unprecedented energy resolution (3%）**
  - **PMT Coverage 78%**
  - **PMT DE > 27%**
  - **LS attenuation length > 20 m**
  - **Minimize the optical loss due to detector material**
  - **Calibration**
- **Low background (e.g. 1 ppt for acrylic, 10^{-15} or 10^{-17} for LS)**

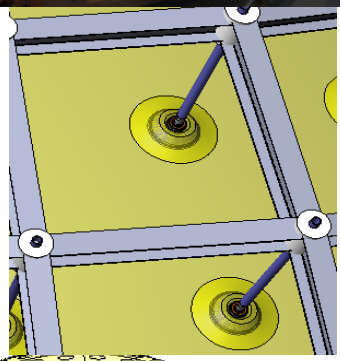
JUNO Detector

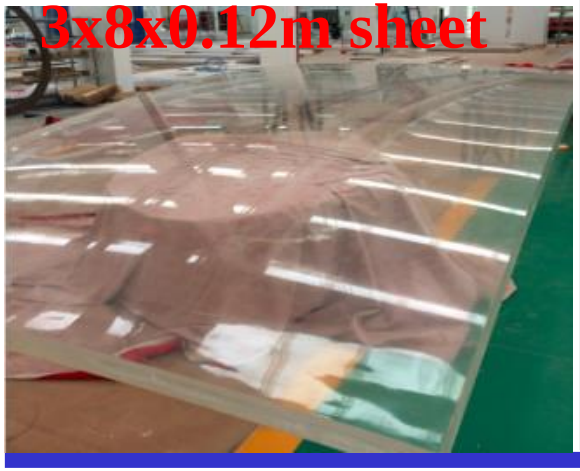


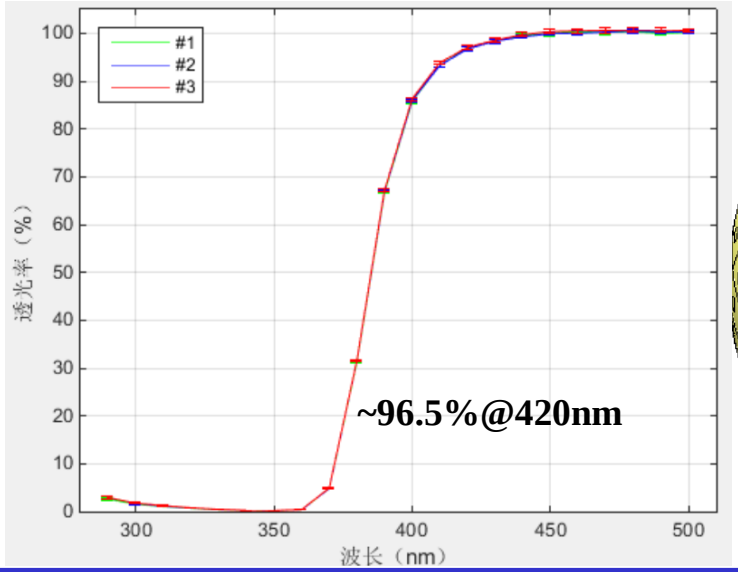
Central Detector

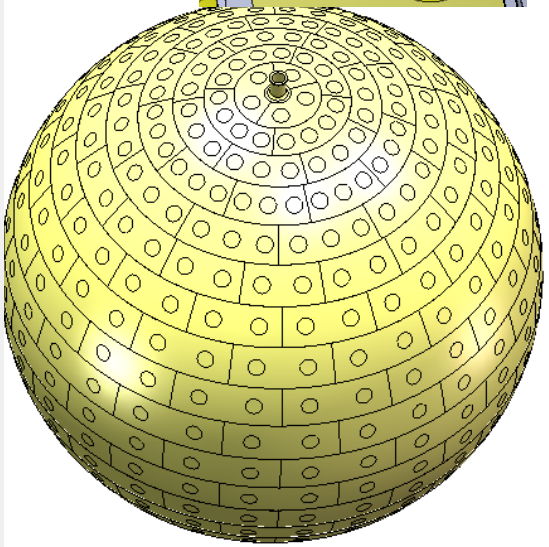
- 35.4-m Acrylic Vessel
  - Acrylic sheets: 8m × 3m ×12 cm
  - Supporting bar to hold the Acrylic tank
  - Stress of acrylic less than 3.5 MPa everywhere
  - Solved all technical problems: No standards for construction, high precision curved sheet, anti-seismic, transparency, low bkg., fast bonding





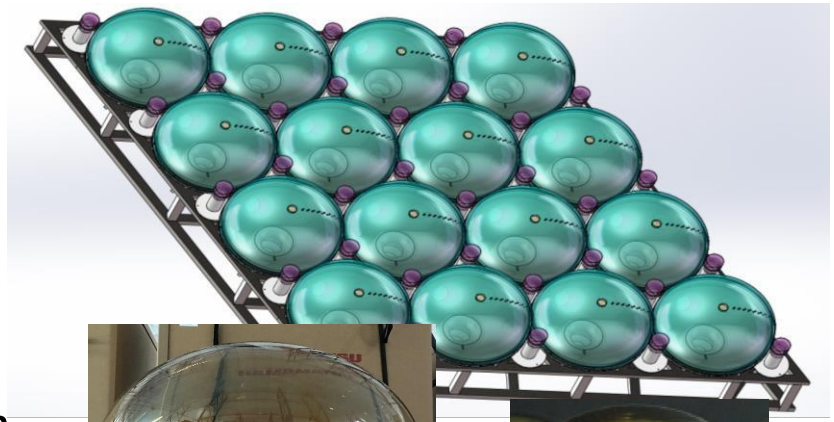


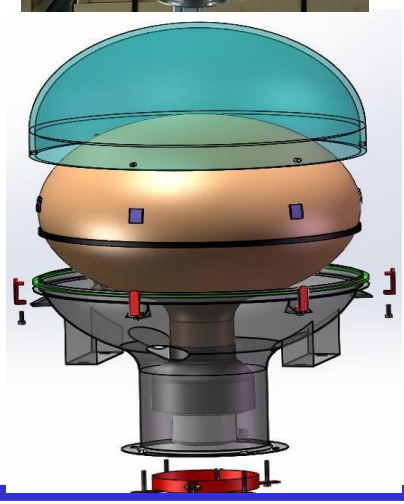




Largest Coverage

- 20” PMT (~18K)
  - MCP-PMT (~13K)
  - Hamamatsu HQE (5K)
- 3”sPMT(~25K)
  - HZC XP72B22 (Photonis)
  - Calibrate non-uniformity and non-linearity of Large-PMTs
    - Reduce energy scale uncertainty
    - Improve energy resolution (non-stochastic term)
  - Increase optical coverage (~3%)
    - Improve energy resolution (stochastic term)
  - Extend energy measurement
    - Improve muon physics
  - Independent system for Supernova

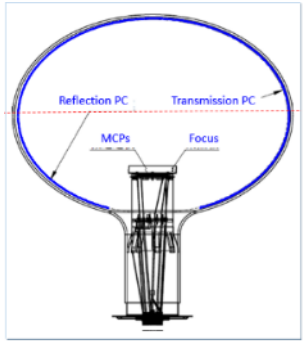


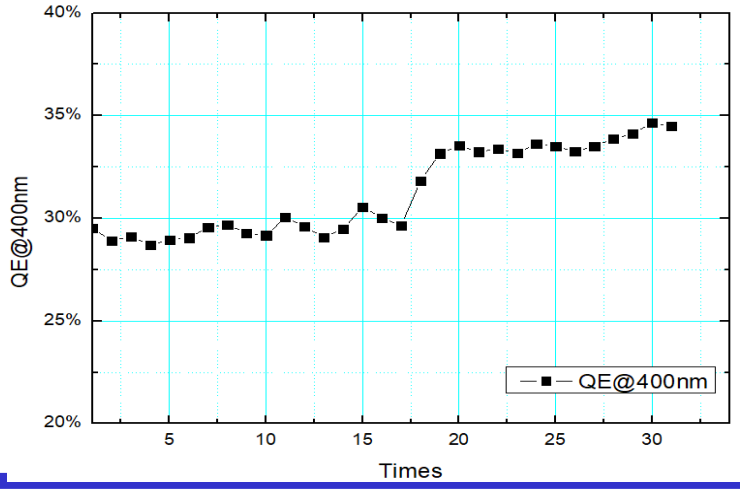


PMT

New type of 20-inch PMT based on MCP

- Started PMT R&D in 2008, chose MCP-PMT in 2009 (Patented by Y.F.Wang, S. Qian, T.C.Zhao, J. Cao in China, US, Russia, Japan, EU)
- 2013: 8" prototypes
- 2014: 20" prototype, PDE 15%
- 2016: Production line





MCP-PMTs

- Continue to improve DE
- > 10000 PMTs delivered

Hamamatsu Dynode PMTs

- All delivered with good quality

3" Dynode PMTs:

- ~19000 produced, ~15000 tested and accepted
- Cables, boxes, electronics, base etc. on track

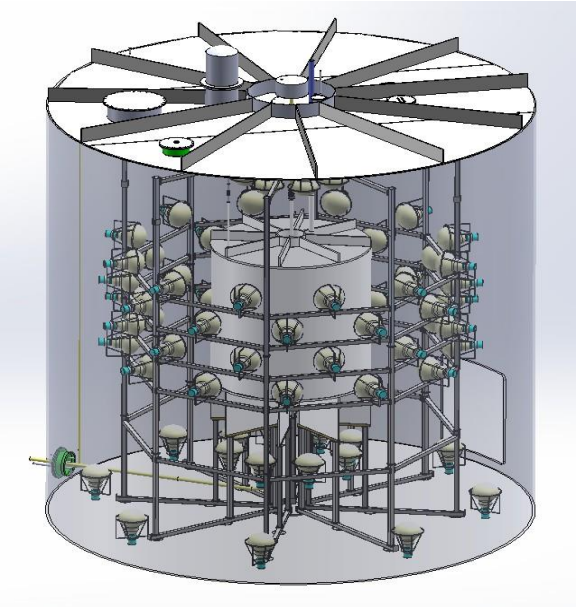
Base/Potting/Protection cover: following up

PDE	Mean（%）
All	28.2
HAMAMATSU	28.1
NNVT	28.3

Most Transparent Liquid Scintillator

Goal

- Highest possible light yield for JUNO:
  - 2.5 g/L PPO + 3 mg/L Bis-MSB
- Low radioactive backgrounds:
  - 10^{-15} g/g for IBD
  - 10^{-17} g/g for solar neutrinos



OSIRIS: An online detector with 20t LS for a sensitivity of 10^{-15} g/g per day

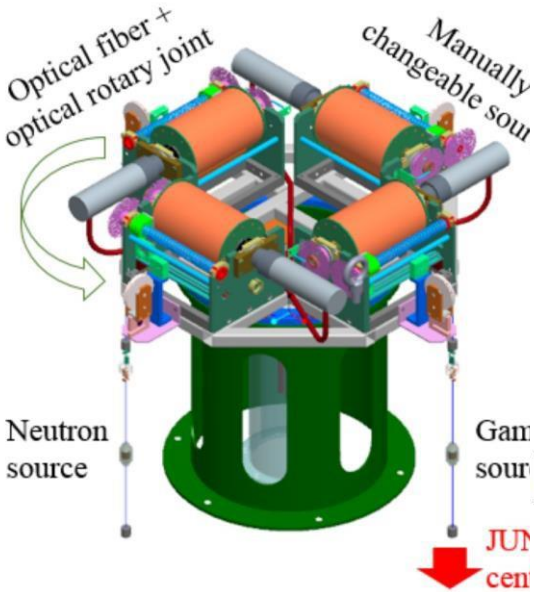
The purification plant to achieve (attn. >20 m)

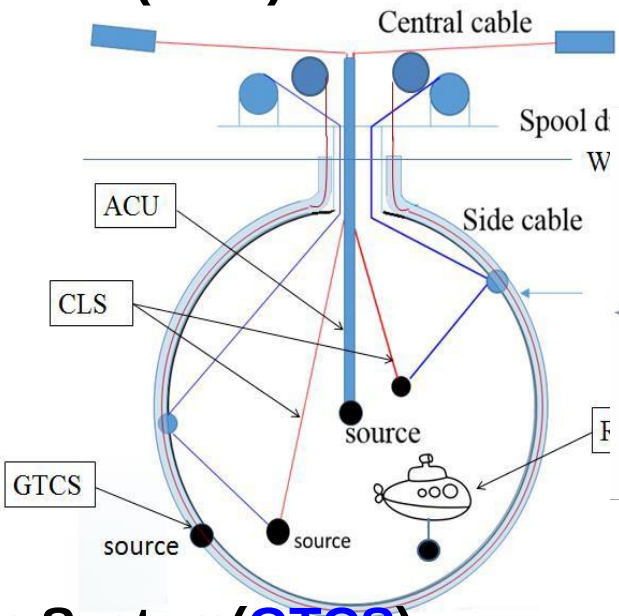
- ⇨ Al_2O_3 filtration
- ⇨ Distillation (Italy)
- ⇨ Gas tripping (Italy)
- ⇨ Water extraction

	LAB (solvent)	LS (0.5g/L)	LS (3g/L)
Attn len	25 m	23.8 m	20.5 m

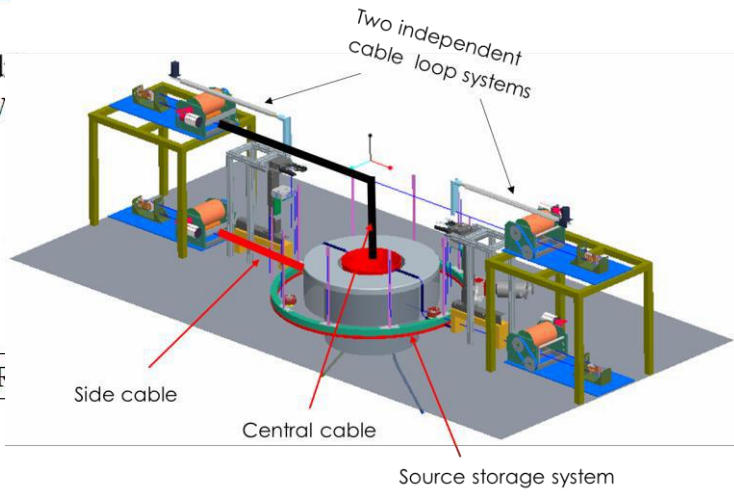
Comprehensive Calibration Plan

Automatic Calibration Unit (ACU)

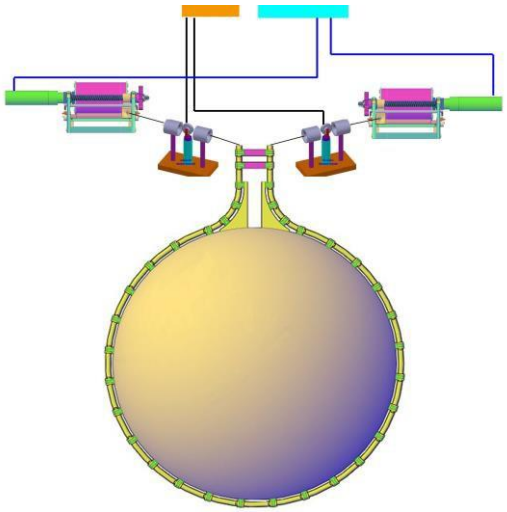




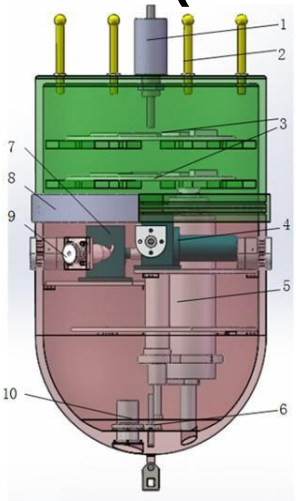
Cable Loop System (CLS)



Guide Tube Calibration System(GTCS)



Remotely Operated Vehicles (ROV)

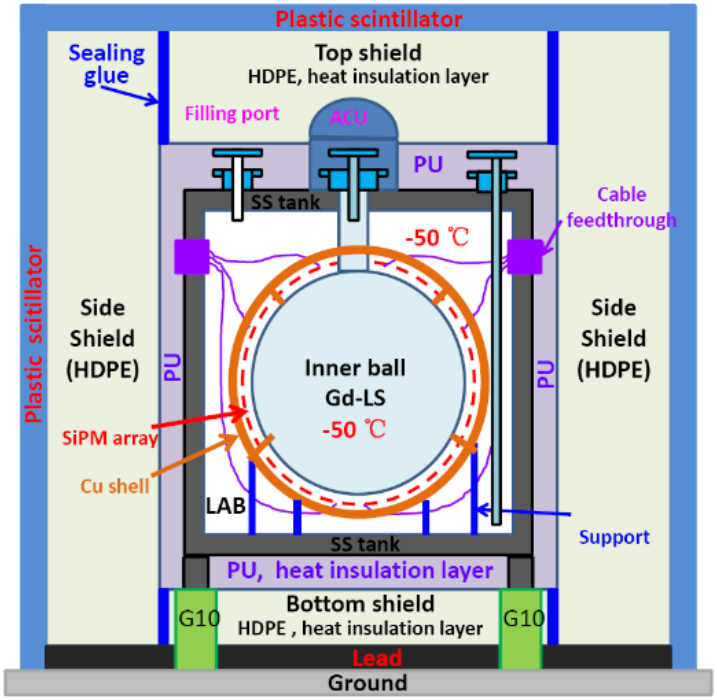


Complementary for covering entire energy range of reactor neutrinos and full-volume position coverage inside JUNO central detector

JUNO-Tao: Cryogenic Detector

- **Taishan Antineutrino Observatory (TAO), a ton-scale, high energy resolution LS detector at ~30 m from the core, a satellite exp. of JUNO.**
- **Measure reactor neutrino spectrum w/ sub-percent *E* resolution.**
  - **model-independent reference spectrum for JUNO**
  - **a benchmark for investigation of the nuclear database**
- **Ton-scale Gd doped Liquid Scintillator (Gd-LS)**
- **Full coverage of SiPM w/ PDE > 50%**
- **Operating at -50 ℃ (SiPM dark noise)**
- **4500 p.e./MeV**
- **Taishan Nuclear Power Plant, 30-35 m from the 4.6 GW_th core**
- **2000 IBD/day (4000)**
- **Online in 2021**

CDR in 2019



JUNO Posters

- **Physics Potential of the JUNO**
- **Taishan Antineutrino Observatory (JUNO-Tao)**
- **JUNO Computing Requirements and Infrastructure**
- **Vertex Reconstruction and Deep Learning Applications in JUNO**

End

- **Detector design has already finalized.**
- **Almost all detector components have been contracted and started mass production**
- **Facility will be delivered in 2020**
- **Complete the construction by 2021.**

Thanks

JUNO collaboration

Collaboration established on July 2014

Now 77 institutions ~600 collaborators

Armenia	Yerevan Physics Institute
Belgium	Université libre de Bruxelles
Brazil	PUC
Brazil	UEL
Chile	PCUC
Chile	UTFSM
China	BISEE
China	Beijing Normal U.
China	CAGS
China	ChongQing University
China	CIAE
China	CUG Beijing
China	DGUT
China	ECUST
China	ECUT Nanchang City
China	Guangxi U.
China	Harbin Institute of Technology
China	IGG Beijing
China	IGG Wuhan
China	IHEP
China	IMP-CAS
China	Jilin U.
China	Jinan U.
China	Nanjing U.
China	Nankai U.
China	NCEPU
China	NUDT
China	Peking U.
China	Shandong U.
China	Shanghai JT U.
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	Zhengzhou U.
Czech	Charles U.
Finland	University of Oulu
France	LAL Orsay
France	CENBG Bordeaux
France	CPPM Marseille
France	IPHC Strasbourg
France	Subatech Nantes
Germany	FZJ-ZEA
Germany	RWTH Aachen U.
Germany	TUM
Germany	U. Hamburg
Germany	FZJ-IKP
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
Latvia	IECS
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
USA	UCI