Overview of the JUNO-TAO detector

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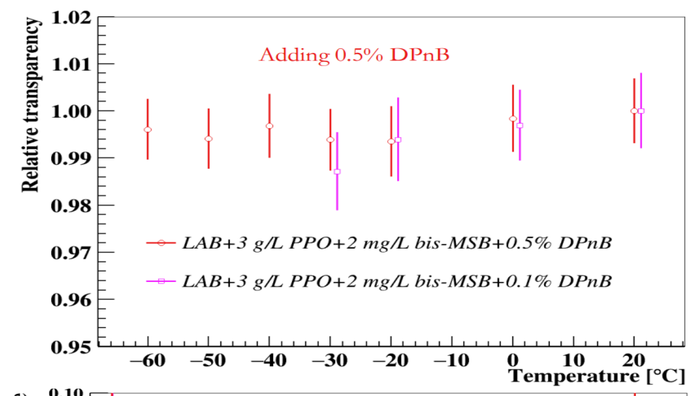
JUNO-TAO [1], *Taishan Antineutrino Observatory,* is a ton level detector at ~30 m from a reactor core of the Taishan Nuclear Power Plant (4.6 GW). It measures the reactor antineutrino spectrum with sub-percent energy resolution by Inverse Beta Decay collecting the lights via ~4000 SiPM tiles.

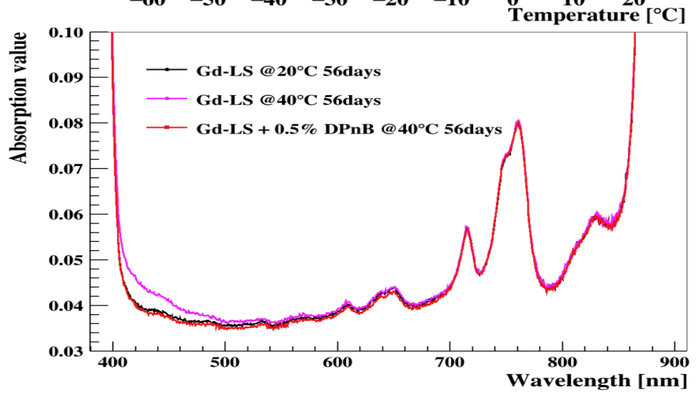
Motivation

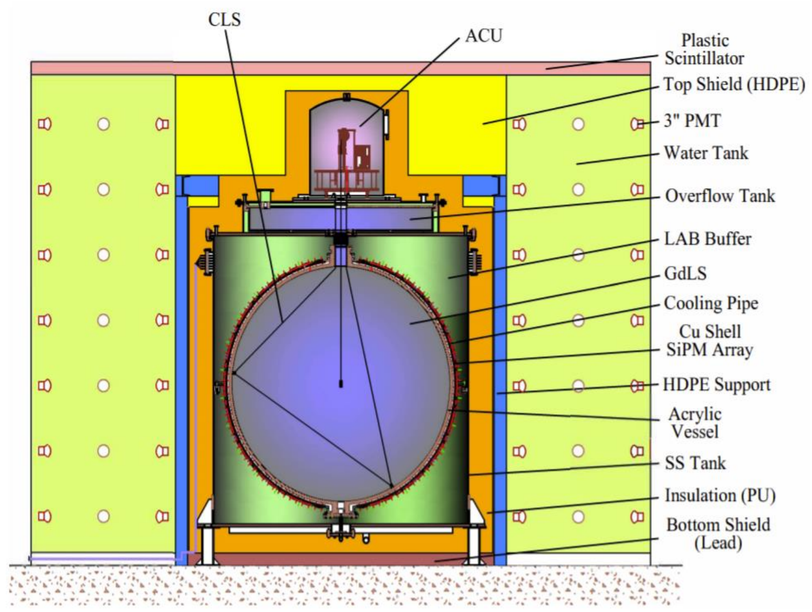
- Measuring the energy spectrum of reactor-$\bar{\upsilon}_e$ to reduce the impact from reactor flux model uncertainties and improve JUNO capability to discover the Mass Ordering
- Providing a benchmark spectrum to short-lived isotopes to nuclear database
- Searching for light sterile neutrino
- Reactor monitoring

GdLS

- A new recipe of liquid scintillator for low temperature composed of: LAB (Lynear Alkyl Benzene) doped with Gadolinium + 3 g/L PPO + 2 mg/L bis-MSB + 0.5% DPnB
  - High light yeld, flash point and transparency at -50 °C
- Plan to dope LAB buffer with Gd to reduce the neutron background
  - Compatibility with materials at -50 °C confirmed
- A.L. (Attenuation Length) of GdLS >10 m (11 m at 430 nm)





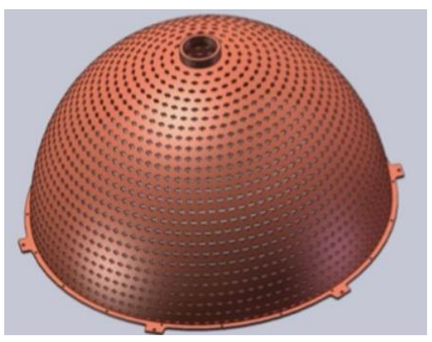


Detector

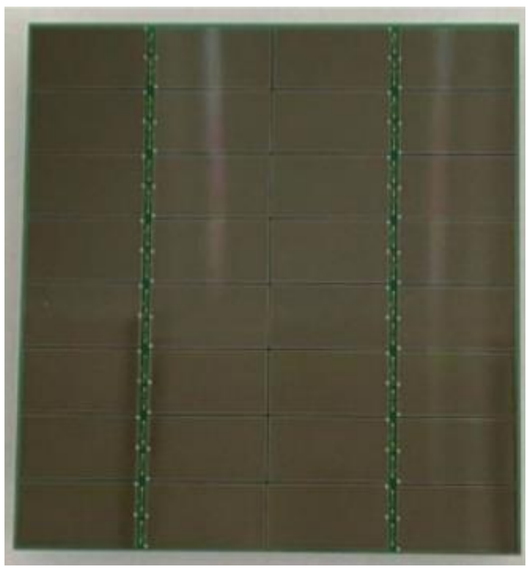
- 2.8 ton of Liquid Scintillator doped with Gadolinium (GdLS) in a spherical vessel with 1.8 m diameter
- Expected 4000 IBD/Day (2000 with 1 ton fiducial volume)
- ~10 m^2 of SiPMs (more than 4000 4 x 8 SiPMs arrays)
- Operate at -50 °C to reduce SiPM dark noise
- From the center to the outside: GdLS → Acrilic vessel → SiPMs and support → LAB Buffer → Criogenic system → water and HDPE shield → muon veto
- High energy resolution: $< 2\ \%/\sqrt{E[MeV]}$

SiPM

- R&D on SiPMs conducted in the last years
- Strict requirements to reach the sensitivity goal
- 4024 tiles from HPK
- 8000 channels with ≤15 % charge resolution
- Cooled by the copper shell support
- Electronics ready to be produced



SiPM support

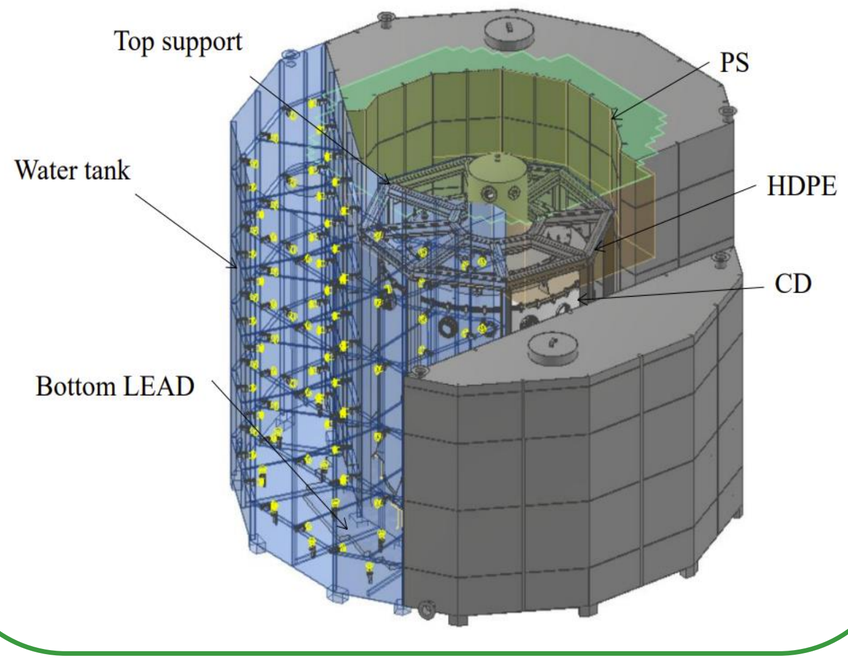


SiPM tile

Muon Veto and Shielding

The detector is not underground → active and passive shielding is required

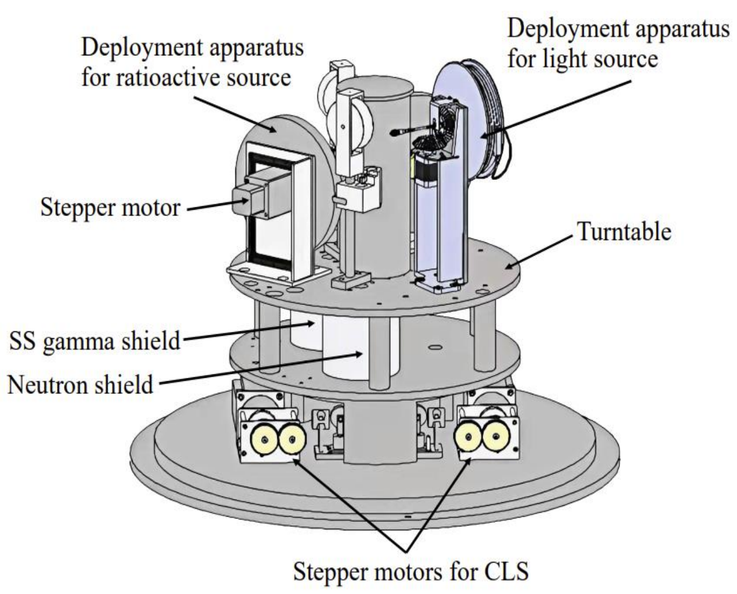
- Top Plastic Scintillator
  - 4 layers, each 2 cm thickness, 1 mm gap between strips
  - Muon VETO efficiency > 95%
  - Light seen by SiPM
- Water Tank
  - Dodecagono, 1.2 m thickness
  - Light seen by 3" PMT



Calibration System

JUNO-TAO calibration system is composed by [2]:

- Automated Calibration Unit (ACU)
  - Can deploy 3 different sources inside the detector alongside the z-axis while a turntable revolves to a specific angle
    - An ultraviolet (UV) light source
    - a ^{68}Ge source
    - a combined source that contains multiple gamma sources and one neutron source
- Cable Loop System (CLS)
  - Designed with a single radioactive source, that can be deploy to off axis position



ACU System

Conclusion

- JUNO-TAO will measure the reactor antineutrino spectrum looking its fine structure
- 1:1 prototype in summer 2022
- JUNO-TAO starts commissioning in 2023

[1] Abusleme, Angel, et al. "TAO Conceptual Design Report: A Precision Measurement of the Reactor Antineutrino Spectrum with Sub-percent Energy Resolution." arXiv preprint arXiv:2005.08745 (2020).
[2] Xu, Hangkun, et al. "Calibration Strategy of the JUNO-TAO Experiment." arXiv preprint arXiv:2204.03256 (2022).