



Status of JUNO

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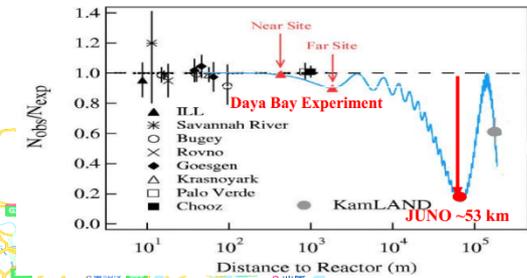
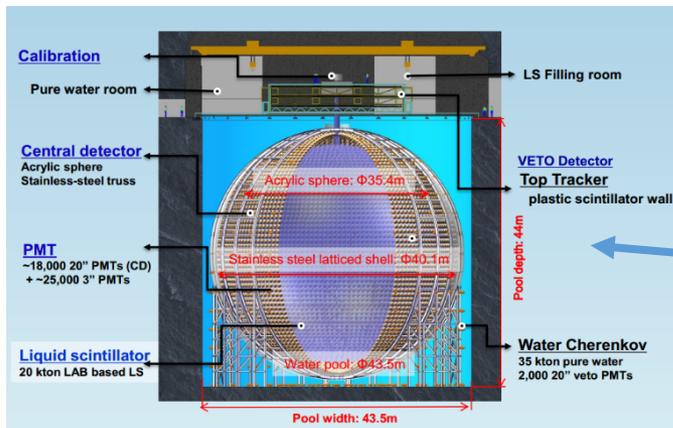
On behalf of JUNO Collaboration



The JUNO Experiment



- Jiangmen **U**nderground **N**eutrino **O**bservatory
- **C**entral detector, **w**ater **C**herenkov detector and **m**uon **t**racker
- $3\%/\sqrt{E}$ energy resolution
- 20 kiloton of LS, $\sim 20,000$ 20" photomultiplier tubes (PMTs) and $\sim 25,000$ 3" PMTs
- Proposed in 2008, approved in 2013





A multi-purpose neutrino experiment

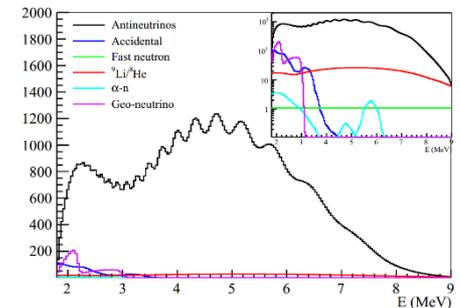
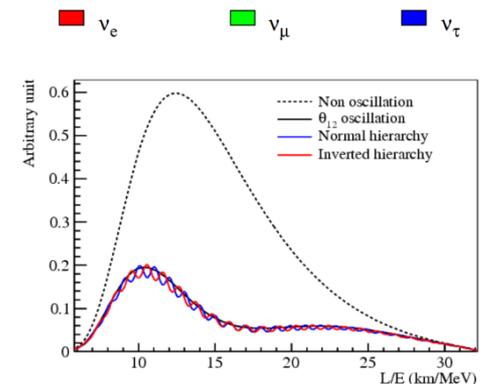
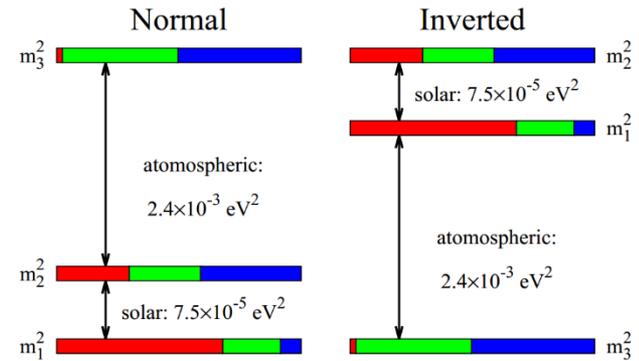


- Rich physics possibilities
 - **Mass hierarchy**
 - **Precision measurement of mixing parameters**
 - Supernovae neutrino
 - Geoneutrino
 - Solar neutrino
 - Atmospheric neutrino
 - Exotic searches including nucleon decay, dark matter

- Inverse beta decay: $\bar{\nu}_e + p^+ \rightarrow e^+ + n$
- Electron antineutrino survival probability in vacuum:

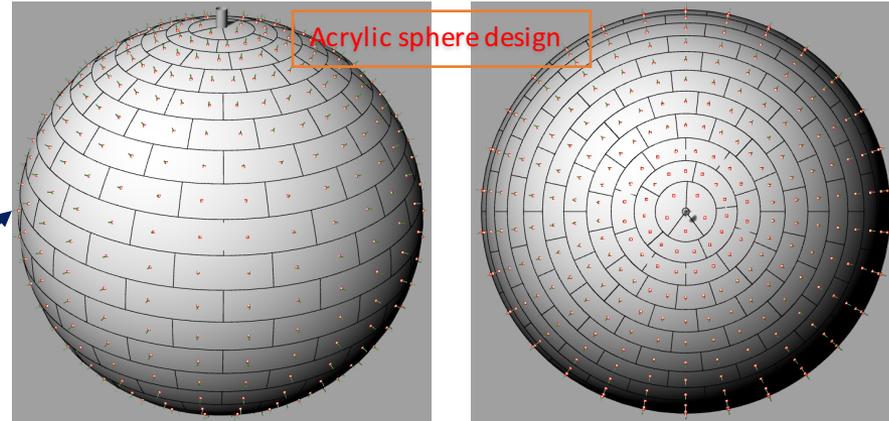
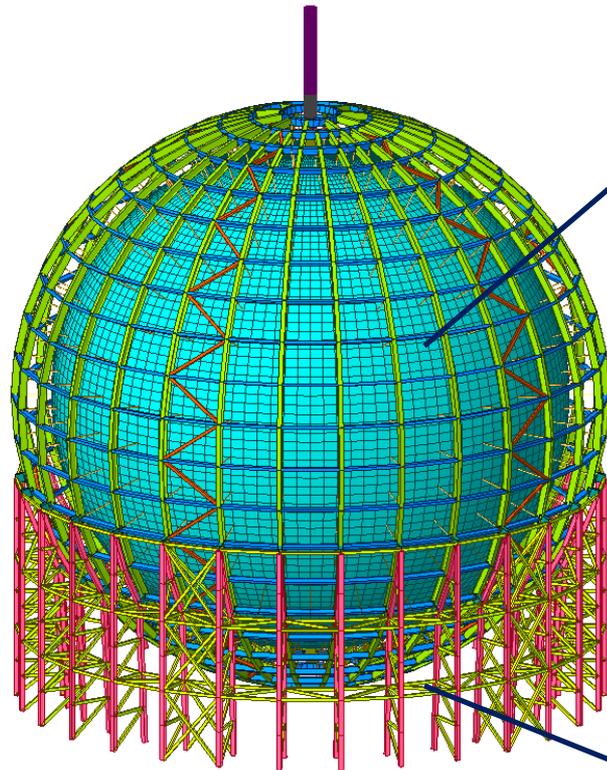
$$\begin{aligned}
 P_{\bar{\nu}_e \rightarrow \bar{\nu}_e} &= 1 - \cos^4 \theta_{13} \sin^2(2\theta_{12}) \sin^2 \Delta_{21} \\
 &\quad - \frac{1}{2} \sin^2 2\theta_{13} [1 - \sqrt{1 - \sin^2(2\theta_{12}) \sin^2 \Delta_{21}} \cos(2|\Delta_{ee}| \pm \phi)]
 \end{aligned}$$

- + for normal hierarchy
- - for inverted hierarchy

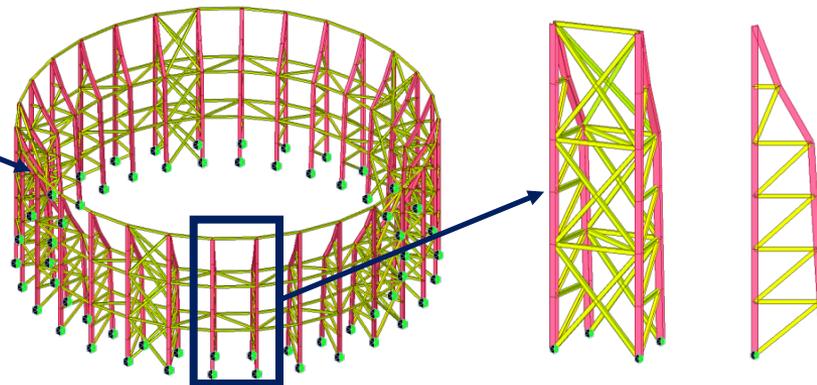




The Central Detector



291 pieces



30 pillars



The Liquid Scintillator

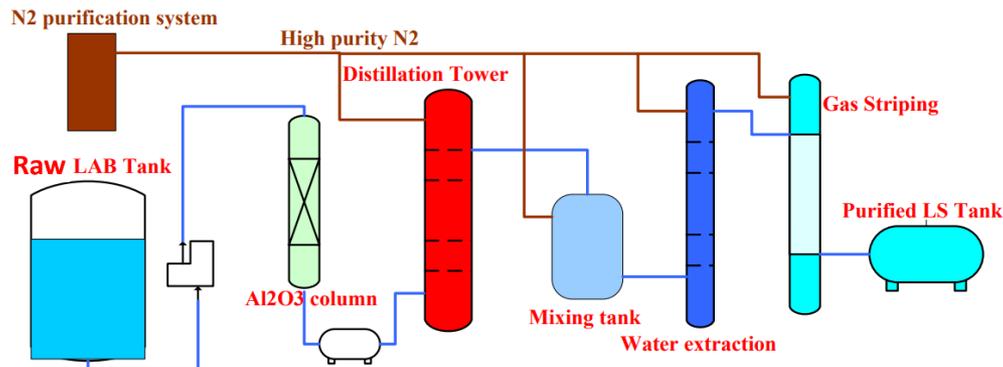


Requirement for LS

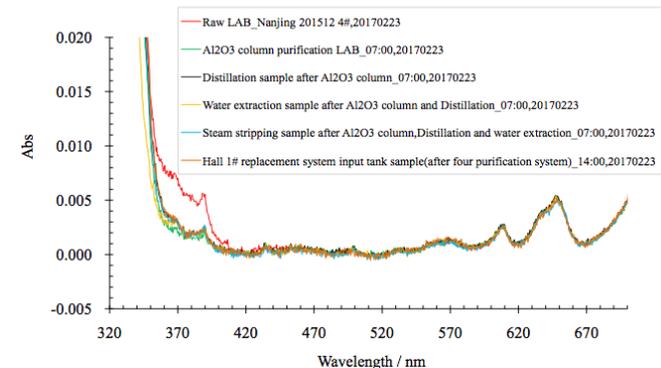
- Low background: $^{238}\text{U} < 10^{-15} \text{ g/g}$, $^{232}\text{Th} < 10^{-15} \text{ g/g}$, $^{40}\text{K} < 10^{-17} \text{ g/g}$.
- High light yield: Optimize the concentrations of fluors
- Long attenuation length: $>20\text{m}@430\text{nm}$
- Purification:
 - Absorption, Distillation, Water extraction, Gas stripping.
- Preliminary recipe: LAB + 3g/L PPO + 15mg/L bis-MSB

LS Pilot Plants experiment

- Pre-study for JUNO LS mass production
- Effects of light emitting substance
- Concentration to light yield and energy nonlinearity
- Check radioactive background
- Which purification method will be used and how to combine them



Final Quality Check before Filling



Attenuation length is $\sim 25\text{m}$ after purification



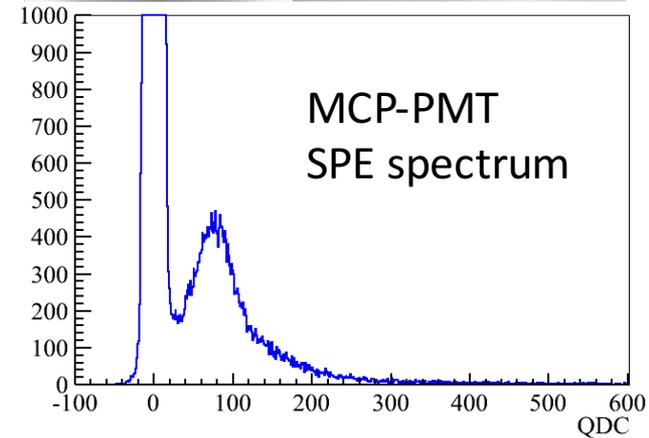
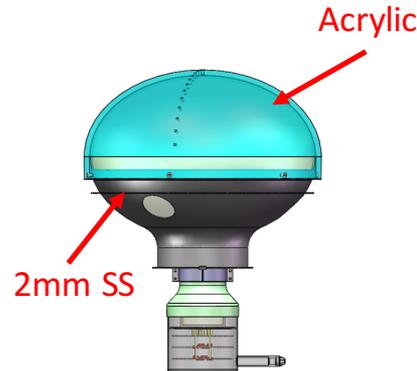
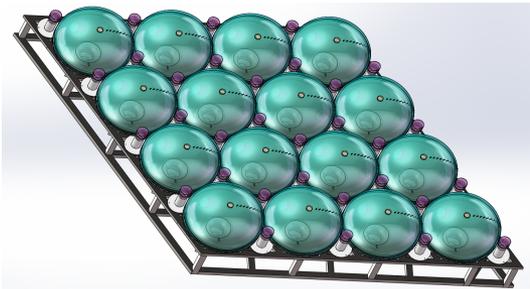
The PMT System



- ~5,000 20" dynode PMT from Hamamatsu
- ~15,000 20" MCP-PMT from NNVT
 - Transmissive photocathode + reflective photocathode
 - High CE
 - Low background glass shell



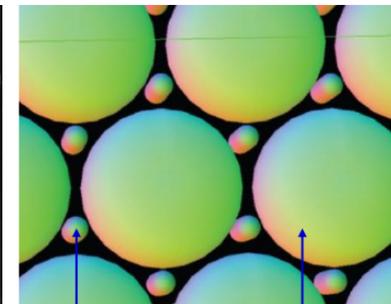
Protection cover



• ~25,000 3" PMT from Zhanchuang(HZC)

- Calibration of non-linear response of 20" PMTs
- Help reconstruction for high energy physics
- Help detection of supernova neutrino

| Parameters | HZC response |
|--------------------------|---|
| QE×CE* @420 nm | 24% (>22%) |
| TTS*(FWHM) of SPE | < 5 ns |
| Peak/Valley ratio of SPE | 3 (>2) |
| SPE signal width(sigma) | 35% (<45%) |
| Dark rate @1/4 p.e. | 1 kHz (<1.8 kHz) |
| Pre/after pulse ratio | <5%, <15% |
| Non-linearity | <10% @1-100 p.e. |
| Radioactivity | ²³⁸ U <400 ppb ²³² Th <400 ppb ⁴⁰ K <200 ppb |



SPMT

LPMT



Summary



- JUNO has rich physics possibilities with the main goals to determine mass hierarchy and precisely measure oscillation parameters.
- JUNO experiment is under construction and is expected to start data taking in 2020.

Thanks!