PROCEEDINGS OF SCIENCE

Design and construction of hundred-ton liquid neutrino detector at CJPL II

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The China Jinping Underground Neutrino Experiment forsees completion of phase II construction around 2025. A hundred-ton liquid scintillator detector, Jinping Neutrino Experiment, will be built one year after that, targeting terrestrial, solar and supernova neutrinos with different interchangeable detection media. We are going to review the status and plans of the project, including construction of the experiment site, design of the detector, instrumentation of the fast frontend electronics and new photomultiplier tubes.

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The China Jinping Underground Laboratory II [1, 2] (CJPL II) would soon become the deepest and largest underground laboratory in the world. It has the lowest cosmogenic and reactor neutrino backgrounds, which is very suitable for MeV neutrino physics [3]. One of the experimental halls is going to host the Jinping Neutrino Experiment (JNE in figure 1) targeting solar neutrinos with various candidate target media, such as LiCl water solution [4] or Ga-doped liquid scintillator [5], terrestrial neutrinos [6, 7] and supernova neutrinos with slow liquid scintillator [8, 9]. JNE could be further upgraded to search for neutrinoless double beta decays and indirectly search for dark matter. The key designs of the JNE detector will be discussed in the following sections.

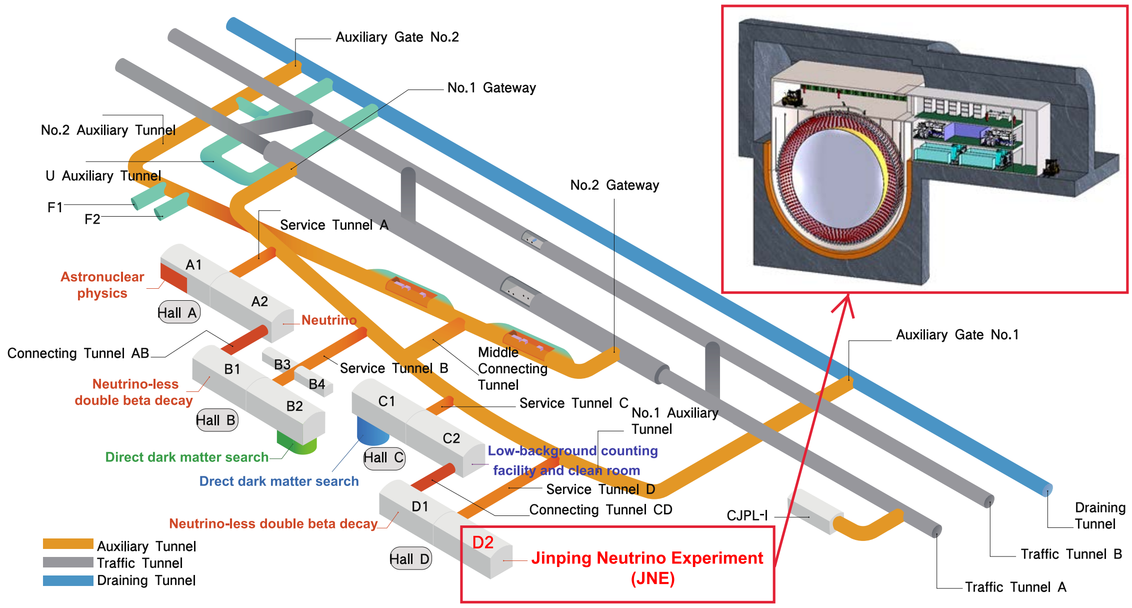


Figure 1: Assigned location of Jinping Neutrino Experiment in China Jinping Underground Laboratory II.

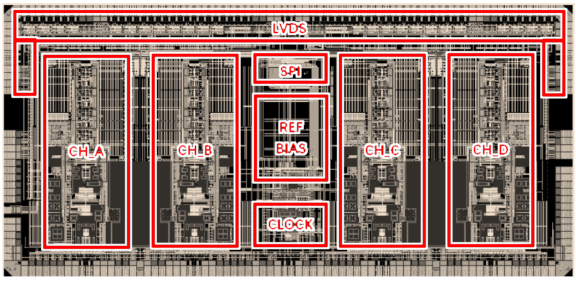
1. Gravity-buoyancy tolerant acrylic vessel

The main acrylic vessel of JNE will be tolerant to both gravity and buoyancy by $\pm 20\,\%$, allowing various detection media to be loaded without redesigning the detector. It is planned to start JNE with a pure water phase and take one of the upgrade solutions.

2. Microchannel plate photomultiplier

We partnered with Northern Night Vision Technology Co., Ltd. to develop a new generation $\varnothing 20\,\mathrm{cm}$ microchannel plate photomultiplier (MCP-PMT in figure 2a), balancing between timing ($\sigma_{\mathrm{TT}} < 1.5\,\mathrm{ns}$) and detection efficiency ($\sim 30\,\%$). The first manufacturing batch of 600 PMTs is completed. Material screening shows that the radioactive contaminants in the PMT glasses meet the designed background level. Characterization of several sample tubes is to be published. We established a waveform analysis algorithm dedicated to this new kind of PMT, based on the methods introduced in by Xu et al. [10]

(a) ⌀20 cm microchannel plate photomultiplier.



(b) Schematics of analog-to-digital converter chip.

Figure 2: Newly developed MCP-PMT (a) and ADC chip (b) for JNE.

3. Low-power-consumption 12-bit 1Gsps waveform digitizer

JNE will be equipped with a waveform digitizer (figure 2b) having 12-bit range and 1Gsps sampling rate, similar performance as what commonly found in the neutrino experiments. At the same time, it will consume power as low as 0.35 watts per channel, so that the electronic system will dissipate less heat and become more stable. The first batch of the chips are taped out with 65 nm MOSFET node. Integration tests are being carried out.

4. Cherenkov and scintillation light dual readout

We are developing liquid scintillator with dual Cherenkov and scintillation readout [11]. It has good potential for particle identification. A one-ton prototype detector [12] is used to demonstrate it [13].

5. Summary

The civil construction is underway. As of 2022, the construction team is digging downward the experimental hall so that we can maximize the detector size. Set out to study MeV neutrino physics at CJPL II with unprecedented innovations, JNE is going to start commissioning around 2026.

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