

# Chinese Physics C

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## Cover Story (Issue 4, 2026): Initial performance results of the JUNO detector

Author: Art McDonald

This paper describes the Jiangmen Underground Neutrino Observatory (JUNO), a 20 Kiloton Liquid Scintillator (LS) detector designed primarily to determine the neutrino mass ordering (NMO), with many other physics capabilities at the forefront of neutrino physics. Neutrinos and anti-neutrinos are produced in specific flavor states, electron, muon or tau neutrinos that are made up of quantum mechanical combinations of mass eigenstates called mass 1, 2 and 3. When the specific flavor state travels after creation, an oscillation pattern is generated depending on the relative values of the masses and their ordering (NMO).

The JUNO detector is the largest liquid scintillator ever built and is carefully designed to observe the oscillation of electron anti-neutrinos produced at the Yangjia and Taishan nuclear power plants, an equal distance of 52.5 km away. This distance is carefully chosen to maximize the sensitivity to the NMO. Although it will take years of operation to achieve the sensitivity required for a definitive answer, initial operation [1] indicates that the detector design properties have been broadly met or exceeded, giving confidence for future success.

The detector is located in a 650-meter-deep underground laboratory in Guangdong, China, and consists of a 20-kton liquid scintillator central detector (CD), a 35-kton water Cherenkov veto detector (WCD), and a 1000 m<sup>2</sup> plastic scintillator top tracker (TT). The underground location is designed to reduce background from cosmic rays, and the signals from the WCD and TT help identify and remove residual events. Signals from local radioactivity are carefully identified and removed, and the liquid scintillator is purified extensively to reduce radioactive contaminants.

The scale of the detector is enormous. It is housed in a cylindrical cavity 43.5 m in diameter and 44 m high. The liquid scintillator is contained in a 35.4 m-diameter transparent acrylic sphere, supported by a stainless steel structure that also houses 17596 20-inch photomultipliers (PMTs) and 25587 3-inch PMTs. This light detection system achieved state-of-the-art performance, with a light yield of 1,785 photoelectrons per MeV at the detector center. The energy resolution was measured at 3.4% for 0.511 MeV  $\gamma$ -rays from a <sup>68</sup>Ge radioactive source, with ongoing efforts to further improve it.

The water and liquid scintillator purification systems performed well to remove residual radioactivity, as certified by a 20-ton subsidiary detector called ORISIS. A complex system for calibrating light emission from radioactive sources was used to measure the LS's energy-response linearity and light attenuation, achieving an attenuation length of 20.6 m at 430 nm, exceeding expectations.

JUNO has successfully met its design objectives, achieving exceptional radiopurity, energy resolution, and detector stability. The experiment is fully operational and ready to pursue its ambitious physics goals, including determining the NMO, studying neutrino oscillation parameters, detecting neutrinos from various sources, and exploring physics beyond the Standard Model for Elementary Particles.

### References

[1] A. Abuslame *et al.* (JUNO Collaboration), arXiv:2511.14593v1<sup>o</sup>

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