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High Precision Reactor Antineutrino Oscillations in JUNO

The Jiangmen Underground Neutrino Observatory (JUNO) experiment is a multipurpose neutrino experiment under construction in South China. This next-generation large-scale detector, featuring a 20-kiloton liquid scintillator target, is primarily designed to study reactor antineutrinos emitted from two nearby nuclear power plants.
JUNO sits at a baseline of approximately 52.5 km, corresponding to the first solar oscillation maximum, where the kinematic phase $\Delta_{21} \simeq \frac{\pi}{2}$. This medium baseline configuration allows for the exploration of three generation effects, making it the first experiment to simultaneously probe oscillations on both the solar and atmospheric scales.

JUNO's primary scientific objective is to determine the Neutrino Mass Ordering (NMO), a fundamental, yet unsolved, question in neutrino physics. Thanks to its strategic location and expected high energy resolution, JUNO is sensitive to the energy-dependent phase shift in the antineutrino oscillated spectrum arising from different mass orderings. This approach, based on vacuum-dominant oscillations, also offers a complementary perspective to Long Baseline (LBL) accelerator experiments, which instead leverage matter effects. Beyond its main goal, JUNO is projected to achieve sub-percent precision for three oscillation parameters, Δm^2_{31}, Δm^2_{21}, and $\sin^2\theta_{12}$, already exceeding the current state-of-the-art in the early stages of data-taking. Such unprecedented precision offers the opportunity to test the standard 3-neutrino paradigm and potentially unveil new physics scenarios.

This poster will focus on JUNO's significant impact on the global neutrino oscillation physics landscape, opening a new era of high-precision measurements. In particular, it will cover JUNO's sensitivity to oscillation parameters, its synergy with LBL experiments for the NMO determination, and prospects to constrain the unitarity of the PMNS mixing matrix through a precise measurement of the Electron Row Unitarity (ERU).

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