PROCEEDINGS OF SCIENCE

Searching for a Sterile Neutrino at J-PARC MLF: JSNS^2 experiment

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The main physics goal of the JSNS^2 (J-PARC Sterile Neutrino Search at J-PARC Spallation Neutron Source) experiment is to search sterile neutrino in the $\Delta m^2 \sim 1$ eV^2 region with 24m baseline. The sterile neutrino signal is expected to be detected by appearance of electron antineutrinos from muon antineutrinos that are produced by the muon decay at rest through inverse beta decay. We will put 17 tons of Gd loaded liquid scintillator detector as a neutrino target, and we expect to get world competitive result after 3 years of data taking. The experiment aims to start data taking at early of 2019.

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1. Introduction

A hint of sterile neutrino in the $\Delta m^2 \sim 1$ eV^2 region initially came from the LSND experiment [1]. Similar phenomena was observed at several different experiments, such as MiniBooNE [2, 3], Gallium source [4], and Reactor experiment [5]. A main physics goal of the JSNS^2 [6] is dedicated to complete survey of the LSND result, with 17 tons of Gadolinium-loaded liquid scintillator (Gd-LS). The JSNS^2 experiment can do this because it will rely on the same neutrino oscillation channel, a neutrino source from muon decay at rest, a detection method of inverse beta decay, and a similar baseline (24m of JSNS^{2}vs 29m of LSND). In addition, it can reject the beam related background and the decay-in-flight background due to a short-pulsed beam of J-PARC. Using Gd-LS, it can significantly decrease the accidental background, and thus result in a better signal-to-noise ratio than LSND.

2. Signal

3 GeV proton beam produced at J-PARC hits the Mercury target and produces intense flux of pions, which decay to muons. Muon antineutrinos from muon decay at rest are neutrino source. If sterile neutrino is exist with Δm^2 near 1 eV^2, muon antineutrino can change flavor to electron antineutrino within 24 m baseline due to oscillation. Oscillated electron antineutrino can be detected through inverse beta decay reaction with the coincidence between prompt positron signal and delayed neutron captured signal by Gd.

3. Detector

JSNS^2 detector consists of an inner acrylic vessel and an outer stainless-steel vessel. 17 tons of Gd-LS will be filled in the acrylic vessel as a neutrino target. Gd unloaded LS will be filled inside of stainless-steel vessel. Space between acrylic tank and stainless-steel tank is optically separated with PMT support structure, to distinguish catcher region and veto region. We will install 193 of 8 inch PMTs at gamma catcher to detect neutrino signals and 48 of 5 inch PMTs at veto region to tag cosmic muons and external background. Figure. 1 shows the conceptual design of JSNS^2 detector.

4. Expected sensitivity

We measured on-site background with a 500 kg plastic scintillators at 2014 [8]. Based on the measurement, we estimated accidental background and beam fast neutron background. Other backgrounds such as anti-electron neutrinos from μ^- decay, $^{12}C(\nu_e, e-)^{12}N_{g.s.}$, fast neutron from cosmic are estimated based on Monte-carlo simulation. Signal efficiency is estimated with mainly Monte-carlo study and 38% efficiency is applied. Figure. 2 shows expected sensitivity of the JSNS^2 with assumption of 3 years of data taking with 17 tons one detector and 1 MW of J-PARC beam power as described at TDR [7].

We plan to increase sensitivity with one more detector after getting additional budget as proposed initially [9]. Figure. 3 shows improved sensitivity with two detectors. We assumed 50 tons of total fiducial volume, 5 years of data taking, and 1 MW of J-PARC beam power.

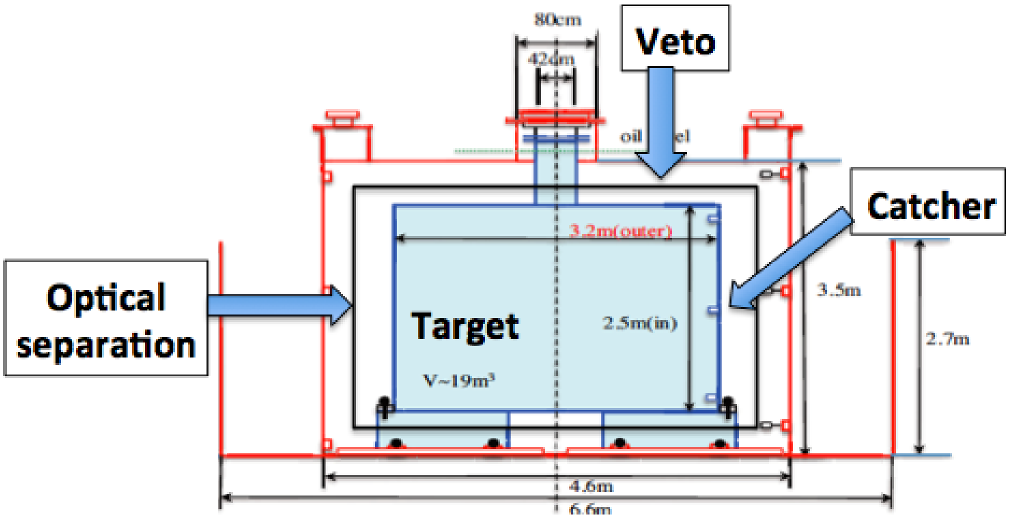

Figure 1: Conceptual design of JSNS^2 detector. From inner most to outer is Target, Catcher, and Veto. Catcher and Veto is optically separated with PMT support structure.

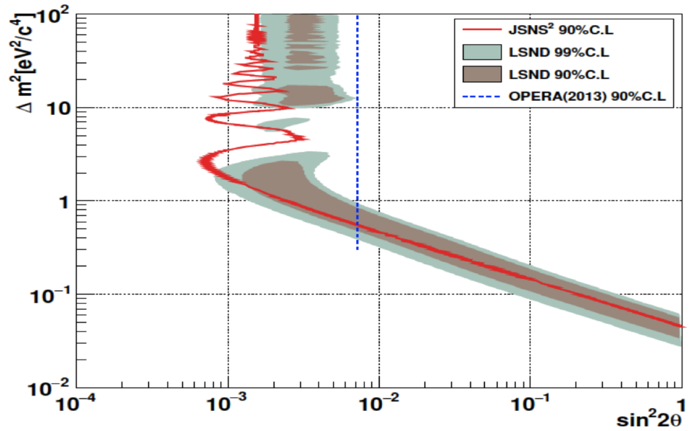

Figure 2: Expected sensitivity of JSNS^2 after 3 years of data taking. We assumed 17 tons one detector, 1 MW of J-PARC beam power.

5. Current status and Plan

With background measurement at 2014, we got 1st stage (out of two) approval from J-PARC Program Advisory Committee (PAC) at Feb, 2015. After that, we got budget of one detector at Jun, 2016. We started preparation of detector vessels. In the mean time, we surveyed PMT noise and finished setup of PMT pre-calibration system. Uniformity test of PMT position was done. Several material compatibility test is on going, which are more than several months now. We expect to finish PMT installation at middle of 2018, parallel with production of Gd-LS and LS. After a couple of months of dry run, we aimed to start physics data taking at the early of 2019.

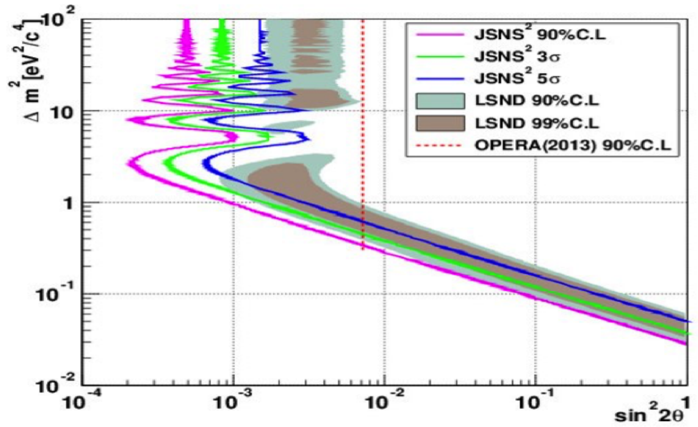

Figure 3: Improved sensitivity of JSNS^2 after 5 years of data taking. We assumed total 50 tons of fiducial volume with two detector and 1 MW of beam power.

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