Expression of interest for a new reactor neutrino experiment at the ILL reactor

Scientific Context

Recently Ref [1] provided new reactor antineutrino reference spectra, increasing the expected antineutrino rate by 3.5%. This triggered the revision of the observed versus predicted event ratios of 19 old reactor neutrino results at distances below 100 m (Ref [2]). The new averaged ratio is $N_{obs}/N_{expected}=0.943\pm0.023$, leading to the so-called reactor antineutrino anomaly, significant at the 98.6% C.L. This deficit could still be due to some unknown in the reactor physics, but it could also be interpreted as an evidence for the existence of a new sterile neutrino state, beyond the standard model. Such a mass state would have both large $\Delta m^2_{new}>1$ eV^2 and a significant mixing to accommodate the data. Hints of such results were already present at the ILL neutrino experiment in 1981 (Ref [3]). The combination of these new reactor data with MiniBooNE and the Gallium neutrino sources experiments (see Ref [4]) strengthens the sterile neutrino hypothesis, leading to solutions such that $\Delta m^2_{new}>1.5$ eV^2 (95% C.L.) and $\sin^2(2\theta_{new})=0.14\pm0.08$ (95% C.L.), disfavoring the no-oscillation case at 99.8% C.L. There is a general agreement that this hypothesis should be tested by new experimental program at reactor, accelerator, and in large liquid scintillator detectors.

Proposal

Sterile neutrinos fitting the reactor antineutrino anomaly of Ref [2] would leave their imprint on the energy spectrum energy of very short baseline (<10m) reactor experiment deployed close to a compact core. In this context the Nucifer experiment, primarily dedicated to demonstrate the potential use of neutrinos for non-proliferation purpose, is going to be located 7 meters away from the Osiris research reactor core at CEA-Saclay (Ref [5]). In a second stage the Nucifer collaboration is investigating the possibility to deploy their detector at ILL, in the basement room B42. An informal meeting on that topic was held on April 21th 2008 with H. Guyon. However Nucifer is primarily optimized for rate-only analysis and may be not enough testing the reactor antineutrino anomaly.

Therefore we would like to propose a new dedicated experiment searching for a shape distortion in the reactor antineutrino spectrum at 10 m or less from the ILL reactor core optimized for the fourth neutrino state search of Ref [2]. The ILL nuclear reactor site has key advantages: it is compact, preventing the washing-out of the oscillation pattern; its fuel is highly enriched in ^{235}U, simplifying the search for a distortion with respect to the predicted spectrum if no oscillation; the site used for the ILL 1981 experiment (room B42) is close enough to the core in the basement, providing the necessary shielding against cosmic rays (a factor 3) and an appropriate distance. The new detector would consist of a few m^3 of liquid scintillator contained in a vessel shielded by low-Z and high-Z materials, and equipped with a PMT readout system (concept of the 1981-ILL and Nucifer neutrino experiments).

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References

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Ref [4] : C. Giunti, M. Laveder, Phys. Rev. D82 (2010) 053005

Ref [5] : A. Porta et al., J. Phys. Conf. Ser. 203 012092 (2010)