

Active and Passive Background Reduction Techniques to Measure Coherent Elastic Neutrino-Nucleus Scattering at the Chooz Nuclear Power Plant

Spécialité Physique de la matière condensée

Niveau d'étude Bac+4/5

Formation Master 2

Unité d'accueil [DPhP](#)

Candidature avant le 01/07/2019

Durée 3 mois

Poursuite possible en thèse oui

Contact [WAGNER Victoria](#)

+33 1 69 08 37 48

victoria.wagner@cea.fr

Autre lien

http://irfu.cea.fr/dphp/Phoce/Vie_des_labos/Ast/ast_groupe.php?id_groupe=3427

Résumé

A new-generation neutrino experiment exploring coherent elastic neutrino-nucleus scattering (CENNS) is being planned at the Chooz nuclear power plant. This internship concentrates on the design and testing of the active muon veto and a Monte Carlo based optimization of the passive shielding.

Sujet détaillé

Coherent elastic neutrino-nucleus scattering (CENNS) is a process in which a neutrino scatters coherently over all nucleons in a nucleus. The coherence increases the CENNS cross-section by up to two orders of magnitudes with respect to standard neutrino detection methods such as the inverse beta-decay (IBD). Thanks to the boost in the cross-section, the flavor blindness and the missing threshold, CENNS offers a unique way to study neutrino properties, and to test the Standard Model of Particle Physics (SM) as well as to search for new physics. One of the main challenges of such CENNS experiments are to reach a sub-keV energy threshold, as well as a low background count rate at such low energies. Nuclear reactors are strong (anti-) neutrino sources, however, experimental sites close to nuclear power plants are typically at a shallow overburden and the cosmic background needs to be reduced.

A new-generation neutrino experiment exploiting CENNS is being designed at the Chooz nuclear power plant in France. To study CENNS, bolometric detectors with an energy threshold below 20 eV will be installed in a new experimental site, called the Very-Near-Site (VNS), inside the inner area of the power plant. First measurements indicate that the overburden at the VNS is below 5 m.w.e., thus, requiring an effective active and passive reduction of the cosmic-ray induced background, such as neutrons and muons. Neutrons are a particularly dangerous background since they feature the same signature as CENNS events.

The CENNS target detectors will be embedded into a compact passive shielding consisting of alternating layers of lead to attenuate gamma-rays and borated polyethylen (PE) to moderate and capture neutrons. Besides a source of background due to electro-magnetic interactions, muons produce neutrons in nuclear reactions, especially in high Z material like lead. To reduce the muon-induced background an active muon-veto based on plastic scintillators will be designed. The veto-system will identify muons passing through the experimental setup, such that coincident events are identified as muon-induced and do not originate from CENNS. An efficient active and passive shielding is crucial for the success of the experiment.

The internship will allow the candidate to study and work on widely used background reduction techniques. The focus lies on the testing and characterization of the muon-veto. In a dedicated test stand at CEA-Saclay, the student will test the performance of the individual plastic scintillators as well as the photo-multiplier tubes (PMT) which are used to read out the scintillation light. The work includes the analysis and comparison of the acquired data. Furthermore, dedicated GEANT4 Monte Carlo simulations to optimize the passive shielding layer are foreseen.

The work will be performed within an international collaboration. In regular meeting the student will have the opportunity to present his work. The internship is minimum 3 months, and can be extended up to 6 month. For M2 students, there may be a possibility to propose a PhD subject after the internship. The ability to work independently and good programming skills are desired.

Mots clés

Compétences

Logiciels

C++, ROOT, GEANT4

Active and Passive Background Reduction Techniques to Measure Coherent Elastic Neutrino-Nucleus Scattering at the Chooz Nuclear Power Plant

Summary

A new-generation neutrino experiment exploring coherent elastic neutrino-nucleus scattering (CENNS) is being planned at the Chooz nuclear power plant. This internship concentrates on the design and testing of the active muon veto and a Monte Carlo based optimization of the passive shielding.

Full description

Coherent elastic neutrino-nucleus scattering (CENNS) is a process in which a neutrino scatters coherently over all nucleons in a nucleus. The coherence increases the CENNS cross-section by up to two orders of magnitudes with respect to standard neutrino detection methods such as the inverse beta-decay (IBD). Thanks to the boost in the cross-section, the flavor blindness and the missing threshold, CENNS offers a unique way to study neutrino properties, and to test the Standard Model of Particle Physics (SM) as well as to search for new physics. One of the main challenges of such CENNS experiments are to reach a sub-keV energy threshold, as well as a low background count rate at such low energies. Nuclear reactors are strong (anti-) neutrino sources, however, experimental sites close to nuclear power plants are typically at a shallow overburden and the cosmic background needs to be reduced.

A new-generation neutrino experiment exploiting CENNS is being designed at the Chooz nuclear power plant in France. To study CENNS, bolometric detectors with an energy threshold below 20 eV will be installed in a new experimental site, called the Very-Near-Site (VNS), inside the inner area of the power plant. First measurements indicate that the overburden at the VNS is below 5 m.w.e., thus, requiring an effective active and passive reduction of the cosmic-ray induced background, such as neutrons and muons. Neutrons are a particularly dangerous background since they feature the same signature as CENNS events.

The CENNS target detectors will be embedded into a compact passive shielding consisting of alternating layers of lead to attenuate gamma-rays and borated polyethylen (PE) to moderate and capture neutrons. Besides a source of background due to electro-magnetic interactions, muons produce neutrons in nuclear reactions, especially in high Z material like lead. To reduce the muon-induced background an active muon-veto based on plastic scintillators will be designed. The veto-system will identify muons passing through the experimental setup, such that coincident events are identified as muon-induced and do not originate from CENNS. An efficient active and passive shielding is crucial for the success of the experiment.

The internship will allow the candidate to study and work on widely used background reduction techniques. The focus lies on the testing and characterization of the muon-veto. In a dedicated test stand at CEA-Saclay, the student will test the performance of the individual plastic scintillators as well as the photo-multiplier tubes (PMT) which are used to read out the scintillation light. The work includes the analysis and comparison of the acquired data. Furthermore, dedicated GEANT4 Monte Carlo simulations to optimize the passive shielding layer are foreseen.

The work will be performed within an international collaboration. In regular meeting the student will have the opportunity to present his work. The internship is minimum 3 months, and can be extended up to 6 month. For M2 students, there may be a possibility to propose a PhD subject after the internship. The ability to work independently and good programming skills are desired.

Keywords

neutrino, particle physics, background rejection

Skills

testing the performance of plastic scintillators read out with a PMT, data analysis, GEANT4 Monte Carlo simulations to optimize the passive shielding

Softwares

C++, ROOT, GEANT4