The Angra neutrino experiment*

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Abstract

The *Neutrinos Angra* detector is a demonstrator experiment to measure the antineutrino flux from nuclear reactors for nuclear safeguards and non-proliferation purposes. The 1 m^3 Gd-loaded water Cherenkov detector will be installed at 25 m from the 4 GW_{th} Angra-II reactor core and detect $\approx 5 \cdot 10^3$ neutrinos per day. The detector is now completely assembled and is being extensively tested at the CBPF. Preliminary analyses with data from the detector were used to asses the electronics and PMT characteristics, as well as to study the muon flux and background rate. The detector will soon be shipped to its destination at the Angra dos Reis nuclear power plant and begin taking neutrino data.

CONCEPT

The *Neutrinos Angra* experiment aims to measure antineutrinos from the Angra-II reactor block of the Angra dos Reis nuclear power plant. Main objective of the experiment is to determine the reactor power from the measured antineutrino flux and, by doing so, demonstrate the possibility of using small-scale neutrino detectors for safeguards and nuclear non-proliferation. For this purpose the detector is designed to be safe, compact, cost-effective, and easily deployable in agreement with recommendations of the International Atomic Energy Agency [1].

DETECTOR DESIGN

The Neutrino Target consists of a volume of 1 m^3 of water doped with Gadolinium (ca. 0.3 %). Antineutrinos from the reactor are detected via the inverse beta decay (IBD) reaction $\nu_e + p \rightarrow e^+ + n$. The positron instantly deposits its energy and annihilates producing a prompt signal. The neutron thermalizes and is then captured on a Gadolinum nucleus. The deexcitation of the nucleus releases several gammas and yields a delayed signal. The coincidence to a previous prompt event creates a characteristic signature for IBD events. The short coincidence time of $\approx 10^{-8}$ s and high deexcitation energy of ≈ 8 MeV sets antineutrino reactions apart from most accidental background events. The Cherenkov light produced in the Target is observed by 32 PMTs (8 inch Hamamatsu R5912) at the top and bottom walls of the vessel. To increase the light yield the Target walls are covered with highly reflective material [2].

The Target is surrounded by active Veto volumes, which are filled with pure water and are equipped with a total of 12 PMTs to observe the Cherenkov light created by cosmic muons. In addition to the active Veto volumes there is a lateral layer of 25 cm of pure water as a passive shielding protecting the fiducial volume from external radioactivity and neutrons induced by cosmic rays.

The experiment will be installed at the Almirante Álvaro Alberto nuclear power plant at Angra dos Reis, Rio de Janeiro. The detector will be placed at a close distance of 25 m from the core of the Angra-II reactor. With 4 GW thermal power of the reactor the expected number of observed antineutrino events is of the order of $5 \cdot 10^3$ events per day. The measurement of the antineutrino flux at this very short baseline also provides a further data point for the investigation of the so-called reactor anomaly. Unlike most other neutrino experiments, the Angra detector will be placed above ground and be exposed to a high rate of cosmic muons and muon-induced backgrounds. Their rejection is an important challenge for the experiment and special attention is paid to the efficient handling of the background. Several analysis techniques are being developed and evaluated to identify and reject background events.

CURRENT STATUS

The detector is now completely assembled at the CBPF and is taking data. Currently, the detector performance and stability is being intensively tested. Acquired physics data has already been used to characterize the PMTs and readout electronics and to study the detector response [3]. It also allows to measure the cosmic muon flux and the rate of further background, which helps to improve the Monte Carlo simulations of the experiment. A calibration campaign is also envisaged. After the tests are concluded the detector will be fully commissioned and shipped to its destination at the nuclear power plant in Angra dos Reis, Rio de Janeiro.

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