PROCEEDINGS OF SCIENCE

Active Neutron Detector for direct Dark Matter searches with the DarkSide-50 experiment at Gran Sasso

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The existence of dark matter is known from gravitational effects, and although its nature remains undisclosed, there is a growing indication that the galactic halo could be permeated by WIMPs with mass of the order of 100 GeV. Direct observation of WIMP-nuclear collisions in a laboratory detector plays a key role in dark matter searches. However, it also poses significant challenges, as the expected signals are low in energy and very rare.

DarkSide is a project for direct observation of WIMPs in a liquid argon time-projection chamber that can meet these challenges. A limiting background for all dark matter detectors is the production in their active volumes of nuclear recoils from the elastic scattering of neutrons. DarkSide-50 is surrounded by a liquid scintillator, doped with Boron, which is used as an active high-efficiency neutron detector. In order to acquire the PMT signal we have developed custom front-end amplifiers with built-in trigger capabilities and a DAQ system based on high-resolution fast digitizers.

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1. Introduction

There are many compelling pieces of evidence for the existence of Dark Matter. Among the best motivated dark matter candidates are Weakly Interactive Massive Particles (WIMPs). Direct observation of WIMP-nuclei collisions in a laboratory detector plays a key role in dark matter searches. However, it poses significant challenges, as the expected signals are low in energy (below 100 keV) and very rare (a few interactions per year per ton of target). Large (0.1-10 ton target mass) *discovery* (underground and ultra low-background) detectors are mandatory.

DarkSide is a project for direct observation of WIMPs in a two-phase liquid argon time-projection chamber (TPC) [1]. The first physics detector in the program is DarkSide-50 (DS-50), with a 50 kg active mass of low-radioactivity underground Argon. The DS-50 TPC is surrounded by a 30 ton borated-liquid scintillator neutron veto. Both detectors are deployed in the Borexino Counting Test Facility, a 1000 ton water shield and Cerenkov muon veto [2]. DarkSide-50 is located underground in Hall C of Laboratori Nazionali del Gran Sasso.

2. The Neutron Detector

The ultimate background for any dark matter detector are neutrons, which can elastically scatter off nuclei in the detector. Neutron-induced single recoils are indistinguishable from WIMP interactions. Instead of passive shielding, a superior method of neutron suppression is the use of an active detector in which the neutrons from both internal, cosmogenic [3], and external sources are detected and the corresponding recoil events induced by neutrons in the argon TPC are thus identified and rejected [4]. An active veto also provides an *in situ* measurement of the true neutron background in the experiment.

DarkSide-50 is equipped with a borated-liquid scintillator (a 1:1 mixture of pseudocumene PC and tri-methylborate) which is used as a Neutron Detector (ND). The ND's tank is a 4 m diameter sphere instrumented with 110 low-background 8" PMTs. ND's PMT signals are fed to custom low noise, high-bandwidth x10-amplifiers with compensated low-drift offset. Such Front-End Modules feature built-in discrimination with coincidence trigger functionality. Amplified signals are acquired by National Instruments high-resolution (10 bit) fast (1.25 GHz) digitizers. The necessary high data throughput is guaranteed by an ad-hoc designed LabVIEW-based data acquisition system.

3. Conclusions

The DS-50 detector is currently under commissioning. The ND has been filled in October 2013 and it is taking data. First physics runs are expected before the end of 2013.

References

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