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Installation and commissioning of the CDMSII experiment at Soudan

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Abstract

In the past year and a half, the Cryogenic Dark Matter Search (CDMS) collaboration has been active at the Soudan mine in installing a system for running ZIP detectors that will be used to search for dark matter in the form of Weakly Interacting Massive Particles. Presently, there is an operating cryogenic system, working electronics, a functional data acquisition and analysis system, passive shielding, an active muon veto, and 12 ZIP detectors. Six of the 12 ZIP detectors have been tested in situ and are fully operational with acceptable noise profiles. CDMS is in the

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process of commissioning the experiment and expects to be making a background measurement by the end of summer 2003.

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Keywords: CDMS; Installation; Soudan

1. Introduction

The Cryogenic Dark Matter Search (CDMS) is an experiment using cryogenic detectors to make a direct detection measurement of Weakly Interacting Massive Particles (WIMPs) [1,2]. WIMPs may constitute a large fraction of the dark matter of the universe [3].

Previous measurements by the CDMS collaboration have been conducted at the Stanford Underground Facility (SUF). This facility has an overburden of 16 m water equivalent and serves as the CDMS shallow site. An irreducible neutron background because of the shallowness of the facility limits the current CDMS sensitivity at SUF [4,5].

Over the past few years, CDMS has started installation of an experimental system at the Soudan mine, which will serve as the CDMS deep site. The Soudan deep site has an overburden of 2090 mwe, which reduces the muon flux by a factor of 10^4. At present, installation of the entire system is complete and the experiment is in the early phases of commissioning. This note is a brief update on the cryogenic, shielding, data acquisition, and analysis systems at the deep site.

2. Cryogenics

The cryogenic system at Soudan is similar in design to the CDMS cryogenic system at Stanford. It consists of an Oxford 400s dilution refrigerator connected to a radioactively clean copper icebox, which houses the ZIP detectors. The system is designed with extensive use of solenoid valves and electronic gauges to minimize the need for manual manipulation. This design has the advantage that many cryogenic operations can be conducted via computer control either from the mine or, if access is not possible, from a trailer at the surface.

The cryogenic system at Soudan was fully assembled and operated, without detectors, in December 2002 achieving a base temperature of 30 mK. The system was cooled down again at the beginning of April 2003 with 12 ZIP detectors. At the end of May, an unfortunate mishap resulted in the loss of the fridge run. The system is currently cooling down.

3. Shielding

In addition to the half mile of rock between the mine and the surface, the Soudan icebox is surrounded by 8.75 in of lead and 19 in of polyethylene to provide shielding from external photons and neutrons. The entire assembly is enclosed in an active muon veto. All of the shielding is in place and the veto has been assembled, calibrated, and tested. A preliminary measurement of the muon flux gives $2.2 \pm 0.1\ \mathrm{m^{-2}s^{-1}}$, which is lower than the flux at Stanford by about 15,000.

4. Data aquisition and analysis

The Soudan analysis cluster is a replica of the Stanford analysis cluster. It consists of six dual-processor Linux machines in a trailer at the surface. The analysis software from Stanford has been copied to the Soudan cluster with some minor modifications to interface with a new data acquisition system.

A new data acquisition system was required at Soudan in order to handle the data throughput required for the projected operation of 42 ZIP detectors. In addition to higher bandwidth, the new system has the capability for remote monitoring and control of the experiment. This feature provides us with the capacity to continue stable operations and perform minor debugging even if access to the mine is restricted. While the detectors were cold, the new DAQ was used to configure the detectors and to take data. It has performed reliably and has demonstrated the ability to handle data throughput at the designed rate of 10 Hz. Data exported by the new DAQ is currently being analyzed by the Soudan analysis cluster.

5. Outlook

The fridge run from April 2003 through May 2003 was an excellent opportunity to debug the entire Soudan system. The cryogenic system has a satisfactory performance. We are currently using the new DAQ for all detector manipulation, experimental configuration, and data acquisition. The online and offline software components are ready for use. In addition to exercising the system, a great deal of effort was invested to achieve noise levels comparable to those of SUF (Fig. 1).

Of the 12 detectors installed, the six detectors of the first tower are being studied. It was decided that the cold electronics for the remaining six detectors would be turned on only after the cryogenic system had demonstrated stability with single tower operations. All six detectors of the first tower have fully operational phonon and charge channels, and can be neutralized without compromising the performance of the cryogenic system. It is expected that by the end of summer 2003, the first tower will be completely neutralized and calibrated, and that a background measurement will be underway.

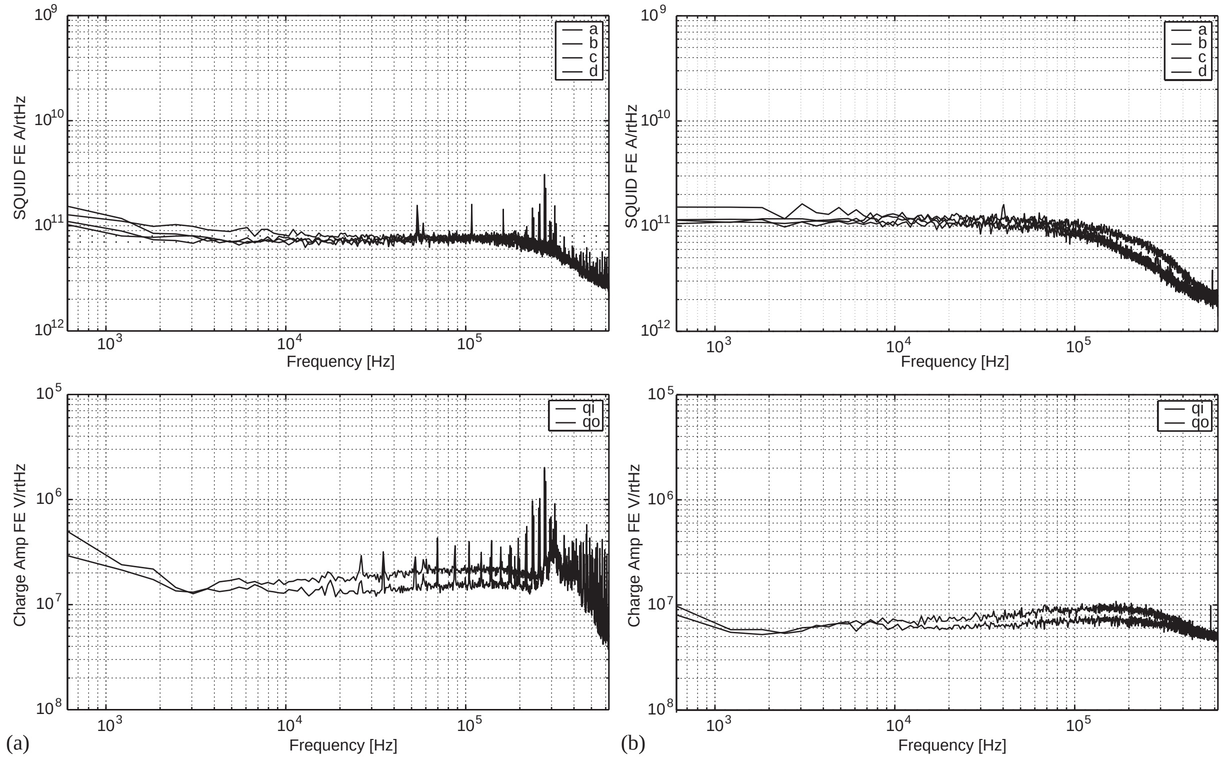

Fig. 1. A comparison of phonon (top) and ionization (bottom) noise spectra for: (a) Soudan and (b) SUF. The sources of the noise peaks and harmonics have recently been identified and can be removed.

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