Dark Matter in Galaxies
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Dark Matter Search Experiments At Boulby Mine

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Abstract. The status of the dark matter search program at the Boulby Underground Laboratory is reviewed. Recent results are presented and plans for future generation experiments are discussed.

1. Introduction

The UK Dark Matter Collaboration (UKDMC) has been operating NaI(Tl) detectors at the Boulby Mine underground site for several years (Smith et al. 1998). Limits on the flux of weakly interacting massive particles (WIMPs), that may constitute up to 90% of the mass of the Galaxy, have been recently set using the data from the first detectors (Ahmed et al. 2003). In recent years emphasis has shifted toward the operation of liquid Xe based detectors (the ZEPLIN program), and Time Projection Chambers, or TPCs (DRIFT). These are potentially more sensitive to WIMP signatures and, in the case of DRIFT, can provide directional information on the WIMP flux.

2. The ZEPLIN I Experiment

The ZEPLIN I detector consists of 3.1 kg fiducial mass of liquid Xe encased in a copper vessel and viewed by 3 PMTs through silica windows. The detector istelf is enclosed in a 0.93 tonne active Compton veto, its function being to veto gamma events from the PMTs and the surroundings. Background discrimination is possible due to the difference in time constant between nuclear and electron recoils. The preliminary limit on the spin-independent WIMP-nucleon cross-section from 230 kg×days of data is shown in Figure 1 in comparison with other world-best limits.

3. The DRIFT Experiment

The DRIFT detector adopts a different approach to identifying a potential WIMP signal (Snowden-Ifft et al. 2000). DRIFT I uses a low pressure gas negative ion TPC capable of measuring the components of recoil track ranges in addition to their energy. It consists of two 0.5 m^2 fiducial volumes defined by 0.5 m long field cages mounted either side of a common cathode plane. Particle tracks are read out with two 1 m long MWPCs, one at either end of the field

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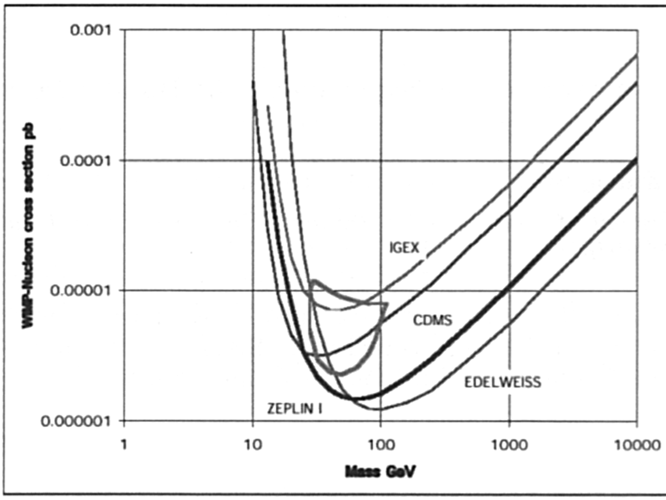

Figure 1. ZEPLIN I limit (preliminary) with limits from other experiments

cages. The difference in track range between electrons, alpha particles and recoils is such that rejection efficiencies as high as 99.9% at 6 keV are possible. After 1 year of operation DRIFT I is expected to reach a sensitivity of $\sim 10^{-6}$ pb. A key feature of DRIFT is its ability to determine the direction of WIMP-induced nuclear recoils, making it uniquely sensitive for detection of the "WIMP wind" expected from the Earth's motion in the galactic Dark Matter Halo.

4. Future Prospects

Facilities for future Dark Matter studies at Boulby have recently been expanded and improved (Paling et al. 2002). Work is now underway on ZEPLINs II, III and ZEPLIN MAX. The latter should have a sensitivity to WIMP-nucleon spin-independent interactions down to 10^{-10} pb. ZEPLIN II is a two phase detector with a target mass of about 30 kg and a sensitivity to WIMP-nucleon cross-section down to 10^{-7} pb. Work is also underway on DRIFT II, proposed to have 30–50 times the sensitivity of DRIFT I through an increase in the volume and gas pressure.

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