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Dark Matter experiments at Boulby mine

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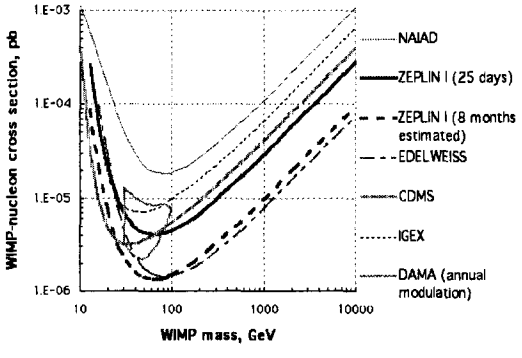
Three dark matter experiments are currently running at Boulby: 1) NAIAD – an array of NaI(Tl) crystals; 2) ZEPLIN I – a liquid Xe scintillation detector; and 3) DRIFT I – a low-pressure gas TPC. NAIAD and ZEPLIN use pulse shape analysis to discriminate between electron recoils, caused by gamma background, and nuclear recoils, which can be produced by WIMPs – dark matter candidates.

NAIAD consists of 2 encapsulated and 6 unencapsulated NaI crystals with the total mass of 65 kg. The detectors do not show the anomalous fast component previously found in several encapsulated crystals [1]. 10.6 kg×year of exposure of 4 detectors have been used to set upper limits on spin-independent WIMP-nucleon cross-section as shown in the Figure (thin solid line). Improvement in the light yield, noise rejection and analysis technique together with increased statistics should result in a factor of 10 improvement in the limits over the next 3 years of data taking.



ZEPLIN I consists of a 3.1 kg fiducial mass liquid Xe target viewed by 3 PMTs and surrounded by a 1 tonne liquid scintillator used as a Compton veto and neutron shield [2]. The WIMP limits after 25 days of running time are shown in the Figure (thick solid line). Two months more data have been collected recently with an estimated factor of 2 improvement in the limits. After 8 months of running ZEPLIN I will probe the whole region of parameter space favoured by DAMA.

DRIFT is designed to search for a sidereal variation of nuclear recoil directions that could constitute a definitive WIMP signature. DRIFT I consists of a 1 m^3 low pressure (40 Torr) TPC filled with electro-negative CS_2 gas with a $\approx$270 V/cm drift electric field [2]. DRIFT I has an electron recoil rejection power $>10^5$ based on the difference in ionisation density and track length. After the first test runs, DRIFT I has started to take data and the first results will soon be available.

The future two-phase Xe detectors ZEPLIN II and III will measure the ratio of ionisation to scintillation using an electric field to extract ionisation electrons from the liquid into a gas phase [2]. The detectors will be installed at Boulby in 2002-2003 and will have a sensitivity to WIMPs of $\sim 10^{-7}$ pb at about 100 GeV WIMP mass. An R&D for one tonne two-phase Xe detector ZEPLIN-MAX has been started with the intention of building the detector by 2006. DRIFT II is designed as a larger volume, higher pressure extension of DRIFT I surrounded by an active veto with a predicted sensitivity down to $\sim 10^{-7}$ pb.

REFERENCES

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2. For reviews of the ZEPLIN and DRIFT experiments see talks at Dark Matter 2002 (www.physics.ucla.edu/hep/DarkMatter/dm2002.html), Les Houches 2002 (leshouches.in2p3.fr) and poster at Neutrino 2002 (neutrino2002.ph.tum.de)

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