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Results and status of the EDELWEISS Wimp search experiment

Expérience EDELWEISS de recherche directe de Wimps : résultats et perspectives

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Collaboration: CNRS/IN2P3 (CSNSM, IPNL), CNRS/INSU (IAP), CNRS/SPM (CRTBT), CNRS-CEA (LSM), CEA/DSM/DRECAM, CEA/DSM/DAPNIA, FZ-Karlsruhe.

***Résumé :** EDELWEISS est une expérience de recherche directe de Matière Noire sous forme de Wimps située au LSM. La collaboration a développé des détecteurs cryogéniques en germanium avec une mesure simultanée de l'ionisation et de la chaleur permettant une discrimination événements par événements du fond radioactif gamma des reculs nucléaires attendus pour les Wimps. Nous présentons ici les résultats obtenus avec trois détecteurs de 320g lors de la première phase de l'expérience (EDELWEISS-I) stoppée début 2004. EDELWEISS est à ce jour la seconde expérience la plus sensible au niveau mondiale. La seconde étape, EDELWEISS-II, qui commencera avec 10kg (30kg à termes) de détecteurs est en cours d'installation au LSM, elle doit permettre de gagner 2 ordres de grandeur sur les résultats actuels.*

Introduction

The CSNSM bolometer team is involved in the EDELWEISS collaboration in which are working laboratories from CNRS (IN2P3, INSU, SPM), CEA (DRECAM, DAPNIA), and, for EDELWEISS-II, from FZ-Karlsruhe.

Astronomical observations indicate that most of the matter in the Universe is dark and non baryonic. The particles forming the non baryonic Dark Matter must be stable, neutral and massive. The most favoured candidates are the WIMPs (Weakly Interacting Massive Particle). In the MSSM (Minimal SuperSymmetric Model) framework, a WIMP candidate is the Lightest Supersymmetric Particle (LSP) which corresponds to the neutralino with a mass between a few tens and a few hundreds of GeV $/c^2$ and a scattering cross section with a nucleon below 10^{-6} pb. In the EDELWEISS experiment, nuclear recoils induced by elastic collisions with WIMPs from the galactic halo are identified in low-

temperature Ge detectors where the ratio of the heat and ionization signals provide an event-by-event discrimination of nuclear recoils from the dominant background coming from γ -rays interactions.

I – EDELWEISS-I: 1kg stage

I 1– Experimental Setup and the detector

Because of the very low event rate expected in the detectors ($\ll 1$ evt/kg/day), the EDELWEISS experiment (described in details in [1]) is located in the LSM (Laboratoire Souterrain de Modane), where the muon flux is reduced by a factor $2 \cdot 10^6$. The cryostat is shielded from the radioactive environment by 10cm of copper and 15cm of lead. An additional 30cm thick paraffine shielding surrounding the experiment allows a reduction of the neutron flux (that produces nuclear recoils similar to those created by WIMPs) by a factor of 100, thus the neutron event rate in

the detector is expected to be ≈ 0.03 evt/kg/day for nuclear recoils above 20 keV [2], small for the present sensitivity.

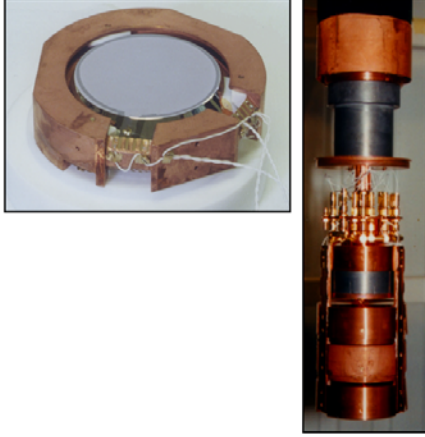


Figure 1: Mounting of the three detectors in the low background cryostat in the LSM. Each detector is equipped with aluminum electrodes and a guard ring to reject event occurring in the lateral part of the crystal. The thermal sensors is glued to the beveled surface, thus the residual radioactivity of the NTD does not induced any signals in the center fiducial volume.

The small one-liter cryostat can house up to three detectors (figure 1). Each detector is a cylindrical Ge crystal with a diameter of 70mm and a thickness of 20mm, the edges have been beveled at an angle of 45° . The ionization signal is collected by aluminum electrodes on each side of the detector. On one side the electrode is segmented allowing to reject those event occurring near the detector edges. Some detectors were equipped with an amorphous layer (Ge or Si) to improve the charge collection efficiency for near surface events. The heat measurement is obtained with a NTD Ge heat sensor glued on one of the electrodes.

I 2– Results

In 2000 and 2002, 11.6 kg.day were recorded with two different detectors and published in [1] and [3]. Since October 2002, three optimized 320g detectors have been simultaneously operated at a regulated temperature of 17mK and about 50 kg.day were added on the previous published data. Figure 2 shows the recorded ratio of ionization over recoil energy (Quenching factor) as a function of recoil energy for the last

EDELWEISS-I run (May-July 2004) with an improved trigger efficiency at low energy (trigger on the phonon signal). A 100% efficiency has been reached down to 15keV. The γ -rays background is only ≈ 1.5 evts/keV/kg/day between 20 and 100 keV before the rejection.

These data are still under analysis but a preliminary result in terms of an upper limit at 90% CL on the WIMP nucleon scattering cross section is shown in figure 3. The previous published limit is confirmed with the improved exposure. We see some events in the nuclear recoil band: it shows that the experiment is now background limited. These events are certainly due, for a major part, to electron recoil occurring near the electrodes and leading to a poor charge collection: they can then mimic WIMPs or neutrons.

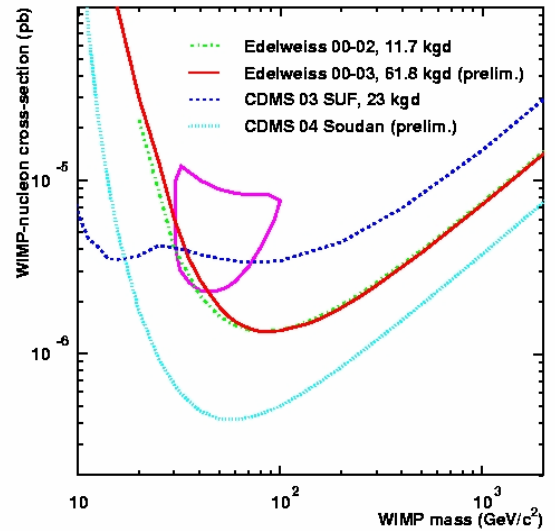


Figure 2: Preliminary spin-independent exclusion limit from EDELWEISS-I obtained combining all the data since 2000. Comparison to other experiments are shown (see [3]).

EDELWEISS has stopped the physics data taking during the summer 2003. Several tests were carried out until march 2004, such as tests of new detector holders, physics of the ionization with a fast electronic (See A. Broniatowski et al. in the following papers), and a test of three bolometers with NbSi thermometric layers (See L. Bergé et al. in the following papers).

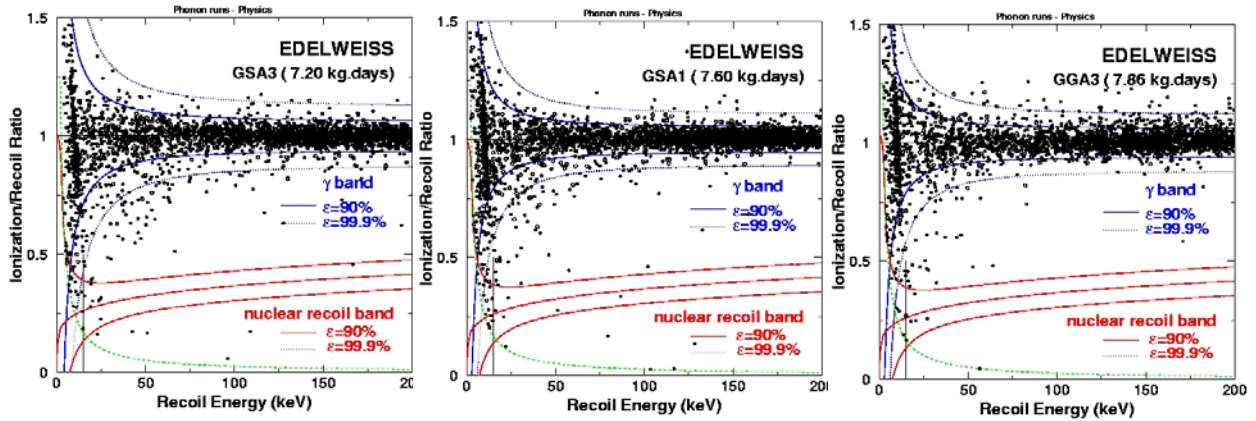


Figure 3: Quenching factor versus recoil energy from the data collected in the center fiducial volume of the three detectors during the last EDELWEISS-I run.

EDELWEISS-I was stopped and dismantled at the end of April 2004 for the installation of the next stage of the experiment, EDELWEISS-II.

II – EDELWEISS-II

To explore more deeply the parameter space of SUSY models, a large mass of detector is required. The collaboration is therefore preparing the second phase of the experiment, EDELWEISS-II. A new 100-liters dilution fridge could contain up to 120 detectors ($\approx 40\text{kg}$).

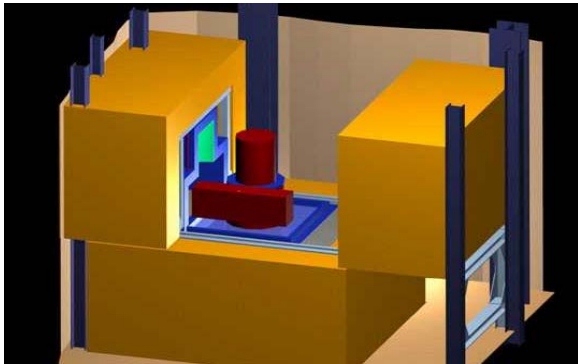


Figure 4: EDELWEISS-II setup. The new reversed cryostat (center) and the external shielding general view (lead in blue, PE in orange).

A first stage is approved and will run with $21 \times 320\text{g}$ Ge-NTD detectors and $7 \times 400\text{g}$ Ge detectors with NbSi thin films sensors for an active rejection of surface events (See L. Bergé et al. in the following papers). With a muon veto, made of about 140m^2 of plastic scintillators and an improved polyethylene (50cm thick) and lead shielding, we are

expecting to gain two orders of magnitude and reach 0.002 evts/day.kg .

A test with two bolometers will be carried out in September 2004 in Grenoble in order to test the new cryostat, with the electronics and the data acquisition and analysis system developed for EDELWEISS-II.

Conclusion

Data taking with EDELWEISS-I has been stopped in early 2004 to prepare installation of EDELWEISS-II. Preliminary analysis of the last data confirm with a greater exposure (60kg.day) the limit already published in 2002. The first run on EDELWEISS-II should begin during summer 2005.

[1] “First results of the EDELWEISS WIMP search using a 320g heat-and-ionization Ge detector”
A.Benoit et al., Physics Letters B, Volume 513, Pages 15-22 (2001). Astro-ph/0106094

[2] “Neutron background studies for the EDELWEISS experiment”

G. Chardin and G. Gerbier for the EDELWEISS collaboration

In proceeding of the 4th International Workshop on the Identification of Dark Matter, York – GB, 02-06/09/2002 (World Scientific, Singapore, 2003)

[3] “Improved Exclusion Limits from the EDELWEISS WIMP Search”

A.Benoit et al., Physics Letters B, Volume 545, Pages 43-49 (2002).

Astro-ph/0206271