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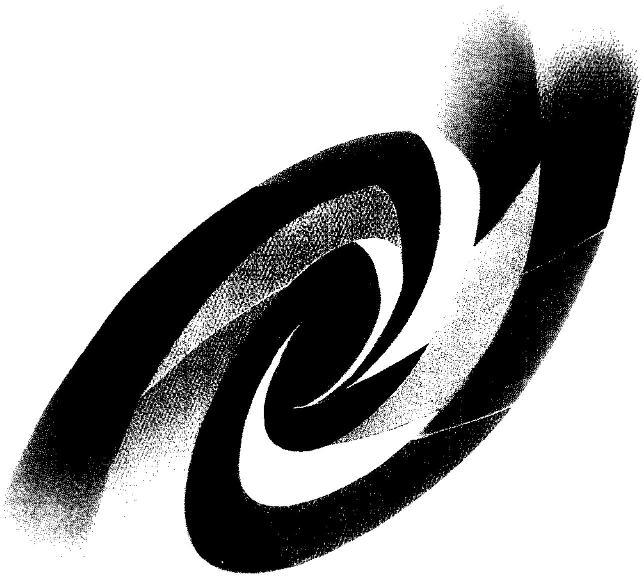

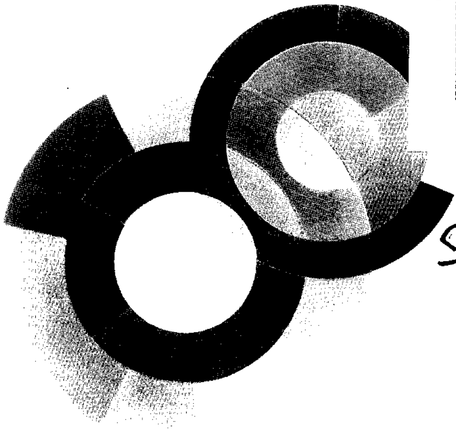

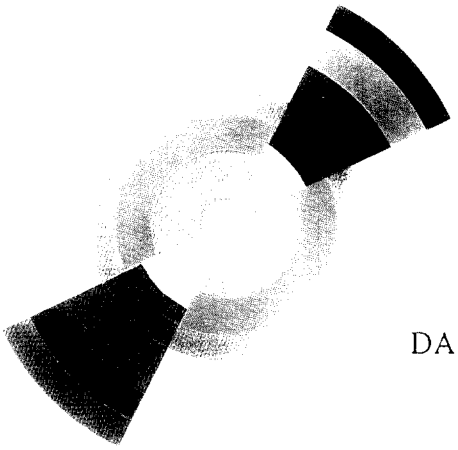

DAPNIA/SPP 95-20 September 1995

THE EDELWEISS EXPERIMENT:
A STATUS REPORT

D. Yvon, for the EDELWEISS Collaboration

DAPNIA

XXX^th Rencontres de Moriond, XV^th Moriond Astrophysics Meeting,
"Clustering in the Universe"
Les Arcs, Savoie, France, 11-18 March 1995

Couverture Sylvie Cabrit et Marc Sauvage

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THE EDELWEISS* EXPERIMENT: A STATUS REPORT

Dominique Yvon
for the EDELWEISS collaboration

*Experience pour DEtecter Les WIMPs En Site Souterrain

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Abstract

We ran a 1.5 keV threshold, 24g bolometer, deep underground, in a selected environment for low radioactivity. The experimental setup is quickly described. Preliminary analysis based on 125 hours of effective running time exhibits a 10 fold improvement in the event rate at energy between 10 and 20 keV relative to the previous attempt in 1991. However, the event rate is still two orders of magnitude higher than the best detectors at these energies. We are currently working at identifying the origin of the radioactive contaminants and developing new detectors.

The "Dark Matter problem" has been extensively discussed in the literature[9]. Some elementary particles could account for a large fraction of the unseen mass. An active field in particle physics is the search for supersymetric particles. The Lightest Supersymetric Particle (LSP), if the R-parity is conserved, is a good candidate for Dark Matter. More generally, the constraint from nucleosynthesis together with the observed value of matter density suggest that Weakly Interacting Massive Particles (WIMPs) would account to part of, if not all, the Dark Matter of the Universe. Goodman and Witten [3] proposed to detect WIMPs through their elastic scattering on nuclei. Several attempts have been conducted already [4]. The main challenges of these experiments consist in achieving a low ($\leq$keV) detection threshold and very low background radioactivity.

The EDELWEISS experiment has been designed as a prototype experiment for WIMPs detection using Bolometers. This is the first bolometer experiment with this physics goal installed in a deep underground site: the Modane Underground Laboratory under a rock shielding of 4800 meter water equivalent depth. The motivation for using bolometers for WIMP detection is double:

First, bolometer detectors are the detectors with the lowest threshold. Since the energy distribution of nucleus recoil is close of an exponential shape, the lower detection threshold is the more efficient.

Second, bolometer detectors are the only known detectors to measure ionisation and heat [7] or heat and light produced by a few keV nucleus recoil. Atomic models predict [5], and measurements have shown [6] that nucleus recoils ionise and scintillate less than electrons of the same kinetic energy. This allows an event by event or a statistical identification of electron and γ interactions, which constitute the main source of radioactive background.

We are now tackling the issues of bolometer experiments. Currently, our main effort is to get rid of parasitic events (microphonics, electromagnetic pulses), selecting low radioactive materials and developing more sensitive bolometers.

1. Experimental set up:

a) The dilution refrigerator.

We built a dilution refrigerator from carefully selected low radioactivity materials. Its base temperature is 35 mK. The available volume is a cylinder of 80 mm diameter and 300 mm height. Fall this year, the cryostat should be upgraded to a base temperature of 10 mK and an available diameter of 90 mm, 300 mm height. An automated gas handling system was developed to run this refrigerator. It allows monitoring the experiment over Internet, and greatly simplify the cooling and the maintenance of the cryostat.

b) The low radioactivity shield.

The refrigerator was placed inside a low radioactivity "outer shield" consisting of 10 to 15 cm of low radioactivity lead and of 10 cm of copper. A 5 cm thick selected iron layer covers this structure for mechanical sustainment.

In the cold part of the cryostat, an internal shield at a temperature of 4 K is made from archaeological lead, between 2 to 5 cm thick. An additional 9 cm archaeological lead shield at 55 mK is blocking the line of sight toward the dilution unit. This shield is designed to provide a 4π steradian shield to the detector.

c) The detector

We have used a 24 g sapphire bolometer with NTD Ge thermometer described in [1]. In running conditions, we got a typical detector sensitivity of 260nV/keV with an impedance of 700 kΩ at zero bias. We tried to run the bolometer with higher sensor impedance. Although the bolometer sensitivity was increased up to 800 nV/keV, the increase in microphonic noise did not improved the energy threshold.

d) The low noise readout system.

We have designed a flexible and dismountable wiring and electronic readout system. Emphasis in the design was put on achieving optimal electronic noise (no ground loops, careful shielding), and reduced sensitivity to microphonics. The preamplifier system was designed according to Ref.[8]. We achieved a noise level close to the thermodynamic limit ($\approx$2 nV.Hz$^{-1/2}$ in running conditions), although most events close to the threshold are due to microphonics. Up to six signal channels can be implemented in this set-up. With the above detector, we observed a 0.9 keV (FWHM) baseline width and ran the detector with an electronic threshold less than 2 keV.

e) Energy calibration.

Due to the 4π archaeological lead shield and to cryogenic constraint, it is difficult to insert a γ source close enough to the detector and get a low energy calibration. thus we placed a ^{60}Co γ source, which provides 1.173 MeV and 1.333 MeV lines, inside the "outer shield" close to the detector. γ went through the 4K shield and we registered the Compton spectrum. Previous measurement showed that the detector response was linear to few %

up to 1 MeV[1]. Fitting the observed spectrum to the montecarlo predicted spectrum allow a calibration better than 5%, dominated by the systematics on linearity and simulations.

2. Preliminary results.

The present results are based on an effective running time of 125 hours. Event shape using a Le Croy 6810 wave shape recorder and time were recorded. Analysis of shape of events showed that a significant fraction of events come from artefacts due to microphonics and electromagnetic noises that we did not completely succeed to shield from. These spurious triggers display different shapes from events due to radioactive background. Off line, we fitted the events' to a template, allowing time shift of events relative to the template. The template was built using low energy Compton events from ^{60}Co calibration runs. A simple cut on the fit residual while retaining 100% of the Compton interaction events allows a complete elimination of the electromagnetic noise events above 5 keV. Further analysis is going on.

After normalisation we get the preliminary spectrum plotted on figure (1).

Above 16 keV, we measured a event rate of 25 events/kg/keV/day. Below 16 keV the event rate rises rapidly. We believe that the event rate is artificially high due to the lack of containment (small size) of the detector. Thus the high energy γ interactions are shifted toward smaller energy. Taking these results into account, we are able to place an exclusion plot for Weakly Interacting Massive Particles figure (2).

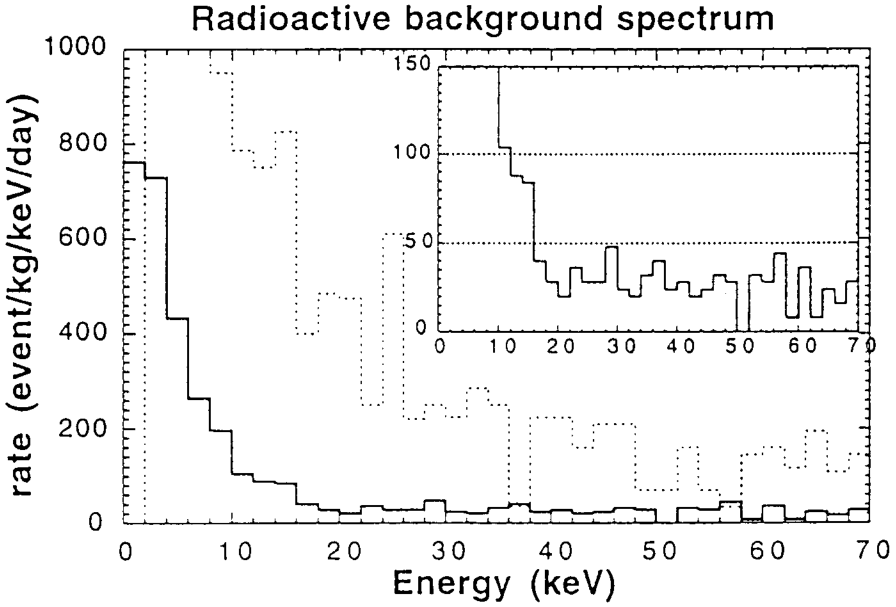

Figure 1: *Radioactive background spectrum normalised to event rate in events/kg/keV/day. Dashed line: result of the 1991 attempt [2], solid line: this experiment. An average event rate of 25 events/kg/keV/day above 16 keV is observed. The insert shows more accuratly the radioactive background at energies above 15 keV.*

3. Future Plans:

We are now measuring the radioactive contaminants of our setup using a 100 cm^3 germanium diode running at 77K inside the cryostat.

We are also developing massive bolometers, using thin films thermal sensors, and involving simultaneous measurements of ionisation and heat signals. Simultaneous measurement of light and heat signals is also being investigated. Our current program includes the measurement of a 1 kg sapphire bolometer and 70 g Ge diodes with simultaneous detection of heat and ionisation signals. These measurements are expected to be completed by mid 1996.

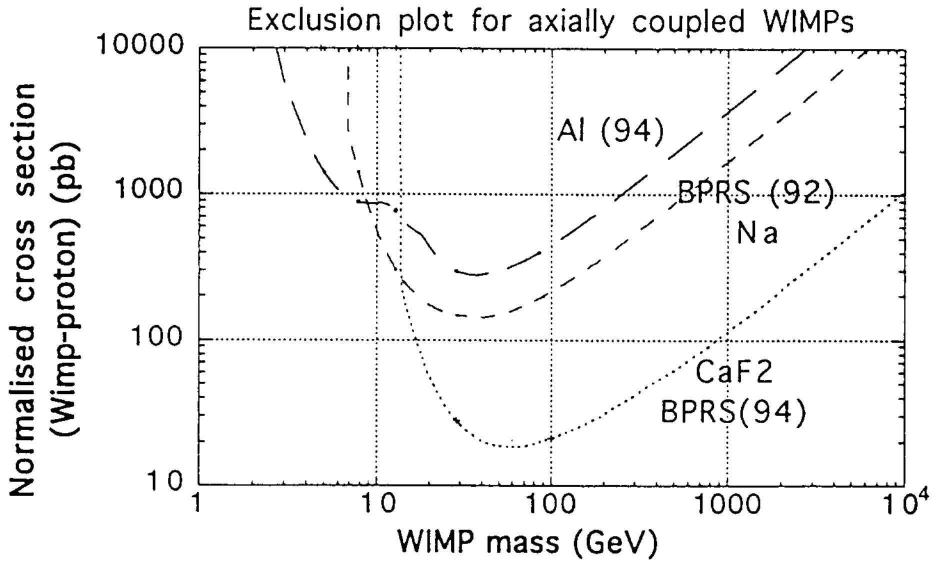

Figure 2: *Exclusion plot in the hypothesis of an axially coupled WIMP, extracted from the background spectrum shown on fig(1). This experiment is labelled as Al(94). For comparison, we plotted the best previous results extracted from [10]. Courtesy of C. Tao and G. Gerbier.*

Acknowledgements.

It is a pleasure to thank the technical support of the collaboration for their help. In this respect, special thanks are due to JP. Soirat (DAPNIA/SPP), Ph. Forget, G. Guerrier (DRECAM/SPEC), JP. Hadjout (IPNL) and M. Martin (IAP). It is also a pleasure to acknowledge useful discussions with J.L Bret and A. Benoît (CRTBT), P. Garoche (URA2), and JP. Torre (IAS) for technical advice of cryogenic environment. F. et Ph. Hubert (CENBG) have been of great help for low radioactivity measurements.

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