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# Dark matter searches with NaI scintillators in the Canfranc underground laboratory: ANAIS experiment

**J Amaré, B Beltrán, J M Carmona, S Cebrián, E García, H Gómez, I G Irastorza[1], G Luzón, M Martínez[*], J Morales, A Ortiz de Solórzano, C Pobes, J Puimedón, A Rodríguez, J Ruz, M L Sarsa, L Torres[2] and J A Villar**

Laboratorio de Física Nuclear, Universidad de Zaragoza, 50009 Zaragoza, Spain
[*]Paper presented at the conference by M Martínez

E-mail: mariam@unizar.es

**Abstract**. A large mass dark matter search experiment with NaI scintillators at the Canfranc Underground Laboratory is underway. A 10.7 kg prototype with improved light collection efficiency and special low-background improvements has been tested and started taking data underground in summer 2005. Preliminary results and prospects for the experiment are presented.

## 1. Introduction

ANAIS is a large mass sodium iodide experiment intended to look for annual modulation in the dark matter signal. It will be carried out at the Canfranc Underground Laboratory, and will consist of 10x10.7 kg NaI(Tl) crystals selected from a set of 14 which have been stored underground at the Canfranc laboratory since 1988. Three of them were used in a previous experiment [1]. In the past years, a first prototype of the ANAIS experiment was installed at Canfranc [2] and achieved a background of 1.2 counts $keV^{-1}$ $kg^{-1}$ $d^{-1}$ in the low energy region after noise rejection by Pulse Shape Discrimination. The improvements recently made in this first prototype to understand and reduce the background are reported in section 2. A second prototype has been constructed aiming at background and threshold reduction. Preliminary results are presented in sections 3 and 4.

## 2. Background reduction

Some tests have been performed to understand and reduce the background [3], taking the first prototype as starting point. The effect of replacing the photomultiplier (EMI 9765) by an ultra-low-background one (EMI 9302LTD) was measured at Canfranc, resulting in a significant background reduction of more than 50% in the $^{40}$K peak, and of around 40% in the 200-600 keV region (see figure 1). A 3-inch-diameter cylindrical methacrylate light guide of 10 cm long was coupled to the crystal quartz window and the photomultiplier. A further reduction of about 20% was obtained in the energy window from 200-600 keV, but this time no change was observed in the $^{40}$K peak suggesting an important internal contribution. The next step implies the removal of all materials near the crystal and strong radiopurity requirements for every new component of the light collecting system. This was the objective of prototype II.

[1] Present address: DAPNIA, CEA, Saclay, France.
[2] CEE fellow under contract HPRN-CT-2002-00322, presently at the Università di Milano-Bicocca, Italy.

## 3. Light collection optimization

Several tests to optimize the light collecting system to be used in the prototype II were performed without NaI crystal inside a tightly sealed copper box containing a Teflon bank to support the two photomultipliers tubes and three Teflon cylinders to house the crystal and the two conical light guides (see figure 2). The first objective was to find the best reflector or diffuser material for crystal and guides among several available: cylinders of Teflon of three different thicknesses (10, 15 and 20 mm) and a polymeric reflecting foil. The second goal was to find out the optimal length of the light guides (5, 10 and 15 cm were tested). The light emission was simulated by means of a pulsed UV-LED and was introduced in the reflecting cavity by an optic fiber emitting the light near the surface of the reflector/diffuser material in three different positions along the crystal.

Different configurations were tested, and the main conclusions were that a large thickness of Teflon slightly increases light collection (around 5% more light every 5 mm of Teflon), but the best light collection is obtained with the reflecting foil. It does not only increases collected light in about 20% with respect to the result obtained with 10 mm of Teflon, but also makes light collection more independent of the light emission position. This increase in collected light with the reflecting foil was confirmed in measurements in Canfranc with the scintillator crystal. The decrease in collected light with longer light guides was measured, finding an average reduction of about 10% every 10 cm of light guide length.

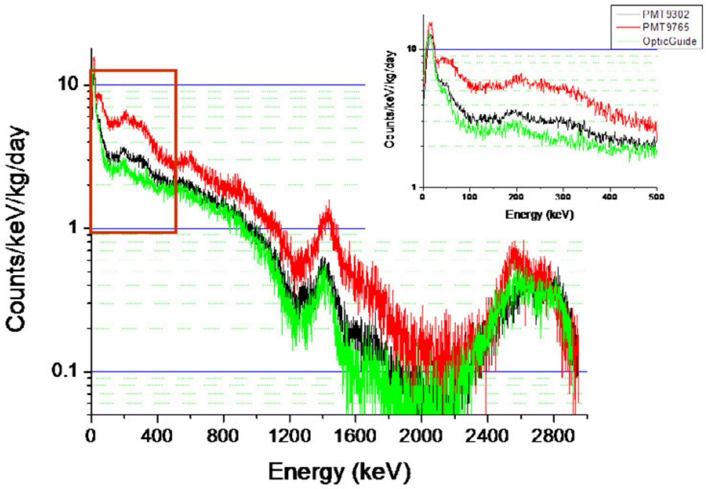


**Figure 1.** Progressive background reduction after replacement of PMT (first step) and the additional coupling of a 10 cm light guide. The inset shows the low energy region (up to 500 keV).

## 4. Prototype II experimental set-up and results

In order to mount the second ANAIS prototype, one of the crystals was extracted from the stainless steel container and all the surrounding material was removed (silicone, diffuser, optical grease...). After that, the crystal surfaces were slightly polished. All the work was done inside a clean box, in dry nitrogen atmosphere. A compromise between background reduction and light collection lead us to choose 10 cm light guides. The naked crystal was coupled to methacrylate light guides and to two low background photomultipliers inside a 1.5 cm thick Teflon cylinder having a polymeric reflecting foil covering the inner surface. Such prototype has been installed at Canfranc inside a shielding consisting of 10 cm of archeological lead, 10 cm more of low-activity lead and an anti-radon PVC box. The interior of the copper box is continuously maintained in dry nitrogen atmosphere.

A $^{232}$Th contamination in the weldings of the copper box has been observed and a proper shielding inside the copper box is being prepared to measure the background level near the threshold while a new crystal encapsulation is designed.

A PSD analysis has been performed to discriminate α events from β–γ ones. After 3.6 days of measurements, an α rate of 210 $kg^{-1}$ $d^{-1}$ was obtained at Canfranc related to the internal contamination on the natural chains. Further details on the analysis and results can be found in [3].

To investigate the energy threshold, a preliminary low energy calibration system has been mounted in the copper box using an internal $^{55}Fe$ source. Some holes in the Teflon cylinder allow the X-rays to reach the crystal at three different positions along one of the surfaces. The position of the source can be manually adjusted from outside the shielding. When the source is facing the crystal, the 5.9 keV peak is clearly visible with the two photomultipliers working in coincidence.

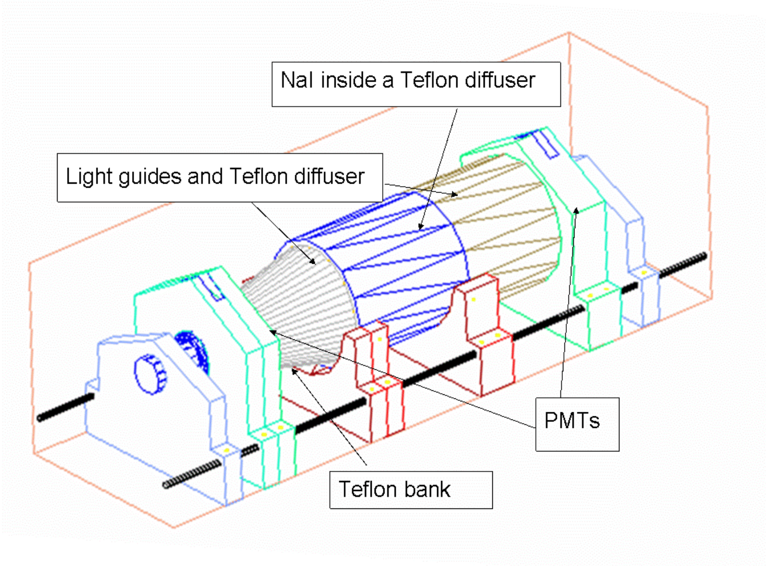


**Figure 2.** Schematic view of the second prototype of the ANAIS experiment.

## 5. Summary and prospects

After a preliminary work of light collection optimization and background reduction, a second prototype of the ANAIS experiment has been installed at Canfranc, consisting of a 10.7 kg NaI(Tl) crystal coupled to two methacrylate light guides and two photomultipliers working in coincidence. PSD has been used to discriminate noise and α events allowing the identification of some internal contaminations. Some slow-varying parameters (relative humidity, nitrogen flux) are being monitored.

The next steps are: a systematic study of the available crystals with the developed techniques, the design of a new encapsulation for the crystals and the completion of the monitoring of slow-varying parameters that could mimic the modulation signal (temperature, radon level, HV supply).

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