LOW ENERGY EVENTS IN ANAIS PROTOTYPE

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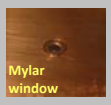
ANAIS (Annual modulation with NaI Scintillators) is a project aiming to set up, at the new facilities of the Canfranc Underground Laboratory (LSC), a large scale NaI(Tl) experiment to look for dark matter annual modulation. NaI(Tl) is an interesting target due to the DAMA/LIBRA positive result. For this goal, a NaI(Tl) ultrapure crystal (9.6 kg) made by Saint-Gobain and sold as similar in quality to DAMA crystals has been mounted in the University of Zaragoza (UZ) as a detector and installed at the LSC. The aim of this prototype is to better characterize ANAIS set-up background at low energy and, after moving to the new LSC hall, start a long measurement in the best background conditions. Although ^{40}K bulk contamination was expected to be much lower, results of the tests carried out show that potassium content will reduce sensitivity for the annual modulated signal. Different set-ups have been carried out in order to determine the best light collection efficiency, while keeping the background as low as possible.

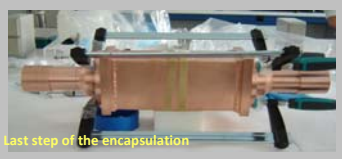
ENCAPSULATION

Fully encapsulated at the UZ:

- Teflon and reflectant layers.
- Synthetic quartz windows.
- Mylar window to allow low energy calibrations.



- Low radioactivity copper encapsulation. Caps for the PMTs and light guides were electroformed at the UZ.



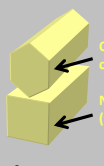
Contamination of all components was measured at the LSC with an HP Ge detector.

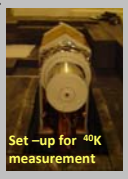
LOW ENERGY EVENTS

An ultrapure NaI(Tl) crystal (9.6 kg) made by Saint-Gobain and similar to DAMA crystals.

^{40}K CONTENT

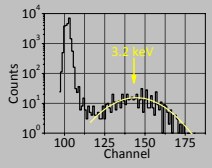
- ^{40}K is the most relevant contaminant in the bulk for the low energy background in NaI(Tl) detectors.
- Set-up for measuring in coincidence with an other NaI(Tl) detector.





- The ^{40}K estimate has been done by measuring X-ray / Auger electron emissions of Argon at 3.2 keV following the EC in the crystal in coincidence with a 1461 keV gamma fully absorbed in the other detector.
- Besides accidental coincidences, events at 3.2 keV are clearly observed. From the measured coincidence rates and GEANT4 estimated efficiencies, the ^{40}K activity can be deduced:

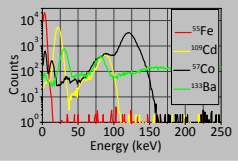
^{40}K Activity = 12.7±0.5 mBq/kg



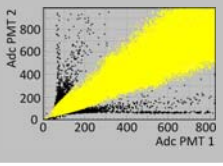
LOW ENERGY CALIBRATIONS

Different radioactive sources (^{55}Fe, ^{109}Cd, ^{57}Co, ^{137}Cs and ^{133}Ba) together with the background events, specially the 3.2keV events coming from internal ^{40}K, are used to study different effects: spatial dependences of the signal, linearity of NaI(Tl) at low energy, noise rejection, counting discrete photoelectrons at very low energy, etc. For instance:

- Spectrums of low energy calibrations:



- Asymmetric events from the background can be rejected:



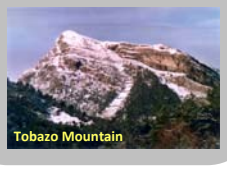
SHIELDING

- 30-cm-thick lead shielding to attenuate gamma radiation.

- Sealed with a plastic bag in overpressure by the injection of N_2 gas to avoid radon intrusion.

- Active vetos to detect muons (although muon rate is very low underground).

- The LSC is located 2450 m.w.e. under the Tobazo Mountain.



LIGHT COLLECTION

PHOTOMULTIPLIERS

Two different low background PMTs have been tested:

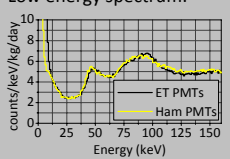
- Electron Tubes Limited 9302B
- Hamamatsu R6233-100

The goal is to determine which are better to use, attending to their contribution to the background and their resolution.

	Quantum Efficiency	Contamination (mBq/PMT)*		
		^{40}K	^{232}Th	^{238}U
ET	30%	420±50	24±4	220±12
Ham	≥35%	663±49	56±3	105±4

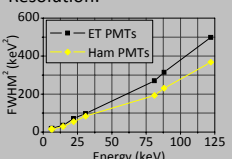
*Measured at the LSC with an HP Ge detector

Low energy spectrum:



Similar background contribution.

Resolution:

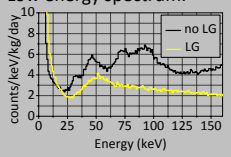


Better for Ham PMTs.

LIGHT GUIDES

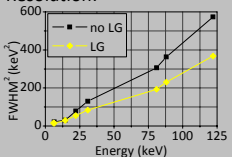
The prototype has been tested with and without light guides (LG).

Low energy spectrum:



Background improvement.

Resolution:



Worse resolution.

Ultra Low background and High Quantum Efficiency PMTs and no lights will be needed → **Ham ULB PMTs R11065.**

Q.E.	Contamination (mBq/PMT)*			
	^{40}K	^{232}Th	^{238}U	^{60}Co
30%	32±9	1.9±0.7	^{238}U → 33±7 ^{226}Ra → 6.7 ±0.9	3.3±0.5

Next step would be test them at the prototype.