LOW ENERGY EVENTS IN ANAIS PROTOTYPE

J Amaré, S Borjabad, S Cebrían, C Cuesta, D Fortuño, E García, C Ginestra, H Gómez, M Martínez, M A Oliván, Y Ortegoza, A Ortiz de Solórzano, C Pobes, J Puimedón, M L Sarsa and J A Villar

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 setup 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.

**LIGHT COLLECTION**

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

**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.

<table>
<thead>
<tr>
<th></th>
<th>$^{40}$K</th>
<th>$^{222}$Th</th>
<th>$^{238}$U</th>
</tr>
</thead>
<tbody>
<tr>
<td>ET</td>
<td>420±50</td>
<td>24±1</td>
<td>220±12</td>
</tr>
<tr>
<td>Ham</td>
<td>663±49</td>
<td>56±3</td>
<td>105±4</td>
</tr>
</tbody>
</table>

*Measured at the LSC with an HP Ge detector.

**LOW ENERGY EVENTS**

**$^{40}$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 GEANT3 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, $^{103}$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.
- Light windows.
  - Sealed with a plastic bag in overpressure by the injection of $N_2$ gas to avoid radon intrusion.
  - Active veto to detect muons (although muon rate is very low underground).
  - The LSC is located 2450 m.w.e. under the Tobazo Mountain.

**LIGHT GUIDES**

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

<table>
<thead>
<tr>
<th></th>
<th>ET PMTs</th>
<th>Ham PMTs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resolution:</td>
<td>620</td>
<td>710</td>
</tr>
<tr>
<td>Energy (keV):</td>
<td>0 - 25</td>
<td>0 - 25</td>
</tr>
<tr>
<td>Counts/keV/kg/day</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

- Better for Ham PMTs.

**Ultra Low background and High Quantum Efficiency PMTs and no lights will be needed $\rightarrow$ Ham UB# PMTs R11065.

<table>
<thead>
<tr>
<th>$^{40}$K</th>
<th>$^{222}$Th</th>
<th>$^{238}$U</th>
<th>$^{57}$Co</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q.E.</td>
<td>3.3±0.5</td>
<td>3.3±0.5</td>
<td>3.3±0.5</td>
</tr>
</tbody>
</table>

Next step would be test them at the prototype.