Analysis and identification of alpha events for NEWS-G

Introduction: What is NEWS-G

NEWS-G is a dark matter search experiment specialized in low mass WIMPs (0.1 to a few GeV/c²). The detector is a spherical proportional counter filled with gas. If a dark matter particle interacts with a gas particle, the resulting nucleus recoil will ionize the gas. An anode at the center of the sphere produces a radial electric field attracting the primary electrons towards the middle. Near the anode, the electric field becomes so strong that the electrons are accelerated enough to ionize even more gas, in what is called a Townsend avalanche. Thus, all the drifting secondary ions produce a detectable signal. The sensitivity threshold goes as low as ½ an electron, which makes it possible to count individual electrons.

The current analysis being done is on the data taken at the *Laboratoire Souterrain de Modane* in France, with neon and methane.

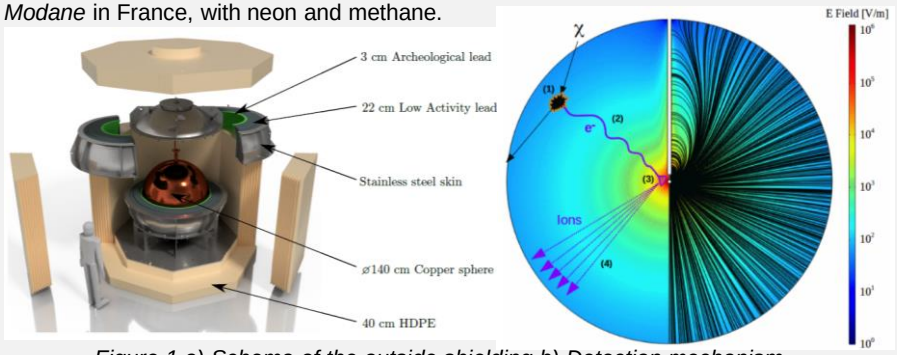

Figure 1 a) Schema of the outside shielding b) Detection mechanism

Fluctuations of the drift time and rate of events

The time it takes for an electron to go from the surface of the sphere to the center is called the drift time, and is measured regularly by sending UV laser pulses on the copper inner surface, which frees electrons through the photoelectric effect.

It was discovered that the drift time fluctuates a lot in a run, dropping suddenly every 30-45 seconds and then slowly rising up again. At the same time as those drops in drift time, the rate of events suddenly increases before coming back to the usual background level in an exponential decline. The related time constant is shorter for rate than drift time, but both depend on the gas composition, pressure and voltage. The jumps in rate are particularly problematic because the influxes of events are at low energy, in the region of interest for dark matter.

Fortunately, the entire phenomenon can be correlated to the presence of alpha events.

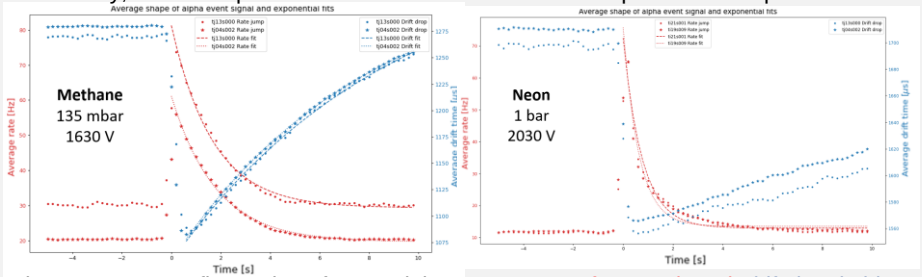

Figure 2: Average fluctuation after an alpha event, Rate of events in red, drift time in blue

Alphas in the detector

The copper surface contains traces of ^{210}Pb which decays towards ^{210}Po, an alpha emitter. The alphas ionize an enormous amount of gas molecules, thus creating a space charge that perturbates the electric field and makes the drift time shorter until the drifting ions reach the inner surface of the sphere. It is still unknown why the rate of events stays high for a few seconds after the alpha. One hypothesis is that it could be related to attachment, i.e. the primary electrons getting caught by gas particles for a few seconds.

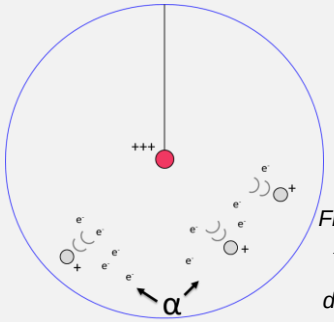

Figure 3: Alpha event diagram

Detection of alpha events

Alpha events are detected as saturated events with a very large width. However, since the processing was not made for events that energetic, the signal is often broken up or cut in half which makes the alphas difficult to detect. To counter that problem, we also use the decreasing baseline in the tail of events following the alpha as an indicator. For the few alphas that still evade that selection, very high rate of events are identified as alpha events as well. The drift time is less stable and hence a weaker indicator, but it is the only usable one in calibration runs that triggered on the laser alone.

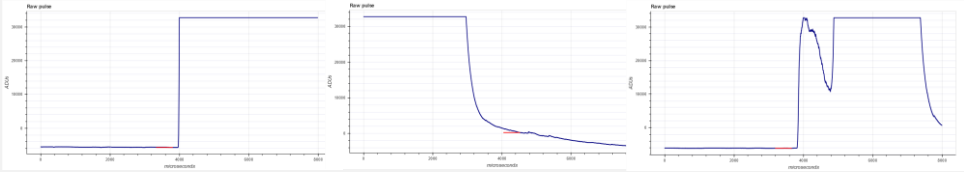

Figure 4 Alpha pulse examples a) Cut at the end b) Cut at the start c) Broken up

Conclusion

Finally, using a cut of 5 seconds after each high width saturated events, strings of decreasing baselines and high rates of events, the low energy background is successively reduced to in the end only 32% of its original amount, while still keeping 88% of the total run time.

The next runs of data taking at SNOLAB will include a low gain channel in order to detect alphas more easily, without saturation of the signal.

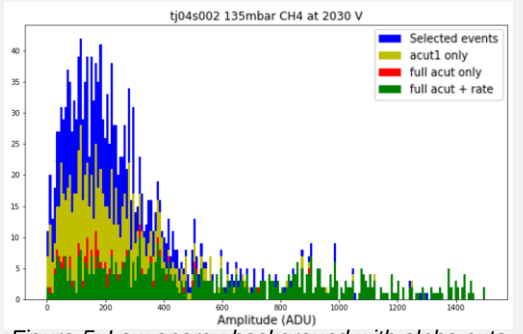

Figure 5: Low energy background with alpha cuts

References

- Q. Arnaud et al., First results from the NEWS-G direct dark matter search experiment at the LSM, Astroparticle Physics97(2018) 54-52.
- Q. Arnaud et al., Precision laser-based measurements of the single electron response of SPCs for the NEWS-G light dark matter search experiment, arXiv:1902.08960
- A. Dastgheibi-Fard & G. Gerbier, Development of Spherical Proportional Counter for light WIMP search within NEWS-G collaboration, arXiv:1904.01944