Ultra Low Background Alpha Counting for SuperCDMS

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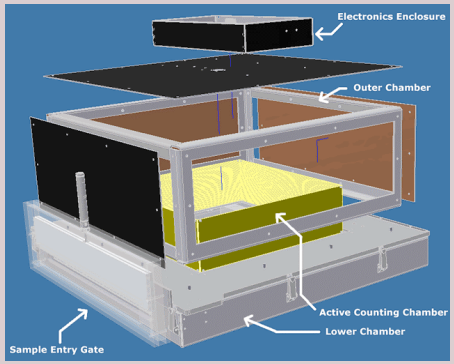
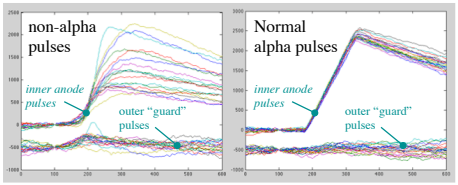
Abstract

The UltraLo-1800 alpha counter is a table-top, particle detector that measures alpha activity levels below 0.005 alphas/cm^2/hr. These sensitivities are necessary for characterizing the radioactivity of materials that will be used in the next phase of the Cryogenic Dark Matter Search (SuperCDMS). The particle counter was designed and patented by XIA LLC.

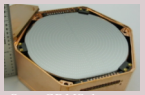


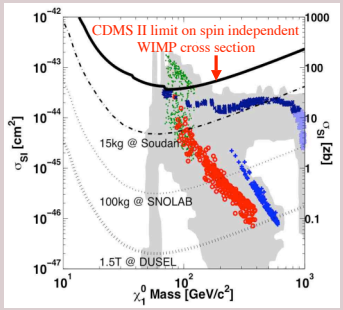
Above: The detector is a large ionization chamber. The inner (counting) chamber is filled with Ar gas. Samples are placed on a large 20"X20" tray at the bottom of the chamber. Ionizing particles produce tracks, which are collected on inner and outer (concentric) electrodes.



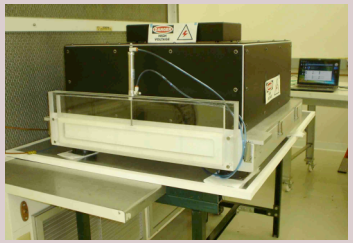
Above: The position and type of particle affect the shape of the recorded pulses. Tracks originating from the edges of the counting region and chamber sidewalls show significant outer electrode activity and are rejected. Tracks originating from the ceiling or volume of the chamber exhibit short risetimes, low energies and/or rounded tops.

Material Screening for SuperCDMS


SuperCDMS detector

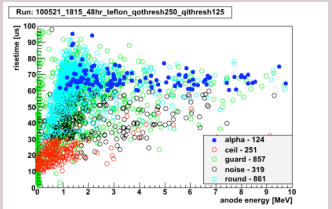


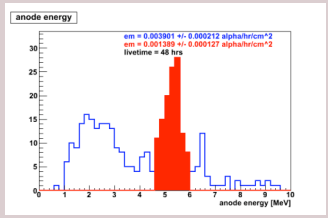
Left: SuperCDMS is the successor to the Cryogenic Dark Matter Search. This experiment uses instrumented Ge crystals, cooled to ~50mK, to search for spin-independent WIMP-nucleon interactions. SuperCDMS is taking place in two stages. The first, *O*(10kg) phase, is currently being deployed at the Soudan Underground Laboratory in Northern Minnesota. The second, *O*(100kg) phase, will be deployed in SNOLAB.

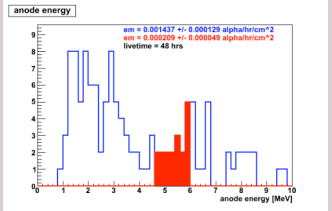


Right: A prototype XIA model is currently being operated at Fermilab. We are using it to screen materials for the fabrication of SuperCDMS detectors as well as materials that will be located close to the detectors (such as detector supports and shielding).

Right: This figure shows data taken from a background run of the XIA detecctor. The risetime versus energy are shown for all events in the run. Only the blue dots are classified as alphas, based on sufficient charge collection in the inner electrode, the risetime and the shape of the pulse at its peak. In the region around 5.3 MeV, which corresponds to the energy of the alpha emitted by ^{210}Po decay, the background is less than 0.0003 alphas/cm^2/hr. This high level of sensitivity allows us to monitor samples for contamination by ^{222}Rn daughters. Below: An example ^{210}Po-alpha peak.

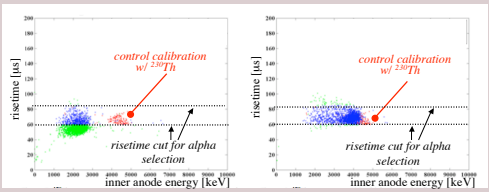




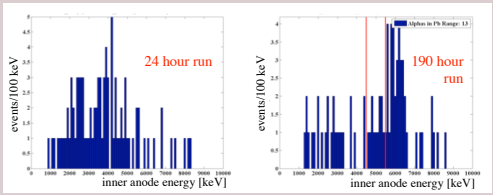


Debugging the Prototype at Stanford

Through a special agreement with XIA, this prototype detector was originally installed at Stanford University to characterize and optimize its performance. The proximity of XIA to Stanford, allowed for a close collaboration between XIA technicians and SuperCDMS scientists. Some of the initial studies performed on the detector are described below.



Above: These plots show the effect of counting a material with a high moisture content. In the left plot, a sample of 1/4" teflon lines the sample tray during a ^{230}Th calibration. The blue events show that the energy and the risetime are degraded compared to a control calibration run (no teflon). In the right plot, the same 1/4" teflon lines the tray during a ^{230}Th calibration run, but after drying the teflon in the chamber with the Argon purge for 4 days.



Above: Early studies also indicated that the steel tray was a significant source of alphas. Lining the tray with a very thin, 2 mil, layer of teflon signficantly reduced the background from the tray. The plot on the left shows a run taken with the empty steel tray. The plot on the right shows a longer run taken with teflon lining the tray. *Note the right and left plots are not normalized by exposure time.*

References

http://www.xia.com/Alpha_products.html

Coleman, S., "Ultra-low Background Counting and Analysis", senior thesis, Stanford University

Fermilab