Muons in DM-Ice are identified by their pulse shape and high energy deposition. Muon events display a similar pulse shape to gamma events, allowing the rejection of alphas through pulse shape discrimination. The highest energy muons saturate the PMTs, creating artificially low PSD variable values. They deposit higher energy than the gamma events, allowing their separation through an artificial cut in the pulse shape height, which is proportional to the energy deposited. This cut was possible both in the ice and in the FNAL test setup. This analysis is in current R&D work and is actively underway.

Muon-Induced Phosphorescence

Muons are observed to induce long-lived phosphorescence (afterglow) in DM-Ice. Phosphorescence has been previously observed in NaI(Tl) detectors on a broad range of timescales, ranging from microseconds to several days. While shorter-lived (≤ milliseconds) decays may be explained with non-dominant but conventional NaI(Tl) decays, longer-living states are believed to be the result of trap production from defects in the crystal. This hypothesis is in agreement with DM-Ice observations. The DM-Ice17 crystals, which are over 10 years old, exhibit phosphorescence with a 8±2 second decay time, while the new R&D crystals exhibit a ~300 millisecond phosphorescence. Only the highest 2% of muon energy depositions induce this effect to an observable degree.

Phosphorescence events are comprised of hundreds to thousands of very low energy events in the single-keV range. While in theory, these events can present a muon-induced modulating background in the low-energy region, they do not pass the standard DM-Ice17 noise removal cuts.

Muon Identification and Modulation

Muons in DM-Ice are identified by their pulse shape and high energy deposition. Muon events display a similar pulse shape to gamma events, allowing the rejection of alphas through pulse shape discrimination. The highest energy muons saturate the PMTs, creating artificially low PSD variable values. They deposit higher energy than the gamma events, allowing their separation through an artificial cut in the pulse shape height, which is proportional to the energy deposited. This cut was possible both in the ice and in the FNAL test setup. This analysis is in current R&D work and is actively underway.

Muon-induced modulating background in the low-energy region is not present in the standard DM-Ice17 noise removal cuts.