Search for the β^+ Decay of ^{144}Pm

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The mean confinement time of cosmic rays within our Galaxy can be determined by comparing the cosmic-ray abundances of suitably long-lived radioactive isotopes to those of their stable neighbors. For heavy elements (Z > 28) the current state of the art in cosmic-ray mass measurements is not sufficient to allow isotopic abundance measurements. This difficulty prompted Drach and Salamon [1] to consider the possibility of using elemental abundances of Tc and Pm, which have no stable isotopes, as cosmic ray clocks. In the case of Pm, only three isotopes, ^{143,144,145}Pm, have sufficiently long half-lives and suitable decay schemes to be present in the cosmic rays. Due to their interactions with the interstellar medium, cosmic rays nuclei are fully stripped of their atomic electrons. This turns a nucleus such as ^{145}Pm, which decays in the laboratory via electron capture, into a stable nucleus. Because of their larger EC decay energies, it is possible for ^{143}Pm and ^{144}Pm to also decay by β^+ emission. In the laboratory, these forbidden decays have to compete with allowed EC decays and so have not yet been observed. As fully stripped nuclei, however, these β^+ decays will determine the cosmic ray half lives of these isotopes.

In a previous experiment [2], we used two 28% efficient Ge detectors surrounded by a 4π NaI annular detector to search for the β^+ decay branches of ^{143,144}Pm. For the case of ^{144}Pm we searched for the β^+ decay to the $J^\pi = 2^+$ level at 697 keV through the observation of 511-511-697 keV triple coincident events. While we did not succeed in observing this decay, we were able to establish a limit of $> 1.2\text{x}10^6$ years for the β^+ decay half life of ^{144}Pm. This is close to the lower limit for this decay mode estimated by Drach and Salamon. In order to maximize our detection efficiency, we had to sandwich the source right in between the two Ge detectors. Because of this close geometry, a major limitation in this experiment was background produced by γ rays Compton scattering from one Ge detector into the other.

In order to improve upon this measurement, we have performed a new experiment by placing a 1.4 μCi source of ^{144}Pm into GAMMASPHERE to search once again for 511-511-697 keV coincidences. This source was produced at the 88-Inch Cyclotron approximately 9 months ago and has been used in one study of the decay scheme of ^{144}Pm [3]. Because of the larger size but smaller solid angle covered by each detector element in GAMMASPHERE and because of the BGO Compton suppressers, this provides a much higher detection efficiency and a substantially lower background environment in which to search for this β^+ decay branch. This ^{144}Pm source was counted in GAMMASPHERE for approximately 4 days. Analysis of the data obtained in this experiment is now in progress. We estimate that we will improve our sensitivity by approximately a factor of 10 over our previous results.

Footnotes and References

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