COSMIC RAY HISTORY DERIVED FROM THE ^{56}Ni CHRONOMETER

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Detailed information on the history of cosmic rays within our Galaxy can be determined by comparing the cosmic-ray abundances of long-lived radioactive isotopes to those of their stable neighbors. Due to their interactions with the interstellar medium, high-energy cosmic ray nuclei are fully stripped of their atomic electrons. This turns nuclei such as ^{7}Be, ^{53}Mn and ^{145}Pm, which decay in the laboratory via electron capture, into stable nuclei as cosmic rays. Because of their larger EC decay energies, it is possible for nuclei such as ^{54}Mn, ^{56}Ni, and ^{144}Pm to decay by β^+ emission. By combining observations of the cosmic-ray abundances of these isotopes with measurements of their β^+ decay half lives, the mean confinement time of cosmic rays in our galaxy and the time interval between nucleosynthesis and cosmic ray acceleration can be deduced.

We performed three experiments on GAMMASPHERE to search for the astrophysically interesting β^+ decay branches of ^{54}Mn, ^{56}Ni, and ^{144}Pm. We placed a chemically purified source of each isotope at the normal target position and searched for the characteristic signature of the β^+ decay of each isotope. In last year's report, we presented our results for ^{54}Mn and ^{144}Pm [1], [2]. Here we report the final results of our study of ^{56}Ni decay [3].

For ^{56}Ni, we measured the energy spectrum of positrons in coincidence with 511-511-158 keV gamma rays that would be produced by the β^+ decay to the $J^p = 3^+$ first excited state in ^{56}Co. To do this, we placed 2.8 μCi of ^{56}Ni inside a 4π plastic scintillator detector and mounted this apparatus at the normal GAMMASPHERE target position. We counted this source for a total of 96 hours.

In the subsequent data analysis, we searched for events in the scintillator detector that were in coincidence with two back-to-back 511's and with a 158-keV γ ray. This triple gating condition removed most of the unwanted background events. We were, however, left with residual events in the scintillator spectrum that were due to the decay of a ^{57}Ni impurity in our source. After subtracting away this remaining background, we were left with no net ^{56}Ni signal but a 1σ upper limit of 77 counts. From this result, we established a limit on the β^+ decay branch of ^{56}Ni to the 158-keV level in ^{56}Co to be 6.3×10^{-5}%. This implies a lower limit on the cosmic-ray half-life of ^{56}Ni of 2.7×10^{4} years. This result suggests that if the time interval between nucleosynthesis and cosmic-ray acceleration is not too long, then ^{56}Ni could survive and reach us in the cosmic rays produced by a nearby supernova explosion.

Footnotes and References

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2. K. Zaerpoor *et al.*, Phys. Rev. C **57**, 2046 (1998).
3. K. Zaerpoor *et al.*, Phys. Rev. C (accepted for publication)