PROTON-INDUCED BACKGROUND STUDIES FOR A SATELLITE GAMMA-RAY EXPERIMENT

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In this experiment (#121) proton irradiation studies of several materials were undertaken to evaluate the feasibility of utilizing a tungsten or lead collimator in a large gamma-ray experiment, the Oriented Scintillation Spectrometer Experiment (OSSE), to be launched on NASA's Gamma Ray Observatory satellite. Normally, such experiments have used NaI and CsI anticoincidence shields and collomators to provide a minimum detector background environment. The purpose of this experiment was to evaluate the background contributions when using a lead or tungsten collimator relative to that obtained with a drilled-hole cesium iodide collimater. A 200 MeV beam at IUCF was used since this is representative of the proton energies in the trapped radiation belts to which the detector is exposed several orbits per day.

Irradiations of CsI, NaI, W and Pb targets were undertaken to provide direct information on the relative γ-ray backgrounds expected from these materials in a geometry which approximates the OSSE collimator configuration. Aluminum was also irradiated since much of the experimental hardware and S/C will be fabricated from aluminum. The 203 MeV beam exited the beam pipe through a 1/16" thick aluminum end plate, passed through a 1/4" thick plastic beam monitor, and then passed directly to the target assembly. The W and Pb targets were each 57 g/cm^2 thick, which is representative of the passive collimator option considered for OSSE and just thick enough to stop a 200 proton beam (range ~55 g/cm^2).

Neutron capture background is expected to be significant in the OSSE detectors. In order to measure this effect the IUCF targets were located in a cylindrical drum which contained ~35 g/cm^2 thick NaI powder. The NaI annulus was used to moderate the neutrons produced in the target and simulate the shield of the OSSE detectors. A 3" x 3" NaI(Tl) crystal placed directly behind the target was used to evaluate the neutron capture background component.

The beam intensity was monitored using the $^{12}C(p,pn)^{11}C$ reaction as observed in the plastic beam monitor. ^{11}C β^+-decays with a 20.5 min half-life, and the 0.511 MeV emission from the plastic was used to measure the total beam dose. The cross section for this reaction at at 200 MeV is 35 ± 3 mb. The total dose on target was ~5x10^{11} protons for monitoring long-lived activity.

Three counting stations were set up to monitor the several targets. Counting station 1 used a 5" dia. x 4" thick NaI(Tl) crystal to monitor the 0.51 MeV γ-rays coming from the plastic beam monitors. Counting station 2 was used to monitor the γ-ray activity from the several primary targets utilizing a 4" dia x 4" NaI monitor detector. For the passive targets (W, Pb and

Al), this station was operated in a single parameter mode measuring the γ-ray spectrum emitted by the passive target. For the CsI(Na) and NaI(Tl) targets, the station was operated in a 2-parameter (coincidence) mode with the target crystals placed face-on to the monitor detector. This permitted a determination of direct activity induced in the NaI(Tl) target crystal, observation of γ-ray emission from the activated crystal and also a determination of the effectiveness of various anti-coincidence levels in rejecting γ-ray emission from the activated crystal using anticoincidence techniques. Counting station 3 was used to monitor the activity in the 3" x 3" NaI crystals placed behind the targets. This activity is nearly all due to neutron capture. Energy spectra were accumulated and recorded on magnetic tape. Many measurements were taken for each target configuration encompassing times after irradiation from 2 minutes to several months.

The results obtained from the IUCF experiment, in conjunction with other analyses, have provided the following conclusions regarding the background in the OSSE detectors:

1. The background below 2 MeV is primarily due to neutron capture on ^{127}I resulting in a ^{128}I β^- spectrum with end-point energy of 2.1 MeV.
2. Proton-induced activity in the 3" x 4" NaI primary detector is nearly equally divided (for the planned Gamma Ray Observatory orbit) between cosmic-ray and trapped proton spallation products.
3. The background contribution in the primary NaI detector from a tungsten or lead collimator will be only ~15% of the total. Because a ~50% larger effective area will be obtained with a passive collimator, use of the passive material will result in improved sensitivity.

Based on the results obtained at IUCF, a passive collimator detector configuration has been recommended and approved by NASA.