X-13

NUCLEAR EMULSION EXPERIMENTS

ON SOUNDING ROCKETS AND SATELLITES

D.E. Guss, C.E. Fichtel, and D.A. Kniffen
Goddard Space Flight Center, Greenbelt, Maryland

Nuclear Emulsions, because they can provide a complete picture of the relative abundances of charged particles over a wide range of particle energy and intensity, are a particularly useful tool for the study of particle populations in space. The fact that emulsions must be recovered for analysis presents the most serious single restriction to their extensive use on sounding rockets and satellites. However, the environmental conditions encountered by rocket payloads are rather severe, and special care must be taken to ensure not only the recovery of the emulsions, but also their recovery in a condition suitable for analysis.

The environmental conditions which rocket borne emulsions must survive are shocks, pressure, and high exit and re-entry temperature. It was determined that emulsions could withstand pressures up to 50 kg/cm^2 without appreciable distortion. This exceeds the pressure which the emulsions encounter in the worst cases. Since emulsions cannot withstand the exit and re-entry temperatures attained by the payload wall, some means must be used for thermal isolation. Fortunately in sounding rockets the high wall temperatures are of short duration, and it was found that providing a long path for conduction from high temperature regions coupled with the use of aluminum coated mylar around the emulsions to reduce radiation heating was sufficient to ensure the recovery of the emulsion in a condition satisfactory for analysis, in most cases.

In the past few years three sounding rocket payloads incorporating nuclear emulsions have been successfully flown and recovered. One of these, flown on a Nike Cajun sounding rocket from Fort Churchill, was used to study the charge distribution and energy spectrum for particles from solar flare events. Another payload designed for an Argo D-8 was used to study the protons in the inner region of the Van Allen Belts. The third system, to study the charge distribution and energy spectrum of galactic cosmic ray very low energy heavy nuclei, was flown on an Aerobee rocket. The first two systems have been discussed previously.[1]

Because of the very small intensity of very low energy heavy nuclei and the short duration of a sounding rocket flight, the primary problem in this experiment was one of obtaining a sufficient number of particles for a meaningful analysis. Hence, it was desirable to expose as large an emulsion surface area as possible to the ambient radiation above the atmosphere.

The payload configuration flown is shown in figure 1. Six emulsion packs were set in each of three trays. At launch a g-activated timer initiated the sequence of events in the payload. At 61 seconds, when the rocket had reached 180,000 feet, a motor was started which extended the three emulsion trays. Then after an exposure of about 350 seconds the motor was again activated which retracted the emulsion trays prior to re-entry. In

[1] IVth International Conference on Nuclear Photography, Munich, 1962.

order to determine the rocket aspect during the flight, one fluxgate magnetometer was orientated along the rocket axis and another perpendicular to the rocket axis. Information from these and a signal indicating the activation of the emulsion tray drive motors were telemetered.

The recovery section of the rocket consisted of a parachute which was deployed by a pressure switch at 18,000 feet on re-entry. The recovery aids consisted of a DPN - 41 radar beacon transmitter, a SARAH beacon, and a dye marker package for visual sighting in the event the payload, which was designed to float, landed in the water. The rocket was flown in September 1963 from Fort Churchill, Canada and all three of the recovery aids worked successfully.

A modification of this experiment is to be flown in July 1964. In this modification, one sheet of emulsion is mounted in a separate frame above the emulsion tray. When the tray is extended the top sheet of emulsion extends also, but the tray is extended further providing a shift between the top sheet of emulsion and the remainder of the emulsion stack. In this way a degree of time resolution is obtained which will alleviate the necessity of making an ascent and descent correction.

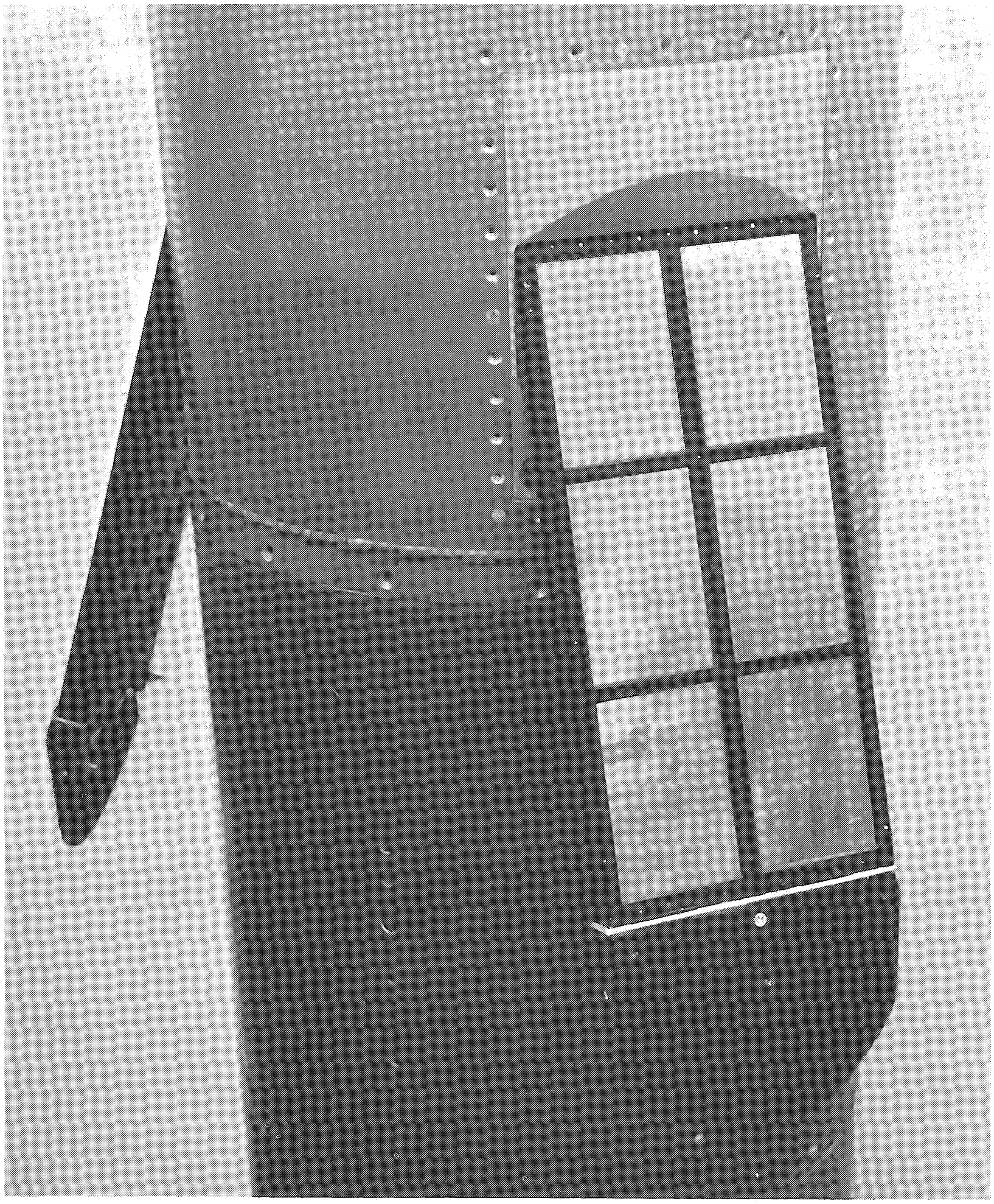
In co-operation with the United States Naval Research Laboratory an emulsion experiment is now being designed to be flown on one of the Gemini manned space capsules. The primary purpose of this experiment will be to study the composition of the heavy nuclei in the primary galactic cosmic rays above the earth's atmosphere. The present knowledge of these nuclei has come mainly from the exposure of emulsion stacks on high altitude balloon flights, and this will provide the first known opportunity to expose emulsions directly to space radiation without the intervention of absorbing materials. Hence, it will be possible to obtain the charge spectrum directly rather than deducing it from the somewhat uncertain fragmentation probabilities of heavy nuclei in the atmosphere.

Because the Gemini capsule will not be oriented for its entire flight some means of time resolution is necessary to differentiate between those heavy nuclei which come into the stack directly as opposed to those which penetrate the space vehicle and stack from below, when the vehicle is not oriented. To accomplish this end, the emulsion stack will be constructed in two sections. The top section will be driven across the lower section by a motor at the rate of 0.25 mm/hr so that by the displacement of a track between sections one can tell when, during the flight, a particular track was formed. Hence, from the known history of the satellite aspect one can tell whether or not the capsule was oriented at the time that an observed heavy nucleus entered the stack.

It is planned that the emulsion pack will be set into a recess and flush with the capsule skin at a position immediately behind the crew compartment. During launch there will be a faring over the package which will be ejected once the capsule has left the atmosphere. Before re-entry one of the astronauts will remove the emulsion pack by reaching out from inside the crew compartment, and it will be stored inside the crew compartment during re-entry.

The heating of the rocket skin during launch is a major problem and subsidiary cooling must be supplied to the emulsion package during the ascent period. During the remainder of the flight the emulsion will be kept cool by insulating it from the capsule and coating the exposed surface with a paint which has appropriate thermal absorption and radiation properties.

In summary, nuclear emulsions can be successfully flown on rocket vehicles and recovered in good condition. The small sounding rockets, though they do not provide a very long exposure, can be used for experiments which cannot be accomplished except outside the atmosphere and, hence, are not amenable to high altitude balloon flights. The sounding rockets have the virtue of giving the experimenter a wide degree of flexibility, since he is, in general, able to do what he wishes with the payload section. Emulsions can also be used on recoverable satellites, but this usually requires adapting the emulsion payload to an existing system. The main advantage of the satellites is the fact that long exposure times can be obtained, and experiments which have previously been done on high altitude balloons under a few grams of residual atmosphere can be done with no absorbing material above the emulsion.



NASA G-64-7826

Fig. 1