A SEARCH FOR SOLAR NEUTRONS ON A LONG DURATION BALLOON FLIGHT

R. Koga
Space Sciences Laboratory, The Aerospace Corporation
El Segundo, CA 90245, USA

G. M. Frye, Jr. and A. Owens
Physics Department, Case Western Reserve University
Clevelend, OH 44106, USA

B. V. Denehy, O. Mace, and J. Thomas
RAAF Physics Department, Melbourne University
Parkville, Victoria, Australia

ABSTRACT

The EOSCOR III detector, designed to measure the flux of solar neutrons, was flown on a long duration RACOON balloon flight from Australia during Jan - Feb, 1983. The circum-global flight lasted 22 days. No major solar activity occurred during the flight and thus only an upper limit to the solar flare neutron flux is given. The atmospheric neutron response is compared with that obtained on earlier flights from Palestine, Texas.

1. Introduction. A solar neutron detector, EOSCOR III, (1) was launched from Alice Springs, Australia (23.5° S) at 2040 UT Jan. 19, 1983 on a 0.44×10^6 m^3 zero pressure polyethylene balloon. As first pointed out by Lally (2), during the summer months at low latitudes, a zero pressure balloon will descend to a stable float altitude after sunset without any ballast drop and then return to its original float altitude after sunrise. Because the magnitude of the day-night altitude excursion is determined primarily by the difference in the radiation seen by the balloon in the day and night environments, Lally (2) has christened this the RACOON (Radiation-controlled balloon) technique. Since we are interested only in a solar observation, the RACOON method is admirably suited to achieving a multi-day observing period at a few mbar altitude with a standard balloon (3).

2. The Flight Characteristics. The circum-global flight was scheduled for the summer to take advantage of the zonal winds which are characteristically uniform both in bearing and velocity, during the three summer months at mid-latitudes. The flight path is shown in Figure 1. The day and night altitudes were initially about 130 and 70 k ft, respectively. The night altitudes remained nearly constant during the flight except when over a very cold cloud deck near Tahiti. The day altitude, however, gradually decreased, reaching approximately 110 k ft one day before termination. The ambient air temperature varied between -20° and -75°C during the flight.

Power for the detector instrumentation was provided by silicad batteries, continuously charged during the day by an array of solar panels. Processed data from the experiment were telemetered to the ground through the METEOSAT and GOES satellites and the position of the balloon continuously monitored by the ARGOS satellite network.

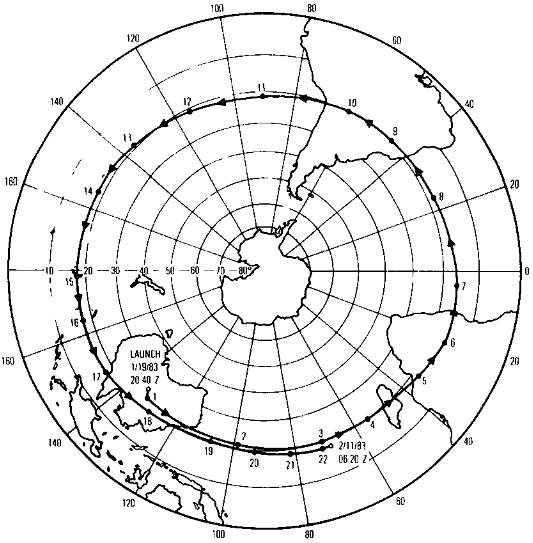

Fig. 1. RACOON Flight Trajectory.

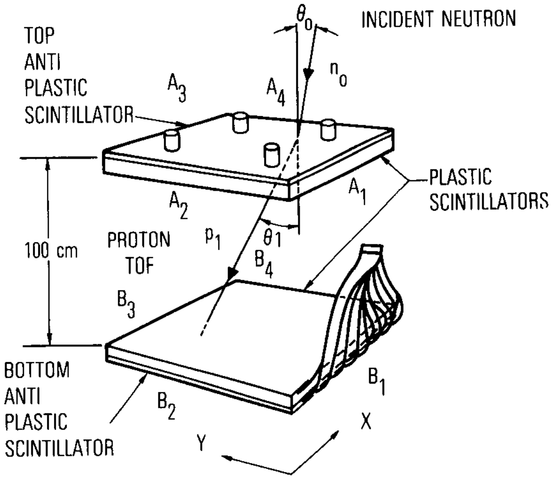

Fig. 2. The EOSCOR III Detector. Adiabatic, Isochronous Light Pipes with 7.8 cm PMT's View the Edges $A_1 \ldots B_4$. (only B_1 shown).

3. Experimental. The detector was designed to measure solar flare neutrons in the energy range 20 to 150 MeV (4). It consisted of two 1 m^2 scintillators separated by a 1 m time-of-flight (TOF) path, as shown in Figure 2. Proton energies from n-p scatters and $^{12}C(n,pX)$ interactions in the upper scintillator were determined by pulse height and TOF measurements. TOF is also used to discriminate the slower moving protons from the more numerous, downward moving Compton electrons. This is shown in Figure 3 where pu, eu, ed, and pd denote upward moving (albedo) protons and electrons, and downward moving electrons and protons, respectively. The separation of these components was made possible by use of a light time compensation technique (1) carried out by an on-board computer. The FWHM of the electron peak was 2.2 ns, which was very close to that obtained during the earlier calibration run at the Indiana University Cyclotron Facility. Raw data related to events within the pd group are telemetered for further analysis.

Solar neutron events are identified by an increase in the neutron counting rate over the atmospheric background, correlated in time with the solar flare. From the gondola position and orientation, the angle θ_o between the vertical detector axis and the neutron arrival direction is known and therefore the neutron energy is given by $E_n = E_p/\cos^2 \theta_o$, where E_n and E_p are the incident neutron and the measured proton energies, respectively.

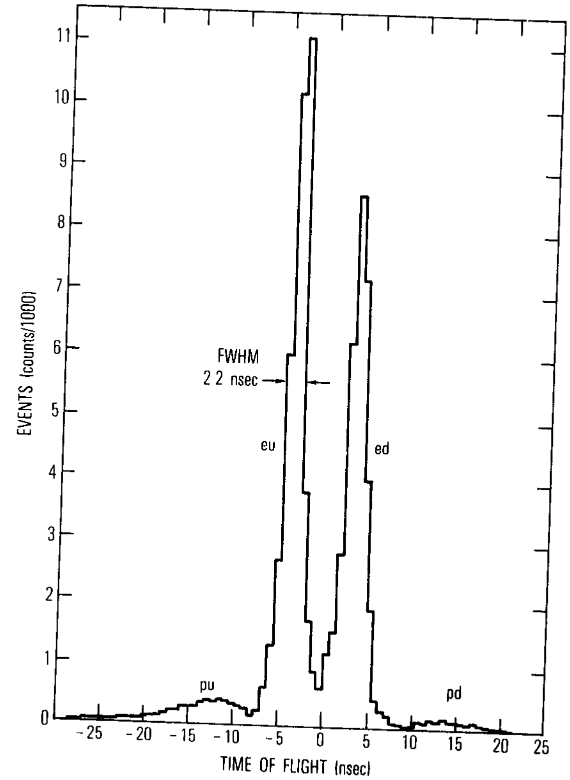

Fig. 3. TOF Spectrum at 3.1 g/cm^2 above Alice Springs.

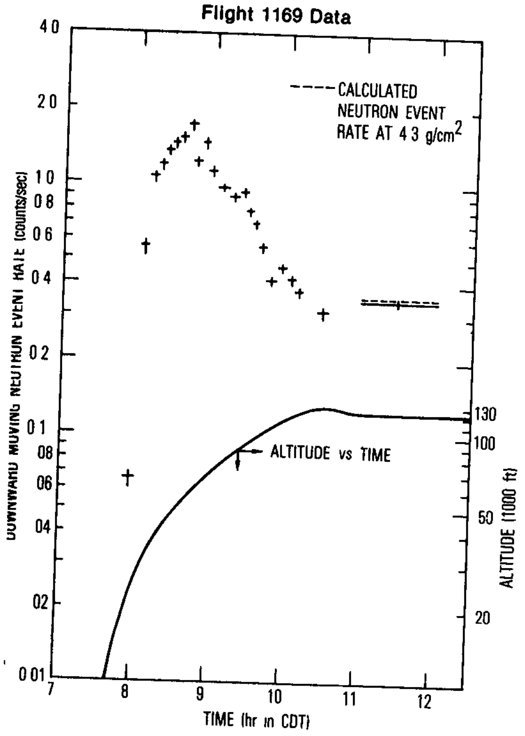

Fig. 4. Event rates of downward moving neutrons at Palestine, Texas (September 25, 1979).

4. Atmospheric Neutrons. Because the atmospheric neutrons are omnidirectional the proton spectrum cannot be unfolded to yield the atmospheric neutron spectrum. However, the counting rates as a function of altitude and geomagnetic cutoff give a measure of the variation of the atmospheric neutron intensity with these parameters. The rate of downward moving neutrons is obtained from group pd in Figure 3. Measurements of high energy neutrons near the top of the atmosphere have been reported for geomagnetic cutoffs 0.4 GV (Thompson, Manitoba), 4.5 GV (Palestine, Texas), and 11.6 (Parana, Argentina) (5,6). The downward moving neutron flux measured by Preszler et al. (6) was used to calculate the expected counting rates for the EOSCOR III detector. The expected rate is shown in Figure 4 along with the measured rates. For comparison the downward moving neutron rates from several previous flights are also listed in Table 1.

Table 1. EOSCOR III Downward Moving Neutron Event Rates

LOCATION	DATE	ALTITUDE (g/cm^2)	RATE (event/sec)
Palestine	25 Sept 1979	4.3	0.34 ± .02
Palestine	17 Oct 1979	9.0	0.61 ± .03
Palestine*		4.6	0.35
Alice Springs	19 Jan 1983	3.1	0.16 ± .01
Alice Springs	19 Jan 1983	4.3	0.22 ± .01

*Calculated from the measured 1971 neutron flux of Preszler et al. (6).

5. Solar Neutrons. The sun was quiet during the observational period of the flight (7) with the exception of normal sporadic C class flares. On January 20, 1983, for instance, there were a few such flares. From our derived neutron counting rates we place a 3σ limit on the solar neutron flux of 3×10^{-3} neutrons cm^{-2} s^{-1}.

6. Acknowledgments. This work was supported by NSF grant ATM 82-06044, the Australian Research Grants Committee, and the RAAF. The work of one of the authors (R.K.) was supported by The Aerospace Corporation-sponsored Research Program.

References

1. Koga, R., et al.; Proc. of the 17 ICRC, 9 (1981) 328.
2. Lally, V.; Proc. XXIV COSPAR conf. Ottawa, I.1.4 (1982).
3. Frye, G. M., Jr.; Adv. Space Sci., 3, no. 6 (1983) 117.
4. Koga, R., et al.; Nuc. Instr. and Meth., 165 (1979) 47.
5. Nazaretz, M. A.: PhD thesis CWRU (1976).
6. Preszler, A. M., et al.; J. Geophys. Res., 81 (1976) 4715.
7. Solar-Geophysical Data, 467B, Boulder, Colorado (1983).