MASTER

**THE GEOGRAPHICAL DISTRIBUTION OF ~100-keV
ELECTRONS ABOVE THE EARTH'S ATMOSPHERE**

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THE GEOGRAPHICAL DISTRIBUTION OF ~100-keV ELECTRONS ABOVE THE EARTH'S ATMOSPHERE

Abstract

Previously unpublished satellite data is used to show the distribution of ~100-keV electrons above the earth's atmosphere. Specific regions of high counting rate are

mapped at altitudes of 300 to 400 km. These regions are used to predict the suitability of various launch sites for rocket-borne x-ray astronomical experiments.

The Problem

Modern soft x-ray astronomical observations are made with large-area proportional counters that have very thin plastic windows. The counters are consequently very sensitive to low energy electrons. An electron with only a few keV of energy can penetrate a typical window, and a flux of ~100 electrons/cm²-sec-ster can double the background counting rate during a typical observation.

Thus, these electrons produce an undesirable effect which, in the

observations we have made, is impossible to distinguish from x-ray data. Consequently, an electron-free region is needed for accurate astronomical observations.

We have derived geographical regions of weak electron flux from low altitude satellite data. These regions can be compared with the locations of rocket launching sites. The best sites should be those farthest from electron regions and can be selected from Figs. 1 and 2.

Satellite Data

In late 1961 we flew particle detectors on four polar-orbiting satellites.^{1,2} One detector consisted of a thin, 5 cm² cesium-iodide scintillator, covered by 0.002 in. of Be, with a 1-ster field-of-view. The satellite was in near-polar orbit so most of the surface of the earth was covered. The detector counting rates were sampled once a second, tape recorded, and read out once each orbit. The data analyzed were taken September 18 and 19, 1961, a geomagnetic quiet time. Satellite apogee

was 410 km at 32°S, perigee was 240 km, at 32°N.

The cosmic ray background in the detectors varied with latitude during the flight in a very consistent fashion. The times when the detectors counted at a rate above the cosmic ray background were noted to occur in specific geographic locations. These were placed on a map and contours of constant counting rate were drawn. Figures 1 and 2 are polar maps with the observed regions of higher

Fig. 1. Regions of high electron flux—northern hemisphere.

counting rate superimposed. The counting rates at a given spot varied with time. Nevertheless, the figures show fairly accurately locations at which particles other than cosmic rays were present. These particles were, in all probability, electrons with energies greater than the

threshold of the detector. Counting rates were highest over the South Atlantic and in the auroral zones. Obviously, these regions are the worst choices for low background experiments and they should be avoided. We wish to direct attention to other low latitude regions of weak

Fig. 2. Regions of high electron flux—southern hemisphere.

electron flux that have not been studied previously.

The observed counting rates were transformed to omnidirectional flux and contours of constant counting rate were plotted in geomagnetic coordinates.³ Figure 3 shows this plot. Since the

observed electron flux was variable, the flux levels assigned to these contours were not very accurate. There are three regions of high flux distinguishable in Fig. 3.

Since the electron spectrum is steep and energy thresholds of x-ray detectors

Fig. 3. Data from satellite 1961 $\alpha\beta$ showing omnidirectional flux of electrons with energies > 100 keV.

are less than 100 keV, counting rates will be higher than the rates predicted from the contours of Fig. 3. If the detector threshold were ~ 100 keV for electrons, 10^2 particles $\text{cm}^2\text{-sec}$ omni-

directional flux would transform to ~ 50 counts/ $\text{cm}^2\text{-sec-ster}$ in the detector. (Our collimator geometry and the observed electron pitch-angle distribution have been used to make this comparison.)

Launching Sites

Figures 1 and 2 show geographic locations of several sites that have been used for x-ray astronomy flights. A rocket launched straight up from one of these locations will follow the magnetic space trajectory indicated in Fig. 3. Points are given for each site at altitudes of 150, 300, and 500 km. The

Thumba range is right on the magnetic equator. The L values shown for Thumba at low altitudes are inexact. Resolute lies at $L > 10$ and L varies. It is inside the northern auroral zone and should be free from the high auroral electron flux much of the time. However, this region is directly connected to interplanetary

Table 1. Rocket observations of electrons.

Reference	Range	Altitude (km)	Energy threshold (keV)	Flux (counts cm ⁻² sec ⁻¹)	Magnetic activity
Cladis <i>et al.</i> ⁴	Wallops Island	1000	50	~10 ⁶	?
Hill <i>et al.</i> ⁵	Kauai	160	3.5	~500	high
Hill <i>et al.</i> ⁵	Johnston Atoll	300	3.5	~800	high
Turiel and MacGregor ⁶	27°N, 125°W	225	20	~10	high
Hayakawa <i>et al.</i> ⁷	Kagoshima	800	5	~150	quiet
Tuohy and Harries ⁸	Woomera	200	20	~2	high

space and subject to incoming low energy solar particles. We observed

these particles from 1961 $\alpha\beta$ but have not shown them in the figures.

Comparison with Rocket Data

Several groups have reported detecting electrons over the rocket ranges considered. Table 1 lists their observations. For comparison, maximum electron counting rates have been roughly derived from the data given in the individual papers. These rates must be divided by counter efficiency to get the actual electron flux.

Since the electron spectrum is very steep and flux varies with magnetic activity, it is impossible to predict electron fluxes precisely from Fig. 3. Nevertheless, Fig. 3 shows why high electron fluxes are expected at low altitude over Wallops Island, why electrons are apparently not seen at low altitude over White Sands, and why our launch site at Kauai is intermediate between these two locations.

Conclusions

The best x-ray astronomy ranges are probably Thumba, White Sands, and Woomera. Wallops Island is one of the worst ranges to use for soft x-ray observations.

As rocket altitude increases, over any range, the number of electrons encountered will also increase.

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