GEOPHYSICAL INSTITUTE

of the

UNIVERSITY OF ALASKA

Final Report

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An electron accelerator was launched aboard an Aerobee 350 rocket (17.03 GE) on 26 January 1969, 0945 UT, and produced four auroral rays which were detected with image-orthicon television systems at two ground stations. The rays were neither bright enough nor of sufficient duration either to be detected visually or to be photographed directly. The purpose of the experiment was to test the feasibility of generating artificial auroras by injecting electrons into the upper atmosphere from a rocket-borne accelerator. This was accomplished by shooting electrons up the field lines and observing the artificial aurora where the electrons re-enter the atmosphere at the magnetically conjugate point in the other hemisphere. Theoretical studies had not been able to provide completely unambiguous answers to such questions as whether the vehicle could capture enough electrons to avoid charging to a high potential or whether the electron beam would remain well collimated. Some studies suggested that the two stream instability or other more subtle plasma instabilities might rob the beam of its energy before it reached the atmosphere.

The Geophysical Institute operated four television cameras at three sites along the Virginia coast. (See Fig. 1) Other optical observing equipment included photometers, a twostage image intensifier, an intensifierplumbicon combination, SuperSchmidt film cameras (normally used to record faint meteor trails), and all-sky film cameras.

Four of the artificial auroral rays (those produced by maximum current and maximum voltage) were detected and recorded by three of the Geophysical Institute's TV systems at two sites separated enough to enable the spatial coordinates of the rays to be determined by triangulation. (See Figs. 2 and 3) The rays were not detected by any of the other instruments. This was due, in part, to the very low intensity of the rays and also due to a rocket motor malfunction that caused the actual locations of the rays to differ from the positions calculated in advance. The 8.7 kev electron beams produced raylike auroras 133 $\pm$ 50 meters wide at altitudes of 104 to about 132 km. These altitudes were obtained partly from the direct triangulation results and partly from a comparison with the positions predicted from the rocket trajectory and direction of the local magnetic field. The results of the two methods agreed to within a kilometer for three rays for which triangulation was possible.

Also, the ray positions were within 0.1° of arc, or approximately 400 meters, of the positions predicted from knowledge of the rocket trajectory and the direction of the local magnetic field.

The brightness of the artificial auroras as viewed from the TV camera stations was estimated to be equal to an aurora of intensity IBC I to IBC II. On the basis of this apparent brightness, the geometry of the signature-pulse auroras, and the light-production efficiency of energetic electrons as given by Dalgarno et al. (1965) the total energy deposition by the electron beam was found to be approximately 2×10^{10} to 4×10^{10} ergs sec^{-1}. No delay was observed between the initiation of a pulse and the appearance of an aurora. Thus we concluded that a sizable fraction or all of the electron-beam energy was dissipated into the atmosphere. There is no indication that the electron beams suffered losses from particle-wave interactions prior to entry into the atmosphere. From the observed persistence of the auroras after electron-beam cutoff, it is concluded that the 3914/5577 ratio in the artificial auroras is between 3 and 7. This value of the ratio is much larger than that observed in natural auroras.

The images of the rays were weak, but careful analysis, including triangulation between the two sites, showed that 1) the beam remained well collimated; 2) most of the initial beam energy was deposited in the atmosphere; 3) plasma instabilities did not play a significant role; and 4) the orientations of the rays were determined with sufficient accuracy to improve our knowledge of the earth's magnetic field over the Virginia coast.

Under the support of this contract a variety of observations on natural auroras also were conducted, partly for personnel training and partly as a means to improve instrumentation and techniques. Published articles resulting from these investigations and from the primary study of the artificial auroras are attached.

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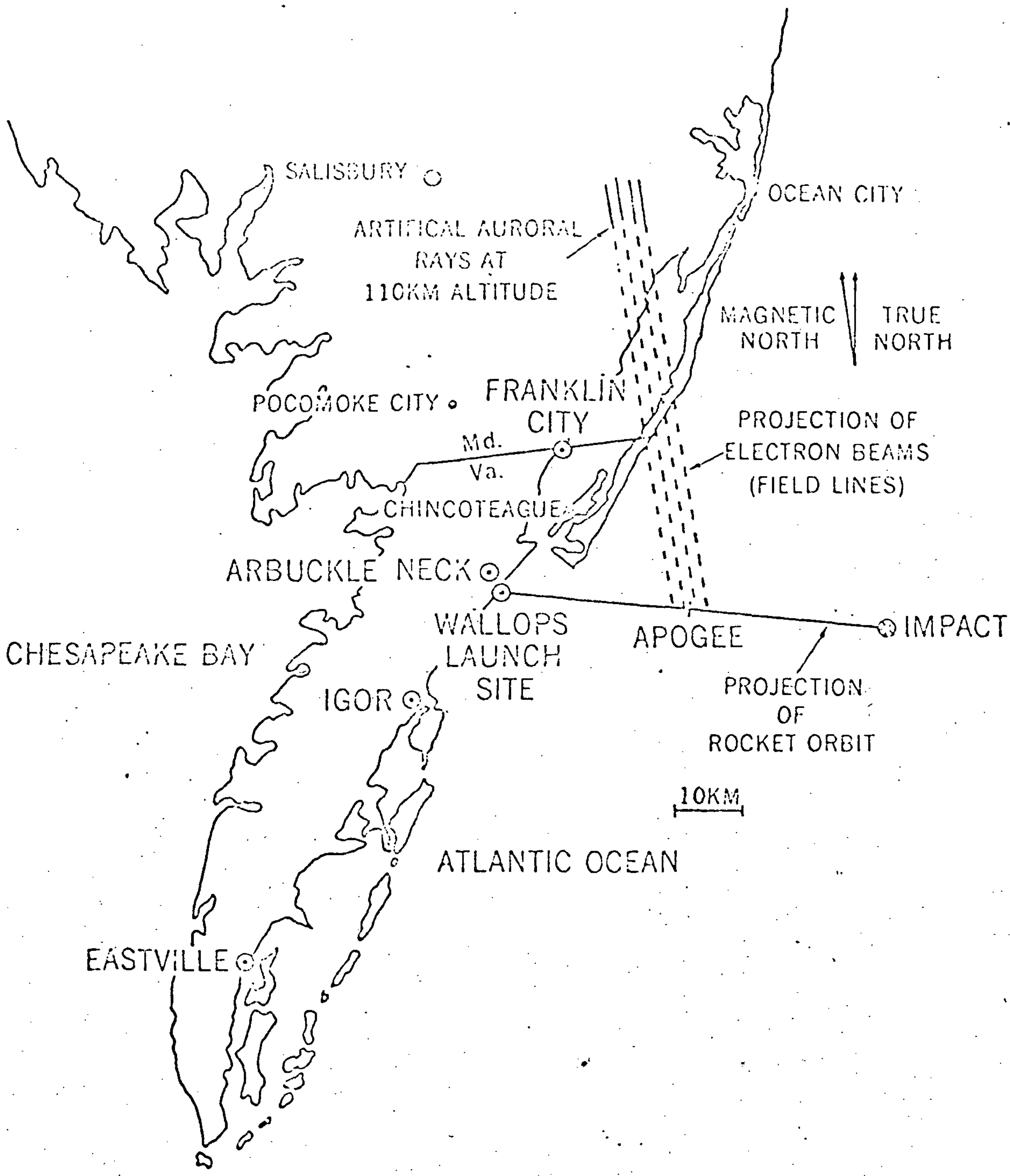
FIGURE CAPTIONS

Fig. 1 Map of lower Delmarva Peninsula showing locations of launch site, four observing stations, and the projection of the rocket trajectory and earth's magnetic field lines for the first four signature pulses.

Fig. 2 Photographs of the four signature pulse auroras recorded at Igor.

Fig. 3 Photographs of the four signature pulse auroras recorded at Franklin.



SALISBURY
OCEAN CITY
ARTIFICAL AURORAL
RAYS AT
110KM ALTITUDE
MAGNETIC
NORTH
TRUE
NORTH
POCOMOKE CITY
FRANKLIN
CITY
Md.
Va.
PROJECTION OF
ELECTRON BEAMS
(FIELD LINES)
CHINCOTEAGUE
ARBUCKLE NECK
WALLOPS
LAUNCH
SITE
APOGEE
IMPACT
CHESAPEAKE BAY
IGOR
PROJECTION
OF
ROCKET ORBIT
10KM
ATLANTIC OCEAN
EASTVILLE

FIG. 1

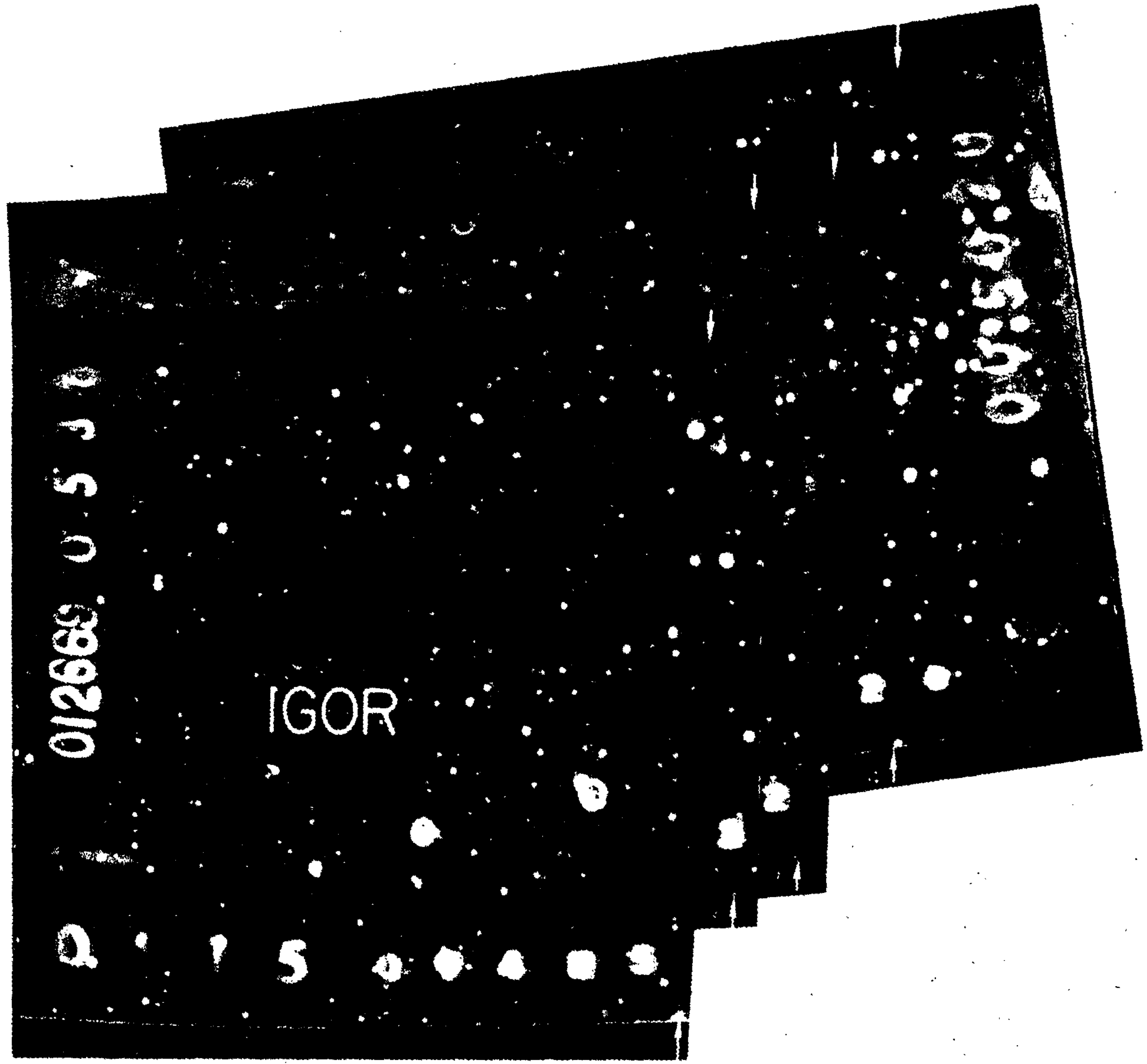


FIG.2

FIG.3