1. INTRODUCTORY REMARKS

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It is for me a privilege to chair the first session of this Symposium, which, in a way, may be regarded as a celebration of the 10th anniversary of the birth of X-ray astronomy.

Although my personal contribution has been only marginal, to watch the growth of this new branch of science has been one of the most exhilarating experiences of my whole life as a scientist. The unexpected and astonishing results that have been following one another in quick succession have been for me a striking illustration of how much the imagination of man lags behind the boundless wealth and complexity of nature.

I am sure you all remember the climate of skepticism in which X-ray astronomy began. Which explains why the avowed purpose of the rocket program which opened up this new field (Figure 1.) was an attempt to detect an X-ray fluorescence from the Moon, rather than a search for extra-solar X-ray sources; although the hope of finding such sources was in fact the main motivation of the program. And you remember the surprise, when the rocket did, in fact, detect a galactic X-ray source many orders of magnitude stronger than any one had expected (Figure 2). In retrospect, we see that the little confidence people had in the worth of X-ray astronomy was due primarily to the failure to reckon with the possible existence of hitherto unknown celestial objects whose emission would lie almost entirely in the X-ray band of the spectrum; although it is also true that most astrophysicists had been too conservative in extrapolating toward the high energies the electromagnetic spectra of known peculiar objects, such as supernova remnants.

The comparatively large X-ray fluxes reaching the Earth from celestial sources explains why so many observations of crucial significance could be carried out even before the launching of the first X-ray satellite, at a time when X-ray astronomers had at their disposal only rockets and balloons, with the well-known limitations of these carriers. Just to mention some of the highlights, there was the identification, by the lunar occultation method, of the source in Taurus with the Crab Nebula (Figure 3); the identification of the source in Scorpio with a faint, apparently insignificant star (Figure 4); the measurement of several X-ray spectra; the discovery of a variability of some X-ray sources; the discovery of an X-ray pulsar; the discovery of the first extragalactic sources. Also, a number of high-resolution X-ray pictures of the Sun were taken with the newly-developed grazing-incidence telescopes (Figure 5), which made it possible to plan confidently the use of these powerful instruments for the extra-solar X-ray astronomy as soon as suitable vehicles will become available. Nor must one forget the discovery of a diffuse, nearly isotropic X-ray background and the fairly accurate measurement of its spectrum.

Bradt and Giacconi (eds.), X- and Gamma-Ray Astronomy, 1–6.

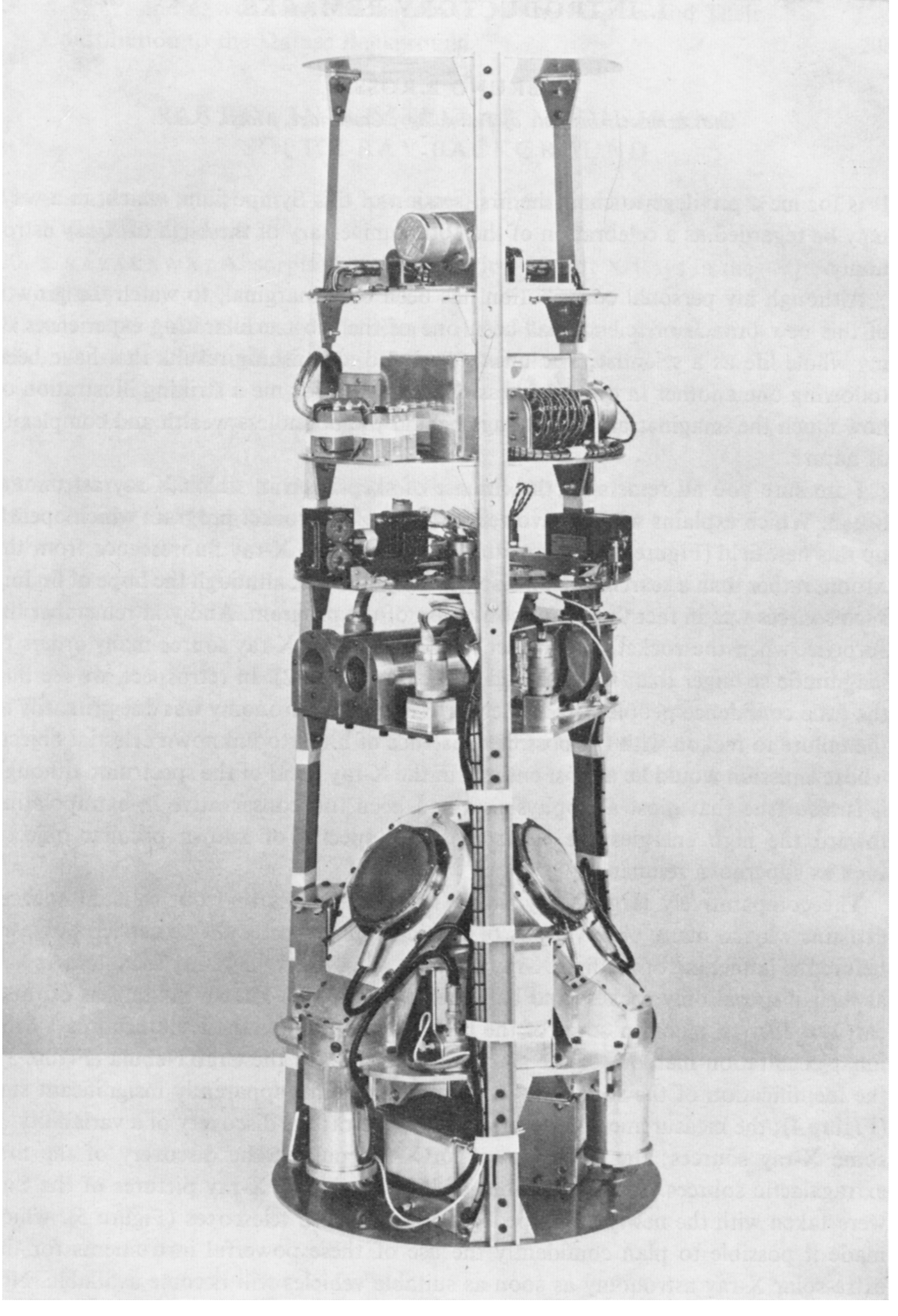

Fig. 1. Payload of the rocket which detected the first extra-solar X-ray source in 1962.

Rockets and balloons will continue to play an important role in the future. But the performance of UHURU (Figure 6) has made it abundantly clear that the availability of satellites marks the opening of a new era for X-ray astronomy. And here again we find that scientists had been too conservative in their expectations. The main purpose

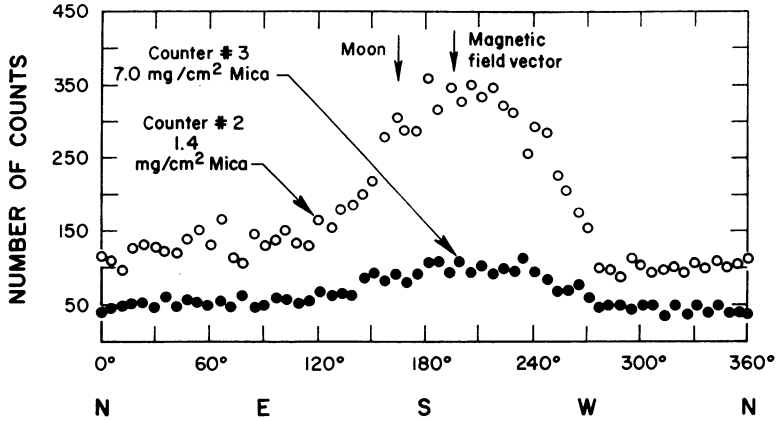

Fig. 2. Signals from a strong galactic source recorded by the rocket in Figure 1 (*Phys. Rev. Letters* **9**, 439).

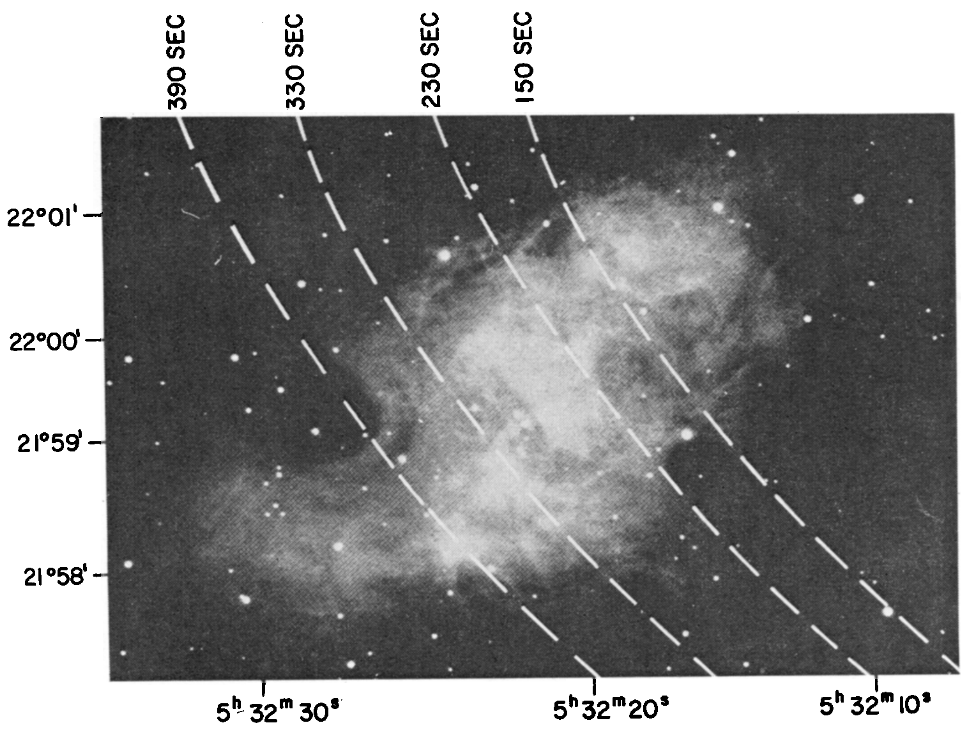

Fig. 3. Identification of the X-ray source in the Crab Nebula by the lunar occultation method in 1964 (*Science* **146**, 912).

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of UHURU, as originally conceived, was to carry out a general X-ray survey of the sky, adding weaker sources to the existing catalogues and determining source positions with good accuracy. UHURU is successfully fulfilling this assignment. But, in so doing, it has discovered new and highly significant features of individual sources; and

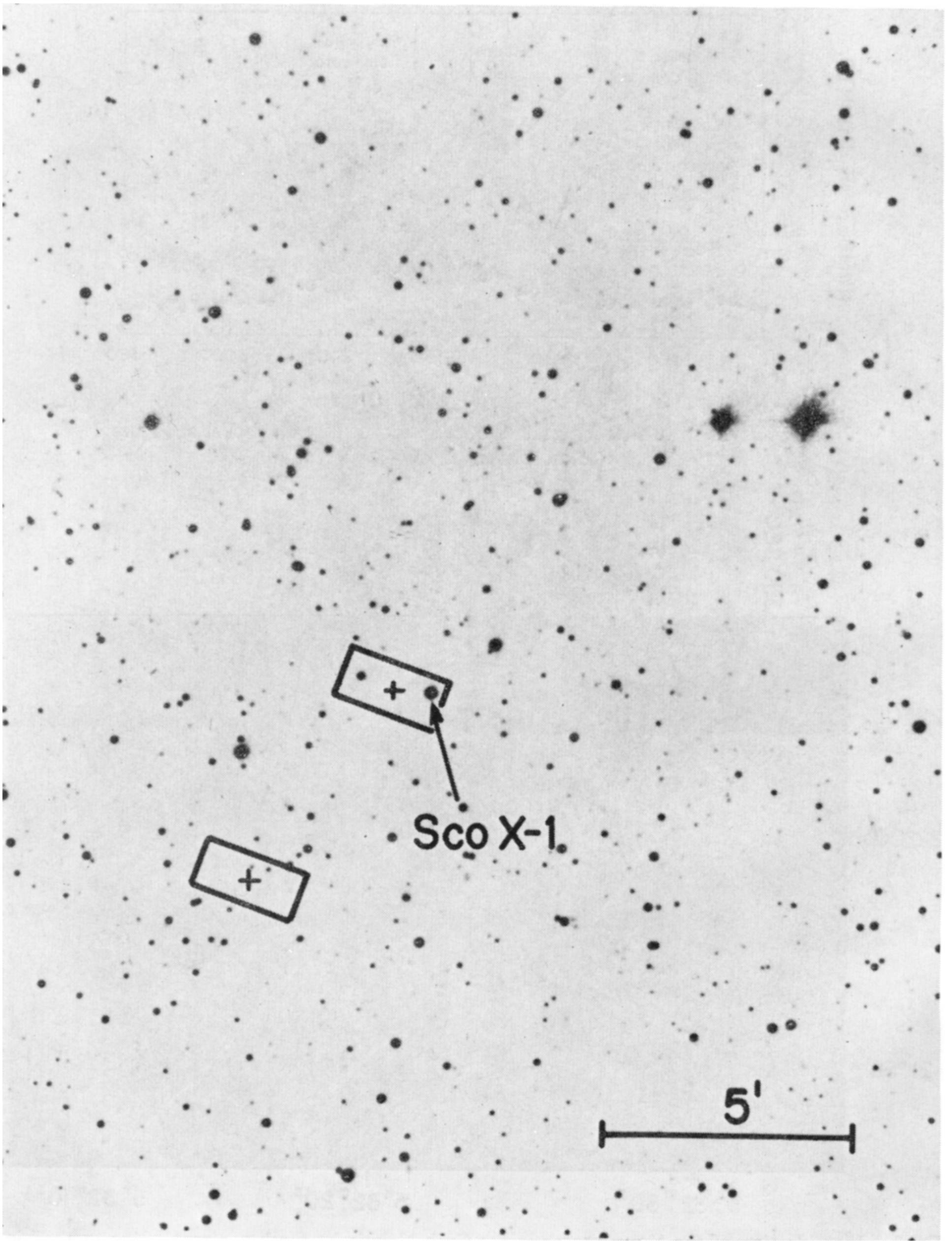

Fig. 4. Identification of Sco X-1 in 1966 (*Astrophys. J.* **146**, 316).

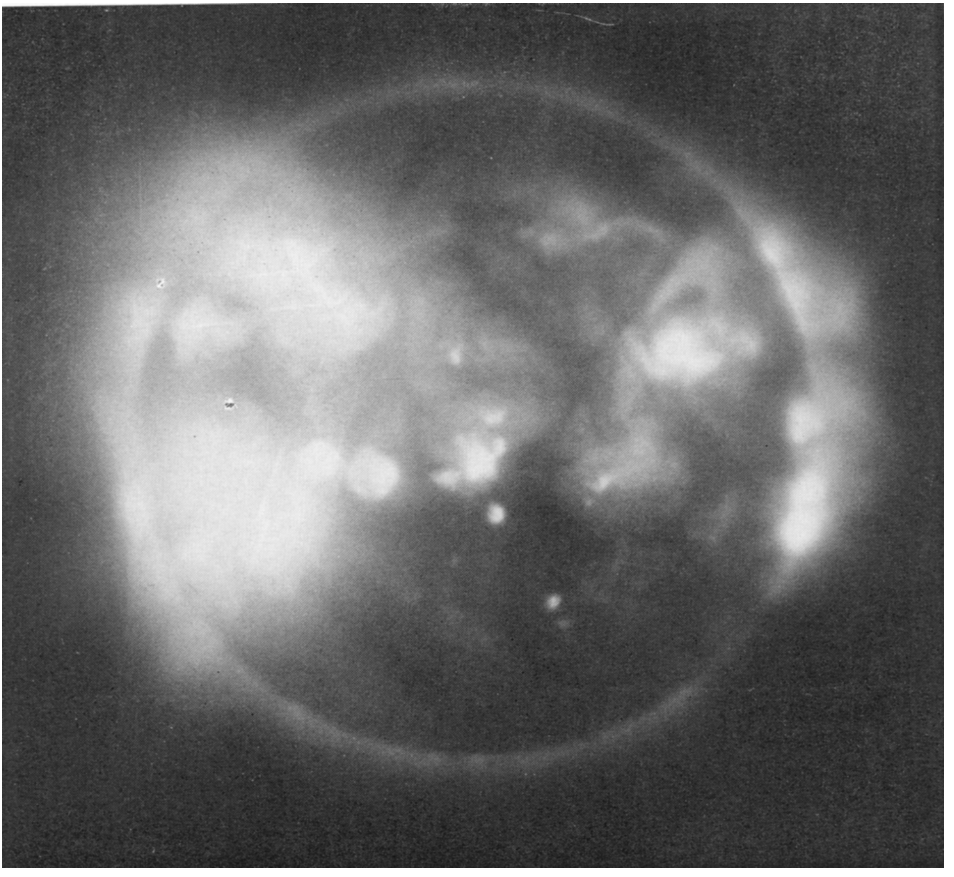

Fig. 5. Photograph of the Sun in soft X-rays (3–30 Å, 44–55 Å) at the end of a lunar eclipse; note Moon shadow to left (1970, *Nature* **227**, 818).

this not by virtue of any sophisticated instrumentation, but because of its ability of scanning the sky at a very slow rate and of going back to any desired source over and over again, on command from the Earth.

Thus, as you well know, a number of galactic sources were found to undergo large, short-time fluctuations in their X-ray emission; fluctuations which in some cases are exactly periodic, in some cases are not. Also long-term periodic changes in the average X-ray intensity were detected for several sources. Detailed studies of these effects have already had far-reaching consequences on our thinking about the nature of the galactic sources. As for the extra-galactic sources several were shown to be extended, suggesting that the association of galaxies into clusters may result in exceptionally strong X-ray emission, indicative perhaps of interactions of the galaxies with the medium between them.

Gamma-ray astronomy has developed at a much slower pace than X-ray astronomy,

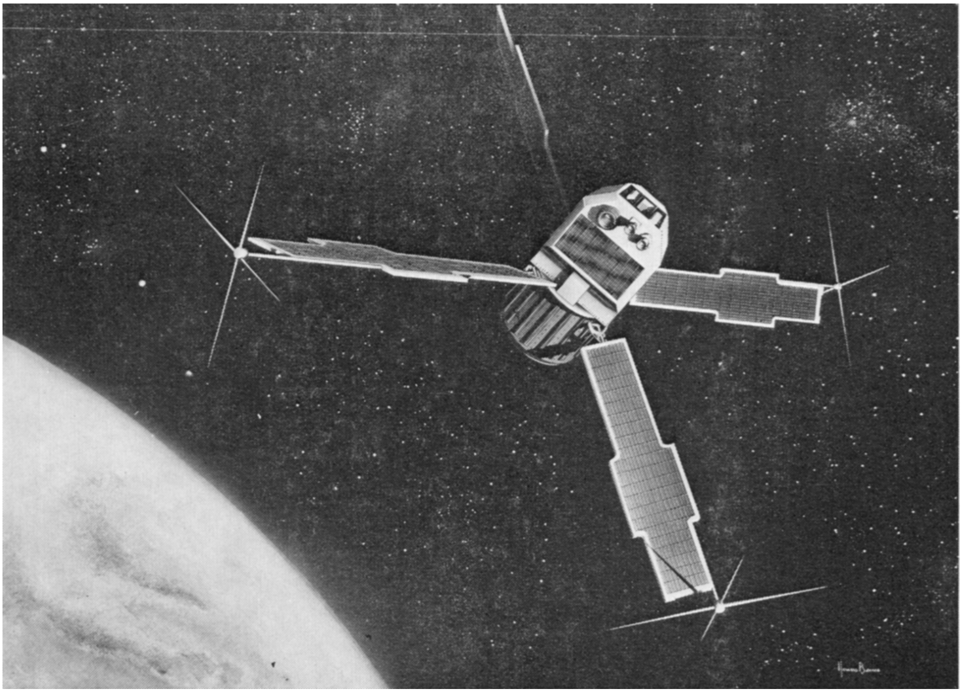

Fig. 6. UHURU: artist's conception.

mainly because of the technical difficulties of detecting very weak γ-ray fluxes. But a promising beginning has been made in this field too.

We still do not have more than tentative theoretical interpretations for the observational results of X-ray and γ-ray astronomy. However it is becoming increasingly clear that the findings of high-energy astronomy will have an important bearing on many of the most crucial problems of contemporary astrophysics, such as the nature and properties of collapsed objects; the possible existence among them of 'black holes'; the physical processes occurring in various kinds of galaxies, particularly in their nuclei; the condition of matter in interstellar and intergalactic space (composition, density, temperature); the related question as to whether our universe is closed or open.

But I do not wish to dwell any longer on past history nor on future expectations, since there are so many new results that we are all anxious to hear about. So let us go on with this morning's program.

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