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Observations of Medium Energy Gamma Ray Emission From The Galactic Center Region

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EMISSION FROM THE GALACTIC CENTER REGION

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ABSTRACT

Measurements of the γ -ray emission in the medium energy range between 15 and 100 MeV, obtained during two balloon flights from Brazil are presented. The importance of this energy region in determining whether π^0 - decay or electron bremsstrahlung is the most likely dominant source mechanism is discussed along with the implications of such observations. Specifically, the data from this experiment suggest that emission from the galactic plane is similar to the theoretical spectrum calculated by Fichtel et al (1976) including both source mechanisms, but with the bremsstrahlung component enhanced by a factor of about 2. A spectral distribution of γ -rays produced in the residual atmosphere above the instrument is also presented and compared with other data. A rather smooth spectral variation from high to low energies is found for the atmospheric spectrum.

Subject headings: Cosmic Rays: general - galaxies: Milky Way -
galaxies: nuclei - gamma rays: general

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I. INTRODUCTION

Recent high energy γ -ray observations (Fichtel et al. 1975; Bennett et al. 1977; Kniffen, Fichtel, and Thompson 1977) and their interpretation (Bignami et al. 1975; Dodds, Strong, and Wolfendale 1975; Fichtel et al. 1976; Paul, Cassé, and Cesarsky 1976; Fuchs, Schlickeiser, and Thielheim 1976; Stecker 1977; Kniffen, Fichtel, and Thompson 1977) have indicated the important role of γ -ray astronomy in understanding the structure and dynamics of our Galaxy. These conclusions are based on the fact that the γ -rays are produced in the interactions of energetic cosmic rays with the interstellar gas in proportion to the product of their densities. The spatial variations in the results from SAS-2 are consistent with such an origin for the bulk of the galactic γ -ray emission (Kniffen, Fichtel, and Thompson 1977) although the relative contributions from compact sources have not yet been established. Fichtel et al. (1976) Schlickeiser and Thielheim (1974), and Shulka and Cesarsky (1977) have pointed out that although the higher energy galactic γ -rays result from the decay of neutral pions produced in interactions involving cosmic ray nucleons, in the region below about 50 MeV the bremsstrahlung process involving cosmic ray electrons becomes dominant over most of the Galaxy. Below about 7 MeV, the background of nuclear lines produced both astrophysically and in some of the spacecraft and detector materials degrade the observations of the cosmic continuum radiation.

Since electrons in energy range from 7 to a few hundred MeV cannot be observed by other means and are highly affected by solar modulation, observations of medium energy γ -rays provide the most direct means of

studying the intensity and distribution of these interstellar galactic cosmic ray electrons. Existing observations are few, with only one group reporting positive results with limited statistics from the galactic plane (Samimi, Share, and Kinzer 1974; Share et al. 1977). For this reason, a program has been undertaken to develop a detector to make medium energy γ -ray observations, and two balloon flights were made in Brazil in November and December 1975 with a preliminary version of this detector to observe the medium energy γ -ray emission from the galactic center region.

II. SCIENTIFIC BACKGROUND

Fichtel et al. (1976) have emphasized the significance of galactic γ -ray observations in the medium energy range. As these authors pointed out, the information obtained from such observations is unique and cannot be obtained from high energy (>100 MeV) γ -ray observations or from radio astronomy. The reason for this is clear from Table I which indicates that while high energy γ -rays are expected to be predominantly due to the decay products of neutral pions produced in collisions of the energetic cosmic ray nucleons with the interstellar gas, the medium energy γ -rays (≤ 70 MeV) result primarily from the bremsstrahlung radiation of electrons traversing the same interstellar gas. Since the interstellar gas density is a common coefficient in the production of the medium and high energy γ -ray components, relative information on the intensity and distribution of energetic electrons in the 7 to ~ 200 MeV range is obtained. This information is unobtainable by other

means because of solar modulation effects (Goldstein, Fisk, and Ramaty 1970) in the case of direct measurements of electrons in the solar vicinity and because of uncertainties in the galactic parameters which affect absorption of the radio signals in the case of radio astronomy observations. On the other hand, this information is extremely valuable in understanding the dynamics and structure of our Galaxy and in determining the origin, confinement and propagation of the cosmic ray electrons. Also, a comparison with the radio observations helps to define better the interstellar properties which make interpretation of the radio data so difficult.

The specific predictions of Fichtel et al. (1976) as refined by Kniffen, Fichtel, and Thompson (1977) are given in Figure 1. These authors show that the total electron intensities are expected to be dominated by the primary electrons throughout most of the Galaxy, and hence the observation of their spatial variations relative to those of the nucleons as revealed by the γ -radiation provides valuable information on the origin and confinement of the electrons relative to those of the nucleons. The calculated spectra shown in Figure 1 are for a galactic longitude of 340° , but as the authors suggest, the relative contributions of bremsstrahlung and π^0 γ -rays should remain constant since both interactions occur with the same interstellar gas. Hence the spectral shapes should apply to other longitudes except perhaps near the galactic center. Here, according to several authors (Cowsik and Voges 1975; Stecker 1977; Piccinotti and Bignami 1977; Shukla and Paul 1977) there may be a significant component of medium energy γ -rays resulting from the Compton scattering of starlight and infrared photons to γ -ray energies by the energetic cosmic ray electrons. Observations of the latter component would provide

important information on the interstellar environment near the galactic center. Ramaty and Westergaard (1976), Schlickeiser and Thielheim (1977), and Shukla and Cesarsky (1977) have indicated that lack of knowledge of the unmodulated electron intensities makes the bremsstrahlung calculations uncertain. Observations of the medium energy γ -ray spectral shape will therefore provide evidence on the interstellar electron intensities.

III. THE EXPERIMENT

a) The Detector

The detector is a modification of an instrument used earlier for high energy γ -ray studies (Ross et al. 1969). The configuration used in the 1975 Brazil balloon flights, depicted in Figure 2, is a modified version of this detector designed to reduce the low energy threshold and to increase the efficiencies for medium energy γ -ray observations. Further modifications in progress will increase the 20 MeV sensitivity by nearly an order of magnitude.

For the 1975 flights the upper assembly, above the plastic scintillator plane consisted of 15 aluminum pair-production plates interspersed between 16 wire frame assemblies. A frame had dimensions of 50 cm x 50 cm and two planes containing 400 wires each, with all wires within one plane parallel, and perpendicular to the wire directions in the facing plane. The modules (pair-production plate plus wire grid) were separated by 1.41 cm. The lower assembly, below the scintillator plane, contained an additional 3 plates and 4 grids, but here the separation was increased to 5.66 cm. A Cerenkov counter was located below the lower assembly. After a pair was formed, the plates served as scattering material to permit an estimate of the energy of the pair members from scattering theory. The spark chamber

stack was encased in a thin aluminum pressure vessel and the inner volume was filled with spark chamber gas. The instrument was surrounded by a dome-shaped plastic scintillator anticoincidence counter.

A γ -ray that entered the detector converted with a known probability into a charged pair that subsequently propagated through the remainder of the telescope. The chamber was triggered when a coincidence occurred between the scintillator and Cerenkov counter without the presence of a signal in the anticoincidence dome. This event signified a neutral particle had entered the instrument and converted to charged secondaries.

When the trigger logic was satisfied, high voltage was applied across the wire planes of each grid. Spark breakdown between wire planes occurred at points along the trajectories of the charged particles as a result of their residual ionization. Each of the wires in the grid threaded a memory core, and the current in the spark served to set the cores of wires intersecting the spark. The two orthogonal sets of wire planes in each spark chamber level thus provide an x-y coordinate position for the particle trajectories of that level. Following the high voltage pulse, a readout and reset scan of all cores was initiated. The addresses of the set cores were encoded into the telemetered data stream along with housekeeping information including magnetometer readouts, temperatures, chamber pressure, atmospheric pressure, battery current, event rate, live-time, and counting rates in the anticoincidence dome, the central scintillator, and the Cerenkov counter. During the readout cycle, the chamber was inhibited from further triggers.

b) Balloon Flights

The instrument described above was flown twice in late 1975 (19 November and 3 December) primarily to study the γ -ray emission from the galactic plane. The flights were launched from Resende, Brazil at

geographic coordinates S22.3 W 44.7. Here, the galactic center region of the sky passes nearly overhead, and the high geomagnetic cutoff (11.2 GV, Shea and Smart, 1975) helps to minimize the background of secondary γ -rays produced by cosmic ray interactions in the residual atmosphere above the instrument.

In each flight, a $8.72 \times 10^5 \text{ m}^3$ (30.8 Mft³) balloon was used for a payload weight of 890 kg, including ballast, and a float altitude corresponding to a residual pressure of 2.5 mb was achieved. The instrument pointed toward the local zenith so that the galactic center region of the sky drifted across the aperture of the detector with the earth's rotation. The azimuthal aspect of the instrument was determined by means of two orthogonal magnetometers whose signals were continually monitored as part of the on-board housekeeping data.

A PCM (pulse code modulated) telemetry system was used to transmit experiment data at a 12 kHz rate during the flights. Information was received at a ground station and recorded along with timing information on analog tapes. In addition, the ground support equipment decoded the data stream to provide a real-time readout of housekeeping parameters and to display pictures of spark chamber events. The trajectory was determined using a digitized tracking antenna to record bearing and elevation angles which, together with altitude information given by onboard pressure sensors, defined the position vector of the balloon.

c) Calibration

An essential task in any γ -ray experiment is an accurate determination of the telescope's efficiency and angular and energy resolutions as functions of the γ -ray energy and arrival direction. The most desirable approach to

determining these properties is to simulate the expected flight exposure with a γ -ray beam produced at a particle accelerator. The requirements for the beam include an independent means of monitoring the flux, and known angular and energy dispersions which are small compared to the resolutions of the telescope. The bremsstrahlung technique for producing a "tagged" photon beam that was used in the SAS-2 calibration (Hartman et al. 1973) unfortunately is not practical at energies below about 50 MeV, the energy region of primary interest in this experiment.

An alternate approach was developed that utilized the in-flight annihilation of positrons in a 10 mil Be target foil to produce two γ -rays whose energies are determined by the incident positron energy and the emission angles of the photons from the beam axis. The positron beam was obtained at the linear accelerator (LINAC) at the National Bureau of Standards in Gaithersburg, Maryland. One of the two photons from the interaction was detected by a NaI crystal located at 20 degrees from the beam axis, and this signal served to flag the presence of the companion photon in the telescope which was located behind a shielding wall with an aperture at the appropriate angle. The efficiency of the "tagging" technique was measured periodically by replacing the telescope with a second NaI crystal. Further details of this method of calibration will be published later.

A complete analysis of the instrument properties using the accelerator beam was not possible due to cost and time limitations. Instead, the calibration data were used to supplement an extensive series of calculations that were made using Monte Carlo techniques to simulate γ -ray and secondary

electron and positron interactions (pair production, Compton scattering, radiative and collisional losses and Coulomb scattering) in the instrument. Detailed histories of each event were tabulated. Those that met the logic requirements of the instrument and in addition satisfied event recognition tests, that in practice are applied to all real events, were noted and compared with the total number of events to determine efficiency.

The efficiency results from the Monte Carlo calculations were found to be about 30% higher than the accelerator results. This apparent discrepancy is qualitatively understood in terms of simplifying approximations made to reduce the computer time required to run these rather lengthy Monte Carlo programs for the particular configuration used in this experiment. For this reason, all Monte Carlo efficiencies were normalized by a factor of $1/1.3$ to match the measured efficiencies. As a further check, the Monte Carlo program was run for the SAS-2 instrument and the results were in close agreement with calibration measurements. In the SAS-2 case no normalization was required. Figure 3 shows the area x efficiency functions for a variety of energies as functions of arrival angle for the telescope used in this experiment. Also shown here are the observed measurements.

In addition to studying the efficiency of the instrument, the Monte Carlo program was utilized to evaluate the energy and angular response functions. For the accepted events, the spark coordinates of the simulated secondary electrons and positrons were used to calculate the energy and arrival direction of each event according to the same procedures used with flight data. Comparison of these results with the input values yielded the desired resolution functions. Figure 4 shows the three-dimensional rms angular uncertainty as a function of energy. It

can be seen that the results from the accelerator exposure agree with the calculated function. At higher energies, the effect of uncertainties in the flight aspect data dominates the angular uncertainty from the Monte Carlo values shown as a dashed line.

The energy resolution from the Monte Carlo analysis is approximately 35 to 38% over the range of energies from 15 to 100 MeV. This is in good agreement with the beam data as well.

d) Data Analysis

The initial step in the data analysis consisted of translating the information from the analog to digital computer tapes. These were used in three different programs. First, housekeeping parameters such as counting rates in the various detector elements, temperatures, power consumption, aspect, altitude, live-time and chamber pressure were tabulated to determine the general operation of the instrument. Second, the picture data, aspect, time, together with supplemental trajectory and magnetic field data were stored into an event catalogue system developed for SAS-2 data analysis. Finally, the data tapes were used to produce microfilm plots of each event that triggered the telescope.

The microfilm pictures of each event were examined visually according to strict criteria to select only those events that result from a pair-production interaction in one of the spark chamber plates. Specifically, two tracks corresponding to the electron and positron had to be observed to originate from a common vertex that was located beneath the upper plate and above the central scintillator. To assure an efficient selection of good events, all of the microfilm was rescanned by an independent observer.

For the next phase of the analysis, the picture information of each selected event was transferred to an interactive graphics display unit where an operator identified and labeled the spark coordinates for each of the two secondary particles in both orthogonal views. The edited events were then analyzed to determine the energy of each electron using a multiple scattering formalism adapted to the multiplate geometry with variable plate separations. The energies were summed to determine the γ -ray energy, and the arrival direction relative to the telescope axis was calculated from an energy-weighted bisector of the electron tracks (Fichtel, Kniffen, and Ogelman 1969). Events that entered the telescope with angles greater than 30° from its axis were eliminated from further consideration. Finally, the orientation, time, and trajectory data were used to map the arrival directions to celestial and galactic coordinates. The analyzed event along with energy and arrival information was then restored to the event encyclopedia.

To determine γ -ray fluxes, tables of exposure factors (effective area \times time) were calculated in $5^\circ \times 5^\circ$ bins in galactic coordinates for several different energy ranges. These factors were obtained from the functions shown in Figure 3 together with trajectory data. Histograms of flux as a function of galactic latitude between $-40^\circ \leq b^{II} \leq 40^\circ$ were obtained by summing events and exposure factors in latitude bands of width comparable to the angular resolution (in one dimension) between longitudes $340^\circ \leq l^{II} \leq 30^\circ$ where the galactic plane flux is expected to be high (Kniffen et al., 1977). Figure 5 shows such a histogram for the energy interval $70 \leq E \leq 100$ MeV. For a uniform flux (within the 30°

acceptance cone from the zenith), the distribution should vary as the solid angle of the bin size, and hence as cosine of galactic latitude for a plot in equal increments of galactic latitude. The solid curve here is a least squares fit to the data excluding the central zone $|b^{II}| < 10^\circ$. This fit gives a measure of the atmospheric plus diffuse γ -ray background. The excess flux in the central region (only three central bins in this case) was used to determine the galactic center intensity. Corrections to the measured energy distribution for the energy resolution of the detector were made to both atmospheric and galactic center components to obtain the best estimate of the true spectrum. In addition a small correction, $\leq 6\%$, was made to the galactic intensities for the "wings" of the angular resolution function that extend beyond the central bins. Similar histograms were obtained for the energy intervals $15 \leq E \leq 30$ MeV, $30 \leq E \leq 70$ MeV and $100 \leq E \leq 200$ MeV.

IV. RESULTS

The results obtained according to the techniques described above may be divided into three categories: the atmospheric secondary γ -ray spectrum, the galactic γ -ray spectrum in the general direction of the galactic center, and the diffuse all sky γ -ray background spectrum. These topics will be discussed below in order and compared with existing data from other experiments in the same or nearby energy regions.

a) Atmospheric Background Spectrum

As discussed above the analysis of the galactic latitude distribution leads to an estimate of the diffuse γ -radiation at high galactic latitudes. For balloon-borne experiments, this radiation consists of the extra-terrestrial diffuse γ -radiation as well as the atmospheric secondary γ -radiation produced as a result of the collisions of energetic cosmic

rays with the residual atmospheric gas and any other material above the detector aperture such as the balloon, gondola, rigging and other support hardware. Great care was taken in this experiment to reduce the overlying material to a minimum so the hardware background amounts to only a small fraction of a percent of the total. Also, the cosmic diffuse γ -radiation contributes less than ten percent of the total observed γ -ray intensity at the float depth of the balloon flight throughout the energy range of this investigation (Fichtel, Simpson, and Thompson 1978). Hence, following the approach of other authors, the total diffuse spectrum at a depth of 2.5 g/cm^2 is taken as being representative of the atmospheric spectrum. The only corrections applied include the effects of detector response (sensitivity and energy resolution) and instrument live-time.

The results are given in Figure 6, together with other related measurements. Where possible, results from measurements near the 11 GV magnetic rigidity cutoff appropriate for these balloon flights were chosen for comparison. However, below 10 MeV, no high cutoff data are available and the results of Schönfelder, Graser, and Daugherty (1977) and Ryan et al. (1977) obtained at a 4.5 GV cutoff have been used. Their reported fluxes as well as those of Thompson (1974) have been divided by a factor of 0.57 as reported by Staib, Frye and Zych (1974) at higher energies for the ratio of the intensities at 11.2 GV to those at 4.5 GV.

The data from this experiment are seen to be consistent with a smooth spectrum extending throughout the range of the observations and connecting with those of Ryan et al. (1977) at lower energies and those of Thompson (1974) and Staib, Frye, and Zych (1974) at higher energies. It should be noted that

the lowest energy point of Thompson is near detector threshold and hence may be less reliable than the higher energy points. A smooth spectrum in the intermediate energy region does not immediately lend itself to a well separated electromagnetic and π^0 -decay component as is suggested by the results of Kinzer, Share, and Seeman (1974) although the influence of the latter appears to be present. However, the sharp peak in their calculated efficiency versus energy response curves at about 50 MeV makes interpretation of results extremely difficult, requiring a detailed knowledge of the uncertainty in energy determination and a careful unfolding of the data with the energy response function. This is unfortunately the energy region where the spectral features appear in their results. As pointed out by Kinzer, Share and Seeman (1974) the calculated spectra of Daniel and Stephens (1974) and Beuermann (1971) also do not show this strong π^0 -decay feature, although these calculations generally do not reproduce the measured spectra and are very sensitive to the flux of reentrant albedo electrons, which is not well known.

The uncertainties in the 20 to 70 MeV energy ranges underscore the difficulties in making γ -ray observations in the medium energy range and the lack of data at these energies. To make further improvements in the observational picture, an extensively redesigned and much improved version of the detector (Morris et al. 1978) is being assembled for a new balloon flight series.

b) Galactic Center and Cosmic Diffuse γ -Radiation

The primary objective of this experiment was a measurement of the medium energy γ -ray emission from the region of the galactic center. Because of limited statistics, it was necessary to accumulate the obser-

vations over the full longitude width of $340^\circ \pm \Delta l^{\text{II}} \approx 30^\circ$, an interval characterized by an overall enhancement in the high energy γ -ray data (Kniffen, Fichtel, and Thompson 1977; Bennett et al, 1977). The energy spectrum obtained in the manner described above and corrected for the energy resolution of the instrument as determined by the calibration and Monte Carlo results is given in Figure 7 together with other recent measurements. The data of this experiment are consistent with those of SAS-2 (Kniffen, Fichtel, and Thompson 1977) and COS-B (Bennett et al. 1977) at high energies, and Kinzer, Share, and Seeman (1974) at lower energies. The best fit to the results reported here is obtained with twice the bremsstrahlung emission assumed by Fichtel et al. (1976) as shown in Figure 1. The total spectrum shown in Figure 7 contains the same π^0 -decay contribution as assumed by Fichtel et al. (1976) but with the increased bremsstrahlung contribution. Such a spectrum is consistent with the uncertainties in the interstellar electron spectrum (Schlickeiser and Thielheim, 1977; Cesarsky and Shukla, 1977).

Growth curves of the ascent portion of the data have been used to obtain an estimate of the cosmic diffuse γ -ray intensity in a manner similar to that described by Share, Kinzer, and Seeman (1974) and Schönfelder, Graser, and Daugherty (1977). An intensity of $(5.2 \pm 3.0) \times 10^{-6} \text{ } \gamma(\text{cm}^2\text{-sr-s-MeV})^{-1}$ is obtained at 55 MeV. This intensity lies about one standard deviation above the SAS-2 measurement (Fichtel, Simpson and Thompson 1978). Other balloon measurements in this energy range (Hopper et al. 1973; Share, Kinzer, and Seeman 1974; Bratolyubova-Tsykjudze et al. 1971) also appear to be above the SAS-2 data as expected in the case of a

marginal signal-to-noise result, and hence balloon results should only be considered as upper limits to the diffuse intensity in this energy range.

V. CONCLUSION

The results obtained in this experiment have provided new data in an energy range where very few reliable data exist. These results have demonstrated that the observation must be made with great care in the design of the instrument, in understanding the instrument response and in analyzing the data. The potential importance of the results makes it highly desirable to make the measurements, using the best available techniques.

The most significant aspect of the results is the observation that there is a larger galactic emission below about 50 MeV than previously believed. This is also suggested by the SAS-2 data (Kniffen, Fichtel, and Thompson 1977). This result is consistent with the interpretation that the contribution to the galactic center emission below 50 MeV due to electron bremsstrahlung is twice as intense as theoretically predicted (Fichtel, et al., 1976), although the uncertainties are too great to exclude other possible interpretations such as an enhanced Compton scattering component in the galactic center region. Additional observations with much improved sensitivity and energy resolution are needed to distinguish between the alternatives. Major revisions of the detector used here are currently underway to provide the needed observations over a significantly larger energy range.

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CAPTIONS TO FIGURES

- FIGURE 1. Expected γ -ray spectrum above 10 MeV for $b^{\text{II}}=0^\circ$ and $l^{\text{II}}=335^\circ$. Shown are the contributions from cosmic ray nucleon-interstellar gas interaction, and from bremsstrahlung emission from primary and secondary electrons with the same interstellar gas (Pichtel et al. 1976). The total spectrum is indicated by the dashed curve. The general features of this spectrum are expected to exist at other longitudes, except possibly near the galactic center where a substantial Compton component might also be present.
- FIGURE 2. Schematic of the medium energy digitized γ -ray telescope
- FIGURE 3. Instrument area \times efficiency as a function of arrival angle with respect to the telescope axis at energies between 15 and 200 MeV. Solid curves are calculated using a Monte Carlo program and reduced by a factor of 1.3 as described in the text to agree with the calibration measurements at 15 and 30 MeV shown by the data points.
- FIGURE 4. Three dimensional angular uncertainty as a function of energy. The curve is calculated by the Monte Carlo program. The dotted curve is instrument resolution alone, while the solid curve includes the added uncertainty in the aspect data during flight. The points shown are from accelerator calibration measurements.
- FIGURE 5. Latitude distribution of 70 to 100 MeV γ -rays summed between longitudes $340^\circ \leq l^{\text{II}} < 30^\circ$. The smooth curve is

a cosine curve fitted to data $|b^{II}| > 10^\circ$ which is the form expected for the atmospheric background in this type of presentation. Only the three central bins were used to calculate the galactic plane emission.

FIGURE 6. Differential atmospheric flux spectrum at 2.5 gm/cm^2 and for a vertical cut off rigidity of $\approx 11.2 \text{ GV}$. Data of other workers have been scaled linearly with observed depth to 2.5 g/cm^2 . Results of Schönfelder et al. (1977) and Ryan et al. (1977) at low energies and the values of Thompson (1974) were scaled by 0.57 as suggested by Staib et al. (1974) to adjust for the cutoff effects from 4.5 GV to 11.2 GV.

FIGURE 7. Differential energy spectrum from the galactic plane. the solid circles and the upper limit are data from this experiment. The data shown with "x" is from Kinzer, Share, and Seeman 1974 and the solid squares are SAS-2 observations (Kniffen, Fichtel, and Thompson 1977). Triangles denote the data from COS-B for the longitude interval from 10° to 40° (Bennett et al. 1977). For comparison, the calculated spectra given in Figure 1 are also shown here, except the bremsstrahlung component has been increased by a factor of 2 to improve agreement with the observations.

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Table 1
SOURCE FUNCTIONS IN THE SOLAR VICINITY

Source Mechanism	Value of Source Function ($\text{cm}^{-3} \text{sec}^{-1}$)	
	10-30 MeV	> 100 MeV
Neutral pion decay*	0.7×10^{-26}	13.0×10^{-26}
Electron bremsstrahlung	11.8×10^{-26}	3.5×10^{-26}
Compton scattering (starlight)	0.6×10^{-26}	0.2×10^{-26}
Compton scattering (3°K)	1.0×10^{-26}	0.2×10^{-26}
Synchrotron radiation	1.0×10^{-30}	0.2×10^{-30}

*Assuming 1.04 hydrogen nuclei cm^{-3} locally in the Galaxy, a helium-to-hydrogen ratio of 0.1 , and heavy-nuclei-to-hydrogen ratio of 0.01 . Standard values were used for the local demodulated cosmic ray nucleon and electron spectra (Fichtel et al. 1976; Kniffen, Fichtel, and Thompson 1977).

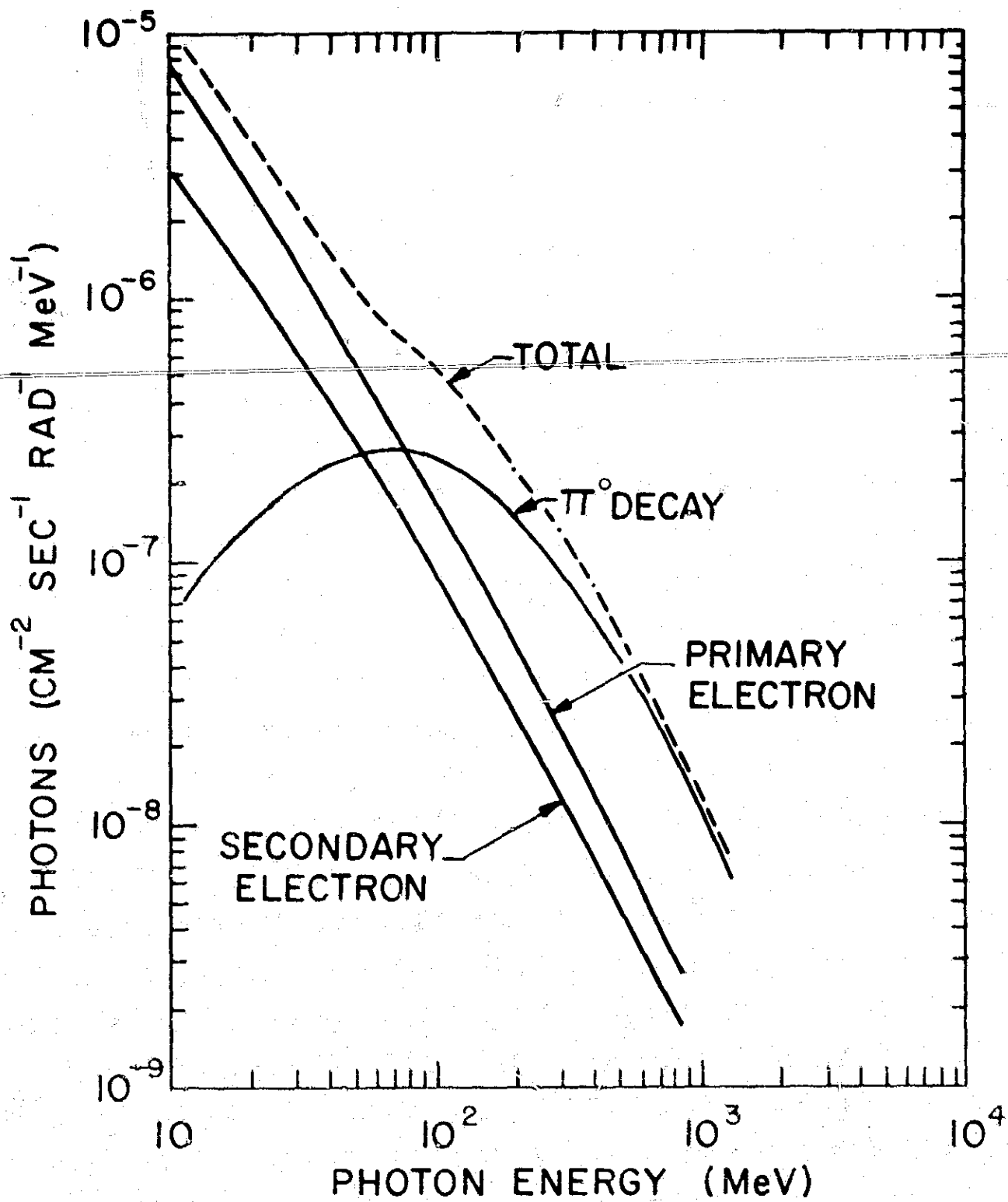


FIGURE 1

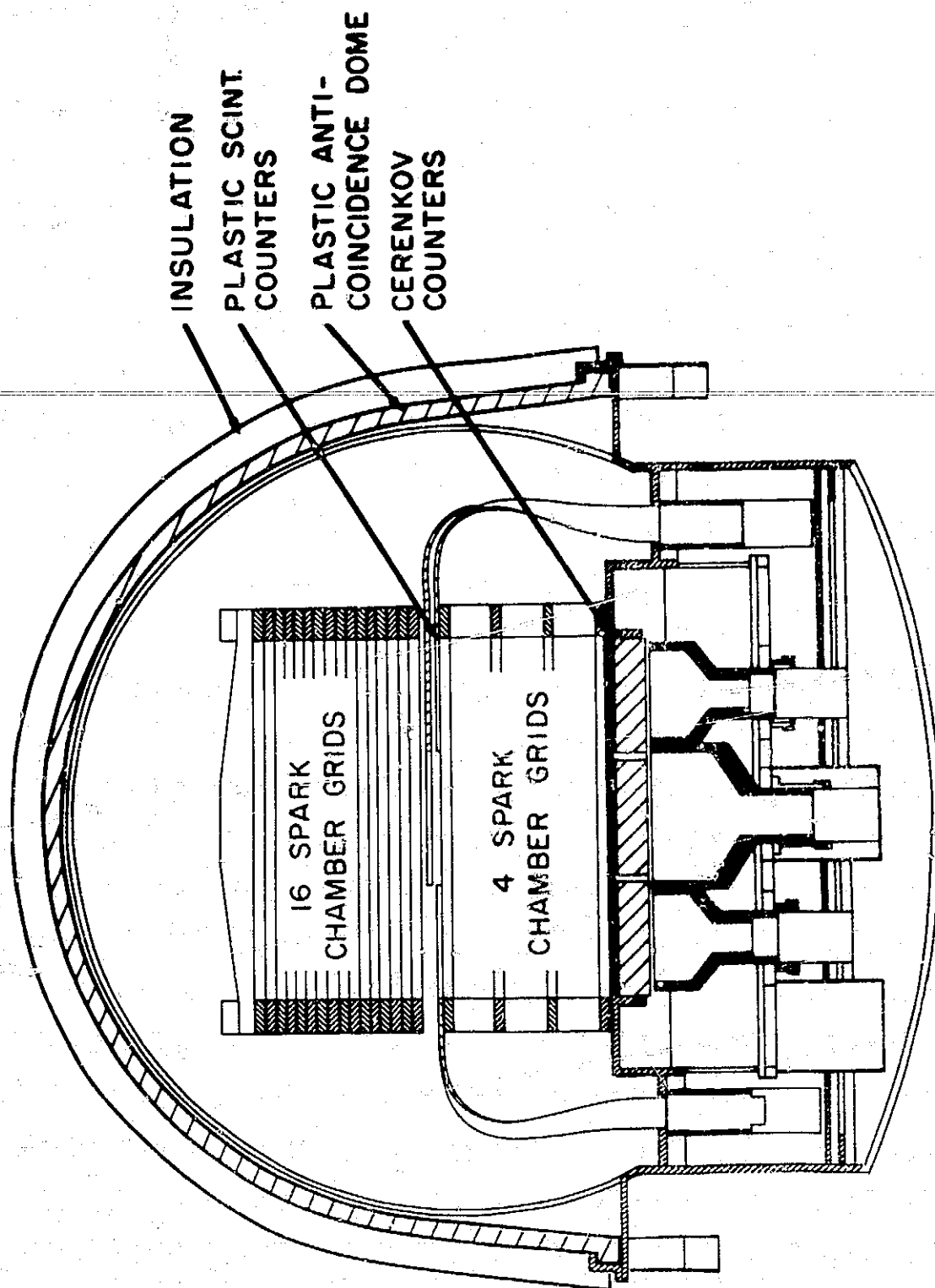


FIGURE 2

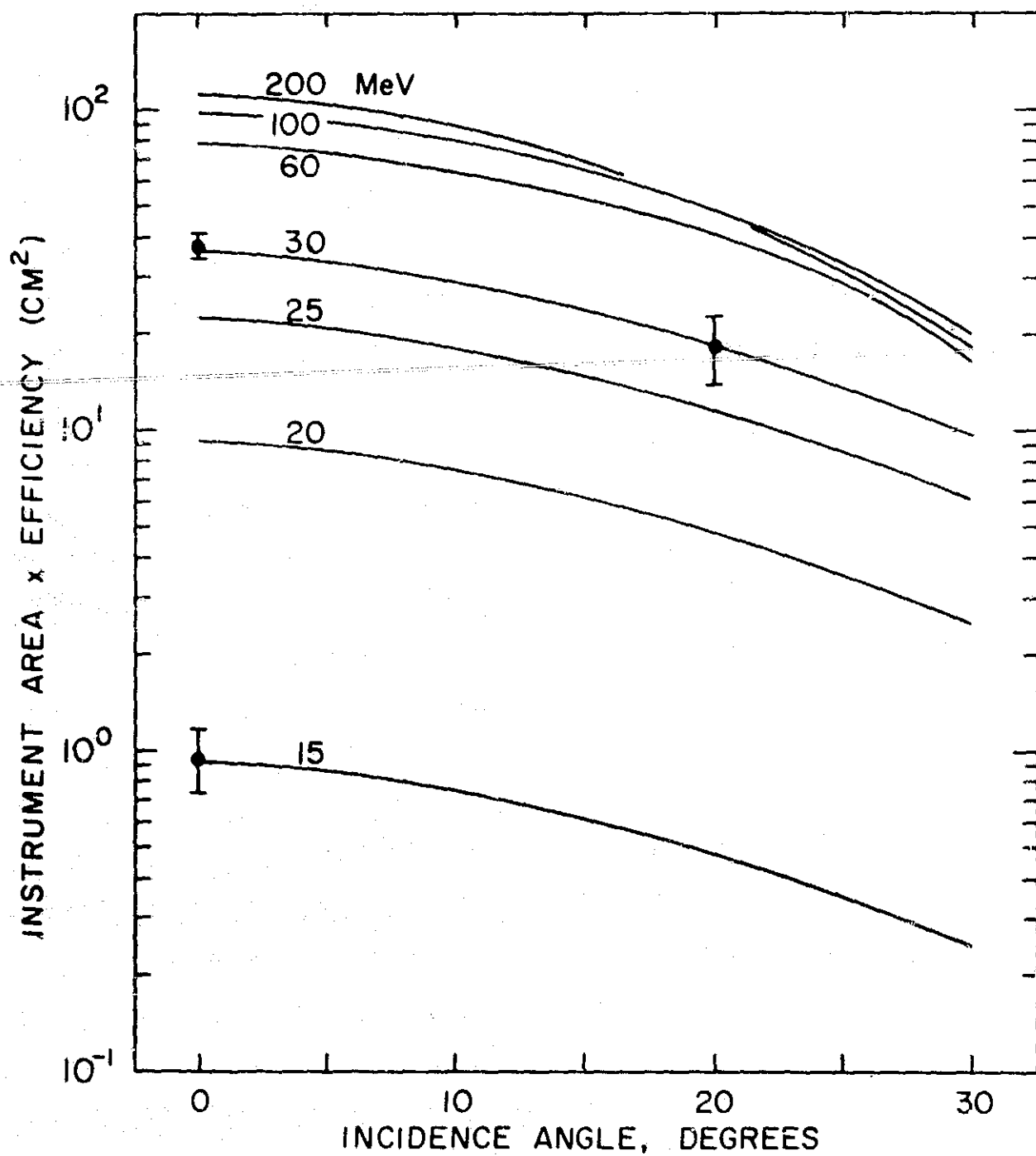


FIGURE 3

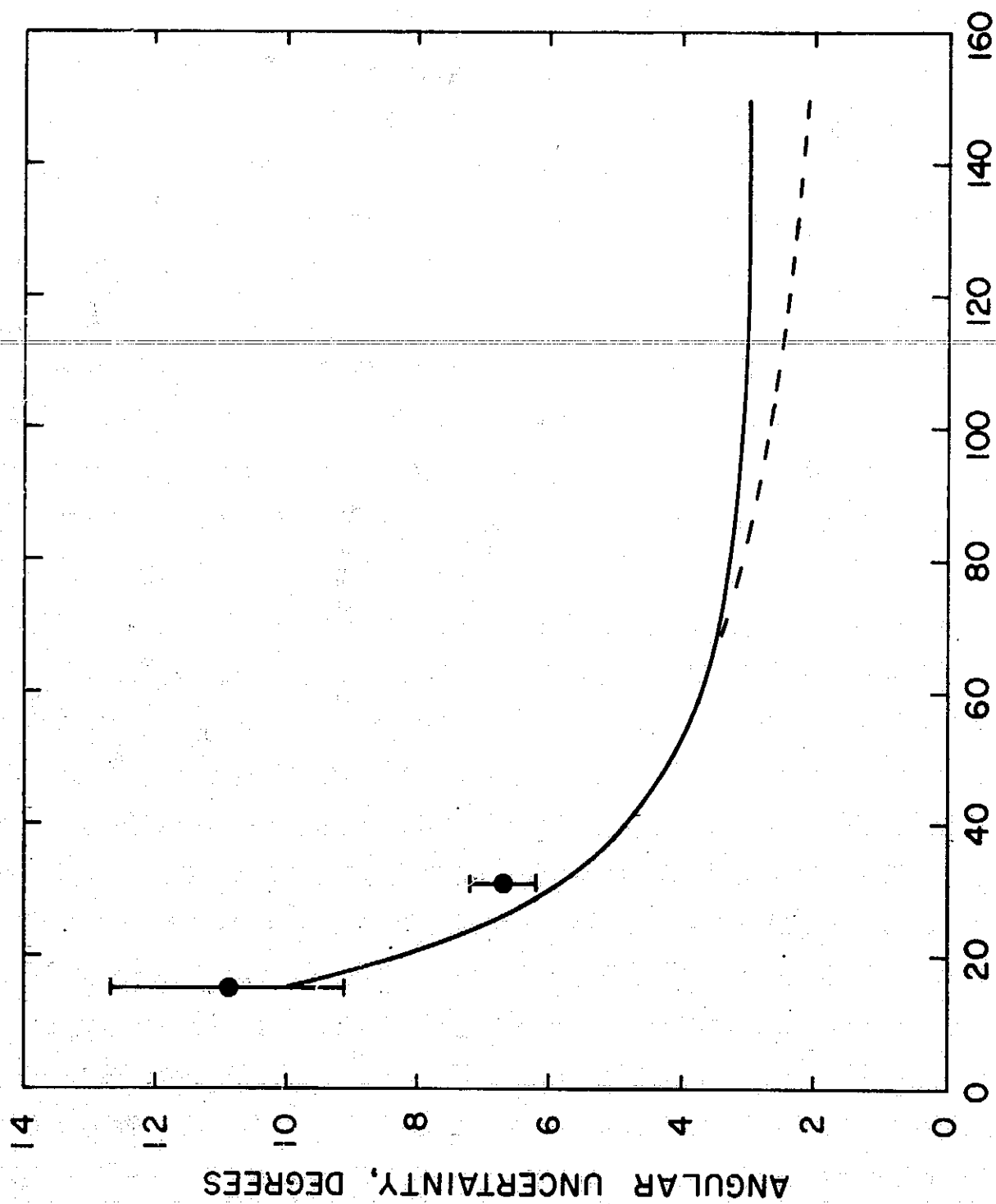


FIGURE 4

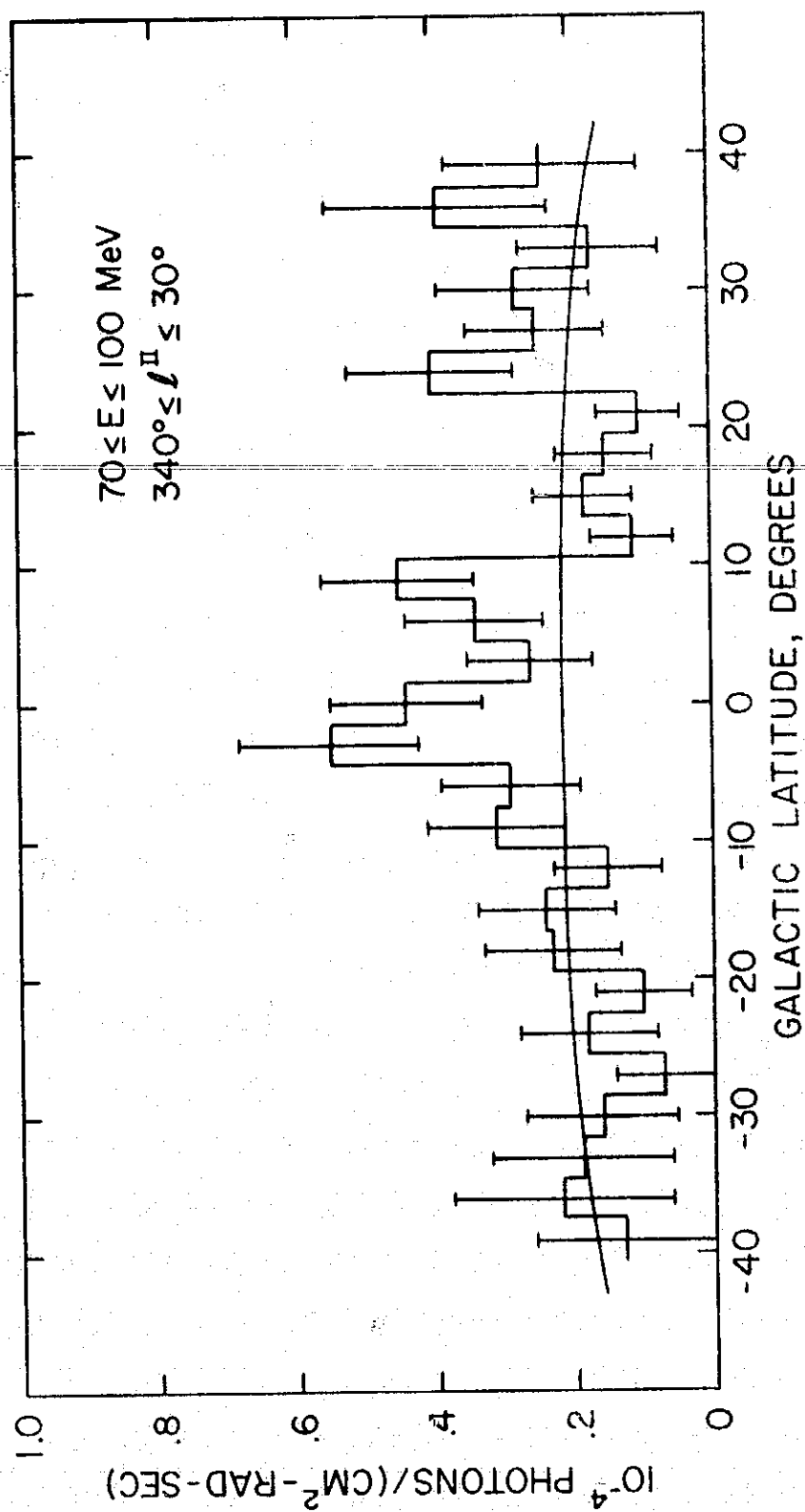


FIGURE 5

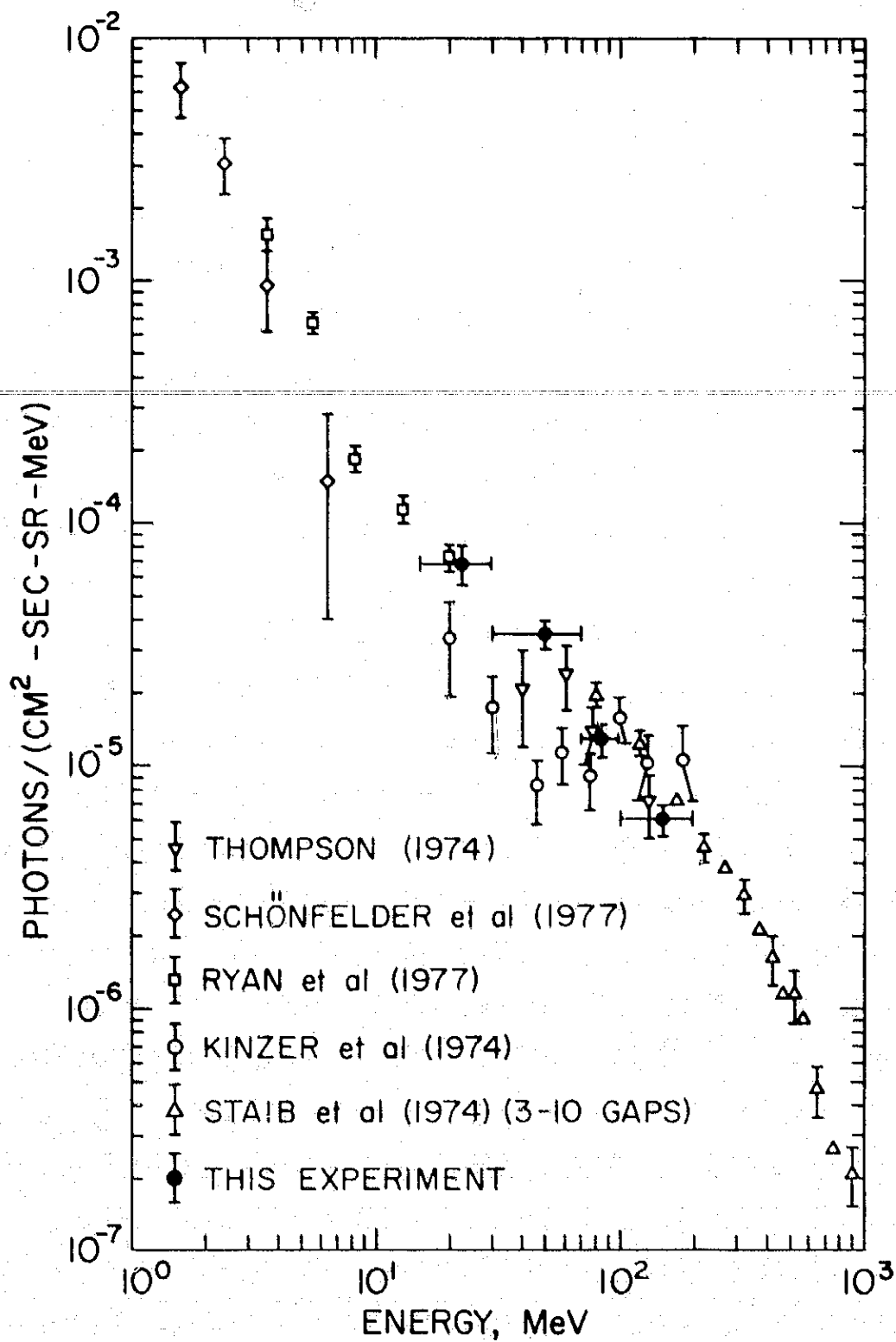


FIGURE 6

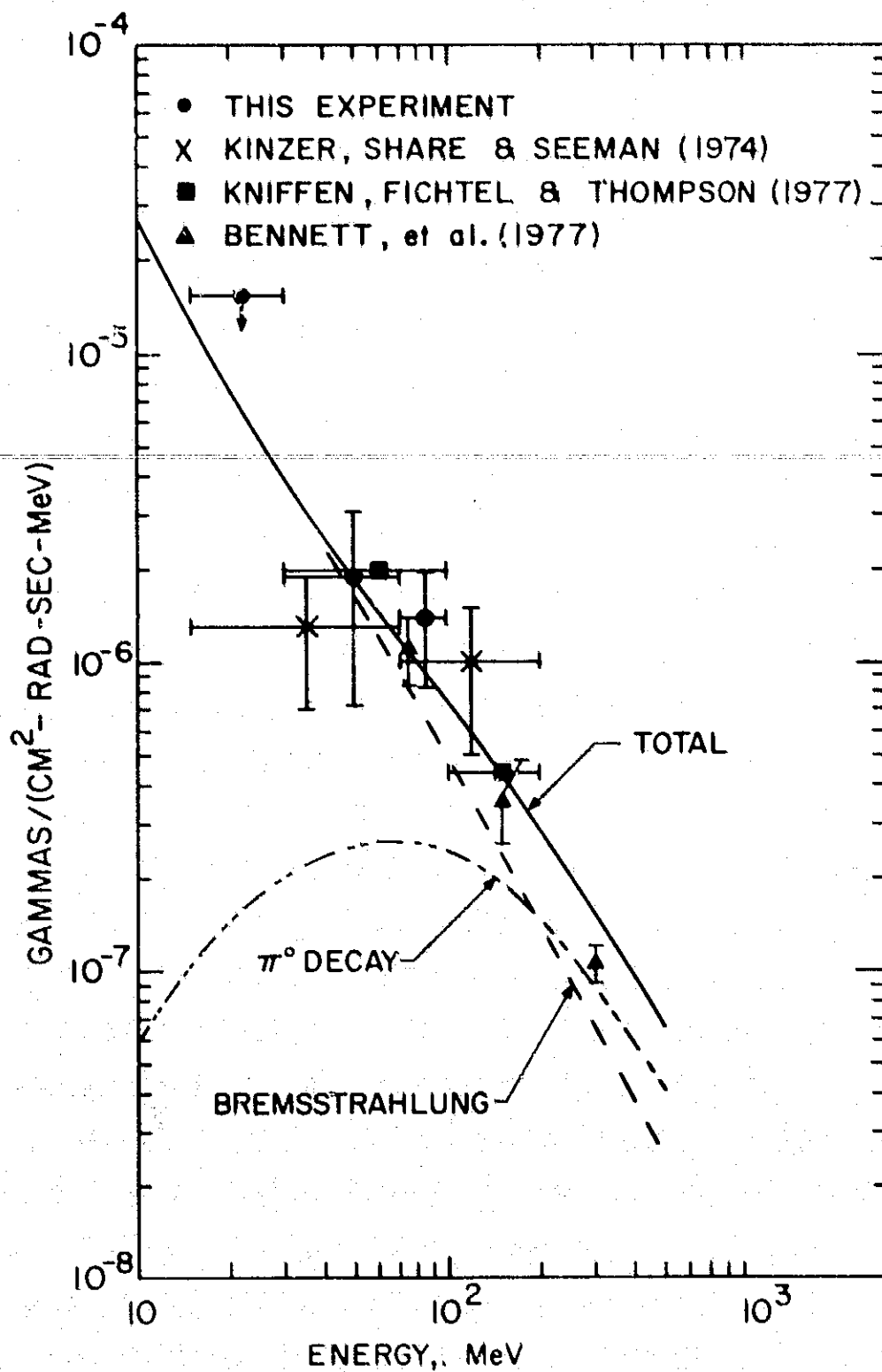


FIGURE 7

BIBLIOGRAPHIC DATA SHEET

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16. Abstract Measurements of the γ -ray emission in the medium energy range between 15 and 100 MeV, obtained during two balloon flights from Brazil are presented. The importance of this energy region in determining whether π^0 -decay or electron bremsstrahlung is the most likely dominant source mechanism is discussed along with the implications of such observations. Specifically, the data from this experiment suggest that emission from the galactic plane is similar to the theoretical spectrum calculated by Fichtel et al. (1978) including both source mechanisms, but with the bremsstrahlung component enhanced by a factor of about 2. A special distribution of γ -rays produced in the residual atmosphere above the instrument is also presented and compared with other data. A rather smooth spectral variation from high to low energies is found for the atmospheric spectrum.			
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