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The Space Physics Group

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I. OSO-III GAMMA RAY DETECTOR

Calibration work on the prototype detector continued, mostly through the efforts of Gordon Garmire at Cal Tech. The results of the analysis work that has been done here as a part of the Ph.D. thesis of M. Ulmer is very briefly summarized below:

1. The measured intensity and galactic latitude distribution of gamma rays arriving from directions near the galactic anti-center can be satisfactorily accounted for by cosmic ray-interstellar gas collisions. This conclusion rests on two assumptions: (a) The interstellar gas density is as implied by 21cm hydrogen line emission studies and (b) the cosmic ray intensity in the galactic disc at distances greater than 10kpc from the center is the same as it is near the solar system.

2. Assumptions equivalent to those made above for regions near the galactic center result in predicted gamma ray intensities that fall far short of the observations. There has been wide speculation in the literature by others on the cause of this discrepancy. Most explanations involve inverse Compton collisions of cosmic electrons with photons of radiation fields suggested by infra-red observations[1, 2, 3]. It seems to us that these explanations, relying as they do on very preliminary, difficult and uncertain infra-red measurements are interesting but premature. Also, the measured pulse height distributions from OSO-III are consistent with a collision-produced, not inverse Compton-produced gamma ray energy spectrum. We have therefore chosen to focus our analysis efforts on the collision process and are thereby led to conclude that the cosmic ray density increases with decreasing distance from the galactic center. The statistical quality of the data from OSO-III does not permit the development of very precise

models. Typical parameters are:

R, kpc	j(R)/j(10)
0-4	70
4-7	6
7-8	4
8-9	2
10-	1

where j(R) is the cosmic ray intensity at R from the galactic center.

The only other astronomical data that bear on the cosmic ray density distribution in the galaxy are from non-thermal radio noise measurements. We have assumed that the density of energetic electrons is proportional to the density of energetic nuclei and then find that the radio noise data are constant with the above model only if the typical magnetic field within R = 3 kpc is about a factor of 1.5 smaller than elsewhere in the disc. If the field is assumed constant everywhere in the disc, the particle density within R = 4 kpc must be decreased by a factor of about two, and the resulting fit to the gamma ray data is less satisfactory.

W. Kraushaar
M. Ulmer

II. ROCKET X-RAY INVESTIGATIONS

Our Aerobee flight 4.175 was launched successfully from White Sands at 23:37 MST, December 4. All systems functioned satisfactorily and we are deeply involved in data analysis. There were three independent gas flow counter systems, one with a Teflon window, one with a Mylar window and one with a Kimfol window. Most of the areas observed were chosen with a view towards our primary goal of understanding the soft x-ray background radiation. We did, however, spend about 30 seconds viewing the Crab Nebula and probably have useful spectral data on the nebula as well as the pulsar.

We are currently preparing the two payloads for the Australian flights. One will be a reflight of the 4.175 payload; the other a reflight of the 4.174 payload.

A. Bunner
P. Coleman
W. Kraushaar
D. McCammon

III. OSO-I X-RAY INVESTIGATION

This investigation was recently approved and funds for a six-month design study will be available soon. Certain crucial developments have already started. In particular, we have developed a proportional counter end seal that maintains the r^{-1} electric field even in the vicinity of the seal and so preserves useful counter area. Also, we are devising a scheme that will allow the last centimeter or so of gas volume near the ends of the counter to be a veto counter. Experience with our rocket counters indicates that such a scheme will provide a very material reduction in background.

A. Bunner
W. Kraushaar

IV. S-150 X-RAY INVESTIGATION

There has been no progress in this area, other than a special audit of our proposed costs.

V. GALACTIC ATOMIC HYDROGEN

We have collected and prepared in summary form a set of graphs that include the most recent and hopefully most reliable data on the columnar density of galactic atomic hydrogen. This will be submitted for publication when as yet unpublished data from one source become available. We have a continuing and important need for this sort of data in both our x-ray and gamma ray work.

H. Daltabuit
W. Kraushaar

VI. SOLAR DEUTERIUM INVESTIGATION AND COMPOSITION OF THE SOLAR WIND

A. IMP H&J Solar Wind Deuterium Experiment

A large effort was made by Analog Technology Corporation to complete the feasibility demonstration model (FDM) and prepare it for environmental tests at GSFC beginning on February 24, 1970. The tight schedule did not permit delivery of the FDM to the University of Wisconsin for evaluation and testing before it was sent to GSFC. As a result there were serious defects in the instrument which prevented proper electrical operation at GSFC. A report describing the tests at GSFC has been prepared and is included as an appendix to this report.

The FDM was returned to the University of Wisconsin where efforts are now underway to correct the problems encountered at GSFC.

B. Ionization Structure in the Solar Wind

The two previous progress reports described a theoretical study of the ionization structure of the solar wind, prompted by discrepancies between the Vela results and several calculations. The emphasis of this program has been two-fold: (1) to study the possible effect of processes not considered in previous calculations and (2) to re-interpret the Vela data including the possible presence of various elemental species in the solar wind in non-negligible quantities.

Processes previously suggested (September 1969) include inelastic collisions between ions — such as charge exchange and ionization — in the corona where the ionization structure of the solar wind is strongly influenced. Ion-ion reaction cross-sections have not been measured, and low energy calculations for strongly endothermic reactions between ions and atoms are meager. Computations are underway to estimate these cross-sections. The possible steady-state presence of supra-thermal particles in the solar wind may be significant for these ion-ion processes.

Also under investigation are the processes affecting neutral material drifting into the solar wind from interstellar space as suggested by Hundhausen and others.

The presence of small amounts of C, N, Ne, Mg, and Si in the solar wind appear to cast doubt on the published interpretation of the Vela data. Coronal, ultra-violet observations, solar cosmic ray measurements, and lunar rock gas analysis data indicate the presence of the above elements in small amounts compared with O. Nevertheless, if the solar wind ionization structure of these elements reflects roughly that in the corona, these elements will be present as ions with mass-to-charge ratios nearly that of the presumably identified oxygen ions.

J. Lange
F. Scherb

VII. SEARCH FOR HELIUM AND HYDROGEN SPECTRAL LINES ASSOCIATED WITH ENERGETIC PARTICLES IN INTERSTELLAR SPACE

Construction of the Coudé hut to enclose the PEPSIOS and associated electronics at the Coudé focus of the GSFC 36-inch telescope was completed in January 1970 and the PEPSIOS was reassembled at the Coudé. Since then the useful scheduled observing time has been devoted to a search for H-beta emission from an HI region in the vicinity of the Crab nebula. The remaining time available for observations near the Crab is becoming very limited as the season progresses into spring. Therefore, other possible HI sources of H-beta emission in more accessible directions at this time of year are being considered.

The analysis of the Kitt Peak helium 10830 data is well underway. The major factor which now determines the pace of the analysis is the turnaround time for jobs submitted to the University of Wisconsin Computation Center but there is very little that can be done to accelerate this process.

R. Reynolds
T. Lode
F. Scherb

VIII. A STELLAR INTERFEROMETER FOR FAINT ASTRONOMICAL OBJECTS

The observing program at Agassiz Station has been terminated and the electronic equipment was returned to the University of Wisconsin.

J. Davidson has completed a computer analysis of Agassiz data on selected binary stars and is writing a Ph.D. thesis describing his results. The analysis of the fringe photographs obtained with the Michelson stellar interferometer at Pine Bluff Observatory is completed and the results will be included in Davidson's thesis.

J. Davidson
R. Brazitis
F. Scherb

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APPENDIX

IMP H&J SOLAR WIND DEUTERIUM EXPERIMENT

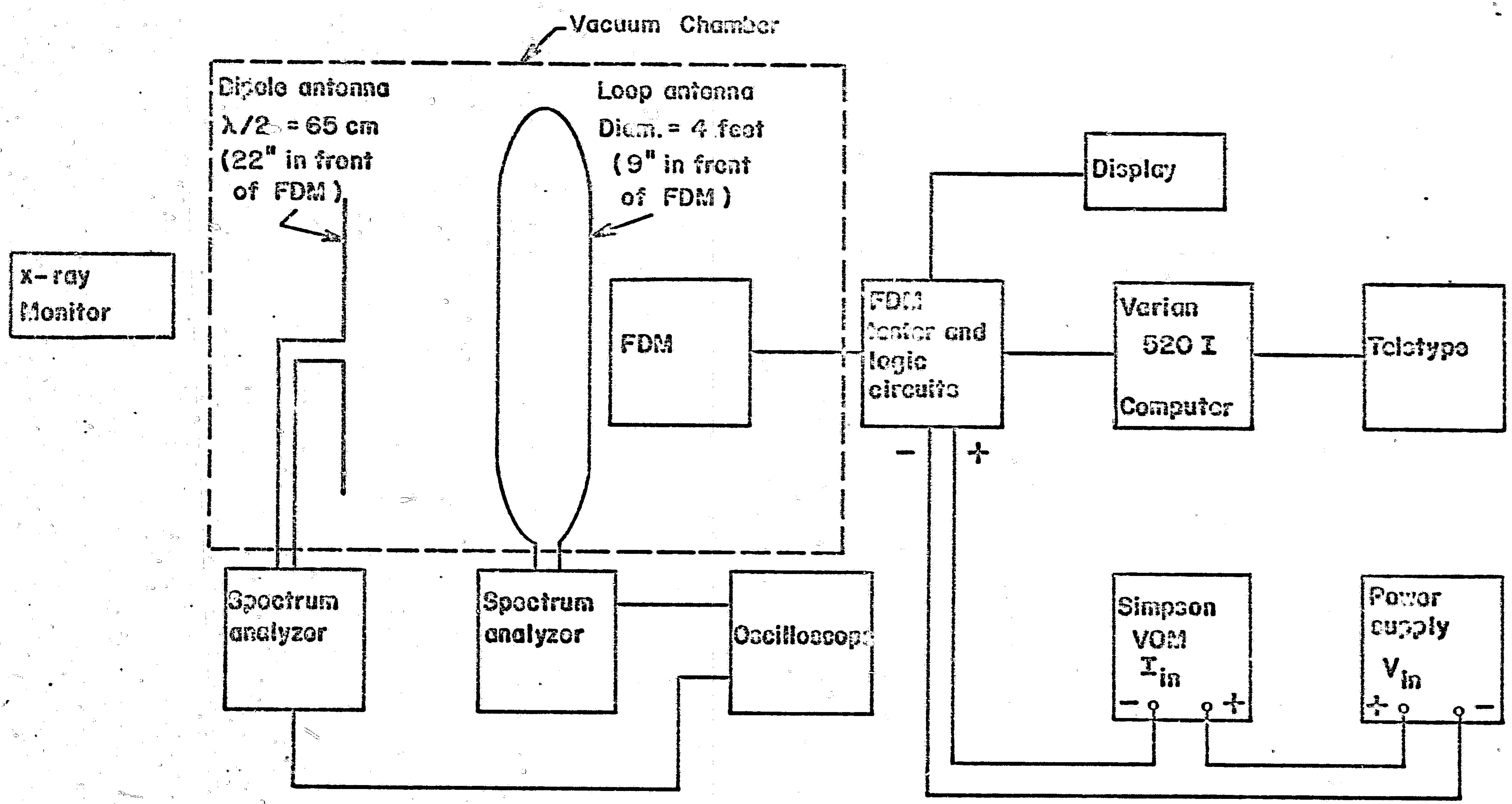
Summary of Feasibility Demonstration Model (FDM) Tests at GSFC, 2/24/70 to 2/28/70

1. Status of the instrument as delivered to GSFC by Analog Technology Corp.
   - a. No digital logic was included in the FDM.
   - b. One surface barrier detector out of four for the deuterium channel was installed and operative.
   - c. No charge spectrum surface barrier detector was installed.
   - d. No parts were screened for the electronic modules.
   - e. The instrument was not prepared for vibration.
   - f. The H.V. module had neither been thermal cycled nor tested in vacuum with the complete instrument.
   - g. The high voltage measuring system was inoperative.

2. Bench Tests (2/24/70) (The instrument was in the vacuum chamber, P = 1 Atmosphere)
   - a. Block diagram of test setup. (see following page)
   - b. The instrument power was turned on (H.V. = 0) with the following results: V_{in} = 28 Volts
     I_{in} = 81.5 ma
     $Power_{in}$ = 2.27 watts
   - c. A normal α-source spectrum was accumulated with the peak in channel 39-1/2.*
   - d. The H.V. was switched to 50 kV. I_{in} immediately went to current limit (134 ma) and began decreasing within 10 sec. This verified that the H.V. switch was operative and the H.V. working.
   - e. A normal α-source spectrum was accumulated with the peak in channel 39-1/2.
   - f. The vacuum chamber was sealed and pumped. No inspection of the instrument was made before pumpdown.

3. Vacuum Test (2/25/70), P = 1.4 x 10^{-6} torr
   - a. The instrument power was turned on (H.V. = 0) with the following results: V_{in} = 29.7 V
     I_{in} = 75 ma
     $Power_{in}$ = 2.23 watts

*A subsequent examination of the instrument log book showed that the spectrum peak measured at ATC before delivery to GSFC was in channel 56. This discrepancy has not been explained yet.



BLOCK DIAGRAM OF FDM TEST SET UP AT GSFC

b. A normal α-source spectrum was accumulated with the peak in channel 44.

c. The H.V. was switched to 50kV. I_{in} rose to 134 ma (current limit) for 10 sec and then the H.V. was switched off. We then switched back to 50kV and I_{in} = 134 ma (current limit) for 20 sec before settling down to 86.5 ma. Such a long period (30 sec) in current limit was judged irregular but tests proceeded.

I_{in} remained at 86.5 ma with $1.0 \times 10^{-6} \leq P \leq 5 \times 10^{-6}$ torr.

RFI scanning with 3khz $\leq f \leq$ 2Ghz yielded no convincing signal from the FDM above room background.

The maximum x-ray intensity measured at the quartz window of the vacuum chamber during current limit = 0.3 mr/hr. The γ-ray intensity settled down to 0.15 mr/hr after the instrument came out of current limit. (1 tolerance for the eye = 0.5 mr/hr.)

d. A normal α-source spectrum was accumulated under the following conditions: H.V. = 50kV

I_{in} = 87 ma

V_{in} = 29.7 V

$P = 1 \times 10^{-6}$ torr

e. An RFI Scan from 1 Mhz to 36 Mhz yielded many spectral peaks corresponding to 10 to 20 μvolts picked up by the loop antenna which were correlated to the power supply on-off switch (H.V. = 0). Interpretation is doubtful due to the noisy environment and the fact that none of the frequencies observed are produced by the FDM.

f. A normal α-source spectrum was accumulated under the following conditions: H.V. = 0

I_{in} = 75.5 ma

V_{in} = 29.7 V

$P = 0.9 \times 10^{-6}$ torr

Peak in channel 43-1/2

g. Instrument power off.

4. Thermal Cycle of H.V. Module

A H.V. module in every way identical to that installed in the FDM (except it was electrically dead) began an intensive thermal test.

$-50°C \leq T \leq +50°C$

$dT/dt = 20°C/hour$

3 hours at terminal temperature

8 hours/half cycle

3 full cycles completed

Results: 1) The RTV rubber filler pulled away from the outer cylinder by ~1/16 inch when T = -50°C.

2) 3 light pipes cracked.

3) The glass marble-filled C61 epoxy end plate separated from the outer cylinder.

5. <u>Vacuum Tests continued (2/26/70)</u>

a. The instrument power was turned on (H.V. = 0, P = 7.5 x 10^{-7} torr) with the following results: I_{in} = 75 ma
V_{in} = 30.0 Volts

b. A normal α-source spectrum was accumulated with the peak in channel 44.

c. The H.V. switch was set to 50kV (P = 1 x 10^{-6} torr). I_{in} immediately rose to 134 ma (current limit) and dropped below this value intermittently for short periods of time (approximately one to two seconds). An α-source spectrum accumulated during this time was noisy.

6. <u>Vacuum Tests continued (2/27/70)</u>

a. The instrument power was turned on (P = 6 x 10^{-7} torr) with the following results: I_{in} = 75 ma
V_{in} = 30.0 Volts

b. A normal α-source spectrum was accumulated with its peak in channel 43-1/2.

c. The H.V. switch was set to 50kV. All attempts to turn the H.V. to 50kV reproduced the results of 2/26/70. The attempt was repeated for P = 1.65 x 10^{-6} torr and P = 1.3 x 10^{-5} torr with similar results. Between each attempt normal α-source spectra were accumulated.

d. The FDM was brought up to 1 atmosphere. The instrument power was turned on and an α-source spectrum was accumulated. Operation was normal with I_{in} = 76 ma, V_{in} = 29.5 V.

e. The H.V. was switched to 50kV. I_{in} came out of current limit 4-1/2 sec after switch-on and settled down to I_{in} = 118 ma at V_{in} = 29.5 Volts.

f. The FDM was turned off.

7. Bench Tests (2/28/70), P ≈ 1 Atmosphere

a. The FDM was inspected and the outer grid was removed. A loose piece of conducting epoxy was pulled off the inner grid support and a frayed wire on the inner grid was pushed down. With the outer grid replaced, the H.V. was turned on with the following results.

I_{in} = 87 to 88 ma

V_{in} = 29.5 Volts

b. An attempt to reach 75kV in air was made as follows:

H.V.	I_{in}	Comments
0	75 ma	
50 kV	86 ma	H.V. steady, no corona
75 kV	131 ma	corona
50 kV	86 ma	H.V. steady, no corona
75 kV	131 ma	corona
50 kV	86 ma	H.V. steady, no corona

c. The FDM was turned off.

8. Instrument Defects

a. An aluminum mounting ring was used for holding the inner grid on the inner canister instead of the requested titanium ring.

b. Conducting epoxy was smeared on the inner grid and its aluminum mounting ring, and inner grid wires were broken in many places.

c. The inside of electronic assembly 3 was dirty with small strands of bare wire present.

d. The connection to the 200V p-to-p khz oscillator output was badly soldered and the bare lead was too close to the jagged edge of the module ground cover.

e. The shield of a cable in electronic assembly 3 was very badly dressed and not properly grounded.

f. The H.V. end of the H.V. assembly was not coated with conducting paint.

g. Exposed surfaces of the teflon mounting for the deuterium detector were not coated with conducting material.

h. The small volume containing the H.V. transformer was not potted.