MIT'S FIRST SCIENTIFIC SOUNDING ROCKET LAUNCH

at

WHITE SAND MISSILE RANGE

7 July 1967

Diary from 1967

and

Commentary (2012)

per

Hale Bradt
(Principal Investigator)

Contribution to CSR/MKI (MIT) historical records and also to the AIP archives re:
Fifty Years of X-ray Astronomy.
Feb. 2, 2013.

Background

This is a "Diary" of our first trip to White Sands Missile Range (WSMR) for the launch of the sounding rocket carrying our payload for the study of celestial x-ray sources. We had spent the past year building and testing it. The field of x-ray astronomy at that time was only five years old. It was my first experiment in x-ray astronomy and MIT's first experience with sounding rockets, which had become available only after WWII. The Aerobee rocket was a smaller and simpler version of the German "V2" rocket that was used to bomb London late in the war. It had a liquid fuel engine that burned for about 50 seconds and a solid fuel booster that burned for only 2 seconds.

Our payload, about 5 feet tall, sat on top of the rocket inside a cylindrical (15-inch diameter) enclosure. It consisted of proportional counters with delicate, easily broken windows, their power supplies, and also collimators and movie cameras ("gun cameras") to photograph stars for aspect (pointing directions of our detectors). At altitude, the detectors would observe the sky out the side of the cylindrical payload enclosure after a motorized door opened. The detectors were pointed toward pre-programmed locations on the sky by orienting the entire rocket with gas jets controlled by a gyroscopic guidance system. The auxiliary systems (guidance, telemetry, parachute) all sat below the science payload above the fuel tanks in separate cylindrical cans.

These service systems and the payload enclosure with the motorized door were all provided by Goddard Space Flight Center (GSFC). We carried out testing (vibration, etc.) at GSFC in Maryland. The launch site at WSMR was run by the U.S. Navy, with real sailors. The site was a "desert ship" in the middle of a U. S. Army base (WSMR). Security led to a significant amount of red tape.

We stayed in the nearby (40 mi) town of Las Cruces NM and worked most days and some nights at the base. We had to calibrate our instruments, run a complete mock launch ("Horizontal Test") in the "Prep" building and later a "Vertical Test" with the rocket in the launch tower. The equipment was supposed to be totally tested and ready to go by the time we got to WSMR. Monkeying with the flight systems thereafter would not be cool. Little did we know!

After a successful launch, after only a few minutes of data acquisition at altitude above about 100 km (~300,000 ft), the rocket would begin its reentry into the atmosphere. The motorized door would close, the fuel tanks would be jettisoned and the entire remaining payload (science plus auxiliary systems) would tumble end over end into the atmosphere, slowing as it did so. At about 20,000 feet, the parachute would open and hopefully safely deliver the payload to earth some 40 miles north of the launch site. Our data would have been telemetered to ground during flight, but our aspect data (photos of stars) was on film in the payload. Recovery of the payload was essential.

This Diary portrays the little things that concerned us while we were at White Sands, and many of them are quite dismaying and others quite humorous, at least in hindsight. The reproduced pages here were typed up the month after the launch. They are based on notes I made while at White Sands. I distributed it to those of us involved. There were misadventures a plenty, and it seems a miracle that, in the end, all went right.

The rocket's success and the results, a confirmation that the galaxy M87 is an x-ray source and the localization of six discrete galactic x-rays sources, was surely the critical factor that earned me tenure the following year. These were the days when students and professors could actually work with flight hardware. Nevertheless, even in those days, it was understood that critical operations were, for the most part, to be performed by the professional engineers and techs.

I explain some of the entries in notes at the end of the Diary.

Personae Dramatis

The MIT team consisted of four scientists, two engineers and two technicians. The Goddard Space Flight Center (GSFC) team consisted of some half dozen or more engineers and technicians. U. S. navy personnel ran the Aerobee launch facility, and WSMR personnel carried out other support functions, such as range safety, etc.

MIT Technical
Robert Rasche: Project and Electrical Engineer (later Proj. Mgr. on SAS-3)
Donald Humphries: Mechanical Engineer
Edward Boughan: Electronic technician (later engineer on SAS-3 and other MKI missions)
Joseph Morris, Mechanical technician
Donald Fairbrother, technician

MIT Science
Hale Bradt, PI
S. Naranan, visitor from Tata Institute, Bombay, India
Saul Rappaport, graduate student (later professor at MIT)
William Mayer, graduate student (later Proj. Scientist SAS-3, Proj. Manager of RXTE and ACIS Chandra, and Assoc. Director of MKI)

GSFC
Bill Russell, ____ Hamilton, ____ Cameron, _____ Tidwell, Morgan Windsor, et al.

This is a copy of the notes I kept during our stay in White Sands Missle Range. Since much of it could be misinterpreted and is personal in nature I urge you to keep this for your personal records but not to duplicate it. Thank you.

In looking this over I find that most of my immediate concern revolved around those of us who were doing the Physics. I remember only too well that every move we made was supported and, in fact, carried out by the MIT engineers and technicians namely Don Fairbrother, Joe Morris, Don Humphries, Ed Boughan, and Bob Rasche. at MIT, and also the GSFC engineers + techs. The 100% success of the payload attests by itself to their effectiveness.

Hale V. Bradt

(august 1967)

THIS IS A DAILY DIARY PRECEDING (and UP TO) MIT'S FIRST SOUNDING-ROCKET LAUNCH TO STUDY CELESTIAL X-RAY SOURCES ON July 7, 1967 - from White Sands Missile Range.

Hale Bradt
30 Aug 82

Submitted to CSR/MIT as Historical Document for free distribution. HB Dec 2012

D-15 6/22/67 Thursday

Arrived late.
No message in Ed's box.
Called 8 rooms to find somebody.
Joe told me our launch was slipped from 6/29 to 7/6 -- next to the last date of our window.
P.M. Recalculated the windows because we were told we could not hold.

D-14 6/23/67 Friday

Pre flight conference.
Ed gets to go on the helicopter--DARN!
Big Day for Saul's counters.
hoses were pinched
trouble in one preamp
windows blown in from last vacuum cycle

D-13 6/24/67 Saturday

Continue working on Saul's counters.
Set up lights for calibration.
Testing Be proportional counters.
Should we change 2 defective counters??

D-12 6/25/67 Sunday

H.B. to Calgary.
Saul and Bill to WSMR for long optical calibration.

D-11 6/26/67 Monday

Countdown with NASA. ("pre-horizontal")
Range time (time we are allowed to radiate with our transmitter) advanced 2 hours.
RUSH
Readjusted 1.7 m sec gate for some channels.

D-10 6/27/79 Tuesday

H.B. arrived again from Calgary and walked into glass wall while waving to the others who were lounging beside the pool. (They thought it was funny -- I didn't!)

Good news: Our launch was advanced to 7/5.
Decided to change the two defective counters first thing tommorrow.

D-9 6/28/79 Wednesday

Remove the whole top bank of counters.
Replaced defective counters and reinstalled bank.
Leak in one of Saul's counters
Tested counter at 1.5 atmospheres and found leak -- the bottom blew off!!
Bob and Don climbed off the ceiling and continued their work.

-Surprise -- the launch day postponed until 7/7 last day of our window.
- Surprise again -- WSMR never notified of our flight source.
Hamilton at GSFC never heard of it!!! HAH!
WMSR will do the best to get approval for source but does not offer much hope.

D-8 6/29/67 - Thursday

OUR BEST DAY

- 7:00 a.m. at motel called MIT and GSFC and raised hell about flight source
- Discovered payload rotated 45° with respect to rocket and entire guidance system.
- Rocket and GSFC equipment 15 pounds overweight.
- Then 20 pounds overweight including a 2" extension required to correct 45° rotation.
  Saul epoxied new bottom on his counter using conducting epoxy to insure good ground.
  Discovered 7 Megohm resistance between sides and back of his other counters as furnished by LND.
  Fixed that with conducting epoxy, too.
- Flight orders for H.B.
- Horray -- I get the helicopter ride during recovery!
- Horizontal Test
- Everything running and okay except for two of Saul's counters.
- H.B. and Bill in conference with Goddard people about extra weight and ways to insure a scan across the Virgo region in case of substandard rocket performance. 5:00 pm
- Bill suggested a reverse 45° rotation of RSP can and positive 90° rotation of our payload to obtain proper orientation without use of heavy 2" extension.
- Decided to increase scan rate across Virgo if we can convince GSFC to change one resistor--calculated we need about 35 ohms.

  P.M.
- Saw The Blue Max at the drive-in.

D-7 6/30/67 - Friday

- Called Bill Russell regarding change of resistor in the ACS system.
- Everybody in my room during long call.
- Final decision -- install one 33 ohm AB -- one watt to be obtained locally (4 place precision, HAH!)
- Nibble corner off of stud on RSP can and rotated the 45° as planned.
- All the above done by 11:00 a.m. (i.e. 8 hours discussion, 2 hours to execute).
  Examined recovery of 1.7 milsec gate pulses.
  Examined dead time incurred by lockout circuit.
- Hamilton at GSFC wired description of our flight source to WSMR.
- He quoted 10 m curies -- it is really 5 -- WSMR upset.

D-6 7/1/67 Saturday

Working on Saul's counters, practicing flowing, etc.
P.M.
Picked up Naranan at El Paso and decided to eliminate all 9 lockouts to improve response to the high rates expected from the Scorpio source.

D-5 7/2/67 Sunday

— Made Big TO DO list for the last four days while soaking up sun at the pool.
4:00 p.m. to 10:00 p.m.
Naranan, Bill and H.B. at WSMR.
Noted the loose camera bracket.
Found collimator B mounting is and always was satisfactory.

D-4 7/3/67 Monday

— Exposed camera to bright daylight 15 minutes and sun 5 sec. with lens open -- exposed about 1 foot of film and burnt hole in one frame -- sure do hope door stays closed on re-entry.
— Changed timer which turns off to 80 sec. to allow film to wind up -- now we are okay if film does not jam at severance.
Check discriminator levels - about .5 volts.
Lowered all discriminator levels.
Measured timing of camera shutter relative to clutch pulse.
Checked payload orientation relative to ACS -- okay ± 1°.
P.M.
Saul and Ed testing the thin window counters, leak rates are under control.
Resolution -- not so hot.
We had just cleaned counters with alcohol.
— Tidwell commisurating about all of our troubles with "weight, scheduling, source clearance, and fins", FINS?!!
Fins are adjusted to give spin rate of 1.76 ± 0.5 rps.
I am told that .5 to 1.5 guarantees pitch-yaw coupling and certain breakup of the rocket at a few thousand feet.
Tidwell asks our schedule for Wednesday, the day of our horizontal check (9:00 a.m.) and decides to readjust the fins on Tuesday. July 4.

D-3 7/4/67 Tuedsay

— Fins now adjusted to 2.03 ± 0.5!!!
Recharge battery.
— Found camera noise on some signal lines.
— Raised discriminator levels. (Moral: Never monkey with a working system.)
Noise continues.
Capacitor on motor contact eliminated noise.
Saul checking gain and resolution of counters until midnight.
Sandwiches and sausages from bowling alley at 10:00 p.m.

D-2 7/5/67 Wednesday

1:00 a.m.
Saul suggests he and I go home to be fresh for horizontal check in the morning -- good idea.
Naranan and Bill doing collimator alignment all night.
Tornado warning before we left. Good luch Bill and Naranan!
We were in bed at 3:00 a.m.
Back at WSMR for horizontal 11:00 a.m.
Noise in some channels during the horizontal test.
Okay immediately after, but channel E not getting through telemetry.
(Noise due to camera? or telemetry?)
Rocket and entire payload installed in tower.
Spare camera motor put on plane in Boston with 15 minutes to spare.
Bob controlling payload remotely from the block house -- remarkable.
5:00 p.m.
Motel for a swim, steak dinner at Johnson's.
10:00 p.m.
Ed and Bill to El Paso to get camera motor.
Midnight Bill and Ed back from El Paso without motor -- pilot took motor on to Pheonix.

D-1 7/6/67 Thursday

Up at 6:00 a.m.
Typed great letter about flight source to convince the powers-that-be that we really needed it.
Vertical testing scheduled for today.
Arrived at WSMR rather depressed about sources and noise in camera motor.
First stop at Radiation Safety Office -- flight source approved.
Out to launch area.
It rained last night -- everything wet with dirty rain water, vertical test postponed until tommorrow morning.
Drying out payload, telemetry, and ACS.
Many connectors were soaked.
Bill picked up camera motor and Ed installed camera motor; installed filter and capacitors on camera and tested that camera in a vacuum for noise. Okay now.
6:00 P.M.
Our payload completely assembled and working.
Covered payload carefully. Flowing dry nitrogen (now I know why everybody else's flight plans call for dry nitrogen in the tower.)
7:00 P.M.
ACS and telemetry all checked out and working.
P.M.
La Posta restaurant with Naranan (it is cheaper if you avoid the combination plate designed for tourists.)
You Only Live Twice at the drive-in with Bill and Naranan.
WHAT A DAY!!

7/7/67 Friday

7:00 A.M.

ACS and telemetry and our payload reinstalled aboard rocket.
Vertical check (9:00 a.m.) -- everything in beautiful shape.
All of Saul's counters working.
T- 130 minutes: washed off rocket with tower spray system!!
Installed cameras with flight film.
Record the many sources on tape via telemetry.
Saul flowed counters. (T - 60)
T - 35 minutes
Radiation with door and access panels shut.
T - 17 minutes.
Composing a blurb for Gunner Briggs to read over the loud speaker system so all the visiting brass, wives, and little kids would know what the flight was about -- meanwhile watching the weather reports to see if we could slip 10 minutes to gain a slightly more favorable launch time.
T - 15 minutes
Finish writing blurb -- winds coming up, decided not to hold
T - 3 minutes
One minute of calibration
H.B. went outside to watch launch. (T - 1 minute)
GABOOM -- left the tower like Batman, cleanest rocket in the USA!
T + 230 seconds
Everybody watching readout.
What a thrill to see Scorpio right on schedule.
To bed at 2:00 a.m., up at 3:30 a.m.
Boughan banging on door.
Back to WSMR to recover payload.
Recovery trivial, but nobody got a helicopter ride!
Payload not damaged and door was shut.
Payload back at Navy prep room by 10:30 a.m.
Bill, Naranan and Saul making final calibrations and packing up our gear all afternoon.
7:00 p.m.
I made my last trip to WSMR to pick up Naranan and returned keys to Navy building (it took me twenty minutes to find it).
8:00 p.m.
Goodbye to WSMR.
To Las Cruces -- my fifth trip on this road today.

7/8
Off to Alburquerque with Naranan: Forgot to turn off on Interstate 25 and went 15 more miles -- all the way to Organ -- Habit, I guess.

Notes (2012)

D–15: I couldn't find anybody at the motel. The "windows" refer to the dates we could launch. The range had their limits and we had ours due the location of our targets relative to the horizon and the necessity of getting star photos; it had to be dark with little or no moon. The slipped launch date was bad news because we had little fallback if the launch had to be scrubbed due to winds or any other factor.

D–14: The recovery the morning after launch could involve a helicopter ride or simply a ride in car or truck. Saul had his own experiment to study very low energy x rays. He used a "flow" proportional counter with extremely delicate plastic film windows. It had a flight gas supply with hoses that continually refreshed the counter gas.

D–13. Apparently two of the eight of our principal detectors had difficulties, probably leaks or high voltage breakdown. These were sealed Beryllium-window proportional counters. It was quite difficult to change them, and definitely not advisable at this point unless it was absolutely necessary.

D–12. I was off to a conference in Calgary where I gave my talk and returned immediately to Las Cruces, on D–10. The optical calibration was to relate the star camera alignment to that of the x-ray collimators.

D–9. The "flight source" was a radioactive source used to calibrate (Saul's?) detectors in flight. To do so required all sorts of permissions. We had gone through all the correct procedures, to our knowledge.

D–4. The concern about the camera was that our valuable star photos could be lost if the motorized door failed to shut prior to reentry and the camera was thus exposed to sunlight.

"Severance" refers to the jolt by explosive bolts when the fuel tanks are jettisoned prior to reentry. "Resolution" refers to the spectral resolution in Saul's counters.

I had found that the discriminator levels were not as low as I had specified; hence we would not record the lowest energy x rays that entered the counters. (I should have noted this back at MIT but had not gdone so given the rush of preparations. I assumed the engineers would get it right. Our engineer, Rasche, was sufficiently chagrined about this that he accommodated me by lowering the level for each of the eight channels. He did this by changing a single resistor in each. This was a big mistake, as we shall see!

I had heard *nothing* about fin adjustments prior to this. I only knew that they were set to spin up the rocket to about 2 revolutions per second to give it stability during ascent. My attitude was that I would pay close attention to things that would make me look stupid – like whether our detectors and the cameras worked properly and whether the rocket guidance system would point our instruments to the correct celestial positions. (We verified with our own calculations the GSFC maneuvering program.) I felt it impossible to master all the rocket systems.

D–3. The highly sensitive preamplifiers for the proportional counter were vulnerable to electrical noise, which could interfere with our data stream. Our lowering the discriminator thresholds opened the door for such noise. This was a very serious problem. We thus replaced the recently installed resistors with the original values. Moral: never push an engineer beyond his better instincts.

D–2. One camera motor was introducing noise, even with an added capacitor and higher discriminator settings. Thus we had one from MIT sent out. It was rushed to Logan, given to the pilot, but unfortunately he forgot to drop it off at El Paso before departing for Phoenix.

D–1. The hot dry days in the desert did not bring the possibility of rain to our innocent minds. Unfortunately, there had been a huge downpour the previous night, and we had left panels in the payload enclosure open. The rain flowed down the launch rails and from there down the sides of the rocket and hence into our open panels. It then flowed downward into the GSFC support packages. The launch rails had been dirtied by propellant from many previous launches, so it was a very dirty bath, which was really bad news for relays and electronic circuit boards. The GSFC people had dutifully closed up and taped all the surface panels on their modules, but that did not protect them from dirty water flowing down *inside* the rocket cylinder from our segment of the payload.

The payload –MIT and GSFC parts – was completely disassembled in the tower, and all the engineers and techs were working busily at cleaning their systems when I arrived, some in the Prep building and some in the tower. No one was in the mood to hear the good news about the flight source. As I entered the tower, a GSFC engineer said, "How could you let this happen?" meaning "How could you be so clueless?," and I hid my guilty feelings by muttered something like, "You are the guys who have been out here many times. Why didn't you tell us this could happen." When I reached Rasche, he was sitting on the expanded metal flooring high in the tower wiping down the circuit boards on our payload, which was next to him on the floor, having been unbolted from the rocket and moved there. When I asked him, "How's it going?", all I got was a growl and "You don't know the troubles you've got!" But, as the diary shows, everything was cleaned up and put together, tested and working by nightfall. It was an amazing feat.

D Day (Launch Day)
Tower sprinkler system. While I was in the blockhouse two hours before launch (it was late afternoon), an electrical short in the tower caused the tower sprinkler system to turn on and totally hose down the rocket. The door to our payload happened to be open making our instruments extremely vulnerable, and, according

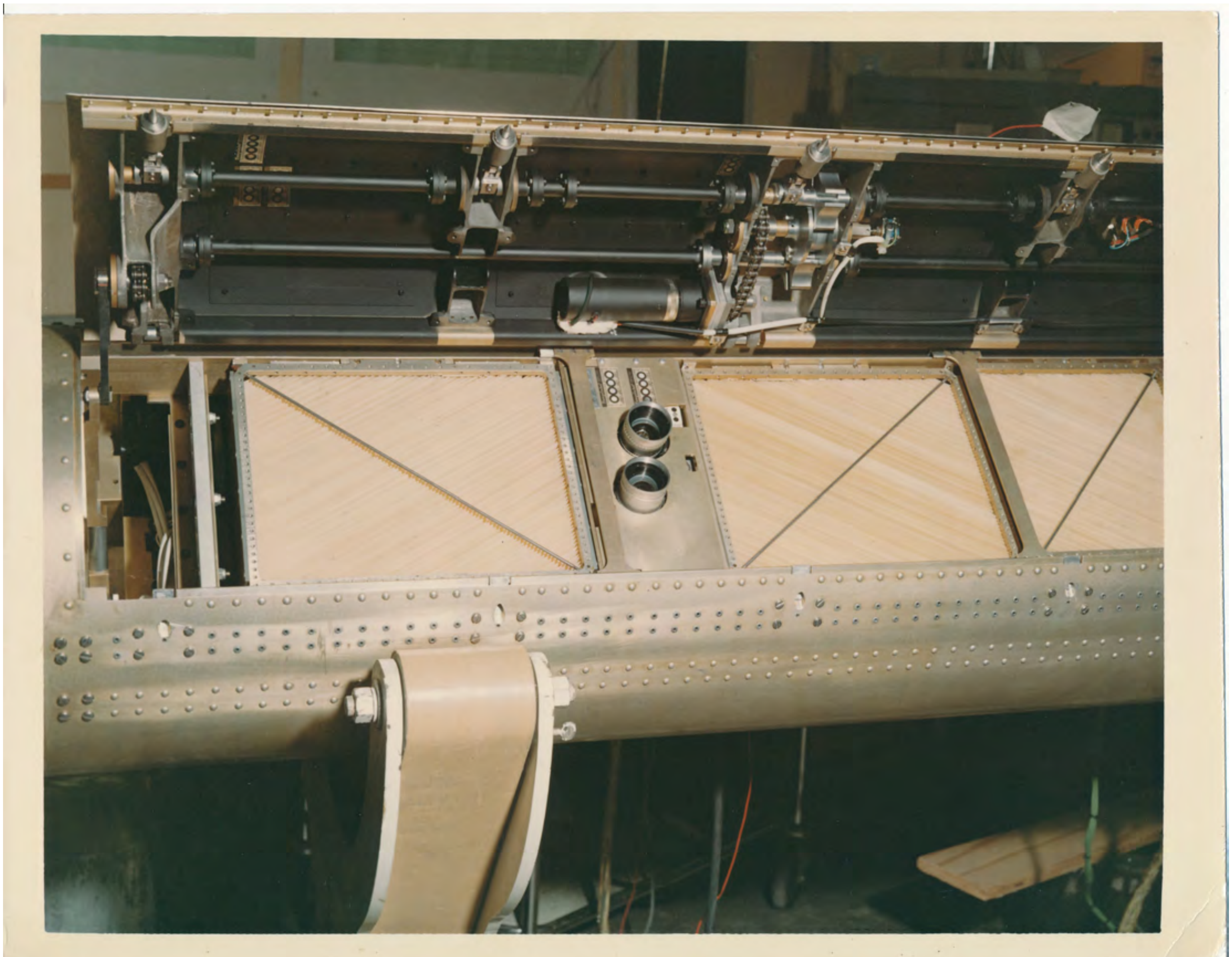
to one account, a jet was directed straight toward it. However, a sailor of the launch team happened to be standing right in front of the open door, so the jet hit him squarely in the back. Fortunately, he had the presence of mind to not move until the water was shut off, so, miraculously, our payload was unharmed.

Flight cameras: Bill Mayer and I took many steps to ensure we got our aspect data back successfully. Bill Mayer had practiced loading the 16mm film into the film cartridges in a dark room many, many times so he could learn all the possible mistakes and thus know how to avoid them for the final critical loading. He also had to remove the lens caps on his last trip to the tower. I had hassled him about that numerous times as well as having it on the check-off list I had made. I forgot to ask him about them when we were all watching the launch from outside the blockhouse (Doing so was against the rules, but what a rush. The rocket shoots out of the tower in a flash with a great roar, nothing like the slow ponderous launches I have seen from Cape Canaveral. We promptly enter the blockhouse before the booster has time to land, which on occasion can be where we were standing.) In the blockhouse, while the rocket was still ascending, I thought of the lens caps and asked Bill, "What about the lens caps?" He smiled and pointed to the low ceiling just above his head. He had taped both of them to the ceiling for all to see. I still shudder to think how publically ridiculous we would have looked had we neglected to remove them.

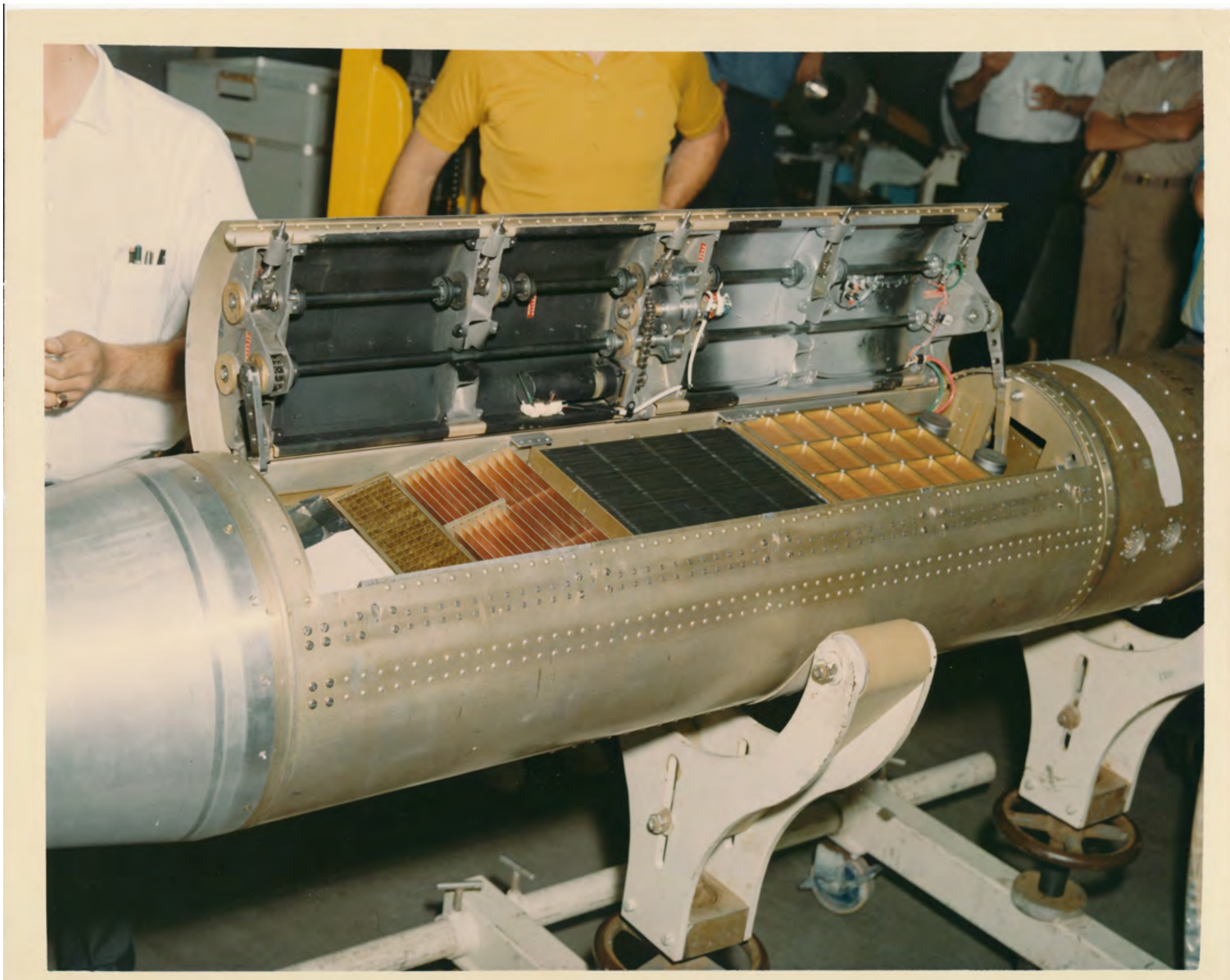
Final comment: Everyone on our team worked day in and day out during those two weeks striving to make it all go right. Each one deserves great credit that, in the end, it did go as hoped with very worthwhile scientific results. It was a true adventure for each one of us.π One of the team commented to me afterward that it was the most exciting that had ever happened to him, then after some thought added, "well except for when I got married."

Sounding Rocket Photos; MIT Program, 1967 – 1972

Horizontal test of the first NASA/MIT Sounding Rocket 4.190, White Sands Missile Range, June 29, 1967. Hale Bradt (far left facing this way), Edward Boughan, Saul Rappaport, and Don Fairbrother(?) (left to right facing this way in center rear), Joseph Morris(?) (facing away in foreground). (NASA Photo)



MIT Payload showing door, rubber “slat” collimators, and cameras for photographing stars to determine payload aspect during flight. Rocket 4.190, 29 June 1967 (NASA Photo)



Payload of MIT's second experiment during horizontal test, July 16, 1968; rocket 4.225. Our collimators are quite more sophisticated than the year before and include an electroformed modulation collimator (gold color) to right. The camera lenses can be seen just beyond it. (NASA Photo)

Recovery of NASA/MIT Rocket payload 4.225, 26 July 1968. The parachute is deployed from the lower (right) casing when the falling and tumbling payload reaches about 20,000 feet altitude. The payload includes the MIT experiment and also guidance and telemetry packages provided by GSFC. GSFC provided the experiment payload cylinder and door. (NASA Photo)

Horizontal test of NASA/MIT rocket 13.039 with MIT's Rodger Doxsey. Sept. 8, 1972. (NASA Photo)