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for the
Apollo 17 LEAM Experiment Data Analysis and Calibration Notebook

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June 13, 2012

(Note: The numbering system, 1., 2., 3., etc., is based on the pages of PDF document, not the page numbers written in the notebook)

- Zero LEAM day: Dec 12, 1972.

Right page: inserted graph of LEAM survival temperature

7. Same left page as #6.
   Right page: Table of LEAM temperature at first dawn (Jan. 9, 1973). Column headers are Date GMT, AJ 11, AJ 09, AJ 07, AJ 08, AJ 06. Indicates when LEAM was off.
8. Left page: plot of "Ball-park" Calibration Curve. Two curves: one for LEAM flight and one for Pioneer-D. Horizontal axis is pha.
   Right page: Table of "Typical" data from real time. Has columns GMT time, UP, EAST, WEST. Numbers in the cells are in the following form: film – grid – pha – film – grid – mic pha.
9. Left page: Reblowing covers to evaluate temperature problems. Turned LEAM on for 23 mins on 11/01/17/22 GMT to give two cover removal commands. Listed 6 conclusions:
   - Calibrations are normal
   - Delta power is 3 watts (normal)
   - Heater is not stuck on
   - Programmed temp _____ and _____
   - Covers are indeed removed
   - Data sheets(?) show no anomalies

   Right page: Reviewing background noise rates to answer high temperature problems. Has data from a 5-hour period on Day 357 when covers were still on. Writes a note to compare to the data on page 5 (which is #8 in this document), when the covers were supposedly removed.
10. Image of inserted graph. Data from WEST sensor from FOY 1. Plots intervals versus counts. Possibly from 5/10/1974.
11. Left page: To-do list for Jan 11, 1973. Several people to talk to (Dave Reasoner, Criswell, and Bob Miley), and some things to study.
    Right page: Notes from a telecon with Dave Reasoner. Conjectures on the dawn anomalies. "Lunar surface voltages may go from -200 volts at night to +20 volts at sunrise – depending on LEAM site relations to plasma sheet. Nighttime in the sheet is -40 to -50 volts. Surface dust sees the potential change in milliseconds of time and moves laterally (??) with a positive charge deposit on the -3 volt LEAM film. This changes the A/C and causes the ___ to heat up. Bursts of the particles arriving on the film would account for the large pha signals. Note: the summers see solar wind particles c. 5° earlier than direct sunlight (90 hours or 3 days 48 hours earlier)."
12. Left page: Bendix chart of ALSEP sunrise/sunset predictions for 1973. Columns are for Apollo 17, 16, 15, 14, and 12.
    Right page: Bendix diagram of Moon Positions Relative to Earth-Sun Line for Jan 5 to Feb 3, 1973.
13. Left page: Hand-drawn diagram of magnetic fields around Earth. Also moon path and plasma sheet.
    Right page: Discussion of lunar surface potentials. "With difficulty, one can predict the time of passage of the moon through the plasma sheet, but it is best to study history of sensors on the moon and in satellites. … The experiment sees the solar wind about 5° earlier than sunlight or about 10 hours earlier. In lunar night the surface potential is -200 volts outside of plasma sheath and perhaps -20 to -30 volts in the plasma sheet. Since

electrons travel faster than protons and ions, the solar wind causes the immediate area to go even more negative by 30 volts. (Note: Previously in the limb a very complex mechanism was see which is yet unknown because some people propose a shock wave or bow shock in that region which is not understood.) Then as the sunlight impacts a site, photoemission drives the zone to +10 to +30 volts. Consider a particle at the interzone between sunlight and dark." Continued on next page.

14. Left page: Hand-drawn diagram of terminator and notes continued from previous page: "The particle is driven leftward by two forces – sources:
    - the interface line moves left
    - the positively charged particle after (levitation) is repelled leftward
    - solar radiation pressure also drives it leftward
    - solar wind forces are negligible

    Now at sunset, considering the west sensor and the danger of being coated with dust. The interface moves left and radiation pressure drives it left. But the interface line is moving _____ or west. The east sensor is more likely to be coated with dust at sunrise than the west sensor at sunset only because of the interface movement.
    Right page: Plot of sun angle versus temperature.
15. Left page: Diagram of ALSEP instrument placement on the surface of the moon.
    Right page: Hand-drawn diagram of ALSEP setup. Also has LEAM coordinates.
16. Left page: Table of Lunar Surface Temperature at Taurus-Littron Site from Mark Langseth. Four columns: Sun angle, °K, °C, and °F.
    Right page: Bendix diagram of Moon Positions Relative to Earth-Sun Line for Feb 4 to Mar 5, 1973.
17. Left page: Page out of a book talking about the shadows of Earth and sun.
    Right page: Graph pasted in from another document of sun angle versus temperature. **Puzzling patterns** Below is a table with dates and times that the instrument was turned on and off.
18. Left page: Bendix diagram of Moon Positions Relative to Earth-Sun Line
    Right page: Bendix diagram of Moon Positions Relative to Earth Sun Line for April 4 to May 2
19. Photocopy of a plot of a dawn to dawn lunation, west sensor. Plotted coincidence events only?
20. Photocopy of plot of one lunation, up sensor. Plotted coincidence events, no multiples.
21. Photocopy of plot of one lunation, up sensor. Upon first glance, no difference from the previous one.
22. Left page: Bendix diagram of Moon Positions Relative to Earth-Sun Line for May 4 to June 1
    Right page: Bendix diagram of Moon Positions Relative to Earth-Sun Line for June 2 to June 30, 1973
23. Left page: Bendix diagram of Moon Positions Relative to Earth-Sun Line for July 2 to July 28, 1973
    Right page: Bendix diagram of Moon Positions Relative to Earth-Sun Line for July 30 to August 28, 1973
24. Bendix documentation of film and collector ID thresholds, pha levels for A and B film. This info is given for the Prototype System, the Qualification System, and the Flight System.

25. Left page: Memo from Ted Breezy to F. A. Heinz about a partial lunar eclipse that was going to take place on May 13, 1976.
    Right page: Diagram of the Apollo missions on the moon and their entry into the umbra and penumbra (Note: The Apollo missions and the ALSEP packages are not in order.)
26. Left page: Same memo from Ted Breezy as above.
    Right page: Table of the times that the moon will enter and exit the umbra and penumbra. Also the times that each ALSEP package will enter and exit the penumbra.
27. Left page: Same diagram as right page on #25.
    Right page: Plot of sun angle and probably temperature. The partial penumbra is marked.
28. Plot of UP sensor from FOY 1. Probably for 4 ½ lunations.
29. Plot of WEST sensor from FOY 1.
30. Plot of EAST sensor from FOY 1. Horizontal axis labeled "Number of 6-Hour Periods", and vertical axis labeled "Integrating number of events". Presumably these labels are the same for the previous two graphs as well because they are very similar.
31. Same plot of EAST sensor from FOY 1, just showing the top part because it was cut off in the previous photograph.
32. Unlabeled plot of linear data.
33. Plot of LEAM temperatures on first "Dawn" – Jan 9, 1973, 1600 hrs GMT. Curves for AJ 11, AJ 09, and AJ 06 plotted. Shows when instrument was put into standby mode and then turned off.
34. Two pages written by Herb Zook (I think). Table of Counts/day on 10 cm x 10 cm versus the momentum threshold. These are predicted values, and they do not take any shielding into account.
35. Left page: Handwritten table of temperature, sun angle, time (GMT), and day. Shows where they turned it off and then back on again. Dates range from July 5th to July 9th, no year is given.
    Right page: Bendix diagram of Moon Positions Relative to Earth-Sun Line for July 30 to August 28, 1973.
36. Left page: List of 9 forces that act on a 5μ size particle. List contains the name and size of the force in dynes. Forces called "moon", "Electrostatic force", and "Cohesive force" are boxed because they are the largest. Also notes that the electric force required to lift the particle is 70 volts/cm.
    Right page: Bendix diagram of Moon Positions Relative to Earth-Sun Line for Aug 29 to Sept 27, 1973.
37. Left page: Notes from an interview of El Goresy of MPI (Max Planck Institute?) on May 29, 1973. Says that lunar soil has about 2000 – 5000 ppm of Na and K. Also talks about Iron Carbonyl particles, which don't have Na or K. "The plasma pulse is there because of the omni-present Na or K."
    Right page: Unlabeled diagram that has the path of interstellar particles (?).
38. Left page: Bendix diagram of Moon Positions Relative to Earth-Sun Line for Sept 28 through Oct 27, 1973.
    Right page: Writes about particles hitting other atoms in the atmosphere before hitting the surface of the moon. Calculates that a particle hits 5 x 10^3 atoms as it impacts the LEAM instrument on the moon. Says John Freeman from Rice University suggests this

may account for the apparent ___ of small pha particles from LEAM. Asks if a particle will lose kinetic energy.

39. Left page: Continues discussion from previous page. Asks if a particle's charge could change as it impacts the aforementioned 5 x 10^3 atoms. Has an equation, but doesn't identify all of the variables. Includes a note to complete the experiment.
    Right page: Information about TOF Event #1 for LEAM. Includes time, films, pha values.
40. Left page: Bendix diagram of Moon Positions Relative to Earth-Sun Line for Oct 28 to Nov 26, 1973
    Right page: Bendix diagram of Moon Positions Relative to Earth-Sun Line for Nov 27 to Dec 26, 1973
41. Left page: Listed Na and K concentrations in lunar soil at the Apollo 17 site, according to EOS data.
    Right page: Hand-drawn diagram of the Aggson Rings. Something about an Ecliptic plane.
42. Left page: Bendix diagram of Moon Positions Relative to Earth-Sun Line for Dec 27, 1973 to Jan 25, 1974.
    Right page: Bendix diagram of Moon Positions Relative to Earth-Sun Line for Jan 26 to Feb 24, 1974
43. Left page: Bendix diagram of Moon Positions Relative to Earth-Sun Line for Feb 24 to March 25, 1974
    Right page: Plots of pha distribution for each of the three sensors. The top graph is for days 277-303 and the bottom graph is for days 269-280 (this is one dawn to dawn lunation). In both, the west sensor picks up the most particles with a pha of 1, but the east and up sensors pick up a lot of particles with a pha of 7.
44. Top: Plot of pha distribution for each of the three sensors from day 304-334.
    Bottom: Plot of integrated numbers of events on the EAST sensor during one lunation. Divides it into the phas 1,2,3 and 4,5,6,7. Well-labeled graph, so this may help understand some of the similar graphs in the notebook.
45. Plots of integrated number of events for the UP and WEST sensors. Similar to the graph on the bottom of #44.
46. Graph of integrated number of events for all three sensors for days 275-304. The up and east sensors get a lot near sunrise. The west sensor begins to steadily increase at noon and continue until sunset.
    Also, diagram of moon orbiting the earth. LEAM position is marked.
47. Plot of integrated events for the front film only for one lunation. Each of the three sensors are represented.
48. Same graph as in #47, but the far right side is visible.
49. Table of LEAM On-Off Times. Columns are On/Off, GMT, Date, and temperature. Also some rows have sun angle.
50. Three tables of pha distribution for five lunations. Gives lunation dates, number of events for each pha value, and average pha. One table for each of the three sensors. These tables go with the three large graphs marked FOY 1.
51. Left page: Plot of temperature, cumulative flux, and cumulative pha for the EAST sensor from days 244 – 255. Data from FOY 1.

Right page: Plot of temperature, cumulative flux, and cumulative pha for the EAST sensor from days 362 - ___. Data from FOY 1.

52. Left page: Plot of temperature, cumulative flux, and cumulative pha for EAST sensor from days 273 - ___. Data from FOY 1.
    Right page: Notes about the preceding 3 plots. Discussion of how there is a rise in the pha and flux before sunrise on the later two sunrises, which led him to believe that temperature doesn't have an effect.
53. Left page: Plot of temperature, cumulative flux, and cumulative pha for EAST sensor from days 303 - ___. Data from FOY 1.
    Right page: Plot of temperature, cumulative flux, and cumulative pha for EAST sensor from days 332 - ___. Data from FOY 1.
54. Left page: Summary plot of preceding 5 plots showing how cumulative flux and cumulative pha vary with lunations. EAST sensor only.
    Right page: Plot of coincidence events only for UP and WEST sensor for days 244 - ___. Also plots temperature. Data from FOY 1.
55. Left page: Plot of coincidence events only for UP and WEST sensor for days 273 - ___. Also plots temperature. Data from FOY 1.
    Right page: Plot of coincidence events for UP and WEST sensor for days 303 - ___. Also plots temperature. Data from FOY 1.
56. Left page: Plot of coincidence events only for UP and WEST sensor for days 332 - ___. Also plots temperature. Data from FOY 1.
    Right page: Plot of coincidence events only for UP and WEST sensor for days 362 - ___. Also plots temperature. Data from FOY 1. Also makes a note that for this dawn and the previous dawn, the flux increases about 15-18 hours before dawn and the slope of the curve does not change as the temperature rises. This is true for the EAST and UP sensors, but not the WEST sensor.
57. Left page: Plot of temperature, cumulative pha, and cumulative flux for the EAST sensor. Data from FOY 2.
    Right page: Plot of temperature and cumulative flux on UP sensor.
58. Left page: Bendix diagram of Moon Positions Relative to Earth-Sun Line for April 24 to May 23, 1974.
    Right page: Bendix chart of ALSEP sunrise/sunset predictions for 1974. Columns are for Apollo 17, 16, 15, 14, and 12.
59. Data extracted from plots on #46. Number of events from each sensor for lunations 41 and 42 (?).
60. Repeat photo of #58.
61. Photocopy of #46, which is a plot of events from days 275 – 304 for each of the three sensors.
62. More photocopies of #46.
63. Left page: Another photocopy of #46.
    Right page: Bendix chart of ALSEP sunrise/sunset predictions for 1976. Columns are for Apollo 17, 16, 15, 14, and 12.
64. Left page: Bendix diagram of Moon Positions Relative to Earth-Sun Line for May 23 to June 21, 1974.
    Right page: Plot of number of events on the east sensor starting day 57, which is Feb. 26, 1974.

65. Left page: Plot of number of events (presumably), sensor not specified.
    Right page: Comments and thoughts on LEAM data. Says one would expect to see more particles at dawn in March than in September – this is observed because the ___ would be shielded in September by the moon body. Also made a prediction that the UP sensor will see very few – if any – interstellars at dawn in June. He said this was because if they came in from an angle of 53° above the ecliptic at 271° longitude (in 21 June) they would have to be severely deflected to come in from below the moon.
66. Left page: Bendix diagram of Moon Positions Relative to Earth-Sun Line for June 21 to July 20, 1974.
    Right page: Bendix diagram of Moon Positions Relative to Earth-Sun Line for July 22 to August 20, 1974.
67. Left page: Bendix diagram of Moon Positions Relative to Earth-Sun Line for August 20 to September 18, 1974.
    Right page: Discussion about multiples and coincidences. Observed that coincidence only and coincidence multiples are very similar as seen in pasted _____ ___ 6 months of data. Film only events are quite different from coincidence events and often appear mutually excluding.
68. Left page: Bendix diagram of Moon Positions Relative to Earth-Sun Line for Sept 18 to Oct 17, 1974.
    Right page: Discussion with Tom Gold on 10/22/74. Talked about damaged particles. Gold wanted to use Berg's gun to simulate damage and derive velocity. If < 2.4 km/sec, the particle is local and volcanic. If >2.4 km/sec, the story is different.
69. Left page: Bendix diagram of Moon Positions Relative to Earth-Sun Line for Oct 18 to Nov 16, 1974.
    Right page: Information about lunar eclipse on November 29, 1974. Gives time for when moon and ALSEP enters penumbra and umbra. Also diagram of the moon entering the eclipse. Also a table of temperature readings at various times and on AJ06, AJ07, AJ08, AJ09, and AJ11.
70. Left page: Bendix diagram of Moon Positions Relative to Earth-Sun Line for Oct. 18 to Nov. 16, 1974.
    Right page: Hand-drawn diagram of moon's orbit around Earth.
71. Left page: Bendix diagrams of Moon Positions Relative to Earth-Sun Line for both Nov. 16 – Dec. 15, 1974 and Dec. 16, 1974 – Jan. 14, 1975.
    Right page: Table of sunrises in 1973. Columns headings are Date, Hoffman, and Langseth.
72. Three Bendix diagrams of Moon Positions Relative to Earth-Sun Line:
    - Jan. 15 – Feb. 13, 1975
    - Feb. 14 – March 11, 1975
    - approx. March 16 – April 14, 1975
73. Left page: Photocopied notes from Derek Perkins, from a telecon between Auer and Perkins, 2/14/75. Discussion on the length of the pulse and the pha signal.
    Right page: Bendix chart of ALSEP sunrise/sunset predictions for 1975. Columns are for Apollo 17, 16, 15, 14, and 12.
74. Plot of the integrated number of events for all pha counts for each of the three sensors. Plotted from dawn to dawn for one lunation.
75. Left page: Discussion of temperature anomalies.

Right page: Table with values every three hours.
(14 Jun 2012: Per Melissa Gaddy, an intern working with David Williams at GSFC, "This is where stuff starts getting confusing. Come back to it when I'm more alert."

76. Table with values for UP, EAST, and WEST. I think it was supposed to have something glued over it.
77. More tables with UP, EAST, and WEST columns.
78. Left page: Continued table with UP, EAST, and WEST columns. Also table with the day and time for each sunrise on LEAM.
    Right page: New table – Coincidences with Multiples
79. Table
80. Table
81. Left page: Table
    Right page: Bendix diagrams of Moon Positions Relative to Earth-Sun Line for July 11 – August 9, 1975.
82. Left page: Three graphs – pha versus number of events (?). One for each of the three sensors. Front film only. Observations also written about the data.
    Right page: Observations on Data. Noted that if the phenomenon is a terminator effect, the flux would rise in the terminator zone and drop as LEAM went away from the terminator.
83. Left page: Three graphs – pha versus the total number of events in 22 lunations, coincidence only. Lines indicate the time of day.
    Right page: Three graphs – pha versus the total number of events in 22 lunations, film only. Line indicates the time of day.
84. Hand-drawn diagram of the moon's orbit around Earth. Includes a dead zone.
85. Left page: Calculations on the number of elemental charges on a particle with a 10-volt potential.
    Right page: Calculations on the speed of an electrostatically accelerated particle.
86. Left page: Plot of average pha / quarterly – Basic plot. Coincidences with multiples.
    Right page: Plot of average pha / quarterly – Slid one month from Basic
87. Left page: Grid plot of impacts, after sunset, 4-7 pha
    Right page: Grid plot of impacts, before sunrise, 0-3 pha
88. Left page: Grid plot of impacts, near sunset, 4-7 pha
    Right page: Grid plot of impacts, after sunset, 0-3 pha
89. Left page: Grid plot of impacts, before sunset, 0-3 pha
    Right page: Grid plot of impacts, near sunrise, 0-3 pha
90. Left page: Grid plot of impacts, near sunset, 0-3 pha
    Right page: Grid plot of impacts, after sunrise, 0-3 pha
91. Left page: Grid plot of impacts, near sunrise, 4-7 pha
    Right page: Grid plot of impacts, after sunrise, 4-7 pha
92. Left page: Grid plot of impacts, before sunrise, 4-7 pha
    Right page: Grid plot of impacts, before sunrise, 4-7 pha
93. A few unlabeled calculations.
94. Left page: Grid plot of impacts, before sunset, 4-7 pha
    Right page: Grid plot of impacts, after sunrise, 4-7 pha
95. Left page: Grid plot of impacts, nighttime, 4-7 pha
    Right page: Grid plot of impacts, after sunrise, 0-3 pha

96. Left page: Grid plot of impacts, daytime, 0-3 pha
Right page: Grid plot of impacts, nighttime, 0-3 pha
97. Left page: Grid plot of impacts, before sunrise, 0-3 pha
Right page: Grid plot of impacts, daytime, 4-7 pha
98. Left page: Letter to Otto Berg from Carl Bailey from Concordia College
Right page: Same plot as right page of #86.
99. Left page: Plot of average pha for each time of day. Coincidences with multiples, average for 22 months, each of the three sensors shown.
Right page: Plot of average pha during near sunrise for 22 months. Shows monthly variations, each of the three sensors shown.
100. Left page: Table of "No Events/Month (Case) For 36 Months". Columns are Case, Total, UP, EAST, WEST, and average phas for UP, EAST, and WEST.
Right page: Plot of coincidence events per month for 35 months. Multiples excluded, each of the three sensors shown.
101. Left page: Plot of number of events per lunation over 3 months. Slide averaged, WEST sensor. Data from table on left page of #100.
Right page: Plot of number of events per lunation over 3 months. Slide averaged, UP sensor. Data from table on left page of #100.
102. Left page: Plot of number of events per lunation over 3 months. Slide averaged, EAST sensor. Data from table on left page of #100.
Right page: Three plots of average pha value per lunation over 3 months. Coincidence only, multiples excluded. Data from table on left page of #100.
103. Left page: Old drawings of grids, but big arrow marking it out and pointing to right page.
Right page: Grid plot of impacts. Shows that for the grid plots the top one is EAST, the middle one is UP, and the bottom one is WEST.
104. Left page: Plots the number of events at different times of day for the EAST sensor. Four different plots are given, one for each grid. On each plot, four lines indicate four different films.
Right page: Notes titled "On Satellite Charging (Synchronous)". Page includes references and notes about voltage differences depending on amount of sunlight.
105. Left page: Bendix chart of ALSEP sunrise/sunset predictions for 1977. Columns are for Apollo 17, 16, 15, 14, and 12.
Right page: Comparison of pre-flight calibration curve theory and Concordia theory.
106. Discussion of a new theory. Talks about solar wind that arrives 2 ½ hours before sunrise and stays 2 ½ hours after sunset.
107. Front of a file folder that contains a fax to Carl Bailey.
108. Cover page of fax to Carl Bailey.
109. Pages 1 and 2 of letter from Otto Berg to Carl Bailey.
110. Pages 3 and 4 of letter from Otto Berg to Carl Bailey.
111. Page 5 of letter from Otto Berg to Carl Bailey.
112. Left page: Plot of velocity versus charge for particles with a pulse height of 2, "slow".
Right page: Plot of velocity versus charge for particles with a pulse height of 3, "slow".
113. Left page: Plot of velocity versus charge for particles with a pulse height of 6, "slow". Also has plot of the distribution of kinetic energies in the corner.

Right page: Plot of velocity versus charge for particles with a pulse height of 7, "slow".

114. Plot of velocity versus charge for particles with a pulse height of 3, "fast".

115. Back of the file folder containing the fax to Carl Bailey.

116. Left page: Three plots for the pha distribution percentages, one for each sensor.
Right page: Photocopy of plot on #45, which is integrated number of events for UP sensor.

117. Photocopy of plot of integrated number of events for EAST sensor from #30.

118. Photocopy of plot of integrated number of events for WEST sensor from #29.

119. Left page: Notes about the gases coming up from the moon. Also at bottom, information about the sensors ** good **
Right page: Discussion "On the Speed of a Stationary Positively Charged Particle Deflected into LEAM". Looks at what the velocity would need to be in order to enter the film.

120. Left page: Continuation of the velocity/charge discussion. Also examines negatively charged particles.
Right page: Notes on the charge distribution at the terminator.

121. Top: plot of breakdown voltages versus pressure*distance. Bottom: Illustration of charged particles on the lunar surface.

122. Left page: Calculating the speed of the terminator.
Right page: Notes on the "Electrostatic Soil Removal on Far Side of Moon"

123. Left page: Table of EAST events at various times of day.
Right page: Table of UP events at various times of day.

124. Left page: Table of WEST events at various times of day.
Right page: Plot of number of events versus lunar day periods. Includes all three sensors.

125. Repeat of #124.

126. Left page: Table of pha averages for various times of day. All three sensors included. Also has pha averages for each time of day and each sensor.
Right page: LEAM sunrise table with Wolf's corrections. Columns include LEAM day, and date/time.

127. Blank.