Apollo 17 Lunar Ejecta and Meteorites Experiment (LEAM)

Film Pulse Height Analyzer (PHA) Levels

LEAM datum values DJ-2, DJ-5, DJ-13, DJ-16, and DJ-25 are the front and rear film Pulse Height Analyzer readings[1], giving a measure of the energy associated with a given event. The numbers are all recorded on 3 bits with a decimal range of 0 to 7. The thresholds to reach each level are given in Figure 1, a table from Otto Berg's LEAM notebook. Note the A film and B film PHA levels are slightly different. The ID thresholds at the top of the table are the energies necessary to trigger the film ID to be recorded. All values are in "MV" which we assume to be millivolts based on the Final Engineering Report for Cosmic Dust Detector (1970, fig. 16). The numbers match well with Figure 2 below, a plot from the Berg LEAM notebook showing a "ball-park" calibration curve for PHA vs. MV.

Flight System

A Film ID Threshold		.9 MV
B Film ID Threshold		.9 MV
A Collector ID Threshold		.8 MV
B Collector ID Threshold		.8 MV
A Film PHA Levels	- 1	1.69 MV
	- 2	2.7 MV
	- 3	6.0 MV
	- 4	15 MV
	- 5	34.5 MV
	- 6	91 MV
	- 7	241 MV
B Film PHA Levels	- 1	1.7 MV
	- 2	2.6 MV
	- 3	6.2 MV
	- 4	15 MV
	- 5	36 MV
	- 6	91 MV
	- 7	242 MV

Figure 1 - PHA levels table – Berg, LEAM Notebook 1, p. 27.

The amount of ionization measured by the LEAM sensors is a linear function of $mv^{2.6}$ (Berg et al., 1973) where m is particle mass and v is velocity.

In order to calculate the mass of the particle from the LEAM instrument, two values are needed. The first is the PHA level from the A film. This will give the range of ionization values in millivolts, which is proportional to $mv^{2.6}$. The value from the time-of-flight sensor will give the velocity (see TOF sensor write-up). The mass can then be solved for if the proportionality constant between the ionization values and $mv^{2.6}$ can be found. At present we do not know this number, but we have some information to put constraints on it.

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[1] DJ-2 = Front Film PHA for Up dual sensor assembly, DJ-5 = Rear Film PHA for Up dual sensor assembly, DJ-13 = Front Film PHA for East dual sensor assembly, DJ-16 = Rear Film PHA for East dual sensor assembly, and DJ-25 = Film PHA associated with the West single sensor, according to Table 6-X – LEAM Measurements in Apollo Lunar Surface Experiments Package Systems Handbook: Apollo 17, ALSEP 5 - Array E / Document Change 1 (1972).

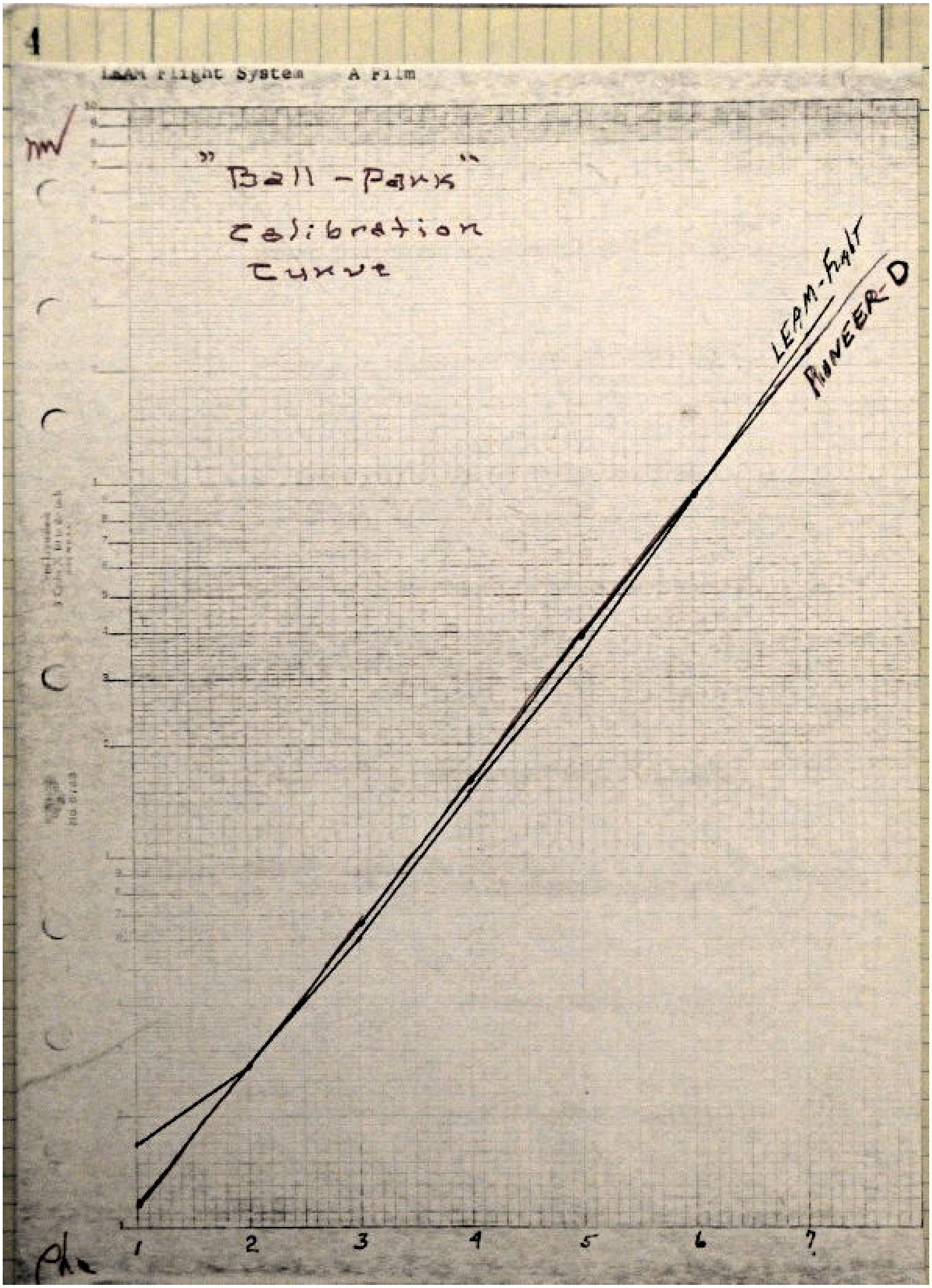

Figure 2 - “Ball Park” Calibration Curve for PHA vs. millivolts for the LEAM flight instrument and the Pioneer-D Cosmic Dust Detector, Berg LEAM Notebook 1, p. 4.

From figure 3 from Otto Berg's LEAM notebook, an example event gives a velocity of 12 km/s and a particle mass of 10^{-11} grams for a PHA of 4. The value of $mv^{2.6}$ for this case would be 63955 $g(cm/s)^{2.6}$. The peak ionization for PHA 4 is between 15 and 34.5 millivolts. So assuming a linear relationship between ionization (i) and $mv^{2.6}$: $mv^{2.6} = ci$, for this case the constant of proportionality c would equal between 1854 and 4264 $g(cm/s)^{2.6}/mv$. Unfortunately we have no other examples like this to narrow down the constant of proportionality.

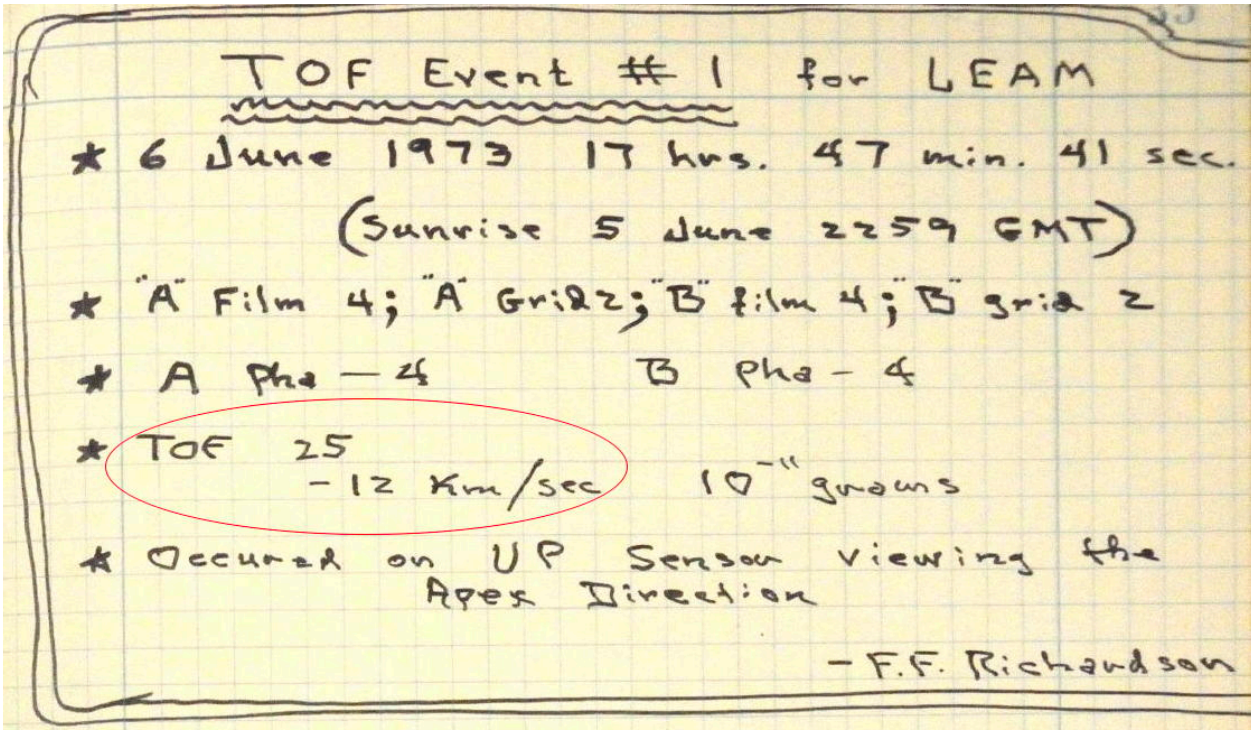

Figure 3 - Example of Event showing PHA values, speed, and mass of particle, Berg LEAM Notebook 1, p. 35.

From Berg et al. (1973, p. 16-5) the minimum particle energy to trigger the PHA is 0.6 erg. To perform this calibration, particle velocities between 1 and 25 km/s were used, giving particle masses to give an energy of 0.6 erg of 1.2×10^{-10} g at 1 km/s and 1.9×10^{-13} g at 25 km/s, or a range of $mv^{2.6}$ of 1200 to 8192. Since the threshold voltage for PHA 1 is 1.69 mv, the proportionality factor would be between 710 and 4847 $g(cm/s)^{2.6}/mv$. This does not help narrow down the range found earlier, but it is at least consistent with the higher energy case.

References

Apollo Lunar Surface Experiments Package Systems Handbook: Apollo 17, ALSEP 5 - Array E / Document Change 1, Unnumbered, NASA Manned Spacecraft Center, Houston, Texas, published 8 August 1972, revised 6 October 1972.

Berg, O.E. and F.F. Richardson, The Pioneer 8 Cosmic Dust Experiment, NASA Technical Note D-5267, NASA, Washington, D.C., July 1969.

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Berg, O. E., D. R. Williams, and M. Gaddy, "Apollo 17 Lunar Ejecta And Meteorites Experiment Calibration Notebook Bundle", NASA Planetary Data System, ID: urn:nasa:pds:a17leamcal, 2017. Digital reproduction of one hand-written laboratory notebook, "LEAM Notebook 1", of calibration analysis for the Apollo 17 Lunar Ejecta And Meteorites (LEAM) Experiment detector which was identical to the Pioneer 8 and 9 Cosmic Dust Detectors (CDD).

Final Engineering Report for Cosmic Dust Detector Model ML 309-1 and Cosmic Dust Detector Ground Support Equipment Model ML 310-1, prepared for NASA/Goddard, Technical Staff, Time-Zero Corporation, NASA CR-110703, 1970. (Available from NASA Technical Reports Service Registered website, https://ntrsreg.nasa.gov for NASA-registered users.)