/docs/ lunar.data.formats

Lunar raw data is formatted as a 'Z' header record and as many 'P' shot-by-shot 'photon' records as are necessary. Each 'Z-P' group contains data for some conveniently short time span. On the 2.7 m system, each group contained data for one 15-45 minute run on a given reflector. Each 45 minute ranging session contains at least 1 such run. On the MLRS, each 'Z-P' group coincides with a 3 minute 'burst' of ranging activity. In the processing of the laser data, there is a compression of data from a run into a normalpoint. The normalpoint set has a 'Z' record + 1 'N' record, instead of a 'Z' record and a number of 'P' records. The format of the 'P' and 'N' record are the same except for the addition of a field giving the number of filtered returns ('P' records) that were averaged to create the normalpoint.

The 80-column COSPAR format used on the 2.7m system has been informally expanded to include information beyond column 80 on the 'P' and 'N' records. These contain information as to data significance, residual, and point angles. Since the installation of the narrow pulse laser at MLRS, another record has been added to the format to permit inclusion of multi-pulse calibration data with the mailing of Z and P records. This is the 'C' calibration record.

I. Z RECORD FORMAT

columns	format	description
1	A1	Record ID = 'Z'
2- 4	I3	Observatory code (=711 for McDonald)
5-14	I10	Julian date * 1000
15-22	I8	Clock offset (microseconds)
23-25	I3	Atmospheric temperature (Celsius)
26-27	I2	Humidity (% saturation)
28-29	I2	Wind speed (km/hr)
30-31	I2	Seeing (0.1 arc sec)
32	A1	Electonic calibration accuracy code
33-34	2X	(spares)
35-37	I3	Laser energy (0.1 Joule)
38-42	I5	Laser frequency (10 gigahertz)
43-45	I3	Pulse length FWHM (100 picoseconds)
46-48	I3	Shot-by-shot resolution (100 picoseconds)
49-51	I3	Photomultiplier dark count (kHz)
52-54	I3	Moon count, i.e. lunar background (kHz)
55-57	I3	Star count (kHz)
58-62	A5	Star identification (alphabetic or numeric ID for star from which star count was obtained)
63-65	I3	Spectral filter width (0.01 nm)
66-68	I3	Spatial filter width (0.1 arc seconds)
69-72	I4	Number of shots in run
73-76	I4	Calendar year
77-78	I2	Month
79-80	I2	Day

II. P RECORD FORMAT

columns	format	description
1	A1	Record ID = 'P'
2-4	I3	Body identifier (Moon = 011)
5-21	I17	Observation epoch (Julian date * 1.E10)
22-26	I5	Telescope code (McDonald 2.7m = 71110)
27-28	I2	Reflector code (0,2,3,4)
29	A1	Observation type (=L)
30	I1	Epoch time base (use 1= UTC)
31-42	I12	Observed time delay (100 psec)
43-47	I5	Uncertainty estimate (100 psec)
48-53	I6	Electronic delay (100 psec)
54-58	I5	Geometric delay (100 psec)
59-61	3X	(spares)
62-66	I5	Frequency offset (parts in 10**11)
67	I1	Delay time base (=1)
68-72	I5	Atmospheric pressure (0.1 mb)
73-76	I4	Calendar year
77-78	I2	Month

```
67      I1      Delay time base (=1)
68-72   I5      Atmospheric pressure (0.1 mb)
73-76   I4      Calendar year
77-78   I2      Month
79-80   I2      Day

        Extensions to 'P' format:

B1      I1      Vernier number (for multi-stop systems; others are blank)
82      I1      Quality flag (0=noise, 1=return)
83-94   F12.2   Observed-predicted range residual (nsec)
95-105  F11.8   Predicted azimuth angle (radians)
106-116 F11.8   Predicted altitude angle (radians)
```

III. N RECORD FORMAT

Same as P record format, except

```
59-61   I3      Number of photon stops in normalpoint
```

IV. C RECORD FORMAT

Extension to Z & P format for multi-pulse data format.

```
columns format  description
 1      A1      Record ID ='C'
 2-73   10F7.2  Fire calibration - fire calibration average (nsec)
```

Note that these calibrations are packed 10 to a record without any time tags. These records may be interspersed with P records within a Z-P group.

The reason for not including the entire magnitude of the fire calibration in this record type is 2-fold:
1) Electronic delay on the P record already contains the fire cal average;
2) C record formats can allow tighter data packing knowing there will not be wide fluctuations in the magnitude of the cal differences.

V. How Do We Get There From Here??

Let me clarify a few things that have caused confusion in the past.

A. Calibration Accuracy Codes

A - better than +/-200 psec
B - +/-200 to +/-400 psec
C - +/-400 to +/-600 psec
D - +/-600 to +/-1000 psec
E - +/-1.0 to +/-1.5 nsec
F - +/-1.5 to +/-2.0 nsec
G - +/-2.0 to +/-4.0 nsec
H - worse than +/-4.0 nsec

= SQRT[(error of mean of fire calibrations)**2 +
(error of mean of return calibrations)**2]

B. Laser Frequency

532.0 nm = 56352
694.3 nm = 43178

C. Pulse length

Full-width half-maximum from fire calibration analysis.
2*(formal sigma of fire calibration)

D. Shot-by-shot resolution

SQRT[(formal sigma of fire calibration)**2 +
(formal sigma of return calibration)**2 +
SUM (formal sigma of each vernier)**2]

E. Uncertainty estimate

D. Shot-by-shot resolution
SQRT[(formal sigma of fire calibration)**2 +
(formal sigma of return calibration)**2 +
SUM (formal sigma of each vernier)**2]

E. Uncertainty estimate
P record:
Sum of electronic calibration accuracy code and shot-by-shot resolution.
N record:
SQRT[(shot-by-shot resolution)**2/N +
(calibration accuracy code)**2 +
(formal sigma of normalpoint data fit)**2/N]
where N is the number of photon returns averaged into normalpoint.

F. Star identification
Any 5 character designation for a star, e.g. VEGA, A LYR, FK409.

G. Number of shots in run
This field is only meaningful for runs when less than 10000 shots have been fired. Above this limit, legitimate entries could be 9999 or blanks.

H. Station/telescope codes

CERGA	01910
HOLLAS	56610
NLRS	41410
McD 2.7m	71110
MLRS	71111

I. Reflector codes
0 -- Apollo 11
1 -- Luna 17 (Lunakhod 1)
2 -- Apollo 14
3 -- Apollo 15
4 -- Luna 21 (Lunakhod 2)

J. Electronic delay
(fire calibration average)
- (return calibration average)
+ (any other electronically introduced range biases)

K. Geometric delay
(Correction to range to the first non-moving point in the ranging system)
+ (correction for finite size of telescope)

This may contain point-angle-dependent terms.

L. Reducted range
r= observed range
- electronic delay
- geometric delay
- observed range * frequency offset * 1.E-11
- refraction correction

M. UTC epoch (firing time)
t= observed time
+ clock offset*1.E-6/86400.