Data Introduction
New Horizons (NH) Radio Experiment (REX)

Science Objectives:

The NH/REX investigation has five objectives: (1) execution of radio occultations at Pluto and Charon (the "targets") to determine atmospheric temperature and pressure as a function of altitude; (2) determination of electron density profiles in the ionospheres of each; (3) estimation of target radii from length of the occultation chords; (4) inference of surface temperature from radiothermal emission measurements of each; and (5) derivation of mass (and higher order gravity field components) of Pluto and Charon from radio tracking data. Some of objectives may be beyond the sensitivity of REX — *e.g.*, Charon may have no detectable atmosphere and ionosphere, and Charon's mass may not be separable from the mass of the Pluto/Charon system. Radio tracking data (needed for the mass/gravity investigation) are not included in the REX archives; disposition of those data is TBD.

Instrument Operation:

REX hardware is redundant (sides A and B); each unit includes an Ultra-Stable Oscillator (USO) and signal processing board that samples X-band (4.2 cm wavelength) spacecraft radio receiver output. Three quantities are stored for transmission to Earth: (1) 102.4ms time-averages of power from a 10 Msps (Mega – million - samples per second) analog to digital converter (ADC), used for radiometry; (2) I/Q samples of a 1kHz downconverted baseband, used for the occultation studies; and (3) an integer time tag which increments every 102.4 ms.

In addition to performance of the USO and signal processing card, REX depends on the spacecraft high-gain antenna (HGA), low-noise amplifier (LNA), analog mixers, waveguides, and cabling. For occultations REX requires an uplink carrier signal transmitted from a NASA Deep Space Network (DSN) station on Earth that is tuned to fall within the 1 kHz I/Q bandwidth.

The redundant USOs are cross-strapped and can be switched between redundant transponders should one USO fail. The side A and B signal processing cards can process signals simultaneously from the right- and left-circularly polarized HGA feeds (RCP and LCP), respectively.. Sides A and B feed Command and Data Handling (C&DH) subsystems 1 and 2, respectively. Data (called REX Output Frames, or ROFs) can be downlinked in "compressed" or "packetized" format; because of anomalies in "compressed" mode, only "packetized" mode was used starting in 2007.

When powered on, REX can deliver samples of input from the HGA (status byte set to 0); or it can be configured to process the following internally generated signals that are substituted for the 10 Msps ADC output: a 200 ns pulse of value +128 followed by zeroes (status 16), a 610.3515625 Hz square wave of amplitude ±256 (status 32), a 19531.25 Hz square wave of amplitude ±256 (status 48); a pseudo-random number (PRN) of amplitude ±1 (status 64); a PRN at full scale (status 80); and all zeroes (status 112).

Reading the Data:

Archival data are stored in directories with names of the form ***yyyymmdd_kkk*** where ***yyyy***, ***mm***, and ***dd*** are the year, month, and day on which data taking started and ***kkk*** is the 6-digit mission elapsed time (MET) prefix. Data files have names of the form ***rex_mmm_0xaaa_nnn.fit*** where ***mmm*** is the 10-digit spacecraft clock time suffix, ***aaa*** is the telemetry application identifier (ApID), and ***nnn*** is the processing level identifier.

aaa = 7b0 (side A compressed), 7b1 (side A packetized),

7b2 (side B compressed), or 7b3 (side B packetized)

nnn = eng (raw data), or sci (calibrated)

A detached PDS label file with name ***rex_mmm_0xaaa_nnn_v.lbl*** accompanies each data file and describes its structure. All data files have records with 2880 bytes and contain data from 1.024 seconds of REX operation; many sequential files must usually be processed to reconstruct a REX observation.

Raw Data: Data files are stored in the FITS format; each consists of several FITS headers, tables, and/or images organized into records of 2880 bytes. An example label fragment is shown below.

```
PDS_VERSION_ID       = PDS3
RECORD_TYPE          = FIXED_LENGTH
RECORD_BYTES         = 2880
FILE_RECORDS         = 28
^HEADER = "REX_0013891463_0X7B1_ENG.FIT"
^ARRAY = ("REX_0013891463_0X7B1_ENG.FIT", 9)
^EXTENSION_IQVALS_HEADER = ("REX_0013891463_0X7B1_ENG.FIT", 11)
^EXTENSION_IQVALS_TABLE = ("REX_0013891463_0X7B1_ENG.FIT", 12)
^EXTENSION_RAD_TIME_TAGS_HEADER = ("REX_0013891463_0X7B1_ENG.FIT", 14)
^EXTENSION_RAD_TIME_TAGS_TABLE = ("REX_0013891463_0X7B1_ENG.FIT", 15)
^EXTENSION_HK_0X004_HEADER = ("REX_0013891463_0X7B1_ENG.FIT", 16)
^EXTENSION_HK_0X004_TABLE = ("REX_0013891463_0X7B1_ENG.FIT", 17)
                                    ...
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The original binary data (ROFs) begin at the record given by ^ARRAY (or ^IMAGE in some files); these data are difficult to extract and will rarely be needed by users. However, ROF byte 4 is the status byte that gives the REX configuration (see above). Unpacked I/Q samples begin at the record given by ^EXTENSION_IQVALS_TABLE; there are 1250 pairs of time-ordered 4-byte MSB integer I and Q values in these two records (unused space at the end of the second record is undefined). Unpacked radiometer values and time tags are stored in the record given by ^EXTENSION_RAD_TIME_TAGS_TABLE. An 8-byte MSB integer radiometer value is followed by a 4-byte MSB integer time tag; there are 10 pairs, and the remainder of the record is undefined.

The radiometer values are accumulated over the 1.024 s file duration but saved at the end of every 102.4 ms interval. The first value in each file contains the 1.024 s sum that should be associated with the previous file. The accumulator is reset before summing begins for the new file. Time tags are initialized at the beginning of an observing session and are incremented by one at every 102.4 ms time step, usually crossing file boundaries without being reset. Time tags are mostly useful for detecting missing files or data corruption; absolute time can be derived from START_TIME in the PDS label file.

Calibrated Data: Structure of the calibrated data files is the same as for the raw data files. But I/Q samples are scaled to ±1000 mv as seen at the ADC input, radiometer values are calibrated to dBm based on cruise measurements of natural radio sources, and time tags are given in seconds. All calibrated values are 4-byte IEEE real floating point numbers.