STEREO – IMPACT – SEP
Solar Electron Proton Telescope (SEPT)
Ground Test Procedures

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v 1.7, 2005/05/12

1 Scope

This note describes the procedures to test the SEPT instruments after integration with the SEP suite, up to, and including integration on the spacecraft.

2 Requirements

To perform these tests, SEPT must be hooked up to a SEP-Central unit, and a communication channel must be set up to send commands to SEP-Central and to receive telemetry packets from SEP-Central.

The gamma source aliveness test requires a radioactive source, like ^{60}Co, with an activity in the order of $1\,\mu$Ci.

3 Tests

Four tests are defined to verify the health of the instrument:

- Quiet run.
- Inflight test pulse generator run.
- ^{60}Co source run.
- Cosmics run.

3.1 Quiet Run

To run this test, the SEPT instruments are configured for nominal mission data acquisition, and collect data for at least ten minutes.

Ten minutes of data are required to make sure that each detector's individual count rate is observed at least once during a one minute observation cycle. Three further minutes are required for the instrument to reach nominal mode after receiving the command to do so.

When the SEP-Central unit is not configured with the connected SEPT instrument's nominal thresholds, sensible detection thresholds must be uploaded before this test.

3.1.1 Procedure

The command to turn the instruments to nominal mode after power up is:

`SPFM`$\langle n \rangle$`-GO`

where $\langle n \rangle$ is either `1`, or `2`, for flight model 1 (S/C ahead) and 2 (S/C behind). This command loads the preconfigured detection thresholds for the appropriate flight instruments.

That command is part of the command

`ALLON`$\langle n \rangle$

which also boots the other instruments of the SEP suite, if that is desirable.

To turn on SEPT into nominal mode without loading thresholds, the distinction between 1 and 2 is not needed, use the command

```
SP-GO
```

If the SEP-Central unit is not known to be configured with proper thresholds for the connected instruments, some sensible values should be loaded for main threshold levels

```
15 MLEV-E!
15 MLEV-N!
```

and guard (coincidence) threshold levels:

```
17 CLEV-E!
17 CLEV-N!
```

Collect data for 10 minutes, to make sure that all commands became effective and eight successive accumulation periods worth of data were recorded.

3.1.2 Results

In the SEP housekeeping packets (APID 577, 0x241 hex), verify that the values returned by the SEP-Central power supply voltage monitors are within range.

In the SEP housekeeping packets, verify that the SEPT temperatures are within range. (Subtract 166 from the raw readings to get degree Celsius.) A raw temperature reading of zero indicates that SEPT is not (yet) sending data. A valid reading confirms that SEPT is responding to commands.

In the SEP housekeeping packets, verify that the raw leakage current readings do not overflow to the value 255. A reading different from 255 indicates that the bias voltage is present. Raw readings between 50 and 150 are expected.

In the SEPT science packets for SEPT-NS (APID 600, 0x258 hex) and SEPT-E (APID 601, 0x259 hex), verify that the spectra contain only noise counts in the lower five energy bins, and only a few sporadic counts in the higher bins of the 32-bin histogram. Excess noise may be caused by disturbances from the environment.

3.2 Inflight Test Pulse Generator

The SEPT instruments have simple inflight test pulse generators to test the analog electronics and the coincidence logic. Serious detector noise problems will also show up.

Pulses of four different amplitudes can be injected into the charge sensitive amplifiers. A 4-bit mask defines the set of inputs subjected to the pulses.

SEP-Central keeps a table of test configurations (amplitude, mask, coincidence mode) to be performed. The first ten entries in the table are preloaded with a set of tests that reasonably covers all detector channels and coincidence conditions, with a single pulse amplitude. The remaining 30 entries repeat these tests with different amplitudes.

A short test would run through 10 entries, a full test runs through all 40 entries. Each test requires a one minute accumulation cycle.

3.2.1 Procedure

Make sure that SEPT is up and running, with reasonable thresholds. This test is usually run after the *quiet mode run*, so that no further action is required. To run a test for $\langle n \rangle$ minutes (usually 10 or 40), do

$\langle n \rangle$ `SPETEST`

$\langle n \rangle$ `SPNTEST`

After $\langle n \rangle$ minutes, the instruments will automatically return to nominal mode.

3.2.2 Results

Identify the SEPT science packets with non-zero test-pulser configuration. (Current versions of the flight software keep the pulser configuration unchanged when the pulse generator run finished. In that case, the previous data packet must show the value 0x4f hex in the mode flags byte.)

All test pulser packets must show about 1 047 000 counts in the single detector counter.

The sixth column in Table 1 tells which spectra should show a corresponding peak. The peaks should be mostly contained in a single energy bin of the spectra.

Table 1: Inflight test pulse generator mode table

seq	**pdfe**	**filter**	**counter**	**pulse**	**peak**
0	anti	nominal	(0) Main 0	(0x28) Main even	even
1	anti	nominal	(1) Main 1	(0x22) Main odd	odd
2	anti	nominal	(2) Main 2	(0x2A) Main even/odd	none
3	anti	nominal	(4) Guard 0	(0x2C) Main/Guard even	none
4	anti	nominal	(5) Guard 1	(0x23) Main/Guard odd	none
5	anti	nominal	(7) Guard 3	(0x29) Main even, Guard odd	none
6	anti	nominal	(6) Guard 2	(0x26) Main odd, Guard even	none
7	coinc	test	(3) Main 3	(0x2A) Main even/odd	all
8	coinc	test	(4) Guard 0	(0x2E) Main/Guard even, Main odd	all
9	coinc	test	(7) Guard 3	(0x2B) Main even, Main/Guard odd	all

pdfe: PDFE operation mode, external coincidence (mode 5) or anti-coincidence (mode 4).

filter: External coincidence filter mode. *nominal*: all other signals contribute (0xAA), or *test*: only the other Main channel contributes (0xFF).

counter: Single detector counter number. Main channels: 0–3, Guard channels 4–7.

pulse: Which PDFE inputs the generated pulse is applied to. The pulser configuration specifies the amplitude in bits 5:4. The value 0 is the highest, 3 the lowest amplitude. For a short run the amplitude is 2, as shown in the table. The bits 3:0 indicate which detector inputs to stimulate. Bit 3: even main, bit 2: even guard, bit 1: odd main, bit 0: odd guard. The A and B sides of the telescopes receive the same stimulation.

peak: Which spectra must show the pulser peak.

3.3 ^{60}Co Source Test

A quick test to certify that all detectors are alive is achieved with a radioactive gamma ray source.

3.3.1 Procedure

The instruments are setup in nominal mode just like for a quiet run in section 3.1.1.

The source, preferably ^{60}Co with an activity in the order of $1\,\mu$Ci, is placed as closely as permitted to the sensor head of the SEPT instrument. When the instrument is standing, it is easy to just lay the source on top of the sensor housing. A small plastic transport container need not be removed from the source. The source should be bagged, to prevent contamination of the instrument. The instrument doors should remain closed.

When the instruments are running in nominal quiet mode, the source is placed for 10 minutes next to each instrument.

3.3.2 Results

After placing the source, wait a few minutes until SEPT science packets arrive with the source present during the full acquisition period.

When the source is present, significant activity should be recorded in higher energy bins in the spectra of all channels.

In eight consecutive acquisition periods, the single detector counter readings should show increased activity compared to quiet run without source.

3.4 Cosmics Run

The SEPT instrument's response to cosmic muons can certify aliveness of the main detector channels, and give a coarse indication that the energy scale is correct.

About two hours of accumulation is necessary to see the peaks of minimum ionizing particles in the spectra.

3.4.1 Procedure

The discriminator thresholds must be raised well above their nominal values to prevent coherent digital noise from triggering the readout. After bringing the instruments up (section 3.1.1), issue:

```
30 MLEV-E!
```

```
30 MLEV-N!
30 CLEV-E!
30 CLEV-N!
```

To start a cosmics run for $\langle n \rangle$ minutes, do

$\langle n \rangle$ `SPECALM`

$\langle n \rangle$ `SPNCALM`

The instruments will return to nominal mode after $\langle n \rangle$ minutes. To abort a cosmics run and return to nominal mode earlier, issue

```
SPENORM
SPNNORM
```

3.4.2 Results

The spectra in the SEPT science packets should be very quiet, mostly no counts at all. Beyond that, any activity is a sign of environmental noise or a problem with the instrument.

To see the minimum ionizing particles peak, the spectra of the whole run must be added, for each channel separately, omitting noisy accumulations with more than, say, three counts.

4 Test sequences

This section defines four test sequences: a *Limited Performance Test* (LPT, 20 minutes), a *Comprehensive Performance Test* (CPT) with (70 minutes) and without ^{60}Co source test (50 minutes), and a cosmics test (120 minutes). See Table 2 for a summary.

Table 2: Test sequences

Test	**LPT**	**CPT**	**CPT+^{60}Co**	**Cosmics**
Quiet run	11 min	11 min	11 min	
Inflight test pulse generator run	12 min	42 min	42 min	
^{60}Co source run (SEPT-E)			11 min	
^{60}Co source run (SEPT-NS)			11 min	
Cosmics Test				123 min
Total	23 min	53 min	75 min	123 min

4.1 Limited Performance Test

The limited performance test is a quick test to confirm that the instruments basic functions are working. During a *quiet run* (section 3.1), the basic housekeeping numbers are checked, and a short *inflight test pulse generator run* (section 3.2) tells wether the analog electronics are alive.

See Table 3 for the complete command sequence. This test can be completed in 23 minutes.

Table 3: LPT command sequence

	power on	1 min
`SP-GO`	start SEPT software	0 min
`15 MLEV-E!`	load main thresholds SEPT-E	0 min
`15 MLEV-N!`	load main thresholds SEPT-NS	0 min
`17 CLEV-E!`	load guard thresholds SEPT-E	0 min
`17 CLEV-N!`	load guard thresholds SEPT-NS	0 min
	record 10 acquisition cycles	10 min
`10 SPETEST`	start itpg run SEPT-E	0 min
`10 SPNTEST`	start itpg run SEPT-NS	0 min
	wait for mode change	2 min
	record 10 acquisition cycles	10 min
	Total time:	23 min

Table 4: CPT command sequence

	power on	1 min
`SP-GO`	start SEPT software	0 min
`15 MLEV-E!`	load main thresholds SEPT-E	0 min
`15 MLEV-N!`	load main thresholds SEPT-NS	0 min
`17 CLEV-E!`	load guard thresholds SEPT-E	0 min
`17 CLEV-N!`	load guard thresholds SEPT-NS	0 min
	record 10 acquisition cycles	10 min
`40 SPETEST`	start itpg run SEPT-E	0 min
`40 SPNTEST`	start itpg run SEPT-NS	0 min
	wait for mode change	2 min
	record 40 acquisition cycles	40 min
	Total time:	53 min

4.2 Comprehensive Performance Test

The comprehensive performance test differs from the LPT only by extending the inflight test pulse generator run to the full 40 minutes, thus providing a more comprehensive test of the analog electronic.

See Table 4 for the complete command sequence. This test can be completed in 53 minutes.

Table 5: CPT+^{60}Co command sequence

	power on SEP-Central	1 min
`SP-GO`	start SEPT software	0 min
`15 MLEV-E!`	load main thresholds SEPT-E	0 min
`15 MLEV-N!`	load main thresholds SEPT-NS	0 min
`17 CLEV-E!`	load guard thresholds SEPT-E	0 min
`17 CLEV-N!`	load guard thresholds SEPT-NS	0 min
	record 10 acquisition cycles	10 min
`40 SPETEST`	start itpg run SEPT-E	0 min
`40 SPNTEST`	start itpg run SEPT-NS	0 min
	wait for mode change	2 min
	record 40 acquisition cycles	40 min
	place source next to SEPT-E	1 min
	record 10 acquisition cycles	10 min
	place source next to SEPT-NS	1 min
	record 10 acquisition cycles	10 min
	Total time:	75 min

Table 6: Cosmics Test command sequence

	power on SEP-Central	1 min
`SP-GO`	start SEPT software	0 min
`30 MLEV-E!`	load main thresholds SEPT-E	0 min
`30 MLEV-N!`	load main thresholds SEPT-NS	0 min
`30 CLEV-E!`	load guard thresholds SEPT-E	0 min
`30 CLEV-N!`	load guard thresholds SEPT-NS	0 min
`120 SPECALM`	start cosmics run SEPT-E	0 min
`120 SPNCALM`	start cosmics run SEPT-NS	0 min
	wait for mode change	2 min
	record 120 acquisition cycles	120 min
	Total time:	123 min

4.3 Comprehensive Performance Test + ^{60}Co

The simple CPT does not test wether the detectors are alive. A ^{60}Co source test is required to confirm that all detectors are connected to the electronics and provide a signal.

See Table 5 for the complete command sequence. This test can be completed in 75 minutes.

4.4 Cosmics Test

The cosmics test can replace or complement the ^{60}Co source test, in cases when bringing a source is difficult, and enough time in a low noise environment is available.

This test requires at least two hours to provide meaningful data, but no operator attention nor telecommanding is necessary during the run. The instruments operate in a very quiet configuration. Therefore, this test can run in the background while other SEP-suite instruments are undergoing tests.

See Table 6 for the complete command sequence.