Ion and Neutral Mass Spectrometer

Instrument Check Out 1 Report

1 December 1999

SWRI Doc Control Number INMS-ICO1-001

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1 – ICO Overview

1.1 Executive Summary (Hunter Waite)

Successful tests of the INMS and ground operations software, as well as a short period of anomalous operation, characterized ICO for INMS. While the first baseline executed erroneously as the result of an incorrect command sequence, a second baseline was accomplished during contingency time. The data from this second baseline indicates INMS operating nominally in all aspects. While this is excellent news, the fact that an incorrect command sequence made it to the instrument suggests certain operational changes are in order before any continued operation of the FM.

This report outlines the events of ICO for INMS in chronological order, based on the major instrument commanding events. The causes and results of the anomalous operation period are explained in great detail in section 4, the results of the second baseline in section 7, and the recommendations for changes in section 8. It may be beneficial to reference Appendix B, "Baseline Summary," when reading baseline related items. Each section also denotes the authoring scientist, engineer or analyst who can provide additional or more detailed information. Please feel free to forward your comments and questions.

1.2 Planned Timeline (Dana Burket)

The timeline presented below is the planned timeline for ICO. All days and times are UTC (Universal Time Code) - to convert to Central Standard Time (for example) subtract 6 hours. For security reasons command names have been replaced by command file names in this report. Appendix C contains a complete list of command files.

DOY 004 - FSW Load and Memory Dump

1) 05:45: – 06:15 UTC
Power on INMS, FSW load, memory dump, go to Sleep 0 State.
All activities executed from the background sequence.

DOY 005 - Pressure Test and Baseline Test

2) 06:35 – 18:15 UTC

Pressure test, INMS real-time power-supply turn-on, INMS baseline
* See contingency scenario that might alter steps 2.2 - 2.4.

2.1) Nominal timing: 06:35 – 06:59 UTC

Upon GO from INMS, send RTC file: i0882a_inms_pressure_test

2.2) Estimated timing: 06:59 – 07:19 UTC

Upon GO from INMS, send RTC file: i0883a_inms_lens_emhv_on

2.3) Estimated timing: 07:19 – 07:39 UTC

Upon GO from INMS, send RTC file: i0884a_inms_rf_on

2.4) Estimated timing: 07:39 – 07:59 UTC

Upon GO from INMS, send RTC file: i0885a_inms_fil1_on

2.5) Estimated timing: 15:00 – 15:07 UTC

Upon GO from INMS, send RTC file: i0886a_inms_sleep1

2.6) 16:15 – 17:30 UTC

INMS baseline test will be executed from the background sequence. The baseline will execute only if the INMS team has previously put the instrument in the Sleep 1 state (step 2.5).

DOY 010 - Pressure Test and Quiet Test

3) 02:05 – 13:12 UTC

INMS pressure test and INMS participation in the Quiet Test

3.1) 02:05 – 02:20 UTC

This pressure check is sent to INMS from the background sequence. Due to a borderline timing gap between two commands (with resulting INMS onboard race condition), this pressure test will probably not execute. INMS will proceed with step 3.2 if it does not execute and step 3.3 if it does execute.

3.2) Conditional estimated timing: 2:20 – 2:44 UTC

If the pressure test from step 3.1 does not execute, INMS will give a GO to send RTC file: i0882a_inms_pressure_test

3.3) Estimated timing: 4:00 – 4:07 UTC

If a successful pressure test in step 3.1 or 3.2, INMS will give a GO to send RTC file: i0886a_inms_sleep1

3.4) Estimated Timing: 5:01:31 UTC

Command in the background sequence will put INMS in Default Science Mode

3.5) Estimated Timing: 13:12 UTC

Command in the background sequence will put INMS in Sleep 0 state.

DOY 13 - INMS Contingency Pass

4) INMS Contingency pass is on DOY 13 and is shared with UVIS. The pass is scheduled for 00:55: – 09:10 UTC

DOY 18 - RADAR/INMS Testing

5) 1:40 – 19:25 UTC

INMS pressure test, INMS participation in Radar/INMS Test, Power Off

5.1) 1:40 – 1:55 UTC

This pressure check is sent to INMS from the background sequence. Due to a borderline timing gap between two commands (with resulting INMS onboard race condition), this pressure test will probably not execute. INMS will proceed with step 5.2 if it does not execute and step 5.3 if it does execute.

5.2) Conditional estimated timing: 1:55 – 2:19 UTC

If the pressure test from step 5.1 does not execute, INMS will give a GO to send RTC file: i0882a_inms_pressure_test

5.3) Conditional estimated timing:

If not necessary to execute 4.2, 1:55 – 2:09 UTC, Else if 5.2 is executed, 2:19 – 2:33 UTC
If a successful pressure test completed in step 5.1 or 5.2, INMS will give a GO to send RTC file: i0886a_inms_sleep1

<u>Note that this RTC should be sent by approximately 8:30 UTC to avoid End of Track at 9:10 UTC.</u>

5.4) 10:45 – 10:45 UTC

Commands in the background sequence will put INMS in Configuration 15 (Filament 1, unity sweep), provided step 5.3 was executed.
Tracking will be lost at approximately _____________ due to Radar testing.

5.5) 19:25 – 19:25 UTC

Commands in the background sequence will turn INMS off and turn on the INMS replacement heater.

***CONTINGENCY**

6) In the event that timing becomes limited on DOY 005, there are some contingency steps that the INMS might choose to take. (There is not a high probability of needing to use these contingency scenarios 6.1 and 6.2 now, since we were able to get approval to begin INMS real-time commanding well before the start of our background sequence on DOY 005 at 16:15 UTC.)

6.1) If we entered this contingency situation, the INMS team might choose to replace steps 2.2 and 2.3 with:

Timing window: 06:59 – 16:08 UTC
Upon GO from INMS, send RTC file: i0888b_inms_cont_le_em_rf

6.2) If we entered this contingency situation, the INMS team might choose to, delete step 2.4

The INMS team has also submitted some real-time command files to cover general contingency situations. These files include:

i0887a_inms_cont_sleep0	Puts INMS in Sleep 0 Mode.
s0889c_inms_cont_off	Turns INMS instrument power off.
s0890c_inms_cont_htr_on	Turns on INMS replacement heater.
s0891a_inms_cont_offhtron	Turns INMS instrument power off and INMS replacement heater on.
i1214a_inms_mro	Does MRO of all INMS RAM space.

All submitted INMS contingency commands should be available for immediate radiation upon a GO from INMS and any other JPL elements necessary, since these contingency commands would be used in the event of a serious anomaly.

1.3 Actual Timeline (Dana Burket)

The timeline presented below is the actual timeline for ICO, including the aborted first baseline, an additional memory dump, dropping the INMS/RADAR test and accomplishing a second baseline during the rescheduled contingency time. All days and times are in UTC. Appendix C contains a complete list of command files. A detailed event log of ICO (sequence C11) can be found in the file B0110M.pef at JPL on the Distributed Operations Management (DOM) system.

DOY 004 - FSW Load and Memory Dump

05:45 - 06:15 CT Background sequence (b0112g) turned replacement heater off, INMS on, ALF load, dumped memory.

DOY 005 - Pressure Test and Baseline Test #1 (aborted)

Time (UTC)	Command File	Description
07:03:14	i0882a_inms_pressure_test	Sent RTC to accomplished INMS pressure test
07:25:44	i0883a_inms_lens_emhv_on	Sent RTC to turn on lens and EM high voltage supplies
07:43:03	i0884a_inms_rf_on	Sent RTC to turn on RF supply (& lens, EMHV supplies)
08:00:16	i0885a_inms_fil1_on	Sent RTC to turn on filament 1 (& RF, lens, EMHV supplies)
15:14:39	i0886a_inms_sleep1	Sent RTC to put INMS in sleep 1 waiting for baseline test
16:15:00	b0112g	Started INMS baseline test (from background sequence, actual start time)
17:14:17	i0887a_inms_cont_sleep0	Sent RTC command to terminate INMS baseline test

DOY 006 - Memory Readout to verify state of INMS Memory

03:38:55 i1214_inms_mro - RTC command initiated a memory readout

DOY 010 - Pressure Test and Quiet Test

Time (UTC)	Command File	Description
02:05:00	b0112g	Ran the INMS pressure test via background sequence (b0112g)
03:03:24	m0117a_reloadram_mro	Sent mini-sequence to reload FSW patches and perform a MRO
04:19:59	i0886a_inms_sleep1	Sent RTC to put INMS in sleep mode 1 awaiting quiet test
05:01:31	b0112g	Put INMS in default science for quiet test via background sequence
13:12:00	b0112g	Put INMS in sleep 0 to end quiet test via background sequence

DOY 011 - Cassini enters safe mode

22:59:26 Spacecraft flight software turned INMS off and the INMS replacement heater on.

Note: After the spacecraft entered safing INMS temperatures remained at safe levels:
S-1700 (electronics box): 4 degrees C
S-1701 (sensor area): -4 degrees C

DOY 021 - Baseline 2 during Contingency Time

Time (UTC)	Command File	Description
10:13:30	m011ga_inms_on_load_mro	Sent mini-sequence to turn INMS heater off, INMS on, load ALFs from SSR, do MRO
11:14:32	i0882a_inms_pressure_test	Sent RTC to execute INMS pressure test
12:39:44	m0118a_inms_cont_seq	Sent mini-sequence to put INMS in sleep 1, the run corrected baseline test
14:09:29	s0891a_inms_cont_offhtron	Sent RTC to turn INMS off and replacement heater on

Section 2 – INMS Turn-on, ALF Load, and Memory Readout

2.1 Overview (Dana Burket)

The INMS instrument was powered on from the spacecraft background sequence at 05:45 UTC on Day of Year (DOY) 004. The INMS flight software patches and instrument operating tables were then loaded to the instrument via the JPL required format, the Assisted Load Format (ALF). A memory readout (MRO) was then executed in order to verify that the INMS flight software patches and instrument operating tables were loaded correctly into instrument RAM. The ALF load and MRO were accomplished via commands that were issued to the INMS instrument from the spacecraft background sequence. The INMS team was able to verify from housekeeping and science dump data packets that the instrument turn-on, ALF load, and MRO all executed nominally. The team also confirmed that the contents of the INMS RAM and IORAM space were as expected by using software tools to compare the MRO data to predict files.

2.2 Test Programs (Rob Thorpe)

Creating the Memory Dump File

After the memory dump was completed and recorded using the INMS-GSE software, the program “inms_mem_dump” was run in the directory where the memory readout files were stored. This program produced an ASCII text file, mem_dump.txt, containing INMS memory addresses and contents listed serially. Already available for comparison were complete memory dumps from the FM - one file containing a RAM memory dump (ramdump.txt) and one containing an IORAM memory dump (ioramdump.fm). These files will be called FM reference files for the rest of this summary. These reference files were also created from the program inms_mem_dump and were in the same format as the files created from the ICO memory dumps.

Comparison Methods

When comparing ICO memory dump files to FM reference files it is important to understand that some memory locations may have different values. Two identical dumps of INMS memory will not be exactly the same because some areas of memory are set aside for stack space and other flight software variable space, and some space is simply not used at all. Therefore, when comparing the ICO memory dump to the reference files it is acceptable that some areas are different.

Two methods were used to analyze the results of the ICO memory readout. The first method was a comparison using the Diff utility built into the Unix operating system on INMS-GSE. The sections of mem_dump.txt containing allowable variances (stack space for example) were stripped out, and the files were compared using the Diff program, which reported no differences. This process took about 25 minutes.

The second method involved the use of a PC Tool called Windiff, which performed a visual comparison of the files. Mem_dump.txt was transferred to a PC using ftp, then loaded into Windiff. It was first compared against ramdump.txt then ioramdump.fm. The comparison process was visual and simple, and accomplished by ensuring that Windiff reported no differences in all appropriate memory areas. This process took about 10 minutes. Figure 2.1 is a Windiff screen-shot (note: red and yellow background colors on lines represent differences between corresponding lines in each file).

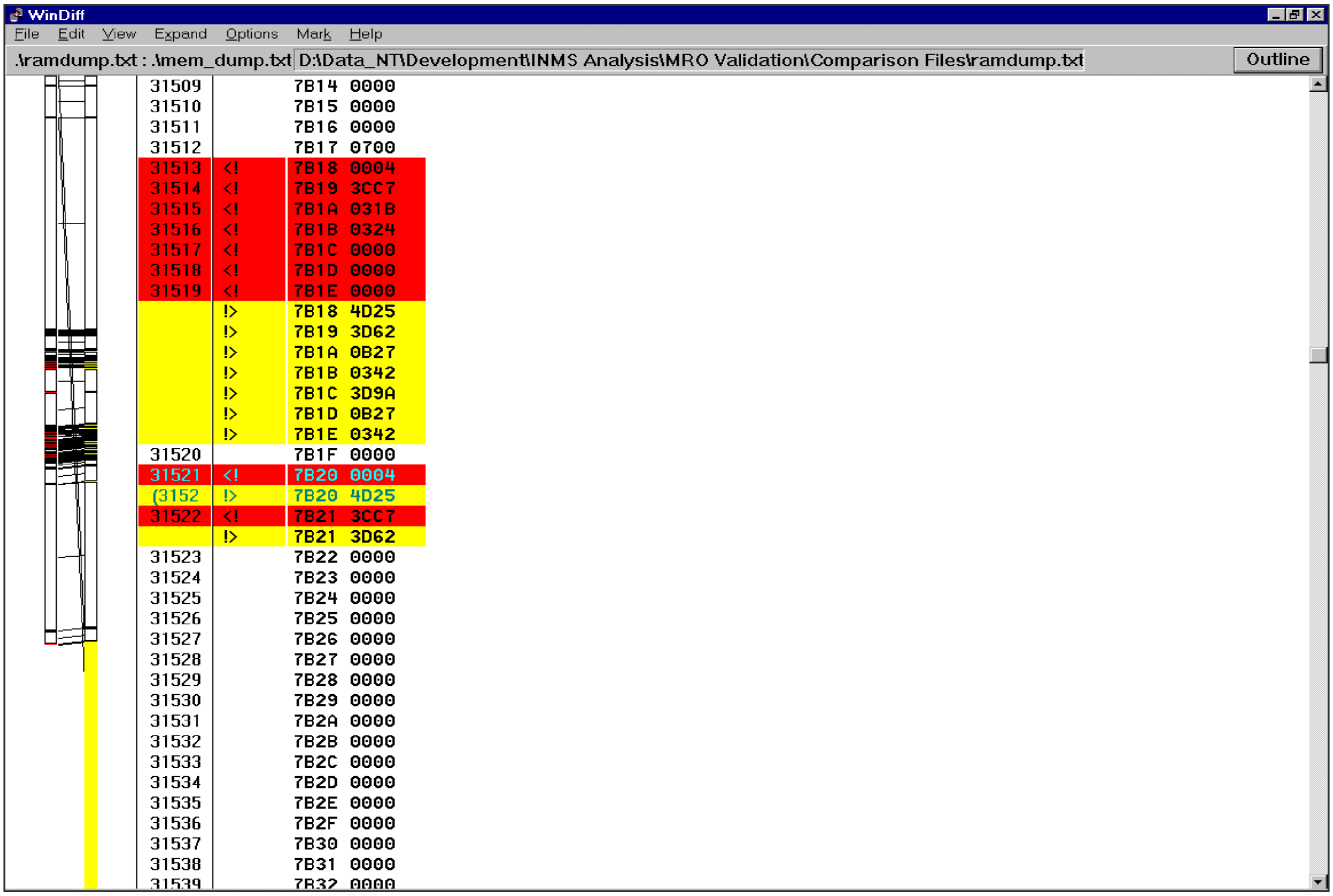

Figure 2.1 – Windiff Screen Shot

Approved Variable Areas of RAM and IORAM

Table 2.1 lists RAM memory areas allowed to be different between two INMS memory dumps. ICO operational tables should be identical, so only memory areas marked “variable…” or “spare…” could contain differing values.

RAM Memory Locations Containing Potential Conflicts		
From	**To**	**Description**
0040	007F	Interrupt vectors
0480	059F	Variable bootstrap area
12E0	12F2	Variable data for aioramla.asm
479C	47AB	Spare
71BE	81FF	Variable data
9000	B802	Variable stack
B908	C6D7	Mass Tables
C6D8	D6C7	Switching Tables
D6C8	E6B7	Trap Tables
E6B8	F6A7	Focus Tables
F6A8	F6D7	DAC Tables
F6D8	F6E7	Velocity Tables
F6E8	F6FB	Spare
F6FC	F8F2	AMB
F971	F987	Variable cmp07 data
F9F1	FA02	Variable cmp08 data

Table 2.1 – INMS RAM Memory Locations Allowed to be Different

Table 2.2 lists IORAM memory areas allowed to be different between two INMS memory dumps. ICO operational should be indentical, so only those memory areas marked “TM Buffer…” and “spare…” could contain differing values.

IORAM Memory Locations Containing Potential Conflicts		
From	**To**	**Description**
0000	1FFF	Sequence Tables
2000	3FFF	Cycle Tables
4000	5FFF	TM Buffer (variable)
6000	632F	Mass Tables
6330	6CBF	Switching Tables
6CC0	764F	Trap Tables
7650	7FDF	Focus Tables
7FE0	7FFF	Spare

Table 2.2 - INMS IORAM Memory Locations Allowed to be Different

Both memory verification methods, cross referenced with the information listed in these tables, proved to be precise and effective. There was one instance in which a RAM data value was different in the ICO ramdump file than in the comparison ramdump file. The use of one additional file, “inms12104.adalist” (a detailed code listing with address generated from a flight software compiler program called “Tartan Adalist”) provided a method of examining the code space using flight software notes. It was determined that the differing data value was in a memory location not in use, and the memory location (479C – 47AB) was added to table 2.1.

2.3 Analysis of MRO (Rob Thorpe)

Four memory readouts were commanded during ICO1. They are listed chronologically by their data directory names as follows:

19990103.2235-ico1_mro1 – This memory readout was performed to confirm the state of the instrument prior to initiating ico1_baseline1. The memory readout data was compared using both techniques described above. Both techniques verified instrument memory identical to FM reference files.

19990105.2241-ico1_mro2_anomaly_resolution – This memory readout was performed to determine the state of the instrument when it was shut down due to anomalous operation. The data from this readout helped resolve the conditions leading to anomalous operation of the instrument. Windiff was used to identify and confirm differences between the state of the instrument and FM reference files.

19990109.1948-ico1_mro3_pre_qt_reload – This memory readout was performed prior to execution of the quiet test to confirm the state of the instrument. Windiff was used to confirm the state of the instrument against FM reference files.

19990121.0348_ico1_mro4 – This memory readout was performed prior to execution of ico1_baseline2. Windiff was used to confirm the state of the instrument against FM reference files.

Conclusion

With the exception of a procedural error occurring while dumping IORAM (see item 4 below), all memory dumps confirmed the memory of INMS at the time of ICO was the same as the memory of the instrument recorded from previous memory dumps.

2.4 Analysis of Engineering Data (John Maurer)

The initial turn-on of the INMS for the purpose of a memory dump (no analog functions) was completed early on the morning of January 4th, 1999. There were no observed instrument problems.

The following are my observations based on very preliminary analysis. These observation are from files 19990103.2235-ico1-mro1 and 19990104.0013-ico1_after_mro1. The INMS is on (in sleep0) receiving data at this time.

a) The initial turn-on temperature was about 0C. The SC reported –5C on the analyzer sensor.

b) After 1/2 hour the LVPS temperature was 7.5C and FB supply 4.5C. The instrument was left in sleep0, meaning that we continued to receive HK data.

c) At the end of 12 hours the LVPS was at 12.7C, Computer 9.9C, EM Supply 9.0C, FB Supply 11.8C, and the RF Tank 7.0C. There was little change over the last hour implying that the temperatures had stabilized. This would imply that we can expect about a 10C to 12C rise in temperature for instrument on in the sleep0 mode.

d) The input current was .338A. This is the same reading found for the last turn-on after T-V testing (in the minimum power mode). It went down to .332A at the end of 12 hours.

e) The RF frequency is 1.664MHz – identical to the last reading after T-V. This indicates that we should expect to see little or no mass tuning shift due to frequency changes.

f) Voltage and bias monitors appear to be nominal – meaning the same as last T-V test.

g) The plotzhk_it script did not print meaningful data – no values and questionable timebase value.

h) The GSE display, on the workstation did not work. However, the script Display, on the laptop worked well for showing and printing tabular displays.

2.5 Packet Summary Report (Florence Tan)

INMS was powered, the patches and tables were loaded using ALF Loads, and commands were uplinked to dump RAM and IORAM space. Analysis of the extracted dump data using two independent verification methods showed no anomalies. A total of 33 commands were sent to dump RAM space and 15 commands to dump IORAM space. Table 2.3 contains MRO statistics.

Dump	No. Sci Dumps received
RAM dump	386 packets
IORAM dump	169 packets
Total	555 packets

Table 2.3 – Memory Readout Statistics

In addition, Table 2.4 shows the following housekeeping words were verified:

Variable	Value	Comment
Imon	0.338A	Sleep 0 current, same as Baseline 44
AGC Mon	1.664 MHz	Same as Baseline 44
BIU_Disc	00h	INMS in Sleep 0 mode
BIU_Err	00h	no errors
BIU Out	E1h	indicates PROM transferred successfully to RAM
Genrl_Stat	xxxx x110 xxxx $xx11_2$ ($x603_{16}$ or $xc03_{16}$ or $xe03_{16}$)	All systems Go
Error_Stat	8000h or 9000h	TGO reset triggered during wait for ALF, Software updating TGO register
Fail_Stat	2000h	ALF load occurred
TC Rcv	48	After RAM and IORAM dump
TC Reject	0	nominal

Table 2.4 – Verified Housekeeping Words

2.6 IO RAM Dump Procedural Error (Florence Tan)

A procedural error was discovered as a result of the analysis of INMS memory dumps. The error occurs as a result of the misuse of the 74QX_IORAMDUMP command. This command is used to dump memory from IO RAM, but is not designed to process dumps across 2000h boundaries. During ICO this command was executed with parameters causing it to cross 2000h boundaries, resulting in incorrect data produced in the dump. However, the command had been used with incorrect parameters when the FM files were created on the EM, so these incorrect templates matched with the memory dumps during ICO.

Correct usage of 74QX_IORAMDUMP causes the contents of IORAM to be dumped into telemetry. The correct useage is as follows:

74QX_IORAMDUMP serial number, starting address, length

Table 2.5 explains the parameters of the 74QZ_IORAMDUMP command.

Command Field	**Legal Values**	**Data Type**	**Comments**
Serial number	0-255	Integer	allows the correlation of TM to TC events
Starting address	0-ffff	Hex	First IORAM address to be dumped
Length	0-7ff	Hex	Number of words to be dumped (Max = 2047 words)

Table 2.5 – Parameters of 74QX_IORAMDUMP command

The IORAM physically consists of 32K (7FFFh) words but consists of 4-2000h segments or pages. Data should only be dumped such that the number of words dumped should not cross 2000h physical address boundaries. In other words, the Starting address + Length should not cross the 2000h, 4000h, 6000h boundaries. This is because of the software does not convert commands to perform inter-boundary paging. This is not a flight software error, rather a software design constraint resulting from the normal software design process. However, incorrect use of this command has resulted in all IO RAM memory dumps to date containing invalid memory information at 2000h crossing values.

Section 3 – Pressure Test and Power Supply Turn-on

3.1 Overview (Dana Burket)

On DOY 005 at 07:03 UTC the INMS pressure test was executed via a real-time command file. The test results were visible in the INMS housekeeping and science data streams and showed that the INMS was at a safe operating pressure. After the pressure test, the INMS power supplies were turned on in stages via real-time command files. First the lens and EM high voltage supplies were turned on, then the RF supply, and finally the filament 1 supply. Housekeeping data and science data stream monitors confirmed that associated currents and voltages were all within expected operating ranges. The INMS instrument thus appeared to be in good health and ready to begin execution of the baseline test.

3.2 Analysis (Dana Burket)

The success of the pressure test and power supply turn-on was assessed by comparing key housekeeping values and monitor values from the science data stream to acceptable operating predicts. See Appendix D for a table of predicts and observed values.

Section 4 – First Baseline

4.1 Overview (Dana Burket)

Anomalies occurred on Day Of Year 005 (DOY 005) 1999 during the execution of the INMS baseline test. The anomalies occurred because of a mistake in manual translation of the baseline command sequence from an ATOL command file to an SASF command file. The Spacecraft Activity Sequence File (SASF) format (the format required and documented by JPL) of the INMS command that was incorrectly translated is:

74GO_MEAS_TABLE(0,"CYCLE",8,0,[0x0004,0x0001,0x0102,0x0f02,0x07fc])

In the ATOL language (the language used in the GSFC lab to communicate to the EM) the corresponding command is:

tc 74go_meas_table 7,0,2,8,0,4,#1,#0102,#0f02,#07fc

The 7 and the 4 in the ATOL command are not valid parameters to the instrument; they are only parameters that communicate something to the ATOL language interpreter. The 7 was correctly ignored when creating the SASF version, but the 4 was not. The confusion occured because there is no documentation on the ATOL format of the INMS commands and because there are other versions of the ATOL command formats that also map to the unique SASF 74GO_MEAS_TABLE command format. For example, another ATOL version of the same command listed above is:

tc 74go_table_4 7,0,2,8,0,#1,#0102,#0f02,#07fc

Notice the absence of the 4 in the parameter list. These two ATOL format types are interspersed throughout the INMS baseline test. Unfortunately an engineer from GSFC, an analyst from SwRI, and I all reviewed the SASF built sequence and did not catch the translation error.

The translation error caused several problems. First, it corrupted some of the onboard operating tables. Second, it caused the instrument to execute with incorrect settings. The third problem, and the most disturbing of these erroneous settings, was the repeated cycling of filaments 1 and 2 (open source filaments). Filament 1 was cycled the most.

The anomalous operation of the instrument occurred early in the baseline and was clearly noticeable on telemetry displays. Therefore the decision was made to terminate the baseline by putting the instrument in sleep mode.

More detailed information follows.

4.2 Limit Checking Report (Thomas Henry)

The automated Limit Checking Tool that SwRI staff developed for ICO offered some additional real-time limit checking capabilities beyond the manual limit checking inspection that has been used in the past. Unfortunately, not all checks made by the tool were realistic due to the difficulty that GSFC and University of Michigan engineers had in defining realistic limits to be incorporated into the software. The tool did add to our limit checking capability, and serves as a prototype for a similar, yet more capable real-time limit checking tool that the SwRI staff will develop for Tour.

4.3.a Anomaly Analysis - Digital Assessment (Florence Tan)

Cycle Table Overwrite

A total of twenty-nine 74go_meas_table commands were erroneous; twenty-five of those commands were executed during the ICO baseline before the baseline was terminated. Each of the commands was erroneous in the same fashion. An extra word was inserted into each of the 74go_meas_table commands. A typical example follows:

74go_meas_table (0,”CYCLE”,8,0,[0x0004,0x0001,0x0101,0x0f01,0x07fd])

↑ Error (extra word)

This resulted in a write to the cycle table (table 8 in this example) of the following data (Table 4.1).

<table>
<tr><th>Word</th><th>Wrong</th><th></th><th colspan="2"></th><th></th><th>Correct</th></tr>
<tr><td>1</td><td>0004</td><td>←</td><td colspan="2">length word (no of cycles to execute)</td><td>→</td><td>0001</td></tr>
<tr><td>2</td><td>0001</td><td></td><td>trap table</td><td>Switching table</td><td></td><td>0101</td></tr>
<tr><td>3</td><td>0101</td><td></td><td>mass table</td><td>Focus table</td><td></td><td>0f01</td></tr>
<tr><td>4</td><td>0f01</td><td></td><td colspan="2">DAC|CS eV|CS on/off|OS eV|OS on/off</td><td></td><td>07fd</td></tr>
<tr><td>5</td><td>07fd</td><td></td><td>trap table</td><td>Switching table</td><td></td><td>.</td></tr>
<tr><td>6</td><td>0000</td><td></td><td>mass table</td><td>Focus table</td><td></td><td>.</td></tr>
<tr><td>7</td><td>0000</td><td></td><td colspan="2">DAC|CS eV|CS on/off|OS eV|OS on/off</td><td></td><td>.</td></tr>
<tr><td>8</td><td>0000</td><td></td><td>trap table</td><td>Switching table</td><td></td><td>.</td></tr>
<tr><td>9</td><td>0000</td><td></td><td>mass table</td><td>Focus table</td><td></td><td>.</td></tr>
<tr><td>10</td><td>0000</td><td></td><td colspan="2">DAC|CS eV|CS on/off|OS eV|OS on/off</td><td></td><td>.</td></tr>
<tr><td>11</td><td>0000</td><td></td><td>trap table</td><td>Switching table</td><td></td><td>.</td></tr>
<tr><td>12</td><td>0000</td><td></td><td>mass table</td><td>Focus table</td><td></td><td>.</td></tr>
<tr><td>13</td><td>0000</td><td></td><td colspan="2">DAC|CS eV|CS on/off|OS eV|OS on/off</td><td></td><td>.</td></tr>
<tr><td>14</td><td>0000</td><td></td><td>trap table</td><td>Switching table</td><td></td><td>.</td></tr>
<tr><td>15</td><td>0000</td><td></td><td>mass table</td><td>Focus table</td><td></td><td>.</td></tr>
<tr><td>16</td><td>0000</td><td></td><td colspan="2">DAC|CS eV|CS on/off|OS eV|OS on/off</td><td></td><td>.</td></tr>
</table>

Table 4.1 – Incorrect Words Written to Cycle Table

Each cycle table consists of a length word followed by 31 3-word records. The number of records used in a cycle is determined by the length word of the cycle table. Each 3-word record specifies the trap, switching, mass, focus, DAC tables, and open and close source filament ionization energies and states. The contents of the 4^{th}, 7^{th}, 10^{th}, 13^{th}, . . . word from the start of the cycle table write determines the state of the filament for the 1^{st}, 2^{nd}, 3^{rd}, 4^{th}, …. record respectively, in the cycle. In the erroneous case, the 3^{rd} word (0f01h) became the 4^{th} word. The 3^{rd} word was originally meant to set the mass table and focus table for that cycle but instead was used as the filament control word. Referring to Table 4.1, if the focus table was an odd number table then the open source filament would turn on every 4 cycles. Additionally, the filament energy setting was dependent on the focus table number. From the MRO dump data, it was shown that the data in each un-initialized cycle table data space were set to zero. It also turns out that the closed source filament was never set to turn on even with the bad data.

Consequences

Analysis of empirical data shows that filament 1 was cycled on 141 times and filament 2 was cycled on 30 times. Table 4.2 summarizes the calculated number of times filaments 1 and 2 were cycled "on" based on the contents of the cycle tables and the number of seconds each erroneous command was executed.

serial no.	time (s)	fil 2	Fil 1
26	126	14	
35	126	14	
40	126		14
66	24		2
68	24		2
69	24		2
70	24		2
71	24		2
72-89	167		18
91-109	162		18
111-125	162		18
129-149	170		18
151-165	160		17
169-185	162		18
189-209	94		10
Calculated		28	141
Empirical		30	141

Table 4.2 – Filament 1 and 2 **On** Times

A problem of greater concern is the number of times the filament was turned on with its ionization energy set to less than 5. Filament 1 was cycled on 137 times and filament 2 was cycled on 26 times with their ionization energy set to 0 (less than 5). It is unclear at this point the extent of damage, if any, to filaments 1 and 2 due the turning them on at low ionization energy settings.

4.3.b Analog Assessment (John Maurer)

Picket Fence

Several discrepancies were observed during the Initial Check Out (ICO) of the INMS. One of them was that during the Baseline Test the following display was observed in the Histogram window (Figure 4.1):

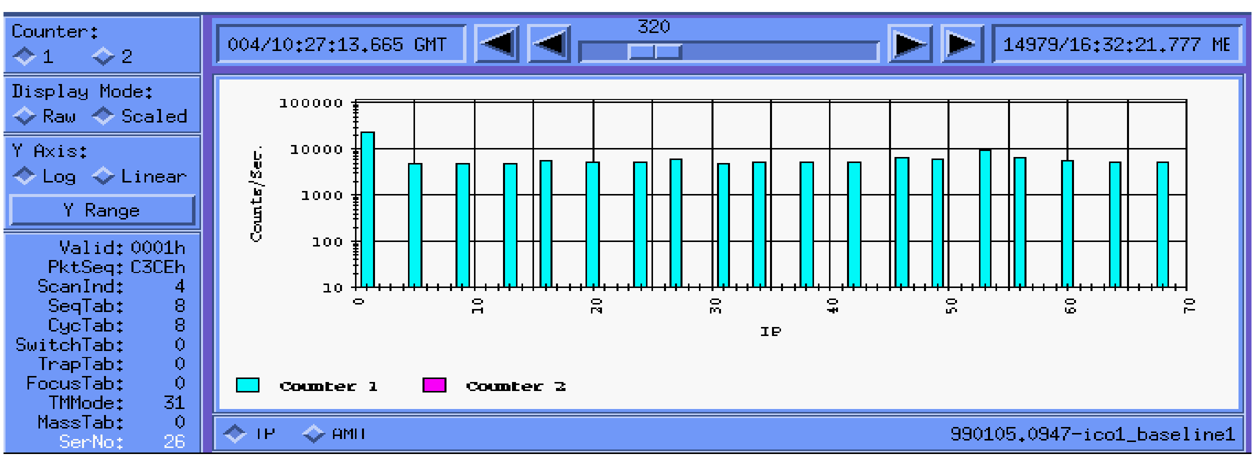

Figure 4.1 – First Baseline Discrepancy

After considerable analysis of the commands sent and digital data received, it was found the EM HV was off and that the detector threshold setting was at 0. This is a similar configuration that is normally included in the noise test run in baseline steps 191 through 198.

Data from the last test in the T-V chamber was checked (File:970322.1359-baseline_43_2nd-ambient), for configuration number 191, where the threshold was set at 1. The following picture is representative of that configuration (Figure 4.2).

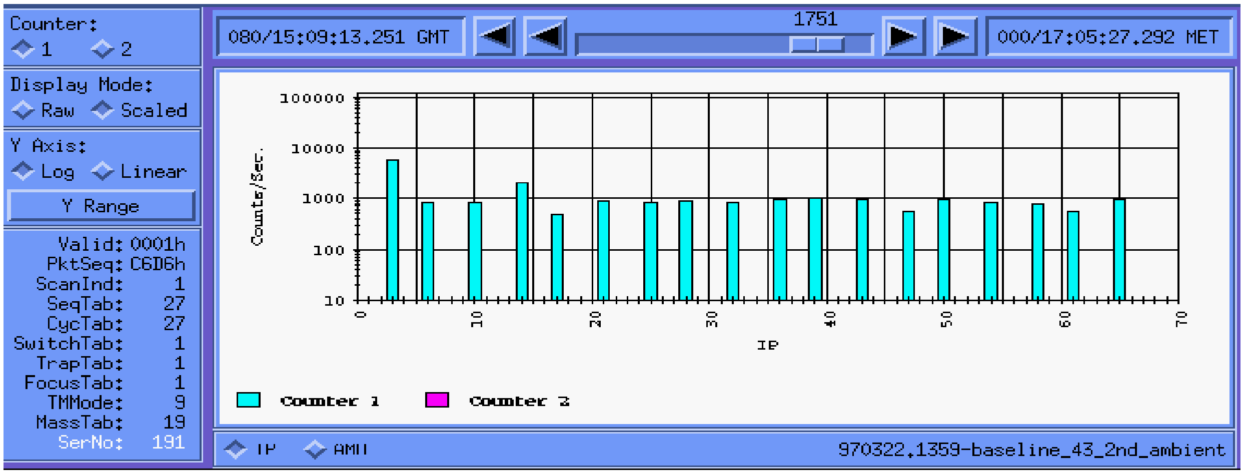

Figure 4.2 – Example from T-V Chamber Test

As can be seen there is remarkably little difference except for perhaps a factor of 2 greater amplitude in the ICO. Thus the instrument has not changed since T-V.

The cause of the cyclic noise is less clear. It is thought to be from either a beat between several of the many oscillators and power supplies or a very slight change in the threshold reference voltage due to unknown sources.

It is believed that the configuration during the ICO was with a threshold of 0 and the normal baseline test uses a minimum threshold of 1 which may explain the difference of 2 between the tests. However from bench testing there was little observed difference between these two values since the threshold is so low (~50 mv) that system noise and ground IR drops will cause a count. Also the characteristics of the first counter stage influences the characteristics. No attempt was made to trim the threshold detector for a specific offset since is was considered unimportant.

Summary: This output is considered a normal system noise and there has been no change since launch.

Filament

Overview: Several discrepancies were observed during the Initial Check Out (ICO) of the INMS. One of them was that during the Baseline Test the ion source HK data was not as expected. A careful analysis of the commands sent showed that the filaments were cycled on and off many times and that the primary Open Source filaments (Fil 1 & Fil 2) were turned on without any ionization potential.

Analysis: After analyzing the commands sent, the digital status words received, and the Memory Read Out (MRO), it was concluded that there were extra word(s) included in the SASF file prepared for uplink to the instrument. These extra words pushed the "correct" bits into a "wrong" location causing a table cycle of 4 when it should have been 1. Further the 3 unknown cycle locations had bits to cause the filament(s) to be off for the 3 "wrong" tables.
Even when the filaments were on (1 out of 4 cycles), the ionization voltage (eV) was commanded to 0. This is no problem for the closed source because there is a hardware trim to set a minimum voltage – even at an eV of 0. However for the Open Source a zero value is required when the gun is running in the target mode for the backup filament and as such, must be able to be commanded to 0 volts.
When a filament is turned on without any (or small) potential a space charge condition exists causing little or no emission. This causes the control loop to drive the filament to full voltage. This can be pictured by running a 6 volt light on a 12 volt battery with a regulator. If the regulator shorts, the bulb will be very bright – for a few seconds. The ion source filament will survive an open loop condition for a few seconds – maybe even a few minutes.

Data: It is very hard to analyze the analog HK data because of the sample rate. The normal HK, that includes emission, target, and filament current, is repeated at a 64 second rate. The cycle rate of the table(s) is 2.2 seconds. Thus it is possible, and Murphy's law makes it probable, that we would never see ion source monitors. There are a limited number of HK monitors in the science packet, and only the emission for filaments 1 and 3 are included.
Without any differential voltage on the filament it is believed that we would not see any emission – which we didn't. But then we would not see any if the filament was off either. This makes any analysis from the science HK nearly impossible.
The science packet includes digital data that has a bit for each filament commanded on. However under certain conditions the table reported value does execute to the filament.
The digital data was extracted and exported to an Excel file. The following number of turn-ons during the test was calculated as follows in Table 4.3.

Filament	**Calculated**	**Normal**
1	141	3
2	30	4
3	4	4
4	5	4

Table 4.3 – Filament Turn-Ons during ICO1 Baseline1

All turn-ons for Fil 1 and Fil 2 were with 0 eV (No ionization voltage). At 2.2 seconds per turn-on, this would mean that Fil 1 was running at full voltage for approximately 5 minutes and Fil 2 for approximately 1 minute.

Summary: The remaining life of Fil 1 and Fil 2 is reduced by an unknown amount. If no changes in currents and emissions can be observed by a complete, "correct", baseline test, then the degradation is probably small.

Addition Info: The following displays are from the ICO baseline test, at configuration 16, (Filament 1 on, dwell on Mass 28). (Figures 4.3 and 4.4).

HK words in science packet (2.2 Second rep Rate)

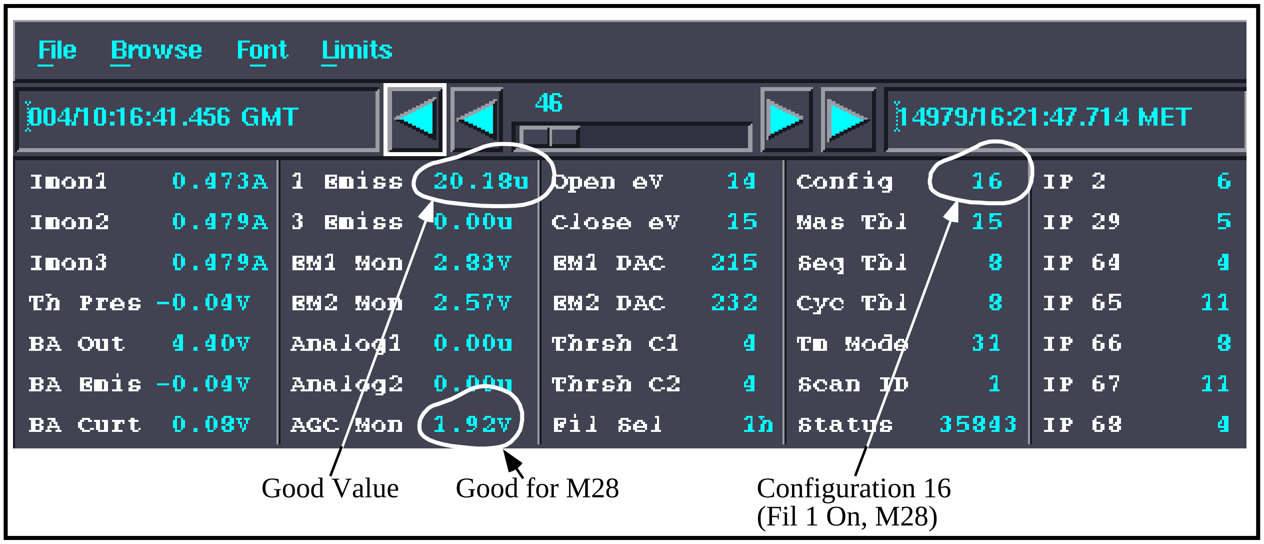

Figure 4.3 – First Baseline Science Data at Config 16 (Before Incorrect Command Set)

HK Packet (64 Second rep rate)

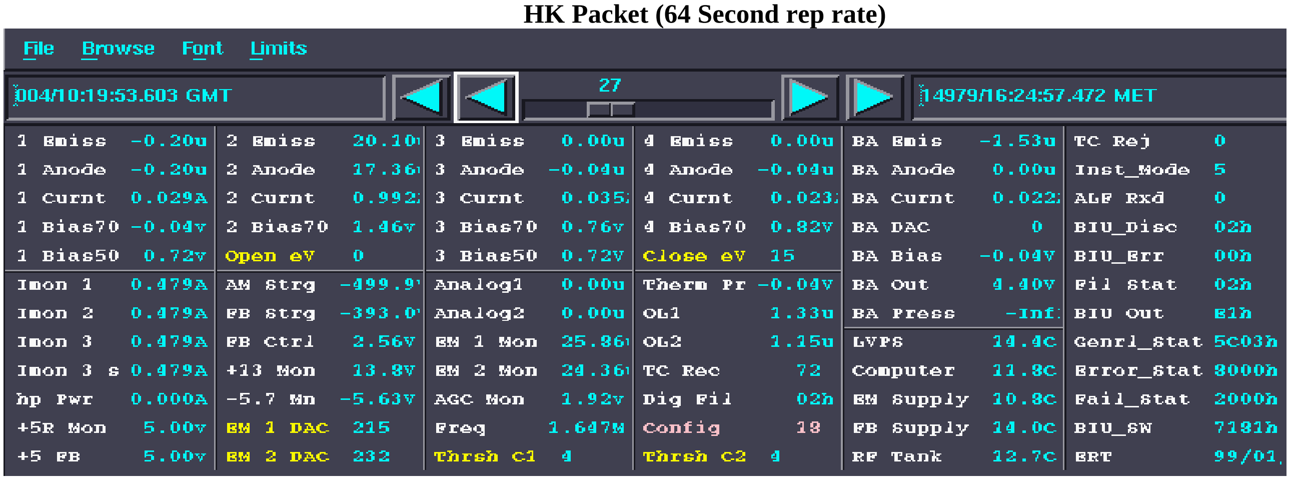

Figure 4.4 – First Baseline at Config 18, Fil 2 on, M28 (Sampled before problems)

Leakage Current

In an effort to investigate the possibility of leakage in the Ion Source 1, HK values before the baseline test (memory dump), and before filament turn-on in the baseline test, and then during the quiet test, which was after the multiple filament 1 turn-ons observed during the baseline test.

Leakage might show up as a shift in the Emis or Anode monitors. The eV is shown to be at 14 or 15 which is the 70 volt potential. Leakage to ground would show on the monitor as an increase in current. Interelectrode leakage would not show.

Figure 4.5 below displays the status during memory dump. It shows the 1 Emiss, 1 Anode, 1 Curnt as nominal values.

1 Emiss	-0.10u	2 Emiss	-0.10u	3 Emiss	0.00u	4 Emiss	0.00u	BA Emis	-1.53u	TC Rej	0
1 Anode	-0.20u	2 Anode	0.00u	3 Anode	-0.04u	4 Anode	0.00u	BA Anode	0.00u	Inst_Mode	1
1 Curnt	0.029A	2 Curnt	0.023A	3 Curnt	0.035A	4 Curnt	0.023A	BA Curnt	0.022A	ALF Rxd	0
1 Bias70	0.64v	2 Bias70	0.64v	3 Bias70	0.76v	4 Bias70	0.82V	BA DAC	0	BIU_Disc	00h
1 Bias50	0.68v	Open eV	14	3 Bias50	0.74V	Close eV	15	BA Bias	-0.04V	BIU_Err	00h
Imon 1	0.338A	AM Strg	-499.9V	Analog1	0.00u	Therm Pr	-0.04V	BA Out	4.40V	Fil Stat	00h
Imon 2	0.338A	FB Strg	-393.0V	Analog2	0.00u	OL1	0.00u	BA Press	-InfP	BIU Out	E1h
Imon 3	0.338A	FB Ctrl	2.62V	EM 1 Mon	0.30u	OL2	0.03u	LVPS	14.0C	Genrl_Stat	FC03h
Imon 3 s	0.406A	+13 Mon	13.9V	EM 2 Mon	0.15u	TC Rec	56	Computer	11.3C	Error_Stat	9000h
hp Pwr	0.000A	-5.7 Mn	-5.72V	AGC Mon	-0.04v	Dig Fil	00h	EM Supply	10.4C	Fail_Stat	2000h
+5R Mon	5.00v	EM 1 DAC	215	Freq	1.647M	Config	11	FB Supply	12.7C	BIU_SW	328Ch
+5 FB	5.00v	EM 2 DAC	232	Thrsh C1	4	Thrsh C2	4	RF Tank	9.0C	ERT	99/01/0

Figure 4.5 – Instrument Status during Memory Dump

Figure 4.6 shows the monitors at the start of the Baseline test. The values are approximately the same.

1 Emiss	-0.10u	2 Emiss	0.00u	3 Emiss	0.00u	4 Emiss	0.00u	BA Emis	-1.53u	TC Rej	0
1 Anode	-0.20u	2 Anode	0.00u	3 Anode	0.00u	4 Anode	0.00u	BA Anode	0.00u	Inst_Mode	2
1 Curnt	0.029A	2 Curnt	0.023A	3 Curnt	0.035A	4 Curnt	0.023A	BA Curnt	0.022A	ALF Rxd	0
1 Bias70	0.64v	2 Bias70	0.64v	3 Bias70	0.76v	4 Bias70	0.82V	BA DAC	0	BIU_Disc	02h
1 Bias50	0.68v	Open eV	0	3 Bias50	0.72V	Close eV	0	BA Bias	-0.04V	BIU_Err	00h
Imon 1	0.332A	AM Strg	-499.9V	Analog1	0.00u	Therm Pr	-0.04V	BA Out	4.40V	Fil Stat	00h
Imon 2	0.332A	FB Strg	-393.0V	Analog2	0.00u	OL1	0.00u	BA Press	-InfP	BIU Out	E1h
Imon 3	0.332A	FB Ctrl	2.62V	EM 1 Mon	0.15u	OL2	0.03u	LVPS	14.8C	Genrl_Stat	EC03h
Imon 3 s	0.088A	+13 Mon	13.9V	EM 2 Mon	0.15u	TC Rec	59	Computer	11.8C	Error_Stat	9000h
hp Pwr	0.000A	-5.7 Mn	-5.72V	AGC Mon	-0.04v	Dig Fil	00h	EM Supply	10.4C	Fail_Stat	2000h
+5R Mon	5.00v	EM 1 DAC	0	Freq	1.647M	Config	12	FB Supply	13.1C	BIU_SW	728Ah
+5 FB	5.00v	EM 2 DAC	0	Thrsh C1	0	Thrsh C2	0	RF Tank	9.0C	ERT	99/01/0

Figure 4.6 – Instrument Status During Start of the Baseline Test

Figure 4.7 shows the status during the quiet test. The 1 Emis is 1 bit higher which is within the noise observed from readout to readout.

1 Emiss	-0.20u	2 Emiss	0.20u	3 Emiss	20.22u	4 Emiss	-0.20u	BA Emis	-1.53u	TC Rej	0
1 Anode	-0.20u	2 Anode	0.00u	3 Anode	8.52u	4 Anode	0.60u	BA Anode	0.00u	Inst_Mode	4
1 Curnt	0.029A	2 Curnt	0.023A	3 Curnt	1.110A	4 Curnt	0.023A	BA Curnt	0.022A	ALF Rxd	0
1 Bias70	0.64v	2 Bias70	0.62v	3 Bias70	1.10v	4 Bias70	0.80V	BA DAC	0	BIU_Disc	02h
1 Bias50	0.68v	Open eV	14	3 Bias50	0.74V	Close eV	15	BA Bias	-0.04V	BIU_Err	00h
Imon 1	0.510A	AM Strg	-502.4V	Analog1	0.00u	Therm Pr	-0.04V	BA Out	4.40V	Fil Stat	04h
Imon 2	0.540A	FB Strg	-395.0V	Analog2	0.00u	OL1	0.00u	BA Press	-InfP	BIU Out	E1h
Imon 3	0.455A	FB Ctrl	2.54V	EM 1 Mon	27.37u	OL2	0.00u	LVPS	16.1C	Genrl_Stat	0C03h
Imon 3 s	0.559A	+13 Mon	13.9V	EM 2 Mon	25.41u	TC Rec	49	Computer	13.1C	Error_Stat	8000h
hp Pwr	0.000A	-5.7 Mn	-5.63V	AGC Mon	2.00v	Dig Fil	04h	EM Supply	13.1C	Fail_Stat	2000h
+5R Mon	5.00v	EM 1 DAC	215	Freq	1.647M	Config	240	FB Supply	15.7C	BIU_SW	39C0h
+5 FB	5.00v	EM 2 DAC	232	Thrsh C1	4	Thrsh C2	4	RF Tank	16.5C	ERT	99/01/1

Figure 4.7 – Instrument Status During Quiet Test

Summary: Based on the above HK samples there has been no observable changes in the monitors – filament 1 off.

EM/IMON Anomaly

Problem: During the INMS baseline-1 checkout the EM1 HV monitor read a full scale value at turn-on 8 times. This overshoot had not been observed during previous testing.

Conclusion: Due to software errors in the command files the EM HV supplies were turned on and off several hundred times. During 8 of these turn-ons the AMUX sampled the HV monitor at the time when the supply was turned on. During previous baseline tests the EM HV was only turned on one time during the test and the HV mon was not sampled at turn-on.

This is a current (not voltage) monitor of the current supplied to the EM. During module testing the voltage (not current) was monitored. Without a detailed check of the module logbook the amount of overshoot cannot be verified, but I recall it was small (<5%).

After integration with the analyzer, with the additional capacitive loads added, no measurements were made of this monitor. Accessibility to such monitors is limited on the assembled instrument.

Bottom line: This is a normal result that was not measured.

4.3.c Selective Anomalous Results (John Maurer)

Overview: Seven times, during the 8 hours of the Cassini/INMS quiet test, a low current reading was observed from the Science MUX, Imon, readout. This was identified as a science packet that was mostly zeros. Figure 4.8 is a chart of the problem.

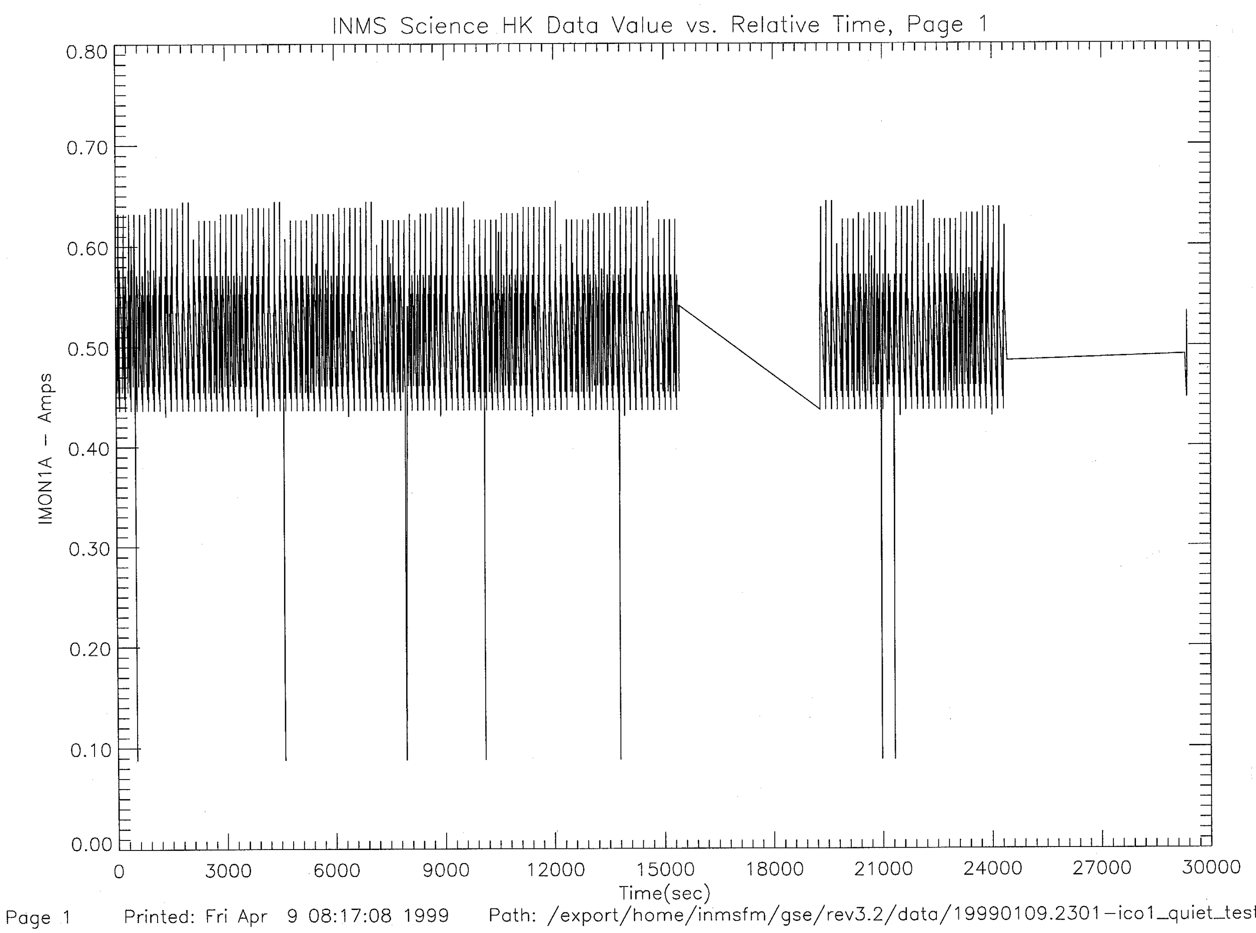

Figure 4.8 – IMON 1,2,3 Combination Plot from Science Data

Details: As can be seen from Figure 4.8 a reading of approximately .09 A was observed 7 times during the quiet turn-on. These occurred at approximately 70 sec, 1 hr, 2.5 hr, 3 hr, 4 hr, and 2 at 6 hours. The 2nd point at approximately 1 hr 13 min (science packet 1991) was found to contain nearly all zeros (Figure 4.9). The converted value read .09A because of an offset in the calibration constant.

Note that the values shown on the left column of Figure 4.9 are valid. These values are for the **next** output and are correct, making some values of the packet valid and some invalid (zero). One of the other bad packets was found to contain one IP value with a 1, making it unclear whether only the DAC and AMUX values are bad and that the counts are valid and are 0s.

```
Archive: 19990109.2301-ico1_quiet_test
Printed: Fri Apr  9 08:25:03 1999


INMS Normal Science
009/00:19:01.607 GMT
14984/06:24:19.472 MET
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Valid        0000h  CCSDS ID     0A40h       IP1 C1   00000h  IP35 C1 00000h  IP1 C2   00000h  IP35 C2 00000h  GenSts     0000h    Seqloop   0
CRC Chk      80ADh  CCSDS Seq    C7E9h       IP2 C1   00000h  IP36 C1 00000h  IP2 C2   00000h  IP36 C2 00000h  SubSysF    0000h    DCONSts   00h
Length       0000h  CCSDS Len    01A5h       IP3 C1   00000h  IP37 C1 00000h  IP3 C2   00000h  IP37 C2 00000h  Amux 0     00h      Cycindx   0
Func.        0000h  CCSDS Flg    00h         IP4 C1   00000h  IP38 C1 00000h  IP4 C2   00000h  IP38 C2 00000h  Amux 1     00h      Seqtime   00000h
Status       0000h  CCSDS Secs   4D2AA613h   IP5 C1   00000h  IP39 C1 00000h  IP5 C2   00000h  IP39 C2 00000h  Amux 2     00h      Veltab    0
RT Addr      0      CCSDS Subs   79h         IP6 C1   00000h  IP40 C1 00000h  IP6 C2   00000h  IP40 C2 00000h  Amux 3     00h      Cycletab  0
Sub Addr     0      Mini PktID   0000h       IP7 C1   00000h  IP41 C1 00000h  IP7 C2   00000h  IP41 C2 00000h  Amux 4     00h      Traptab   0
1553 Cnt.    0000h  Elsp Seq t   005Ah       IP8 C1   00000h  IP42 C1 00000h  IP8 C2   00000h  IP42 C2 00000h  Amux 5     00h      SWTab     0
RTIU Secs.   0      Scan Index   1           IP9 C1   00000h  IP43 C1 00000h  IP9 C2   00000h  IP43 C2 00000h  Amux 6     00h      MassTab   0
RTIU RTI     0      Seq. Table   1           IP10 C1  00000h  IP44 C1 00000h  IP10 C2  00000h  IP44 C2 00000h  Amux 7     00h      FOCTab    0
                    Cyc. Table   1           IP11 C1  00000h  IP45 C1 00000h  IP11 C2  00000h  IP45 C2 00000h  Amux 8     00h      DATab     0
1553 ST 0    0000h  DAC1         85h         IP12 C1  00000h  IP46 C1 00000h  IP12 C2  00000h  IP46 C2 00000h  Amux 9     00h      CLFilLvl  0
1553 ST 1    0000h  DAC2         68h         IP13 C1  00000h  IP47 C1 00000h  IP13 C2  00000h  IP47 C2 00000h  Amux 10    00h      CLFilOn   0
1553 ST 2    0000h  DAC3         00h         IP14 C1  00000h  IP48 C1 00000h  IP14 C2  00000h  IP48 C2 00000h  Amux 11    00h      OPFilLvl  0
1553 ST 3    0000h  DA4 Thrs1    44h         IP15 C1  00000h  IP49 C1 00000h  IP15 C2  00000h  IP49 C2 00000h  Amux 12    00h      OPFilOn   0
1553 ST 4    0000h  DA5 EM1      D7h         IP16 C1  00000h  IP50 C1 00000h  IP16 C2  00000h  IP50 C2 00000h  Amux 13    00h      RTIcnt    0000h
1553 ST 5    0000h  DA6 EM2      E8h         IP17 C1  00000h  IP51 C1 00000h  IP17 C2  00000h  IP51 C2 00000h  TC Rec     0        DTScnt    0000h
1553 ST 6    0000h  TM Mode      21          IP18 C1  00000h  IP52 C1 00000h  IP18 C2  00000h  IP52 C2 00000h  TC Rej     0        STMcnt    0000h
1553 ST 7    0000h  Mass #       1           IP19 C1  00000h  IP53 C1 00000h  IP19 C2  00000h  IP53 C2 00000h  ALF Rec    0
1553 ST 8    0000h                           IP20 C1  00000h  IP54 C1 00000h  IP20 C2  00000h  IP54 C2 00000h  ALF Rej    0
1553 ST 9    0000h                           IP21 C1  00000h  IP55 C1 00000h  IP21 C2  00000h  IP55 C2 00000h  Ser# 1     00h
1553 ST 10   0000h                           IP22 C1  00000h  IP56 C1 00000h  IP22 C2  00000h  IP56 C2 00000h  Time 1     000000h
1553 ST 11   0000h                           IP23 C1  00000h  IP57 C1 00000h  IP23 C2  00000h  IP57 C2 00000h  Ser# 2     00h
1553 ST 12   0000h                           IP24 C1  00000h  IP58 C1 00000h  IP24 C2  00000h  IP58 C2 00000h  Time 2     000000h
1553 ST 13   0000h                           IP25 C1  00000h  IP59 C1 00000h  IP25 C2  00000h  IP59 C2 00000h  Ser# 3     00h
1553 ST 14   0000h                           IP26 C1  00000h  IP60 C1 00000h  IP26 C2  00000h  IP60 C2 00000h  Time 3     000000h
1553 ST 15   0000h                           IP27 C1  00000h  IP61 C1 00000h  IP27 C2  00000h  IP61 C2 00000h  CRC        0000h
1553 ST 16   0000h                           IP28 C1  00000h  IP62 C1 00000h  IP28 C2  00000h  IP62 C2 00000h
1553 ST 17   0000h                           IP29 C1  00000h  IP63 C1 00000h  IP29 C2  00000h  IP63 C2 00000h
                                             IP30 C1  00000h  IP64 C1 00000h  IP30 C2  00000h  IP64 C2 00000h
                                             IP31 C1  00000h  IP65 C1 00000h  IP31 C2  00000h  IP65 C2 00000h
                                             IP32 C1  00000h  IP66 C1 00000h  IP32 C2  00000h  IP66 C2 00000h
                                             IP33 C1  00000h  IP67 C1 00000h  IP33 C2  00000h  IP67 C2 00000h
                                             IP34 C1  00000h  IP68 C1 00000h  IP34 C2  00000h  IP68 C2 00000h
```

Figure 4.9 – INMS-GSE Science Screen, Packet 1991

Conclusion: The anomaly is probably not a spacecraft or transmission problem because some of the words are valid. It is probably a function of the flight software that missed including this data in the transmitted packet. More detailed analysis of the operation of the flight software and hardware will be required to understand the cause of this anomaly.

Section 5 – Sequence Correction

5.1 Error Correction (Dana Burket)

After analyzing the anomaly of the first baseline test and its results, the decision was made to correct the problem and re-run the baseline during contingency time.

To prepare for this second baseline test real-time telemetry plotting software was developed to provide more immediate visibility into unexpected values of key monitoring values from INMS. (One of the mistakes of the team on DOY 005 was to leave the instrument on longer than necessary because we did not have good visibility into all anomalies that were occurring due to the corrupted tables.) Second, the SASF command sequence was corrected and painstakingly reviewed by several personnel to ensure there were no additional errors. Additionally, in-house software was developed to analyze SASF command file and emulate INMS memory to ensure the memory was initialized properly. The software corroborated the by-hand analysis of the SASF file. Finally, prior to the Quiet Test (instrument interference test) on DOY 010, the operating tables were re-loaded, dumped and compared with existing templates to confirm they were all as expected.

5.2 Sequence Validation Software (Thomas Henry)

An SASF sequence validation program (SVS) was commissioned shortly after the first baseline ended. The program was designed to take an SASF file and produce an INMS memory file, which could be compared against an INMS memory file template. Florence Tan created the memory template file containing a depiction of INMS memory. The sequence validation software produced a separate memory file. The two files were compared with the Windiff program (see section 2.3). Below, as Figure 5.1, are examples of the two files.

INMS Memory Template File (by Florence Tan)	Sequence Validation Software Memory Output File
15 10 10 1 1 1 1 1 1 15 0 14 1 1 -	15 10 10 1 1 1 1 1 1 15 0 14 1 1 -
16 8 8 1 1 1 15 1 1 15 0 14 1 1 -	16 8 8 1 1 1 15 1 1 15 0 14 1 1 -
17 10 10 1 1 1 1 1 1 15 0 14 1 2 -	17 10 10 1 1 1 1 1 1 15 0 14 1 2 -
18 8 8 1 1 1 15 1 1 15 0 14 1 2 -	
19 12 12 1 1 2 1 2 1 15 1 14 0 - 3	19 12 12 1 1 2 1 2 1 15 1 14 0 - 3
20 8 8 1 1 2 15 2 1 15 1 14 0 - 3	20 8 8 1 1 2 15 2 1 15 1 14 0 - 3
22 12 12 1 1 2 1 2 1 15 1 14 0 - 4	22 12 12 1 1 2 1 2 1 15 1 14 0 - 4
23 8 8 1 1 2 1 2 1 15 1 14 0 - 4	
24 10 10 1 1 8 24 8 1 15 1 14 1 2 4	24 10 10 1 1 8 24 8 1 15 1 14 1 2 4
25 11 11 12 1 1 2 1 1 15 1 14 1 2 4	25 11 11 12 1 1 2 1 1 15 1 14 1 2 4
1 1 3 1 1 15 1 14 1 2 4	1 1 3 1 1 15 1 14 1 2 4
1 1 4 1 1 15 1 14 1 2 4	1 1 4 1 1 15 1 14 1 2 4
1 1 5 1 1 15 1 14 1 2 4	1 1 5 1 1 15 1 14 1 2 4
1 1 6 1 1 15 1 14 1 2 4	1 1 6 1 1 15 1 14 1 2 4
1 1 7 1 1 15 1 14 1 2 4	1 1 7 1 1 15 1 14 1 2 4
. . .	. . .

Figure 5.1 – Excerpt from INMS Memory Template and SVS Memory File

The files were several hundred lines long. SVS was written in the short time after ico1_baseline1 and before ico1_baseline2. As a result of this few-day development cycle, SVS was not able to be written to convert every possible SASF command line into a memory image. There was enough time to create a memory image that was 99% complete, with the exceptions noted in Windiff and checked manually.

5.3 Real Time Monitoring (Thomas Henry)

In order to provide real-time graphical depiction of critical INMS telemetry values, software was adapted from a similar CAPS tool. This tool accepted as input INMS data residing in a disk file. It displayed a subset of the science diagnostics in a graphical scrolling format, while also plotting the raw EM counter values. Specifically it displayed current monitors, high voltage monitors, and decoded the DAC filament value, as well as the raw EM counter values. This tool may be useful for future housekeeping at-a-glance. A typical screen output is shown in Figure 5.2.

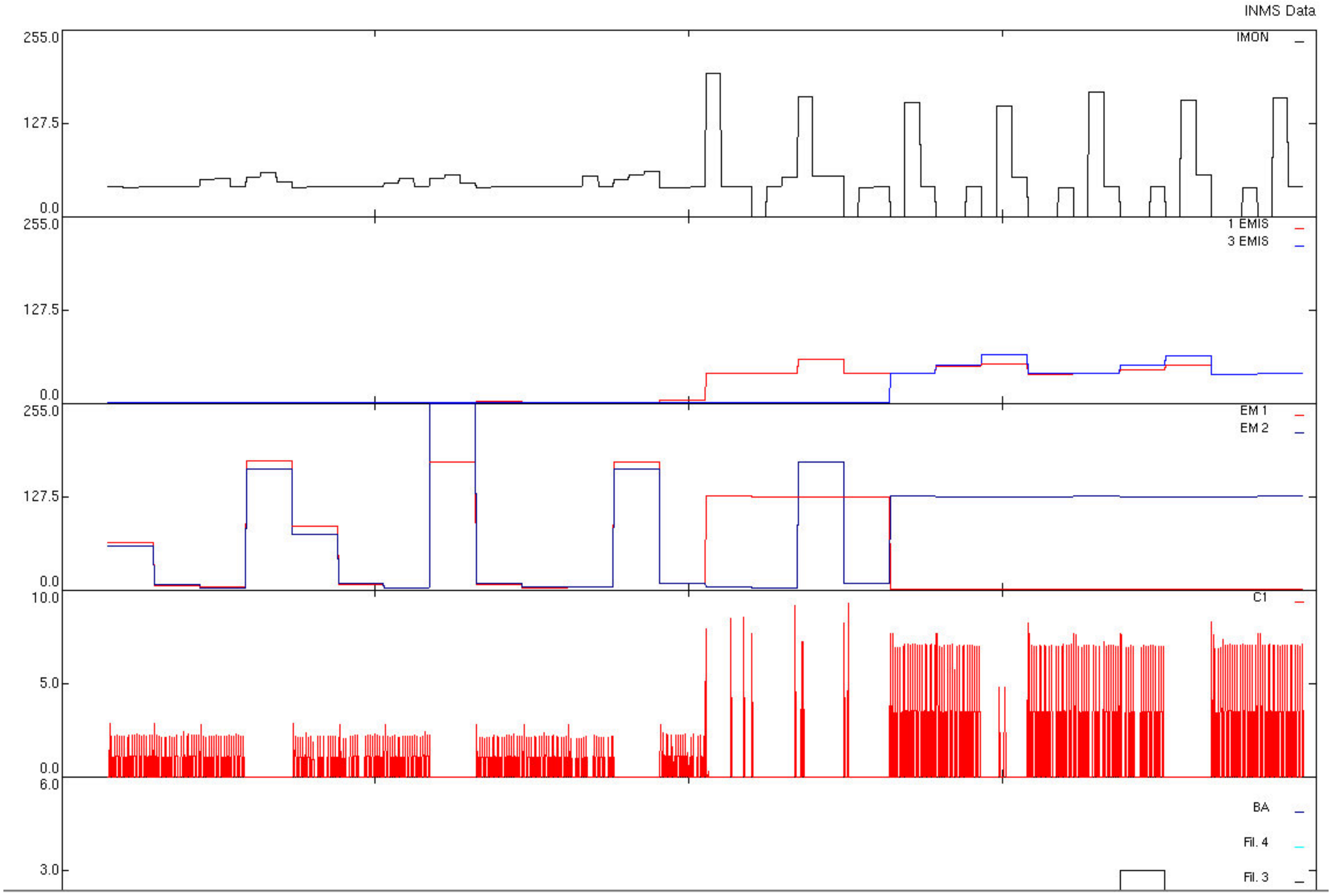

Figure 5.2 – Real Time Monitoring Software Screen Shot

Section 6 – Quiet Test

6.1 Overview (Dana Burket)

Prior to INMS participation in the Quiet Test, the ALF load to load INMS flight software patches and operating tables was resent to the instrument in order to correct tables that were corrupted due to the anomaly that occurred in the first execution of the baseline test. An MRO confirmed that the load was successful. Another pressure test confirmed that INMS was in a safe operating state.

The Quiet Test is a test to measure interference among the instruments. The instruments each take turns operating in the most noisy state of the instrument while the other instruments operate in their respective "listen" modes. This test was very similar to the Quiet Test run in ATLO. INMS operated nominally in default science (see Note[1] for more details on default science) mode during the Quiet Test. INMS's quiet state and listen state are both considered to be the same. The instrument did not detect any appreciable interference, although after thorough analysis of the data, slight interference may appear.

Note[1] - "Default Science" is one way of describing the operations of sequence table 1. This table executes cycle table 1 for 92 seconds and cycle table 3 for 55 seconds. Cycle table 1 accomplishes a complete unity sweep (mass 1 to 70) for both the open and closed source, alternating every 2.2 seconds (one science packet). Cycle table 3 also alternates between open and closed source every 2.2 seconds. Like cycle table 1 the open source performs a unity sweep, but during the periods where the closed source is operating a fine sweep is accomplished over several cycles using mass tables 1 through 13.

6.2 Analysis (Rob Thorpe)

Analysis of the quiet test data shows INMS operating nominally with no significant anomalies or interference from other instruments. Dana monitored telemetry and noticed EM1 monitor variation between 3.45V and 3.55V during other instrument noisy periods (ISS was most significant), but also during the INMS noisy period when other instruments were "quiet". While this may or may not be significant, some second order trend analysis needs to be completed.

The results of quiet test analysis are graphed below. The data graphed is the sum of the counts/ip for each packet, or counts per scan (IP 68 is thrown out as it is sometimes used for total counts). During the quiet test INMS is operated in default science mode (sequence table 1), which repeatedly cycled through several different mass tables (mass table 1 open & closed source for 92 seconds, then alternating mass table 1 open source and mass tables 1-13 closed source for 55 seconds). The alternating mass tables produce the different data series. Presented on the next several pages is the summary graph of INMS counts for the entire period, several graphs of the counts per hour, and a table of the quiet test schedule.

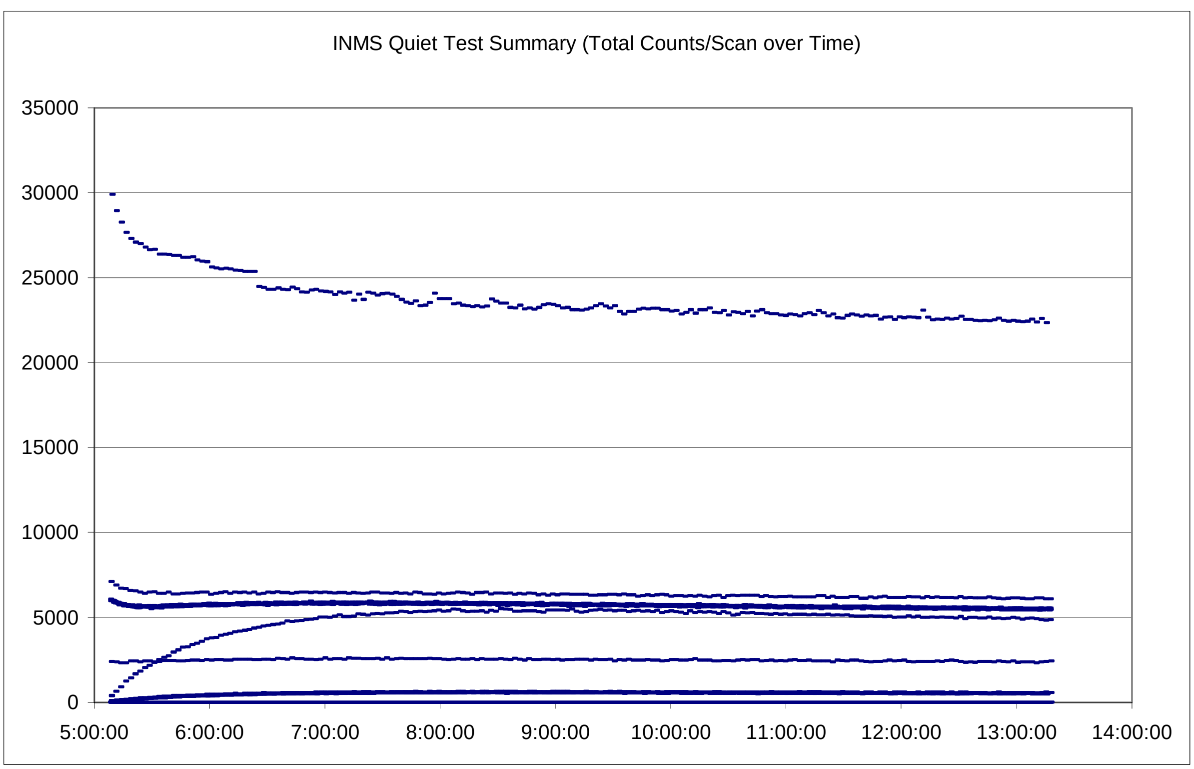

Figure 6.1 – INMS Quiet Test Summary

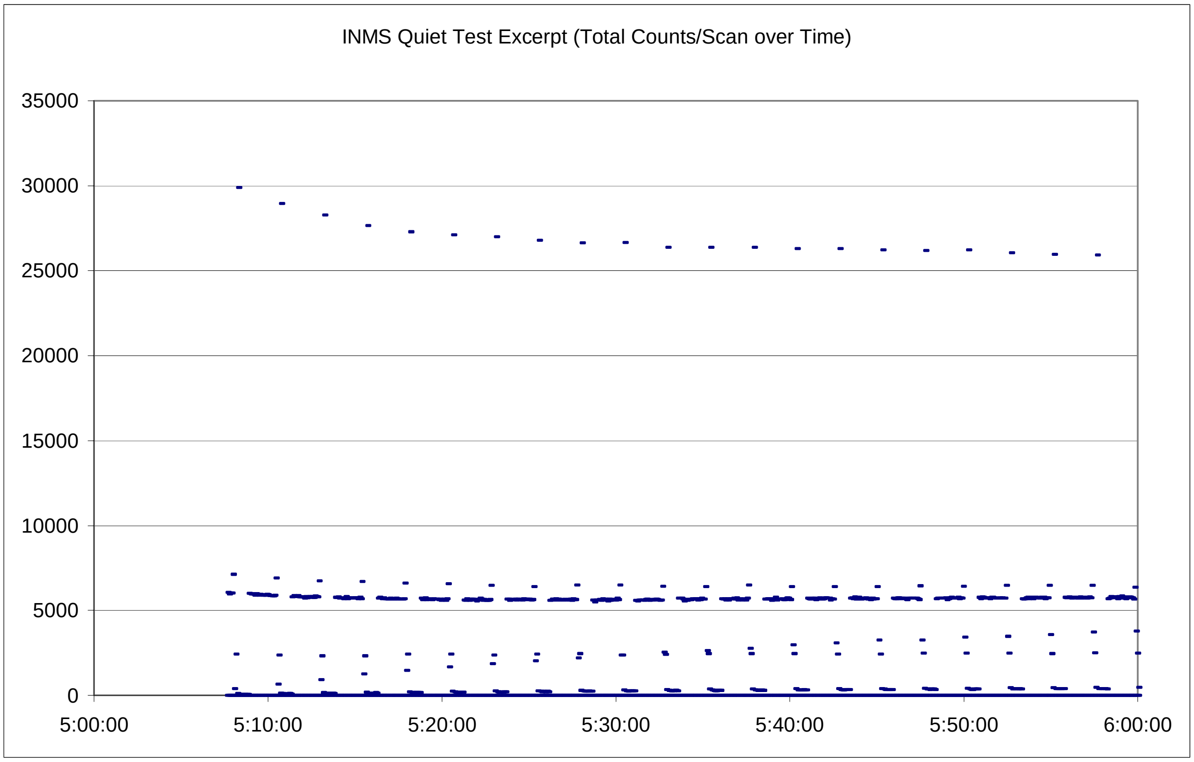

Figure 6.2 – INMS Quiet Test from 5:00 to 6:00

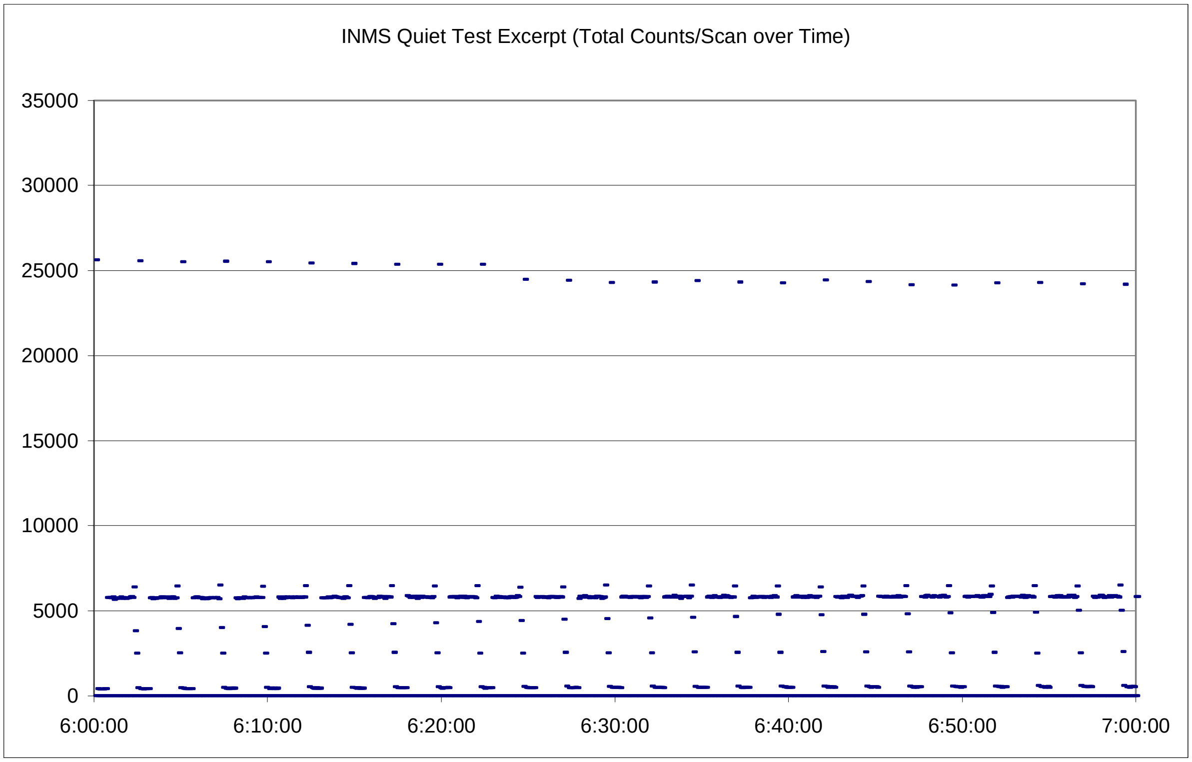

Figure 6.3 – INMS Quiet from, 6:00 to 7:00

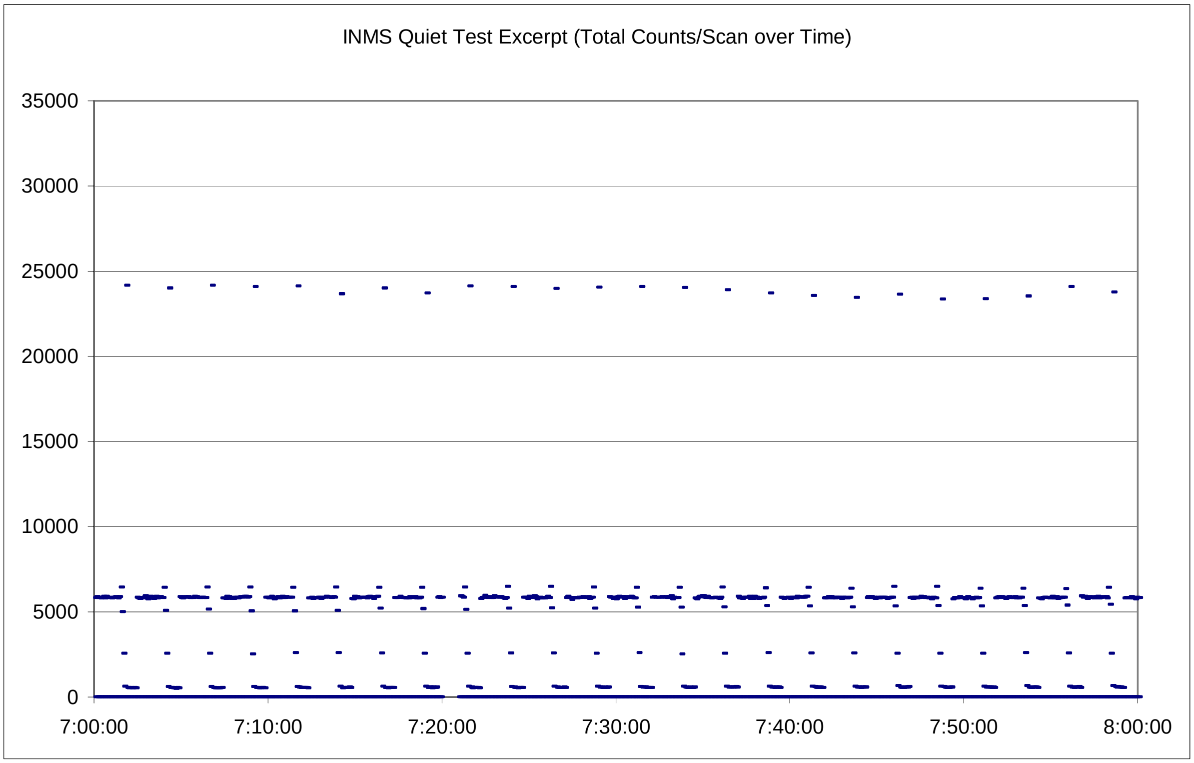

Figure 6.4 – INMS Quiet Test from 7:00 to 8:00

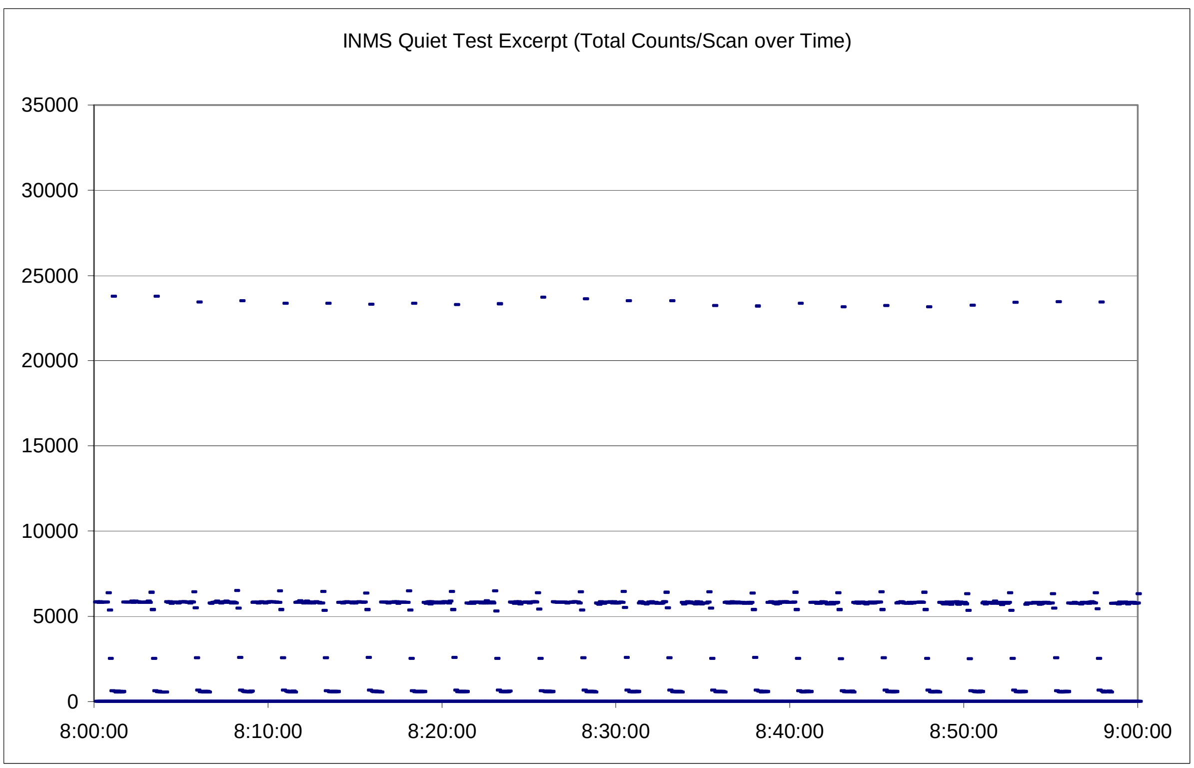

Figure 6.5 – INMS Quiet Test from, 8:00 to 9:00

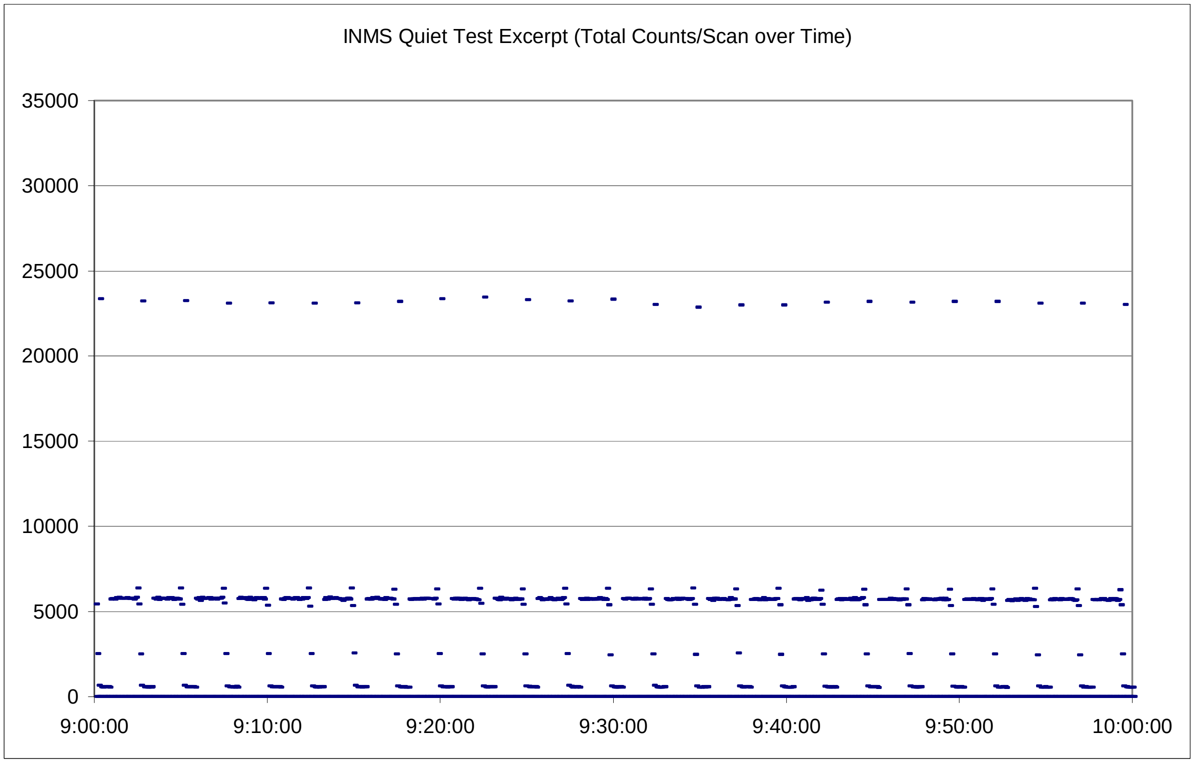

Figure 6.6 – INMS Quiet Test from 9:00 to 10:00

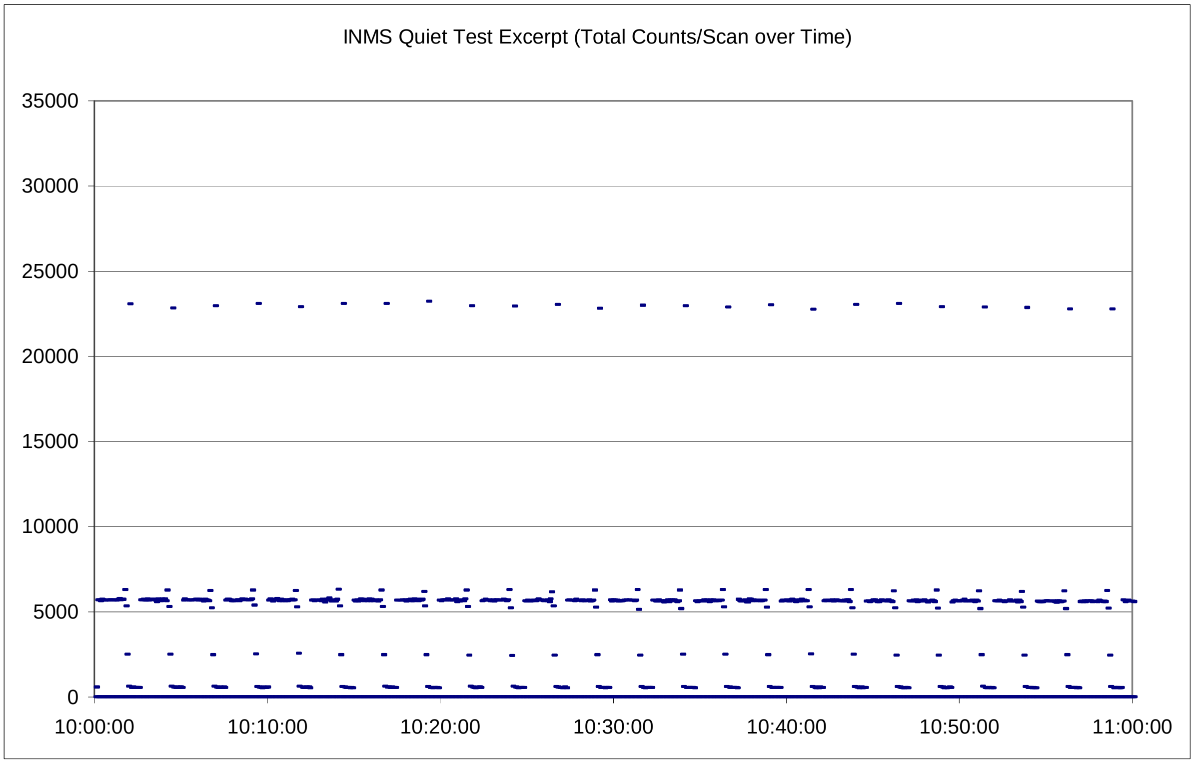

Figure 6.7 – INMS Quiet Test from, 10:00 to 11:00

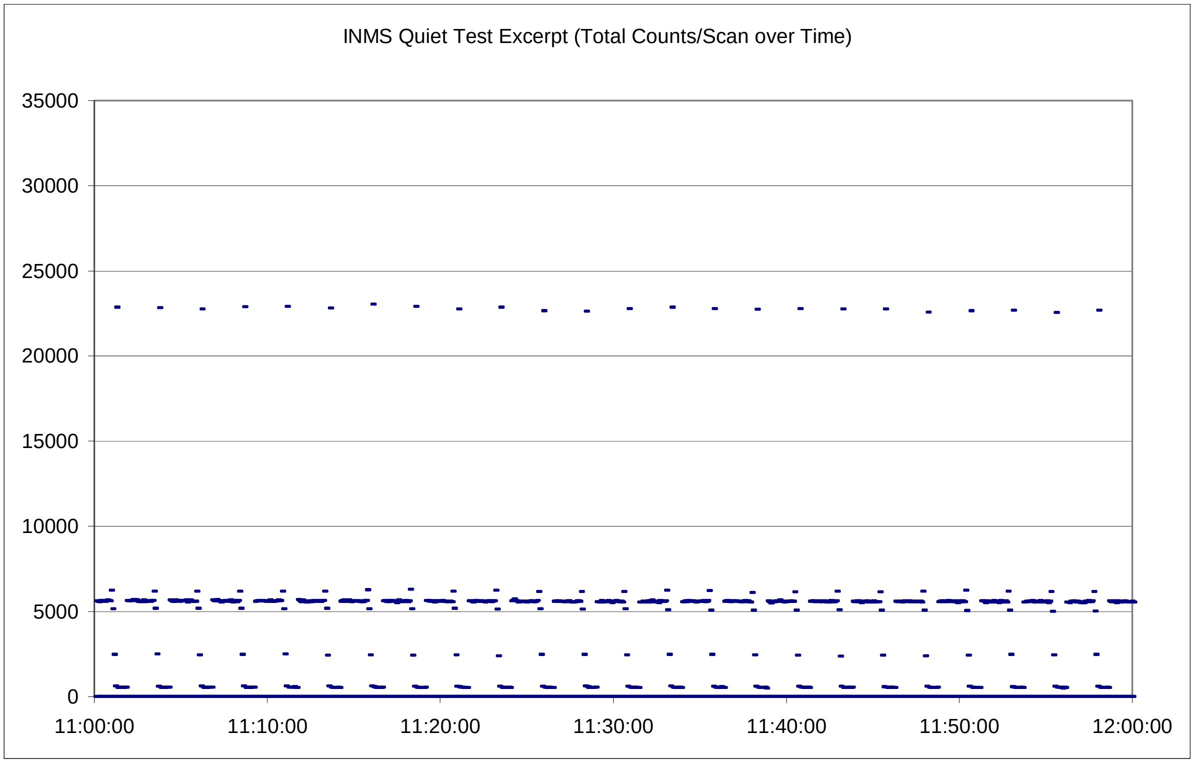

Figure 6.8 – INMS Quiet Test from 11:00 to 12:00

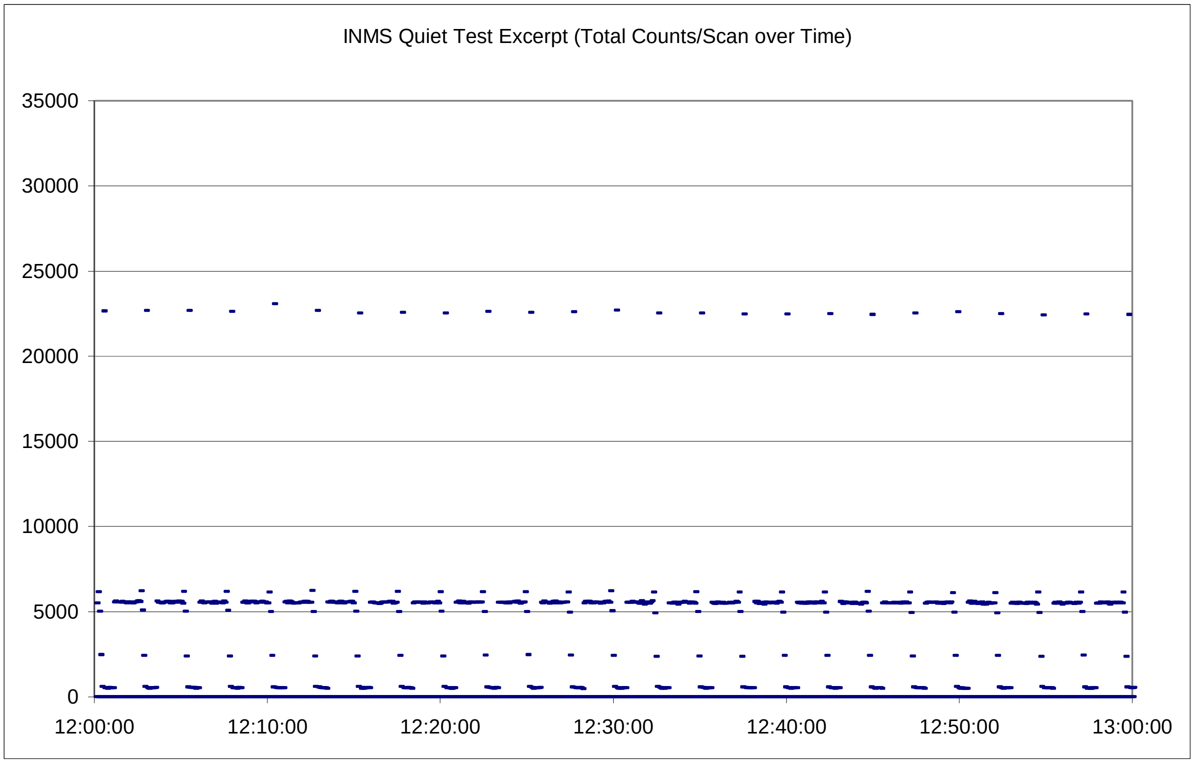

Figure 6.9 – INMS Quiet from, 12:00 to 13:00

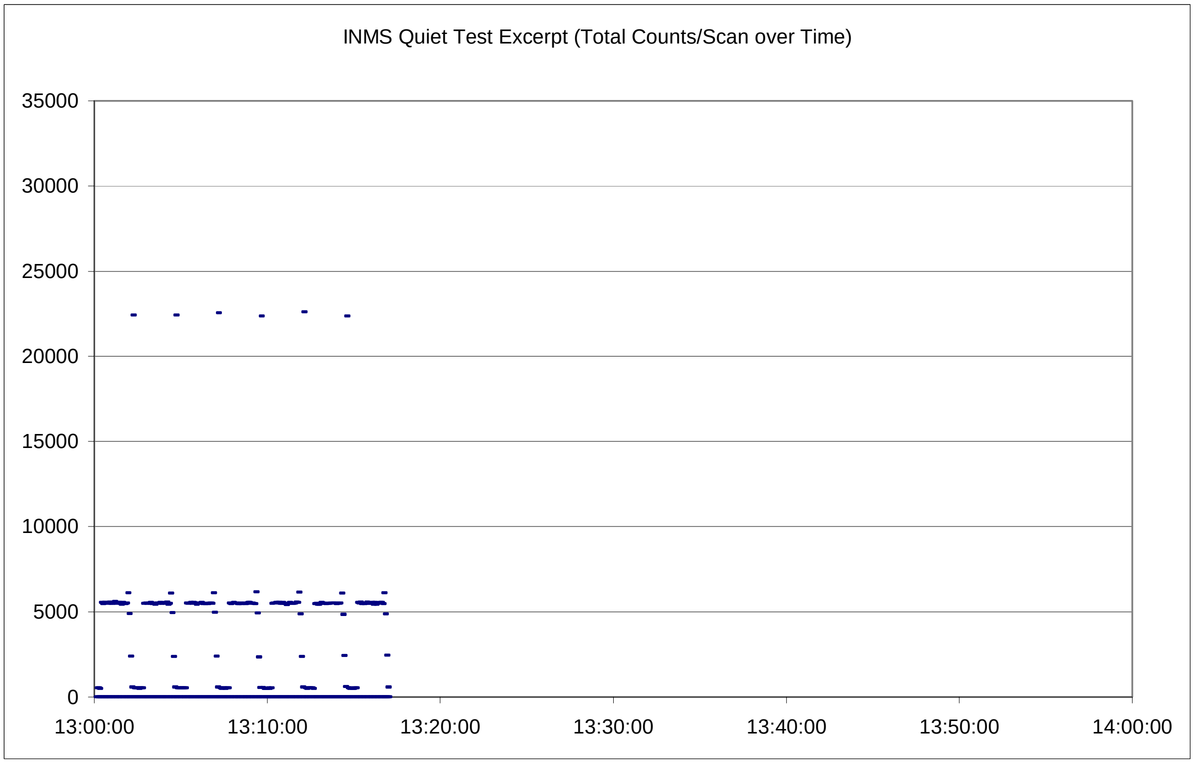

Figure 6.10 – INMS Quiet Test from 13:00 to 14:00

Time (DOY-010)	Event	Time	Event	Time	Event
05:10:00	CAPS Noisy (*)	07:35:30	CDA Noisy		TLM OFF
05:20:00	CAPS Quiet (**), CDA Noisy	07:55:30	CDA Quiet	11:55:00	Quiet Test #3 (RSS)
05:40:00	CDA Quiet	07:56:00	CIRS Noisy	11:55:30	CAPS Noisy
05:41:00	CIRS Noisy	08:06:00	CIRS Quiet	12:05:30	CAPS Quiet
05:51:00	CIRS Quiet	08:06:30	INMS Noisy	12:06:00	CDA Noisy
05:51:30	INMS Noisy	08:16:30	INMS Quiet	12:26:00	CDA Quiet
06:01:00	INMS Quiet	08:17:00	ISS Noisy	12:26:30	INMS Noisy
06:02:00	ISS Noisy	08:32:00	ISS Quiet	12:36:30	INMS Quiet
06:16:00	ISS Quiet	08:32:30	MAG Noisy	12:37:00	MAG Noisy
06:17:00	MAG Noisy	08:42:28	MAG Quiet	12:46:58	MAG Quiet
06:27:00	MAG Quiet	08:43:00	MIMI Noisy	12:47:30	MIMI Noisy
06:28:00	MIMI Noisy	08:53:00	RPWS LP Noisy	12:53:00	RPWS LP Noisy
06:33:00	CAPS Noisy	08:58:30	RPWS Sounder Noisy	12:57:32	MIMI Quiet
06:43:00	CAPS Quiet	09:08:00	RPWS Quiet	13:03:00	RPWS Sounder Noisy
06:44:00	RPWS LP Noisy	09:09:00	UVIS Noisy	13:13:00	RPWS Quiet
06:53:00	MIMI Quiet	09:14:00	UVIS Quiet		TLM ON
06:54:00	RPWS Sounder Noisy	09:14:01	End VIMS part 2 Quiet Test	13:16:00	CAPS return to state in before QTs
07:04:00	RPWS Quiet	09:14:30	VIMS Noisy		
07:04:30	UVIS Noisy	09:19:00	VIMS Listen		
07:09:30	UVIS Quiet	09:30:00	S&ER3 Test		
07:10:00	VIMS Noisy	09:49:00	SAF 142.2 (2kbps)		
07:21:00	VIMS Listen	09:51:00	CIRS to sleep for Quiet Test #3		
07:25:00	CAPS Noisy	09:51:10	UVIS to sleep for QT #3		
07:35:00	CAPS Quiet	09:51:15	VIMS to sleep for QT #3		

Table 6.1 – Quiet Test Schedule

Section 7 – Second Baseline

7.1 Overview (Dana Burket)

The INMS team was given the opportunity to rerun the baseline test during a contingency window on DOY 021. The originally assigned INMS contingency period on DOY 013 was not used due to the unexpected spacecraft safing occurring shortly before that period. On DOY 021, a load-and-go mini-sequence was issued to INMS which executed a replacement heater turn-off, instrument turn-on, ALF load, and MRO. The results of the MRO were verified, and the INMS team proceeded with a pressure test of the instrument using a real-time command file. After verifying successful completion of the pressure test, the INMS team gave a "go" to upload a mini-sequence containing the corrected baseline test. The baseline executed to completion with apparent nominal results. Subsequent analysis confirmed the test was successful and INMS was operating as expected. The instrument was powered off and the replacement heater was powered on via a real-time command.

7.2 Limit Checking (Thomas Henry)

The Limit Checking software worked in the same fashion as in the first baseline. No changes were made to the tool. John and Florence manually checked the limits just they did in the first baseline test. Displays showed INMS operating nominally on the second baseline.

7.3 Monitoring (Hunter Waite)

The real-time monitoring tool described in section 5.3 was used for the first time during this baseline. Total instrument current values (IMON) and filament 1 and 3 current monitors were carefully observed at high time resolution for anomalies. The real-time monitoring tool, specifically designed to make filament cycling obvious, displayed no anomalies.

7.4 Analysis (Hunter Waite)

Analysis of baseline spectra and counts, housekeeping and science telemetry data and the comparison of lens tuning data with that of previous baselines indicates the instrument fully functional and operating within expected parameters. The following items are notes or small deviations of interest from expected data which potentially merit further discussion (for detailed information on serial numbers please see Appendix B).

Baselines used for comparison

19990121.0628-ico1_baseline2, 19970326.1325-baseline_44_jpl_atlo, 19970528.1012-ksc

Analysis Items

a) Some of the Mass 28 dwells display a trend toward decreasing counts (example - Figure 7.21), which are a function of the previous state of the ion source and the process of approaching thermal equilibrium. These trends should be accounted for in orbital operations by warming up the filaments prior to taking measurements.

b) A comparison of counting deviations for the dwells shows a close comparison between expected and standard deviation. Again, while the data shows the instrument operating nominally, small discontinuities may bear second order analysis.

c) SN 20 vs 23: Closed source filament #3 shows a factor of two counting rate decrease relative to filament #4. This also occurs on the equivalent KSC and ATLO baselines (however, not at low eV – SN 31 vs 33). This indicates some efficiency change that has not been thoroughly understood at this point.

d) In both the closed and open sources, overall count rate and dominance of ^{40}Ar appears similar to the ATLO baseline. However, the water group, methane abundance, and N_2 to some degree are lower in ICO as compared to ATLO.

e) SN 15 / SN 17: Ratios of filament 1 and 2 at high electron energy (~ 70 eV) are similar.

f) SN 15 / SN 19: Filament 1 to 3 ratio at high electron energy (~ 70 eV) are similar.

g) SN 19 / SN 22: Filament 3 to 4 ratio at high electron energy (~ 70 eV) is near 1, but was higher in ATLO.

h) Serial #'s 24-44

SN 17 / SN 24 is smaller (0.6) than in ATLO (0.8).
SN 22 / SN 27 is the same in ICO versus ATLO
SN 22 / SN 30 is the same in ICO versus ATLO
SN 19 / SN 32 is the same in ICO versus ATLO
SN 17 / SN 34 is the same at ^{40}Ar and less in ICO (vs ATLO) for CH_4
SN 15 / SN 36 is the same at ^{40}Ar and less in ICO (vs ATLO) for CH_4
SN 36 / SN 38 is the same before and after and is very near 1.0

i) Filaments 1 and 2 are healthy.

j) Detailed PHD analysis will follow development of appropriate software.

k) Lens and RF tuning from the ICO baseline and previous FM baseline tests compare well (example - Figure 7.8).

l) SN 45: Ratio of C1/C2 is 6200 +/- 400 relative to ATLO testing at 5900 +/- 500.

m) SN 54: He is slightly increased in ICO relative to ATLO.

n) SN 55: Further work is required to determine CH_4 cracking pattern ratios

o) SN 242-245: Crosstalk looks perhaps even better in ICO than in ATLO.

7.5 Selected Graphs (Hunter Waite)

The following pages contain several graphs from ico1_basline2 characterizing INMS operation.

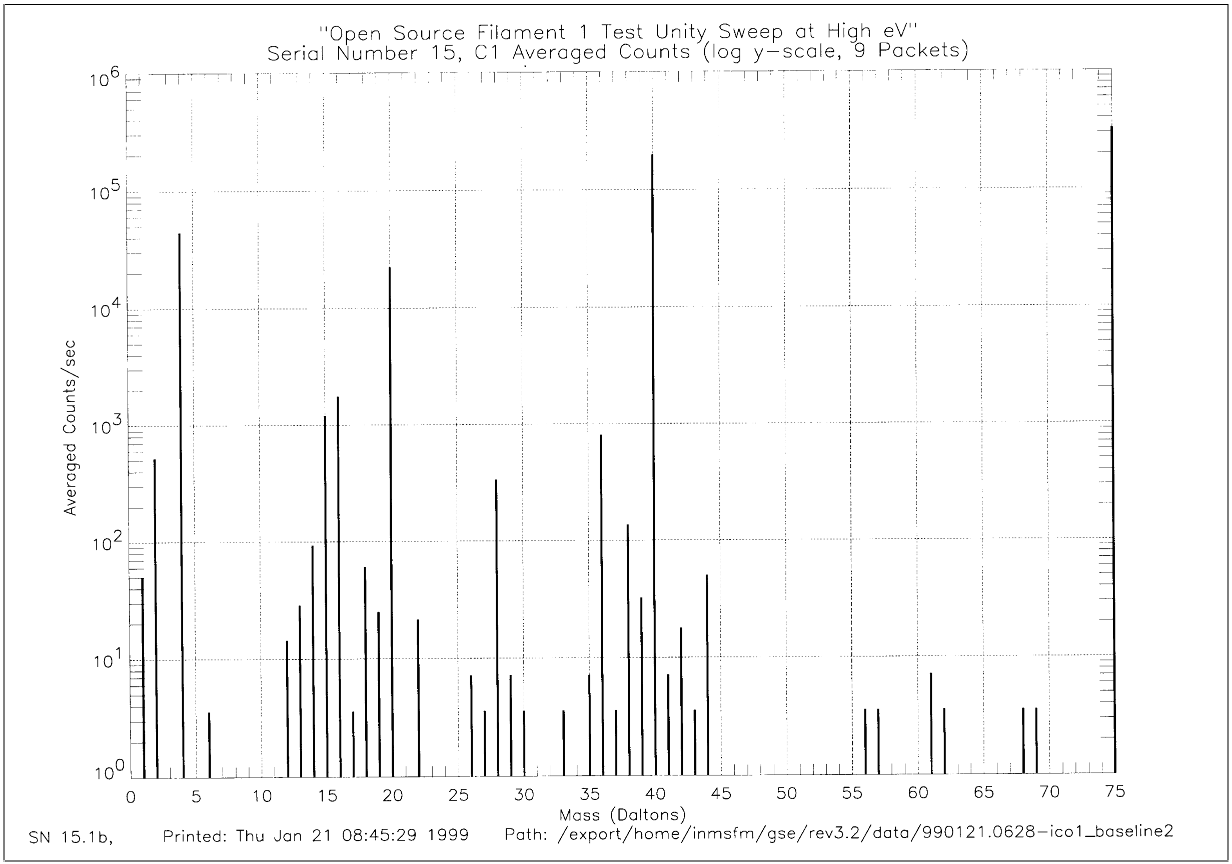

Figure 7.1 – Open Source Filament 1 Unity Sweep at High eV

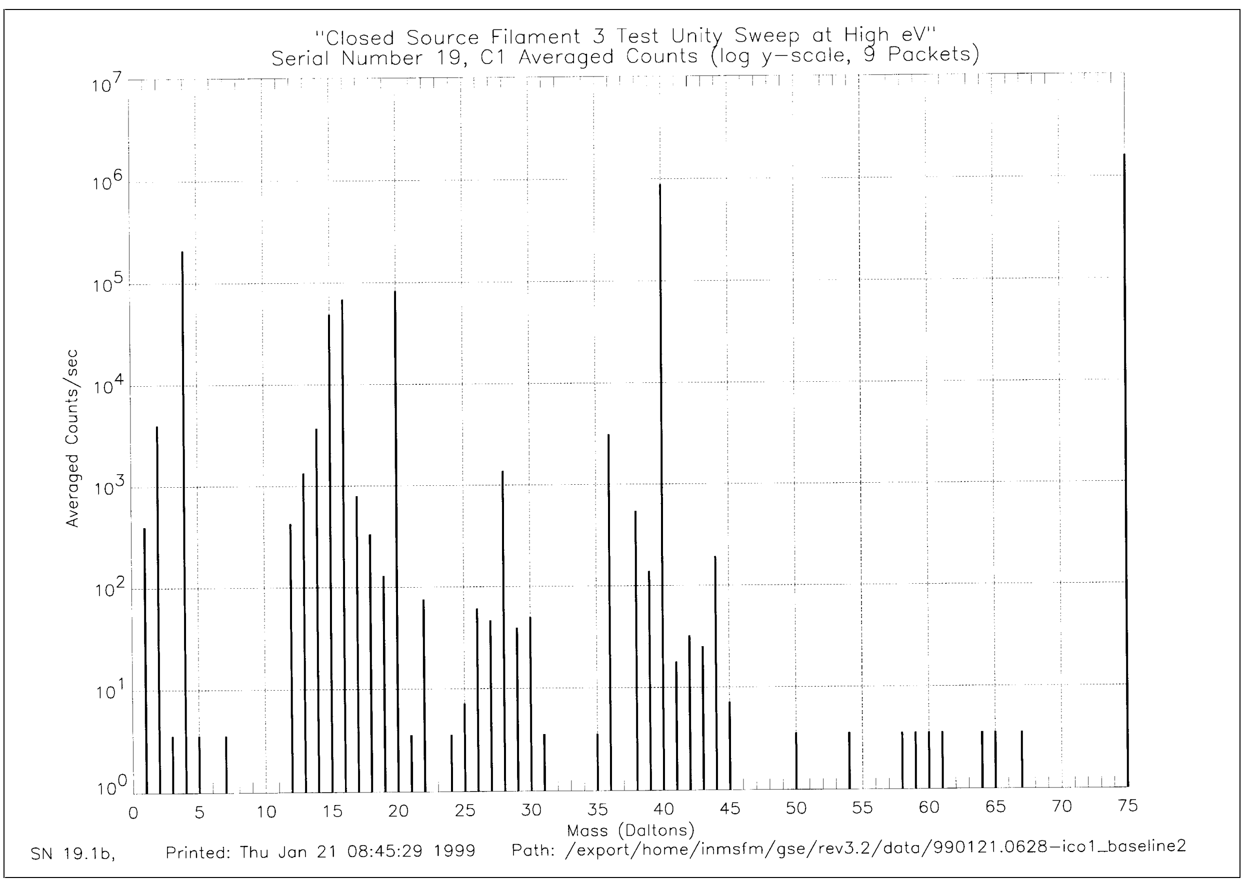

Figure 7.2 – Closed Source Filament 3 Unity Sweep at High eV

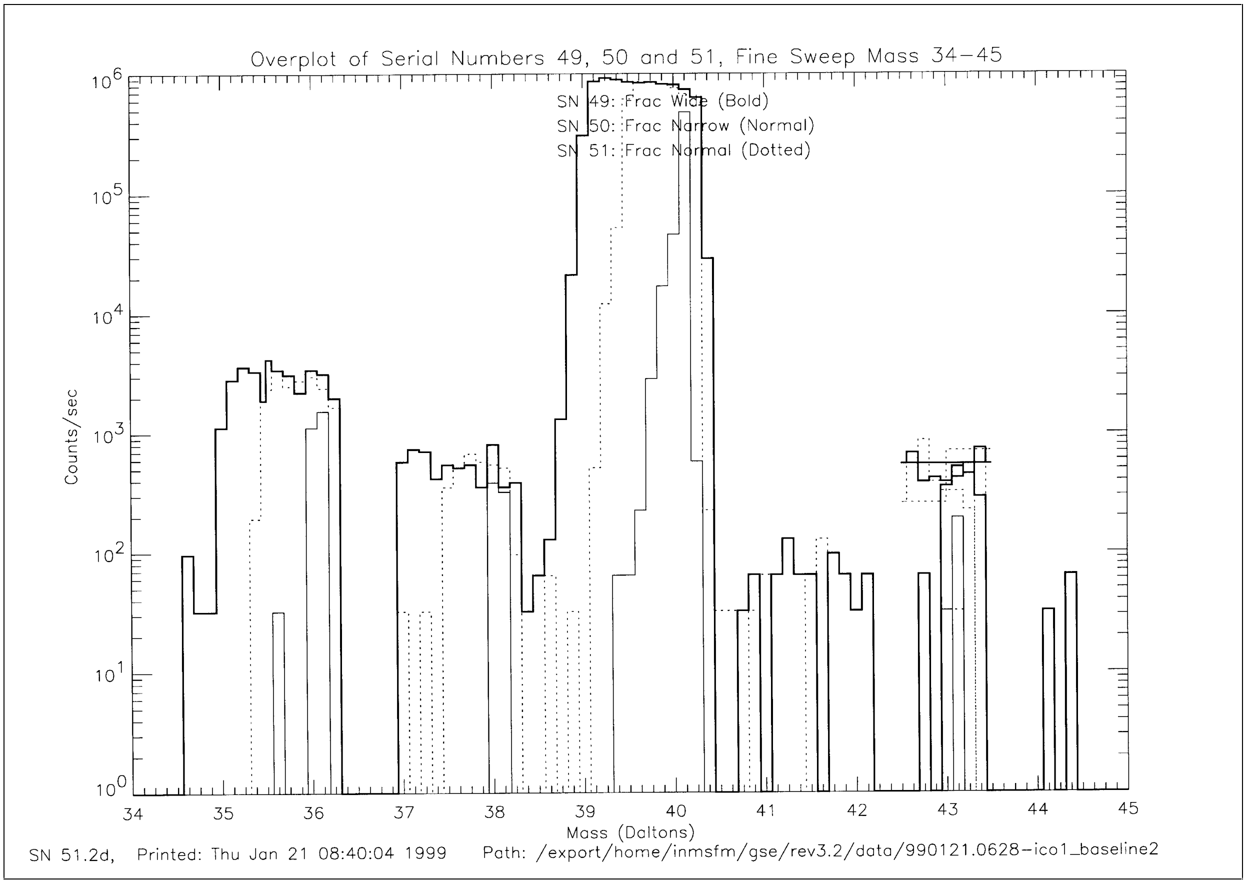

Figure 7.3 – Overplot of Fine Sweep with Peak Width Set Narrow, Normal and Wide

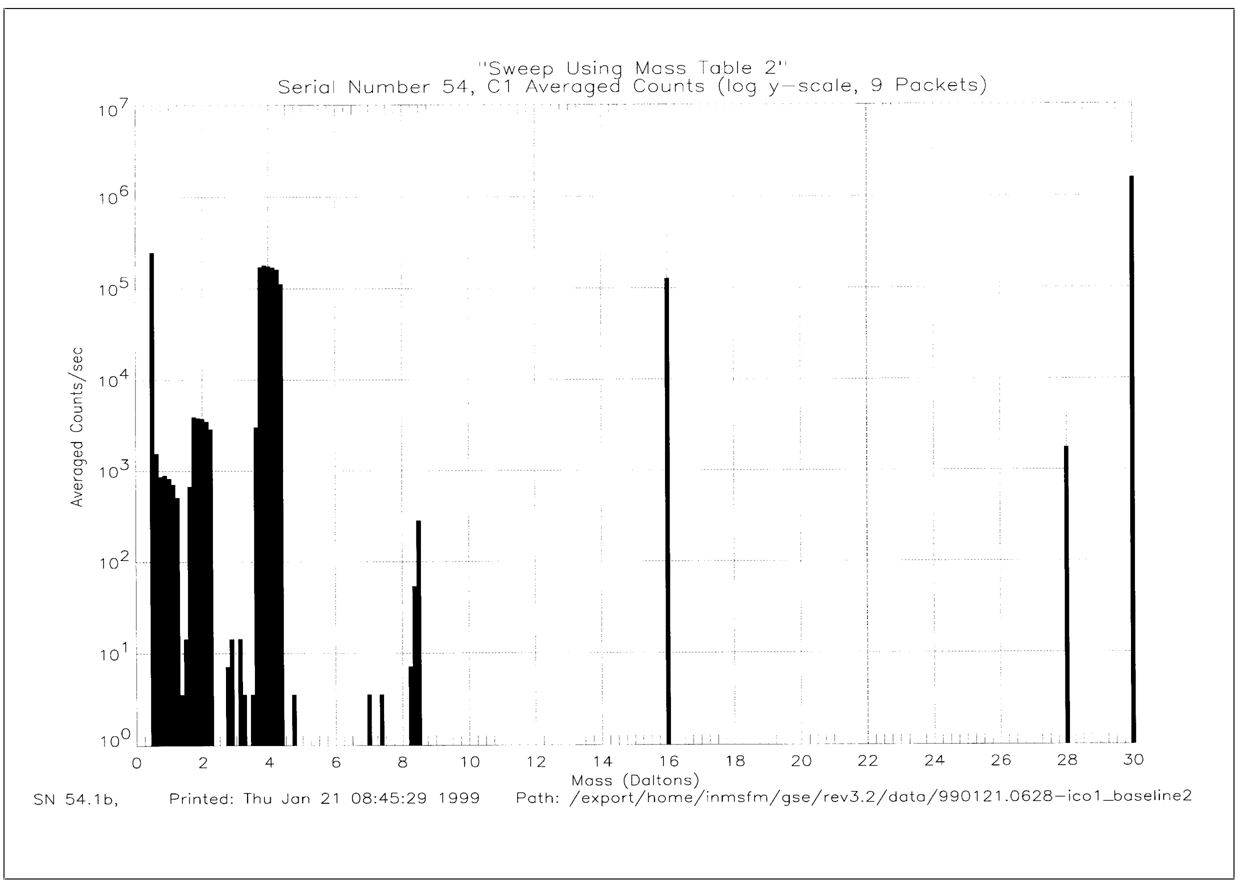

Figure 7.4 – Fine Sweep Using Mass Table 2

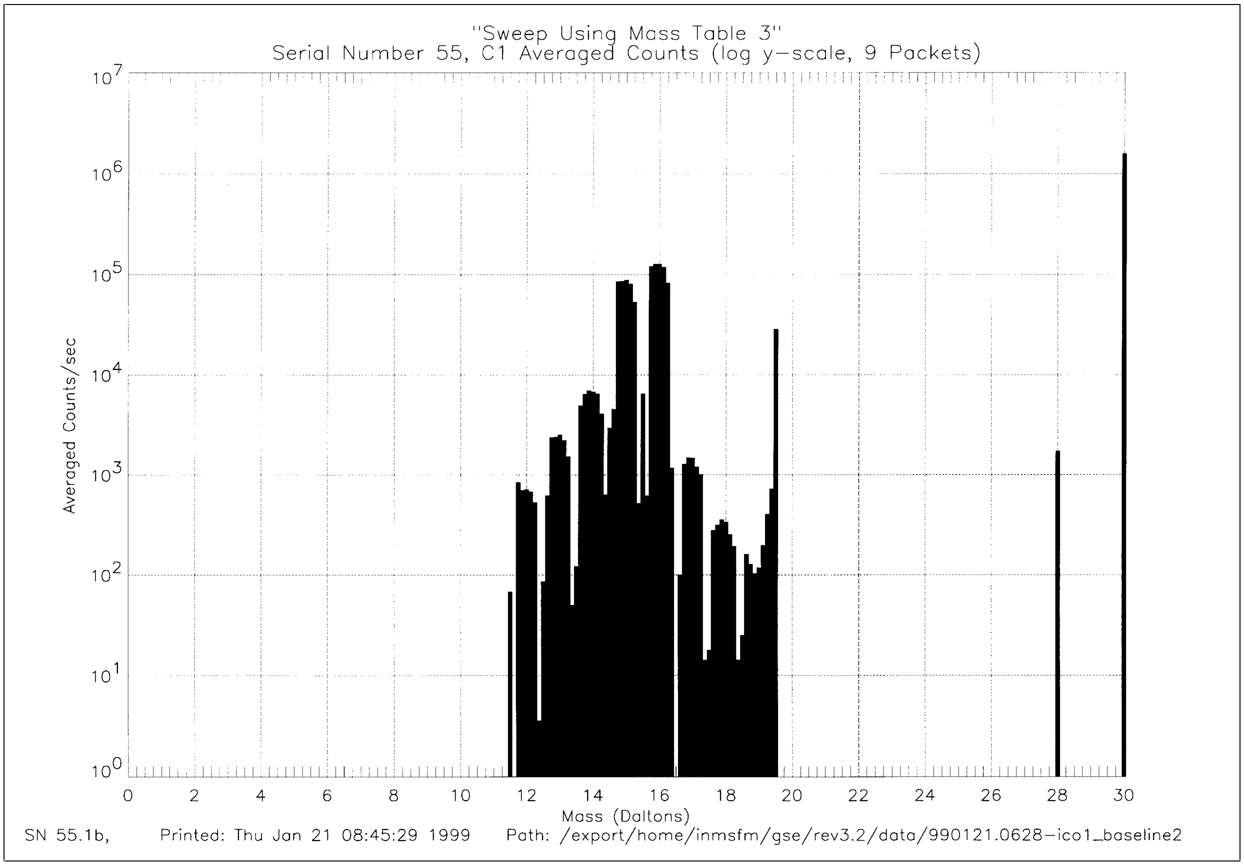

Figure 7.5 – Fine Sweep Using Mass Table 3

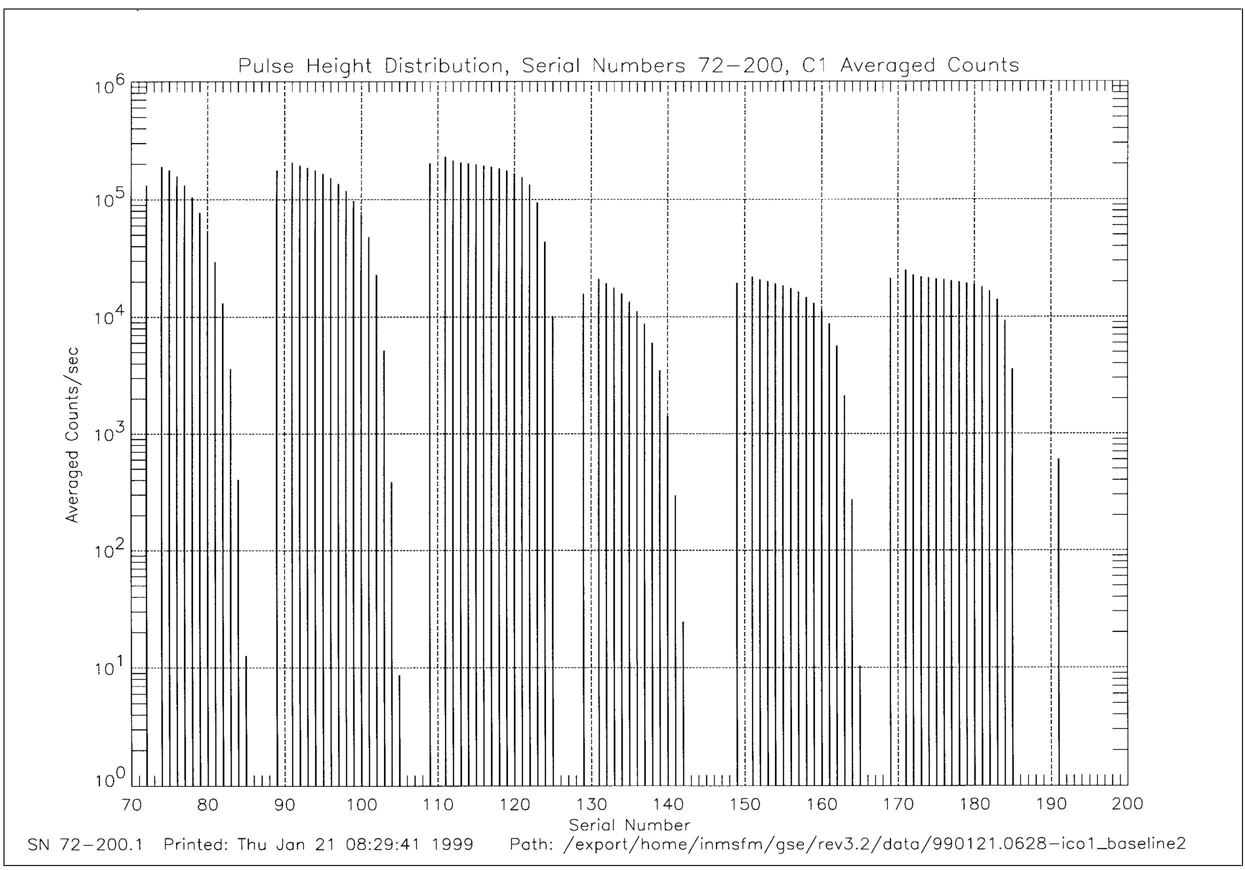

Figure 7.6 – Pulse Height Distribution for C1

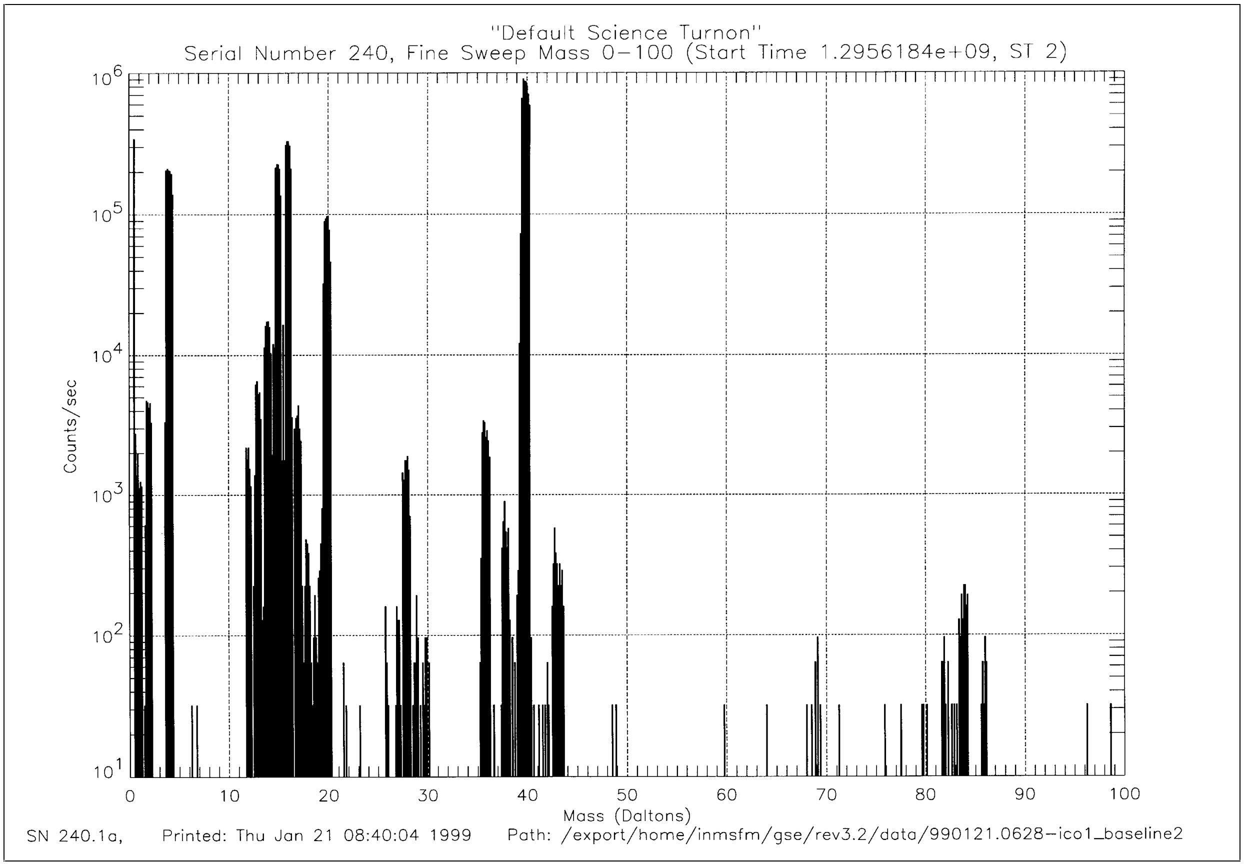

Figure 7.7 – Fine Sweep Mass 0-100

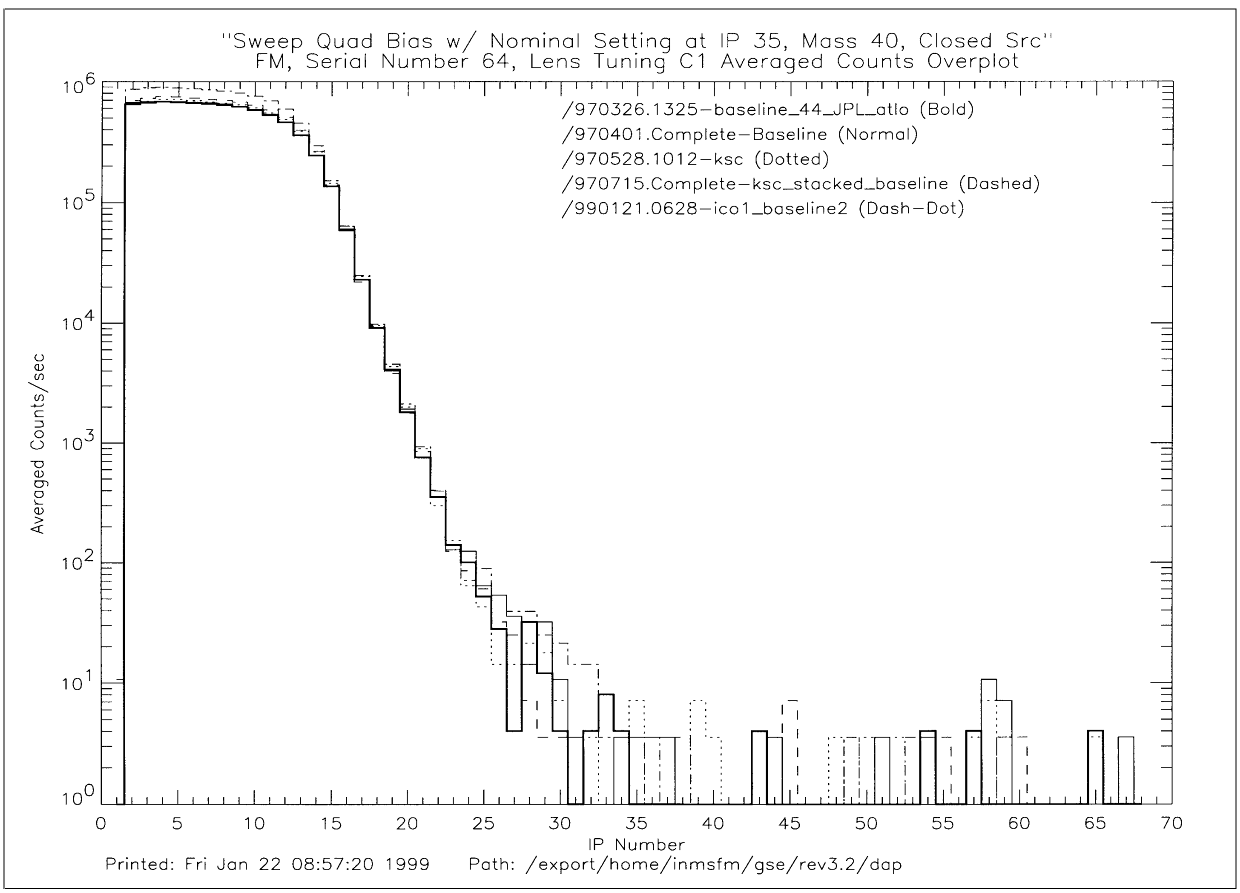

Figure 7.8 – Optics Lens Tuning Overplot of Quad Bias with Previous FM Baselines

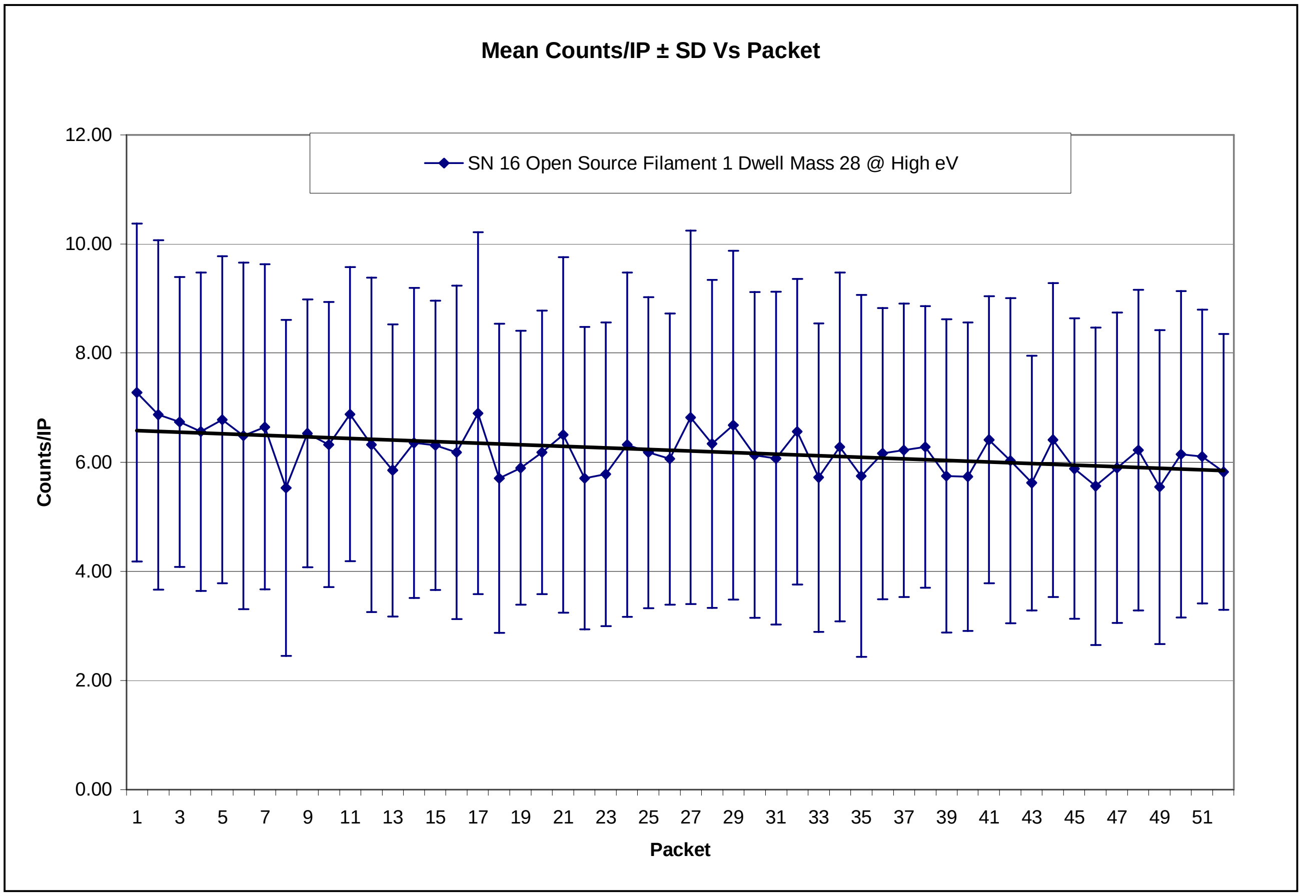

Figure 7.9 – SN 16 Counts/IP vs Packet with Standard Deviation

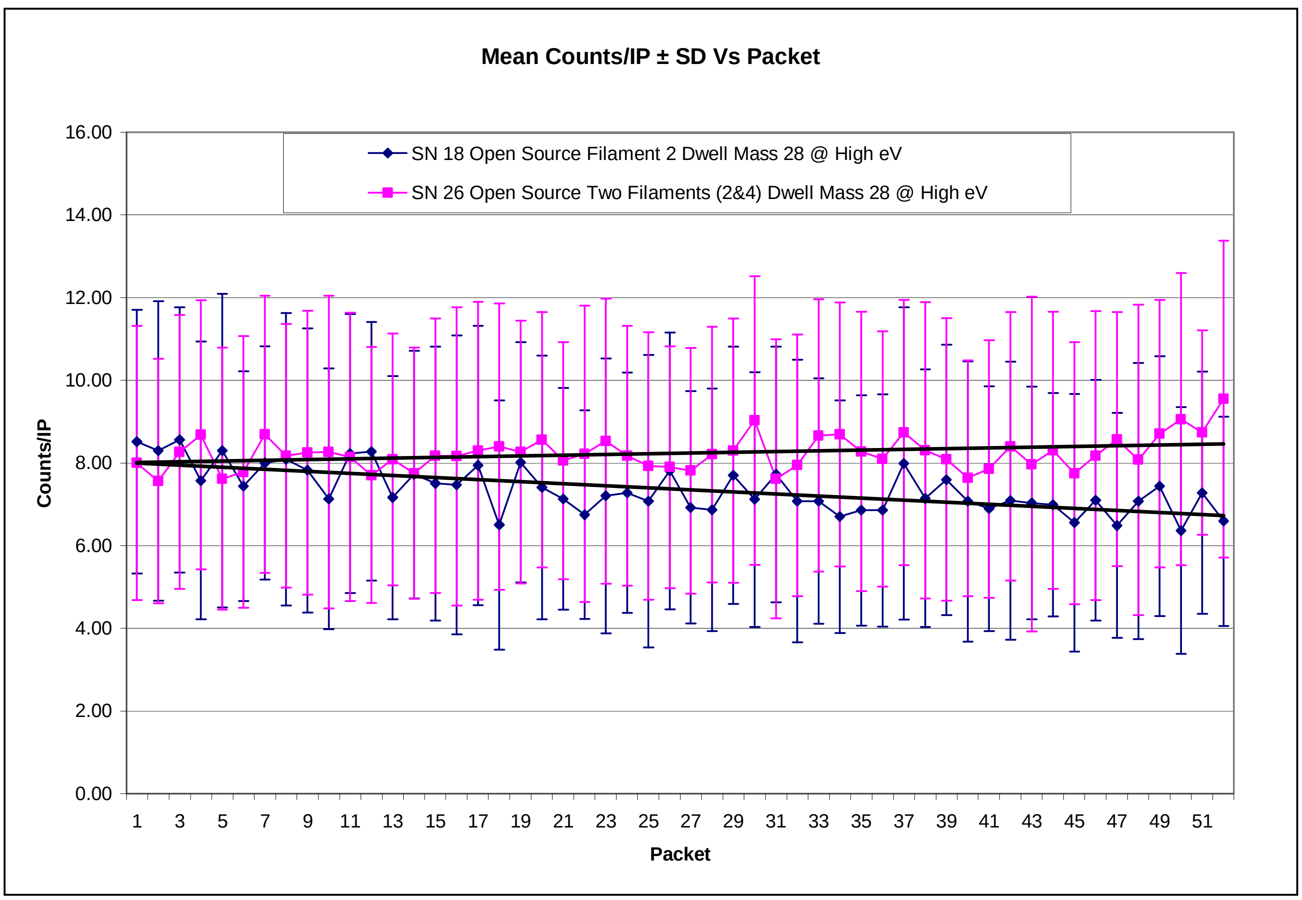

Figure 7.10 – SN 26 Counts/IP vs Packet with Standard Deviation

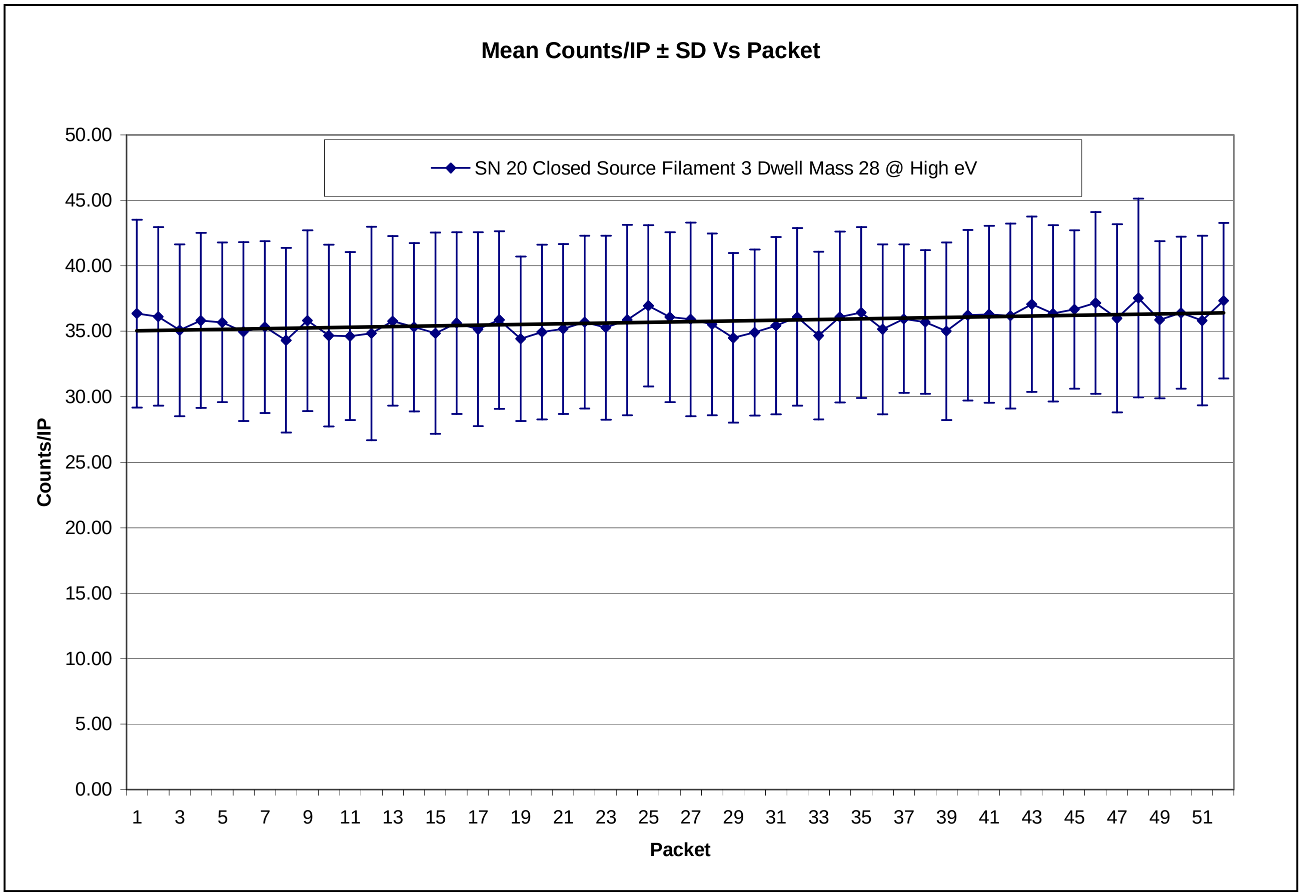

Figure 7.11 – SN 20 Counts/IP vs Packet with Standard Deviation

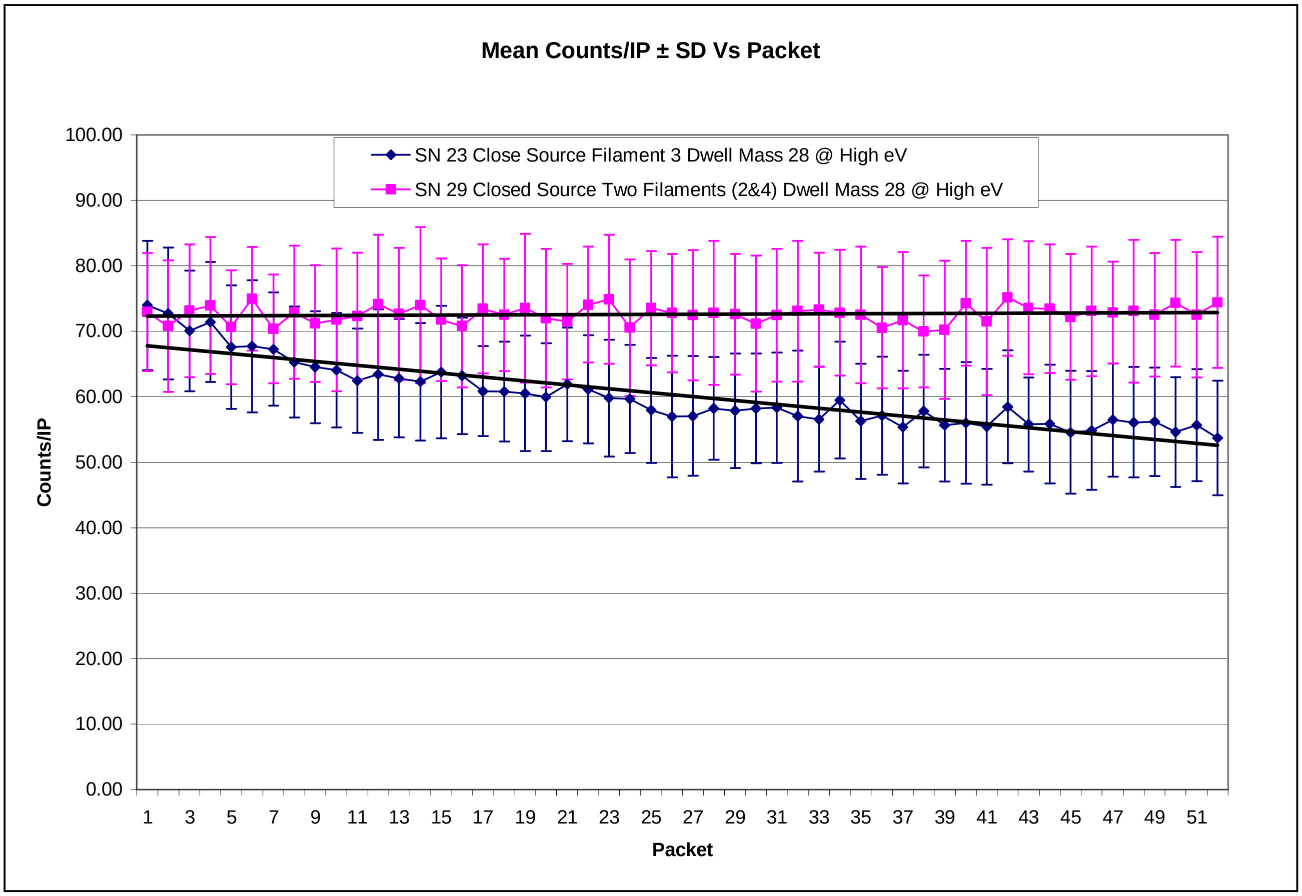

Figure 7.12 – SN 23, 29 Counts/IP vs Packet with Standard Deviation

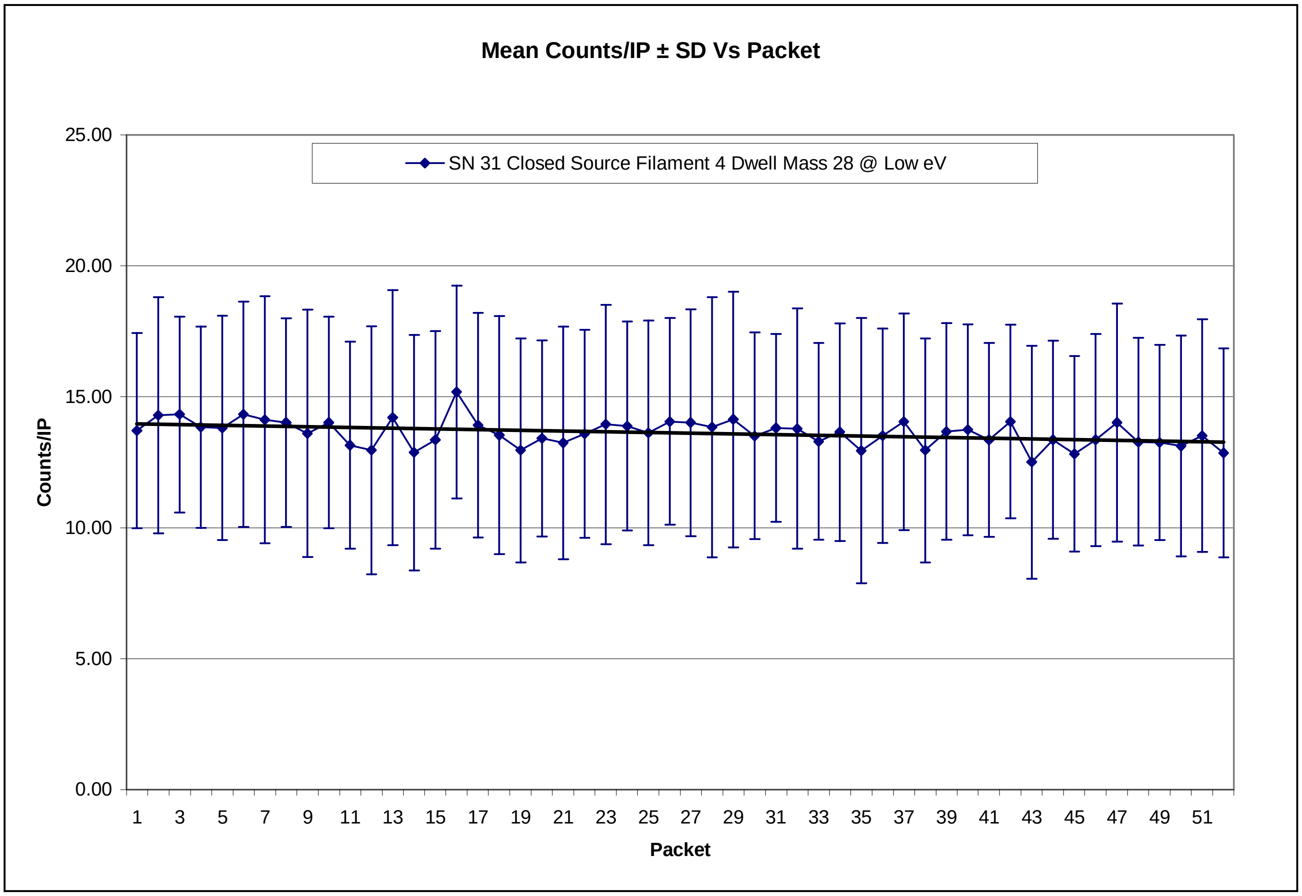

Figure 7.13 – SN 31 Counts/IP vs Packet with Standard Deviation

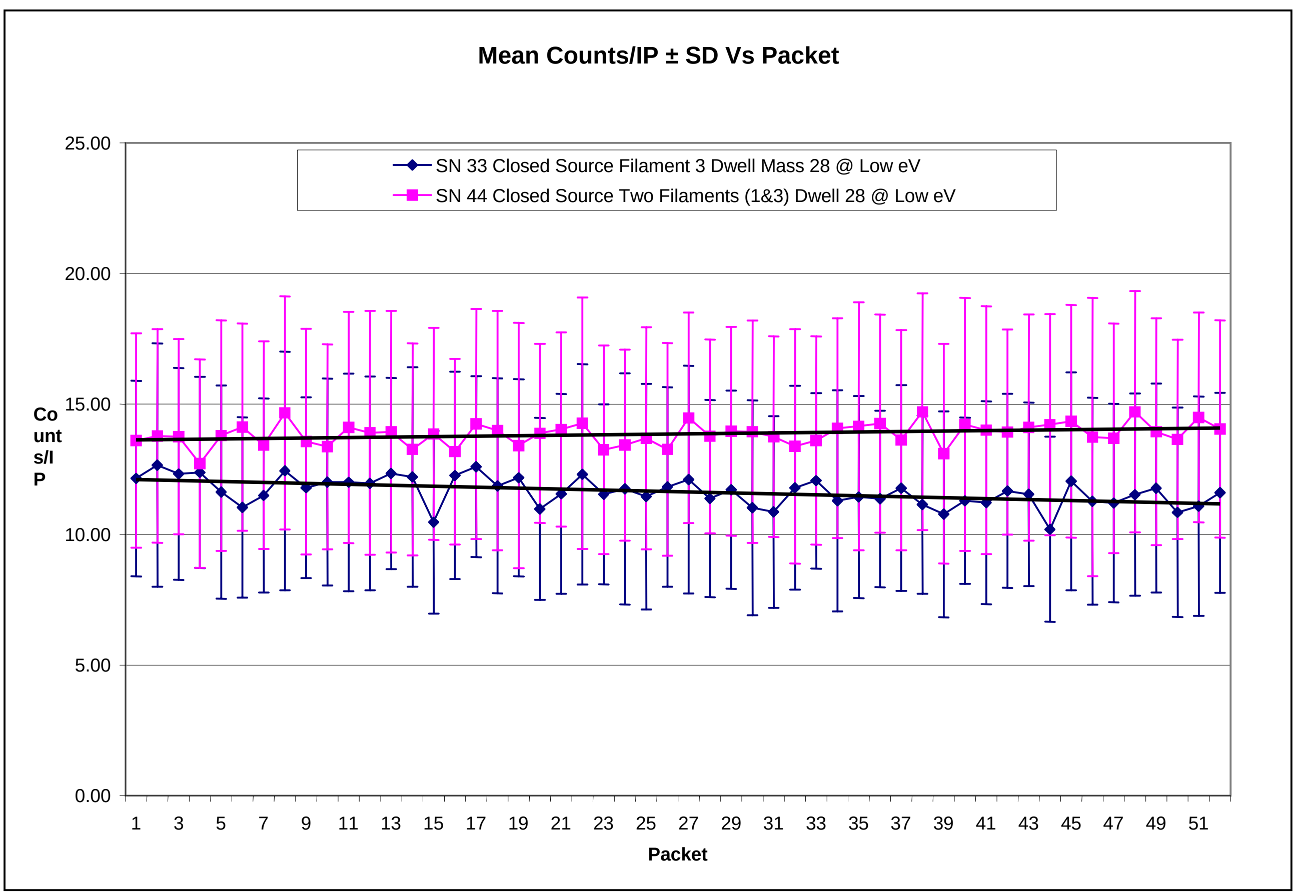

Figure 7.14 – SN 33, 44 Counts/IP vs Packet with Standard Deviation

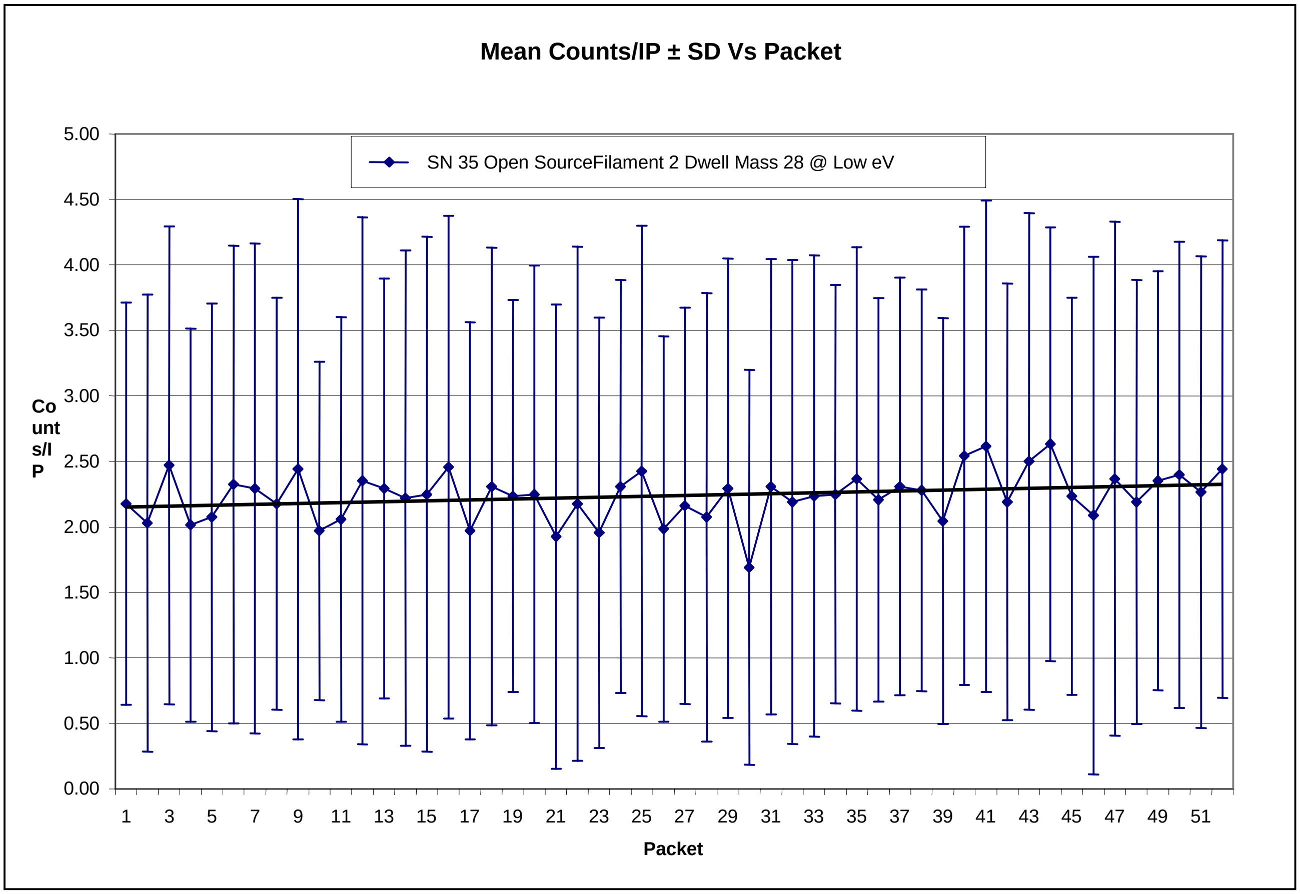

Figure 7.15 – SN 35 Counts/IP vs Packet with Standard Deviation

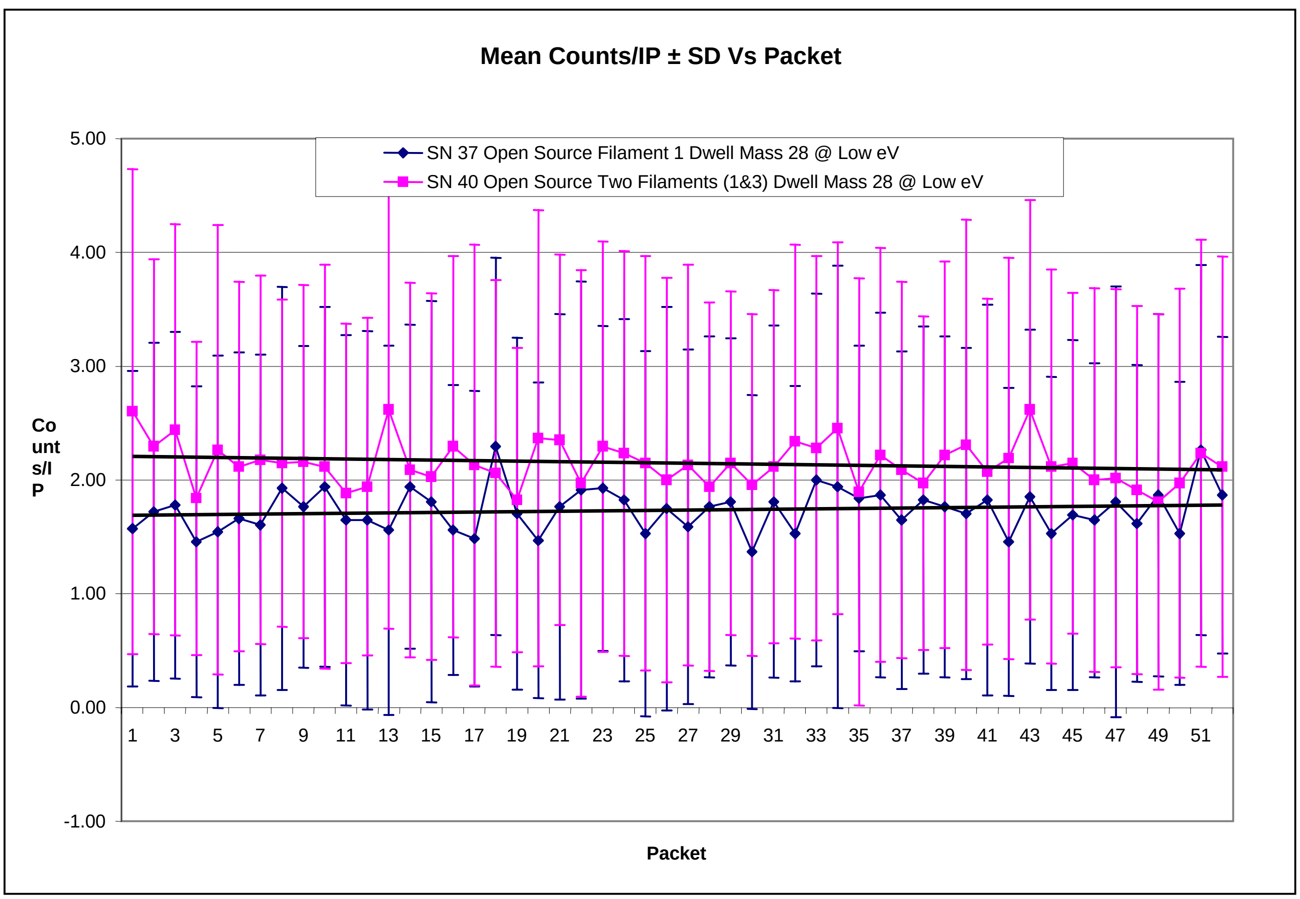

Figure 7.16 – SN 37, 40 Counts/IP vs Packet with Standard Deviation

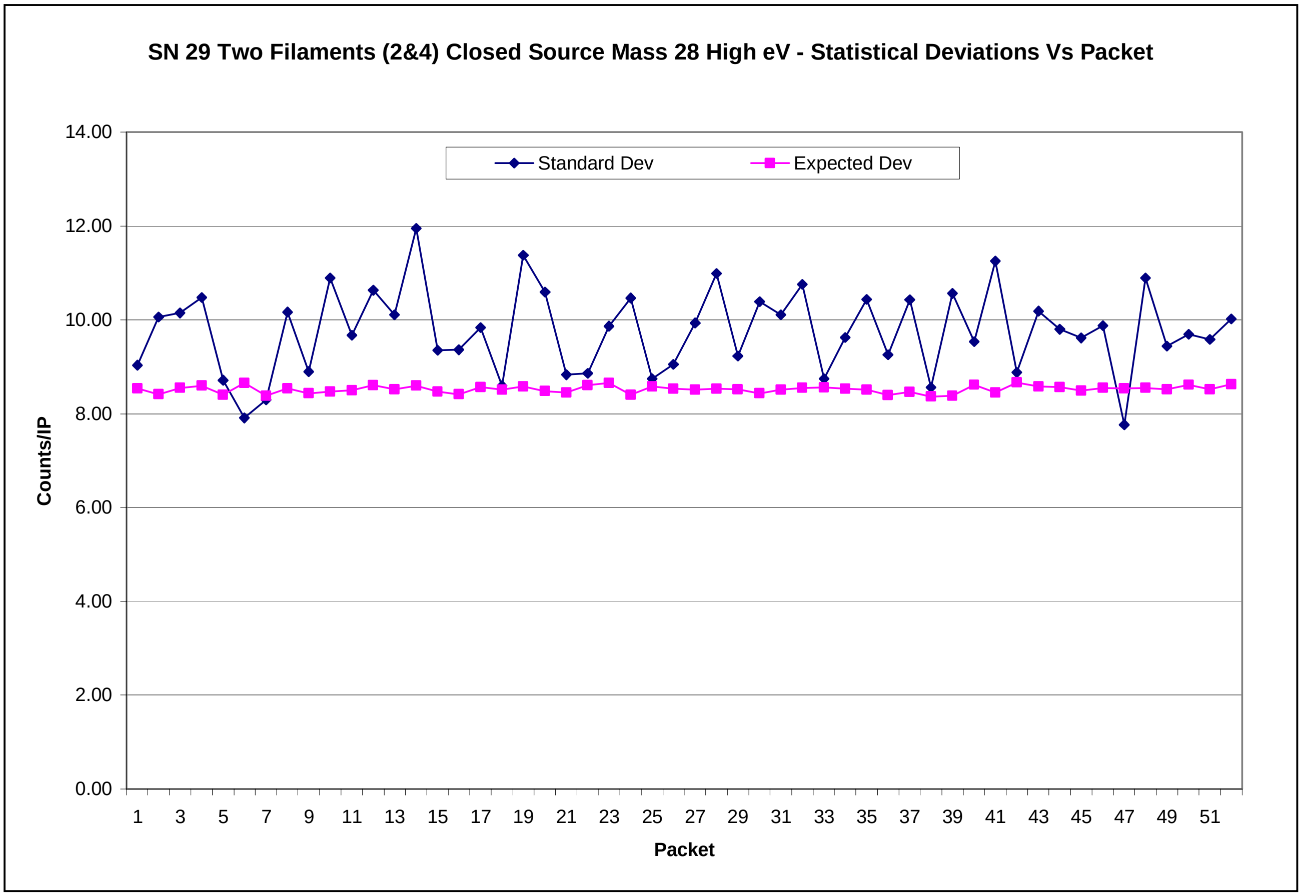

Figure 7.17 – SN 29 Comparison of Standard and Expected Deviation

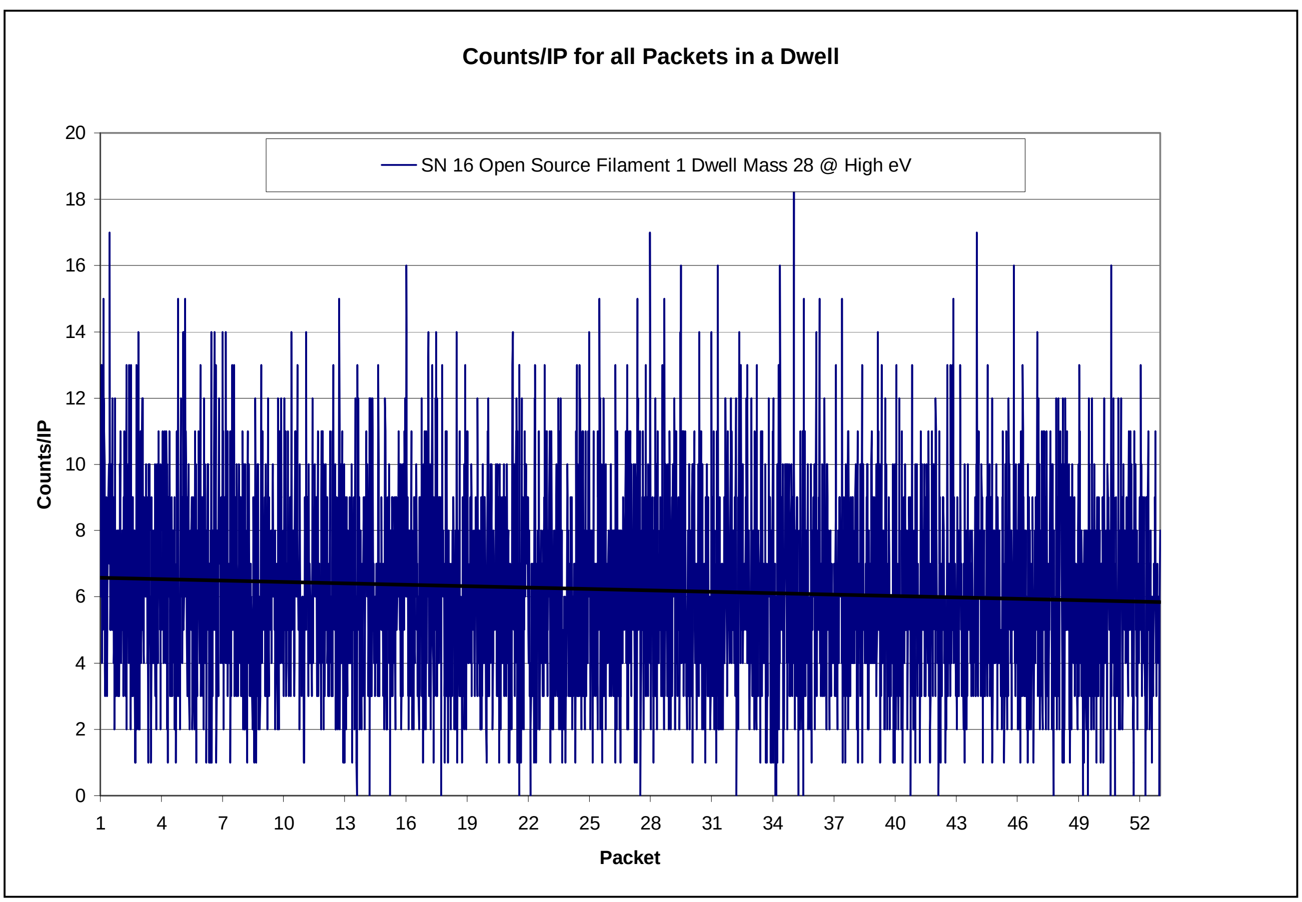

Figure 7.18 – Filament 1, SN 16 Counts/IP vs Packet

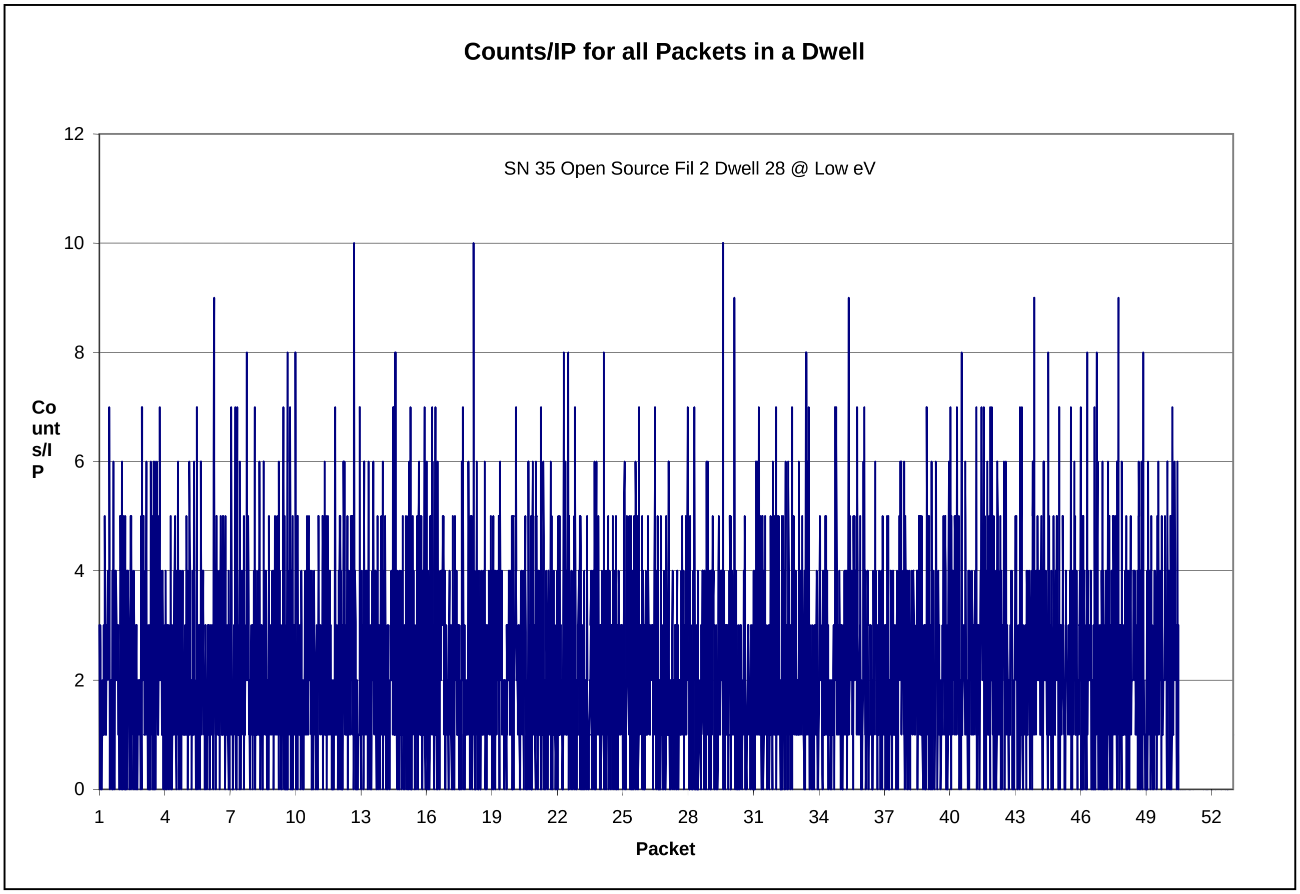

Figure 7.19 – Filament 2, SN 35 Counts/IP vs Packet

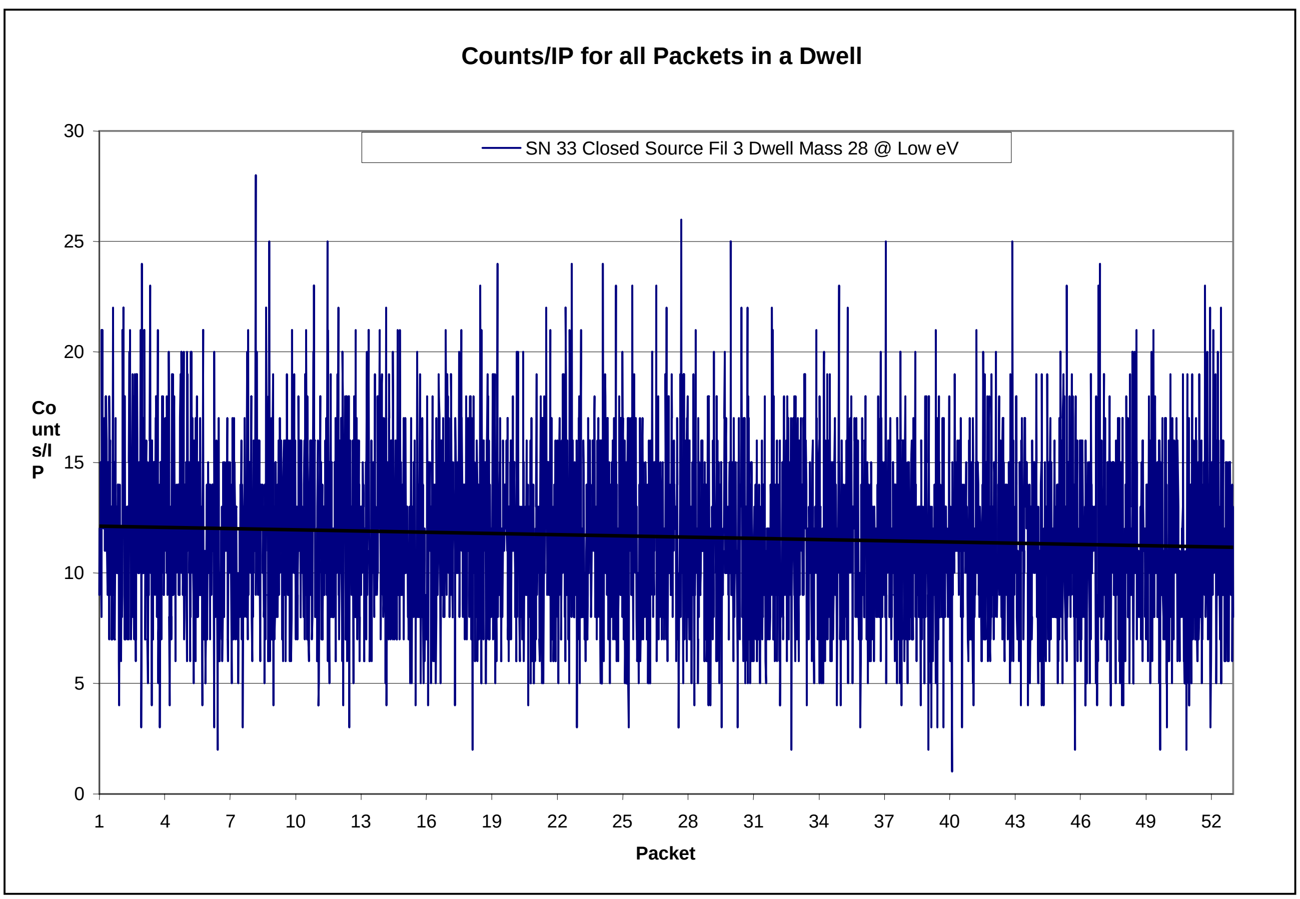

Figure 7.20 – Filament 3, SN 33 Counts/IP vs Packet

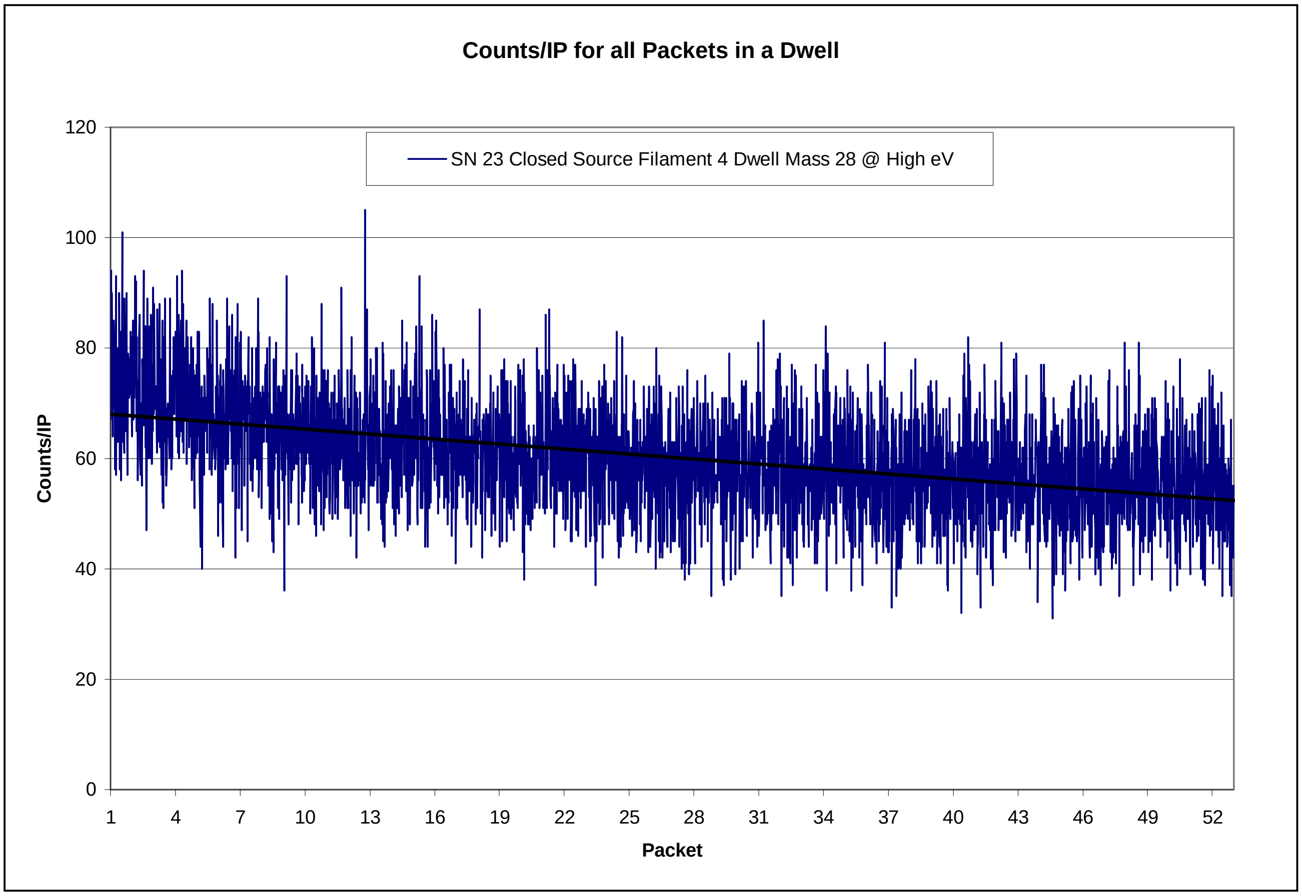

Figure 7.21 – Filament 2, SN 23 Counts/IP vs Packet

Section 8 – Conclusion

(Hunter Waite)

ICO for INMS was characterized by several successful tests of the instrument and ground operations software. It was also characterized by anomalous operation of the instrument that was detected, halted, understood and corrected to resume nominal operation. ICO provides us with information showing the instrument in normal operating state, and excellent feedback on operations procedures that suggest definite changes prior to further operations of the instrument.

Data received from INMS shows the instrument operating nominally. Analysis of data from the second baseline test and other ICO tests suggest INMS is operating within normal parameters, with no indication of damage as a result of the anomalous operation during the first baseline. Comparison of INMS ico1_baseline2 data against previous pre-launch baseline data sets shows a close and highly acceptable correlation between instrument operations tests, as well as a correlation of telemetry streams displaying the status of instrument electronics. Particularly notable is the close correlation of optics lens tuning data between ico1_baseline2 and previous FM baselines. However, there remain some issues that require attention prior to further operation of INMS.

While ICO was ultimately successful, there are several areas where improvement is needed.

- The manual process of translation from ATOL to SASF failed.
- Remote engineering support for creating command sequences resulted in delays and errors.
- Remote engineering support and operation of the EM resulted in delayed and complicated anomaly analysis.
- The procedure for dumping IORAM was complicated and undocumented.
- The procedure of overwriting tables to accomplish baseline requirements added unnecessary complication to the baseline.

Further operation of the instrument should not be attempted until these issues are fully addressed and, in certain cases, changes are implemented and tested. Because of the potential for damage to the instrument and the consumable nature of the filaments, INMS cannot operate without an operational command sequence that has been completely tested on the EM and can then be uploaded, without change, to the FM. I suggest the following measures be taken to ensure future nominal operations of INMS:

- Implement a GSE system allowing identical SASF files to be generated for the EM and FM.
- Ensure all future operational sequences are checked out on the EM and the identical command file uploaded to the FM.
- Move the breadboard flight software prototype to SWRI and borrow the EM for operations verification and testing.
- Transfer flight software knowledge to SWRI.
- Get local engineering and operational training of the EM.
- Change the baseline sequence to avoid table overwrites and change IORAMDUMP procedures to prevent dump errors.
- Trim the EM DACs to duplicate the behavior of the FM DACs, so identical tables can be run on both.

Cassini operations beginning at SOI -2 offer an excellent opportunity to validate the procedural changes and software configuration changes suggested above. Originally, testing of system changes was planned for ICO-2, but delays in deployment of the JPL supported Heurikon system resulted in postponement. With the prospect of a busy schedule the closer Cassini gets to Saturn, we believe it is best to accomplish the complete checkout of INMS systems operations as early as possible.

While I am pleased with the data retrieved and the demonstrated nominal operations of INMS during ICO1, I believe there are critical procedural and operational changes to be made prior to further operation of INMS, and these changes should be tested as early as possible in the SOI -2 timeframe. Accomplishing these changes and performing early testing requires concerted effort, but I believe the payoffs are well worth the effort. I welcome your support and comments.

Appendix A – Acronyms

Acronym	**Definition**
ALF	Assisted Load Format
AMUX	Analog Multiplexer
ASCII	American Standard Character Code for Information Exchange
ATLO	Assembly, Test and Launch Operations
ATOL	Assembly, Test and Operations Language
BIU	Bus Interface Unit
CAPS	Cassini Plasma Spectrometer
CDA	Cosmic Dust Analyzer
CIRS	Cassini Infrared Spectrometer
DAC	Digital to Analog Converter
DOY	Day of Year
EM	Engineering Model of INMS
EM	Electron Multiplier
EMHV	Electron Multiplier High Voltage
FB	Filament Bias
FM	Flight Model of INMS
FSW	Flight Software
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
HK	Housekeeping
HV	High Voltage
ICO	Instrument Check Out
ICO, ICO1, ICO-1	In this document references the first of two planned instrument check-outs planned for Cassini.
IMON, Imon	Current Monitor
INMS	Ion and Neutral Mass Spectrometer
IORAM	Input-Output Read Only Memory
IR	Current Resistance
ISS	Imaging Science Subsystem
KSC	Kennedy Space Center
MAG	Magnetometer
MIMI	Magnetospheric Imaging Instrument
MRO	Memory Read-Out
MUX	Multiplexer
PC	Personal Computer
RAM	Random Access Memory
RF	Radio Frequency
RPWS	Radio and Plasma Wave Science
RSS	Radio Science Subsystem
RTC	Real Time Command
SASF	Spacecraft Activity Sequence File
SCET	Spacecraft Event Time
SCI	Science
SD	Standard Deviation
SN	Serial Number
SOI	Saturn Orbital Insertion
SSR	Solid State Recorder
SVS	Sequence Validation Software
SWRI	Southwest Research Institute
TC	Telecommand
TM	Telemetry
T-V	Thermal-Vacuum
UTC	Universal Time Code

UVIS	Ultraviolet Imaging Spectrometer
VIMS	Visual and Infrared Mapping Spectrometer

Table A.1 - Acronyms

Appendix B – Baseline Summary

Sec	Serial #	Function	eV	Fil	Data	1	2	3	4	Time	Mass Table #	Analysis	Comments
1	5	BA Test								360			Check go/no-go at DAC 0, then pressure at max.
2	15	Unity	H	1	O	1				20	1	A	A = avgscience program to avg for specific config.
	16	Dwell M28	H	1	O					120	15	HK	HK = ilim program –checks each HK word.
	17	Unity	H	2	O		1			20	1	A	Unity step – Use avgscinece to average all packets.
	18	Dwell M28	H	2	O					120	15	HK	Dwell on M28 for stable currents and monitors.
	19	Unity	H	3	C			1		20	1	A	
	20	Dwell M28	H	3	C					120	15	HK	
	22	Unity	H	4	C				1	20	1	A	
	23	Dwell M28	H	4	C					120	15	HK	
3	24	Unity	H	2/4	O		1			20	24	A	
	25	Fract	H	2/4	O					33	2-13	Swp	Swp = iswp program that plots the 12 frac swp.
	26	Dwell M28	H	2/4	O					120	15	HK	
	27	Unity	H	2/4	C					20	24	A	
	28	Fract	H	2/4	C					33	2-13	Swp	Table 1 is mass 1 thru 77.
	29	Dwell M28	H	2/4	C					120	15	HK	Table 24 is mass 1 thru 99 with gaps.
4	30	Unity	L	4	C				1	20	1	A	
	31	Dwell M28	L	4	C					120	15	HK	
	32	Unity	L	3	C			1		20	1	A	
	33	Dwell M28	L	3	C					120	15	HK	
	34	Unity	L	2	O		1			20	1	A	
	35	Dwell M28	L	2	O					120	15	HK	All programs must have the s/n for
	36	Unity	L	1	O	1				20	1	A	the program to be enabled in .pro.
	37	Dwell M28	L	1	O					120	15	HK	
5	38	Unity	L	1/3	O			1		20	24	A	In table 24 the 1st 2 totals are for
	39	Fract	L	1/3	O					33	2-13	Swp	the current source. The 2nd 2
	40	Dwell M28	L	1/3	O					120	15	HK	totals are for the "other" source.
	41	Unity	L	1/3	C					20	24	A	
	42	Fract	L	1/3	C					33	2-13	Swp	
	44	Dwell M28	L	1/3	C					120	15	A	
6	45	Unity	H	4	C				1	120	1	A	Compare counts to sum
	46	Summation	H	4	C					120	1	A	Ref for summation mode
7	49	Frac Wide	H	4	C					33	2-13	Swp	Wide Mass Peaks
	50	Frac Narrow	H	4	C					33	2-13	Swp	Narrow Mass Peaks
	51	Frac Norm	H	4	C					33	2-13	Swp	Normal Peaks for Ref
	52	Frac Left	H	4	C					33	2-13	Swp	Normal moved Left
	53	Frac Right	H	4	C					33	2-13	Swp	Normal moved Right
	54	Tbl 2	H	4	C					33	2	A	Check RF HF Gain & Offset
	55	Tbl 3	H	4	C					33	3	A	Check RF LF Offset
	56	Tbl 12	H	4	C					120	12	A	Chect RF LF Gain
8	58	QL1	H	4	C					20	19	A	4bit/step ±~6.7V ctr@IP 35=-88V
	59	QL2	H	4	C					20	19	A	2bits/step ±~3.3V ctr@IP 35=0 V
	60	QL3	H	4	C					20	19	A	4bit/step ±~6.7V ctr@IP 35=-88V
	61	QL4	H	4	C					20	19	A	2bits/step ±~3.3V ctr@IP 35=0 V
	62	QL5/6	H	4	C					20	19	A	4bit 1bit/step ±20 V ctr@IP 35=0 V
	63	Lens 1	H	4	C					20	19	A	1bit/step ±10 V ctr@IP 35=-30V

	64	Quad Bias	H	4	C					20	19	A	1bit/step –2, 4 V ctr@IP 10=-1V
	65	OL1	H	1	O	1				20	19	A	1bit/stp ±2.5 V ctr@IP 35=0V
	66	Ol2	H	1	O					20	19	A	1bit/stp ±2.5 V ctr@IP 35=0V
	67	OL3	H	1	O					20	19	A	2bit/stp –40, 0 V ctr@IP 35=–13
	68	OL4	H	1	O					20	19	A	2bit/stp –60, 0 V ctr@IP 35=–30V
	69	Top	H	1	O					20	19	A	3bits/stp ±40 V ctr@IP 35=0V
	70	Energy	H	1	O					20	19	A	1bit/stp –60, –50 V ctr@IP 35=0,0,-54,-54
	71	Quad Bias	H	1	O					20	19	A	1bit/step –2, 4 V ctr@IP 10=-1.5V Add 3/13/97
9	73-88	Low HV M40	H	1	O					160	19	IA	IA = iaip program that averages all words in a SN
	90-105	Nom HV M40	H	1	O					160	19	IA	then plots the average with s/n for the x-axis.
	110-125	Hi HV M40	H	1	O					160	19	IA	First set, threshold 15 to 1, at mass 40.
	130-145	Low HV M20	H	1	O					160	25	IA	Second set, threshold 15 to 1, at mass 20.
	150-145	Nom HV M20	H	1	O					160	25	IA	
	170-185	Hi HV M20	H	1	O					160	25	IA	A = 2500, 2700, & 2900 V B = 2800, 2900 & 3000 V
	190-198	HV Off	H	1	O					80	19	IA	EM off, measure system noise
10	210-222	Memory Dump								420			Dump memory in sleep - in sci-packets. No sci-data.
	240	Default Sci	H	2/4	C		1		1	480	1-13		
11	242	Crosstalk	H	2	O					33	1	A	Open count ref
	243	Crosstalk	H	2	C					33	1	A	Closed xtalk value open to closed
	244	Crosstalk	H	3	C			1		33	1	A	Closed xtalk ref
	245	Crosstalk	H	3	O					33	1	A	Open count value Closed to open
	251-252	BIU Reset		–	–					150			BIU discrete & tc reject test
		Total Number of Filament Ons				**3**	**4**	**4**	**4**	**88**	Minutes		

Figure B.1 – Baseline Summary

Note - Filament Designations:

Filaments 1,2 Open Source
Filaments 3,4 Closed Source

Filaments 1,3 Primary Filaments
Filaments 2,4 Secondary Filaments

Appendix C – INMS Command File Summary

For security reasons the actual commands are not listed. Table C.1 summarizes the command files containing commands executed in ICO 1 for INMS.

Name	**Command Type**	**Description**
b0112g	planned	Cassini integrated background sequence for ICO-1 (sequence C11)
i0882a_inms_pressure_test	planned	Execute INMS Pressure Test
i0883a_inms_lens_emhv_on	planned	Turn on lens and EM high voltage supplies
i0884a_inms_rf_on	planned	Turn on RF supply (& lens, EMHV supplies)
i0885a_inms_fil1_on	planned	Turn on filament 1 (& RF, lens, EMHV supplies)
i0886a_inms_sleep1	planned	Go to INMS Sleep 1 state
i0887a_inms_cont_sleep0	Contingency	Go to INMS Sleep 0 state
i0888b_inms_cont_le_em_rf	Contingency	Turn on lens, EM high voltage, and RF supplies
i1214a_inms_mro	Anomaly resolution	MRO of RAM and IORAM
m0117a_reloadram_mro	Anomaly resolution	Reload RAM with ALF load from SSR, do MRO
m0118a_inms_cont_seq	Anomaly resolution	Go to INMS Sleep 1 state, run corrected INMS baseline test
m011ga_inms_on_load_mro	Anomaly resolution	Turn INMS heater off, turn INMS on, load ALFs from SSR, do MRO
s0889c_inms_cont_off	Contingency	Turn INMS off
s0890c_inms_cont_htr_on	Contingency	Turn on INMS replacement heater
s0891a_inms_cont_offhtron	Contingency	Turn INMS off and replacement heater on

Table C.1 - INMS ICO Command File Catalogue

Appendix D – Housekeeping Predicts for Pressure Test and Power Supply Turn-on

BA Pressure Test (Serial # 5)
RTC file: i0882a_inms_pressure_test, Nominal timing: 06:35 – 06:59 UTC, Actual start time: 07:03:34 UTC

Sci HK Monitors	**Expected**	**Actual**
BA Out (~ 4.4 V. Decreases with time as pressure test proceeds.)	~ 4.4 V - decreases	4.4 V
BA Curnt (~0.9A. Increases to ~1 A as test proceeds.)	~0.9A - 1.0A	0.022-0.947 A
BA Anode (never over 110 uA. Increases as time proceeds.)	< 110 uA	101.93 uA
IMON		0.4 A

HK Monitors	**Expected**	**Actual**
BA Step (starts at 15 and goes down to ~5.)	15 -> 5-0	4
BA Press (appears on screen as < 2.)	< 2x10-5 T	0.11
Dig Fil	20h	20h

Ion Optics and Multiplier High Voltage Turn-on (Serial # 10)
RTC file: i0883a_inms_lens_emhv_on, Estimated timing: 06:59 – 07:19 UTC, Actual start time: 07:25:44 UTC

Sci HK Monitors	**Expected**	**Actual**
EM1 Mon (will increase in the 30 – 40 microA range.)	= 20 – 40 uA	24.96 uA
EM2 Mon (will increase in the 30 – 40 microA range.)	= 20 – 40 uA	23.61 uA
AGC Mon	~ -0.04 V	-0.04 V
Imon1, Imon2, Imon3	~ 0.34 A	0.338 A

HK Monitors	**Expected**	**Actual**
EM1 DAC	~ 215 DN	215
EM2 DAC	~ 232 DN	232
FREQ	1.664 MHz	1.664 MHz

RF On (Serial # 11)
RTC file: i0884a_inms_rf_on, Estimated timing: 07:19 – 07:39 UTC, Actual start time 07:43:04 UTC

Sci HK Monitors	**Expected**	**Actual**
EM1 Mon	= 30 – 40 uA	25.11 uA
EM2 Mon	= 30 – 40 uA	23.61 uA
AGC Mon	~ 1.8 V	-0.04 V
Imon1, Imon2, Imon3	~ 0.41 A	0.338 A

HK Monitors	**Expected**	**Actual**
EM1 DAC	~ 215 DN	215
EM2 DAC	~ 232 DN	232
FREQ	1.664 MHz	1.647

Filament 1 On (Serial # 12)
RTC file: i0885a_inms_fil1_on, Estimated timing: 07:39 – 07:59 UTC, Actual start time 08:00:16 UTC

Sci HK Monitors	**Expected**	**Actual**
EM1 Mon	= 30 – 40 uA	25.26 uA
EM2 Mon	= 30 – 40 uA	23.76 uA
AGC Mon	~ 1.8 V	1.94 V
Imon1, Imon2, Imon3	~ 0.47 A	0.479
1 Anode	~ 20.3 uA	20.18 uA
Filament 1	on, only	on, only

HK Monitors	**Expected**	**Actual**
EM1 DAC	~ 215 DN	215
EM2 DAC	~ 232 DN	232
FREQ	1.664 MHz	1.664 MHz
1 Emiss	18.7 uA	16.31 uA

Figure D.1 - Housekeeping Predicts for Pressure Test and Power Supply Turn-on

Appendix E – Contacts

Name	Title	Organization	Phone	Email
Hunter Waite	Team Leader	SWRI	(210) 522-3493	hunter@kronos.space.swri.edu
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