FOS IDT Report RSDP/FOS-009

Standard Case Reductions - Count to Countrate Conversion - Part 2

V. Junkkarinen

1988 March 17

Abstract

The results of more tests of the SOGS/RSDP software for FOS data are presented. All of these tests involve just the count to countrate conversion stage in the reduction process. Tests of input data with multiple "Y-steps", with diodes flagged in a dead-diode table, and with non-standard array lengths are described. The software executed by using the command "CALFOS" is found to be capable of dealing properly with these cases at the count to countrate conversion stage.

Introduction

An earlier report (the "RSDP/FOS-002" report) describes tests of the basic countrate conversion that is performed by the software executed with the command "CALFOS". This report deals with tests of other features of the software that are necessary for the proper reduction of data from the FOS and are performed at the count to countrate conversion stage. The sky and/or background "Y-steps" of spectra with multiple "Y-steps" are available for verification only at the count to countrate stage. At further stages only object minus sky and/or background are produced by CALFOS. The software correction for dead-diodes is conveniently checked at the count to countrate stage, because this correction only involves the countrate calculation and the associated error.

The ability to reduce "non-standard" data to countrates can be tested at the count to countrate stage. "Non-standard" data is produced when some of the user selectable parameters are chosen to be different from the the "standard" FOS values. These parameters, XSTEPS, OVERSCAN, FSTCHNL, and NCHNLS, will sometimes be varied from "standard" values in order to optimize the data-set produced by the FOS to the observations required. Countrate calculations and paired-pulse corrections can be applied to "non-standard" data sets; but further data reduction by CALFOS is restricted to the standard values of these parameters.

Each of the features and capabilities described above is tested using synthetic data. The input data values are generated using the tasks in an IRAF package called "newtools" created by Bernie Simon to support RSDP testing. The output data values are verified by calculating values at selected points with a calculator (HP 15C) or by comparing the output array to an array calculated using a series of operations with SDAS/IRAF. The SDAS/IRAF system provides a test of the "CALFOS" software, since it was developed independently of "CALFOS". The following sections describe the individual tests.

Multiple Y-Steps

The synthetic input data for this test consist of the three "Y-steps" shown in Figure 1. The "Y-steps" are concatenated into a single long one-dimensional array with the 1st 1/3 of the points representing the 1st "Y-step" etc. The data input into the CALFOS routines must have this form. The two output arrays are shown in Figures 2 and 3. Figure 2 is the countrate array and Figure 3 is the error array. The integration time is 0.5s so the countrate is numerically twice the the raw count value at locations where the array is sampled by the usual OVERSCAN diodes. To verify that CALFOS properly calculates the scaled errors, an error array is calculated using the IRAF/SDAS tasks "sdas.arrayops.sqroot" and "images.imarith". The calculation consists of taking the square root of the input array, dividing that by the input array, and multiplying the result by the CALFOS generated countrate output array. The difference between this error array and the one calculated by CALFOS is shown in Figure 4 for all points greater than one. At point one where the input ramp was zero, CALFOS assigns an error at a level of one photon. There is a note about this at the end of the report. At count levels different from zero, Figure 4 verifies the CALFOS scaled error calculation. The results in Figure 4 are consistent with rounding errors of floating point numbers stored as "REAL*4".

Dead-Diode Table Test

Diodes that are flagged as being dead do not contribute to the output data in any way. This function of the flight hardware is necessary to avoid contaminating the output over many output channels with counts from a few defective diodes. The count to countrate conversion must take into account the effect of partial sampling when there are dead diodes. If an output channel normally receives counts from M diodes because of overscanning and if D of those diodes are dead, then the counts in that channel are low by a factor of (M-D)/M. So the software can compensate for dead diodes by adjusting the integration time used in the countrate calculation to be (M-D)/M times the integration time without any dead diodes. Equivalently, the countrate assuming no dead diodes can can be multiplied by M/(M-D). One way to test the operation of the software routines that handle dead diodes is to use an input data array that would produce a constant output countrate if there were no dead diodes. Then by introducing dead diodes, the output levels at corresponding locations are tested to determine if the values are M/(M-D) times the level without dead diodes.

Figure 5 shows the dead-diode array used for these tests. There are 512 diodes and a value of 0 in the array indicates a dead diode. The locations in the dead diode array with values of 0 are: 2,100,200,201,202,298,300,302,401,402,403,404,405. This array like all IRAF/SDAS arrays is 1-indexed i.e. the first element is element number one. FOS diodes and the diode number used for FCHNL are 0-indexed. So the 512 diodes in the FOS are numbered from 0 to 511. The dead diode array described above corresponds to turning off FOS diodes 1,99,199,200,201,297,299,301,400,401,-402,403,404. Since both conventions for numbering diodes are in common use, it is necessary to specify a diode number and the numbering convention.

The input data set "points at" a dead-diode file. The file names for the dead-diode file (header and data) appear in the input data-set header file with the ".d0h" extension. This dead-diode file is used if the parameter "DEFDDTBL" in the ".d0h" file is set to "F" - else the CALFOS routines use a default dead-diode table. Figure 6 shows the result of using the dead-diode array of Figure 5 with an input count spectrum that would produce a constant countrate of 2000c/s with no dead diodes. The input spectrum has NXSTEPS = 4, OVERSCAN = 5, and NCHNLS = 512, which is a standard FOS setup that produces a 2064 point spectrum. The lowest number output point (1-indexed) with a possible contribution from a diode at 0-indexed location N is given by NXSTEPS * (N - FCHNL) + 1, where FCHNL is the 0-indexed location of the first diode and is 0 for the data set used for this test. The correction for dead diodes is easily verified and the output array shows that points that are not sampled at all are set to zero. The table below gives a few values that were checked with the IRAF utility "listpixels".

Channel	N	M-D	countrate w/o dead diodes	countrate CALFOS output
4	1	1	2000.0	2000.000
5	2	1	2000.0	4000.000
13	4	3	2000.0	2666.667
397	5	4	2000.0	2500.000
801	5	3	2000.0	3333.333
805	5	2	2000.0	5000.000
1616	5	1	2000.0	10000.000
1617	5	0	2000.0	0.000

Non-Standard Parameters

Two tests were performed. For the first, the values of FCHNL and NCHNLS were changed from the standard values of 0 and 512 to 286 and 128 respectively. The values of NXSTEPS and OVERSCAN were left at 4 and 5. When less than the entire array of diodes is used for observations, the software must keep track of the absolute diode locations in order to apply the dead-diode correction. So the dead-diode table used for the dead-diode tests described above is enabled for this test. The input array values are 1000 counts except at the ends of the arrays where the array values are adjusted to be proportional to the fractional sampling. This adjustment is made using the "newtools" task "overscan". The effective integration time is set to 0.5 s at points sampled by the full OVERSCAN diodes. Figure 7 shows the output from CALFOS. As expected, the countrate is 2000.0 s^{-1} (1000.0 counts / 0.5 s) except where influenced by the dead diodes. Since the test input array was not scaled to reflect the reduced sampling at points influenced by dead diodes, the output array shows enhanced countrates at these points. The first point different from 2000.0 is point number 45 (1 indexed) while the first dead diode in the range of diodes used is at diode 297 (0 indexed). The first point (1 indexed) to which diode "N" (0 indexed) contributes is NXSTEPS * (N - FCHNL) + 1. This gives 4 * (297 - 286) + 1 = 45 which agrees with the output and verifies the "CALFOS" routines.

For the second test in this section, the values of NXSTEPS and OVERSCAN are changed from the standard values of 4 and 5 to 2 and 3 respectively. The raw data values from the test described above are retained, as well as the values of FCHNL and NCHNLS. New input arrays are prepared to properly reflect the array length produced by this choice of parameters. The effective integration time away from dead diodes is 0.3 s. The predicted countrate is 1000.0 / 0.3 s = 3333.333 s^{-1} where the data is not influenced by dead diodes. Figure 8 shows the output from CALFOS. The predicted countrates are confirmed. The dead diode at 297 (0 indexed) first influences the output array at point number 23 (1 indexed) which, by the calculation described in the previous paragraph, is the predicted value.

Conclusions

These tests verify operation of the count to countrate conversion software in the three areas tested. Arrays with multiple "Y-steps" are properly converted to countrates. Corrections are computed for output channels affected by dead diodes. And the software is capable of computing countrates for data-sets with non-standard values of OVERSCAN, NXSTEPS, FCHNL, and NCHNLS.

Recommendation

In an earlier report, the "RSDP/FOS-002" report, it was recommended that the error array value associated with zero photons detected be set to 0.0. This recommendation is withdrawn, because the assignment of zero error can cause anomalous results in certain kinds of software that is used to fit data. The current RSDP software assigns an error array value when zero photons are detected that is numerically equal to the error array value when one photon is detected. This approximation is an acceptable method of preventing problems that occur when data with unusually small errors are analyzed.

The tests reported here cover three features of the data reduction software. One feature not tested is the Reject Array. This array records the missing integrations when the Reject Array is enabled. Since the entire diode array is rejected if a burst of noise is detected, the Reject Array is indexed by NXSTEPS and OVERSCAN as well as YSTEPS and SLICES. The Reject Array will not be used for most observations since the normal mode of operation will be to re-try an integration if noise is detected. The Reject Array is needed if timing is critical. In order to test this feature, a sample file containing a Reject Array is needed. In particular the header items must be in a fixed order since "CALFOS" finds items by location in the header. The software that converts FOS data into a GEIS data-set suitable for input to "CALFOS" was run by Ed Nelan of STScI with input data in which the Reject Array was present and enabled. No reject array in GEIS format was generated. Ed Nelan has begun (as of 13 November 1987) steps to repair this software. Reject Array function will be tested and reported when a suitable data-set is available.

Figure 1: Input Count Array with 3 Y-Steps

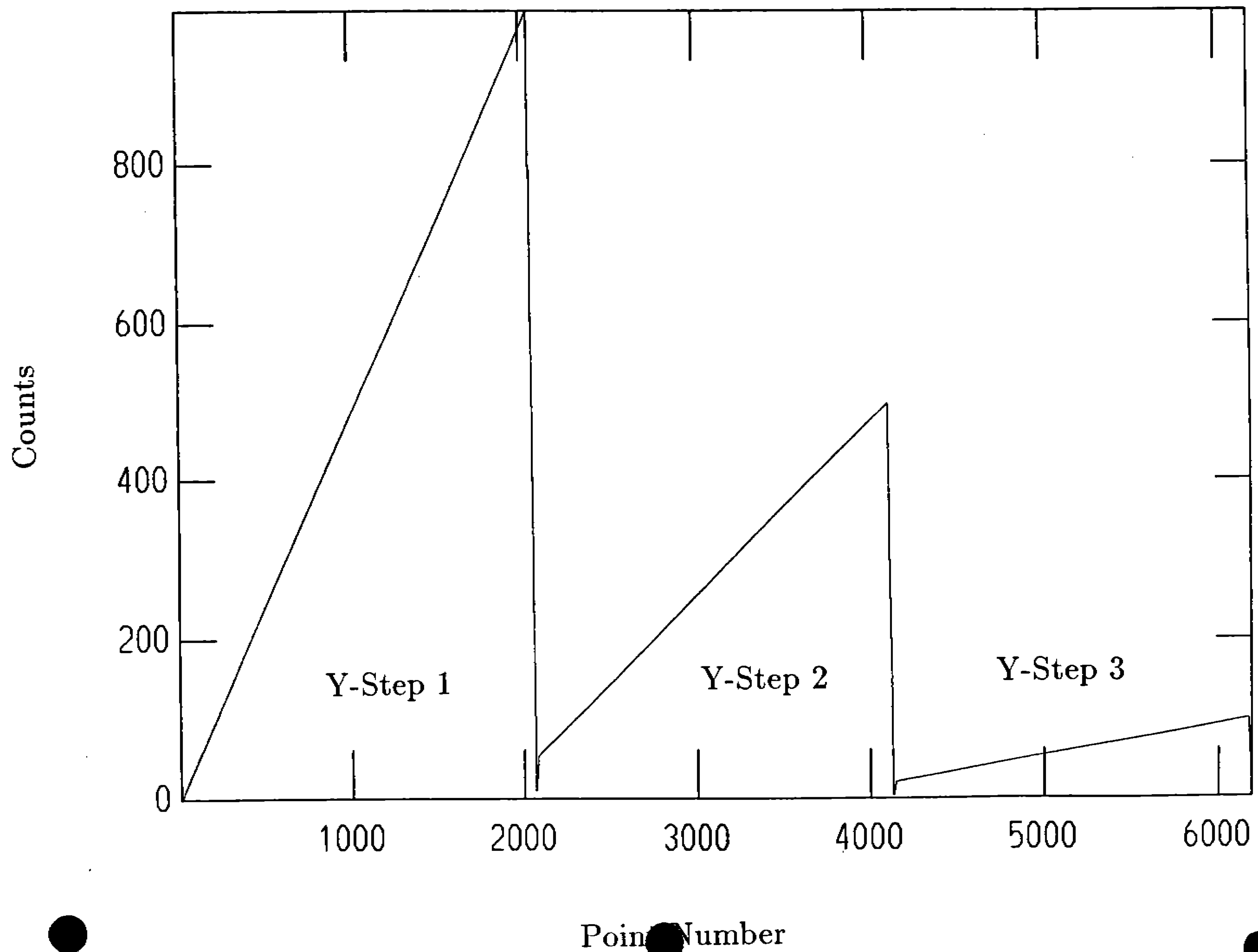

Figure 2: Output Countrate Array with 3 Y-Steps

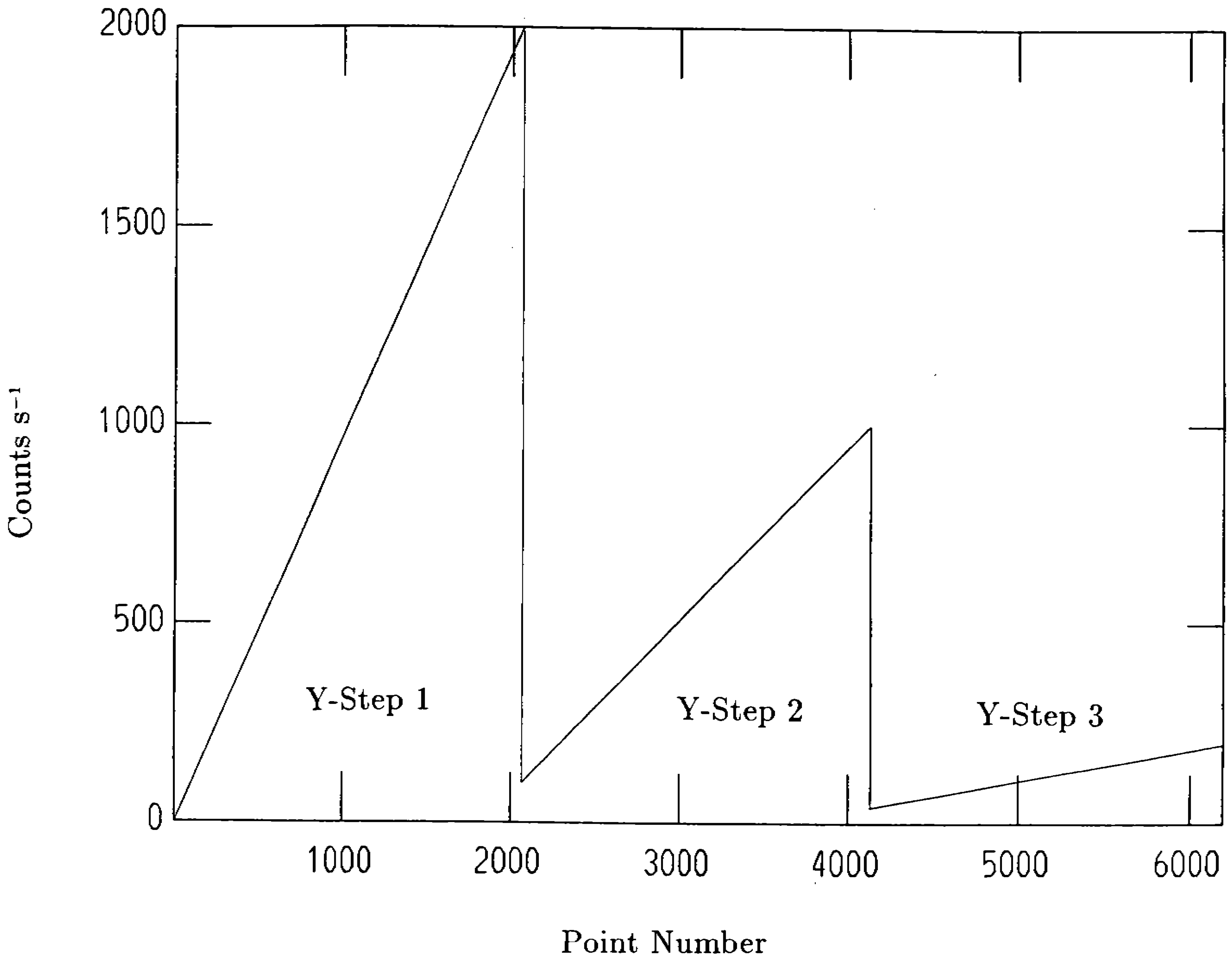

Figure 3: Output Error Array with 3 Y-Steps

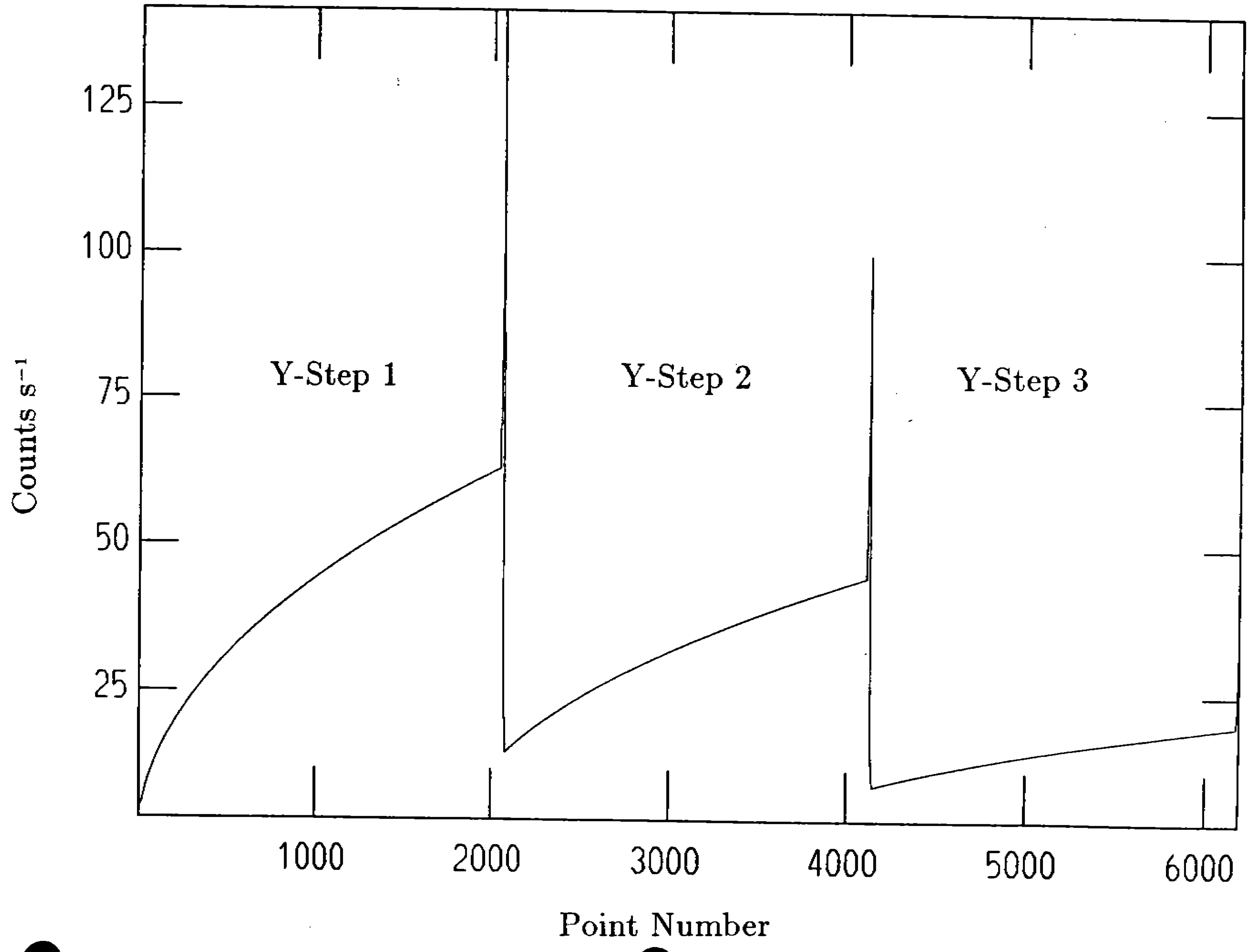

Figure 4: Difference in Output Error Arrays
(SDAS/IRAF calculated - CALFOS calculated)

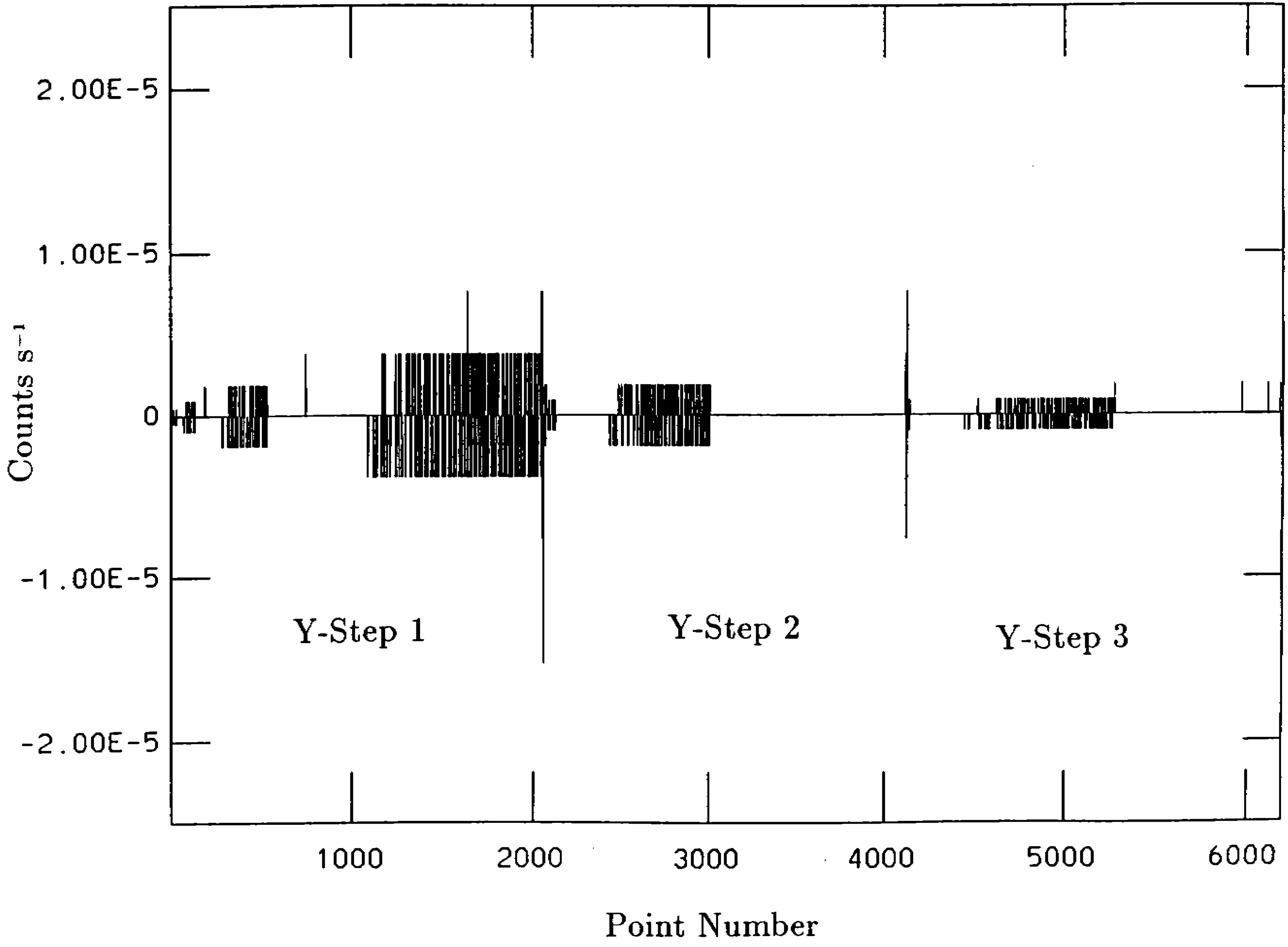

Figure 5: Dead-Diode Array for Software Test

(Value = 0.0 flags dead-diodes)

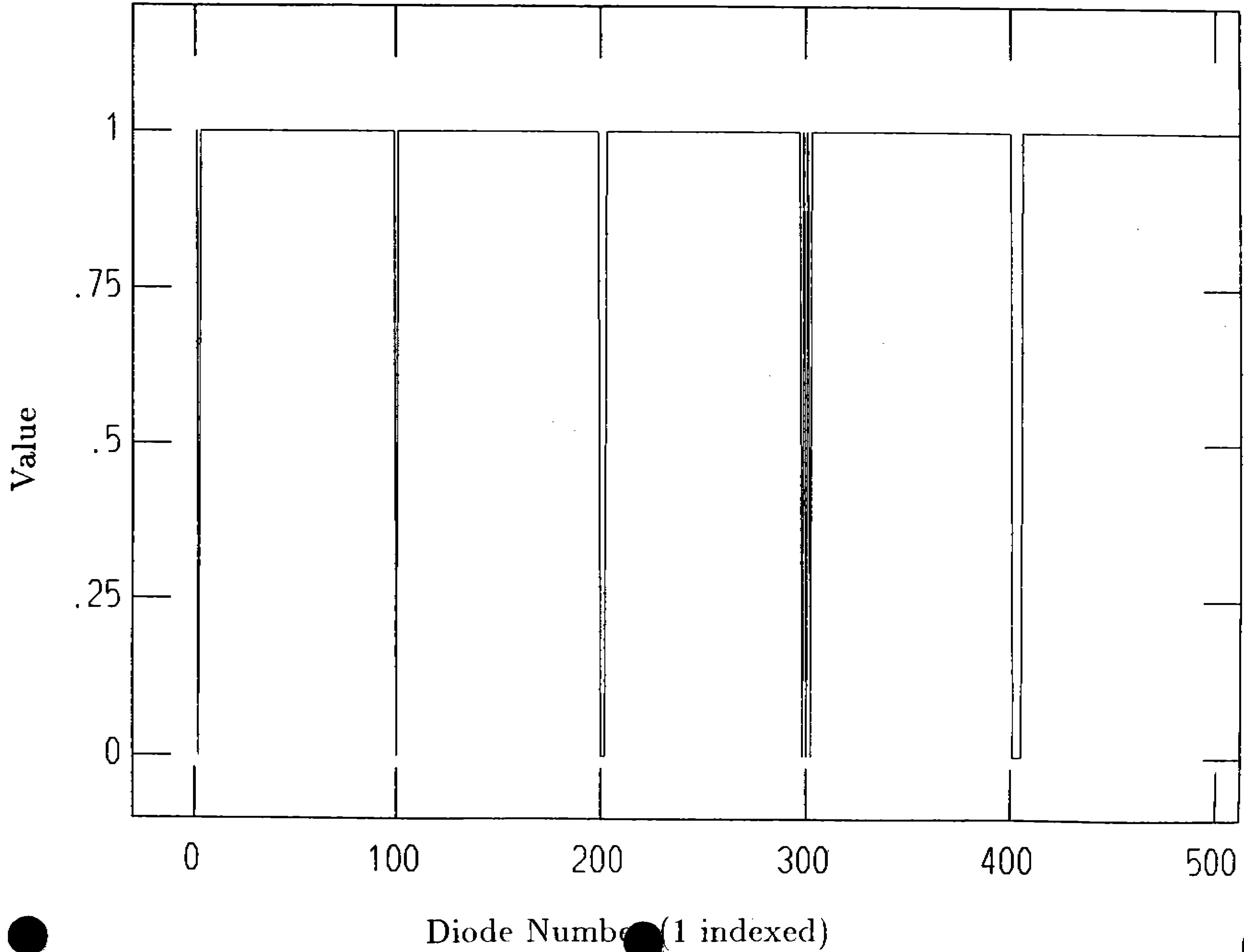

Figure 6: CALFOS Output - Dead-Diode Test

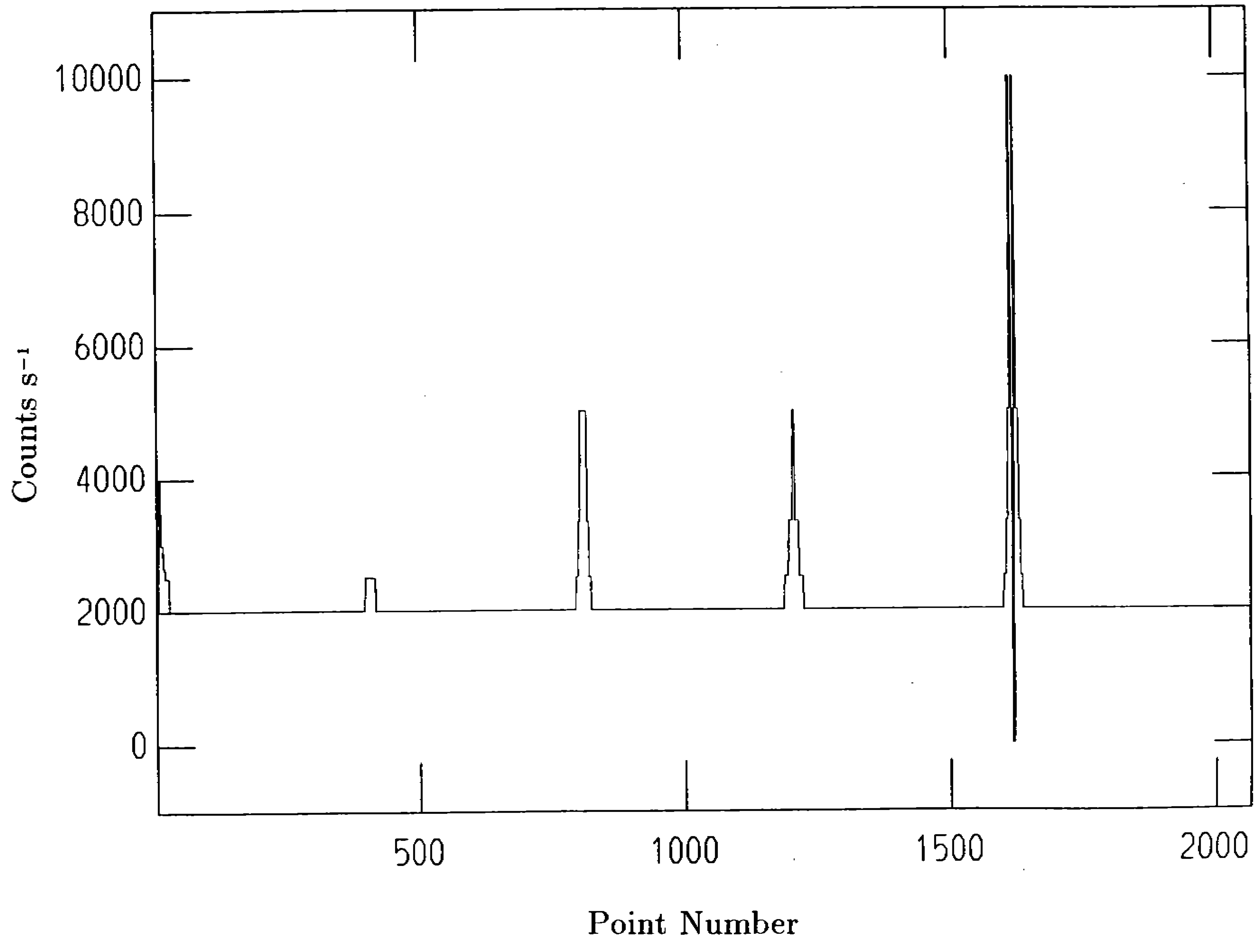

Figure 7: CALFOS Output - Short Array Test
(FCHNL = 286, NCHNLS = 128, NXSTEPS = 4, OVERSCAN = 5)

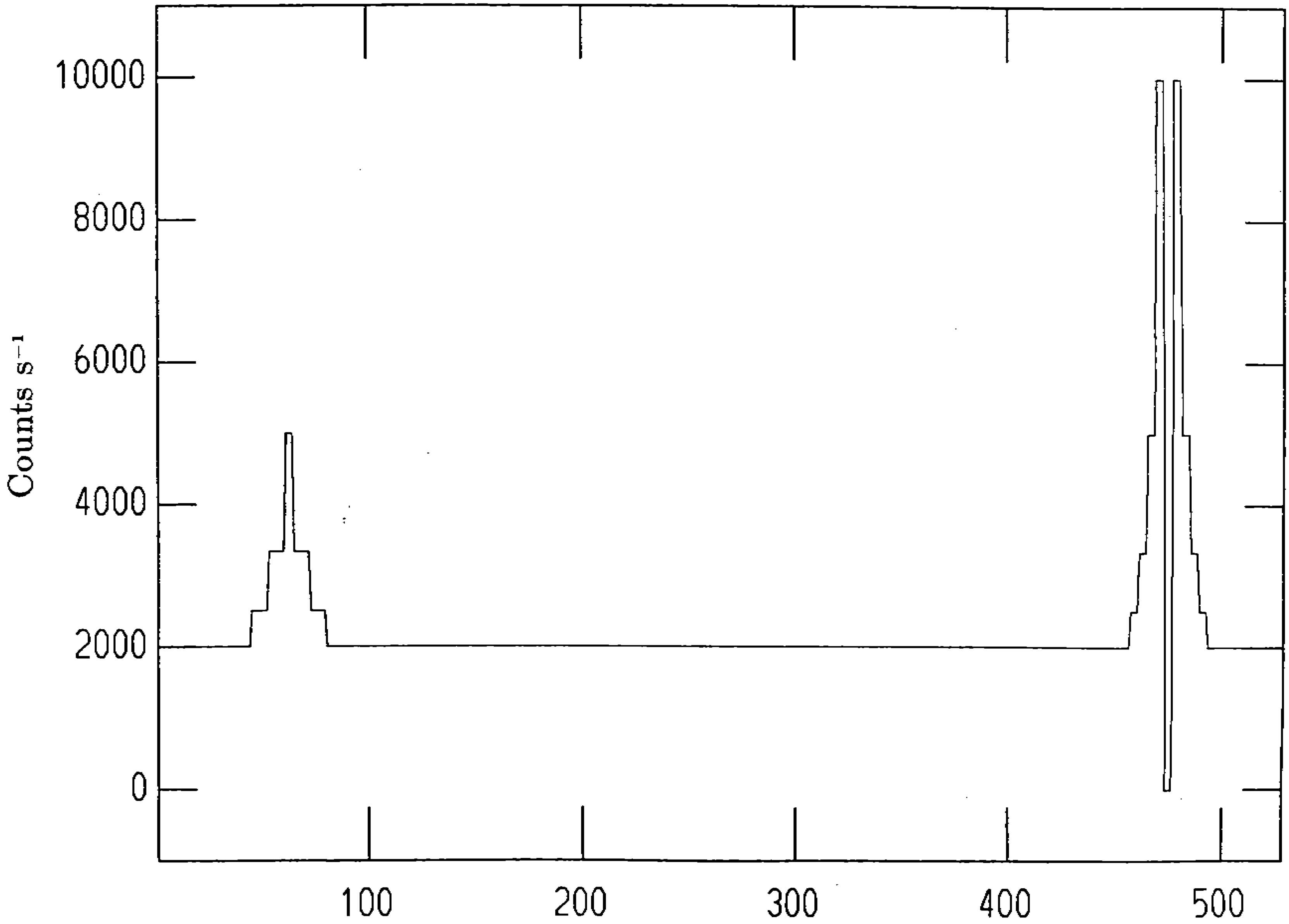

Figure 8: CALFOS Out - "Non-Standard" NXSTEPS & OVERSCAN (FCHNL = 286, NCHNLS = 128, NXSTEPS = 2, OVERSCAN = 3)