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THE FAINT OBJECT SPECTROGRAPH BINARY SEARCH TARGET ACQUISITION SIMULATOR BS4

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Abstract

The Faint Object Spectrograph binary search target acquisition simulator is described. The operation and limitations of the simulator are discussed. Examples are presented demonstrating how the simulator may be used to evaluate the performance of the NSSC-1 FOS binary search target acquisition processor and perform causal analysis of failed binary search target acquisitions.

I. Introduction

The Faint Object Spectrograph binary search target acquisition simulator, version 4.0 (*BS4*) is a software package designed to simulate faithfully the operation of the NSSC-1 FOS binary search target acquisition processor. *BS4* is a complete *ab initio* rewrite of the binary search target acquisition simulator.

BS4 is designed to serve three principal functions: (1) evaluation of the performance characteristics of the FOS binary search target acquisition processor applied to targets with user specified surface brightness profiles; (2) optimization of global processor parameters common to all FOS binary search target acquisitions; and (3) causal analysis of failed FOS binary search target acquisitions.

II. Operation

The *BS4* simulator operates in one of two modes, depending on the format of the input data supplied by the user. The standard mode of operation is termed "normal" mode. In this mode, the user supplies as input data a ("white" light) surface brightness image of the area of the sky covered by the `4.3` FOS target acquisition aperture. The simulator is then used to acquire the target that is located somewhere within the field of the target acquisition aperture. The simulated acquisition can be repeated as required, varying the user-changeable binary search target acquisition processor parameters as necessary until the optimum values of the parameters are established. Repeated execution of the simulated acquisition may be used to evaluate the probability of a successful on-board acquisition for the specified input parameters and target surface brightness distribution. This mode may also be used by the instrument scientists as a testbed to fine-tune the global binary search target acquisition processor parameters that are specified in commanding. Since these parameters are common to all FOS binary search target acquisitions, application of correct, optimized values is critical to maximizing the overall success probability of the binary search target acquisition processor.

The second mode of operation is termed "diagnostic" mode, and is used to diagnose the performance of the FOS binary search target acquisition processor given existing binary search target acquisition data. In this case, the input data consist of an existing raw counts dataset from an on-board binary search target acquisition. The simulator reads successive groups from the dataset and performs the actions of the binary search target acquisition processor. The values of key critical binary search target acquisition processor variables may be output at each step during the execution of the algorithm, providing a mechanism for evaluating the detailed operation of the processor. This mode may be used by the instrument engineers to analyze failed binary search target acquisitions to evaluate the cause of the failure. If the failure resulted from improperly set bright or faint limits, the actual location of the target within the target acquisition aperture may be established in many cases.

In both modes, operation of the simulator is simple. First, the input data required by the simulator (an STSDAS format image of the correct size for normal mode, an STSDAS format FOS raw counts .d0h/.d0d dataset for diagnostic mode) are read into the simulator using the `read` command. Second, the value of certain key user specified values (such as `NMIN` and `NMAX`) may be entered with the appropriate commands, or the default values accepted. The `tracelevel` may be set to a value higher than the default if more detailed diagnostics than are normally output are required. Finally, the processor is executed using the `acquire` command.

Examples of simulator operation are included in appendix A, while a complete listing of *BS4* commands is provided in appendix B.

III. Data Formats

BS4 reads data written in STSDAS format. These datasets consist of a pair of files: a header file which usually has a .hhh file extension, and a data file which usually has a .hhd file extension. The standalone IRAF F77 routines are used for all access to STSDAS format datasets.

In normal mode, the user must provide in a format recognized by the *BS4* simulator a dataset containing a two dimensional image representing the surface brightness distribution of the area of the sky that is covered by the `4.3` target acquisition aperture. Poisson noise will be added by the simulator after the input data are scaled to the number of peak counts detected according to the specifications of the user, and should therefore *not* be included in the input image.

A standard format image consists of a 768×768 pixel two dimensional dataset that samples fully the area of the sky covered by the `4.3` aperture. The `4.3` aperture is assumed to cover an area of exactly 4″.29 × 4″.29 on the sky without COSTAR, and precisely a factor of 1.16 smaller than this in both dimensions with COSTAR. Corresponding pixel sizes are ~5.59 mas without COSTAR, and ~4.82 mas with COSTAR. However, the conversion from microns on the photocathode to angular distance on the sky is not used internally in the simulator except in routine YFBCTR *after* the acquisition is completed to convert the size of the computed slew from pixels to an angular distance on the sky. *All operations of the binary search target acquisition processor are independent of the plate scale.* The success or failure of the algorithm to acquire a given target does not depend on the assumed plate scale. The only requirement for the simulator is that the pixel image provided be scaled so that there are 768 pixels across the target acquisition aperture which is assumed to have dimensions that are exactly twelve times the diode width in X and three times the diode height in Y. With this scaling, each input image pixel will be exactly one X-base unit in width and one Y-base unit in height.

Alternatively, image data may be provided in a format that has already been sampled by the FOS diode array in the X direction. These data sets will have dimensions of 51, 52, 63, or 64 pixels in the X direction and 768 pixels in the Y direction. Each pixel corresponds to the area of the image of the 4.3 aperture that is one Y-base unit in height and that has been sampled by the FOS diode array quarter stepped in X. With an overscan value of five, this results in 64 pixels in the X direction. However, the last pixel in the X direction is not illuminated and is therefore always zero, so instead 63 pixels may be provided. Furthermore, since the target acquisition aperture truncates the illuminated part of the diode array to an area just 12 diodes (48 quarter steps) wide, the overscan regions at each end of the pixel array can be ignored, allowing a quarter stepped X size of 52 pixels (or 51 if the last always-zero pixel is eliminated).

If the user provides an input image that is already subsampled (i.e. the X dimension equals 51, 52, 63, or 64), then the image must be corrected by the user for counting losses that occur due to the inter-diode gap, which is 20% of the inter-diode spacing.

In diagnostic mode, *BS4* expects the input data to be a FOS .d0h/.d0d raw counts dataset. These datasets may either be one dimensional with 64 pixels, or two dimensional with an X size of 64 pixels and a Y size of 1 pixel. The datasets must be in group format, with a minimum of three groups and a maximum of eleven groups. Each group will be read in order by the simulator, and the first three groups will be the middle, lower, and upper frames (in that order) used in the first part of the binary search target acquisition processor operation (aperture mapping). Subsequent groups will be the frames used in placing the desired target on the edge of the diode array.

IV. Theory of Operation

The primary operational modules of *BS4* are based on a direct port to DEC Fortran of the 30 January 1993 version of the Caine, Farber, and Gordon PDL version of the FOS NSSC-1 Application Processors Baseline 5.2 Drop. The choice of DEC Fortran as the target language for the port was based on the high degree of similarity between the Caine, Farber, and Gordon PDL and Fortran with DEC extensions. To maximize the fidelity of *BS4* to the on-board NSSC-1 implementation of the binary search target acquisition processor, only purely syntactic changes and the minimum semantic and algorithmic changes necessary for a successful port were applied to the PDL code. All ancillary code was developed separately.

The operation of the simulator is controlled directly by user commands, which are immediately interpreted and acted upon after entry. Operation is synchronous, with each command being completed before subsequent commands are executed. To acquire a target, the user must first input the required image or FOS data using the `read` command to read the data into the image buffer.

After the image data have been read successfully into the image buffer, subsequent actions of the simulator depend on the input data format. If the image data comprise a two dimensional $n \times 768$ pixel image, where $n = 51$, 52, 63, 64, or 768, then the input data are assumed to be an image of a field to be acquired, and the simulator is placed in normal mode. If the data array is a one dimensional 64 pixel image or a two dimensional 64×1 pixel image, then the input data are assumed to be a binary search target acquisition raw counts dataset, and the simulator is placed in diagnostic mode.

If the input image is 768×768 pixels in size, then it is sampled onto the diode array using standard X-stepping and overscan parameters ($NSTEPS = 4$ and $OVERSCAN = 5$). The diodes are assumed to be exactly $200\,\mu m$ (256 Y-base units) high, and $40\,\mu m$ wide spaced on $50\,\mu m$ centers. The sampling accounts effectively for the dead space between the diodes. Since the input image pixel size in X is equal to one X-base unit, the inter-diode gap does not align naturally on pixel boundaries. The misalignment is treated by assuming that the intensity within a given image pixel is uniformly distributed over the area of the pixel, and the fraction of the intensity from any image pixel contributing to a diode is assumed to be equal to the fraction of the area of the image pixel contributing to the diode. Since the image pixels are much smaller than the diode size, this assumption should be in error by no more than $\sim$0.4%.

Once the data have been read by the simulator, the user may change certain simulator parameters and binary search target acquisition processor parameters in NSSC-1 common from their default values by using the appropriate commands (see Appendix B). For example, the user may change the detected number of counts in the peak FOS pixel by using either the `scale` command to set the value explicitly, or by using the `exptime` command to change the exposure time relative to the exposure time recorded in the input data header.

Finally, the user commands the simulator to acquire the target using the `acquire` command.

In normal mode, the acquisition proceeds first by scaling the subsampled input data to the user specified intensity. The peak FOS pixel is determined by the simple expedient of finding the FOS X-channel number and Y-base value of the subsampled input data image that has the maximum number of counts. This location is *assumed* to be the center position of the peak FOS pixel. If the surface intensity distribution is well behaved (i.e. reasonably symmetric and centrally condensed), then the assumption will be quite accurate. At the time of writing, binary search target acquisition is recommended only for non-variable point source targets with well known magnitude and colors. Although the assumption may be incorrect if the surface intensity distribution is poorly behaved, this possibility is not considered when determining the location of the peak FOS pixel, both because of the complexity involved in doing so, and because of the additional computing time required. Whether the assumption is correct or not does not affect the operation of the binary search target acquisition processor. However, user specified scaling of the peak FOS pixel counts will be incorrect if the assumption is invalid. The total number of counts in the peak FOS pixel is computed by summing the subsampled input data image pixels that span the Y-base range $Y\text{-peak} - 128 : Y\text{-peak} + 127$.

Following scaling, the input data that are subsampled in X are summed over the range of Y-bases spanned by the current diode Y location. Poisson noise is added to the resulting one dimensional array, and the data are then integer-truncated to form an array representing the detected number of counts in each FOS pixel. The detected counts are placed in the NSSC-1 binary search target acquisition processor N array.

If the user supplied input data array is already subsampled in X (X dimension of 51, 52, 63, or 64 pixels), then the data are placed in the N array after scaling and the addition of Poisson noise, with the appropriate pixels at each end of the N array zero-filled if less than 64 pixels in X are supplied by the user.

In diagnostic mode, at each step in the binary search target acquisition, the corresponding group from the input dataset is placed directly into the N array. No data scaling takes place, and no Poisson noise is added. The observed value of the Y-base is derived from the YPOS group parameter in the data header. If the current group is the first group in the dataset, then this value is taken as a fiducial reference for the Y-base zero point. Otherwise, the observed Y-base value is compared to the calculated Y-base value (stored in the binary search target acquisition processor variable $YBASKP$). If the values do not agree after correcting for the different zero points, a warning message is printed listing the observed and predicted values of the Y-base.

The NSSC-1 FOS science data processor, YFSDPR, is then called to perform the next step of binary search target acquisition, as determined by the values of certain variables stored in NSSC-1 common. YFSDPR calls YFDVCK and YUNSCR to perform the data validity check and unscramble the science data into the N array. Since the simulator populates the N array directly, most of the operations of these routines are not performed. However, several key variable values are set, and YUNSCR performs the important task of scaling the N array by dividing by the value of the NSSC-1 binary search target acquisition processor variable $YSCALE$, which is presently set to 5 (this is done to reduce the probability of integer overflow later during the binary search target acquisition processing). Handling the reject array and dead diode array is normally performed by YUNSCR. However, these tasks are *not* presently performed by the simulator. *Binary search target acquisition data that were obtained using the reject mechanism, or that have dead diodes contributing, will not be handled correctly be BS4 in diagnostic mode at the present time.* At the time of writing, neither the reject array nor the dead diode array are required during execution of the binary search target acquisition processor onboard the spacecraft.

After calling YUNSCR, YFSDPR calls YFBSPR, the NSSC-1 FOS science data processor for binary search mode 2 target acquisition. This routine oversees the subsequent steps of the binary search target acquisition, and calls several routines to perform the necessary actions. The details of the actions performed will not be detailed here, as an understanding of them is not required to run the *BS4* in normal mode. Persons interested in decoding the detailed diagnostics provided by the simulator when `tracelevel` is set to 2 or 3, or who will be running the simulator as a diagnostic tool to analyze failed binary search target acquisitions, are referred to a listing of the Caine, Farber, and Gordon PDL version of the FOS NSSC-1 Application Processors.

If the binary search is successful, YFBSC2 (which is called by YFBSPR) calculates the location of the target and then calls YFBCTR to perform the coordinate transformation and prepare to slew the telescope. In the simulator version, the call to ZISLEW is not performed; instead the X-channel and Y-base locations of the identified target, and X and Y sizes of the computed slew (telescope motion in the FOS X, Y coordinate system), are output. A success message is output and control is returned to the user.

If the binary search is not completed with the current step, control is returned to YFSDPR. If further binary search steps are possible, YFSDPR calls YFM2PR to determine the new Y-base for the next step in the search process, and the entire process repeats. Otherwise the binary search is unsuccessful. An error message is output and control is returned to the user.

V. Known Bugs and Deficiencies

There are no known bugs.

There are a number of deficiencies associated with limitations of the implementation that arise because of architectural differences between the NSSC-1 and the machines on which the simulator can execute. The effect of these deficiencies is to reduce the fidelity with which the simulator is able to reproduce the behavior of the onboard binary search target acquisition processor. While these differences in implementation should not produce erroneous behavior of the simulator in general, in some very rare circumstances the simulator may fail to reproduce correctly the behavior of the onboard processor.

The first deficiency arises because of computer word length differences. The NSSC-1 uses a signed 18-bit word for integer arithmetic. In the simulator, signed 32-bit INTEGER*4 arithmetic is used. (A prototype implementation of the simulator used signed 16-bit INTEGER*2 arithmetic. However, the reduced dynamic range proved to be inadequate for normal operation.) Consequently, some arithmetic operations may complete successfully in the simulator that would fail in the onboard processor because of arithmetic overflow.

Places in the PDL code where overflow of 18-bits of arithmetic precision is considered possible have overflow trap checking built into the code. This is simulated in *BS4* by incorporating an explicit comparison of the results of the computation with the maximum signed 18-bit value, $2^{17}-1$, and taking the overflow trap actions if this check is violated. In one place in the PDL code, double precision (36-bit) integer arithmetic is used. The simulator instead currently uses 32-bit integer arithmetic. Overflowing $2^{31}-1$ in the simulator will result in an unavoidable operating system integer overflow trap, even though the operation may complete successfully in the onboard processor. However, this failure mode has not been seen during extensive experimentation with *BS4* since the large numbers of counts required to trigger this failure do not occur in normal binary search target acquisitions.

The order of execution of operations in the NSSC-1 assembler code implementation of the binary search target acquisition processor may be different those produced by the FORTRAN compiler. This can occur because the FORTRAN standard allows reordering of commutative arithmetic operations of equal precedence. For example, the statement $D = A + B - C$ compiled using the current implementation of the DEC FORTRAN compiler will generally first add A and B, and then subtract C from the result. An arithmetic overflow could occur if the sum of A and B exceeds the maximum integer value, even though the value of D is less than the maximum value. In cases where arithmetic overflow may be important, the expression is reordered in the simulator to reflect the actual implementation defined by the NSSC-1 assembler code (which in the above case would often be implemented as $D = A + [B - C]$).

The simulator assumes that the edges of the `4.3` target acquisition aperture project in the X-direction precisely onto pixel boundaries. In the real instrument, the edges of the `4.3` target acquisition aperture do not necessarily project onto pixel boundaries.

Finally, the simulator uses the standalone IRAF F77 routine UERGET to return any error message text from the standalone IRAF F77 routines that are used to access STSDAS format data files. UERGET will return the error message text correctly only if the logical names IRAFLIB and STSDASDISK are defined correctly.

Appendix A
Examples

Example 1: The file test.hhh is a 768 × 768 pixel image of the unresolved nucleus of an elliptical galaxy. The data are `read`, minimum and maximum limits for the peak pixel are set, and the data are `scaled` to a peak of 240 counts. This example illustrates a normal mode simulation.

```
① $ run bs4

        Faint Object Spectrograph Binary Search Simulator Version 4.0.0

② Command : read test.hhh
  EXPTIME not set in header; Setting EXPTIME = 1.0
③ Command : nmin 120
  Command : nmax 30000
④ Command : scale 240
⑤ Command : acquire


⑥ Peak channel counts =    240.000,
  Target peak located at channel  35, Y-base   -1
  EXPTIME =      0.189


⑦ Target located at channel 34.947, Y-base    0
  X-slew =  0.149 arcseconds, Y-slew =  0.000 arcseconds
⑧ Target acquisition completed


⑨ Command : status
  BRT      =       1
  HWHM     =       4
  INVRT    =      NO
  MTSV     =       2
  NMAX     =   30000
  NMIN     =     120
  PEAK     =    FULL
  STT      =     200
  TLR      =       4

  COSTAR   =     YES
  EXPTIME  =       0.189
  SCALE    =     240.000
①⓪ Command : exit
  FORTRAN STOP
  $
```

① The user executes *BS4*. The syntax of this command will be installation specific.

② The user reads in the image data file containing the input surface brightness distribution. Since the exposure time header keyword `EXPTIME` does not exist, the exposure time that produced the input data image is normalized to 1.0.

③ The users sets the lower and upper window limits to 120 and 30000 counts, respectively, equivalent to setting the values of `FAINT` to 1320 and `BRIGHT` to 330000.

④ The user rescales the input surface brightness distribution to 240 counts in the FOS pixel centered on the position of the maximum in the (subsampled) input source distribution. Rescaling the input data will alter the exposure time.

⑤ The user requests *BS4* to `acquire` the target.

⑥ *BS4* reports the location of the maximum in the (subsampled) input source distribution, that the number of counts in the FOS pixel centered at this location, and the exposure time.

⑦ After the target acquisition completes, *BS4* reports the position where the binary search target acquisition processor located the target. Since the target surface brightness distribution is well behaved, these values fall close to the estimated values computed above. The program then reports the sizes of the slews requested to center the target in the aperture.

⑧ *BS4* reports that the target acquisition completed successfully.

⑨ The user requests that the current status of simulator. This outputs the values of a number of key *BS4* parameters. An explanation of the meaning of each parameter is included in Appendix B with the associated command.

①⓪ The user exits *BS4* and returns to the operating system.

Example 2: The file y0uz0101t.d0h is a pre-COSTAR binary search dataset obtained during a successful FOS binary search target acquisition. After the data are **read**, the **tracelevel** is set to 2 to produce the additional diagnostic output. This example illustrates the use of diagnostic mode to evaluate the performance of the binary search target acquisition processor with existing data.

```
$ run bs4

        Faint Object Spectrograph Binary Search Simulator Version 4.0.0

   Command : read y0uz0101t.d0h
①  Command : tracelevel 2
②  Command : costar no
   Command : acquire


③  Reading data group  1 ...
④  Sky background median (YNMEAN)           =      3
   Sky background variance (0th order approx: YVARI1) =      2
⑤  Global minimum value for a peak (GLBPK) =      7
   Lower window limit (NMIN)               =      0
   Upper window limit (NMAX)               =  65535
⑥  Number of peaks found (J)               =      1
   Peak channel     channel counts
          40              26
⑦  Sky background mean (YNMEAN)            =      2
   Sky background variance (YVARI1)        =      3
⑧  Global minimum value for a peak (GLBPK) =      8
   Lower window limit (NMIN)               =     12
   Upper window limit (NMAX)               =    600
⑨  Number of peaks found (J)               =      1
   Peak channel     channel counts
          40              26
①⓪ Peak channel     lower channel     upper channel     peak counts
          40             36                44               138
①① Frame number (YFRCTR)                   =      1
   Y-base (YBASKP)                         =      0
   Number of peaks found (YPKCT(YFRCTR))   =      1
   Channel numbers of peaks (M(1 : YPKCT(YFRCTR), YFRCTR)) =    40
①② YFM2PR action requested (YFM2CF)        =      1

   Reading data group  2 ...

   .
   .
```

.

```
①③ Total number of peaks found (YFOUND)     =      1
①④ First  1 brightest peaks:
        peak numbers (JMAX(1 : YNBRT))         =        1
        channel numbers (M1(JMAX(1 : YNBRT))) =      -40
        peak counts (NCTS1(JMAX(1 : YNBRT)))  =      138
①⑤ Peak number for binary search (YOBSJ)    =      1
    Peak channel for binary search (YBSM)    =     40
    Peak counts for binary search (YNMAX)    =    138
①⑥ Search direction                         =     UP
    YFM2PR action requested (YFM2CF)         =      2


    Reading data group  4 ...
    Sky background median (YNMEAN)               =      3
    Sky background variance (0th order approx: YVARI1) =      2
    Global minimum value for a peak (GLBPK) =      7
    Lower window limit (NMIN)                    =      0
    Upper window limit (NMAX)                    =  65535
    Number of peaks found (J)                    =      3
    Peak channel      channel counts
            32                  8
            41                 32
            47                 10
    Sky background mean (YNMEAN)                 =      1
    Sky background variance (YVARI1)             =      2
    Global minimum value for a peak (GLBPK) =      5
    Lower window limit (NMIN)                    =     12
    Upper window limit (NMAX)                    =    600
    Number of peaks found (J)                    =      1
    Peak channel      channel counts
            41                 32
    Peak channel      lower channel      upper channel      peak counts
            41                 37                 45                173
①⑦ Group number (YGPCTR)                        =      1
    Y-base (YBASKP)                              =    128
①⑧ Closest peak to target peak is peak number  1, channel number 41
    Counts in target peak (YNTARG)               =    173
①⑨ Lower edge centering limit (I2TMP2)      =     59
    Upper edge centering limit (I2TMP3)      =     79
    Counts in target peak (YNTARG)           =    173
②⓪ Target is still (or back) on the diode array
②① New maximum found; setting YNMAX to current YNTARG =    173
    YFM2PR action requested (YFM2CF)         =      2


    Reading data group  5 ...

    .
    .
    .


    Reading data group  7 ...
    Sky background median (YNMEAN)               =      3
    Sky background variance (0th order approx: YVARI1) =      2
    Global minimum value for a peak (GLBPK) =      7
    Lower window limit (NMIN)                    =      0
    Upper window limit (NMAX)                    =  65535
    Number of peaks found (J)                    =      3
    Peak channel      channel counts
            39                 18
            45                 11
            50                  8
    Sky background mean (YNMEAN)                 =      2
    Sky background variance (YVARI1)             =      2
    Global minimum value for a peak (GLBPK) =      6
    Lower window limit (NMIN)                    =     12
    Upper window limit (NMAX)                    =    600
```

```
    Number of peaks found (J)                  =       1
    Peak channel      channel counts
            39                 18
    Peak channel      lower channel      upper channel      peak counts
            39                 35                 43                 90
    Group number (YGPCTR)                      =       4
    Y-base (YBASKP)                            =     240
    Closest peak to target peak is peak number  1, channel number 39
    Counts in target peak (YNTARG)             =      90
    Lower edge centering limit (I2TMP2)        =      75
    Upper edge centering limit (I2TMP3)        =      97
    Counts in target peak (YNTARG)             =      90
②② Target is on the edge of the diode array
②③ Sky background median (YNMEAN)             =      17
    Sky background variance (0th order approx: YVARI1) =       4
②④ Global minimum value for a peak (GLBPK) =      25
    Lower window limit (NMIN)                  =       0
    Upper window limit (NMAX)                  =  131071
②⑤ Number of peaks found (J)                  =       3
    Peak channel      channel counts
            32                 32
            41                126
            49                 39
②⑥ Sky background mean (YNMEAN)               =       7
    Sky background variance (YVARI1)           =       8
②⑦ Global minimum value for a peak (GLBPK) =      23
    Lower window limit (NMIN)                  =      60
    Upper window limit (NMAX)                  =    3000
②⑧ Number of peaks found (J)                  =       1
    Peak channel      channel counts
            41                126
    Peak channel      lower channel      upper channel      peak counts
            41                 37                 45                702
②⑨ YISUMX                                     =   33474
    YISUM                                      =     832
    YFVCTR                                     =    3591  2800

③⓪ Target located at channel 40.233, Y-base  112
    X-slew =  0.645 arcseconds, Y-slew =  0.626 arcseconds
    Target acquisition completed

    Command : exit
    FORTRAN STOP
    $
```

① The user sets the **tracelevel** to 2. This alters the amount of output diagnostics that *BS4* will provide to the user.

② The user specifies that the slew sizes output by *BS4* at the termination of a successful binary search target acquisition should be computed using the pre-COSTAR plate scale values.

③ *BS4* reports that group number 1 of the data file is currently being read. Subsequent diagnostics output by the simulator will refer to this data group.

④ These are the initial estimates of the sky background level in scaled counts computed the first time NSSC-1 routine YFMSSV is called with the current N array. The median sky value and the first estimate of the sky variance are reported.

⑤ The criteria for identifying a peak are reported. These are the global minimum value, and the scaled window limits. In the first call to NSSC-1 routine YFPKFD, the window limits are set to find all peaks that should be excluded when computing accurate values for the sky background mean and variance.

⑥ The number of peaks identified by NSSC-1 routine YFPKFD is reported, together with the channel location and scaled number of channel counts for every peak. This peak search identifies those peaks that will be excluded when NSSC-1 routine YFMSSV computes the background mean and variance values.

⑦ Revised values for the background mean and variance are reported. These values are computed in NSSC-1 routine YFMSSV by excluding the channels within *YHWHM* channels of each peak identified above from the background computation.

⑧ The revised value for the global minimum value, as well as the scaled lower and upper window limits, are reported by NSSC-1 routine YFPKFD.

⑨ The number of peaks identified by NSSC-1 routine YFPKFD is reported, together with the channel location and number of scaled counts in the channel for every peak. This peak search identifies those peaks that meet the user specified window criteria.

①⓪ For each of the peaks, NSSC-1 routine YFMSSV reports the peak channel number, the lower and upper channel numbers (*YHWHM* channels on each side of the peak), and the total number of scaled counts above the background in the peak.

①① NSSC-1 routine YFBSC1 reports the frame number and Y-base of the current binary search step, the number of peaks identified, and their channel numbers.

①② NSSC-1 routine YFM2PR reports the action requested to set up the appropriate Y-base value for the next binary search step to be acquired.

①③ The total number of peaks identified during execution of part 1 of the binary search target acquisition processor is reported by NSSC-1 routine YFBSC1.

①④ For the **aa** brightest peaks, where **aa** is the value of the user specified parameter `YNBRT` (equal to the exposure logsheet optional parameter `NTHSTAR`), NSSC-1 routine YFBSC1 reports the peak number, the channel number, and the scaled counts in the peak. The channel number of the selected target peak is negative.

①⑤ NSSC-1 routine YFBSC1 reports the peak number, peak channel, and scaled counts in the selected target peak to be acquired during part 2 of the binary search target acquisition.

①⑥ NSSC-1 routine YFBSC1 reports the initial Y search direction that will be used during part 2 of the binary search target acquisition.

①⑦ NSSC-1 routine YFBSC2 reports the "group" number and Y-base of the current binary search step.

①⑧ NSSC-1 routine YFBSC2 reports the peak number, channel number, and number of scaled counts in the peak identified in the latest binary search step in part 2 of the binary search target acquisition that is positioned in X closest to the channel number of the target peak identified in part 1.

①⑨ The minimum and maximum number of scaled counts allowed in the target peak if the target is on the edge of the diode array are reported by NSSC-1 routine YFETST.

②⓪ Based on the comparison of the number of scaled counts in the target peak to the edge centering limits, NSSC-1 routine YFBSC2 reports whether the target is on, off, or on the edge of the diode array.

②① During execution of part 2 of the binary search target acquisition, NSSC-1 routine YFBSC2 has determined that the number of scaled counts in the target is larger than previously determined. The number of scaled counts in the target peak is reset to the current (higher) value.

②② NSSC-1 routine YFBSC2 reports that with the current Y-base setting the target is on the edge of the diode array.

②③ These are the initial estimates of the sky background level in unscaled counts computed the first time NSSC-1 routine YFMSSV is called with the current N array. The median sky value and the first estimate of the sky variance are reported.

②④ The criteria for identifying a peak are reported. These are the global minimum value, and the unscaled window limits. In the first call to NSSC-1 routine YFPKFD, the window limits are set to find all peaks that should be excluded when computing accurate values for the sky background mean and variance.

②⑤ The number of peaks identified by NSSC-1 routine YFPKFD is reported, together with the channel location and unscaled number of channel counts for every peak. This peak search identifies those peaks that will be excluded when NSSC-1 routine YFMSSV computes the background mean and variance values.

②⑥ Revised values for the background mean and variance are reported. These values are computed in NSSC-1 routine YFMSSV by excluding the channels within *YHWHM* channels of each peak identified above from the background computation.

②⑦ The revised value for the global minimum value, as well as the unscaled lower and upper window limits, are reported by NSSC-1 routine YFPKFD.

②⑧ The number of peaks identified by NSSC-1 routine YFPKFD is reported, together with the channel location and number of unscaled counts in the channel for every peak. This peak search identifies those peaks that meet the user specified window criteria. For each of the peaks, NSSC-1 routine YFMSSV reports the peak channel number, the lower and upper channel numbers (*YHWHM* channels on each side of the peak), and the total number of unscaled counts above the background in the peak.

②⑨ The X-channel weighted and unweighted sums of the unscaled target peak counts (above the background) are reported by NSSC-1 routine YFBSC2. Dividing `YISUMX` by `YISUM` yields the X centroid position of the target peak. `YFVCTR` is the slew offset vector request in NSSC-1 routine YFBCTR that should center the target.

③⓪ After the target acquisition completes, *BS4* reports the position where the binary search target acquisition processor located the target. The program then reports the sizes of the slews requested to center the target in the aperture.

Example 3: The file y0xc0101t.d0h is a pre-COSTAR binary search dataset obtained during a failed FOS binary search target acquisition. The user specified a lower window limit (`NMIN`) of 60; 63 counts were detected in the third group of the binary search raw data file. After the data are `read`, the `tracelevel` is set to 3 to produce the maximum diagnostic output. This example illustrates the use of diagnostic mode to determine the reason for the failure of the binary search target acquisition processor with existing data.

```
$ bs4

        Faint Object Spectrograph Binary Search Simulator Version 4.0.0

   Command : read y0xc0101t.d0h
   Command : costar no
①  Command : tracelevel 3
   Command : acquire
```

```
   Reading data group  1 ...
②  Entering module YFSDPR
   Entering module YFDVCK
   Exiting  module YFDVCK
   Entering module YUNSCR
   Exiting  module YUNSCR
   Entering module YFBSPR
   Entering module YFMSSV
   Entering module YFSQRT
   Exiting  module YFSQRT
   Sky background median (YNMEAN)            =      0
   Sky background variance (0th order approx: YVARI1) =      0
   Entering module YFPKFD
   Global minimum value for a peak (GLBPK) =      0
   Lower window limit (NMIN)               =      0
   Upper window limit (NMAX)               =  65535
   Number of peaks found (J)               =      5
   Peak channel     channel counts
             10                   1
             17                   2
             25                   3
             32                   3
             37                   1
   Exiting  module YFPKFD
   Entering module YFSQRT
   Exiting  module YFSQRT
   Sky background mean (YNMEAN)            =      0
   Sky background variance (YVARI1)        =      0
   Entering module YFPKFD
   Global minimum value for a peak (GLBPK) =      0
   Lower window limit (NMIN)               =     12
   Upper window limit (NMAX)               =    600
   Number of peaks found (J)               =      0
   Exiting  module YFPKFD
   Exiting  module YFMSSV
   Entering module YFBSC1
   Frame number (YFRCTR)                   =      1
   Y-base (YBASKP)                         =      0
   Number of peaks found (YPKCT(YFRCTR))   =      0
   Exiting  module YFBSC1
   Entering module YFM2PR
   YFM2PR action requested (YFM2CF)        =      1
   Exiting  module YFM2PR
   Exiting  module YFBSPR
   Exiting  module YFSDPR


   Reading data group  2 ...

   .
   .
   .


   Reading data group  3 ...
   Entering module YFSDPR
   Entering module YFDVCK
   Exiting  module YFDVCK
   Entering module YUNSCR
   Exiting  module YUNSCR
   Entering module YFBSPR
   Entering module YFMSSV
   Entering module YFSQRT
   Exiting  module YFSQRT
   Sky background median (YNMEAN)            =      0
   Sky background variance (0th order approx: YVARI1) =      0
   Entering module YFPKFD
   Global minimum value for a peak (GLBPK) =      0
   Lower window limit (NMIN)               =      0
```

```
   Upper window limit (NMAX)              =  65535
③ Number of peaks found (J)               =      7
   Peak channel     channel counts
            8                   1
           17                   2
           22                   2
           27                  12
           32                   3
           37                   2
           42                   1
   Exiting  module YFPKFD
   Entering module YFSQRT
   Exiting  module YFSQRT
   Sky background mean (YNMEAN)           =      0
   Sky background variance (YVARI1)       =      0
   Entering module YFPKFD
④ Global minimum value for a peak (GLBPK) =      0
   Lower window limit (NMIN)              =     12
   Upper window limit (NMAX)              =    600
   Number of peaks found (J)              =      0
   Exiting  module YFPKFD
   Exiting  module YFMSSV
   Entering module YFBSC1
   Frame number (YFRCTR)                  =      3
   Y-base (YBASKP)                        =    256
   Number of peaks found (YPKCT(YFRCTR))  =      0


⑤ Total number of peaks found (YFOUND)    =      0
   Entering module YLKELS
   Exiting  module YLKELS
   Exiting  module YFBSC1
   Exiting  module YFBSPR
   Entering module YFHERR
⑥ Error: FOS Status Buffer Message.  Number =   3202, Parameter =     10
          Target acquisition error occurred.  YGIVUP =     10
   Exiting  module YFHERR
   Exiting  module YFSDPR
⑦ Target acquisition failed - no object in field

   Command : exit
   $
```

① The user sets the **tracelevel** to **3**. This alters the amount of output diagnostics that *BS4* will provide to the user.

② When **tracelevel** is set to **3**, *BS4* produces a flowtrace indicating when each NSSC-1 routine is entered and exited, enabling a user armed with a listing of the Caine, Farber, and Gordon PDL version of the FOS NSSC-1 Application Processors to follow the operation of the binary search target acquisition processor through the various NSSC-1 routines.

③ NSSC-1 routine YFPKFD identifies 7 peaks in the third binary search step obtained during part 1 of the binary search target acquisition. The maximum number of scaled channel counts in a peak is 12, and this is observed at channel 27.

④ The global minimum value for a peak, and the scaled window limits, are reported by NSSC-1 routine YFPKFD. Since the lower window limit is 12 scaled counts, a minimum of 13 scaled counts in a peak channel is required to satisfy the user specified lower window criterion. The binary search target acquisition failed because of insufficient counts. Since the NSSC-1 variable *YSCALE* is 5, this means that a minimum of $5 \times 13 = 65$ unscaled counts is required above the sky background to satisfy the user specified minimum window count criterion (in this example, the actual number of unscaled counts above the background was 63).

⑤ NSSC-1 routine YFBSC1 reports that no peaks were identified that met the user specified window criteria during part 1 of the binary search target acquisition.

⑥ The simulator reports that an FOS status buffer message was issued because of the unexpected failure. The message number and message parameter are output, together with a translation of the message number.

⑦ *BS4* outputs a summary message indicating that the target acquisition failed because no objects were identified in the field.

Appendix B
BS4 Commands

BS4 is command driven. The user issues commands at the prompt and the corresponding action executes immediately. The commands and their actions are described below.

`ACQUIRE`

Run the binary search simulator with the current parameter values and data. See also `GO`, `RESUME`.

`BRT <1-12>`

Select target to acquire if more than one target is identified. Targets are sorted in order of decreasing brightness, with target number 1 being the brightest target. This value of this parameter is the equivalent of the exposure logsheet optional parameter `NTHSTAR`. See also `YNBRT`.

`BYE`

Exit from the binary search simulator. See also `EXIT`, `QUIT`, `STOP`.

`COSTAR <YES | NO>`

Specifies whether the COSTAR FOS plate scale should be used for slew size calculations.

`EXIT`

Exit from the binary search simulator. See also `BYE`, `QUIT`, `STOP`.

`EXPTIME <real>`

Set binary search exposure time to `<real>`. Setting EXPTIME to 0.0 causes the simulator to autoscale the data to 300 counts in the peak pixel. This value of this parameter is the equivalent of the exposure logsheet quantity `TIME_PER_EXP`. See also `INTTIME`.

`GO`

Run the binary search simulator with the current parameter values and data. See also `ACQUIRE`, `RESUME`.

`HELP {<command>}`

Provide help information on binary search simulator commands. `HELP` by itself lists the commands available, while `HELP <command>` provides further information about command `<command>`.

`HWHM <integer>`

Set the expected peak half width at half maximum in pixels, specified as a multiple of the FOS HWHM. This is an SMS parameter, with a default value of 4. See also `YHWHM`.

`INTTIME <real>`

Set binary search exposure time to `<real>`. Setting INTTIME to 0.0 causes the simulator to autoscale the data to 300 counts in the peak pixel. This value of this parameter is the equivalent of the exposure logsheet quantity `TIME_PER_EXP`. See also `EXPTIME`.

`INVRT <YES | NO>`

Invert the offset slew request vector values? This is an SMS parameter, with a default value of `YES` for TALED acquisitions, `NO` otherwise. See also `YTAINV`.

`MTSV <integer>`

Set the multiple of the sky variance above the mean necessary to identify a peak. In order to be considered a peak, in addition to satisfying other criterion, a pixel must contain more than mean + (`MTSV` * variance) counts. This is an SMS parameter, with a default value of 2. See also `SIGMA`, `SMOTSV`.

`NMAX <integer>`

Set the value for the maximum number of counts in the peak pixel that a target can have and satisfy the criterion of being a peak. The value of this parameter is the equivalent of the exposure logsheet optional parameter `BRIGHT` divided by 11, and defaults to 3000 if not specified.

`NMIN <integer>`

Set the value for the minimum number of counts in the peak pixel that a target can have and satisfy the criterion of being a peak. The value of this parameter is the equivalent of the exposure logsheet optional parameter `FAINT` divided by 11, and defaults to 60 if not specified.

`PEAK <FULL | FIRST>`

Specify whether the entire aperture is mapped by binary search, or whether mapping is to stop when the first peak is found. This is an SMS parameter, with a default value of `FULL`. See also `YNPEAK`.

`QUIT`

Exit from the binary search simulator. See also `BYE`, `EXIT`, `STOP`.

`READ <filename>`

Read a data array into the binary search target acquisition simulator. The data file should be in STSDAS format. This command does an implicit `RESET` and updates `EXPTIME` from the data header.

RESET

Reset all binary search parameters, other than EXPTIME which is not altered, to their default values.

RESUME

Run the binary search simulator with the current parameter values and data. See also ACQUIRE, GO.

SCALE <real>

Set the number of counts in the peak pixel of the data to the value specified.

SIGMA <integer>

Set the multiple of the sky variance above the mean necessary to identify a peak. In order to be considered a peak, in addition to satisfying other criterion, a pixel must contain more than mean + (SIGMA * variance) counts. This is an SMS parameter, with a default value of 2. See also MTSV, SMOTSV.

SMOTSV <integer>

Set the multiple of the sky variance above the mean necessary to identify a peak. In order to be considered a peak, in addition to satisfying other criterion, a pixel must contain more than mean + (SMOTSV * variance) counts. This is an SMS parameter, with a default value of 2. See also MTSV, SIGMA.

STAT <integer>

Set the scale factor to allow for square root statistical fluctuations for edge centering. This is an SMS parameter, with a default value of 200. See also STT, YSTAT.

STATUS

Print the current values of the binary search target acquisition simulator parameters.

STOP

Exit from the binary search simulator. See also BYE, EXIT, QUIT.

STT <integer>

Set the scale factor to allow for square root statistical fluctuations for edge centering. This is an SMS parameter, with a default value of 200. See also STAT, YSTAT.

TLR <integer>

Set the tolerance for putting the target on the edge of the diode array. This is an SMS parameter, with a default value of 4. See also YTOLER.

TRACELEVEL <0-3>

Set the level of diagnostic printout. The default value, 0, prints information only as to the success or failure of the acquisition and the offset slew size. A value of 1 prints in addition the values of certain key values at critical points during the binary search. A value of 2 prints in addition a complete list of the values of key variables during the binary search. A value of 3 prints in addition a flow trace of NSSC-1 routine entries and exits.

YHWHM <integer>

Set the expected peak half width at half maximum in pixels, specified as a multiple of the FOS HWHM. This is an SMS parameter, with a default value of 4. See also HWHM.

YNBRT <1-12>

Select target to acquire if more than one target is identified. Targets are sorted in order of decreasing brightness, with target number 1 being the brightest target. This value of this parameter is the equivalent of the exposure logsheet optional parameter NTHSTAR. See also BRT.

YTAINV <0 | 1>

Invert the offset slew request vector values? This is an SMS parameter, with a default value of 1 for TALED acquisitions, 0 otherwise. See also INVRT.

YNPEAK <1 | 2>

Specify whether the entire aperture is mapped by binary search, or whether mapping is to stop when the first peak is found. This is an SMS parameter, with a default value of 2. See also PEAK.

YSTAT <integer>

Set the scale factor to allow for square root statistical fluctuations for edge centering. This is an SMS parameter, with a default value of 200. See also STT, STAT.

YTOLER <integer>

Set the tolerance for putting the target on the edge of the diode array. This is an SMS parameter, with a default value of 4. See also TLR.

Appendix C
BS4 Error Messages and Diagnostics

Arithmetic overflow in YFBSC2 while computing NSUM (edge case).

YOFCNT = aaaaaa

Explanation: FOS status buffer message 3221. An integer overflow has occurred while computing the value of *NSUM(I)* for the edge case in NSSC-1 routine YFBSC2. *NSUM(I)* is set to 131071. aaaaaa is the count of the number of overflows during summation into the *NSUM* array. (*NSSC-1 Routine YFHERR*, tracelevel 0.)

Arithmetic overflow in YFBSC2 while computing NSUM (non-edge case).

YOFCNT = aaaaaa

Explanation: FOS status buffer message 3222. An integer overflow has occurred while computing the value of *NSUM(I)* for the non-edge case in NSSC-1 routine YFBSC2. *NSUM(I)* is set to 131071. aaaaaa is the count of the number of overflows during summation into the *NSUM* array. (*NSSC-1 Routine YFHERR*, tracelevel 0.)

`Arithmetic overflow in YFBSC2 while computing YISUM.`
`High-order word of YISUM = aaaaaa`

Explanation: FOS status buffer message 3225. An integer overflow has occurred while computing the value of *YISUM* in NSSC-1 routine YFBSC2. aaaaaa is the high-order 16-bit word of *YISUM* when the overflow occurred. (*NSSC-1 Routine YFHERR*, `tracelevel 0`.)

`Arithmetic overflow in YFMSSV while computing NCTS1. K = aa`

Explanation: FOS status buffer message 3224. An integer overflow has occurred while computing the value of *NCTS1(K)* in NSSC-1 routine YFMSSV. *NCTS1(K)* is set to `131071`. aa is the peak number for which the overflow occurred. (*NSSC-1 Routine YFHERR*, `tracelevel 0`.)

`Arithmetic overflow in YFMSSV while computing SUMSQ. I = aa`

Explanation: FOS status buffer message 3223. An integer overflow has occurred while computing the value of *SUMSQ* in NSSC-1 routine YFMSSV. *SUMSQ* is set to `131071`. aa is the channel number at which the overflow occurred. (*NSSC-1 Routine YFHERR*, `tracelevel 0`.)

```
BRT      = aaaaaa
HWHM     = bbbbbb
INVRT    =     NO |     YES
MTSV     = cccccc
NMAX     = dddddd
NMIN     = eeeeee
PEAK     =  FIRST |    FULL
STT      = ffffff
TLR      = gggggg

COSTAR   =    YES |      NO
EXPTIME  = hhhhhh.hhh
SCALE    = iiiiii.iii
```

Explanation: The output of the `status` command defining the current simulator parameters is listed. See the information on the associated commands in Appendix B for the meaning of each item.

`Channel numbers of peaks (M(1 : YPKCT(YFRCTR), YFRCTR)) = aa bb ...`

Explanation: The integer X-channel numbers of the peaks found in the current binary search step during execution of part 1 of the binary search target acquisition processor (YFBSC1). (*NSSC-1 Routine YFBSC1*, `tracelevel 1`.)

`Closest peak to target peak is peak number aa, channel number bb`

Explanation: The peak number, aa, and associated channel number, bb, of the closest peak identified in a binary search step during execution of part 2 of the binary search target acquisition processor (YFBSC2) to the target peak identified during execution of part 1 of the binary search target acquisition processor (YFBSC1). (*NSSC-1 Routine YFBSC2*, `tracelevel 2`.)

`Counts centered on channel aa (YNTARG) = bbbbb`
`lower channel limit = cc, upper channel limit = dd`

Explanation: No peaks were identified in a binary search step during execution of part 2 of the binary search target acquisition processor (YFBSC2). Therefore, the processor has computed the number of counts, **bbbbb**, in the "peak" above the mean value *YNMEAN* between channels **cc** and **dd** (inclusive) that are one *YHWHM* above and below channel **aa** which is the channel location of the target peak identified during execution of part 1 of the binary search target acquisition processor (YFBSC1). (*NSSC-1 Routine YFBSC2*, `tracelevel 2`.)

`Counts in target peak (YNTARG) = aaaaa`

Explanation: The number of counts in the peak identified as the target peak in a binary search step during execution of part 2 of the binary search target acquisition processor (YFBSC2). The peak is identified as the target peak because its channel location is no more than *YHWHM* channels from the channel location of the target peak identified during execution of part 1 of the binary search target acquisition processor (YFBSC1). (*NSSC-1 Routine YFBSC2*, `tracelevel 2`.)

`Counts in target peak (YNTARG) = aaaaaa`

Explanation: The number of counts, **aaaaaa**, in the peak identified as the target peak during execution of the edge test in part 2 of the binary search target acquisition processor (YFBSC2). (*NSSC-1 Routine YFETST*, `tracelevel 1`.)

`Duplicate peak identified:`
`peak number a (channel bb) in frame 1, and`
`peak number c (channel dd) in frame e`

Explanation: Peak number **c** at channel **dd** in binary search step **e** is located less than *YDXS* channels from peak number **a** at channel **bb** in step **1**, and is therefore identified as a duplicate observation of that peak during execution of part 1 of the binary search target acquisition processor (YFBSC1). The peak will be identified with whichever step has the greatest number of counts associated with the peak. (*NSSC-1 Routine YFBSC1*, `tracelevel 2`.)

`Entering module YFBCTR`

Explanation: The binary search target acquisition processor is entering the NSSC-1 routine YFBCTR (Binary scaled coordinate transformation for centering). (*NSSC-1 Routine YFBCTR*, `tracelevel 3`.)

`Entering module YFBSC1`

Explanation: The binary search target acquisition processor is entering the NSSC-1 routine YFBSC1 (Processing for part 1 of the binary search case statement). (*NSSC-1 Routine YFBSC1*, `tracelevel 3`.)

`Entering module YFBSC2`

Explanation: The binary search target acquisition processor is entering the NSSC-1 routine YFBSC2 (Processing for part 2 of the binary search case statement). (*NSSC-1 Routine YFBSC2*, `tracelevel 3`.)

`Entering module YFBSPR`

Explanation: The binary search target acquisition processor is entering the NSSC-1 routine YFBSPR (Science data processor for binary search mode 2 target acquisition). (*NSSC-1 Routine YFBSPR*, `tracelevel 3`.)

`Entering module YFDVCK`

Explanation: The binary search target acquisition processor is entering the NSSC-1 routine YFDVCK (Check the validity of data input by science data storage processor). (*NSSC-1 Routine YFDVCK*, `tracelevel 3`.)

`Entering module YFETST`

Explanation: The binary search target acquisition processor is entering the NSSC-1 routine YFETST (Test the position of the object with respect to the diode array). (*NSSC-1 Routine YFETST*, `tracelevel 3`.)

`Entering module YFHERR`

Explanation: The binary search target acquisition processor is entering the NSSC-1 routine YFHERR (Error handler). (*NSSC-1 Routine YFHERR*, `tracelevel 3`.)

`Entering module YFM2PR`

Explanation: The binary search target acquisition processor is entering the NSSC-1 routine YFM2PR (Mode 2 target acquisition processing module). (*NSSC-1 Routine YFM2PR*, `tracelevel 3`.)

`Entering module YFMSSV`

Explanation: The binary search target acquisition processor is entering the NSSC-1 routine YFMSSV (Holland Ford's mean sky and sky variance algorithm). (*NSSC-1 Routine YFMSSV*, `tracelevel 3`.)

`Entering module YFPKFD`

Explanation: The binary search target acquisition processor is entering the NSSC-1 routine YFPKFD (Holland Ford's target acquisition peak-finding algorithm). (*NSSC-1 Routine YFPKFD*, `tracelevel 3`.)

`Entering module YFSDPR`

Explanation: The binary search target acquisition processor is entering the NSSC-1 routine YFSDPR (Process FOS science data from NSSC-1 scratch pad memory). (*NSSC-1 Routine YFSDPR*, `tracelevel 3`.)

`Entering module YFSQRT`

Explanation: The binary search target acquisition processor is entering the NSSC-1 routine YFSQRT (Integer square root function by Newton's method). (*NSSC-1 Routine YFSQRT*, `tracelevel 3`.)

`Entering module YLKELS`

Explanation: The binary search target acquisition processor is entering the NSSC-1 routine YLKELS (Go on to secondary target or expand search). (*NSSC-1 Routine YLKELS*, `tracelevel 3`.)

`Entering module YUNSCR`

Explanation: The binary search target acquisition processor is entering the NSSC-1 routine YUNSCR (Unscramble science data into array N). (*NSSC-1 Routine YUNSCR*, `tracelevel 3`.)

`Error: Ambiguous command : aaaaaa`

Explanation: The command `aaaaaa` entered by the user is not unique. Re-enter the command specifying more characters.

```
Error: Expected to process group aa of the data file,
  but the data file only contains bb group(s)
```

Explanation: The simulator computed that more groups of data are required to complete the binary search target acquisition in diagnostic mode than are present in the data file. `aa` is the data group number the simulator attempted to read; `bb` is the number of data groups present in the file.

`Error: File format not recognized`

Explanation: The data file specified by the user with the `read` command does not incorporate data in any of the one or two dimensional data formats supported by the simulator. Re-enter the `read` command specifying the correct file.

`Error: FOS Status Buffer Message. Number = aaaa, Parameter = bbbbbb`

Explanation: One of the NSSC-1 FOS processors encountered an error that was trapped and produced an FOS status buffer message. `aaaa` is the error message number; `bbbbbb` is the associated parameter that caused the failure. (*NSSC-1 Routine YFHERR*, `tracelevel 0`.)

`Error: Internal error in getcommand. Command = aaaaaa`

Explanation: An internal error has occurred in the simulator. Please forward a listing of the session and the code `aaaaaa` to the author.

`Error: Internal error in getcommand. PEAK = aaaaaa`

Explanation: An internal error has occurred in the simulator. Please forward a listing of the session and the code `aaaaaa` to the author.

`Error: Invalid filename or file does not exist : aaaaaa`

Explanation: The filename **aaaaaa** specified by the user with the `read` command is either invalid, or the file could not be found. Re-enter the `read` command with the correct filename.

`Error: No data array has been input - use READ command to input data`

Explanation: The user attempted to `acquire` without reading in the target data. Use the `read` command to input the target data and then re-enter the `acquire` command.

```
Error: Opening file : aaaaaa
       Error status returned from IRAF I/O routine:
bbbbbb
```

Explanation: The filename **aaaaaa** specified by the user with the `read` command could not be opened by the standalone IRAF F77 I/O routines. **bbbbbb** is the error returned by the standalone IRAF F77 routine UERGET. Re-enter the `read` command specifying the correct file.

```
Error: Reading file.  Error status returned from IRAF I/O routine:
aaaaaa
```

Explanation: The data file specified by the user with the `read` command could not be read by the standalone IRAF F77 I/O routines. **aaaaaa** is the error returned by the standalone IRAF F77 routine UERGET. Re-enter the `read` command specifying the correct file.

`Error: Unrecognized command : aaaaaa`

Explanation: The command **aaaaaa** entered by the user is not recognized by the simulator.

`Error: While reading command`

Explanation: An error occurred when the simulator attempted to read the command entered by the user. Re-enter the command correctly.

`Error: While reading filename`

Explanation: An invalid character was found in the filename specified as part of the `read` command. Re-enter the command with the correct filename.

`Error: While reading value - expected aaaaaa or bbbbbb`

Explanation: An invalid value was specified by the user. Only values **aaaaa** or **bbbbb** are acceptable. Re-enter the command specifying a valid value.

`Error: While reading value - expected integer between aaaaa and bbbbb`

Explanation: An invalid value was specified by the user. Only integer values between **aaaaa** and **bbbbb** are acceptable. Re-enter the command specifying a valid value.

`Error: While reading value - expected non-negative real number`

Explanation: An invalid value was specified by the user. Only non-negative real values are acceptable. Re-enter the command specifying a valid value.

`Exiting module YFBCTR`

Explanation: The binary search target acquisition processor is exiting the NSSC-1 routine YFBCTR. (*NSSC-1 Routine YFBCTR*, `tracelevel 3`.)

`Exiting module YFBSC1`

Explanation: The binary search target acquisition processor is exiting the NSSC-1 routine YFBSC1. (*NSSC-1 Routine YFBSC1*, `tracelevel 3`.)

`Exiting module YFBSC2`

Explanation: The binary search target acquisition processor is exiting the NSSC-1 routine YFBSC2. (*NSSC-1 Routine YFBSC2*, `tracelevel 3`.)

`Exiting module YFBSPR`

Explanation: The binary search target acquisition processor is exiting the NSSC-1 routine YFBSPR. (*NSSC-1 Routine YFBSPR*, `tracelevel 3`.)

`Exiting module YFDVCK`

Explanation: The binary search target acquisition processor is exiting the NSSC-1 routine YFDVCK. (*NSSC-1 Routine YFDVCK*, `tracelevel 3`.)

`Exiting module YFETST`

Explanation: The binary search target acquisition processor is exiting the NSSC-1 routine YFETST. (*NSSC-1 Routine YFETST*, `tracelevel 3`.)

`Exiting module YFHERR`

Explanation: The binary search target acquisition processor is exiting the NSSC-1 routine YFHERR. (*NSSC-1 Routine YFHERR*, `tracelevel 3`.)

`Exiting module YFM2PR`

Explanation: The binary search target acquisition processor is exiting the NSSC-1 routine YFM2PR. (*NSSC-1 Routine YFM2PR*, `tracelevel 3`.)

`Exiting module YFMSSV`

Explanation: The binary search target acquisition processor is exiting the NSSC-1 routine YFMSSV. (*NSSC-1 Routine YFMSSV*, `tracelevel 3`.)

`Exiting module YFPKFD`

Explanation: The binary search target acquisition processor is exiting the NSSC-1 routine YFPKFD. (*NSSC-1 Routine YFPKFD*, `tracelevel 3`.)

`Exiting module YFSDPR`

Explanation: The binary search target acquisition processor is exiting the NSSC-1 routine YFSDPR. (*NSSC-1 Routine YFSDPR*, `tracelevel 3`.)

`Exiting module YFSQRT`

Explanation: The binary search target acquisition processor is exiting the NSSC-1 routine YFSQRT. (*NSSC-1 Routine YFSQRT*, `tracelevel 3`.)

`Exiting module YLKELS`

Explanation: The binary search target acquisition processor is exiting the NSSC-1 routine YLKELS. (*NSSC-1 Routine YLKELS*, `tracelevel 3`.)

`Exiting module YUNSCR`

Explanation: The binary search target acquisition processor is exiting the NSSC-1 routine YUNSCR. (*NSSC-1 Routine YUNSCR*, `tracelevel 3`.)

`EXPTIME not set in header; Setting EXPTIME = 1.0`

Explanation: The data file specified by the user does not include an EXPTIME header value defining the binary search target acquisition exposure time that is associated with the input data. EXPTIME has been arbitrarily set to 1.0 seconds by the simulator.

```
First aa brightest peaks:
    peak numbers (JMAX(1 : YNBRT))            =      bb      cc ...
    channel numbers (M1(JMAX(1 : YNBRT)))     =      dd      ee ...
    peak counts (NCTS1(JMAX(1 : YNBRT)))      =   fffff   ggggg ...
```

Explanation: Listing of the brightest `aa` peaks found during execution of part 1 of the binary search target acquisition processor (YFBSC1). `aa` is determined by the setting of `YNBRT`. The peak numbers, associated channel numbers, and total number of counts, of each peak is listed in order of decreasing peak brightness. (*NSSC-1 Routine YFBSC1*, `tracelevel 2`.)

`Frame number (YFRCTR)                 =      a`

Explanation: The value of the frame counter during execution of part 1 of the binary search target acquisition processor (YFBSC1). Frame numbers `1`, `2`, and `3` refer to the middle, lower, and upper binary search steps, respectively, of the `4.3` target acquisition aperture scan. (*NSSC-1 Routine YFBSC1*, `tracelevel 1`.)

```
Global minimum value for a peak (GLBPK) = aaaaaa
Lower window limit (NMIN)               = bbbbbb
Upper window limit (NMAX)               = cccccc
```

Explanation: In order for a channel to be considered a peak during execution of the peak finding algorithm, the channel must have more than `aaaaaa` counts. This value is equal to the mean sky value plus *SMOTSV* times the sky variance. In addition, the number of counts must be greater than `bbbbbb` and less than or equal to `cccccc`, which are the window limits that can be set by the user. A final requirement is that the channel must have a locally maximal number of counts. (*NSSC-1 Routine YFPKFD*, `tracelevel 2`.)

`Group number (YGPCTR)                 =      a`

Explanation: The value of the group counter during execution of part 2 of the binary search target acquisition processor (YFBSC2). Group numbers start at `1` and increase to a maximum value of `8`, referring to consecutive binary search steps while attempting to place the target on the edge of the diode array. (*NSSC-1 Routine YFBSC2*, `tracelevel 1`.)

`Integrating ...`

Explanation: The simulator is computing the channel counts in the *N* array for the current integration of the binary search target acquisition processor in normal mode.

`Lower edge centering limit (I2TMP2)      = aaaaaa`

Explanation: The minimum number of counts, aaaaaa, allowed in the peak if the peak is to be considered to be on the edge of the diode array during execution of the edge test in part 2 of the binary search target acquisition processor (YFBSC2). (*NSSC-1 Routine YFETST*, `tracelevel 1`.)

`More than 4 peaks found in YFMSSV.  J = aaaaaa`

Explanation: FOS status buffer message 3232. More than 4 peaks were returned to NSSC-1 routine YFMSSV. aa is the number of peaks returned to YFMSSV by YFPKFD. (*NSSC-1 Routine YFHERR*, `tracelevel 0`.)

`More than 10 peaks found in YFPKFD.  J =     aa`

Explanation: FOS status buffer message 3231. More than 10 peaks were detected while identifying peaks in the NSSC-1 routine YPKFD. aa is the index of the new peak. (*NSSC-1 Routine YFHERR*, `tracelevel 0`.)

`NCTS1 overflowed for peak aa, NCTS1      =    bbbbbb`

Explanation: Computation of *NCTS1* overflowed for peak number aa during computation of the mean sky and sky variance (YFMSSV). The computed value of *NCTS1* is bbbbbb. *NCTS1* is set to 131071, and an FOS status buffer message is triggered. (*NSSC-1 Routine YFMSSV*, `tracelevel 2`.)

`New maximum found; setting YNMAX to current YNTARG = aaaaaa`

Explanation: The total number of counts in the target peak identified in the current binary search step during part 2 of the binary search target acquisition processor (YFBSC2) is larger than the previous computed value. (*NSSC-1 Routine YFBSC2*, `tracelevel 2`.)

`No help is available for aaaaaa`

Explanation: No help information is available for subject aaaaaa. Check that tt aaaaaa is not mis-spelled.

`No peaks found`

Explanation: No peaks were identified in a binary search step during execution of part 2 of the binary search target acquisition processor (YFBSC2). (*NSSC-1 Routine YFBSC2*, `tracelevel 2`.)

`No peaks found in data array`
`EXPTIME = aaaaaa.aaa`

Explanation: The simulator has determined that there is no maximum in the input data. The exposure time used during the simulator run is aaaaaa.aaa seconds.

`No peaks identified within YHWHM of expected position`

Explanation: Although one or more peaks were identified in a binary search step during execution of part 2 of the binary search target acquisition processor (YFBSC2), none of them is identified as the target peak because none of the peaks has a channel location that is no further than *YHWHM* channels from the target peak identified during execution of part 1 of the binary search target acquisition processor (YFBSC1). (*NSSC-1 Routine YFBSC2*, `tracelevel 2`.)

`NSUM overflowed at channel aa, NSUM =   bbbbbb`

Explanation: Computation of *NSUM* overflowed at channel aa during part 2 of the binary search target acquisition processor (YFBSC2). The computed value of *NSUM* is bbbbbb. *NSUM* is set to 131071, and an FOS status buffer message is triggered. (*NSSC-1 Routine YFBSC2*, `tracelevel 2`.)

`Number of peaks found (J)              =     aa`

Explanation: The number of peaks found during execution of the peak-finding algorithm. (*NSSC-1 Routine YFPKFD*, `tracelevel 2`.)

`Number of peaks found (YPKCT(YFRCTR))  =     aa`

Explanation: The number of peaks found in the current binary search step during execution of part 1 of the binary search target acquisition processor (YFBSC1). (*NSSC-1 Routine YFBSC1*, `tracelevel 1`.)

```
Peak channel     channel counts
      aa               bbbbbb
```

Explanation: The channel numbers, aa, and the number of counts in the channel, bbbbbb, of each peaks found during execution of the peak-finding algorithm. (*NSSC-1 Routine YFPKFD*, `tracelevel 2`.)

```
Peak channel counts = aaaaaa.aaa,
Target peak located at channel  bb, Y-base cccc
EXPTIME = dddddd.ddd
```

Explanation: The simulator has determined that the counts in a pixel centered on the maximum of the input data are aaaaaa.aaa. The maximum of the input data is located at X channel number bb and Y-base cccc. The exposure time used during the simulator run is dddddd.ddd seconds.

`Peak channel for binary search (YBSM)    = nnnnnn`

Explanation: The *negative* of the X-channel of the peak identified during execution of part 1 of the binary search target acquisition processor (YFBSC1) that represents the target to be acquired during part 2 of the binary search target acquisition processor (YFBSC2). (*NSSC-1 Routine YFBSC1*, `tracelevel 2`.)

`Peak channel      lower channel      upper channel      peak counts`
`      aa                bb                 cc              dddddd`

Explanation: During calculation of the sky mean and variance in the NSSC-1 routine YFMSSV, peaks in the data were found centered on channel **aa**, running from channel **bb** to channel **cc**, with **dddddd** counts. These peaks were excluded from computation of the sky mean and variance. (*NSSC-1 Routine YFMSSV*, `tracelevel 2`.)

`Peak counts for binary search (YNMAX)    = nnnnnn`

Explanation: The number of counts in the peak identified during execution of part 1 of the binary search target acquisition processor (YFBSC1) that represents the target to be acquired during part 2 of the binary search target acquisition processor (YFBSC2). (*NSSC-1 Routine YFBSC1*, `tracelevel 2`.)

`Peak number for binary search (YOBSJ)    = nnnnnn`

Explanation: The number of the peak identified during execution of part 1 of the binary search target acquisition processor (YFBSC1) that represents the target to be acquired during part 2 of the binary search target acquisition processor (YFBSC2). (*NSSC-1 Routine YFBSC1*, `tracelevel 2`.)

`Reading data group aa ...`

Explanation: The simulator is reading data group number **aa** into the N array in diagnostic mode.

`Requested YFXCTR                         = aaaaaa`
`Requested YFYCTR                         = bbbbbb`

Explanation: The values of the requested X (**aaaaa**) and Y (**bbbbb**) coordinates (in scaled photocathode microns) of the current step of the 4″ raster scan during execution of the expanded target search routine (if allowed) following failure of the initial binary search acquisition. (*NSSC-1 Routine YLKELS*, `tracelevel 2`.)

`Search direction                         =   DOWN |      UP`

Explanation: The initial search direction that will be used during part 2 of the binary search target acquisition processor (YFBSC2). A search direction of `DOWN` corresponds to using the upper edge of the diode array for centering in the Y direction, while a search direction of `UP` corresponds to using the lower edge of the diode. (*NSSC-1 Routine YFBSC1*, `tracelevel 2`.)

`Sky background mean (YNMEAN)             = aaaaaa`

Explanation: The computed mean value of the sky background, ignoring peaks. (*NSSC-1 Routine YFMSSV*, `tracelevel 2`.)

`Sky background median (YNMEAN)           = aaaaaa`

Explanation: Computed median value of the sky background. (*NSSC-1 Routine YFMSSV*, `tracelevel 2`.)

`Sky background variance (0th order approx: YVARI1) =     aaa`

Explanation: Approximation of the variance of the sky background computed as the square root of the median value. (*NSSC-1 Routine YFMSSV*, `tracelevel 2`.)

`Sky background variance (YVARI1)          =     aaa`

Explanation: The computed variance of the sky background, ignoring peaks. (*NSSC-1 Routine YFMSSV*, `tracelevel 2`.)

`Target acquisition completed`

Explanation: The binary search target acquisition completed successfully.

`Target acquisition error occurred.  YGIVUP =     aa`

Explanation: FOS status buffer message 3202. The NSSC-1 FOS science data processor determined that an error occurred during target acquisition. `aa` is the target acquisition error indicator. The possible failure values of *YGIVUP* associated with the binary search target acquisition processor are `2`: *YFM2CF* had invalid value in NSSC-1 module YFM2PR, `3`: *YSDPRC* had invalid value in NSSC-1 module YFSDPR, `4`: *YFSDFL* had invalid value in NSSC-1 module YFBSPR, `5`: too many peaks (> 4) were identified in a binary search frame, `6`: science data failed data validity test in NSSC-1 module YFDVCK, `7`: *YEDGE* had invalid value in NSSC-1 module YFBSC2, `8`: 5 frames of data have been processed in binary search mode without placing the object on the diode edge, `9`: $4''$ raster scan has been exhausted without finding an object, `10`: neither a pre-planned branch nor the $4''$ raster scan are available, and no object has been found at the current pointing coordinates , and `11`: *YFXCTR* computation failed in NSSC-1 module YFBSC2. (*NSSC-1 Routine YFHERR*, `tracelevel 0`.)

`Target acquisition failed`

Explanation: The binary search target acquisition failed.

`Target acquisition failed - field too crowded`

Explanation: The binary search target acquisition failed because there are too many targets in the target acquisition aperture.

`Target acquisition failed - insufficient data groups`

Explanation: The binary search target acquisition failed in diagnostic mode because there are too few groups of data in the input data file.

`Target acquisition failed - no object in field`

Explanation: The binary search target acquisition failed because there are no targets in the target acquisition aperture.

`Target acquisition failed - unable to place target on diode edge in 8 moves`

Explanation: The binary search target acquisition failed because the binary search target acquisition processor could not place the target on the edge of the diode array in the maximum allowed number of binary search steps.

`Target is not on the diode array`

Explanation: Part 2 of the binary search target acquisition processor (YFBSC2) has determined that the target is not on the diode array. (*NSSC-1 Routine YFBSC2*, `tracelevel 1`.)

`Target is on the edge of the diode array`

Explanation: Part 2 of the binary search target acquisition processor (YFBSC2) has determined that the target is on the edge of the diode array. (*NSSC-1 Routine YFBSC2*, `tracelevel 1`.)

`Target is still (or back) on the diode array`

Explanation: Part 2 of the binary search target acquisition processor (YFBSC2) has determined that the target is on the diode array. (*NSSC-1 Routine YFBSC2*, `tracelevel 1`.)

`Target located at channel aa.aaa, Y-base bbbb`
`X-slew = cc.ccc arcseconds, Y-slew = dd.ddd arcseconds`

Explanation: `aa.aaa` and `bbbbb` are the X-channel and Y-base positions of the acquired target. `cc.ccc` and `dd.ddd` are the X and Y slew offset vector components (telescope motion in the FOS X, Y coordinate system), needed to center the acquired target, in units of arcseconds on the sky. (*NSSC-1 Routine YFBCTR*, `tracelevel 0`.)

`Total counts in peak number a in frame b (NCTS1(cc)) increased to  ddddd`

Explanation: The counts associated with a duplicate observation of peak number `a` in binary search step `b` have been added to the value for that peak *NCTS1(*`cc`*)*, increasing its total counts to `ddddd` during execution of part 1 of the binary search target acquisition processor (YFBSC1). (*NSSC-1 Routine YFBSC1*, `tracelevel 2`.)

`Total number of peaks found (YFOUND)    =    aa`

Explanation: The total number of non-duplicate peaks `aa` found during execution of part 1 of the binary search target acquisition processor (YFBSC1) after the completing all of the binary search steps. (*NSSC-1 Routine YFBSC1*, `tracelevel 1`.)

`Upper edge centering limit (I2TMP3)    = aaaaaa`

Explanation: The maximum number of counts, `aaaaaa`, allowed in the peak if the peak is to be considered to be on the edge of the diode array during execution of the edge test in part 2 of the binary search target acquisition processor (YFBSC2). (*NSSC-1 Routine YFETST*, `tracelevel 1`.)

`Warning: YPOS in group header does not agree with predicted value.`
`YPOS = aaaaa, predicted bbbbb`

Explanation: The simulator computed that the next data group read into the N array in diagnostic mode should have a Y-base value of `bbbbb`, but the observed Y-base value in the header is `aaaaa`.

`Y-base (YBASKP)                    =    aaaa`

Explanation: The value of the *Y*-base setting of the current binary search step during execution of part 1 of the binary search target acquisition processor (YFBSC1). (*NSSC-1 Routine YFBSC1*, `tracelevel 1`.)

`Y-base (YBASKP)                    =    aaaa`

Explanation: The value of the *Y*-base setting of the current binary search step during execution of part 2 of the binary search target acquisition processor (YFBSC2). (*NSSC-1 Routine YFBSC2*, `tracelevel 1`.)

`YEDGE has an invalid value in YFBSC2.  YEDGE = aaaaaa`

Explanation: FOS status buffer message 3205. The value of *YEDGE* returned by NSSC-1 routine YFETST that determines whether the target is on the edge of the diode array, on the diode array, or off the diode array is invalid in NSSC-1 routine YFBSC-2. (*NSSC-1 Routine YFHERR*, `tracelevel 0`.)

`YFM2CF has an invalid value in YFM2PR.  YFM2CF = aaaaaa`

Explanation: FOS status buffer message 3220. The value of *YFM2CF* that determines the action requested of the NSSC-1 routine YFM2PR that computes the *Y*-base of the next frame of FOS data to be obtained is invalid. `aaaaaa` is the invalid value detected in NSSC-1 routine YFM2PR. (*NSSC-1 Routine YFHERR*, `tracelevel 0`.)

`YFM2PR action requested (YFM2CF)        =      a`

Explanation: The value `a` determines the action requested to set up the next *Y*-base command data field to be used to acquire the next frame of FOS data. The valid actions for the binary search target acquisition processor are `1`: take the next step in the full aperture scan, `2`: take the next geometrically decreasing step in *Y*-base in the same direction as the last step, `3`: take the next geometrically decreasing step in *Y*-base in the opposite direction as the last step. (*NSSC-1 Routine YFM2PR*, `tracelevel 2`.)

`YFOUND = aa, YPK = bb, YPKELM = cc`

Explanation: The number of peaks `aa` found during execution of part 1 of the binary search target acquisition processor (YFBSC1) *prior* to the inclusion of the peaks identified in the current binary search step, together with the number of peaks `bb` identified in the current step and the number of peaks eliminated as duplicates in the current step. (*NSSC-1 Routine YFBSC1*, `tracelevel 2`.)

`YFSDFL has an invalid value in YFBSPR.  YFSDFL = aaaaaa`

Explanation: FOS status buffer message 3201. The value of *YFSDFL* that determines whether stage 1 (YFBSC1) or stage 2 (YFBSC2) of the binary search target acquisition processor is called by the NSSC-1 FOS binary search target processor is invalid. `aaaaaa` is the invalid value detected in NSSC-1 routine YFBSPR. (*NSSC-1 Routine YFHERR*, `tracelevel 0`.)

`YFVCTR = aaaaa bbbbb`

Explanation: **aaaaa** and **bbbbb** are the X and Y slew offset vector components needed to center the acquired target, after any inversion if applicable, in units of microns at the photocathode. (*NSSC-1 Routine YFBCTR*, `tracelevel 2`.)

`YISUMX = aaaaaa`
`YISUM = bbbbbb`

Explanation: **aaaaaa** and **bbbbbb** are the X-channel weighted and unweighted sums of the counts in the target peak above the mean value *YNMEAN* after the target has been placed on the edge of the diode array during part 2 of the binary search target acquisition processor (YFBSC2). (*NSSC-1 Routine YFBSC2*, `tracelevel 2`.)

`YSDPRC has an invalid value in YFSDPR. YSDPRC = aaaaaa`

Explanation: FOS status buffer message 3200. The value of *YSDPRC* that determines which processor is called by the NSSC-1 FOS science data processor is invalid. **aaaaaa** is the invalid value detected in NSSC-1 routine YFSDPR. (*NSSC-1 Routine YFHERR*, `tracelevel 0`.)