FGS Data Reduction Tutorial

(Last updated 22-Jun-09)

§1 DATA RETRIEVAL:

1. The FGS data can be found at the MAST website: http://archive.stsci.edu

2. For non-proprietary data you may retrieve it anonymously
   Username = anonymous, Password = your e-mail
   or create an account
   http://archive.stsci.edu/registration/registration_form.html

3. From the drop down menu of **Mission_Search** choose **Hubble**.

4. To retrieve all your data enter your **Proposal ID** (e.g. 11943). Otherwise, you can use any of the other search criteria.
   a. Each row in the output corresponds to a separate observation of the target. The two main columns to look at are the Dataset and the Target Name.

   b. Taking the first Dataset as an example: **FB9C2W01M**
      F - Stands for the instrument used, in this case FGS.
      B9C - Is unique to the proposal ID, in this case 11943.
      2W - Is a base 36 number corresponding to the visit number.
      01 - Is the exposure number. Multiple exposures are due to long and short scans.
      M - Means that the data is merged, which is the case for all FGS data.

5. Once you mark the appropriate rows that you would like retrieve or click on **Mark All**, click **Submit marked data for retrieval from STDADS**.

6. For username and password see Step 2 above. Use the Delivery Option **STAGE: Put the data onto the Archive staging Disk**. You will receive an e-mail when your data is available to download via FTP and you will be assigned a request number.

7. In a terminal window, go to the directory where you want to store the raw data files **(/Users/fgs/fgsdata/<Proposal ID>)**. FTP into the archive
   %>ftp archive.stsci.edu
   and use your account information. (see Step 2)

8. Change to the directory where your data is stored.
   ftp>***cd stage/<user name>/<request number>***

9. Transfer the files from the archive onto your computer.
   ftp>*mget *fits*
   mget <file name>.fits [anpqy]? *a*

10. Logout **ftp>*bye***.

§2 TRANSFER MODE REDUCTION:

- **IRAF and STSDAS**

1. Run IRAF in the terminal. (**NOTE**: **login.cl** is in **/Users/fgs/iraf/** directory.)
   %>*cl*

2. Load the STSDAS package.
   ecl>*stsdas*
   stsdas>*set imtype = hhh*

3. Change to the correct directory.
   stsdas>*cd ../fgsdata/test*

4. Use the fits reader to make GEIS files out of the fits files.
   stsdas>*strfits *fits*
   IRAF filename: <*Hit Enter*>

5. Exit IRAF.
   stsdas>*logout*

This routine creates 2 sets of files for each FGS: **<file name>.a1d** & **<file name>.a1h**
1 – corresponds to FGS1r. This is the nominal science FGS, or the astrometer.
d – stands for data file.
h – stands for header file.
See the FGS Data Handbook Section 2.1.1 for more detailed description.
The figure below shows an example of the output from STRFITS.

- **IRAF and STSDAS**

```
[nelan:~] fgs% cd iraf/
[nelan:~/iraf] fgs% pwd
/Users/fgs/iraf
[nelan:~/iraf] fgs% cl

    NOAO/IRAFNET PC-IRAF Revision 2.14.1 Mon Sep 15 10:12:05 MST 2008
    This is the RELEASED version of IRAF V2.14 supporting PC systems.


  Welcome to IRAF.  To list the available commands, type ? or ??.  To get
  detailed information about a command, type `help <command>'.  To run  a
  command  or  load  a  package,  type  its name.   Type  `bye' to exit a
  package, or `logout' to get out  of the CL.    Type `news' to find  out
  what is new in the version of the system you are using.

  Visit http://iraf.net if you have questions or to report problems.

  The following commands or packages are currently defined:

      apropos     images.     noao.       proto.      system.
      dataio.     language.   obsolete.   softtools.  tables.
      dbms.       lists.      plot.       stsdas.     utilities.

ecl> stsdas


      +-------------------------------------------------------------+
      |       Space Telescope Science Data Analysis System          |
      |                 STSDAS Version 3.9                          |
      |                                                             |
      |   Space Telescope Science Institute, Baltimore, Maryland    |
      |   Copyright (C) 2003 Association of Universities for        |
      |            Research in Astronomy, Inc.(AURA)                |
      |       See stsdas$copyright.stsdas for terms of use.         |
      |         For help, send e-mail to help@stsci.edu             |
      |                                                             |
      +-------------------------------------------------------------+
      analysis.   describe    fitsio.     hst_calib.  problems    toolbox.
      contrib.    examples    graphics.   playpen.    sobsolete.

stsdas> set imtype = hhh
stsdas> cd ../fgsdata/test
stsdas> strfits *fits
IRAF filename:
Fits_file        IRAFNAME            Dimensions     BP DATE       OBJECT
fb9r0101m_a1f.fi fb9r0101m.a1h       733987         32 2008-12-22 LB11146

ts
fb9r0101m_a2f.fi fb9r0101m.a2h       733987         32 2008-12-22 LB11146

ts
fb9r0101m_a3f.fi fb9r0101m.a3h       733987         32 2008-12-22 LB11146

ts
fb9r0101m_dmf.fi fb9r0101m_cvt.dmh                  8  2008-12-22 LB11146

ts
fb9r0101m_trl.fi fb9r0101m.trl                      8  2008-12-22

ts
                 fb9r0101m.trl       132  6     Ncols=  1
fits             Error reading record 1
AFTER RFT_READ_FITS
ERROR: RFT_READ_HEADER: Not a FITS file
stsdas> log
[nelan:~/iraf] fgs% cd ../fgsdata/test/
[nelan:~/fgsdata/test] fgs%
```

- **FGSPLOT**

1. For a preliminary look at the data, use the FGSPLOT tool.

   %>fgsplot

   FGSPLOT provides many options to view the data. The following steps will only describe how to view a coadded image. For information on the acquisition path, see the FGS Data Handbook Section 1.3.

2. For the following steps I will use as an example the data in **/Users/fgs/fgsdata/test**. This is data for the star LB11146 from the Proposal ID 11944. FGS1r was used as the astrometer. When you are prompted, enter the header filename for the astrometer data file.

   enter header file name: ***fb9r0101m.a1h***

3. To see the actual scans use the **(zx)** and/or **(zy)** options. These images are coadded, but are not shifted.

4. Hit enter for defaults for scan **numbers used in averaging**, **First sample** and **Last Sample**.

5. Use a binning number of ***2.*** or ***3.***
6. Hit enter for the **sub scan length**, or enter a value smaller than the **measured scan length**.

7. For the **graph title** enter the star name or leave it blank. Then enter your preference for **line type**.

8. Hit enter to continue and use the default for the **vertical scale**.

9. You do not nave to output the plot to a file.

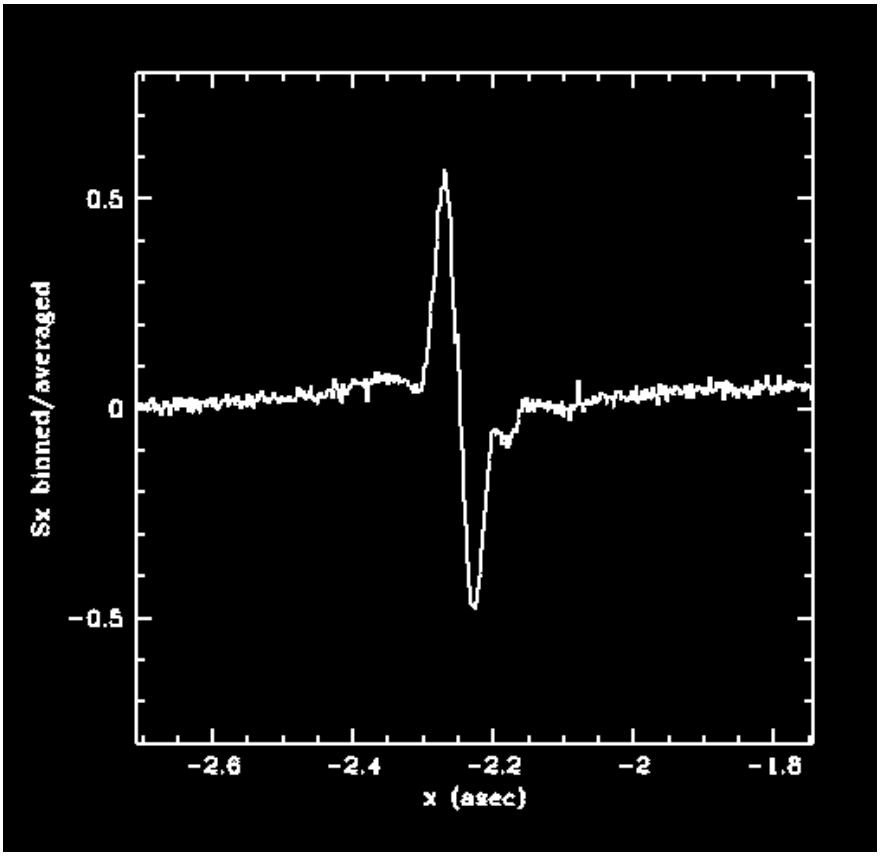
10. Enter ***y*** if you wish to plot something else. This will return to the initial menu options. ***n*** will exit FGSPLOT.

- **FGSPLOT**

```
[nelan:~/fgsdata/test] fgs% fgsplot


 enter header file name: fb9r0101m.a1h

 naxis1:  73398
 ast_id: 1
 mode:   TRANSFER
 obs_date: 2008 355 23:32:46

 Data loaded, #bytes:   2055144
 Flags located
 data quality assessed


                      Table of graphics options:
                    Select the desired graphics option
   (1)  X vs. Y
   (2)  Sx-curve vs. x-axis          (a)  X           (h)  PMTYA
   (3)  Sy-curve vs. y-axis          (b)  Y           (i)  PMTYB
   (4)  Rx vs. X                     (c)  Sx-curve    (j)  [PMTXA + PMTXB]
   (5)  Ry vs. Y                     (d)  Sy-curve    (k)  [PMTYA + PMTYB]
   (6)  x-position vs. time          (e)  Time        (l)  PMTsum
   (7)  y-position vs. time          (f)  PMTXA       (m)  Theta A
   (8)  Sx vs. time                  (g)  PMTXB       (n)  Theta B
   (9)  Sy vs. time
   (10) [PMTXA + PMTXB] vs. time
   (11) [PMTYA + PMTYB] vs. time                (Z)  I/O Parameters
   (12) PMTsum vs. time
   (zx) co-added X s-curves                     (ux)  FESAVG_X
   (zy) co-added Y s-curves                     (uy)  FESAVG_Y
   (xa) co_added XA pmt counts                  (xb)  co_added XB pmt counts
   (ya) co_added YA pmt counts                  (yb)  co_added YB pmt counts
   (xs) co_added XA,B pmt counts                (ys)  co_added YA,B pmt counts
                     Your choice (? for help) ->  zx

                          OBS mode -> TRANSFER

                               Flags are:
                      Search.........................  1008
                      Coarse Track...................  1032
                      Coarse Track Data Valid........  1512
                      Fine Lock......................  3630
                      Fine Lock Data Valid...........    -1
                      SSM............................  3642
                      ************************************
               Scan   1:    Start .....  4162   End .......  7821
               Scan   2:    Start .....  7302   End ....... 11221
               Scan   3:    Start ..... 10707   End ....... 14621
               Scan   4:    Start ..... 14099   End ....... 18022
               Scan   5:    Start ..... 17507   End ....... 21429
               Scan   6:    Start ..... 20906   End ....... 24824
               Scan   7:    Start ..... 24307   End ....... 28230
               Scan   8:    Start ..... 27702   End ....... 31628
               Scan   9:    Start ..... 31117   End ....... 35028
               Scan  10:    Start ..... 34514   End ....... 39422
               Scan  11:    Start ..... 37921   End ....... 42822
               Scan  12:    Start ..... 42304   End ....... 46220
               Scan  13:    Start ..... 45709   End ....... 49613
               Scan  14:    Start ..... 49105   End ....... 53025
               Scan  15:    Start ..... 52505   End ....... 56421
               Scan  16:    Start ..... 55907   End ....... 59821
               Scan  17:    Start ..... 59315   End ....... 62711
               Scan  18:    Start ..... 62703   End ....... 66632
               Scan  19:    Start ..... 66117   End ....... 70025
               Scan  20:    Start ..... 69516   End ....... 73398
                      ************************************
                      Maximum Number of Samples ..... 73398
```

- **FGSPLOT**

```
enter scan numbers to be included in averaging (RET=all) -> []
                              OBS mode -> TRANSFER

                                   Flags are:
                          Search.........................  1008
                          Coarse Track...................  1032
                          Coarse Track Data Valid........  1512
                          Fine Lock......................  3630
                          Fine Lock Data Valid...........    -1
                          LOS............................    -1
                          Stop...........................    -1
                          SSM............................  3642
                          Star Presence False............    -1
                          Maximum Number of samples ..... 73398

                       First sample (default = 1, -1 for TURBO) ->
                            Last sample (default = 73398) ->
enter binning interval (in milli arc seconds) .... -> 2.

   ....................... measured scan length -> 0.96
   ...................... enter sub scan length ->

              graph title ->
              enter line type ([so]lid or [sy]mbols or [bo]th) ->  so

                 x_min ->    -2.709          y_min ->    -0.479
                 x_max ->    -1.745          y_max ->     0.571
 continue? ->
 enter the "verticle scale (0.8=default) ->
warning: this program uses gets(), which is unsafe.
 output the plot to a file? ................... -> n
                  plot another? ([y], [n], or [z]oom) ->  y
```

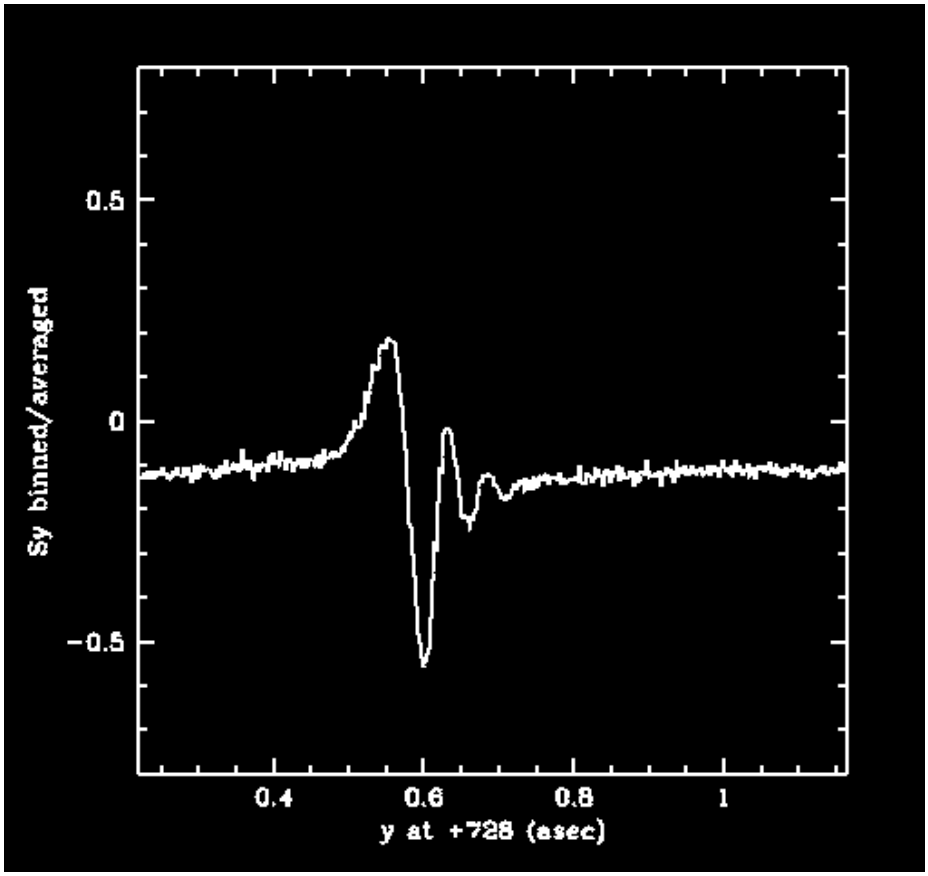


- **FGSPLOT**

```
                    Table of graphics options:
                  Select the desired graphics option
(1)  X vs. Y
(2)  Sx-curve vs. x-axis          (a)  X           (h)  PMTYA
(3)  Sy-curve vs. y-axis          (b)  Y           (i)  PMTYB
(4)  Rx vs. X                     (c)  Sx-curve    (j)  [PMTXA + PMTXB]
(5)  Ry vs. Y                     (d)  Sy-curve    (k)  [PMTYA + PMTYB]
(6)  x-position vs. time          (e)  Time        (l)  PMTsum
(7)  y-position vs. time          (f)  PMTXA       (m)  Theta A
(8)  Sx vs. time                  (g)  PMTXB       (n)  Theta B
(9)  Sy vs. time
(10) [PMTXA + PMTXB] vs. time
(11) [PMTYA + PMTYB] vs. time                (Z)  I/O Parameters
(12) PMTsum vs. time
(zx) co-added X s-curves                     (ux) FESAVG_X
(zy) co_added Y s-curves                     (uy) FESAVG_Y
(xa) co_added XA pmt counts                  (xb) co_added XB pmt counts
(ya) co_added YA pmt counts                  (yb) co_added YB pmt counts
(xs) co_added XA,B pmt counts                (ys) co_added YA,B pmt counts
                  Your choice (? for help) ->  zy

                        OBS mode -> TRANSFER

                             Flags are:
                    Search.........................  1008
                    Coarse Track...................  1032
                    Coarse Track Data Valid........  1512
                    Fine Lock......................  3630
                    Fine Lock Data Valid...........    -1
                    SSM............................  3642
                    ************************************
          Scan   1:    Start .....  4162   End ....... 7821
          Scan   2:    Start .....  7302   End ....... 11221
          Scan   3:    Start ..... 10707   End ....... 14621
          Scan   4:    Start ..... 14099   End ....... 18022
          Scan   5:    Start ..... 17507   End ....... 21429
          Scan   6:    Start ..... 20906   End ....... 24824
          Scan   7:    Start ..... 24307   End ....... 28230
          Scan   8:    Start ..... 27702   End ....... 31628
          Scan   9:    Start ..... 31117   End ....... 35028
          Scan  10:    Start ..... 34514   End ....... 39422
          Scan  11:    Start ..... 37921   End ....... 42822
          Scan  12:    Start ..... 42304   End ....... 46220
          Scan  13:    Start ..... 45709   End ....... 49613
          Scan  14:    Start ..... 49105   End ....... 53025
          Scan  15:    Start ..... 52505   End ....... 56421
          Scan  16:    Start ..... 55907   End ....... 59821
          Scan  17:    Start ..... 59315   End ....... 62711
          Scan  18:    Start ..... 62703   End ....... 66632
          Scan  19:    Start ..... 66117   End ....... 70025
          Scan  20:    Start ..... 69516   End ....... 73398
                    ************************************
                    Maximum Number of Samples ..... 73398

enter scan numbers to be included in averaging (RET=all) ->

                        OBS mode -> TRANSFER

                             Flags are:
                    Search.........................  1008
                    Coarse Track...................  1032
                    Coarse Track Data Valid........  1512
                    Fine Lock......................  3630
                    Fine Lock Data Valid...........    -1
                    LOS............................    -1
                    Stop...........................    -1
                    SSM............................  3642
                    Star Presence False............    -1
                    Maximum Number of samples ..... 73398
```

- **FGSPLOT**

```
                First sample (default = 1, -1 for TURBO) ->
                    Last sample (default = 73398) ->
enter binning interval (in milli arc seconds) .... -> 2.


   ..................... measured scan length -> 0.94
   ..................... enter sub scan length ->

            graph title ->
            enter line type ([so]lid or [sy]mbols or [bo]th) ->  so

               x_min ->   728.219          y_min ->    -0.554
               x_max ->   729.164          y_max ->     0.192
continue? ->
enter the "verticle scale (0.8=default) ->
output the plot to a file? ................. -> n

                plot another? ([y], [n], or [z]oom) ->  n
```



- **CALFGSA**
  1. CALFGSA is used on both TRANS and POS Mode Data to separate the GEIS files into individual scans. To run, just type CALFGSA in the terminal window:

     %>*calfgsa*

  2. You will be prompted for "observation rootname". This can be in the form of an individual file

     enter observation rootname: *fb9r0101m*

     or a list (obs.lis) with the rootnames of the header files

     enter observation rootname: *@obs.lis*

CALFGSA will create individual files for each scan and for each FGS in the format: **<filename>.1s5**

1 – corresponds to FGS1r. This is the nominal science FGS, or the astrometer.

s – stands for scan.

5 – is the scan number.

The program also outputs 2 preliminary co-added files for both x- and y- axes: **<filename>.coadd.x.ps** & **<filename>.coadd.y.ps**

```
[nelan:~/fgsdata/test] fgs% calfgsa
 enter observation rootname: fb9r0101m

 processing obs: ......... -> fb9r0101m
 observing mode ........... -> TRANSFER
 number of samples ........ ->  73398
 filter ................... -> F583W
 target magnitude ......... -> 14.32
 target_id ................ -> 11944_462
 target name .............. -> LB11146
 obs date ................. -> 2008 355 23:32:46
 telemetry format ......... -> FN
 FGS V2 OFFSET (align pt) . ->    0.00
 FGS V3 OFFSET (align pt) . ->    0.00

 sl, xmax/min, ymax/min:  1.35    -1.25   -2.12  730.01  729.16
 writing data files for scan# :   1
 writing data files for scan# :   2
 writing data files for scan# :   3
 writing data files for scan# :   4
 writing data files for scan# :   5
 writing data files for scan# :   6
 writing data files for scan# :   7
 writing data files for scan# :   8
 writing data files for scan# :   9
 writing data files for scan# :  10
 writing data files for scan# :  11
 writing data files for scan# :  12
 writing data files for scan# :  13
 writing data files for scan# :  14
 writing data files for scan# :  15
 writing data files for scan# :  16
 writing data files for scan# :  17
 writing data files for scan# :  18
 writing data files for scan# :  19
 writing data files for scan# :  20
[nelan:~/fgsdata/test] fgs%
```

- **PTRANS**

1. To process the TRANS data and make the final S-curve run PTRANS.
   %>*ptrans*

2. Like CALFGSA, when prompted for the name of the file(s) you can enter an individual file rootname
   enter: name of the obs or file with list of scans -> *fb9r0101m*
   or a file list preceded by an @ sign
   enter: name of the obs or file with list of scans -> *@obs.lis*

3. Next you will be prompted to perform a cross correlation. For anything fainter than V > 14 mag, you run the risk of cross correlating the noise, so you should perform two runs: once with cross correlating and once without cross correlating. Otherwise, always cross correlate. The default is yes.
   perform cross correlation (y/n) ……..…… -> *y*

4. For the following prompts use the default by hitting enter **<*CR*>**, but I have included here what each default is:
   use 100 mas range for cross correlation (y/n) …. -> <*CR* = *y*>
   process which axis (<CR> = both X and Y) …….. -> <*CR*>
   shall the individual scans be output? …… -> <*CR* = *n*>
   set x, y limits of data to be analyzed ? …… -> <*CR* = *n*>
   de-jitter scans (y=default, n=no-dejitter) ? … -> <*CR*>
   add constants to PMT data? …… -> <*CR*>

5. After PTRANS processes the data, you will work with the X-axis data first. When prompted to specify the reference scan number, choose the middle scan (i.e. if there are 20 scans, enter 10)
   specify the X-axis reference scan number: *10*
   PTRANS will shift and bin all the other scans to this reference scans. If it does not work, then exit PTRANS and start over with another reference scan.

6. The program will print out a table with information about each scan. The columns to take special note of are:
   scan – the scan number.
   shift – how much the scan is was shifted (in mas) to line up with the reference scan. Throw out scans with large significantly large shifts.
   rel_diff – is the ratio between sd_fr and ave_sd_fr. This should be about 1 but a good range in values in from 0.7 to 1.4.
   The other 4 columns are the standard deviations and average standard deviations from the mean S-curve in the fringe (fr) and the wings (wg).

   After taking a look at the shifts and rel_diff, you are prompted with several options. After performing each, you will return to this menu.:

- **enter scan numbers to omit** – you can enter in the individual scan number of a scan with a large shift and/or a bad rel_diff that you do not want in the final co-added S-curve.

  … -> 20

  If you want to omit more than one scan, just enter the numbers, separated by commas.

  … -> 1, 20

  If you accidentally omit a scan, you can include by entering a negative sign in front.

  … -> -1

  The X-axis co-added S-curve and the Y-axis co-added S-curve do NOT need to have the same scans included. For example, the X-axis you may have omitted scan #1 but in the Y-axis scan #1 is perfectly acceptable.
- **set maximum allowable threshold (fx.xx)** – this is the maximum threshold for rel_diff. If you want to exclude a rel_diff larger than 1.2 just enter:

  …-> f1.20
- **choose to plot a scan (p#)** – if you want to plot an individual scan, enter the letter ***p*** followed by the scan number (no space).

  … -> p20

  This will plot the individual scan in blue and the unsmoothed, co-added scan in red. You will be prompted for the range to plot the data. Use ***a*** (all) for the first plot. Then you will be asked to output plot to a file, re-plot data with different limits and mark scan for deletion. The default for all of these is no (***n***). Then you are given the option to plot another scan (enter just the scan number) or if you hit enter, you will return to the main menu.
- **compare smooth/un-smoothed data (cp)** – Typing ***cp*** will plot the smoothed, co-added data in red and the unsmoothed, co-added data in blue. Use this to make sure you are not compromising the quality of the final smoothed S-curve and whether you need to change the smoothing parameter.

  You will be prompted for the smoothing parameter. You can hit enter to use the default or current value or enter an integer. (see below how to choose smoothing parameter)

  ---> 4000

  Next you can choose the plot range by either entering ***a*** for the whole plot range, ***s*** to plot the ranges used previously in PTRANS or you can choose the X and Y min and max values.

  ----------> xmin: *s*

  Then you will be prompted if you want to output the file and if you would like to re-plot with different limits. Choosing a smaller X-range (e.g. -0.2 to 0.2) will let you see more detail in the smoothing, as well as remove the edges of the scan that are bad due to instrumentation effects. I would set the limits of the plot here.
- **change the smoothing parameter (sm)** – You will get a better fit when using BINARY_FIT below with smoother data. The default value is 1000. For a faint star V~14 mag, the smoothing parameter will be roughly around

4000. It will be higher for brighter objects. You may want to start by changing the value in steps of 1000 and refine it to steps of 50. This is a case where bigger is better. The smoothing parameter will be approximately the same for both axes.
In the case where you have multiple fringes due to more than one star in the FOV, then first smooth the curve to the primary and double check the secondary.
After entering the smoothing parameter you will be prompted to label the plot, output the plot to file and reset the plot limits. Hit enter for all of these and go to **cp** to plot the smoothed curve.

- Hitting enter will set the smoothing parameter and set the scans used for the final S-curve.
  For label #1, enter the target name.
  For label #2, enter the date.
  (NOTE: The name and data are outputted when you run STRFITS or you can find that information in the **<file name>.tab**
  Hit enter when prompted to output to a file and re-do with new limits or title.
  If this is the X-axis and you are doing both, the program will repeat steps 5-6 for the Y-axis.
  Otherwise the program ends here.

PTRANS outputs a total of 6 files, 3 files for both the X-axis and Y-axis.

fb9r0101m.cx – co-added, cross correlated and de-jittered X-axis S-curve
fb9r0101m.cx0 – same as above, but shifted to the reference scan
fb9r0101m.cx0s – same as .cx0 but also smoothed

- **PTRANS**

```
[nelan:~/fgsdata/test] fgs% ptrans

 enter: name of the obs or file with list of scans -> fb9r0101m
 perform cross correlation (y/n) ................. -> y
 use 100 mas range for cross correlation (y/n) .... ->
 using range =  100.0 mas
 process which axis (<CR> = both X and Y) ........ ->

 shall the individual scan files be output? ...... ->
 set x,y limits of data to be analyzed ? ......... ->
 de-jitter scans (y=default, n=no de-jitter) ? ... ->

 add constants to PMT data ? ..................... ->
 dominant guide star in FGS #2

 processing raw data files:
 scan number:           1
 xmin, xmax:    -2.7086710087152595       -1.7480594591125458
 ymin, ymax:     728.21950078515306        729.16329579213709

 scan number:           2
 xmin, xmax:    -2.7086710087152595       -1.7469691594016494
 ymin, ymax:     728.21950078515306        729.16329579213709

 scan number:           3
 xmin, xmax:    -2.7086710087152595       -1.7469691594016494
 ymin, ymax:     728.22016328280688        729.16329579213709

 scan number:           4
 xmin, xmax:    -2.7086710087152595       -1.7436862066207657
 ymin, ymax:     728.22016328280688        729.16529635453526

 scan number:           5
 xmin, xmax:    -2.7075812004943103       -1.7436862066207657
 ymin, ymax:     728.22016328280688        729.16529635453526

 scan number:           6
 xmin, xmax:    -2.7075812004943103       -1.7469691594016494
 ymin, ymax:     728.22016328280688        729.16395741226677

 scan number:           7
 xmin, xmax:    -2.7086710087152595       -1.7469691594016494
 ymin, ymax:     728.21950078515306        729.16395741226677

 scan number:           8
 xmin, xmax:    -2.7086710087152595       -1.7469691594016494
 ymin, ymax:     728.21950078515306        729.16329579213709

 scan number:           9
 xmin, xmax:    -2.7086710087152595       -1.7469691594016494
 ymin, ymax:     728.21950078515306        729.16329579213709

 scan number:          10
 xmin, xmax:    -2.7086710087152595       -1.7447765062609877
 ymin, ymax:     728.21950078515306        729.16529635453526

 scan number:          11
 xmin, xmax:    -2.7086710087152595       -1.7447765062609877
 ymin, ymax:     728.22016328280688        729.16529635453526

 scan number:          12
 xmin, xmax:    -2.7086710087152595       -1.7469691594016494
 ymin, ymax:     728.22016328280688        729.16395741226677

 scan number:          13
 xmin, xmax:    -2.7075812004943103       -1.7469691594016494
 ymin, ymax:     728.22016328280688        729.16395741226677
```

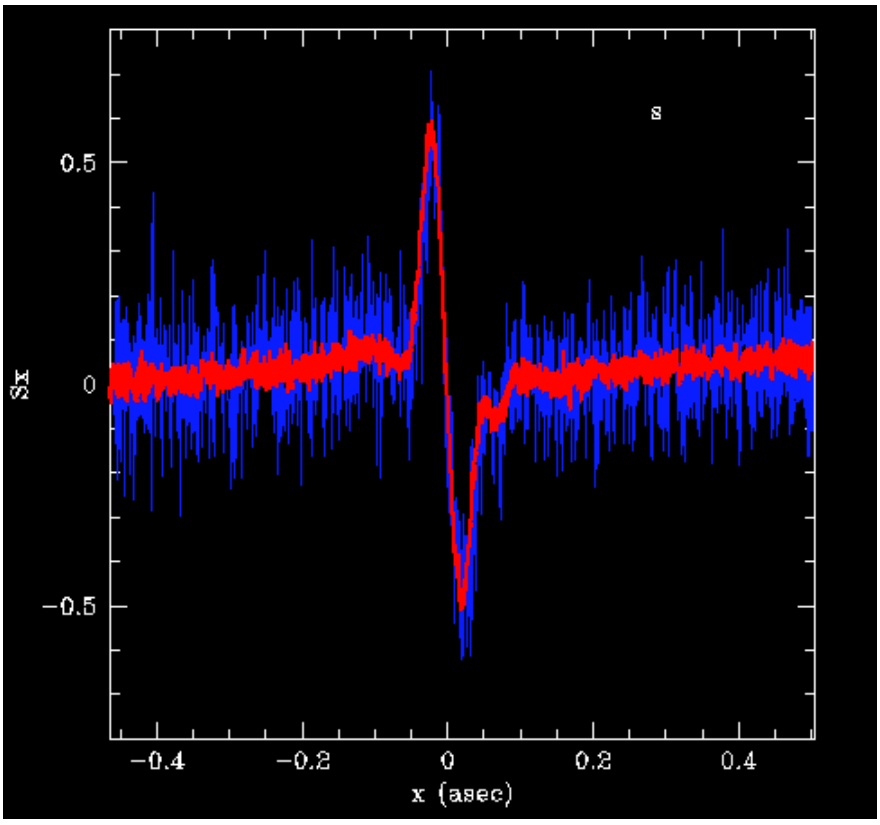
- **PTRANS**

```
scan number:          14
xmin, xmax:    -2.7075812004943103       -1.7425918849853601
ymin, ymax:     728.22016328280688        729.16530157871364

scan number:          15
xmin, xmax:    -2.7086710087152595       -1.7425918849853601
ymin, ymax:     728.22016328280688        729.16530157871364

scan number:          16
xmin, xmax:    -2.7086710087152595       -1.7425918849853601
ymin, ymax:     728.22016328280688        729.16596320211374

scan number:          17
xmin, xmax:    -2.6605946362008095       -1.7425918849853601
ymin, ymax:     728.26632437996125        729.16596320211374

scan number:          18
xmin, xmax:    -2.7075812004943103       -1.7436862066207657
ymin, ymax:     728.22016328280688        729.16529635453526

scan number:          19
xmin, xmax:    -2.7086710087152595       -1.7436862066207657
ymin, ymax:     728.21950078515306        729.16529635453526

scan number:          20
xmin, xmax:    -2.7086710087152595       -1.7447765062609877
ymin, ymax:     728.21950078515306        729.16529635453526

scan:   1    -2.260  0.758  -0.770          1.529
            728.542  0.374  -0.724          1.098

scan:   2    -2.263  0.773  -0.653          1.426
            728.537  0.422  -0.721          1.143

scan:   3    -2.265  0.664  -0.652          1.316
            728.516  0.447  -0.643          1.090

scan:   4    -2.267  0.732  -0.659          1.391
            728.548  0.397  -0.750          1.147

scan:   5    -2.274  0.699  -0.718          1.417
            728.557  0.391  -0.730          1.122

scan:   6    -2.266  0.684  -0.687          1.371
            728.570  0.472  -0.694          1.167

scan:   7    -2.261  0.750  -0.702          1.452
            728.528  0.559  -0.718          1.276

scan:   8    -2.273  0.844  -0.699          1.543
            729.047  0.378  -0.745          1.123

scan:   9    -2.270  0.717  -0.689          1.406
            728.559  0.421  -0.753          1.174

scan:  10    -2.268  0.732  -0.670          1.403
            728.561  0.452  -0.694          1.146

scan:  11    -2.269  0.770  -0.614          1.384
            728.542  0.377  -0.695          1.072

scan:  12    -2.265  0.880  -0.800          1.680
            728.547  0.383  -0.692          1.075

scan:  13    -2.264  0.741  -0.707          1.448
            728.548  0.443  -0.691          1.134

scan:  14    -2.282  0.747  -0.670          1.417
            728.552  0.396  -0.792          1.188
```

- **PTRANS**

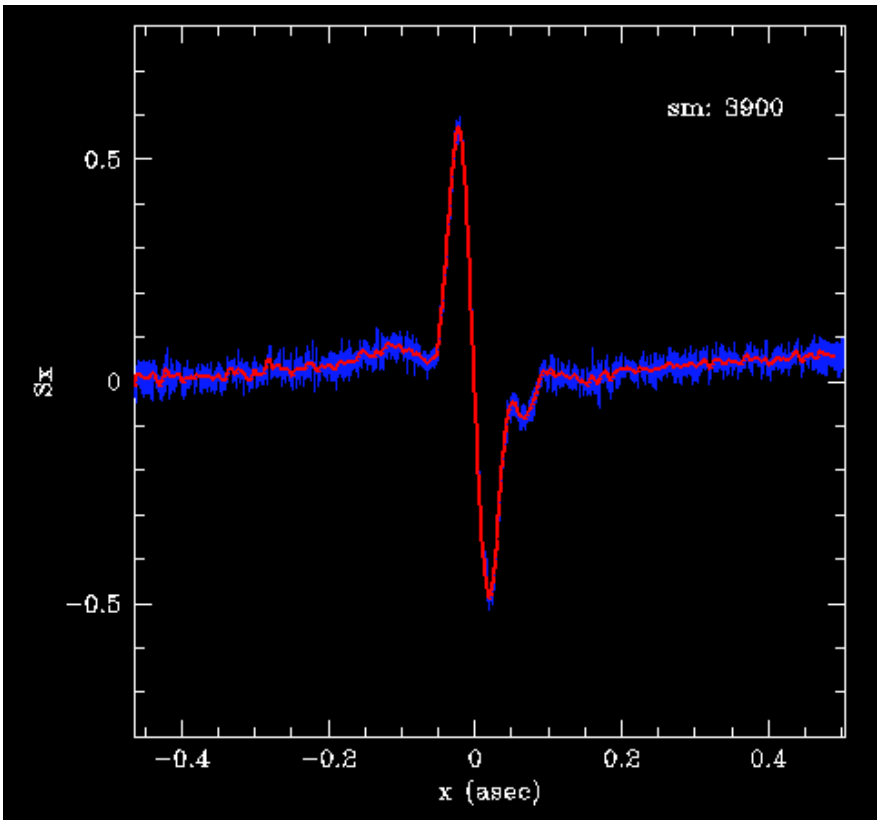
```
scan:  15    -2.279  0.756  -0.631          1.387
            728.529  0.443  -0.670          1.113

scan:  16    -2.269  0.724  -0.615          1.339
            728.557  0.449  -0.711          1.161

scan:  17    -2.276  0.736  -0.647          1.384
            728.555  0.412  -0.718          1.130

scan:  18    -2.273  0.689  -0.700          1.389
            728.555  0.397  -0.736          1.134

scan:  19    -2.267  0.732  -0.627          1.359
            728.541  0.537  -0.733          1.270

scan:  20    -2.275  0.721  -0.711          1.433
            728.566  0.413  -0.747          1.161


specify the X-axis reference scan number: 10

processing x axis, iteration #           1

xzero:   -2.2467071101096820
wings_ave, i:    8.47823167251000320E-002          20
fringe_ave, i:   8.54741931879314659E-002          20

       ----------- x axis ------------
 scan    shift     rel_diff    sd_fr       sd_wg     ave_sd_fr   sd_wings

    1     0.98      1.13      0.0964      0.0885      0.0855      0.0848
    2     2.90      1.04      0.0887      0.0853      0.0855      0.0848
    3    -1.78      0.86      0.0738      0.0831      0.0855      0.0848
    4     0.66      1.03      0.0884      0.0826      0.0855      0.0848
    5     0.90      0.96      0.0817      0.0856      0.0855      0.0848
    6    -0.02      0.98      0.0841      0.0854      0.0855      0.0848
    7    -0.49      0.89      0.0764      0.0863      0.0855      0.0848
    8    -0.98      0.99      0.0844      0.0845      0.0855      0.0848
    9    -1.29      1.02      0.0873      0.0845      0.0855      0.0848
   10     0.00      0.92      0.0790      0.0845      0.0855      0.0848
   11    -1.89      1.05      0.0894      0.0849      0.0855      0.0848
   12    -1.50      1.00      0.0859      0.0841      0.0855      0.0848
   13    -1.19      1.04      0.0890      0.0864      0.0855      0.0848
   14    -2.30      1.00      0.0853      0.0840      0.0855      0.0848
   15    -1.69      1.08      0.0919      0.0868      0.0855      0.0848
   16    -2.48      1.02      0.0871      0.0846      0.0855      0.0848
   17    -3.15      0.98      0.0838      0.0797      0.0855      0.0848
   18    -1.60      0.97      0.0828      0.0864      0.0855      0.0848
   19    -2.41      0.96      0.0822      0.0841      0.0855      0.0848
   20    -4.10      1.07      0.0918      0.0843      0.0855      0.0848

enter scan numbers to omit,
or    set maximum allowable threshold (fx.xx)
or    choose to plot a scan (p#)
or    compare smoothed/un-smoothed data (cp)
or    change the smoothing parameter (sm) .... -> p20

 npts, npts_coadded:         3992        3992
 x_plot(1), x_plot(npts):  -0.46365645270676481       0.50417855519302979


"x" data ranges from (min,max) = (-0.464, 0.504)
enter range to be plotted ("a" plots all, "s" plots same as before)

                              ---------->  xmin: a
warning: this program uses gets(), which is unsafe.
 output the plot to a file? ..... ->
 re-plot data with different limits? ..... ->
 mark scan for deletion? ..... -> y
 enter next scan to plot ..... ->
```

- **PTRANS**



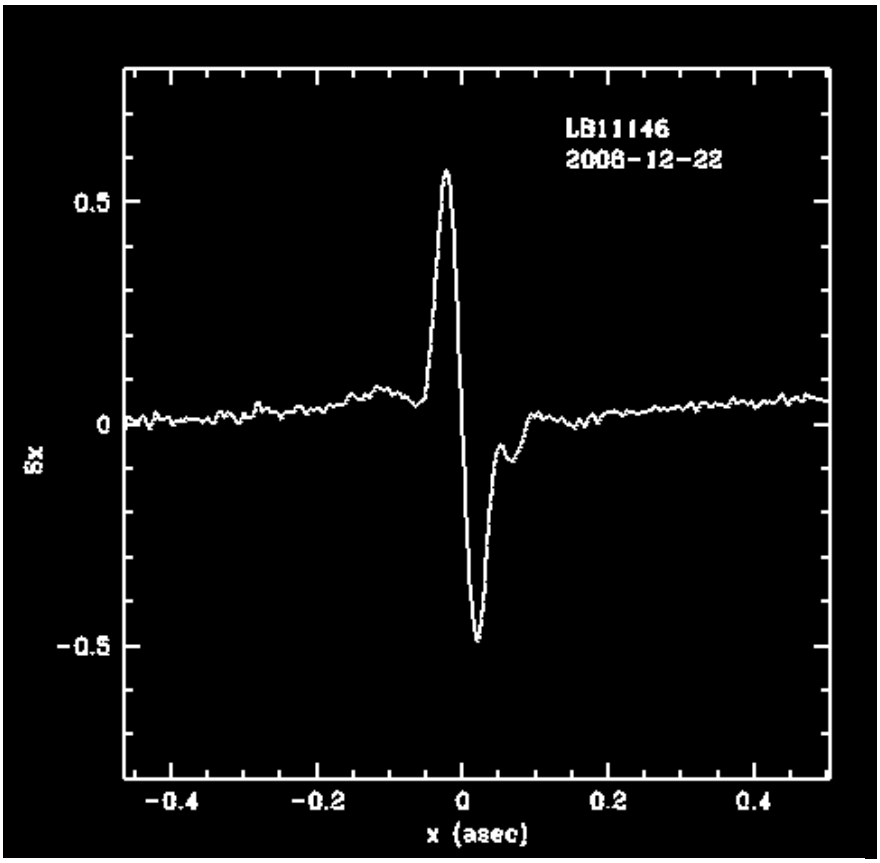

```
enter scan numbers to omit,
or    set maximum allowable threshold (fx.xx)
or    choose to plot a scan (p#)
or    compare smoothed/un-smoothed data (cp)
or    change the smoothing parameter (sm) .... -> cp


smoothing parameter currently set as sm =     0
enter new value (<CR> retains current value) --- > 3900
 in s_smooth: iter =    3900.0000000000000


"x" data ranges from (min,max) = (-0.464, 0.504)
enter range to be plotted ("a" plots all, "s" plots same as before)

                                ---------------->  xmin: a
output the plot to a file? ................... ->
re-plot data with different limits? ......... ->
```

- **PTRANS**




```
 enter scan numbers to omit,
 or    set maximum allowable threshold (fx.xx)
 or    choose to plot a scan (p#)
 or    compare smoothed/un-smoothed data (cp)
 or    change the smoothing parameter (sm) .... -> 

  in s_smooth: iter =    3900.0000000000000

 Enter label#1 for final plot:

LB11146

 Enter label#2 for final plot:

2008-12-22

 "x" data ranges from (min,max) = (-0.464, 0.503)
 enter range to be plotted ("a" plots all, "s" plots same as before)

                                  ---------------> xmin: s
 output final plot to a file? ..................  ->
 re-do final plot with new limits or title?  ->
```

- **PTRANS**

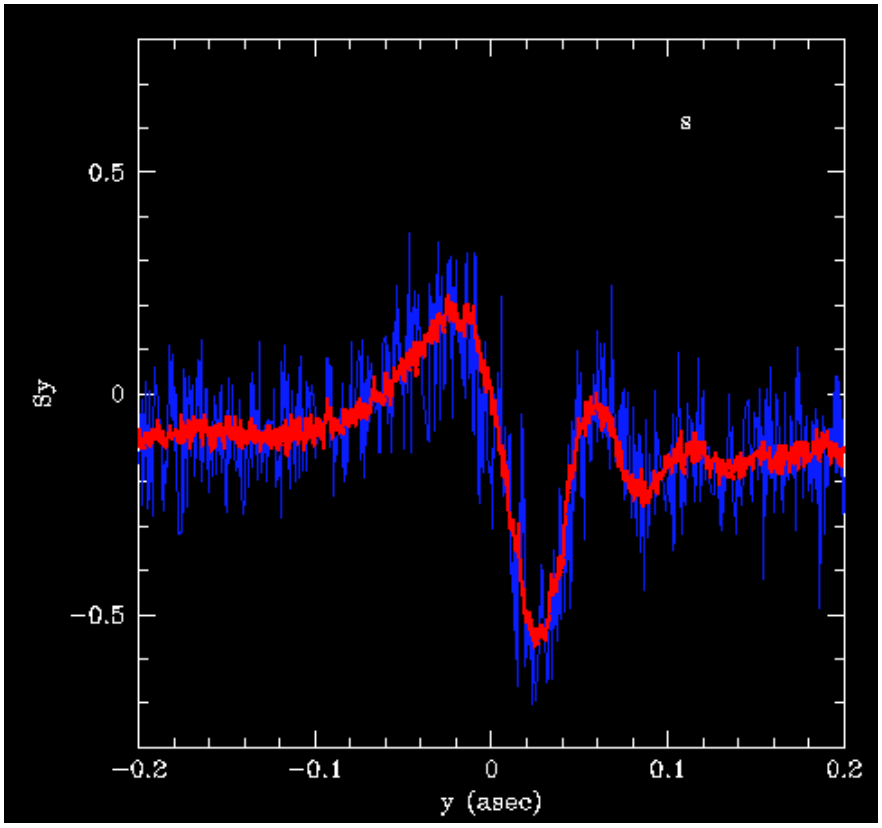



```
specify the Y-axis reference scan number: 10
reference scan ID:  10


processing y axis, iteration #          1

xzero:    728.57313933701244
wings_ave, i:    8.50572280693456 76E-002          20
fringe_ave, i:   0.10758231024750227               20
```

	y axis					
scan	shift	rel_diff	sd_fr	sd_wg	ave_sd_fr	sd_wings
1	5.66	1.04	0.1121	0.0855	0.1076	0.0851
2	10.82	1.04	0.1120	0.0836	0.1076	0.0851
3	-0.13	0.93	0.1005	0.0848	0.1076	0.0851
4	1.92	1.05	0.1127	0.0888	0.1076	0.0851
5	4.77	1.02	0.1103	0.0834	0.1076	0.0851
6	7.70	1.20	0.1287	0.0833	0.1076	0.0851
7	3.47	0.87	0.0933	0.0830	0.1076	0.0851
8	5.01	1.10	0.1188	0.0852	0.1076	0.0851
9	2.66	0.98	0.1056	0.0836	0.1076	0.0851
10	0.00	0.94	0.1016	0.0854	0.1076	0.0851
11	-0.86	0.91	0.0978	0.0844	0.1076	0.0851
12	-0.32	0.93	0.1000	0.0861	0.1076	0.0851
13	-1.35	0.96	0.1036	0.0821	0.1076	0.0851
14	-6.71	1.03	0.1110	0.0845	0.1076	0.0851
15	-3.22	1.11	0.1192	0.0883	0.1076	0.0851
16	-2.67	0.92	0.0986	0.0853	0.1076	0.0851
17	-0.39	1.07	0.1148	0.0872	0.1076	0.0851
18	-6.51	1.03	0.1109	0.0870	0.1076	0.0851
19	-5.08	0.92	0.0985	0.0867	0.1076	0.0851
20	-3.50	0.95	0.1018	0.0831	0.1076	0.0851

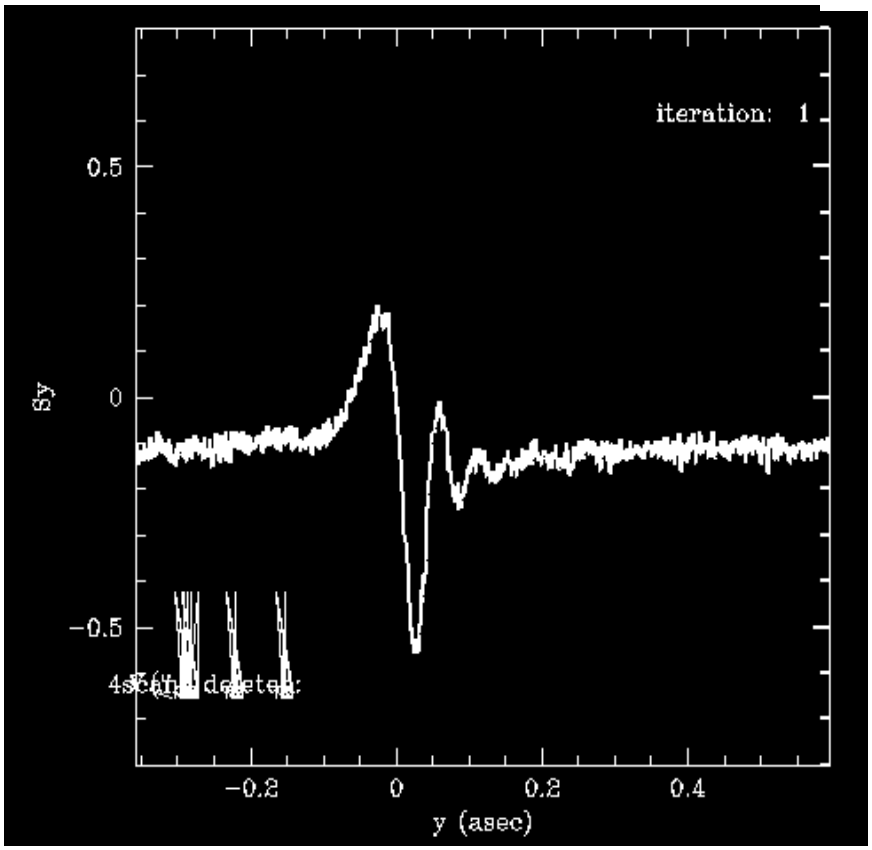
- **PTRANS**

```
enter scan numbers to omit,
or    set maximum allowable threshold (fx.xx)
or    choose to plot a scan (p#)
or    compare smoothed/un-smoothed data (cp)
or    change the smoothing parameter (sm) .... -> p2

 npts, npts_coadded:         4053        4053
 x_plot(1), x_plot(npts):  -0.35682322589548221       0.59482689930359811


"x" data ranges from (min,max) = (-0.357, 0.595)
enter range to be plotted ("a" plots all, "s" plots same as before)
                                ---------------> xmin: -0.2
                                ---------------> xmax: 0.2

"y" data ranges from (min,max) = (-0.703, 0.362)
enter range to be plotted (<cr> plots +/-0.8)  ymin:

output the plot to a file? ..................... ->
re-plot data with different limits? ......... ->
mark scan for deletion? ....................... -> y
enter next scan to plot ....................... ->
```



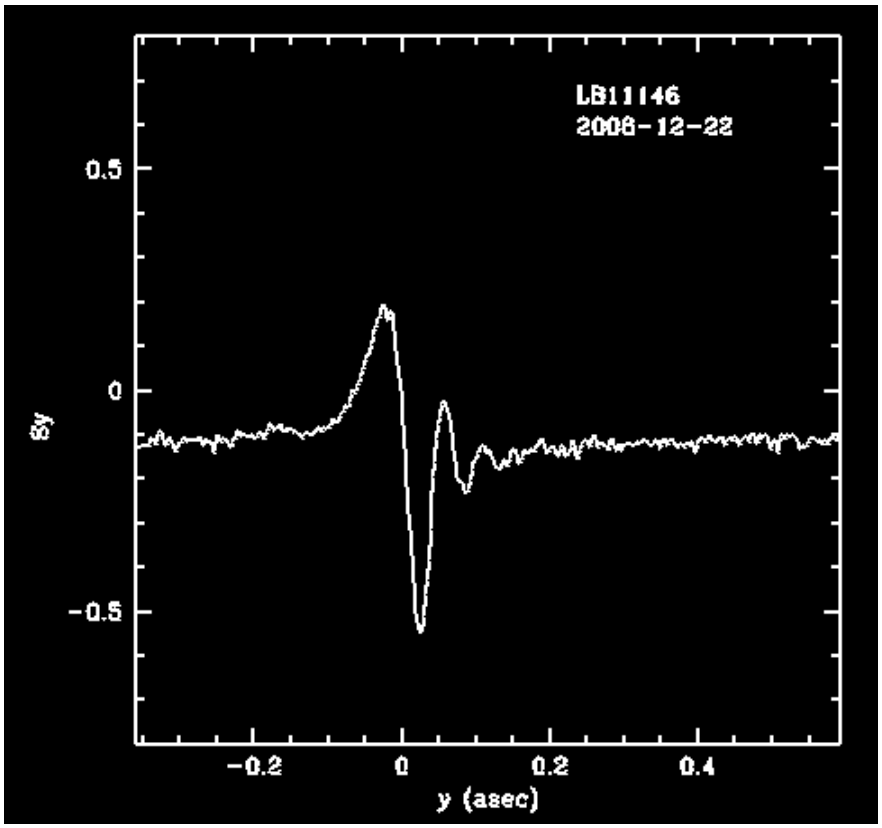
- **PTRANS**

```
enter scan numbers to omit,
or    set maximum allowable threshold (fx.xx)
or    choose to plot a scan (p#)
or    compare smoothed/un-smoothed data (cp)
or    change the smoothing parameter (sm) .... -> 6,14,18

 in s_smooth: iter =    1000.0000000000000

Enter label for this iteration plot:

"x" data ranges from (min,max) = (-0.357, 0.594)
enter range to be plotted ("a" plots all, "s" plots same as before)

                                  ---------->  xmin: a
output plot of iteration to a file? ........ ->
re-do iteration-plot with new limits? ...... ->
```



- **PTRANS**

```
processing y axis, iteration #          2

xzero:    728.57536439243472
wings_ave, i:    8.55149235687815701E-002          15
fringe_ave, i:   0.10486197058670292               15

       ---------- y axis ------------
 scan    shift     rel_diff     sd_fr       sd_wg     ave_sd_fr   sd_wings

    3    -0.13       0.94       0.0981      0.0863      0.1049      0.0855
    4     1.92       1.12       0.1175      0.0902      0.1049      0.0855
    5     4.77       1.09       0.1147      0.0851      0.1049      0.0855
    7     3.47       0.87       0.0909      0.0818      0.1049      0.0855
    8     5.01       1.11       0.1162      0.0848      0.1049      0.0855
    9     2.66       0.96       0.1011      0.0847      0.1049      0.0855
   10     0.00       0.96       0.1012      0.0843      0.1049      0.0855
   11    -0.86       0.93       0.0979      0.0853      0.1049      0.0855
   12    -0.32       0.92       0.0961      0.0849      0.1049      0.0855
   13    -1.35       1.00       0.1044      0.0818      0.1049      0.0855
   15    -3.22       1.15       0.1207      0.0886      0.1049      0.0855
   16    -2.67       0.94       0.0982      0.0856      0.1049      0.0855
   17    -0.39       1.11       0.1166      0.0870      0.1049      0.0855
   19    -5.08       0.93       0.0976      0.0886      0.1049      0.0855
   20    -3.50       0.97       0.1018      0.0837      0.1049      0.0855

                                ---------------> xmin:
output final plot to a file? ..................  -> n
re-do final plot with new limits or title?  ->
[nelan:~/fgsdata/test] fgs%
```



- **CP_SCURVES**

1. You can use the CP_SCURVES routine to look at the output S-curves from PTRANS and also to check if the star is a binary. The program also creates postscript files of the S-curves. Run CP_SCURVES:

   %> *cp_scurves*

2. You can compare any two sets of S-curves, as long as they are from the same axis (X or Y). When prompted to specify the files, enter the filename with the extension:

   specify s-curve 1 file: fb9r0101m.cx0
   specify s-curve 2 file: fb9r0101m.cx0s

3. Then you will be asked which axis (x or y):

   enter fgs axis (x or y) ….. -> *x*

4. Enter the name of the output file:

   enter output file name …… -> *fb9r0101m.cx0.ps*

5. You must specify the graph boundary for the x-axis

   specify graph boundaries …. -> -0.2,0.2

6. The program will plot the first file in red, the second in blue and the difference between the two curves in white. The white curve should be centered on S(x or y) = 0. You will be prompted if the white curve needs to be adjusted, meaning if you want it to be shifted up to be in the plot, or shifted down so that it is not plotted in the window.

   Does diff curve need to be adjusted? ……. -> <*CR*=*n*>

   If you want to shift it, then you will be prompted how much you would like to shift the white curve in units of the ordinate (vertical) axis. A positive number will shift it down; a negative number will shift it up.

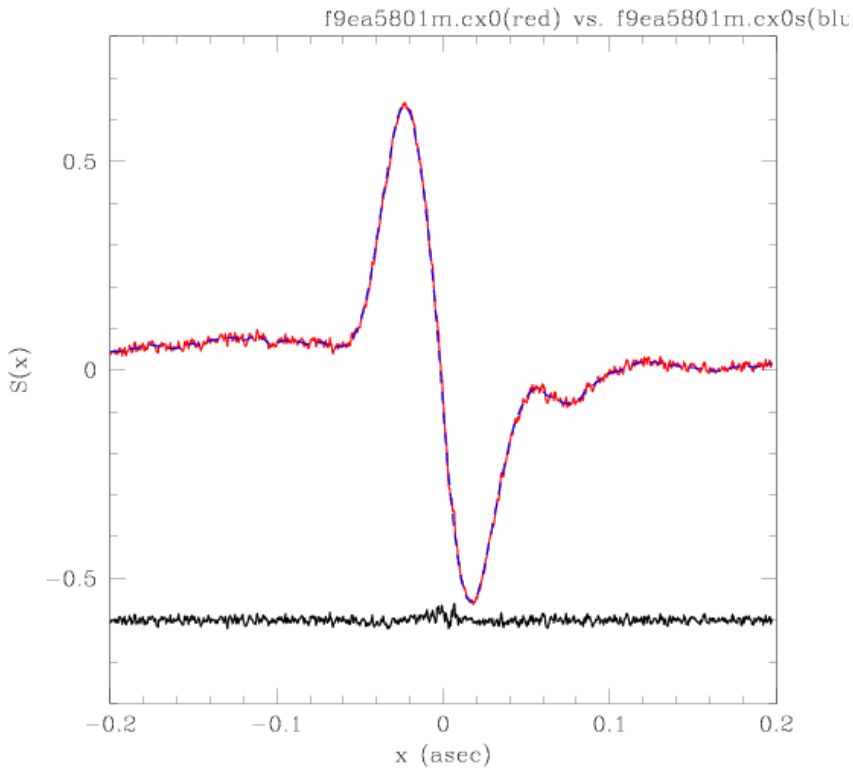
   Enter increment for curve to be shifted (from zero) -> -0.5
   Does diff curve need to be adjusted? ……. -> <*CR*=*n*>

7. Finally you will be prompted if you would like to output plot to a file. If you choose to do so, it will create a postscript file of the final plot with the name you specified above.

   Output the plot to a file? ……. -> *y*

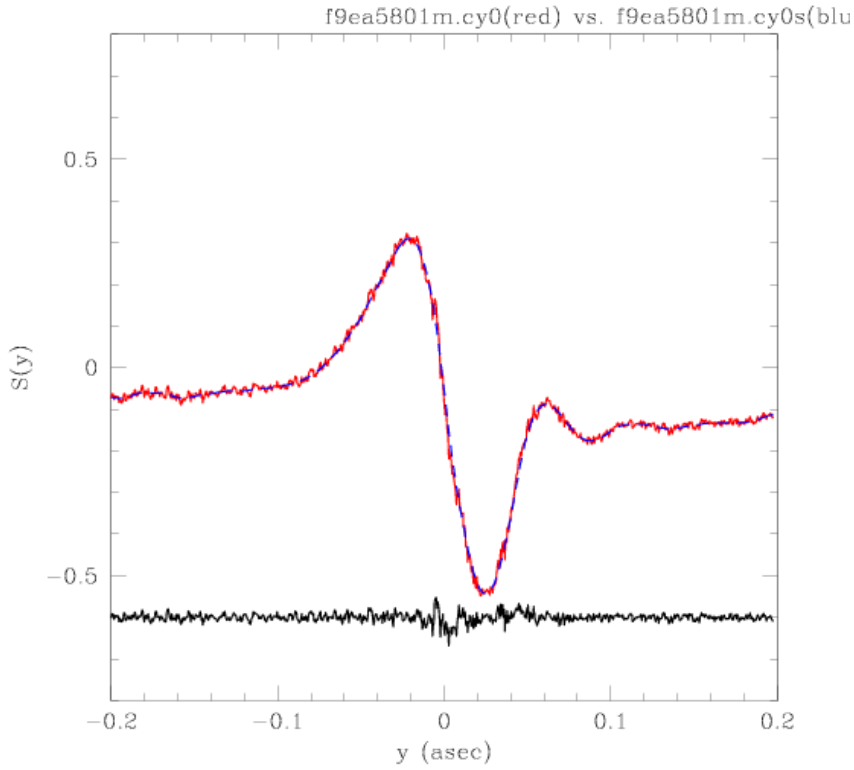
- **CP_SCURVES**

```
[nelan:~/fgsdata/test] fgs% cp_scurves
specify s-curve 1 file : fb9r0101m.cx0
specify s-curve 2 file : fb9r0101m.cx0s
 s2_file: fb9r0101m.cx0s


 n1, n2, np:   3992   968  1573


 from least_squares: a10, a11, sd1:     0.028986     0.033213     0.019677
                     a20, a21, sd2:     0.008476     0.061936     0.091747

 shift (mas) ..... : -0.0003

 in fringe: number of points      :  798
            normalized difference : -0.001913
            total fringe area     :  0.036606
            total fringe diff     :  0.002238

 in wings:  number of points      : 1573
            normalized difference :  0.383349
            total wings area      :  0.006020
            total wings diff      :  0.002308


enter fgs axis (x or y) ..... -> x
enter output file name ..... -> fb9r0101m.cx0.ps
specify graph boundaries .... -> -0.5,0.5
warning: this program uses gets(), which is unsafe.
 Does diff curve need to be adjusted? ..... ->
 Output the plot to a file? ................ -> y
```



- **CP_SCURVES**

```
[nelan:~/fgsdata/test] fgs% cp_scurves
specify s-curve 1 file : fb9r0101m.cy0
specify s-curve 2 file : fb9r0101m.cy0s
 s2_file: fb9r0101m.cy0s


 n1, n2, np:   4053   952  1551


 from least_squares: a10, a11, sd1:    -0.119119    -0.013777     0.023408
                     a20, a21, sd2:    -0.052253    -0.072846     0.089380

 shift (mas) ..... : -0.0002

 in fringe: number of points      :  821
            normalized difference :  0.005252
            total fringe area     :  0.032149
            total fringe diff     :  0.002683

 in wings:  number of points      : 1551
            normalized difference :  0.110785
            total wings area      :  0.022694
            total wings diff      :  0.002514


enter fgs axis (x or y) ..... -> y
enter output file name ..... -> fb9r0101m.cy0.ps
specify graph boundaries .... -> -0.2,0.2
warning: this program uses gets(), which is unsafe.
 Does diff curve need to be adjusted? ..... ->
 Output the plot to a file? ................ -> y
[nelan:~/fgsdata/test] fgs%
```



§3 FINDING CALIBRATORS

There are six main criteria for choosing a calibrator:

1. The star must be single. Compare the S-curve with other single stars to make sure that they look the same.

2. Make sure that the calibrator and the target star were observed on the same side of January 22, 2009. There was an adjustment of the y-axis of FGS1r and the S-curves prior to this data are different than those after this date. You can find the data of observation in the **<root name>.tab** file. The data will be in the following format: **yyyy/ddd** – the year, followed by the day of the year (January 1 = 001). You can use the program UTDATE (see §5 below) to convert to the more conventional date format.

3. You want the calibrator and the target to have been observed near in date. See step 2 above on how to determine the date of observation.

4. The calibrator and target should have similar B-V colors. You can look these up in SIMBAD.

$(B-V)_1$	$(B-V)_2$	Acceptable?
0.0	0.5	Yes
-0.3	2.1	No

NOTES:

- Targets fainter than V = 14 mag the dark current is incoherent with the star. You do NOT want an equally faint calibrator. Use a brighter calibrator and the BINARY_FIT routine will take it into account.
- For targets brighter than V = 8 mag you need to account for dead time (10% of photons not accounted for)

5. Both the calibrator and target need to be observed with the same FGS (1r,2,3).

6. The observations need to be done in the same filter (e.g. Neutral Density (ND) or F583W).

§4 BINARY FITTING

- **BINARY_FIT**

1. When you have a star that is a binary and have found a suitable, single star calibrator, run **BINARY_FIT** in the terminal.
   %>*binary_fit*

2. Enter the corresponding number to the axis you would like to fit.
   choose axis to fit: 1=x, 2=y, 3=x&y --> *3*

3. Then you will be prompted to enter the name of the output file. This can overwrite pre-existing files.
   enter name of the output file to be created …….. -> *mt696.ps*

4. Then enter the shifted and smoothed filename for the corresponding axis.
   enter X-axis data filename …… -> *f9ea5801m.cx0s*

5. When you are prompted for a bright model star file name, you enter the filename of your calibrator.
   enter X-axis bright model star file name …….. ->*f9ea0701m.cx0s*

6. You will be prompted for a faint model. You can use this option if the companion to the primary is a different color. Otherwise, it will use the bright model S-curve to fit both components.
   enter X-axis faint model star file name …….. ->

7. When asked if you want to adjust the target magnitude, you especially want to do this for faint objects. You will be asked this twice.
   adjusting point source S-curve to target magnitude
   proceed with adjustment? ---------- > *y*

8. From looking at the S-curves you should get an idea of the separation and magnitude difference of the components. First the program, asks for the separation (in arcseconds). Make sure you estimate is within 50mas, because that is the search window when the program is looking for a companion to fit.
   enter N if the separation is narrow <|0.025|:
   enter W if the separation is wide <|0.100|:
   enter V if the separation is very wide <|0.300|:
   enter G for specific response initial estimate [N/W /V/G]: *G*

9. You are then asked for the magnitude difference. Usually an estimate of 1.0 for close companions is a good starting point.
   enter the estimated magnitude difference -> 1.

10. The magnitude difference should not be held fixed unless the value is from another source and known very well.

magnitude difference to be held fixed? -><*CR*=*n*>

11. If you did NOT enter '***G***' in step 8, the program will repeat steps 4-10 for the y-axis, if fitting both axes. Otherwise, it will continue to step 12.
    If you chose '***G***' in step 8, you will be prompted to enter the separation in mas. A positive number will mean the secondary is to the right of the primary, a negative number will mean that the companion is to the left of the primary.
    Enter separation (mas) ….. -> -9.4
    Enter zero point …….. -> 0.

12. If your x and y fits are consistent or if you are only doing one axis, then continue to step 13.
    More often than not, they will not be consistent and you will be asked choose which axis you would like to refit. Usually, the X-axis is the better and more consistent fit, but choose which ever axes has the larger **Sum of Squares**. The closer the value is to zero, the better the result.
    Choose which axis to refit (X or Y): *X*
    It will repeat step 11 if applicable.

13. The program will then output the final results of the fits and plot the axes that were fit.
    enter desired range to plot: (<cr> plots -0.2,0.2)
    ("a" plots all)
    xmin: <*CR*>
    The plot will show the S-curve of your binary in red and the model fit in blue. The difference between the two is the white line.

14. You will then be prompted if you want to shift the position of the "**diff curve**" or the white line in the plot. (see CP_SCURVES step 6).
    Does diff curve need to be adjusted? ……. -> <*CR* =*n*>

15. Then you are asked if you want to output the plot. Default is no.
    Output the plot to a file? ……. -> <*CR*=*n*>

16. You will be given the option to replot with different ranges, which will repeat from step 13. You must enter something here to continue.
    re-plot the date with different (x,y) limits --> *n*
    If this is the last axis, then the program will end here. Other wise it will repeat from step 13.

The output we are interested in is the difference in magnitude (**Δm**), separation (**ρ**) and position angle (**θ**). The errors calculated by BINARY_FIT are too small. Good estimates for the errors are:

Δm	0.1 mag
θ	0.02°
ρ	1-2 mas

- **BINARY_FIT**

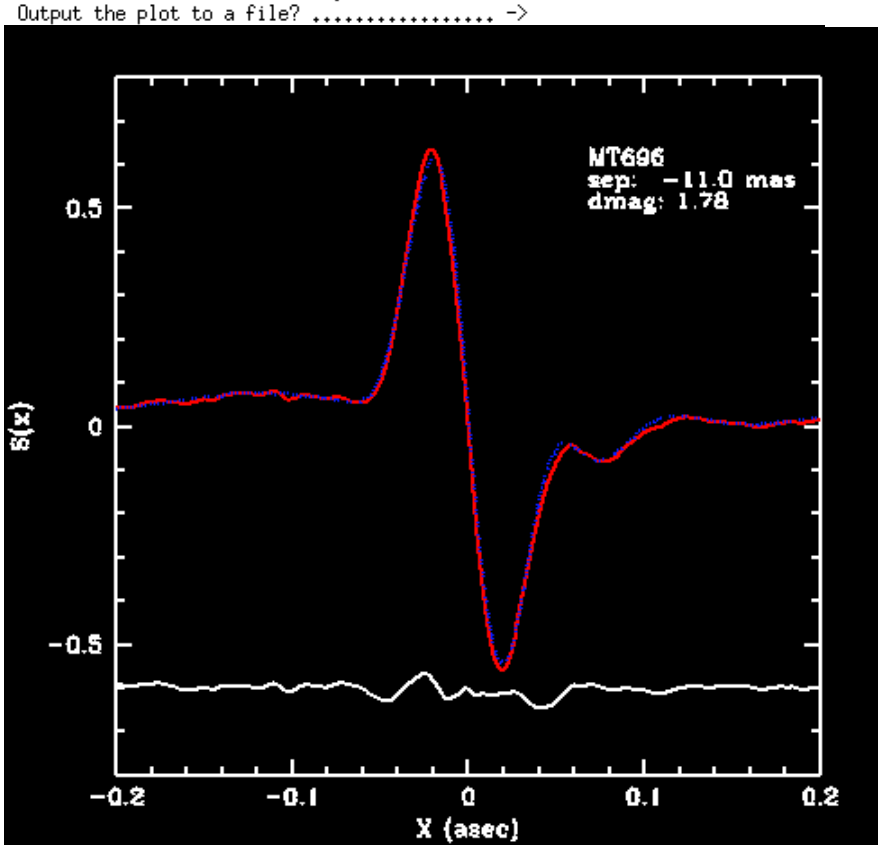
```
[nelan:~/fgsdata/test] fgs% binary_fit
 choose axis to fit: 1=x, 2=y, 3=x&y --> 3

 enter name of the output file to be created ..... -> mt696.ps
 enter X-axis data file name ..................... -> f9ea5801m.cx0s
 enter X-axis bright model star file name ........ -> f9ea0701m.cx0s
 enter X-axis faint model star file name ......... ->
 data tab file -> f9ea5801m.tab

 modfile1: f9ea0701m.cx0s
 modfile2: f9ea0701m.cx0s
  model_tab: f9ea0701m.tab

  model_tab: f9ea0701m.tab

 data filter: F583W
 mod filer:   F583W


 adjusting point source S-curve to target magnitude
 proceed with adjustment? ------------------------ > y

  model S-curve being adjusted to magnitude of science target, axis: X
 background counts (xa,xb,ya,yb):   3.6  1.6  3.7  5.9


 adjusting point source S-curve to target magnitude
 proceed with adjustment? ------------------------ > y

  model S-curve being adjusted to magnitude of science target, axis: X
 background counts (xa,xb,ya,yb):   3.6  1.6  3.7  5.9



 enter N if the separation is narrow    <|0.025|:
 enter W if the separation is wide      <|0.100|:
 enter V if the separation is very wide <|0.300|:
 enter G for specific inital estimate [N/W /V/G]: G

 enter the estimated magnitude difference -> 1.
 delta mag, b1, b2 --->  1.000      0.715      0.285


 magnitude difference to be held fixed?   -> n
 nfit:            4
 Bias held at 0.0
 Enter separation (mas) ..... -> -9.4
 Enter zero point ............ ->
0.
 X-axis Solution:
 Star brightnesses: 0.674   0.326 +/- 0.076
        Separation:    9.0 +/- 0.6 mas
 Zero-point offset:       -3.4 +/- 1.1 mas
              Bias:  0.004 +/-  0.000
    Sum of squares:  0.0786

 enter Y-axis data file name ..................... -> f9ea5801m.cy0s
 enter Y-axis bright model star file name ........ -> f9ea0701m.cy0s
 enter Y-axis faint model star file name ......... ->
 modfile1: f9ea0701m.cy0s
 modfile2: f9ea0701m.cy0s

 adjusting point source S-curve to target magnitude
 proceed with adjustment? ------------------------ > y

  model S-curve being adjusted to magnitude of science target, axis: Y
 background counts (xa,xb,ya,yb):   3.6  1.6  3.7  5.9
```

- **BINARY_FIT**

```
adjusting point source S-curve to target magnitude
proceed with adjustment? ------------------------ > y

 model S-curve being adjusted to magnitude of science target, axis: Y
background counts (xa,xb,ya,yb):   3.6  1.6  3.7  5.9


enter N if the separation is narrow    <|0.025|:
enter W if the separation is wide      <|0.100|:
enter V if the separation is very wide <|0.300|:
enter G for specific inital estimate [N/W /V/G]: G

enter the estimated magnitude difference -> 1.
delta mag, b1, b2 --->  1.000      0.715      0.285


magnitude difference to be held fixed?   -> n
nfit:            4
Bias held at 0.0
Enter separation (mas) ..... -> 12.4
Enter zero point ........... -> 0.
Y-axis Solution:
Star brightnesses: 0.838   0.162 +/- 0.005
       Separation:   22.5 +/- 0.4 mas
Zero-point offset:       -2.1 +/- 0.1 mas
             Bias:  0.005 +/-  0.000
   Sum of squares:  0.0400

Fit converged in X and Y but magnitudes not consistent.
Choose which axis to refit (X or Y): x
Bias held at 0.0
Brighter star intensity held at : 0.838
Enter separation (mas):
-9.4
Enter zero point (asec): 0.0
X-axis Solution:
Star brightnesses: 0.838   0.162 +/- 0.005
       Separation:  -11.0 +/- 0.2 mas
Zero-point offset:       1.1 +/- 0.0 mas
             Bias:  0.004 +/-  0.000
   Sum of squares:  0.0840


phi:       -26.114928416976717
PA_APER:    0.0000000000000000

     X sep:   -11.0 mas    dmag(x):  1.78
     Y sep:    22.5 mas    dmag(y):  1.78

 Total separation: ..................... ->  25.0 mas
 Magnitude diff for larger separation: ... ->  1.78

 Binary position angle ................. -> 333.8851

 star name: MT696
 xdmag:        1.7835346641994787
 ydmag:        1.7835346641994787
 xsep:        -11.018170997977084
 ysep:         22.476065789471395
i =            1

separation (mas) ... ->  -11.0
delta_magnitude .... ->    1.8
s_curve max ........ ->  0.615
s_curve min ........ -> -0.544
s_curve pk-pk ...... ->  1.159


shift (mas) ...... :            -0.239
```

- **BINARY_FIT**

```
in fringe: number of points      :  200
           normalized difference :  0.046543
           total fringe area     :  0.041928
           total fringe diff     :  0.002614

in wings:  number of points      :  400
           normalized difference :  0.116278
           total wings area      :  0.005699
           total wings diff      :  0.000663


(xmin, xmax) = (-0.7, 0.7)
enter desired range to plot: (<cr> plots -0.2,0.2)
                             ("a" plots all)
                                                    xmin:
 calling sm_plot
warning: this program uses gets(), which is unsafe.
 Does diff curve need to be adjusted? ..... ->
 Output the plot to a file? ................ ->
```



- **BINARY_FIT**

```
re-plot the data with different (x,y) limits -->
n
 i =           2

 separation (mas) ... ->   22.5
 delta_magnitude .... ->    1.8
 s_curve max ........ ->  0.297
 s_curve min ........ -> -0.548
 s_curve pk-pk ...... ->  0.845


 shift (mas) ...... :              2.454

 in fringe: number of points      :  200
            normalized difference :  0.033757
            total fringe area     :  0.037968
            total fringe diff     :  0.001803

 in wings:  number of points      :  400
            normalized difference :  0.027396
            total wings area      :  0.019020
            total wings diff      :  0.000521



 (xmin, xmax) = (-0.7, 0.8)
 enter desired range to plot: (<cr> plots -0.2,0.2)
                              ("a" plots all)
                                                    xmin:
  calling sm_plot
 Does diff curve need to be adjusted? ....... ->
 Output the plot to a file? ................. ->

re-plot the data with different (x,y) limits --> n
```

§5 OTHER ROUTINES

- **TBINARY**
  This routine creates S-curves for 3 or more objects in the FOV.

- **UTDATE**
  This program converts the UT date, in the form day of the year, to month and the day. It also takes into account leap years:

  %>*utdate*
  enter date (mm/dd) or day of the year (ddd) -> *247*
  is this a leap year? ----------> *n*
  the calendar date is -> sep 4.

  UTDATE also converts from calendar date to day of the year:

  %>*utdate*
  enter date (mm/dd) or day of the year (ddd) -> *09/04*
  is this a leap year? ----------> *n*
  the ut date is -> 247

  This program is especially useful when finding calibrators according to date for your target.