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Codes for the Reduction of
Digital Pinex Data

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by

Louis M. Beyer

ABSTRACT

Code DENBIG was written to reduce the digital pinex data received from the Nevada Test Site (NTS) and Transient Reactor Test Facility (TREAT) experiments. Output modes are density plots, contour plots, splatter plots, equivalent radius calculations, line cuts, and reduced data in matrix form. Provisions are included to incorporate subtraction of dryrun data, transfer function corrections, and pinhole absorption corrections. Code DARN processes pinex data in which electromagnetic pulse shifts have eliminated sync tips or caused unsaturated amplitude variations. These induced problems are eliminated by clamping the data, point by point, to dryrun data. The DARN output modes are a subset of those of DENBIG. The data frame established by DARN can be filed for subsequent input to DENBIG. Program descriptions and operating instructions are discussed.

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PART I

DENBIG, A CODE FOR THE REDUCTION OF DIGITAL PINEX DATA

I. INTRODUCTION

Computer code DENSITY¹ has for several years been the primary analysis program of digitally recorded Nevada Test Site (NTS) pinex data. Some minor changes through the years, plus new features and modified operating procedures recently incorporated, merited an updated report on the code. Part I of this report describes the code in its updated form, now called DENBIG.

Experience with problems encountered in pinex data recording suggested that slightly different analysis procedures could be used to extract good run data by incorporating more dependence on dryrun data. An alternate version of DENSITY,¹ code DARN, written specifically to analyze data with electromagnetic pulse shifts, is described in Part II of this report.

The pinex data recorded digitally at NTS is preprocessed into consecutive amplitude values of segments of TV lines. Each amplitude corresponds to the intensity within a 50-ns sweep interval of the camera. Therefore, a 30- μ s sweep time translates into about 600 data points per line. The camera is then clamped to dc zero, producing several points at that level, followed by a negatively biased horizontal synchronization tip (HST) of about 2.5- μ s duration before another line sweep begins. Figure 1 demonstrates a segment of the input data, showing an HST, data line, and the beginning of the next HST. It is the task of the code to decompose at least 155 000 consecutive amplitude values into about 240 lines of 600 points each and to transform the resulting data into useful results. The code is dimensioned to handle line lengths as long as 1500 points, such as those encountered when 33-ms cameras are used.²

1. W. M. Sanders, Los Alamos Scientific Laboratory internal report (1972).

2. G. J. Berzins and K. S. Han, "Pinhole Imaging of a Test Fuel Element at TREAT." To be published in Nucl. Sci. Eng.

Fig. 1.

An arbitrary segment of the data-plotted amplitude vs point number. Demonstrated are the definitions tip, threshold and porch levels, leading and trailing edges of the HST, and the extent of one line of TV data.

II. REDUCTION OF THE DATA INTO A SQUARE ARRAY

A. Line Clamping

A number is entered by the user with a value halfway between the bottom of the HST (tip value) and the dc zero level (porch value). This is the initial threshold value. The code then searches data until it finds a data point below this threshold. This position is taken as the beginning of the first HST. It then searches forward until a data point exceeds the threshold. This position is taken as the end of the first HST. The HST data are then severely smoothed by a seven-point, five-times-repeated smoothing function. An exact position (± 0.01 data point) is then calculated where the leading edge of the HST crosses the threshold. This value (XSLIM)

ties the data for the TV line, which follows the trailing edge of the HST, to the HST leading edge crossing of the threshold. Average values of the tip and the following porch are then averaged for a new threshold value. The above definitions are depicted in Fig. 1.

The search for data of the first TV line then proceeds by picking up at the last point searched (the point of the HST's trailing edge) and by searching forward until the threshold again exceeds the data, that is, until the next HST is encountered. The number of data values in the line, the line number, XSLIM, and the data values are filed on tape.

The code has now encountered the second HST, enabling the above steps to be repeated on succeeding data. During the process of analyzing each point, user-entered variables cause checks on valid HST (too short or too long), valid lines (too short or too long), and background subtraction (subtract porch value point by point, or no subtraction). In addition, some electronically induced problems are manipulated, as shown in Fig. 2. The HST shown here has a positive ringing on the porch, causing an excessive porch and threshold calculation that, in turn, misplaces the next HST. The code checks new porch calculations against the old value and steps up the porch position for repeated new calculations until new and old agree to within 10%, or it uses the old value. Various other checks are built into the code.

Fig. 2.

The HST has an induced ringing on the porch that the code detects and skips in porch calculations.

The process of analyzing an HST, finding and storing the succeeding line, and repeating is continued until a user-entered line limit is reached.

B. Matrix Conversion

The data are now stored as about 240 rows of about 600 points each row. The number of points in each line is not necessarily the same, nor is the displacement, XSLIM, from the leading edge of each HST a constant. An interpolation routine is next applied to align the starting point of each line, condense the line length to 500 points, and finally expand the number of lines to 500. In addition, user-entered parameters can redefine beginning row and column numbers, as well as produce magnification in the x and y directions to square the frame of interpolated data.

Considerable smoothing of the data occurs during the interpolation process. The smoothing function is user entered in terms of the number of points used in the smooth and weights. For a seven-point smooth, four weights $S_1 - S_4$ are entered. A smoothed value YS_J is then calculated from data values $Y_{J-3} - Y_{J+3}$.

$$YS_J = S_1 (Y_{J-3} + Y_{J+3}) + S_2 (Y_{J-2} + Y_{J+2}) \\ + S_3 (Y_{J-1} + Y_{J+1}) + S_4 Y_J$$

Ideally, the smoothing takes out high-frequency fluctuations in the data (noise) and leaves low-frequency variations unaltered. Figure 3 shows the smoothing factor as a function of x for the function $\cos(3\pi x)$ with the indicated values for the smoothing coefficients S_j . This curve may be interpreted in terms of a frequency dependence by associating the 50-ns time interval between successive points with x . If seven successive points above a background constitute $1/8$ wavelength of an oscillation, the fourth would be smoothed to 98% of its original value, and the frequency would be 0.35 MHz. Conversely, if seven data points constitute a full oscillation, the midpoint is smoothed to 20% of its original value and the frequency would be 2.86 MHz. The 50% smoothing point of coefficients given corresponds to a frequency of about 2.5 MHz.

The code also has the option of next processing the frame of dryrun data in an analogous procedure

Fig. 3.

A plot of $\cos 3\pi x$ and the smoothing magnitude vs x .

so that this background data can be subtracted, thus eliminating variations in the camera background across each line. The camera variation as a function of position is demonstrated in Fig. 1, which is almost entirely background data. This is an important data correction because each camera variation may be different.

III. DATA CORRECTIONS AND PLOTS

A. Transfer Function Application

The data on amplitude output vs light input for each camera is known as the transfer function. These data are obtained at NTS directly by measuring the output voltage of the camera as a function of calibration light intensity, and from the dryrun frames as the counts above background for the line of the frame through the center of the calibration lights. After normalizing voltage to counts, the code accepts data on counts vs intensity and constructs a mathematical expression for the transfer following subtraction of the dryrun data, although it can be applied to the shot frame directly if no dryrun subtraction is exercised. Data distortion will occur near the ends of the lines in this latter case unless the

camera line is extremely flat. In addition, transfer data must be total counts above the *porch* value if no dryrun subtraction is applied.

The quality of the data is greatly enhanced by proper dryrun subtraction and transfer function application, as shown in Figs. 4-6. Figure 4 is a shot frame with no transfer function corrections nor background subtraction. Figure 5 shows the results of separately applying the transfer function (relative to porch values) to the shot and dryrun frames successively, followed by subtraction. Figure 6 shows the results of subtracting the frame of dryrun data from the shot frame, followed by transfer function (relative to zero background) application. The most prominent improvement in the data is the proper correction in low amplitude regions of the frame due to proper subtraction in regions where camera lines are not flat.

The data in the 500-by-500 point matrix, after all background and transfer function corrections, are the final internal representation. These data can be saved on file in this form for later input to the same code, can be printed (all or a specified part), or can be plotted in several representations.

Fig. 4.

A density plot of shot data with calibration lights near the top, with no background or transfer function correction.

Fig. 5.

A density plot of the same shot as Fig. 4 with the transfer function applied separately to shot and background frames followed by background subtraction.

Fig. 6.

A density plot of the same shot as Fig. 4 with the background frame subtracted from the shot frame followed by a transfer function correction.

B. Data Representation by Plots

The data in matrix form can be output to film plots of several forms: density plots, contour plots, splatter plots, and line plots (a cut across any part of the matrix). The highest data point (MAX) is usually normalized to 100 in plot routines.

1. Density Plots. The density plot represents various regions of the matrix with the same range of amplitude with a particular degree of darkening on film. The usual procedure is to use three levels of plotting density: black, halftone, and white, with all points in the matrix 0.95 MAX-1.00 MAX black, 0.90 MAX-0.95 MAX halftone, 0.85 MAX-0.90 MAX white, 0.80-MAX-0.85 MAX black, etc. Therefore, the plot progresses from high intensity to low in the order black, halftone, white, black, halftone, white, etc. Successive areas of equal shading are separated by 15% MAX. The percentage range and number of levels (that is, 1/3 tone, 1/4 tone, etc., also options) are user chosen. Figures 4-6 are density plots.

2. Contour Plots. Contour plots are generated on film by connecting adjacent points of the matrix in the x direction, where one of the points has the contour value specified. The process is repeated in the y direction. The results are almost continuous lines of equal intensity (value is user specified), but not overly satisfying. Figure 7 is a contour plot of the matrix of Fig. 6.

3. Splatter Plots. Splatter plots are a two-level representation of the data. All points within a specified intensity range are exposed, whereas those outside that range are unexposed. Figures 8 and 9 are splatter plots of two intensity levels of the same data as Fig. 6.

4. Line Plots. A line plot of the intensity variation across the frame in any direction can be obtained by specifying the starting and ending row and column numbers. Figure 10 is a line plot taken horizontally across the middle of the data of Fig. 6. Up to 20 line plots can be generated in execution of the code. A density plot generated in the same run will have numbered lines superimposed upon it showing the cut taken for each line plot.

Fig. 7.
A contour plot of the same data as Fig. 6.

Fig. 9.
A splatter plot of the same data as Fig. 6, where all points in the matrix with amplitude 25 - 100% of the maximum are black.

Fig. 8.
A splatter plot of the same data as Fig. 6, where all points in the matrix with amplitude 0 - 100% of the maximum are black.

Fig. 10.
A line plot of row 306 from the data of Fig. 6.

5. Miscellaneous Features. Output plots can be crosshatched with any number of grid lines to facilitate positioning regions of interest. Ten divisions in each direction are usually convenient. Alternatively, a polar grid can be superimposed on output plots by specifying the origin (row and column number) and radius of each circle desired.

An additional calculation provided by the program is the equivalent radius of circular contours within the matrix that enclose integrated amplitudes for a particular intensity range. Thus you can output the "center of gravity" of the matrix and the radius of a circle centered there that contains 5% of integrated amplitude, as well as 10%, 15%, etc. Results are in numeric form rather than plot form.

Corrections for the pinhole transmission can also be applied to the matrix. The correction curve of transmission vs radius from the pinhole code is input. The coordinates of the center of the frame can be those calculated by the above equivalent radius calculation. In this case, the results of the 5%, 25%, 50%, and 75% centers of the range integrated are sequentially taken. Optionally, the center can be an input parameter. In either case, the corrected matrix is then plotted by a density plot.

IV. OPERATING INSTRUCTIONS

A. Data Sets

1. External Data Sets. Data received from NTS are usually unscrambled and stored in mass storage before executing this code. If this is the case, FSET1 refers to shot data and FSET2 is the dryrun data.

If the code is to output the final 500-by-500 matrix on tape, or if it is to use such data as input for further processing, FSET19 is used. Control cards must establish this file if it is to be saved.

2. Internal Data Sets. As lines of the TV data are clamped, they are written in sequence on FSET13 until interpolated into a 500-by-500 array. If the shot frame is to have background subtracted, the shot matrix is saved on FSET18 until the dryrun data are clamped and interpolated.

No control cards are necessary to establish FSET13 and FSET18.

B. General Operation Parameters

The data input to the program begins with input of keyvalues or keywords, in NAMELIST format, described in Appendix A. If parameters are omitted, they may be assigned default values. Some keywords or keyvalues initiate further input. That sequence, given in required order, is described in Appendix B with accompanying formats. Default values have been extensively assigned to greatly simplify input.

IV. SUMMARY

This report describes the operation and input for code DENBIG, an update of the very successful code DENSITY.¹ Changes incorporated into DENBIG include

- a. An improved background subtraction operation,
- b. Separate application of the transfer function to shot and dryrun data before subtraction,
- c. A routine to accurately calculate porch and threshold values when "ringing" occurs on the porch,
- d. Extended data capacity to handle line lengths of up to 1500 data points, which may be encountered with TREAT² data and new digitizers, and
- e. Extensive tables of default values most commonly assigned to input parameters.

It is anticipated that the updated description and simplified input will benefit present and future users of the code.

V. ACKNOWLEDGMENTS

Several persons are responsible for this beneficial and enjoyable Visiting Staff Member appointment at LASL. K. S. Han and W. H. Roach were most helpful in all aspects of my visit. S. T. Donaldson and B. M. Wheat were patient, encouraging, and very helpful during struggles with an unfamiliar computer. I wish to especially thank G. J. Berzins, who was instrumental in obtaining the appointment and so ably directed the problem.

APPENDIX I-A

KEYWORD PARAMETERS

Name	Values	Description
TITLE =	60H(60 Characters)	Any input title.
TYPE =	10HFUNNGAMESb 10HGMX11bDATA 10HULTRA bDATA 10HCARD bDATA b	NTS data input (default value). GMX11 data input. Matrix input data. Card data input.
DERIV =	10Hbbbbbbbbb 10HGRADIENTS	Interpolation using data values (default value). Interpolation using derivatives.
IFILE =	#	Shot data file number.
IBFILE =	#	Dryrun data file number for subtraction.
NHSMOO =	#	Number of times to smooth horizontally (default=7).
NHSMOO =	#	Number of times to smooth vertically (default = 1).
NOPTSM =	#	Number of points to use in smoothing (default = 7).
SS(1) =	#, #, #, #	(NOPTSM + 1)/2 smoothing coefficients.
NORM =	0 1 2	No plot normalization. Percentage normalization for plots (default value). Plot maximum is input value.
ICBKG =	0 1	No constant background subtraction (default value). Constant to subtract from matrix is input.
NOLIN =	#	Number of vertical and horizontal lines to superimpose on plots (default = 10).
IPRNT =	0 1	No line print of matrix (default value). Input region of matrix to print.
ITAPO =	0 1	No output of matrix on FSET19 (default value). Output matrix on FSET19.

Name	Values	Description
ID =	2	(Used only if dryrun on FSET2 is to be clamped and plotted as individual frame.)
NBR =	#	Number of lines to delete from matrix (default=0).
ITRANS =	0	No transfer function correction (default value).
	1	Transfer function data to be input.
NOLNS =	#	Number of line plots desired (default=0).
NUM11 =	#	Channel shift from HST end to porch beginning.
NUM21 =	#	Channel width of porch integration. If #=0, no KLAMP subtraction.
NUM31 =	#	Channel shift for HST integration.
NUM41 =	#	Channel width of HST integration.
NUM42 =	#	Minimum HST channel width.
NUM43 =	#	Minimum VST channel width.
NUM44 =	#	Maximum VST channel width.
MINLIN =	#	Minimum channel width for line.
LINTOT =	#	Maximum channel width for line.
XSTART =	#	Data point number interpolated to column 1 of matrix (may be non-integer or negative, default=0).
DELX =	#	Interpolation interval along a matrix row. The smaller DELX gives the larger magnification (default=1.0).
YSTART =	#	TV line number interpolated to column 1 of the matrix (may be negative or non-integer, default=0).
DELY =	#	Interpolation interval along the columns (default=0.5).
NOCS =	#	Number of circles to superimpose on graph, with center point and radius to be input (default=0).

Name	Values	Description
INTEG =	0	No equivalent radius calculation.
	1	Equivalent radius calculation desired. Parameters ZINMIN, ZINMAX, INBNN, JLX, JRX, JTY, JBY, CONVDS also in NAMELIST if INTEG=1 (default=0).
IPEN =	0	No pinhole transmission correction (default value).
	1	Pinhole transmission correction with frame center calculated by the above integration routine.
	2	Pinhole transmission with frame center as input parameter.
LEVLOK =	0	Plotting levels are input values (default value).
	1	Plotting levels used are default values.

APPENDIX I-B

PARAMETER DEPENDANT INPUT

Depending upon the value of the NAMELIST input parameters, additional data may be required. This card input must be in the following order with the data prepared in the indicated format. The text below describes the required input in FORTRAN form plus a short functional description. All FORMAT statement numbers are stated as unity for ease of presentation. The following input order refers specifically to TYPE=FUNNGAMES.

```

READ (5,1) LINFLM
1 FORMAT(I5)

```

This variable is the film line number of shot data where the first data above dc zero occurs. Line search of previous data is eliminated.

```

IF(NBR.GT.0) READ(5,1) (NBR(I), I=1, NBR)
1 FORMAT(12I6)

```

These data are the rows to be eliminated from the matrix.

```

IF(ICBKG.EQ.1) READ(5,1) CBBKG
1 FORMAT(E12.7)

```

This variable is subtracted from the final matrix, point by point.

```

      IF(NORM.GT.0) READ(5,1) ILNOR, IRNOR, ITNOR, IBNOR
1    FORMAT(4I6)

```

These variables define the left, right, top, and bottom limits of the region of the matrix to search for maximum amplitude during normalization.

```

      READ(5,1) ITHRES
1    FORMAT(I6)

```

This input value is the initial guess for the threshold value used by the code in clamping. Its value should be an average of the tip and porch values at region LINFLM.

```

      IF(IBFILE.EQ.0) GO TO 100
      READ(5,1) XSTART, DELX, YSTART, DELY
      READ(5,2) LINFLD
      READ(5,1) AASLP, BBCON
      READ(5,3) ITHRES
1    FORMAT(4E12.7)
2    FORMAT(I5)
3    FORMAT(I6)
100 CONTINUE

```

If a background file is to be subtracted, the squaring parameters for the dryrun matrix are entered, as are the line of film where data begins, a multiplicative (AASLP) and additive (BBCON) constant for each dryrun matrix point (usually 1.0 and 0.0), and the initial threshold for the dryrun data. These data are input only if IBFILE $\neq$ 0.

```

      IF(ITRANS.EQ.0) GO TO 100
      READ(5,1) NOTRP
      READ(5,2) (XTR(I), YTR(I), I=1, NOTRP)
1    FORMAT(I6)
2    FORMAT(2F12.2)
100 CONTINUE

```

If a transfer function is to be applied to the data, the number of points on the curve is entered on a card, then on a card for each curve point. XTR(I) is the original value; YTR(I) is the transformed value. It is convenient if these data are first normalized so that XTR(NOTRP) = YTR(NOTRP).

```

      IF(NORM.NE.2) GO TO 100
      READ(5,1) CMAX
1    FORMAT(F12.0)
100 CONTINUE

```

Norm=2 gives you the option of "overexposure" of a density plot by inputting a maximum amplitude CMAX less than the maximum data value.

```

      IF(LEVLOK.EQ.1) GO TO 100
      READ(5,1) ITOP, IBOT, IFRAM, ICOLOR, IEXP, IDOPE, INEG
1    FORMAT(2F6.0, 5I6)
100 CONTINUE

```

The LEVLOK=1 parameter allows default plot parameters. If LEVLOK=0, read in levels sequentially. If the mode specified in NAMELIST is not CONTOUR, DENSITY, or SPLATTER, set ITOP = 999999. Otherwise, this card determines one of the levels of exposure for a plot. Repeat this card for each level of exposure desired on a plot. Terminate the input of exposure levels with 999999 as input for ITOP. The input parameter description for the various modes follows.

- ITOP - Contour level, top of density level, or highest level to be splattered.
- IBOT - Bottom of density level or lowest level to be splattered. Contour mode ignores this parameter.
- IFRAM - Number of frames to advance film before plotting. Usually this parameter is two for the first level of a plot, 0 for succeeding levels.
- ICOLOR - Color select code for color plots
 - =0 white
 - =1 red
 - =2 green
 - =3 blue
- IEXP - 4020 exposure level to use
 - =0 heavy exposure (normal)
 - =1 light exposure
- IDOPE - Point density to use
 - =0 plot every point (fully expose)
 - =1 plot every other point (half-tone)
 - =2 plot every third point, etc.
- INEG - Reverses the sense of exposure from positive to negative if INEG≠0

The next card determines whether to plot the same data in an alternate mode or to continue.

```

READ(5,1) MODE, LEVLOK
1 FORMAT(A10, I1)

```

This input allows further plotting of data in a new mode (CONTOUR, DENSITY, OR SPLATTER) and whether to accept default levels or enter new ones. *If more plotting is done, this input must be followed by additional exposure level cards if LEVLOK=0.* If plotting in these three modes is complete, enter ALLbDONEbb1 or ALLbDONE, depending on whether default levels are acceptable or not.

```

IF(NOLNS.EQ.0) GO TO 100
READ(5,1) (X1(I), Y1(I), X2(I), Y2(I), I=1, NOLNS)
1 FORMAT(4F6.0)
100 CONTINUE

```

A line plot is generated for each of NOLNS cuts across the matrix. One input card of four numbers is required for each cut. The parameter definitions are

X1(I), Y1(I) - the starting point (column, row) in the 500-by-500 matrix for the ith line plot.

X2(I), Y2(I) - the termination point in the matrix of the ith line plot.

```
IF(IPRNT.EQ.0) GO TO 100
READ(5,1) (JLLT, IRRT, ITTP, IBBM, I=1, IPRNT)
1 FORMAT(4I6)
100 CONTINUE
```

This input defines the rectangular area of the matrix to be listed on the line printer. The parameter definitions are

JLLT - leftmost column
 IRRT - rightmost column
 ITTP - topmost row
 IBBM - bottommost row

There will be IPRNT of these input cards.

```
IF(NOCS.EQ.0) GO TO 100
READ(5,1) (XC, YC, RAD, IAVC, I=1, NOCS)
1 FORMAT(3F6.0,I6)
100 CONTINUE
```

The radial grid lines superimposed on graphs are input by matrix coordinates. There will be one card for each circle to be drawn.

XC, YC - the column and row number of the circle center.

RAD - the circle radius in number of matrix points (that is, between 1 and 500).

IAVC - film advance
 =0 no advance before plotting
 =# advance # frames before plotting.

The following input is required if pinhole transmission corrections are required.

```
IF(IPEN.EQ.0) GO TO 100
IF(IPEN.GE.2) GO TO 99
READ(5,1) RMAX
READ(5,2) NCR, (X(I), Y(I), I=1, NCR)
1 FORMAT(2F6.0)
```

2 FORMAT(I6/(2F6.0))

GO TO 100

99 READ(5,1)RMAX, CONVDS

READ(5,2)NCR, (X(I), Y(I), I=1), NCR)

READ(5,2)IPENN

READ(5,1)XCEN, YCEN

REPEAT LAST IPENN TIMES

100 CONTINUE

The IPEN parameter determines whether or not pinhole transmission corrections are to be applied to the final matrix. If IPEN=1, the code also assumes that INTEG = 1 and the 5%, 25%, 50%, and 75% "center of gravity" automatically will be applied consecutively as centers. If IPEN=2, the center of the frame is input manually. The definitions are

RMAX	- the maximum radius (in mm) from the center of the frame for which the correction is to be applied,
NCR	- the number of input points on the transmission curve,
X(I),Y(I)	- the radius (in mm) and transmission (0-1) values,
IPENN	- the number of times to manually input center coordinates, and
XCEN,YCEN	- the center in matrix coordinates, column number, and row number.

If the NAMELIST input is TYPE=ULTRAbDATA, the dryrun data input and transfer function input are omitted. The same is true if TYPE=PACKEDTAPE. If TYPE=GMX11bDATA or TAPEbDATA, the input is the same as FUNNGAMES. If the input is TYPE=CARDbDATA, input of an established 500-by-500 matrix is through cards, and several options exist in the code, none of which are very attractive. Use of this TYPE is discouraged.

APPENDIX I-C

SAMPLE INPUT

The following input assumes that control cards have staged files of shot data to FSET1 and files of dryrun data to FSET2 from mass storage. The input will be given, followed by a discussion of output produced.

CARD COLUMN

1	2	3	4	5	6	7
---	---	---	---	---	---	---

```

1234567890123456789012345678901234567890123456789012345678901234
P$FUNDI
-TITLE=60HANYTTITLE
-IFILE=11,IBFILE=11,MINLIN=1000,LINTOT=1500,ITRANS=1

- NUM11=10,NUM31=40,NUM31=10,NUM41=40,NUM42=160,NUM43=400,NUM44=600
- SS(1)=-0.03125,0.0,0.28125,0.5,
- XSTART=0.0,DELX=2.10,YSTART=0.0,DELY=0.5,
- LEVLOK=1,IPEN=1,
- INTER=1,ZINMIN=40.0,ZINMAX=100.0,INBNN=12,JLX=175,JFY=425,JTY=80,JBY=325,
- CONVDS=0.06451$
---17
---150---350---150---350
---700
0.0-----2.0-----0.0-----0.5
---16
1.0-----0.0
---650
----4
0.0-----0.0
14.7-----9.2
115.0-----97.3
342.0-----416.1
SPLATTER--1
ALL-DONE--1
56.7
-----5
0.0---1.0
4.05--0.995
12.15-01963
20.25-0.912
36.45-0.791
$FM

```

The above input causes default to **MODE=DENSITY**, **TYPE=FUNNGAMES** and **DERIV=blank**. The shot data are on file 11 of **FSET1** and dryrun data on file 11 of **FSET2**. The code will accept line lengths (number of points in line *plus* HST) between 1000 and 1500 points as valid. A transfer function will be input, the plot levels will be default values, equivalent radius calculation will be performed, and pinhole corrections with centers of gravity calculated by the equivalent radius routine will be made. **DELX** and **DELY** values are chosen initially so that **MINLIN/DELX=500** and **TV lines/DELY=500**.

The formatted data input cards are: film line number of first shot HST; normalization range; shot threshold; squaring parameters for dryrun data; film line number of first dryrun HST; dryrun multiplicative and additive numbers; dryrun threshold; number of points in transfer curve; four transfer curve points; further plot command with default plot levels; end of plotting of data frame; maximum radius for pinhole corrections; five points on pinhole correction curve; and data points for pinhole correction curve.

The program will clamp the shot frame, normalize, and plot in the density mode using default levels; clamp the dryrun frame, normalize and plot in the density mode using default levels; subtract the dryrun from the shot frame, apply the transfer function to the difference, then normalize and plot in the density mode using default levels. The corrected frame will then be plotted in the splatter mode using default levels for that mode. Equivalent radius calculations will then be performed in 12 intervals of 5%, with numerical results printed. The radius of the 1st, 4th, 9th, and 12th intervals will then be sequentially applied as centers for pinhole calculations, with corrected frames for each radius plotted automatically in the density mode.

PART II

DARN, A CODE FOR THE REDUCTION OF DIGITAL PINEX RUN DATA WITH EMP SHIFTS

I. INTRODUCTION

The format and processing procedures of digitally recorded pinex data of NTS experiments are described in Part I of this report. The processing code, DENBIG, gives very good results from normal input data. However, the environment of the cameras and signal cables may induce [by electromagnetic pulse (EMP)] momentary amplitude shifts in transmitted data, as well as squelching the important sync tip signals. The latter signals are necessary for line end point determination in normal processing.

Code DARN attempts to eliminate the above two problems by depending on real background and sync tip positions in run and dryrun data being consistent.

II. LINE CLAMPING

Tests on several data sets have demonstrated that dryrun and run data are highly consistent with respect to timing once data transmission has started. Figures 11 and 12 show the data in the region of the first horizontal sync tip (HST) from the dryrun and run, respectively. The initial shift in positions of the leading edges is 192 data points or $9.6 \mu\text{s}$ in the initial timing sequences. However, as subsequent points are inspected in the data sets, HST positions maintain this constant displacement. Figures 13 and 14 demonstrate the constancy at a position more than 100 000 points later in the data sets.

One can thus infer HST positions in run data by determining HST positions in dryrun data and the initial displacement of the first run and first dryrun HST. This procedure allows run lines to be clamped when the HST has been clobbered.

The code uses FSET1 and FSET2 as run and dryrun input files, respectively. The data from FSET2 is searched until the beginning and ending point of the first HST is determined. The first HST of the run data is then found and the displacement

Fig. 11.

The dryrun data segment that contains the first HST, which begins at point number $16 \times 700 + 584 = 11784$.

Fig. 12.

The run data segment that contains the first HST, which begins at point number $16 \times 700 + 392 = 11592$.

Fig. 13.

The dryrun data segment that contains the HST at the end of TV line #219, beginning at point #205 X 700 + 596 = 144096.

Fig. 14.

The run data segment that contains the HST at the end of TV line #219, beginning at point #205 X 700 + 404 = 143904. The displacement remains at 192 points.

determined. A line of dryrun data is then determined by taking all points from the end of the first dryrun HST to the beginning of the second. The number of data points in this line, the displacement of the first point from leading edge of the HST (XSLIM) and the data points themselves are written on FSET14. The same number of points are then written from the run data set, FSET1, onto

FSET13, along with the XSLIM value determined from the dryrun. The second dryrun HST is then determined, and that number of points skipped over in run data. Successive lines and HSTs are generated by looping through the above procedure. Care is taken to keep data alignment from FSET1 and FSET2 with the proper displacement determined from HST No. 1. Porch and threshold values described in the operation of DENBIG are determined from dryrun data only and are applied to both run and dryrun lines when appropriate.

III. AMPLITUDE CORRECTIONS

Figures 15 and 16 are equivalent sections of run and dryrun data where a constant shift in amplitude of the run data was induced by an EMP. As is evident from Figs. 13 and 14, the true background of the run data should be only a small shift from the dryrun data. The code attempts to remove the EMP shift by integrating over equal areas near the ends of run and dryrun lines and by subtracting the average difference from the run line. Therefore, shift corrections are included on a line-by-line basis, each line of data being compared to its equivalent dryrun line amplitude.

Fig. 15.

A segment of run data that contains an EMP shift. The data on the left and right extremities are dc zero or porch levels. The HSTs are missing. The porch-to-pedestal displacement is also too large.

Fig. 16.

A segment of the dryrun data showing the same TV line as the run data of Fig. 5. The EMP shift in the data of Fig. 5 is removed by subtracting the difference in pedestal values of the two data sets from the run data.

Figure 17 is a photograph of a frame of data on a TV monitor that demonstrates the presence of shifts in the incoming data in three regions of the frame. The digitized data lacked many sync tips, preventing analysis by code DENBIG without time-consuming, hand-performed, data corrections. Figure 18 is a density plot of the frame output by DARN with an inadequate shift correction, but demonstrating the ability to clamp lines without sync tips. Figure 19 is a density plot output by DARN with sync tip, threshold, and background levels all tied to dryrun data. This figure is a striking example of how important good dryrun data can be to subsequent run analysis. Good corrections cannot be made, however, in those cases where EMP shifts are so large that saturation of the 12-bit digitizer occurs.

IV. PROGRAM OUTPUT

Code DARN requires more storage to handle run and dryrun files simultaneously than does its predecessor DENBIG. Storage limitations require that some of the options of DENBIG be omitted, particularly pinhole corrections, equivalent radius

Fig. 17.

A TV monitor photograph of the data presented in Figs. 8 and 9.

calculations, and plots of line cuts. However, code DARN does take the clamped lines of both the run and dryrun, interpolates each frame into a 500-by-500 array, and applies transfer function corrections and subtraction of dryrun frame from run frame. The density, contour, and splatter plot routines are available for each frame.

Limitations on calculations by DARN require an understanding of internal data representation. FSET13 contains the clamped line data of the run, corrected for EMP shifts, whereas FSET14 contains the clamped line data of the dryrun. These files can be saved for subsequent interpolation and processing by DENBIG. Alternatively, FSET18 contains the interpolated 500-by-500 array of run data, corrected by applying an input transfer function, whereas FSET19 contains the dryrun frame. These files can also be saved for further processing.

Fig. 18.

A density plot of the run data of Fig. 7 with inadequate removal of EMP shift level.

Fig. 19.

A density plot of the run data of Fig. 7 with all data referred to dryrun data, effectively removing EMP shifts.

V. CONCLUSIONS

The importance of ensuring good dryrun data under identical conditions to the run cannot be overemphasized. When run data contains no shifts, the dryrun can be used effectively to subtract irregularities in camera response as a function of position across the line, as well as to establish a transfer function without background effects. When shifts do occur, the results presented in this report

demonstrate that accurate data can be extracted without any direct alterations of the data. Code DARN accurately determines nonsaturated shift levels and properly positions sync tips by referencing all run data to dryrun data. When shifts are so large as to cause saturation, most probably the sync tips will be missing. Code DARN can at least establish the data frame, enabling extraction of that part of the data frame that has nonsaturated values.

APPENDIX II-A

INPUT PARAMETERS

The input to DARN is very similar to that of DENBIG, except the options INTEG, IPEN, NOLNS, and NOCS are inoperative, whereas others have only a single applicable function. These are TYPE = FUNNGAMES, TIPP = blank, and DERIV = blank.

The following input description assumes a familiarity with DENBIG input.

Card 1: READ(5,FUNDI)

This is the NAMELIST group, except as noted above, described in DENBIG.

Card 2: READ(5,1)LINSHOT

1 FORMAT(I5)

This is the film line number where the first valid HST of the run occurs.

Card 3: READ(5,1)LINDRY

1 FORMAT(I5)

This is the film line number where the first valid HST of the dryrun occurs.

Card 4: IF(ICBKG.EQ.0)GOTO 100

READ(5,2)CBKG

2 FORMAT(E12.7)

100 CONTINUE

This parameter allows a constant value to be subtracted from the final run frame.

Card 5: IF(NORM.EQ.0)GO TO 100

READ(5,3)ILNOR, IRNOR, ITNOR, IBNOR

3 FORMAT(4I6)

100 CONTINUE

These values are the left and right column limits and top and bottom row limits of the final frame to search for maximum amplitude of output plots.

Card 6: READ (5,3) ITHRES

3 FORMAT (4I6)

This value is the initial threshold for HST search in the run data. It should be an average of the first tip and porch values.

Card 7: READ(5,DARNIN)

MOD1 = 10HDARNbbbbbb

IFLDR = file # of dryrun data.

ITHDR = threshold of dryrun data.

SHIFT = difference in amplitude between shot and dryrun pedestal.

TOL = decimal fraction of SHIFT which can be tolerated in pedestal comparison without correction for EMP. A value of 0.05 is suggested.

NOWPLT = 1 for plots of each frame produced.

= 0 for plot of final subtracted frame only.

The above NAMELIST input file initializes dryrun and pedestal parameters.

Card 8: IF(ITRANS.EQ.0)GO TO 100

READ(5,1)NOTRP, (XTR(I), YTR(I), I=1, NOTRP)

1 FORMAT(I6, (2F12.0))

100 CONTINUE

The number of points on the transfer curve and point values are entered on successive cards if a transfer function correction is included.

The maximum amplitude of output plots is entered here if the "overexposure" feature is desired.

```
100 CONTINUE
  99 READ(5,2)MODE
  2 FORMAT(A10)
```

Card 11: READ(5,1)XSTART, DELX, YSTART, DELY
1 FORMAT(4E12.0)

**Card 12: READ(5,1)AA, BD
1 FORMAT(2E12.7)**

```
Card 13: IF(NORM.NE.2)GO TO 100
        READ(5,1)CMAX
        1 FORMAT(F12.0)
        100 CONTINUE
```

```
Card 14: IF(NOWPLT.NE.1)GO TO 100
        READ(5,1)ITOP, IBOT, IFRAM, COL, IEXP, IDOPE
1  FORMAT(2F6.0, I6, F6.0, 4I6)
        IF(ITOP.GT.999998)GO TO 99
```

```
100 CONTINUE
    99 READ(5,2)MODE
    2 FORMAT(A10)
```

22

Card 15: 10 READ(5,1)ITOP, IBOT, IFRAM, COL, IEXP, IDOPE
IF(ITOP.GT.999998)GO TO 100

,

,

,

GO TO 10

100 READ(5,2)MODE

,

,

,

The plotting intervals for the final difference frame are entered next followed by an input MODE. If no further plots are desired, MODE is ALLbDONE. Alternatively, one of the other modes can be entered, followed by further plotting interval input.