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MANHIST User's Guide*

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ABSTRACT

MANHIST is a program allowing interactive manipulation of histograms, *e.g.* retrieving histograms from files, cataloging, displaying and fitting. It can be run on any VMS system and accepts DCL like commands. MANHIST is built upon the CERN histogram packages HBOOK and HPLOT and the Unified Graphic System from SLAC.

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1. Program command interface

MANHIST is a program designed for the interactive manipulation of histograms. To define it in one sentence, it constitutes an interactive interface between the user and the histogram packages from CERN: HBOOK[1] and HPLOT.[2] However MANHIST is more than that since it allows things which are not possible from HBOOK or HPLOT. Among other things, it allows the interactive fitting of histograms, *i.e.* fits with functions defined by the users without coding.

This is how the program started in 1976. It was first written in FORTRAN. The functionality of the program was that of the commands FILE, FETCH and FIT. When I first worked on a VAX, I promptly rewrote the compiler and function evaluator in MACRO since VAX assembly is much easier to use for these things than FORTRAN and the speed increase made it a real program. I modified the graphic interface of HPLOT to be the SLAC Unified Graphic System[3] which is a very good graphic package. Soon, friends seeing me using the program asked to use it too. From 1979 on, a long process of inserting new ideas from other users and myself helped turning MANHIST into a huge program offering most what physicists like to do during the study of their final results. I like to emphasize here that the main reason why MANHIST has been so successful is that it has been exposed to many users in different institutions who have helped me debugging all the features and suggested changes.

The current version of MANHIST was written for the VAX and makes extensive use of all facilities provided by the VMS operating system. Your installation should have a symbol `MANHIST` defined as `RUN MANDIR:MANHIST`. The logical name `MANHIST_HELP_LIB` must be defined to `MANDIR:MANHIST.HLB` if you want the help facility to work. Commands are decoded using the parser provided in the run time library. Because of this, the command syntax is very similar to that of DCL commands. Therefore commands may be abbreviated as long as there is no ambiguity with another one. MANHIST can only be run under the VMS operating system, on a VAX of any size.

General command syntax

A typical command looks like:

⟨*verb*⟩ {/⟨*qualifier*⟩ } ⟨*parameter*⟩

where ⟨*verb*⟩ is the command name and ⟨*qualifier*⟩ its qualifiers. A command may have several qualifiers. The qualifiers are usually optional, this is why they are shown between braces. Except when this does not make sense, default qualifiers settings and/or values are provided. The choice for the default has been determined by usage so that if you fit the category of an average user, you will hardly need to use qualifiers. Entities enclosed in ⟨⟩ and written in italics denotes a single string of characters (*i.e.* no blanks between them) unless explicitly stated. We will keep this notation throughout the manual. ⟨*parameter*⟩ is usually the histogram number and may also be omitted. In that case, the previous number is used. This allows less typing and is extremely useful when writing command files (also called indirect files) which accomplish quite a lot without using an explicit histogram number. Here is a example of such series of commands:

```
FIT/NOPLOT/NOPRINT /GAUSS
SET WINDOW/NX=1/NY=1
PLOT RESULT
SET WINDOW/NY=2/SAME/WIN=2
PLOT
```

Assuming these commands are stored on the file PRETTY.EXC, the following MAN-HIST commands:

```
FETCH
@PRETTY
```

fetches the next histogram on the current input file and redefines the default ID., fits the histogram with a Gaussian distribution, plots the results of the fit on the top of the plot page and plots the histogram underneath the results together with the fit function. This is already a very advanced example, and yet you

would notice that most of the commands are simple, do not refer explicitly to the histogram number and have name which are fairly descriptive about what they will be doing. At this point, people knowing HBOOK and HPLOT will have understood what the file does without reading the rest of the manual.

If you do not understand, just keep reading and come back later when these commands have been explained. I rather give examples performing a useful task, at the sake of being unclear at the first reading, instead of showing abstract manipulations which will mean absolutely nothing, even after knowing the entire manual. After all, manuals are meant to be read several times!

On-line help

MANHIST uses the help library facility provided by VMS. Thus at any time the user can ask for help by simply typing

```
HELP
```

```
HELP ⟨topic⟩
```

This command places the user into the help facility and I assume here that anyone running MANHIST is familiar on how to retrieve help from a library *. Users familiar with HBOOK will not have to read this manual further because the help facility is usually enough for most application. Of course, to learn about things which are not provided by HBOOK, this manual is preferable.

Command files

From the above example, we have seen that commands could be stored on files and be executed from them. As for DCL (release 3.7), the command files may be nested up to 8 levels. A command file is called like a DCL command, *i.e.* by typing a "@" before the file name. Their execution stops when the end of file is reached. In order not to be mixed with anything else, .EXC is the default extension for MANHIST command files. Like in DCL, parameters may be passed

* If not, read the DCL manual under the entry HELP.

to command files. Inside the file, they are referred to as 'P1, 'P2, *etc...* These parameters can only be used within a command file, since usually they are not defined when MANHIST starts executing. By default, a command file executes without echoing its input on the terminal. The echo can be turned on by issuing:

```
SET VERIFY
```

and the following command turns the echo off:

```
SET NOVERIFY
```

The execution of a command file may be suspended by either introducing the commands PAUSE or @TT:. The first command will simply suspend the execution until a carriage return is typed in. The second one defines in effect the terminal as the next level of indirect file. It gives more freedom to perform some actions before resuming the initial file execution. To resume execution of the command file, one simply types a control-Z which signal the end of file on the terminal input. A good example of it is in the command file which runs a demonstration of MANHIST which is listed in a separate section. The file name is usually MANEXMPLE.EXC and resides in the same directory as MANHIST. There is a DCL command file (with the same file name and extension .COM) which starts the demonstration run. This is the best way of getting acquainted with MANHIST.

Foreign commands and symbols

It is also possible to use symbols declared at the DCL level inside MANHIST commands or as new commands. New commands are entered alone whereas symbols are enclosed within quotes. Here are two examples to illustrate the difference between commands and symbols. The opening of a graphic device can be stored in a symbol which will be called within MANHIST:

```
$ VT = "OPEN/TERM SDD4010,RVT100"
$ MANHIST
MANHIST> VT
```

where the underlined text corresponds to the machine prompts. A symbol defining a new command may simply save a lot of typing:

```
$ GET = "FETCH/GLOBAL"
$ MANHIST
MANHIST> 'GET MYHISTFIL
```

but here the leading quote is necessary to force MANHIST to look for a symbol. So, in this case, MANHIST is not as convenient as DCL since commands requiring parameters must be flagged by a leading quote.

Qualifier syntax

Qualifiers come in two flavors: single or equated to some value. Look at the WINDOW command above to see an example of it. The value may be an integer or a real number, a key word or a text string. In the manual we will denote an integer value with n and a real number with x. Numbers follow the normal FORTRAN syntax. Text string must be enclosed within double quotes (" " "). Thus example of legal text strings are:

```
CUT/ID=1/TITLE="HISTOGRAM TITLE"
SET TITLE "USING THE ""SOFT"" CUT"
```

Like in DCL, if a double quote is part of the string, it must be doubled. When writing a command file which is very general, parameters may not be the best solution because it is difficult to remember a lot of parameters. Thus, the qualifiers will also accept a construct causing MANHIST to prompt you for an input:

/⟨qualifier⟩ =."⟨prompt text⟩ "*

where the prompt text may be any string of characters (except for the double quote which must be doubled). A trained eye will recognize that the routines used for input are the same as those used to input fit parameters. However, here it was not possible to keep a default value stored for each qualifier. Thus the default value supplied by the prompting routine is usually not useful. This construct is also accepted for the histogram number when it is the parameter

of the command. As an example, the following commands let you get a specific histogram, cut its range so that local fits be performed:

```
DELETE 999
FETCH *."Next id"
CUT/ID=999/MIN=*."Lower cut"/MAX=*."Upper cut"
```

Command memory

It is possible to store a series of commands in memory. The storage of commands is initiated by typing

```
SET MEMORY/ON
```

and is closed with

```
SET MEMORY/OFF
```

All commands typed in between these two lines will be executed and stored in a memory buffer. The stored commands can be recalled for execution with the command:

```
@MEMORY
```

This is useful when a series of commands is not general enough to be part of a command file but complicated enough to be a bother to type them again and again. The content of the command memory can be listed with the command

```
SHOW MEMORY
```

Of course, the content of the command memory is lost when you exit MANHIST.

1.1 Executing DCL commands from MANHIST

DCL command can be spawned from MANHIST by prefixing them with DCL. As an example, the following

```
DCL DIR *.HBK
```

will help you remember your histogram file names without exiting MANHIST. The user must be aware that a spawned command is in effect another process. Therefore, any symbols or logical name which the command may be creating will not be accessible to you. In particular, you cannot change your default directory with such a command.

Command abort and termination

Command execution can be aborted by typing a control-C. The control is immediately returned to MANHIST main command input. If a plot was in progress, it is interrupted and the plot buffer is cleared. Thus if you were in overlap mode, you start with a new screen. If any command files are executed, they will be closed. Finally, typing EXIT let you return at the DCL level. This command will also terminates the execution of MANHIST if it appears in a command file.

2. Input of histograms

MANHIST was designed for data analysis as performed in high energy physics. Histograms are created and filled by a program processing events from tapes and they are stored on a file, usually residing on a disk drive. HBOOK offers many way to save histograms and there is one command for each of these. I explicitly refer to the HBOOK routine used for each of the format and users are advised to read the corresponding sections of the HBOOK manual.

2.1 HISTOGRAMS SAVED WITH HSTORE

HSTORE records histograms one by one, therefore MANHIST will retrieve them in a similar way using the routine HFNEXT. The file onto which the histograms are saved must first be opened with the command:

FILE ⟨*file name*⟩

where the default extension for the file is .HBK. However, ⟨*file name*⟩ may be any valid DCL file name. In particular, referring file across DECnet works perfectly

fine. If the file cannot be found, an error message will follow the request. In case a file had previously been opened, MANHIST will first close it before opening the new one. Thus, if a file cannot be opened, MANHIST is left without any file opened for histogram input.

After the input file has been defined, histograms can be fetched by issuing the command:

FETCH{/⟨*qualifier*⟩ } {⟨*histogram number*⟩ }

where ⟨***histogram number***⟩ corresponds to the ID parameter of the HBOOK1 routine. For sake of brevity, the histogram number will be henceforth called ID. If there is no file opened for input, an error message is issued and no action is taken. It should be noted that the histograms do not need to be fetched in the same order they were written on the file. However, this is not efficient because the file will be rewound each time one histogram is read out of sequence.

As shown earlier, the ID may be omitted thus causing the next histogram on the file to be loaded. In this case, the number of the histogram read in will become the default ID for all subsequent commands which accepts a histogram number as parameter. See how the example with the file PRETTY.EXC works. If you use FETCH without parameters, the file will be closed when the end of file is reach, *i.e.* when there is no more histogram on the file, and an error message is issued.

The command FETCH calls the routine HFNEXT and reads each histograms one by one until the desired ID is reached. If HFNEXT read a histogram which is already in memory, it will add the content of the new histogram to that of the old (provided both histograms have consistent limits and size). To avoid this, all histograms previously read in memory are deleted before a new one is fetched. This allows people to save histograms with the same id on the same file. Automatic deletion maybe turned off by adding the qualifier /NODELETE to the FETCH command. This qualifier must be used with care. As an example, consider a file onto which histograms 1,2,3,4,1,5 have been saved in this order. Suppose

the user types (after opening the file):

```
FETCH

FETCH/NODELETE 5
```

The first command will load the first occurrence of ID 1, *i.e.* the one preceding ID 2. The next command will read and delete IDs 2,3 and 4. Then ID 1 will be added to the one already in memory (*cf.* the description of HFNEXT in the HBOOK manual). Finally ID 5 will be read. Nothing will transpire because HBOOK does not warn you in such case, but the user will have a bad surprise when looking at his histograms. In order to prevent similar mishaps, all histograms are deleted from the memory when the file must be rewound (for example in case a histogram is fetched out of sequence), and MANHIST prints the following warning message

```
File repositioned at beginning.
```

In most of cases, the user is only accessing one histogram at a time and therefore the default for **FETCH** is not a restriction.

The command **FILE** does not delete histograms previously loaded. It is therefore possible to load two histograms from separate files in the memory.

In case the user does not remember which histograms are stored on the file, the command:

```
SHOW FILE
```

will make a listing of all histogram IDs and their titles on the terminal. The file will be rewound prior the listing and all histograms will be deleted from the memory. The file is rewound again after the listing is typed out. This command does not leave any histograms in the memory.

2.2 HISTOGRAMS SAVED WITH HMSAVE

Histograms which have been saved by a call to HMSAVE can be retrieved with the command:

```
FETCH/GLOBAL ⟨file name⟩
```

This has the advantage of loading the entire set of histograms as they were in memory at the time HMSAVE was called. In particular, the global title* is saved too. ⟨*file name*⟩ must be a valid DCL file name. If no extension is given, .HGL is used as a default. If the user does not remember which histograms were saved on the file, the command:

```
SHOW HISTOGRAM
```

will print the index† of the HBOOK common after the FETCH command has been executed. This command may be used at any time to find out which histograms are currently loaded in the memory and is of course independent of the way the histograms have been read in.

Because the FETCH/GLOBAL command restores the entire HBOOK common in memory, all previously loaded histograms will be erased from the memory. However, it is still possible to load histograms from files of different type with a little care. Let us assume that the histograms IDs 1,2,3,4,5 have been saved on file ALL.HGL using HMSAVE and IDs 11,12,13,14,15 has been saved on SINGLE.HBK using HSTORE. If the user wants to plot histograms 5 and 15 using the same scale on the same plot ,* he will give the following commands:

```
FETCH/GLOBAL ALL
FILE TMP
FETCH/NODELETE 15
SET SCALE/COMMON 5,15
```

⋆ *cf.* the description of the routine HTITLE in the HBOOK manual.

† for the HBOOK users, the routine HINDEX is called.

* This is one of the rare cases where one needs to have more than a single histogram in memory.

```
PLOT 5

PLOT/SAME 15
```

However, it is not possible to simultaneously load histograms stored in two different "global" files without introducing a temporary file as described in the next chapter.

2.3 HISTOGRAMS SAVED WITH HWRITE

The routine **HWRITE** saves the HBOOK common in an ASCII file in order to be easily transported between machines of different type. In particular, these files can be exchanged over an heterogeneous network of computers. MANHIST will read such a file with the command:

FETCH/GLOBAL/FOREIGN ⟨*file name*⟩

MANHIST assumes that **HWRITE** had been called as:

```
CALL HWRITE(0,LUN,0,800,-1)
```

which is the default in HBOOK. Here again ⟨*file name*⟩ must be a valid file name. If no extension is given, .HFG is used as a default.

This command is very similar to the previous one. The entire memory is overwritten and previously loaded histograms are erased.

2.4 HISTOGRAMS DEFINED BY HAND

Whereas, most histograms are created by sophisticated analysis programs, there are times when one likes to work with some numbers which have been generated by hand (most likely a hand holding a calculator!). On the other hand, this gives the possibility for people not using HBOOK to load histograms into MANHIST. However this is restricted to 1-dimensional histograms. The command:

FETCH/FILE=⟨*file name*⟩ ⟨*histogram number*⟩

will load a single histogram from ⟨*file name*⟩ with default extension .TOP. Note that the ID must be given since the file does not contain any information about histogram number.

Instead of introducing a new format, I chose to use the syntax of TOP DRAWER[4] because it is a very popular program at SLAC. Instead of giving a detailed syntax description, I'd rather give an example which will speaks from itself of a file in TOP DRAWER format:

```
SET ORDER X Y DY
TITLE TOP 'TEN POINTS ON A PARABOLA'
0.0 1.0 .5
1.0 5.5 .5
2.0 9.0 .5
3.0 11.5 .5
4.0 13.0 .5
5.0 13.5 .5
6.0 13.0 .5
7.0 11.5 .5
8.0 9.0 .5
9.0 5.5 .5
10.0 1.0 .5
HIST
```

The first line defines what the format is, here the abscissa, ordinate and error of ordinate. An alternative is SET ORDER X Y if no error bars are given or if the default error bar are adequate (*cf.* SET ERROR command). The second line defines the title which is given between single quotes. The title line must be given; if not an error occurs. Finally, the points are given and the list must be closed by the keywords: HIST, JOIN or PLOT. TOP DRAWER has of course much more commands but this is all what MANHIST will recognize. Most other commands will be ignored and some may even cause errors. TOP DRAWER being such a

wonderful program, reproducing all the functionality of it in MANHIST would has been a lot of work (and duplication!).

This format allows to enter non-equidistant values as well. If the X values are not equidistant within tolerance (1/1000), a special format of "histogram" will be created. Of course, this is no longer a histogram but a collection of coordinates in a plane. These special histograms can only be plotted or fitted. All other commands will reject them.

3. Output of histograms

Since MANHIST allows to create new histograms as well, the user may want to save them for later use by MANHIST or any other program. There is an output command corresponding to each of the previous input format. In all cases, saving histogram does not erase them from memory.

3.1 SAVING HISTOGRAMS IN HSTORE FORMAT

The command

CATALOG ⟨*file name*⟩

opens a file into which histograms will be written using HSTORE. As for FILE, .HBK is the default file extension. If another file had previously been opened for output, it is first closed. A histogram file may be extended if you use the /APPEND qualifier. In this case the file must exist and saved histograms are appended to the file.

Histograms are written one by one on the file with the command

SAVE {⟨*histogram number*⟩ }

The command

SAVE/ALL

will save all histograms currently loaded in the memory. If no file has been opened for output, the SAVE command will issue an error message.

If the output file need to be used immediately by MANHIST, the command

```
CLOSE
```

will close the output file. This is useful when one uses a file as temporary storage. Using a temporary file in HSTORE format is the only way to simultaneously load histograms which have been saved on two different "global" files. Assuming that IDs 1,2,3,4,5 and 11,12,13,14,15 have been saved on files ALL1.HGL and ALL2.HGL respectively, the following commands will be necessary in order to do the same operation presented in the previous example:

```
FETCH/GLOBAL ALL2
CATALOG TMP
SAVE 15
CLOSE
FETCH/GLOBAL ALL1
FILE TMP
FETCH/NODELETE 15
SET SCALE/COMMON 5,15
PLOT 5
PLOT/SAME 15
```

If the CLOSE command was not there, the file TMP.HBK could not be opened for read since it would still be opened for write.

3.2 SAVING HISTOGRAMS IN HMSAVE AND HWRITE FORMAT

There are two commands

```
SAVE/GLOBAL ⟨file name⟩
```

and

`SAVE/GLOBAL/FOREIGN` ⟨*file name*⟩

corresponding to the similar **FETCH** commands. I think that no further explanations are required.

3.3 SAVING HISTOGRAMS IN TOP DRAWER FORMAT

Histograms can also be saved in TOP DRAWER format. The main reason is to allow people to use features which are not part of MANHIST, like placing comments, arrows, special symbols *etc...* on the plot. TOP DRAWER allows several plots to be stored in one file since the ID of the histograms is not used by TOP DRAWER. Therefore the commands are the following:

`CATALOG/TOP` ⟨*file name*⟩

to open the file and

`SAVE/TOP` {⟨*histogram number*⟩ }

to save single histograms. In the most general case* MANHIST will not be able to read back this file, so that the `CLOSE` command is not needed for this kind of files.

Output for different formats are completely independent from each other although the command verbs are the same. It is thus possible to have one output file of each type (`HSTORE` and TOP DRAWER) open at the same time.

⋆ when the histogram has a fit function stored with it for example.

4. Terminal and printer outputs

One of the reason for using MANHIST is the interactive display of histograms. Histograms can be typed in printer format (HBOOK output) or plotted if you are lucky enough to have a graphic device. This section will describe the options for the printer output.

4.1 OUTPUT FORMATTING AND RE-DIRECTION

By default, MANHIST will direct any output coming from HBOOK and certain MANHIST results (like fit results) on the terminal. The default size of the terminal is assumed to be 24 lines by 80 columns. If your terminal has other dimensions, the command

SET FORMAT {**LINES=**⟨*number of lines*⟩ } {**COLUMNS=**⟨*number of columns*⟩ }

allows to modify the default format. At least one of the two qualifiers must be specified. However, the corresponding HBOOK routine does not yet support the variable number of columns. Thus it is a good idea to issue the DCL command

SET TERM/NOWRAP/WIDTH=⟨*number of columns*⟩

before running MANHIST if you are planning to use the print command a lot. Let us recall that this kind of DCL command will not be effective when issued from MANHIST using the DCL prefix.

If you want to save the printout, the command

SET MODE/RECORD

will modify the output format to 60 lines by 132 columns and write all output on the file HISTRES.DAT. You can switch back to the default output by typing

SET MODE/SCRATCH

You can switch back and forth between the two modes as often as you please. A single file is written. Once you get out of MANHIST, you will have to print it with the DCL PRINT command.

The current status of the format and mode of output can be checked with the commands

```
SHOW FORMAT

SHOW MODE
```

4.2 PRINTING HISTOGRAMS

The command to print a histogram is

PRINT{/⟨*qualifier*⟩ }{⟨*histogram number*⟩ }

Without qualifier, a print of the histogram is generated. If the histogram is one-dimensional, the only possible qualifier is /MOMENTS .* If it is specified, the following information is printed:

- the histogram underflow,
- the integrated sum of all bins,
- the histogram overflow,
- the average,
- the standard deviation,
- the skewness,
- the kurtosis,
- the number of equivalent events,
- the full width at half maximum (FWHM) absolute and as a fraction of the average.

In this case, the histogram is not printed. The computation of the FWHM is a very simple algorithm. Let x be the largest content of a bin in the histogram. Then the FWHM is the difference between the lower limit of the first bin from the left whose content is greater or equal to $\frac{x}{2}$ and the lower limit of the first bin from the right whose content is less than $\frac{x}{2}$.

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* Though /HIST will be accepted without affecting the command.

In case the histogram was 2 dimensional, more than one histogram will be printed if the histogram was declared with several booking options. If you want to select only a part of the histogram, the following qualifiers allow partial printing.

— /HIST selects the scatter plot only,

— /PROX selects the X projection,

— /PROY selects the Y projection,

— /SLIX=n selects the n^{th} slice in X,

— /SLIY=n selects the n^{th} slice in Y,

— /BANX=n selects the n^{th} band in X,

— /BANY=n selects the n^{th} band in Y.

Of course, the selected item must have been booked when the histogram was initially declared.

4.3 SELECTING WHAT TO PRINT

The histogram printout contains a lot of information. More can be added, or some can be omitted. The following command allows you to set the print options for all histograms which are currently loaded in the memory

```
SET PRINT{/⟨qualifier⟩ }
```

Histogram are read in from file with the print options they had when they were saved. Print options are a property of the histogram and are saved with it. Thus, if your modify the print option and save the histogram, the modification will stay in effect.

For example, let us assume than one histogram is save on file A.HBK with the HBOOK default print settings. Consider the following command stream:

```
FILE A
FETCH
PRINT
SET PRINT/ERROR=YES
PRINT
```

```
CATALOG B
CLOSE
FILE B
FETCH
PRINT
```

The first print will generate a printout using the default HBOOK settings. However, the next two printout will have the error printed along with the histogram.

Several qualifiers may be specified on one command. Each qualifier must be equated to the string YES or NO in order to enable or disable the print option. As an example:

```
SET PRINT/STATISTICS=NO
```

will disable the printing of the statistical information for all histograms currently in memory, and

```
SET PRINT/ERROR=YES
```

will enable the printing of the errors if any have been defined. The rest of the qualifiers are:

- /CONTENT to enable or disable the printing of the histogram's content,
- /CHANNEL to enable or disable the printing of the channel number,
- /FUNCTION to enable or disable the printing of the fit or the superimposed function if any exists,
- /INTEGRATED to enable or disable the printing of the integrated content,
- /LOW_BIN to enable or disable the printing of the low bin limit.

5. Output to a graphic device

A picture is worth a thousand words, especially if the picture can be obtained without effort. MANHIST provides you with the possibility of creating figures of publication quality (depending upon your hard copy graphic device). The only limitation will be your imagination and your capacity to remember all features which will be described hereafter.

5.1 DECLARING A GRAPHIC DEVICE

A mentioned earlier, MANHIST uses the Unified Graphics System (UGS) of SLAC as a graphic package. Therefore, you should be familiar with the name of the devices which are supported on your installation. If the person taking care of MANHIST at your site is doing a good job, the help entry for the OPEN command should have a short description of all available devices. A graphic device is opened for output with the command

OPEN{/⟨*qualifier*⟩ } ⟨*device name*⟩

The device name will in fact contain more that the simple device name since it is the string which is passed to the UGS routine UGOPEN* . An example has been given earlier in the illustration of the symbol definition. There, the symbol VT is equated to the command necessary to declare a Retrographic VT640 to UGS. The string ⟨*device name*⟩ is passed without checking to UGS which does the parsing himself. As a result, no abbreviation are allowed in the device name string.

MANHIST has been designed for graphic devices which are producing their output independently from the terminal which is running the program. A plot is sent after the command doing the request. However, because such interactive devices are expensive, a lot of people use cheap graphic terminals instead. If you are using one of those, the plot may mingle with the normal output and, even

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* This way, the code of MANHIST is independent of the possible graphic device.

worse, the screen may be cleared before you have had time to see everything [†]. You can tell MANHIST that the output of a plot is coming to your terminal with the /TERMINAL qualifier. The program will then prompt you for input (a carriage return is enough) before the screen is cleared and the plot is sent and after the plot is sent, but before clearing the screen again. However, windowing and plot overlay will not be working right in this mode. So if you are planning to use windowing and overlay you should add /OVERLAP after the /TERMINAL qualifier. With the option /OVERLAP selected, the whole graphic screen is kept in memory and redrawn when necessary.

When working with the /TERMINAL/OVERLAP options you have the option to send the screen content to a hard copy device by entering an H after the plot has been produced. Thus you can construct sophisticated figures on a screen and decide to plot them out on paper if you are satisfied with them. The hard copy device is defined by including the /HARDCOPY qualifier in the OPEN command. No other switch can be specified with this option. The hardcopy device stays aside of the normal devices because it can only be accessed after plotting on a device declared with the terminal and overlap options.

UGS allows you to declare up to 8 graphic devices at the same time. Everytime an OPEN command is issued for a legal device, it becomes the active device, *i.e.* the device to which plots will be sent. The command

```
SHOW DEVICE
```

will let you see which is the current active device. Typing

```
SHOW DEVICE/ALL
```

will give you a list of all opened device together with their channel numbers where the active device is flagged with a star. Unfortunately, UGS does not returns the full string of characters which was passed to the routine UGOPEN; only

---

† A good example of this behavior is the plotting of a scatterplot which was booked with projections and/or bands, or the default for the FIT command.

the device name is returned and the options are missing. If you have ambiguity problems, you should know that MANHIST assigns device channels in the order of declaration, *i.e.* the first device opened gets the channel number 1, *etc...*

The active device may be redefined by typing

```
SET DEVICE/CHANNEL=n
```

where n is the device channel number. Note that the hard copy device cannot be selected. However it is possible to define the same device normally and as the hard copy device. Some plot commands will also accept the /CHANNEL qualifier and thus let you redefine the active device at the same time a plot command is issued. As an example

```
SET DEVICE/CHANNEL=1

PLOT/PROX 10
```

is equivalent to

```
PLOT/CHANNEL=1/PROX 10
```

5.2 PLOTTING HISTOGRAMS

Histograms are plotted with the command

PLOT{⟨*qualifier*⟩ } {⟨*histogram number*⟩ }

By default 2-dimensional histograms are plotted with the scatterplot option of HPLOT. This is not a true scatterplot, but the points are obtained using a random number generator within each bin. Read the HPLOT manual for more information. Like for the print command, all booking options of a 2-dimensional histogram will be plotted. The same qualifiers allow selective plotting of booking options

— /HIST selects the scatterplot only,

— /PROX selects the X projection,

— /PROY selects the Y projection,

— /SLIX=n selects the n^{th} slice in X,

— /SLIY=n selects the n^{th} slice in Y,

— /BANX=n selects the n^{th} band in X,

— /BANY=n selects the n^{th} band in Y.

The graphic device may also be changed with the /CHANNEL=n qualifier and becomes the active device from then on.

If you want to overlay several histograms on top of each other, the /SAME qualifier must be used. The line texture is changed. HPLOT will generate different texture for as many as 5 histograms plotted on the same graph. They are in order: solid (for the original plot), dashed(for the first plotted with the /SAME option), dot-dashed, sparse dotted, dotted. The sixth histogram (or the fifth one plotted in a row with the /SAME option) will be plotted again with a solid line and the order of textures will start from there again. There are no limits to the number of histograms which can be overlayed over than your ability to tell the difference between them. Like in HPLOT, each overlayed histogram will be plotted with its own scale. In order to define a common scale you must use the SET SCALE command which has several options for generating a common scale.

A standard plot has the histogram title at the bottom of the X axis and the general title (if any) at the top of the plot. You can label each of the axes with the qualifiers

/X_AXIS="⟨*text string*⟩ "

/Y_AXIS="⟨*text string*⟩ "

in order to add more information.

5.3 3 DIMENSIONAL VIEWING

2-dimensional histograms may also be viewed in 3 dimension with the command

VIEW{⟨*qualifier*⟩ } {⟨*histogram number*⟩ }

where the qualifiers are

— /CHANNEL=n in order to change the current graphic device,
— /THETA=x to define the azimuthal angle of viewing and
— /PHI=x to define the polar angle of viewing in degrees,
— /HIDDENLINE selects the removal of hidden lines,
— /CUBE will display the histogram as piles of blocks and
— /LEGO will generate the lego plot made famous by the UA1 and UA2 collaborations.

Of course, the three last qualifiers are exclusive. The nicest effect is obtained with the /CUBE option, however it is very time consuming and it will blow up if the binning of the histogram is too high. /LEGO is the best since it is reasonably fast and works with many bins. However it is restricted to viewing angles between 0 and 90 degrees.

5.4 CONTOUR PLOTS

UGS has a nice algorithm to generate contour plots of histograms. This is an alternative to 3 dimensional viewing and allows to see small features which would not be seen if some bins are highly populated. The command is

CONTOUR{⟨*qualifier*⟩ } {⟨*histogram number*⟩ }

where several qualifiers are possible

— /PRIMARY=n defines the number of primary contour line. Primary contour lines are drawn with a solid line. The default number is 5.
— /SECONDARY=n defines the number of additional contour lines between the primaries. Secondary contour lines are drawn with a dashed line. The default number is 1.
— /MINIMUM=x defines the location of the lowest contour line. The default is zero.
— /MAXIMUM=x defines the location of the highest contour line. The default is the maximum of the histogram.
— /NOLABEL suppress the labeling of the contour lines.

Default values are usually adequate. Contour is as time consuming as 3 dimensional viewing. The time will increase with the number of contour lines generated. The best effect are obtained if the histogram has been filled with large statistics. Sparsely populated histograms will yield erratic contour plots. If you are working with a "terminal" graphic device, there will be a significant amount of time after the prompt which lets MANHIST clear the screen and the appearance of the plot. 3 dimensional viewing will have the time delay before the prompt. The computing time is about the same, but waiting in front of a blank screen seems longer than when the screen is full.

5.5 WINDOWING

By default, one histogram is drawn on the screen. However, HPLOT gives the possibility of drawing several histograms on a single page or screen. The command

```
SET WINDOW{/⟨qualifier⟩ }
```

let you change the number of histograms which are plotted on a page. The qualifiers are

- /NX=*n* defines the number of partitions along the X direction.
- /NY=*n* defines the number of partitions along the Y direction.
- /WINDOW=*n* defines the number of the window where the next histogram will be plotted.
- /SAME prevent the initialization of a new page in case the window number is out of sequence.

Windows are numbered from left to right first and from top to bottom. Thus the command

```
SET WINDOW/NX=2/NY=3
```

generates windows numbered as follows:

1	2
3	4
5	6

Histograms are plotted on successive windows unless you use the command with the /WINDOW=*n* qualifier to redefine the order. The windowing stays in effect until explicitly redefined to another format. The default format is a single window. Here is an example which produces an insert plot in the upper right hand corner of the main drawing.

```
SET WINDOW/NX=1/NY=1
PLOT 1
SET WINDOW/NX=2/NY=2/SAME/WINDOW=2
PLOT 2
```

The first line simply redefines the format to the default in case this was not the case. This is always a good idea to do so in command files, since you do not know what will be the setup when the file is executed.

5.6 CHANGING THE PLOT FORMAT

The command

SET PLOT{/⟨*qualifier*⟩ }

allows to modify the layout of the plot page and certain plotting options. This command has a lot of possible qualifiers. The first class of qualifiers enable or disable the insert of some information about the histogram (ID, average, sigma, *etc...*). These qualifiers will disable the display of the information they control if it is prefixed by a NO. They are

— /IDS enables the display of the histogram ID.

— /CONTENT enables the display of the integral of the histogram.

— /OVERFLOW enables the display of the under- and overflow of the histogram.

— /MEAN enables the display of the average.

— /SIGMA enables the display of the standard deviation.

— /STATISTICS is a short notation for /CONTENT/MEAN/SIGMA.

— /ALL enables all the above options.

— /NONE disables all the above options.

Options are plotted in the order: ID, contents, overflows, mean and sigma If an option has not been selected, it will not appear in the sequence. However, an option will not be plotted if it falls outside the histogram plot boundaries. If this is the case, you will have to reduce the size of the comment characters in order for all options to fit in. Options remain in effect until they are explicitly turned off. They do not apply to histograms and are not saved when a histogram is written on file. When you overlay two histograms on top of each over and you want the statistics of the first histogram displayed, you should explicitly turn the option off before plotting the second histogram which is overlayed. If not, the statistics of the latter will also be overlayed and the result may be quite unreadable. The following commands achieve this

```
SET PLOT/STATISTICS
PLOT 1
SET PLOT/NOSTATISTICS
PLOT 2
```

Note that, here the second command could also have been SET PLOT/NONE.

The next group of qualifiers call the HPLOT routine HPLOPT and the qualifiers are simply the key word which this routine expects.

— /NEAH selects that histograms which have defined error bars are plotted as crosses. The vertical bar corresponds to the error bar and the horizontal one to half of the bin width. This is the default.

— /EAH selects that the error bars are plotted along with the histogram shape.

— /CHA selects that 2-dimensional histograms be plotted with the bin contents

represented by a single character. This option is much faster than the scatterplot option.

— /NCHA selects that 2-dimensional histograms are plotted as a scatterplot. This is the default.

— /COLOR=⟨*color name*⟩ selects the color for the subsequent plots. The possible colors are: WHITE, RED, BLUE, GREEN, YELLOW, MAGENTA and CYAN. However, their availability is subject to the type of graphic device selected. Look in the UGS manual for details concerning specific devices. The default is WHITE which corresponds to black for a hard copy device.

The last class of qualifiers allows to change the plot page layout. The key words corresponds to those of the routine HPLSET and the user should consult the HPLOT manual for a detailed discussion of each quantities. Dimensions in HPLOT are defined in centimeters. However this may not be correct depending on how the graphic device routine has been written. The default number are given so that the user can define the scaling factor needed for conversion.

— /XSIZ=x sets the length in cm of the X axis. The default is $x = 21.\,cm.$

— /YSIZ=x sets the length in cm of the Y axis. The default is $x = 29.7\,cm.$

— /DASH=X sets the length of basic dashed segment. The default is $x = 0.2\,cm.$

— /DMOD=n sets the dash mode. The default is $n = 0.$

— /XMGL=x sets the left X margin. The default is $x = 2.\,cm.$

— /XMGR=x sets the right X margin. The default is $x = 2.\,cm.$

— /XLAB=x sets the distance between the Y axis and the Y label. The default is $x = 2.4\,cm.$

— /XVAL=x sets the distance between the Y axis and the Y axis values. The default is $x = 0.3\,cm.$

— /XTIC=x sets the tick mark length on the X axis. The default is $x = 0.3\,cm.$

— /YMGL=x sets the lower Y margin. The default is $x = 2.\,cm.$

— /YMGU=x sets the upper Y margin. The default is $x = 2.\,cm.$

— /YLAB=x sets the distance between the X axis and the X label. The default

is $x = 0.8\,cm$.

— /YVAL=x sets the distance between the X axis and the X axis values. The default is $x = 0.2\,cm$.

— /YTIC=x sets the tick mark length on the Y axis. The default is $x = 0.3\,cm$.

— /YNPG=x sets the Y position of the page numbers. The default is $x = 0.6\,cm$.

— /YHTI=x sets the Y position of the histogram title. The default is $x = 1.2\,cm$.

— /XWIN=x sets the X margin for windows. The default is $x = 2.\,cm$.

— /YWIN=x sets the Y margin for windows. The default is $x = 2.\,cm$.

— /KSIZ=x sets the size of the special Hershey characters. The default is $x = 0.28\,cm$.

— /GSIZ=x sets the size of the global title. The default is $x = 0.28\,cm$.

— /TSIZ=x sets the size of the histogram title. The default is $x = 0.28\,cm$.

— /ASIZ=x sets the size of the axis title. The default is $x = 0.28\,cm$.

— /CSIZ=x sets the size of the comments. The default is $x = 0.28\,cm$.

— /PSIZ=x sets the size of the page numbers. The default is $x = 0.28\,cm$.

— /VSIZ=x sets the size of the values for the axis. The default is $x = 0.28\,cm$.

— /SSIZ=x sets the size of the asterisks for the function. The default is $x = 0.28\,cm$.

— /2SIZ=x sets the size of the scatterplot characters and table numbers. The default is $x = 0.28\,cm$.

— /DSET resets all defaults value for the above settings.

5.7 SCALING

By default, the scale for plots and prints is computed in a reasonable way for 1-dimensional histograms so that the histogram shape be visible and the scale factor be a decent number. For 2-dimensional histograms, the scale factor is determined by the value which was given to the HBOOK2 routine to determine the maximum possible bin content. The command

SET SCALE{/⟨{⟨*histogram number*⟩ }⟩ }{,⟨*histogram number*⟩ }

allows to change the default setting. If no histogram number is given, the command will apply to all histograms currently in memory. If IDs are given, only those will be affected. Except for /FACTOR, the command will only affect the scaling of 1-dimensional histograms. The possible qualifiers are:

— /LOGARITHMIC ask that the histogram be plotted with a logarithmic scale. This will also applied to the printed output.

— /LINEAR ask that the histogram be plotted with a linear scale. This will also applied to the printed output.

— /INTEGER ask that the histogram be printed with a integer scale. This command does not affect plotting.

— /FACTOR=x define x as the scale factor for a 2-dimensional histogram. If $x = 0$, the scale factor is computed automatically. This will also applied to the printed output.

— /MINIMUM=x defines the minimum range for the scale limits. This will also applied to the printed output.

— /MAXIMUM=x defines the maximum range for the scale limits. This will also applied to the printed output.

— /COMMON compute a common scale for all specified histograms. This will also applied to the printed output.

— /LIKE=n set the scale of histogram n for all specified histograms. This will also applied to the printed output.

Like the print settings, the scaling is a property of the histogram. Thus, if a call to HLOGAR(1) had been made in the program which created the histogram before saving histogram 1, it will appear in MANHIST with a logarithmic scale. Similarly, the /LIKE qualifier computes the maximum and minimum of the scale and calls the routine HMINIM and HMAXIM. Thus the scaling remains even when the histogram needed to perform the scaling has disappeared from memory.

High energy physicist have a more elaborate way to compare the scale of two

histograms. The command

NORMALIZE/ID=n m

will multiply the contents of histogram m so that its integral be equal to that of histogram n. This method is used to compare two distributions obtained with different statistics. Note that the NORMALIZE command modifies the contents of the histogram whereas the SET SCALE command only changed the way a histogram is displayed.

6. Histogram fitting

The main reason for using MANHIST is the possibility of interactive fitting. MANHIST has many functions which have already been defined because they are very common. In addition, you can specify your own function by typing its formula in FORTRAN-like syntax. If you are not sure what are the best starting values for the fit parameters the CHECK command allows to overlay a function on top of a histogram and to plot it.

6.1 THE FIT COMMAND

The fitting of the histogram is performed with the routine FUMILI modified for HBOOK. Histogram fitting is requested with the command

FIT{/⟨*qualifier*⟩ } {⟨*histogram number*⟩ }{⟨*function expression*⟩ }

If the function expression is omitted, the previously declared function is used. The qualifiers of the FIT command are

— /PRINT=n requests the printing of every n iterations. If $n = 0$, only the end result is printed. The partial iterations are printed by the FUMILI routine which numbers the parameters from 1 on. The final print has the correct parameter names and gives the full correlation matrix. The default for this qualifier is /PRINT=0.

— /NOPRINT disables printing of the results.

— /DEVIATION=PLOT enables that the deviation between the histogram and the fit function be plotted as an insert in the upper right hand corner of the histogram plot. This is the default.

— /NODEVIATION suppress the plotting of the deviation histogram as an insert.

— /DEVIATION=n requests that MANHIST stores the deviations between the histogram and the fit function in a histogram with ID= n. The deviation histogram has the same error bars than the histogram which was fitted. In this case, the deviation histogram is not plotted.

— /NOPLOT suppress the plotting of the histogram after the fit. By default, the histogram is plotted on a full page with the plot function overlaid.

— /ERRORS requests that the error bars of the histogram be taken into account in the fit, *i.e.* each bin is weighted according to the inverse square of the error bar. If no error bars have been defined, the square root of the histogram content is used as the error for each bin. To avoid division by zero, HBOOK ignores bins with zero error. Thus, if you do not have error bars defined, bins with zero content are not taken into account for the fit. If you want to include them, you should use the SET ERROR command.

— /NOERRORS requests that all bin be considered with equal weight in the fit. Bins with zero content are thus included in the fit. In this case, the chi-square value will not be meaningful.

— /QUERY determines that the starting values for the fit parameter be asked to the user. This is the default for user defined functions. The query also allows to set limit on the parameter range.

— /NOQUERY determines that the starting values for the fit parameter will not be asked This is the default for predefined functions because the starting values are evaluated automatically. The query also allows to set limit on the parameter range.

The end result printout gives the histogram ID and title, the chi square, degree of freedom and confidence level, the function's formula or name and a table containing the parameter's names, their value, errors and correlations.

6.2 SYNTAX FOR USER DEFINED FUNCTIONS

The function's formula is given to the program following the FORTRAN syntax except for the following restrictions: the variable name must be X (and Y if the histogram is 2-dimensional). The fit parameter names are restricted to P0, P1, *etc...* You must also use successive numbers for the numbering of parameters, *i.e.*, if a function uses P4, it must also use P0, P1, P2 and P3. Constants may be included in the formula and are interpreted as floating point values. In addition the following constants have been defined for convenience:

$$\begin{aligned} \texttt{PI} &= \pi = 3.14159\ldots \\ n\texttt{PI} &= n\pi \\ \texttt{PI}n &= \frac{\pi}{n} \end{aligned}$$

where n is any integer. If you are omitting the histogram ID in the FIT command, you cannot specify a constant at the beginning of the function expression because it will be interpreted as an ID. Thus

```
FIT 1 2.0*X+P0
```

will work but

```
FETCH 1

FIT 2.0*X+P0
```

will attempt to fit histogram 2 with the function .0*X+P0. Of course, here it will fail immediately since histogram 2 is not in the memory. It is always possible to write an expression without a constant at the beginning, so this could be considered as good practice. If you cannot avoid it, you must either specify the histogram number or put the function's expression between parenthesis. Standard mathematical functions of the FORTRAN library are available: ABS, SQRT, EXP, LOG, SIN, COS, TAN, ASIN, ACOS, ATAN, SINH, COSH and TANH. In addition, the

following special functions have been defined:

$$\begin{aligned}
\texttt{H(X)} &= \begin{cases} 1, & \text{if } x \geq 0; \\ 0, & \text{otherwise,} \end{cases} \\
\texttt{HX(X)} &= x\texttt{H(X)} \\
\texttt{SIGN(X)} &= 2\left(\texttt{H(X)} - .5\right) \\
\texttt{INT(X)} &= \lfloor x \rfloor \\
\texttt{NINT(X)} &= \begin{cases} \lfloor x + .5 \rfloor, & \text{if } x \geq 0; \\ \lfloor x - .5 \rfloor, & \text{otherwise,} \end{cases} \\
\texttt{ERF(X)} &= \frac{2}{\sqrt{2\pi}} \int_0^x e^{-\frac{t^2}{2}} dt
\end{aligned}$$

The operators are the usual FORTRAN operator +, -, *, / and ** (power). A power to an integer constant is translated in the appropriate number of multiplications. As an example the following command

```
FIT 1 P0*EXP(-.5*((X-P1)/P2)**2)/(SQRT(2PI)*P2)
```

will fit histogram 1 with a gaussian function with P0 the normalized amplitude, P1 the average and P2 the standard deviation. If you try this example be aware that in order to compute the number of events in the peak, you must take the bin width into account. Indeed, unless you are working with discrete distributions, the content of a bin is proportional to the *integral* of the probability density function over the bin, thus

$$\begin{aligned}
\frac{N_{bin}}{N_{Total}} &= \int_{x_{low}}^{x_{high}} P\left(X\right) \, dx \\
&\simeq P\left(X\right) \, \left(x_{high} - x_{low}\right)
\end{aligned}$$

where $P\left(X\right)$ is the probability density function and x_{low} and x_{high} are the bin limits.

6.3 PREDEFINED FUNCTIONS

Because some functions are very common, they have been coded inside MANHIST. Predefined functions can be selected by typing the appropriate qualifier instead of a function expression. As an example, the previous command is advantageously replaced by

```
FIT 1/GAUSS
```

The fit results are printed with explicit parameter name. If it has a meaning, the FWHM is computed and is printed after the parameter table, both in absolute value and in percent of the peak position. In case there is no analytical formula for the FWHM, the determination of the half points is made using a Newton-Ralphson method. It is possible that this method does not converge and an error message will be printed. Because this program is used by high energy physicists, most of the functions describes peak shapes.

When the function has a well-defined integral, the first parameter is the number of events in the distribution, taking into account the bin width of the histogram.

By default, the starting values are computed by MANHIST using the lowest order moments of the histogram. However, if the main feature of the distribution is only partially contained in the histogram, the starting values will be wrong and there is a risk that the fit will not converge to the proper solution. For example, this may occur when you are trying to fit a Gaussian distribution to a histogram which contains only one side of the distribution. Then the estimate for the number of events is off by a factor of two and those for the average and variance are simply wrong. In this case the fit will converge after an unusually long time. But there are cases where it may never converge properly. Using the /QUERY options will allow you to give proper starting values to the program.

Gaussian or normal distribution

The Gaussian distribution is defined as

$$N(x) = \frac{N_0}{\sqrt{2\pi\sigma^2}} e^{-\frac{(x-\mu)^2}{2\sigma^2}}$$

and is selected with /GAUSS. The fit parameters are N_0 the number of events in the peak, μ the peak position, and σ the standard deviation.

Gamma distribution

The gamma distribution is defined as

$$N(x) = N_0 \frac{\eta}{\mu\Gamma(\eta)} \left(\eta \frac{x}{\mu}\right)^{\eta-1} e^{-\eta\frac{x}{\mu}}$$

and is selected with /GAMMA. The fit parameters are N_0 the number of events in the peak, μ the peak position, and σ the exponent of the variable.

Cauchy or Breit-Wigner distribution

The Cauchy distribution is defined as

$$C(x) = \frac{N_0}{\pi} \frac{\Gamma}{x^2 + \Gamma^2}$$

and is selected with /CAUCHY. The fit parameters are N_0 the number of events in the peak, μ the peak position, and Γ the width.

Exponential distribution

The exponential distribution is defined as

$$E(x) = \frac{N_0}{\lambda} e^{-\lambda x}$$

and is selected with /EXPONENTIAL. The fit parameters are N_0 the number of events in the distribution, and λ the exponential falloff.

Polynomial

A polynomial of order n is selected by the switch /POLYNOM=n. P0 is the constant term, P1 the linear term, *etc...*

Shower profile function

This function describes very well the distribution of energy deposited in a *Crystal Ball*-like detector. It can also be applied with some success to asymmetrical peak shapes. It is defined as:

$$S(x) = \begin{cases} N_0\, e^{-\frac{(x-\mu)^2}{2\sigma^2}}, & \text{if } xd > E_0; \\ N_1 \left(\frac{E_1 - E_0}{E_1 - x}\right)^r, & \text{otherwise,} \end{cases}$$

where

$$E_0 = \mu + d\sigma$$

The parameters E_1 and N_1 are determined so that the function and its first derivative are continuous. The parameters are N_0 the peak amplitude, μ the peak position, σ the standard deviation of the normal distribution, d the distance of the discontinuity from the peak expressed in unit of σ and r the power falloff. d is positive if the peak asymmetry presents an excess of events on the left of the peak. The function is selected with the /CBENRG qualifier. This function is very stable but some shapes are completely insensitive to the value of r which will become very large during the fit. In this case, it is recommended to limit the range of r.

Gaussian distribution with an exponential tail

This function describes an asymmetrical peak which cannot be fitted with a gaussian distribution. It is defined as

$$G(x) = \begin{cases} N_0\, e^{-\frac{(x-\mu)^2}{2\sigma^2}}, & \text{if } x < \mu; \\ N_0\, e^{-\frac{(x-\mu)^2}{2\sigma^2}} + Axe^{-\frac{x}{\lambda}}, & \text{if } x \geq \mu. \end{cases}$$

when the tail is on the right hand side of the peak. The formulas must be

exchanged if the tail is on the other side. The fit parameters are N_0 the peak amplitude, μ the peak position, σ the standard deviation, A the amplitude of the exponential tail and λ the exponential falloff of the tail. The function is selected with the /GASEXP qualifier. The skewness of the histogram is used to determined where the tail is. If you do not agree with this choice, it is possible to constrain the side on which the tail is by typing /GASEXP=RIGHT or /GASEXP=LEFT. This function can become unstable and the default starting values may not always be adequate.

Gaussian distribution connected to a Fermi function

This is another function which will fit an asymmetrical peak. It is defined as

$$F(x) = \begin{cases} N_0\, e^{-\frac{(x-\mu)^2}{2\sigma^2}}, & \text{if } x > E_0; \\ \frac{N_1}{1+e^{\frac{a-x}{b}}}, & \text{otherwise,} \end{cases}$$

where

$$E_0 = \mu + d\sigma\,.$$

The parameters a and N_1 are determined so that the function and its first derivative are continuous. The parameters are N_0 the peak amplitude, μ the peak position, σ the standard deviation of the normal distribution, d the distance of the discontinuity from the peak expressed in unit of σ and b the falloff of the Fermi function. This function is selected with /GAFER. The asymmetry of the line maybe opposite if d is negative. Then the two formulas are exchanged with $x - a$ replacing $a - x$ in the formula of the Fermi function.

Difference between two Fermi functions

This function will fit large structure which are asymmetric and have a peak too flat to be fitted with gaussian function with asymmetry. It is defined as:

$$D(x) = N_0 \left\{ \frac{1}{1+e^{\frac{a_1-x}{b_1}}} + \frac{1}{1+e^{\frac{x-a_2}{b_2}}} \right\}.$$

The parameters are N_0 the peak amplitude, p the peak center, w the width of

the peak, b_1 and b_2 the falloffs of the two Fermi functions, where

$$p = \frac{b_2 a_1 + b_1 a_2}{b_2 + b_1}$$
$$w = a_2 - a_1 .$$

If this function is used to fit a peak shape which is not flat enough, the fit can becomes extremely unstable if the peak amplitude is not restricted. It is easy to see that, in this case, one of the solutions can have a very small width and a huge amplitude while the other one has an amplitude corresponding to the peak height. The latter is usually more stable.

Arbitrary shape

It is possible to use the shape of another histogram as the fit function. The parameters are the relative ratio of the Y scale, the "gain" of the X scale and an offset for the X scale. The values are linearly interpolated between bins. Thus the histogram used as a function should be smooth enough. This function is selected with `/HIST=`n where n is the ID of the histogram to use. Because one may forget that the histogram used as a fit function can easily be erased from memory, this function is not remembered and must therefore always be specified explicitly. This function can be used to implement functions which are too complicated to be entered with the formula or for which no analytic expression exists. In particular, it can be used to fit the background to a signal if one has histograms with signal and without.

Peaks on top of an arbitrary background

If you want to fit several gaussian distribution sitting on top of a background, the qualifier

`/PEAKS=`n ⟨*function expression*⟩

lets you define a function with n gaussian distribution added together to the given function. ⟨*function expression*⟩ may be any of the predefined functions

(except for /PEAKS itself) or a user defined function. As an example, to fit three peaks on top of a parabolic background, one types

```
FIT /PEAKS=3 P0+X*(P1+X*P2)
```

or using the predefined polynomials

```
FIT /PEAKS=3/POLYNOM=2
```

MANHIST will then prompt you for the range of each peak. If you are the lucky user of a graphic device which allows a locator* input, you can specify the range of the peak directly on the histogram plot. The peak range consists of the two points located at approximately $\pm 3\sigma$ of the peak center. This is used to remove the peaks to fit the background alone in order to compute the starting values of the peak parameters. After this, a global fit is performed. The parameter of the background function are listed first. Each peak is fitted with a gaussian and is described by three parameters: the number of events in the peak, its position and its standard deviation.

6.4 ADDITIONAL PREDEFINED FUNCTIONS

Three functions belong to a separate class because they correspond to a discrete distribution. In the most general case, the distribution which has been accumulated in the histogram is not directly a discrete distribution because it was obtained by an experimental measurement susceptible to fluctuations. In other words, if n is the name of the discrete variable, the variable used to filled the histogram was x where, for a given n, the average of x is given by $gn+p$. g is called the gain and p the pedestal. Thus in addition to the distribution parameters, there are three additional parameters which characterize the histogram: N_0 the total number of events, g the gain and p the pedestal. These are always the first three parameters of the fit function.

---

* cross hair, cursor, joy stick or mouse

The distribution are evaluated by calculating the generating function on a unit circle in the complex plane and by applying the fast Fourier transform to these point. The method is explained in an article of mine.[5]

Poisson distribution

The probability of obtaining n counts is defined by

$$P_n = \frac{\mu^n e^{-\mu}}{n!}$$

where μ is the fit parameter. This parameter is the average of the distribution.

Contagious Poisson distribution

The probability of a contagious Poisson distribution is defined by

$$P_n = \sum_{k=0}^{\infty} \frac{(\eta k)^n e^{-\eta k}}{k!} \frac{\mu^k e^{-\mu}}{k!}$$

where μ and η are the fit parameter. This distribution describes the probability of two convoluted Poisson distributions. μ is the average of the first distribution, η is the multiplication's factor leading to the final distribution. The computation of the starting value for this distribution requires the four lowest order moments. Because the computation of the kurtosis is wrong as soon as there are some overflows, the starting values for the parameters are always asked. Using `CHECK` before a fit is a must.

Contagious Landau distribution

This distribution is used to measure the response of a $\frac{dE}{dx}$ detector in the Landau model. It is fully described in reference 5. The parameters are: η the collection factor, ξ_0 the amount a energy deposited per unit length of medium for a particle of charge unity and infinite velocity, γ the velocity of the particle and I the ionization potential of the medium. There are no simple recipe to calculate reasonable starting values so the parameters are always asked. Moreover, the distribution is almost insensitive to γ and I and it is a good idea to have them fixed.

6.5 DEFINING THE STARTING VALUES

If the fit function is user defined or if the /QUERY qualifier was used, MANHIST will prompt you for starting values for each of the parameters. The routine used for input, allows you to type any valid floating point value. If you type a carriage return however, it will keep the default value which was printed in the prompt text. Since parameters are kept in memory, it will contain the results of the previous fit (if one has been made) for each parameter. If you did not change the function or if you are using a function with similar parameters, you have the possibility of using these values as starting point for the fit. This is also convenient if you want to overlay the same function on several histograms using the CHECK command.

If you are doing a fit (instead of a CHECK), you will be asked whether the parameter is free, which means this parameter can be varied over the entire spectrum of floating point number available. Typing a carriage return will assume that your answer to the question is yes. If you answer no, you will be prompted for the lower and upper limits for the range of variation of this parameter. The default values are set to the largest negative and positive number which can be produced on a VAX. It is good practice to reduce the range of variation for the fit parameters. This avoids to goes into non physical regions and speeds up the fitting. Unfortunately, HFIT does not allow to set the domain of variation of one parameter to zero. So if you want to have a parameter which is constant, you will have first to determine in which direction the fit wants it to vary and set the limits accordingly.

Since predefined functions can have their parameters estimated from the histogram data, they do not ask for starting values by default. However, the default may be overwritten by the /QUERY qualifier if one wants to take advantage of the previous fit results or to limit the range of variation.

6.6 THE CHECK COMMAND

The CHECK command has the same syntax than the FIT command and supports all its qualifiers (although some of then are out of context). This command will compute the function and overlay it on the histogram. In this case, the parameter values are always asked except if the /NOQUERY qualifier is explicitly used. Of course, the question whether the parameter is free or not will not be asked. The command allows to check whether the start values for the parameters are adequate or simply to compare a histogram with a previous fit. The deviation plot is not produced by default. In order to obtain it, the qualifier /DEVIATION=PLOT must be used.

6.7 FIT RELATED COMMANDS

The function stored in memory is common to both commands FIT and CHECK. Thus one does not need to type the function expression very often. Once the user has decided upon a fit function, he will be able to overlay the previous fit function on a new histogram or simply play with other parameters values without having to type it. In case the user does not remember which function he is currently using, the command

```
SHOW FUNCTION/FIT
```

will display the function's formula. In case of a predefined function, the function's name is printed.

Fit results are so important that one would like to have them printed on the same page than the histogram itself. To achieve this, the plot results are saved on a scratch file everytime a fit is done, even when the /NOPLOT switch is specified in the command. The command

```
PLOT RESULT
```

will plot the results of the last fit in table form on the upper half of the next window. Unless the window corresponds to a full page, there is little chance that

the results be readable. The results are tabulated in the same way that they are printed. In order not to lose information, the size of the characters used to print the parameter names, values, errors and correlation are scaled so that the longest line (that of the last parameter) fits across the page. This is usually good enough unless the number of parameters is very large. If you prefer to lose part of the correlation matrix and be able to read the parameter values, you can supersede the character scaling by specifying the /LINES=*n* qualifier after the command, where *n* is the parameter line which should still fit within the histogram box. Characters falling outside the box are clipped.

7. Creating new histograms

HBOOK gives the user opportunities of defining fancy booking options for 2-dimensional histograms. However, if you like for fit a projection, a band or a slice as a one-dimensional histogram, you will have to work a little in order to do it because it is not directly available as a histogram in HBOOK. MANHIST gives you the possibility of creating a new histogram out of a booking options. In fact, you can even perform this task when the option was not booked. MANHIST provides many other ways to create new histograms.

7.1 EXTRACTING BOOKING OPTIONS

When a 2-dimensional histogram has been booked with some options — projections, slices or bands — it is possible to create a 1-dimensional histogram from one option with the command

CREATE/ID=*n*{/⟨*qualifiers*⟩ ⟩ } {⟨*histogram number*⟩ }

where *n* is the ID of the newly created histogram. One of the optional qualifier allows to select a title for the new histogram and come in two flavors

/TITLE="⟨*title string*⟩ "

/TITLE=SAME

The latter will of course select the original title. If this qualifier is omitted, the title will be that of the old histogram prefixed with a string describing the selected option.

The following qualifiers select the option. Only one of them can be used on the command.

— /HIST will create a new histogram with the 2-dimensional histogram without any other booking options.

— /PROX or /PROY will create a 1-dimensional histogram which is the X or Y projection of the original.

— /BANX=n or /BANY=n will create a 1-dimensional histogram out of the select band.

— /SLIX=n or /SLIY=n acts similarly on the slices.

It is important to stress that the booking option must exists in order to use the command. If this is not the case, one should use the CUT command. Of course, most of the qualifiers will not be accepted if the histogram is 1-dimensional. Also the overflow and underflow information are lost.

If none of the qualifiers are used, a duplicate of the histogram is made. This will also be the case if you specify /HIST for a 1-dimensional histogram. This is a way of changing the ID of a histogram if you need to simultaneously load two histograms saved with the same ID into memory.

7.2 EXTRACTING PIECES OF A HISTOGRAM

The CUT command allows to extract portion of an histograms. It can be used to restrict the range of a 1-dimensional histogram or to create projections out of a 2-dimensional one. The syntax of the CUT command is

CUT/ID=n{/⟨{⟨*histogram number*⟩ }⟩ }

where n is the ID of the newly created histogram. This command is very similar to the CREATE command. The main difference is that CREATE only extract exist-

ing information from a histogram whereas CUT generates the information. The /TITLE qualifier acts the same as before.

The qualifiers /MIN=x and /MAX=x allow to define limits for the extraction. If one or the other is omitted, the limit used will correspond to the corresponding bound of the histogram. They act differently whether the histogram is 1- or 2-dimensional. These limits may also be entered with a locator if the current device supports one. If this case, the qualifier SENSE must be used instead. Windowing is temporarily reset and the histogram will then be plotted on a full page. The user can then use the locator to select the range. If the limits do not correspond to a bin limit they will be changed to the closest bin boundary and an informative message will appear.

If the histogram is 1-dimensional, the new histogram contains the bins of the old one which are between the specified limits. Underflow and overflow information is lost.

For 2-dimensional histograms, /PROX or /PROY must be specified as qualifiers. Then the new histogram consists of the projection onto the specified direction within limits applying to the other variable, *i.e.*

```
CUT/ID=2/PROX/MIN=10./MAX=80.  1
```

will create histogram 2 as being a projection on the X axis of histogram 1 restricted to the bin which lay in the band defined by $10 < y < 80$. Thus, this command allows to generate projections and bands or slices when they were not specified as a booking option. However, the user must be sure that the 2-dimensional histogram did not saturate, otherwise the projection will not be correct. There is also a fundamental difference between projections which have been booked and projection generated with the CUT command because the information about overflows in the direction perpendicular to that of the projection will be lost. To be more explicit, let us assume that histogram 1 is a 2-dimensional histogram booked with $0 < x < 100$, $10 < y < 90$ and a call of HBPROX had been made. Then, after the following commands

```
CREATE/ID=2/PROX 1

CUT/ID=3/PROX 1,
```

histograms 2 and 3 will not be equal if histogram 1 was filled with points for which $0 < x < 100$ and $y > 90$. This fact may be turned to your advantage to get the x distribution of the points falling outside range for the y variable by taking the difference between histogram 2 and 3.

The CUT command allows you to generate a histogram (ID= n) with the same booking option than another and filled with a constant. The command is

CUT/ID=n/CONSTANT=x ⟨*histogram number*⟩

and the TITLE qualifier may be used as well. Combined with the histogram arithmetic, it allows to subtract (or add) a constant to all channels of a histogram. An example of it will be given at the end of the next section.

7.3 ARITHMETIC BETWEEN HISTOGRAMS

HOPERA is my favorite HBOOK subroutine, maybe because I used to work on polarization experiments. If one measures the angular distribution of some events for two opposite polarization of the target (as an example), then the polarization parameter can be extracted by taking the ratio between the difference and the sum of the two histograms, *i.e.*

$$P_i = \frac{A_i - B_i}{A_i + B_i} \quad \text{for } x = 1, \ldots, n$$

where n is the number of bins in each histograms, A_i and B_i are the content of the histograms for opposite polarization of the target and P_i is the polarization parameter. The ability of performing operations on histograms is so useful that is was the next command added to MANHIST after the fit was working. The syntax is quite different for the rest

⟨ID⟩ = {(⟨*constant*⟩)}⟨ID⟩ ⟨*operator*⟩ {(⟨*constant*⟩)}⟨ID⟩

where ⟨*operator*⟩ can be +, -, * or /. ⟨*constant*⟩ follows the usual FORTRAN-like syntax. If omitted, constants are defaulted to 1. Both operand histograms must have been declared with same limits and bin number. The result histogram may be the same as one of the operand. If not, a new histogram is created with the same booking options than the operand and the title is that of the first one. See the description of HOPERA in the HBOOK manual for more detail.

Let assume that one has measured an angular distribution in histogram 1 with the target spin up and in histogram 2 with the target spin down, and that both histograms have been saved using HSTORE on file POLAR.HBK. Then the following commands will compute the angular dependence of the polarization parameter.

```
FILE POLAR
3=1-2
4=1+2
3=3/4
```

After this sequence of instructions, histogram number 3 will contain the polarization distribution. The errors, however, will not be computed if the histograms 1 and 2 were not booked with the HBARX option. To ensure the correct computation of the errors in this case, the following commands will perform the correct sequence.

```
FILE POLAR
FETCH 1
SET ERROR
FETCH/NODELETE 2
SET ERROR
3=1-2
4=1+2
3=3/4
```

Finally, if the two histograms contain a constant background, the following sequence of commands will first remove the background and then compute the

polarization.

```
FILE POLAR
FETCH 1
SET ERROR
FETCH/NODELETE 2
SET ERROR
CUT/ID=99/CONSTANT=100.
1=1-99
2=2-99
3=1-2
4=1+2
3=3/4
```

If a HSTORE file is currently opened, the histograms used as operand do not need to be loaded in memory. If they are not, they will be searched from the file. Restriction to the FETCH/NODELETE command will apply here too!

7.4 REMOVING PORTIONS OF A HISTOGRAM

The command

CLEAR/ID=*n*{/({{⟨*histogram number*⟩ }) }{FOR ⟨*function expression*⟩ }

allows to create a histogram in which a selected region has been cleared. The optional qualifier, /TITLE, works as for the CREATE command. If omitted, the title of the new histogram will be that of the old prefixed with the string "Cleared". ⟨*function expression*⟩ is a function which is given using the same syntax as for user defined functions of the FIT command. The expression is evaluated at the center of each bin. If the result is not positive, the bin content is cleared.

As for the fit function, the CLEAR function formula is stored in memory and will be used if the function is omitted on the next CLEAR command. Of course

the first command must specify a function. If the user does not remember what is the expression used for clearing, the command

```
SHOW FUNCTION/CLEAR
```

will display the function's formula. The function may contain parameters. If it does, parameters will be prompted like for the CHECK command. These parameters are independent from those of the fit function.

If the current graphic device is equipped with a locator input, the command may be typed as

CLEAR/ID=*n*/SENSE{/⟨{⟨*histogram number*⟩ }⟩ }

in order to select a segment on a 1-dimensional histogram or a square for a 2-dimensional one. As for the CUT or the FIT /PEAKS commands, the histogram will be drawn on the screen and the locator can be moved to indicate two positions. The position are rounded off to the nearest bin limit if necessary and a message is issued if this is the case. The order of input determines whether the inside or the outside of the region is cleared. If the X position of the first position is larger than that of the second, the outside of the segment or of the square is cleared.

If a 1-dimensional histogram had been booked with error bars, the cleared bins are assigned a error of zero. In the 2-dimensional case, only a single histogram is generated regardless of the booking options of the histogram used as input. If projections, bands and/or slices are required, the CUT command should be used.

The utility of this command will be demonstrated in an example which will illustrate the use of other commands as well. Let us suppose than histogram 1 (1-dimensional) contains an asymmetrical peak sitting of top of an arbitrary background which can be approximated by a third order polynomial. The goal is to fit the peak which lies in the region $100 < x < 300$. We assume that the histogram is already in memory.

```
CLEAR/ID=2 1 FOR (X-100)*(300-X)
```

```
FIT 2 /POLYNOM=3
CHECK/DEV=3 1
FIT 3 /GAFER
```

The first command clears the region where the peak is. The second will perform the polynomial fit. Because the fit will ignore the points with zero error bars, the zone of the peak is not included in the fit. The check command is then used to generate the difference between the original histogram and the fitted background. These differences are stored in histogram 3. Note that the CHECK will use the same function used in the last fit. The parameters will be prompted but the default values will be the results of the last fit so that the user only needs to type four carriage returns. The final fit will deliver the peak parameters.

7.5 SMOOTHED HISTOGRAMS

Smoothed histogram are generated with the command

SMOOTH/ID=*n*{/⟨{⟨*histogram number*⟩ }⟩ }

where the optional qualifier is /TITLE as described in the previous commands. If omitted, the title is prefixed with the string "Smoothed". The algorithm used is "353QH *twice*".[6]

7.6 REDEFINING THE BINNING

It is possible to group bins together to generate a histogram with a larger bin size with the command

MERGE/ID=*n*{/⟨{⟨*histogram number*⟩ }⟩ }

where one of the optional qualifiers is /TITLE as described earlier. If omitted, the title is prefixed with the string "Merged". The two other qualifiers are /BINX=*n* and /BINY=*n* where *n* is the number of bin to be added together. For a 1-dimensional histogram, /BINX=*n* is mandatory. One of the two qualifiers must be specified for a 2-dimensional histogram. The last bin of the new histogram

may be the combination of less bins than specified if the number of bins is not a multiple of that of the original histogram.

7.7 HISTOGRAM FILLED WITH A FUNCTION

It is possible to generate a histogram whose contents is the value of an arbitrary function evaluated at the center of each bin with the command

FUNCTION/ID=n{/⟨*qualifiers*⟩ } {⟨*histogram number*⟩ }⟨*function expression*⟩

where the qualifiers corresponds to the parameters of the routines HBOOK1 and HBOOK2.

- /TITLE="⟨*title string*⟩ " defines the title of the histogram.
- /BIN=n defines the number of bin for a 1-dimensional histogram.
- /MINIMUM=x defines the lower limit for a 1-dimensional histogram.
- /MAXIMUM=x defines the upper limit for a 1-dimensional histogram.
- /XBIN=n defines the number of bin in the X direction for a 2-dimensional histogram.
- /XMINIMUM=x defines the lower limit of the X variable for a 2-dimensional histogram.
- /XMAXIMUM=x defines the upper limit of the X variable for a 2-dimensional histogram.
- /YBIN=n defines the number of bin in the Y direction for a 2-dimensional histogram.
- /YMINIMUM=x defines the lower limit of the Y variable for a 2-dimensional histogram.
- /YMAXIMUM=x defines the upper limit of the Y variable for a 2-dimensional histogram.

If any of these qualifiers is omitted, the corresponding value is taken from the declaration of the histogram specified as parameter or from the last accessed histogram if no parameter is specified.

Instead of a long series of qualifiers, the following

```
/BIN=n/MINIMUM=x/MAXIMUM=x/SCATTERPLOT
```

will declare a scatterplot with identical binning and limits in the X and Y direction.

The function expression may contain parameters, in which case they will be prompted to the user. The function expression is not kept in memory however, so that if the user wants to use the command to study the behavior of the function by generating several histograms with different parameter values, it is best to store the command on an indirect file or in the memory. As an example:

```
SET MEMORY/ON
DELETE/ALL
FUNCTION/BIN=300/MIN=-10/MAX=10/ID=1 (1./(1.+EXP((X-P0)/P1)))
PLOT 1
SET MEMORY/OFF
```

allows you to display the shape of a Fermi function for various parameters by just typing @MEMORY. In this example, the delete command makes sure that no histogram with the same ID exists. Also note that the function starts with an extra parenthesis to avoid the leading constant to be mistaken for a histogram ID.

8. Miscellaneous commands

8.1 HISTOGRAM DELETION

The command

```
DELETE {⟨histogram number⟩ }
```

allows to remove a histogram from memory. Of course, the histogram is not removed from the file is was read from. In order to remove all histogram from the memory type

```
DELETE/ALL
```

8.2 GENERAL HEADER FOR PLOTS

As mentioned in the chapter devoted to histogram input, the routine HSTORE does not save the general title. If you like to include one or if you want to overwrite the current one, type

SET TITLE "⟨*title string*⟩ "

8.3 USING HPLOT SOFTWARE CHARACTERS

HPLOT generates its own set of characters. This set has three fonts respectively named roman, greek and special symbols (mostly mathematical). Each of the font has upper and lower case characters. Lower case characters are not recognized by HPLOT so that the title must be typed in upper case if you want to be able to read them on the plot. The user should refer to the HPLOT manual for a detailed description of the fonts but here is a summary of the special characters which allow to switch between fonts and generate sub- and superscripts.

& will backspace one character.

∨ will switch to superscript.

? will switch to subscript.

! will return to normal level of script.

< will switch to lower case.

> will switch to upper case.

[will switch to the greek font.

] will return to the font used before the switch to greek occurred

" will switch to the special symbol font.

will return to the font used before the switch to special symbol occurred

8.4 CREATING ERRORS FOR HISTOGRAMS

The default errors for histograms is the square root of the contents. This is fine for most application, but when you perform arithmetic with histogram, the error propagation is not done unless errors bars have explicitly been assigned to at least one of the operands. The command

SET ERRORS {⟨*histogram number*⟩ }

assign error bars to the histograms which are equal to the square root of the content. This command will do nothing if the histogram already has error bars defined.

As mentioned in the chapter devoted to fitting, bins with zero content, because they have by default a zero error, are not taken into account in a fit. We have seen how one can take advantage of it in the example for the CLEAR command. The command

SET ERRORS/ZERO=x {⟨*histogram number*⟩ }

defines the errors for the bins with zero content to be equal to x. This way you can adjust the weight of these bins for the fitting.

8.5 AUTOMATIC PLOTTING

The command

BROWSE{/⟨*qualifier*⟩ }

will fetch histograms from a file in HSTORE format which must has been opened with a file command. Histograms are fetched one by one and plotted on the current graphic device. This command is intended to be executed in batch mode for mass production. The input file is closed when all histograms have been processed. The command supports the following qualifiers.

— /QUERY will cause the execution of the command to pause after each histogram has been processed. The user is asked whether is want to resume execution or not.

— /CHANNEL=*n* redefines the current graphic device.

— /PRINT will cause the histograms to be printed instead of plotted.

— /FILE=⟨*file name*⟩ will cause the indirect file ⟨*file name*⟩ (default extension .EXC) to be executed for each histogram with the histogram ID as the parameter.

As an example, let assume that all histograms of a file represents discriminator curves and must be fitted with a Fermi function Let also assume that the user want a quality display of the fits like the one generated by the file PRETTY.EXC shown at the beginning of the manual. The user will write a file NICE.EXC containing the following commands

```
FIT/NOPLOT/NOPRINT 'P1
SET WINDOW/NX=1/NY=1
PLOT RESULT
SET WINDOW/NY=2/SAME/WIN=2
PLOT 'P1
```

Let us assume that the histograms are stored on file HISTO.HBK with IDs 1,2,3 and 4. Then one could type

```
FILE HISTO
FETCH
FIT/NOPLOT/NOPRINT PO/(1.+EXP((X-P1)/P2)
SET WINDOW/NX=1/NY=1
PLOT RESULT
SET WINDOW/NY=2/SAME/WIN=2
PLOT
FETCH
@NICE
FETCH
@NICE
FETCH
```

```
@NICE
```

However, if the histograms have very similar parameters, *i.e.* the results of one fit can be used as the starting values of the others, one can use the BROWSE command efficiently by slightly modifying the command file to

```
FIT/NOPLOT/NOPRINT/NOQUERY 'P1
SET WINDOW/NX=1/NY=1
PLOT RESULT
SET WINDOW/NY=2/SAME/WIN=2
PLOT 'P1
```

Then typing

```
FILE HISTO
FETCH
FIT/NOPLOT/NOPRINT P0/(1.+EXP((X-P1)/P2)
SET WINDOW/NX=1/NY=1
PLOT RESULT
SET WINDOW/NY=2/SAME/WIN=2
PLOT
BROWSE/NOQUERY/FILE=NICE
```

will perform the fits automatically for all the histograms stored on the file after the first one. Note that the file NICE.EXC is independent of the fit function. All that is needed is that the fit results can be used as the starting values for the next one.

9. Demonstration command file

Dr. Jim Napolitano began writing a demonstration file which I have tried to keep up to date as I introduced new commands. This file is intended to be a tutorial for the novice. I include a listing of the terminal output generated by the command file The plots were produced on a versatec and are included at the end of the manual in the order they have been generated. The command used to open the graphic device was:

```
OPEN VEP12FF,ROTAXIS,GENIL
```

where the ROTAXIS option forces the plot to be vertical and the GENIL option is used to generate thick lines. All user inputs are in lower case. During the execution of the file, the terminal width was set to 80 columns and the wrapping was suppressed. Because of this, the output for the SHOW HISTOGRAM command and the fit results are truncated.

```
$ show time
  23-MAR-1985 08:32:26
$ set terminal/nowrap
$ @mandir:manexmple
Previous logical name assignment replaced
Previous logical name assignment replaced
  ##### MANHIST Help Session #####
Respond to the MANHIST> prompt with the
statement @MANDIR:MANEXMPLE.
*****   MANHIST  V 5-00   *****
MANHIST>@mandir:manexmple
MANHIST...!
MANHIST...!     MANHIST, WRITTEN BY D. BESSET OF PRINCETON UNIVERSITY, IS
MANHIST...! A PROGRAM FOR MANIPULATING HISTOGRAMS.  WRITTEN SPECIFICALLY FOR
MANHIST...! THE VAX/VMS OPERATING SYSTEM, IT IS A USER-UTILITY INTERFACE
```

```
MANHIST...! TO THE CERN-HBOOK HISTOGRAM LIBRARY.
MANHIST...!
MANHIST...!     THIS COMMAND PROCEDURE IS MEANT AS A GUIDE TO THE
MANHIST...! AVAILABLE COMMANDS IN MANHIST.  EXAMPLES ARE GIVEN FOR NEARLY ALL
MANHIST...! COMMANDS IN A LARGE VARIETY OF SITUATIONS.  AT VARIOUS POINTS IN
MANHIST...! THIS EXAMPLE, EXECUTION IS HALTED BY MEANS OF THE @TT COMMAND.
MANHIST...! AT THIS POINT YOU MAY TYPE IN COMMANDS TO TRY OUT THE NEW EXAMPLE,
MANHIST...! OR JUST RESUME EXECUTION BY TYPING CONTROL-Z (I.E. THE CTRL AND Z
MANHIST...! KEYS DEPRESSED SIMULTANEOUSLY).  IF YOU WANT TO EXIT FROM THIS
MANHIST...! EXAMPLE AT ANY TIME, JUST TYPE "EXIT" AFTER THE @TT COMMAND.
MANHIST...!
MANHIST...!     FOLLOWING IS AN @TT COMMAND.  TRY RESUMING USING THE COMTROL-Z
MANHIST...! COMMAND, OR TYPE "HELP", OR "EXIT" IF YOU ARE BORED ALREADY.
MANHIST...!
MANHIST...@TT
MANHIST>^Z
MANHIST...!
MANHIST...!     MANHIST COMES WITH AN EXTENSIVE HELP LIBRARY.  TO ACCESS IT,
MANHIST...! SIMPLY TYPE HELP FOLLOWED BY THE COMMAND THAT YOU ARE INTERESTED IN.
MANHIST...! FOR EXAMPLE "HELP INDIRECT" HELPS ON SO-CALLED INDIRECT COMMANDS
MANHIST...! WHICH ARE ENTERED BY EXECUTING A FILE WITH A LIST OF MANHIST
MANHIST...! COMMANDS.  THE FILE MANEXMPLE.EXC WHICH IS RUNNING THIS EXAMPLE
MANHIST...! SESSION IS ONE SUCH INDIRECT COMMAND FILE.  OTHER INFORMATION ON
MANHIST...! INDIRECT COMMAND FILES CAN BE OBTAINED BY TYPING "HELP SET VERIFY"
MANHIST...! OR "HELP SET MEMORY".  IF YOU ARE A NOVICE USER, IT IS A GOOD IDEA
MANHIST...! TO TYPE HELP FOR EACH OF THE COMMAND THAT YOU WILL SEE DURING THIS
MANHIST...! SESSION AFTER AN @TT COMMAND.  THEN YOU CAN RESUME THE NORMAL FLOW
MANHIST...! BY TYPING CONTROL-Z.
MANHIST...!
```

```
MANHIST...!     NOW WE WILL GET STARTED.  TYPE CONTROL-Z WHEN YOU ARE READY
MANHIST...! TO GO.
MANHIST...!
MANHIST...@TT
MANHIST>^Z
MANHIST...!
MANHIST...!     AN EXAMPLE HISTOGRAM FILE HAS BEEN PROVIDED FOR THIS EXAMPLE.
MANHIST...! IT IS CREATED WITH THE A CALL TO THE HSTORE SUBROUTINE IN THE HBOOK
MANHIST...! LIBRARY.  MANHIST ITSELF CAN ALSO BE USED TO CREATE SUCH FILES.
MANHIST...! WE WILL GET TO THAT LATER.  THE FILE IS ACCESSED VIA THE COMMAND
MANHIST...! "FILE" AS FOLLOWS:
MANHIST...!
MANHIST...FILE MANDIR:MANEXMPLE.HBK !MANDIR IS LOGICAL NAME OF DIRECTORY
MANHIST...!                          IN WHICH MANHIST IS KEPT
MANHIST...SHOW FILE
All histograms are deleted.
File repositioned at beginning.
Table of histograms on file MANDIR:MANEXMPLE.HBK
************************************************
        1 (1-dim.) TEST HISTOGRAM 1
        2 (1-dim.) TEST HISTOGRAM 2
        3 (2-dim.) SCATTERPLOT EXAMPLE
File repositioned at beginning.
MANHIST...@TT
MANHIST>^Z
MANHIST...!
MANHIST...!     NOW WE ARE READY TO MANIPULATE THE HISTOGRAMS IN THE
MANHIST...! EXAMPLE FILE.  THIS FILE WILL PLOT THE RESULTS ON A GRAPHIC
MANHIST...! DEVICE THAT YOU CHOOSE.  TO CHOOSE A GRAPHIC DEVICE, USE THE "OPEN"
```

```
MANHIST...! COMMAND. IF YOU HAVE THE CHOICE, PICKUP A DEVICE WHERE THE PLOT
MANHIST...! OUTPUT CAN BE VIEWED AT ONCE AND WHERE THE PLOT IS NOT DISPLAYED
MANHIST...! ON THE TERMINAL, LIKE THE FOLLOWING:
MANHIST...!
MANHIST...!  "OPEN SDDGRIN"                          FOR A GRINNEL GRAPHIC SYSTEM
MANHIST...!  "OPEN SDD4010,CHANNEL=TEKTERM"            FOR REMOTE TEKTRONIX(*)
MANHIST...!  "OPEN SDD4010,RVT100,CHANNEL=_TTA2:"    FOR REMOTE RETROGRAPHICS VTO
MANHIST...!  "OPEN SDD4010,RADM3A,CHANNEL=_TTA2:"    FOR REMOTE RETROGRAPHICS ADA
MANHIST...!
MANHIST...!(*) ASSUMING THE LOGICAL NAME TEKTERM HAS BEEN ASSIGNED TO THE RIGHT
MANHIST...!    TERMINAL. IF NOT, USE THE DEVICE NAME (_TTXX:).
MANHIST...!
MANHIST...! IF YOU DO NOT HAVE ONE OF THOSE, TYPE CTRL-Z
MANHIST...@TT
MANHIST>^Z
MANHIST...!
MANHIST...! IF YOU ONLY HAVE A GRAPHIC TERMINAL, TRY IT, BUT KEEP IN MIND THAT
MANHIST...! THE WINDOWING WILL NOT BE AS EFFECTIVE AS IT SOUNDS. THESE ARE THE
MANHIST...! GRAPHIC TERMINALS THAT MANHIST RECOGNIZED:
MANHIST...!
MANHIST...!  "OPEN SDDGIGI"                          ON A REGIS SPEAKING TERMINAL
MANHIST...!  "OPEN SDD4010"                          ON A TEKTRONIX TERMINAL
MANHIST...!  "OPEN SDD4010,RVT100"                   ON A RETROGRAPHICS VT100
MANHIST...!  "OPEN SDD4010,RADM3A"                   ON A RETROGRAPHICS ADM3A
MANHIST...!
MANHIST...! IF YOU DO NOT HAVE ONE OF THOSE, TYPE CTRL-Z
MANHIST...@TT
MANHIST>^Z
MANHIST...!
```

```
MANHIST...! FINALLY, YOU CERTAINLY LIKE TO GET A RECORD OF THE PLOT ON A
MANHIST...! HARDCOPY DEVICE TO STUDY DETAILS (AND TO MAKE ADVERTISEMENT!).
MANHIST...! THESE ARE THE HARDCOPY DEVICES THAT MANHIST RECOGNIZED:
MANHIST...!
MANHIST...!  "OPEN VEP12FF,ROTAXIS,DDNAME=MANEXMPLE.PLT" FOR VERSATEC PLOTS
MANHIST...!  "OPEN PRNTRNX,ROTAXIS,DDNAME=MANEXMPLE.PL   FOR PLOTS ON THE
MANHIST...!                                PRINTRONIX VERSATEC EMULATOR.
MANHIST...!
MANHIST...!     IF YOU ARE NOT USING A GRAPHIC DEVICE NOW, DO NOT TYPE AN
MANHIST...! "OPEN" COMMAND.  HARMLESS ERROR MESSAGES WILL APPEAR PERIODICALLY.
MANHIST...! YOU MAY ALSO VIEW THE EXAMPLE USING THE PRINT COMMAND AFTER EACH
MANHIST...! EXAMPLE.
MANHIST...!
MANHIST...@TT
MANHIST>open vep12ff,rotaxis,genil,ddname=manexmple.plt
MANHIST>^Z
MANHIST...!
MANHIST...!     PRESUMABLE YOU HAVE NOW CHOSEN A GRAPHIC DEVICE.  FOR MORE
MANHIST...! INFORMATION, REQUEST "HELP" ON THE COMMANDS "OPEN", "SET DEVICE"
MANHIST...! AND "SHOW DEVICE".
MANHIST...!
MANHIST...!     NOW EXAMINE THE FILED HISTOGRAMS.  WE COULD LOOK AT THEM
MANHIST...! ONE AFTER THE OTHER WITH THE "BROWSE" COMMAND, BUT INSTEAD WE WILL
MANHIST...! EXAMINE THEM ONE-BY-ONE HERE.
MANHIST...!
MANHIST...FETCH 1
MANHIST...PLOT
MANHIST...!
MANHIST...!     YOU HAVE JUST PLOTTED THIS HISTOGRAM ON THE CHOSEN DEVICE.
```

```
MANHIST...!
MANHIST...@TT
MANHIST>^Z
MANHIST...!
MANHIST...!     THE EXAMPLE HISTOGRAM IS A PULSE HEIGHT SPECTRUM FROM A
MANHIST...! NAI(TL) DETECTOR FROM BOMBARDING A 6-LI TARGET WITH AN ALPHA BEAM.
MANHIST...! THE HIGH ENERGY GAMMA LINES ARE LESS PROMINENT AND ARE HARD TO SEE.
MANHIST...! WE CAN FORCE A LOG SCALE TO EXAMINE THEM MORE CLEARLY.
MANHIST...!
MANHIST...SET SCALE/LOG
MANHIST...PLOT
MANHIST...!
MANHIST...@TT
MANHIST>^Z
MANHIST...!
MANHIST...!     NOW LET'S GET THE NEXT HISTOGRAM.  THIS IS FROM BOMBARDMENT OF
MANHIST...! THE SAME TARGET WITH A SLIGHTLY HIGHER ENERGY ALPHA BEAM.  THE
MANHIST...! DEFAULT OF FETCH WOULD BE TO DELETE THE EXISTING HISTOGRAM, BUT
MANHIST...! THIS DEFAULT MAY BE OVERRIDDEN.
MANHIST...!
MANHIST...FETCH/NODELETE
Read histogram ID           2
MANHIST...SET SCALE/LOG
MANHIST...PLOT
MANHIST...!
MANHIST...@TT
MANHIST>^Z
MANHIST...!
MANHIST...!     NOW WE EXAMINE A PARTICULAR PORTION OF THE SPECTRUM.  WE
```

```
MANHIST...! "CUT" OUT THE INTERESTING PORTIONS OF THE TWO HISTOGRAMS, PLOT
MANHIST...! THEM EACH, THEN "NORMALIZE" THEM TO THE SAME AREA AND PLOT ONE
MANHIST...! ON TOP OF THE OTHER. WE ALSO REQUEST THAT THE ID AND THE STATISTICS
MANHIST...! BE PLOTTED ALONG FOR THE FIRST TWO. (SET PLOT HAS MANY OPTIONS!
MANHIST...! CONSULT THE HELP FOR IT).
MANHIST...!
MANHIST...CUT/MIN=800/MAX=880/ID=100 1
Minimum cut value reset to     800.     to correspond to a bin limit
Maximum cut value reset to     880.     to correspond to a bin limit
MANHIST...CUT/MIN=800/MAX=880/ID=101 2
Minimum cut value reset to     800.     to correspond to a bin limit
Maximum cut value reset to     880.     to correspond to a bin limit
MANHIST...SET WINDOW/NX=2/NY=2
MANHIST...SET PLOT/IDS/STATISTICS
MANHIST...PLOT 100
MANHIST...PLOT 101
MANHIST...SET PLOT/NOIDS/NOSTATISTICS
MANHIST...NORMALIZE/ID=100 101
MANHIST...PLOT 101
MANHIST...PLOT 100
MANHIST...PLOT/SAME 101
MANHIST...SET WINDOW/NX=1/NY=1
MANHIST...!
MANHIST...!     THE VERTICAL SCALES ON THE OVERPLOT ARE SET DIFFERENTLY FOR
MANHIST...! EACH HISTOGRAM.  THEY CAN BE FORCED THE SAME BY USING THE COMMANDS
MANHIST...! "SET SCALE/MIN", "SET SCALE/MAX", OR "SET SCALE/COMMON".
MANHIST...!
MANHIST...@TT
MANHIST>^Z
```

```
MANHIST...!
MANHIST...!      INSTEAD OF "CUT", HISTOGRAMS MAY BE "CLEARED".
MANHIST...!
MANHIST...CLEAR/ID=102 100 FOR X-820.0
MANHIST...PLOT 102
MANHIST...@TT
MANHIST>^Z
MANHIST...!
MANHIST...!      WE MAY ALSO "SMOOTH" HISTOGRAMS USING AN AVERAGING
MANHIST...! ALGORITHM (353QH TWICE).
MANHIST...!
MANHIST...SMOOTH/ID=103 101
MANHIST...PLOT 103
MANHIST...@TT
MANHIST>^Z
MANHIST...!
MANHIST...!      WE HAVE BEEN MAKING A LOT OF NEW HISTOGRAMS.  WE CAN SEE
MANHIST...! WHICH ONES ARE STORED IN MEMORY AND WHAT THEIR PARAMETERS ARE.
MANHIST...! THE PRINTOUT IS DESIGNED FOR A 132 CHARACTER LONG OUTPUT DEVICE
MANHIST...! (E.G. A LINE PRINTER).  IF YOU ARE ON A VT100 TERMINAL (AND NOT
MANHIST...! EXECUTING FROM A COMMAND PROCEDURE) YOU COULD ISSUE THE COMMAND
MANHIST...! "DCL SET TERM/WIDTH=132" TO CHANGE YOUR TERMINAL CHARACTERISTICS.
MANHIST...!
MANHIST...SHOW HIST
.....................................................................
.                                                                   .
.   HBOOK   VAX  CERN              VERSION   3.31       HISTOGRAM AND PLOT INDE.
.                                                                   .
.....................................................................
```

NO	TITLE	ID	B/C	ENTRIES	DIM		NCH.
1	TEST HISTOGRAM 1	1	32	4750	1	X	95.
2	TEST HISTOGRAM 2	2	32	4750	1	X	95.
3	C<UT> TEST HISTOGRAM 1	100	32	80	1	X	8.
4	C<UT> TEST HISTOGRAM 2	101	32	80	1	X	8.
5	C<LEARED> C<UT> TEST HISTOGRAM 1	102	32	80	1	X	8.
6	S<MOOTHED> C<UT> TEST HISTOGRAM 2	103	32	80	1	X	8.

MEMORY UTILISATION

MAXIMUM TOTAL SIZE OF BLANK COMMON 2700

USER AREA IN BLANK COMMON 0

MANHIST...@TT

```
MANHIST>^Z
MANHIST...!
MANHIST...!     LET'S GET RID OF ALL THESE EXTRA THINGS AND DO SOME OTHER
MANHIST...! EXAMPLES.
MANHIST...!
MANHIST...DELETE/ALL
MANHIST...FETCH 1
File repositioned at beginning.
MANHIST...FETCH/NODEL 2
MANHIST...!
MANHIST...!     THE DATA FROM SPECTRUM 2 WERE TAKEN FOR ONLY 0.40 AS LONG A
MANHIST...! TIME AS SPECTRUM 1.  LETS SUBTRACT THE TWO AND SEE WHAT IS LEFT.
MANHIST...! SINCE THE DEFAULT ERRORS ARE THE SQUARE ROOT OF THE CONTENT, AND
MANHIST...! THAT NEITHER HISTOGRAMS HAVE BEEN BOOKED WITH ERRORS (HBARX), WE
MANHIST...! FIRST HAVE TO DEFINE ERRORS WITH THE SET ERROR COMMAND SO THAT THE
MANHIST...! RESULT OF THE OPERATION HAVE THE CORRECT ERRORS FOR LATER USE.
MANHIST...!
MANHIST...SET ERROR 1
MANHIST...SET ERROR 2
MANHIST...100=(0.5)2-(0.2)1
MANHIST...CREATE/ID=101/TITLE="<[G]> S<PECTRUM" 100
MANHIST...PLOT 101
MANHIST...!
MANHIST...@TT
MANHIST>^Z
MANHIST...!
MANHIST...!     THE PEAK AROUND CHANNEL 500 IS OF INTEREST. LET'S EXAMINE
MANHIST...! IT BY CUTTING IT OUT, PLOTTING IT, AND PRINTING IT. THIS TIME
MANHIST...! THE ID AND STATISTICS ARE PLOTTED ALONG. NOTE THAT BECAUSE OF THE
```

```
MANHIST...! LARGER PLOT, MORE STATISTICS THAN LAST TIME COULD BE PLACED ON THE
MANHIST...! PLOT.
MANHIST...!
MANHIST...CUT/MIN=490/MAX=550/ID=102/TITLE="PEAK" 101
Minimum cut value reset to     490.     to correspond to a bin limit
Maximum cut value reset to     550.     to correspond to a bin limit
MANHIST...SET PLOT/STATISTICS/IDS
MANHIST...PLOT 102
MANHIST...SET PLOT/NOSTATISTICS/NOIDS
MANHIST...SET PRINT/ERROR=YES
MANHIST...!
MANHIST...!     TYPE CONTROL-Z TO GET THE PRINTOUT.
MANHIST...!
MANHIST...CTT
MANHIST>^Z
MANHIST...PRINT 102
PEAK
HBOOK     ID =       102                                          DATE  23/03/85 1
    1000       00000000000000000000000000000000000000000000000000000000000000000
CHANNELS  10   0        1         2         3         4         5         6
          1    12345678901234567890123456789012345678901234567890123456789012345678901234567890
CONTENTS 100   22222233333344455566666676666655444333322222111111111111111111
         10    59667601487938958747998816560081863983374120977876432345224 5
          1.   91016586614272193672335638020358442741666515539251758910873 5
          0    22122561795029685735776930820491688902898232840590377412953 9
ERROR     10   11111111111111111111111111111111111111111111111111111111 1111 11
          1.   23223333444556678789999999898887665544422111101100009000090 0
          0    83880076498196770992554692913211638291193996480097409125094 7
          0    78867395751961485771094010810667856803946350190748339185270 1
```

```
          0   915313408249485978932148798235062706343576842109900065738213
LOW-EDGE 100  444444444445555555555555555555555555555555555555555555555555
         10   899999999990000000000111111111122222222233333333334444444444
          1.  901234567890123456789012345678901234567890123456789012345678
          0   555555555555555555555555555555555555555555555555555555555555
* ENTRIES =         60      * ALL CHANNELS = 0.2241E+05      * UNDERFLOW = 0.000
* BIN WID = 0.1000E+01      * MEAN VALUE   = 0.5150E+03      * R . M . S = 0.130
MANHIST...@TT
MANHIST>^Z
MANHIST...!
MANHIST...!     PRINTING A HISTOGRAM MAY BE VERY USEFULL IF ONE WANTS TO LOOK AT
MANHIST...! THE CHANNEL CONTENTS, ERROR, INTEGRATED CONTENT, ETC... HOWEVER IF
MANHIST...! ONE WANTS TO LOOK ONLY AT THE STATISTICS, HERE IS A FASTER COMMAND:
MANHIST...!
MANHIST...PRINT/MOMENT
 Statistical moments for histogram          102
Underflow: 0.00000E+00        Integral:  22409.          Overflow: 0.00000E+00
Average :  515.01             Sigma    :  13.669
Skewness: 0.31324             Kurtosis:  4.0397
Eq. evt.:  60.000
FWHM    :  29.000     ,     5.6310%
MANHIST...@TT
MANHIST>^Z
MANHIST...!
MANHIST...!     WE NOW WILL FIT THE PEAK TO A GAUSSIAN PLUS A LINEAR
MANHIST...! BACKGROUND. FIRST THE COMMAND CHECK IS USED TO FIRST GOOD FIRST GUES
MANHIST...! FOR THE START VALUES OF THE FIT ROUTINE. CALLING CHECK BEFORE FIT
MANHIST...! IS NOT REQUIRED BUT MAY BE MOST USEFULL TO BE SURE THE STARTING
MANHIST...! VALUES ARE OK. DUE TO THE LIMITED PRECISION OF THE COMPUTER, A FIT
```

```
MANHIST...! STARTING VERY FAR FROM THE SOLUTION MAY NEVER CONVERGE DEPENDING
MANHIST...! ON THE FUNCTION. IN RESPONSE TO THE PROMPT FOR THE PARAMETER VALUE,
MANHIST...! ENTER:
MANHIST...!      500     FOR P0
MANHIST...!      .006    FOR P1
MANHIST...!      515     FOR P2
MANHIST...!      1100    FOR P3
MANHIST...! AND -1.8     FOR P4
MANHIST...! IF YOU WANT TO ENTER A BETTER FIRST GUESS, TYPE THE "CHECK"
MANHIST...! COMMAND AGAIN. WHEN YOU ARE SATISFIED WITH THE GUESS, TYPE CTRL-Z
MANHIST...! TO GO ON.
MANHIST...!
MANHIST...CHECK 102 P0*EXP(-P1*(X-P2)**2)+P3+P4*X
Value of parameter P0 is 0.E+00, new value ?_500
Value of parameter P1 is 0.E+00, new value ?_.006
Value of parameter P2 is 0.E+00, new value ?_515
Value of parameter P3 is 0.E+00, new value ?_1100
Value of parameter P4 is 0.E+00, new value ?_-1.8
MANHIST...!
MANHIST...@TT
MANHIST>^Z
MANHIST...!
MANHIST...!      NOW WE CAN FIT THE DATA TO THE FUNCTION AND PUT THE DEVIATION
MANHIST...! IN ANOTHER HISTOGRAM.  FIRST EXAMINE THE FUNCTION AGAIN (TO REMIND
MANHIST...! US OF WHAT WE TYPED IN) AND THEN ANSWER THE QUESTIONS.  YOU MAY
MANHIST...! CHOOSE TO FIT ONLY A SUBSET OF THE PARAMETERS UP TO THE MAXIMUM
MANHIST...! TYPED IN.  THE RESULT OF THE FIT IS PRINTED ALONG WITH THE FUNCTION
MANHIST...! THE FUNCTION DEFINED BY THE COMMAND CHECK IS ALSO USED FOR THE FIT
MANHIST...! COMMAND.
```

```
MANHIST...!
MANHIST...SHOW FUNCTION
Fit function:
 P0*EXP(-P1*(X-P2)**2)+P3+P4*X
MANHIST...FIT/DEV=103 102
Starting value of parameter P0 is 500., new value ?_
Free parameter ? (Y/N)_
Starting value of parameter P1 is 6.00000005E-03, new value ?_
Free parameter ? (Y/N)_
Starting value of parameter P2 is 515., new value ?_
Free parameter ? (Y/N)_
Starting value of parameter P3 is 1100., new value ?_
Free parameter ? (Y/N)_
Starting value of parameter P4 is -1.8, new value ?_
Free parameter ? (Y/N)_
Fit results for histogram:       102
**********************************
PEAK
Chi square: 64.36     D.o.F.:  55  Confidence level: 0.1816
Fit function:  P0*EXP(-P1*(X-P2)**2)+P3+P4*X
     5 Parameter(s).
                                                    Correlation coefficients
     Parameter name      Value              Error          1      2      3
               P0 :    504.657      +-    6.46105
               P1 :   0.614873E-02 +-   0.222300E-03    -0.079
               P2 :    513.353      +-   0.128892        -0.173  0.446
               P3 :    1108.36      +-    82.6858        -0.406  0.659  0.615
               P4 :   -1.78006      +-   0.152979         0.396 -0.641 -0.616 -
MANHIST...SHOW FUNCTION
```

```
Fit function:
 PO*EXP(-P1*(X-P2)**2)+P3+P4*X
MANHIST...!
MANHIST...@TT
MANHIST>^Z
MANHIST...!
MANHIST...!     NOW PLOT THE RESULT OF THE FIT AND THE DEVIATION ON TOP OF EACHR
MANHIST...!
MANHIST...SET WIND/NY=2
MANHIST...PLOT 102
MANHIST...PLOT 103
MANHIST...SET WIND/NY=1
MANHIST...!
MANHIST...@TT
MANHIST>^Z
MANHIST...!
MANHIST...!     WE CAN SAVE THE RESULTS OF OUR LABORS IN ANOTHER HISTOGRAM
MANHIST...! FILE.
MANHIST...!
MANHIST...CATALOG SAVEXMPLE.HBK
MANHIST...SAVE 102
MANHIST...SAVE 103
MANHIST...!
MANHIST...!     WE MAY ALSO SAVE A SPECIFIC HISTOGRAM IN TOP-DRAWER FORMAT
MANHIST...!
MANHIST...CATALOG/TOP SAVEXMPLE.TOP
MANHIST...SAVE/TOP 102
MANHIST...!
MANHIST...@TT
```

```
MANHIST>^Z
MANHIST...!
MANHIST...!     CHECK THE HISTOGRAMS SAVED IN THE FILE SAVEXMPLE.HBK
MANHIST...!
MANHIST...CLOSE
MANHIST...FILE SAVEXMPLE
MANHIST...SHOW FILE
All histograms are deleted.
File repositioned at beginning.
Table of histograms on file SAVEXMPLE
**************************************
      102 (1-dim.) PEAK
      103 (1-dim.) F<IT DEVIATION FOR> PEAK
File repositioned at beginning.
MANHIST...!
MANHIST...!     THE CONTENTS OF THIS FILE MAY BE PUT IN A FILE CALLED
MANHIST...! HISRES.DAT FOR LATER PRINTOUT ON A LINE PRINTER.
MANHIST...!
MANHIST...SET MODE/RECORD
Format set to          60 lines         145 columns
MANHIST...SHOW FILE
All histograms are deleted.
File repositioned at beginning.
File repositioned at beginning.
MANHIST...BROWSE/PRINT/NOQUERY
Read histogram ID         102
Read histogram ID         103
No more IDs on file SAVEXMPLE
File has been closed.
```

```
MANHIST...SET MODE/SCRATCH
Format set to          36 lines          90 columns
MANHIST...!
MANHIST...@TT
MANHIST>^Z
MANHIST...!
MANHIST...!     NOW WE MOVE ON TO SOME SCATTERPLOT EXAMPLES.
MANHIST...!
MANHIST...FILE MANDIR:MANEXMPLE
MANHIST...FETCH 3
MANHIST...PLOT/HIST
MANHIST...!
MANHIST...@TT
MANHIST>^Z
MANHIST...!
MANHIST...!     THAT HISTOGRAM WAS CREATED WITH PROJECTIONS.  THEY CAN
MANHIST...! BE PLOTTED AS WELL.
MANHIST...!
MANHIST...PLOT/PROX
MANHIST...!
MANHIST...@TT
MANHIST>^Z
MANHIST...!
MANHIST...PLOT/PROY
MANHIST...!
MANHIST...@TT
MANHIST>^Z
MANHIST...!
MANHIST...!     IN ADDITION, THE PROJECTIONS CAN BE TURNED INTO HISTOGRAMS
```

```
MANHIST...! OF THEIR OWN AND MANIPULATED AS ABOVE.
MANHIST...!
MANHIST...CREATE/PROX/ID=101 3
MANHIST...PLOT 101
MANHIST...!
MANHIST...@TT
MANHIST>^Z
MANHIST...!
MANHIST...!     JUST AS WE MAY "CLEAR" AWAY BINS ON A HISTOGRAM, WE MAY
MANHIST...! "CLEAR" AWAY REGIONS ON A SCATTERPLOT.
MANHIST...!
MANHIST...CLEAR/ID=102 3 FOR 0.3-(X**2+Y**2)
MANHIST...PLOT/HIST 102
MANHIST...@TT
MANHIST>^Z
MANHIST...!
MANHIST...!     NOW LET US SEE ANOTHER USE OF THE CUT COMMAND. THE CLEARED
MANHIST...! HISTOGRAM DOES NOT HAVE PROJECTION DECLARED. THE COMMAND CUT WILL
MANHIST...! ALLOW TO DEFINE PROJECTIONS COMPUTED FROM THE SCATTERPLOT ITSELF.
MANHIST...! IN FACT THE COMMAND CUT CAN BE USED TO CREATE ANY PROJECTION, BAND
MANHIST...! AND/OR SLICES WHEN THESE HAD NOT BEEN DECLARED WHEN THE HISTOGRAM
MANHIST...! WAS BOOKED.
MANHIST...!
MANHIST...CUT/ID=105/PROX
MANHIST...CUT/ID=106/PROY
High limit cut value reset to      1.00      to correspond to a bin limit
MANHIST...SET WIND/NX=1/NY=2
MANHIST...PLOT 105
MANHIST...PLOT 106
```

```
MANHIST...@TT

MANHIST>^Z

MANHIST...!

MANHIST...!     WE MAY ALSO "VIEW"  SCATTERPLOTS IN 3-D.

MANHIST...!

MANHIST...SET WINDOW/NX=1/NY=1

MANHIST...VIEW 3

MANHIST...@TT

MANHIST>^Z

MANHIST...!

MANHIST...!     OF COURSE ONE CAN CHANGE THE VIEWING ANGLE. THE NEW VALUES

MANHIST...! WILL REMAIN IN EFFECT UNTIL YOU CHANGE THEM AGAIN

MANHIST...!

MANHIST...VIEW/PHI=200/THETA=60 102

MANHIST...!

MANHIST...@TT

MANHIST>^Z

MANHIST...!

MANHIST...!     ONE CAN REMOVE THE HIDDEN LINES USING THE /HIDDENLINE OPTION.

MANHIST...! HOWEVER THE COMPUTING TIME WILL INCREASE.

MANHIST...!

MANHIST...VIEW/HIDDENLINE 102

MANHIST...@TT

MANHIST>^Z

MANHIST...!

MANHIST...!     FOR REAL FANCY EFFECT, THE /CUBES OPTION MAY BE THE BEST,

MANHIST...! BUT HERE AGAIN, THE CPU TIME COMSUMPTION IS HIGH.

MANHIST...!

MANHIST...VIEW/CUBES 3
```

```
MANHIST...@TT
MANHIST>^Z
MANHIST...!
MANHIST...!     FINALLY, CONTOUR LINES CAN BE DRAWN FOR SCATTERPLOTS.
MANHIST...! THIS IS CPU TIME CONSUMING BUT IT MAY BE VERY USEFULL IN DETECTING
MANHIST...! SMALL STRUCTURES WITHIN A DENSE SCATTERPLOT.
MANHIST...!
MANHIST...CONTOUR/PRIMARY=12/SECONDARY=1/MINIMUM=0/MAXIMUM=22
MANHIST...@TT
MANHIST>^Z
MANHIST...!
MANHIST...!     2-DIMENSIONAL HISTOGRAMS CAN HAVE THEIR BINNING MERGED TOGETHER
MANHIST...! IF DESIRED VIA THE COMMAND:
MANHIST...!
MANHIST...MERGE/ID=1/BINX=2/BINY=2
MANHIST...!
MANHIST...!     THIS NEW HISTOGRAM WILL BE VIEWED IN 3-D USING THE LEGO OPTION
MANHIST...! WHICH IS MORE EFFICIENT THAN THE /CUBE OPTION, BECAUSE IT IS RESTRID
MANHIST...! IN ANGULAR RANGE.
MANHIST...!
MANHIST...VIEW/LEGO 1
MANHIST...@TT
MANHIST>^Z
MANHIST...!
MANHIST...!     IF THE USER WANTS TO ACCESS HISTOGRAMS AS A GROUP, THE COMMAND
MANHIST...! FETCH/GLOBAL ALLOWS TO INITIALIZE THE ENTIRE HBOOK MEMORY USING THE
MANHIST...! CONTENT OF A FILE CREATE BY A SAVE/GLOBAL COMMAND OR A CALL TO THE
MANHIST...! ROUTINE HMSAVE.
MANHIST...!
```

```
MANHIST...DELETE/ALL
MANHIST...FETCH/GLOBAL MANDIR:MANEXMPLE
All ID are deleted from memory.
MANHIST...SHOW HIST
S<HOWER ENERGY>    1.00 G<E>V
.....................................................................
.                                                                   .
.   HBOOK   VAX  CERN              VERSION   3.31       HISTOGRAM AND PLOT INDE.
.                                                                   .
.....................................................................
.                                                                   .
.  NO                    TITLE                      ID  B/C  ENTRIES DIM   NCH.
.                                                                   .
.....................................................................
.                                                                   .
.                                                                   .
.   1  S<IDE LEAKAGE>                             1000  32      500  1  X   10.
.                                                                   .
.                                                                   .
.   2  E<NERGY LEFT IN> BGO                       1001  32      500  1  X   10.
.                                                                   .
.                                                                   .
.   3  E<NERGY LEFT IN> AL <WRAPPING>             1002  32      500  1  X   10.
.                                                                   .
.                                                                   .
.   4  B<ACK SCATTERED LEAKAGE>                      2  32      500  1  X   10.
.                                                                   .
.                                                                   .
.   5  R<EAR LEAKAGE>                                4  32      500  1  X   10.
```

```
.                                                                    .
.                                                                    .
.....................................................................
MEMORY UTILISATION
     MAXIMUM TOTAL SIZE OF BLANK COMMON              800
     USER AREA IN BLANK COMMON                       0
MANHIST...@TT
MANHIST>^Z
MANHIST...!
MANHIST...!     1-DIMENSIONAL HISTOGRAM CAN ALSO HAVE THEIR BINS MERGED TOGETHER
MANHIST...! TO CREATE A NEW HISTOGRAM WITH LESS BINS.
MANHIST...!
MANHIST...MERGE/ID=1/BINX=2 1001
MANHIST...SET WINDOW/NY=2/NX=1/WIN=1
MANHIST...PLOT 1001
MANHIST...PLOT 1
MANHIST...@TT
MANHIST>^Z
MANHIST...!
MANHIST...!     THE LAST EXAMPLE SHOWS HOW ONE MAY EXTRACT DATA THAT IS NOT
MANHIST...! IN HISTOGRAM FORM (I.E. UNEQUALLY SPACED X-VALUES) AND MANIPULATE
MANHIST...! IT WITH MANHIST.  THE DATA IS KEPT IN A FILE WITH TOPDRAWER FORMAT.
MANHIST...! AN ID NUMBER MUST BE SPECIFIED WHEN "FETCHING" THE DATA.
MANHIST...!
MANHIST...DELETE/ALL
MANHIST...FETCH/FILE=MANDIR:MANEXMPLE.TOP 1
MANHIST...PLOT 1
MANHIST...!
MANHIST...!     THE DATA MAY THEN BE FIT, ETC... IN THE USUAL MANNER.  IF YOU
```

```
MANHIST...! WOULD LIKE TO PLAY WITH THE DATA YOU SEE, TRY FITTING IT TO THE
MANHIST...! FUNCTION PO+P1*ATAN((X-P2)/P3). TRY FIRST YOU BEST GUESS WITH THE
MANHIST...! CHECK COMMAND AND THEN TYPE FIT. IF YOU GUESS IS WAY OFF, YOU WILL
MANHIST...! GET AN ERROR MESSAGE, BUT YOU CAN TRY AGAIN AS LONG AS YOU WISH.
MANHIST...!
MANHIST...@TT
MANHIST>fit p0+p1*atan((x-p2)/p3)
Starting value of parameter P0 is 504.6568, new value ?_250
Free parameter ? (Y/N)_
Starting value of parameter P1 is 6.14872715E-03, new value ?_125
Free parameter ? (Y/N)_
Starting value of parameter P2 is 513.35315, new value ?_1.072
Free parameter ? (Y/N)_
Starting value of parameter P3 is 1108.3639, new value ?_.001
Free parameter ? (Y/N)_
Fit results for histogram:          1
************************************
$NON-HISTOGRAM DATA EXAMPLE
Chi square: 53.93     D.o.F.:  21  Confidence level: 0.0001
Fit function: P0+P1*ATAN((X-P2)/P3)
     4 Parameter(s).
                                                    Correlation coefficients
     Parameter name      Value              Error          1      2      3
               P0 :    250.059      +-    2.17755
               P1 :    122.691      +-    1.92260        0.465
               P2 :    1.07168      +-  0.352376E-04     0.760  0.227
               P3 :  0.835608E-03   +-  0.472055E-04    -0.125  0.645 -0.292
MANHIST>exit
Delete the file SAVEXMPLE.HBK?: y
```

```
Delete the file SAVEXMPLE.TOP?: y
Delete the file HISRES.DAT?: y
To run MANHIST on your own, you should include
the statements
  ASSIGN DISKO:[DIDIER.MANHIST]MANHIST.HLB MANHIST_HELP_LIB
  MANHIST:== RUN DISKO:[DIDIER.MANHIST]MANHIST
in your login file.  Then, just type MANHIST to
start a MANHIST session.
$
```

10. Index

Here are all the commands and qualifiers which are accepted by MANHIST. The first column refers to the page where the command has been introduced in the manual. The second column contains the command. Qualifiers listed on the same line cannot be used simultaneously. The default qualifier, if any, is flagged by an asterisk (*). Indirect file and arithmetic between histogram are not shown because their syntax is different.

```
 7   EXIT
 8   FETCH   /DELETE*          /NODELETE        /FILE=⟨file name⟩ /GLOBAL /FOREIGN
 7   FILE
31   FIT     /DEVIATION=PLOT*/NODEVIATION     /DEVIATION=n
             /PLOT*  /NOPLOT
             /QUERY  /NOQUERY
             /ERRORS*/NOERRORS
             /PRINT=0*         /PRINT=n         /NOPRINT
52   FUNCTION/ID=n
             /TITLE=SAME       TITLE="⟨title string⟩ "
             /XBIN=x /BIN=x
             /XMINIMUM=x       /MINIMUM=x
             /XMAXIMUM=x       /MAXIMUM=x
             /YBIN=x /SCATTERPLOT
             /YMINIMUM=x
             /YMAXIMUM=x
 3   HELP
51   MERGE   /ID=n
             /TITLE=SAME       TITLE="⟨title string⟩ "
             /BINX=n
             /BINY=n
31   NORMALIZE        /ID=n
20   OPEN    /TERMINAL         /HARDCOPY
             /OVERLAP
 4   PAUSE
22   PLOT    /ALL*   /HIST   /PROX   /PROY   /BANX=n /BANY=n /SLIX=n /SLIY=n
             /CHANNEL=n
             /SAME
             /X_AXIS=⟨title string⟩
             /Y_AXIS=⟨title string⟩
43   PLOT    RESULTS
17   PRINT   /ALL*   /HIST   /PROX   /PROY   /BANX=n /BANY=n /SLIX=n /SLIY=n
13   SAVE    /ALL
             /GLOBAL
             /FOREIGN
```

22	SET	DEVICE	/CHANNEL=*n*	
55		ERRORS	/ZERO=*x*	
16		FORMAT	/LINES=*n*	/COLUMNS=*n*
6		MEMORY	/ON	
			/OFF	
16		MODE	/SCRATCH	
			/RECORD	
26		PLOT	/EAH	
			/NEAH	
			/CHA	
			/NCHA	
			/IDS	
			/NOIDS	
			/CONTENT	
			/NOCONTENT	
			/MEAN	
			/NOMEAN	
			/SIGMA	
			/NOSIGMA	
			/OVERFLOWS	
			/NOOVERFLOWS	
			/STATISTICS	
			/NOSTATISTICS	
			/ALL	
			/NONE	
			/COLOR=(*color*)	
			/XSIZ=*x*	
			/YSIZ=*x*	
			/DASH=*x*	
			/DMOD=*x*	
			/XMGL=*x*	
			/XMGR=*x*	
			/XLAB=*x*	
			/XVAL=*x*	
			/XTIC=*x*	
			/YMGL=*x*	
			/YMGU=*x*	
			/YLAB=*x*	

```
                    /YVAL=x
                    /YTIC=x
                    /YNPG=x
                    /YHTI=x
                    /XWIN=x
                    /YWIN=x
                    /KSIZ=x
                    /GSIZ=x
                    /TSIZ=x
                    /ASIZ=x
                    /CSIZ=x
                    /PSIZ=x
                    /VSIZ=x
                    /SSIZ=x
                    /2SIZ=x
                    /DSET=x
17          PRINT
30          SCALE
54          TITLE
 4          NOVERIFY
 4          VERIFY
25          WINDOW
21  SHOW    DEVICE  /ALL
 9          FILE
17          FORMAT
10          HISTOGRAMS
 6          MEMORY
17          MODE
43          FUNCTION/FIT*
50                  /CLEAR
51  SMOOTH  /ID=n
            /TITLE=SAME     /TITLE="⟨title string⟩ "
23  VIEW    /NOHIDDENLINE*  /HIDDENLINE     /CUBES  /LEGO
            /THETA=x
            /PHI=x
```

11. Installation guide

MANHIST is delivered with a standard set of files. The primary purpose of these files is to customize the program to the system. Because the set of available graphic devices vary from place to place, it is likely that the program should be relinked with the proper device access routines which are found in the local copy of the Unified Graphic System. A copy of UGS is included in the standard distribution backup which contains most of the devices in use at SLAC. If you need to include a new device, you should contact Robert Beach at SLAC to obtain the code and the documentation on how to proceed. A complete copy of the CERN libraries is also included in case you do not have them.

An other purpose of the distribution kit is to give the possibility to make further distributions possible because there is no centralized distribution. If you do not know where to get the program, contact the following persons on BITnet:

— Dr. James Napolitano, account JIMNAP@ANLPHY

— or the account SYSTEM@SLACCB which will correspond to whoever is currently in charge of the system on which MANHIST has been developed.

The code is not provided to insure that all versions correspond to this manual. Here is a summary of the files included in the distribution kit.

MANHIST.TXT contains the release notes and the installation guide
MANHIST.BCK is the command file which create the distribution kit
MANHIST.EXE is the executable code of MANHIST,
MANHIST.HLB is the help library for MANHIST,
MANHIST.OLB contains all routines for MANHIST,
HPLUGS.COM contains all the routines to interface HPLOT to UGS,
DHBLIB.OLB contains some general utilities used by MANHIST,
DHBLIB.HLB is the help library for the above routines,
LNKMAN.COM is a command file to link MANHIST,
MANEXMPLE.COM is the command file to start the tutorial,

MANEXMPLE.EXC is the MANHIST command file for the tutorial,

MANEXMPLE.HBK contains the tutorial histograms saved in HSTORE format,

MANEXMPLE.HGL contains the tutorial histograms saved in HMSAVE format,

MANEXMPLE.TOP contains the tutorial histograms saved in TOP DRAWER format.

Of course, most of the command files contains directory references which must be edited before they can be used. The command file to link MANHIST is merely a template and this is the place where the graphic devices must be specified.

REFERENCES

1. R. Brun, I. Ivanchenko, P. Palazzi, HBOOK Users Guide, version 3.0 CERN, DD/US/72, December 1977.

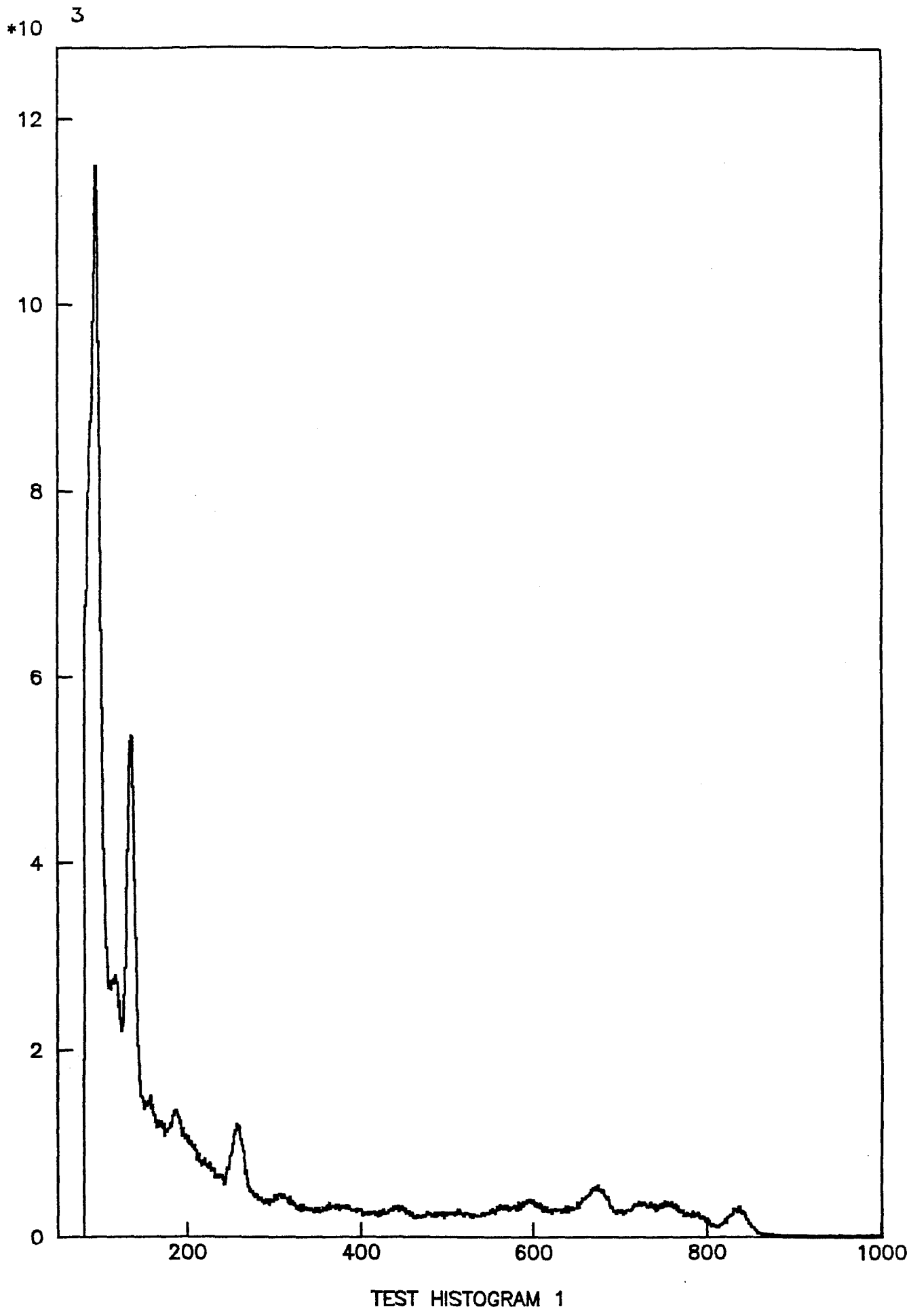
2. R. Brun, H. Watkins, HPLOT Users Guide, version 3.0 CERN, DD/EE/80-2, October 1982 revision.

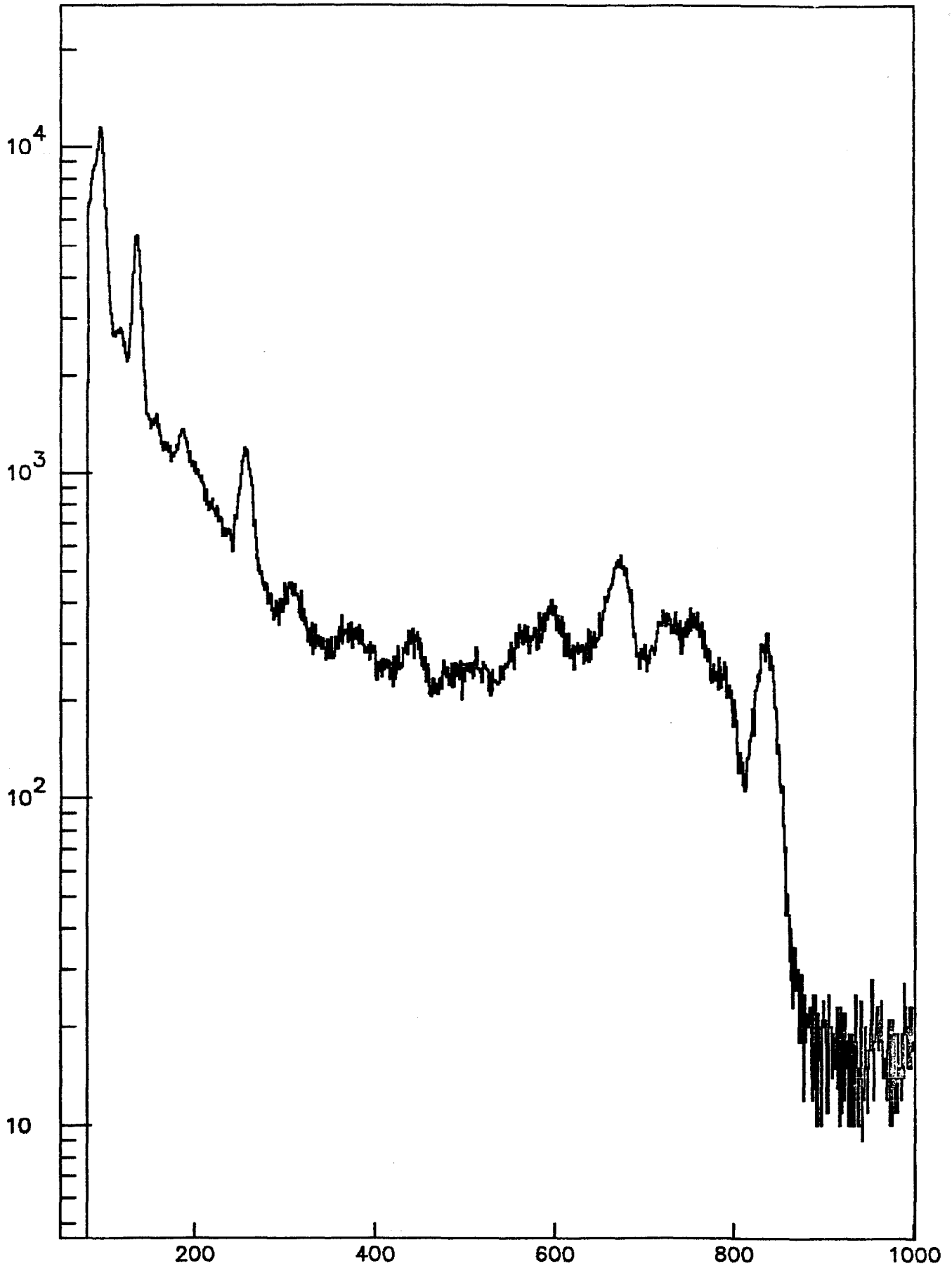
3. R. C. Beach, The Unified Graphic System for FORTRAN 77, Programming Manual, Stanford Linear Accelerator Center, Stanford California 94305, CGTM Number 203, August 1981.

4. R. B. Chaffee, Top Drawer, Stanford Linear Accelerator Center, Stanford California 94305, CGTM Number 178, November 1980.

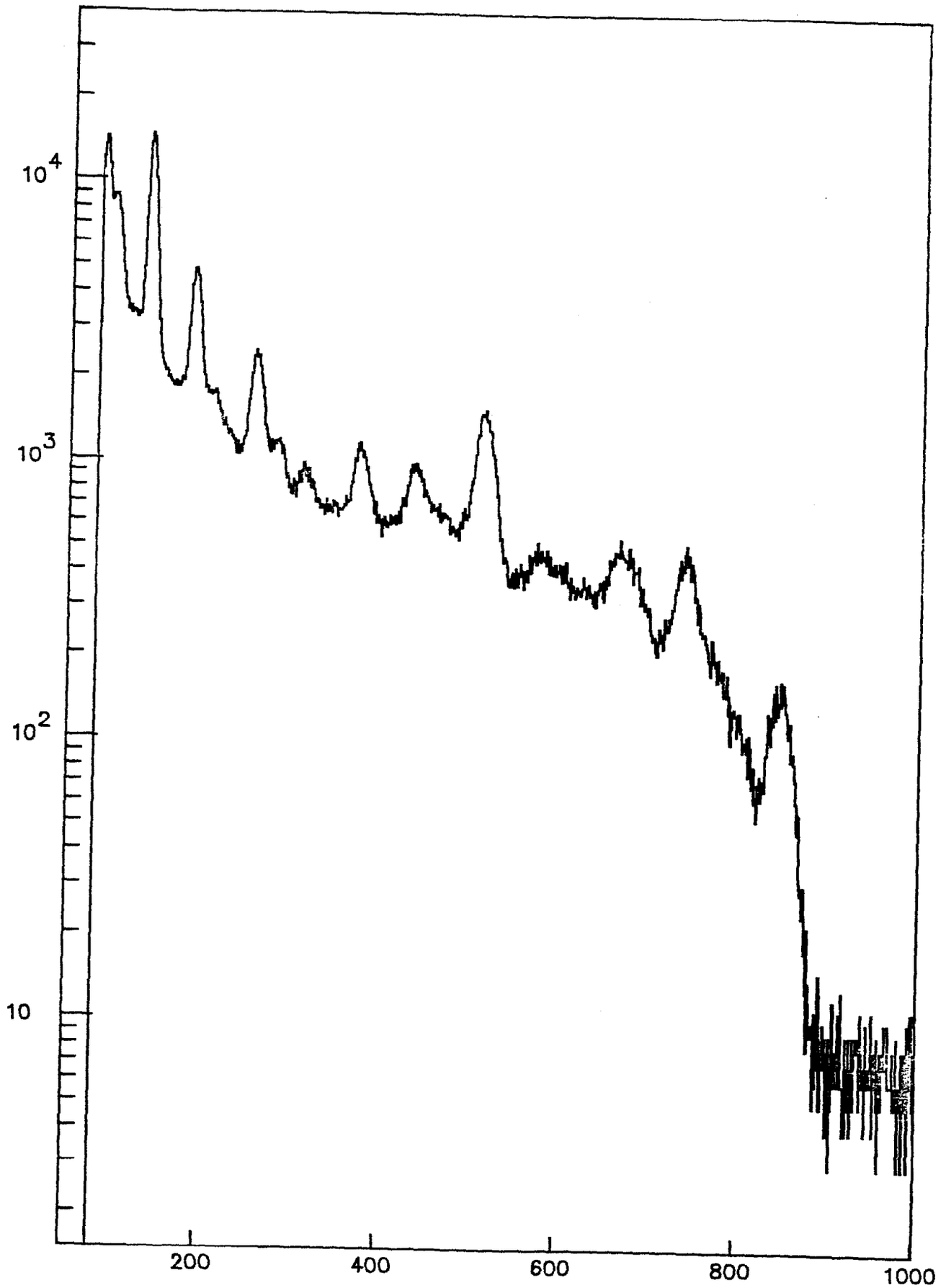
5. D. Besset, SLAC-PUB-3574, February 1985, submitted to N. I. M.

6. J. H. Friedman, *Data Analysis Techniques for High Energy Particle Physics, proceeding of the 1974 CERN School of Computing, Godoysund (Norway) August 1974 (Cern 74-23)*

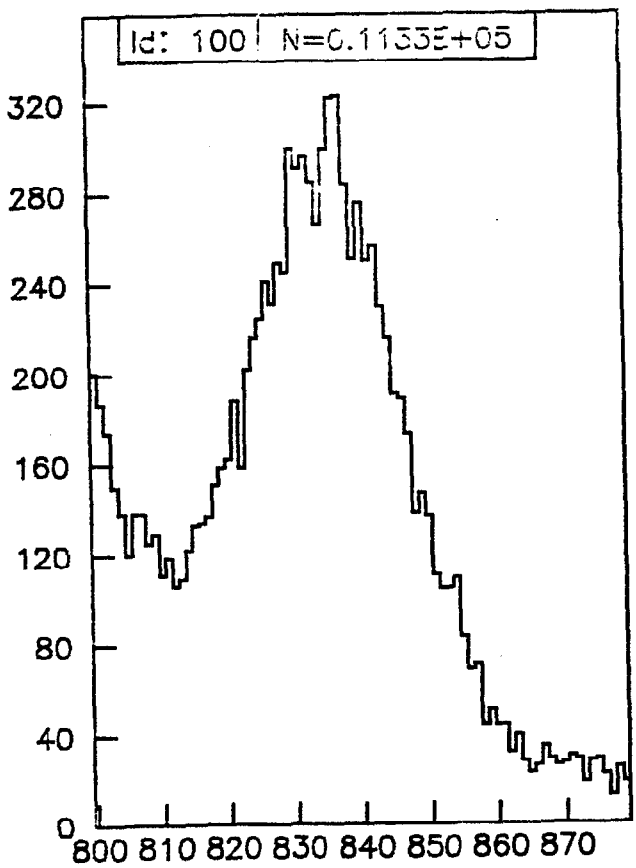

*10 3
12
10
8
6
4
2
0
200
400
600
800
1000
TEST HISTOGRAM 1



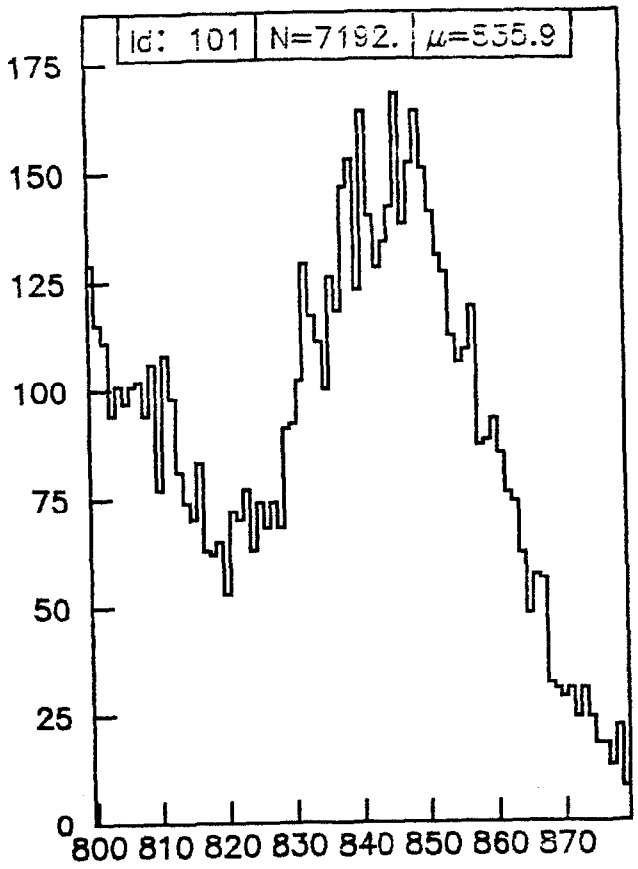
TEST HISTOGRAM 1



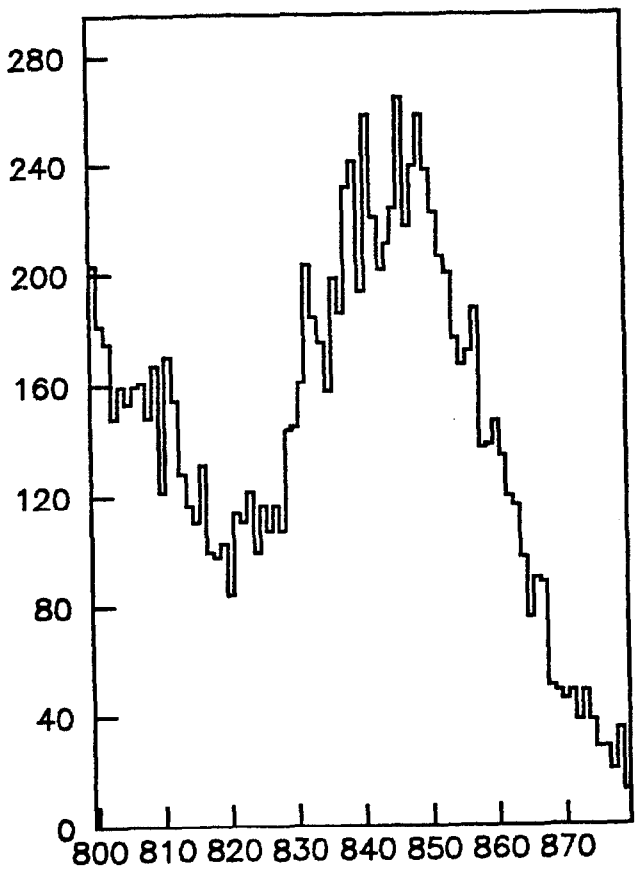
TEST HISTOGRAM 2



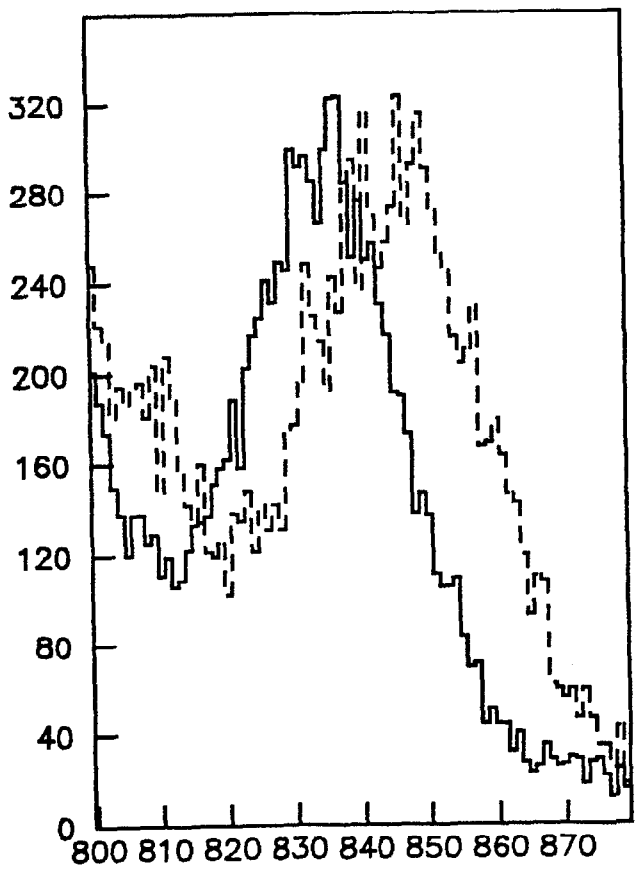
Cut TEST HISTOGRAM 1



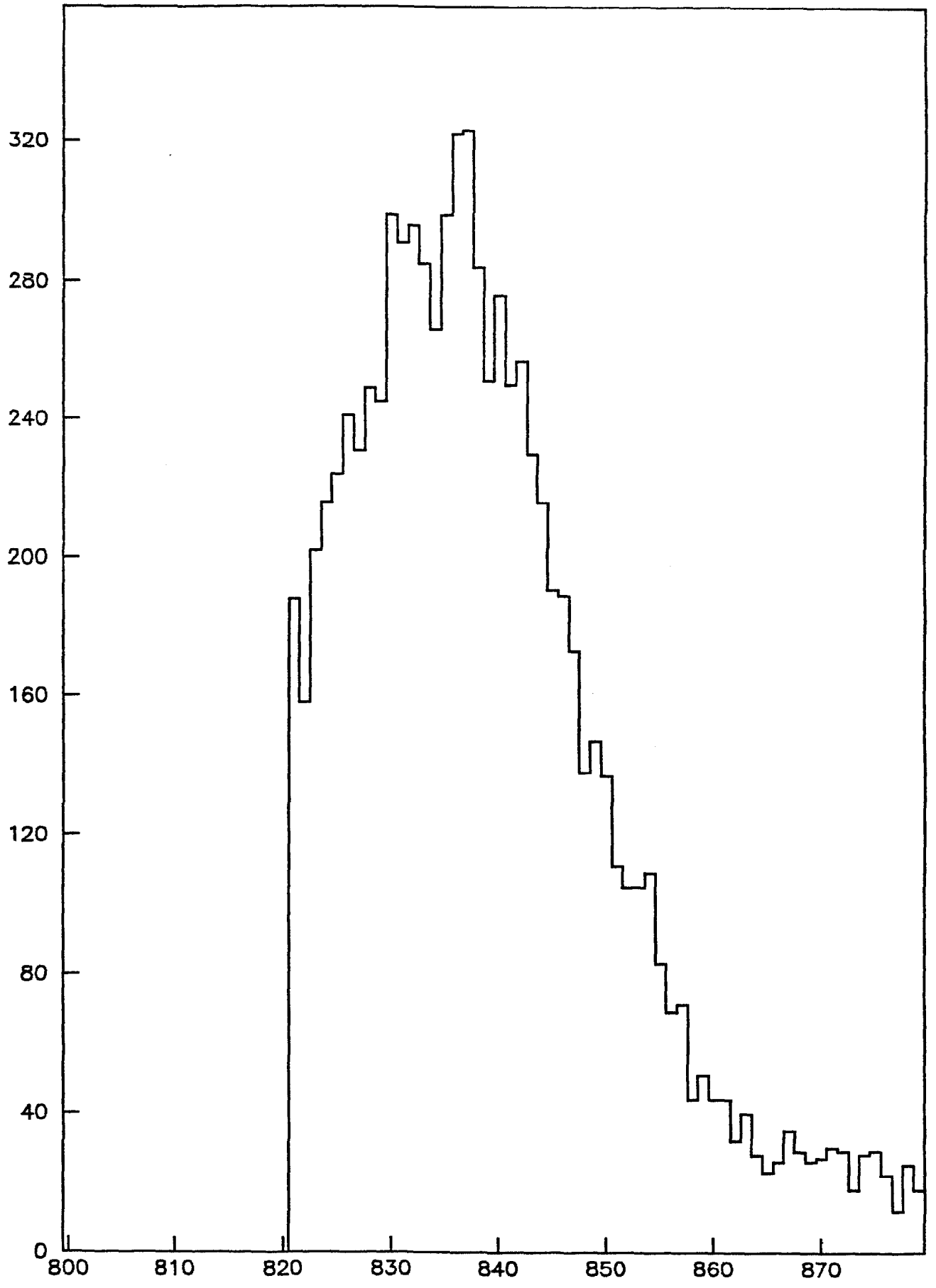
Cut TEST HISTOGRAM 2



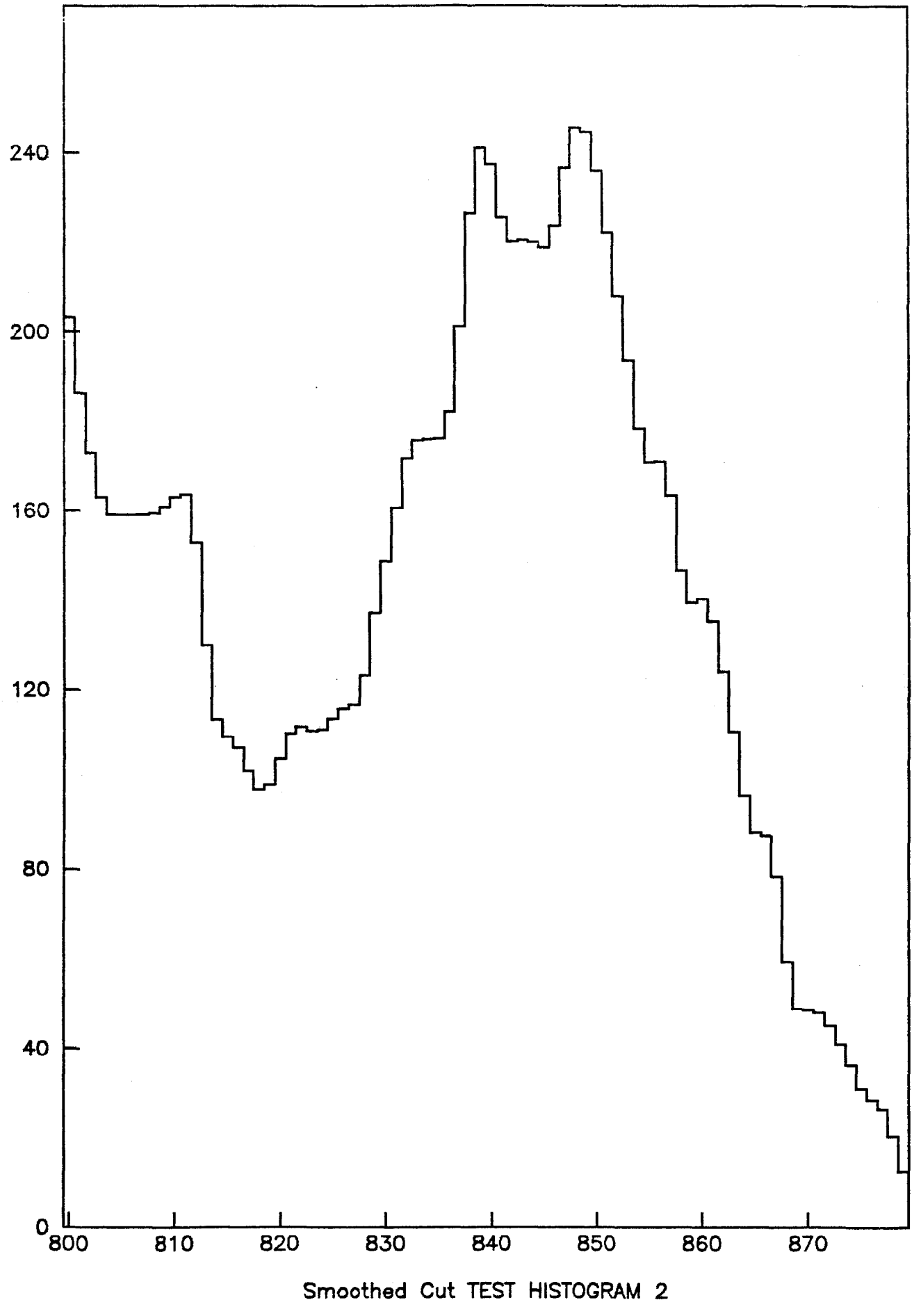
Cut TEST HISTOGRAM 2

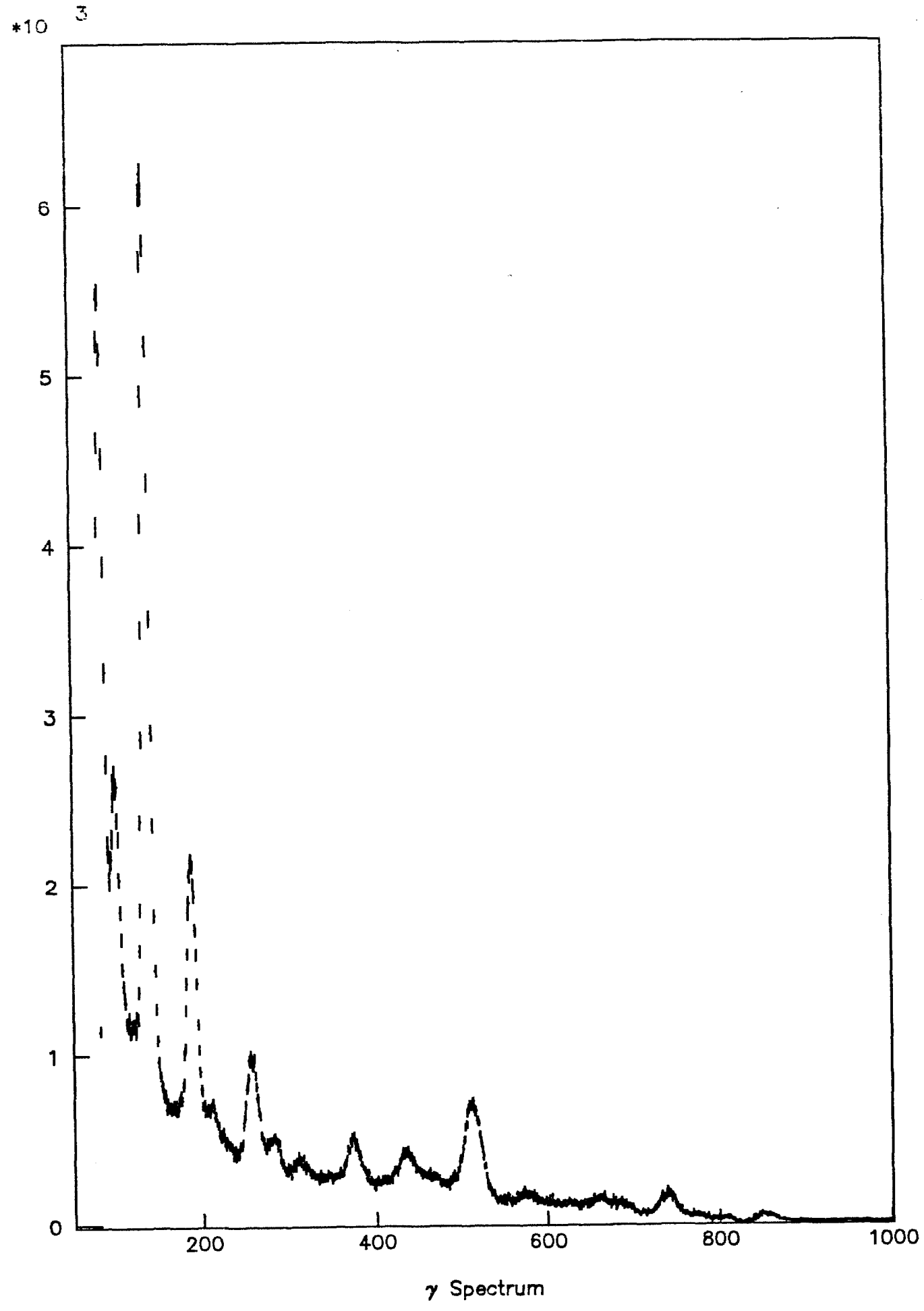


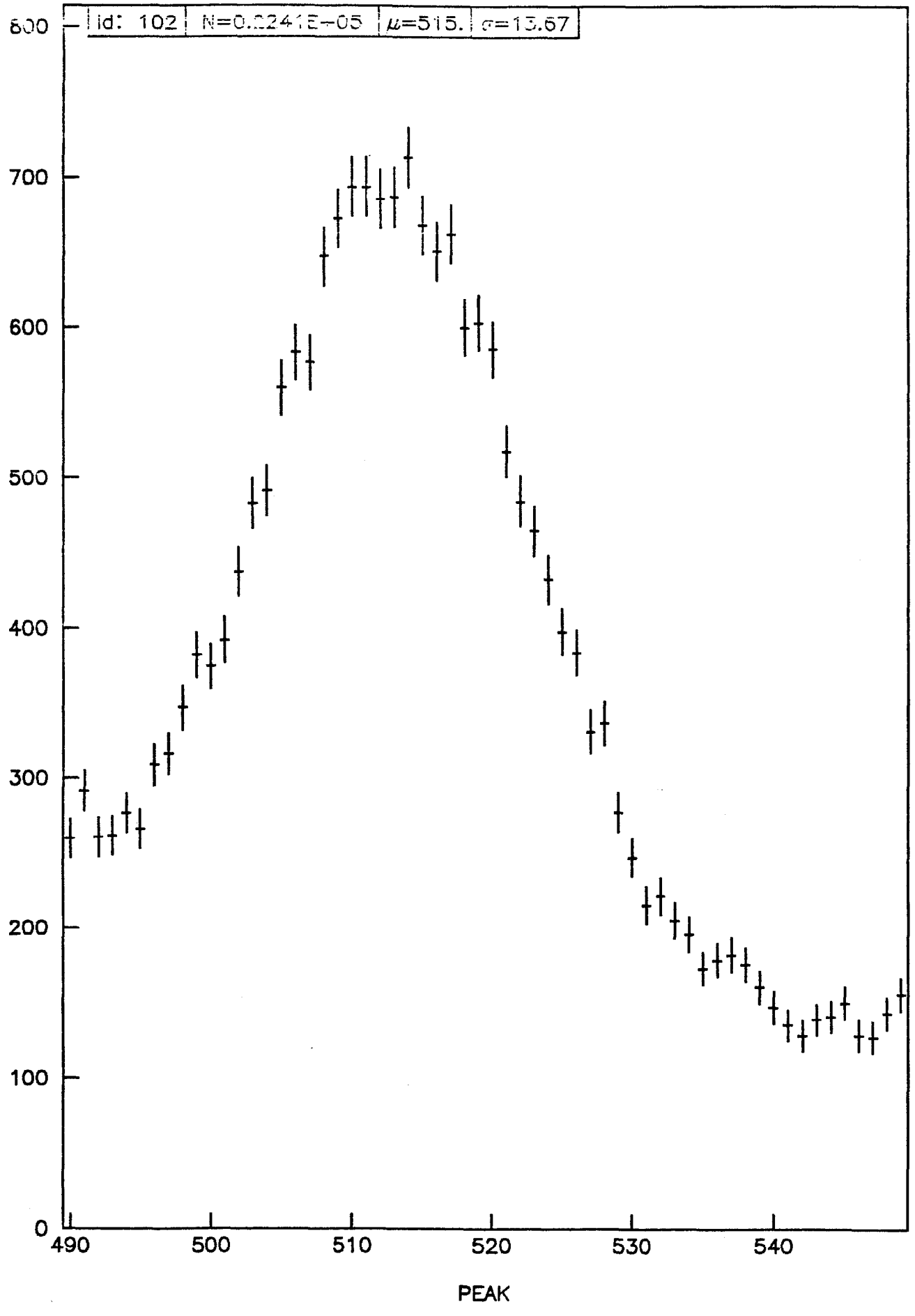
Cut TEST HISTOGRAM 1

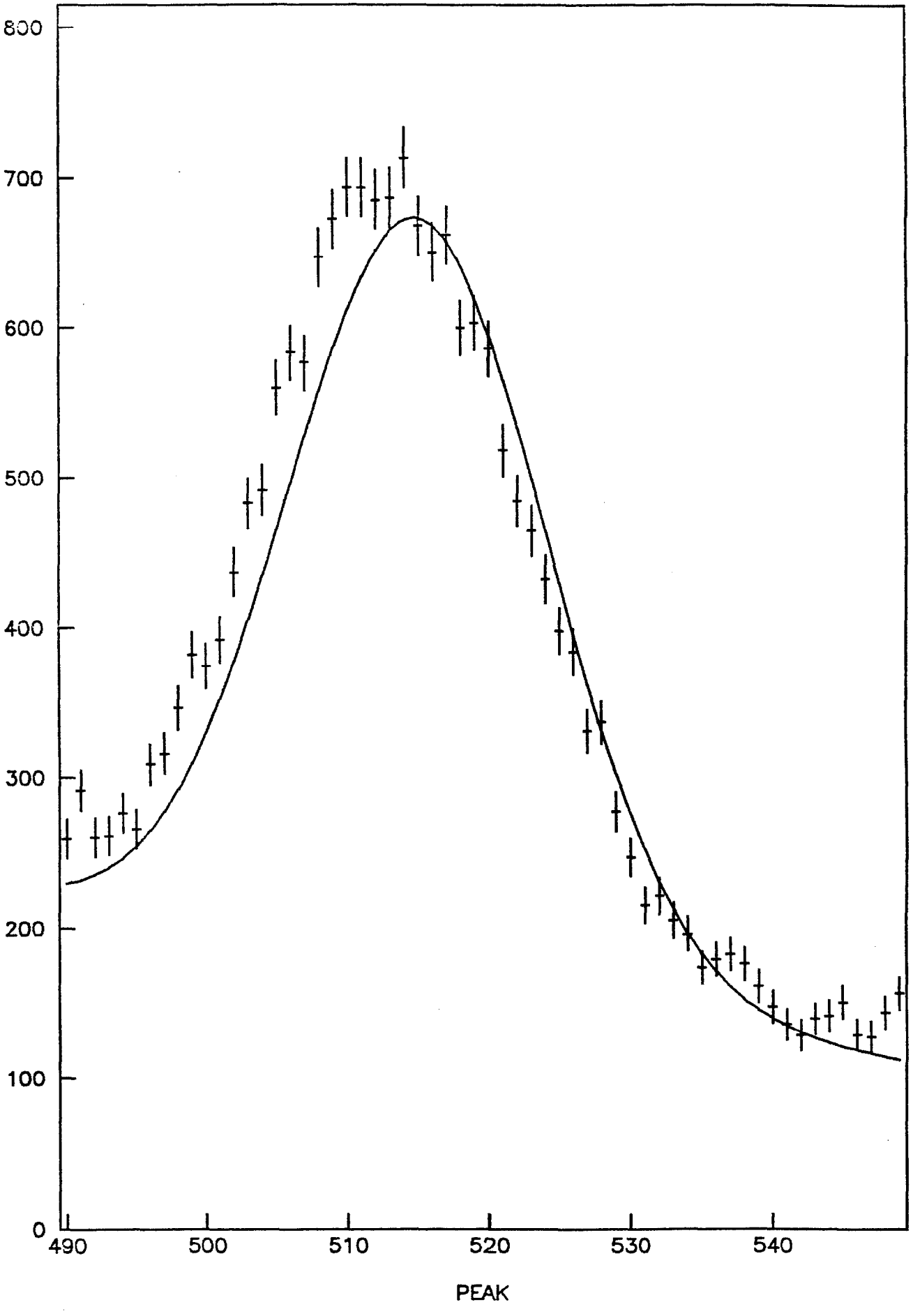


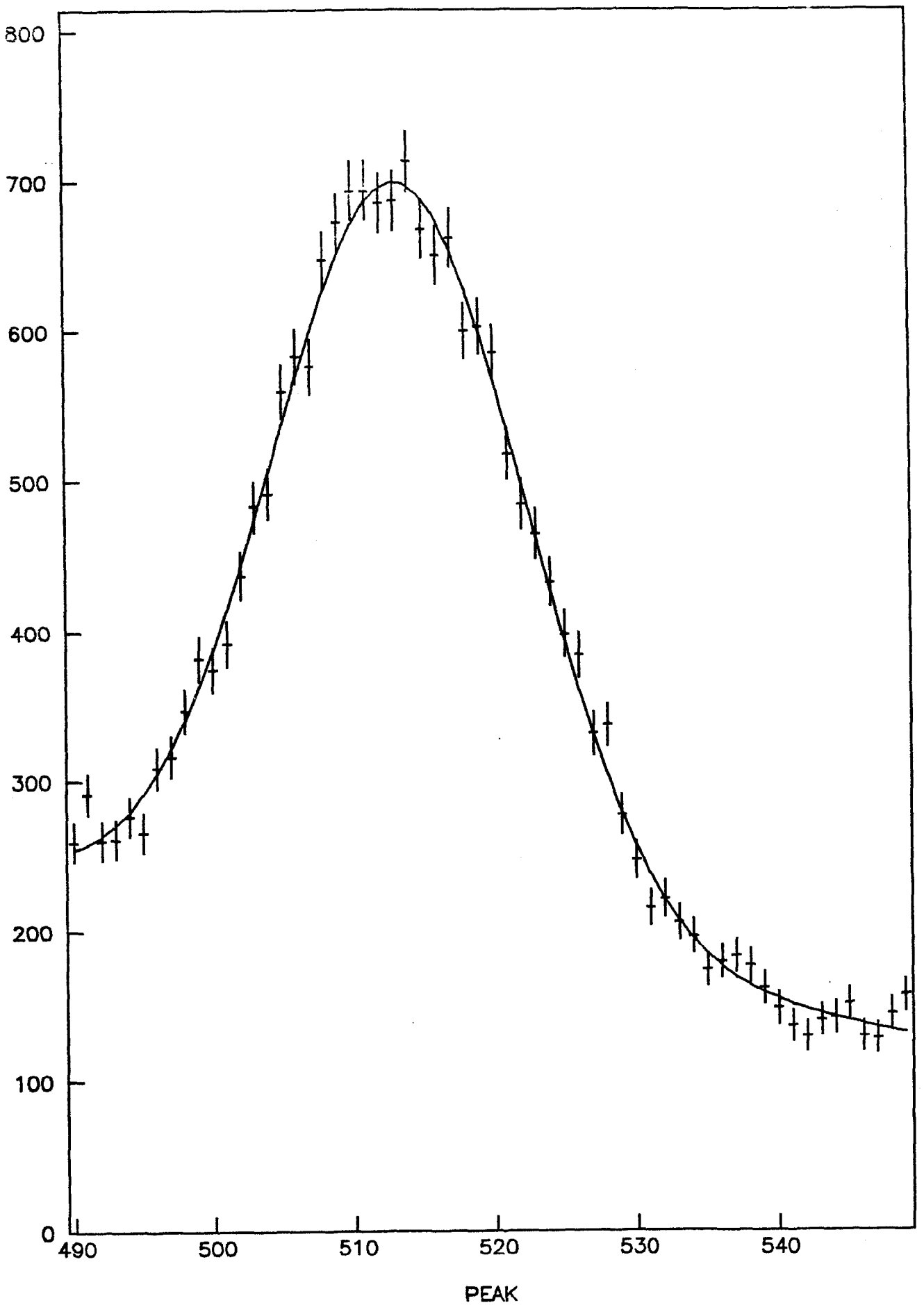
Cleared Cut TEST HISTOGRAM 1

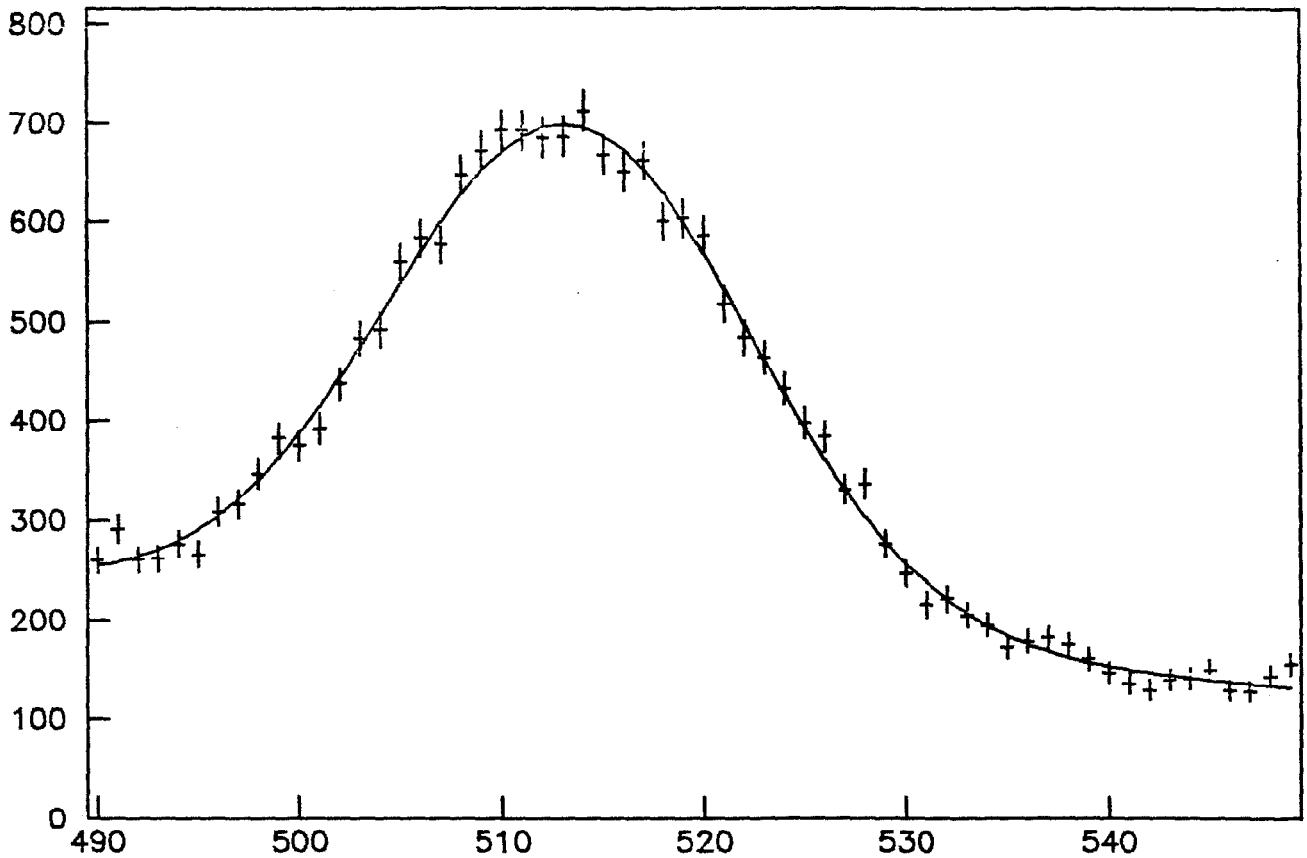

240
200
160
120
80
40
0
800
810
820
830
840
850
860
870
Smoothed Cut TEST HISTOGRAM 2


*10 3
6
5
4
3
2
1
0
200
400
600
800
1000
γ Spectrum

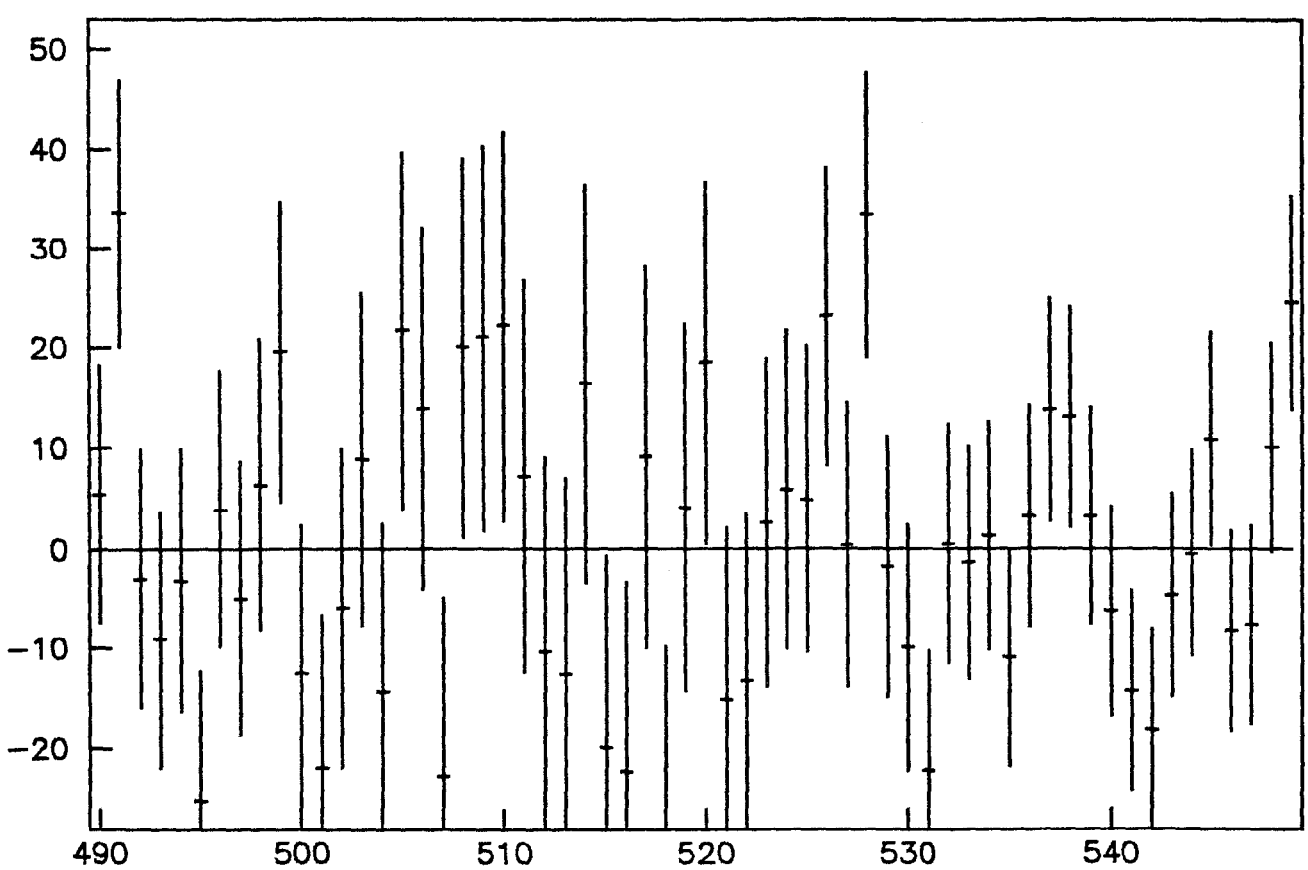

id: 102
N=0.2241E-05
μ=515.
σ=13.67
800
700
600
500
400
300
200
100
0
490
500
510
520
530
540
PEAK


800
700
600
500
400
300
200
100
0
490
500
510
520
530
540
PEAK

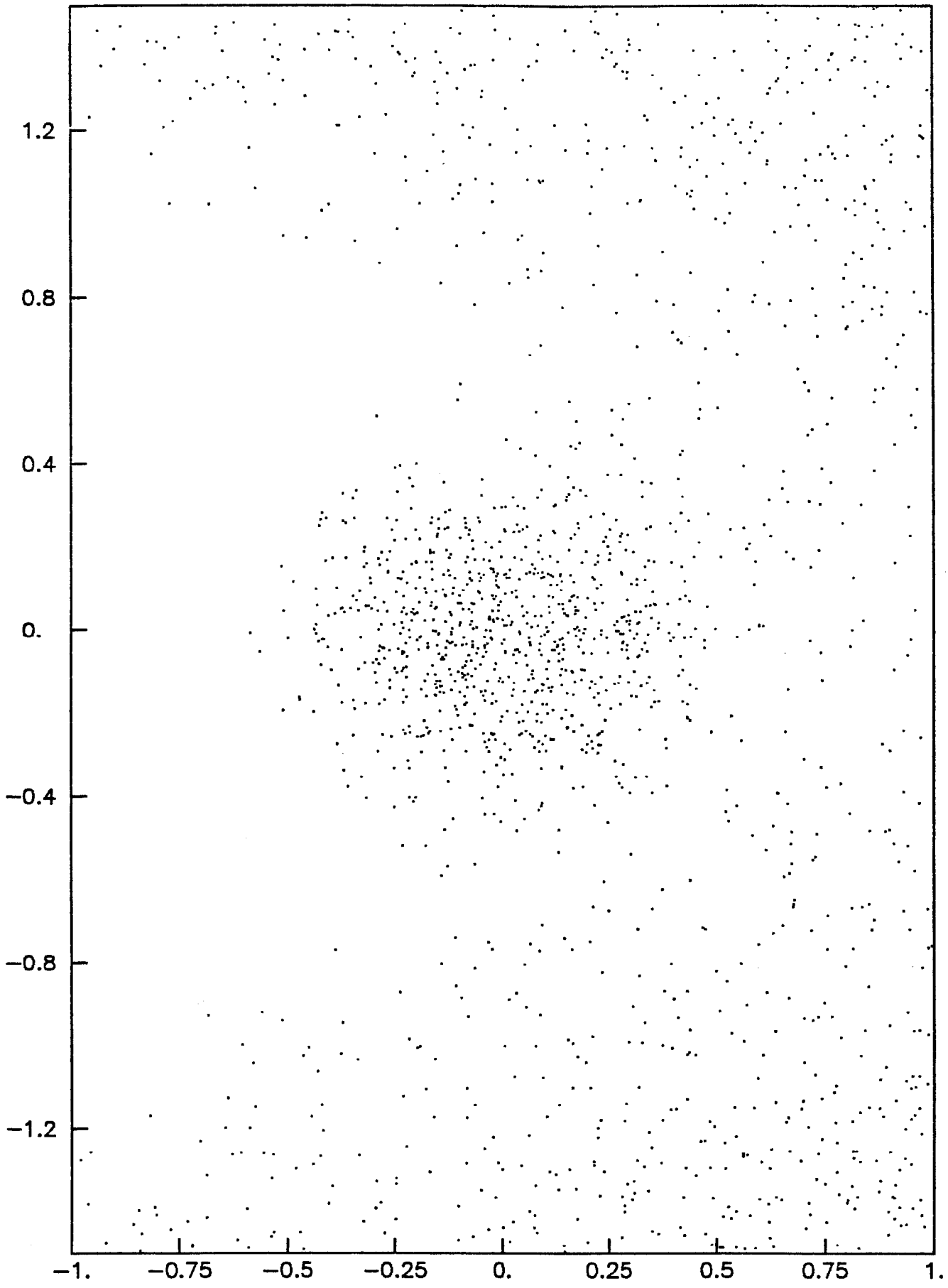

800
700
600
500
400
300
200
100
0
490
500
510
520
530
540
PEAK



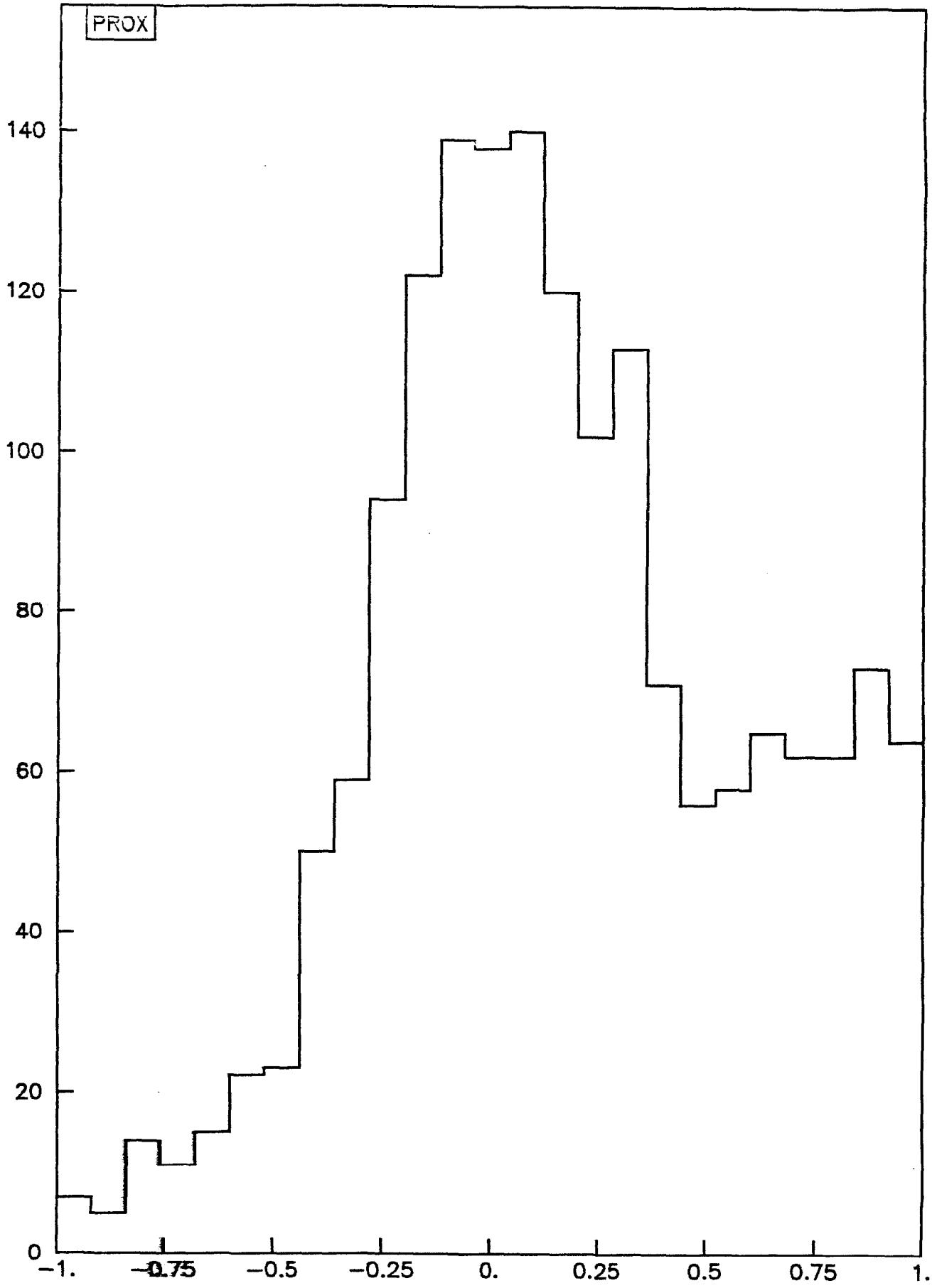
PEAK



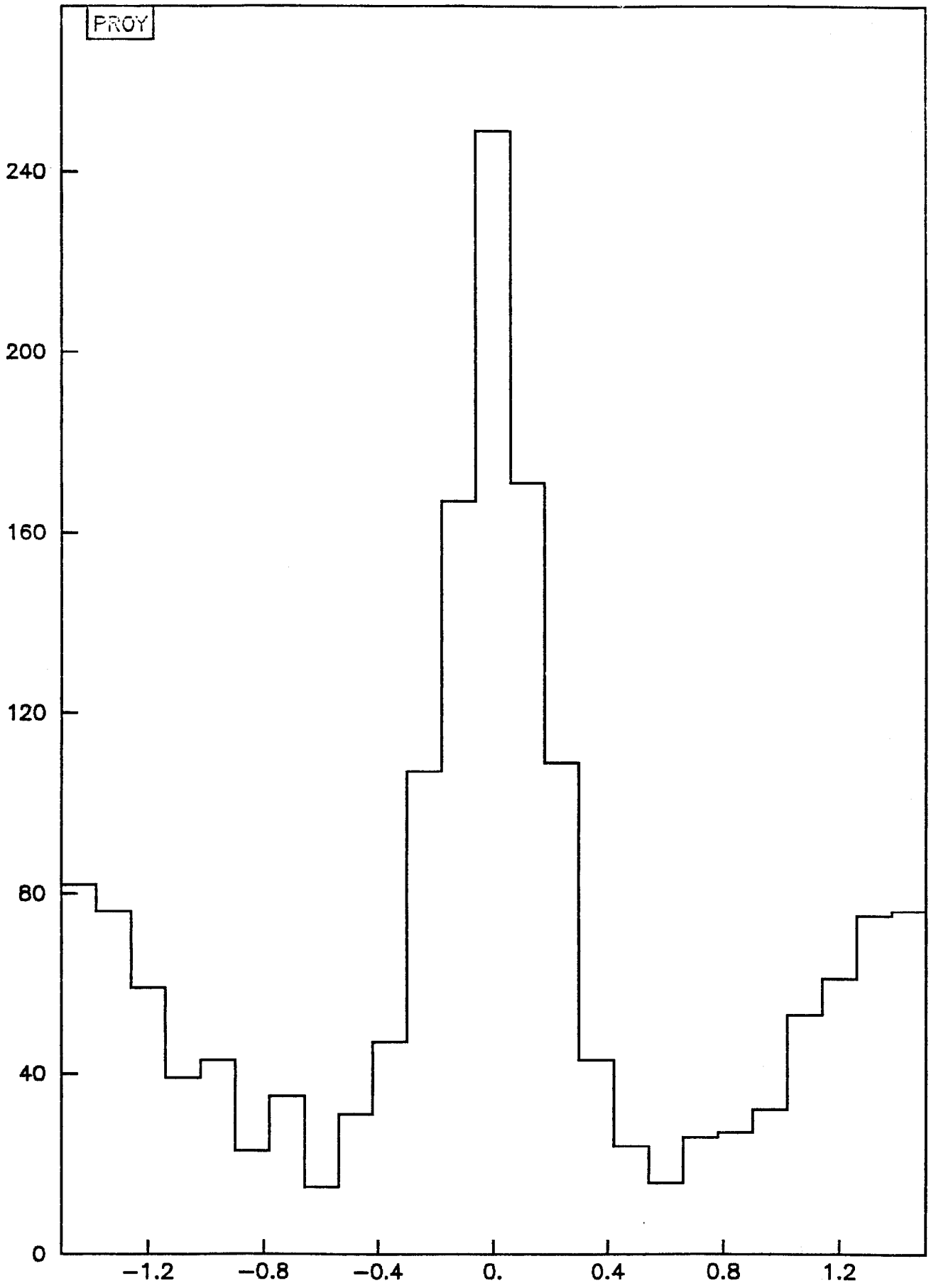
Fit deviation for PEAK



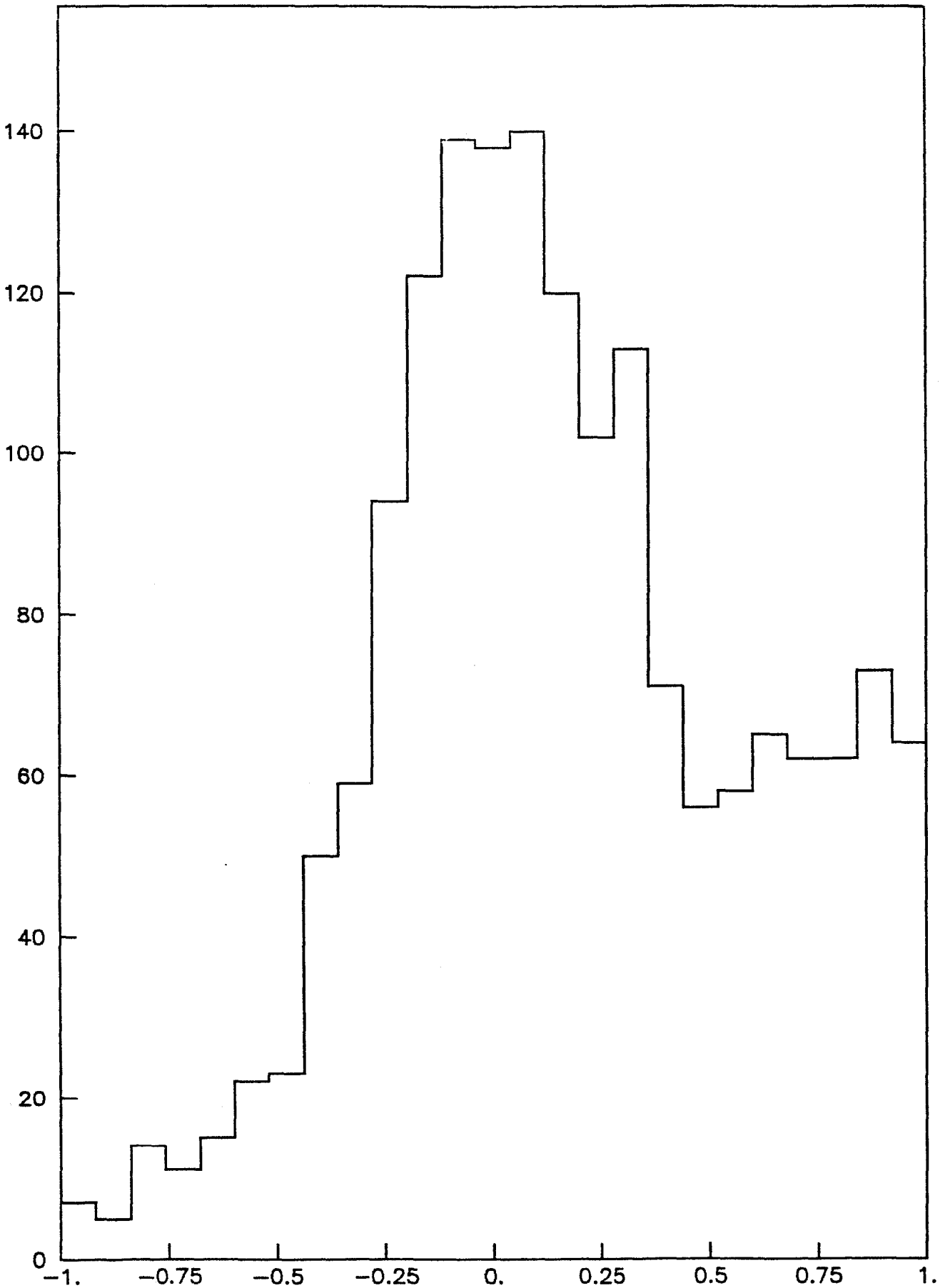
SCATTERPLOT EXAMPLE



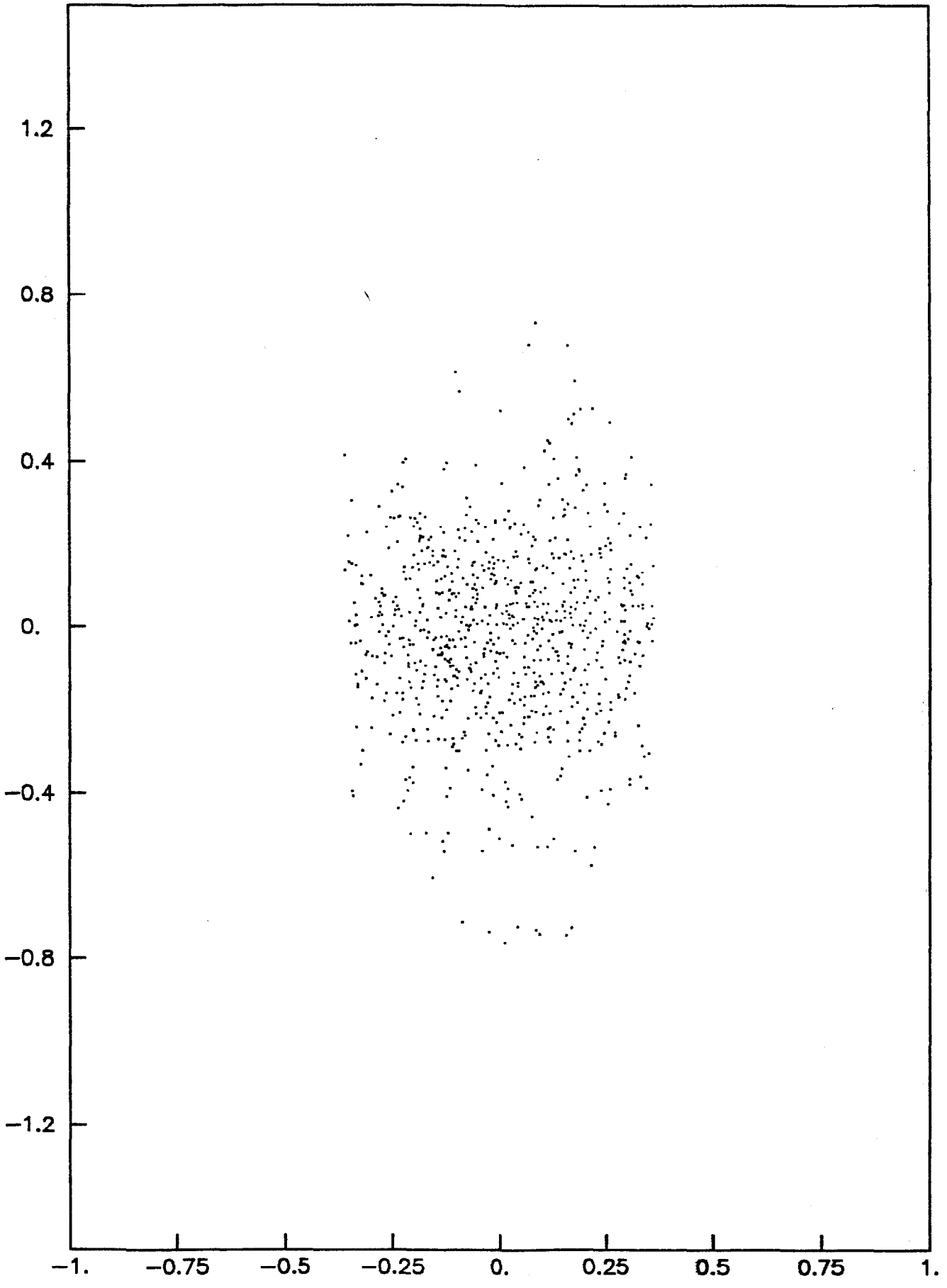
SCATTERPLOT EXAMPLE



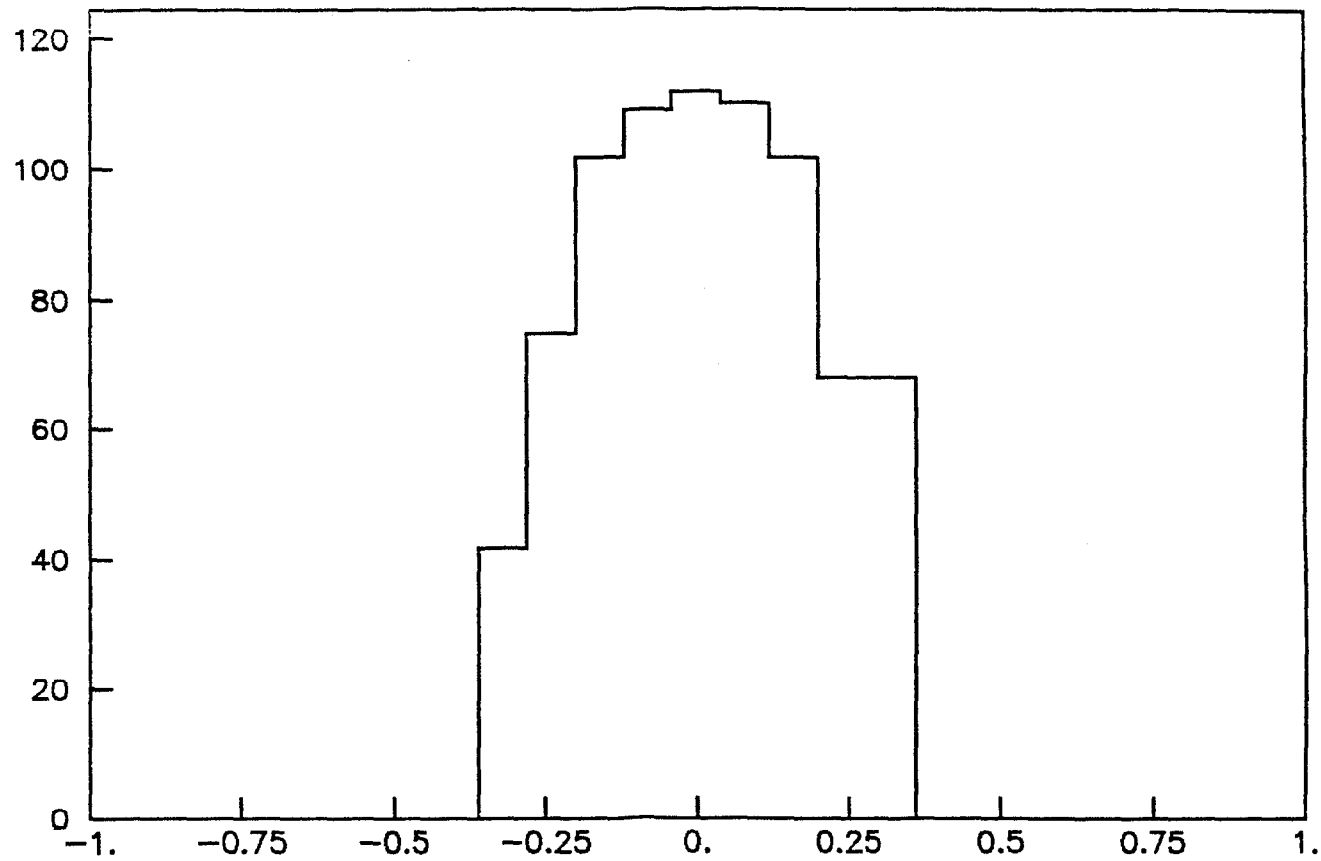
SCATTERPLOT EXAMPLE



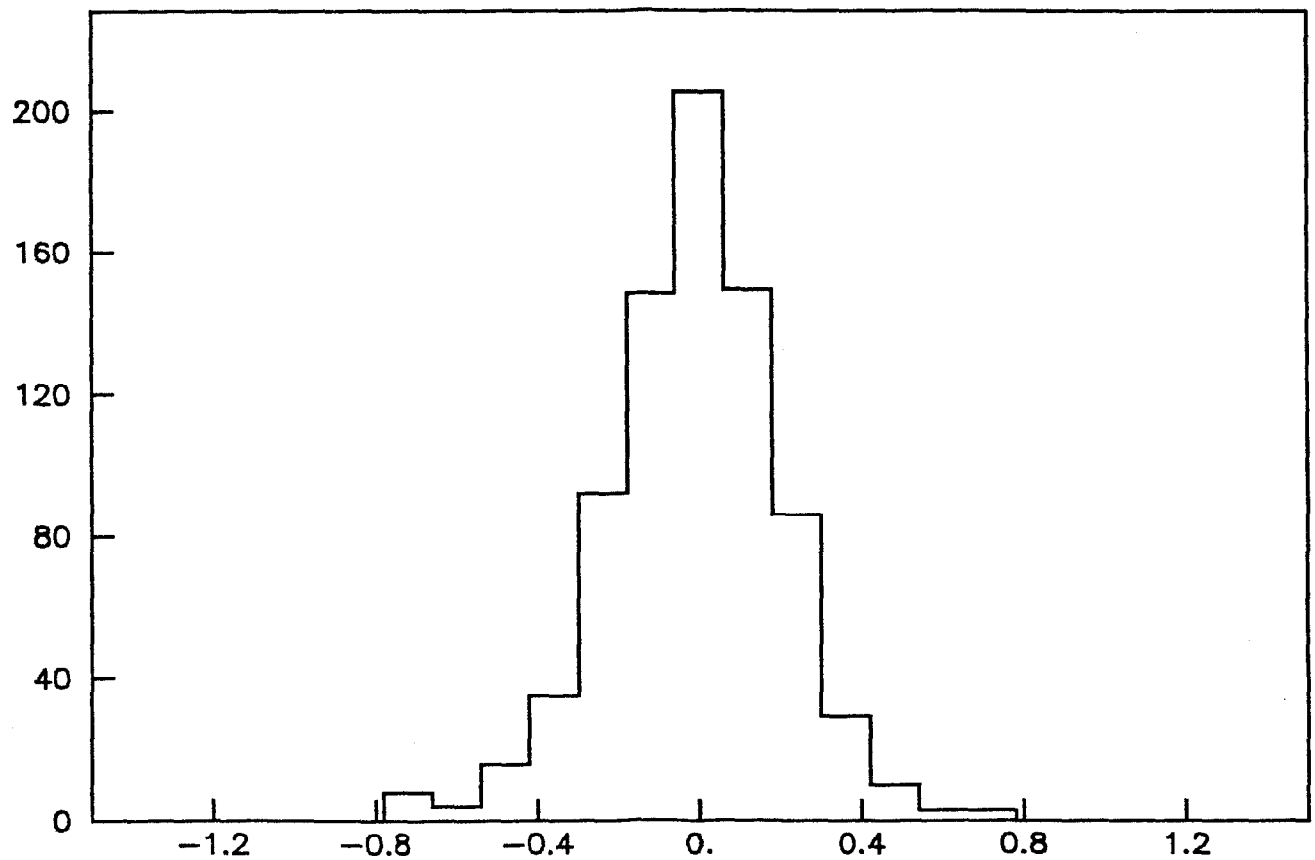
X projection of SCATTERPLOT EXAMPLE



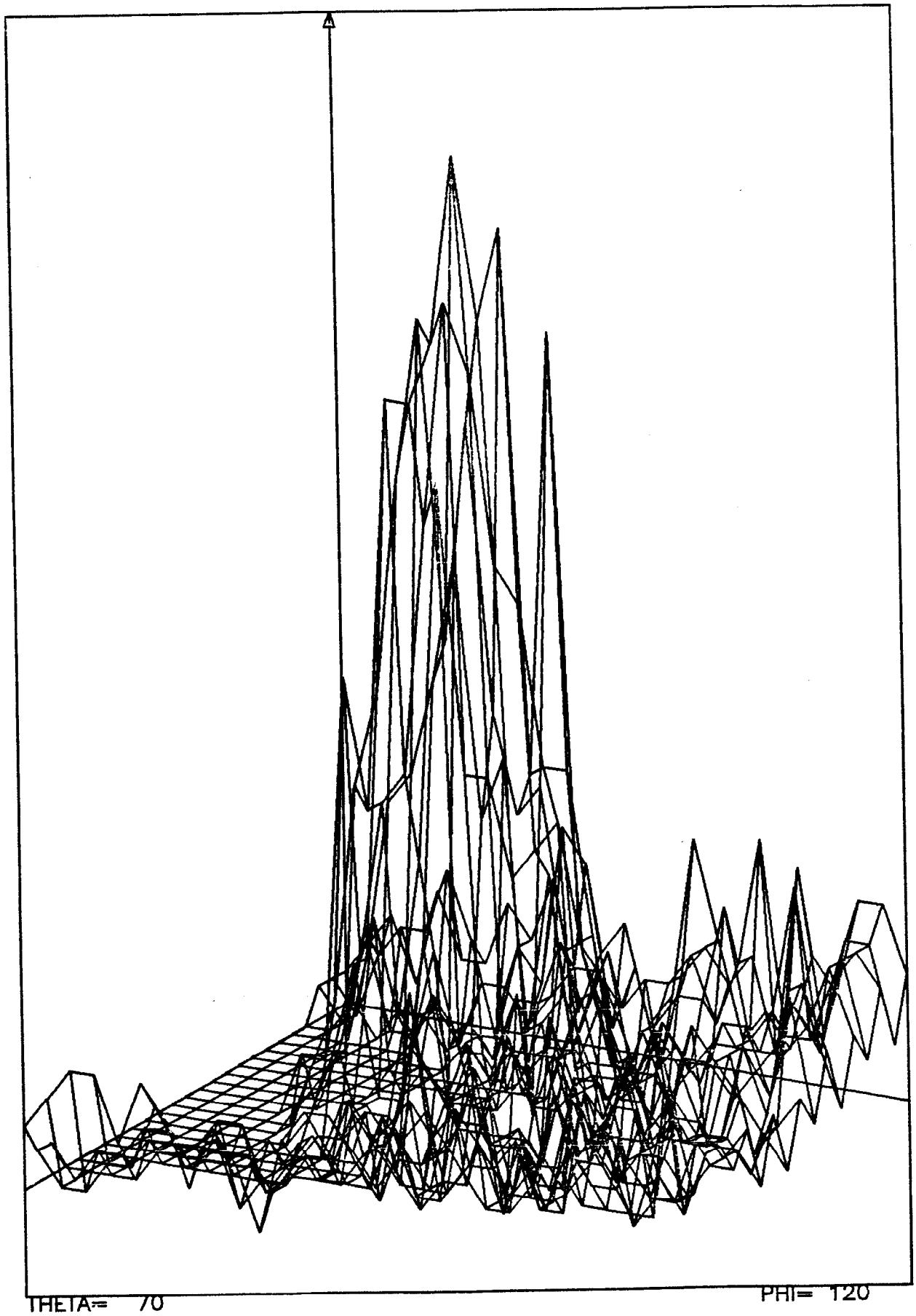
Cleared SCATTERPLOT EXAMPLE



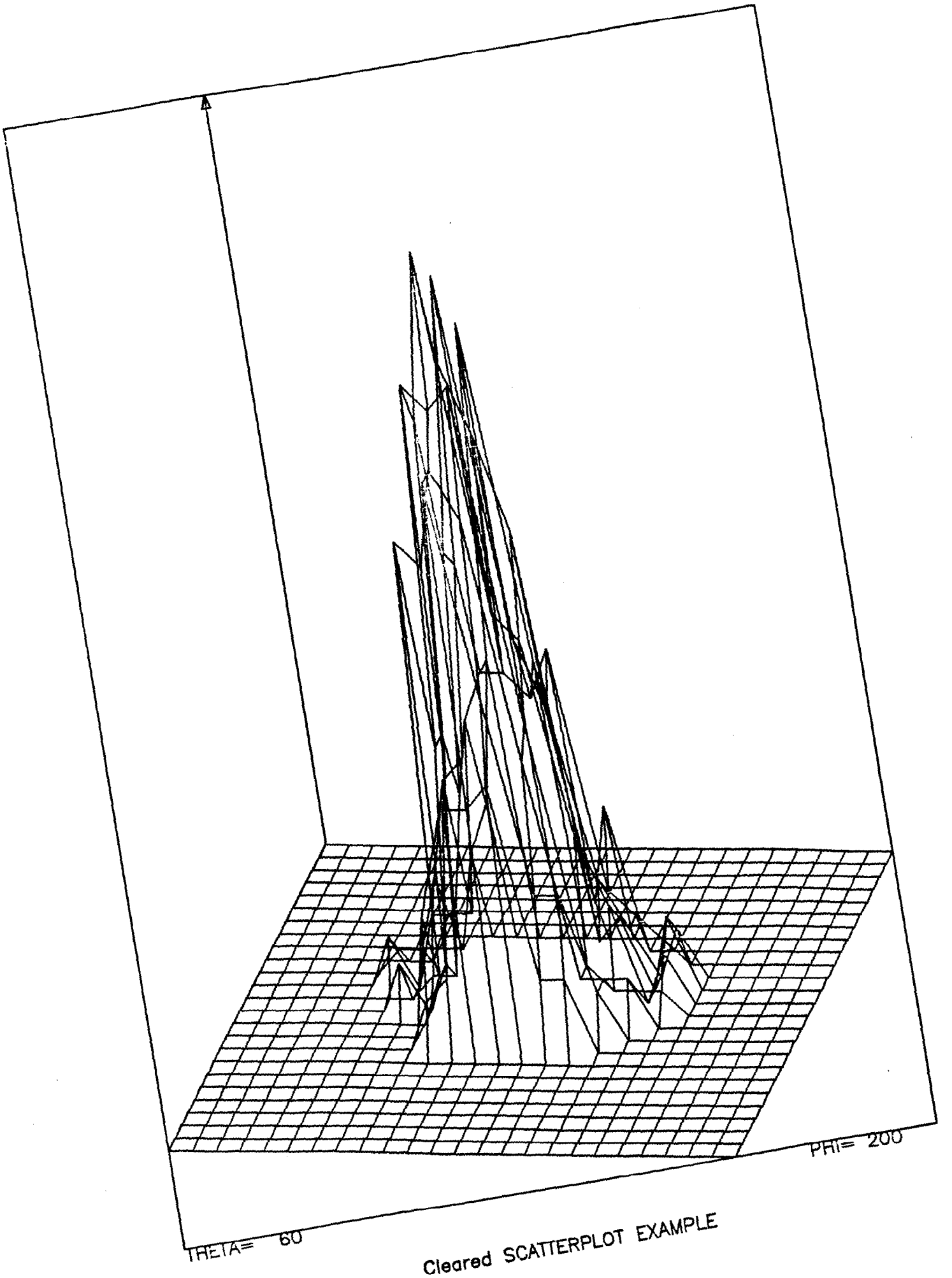
X projection of Cleared SCATTERPLOT EXAMPLE



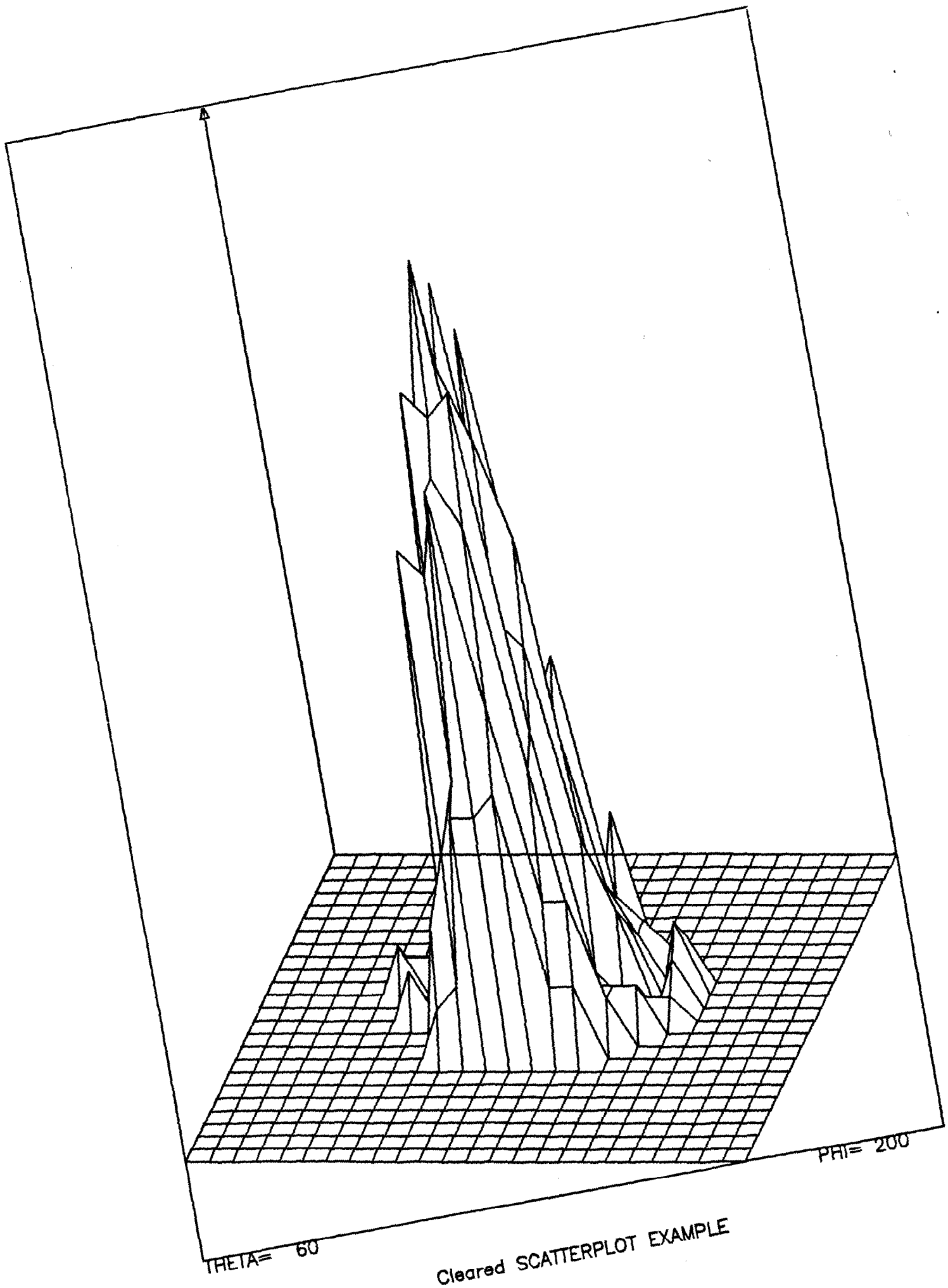
Y projection of Cleared SCATTERPLOT EXAMPLE



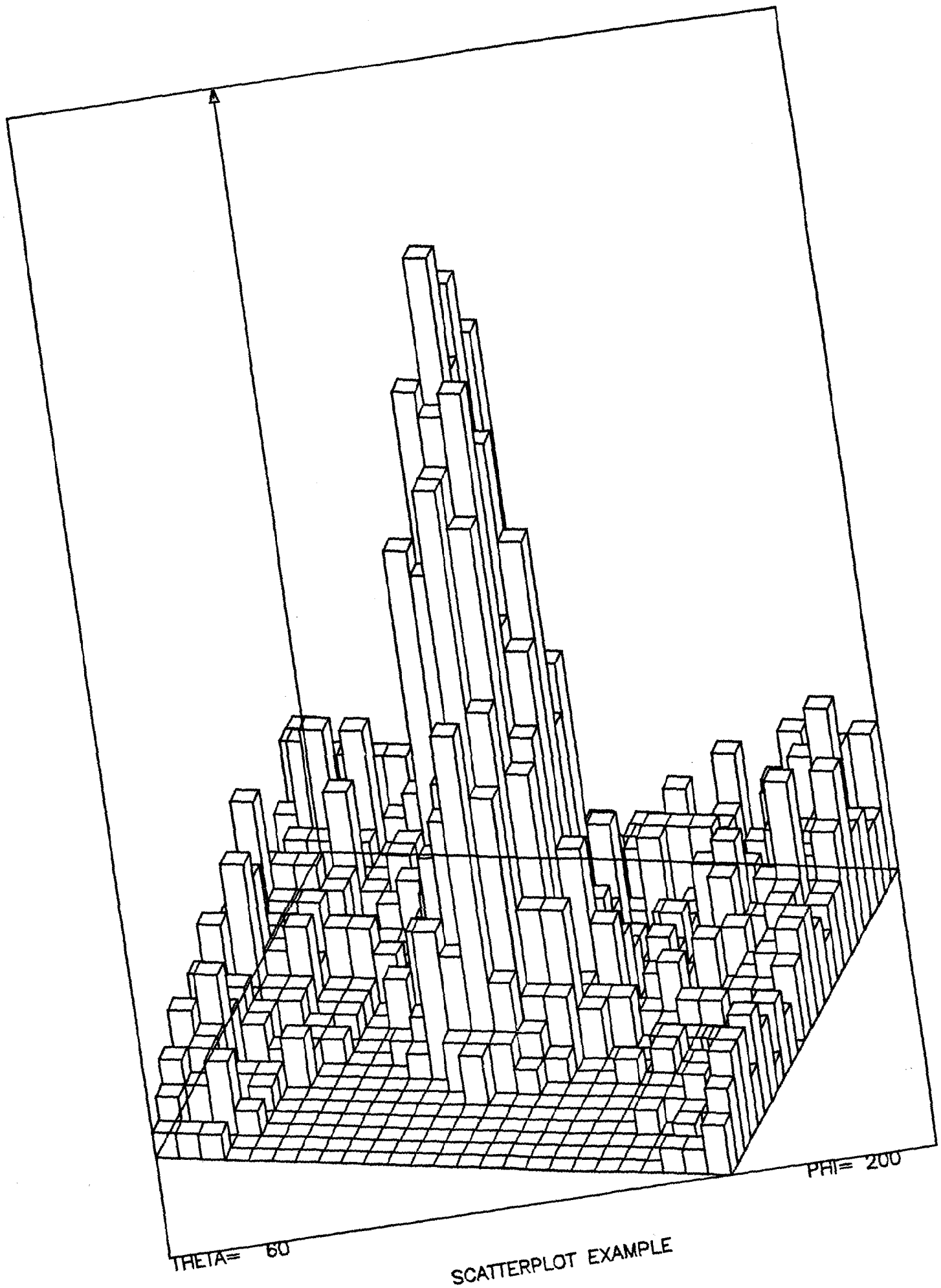
SCATTERPLOT EXAMPLE



Cleared SCATTERPLOT EXAMPLE

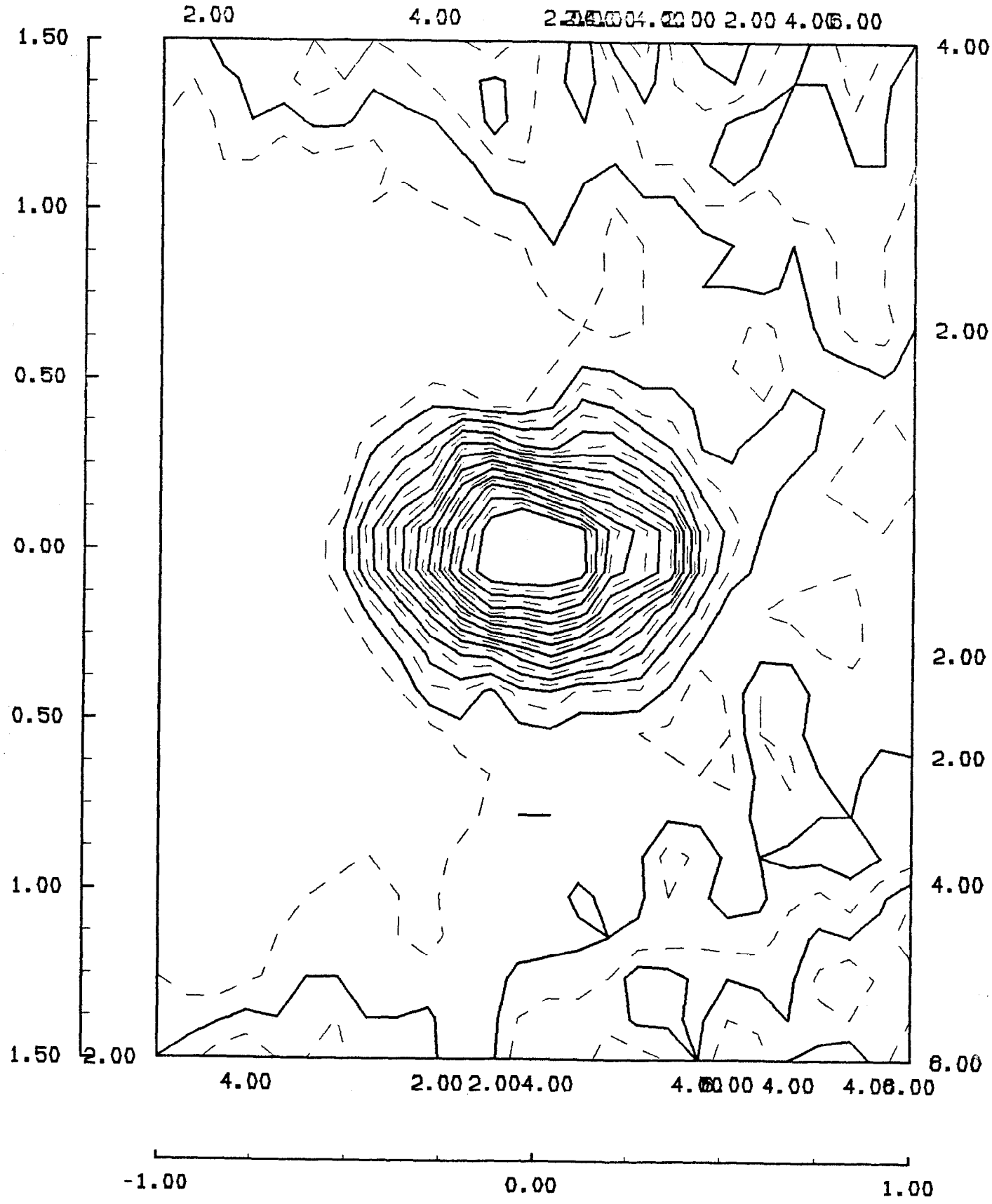


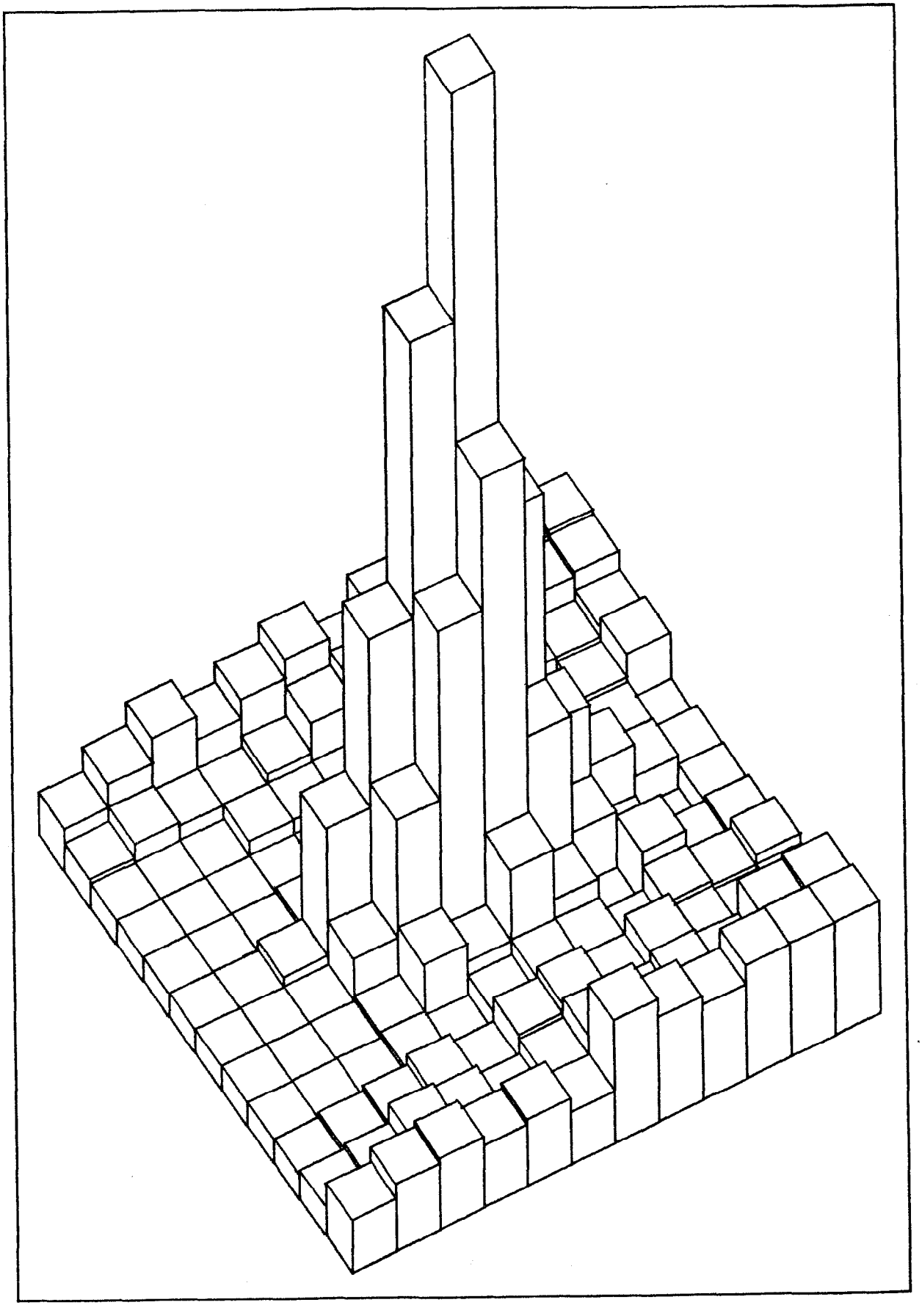
Cleared SCATTERPLOT EXAMPLE



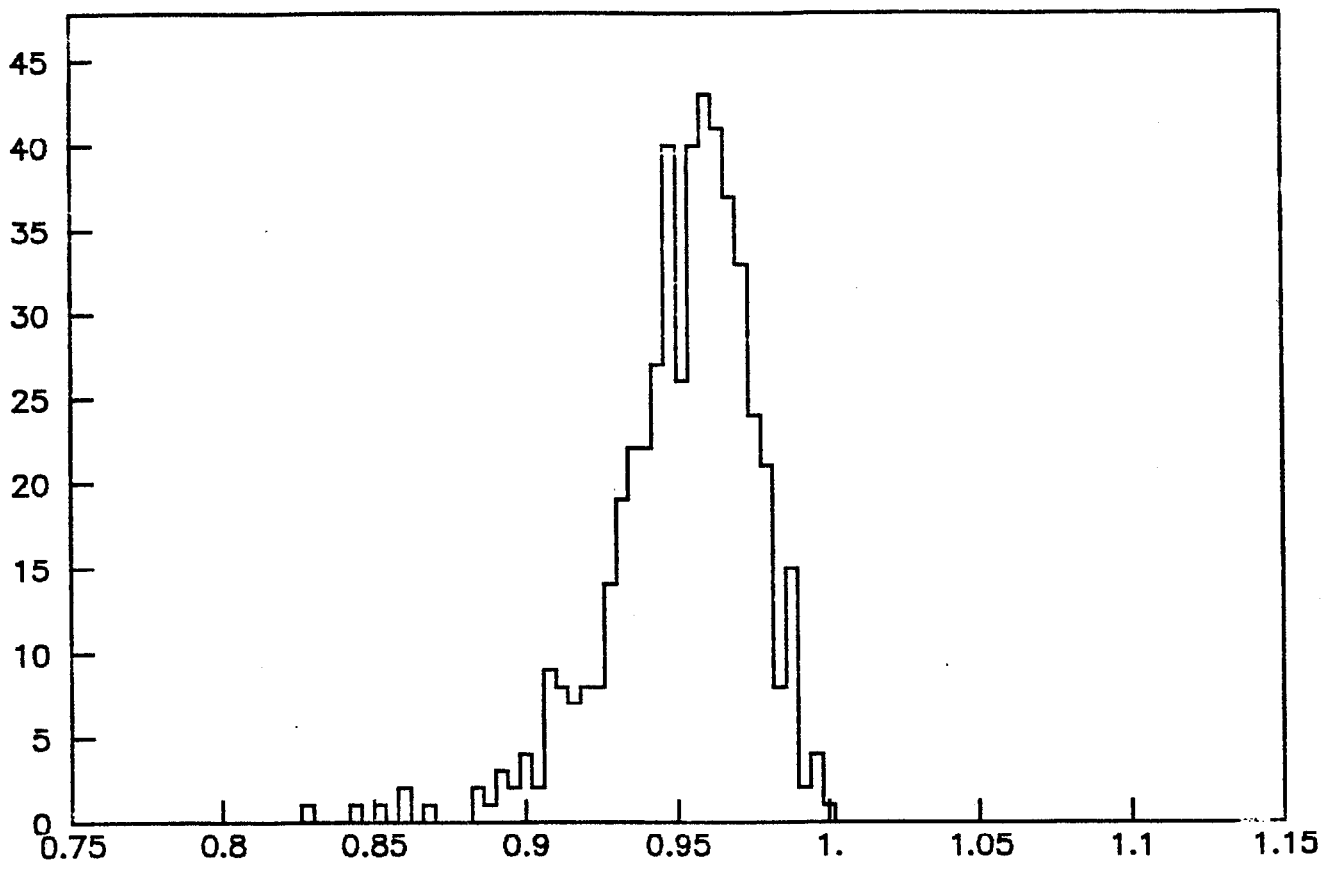
SCATTERPLOT EXAMPLE

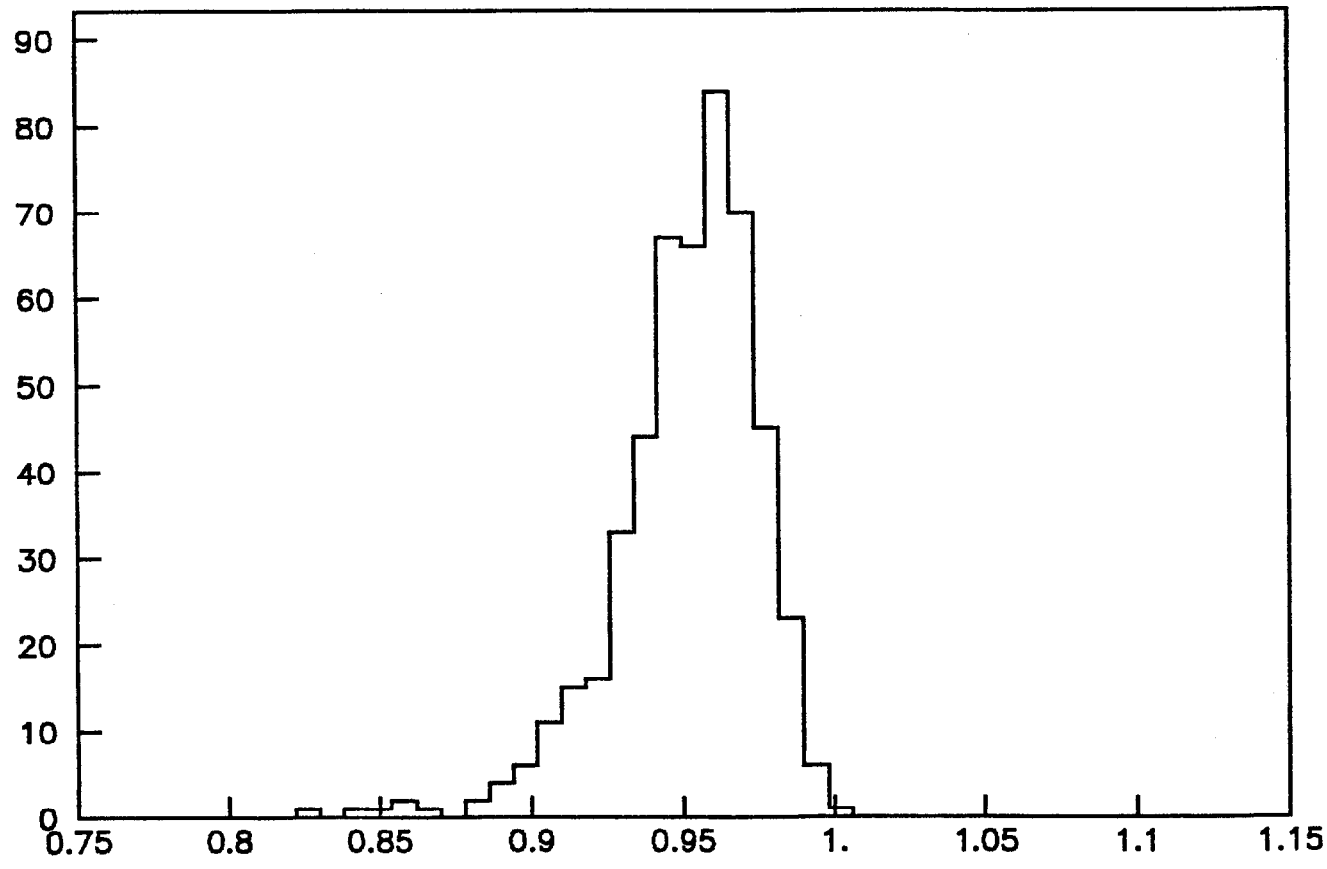
SCATTERPLOT EXAMPLE

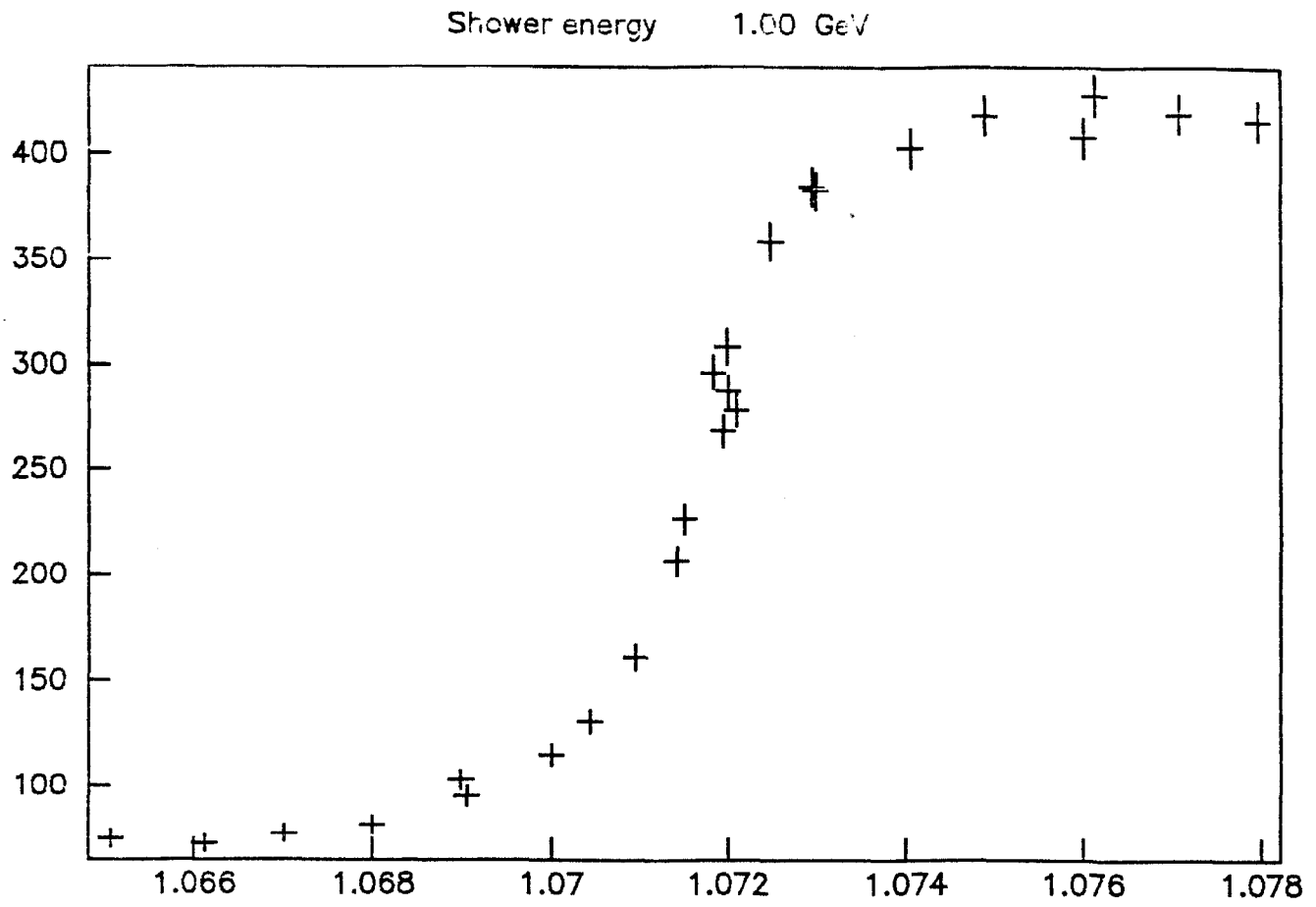




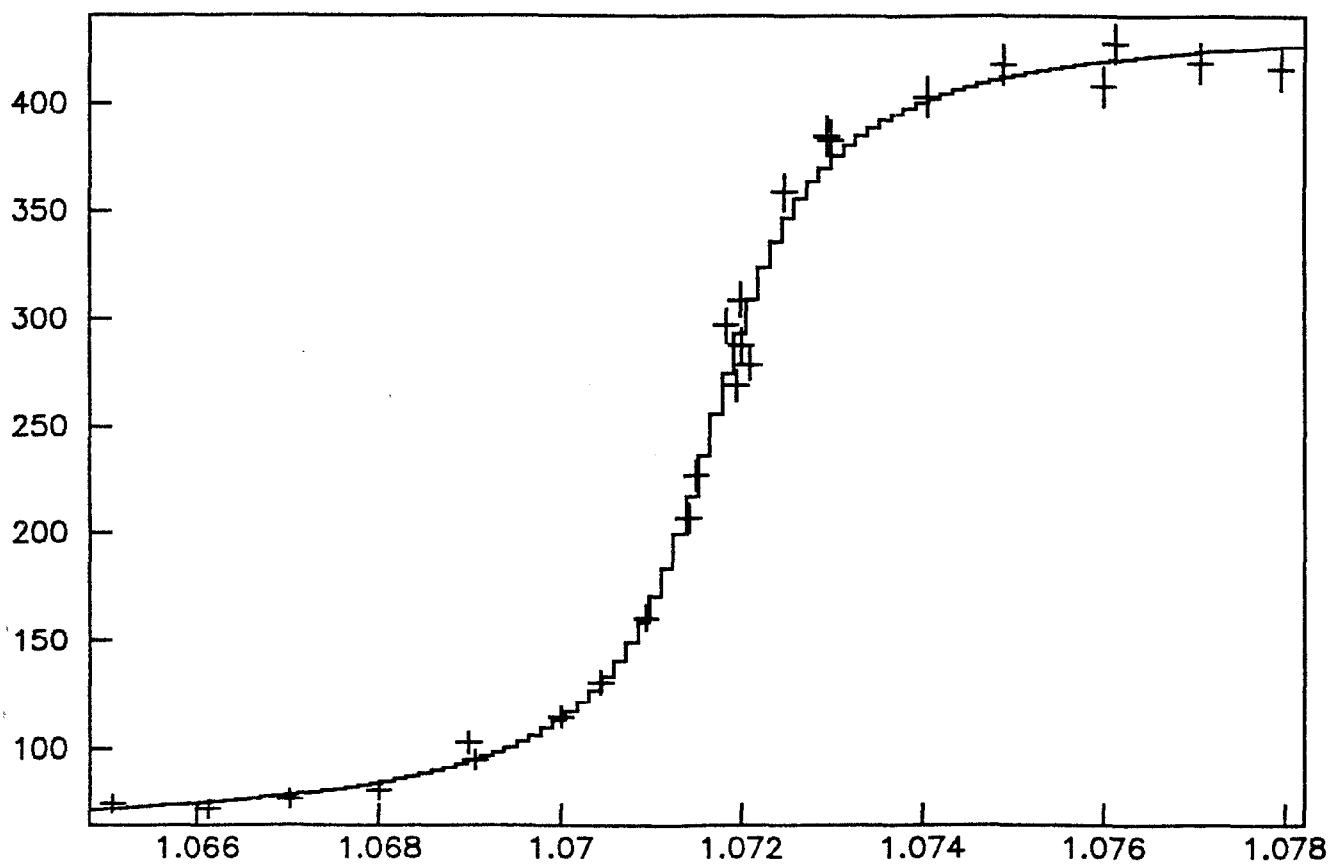
Merged SCATTERPLOT EXAMPLE


Shower energy 1.00 GeV
45
40
35
30
25
20
15
10
5
0
0.75
0.8
0.85
0.9
0.95
1.
1.05
1.1
1.15
Energy left in BGO


90
80
70
60
50
40
30
20
10
0
0.75
0.8
0.85
0.9
0.95
1.
1.05
1.1
1.15
Merged Energy left in BGO



NON–HISTOGRAM DATA EXAMPLE



NON–HISTOGRAM DATA EXAMPLE