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PROPHET - A Program for Histogramming Monte Carlo Data from SAGE

PROPHET is a collection of FORTRAN subroutines for histogramming Monte Carlo simulated data output from SAGE.[1] These routines provide a flexible framework for summarizing the results of the Monte Carlo simulations or obtaining predicted experimental distributions from dynamical models. The control quantitites that define the histograms for PROPHET are set up with FORTRAN coding, and their pictorial displays are printed on a standard computer line printer.

The type, number, and control quantities (boundaries, bin widths, number of bins, labels) for the displays are set up by the user with FORTRAN coding. The user may enter the control quantities with FORTRAN DATA statements, FORTRAN executable statements, or by reading data cards in formats of his own choosing. The determination to enter some data from a particular Monte Carlo generated event on some particular histogram is made in a user-coded routine. Using any FORTRAN coding desired, the user determines what is to be plotted and calls a subroutine to enter each quantity into the desired plot. Since all testing is accomplished with FORTRAN logic and the control quantities for the plots are set up with FORTRAN coding, it is possible to produce a large number of plots with minimum effort on the part of the user.

The program will superimpose user-coded curves on histograms and calculate a chi-square between the curve and the histogram. The program will display the histograms in a standard linear or semilogrithmic representation. The contents of each histogram are made available to the user just before it is printed, allowing modification or storage of the contents. Furthermore, the user need not specify the boundaries of his histograms; at his request, the program will automatically adjust the boundaries of any plot so as to contain all of the quantities entered.

The following control quantities are input to the program and must be supplied by the user.

COMMON/TOTALS/NHISTS/H1/HZ/H2/DH/H3/NH/H4/IH

NHISTS is the number of histograms desired

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[1] "SAGE - A General System for Monte Carlo Event Generation with Preferred Phase Space Density Distributions", Lawrence Berkeley Laboratory Group A Programming Note No. P-189 (Revised), Jan. 1971; also SLAC Computation Group Technical Memo No. 145, Dec. 1972.

The following quantities control histogram displays and must be dimensioned NHISTS (or larger):

HZ(n) - lower limit of nth histogram (real);

DH(n) - bin width of nth histogram (real);

NH(n) - number of bins in nth histogram (integer $\leq$ 120);

IH(n) - indicator of which kind of plot is desired (integer $\leq$ 12);

= 1 - histogram, plain and simple;

= 2 - histogram with user function superimposed;

= 3 - histogram with user function superimposed and chi-square calculated;

= 4 - "big bin" histogram -- uses 120 spaces on paper even though only 2, 3, 4, 5, 6, 8, 10, 12, 15, 20, 24, 30, 40, or 60 bins are requested;

= 5 - "big bin" histogram with user function;

= 6 - "big bin" histogram with user function and chi-square;

= 7-12 - same as 1-6 except histogram is displayed in semi-logrithmic representation.

The quantity HZ(n) may be set by the user to 1HF, 4HFIND, or 7777.0 if it is desired that the program adjust the lower limit of the corresponding plot coordinate so as to contain the smallest data point. Similarly, DH(n) may be set to 1HF, 4HFIND, or 7777.0 if the user wishes the program to adjust the upper limit of the corresponding plot coordinate so as to contain the largest data point.

B. User Titles

There is an optional provision for inserting user titles on histograms. To insert titles on all histograms, include the statement

COMMON/ULABEL/ILABEL/HISTLB/HLAB(8,nhists).

Set ILABEL equal to 1, and store the label of the nth histogram in HLAB(I,n), I=1,8. Each title is 8 words and, thus, 32 characters long. If all 32 characters are not used, the unused ones must be set to blanks. Also, if all titles are not used, the unused title locations must be set to blanks. Titles, like other control quantities, may be set up with FORTRAN DATA statements, FORTRAN executable statements, or FORTRAN READs from data cards.

C. Working Storage

The user must set aside a working storage for PROPHET by including the FORTRAN statement

```
COMMON  /  / Z(ndim)
```

where $ndim \geq \sum_{i=1}^{nhists} [NH(i)+8] + 1524$

D. Initialization

Before any data is entered into any histogram, the subroutine call

```
CALL PROPHT (4HINIT)
```

must be executed.

E. Entering Data into Histograms

For each Monte Carlo event that the user generates, he must decide to which histogram(s), if any, the event is to contribute, how many times, and what quantity is to be plotted in each case. A quantity is entered into a histogram by executing the subroutine call

```
CALL HIST(I,X,WT)
```

or

```
CALL H(I,X,WT).
```

The quantities in the calling sequence are

X = quantity to be histogrammed (real)

I = number of the histogram to which the quantity is to be entered (integer)

WT = weight to be applied to the entry (real).

The calling sequence quantities may be any legal FORTRAN expression, such as constants, variables, arithmetic expressions, and calls to function subroutines.

The user may employ any type of FORTRAN coding to decide upon which plots an event should go and how many times, as well as to construct quantities to be plotted.

Multiplicities (plotting more than one quantity from the same event on the same plot) are accomplished by simply calling HIST more than once for a given plot for the same event.

F. Finalization and Printing Histograms

After all Monte Carlo events have been generated and all data has been entered into the histograms, the execution of the subroutine call

```
CALL PROPHT(4HPRNT)
```

will cause the pictorial histogram displays to be printed.

G. Modifying and Storing Histograms

Just before the histogram is printed, the program presents the bin contents to the user via a user coded subroutine

```
SUBROUTINE USRHST(H,N)
Real H(1)
```

Upon entry to the subroutine, each element of the array H contains the contents of the corresponding bin for the nth histogram. The user can code this subroutine to alter the contents of the histogram or store the contents on some permanent storage medium (for example, punched cards).

If no user subroutine is provided, a default subroutine is executed which simply normalizes each histogram to 1000 events.

H. Plotting Functions over Histograms

In order to superimpose a curve on a data histogram, the user must do two things:

(1) Set IH(n) for the desired nth histogram to the appropriate value, as described above in Section A; the legal values are IH(n)=2,3,5,6,8,9,11,12.

(2) Code the routine UFUN with the following calling sequence:

```
FUNCTION UFUN(X,N)
```

N is the histogram number upon which the curve is to be superimposed, and X is the abscissa coordinate for which the function is to be evaluated. Both N and X are input to the routine; the user must execute a statement of the form

```
UFUN = some function of N and X
```

before returning to the calling program. The user function may have arbitrary normalization, since the histogramming routine automatically normalizes it to the total number of events in the histogram.

I. PROPHET Printed Output

Two histogram formats are available with PROPHET, the standard "SUMX" format and the "big bin" format. The user selects which is used for a given histogram by setting the histogram flag IH(n) to the appropriate value as described in Section A.

The standard "SUMX" format allows one printer column per bin with a maximum of 120 bins. The number of events in each bin is printed vertically, below the pictorial column for the bin, and the abscissa value of the lower edge of the bin is printed vertically, below the number in the bin.

The "big bin" format uses more than one column per bin and always uses 120 columns to display the histogram. The number of bins for a "big bin"-histogram display must divide evenly into 120. Legal values are 2, 3, 4, 5, 6, 8, 10, 12, 15, 20, 24, 30, 40, and 60. At the base of the histogram, the lower edge value of each bin is printed vertically below the lower edge of the bin, and the number of events in each bin is printed vertically below the center of the bin.

The "big bin" format allows for negative bin contents which might arise from subtracting histograms. (Histograms may be subtracted by using negative weights with multiplicities in the user routine.) The standard "SUMX" format will not print negative bin contents.

The following summaries appear beneath each display:

1) the sum of weights in the histogram.
2) the sum of weights which underflow and underflow the boundaries of the histogram.
3) the largest and smallest values of the quantity plotted.
4) the mean and standard deviation of the quantity plotted for those entries that contribute to the histogram.

J. A Simple Example

Consider the second example on page 27 of Ref. 1. Suppose in the reaction Beam + Target $\rightarrow A_1+A_2+A_3+A_4$, the user wishes the invariant mass distributions of particle combinations A_1+A_2, $A_1+A_2+A_3$, for uniform phase space generation. The following simple coding would construct and display these distributions.

```
      COMMON / /  Z(2000)  /TOTALS/NHISTS
      COMMON/H1/HZ(2)/H2/DH(2)/H3/NH(2)/H4/IH(2)
      DATA NHISTS, HZ, DH, NH, IH/2,4*1HF,2*50,2*1/

      REAL S(4), N(2), W(2), U(3), P(4,4)
      DATA S,N/m1,m2,m3,m4,4,1/

      CALL PROPHT(4HINIT)
      CALL INITLO(ECM)

      DO 1 IEV=1, 5000
      CALL GOGEN (ECM,2HCM,N,S,U,P)
      CALL WT(W)
      CALL H(1,U(2),W(1))
    1 CALL H(2,U(3),W(1))

      CALL PROPHT(4HPRNT)

      STOP
      END
```