MINUS3 - A GENERAL PURPOSE DATA ACQUISITION SYSTEM AT
LBL'S 88"-CYCLOTRON AND SUPERHILAC*

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Abstract

MINUS3 is a general, multi-tasked data acquisition package operating on the ModComp IV/25 computers at both the 88"-Cyclotron and SuperHILAC. It currently can acquire data via three different channels: interrupt; serial DMA link; and remote slave units for histogram type data. Two additional acquisition paths, CAMAC (with programmable differential branch drivers) and MODACS (for multiple CPU linkages and control) are scheduled to be added in the near future. The package operates in a prioritized, time-available mode which permits it to dynamically adapt to microscopic data rate structures due to beam characteristics at different accelerators. Special hardware has been added to the graphics system to provide enhanced high-speed interactive capability. The program framework is also designed as a parasitic environment in which users may, in parallel, attach their own specialized and independent code.

Introduction

The software package MINUS3 is currently utilized for the acquisition, control, and on-line analysis of data from experiments performed with both the 88"-cyclotron and SuperHILAC accelerators at the Lawrence Berkeley Laboratory. The 88"-Cyclotron is a multi-particle, variable-energy, sector-focused cyclotron. At present it is capable of accelerating protons to 60 MeV, light ions ($Z \leq 4$) to about 35 MeV/A, and heavy ions to energies of 140 MeV/A . From the point of view of data acquisition, the cyclotron produces an essentially continuous beam. Thus, for a given experiment, the data rates are roughly constant and continuous.

The SuperHILAC is a heavy ion linear accelerator capable of accelerating ions (up to ^{208}Pb) to energies up to 8.5 MeV per nucleon. It is a pulsed machine giving 36 pulses per second, each approximately 4 msec in duration. The accelerator also permits the time-sharing of beams of different ions into different experimental areas. Data acquisition at this facility therefore requires handling intense bursts of information approximately every 30 msec.

The types of experiments carried out at both accelerators vary greatly and include polarization work, gamma-ray studies, nuclear particle spectroscopy, and investigation of nuclear reaction mechanisms. Historically most research groups independently handled their own acquisition problems, often with their own computers. In 1975,

however, a decision was made to attempt to standardize the problem of data acquisition and handling at both accelerators. This standardization includes using the same computer, acquisition hardware, and software framework for the majority of experiments.

Computer Configuration

One of the first steps in standardizing the acquisition environment was the decision that, during on-line data acquisition, the total resources of one computer would be devoted completely to the experiment. This computer would then be expected to handle data acquisition and data storage as well as to provide all the interactive control and real-time processing (including monitoring, analysis, and display) required. The decision to utilize one dedicated computer for acquisition was based on the belief that the on-line demands on the CPU, particularly in the area of real-time, event-by-event analysis, would be substantial and would continue to increase. Indeed, it was felt future requirements, both in acquisition and in on-line analysis, might exceed the capability of a single computer.

The selection of ModComp IV/25 computers was based primarily on their multi-task hardware features (e.g., hardware mapping and register saving), the available map space (131K bytes/task), the memory capacity (524K bytes), and the ability of the CPU to perform fast 32-bit integer operations. Three of these computers came on-line in the summer of 1976. Currently four of these computers are in use and a fifth, a new ModComp Classic, is being installed. In order to maintain complete compatibility between the computers and to run standard operating systems and acquisition software, all systems are configured with the following minimum hardware:

1. 328K bytes of memory
2. Three, 2.5 Mbyte cartridge discs
3. Two magnetic tape drives (75ips)
4. Hardcopy operator console
5. Specially modified Tektronix 4014 graphics terminal
6. Versatec 1000 LPM printer/plotter/copier
7. Standard data acquisition hardware (discussed in the following section).

The Tektronix 4014 terminals have been specially modified to provide better interactive and display features. The keyboard portion of the terminal has been lengthened 2 inches by inserting a machined plate containing 15 physical switches at the base of the storage screen (figure 1). These switches, some of which are two position, together with 4 standard switches on the Tektronix 4014, have been interfaced to the computer to provide 31 readable switch positions. The switches themselves have no intrinsic hardware function but are monitored by software to provide a wide range of functions depending on the program executing. In the acquisition environment the switches provide features

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Fig. 1. Tektronix 4014 keyboard modified to include a set of interactive switches.
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ranging from simple x, y, or z scale manipulation to dynamic interactive background fitting and multiple peak deconvolution. In addition, each switch also contains an independent light which is also operated under software control. These lights may be used for any function, such as blinking to indicate user action is required, but in a typical acquisition environment they are employed as a user aid. For any given combination of switch settings, the lights will indicate what remaining user options are available.

An additional "safety" switch was also added to the terminal. The function of this switch is to disable some standard hardware features of the 4014. In particular, these include the line/local switch, the teletype-lock key and the margin-control switch. This modification protects the user against accidentally altering any of these switches which would normally change or suspend the operation of the scope. The installation of this safety device resulted in about a 75% reduction in the number of reported hardware problems.

The standard transmission rate of graphics information from the computer to the terminal (9600 baud) also necessitated some hardware additions. This transmission rate proved far too slow for effective interaction with the scope. This is especially true when high density plots (multiple 1- and 2-dimensional displays) are involved. (See sections on HYDRA and SPACE.) To alleviate this situation a special direct memory interface connection was constructed between the main computer and the 4014 terminal. With this link, graphics information can be transmitted at rates equivalent to approximately 120K baud.

Data Acquisition Hardware

For purposes of description, the data acquisition hardware will be divided into three classes:

1. High-Speed Event Recorded Data
2. Histogram Data
3. Periodic or Low Speed Information.

Event-by-event data have traditionally been acquired by using a multiplexed ADC system to provide up to 16 channels of information per event. The ADC provides 12-bit accuracy with a fixed conversion time of 30 μ sec.¹ The multiplexer² provides the ability to stretch signals up to 1 msec with stability of better than 1 part in 5000. Data acquisition utilizing this setup is carried out over a high-speed serial link to the computer. Using this acquisition channel, data are acquired in an interrupt mode, with the CPU processing one interrupt per parameter. The maximum data collection rate, approximately 18K parameters/sec, is limited primarily by the speed of the front end electronics.

In order to achieve higher data rates and to decrease the CPU overhead in data processing, a DMA data acquisition interface has been constructed, integrated into the system, and is in the final stage of testing. This channel was designed so that it could operate with new fast 12-bit ADC units, having fixed conversion times of about 5 μ sec. With this channel the maximum acquisition rate is expected to be between 50 and 70K parameters/sec, but in practice will be limited to less than this by tape storage speeds.

It is anticipated that in the near future it will be necessary to process more than 16 parameters/event. At this point it will become advantageous to utilize data acquisition hardware different from the traditional multiplexed ADC approach. Although the DMA channel is not limited in the number of parameters/event it can handle, it appears that it may be economically more feasible to move to a CAMAC based environment. The initial cost of such a conversion may be substantial considering neither accelerator currently operates with CAMAC. It is hoped, however, that in the long run, and with a large number of parameters/event, this solution will be more cost effective and flexible. To this end, it was decided to utilize the Differential Branch Driver (DBD) interface developed by the Los Alamos Scientific Laboratory.³ This unit provides up to 8 DMA channels to the computer, each controlled by a separate instruction stack in the D3D. One such unit has been purchased and installed on one of the ModComp IV/25's and is currently being tested and integrated into the system. The inclusion of these three modes of event-by-event data acquisition in the operating environment is schematically shown in figure 2. The software impact will be discussed in the section on CHAOS (no pun intended).

The necessity of being able to process high-speed histogram or singles type of information was recognized in the initial system design. This type of data results in adding one to some memory location in order to create various individual spectra, as opposed to independently recording every event as described previously. Since this type of data can run at very high rates and can be required in addition to event recording, it appeared simpler and more efficient to move it from the main CPU to an external processor. Figure 2 schematically indicates the two methods, analyzers or external memories, by which such information is handled. Both devices offer the common

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Fig. 2. Schematic layout of the MINUS3 data acquisition software with associated hardware.

capability of accepting routed ADC inputs to create multiple spectra of the desired resolution (12-bits maximum) within their own local memories. In both cases 24-bit memory is used and the units can operate in the add-one mode at speeds of about 300 nsec per data word. The external memory is simply an external block of bulk memory with a specialized interface. The analyzers are built around the TI960 processor and provide many local and traditional analyzer functions, such as a small display screen, peak integration capability, etc. More than one analyzer may be connected at a time. In this manner a user can have both a local display at the analyzer as well as a more versatile dynamic display on the computer graphics terminal. Both analyzers and external memories are connected to the computer through a serial link and may be controlled and dynamically monitored by the main computer.

A final class of data which must be handled is the acquisition and control of periodic information. This could include such items as scalars, pressure or temperature monitoring devices, scatter chamber positions, magnet currents, etc. This class of information is characterized by being sampled at much lower rates, typically at some predetermined time, count, or interrupt determined interval. In addition some positive action by the computer, such as clearing scalars, may also be required. Figure 2 indicates two proposed channels to handle this type of information. One is simply a low speed

CAMAC link, probably identical to the previously mentioned high-speed event link, but utilized somewhat differently. The MODACS link is a ModComp supplied unit designed both for dynamic control and to connect multiple CPU's. This link will therefore be utilized in situations demanding more involved type of control and feedback of dedicated equipment, including closed loop control. The CPU will be set up initially by the main computer and will subsequently supply status and monitor information as requested. Further discussion of the use of these units is contained in the section on TIME.

MINUS3 Acquisition Package

The general design goal was to provide the following capabilities:

1. Versatility--The package must be able to accommodate a wide range of experimental requirements.
2. Direct interaction--The package must permit users to interact directly with the real-time graphics display of data to obtain information or transform spectra.
3. Dynamic control--The user should be able to easily and rapidly alter sorting conditions on the live data and to examine new projections at will.

4. Flexibility--The user should be able to easily and rapidly alter monitor conditions. This includes, for example, the creation of new monitor conditions or the utilization of different transformation functions on the data to create new artificial parameters.
5. Ease of usage--The package should be very easy to use. This is particularly important since considerable use of the package is anticipated by outside user groups who are only present at LBL for relatively brief periods.
6. Simple user interfaces--This would permit specialized user software to be easily attached to the existing framework to provide a wide range of highly specialized services.
7. Safety--This requires that all interaction with the package be carefully examined to minimize the possibility that input errors could lead to program crashes. Further, effort should be made to localize functions such that errors occurring during acquisition affect only local tasks, which may be restarted, and not the acquisition stream. Finally, all critical areas should be monitored and any malfunction clearly reported to the user and appropriate action taken (e.g., stopping the experiment and sounding an alarm).

With these goals in mind the multi-task, software acquisition package called MINUS3 has evolved over the past three years. The structure of the package is shown schematically in figure 2. The function and interaction of each task will be described in the following sections.

1 CHAOS

The function of the task CHAOS is to handle all problems associated with direct event acquisition and the control of related hardware. The task interacts with the user via a hard-copy terminal and permits the selection of the type of data acquisition hardware to be used and, in the case of CAMAC, the configuration of the equipment. During acquisition one of the functions of the code is the allocation of buffer space for incoming data. In order to effectively handle a wide range of data rates, the size of each acquisition buffer is not determined by the size of the tape records being written, but rather is dynamically adjusted according to the actual data rate. The purpose of this feature is to permit examination or analysis of the data as quickly as possible. In the case of low data rates, for example, the individual input buffers may be only 100 words long. Each buffer is then rapidly available for analysis and display. Even a rates of only a few events per second, users may quickly view the incoming data rather than waiting for a long 1000 word tape record to be filled. At higher rates the buffer size is increased to a maximum of one tape record to optimize the transfer and minimize CPU overhead.

At present it is planned that CHAOS will also handle the acquisition and inclusion of periodic information, such as scalars, pressures, currents, etc. This information is typically read on demand, at fixed-time or -count intervals, or by triggering

an external low-rate interrupt. These monitoring conditions, if desired, would be requested and described by the user initially. CHAOS would then select and reserve appropriate space in the outgoing data buffer to store this information as it is obtained. As each piece of periodic information is processed a label will be associated with it indicating the time at which it was acquired. More complex monitoring and control functions will be handled by a small dedicated CPU via a ModComp MODACS link as indicated in figure 2. In this case code and/or user defined monitor conditions will be down loaded into the auxiliary CPU. This unit will directly carry all necessary monitoring functions, including feed-back control if desired, and will supply the information to CHAOS as requested.

Once data acquisition is underway CHAOS must, if necessary, handle the synchronization of the storage and sorting tasks, RESTOR and ORDER. This synchronization is discussed respectively in the sections describing these tasks. The major effect on CHAOS is the situation where acquisition rates exceed storage rates, resulting in lost data. Two methods are provided in this situation. In the default mode, if no buffers are available for incoming data, CHAOS will switch acquisition to a small secondary buffer. Data placed in this buffer will be lost. When the buffer is full a record will be kept of the number of events processed and a check made to see if output buffers are now available. If they are not, the above process is repeated. When acquisition is terminated a report is made to the user indicating the total number of events processed and the total number lost. Alternatively CHAOS can be instructed to terminate acquisition until such time as a buffer becomes available. In this mode the effective dead time would be determined by monitoring the external hardware.

The user interaction with CHAOS is conversational, normally question and answer. If a question is not understood or more information desired, a "?" can be entered. Although the primary function of the task is data acquisition, it also permits the replay of event data tapes. During acquisition or replay this task will not accept any direct input from users, and monitors only a few words of critical information from other tasks. Furthermore, during these operations there exists no path by which users may affect any information utilized by this task. This isolation is designed to minimize the possibility of failure during critical operations. CHAOS resumes user communication in the following situations: termination of acquisition (this is accomplished by hardware commands issued by other tasks); by reaching the end of a data set being replayed; or by some malfunction (e.g., tape failure) detected by the MINUS3 package.

Having determined the acquisition requirements of the user, CHAOS will activate the additional tasks required to handle data storage, analysis, monitor and display capability, and user interaction.

2. RESTOR

This relatively simple task has the highest priority of any task in the package. Its function is to handle the storage and retrieval of event-recorded information. The task, which is normally suspended, is activated by CHAOS when a full tape buffer of data exists. RESTOR attempts to store this information according to user defined conditions. By default, the data are stored on magnetic tape in 1000 word records, although different conditions can be specified. The tape writing is carried out in a quick-return mode and all operations are monitored directly by this task.

The most important duty of this task is error handling. Before data acquisition may begin this task must: 1) verify the condition of the storage unit, making sure it is both available and operational; 2) take exclusive use of the unit to prevent any other task from accessing it; and 3) verify that the unit is properly positioned for writing. This last requirement insures that previously existing information is not accidentally destroyed. Before the recording of data is permitted, RESTOR checks that the unit is positioned at the logical end-of-medium. If this is not the case the user is informed that the unit is mispositioned and some action is required. Typical choices would be to either reposition to the logical end-of-medium (a single command) or to initialize the medium for re-use. Only after successfully writing a descriptive header record is acquisition permitted to begin.

During acquisition RESTOR constantly monitors the writing process. Any detected transmission errors are handled by the task directly, not by the operating system. The task will attempt to recover from simple errors (e.g., parity) in both the acquisition and replay modes. Direct user communication with this task does not occur unless some non-recoverable problem is detected. In this event the task has the ability to immediately terminate data acquisition and to sound alarms. In all cases, however, the user is notified of the nature of the difficulty and is given the choice of either terminating the process or retrying the I/O operation after attempting to correct the difficulty. If the data buffer contains periodic information, RESTOR will copy that portion of the data into its own temporary buffer for subsequent storage on a special disc file. After successfully processing a data buffer, the task indicates that this portion of memory is now available for reuse.

3. ORDER

The purpose of this task is to analyze or process the raw data in a manner defined by the user. The types of analysis capabilities include the following:

- a) **Definition of Artificial or Pseudo Parameters--** This permits artificial parameters to be created which are functional transformations of the current parameter set. This feature will be discussed more fully below.
- b) **Creation of 1-Dimensional Spectra--**Each spectrum may contain any number of channels up to

a maximum of 4096. The channels for a given spectrum may be defined as consisting of either 2 or 4 bytes.

- c) **Projection of Gated 1-D Spectra--**This permits the allocation of memory to be used for projecting information on a parameter according to a set of conditions to be specified later. The actual specification of a given set of correlation conditions is normally an interactive and dynamic function. (See HYDRA.)
- d) **Creation of 2-Dimensional Spectra--**These are effectively plots of parameter x vs y with the z direction representing intensity. Any number of channels (up to 4096) may be selected for both the x and y axes. The only restriction is that the total amount of available memory cannot be exceeded.
- e) **Projection of Gated 2-D Spectra--**This is similar to item (c), but the correlation conditions are used to project a 2-D spectrum.
- f) **Free-form or Functional Gating--**Memory is allocated to permit the storage of a 2-dimensional free-form gate. The actual gate may be defined interactively at any time (see SPACE) and used as a projection condition (item (c) or (e) above).
- g) **Scatter Plots--**This provides the capability of plotting 2-parameter correlations on the screen directly and in high resolution (up to 4096 x 4096). In this situation information is not stored in memory and exists only on the screen. Such spectra may, however, be used to set gating conditions in high resolution.
- h) **Biased Spectra--**The program supports the capability of dynamically biasing both 1- and 2-dimensional spectra. This enables regions of parameter space to be shown in greater resolution without the need for additional memory allocation.
- i) **Filtering--**Filters are defined as sets of correlation conditions similar to those mentioned in part (c). However, they have the effect of removing information from the analysis stream (but not the data stream). This has the practical result of speeding up analysis.

The above list is intended to indicate the types of analysis currently supported by the task, or under development (items f, g, h and i). The philosophy of ORDER is to make a block of memory (currently about 60K bytes) available for use in storing analysis results. The specific details of the utilization of this memory should, however, be completely determined by each user.

In addition to the actual analysis of data, it is important that the task allow the user to add, delete, or change analysis conditions with a minimum of effort. ORDER will normally communicate with the user only on request (actually by a command to CHAOS). It is highly conversational and

is capable of processing either single or multiple commands. It provides guidance in its own operation by providing prompting information, by suggesting the next logical step, or by indicating what options are available. All input values are checked for consistency and the user informed of any discrepancy. In this way virtually all serious input errors are avoided. Modifications can be made during analysis setup in any order. Adding a 2-D spectrum to a given configuration, for example, requires only a 2 character command ("TD") and the 5 integer values requested by the task.

To achieve easy interaction it is normally desirable to minimize typed input. ORDER attempts to accomplish this in two ways: through the effective use of default values and directoried libraries of analysis conditions. With respect to defaults, MINUS3 will acquire data and produce spectra even if no analysis conditions are specifically given. In the case of changes or additions, ORDER will always assume the last used value of a parameter if none is specified. In the previous example, the addition of a 2-D spectrum of the same size as the previous 2-D spectrum would only require typing 3 integer values. The task also permits analysis conditions to be stored or retrieved from labeled disc libraries on command. In addition, for safety, the current set of conditions is saved automatically on the completion of a setup and may be restored if necessary. Finally, the specification of analysis conditions is further simplified, where practical, by making conditions variable and allowing them to be specified as necessary in an interactive graphics environment. This includes such information as the number and type of gating conditions, the determination of their limits (including free-form gates) and dynamically selecting spectrum biasing conditions.

The use of artificial parameters is a particularly important tool in analysis. ORDER offers three ways in which a user may achieve transformations of the basic data. A set of standard equations is directly available for transformations. It includes the following:

- a) $P = (x/A + y/B + z)$
- b) $P = (x/A + y)**B - (y)**B$
- c) $P = (x + A) * (y + B)**2$
- d) $P = 1/(x - A)**2$
- e) $P = x/(A*x + B*y)$
- f) $P = A*x + B*y + C*(x + y)**D$
- g) $P = A + B*x + C*x^2 + D*x^3 + E*x^4 + F*x^5$
- h) $P = A*\text{SQRT}(x)$
- i) $P = A*\text{LOG}(B*x)$
- j) $P = A*\text{EXP}(B*x)$

where the variables x, y and z refer to existing parameters, A, B, C, etc., are constants and P is the new parameter being created. For the purposes of speed, these calculations are either carried out using integer arithmetic or table lookup techniques. If tables are required, the necessary memory is obtained from the user's current display buffer.

If this basic list does not provide the desired transformation, the list may be chained to produce more complex results. A new parameter, say number 12, for example, could be created using equation (a). This value could then be used as an input to another equation, say as x of equation (c). Further, if the intermediate calculation value stored in parameter 12 is, by itself, not interesting, the final result of the second transformation could also be stored as parameter 12. If the necessary transformation still cannot be obtained, the capability of directly attaching user written sub-routines is currently being developed. In this case a user would maintain an independent library of routines which could optionally be attached when the MINUS3 package was loaded. Basically these routines would be passed one event at a time and would return whatever transformations were desired.

It is clearly possible to have real-time data rates such that the requested event analysis cannot be carried out in the available time frame for all events. In order not to slow down the acquisition stream the situation is handled in the following manner. ORDER maintains a pointer into the live data buffer. One event is copied from this buffer beginning at the pointer location into a small second buffer and the value of the pointer updated. The specified analysis is then carried out on the secondary buffer. If, while this processing is being carried out, CHAOS determines that this area of the live data buffer is needed for new data, ORDER's pointer is simply moved to a currently non-volatile area. After completing its current analysis, ORDER will therefore obtain its next event at the new location. In this event a record is kept of the number of events skipped and ORDER can report the percentage of total events it has analyzed.

4. HYDRA

HYDRA is the largest and most complex task in the MINUS3 package. Its primary function is that of a monitor program and interactive graphics interface for the user. It therefore utilizes the modified Tektronix 4014 terminal and switch interface described in the section on Computer Configuration and shown in figure 1. HYDRA may be used to dynamically monitor information from different sources. These include 1-dimensional histogram spectra created by ORDER; live spectra acquired by either the TI analyzers or external memory (see section on Data Acquisition Hardware) or stored spectra from tape. These links are indicated in figure 2.

Information from any of these sources may be monitored at any time without interference. To accomplish this HYDRA utilizes two basic data buffers. The primary buffer is shared with ORDER and normally contains analyzed event data. The secondary buffer is utilized to store additional monitor information as requested. The practical result of this is to permit the user to freely monitor and interact with either the event recorded information or the live histogram data, or to replay previous results with no effect on acquisition results. Further HYDRA has the ability to store on tape the results it is currently monitoring. Storage and retrieval of information from tape may be carried out any time and

acquisition need not be halted. To prevent any possible conflicts with an acquisition tape, HYDRA utilizes its own tape handling routines, similar to those described under RESTOR, to safeguard operation.

Currently HYDRA can simultaneously handle up to 24 1-dimensional spectra from any data source (i.e., 24 event-recorded projections or 24 spectra from tape), and each spectrum may have different lengths (up to a maximum of 4096 channels). A user may choose to display any one spectrum, all spectra simultaneously, or any selected subset in any order desired. Each spectrum may, independently, be displayed as linear or log, with the x-axis expanded or full scale and with the y-axis either automatically normalized or set manually. These features are, for the most part, controlled and selected dynamically by means of the interactive switches. In addition to these standard analyzer type functions, HYDRA also offers the following general features.

- a) Interactive Backgrounds--Independent background curves may be determined and stored for each spectrum. Each background can be subtracted from its spectrum whenever desired.
- b) Peak Fitting--Dynamically selected regions of a spectrum may be fitted with single or multiple Gaussian or asymmetric shapes. The results of the fitting may be removed from the data if desired.
- c) Gates--The task permits gating or correlation conditions to be defined or altered dynamically when monitoring event-recorded data.
- d) Smoothing or Channel Sums--Histogram data may be displayed as a "smoothed" spectrum (using a number of possible smoothing options) or as a 2 or 3 channel summed spectrum.
- e) Spectrum Shifting and Normalization--Any spectrum may be shifted or multiplied by a constant value.
- f) Spectrum Addition and Subtraction--Spectra of the same size may be added or subtracted.
- g) Plots and Lists--Any displayed spectrum may be plotted or listed, channel-by-channel. Hard copies of the screen can also be made by the hardware.

These functions are generally independent and may be combined at will. Thus, for example, a background may be removed from spectrum 1, spectrum 2 shifted by 10 channels, added to the display of spectrum 1 minus background, the resulting information smoothed and a plot made.

HYDRA uses a virtual display concept to produce the types of transformations previously discussed. With this technique only a single memory buffer is ever actually displayed. All virtual displays are dynamically created in this buffer as needed. In this manner the basic data are never actually altered. Another graphics technique employed by this task is the simultaneous utilization of both stored and refreshed images. This has the effect of creating two very different intensity levels,

and makes the visual comparison of screen information (e.g., the sum of spectra compared with the original) much easier to understand.

As a general utility feature, HYDRA may also be requested to run any task existing in the system. The details of this option are contained in the discussion of the OVERSEE task in the following section.

5. SPACE, TIME and OVERSEE

The four tasks reviewed previously are all memory resident. The three tasks discussed in this section are auxiliary tasks and are only executed when required. They run in place of HYDRA both in terms of CPU time and, if necessary, memory.

Just as HYDRA handles 1-dimensional spectra, SPACE handles 2-dimensional ones. It is invoked by simply setting a switch on the Tektronix keyboard. SPACE is similar to HYDRA in its theory of operation and utilizes the graphics display and interactive switches for communication. At present it can handle up to nine 2-D spectra and can display one or more at a time. It permits the removal of background (a constant value); allows the integration of rectangular regions; supports the dynamic setting of gating conditions; and can produce line-printer maps of 2-D spectra.

A number of improvements to this task are currently under development. Of particular importance is the ability to set and utilize free-form regions. Such regions could then be used for gating conditions, integration, and the projection of 1-D information. Other features under development include log-linear displays; biased 2-D capability; the ability to store and replay 2-D spectra from tape (in a manner analogous to HYDRA); spectrum-smoothing capability; and contour mapping. Other possible additions being considered for the future include offering various types of 2-D display (e.g., isometric and perspective) with rotational capability, spectra manipulation (addition, subtraction, etc.), non-normal 1-D projections (i.e., not on the x and y axes), and more complex background manipulation.

The task TIME, shown in figure 2, is currently being designed. Its purpose is to utilize the graphics terminal to display and manipulate the periodic or time-dependent information acquired by the computer, either in a real time or a play-back mode. Unlike HYDRA and SPACE, no spectra or results actually pre-exist for this task to display. As indicated in the section on RESTOR, periodic data are written on disc as well as tape. TIME will interact with the user to determine what information is of interest. The disc file will then be searched to obtain the necessary raw data. This information will then be processed in an appropriate manner to produce the requested displays. One possible request might be to see the variation of counting rates for a set of scalars at a fixed time interval over a particular 2 hour period. Other requests might be to view the time correlation of a particular current reading or perhaps the variation of a bias voltage with temperature. TIME therefore serves to provide visual display of auxiliary information which may have

importance to the historical or current environment in which the event data were acquired. Ultimately it is desirable to be able to accept or reject records of event data according to conditions in the periodic data.

As mentioned in the previous section, HYDRA will accept a request to execute any task in the system. As a result of this request HYDRA will load the task OVERSEE. OVERSEE will attempt to locate and run the requested task. If it is successful the following conditions will apply: the new task will be given at least 131K bytes of memory in which to execute; it will be given the graphics terminal to use, if desired; and it will be provided all the CPU time not necessary for data acquisition and data sorting. As a precautionary measure OVERSEE will periodically monitor the user task. If for any reason the task execution ceases, OVERSEE will resume HYDRA. As a failsafe measure OVERSEE also monitors one of the interactive switches. This switch must be set while the user task is executing. If the switch is reset, OVERSEE will abort the user task, regardless of what it was doing, remove it from memory and resume HYDRA. In any case HYDRA will resume at the point it was interrupted, but with current, updated spectra. One special task a user can request is a standard background. In this case the user may write, edit and store code and then compile, assemble, link, and run it. This can be carried out during acquisition and all the safeguards discussed above still apply.

Summary

A set of tasks has been created to handle the general problem of data acquisition at two LBL accelerators. This framework of tasks, now called MINUS3, has been in operation since mid-1976. The on-line results to date have been quite satisfactory and the hardware and software standardization have greatly improved and simplified the problem of acquisition. A major design criterion for this package was that as much of the traditional off-line analysis capability as possible be available to the on-line user. Although MINUS3 was designed for on-line data acquisition, and despite the fact that many planned analysis capabilities have not as yet been completed, the package currently serves as the sole off-line analysis program for a considerable number of experimental groups.

It is, of course, not possible for a single

package to contain all the analysis capabilities required by all experiments in an optimum fashion. MINUS3 attempts to satisfy those more-or-less standard requirements which are common to a large number of experiments. For more specialized requirements it is expected that users will supply their own code. To facilitate this, the concept of parasitic programming has been utilized. Basically this means that special programs and subroutines are completely written and maintained by the user. These codes may then be dynamically attached to (or run in conjunction with) the standard package as desired by the user. These user codes then function as independent parasites of the main package. In establishing such a structure it is important that a number of well defined interfaces be established between the main code and potential user codes. The advantage of this approach is that both the user and the main code may be developed and maintained independently of each other. A capability added to the MINUS3 package can, for example, be immediately used in conjunction with pre-existing user code. Inter-code interfaces can range from simple disc buffers, written by one code and read by another, to overlapping common regions mapped into user tasks. The optional user transformation subroutines, described in the section on ORDER, and the ability for users to safely execute and code (see discussion on OVERSEE) are examples of this technique. It therefore appears that the MINUS3 package in conjunction with user-supplied parasitic code will be able to provide the benefits of standardization, versatility and powerful analysis capability, both on- and off-line, required at both accelerators.

References

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