PUNCH: THE SNS DATA ACQUISITION SYSTEM

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PUNCH is the name given to the interconnected systems of data acquisition electronics (DAE), CAMAC, front-end minicomputers (FEMs) and HUB computer which provide the control, acquisition, display, storage and analysis functions required by SNS neutron scattering instruments.

It can conveniently be divided into 3 major sub-systems :

1. Data acquisition and instrument control
2. Data flow (networking and archival)
3. Data display and manipulation

The hardware and software components of these three subsystems are shown in table 1.

TABLE 1

System	Hardware	Software
Data Acquisition and Control	FEM (VAX 730) DAE CAMAC	Instrument Control Program (ICP)
Data Flow	Cambridge Ring (CR82) HUB (VAX 750) (VAX 8600 Sept 85)	PUNCH PROTOCOLS PUNCH ARCHIVAL
Data Display and Manipulation	HUB, FEM Pericom VT200/t4014	GENIE 72.1

The following sections give a brief overview of these systems.

1. Data Acquisition and Control

Each SNS instrument is equipped with the following hardware configuration :

DAE
Instrument Crate
System Crate

CAMAC
Camac Crate
Intelligent Crate Controller

VAX-11/730
730CPU (VAX/VMS)
FP730 floating point accelerator
1-2 Mbytes memory
10 Mbytes removable disk
121 Mbyte fixed disk
3010 SEEL Cambridge Ring DMA interface console
Pericom 1000 x 1000 graphics terminal
Pericom VT100 control/edit terminal
NDK dot-matrix printer (graphics)

This is shown in the block digaram Figure 1.

The DAE 'time-stamps' neutron events and increments the appropriate word in a large (1-16 Mbyte) histogramming memory. The time channel boundaries may be set by software to any multiple of a basic 32 MHz clock. Individual detectors may be mapped to any spectrum providing a totally flexible detector ganging procedure.

The principal parameters of the DAE are :

- up to 64k detectors
- up to 32k time channels
- up to 16M channels
- 20 MHz peak rate/detector
- 1 MHz max mean rate/system crate
- up to 16 system crates

The DAE is the subject of a subsequent paper at this meeting and further details are given there.

A CAMAC crate, containing an intelligent crate controller and associated modules, is connected to each FEM via an asynchronous RS232 serial line.

This enables beam-line and sample-environment components (such as stepping motors, vacuum sensors, etc) to be activated or measured. Measurements may be on user demand or by continuous monitoring. All control of the DAE and CAMAC is via the VAX 730 FEM computer.

This configuration, described above, enables the user to :

- control the course of a series of runs from high level commands entered through the FEM keyboards
- view the data
- manipulate and merge data sets
- store the data on disk (20-100 runs)
- transfer data to the HUB computer (via the Cambridge Ring local area network)

At present there are five VAX 11/730 computers installed as FEM computers. They all use the VAX/VMS operating system and are therefore totally software compatible with the HUB computer, presently a VAX 11/750. The HUB computer will be upgraded to a VAX 8600 in September 1985 by which time a total of nine FEM computers should be in operation (8 x 730, 1 x 750).

2. Data Flow

The network joining the FEM and HUB computers is a 3.5 km Cambridge Ring running CR82 protocols at levels 0,1,2. The network provides for two types of traffic, terminal and file-transfer, and different protocols are used for the two - to provide the most efficient for each one. A schematic of the network is given in Figure 2.

The terminal traffic is presently between some 53 terminals distributed geographically between R3, R6, R69 and R55 and 6 VAX computers sited in R69 (1), R55 (4) and R3 (1). This traffic is carried on the Cambridge Ring using a locally developed [1] 'single-shot' protocol and back-to-back terminal multiplexers (SEEL model 3012). This protocol transmits individual bytes as generated at the terminal or computer interface and is particularly effective in transparently supporting full-screen editing and graphics input. The protocol also provides :

- a multi-source, single-sink service (enabling line-printers and status displays to be accessed from many computers)
- a computer-name server
- distributed architecture (no centrally stored lists)

Although developed 'in house' this system is now marketed by SEEL as the DISTRIBUTED NETWORK SWITCH.

File transfer is accomplished using SEEL DMA interfaces (model 3010 single Hex UNIBUS board) and non-standard network/transport/service layers (3,4,5). Currently disk to disk copying is achieved at total elapsed rates of 200 kbits/sec.

Raw data created at the FEM computers is staged to HUB disks using the file-transfer protocols described above. The data is then archived to tape using PUNCH ARCHIVE software.

The upgrade of the HUB to a VAX-8600 (September 1985) with a high-speed (4 Mips) processor, 12 Mbyte or memory and a disk store of 3 Gbytes will provide users with the necessary facilities to enable computer on-line data analysis to be performed.

3. Data Manipulation and Display

We have attempted to provide a common solution to the problem all instruments pose for the first stages of data analysis. All instruments require spectra to be added, subtracted, normalised and adjusted to different scales. In the early stages of an instrument's development it is especially necessary to be able to follow novel data reduction routes unsuited to standard data reduction programs.

The solution is in the form of the program GENIE which essentially provides the user with a LANGUAGE for data manipulation.

GENIE has grown rapidly since October 1984 when it started life as a display package for SNS data running over the graphics system GKS 6.2. This original program was written by W I F David. From January to June 1985 the initial program has been transformed (by the efforts of WIFD,

MWJ, KJK, SPG, GDC) to become a language for displaying and manipulating spectra. The program now runs over the Rutherford Appleton Laboratory standard GKS Mk 7.2.

The program deals with the usual requirements of primary neutron analysis packages :

- Graphical display with
    - routing to hard-copy devices
    - selection of log/linear axes, x/y limits, header, binning, markers/histogram, screen resolution, graticule, screen size, error bars
    - cursor x,y location
    - cursor zoom
    - multiple spectrum plotting

- REBIN and UNITS commands to transform x axes from time-of-flight to physical units of interest.

- FUNCTION commands to enable y-value transformations. These may be user supplied without program relinking.

- FITTING commands to enable least-squares fitting of standard or user-supplied functions (e.g. peak fitting)

However the features which render GENIE a language rather than a simple program are the following :

- Operation from a stored list of instructions
- Flow control (DO, END DO, GOTO)
- Algebraic manipulation of spectra
- Parameter substitution
- I/O to screen or disk files

As an example, Table 2 gives the complete listing of a command file which includes comments describing its operation and purpose.

The GENIE program is provided on the HUB and each FEM computer where it can access both stored data on disk and 'live' data accumulating in the DAE.

References

[1]   A Single Terminal Multiplexer for a Cambridge Ring, W C A Pulford
and R T Lawrence, J of Microcomputer Applications (1984) 7 139-147

TABLE 2

```
******************************************************************************
 Directory:              SYS$SYSDEVICE:[HRPD]
 Filename:               FOCUS.COM
 Time:                   10-JUL-1985 18:05
******************************************************************************


 !
 !      ***** SOFTWARE FOCUSSING OF HRPD DIFFRACTION SPECTRA ******
 !
 !   This command file focusses NOSPEC spectra from run number IRUNNO.
 !
 $ INQUIRE IRUNNO "  Which run number do you wish to look at"
 $ INQUIRE IPOS "  Is the sample at the 1m. or 2m. position (1/2)"
 $ INQUIRE ISP "  Which spectrum do you wish to start with"
 $ INQUIRE NOSPEC "  How many spectra do you wish to add together"
 !
 > @FOCUS'IPOS' IRUNNO ISP NOSPEC
 !
 !
 $ IRUNNO= P1             ! Run number passed from FOCUS.COM
 $ ISP= P2               ! Initial spectrum number
 $ NOSPEC= P3            ! Number of spectra to be added together
 > ABB 'IRUNNO' AA       ! Abbreviate data-file to AA for convenience
 > W1= AA(S'ISP')        ! Fill workspace 1 with initial spectrum
 $ ! Evaluate secondary flight path and two theta for each spectrum
 $ PATH2= 1.100774 - 0.626785E-02*ISP + 0.1236448E-03*ISP*ISP
 $ TTH= 176.7727 -0.814087*ISP - 0.305026E-02*ISP*ISP
 > SET PAR 1 95 'PATH2' 'TTH' 0 2
 > U/D W1                ! Convert to d scale
 $ NOSPEC= NOSPEC-1
 $ DO I= 1,NOSPEC        ! Do loop beginning
 $ ISP= ISP-1
 > W2= AA(S'ISP')        ! Fill workspace 2 with next spectrum
 $ ! Evaluate secondary flight path and two theta for each spectrum
 $ PATH2= 1.100774 - 0.626785E-02*ISP + 0.1236448E-03*ISP*ISP
 $ TTH= 176.7727 -0.814087*ISP - 0.305026E-02*ISP*ISP
 > SET PAR 2 95 'PATH2' 'TTH' 0 2
 > U/D W2                ! Convert to d scale
 > REB W1 W2             ! Make W2 bins commensurate with W1 bins
 > W1= W1+W2             ! Add W2 to W1
 $ END DO               ! End of Do loop
 > W3= W1               ! Make W3 equivalent to W1
 $ ! Find the middle spectrum and associated L2 and 2 theta
 $ JSP= ISP + 0.5*NOSPEC
 $ PATH2= 1.100774 - 0.626785E-02*JSP + 0.1236448E-03*JSP*JSP
 $ TTH= 176.7727 -0.814087*JSP - 0.305026E-02*JSP*JSP
 > SET PAR 3 95.0 'PATH2' 'TTH' 0 2
 > U/T W3                ! Convert W3 back to time-of-flight
 > D W3                 ! Display W3
```
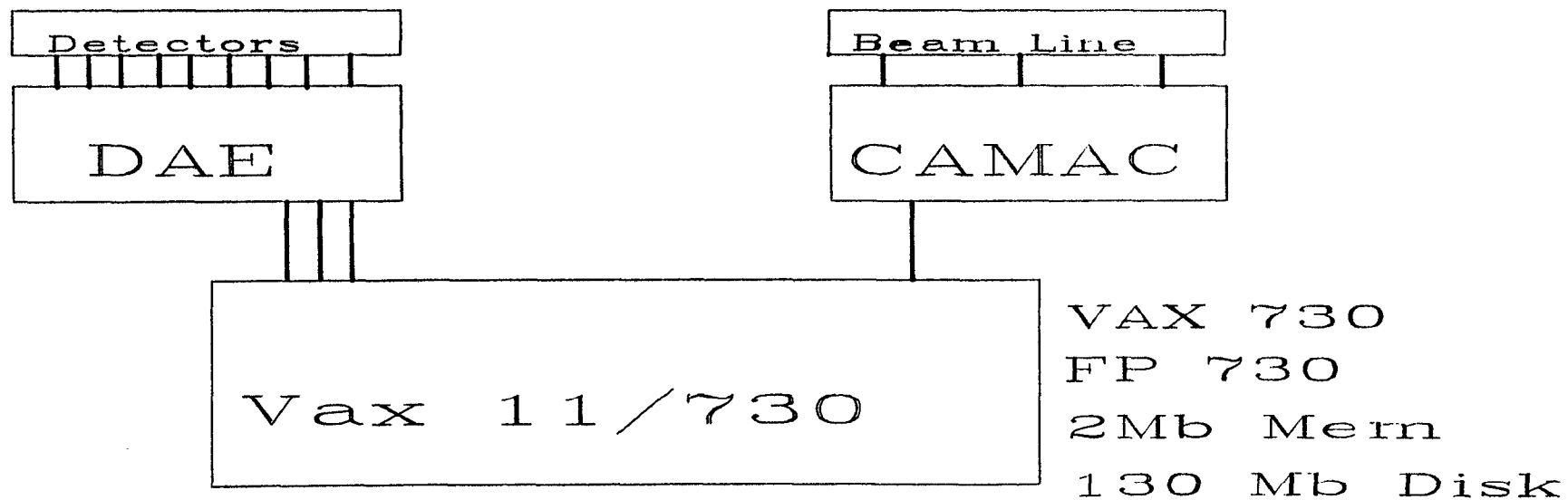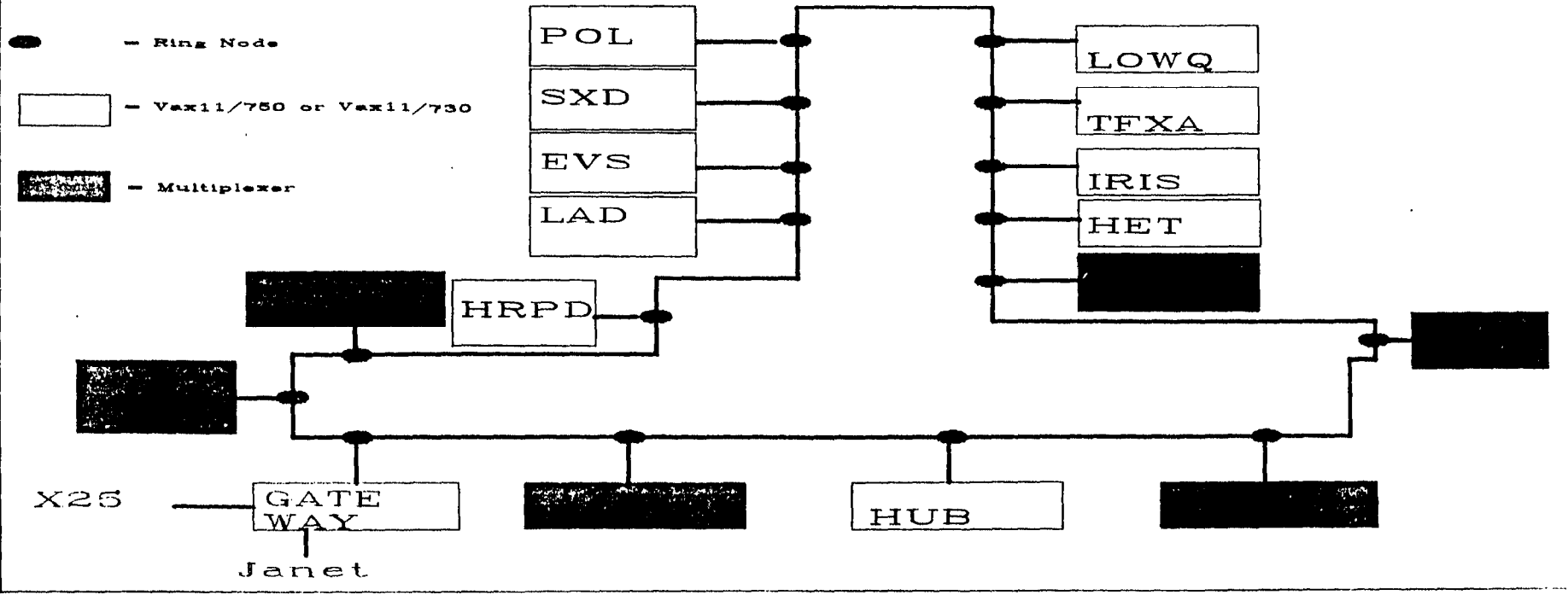
FIGURE 1

S.N.S Cambridge Ring

● — Ring Node

☐ — Vax11/750 or Vax11/730

▓ — Multiplexer

POL		LOWQ
SXD		TFXA
EVS		IRIS
LAD		HET

HRPD

X25

GATE
WAY

Janet

HUB

FIGURE 2