# New KENS data acquisition system

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## 1. Introduction

Measurements made using the pulsed neutron technique have the advantage of a wide dynamical range in Q-ω space with multiple scans along the loci defined by the kinematic constraint. The measured TOF data, however, do not give direct results in Q-ω space because the data is obtained as a function of time-of-flight (TOF) and modulated by the incident neutron spectrum; also, the scanning path does not have simple loci in Q-ω space. This is clearly different from a measurement at a reactor using a constant wavelength technique. Therefore, it is important to make on-line analysis during the data acquisition phase of an experiment to understand the results obtained.

The best science often requires that a number of neutron techniques are used on the same material. Sometimes it becomes necessary to use two or more spectrometers for a given sample because most instruments at a pulsed-neutron facility are optimized to make measurements in specific areas of Q-ω space. Thus, it is also important to have a data acquisition system with the same user interface for all spectrometers.

Furthermore, it is helpful for visiting experimenters to finish the necessary data corrections during their stay at the facility and take the data in a reduced form to their home institute for further analysis because data obtained back at a pulsed-neutron facility usually include enormous amounts of bytes and various wave-dependent correction factors. For this purpose adequate CPU power is required.

By satisfying the above requirements on a data collection and manipulation system, a pulsed-neutron facility can be more easily used by outside users and is more competitive against a continuous neutron source.

Experimenters need various capabilities both during and after a run to facilitate the discussion of results and the preparation of manuscripts. Some of these capabilities include word-processing programs, drawing and quick-graphing software, and a method for conveniently doing calculations. For all these purposes, we need intelligent and user-friendly workstations.

In this report we discuss a data acquisition system, KENSnet, which is newly introduced to the KENS facility.

## 2. Required performances for a data acquisition system

To estimate the required disk storage and CPU power, we consider the data collection rate and turn-around time for preliminary data analysis in the case of the small-angle neutron-scattering instrument SAN, which gives the highest data-collection rate (word/hour) at KENS.

### 2.1 Data collection rate

We show the data-collection rate at KENS in Table 1, where 4 bytes are allocated per channel. One histogram of about 0.36 Mbytes (91 K channels x 4 bytes) is taken within 1.5 hours, and the accumulated data becomes 650 Mbytes per year. Data are usually analyzed within three months, so roughly 160 Mbytes are necessary for temporary disk storage.

| Instrument | SAN | TOP | LAM | HRP | MRP | RAT /CAT | PEN | MAX | HIT | WIT | FOX | INC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| nd of SD | 6 | 3 | 19 | 9 | 6 | 2 | 16 | 16 | 50 | 16 | | 200 |
| nt of SD | 512 | 512 | 512 | 16,000 | 8,000 | 8,000 | 512 | 512 | 1,000 | 512 | | 4,000 |
| no. of PSD | 43 | 4 | | | | | | | | | 1 | |
| nd of PSD | 2,752 | 256 | | | | | | | | | 128 | |
| nt of PSD | 32 | 32 | | | | | | | | | 512 | |
| n = nd*nt | 91,136 | 9,728 | 9,728 | 144,000 | 48,000 | 16,000 | 8,192 | 8,192 | 50,000 | 8,192 | 65,536 | 800,000 |
| Typical time to obtain one histogram (h) | 1.50 | 2 | 6 | 20 | 4 | 10 | 3 | 40 | 2 | 2 | 5 | 20 |
| Data Collection Rate: | | | | | | | | | | | | |
| Words/hour | 60,757 | 4,864 | 1,621 | 7,200 | 12,000 | 1,600 | 2,731 | 205 | 25,000 | 4,096 | 13,107 | 40,000 |
| Mbyte/day | 4.86 | 0.39 | 0.13 | 0.58 | 0.96 | 0.13 | 0.22 | 0.02 | 2.00 | 0.33 | 1.05 | 3.20 |
| Mbyte/year | 656 | 53 | 18 | 78 | 130 | 17 | 29 | 2 | 270 | 44 | 142 | 432 |

**Table 1** Data collection rate in the KENS. nt is the number of time channels, nd is the number of detectors. SD is a single detector. PSD stands for a linear position-sensitive detector.

During the measurement, the two-dimensional data of 0.36 Mbytes are to be converted to S(Q) in a short time, e.g., one minute. This requires 1 MIPS of CPU power from our experience.

So we put criteria at about 1MIPS for CPU speed and 150 Mbytes for storage capacity for a computer per spectrometer.

## 3. Data acquisition system

### 3.1. Computing system

We chose models from the VAX family of computers with their proprietary operating system, VMS. The computers are made by the Digital Equipment Corporation and used world wide by other neutron scattering facilities. Most important, the VMS operating system has a very user friendly interface and is well suited to instrument control applications. A hub computer, VAX 8350, has 16 Mbytes of main memory, about one Gbyte of disk storage, and about 2.5 MIPS of CPU speed. Data acquisition computers (DAC) are VAX station II/GPX's. They control the data acquisition electronics (DAE). There are eight DAC's, which have the following: 5 Mbytes of main memory, one or two of 140 Mbytes disk storage, and about 1 MIPS of CPU speed. The CPU power of the DAC is enough to make preliminary data analysis during the experiment to understand the results. The disk storage of DAC is enough for the required data amount. The layout of the total system is shown in Fig. 1.

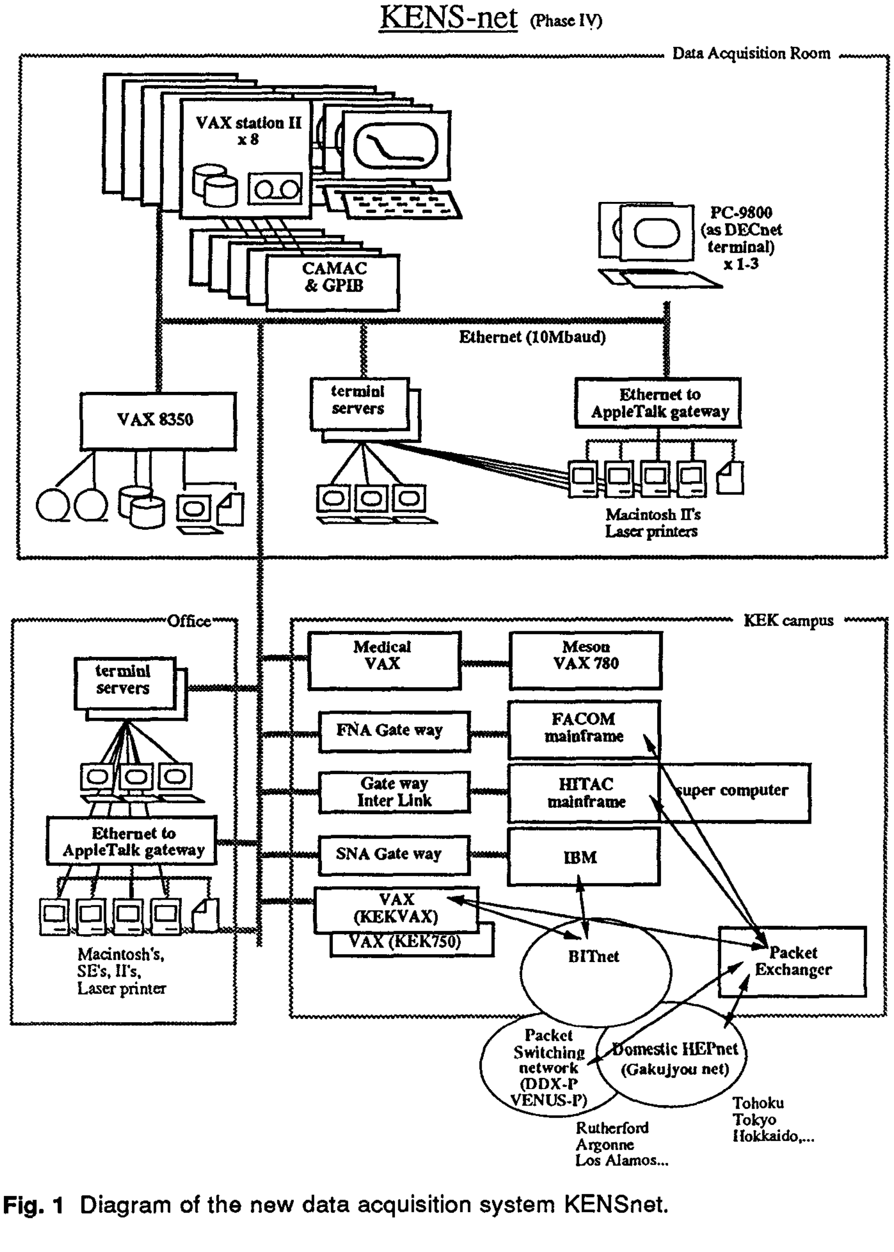


**Fig. 1** Diagram of the new data acquisition system KENSnet.

These computers are connected by a network (Ethernet; 10 Mbps) and form a local area VAX cluster (LAVc). An operating system (VAX/VMS) resides only on the hub computer (boot member), and all the other DAC's (satellite members) use the operating system through the network. Therefore, maintenance is done only on the operating system of the boot member, and this saves a lot of time and man power for system management. On the occasion of the shutdown of the boot member, the satellite member can start up by itself. Therefore, there is no risk of cluster-wide failure caused by a single machine. The LAVc is also very convenient because any disk in the cluster can be accessed from any VAX as if it were a local disk of its own. Each CPU is shared flexibly by batch jobs entered within the local area cluster, which gives effective use of the total CPU power.

The front-end computers (FEC), Apple Macintosh Plus and Macintosh II, were chosen for their user-friendly manipulation and intelligence. These are connected to AppleTalk or Ethernet (Fig. 2). Users can manipulate very easily plotting and drawing tools, and can do convenient calculations using results corrected by the DAC for discussion and other considerations. Both word processing for manuscripts and controlling DAC's using emulated terminals ( VT100 / Tektronics 4014 emulation ) on behalf of experiments can be done. These functions of the front-end computer, so-called "work stations," are important to achieving efficient experiments.

### 3.2 Networking

The VAX computers are connected by a DECnet network mediated by Ethernet; Macintosh computers are connected by AppleTalk. By introducing a gateway, KINETICS's FastPath, and a communication program, Alisa-System's AlisaTalk, both types of computers can communicate with each other. Certain files on a VAX disk can be accessed from the Macintosh, and applications software for the Macintosh can be down-loaded to the VAX.

Laser printers on the AppleTalk network can be used from both the Macintosh and VAX computers. The Macintosh controls the DAC through a terminal server on Ethernet or through Ethernet directly using TCP/IP protocols.

On the other hand DECnet extends to the central VAX computers in the Laboratory and to the world through HEPnet (network for High Energy Physics). We can communicate with other foreign institutes. The Ethernet also links us to the mainframes (HITAC, FACOM) of the Central Computer Division, and those are used for heavier calculations, analysis, and Bitnet services.

Users in outside institutes can access KENSnet through telephone modem links, a packet-switching network (DDX-P), or HEPnet.

### 3.3 Data acquisition electronics (DAE)

We have developed new CAMAC-based data acquisition electronics (Fig. 3). A Gate module receives a signal of proton extraction time from the accelerator and checks the veto signals from the sample environment equipment (vacuum, temperature, chopper phasing, etc.). Then the enable signal is issued to a Delay-Time module. A Time-Control module starts timing from the delayed start signal from the Delay-

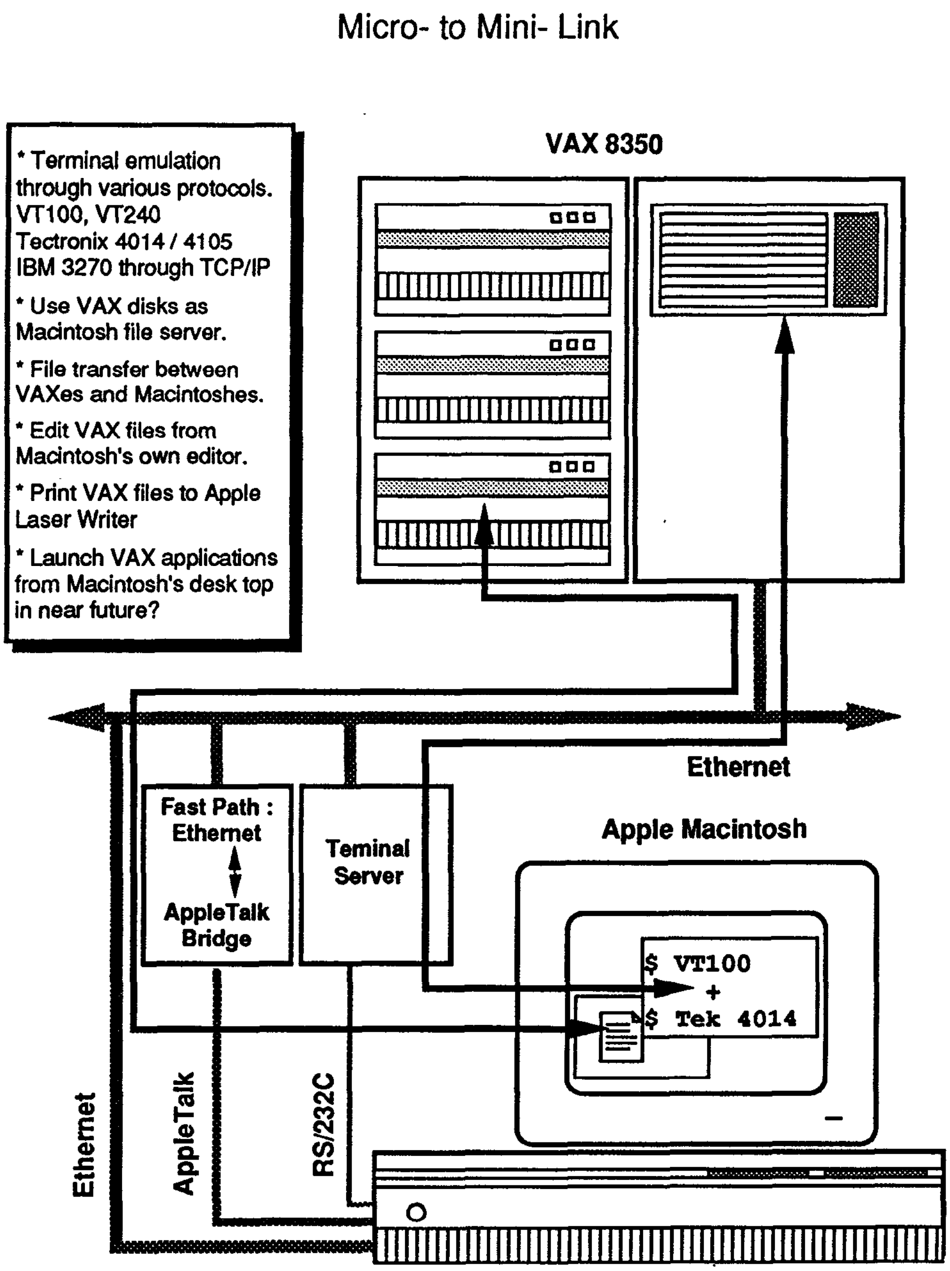


**Fig. 2** Diagram of Macintosh/VAX link.

Time module and distributes an encoded time-boundary address to Memory modules at the preset times, enabling the Memory modules to accumulate data histograms. There are two types of Memory modules, which have 4 or 8 inputs for a detector signal. One Memory module has 16 K words (16 or 24 bits), which is shared by 2 to 4 or 8 histograms. To match the time resolution with other contributions, the time boundary of the Time-Control module and the delay time of the Delay-Time module can be set by the DAC flexibly in arbitrary width with the minimum step of 62.5 ns and minimum base width of 0.5 or 1 μs.

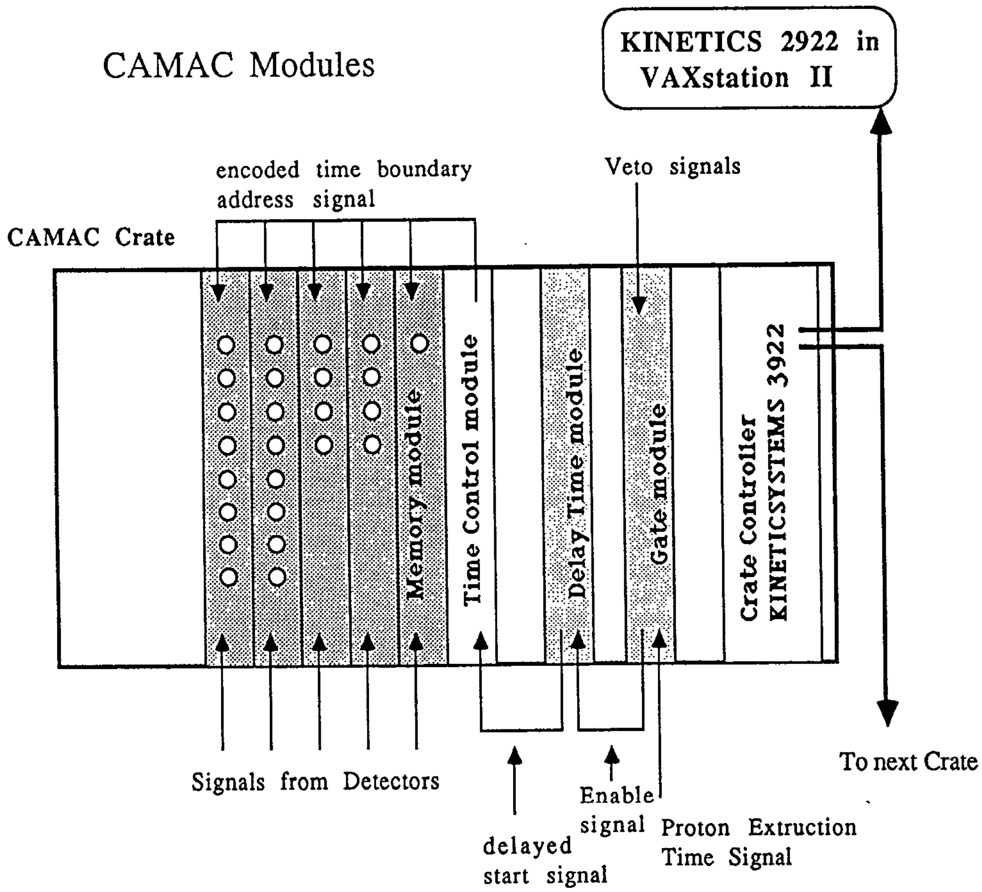


**Fig. 3** Diagram of the new data acquisition electronics.

We inherited the traditional concept in KENS data acquisition electronics, i.e., one-to-one correspondence of detector-to-histogram relation. This method needs enormous data storage in some cases; however, our low-cost, high-performance memory modules enable us to realize the above concept. We can manipulate the data and reduce them for certain purposes after the experiment, which provides a high degree of flexibility in the data analysis and reduces a risk of troubles from noisy detectors.

CAMAC crates are connected to the DACs via a pair of KINETICSYSTEMS CAMAC Crate Controllers and Q-Bus Adapters, which lets us put CAMAC crates up to 150 meters from the computers. We can accommodate up to eight crates.

Sample-environment control is done by GP-IB devices, which are connected to the DAC via GP-IB extenders, enabling very long cables (up to 1.8 km) to be used. Sample environments, such as temperature and magnetic field, can easily be controlled by commercially available GP-IB devices.

### 3.4 Software of new data acquisition system

The data acquisition control program (ICP) and the general data analysis program (Genie) were both developed at ISIS[1,2] and have been installed in the new data acquisition system. They give the experimenter "user-friendly" data acquisition and a good environment for data manipulation. The ICP controls the DAE and transfers the histogram data into the computers.

The hardware-dependent parts in the ICP were modified to fit the DAE system at KENS. The modified ICP allows the use of different kinds of DAE depending on the detector system, e.g., position-sensitive or single detectors. As Genie is independent of hardware environment, only minor changes were performed to the data size.

All of the software used on the Macintosh computers is commercially available: terminal emulation software for the VT100 and Tektronics 4014, which controls DAC as a terminal and transfer files between FEC and DAC; DECnet AppleTalk linking software, which allows communication between FEC and DAC and gives file-serving and print-spooling environments. Also, spread-sheet and quick-graphing software conveniently manipulates corrected and reduced data.

## 4. Discussion

The compatibility with ISIS in data acquisition and analysis is very important in achieving excellent UK-Japan collaboration. Japanese scientists can immediately start their experiments at ISIS, and the analysis of data taken at ISIS can be continued in Japan. This system saves a lot of time for the scientists in the preliminary steps of an experiment and in the later stages of data analysis.

Now all the pulsed spallation neutron facilities–ISIS, ANL, LANSCE and KENS–have the same proprietary operating system, the VAX/VMS. We can circulate or exchange analysis programs between the facilities and run them without any difficulties.

Intelligent work stations are a great convenience to the experimenter. So far, data acquisition systems have been designed only for controlling data acquisition electronics and analyzing data. However, we often need quick graphing, curve-fitting, and calculations to determine the next direction of the experiment. Much excellent software for these purposes is commercially available for the Macintosh computer. We can use such functions without writing any programs. By combining these general-purpose, convenient programs for the FEC and the data acquisition programs for the DAC, we create a high performance and very effective data acquisition system. This set-up represents the most significant difference found between us and other neutron facilities.

## Acknowledgements

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## References

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