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The SINQ Data Acquisition Environment

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ABSTRACT

The data acquisition environment for the neutron scattering instruments supported by LNS at SINQ is described. The intention is to provide future users with the necessary background to the computing facilities on site rather than to present a user manual for the on-line system.

1. Introduction

A user's view of the data acquisition system (DAQ) of a neutron scattering instrument is typically as shown in Fig. 1. Commands to the system are entered via the key-

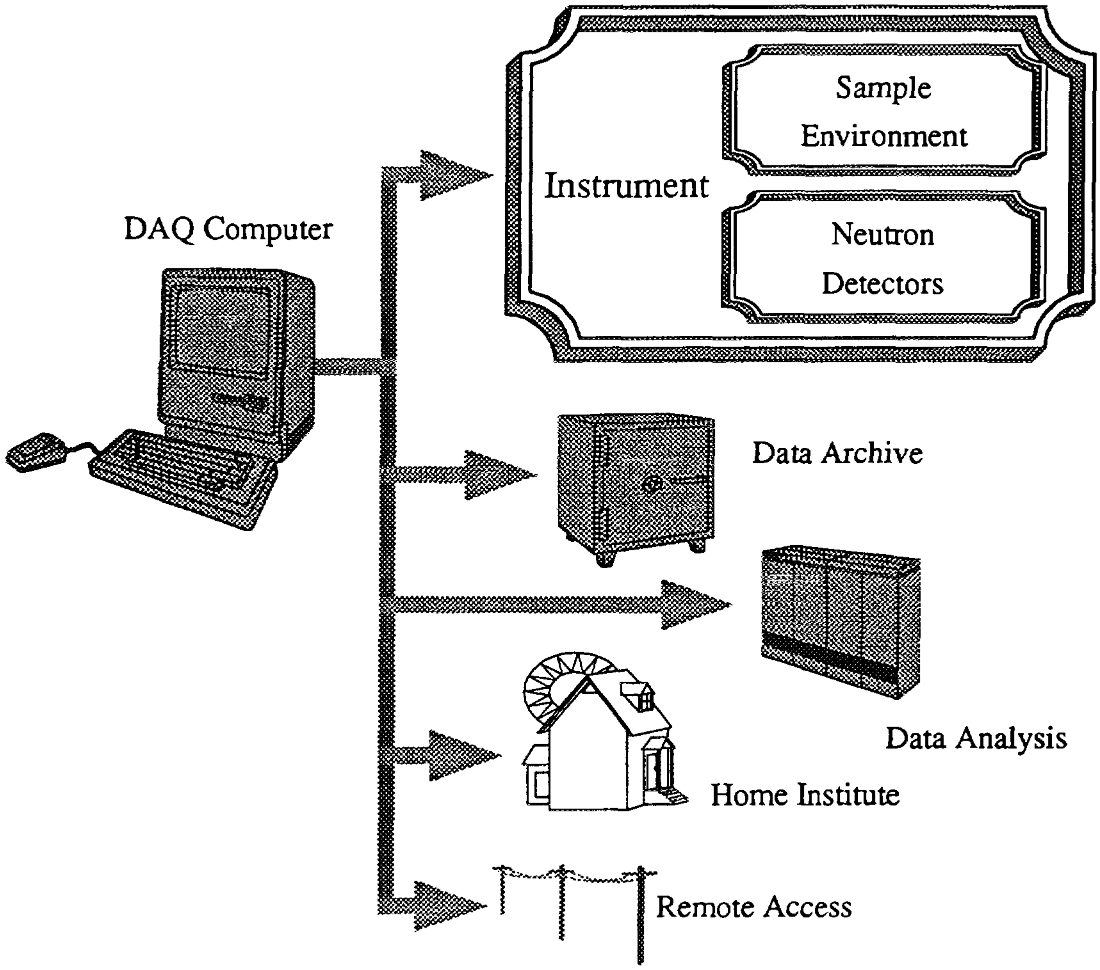

Fig. 1 : User View of a Neutron Scattering Data Acquisition System

board and mouse of the DAQ computer and the feedback to the user is via the display. This is particularly the case if one is working in a counting room, remote from the instrument.

The user requires the means of setting the environment of his sample and, once these settings have been realised, to perform a measurement. The results of the measurements must be archived for later analysis.

The DAQ system should:

- provide the user with an ergonomic, physics oriented interface to the instrument;
- provide the user with sufficient feedback to satisfy him that his measurement is proceeding correctly;
- continually monitor the sample's environment, generating alarms and taking appropriate action if parameters such as temperature go out of tolerance;
- automate routine procedures wherever feasible, allowing the user to initiate measurement sequences which may last for several hours;
- allow remote access, possibly via modem, so that the user may monitor the progress of a measurement sequence and, if necessary, take corrective action.

Access to the user's home institute (e.g. for e-mail or for the transfer of measured data) and access to data analysis engines (e.g. for on-line analysis in real-time of the measured data) should also be available.

2. Data Acquisition Configuration

A block diagram of a SINQ instrument is shown in Fig. 2. Most of the "slow" devices associated with the instrument geometry and sample environment are controlled via RS-232-C devices connected to a terminal server. The various types of multi-detector are connected via a fibre optic link to a histogramming memory. More details of the interfacing of these devices is given in Section 6.

A very early decision was made in the design of the SINQ data acquisition system [1] to use an Ethernet based network for interconnecting the components of the system. The resulting configuration is shown in Fig. 3. The use of a network interconnection strategy has provided great freedom in the physical location of the various devices. The location of devices as shown in the diagram is therefore subject to change. In the early design stages, it was assumed that most activity, and hence most of the electronics, would be situated in the counting rooms, as is normal with experiments at particle accelerators. With the passage of time, the expected centre of gravity of activity seems to be drifting towards the vicinity of the instrument, more in keeping with the practice at reactor centres.

For routine operation, however, it is still expected that the data acquisition computer will be used directly and will be located in the counting room. For setting up operations, an X-terminal, located near to the instrument, will be available for running tests by means of a remote-login to the data acquisition computer.

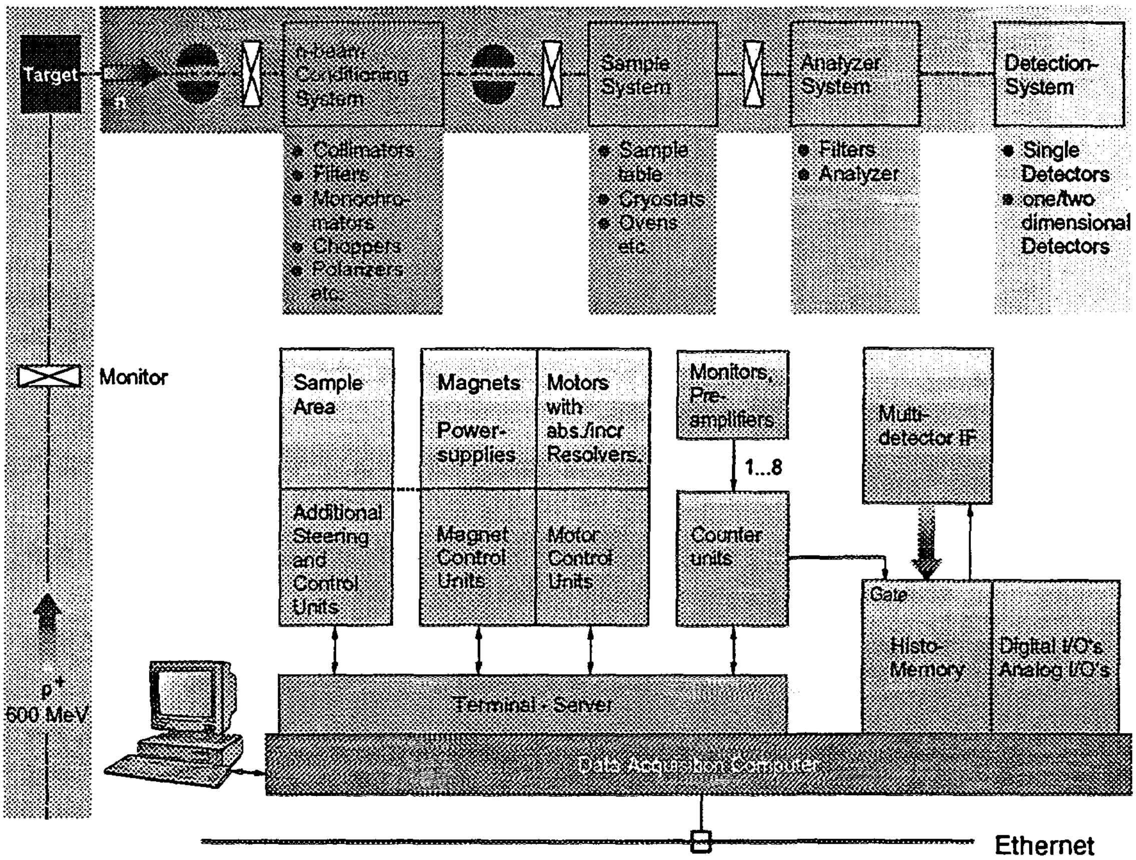

Fig. 2 : Block Diagram of a SINQ Instrument

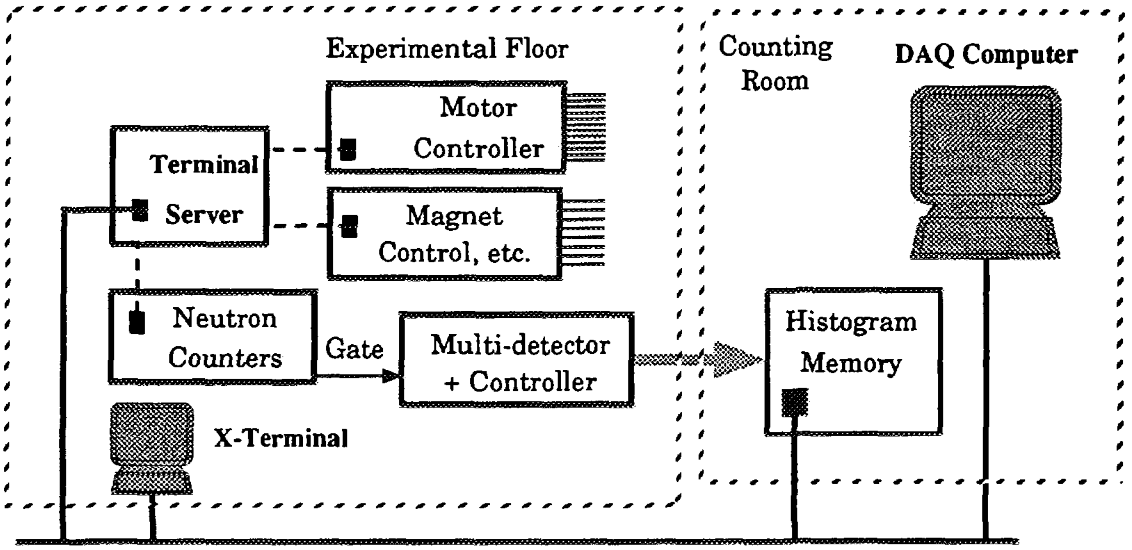

Fig. 3 : Typical SINQ Instrument Layout.
The Ethernet connections are only schematic. See Sect. 3 for more detailed information. The Terminal Server may also handle GPIB devices.

- - - = RS-232-C
⇒ = Fibre Optic Link

For low-level debugging of the RS-232-C devices, the "terminal server", which is also located in the vicinity of the instrument, can be used in stand-alone mode. For large instruments such as SANS, it may be advantageous to install a second terminal server with its relatively reliable network cable rather than attempting to drive RS-232-C connections over long distances.

3. Computer Networking

The main advantage and motivation for using the Ethernet for interconnecting the various components of the data acquisition system is the increased geographical flexibility in locating the various devices of the system without the necessity of designing and installing complicated cabling systems.

There are, of course, potential disadvantages to this approach which must be considered:

- a failure in one of the, normally transparent, network components can block data acquisition and be difficult to locate;
- the network must be configured so that there is sufficient isolation between the various instruments to avoid mutual interference;
- certain experiments may saturate the network. In general, though, the Ethernet bandwidth is more than adequate for most neutron scattering experiments and can, if necessary, be expanded further;
- there is the possibility of destructive hacking.

Experience at PSI has shown that the advantages outweigh the disadvantages. Medium energy particle physics and μSR experiments on the PSI cyclotron use Ethernet connections to transfer data between front-end data acquisition computers and back-end monitoring/data-archiving computers [2]. The network is realised via thin-wire Ethernet cable segments and failures due to the network have proven to be minimal.

In the SINQ halls, the network capability is much higher. The network cabling is concentrated through three network "hubs". From these hubs, there is a fibre optic link to the vicinity of each instrument and several 10baseT (twisted-pair Ethernet) connections to each counting room. The fibre optic links are terminated in distribution boxes with 8 10baseT connections per instrument. The network connection hierarchy is shown in Fig. 4. Each experiment has its own independent Ethernet for devices in the vicinity of the instrument and for devices in the counting room. Transfers between the counting room and the experimental floor, however, go via the hub and could be subject to interference from other experiments. The comparatively high bandwidth of the hub is expected to render this interference insignificant. If it proves to be a problem, extra isolation can be installed in the hub.

Since there is likely to be a relatively high data traffic between the histogram memory module (see Sect. 6.3) and the host computer, it is intended to locate both of these in the counting rooms so that the data transfers do not go via the hub. A separate fibre optic link between the instrument and its counting room will be installed to enable this.

4. Data Acquisition Software

So far, effort has been concentrated on software for the triple-axis and diffraction experiments. In this respect, we are very grateful to ILL and, in particular, Alain Barthélemy and John Allibon, for allowing us to adopt and adapt their MAD/TASMAD software to the SINQ environment. The main work on our side has been:

- to replace the sections of code associated with the driving of motors and neutron counters to use PSI equivalents;
- to modify the *PLOT* command so that it provides a better quality plot of the current measurement by means of the PGPLOT package;
- to enhance the MSPY program, a utility which provides an updating display of the status of TASMAD, so that a plot of the current scan is presented and
- to modify the data format of the archived data to follow the recommendations of the SOFTNESS working group.

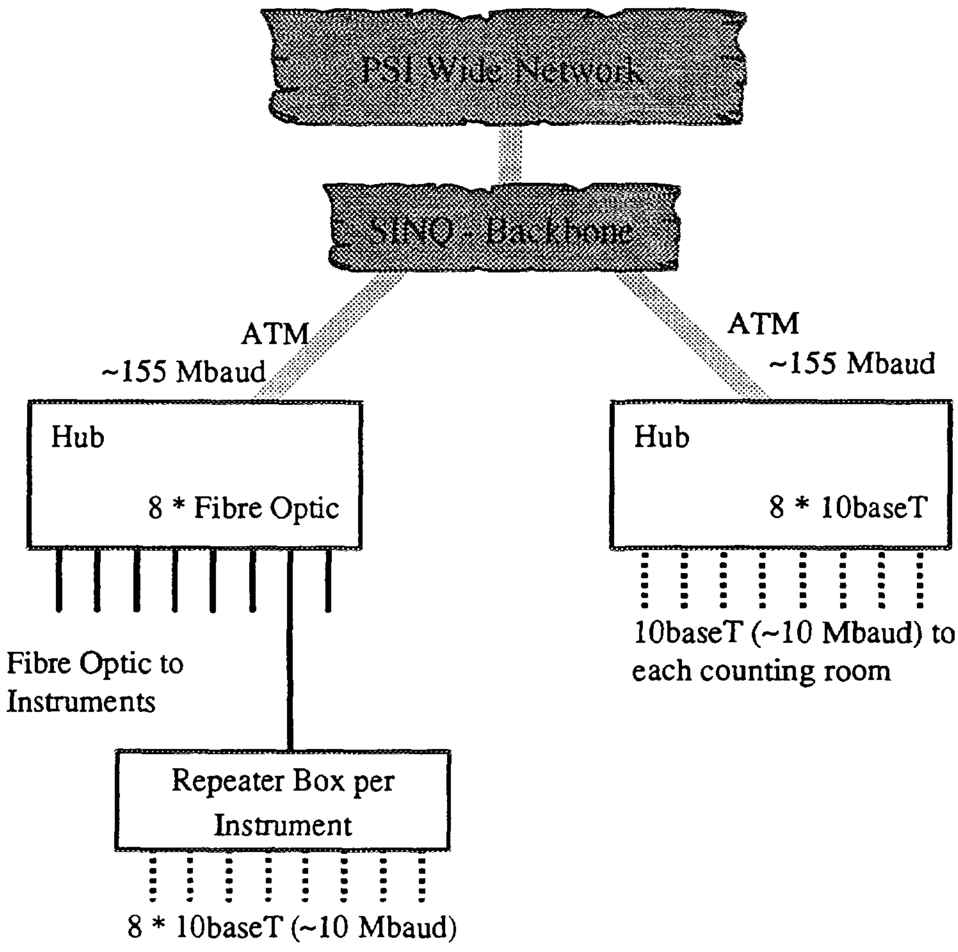

Fig. 4 : Network Hierarchy in the SINQ Halls

The development of code to handle the histogram memory with associated multi-detectors and to handle a temperature controller is still in development.

MAD, in its various forms, is a command-line oriented system running under the OpenVMS operating system on VAX or AXP computers. The possibility of porting the software to a Unix environment prior to the startup of SINQ is still open. An alternative route, which is being explored and which may prove to be more user friendly and portable, is to use the Tcl/Tk scripting language as a means of implementing the MAD capabilities.

For details of using MAD, reference should be made to the user documentation [3]. The following two examples are provided simply to give a flavour of what is available:

```
MAD > lt

     TARGETS AND POSITIONS
     *********************
        POSN     TARG           POSN     TARG
  A1    80.00    -1.65     A2   163.76   163.76
  etc.

MAD > scan en 16 den 2 np 15 mn 10000
```

The first command, lt, is the "List Targets" command. The actual and requested (target) motor positions are displayed. The second command, *scan,* is the command to perform a scan. This may be either a scan of simple physical quantities such as motor positions or temperature or, as in the above example, something much more complex. In the example, a 15 point (np) scan of the neutron energy transfer (en) about a central value of·16 meV is performed. The step size (den) is 2 meV and, at each position, a measurement is performed until the incident neutron monitor (mn) has accumulated a count of 10000.

5. Data Archiving and Data Transfer Facilities

In October 1994, the first workshop on Software Development at Neutron Scattering Sources, SOFTNESS, took place at ANL, Argonne. A small group of software specialists, mainly from neutron and X-ray sources in the USA, met to discuss the common problems in software development and support at the various sites. A follow-up meeting took place at NIST, Gaithersburg, in September, 1995. The most fruitful result of these meetings to date has been the specification of a common data format, NEXUS [4].

A description of NEXUS would exceed the scope of this report. Suffice it to say that it is based on the Hierarchical Data Format, HDF [5]. This was originally designed as a platform independent data format for the exchange of scientific data at the NCSA, Illinois. The HDF library is available for a wide range of computer architectures and operating systems and HDF files are portable between these various systems. Scaler and vector data items can be created within an HDF file and grouped together into a self-describing hierarchy. This is ideal for saving neutron scattering data.

The triple-axis software has been enhanced to provide a command for writing data files following the current NEXUS proposals. The existing ILL ASCII format is, of course, also available. Conversion programs from NEXUS to other data formats will be provided as required.

The simplest place to store one's measured data is on the disk of the data acquisition computer. Disk space here is, however, limited. It is intended to set up a procedure so that acquired data files are transferred automatically to the central PSI file archive. There is also the possibility of transferring data to one's home institute via the Internet or of writing it to various types of tape or diskette.

6. Instrument Interfacing

This section should not be relevant to the average user of SINQ since it is the purpose of the data acquisition software to conceal such details from him. However, on those hopefully rare occasions where there are hardware or software problems with the system, such details may be helpful in resolving the problem.

6.1 RS-232-C Devices

As can be seen from Figures 2 and 3, most interfacing with an instrument's hardware is via asynchronous serial RS-232-C connections. For those devices developed at PSI, there is a simple command/response protocol over the serial line. There is also an interrupt mechanism provided in the protocol but the use of this has been avoided in the software in the interests of reliability and with a view to transferring the software to other operating systems in the future.

The serial devices are connected to a *terminal server*. The server software has been developed using LabVIEW. It operates as a classical TCP/IP server providing a service to its clients, in this case, the MAD software running on the host computer. Up to 8 clients may be active concurrently on any given server, MAD establishes connections to the server on a per device basis and is therefore able to communicate with several servers concurrently.

6.2 GPIB Devices

At present, there are no devices foreseen which require interfacing via the GPIB (IEEE-488) bus. Should the requirement for GPIB devices arise, a GPIB interface will be added to the terminal server. LabVIEW, the subsystem used to implement the server, provides good GPIB support. It should therefore be straightforward to extend the TCP/IP protocol of the terminal server to cover GPIB devices and to enhance the terminal server software accordingly.

6.3 Multi-detectors and Position Sensitive Detectors

The interfacing of multi-detectors and position sensitive detectors is currently being developed. A block diagram of the electronics is shown in Fig. 5. The multi-detector interface can be configured to suit the various types of detector and will convert signals from the detector into a data stream via a fibre optic link to the histogram memory.

The histogram memory is realised as a PowerPC single board computer housed in a VME module. In its first version, at least, it will act as a TCP/IP server to the data acquisition software in a similar way to that which has been employed successfully in the µSR experiments at PSI [6]. The data acquisition software will be able to configure the histogram memory, instruct it to acquire data and to read out the compiled histograms via the network link.

7. Conclusion

This report has attempted to provide prospective users with an overview of what they might expect to be available on the various SINQ instruments. At the time of writing (July 1996), there was still no complete spectrometer available on which realistic testing could be performed. Some changes are therefore to be expected before the first

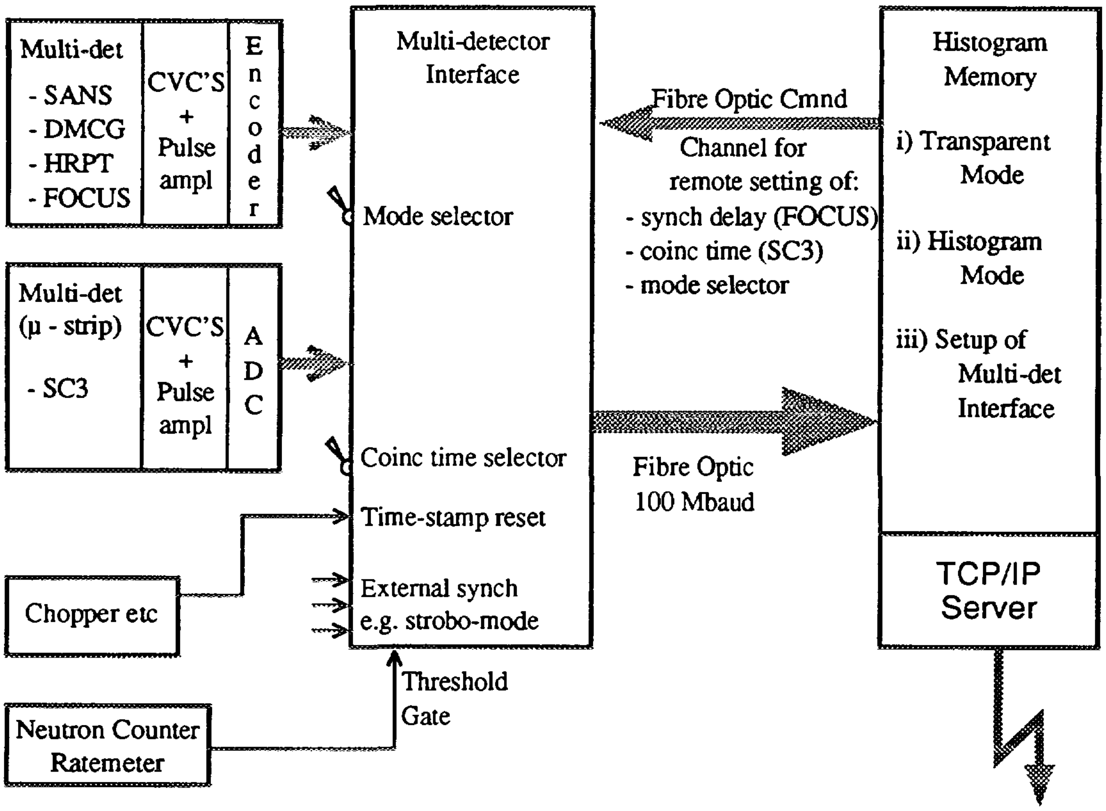

Fig. 5 : Block Diagram of Detector Electronics

neutron will be measured. It is hoped that these changes will be more of a cosmetic nature and that the fundamental structures described here will remain valid.

8. Acknowledgements

Apart from the indebtedness to ILL already mentioned in the text, I should like to thank my co-workers, Heinz Heer, Mark Könnecke, Marc Pepin and Markus Zolliker for their valuable contributions. We are also very grateful for the efforts of many groups at PSI, in particular the Networking Group under Hermann Kneis and the Electronics Group under Nik Schlumpf.

9. References

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5. HDF is available via anonymous FTP from *ftp.ncsa.uiuc.edu.* Documentation will be found in directory /Documentation/HDF/HDF3.3/Ref_Manual.
6. D.Maden, *The μSR Histogram Memory Server*, PSI Internal Report CTN-94-005, Oct 1994.