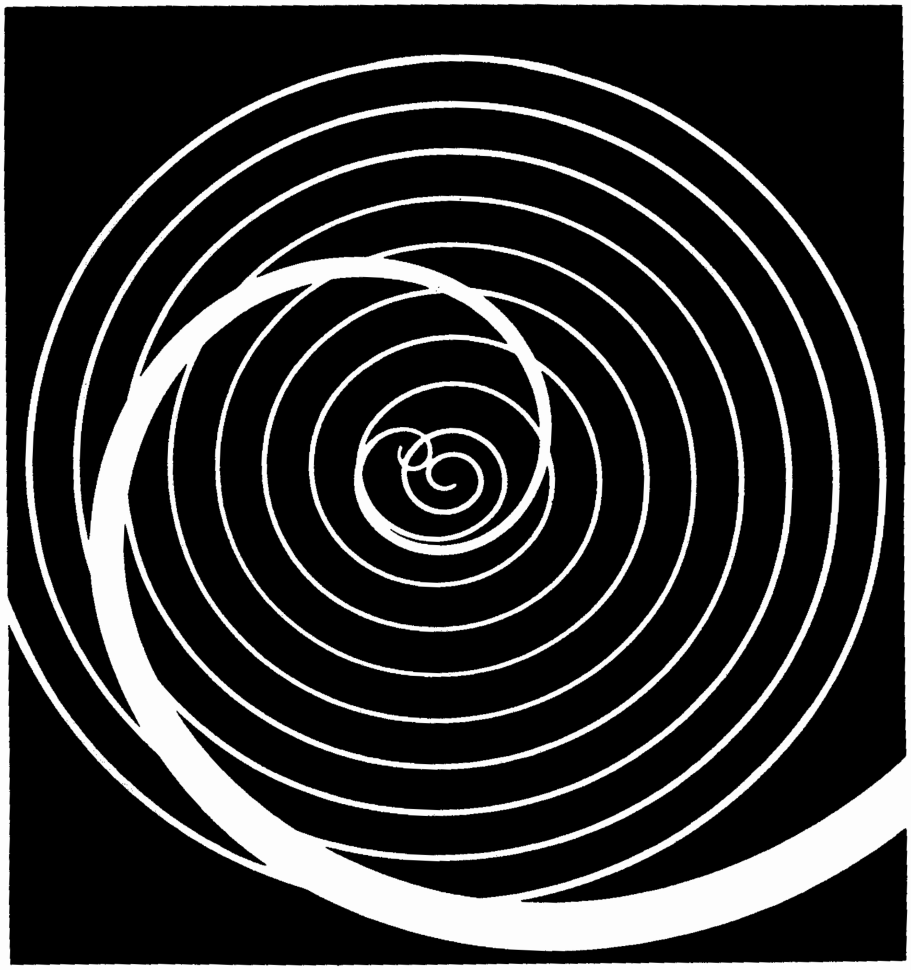
fermilab report

Fermi National Accelerator Laboratory Monthly Report

July/August
1988



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Editorial Assistant: C. J. Kania

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88/7 **Fermi National Accelerator Laboratory**

On the cover: *The main illustration from the poster announcing the symposium on Future Polarization Physics at Fermilab. The design is by Fermilab Artist Angela Gonzales. A recap of the symposium is on page 41.*

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Milestones to Date for the 1988-1989 TEVATRON Collider Run

On September 7, 1988, the TEVATRON at Fermilab reached its design luminosity of 10^{30} $cm^{-2}sec^{-1}$. During the week of September 9 through September 12, 1988, the TEVATRON achieved a new record initial luminosity of 1.25 x 10^{30} $cm^{-2}sec^{-1}$. (For purposes of comparison, CERN's previous record luminosity was 4 x 10^{29} †.) The TEVATRON's integrated luminosity for one week reached 204 inverse nanobarns, and the integrated luminosity for one store was 50.1 inverse nanobarns (CERN's best to date was 22.9 †).

The largest pbar stack equaled 46.6 milliamps (CERN has had about 60†), and 142 milliamps of pbars were stacked during that week, with an average stacking rate of 1.16 milliamps per hour. There were three stores with initial luminosity > 10^{30} :

Store 1578 (2200 9/7) 1.02 x 10^{30}
Store 1580 (0815 9/9) 1.25 x 10^{30}
Store 1583 (1930 9/10) 1.1 x 10^{30}

Under the leadership of Gerry Dugan, the accelerator has thus far delivered 625 inverse nb thus far. Two hundred and four of these were delivered from the 5th through the 12th. Thus, the prospects are very encouraging for the Collider Detector at Fermilab reaching and even exceeding the goal of 1000 inverse nanobarns on tape for the 1988-1989 Collider run.

The Fermilab Long-Range Schedule for operation of the TEVATRON is on page two of this issue of *Fermilab Report*.

(† Comparisons with CERN results are as of press date. CERN's 1988 Collider run with their new ACOL should be just under way as you read this. It is expected that CERN performance figures will be substantially improved in the near future. We may be in for a real horse race.)

Fermilab Long-Range Schedule

August, 1988

FY	FY88				FY89			FY90			
Y	1987	1988			1989				1990		
Beam line / M	O N D	J F M A: CHANGEOVER AND STUDIES	M J: COMMISSIONING	J A S O N D J F M A: COLLIDER RUN	M J J A S: CHANGEOVER AND STUDIES	O: STARTUP	N D J F M A M	J J A: CHANGEOVER AND STUDIES	S O: COMMISSIONING	N D: COLLIDER RUN
MW	706/672						706/672			
MT	741 test T755						741 test			
MC	731						773			
MP	704 calib 581			741			704* / 581			
ME	772			735			?			
NW	740 test						740 test			
NC/NT	632,733 745,770			713			782,790			
NE	653,711			710			690			
NM	665			740 test			665			
PW	705						771			
PC	756						761			
PE	769						791			
PB	687						687,774 / 683			
AC	760 test**	760 test**					760**			

* Also short test runs for E773

** Also Pbar-source improvement and studies

New Developments at the Fermilab Advanced Computer Program (I.): A Second-Generation Multiprocessor for Experimental High-Energy Physics

T. Nash, H. Areti, R. Atac, J. Biel, A. Cook,
J. Deppe, M. Edel, M. Fischler, I. Gaines, R. Hance, D. Husby,
M. Isely, M. Miranda, E. Paiva, T. Pham, and T. Zmuda

Introduction

High-energy physicists, like most scientists, have always wanted more computer power than they could afford to buy. In the commercial marketplace, the emphasis is on software-backward compatibility, product differentiation, and isolation of a client "herd." On the scientist's computing agenda, raw processing power in a relatively easy-to-use form, not corporate profitability, is the dominant issue.

Despite the fact that industry is not motivated by the rest of the market to provide the extremely cost-effective computer systems demanded by much of science, it does provide an extraordinary array of components (chips, modules, peripherals, work stations, software, etc.) that can be assembled into what science requires. For over five years, the Advanced Computer Program (ACP) at Fermilab has drawn from industrial components to design and produce usable parallel computer systems of such cost effectiveness that high-energy physics (HEP) experiments are now being carried out that would otherwise be unthinkable.

In addition to its dependence on the latest offerings of industry, the ACP also takes advantage of developments coming from computer science. However, just as with industry, the motivations of natural and computer scientists have significant areas of divergence. When commissioning a new architecture prototype, the interest of computer science primarily extends to proof of principle. Although also concerned with the latest from computer science, the ACP has the goal-driven motivations of its scientific clientele. The ACP's activities, therefore, fall in the rather wide gap between the exploratory spirit of computer science and the

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This article is based on a talk given by T. Nash at the "Workshop on Computational Atomic and Nuclear Physics at One Gigaflop" at Oak Ridge, Tennessee, April 14-16, 1988, and is also available as Fermilab preprint Conf-88/97.

production reliability and conservatism of industry. ACP systems must both take advantage of advanced concepts and components, and be robust enough to satisfy a large community of demanding users.

In common with computer science, the ACP is aiming toward reasonably general-purpose parallel computers. The difference is that the ACP cannot focus, as computer science usually does, on the often academic complications of the end goal. Rather, the ACP must take a step-wise approach, dealing with the easier, more obviously parallel, problems first. At each step, as more complex issues are addressed, there must be a fully working, commercializable machine that delivers the maximum cost effectiveness available at the time.

With their different perspective, natural scientists have brought to the computer-development community new philosophical and architectural approaches to investigate. The dynamic nature of scientific problems means that programs are frequently changed, often extensively. The scientific user generally has a deep understanding of the structure of the problem and the capability and willingness to map the algorithm to optimally cost-effective computer architectures. Issues of software compatibility can certainly become painfully acute at mundane levels like compiler syntax. However, when it comes to the global scale of a problem, scientists are virtually unique at this time in their receptiveness to explicit (user directed), as opposed to implicit (automatic), decomposition of programs onto parallel computers.

Fox and Seitz at Cal Tech, driven initially by the needs of theoretical physics, established the viability of hypercubes, the quintessential explicitly parallel, local memory architecture. These are now the subject of much attention in computer science, which earlier had focused heavily on global memory architectures and attempts at automatic parallelization of whole algorithms. Similarly, the natural parallelism inherent in the experimental HEP computing problem (running the identical reconstruction program on many millions of different events) suggests a simple parallel-processing solution. The pioneering emulator work by Kunz et al., at SLAC, demonstrated the feasibility of using multiprocessor systems to provide cost-effective computing for the reconstruction of experiment events.

Almost a decade after the first SLAC emulator, powerful 32-bit microprocessors allowed the ACP at Fermilab to develop even more convenient and cost-effective event-oriented parallel-processing systems using many more CPU's. Such systems are now an acknowledged important component of computing in high-energy physics. They have made crucial contributions to data analysis in a number of current experiments, and will be indispensable for the large experiments of the Superconducting Super Collider era. The first-generation ACP systems are rapidly becoming a standard. There are over 30 installations in universities and laboratories worldwide, primarily, though not exclusively, for HEP applications. The first of these ACP systems, which provide CPU power at a cost of less than $2500 per VAX 780 equivalent, were brought online two years ago. The initial 110 processor system, along with several newer installations, have been heavily used at Fermilab for physics event reconstruction.

In this first of two articles, we will cover the new ACP systems for experimental HEP, which, early in the next year, will provide well over an order of magnitude increase in cost effectiveness over the original systems. This second generation project will also allow much higher bandwidth for both I/O and interprocessor communication, and will have software tools allowing almost any UNIX-, VMS-, or (potentially) VM-based processor to be used equivalently as a node or "front end" in a multiprocessor ACP system. Perhaps most important is the way in which this new system allows for integration of powerful "back end" multiprocessors, now usable for both reconstruction and physics analysis, into a modern Ethernet-based workstation environment. In the September/October issue of *Fermilab Report*, we will discuss the multi-array processor system for theoretical physics.

The mandate for ACP development remains the computing needs of high-energy physics. However, the potential applicability of these new systems, particularly the one aimed at theoretical physics, is far broader than HEP alone.

The Second-Generation ACP Multiprocessor

The continued saturation of computers (including ACP systems) by HEP experimenters motivates the development of a second generation of the successful ACP Multiprocessor system. Industry is continuing to provide a stream of often surprisingly powerful technology that we can harness to meet the severe challenges of this science. Frankly, some of industry's new components are making our task particularly pleasurable and rewarding these days. A variety of new and increasingly powerful microprocessors are now available to incorporate into multiprocessors. Beyond the new versions of existing processors (like the 25-MHz 68030s replacing 16-MHz 68020s), there are entirely new families of chips. Most of these are based on the Reduced Instruction Set Computer (RISC) architectural philosophy. It was noted in the 1970s that many complex instructions in traditional machines with large instruction sets, like the IBM 360s and DEC VAXes, were rarely used. They effectively increased the cycle time for all instructions because they mandated extensive microcode. RISC machines are generally pipelined with no microcode and very fast instruction cycles. They defer complex instructions to software.

New processors that will offer at least a factor of 3, and in one case as much as a factor of 20, more performance than the first-generation ACP processors based on 68020s include: the MIPS R2000 and R3000 RISC chips; the Fairchild, now Intergraph, Clipper chip set; the AMD 29000 RISC chip; the Sun SPARC RISC chip; the INMOS T800 transputer; the Motorola 88000 RISC chip; and the National Semiconductor 32532 processor. Unlike earlier processors, many of these have usable FORTRAN and C COMPILERS and UNIX operating systems even before the hardware is available.

The broad availability of UNIX is particularly important. As we will describe below, the new ACP architecture will support any processor running UNIX (or VMS) that can be connected via VME or Ethernet. It is very difficult to predict with any certainty which processor or commercial single board (or single slot) computer (SBC) will be most cost effective in the future. The openness of the ACP system permits competitive purchase of processor nodes based on performance benchmarks and price.

The large increase in CPU power available for the second-generation ACP system requires a redesign of the multiprocessor hardware and software system architecture to remove bottlenecks in current systems that would be felt at the higher performance levels. The bottlenecks are I/O and interprocessor communication bandwidth, and the CPU power available for the host process. Continuing the successful strategy of attacking computing limitations with parallelism, the new architecture solves I/O and host limitations by supporting parallel I/O and parallel host processing. Moreover, to avoid mini-computer bus bandwidth restrictions, any node may take on host functions, including I/O, through controllers in its own local crate. Though significant, the changes in the new system hardware and software are designed to be as transparent as possible to users of the original system.

In the following, we describe the fast new ACP SBC, and then the new interconnection modules and topologies, the new (parallel) I/O options, and the new software system architecture, all designed to support the large increase in performance that will be available.

A Fast New ACP Processor Node

As it has in the past, the ACP is encouraging competition in SBC's targeted at parallel processing by developing an extremely cost-effective VME SBC. The choice of the R3000 RISC processor from MIPS Computer Systems, Inc., for this design was based on performance evaluations of the microprocessors referred to earlier. The ultimate standard is how real physics code runs in a high-level language, since it does not matter how many million instructions per second (MIPS) the CPU can execute if the instructions are not useful in FORTRAN or C, and if the compilers fail to provide sufficient optimization. The ACP has performed benchmarks on several of the new chips using a suite of high-energy physics FORTRAN programs (a small Monte Carlo/track reconstruction package; an actual fixed-target tracking code running on experimental data; and a floating-point-intensive theoretical calculation). These benchmarks were run on a 16-MHz MIPS R2000 system. For the three benchmarks, performances were 7.9, 6.4, and 7.4 times that of a VAX 780, which is generally accepted as the standard 1-MIP normalization. The new ACP node will use an R3000, the new improved version of the R2000. Carefully taking into account processor, cache, as well as clock speed differences, leads to a projected HEP code performance of 12-15 VAXes for 25-MHz R3000 boards and 16-20 VAXes for the 33-MHz versions we expect to use.

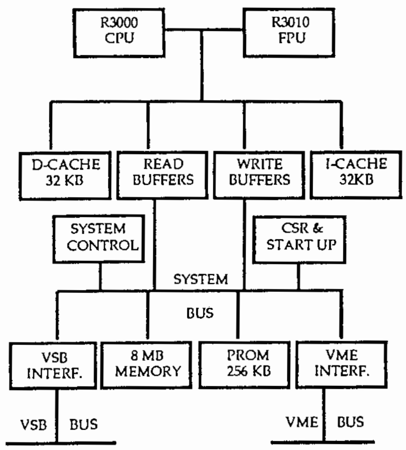

***Fig. 1.** The ACP MIPS processor, block diagram.*

The ACP MIPS processor module (Fig. 1) consists of:

1) a 25- or 33-MHz MIPS R3000 CPU;

2) a 25- or 33-MHz MIPS R3010 floating point unit;

3) Four Write Buffers;

4) a 32-KByte instruction cache;

5) a 32-KByte data cache;

6) 8 MBytes of parity-checking main memory, made up of 1-Mbit (100-nsec nibble mode access) drams, expandable to 24 MBytes via VSB (VME System Bus);

7) interval timers that can interrupt the CPU;

8) a full-function VME Master Slave interface supporting 20 MBytes per sec block transfers;

9) a full-function VSB interface for peripherals and memory extensions.

The ACP MIPS processor module will be packaged as two connected boards that will fit in one standard VME slot. One board will contain the processors and cache; the other board will have main memory and the VME and VSB interfaces. Up to two extra memory boards may be plugged into other slots and connected via VSB to allow a total of 24 MBytes. The modular nature of this design means that as new components (denser memory or faster processors) become available, only one board at a time will need updating. With 4-Mbit DRAM expected in a year or so, 32 MBytes will be possible without an expansion board (or up to 96 MBytes with maximum expansion).

The new CPU module will provide high-level language processing power with a cost effectiveness of well under $200/VAX 780 equivalent, based on the physics benchmarks and features listed above. The FORTRAN compiler is the best we have encountered for a microprocessor. It supports VMS extensions and compares favorably with the VMS compiler in convenience and sophistication. Since the MIPS CPU chip has on-chip memory management, the board will be able to run the full UNIX operating system, booting either from a VME disk drive or using the Network File System (NFS) over the Branchbus. Full UNIX program development tools are available. This processor will form the cornerstone of the second-generation ACP systems.

New Interconnect Topologies

The original ACP multiprocessor used a single (MicroVAX) host which was the master of large numbers of microprocessor nodes. The ACP Branchbus was developed to link several high-performance commercial local bus crates (like VME) to a host and/or a data acquisition system. It is optimized for high-speed block transfers. No commercial alternative was available. The original Branchbus is a 32-bit bus connecting a single master (QBus, Unibus, or FASTBUS) to multiple crates (VME), with block transfers at up to 20 MBytes/sec. Improvements to the Branchbus system of interfaces allow higher performance and more complex interconnection schemes.

The new VME Branchbus Controller (VBBC) allows any VME master, in particular any node (or smart I/O device controller) in an ACP multiprocessor system to act as a Branchbus master and read or write to any Branchbus address. Any processor in the system can communicate with any other processor without host intervention, allowing the more elegant system architectures described below. Figure 2 shows a block diagram of a high-performance, offline ACP system using the VBBC. Here no specialized MicroVAX is required as a host; a standard node takes on that function, and an accompanying smart tape controller can transfer data directly from tape to any node in the system. The VBBC is a VME slave and Branchbus master. It is a shared resource in the VME crate, allocated on a first-come, first-served basis by a test-and-set bit in its control register. Once programmed with the Branchbus control words and address, the Branchbus cycles occur transparently to the VME master, which simply reads or writes data to the VBBC. First prototypes of the VBBC are now working.

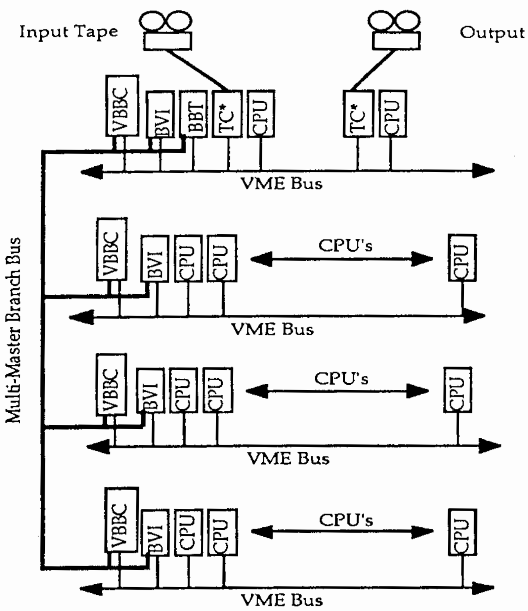

***Fig. 2.** A high-performance offline ACP system.*

As implied above, the Branchbus now supports multiple masters. A distributed arbitration scheme similar to that used on the SCSI bus allows up to 16 masters to share the bus. Existing masters (Q/UBBC modules) can be used in multi-master systems by replacing their existing Branchbus Interface Daughter Board with a new Multi-Master Branchbus Interface Daughter Board which handles the arbitration transparently to the user.

The ACP Branchbus Switch allows full crossbar interconnection of up to 16 Branchbuses (or more using multiple switches). With this switch, any Branchbus master device can connect to any slave in the entire switch-connected system. All channels of the switch can be active simultaneously. For example, eight of the Branchbuses could be connected to the other eight, all transferring data simultaneously, giving an aggregate bandwidth of 8x20 MBytes/sec or 160 MBytes/sec (in addition to any local bus activity on any of the VME crates in the system). Thirteen Texas Instrument 16x16x4-bit crossbar chips (TI 74AS8840) are used for the main switching elements. The switch is a backplane in a 6U by 280 mm Eurocard crate. Modules may be plugged into the Switch Crate (see Fig. 3, page 10) much as with VME. However, instead of the signals being connected in a bus structure, each slot in the crate is a crossbar switch point. The first two Switch Crates are built and working.

Two modules now exist that plug into the switch crate. One is the Branchbus Switch Interface Board (BSIB) which converts the differential RS485 signals on the standard Branchbus cables to the single-ended TTL version of Branchbus used on the Switch backplane. The BSIB brings one standard Branchbus, with its VME crates, host, FASTBUS, etc., into a port of the Switch, and allows them to be switched to whatever else is plugged into the Switch Crate, such as other Branchbus circuits. Use of the Switch in this way will allow multiprocessor systems to obtain extremely high bandwidth for interprocessor communication. The second existing module that plugs into the Switch is the Floating Point Array Processor (FPAP), a 20-MFlop device that is used for theoretical physics (primarily lattice gauge) calculations.

Parallel Input/Output

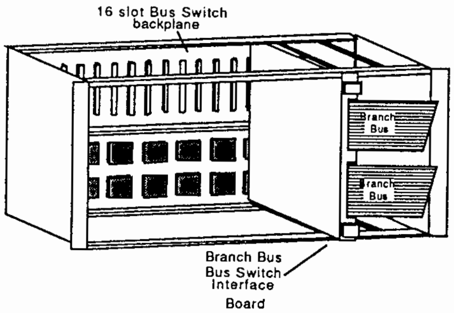

Fig. 3. The ACP Branchbus Switch. The backplane uses single-ended TTL Branchbus protocol.

Although it will continue to be possible to read and write tapes through a VAX or MicroVAX into an ACP system, high-performance operation will take advantage of I/O devices that interface directly to the multiprocessor system bus. Unlike Unibus and QBus tape drives, VME interfaces will give a bandwidth potential, depending on the I/O device, of up to the 20-30 MBytes/sec allowed by VME rather than the roughly 1 MByte/sec possible with minicomputer buses. One such VME tape interface, the Ciprico TM3000, has been used for data acquisition at Fermilab.

Parallel I/O is particularly encouraged by the availability of inexpensive, high-capacity, mass-storage devices which interface directly to VME. It is made possible by the availability of I/O directly in the node crates and by the new capability of a processor and/or its intelligent I/O controller to write through a VBBC from one crate to another. The multiprocessor system will have available to it many devices, all reading and writing simultaneously, allowing the total I/O bandwidth to be increased to whatever level is required.

New I/O devices are replacing standard 6250-bpi magnetic tape. These are very appealing to HEP experiments anticipating huge amounts of data, such as one approved Fermilab experiment which is planning to record tens of billions of events. At this time, video-tape cassettes appear most promising. The 8 mm format can pack well over 100 times the data in a given volume of shelf space as can conventional tapes, and they are at least an order of magnitude more cost effective. Current devices allow bandwidths comparable to those achieved with standard 6250-bpi tapes, with further improvements expected in the next year.

The ACP has tested the 8 mm video-tape device manufactured by Exabyte Corporation. Currently available devices store 2 GBytes (as much as 12 conventional tapes) on a standard $10 tape cassette. The drives cost less than $3000 and can deliver data at 250 KBytes/sec through a SCSI bus interface to VME or QBus. Both density and speed are expected to double in the next year.

The Exabyte drive package allows the design of a cheap and simple mechanical loader. Such a design is under way. It will incorporate a reader for optical bar code labels to insure mounting of the correct set of tapes from a large data sample.

Automating tape loads eliminates the time for human operators to mount tapes, which becomes significant when tapes are being processed at high speed.

The ACP plan at this writing is to support the Exabyte drives. However, it is important to emphasize that no standard has yet emerged in this rapidly developing field, and the long-term reliability of such devices has not been established. Nonetheless, it is clear that one can count on far better I/O performance than has been available.

Software System Architecture

The redesign of the system software for the Second-Generation ACP System will support the greatly improved performance and flexibility of the new processing, I/O, and communication hardware, while reducing the complexity encountered by both beginning and sophisticated users. It will allow existing applications to run with minimal changes, yet will provide a variety of powerful new features to allow users to realize the full potential of the new processors. Integration will be possible into a variety of computing situations, including large mainframe computer centers and the traditional VAX or MicroVAX host. Most important, in our view, is a distributed computing UNIX (or VMS) workstation environment in which the multiprocessor will function as a fully integrated back-end engine directly controlled from the workstations. The general hardware environment supported is shown in Fig. 4. Because of the emphasis on portable, nearly universal standards, it will be straightforward to incorporate any computer that runs UNIX and/or can communicate via TCP/IP over Ethernet. This makes the system open and receptive to future requirements and product options.

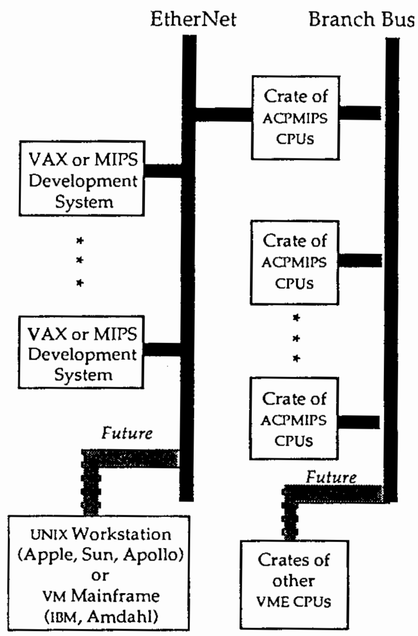

Fig. 4. The Second-Generation ACP System: general hardware and network environment.

As before, the ACP System Software is a tool to make it easy for physicists to bring their programs to a high-performance multiprocessor environment. An application for the second-generation system is decomposed into a set of cooperating processes. Support for running these sets of processes as a job, including interprocess communication and synchronization, startup, etc., is provided by the ACP System Software. The processes run on an ACP Multiprocessor System interconnected by Branchbus and on any associated UNIX or VMS (later, possibly, also VM) computers connected via Ethernet and TCP/IP. They may be distributed as appropriate over the available computers. In this way, a multi-process job may be tested first in a single machine and then with increasing numbers of nodes. Program development is done using the full set of UNIX (or VMS) tools, including compilers, linkers, and debuggers, of the computer on which the process will run.

Any node process can assume the functions previously exercised only by the VAX host processor. Any node process in the system can do I/O, reading or writing data tapes and accessing disk files. And any node process in the system can do "send" or "get" operations to or from an individual process (chosen by the system software from a class or rank of node processes) or set of processes in a given class or rank. As before, the system software will automatically find an available node process for the user. The ability to send and get to multiple nodes in a class allows "broadcast"- and "accumulate"-type operations.

Along with the traditional `send` and `get` type of ACP communication routines, there will be a variety of more primitive, yet powerful and easy to use, interprocess communication mechanisms. A process may send a block of data directly to a block of virtual address space in another process, or it may call a subroutine in another process (remote subroutine call), or it may send a small data packet (a message) to another process. Users of the new system will have direct access to process queues which they may define as they require or use in standard, traditional ACP-defined ways (like node process *ready* or *complete*). Synch points provide a way for all processes in a class to synchronize program execution.

There are many possible process configurations that the new system can support. An example for a reconstruction problem with multiple input tapes is shown in Fig. 5. Note that this is a software configuration; the actual hardware connection of the nodes is over Branchbus via VBBCS and Bus Switches (if necessary) and is transparent to the programmer. Nodes in the top rank read events from data tapes and pass them along to either class 2 or class 3 nodes, which process events of different trigger types. Nodes in the bottom rank collect events from any nodes in the middle rank, either class 2 or class 3, for output to tape.

Another important configuration has enormous implications for physics data analysis (as opposed to reconstruction). Here, the top rank of nodes is the same

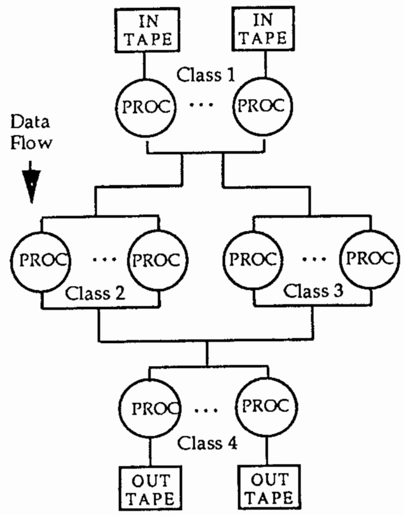

Fig. 5. A multi-rank configuration. Processes are indicated by circles.

as in Fig. 5, and the second rank consists only of one or more workstations and, perhaps, a single data-recording process. With such a configuration, a whole experiment's data base of data summary tapes (DSTS) can be read and analyzed in parallel in much less than an hour. The traditional means of passing hundreds of DSTS through a computer center for a physics analysis pass often takes weeks.

Conclusion

To summarize, the Second-Generation ACP System architecture is designed to support large increases in processing power and in I/O and communication bandwidth. It provides a set of hardware and software building blocks so that a system can be matched to the set of applications it will run. One can provide enough I/O devices and Branchbus interconnects so there are no bandwidth limitations. The number of basic CPU nodes is determined by processing power requirements, while special computer nodes, such as workstations or mainframes, can be incorporated into the Ethernet side of the system when needed and available. As each job is run on the system, nodes are assigned to run particular user processes (input, output, event processing, etc.) as appropriate. Not only the traditional compute-bound event reconstruction, but also more I/O-intensive data analysis will find a home on these systems.

Experimental Notes

E-731 Measures CP Violation Parameter ε′/ε

Ever since the violation of CP symmetry (charge conjugation and parity) was first observed at the Brookhaven AGS by Val Fitch and James Cronin's Nobel Prize-winning experiment, this has been an area of fruitful physics research. In mid-February, a group from the University of Chicago, Fermilab, Princeton University, and Saclay (France), as Fermilab Experiment 731, completed a data run, the primary goal of which was to measure the "direct" CP violation parameter $|\varepsilon'/\varepsilon|$ to an accuracy better than plus or minus 0.001. The experiment (E-731) accumulated over 5000 data tapes and is currently analyzing the sample in an attempt to measure the double ratio below to 0.6% of itself.

$$\frac{\Gamma(K_L \to \pi^+\pi^-)/\Gamma(K_S \to \pi^+\pi^-)}{\Gamma(K_L \to \pi^0\pi^0)/\Gamma(K_S \to \pi^0\pi^0)} = 1{+}6\,\frac{|\varepsilon'|}{|\varepsilon|}$$

So far, about 200 data tapes have been analyzed in detail in addition to the off-line monitoring which sampled one out of every 20 tapes throughout the run. The data quality was found to be excellent. The expected number of reconstructed $K_L \to \pi^0\pi^0$ decays is over 250,000, with substantially larger statistics for the rest of the decay modes. The corresponding statistical power is more than adequate to achieve the goal, and the experiment is currently performing the first-round data crunching on a 20% sample using the Advanced Computer Program (ACP) system developed at Fermilab.

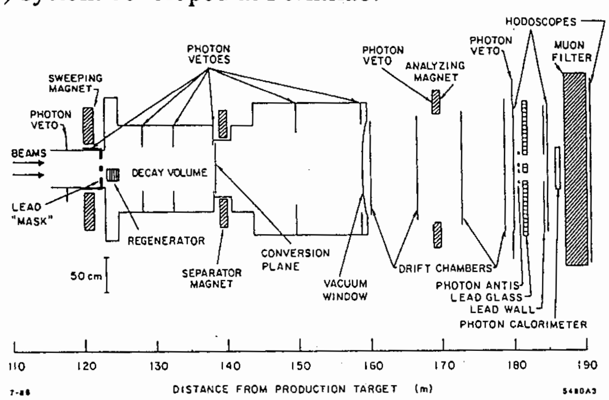

Fig. 1. Side view of the E-731 detector.

Figure 1 shows a side view of the detector. A double K_L beam enters the decay region at the spot where a regenerator moves alternately between the two beams during each spill from the TEVATRON, producing K_S decays. The double beam configuration allows many systematic effects (difference in beam intensities, dead times, veto counter inefficiencies, etc.) for both the vacuum beam (no regenerator) and the regenerated beam to cancel when the above ratio is formed.

Charged pions are detected and momentum analyzed by four sets of drift chambers, each consisting of a pair of horizontal and vertical wire planes. The neutral decays are reconstructed by locating and measuring the energy of electromagnetic showers in the lead glass array (see Fig. 1). The raw pulse height of each of the 804 blocks are gain matched during data taking to within 5%, allowing the use of a fast online cluster finder to select events with just four clusters at the trigger level. Background caused by $K_L \to 3\pi^0$ decays with only four clusters detected at the lead-glass array is reduced by using 10 sets of photon veto counters. The muon wall and muon counters are used to reject $K_L \to \pi\mu\nu$ decays which are a background in the $K_L \to \pi^+\pi^-$ sample.

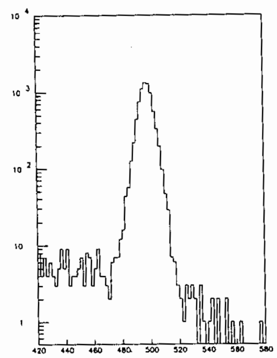

Fig. 2. *Center of energy distribution.*

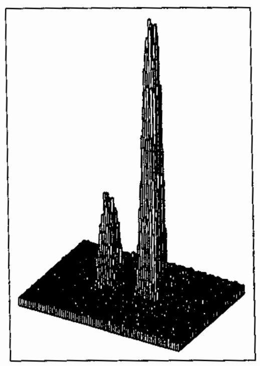

Fig. 3. *$2\pi^0$ Mass distribution*

Figure 2 shows the center-of-energy distribution for the reconstructed $K \to 2\pi^0$ decays for about 2% of the data. The higher peak corresponds to the regenerated beam, with the lower peak showing the vacuum beam. They are clearly separated, but there is cross-over from the regenerated beam to the vacuum beam due to the scattering of kaons at the regenerator. This background is at the few-per cent level and can be reliably subtracted. The $2\pi^0$ mass distribution is shown in Fig. 3 for the vacuum beam. The background is dominated by $3\pi^0$ decays and is about 0.5%.

A pair of thin scintillator planes, between which a lead sheet of 0.1 radiation length can be inserted to convert photons, is at the downstream end of the decay volume. The converted pair helps to uniquely identify the beam from which a detected kaon decay originated, but the statistics is reduced by a factor of five. This mode (conversion mode) will be used as a cross check of the non-conversion mode. Three kinds of data were taken by E-731:

1) Charged Mode (lead sheet out): The primary trigger is for the $K \rightarrow \pi^+\pi^-$ candidates. The typical beam intensity was 0.5×10^{12} protons/spill with 240-million triggers taken, corresponding to about 400,000 $K_L \rightarrow \pi^+\pi^-$ events and three times as many $K_S \rightarrow \pi^+\pi^-$. Charged mode data cannot be taken with the lead sheet in because the multiple scattering would degrade the momentum resolution.

2) Neutral Mode (lead sheet in): Both the conversion mode and non-conversion mode data were taken together. The typical beam intensity was 1.3×10^{12} protons/spill with 120 million triggers for the non-conservation mode being taken. This corresponds to about 170,000 $K_L \rightarrow 2\pi^0$ events and three times as many $K_S \rightarrow 2\pi^0$. The corresponding yields for the conversion mode are about five times less.

3) Combined Mode (lead sheet out): Data from all four decay modes (double ratio shown above) were taken simultaneously. The typical beam intensity was 0.8×10^{12} protons/spill with 60 million triggers taken for both the charged and non-conversion neutral modes. This corresponds to about 110,000 $K_L \rightarrow \pi^+\pi^-$ and 80,000 $K_L \rightarrow 2\pi^0$ decays, with about three times as many K_S decays also written to tape.

Apart from the regular data tapes described above, many tapes including specialized data were also written. This includes such things as data taken with the vacuum (and regenerated) beam only, trigger-study tapes, and lead-glass calibration data using e^+e^- pairs that were converted upstream and illuminated the lead-glass array. In addition, so-called "light flasher events" for the lead-glass gain tracking were taken at 1 Hz throughout the run, and random trigger events, allowing the study of the effect of accidental hits, were also taken together with the regular data rate.

*("**Experimental Notes**" continued)*

In addition to measuring $|\varepsilon'/\varepsilon|$, the large K_L flux allows E-731 to study rare K_L decays such as $K_L \rightarrow \pi^0 e^+e^-$ and $K_L \rightarrow \pi^0 \gamma\gamma$. The 5000 data tapes written have turned out to be very rich in physics beyond the immediate scope of the experiment. Analyzing a data sample of this magnitude presents unique computational problems and the added data crunching capacity of the ACP has been and will continue to be indispensable to the analysis of the entire data sample.

At the E-731 end-of-run party. Left to right: Mike Woods, Lawrence Gibbons, Ritchie Patterson, Vaia Papadimitriou, and Magnus Karlson.

As stated above, many experiments have chosen to peer into the window of CP violation over the last decade. Recently, the CERN NA-31 group published evidence that the $|\varepsilon'/\varepsilon|$ parameter was non-zero. Their value, which is three standard deviations from zero, was obtained by a different technique than that used by E-731; the group is currently running again, hopefully to confirm this finding. Also at CERN, an experiment (CPLEAR) at the LEAR facility will soon be addressing the same issues of CP, using yet another technique. E-731 is grateful to the SIN group, which is a member of the CPLEAR collaboration, for providing a giant Toblerone chocolate bar for the E-731 end-of-run party (see photograph above). - *Hitoshi Yamamoto*

E-581/704 - Initial Operation of the Polarized Beam at the TEVATRON

For a number of years there has been considerable interest in investigating polarization phenomena in the TEVATRON energy regime, since there exist many experimental indications that spin effects are significant at high energy. Ex-

*("**Experimental Notes**" continued)*

periments 581/704 at Fermilab are designed to address a number of spin-physics questions raised by observing the remarkable existing data. A new polarized proton beam was commissioned during the 1987-1988 fixed-target run at the TEVATRON.

E-581 consists of the design, construction, and dedication of polarized proton and antiproton beams. A beam of protons accelerated by the TEVATRON to 800 GeV incident on a beryllium target produces, among other particles, Λ's and anti-Λ's. Parity-violation in the subsequent decays $\Lambda \rightarrow p + \pi^-$ and $\overline{\Lambda} \rightarrow \overline{p} + \pi^+$ result in a polarization of 64% along the proton (antiproton) momenta in the Λ ($\overline{\Lambda}$) c.m. system, respectively. These decay particles provide the world's highest energy polarized proton beam and only polarized antiproton beam (Fig. 1).

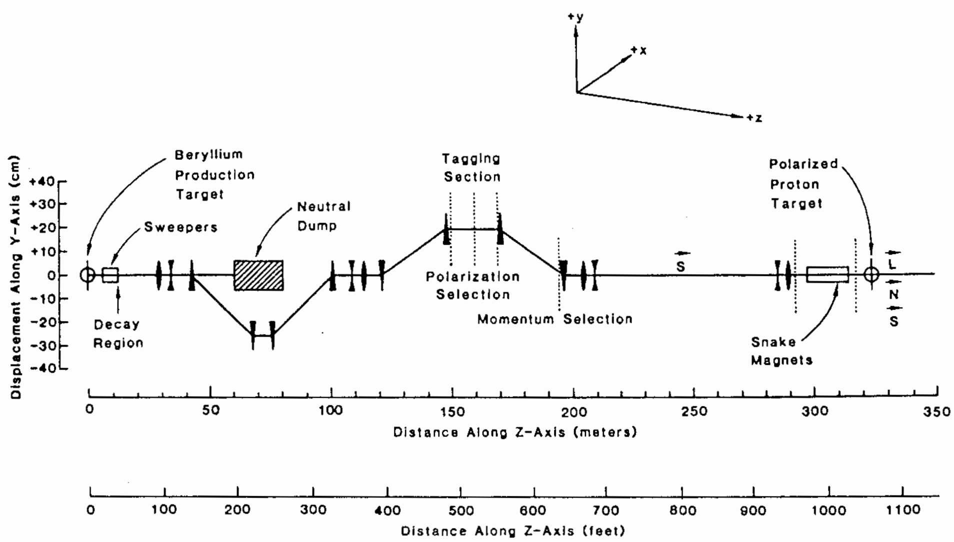

Fig. 1. *Side view of the Fermilab Polarized Beam.*

A beam of such protons or antiprotons, correlated in phase space with the trajectory of the parent particle, is collected at a mean momentum of 185 GeV/c and transported to an intermediate focus where a polarization tag can be made. Near the final focus is a series of 12 "snake magnets" that precess the spin from horizontal to vertical or longitudinal and also reverse the polarization direction in order to reduce systematic errors. Such reversal is done every 10 minutes (≈10 TEVATRON spills).

*("**Experimental Notes**" continued)*

During the recent fixed-target run at Fermilab, this beamline was initially commissioned with 30-GeV hadrons and positrons for beamline tuning and calibration of various detectors. A few weeks were provided with 800-GeV protons incident on the beryllium target in order to study the proton and antiproton yields and to measure the beam polarization. Usable protons and antiprotons were selected by their tagged position corresponding to a calculated polarization magnitude of > 35%. Two threshold Cerenkov counters were used upstream of the snake magnets to reject pions in the beam. Measurements of the beam flux for 1×10^{12} incident protons per 20-sec spill were:

	Tagged Beam ($P_{beam} > 35\%$)	Total Beam (protons or antiprotons)	Background π's
Protons	8×10^6	1.5×10^7	1.5×10^6
Antiprotons	4×10^5	7.5×10^5	3.8×10^6

These measured intensities are in good agreement with design calculations. An increase in the primary intensity to 4×10^{12} incident protons/20-sec spill is expected for the next data-taking period.

Two polarimeters were used to measure the absolute polarization and to confirm the validity of the tagging method. One relies on the Primakoff effect, where the analyzing power for dissociation of an incoming high-energy proton into a (πN) system by the Coulomb field of a heavy nucleus can be related to the known low-energy polarized-target asymmetry in photoproduction of the corresponding (πN) system. Asymmetries in the low-energy photoproduction are quite large, up to 90% in certain kinematic regions. The same analyzing power in the corresponding kinematic region will occur in the proton-induced process at high energy. Using a 3-mm lead target, lead-glass calorimeter, and a magnetic spectrometer, it was possible to observe the Primakoff events in the $|t| < 10^{-3}$ $(\mathrm{GeV}/c)^2$ region and the mass range, $1.34 < M(p, \pi^0) < 1.50$ GeV. About 3000 events using protons with greater than 35% polarization were collected in 48 hours. The beam polarization was determined to be 40 ±12%, in agreement with the design calculations. No asymmetries were found in kinematic regions where the low-energy photoproduction data show a zero analyzing power. Data collected in a short test run with the polarized antiproton beam were only sufficient to observe the Primakoff process.

The other polarimeter uses the Coulomb-Nuclear interference effect in pp ($\bar{p}$p) elastic scattering. The analyzing power, arising from the interference term be-

("Experimental Notes" continued)

tween the nuclear non-flip amplitude and the electromagnetic spin-flip amplitude, is ≈5% at $|t| = 3 \times 10^{-3}$ $(GeV/c)^2$ and is energy independent. A one-day measurement was sufficient to show that elastic scattering from hydrogen in the active scintillator target could be distinguished from background. Preliminary analysis indicates the beam polarization to be consistent with design expectations.

In the next fixed-target period, E-704 will use the polarized beam to study polarization phenomena at the highest energy available. The experiment aims to study inclusive π^0, Λ^0, Σ^0 (at large $p_\perp$), and $\pi^\pm$ (at large x_F) production using an unpolarized hydrogen target. The difference in total cross sections in longitudinal spin states in pp ($\bar{p}$p) scattering will also be studied using a polarized proton target.

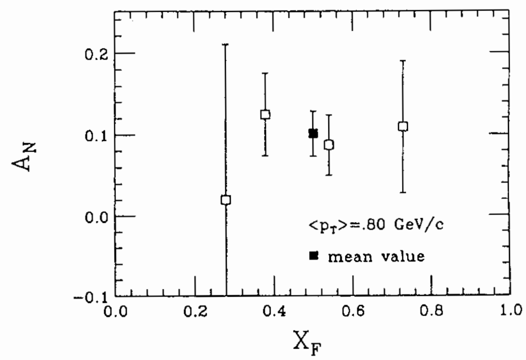

Fig. 2. *Analyzing power results vs. Feynman x.*

An initial result, which is indicative of the physics to come, is produced by the measurement of an asymmetry in inclusive π^0 production at large x. A significant asymmetry of (10 ±3)% was measured (see Fig. 2). This process will be used by E-704 as a beam polarization monitor. Data with antiprotons indicate an average asymmetry of (-26 ±19)%.

The E-704 collaborating institutions are Argonne National Laboratory, Fermilab, Kyoto University, Kyoto Sangyo University, University of Iowa, Kyoto University of Education, LAPP-Annecy, Los Alamos National Laboratory, Northwestern University, Rice University, CEN-Saclay, IHEP-Serpukhov, University of Texas, University of Udine, Univ. Occup. Environ. Health (Kita-Kyushu), Hiroshima University, and INFN-Trieste. - *A. Yokosawa*

QA at Fermilab; The Hermeneutics of NQA-1

Mark W. Bodnarczuk

The history and interrelationship between quality assurance (QA) professionals and scientific researchers has been long and sometimes antagonistic. In the early 1970s, what was then called the Atomic Energy Commission (AEC) launched a program to standardize the quality-assurance programs at laboratories that were involved in nuclear reactor research. Because this was a new endeavor, one of the key issues was to find QA models that could be used as guides in developing these programs. The early programs used models from the aerospace and nuclear industry as a guide, producing the Reactor Development Technology (RDT) Standards. These were heavily influenced by traditional safety methodologies. Over the course of the next ten years, some of the scientists and engineers who did the technical work at these laboratories increasingly viewed this approach as a rigid bureaucracy which could usurp management prerogatives and even threaten the goals of some programs. The result was a rejection of this type of so-called "institutional quality assurance" by many laboratory personnel. Some researchers even left the laboratories because they felt that the regulations were undermining the process of scientific advancement. Most ironically, these programs (even when implemented) often produced little or no progress toward effective institutional QA programs. QA professionals wondered how they could develop an institutional QA approach that assured real quality and didn't drive the scientific talent away from the laboratories or stifle one of the most important aspects of scientific progress; creativity.

By 1981, the need for new directions in QA was unavoidably recognized. But the one problem faced previously (the need for appropriate QA models to be used as a guide) once again demanded a solution. What should the Department of Energy (DOE) use as a model for QA design and how could they avoid the confining effects of the previous AEC programs? A few years earlier in 1979, an American Society of Mechanical Engineers committee prepared an American National Standard called NQA-1 which was to be used in designing, building, and operating nuclear power plants. The DOE subsequently began using NQA-1 as the preferred model for QA. Shortly thereafter, DOE Order 5700.6A and 5700.6B (Quality Assurance) required all DOE contractors to have a QA program that meets the 18 basic requirements of NQA-1. However, this order has been slow in implementation because some national laboratories resisted taking a single document like NQA-1, which was specifically designed for nuclear reactors, and applying it to all laboratories, even basic research facilities like Fermilab.

Fermilab historically has had rigorous peer review and quality standards which produced a successful 20-year operating record of proposing, building, running, and completing high-energy physics experiments. Yet this was accomplished without a formalized, institutional QA program. After the advent of DOE Order 5700.6B (Quality Assurance), the Director's Office at Fermilab organized the Quality Assurance Committee (QAC) and as Chairman, I was directed to head the design and development of an institutional QA program. The QAC is composed of appointed QA officers from each Division/Section at the Laboratory who share line responsibility for QA in that division and represent their division to the QAC.

The Hermeneutics of NQA-1

Department of Energy Order 5700.6B (Quality Assurance) raises the primary issue addressed by this article. Although NQA-1 was written and designed specifically for use in nuclear reactors and nuclear facilities, the DOE order requires even non-nuclear facilities like Fermilab to comply with the 18 basic requirements of NQA-1. During the last two years, one of the significant problems that faced the new QA staff at Fermilab was how to integrate and apply NQA-1 to the existing laboratory structures in a way that both satisfied the requirements and did not displace the deep sense of peer review and quality traditions that are built into the high-energy physics community. Some QA professionals suggest that the full "traditional" application of all the requirements of NQA-1 is appropriate even in these non-nuclear facilities, while other QA professionals have asserted that this approach is unrealistic and even counter productive. Given the fact that non-nuclear laboratories must use NQA-1 as a standard, how can this be accomplished effectively? This article describes one model that has been used successfully to address this question. The remainder of the article will attempt to show that the success or failure of an NQA-1-based institutional QA program at a non-nuclear laboratory like Fermilab depends crucially on how NQA-1 is interpreted and how it is applied.

What is hermeneutics and why are hermeneutical considerations relevant for QA? Webster's dictionary defines hermeneutics as "the methodological principles of interpretation in regard to legal, literary, and biblical texts." Hermeneutics has two distinct yet related components. The first is the interpretation of documents within the context in which they were written, the second is the application of those interpretations to other non-related contexts and environments. These two components comprise an important concept which we will call context sensitivity, i.e., not directly imposing something that was written for one specific context indiscriminately upon an entirely different context.

For instance, the writing and passing of legislation in the United States is not an end in itself. One law must often be interpreted in myriad different contexts, making it difficult to determine the true intent of the law as applied to widely divergent cases. A major hermeneutical problem today in jurisprudence is trying to understand what the United States Constitution meant within the historical context in which it was written, and how we can apply those same laws today in a country that is far removed both in time and culture. The Supreme Court must fold context sensitivity into its decisions about, and interpretations of, our laws. This paper suggests that NQA-1 is as subject to the interpretive and applicative principles of hermeneutics as any other field including jurisprudence. In fact, the problems of applying one law to vastly different cases is precisely analogous to our issue of applying one standard (NQA-1) to many very different nuclear and non-reactor laboratories. Using NQA-1 likewise demands context sensitivity.

We will now present a critical analysis of NQA-1, focusing on the teleological aspects of the standard (teleology has to do with goals from the Greek word *telos* which means end or purpose). What is the overall goal and teleological purpose of NQA-1? As stated earlier, NQA-1 was specifically designed as a guide in developing QA programs for nuclear reactors and nuclear facilities. It consequently describes both the requirements and non-mandatory guidelines for siting, designing, constructing, operating, and decommissioning nuclear facilities. The document has a modular design, i.e., the basic and supplementary requirements allow an individual to use the entire document or only portions of it. The number of modules used depends upon the nature and scope of the work being performed and requirements imposed by the sponsoring agencies. NQA-1 was designed to provide an organized framework which applies to any structure, system, or component essential to the satisfactory performance of a nuclear facility. The full "traditional" application of NQA-1 to nuclear facilities operated under contract for DOE is required and appropriate. The real question in this article is this: To what degree do the goals, categories, and guidance found in NQA-1 capture the essential components of all projects including those at non-reactor facilities? The answer to this question depends on how the standard is interpreted and subsequently applied.

There are two standard ways of interpreting NQA-1: traditionally and non-traditionally. The traditional approach uses NQA-1 as a "grid" or "mold" into which the "wax-like" management structures and the procedures of personnel are poured. The result is a molded structure formed "in the likeness of" NQA-1. The mapping between NQA-1 and the organization is designed to be 1-to-1. This approach is appropriate and necessary for nuclear reactors and other high-level nuclear facilities. But in basic research facilities like Fermilab, the nature and design of the management structure and the broad parameters of the operations of the laboratory are the choice of the contractor. It is in these environments that the "non-traditional" interpretation and application of NQA-1 has been used with success. In these situations, NQA-1 is used as a standard against which the existing quality traditions and peer review standards of the laboratory and the scientific community are measured and, if necessary, changed or re-normalized.

The issue at stake here is the appropriate use of NQA-1 in the appropriate environment. More precisely, it is using NQA-1 as a tool, matching the proper application of the standard to the job being done. This is just good common sense. All tools must be appropriately matched to the jobs they are used for. One does not use a 20-pound sledge hammer to gently tap a tiny gear into a Swiss watch and neither does one use a tiny jeweler's hammer to break up the black top in a driveway. Both are hammers. Both are useful when used properly. Both are useless or destructive when used in the wrong application. Attempts to apply NQA-1 traditionally in non-traditional, non-nuclear environments can lead to the "20-pound sledge hammer effect" on the creativity of laboratory scientists. The results can vary from covert resistance to overt noncompliance.

The non-traditional hermeneutic for NQA-1 attempts to capture the true teleological intents of the document without displacing the deeply ingrained traditions of quality standards and peer review that have been foundational to the overall success of the theoretical and experimental paradigms of high-energy physics. By using the non-traditional approach, Fermilab has not only overcome some of the historical antagonism between scientists and QA professionals, but it has developed an institutional QA program that fully complies with the intents of NQA-1 without seriously constraining the creative abilities of our scientists. This same basic approach is elastic enough to accommodate alternative versions which have been used at other laboratories with success.

Conclusion

What are hermeneutical considerations and why are they relevant for QA? The important issue here was context sensitivity, i.e., not taking a document specifically designed for one context and indiscriminately imposing it upon very different contexts. In our case, this means flexibility in the way that NQA-1 is applied to "non-traditional" basic research facilities. What are the teleological aspects of NQA-1 given this "non-traditional" interpretation? NQA-1 should function as a standard/reference point against which procedures and quality traditions in the scientific community can be compared, measured, and if necessary renormalized. It should not be viewed as a structure into which the "wax-like" management structures and procedures of personnel can be poured.

Finally, some QA professionals have suggested developing another national consensus standard to use in non-nuclear environments where institutional QA is needed or required, but as we have suggested, this is not necessary. NQA-1 is an appropriate standard for non-nuclear environments if interpreted and applied properly. In addition, developing another national consensus standard would not only demand a significant amount of time and money, but in the end it would reintroduce the same problems that we have solved hermeneutically, namely how should this new national consensus standard be applied to a wide variety of national laboratories?

A synopsis of how ANSI/ASME NQA-1 has been applied to DOE-CH laboratories can be found in the document "Institutional Quality Assurance at DOE-CH Laboratories; 'A Partnership'" published by the U. S. Department of Energy Chicago Operations Office. Additional information on the particulars of Fermilab's QA program can be found in "Towards an 'Orthodox' Quality Assurance Program; Canonizing the Traditions at Fermilab," (FERMILAB-Conf-88/31) by Mark Bodnarczuk, or in the Fermilab institutional and divisional QA programs, which are available from all Fermilab divisional QA officers.

Education Outreach at Fermilab: A Summer of Learning

Fermilab's long-standing commitment to science education continues unabated. The following compendium of articles illuminates some of the Lab's programs, some of the people who conduct those programs, and some of the people who benefit from those programs.

I.

Forty-five science and 15 mathematics teachers participated in the Summer Institute for Science and Mathematics Teachers (SISMT) held from June 13 to July 8, 1988, at Fermilab. The SISMT is an annual program sponsored by the Friends of Fermilab and inaugurated in the summer of 1983. The curriculum included biology, chemistry, and physics until 1987 when mathematics was added. Since its inception, 270 science and 30 mathematics teachers have attended the Institute.

This year's participants included teachers from outside the Fermilab area, particularly educators from rural schools. Work began on the program early last fall when Marjorie G. Bardeen, Friends of Fermilab Program Director, and the Institute staff prepared the program announcement, reviewed the curriculum, and began selecting instructors. The staff looked for instructors who, in addition to being experts in their field, had the ability to present material on current research to an audience of fellow teachers. According to Lee Marek, SISMT Chemistry Coordinator, the staff sought out teachers with a love for the subject to be taught.

The 1988 staff included Institute Director William E. West, Science and Technology Chair at Naperville Central High School, Naperville, Illinois; Biology Coordinator George S. Zahrobsky, Science Department Chair at Glenbard West High School in Glen Ellyn, Illinois; Chemistry Coordinator Lee Marek, chemistry teacher at Naperville North High School; Mathematics Coordinators Terry Perciante, mathematics professor at Wheaton College, Wheaton, Illinois, and Lee Yunker, Mathematics Department Chair at West Chicago High School, West Chicago, Illinois; and Physics Coordinators Robert D. Grimm, physics teacher at William Fremd High School in Palatine, Illinois, and Scott Welty, physics teacher at Maine East High School in Park Ridge, Illinois.

The four-week program consisted of morning sessions at Fermilab and afternoon sessions at Naperville Central High School. The morning sessions included three parallel seminars in each of the four disciplines (physics, biology, mathematics, and chemistry), and two plenary-session lectures on current research and contemporary relations among science, technology, and society. Plenary session lecturers included Leon Lederman and Rocky Kolb of Fermilab. The afternoon sessions were devoted to laboratory and computer work. Participants were exposed to a variety of instructional materials and teaching strategies designed to stimulate student interest in science and mathematics. Participants presented a classroom activity to their colleagues and completed daily assignments normally requiring about two hours of homework. For their effort they received a stipend and could earn 4-1/2 semester hours of graduate credit from Aurora University, Aurora, Illinois. A follow-up session will be held in each discipline during the academic year, and a newsletter will keep participants and staff in touch with one another.

Each discipline had its own course objectives. In the physics section, Bob Grimm and Scott Welty arranged a series of seminars with Fermilab scientists and presented classroom materials based on modern physics topics. "We tried to show [the participants] how the Cockcroft-Walton, TEVATRON, and Collider Detector at Fermilab work in such a way that they could take this knowledge back to the classroom and adapt it to their teaching methods," said Grim and Welty. The chemistry curriculum was organized by Lee Marek according to a phenomenological approach to chemistry: practical demonstrations in classroom teaching and the use of computer materials as teaching aids. George Zahrobsky focused the biology curriculum on cell organization and behavior, evolution, taxonomy, and physiology-neurology/endocrinology. The mathematics curriculum included discrete mathematics, fractals (geometry), and the computer applications of geometry.

Leonard Freidhof, a 1988 SISMT participant and a teacher from Lanark, Illinois, a small town 90 miles west of Fermilab, teaches chemistry, physics, and human physiology in a high school with 250 students. Friedhof noted that he learned a great deal during his four weeks at Fermilab, and will return to his school with new ideas on using demonstrations to spark interest and excitement in the learning of chemistry. Friedhof plans to share his new knowledge with educators from at least nine other schools in his area.

Mary Lenich of Joliet Township High School, Joliet, Illinois, and Michael Timpanaro of Driscol High School in Addison, Illinois, were two biology participants. Lenich teaches all levels of biology, while Timpanaro teaches biology, physics, chemistry, physical science, anatomy and physiology, and astronomy. They will return to their respective schools with such information as new uses for computers, directions for making holograms for the high school science clubs they sponsor, and a firm grounding in new theories on primitive atmospheres and DNA.

The 1988 Summer Institute for Science and Mathematics Teachers was funded by the National Science Foundation, the Forest Fund, the Furnas Foundation, the Grainger Foundation, the U.S. Department of Energy, and Universities Research Association, Inc.

II.

In 1970, Fermilab's Summer Program for Minority Physics Students, administered by the Fermilab Equal Employment Opportunity Office (EEO), opened a new door of technical and scientific opportunities for minority college students. By 1988, it has evolved into a successful and well-respected program that attracts some of the country's brightest students.

Participating students are usually physics, engineering, or computer-science majors from a variety of small and large universities and colleges. A few of the institutions represented by this summer's students include Berea College, Central State University in Ohio, Dillard University, Pennsylvania State University, Prairie View A&M University, Purdue University, Stanford University, and the University of Puerto Rico.

Individually and as a group, the students have impressive credentials and lofty aspirations. For example, several have already conducted independent research. Others have lengthy lists of scholarships, activities, and service organizations. Most plan to pursue graduate degrees.

During the course of the program, students are exposed to high-tech, state-of-the-art equipment and new ideas through attendance at lectures and tours of Lab facilities. "I'm excited by the idea of actually working on something that has real-world applications," said David Johns, a manufacturing engineering major at Central State University. Carol Spann, a physics and math major at Berea College, felt that "The opportunity to be involved in something that could possibly save lives, such as the Loma Linda medical accelerator project, is an honor and a tremendous responsibility."

The students work in a variety of settings within Fermilab. Some, such as Kevin Fischbach, a mechanical engineering major and physics and math minor at the University of Puerto Rico, work in an office. Others, like Carol Spann, work in the heart of laboratories scattered around the Fermilab site. Almost all of them work with computers to analyze data and write programs.

Several students mentioned that they enjoyed both the working atmosphere of the Lab and the benefits of the program, which include a stipend for 10 weeks of work, round-trip transportation between home and Fermilab, and housing at the Illinois Science and Mathematics Academy. and use of government vehicles. And according to Dianne Engram, Manager of the EEO Office, participating physics majors are eligible for a graduate fellowship program through Universities Research Association, Inc.

Fermilab Director Leon Lederman selects a committee to oversee the program. Finley Markley (Technical Support Section) serves as committee chairman. Committee members include Dianne Engram, Carmenita Moore (Research Division), Jorge Morfin (Research Division), Dave Ritchie (Research Division), Elvira Rodriguez, (EEO), and Elliott Treadwell (Accelerator Division). Frank Cole (Loma Linda Project) and Herman White (Research Division) served as co-chairmen for many years. Jim Davenport, Chairperson and Professor of Physics, Virginia State University, has served as the Program Coordinator for 14 years.

Each fall, committee members visit colleges and universities throughout the country to interview students for the summer program. The committee is highly selective; only 20 students can participate each summer. The applicants must meet high academic standards: They need to have at least a B grade-point average. Each student must also fill out an application form, submit college transcripts, and forward three recommendations.

The EEO office handles the administrative details of the program, including travel, payroll, housing, and planning social events. "We try to make sure that their experience at Fermilab is as enjoyable as possible," Engram said. She explained that during the application process, the committee reviews staff proposals for student research assignments. Based upon the staff proposals and student applications, committee members match qualified students with appropriate assignments. The students then receive a letter offering them a summer appointment at Fermilab.

Throughout the summer, Program Coordinator Davenport monitors the students and their progress. He said that he plays several roles, ranging from mentor to coordinator, and his goal is to ensure that the experience at Fermilab is "intellectually challenging and academically beneficial." As mentor, he advises students on writing and presenting scientific papers, serves as a link between Lab staff and visiting students, and helps the students to work through physics problems as they arise. As coordinator, he works with the Laboratory to ensure the program's continued success.

Because of the minority student program at Fermilab, the students believed that they are better prepared to face graduate school and the work world. Furthermore, the students felt that the program's most valuable quality is "real-world" engineering and research experience, both applied and theoretical: "I would strongly encourage other students to apply to the program," said Johns.

- Kevin A. Brown

III.

Roberto Vega is the first Ph.D. recipient to emerge from Fermilab's Summer Program for Minority Physics Students. As a participant in the program, he also received a Graduate Fellowship from Universities Research Association, Inc., that financed a portion of his graduate education. The Lab recently awarded Vega, who received his degree in particle physics from the University of Texas at Austin, a plaque in recognition of his achievement.

Roberto's road to success, although long and difficult, was also challenging and exciting. He recalled that "In Brooklyn, where I grew up, it was survival of the fittest. If you studied, you were a sissy - you weren't supposed to do your homework, you weren't supposed to study. And even though I got through high school, most of my teachers didn't think I would amount to much."

For three consecutive summers, Roberto participated in the program at Fermilab. "In 1983, the first summer I was in the program, I worked on a variety of projects. For about three days, I did what they called cutting cables. I thought that it was about the crummiest job you could do. At the time, I was a little upset that I had to do it, but I later realized that somebody had to do it and I wasn't really trained to do anything else." In 1984, Roberto worked with Rocky Kolb, Co-Head of the Fermilab Astrophysics Group, on theoretical research about monopoles and very massive particles produced early in the Universe. In 1985, after beginning his doctoral program, he primarily worked on high-energy neutrino interactions with Chris Quigg, then Head of the Fermilab Theoretical Physics Department.

"As a part of the program, I felt that there were people who believed I could achieve my goals," he said. "It really helped to have people who believed in me." One person in particular, Frank Cole, who, for many years, served as co-chairman of the summer-student program committee, inspired Roberto to succeed. "I looked up to him as a well-known accelerator physicist - he impressed me; he talked to me; he was interested in me and that I did well. And every time I had a problem and called him up, he would always help me." For Roberto, Frank Cole's support was tremendously important because "I thought about changing from physics to something less frustrating, but Frank always encouraged me to stick it out."

While he was at Fermilab to receive his award, Roberto wanted to make time in his busy schedule to meet with students in this summer's program. "I wanted to talk to the current students because I was in their place three years ago. I know that a lot of them have an attitude of 'I'm not going to stay in physics because, number one, it's too hard, and number two, it's not financially rewarding on a large scale.' But I wanted to get them to see that there are other, very personal compensations in the field. Physics can be very exciting and money will never buy that."

For his masters degree at Georgia Tech, Roberto worked on integrated optics, not particle physics. "What happened was that I really got into particle physics by accident. I didn't even know particle physics was a field until a friend of mine, who was planning to pursue a Ph.D. at the University of Texas at Austin, started talking to me about all of these different particles and quarks and some of these other weird names used in particle physics. I was amazed that there was a whole field that I didn't know anything about." Roberto found this very interesting and decided to continue his education at the University of Texas.

Financially, Roberto was reasonably secure at Georgia Tech because they paid him a stipend and covered his tuition and fees. "But when I applied to the University of Texas, there were so many applicants, and the competition was so very, very intense, that they said I could attend, but without a fellowship."

Discouraged, but determined to achieve his goal, he took out a $5000 loan and went to Texas. "At that time I was married and had one son, so I really took a big risk. But after a semester, I received the fellowship from Fermilab, and the university awarded me a graduate fellowship because I did well during my first semester." Looking back, "I was a little crazy in taking off for Texas, but I think one of the major reasons it worked out is because of the support I received from Fermilab."

Based upon his experiences so far in the field, Roberto offered his views on physics and physicists: "Physics can get pretty complicated, but usually it's because physicists complicate it. For example, you can say a lot of things in physics more simply without using math. Furthermore, physicists used to be a small, close-knit group that rarely communicated with people outside their community." However, he believes that "the physics community is changing; they want to let people know what's going on."

Roberto's future should be bright. With guarded optimism, he felt that "My ideal future would be a job at some kind of university that has a graduate program where I could teach and do research. I don't know if that will happen, but I hope it does." - *Kevin A. Brown*

IV.

"Personally, I believe that I would never have had a chance to experience this type of professional growth without the Illinois Research Corridor Summer Jobs Program,"

said Donald Whelpley, a teacher at Downers Grove South High School, Downers Grove, Illinois. Initiated in 1983 by physicists at Fermilab, this innovative professional development program provides summer employment for a select group of high school teachers at Fermilab and other local high-tech companies.

According to Gail A. Digate, Executive Director, Corridor Partnership for Excellence in Education, over 55 candidates from 38 junior and senior high schools throughout northern Illinois, Chicago, and southern Wisconsin applied to the program. "Excellence in classroom teaching, professional involvement in science and mathematics, and superior academic credentials are the major factors used in the selection process," Digate said. Thirty-two of the 55 applicants were offered summer positions, 19 of them at Fermilab.

Other companies participating in the 1988 program included Amoco Research Center, Argonne National Laboratory, AT&T Bell Laboratories, AT&T Network Software Center, Geo. J. Ball, Inc., the Morton Arboretum, and Nalco Chemical Company. "Involvement in this program illustrates the company's commitment to the importance of pre-college education in a very real way," said Digate. Funding to support the program comes entirely from the participating companies.

"Now in its sixth year of operation, the Summer Jobs Program affords an important mechanism by which skills and ideas that are critical in industry and research can be made available to junior and senior high school students by way of the employment experiences of their teachers," said Arlene Lennox, Head of the Fermilab Neutron Therapy Facility and on-site coordinator of the program. "It also gives dedicated and competent teachers the opportunity to work side by side with professionals in their field using state-of-the-art techniques and equipment."

Participants at Fermilab this summer, their supervisors, and their projects, included:

Bruce Basak (Glenbard West High School) assisted Finley Markley (Technical Support) on warm superconductors and electrical properties of curing expoxy resins. . . William Burt (Glenbard East High School) worked with Ruth Pordes (Data Acquisition Group) on computer programming. . . Frank Burynski

(West Chicago High School) helped Bruce Brown (Magnet Test and Development Facility) analyze magnet measurement data. . . Dane Camp (Downers Grove South High School) worked with David Eartly on continuing development of a cable data base for the D0 Experiment detector. . . Raymond Dagenais (Waubonsie Valley High School) worked with Sam Baker and Bill Freeman (Safety Section) on radiation-related projects. . . George Eblin (Downers Grove North High School) and Jim Hanlon (Physics Section) worked on implementation of a CAMAC-based control system for film-measuring machines. . . Hans Gouger (Parker High School, Janesville, Wisconsin) worked with Forrest Davenport (Physics Section) to develop software to support the E-687 trigger electronics. . . Joel Klammer (Valley Lutheran High School in St. Charles) assisted Ray Hanft (Magnet Test and Development Facility) on a computer interface to a superconducting-cable measuring machine. . . Paul Madsen (Hinsdale South High School) worked with Win Baker (Research Division) on data analysis for E-706 and shiftwork on E-710. . . Charles Osborne (West Chicago Junior High School) assisted Karen Kephart (Physics Section) on the construction of the D0 Experiment detector. . . Saulius Ploplys (Buffalo Grove High School) and David Harding (Pbar Source Department) worked on analysis of data from the Pbar beam-position monitor system. . . Yvonne Richter (Benet Academy in Lisle) worked with Judith Nicholls (Computing Department) on program conversion and improvement in the Users Support Group. . . Michael Salisbury (Plainfield High School) helped Mary Jane Nichols install and develop a software package for inventory control in the Information Systems Department. . . Kent Luetke-Stahlman (Sycamore High School) worked with Jeff Petter (Pbar Source Department) to develop PASCAL programs to run on an IBM PC/AT interfaced to a Hewlett-Packard network analyzer. . . Rosemary Sterr (Benet Academy) performed data analysis of stochastic noise from the axion search experiment rf cavity with Frank Nezrick (Experimental Support Department) . . Thomas Todd (Wheaton Central High School) lent a hand to Curt Owen (Loma Linda Project) on quality-control measurements for magnets in the Loma Linda proton medical accelerator project. . . Donald Whelpley (Downers Grove South High School) worked with Larry Ketcham (Experimental Areas Support Department) on computer programming for the Alignment Group. . . Michael Wilson (Naperville North High School) helped Cary Dowat (Data Communications) develop a system for monitoring the use of the networks at Fermilab. . . Randall Zamin (Downers Grove South High School) developed training materials and study guides for accelerator operators with Bob Mau (Accelerator Division).

Fermilab in Retrospect - 20 Years and Counting

[As activity increased in 1968 at the new National Accelerator Laboratory, so did the volume of information in the *Monthly Report of Activities*. What follows is selected out for interest, not completeness. - ed.]

MONTHLY REPORT OF ACTIVITIES

F. T. Cole

July 1, 1968

General

1. Status of Appropriation. The House Appropriations Committee reported to the House of Representatives a bill containing an FY 69 construction appropriation of $7.1 million for NAL, with a restriction to architect-engineering work only. In addition, the bill contains $4.15 million in operating money. This bill was passed by the House on June 19 and sent to the Senate. Our hope is that the Senate will restore funds so as to allow us to begin construction. This will require a Senate bill different from that of the House and a favorable result in the ensuing conference.

4. Storage-Ring Study. A summer study on storage rings for NAL will be held at Oak Brook and the Campus, with L. C. Teng in charge. The main responsibility will be carried by NAL staff, with help from visitors. The study will continue through the summer, with a period of concentration August 19 to August 30.

5. Internal-Target Area. A tentative decision has been made to replace the previously planned internal-target experimental area by equivalent facilities in the external proton beam. These facilities are believed to provide a greater physics potential in an external beam.

6. Aspen Summer Study. A summer study on research facilities and experimental facilities is being held in Aspen, Colorado. About 75 physicists from many laboratories and universities are participating. These physicists are considering, among other topics, the use of a very large bubble chamber at NAL and the replacement of the internal-target area by equivalent external-target facilities discussed in the preceding paragraph.

7. Laboratory Staff. On July 1, the Laboratory had 200 employees, including 54 scientists and engineers. It is of interest that this meets exactly the goal we set a year ago, at a time when there were only 10 NAL employees.

Main Ring

1. Magnet Power Supply. A detailed study has been made of the effect of the pulsed magnet load on the public-utility grid, with the assistance of Professor Van Ness of Northwestern University. The power company was willing to specify the maximum tolerable voltage fluctuation. At the same time, the various electrical equipment manufacturers were asked to give estimated costs for the equipment for the motor-flywheel energy-storage scheme. The estimated costs of the two systems are approximately equal, the cost of the energy-storage system being about equal to the cost of the 345-kV substation required for direct pulsing. No evidence was developed to indicate that the direct pulsing would cause any trouble with the utility system. On the basis that the simplest system is the best, a decision was made to design the electrical-power system with provision for the pulsed magnet load (no local energy-storage system).

national accelerator laboratory

MONTHLY REPORT OF ACTIVITIES

F. T. Cole

August 1, 1968

General

1. Status of Appropriation. The Senate passed on July 20, 1968, a bill containing a $20 million appropriation for NAL with authorization for construction. The subsequent House-Senate Conference Committee reported on a public-works bill containing a $12.074 million appropriation for NAL, with limited construction authorized. This bill was passed by the House on July 25 and by the Senate on July 30 and has been sent to the President.

The relevant portion of the bill is as follows:

> "AMENDMENT NO. 18. Appropriate $461,574,000 instead of $456,600,000 as proposed by the House and $469,500,000 as proposed by the Senate. The increase in the House bill amount is for the 200 BeV accelerator to be located in DuPage and Kane Counties, Illinois. The Bill provides a total for the project of $14,574,00 including available carry-over funds of $2,500,000. The amount provided is to be allocated as follows: Engineering and design, $8,674,000;

Land improvements, $700,000. Other structures (transfer hall, booster housing, linac housing), $5,000,000; and for temporary utilities related to the other structures, $200,000. The funds made available shall not be allocated to any other phase or components of the project plan, but flexibility is granted in the allotment of the carry-over of the $2.5 million to the items specified above."

The carry-over referred to is the $2.5 million appropriated as part of the FY 68 appropriation of $7.333 million, but not released until now.

Excluded from the authorization are procurement of the copper-clad steel material for the linac tanks, procurement of transformers and switch gear for the site electrical system, procurement of chillers, boilers and water-treatment and cooling equipment, and contingency funds.

That the Transfer Hall rather than the Cross Gallery is authorized appears to be an accident in grouping the structures in the historical format of the Schedule 44 of October 15, 1967. We are requesting a clarification to allow us to construct the Cross Gallery rather than the Transfer Hall (they are equal in cost), because the Cross Gallery provides entrance to the Booster Housing.

In spite of this severe cutback in funds, the Director of the Laboratory continues to hold to the scheduled beam date of June 30, 1972.

4. Laboratory Staff. On August 1, the Laboratory had 222 employees, including 62 scientists and engineers.

Main Ring

1. Magnet Models. The 3-foot bolted magnet model (B2 configuration) has been assembled, powered, and preliminary magnetic measurements have been made on it. A photograph is attached. These tests are all with dc because the power supply has not yet been made to operate properly as a pulsed supply. The water cooling is a temporary arrangement that allows only intermittent operation, although the evaporative cooler has been delivered and the contract let for its connection. The B vs. I curve is as expected, showing a 3 to 4% saturation at 18 kG and about 15% at 22 kG. The remanent field is as predicted from the coercive force measured for the iron (there are two different kinds of iron in the model), and the sextupole in the remanent field scales as expected with the field. The field uniformity across the aperture is virtually independent of the field value up to 18 kG. There is some lack of symmetry about the centerline, due, we believe, to imprecision in the placement of the conductors in the coils.

A 20-foot half core has been constructed to check fabrication and welding techniques. It exhibits excessive waviness due to the stresses induced by the intermittent welding technique used to attach the side straps to the laminations. We are considering two solutions:

(a) Continuous welds done simultaneously by a four-head automatic welding machine. Although this could also introduce distortion, such distortions will be of a long-wavelength character so that they can be eliminated by the support given by the box beam.

(b) Notching of the sides of the laminations so that the side straps are set in. The side straps must have their edges machined, and fit well, but then become a part of the magnetic circuit. Spot welds at intervals of 1 to 2 feet prevent the straps from bowing away from the laminations. A notching die has been delivered. An advantage of this scheme is that the overall width of the magnet structure can be reduced significantly. A 20-foot box beam is under construction; the fabricated I-beams have been delivered to the machine shop.

2. Plans for the Coming Month. Negotiations with the computer manufacturers have been completed for the model-magnet testing data-recording system. The order will go out very soon.

The bids for the quadrupole-lamination die have been received with prices within the budget and the order will go out within a week. The coil bids are due shortly.

Lab Notes

Symposium on Future Polarization Physics at Fermilab...

Frequently dismissed by theorists as an inessential complication, spin dependence observed in a variety of hadronic processes has proven to be the rocky shoal of many models. Such may again be the case as spin measurements are extended to higher energies and larger momentum transfer where perturbative QCD is believed to be the beacon.

At the symposium on "Future Polarization Physics at Fermilab," held June 13-14, 1988, about 100 experimenters and theorists met to exchange views on the pursuit of spin dependence with high-energy polarized beams of protons, antiprotons, hyperons, and muons. The symposium coincided with the announcement of the first results from the newly commissioned polarized proton and antiproton beamlines at the TEVATRON. Many vigorous discussions and lively informal conversations occurred among the participants.

Experimental results presented at the symposium included the remarkable new data from the EMC muon-scattering program at CERN; these suggest that the proton spin is not a simple reflection of the spin of the leading quark. The initial operation and future plans for the polarized proton and antiproton beams at Fermilab were discussed, along with a summary of results obtained with the accelerated polarized proton beam at Brookhaven National Laboratory and the new measurement of polarization in Ω^- production at Fermilab. Several talks were devoted to technical developments; these included the possibility for accelerating polarized protons in the TEVATRON, the utilization of a large polarized target in the polarized muon beam, the possibility of obtaining polarized protons from the decay of Σ^+'s, and some intriguing possibilities with polarized electron beams and polarized ^{3}He targets. A report was given on plans for a unique test of the Siberian snake principle for overcoming the depolarizing "resonances" in synchrotrons in an elegant manner.

Theoretical topics included new information on the spin distributions of quark, antiquark, and gluon constituents, spin-dependent structure functions in QCD, production dynamics, large p_T effects, heavy flavor physics and polarization experiments, the origin of hyperon polarization, polarization effects in elastic scattering, and parity violation using a longitudinally polarized beam. Discussions which followed many of the talks provided further stimulation to the design of new experimental tests.

*("**Lab Notes**" continued)*

J. D. Bjorken concluded the symposium by stressing the need for further study of the x and Q^2 dependences of the spin-dependent quark and antiquark densities of the proton and neutron, and of the transfer of polarization to gluons. He summarized important measurements using polarized beams to be carried out in leptoproduction, hard collisions at large $p_{\perp}$, direct-photon production, and elastic scattering, both at high-energy and large-momentum transfer. He emphasized that tests of the Bjorken sum rule are tantamount to direct tests of QCD. Study of spin transfer to gluons appears to require double-asymmetry hard-scattering processes which are well understood in terms of perturbative QCD. At least this implies a high-intensity source of the highest energy possible. Such developments would require broad interest and strong physics justification. Finally, Bjorken commissioned spin-physics enthusiasts to continue to search for innovative ways to use this unique probe of matter. It is clear that "oriented" particles will continue to be fascinating even at the highest energies.

- A. Yokosawa

Kapchinskii, Sessler, and Teplyakov Honored by US Particle Accelerator School...

The US Particle Accelerator School has honored Andrew M. Sessler of the United States and, jointly, Ilja M. Kapchinskii and Vladimir A. Teplyakov of the Union of Soviet Socialist Republics for their contributions to the development of accelerator physics and technology. Sessler is now Senior Scientist and was formerly Director of the Lawrence Berkeley Laboratory. Kapchinskii is Professor of Physics at the Institute for Theoretical and Experimental Physics in Moscow; Teplyakov is a Scientist and Deputy Director of the Institute for High Energy Physics at Serpukhov.

Sessler was cited for his contributions to the understanding of particle-beam instabilities. Kapchinskii and Teplyakov were cited jointly for their invention of the radio frequency quadrupole. Each of the two prizes is $2000. The 1988 awards were presented at a ceremony held on the evening of Wednesday, July 13, 1988, at Snowmass, Colorado, during the "Summer Study on High Energy Physics in the 1990's," organized by the Division of Particles and Fields of the American Physical Society. The Accelerator School gives two prizes each year. Winners are chosen on a competitive basis. The 1988 Prize Committee members were Roy Billinge, James E. Leiss, Claudio Pellegrini, and John Rees.

The School attracts scientists and students in physics, engineering, and related disciplines from all over the world, who gather for two to four weeks each year. Basic and advanced courses on the theory and operation of particle accelerators are offered to those who attend. The School serves an increasing need for more and higher education for those who conceive, design, operate, and use particle accelerators. This need for the School has arisen because Accelerator Science itself has grown into an interdisciplinary branch of physics integrating advances in electronics, cryogenics, and other technologies to produce increasingly varied and specialized instruments in the service of science and society.

Since its inception in 1981, the Particle Accelerator School's annual program has been sponsored by the U.S. Department of Energy, the National Science Foundation, and major U.S. high-energy physics laboratories, including Fermilab. This year's awards were supported by the Universities Research Association, Inc., the Continuous Electron Beam Accelerator Facility, the Houston Area Research Center, Intermagnetics General Corporation, Varian Associates-Vacuum Products Division, and Westinghouse.

Manuscripts and Notes

prepared or presented from July 16, 1988, to September 9, 1988. Copies of Fermilab TM's, FN's, and preprints (exclusive of Theoretical Physics and Theoretical Astrophysics preprints) can be obtained from the Fermilab Publications Office, WH 3E, or by sending your request to (DECnet) FNAL::TECHPUBS or (BITnet) TECHPUBS@FNAL. For Theoretical Physics or Theoretical Astrophysics preprints, contact those departments directly.

Experimental Physics Results

Experiment #531

S. G. Frederiksen, "The Production Mechanism and Lifetimes of Charmed Particles," (Ph.D. Thesis, July 1987, University of Ottawa, Ottawa, Ontario, Canada)

Experiment #691

J. C. Anjos et al., "Measurement of $D_s^{\pm}$ and $D^{\pm}$ Decays to Non-Strange States," (FERMILAB-Pub-88/90-E; submitted to Phys. Rev. Lett.)

Experiment #778

N. Merminga et al., "An Experimental Study of the SSC Magnet Aperture Criterion," (FERMILAB-Conf-88/94-E [SSC-182]; presented at the European Particle Accelerator Conference, Rome, Italy, June 7-11, 1988)

General Particle Physics

R. W. Fast et al., "Conceptual Design of a Superconducting Solenoid for a Magnetic SSC Detector," (TM-1531 [SSC-N-526], presented at the 12th International Cryogenic Engineering Conference, Southampton, England, July 12-15, 1988, and submitted for publication in the conference proceedings)

D. Green, "Particle Properties on an ABACUS," (FN-492)

H. E. Montgomery, "Electron and Muon Physics Sessions: Summary," (FERMILAB-Conf-88/81; summary talk given at the Conference on the Intersections of Nuclear and Particle Physics, Samoset, Maine, May 1988)

L. Roberts, "Monte Carlo Simulation of Silicon Vertex Detector for Bottom Collider Detector - Part I," (FN-488)

Accelerator Physics

Y.-C. Chao and K.-Y. Ng, "Analytical and Numerical Evaluation of Landau Cavities in the Fermilab Booster," (FERMILAB-Conf-88/101; presented at the European Particle Accelerator Conference, Rome, Italy, June 7-11, 1988)

Y. Chao et al., "Improving the Fermilab Booster Emittance," (FERMILAB-Conf-88/102; presented at the European Particle Accelerator Conference, Rome, Italy, June 7-11, 1988)

J. D. Cossairt et al., "Measurements of Neutrons in Enclosures and Outside of Shielding at the TEVATRON," (FERMILAB-Conf-88/106; to be presented at the 22nd Midyear Topical Meeting of the Health Physics Society, San Antonio, Texas, December 4-8, 1988, and published in the proceedings of same)

G. Jackson et al., "Luminosity Lifetime in the TEVATRON," (FERMILAB-Conf-88/80; presented at the European Particle Accelerator Conference, Rome, Italy, June 7-11, 1988)

G. R. Lambertson and K.-Y. Ng, "Beam Impedances of Position Monitors, Bellows, and Abort Kicker," (FN-487 [SSC-N-517]; submitted to the Proceedings of the Workshop on RHIC Performance, Brookhaven National Laboratory, Upton, Long Island, New York, March 21-26, 1988)

P. M. Mantsch, "Prospects for 6 to 10 Tesla Magnets for a TEVATRON Upgrade," (TM-1533; prepared for the DPF Summer Study: Snowmass '88, High Energy Physics in the 1990s, Snowmass, Colorado, June 27-July 15, 1988)

P. S. Martin and D. W. Wildman, "Bunch Coalescing and Bunch Rotation in the Fermilab Main Ring: Operational Experience and Comparison with Simulations," (FERMILAB-Conf-88/87; presented at the European Particle Accelerator Conference, Rome, Italy, June 7-11, 1988)

J. Strait et al., "Tests of Full Scale SSC R&D Dipole Magnets," (TM-1545[SSC-N-538], presented at the 1988 Applied Superconductivity Conference, San Francisco, California, August 21-25, 1988)

L. C. Teng, "Spin Dynamics in Accelerators and Storage Rings," (FN-489; plenary paper given at the 3rd Conference on the Intersections between Particle and Nuclear Physics, Rockport, Maine, May 14-19, 1988)

A. Van Ginneken, "Estimated Radiation Levels in SSC Detectors," (FN-490; to appear in *Report of the Task Force on Radiation Effects at the SSC*, M. G. D. Gilchriese, ed., SSC-SR-1035 [1988])

Theoretical Physics

C. H. Albright and M. Lindner, "Nonlinear Evolution of the 3-Family Fritzsch Mass Matrices," (FERMILAB-Pub-88/82-T; submitted to Phys. Lett. B)

J. E. Kim and K. Lee, "The Scale Problem in Wormhole Physics," (FERMILAB-Pub-88/95-T; submitted to Phys. Rev.)

M. Mangano and S. Parke, "Approximate Four Jet Cross Sections," (FERMILAB-Conf-88/109-T; invited talk presented by Stephen Parke at the 7th Topical Workshop on Proton-Antiproton Collider Physics, Batavia, Illinois, June 20-24, 1988)

M. Mangano and S. Parke, "Approximate Multi-Jet Cross-Sections in QCD," (FERMILAB-Pub-88/92-T; submitted to Phys. Lett. B)

M. Mangano and M. Porrati, "Properties of Supersymmetry Breaking via Gravitino Condensation," (FERMILAB-Pub-88/75-T; submitted to Phys. Rev. Lett.)

V. Višnjić, "Fermion Generations from the Strongly Coupled Higgs Sector [A Variation on a Theme of Veltman]," (FERMILAB-Pub-88/103-T; submitted to Phys. Lett.)

Theoretical Astrophysics

C. Alcock and A. Olinto, "Exotic Phases of Hadronic Matter and Their Astrophysical Application," (FERMILAB-Pub-88/58-A; to appear in Ann. Rev. Nucl. and Part. Phys.)

E. Copeland et al., "Non-topological Cosmic Strings," (FERMILAB-Pub-88/63-A; submitted to Phys. Rev. D)

M. Gleiser, "Stability of Boson Stars," (FERMILAB-Pub-88/67-A; submitted to Phys. Rev. D)

P. Jetzer, "Dynamical Instability of Bosonic Stellar Configurations," (FERMILAB-Pub-88/66-A; submitted to Phys. Rev.)

K. Maeda et al., "Inflation in a Renormalizable Cosmological Model and the Cosmic No Hair Conjecture," (FERMILAB-Pub-88/70-A; submitted to Phys. Rev. D)

L. M. Widrow, "Zero Modes and Anomalies in Superconducting Strings," (FERMILAB-Pub-88/61-A; submitted to Phys. Rev. D)

Computing

T. Nash et al., "High Performance Parallel Computers for Science: New Developments at the Fermilab Advanced Computer Program," (FERMILAB-Conf-88/97; talk given by Thomas Nash at the Workshop on Computational Atomic and Nuclear Physics at One Gigaflop, Oak Ridge, Tennessee, April 14-16, 1988)

Colloquia, Lectures, and Seminars

by Fermilab staff, at Fermilab, July-August 1988, unless otherwise noted.

July 6

S. Pordes: "Introduction to Particle Detectors"

July 7

L. Chapman: "Artificial Intelligence Applications - A Report on the IEA/AIE Conference"

C. Briegel and K. Cahill: "The New Fermilab FIRUS System"

July 12

M. Afdal: "Compatibilities and Incompatibilities of HBOOK3/HBOOK4 with HBOOK4/HPLOT5: Some Case Studies"

L. M. Lederman: "The SSC and Its Importance to Future Science," CENTEL Cable Television - "Accent on Issues," Wheaton, Illinois

July 13

J. Cooper: "Description and Status of the CDF"

July 14

G. Bock: "Kaon Physics in the 1990s," summary talk, Kaon Physics Working Group, DPF Summer Study: Snowmass '88, High Energy Physics in the 1990s, June 27-July 15, 1988, Snowmass, Colorado.

July 19

E. Treadwell: "Monte Carlo and Detector Simulation Techniques in High-Energy Physics"

July 21

D. Harding: "Automated Beam Injection Tuning in the $\bar{p}$ Source"

July 25

H. Harari: "Heavy Flavors - 88"

July 26

S. Holmes: "Summary of the Snowmass Hadron Collider Working Group"

July 27

J. Bjorken: "The Fifth Force"

H. Harari: "Heavy Flavors - 88"

July 28

C. N. Brown: "Twenty Years of Drell-Yan Dileptons," 16th SLAC Summer Institute, Stanford Linear Accelerator Center, Stanford, California.

J. Cooper and J. Elias: "Background Measurements at CDF"

D. Trbojevic: "Vacuum Measurements at B0 in the TEVATRON"

July 29

H. Harari: "Heavy Flavors - 88"

August 2

G. Dugan, J. Marriner, D. Finley, and P. Martin: "TEVATRON Collider Performance, Present and Anticipated"

August 3

N. Turok: "The Big Bang and the Universe on Very Large Scales - A New Testing Ground for High-Energy Physics"

August 9

L. M. Lederman: (Banquet address), XXIVth International Conference on High-Energy Physics, Max Planck Institute, Munich, Germany

August 11

L. Michelotti: "Beam-Beam Interaction in the Upgrade"

August 14

L. M. Lederman: "The TEVATRON," Ettore Majorama Center for Scientific Culture, Erice, Italy

August 15

M. Jenkins: "Hadronic Production of Charmonium at 300 GeV/c," 1988 Divisional Meeting of the Division of Particles and Fields of the American Physical Society, Storrs, Connecticut

P. Kasper: "A First Look at E-687," 1988 Divisional Meeting of the Division of Particles and Fields of the American Physical Society, Storrs, Connecticut

J. P. Negret: "Elementary Particle Physics/Relativistic Kinematics," II International Course on Elementary Particle Physics, CIF, Bogota, Columbia

M. Purohit: "Status of Hadro- and Photo-Production of Charm and Comparisons with QCD Predictions," 1988 Divisional Meeting of the Division of Particles and Fields of the American Physical Society, Storrs, Connecticut

August 16

D. Ritchie: "Breaking Up is Hard to Do: Restructuring the FNAL Vax Cluster USR$ROOT File Base"

S. Wolbers: "Deep Inelastic Muon Scattering at 500 GeV/c and 100 GeV/c," 1988 Divisional Meeting of the Division of Particles and Fields of the American Physical Society, Storrs, Connecticut

C. Johnstone: "A-Dependence of Leading Particle Production by 800-GeV/c Protons," 1988 Divisional Meeting of the Division of Particles and Fields of the American Physical Society, Storrs, Connecticut

D. Stewart: "Production of High P_t Jets in Proton-Nucleus Collisions," 1988 Divisional Meeting of the Division of Particles and Fields of the American Physical Society, Storrs, Connecticut

August 17

R. Rubinstein: "Pbar p Elastic Scattering and Total Cross Section," 1988 Divisional Meeting of the Division of Particles and Fields of the American Physical Society, Storrs, Connecticut

S. Delchamps: "300-GeV/c Pion and Proton Induced Interactions Containing High-P_t Photons," 1988 Divisional Meeting of the Division of Particles and Fields of the American Physical Society, Storrs, Connecticut

August 23

P. Mantsch: "High-Field Magnets for the TEVATRON Upgrade"

J. P. Negret: "Proton Decay and Cosmic Neutrino Experiments Underground," II International Course on Elementary Particle Physics, CIF, Bogota, Columbia

August 25

J. Marriner: "How Many Antiprotons Can the Accumulator Hold?"

P. Martin: "Main Ring Losses during Collider Operation"

August 26

R. K. Ellis: "The Status of Perturbative QCD," Plenary Session, Munich

G. Bock: "CP Violation in $K^\circ \rightarrow 2\pi$ Decays - Status Report on E-731," Workshop on Rare Kaon Decays and CP Violation, Brookhaven National Laboratory, Upton, New York

August 30

T. Nicol, J. Theilacker and T. Peterson: "Magnet Cryostat Designs and Cryogenic Considerations for TEVATRON Upgrade"

Dates to Remember

September 14-16, 1988

Conference on New Directions in Neutrino Physics at Fermilab. Fermilab, Batavia, Illinois. For information, contact Phyllis Hale, Fermilab Users Office, (312) 840-3111 or (BITnet) NUDIR@FNAL.

September 19, 1988

Deadline for receipt of material to be considered at the October Physics Advisory Committee meeting (contact J. Coleman or T. Yamanouchi, ext. 3027).

September 21-24, 1988

Lattice Gauge Theory Workshop. Fermilab, Batavia, Illinois. For information, contact Phyllis Hale, Fermilab Users Office, (312) 840-3111 or (BITnet) LAT88 @ FNAL

October 20-21, 1988

Physics Advisory Committee meeting (Please note change from December meetings in recent years)

November 14-16, 1988

Workshop on Scintillating Fiber Detector Development for the SSC. Fermilab, Batavia, Illinois. For information, contact Phyllis Hale, Fermilab Users Office, (312) 840-3111, (Telex) 910-230-3233, or (BITnet) SCIFI8-8@FNAL