
ing, our ability to meet the schedule of completing all construction activities by the end of 1986 depends critically on pushing as hard as possible our current research and development programme designed to solve the technical problems. Thus we are faced with the dual task of advancing this effort rapidly while at the same time operating our facilities which support both our physics programme and that of many other institutions in the United States and abroad.

We hope to schedule the break-in into the SLAC structure and joining the SLC ring to that structure during our regular summer shutdown, similar to the procedure which we executed with PEP. Once this break-in and junction has been successfully accomplished, the technical interaction between the SLC and the ongoing SLAC activities will consist mainly of carrying out tests in the linear accelerator and making major revisions to its installations and control system. These improvements are necessary to have the SLC live up to its expectations, but will at the same time improve the performance of the 2-mile linac in its own right.

However, this is not all. In addition

to giving the green light on the SLC, the President's budget also provides funding for two other important new projects: a very substantial growth in synchrotron radiation facilities and an off-axis injector that will make it possible to generate low energy beams in linac End Station A for nuclear-structure physicists and others needing beams of energy no greater than 3 GeV. At the same time the off-axis injector will make it possible to inject into the SPEAR electron-positron ring without having to power the entire accelerator. As a result of this new scheme it might well be possible in the future to operate SPEAR (and therefore synchrotron radiation experiments) together with the low energy programme in End Station A during the summer months, when we are highly restricted in the use of electric power. This should greatly increase our scheduling flexibility, in particular once SLC becomes operational.

Stanford Synchrotron Radiation Laboratory is planning to expand its operations substantially over the next few years. SSRL and SLAC are each independent laboratories reporting to the Stanford University administration, with each determin-

ing its own programme under the general policies of the University of California, although an independent laboratory, depends on a reimbursable basis on SLAC for technical support in many areas. As SSRL expands questions are raised whether this type of relationship will continue to serve the needs. Accordingly, the Provost has just appointed a committee under the chairmanship of Sidney Drell, Deputy Director of SLAC, to make recommendations on the long-range future relationship between SSRL and SLAC.

All this means that SLAC staff will be involved in three major construction activities — the SLC, the off-axis injector, and whatever help we can give SSRL in connection with the SPEAR upgrading programme and support of synchrotron radiation work. Nonetheless, the ongoing particle physics programme will continue with highest priority. This commitment generates a major load on SLAC's technical and administrative staffs, and I hope that the confidence which the government has shown us in giving us the green light on all these ventures will be vindicated.

Fast work

One of the most impressive aspects of the initial evidence for W particles (see March issue, page 43) was how fast the evidence emerged from the mass of collected data. This was underlined by Leon Lederman in his conclusion at the recent Rome collider physics workshop.

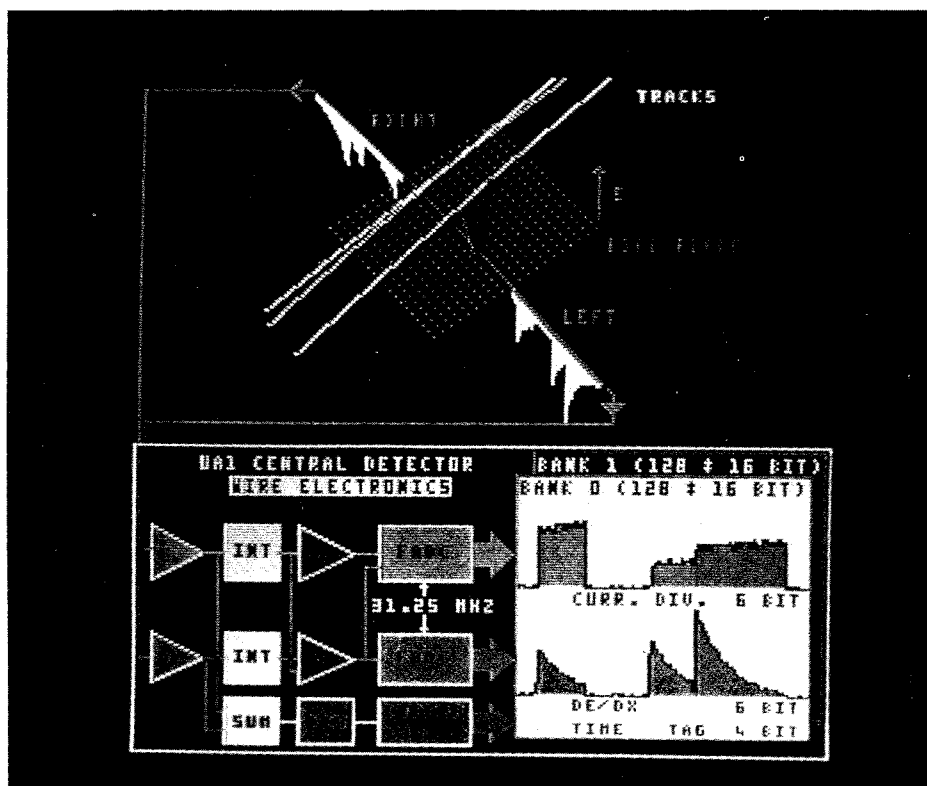
The 1982 period of proton-antiproton collisions in the CERN SPS ring finished on 6 December. In the

two month run, the big UA1 and UA2 experiments had each been exposed to some 10^9 collisions. By the time of the Rome collider workshop (12 January), the experimenters had been able to enjoy Christmas and to comb their recorded data for the handful of examples of lone high transverse momentum electrons 'balanced' by missing energy. These events are explained as the decays of charged

weak bosons into an electron and a neutrino.

These high energy proton-antiproton collisions are extremely complex, producing sprays of secondaries. However only a small fraction are of immediate physics interest, and judicious triggering greatly assists the subsequent data handling and timely extraction of physics results.

Schematic of the readout system for one of the 6 000 sense wires in the UA1 central detector. Output from the fast digitizing system is stored in a circular 128 16-bit word buffer.



The UA1 system

The detector of the UA1 experiment has almost full solid angle coverage, with a series of detectors providing particle tracking, electromagnetic and hadron calorimetry (energy deposition), muon identification and magnetic analysis.

The triggering system is activated by a pulse produced by the approaching proton and antiproton bunches. This pulse starts a time-of-flight measurement which ensures that the outgoing particles originate within the detector, rejecting background at the trigger level. In addition, two fast processors decide if the data is to be read out before the next colliding bunch arrives. One processor can be programmed to select events with specific patterns of energy deposition in the calorimeters. The other picks out muons originat-

ing from the interaction (rather than the decay of other particles).

A more precise muon selection is planned for future runs, using the FAMP microprocessor system. But this second level trigger may cover many bunch crossings. Also on-line filtering of the data is envisaged using the 168E microprocessor (see January/February 1980 issue, page 450), to reduce the amount of data which has to be written to tape.

Most of the event data comes from the central detector, consisting of a large array of drift chambers with image readout. The fast digitizing electronics samples the wire pulses (energy loss and track position) and drift times every 32 ns and over 4 μ s. For each event, this produces about 1.6 Mbytes of precise digital information, stored in a temporary buffer memory.

Initial data reduction is handled by a CAMAC crate including a special

readout processor incorporating complementary microprocessors to handle data formatting and control functions. The number-crunching microprocessor is extremely fast, while the other is user-friendly and well supplied with interfaces. Each of the 110 crates handles 60 wires.

In fact the data processing power of the readout processor system is more than an order of magnitude larger than a large conventional computer and is well able to reduce the incoming primary information to simple coordinates (drift time, wire number, track position, etc.) to about 100 000 bytes per event.

With such a large and complex detector, equipment monitoring is also extremely important. Thus another vital function of the readout processor is to watch for malfunctions and take appropriate action so that precious running time is not lost. A lot of emphasis is placed on parallel processing.

After compaction, the data is read out to 200 CAMAC crates in a mobile control room. Data collection uses the CERN 'Romulus/Remus' method, based on branch drivers and crate controllers, linking the crates in a tree-like structure, carrying the data stream to a single branch driver.

A router unit can switch the data between two separate vertical highways, permitting additional data acquisition and monitoring subsystems. SUPERCARIAR microcomputers (see May 1980 issue, page 112) run monitoring and display programs.

At this level, parallel data acquisition takes about 5 ms. Data reduction takes about 15 ms. Full electronics dead time is from 20 to 30 ms, permitting a maximum of 30 events per second to be accepted at this stage.

After this parallel readout, the data

The UA2 detector, designed to study the properties of the hadronic jets and the leptonic decays of weak bosons produced in the high energy proton-antiproton collisions in the CERN SPS ring.

(Photo CERN 293.3.82)

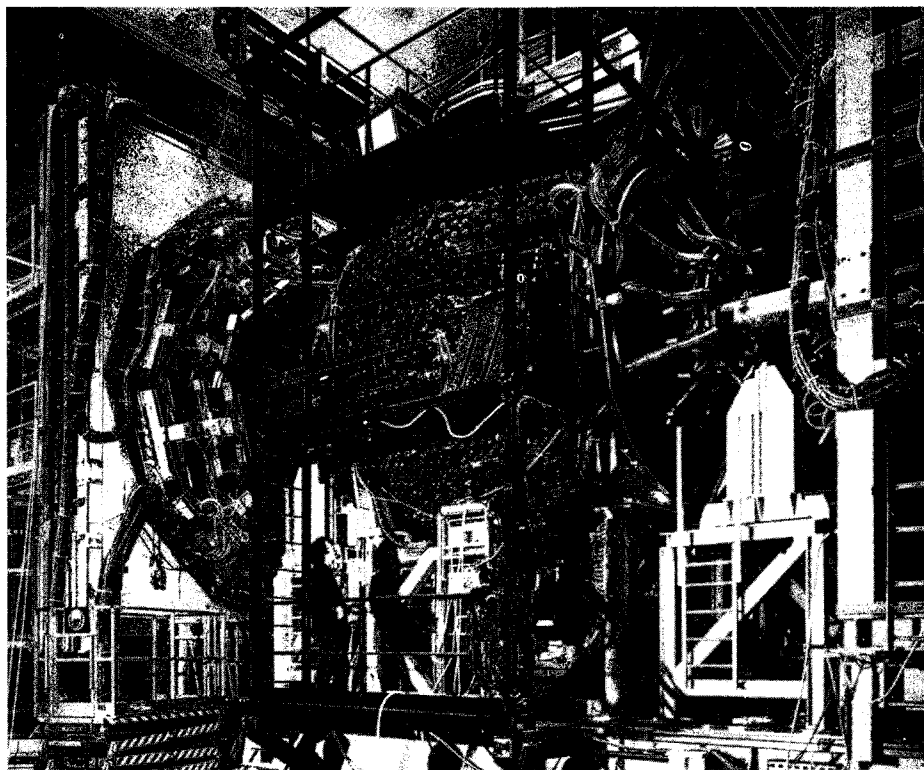
is merged into five branches and passed to the main control room, one hundred metres downline. Before passing into the data acquisition computer, a system of routers with buffer memory allows data to be passed to different systems.

UA1 on-line computing is based on two pairs of Norsk Data 100/500 16 and 32 bit machines. In addition, two Hewlett Packard minicomputers provide special functions and SUPERCAVIAR micros look after equipment control and monitoring. There is a link to the main CERN computer centre. Off-line, a VAX 11 drives a Mekatek interactive graphic display, running the specially developed MERLIN system.

The Nord 100 runs a multiuser, multitasking virtual memory operating system, and a CERN-developed package (DAS) controls all aspects of data taking, reading the CAMAC and writing the data to tape. The powerful 32-bit Nord 500 uses the Nord 100 as a front end, and carries out full event analysis of sample events and accumulation of experimental statistics, as well as providing on-line event displays, such as the one on the cover of our January/February issue.

At current trigger rates of about one event every two seconds, there is no problem with tape writing. This would become a bottleneck if several events per second were being recorded. Further real time data reduction will be possible using the CERN-built 168E microprocessors in the extended trigger system.

In the 1982 run, some 10^9 proton-antiproton collisions resulted in data from some 10^6 events being recorded on tape. Three types of trigger — hadron jets, electrons and muons, all at high transverse momentum — were run in parallel, with less than 10 per cent dead time. The data filled 1000 magnetic tapes.



While the experiment was running, special tapes were written periodically to extract the mass of calibration constants for the different parts of the detector. These constants were used in the subsequent analysis of the raw data. The electron trigger and selected jet trigger data were analysed while the experiment was running with typically a few days delay. The remaining muon and jet trigger data are being worked on at CERN, Rutherford and Saclay, starting again from the stockpile of 1000 raw data tapes.

In the off-line analysis of the electron triggers, UA1 data was first subjected to a filter program to tighten up the trigger criteria and reconstruct with precision what happened in the calorimeters. Using the reduced data sample, other programs handled the reconstruction of events in the central detector and applied further filtering and checks.

Finally, from a sample of a few hundred events examined visually using the MERLIN system, 39 serious candidates remained and six of these were deemed to be 'clean'.

Off-line, a differently filtered data sample was analysed independently on the basis of missing transverse energy (expected to be due to an invisible neutrino), and provided the same six final events.

The UA2 experiment

The UA2 detector is designed to look at hadronic jets and the decays of the weak bosons. 240 individual lead-scintillator and iron-scintillator sandwich counters are clustered around the collision region, and the forward and backward cones contain additional lead-scintillator counters for electron identification, and magnetic spectrometers to measure

the asymmetric charge distributions expected from the leptonic decays of W bosons.

The experiment benefitted from thorough initial testing and from the first SPS collider run in 1981. During the big run at the end of last year, continual testing and calibration ensured that everything was in good shape, and allowed rapid interpretation of the collected data.

The trigger logic is gated by the timing pulses from the SPS, and first level event selection is based on the amount and the clustering of energy deposition. The fast hardwired electronics does this with no appreciable dead time. In the 1982 run, about a million triggers were accepted, of which about 20 per cent were of the type which could contain electrons.

The data from these events (about

10 Kbytes per event) goes to the experiment's VAX 11/780 computer, which provides on-line capabilities for equipment testing, calibration and monitoring, event acquisition, display, writing to tape, etc.

All accepted events were collected on tape for subsequent off-line analysis. In addition, about five per cent of the data, containing potentially the most interesting events, were stored on an additional tape. In this way the results were examined day by day for suggestions of the weak bosons. The full trigger sample was used for the main off-line analysis.

Off-line, separate program modules, dealing with different parts of the detector, make for rapid analysis of the data. In the search for the high transverse momentum electrons,

the calorimeter data was first subjected to a sophisticated analysis. This selected out 363 events, which were then exposed to the full power of the off-line programs. As a result, the handful of candidate events was obtained within a few days of the end of the run, and presented publicly in January. No final visual selection was necessary. Within a few weeks of the end of the run, all data on the production of hadron jets was processed, and detailed physics analysis in full swing.

The UA2 data acquisition and analysis system is not being pushed to its limits and could accommodate higher proton-antiproton interaction rates without too much trouble. There are no immediate plans to enhance the trigger system.

ECFA responds to its title

The European Committee for Future Accelerators, ECFA, is paying close attention to the adjective 'future' in its title with two major developments to prepare for particle physics in the years to come. These were discussed at the Plenary Meeting of ECFA in December.

The first is, hopefully, for the fairly near future and concerns the high energy electron-proton colliding beam machine, HERA, which has been proposed for construction at the DESY Laboratory (see page 90). ECFA, together with DESY and NIKHEF (the Amsterdam Laboratory), are organizing a Workshop with the title 'Experimentation at HERA', to be held in Amsterdam 9-11 June. This is a follow-up to the Wuppertal Meeting on 'Physics with Colliders' held in October 1981 (see January issue 1982).

The Workshop will divide its subject under six headings — Technology for detectors, Requirements on intersection regions, Detection of photoproduction and small phenomena, Detection of charged and neutral current events and measurement of structure functions, Detection of exotic particles, Use of existing detectors.

The second development involving ECFA is a move to promote accelerator physics research in Europe with an eye on the very long term future. The need to stimulate research on new methods of particle acceleration for the machines which could be needed to tackle the physics of the next century emerged clearly from the Conference at Oxford on 'The Challenge of Ultra-high Energies' which was sponsored by ECFA and organized by the Ruther-

ford Appleton Laboratory (see December 1982 issue, page 404). It is also a concern of the International Committee for Future Accelerators, ICFA, which considers the problems of particle accelerators in a world-wide context.

John Mulvey, the Chairman of ECFA, prepared a paper (ECFA/82/64 rev.) on the subject (from which the rest of this article is largely drawn), which was endorsed by ECFA at its December meeting. He first listed several technologies which might contribute to progress up to near the end of the century. Superconducting r.f. cavities offer the prospect of accelerating gradients of up to 10 MV per metre and could help LEP to reach energies of up to 120 GeV with acceptable power consumption. Copper r.f. cavities in linear accelerators have been