DATA HANDLING FOR THE WIDE-ANGLE HALL JET EXPERIMENT

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INTRODUCTION

The subcommittee on data handling for the two-arm spectrometer in the wide-angle hall has based its study on the draft report by Aronson et al. (Appendix EA-I in this volume). It has attempted to produce a design of the several layers of triggering and a schematic data acquisition system; discussed the configuration of the local intersection computer system (LICS); and estimated the time required to analyze a typical event. We have chosen to focus on a specific piece of physics, the inclusive production of jets at 90° , with the aim of measuring the production cross section for these jets and the distributions of their constituents.

The apparatus (Fig. 1) is essentially that of Appendix EA-I. There is a vertical magnetic field near the intersection region followed by various detectors spanning ± 300 mrad in both vertical and horizontal directions. The last of these detectors (hadron calorimeter) ends at about 11 m from the intersection point and occupies an area of $7 \times 7 \text{ m}^2$. Five drift chamber modules span the spectrometer (typically xxyyvv planes in each module). Between the modules there are various threshold Cerenkov counters. Calorimeters with five sampling front ends to produce electromagnetic showers surround the aperture. Pertinent details of the detectors, as used in this report, are listed below.

Drift chambers:	(5 modules of 6 planes) x 2 arms, cell size increasing from 4 mm to 2 cm	~20,000 wires
Calorimeters:	Total area of 82 m^2 x 2 arms, Fe-acrylic scintillator with wave- shifter bars to photomultipliers, 5 longitudinal sections x 2 arms	1,400 tubes
Cerenkovs:	200 photomultipliers per counter x 5 counters x 2 arms	2,000 tubes

The most sensitive aspect of an experiment on jet production is finding a trigger that selects the high p_t jet without bias and without excessive background. The jet, being a complex collective phenomenon, can best be selected by a reasonably complex trigger utilizing fairly complete kinematic information on all its particles. Thus, it seems to us imperative that a jet trigger be based on the energy and angles of both charged and neutral components (and perhaps particle type), and that this information be made available quickly in a usable form. To provide time to obtain this kinematic

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MASTER

Fig. 1. Wide-angle hall spectrometer.

information, a pretirgger that is unbiased for any real jets is required. Single-particle momentum and total energy content are the obvious possibilities for this pretirgger, and both are discussed below.

The group took as its goals for trigger selectivity the design of a pretirgger operating in 200 to 300 nsec which would reduce the rate to about 10^4 per sec. A slow trigger, based on topological properties of the event, was then added to reduce the rate to about 10 per sec within a period of 50 μ sec. We have kept in mind a "typical" event, in which a high energy jet contained in the spectrometer consists of 10 charged particles and 5 neutrals.

The group organized itself loosely into four areas, with considerable cross-talk among them:

Pretirgger: Gordon, Grannis, Morris

Slow trigger: Cassel, Engelmann, Meadows, Stein, Malik

Computer analysis: Grannis, Plano, Saulys

Monitoring and testing: Gordon, Morris, Saulys

Our report is organized along these same lines and is based on contributions from these working subgroups.

Fig. 2. Single-particle rate vs $p_{\perp}$.

$$N = L \Delta y \Delta \varphi \int_{p_{\perp}}^{\infty} dp'_{\perp} p'_{\perp} \frac{d\sigma}{dy d^2 p'_{\perp}} ;$$

$$\Delta y = \pm 0.8, \quad \Delta \varphi = \pm 0.3,$$

$$L = 10^6 \text{ cm}^{-1} \text{ sec}^{-1}.$$

PRETRIGGER

Figure 2, taken from Appendix EA-I, shows the single-particle rate vs p_t for the proposed spectrometer. The lesson is clear: a good pretrigger, based on some particle having a momentum greater than some cutoff, will reduce the rate markedly. We have investigated the acceptance and rates of the spectrometer at the various chamber planes. The geometry is defined in Fig. 3. Rays of various p_t and φ were traced through the system; the φ acceptance vs p_t is shown in Fig. 4 for the first two planes and the last plane. The cutoff in p_t imposed by the magnet is 0.325 GeV/c in the early planes and 0.5 GeV/c at the end. The intercept of the projected tracks at the vertical plane through the beams (b) is approximated by

$$b(p_t) \approx 0.65L^2/2p_t \quad (L = \text{magnet length})$$

for large p_t and small φ . Since this projected displacement is used in the slow trigger for momentum determination, it is useful to know the validity of this approximation. Figure 5 shows the variation of b vs p_t and φ . For low momentum tracks, considerable correction is necessary, and determination of p_t requires knowledge of both b and φ .

Studies were made to estimate the rate reduction given by pretriggers of two types: a single charged track with momentum above some cut, and total energy deposit in the calorimeter. These studies were performed by using Monte Carlo generated jets and backgrounds (R. Engelmann, in a talk at this Workshop). The single-particle trigger is made by demanding hits in the first three

Fig. 3. Spectrometer geometry. In the thin-magnet approximation, $p = \Delta p \cdot D/b$; $p = 0.3 \int B d\ell$ (but thin-magnet approximation is crude).

Fig. 4. Acceptance vs p at various drift planes.

chamber planes (bending coordinate only) through the use of pre-loaded RAM matrices whose bits are set to one or zero depending on whether or not the particular three-plane correlation is an allowed track.

Jets were generated in batches of 100 at each of 19 values of p_t (10 GeV/c $\rightarrow$ 100 GeV/c) and 14 values of polar angles from the beam ($20^\circ \rightarrow 150^\circ$). The events were generated randomly at azimuthal

Fig. 5. Projected track offset (b) vs initial track angle (ϕ).

angles between -70° and $+70^\circ$, where 0° lies along the spectrometer axis. A total of 26,600 events were generated.

RAM files were created based on tracks with $p_t > p_{low}$ from these jets; p_{low} was 1.0, 2.0, and 5.0 GeV/c for the three files. The cell size was 2 cm in each chamber. The chambers were at $z = 160, 234, \text{ and } 380$ cm, and had vertical apertures of 198, 300, and 552 cm. The RAM had dimensions of $100 \times 150 \times 300$ cells. The fraction of the total bits filled in the RAM for $p_{low} = 1, 2, \text{ and } 5$ was 0.30%, 0.19%, and 0.12%, respectively. Accidental correlations are thus not expected to be a large problem. The fraction of jets that trigger the RAM at each p_t is shown in Fig. 6. This fraction is computed for only those jets whose direction lies within 200 mrad of the z -axis.

The tracks from jets that did not have any track with $p_t > p_{cut}$ were used to study background triggers; p_{cut} was defined to be $0.8p_{low}$, since the finite cell size in the RAM does not give a sharp momentum selection. For $p_{low} = 1.0$ and 2.0, there were 27 and 35 false triggers in 1750 and 4000 events, respectively; all of these were single-track triggers. For $p_{low} = 5.0$, all but 13 of the triggers were single tracks.

An additional test for background triggers was done by using a file of 10,500 events with random, low-momentum tracks. Of these, 3281 events contained one or more tracks that entered the apparatus. The results for each RAM file are given below.

p_{low}	Total triggers	Two-track triggers	One-track trigger $< 0.8p_{low}$	One-track trigger $> 0.8p_{low}$
2	9	0	4	5
5	4	0	0	4

The distribution in the number of tracks entering the apparatus was as follows:

Tracks:	1	2	3	4
No. of events:	635	133	13	5

Our conclusions on this pretrigger are that it can be made relatively background free. However, in order to produce little bias on the jets themselves, p_{low} must be kept to a small value and thus allow a relatively high pretrigger rate. For example, if we require the pretrigger rate to be 10^4 Hz, p_{low} must be set to about 1.5 GeV (see Fig. 2); then good efficiency for jets is not reached until $p_{jet} \geq 30$ GeV/c, as indicated in Fig. 5.

To determine the efficiency of the calorimeter energy threshold pretrigger, the Monte Carlo events were studied. Each of the jet decay products was summed into Σ_p if it hit any of the calorimeters. The energy of each particle was smeared by a Gaussian with $\sigma = \sqrt{E}$ for charged hadrons and $\sigma = 0.2\sqrt{E}$ for neutrals. The efficiency was defined as fraction of jets having more than the threshold p_t of those jets whose axis was within $|p_x/p_z| < 0.25$ and $|p_y/p_z| < 0.3$. The

Fig. 6. Fraction of jets triggering RAM vs p_t .

efficiency for various cuts is shown in Fig. 7. The efficiency at p_t (threshold) = 20 GeV/c changes from 10 to 90% for $\Delta p_{jet} \sim 10$ GeV/c, whereas at p_t (threshold) = 80 GeV/c, it changes from 10 to 90% for $\Delta p_{jet} \sim 15$ GeV/c. The effect of this rather slow turn-on is shown in Fig. 8, where the efficiency is multiplied by the estimated jet cross section. Again, the cross section shows a serious bias for

Fig. 7. Trigger efficiency vs p_t (jet) for various thresholds.

Fig. 8. Trigger efficiency $\times$ jet cross section.
 •, jet model; o, jet model $\times$ efficiency ($\Sigma p_{\perp} > 20 \text{ GeV/c}$).

the first 10 GeV/c. However, the fraction of jets detected well above the cut is rather independent of $p_{\perp}$; therefore, the shape of the differential cross section could be measured whereas the magnitude would have to be inferred.

We conclude that the calorimeter pretrigger will be reasonably effective for $p_{\text{jet}} \gtrsim 20 \text{ GeV/c}$, and the pretrigger rate can be kept comfortably small while retaining good efficiency for triggering on jets. Note, however, that in this pretrigger, as in the charged-particle pretrigger, we have considered only jets with axes in the center of the spectrometer aperture. Both pretriggers are biased against jets whose axes aim nearer the edges. In this sense the proposed apparatus may in fact be too small.

The layout of the pretrigger logic is shown in Fig. 9. The fast strobe, based on a scintillation hodoscope or the equivalent, is the primary timing signal for the event. The pretrigger select is simply an OR of those pretrigger conditions enabled and emits an output pulse with the stroke time after 300 nsec. This pretrigger then enables the appropriate controllers for the slow trigger logic.

SLOW TRIGGER

In a jet experiment, the criteria for accepting events are extremely sensitive; there is considerable danger that the final properties of any jets observed will reflect only the trigger bias. We have assumed that the criteria likely to be useful in selecting relatively unbiased jets are (a) total energy above some cutoff

value, and (b) multiplicity (or clustering) of emitted particles. Further criteria for specific studies may include the demand for a leading particle of a certain type (K , $\bar{p}$, etc.).

The total energy cut, in order to be efficient, must ensure that all particles be included without large accidental background in identifying tracks, and that the resolution of the E_{tot} determination be good enough that the desired events comprise a large fraction of the trigger sample. For such a cut to be made with sufficient precision and speed, we see a great need for fast decision-making special function processors (SFP) in the slow trigger. In building the SFPs, the algorithm and the device readout itself must be carefully constructed to minimize time lost in reconfiguring data for acceptance by the algorithm.

The layout of the slow trigger logic we visualized is given in Fig. 10. The raw data flow in parallel from the three types of devices. In each case they are stored in a generalized delay line during the time required for pretrigger decision and subsequent readout. The delay might be a digital delay in the case of drift-chamber time pulses and either CCD or sample-and-hold amplifiers for calorimeter and Cerenkov counters. Upon decision to process further, dedicated controllers present the raw information to an

Fig. 11. Track-finding and momentum algorithm.

SFP. Here the formatting of the detector information is crucial in easing the time required for addressing the data arrays. Detector elements with no information are suppressed at this stage. The SFPs are intended to produce device-specific information: track parameters and momenta, calorimeter cluster locations and energy, and Cerenkov cluster size and position. The SFPs at the next level are intended to correlate the device information to produce the final trigger: total jet energy (charged plus neutral), spatial clustering, leading-particle type, multiplicity, etc.

We have chosen one special function processor for specific study, the one responsible for finding tracks in the chambers and computing momenta. The algorithm (Fig. 11) is based on the geometry of Fig. 3.

The specific problem addressed was that of computing Σp_t (the sum of charged-particle transverse momenta). For each track, the variable p_t was defined by its position and direction in the yz view. For the purposes of the algorithm, it was assumed that co-ordinates from three y measuring planes (those used by the RAM in the pretrigger) were available in wire address form. Pairs of read-outs from planes 1 and 3 were matched, where possible, to hits in plane 2. It was assumed, for the purpose of generating a trigger, that such combinations of three hits on a line represented tracks. For each track, the value for p_t was drawn from a two-dimensional lookup table indexed by wire numbers in planes 1 and 3. The scaling is introduced to simplify the interpolation at plane 2. The algorithm required a time given empirically as $t \sim 2.4n_1n_3 + N$ (μsec of CDC 7600) where n_1 , n_3 are the numbers of hits in planes 1 and 3, and N is the number of tracks found. Clearly, to form a trigger, a single processor such as the 7600 would require a time of about 250 μsec for 10 clean tracks--much longer than the 100 μsec available assuming the pretrigger could provide a rate of 10^4 events per sec. Algorithms such as the one described here are, however, clearly amenable to parallel processing, simply by dividing the hits within plane 1 or 3 (whichever has the greater number) among a finite number ($\sim n_1$ or n_3) of processors. With cycle times comparable with that of the 7600, the trigger could thus be formed in a reasonable time. Problems associated with such a system include the following:

- a. General-purpose microprocessors with cycle times comparable with those of the 7600 are not currently available, although they might well be within the next few years.
- b. Tracks found as described are subject to contamination from accidental coincidences of hits on the three planes. Such extra tracks tend to overestimate Σp_t , a potentially catastrophic circumstance in view of the expected fourth-power law cross-section dependence of this quantity. Significant improvement could be achieved by including information from x-measuring planes, but the computing time would thereby increase unless a significantly larger number of processors were used.
- c. Restriction of the track algorithms to the use of three planes makes possible the loss of tracks where one or more of these operates at $<100\%$ efficiency.

d. Naturally, some tracks simply miss one of the planes and are therefore omitted from Σp_t .

Thus we conclude that an SFP made of parallel microprocessors will not be an attractive solution for the tracking problem. An alternative that sounds promising but is as yet unproven has been suggested by Sippach (Benenson et al., "A Hardware Architecture for Processing Detector Data in Real Time," in this volume). A Sippach fast track processor (SFTP) can provide many essential functions in the data acquisition and analysis system, ranging from a smart trigger to fitting tracks and calculating their momentum vectors and χ^2 's. To be concrete, the potential for the use of a system based on these ideas in a smart trigger for total charged momentum in the spectrometer is described here.

We assume that the combination of the fast event strobe and the RAM trigger reduces the data rate to <100 kHz, so that the chamber hits (drift-wire numbers or address of groups of proportional chamber wires ganged in strips about 1 cm wide) can be read out and processed before the next event. In the layout in Fig. 12,

Fig. 12. Processor logic.

the chamber latches for the y (bend) planes in chambers 1, 2, and 3 are first converted to the addresses y_1 , y_2 , and y_3 of the wires that have been hit. For chambers 1 and 3, the SFTP first scales the wire numbers to new numbers y_1' and y_3' such that $y = y_1' + y_3'$ is the wire number prediction in chamber 2 for a straight track through y_1 and y_3 . These scaled values are stored sequentially in the LIST GENERATE module during each WRITE clock cycle when data appear from the ADDRESS generator. The LIST GENERATE module also steps sequentially through each possible pair of (y_1', y_3') values during subsequent cycles of the READ clock. The READ and WRITE clocks are alternate half-cycles of a 20-MHz clock, so that READ and WRITE cycles both occur at a rate of 20 MHz but always at separate times. As a pair (y_1', y_3') is chosen, they are added to form $\hat{y}$ and passed on to the MAP module. Meanwhile, the MAP module has been accumulating a list of hits in chamber 2 during the same WRITE cycles in which data were stored in the LIST GENERATE module. The hits in chamber 2 are stored as single bits, addressed by the wire number y_2 . Checking consistency between y_1 and y_3 and some hit in chamber 2 is then reduced to a lookup, somewhat like that in the RAM system, and it is completed in the same READ cycle during which the pair (y_1', y_3') was generated. Therefore, the scan of the chambers to find tracks is reduced to a two-dimensional scan, and the time required to find all track combinations is given by $50n_1n_3$ nsec, where n_1 and n_3 are the numbers of hits in chambers 1 and 3, assuming that the processor is not delayed by a slow interface. If each chamber had as many as 20 hits, the time required to obtain a complete track list would be 20 μ sec.

To find the total momentum in the spectrometer, the indices I_1 and I_3 , which point to the location of the pair (y_1', y_3') in the original hit lists, are passed down to the LOOKUP module. Since the LOOKUP module had been storing the hits in the same sequence as the LIST GENERATE module, these indices can retrieve the wire addresses y_1 and y_3 . These addresses are then used to calculate the momentum of the track in the p module, which is either an arithmetic unit using a fast linear algorithm to compute p from y_1 and y_3 , or a $100 \times 300 = 30,000$ -word memory in which the momentum values are stored with y_1 and y_3 used as addresses. The SUM module, Σp , then sums the total charged-particle momentum, which is compared with a preset minimum to decide either to continue or to abort both further data acquisition and processing for the event. The momentum calculated in this way will be accurate to about 10% because of the 1-cm cell size in the chambers.

This system is the most elementary one that would be useful. The full power of SFTPs is realized by using them to find track segments in all views, to combine views, to fit complete tracks, and to find their momenta and χ^2 's. Track segments in other views would be obtained simultaneously in similar processors that do not include the momentum calculation modules. Modules not shown here would assemble lists of track segments in all views, check for consistency, and fit the tracks. Since this system functions by having no control other than the division between READ and WRITE

cycles, modules that can act independently do so, and modules that require results from lower levels act as soon as information is available. The SFTP realizes that it is finished with an event when the last module in the system receives a COMPLETE bit for each of its input lists. This COMPLETE bit is generated at each level from the coincidence of COMPLETE bits coming from lower levels, starting with a COMPLETE bit generated by each interface when it has read in all the wires in its chamber plane.

This high degree of parallel calculation and lack of overall control means that the entire fitting and momentum analysis can be done in times comparable with the original N^2 time that it took to scan through the entire list of pairs of hits in chambers 1 and 3. With a factor of 2 used for safety, the tracks in the chambers could be found and fitted in a time such as 40 μ sec, which is smaller by a factor of 100 to 1000 than the time estimated for the same operations in the CDC 7600.

The design of the SFTP is modular, so that changing the "program" for track finding, fitting, and rejection could be accomplished with reasonable effort. Intermodular connections are made with multiple coax cable, typically with 20 cables. If a "complete" system were implemented at the beginning, the results could be ignored until experience with the experiment and with the SFTP built up enough confidence to allow use of the system for more sophisticated triggers, e.g., minimum number of tracks coming from a common vertex along the beam direction.

We have made some estimates of the slow trigger efficiency by using the Monte Carlo program (Benenson et al., op. cit.). The generated events were treated as follows: x-y strips with 1-cm spacing were assumed. Charged tracks were rounded off to the nearest 1 cm² in planes 1 and 3. A hit within 1 cm in plane 2 was looked for. If one was found, the trajectory, with slope and intercept at the magnet exit plane calculated from these rough coordinates, was traced through the magnet assuming the target width in y, z to be zero. The Σp_i summed over charged particles was calculated. For neutrals (assumed to be π^0 's with the full E_{π^0} hitting the em calorimeters), $\sigma/E = 0.2/\sqrt{E}$ was used to smear them out and added to the above sums (the contribution of the π^0 angle error was assumed to be negligible), in order to get the trigger transverse momentum p_t . The detected jet axis, the vector $p = (\Sigma p_x, \dots, \Sigma p_z)$, had to point to within an angle θ_{cut} with respect to the spectrometer axis.

The trigger efficiency vs p_t of the jet is given in Fig. 13 for various thresholds. Two values of θ_{cut} , 0.20 and 0.35, are used, corresponding to 25% and 70% of the spectrometer effective solid angle (weighted by the jet's angular distribution).

The transition from zero to full efficiency is seen to be somewhat less sharp than with the calorimeter pretrigger of Fig. 7 because of the momentum resolution for charged tracks. Improvement can be realized by using calorimeter determination of high momentum particles and spectrometer measurement at low momentum.

However, even in the worst case (Fig. 13 with $\theta_{cut} < 0.35$), it appears that a slow trigger rate of < 10 Hz can be achieved for $p_{jet} \geq 20$ GeV/c by using a Σp_L cut of about 7 to 8 GeV/c.

Fig. 13. Trigger efficiency vs p_L of jet.

ON-LINE AND OFF-LINE ANALYSIS COMPUTERS

The overall flow of data is indicated in Fig. 14. It is proposed that the detector be broken up into logical sections entirely independent of one another, except that the triggers may combine data from several sections and enable gates in several sections. A typical section might consist of a drift-chamber system, a hadron calorimeter, or a set of Cerenkov counters, and associated electronics through the device processor (DP).

Fig. 14. Data flow for specific device type (drift chambers, Cerenkov counters, calorimeters).

The function of the DP is to accept data from the detector section when notified by the trigger, to make simple histograms and other tests of the data, to apply calibrations, to reformat as desired (zero suppression will in general have been previously carried out), and to pass the data on to the LICS via a fast bus. The DP also checks continually on critical voltages, magnet currents, etc., and, if a malfunction is detected, will correct it if feasible or inform the experimentors. It will also be able to generate signals in the detector and its electronics so as to check all components as thoroughly as possible. Other functions may include calibration of critical elements and the setting of pedestals.

It is expected that the DP will be developed while the associated detector section is under development and will be used in the testing and debugging of the hardware. Thus, the software will grow and improve with the hardware.

The DP should be equipped with display terminals and a reasonably fast printer, so that histograms, tables of voltages and calibration constants, etc., can be quickly and conveniently communicated. Full software should be available. A typical DP might be the equivalent of a rather fully equipped PDP-11 costing \$20,000 to \$40,000 (with, perhaps, SFPs attached).

The LICS reads in the zero-suppressed and cleanly formatted data from all associated DPs. It can be used to fully process all events as well as to make detailed and complete tests of the entire experiment. The LICS then writes the fully reconstructed event as well as, if desired, the "raw" data. It is to be hoped that, as experience and confidence are gained, the option of simply discarding the raw data will be increasingly utilized.

The LICS must have the power of a 7600 to keep up with the expected event rate (see below). This may be reasonably economical in five years, especially as some of the more time-consuming chores are expected to be performed by SFPs. It is recommended that all LICSSs be compatible and that extra units be available so that program improvement and debugging as well as extra running can be easily carried out without interfering with data gathering.

The connection between DP and LICS is accomplished by a fast shared bus of the type discussed by Leipuner ("Some Notes on the Fast Bus System," in this volume). Inasmuch as large amounts of calibration constants must be generated in this experiment and then used in the DPs for removing nonlinearities, pedestal subtraction, gain correction, and the like, we recommend that LICSSs be equipped with a large core memory of relatively slow speed. We estimate 10^5 bytes to be sufficient.

We have estimated event analysis times for a typical event in this experiment (Table 1), primarily on the basis of the times required in similar tasks in present experiments. The largest uncertainty is encountered in obtaining track pattern recognition times. There is a large multiplicity, but some simplification due to the expectation of straight-line segments and some information within a given drift-cell module on angles as well as position.

Table 1
Event Analysis Times

	CDC 7600 equivalent (msec)
1. Pattern-recognize 8-prong event in ~30 drift-chamber planes	25-100
2. Fit charged tracks (fringe-field corrections TDC nonlinearity, etc.), giving $\{p, \vec{r}\}_i$	5
3. Pattern-recognize calorimeter clusters, giving $\{E, X, Y, \text{type} = \begin{smallmatrix} \text{em} \\ \text{hadron} \end{smallmatrix}\}$	10- 30
4. Identify charged tracks in Cerenkov arrays ($\pi/K/p/?$)	5
5. Do the physics - jet kinematics	5- 10
Total	100±50

At data (trigger) rates of 10 per sec,
one 7600 equivalent keeps up with experiment.

There may well be assistance in pattern recognition from the special track finding processor which we have not included. Whether all event processing in this experiment should be done in an LICS or some in a larger central computer is an open question. The analysis task here seems near the limit of what could be accomplished at the site of the experiment.

MONITORING AND TESTING

With large-scale experiments employing many devices and detector elements, the task of monitoring performance and testing system components becomes a major one. The limited access to experimental equipment exacerbates the problem. It would be senseless to specify any monitoring scheme in detail now, but we can offer some general comments, some implicit in the above presentation.

A. Large amounts of calibration constants and gain corrections are required (typically several per element of detector), and thus large amounts of (slow) core are required for their storage.

B. Efficient debugging of the apparatus, both in test beams and in ISABELLE, requires good displays and test programs. Such activities should be carried out in parallel as much as possible. Hence, the device processors discussed above, dedicated to a single detector group, seem a natural solution. These DPs would be regarded as an integral part of the device itself and would be developed with the hardware.

C. Extensive checking of system electronics is required, and some appreciable fraction of live-time should be spent in searching for faulty elements. The DP thus should be programmed to initiate these system checks, to monitor their results automatically, and to warn the experimenter quickly of failures. Clearly, the full data set from these experiments is too large for efficient monitoring by personnel; therefore, the automated checks must be efficient and thorough.

D. The final check of the experiment must be at the level of full event checking: event reconstruction and physics output. Such checking must be done by the LICS and should be based on appreciable sampling statistics. Thus, even if the LICS cannot cope with complete event analysis, it must be powerful enough to digest thoroughly a third or more of the data collected in real time.

CONCLUSIONS

We have discussed the data-handling needs for a jet production experiment in the wide-angle hall. Most of the specifics presented will, of course, be changed in any such experiment mounted in ISABELLE; however, the general structure proposed is likely to be realistic. The jet experiment is interesting to consider now in that it relies heavily on special function processors for selecting interesting events. The time-line diagram (Fig. 15) indicates that by the time of the slow trigger ($\sim 50 \mu\text{sec}$), a sophisticated pre-analysis of the event must have been completed. Currently available processors are not capable of such speedy reduction, and this points to a need for development over the next few years.

Our major conclusions are listed below:

A. The experiment, as proposed, does not appear to place unrealistic demands on detector technology. However, we conclude that, for a jet study, the aperture suggested may well be insufficient, and the experiment might well require additional detector capability at angles outside the spectrometer cores.

Fig. 15. Data acquisition time line.

B. Pretriggers based on single energetic particles or on total jet energy are likely to work, although more study of the pre-trigger is desirable. Triggering for jets of total momentum ≤ 20 GeV/c is difficult.

C. The slow trigger is the crucial aspect of this experiment. Parallel processing by hardware devices seems the order of the day. This area is one of great importance for support and study by ISABELLE. The utility and performance of the scheme we suggest here deserves more study than we have given it. For example, it would be extremely useful to understand in more detail the feasibility of generating full-jet energy reconstruction within 50 μ sec, and to determine, by Monte Carlo studies, what efficiency such a trigger might have and what its resolution in E_{jet} would be.

D. Organization of data handling through device processors dedicated to a specific set of detectors would be invaluable for efficient data collection and monitoring.

E. The local intersection computer system (LICS) should be a powerful computer for this experiment. The event analysis time is estimated at $100 \pm$ msec, and efficient running requires that appreciable fractions of data be fully analyzed. A large core memory should be included in the configuration for storage of calibration data.

F. Our subgroup tended to favor bringing most signals outside the experimental hall before proceeding with reformatting, zero suppression, or analysis by SFPs. For this experiment, this implies about 50,000 cables penetrating the shield wall, although the bulk of these would be multicable wires from the drift chambers, as shown below.

Cable Connections

Drift chambers	All wires	~40,000	Flat cable
Calorimeter	Photomultipliers	~ 1,500	Coax
Cerenkov	Photomultipliers	~ 2,000	
High voltage, etc.		~ 500	
	Total	44,000	