2. MASTER

BNL-25864

APPENDIX EA-II

OPEN AREAS AND OPEN ACCESS *

A.M. Thorndike, BNL

I. OBJECTIVES OF OPEN AREA DESIGN

NOTICE
This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Department of Energy, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

The main objective of the two open areas in the present ISABELLE design has been to provide flexibility with respect to the size and shape of experimental equipment that would eventually be installed there. No permanent building would be installed initially. One possibility would be to enclose each experiment in a temporary structure that would provide weatherproofing and shielding; another possibility would be to erect a permanent building at a later time, when experience has made the needs clearer than they are at present.

The secondary objective of the design of open areas has been to keep initial costs as low as practicable.

Another objective might be added, however, which we indicate by the term "open access." This note will explore this idea and some design concepts based on it. In the ISABELLE 1977 Summer Workshop there was considerable discussion of the importance of techniques for inserting large pieces of experimental equipment quickly and removing them with equal ease and speed (BNL 50721, pp. 303-8 and 330-40).

Since enclosed halls have certain restrictions in this respect, open areas may be helpful in providing this feature. If the mechanical and electrical aspects could be handled quickly, one might even attempt to reduce the time spent on bureaucratic procedures in order to expedite the introduction of new experiments and new ideas in these areas. The test beam at the AGS has been very useful, in part because procedures for access to it are simple and informal. This aspect of access will not be discussed further here.

We will assume that if a scheme for moving equipment in and out of position quickly could be arranged, it would be useful. What we mean by "quickly" is simply that the time required should be much less than in conventional enclosed halls. At the ISR, experiments usually stay in place for more than a year at a time, and this duration is not much different at other major high energy physics laboratories. If an experiment could be moved in or out in a few days (or less), dwell times of a month (or less) would be possible. This would mean that an experiment could move into position and out again several times before completion.

This capability could be used simply to alternate running periods in place with modification or repair periods in an "outside" position where the equipment could be worked on easily. Going somewhat further, two experiments could alternate in the "inside" position, as in time-sliced computer operation. In fact, such a capability for alternate operation is equivalent to
*Supported in part by the United States Department of Energy.

switching an external beam to different experimental setups, if it could be made easy enough, and the value of beam switching is well known.

It is not possible to move a typical complicated experiment quickly by disassembling it into individual pieces and putting it back together again. One must be able to move the entire experiment in a single piece (or a few). The number of connections must be minimized. Quick-disconnect connections must be provided that are convenient and reliable. These conditions could be achieved with careful design if it is really useful to do so. We visualize movable platforms on which experiments would be built, with capacities of up to about 1000 tons per platform. Most experiments could be built on a single platform or on a few. One can think of these platforms as modules that plug into an experimental area the way electronics boards plug into a standard crate. The principle is the same.

Moving the experimental apparatus is not the only problem. The shielding must also be moved out of the way. Many thousands of tons of shielding are required for an open area. If a part of it is to be moved quickly, it must also be organized into a small number of large units. Since the amount is large, it must be made of an inexpensive material. Sand and water are advantageous from the cost viewpoint. We will describe a scheme using large tanks filled with water.

The other essential technology is the connection system providing power, coolant, gases, controls, and data transmission. This is more complex, and we will present some ideas on the system design. In general, it is important to make the equipment on a given platform as complete and self-contained as possible, with a minimum of interconnections. It would be interesting to design specific experiments in this context, but this note will not go that far.

II. OVERALL DIMENSIONS

In the January 1978 ISABELLE Proposal (BNL 50718) the two open areas are assigned a length of 80 m, and the hardstand area is given a width of 40 m. In this note we are considering a conceptual design that might be adopted for a future development of these areas. We assume that a large building will eventually be built in each area, covering the whole area with a structure much like the experimental area at the AGS. Shielding would be installed inside the building and moved into different configurations to fit the needs of successive experimental programs.

To provide long-term flexibility a width ≥ 40 m seems desirable. We retain the 80 m length and assume a width of 60 m. We assume that an overhead crane is provided with a 60-m span. This is quite large, but very valuable for flexibility in operation of the area.

The experimental platforms and shielding pieces that are to be moved around in this area fit together in a standardized way,

Fig. 1. Cross section of future enclosure for open areas.

referred to a rectangular grid. Standard squares are 5X5 m, 2.5X2.5 m, or 1.25X1.25 m. Both experimental platforms and shielding pieces will be sized accordingly. For example, one standard experimental platform would be 5 m wide and 10 m long.

Appropriate building dimensions are indicated in Fig. 1. All shielding would be inside this large hangar-like enclosure.

III. SHIELDING PIECES

To make rapid moves possible the pieces must be large. We propose that this be accomplished by the use of tanks filled with water, with a capacity of about 200 tons. The water is pumped out when the shielding must be moved. If it is possible to achieve a ratio of 10 to 1 in the weight of water to empty tank, then the tank can be moved with a 20-ton crane.

The walls of the shielding could be made of units very similar to the silos that comprise the walls of the enclosed halls. They could be 5X5 m in horizontal dimensions and 8 m high (to the approximation that 1 m³ of water weighs a ton). Figure 2 shows a typical shielding arrangement made of such pieces, with 50X15 m space inside for the experiment. There are 36 wall pieces in all.

Roof beams are also required. A thickness of 4 m would be about what is needed, so that 4X2.5X20 m could be roof beam dimensions for a 200-ton weight. In Fig. 2 there are 22 roof pieces.

To move shielding one first pumps the water out and then moves the empty tanks by crane. Figure 3 shows a very large opening made by removing 12 roof pieces and 6 wall pieces. If the water can be pumped out of a tank in 20 min, the move could be done in about an 8-h shift. This requires a fair-sized pump. For example, 10 ton/min against a 50-ft head is 10⁶ ft-lb per min, which is ~30 horsepower. In a 1-ft-diam pipe the velocity is about 8 ft/sec.

Fig. 2. Experiment in place. (Open area plan, 80x60 m.)

Fig. 3. Experiment and shielding removed.
(Open area plan, 80x60 m.)

This seems reasonable. Some large hose and connectors are required, as used at an oil terminal.

The weight ratio of 10 to 1 for liquid to empty tank may be a bit optimistic. For instance, a steel box with 1-cm walls has $(4 \times 5 \times 8 + 2 \times 5 \times 5) \times 0.01 \text{ m}^3$ of steel = 2.1 m^3 of steel. This weighs about 16 tons. Thus a rather complex cellular structure might be required for adequate rigidity, especially for the roof. Aluminum would be a possibility, but more expensive. To avoid cracks between pieces one might need double layers or more complex shapes. A detailed design would need careful thought. There would need to be good assurance that leaks could be controlled. Denser liquid slurries rather than plain water might be advantageous, but they would present practical problems.

If the weight ratio that can be achieved is much below 10 to 1, the scheme has no advantage over standard concrete shielding.

IV. EXPERIMENTAL PLATFORMS

In the construction of electronic circuits many individual components go onto cards that are more or less standardized; imagine a similar approach to high energy experiments (this requires a rather good imagination). The experimental platform provides a mechanical support on which a number of counters, wire planes, calorimeters, and absorbers or magnets of moderate size can be mounted to form a large and complex subsystem which works as a unit and is moved in and out as a unit.

Normal wheels have capacities that do not exceed about ten tons apiece. Units are commercially available, however, with multiple rollers that permit slow motion of much larger loads. For example, the Model 7X Mammoth Flat-Top Roller (Hillman Equipment Co., Wall, NJ) is rated at 500 tons per unit. One can, therefore, think in terms of a platform supported by three such units with a total weight of 1000 tons and some reserve capacity. A heavy bridgelike structure would be required if the weight is distributed over a considerable area. If most of the weight is concentrated in a single magnet or calorimeter, the rollers would be located under it, and lighter components supported from it. (The movable wide-angle spectrometer of the ARGO system at the AGS was built in this way with a 48 D 48 magnet as the central element.)

This Hillman Mammoth roller is 30 in. long by $19\frac{1}{2}$ in. wide but only $9\frac{3}{4}$ in. high. It has 16 contact rolls and 240 square inches of nominal bearing area. It rolls best on a smooth steel surface, which must be level and supported by an adequate foundation. Smaller rollers have a swivel design, but for the largest ones it would be necessary to jack the load up and realign rollers to change direction. For most moving a heavy-duty winch should be satisfactory for pulling the load by cable. For more precise location a hydraulic mechanism might be best. One can, of course, provide a fine adjustment of individual components relative to the

platform as a whole. In many cases, positions can be measured more accurately than they can be set; it is then best to apply the appropriate offsets during data analysis calculations.

Such a roller system appears to have two advantages over larger wheels riding on rails: it is more compact for a given weight to be moved, and it provides more flexibility for moving in different directions to reach any desired location in the area.

Figure 4 is a sketch of a platform which might support one half of the neutral lepton detector described in the 1975 ISABELLE Summer Study (BNL 20550). This unit would move into position from one side of the beam tubes, and a companion unit from the other side. No detailed design has been worked out, but such a concept seems possible to implement.

Fig. 4. Platform supporting neutral lepton detector, wt. ~250 tons. Crossing point is to the right. (R = roller units.)

V. CONNECTIONS

A set of experimental equipment that is to be moved in and out of operating position in pieces will not be practical if large numbers of interconnections are involved. Each piece should be as self-contained as possible. A data-handling system with fast logic on each piece fits such a design best, especially if there is a local processing node to do initial selection of events of interest. Thus the envisaged mechanical design is most compatible with a network approach to data processing which minimizes the number of cables or other physical paths for data being transmitted from one piece to another.

Electrical power is a necessity for all experiments. The number of connections will be reduced if a single ac level is brought in and all transformers and rectifiers are local at each piece. This may not always be satisfactory. If there is a real need to bring several ac levels to the experimental platforms, that can always be done. A need to adjust several ac or dc levels inde-

pendently from outside the platform can be met by remotely controllable power supplies. With a digital control system a single control channel can handle many units so that the number of wires to be connected can be kept small. In most cases a single power cable and a single digital channel for control and monitoring information can do the job.

Large dc power supplies for magnets may be an exception because they need to be accessible for service, because they are too large to fit inside shielding, or for other practical reasons. If so, the number of dc power leads can be minimized by running magnet coils in series so that a single set of leads provides power for all magnets (as in the ISABELLE ring).

Electrical power leads tend to be easier to handle if the amperage is relatively low and voltage correspondingly high. This is likely to involve safety problems. In any case, making or breaking connections for major power service would be a job for a specially trained crew familiar with the necessary safety precautions and other system procedures.

Normally conventional magnets will be cooled by water and superconducting magnets by helium gas. In the latter case, a local refrigerator may be supplied with warm helium gas from a remote compressor station. Cold helium gas will be supplied from the central refrigerator, but connections involving insulated transfer lines for gas or liquid at cryogenic temperatures are not readily available that have low heat leakage and are easy to operate. For warm gases and cooling water, commercial quick-disconnect fittings and hoses should be satisfactory.

Another common requirement is the provision of gases for wire planes, Cerenkov counters, and other detectors. In most cases commercial quick-disconnects should be adequate. If many different gas lines would have to be connected, however, a better solution might be to design a self-contained system with control provided electrically. Such a system would have to be well engineered for good reliability. Standard equipment might be provided from a pool like HEEP to facilitate building such modular experimental systems. The technology involved would be similar to that used in ISABELLE controls.

The data-handling system will fit the overall scheme best if conversion from analog to digital form is done at an early stage, with digital data flowing over a limited number of high-speed channels. It is advantageous for the first stage of data selection to be done locally by hard-wired circuitry, microprocessors, or local data analysis nodes, so that the rate of data transmission to the acquisition and control station is reduced. This approach would fit well with a network design of the data-handling system. The present discussions of new circuitry standards ("fast bus") seem to be headed in that direction.

The corresponding control scheme for setting voltage levels, currents, pressures, positions, and other variables involves a digital control signal, a scheme for addressing the unit to be controlled, and local hardware to interpret the control message

Fig. 5. "Connection center" locations, B.
(Open area plan, 80x60 m.)

and set the desired variable. The information flow in bits/sec is likely to be many orders of magnitude lower than for data, and the hardware may be quite different. In principle, the control problem is the inverse of the data problem when expressed in these terms.

For transmitting data a high-speed channel (or a small number of them) is desirable to reduce the number of connections. Co-axial cable is the standard method for transmission. Fiber optic cable is an alternative that is smaller in size, has high bandwidth, and is expected to become competitive in terms of cost. Fiber optic connectors are commercially available. Connectors could be eliminated, in a sense, by using microwave or laser light beam transmission down a pipe through the shielding. A laser beam might transmit data through water shielding, given transparent windows, but such a technique probably would not be worth the bother.

In each area there should be several "connection centers" at which power, cooling, data and control channels, and other standard services are available and easy to connect to. High power and voltage should probably be segregated for safety reasons. These "connection centers" should be located both inside the shielding and outside. Figure 5 shows a reasonable choice of locations which requires no trenches or interruptions in the floor.