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national accelerator laboratory

MONTHLY REPORT OF ACTIVITIES*

F. T. Cole

July 1, 1968

*Work done under auspices of the U. S. Atomic Energy Commission.

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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.

2. Site Acquisition. All except three homeowners in the Village of Weston have accepted offers from the state for their properties. We plan to move all Oak Brook operations to the "Campus" on or about August 1, when enough houses are to be available. An elegant plan for our use of the Campus, covering our laboratory, shop, and office-space, and utility development has been made.

3. Design Report. We have distributed all 1,500 copies of the January Design Report and have a number of requests on hand. We are now producing a second printing of 500 copies and are taking the opportunity to update the lattice and parameters in the report.

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).

2. Magnet Computations. The magnetic design of the magnets, using the computer programs LINDA and TRIM, is nearing completion. The design work is discussed under "Theory" below.

The quadrupole die and coils are out for bids. Proposals for trial lots of magnet steel have been received from several steel companies and more are expected within a few days. A trial lot will be ordered from each steel company submitting a responsive proposal.

Proposals for the digital data-recording system for magnetic measurements have been received and are being evaluated. Unforturnately, two of the major manufacturers declined to quote, but there are a number of satisfactory proposals.

4. Materials Handling. A design for a magnet-handling vehicle has been developed that appears worth pursuing in detail with manufacturers.

5. Plans for the Coming Month. Magnetic tests of the model magnet will be carried out. The model quadrupole will be ordered.

Booster

1. Magnet Design. To further reduce the total magnet cost, it has been decided to eliminate the sagitta aperture-allowance requirement by curving the basic magnet units. This will be done by stacking the laminations in parallel along a curved contour. Further, it has been found that the total stored energy of the magnet system, and with this, its cost, can be reduced by using two magnet apertures per D magnet and two apertures per F magnet. Consequently, it has been decided to use four basic apertures for the magnet structure.

Serious consideration is presently being given to further reduction of the magnet cost (without compromising the basic booster acceptance) by eliminating the all-metal vacuum chamber. This would reduce the magnet gap requirement by approximately 1/4 in. and, consequently, would significantly reduce the overall magnet size. In this case, the vacuum

chamber would be the inside of the magnet core and coil structure, which could be lined with a thin metal sheet to reduce outgassing of the potted structure. The magnet would also be enclosed by an outside vacuum envelope. It seems possible to integrate the forevacuum and high-vacuum systems, while preserving the possibility that the high-vacuum domain within the magnet would still meet the pressure requirements of 5×10^{-7} torr.

2. Enclosure Design. The magnet design changes above will result in a significant reduction in the power-supply requirements; the size of the power-supply chokes and capacitors will also decrease significantly. Consequently, it seems possible to locate these components in the accelerator enclosure proper. This approach is presently being studied further and its consequences for the equipment gallery examined. It seems possible to reduce the equipment gallery from a 360-degree structure to two (each) 75-degree structures and still meet the requirements of locating all necessary components of the rf system, services, etc. in the equipment gallery.

3. Magnet Support System. Details of the magnet-support system have evolved. A single support unit will be used for a F and a D magnet, together forming a magnet module. Two such modules will be supported in a coupled fashion at their adjoining ends, while the support on the opposite ends will be two-thirds the length of a support beam away from the coupled support. A four-point support system will be used. This

will not create a redundant condition because of the flexure of the support beam and because of the range of adjustments considered necessary.

4. Model Program. Work has continued on the basic components. The design of the stacking fixture has essentially been completed, and some subsections of a vacuum-chamber model have been received. In addition, construction of model-magnet measurement coils has been started. A data-gathering system for the magnet measuring program is presently being studied.

5. Plans for the Coming Month. Input parameters for the pre-Title I Report are being examined and it is expected that during the next month the basic conceptual design for this can be completed.

Linac

1. Linac Research Building. The improvement in the linac research building has proceeded slowly. The final connection to the main power in the linac model shop should be completed by July 4, so that the machine shop will become operational. Power to the other experimental facilities in the building should be completed by the middle of July, which will then allow the 500 kW, 200 MHz amplifier-driver to be driven at full power. Plans have been completed for moving a third building between the two existing office buildings adjacent to the research building and enclosing the area between these buildings and the research building.

2. Modelling Program. The low-level stages in the 500 kW, 200 MHz amplifier-driver have been operated up to 2 kW and proper functioning of the control circuits verified. Most materials for the preaccelerator high-gradient column have been delivered and fabrication has started. Improvements have been made in the drift-tube positioning device and its operation verified in a mechanical modelling cavity, using the recently acquired laser-alignment instrument for detecting positioning errors. The problems associated with the fabrication of the 10 MeV quadrupoles seem to now be resolved and quadrupole fabrication is proceeding.

Purchase orders have been issued for the 10 MW rf modulator, the rf power-amplifier cavity, and the rf resistive load. The orders for the 850 kV high-voltage supply, and the high-vacuum pumps for the preaccelerator and 10 MeV cavity are expected to be ready soon. Evaluation of proposals for the field-measuring and control monitor is in process. Proposals for the rolling,welding, and fabrication of the 10 MeV cavity are expected by July 15.

A cooperative effort with ANL on the high-voltage testing of a high-gradient preaccelerator column has been in progress. During the last month, a stainless-steel electrode and an electrode fabricated from an alloy of copper and tungsten were tested, with good results from the latter. Should this development work be successful, some of the design

features will be used in the NAL design and some early high-voltage testing initiated using the ANL high-voltage test facility.

A particle-dynamics program (PARMILA) capable of running many particles through the linac has been adapted to the NAL computer facility. Information on linac cavity acceptances, emittances and inter-cavity spacing is now being developed and studied.

3. Building Design. The linac building design has been advanced and Title I drawings are being prepared. The equipment layout in the gallery is being modified to reflect the changes in the building and the latest information obtained from the fabricators of the rf-system components.

4. Plans for the Coming Month. Title I on the linac building will be completed. Procurement of the components for the 10 MeV linac prototype will continue. Final installation of the electrical power in the linac research building will be completed so that full power tests on the model linac cavities can proceed.

Accelerator Theory

1. Computation. New facilities are being added to the SYNCH computer program to aid studies of coupled motion and of more general misalignments. This is done using 7-component vectors (x, x', y, y', $\Delta p/p$, 1) and corresponding 7 x 7 matrices representing magnet and drift transfer matrices, coordinate shifts, rotations, etc. The program manipulates these vectors and matrices and finds closed orbits, eigenvalues and eigenvectors. A

version of this program for the IBM-360 now exists externally identical to the CDC-6600 code.

The magnet design code LINDA can now be run on the NYU-6600 over the data link. It has been partially converted to run on the Argonne 360.

2. Main-Ring Magnet Parameters. Field computation and design using the TRIM program on the Argonne 360-75/50 computer led to the following parameters for the main-ring bending magnets.

Yoke	B1 (in.)	B2 (in.)
Outer dimension	25 x 16	25 x 14
Beam aperture	5 x 1.5	4 x 2
Pole width	9.29	8.43
Coil-window dimension	2 x 4	3 x 4
Top-yoke thickness	6	5
Side-yoke thickness	5.855	5.285
Coil		
Total no. of turns	12	16
No. of turns in window	9	12
No. of turns in between poles	3	4
Dimension of coil in window	2 x 4	3 x 4
Dimension of coil in between poles	2.145 x 1.5	2.215 x 2

With these parameters and with the thicknesses of the insulations next to the aperture properly adjusted, the field-gradient index $k = \frac{B'}{B}$ stays within $\pm .005\ m^{-1}$ over 85% of the horizontal aperture up to 18 kG and over about 70% of the horizontal aperture at 19.5 kG. The degree of saturation, expressed as the ratio of the ampere-turns required to

that for infinite permeability is 1.037 at 18 kG, essentially identical for both magnets. Pole-face crenellation will be introduced next to widen the good-field aperture beyond 19 kG.

3. Booster Magnet. An analytical approach first used by Hardt at DESY has been adopted tentatively for the determination of the booster magnet pole profiles. These profiles have been used to specify die shapes for model-magnet laminations.

Modifications of this procedure which include the effect of nearness of the magnet yoke have been programmed for the CDC-3600. POLPAR utilizes matrix inversion to calculate certain critical parameters from input data such as gradient limits and radial extent of good field. POLCNTR takes these critical parameters and effects a Schwarz-Christoffel transformation to obtain pole contours, magnetic field on the contour, magnetic field on the median plane, and gradients on the median plane.