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MECHANICAL DESIGN OF THE LAMPF LOW ENERGY PION CHANNEL*

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Summary. A pion channel has been designed and nearly completed that will provide a good quality, high intensity pion beam of energies up to 300 MeV. Important channel features are a vertical bend plane, close alignment tolerances, short channel length, and remote handling near the production target. These features influenced the mechanical design of the magnets, support and alignment, collimation system, vacuum system, and shielding.

Channel Design

The Low Energy Pion Channel at the Los Alamos Meson Physics Facility (LAMPF) is designed to provide a high-resolution, variable-energy pion beam for nuclear structure, particle physics, and radiochemistry research. Pion energy will range from 20-300 MeV. Momentum spread can be varied from ±0.05% to ±2.0% $\Delta p/p$. Pions are produced in a rotating-wheel target by 800 MeV protons from the LAMPF side-coupled resonant-cavity linac. The production angle is 45° in the forward direction with a maximum solid angle of 20 millisteradians. Pion fluxes of up to 10^9 π^+/sec are expected at the higher energies.

The channel is an achromatic optical system consisting of four bending magnets and entrance and exit quadrupole doublets (Fig. 1). The bend plane is vertical for better optical matching to the target. The beam centerline is 35.5-ft. long with 60° bends. This length is kept as short as possible to minimize in-flight pion decay.

High residual-radiation levels will exist near the pion-production target after operation begins at high proton currents. Therefore components located between the production target and the second bending magnet will require remote handling. These components and their vacuum, power, and water connections have been designed for servicing or removal by the "Merrimac" remote-handling system.[1]

Channel Hardware

Magnets

Coils for the front quad-doublet and first bending magnet are wound with mineral-insulated cable.[2] Since the last bending magnet and quad-doublet are identical to those at the channel entrance, they also use mineral-insulated cable. This provides a built-in set of spares for the magnets in the high-radiation area. The second and third bending magnets use conventional epoxy coils.

The two doublets are made of narrow quadrupoles originally designed for use in the proton-beam transport system. The pole-tip ends have a 45° chamfer to reduce the harmonic components of the fringe field.

All the bending magnets are picture-frame magnets with 6-in. gaps. Entrance and exit edges of the poles are curved to provide sextupole focusing for correcting second-order terms in the beam optics. These edges have a 2 1/2-in. x 45° chamfer. Field clamps with moveable segmented nosepieces are adjusted to set the effective boundary to the desired position and shape.

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Support and Alignment

The channel is supported on three stands. These stands are mounted on jacks tied to an 8-ft. thick concrete slab, which also supports the pion-production target. The stands are fabricated from heavy plate to allow close-fitting shielding to be stacked around and under them.

The quadrupoles are assembled into doublets in an optical-tooling dock and are mounted on the stands with a three-point kinematic support. The support allows a doublet to be removed and replaced without re-alignment. This is a requirement for remote handling.

The need to rotate the first bending magnet to a horizontal position for remote removal led to the use of four trunnions to support each bending magnet. The trunnions rest on vee-blocks and flat pads shimmed into position on the stands. Jigs and optical tooling methods are used, and typical positional tolerances are ±0.010 in.

Collimation System

4-jaw Collimators. There are four 4-jaw collimator sets. The 2-in. thick jaws in each pair are kept an equal distance from the beam centerline by being mounted on opposite hand ball screws. Each set of ball screws, located in the vacuum, is driven by a stepping motor through a bellows-sealed rotary feedthrough. A 10-turn potentiometer indicates jaw position. The stepping motor and potentiometer sub-assembly can be remotely removed and replaced.

Each 4-jaw collimator set is mounted on a single vacuum tank flange and can be removed from the vacuum system without removing the vacuum tank. This allows the 4-jaw collimator near the production target to be remotely removed by the Merrimac system.

Beam Plug. The beam plug is mounted along with the second 4-jaw collimator in a tank supported on rails from the second bending magnet. The rails allow the tank to be removed and replaced by the Merrimac system. The vacuum flanges on both ends of the beam-plug box are remotely disconnected by the Merrimac system.

Momentum Slit. Located at the center of the channel, the momentum slit is used to select the momentum bite ($\Delta p/p$) desired at the channel output. The slit is a pair of 3/4-in. thick jaws, each independently driven. The horizontal opening between the jaws can be varied in size and set anywhere in the beam envelope.

Proton Absorber. The proton-absorber assembly consists of two 4-position wheels rotated between positions by friction drives. The wheels are held in position by detents and the position in the beam is indicated by microswitches. An experimenter can load the wheels with various materials (foils, CH_2) in each position to suit the needs of his experiment.

Vacuum System

The pressure required for operation of the channel is 1×10^{-3} Torr or lower. The channel vacuum tube is isolated from the proton-beam vacuum by a foil window,

and is pumped through a single connection downstream of the fourth bending magnet. The pump is a 164-cfm Roots-blower package with a refrigerated baffle.

Tanks for the quadrupoles are seamless type-304 stainless tubing. The tubing in the 11-in. quads is pressed to a 13-in. x 8-in. oval cross-section to accommodate the beam envelope. The tubing in both quads of a doublet is welded directly to the collimator tank between the magnets to minimize the length of the unit.

The bending-magnet tanks are rectangular in cross section, welded of 1/4-in. thick type-310 stainless steel. The tanks are curved to follow the arc of the beam through the bending magnets. To avoid disassembly of the magnets after field mapping, the tanks are slipped through the magnet gaps and the flanges welded on.

Metal vacuum seals are used upstream of the second bending magnet and elastomer O-rings downstream. The four remote-actuated flanges use k-seals. The other metal seals are 0.062-in. diameter aluminum wire.

The remote-actuated flanges get their sealing force from Con-o-seal type clamps. The joints require approximately 1/2-in. of axial motion for disengagement. This motion is provided for by stainless-steel bellows welded into the vacuum tube at the joint. The joint assembly includes guides, flange retractor, and clamp retainer.

Shielding

The channel will be buried in the 23-ft. high proton-beam shielding. A horizontal shielding door above the first three channel magnets allows access for the Merrimac remote handling system. The support under the center stand is filled with steel to provide 9-ft. of shielding along the beam line.

In order to reduce the solid angle for stray charged particles and for neutrons, brass shielding is installed between the quadrupole coils and vacuum tube. Brass is used to fill the bending-magnet gaps outside the vacuum tanks.

Experimental Cave and Controls

A concrete-block cave will be built as required to shield experiments at the channel output. A quad-doublet after the first focus in the experimental cave can pass beam to another target downstream. Chemistry irradiations can be done at a beam dump in the rear wall of the cave. The possibility of using a switching magnet has been looked at for the future.

Controls for the channel and the experiments are housed in a metal counting house located next to the experimental cave. There is a PDP-11 computer and space for 16 experimenters' racks. Patch panels connect the counting house to the experimental cave and the channel.

Acknowledgements

The optical design of the channel was done by Dr. R. Burman. A. Harvey designed the magnets.

References

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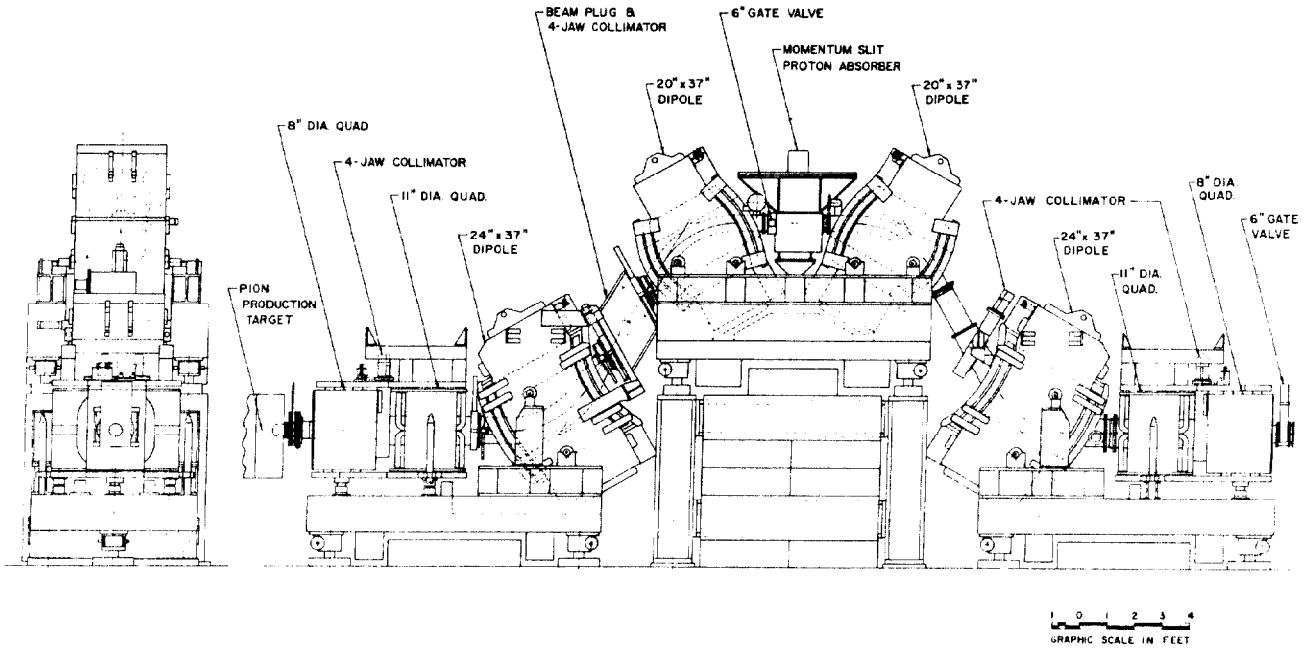


Fig. 1. Front and side elevation view of LAMPF Low Energy Pion Channel. Height of beam centerline at entrance and exit is 5'-0".