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RESEARCH-FACILITY DEVELOPMENT PROPOSAL

LOS ALAMOS MESON PHYSICS FACILITY

Therapy Beam Development - Biomedical Channel Tuning

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Participants

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Four static beams to be used for therapy will be developed along with a fan beam to be used for future dynamic treatments. In addition, we propose to arrive at an understanding of the beam shaping section (Q4-Q8) of the channel so that future beam development will be simplified.

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PROPOSAL INFORMATION

Beam Area: Area A East

Secondary Channel: biomedical channel

Beam Requirements: full use of biomedical channel

Primary Beam Requirements:

Intensity: 0.3uA peak current; corresponds to about 300uA peak in Area A with A3 plug in mid-position

Energies: Whatever is available on our target

Spot Size: Selected periods of optimum vertical spot size (0.3 cm rms)

Running Time Required:

Installation Time: 100 hours

Debug Time: 14 shifts associated with A-east cycle zero

Data Runs: 50 shifts

Scheduling: Spring-Summer 1976

Major LAMPF Apparatus Required: Substantial electronics

Special Requirements: A3 plug in mid-position, later the low intensity 1 in 10 pulse

Special Services: Necessary gates for 1 in 10 low intensity pulse

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Four static beams are planned for clinical work. They have high dose regions in the following configurations: (1) 4 cm diameter x 4 cm deep, (2) 6 cm x 6 cm x 4 or 5 cm deep, (3) 8 cm x 10 cm x 4 or 5 cm deep, and (4) 12 cm x 16 cm x 7 cm deep. The shapes of these beams will be ellipsoidal. In the transverse dimensions the dose distribution must be flat to a prescribed tolerance.

In the depth dimension, the dose is ultimately to be clinically flat; however, initially we will rely on effective dose calculations to find the desired shape for the momentum distribution. We also propose to find a fan beam tune that will be suitable for future dynamic treatments. This beam is to be broad and flat in one transverse dimension and narrow in the other transverse dimension.

Trial TRANSPORT solutions have been found for each tune. Our previous work gives a measure of how well these solutions can predict the actual beams. Starting with trajectories above Q4, the TRANSPORT matrices can predict the positions of particles at the output plane to within about 1 cm rms and the angles to within 25 mr rms. For typical tunes, spot sizes are determined to within 10%, angular spreads to within 20% and positions of waists to within roughly 15 cm. The procedure for tuning Q4-Q8 to match the desired TRANSPORT solution will use both measured beam properties and measured matrix elements. With 5 multiwire proportional chambers operating we can get approximate matrix elements for the transformation from the first focus or from the top of Q4 to the end of the channel. Using either calculated or measured derivatives of the beam properties or of the matrix elements with respect to quad currents, we can do a hand-operated optimization.

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Each beam will be field flattened, and our TRANSPORT solutions have to be consistent or modified to accommodate this additional constraint. Figure 1 is included as illustration to indicate what is meant by "field flattening" as applied to the broad transverse profile of a fan tune. The upper profile was measured during the previous run period and is unacceptably peaked in the middle. An irregularly shaped collimator was mathematically inserted at the top of Q4 resulting in the loss of 25% of the beam. This is an easy procedure since we measured the pion trajectories after BM03 as well as the position at the exit of the channel. The lower profile is the flattened result displayed before collimation of the edges. Other flattening procedures use multiple coulomb scattering in thin plates (1 - 2 MeV) along with collimation to achieve the desired flattness. We are proposing to experimentally study these flattening techniques, finding ones that work with a minimum loss of beam. This study will get feedback from dose measurements done under Proposal #271, "Therapy Beam Development - Dosimetry."

An initial biological model is just now becoming available so that design of static stopping distributions can take place. Stopping depth thicknesses of 4 to 7 cm are needed. The momentum distributions will be tailored by use of the Slit 2 momentum defining jaws, "poor" wedges, or momentum shaping collimators in the Y-Z plane. We can simulate the effects of each of these devices on the existing momentum spectra now on tape, and we propose to experimentally verify the momentum distributions with the BM03 spectrometer. We will also at this time verify the narrowing of the momentum spectrum expected with an optimized wedge.

The maximum depth required for the static beam work is 12 cm. We have so far worked with depths of 19 cm. A lower energy beam provides better sharpness on the sides and on the downstream edge at the expense of higher contamination and possibly lower dose rate in large volumes. We will weigh these factors and select

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a momentum or momenta to be used for the tuning work. Certain beam measurements will be done at high momentum to minimize scattering effects. A wedge is being designed to give a narrow beam of 12 cm range while accepted ± 10% momentum bite. Even though the static beam work does not require a narrow beam, we are preparing for exploratory experiments with the range shifter and with ridge filters.

A second, but related, objective of the proposal is to arrive at a thorough understanding of the transformation properties of the beam shaping section of the channel (Q4-Q8). The upper portion of the channel was tuned in 1974,[1] and an optimized tune for the entrance triplet was found. MWPC's will be installed so that the five dimensional phase space above Q4 can be determined. We will make a catalog of tapes for this single tune with several settings of Slit 1 and Slit 2 which have been added since the upper part of the channel was tuned. These tapes will serve as reference for future studies. This catalog serves as input to ray tracing codes that include apertures in the beam shaping section. The codes predict at the exit of the channel trajectories that are used in field flattening studies, collimator studies, or possibly treatment planning. We are now faced with the prospect of having to measure particle trajectories for every tune to be used in therapy treatment planning. If Q4-Q8 can be sufficiently well-understood we might not have to forever measure every tune.

A MWPC voltage modulator has been developed by D. Doss. We have so far demonstrated that a conventional chamber can be pulsed without apparent physical damage and without causing the chamber to draw measurable current. Using a source, we have seen normal outputs of the chamber as soon as the voltage has stabilized.

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Oscillation of amplifier cards was observed during the transients on an old chamber where card thresholds were not set uniformly. We did succeed in eliminating the oscillations on a new chamber with tested cards, and with amplifier bias values very much lower than needed to plateau. However, the crucial test of connecting the chamber to the encoder has not been made; in this final configuration, the system is much more noise sensitive and induced oscillations could well be a major problem. We should also note that our projected time estimates should be doubled or tripled for any tuning to be done on one pulse in ten.

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REFERENCES

1. M. A. Paciotti, J. N. Bradbury, J. A. Helland, R. L. Hutson, E. A. Knapp, and O. M. Rivera, "Tuning of the First Section of the Biomedical Channel at LAMPF," IEEE Transactions on Nuclear Science, Vol. NS-22, No 3, June 1975. LA-UR-75-447.

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