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OFFICE MEMORANDUM

TO : Distribution

DATE: December 10, 1971

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FROM : R. L. Hutson, MP-7

SUBJECT: TREATMENT PLANNING FOR PION BEAMS

SYMBOL : MP-7

Because the beams from conventional therapy machines can be approximated as coming from a point source, the treatment planning programs can be based on schemes which calculate dose along radials from the source.

The more complex phase space characteristics of the pion beam makes things harder.

Since it will be a long time before we get measured dose distributions on which to base treatment planning calculations, we need to simulate reality as best we can now.

I suggest the following approach. Assume that the treatment mode will be to tune the channel to transport pions of some nominal maximum range, say 25 cm in tissue. Place an adjustable thickness pion energy degrader above the patient. I am going to call this degrader a range shifter RS and call its equivalent tissue thickness RST.

Now adjust the patient's vertical height with respect to the channel so that the beam configuration, which is a function of the tuning of the last quads, is as desired at the distal surface of the target colume. Also adjust the RST so that the pions (the beam is approximately monoenergetic) stop at this distal surface.

As a function of integrated pion flux, move the patient downward so that the beam configuration moves upward through the patient. At the same time increase the RST so that the pion stopping plane moves upward at the same rate.

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Place a collimator above the RS. Vary the collimator plane (CP) aperture as the stopping region moves upward so that the high dose region will conform as closely as possible to the target volume. Refer to Fig. 1.

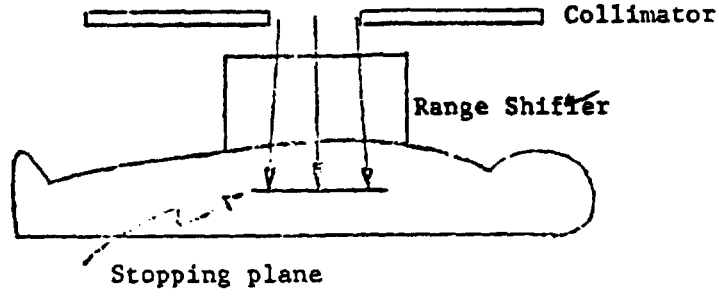

Figure 1.

How can we do treatment planning now based on this scheme?

Step 1 - Use the program PIFLUX to calculate (to 2nd order in beam optics according to the program TRANSPORT) the position and direction of a large number of reference rays in the CP. Save this ray position and direction information.

Step 2 - Set up a 3D dose matrix to encompass the volume which will be receiving pion dose. Let the 25-cm-depth surface of this volume correspond to the distal surface of the target volume. Dose information will be stored in this matrix.

Step 3 - Trace the reference rays, which lie within the CP aperture, through the dose matrix. Using a monoenergetic beam depth dose curve such as those generated by Alsmiller, assign dose to each matrix cell. RBE can be assigned along the curve as desired. Also weight the dose according to the desire integrated flux for the present stopping plane depth.

Step 4 - Increment the RST and the distance of the matrix from the CP and repeat Step 3. Set the CP aperture to the new size.

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Continue the Step 3-Step 4 cycle until the stopping plane has been swept through the target volume.

Straggling is already considered in the Alsmiller calculations.

Multiple scattering can be taken into account by assigning a random, properly weighted transverse displacement to each of the reference rays as they are traced through the dose matrix.

The process described is a jumping off place for setting up treatment planning. Experience will show where simplifications and additions are appropriate.

I believe that, in principle, this represents the best we can possibly do with the information we have.

As measured dose distributions become available that information can very probably be adapted to at least part of the general scheme outlined above.

RH:pat

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