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OFFICE MEMORANDUM

TO : Distribution

DATE: November 20, 1973

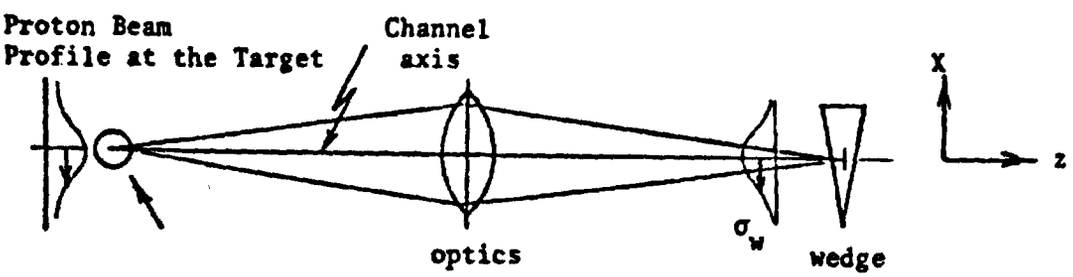
FROM : R. Hutson RLH

SUBJECT : MOMENTUM SPREAD OF THE BIOMED PION BEAM

SYMBOL : MP-3

Introduction

This memo summarizes the results of some PIFLUX studies carried out to determine the magnitudes of various contributions to the momentum spread of the beam as it leaves the wedge energy degrader. The figure below is a schematic diagram of the relevant parameters. As an example I chose the case in which the X magnification, M_X, of the target image formed at the wedge equals -1.2.



Because of the momentum dispersion of the beam at the wedge, a finite pion beam spot size at the wedge is translated into a finite momentum spread of the beam as it leaves the wedge. The rms momentum spread, S, is given by $S = \sigma/d$ where σ is the rms spot size in cm and d is the dispersion in cm/% $\Delta P/P_o$.

Definitions

d : dispersion at wedge = 0.678 cm/% $\Delta P/P_o$.

σ_p: rms proton beam width in the X direction at the target = 0.25 cm.

σ_w: rms pion spot size at wedge for a monoenergetic beam, assuming no multiple scattering in the path between target and wedge. $S_w = \sigma_w/d = 0.317\%$. To first order $\sigma_w = M_x \sigma_p$.

σ_{scat}: rms increase in pion spot size at wedge due to multiple scattering in the path between target and wedge

$\sigma_{scat} = 0.778$ cm at $E_\pi = 95$ MeV. $S_{scat} = \sigma s/d = 1.15\%$
$= 1.24$ cm at $E_\pi = 53$ MeV. $S_{scat} = \sigma s/d = 1.83\%$

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	Case 1 (E_π = 53 MeV)	Case 2 (E_π = 95 MeV)
σ	3.5	2.9
f_1	0.56	0.66
f_w	~ 0.95	~ 0.95
f_2	0.38	0.51
D	0.91	0.75

$F_1 = 0.64 = 1.2\ F_2$ $\quad$ $F_2 = 0.52$

Multiple coulomb scattering was not considered, but the reduction of F will be worse at 53 MeV so that $F_1 < 1.2\ F_2$. Actual dose rates within a given treatment volume are of course a strong function not only of F but also of the geometry of the treatment volume.

Electron Contamination

Experimental data obtained at Berkeley by a LAMPF group three or four years ago indicates that the electron contamination of our beam will be as shown below.

at E_π = 53 MeV, e^-/π^- = 0.44

at E_π = 95 MeV, e^-/π^- = 0.09

Muon Contamination

Considering only pion decay in the last straight section of the channel the μ^-/π^- ratio at E_π = 53 MeV is about 50% greater than the ratio at E_π = 95 MeV.

Summary

The comparisons made above do not necessarily reflect results that would be obtained by detailed analysis of a particular case but they do indicate the trends to be expected; that is, that the number of pions stopped in tissue are not very different in the two cases but that both electron and muon contamination will be significantly worse in the 53-MeV case.

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