PROTON BEAM DOSIMETRY INTERCOMPARISON WITH IONIZATION CHAMBERS (*)

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ABSTRACT

The absolute dosimetry intercomaprison of the INS 52 MeV proton beam using various ionization chambers was performed to establish the standard of proton dosimetry for the bio-medical applications. The agreement better to ±4 % (standard deviation) was obtained among the participants. The instability of the proton beam seems to be responsible for the deviations of the results.

Introduction

The high energy proton beams are recently used in the bio-medical applications, because of their unique dose distributions in irradiated tissue (Bragg curve). Radiobiological experiments have been carried out with the 52 MeV proton beam from the INS FM Cyclotron. Accurate determination of the absorbed dose in biological tissues is vitally important to enable the quantitative analysis of the proton irradiations. Thus, the proton beam dosimetry intercomparison program was organized to compare the techniques and also to establish the standard of the absolute proton dosimetry, among the facilities utilizing the bio-medical proton beam irradiations.

Method

A benchmark proton irradiation field was prepared at the FM Cyclotron of INS. The 52 MeV proton beam was extracted into air through SUS foil and shaped into 3x3 cm field size. The beam profile was monitored by the multi-wire ionization chamber profile monitor to give the uniform intensity distribution over the field. A transmission ionization chamber (He gas flow) was used to monitor the integral beam intensity. The ionization chambers, used for the dosimetry intercomparison, are (1) 13mm$^{\phi}$ by 5mmt Parallel Plate Tissue Equivalent (PPTE) chamber (Univ. of Tokyo), (2) 10$^{\phi}$ by 4.4t PPTE chamber (NIRS) and (3) 0.1cc Spherical chamber (MGH). Either the TE gas (C3H8 64.4%, CO2 32.4% and N2 3.2%) or air was filled in the chamber. Prior to the proton dosimetry, the calibration of chambers to the standard Co-60 gamma field was performed. The agreement better to 1 % was obtained for the Co-60 calibration, which is the basis for proton dosimetry. The entrance dose of the 52 MeV proton beam was measured by the participants and the results are compared.

Results and Discussions

The results of intercomparison measurements are summarized in Table 1. The first raw shows the reported proton dose in tissue (Gy) in a monitor unit. The precision of the measurements itself is within one percent. All the stated dose includes the necessary correction and conversion factors, in translating the observed charge in chamber into the absorbed dose in tissue, based on the Cavity theory, such as gas density, saturation corrections, $\bar{W}$-values or stopping power ratio. The accuracy of

the conversion is estimated to be about ± 6%.
Two corrections for the beam inhomogeneity on the chamber size and shape were made. Fig.1 shows the two dimensional beam profile measured with a small silicone diode (Maruhashi 1980). The iso-dose contours are produced, assuming that both horizontal and vertical profiles remain unchanged independent on the location. As the dose profile is not uniform within the sensitive area of the chambers, correction was made for each chamber taking the size and shape of the chamber and the beam profile into account. The beam non-uniformity correction factors thus estimated was 2.8%(1), 1.4%(2) and 1.5%(3), respectively. Fig.2 shows the Bragg curve of this proton beam in Lucite. At the entrance region, the dose increases as the absorber thickness increases. So, the thickness of the chamber wall is to be corrected for the true entrance dose. This wall thickness correction amounted to -2.4%(1), -2.4%(2) and -4.3%(3), respectively. The corrected dose is shown in the second raw of Table 1.
The overall agreement better to ± 4% (standard deviation) was obtained, which is within the stated accuracy of ± 6%. However, the stated dose by NIRS is substantially higher that others. One reason for this may be that the proton beam profile is not always constant as shown in Fig.1, which yielded the fluctuation of the central dose.

Table 1. Results of Proton Dosimetry Intercomparison at INS

	Tokyo Univ. TE-TE	Tokyo Univ. TE-Air	NIRS TE-TE	NIRS TE-Air	MGH TE-TE	MGH TE-Air	Average
Stated Dose(Gy)	0.125	0.125	0.1395	0.133	0.126	0.130	0.129(±4.0%)
Corr. Dose(Gy)	0.125	0.125	0.138	0.132	0.122	0.125	0.129(±4.2%)

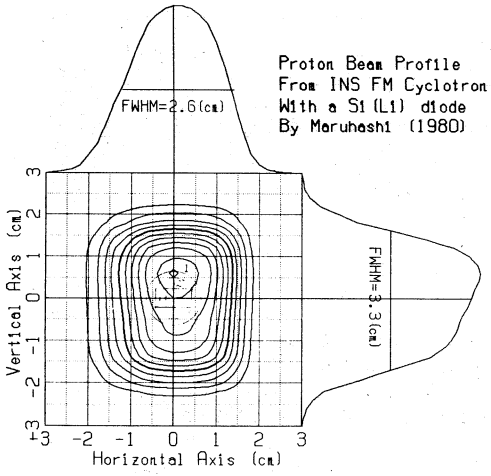

Fig.1 Profile of 52 MeV proton

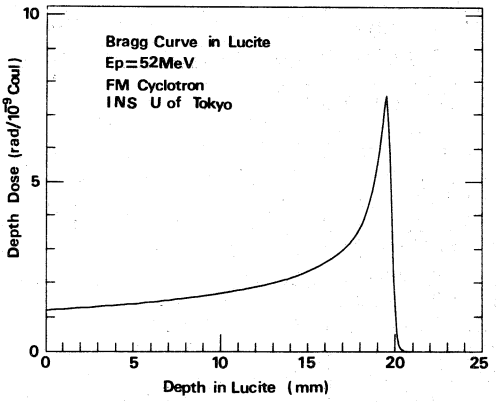

Fig.2 Bragg curve of 52 MeV proton

Acknowledgement We are grateful for Mr.Sugai,I., Mr.Takaku,K., Dr.Hasegawa,T. and Dr.Hirao,Y. of INS in their valuable cooperation in this project.
(*) Work supported by the US-Japan Cooperative Cancer Research Program (High LET Radiation Therapy)