A9－5

Proton dosimetry intercomparison based on the ICRU protocol

Akifumi Fukumura[1], Yasuyuki Futami[1], Takeshi Hiraoka[1], Kaname Omata[1], Mitsue Takeshita[1], Kiyomitsu Kawachi[1], Tatsuaki Kanai[1], Nobuyuki Miyahara[1], Stanislav Vatnitsky[2], Michael Moyers[2], Daniel Miller[2], Greg Abell[2], Eros Pedroni[3], Adolf Coray[3], Alejandro Mazal[4], Wayne Newhauser[5], Oliver Jaekel[6], Juergen Heese[7], Lynn Verhey[8], Inder Daftari[8], Erik Grusell[9], Alexander Molokanov[10] and Charles Bloch[11]

[1]NIRS(Japan), [2]LLUMC(USA), [3]PSI(Switzerland), [4]CPO(France), [5]NPTC(USA), [6]DKFZ(Germany), [7]HMI(Germany), [8]UCSF(USA), [9]UUH(Sweden), [10]JINR(Russia), [11]IUCF(USA)

Several new proton therapy projects are in progress globally, especially in Japan. However dosimetry standards for proton beam have not been established. It is necessary for proton therapy facilities to compare the absorbed dose determined by their own dosimetry system with others and to evaluate the consistency of absorbed dose.

The International Commission on Radiation Units and Measurements (ICRU) has recently published a proton dosimetry protocol (ICRU report 59), which provides updated physical data to derive proton absorbed dose-to-water and recommends using ionization chambers calibrated in a cobalt-60 beam in terms of air kerma or absorbed dose-to-water.

We report the results of the international proton dosimetry intercomparison, in which the ICRU protocol was first adopted. The comparison was performed at Loma Linda University Medical Center (LLUMC) with participation of worldwide eleven institutions.

Table 1: Proton beam data (following the notation given in ICRU 59)

Parameter	Value
Accelerator proton energy, MeV	155
Proton energy incident on phantom, MeV	135
Field size, cm	15×15
Width of SOBP, cm	6
Range (R) in water to 10% dose pt., cm	13.79
Depth (D) of measurements in water, cm	10.27
Residual range (R-D), cm	3.52
Stopping power ratio $(s_{w,air})_p$ at this energy	1.132
K_{hum}	0.997
w_t/W_c	1.031
C_p	1.167
k_p	1.030

The dose measurements were carried out at horizontal beam line of the LLUMC proton therapy facility. An ionization chamber was located at the center of the 6 cm-width spread-out Bragg peak of energy-modulated proton beam with accelerator energy of 155 MeV. Table 1 shows the data of the proton beam, in accordance with ICRU dosimetry worksheet. Each ionization chamber was irradiated by proton beam of which quantity is 10^6 Monitor Unit(MU).

In advance of the proton measurement, all ionization chambers were calibrated in a ^{60}Co γ -ray field with LLUMC chambers which are traceable to the National Institute of Standards and Technology (NIST, USA). The center of the sensitive volume of each chamber was placed in a polystyrene phantom at a depth of 5 cm, a field size of 10 cm$\times$10 cm and source-to-chamber distance of 80 cm. The measurements were carried out without correction to the effective point of measurement. Two German institutions adopted calibration factors in terms of absorbed dose-to-water.

Table 2 summarizes the results of the proton dosimetry intercomparison. The ICRU protocol recommends employing thimble ionization chambers. Then the data obtained by other-type chambers were not taken into account in Column 4 of the table. The standard deviation of the dose measurement among the participants was less than 1% of the mean value. The results showed that the ICRU protocol should be adopted for practical proton beam calibration and that this consistency of the comparison established a worldwide common framework for proton absorbed dose.

Table 2: The results of proton dosimetry intercomparison

Institution	Ionization chamber	Proton dose (Gy/10^6MU)	Institution's statement of proton dose (Gy/10^6MU)	Deviation from mean (%)
LLUMC	Exradin T1	1.361	1.365	-0.5
	PTW Farmer	1.369		
NIRS	PTW Farmer	1.369	1.383	+0.8
	Exradin T2	1.396		
PSI	Exradin T1	1.358	1.363	-0.7
	Exradin T2	1.368		
CPO	Far West IC-18	1.385	1.385	+0.9
NPTC	Exradin T1	1.364	1.361	-0.8
	Exradin T1	1.358		
DKFZ	PTW Farmer	1.363	1.363	-0.7
	Wellhofer IC03	1.384		
HMI	PTW 0.125cc	1.360	1.360	-0.9
	PTW Marcus	1.417		
UCSF	Far West IC-17A	1.400	1.400	+2.0
UUH	Far West IC-18	1.381	1.381	+0.6
JINR	CEM Far TE-2	1.375	1.375	+0.2
IUCF	Exradin T1	1.361	1.361	-0.8
	PTW Marcus	1.376		
Mean			1.372$\pm$0.012	