

Profile Measurements at large Field Sizes

MEPHYSTO mc² 3.2 or higher

1 Problem

The acquisition of basic beam data for radiotherapy treatment planning systems may necessitate the measurement of photon beam profiles in a water tank at field sizes that are too big for the size of the tank.

One of the most challenging measuring tasks is a profile measurement at a source-to-surface distance (SSD) of 100 cm at a nominal field size of 40 cm x 40 cm. The required scanning lengths are listed in Table 1, assuming that the field size is defined at an isocenter distance of 100 cm, and that an additional margin of 3 cm on each side of the profile shall be measured.

Measuring depth	Field size 40 cm x 40 cm, defined at isocenter distance of 100 cm		
	SSD = 100 cm	SSD = 90 cm	SSD = 80 cm
0 cm	46	42	38
5 cm	48	44	40
10 cm	50	46	42
15 cm	52	48	44
20 cm	54	50	46
25 cm	56	52	48
30 cm	58	54	50
35 cm	60	56	52
40 cm	62	58	54

Table 1: Scanning lengths (in cm) required to measure a profile within the positions of the 50% dose values plus an additional margin of 3 cm on each side. The red figures indicate situations which cannot be fully measured with a PTW MP3-M system (max. scanning length 50 cm).

2 Solutions

PTW offers the following possibilities to overcome the problem:

1. Measure at a reduced SSD, convert the measured data to the desired SSD
2. Measure half-sided profiles, symmetrize the measurements
3. Measure half-sided profiles, shift the tank, and put the halves together

Solutions 2 and 3 are described in the MEPHYSTO software manual. The details relevant for solution 1 are explained in the following.

SSD conversion

To measure large fields without shifting the water tank the SSD can be reduced to 90 cm or 80 cm according to Table 1. MEPHYSTO (Version 3.2 or higher) features a “Convert SSD” function in the “Processing” menu that transforms the profiles measured at a reduced SSD’ to the desired SSD. The conversion is done using the following formula:

$$x = x' \cdot \frac{SSD + d}{SSD' + d}$$

where d is the measuring depth, x’ the off-axis coordinate of the measured profile, and x the corresponding coordinate of the converted profile.

As the conversion is based on geometry only, deviations in the penumbra and scattering region of the profiles are unavoidable. While the general shapes of the profiles are almost identical and the field sizes match within 0.2 mm, the penumbra widths obtained with the “Convert SSD” function are slightly larger than the ones obtained by measurement. The differences increase with measuring depth, but normally do not exceed the values listed in Table 2, neither for flattened beams nor for flattening filter free (FFF) beams.

Detector	SSD = 90 cm	SSD = 80 cm
Ionization chamber 0.125 cm ³	0.5 mm	1.0 mm
Dosimetry Diode P	0.3 mm	0.5 mm

Table 2: Deviation between penumbra widths obtained from converted profiles and from profiles measured at SSD = 100 cm. The widths of the converted profiles are larger but do not exceed the indicated values.

A typical penumbra width for a 40 cm x 40 cm field at a depth of 20 cm is in the order of 15-20 mm, and an inaccuracy of 1 mm can be accepted in many practical cases. Therefore, the implemented conversion function is considered to be adequate, especially in view of the facts that measured penumbra widths depend on the type of used detector, and that tank shifts are also prone to errors.

3 Summary

The easiest way to measure beam profiles at a field size of 40 cm x 40 cm, a SSD of 100 cm and at depths greater than 10 cm (SSD Setup) or 20 cm (Isocentric Setup) is the reduction of the SSD for the measurements. The measured profiles are conveniently scaled to the desired SSD by the MEPHYSTO software (Version 3.2 or higher). The converted profiles exhibit a very good agreement in terms of general shape and field size, the penumbra widths, however, may deviate by up to 1 mm. This is considered acceptable in most practical cases.