Simplifying Assumption for Determining Sc and Sp

ANDERSON Regional Medical Center

Paul King, Alice Cheung, Scott Anderson, Greg Thompson, Madison Fletcher

Anderson Regional Cancer Center
Meridian, Mississippi

Purpose

Total scatter factor, Scp(mlc, jaw), is a function of collimator field size and effective field size. It is useful to simplify Scp by modeling it as separable into component functions Sc(jaw) and Sp(mlc). The conventional technique for separating Sc from Sp uses the method described by Khan[1]. Using Khan's method, these components are separated as follows.

$$Sp(mlc) = \frac{Scp(mlc = jaw)}{Sc(jaw)} \quad \textit{Eq. 1}$$

A simpler method would be to distribute Scp equally between Sc and Sp.

$$\sqrt{Scp(mlc = jaw)} = Sc(jaw) = Sp(mlc) \quad \textit{Eq. 2}$$

This alternative method would require only a subset of the data required by Khan's method, conveniently excluding all in-air measurements. The goal of the present work is to benchmark the accuracy of this simpler method against the conventional method.

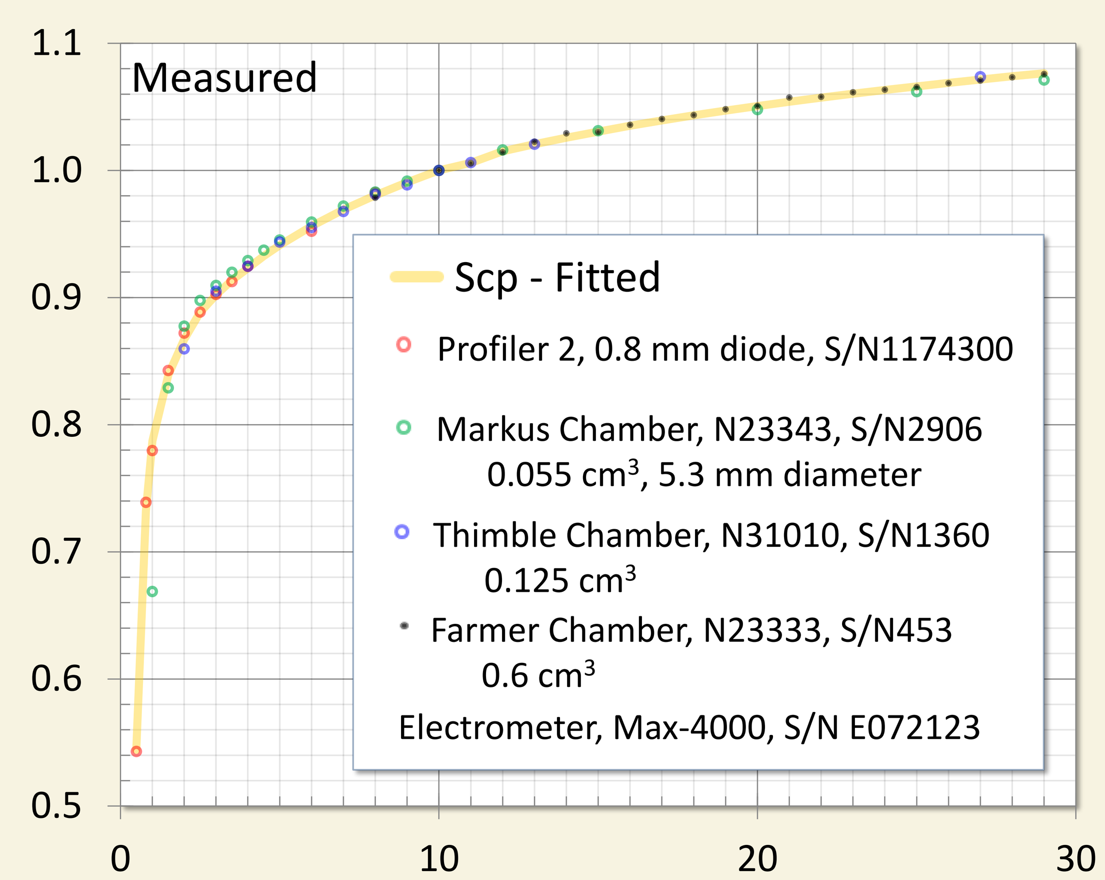
Methods

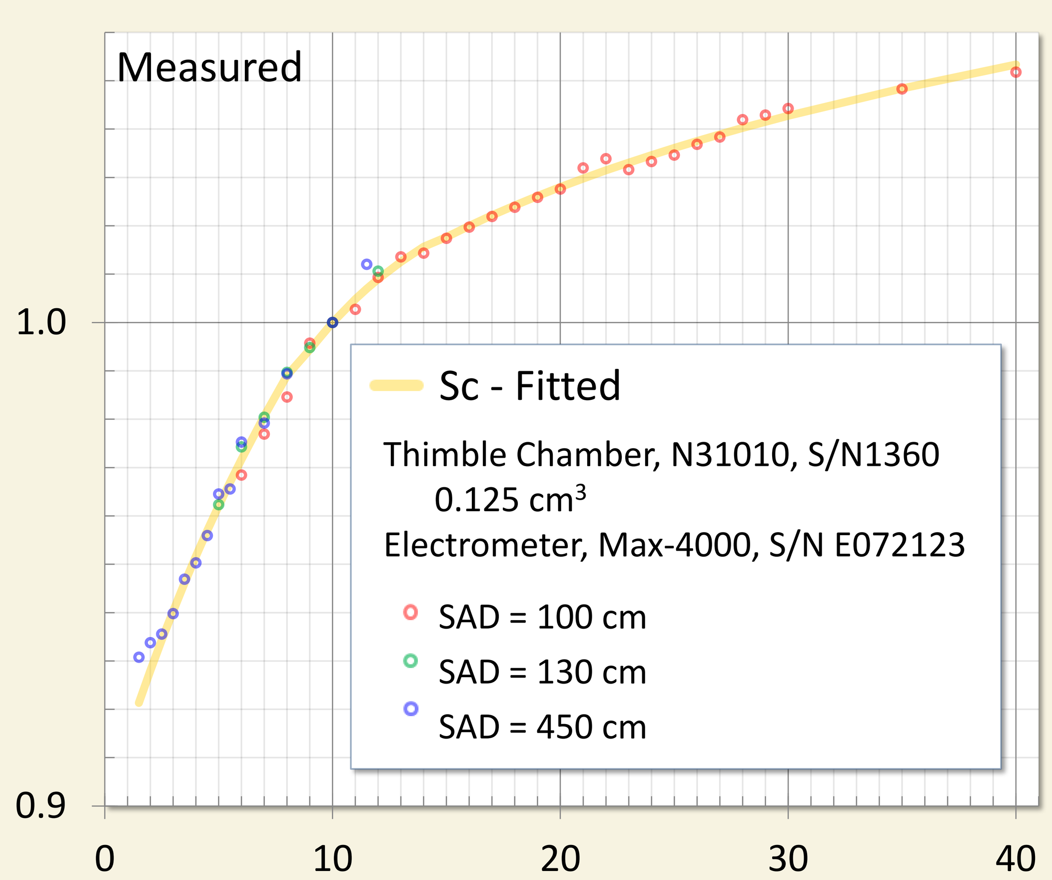
Radiation output measurements were made using 100 MU of the 6 MV photon beam produced by a Clinac 23EX.

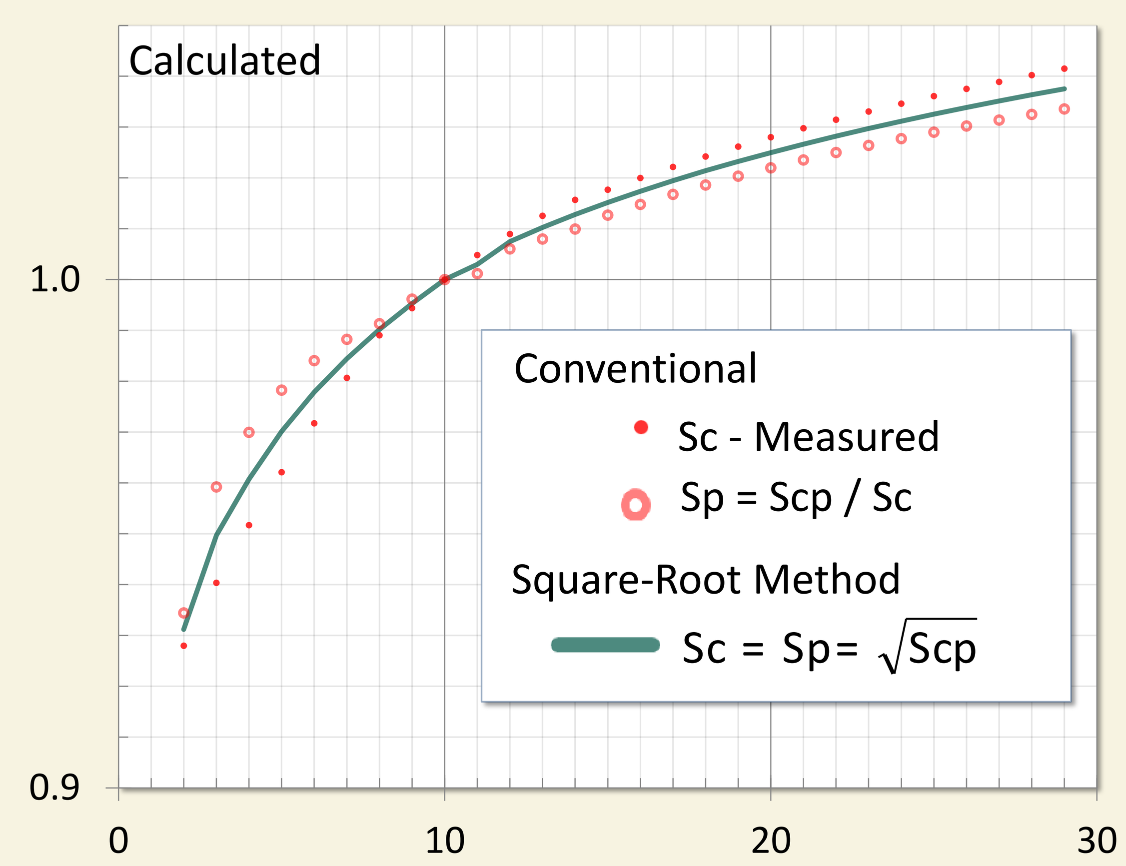
Scp and Sc curves were measured and fitted using the conventional method.

Relative output was measured at the nominal d_{max} (1.5 cm) in a plastic water phantom. In-air measurements were made using a 1.4 cm acrylic buildup-cap.

These were used to calculate a conventional Sp. The square-root of the measured Scp curve was also taken to calculate alternative Sc and Sp curves.







A 0.125 cc ion chamber was used to measure Scp values for a set of blocked benchmark fields. Field size combinations were limited to between 2x2 and 29x29 to ensure no measurement artifact from the chamber or phantom.

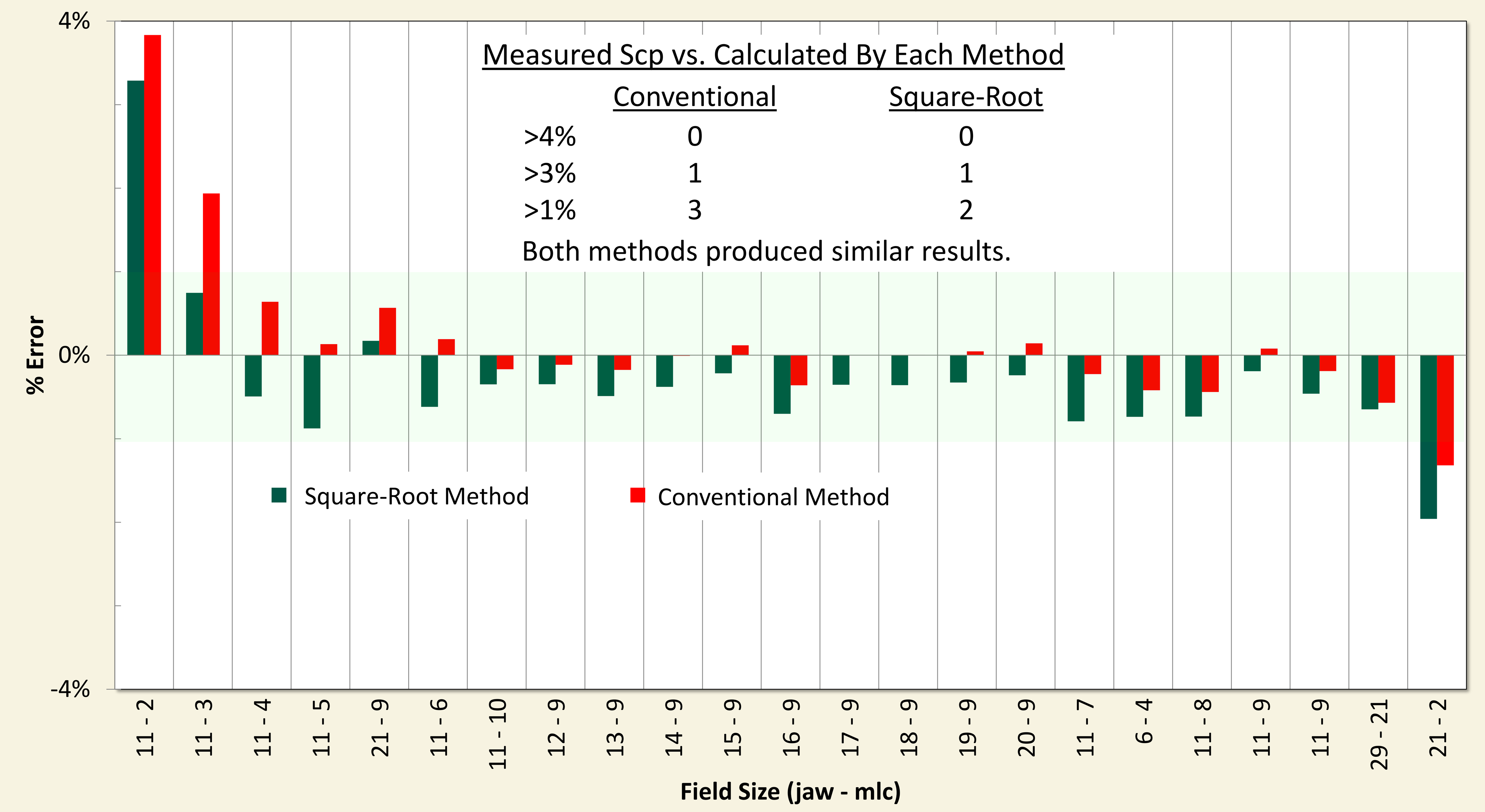
Measured values were then compared to those predicted, both by the conventional method and by the proposed square-root method. The measurements were then re-sequenced to help visualize the results.

JAW	11	11	11	11	21	11	11	12	13	14	15	16	17	18	19	20	11	6	11	11	11	29	21
MLC	2	3	4	5	9	6	10	9	9	9	9	9	9	9	9	9	7	4	8	9	9	21	2

References

[1] F. Khan, The Physics of Radiation Therapy, Williams & Wilkins, Baltimore, MD, 1984.
[2] K. Lam and R Ten Haken, "In phantom determination of collimator scatter factor", Med. Phys., 7, 1207-1212 (1996).

Results



Discussion and Conclusion

The conventional technique for separating Sc from Scp is the division method described by Khan, given in equation 1. Khan's method depends on the simplifying assumption that output in-air, Sc, can be appropriately measured using a buildup-cap, so that Sp is calculated as Scp / Sc. Under this assumption, measured values of Sc correspond to a zero effective field size with no Sp component.

Use of a buildup-cap imposes limits on accuracy, and accuracy is most important among the useful properties of any candidate measurement method. In this context, accuracy means the ability of the resulting Sc and Sp functions to adequately predict composite Scp(mlc, jaw) values across the range of useful combinations of collimator and effective field size.

Lam and Ten Haken[2] suggest an alternative to Khan's method, seeking to eliminate the distorting effect of the buildup-cap by eliminating the in-air measurement. They achieve this by measuring Scp under varying combinations of collimator and effective field size and inferring the component functions from these composite measurements. Their method does reduce small-field distortion, though at the cost of much greater complexity.

It can be shown by measurement* that Scp, measured exclusively in-phantom, is not perfectly and uniquely separable into Sc and Sp. As ideal separation is not possible, no method of separation is ideal. So, though useful, Lam and Ten Haken's method is not ideal.

The square-root method, presented here, avoids in-air measurement like Lam and Ten Haken's. But, simplicity is a useful property in any analysis method. The square-root method was selected to provide the simplest possible approach.

Over the 23 benchmark cases evaluated, the square-root method was shown to be no less accurate than Khan's. Each method produced blocked-field Scp values which agreed with measured values within 4% for all cases and within 3% for all but one case. The conventional method agreed within 1% in all but 3 cases, while the square-root method agreed within 1% for all but 2 cases.

Though it would need to be validated for any specific beam to which it might be applied, under the conditions studied, use of the simplifying assumption that Sc = Sp would seem to be both justified and useful.

* *Suppose Scp was perfectly separable into Sc and Sp. Because Sc(10) ≡ 1, Sp(mlc<10) could be directly determined by measuring Scp(10, mlc) . A series of similarly linked measurements could then be used to incrementally determine all values of Sc and Sp to yield consistent functions. Refuting separability requires demonstrating that the result of this process is not consistent. This is shown with 3 measured values.*

Measurement	Definition	Analysis
Scp(4, 10) = 0.962	Sc(10) = 1.000	Scp(4, 10) & Sc(10) ⇒ Sp(4) = 0.962
Scp(4 ,21) = 0.971		Scp(4, 21) & Sp(4) ⇒ Sc(21) = 1.009
Scp(10, 21) = 1.029		Scp(10, 21) & Sc(21) ⇒ Sp(10) = 1.020
	Sp(10) = 1.000	But, Sp(10) ≠ 1.020
		Thus, Scp is not fully separable

Poster Number: SU-E-T-293
Presented at AAPM 56th Annual Meeting & Exhibition
July 20-24, 2014
http://bit.ly/1lCYak4

1704 23rd Avenue
First Floor
Meridian, Mississippi 39301