# Small field output correction factors at 18MV

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## Background and Objective

The response characteristics and correction factors for detectors in small megavoltage photon fields are well studied and summarized in [1]. In this report, only accelerator energies up to 10 MV were considered, as these are the primary energies recommended for stereotactic treatments and intensity modulated radiotherapy. However, many facilities operate accelerators providing also energies up to 18MV, which still need to be characterized and commissioned. Literature data for detector response at such high energies is sparse. Therefore, in this work we compare the response characteristics of ten detectors for small fields at photon energies of 18 MV to extend the available data.

## Methods

- **The considered detectors:** PTW Semiflex-3D-31021, PTW PinPoint-31006, PTW 60012, PTW 60008, Sun Nuclear EDGE, iba PFD-3G-pSi and iba SFD, PTW 60019, EXRADIN scintillator: W2-1x3 and GAFChromic EBT-3 film.

- **Measurement Setup:** ELEKTA Versa HD accelerator at 18MV together with of a PTW MP3 water-phantom at a source to surface distance (SSD) of 90 cm and the considered detector isocentrically at 10 cm depth with their effective points of measurement as stated by the manufacturers.

- **Field-sizes :** 10x10cm², 6x6cm2, 4x4cm², 3x3cm², 2x2cm², 1.4x1.4cm², 1x1cm² , 0.9x0.9cm², 0.8x0.8cm² , 0.7x0.7cm², 0.6x0.6cm² and ,0.5x0.5cm² . All measurements started with the 10x10cm2 field descending to the 0.6x0.6cm2-field repeating this series three times. Detectors were mounted axial, if possible.

- **EXTRADIN scintillator W2-1x3** was calibrated following the small field water tank method described by the manufacturer, irradiating the fiber in minimum and maximum configuration in a 10x10cm² field.

- **Film analysis:** The dose down to 2 cm field size was calculated as the arithmetic average of the central 15x15 pixel region. For the small fields we used the sum of two sigmoid functions to fit each dose grit in x- and y-direction, followed by a fit to the maxima of both directions to get both the real field size (FWHM) and the maximum dose of the field.

- **Calculation:** For each detector field output correction factor were calculated according to [1] using film as the dose reference. Because the calculation of the correction factors get influenced even from small dose-fluctuations, the film data were fitted by an analytical physical dose size dependence, established by [2].

## Results and Discussion

- **General observations:**
An increase of the correction factor happen again below the field size of 1 cm for all detectors with the most pronounced manifestation for the PFD diode.

- **Scintillator W2-1x3:**
deviated least from the film.

- **Shielded diodes (PTW-60008, Sun Nuclear EDGE):**
showed the highest overresponse at small field-sizes

- **Unshielded diodes (PWD-60012, SFD):**
over-responded
at small fields due to charged particle disequilibrium and
at large fields due to more low energy-photons

- **PFD and PTW MicroDiamond:**
increasingly overresponded below field sizes of 3 cm resulting in corrections higher than for the unshielded but lower than for the shielded diodes.

- **Ionization chambers:**
show the known volume effects at small fields and their response decreases there up to 10% for the Pinpoint detector and up to 25% for the Semiflex 31021 detector.

- **Comparison 18 MV and 10 MV:**
There is very little difference between the corrections for PTW 60012 and PFD at 18 MV and in [1] for 10 MV (filled symbols in figure 1).
For PTW-60008 and SFD the corrections in [1] increase from 6 MV to 10 MV. This trend continues also to 18 MV.
MicroDiamond and EDGE-diode also require larger corrections at 18 MV.

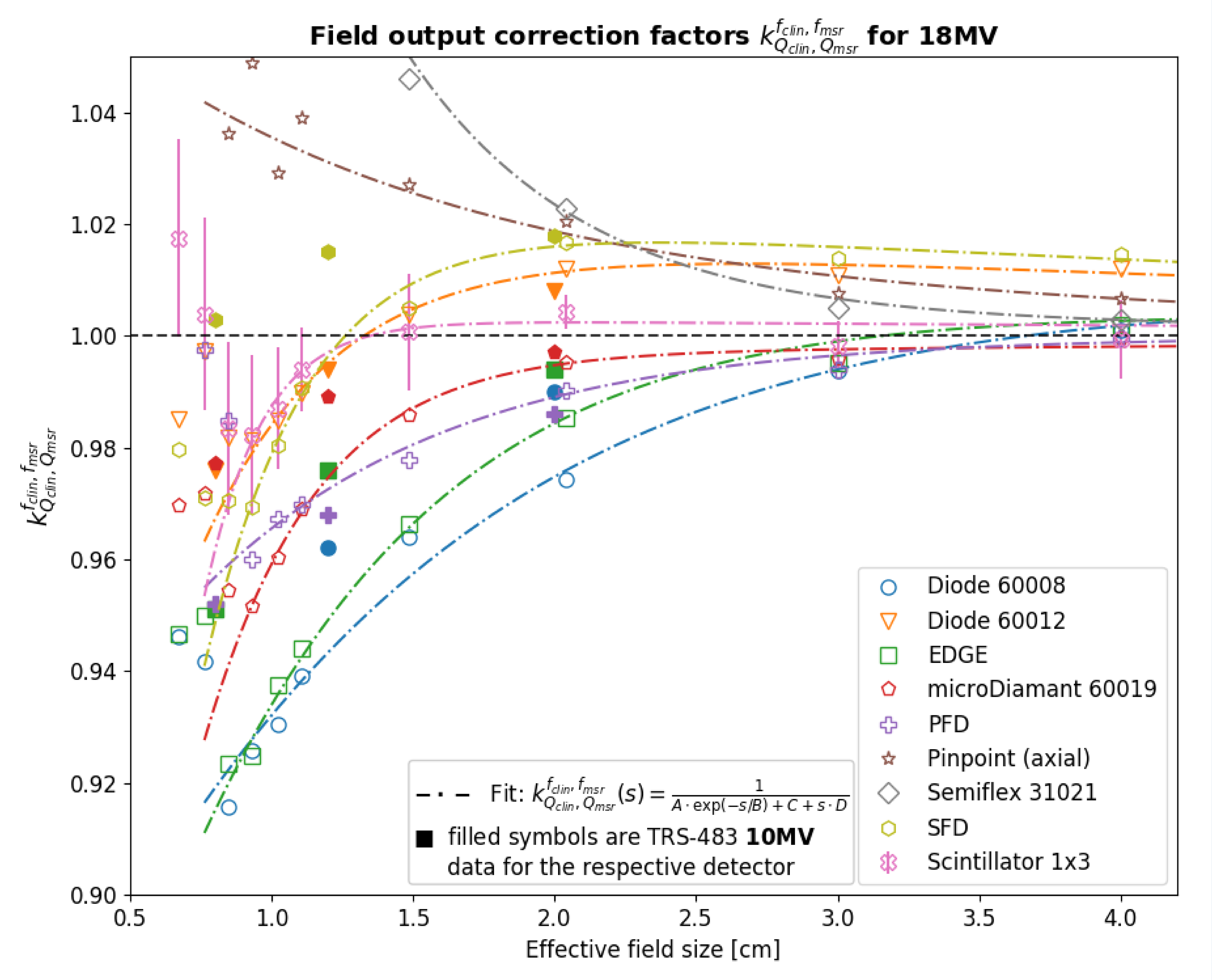


**Figure 1:** Field output correction factors for different detectors at 18 MV, depending on the measured field-size. The filled symbols show the corresponding values at 10 MV published by [1| for comparison. Only error bars for the scintillator are shown for clarity purposes.

## Conclusions

- **Field output correction factors were determined for 18 MV for quadratic fields between 10 cm and 0.5 cm side length.**
- **For most detectors the corrections are larger than those tabulated for 6 MV and 10 MV in [1].**
- **The use of beam quality specific field output correction factors will improve the accuracy of output data in small high-energy photon fields.**

## References

[1] INTERNATIONAL ATOMIC ENERGY AGENCY, Dosimetry of Small Static Fields Used in External Beam Radiotherapy, Technical Reports Series No. 483, IAEA, Vienna (2017).
[2] O. A. Sauer and J. Wilbert, Measurement of Output Factors for Small Photon Beams: Measurement of Output Factors for Small Photon Beams, Medical Physics 34, 1983–1988 (2007)..

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