International Conference on Advances in Radiation Oncology #ICARO2

# Application of the PTW microDiamond in small field dosimetry on different accelerators: Comparative measurements and Monte Carlo calculations

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# Introduction

- Literature data on PTW microDiamond (mD) in small fields are in fairly good agreement down to about 1 cm field size, while controversial results are reported for very small fields: for 5 mm field sizes correction factors  ranges from -4% to + 2%

- Reasons for discrepancies are still not clear, they could include
  - variability of individual detector properties
  - differences in beams produced by different linacs
  - issues of detector modelling in Monte Carlo simulations
  - differences in measurement protocol

- In this work, an investigation of the mD response has been carried out with purpose
  - To evaluate variability of dosimetric properties among individual mD detectors
  - To assess influence of accelerator type and collimation system on the mD response
  - To  check consistency of Monte Carlo calculation of mD output correction factors for three different linacs

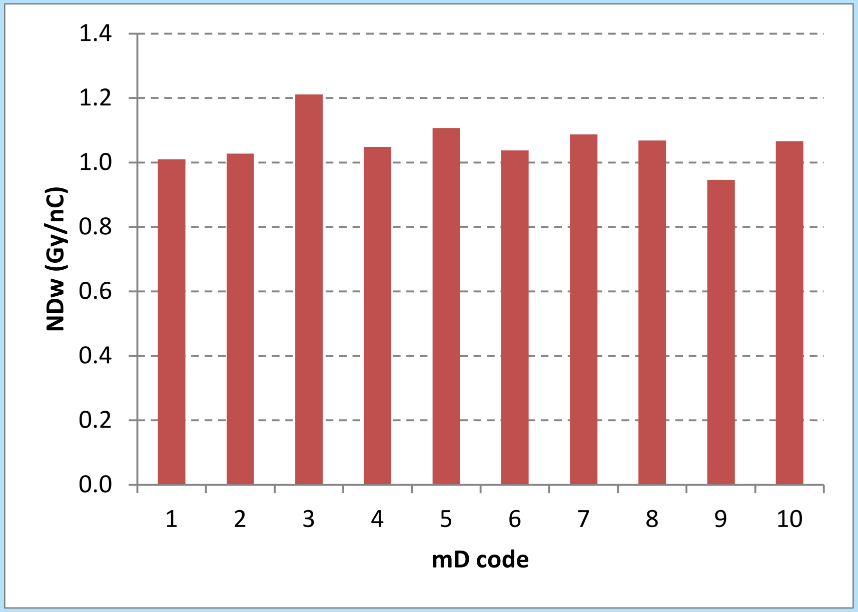
# Materials and Methods

| *Accelerator type* | *$TPR_{20,10}$* | *Collimation system* | *Nominal field size (mm)* |
|---|---|---|---|
| CyberKnife | 0.640 | Fixed collimators | 5 to 60 diameter |
| Varian DHX | 0.670 | Jaws | 6 to 100 square side |
| Elekta Synergy | 0.683 | Jaws and MLC | 6 to 100 square side |

| **Detector type** | *Number of detectors* | *Diameter (mm)* | *Thickness (µm)* |
|---|---|---|---|
| mD PTW 60019 | 10 | 2.2 | 1 |
| Ediode PTW 60017 | 2 | 1.1 | 30 |

- $N_{Dw}$ measurement in Co-60 beam and $k_Q$ determination in accelerator beams for ten mD detectors
- Monte Carlo calculation of mD and Ediode $k_{Q_{clin},Q_{msr}}^{f_{clin},f_{msr}}$ factors for the beams actually used
- Validation of $k_{Q_{clin},Q_{msr}}^{f_{clin},f_{msr}}$ calculation for the mD by comparison of field factor measurements by mDs and Ediodes

# Results: calibration coefficients and $k_Q$




microDiamond $N_{Dw}$ calibration factors
Type A uncertainty 0.3% (k=1)

- $N_{Dw}$ average value
  1.06 Gy/nC ± 6.5% (k=1)
  with maximum spread
  about 25%
- Sensitivity variations are consistent with an active volume thickness
  1 µm ± 0.06 µm (k=1)
  and a maximum deviation from nominal thickness (1µm)
  ~ 250 nm

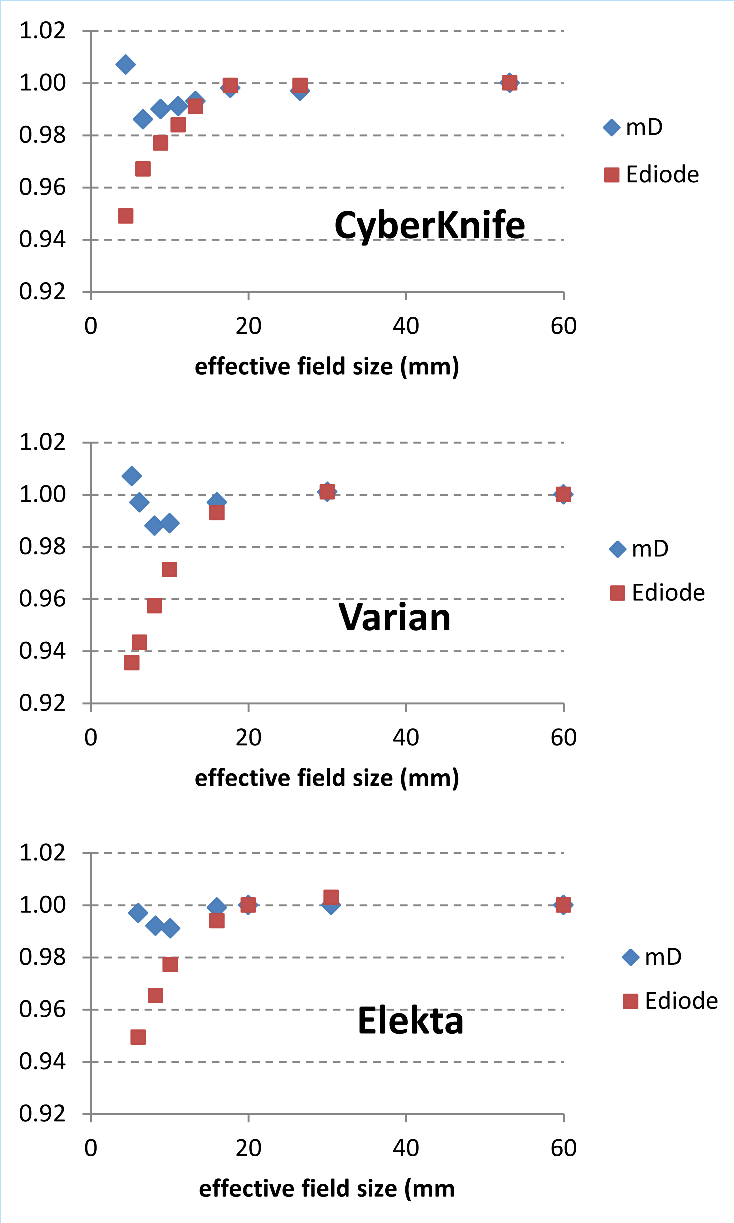
These variations have negligible effects on output correction factor calculation

| measured $k_Q^{(*)}$, 6 MV beams | | | |
|---|---|---|---|
| | CyberKnife | Elekta | Varian |
| Average value | 0.982 | 0.978 | 0.978 |
| st. dev. (%) | 0.4% | 0.4% | 0.4% |

(*)Type A uncertainty 0.5% (k=1)

High reproducibility of $k_Q$ values among ten mDs in three linac beams

# Results: MC output correction factors




Type A uncertainties ≤0.3% (k=1)

$$k^{f_{clin}, f_{msr}}_{Q_{clin}, Q_{msr}} = \frac{D^{f_{clin}}_{w,Q_{clin}} / D^{f_{clin}}_{det,Q_{clin}}}{D^{f_{msr}}_{w,Q_{msr}} / D^{f_{msr}}_{det,Q_{msr}}}$$

- mD correction factors are between
  +0.7% and -1.4%
- The behaviour of mD correction factor at smaller field sizes originates from a trade-off between perturbation and volume averaging effects
- Ediode correction factor monotonically decreases with field size (correction is around 6% for the smallest fields)

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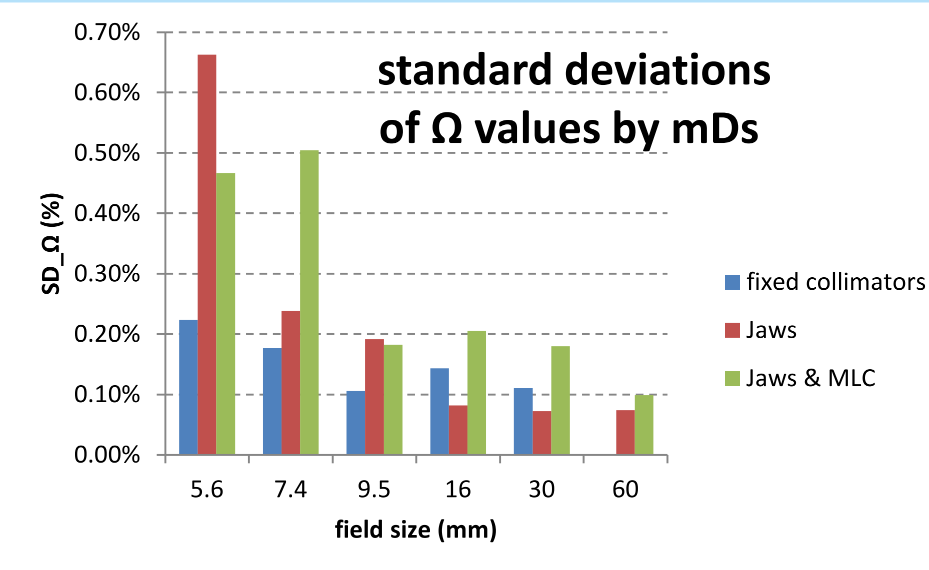
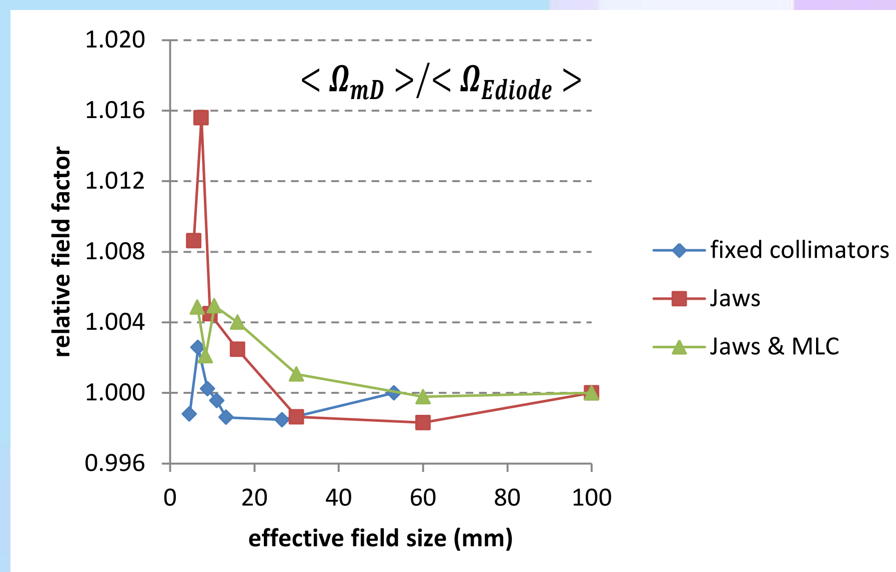
# Results: Field factors




$$\Omega^{f_{clin},f_{msr}}_{Q_{clin},Q_{msr}} = \frac{M^{f_{clin}}_{Q_{clin}}}{M^{f_{msr}}_{Q_{msr}}} k^{f_{clin},f_{msr}}_{Q_{clin},Q_{msr}}$$

- Agreement between $< \Omega_{mD} >$ and $< \Omega_{Ediode} >$ is generally well within 1%
- Taking into account difference in beam size (~0.1 mm) between mDs and Ediodes irradiations the odd 1.6% difference reduces to 0.8%
- In case of fixed collimators agreement is better than 0.3%

- SD of field factor values is generally below 0.5%
- The smallest SD values are found for beams shaped by fixed collimators
- Larger SD values at smaller field sizes are related to a lower reproducibility of small beams shaped by jaws or multi leaf collimators

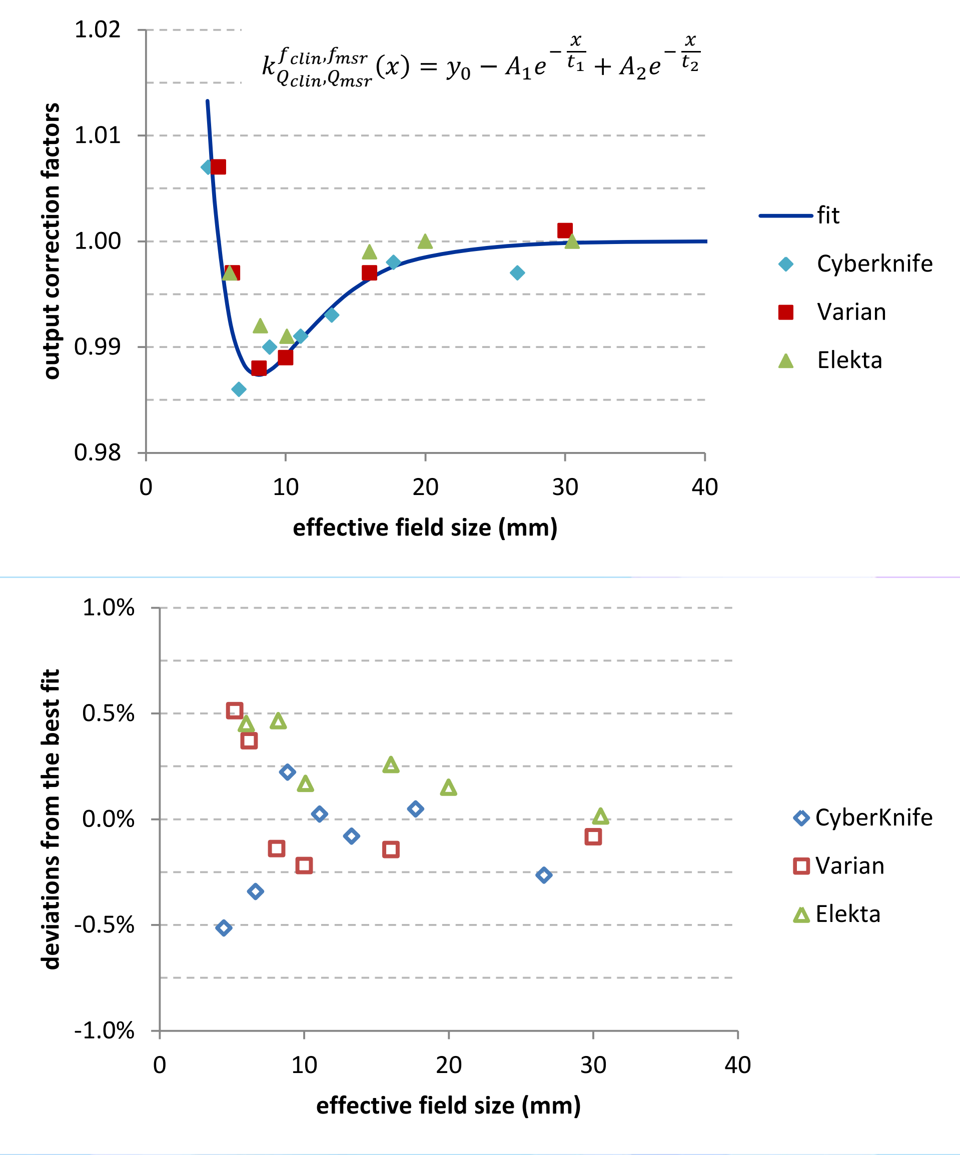


# Discussion

- The good agreement obtained between mD and Ediode field factors provides a validation of the mD Monte Carlo modelling

- Output correction factors show similar qualitative and quantitative behaviour in three linacs with different collimator systems

- A best fit function of all data allows to reproduce within ±0.5% $k^{f_{clin},\,f_{msr}}_{Q_{clin},Q_{msr}}$ values specifically calculated for each linac beam



# Conclusions

- Homogeneous results have been obtained from ten mD detectors, indicating a good reproducibility of their fabrication process.

- The Monte Carlo simulation of microDiamond is proved to be capable of providing reliable output correction factors

- A unique set of mD output correction factors can be applied in beams shaped by different collimation systems according to the actual beam size

- mD output correction factors are lower than 1.5% down to 5 mm beam diameter