# Assessment of MicroDiamond PTW 60019 detector and its use in small radiosurgery fields of Leksell Gamma Knife

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## I. Purpose

Modern radiotherapy is based on using small radiation fields and their segments. For clinical use they need to be verified by measurement. But measurement of small radiosurgery fields is very problematic task because of dosimetry challenges, such as loss of charged particle equilibrium, accurate positioning of detector and its small volume. Purpose of this study is to assess new synthetic single crystal MicroDiamond PTW 60019 detector. Its dosimetry characteristics from the manufacturer and especially small size of its sensitive volume (0.004 $mm^3$) make the detector promising tool for this task.

## II. Materials and Methods

In this study basic dosimetry characteristics of MicroDiamond detector were verified in clinical linear accelerator photon and electron beams. Measurements involved short time stability and detector response dependence on dose rate, beam energy, temperature and angular dependence. In addition, measurement of relative output factors for Leksell Gamma Knife Perfexion was performed in order to test dosimeter performance for small fields. Collimator sizes 4 mm, 8 mm and 16 mm were used. Results obtained by this detector were compared with ELEKTA reference values and independent Monte Carlo Geant4 simulation.

## III. Results

Before starting the measurement, stabilization of detector response had to be performed. Two MicroDiamond detectors were tested for this measurement. To achieve the response stability less then 0,1% (calculated as difference between maximum and minimum response value relative to mean value of reponses) the preirradiation doses 34 and 22 Gy were needed respectively for detector number 1 and 2.

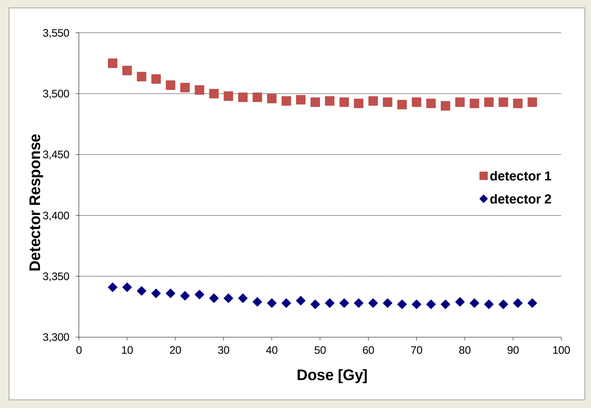


**Fig.1:** *Detector response stability*

### Dose Rate Dependence

Accelerator photon energy 6MV was used with dose rate 100cGy/min – 600cGy/min. Detector was set in accelerator calibration setup (SAD = 100 cm, depth = 5 cm, field size 10 x 10 cm). Measurement was performed in integral mode of Unidos electrometer. Results are presented in Fig.2 and Tab.1.

### Energy Dependence

Photon energies 6MV and 18MV were used because these two energies set borders for clinically used energy spectrum of modern radiotherapy machines. Energy dependence of response was also performed for 5 electron energies (6-20 MeV). All responses were corrected to actual absolute dose using calibrated detector (Farmer chamber for photons, Roos chamber for electrons). See Fig.3 and Tab.1.

### Temperature Dependence

6 different water temperatures (16,2 – 34.4°C) were used to measure temperature dependence of detector response. Results are given in Fig.4.

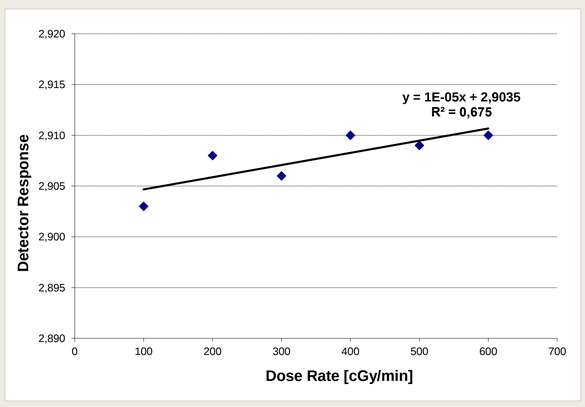


**Fig.2:** *Dose rate dependence*

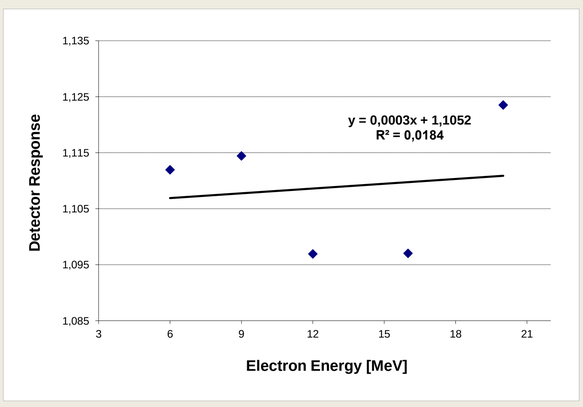


**Fig.3:** *Electron energy dependence*

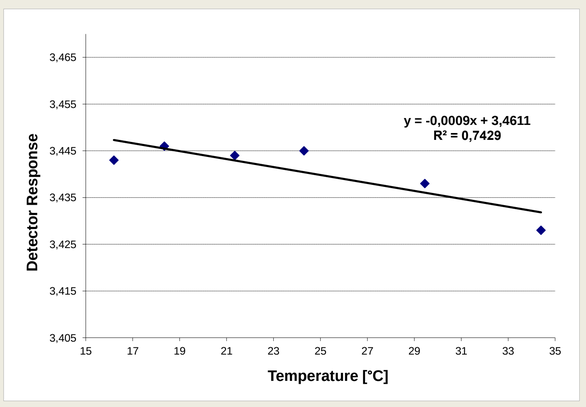


**Fig.4:** *Temperature dependence*

Differences between minimum and maximum response values for all the tests mentioned above (normalized to mean value) are shown in the Table 1.

**Tab.1:** *Results for measured dosimetric properties of MicroDiamond detector →*

| Resp. dependence | (max-min)/mean [%] |
|---|---|
| Dose Rate | 0,24 |
| Photon Energy | 0,12 |
| Electron Energy | 2,4 |
| Temperature | 0,52 |

### Leksell Gamma Knife Output Factor measurement

Finally, MicroDiamond detector was used to measure relative output factors of 4 and 8 mm collimator of Leksell Gamma Knife Perfexion. The values were compared with ELEKTA values (0,814 and 0,900) and values calculated with Monte Carlo Geant4 (see Table 2).

**Tab.2:** *Gamma Knife results ↓*

| Detector | 4 mm ROF | 8 mm ROF | Deviation to vendor´s values [%] | |
|---|---|---|---|---|
| | | | 4 mm ROF | 8 mm ROF |
| MicroDiamond | 0,831 ± 0,001 | 0,900 ± 0,001 | 2,1 | -0,1 |
| MC Geant4 calculated | 0,826 ± 0,006 | 0,918 ± 0,004 | 1,5 | 2 |

## IV. Conclusions

New MicroDiamond PTW 60019 detector appears to be a promising detector for relative output factor measurements in small radiosurgery fields. All verified dosimetric properties of the detector are in limits set by manufacturer, only response dependence on electron energy needs further research. Incovenient discovery is also relatively high pre-irradiation dose which is necessary prior to measurement before the detector can provide reliable data. Further measurements with this detector will follow.

## V. References

[1] http://www.ptw.de/

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