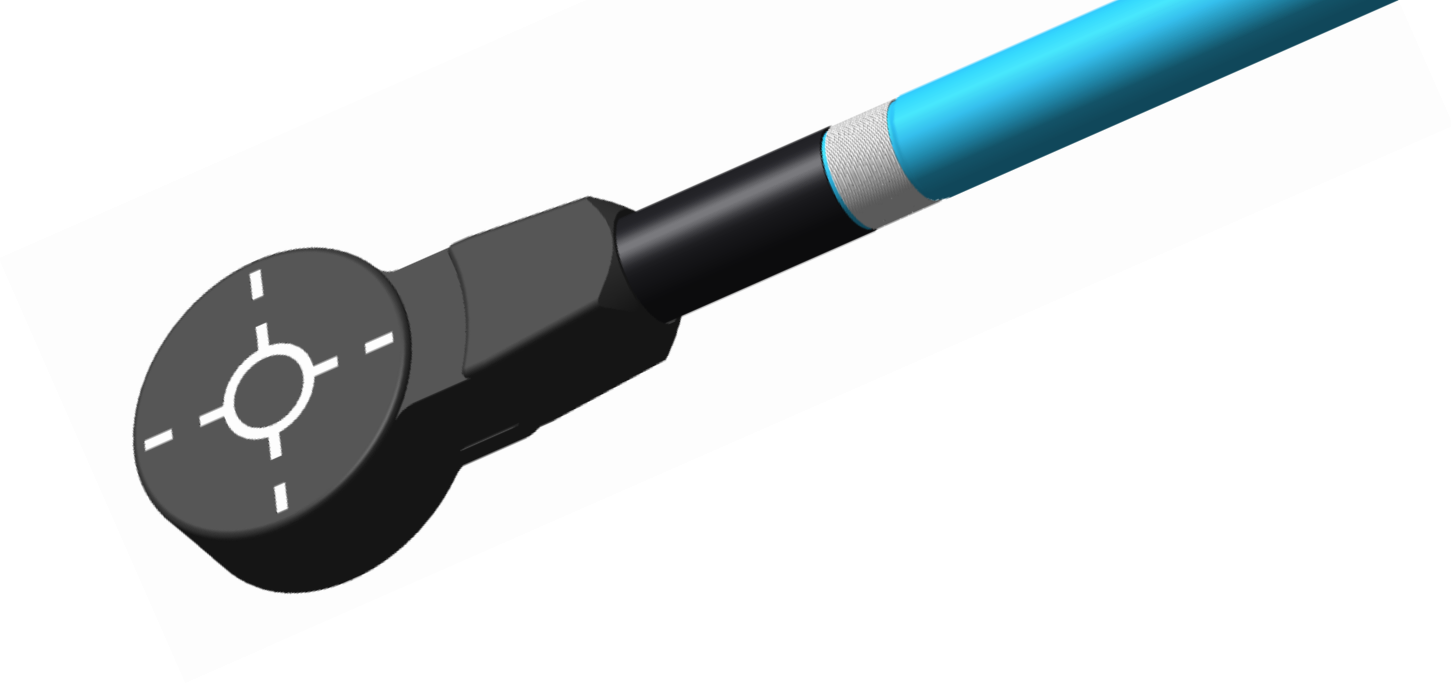
FRPT 2021
FLASH RADIOTHERAPY & PARTICLE THERAPY
VIRTUAL CONFERENCE
1-3 DECEMBER 2021



UHDpulse

VENTED IONIZATION CHAMBERS FOR ULTRA-HIGH DOSE PER PULS CONDITIONS

Rafael Kranzer[1,2], Andreas Schüller[3], Daniela Poppinga[1,] , Jan Weidner[1], Hui Khee Looe[2], Björn Poppe[2]

[1] PTW-Freiburg (R&D), Freiburg 79115, Germany, [2] University Clinic for Medical Radiation Physics, Medical Campus Pius Hospital, Carl von Ossietzky University Oldenburg, 26121 Germany

[3] Physikalisch-Technische Bundesanstalt, Braunschweig 38116, Germany

PTB

CARL VON OSSIETZKY universität OLDENBURG

PTW THE DOSIMETRY COMPANY

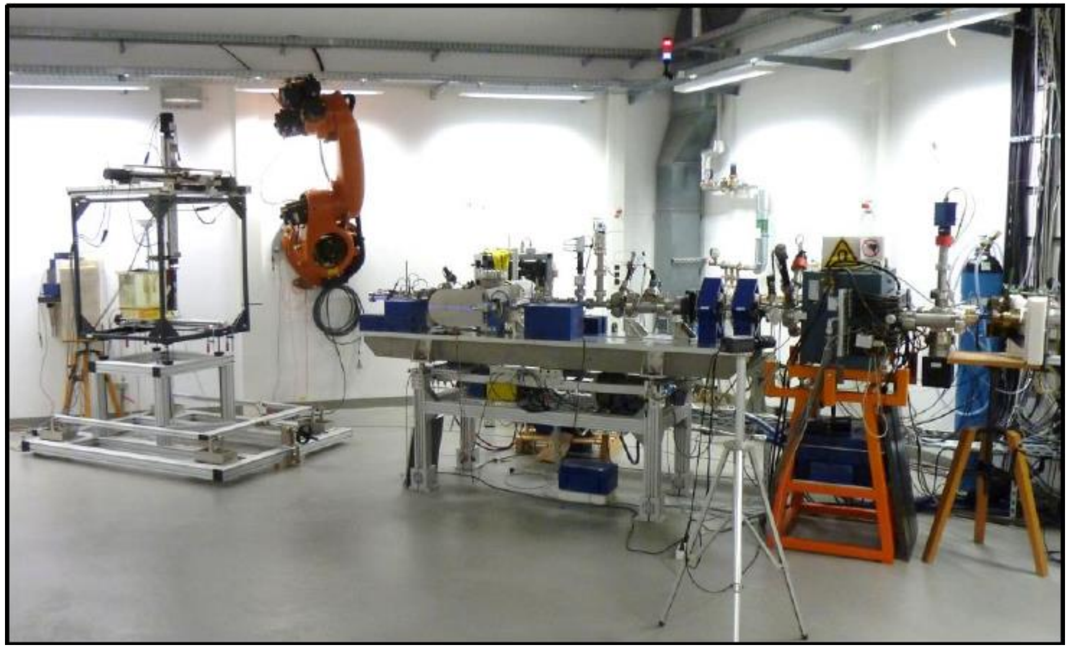
Disclosure

- Rafael Kranzer, Jan Weidner and Daniela Poppinga are PTW employees

- This project (18HLT04) has received funding from the EMPIR programme co-financed by the Participating States and from the European Union’s Horizon 2020 research and innovation programme.

Investigation

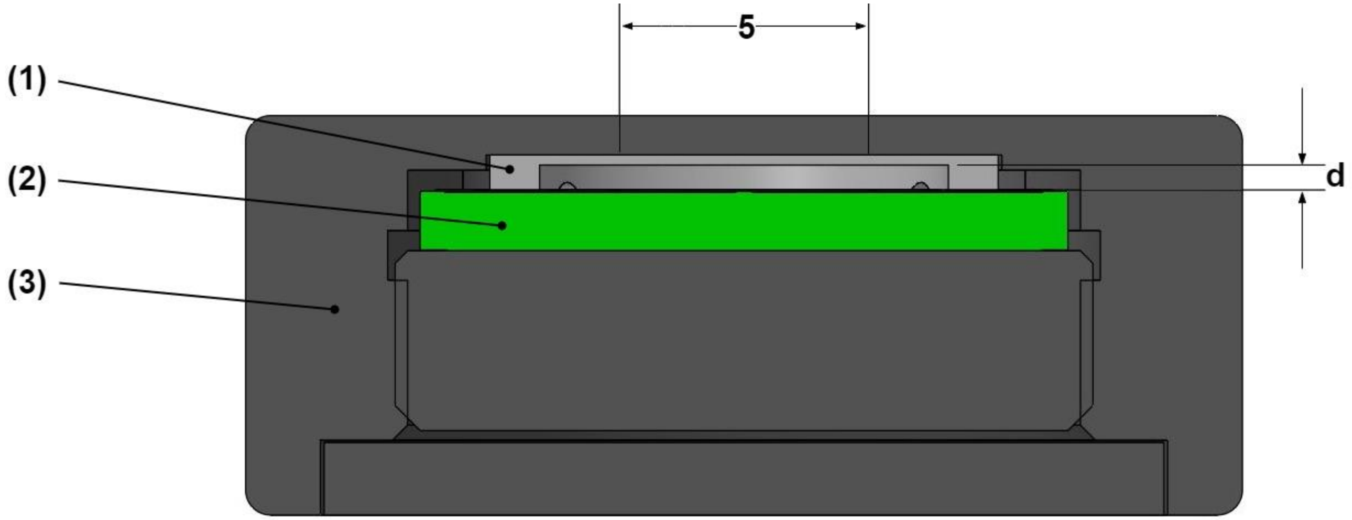
- PTB research electron accelerator
  - Energy 20 MeV
  - PRF = 5 Hz, t_{pulse} = 2.5 µs
  - Current transformer (Bergoz ICT) as beam monitor calibrated against alanine



- Numerical approach
  - By solving a system of differential equations that describes the charge creation and transport in the ionization chamber (Gotz et al. 2017, Kranzer et al. 2020)
  - Simulation of the charge collection efficiency

Investigation

- Detectors
  - Parallel Plate Ionization Chambers (PPIC)
  - With electrode distances *d* of 1.0, 0.5 and 0.25 mm
  - Chamber voltages of 125, 250 and 500 V



(1) HV Electrode (Graphite)

(2) PCB (FR4)

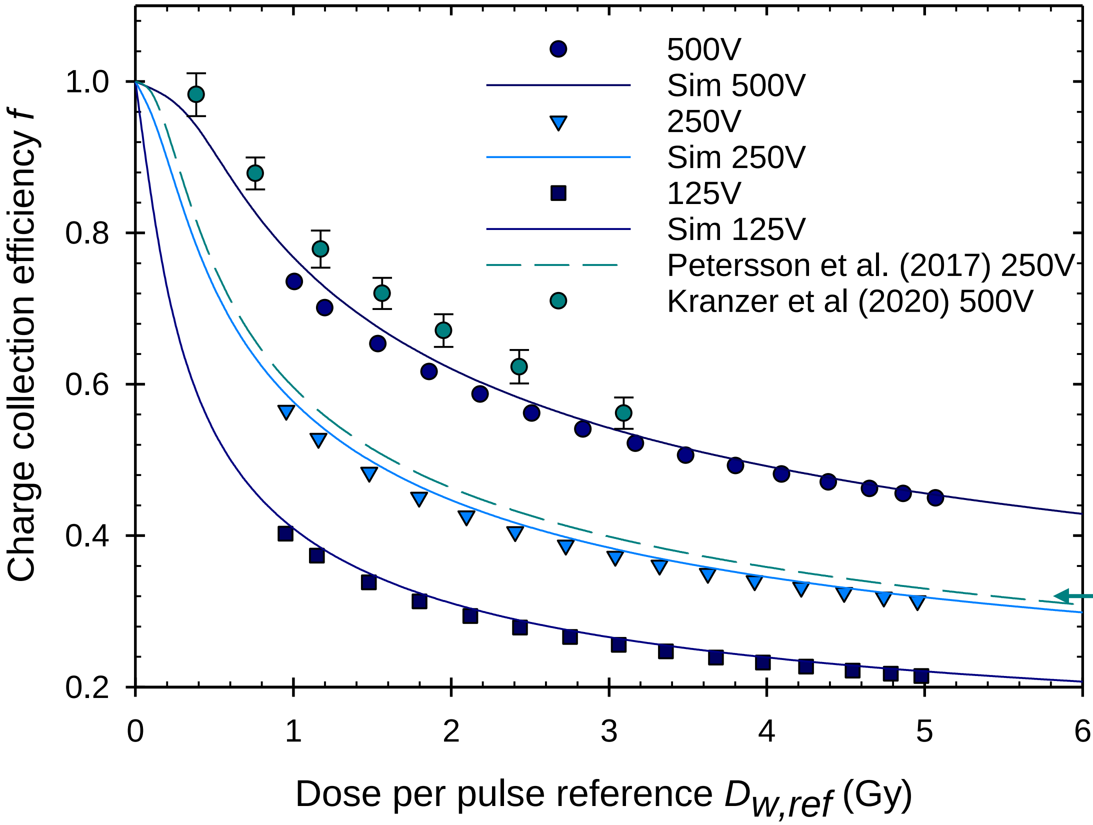
(3) Housing (PS)

PTW THE DOSIMETRY COMPANY

Results

Charge collection efficiency $f = \frac{1}{k_S} = \frac{(M - M_0) \times N_{Co60,Dw} \times k_{cross} \times k_P}{D_{w,ref}}$

Electrode distance d = 1 mm

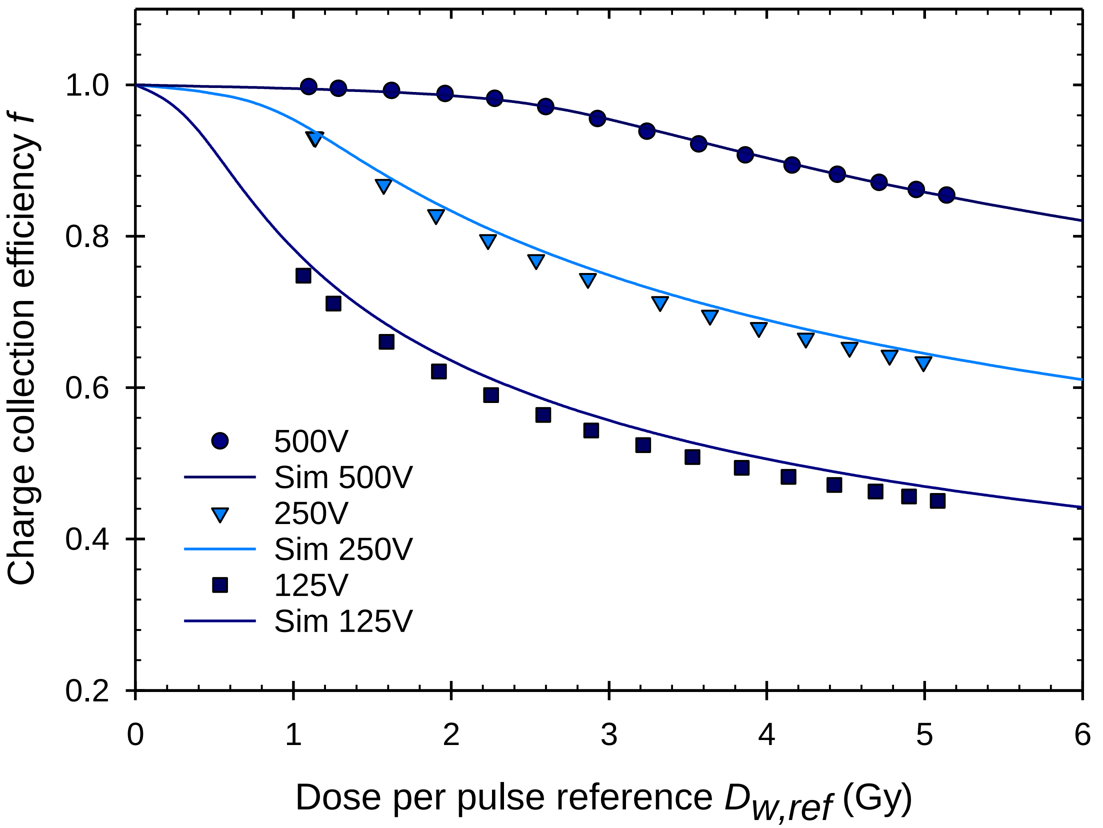


$$k_s \approx \left(1 + \left(\frac{DPP[\mathrm{mGy}]}{U[\mathrm{V}]}\right)^{\alpha}\right)^{\beta}$$

Results

Charge collection efficiency $f = \frac{1}{k_S} = \frac{(M - M_0) \times N_{Co60,Dw} \times k_{cross} \times k_P}{D_{w,ref}}$

Electrode distance d = 0.5 mm

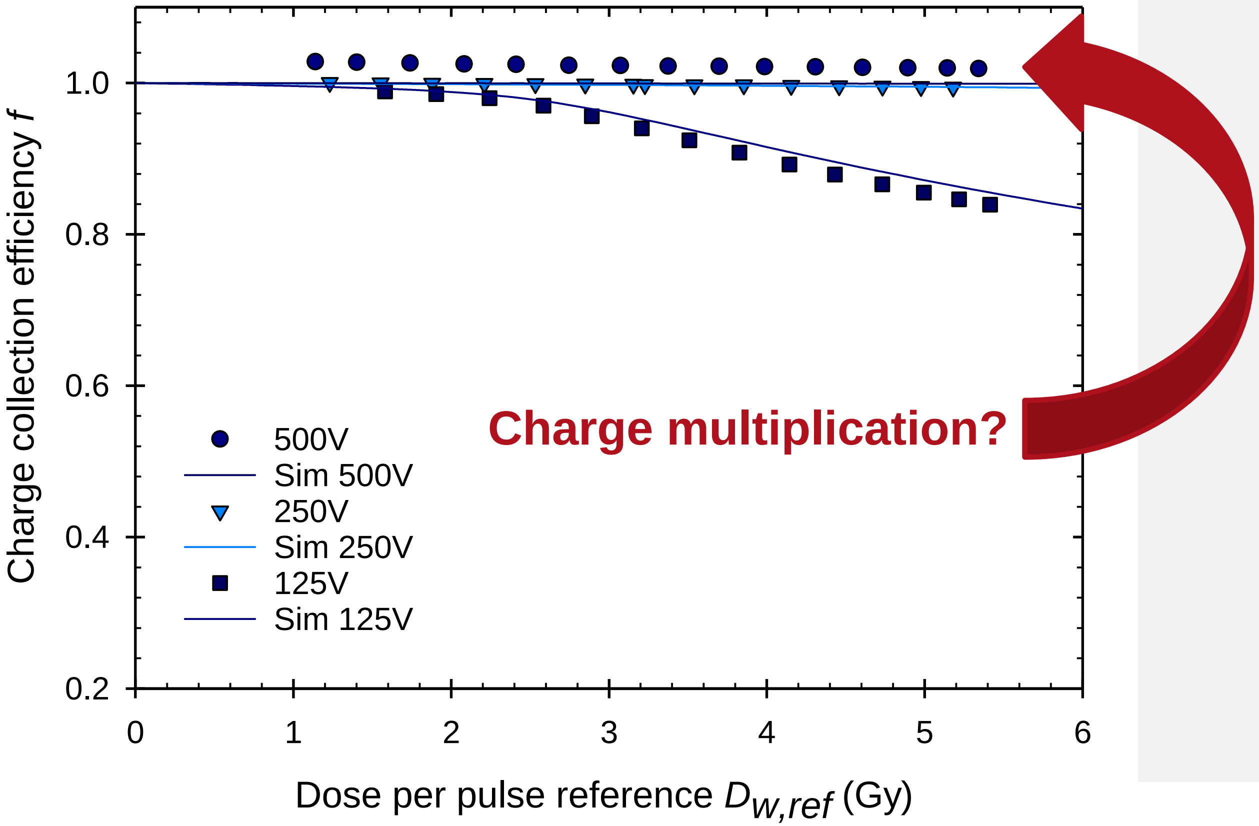


PTW THE DOSIMETRY COMPANY

Results

Charge collection efficiency $f = \frac{1}{k_S} = \frac{(M - M_0) \times N_{Co60,Dw} \times k_{cross} \times k_P}{D_{w,ref}}$

Electrode distance d = 0.25 mm

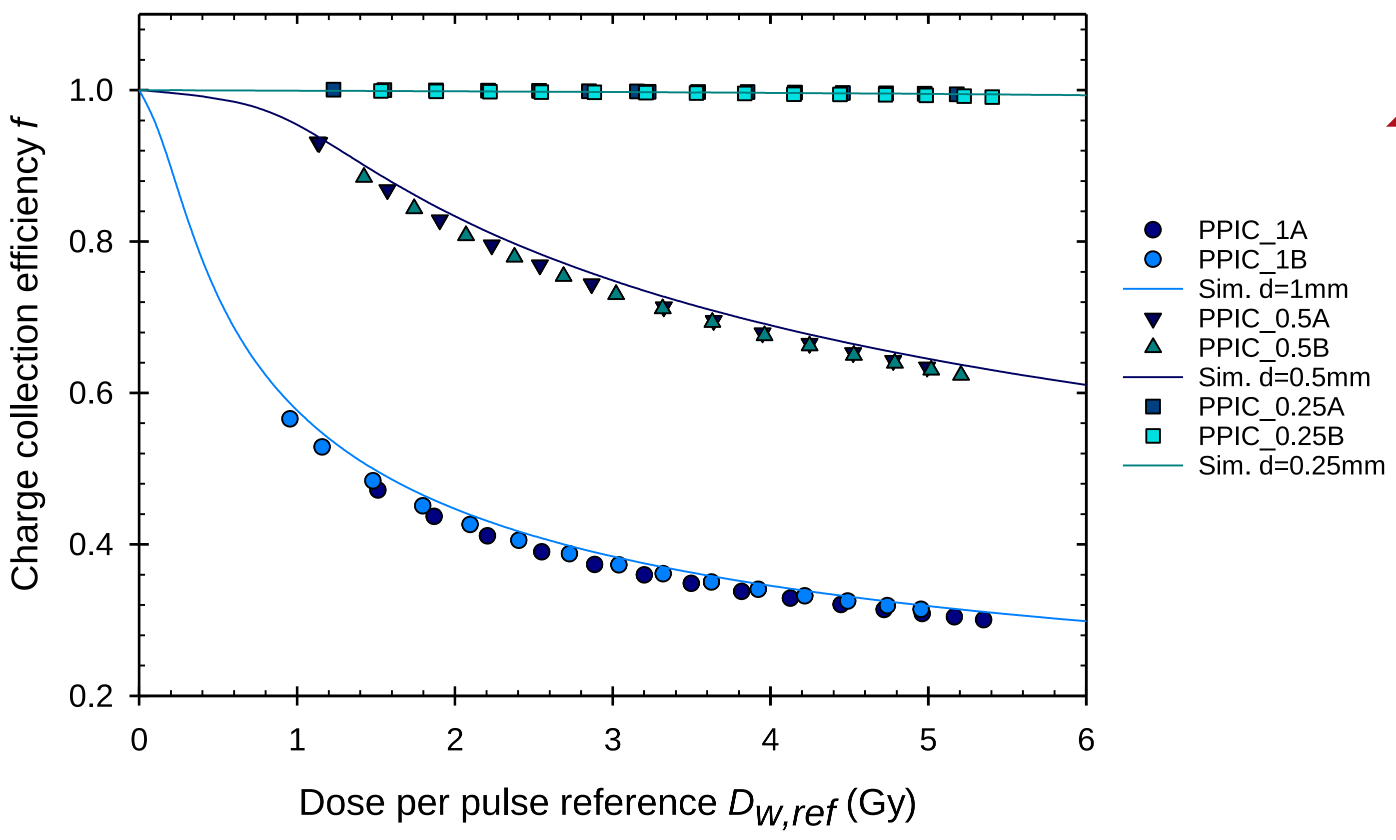


PTW THE DOSIMETRY COMPANY

Results

Charge collection efficiency $f = \frac{1}{k_S} = \frac{(M - M_0) \times N_{Co60,Dw} \times k_{cross} \times k_P}{D_{w,ref}}$

Chamber voltage U = 250 V



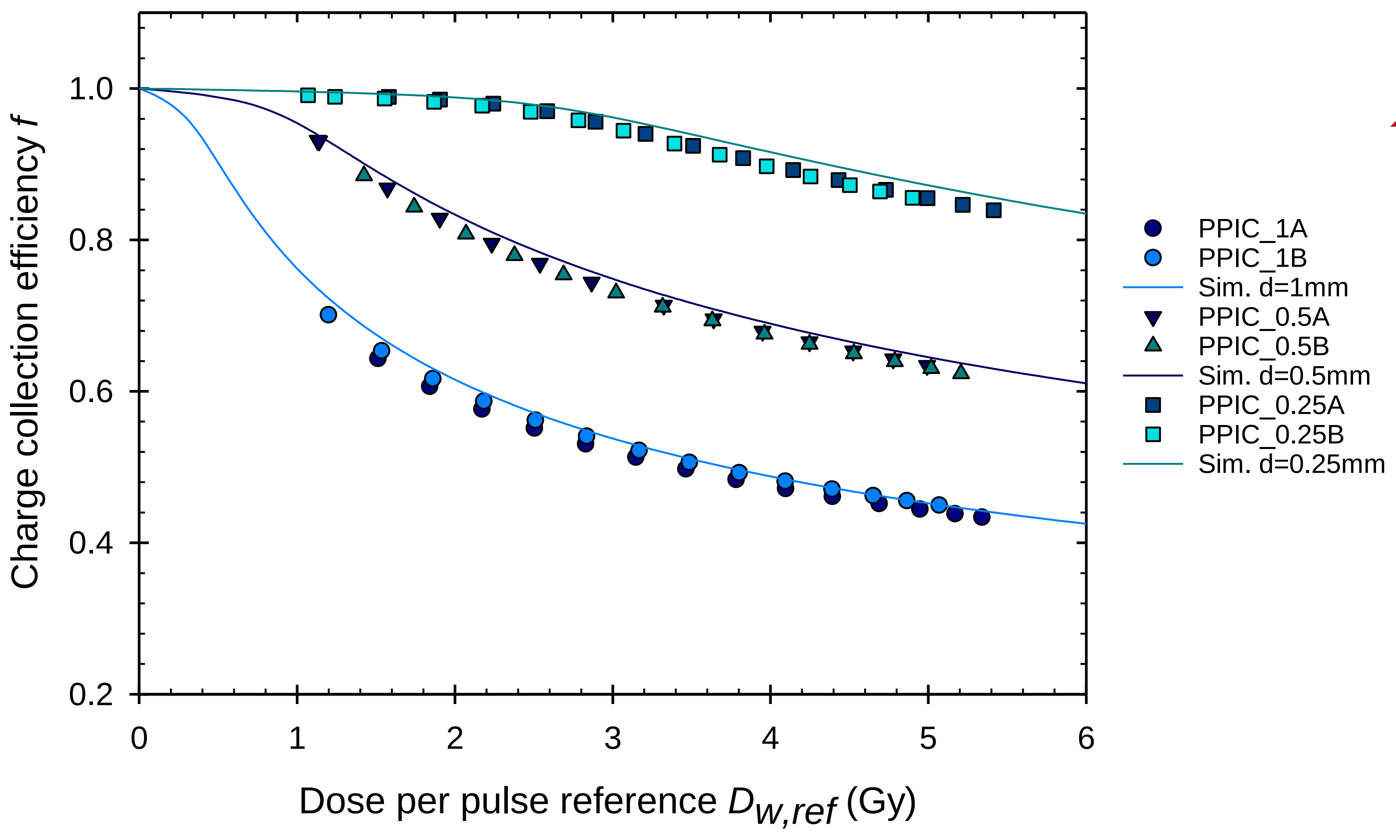
Decrease of the electrode distance

Increase in field strength

Results

Charge collection efficiency $f = \frac{1}{k_S} = \frac{(M - M_0) \times N_{Co60,Dw} \times k_{cross} \times k_P}{D_{w,ref}}$

Field strength E = 500 V/mm

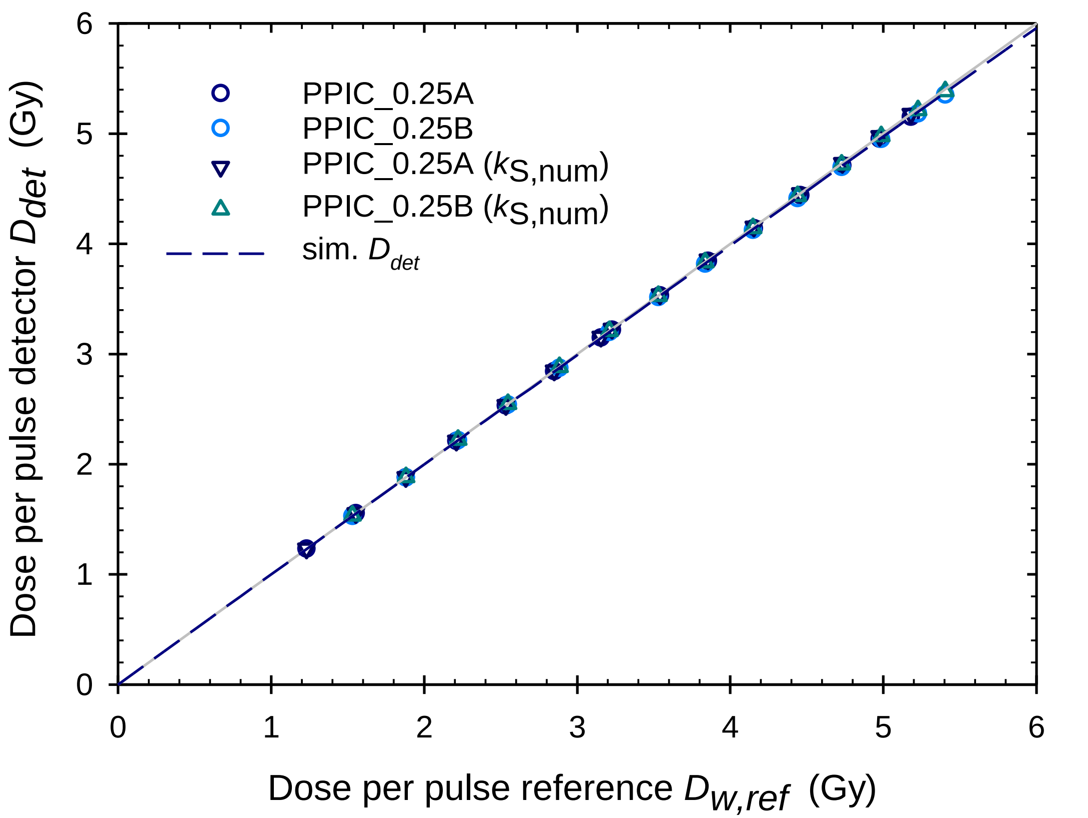


Decrease of the electrode distance

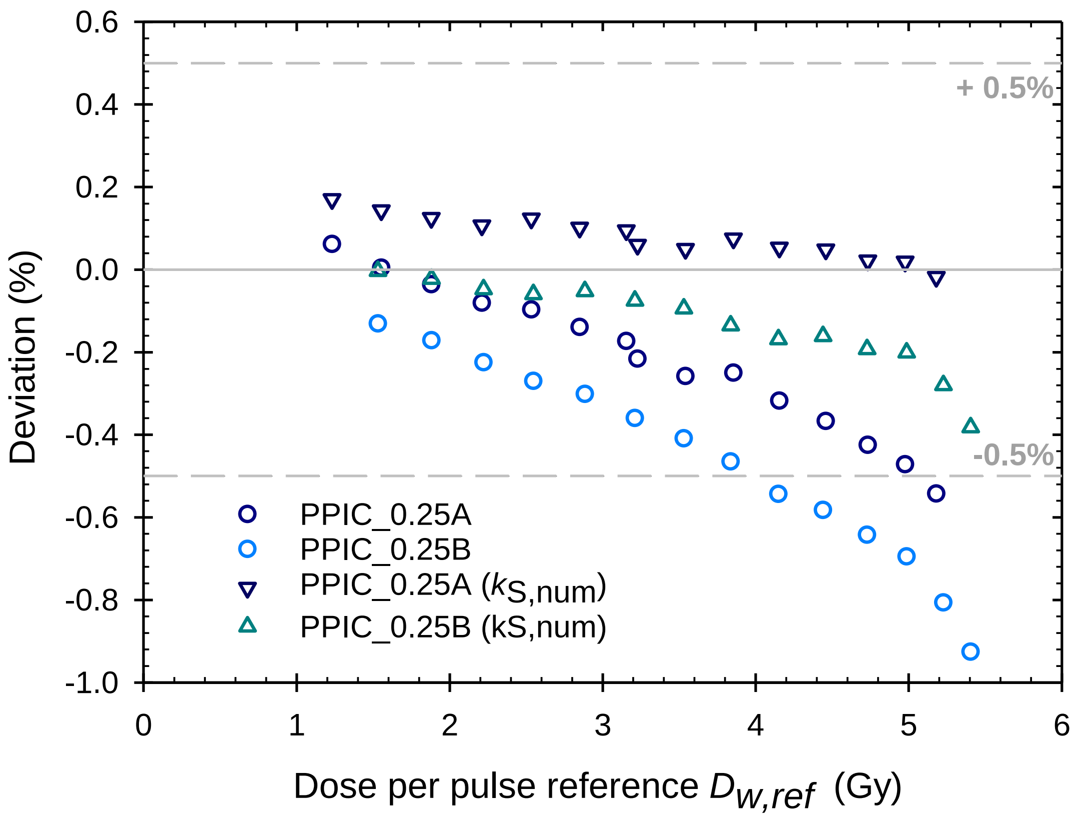
Results

Measured dose vs reference dose per pulse

Linearity of PPIC (d = 0.25 mm, U = 250V)



Deviations



PTW THE DOSIMETRY COMPANY

Conclusion

- Electrode distance is the crucial parameter for charge collection efficiency at ultra-high dose per pulse
- Ultra thin PPICs show recombination losses < 1% up to 5.5 Gy/pulse (see also talk of F. Gomez)
- They are a promising tool for real time dosimetry in FLASH-RT allowing the use of established protocols for reference dosimetry
- The numerical approach is extremely useful for the understanding of the effects and to predict the charge collection efficiency (see also talks of F. Gomez and J. Paz-Martin)

PTW THE DOSIMETRY COMPANY