VENTED IONIZATION CHAMBERS FOR ULTRA-HIGH DOSE PER PULS CONDITIONS

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Disclosure

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

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Investigation

- **PTB research electron accelerator**
  - Energy 20 MeV
  - PRF = 5 Hz, $t_{\text{pulse}} = 2.5 \, \mu\text{s}$
  - 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)
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

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

Charge collection efficiency $f$

Dose per pulse reference $D_{w,ref}$ (Gy)

500V
Sim 500V
250V
Sim 250V
125V
Sim 125V
Petersson et al. (2017) 250V
Kranzer et al (2020) 500V

Charge collection efficiency $f$

Dose per pulse reference $D_{w,ref}$ (Gy)
Results

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

Electrode distance $d = 0.5$ mm
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

Charge multiplication?
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

![Graph showing dose per pulse reference vs detector dose for PPIC and deviations](image-url)
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)
Thank you!
Any Questions?