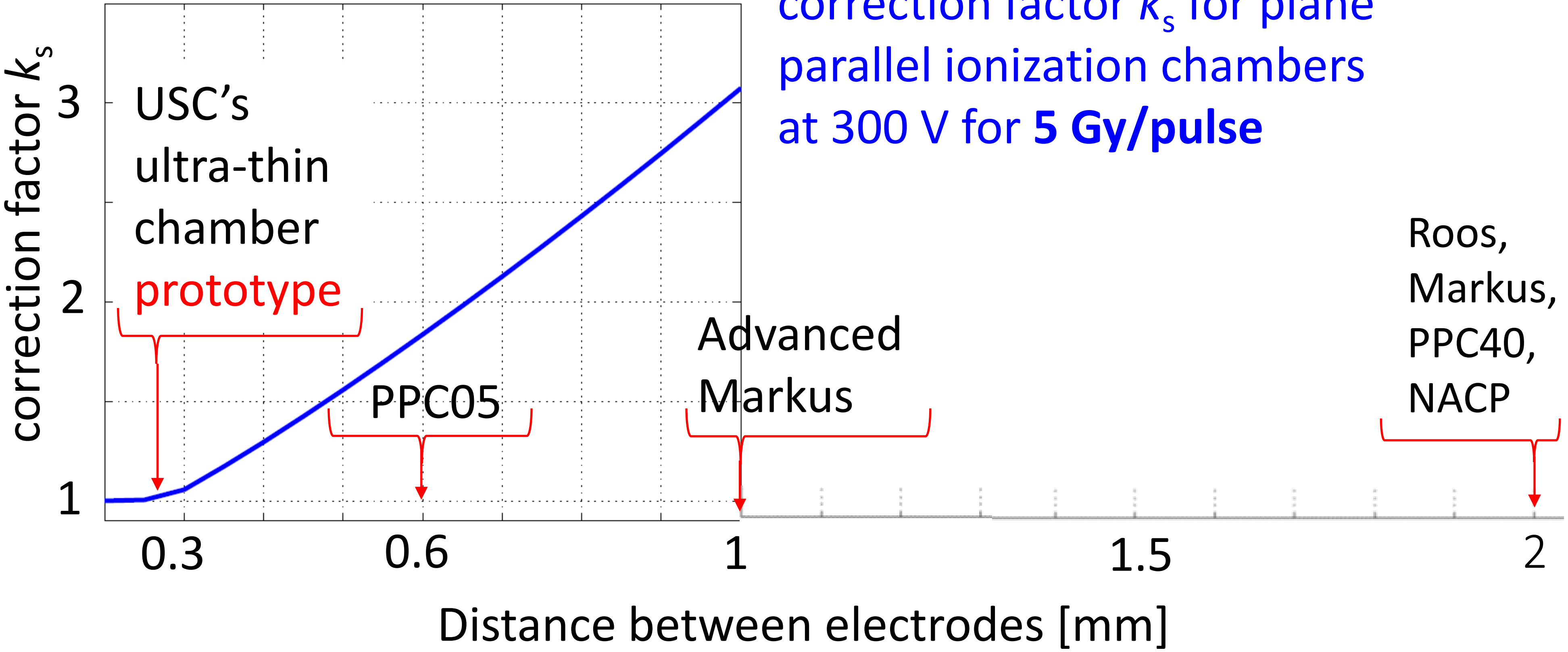
# EMPIR UHDpulse progress

# Upcoming developments for dosimetry for FLASH RT

## Prototype ionization chambers for ultra-high DPP

Simulated ion recombination correction factor $k_s$ for plane parallel ionization chambers at 300 V for **5 Gy/pulse**

*Ionization chamber prototype (0.27 mm)*




Faustino Gomez et al., to be published

ULTRA THIN PLANE-PARALLEL IONIZATION CHAMBERS: EXPANDING THE RANGE OF AIR IONIZATION CHAMBERS INTO ULTRA-HIGH DOSE RATE.

Type: Abstract Submission FRPT

Topic: A. Radiation modalities / AS02 Quality assurance and real time measurement of FLASH doses: ionisation chambers, film, solid state detectors, scintillators

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Accepted for presentation @ FRPT

**Background and Aims**

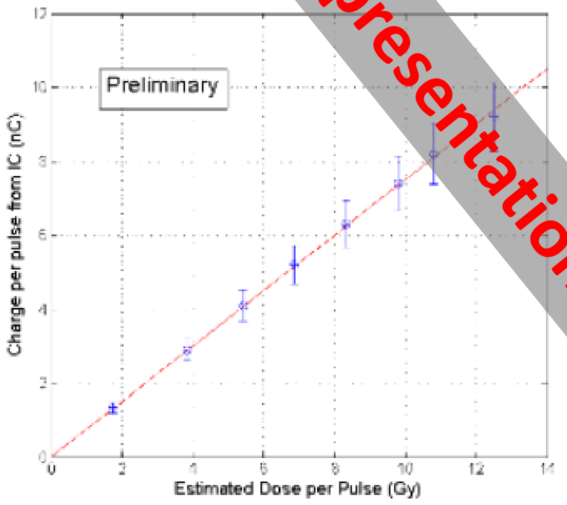
Ionization chambers (IC) have been and remain the secondary standard of choice in the vast majority of hospitals all over the world. When an IC is irradiated at dose rates that exceed the conventional limits the ion recombination correction factor of these chambers starts to increase. Working in these regimes is unfeasible as the required correction factors exceed dosimetry standards. Analytical theories describing ion recombination effects fail to actually describe their behavior in the ultra high dose rate (UHDR).

**Methods**

Ultra-thin gap plane-parallel ionization chambers exhibit a submillimetric electrode distance. This geometry enhances the collection of the charge carriers by increasing the electric field strength inside the chamber and reducing the charge carrier densities between electrodes. The free electron fraction is much higher than in a conventional chamber, decreasing the amount of ion-recombination. The experimental measurements have been performed in UHDR electron beams (7 MeV and 9 MeV) at SIT ElectronFLASH accelerator.

**Results**

utic_vs_dpp.png

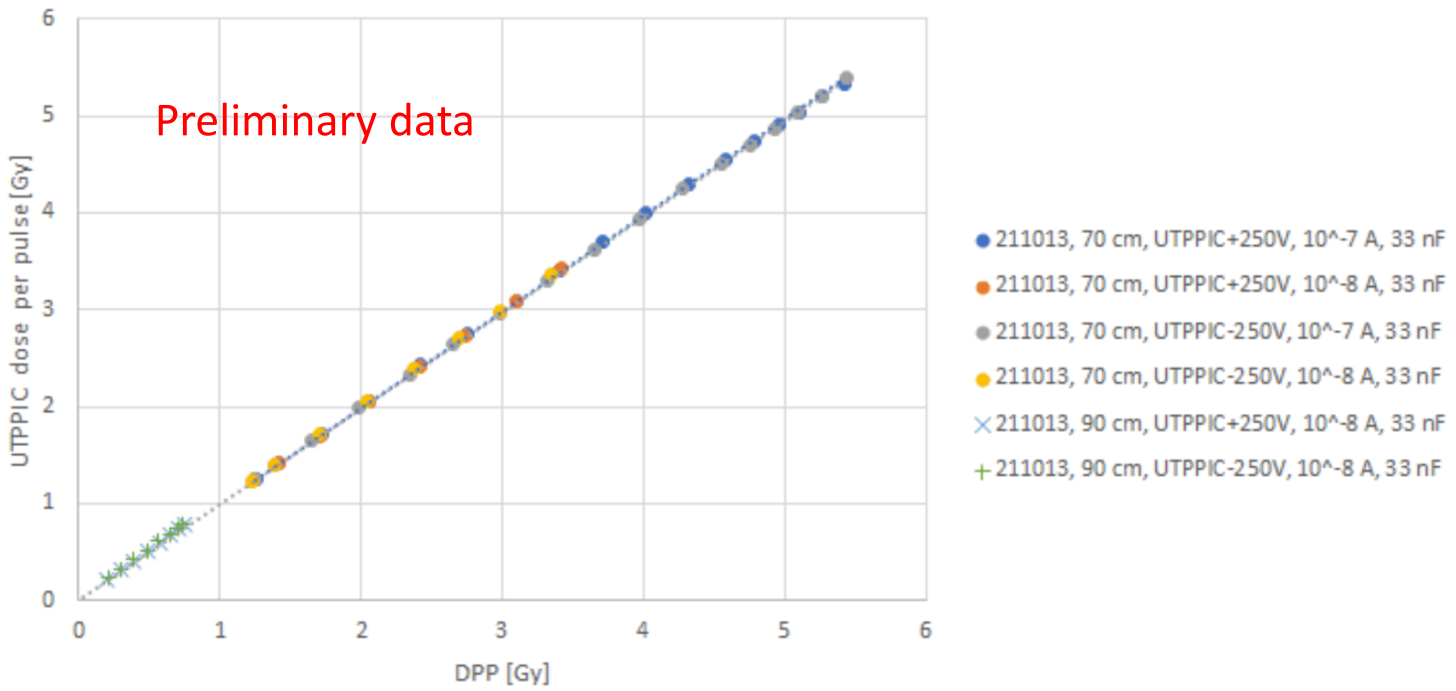



enlarge

Figure 1: Response of an ultra-thin plane parallel ionization chamber prototype with a 0.27 mm gap polarized at -250 V in an electron beam from a SIT ElectronFLASH accelerator without application of any ion recombination correction.

**Conclusions**

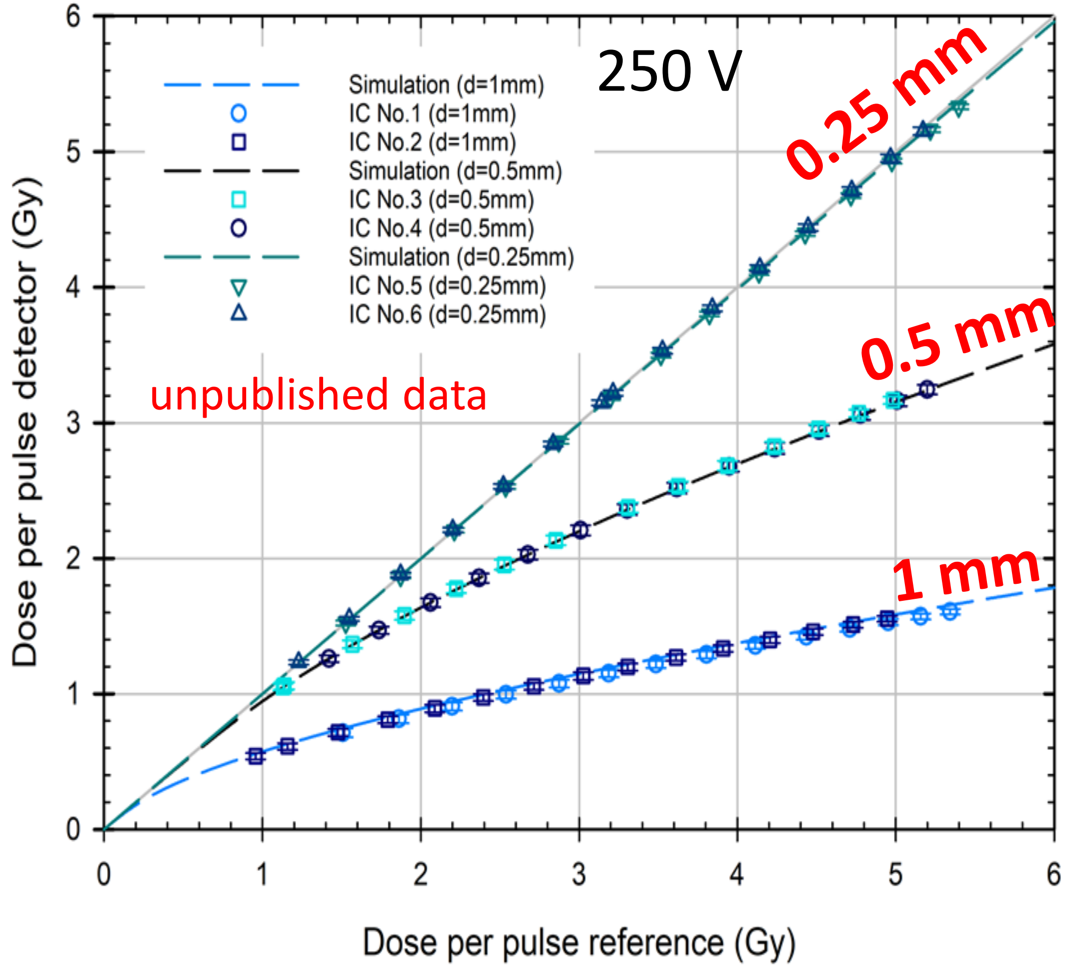
Ultra thin gap plane-parallel ionization chambers are a promising option as secondary standard dosimeters for the FLASH radiotherapy quality assurance.




Performance of USC prototype of thin gap IC in high dose per pulse e-beam (MELAF). Deviation of measured vs predicted DPP is ~1% up to 6 Gy/pulse. Next stage: measurements to be complemented using SIT e-FLASH LINAC.

# Upcoming developments for dosimetry for FLASH RT

## Prototype ionization chambers for ultra-high DPP




PTW THE DOSIMETRY COMPANY

**VENTED IONIZATION CHAMBERS FOR ULTRA-HIGH DOSE PER PULS CONDITIONS**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Accepted for presentation @ FRPT


**Background and aims**

Vented ionization chambers (IC) are used as the standard dosimeter for clinical reference dosimetry. For ultra-high dose per pulse (DPP) in the range of 0.6 – 10 Gy, as under investigation for FLASH radiotherapy with electrons, available ICs show large deviations due to ion recombination. However, it is desirable to use ICs also under ultra-high DPP conditions as a secondary standard.

**Methods**

Parallel plate prototype ICs with different electrode distances d manufactured by PTW were investigated at PTB's research electron accelerator (20 MeV, 5 Hz, 2.5 µs pulse duration). To determine the DPP reference, the beam current monitor was calibrated against alanine. The measurements were compared to a numerical approach by solving a system of partial difference equations, taking into account charge creations by the radiation, their transport and reaction in an applied electric field.

**Results**

As the electrode distance decreases, the deviations due to ion recombination become smaller. For the prototype with d=0.25mm, almost no deviation is detectable anymore. There is a good agreement between measurements and simulations.


- Prototypes of parallel plate ionization chambers with very small electrode distances show linear response in the ultra-high DPP range.

# Upcoming developments for dosimetry for FLASH RT

microDiamond detector for ultra-high DPP

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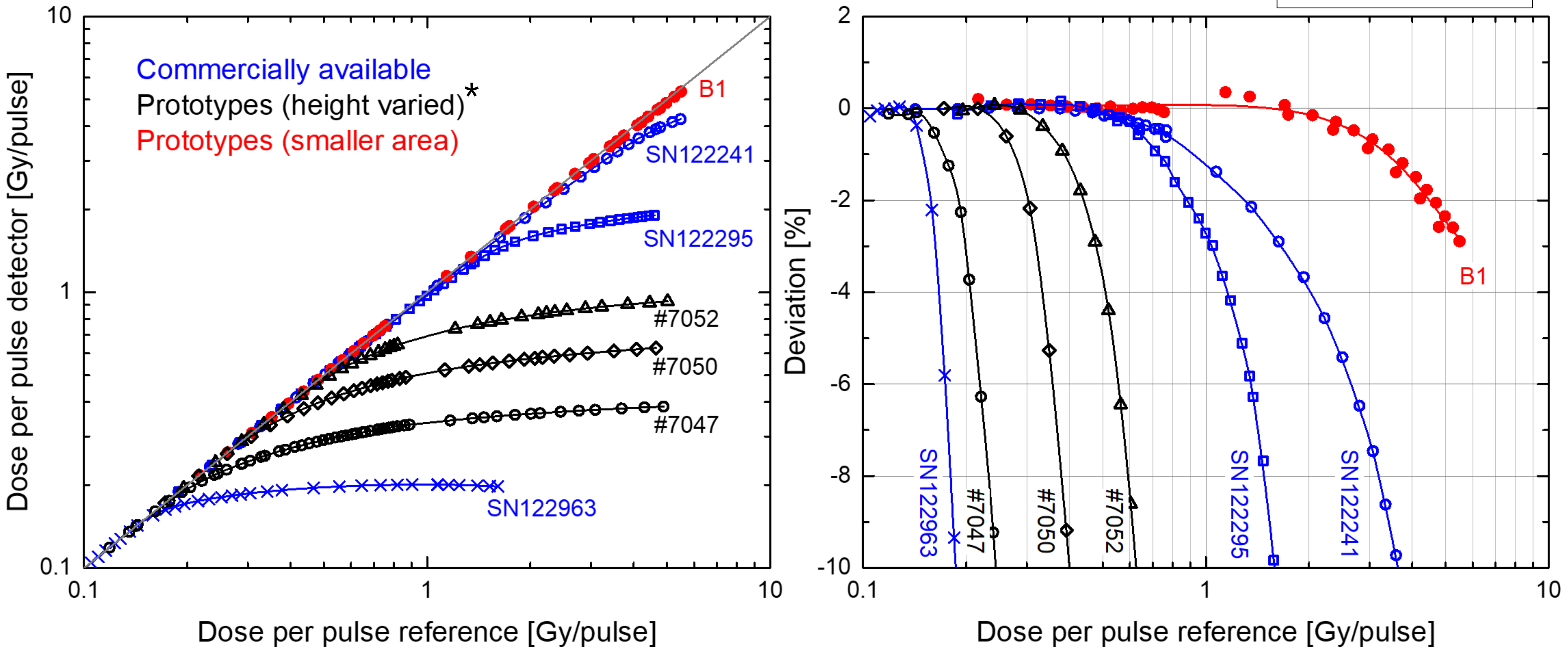
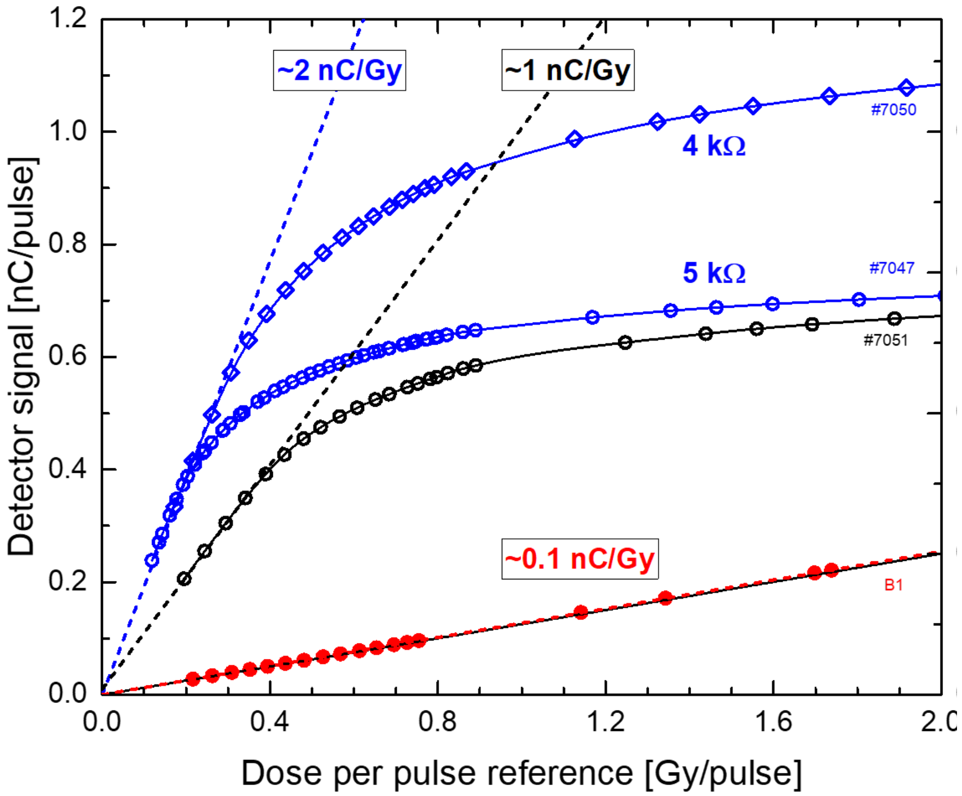
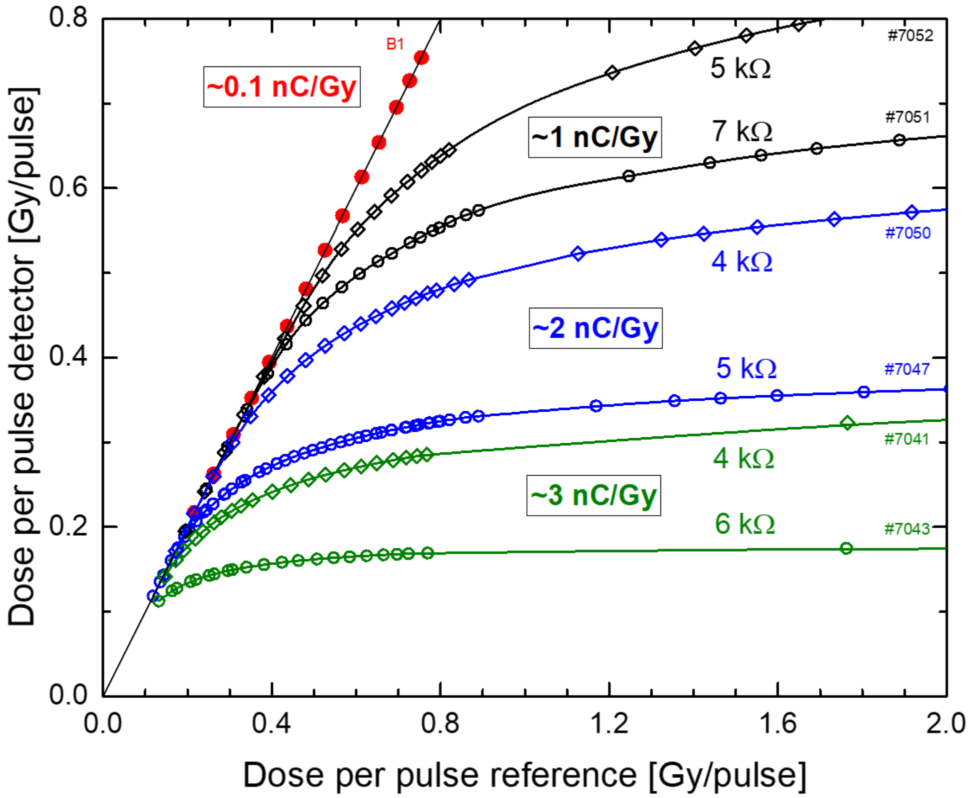


# Coming developments for dosimetry for FLASH RT

## microDiamond detector for ultra-high DPP




- Commercially available microDiamond detectors show saturation effects at different DPP levels.
- The linear range can be extended to the ultra-high DPP range by reduction of sensitivity and resistance.

# PTB activities

**PTB work:**

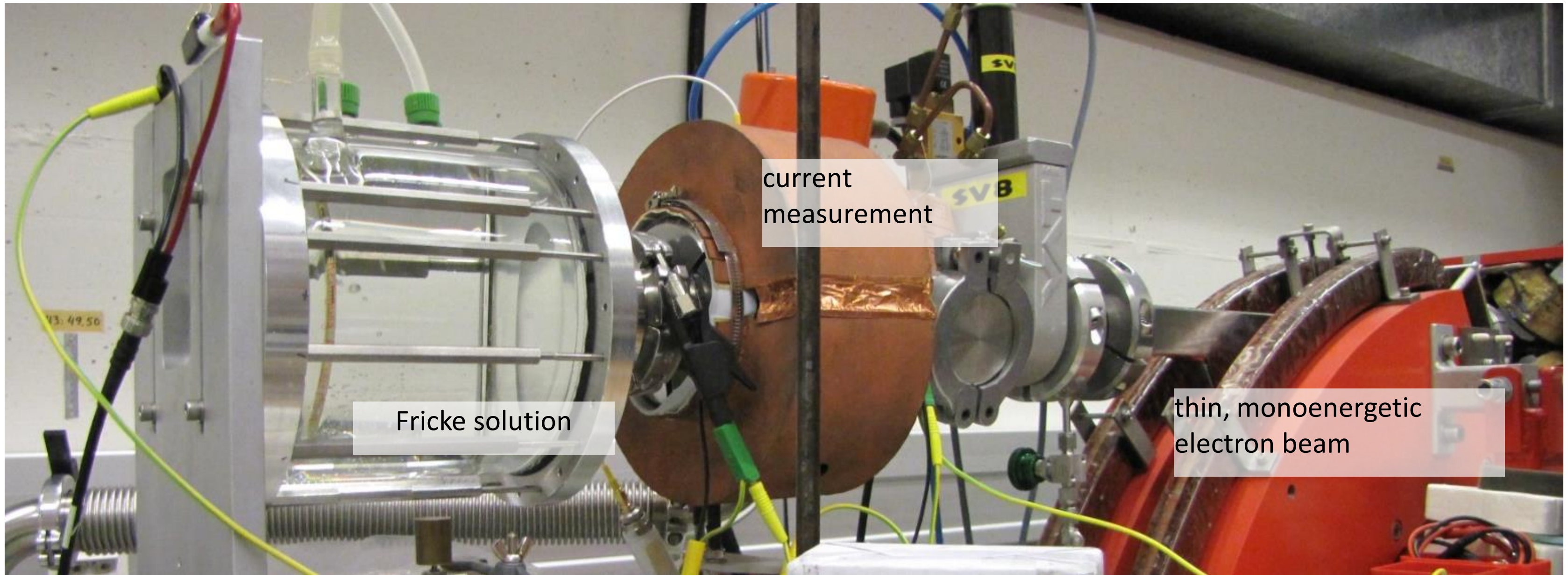
- First draft: *Code of Practise for clinical absorbed dose measurement in UHD electron beam*
- Establishment of the PTB's reference UHPDR electron beam
  - Characterisation in-beamline and in-water + MC model
- Validation of Alanine/ESR secondary standard measurement system

**Collaboration:**

- with U. Laval on scintillator have lead to a presentation at the upcoming FRPT conf. (Vienna, Dec.)
- Thermal and Monte Carlo simulation of the Gr.-probe calorimeter (Aerrow)
  - By group at McGill university (F. Keszti)

# Fricke dosimetry

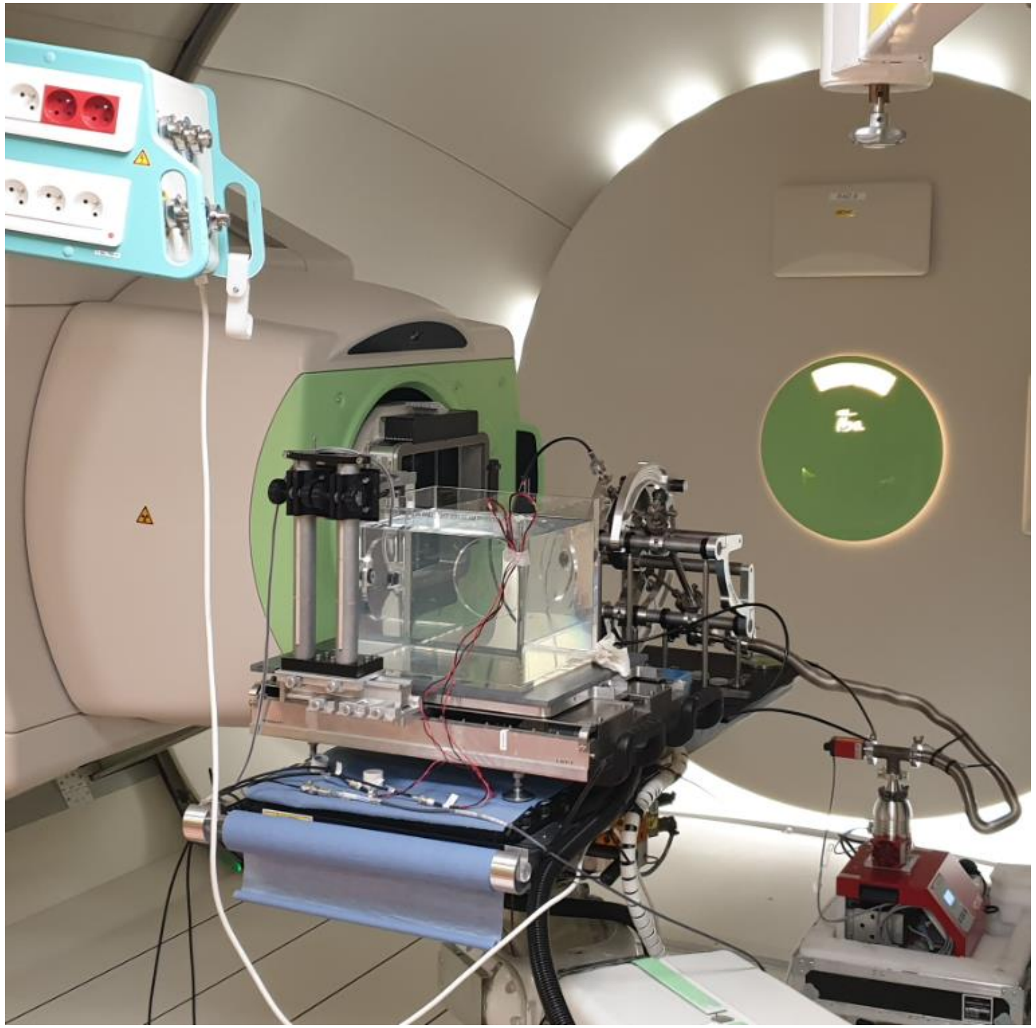
- **Fricke dosimetry as a pimary standard for absorbed dose to water in electron beams.**
  Realized by means of the total absorption technique.
  → Current measurement was recalibrated with reference device from PTB




- **Fricke (chemical) dosimeter - a small bag as a transfer standard.**
  Under investigation in ultra high dose rate electron beams.
  → Compared to Alanine (PTB), Gafchromic film and Advanced Markus Chamber
  → Found to be dose rate independent < 1Gy/pulse (of 3$\mu$s duration)
  → Irradiations ongoing at METAS and CHUV up to 10 Gy/pulse

Dosimetry campaign at Instiut Curie employing UHDR proton beam

National Physical Laboratory



Calorimetry measurements performed with NPL primary standard graphite calorimeter with 226 MeV UHDR proton beam, 6 cm x 6 cm field size, dose rate >40 Gy/s

→ Challenge to operate a beam above 6x6 cm2 due to radiation safety aspects

- Calorimetry complemented with IC measurements (Roos, Adv. Markus, PPC05, Semiflex)
- 5 abstracts accepted for presentation at FRPT (covering UHDR electron, proton and X-rays beams)

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UHDpulse

**http://uhdpulse-empir.eu/**