

# Dosimetry for FLASH radiotherapy with electron beams

UHDoulse

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Joint Conference of the ÖGMP, DGMP and SGSMP, 19.-21.9.21, virtual



# **Dosimetry for FLASH radiotherapy with electron beams**

#### **Contents**

- FLASH irradiation: Ultra-high dose rate / dose per pulse
- Dosimetry at ultra-high dose per pulse
- Coming developments for dosimetry for FLASH RT





#### Pulsed electron beam from a Linac



Wilson et al., Front. Oncol. 9:1563. http://dx.doi.org/10.3389/fonc.2019.01563

#### <u>FLASH treatment of a human patient</u> (lymphoma on skin)

- delivered total dose: 15 Gy
- 10 pulses (of 1 µs duration)
- treatment time: 90 ms
- Dose per pulse: 1.5 Gy



Bourhis et al., Radiother. Oncol. (2019) http://dx.doi.org/10.1016/j.radonc.2019.06.019



https://doi.org/10.1038/s41598-020-78017-7

#### FLASH treatment of cancer at dogs

- Delivered total dose: 15 35 Gy in 7-16 pulses
- Treatment time: 30 75 ms
- Mean dose rates: 400-500 Gy/s
- Pulse dose rates: ~0.7 MGy/s
- Dose per pulse: 2 Gy



treatment of canine leg

20.9.2021, Joint Conference of the ÖGMP, DGMP and SGSMP

Konradsson et al., Front. Oncol. (2021) 11:658004 https://doi.org/10.3389/fonc.2021.658004

#### Behavior of ionization chambers



#### Passive detectors

OSLD, TLD, alanine, radiochromic film

#### Advantage:

independent of dose rate,
suitable for ultra-high DPP

#### Disadvantage:

 not real-time readout, takes hours or days to get a dose value PTB's, alanine dosimetry system

Dose traceable to PTB's primary standard



#### Alanine pellets



ESR spectrometer

#### PTB reference field for ultra-high dose per pulse





PTB's Research electron accelerator

Beam line with water phantom

E = 0.5 - 50 MeV

up to 7 Gy/pulse (SSD 0.7 m, 20 MeV)

#### PTB reference field for ultra-high dose per pulse





Alanine pellets at reference depth in water phantom



current transformer: Non-destructive beam pulse charge measurement (uncertainty < 0.1 %)



Prototype ionization chambers for ultra-high DPP



#### Prototype ionization chambers for ultra-high DPP





microDiamond detector for ultra-high DPP





### Summary

- There is no real-time dosimetry system for FLASH RT with electron beams up to now.
- Commercially available ionization chambers show large deviations at ultra-high dose per pulse (DPP) due to ion recombination.
- Prototypes of parallel plate ionization chambers with very small electrode distances show linear response in the ultra-high DPP range.
- 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.



The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

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.



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

\*Diamond prototypes are produced at the Industrial Engineering Department of Rome Tor Vergata University in cooperation with PTW.

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FRPT2021 special issues in

- Radiotherapy & Oncology
- Physica Medica

#### LATE-BREAKING ABSTRACT SUBMISSION IS OPEN UNTIL 22 SEPTEMBER 2021



#### https://frpt-conference.org/