EMPIR project UHDpuls (18HLT04)

Christian Kottler
on behalf of the UHDpulse consortium
Project Overview

• Title: “Metrology for advanced radiotherapy using particle beams with ultra-high pulse dose rates”

• Project acronym: UHDpulse

• EMPIR Call: 2018 / Health

• Type: Joint Research Project

• Coordinator: Andreas Schüller (PTB)

• Start date: September 1st, 2019

• Duration: 36 months

• Budget: 2.1 Mio. €

• Web site: http://uhdpulse-empir.eu/

• Logo: UHDpulse
“Irradiation at ultra high dose-rate increases the differential response between normal and tumour tissue”

Favaudon et al., Sci Transl Med 6 (2014) 245ra93
DOI: 10.1126/scitranslmed.3008973
before FLASH

nasal carcinoma not eligible for surgery

7 month after FLASH

Vozenin et al., Clin Cancer Res 25 (2019) 35
DOI: 10.1158/1078-0432.CCR-17-3375
FLASH-RT

Reduced pig skin toxicity with FLASH-RT

Irradiation with 22 - 34 Gy

36 weeks post-RT:

Conventional (5 Gy/min)

necrotic lesions

FLASH (300 Gy/s)

normal appearance of skin

Vozenin et al., Clin Cancer Res 25 (2019) 35
DOI: 10.1158/1078-0432.CCR-17-3375
Beams with **Ultra-High Pulse Dose Rates**

**UHPDR:**
- ultra-high dose per pulse
- ultrashort pulse duration
- both
## Metrological challenges

<table>
<thead>
<tr>
<th></th>
<th>FLASH</th>
<th>conventional</th>
</tr>
</thead>
<tbody>
<tr>
<td>dose per pulse</td>
<td>1 – 10 Gy</td>
<td>0.3 mGy</td>
</tr>
<tr>
<td>pulse width</td>
<td>1 – 2 us</td>
<td>3 us</td>
</tr>
<tr>
<td>dose rate during</td>
<td>$10^6$ Gy/s</td>
<td>$10^2$ Gy/s</td>
</tr>
<tr>
<td>pulse repetition</td>
<td>10 – 100 Hz</td>
<td>200 Hz</td>
</tr>
<tr>
<td>frequency</td>
<td></td>
<td></td>
</tr>
<tr>
<td>mean dose rate</td>
<td>40 – 1000 Gy/s</td>
<td>0.05 Gy/s</td>
</tr>
<tr>
<td>time for dose</td>
<td>100 ms</td>
<td>4 min</td>
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<tr>
<td>delivery</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Typical behavior of ordinary ionization chambers**

Petersson et al., Med Phys 44 (2017) 1157
DOI: 10.1002/mp.12111

![Graph showing ion collection efficiency comparison between conventional and FLASH methods](image)
The ultimate goal of the project is…

…to provide the metrological tools needed to establish traceability in absorbed dose measurements of UHPDR particle beams.

The specific aims of the project are:

- Development of primary and secondary absorbed dose standards and reference dosimetry methods
- Characterization of state-of-the-art detector systems in UHPDR beams
- Development of methods for relative dosimetry and for the characterization of stray radiation
- Provide input data for future CoP in UHPDR beam dose measurement
UHDpulse Project Consortium

5 National Metrology Institutes
leading in the field of dosimetry

2 academic hospitals
pioneers in FLASH-RT

3 universities
experts in detector development
pioneer in laser-driven beams

3 national research institutes
pioneer in detector development
pioneer in laser-driven beams
dosimetry expert

1 European research institute
laser-driven beam research

2 companies
expert in detector development

NMI’s

Irradiation
facility provider

Radiation
detector developer

http://uhdpulse-empir.eu/
UHDpulse - Work Package Structure

**WP1: Primary standards**
- Definition of reference conditions
- Reference radiation fields
- Adapting primary standards (water calorimeter, Fricke dosimeter)
- Prototype graphite calorimeters for laser-driven beams

**WP2: Secondary standards, relative dosimetry**
- Transfer from primary standards
- Characterizing established detector systems
- Formalism for reference dosimetry for future Code of Practice

**WP3: Detectors for primary beam**
- Novel and custom-built active dosimetric systems
- Beam monitoring systems

**WP4: Detectors and methods outside primary beam**
- Active detection techniques for pulsed mixed radiation fields of stray radiation
- Methods with passive detectors
http://uhdpulse-empir.eu/

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Thank you very much for your attention