

Overview and current status of the Joint Research Project UHDpulse – “Metrology for advanced radiotherapy using particle beams with ultra-high pulse dose rates”



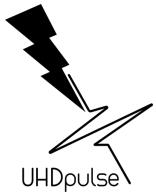
Andreas Schüller
Working Group 6.21 “Dosimetry for radiotherapy”
on behalf of the UHDpulse consortium

Overview and current status of the Joint Research Project UHDpulse – “Metrology for advanced radiotherapy using particle beams with ultra-high pulse dose rates”



Andreas Schüller

CONFLICT OF INTEREST DISCLOSURE: nothing to disclose



European Joint Research Project UHDpulse

Titel: Metrology for advanced radiotherapy using particle beams with ultra-high pulse dose rates

Funding: EMPIR (2.1 M €)

Duration: Sep/2019-Feb/2023

Coordinator: Andreas Schüller (PTB)

Topic:
tools for dose measurements for
- FLASH radiotherapy & proton therapy
- VHEE radiotherapy
- laser driven beams

Website: <http://uhdpulse-empir.eu>



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

Schüller et al., *The European Joint Research Project UHDpulse ...*
Physica Medica 80 (2020), 134-150
<https://doi.org/10.1016/j.ejmp.2020.09.020>



Partners and Collaborators

Metrology Institutes



7 Metrology institutes

5 Hospitals

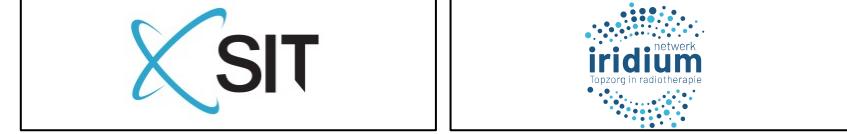
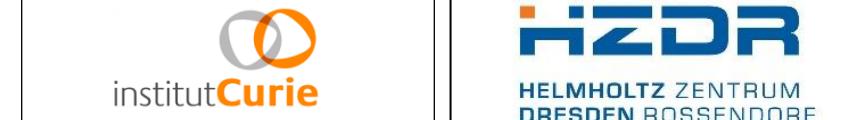
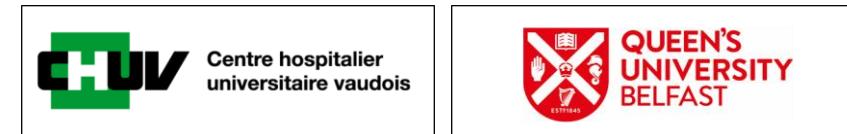
7 Universities

6 Research institutes

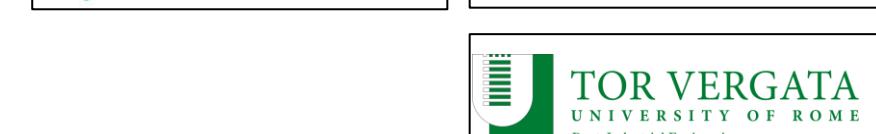
8 Companies

+ Proton therapy network INSPIRE

Irradiation facilities / providers



Detector developers / providers



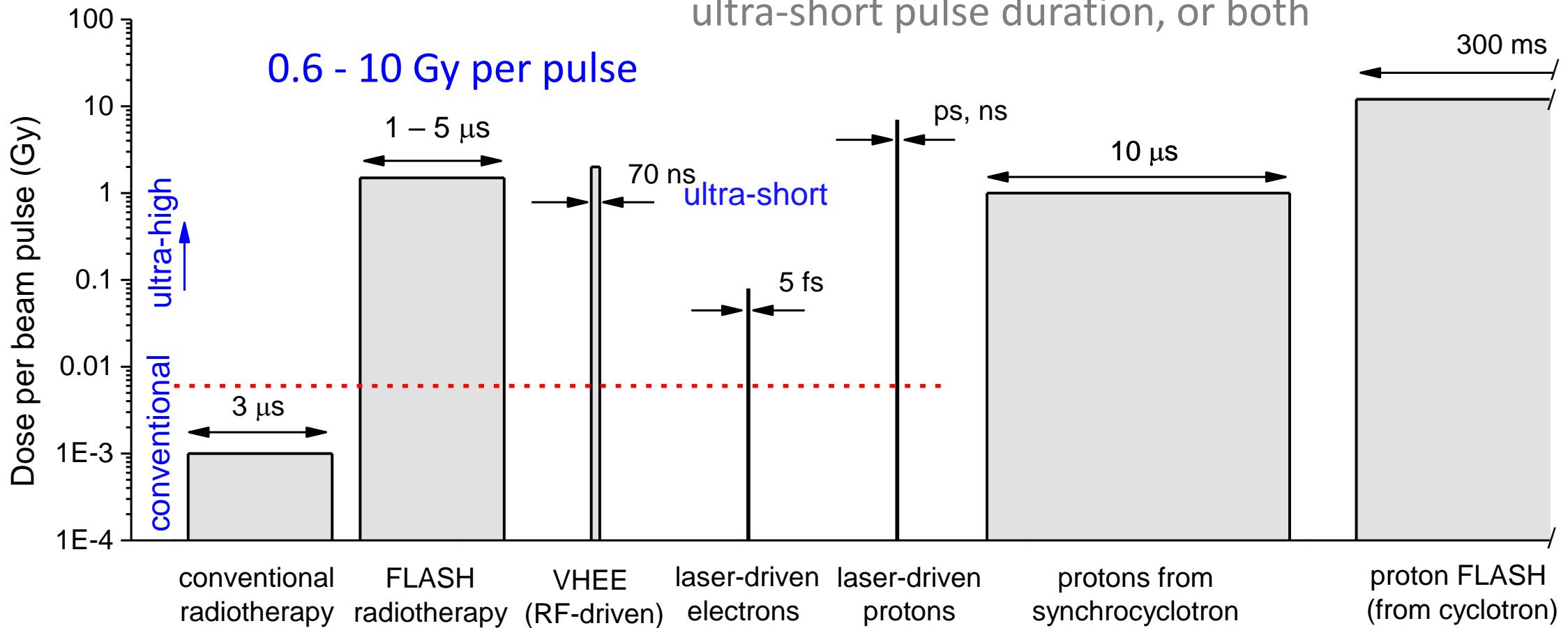


dosimetry

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

electrons, protons

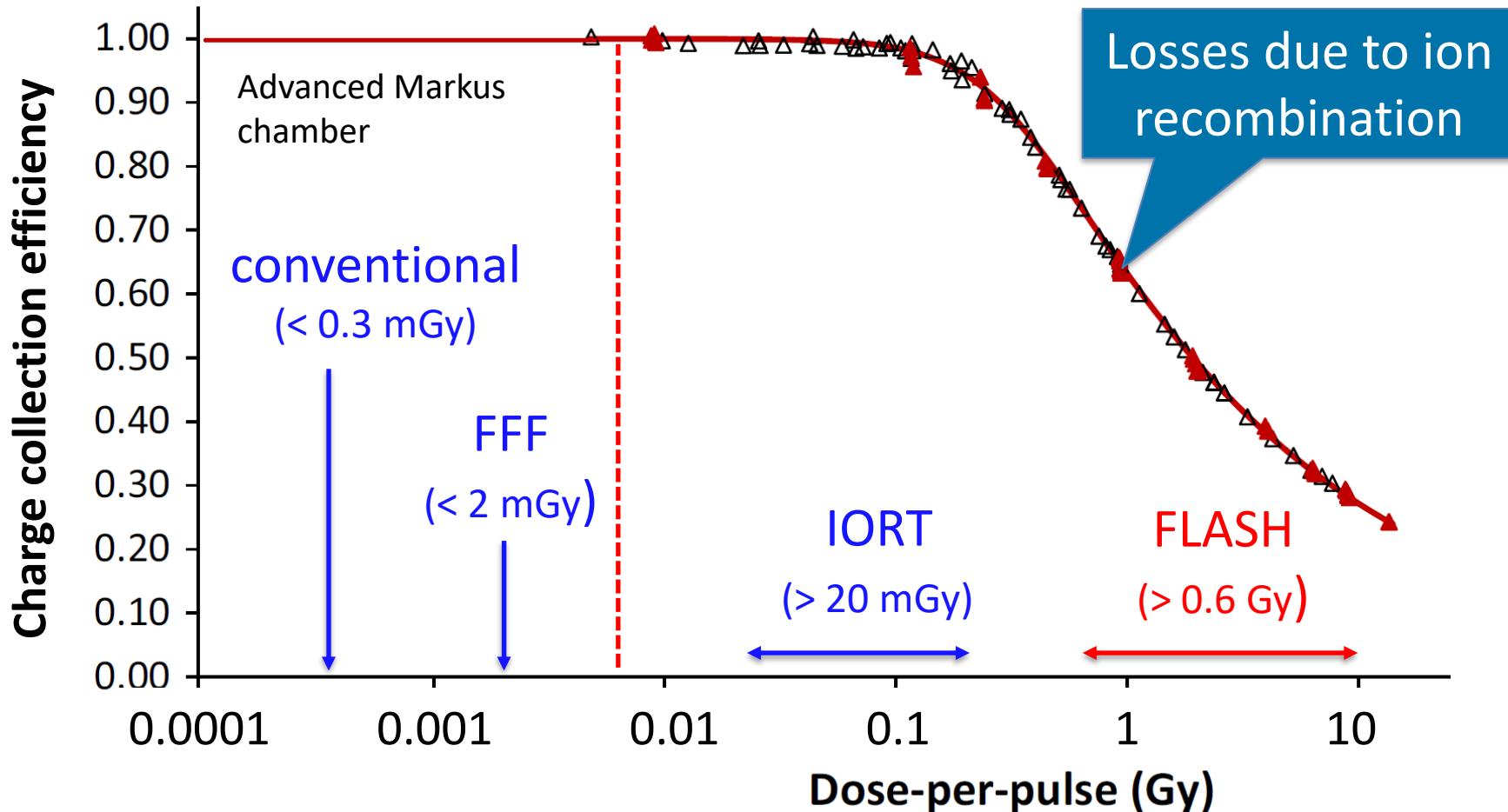
ultra-high dose per pulse,
ultra-short pulse duration, or both





Metrological challenge at FLASH RT

Typical performance of ionization chambers



- There are
- **no** active dosimeters for real-time measurements
 - **no** formalism (CoP) for reference dosimetry



Current developments for dosimetry for FLASH RT

Ultra-high pulse dose rate reference electron beam at PTB



PTB's Research electron accelerator

$E = 0.5 - 50 \text{ MeV}$

$t_{\text{pulse}} = 0.1 - 3 \text{ us}$



Beam line with water phantom

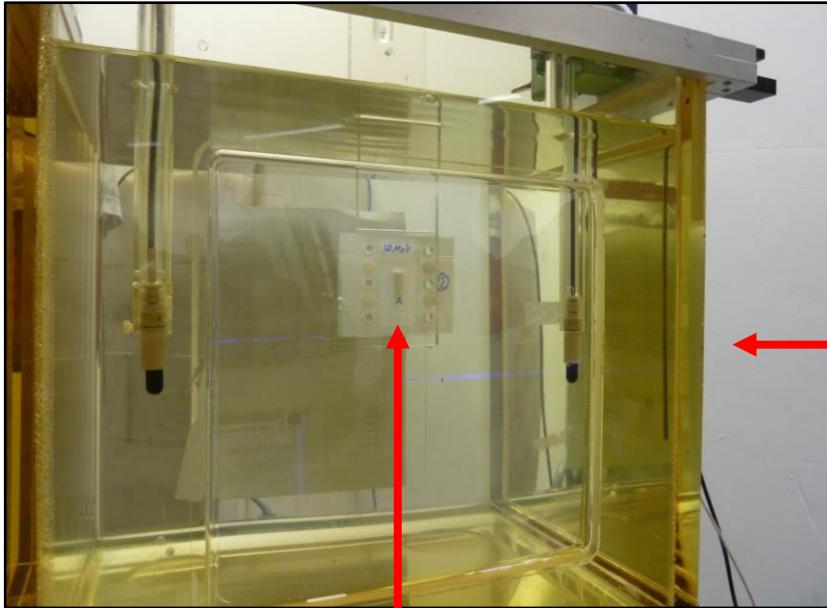
up to 7 Gy per pulse (SSD 0.7 m, 20 MeV)

in preparation: up to 15 Gy per pulse (SSD 0.5 m, 20 MeV)

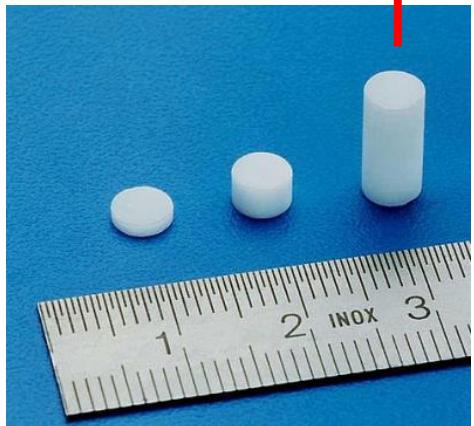


Current developments for dosimetry for FLASH RT

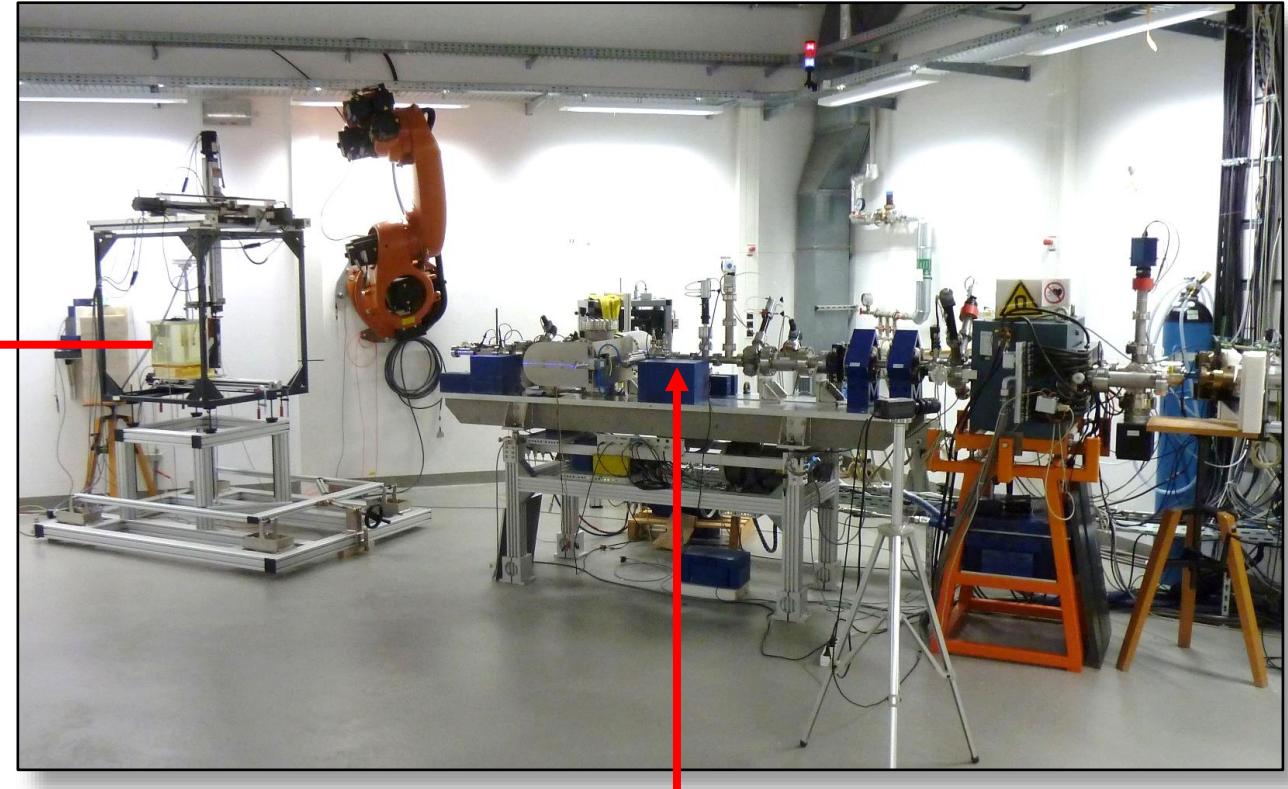
Ultra-high pulse dose rate reference electron beam at PTB



*Alanine pellets at
reference depth
in water phantom*



Dose traceable to
primary standard

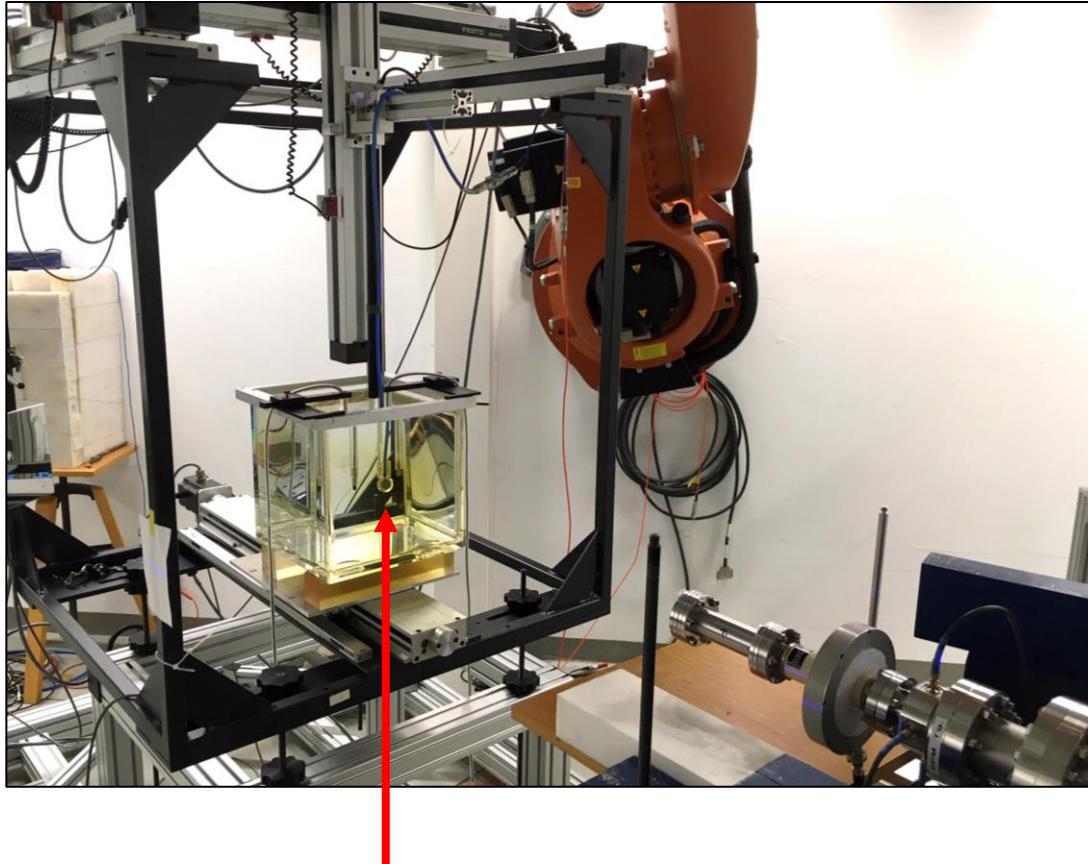


Current transformer (Bergoz ICT): Non-destructive
absolute beam pulse charge measurement
(uncertainty < 0.1 % @ 70 nC/pulse)

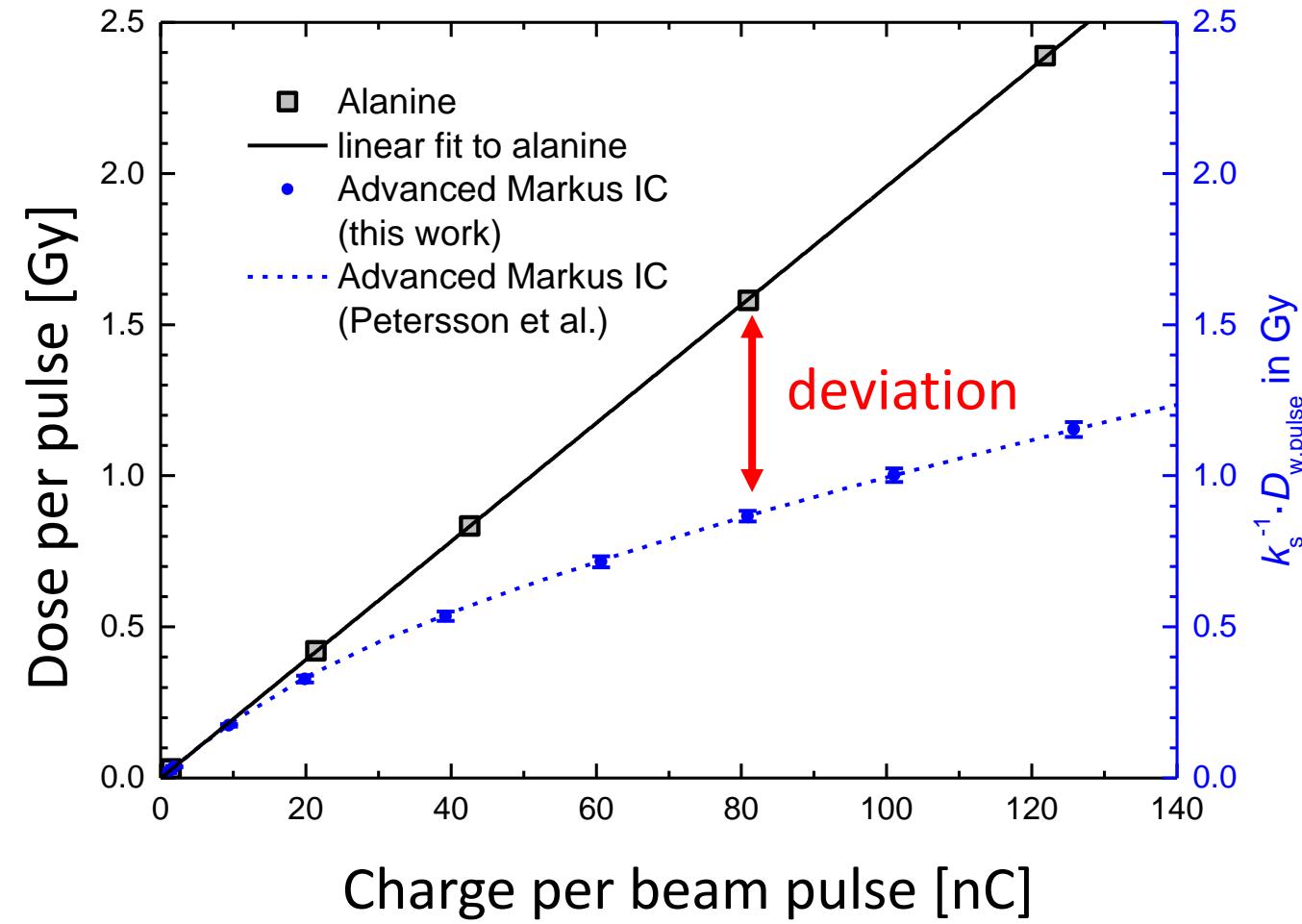


Current developments for dosimetry for FLASH RT

Ultra-high pulse dose rate reference electron beam at PTB



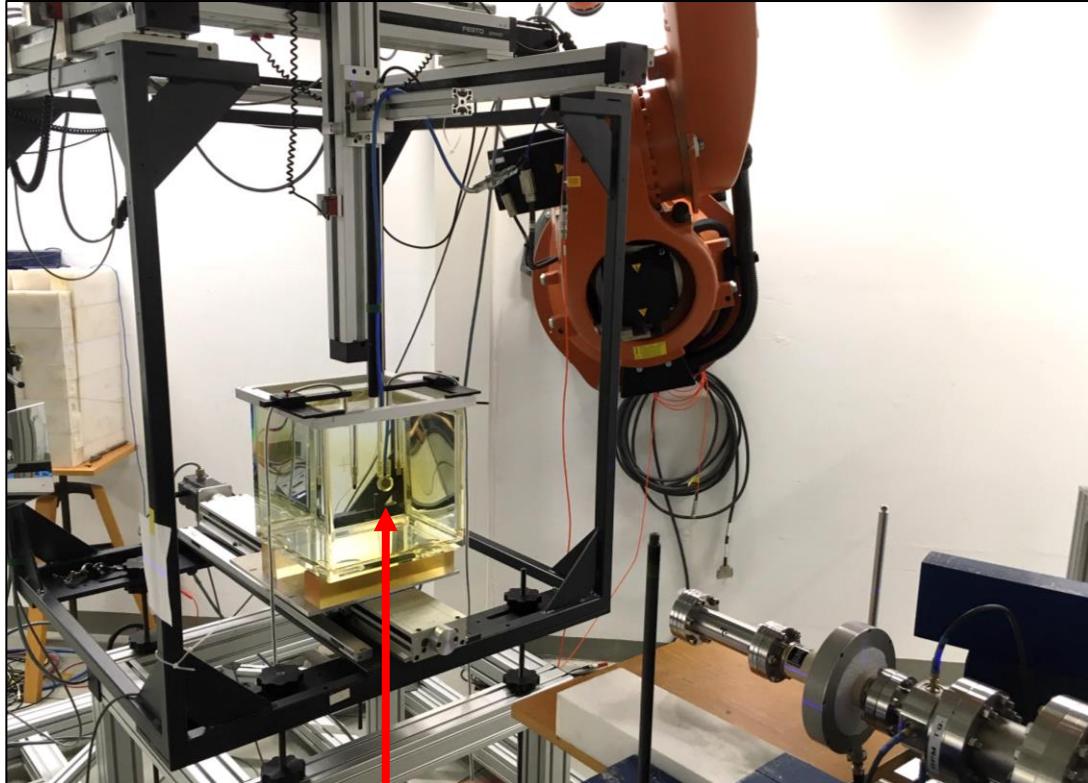
*Detector under test at reference depth
in water phantom*





Current developments for dosimetry for FLASH RT

Ultra-high pulse dose rate reference electron beam at PTB



*Detector under test at reference depth
in water phantom*

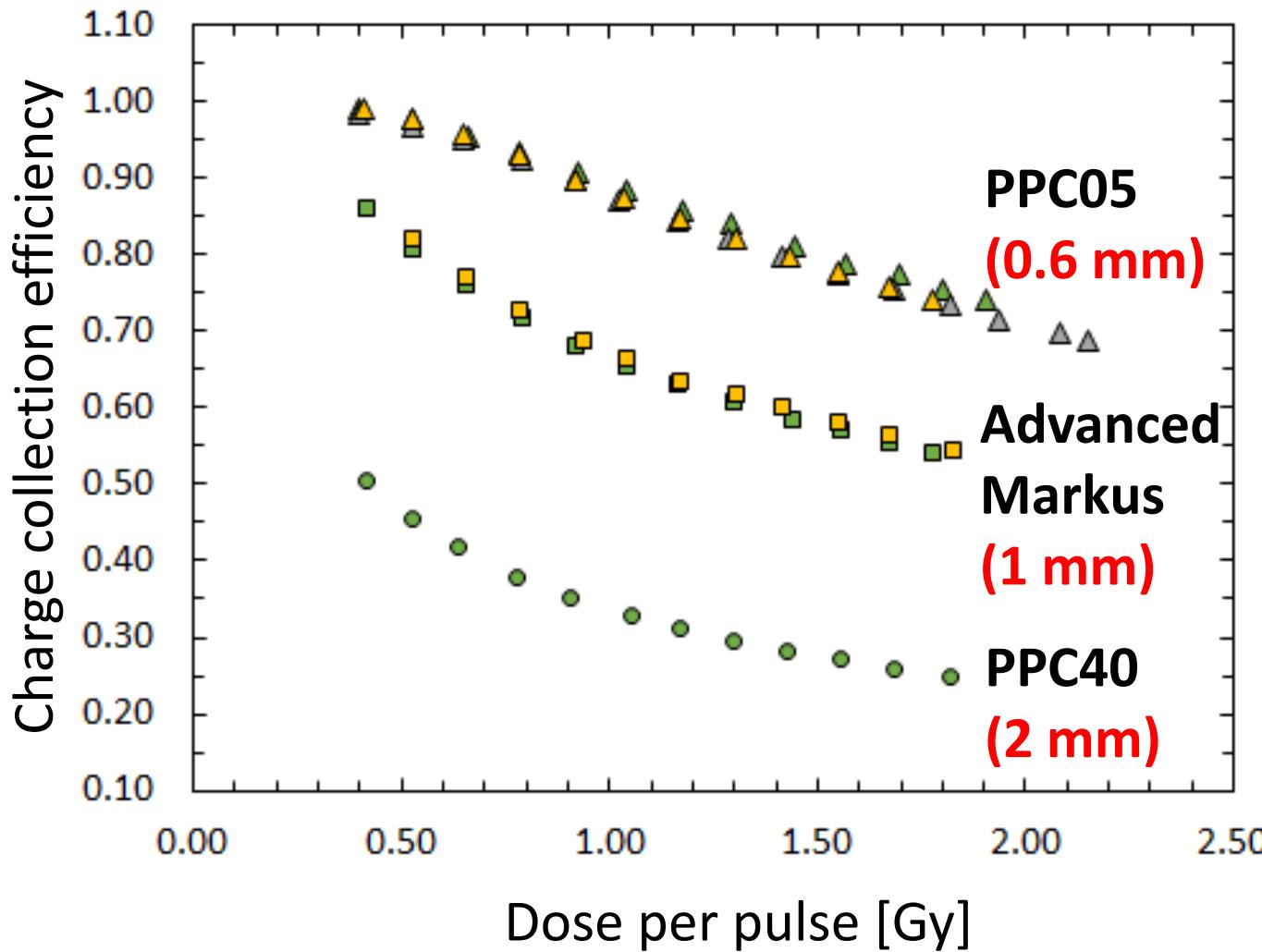


Video: Flashes of Cherenkov light in water phantom during ultra-high dose per pulse irradiation (PRF = 5 Hz)



Current developments for dosimetry for FLASH RT

Corrections functions for commercially available ionization chambers

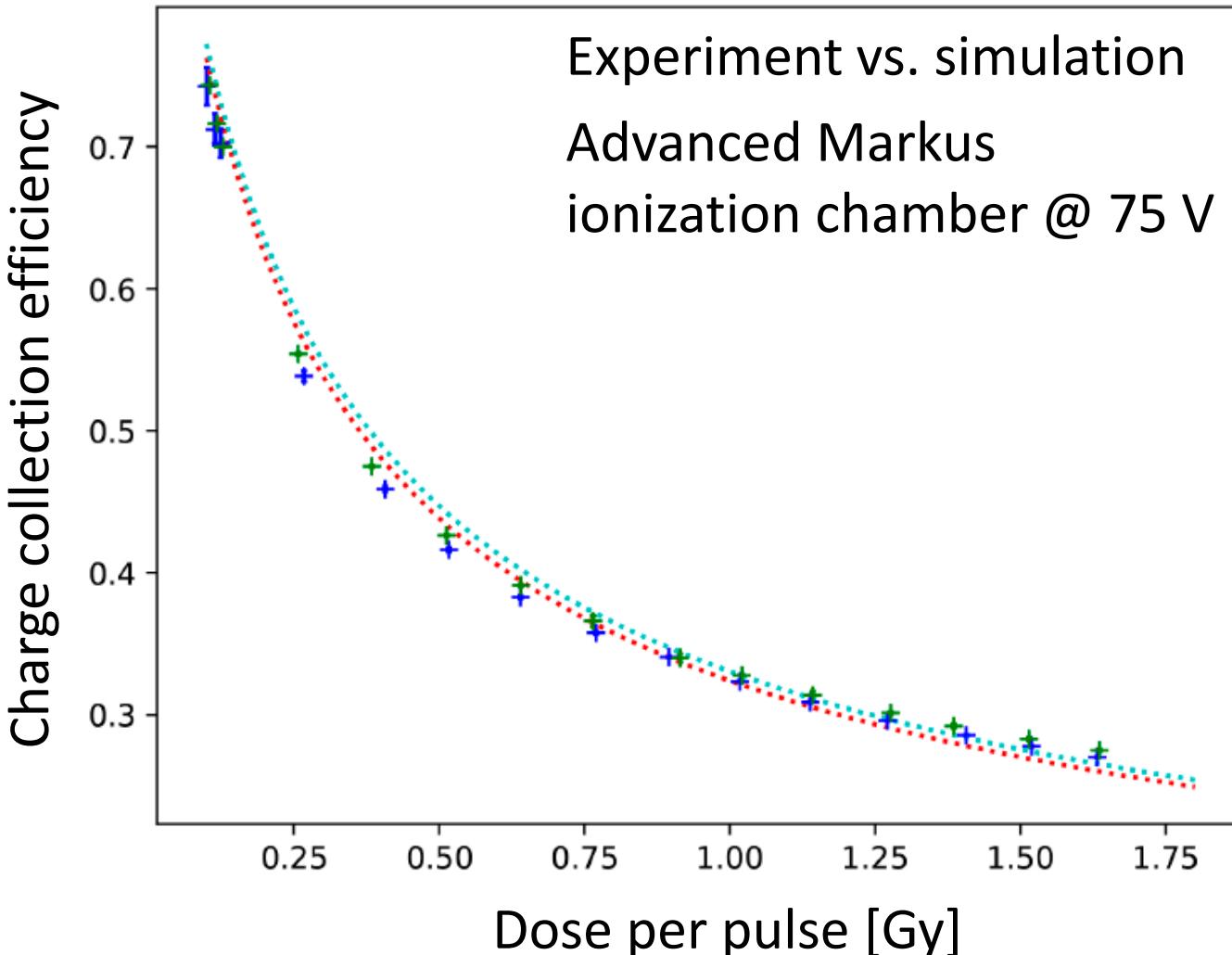


see talk of Alexandra Bourgouin (PTB)
in this session



Current developments for dosimetry for FLASH RT

Theoretical models for ionization chambers at ultra-high dose per pulse



see talk of Jose Paz-Martin (USC)
in session “QA and Dosimetry II”
(tomorrow)

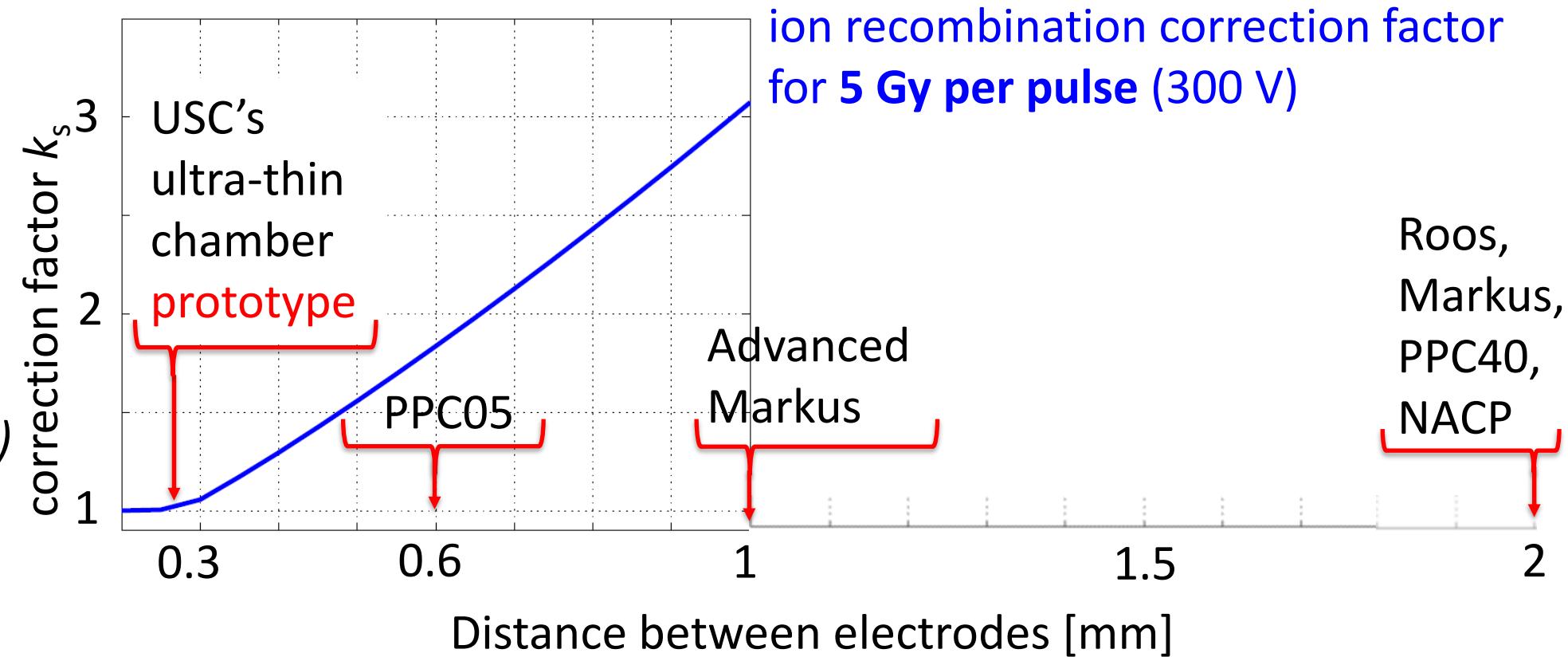


Current developments for dosimetry for FLASH RT

Prototype ionization chamber for ultra-high dose per pulse



Ionization chamber prototype (0.27 mm)



see next talk by Faustino Gomez (USC)

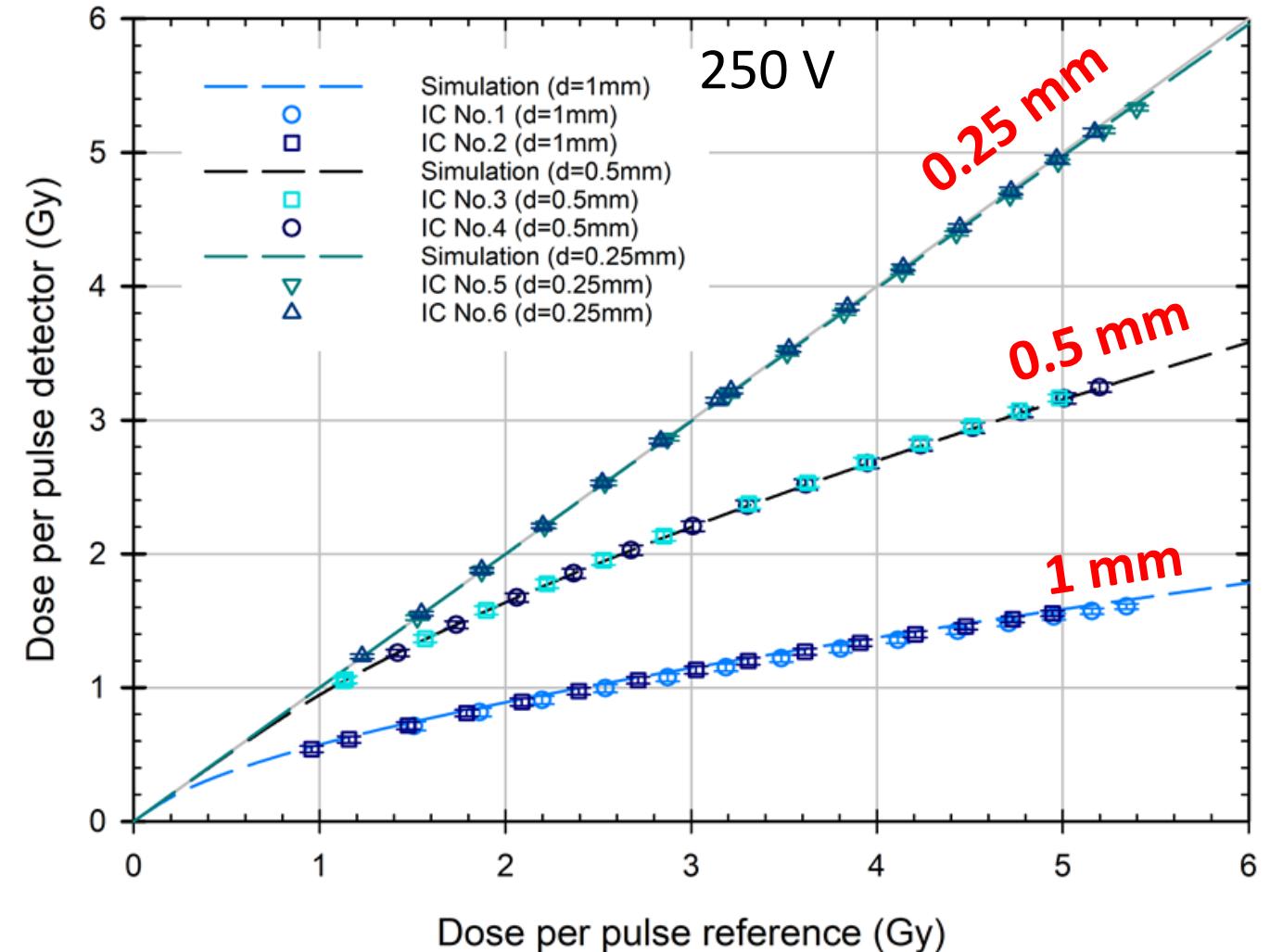


Current developments for dosimetry for FLASH RT

Prototype ionization chamber for ultra-high dose per pulse



see talk of Rafael Kranzer (PTW)
“Dosimetry II (UHDpulse)” (Fri)





Current developments for dosimetry for FLASH RT

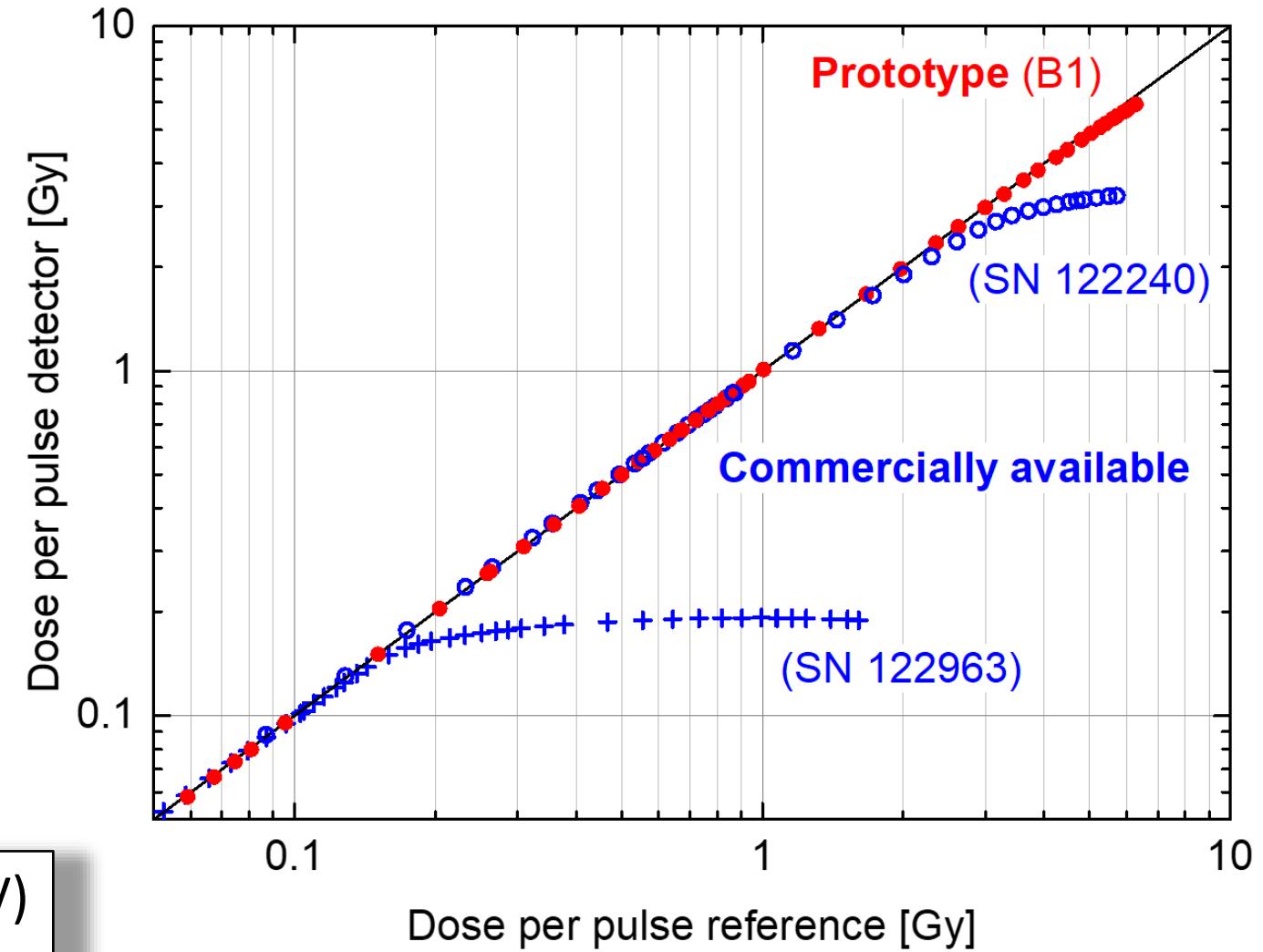
Prototype diamond detectors for ultra-high dose per pulse



*

see talk of Rafael Kranzer (PTW)
“QA & Dosimetry I” (today)

see talk of Gianluca Verona Rinati (URTV)
“QA & Dosimetry II” (tomorrow)





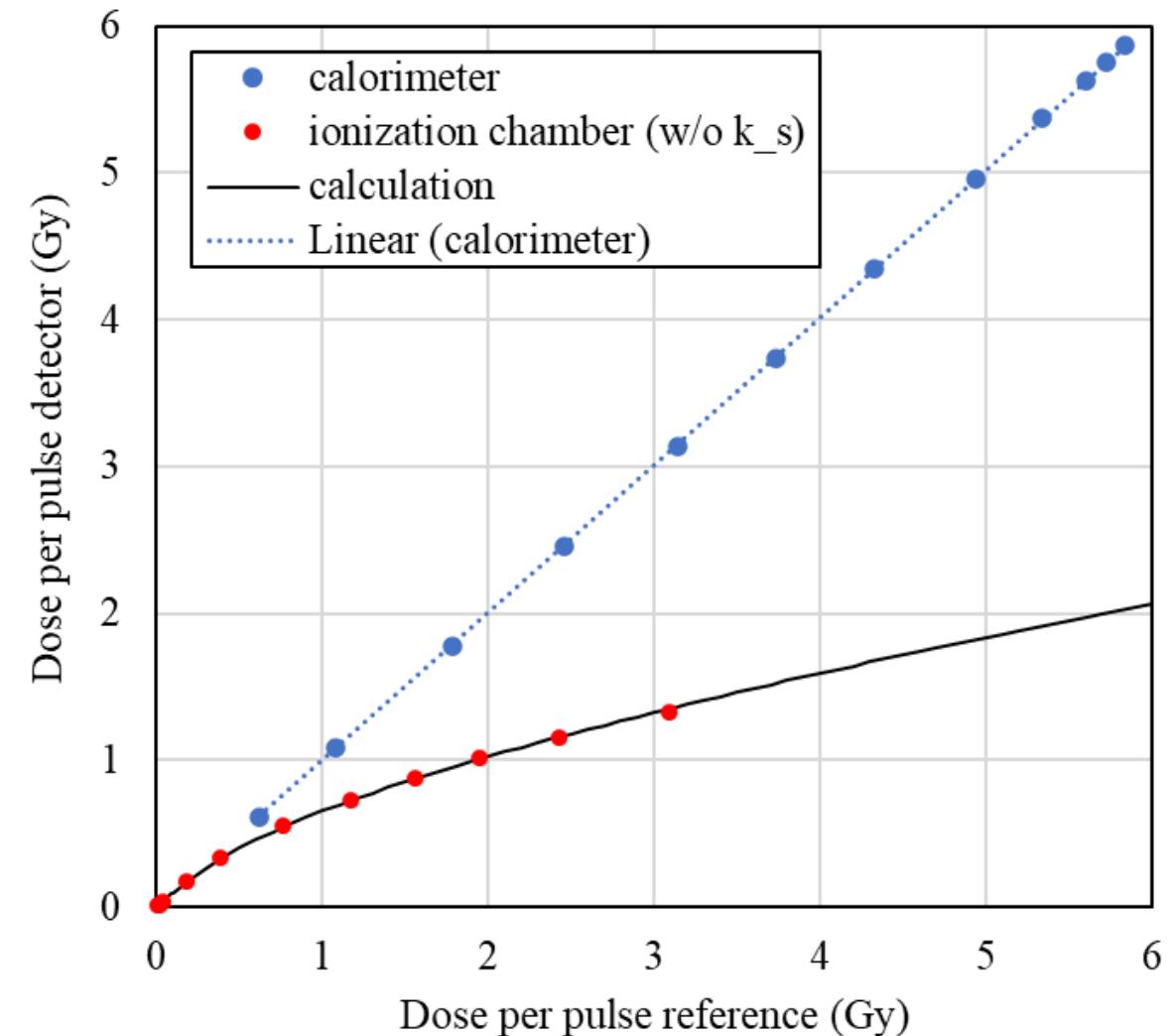
Current developments for dosimetry for FLASH RT

Graphite Probe Calorimeter prototype for ultra-high dose per pulse



*Calorimeter Aerrow
(and ionization chamber)*

see talk of Alexandra Bourgouin (PTB)
“QA and Dosimetry II” (tomorrow)





UHDpulse contributions at FRPT2021

Dosimetry for FLASH RT with electrons



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



FRICKE DOSIMETRY AS A PRIMARY STANDARD AND REFERENCE FOR ABSORBED DOSE TO WATER IN ULTRA HIGH PULSE DOSE RATE ELECTRON BEAMS
Franziska Frei



ION COLLECTION EFFICIENCY IN ULTRA-HIGH DOSE PER PULSE ELECTRON BEAMS
Alexandra Bourgouin



PLASTIC SCINTILLATOR UNDER ULTRA-HIGH DOSE RATE ELECTRON BEAM: LONG TERM DAMAGES AND CHANGES IN OPTICAL RESPONSE
Boby Lessard



VENTED IONIZATION CHAMBERS FOR ULTRA-HIGH DOSE PER PULS CONDITIONS
Rafael D. Kranzer



REALIZATION AND CHARACTERIZATION OF NOVEL DIAMOND DETECTOR PROTOTYPES FOR FLASH THERAPY APPLICATION
Gianluca Verona Rinati



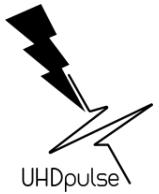
MONITORING A FLASH BEAM: FOR PRECLINICAL STUDIES AND TOWARDS CLINICAL APPLICATIONS
Sophie Heinrich



FASTER THAN LIGHT: CAN SCINTILLATORS GUIDE ELECTRON FLASH EXPERIMENTS?
Verdi Vanreusel



NEW DEVELOPMENTS ON SIC DOSIMETERS FOR ADVANCED RADIOTHERAPIES
Celeste Fleta



UHDpulse contributions at FRPT2021

Dosimetry for FLASH RT with electrons (2)



PERFORMANCE OF A PROBE-TYPE GRAPHITE CALORIMETER (AERROW) IN ULTRA-HIGH DOSE PER PULSE ELECTRON BEAMS
Alexandra Bourguin

SECONDARY STANDARD DOSIMETRY: UNDERSTANDING THE IONIZATION CHAMBERS FOR THE FUTURE ULTRA-HIGH DOSE RATE APPLICATIONS
Jose Paz-Martin

LINEARITY OF DIAMOND DETECTORS IN ULTRA-HIGH DOSE-PER-PULSE ELECTRON BEAMS
Rafael D. Kranzer

DOSIMETRIC COMPARISON SCHEME FACILITATING MULTI-CENTER FLASHRT PRE-CLINICAL STUDIES
Claude Bailat

ESTABLISHMENT OF A FLASH RADIOTHERAPY FACILITY AT NPL AND DOSIMETRY STUDY
Alexandros Douralis

FLUKA MONTE CARLO FOR BASIC DOSIMETRIC STUDIES OF UHPDR ELECTRON BEAMS
Adrian Knyziak

CHARACTERIZATION OF OSL AND TL DOSIMETERS WITH DATA COLLECTED AT THE MT25 CYCLIC ELECTRON ACCELERATOR
Anna Cimmino

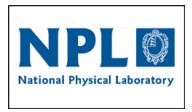


UHDpulse contributions at FRPT2021

Dosimetry for FLASH proton therapy



ION RECOMBINATION CORRECTION FACTORS AND BENCHMARK OF DETECTORS IN A VERY-HIGH DOSE RATE PROTON SCANNING BEAM
Amélia Maia Leite



DEVELOPMENT AND TEST OF A SMALL PORTABLE GRAPHITE CALORIMETER FOR USE IN ULTRA-HIGH DOSE RATE PARTICLE BEAMS
Russell A. Thomas



MULTI-LEAF FARADAY CUP FOR QUALITY ASSURANCE IN RADIATION THERAPY WITH ELECTRON AND ION BEAMS AT CONVENTIONAL AND
ULTRA-HIGH DOSE RATE



Andreas Schüller



Spectral - and intensity-sensitive characterization of pulsed FLASH proton fields with the pixel detector TimePIX3



Cristina Oancea



DEVELOPMENTS IN ACTIVE NEUTRON SPECTROMETRY FOR NEUTRON STRAY RADIATION FIELD CHARACTERIZATION IN FLASH
RADIOThERAPy



Miroslav Zboril

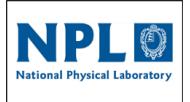


MONTE CARLO MODELLING OF PIXEL CLUSTERS IN TIMEPIX DETECTORS USING THE MCNP CODE
Jaroslav Šolc



UHDpulse contributions at FRPT2021

Dosimetry for VHEE

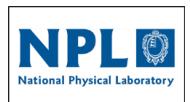


CALORIMETRY FOR ULTRA-HIGH-DOSE-RATE VERY HIGH ENERGY ELECTRON BEAMS
Michael McManus

Dosimetry for Laser driven beams



IRRADIATION OF LUMINESCENCE DOSIMETERS IN STRAY RADIATION FIELD IN LASER-DRIVEN ACCELERATORS
Anna Cimmino



CALORIMETRY TECHNIQUES FOR ABSOLUTE DOSIMETRY OF LASER-DRIVEN IONS BEAMS
Sean McCallum



DOSIMETRY AND BEAM DELIVERY ARRANGEMENTS FOR SINGLE-SHOT, ULTRA-HIGH DOSE-RATE RADIobiology EXPERIMENTS EMPLOYING LASER-ACCELERATED IONS
Giuliana Milluzzo

Acknowledgement

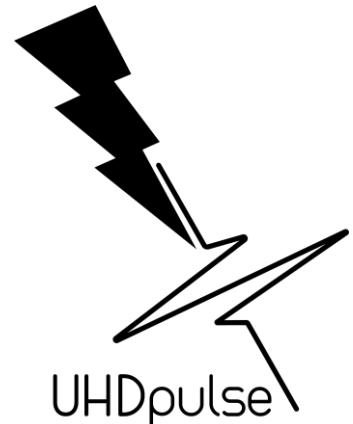
(in alphabetical order):

I. Ambrozova, U. Ankerhold, L. Archambault, R. Ashraf, C. Bailat, M. Borghesi, A. Boso, A. Bourgouin, P. Bruza, S. Busold, M. Caresana, A. Cimmino, L. De Marzi, V. Djonov, A. Douralis, M. Durante, M. Dutreix, F. Fausti, F. Keszti, G. Felici, C. Fleta, J.-M. Fontbonne, C. Fouillade, F. Frei, A. Gasparini, U. Giesen, L. Giuliano, F. Gomez, L. Grasso, T. Hackel, S. Heinrich, J. Jakubek, R.-P. Kapsch, K. Kirkby, A. Knyziak, R. Kranzer, C. Lahaye, M. Lavagno, A. Leite, V. Linhart, B. Lessard, H. K. Looe, C. Makowski, M. Marinelli, S. McCallum, M. McEwen, M. McManus, T. Michel, G. Milluzzo, S. Motta, C. Oancea, V. Olsovcova, H. Palmans, K. Parodi, J. Pawelke, J. Paz-Martin, P. Peier, K. Petersson, J. Pivec, B. Poppe, D. Poppinga, M. Pullia, J. Renaud, N. Roberts, F. Romano, S. Rossomme, S. Safai, S. Salvador, C. S. Schmitzer, A. Schönfeld, B. Simon, J. Solc, F. Stephan, A. Subiel, R. A. Thomas, M. Trachsel, F. Vanhavere, V. Vanreusel, D. Verellen, G. Verona Rinati, J. Seuntjens, R. Versaci, P. von Voigts-Rhetz, M. Zboril



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<http://uhdpulse-empir.eu/>