# Faster than light: Can scintillator detectors guide electron FLASH experiments?

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# Faculty Disclosure

| | |
|---|---|
| X | No, nothing to disclose |
| | Yes, please specify: |

| Company Name | Honoraria/ Expenses | Consulting/ Advisory Board | Funded Research | Royalties/ Patent | Stock Options | Ownership / Equity Position | Employee | Other (please specify) |
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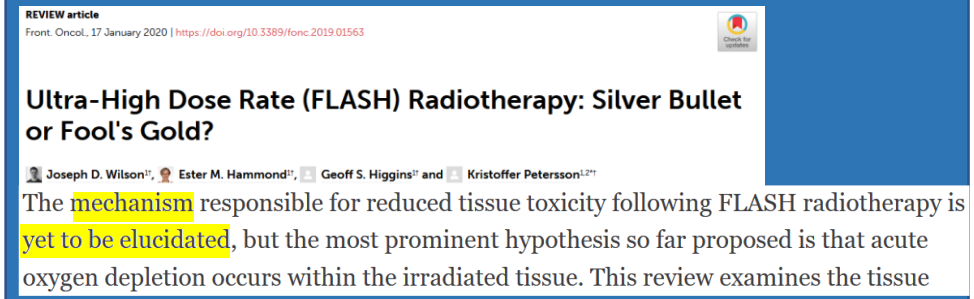
# Introduction: FLASHy question

The FLASH effect!

## How does it work?



REVIEW article

Front. Oncol., 17 January 2020 | https://doi.org/10.3389/fonc.2019.01563

**Ultra-High Dose Rate (FLASH) Radiotherapy: Silver Bullet or Fool's Gold?**

Joseph D. Wilson[1*], Ester M. Hammond[1*], Geoff S. Higgins[1*] and Kristoffer Petersson[1,2*†]

The mechanism responsible for reduced tissue toxicity following FLASH radiotherapy is yet to be elucidated, but the most prominent hypothesis so far proposed is that acute oxygen depletion occurs within the irradiated tissue. This review examines the tissue

## What are the beam characteristics?

LETTER | AUGUST 27 2020

**All Irradiations that are Ultra-High Dose Rate may not be FLASH: The Critical Importance of Beam Parameter Characterization and *In Vivo* Validation of the FLASH Effect**

Marie-Catherine Vozenin ; Pierre Montay-Gruel ; Charles Limoli ; Jean-François Germond

*Radiat Res* (2020) 194 (6): 57

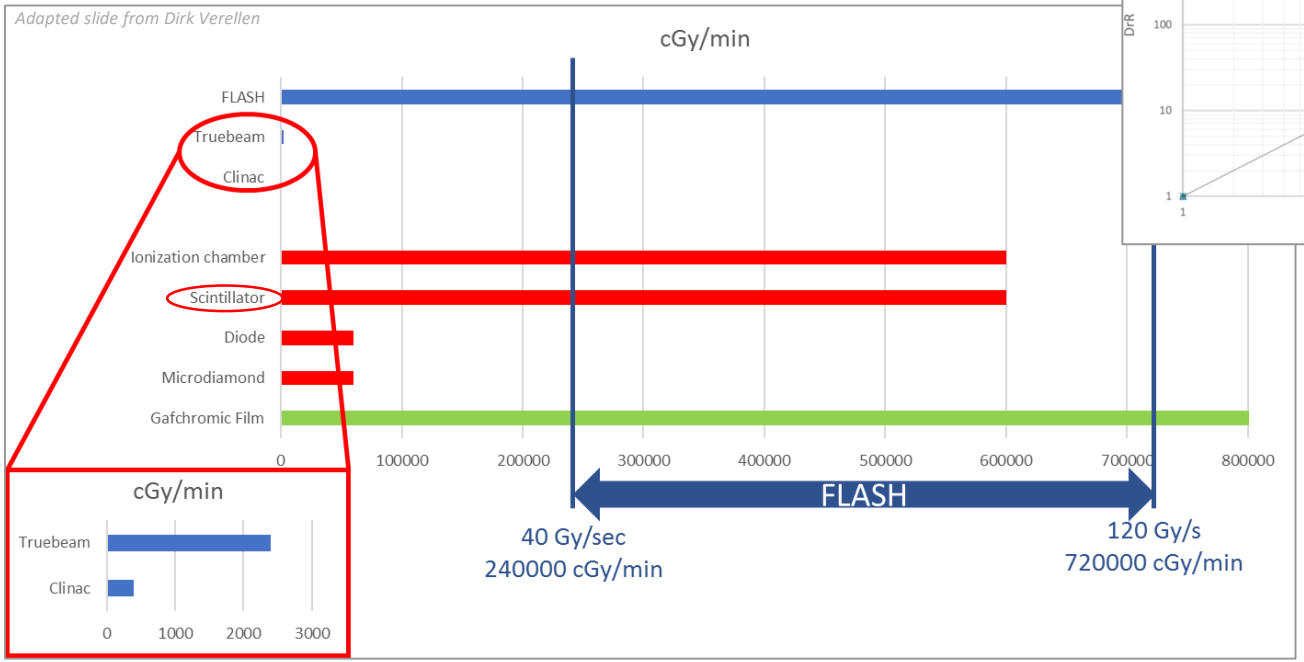
MEDICAL PHYSICS

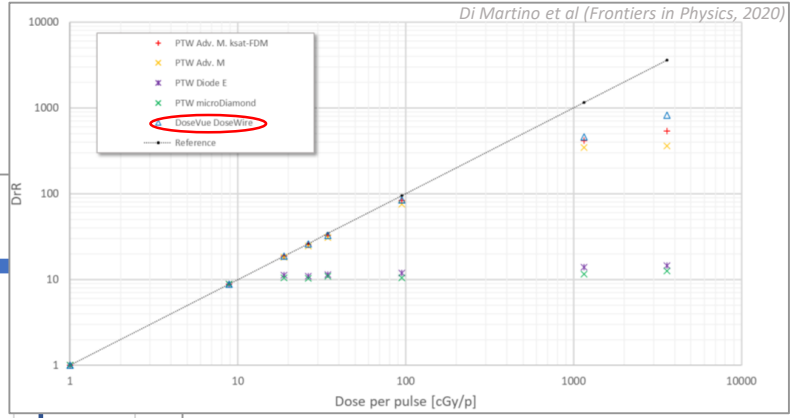
The International Journal of Medical Physics Research and Practice

**Minimum dose rate estimation for pulsed FLASH radiotherapy: A dimensional analysis**

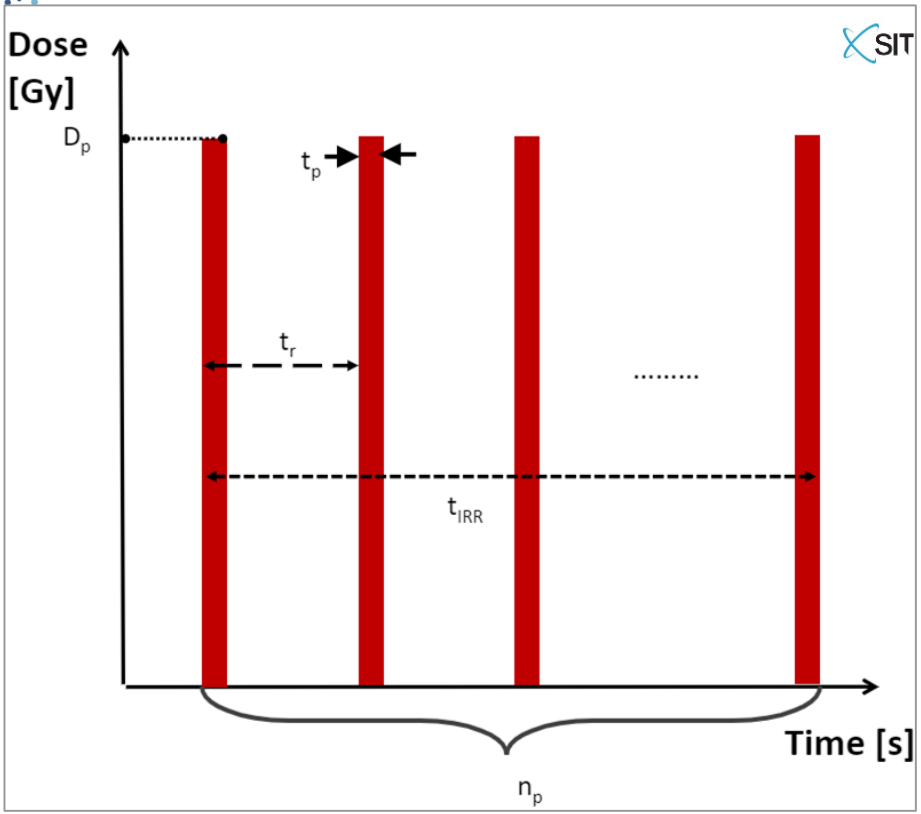
Sumin Zhou, Dandan Zheng, Qiyong Fan, Ying Yan, Shuo Wang, Yu Lei, Abigail Besemer, Christina Zhou, Charles Enke

# Introduction: Dosimetry



# Introduction: Dosimetry

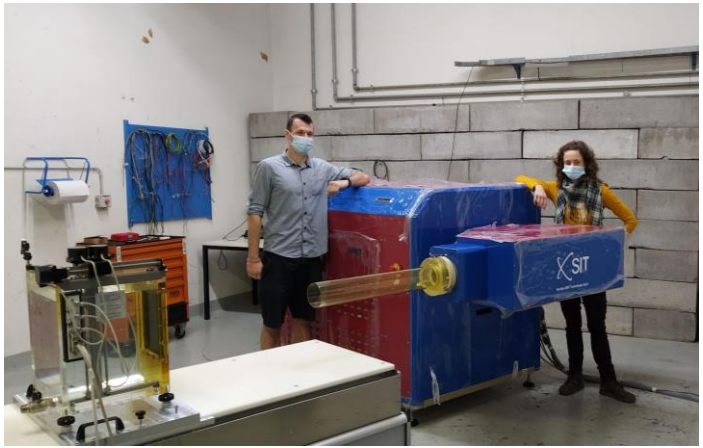



## Dosimeter characteristics:

- Linear with total dose
- Linear with dose per pulse
- Stable with dose rate
- Stable with instantaneous dose rate
- Stable with Pulse repetition frequency

# Materials (and Methods)

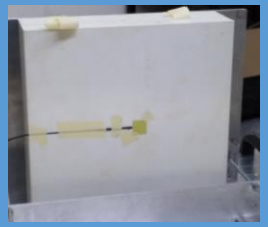
## ElectronFlash (ELF)



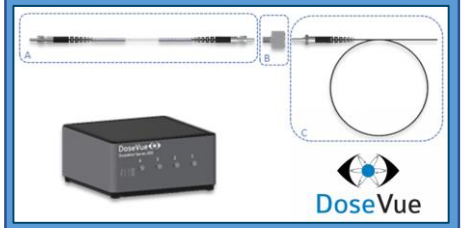
## $AL_2O_3$:C-based

**SCK_X1:**
- Crystal
- $Al_2O_3$:C

**SCK_P1:**
- Powder
- $Al_2O_3$:C,Mg

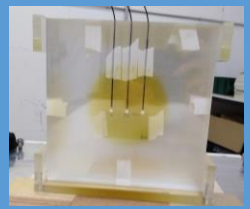


## $Y_2O_3$:Eu-based




IH000009/IH000010:
- Clinical point scintillator

POF235/POF236/POF237:
- Experimental
- Decreased concentration

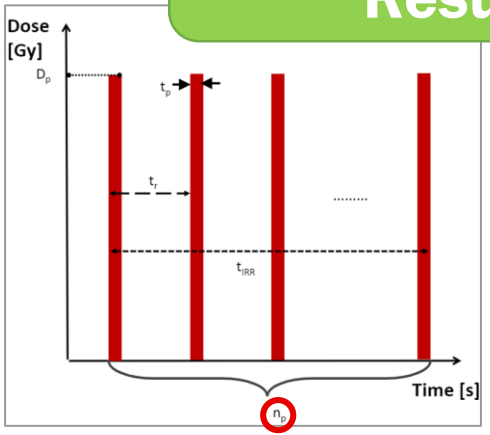


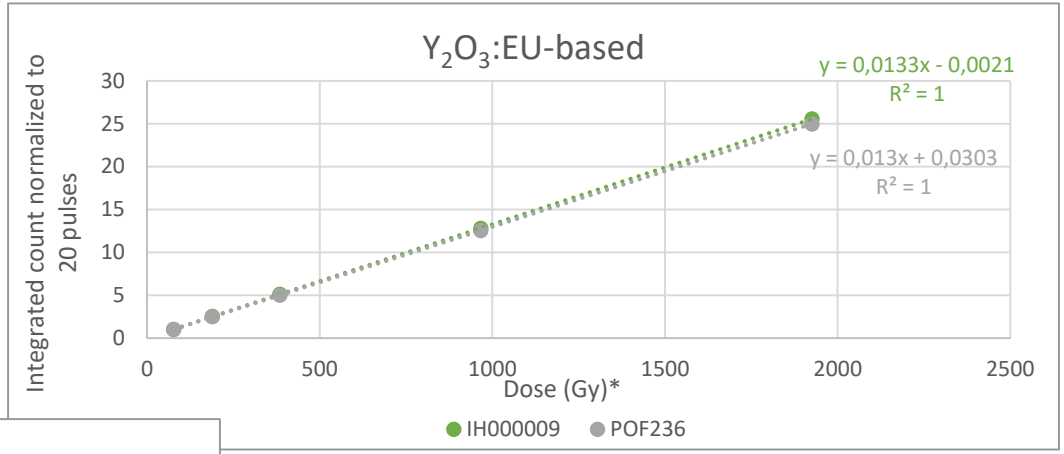
# (Materials and) Methods

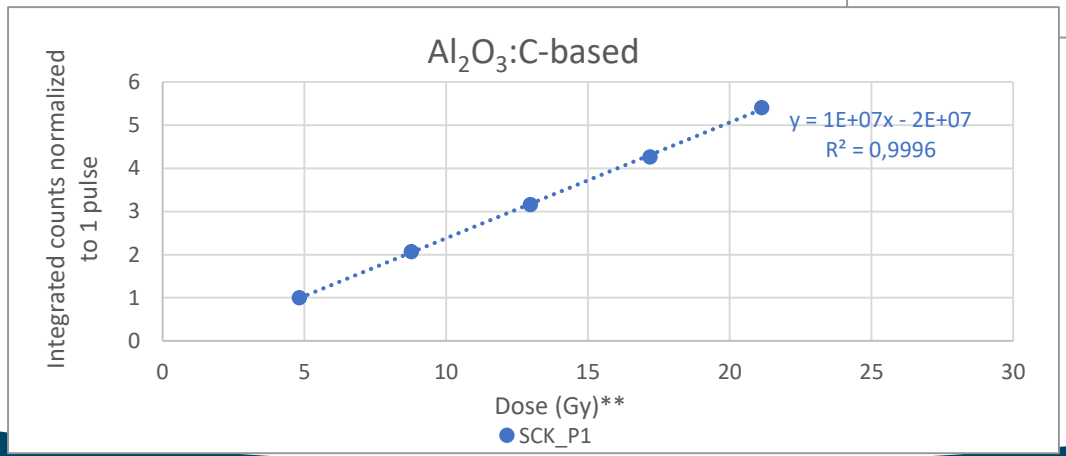
| | $Al_2O_3$:C-based | $Y_2O_3$:Eu-based |
|---|---|---|
| Scintillating wavelength | 420 nm | 611 nm |
| Wavelength filter | Yes | Yes |
| Background subtraction | Yes (by median of measurement) | No |
| Sampling frequency | 200 Hz | 1 Hz |
| Reference | Alanine (direct/indirect*) EBT-XD film | Alanine (indirect*) |

* Indirect = by calibration of internal monitoring system (based on internal toroid reading)

# Results: Linearity with Dose



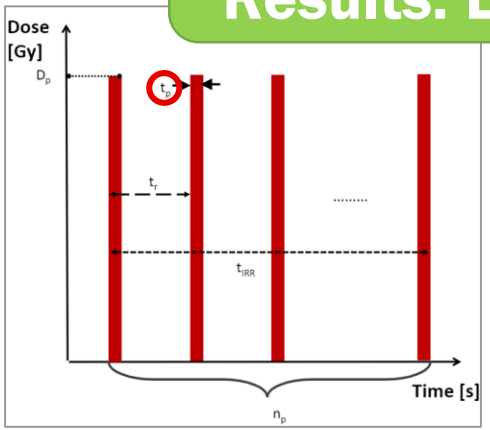

* MU-based dose

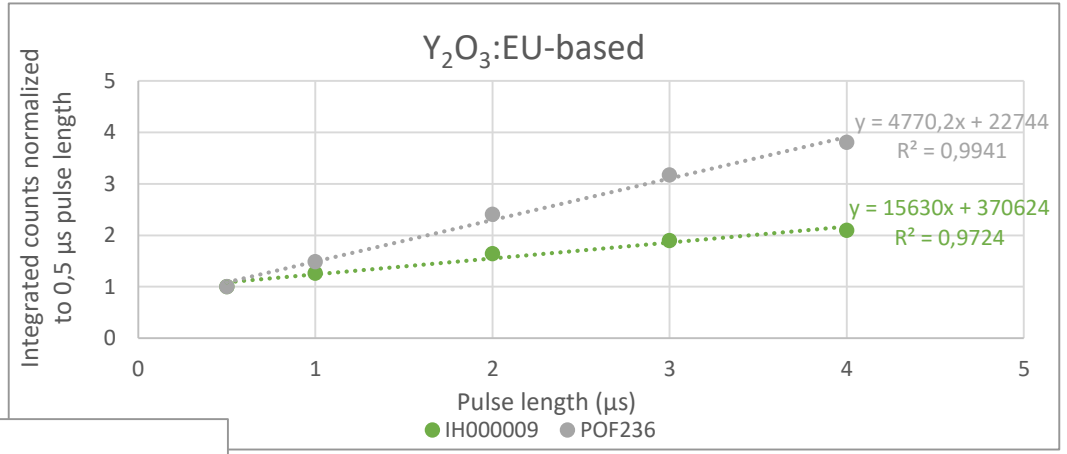
**Very good linearity with total dose up to**

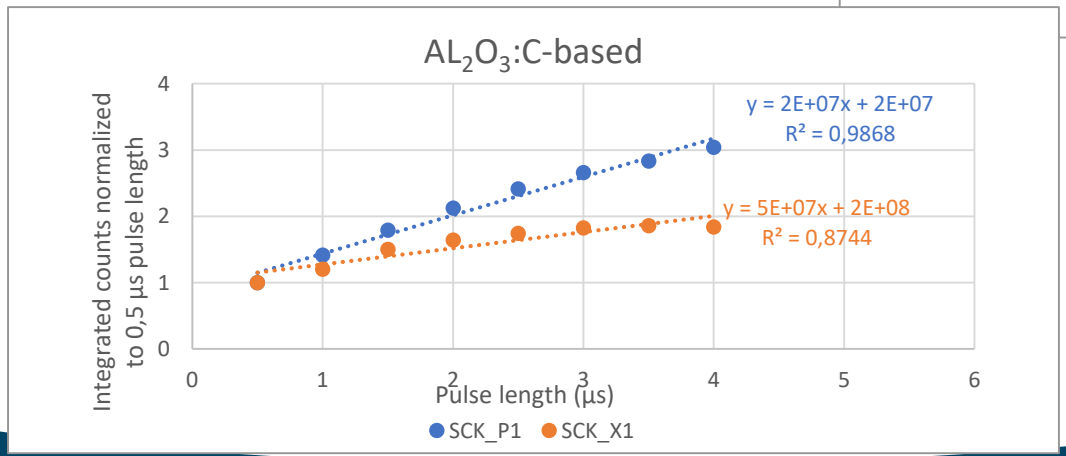
- **1900 Gy ($Y_2O_3$:EU)**
- **21 Gy ($Al_2O_3$:C,Mg)**

** Film dose

# Results: Linearity with Dose Per Pulse

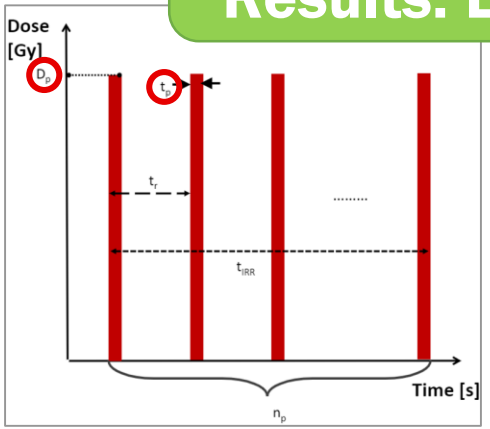


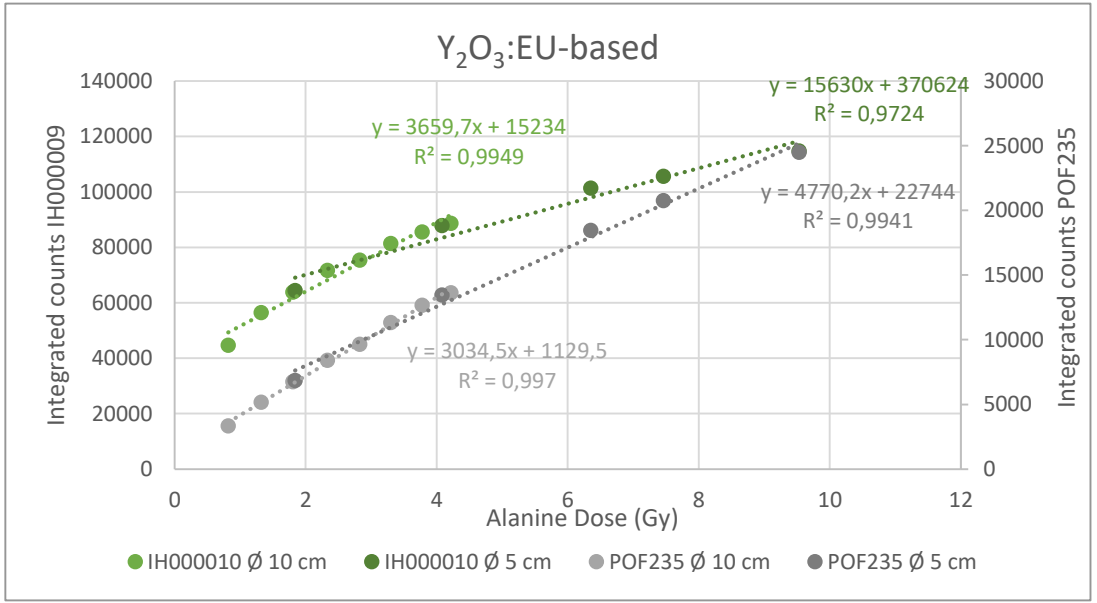




**Ok linearity with pulse length (dose per pulse), low saturation observable**

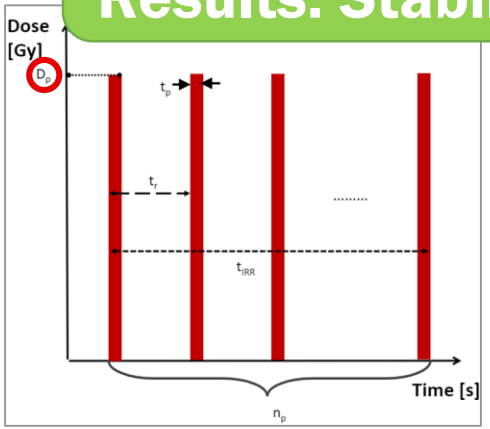
# Results: Linearity with Dose Per Pulse

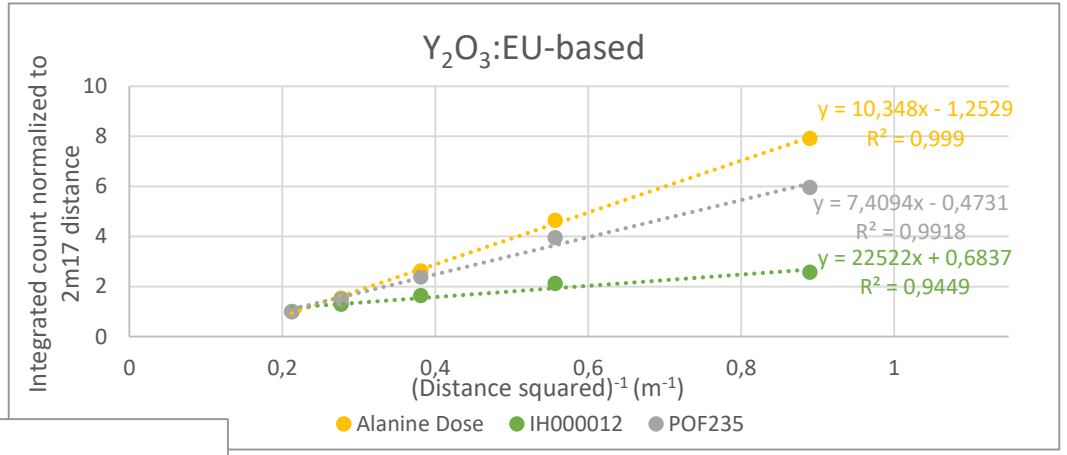


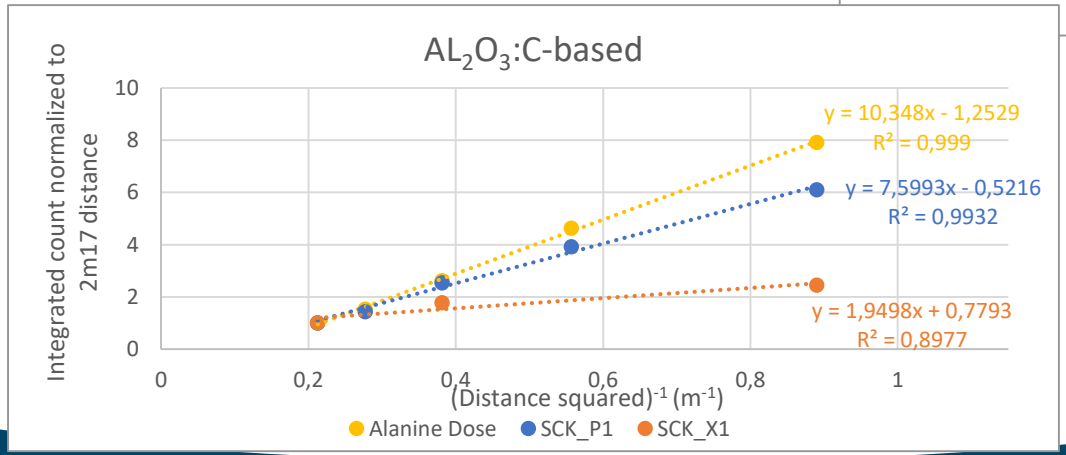

- Degradation of linearity with dose per pulse with increasing dose per pulse
- Poor linearity with instantaneous dose rate



# Results: Stability with instantaneous dose rate

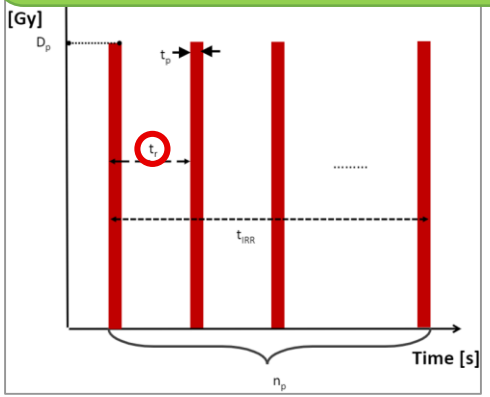


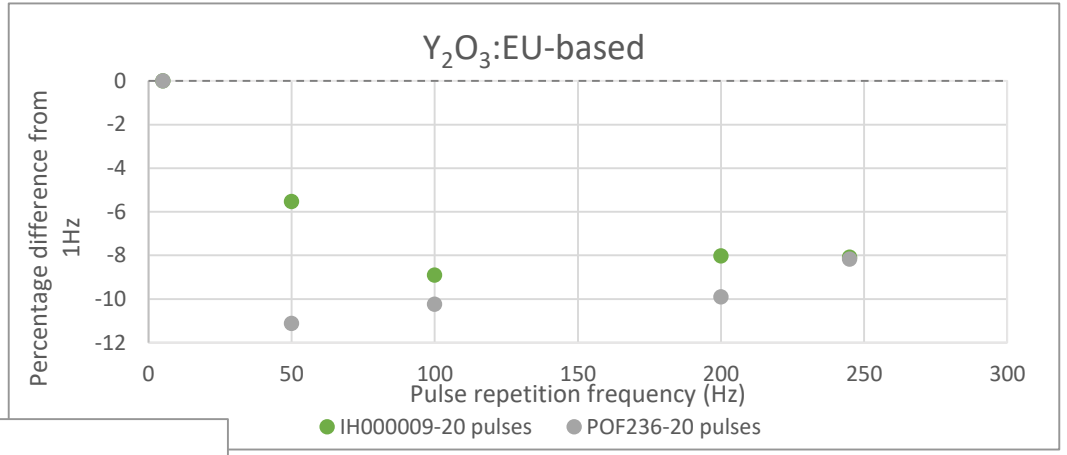



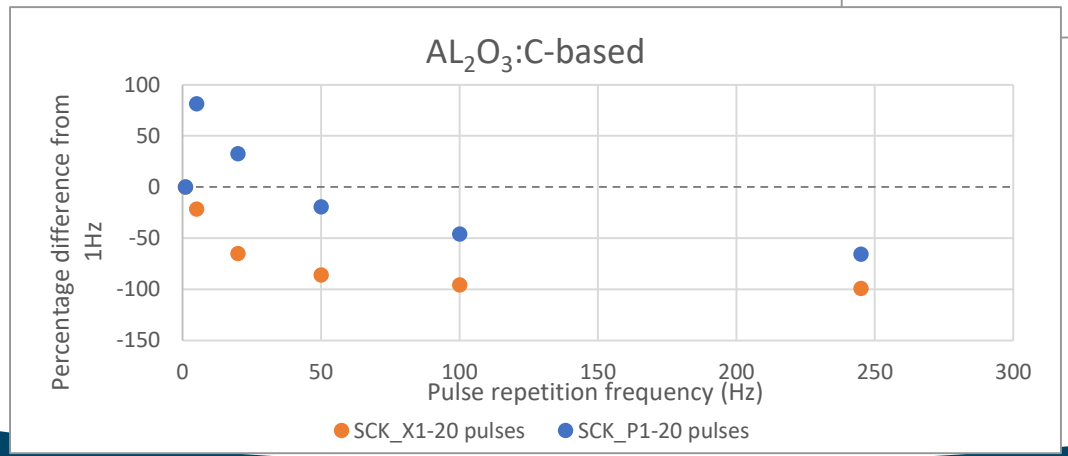




**Stability with iDR via inversed square law**
**➔ Good stability with iDR up to ±1MGy/s**

# Results: Stability with Pulse Repetition Frequency

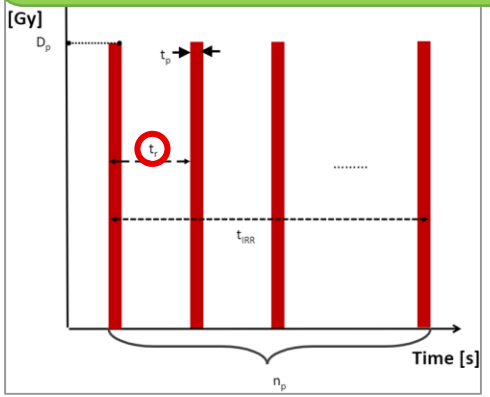


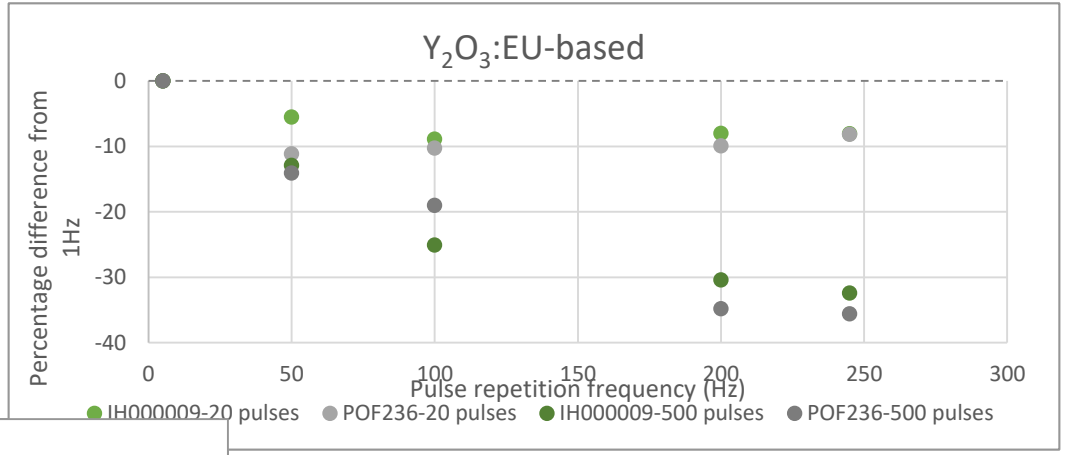



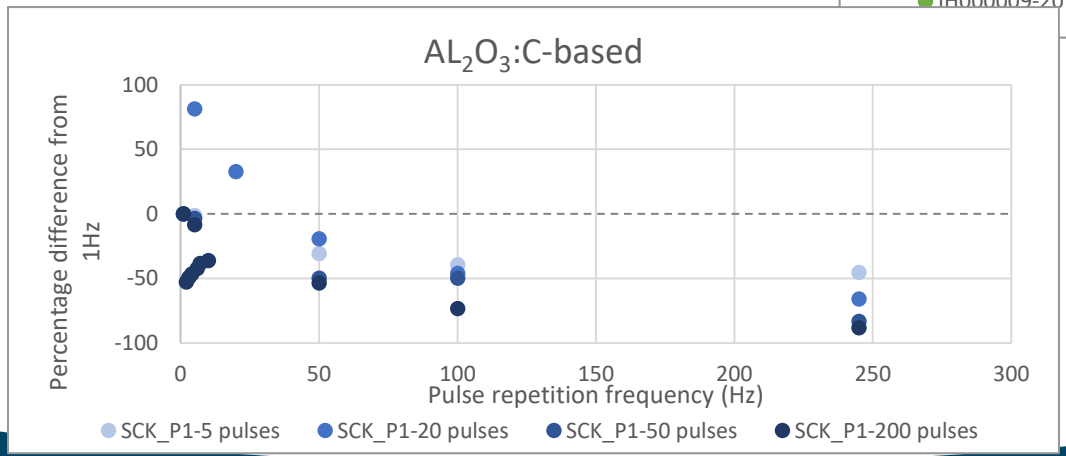




- **Poor stability with PRF**

# Results: Stability with Pulse Repetition Frequency

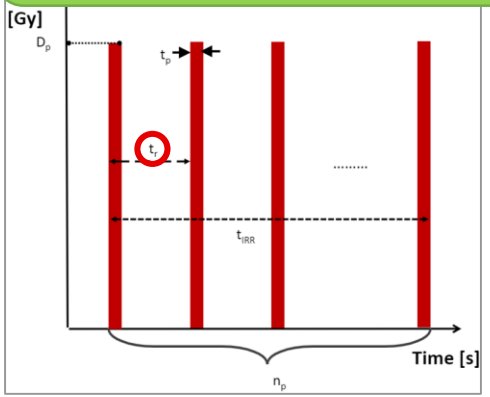


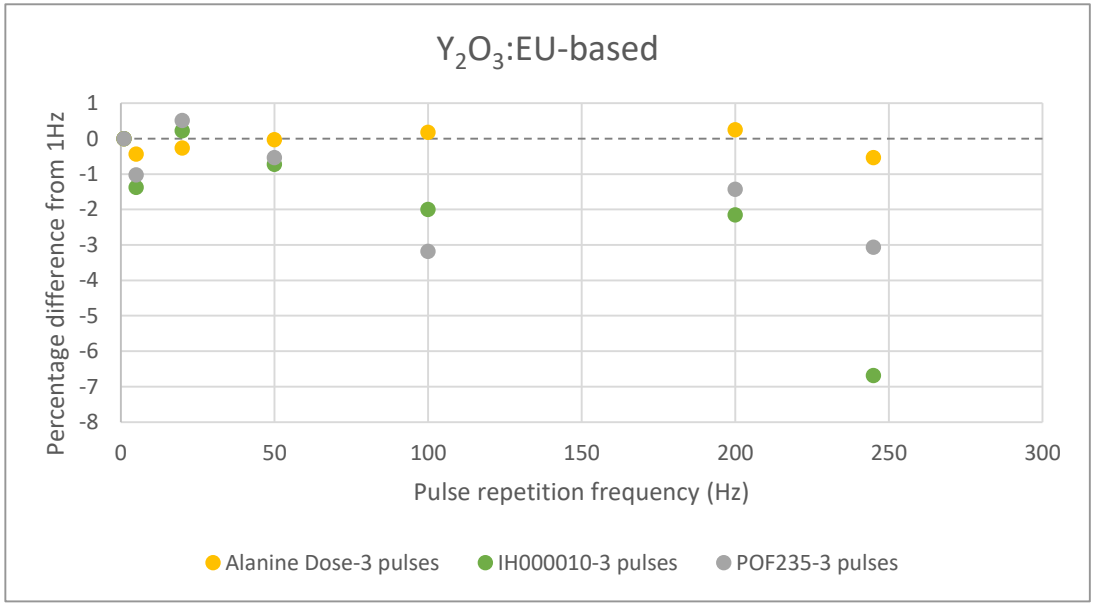




- **Poor stability with PRF**
- **Decreasing stability with # pulses**

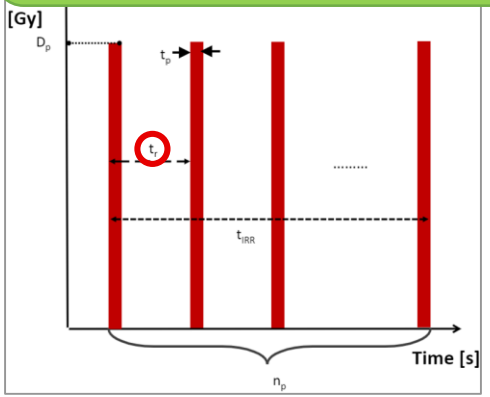
# Results: Stability with Pulse Repetition Frequency

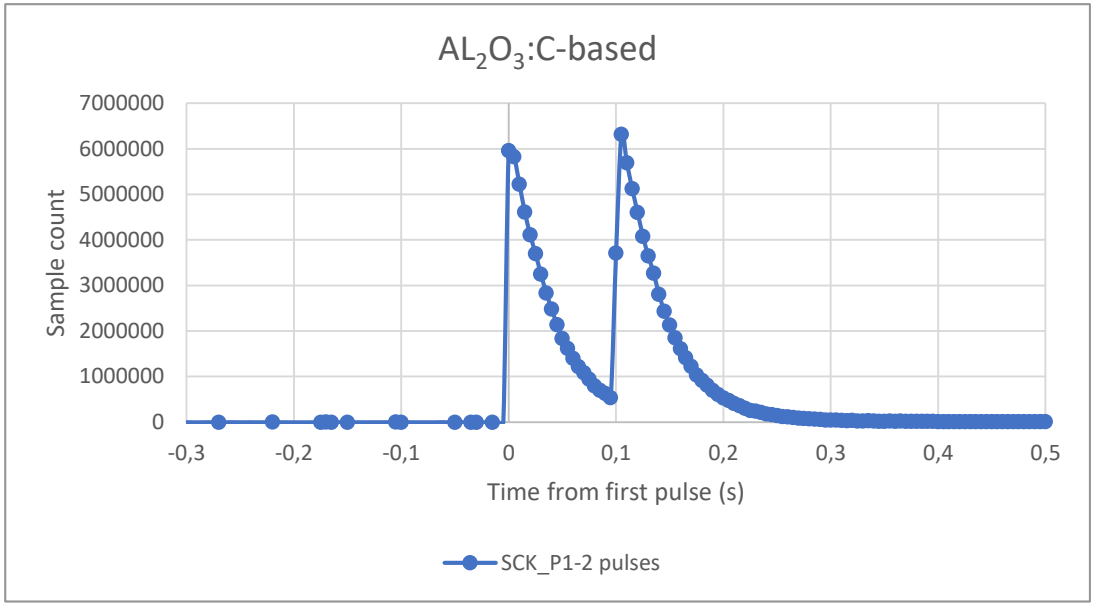



**Poor stability with PRF**



# Results: Stability with Pulse Repetition Frequency

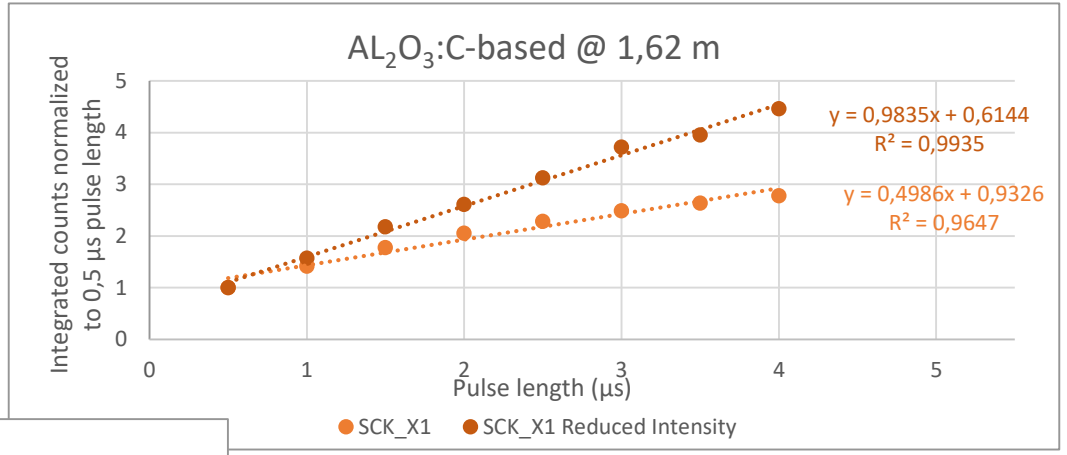


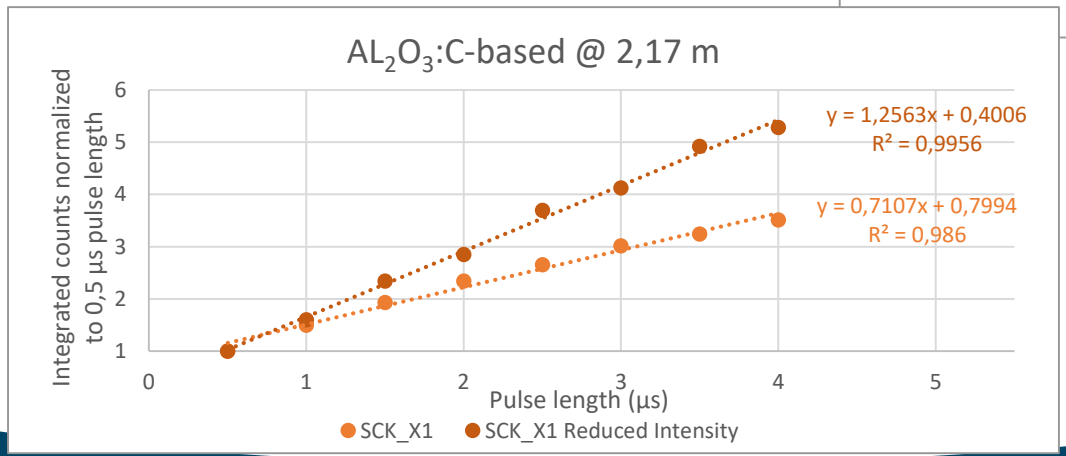




**Poor stability with PRF**
**➔ Due to scintillating decay time**

# Results: Decreasing light intensity

**Decrease of the light intensity using a paper filter**



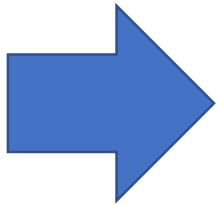

**Saturation effect occurs at higher dose per pulse**

# Conclusion

## Can scintillator detectors guide your electron FLASH experiments?

Dosimeter characteristics:

- Linear with total dose ☑
- Linear with dose per pulse ☒
- Stable with dose rate ☒
- Stable with instantaneous dose rate ☑
- Stable with Pulse repetition frequency ☒



**Not YET:**

- Saturation with dose per pulse

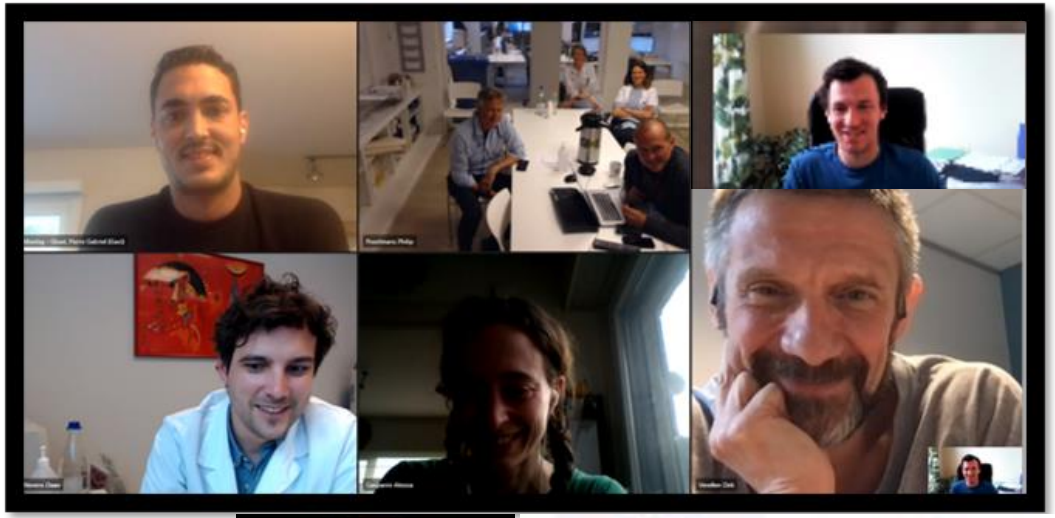
➔ reduction of sensitivity/signal intensity

- PRF dependence

➔ Decrease scintillation time

# Made possible by the FLASH team:

## The EL(F)ves



## The (baby)SITters

## The RDA-team