Time-Resolved Proton Beam Dosimetry for Ultra-High Dose-Rate Cancer Therapy (FLASH)

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Outline

- **Ultra-high dose rate radiation therapy (FLASH)**
- **Development of new detectors for FLASH at the University of Bern**
- **Results with proton and electron beams**
- **Conclusion and outlook**

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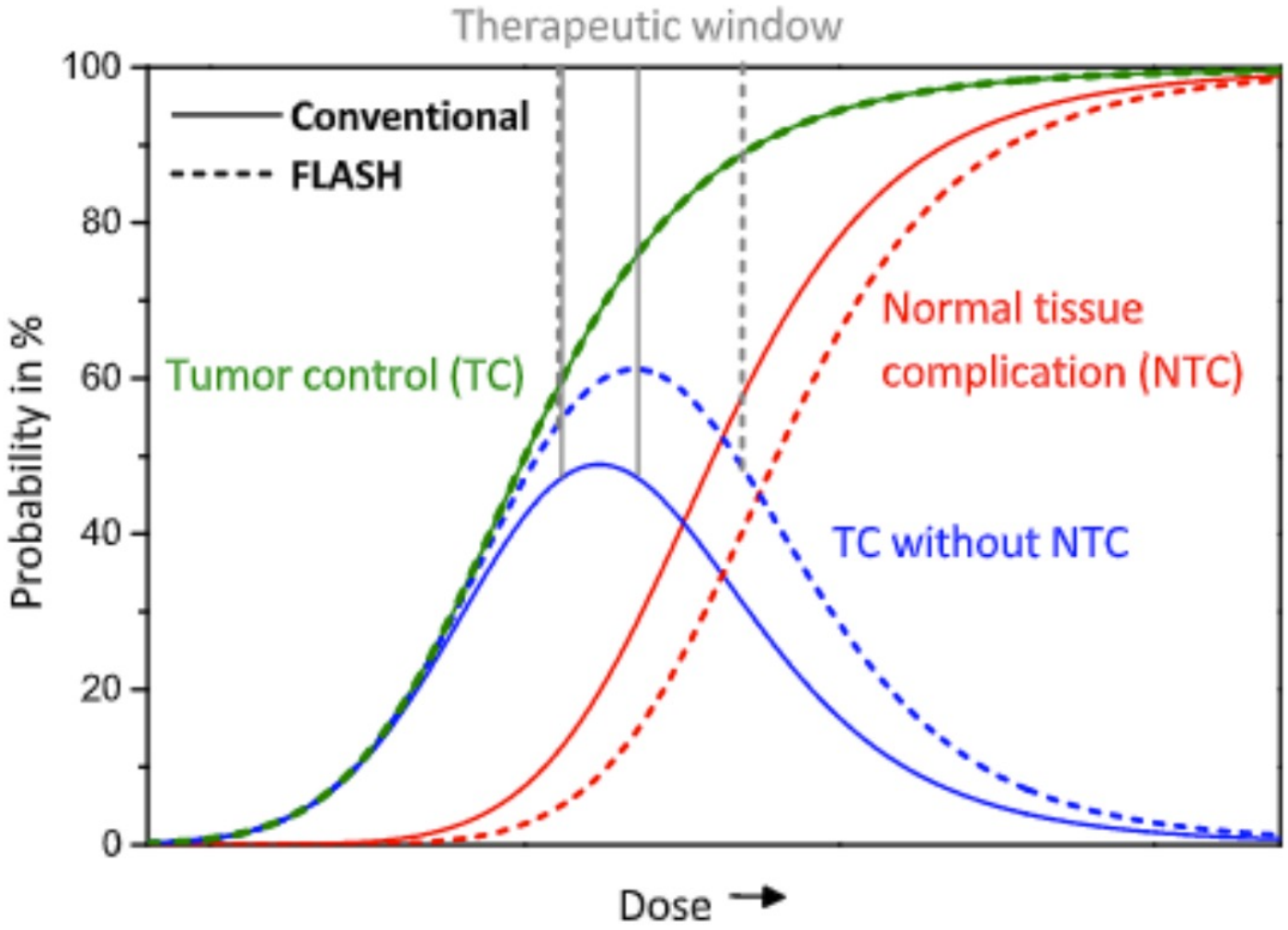
The “FLASH effect”

FLASH	CONVENTIONAL
> 40 Gy/s	~ 0.1 Gy/s
< 300 ms	~ minutes

First treatment of a patient with FLASH at CHUV Lausanne in 2018

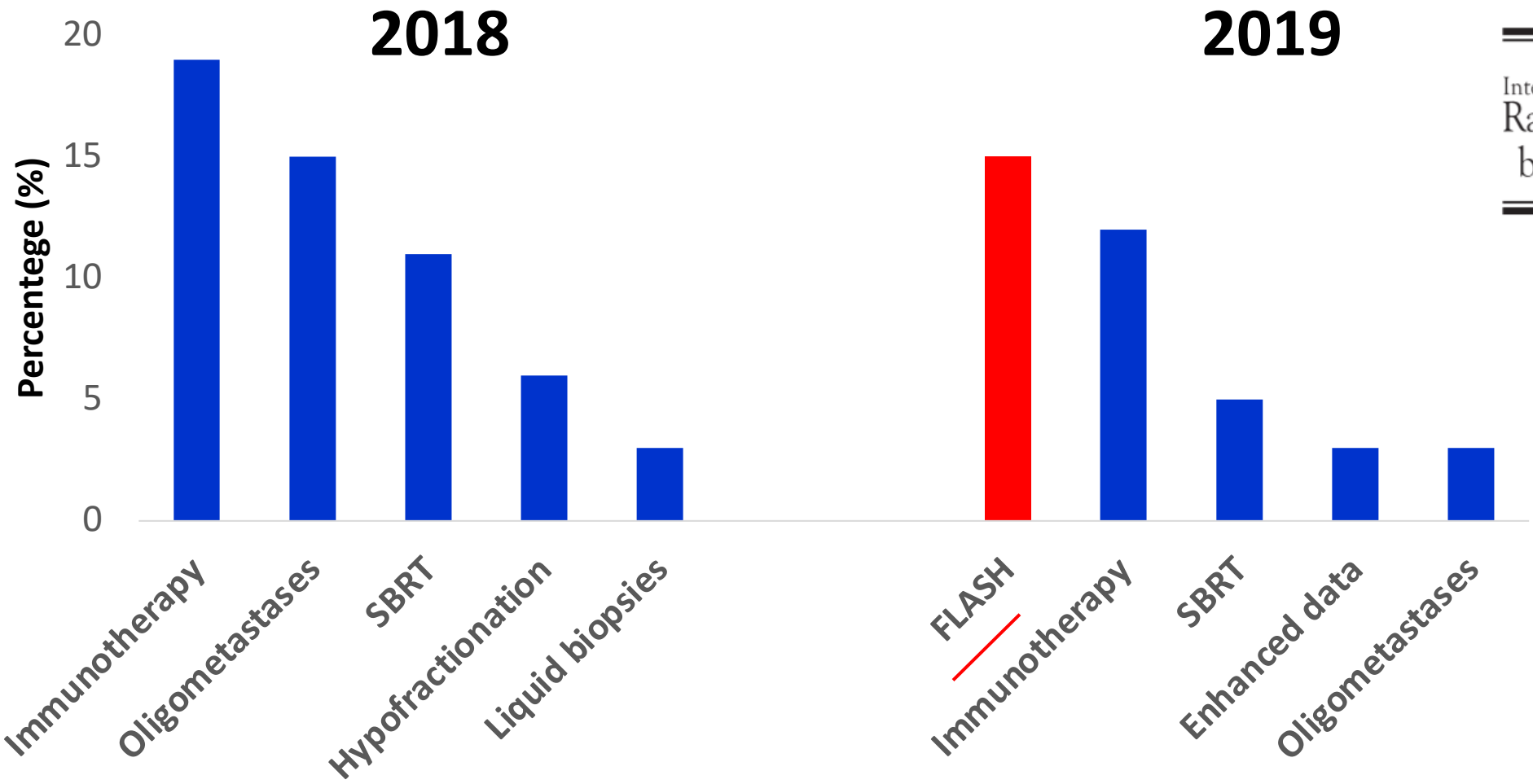
1 day **3 weeks** **5 months**

J. Bourhis, et al. *Radiother Oncol* 139 (2019): 18-22



A. Schüller *et. al.*, Phys. Med., 2020, 80: 134-150 (http://uhdpulse-empir.eu/)

ASTRO Membership's opinion on: "What is the One Big Discovery that needs to be translated into the clinic RIGHT NOW?"



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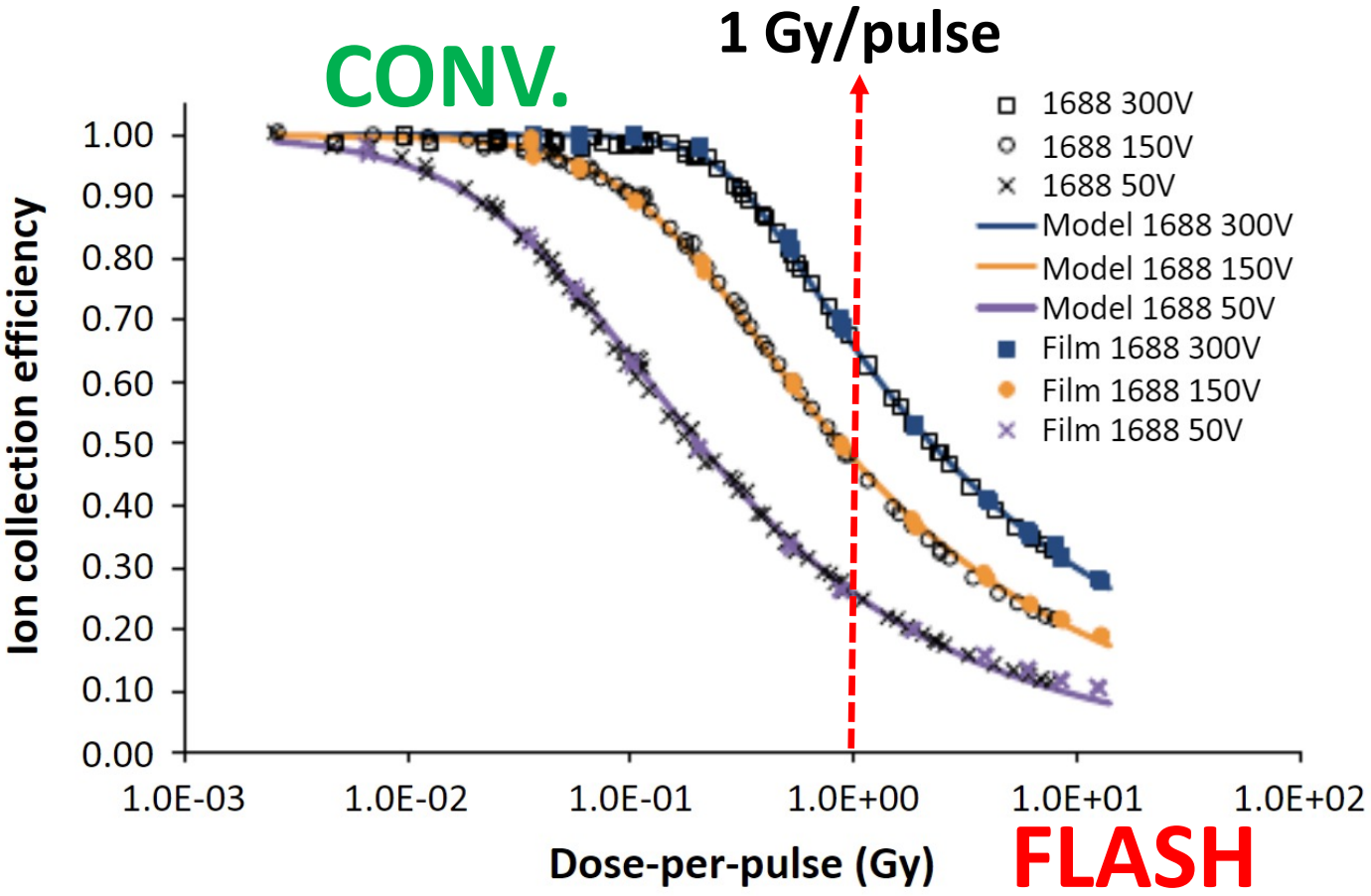
FLASH clinical translation



Petersson et al., Med. Phys. 44 (2017) 1157

- **Dosimetry is a major challenge for the FLASH clinical translation**
- **Well-established dosimeters (e.g. ionization chambers) fail under FLASH dose-rates**

- **Ultra-high dose rate radiation therapy (FLASH)**
- **Development of new detectors for FLASH at the University of Bern**
- **Results with proton and electron beams**
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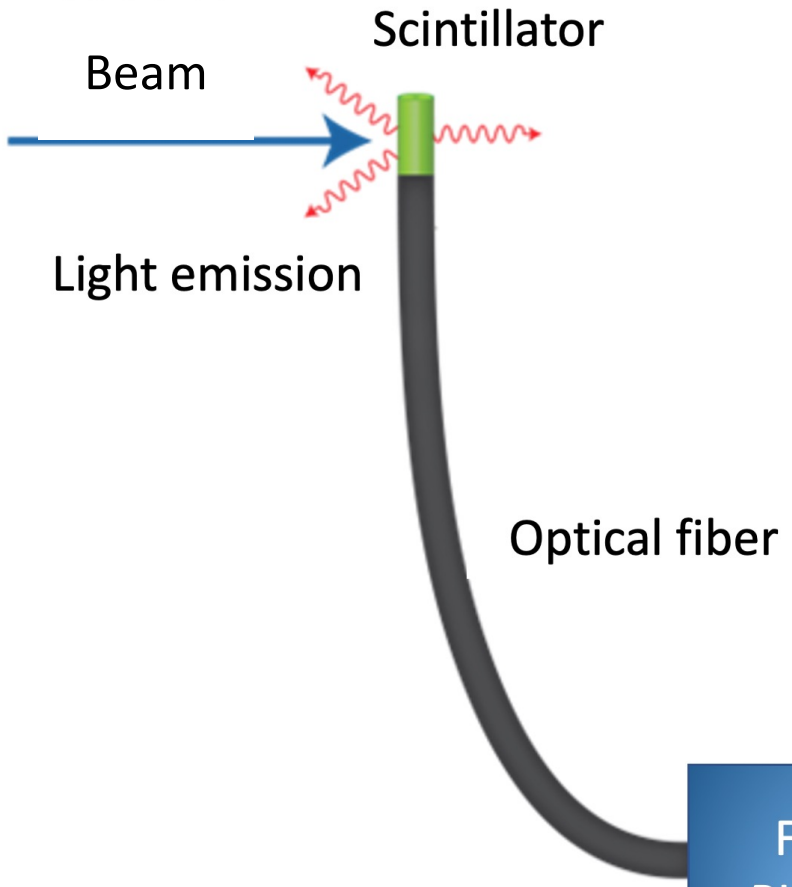
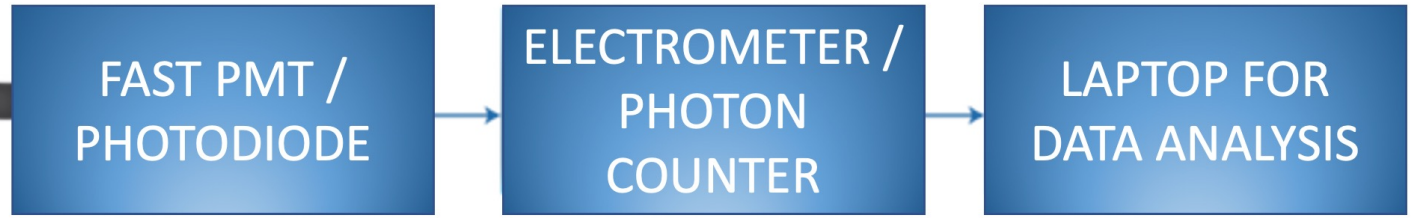
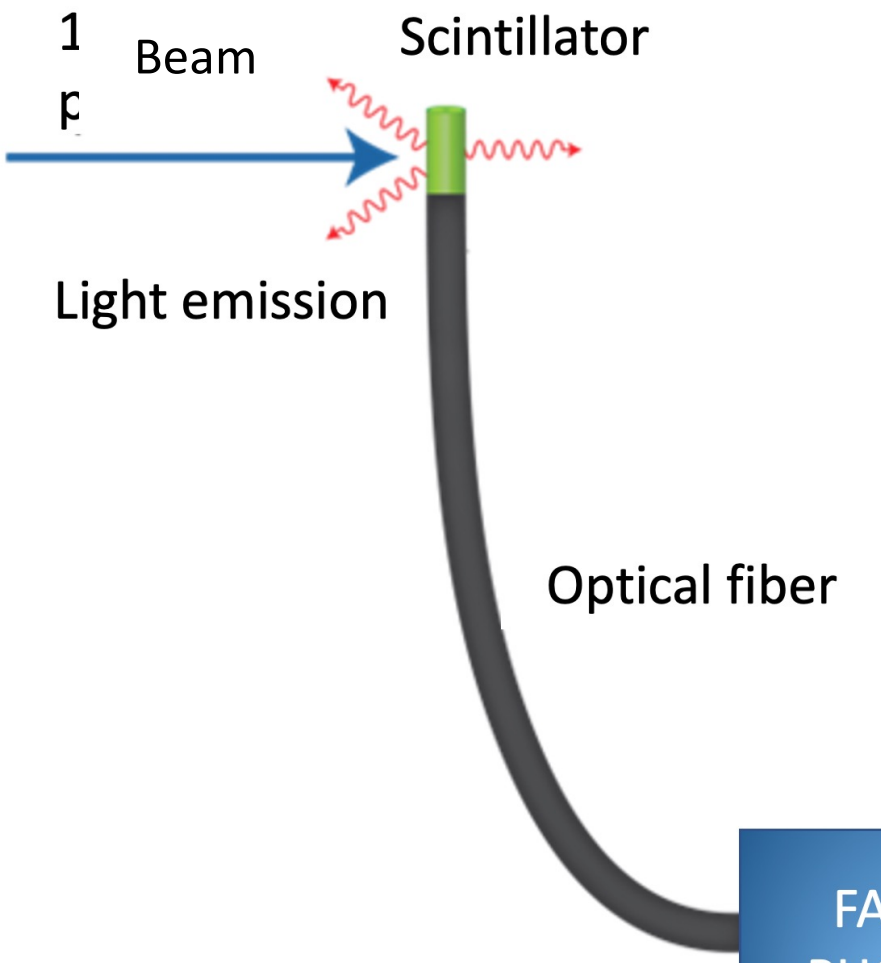
The PROOF project: Precision dosimetry in FLASH radiotherapy with optical fibers



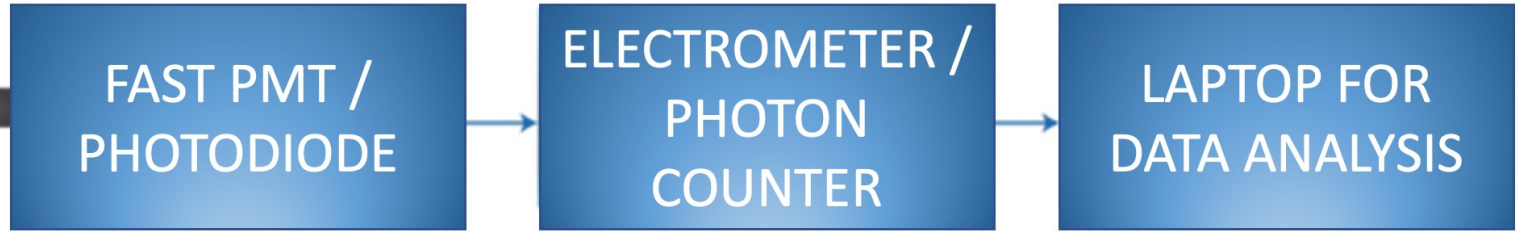
- **Project funded by the Bern Center for Precision Medicine (BCPM) of the University of Bern**
- **First tests at the Bern cyclotron lab located at the Bern University Hospital (Inselspital)**



Experimental setup (1)

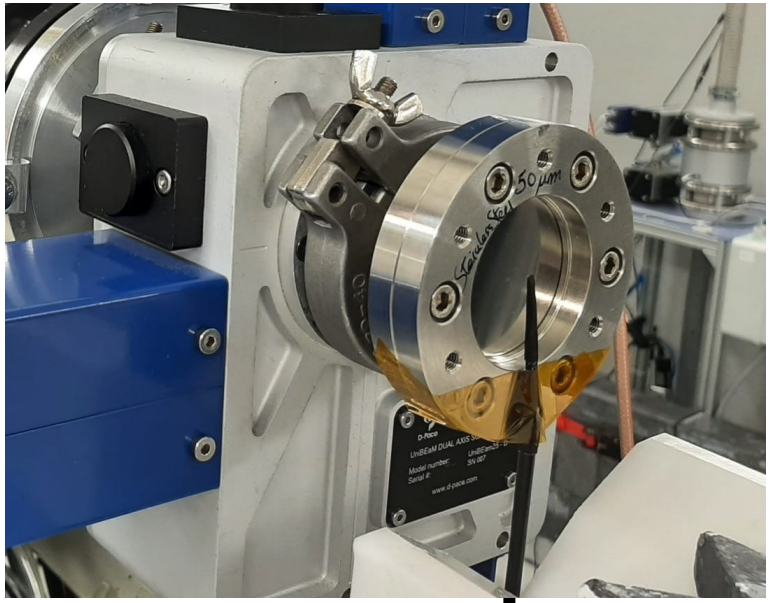


- **Scintillators:** Polystyrene, Y-BaF_2, GAGG of different size (0.5x0.5x2 mm^3)
- **Setup 1:**
  800 MHz PMT from Hamamatsu
  Keysight pico-ammeter
- **Setup 2:**
  Fast (40 ps) APD from IDQ
  Multi-channel scaler (time resolution down to 100 ns)

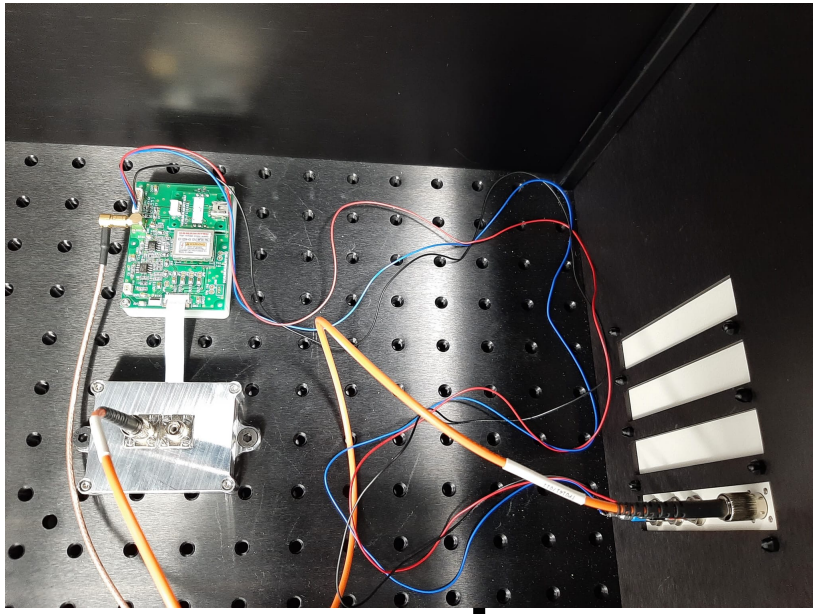


Experimental setup (2)

Scintillator coupled with optical fiber



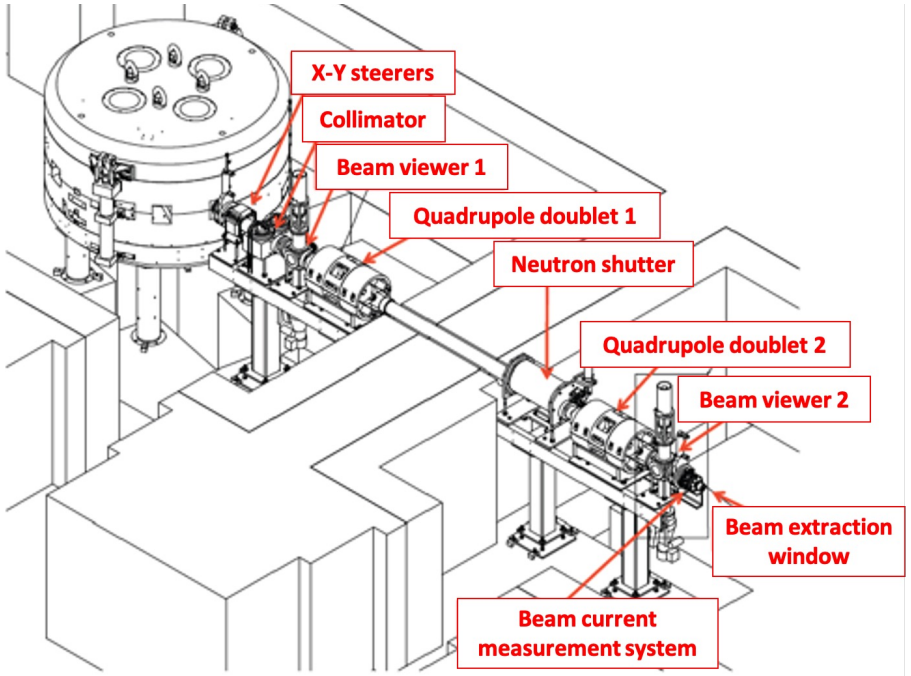
Photodetector in a darkbox

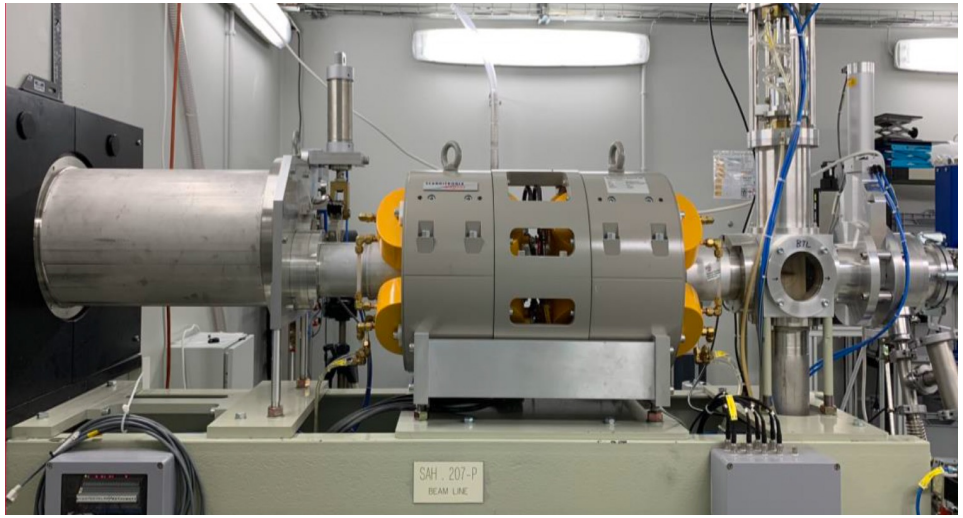


Optical fiber

- **High spatial resolution (~ mm or less)**
- **High time resolution (down to 100 ns)**
- **No radiation damage to photodetector and electronics**

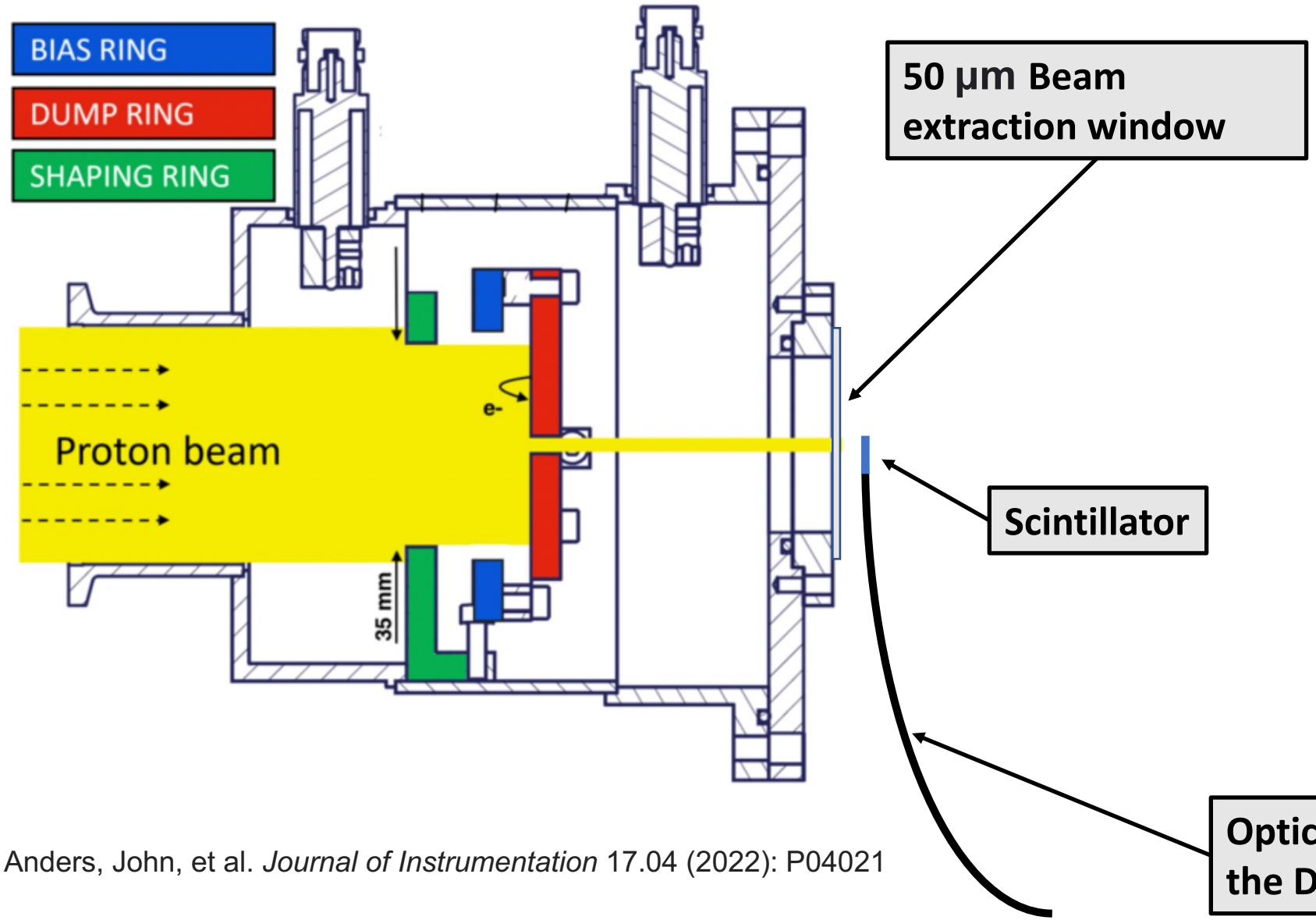
The Bern medical cyclotron

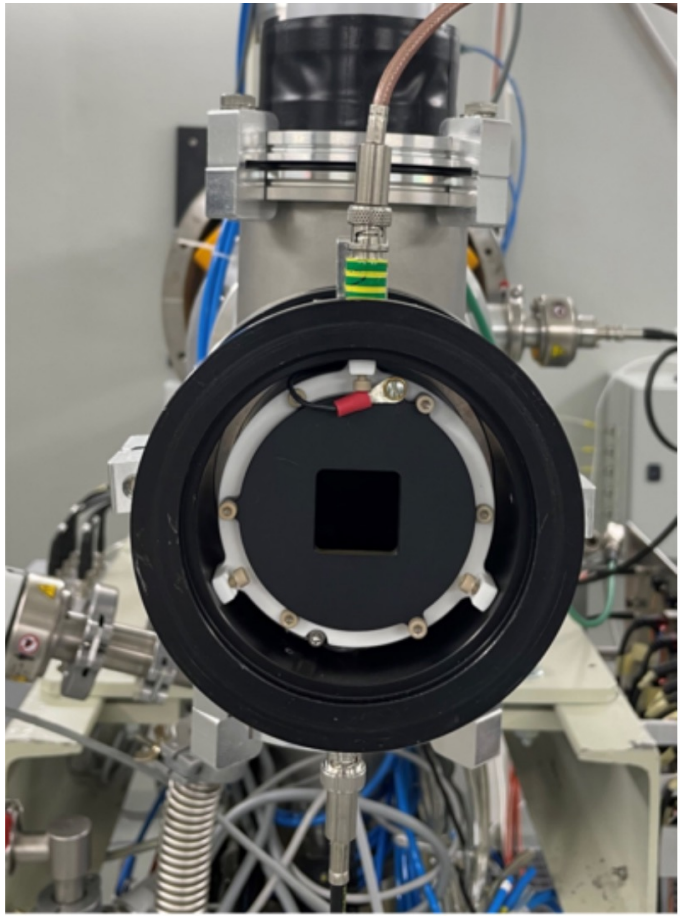




- IBA 18/18 cyclotron
- 8 exit-ports
- 6-meters long beamline
- Current in the range from ~ pA to 150 µA
- RF 42 MHz

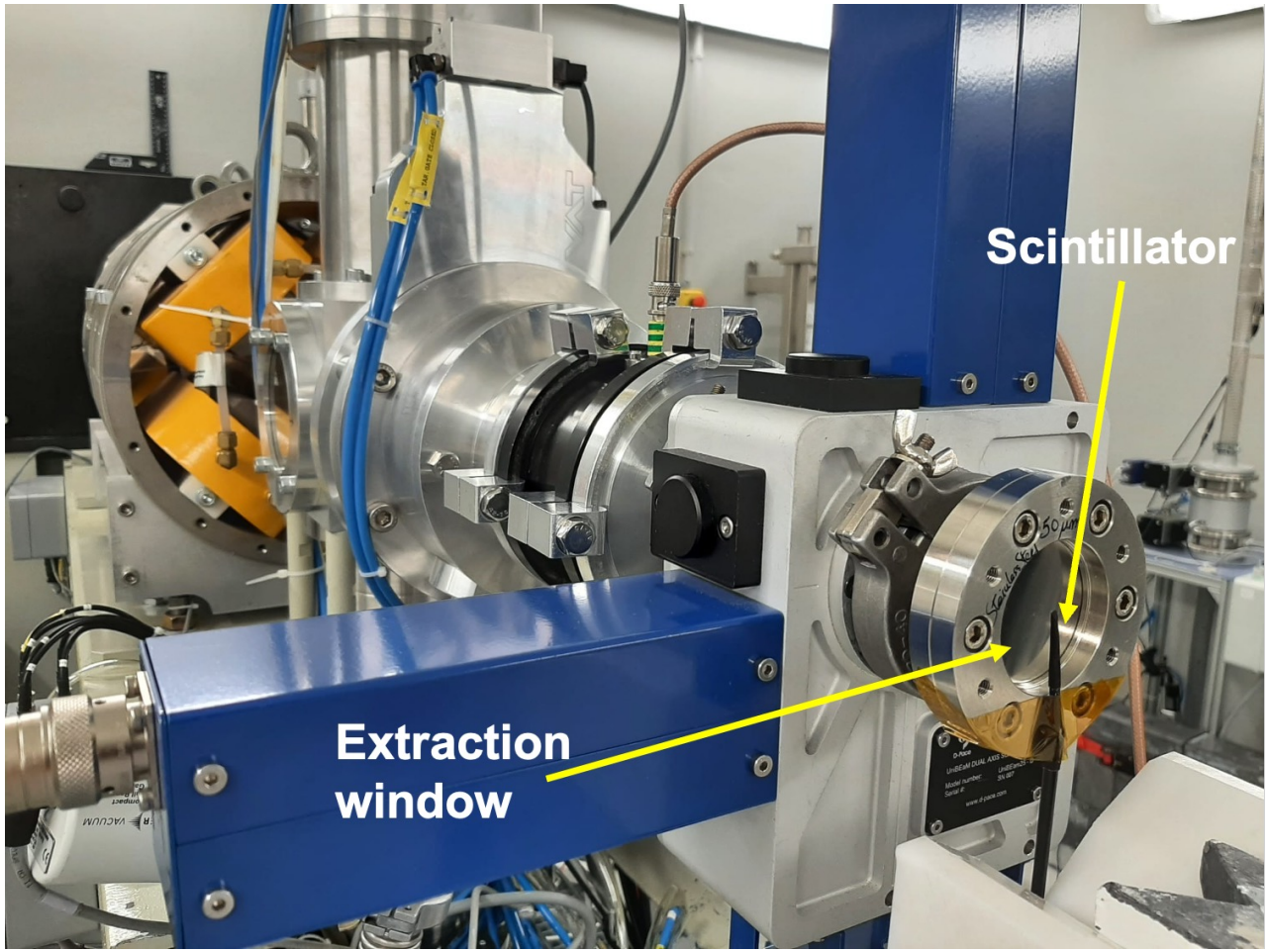
Independent dosimetry





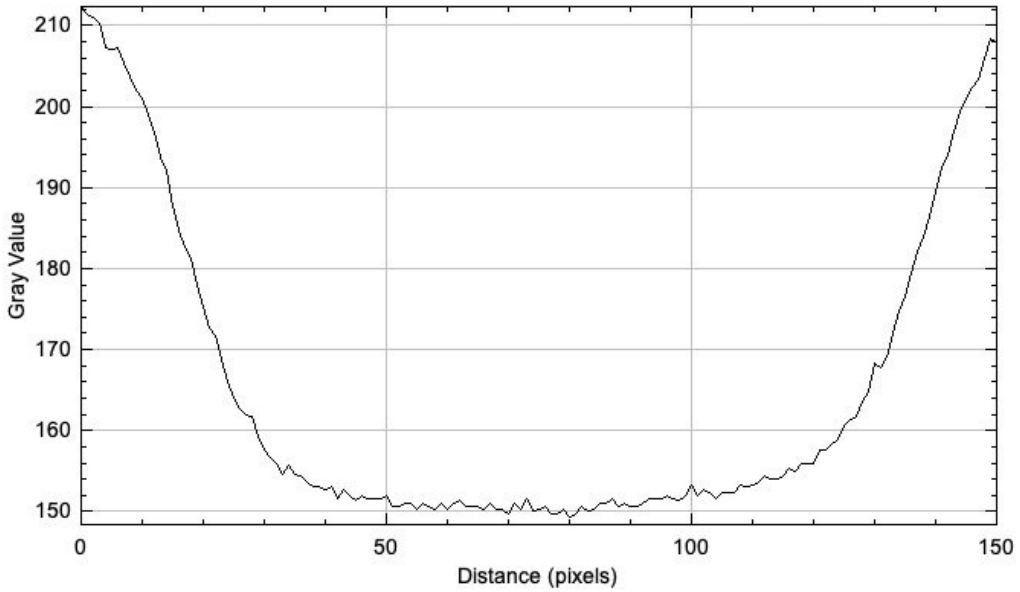
Anders, John, et al. *Journal of Instrumentation* 17.04 (2022): P04021

Beam diagnostics



- Dose rate in the position of the scintillator from 40 Gy/s

- Verification with RCFs



UniBEaM beam profiler developed by UniBern and commercialized by D-PACE

D-Pace

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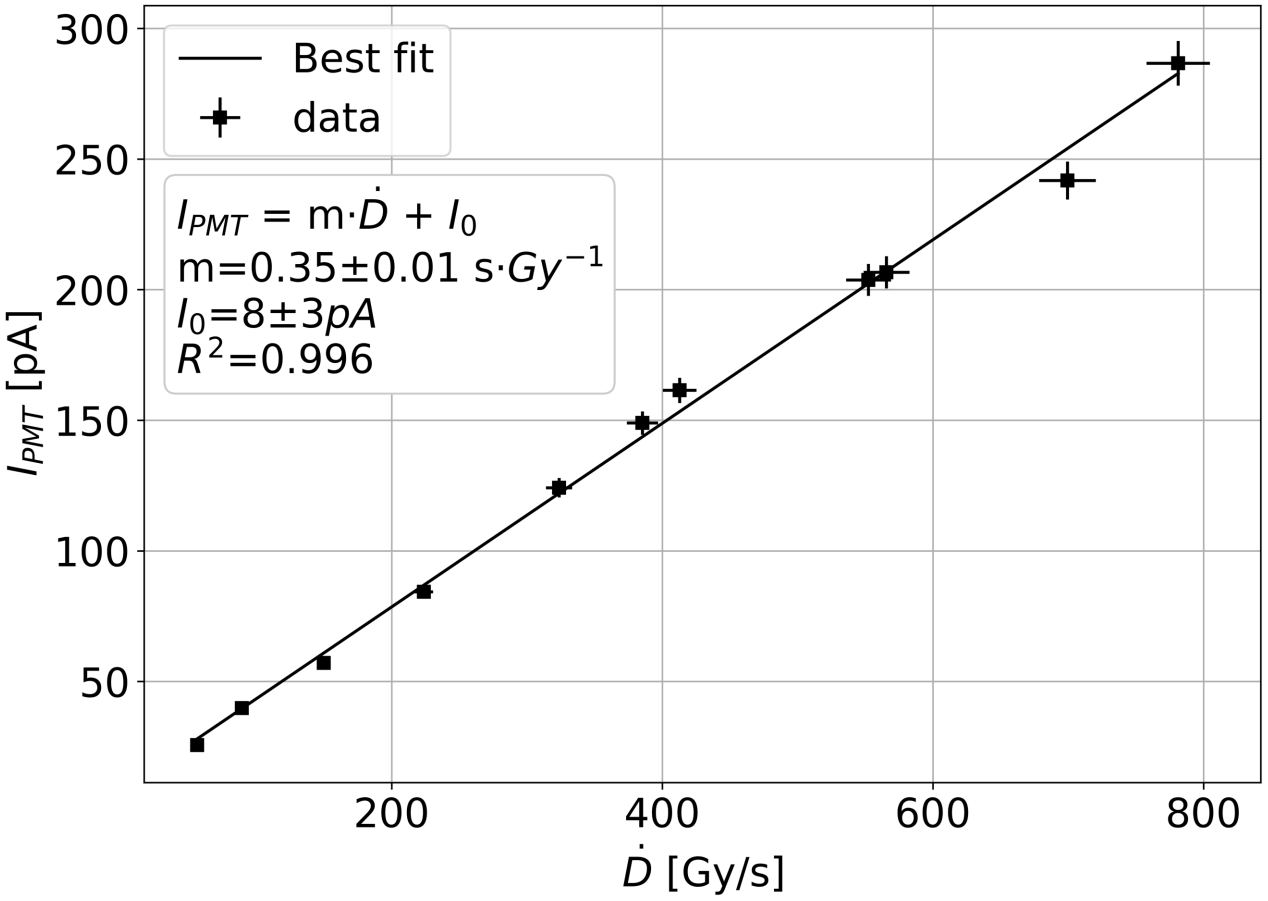
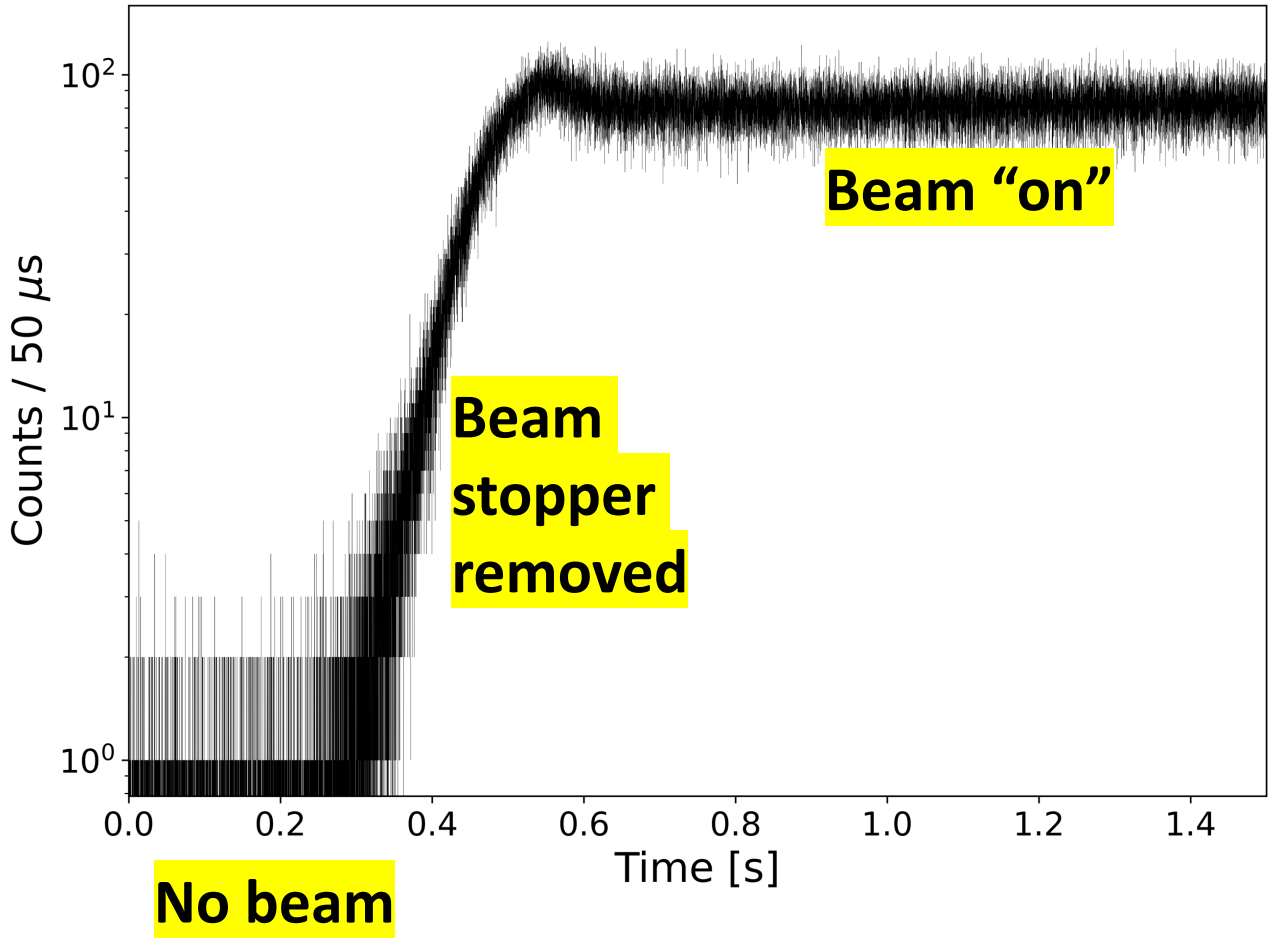
Results at the Bern medical cyclotron

1) linearity with dose rate

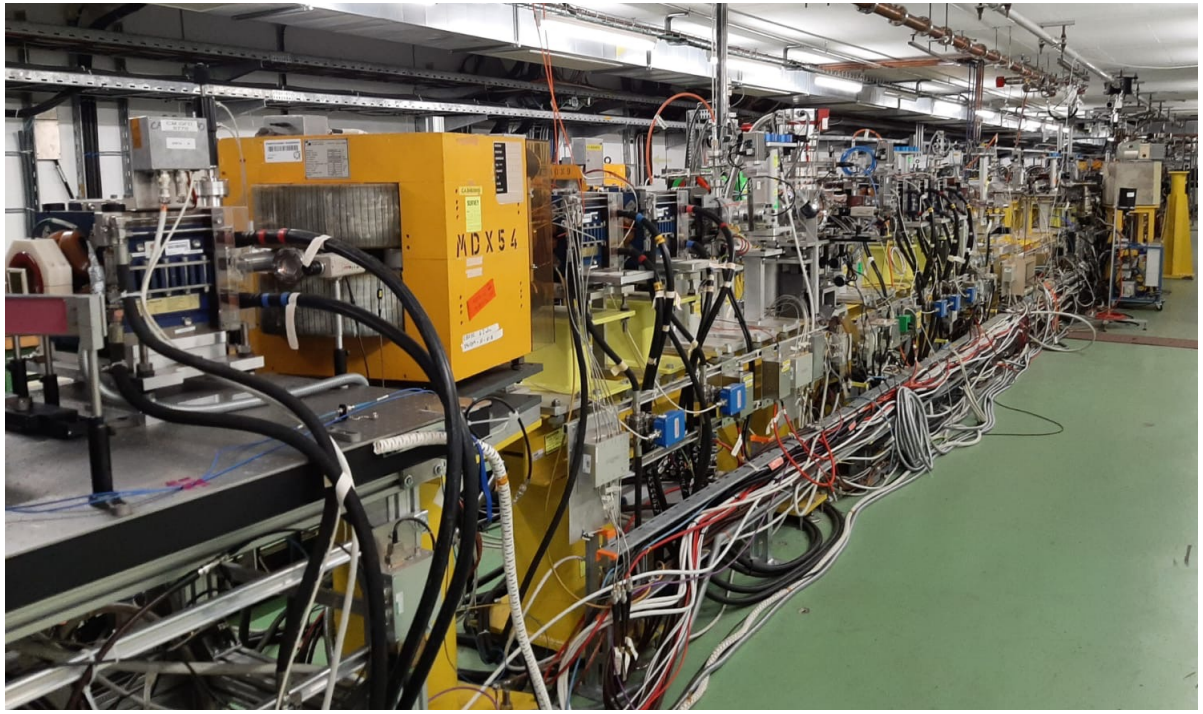


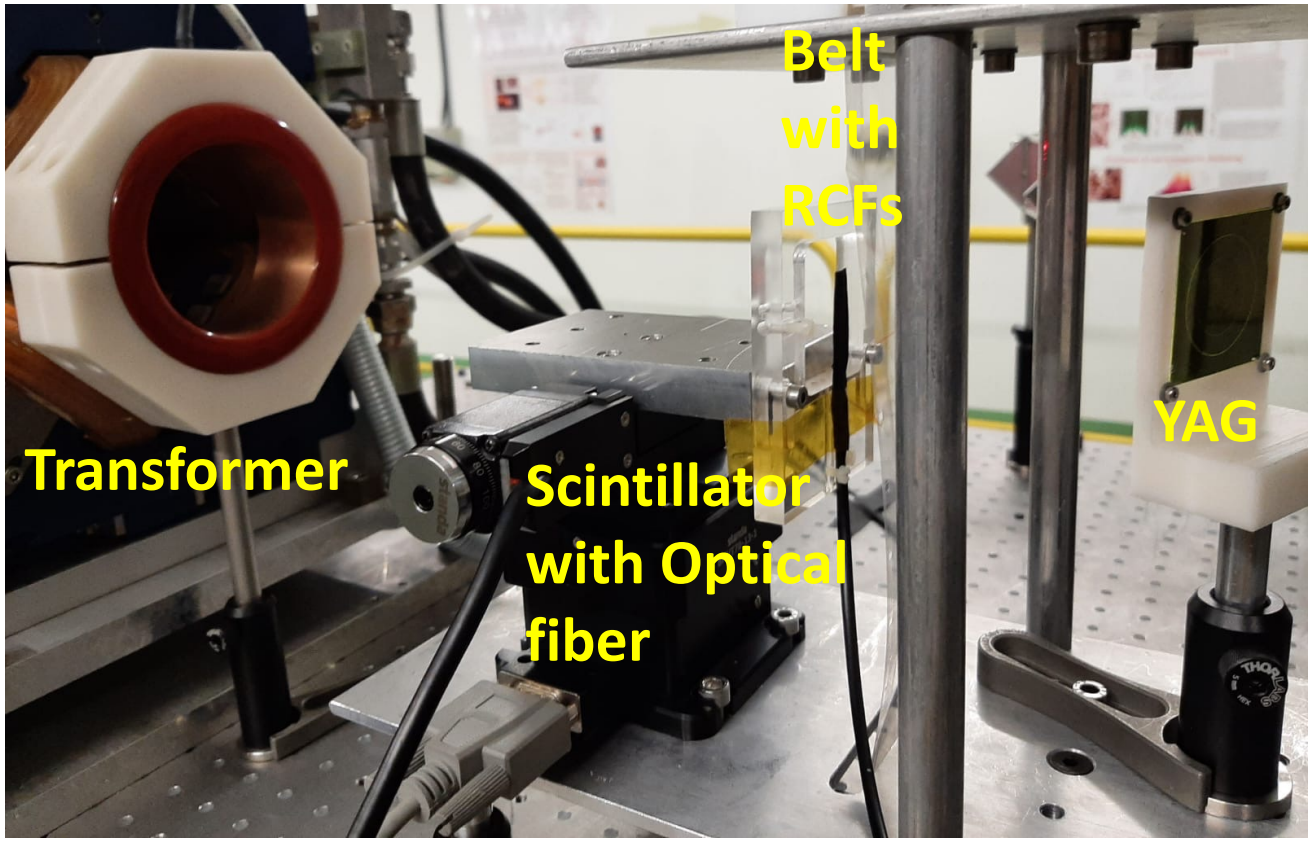
2) Beam monitoring



Tests with VHEEs at the CLEAR at CERN

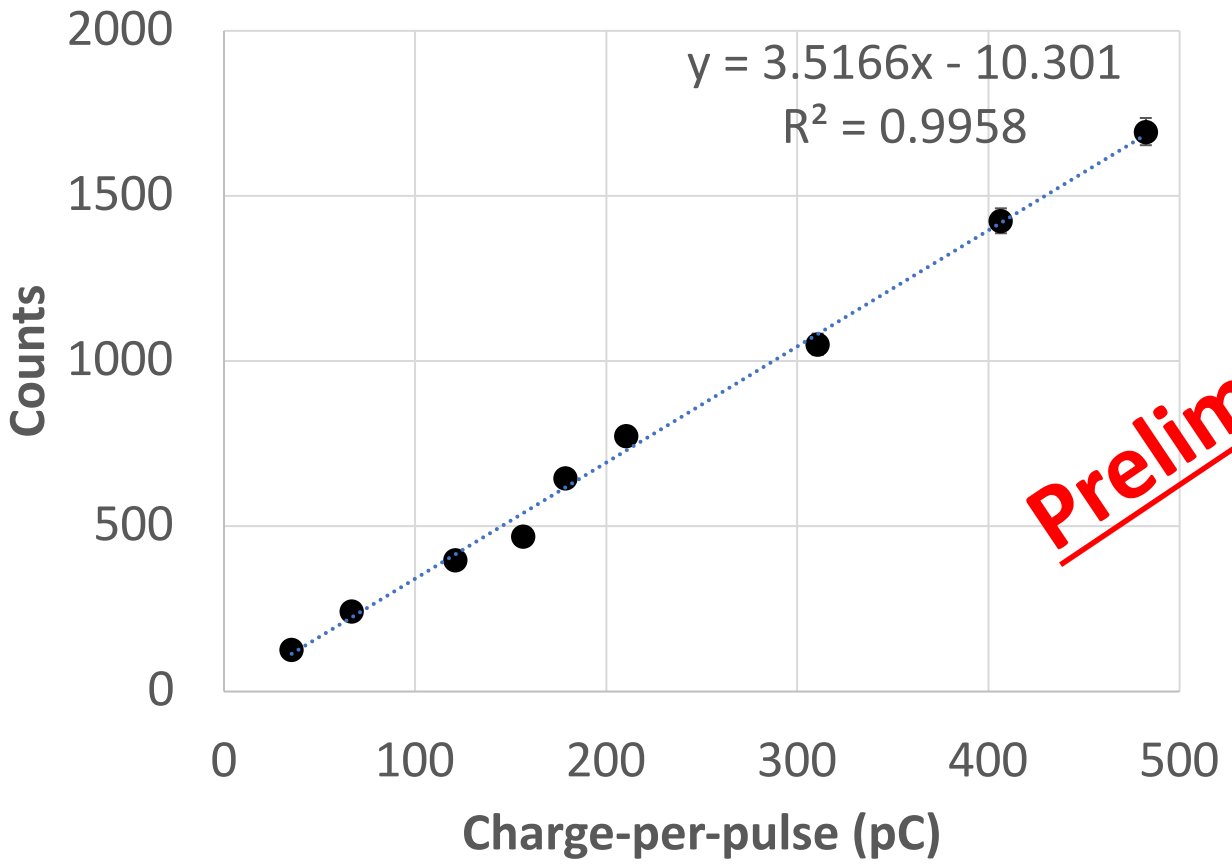
180 MeV VHEEs - 1 Hz repetition rate





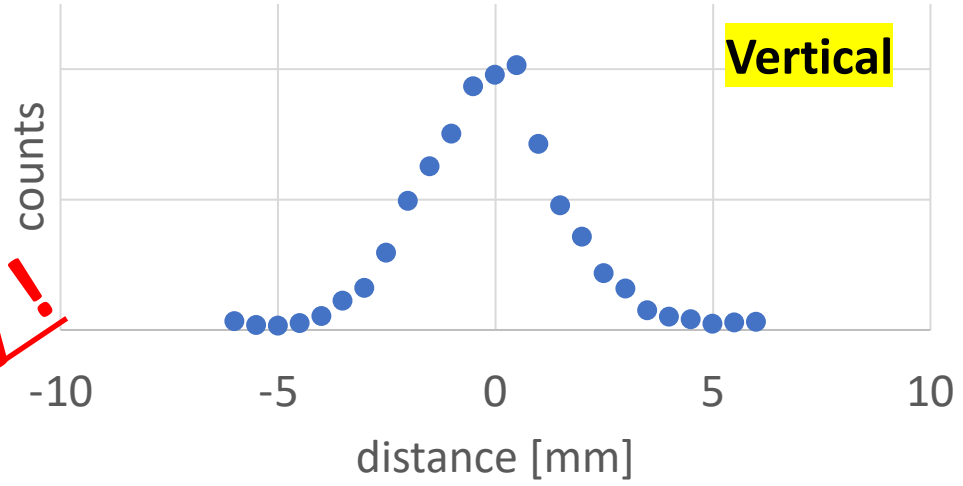
Results at the CLEAR facility at CERN

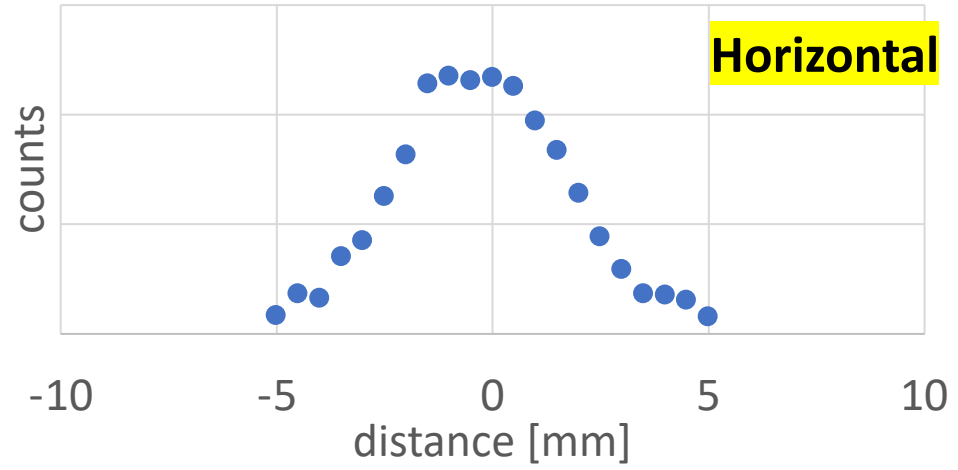
1) Linearity with charge per bunch



Preliminary !

2) Beam profiles





Conclusion and outlook

- **FLASH RT is very promising… FLASH clinical translation is challenging**
- **Development of new dosimeters for FLASH RT at the University of Bern**
- **High spatial (~mm) and time (>100 ns) resolution**
- **Test of scintillators with high radiation resistance**
- **Energy dependence**

Acknowledgments

This project was partially funded by the Bern Center for Precision Medicine (BCPM), University of Bern and by the Swiss National Science Foundation (SNSF) [Grant: CRSI5_180352].
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We also thank Dominik Wermelinger who is carrying out his Bachelor's thesis in this project

UNIVERSITÄT BERN

Thank you for your attention