XXXII INTERNATIONAL SEMINAR of NUCLEAR and SUBNUCLEAR PHYSICS "Francesco Romano"

FLASH-DC

A BEAM MONITORING PROJECT FOR FLASH RADIOTHERAPY

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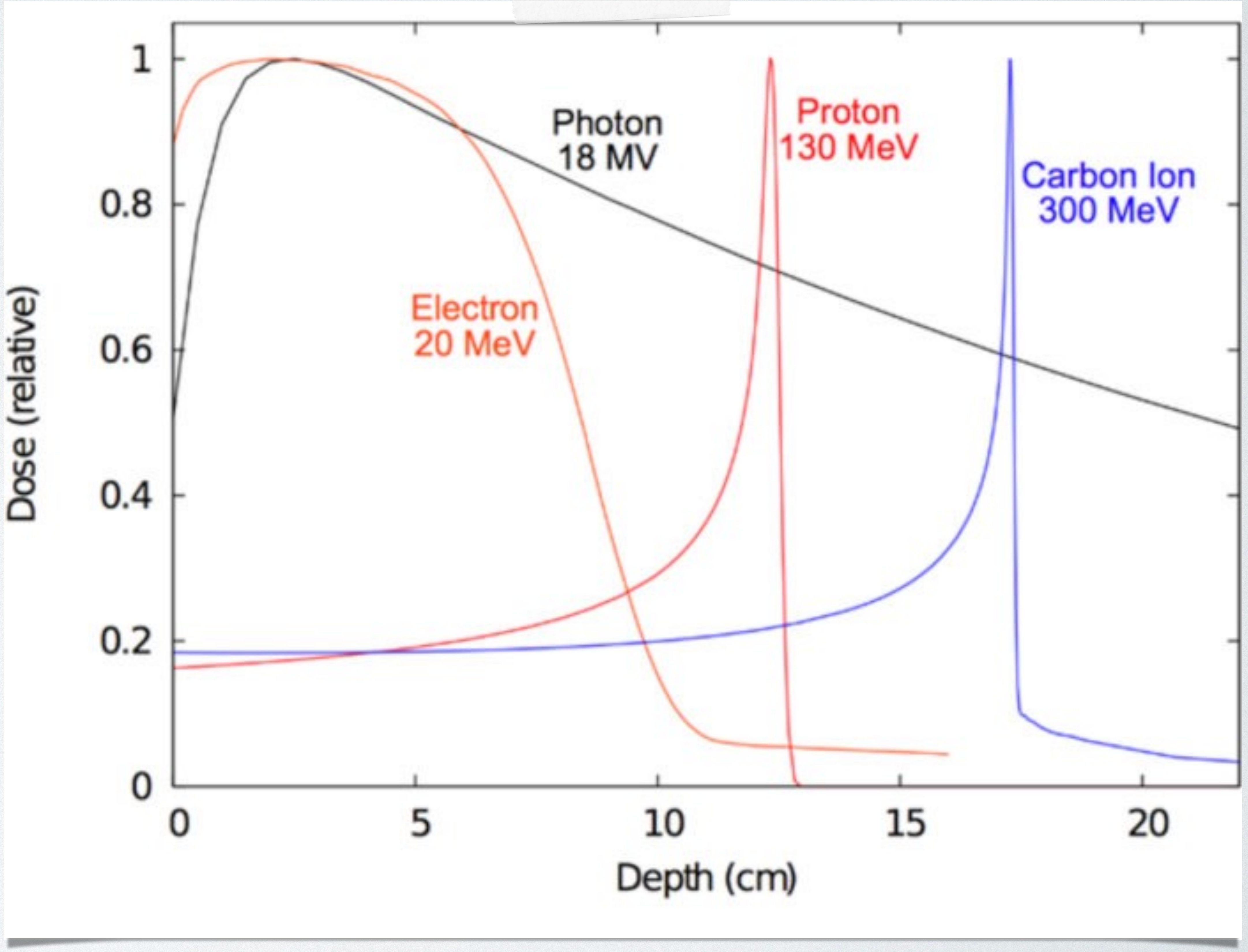
PARTICLES FOR MEDICINE

- Conventional radiotherapy using X-rays (**photons**) has achieved significant results in **tumor control**. However, it is limited by dose near `organs at risk`.
- **Objective**: *maximize* tumor control, *minimize* damage to healthy tissues (therapeutic ratio).
- With the emergence of Particle Therapy (**protons** and **carbon ions**) spatial dose conformity has reached its practical limit.
- Large accelerators needed to produce high energy beams.
- What about **electrons**? Are they a viable alternative?

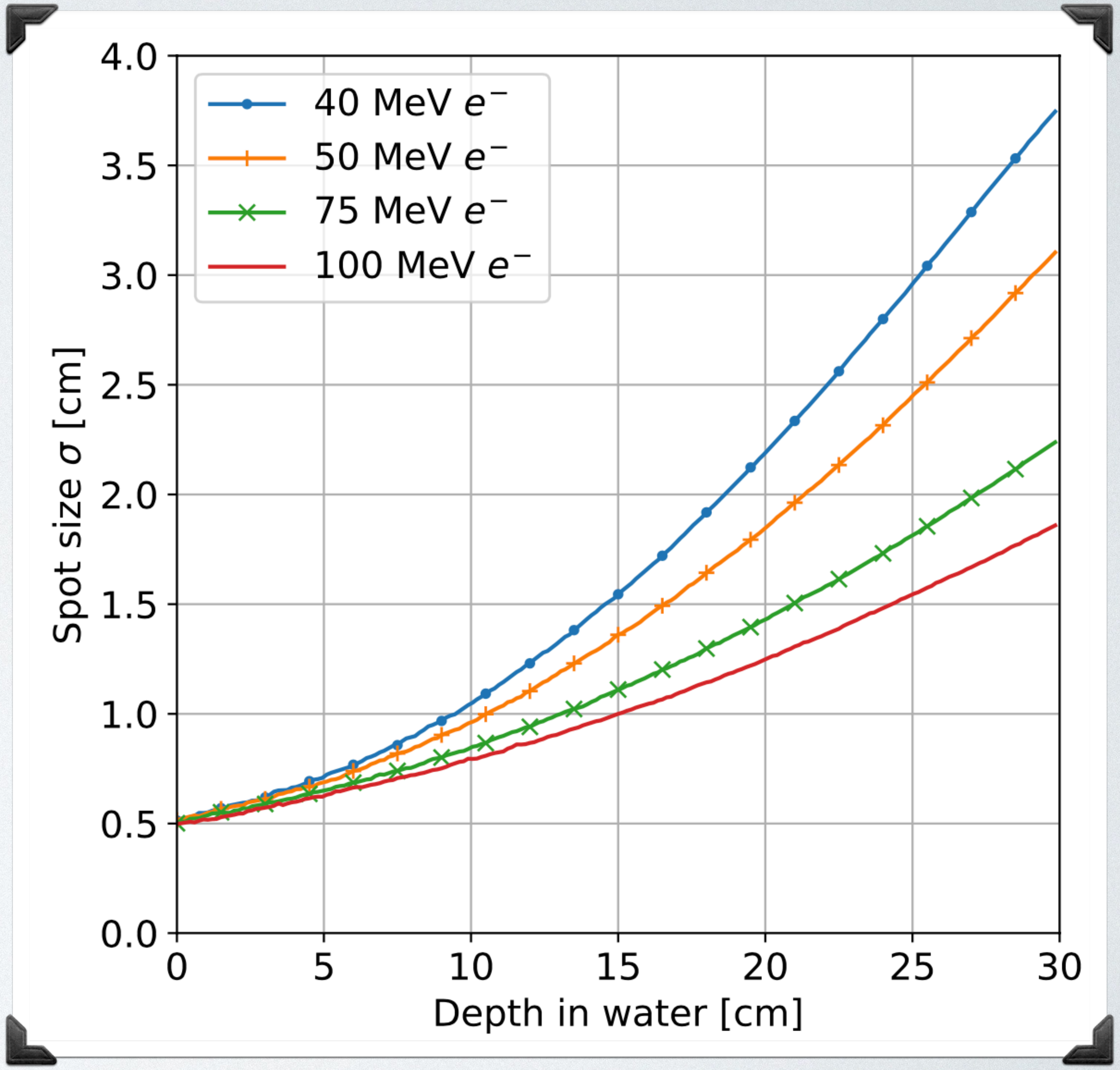
$$D = dE/dm \ [Gy]$$



Kaiser A. et al, "Proton Therapy Delivery"
doi: 10.3791/58372

ARE VHEE COMING TO TOWN?

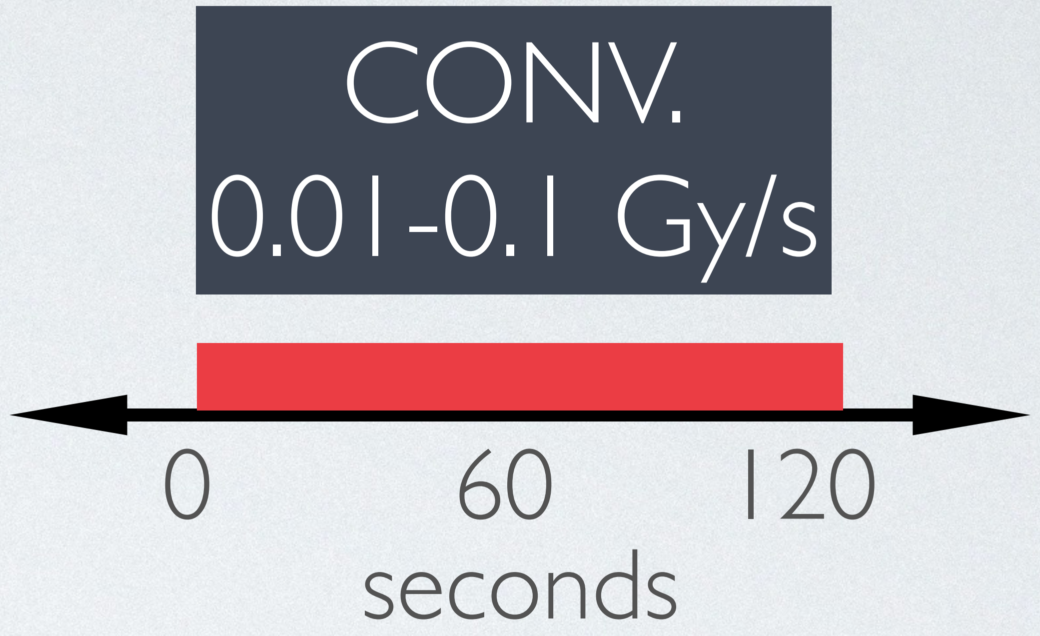
- Up until now, "yes".
- The idea to use electron beams with E > 50 MeV (Very High Energy Electrons - VHEE) to cure **deep seated tumors** has been halted by the high cost in space, power and technology needed to reduce the spread of the lateral dose.
- However, new progress in the **acceleration technologies** and the observation of the **FLASH effect** could "*clear the way*" for the use of (V)HEE in clinical practice.
- The impact on healthy tissue of the particles scattered laterally should be greatly reduced (lower energy needed, machine easier to build).

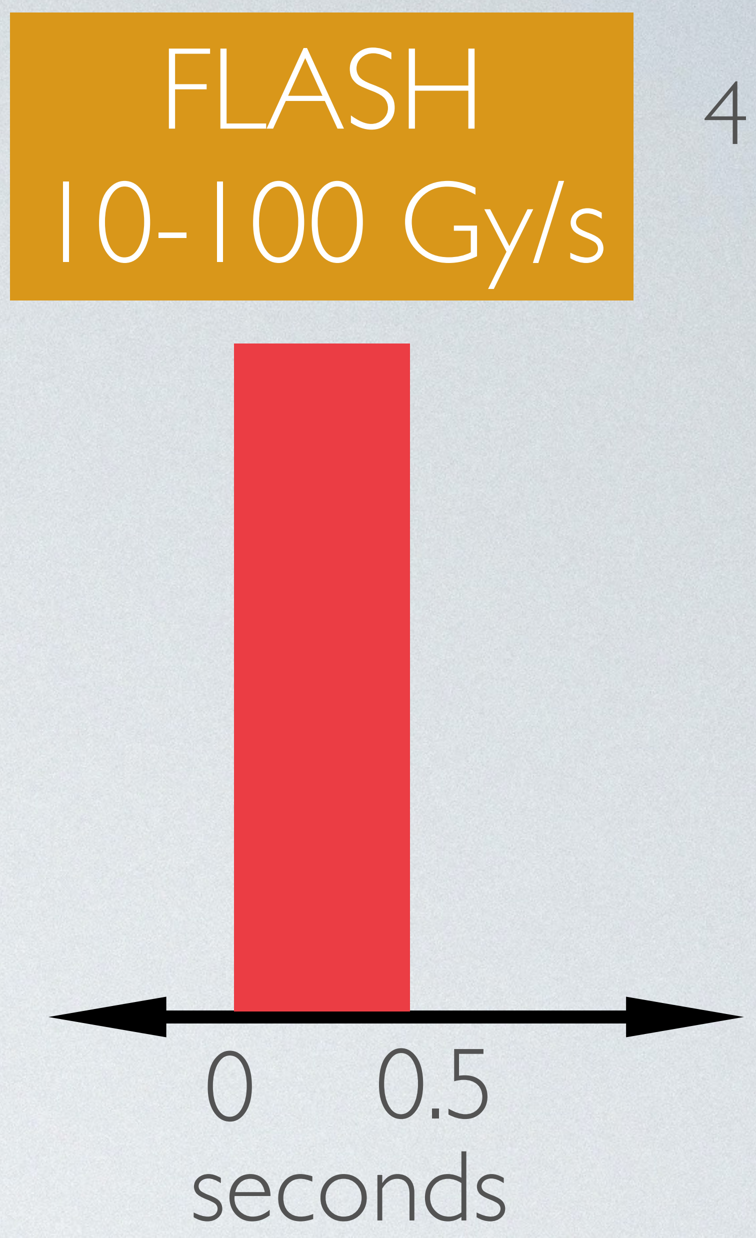


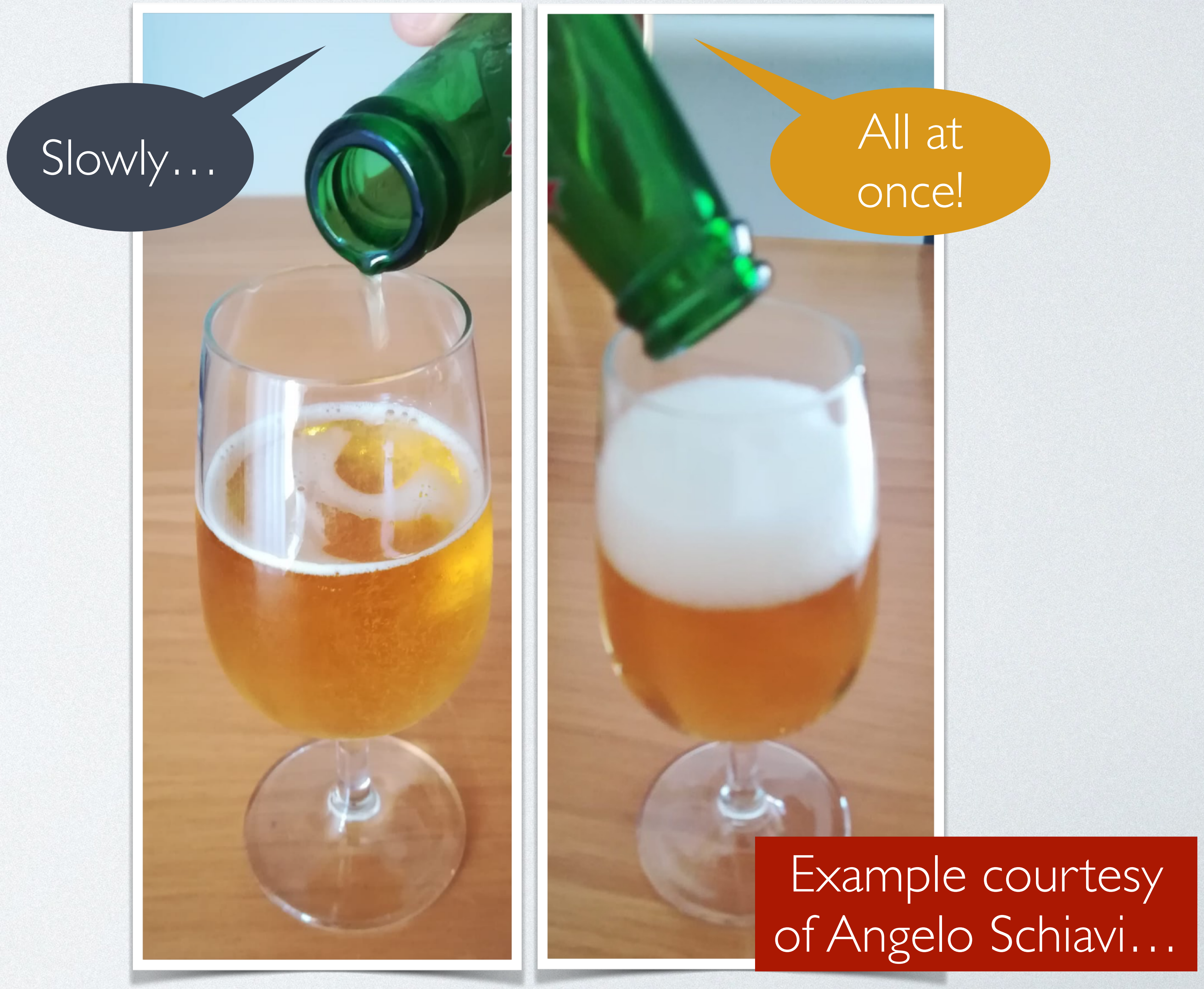
Lateral spread of VHEE beams (MC simulation)

FLASH EFFECT

- **Conventional radiotherapy**: mean dose rate of ≈0.01 Gy/s, delivered over treatment sessions lasting some minutes.
- To **trigger FLASH effect**: Increase mean dose rate up to >10 Gy/s, delivered in a much shorter time (<500 ms).
- The same amount of dose to the solid tumor, but concentrated in less time using more intense beams.
- <u>**Increase in therapeutic ratio.**</u> Tumor control is preserved, no significant damage to nearby healthy tissues.
- It has been suggested also for photons and protons.





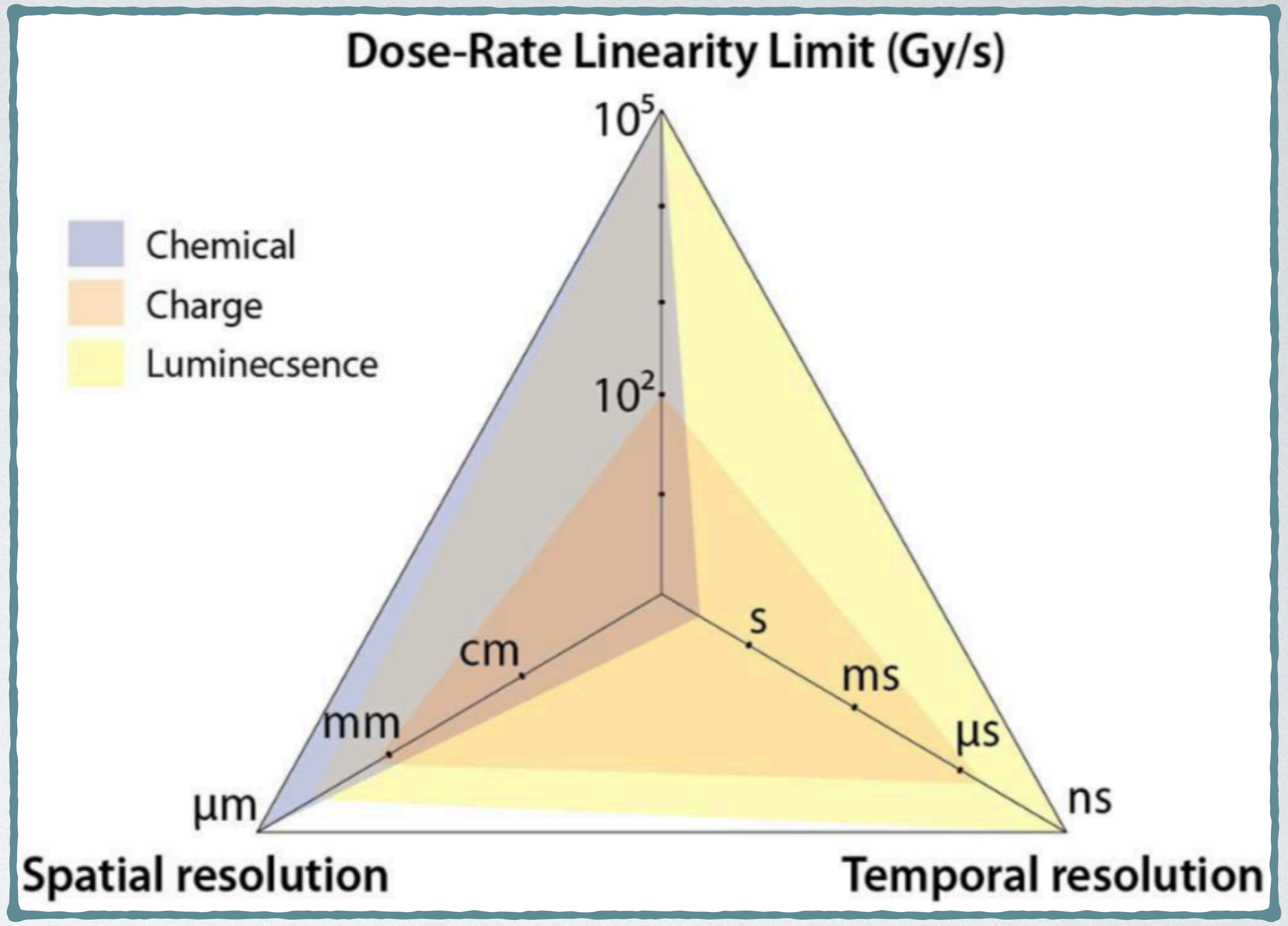


FLASH-DC

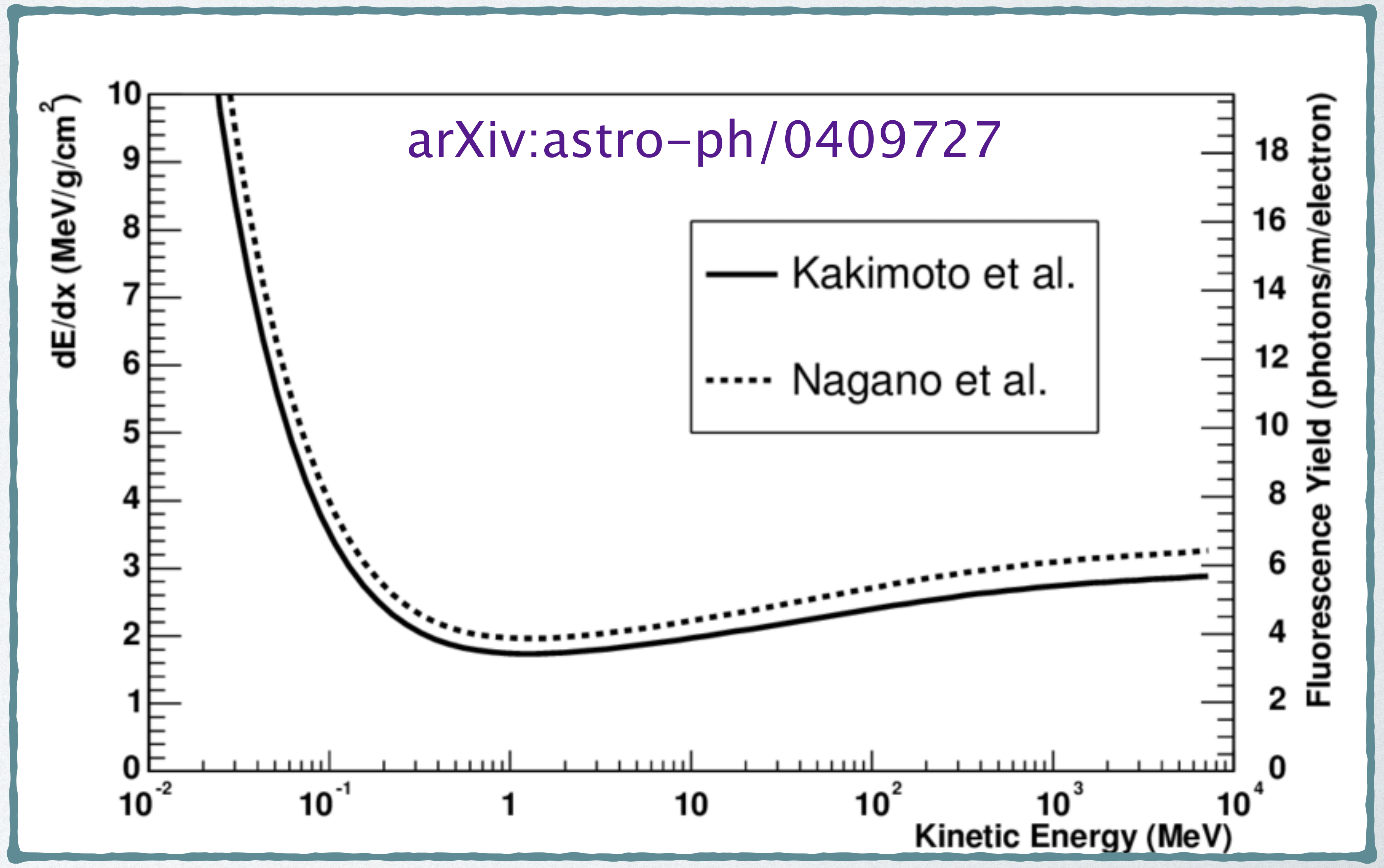
- From a physical point of view, FLASH effect could be described as a **threshold** phenomenon.
  Where is this threshold? What parameters it depends on?

- **FLASH-DC project**: develop a **beam monitoring system** with high spatial and temporal resolution, capable to work on the widest possible range of possibilities for FLASH machines (type of particle, energy, pulses duration…).

- Why **fluorescence**?
  — No energy threshold
  — Photons emitted isotropically
  — Simple and cheap to produce
  — Minimal impact on the irradiation of the patient

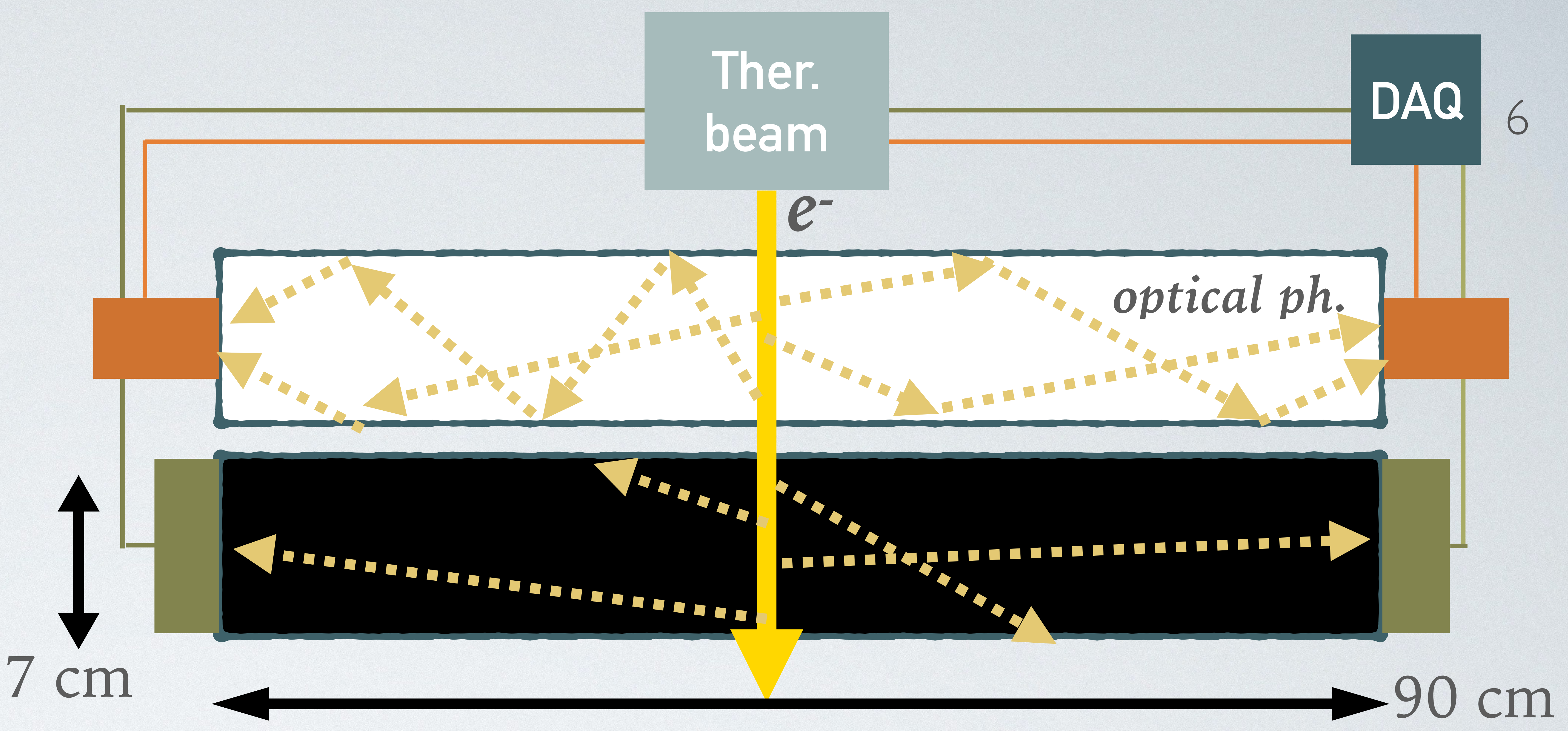


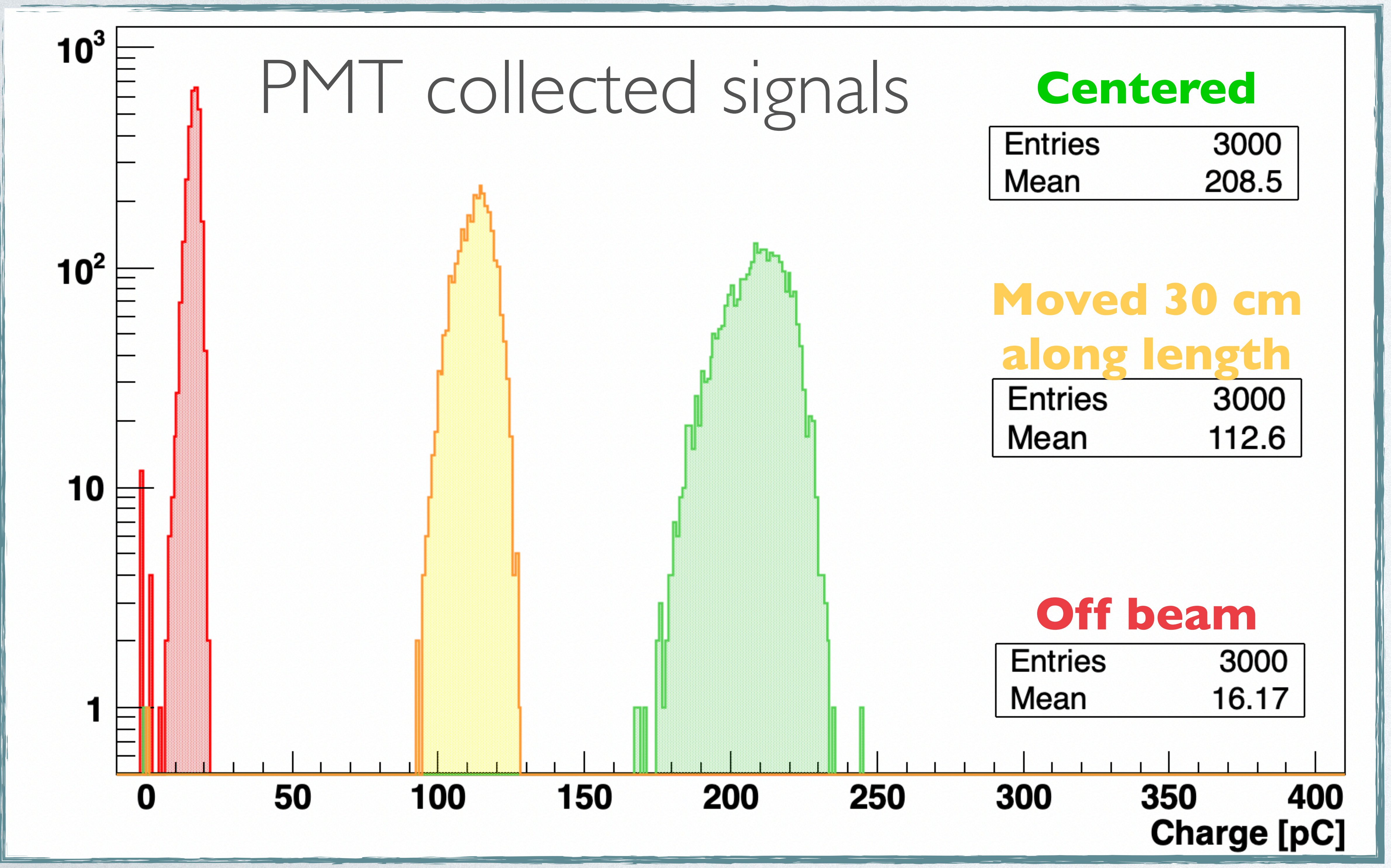
Ashraf MR et al, "Dosimetry for FLASH Radiotherapy"
doi: 10.3389/fphy.2020.00328

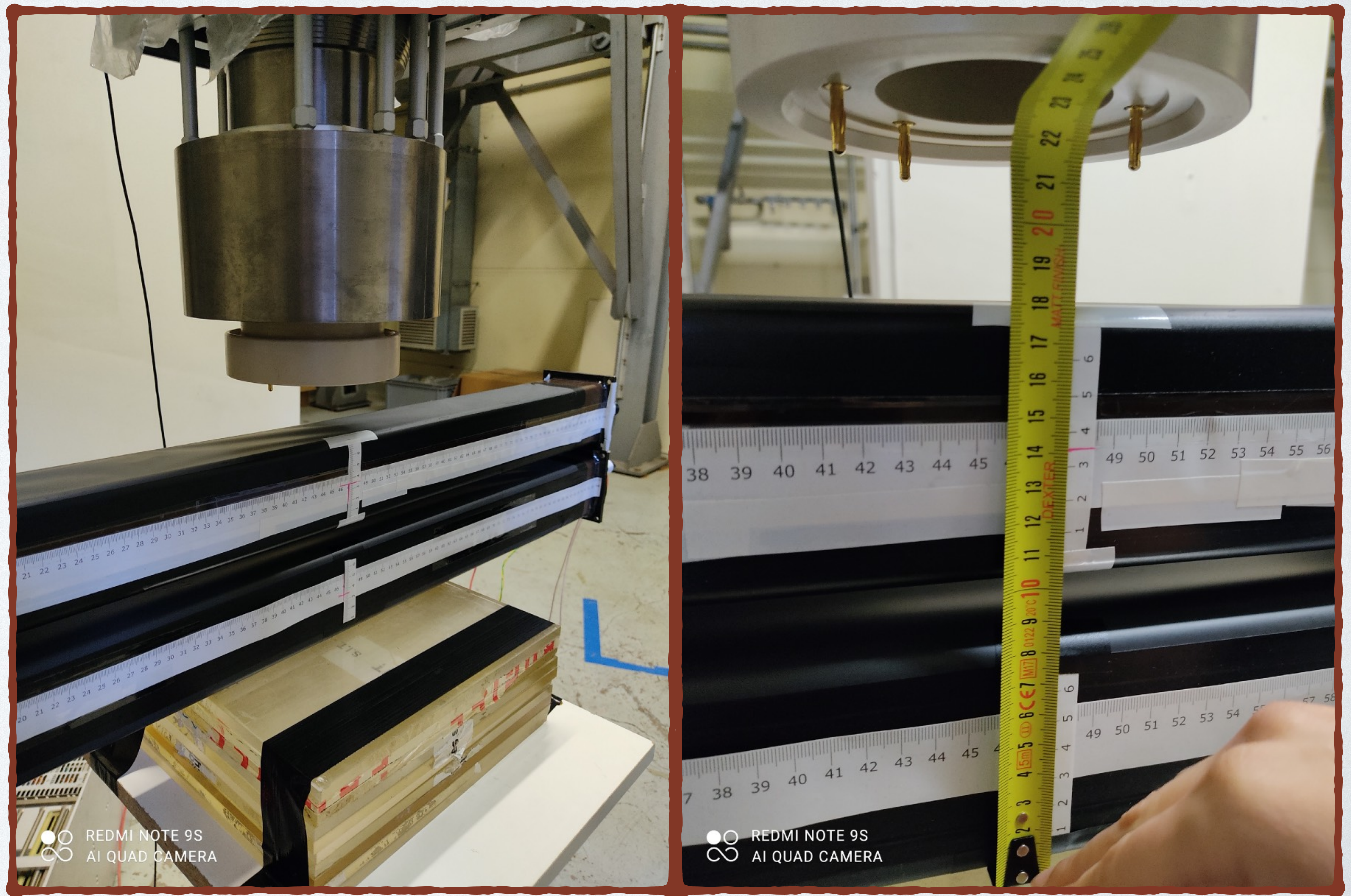


FLASH-DC

- Prototype of a detector based on fluorescence: a plastic parallelepiped filled with **air**, with a **PMT** at opposite edges.
- Tested at an electron therapy beam facility in Aprilia, with a 4μs pulse of 10^{10} **e-** of energy 6 MeV.

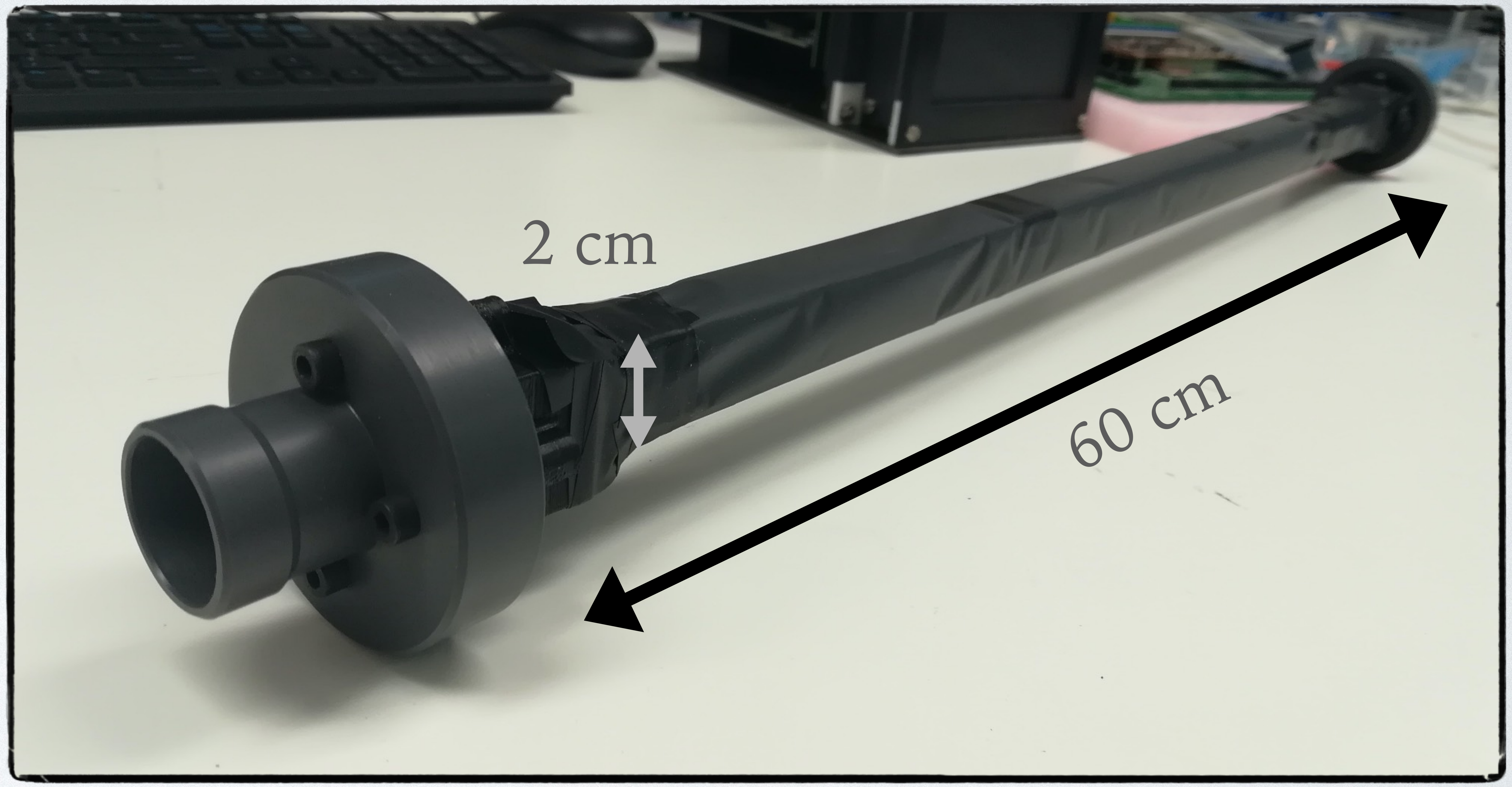






THE USUAL TO-DO LIST

- Another cycle of tests, with a new, *smaller* prototype, is on the works.
- Measure **spatial** and **temporal** resolution.
- With the help of **FLUKA** MC simulations, we will estimate the light output and detection efficiency of the device under FLASH working conditions.
- Design a detector able to reconstruct a **2D** map of the beam position coupled with dose information.



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Thank you for your attention.