

# Dosimetric experiments at high and low dose rates at FLASHlab@PITZ

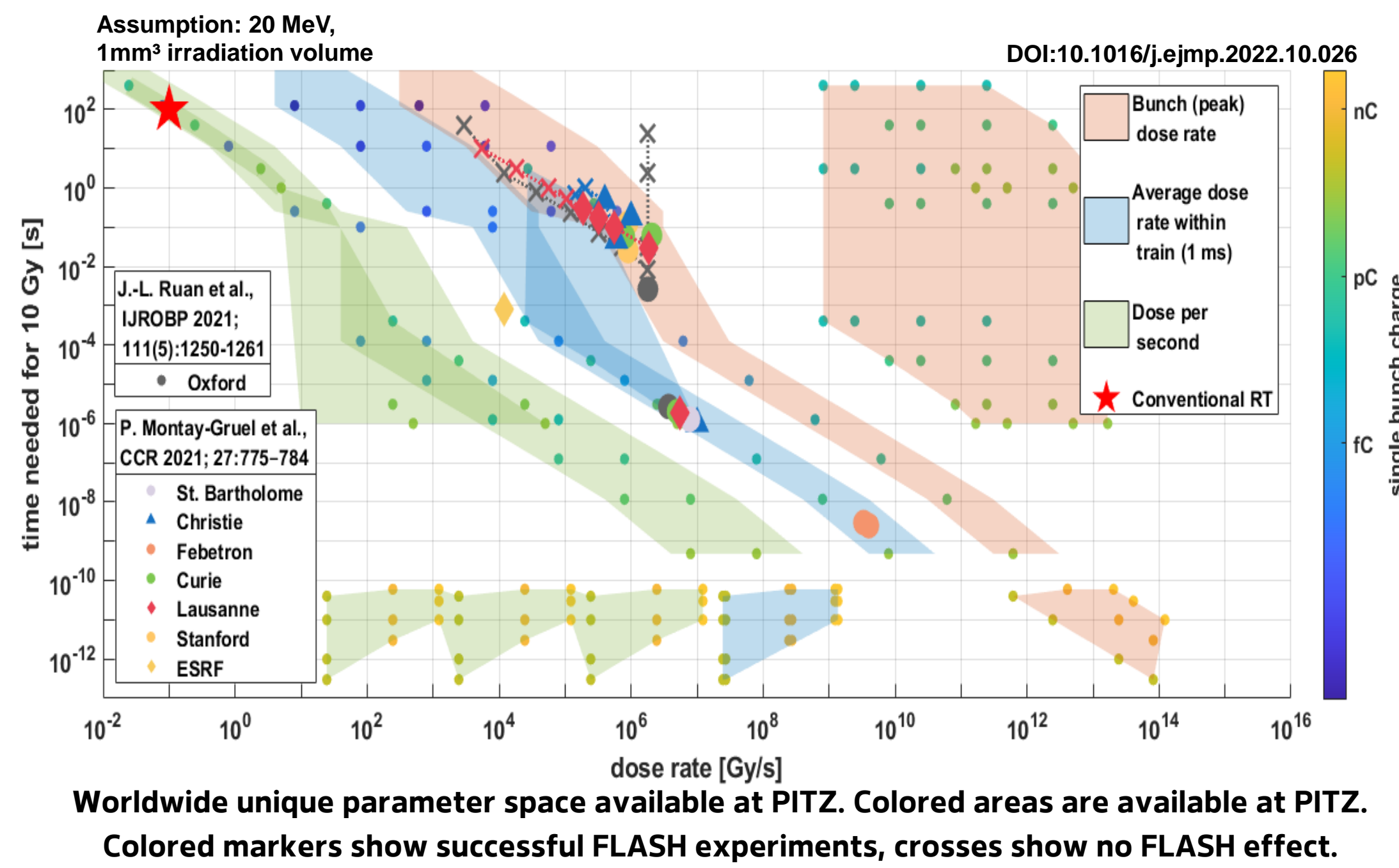


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## FLASH radiation therapy

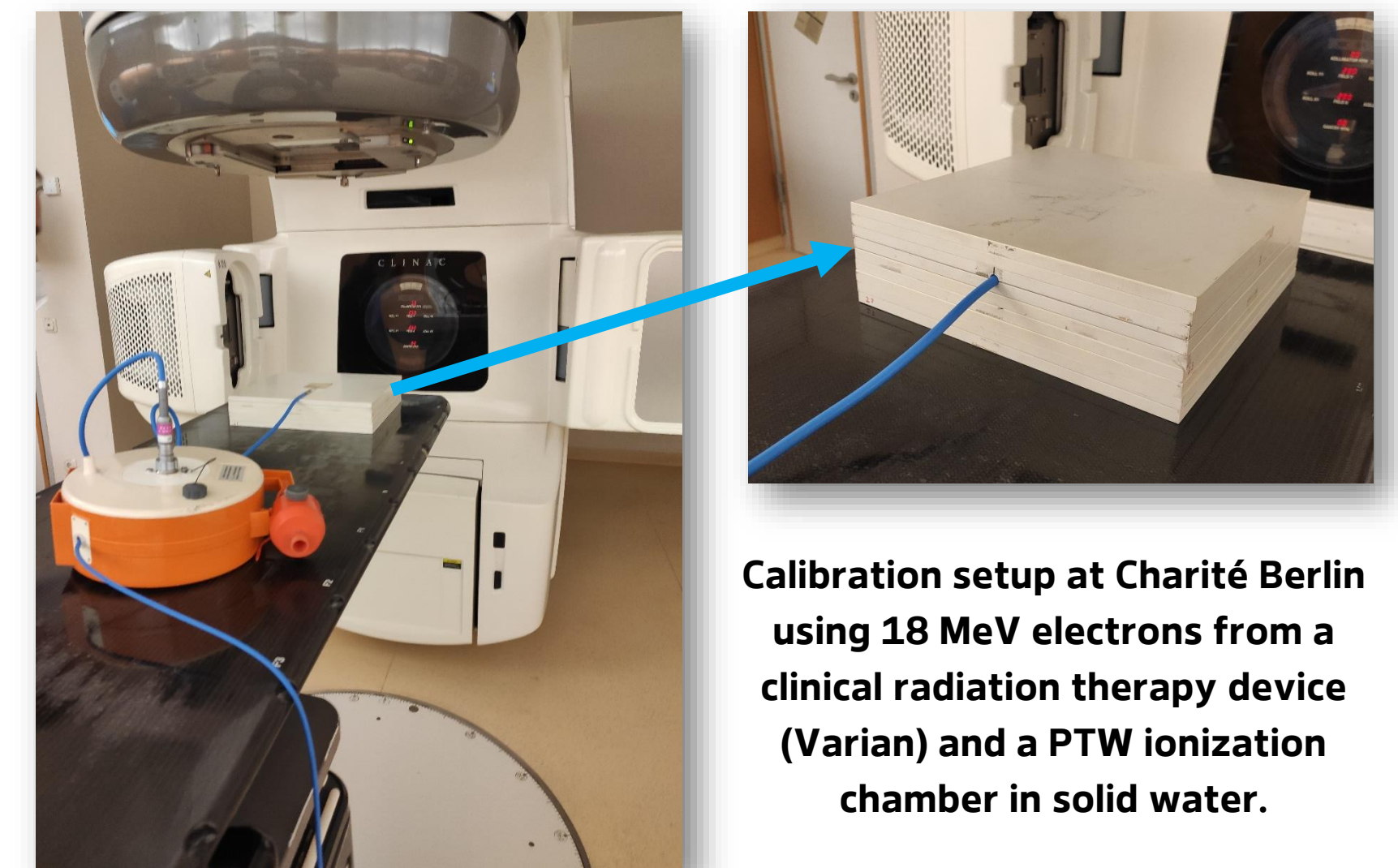
- New technique of **cancer treatment**
- Irradiation with dose rates  $> 40 \text{ Gy/s}$
- Same cancer control as conventional radiation therapy but **increased tissue sparing**
- Search for best parameters is ongoing
- PITZ is perfectly suited because of the **wide parameter range** available
- Bunch charge, number of bunches, number of trains, repetition rate and beam size can be adjusted
- Dose rates down from  $0.02 \text{ Gy/s}$  up to  $10^{14} \text{ Gy/s}$  are possible

## Parameter space available at PITZ

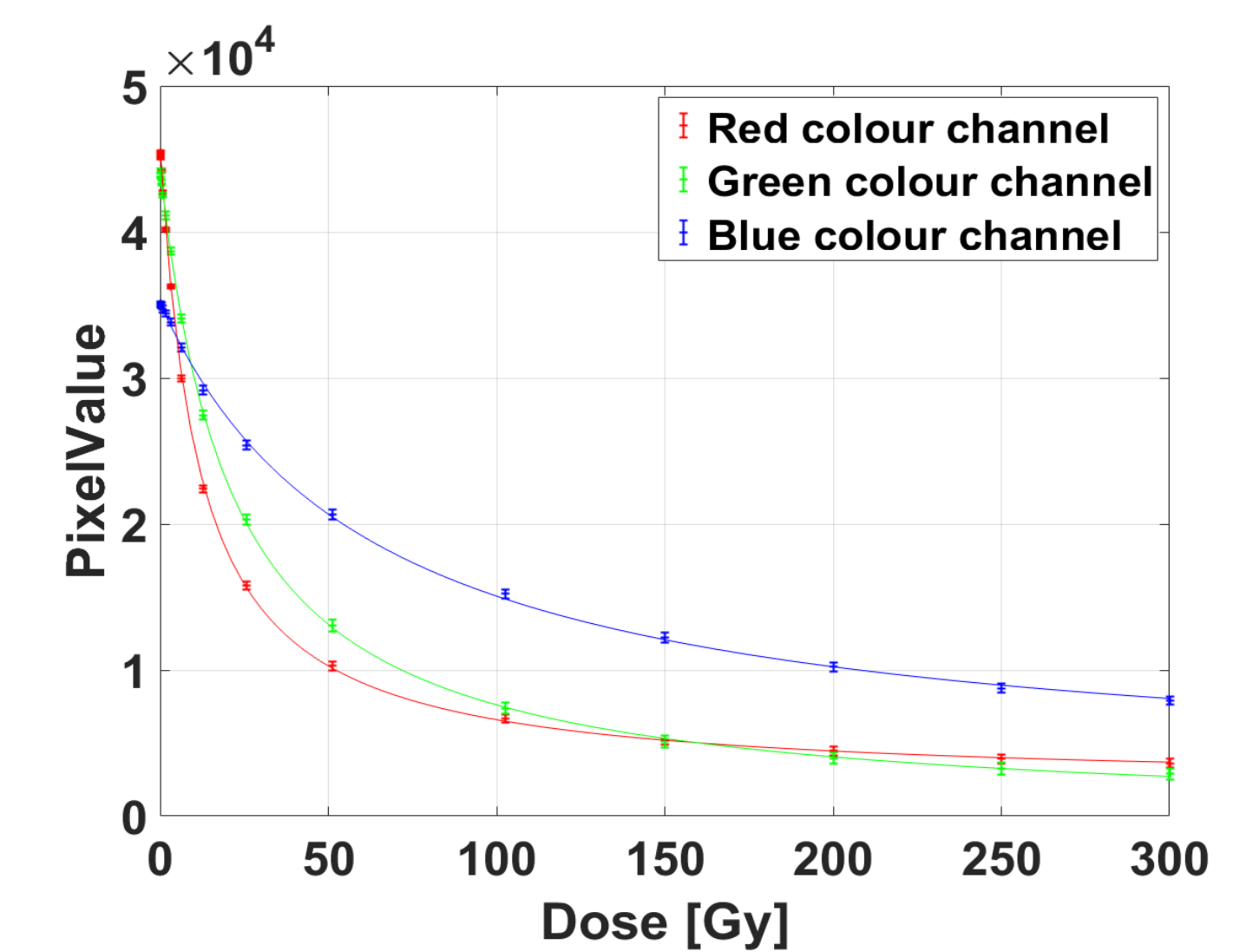


## Calibration of Gafchromic EBT-XD films

- Calibration was done in the **Charité university hospital**
- Clinical radiation treatment device (Varian Clinac) with homogeneous field size of  $25 \times 25 \text{ cm}^2$
- In solid water for a more homogeneous beam distribution
- Reference dosimetry: PTW Semiflex  $0.3 \text{ cm}^3$  calibrated at PTB together with PTW Unidos electrometer

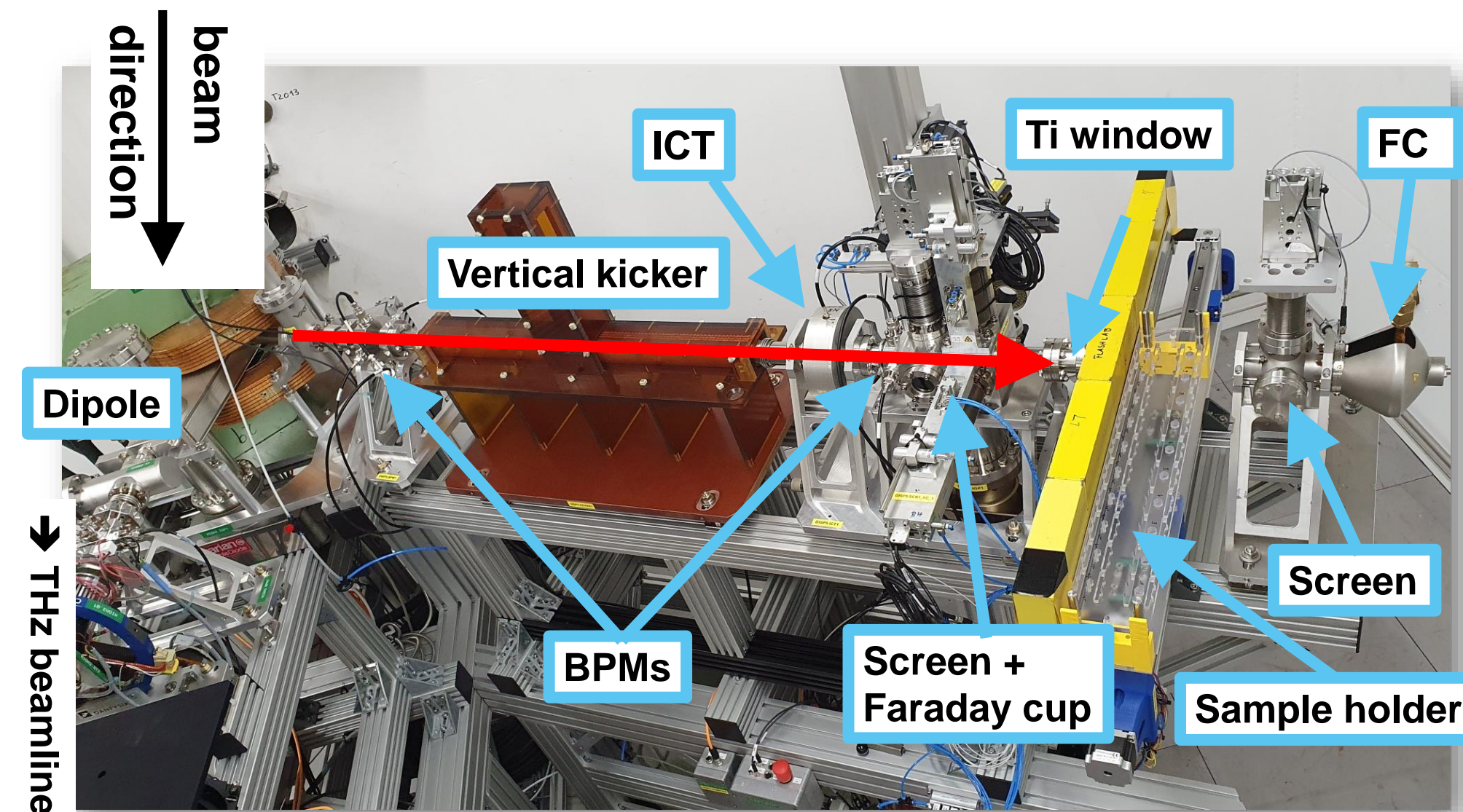


- Irradiation of reference films from  $0.1 \text{ Gy}$  up to  $300 \text{ Gy}$  mostly in geometric progression
- **All 3 colour channels** used for dose calculation
- Readout: 24 hours after irradiation



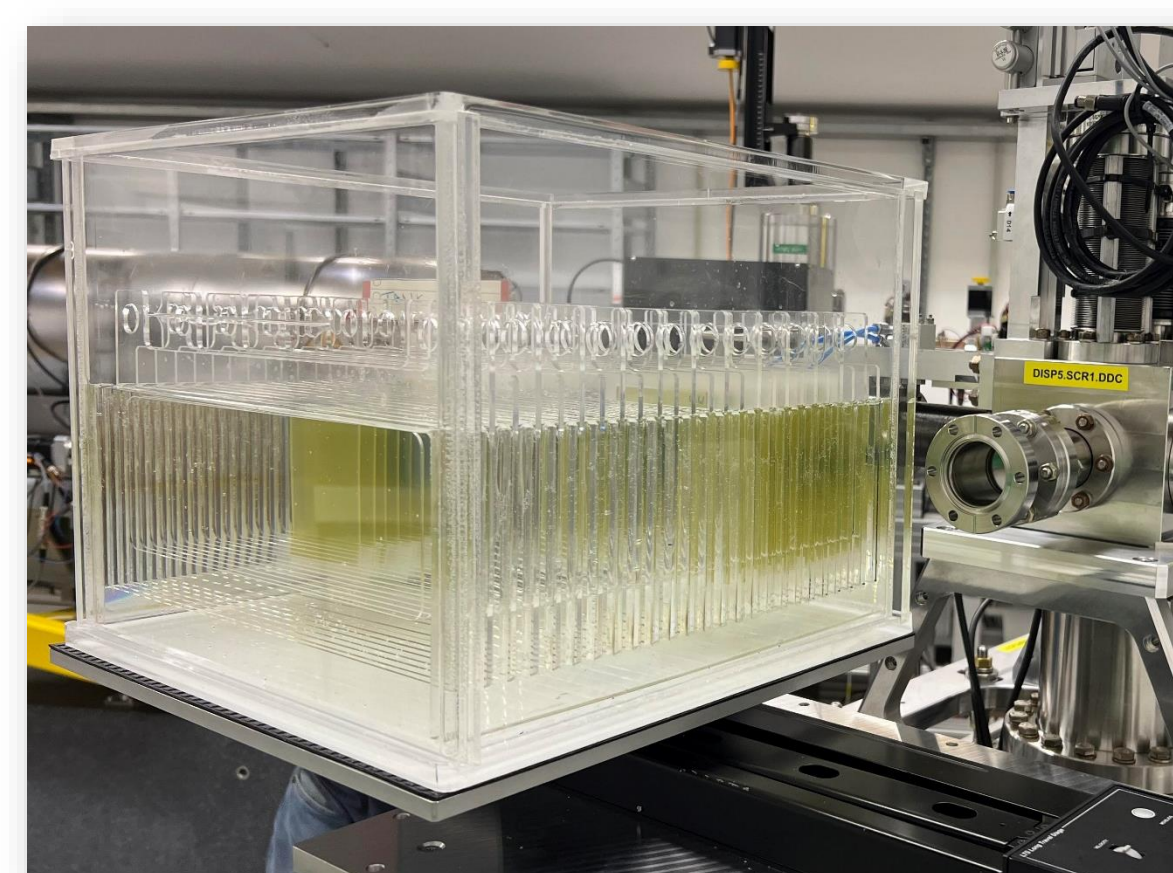
## The preliminary FLASHlab setup at PITZ

- Preliminary setup was built **end of 2022**.
- Different diagnostic systems are available:
  - BPMs & Screens for beam position/shape measurement
  - ICT & Faraday cups for beam charge measurements
- The vertical kicker (not yet functional) can be used to paint an area with the beam by kicking each bunch to a different location.
- The sample holder is mounted on a **motorized transverse stage**.
- Samples are put in Eppendorf tubes. One Gafchromic film before and one after each tube.

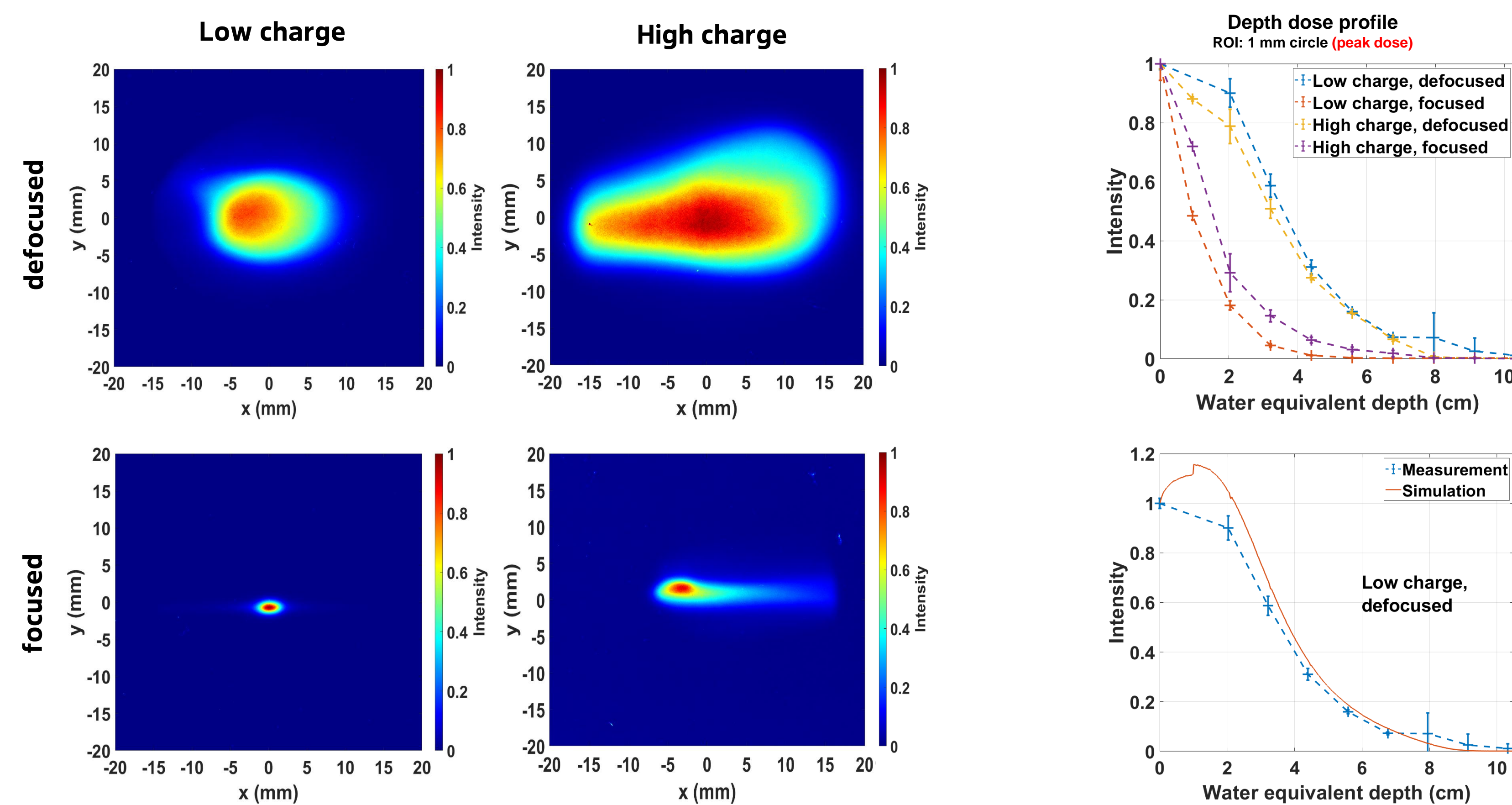


## Depth dose profiles in water

- Sample holder and all components behind can be dismantled and replaced by a  **$30 \times 30 \times 30 \text{ cm}^3$  water phantom**
- Gafchromic films were placed on the outside and inside of the phantom as well as approximately each  $1 \text{ cm}$  in water
- 4 different beam profiles were measured: high/low charge respectively focused or defocused
- Comparison between **Monte Carlo simulations** using FLUKA and measurements show **good agreement**
- Build-up effect occurs in the wall of the phantom and cannot be resolved with films

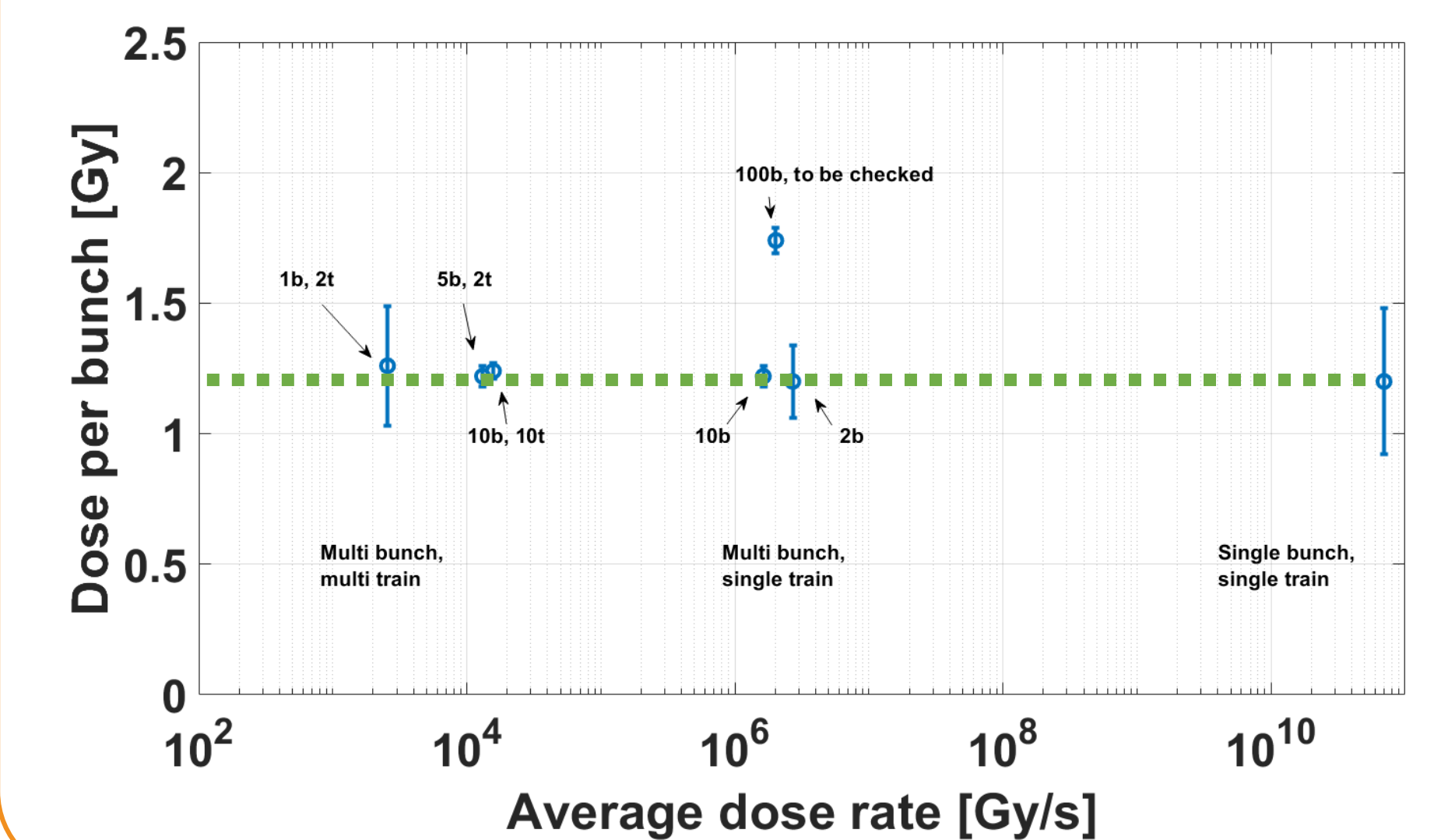


Setup for depth dose measurements in water phantom



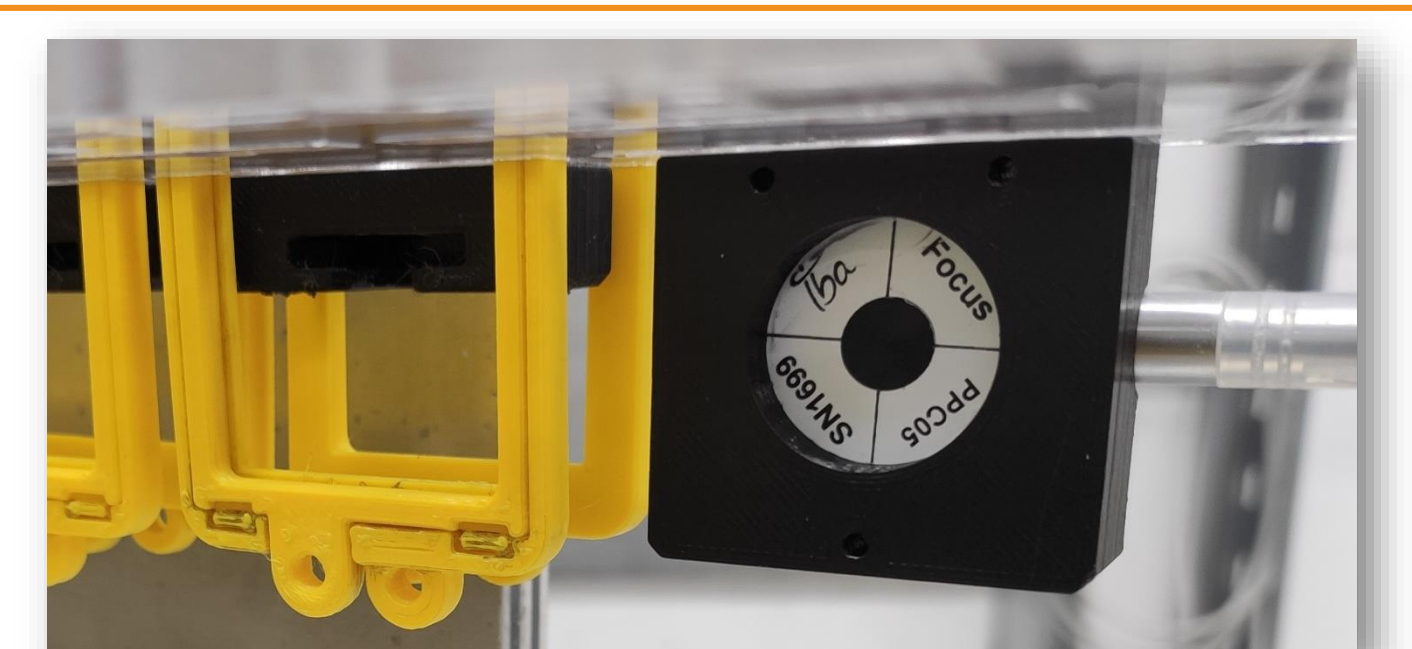
## Dose rate linearity test

- Dose rate linearity was investigated up to the highest dose rate currently achievable at PITZ
- Different dose rates were achieved by modifying the irradiation time:
  - Multi bunch, multi train:  $\sim \text{ms}$
  - Multi bunch, single train:  $\sim \mu\text{s}$
  - Single bunch, single train:  $\sim \text{ps}$
- **Dose rate independence** was proven up to  $7 \times 10^{10} \text{ Gy/s}$  using a single bunch with a length of  $18 \text{ ps}$  (FWHM) and a charge of  $940 \text{ pC}$



## Conclusion and outlook

- The PITZ accelerator at DESY Zeuthen can **provide conventional dose rate up to ultra high dose rate** due to its uniquely wide parameter space.
- The preliminary FLASHlab@PITZ setup was built end of 2022. A movable stage or a water phantom can be mounted.
- **Gafchromic films were established as reference dosimeters.** Calibration of the films was done at the Charité university hospital using a clinical radiation device.
- Depth dose profiles in water were measured for 4 different beam profiles and compared with FLUKA simulations. **They show good agreement.**
- Dose rate linearity of Gafchromic films was proven up to  $7 \times 10^{10} \text{ Gy/s}$ .
- Cross-calibration with **Alanin and TLDs** is planned. A **PPC05** ionization chamber will be reference for low dose rates.



PPC05 ionization chamber mounted on the movable stage at location of the sample.