Physikalisch-Technische Bundesanstalt
Braunschweig and Berlin
National Metrology Institute

UHDpulse

Technische Universität München

Investigation of Plastic Material Properties Exposed to Ultra-high Dose Rate Electron Beam

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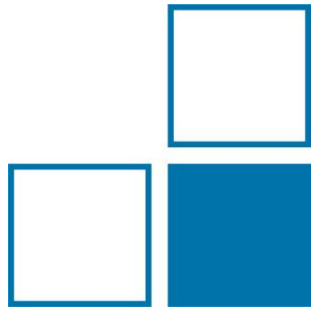
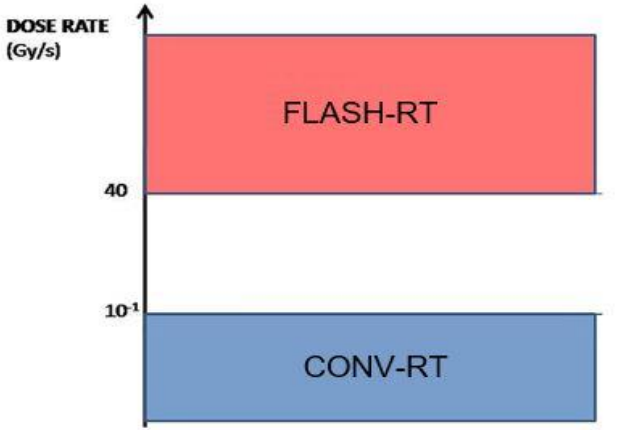


Introduction to FLASH radiotherapy

- FLASH radiotherapy (FLASH-RT) is a promising cancer treatment that involves an almost instantaneous delivery of a high radiation dose in only a few radiation pulses of ultra-high dose rate.
- Reduces the adverse side effects on healthy tissue.



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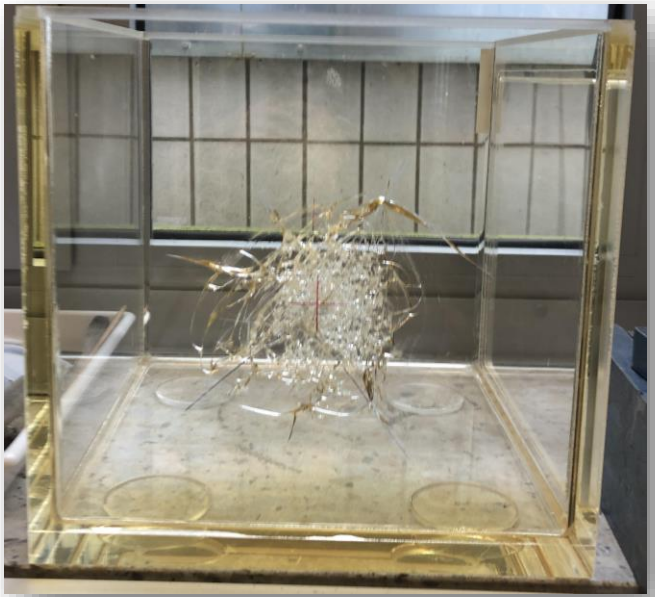
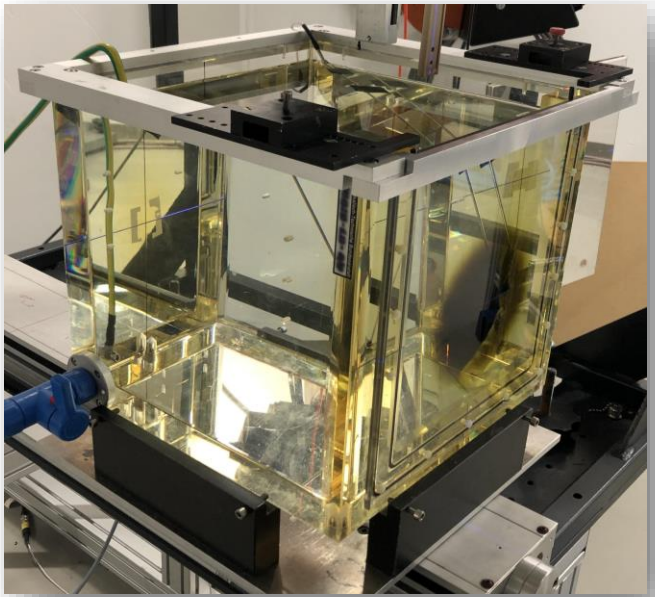
Comparison of FLASH RT vs. Conventional RT		
	Flash RT	Conventional RT
Average Dose Rate	> 40 Gy/s	5 Gy/min
Treatment Time	< 500 ms	~4 min
Dose Per Pulse (DPP)	0.6-10 Gy	0.3 mGy

Motivation of the project

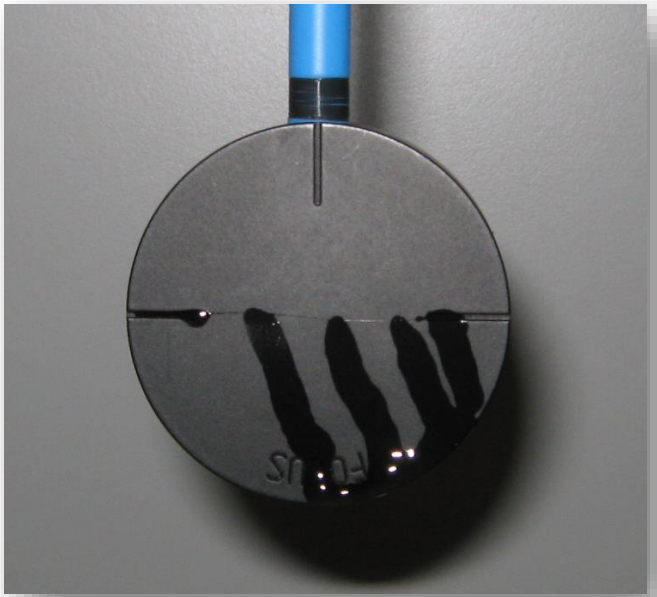
- Plastic materials used in FLASH radiotherapy change colour rapidly and crack.





Motivation of the project

- Plastic materials used in FLASH radiotherapy change colour rapidly and crack.
- Not only water tanks but detectors are also damaged.



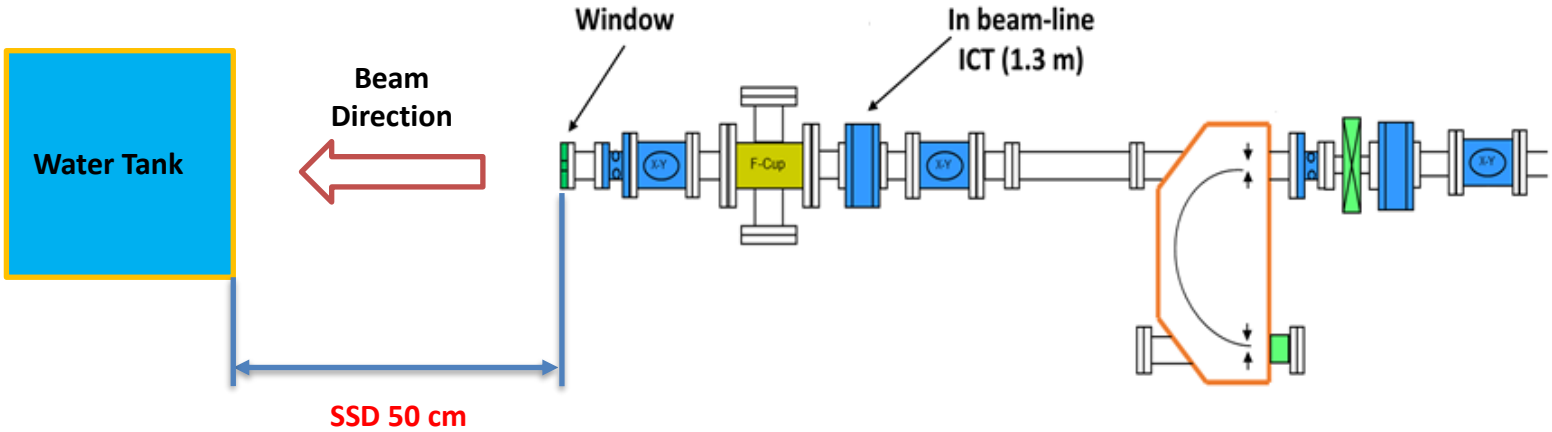
Ion collection efficiency (CCE) in ultra-high dose per pulse electron beams, Alexandra Bourgouin

Electron LINAC

- Metrological Electron Accelerator Facility (MELAF) at PTB, Germany

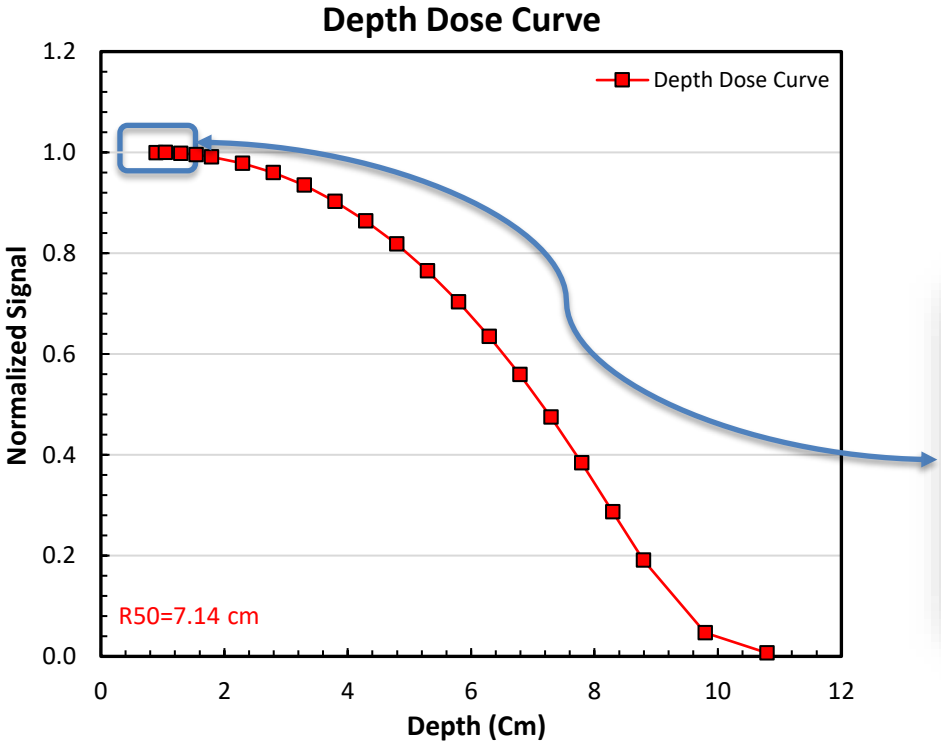
Electron LINAC Setup

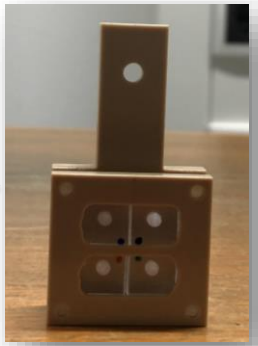
- Irradiation of samples was carried out at 20 MeV, 10 Hz pulse repetition frequency, and pulse width of 2.5 µs.



Irradiation dose levels

- Samples irradiated with 11Gy/pulse.





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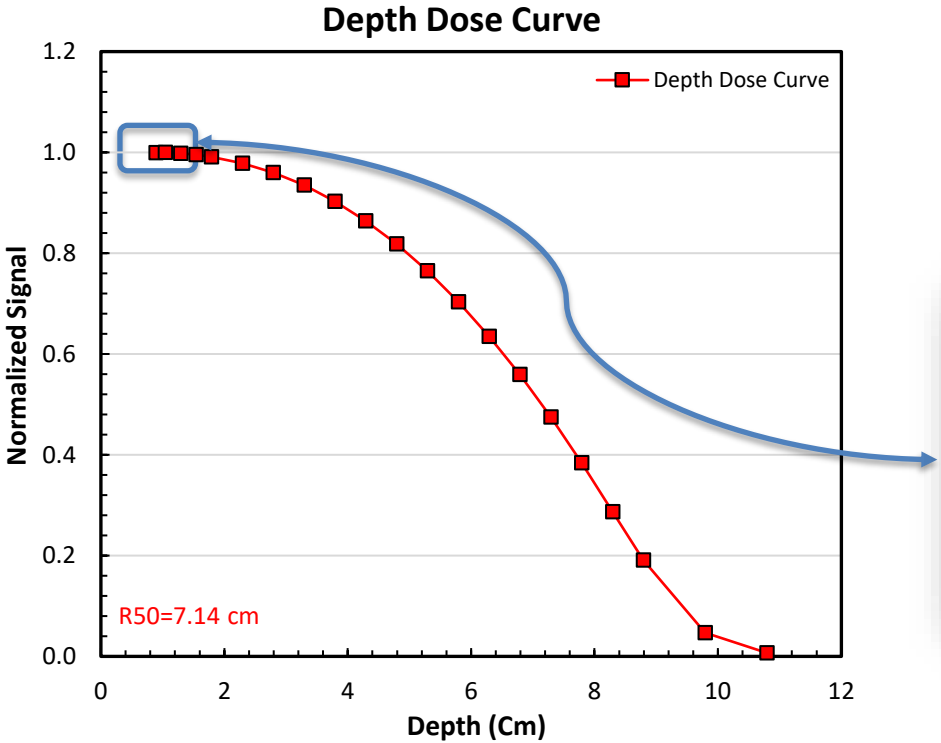

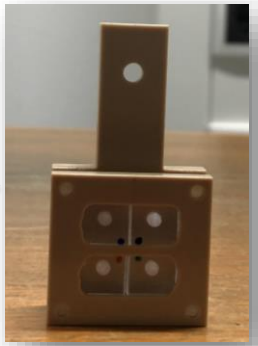

# of Dose Level	Dose (Gy)
1	**1,000,000**
2	**500,000**
3	**100,000**
4	**10,000**
5	**1,000**
6	**100**
7	**0**

Plastic materials tested

- Mostly standard plastics
  - Polymethyl methacrylate (PMMA)

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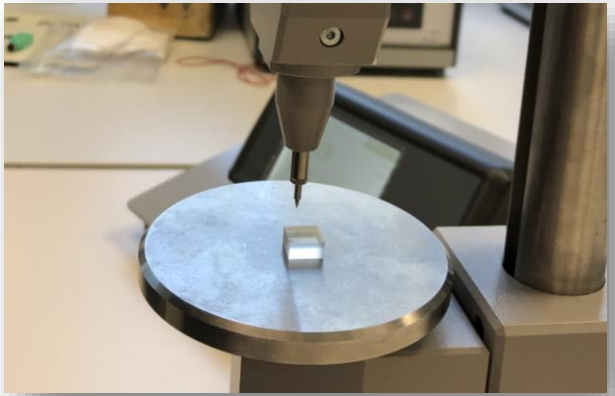
- All materials have ≈ 5mm thickness

Material properties tested

- Mechanical properties
  - Hardness

Bareiss Digitest II
Range 0 - 2 N / 0-20 N
Uncertainty ± 0.0000005



Material properties tested

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  - Hardness

    Bareiss Digitest II
    Range 0 - 2 N / 0-20 N
    Uncertainty ± 0.0000005

- Hardness measurements have been completed after irradiation.

Material properties tested

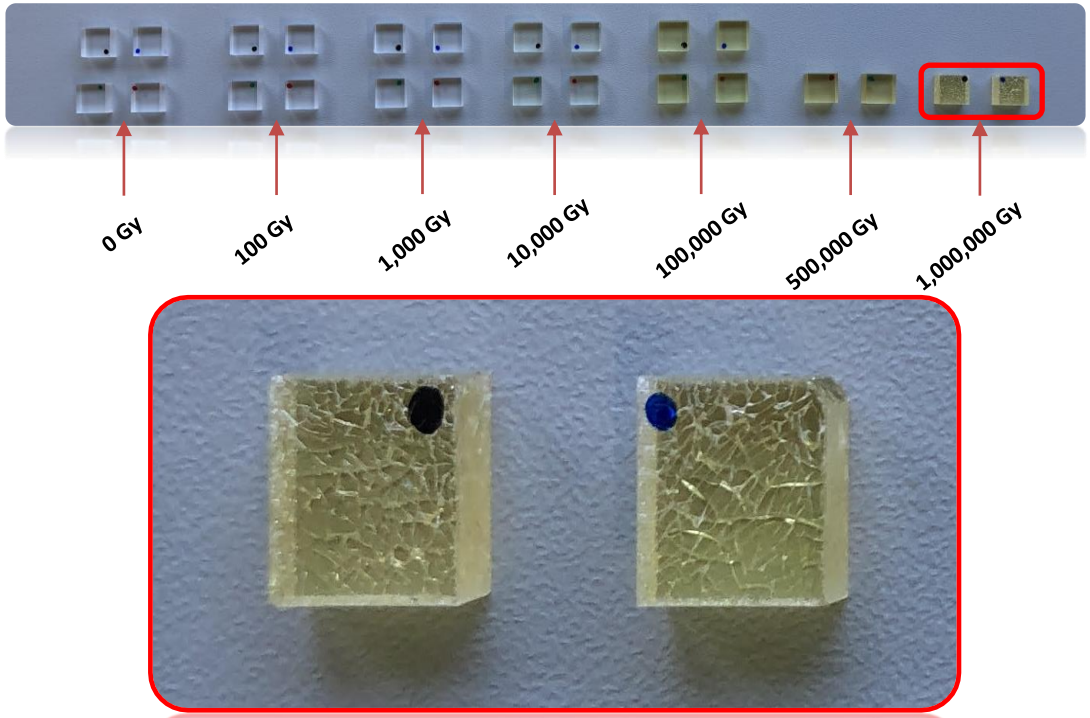
- Optical properties

  - Optical density (Optical transmission)

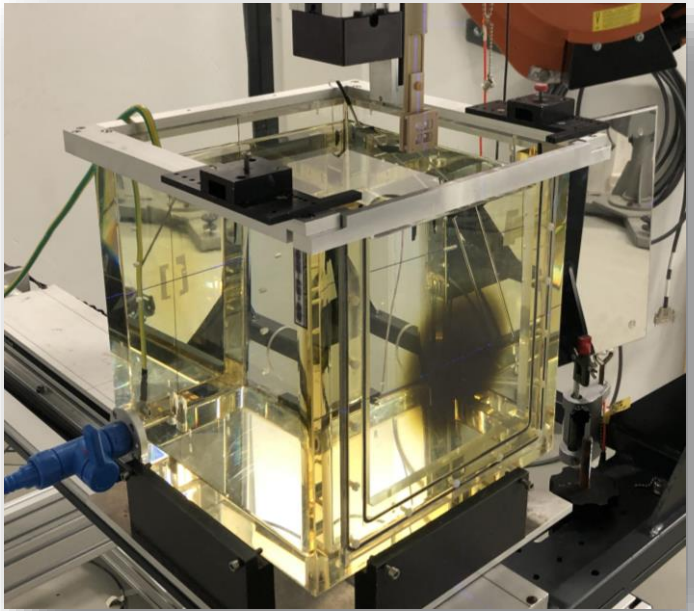
    Macbeth TR-1224 Densitometer
    Range 0.00 to 4.00 OD
    Uncertainty ± 0.02

- Optical density measurements have been completed before and after irradiation.

Qualitative observations



Qualitative observations



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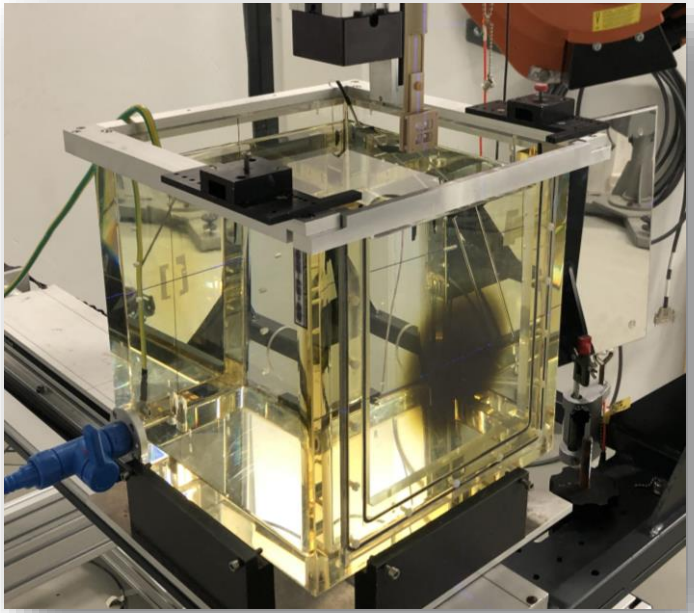
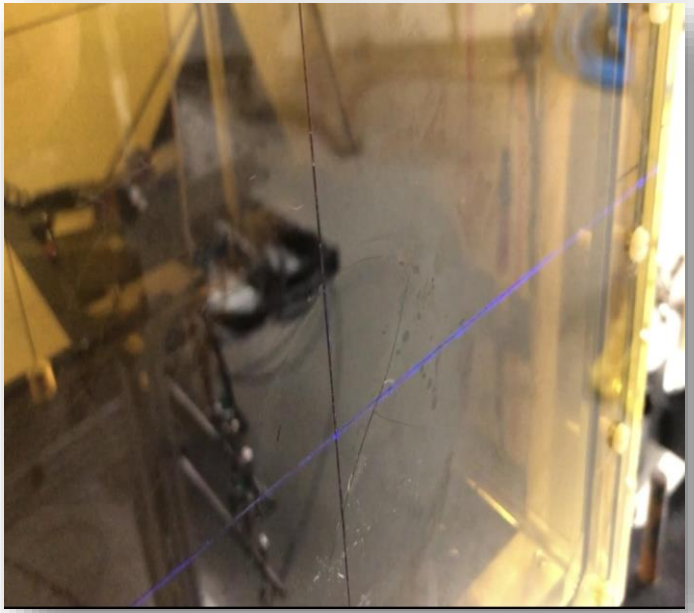


7±1 MGy



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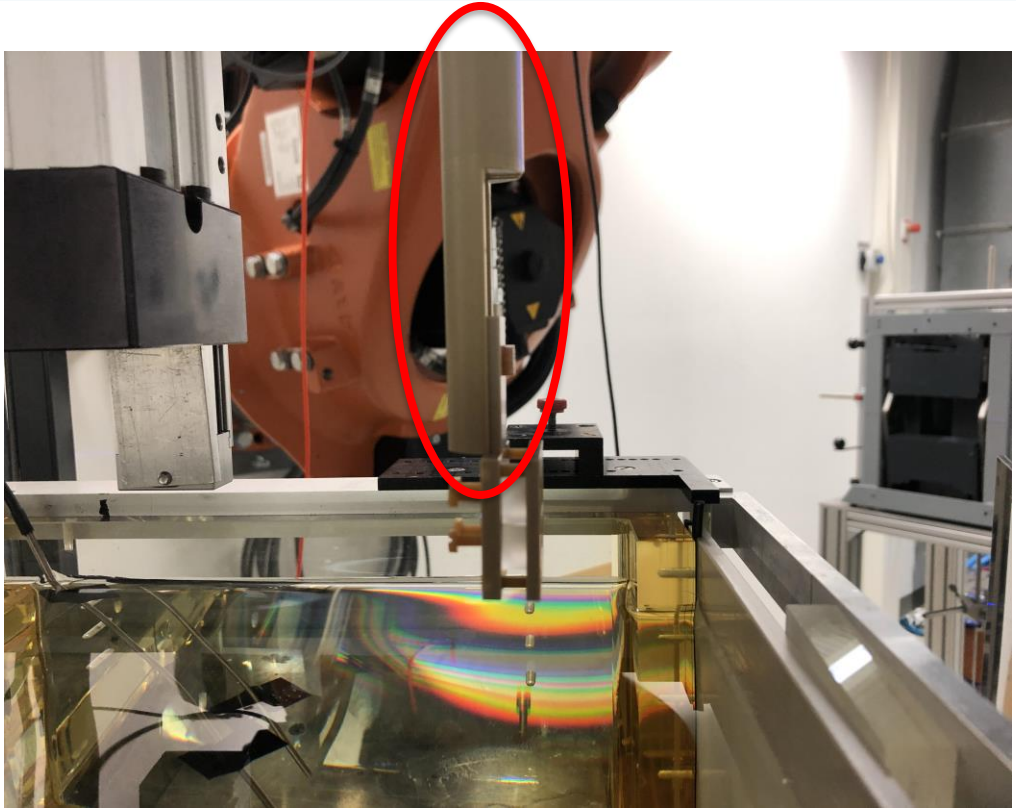
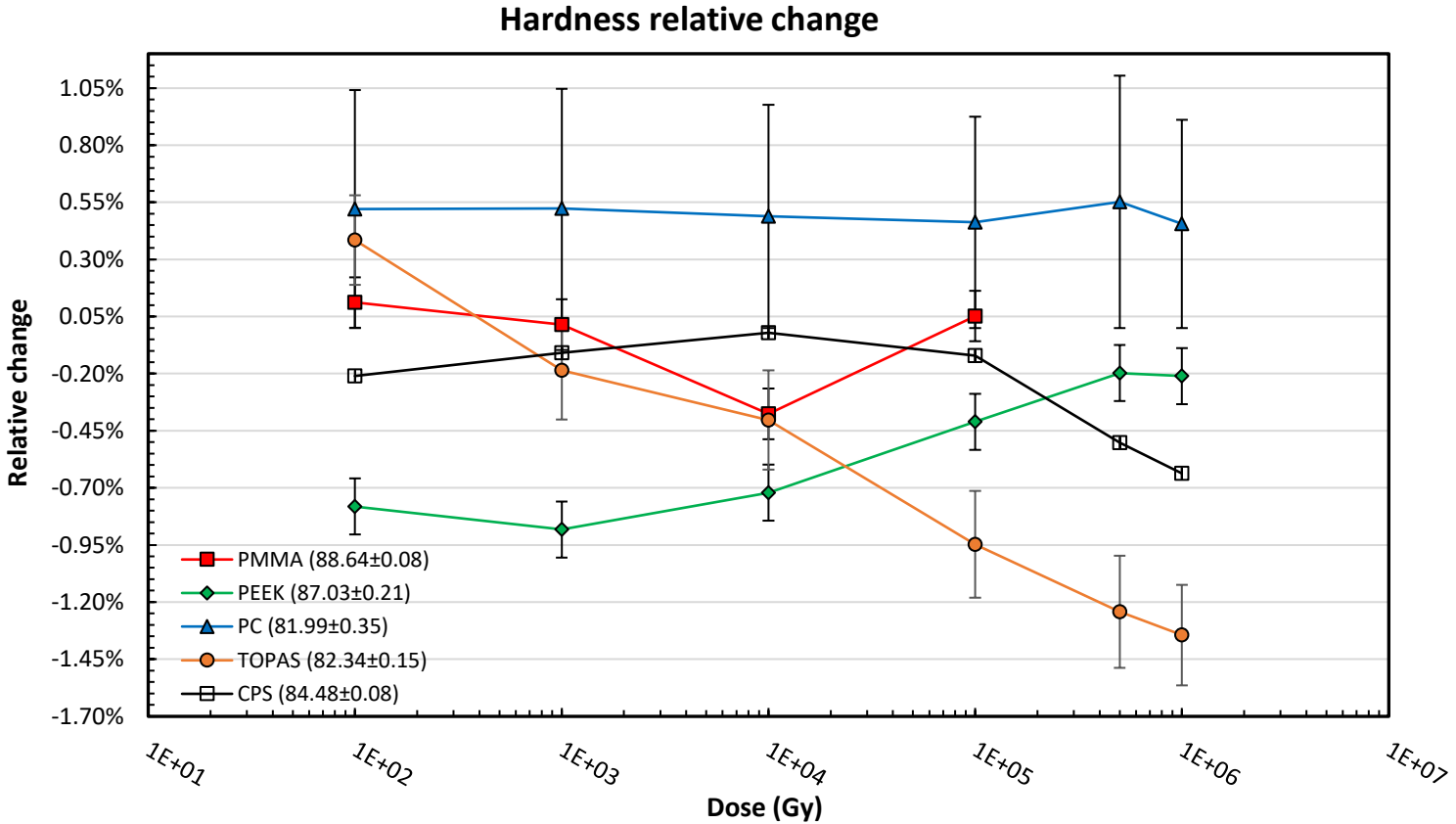
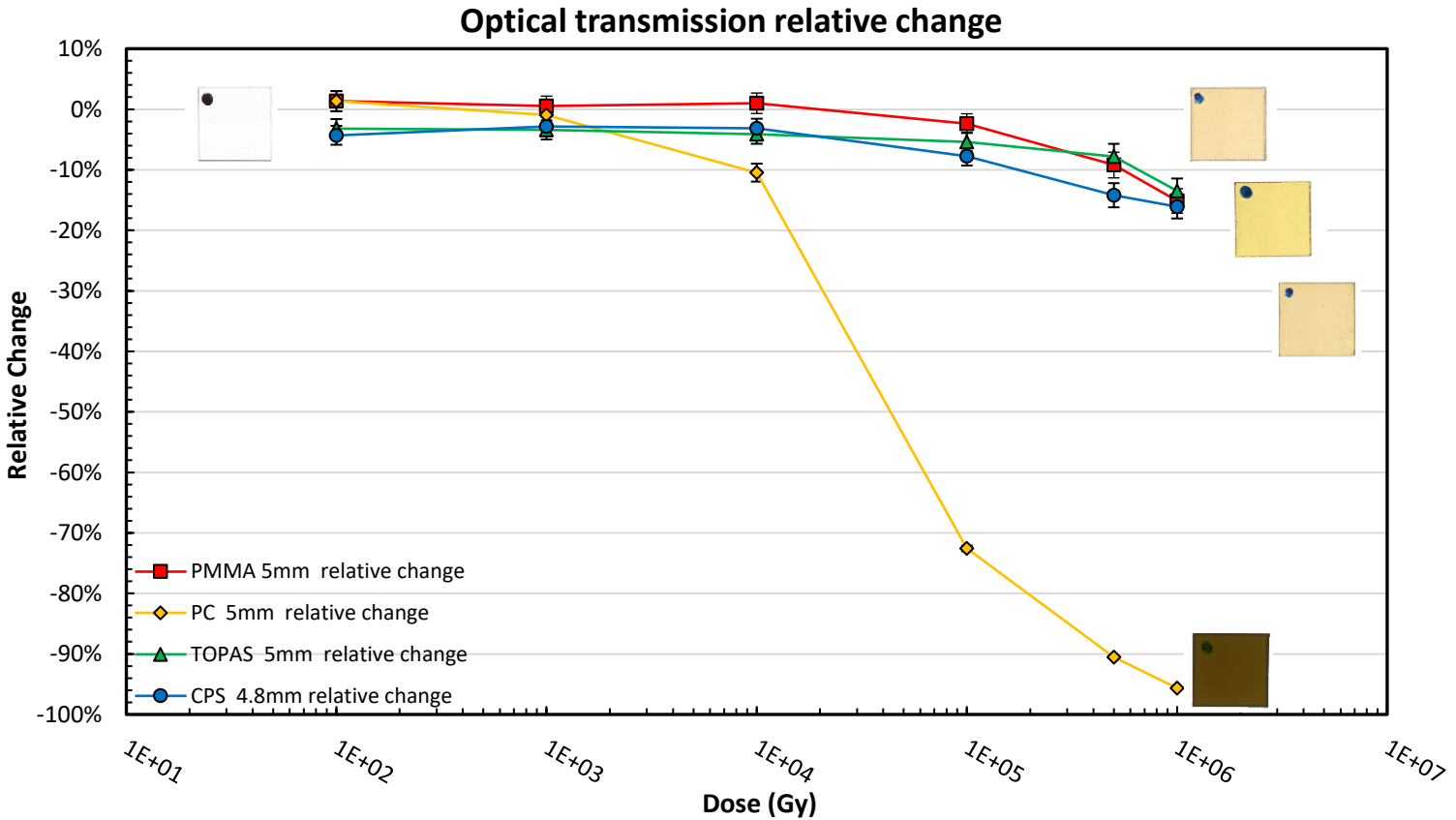


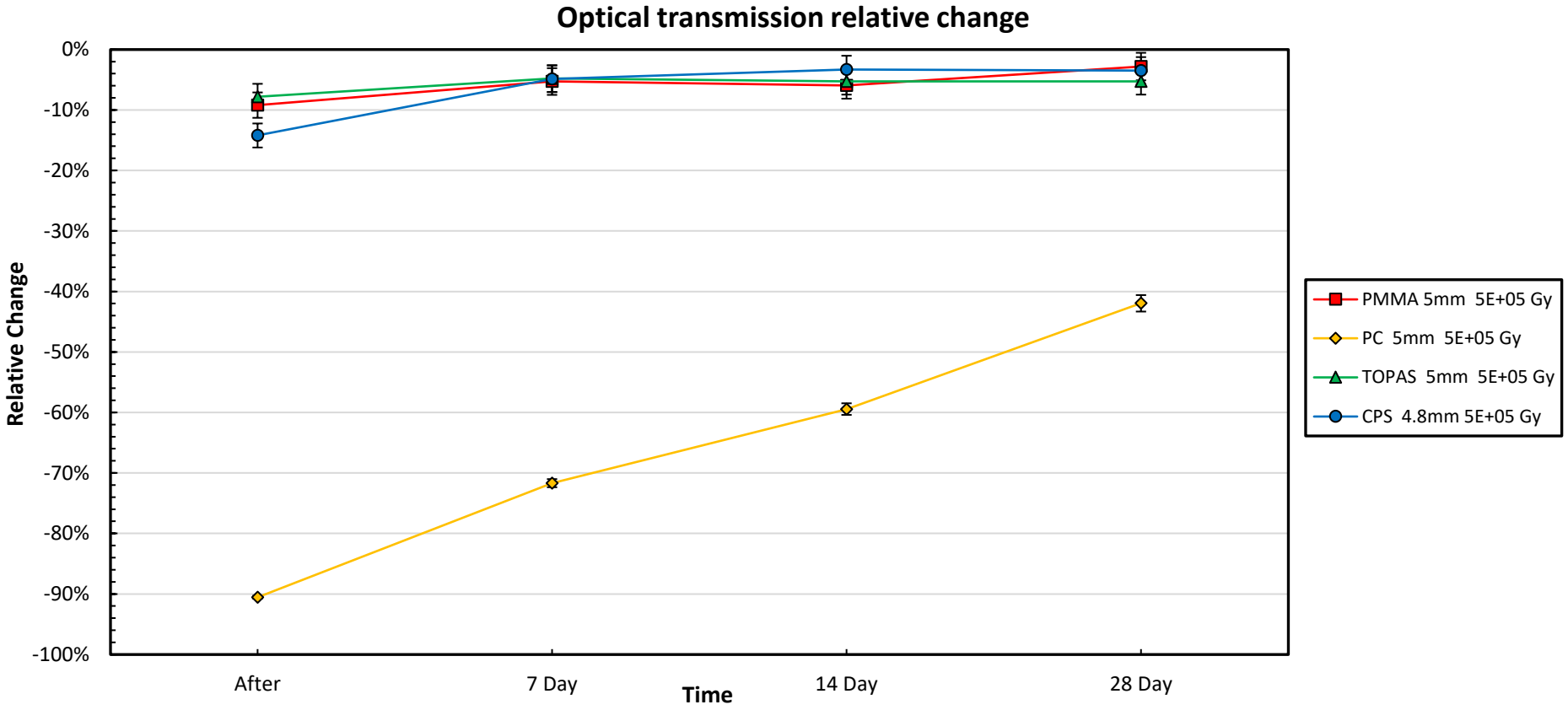
Hardness results



Optical transmission results



Optical transmission results



Conclusion

- Mechanical properties
  - We could not correlate mechanical damage with mechanical property changes.

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  - We could not correlate mechanical damage with mechanical property changes.
- Optical properties
  - Healing effect has been observed on optical transmission properties.

Conclusion

- PEEK showed that it is the most radiation resistant and suitable candidate for FLASH electron beams in the materials we tested if opacity is not a problem.

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Conclusion

- PEEK showed that it is the most radiation resistant and suitable candidate for FLASH electron beams in the materials we tested if opacity is not a problem.
- For transparent materials, TOPAS and CPS showed that they are suitable candidates.
- Results show that PC and PMMA are unsuitable for some FLASH electron beams.

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Acknowledgements

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Thank you!

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