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Treatment plans verification in proton therapy using the FBX chemical dosimeter

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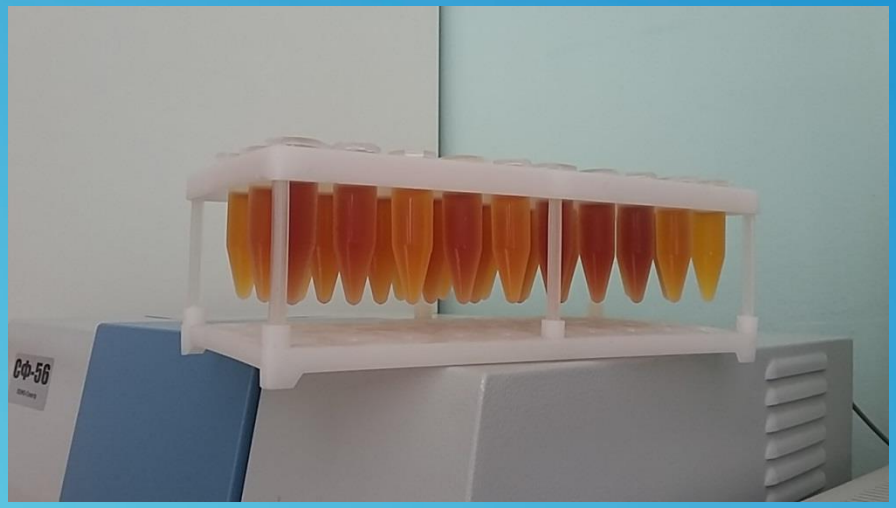
Introduction

- Using scanning beam technique in proton therapy allows to improve the conformity of tumors irradiation of various sizes and localizations. This method is implemented on the proton therapeutic complex "Prometheus" (ZAO Protom), located in the MRRC, Obninsk.
- Slight variation in dose distribution is characteristic of executable (performing) irradiation plans despite the high proton irradiation accuracy. So measurements at different points of the irradiated volume must be carried out several times to determine the dose distribution correctly. This procedure takes a lot of time of the accelerator operation.
- To solve this problem the dosimetry system which able to determine the average dose for the entire volume of interest for one execution of the plan can be used.

Materials and methods

Chemical dosimeter calibration

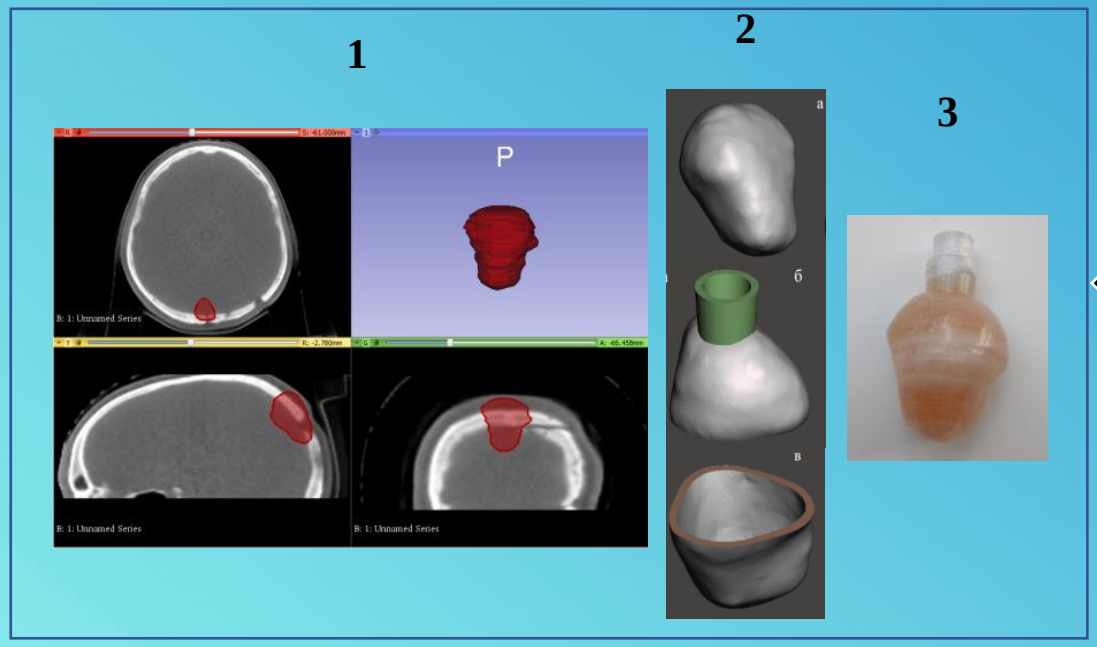
- FBX-dosimeter calibration curves for standard gamma radiation and for scanning proton beam were obtained previously.
- Liquid chemical dosimeters can be irradiated in the vials (volume 5 ml).
- Optical density was measured by using an SF-56 spectrophotometer.



Materials and methods

Verification of treatment plan

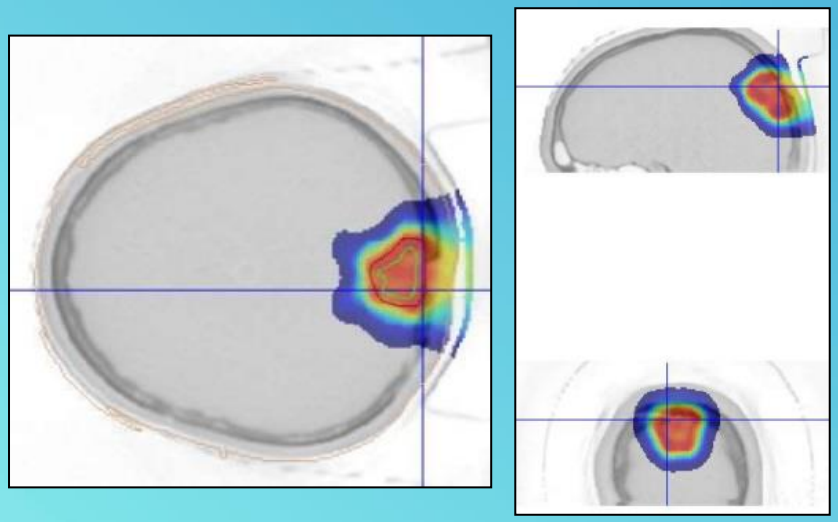
- The vials for the FBX dosimeter were prepared from thermoplastic by means of 3D-printing.
- The shape of vial repeated the PTV volume of a patient treated by proton therapy in MRRC.



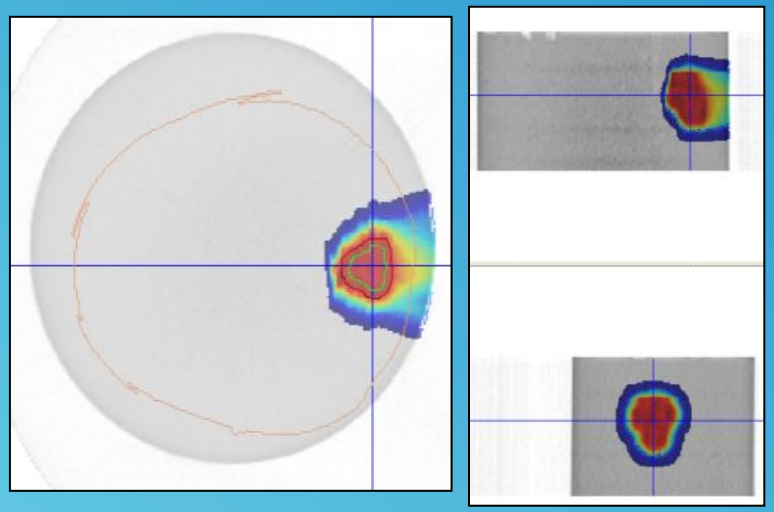
Constructing of model [1], processing [2] and manufacturing model [3] for filling solution FBX

Materials and methods

- Then the vial tomogram was combined with the patient tomogram and the resulting file was used to calculate the irradiation plan.
- The exposure directions and the proton energy range corresponded approximately to the treatment planning (therapeutic plan).
- The tomogram was performed on a conical tomograph included in the complex of proton therapy for every vial which was filled with water and installed in an aqueous phantom.



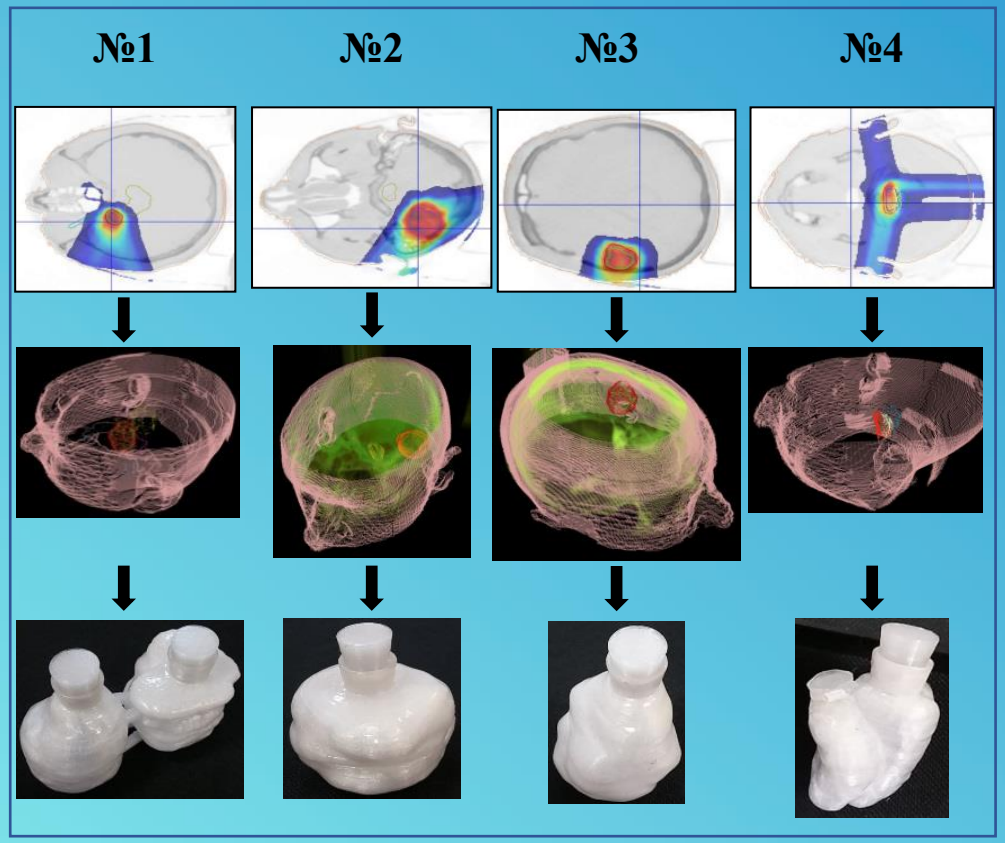
Therapeutic plan



Irradiation plan (phantom)

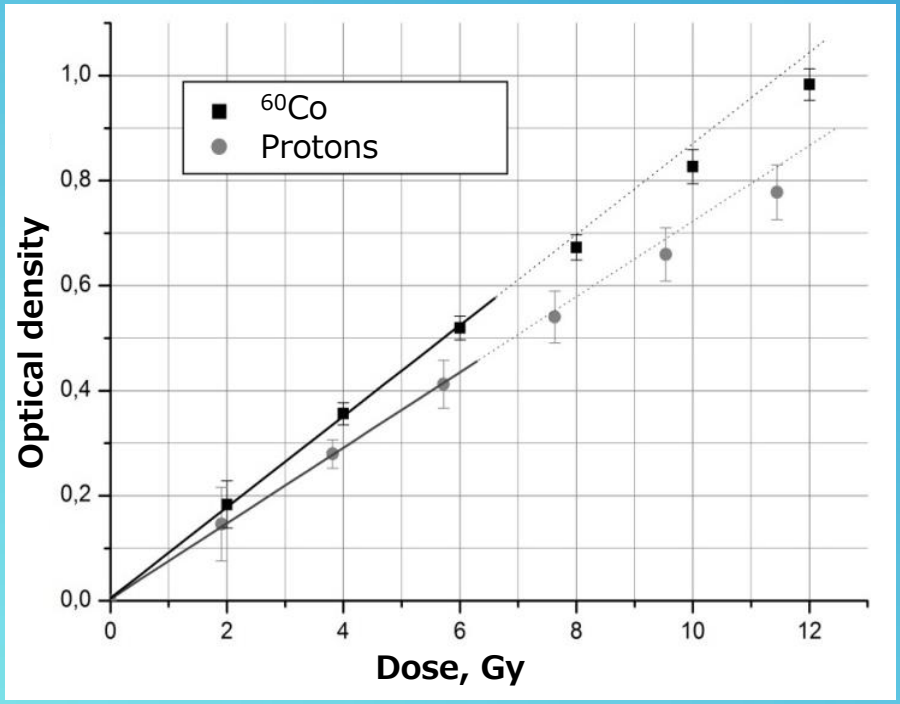
Materials and methods

- The vials were filled with a dosimetric solution just before irradiation. Optical density measurements were performed in an hour after the end of exposure.
- Four vials were used, two of them contained the volume of PTV and a nearby critical organ, three or more measurements for each vial were taken.

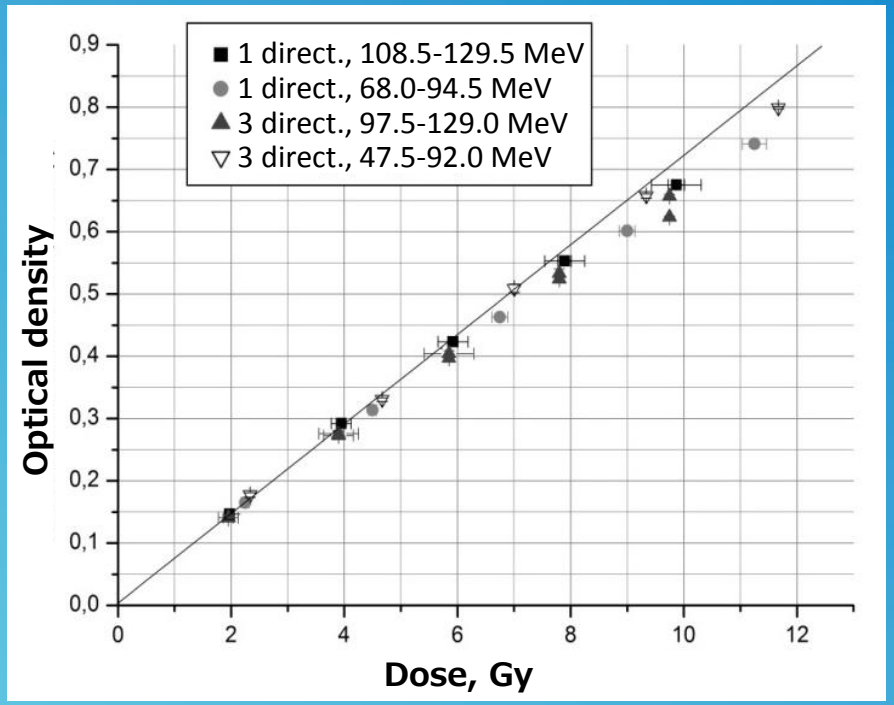


Results

FBX-dosimeter calibration curves



The calibration curves for standard gamma radiation and for scanning proton beam

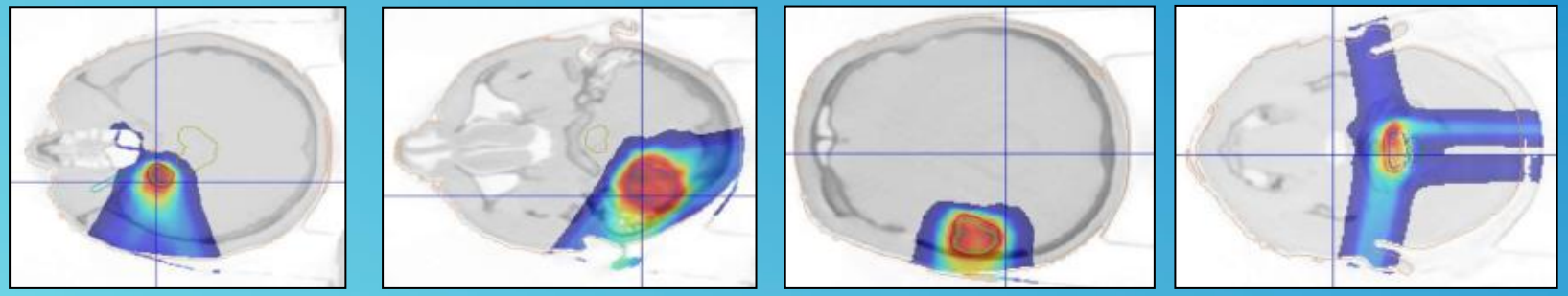


The dependence of the optical density of FBX on the dose of protons of different energies and on the number of irradiation directions

Results

Average absorbed dose in model volume measured by the chemical dosimeter FBX

№1 №2 №3 №4



№ плана	№1 (PTV)	№2 (PTV)	№3 (PTV)	№4 (PTV)	№4 (Critical structure)
D (plan), Gy	5.32	5.30	5.63	5.33	1.70
<D> (FBX), Gy	5.01	5.47	6.19	5.02	1.24

Results and discussion

- The variations between measured average values of the dose determined according to the described method in the volume of PTV by FBX dosimeter and by planning system are in the range of 10%.
- The optical density of FBX solution for a critical structure located at ~10 mm from PTV did not differ from the control level. When irradiating volumes were located close to each other, the dose in the critical organ model determined by FBX was 25% of the PTV dose and 32% of the planning system dose.
- This study is the first step in the constructing (designing) of personalized phantoms for quick verification of irradiation plans for proton scanning beam.

Thanks for attention!