INTERNATIONAL MASTERCLASSES

hands on particle physics

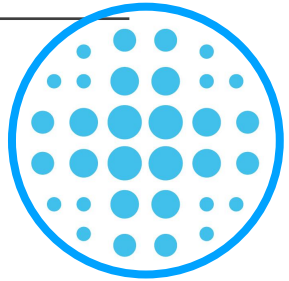
Particle Therapy Masterclass 2021

11th March 2021

TRAINING OF PARTICLE THERAPY PLANNING

CHARLES UNIVERSITY, PRAGUE FT. PROTON THERAPY CENTER PRAGUE

<BRAVE STUDENT> ON BEHALF OF PRAGUE COLLECTIVE



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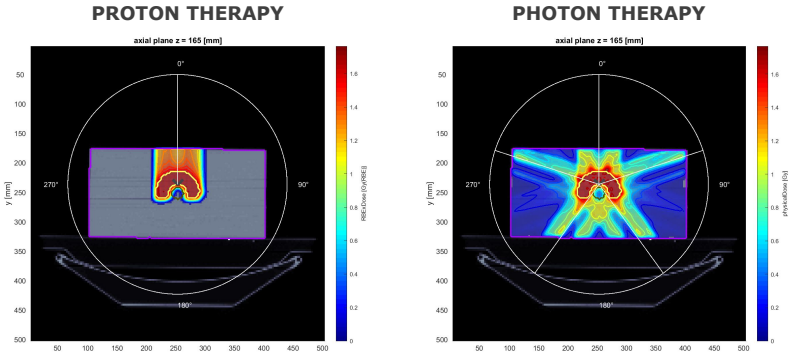
C-PHANTOM

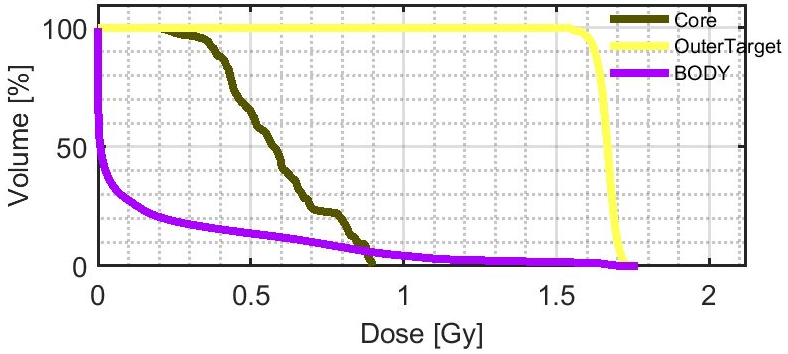
The C-phantom composed of C-shaped target volume and two organs at risk (skin and core) was used as an introduction to the matRad software.

We learned the main differences between photon and proton therapy.

Optimization process was improved using suitable objectives and constraints of dose in specific locations.

Therapy Type	Photons	Protons	Photons (more beams)	Photons (more beams + O&C)
D_OAR / D_tar	0.75	0.17	0.46	0.26





LIVER TREATMENT

The second task introduced CT-images of liver locality surrounded by defined target volumes.

We have compared best student results obtained for combined 5 photon beams with 1 proton or carbon ion beam (see the tables). Individual dose distributions show comparable efficiency of more preferred hadron-based beams.

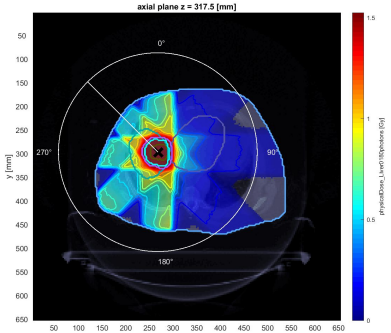
Therapy Type	Photons	Protons	Carbon Ions
D_OAR / D_tar	0.38	0.14	0.15

Structures Under Study [Gy / fraction]			
Region	Photons	Protons	Carbon Ions
GTV	1.50	1.51	1.50
Kidney_RT	0.00	0.00	0.00
Kidney_LT	0.00	0.00	0.00
Stomach	0.02	0.00	0.00
Small Bowel	0.00	0.00	0.00
Large Bowel	0.00	0.00	0.00
Celiac	0.00	0.00	0.00
Liver	0.25	0.17	0.17
Heart	0.22	0.02	0.03
Spinal Cord	0.04	0.00	0.01
Duodenum	0.00	0.00	0.00
CTV	1.50	1.51	1.50
Skin	0.05	0.02	0.02
PTV	1.50	1.49	1.49

COMPARISON OF PARTICLE THERAPY FOR LIVER

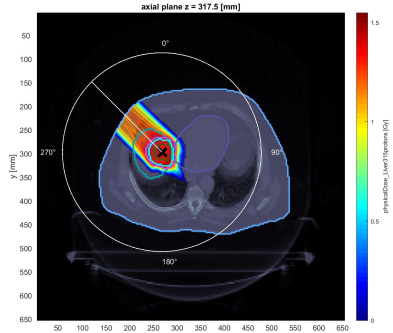
PHOTON THERAPY

Correct use of 5 photon beams ensures acceptable dose distribution in the target volume area, but also higher intensity behind and in front of the target is observed.



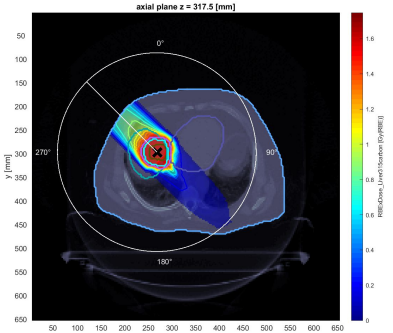
PROTON THERAPY

Use of just 1 proton beam generates slightly more dose in front of the target, but as we have learned today from the Bragg peak benefits no dose behind is observed.



CARBON ION THERAPY

The different relative biological effectiveness of carbon ions results in lower dose delivered in front of the target. The residual dose could be observed behind the peak.



COMPARISON OF PARTICLE THERAPY FOR LIVER

PHOTON THERAPY

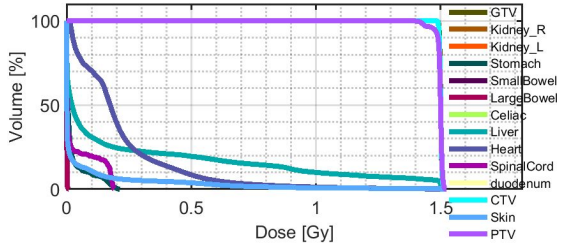
Dose in the target volume reached its desired maximum, but the healthy tissue irradiation is higher than in case of hadron-based therapies (difference especially in heart and spinal cord region).

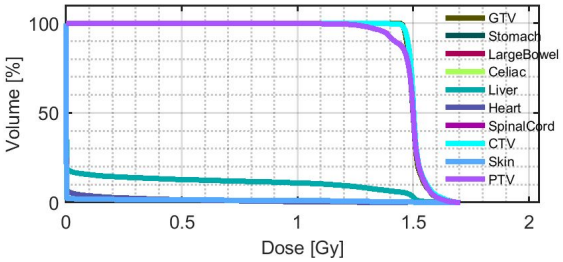
PROTON THERAPY

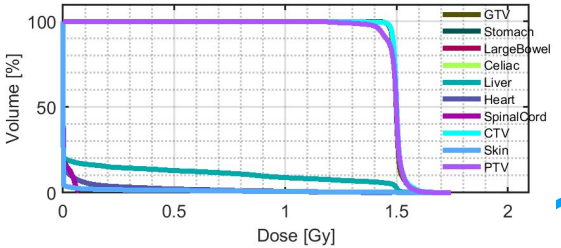
There is a bit slower drop-off in target dose in case of proton beam, but the deviation is not significant. Surrounding organs are not affected in any serious way in comparison with photon therapy.

CARBON ION THERAPY

The edge of the dose distribution of target volume is slightly sharper than in case of protons, but no significant dose differences are detected in other structures.





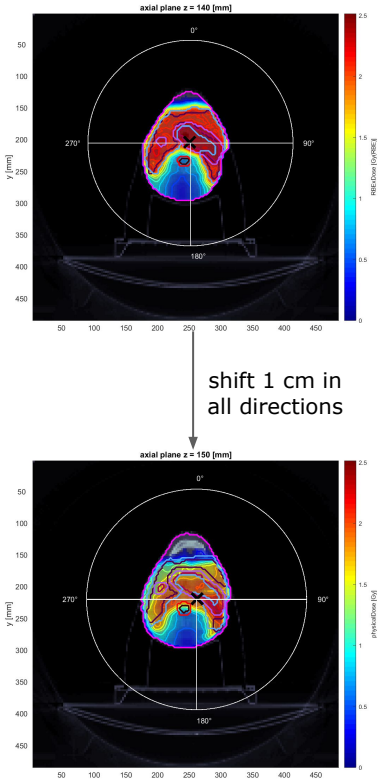


HEAD AND NECK TREATMENT

Last task introduced CT-images of head and neck region surrounded by chosen target volumes.

We have used suggested **proton treatment** with 3 beams (here 90, 180, 270°). The situation of positioning placement error was simulated by the isocenter offset.

The table shows significant systematic error. The OAR regions are overdosed and targets slightly underdosed.



Structures Under Study [Gy / fraction]		
Region	**Unshifted**	**Shifted**
Brain Stem	0.18	0.54
Cerebellum	0.52	0.83
CTV63	2.13	1.92
GTV	2.34	2.16
Larynx	1.03	0.85
Lens_LT	0.00	0.00
Lens_RT	0.00	0.00
Lips	0.04	0.01
Optic_Nrv_LT	0.00	0.05
Optic_Nrv_RT	0.00	0.02
PAROTID_LT	0.75	1.87
PAROTID_RT	0.72	0.76
PTV63	2.11	1.82
PTV70	2.32	2.13
Skin	0.45	0.44
Spinal Cord	0.58	0.93
TM_JOINT_LT	1.67	1.84
TM_JOINT_RT	1.16	0.87

CONCLUSION

The widely-used and cheaper photon therapy even combined from several beams was not able to reduce dose delivered into OAR regions as much as hadron-based beams.

The proton and carbon ion therapy were compared in case of single beam. Carbon ions appeared to give less load to healthy tissue, but larger area is affected than in proton case. In average, we did not observe significant difference in single beam example, but given sharper edge of carbon ions' DVH and greater RBE value it should be potentially the best option.

Unfortunately, crash of the matRad software during starting procedure was observed for most of our students after today's Windows updates, so some of them have to reinstall software or watch lector's shared screen.

Thank you for your attention!