Hands-on treatment planning with matRad

Particle Therapy MasterClass PTMC

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CTU in Prague

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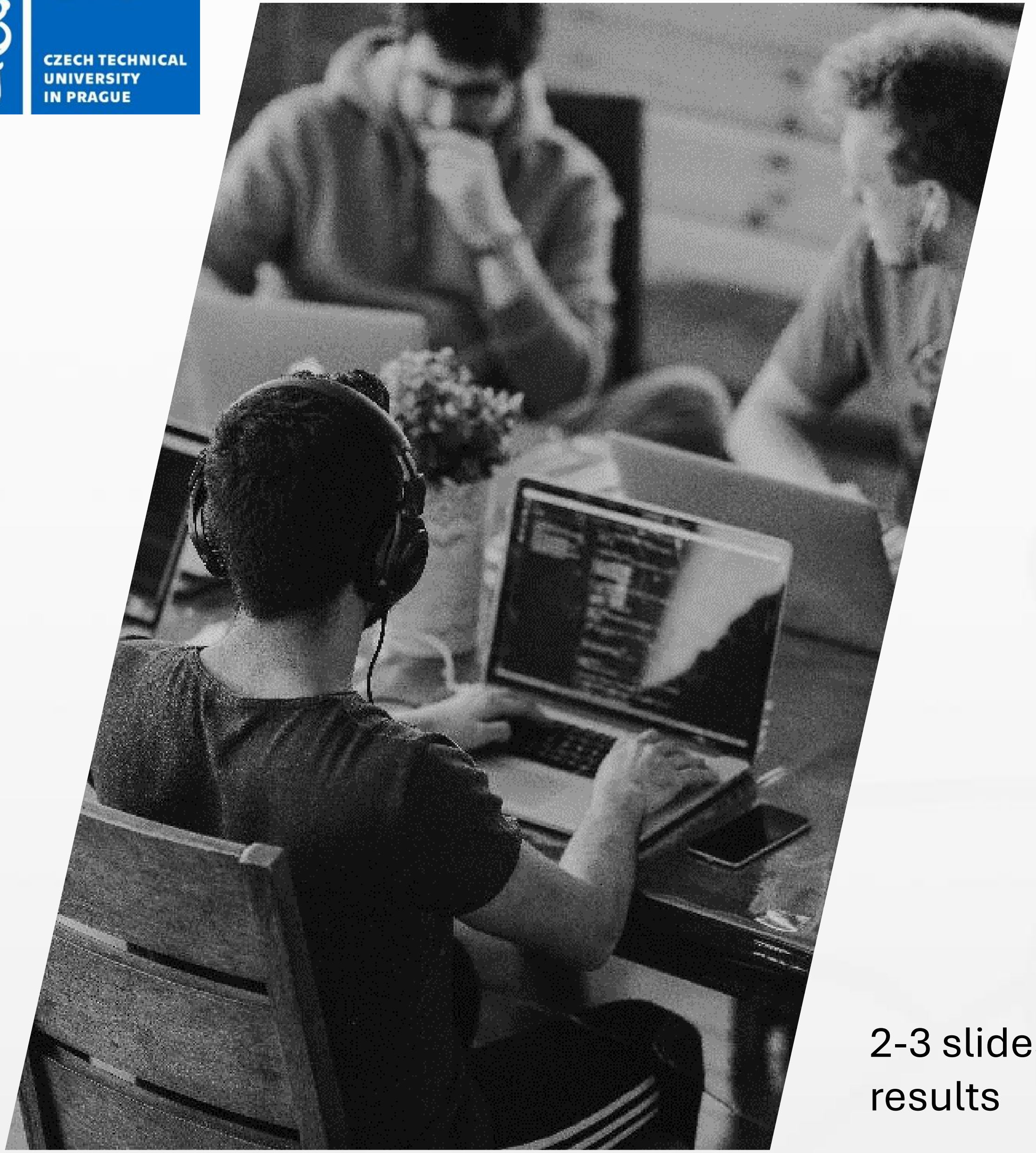


Agenda

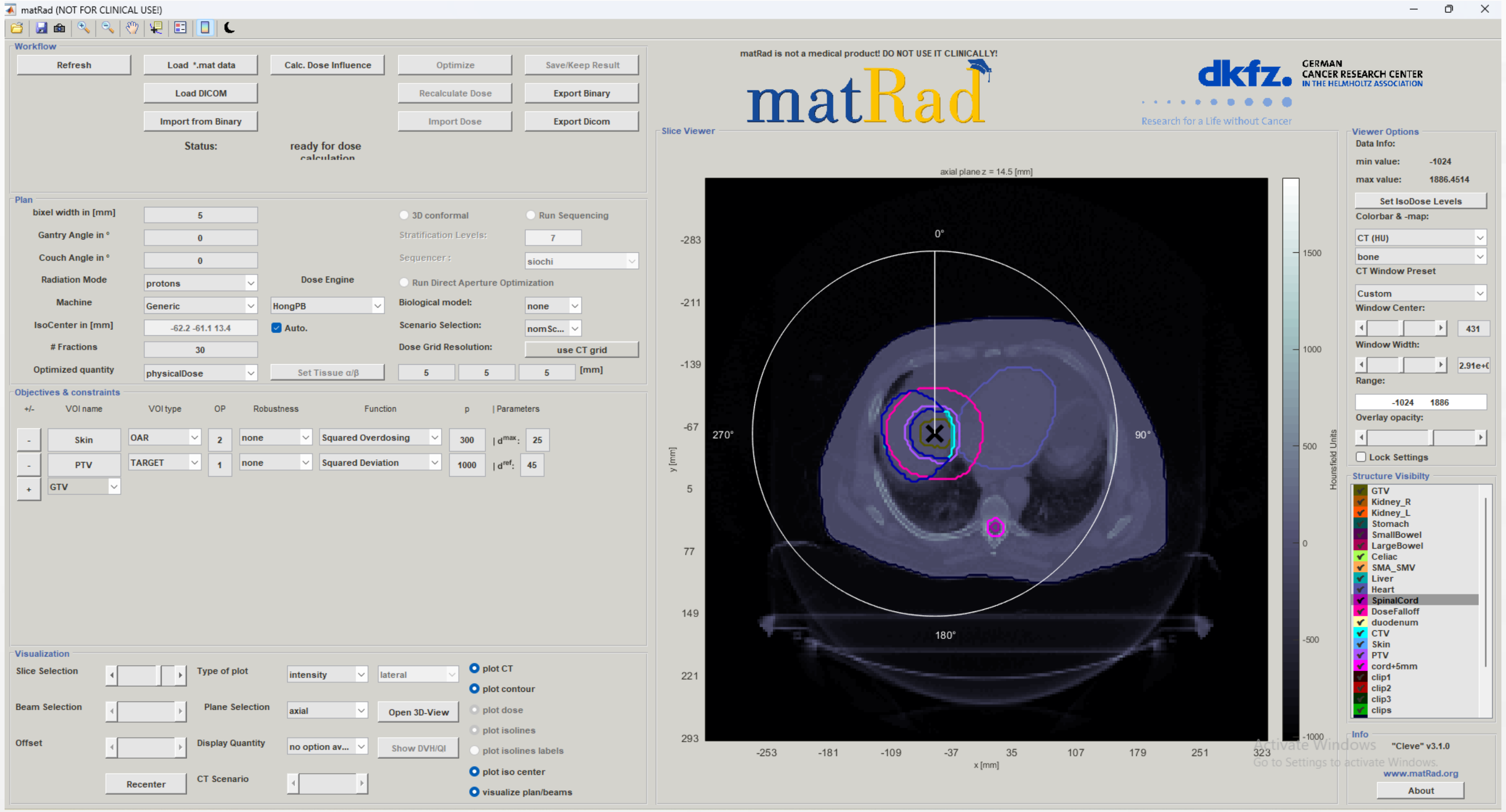
- Introduction
- 1st Exercise-TG119 phantom
- 2nd Exercise-Carbon ion TP for a liver patient
- 3rd Exercise-Head and Neck phantom
- Conclusions

2-3 slides should be prepared for at least 2 students to present the results

INTRODUCTION

matRad is an open-source software for radiation treatment planning of intensity-modulated photon, proton, and carbon ion therapy.

matRad was developed for educational and research purposes and it is entirely written in MATLAB.

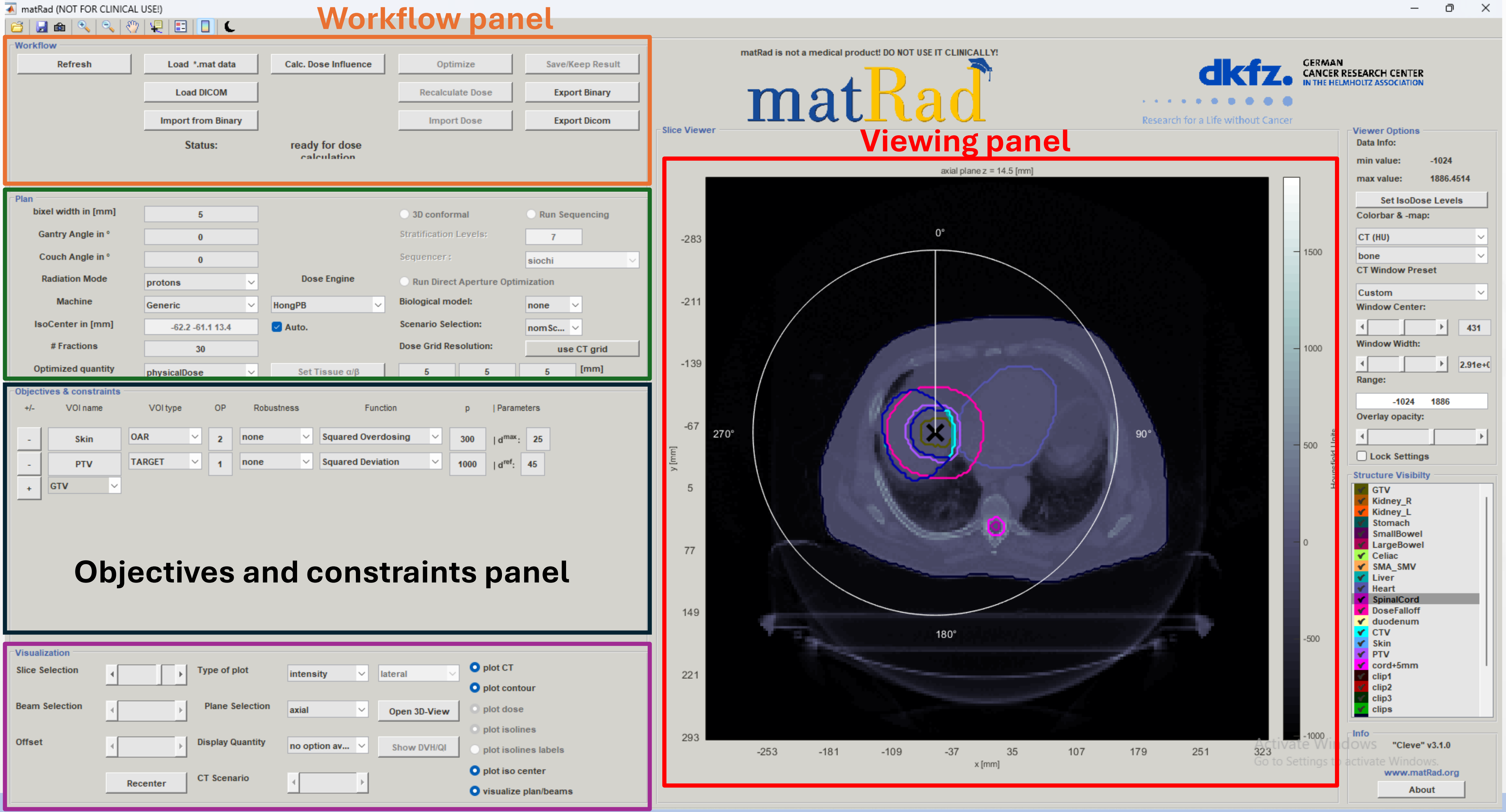


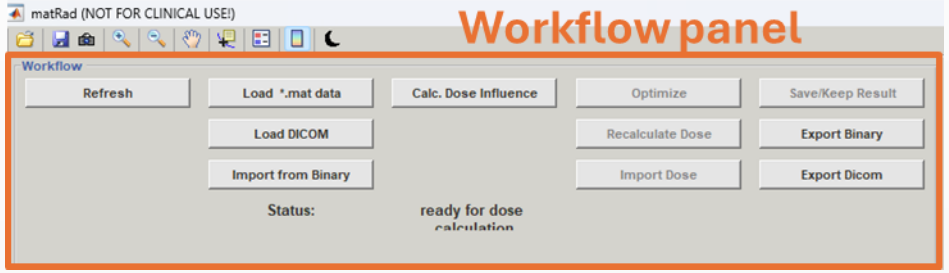
latest version 3.1.0

https://github.com/e0404/matRad/releases/tag/v3.1.0

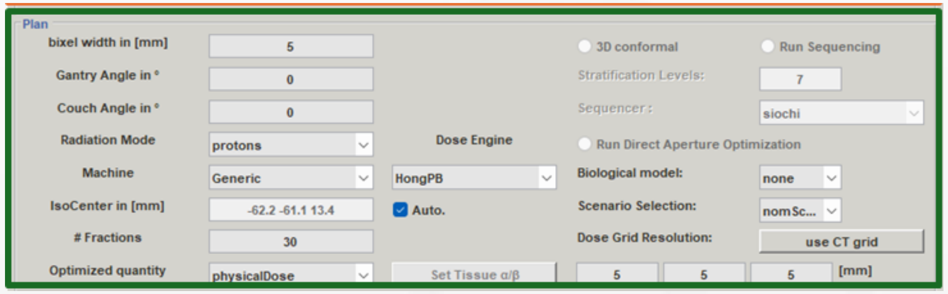
Plan selection

Visualization panel



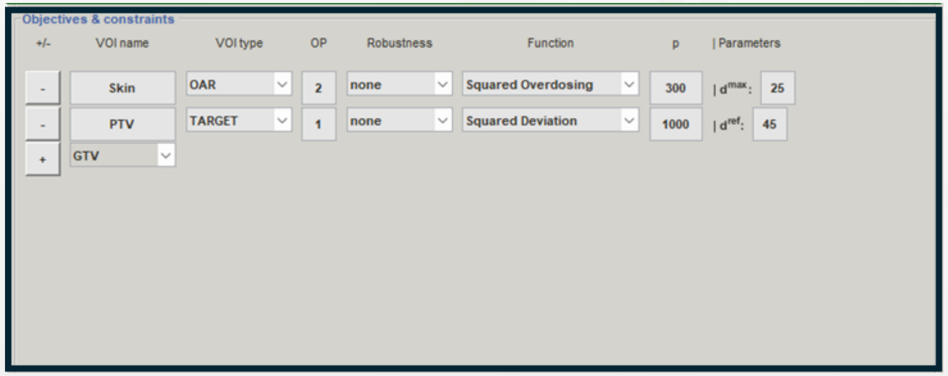


In this panel you can open the previously charged data, with Load *mat data button. It will also charge information about the target tissue and the surrounding healthy organs.



Plan selection

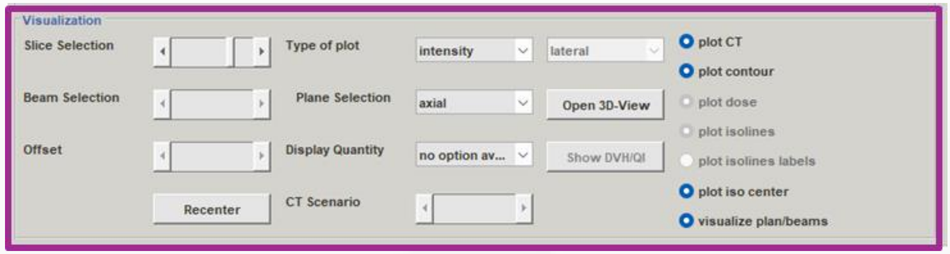
Here you can change the gantry angles, and the couch angles will automatically set. Also, you can find the radiation mode button where you can select the particle beam for the therapy treatment. The isocenter that was verified, and number of fractions that are prescribed by the radiation oncologist.

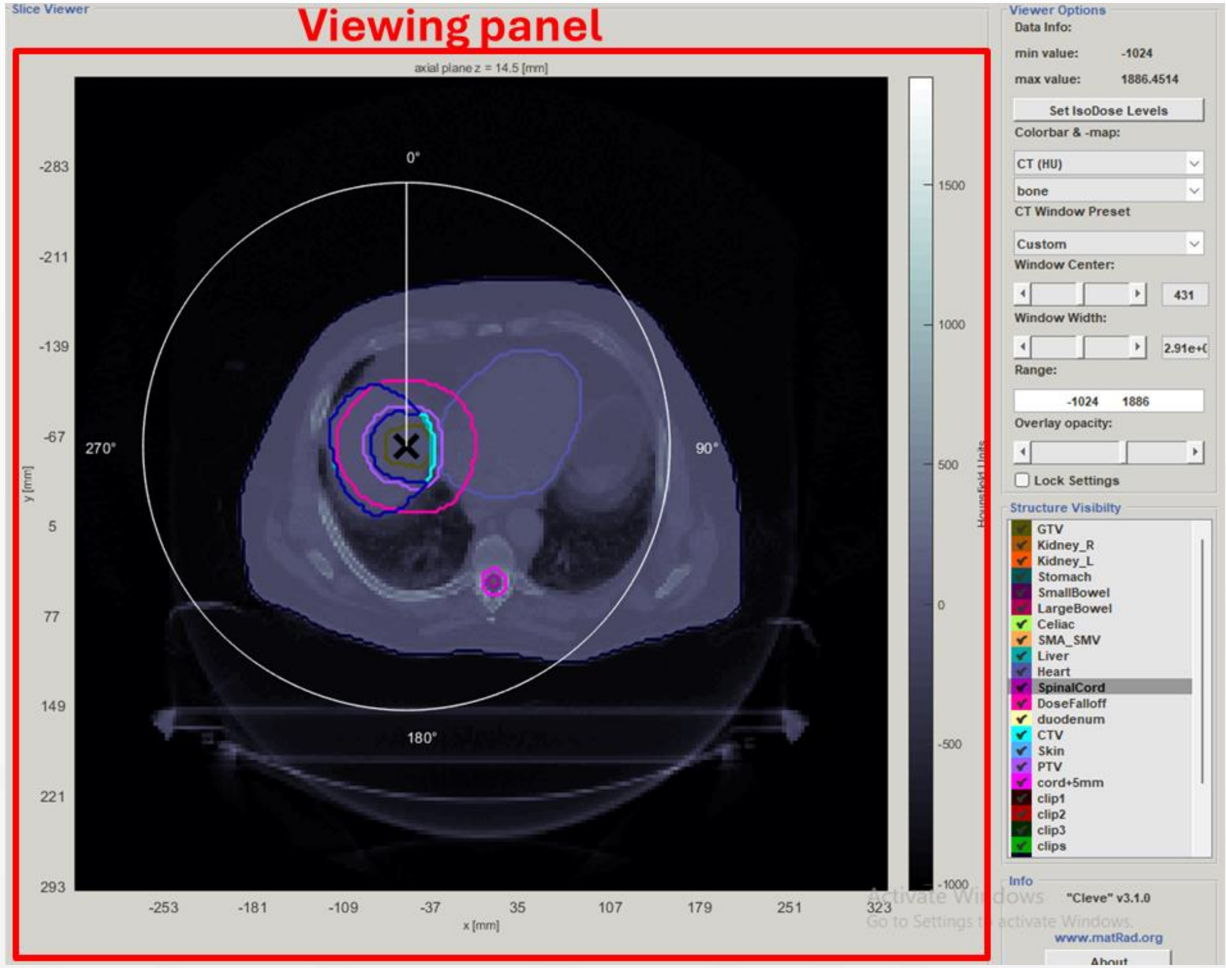


Objectives and constraints panel

In this panel you will see (after you insert the data) the organs of interest (target), as well as the organs at risk that are about to be irradiated, and we want to avoid obtaining more dose.

Visualization panel



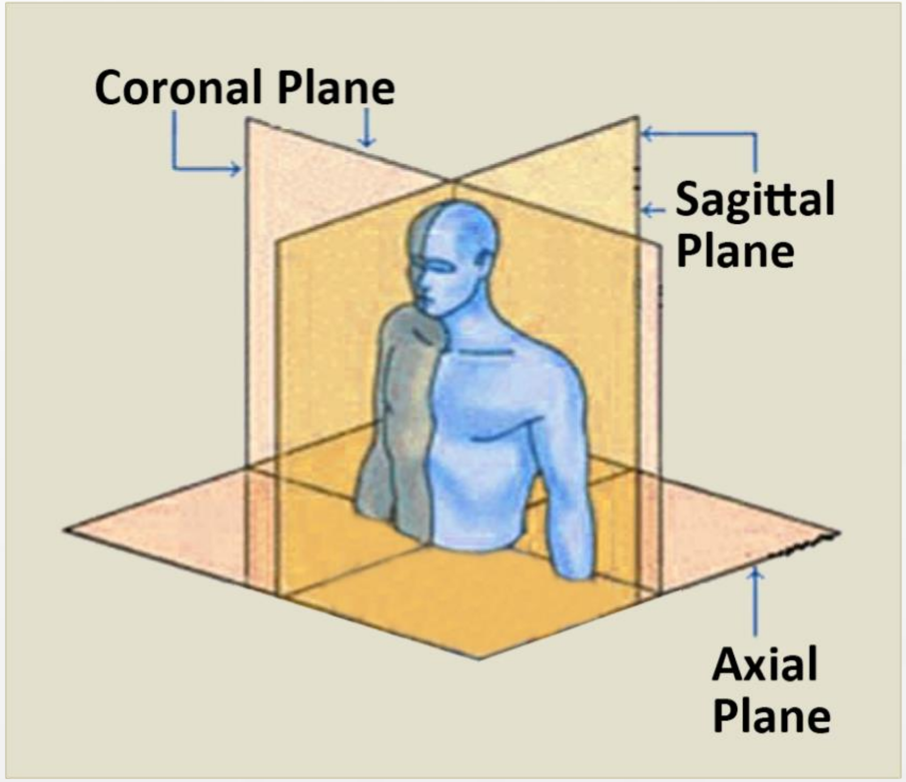


Here you can select what you will see in the viewing panel, for example, if you want to visualize the plan/beam for a better understanding of the different angles of the irradiation, plot the isocenter with an X, and so on.

Also, you can move within the 3D image to see the slice that you want.

In addition, there is a plain selection button with the choices of axial, sagittal and coronal.

Reconstruction planes



DEFINITIONS AND CLARIFICATIONS ON SOFTWARE:

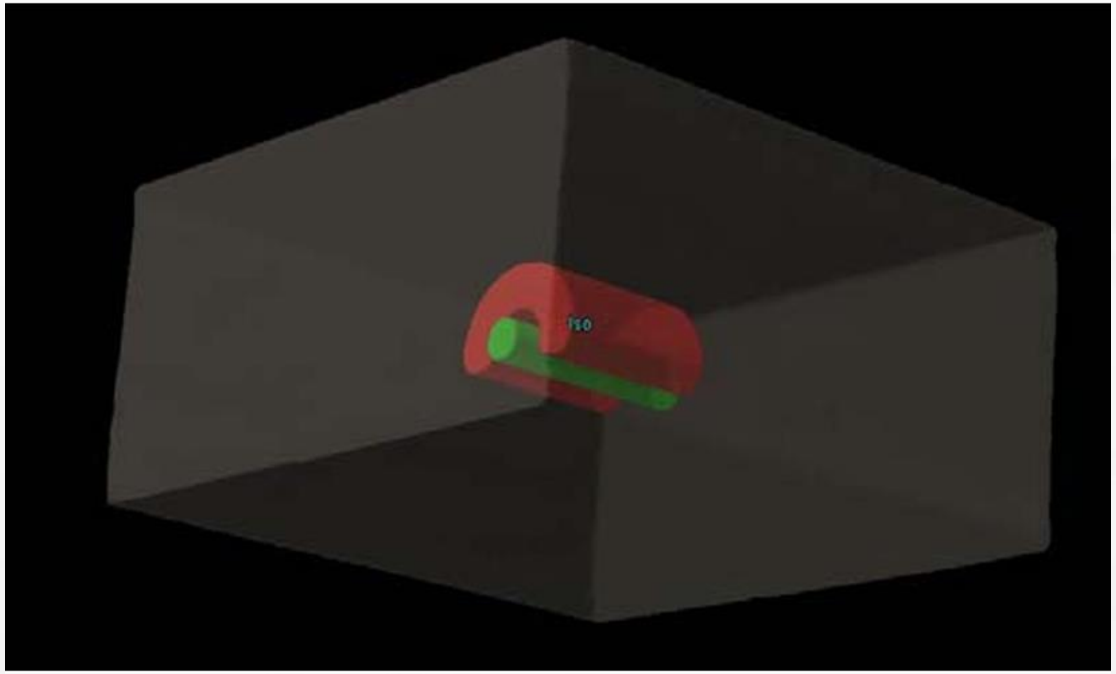
- PTV is the "Planning Target Volume" that should be irradiated.
- GTV is the gross tumor volume (what in general can be seen on the image)
- CTV is the clinical target volume (where the physician thinks there is still cancerous tissue despite being directly visible in the image).
- OAR means "Organ at risk", basically organs that are more sensitive than the general healthy tissue.

1st Exercise-TG119 Phantom

OBJECTIVES

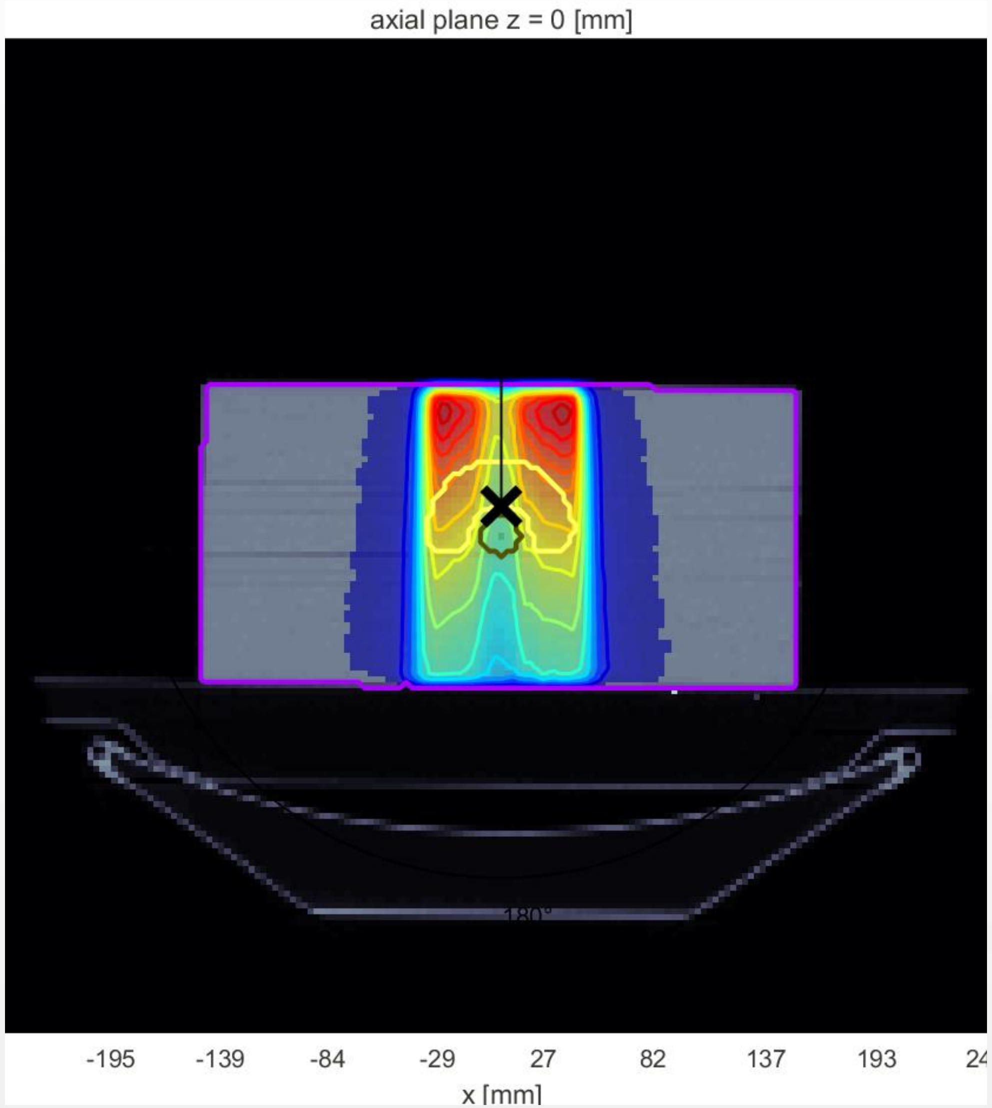
1. Load the TG119 phantom via the Load *.mat button (**TG119.mat**)
2. Set radiation modality to Photons and define **one** beam angle (**gantry angle**)
3. Trigger dose calculation via button (**Calc. Dose Influence**)
4. Start inverse optimization by click in on (**Optimize**) and analyze the resulting dose distribution
5. Save the optimization result via (**Save/Keep Result**). Next, show the DVH by (**Show DVH/QI**)
6. Change the radiation modality to: Protons and leave the beam angles unchanged
7. Repeat steps 3-5 and compare the dose distributions on the basis of photons and protons
8. Try to define a better photon treatment plan by defining more beam angles (0°, 72°, 144°, 216°, 288°)
9. Compare the results

TG119 PHANTOM



Microsoft Word - TG119_Instructions_102109.doc

The phantom is a box that contains a C-shape surrounded a cylinder (central avoidance structure). The center core is a cylinder 1 cm in radius.



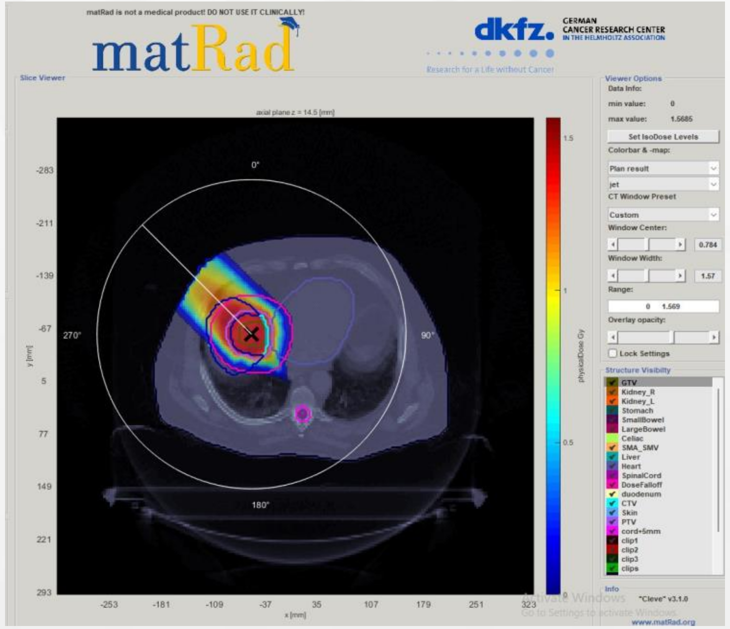
Discussion

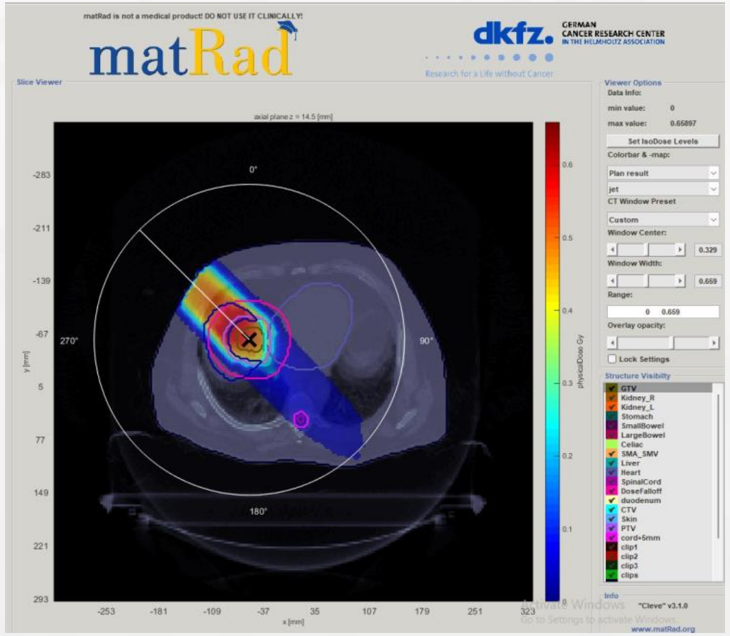
- What conclusions can be drawn from comparing photons and protons in the dose distribution?
- What insights can you share about the comparison of the histograms?

2nd Exercise-Carbon Ion TP for a liver patiente

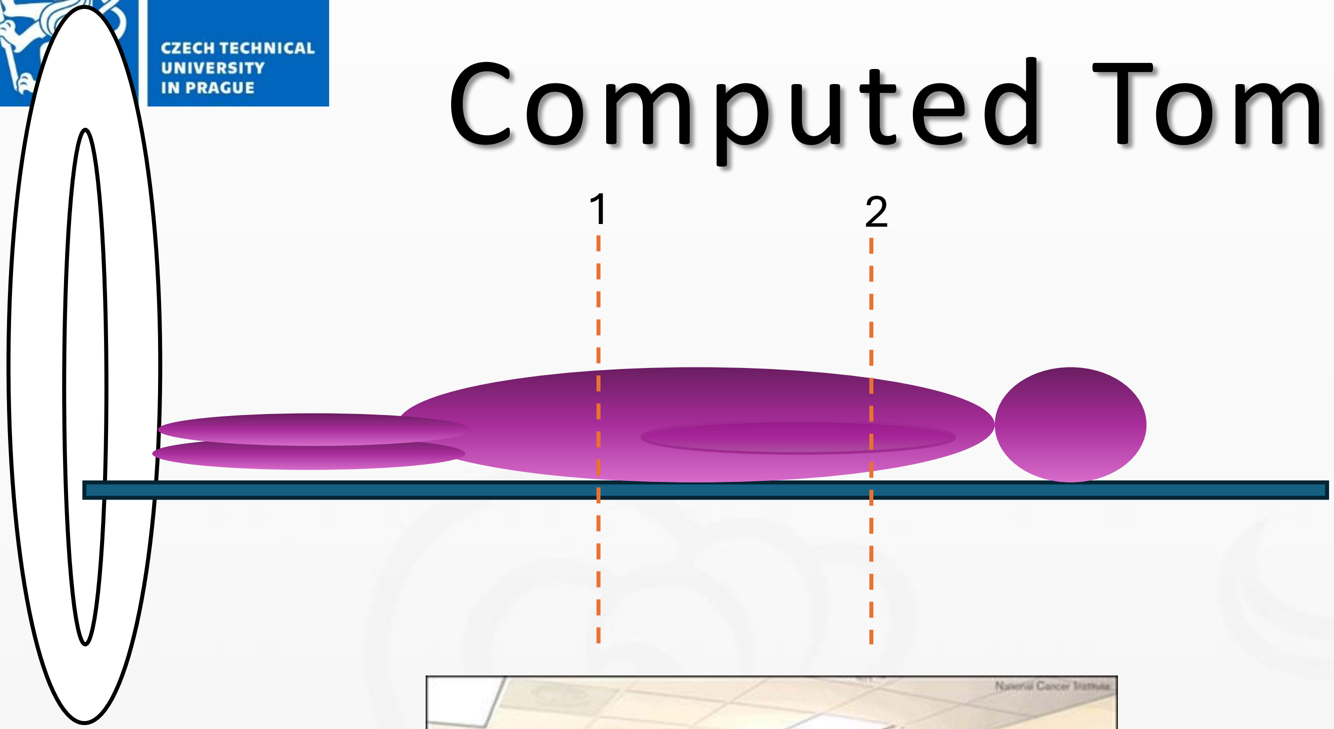
OBJECTIVES

1. Load the liver patient case via the Load *.mat button (**LIVER.mat**)
2. Define a photon treatment plan (0°, 72°, 144°, 216°, 288°) beam direction as well as a proton treatment plan with one beam from 315°
3. Analyze the differences of the optimized treatment plans
4. Create a carbon ion treatment with the exact same settings as used for the proton treatment plan – What difference can now be observed? (calculation time/dose distribution/ biological and physical dose)





Computed Tomography (CT) scan



https://www.cancer.gov/about-cancer/diagnosis-staging/ct-scans-fact-sheet

Coronal view

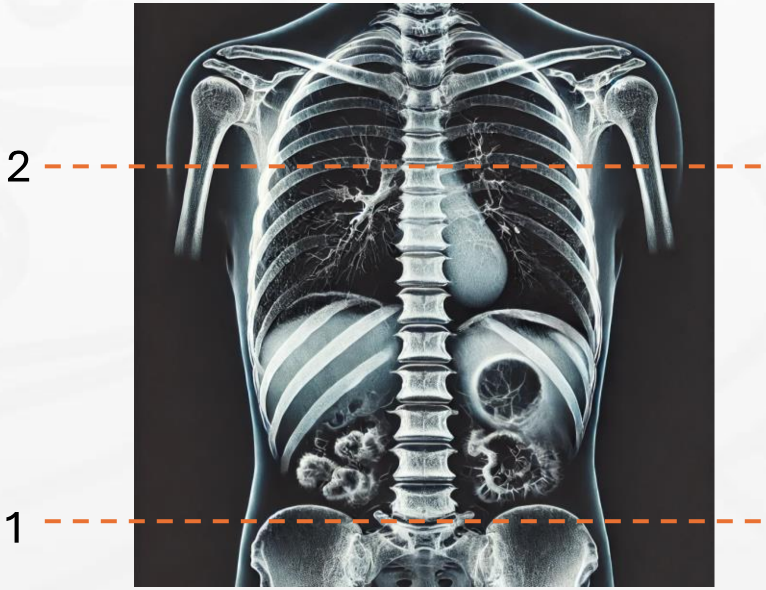
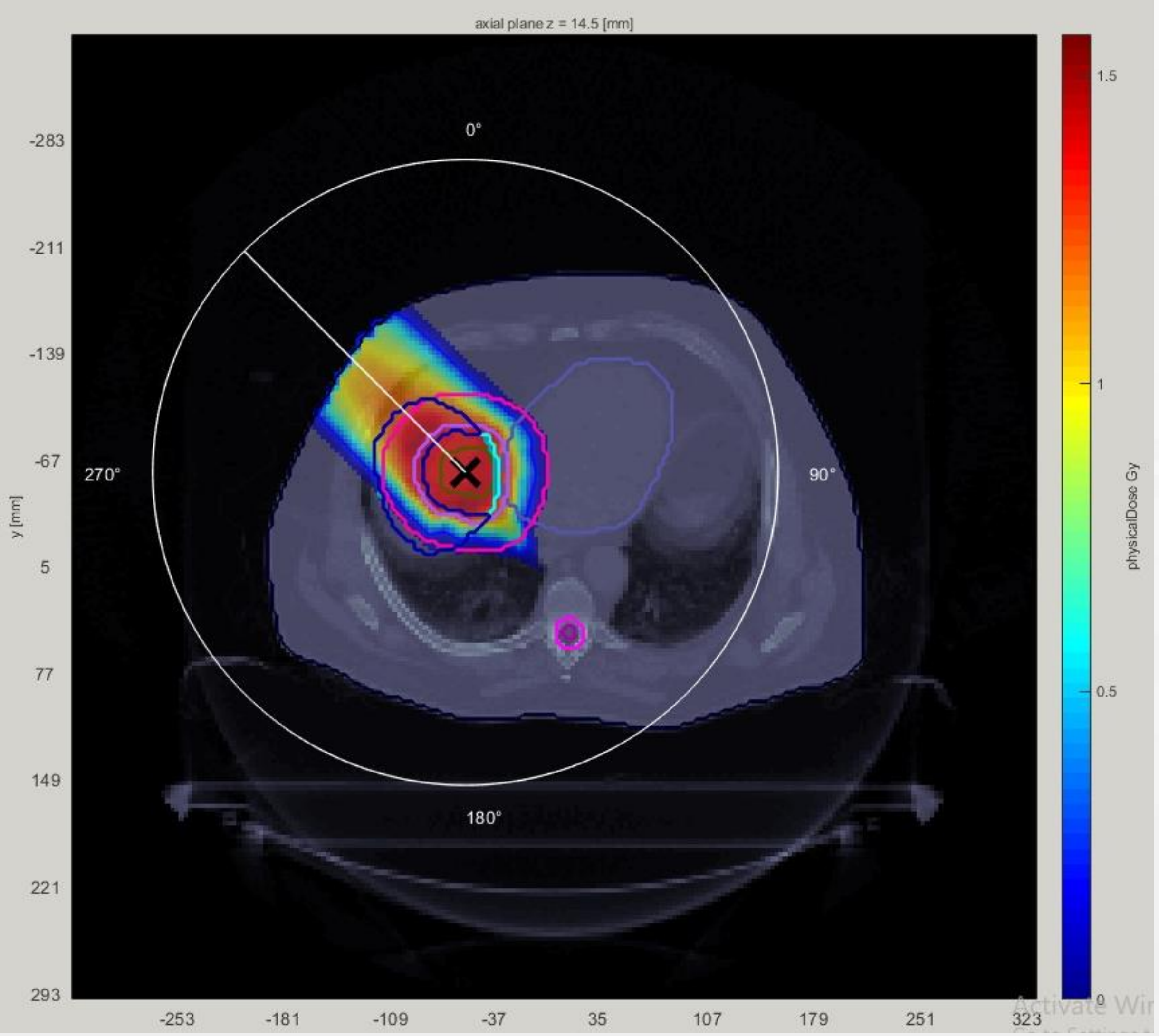


Image generated with AI



Discussion

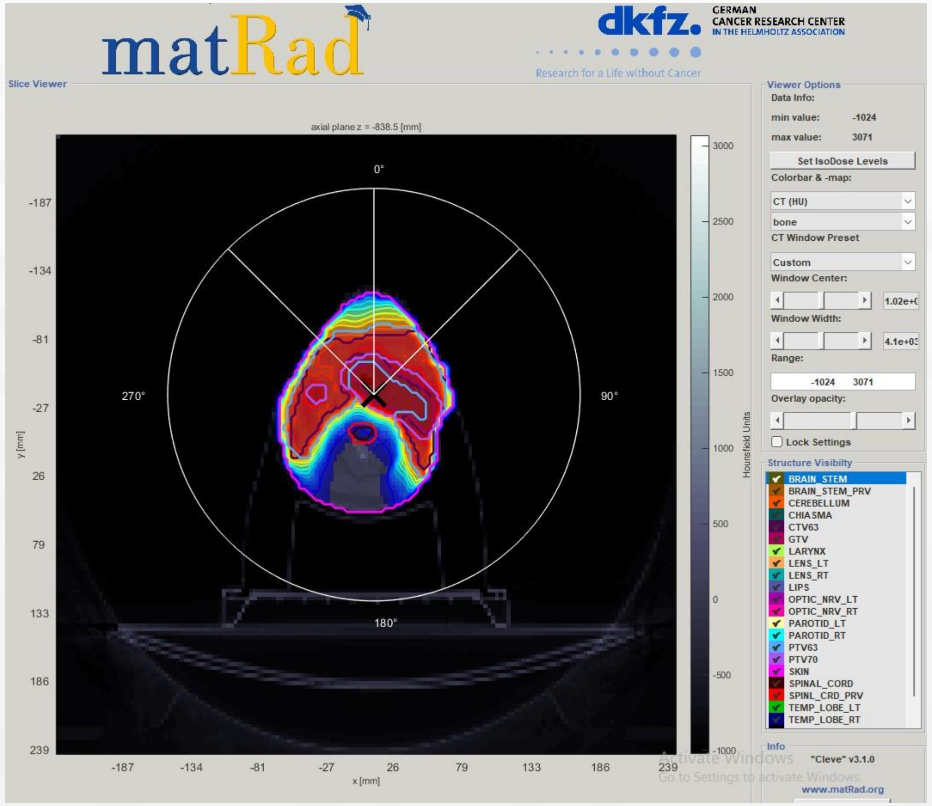
- What differences can be observed with a carbon ion treatment compared with proton and photon treatment?
- Discuss about the calculation time, dose distribution, biological and physical dose.

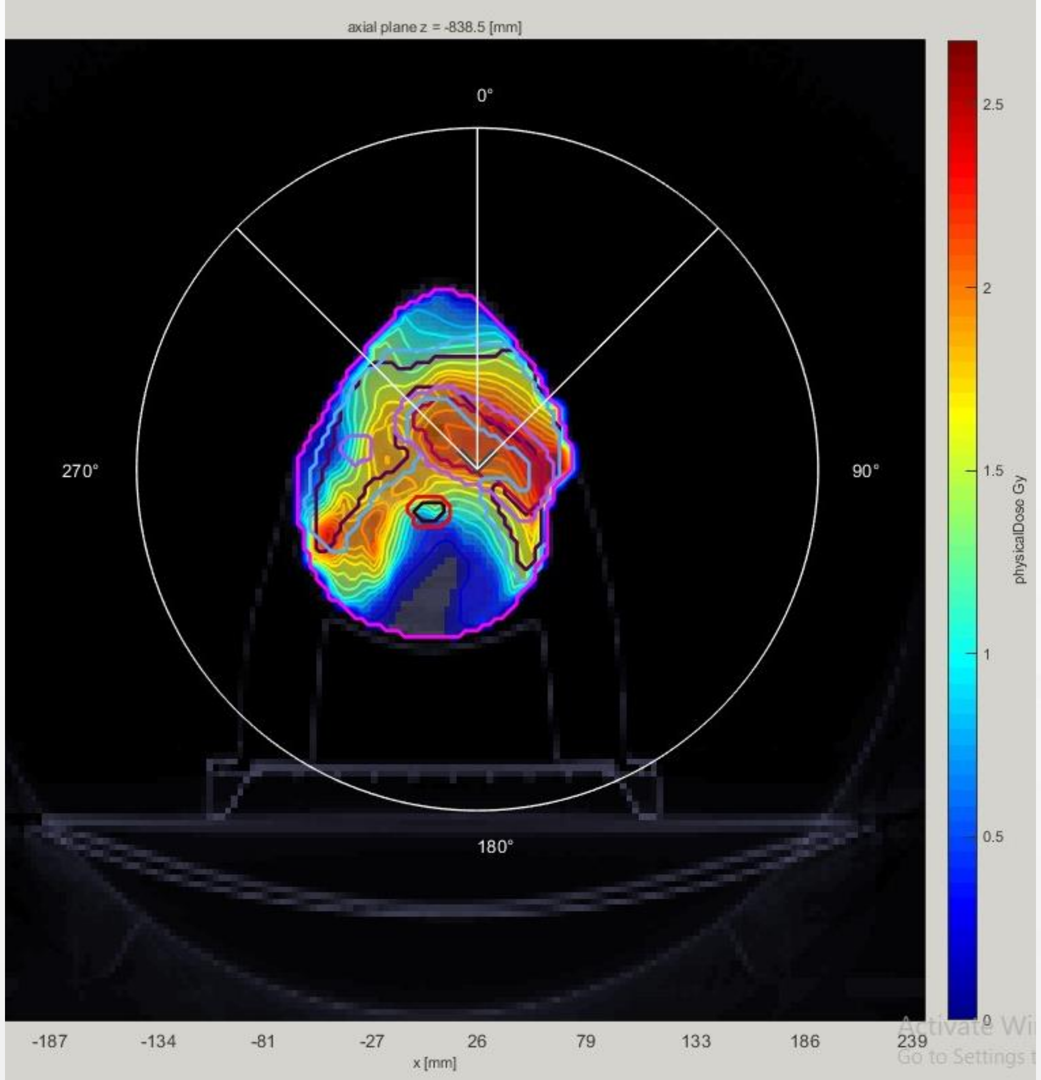
3rd Exercise-Head and Neck phantom

OBJECTIVES

- Load a head patient case (**HEAD_AND_NECK**)
- Add three proton beam angles on your own
- Calculate and optimize the dose and analyze the result (**Show DVH/QI**)
- Simulate a patient positioning error: Remove the hook at the auto iso-center checkbox and define a new iso-center thereby introducing an offset

CAUTION: **Recalculate** the dose based on the previously optimized pencil beam intensities by clicking on the button (**Recalc**). <u>Do not perform a new optimization!</u>





Discussion

- Analyze and compare the resulting dose distribution. What changed?

Questions?

Let's play with Kahoot

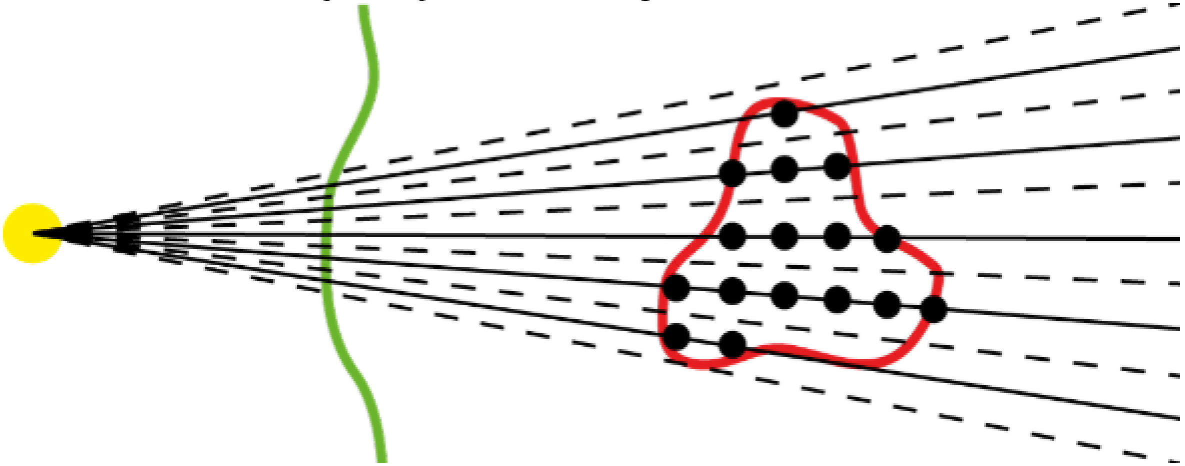
www.kahoot.it

Thank you for your attention!

Ray and bixel concept

The irradiation geometry is organized to a ray and bixel concept, which is schematically shown below.

Schematic visualization of the ray and bixel concept



From a virtual radiation source (yellow) the target volume (red) within the patient (green) is covered by equidistant rays (solid black). Note that only a two-dimensional cut through a three dimensional cone of rays is shown for clarity. In the isocenter plane (not shown) the distance of the individual rays corresponds to the bixel width (compare pln struct). For photons, the term bixel refers to a discrete rectangular fluence element (the limits of the individual bixels are shown in dashed black). Together, all bixels cover the entire target volume.

For 3D IMPT for particles, we have an additional degree of freedom, namely the particle energy to be considered. This is accounted for during the stf-struct generation by determining the depth of the target volume on individual rays and placing spots (black dots) accordingly.

More information about the ray and bixel concept (though with slight variations in nomenclature) can be found in sections 2.3 and 2.5 Nill (2001).