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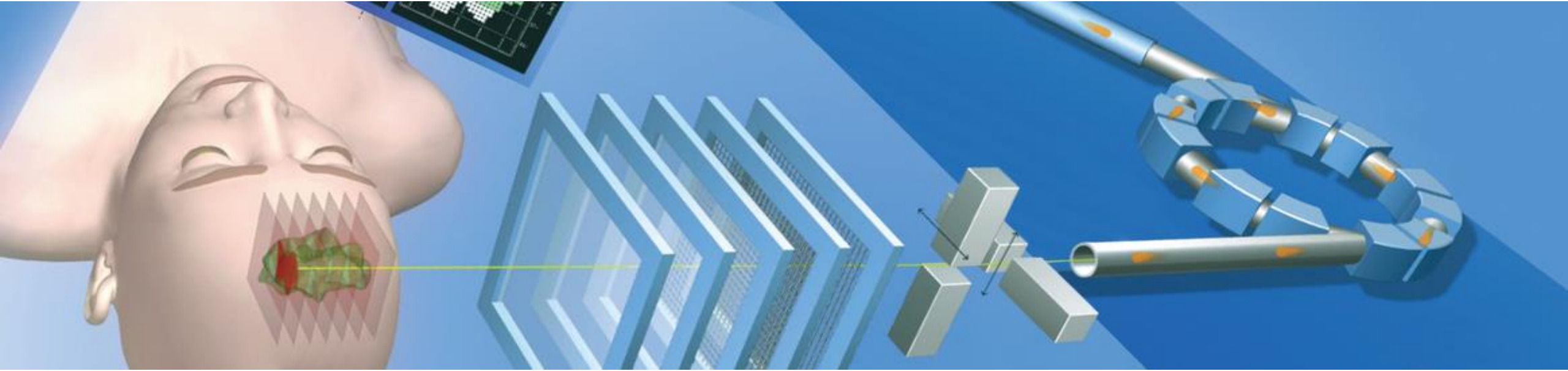
Introduction to the use of MatRad software for treatment planning

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How is a treatment plan designed?

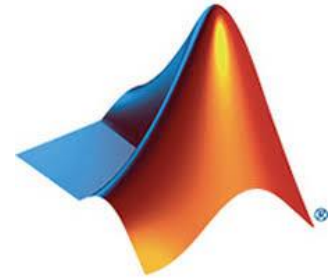


matRad 

What is MatRad?

- MatRAD is an open source software tool for designing radiation therapy plans with a modulated beam of photons, protons and carbon ions.
- Its name derives from the combination of two words:

MatLab + Radiation = MatRad



Source: <http://bit.ly/3sX756v>

- Developed by scientists at the German Cancer Research Center, DKFZ in Darmstadt.
- Use exclusively for research and educational purposes.

dkfz. GERMAN
CANCER RESEARCH CENTER
IN THE HELMHOLTZ ASSOCIATION

Source: <http://bit.ly/3uXfNDt>

Where is MatRad used today?

+30 INSTITUTES

matRad – community



TUM

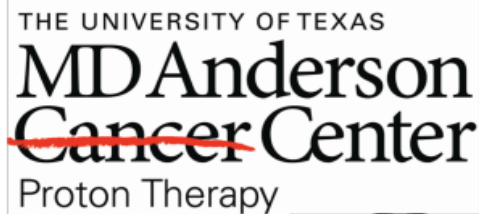
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- With thousands of users worldwide.
- For more information visit the map at the following link:

Link: <https://bit.ly/MatRadUsers>



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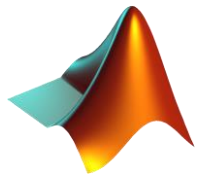
How can I use the software?

➤ For research purposes:

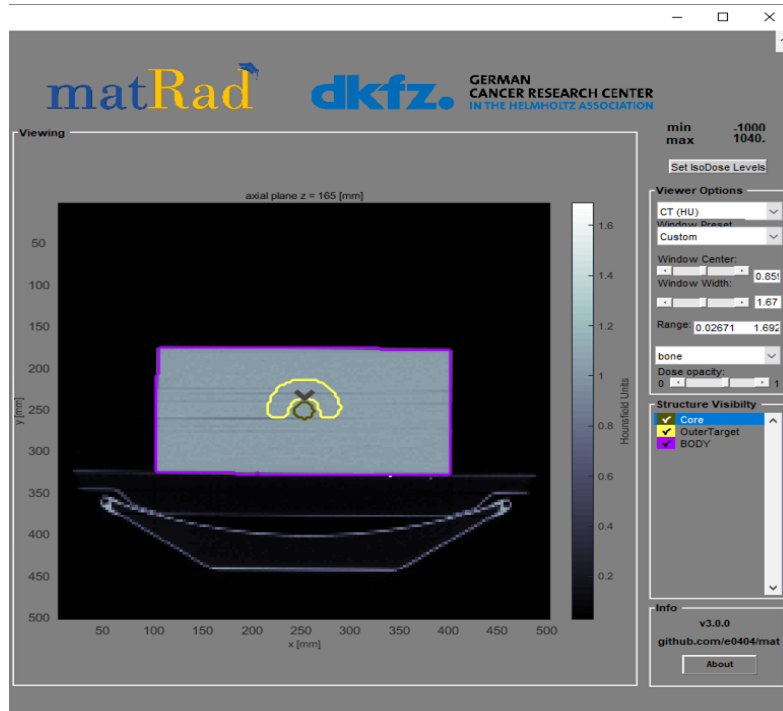
- The program gives the possibility to use many parameters, for more realistic simulations.
- Uses the complete Mat Lab code for detailed analysis.
- Requires more computing power.

➤ For educational purposes:

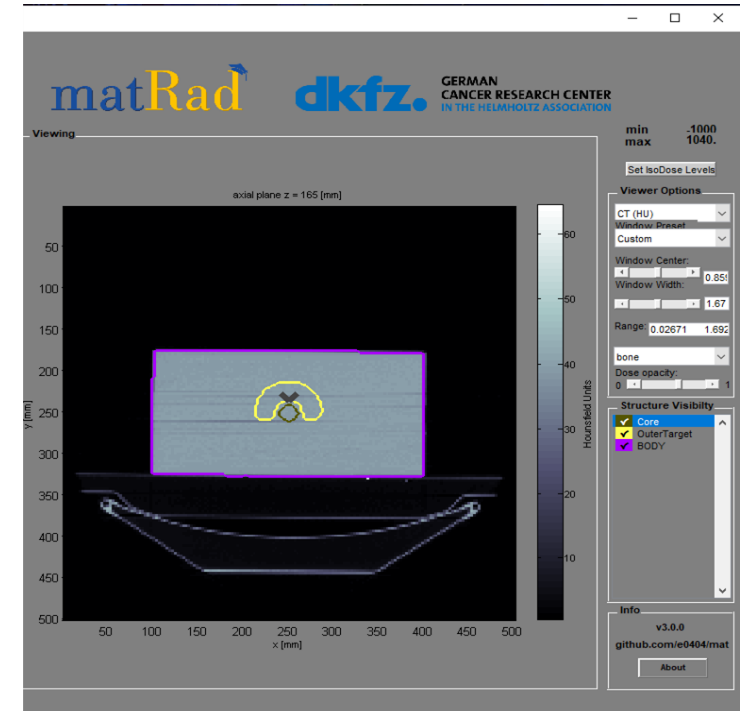
- For educational use, the simplified form of the software on Windows, Linux, Mac is recommended.
- Requires less storage space and computing power.
- Does not require IDE (integrated development environment) for the use of the software.



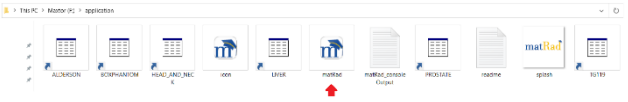
**+Computing
Power**



**-Computing
Power**



How does MatRad work?



We enter the patient data

We set the parameters of the treatment plan (Radiation geometry etc.)

We calculate the dose of distribution to the cancerous tissue through algorithms

Visualization of the plan with the reverse planning technique (Inverse planning)

Completion of Simulation

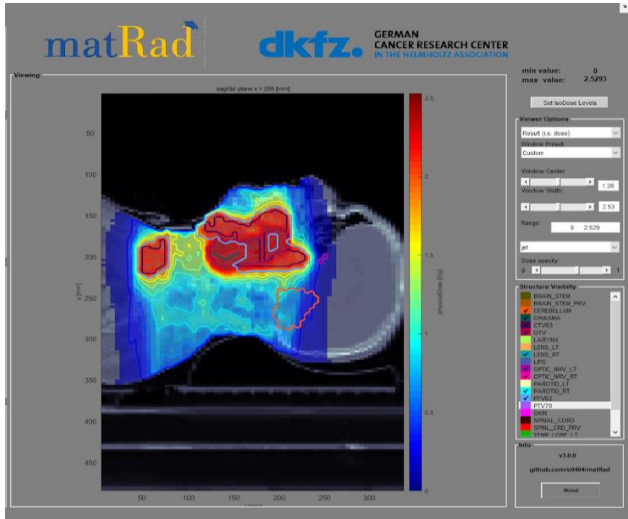
Data files:

- I. Test Sample (C-phantom)
- II. Liver
- III. Head n Neck

$$d(x, y, z_{rad}) = \sum_i Z_i(z_{rad}) \iint dx' dy' \psi(x', y') F(x', y') K_i(x' - x, y' - y)$$

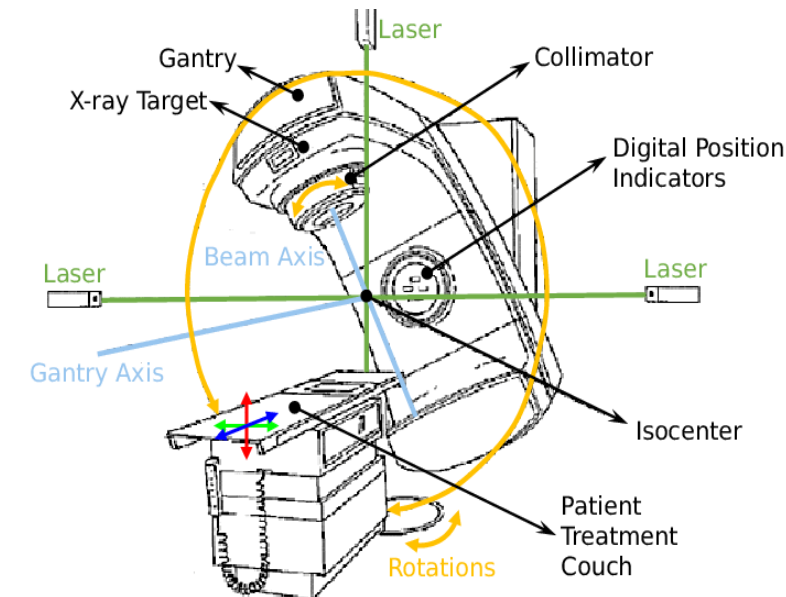
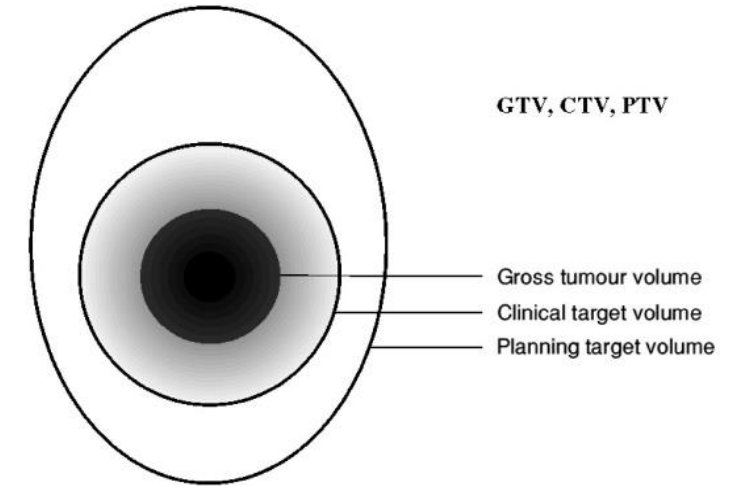
$$\begin{aligned} &\min f(d(w)), w \in \mathbb{R}^n \\ &f = \sum_i p_i f_i \\ &s. t. \quad d = Dw \\ &\quad \quad c_l \leq c(w) \leq c_u \\ &\quad \quad w_l \leq w \leq w_u \\ &f(w): \mathbb{R}^n \rightarrow \mathbb{R}, c(w): \mathbb{R}^n \rightarrow \mathbb{R}^m \end{aligned}$$

Procedure



Fundamental definitions used by MatRad

- **GTV** or gross tumor volume is defined as the macroscopic target tumor and is the exact location of the malignancy, as evidenced by imaging methods. It may consist of the initial tumor, metastatic lymphadenopathy or other metastases.
- **CTV** or clinical target volume is defined as the target clinical tumor (where the radio physicist assumes that cancerous tissue is still present). It consists of the tumor that is shown, if there is any, and any tissue with suspected tumor. It is designed with the requirement that cancer cells should not be located outside its region.
- **PTV** or "Planning Target Volume" is defined as the target volume for design. Includes CTV with an internal margin (IM) and an additional margin for placement (setup margin (SM)), which refers to patient movement and placement error.
- **OAR** or "Organs At Risk", which are the organs that are more sensitive compared to healthy tissue. Organs in danger need adequate protection. Once the endangered organs are identified, an extra safety margin should be added to include their movement.
- **Gray (Gy)** is a unit of measurement of energy absorption derived from ionizing radiation. Is equal to the energy absorption of one joule of matter with a mass of one kilogram, $1 \frac{\text{Joule}}{\text{kg}}$.



The graphical interface of MatRad

The screenshot displays the MatRad graphical user interface, which is used for radiation therapy optimization. The interface is divided into several functional areas:

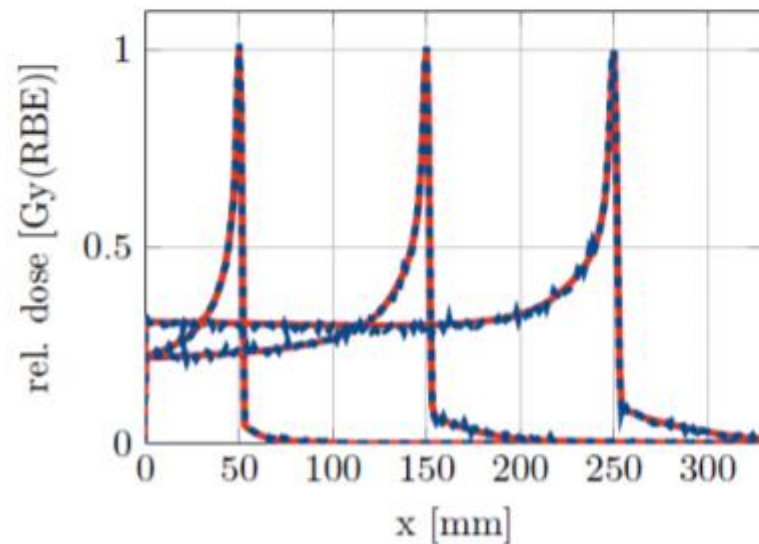
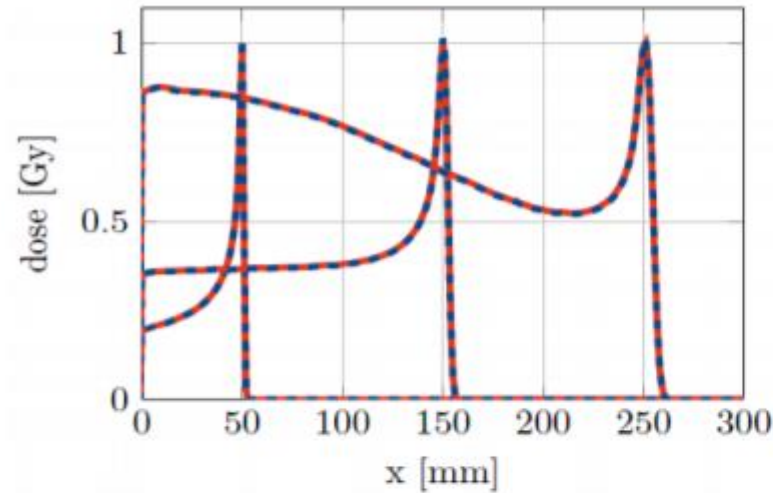
- Workflow:** Contains buttons for Refresh, Load *.mat data, Calc. influence Mx, Optimize, Save to GUI, Load DICOM, Recalc, Export, Import from Binary, and Import Dose. The status indicates "plan is optimized".
- Plan:** Includes input fields for beam width (5 mm), Gantry Angle (0, 72, 144, 216, 288), Couch Angle (0, 0, 0, 0, 0), Radiation Mode (photons), Machine (Generic), IsoCenter (251.3, 226.4, 162.6), # Fractions (30), and Type of optimization (none). It also has checkboxes for "use MC (VMC++) dose calculations", "3D conformal", "Run Sequencing", and "Run Direct Aperture Optimization", along with a Stratification Levels field set to 7.
- Objectives & constraints:** A table listing three objectives:

	VOI name	VOI type	prio...	obj. / const.	penalty	dose	EUD	vol.
1	Core	OAR	2	square overdosing	300	25	NaN	
2	OuterTarget	TARGET	1	square deviation	1000	50	NaN	
3	BODY	OAR	3	square overdosing	100	30	NaN	

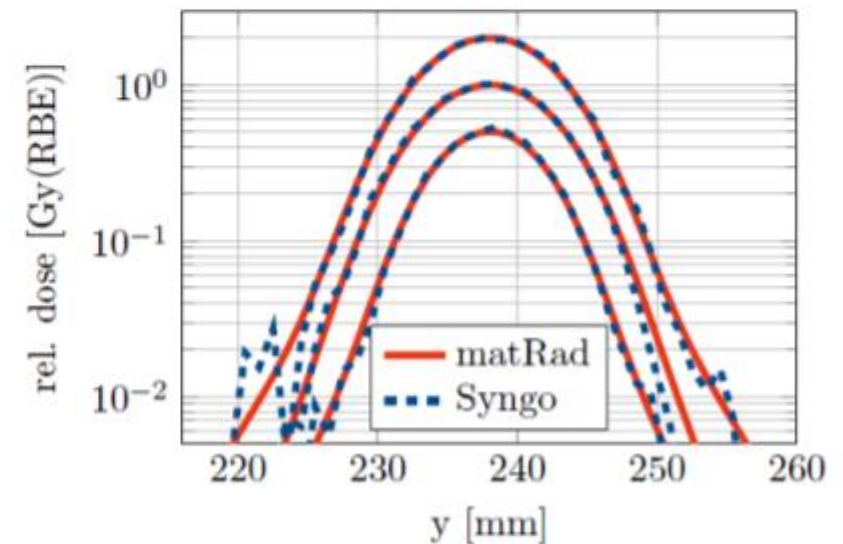
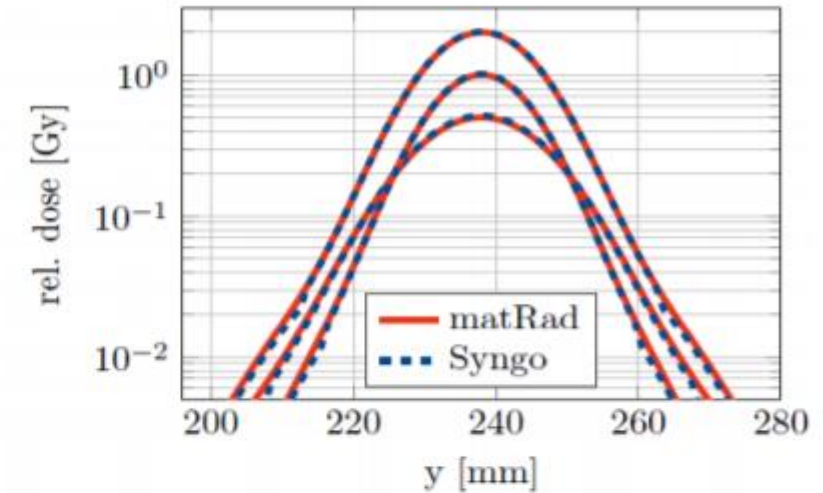
- Visualization:** Features "Slice Selection" and "Beam Selection" fields, "Type of plot" (intensity), "Plane Selection" (axial), and "Display option" (physicalDose). It includes checkboxes for "plot CT", "plot contour", "plot isocms", "plot dose", "plot isocms labels", and "plot iso center". A "Show DVH/QI" button is also present.
- Viewing:** A central 2D plot showing the dose distribution in an axial plane at z = 165 mm. The x-axis represents the width in mm (50 to 500), and the y-axis represents the vertical position in mm (50 to 500). A color scale on the right indicates physical dose in Gy, ranging from 0 (blue) to 1.6 (red).
- Viewer Options:** Includes "Result (i.e. dose)", "Window Power" (Custom), "Window Center" (0.884), "Window Width" (1.77), "Range" (0 to 1.768), "jet" color map, and "Dose opacity" (1).
- Structure Visibility:** A list showing "Core" (unchecked), "OuterTarget" (checked), and "BODY" (checked).
- Info:** Displays the version "v3.0.0" and the GitHub repository "github.com/v0404/matRad".

Comparison of MatRad with Syngo clinical software

- ✓ Syngo software is used clinically in Heidelberg (HIT).
- ✓ Display of the relative dose in Gray (Gy) as a function of the depth of the beam in human tissue in millimeters (mm).
- ✓ The results are almost identical !!!



(a) central depth dose profiles



(b) lateral dose profiles

MatRad features

- Open source software and access to real life patient data. Widespread use in the Medical Physics community.
- Standalone (matRad.exe) can be used without permission.
- User friendly and provides easy data visualization functions.
- Convenient and fast debugging.
- Simple syntax compared to more abstract programming languages (e.g. C++).

More information about the software

- Many functional examples of the software are available as well as enough educational material.
- 29 pages available at Wiki: <https://github.com/e0404/matRad/wiki>

About matRad	Quick Setup	Technical Documentation
		
About matRad	Quick Setup	Technical Documentation
Introducing matRad - what it does	A how-to guide to successfully run matRad	Technical documentation on matRad and its functions

- The official page of the software is given at the following link: <https://e0404.github.io/matRad/>

Thank you very much for your attention

And

**I am waiting for you to study them in more detail
in the hands on session!**