



MatRad

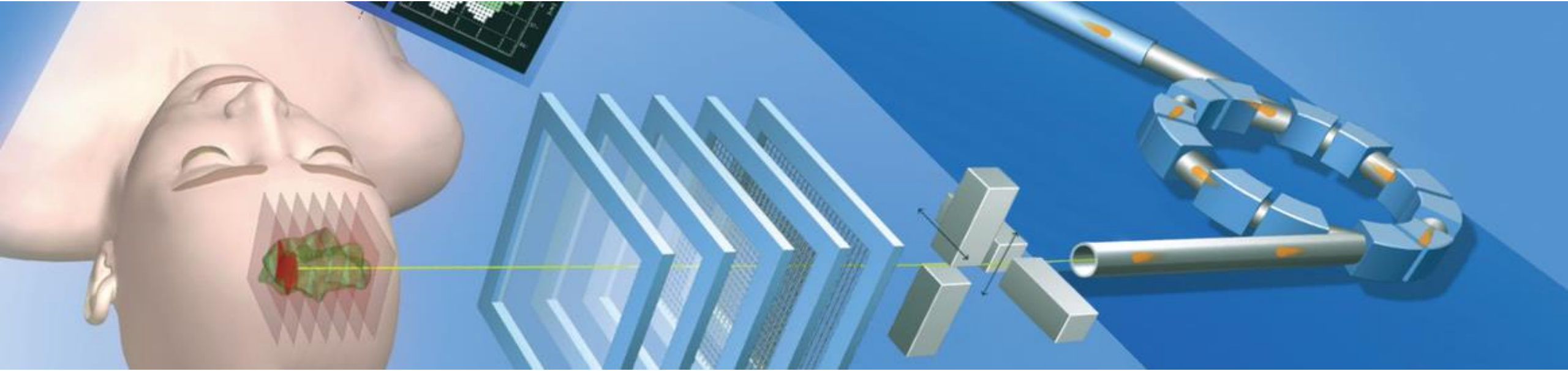
Treatment Planning Software

Ganesh Tambave
NISER, Bhubaneswar

9 April, 2022

Reference: Aristeidis Mamaras presentation

How is a treatment plan designed?

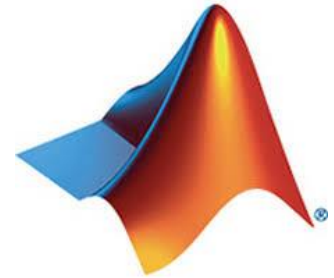


matRad 

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



TECHNISCHE
UNIVERSITÄT
MÜNCHEN

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

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



MEDICAL UNIVERSITY
OF VIENNA



大阪大学
OSAKA UNIVERSITY



UNIVERSIDAD
COMPLUTENSE
MADRID



GERMAN
CANCER RESEARCH CENTER
IN THE HELMHOLTZ ASSOCIATION

THE UNIVERSITY OF TEXAS

MD Anderson
~~Cancer Center~~

Proton Therapy



Universität
Zürich^{UZH}



UNIVERSITY OF
OXFORD

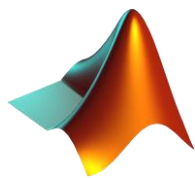
How can we use the software?

➤ For research purposes:

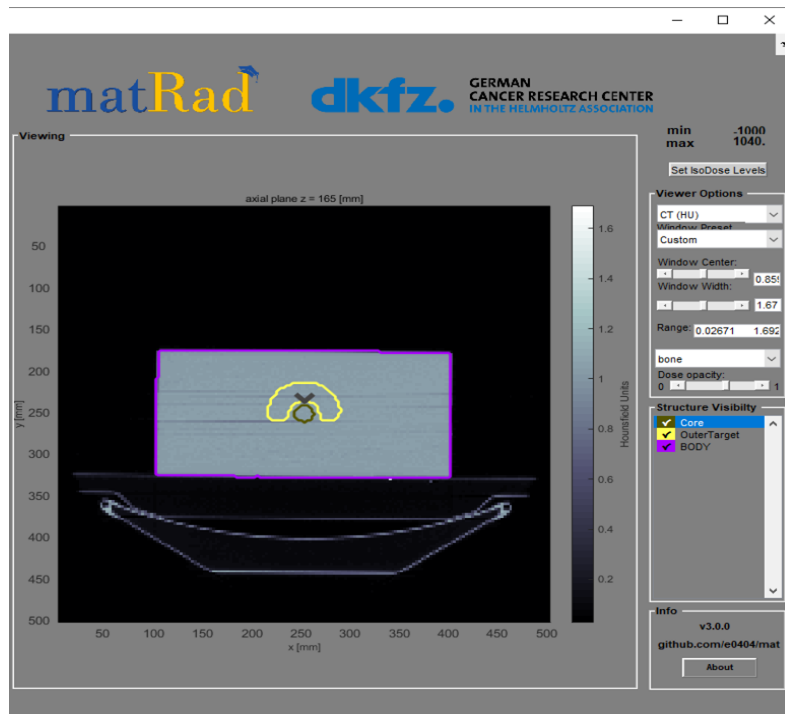
- The program gives the possibility to use many parameters, for more realistic simulations.
- Uses the complete Mat Lab code for detailed analysis.
- Requires more computing power.

➤ For educational purposes:

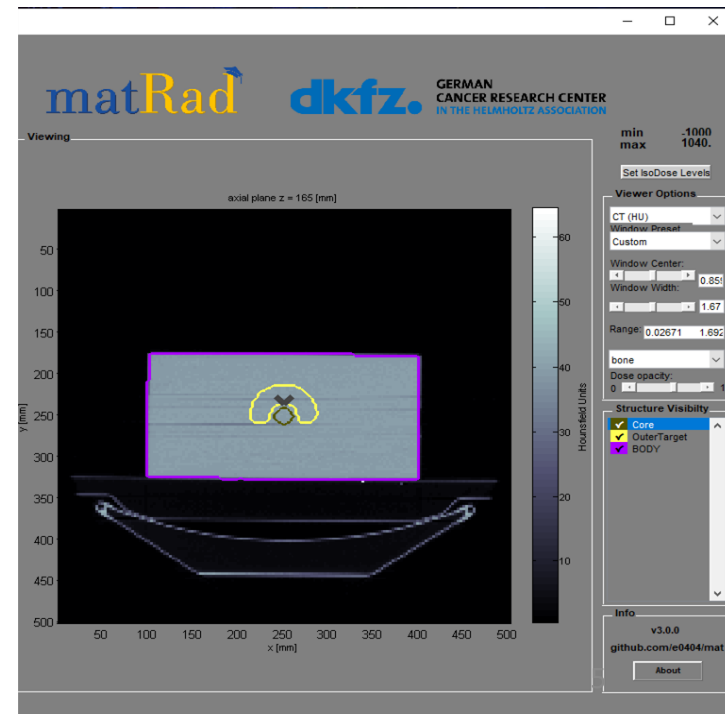
- For educational use, the simplified form of the software on Windows, Linux, Mac is recommended.
- Requires less storage space and computing power.



+Computing Power



-Computing Power



How does MatRad work?

Data files:

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

Parameters:

- I. Gantry angle
- II. Couch angle
- III. Radiation type (photon, proton, carbon ions etc.)

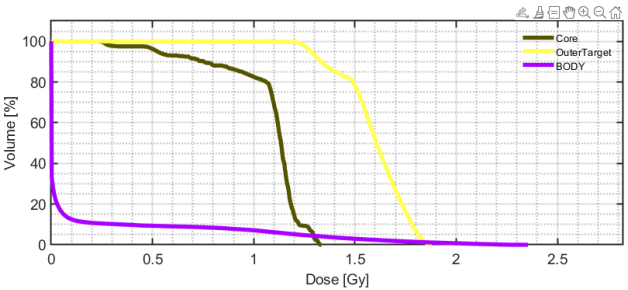
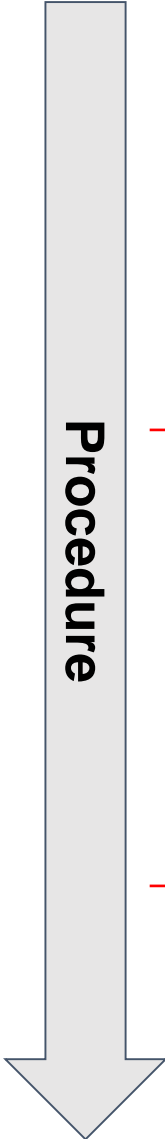
We enter the patient data

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

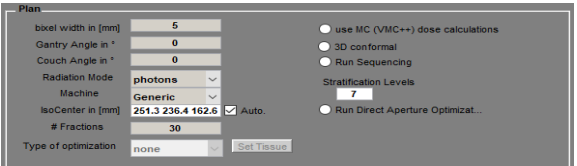
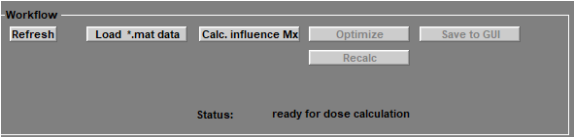
We calculate the dose of distribution to the cancerous tissue through algorithms

Visualization of the plan

Completion of Simulation

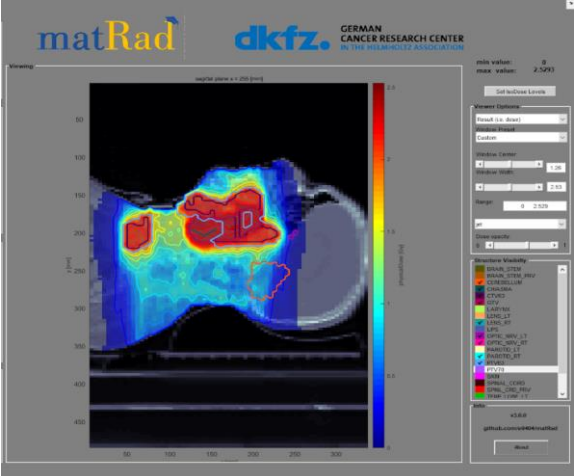
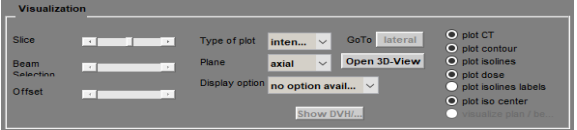


	max	min	mean	std
Core	1.3349	0.2372	1.0725	0.2146
OuterTarget	1.8801	1.0767	1.5918	0.1560
BODY	2.3556	0	0.1361	0.4030

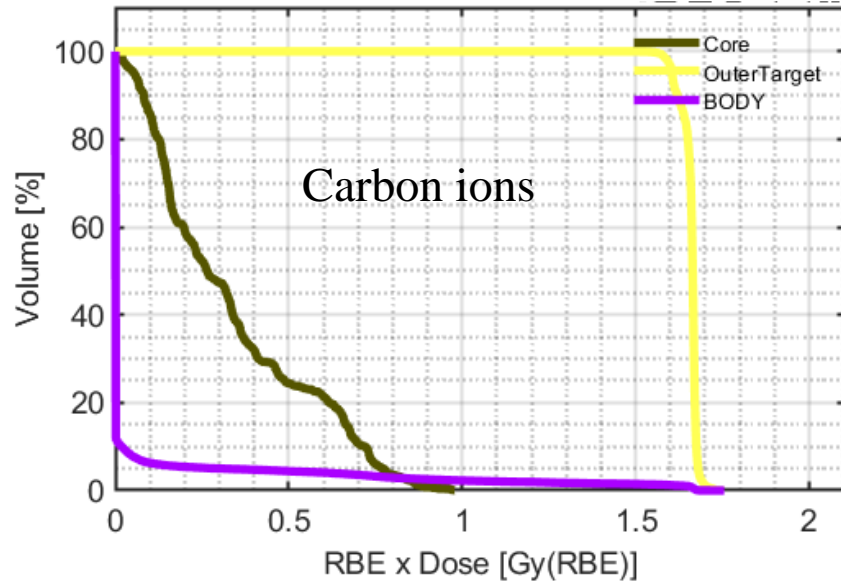
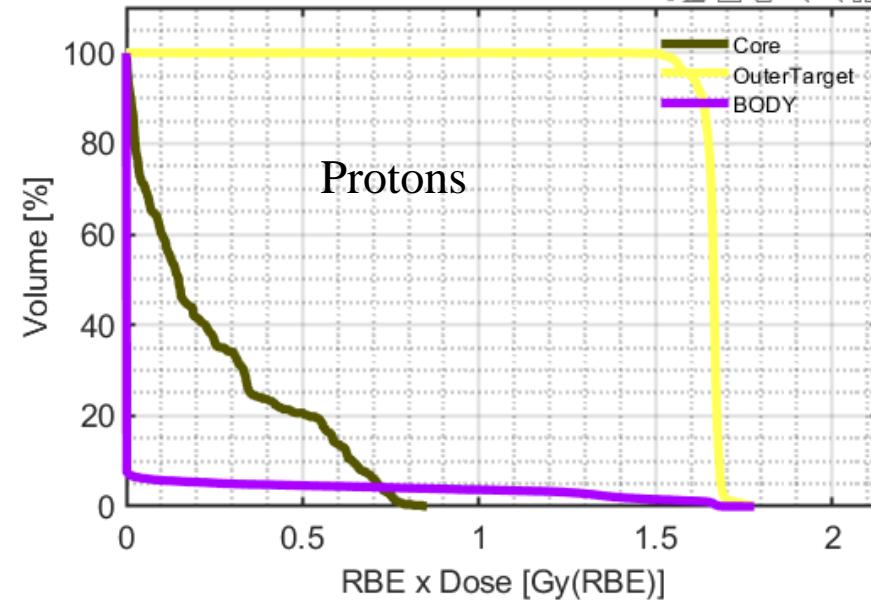
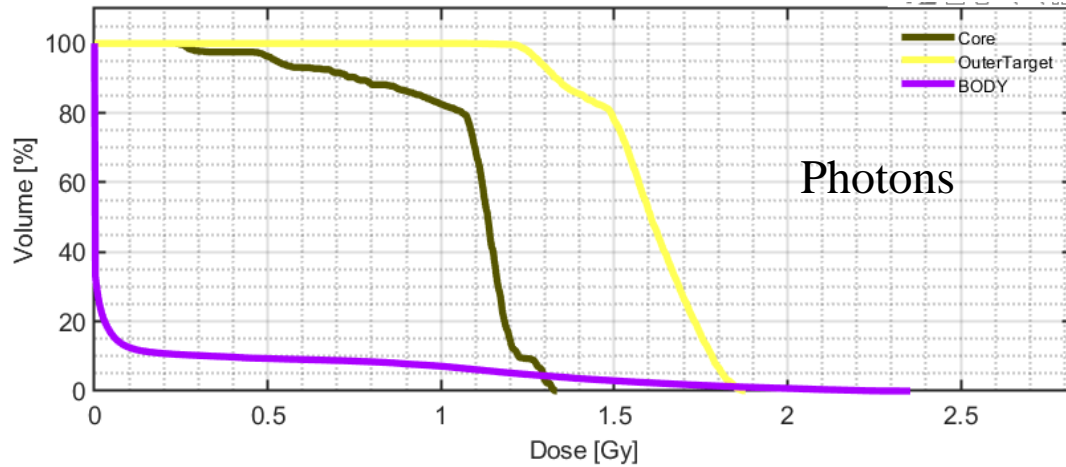


Objectives & constraints

VOI name	VOI type	priority	obj. / const.	penalty	dose	EUD	volume	rc
1 Core	DAR	2	square overdosing	300	25	NaN	NaN	+
2 OuterTarget	TARGET	1	square deviation	1000	50	NaN	NaN	-
3 BODY	DAR	3	square overdosing	100	30	NaN	NaN	+



Radiation type dose volume comparison (TG119)

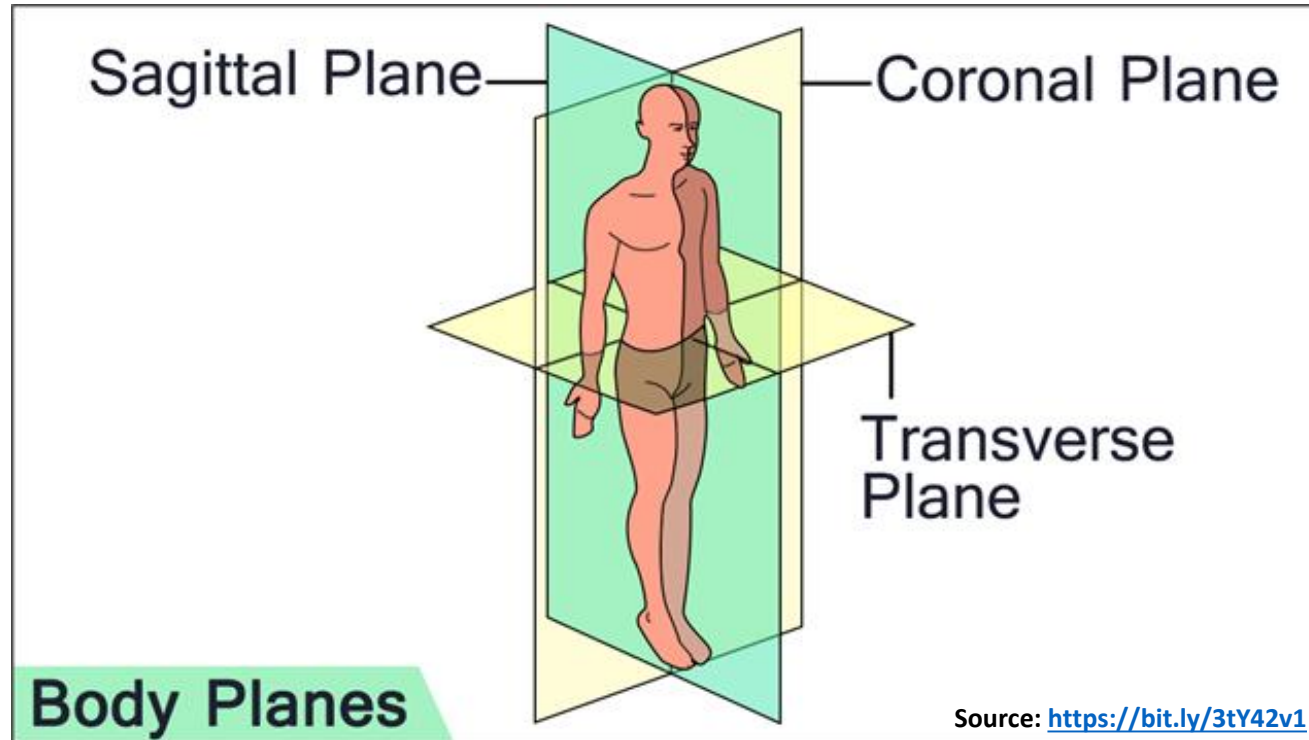


Photons	max	min	mean	std
Core	1.3349	0.2372	1.0725	0.2146
OuterTarget	1.8801	1.0767	1.5918	0.1560
BODY	2.3556	0	0.1361	0.4030

Protons	max	min	mean	std
Core	0.8525	1.1241e-09	0.2402	0.2380
OuterTarget	1.7802	1.4057	1.6581	0.0300
BODY	1.7802	0	0.0638	0.2840

Carbon ions	max	min	mean	std
Core	0.9793	0.0048	0.3344	0.2405
OuterTarget	1.7564	1.4947	1.6580	0.0235
BODY	1.7564	0	0.0564	0.2496

Planes in visualization



- **Sagittal plane:** It separates the body equally in left and right parts.
- **Coronal plane:** It separates the body into two parts, anterior (front) and posterior (back).
- **Transverse/Axial/Horizontal plane:** It separates the body at the upper and bottom parts.

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:

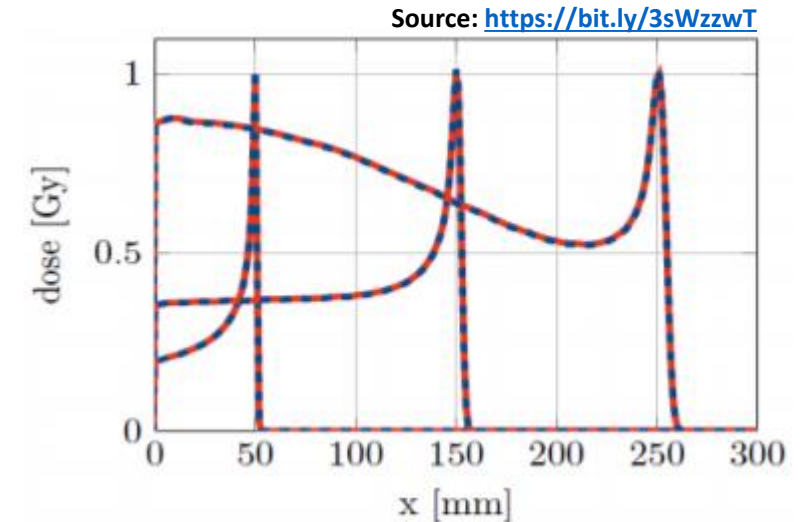
- Workflow:** Contains buttons for Refresh, Load *.mat data, Calc. influence Mx, Optimize, Save to GUI, Load DICOM, Recalc, Export, Import from Binary, and Import Dose. The status indicates "plan is optimized".
- Plan:** Includes input fields for beam width (5 mm), Gantry Angle (0, 72, 144, 216, 288), Couch Angle (0, 0, 0, 0), Radiation Mode (photons), Machine (Generic), IsoCenter (251.3, 226.4, 162.6), # Fractions (30), and Type of optimization (none). It also has checkboxes for MC 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 sliders for Slice and Beam Selection, dropdowns for Type of plot (intensity), Plane Selection (axial), and Display option (physicalDose). It includes buttons for GoTo, Open 3D-View, and Show DVH/QI, and a list of plot options like plot CT, plot contour, plot isocms, plot dose, plot isocms labels, plot iso center, and visualization post / 3 beams.
- Viewing:** Shows a 2D dose distribution plot on an axial plane at z = 165 mm. The plot uses a color scale for physical dose (Gy) ranging from 0 to 1.6. The x-axis represents distance in mm (50 to 500), and the y-axis represents distance in mm (50 to 500). A white outline of the patient's body is visible at the bottom of the plot area.
- Viewer Options:** Includes settings for Result (i.e. dose), Window Power (Custom), Window Center (0.884), Window Width (1.77), Range (0 to 1.768), and Dose opacity (1).
- Structure Visibility:** A list showing visibility for Core, OuterTarget, and BODY.
- Info:** Displays version v3.0.0 and the GitHub repository github.com/v0404/matRad, with an About button.

Comparison of MatRad with Syngo clinical software

- Syngo software is used clinically in Heidelberg (HIT).
- Display of the dose in Gray (Gy) as a function of the depth of the beam in human tissue in millimeters (mm).
- The results are almost identical !!!
- MatRad is not used in clinic, it is designed for research and educational purpose.



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

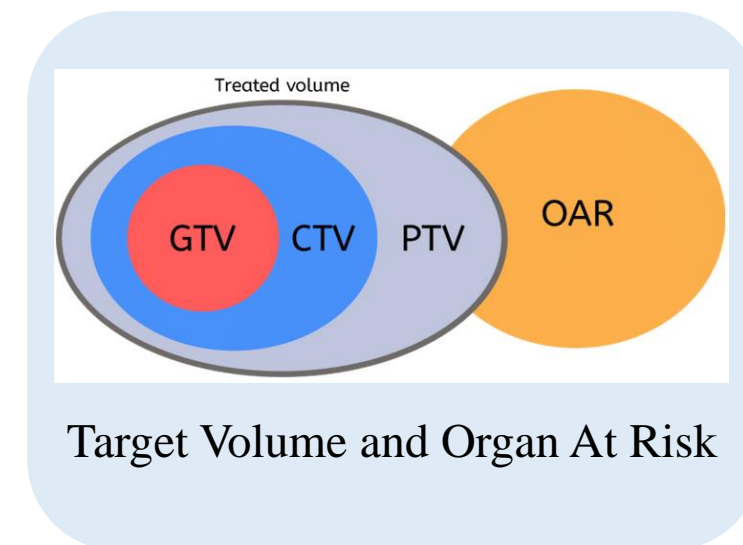
- The official page of the software is given at the following link: <https://e0404.github.io/matRad/>

Thank you

Lets work together in the hands on session!

Some definitions used by MatRad

- **GTV** (Gross Tumor Volume) is defined as the target tumor and is the exact location of the malignancy (cancer), as evidenced by imaging methods.
- **CTV** (Clinical Target Volume) is defined as the target clinical tumor (where the radio physicist assumes that cancerous tissue is still present). It is designed with the requirement that cancer cells should not be located outside its region.
- **PTV** (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** (Organs At Risk): 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 the measure of the energy deposited in matter by ionizing radiation per unit mass
Is equal to absorbed dose of 1 Joule/kilogram



Target Volume and Organ At Risk