

2. WHAT SOFTWARE WILL WE USE?: MATRAD

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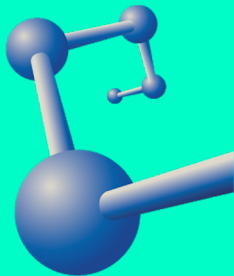
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IPPOG's Member

Instituto de
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Nucleares
UNAM



International Particle
Physics Outreach Group

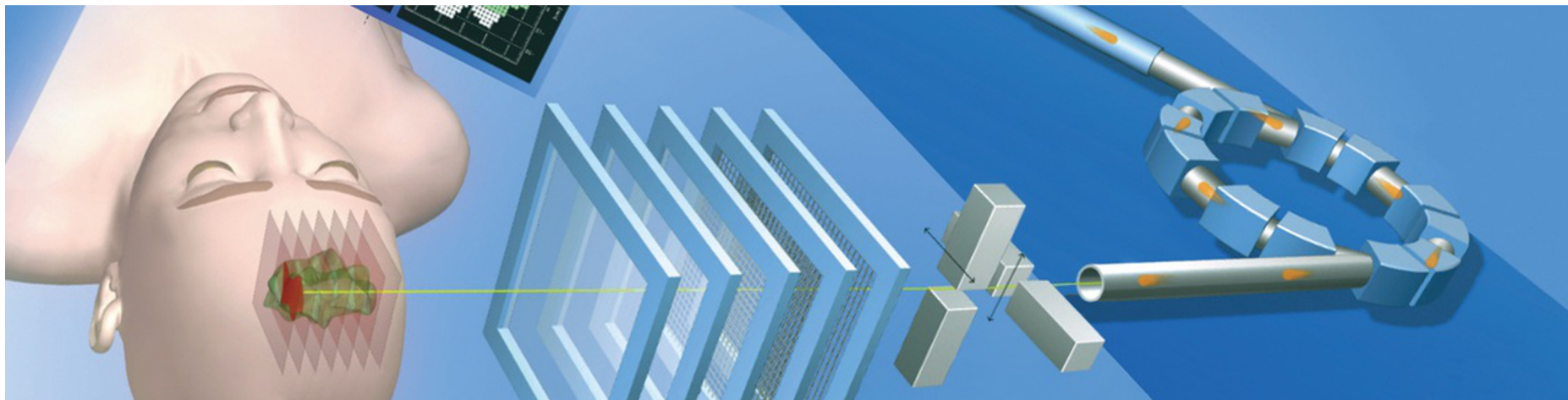


ARISTOTLE
UNIVERSITY OF
THESSALONIKI





1. WHAT IS MATRAD?



matRad is a tool kit allowing optimization of treatment planning with photons, protons, ions for educational and research purposes.

matRad

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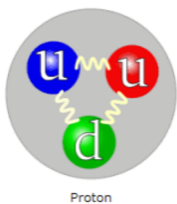


IPG
International Particle
Physics Outreach Group

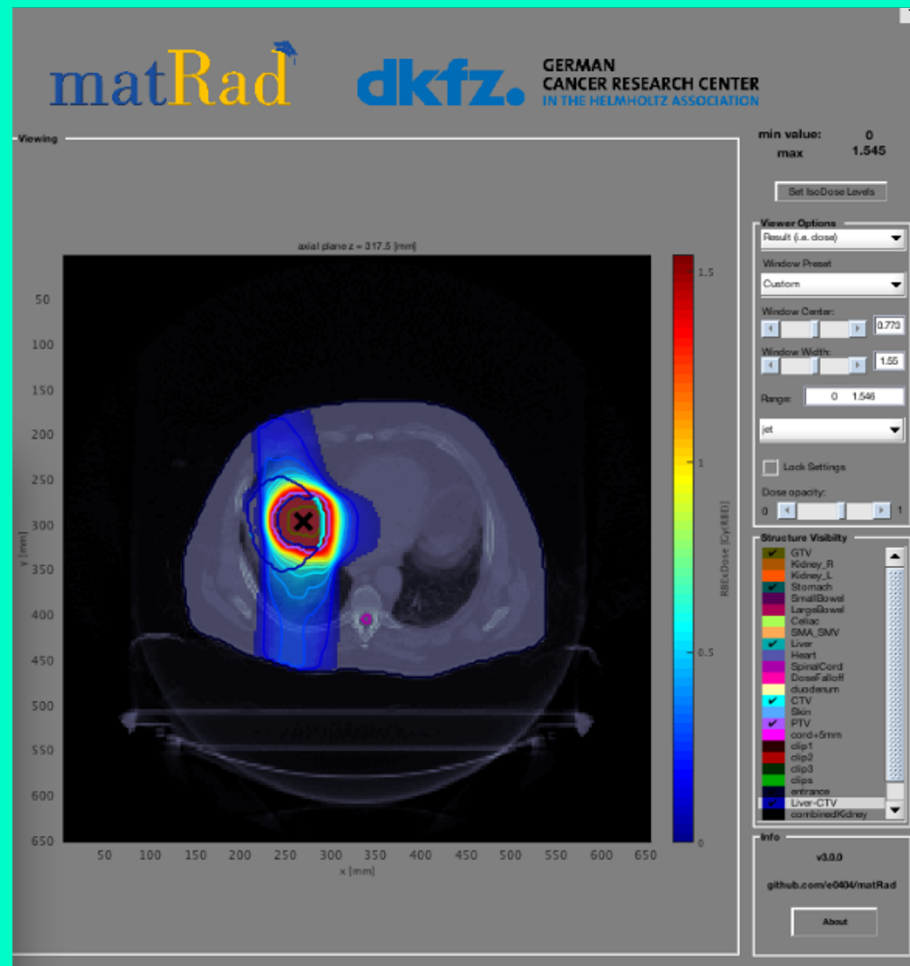
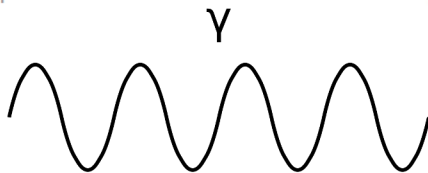


matRad

THE MATRAD EDUCATIONAL AND RESEARCH SOFTWARE WAS DEVELOPED BY THE GERMAN CANCER RESEARCH CENTER IN ORDER TO HANDLE TREATMENT PLANNING IN AN EASY WAY WITH PROTONS, PHOTONS AND CARBON IONS.



Carbon ion (6+)



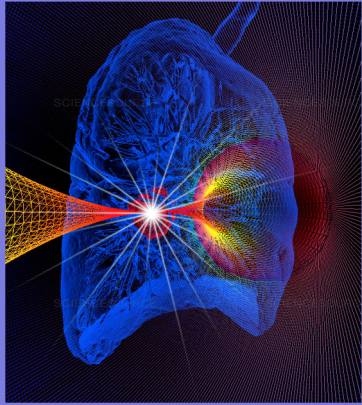
2. WHERE IS MATRAD USED TODAY?

+30 INSTITUTIONS

CURRENTLY MATRAD IS USED BY MORE THAN 30 OFFICIAL INSTITUTIONS, AMONG THEM RESEARCH GROUPS AND A VARIETY OF UNIVERSITIES INTERNATIONALLY RECOGNIZED FOR THEIR HIGH PERFORMANCE AND EXCELLENT RESULTS GLOBALLY.



HERE YOU CAN SEE SOME OF THE INSTITUTIONS WE ARE TALKING ABOUT



matRad – community



TECHNISCHE
UNIVERSITÄT
MÜNCHEN



MEDICAL UNIVERSITY
OF VIENNA



大阪大学
OSAKA UNIVERSITY

dkfz.

GERMAN
CANCER RESEARCH CENTER
IN THE HELMHOLTZ ASSOCIATION

THE UNIVERSITY OF TEXAS

MD Anderson
Cancer Center

Proton Therapy



UNIVERSIDAD
COMPLUTENSE
MADRID



UNIVERSITY OF
OXFORD



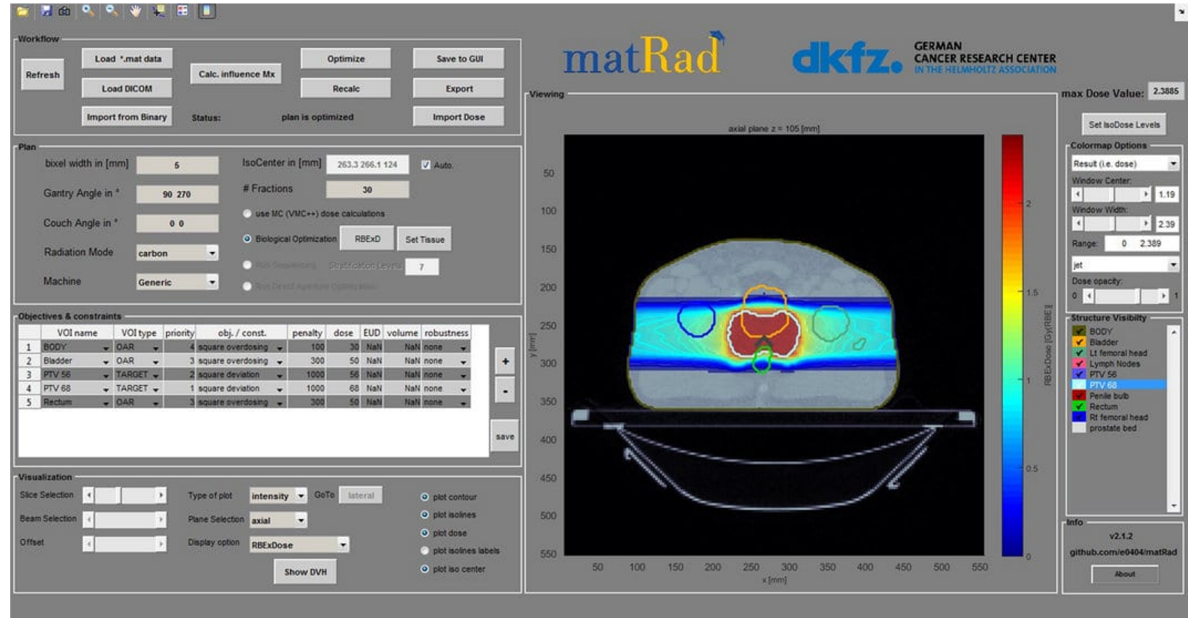
Universität
Zürich^{UZH}



FOR MORE INFORMATION, YOU CAN CONSULT THE FOLLOWING MAP: [HTTPS://BIT.LY/MATRADUSERS](https://bit.ly/matradusers)

3. IN WHAT WAYS CAN THE SOFTWARE BE EXECUTED?

IT CAN BE EXECUTED THROUGH MATLAB OR WITH THE MATRAD APPLICATION FOR WINDOWS:

The image shows the matRad application interface. It features a top toolbar with buttons for Refresh, Load *.mat data, Load DICOM, Import from Binary, Calc. influence Mx, Optimize, Save to GUI, Recalc, Export, and Import Dose. The main window is divided into several sections: Plan, Objectives & constraints, Visualization, and a central viewing area. The Plan section includes fields for bixel width, IsoCenter, Gantry Angle, Couch Angle, Radiation Mode, and Machine. The Objectives & constraints section contains a table with columns for VOI name, VOI type, priority, obj. / const., penalty, dose, EUD, volume, and robustness. The Visualization section includes controls for Slice Selection, Beam Selection, Offset, Type of plot, Plane Selection, Display option, and Show DVH. The central viewing area shows an axial plane z = 195 [mm] with a color scale for RBE Dose [GyRBE]. The right sidebar contains controls for max Dose Value, Colormap Options, and Structure Visibility.

VOI name	VOI type	priority	obj. / const.	penalty	dose	EUD	volume	robustness
1 BODY	DAR	4	square overdosing	100	30	NaN	NaN	none
2 Bladder	DAR	3	square overdosing	300	50	NaN	NaN	none
3 PTV 56	TARGET	2	square deviation	1000	56	NaN	NaN	none
4 PTV 68	TARGET	1	square deviation	1000	68	NaN	NaN	none
5 Rectum	DAR	3	square overdosing	300	50	NaN	NaN	none

4. WHAT FORM OF EXECUTION IS RECOMMENDED FOR MATRAD?



EDUCATIONAL PURPOSES



- PROCESSING POWER

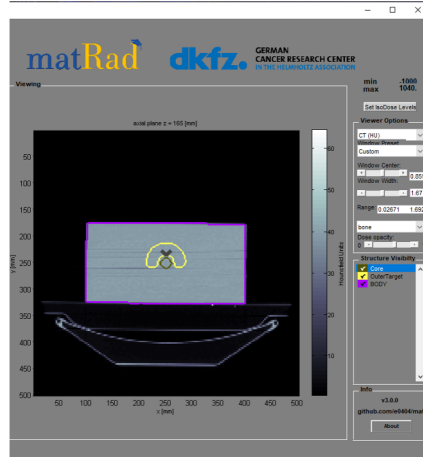
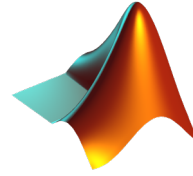


IMAGE OF MATRAD EXECUTED FROM WINDOWS APP



RESEARCH



+ PROCESSING POWER

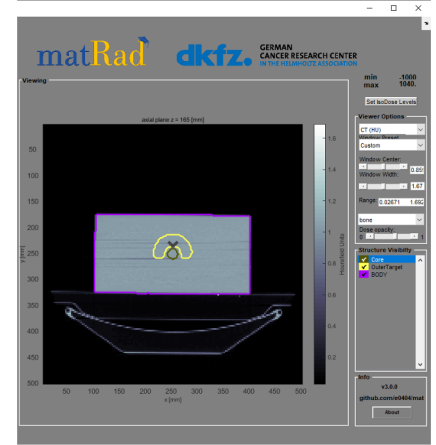


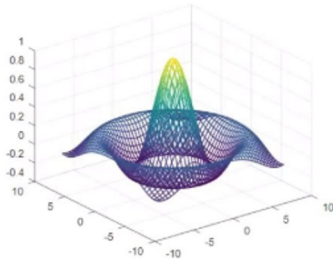
IMAGE OF MATRAD EXECUTED FROM MATLAB

FOR EDUCATIONAL PURPOSES THE USE OF MATRAD AS A WINDOWS APPLICATION IS RECOMMENDED, AS IT TAKES UP LESS STORAGE SPACE AND DOES NOT REQUIRE AN IDE (INTEGRATED DEVELOPMENT ENVIRONMENT) TO USE THE SOFTWARE.

FOR RESEARCH PURPOSES, WHICH INVOLVES TESTING TREATMENTS WITH SPECIFIC PARAMETERS THAT LEAD TO MORE REALISTIC SIMULATIONS, IT IS RECOMMENDED TO USE MATLAB TO PERFORM A MORE DETAILED ANALYSIS. THIS REQUIRES A HIGHER PROCESSING POWER.

5. TWO PECULIAR FACTS

- IN CASE ONE NEEDS TO USE MATLAB IDE FOR FURTHER ANALYSIS AND A MATLAB LICENSE IS ABSENT, ONE CAN USE GNU OCTAVE, WHICH IS WRITTEN IN C / C++ AND IS COMPATIBLE WITH MATLAB SYNTAX.
- THE GRAPHICAL USER INTERFACE (GUI) IS THE SAME WHEN EXECUTING MATRAD FROM ANY OF THE AVAILABLE OPTIONS. HOWEVER... IT IS MORE EFFICIENT TO EXECUTE IT THROUGH THE IDE.

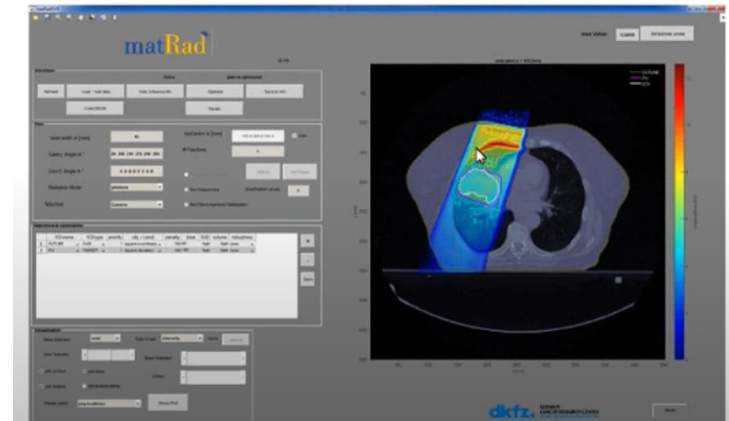


Scientific Programming Language

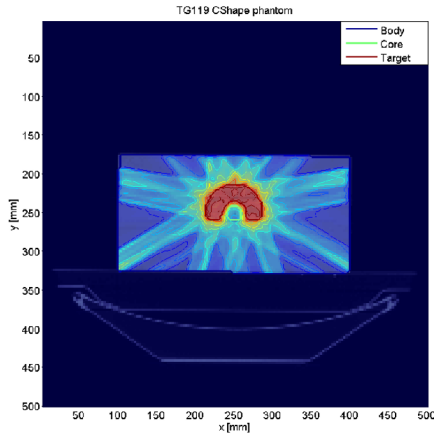
- Powerful mathematics-oriented syntax with built-in plotting and visualization tools
- Free software, runs on GNU/Linux, macOS, BSD, and Windows
- Drop-in compatible with many Matlab scripts

Download

Docs



6. WHY IS MATRAD BASED ON MATLAB?



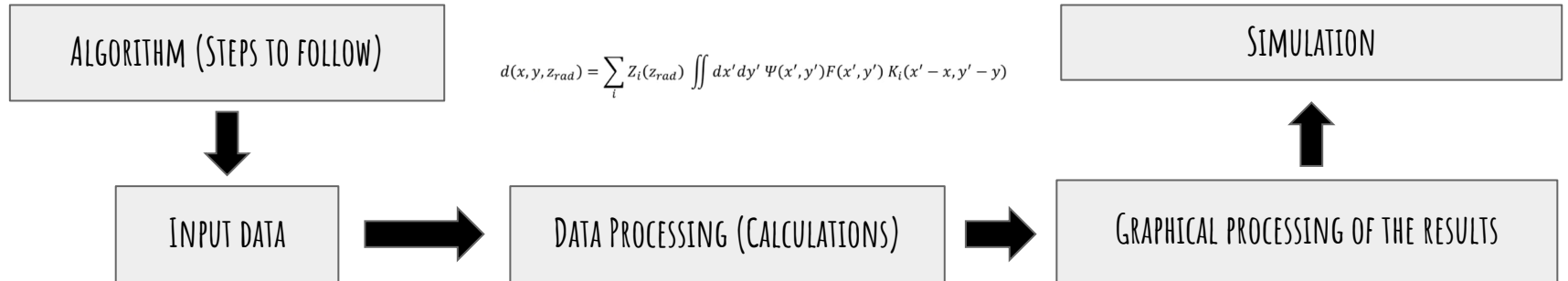
- EASY TO USE DATA VISUALIZATION
- OPTIMIZED DEBUGGING
- ALLOWS FAST DEVELOPMENT OF TREATMENT PROTOTYPES
- WELL KNOWN SOFTWARE IN THE MEDICAL PHYSICS COMMUNITY FOR ITS EFFECTIVENESS.
- SIMPLE SYNTAX COMPARED TO ABSTRACT PROGRAMMING IN LANGUAGES LIKE C ++
- ALLOWS A STANDALONE EXECUTABLE (MATRAD.EXE), WHICH CAN BE USED WITHOUT A LICENSE.



7. HOW DOES THIS SOFTWARE WORK?

THE OPERATION OF THIS SOFTWARE IS POSSIBLE THANKS TO THE ALGORITHMS DEVELOPED BY THE PROFESSIONALS FROM INTERDISCIPLINARY AREAS WHO ARE PART OF THIS PROJECT.

THANKS TO THE PROCEDURES PREVIOUSLY PROGRAMMED, THE INPUT DATA IS USED TO PERFORM THE CALCULATIONS AND THUS, DISPLAY THE OPTIMIZED RESULTS OF THE SIMULATIONS ON THE VISUALIZATION PANEL.



8. HOW IS DATA PROCESSING CARRIED OUT?

IN THE PREVIOUSLY MENTIONED ALGORITHMS, THE INPUT DATA ARE TAKEN AS VARIABLES, WHICH ALREADY HAVE A CERTAIN MEMORY LOCATION RESERVED. LATER THESE ARE STORED IN DIFFERENT TYPES OF DATA STRUCTURES THROUGH MATRICES, VECTORS, ETC., AND THEN THEY ARE PROCESSED ACCORDING TO THE MATHEMATICAL PROCEDURE THAT EACH OF THEM MUST FOLLOW ACCORDING TO THE ALGORITHM AND ITS PARAMETERS. FINALLY, THE RESULTS ARE STORED IN A RESERVED SPACE.

Fields	gantryAngle	couchAngle	bixelWidth	radiationMode	SAD	isoCenter	numOfRays	ray	sourcePoint_bev	sourcePoint	numOfBixelsPerRay
1	0	30	5	'photons'	1000	[251.3089,23...	302	1x302 struct	[0,-1000,0]	[0,-1000,0]	1x302 double
2	21.1700	47.1400	5	'photons'	1000	[251.3089,23...	309	1x309 struct	[0,-1000,0]	[245.6483,-932...	1x309 double
3	42.3400	64.2800	5	'photons'	1000	[251.3089,23...	300	1x300 struct	[0,-1000,0]	[292.2937,-739...	1x300 double
4	63.5100	81.4200	5	'photons'	1000	[251.3089,23...	248	1x248 struct	[0,-1000,0]	[133.5270,-446...	1x248 double
5	84.6800	98.5600	5	'photons'	1000	[251.3089,23...	180	1x180 struct	[0,-1000,0]	[-148.2039,-92...	1x180 double
6	105.8500	115.7000	5	'photons'	1000	[251.3089,23...	247	1x247 struct	[0,-1000,0]	[-417.1714,273...	1x247 double
7	127.0200	132.8400	5	'photons'	1000	[251.3089,23...	293	1x293 struct	[0,-1000,0]	[-542.8920,602...	1x293 double
8	148.1900	149.9800	5	'photons'	1000	[251.3089,23...	308	1x308 struct	[0,-1000,0]	[-456.3935,849...	1x308 double
9	169.3600	210	5	'photons'	1000	[251.3089,23...	314	1x314 struct	[0,-1000,0]	[-159.9008,982...	1x314 double
10	190.5300	225	5	'photons'	1000	[251.3089,23...	313	1x313 struct	[0,-1000,0]	[129.2240,983.1...	1x313 double
11	211.7000	240	5	'photons'	1000	[251.3089,23...	314	1x314 struct	[0,-1000,0]	[262.7358,850.8...	1x314 double
12	232.8700	255	5	'photons'	1000	[251.3089,23...	286	1x286 struct	[0,-1000,0]	[206.3481,603.6...	1x286 double
13	254.0400	270	5	'photons'	1000	[251.3089,23...	215	1x215 struct	[0,-1000,0]	[0,274.9662,-96...	1x215 double
14	275.2100	285	5	'photons'	1000	[251.3089,23...	202	1x202 struct	[0,-1000,0]	[-257.7498,-90...	1x202 double
15	296.3800	300	5	'photons'	1000	[251.3089,23...	270	1x270 struct	[0,-1000,0]	[-447.9335,-444...	1x270 double
16	317.5500	315	5	'photons'	1000	[251.3089,23...	309	1x309 struct	[0,-1000,0]	[-477.2593,-737...	1x309 double
17	338.7200	330	5	'photons'	1000	[251.3089,23...	307	1x307 struct	[0,-1000,0]	[-314.3031,-931...	1x307 double

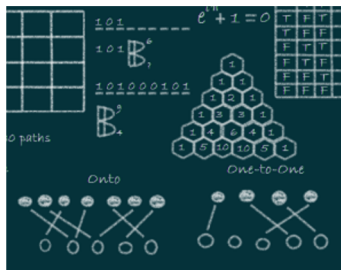
Field	Value	Min	Max
numOfBeams	2	2	2
numOfVoxels	3047040	30...	30...
resolution	1x1 struct		
numOfRaysPerBeam	[303 303]	303	303
totalNumOfRays	606	606	606
totalNumOfBixels	16448	16...	16...
dimensions	[184 184 90]	90	184
numOfScenarios	1	1	1
bixelNum	16448x1 double	1	43
rayNum	16448x1 double	1	303
beamNum	16448x1 double	1	2
physicalDose	1x1 cell		

8. HOW IS DATA PROCESSING CARRIED OUT?

INPUT



STORAGE OF VARIABLES THROUGH DATA STRUCTURES



PROCESSING

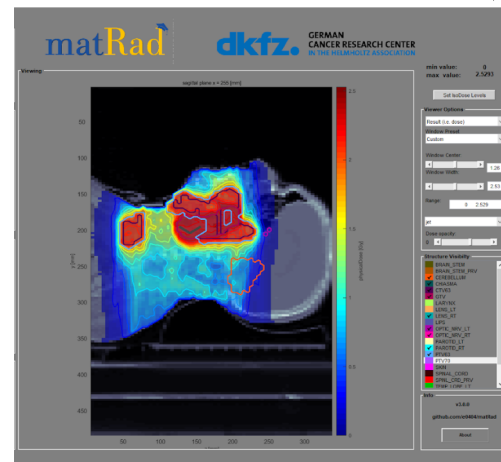
$$\min f(d(w)), w \in \mathbb{R}^n$$

$$f = \sum_i p_i f_i$$

$$\text{s. t.} \quad \begin{aligned} d &= Dw \\ c_l &\leq c(w) \leq c_u \\ w_l &\leq w \leq w_u \end{aligned}$$

$$f(w): \mathbb{R}^n \rightarrow \mathbb{R}, \quad c(w): \mathbb{R}^n \rightarrow \mathbb{R}^m$$

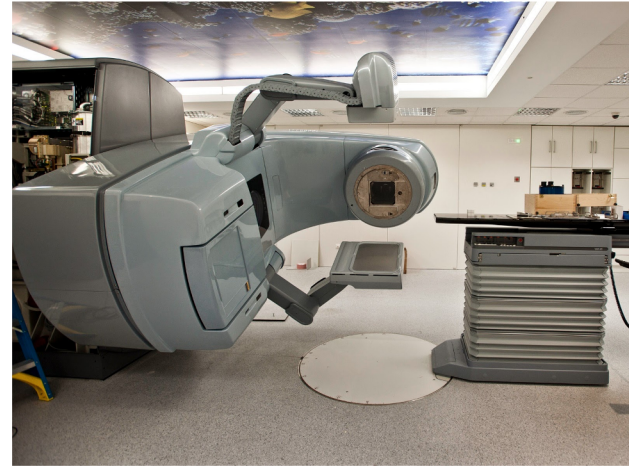
RESULTS STORAGE AND VISUAL PROCESSING



PROCEDURE

9. WHERE DOES ALL THAT REALLY APPLY?

EVERYTHING LEARNED IN THIS MASTERCLASS IS APPLIED PROFESSIONALLY IN HEALTH CENTERS WHERE SPECIALIZED EQUIPMENT IS AVAILABLE TO PERFORM VARIOUS CLINICAL PROCEDURES THROUGH RADIOTHERAPY IN ORDER TO HELP THE TREATMENT OF A WIDE VARIETY OF DISEASES, INSTEAD OF MORE COMPLICATED AND PAINFUL PROCEDURES.



10. HOW ARE THE FACILITIES OF A PARTICLE THERAPY CENTER?





TO LEARN MORE ABOUT THE ELEMENTS OF A PARTICLE THERAPY FACILITY, YOU CAN VISIT THE FOLLOWING LINK:

[HTTP://WWW.CERN.NYMUS3D.NL/MAPS](http://www.cern.nymus3d.nl/maps)

WE'RE READY FOR THE
NEXT STEP!

Go to the file
`"3_Installation"`