

Particle Therapy Masterclass

Supervisors:

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HSSIP

High-School Students
Internship Programme

Presenters:

Danai Vasiloglou

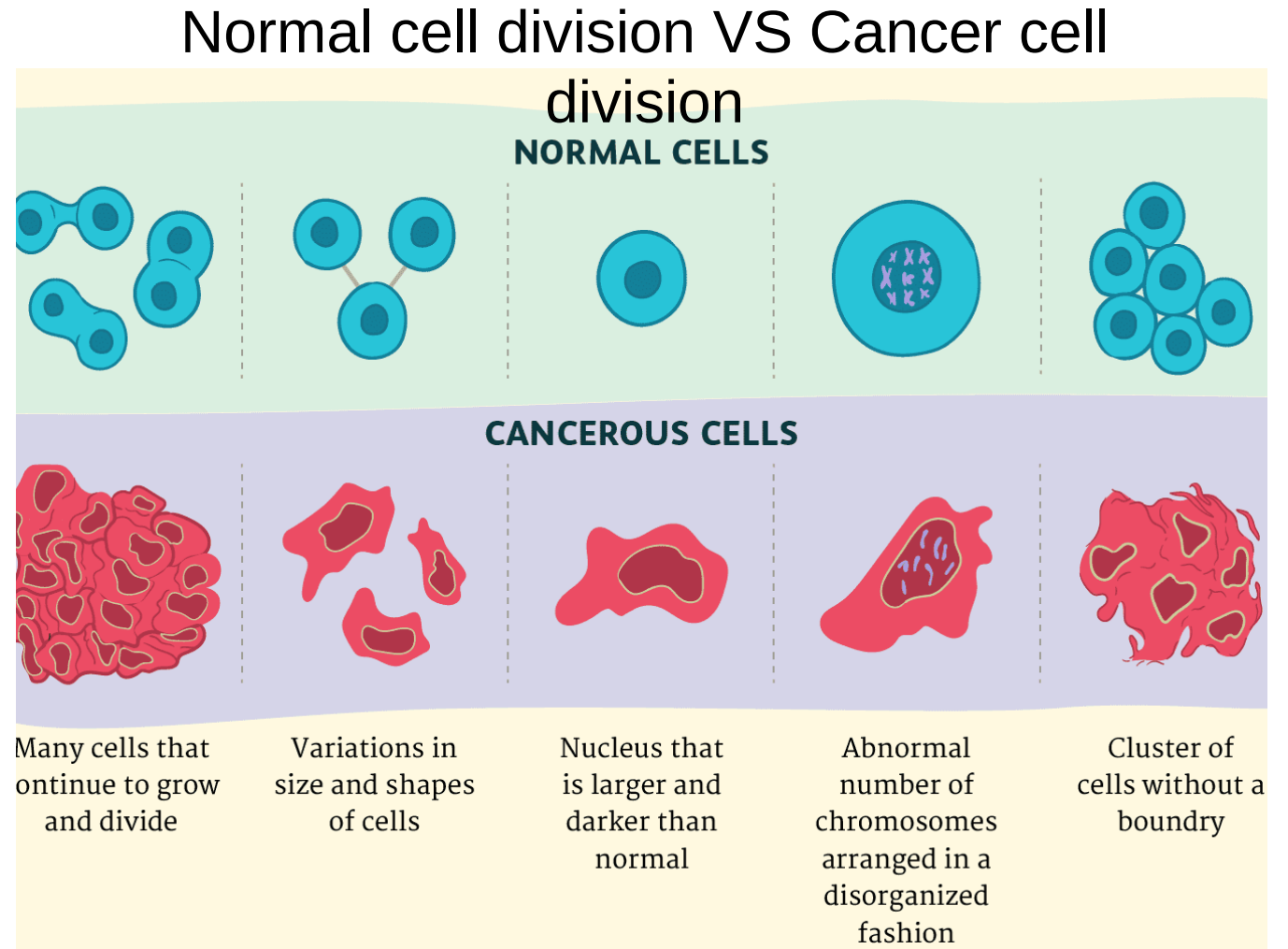
Nikolaos Fatouras

What is Cancer?

- Disease that causes body cells to grow uncontrollably and spread to other parts of the body.

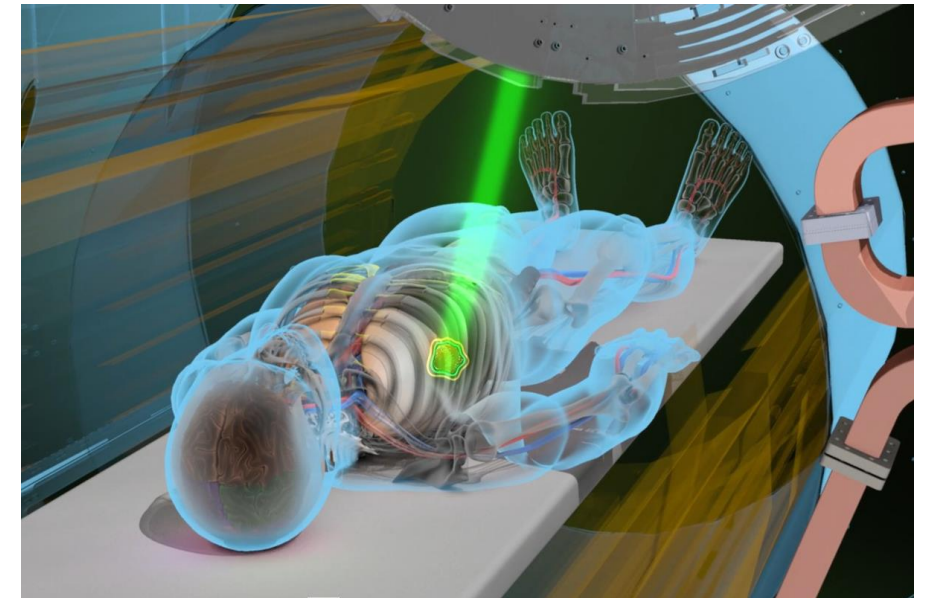
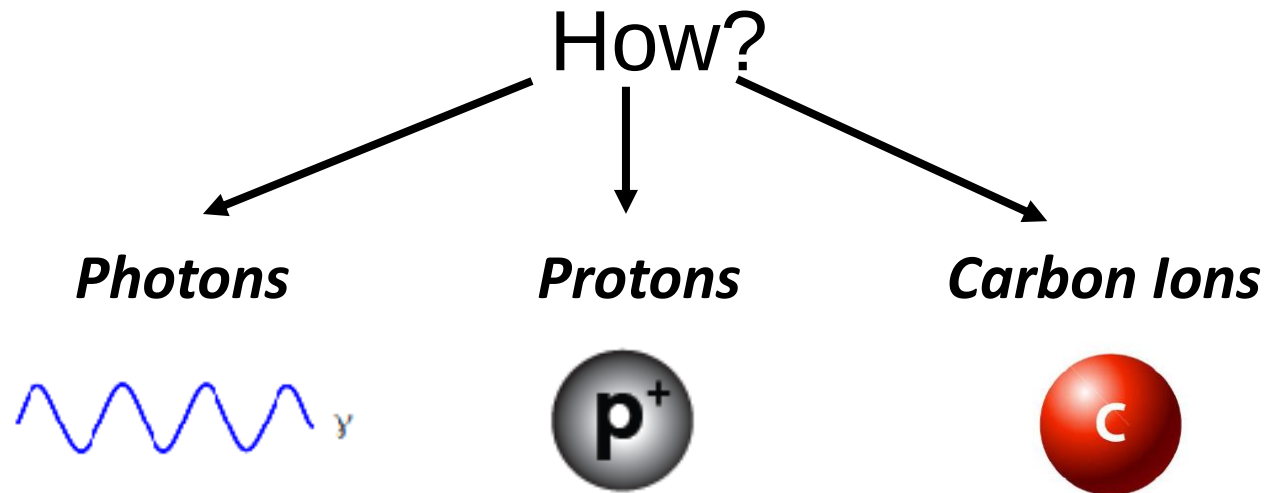
Types of Cancer Treatment

- Surgery
- Chemotherapy
- **Radiation Therapy**
- Targeted Therapy
- Immunotherapy
- Stem Cell or Bone Marrow Transplant
- Hormone Therapy

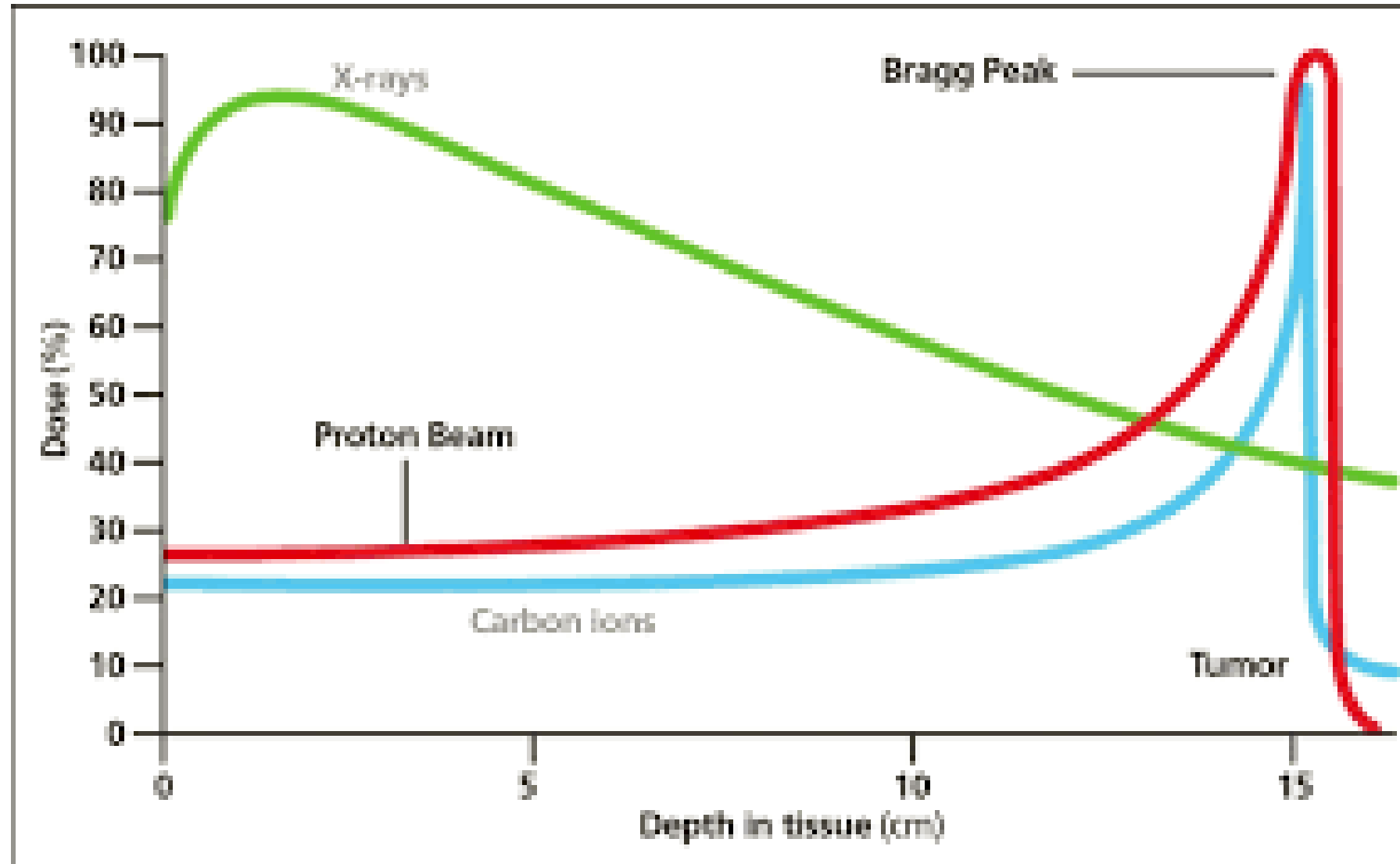


INTRODUCTION TO PARTICLE PHYSICS->MEDICAL APPLICATIONS

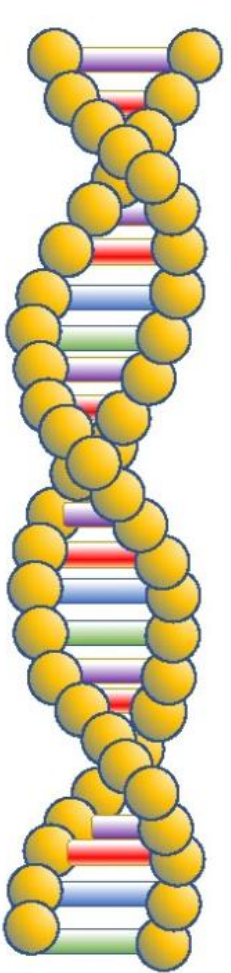
Radiation Therapy : -Uses high doses of ionizing radiation to kill cancer cells
-*Goal*: spare healthy tissues



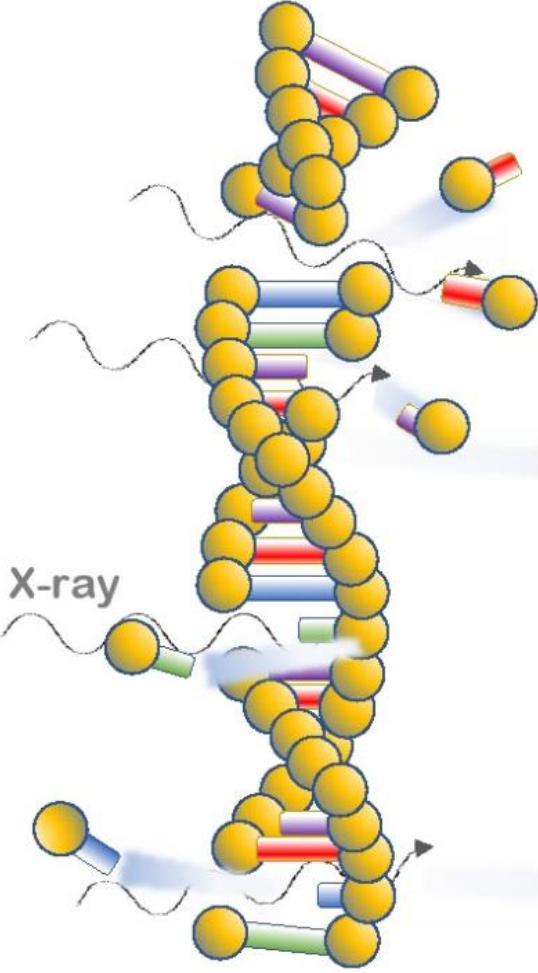
BRAGG PEAK



Comparison of DNA damage caused by different particles

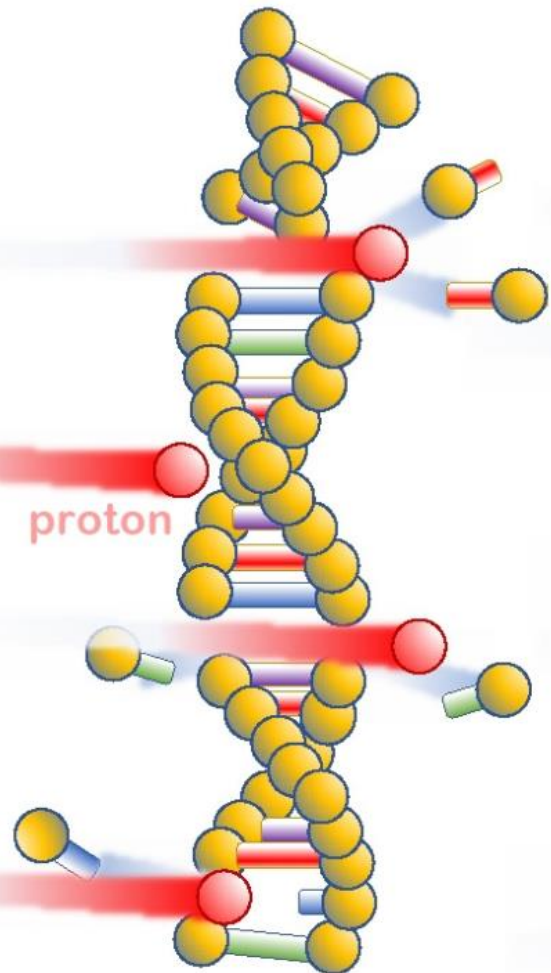


DNA



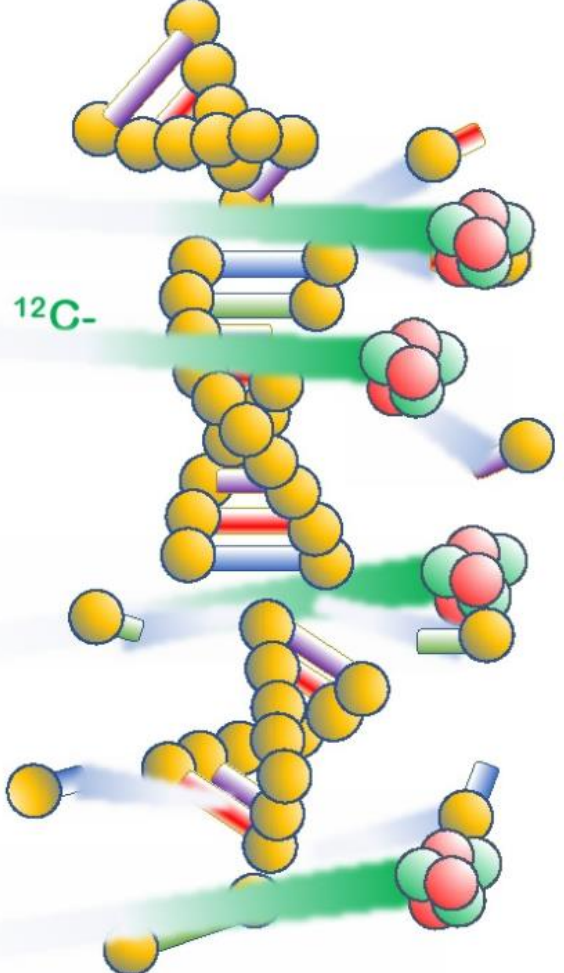
X-ray

X-ray



proton

protons



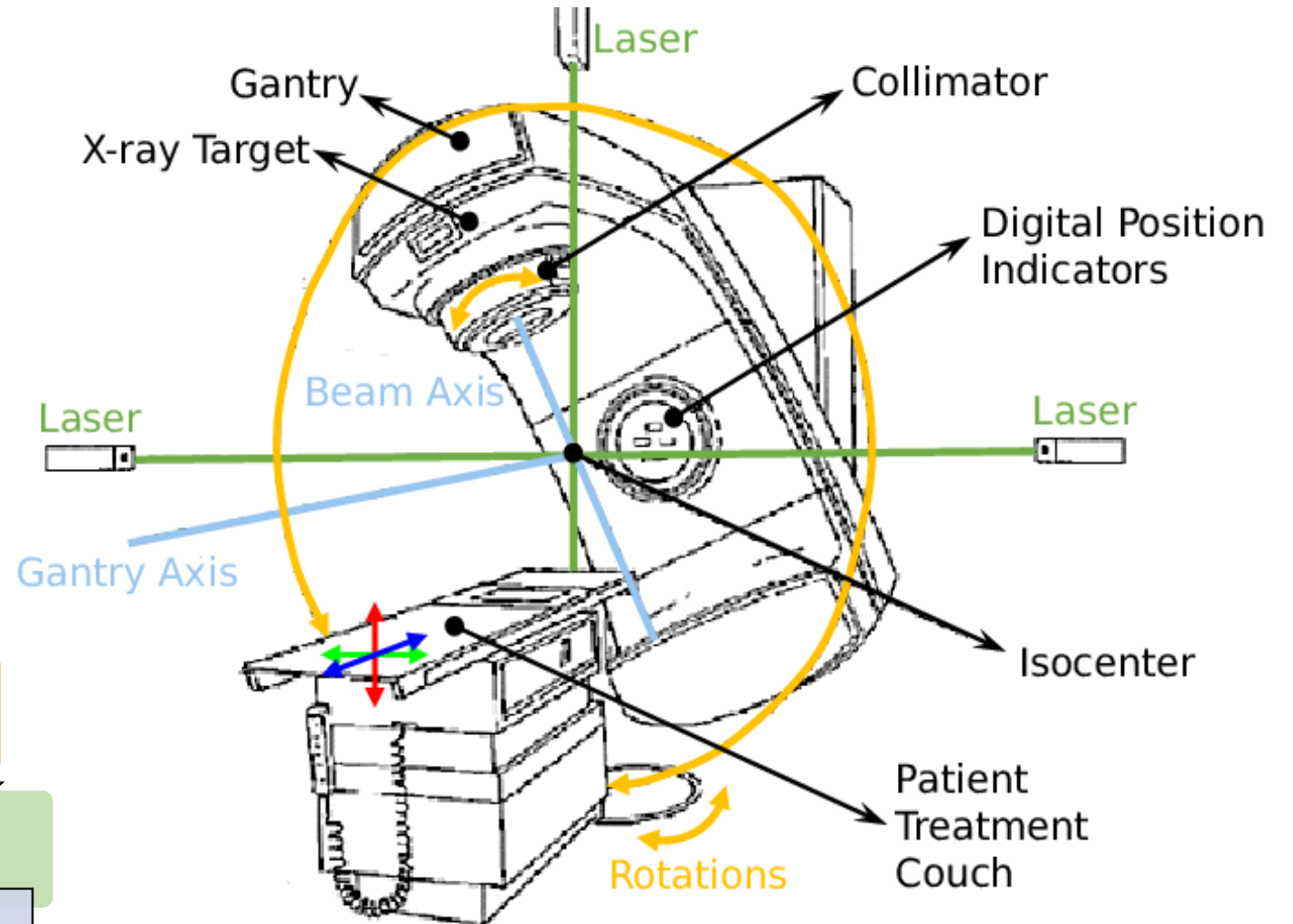
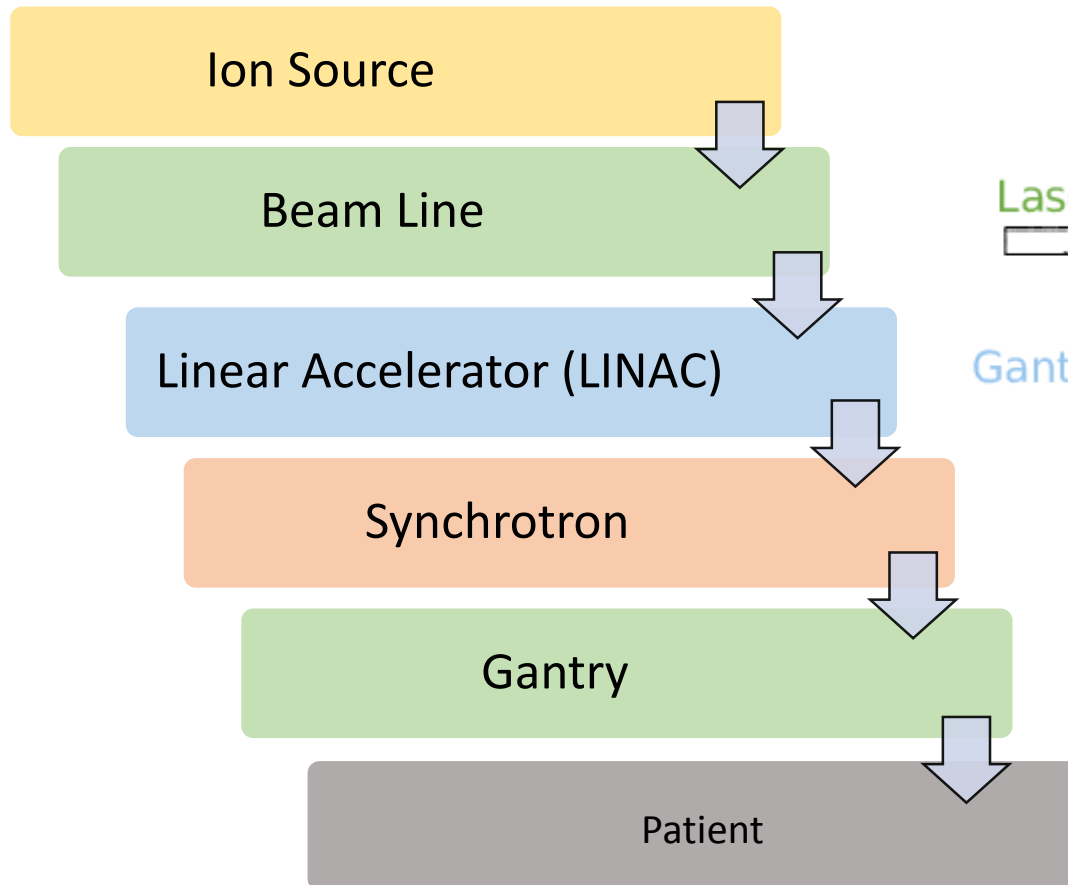
$^{12}\text{C}^-$

$^{12}\text{C}^-$ -ions

Facilities: From the source to the patient

[Map of Medical Centre](#)

The beam's journey



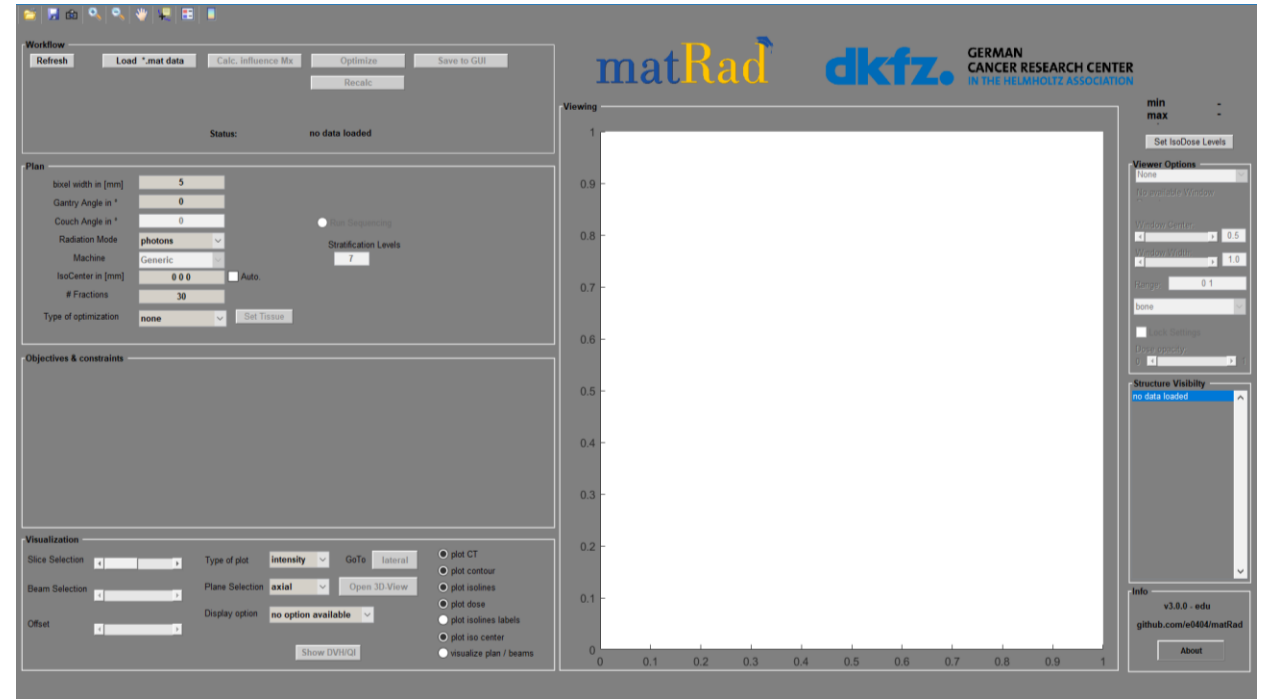


matrad software

PARTICLE THERAPY TREATMENT PLANNING SIMULATIONS

- **matRad** is an open-source software developed by the German Cancer Research Centre (DKFZ).

It is used for cancer treatment simulations, involving photons, protons or carbon ions for educational and research purposes.



dkfz.

DEUTSCHES
KREBSFORSCHUNGSZENTRUM
IN DER HELMHOLTZ-GEMEINSCHAFT

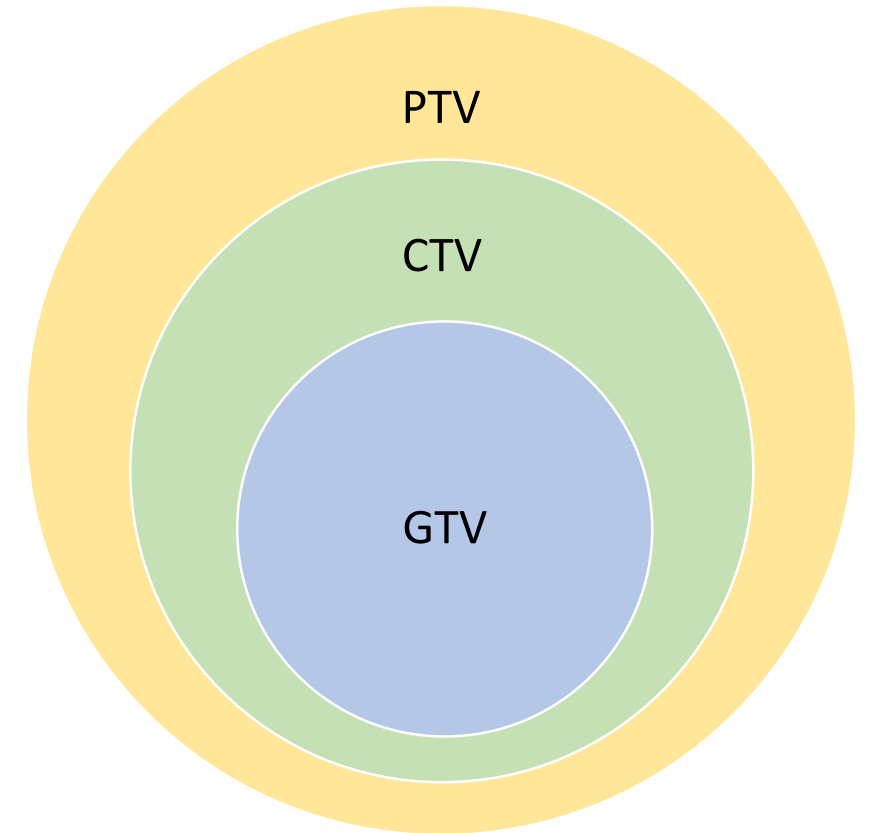


Forschen für ein Leben ohne Krebs

matRad

Useful Concepts

- **Gantry angle** → Vertical rotation of the axis of the machine from which the particle beams come from.
- **Couch angle** → Horizontal rotation of the patient's bed
- **GTV** → *Gross Tumor Volume*: Tumor volume that is visible on the images.
- **CTV** → *Clinical Target Volume*: Volume of the tissue including the GTV and regions where invisible tumor tissue is expected.
- **PTV** → *Planning Target Volume*: Includes the GTV and CTV as well as a safety tissue volume to take uncertainties into account.

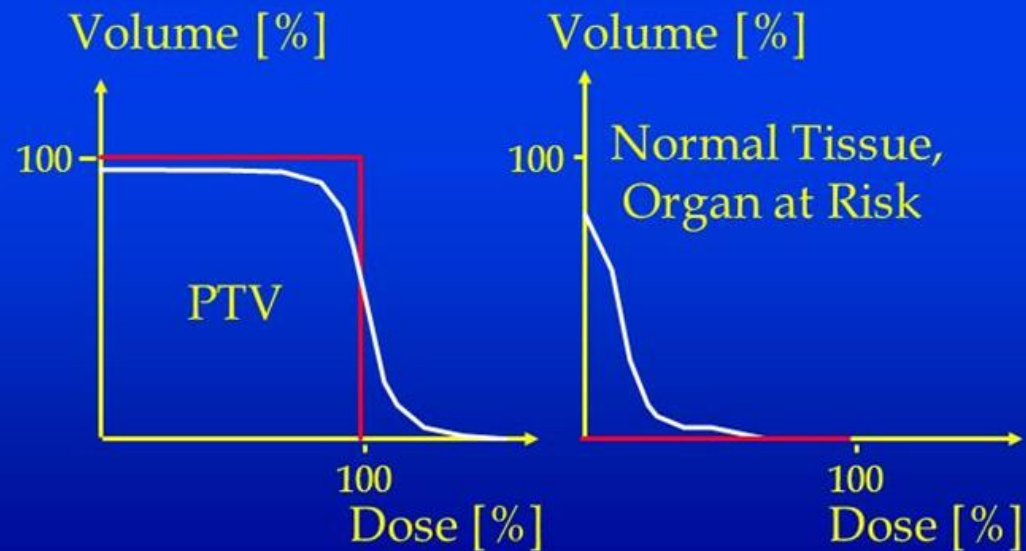


Useful Concepts

- DVH → *Dose-Volume Histogram*

Ideal Treatment vs. Reality

Dose Volume Histogram





matrad application-liver case

liver case-photons

- Photons-Treatment Plan

Workflow

Refresh Load *.mat data Calc. influence Mx Optimize Save to GUI

Recalc

Status: plan is optimized

Plan

bixel width in [mm]

Gantry Angle in °

Couch Angle in ° Run Sequencing

Radiation Mode **photons** Stratification Levels

Machine Generic

IsoCenter in [mm] Auto.

Fractions

Type of optimization none

Objectives & constraints

+/-	VOI name	VOI type	OP	Function	p	Parameters
-	Skin	OAR	2	Squared Overdosing	300	d^{max} : 25
-	PTV	TARG...	1	Squared Deviation	1000	d^{ref} : 45
+	GTV					

Visualization

Slice Selection

Beam Selection

Offset

Type of plot **intensity** GoTo **lateral**

Plane Selection **axial**

Display option **physicalDose**

plot CT
 plot contour
 plot isolines
 plot dose
 plot isolines labels
 plot iso center
 visualize plan / beams

matRad dkfz. GERMAN CANCER RESEARCH CENTER IN THE HELMHOLTZ ASSOCIATION

Viewing

axial plane z = 317.5 [mm]

min max n 1.5294

Viewer Options

Result (i.e. dose)

Window Preset **Custom**

Window Center:

Window Width:

Range:

jet

Lock Settings

Dose opacity:

Structure Visibility

- GTV
- Kidney R
- Kidney L
- Stomach
- SmallBowel
- LargeBowel
- Celiac
- SMA SMV
- Liver
- Heart
- SpinalCord
- DoseFalloff
- duodenum
- CTV
- Skin
- PTV
- cord+5mm
- rlin1

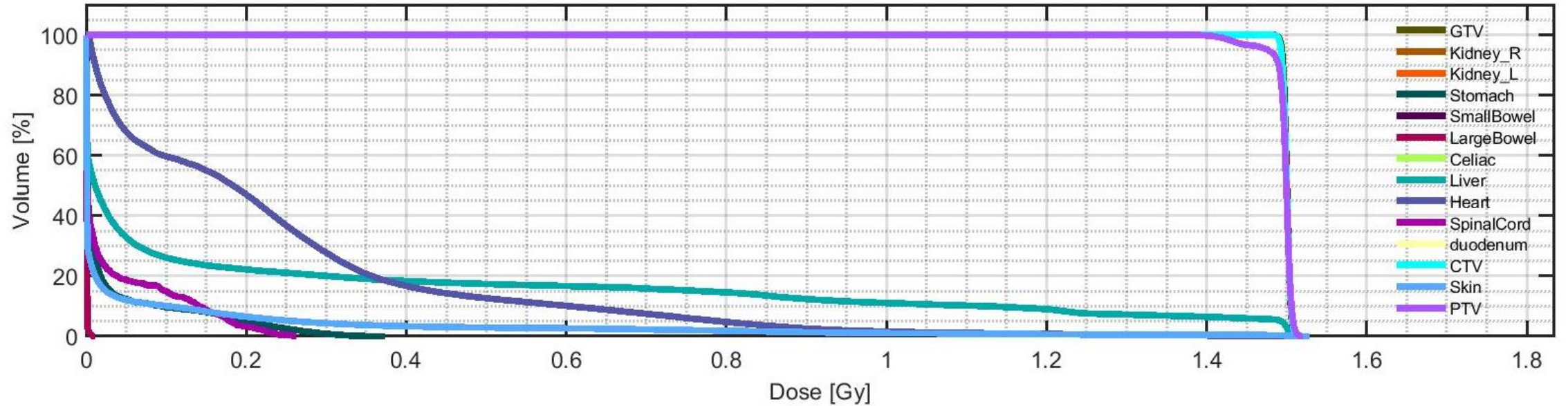
Info

v3.0.0 - edu

github.com/e0404/matRad

liver case-photons



- Photons-DVH



	max	min	mean	std
GTV	1.5184	1.4860	1.5004	0.0039
Kidney_R	0	0	0	0
Kidney_L	0	0	0	0
Stomach	0.3737	0	0.0265	0.0642
SmallBowel	0	0	0	0
LargeBowel	0.0117	0	1.3184e-04	8.1488e-04
Celiac	0	0	0	0
Liver	1.5294	0	0.2325	0.4512
Heart	1.5016	0.0010	0.2346	0.2535
SpinalCord	0.2623	0	0.0312	0.0610
duodenum	0	0	0	0
CTV	1.5184	1.4836	1.5001	0.0043
Skin	1.5294	0	0.0478	0.1773

liver case-protons

- Protons-Treatment Plan

**GERMAN
CANCER RESEARCH CENTER
IN THE HELMHOLTZ ASSOCIATION**

Workflow

Refresh Load *.mat data Calc. influence Mx Optimize Save to GUI

Recalc

Status: plan is optimized

Plan

bixel width in [mm] 5

Gantry Angle in ° 0 270 310

Couch Angle in ° 0 0 0

Radiation Mode protons

Machine Generic

IsoCenter in [mm] 265.8 296.7 316.4 Auto.

Fractions 30

Type of optimization const_RBExD

Run Sequencing

Stratification Levels 7

Objectives & constraints

+/-	VOI name	VOI type	OP	Function	p	Parameters
-	Skin	OAR	2	Squared Overdosing	300	d_{max} : 25
-	PTV	TARG...	1	Squared Deviation	1000	d_{ref} : 45
+	GTV					

Visualization

Slice Selection Type of plot intensity GoTo lateral

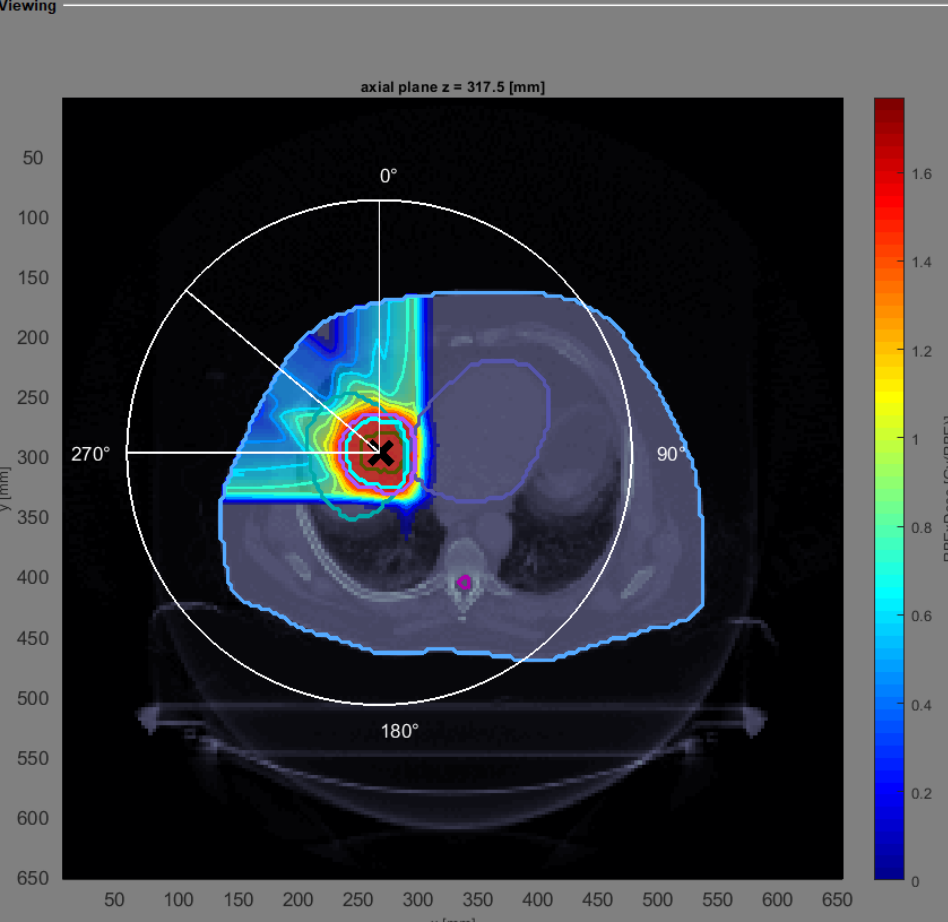
Beam Selection Plane Selection axial

Offset Display option RBExDose

- plot CT
- plot contour
- plot isolines
- plot dose
- plot isolines labels
- plot iso center
- visualize plan / beams

Viewing

axial plane z = 317.5 [mm]



min 0

max 1.7692

Viewer Options

Result (i.e. dose)

Window Preset Custom

Window Center:

Window Width:

Range: 0 1.769

jet

Lock Settings

Dose opacity:

Structure Visibility

- GTV
- Kidney R
- Kidney L
- Stomach
- SmallBowel
- LargeBowel
- Celiac
- SMA SMV
- Liver
- Heart
- SpinalCord
- DoseFalloff
- duodenum
- CTV
- Skin
- PTV
- cord+5mm
- lin1

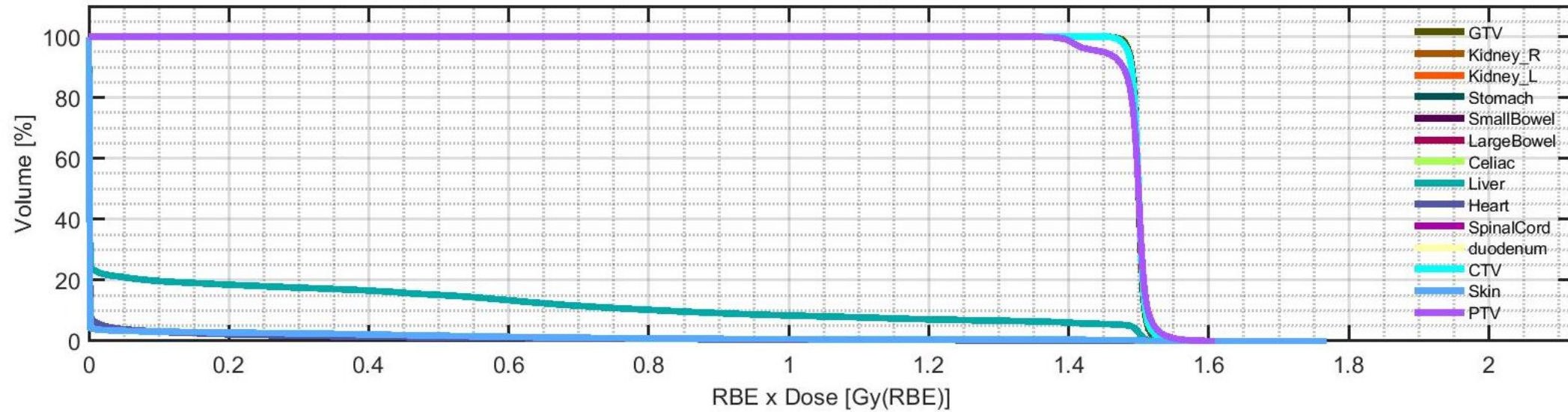
Info

v3.0.0 - edu

github.com/e0404/matRad

liver case-protons



- Protons-DVH



	max	min	mean	std
GTV	1.5466	1.4597	1.4995	0.0086
Kidney_R	0	0	0	0
Kidney_L	0	0	0	0
Stomach	0	0	0	0
SmallBowel	0	0	0	0
LargeBowel	0	0	0	0
Celiac	0	0	0	0
Liver	1.5638	0	0.1816	0.4194
Heart	1.5257	0	0.0169	0.1121
SpinalCord	0	0	0	0
duodenum	0	0	0	0
CTV	1.5591	1.4260	1.4997	0.0100
Skin	1.7692	0	0.0209	0.1367
PTV	1.6088	1.3377	1.4955	0.0245

liver case-carbon ions

- Carbon Ions-Treatment Plan

GERMAN
CANCER RESEARCH CENTER
IN THE HELMHOLTZ ASSOCIATION

min n
max 1.6614

Set IsoDose Levels

Workflow

Refresh Load *.mat data Calc. influence Mx Optimize Save to GUI

Recalc

Status: plan is optimized

Plan

bixel width in [mm] 5

Gantry Angle in ° 0 270 310

Couch Angle in ° 0 0 0 Run Sequencing

Radiation Mode carbon Stratification Levels

Machine Generic 7

IsoCenter in [mm] 265.8 296.7 316.4 Auto.

Fractions 30

Type of optimization LEMIV_RBExD Set Tissue

Objectives & constraints

+/-	VOI name	VOI type	OP	Function	p	Parameters
-	Skin	OAR	2	Squared Overdosing	300	d_{max} : 25
-	PTV	TARG...	1	Squared Deviation	1000	d_{ref} : 45
+	GTV					

Visualization

Slice Selection Type of plot intensity GoTo lateral plot CT

Beam Selection Plane Selection axial Open 3D-View plot contour

Offset Display option RBExDose plot isolines

plot dose

plot isolines labels

plot iso center

visualize plan / beams

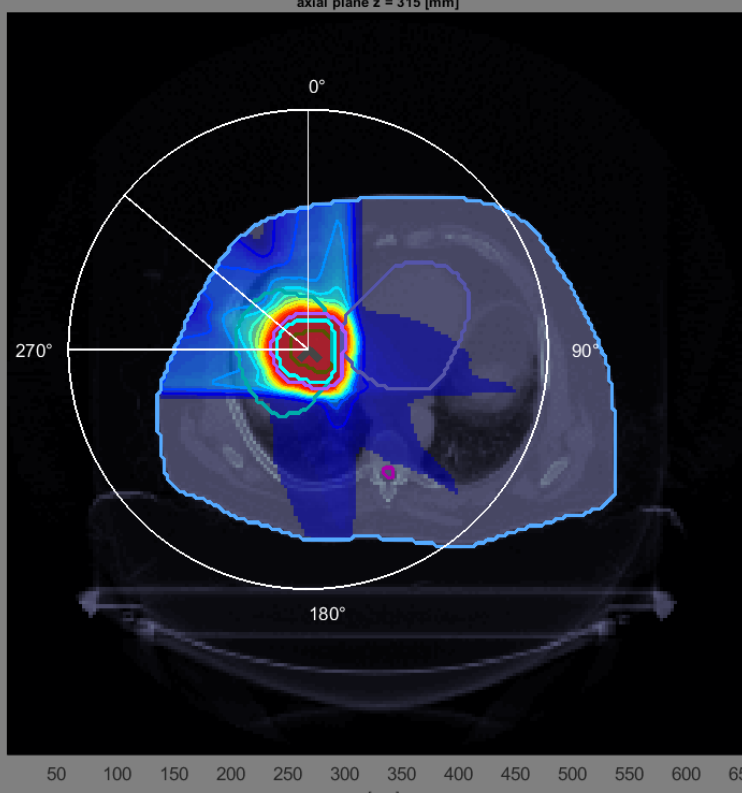
axial plane z = 315 [mm]

0°

270°

90°

180°



RBE x Dose [Gy(RBE)]

1.6

1.4

1.2

1

0.8

0.6

0.4

0.2

0

Viewer Options

Result (i.e. dose)

Window Preset Custom

Window Center: 0.831

Window Width: 1.66

Range: 0 1.661

Dose opacity: 1

Lock Settings

Structure Visibility

- GTV
- Kidney R
- Kidney L
- Stomach
- SmallBowel
- LargeBowel
- Celiac
- SMA SMV
- Liver
- Heart
- SpinalCord
- DoseFalloff
- duodenum
- CTV
- Skin
- PTV
- cord+5mm
- clix1

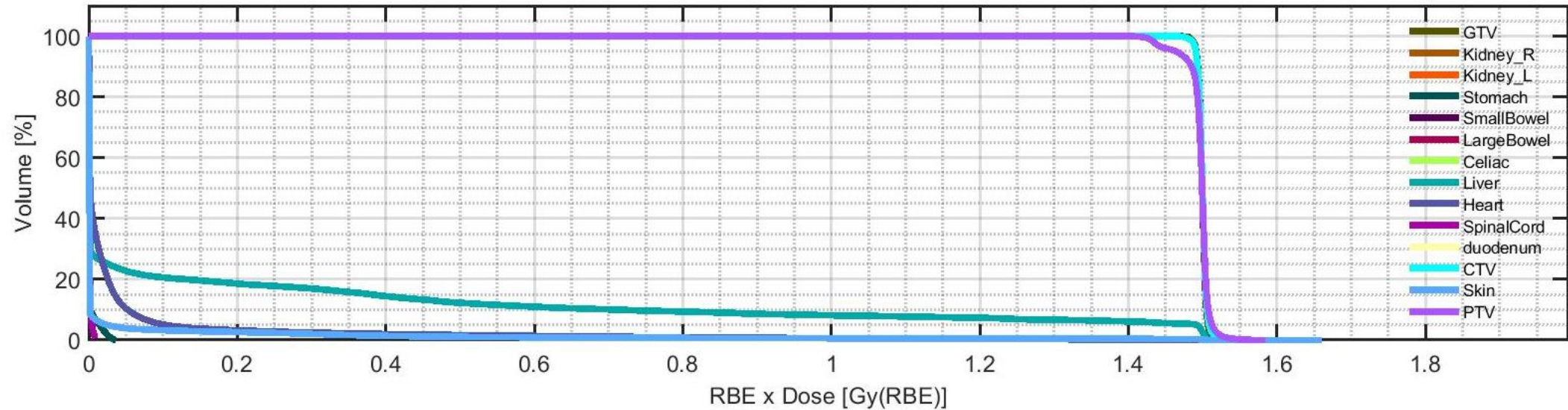
Info

v3.0.0 - edu

github.com/e0404/matRad

liver case-carbon ions

- Carbon Ions-DVH



	max	min	mean	std
GTV	1.5259	1.4732	1.4995	0.0051
Kidney_R	0	0	0	0
Kidney_L	0	0	0	0
Stomach	0.0379	0	0.0016	0.0054
SmallBowel	0	0	0	0
LargeBowel	0	0	0	0
Celiac	0	0	0	0
Liver	1.5398	0	0.1737	0.4086
Heart	1.5119	0	0.0332	0.1307
SpinalCord	0.0100	0	5.1405e-04	0.0016
duodenum	0	0	0	0
CTV	1.5529	1.4577	1.4998	0.0063
Skin	1.6614	0	0.0189	0.1258
PTV	1.5843	1.3888	1.4965	0.0165

Comparison

Photons

- “Give” most of their energy by the time they enter the body
 - Affect nearby tissues
- May be ineffective in destroying the tumor (less targeted)

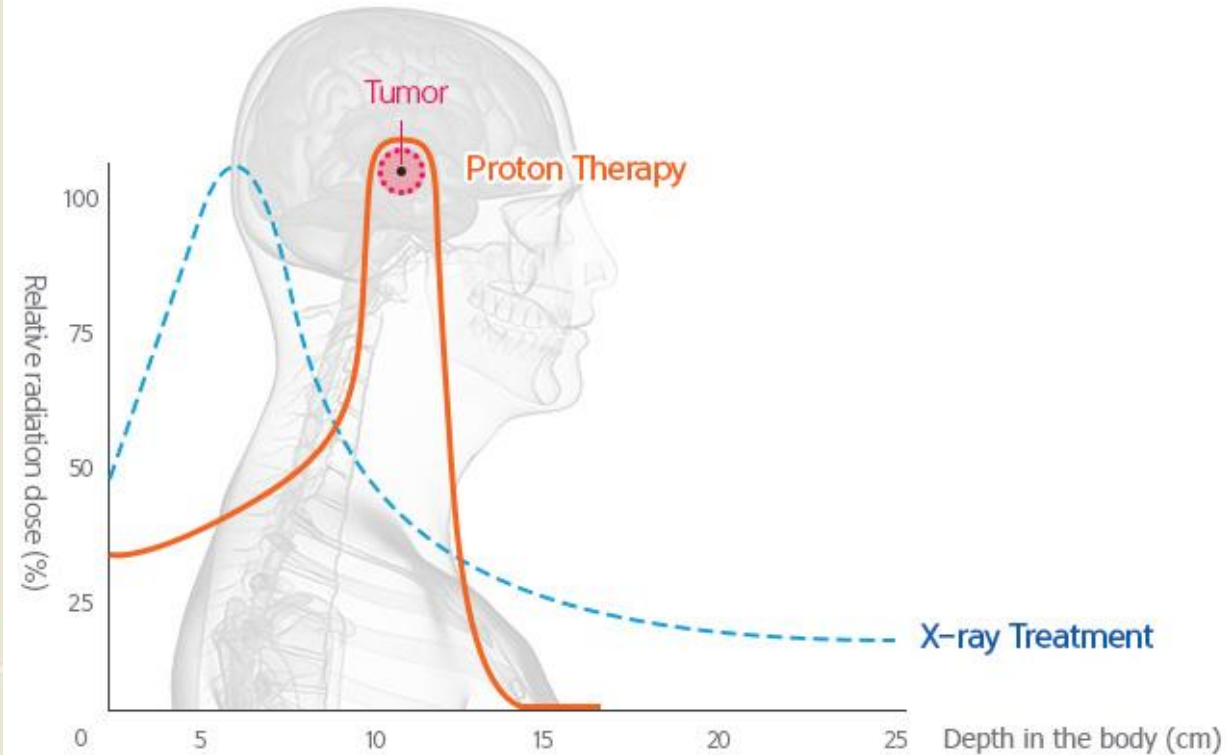
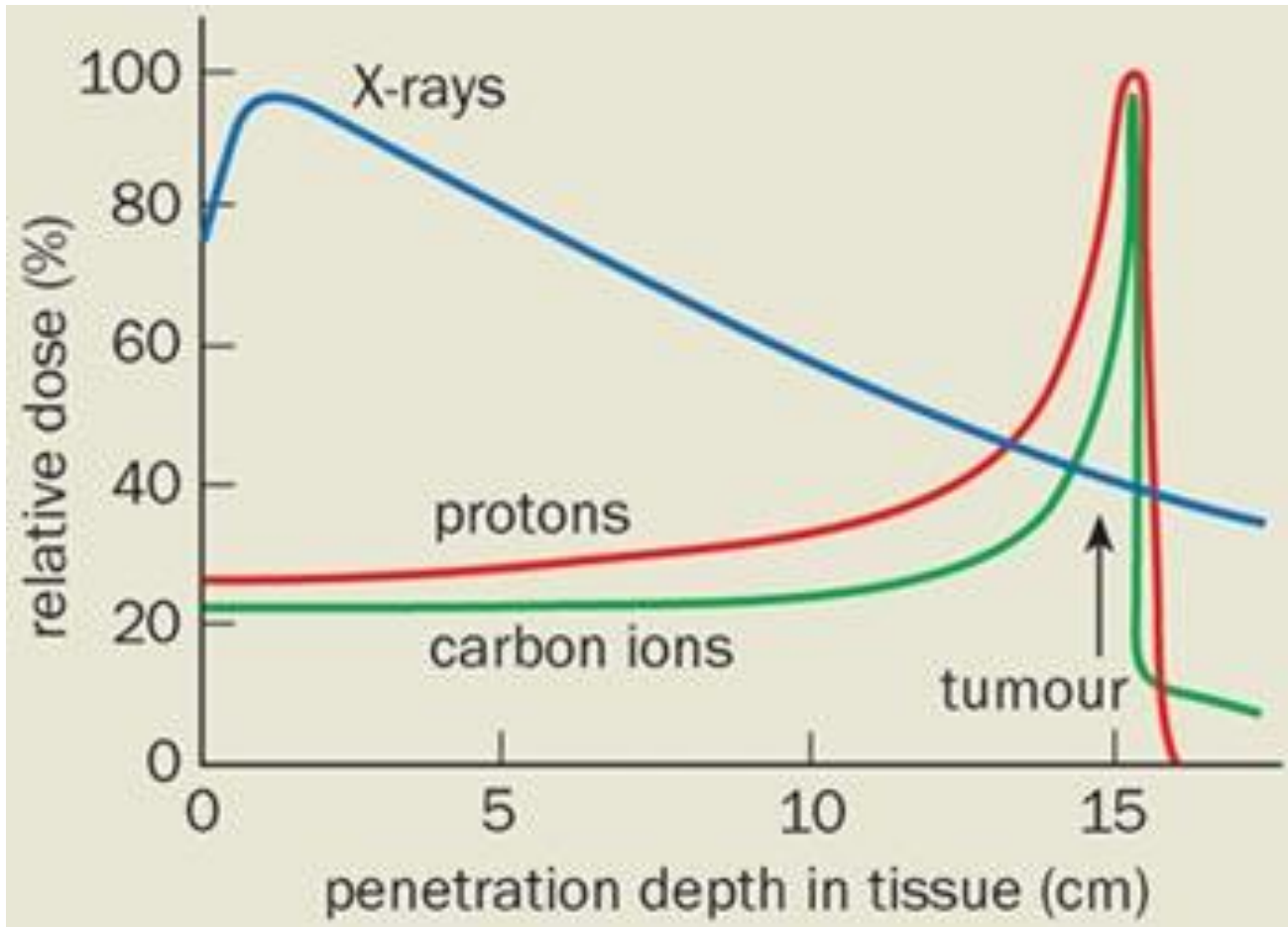
Protons

- “Give” most of their energy after entering the body, in a small concentrated area
- Targeted to the tumor

Carbon Ions

- “Give” most of their energy after entering the body, in a concentrated area
- However, part of their energy also spreads in a less concentrated area after the target-tumor, mildly affecting nearby tissues

Comparison





webpage creation

webpage creation

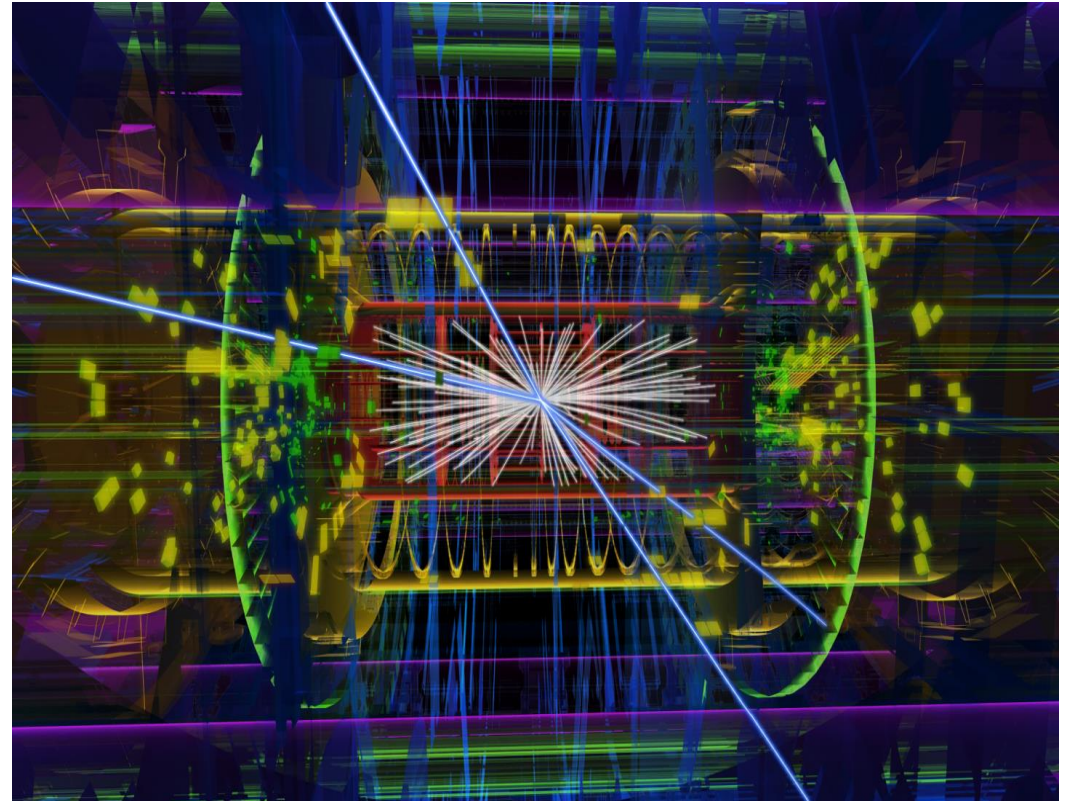
Danai

Triple "A" Programme (Astronomy and Astrophysics
in Athens) 2021



Nikos

TEST Nikolaos Fatouras



Danai

Triple "A" Programme (Astronomy and Astrophysics in Athens) 2021

19 Sep 2021, 10:00 → 21 Sep 2021, 23:00 Europe/Athens

Athens

Aristeidis Mamaras (Aristotle University of Thessaloniki (GR)), Danai Vasiloglou, Nikolaos Fatouras

Description The **Triple "A" Programme 2021** is a programme ideal for any european high school student who is interested in the fields of Astronomy and Astrophysics and wants to expand their knowledge whilst exploring one of the most culture-wise wealthy cities in the world: Athens!

Through various lectures and visits the students have the oppotunity to unravell the "mysteries" both of Athens and the universe!

The organising team is looking forward to welcome the Triple "A" Programme students here in Athens, Greece!

Triple "A" Programme Organising Team

- ✉ aristeidis.mamaras@cern.ch
- ✉ danai.vasiloglou@cern.ch
- ✉ nikolaos.fatouras@cern.ch
- ☎ +30 6900000000
- ☎ +30 6911111111
- ☎ +30 6922222222

SUNDAY, 19 SEPTEMBER

11:00 → 13:30 **Arrival Day: Welcome to Athens**

- 11:00 **Check-in** ⌚ 1h
- 13:00 **Receive town maps & Group photo** ⌚ 30m
Meeting point at the Reception Hall



08:30 → 10:30 **Breakfast time**

🕒 2h

11:00 → 13:00 **Welcome Presentation**



11:00 **Welcome to Athens**

🕒 45m 📍 Main auditorium

A warm welcome from the organising team and useful info for your stay

Speaker: Aristeidis Mamaras (Aristotle University of Thessaloniki (GR))

12:00 **Introduction to Astronomy: History of Astronomy**

🕒 1h 📍 Main auditorium

Speaker: Nikolaos Fatouras

13:00 → 15:00

Lunch Time

🕒 2h

19:00 → 23:00 **Time to explore!: Visits in Athens**



19:00 **Acropolis**

🕒 2h

Visit the Parthenon and the Acropolis Museum

TIP: Bring your cameras!!

21:00 **Thissio**

🕒 2h

Grab a bite from a traditional greek restaurant and go stargazing at Pnyx Hill ! (open the map and the food recommendation links below if you need help!)

TIP: Bring your cameras!!



Useful Links.docx



Useful Links.pdf

08:30	→ 10:30	Breakfast time	🕒 2h
11:00	→ 13:25	Lecture	📍 Main Auditorium
11:00		From Quarks to Cosmos: how did we get something from nothing?	🕒 1h 30m
		Speaker: Danai Vasiloglou	
12:45		European Southern Observatory (ESO)	🕒 40m
		Learn about the ESO and watch a related video on its greatest discoveries in the 21st century	
		Speaker: Nikolaos Fatouras	
		video link	
13:30	→ 15:30	Lunch Time 🕒 2h	
18:30	→ 21:00	Time to explore!: Visits in Athens	
		Get your bikes and get ready for a ride around Athens! A great treasure is waiting for you afterwards..!!	
		Bike route	
18:30		Riding and Sightseeing	🕒 1h 30m
		Regular stops will be made throughout the ride in order to familiarise with the different areas we visit along the way.	
		TIP: Bring your cameras!!	
		Speakers: Aristeidis Mamaras (Aristotle University of Thessaloniki (GR)), Danai Vasiloglou, Nikolaos Fatouras	
20:00		Picnic time	🕒 1h
		Get some food from Mavili Square and gather at Parko Eleftherias next to Megaron Mousikis. Have a nice Picnic time!	
21:00	→ 22:30	BONUS! : STARGAZING	
		Watch the night night sky and identify as many constellations and stars as possible! See yourself getting to know the night sky better and better.	
		Conveners: Aristeidis Mamaras (Aristotle University of Thessaloniki (GR)), Danai Vasiloglou, Nikolaos Fatouras	
22:00		FUN FACTS: Sun	🕒 30m
		Get some very interesting info while watching the night sky	

TEST Nikolaos Fatouras



Sunday 19 Sep 2021, 10:00 → 16:00 Europe/Zurich

CERN

Description Dear user,

Welcome to your weekly test!

This event has the potential to help you consolidate the knowledge that you acquired from our Masterclasses. Then you will have the opportunity to see your results and understand in which of the topics you are not at the desired level.

The test will provide you with invaluable knowledge, which -for sure- is going to broaden your knowledge on Particle Therapy and give you a better view on how Particle Physics work.

If all of your answers are correct, it would be a pleasure for us to contribute to our schools and be a part of our ambitious team. Your help is decisive for our exploring the benefits and new potential techniques for Particle Cancer Therapy.

Let's start!

10:00 → 10:45

First Meeting

45m



Introduction to Particle Therapy, its aim and first Q&A.

We will provide you with slides that we recommend you to read in order to have the first contact with this field and carry through the upcoming test.

Speaker: Nikolaos Fatouras

10:45 → 12:15

Discover Particle Physics!



In this sector, you will be taught about the basic principles of Nuclear Physics!

What about quarks and the forces that restrain them? How electrons do not crash down into the nucleus?

10:45

The fantastic world of Quarks

45m



Speaker: Danai Vasiloglou

11:30

Discoveries that changed our comprehension of the universe

45m



In this topic, you will receive an e-booklet with all the necessary information and pictures that will help you understand the structure of atoms according to 20th-century data.

Speaker: Nikolaos Fatouras

12:15 → 13:00

Lunch

🕒 45m

13:00 → 13:45

Discover Particle Physics!



In this sector, you will be taught about the basic principles of Nuclear Physics!
What about quarks and the forces that restrain them? How electrons do not crash down into the nucleus?

Convener: Nikolaos Fatouras

13:00

An attempt to concentrate all theories in one: The Theory of Everything

🕒 45m



All long, Physicists are trying to conjoin all theories and equations in one. But since the early days of Physics, this is still a big dream of everybody. Forces like electromagnetic, strong and weak nuclear forces and gravity are so different, but also they seem to be interdependent and have a common point of contact. How the discovery of the Higg's boson contributed to this belief?

Speaker: Nikolaos Fatouras

13:45 → 14:45

Partcle Physics and Medicine

🕒 1h



The different discoveries in the field of Particle and Fundamental Physics have countless of applications on Medicine. Our goal is to find constantly new ways to treat cancer, through the knowledge that has been offered to us from research.
In this sector, you are going to learn about different applications of Particle Physic's discoveries on Medicine (e.g. PET scanning, proton and carbon-ion cancer therapy and their difference with conventional photon (X-ray) therapy.
We aim to give you a first glimpse of the software that is been used for cancer treatment planning and to familiarize you with that.

Speakers: Aristeidis Mamaras (Aristotle University of Thessaloniki (GR)) , Danai Vasiloglou, Nikolaos Fatouras

14:45 → 16:00

Test

🕒 1h 15m



It's time to apply the knowledge you acquired today on the test. Once you successfully finish the test, there will be a special gift waiting for you. Then, you will follow all the required procedures to be a part of our team.

BIBLIOGRAPHY

- https://www.google.com/search?q=radiation+therapy&sxsrf=AOaemvlduQDlCbsYMs9jc5mqrX1WdnRLMg:1632388446454&source=lnms&tbm=isch&sa=X&sqi=2&ved=2ahUKEwjXw_Hr4JTzAhWmQfEDHVEYAnYQ_AUoAXoECAEQAw&biw=1536&bih=722&dpr=1.25#imgrc=cQrIP4qaBck3ZM

<https://www.dekade-gegen-krebs.de/de/deutsches-krebsforschungszentrum-heidelberg-dkfz-1711.html>

https://docs.google.com/presentation/d/1N2IFX3Ziih4sKjzmDcgLI3_JefL4A8BB/edit#slide=id.p1

https://docs.google.com/presentation/d/1AC7BPNYCC1WhaXdCqifkr8Gj3vJb6Wz5/edit#slide=id.g8b7a159b69_0_170

https://www.google.com/search?q=dose+volume+histogram&sxsrf=AOaemvKGrxOC0c3MYN4s4biVCx0JqckMSw:1632413382894&source=lnms&tbm=isch&sa=X&ved=2ahUKEwjQhMHevZXzAhXK-KQKHamwCvMQ_AUoAXoECAEQAw&biw=1536&bih=722&dpr=1.25#imgrc=tcEUOkQItU9RvM

https://www.google.com/search?q=dose+volume+histogram&sxsrf=AOaemvKGrxOC0c3MYN4s4biVCx0JqckMSw:1632413382894&source=lnms&tbm=isch&sa=X&ved=2ahUKEwjQhMHevZXzAhXK-KQKHamwCvMQ_AUoAXoECAEQAw&biw=1536&bih=722&dpr=1.25#imgrc=tcEUOkQItU9RvM&imgdii=s14ksmuWbzOSSM

https://www.google.com/search?q=cern+logo&sxsrf=AOaemvK3xYXcJZSvAh0cHEjRNLOUNwcaxA:1632382008771&source=lnms&tbm=isch&sa=X&sqi=2&ved=2ahUKEwiun5TuyJTzAhU6F1kFHVzFBXkQ_AUoAXoECAEQAw&biw=1536&bih=722&dpr=1.25#imgrc=1TnrrXP83uCSiM

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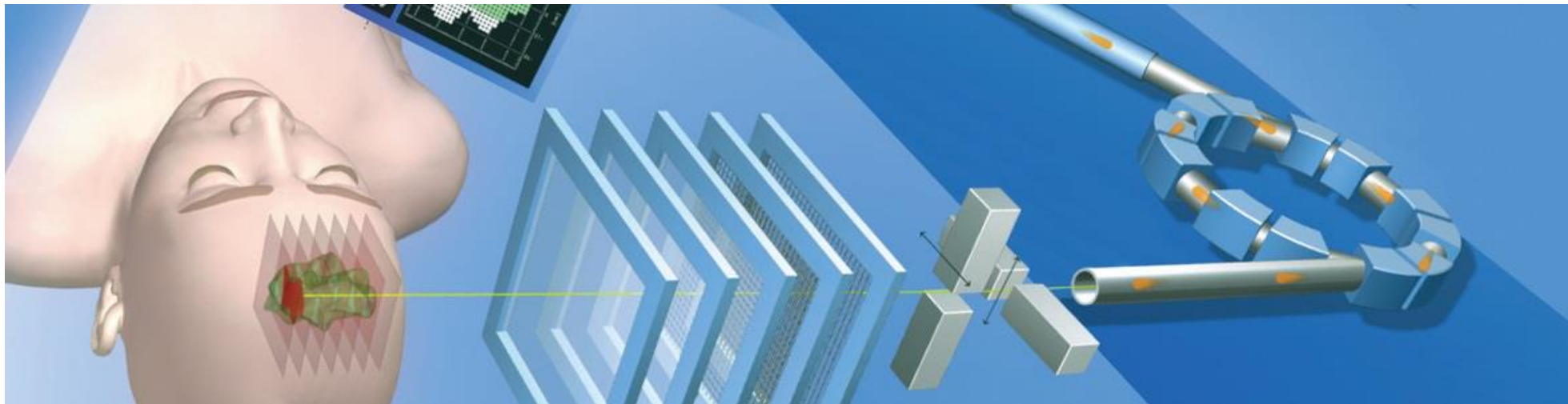


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THANK YOU FOR YOUR
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BACK UP

Useful Concepts

- DVH \rightarrow *Dose-Volume Histogram*

