23 May 2019

IPPOG
Steering Group Meeting

Particle Therapy MasterClass

Overview & Pilot Report

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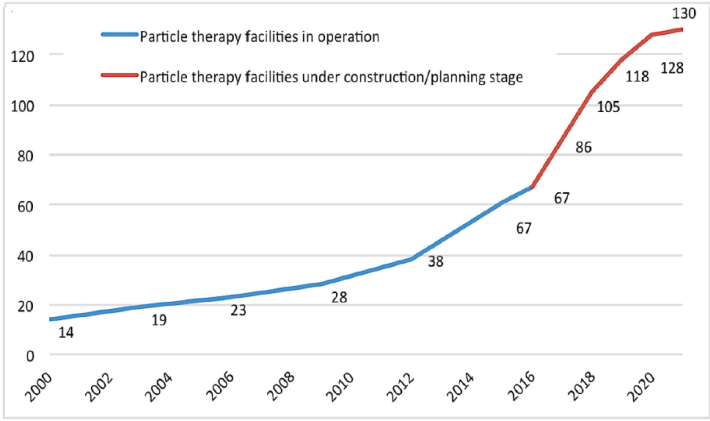
German Cancer Research Center – DKFZ

MasterClass on Particle Therapy – Why?

- Show students that particle physics is not only fundamental research, but can also be ***applied***

  → fundamental research spawns “real life” applications



- Particle therapy has left the experimental stage and is clinically established

- Cancer is a widespread disease (2012: 14e6 new cases, 50% mortality 10y)

  → almost everybody will be somehow affected (family, friends, etc.)

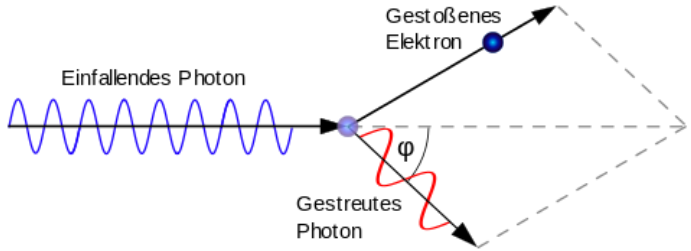
- The nature of cancer is often not well explained / understood at school level

Pilot MasterClass on Particle Therapy at DKFZ, April 5th – Schedule

Participants: 17 students (age 16-18) from the Heidelberger Life Science Lab

- 9:15 – 11:30: Lectures on **physics background & treatment planning**
- 11:30 – 12:15: Lunch
- 12:30 – 13:30: Visit (in Heidelberg: HIT)
- 14:00 – 16:00: Hands-on Particle Treatment Planning
- 16:00 – 16:30: Internal discussion of results
- 16:30 – 17:00: Video conference (with GSI & CERN)

Introductory Lectures



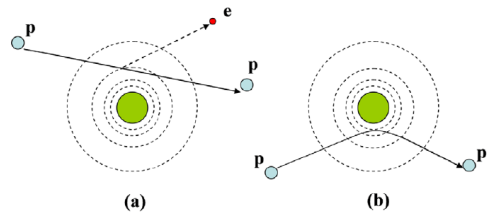
1st lecture – **From particle physics to radiation dose**

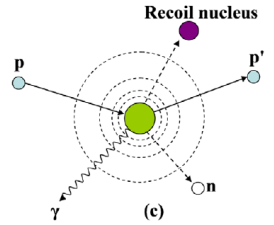
- What is cancer? How can we treat it? Why radiation therapy?
- What is radiation dose?

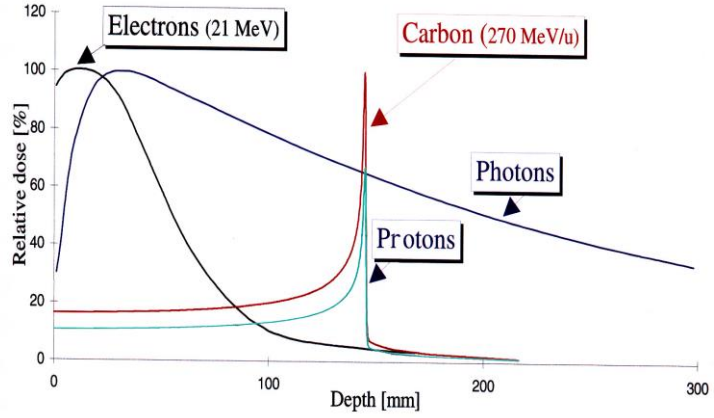
  → Interactions of particles with matter

  → different types of radiation (photons vs. charged particles)
- How do we produce radiation dose clinically?

  → accelerators (LINACs, synchrotrons, cyclotrons?)





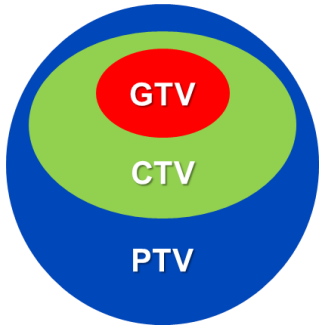


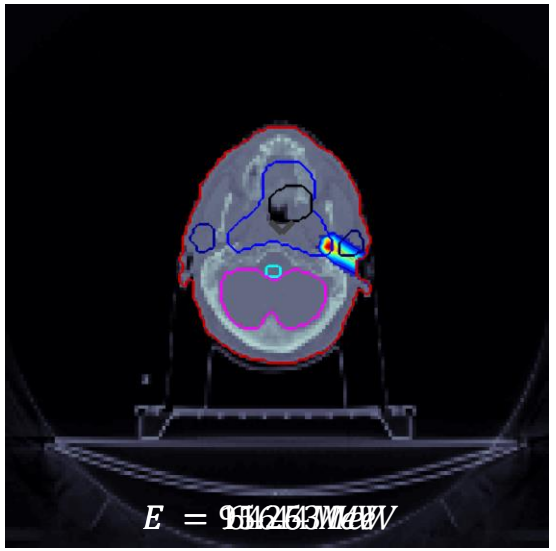
Depth in the body (mm)

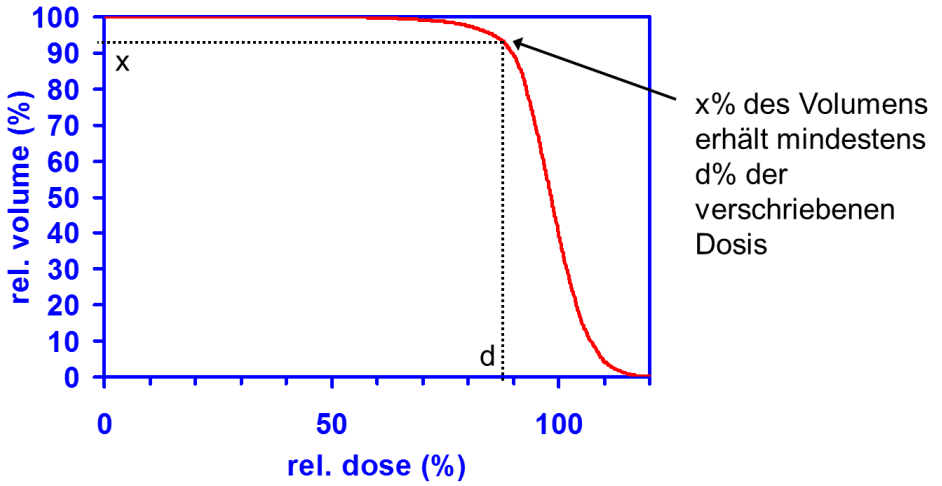
Introductory Lectures

2nd lecture – **Treatment Planning**

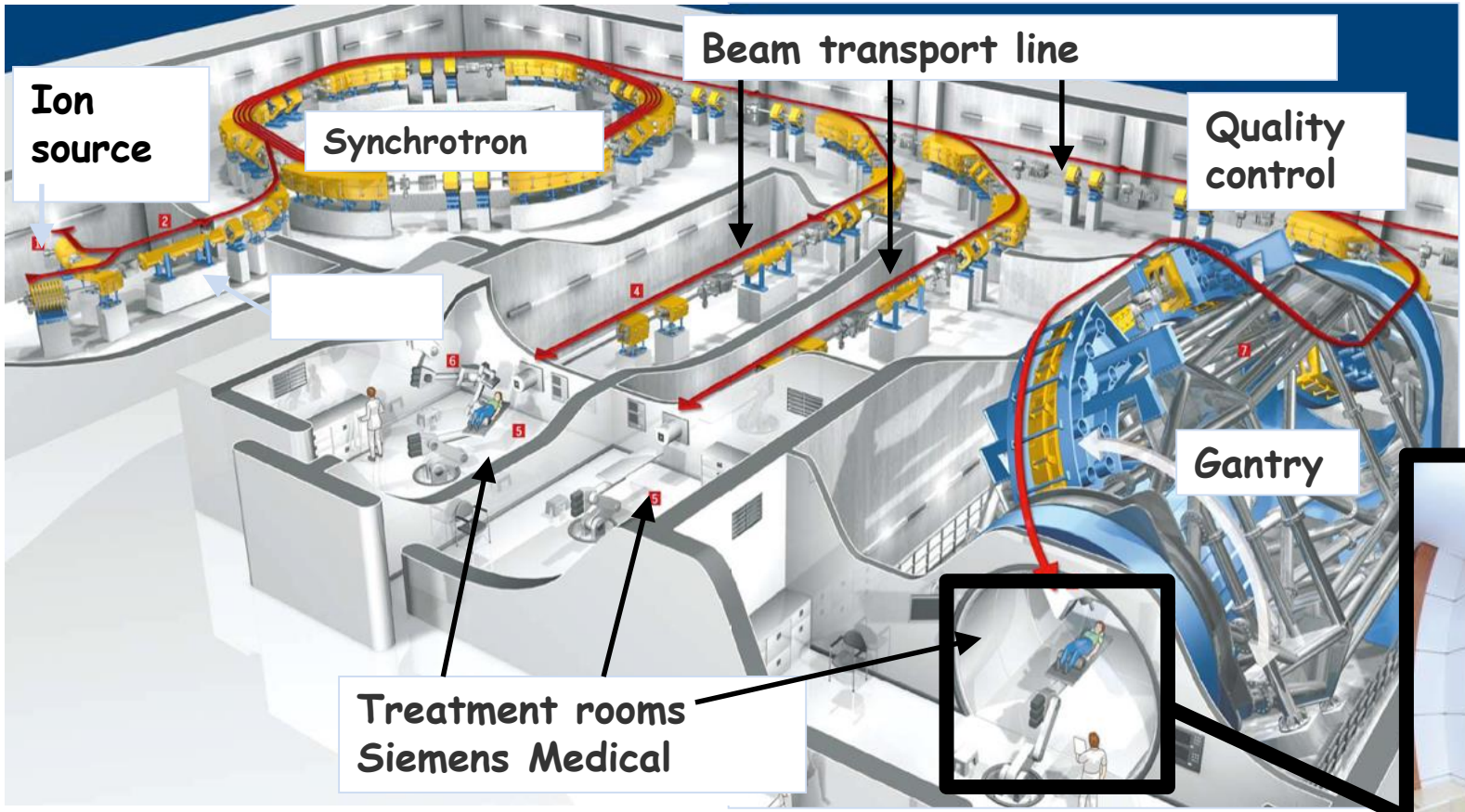
- How do we see inside the body? → Imaging (CT)
- How do we find the tumor? → Segmentation
- **How do we plan the treatment?**
  - How do we calculate dose?
  - How do we optimize dose?
  - How do we evaluate the treatment plan?







Visit – Heidelberg Ion Therapy Center (HIT)



First carbon ion facility with 360 degree gantry
(First patients in 2009)

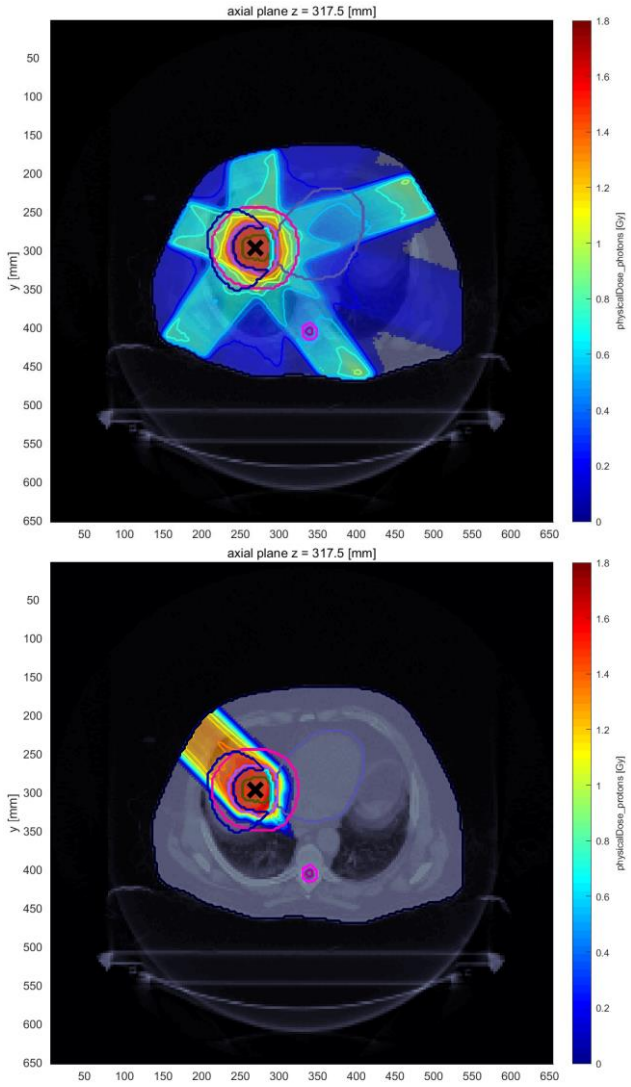
Measurement: Hands-On Treatment Planning

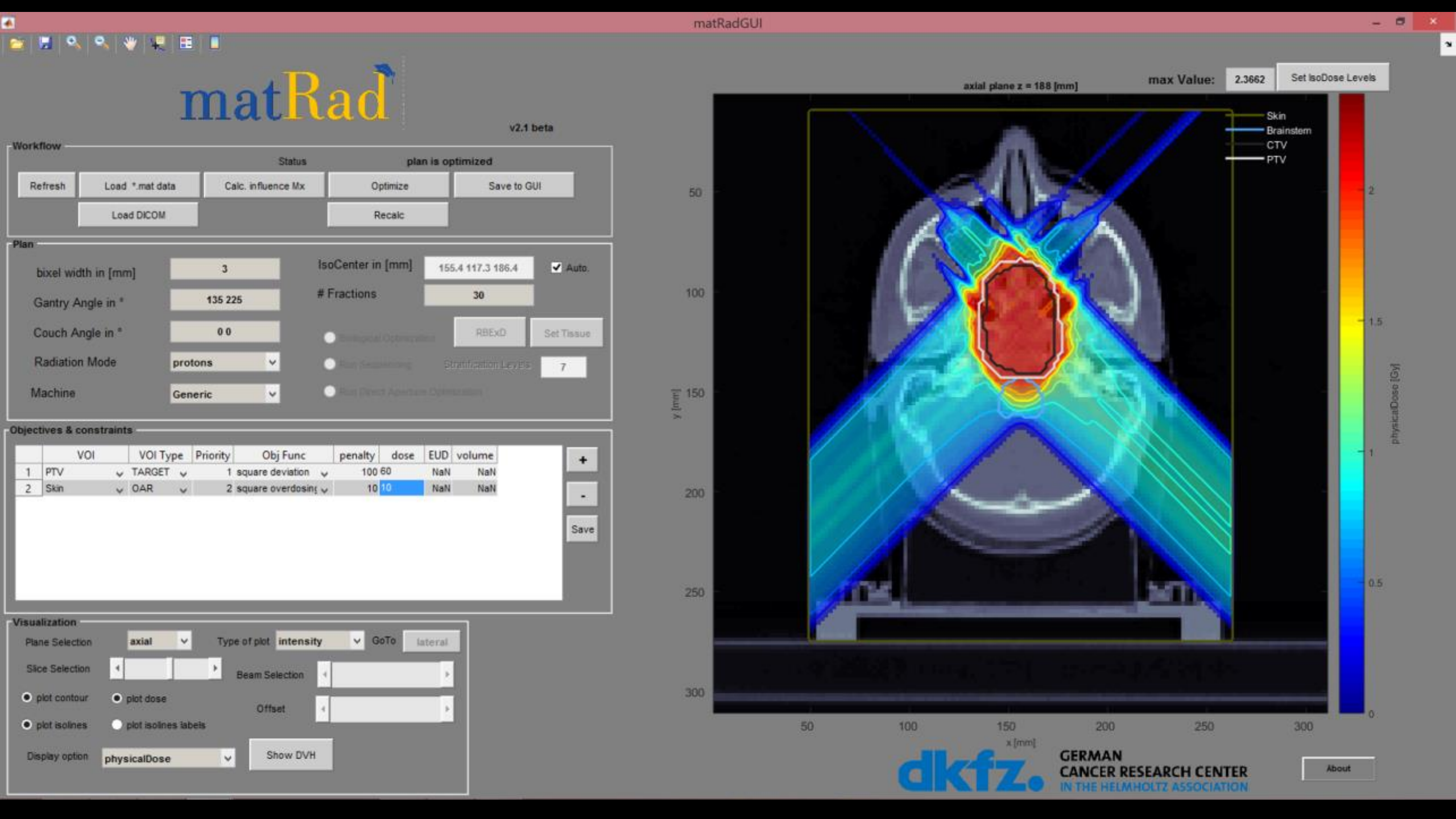
- Based on our Matlab open source toolkit matRad

  → simplified MasterClass version compiled as standalone software

  1. Treatment planning with photons
  2. Treatment planning with protons & carbon ions

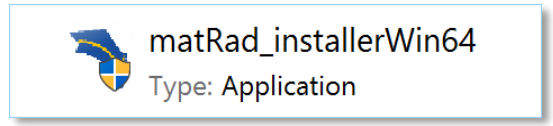
     → show advantage of particle treatment plans
  3. Difficulties of particle therapy planning
     - biological treatment planning
     - impact of uncertainties




matRadGUI
matRad
v2.1 beta
Workflow
Status
plan is optimized
Refresh
Load *.mat data
Calc. influence Mx
Optimize
Save to GUI
Load DICOM
Recalc
Plan
bixel width in [mm]
3
IsoCenter in [mm]
155.4 117.3 186.4
Auto.
Fractions
30
Gantry Angle in °
135 225
Couch Angle in °
0 0
RBExD
Set Tissue
Radiation Mode
protons
Stratification Levels
7
Machine
Generic
Objectives & constraints
VOI
VOI Type
Priority
Obj Func
penalty
dose
EUD
volume
1 PTV TARGET 1 square deviation 100 60 NaN NaN
2 Skin OAR 2 square overdosing 10 10 NaN NaN
+
-
Save
Visualization
Plane Selection
axial
Type of plot
intensity
GoTo
lateral
Slice Selection
Beam Selection
plot contour
plot dose
Offset
plot isolines
plot isolines labels
Display option
physicalDose
Show DVH
axial plane z = 188 [mm]
max Value:
2.3662
Set IsoDose Levels
Skin
Brainstem
CTV
PTV
y [mm]
x [mm]
physicalDose [Gy]
50
100
150
200
250
300
0
0.5
1
1.5
2
GERMAN
CANCER RESEARCH CENTER
IN THE HELMHOLTZ ASSOCIATION
About

matRad - an open-source toolkit for dose calculation and optimization

- 3D dose calculation
  - Photons: Singular value decomposed pencil beam algorithm
  - Protons: Pencil beam algorithm
  - Carbon ions: Pencil beam algorithm & RBE computation
- Dose optimization
  - Photons: Physical dose optimization
  - Protons: Fixed RBE (1.1) dose optimization
  - Carbon ions: Variable RBE dose optimization
- GUI for visualization and analysis and standalone



- Base data

  Example patient data (CORT data set) & DICOM Import

  Physical & biological base data for a photon LINAC, a proton machine, and a carbon ion machine

www.matrad.org

Acknowledgements

GERMAN CANCER RESEARCH CENTER IN THE HELMHOLTZ ASSOCIATION

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Particle Therapy MasterClass – Survey Results

- How much did you enjoy the masterclass? (1 to 5):

  Average: **4.8 ± 0.4**

- How easy or difficult was the masterclass? (1 to 5):

  Average: **2.6 ± 0.5**

- Favorite parts:

  1. Tour
  2. Hands-On Treatment Planning with matRad
  3. Introductory Lectures