University of Zurich[UZH] | USZ Universitäts Spital Zürich

Exercise class – Ex10

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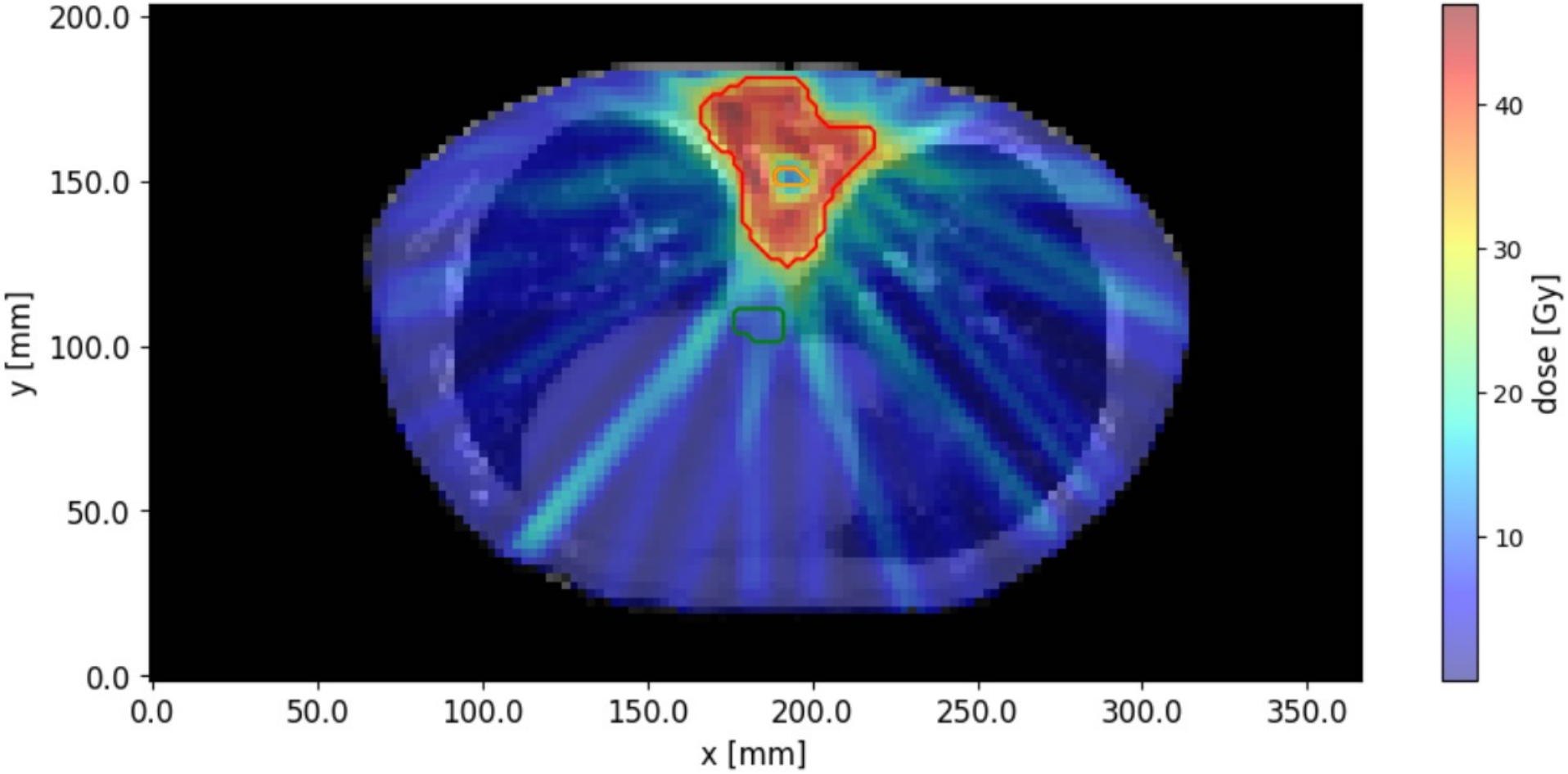
Exercise 8

Well solved!



General Remarks

Penalties are usually normalised by number of voxels in that organ!

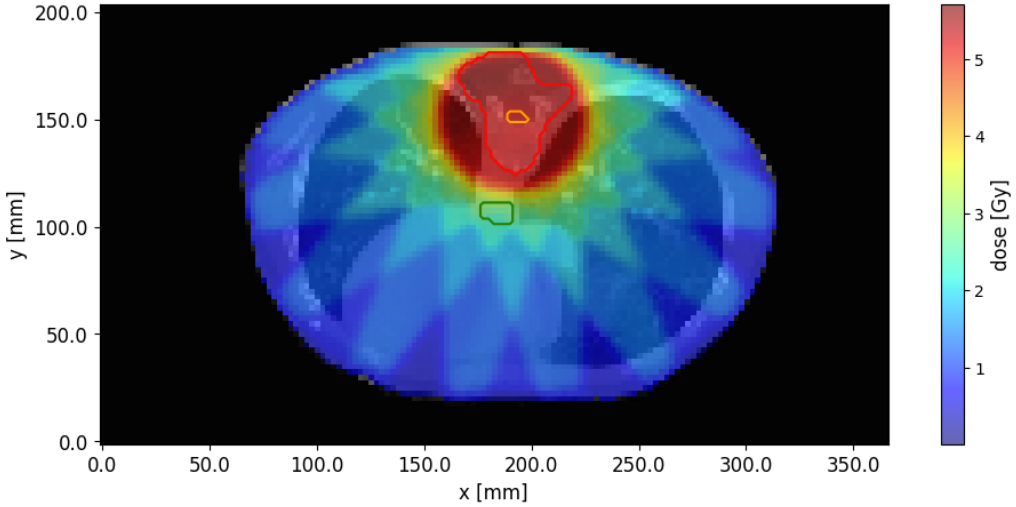
```
# spinal cord
TPopt['vois'][4] = {
    'name': 'spinal cord',
    'nVoxels': np.sum(voi == 4),
    'maxdose': 20.0,
    'overdosepenalty': 30.0,
    'mindose': 0.0,
    'underdosepenalty': 0.0,
}
```

```
for voi_index, voi_params in TPopt['vois'].items():
    mask = (voi == voi_index)
    maxdose[mask] = voi_params['maxdose']
    mindose[mask] = voi_params['mindose']
    overdosepenalty[mask] = voi_params['overdosepenalty'] / voi_params['nVoxels']
    underdosepenalty[mask] = voi_params['underdosepenalty'] / voi_params['nVoxels']
```

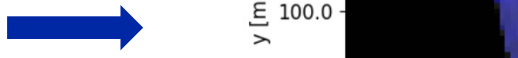
Student solution for ex. 8

Exercise 9

Fluence map optimization with hard constraints!



Optimize fluence of beamlets F_j



subject to:

$d_i \leq U_i^{max}$

$F_j \geq 0$

Any questions regarding ex.9?

Exercise 10

Implement proton treatment plan optimization!

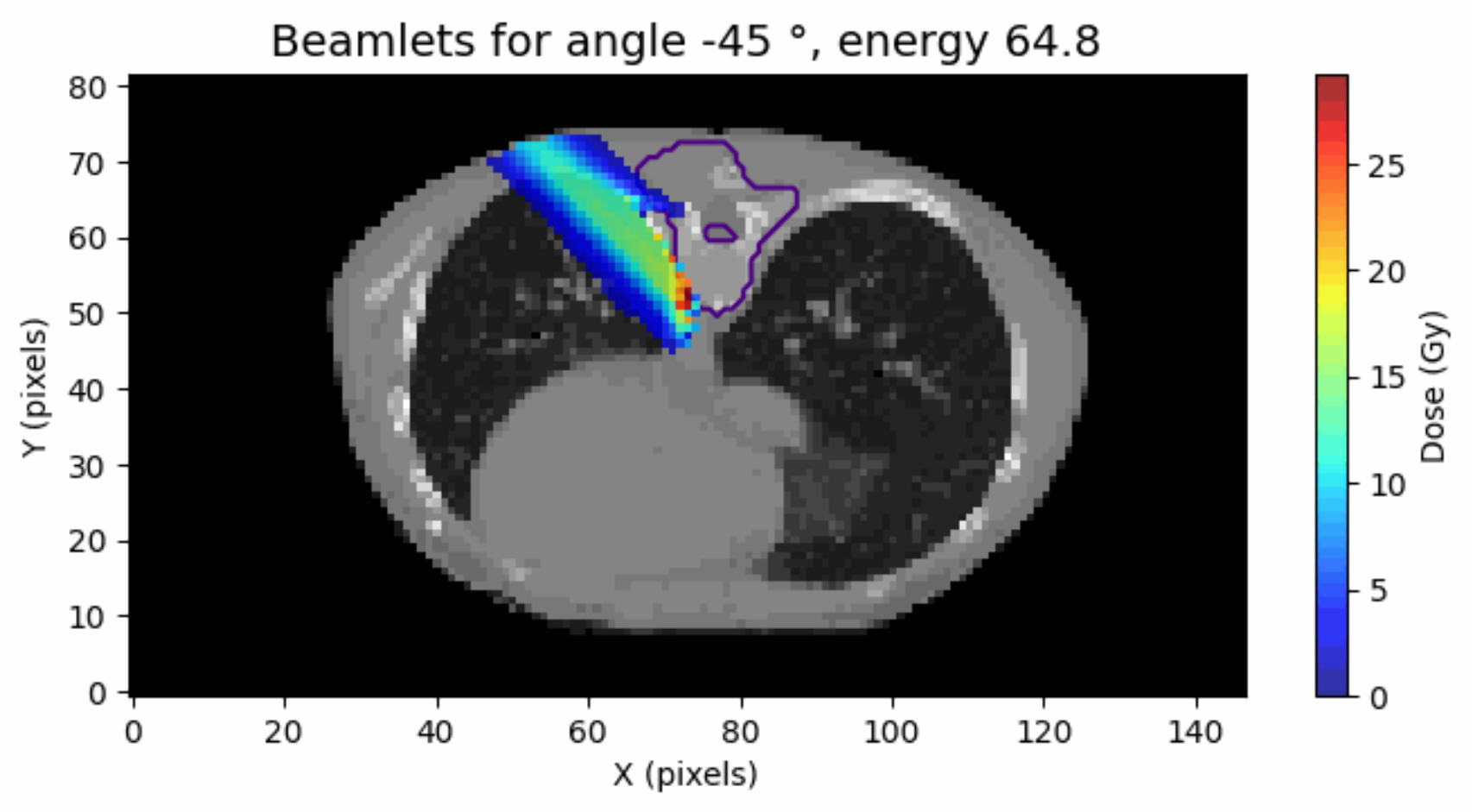
Step 1: Create dose-influence matrix (Dij) for IMPT optimization

- Place beamlets **5mm** apart (equivalent to photons)
- Use **3** beams with **angles - 45, 0, 45**

Now need to determine right proton energies!

Exercise 10

Determine energies for which the Bragg peak falls within the target volume!



Exercise 10

How to find right energies?

- Simple approach: For each beam angle determine determine the minimum and maximum radiological depth in the target volume. Then include all energies that fall into that range

- ‘Hard’ approach: For each lateral beamlet position perform raytracing, to determine the depths that need to be covered by the beamlets.

→ **Initialise a single beamlet for each energy.**

Exercise 10

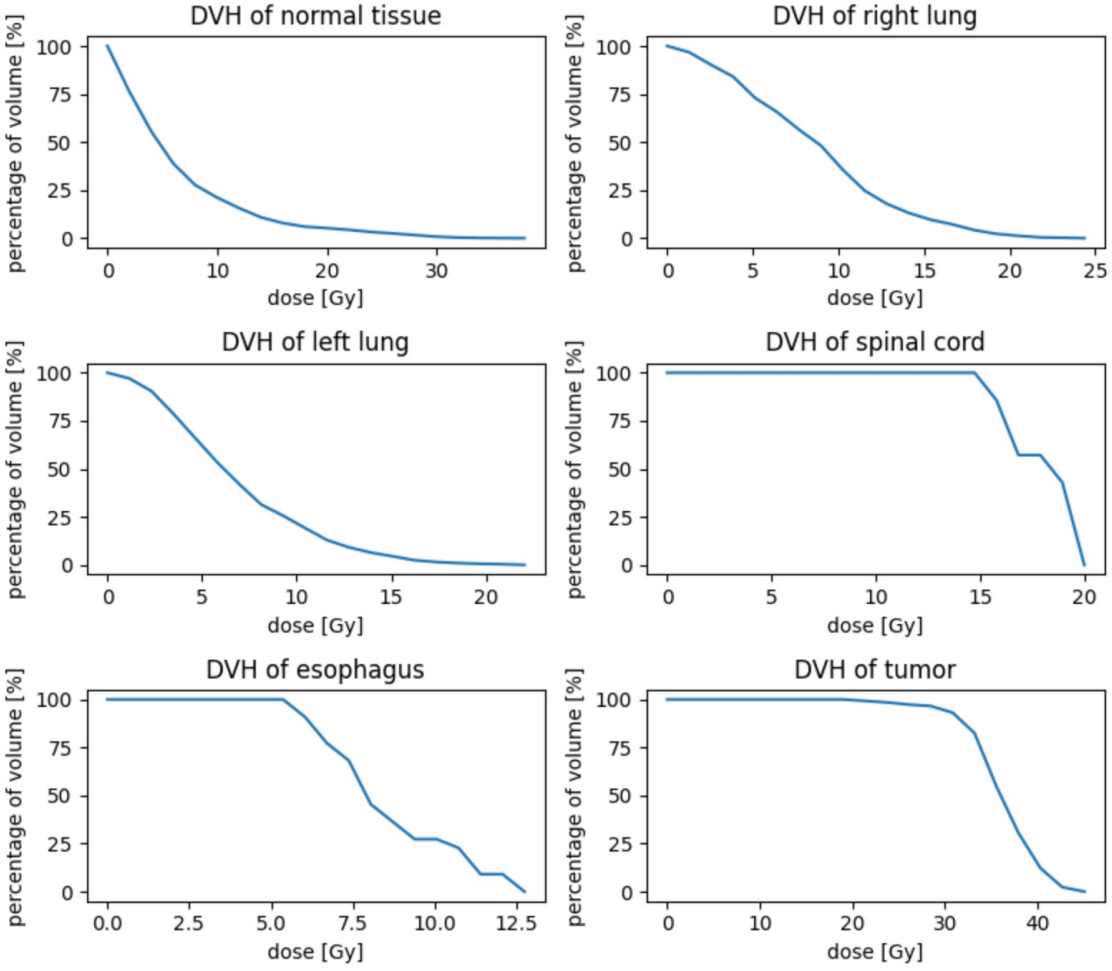
Step 2: Comparative treatment planning

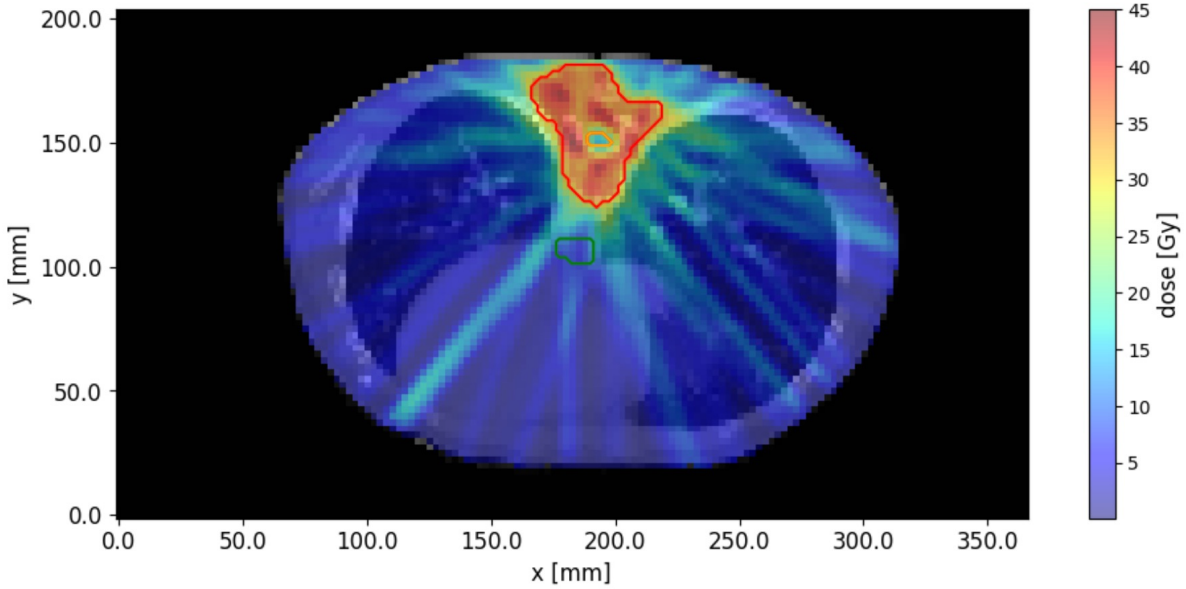
For both photons and protons:

- Optimize fluence of beamlets to obtain dose distribution
- Compute DVHs for all structures (use `scipy.stats.ecdf`)

→ Compare them to each other!

Exercise 10 – Photon plan





Exercise 10 – Proton plan