



University of  
Zurich <sup>UZH</sup>

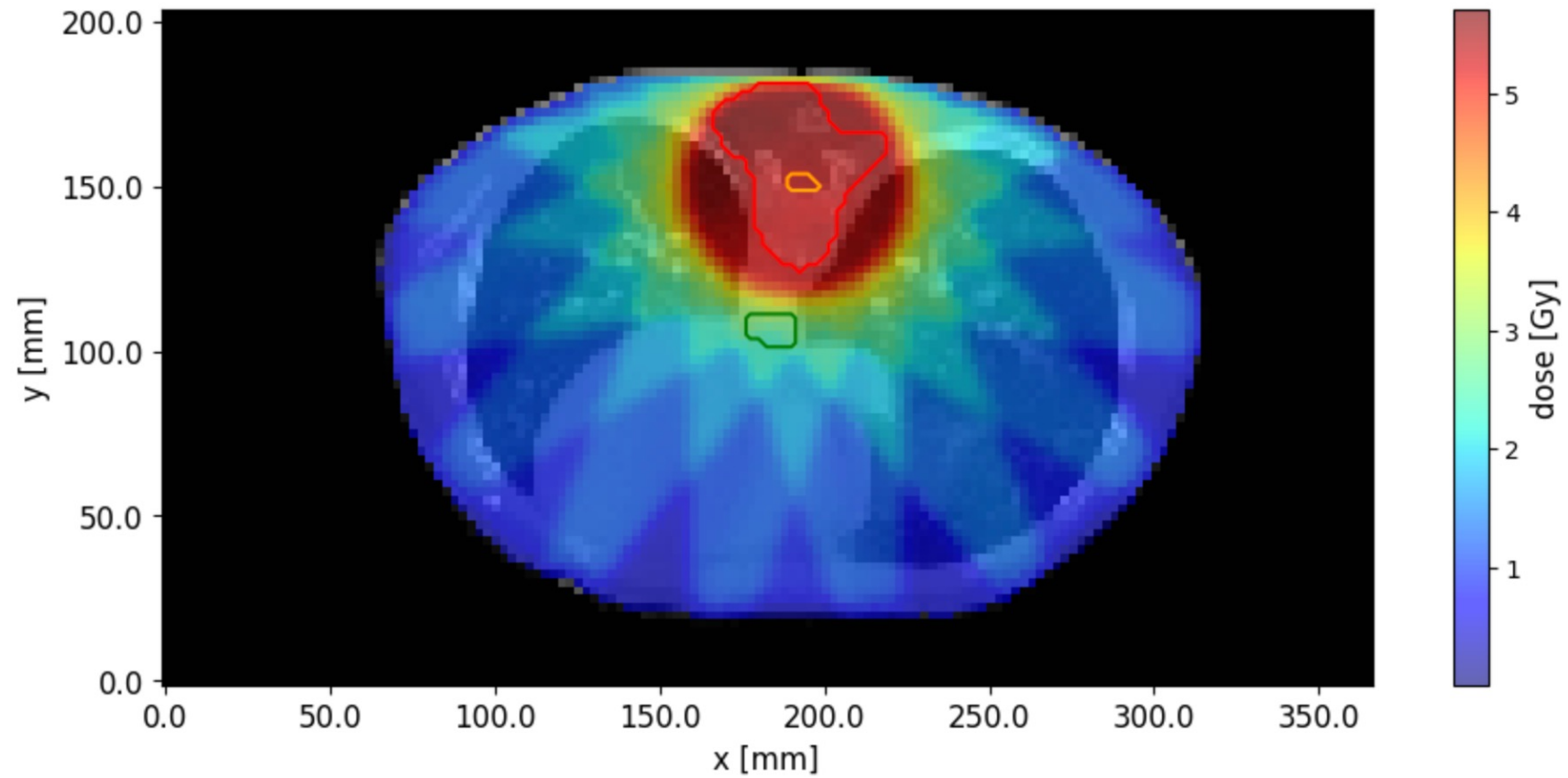
**USZ** Universitäts  
Spital Zürich

# Exercise class – Ex9

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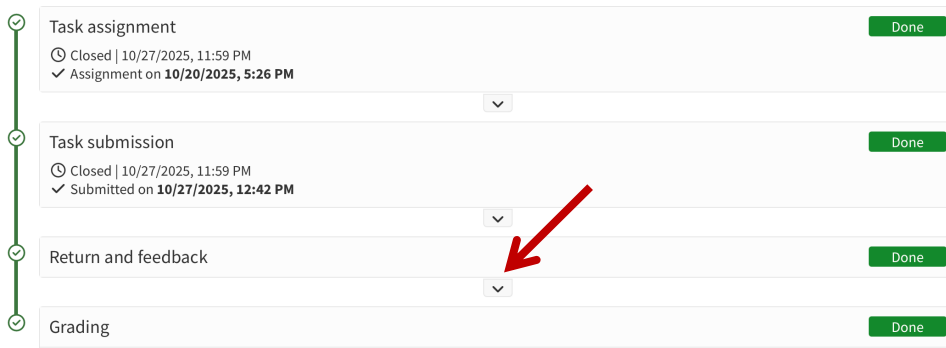
## Exercise 7

Well solved!



# General Remarks

- Add a **colorbar** to your plot!
- Check if I left any **comments**, even though the solution was accepted.



This screenshot shows a vertical timeline of task stages. The stages are: Task assignment, Task submission, Return and feedback, and Grading. Each stage has a 'Done' button. A red arrow points to the 'Return and feedback' section, which contains a dropdown arrow indicating it can be expanded.

Task assignment

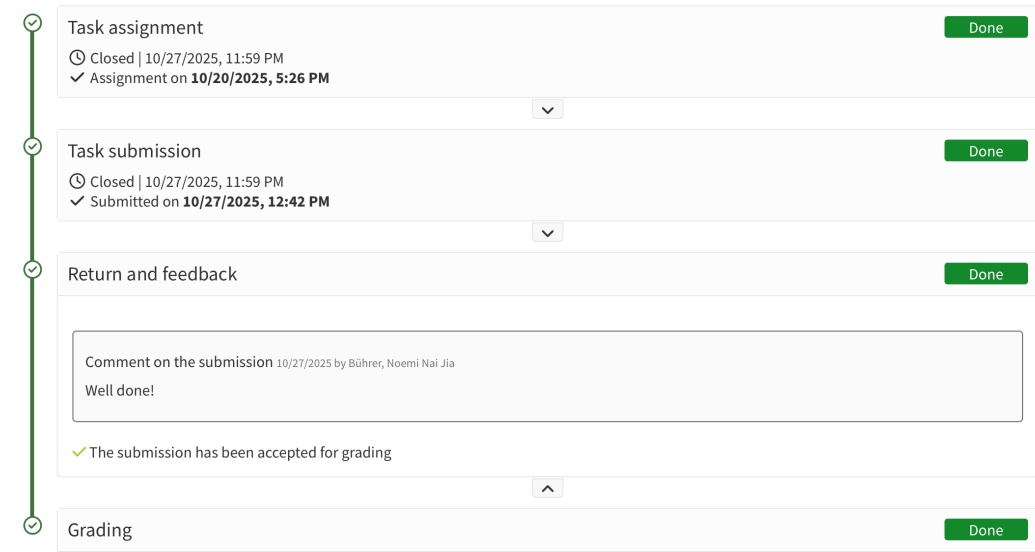
Closed | 10/27/2025, 11:59 PM  
✓ Assignment on 10/20/2025, 5:26 PM

Task submission

Closed | 10/27/2025, 11:59 PM  
✓ Submitted on 10/27/2025, 12:42 PM

Return and feedback

Grading



This screenshot shows the expanded 'Return and feedback' section. It displays a comment on the submission and a confirmation message. The comment is: 'Comment on the submission 10/27/2025 by Bühner, Noemi Nai Jia Well done!'. Below the comment, it says: '✓ The submission has been accepted for grading'.

Task assignment

Closed | 10/27/2025, 11:59 PM  
✓ Assignment on 10/20/2025, 5:26 PM

Task submission

Closed | 10/27/2025, 11:59 PM  
✓ Submitted on 10/27/2025, 12:42 PM

Return and feedback

Comment on the submission 10/27/2025 by Bühner, Noemi Nai Jia  
Well done!

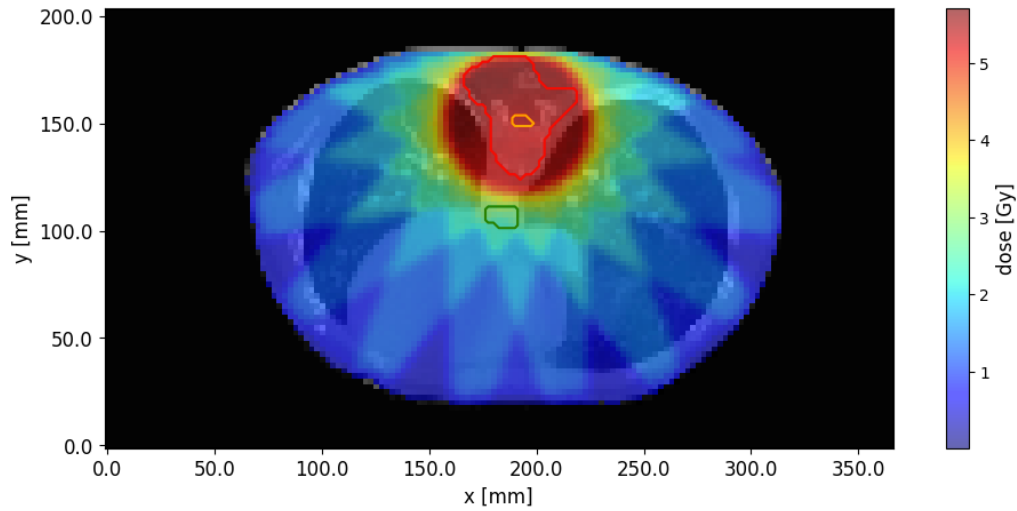
✓ The submission has been accepted for grading

Grading

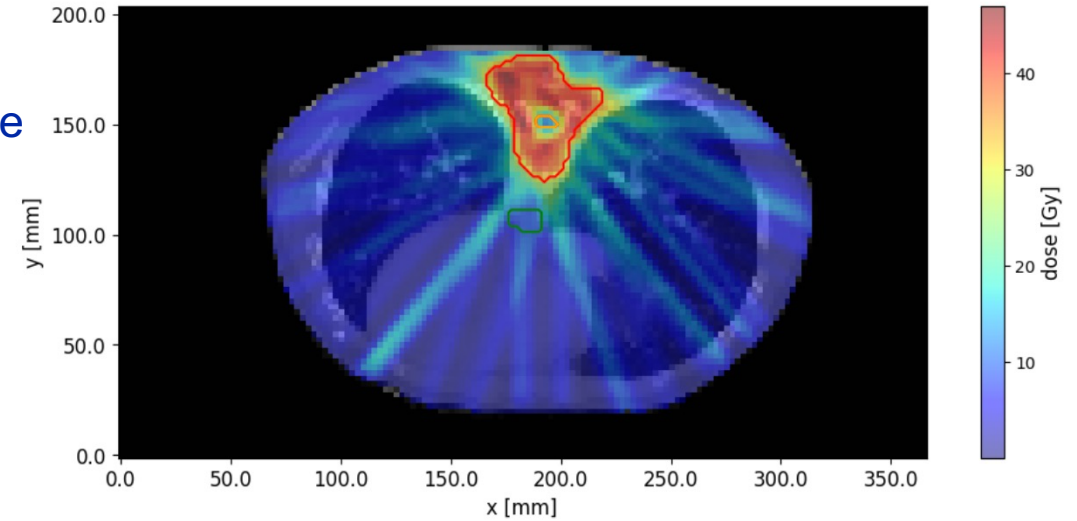
## **Student solution for ex. 7**

## Exercise 8

Implement IMRT fluence map optimization algorithm!



Optimize fluence  
of beamlets  $F_j$



Any questions regarding ex.8?

## Exercise 9

### Implement fluence map optimization with hard constraints!

Use `scipy.optimize.minimize` to solve a treatment plan optimization problem of the form

$$\text{minimize} \quad \sum_i w_i^o (d_i - D_i^{max})_+^2 + \sum_i w_i^u (D_i^{min} - d_i)_+^2 \quad (1)$$

$$\text{subject to} \quad d_i \leq U_i^{max} \quad (2)$$

$$F_j \geq 0 \quad (3)$$

### `minimize(method='SLSQP')`

`minimize(fun, x0, args=(), method=None, jac=None, hess=None, hessp=None, bounds=None, constraints=(), tol=None, callback=None, options=None)`

Minimize a scalar function of one or more variables using Sequential Least Squares Programming (SLSQP).

## Exercise 9

### Hints

1. Use the SciPy documentation of `scipy.optimize.minimize` to learn how to use the function.
2. Use the method `SLSQP`, this allows you to define constraints and bounds.
2. Maximum dose constraints represent linear inequality constraints.
3. The non-negativity constraints represent bounds for the optimization variables.
4. In addition to the objective function, also provide the gradient to `scipy.optimize.minimize`. This can be done via the input parameter 'jac'.

## Exercise 9 – What we expect!

