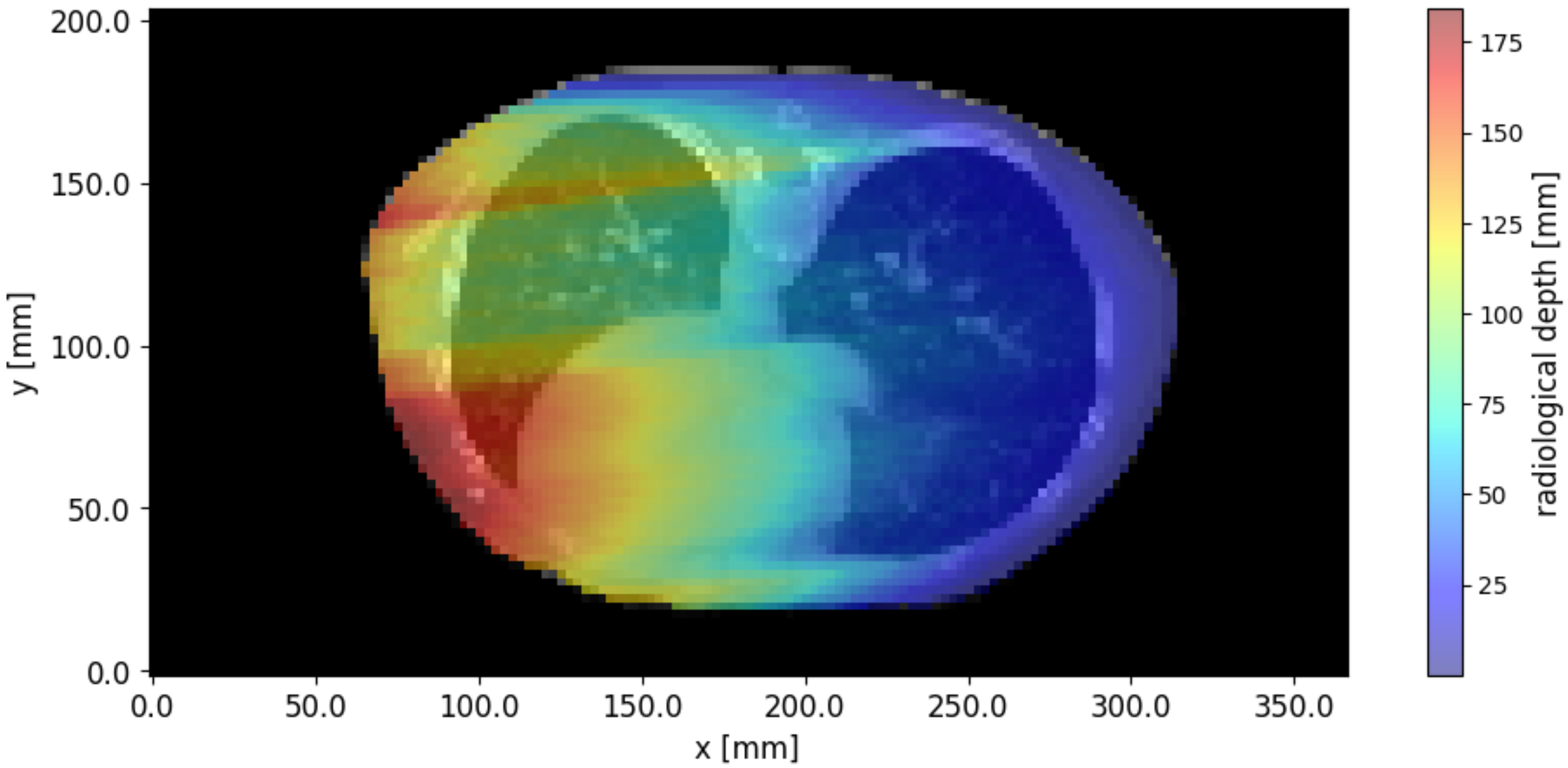
Exercise class – Ex5

Noemi Bührer, noeminaijia.buehrer@uzh.ch

Exercise 3

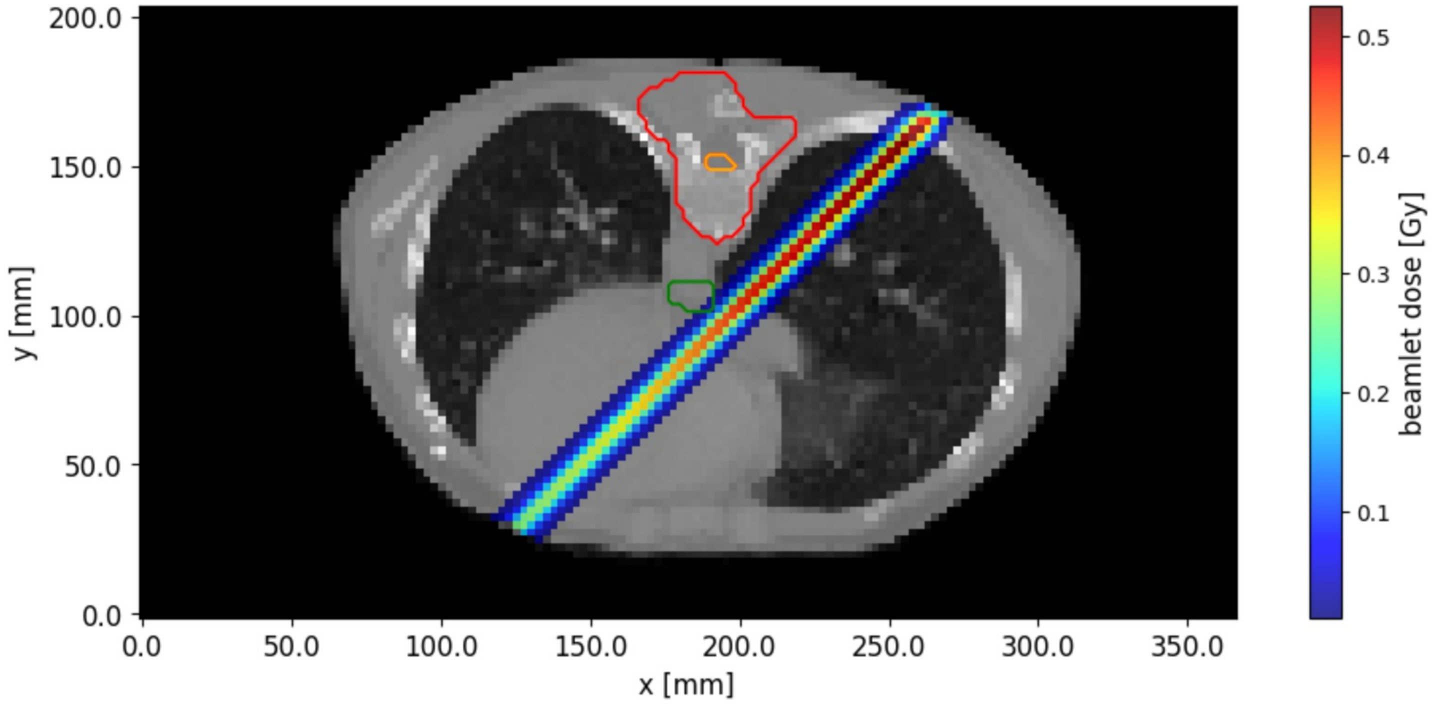
Compute radiological depth → well solved!



Student solution for ex. 3

Exercise 4

Calculate dose distribution of a photon beam in the patient!



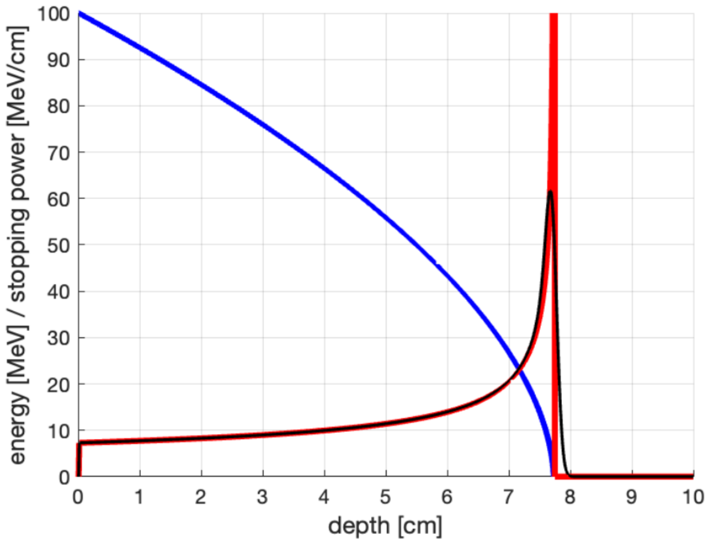
Any questions regarding ex.4?

Exercise 5

Explore the Bethe-Bloch equation in water!

$$-\frac{dE}{dz} = \frac{4\pi e^4}{m_e c^2}\frac{N_e}{\beta^2}\left(\frac{1}{4\pi\epsilon_0}\right)^2\left[\ln\left(\frac{2m_e c^2\beta^2}{I(1-\beta^2)}\right)-\beta^2\right] \qquad \frac{E(z+\Delta z)-E(z)}{\Delta z} = S(E(z))$$

1. **Calculate depth dose curve of a proton beam from Bethe-Bloch**
   → numerical integration: residual proton energy E(z)
   → dE/dz: deposited energy



Energy E

Energy loss dE/dz

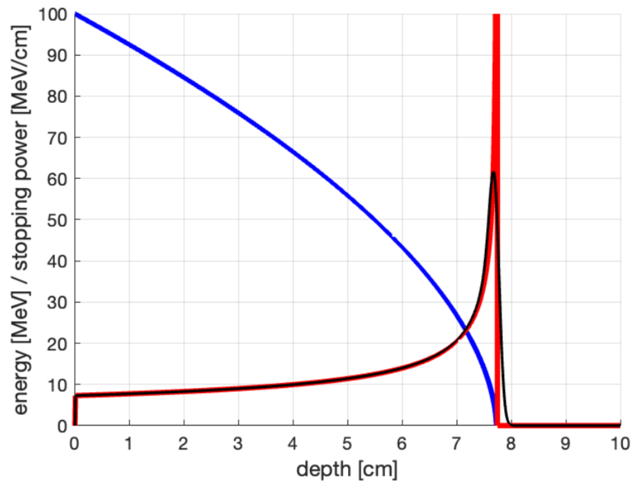
Exercise 5

2. Take range straggling into account

Range straggling can be described by convolving the depth-dose curve with a Gaussian distribution

→ define gaussian g(x) with $$\sqrt{\sigma_R^2} = 0.012\, R^{0.935}$$

→ convolve the functions $$(f * g)(t) := \int_{-\infty}^{\infty} f(\tau) g(t-\tau)\, d\tau$$



Energy E

Energy loss dE/dz

Range straggling

Exercise 5 – hints

1. Be careful with units!
2. Consider relativity!

$$E = \frac{m_p c^2}{\sqrt{1 - \frac{v^2}{c^2}}} - m_p c^2$$

3. Double check the range by comparing with textbook values.