



University of
Zurich ^{UZH}

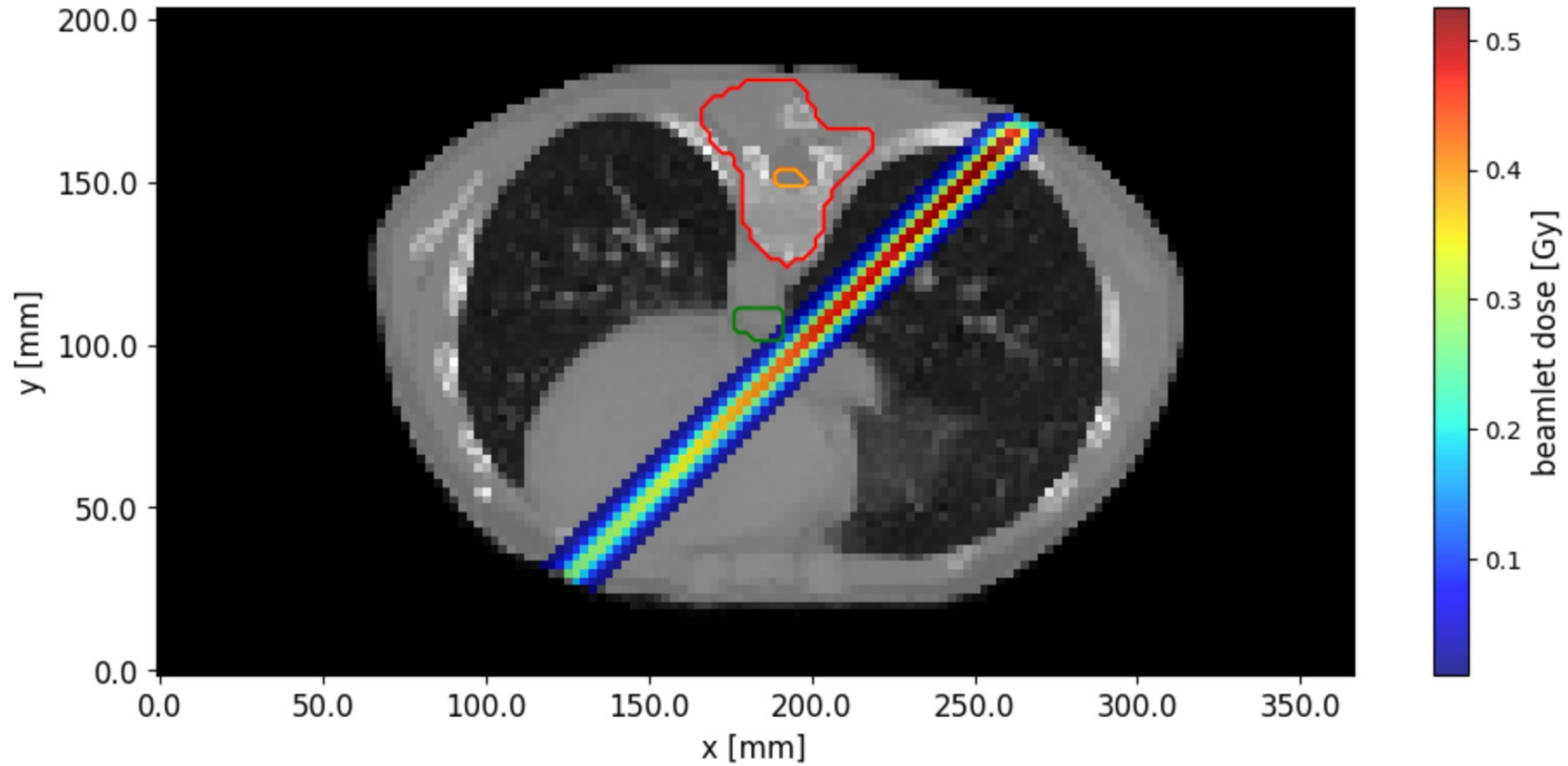
USZ Universitäts
Spital Zürich

Exercise class – Ex6

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Exercise 4

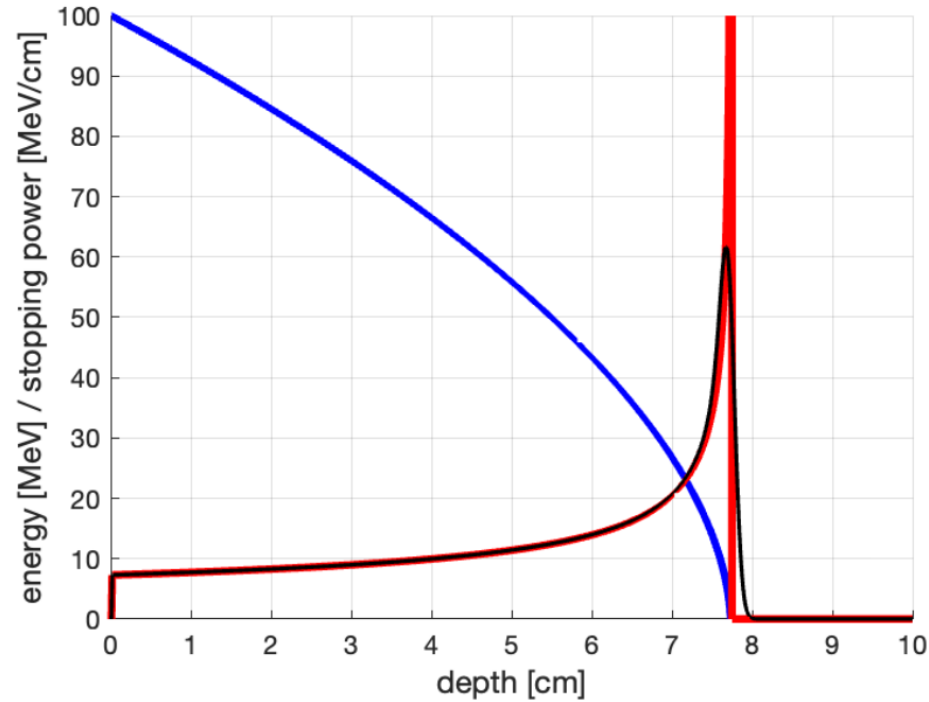
Mostly well solved, some difficulties...



Student solution for ex. 4

Exercise 5

Bethe-Bloch equation in water



Energy E

Energy loss dE/dz

Range straggling

Any questions regarding ex.5?

Exercise 6

Implement a proton pencil beam dose calculation algorithm!

Write a function:

```
calculate_proton_pencil_beam_dose(angle, energy, latpos, raddepth)
```

`angle` the angle of the incident beam,

`energy` the initial proton energy,

`latpos` the lateral position of the beam's central axis relative to the isocenter,

`raddepth` the radiological depth matrix for that beam angle.

Exercise 6

We've seen in the lecture that:

$$D(x, y, z) = D_0(z_{rad}(z), E_0) \frac{1}{2\pi\sigma^2(z_{rad}(z), E_0)} \exp\left(-\frac{x^2 + y^2}{2\sigma^2(z_{rad}(z), E_0)}\right)$$

$D_0(z, E_0)$: depth dose curve in water

$\sigma(z, E_0)$: width of the beam

→ dose defined by radiological depth and x-coordinate!

Exercise 6

The beam width $\sigma(z, E_0)$ and the depth dose curve $D_0(z, E_0)$ in water are provided in *protondosedata.zip*.

Dose distributions for
different initial energies

- pbmcs32.0.dat
- pbmcs40.2.dat
- pbmcs47.3.dat
- pbmcs53.6.dat
- pbmcs59.4.dat
- pbmcs64.8.dat
- pbmcs69.8.dat
- pbmcs74.6.dat
- pbmcs79.2.dat
- pbmcs83.5.dat
- pbmcs87.7.dat
- pbmcs91.8.dat
- pbmcs95.7.dat
- pbmcs99.5.dat



		D_0	σ
data > protondosedata > pbmcs99.5.dat			
1	0.0000	3256.1840	7.0915
2	0.9000	3288.4143	7.0960
3	1.9000	3314.3708	7.1007
4	2.9000	3328.1217	7.1058
5	3.9000	3370.2122	7.1110
6	4.9000	3397.0884	7.1165
7	5.9000	3421.5304	7.1222
8	6.9000	3461.6003	7.1282
9	7.9000	3500.1658	7.1343
10	8.9000	3539.5519	7.1406
11	9.9000	3574.5618	7.1471

Depth in mm

edata.dat : available proton energies

rdata.dat : corresponding ranges

Exercise 6

Same steps as in ex. 4:

1. Calculate radiological depth matrix
2. Compute the distance to the beam central axis
3. Compute dose with radiological depth and lateral distance
→ additionally extract D_0 and σ of the corresponding depth and E_0

Remark: it is sufficient to calculate the dose to the centre of the voxel!

Exercise 6 – What we expect!

