



# GATE biodose actor

## GATE scientific meeting 2023

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# Biological dose

## Objective of the biological dose

effects of the physical dose on biological tissues

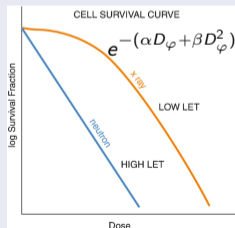
$$D_B = RBE \times D_\varphi$$

$D_B$  : biological dose,  $D_\varphi$  : physical dose,  $RBE$  : Relative Biological Effectiveness

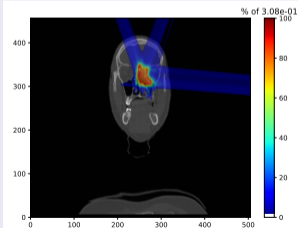
### nano/micro scale

- mMKM  
(Kase et al., 2006)
- NanOx  
(Cunha et al., 2017)

### cellular scale



### macro scale



Cell line: Human Salivary Glands (HSG)  $\implies$  HSG\_mMKM.db or HSG\_NanOx.db

```
Fragment 1;  
...  
Fragment 2;  
...  
Fragment 6;  
...  
Fragment 8;  
...  
Fragment 10;  
...
```

## Biophysical model databases

Cell line: Human Salivary Glands (HSG)  $\implies$  HSG\_mMKM.db or HSG\_NanOx.db

Fragment 1;  $\leftarrow$  ion type

...

Fragment 2;  $\leftarrow$

...

Fragment 6;  $\leftarrow$

...

Fragment 8;  $\leftarrow$

...

Fragment 10;  $\leftarrow$

...

## Biophysical model databases

Cell line: Human Salivary Glands (HSG)  $\implies$  HSG\_mMKM.db or HSG\_NanOx.db

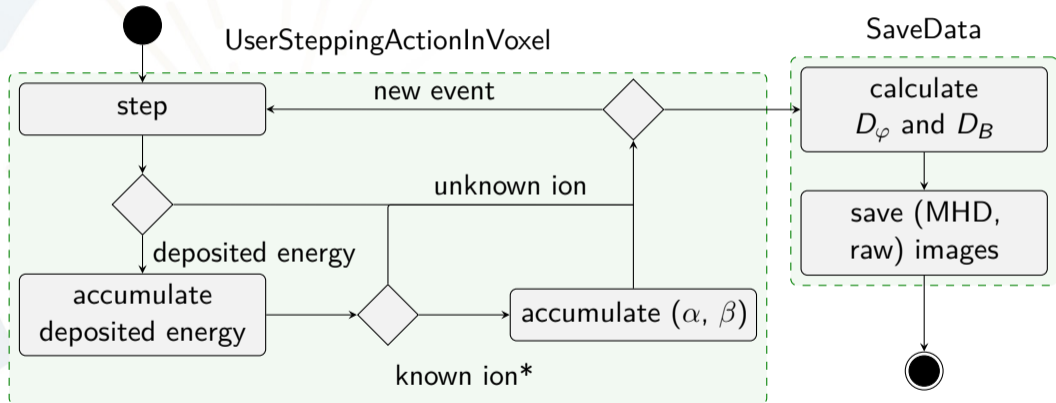
energy alpha                      beta  
(MeV) (Gy)

```
Fragment 1;
...
Fragment 2;
...
Fragment 6;
...
Fragment 8;
...
Fragment 10;
...
```

```
0.1 1.57949019869911 0.047
0.125 1.54247543384665 0.047
...
1 0.684390916768456 0.047
...
10 0.271999732662595 0.047
...
100 0.202595018458597 0.047
...
300 0.196771041884298 0.047
```

$\implies (\alpha, \beta)$  linearly interpolated from the database file

# BioDoseActor main process

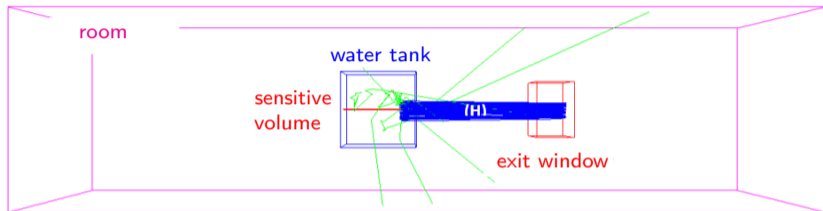


\* ion in {Hydrogen, Helium, Carbon, Oxygen, Lithium}

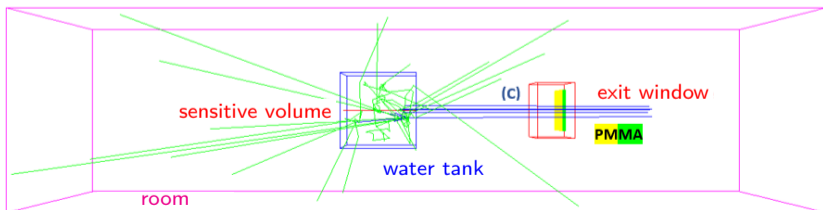
# proton and C-ion clinical PBS beams in water

- Human Salivary Glands
- Pencil Beam Scanning:
  - H: 95.9 – 113 MeV/u
  - C: 120 – 402 MeV/u
- Water box:  
40 × 40 × 40 cm<sup>3</sup>
- Sensitive volume:  
3 × 3 × 400 cm<sup>3</sup>
- Voxel size:  
1 × 1 × 1 mm<sup>3</sup>
- PhysicsList:
  - H: QGSP\_BIC\_EMZ
  - C: Shielding\_EMZ
- multiple stepfunctions
- multiple steplimiters

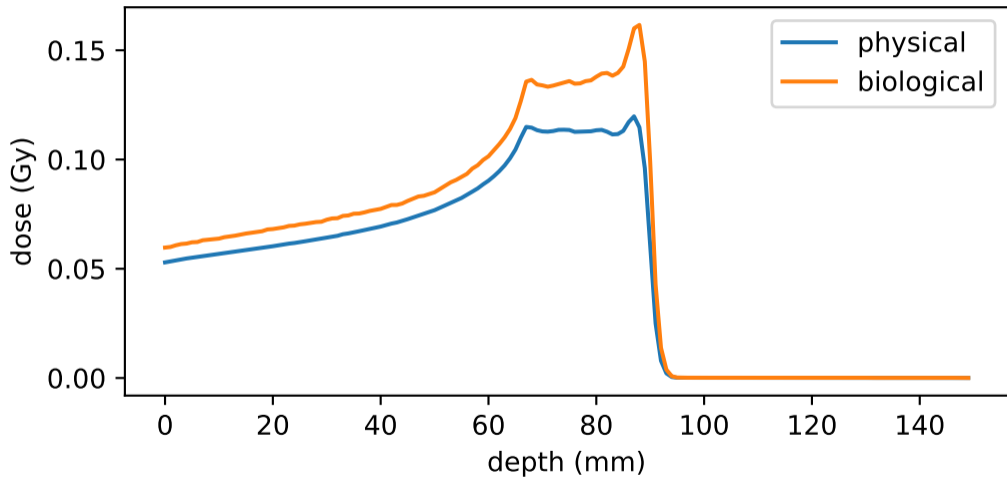
H-ion:



C-ion:

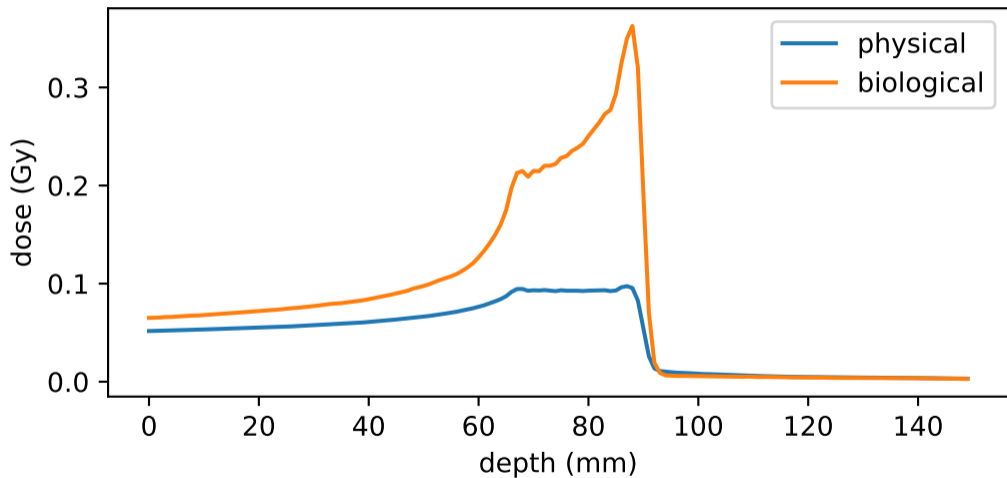


## Results – water, proton, NanOx



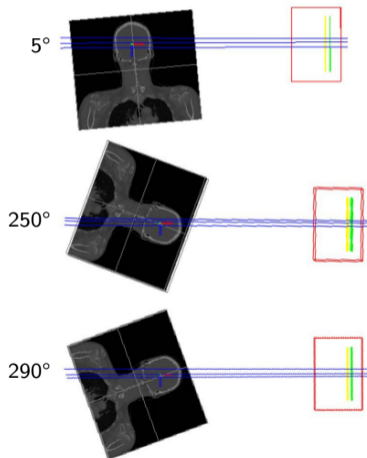


## Results – water, carbon-ion, mMKM

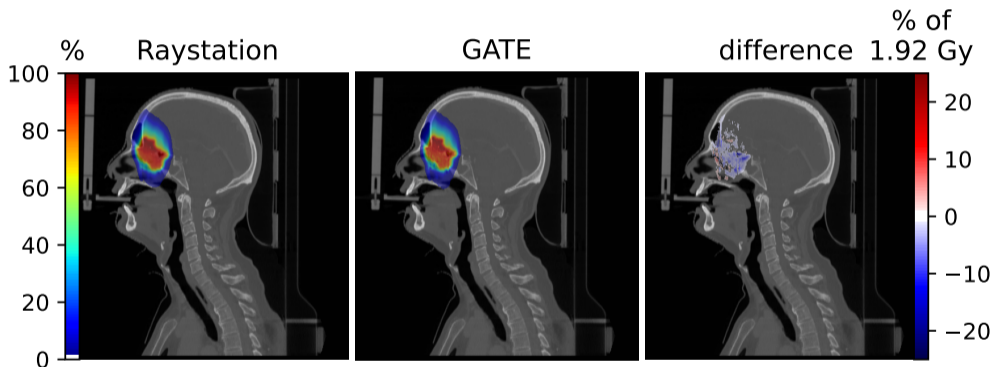


## C-ion clinical PBS beams in patient

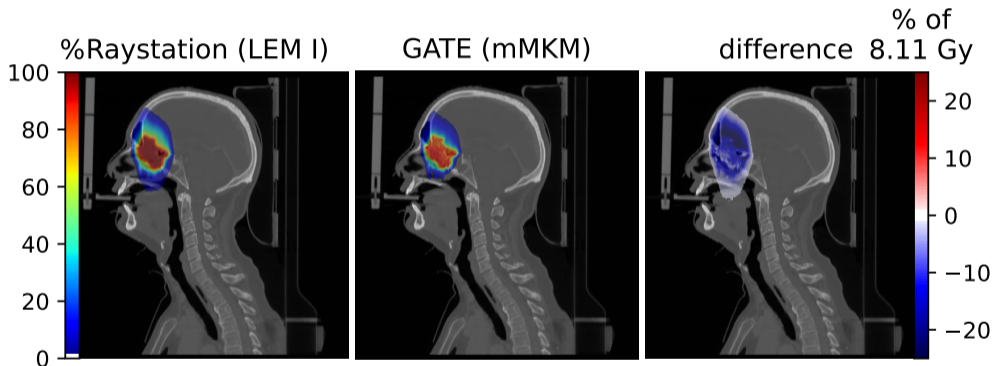
- Human Salivary Glands
- Pencil Beam Scanning
- CT:  $50 \times 50 \times 44 \text{ cm}^3$
- Voxel size:  
 $0.97 \times 0.97 \times 2 \text{ mm}^3$
- PhysicsList:  
Shielding\_EMZ
- 3 beams
- sinonasal chordoma



## Results – C-ion, physical dose



## Results – C-ion, biological dose (mMKM)



## Converted to GATE 10

- Biodose actor class from GATE 9
- GATE 9 biodose "messenger" class (now in Python)

## Work in progress

- Pencil Beam Scanning source (Martina Favaretto (MedAustron))
- benchmark for the biodose actor

### Biodose actor (GATE 9) validated

- in water and patient;
- with two biophysical models: mMKM, NanOx.

### Next

- cross comparison to be done with RBE actor by MedAustron
- Biodose actor in GATE 10 by june 2023
- Tumor Control Probability (TCP) / Normal Tissue Control Probability (NTCP) actor (postdoc Thomas Berger, LABEX primes, 1 year)