WHICH IMPACT OF TUMOR DENSITY VARIATIONS ON ABSORBED DOSE IN EXTERNAL RADIOTHERAPY

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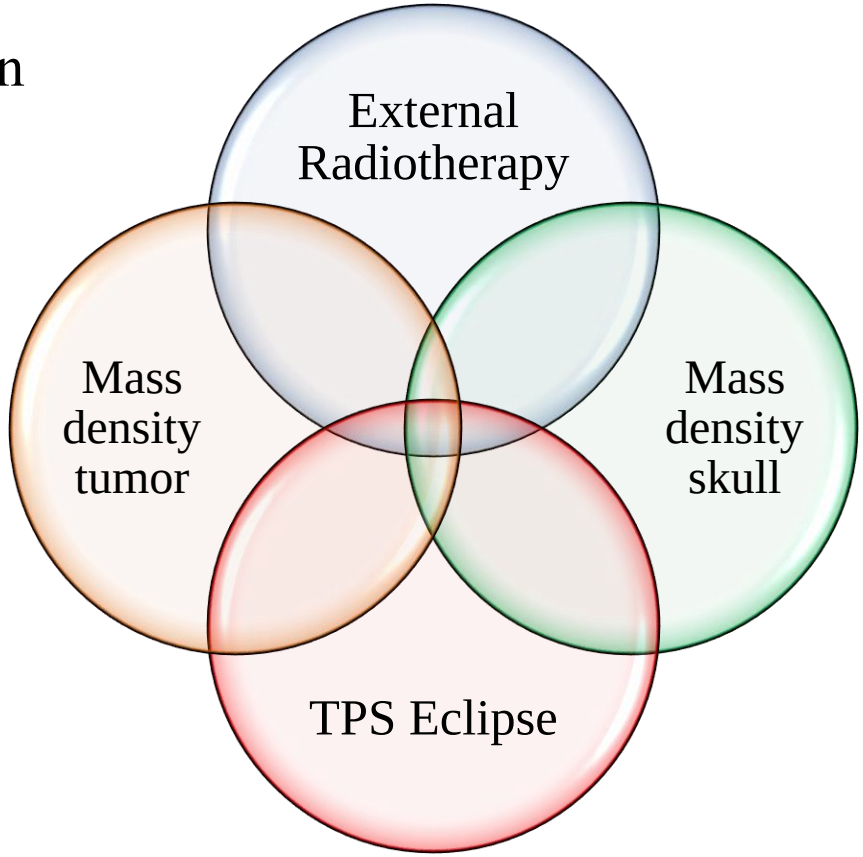
Aim & context

Dosimetry in external radiotherapy: based on Computed tomography (CT)

In MRI, heterogeneities result in density variations within the tumor, e.g. glioblastomas.

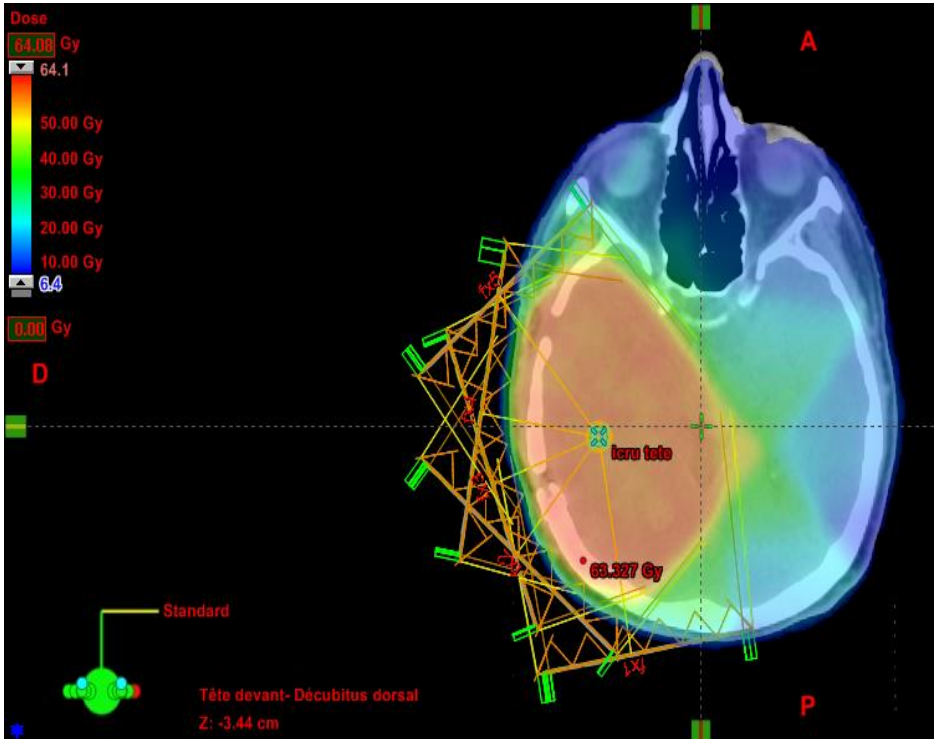
Aim: To evaluate the influence of a slight variations on mass density within the tumor by dosimetric study and quantify the impact of those variations on 3D dose distribution.



Materials

- TPS Eclipse:
  Analytical Anisotropic Algorithm (AAA)

→ 5 Fields
→ 6 MV
→ 2 Gy per fraction, 30 sessions, total: 60 Gy
→ Optimized dynamic Intensity-Modulated-Radiotherapy



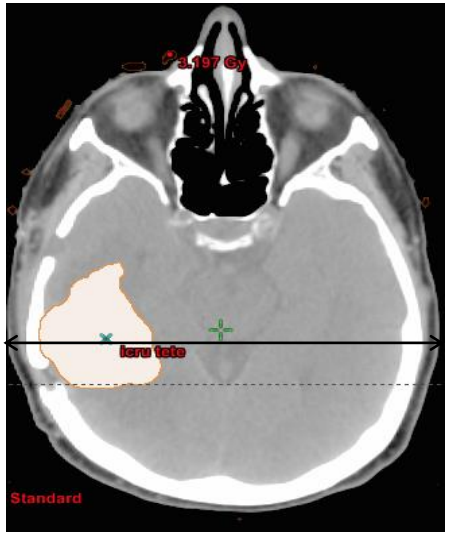
Methods

- Density variation in GTV Gross tumoral volume)

→ 1.04 (reference)
→ to 1.8 g. cm^{-3}
→ by step 0.1 g. cm^{-3}

- Analyse:

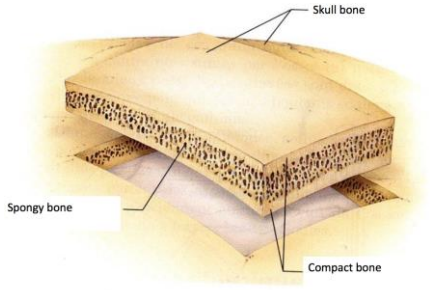
→ Dose profiles
→ Volume Dose histograms GTV, CTV, PTV
→ Dose distribution differences between reference and different studies
→ Dose structure



Study name	Mass Density (g.cm^{-3})	Electronic density	HU
Reference	1,04	1	40
GTV1,1	1,12	1,09	180
GTV1,2	1,22	1,17	350
GTV1,3	1,30	1,25	480
GTV1,4	1,40	1,34	650
GTV1,5	1,51	1,44	850
GTV1,6	1,60	1,51	950
GTV1,7	1,70	1,62	1140
GTV1,8	1,80	1,68	1290

Methods

- Comparison between density skull visible by CT (reference) and segmentation of skull manually
  → Segmentation of skull : compact and spongy bone

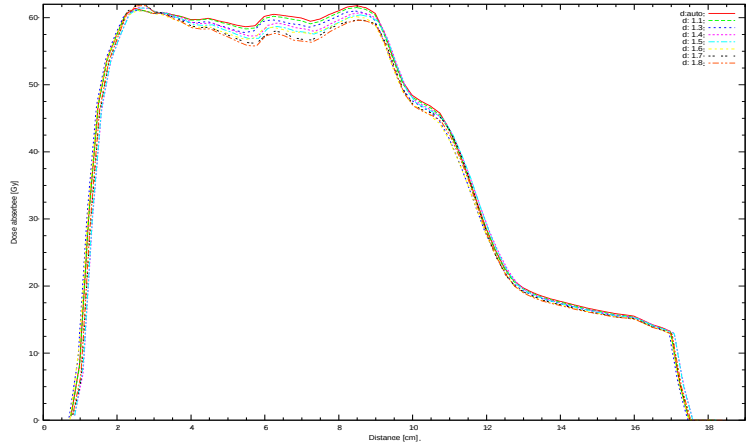


- Density variation in skull bone

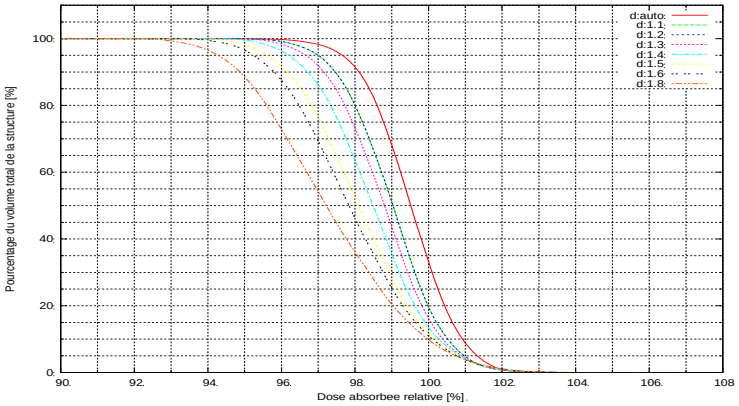
Skull Bone	Mass density ($g.cm^{-3}$)	Electronic density	HU
Compact bone	1,92	1,18	1480
Spongy bone	1,18	1,15	300

Results: Density variation in tumor

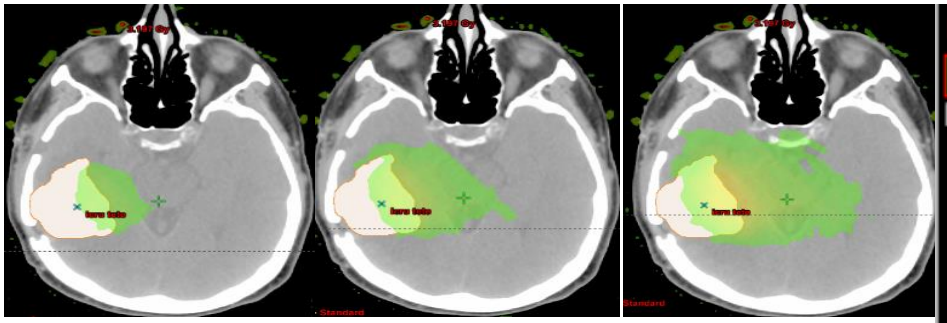
Dose profiles



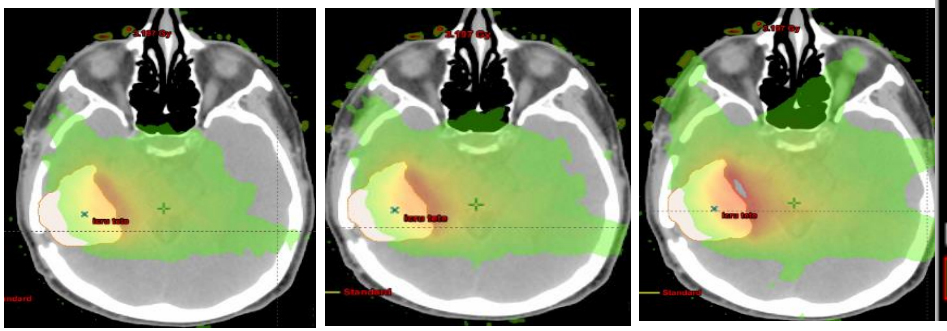
Volume Dose histograms



Dose distribution difference



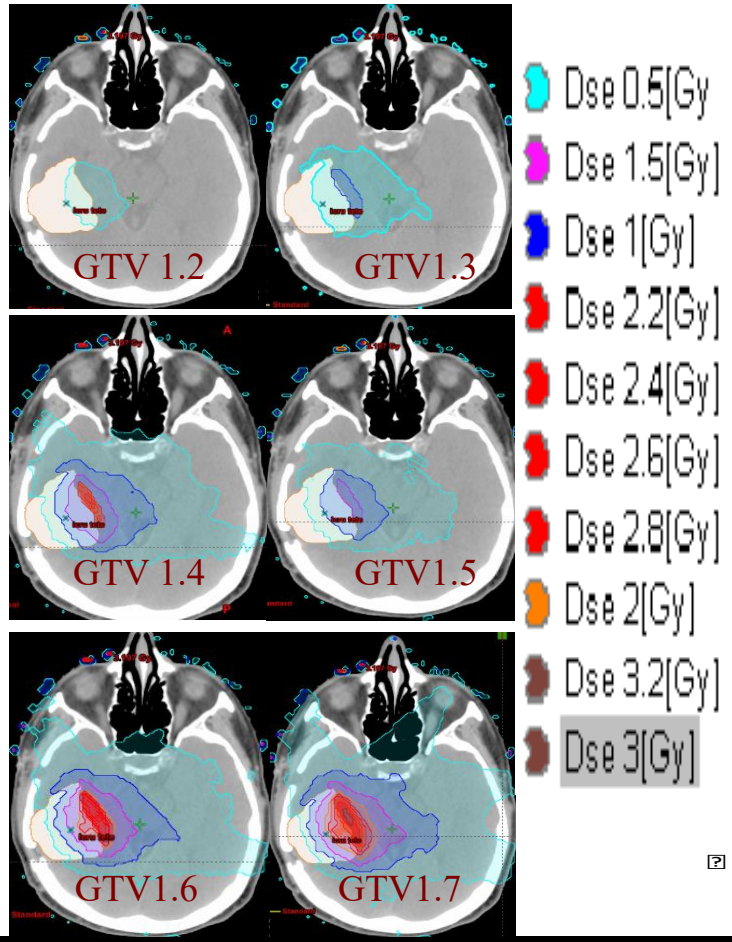
GTV 1.2 GTV1.3 GTV1.4



GTV1.5 GTV1.6 GTV1.7

Results: Density variation in tumor

Dose structure

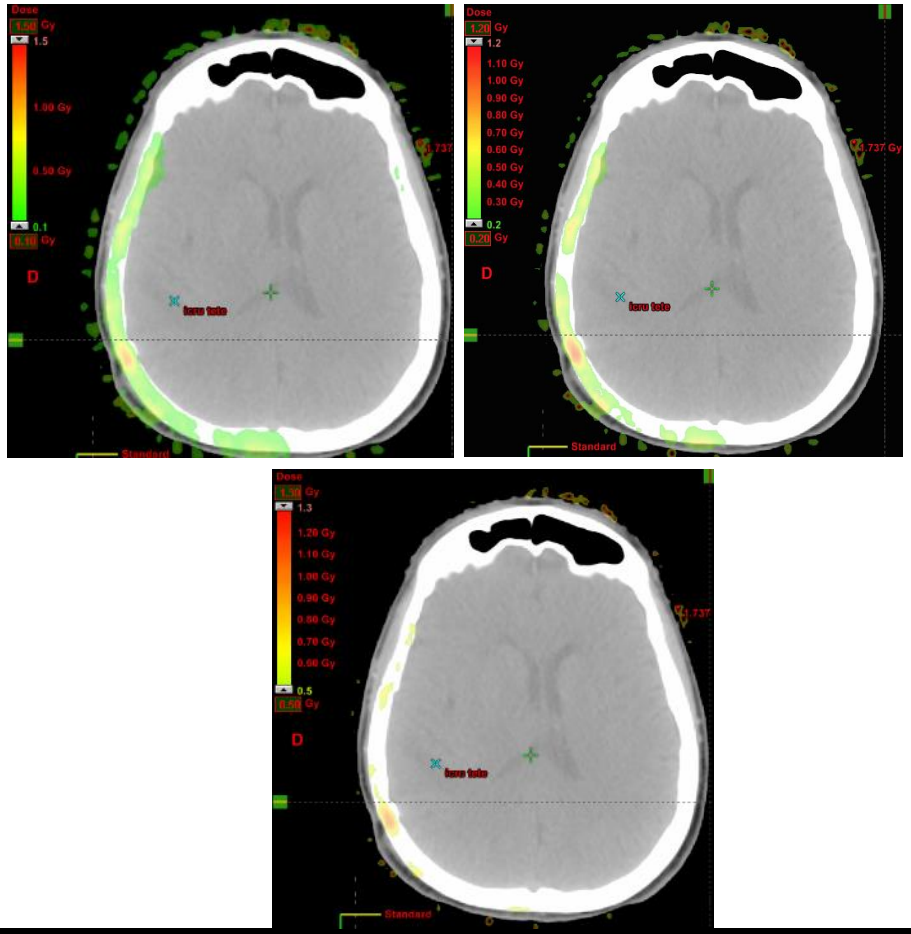


Dose structure table

Volume (cm^3)	Mass density (g.cm^{-3})							
ΔDose (Gy)	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8
0.5	11,81	33,93	71,45	124	205,8	258,6	327	390,5
1	3,12	3,16	6,23	24,83	50,78	69,55	91,92	115,1
1.5	0,82	0,82	0,83	2,01	14,43	25,35	40,06	52,74
2	0,2	0,2	0,2	0,2	1,43	6,84	15,88	25,12
2.2					0,2	3,11	10,25	18,21
2.4						0,66	5,84	12,56
2.6						0,07	2,82	8,37
2.8							0,76	4,98
3							0,13	2,49
3.2							0,01	0,75
3,4								0,15

Results: Density variation in skull

- Dose distribution difference between reference and segmentation study



ΔDose (Gy)	Volume (cm^3)
0,2	73,89
0,3	41,71
0,4	24,39
0,5	14,73
0,6	9,2
0,7	5,5
0,8	3,56
0,9	2,26
1	1,5
1,1	0,97
1,2	0,72
1,3	0,44

Conclusion

- Density variation study in tumor:

DVH and profiles : slight dose increase in surface GTV for the highest densities
From a change of 0.5 g.cm³ within the tumor, dose prescriptions limits of ±3% are not any more guaranteed.

In brain tumors, the change of density should be important enough to observe significant changes of dose.

- Segmentation skull study:

No need for external radiotherapy treatment to achieve a segmentation of the skull bone to consider more finely the mass