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# Multiple brain metastasis radiosurgery using dedicated treatment planning system: a dosimetric study

Marie-Claude Biston<sup>1,2</sup>, Myriam Ayadi<sup>1</sup>, Pauline Dupuis<sup>1</sup>, Thomas Baudier<sup>2</sup>, Claude Malet<sup>1</sup>, Marie-Pierre Sunyach<sup>1</sup>

1 Léon Bérard Cancer Center, University of Lyon, F-69373 Lyon, France

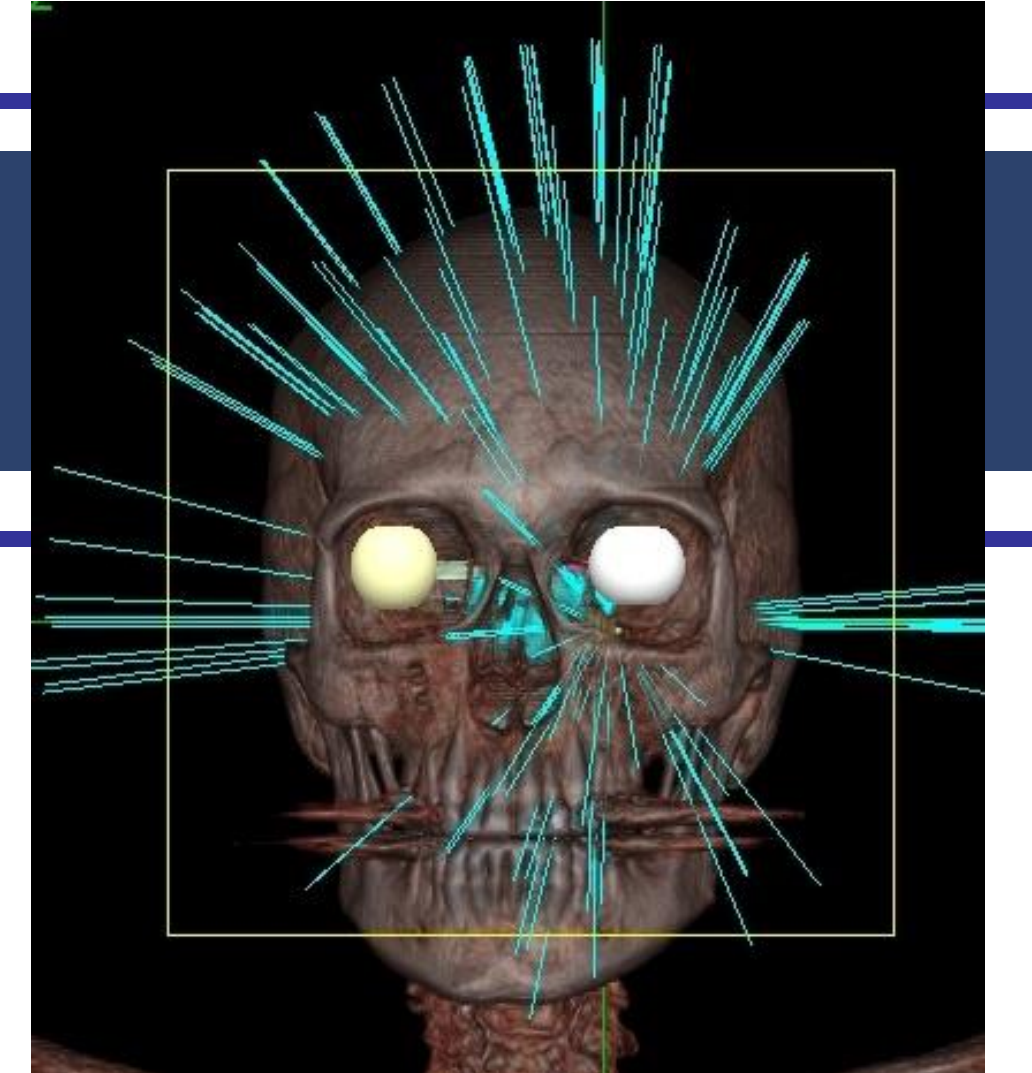
2 Université de Lyon, CREATIS, CNRS UMR5220, Inserm U1044, INSA, F-69622 Lyon, France

## OBJECTIVE

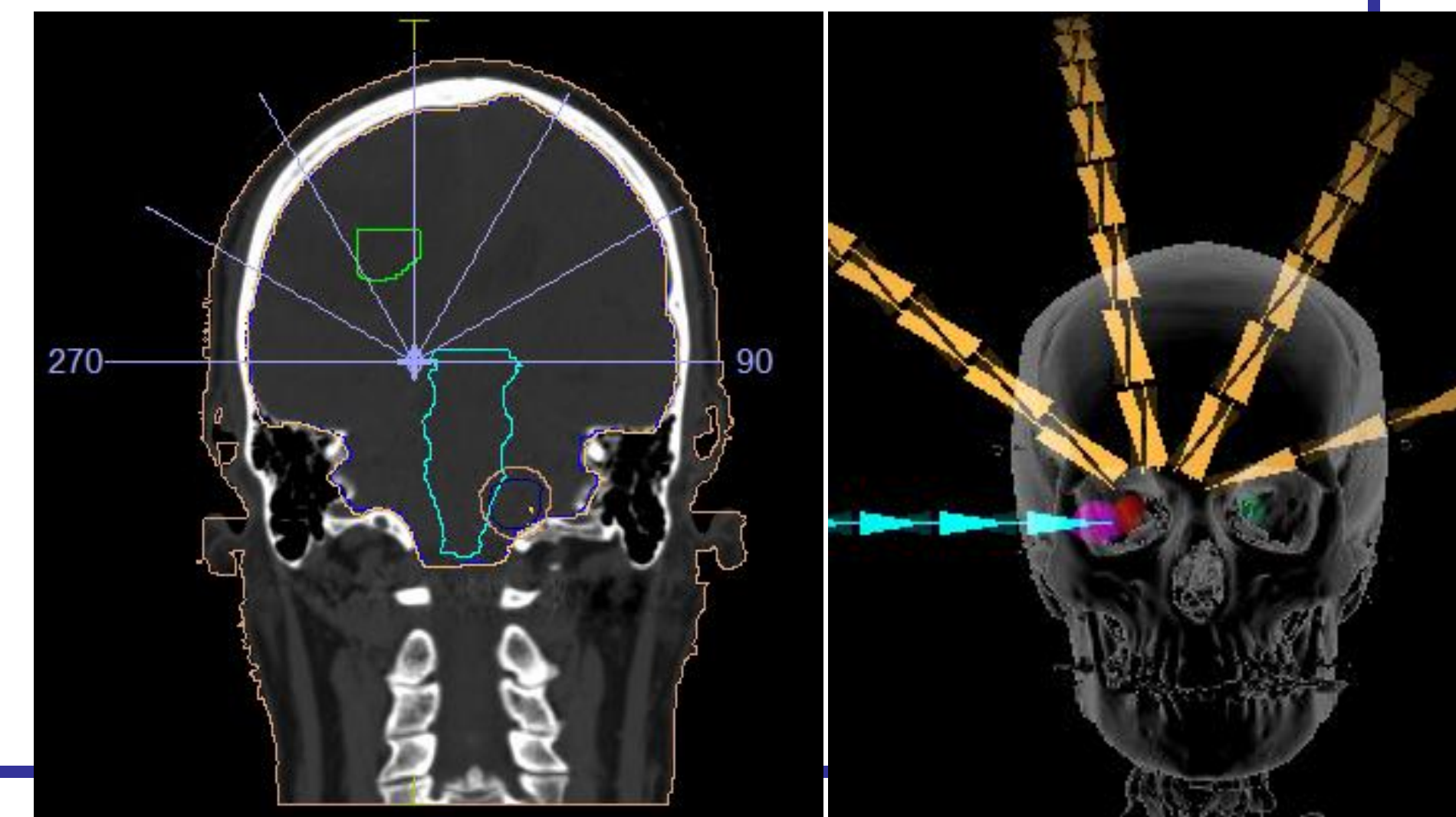
The objective was to compare the performances of conventional versus dedicated linear accelerator for the stereotactic treatment of multiple brain metastases. Cyberknife<sup>®</sup> plans were compared to those obtained with a treatment planning system (TPS) designed for treating multiple brain metastases on conventional linac and to another one used in routine for volumetric modulated arc therapy planning (VMAT).

## MATERIAL / METHODS

- 8 patients with 2-8 tumors previously treated with the Cyberknife
- Planned with **Elements<sup>®</sup> (v.1.5, Brainlab)**, **Monaco TPS (V 5.11.02, Elekta)** and **Multiplan (V3.2.0, Accuray)**
- CTV-to-PTV margins = 2mm (PTV sizes = 0.27-2.8 cc)
- Prescribed dose = 20 Gy delivered @ isodose 80%, covering 96-99% of the PTV
- Cyberknife plans = **2-3 fixed-size collimators** for each metastase (> 50 nodes and > 200 beams)
  - Ray Tracing algorithm (grid size 1mm)
- Elements **DCAT** plans = **Automatic optimization** using 5-6 table (T) angles, **160° arcs**; collimator rotation (4 or 25°)
  - Pencil beam algorithm (grid size 0.9 mm)
- Monaco **VMAT** plans = **4 to 6 arcs** T0° (arc 360°)+non coplanar- **equally spaced** T angles (every 30 or 45°) - no collimator rotation.
  - 1 CW arc per table angulation (max 80 Control-Points)
  - Monte Carlo algorithm (1% per plan - grid size 2mm)
- Mono-isocentric technique
- VMAT & DCAT Delivered with a **Versa HD<sup>®</sup>** Linac equipped with an **Agility<sup>®</sup>** MLC (5mm leaves)
- Paddic Conformity index calculated (PCI)
- V healthy brain receiving 10 (V10), 12 (V12) and 5 (V5) Gy
- Log file analysis for DCAT and VMAT plans



$$PCI = \frac{TV_{PI}}{PI} \times \frac{TV_{PI}}{TV} = \frac{TV_{PI}^2}{PI \times TV}$$



## RESULTS

### Dose to the PTVs (Table 1):

- Better CI and higher mean dose with the Cyberknife
- **Better CI for Elements DCAT** than for Monaco VMAT.
- **Higher mean dose and less variability VMAT** than for Elements DCAT

### Dose to the Brain (Table 1):

- **Lower dose to the brain** for DCAT plans.
- Higher V<sub>5Gy</sub> for VMAT plans.

	Multiplan <sup>®</sup> Cyberknife	Elements <sup>®</sup> DCAT	Monaco <sup>®</sup> VMAT
CI (±SD)	1.26 (0.06)	1.29 (0.12)	1.33 (0.11)
Mean dose (±SD)	22.47 (0.29)	22.06 (0.55)	22.27 (0.43)
V5 Gy (±SD)	94 (74.02)	82.75 (67.07)	146.16 (133.6)
V10 Gy (±SD)	22.22 (12.7)	19.43 (11.11)	30.58 (18.04)
V12Gy (±SD)	16.09 (8.90)	13.78 (7.76)	20.73 (11.65)

Table 1: Volume (cm<sup>3</sup>) of healthy brain receiving a critical dose level for each technique

### Delivery efficiency (Elements vs VMAT):

- Number of MUs = 5037 (±1090) for Elements vs 8477 (±1651) for VMAT
- Delivery time ~ 18min (Elements) vs 23min (VMAT) vs >1h-1h30 (Cyberknife)
- VMAT vs Elements : larger segments, and more important fluctuations in dose rate and gantry speed (Example : Figure 2)

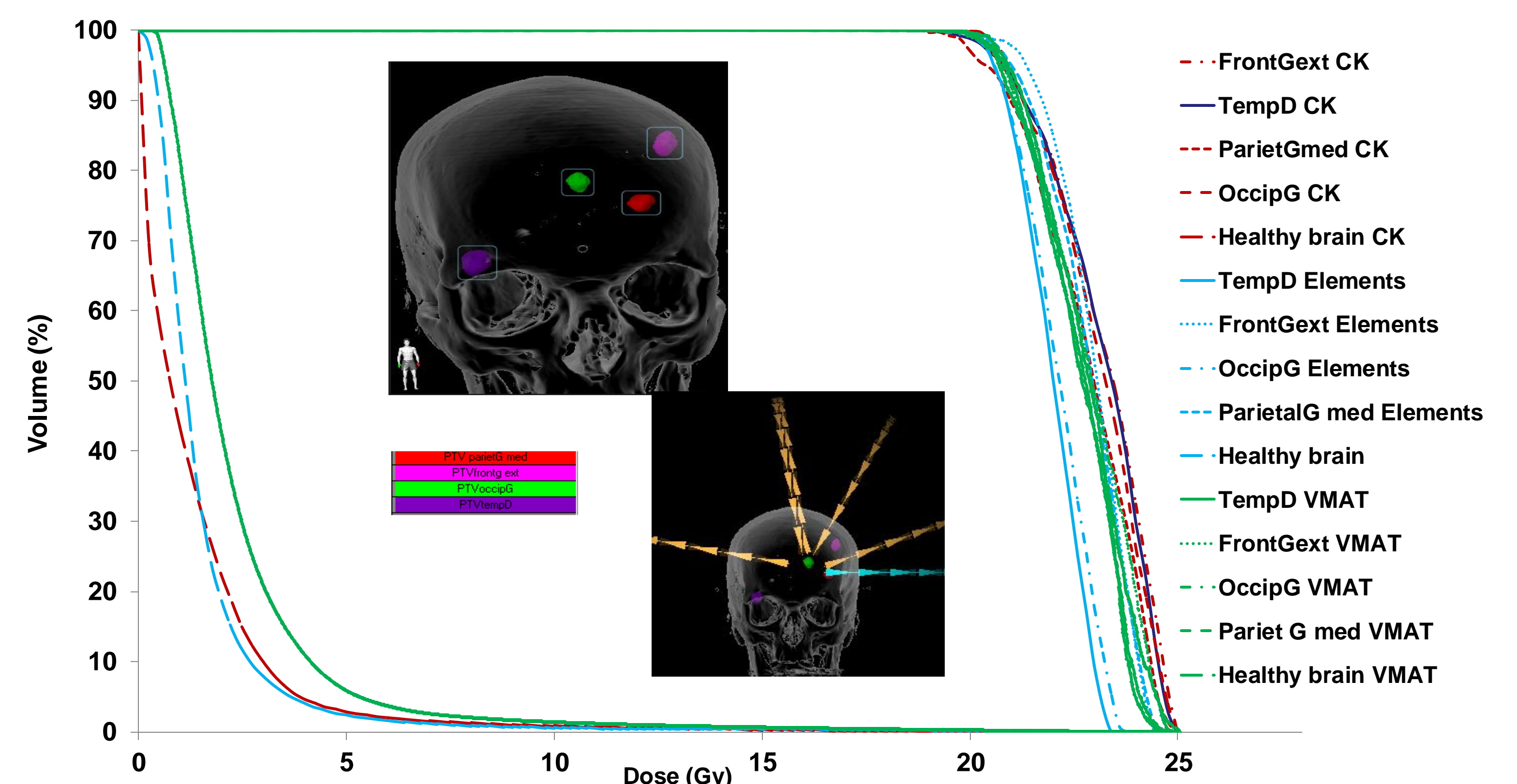


Figure 1: Comparison of the dose profiles obtained with the 3 techniques for one patient with 4 tumors. The ballistic used for Elements is represented in the bottom right image.

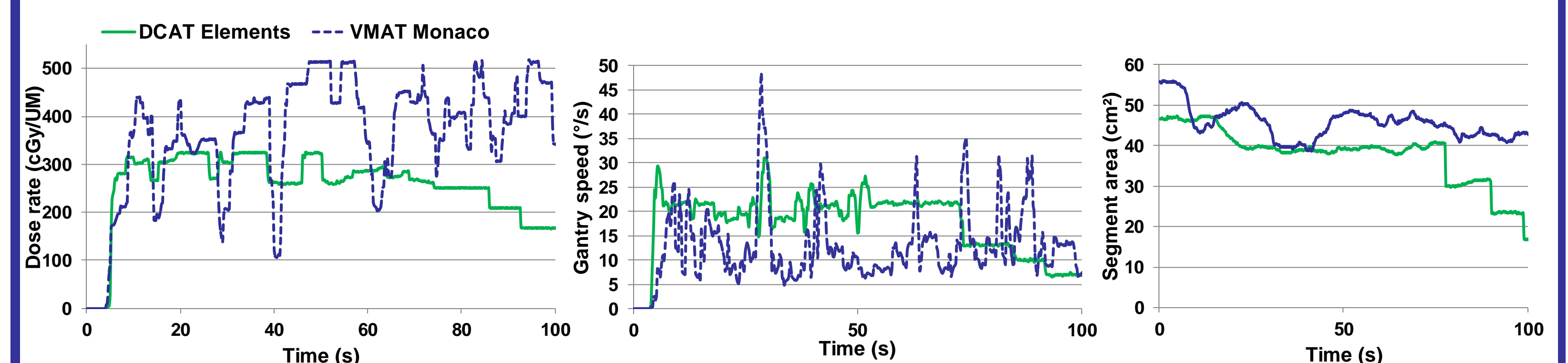


Figure 2: Dose rate, gantry speed and segment area fluctuation in function of irradiation time, and in function of the technique, for a representative patient of the cohort.

## CONCLUSION

Elements<sup>®</sup> DCAT is a **robust automatic planning solution** for treating multiple brain metastasis. The planning time is considerably reduced compared to the 2 other techniques, and the system is nearly operator independent. For clinically acceptable plan quality the delivery efficiency is considerably better with linac-based stereotactic radiosurgery than with Cyberknife.