# EUROPEAN SYNCHROTRON RADIATION FACILITY

# BIOMEDICAL APPLICATIONS IN SYNCHROTRON RADIATION

**The synchrotron radiation-based medical research programme at the ESRF includes both pre-clinical and clinical applications of imaging for diagnosis and radiation therapy. All programmes developed on the ESRF Medical Beamline ID17 result from fruitful collaboration with different institutions. These include the Centre Hospitalier Universitaire of Grenoble, the Helsinki University and various Italian institutes. The involvement of the CHU team in particular enables clinical protocol feasibility studies.**

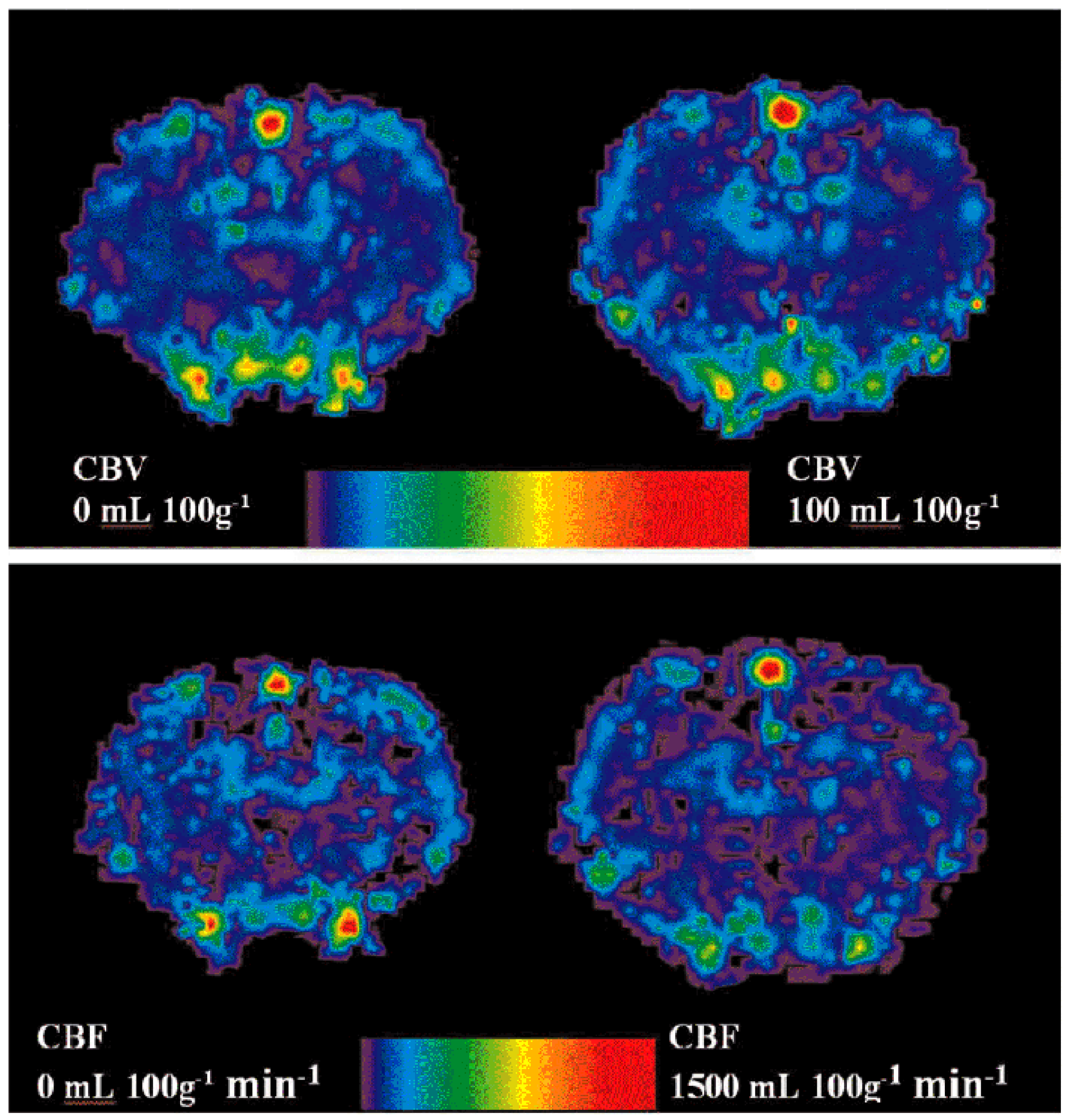
## Radiotherapy to heal brain tumours

Radiotherapy is one of the most important activities performed at the Medical Beamline. Three innovative techniques are currently under development to target highly aggressive brain tumours:

**Microbeam Radiation Therapy** consists of irradiating the subject tissue with a spatially fractionated beam. This allows a delivery of lethal doses to the tumour whilst sparing surrounding healthy brain tissue. Important steps have been taken from the pre-clinical phase towards the eventual treatment of human tumours.

**Tomotherapy** consists of irradiating an iodine-loaded tumour with a monochromatic X-ray beam (between 50 and 100 keV). The iodine passes through the impaired tumour vasculature so that the radiation dose delivered to the tumour is locally enhanced via energy absorption by the heavy element.

**Photon Activation Therapy** is performed when the tumour has been previously loaded with cis-platinum (a widely used chemotherapy drug entering the nucleus). Subsequent irradiation with a monochromatic X-ray beam at energies above the platinum K-edge causes greater DNA damage. Outstanding increases in survival rates for rats bearing gliomas have already been achieved.




**Top:** CBV maps of two healthy rat brains (coronal view). From purple to red the CBV increases from 0 to 100 mL 100 $g^{-1}$.
**Bottom:** CBF maps of the same rat brains. From purple to red the CBF increases from 0 mL 100 $g^{-1}$ $min^{-1}$ up to 1500 mL 100 $g^{-1}$ $min^{-1}$. Black pixels inside the brain slices indicate voxels where the CBF cannot be determined.

## Imaging techniques

**Cerebral perfusion studies** are made in CT mode by temporal subtraction after the first passage of a contrast agent. Cerebral Blood Volume or Flow and Permeability Coefficients are derived from direct measurement of contrast agent concentration. Such parameters are essential for the analysis of brain disease physiopathology (mainly tumour processes), for therapy efficiency and the study of novel contrast agents.

**The Diffraction Enhanced Imaging (DEI)** modality is especially applicable to soft-tissue imaging such as mammography. The method is based on the use of highly-monochromatised radiation, passing through an analyser crystal in order to obtain an edge enhancement at the interfaces of regions with different refractive indices. Excellent correspondence has been established between tomographic slices and histological cuts of the same layer in cancerous tissue samples.

**The Functional Lung Imaging Programme** involves the dynamic measurement of Xenon concentration in the airways to obtain maps of regional lung ventilation. Projection images, CT and spiral CT are used to access the local specific lung ventilation of rabbit lungs after an asthma crisis. This tool is particularly valuable in the experimental study of small airway pathophysiology, the role of local mediators and pharmaceutical agents and the development of experimental models of obstructive lung diseases such as asthma or emphysema.

**Angiography** enables the visualisation of coronary arteries. Dual-energy images are acquired at the beamline during the bolus passage of an iodine contrast agent after an intravenous infusion. Two validation clinical protocols have already been completed on 62 volunteer patients.

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