An intra-operative beta probe for brain tumor surgery

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Treatments of brain tumors

- ✓ 40 % of adult brain tumors are glioma (5 to 10/100 000 cases each year)
- ✓ Gliomas have high diffusion and proliferation capabilities
- ✓ High-grade gliomas have a poor vital pronostic (survival under 1 year)

- ✓ Surgery is still the more efficient treatment
- ✓ Current medical imaging systems aren't sensitive enough to detect the entire extent of the tumor

⇨ Development of new intraoperative systems to help in real time the surgeon during the excision

New miniaturized tools dedicated to cancer surgery

Two complementary families of intraoperative detectors

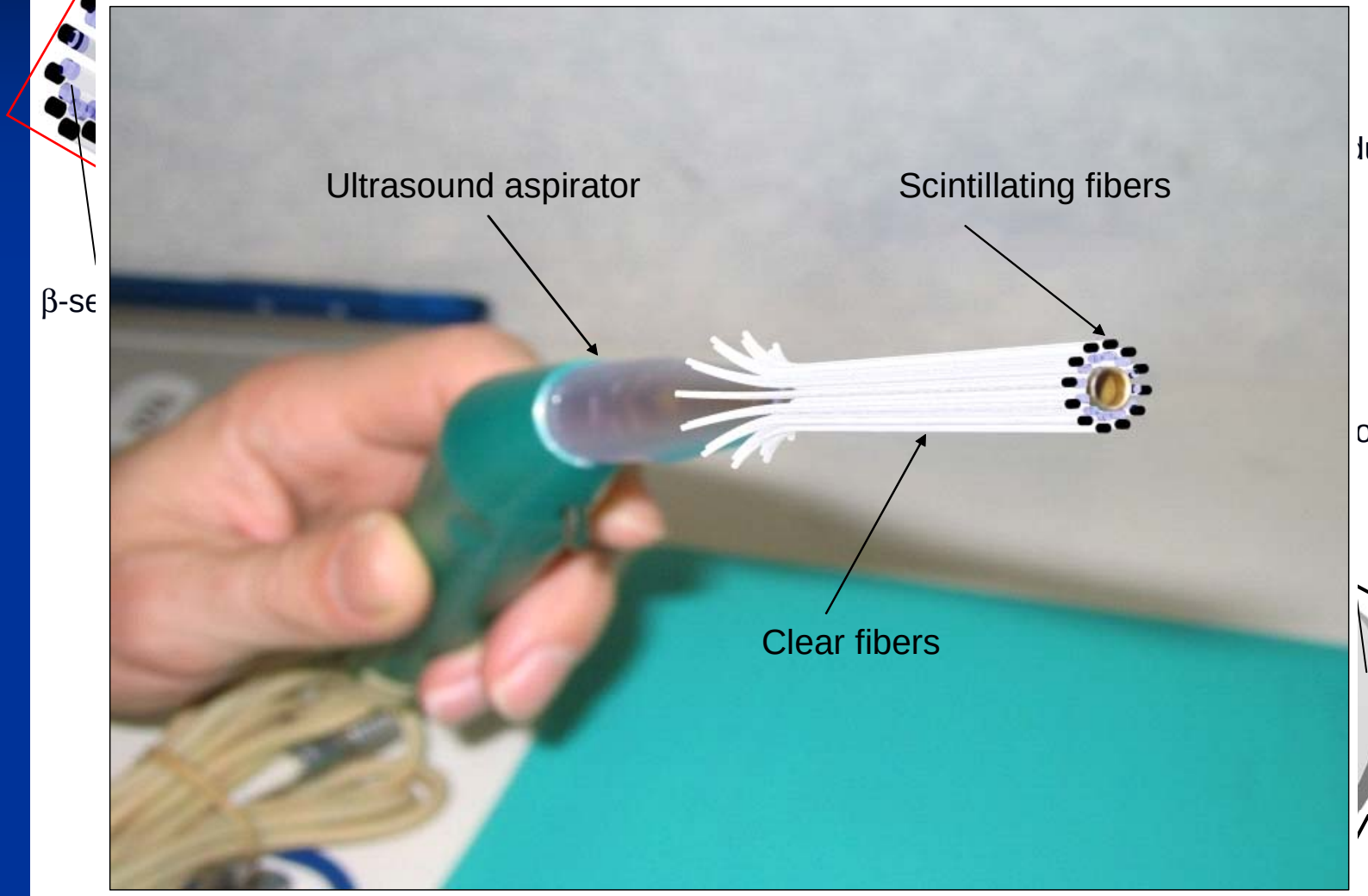
✓ Standard imaging systems adapted to the surgical room (ultrasound, scanner, low-field MRI)
✓ Systems using a pharmaceutical tracer (labelled with radioactivity or fluorescence) coupled to a miniaturized detection probe.

Instrumentals constraints imposed by the detection of brain tumors

- ✓ Very high sensitivity (detection of tumor edges)
- ✓ Compactness (small operative wound)
- ✓ Gamma background noise discrimination
- ✓ Correlation between the image and the real position of the tumor

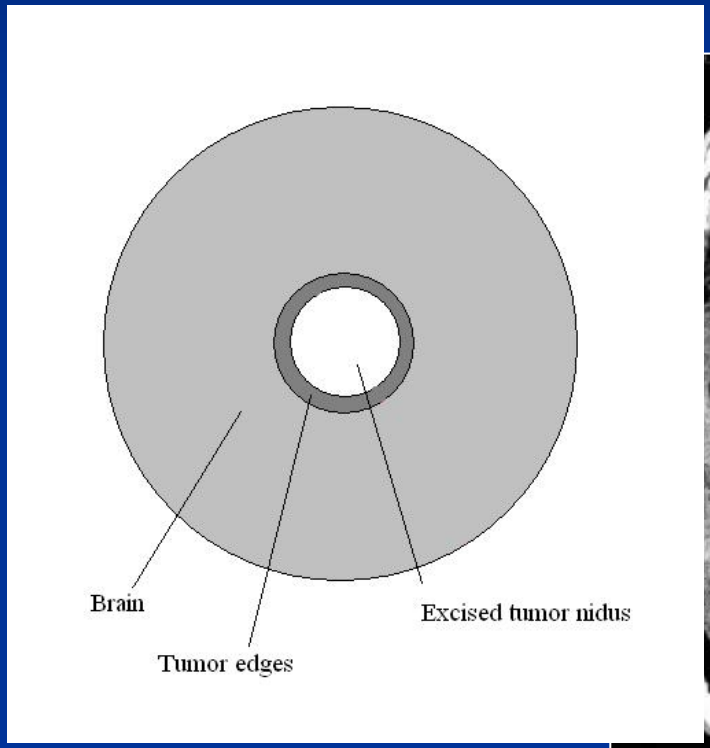
⇒ **Development of an intraoperative probe dedicated to the detection of β^+ particles and built around plastic scintillating fibers.**

Principle of the beta intraoperative probe

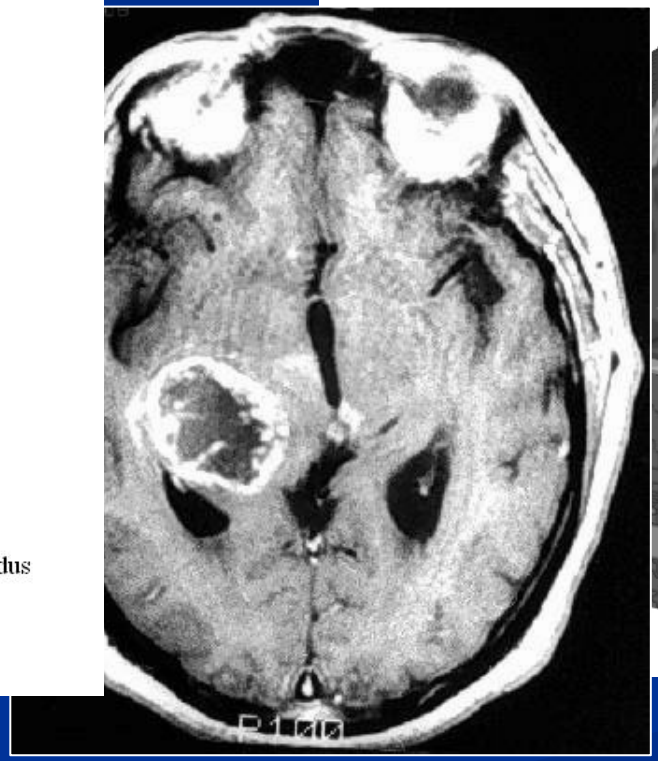


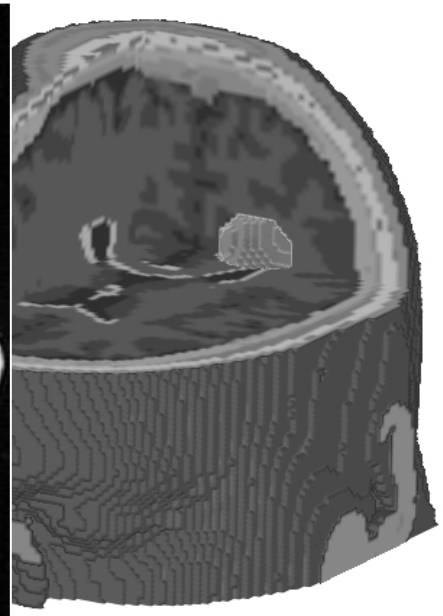
Optimization of the detector geometry by Monte Carlo simulations (MCNP 4C)

Numerical phantoms



Geometrical phantom





Voxelised anthropomorphic phantom
(Mc Gill University)

Optimization of the detector geometry by Monte Carlo simulations (MCNP 4C)

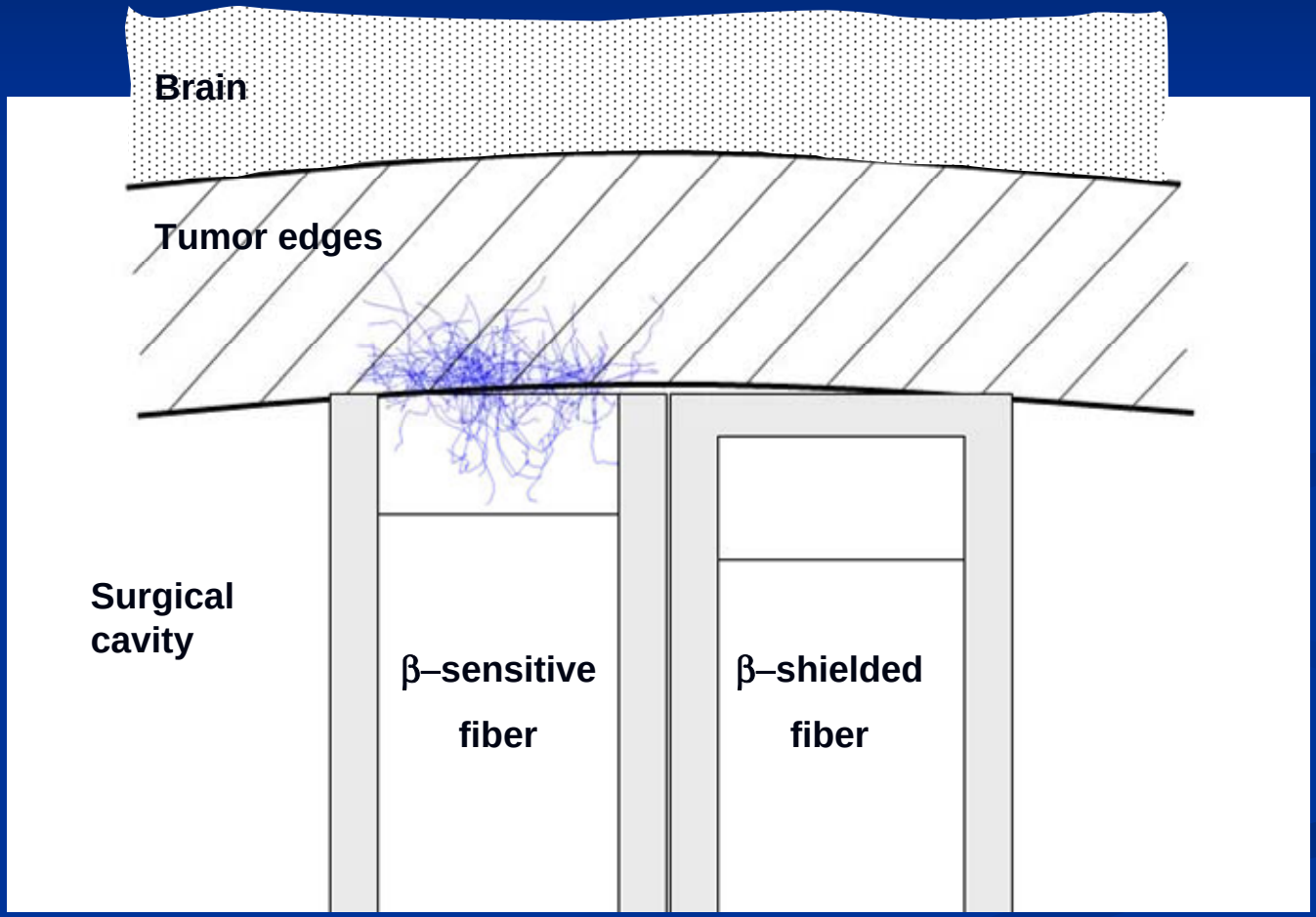
Radioactif tracers

	SUV Tumor	SUV White matter	SUV Cortex
^{18}F-FDG	5.2	3.3	3.7
^{18}F-FET	2.5	0.65	0.9
^{18}F-Choline	1.5	0.15	0.15

SUV= Standard Uptake Value

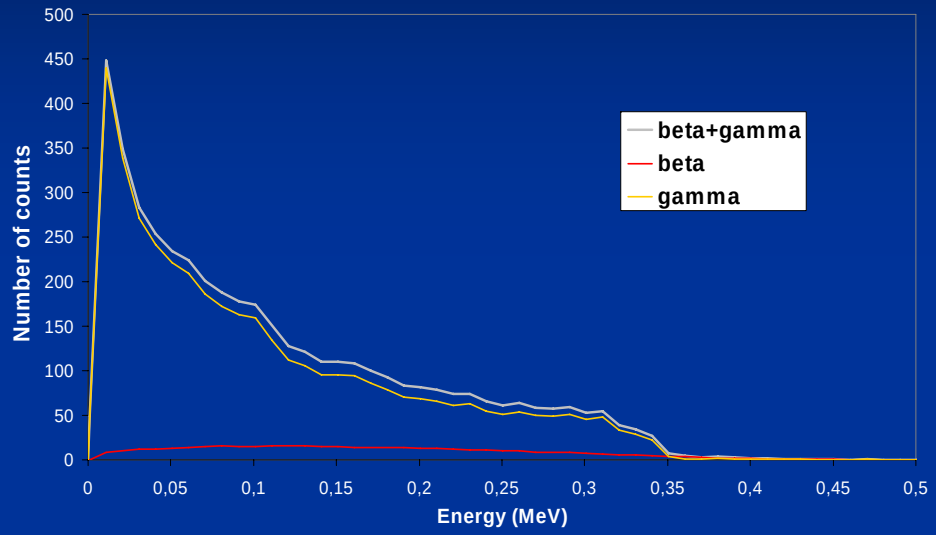
Optimization of the detector geometry by Monte Carlo simulations (MCNP 4C)

Detector geometry

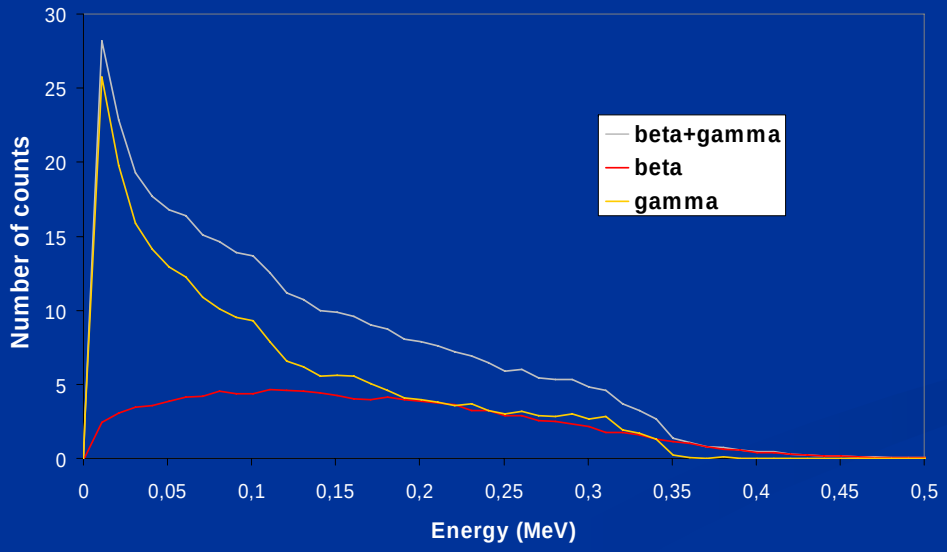


Optimization of the detector geometry by Monte Carlo simulations (MCNP 4C)

Gamma background noise characterization



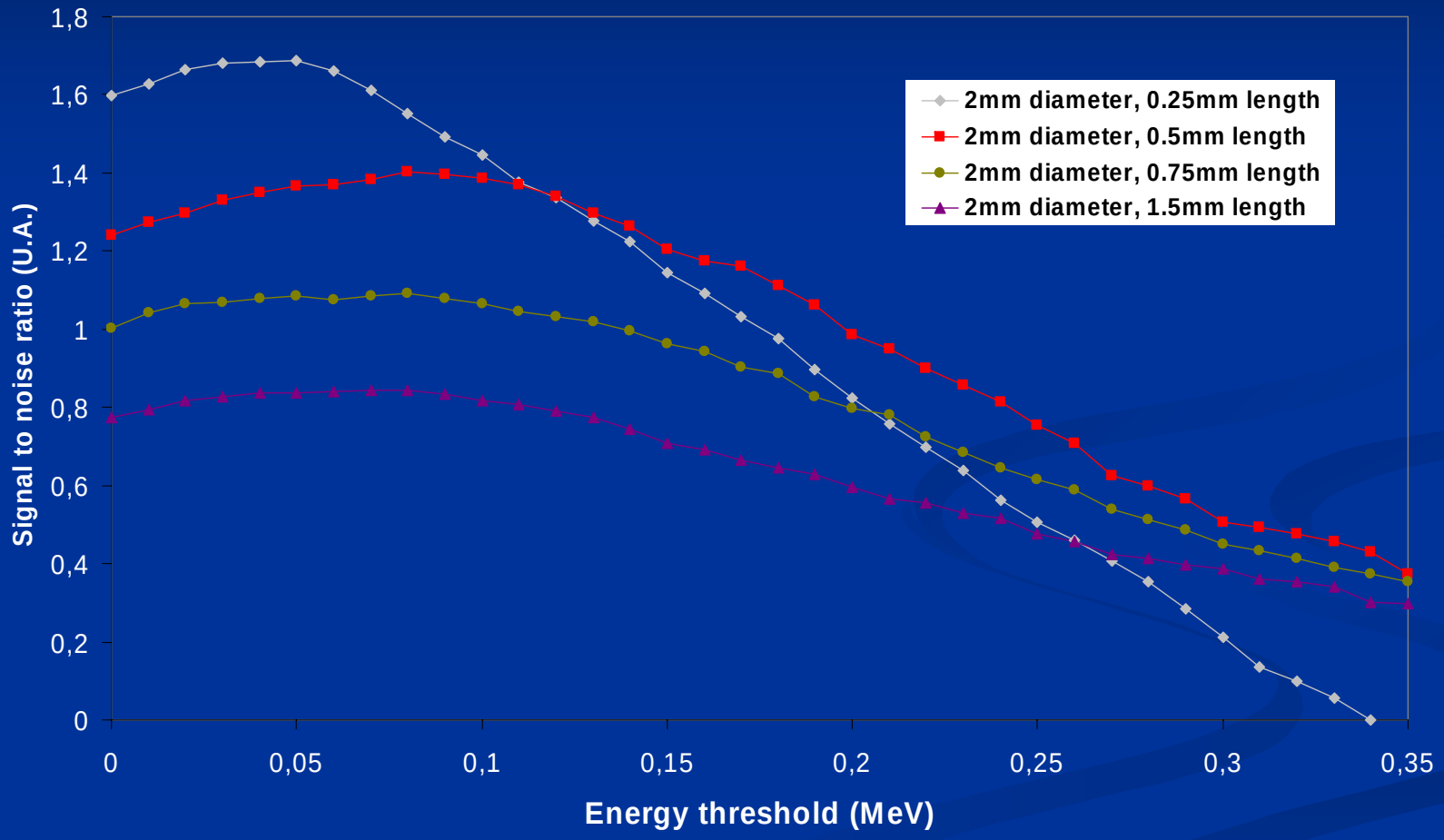
^{18}F-FDG



^{18}F-Choline

Optimization of the detector geometry by Monte Carlo simulations (MCNP 4C)

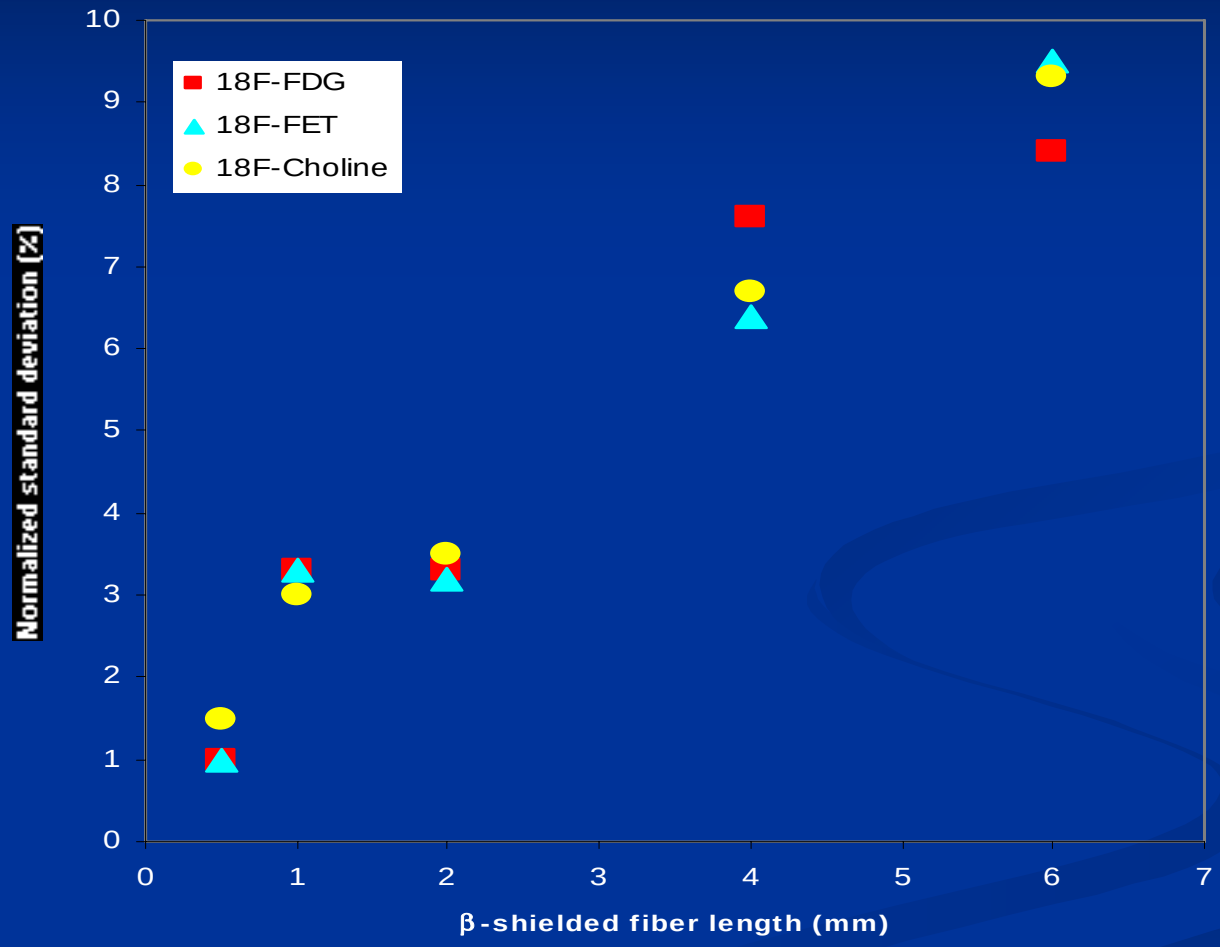
β-sensitive fiber



Choice of a 2mm diameter and 0.5mm length β-sensitive fiber

Optimization of the detector geometry by Monte Carlo simulations (MCNP 4C)

β-shielded fiber



Choice of a 2mm length β-shielded fiber

Expected theoretical performances

- ✓ Overall β sensitivity of 72cps/μCi/ml
- ✓ Sensitivity volume of 48 ml
- ✓ Gamma ray discrimination efficiency of 99.6 % for ^{18}F-FET
- ✓ Minimum detectable radiotracer concentration:

Radiotracer	Minimum detectable concentration (μCi/ml)	Bulk tumor concentration (μCi/ml)
^{18}F-FDG	0.35	0.59
^{18}F-FET	0.10	0.29
^{18}F-Choline	0.04	0.17

Prospects

Thank you for your attention !