STEPBRAIN: a stereolitographed phantom of the brain for Nuclear Medicine, Computed Tomography and Magnetic Resonance applications.

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Introduction:

- This phantom has been designed to validate different techniques for partial volume effect correction in low-resolution images.
- It was carried out within PVEOut, an EC co-financed project (QLG3-CT2000-594)

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Phantom requirements:

- To simulate human brain architecture as seen in NM
  - allowing for separate filling of GM, WM and CSF.
- To simulate as accurately as possible brain architecture as seen in MRI
  - with minimum possible wall thickness
  - and with maximum possible adherence to complexity of brain tissue shapes.

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Methods and Materials:

- It was built by a rapid prototyping technique applied to a digital model derived from a 1.5T MRI dataset of a 35 y.o. normal volunteer composed of 150 3mm-thick partially overlapping slices (1mm increment) covering the whole brain.

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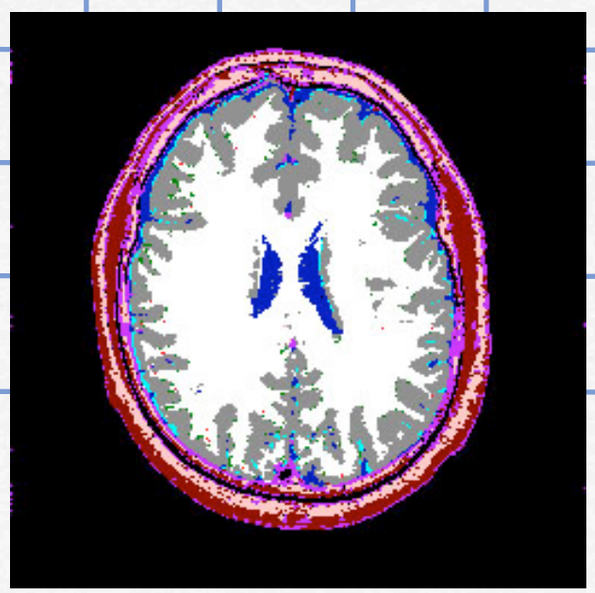
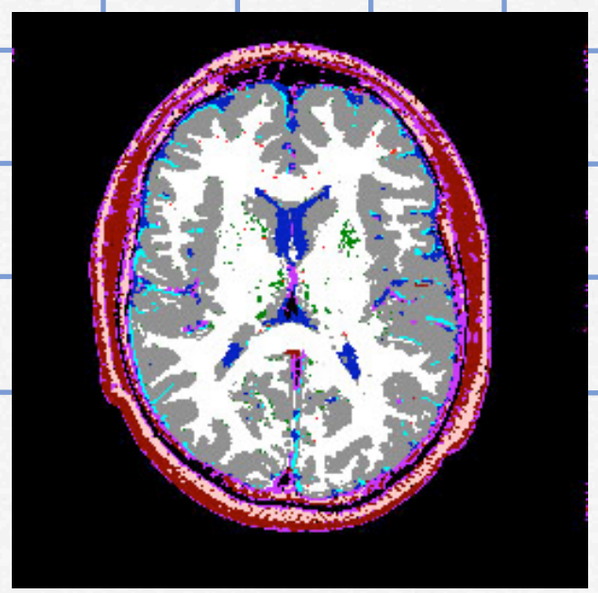
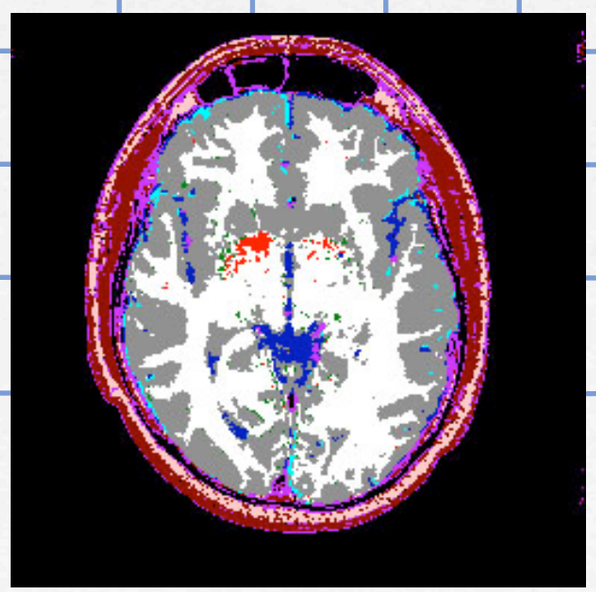
Methods and Materials:

- For each slice location T1-, PD- and T2-weighted spin-echo images were obtained, and segmented into GM, WM and CSF using a multiparametric technique (Magn Reson Med 1997;37:84).







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Methods and Materials:

- The subsequent processing of the segmented images by homemade and industrial software included:
  - manual editing of the basal ganglia to ensure their connection with GM to allow proper filling;
  - filling of the vessels located inside the parenchyma with the tissue type that occur most frequently on the surrounding pixels;
  - final elimination of "isles" of pixels inside a tissue type not connected in 3-D with other pixels of the same type;

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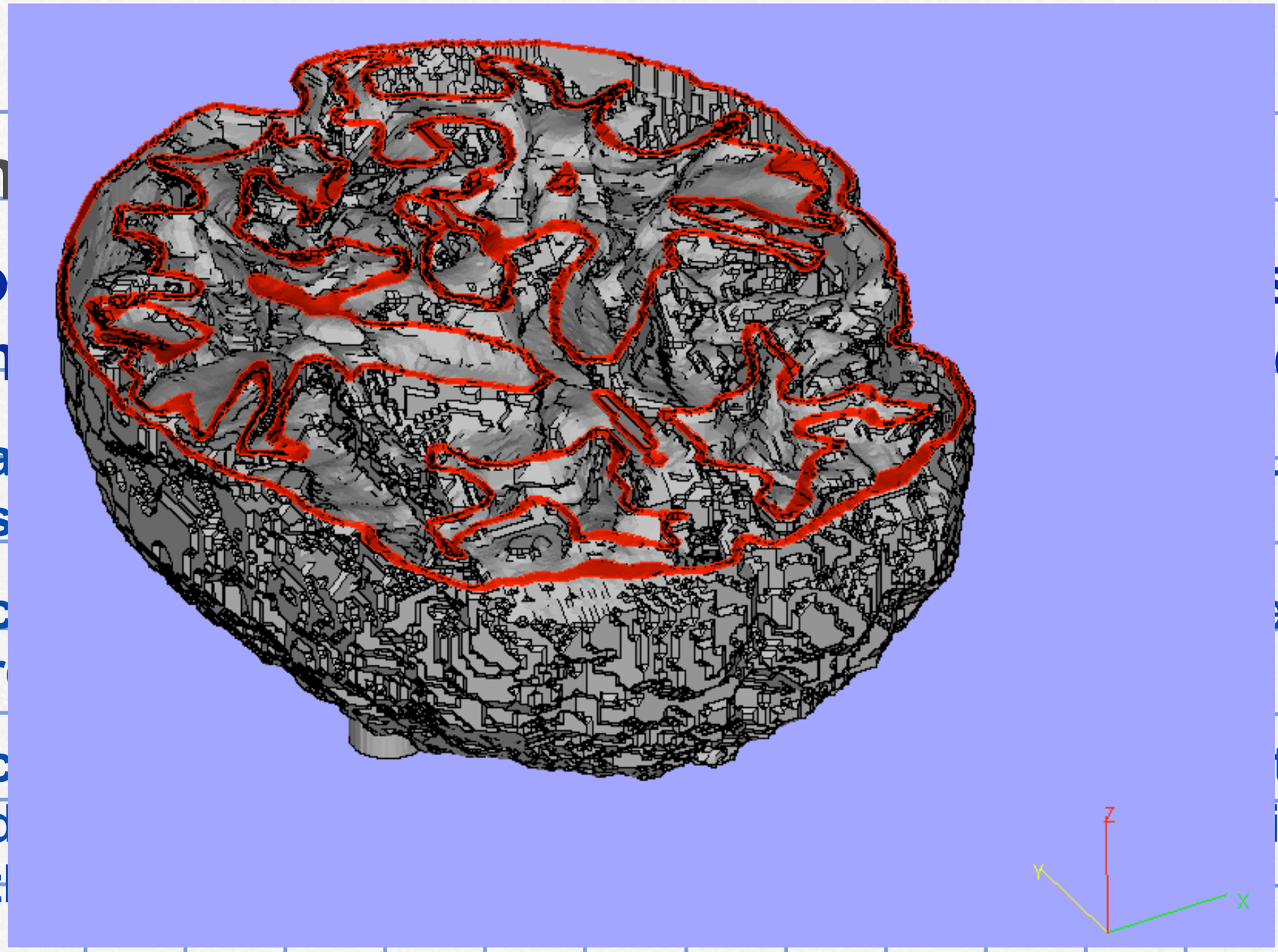
Methods and Materials:

- **Processing of the segmented images by homemade and industrial software included:**
  - **a 5x5x3 median spatial filtering of the entire volume to smooth the boundaries of the tissues;**
  - **conversion of the binary file into a vectorial representation of the surfaces;**
  - **creation of the hollow of GM and WM compartments defining the separation 1.5mm-thick walls separating the three compartments;**
  - **adding of tubes to allow filling of GM and WM compartments.**



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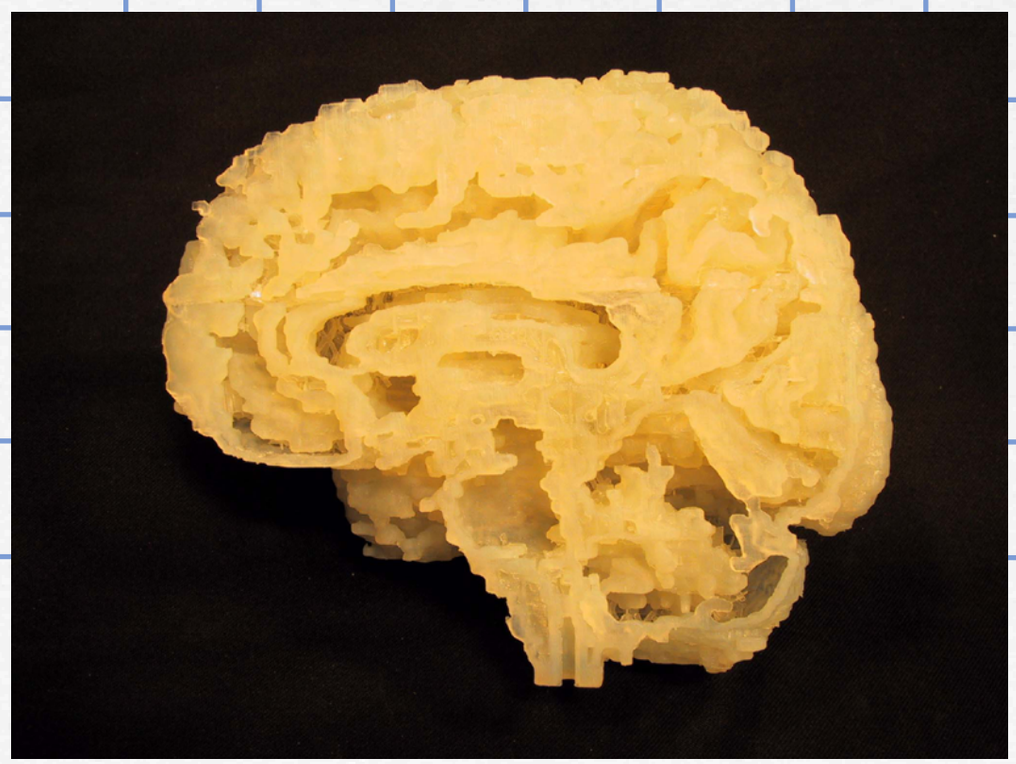
  - adding of tubes to allow filling of GM and WM compartments.

Methods and Materials:

- The resulting file was used to drive a stereolitography machine that polymerized a hydrophobic resin with a laser beam in regions corresponding to the walls, providing the final phantom.



Methods and Materials:

- GM and WM compartments were then filled with solutions with different isotope concentrations for PET/SPET scanning (4/1 ratio to simulate GM/WM contrast), while different Mn-Gd concentrations were used to simulate different GM/WM relaxometric properties.

Results:

- The resulting phantom at the current wall thickness proved to be waterproof , with no communication between GM and WM compartments, and suitable for CT, MR, PET and SPET scanning.

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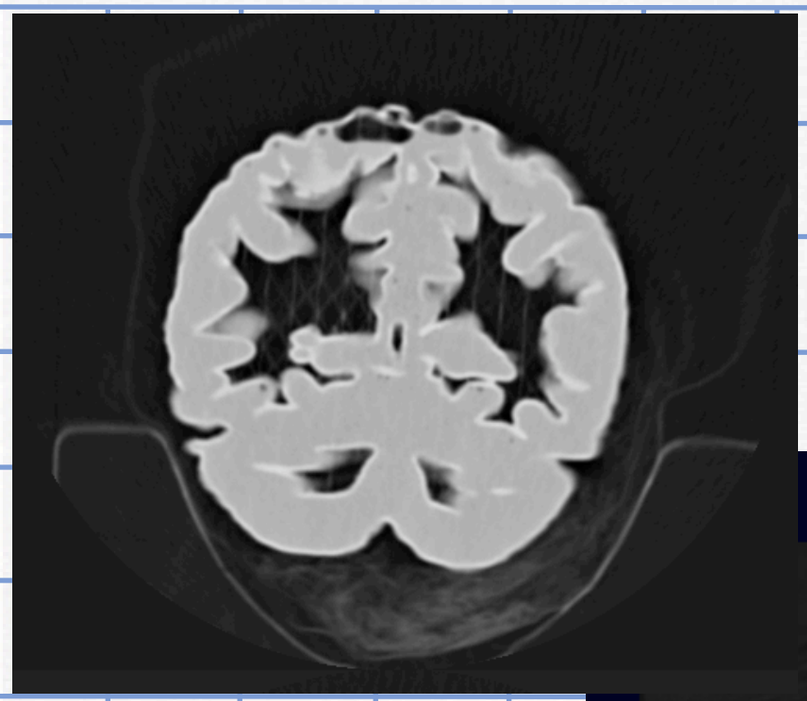
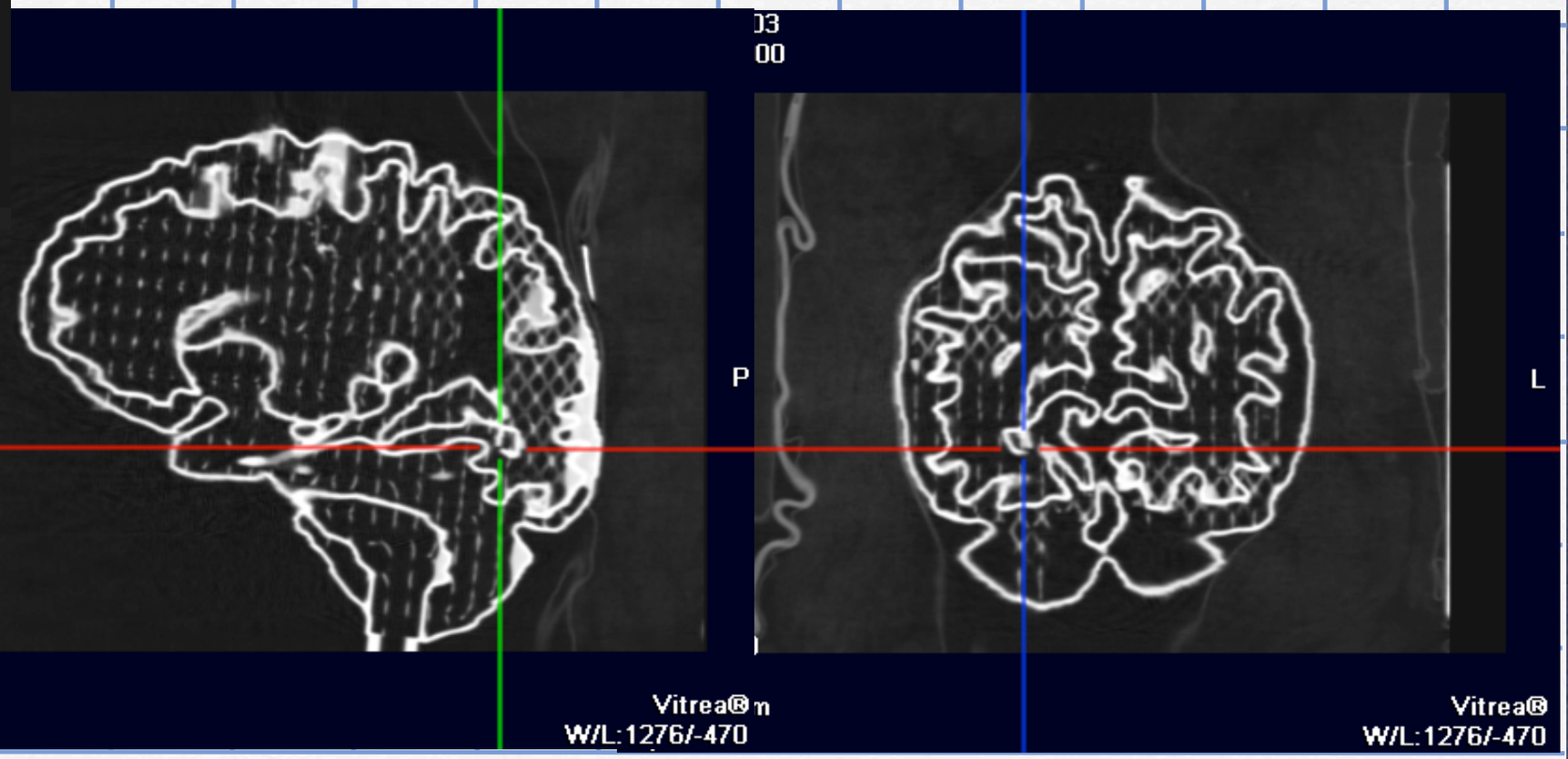
CT





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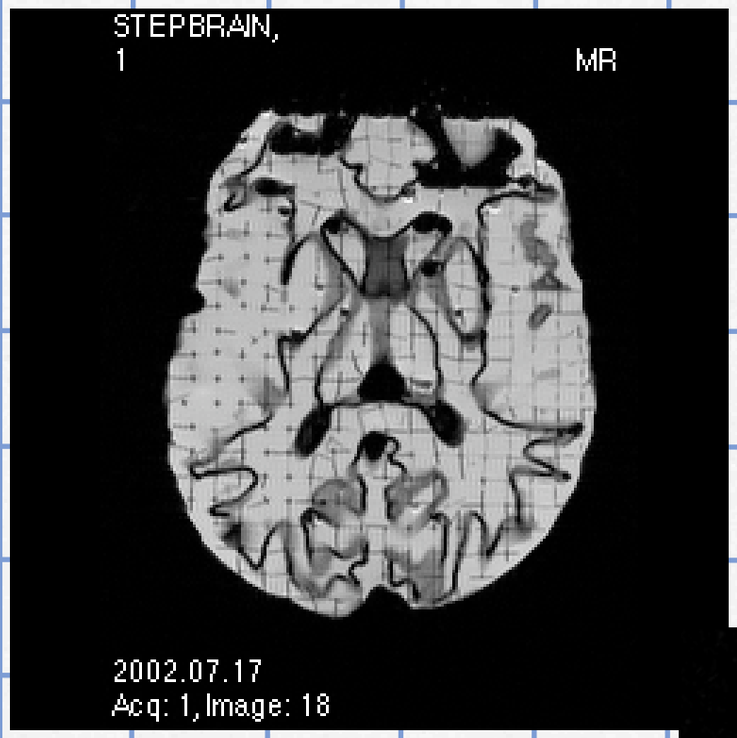
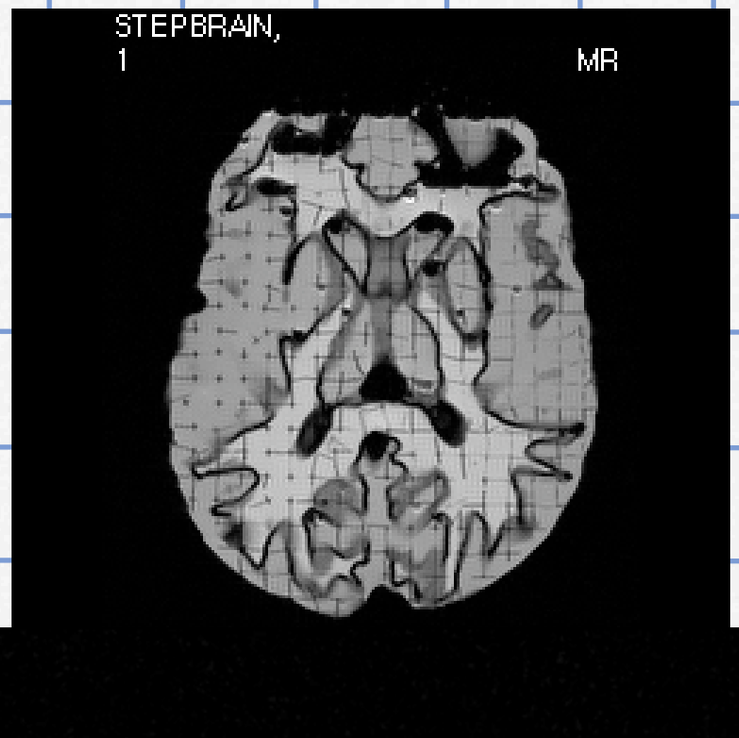
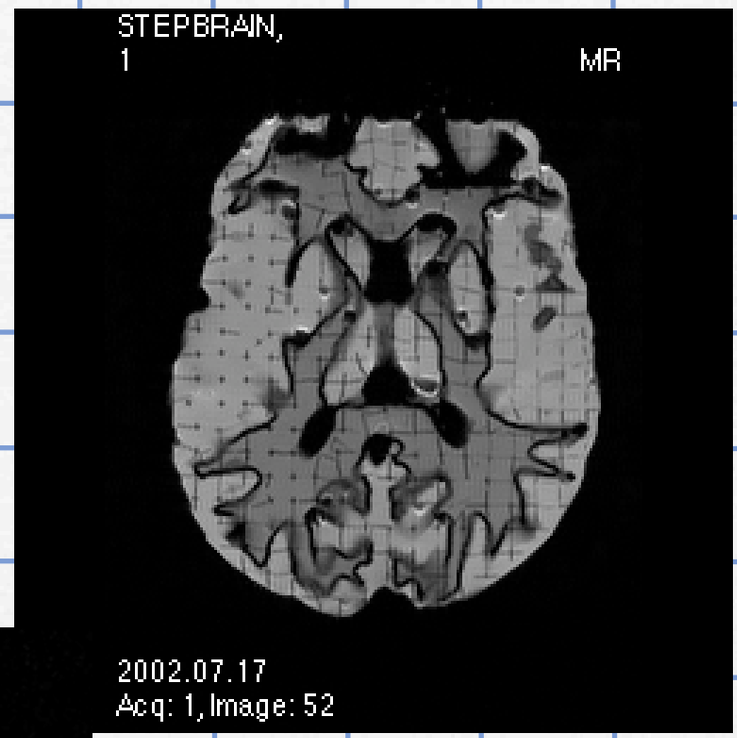
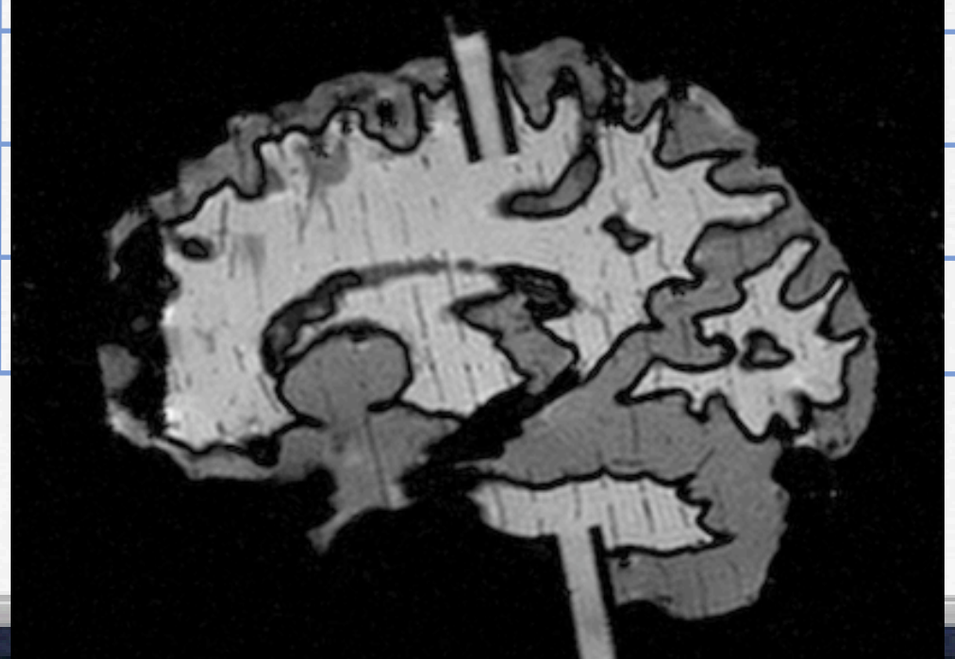


PDw





T_2w



T_1w

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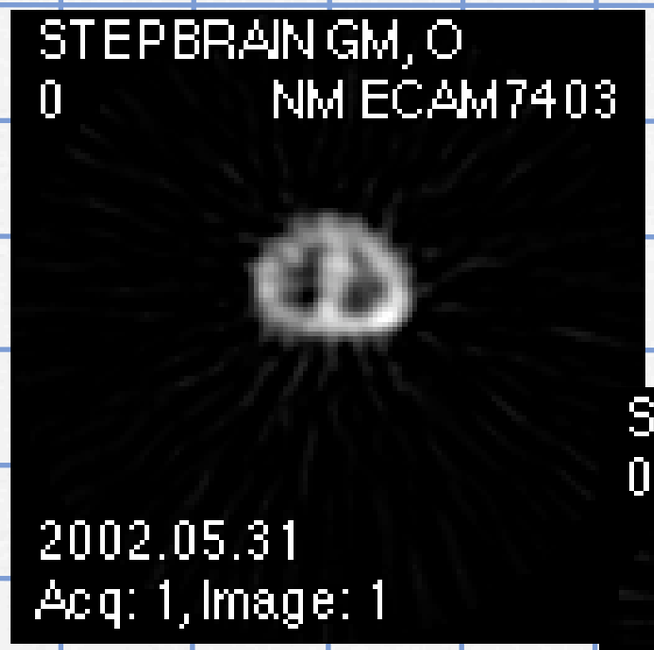
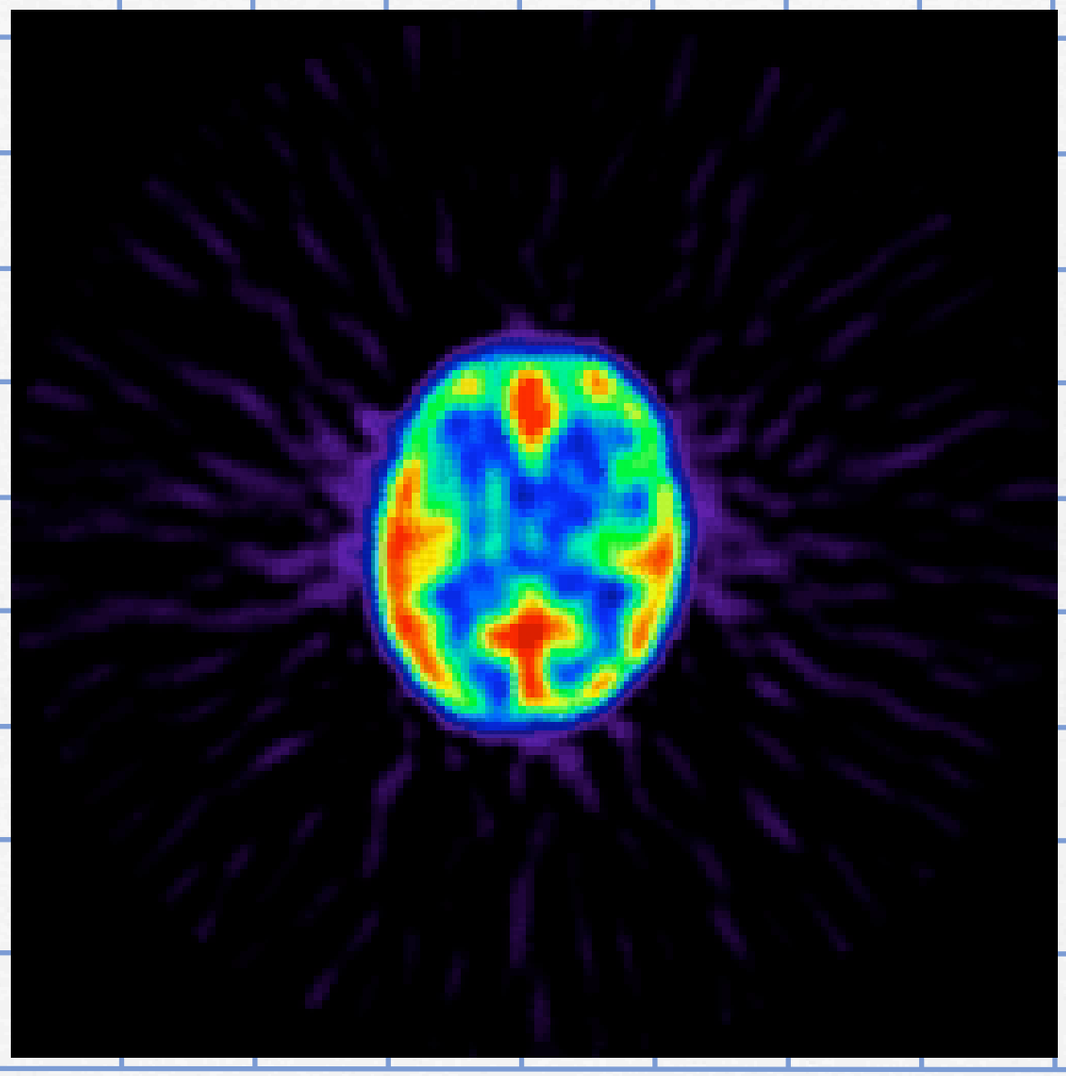
SPET





Conclusion:

- We have shown the feasibility of an anthropomorphic phantom suitable for multi-modality (nuclear medicine and MR/CT) imaging, using stereolitography.

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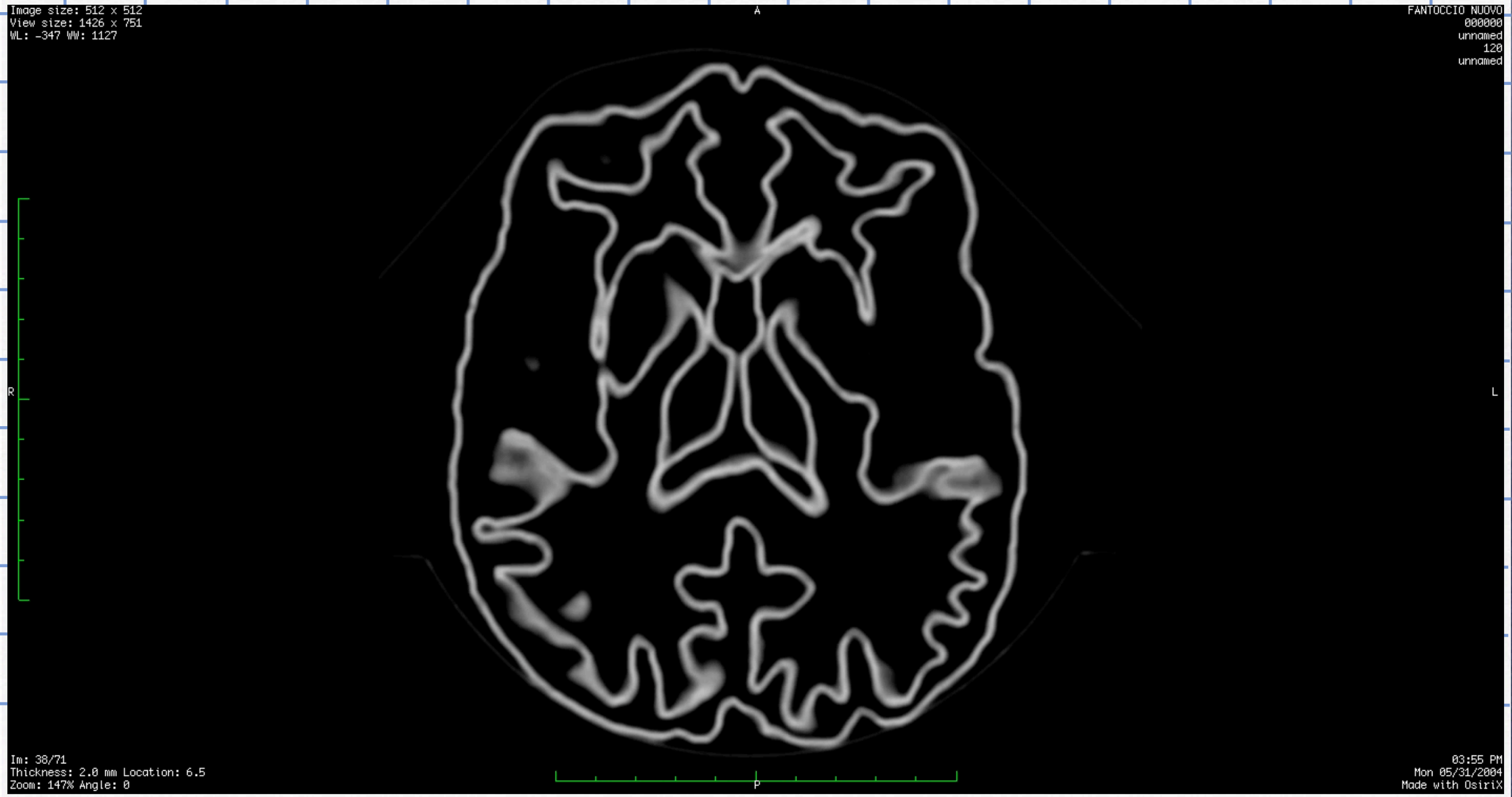
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