MNPS: Mevis Neurosurgery Planning System. Overview (June 2020).

By Armando Alaminos Bouza

MNPS allows pre-planning and simulation of several stereotactic neurosurgery procedures. It has support for most stereotactic apparatus on the market. MNPS is a software only system, it is not exclusive of any particular stereotactic manufacturer. Some of its functionalities are: stereotactic coordinates computation, stereotactic localization with X-ray images, image registration and fusion, functional neurosurgery tools, brain atlases, tractography, brachytherapy, radiosurgery, and more. MNPS has corrections for ring tilt and swivel inside CT/MRI gantry for all stereotactic systems. There is also support of DBS geometry, electric field, and VTA, for several brands and models.

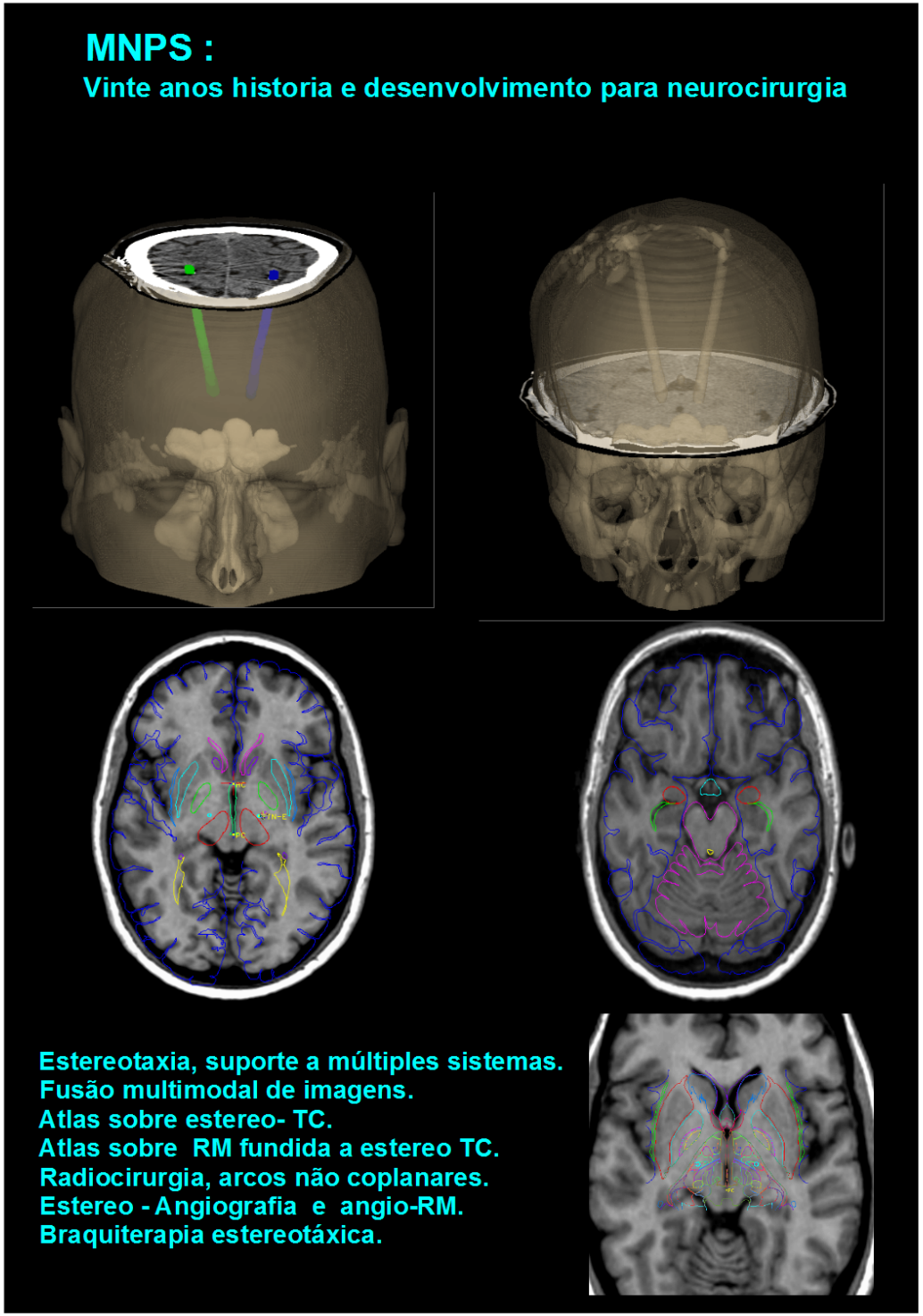
The present MNPS was born in 1989 as "NSPS". "MSPS" was its second name. Bibliography referring the use of NSPS/MSPS/MNPS is presented at the end.

MNPS is a Windows based system. It must be used on computers with Intel CPUs and NVidia graphic processors are recommended. Allows use on notebooks and surface computers, needs one free USB port.

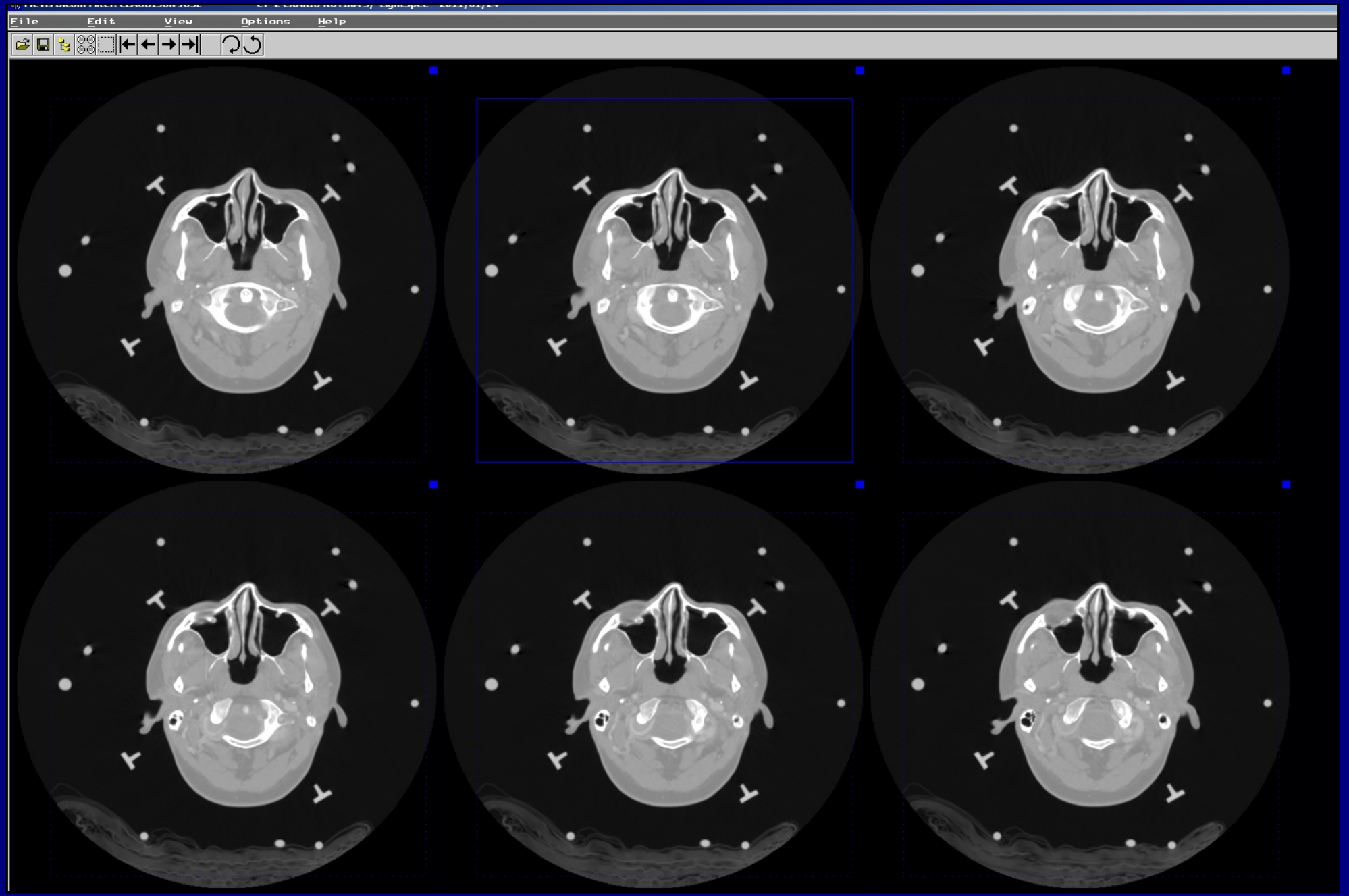
www.mevis.com.br

MNPS has a long history. The first lines of its code were written in 1989, for a Riechert-Mundinger system.

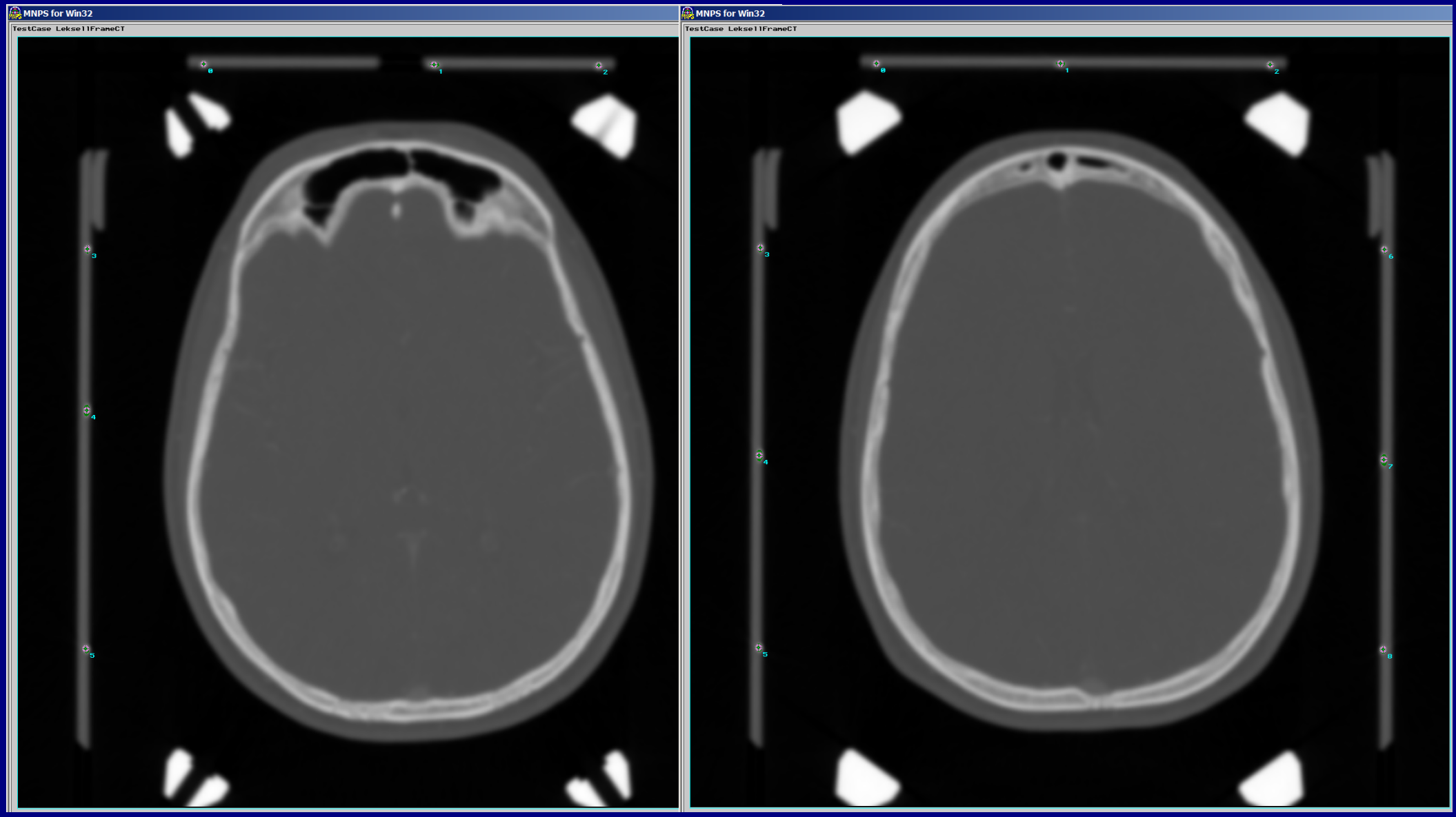
The right image shows a banner from a meeting in Brazil, 2010.



MNPS : Importing patient's images

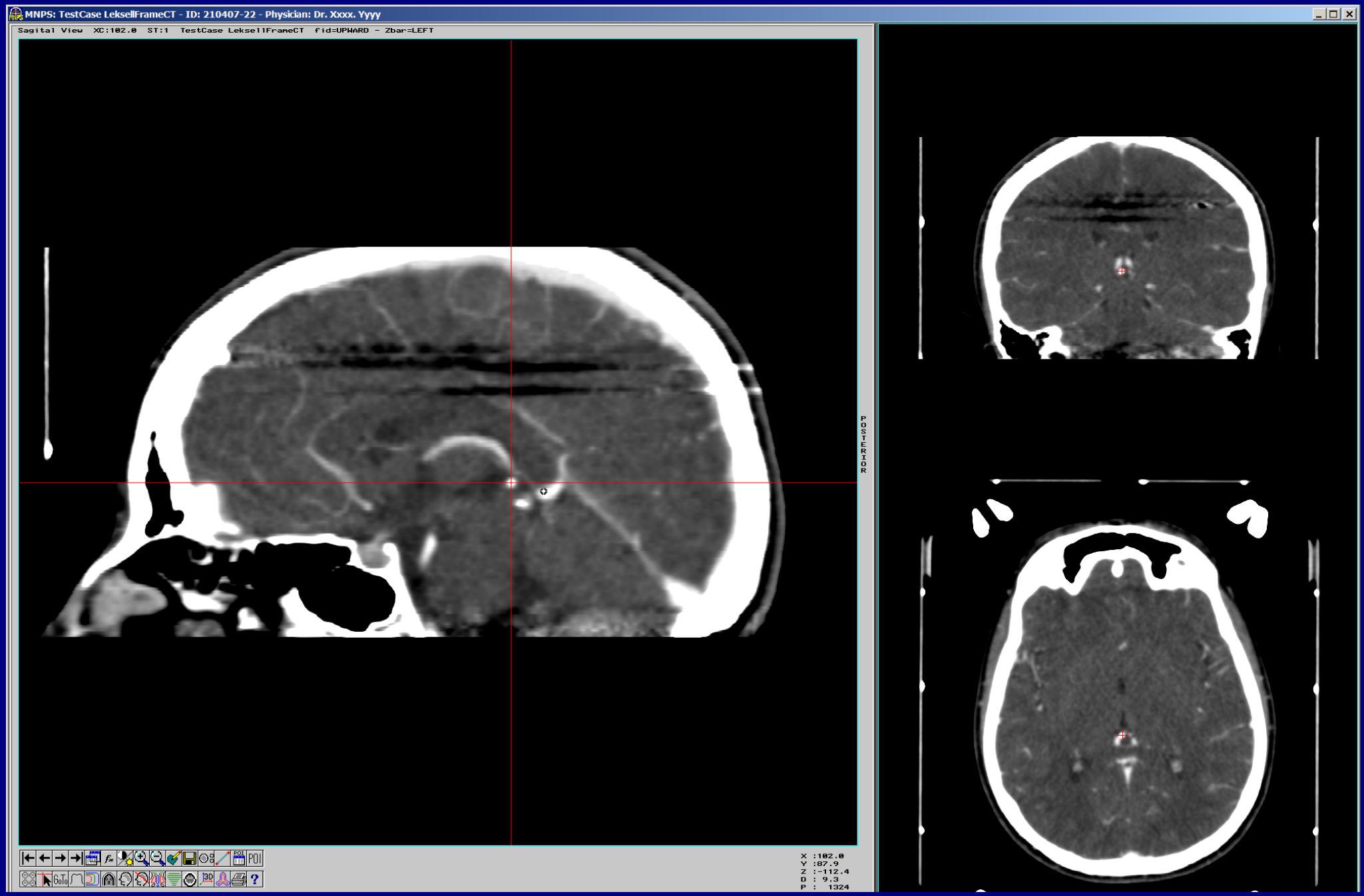


Support for DICOM, NifTI, PNG, TIFF and some proprietary image formats. Allows use of CT, MRI, PET and SPECT, but for 99% of the cases only CT and MRI are used. PNG and TIFF image are not recommended due to lack of geometric data.

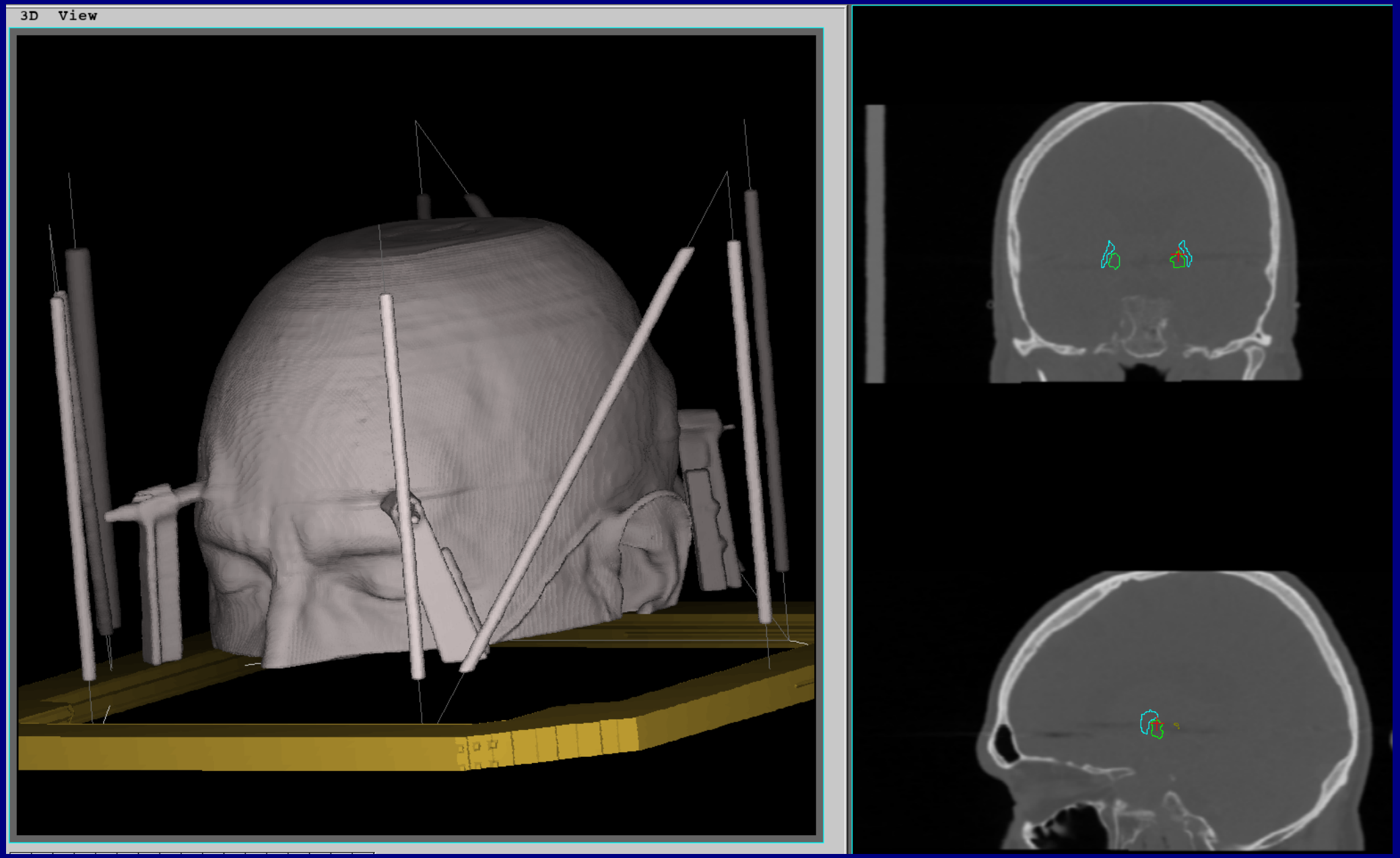


MNPS : Automatic fiducials detection for any supported stereotactic device, even those systems with markers embedded in plastic plates, resulting in lower contrast localizers. In the rare case where MNPS fails to find the fiducials, the operator can set the fiducials manually for that tomogram.

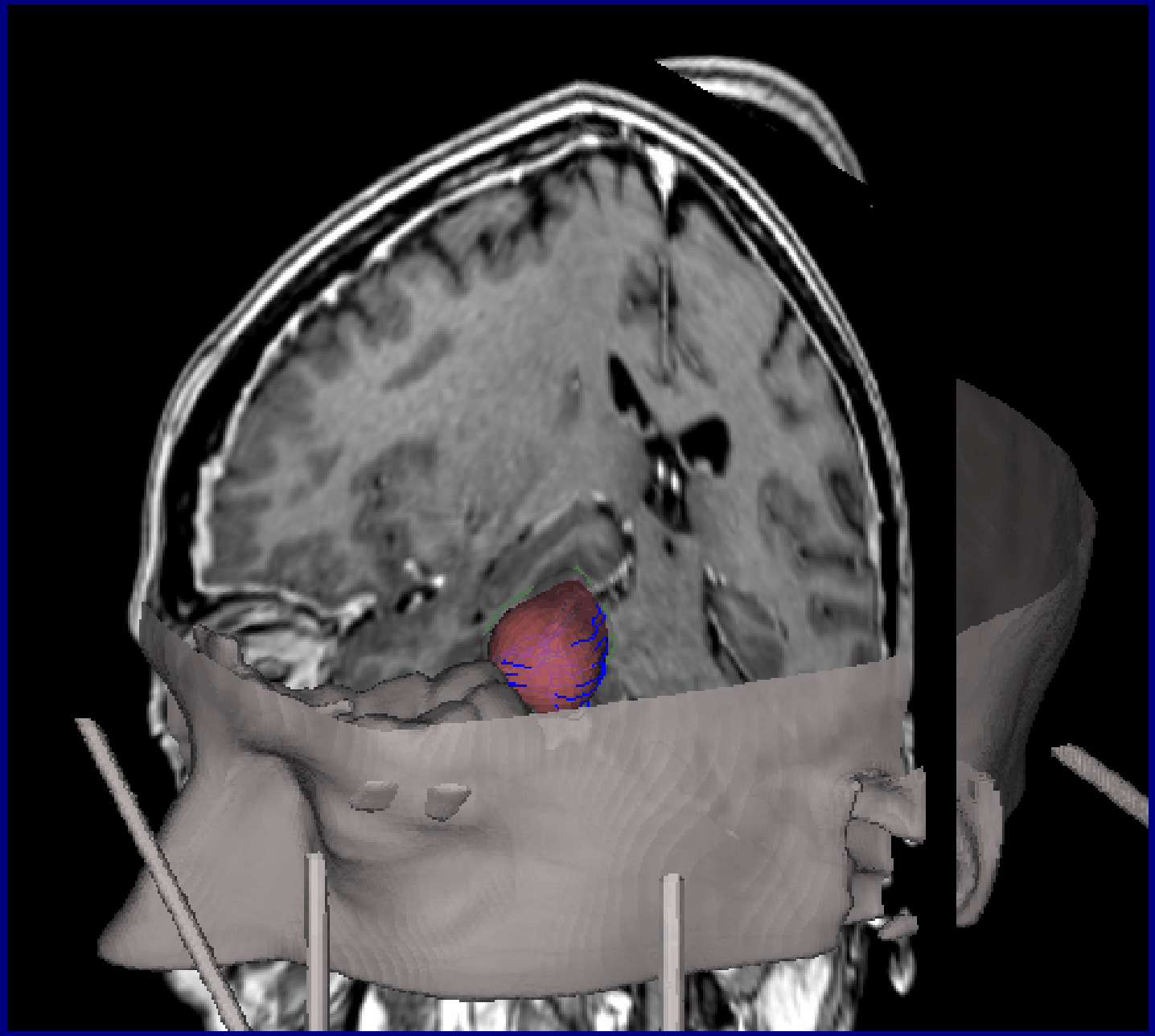
2D planning window. Stereotactic coordinates of the red cursor are continuously displayed. Reformatted images at the left are co-planar with red cross at main window. Reformatted images are rendered in real time following cursor movement.



Main window with reformatted image. Screenshot of planning over a reformatted sagittal image. MNPS accepts images with tilt and swivel. Stereotactic coordinates from images with tilt/swivel are corrected. CT calibration bias in stereotactic images are also corrected based on fiducials markers positions.

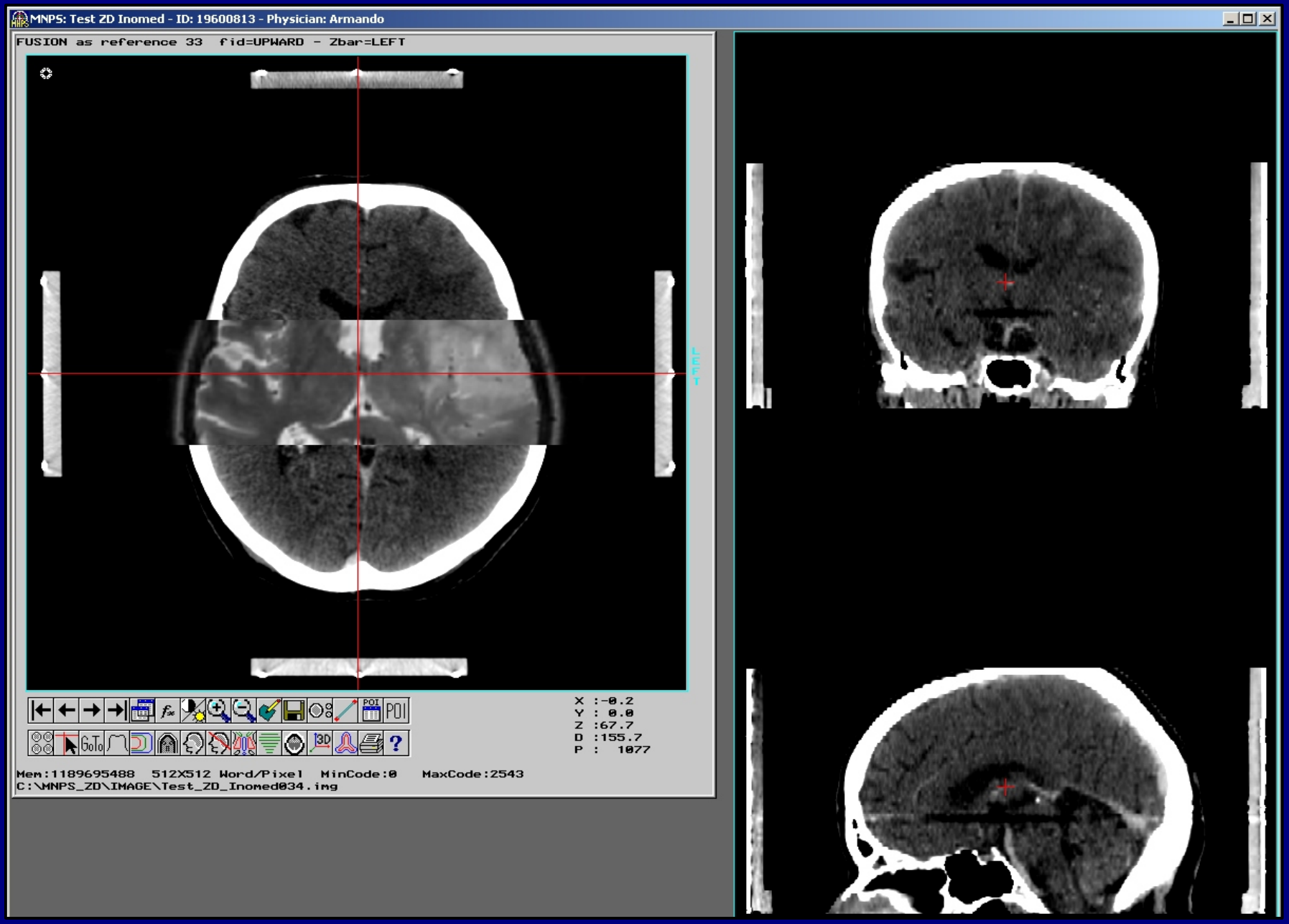


MNPS 3D window. Isodensity solid surface at skin level.



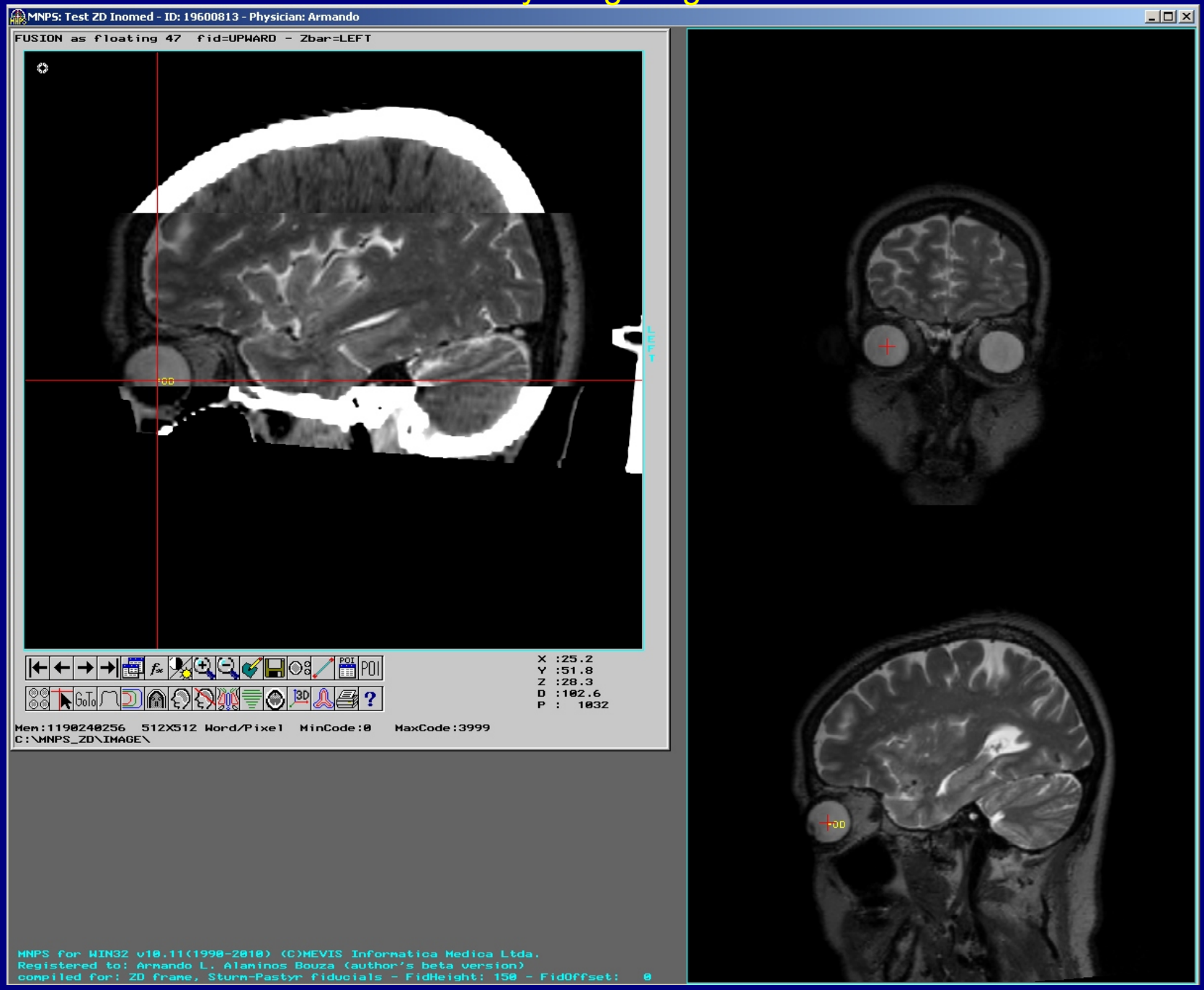
MNPS. Detail from 3D window with projection of principal planes and rendering the surface of a Region of Interest (ROI) drawn by the operator (red surface). There are several tools for image segmentation.

MNPS: Multimodality image registration and fusion.



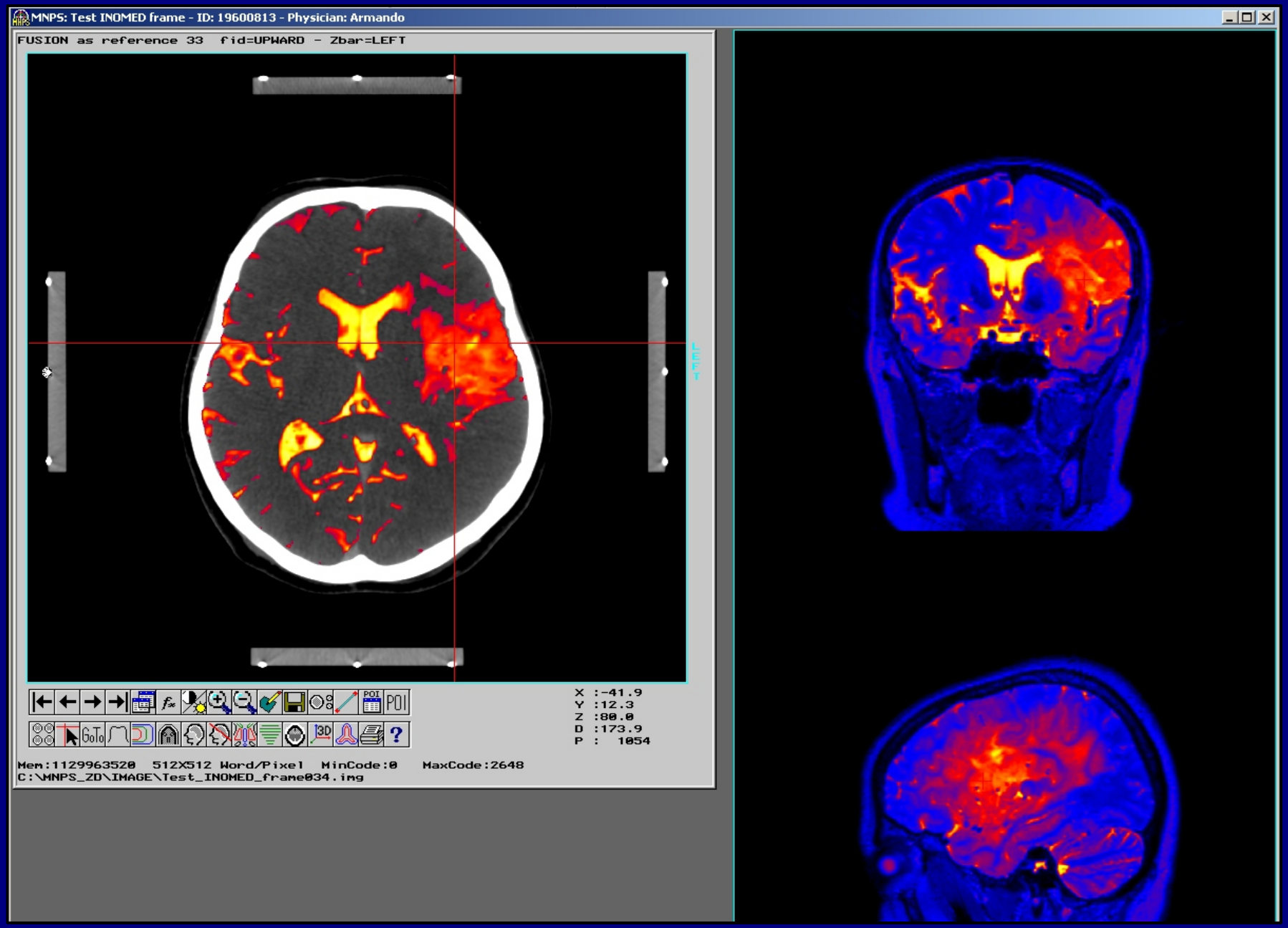
Non-stereotactic MRI or PET images can be registered into stereotactic CT space. MRI images can be distorted by some stereotactic frame parts inside the magnetic field, so it is advisable to use CT instead of MRI with the frame attached.

MNPS: Multimodality image registration and fusion.

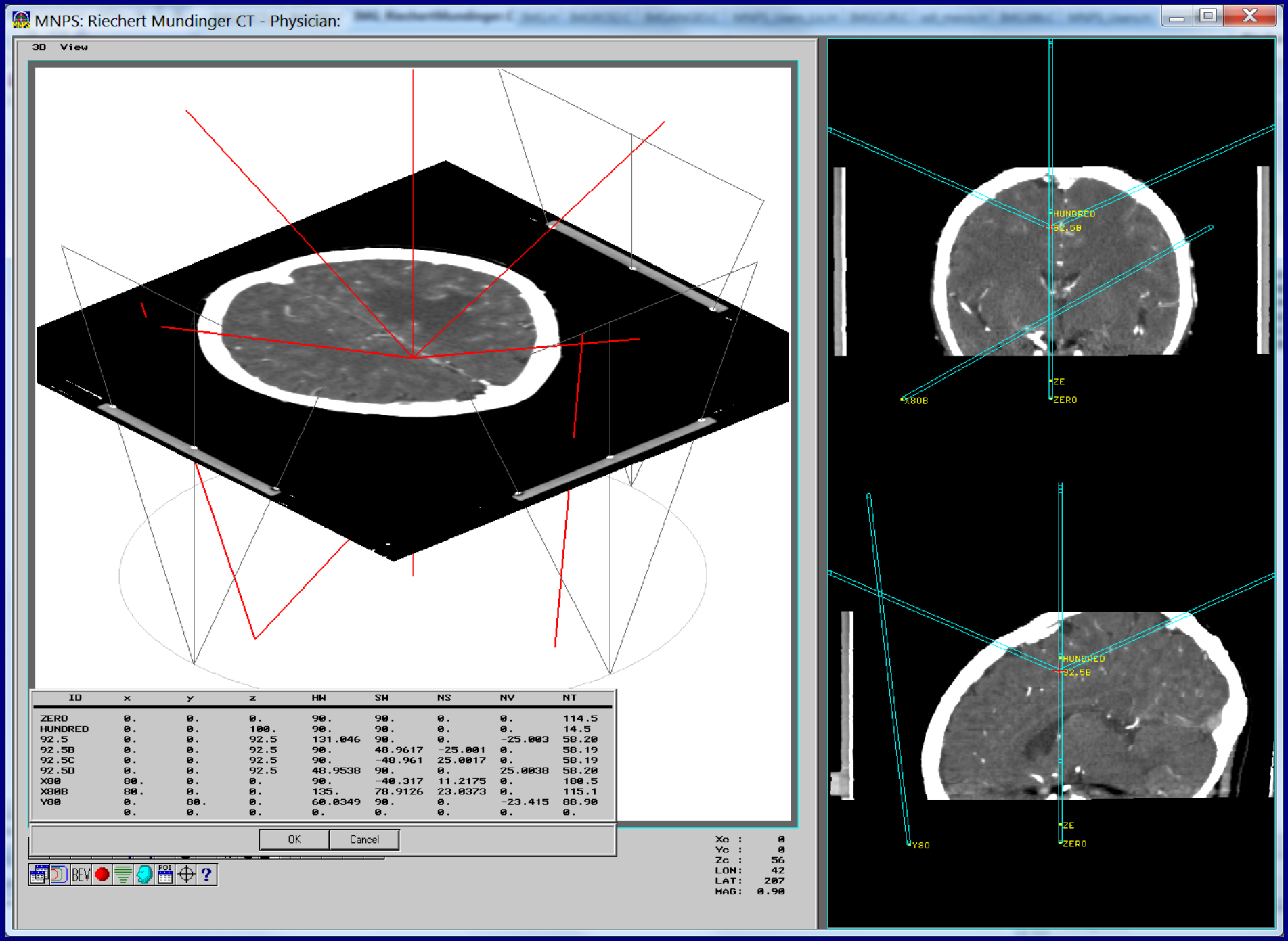


Reformatted images rendering MRI. Coordinates are stereotactic, even if cursor is over MRI. MNPS allows image registration with axial, coronal or sagittal MRI sets.

MNPS : Stereotactic CT and non-stereotactic MRI.

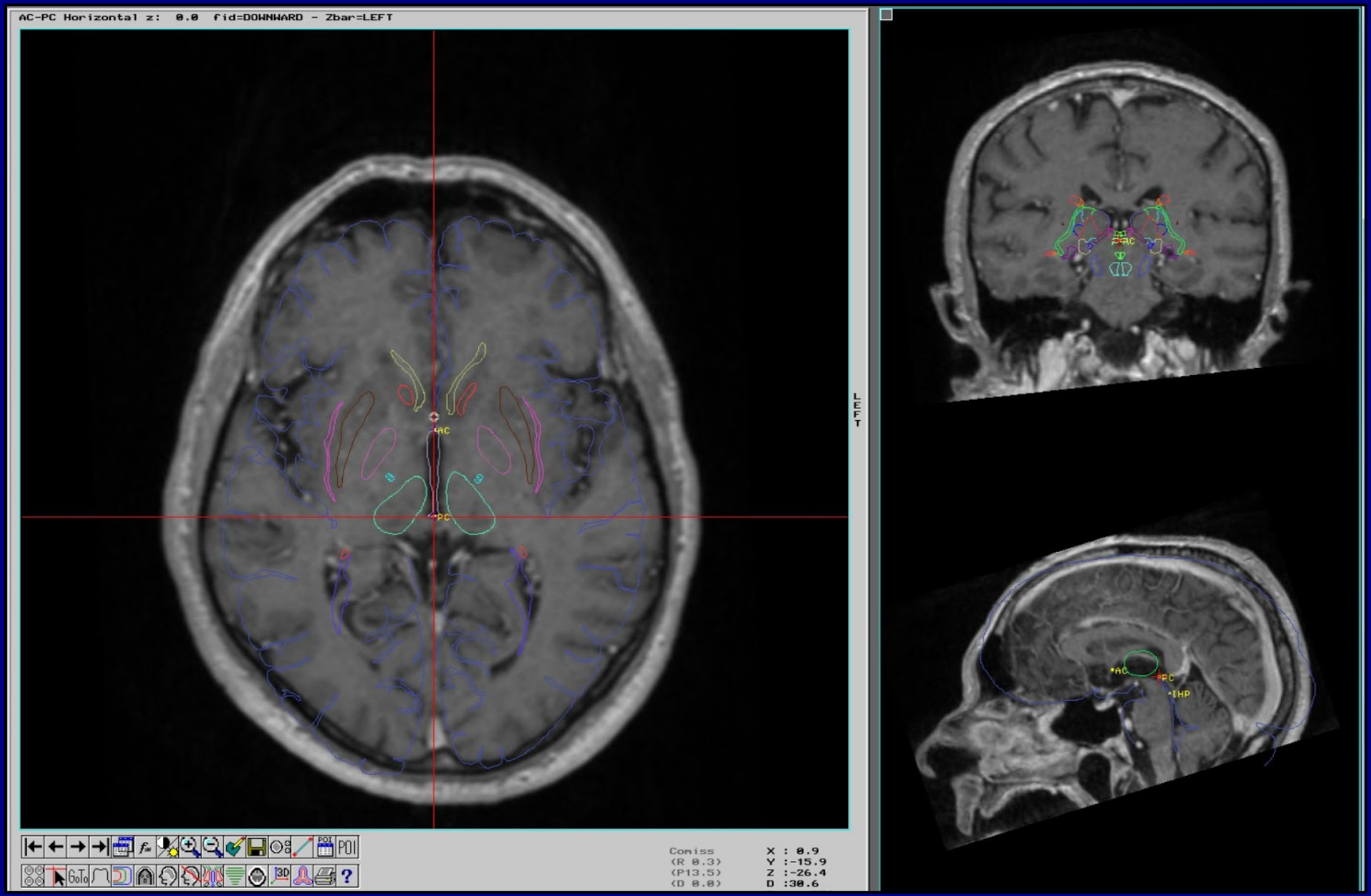


MRI rendered in false color. In the main window a high-band filter was used removing MRI voxels with low signal response.

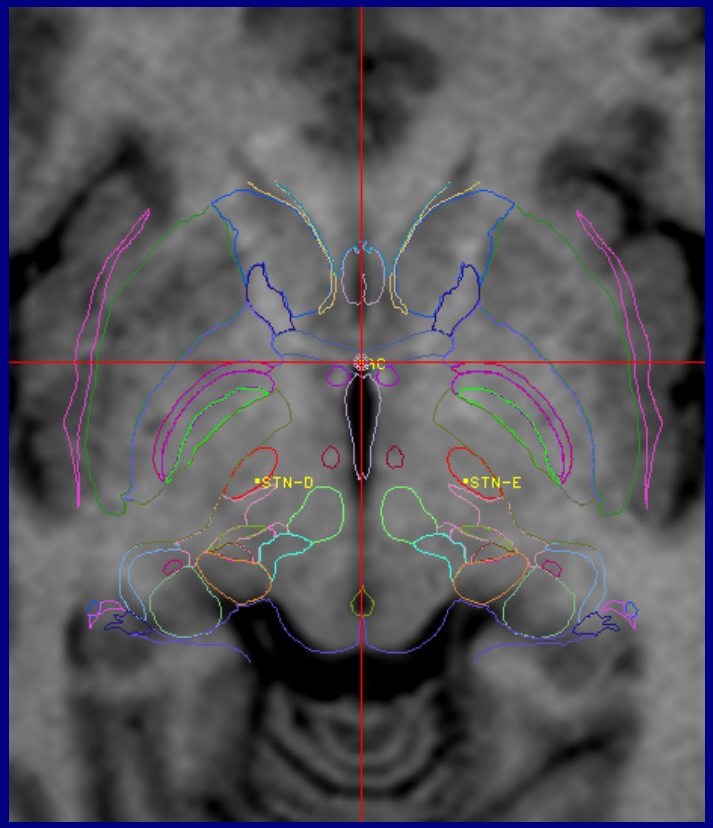


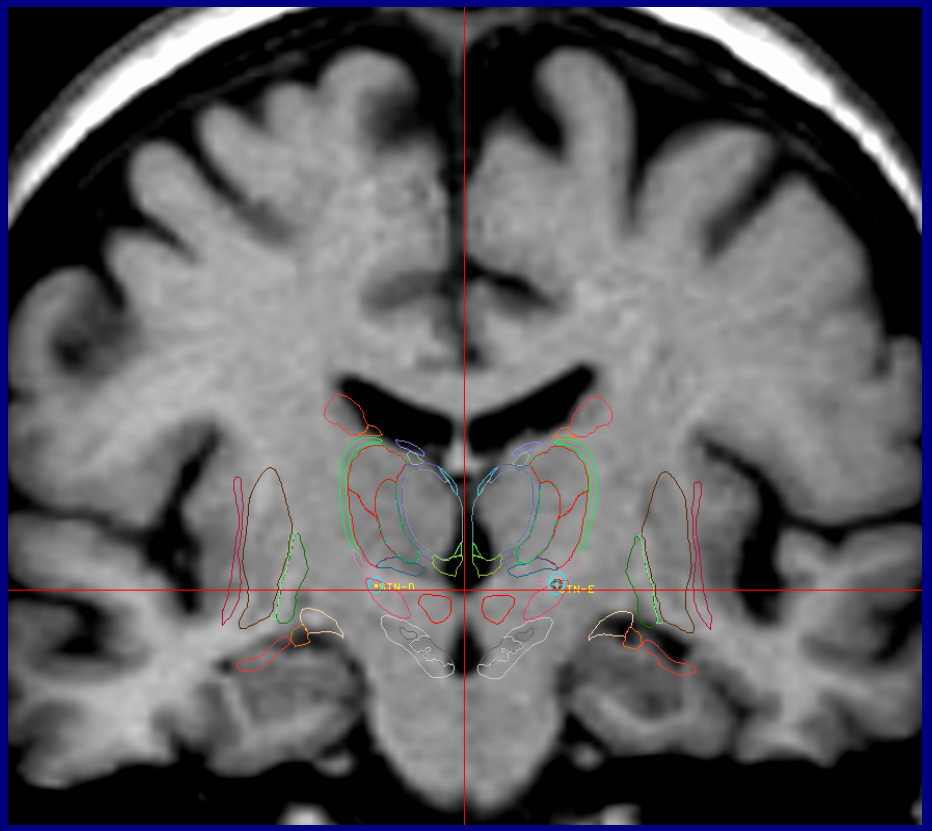
Stereotactic coordinates and trajectory projection. MNPS shows the stereotactic coordinates as a table at the left bottom side of the main window. For a Riechert-Mundinger system (case of the image), four angles an the needle depth are shown. For isocentric systems, only two angles are presented.

Functional neurosurgery tools on MNPS.



Most functional resources depends on the positions of three landmarks: AC (anterior commissure), PC (posterior commissure) and IHP (a point on the mid sagittal plane). The registration of all maps to the brain are based on those points. AC, PC and IHP definition is the operator's responsibility, there is not automatic method so far.

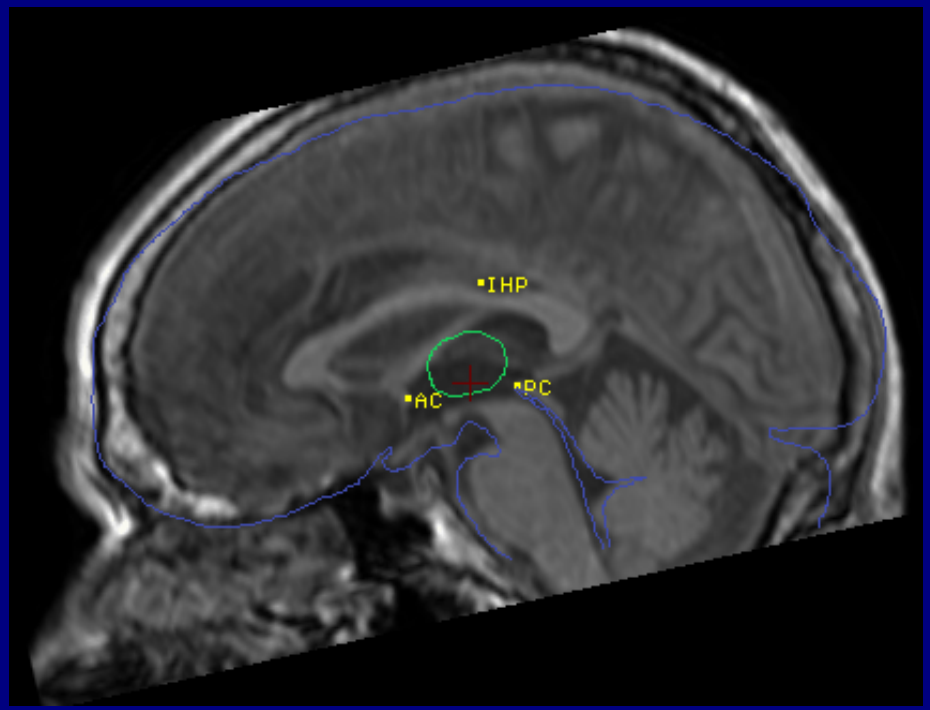




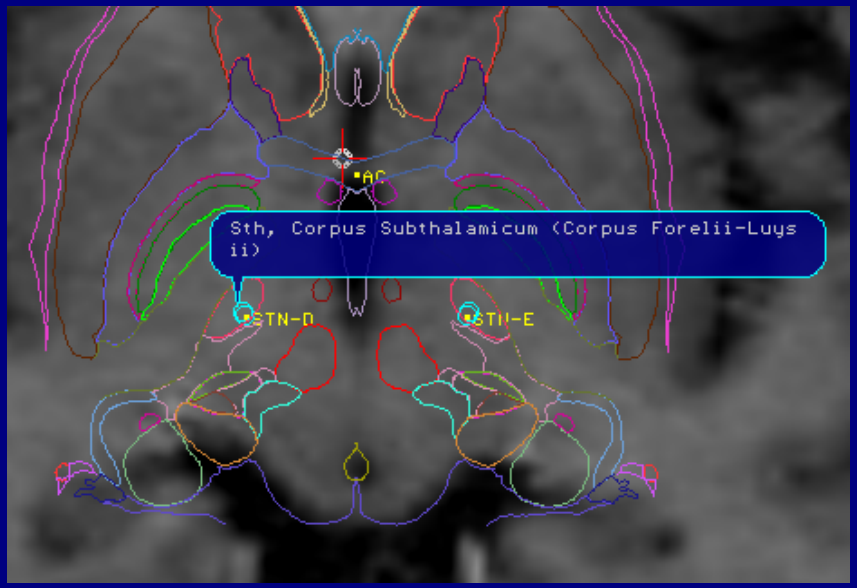
Maps overlayed on patient's brain.

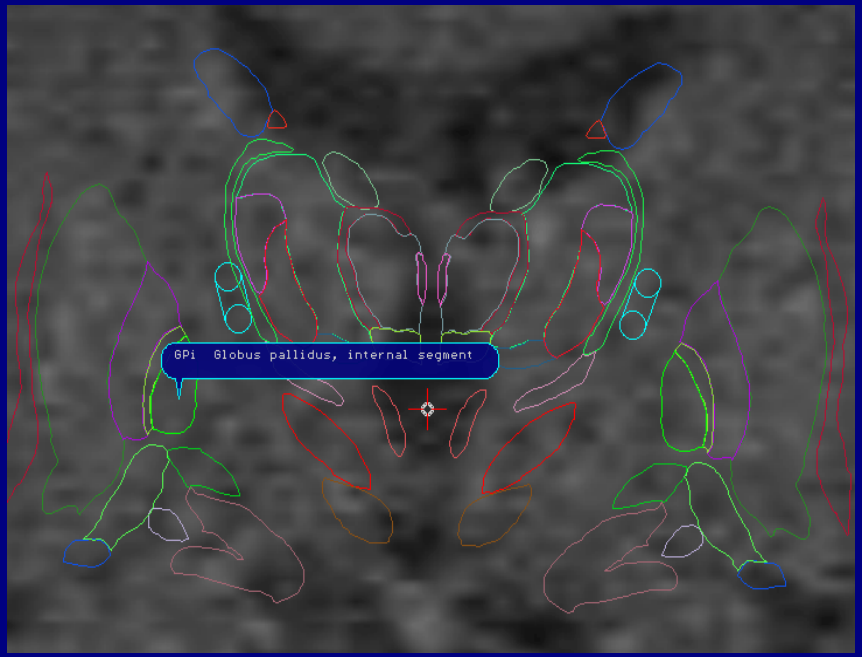
The maps were digitalized as vectors. Vectorial representation of maps has the advantage of allowing deformations for a better fit between the model's brain and the patient's brain.

The name of the nucleus is also stored, so that the operator can query MNPS about the name of any structure.

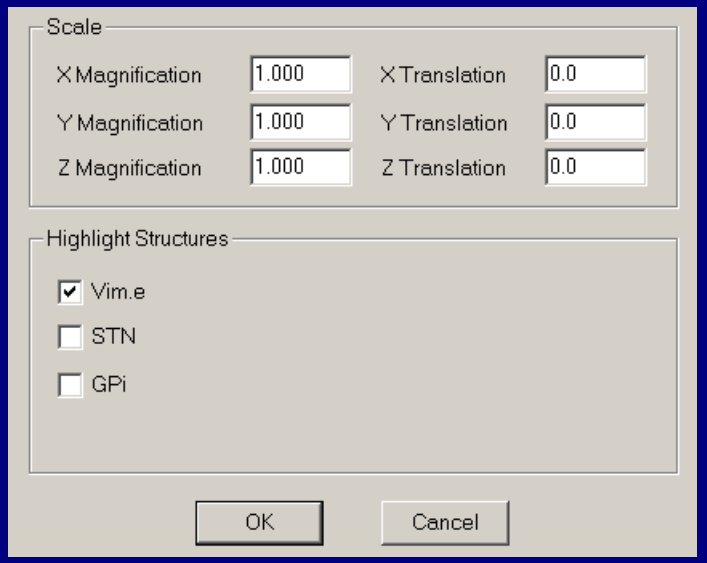


MNPS : Other tools for functional surgery planning





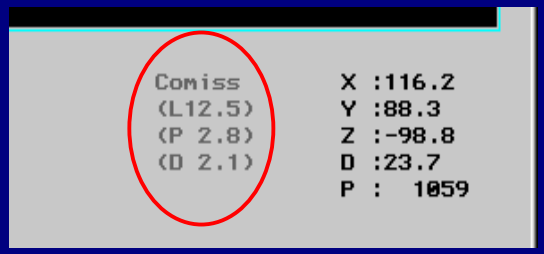
Maps allows query for the name of each structure as the cursor is moved



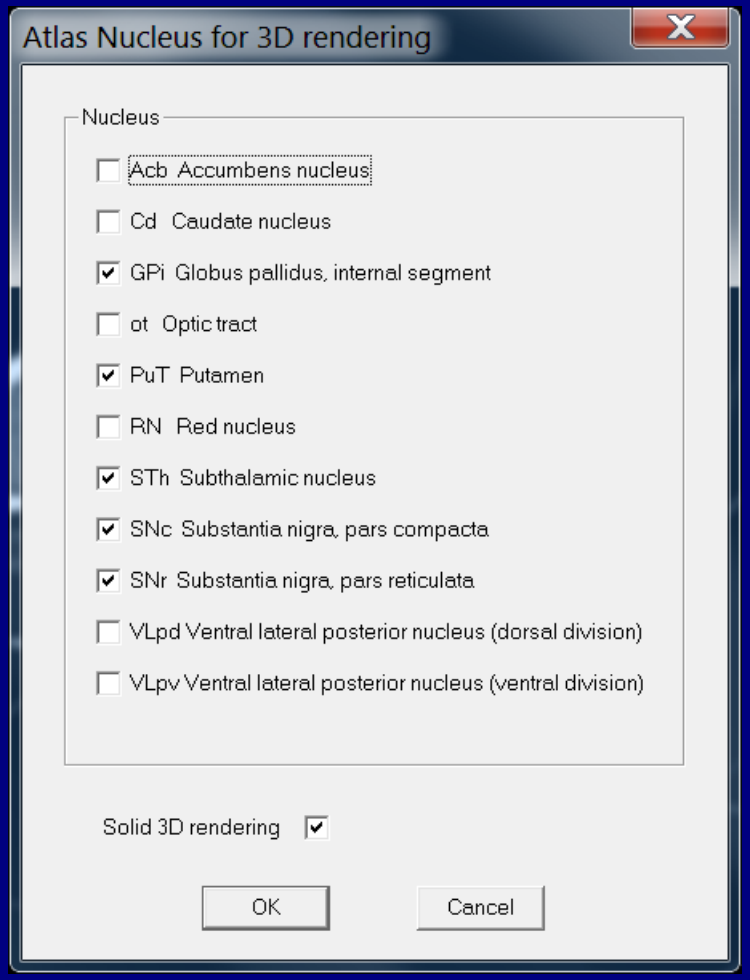
Vectorial maps allows some deformations and scaling operations to try a better fit into patient's topography. This is a detail of the maps setting window.

MNPS : Other tools for functional surgery planning

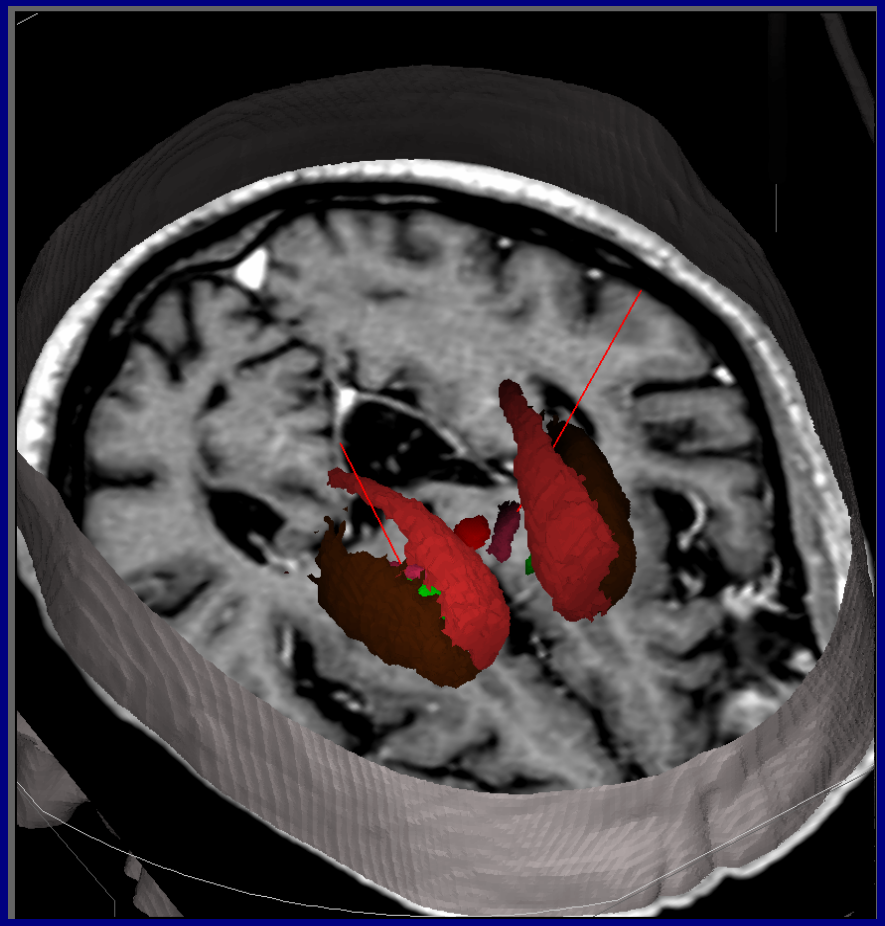
Some common targets can be suggested by MNPS based on AC, PC and IHP location.

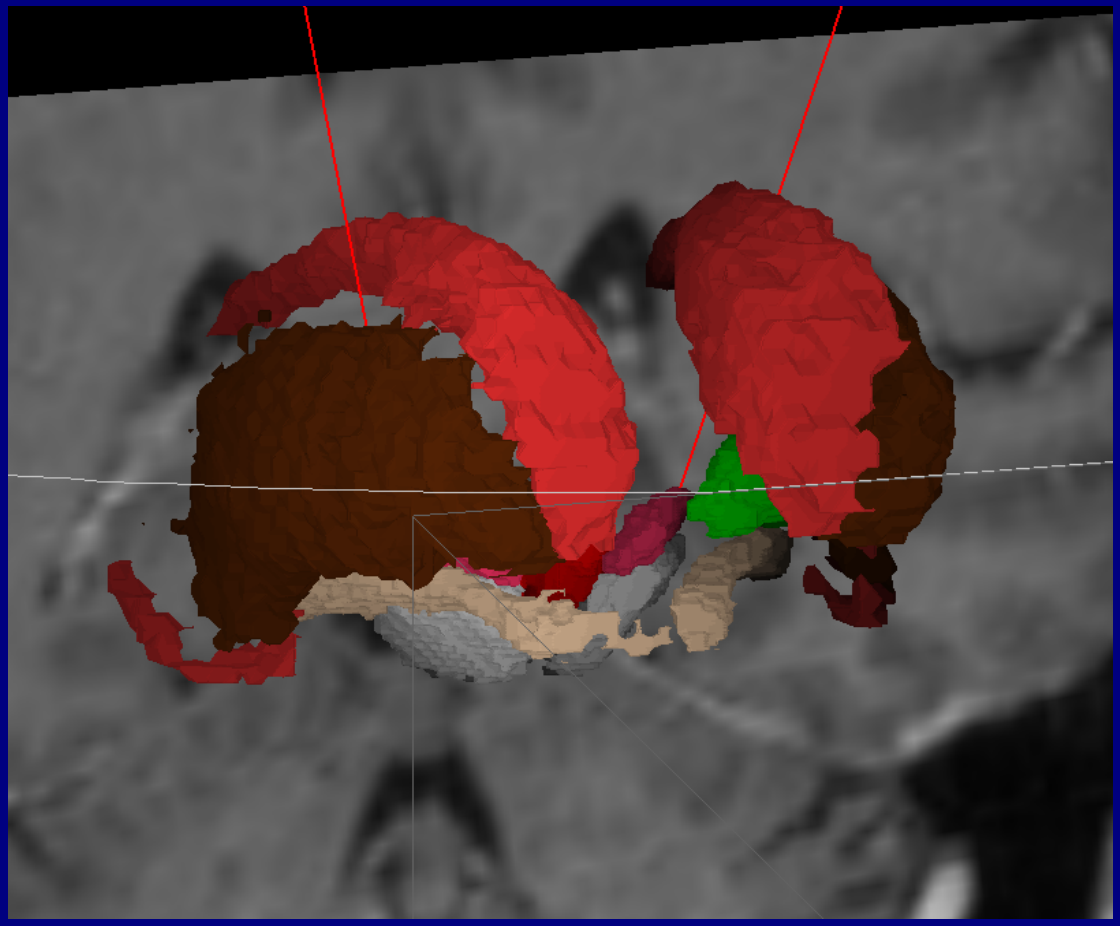


Once the user marks AC, PC and IHP, MNPS stars reporting commissural coordinates. The commissural Cartesian system in MNPS has origin at the inter-comissural point.

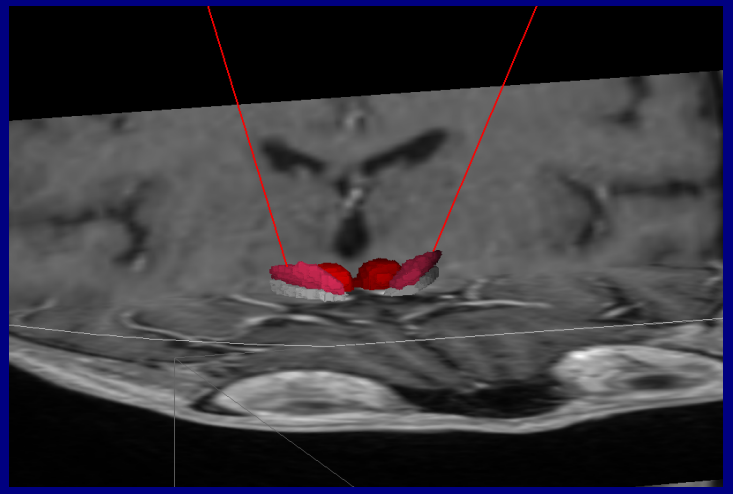


Nuclei with 3D representation





MNPS : 3D volumetric rendering of some functional nuclei with projected trajectories for a DBS or electrode.

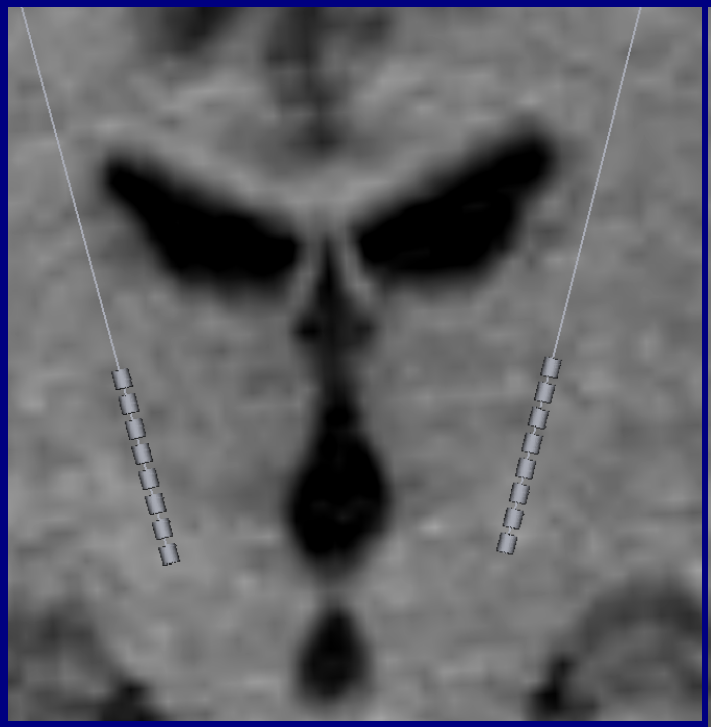


Precise geometrical model and rendering of several DBS by brand and model.

DBS Selection Menu

```
Select a DBS brand & model

Medtronic   1.5 mm spacing
Medtronic   0.5 mm spacing
St.Jude     1.5 mm spacing
St.Jude     0.5 mm spacing
Boston Scien.   8 contacts
Boston Scien.Dir Cartesia
SceneRay    0.5 mm spacing
SceneRay    1.0 mm spacing
SceneRay    1.5 mm spacing
St.Jude.Dir 0.5mm spacing
St.Jude.Dir 1.5mm spacing
```

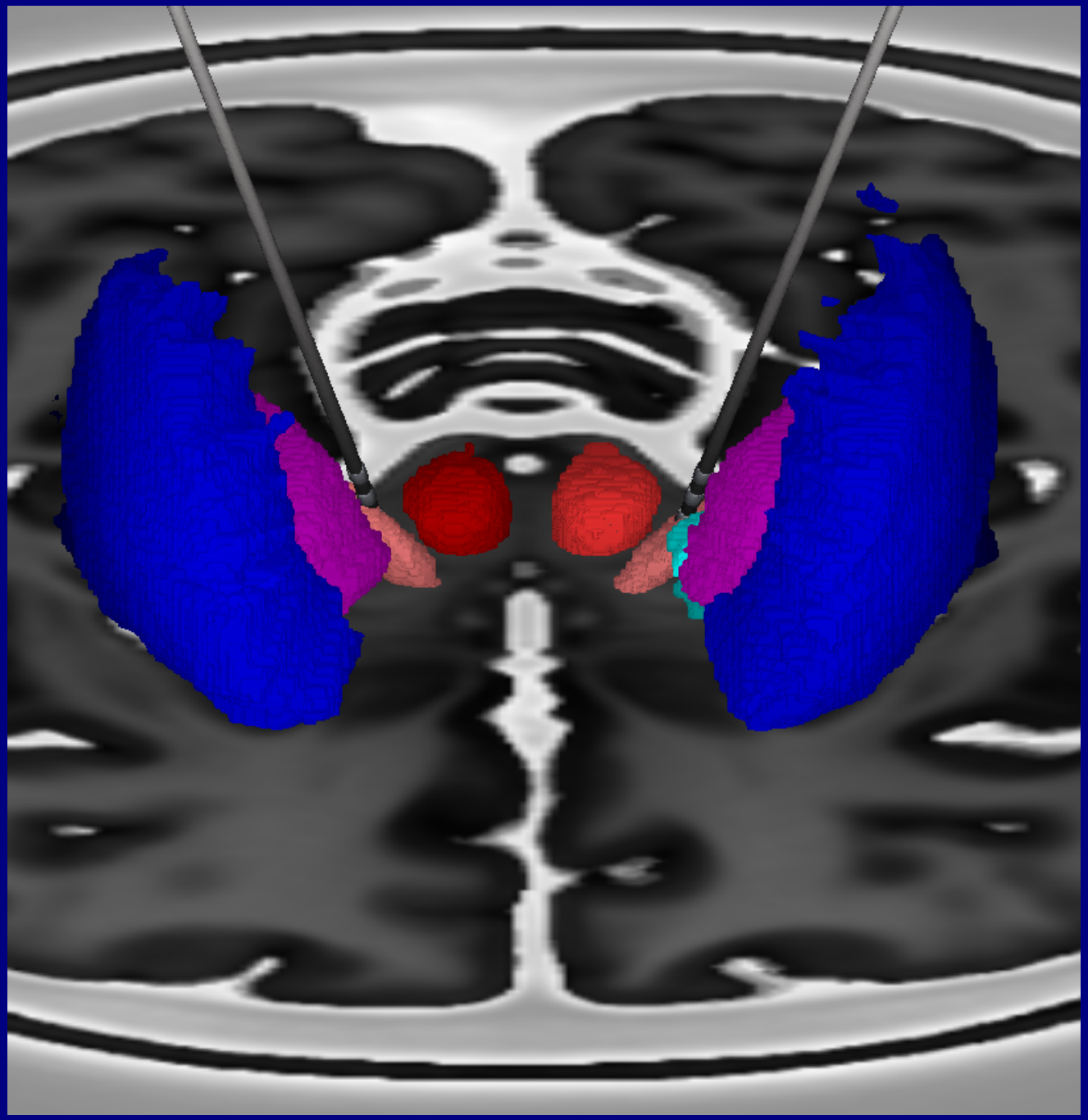


Boston Scientific

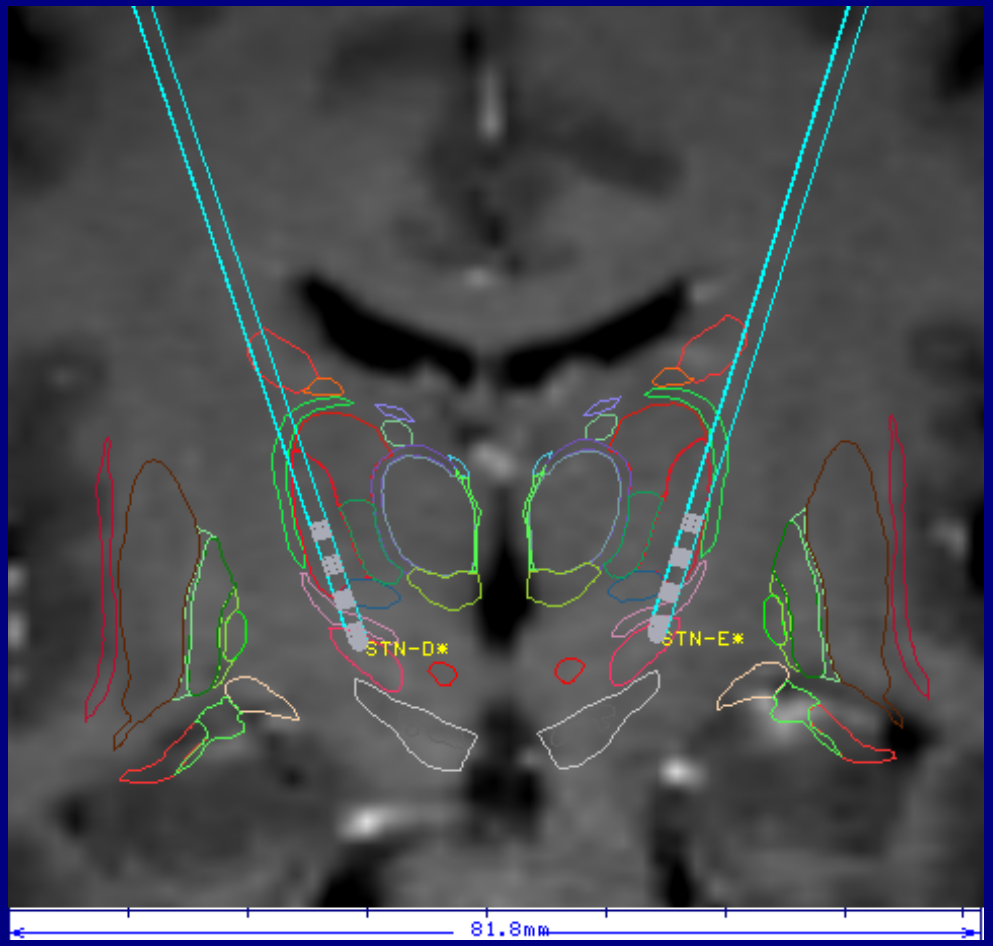
Medtronic

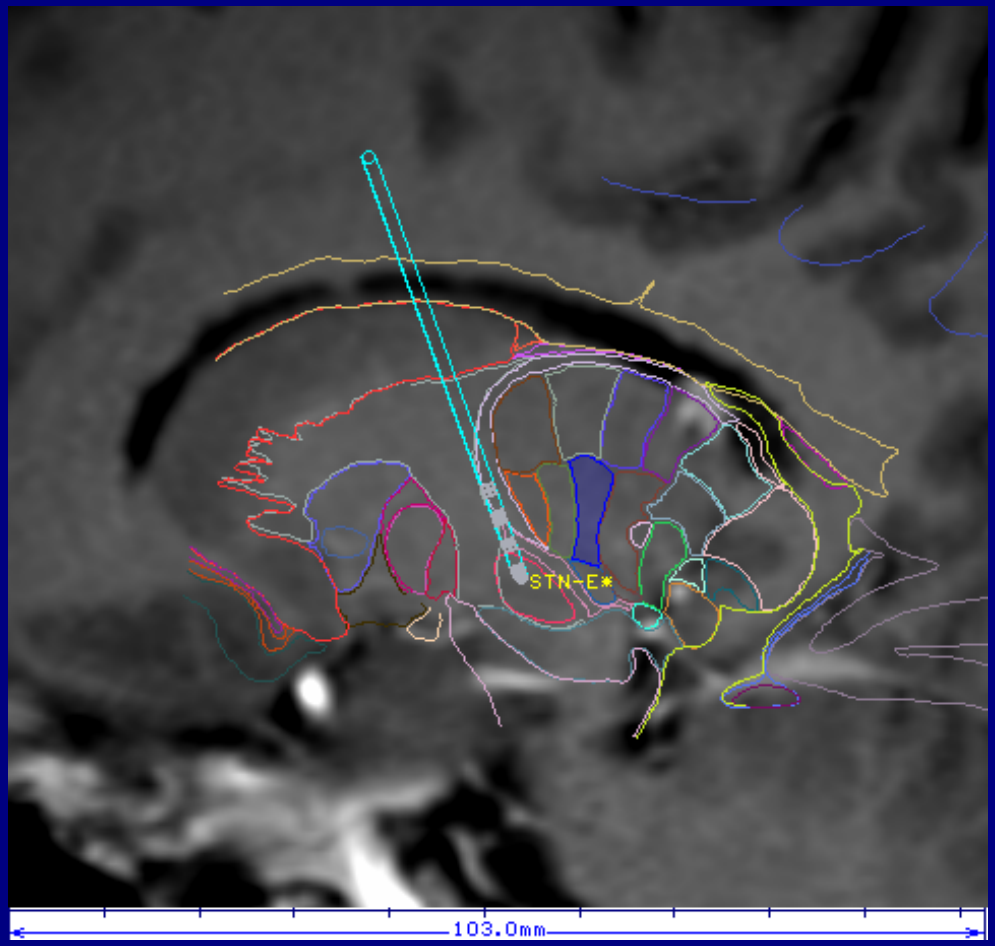
Saint Jude

3D Rendering of bilateral DBS entering the STn,
as part of pre-planning for a functional procedure

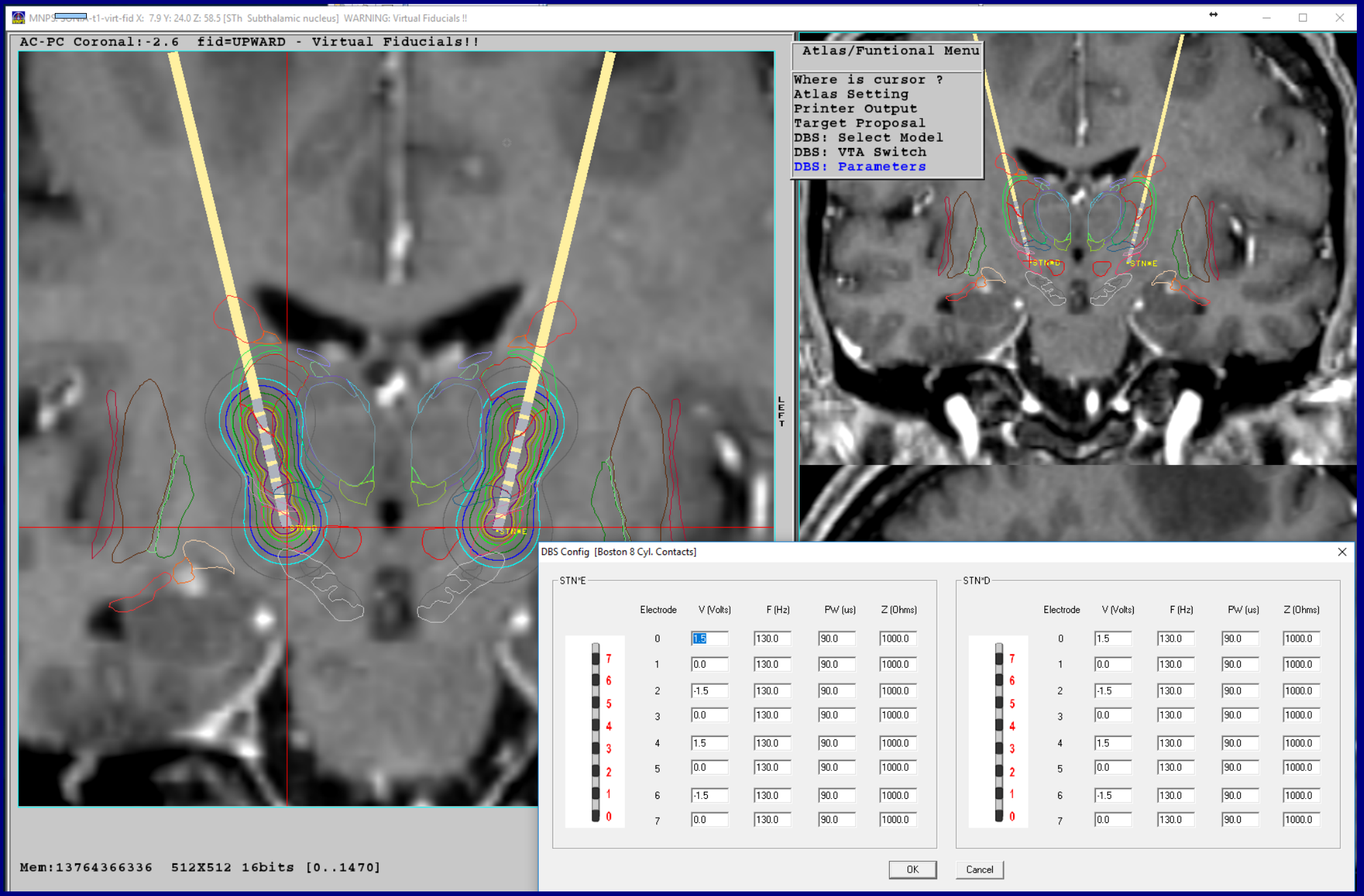


MNPS showing DBS over registered MRI image with overlayed functional maps. This is a DBS with 1.5 mm electrode size with 1.5 mm spacing.

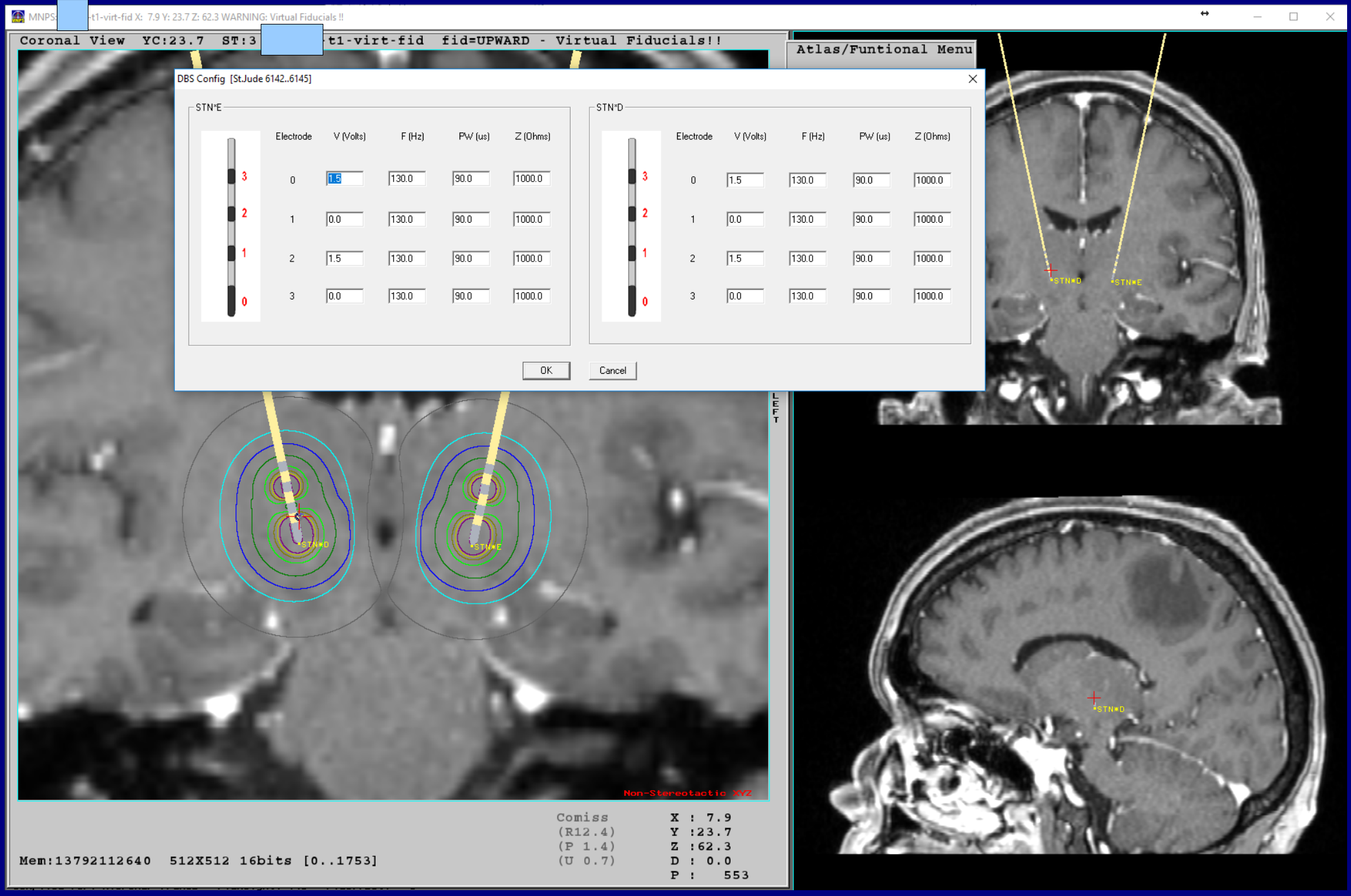




Implementation of the Electric Field model (FEM solution) allowing presentation of Electric Field Modulus around a set of DBS leads. Brain tissue is treated as homogeneous and isotropic (conductivity and permittivity are constant for all tissue).



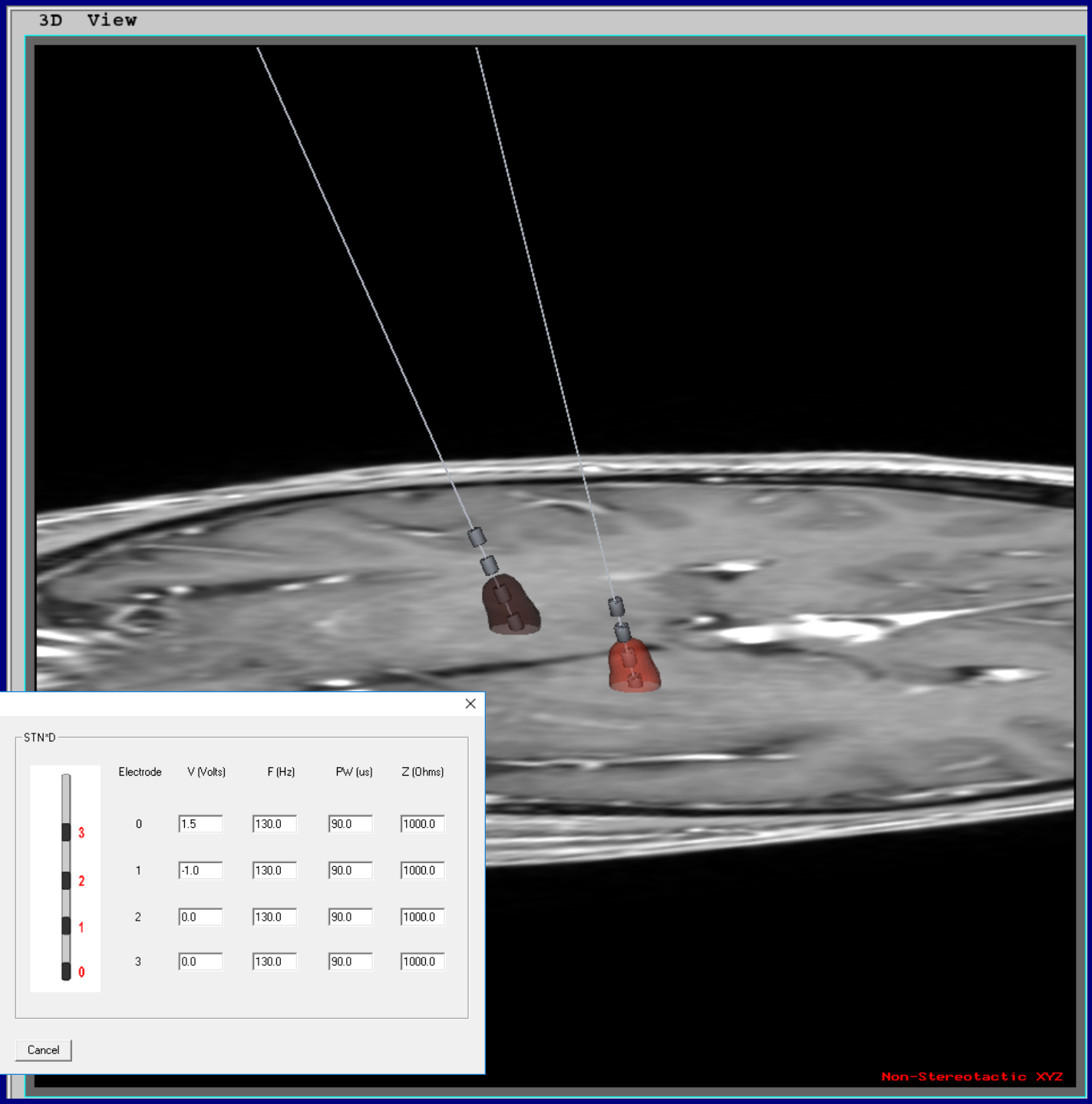
Finite Element Model (FEM) of the electric field allows simulation of arbitrary shaped contact. Note the eccentricity of the field near the contact, specially for the tip of a Saint Jude lead. Also observe the influence of several active contacts on the resulting field.



MNPS rendering VTA on the 3D window.

Volume of Tissue Activated (VTA) shown with 50% transparency.

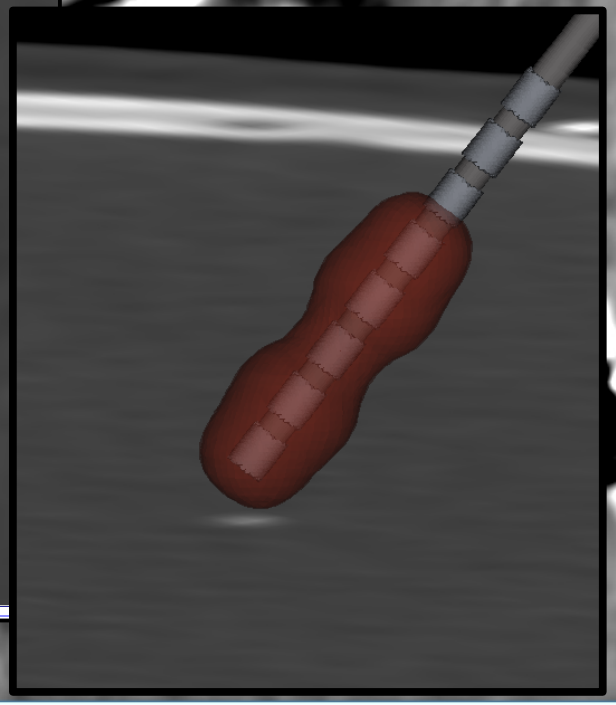
Conductivity and permittivity of tissue are assumed isotropic. Correlation between electric field and VTA are taken from literature.



MNPS: MS-case-10-ct-post X:-12.6 Y:-13.0 Z:-10.4 WARNING: Virtual Fiducials !!

Probe-View - offset: -0.0 - Virtual Fiducials!!

Tilted x:-12.7 y:-12.9 z:-10.2 beta: 66.5 fid=UPWARD - Virtual Fiducials!!



Functional-Atlas Menu

Where is cursor ?
Atlas Setting
Printer Output
Target Proposal
Atlas Struct to ROI
DBS: Select Model
DBS: VTA Switch
DBS: Parameters
Render 3 Planes VTA
VTA Conformity Index

DBS Config [Boston 8 Cyl. Contacts]

DBS*L

Electrode	I (mA)	F (Hz)	PW (us)	Z (Ohms)
0	1.0	130.0	90.0	1000.0
1	-1.5	130.0	90.0	1000.0
2	1.0	130.0	90.0	1000.0
3	-1.5	130.0	90.0	1000.0
4	1.0	130.0	90.0	1000.0
5	0.0	130.0	90.0	1000.0
6	0.0	130.0	90.0	1000.0
7	0.0	130.0	90.0	1000.0

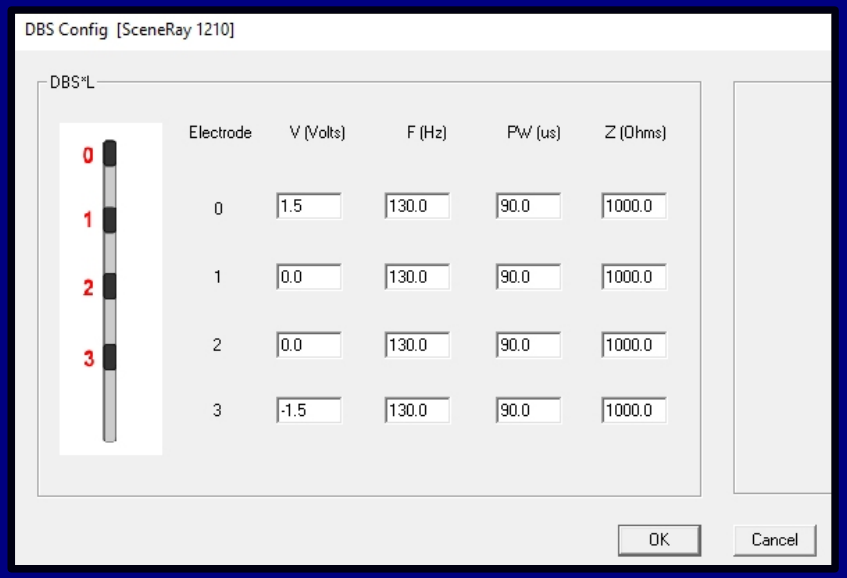
Electrode	I (mA)	F (Hz)	PW (us)	Z (Ohms)
0				
1				
2				
3				
4				
5				
6				
7				

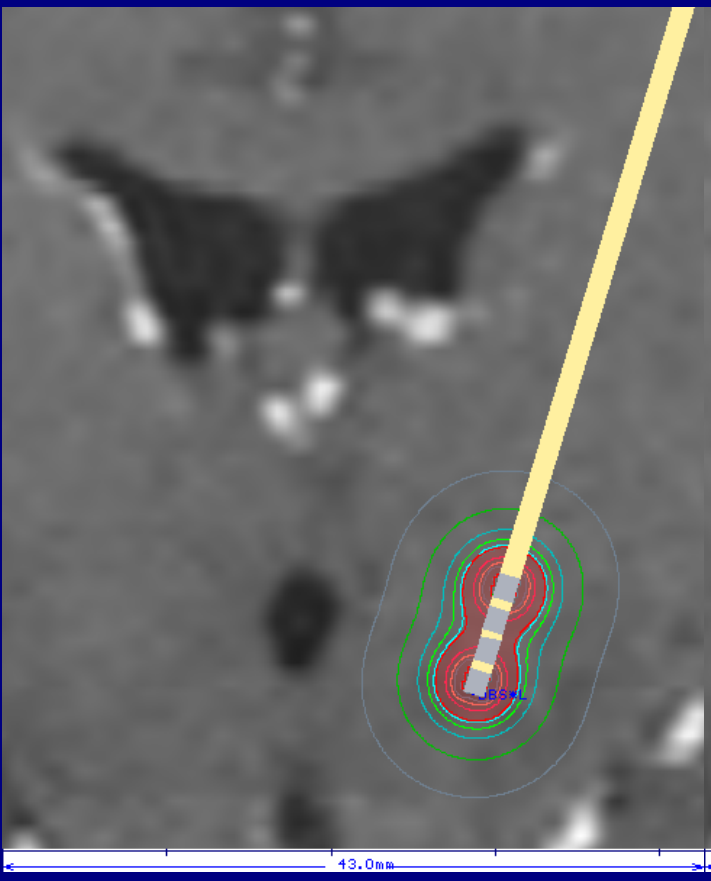
OK Cancel

Mem:13005135872 512X512 16bits [0..3735] (D 3.5) D : 4.0

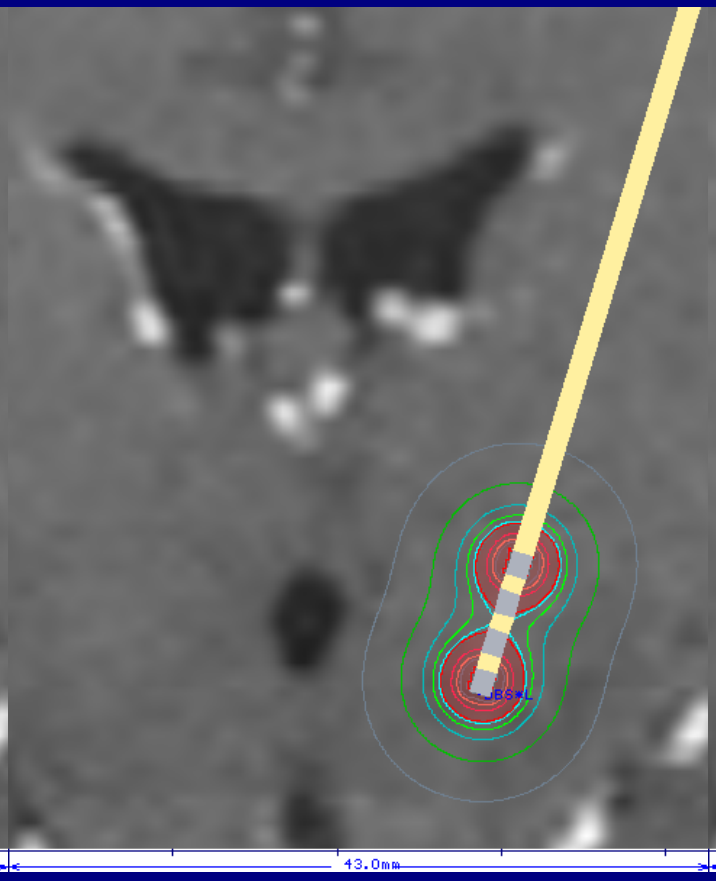
MNPS: Support to SceneRay DBS models

Three models with the same electric parameters resulting in slightly different electric fields and VTA, due to contact spacing.

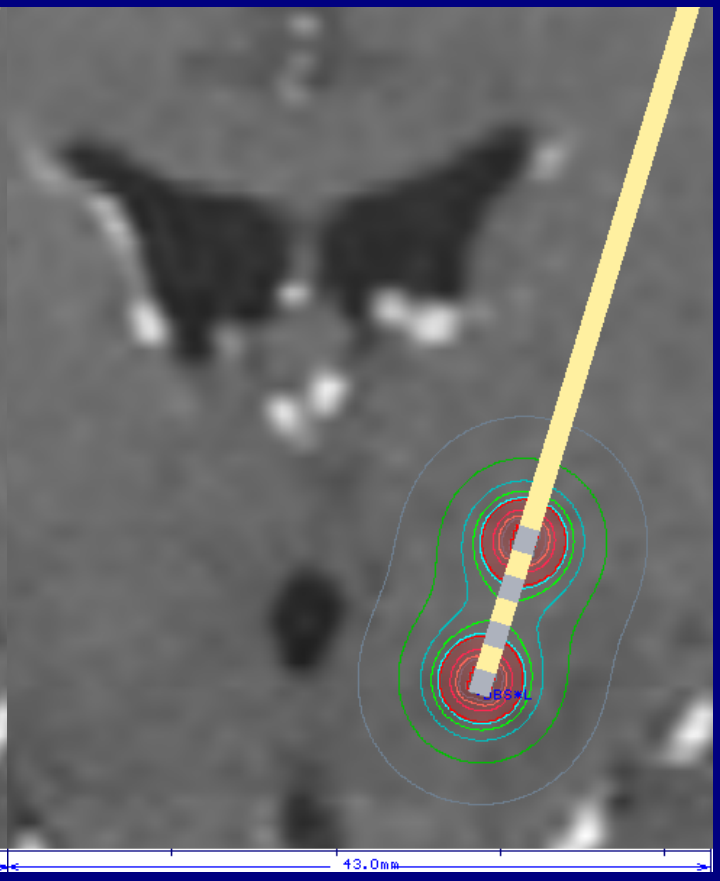




SceneRay 1200



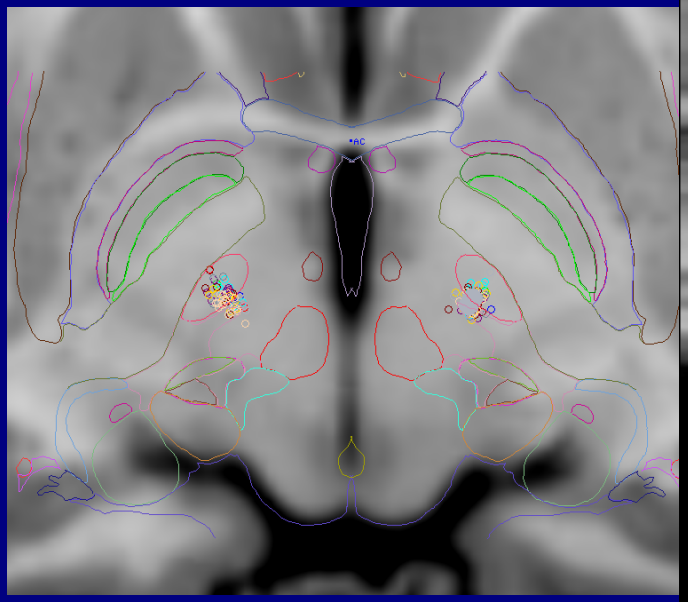
SceneRay 1211

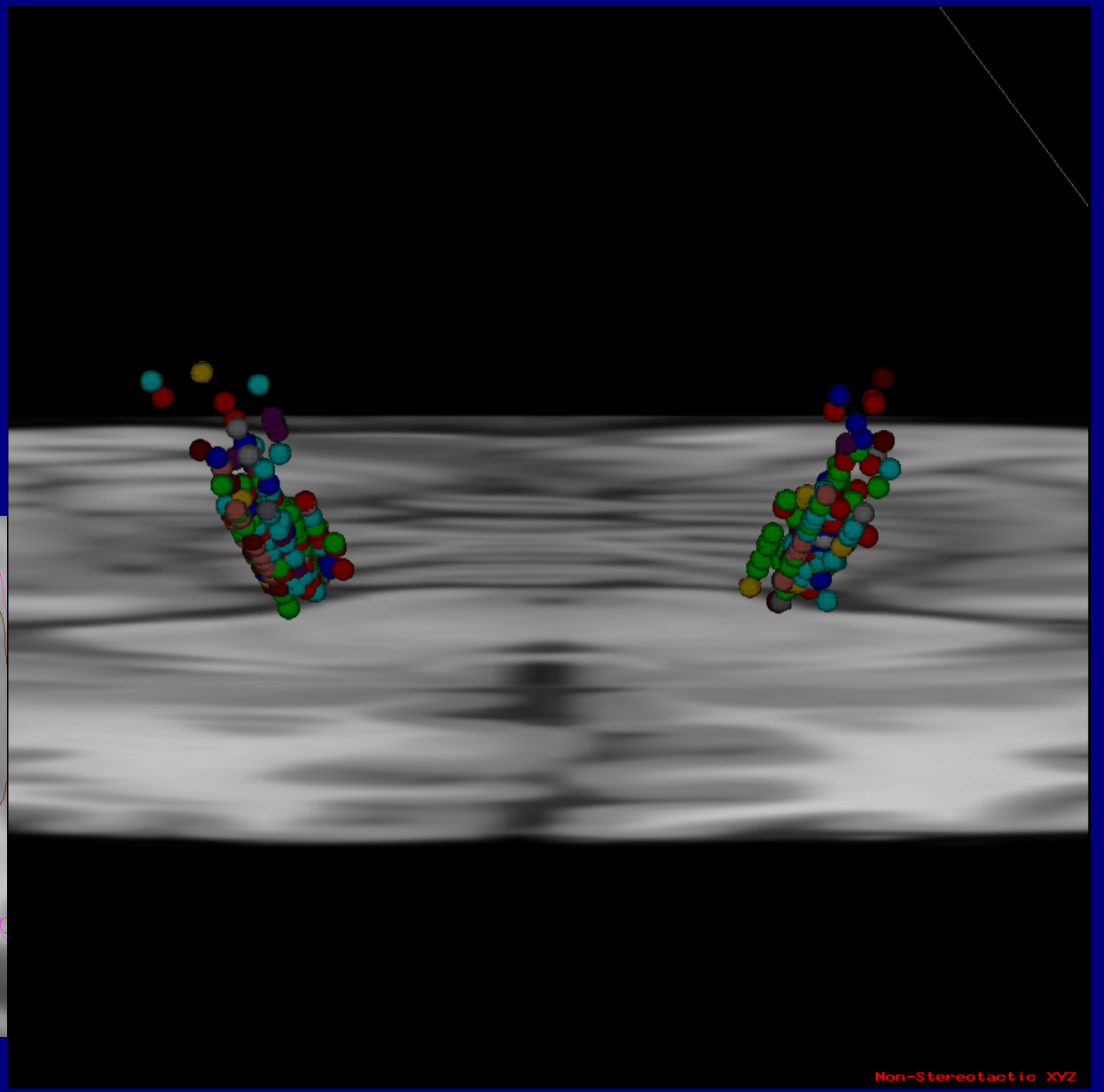


SceneRay 1210

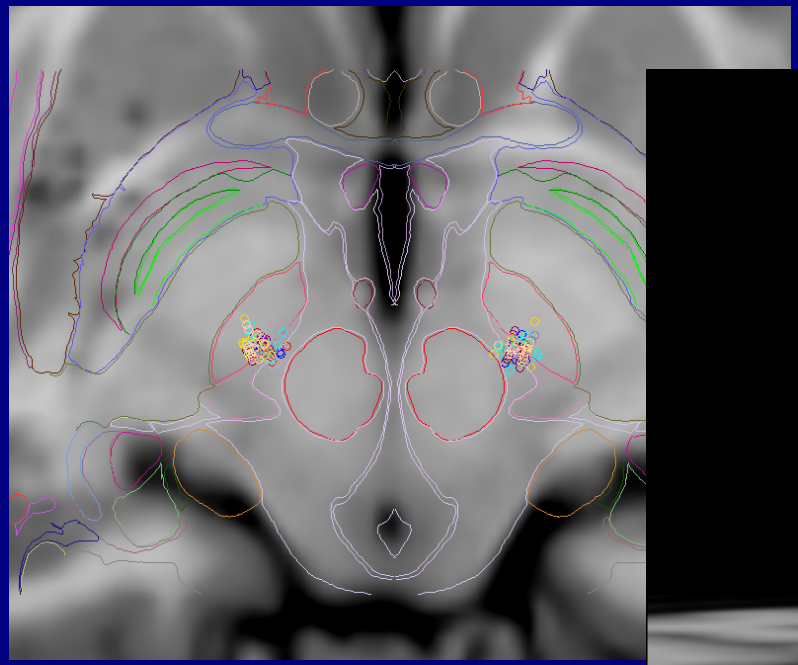
Kinesthetic points rendering. All the following points were collected by Dr. Mark Sedrak with software tools developed by him.
By courtesy of Dr. Sedrak the tools are available at the following link
https://app.box.com/s/4zxysoc3bltxvvt4cwcplpbkntoi9cll

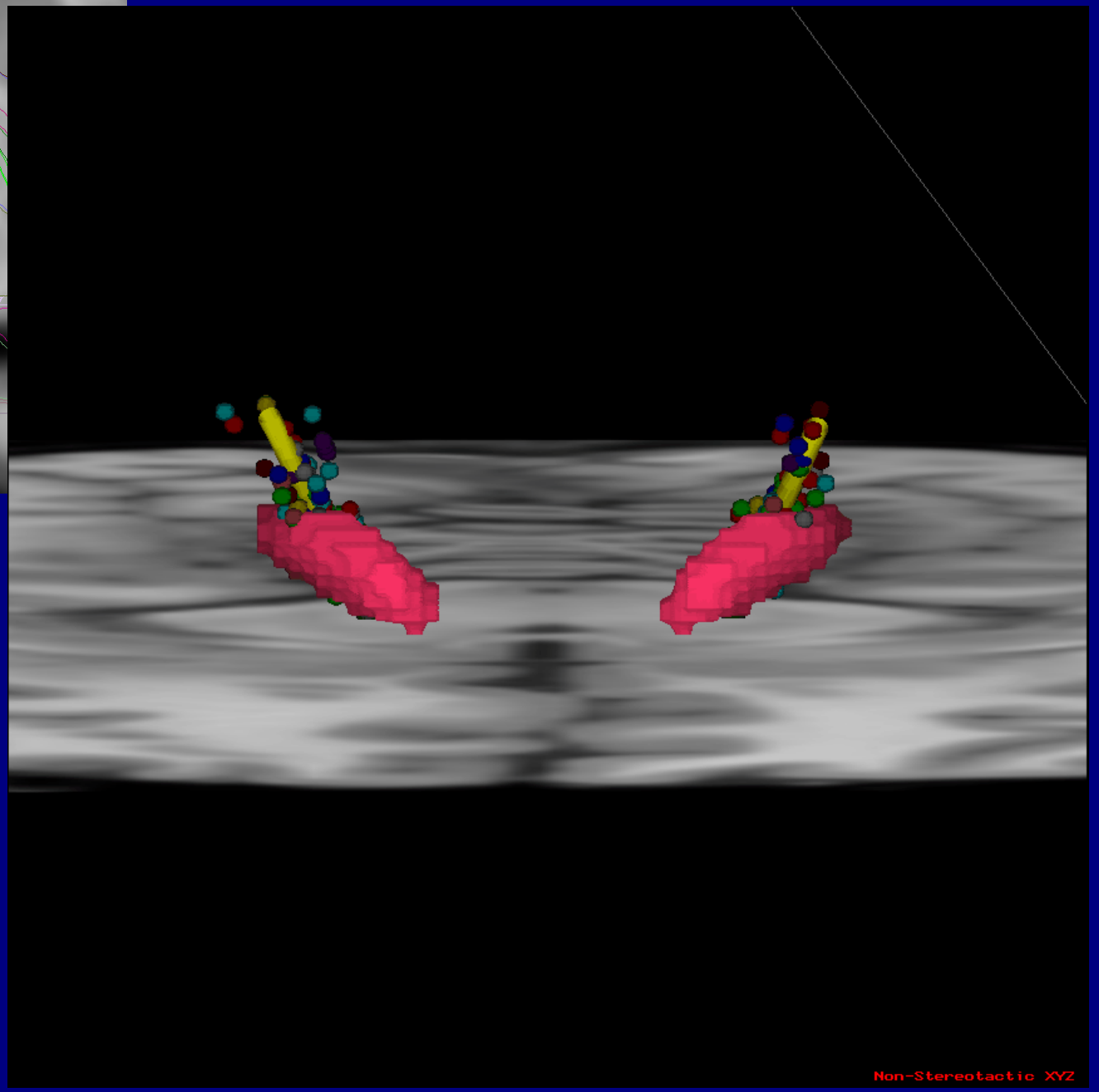
Points collected following trajectories to STn. Each color represent a different location of the response.



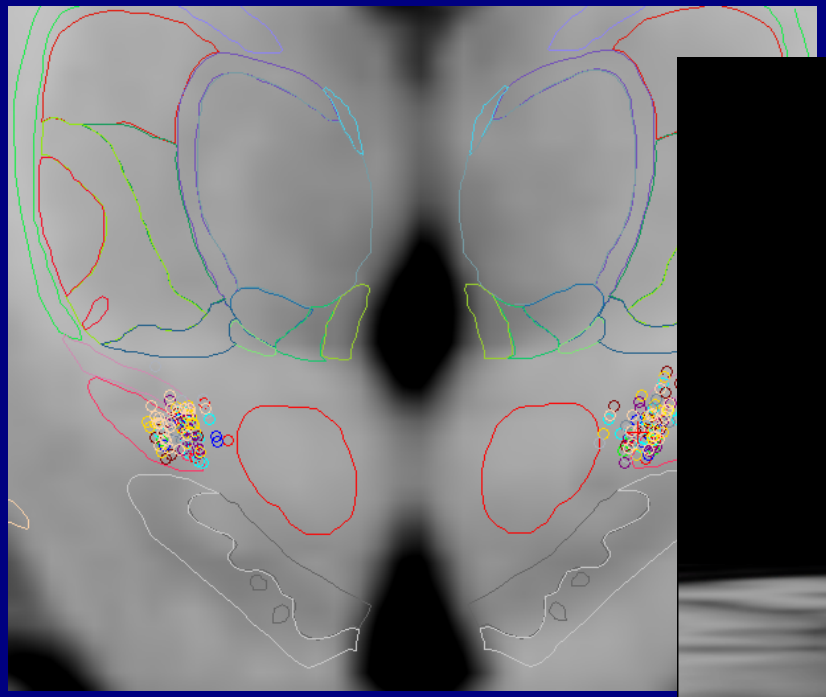


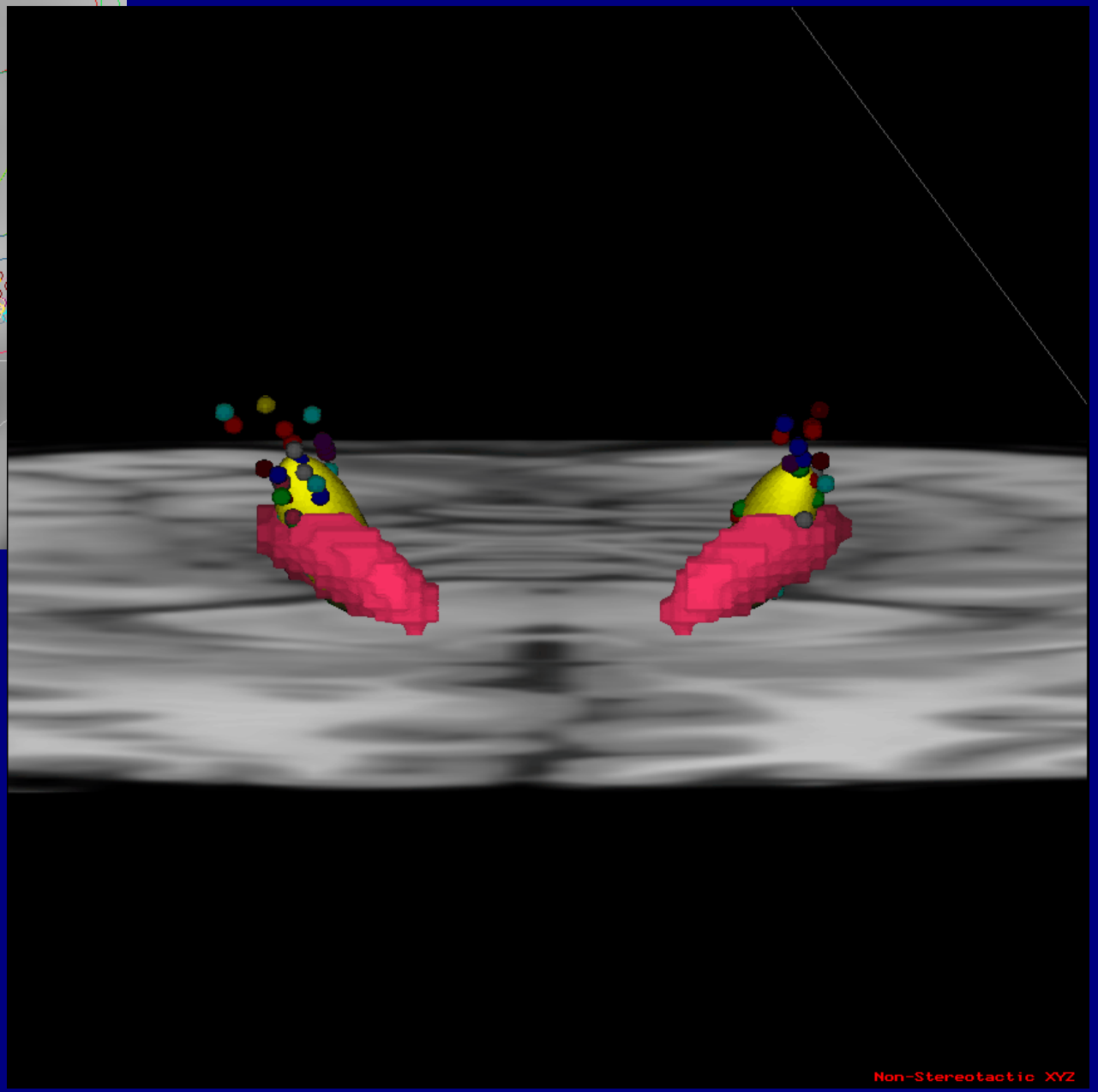
Less square regression line (3D) of kinesthetic points collected in STn explorations.
Courtesy of Dr. Mark Sedrak



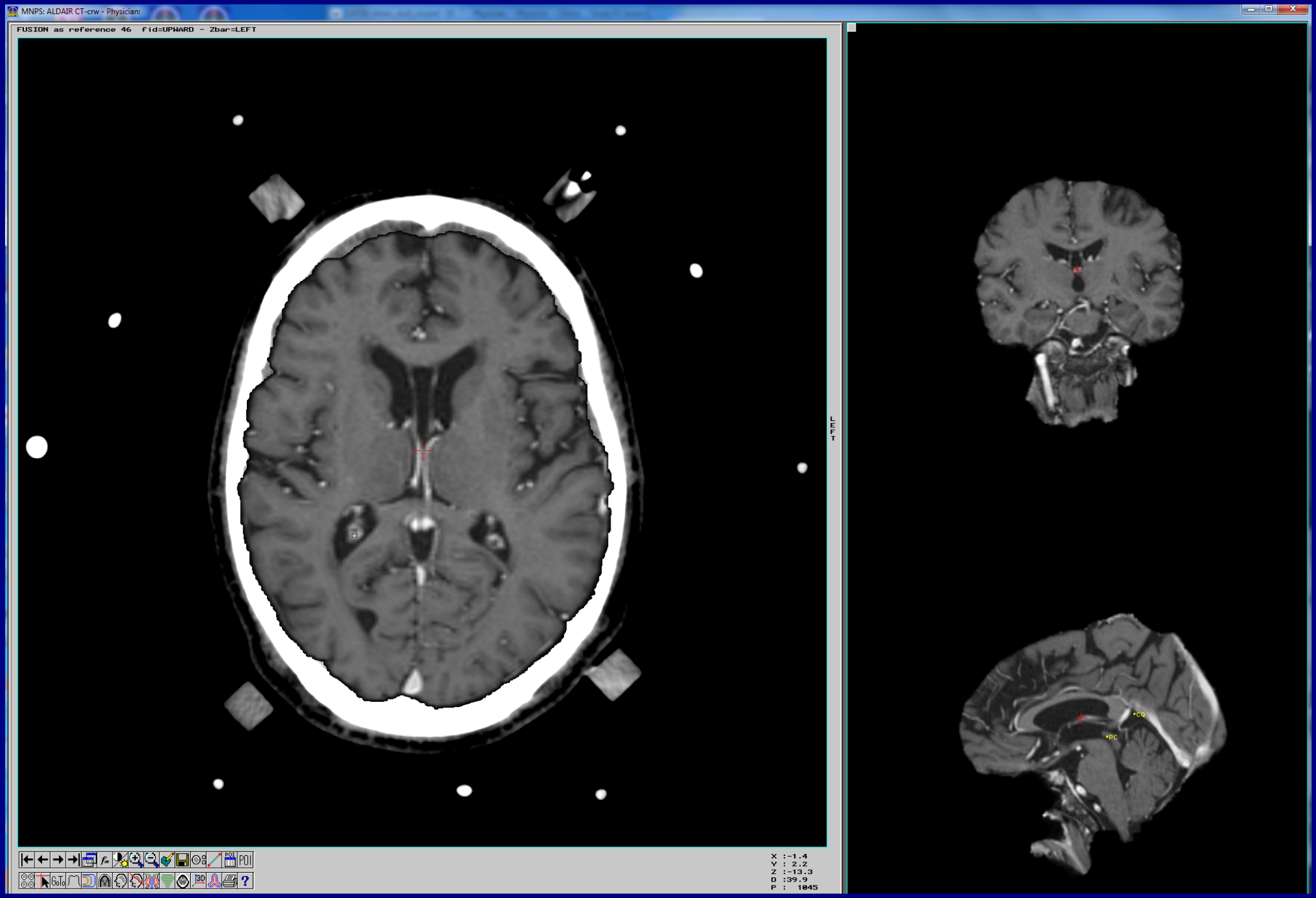


Probabilistic ellipsoid of kinesthetic points, with main axis as two root mean square of the point cloud measure from the points center of mass. Lateral axis equals two standard deviations measured as distance to main axis.
Courtesy of Dr. Mark Sedrak

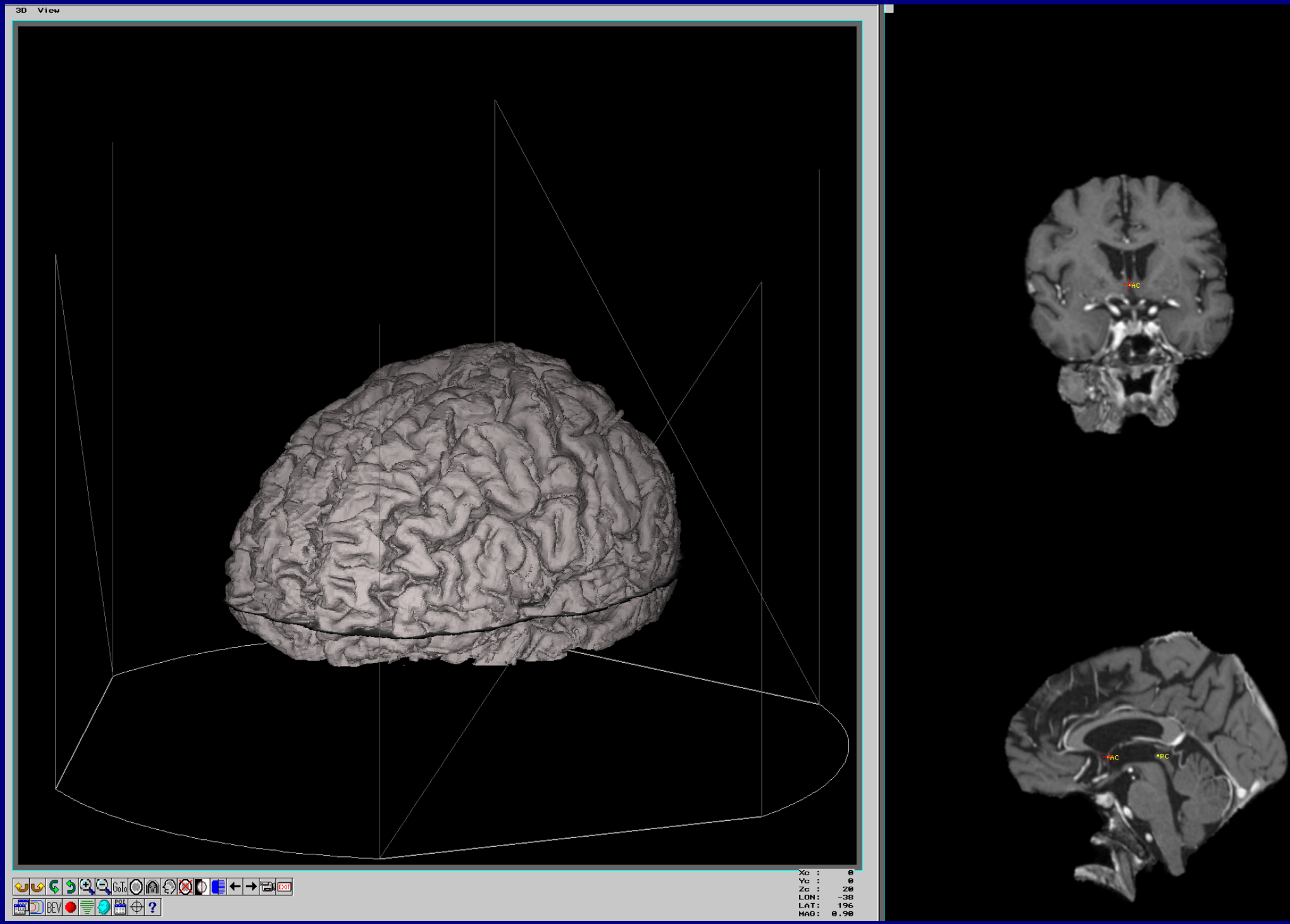




Registration and fusion after skull stripping of MRI images



Registration and fusion after skull stripping of MRI images. 3D rendering



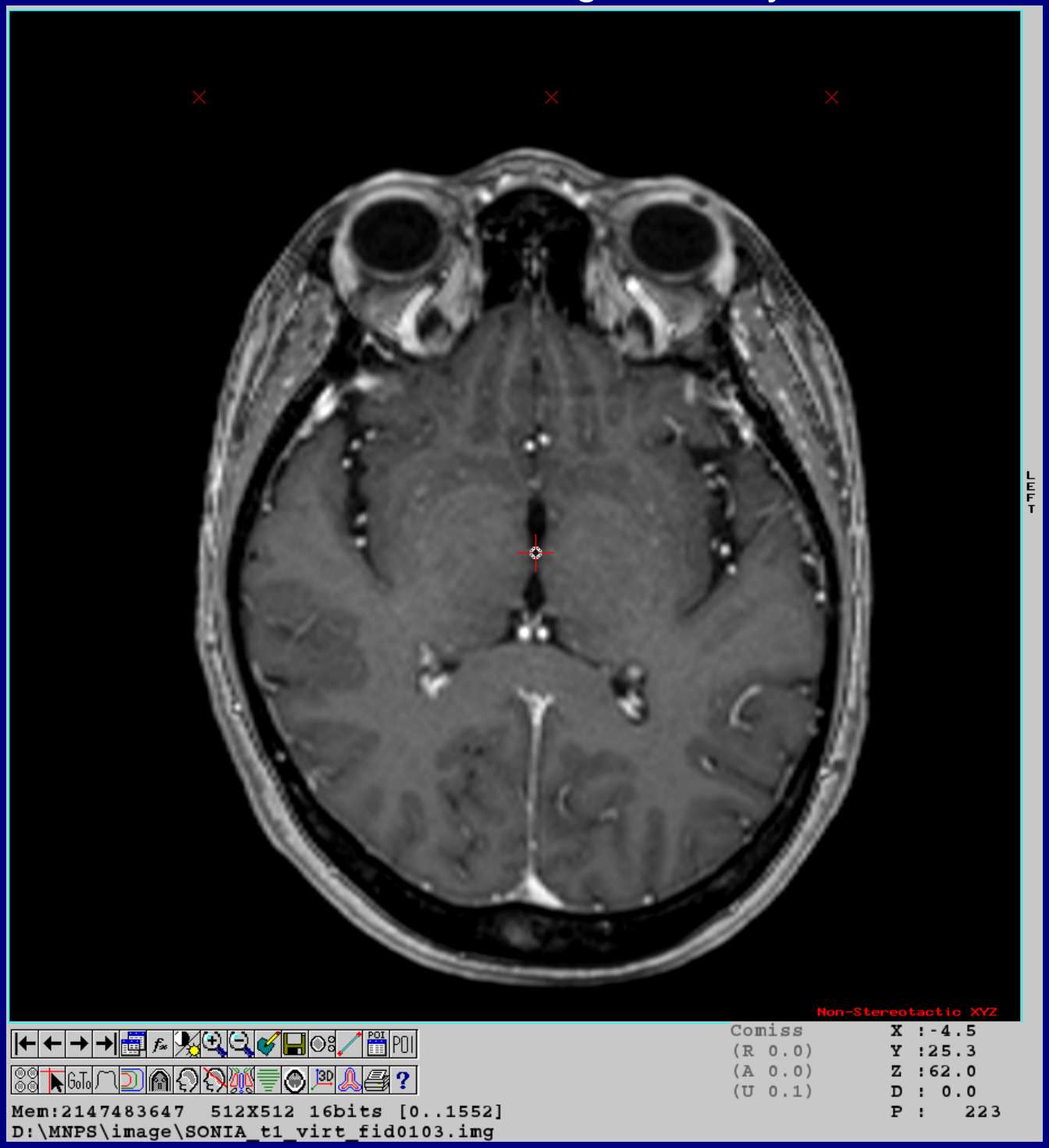
“Virtual Fiducials Mode” allows non-stereotactic images directly into MNPS.

WARNING :

Coordinates in Virtual Fiducials Mode are not stereotactic

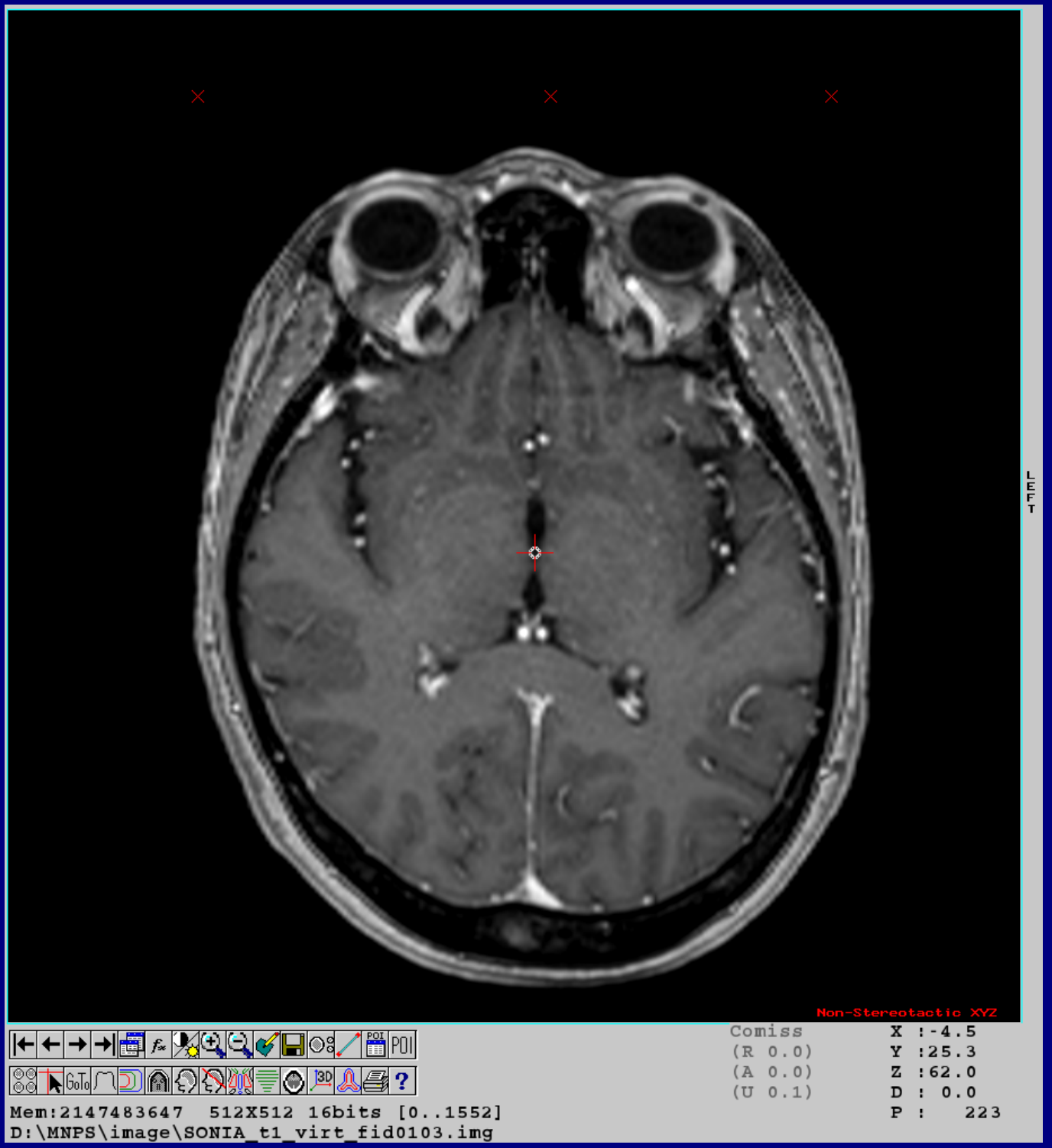
Do not use on surgery !

On the other hand, commissural coordinates are useful for pre- and post-planning.

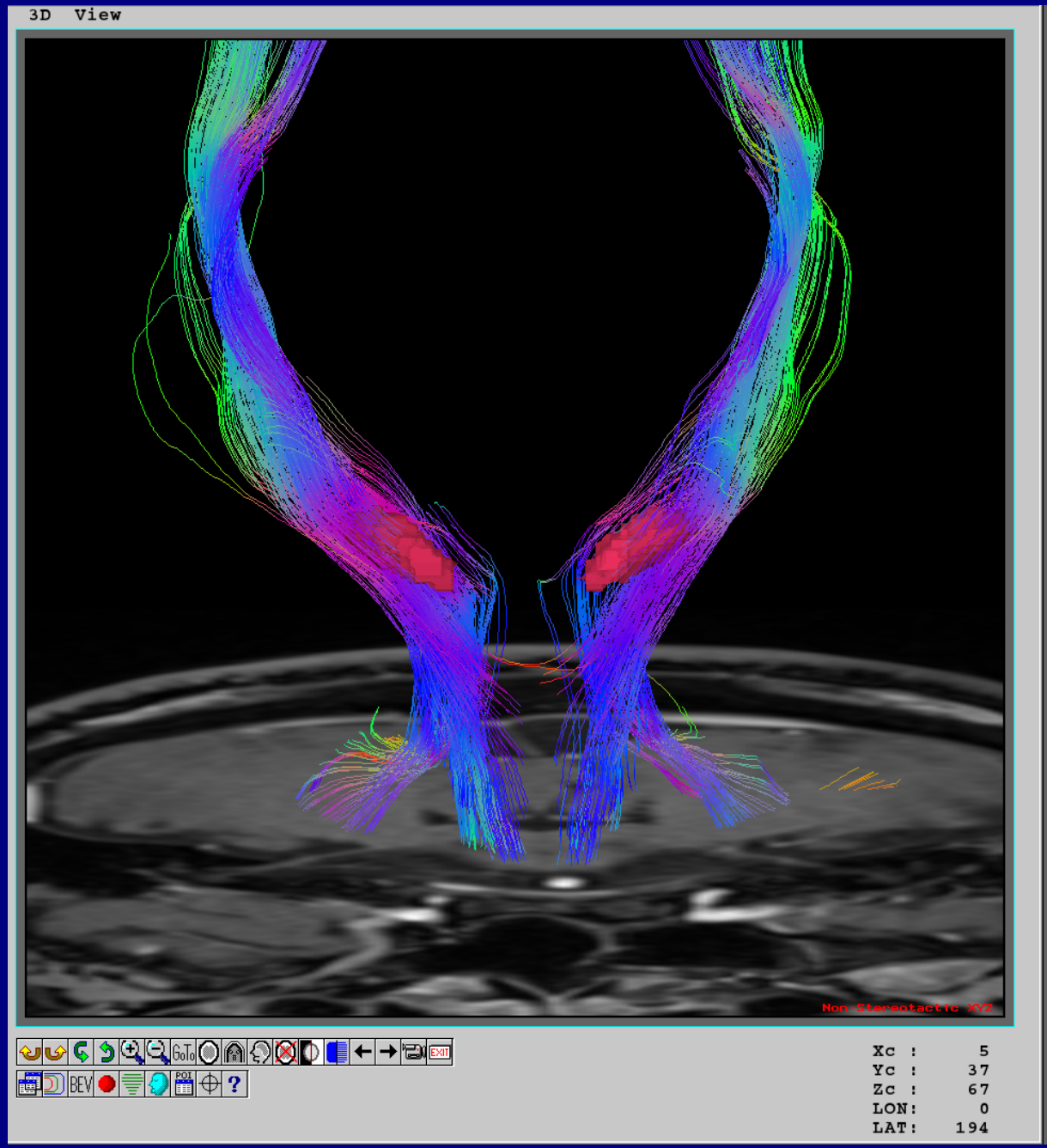


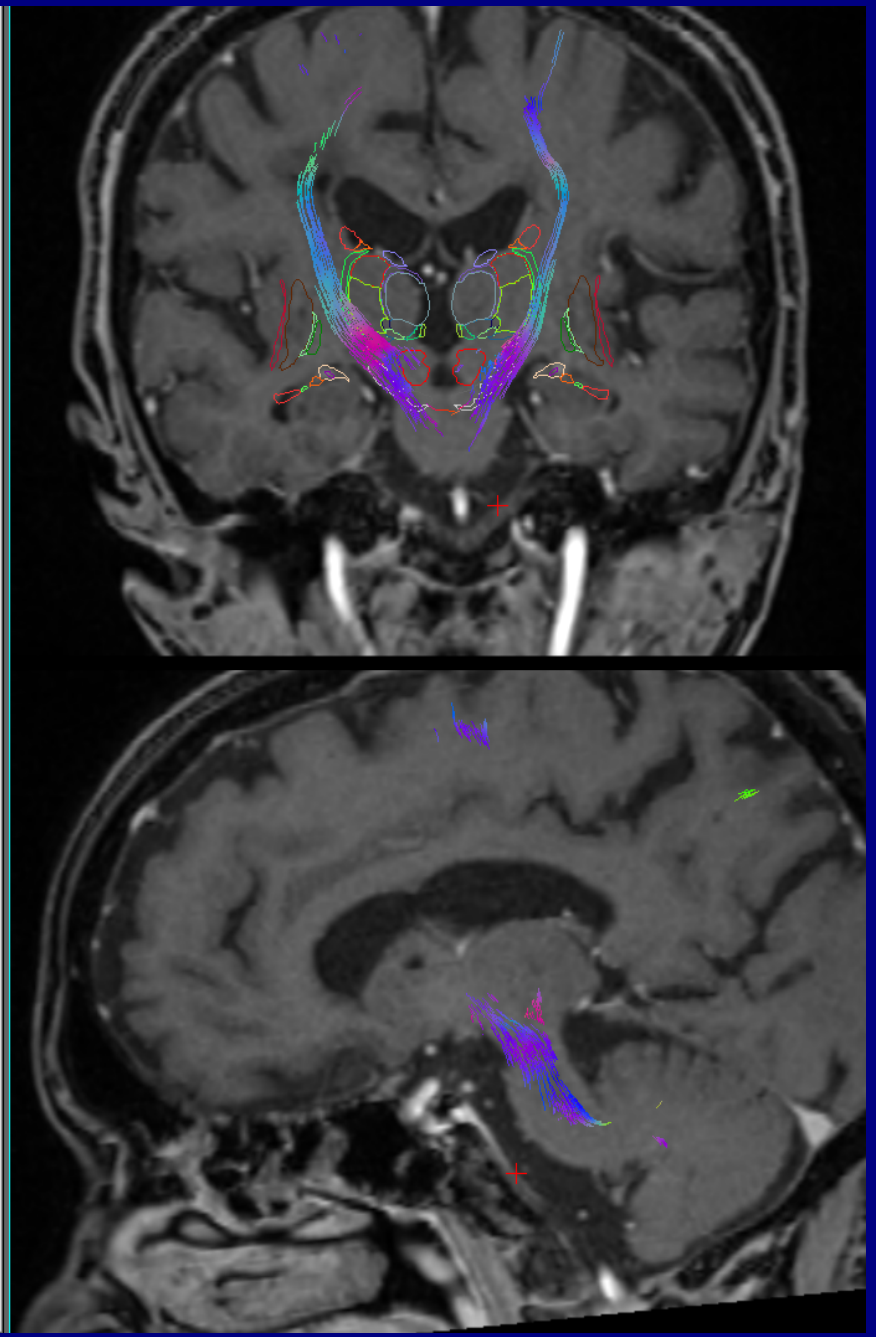
Virtual Fiducials Mode is convenient for pre-planning and also for post-planning.

In Virtual Fiducials Mode all the tools available for Stereotactic image sequences can be used on non-stereotactic image sets

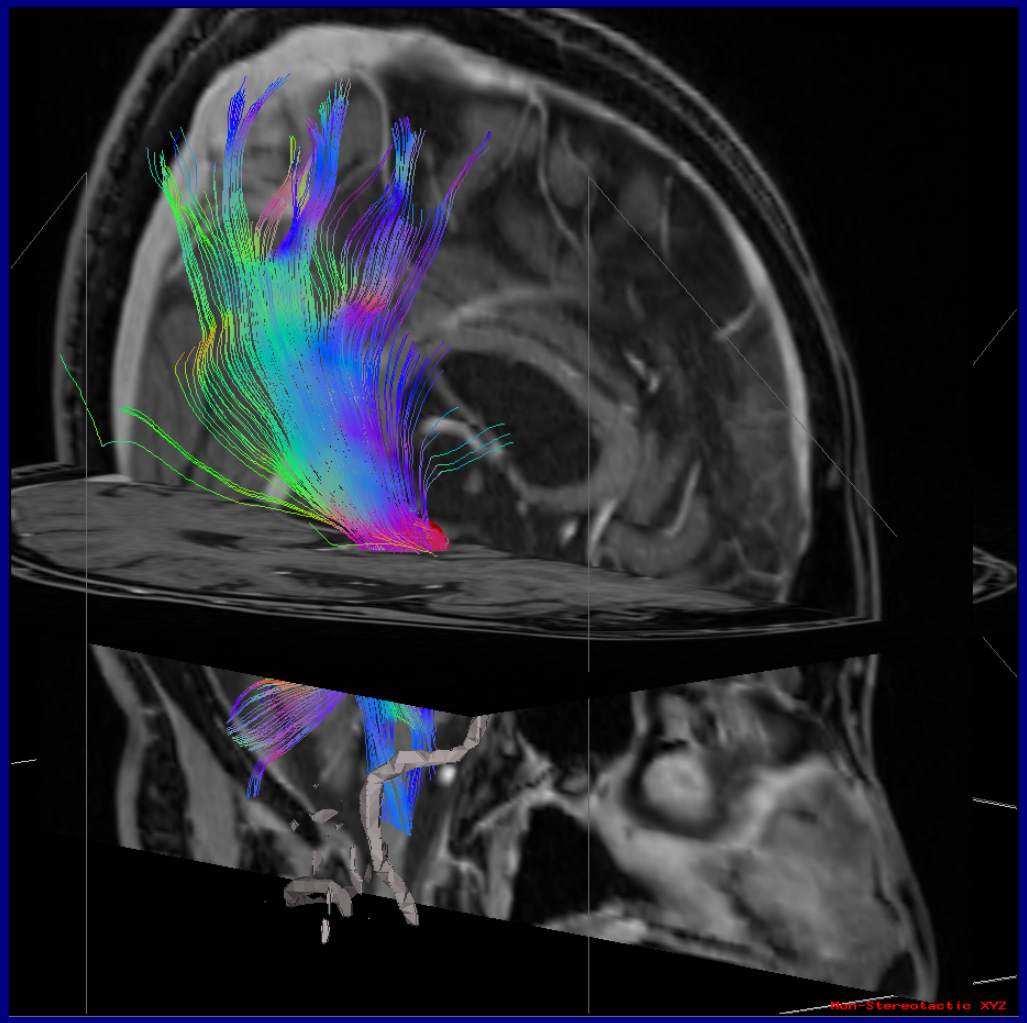


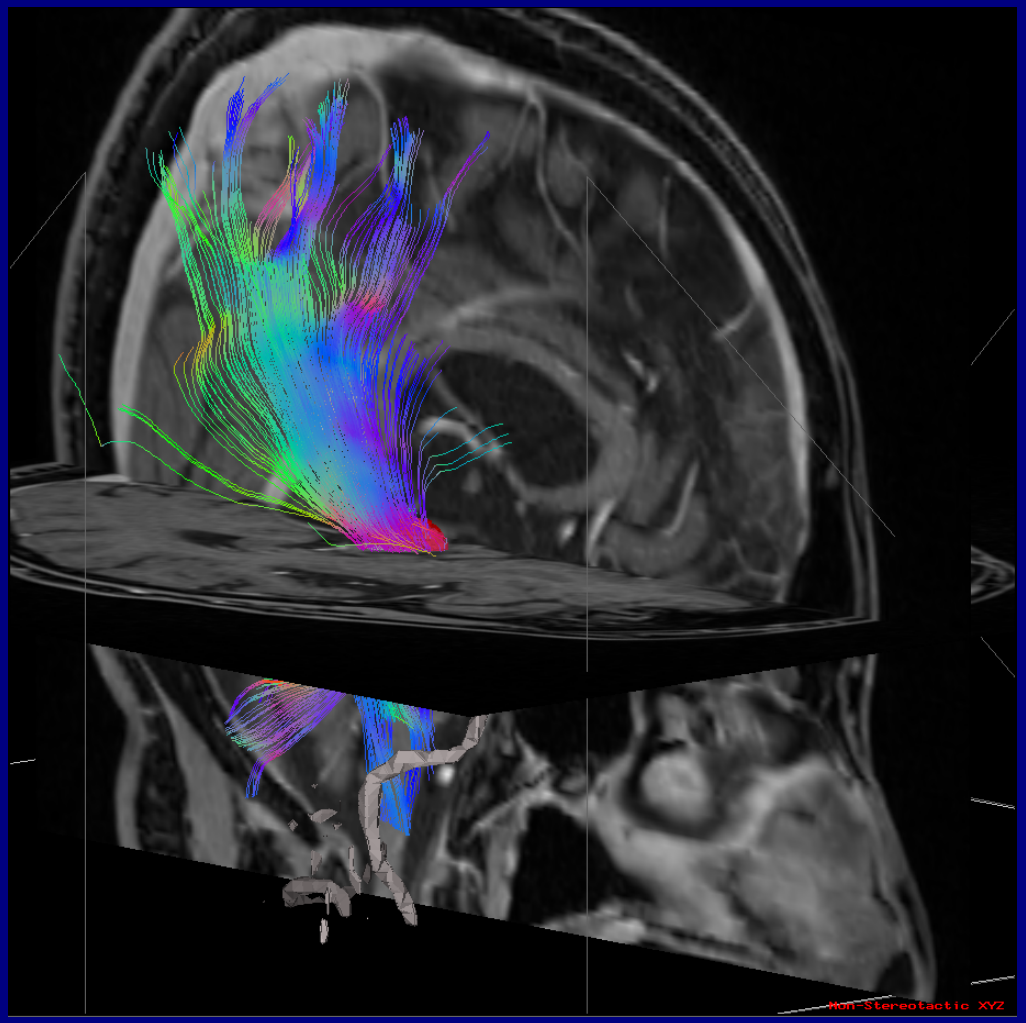
MNPS imports DTI tractography from .OBJ or .TRK files. The user can process the original DTI volume with its preferred DTI analysis system and export the fiber tracks for use on MNPS. We have successfully imported fiber tracks from DTI-Studio, FSL, and 3D-Slicer.





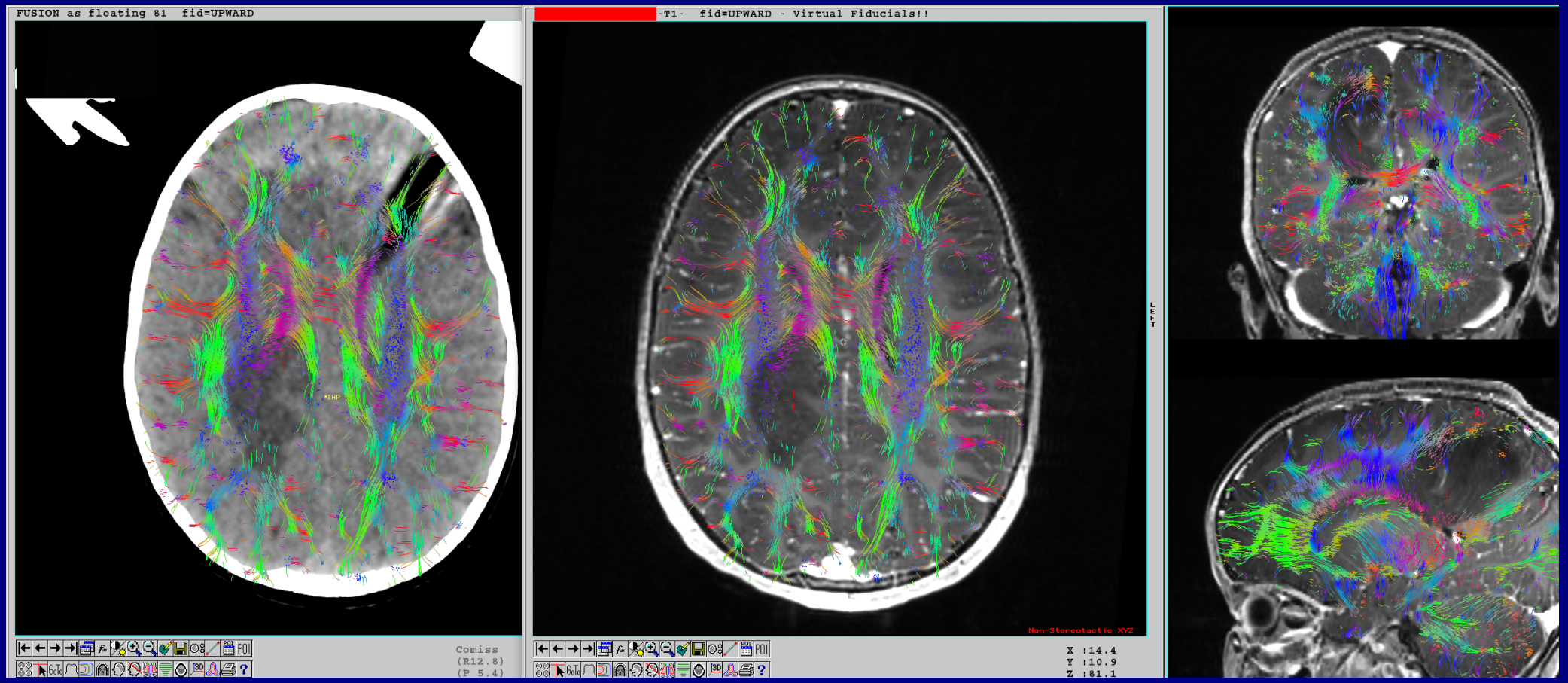
Fiber tracks can be overlaid to functional map nuclei, ROI volumes, instrument tracks, etc, rendered in 2D and 3D. The user can select fibers from a region and hide fibers not crossing that region.

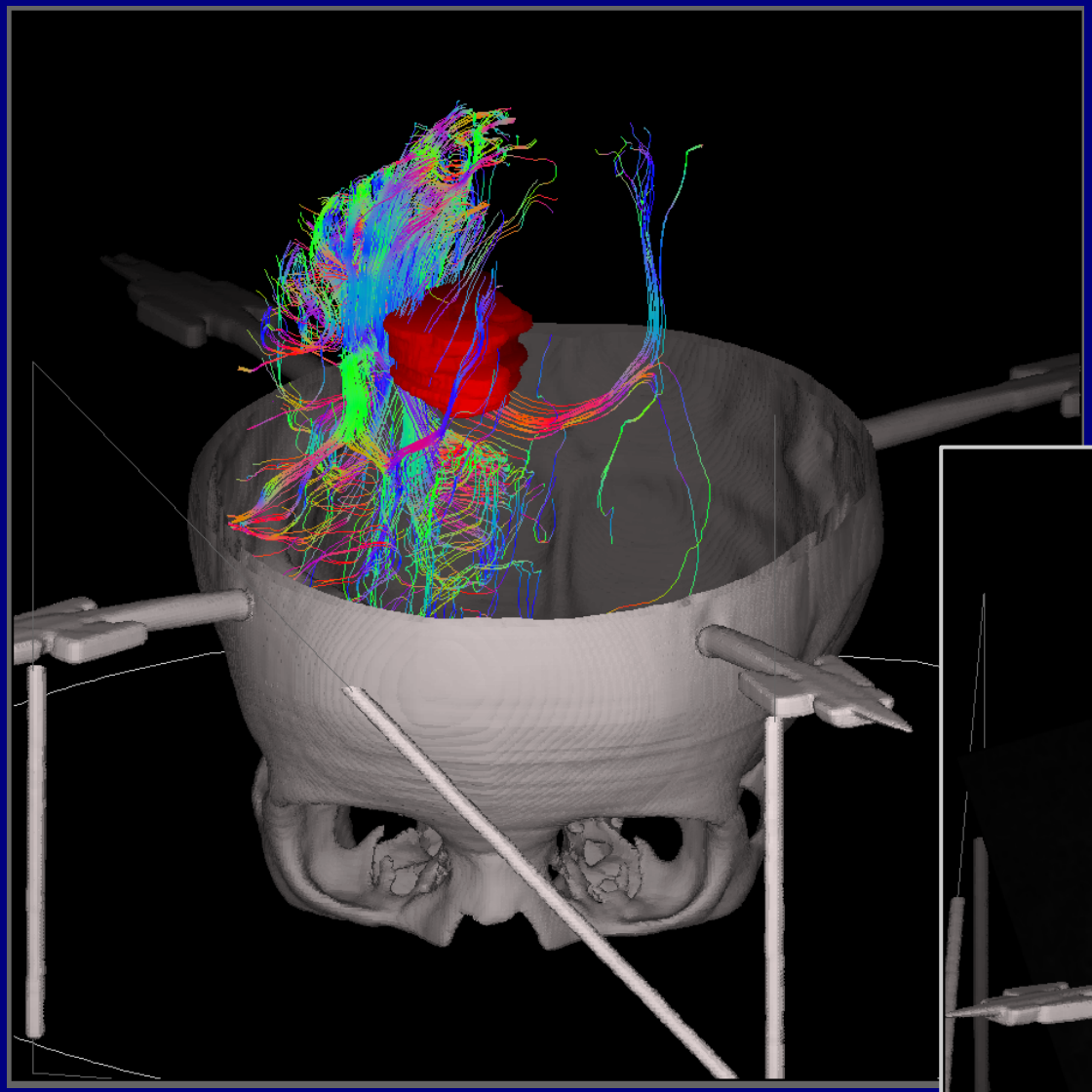




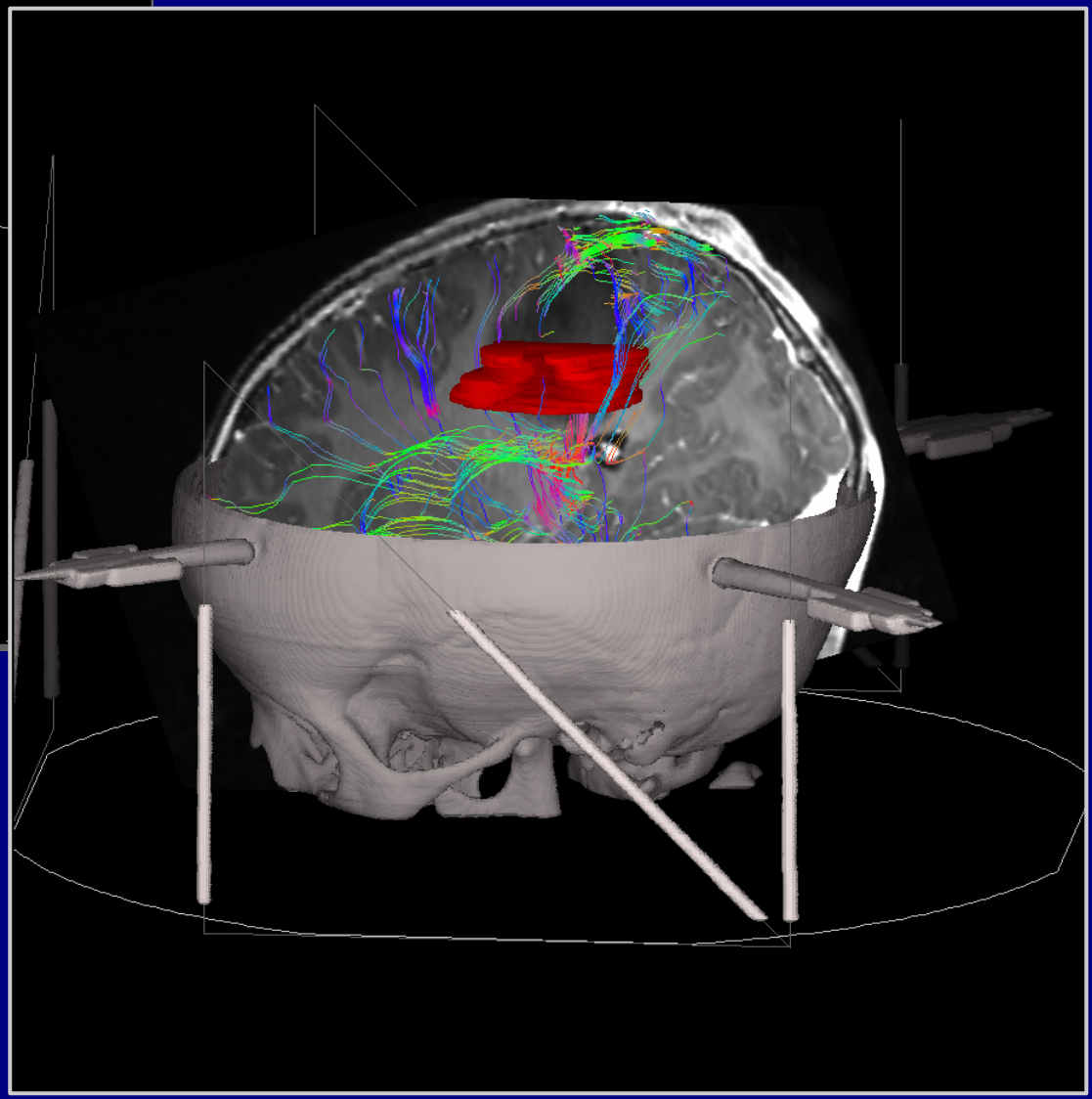
Sample images showing fibers crossing the region of STn and Red Nuclei.

Fiber tracks can be imported do stereo-CT via multi-modal image registration with MRI volumes.





Fiber tracks imported into stereo-CT space via image registration.
Border of a surgery target segmented and rendered as solid 3D object (in red).



Also, use image registration to import tracks from DTI volume into T1 or T2 volumes. Care should be taken with significant image distortion, common on DTI volumes. Non-rigid registration can be handy to deal with some distortion.

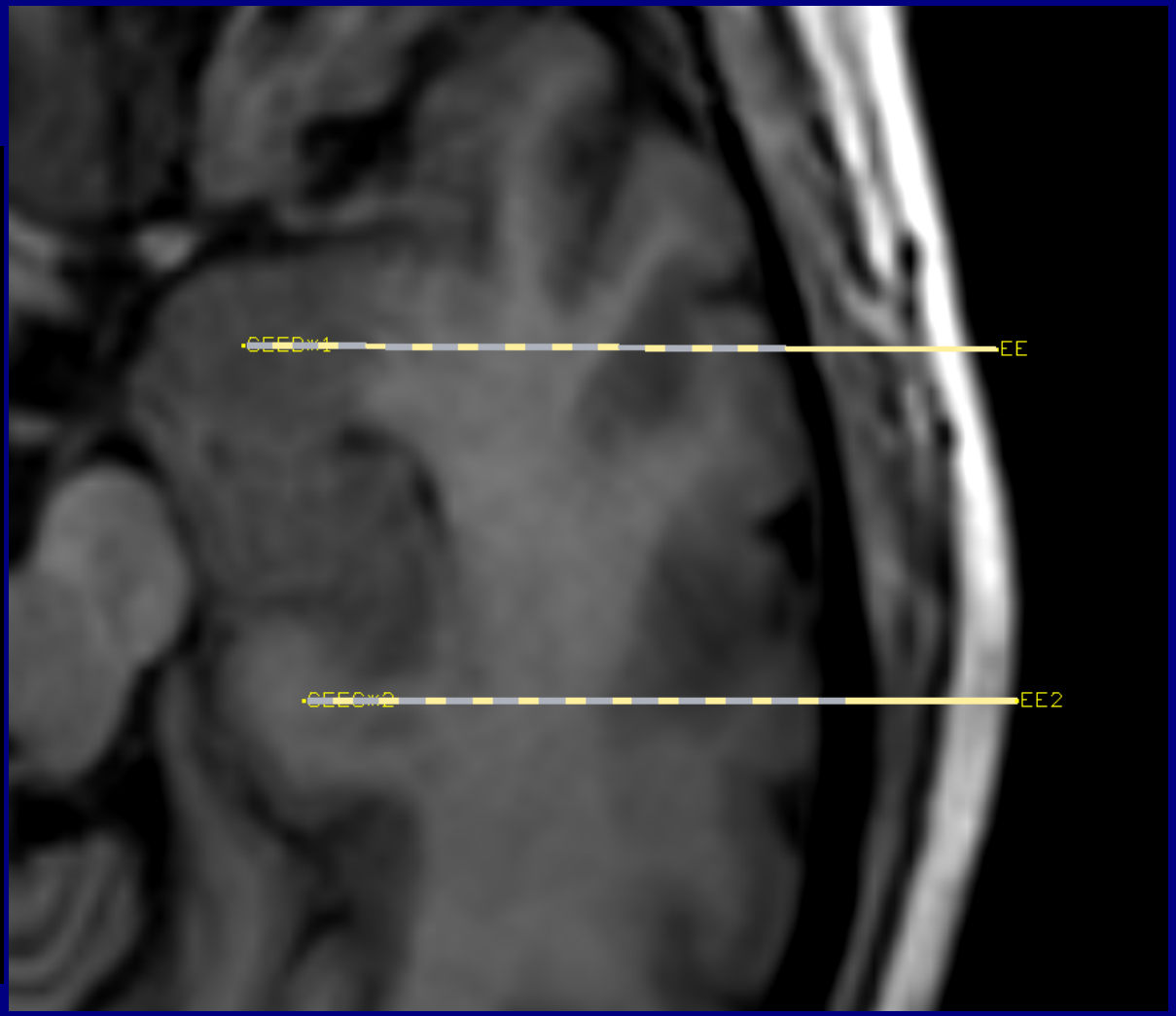
Functional neurosurgery resources.
Geometric model of sEEG electrodes (epilepsy).
This feature allows you to know the coordinates of each contact.

Functional-Atlas Menu

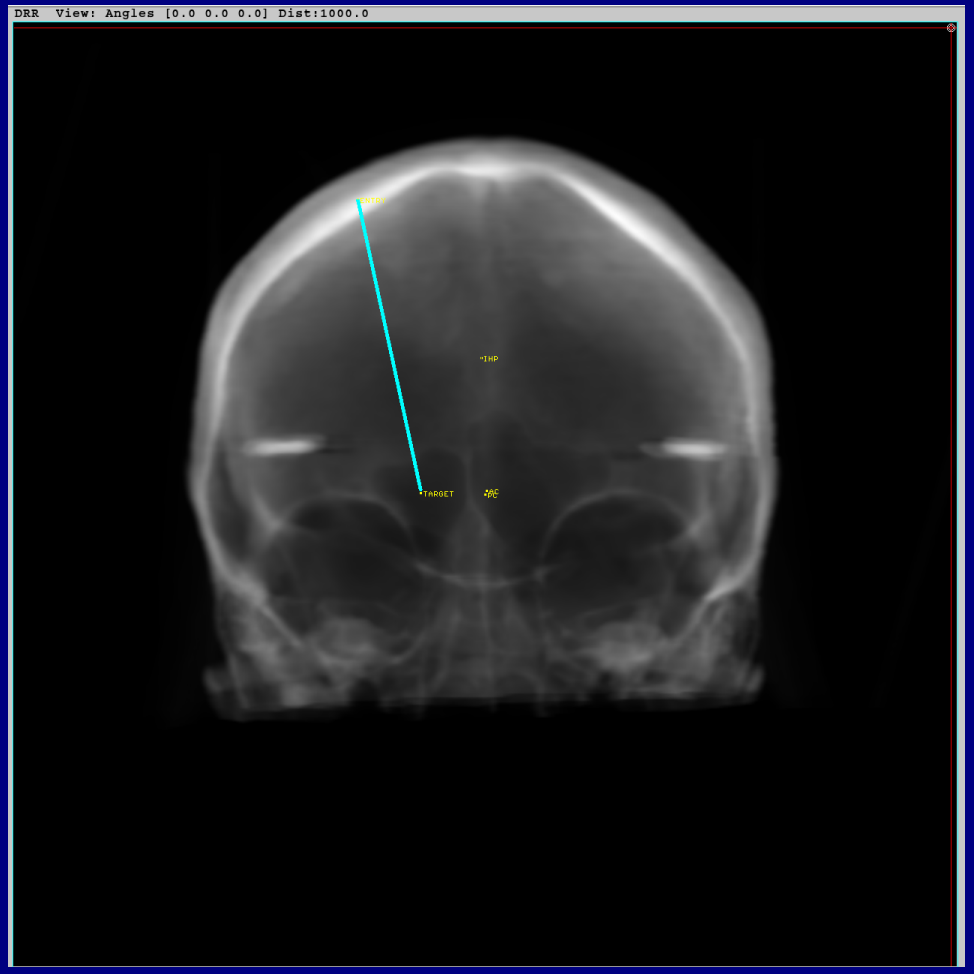
- Where is cursor ?
- Atlas Setting
- Printer Output
- Target Proposal
- Atlas Struct to ROI
- DBS: Select Model
- DBS: VTA Switch
- DBS: Parameters
- Render 3 Planes VTA
- VTA Conformity Index
- RF Lesion estimation
- **sEEG: Select Model**

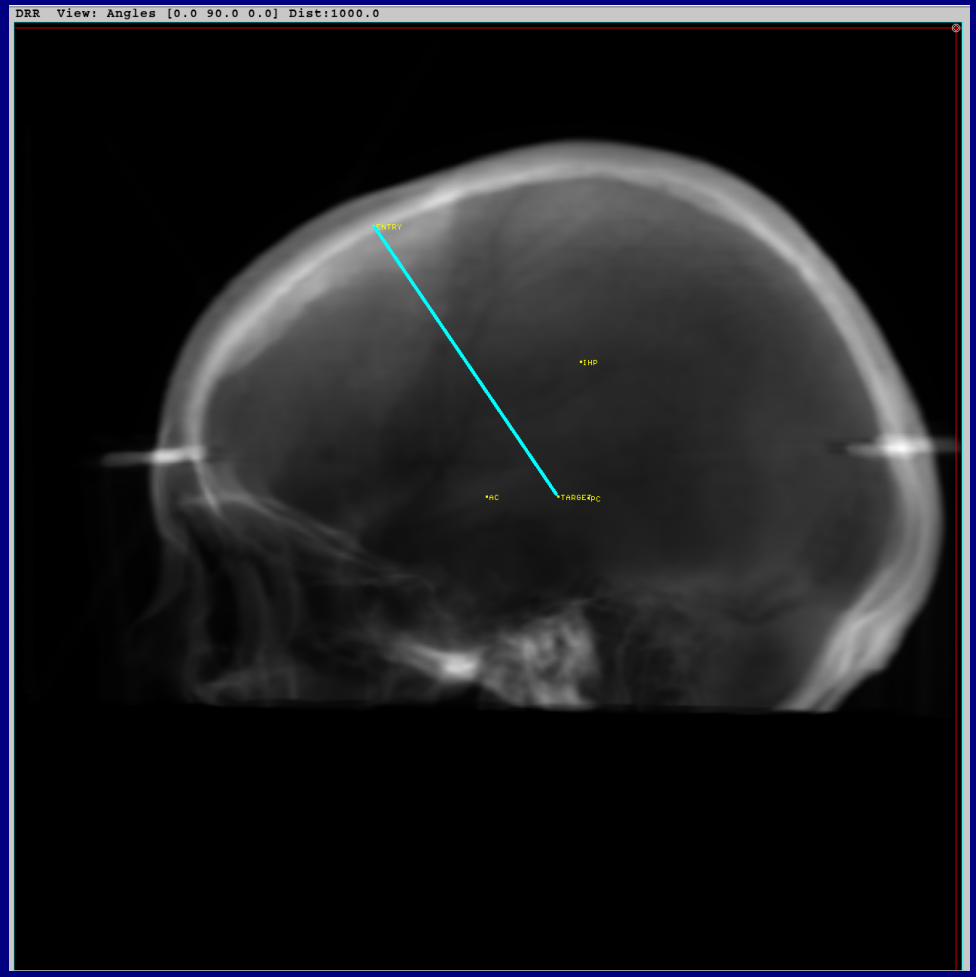
Select sEEG Electrode

DIXI	Diam:0.80	n: 5	len:2.00	spa:1.50
DIXI	Diam:0.80	n: 8	len:2.00	spa:1.50
DIXI	Diam:0.80	n:10	len:2.00	spa:1.50
DIXI	Diam:0.80	n:12	len:2.00	spa:1.50
DIXI	Diam:0.80	n:15	len:2.00	spa:1.50
PMT	Diam:0.80	n: 8	len:2.00	spa:1.50
PMT	Diam:0.80	n:10	len:2.00	spa:1.50
PMT	**Diam:0.80**	**n:12**	**len:2.00**	**spa:1.50**
PMT	Diam:0.80	n:14	len:2.00	spa:1.50
PMT	Diam:0.80	n:16	len:2.00	spa:1.50
PMT	Diam:0.80	n:16	len:2.00	spa:1.97
PMT	Diam:0.80	n:16	len:2.00	spa:2.43
AD-T	Diam:1.12	n: 4	len:2.41	spa:2.59
AD-T	Diam:1.12	n: 6	len:2.41	spa:2.59
AD-T	Diam:1.12	n: 8	len:2.41	spa:2.59
AD-T	Diam:1.12	n:10	len:2.41	spa:2.59
AD-T	Diam:1.12	n:12	len:2.41	spa:2.59
AD-T	Diam:1.12	n: 4	len:1.32	spa:0.88
AD-T	Diam:1.12	n: 6	len:1.32	spa:0.88
AD-T	Diam:1.12	n: 8	len:1.32	spa:0.88

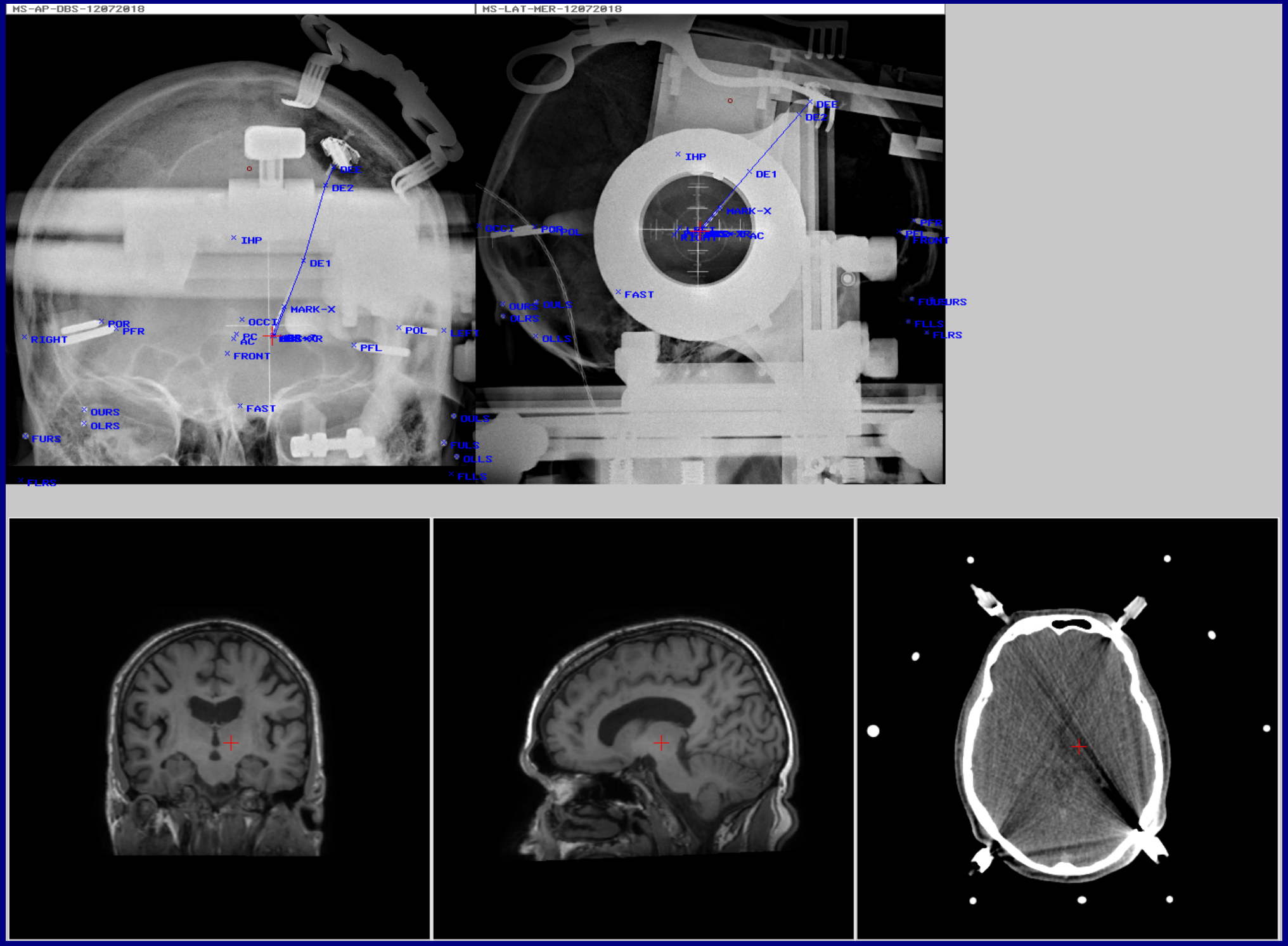


Digitally Reconstructed Radiograph (DRR) generation.

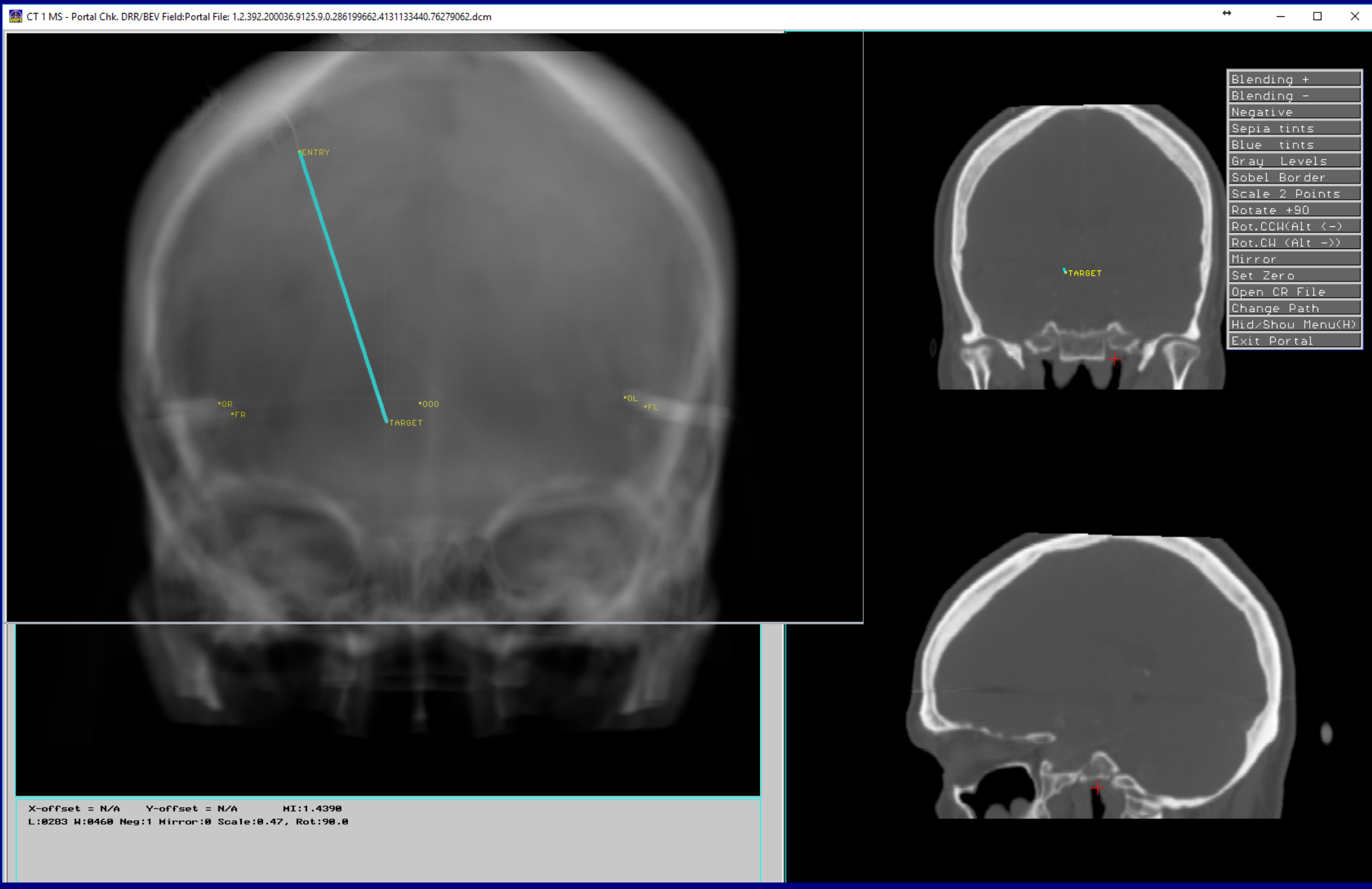




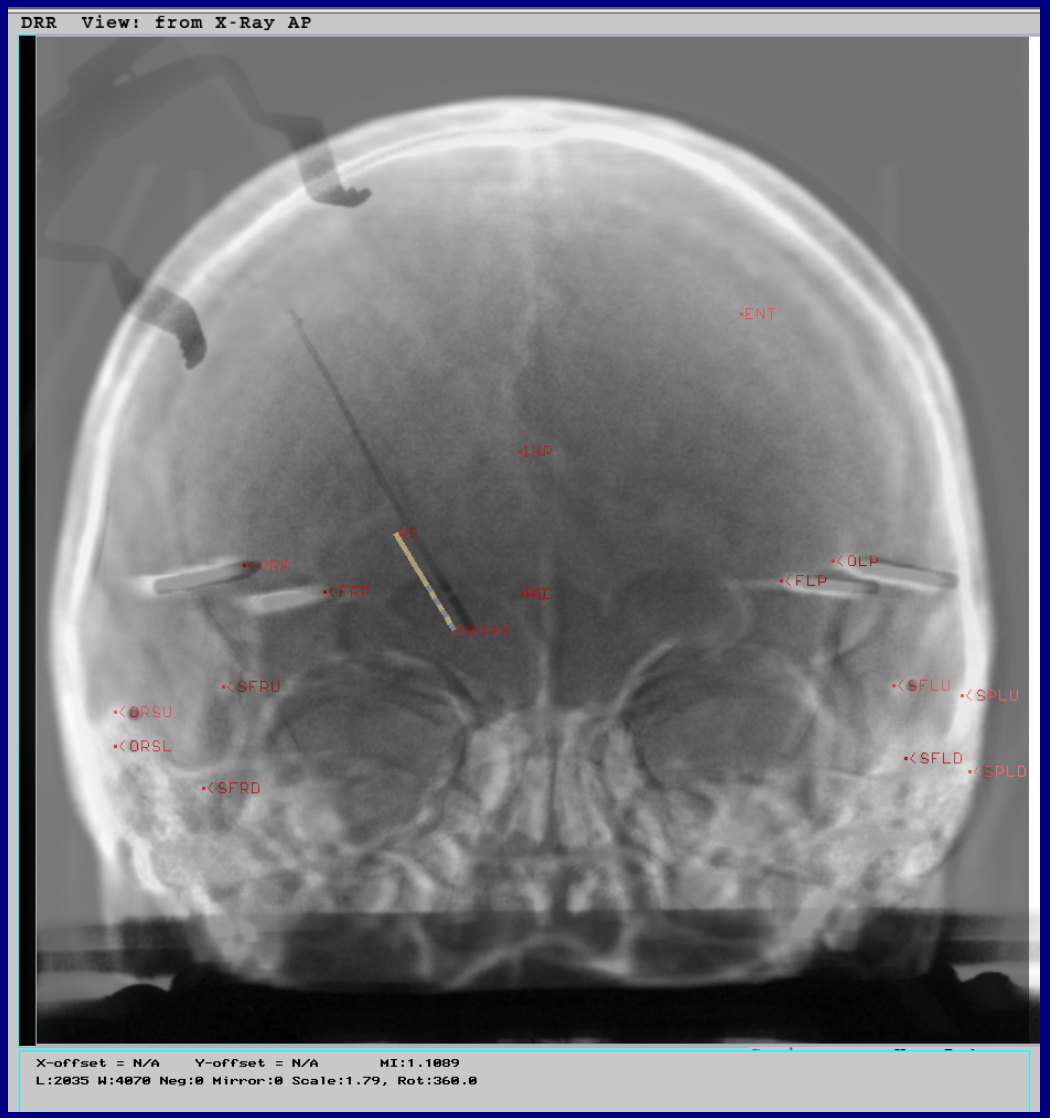
2D-3D registration for intra-op verification of DBS or any probe position with X-rays



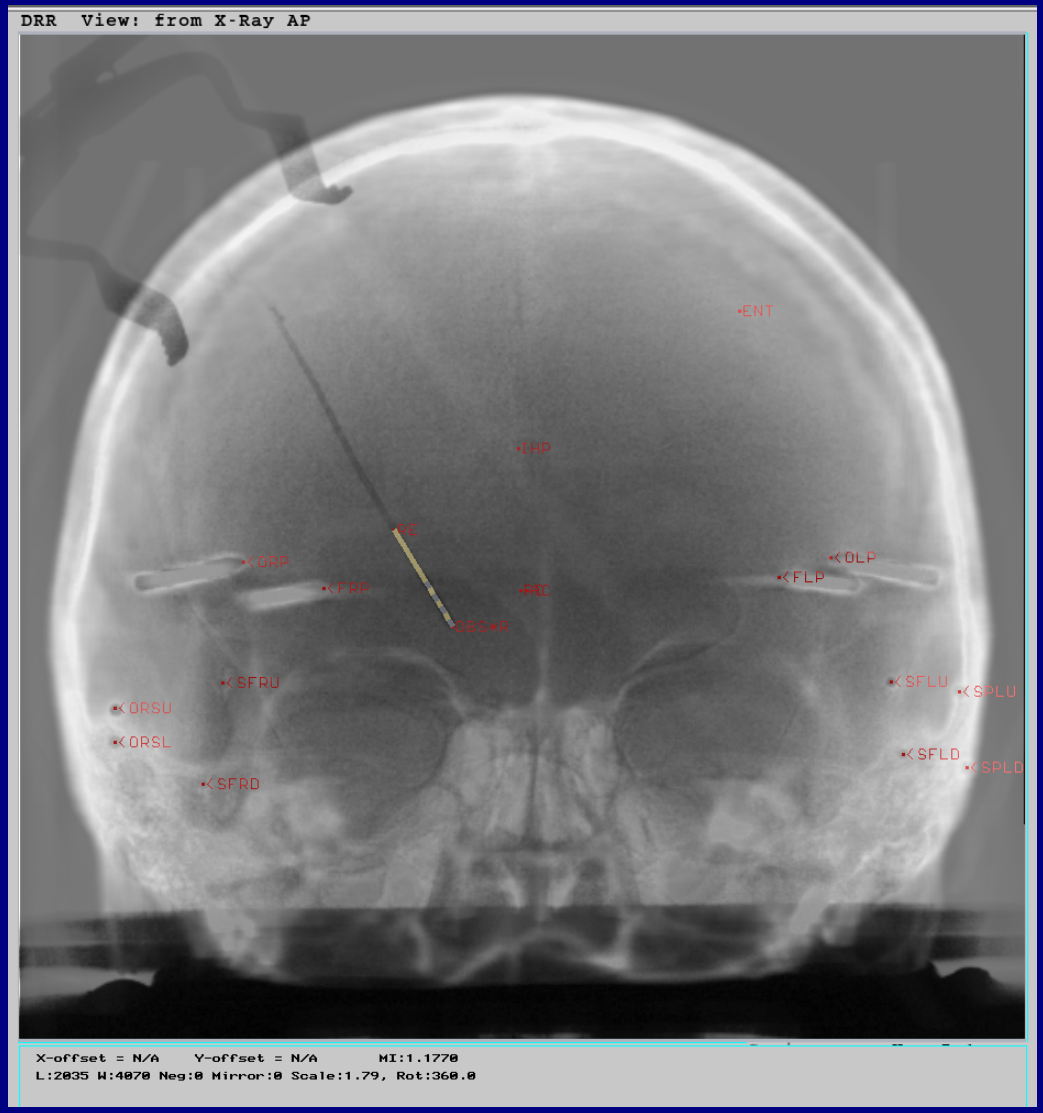
“Portal Check”: New tool for comparing DRR, including a virtual probe, with an X-ray taken intra-op. It helps for verifying the placement of a DBS or any other instrument.



Checking a DBS position by matching a DRR and its corresponding X-ray

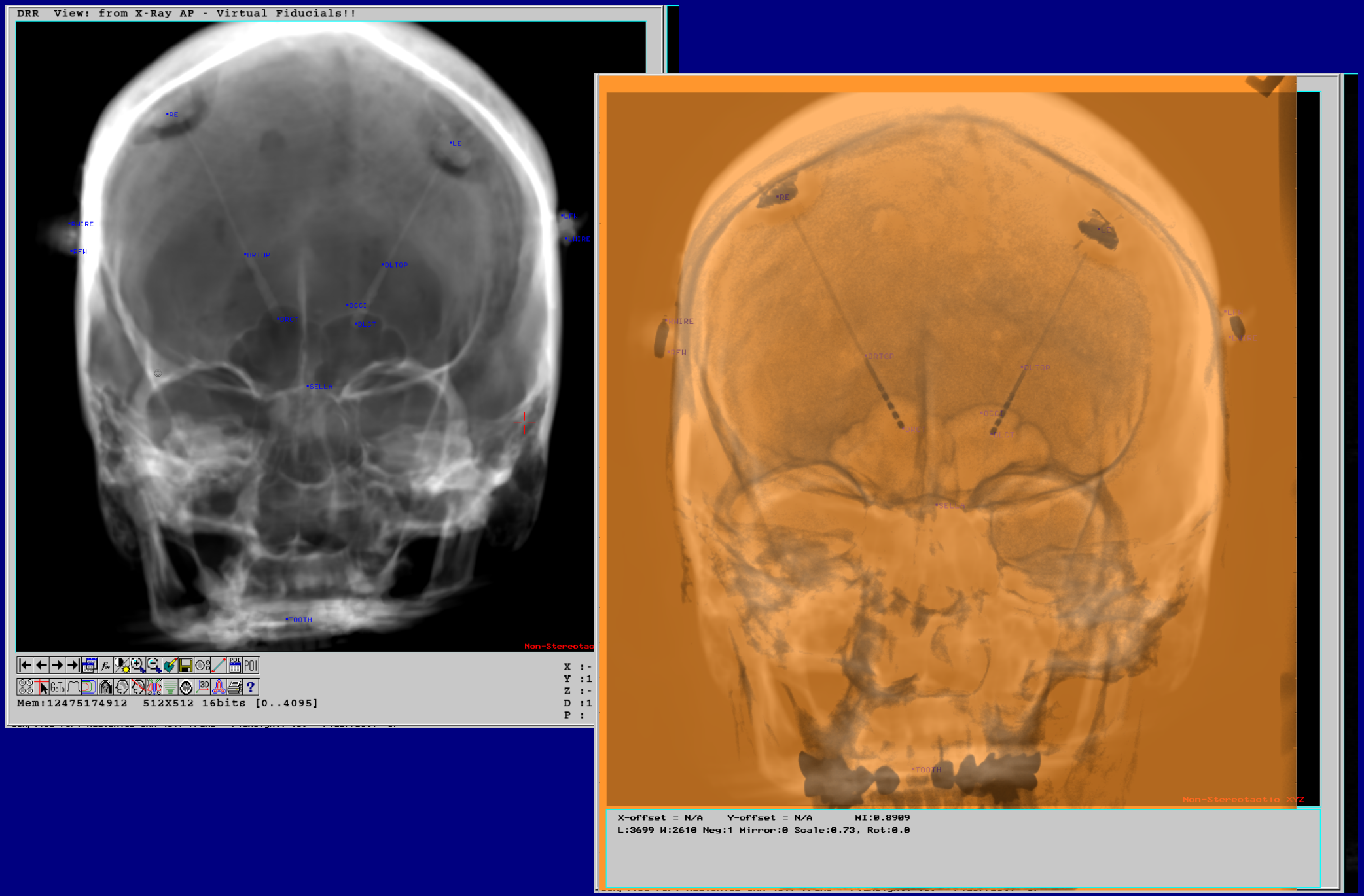


Wrong registration, MI = 1.1089



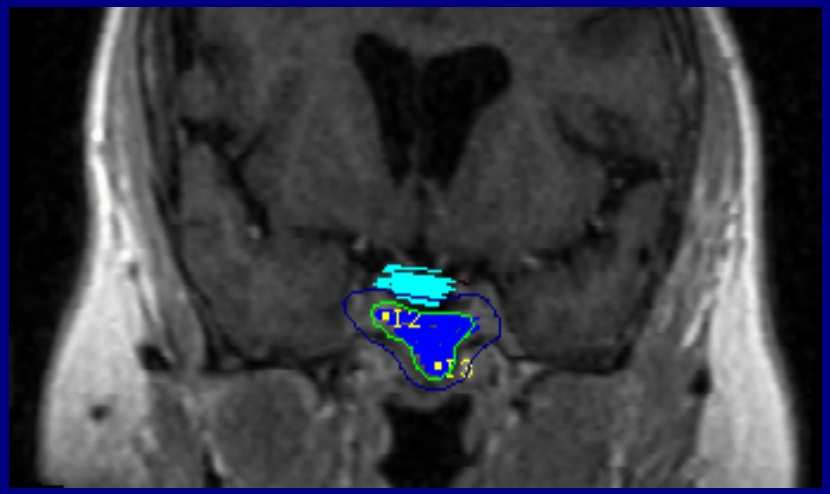
Best registration MI = 1.1770

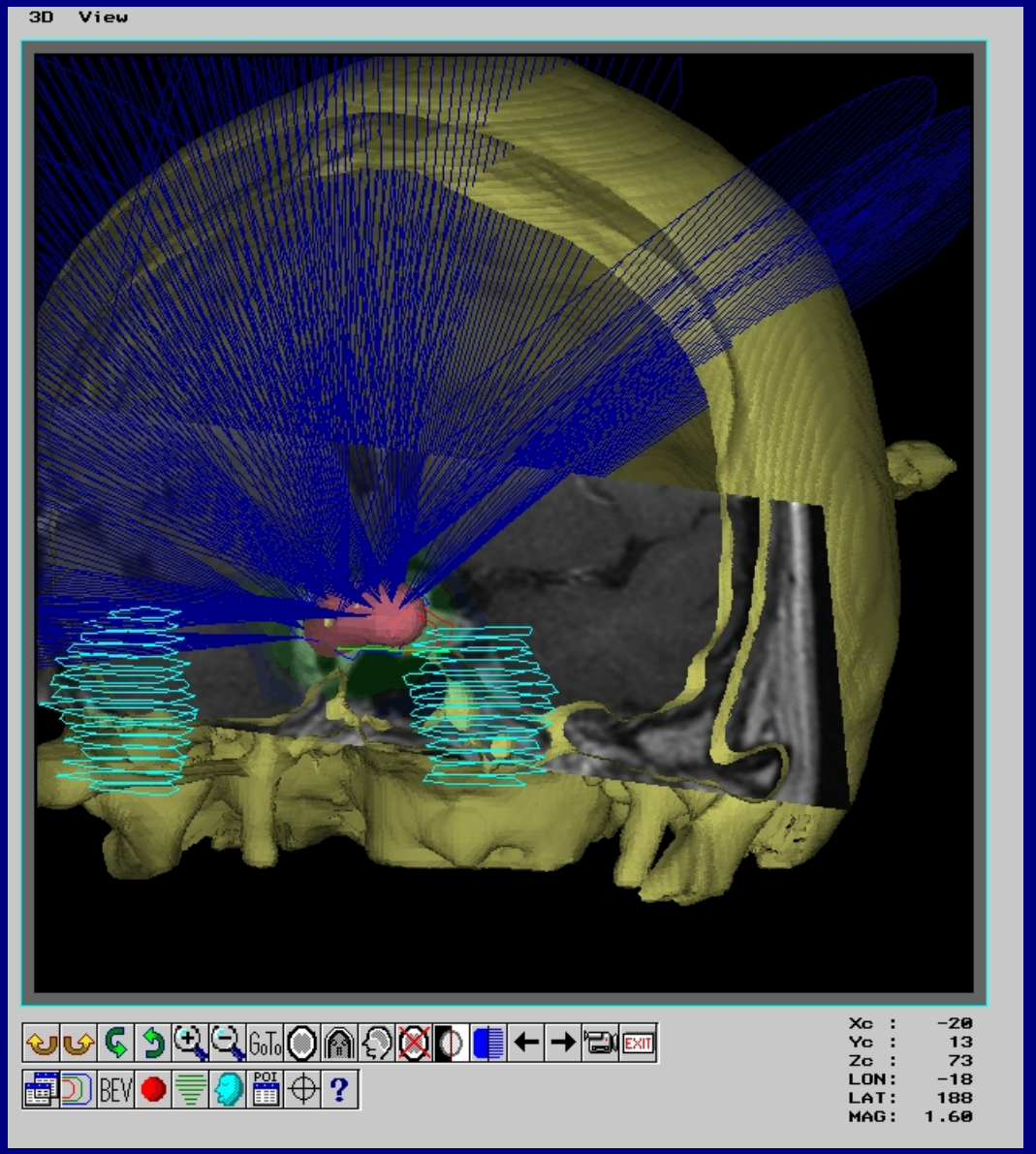
MNPS - DRR and X-rays, registration using intrinsic landmarks.



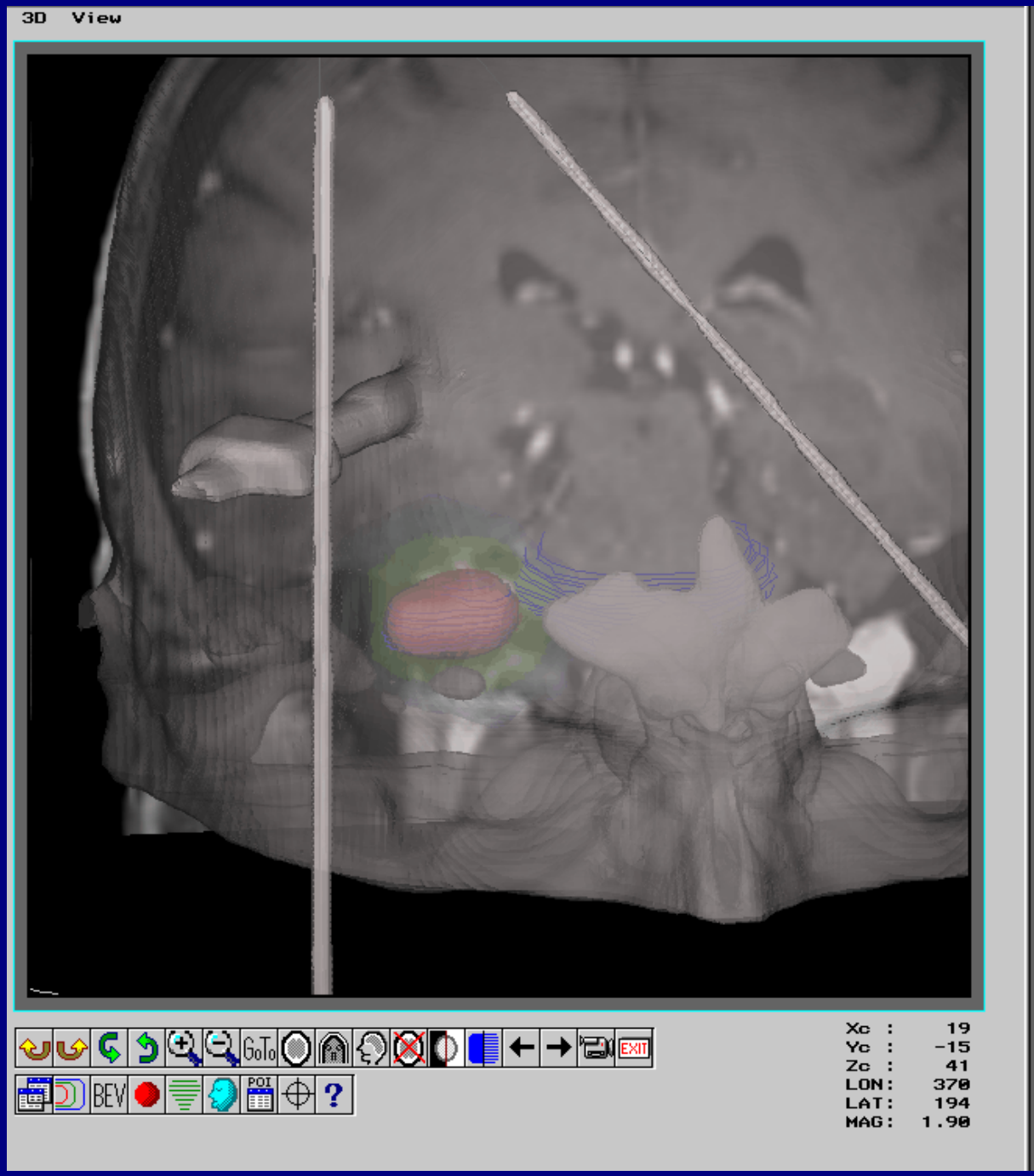
MNPS : Stereotactic Radiosurgery (SRS) tools.

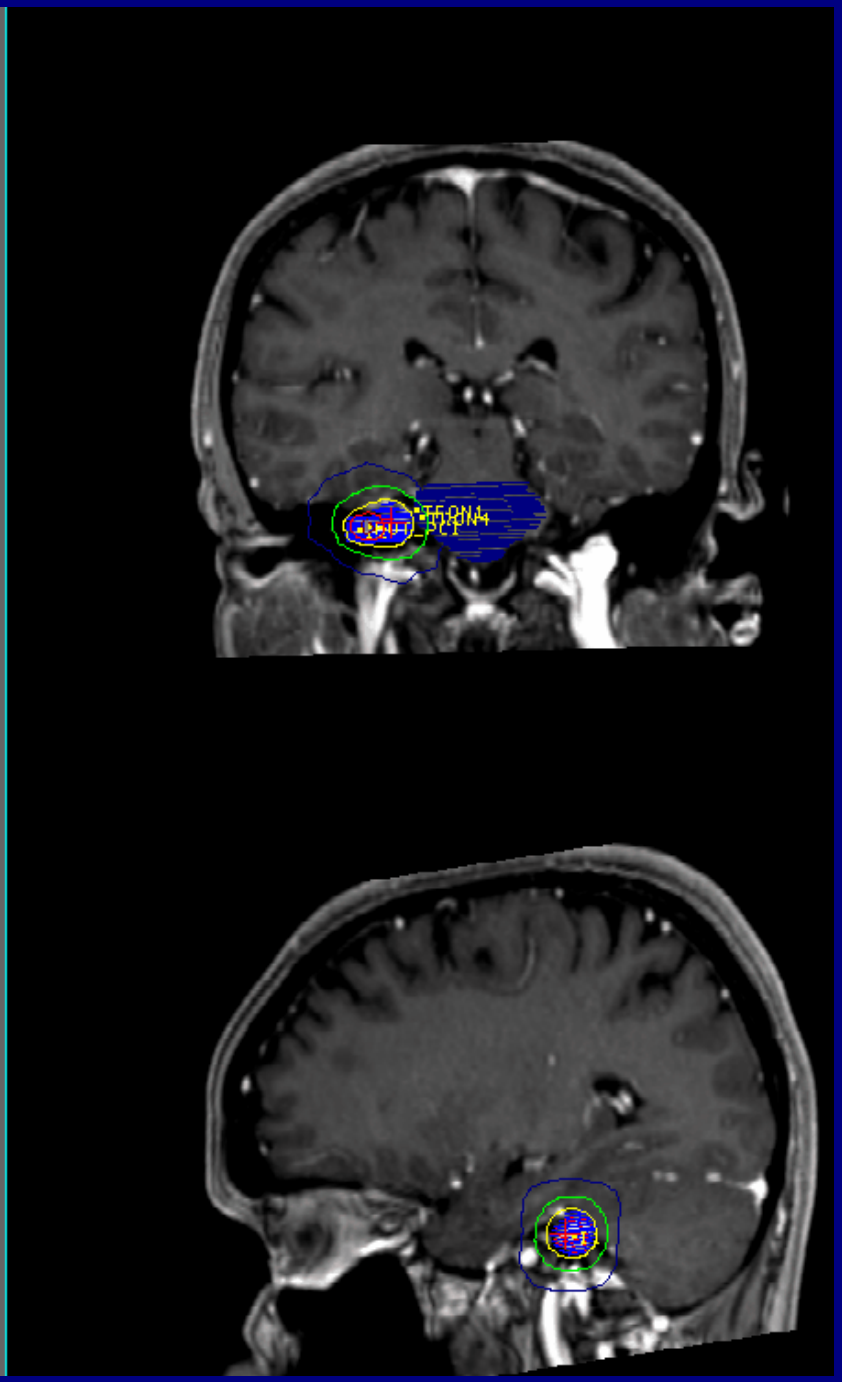
It is LINAC based SRS, with circular collimators. The dose should be delivered by non-coplanar radiations arcs. Up to 64 arcs are available. Isodose maps are rendered in 2D and 3D surfaces. For SRS planning the stereo-CT is mandatory, all dosimetry is based on Houndfield units, but MRIs could be used via registration and fusion with stereo-CT.





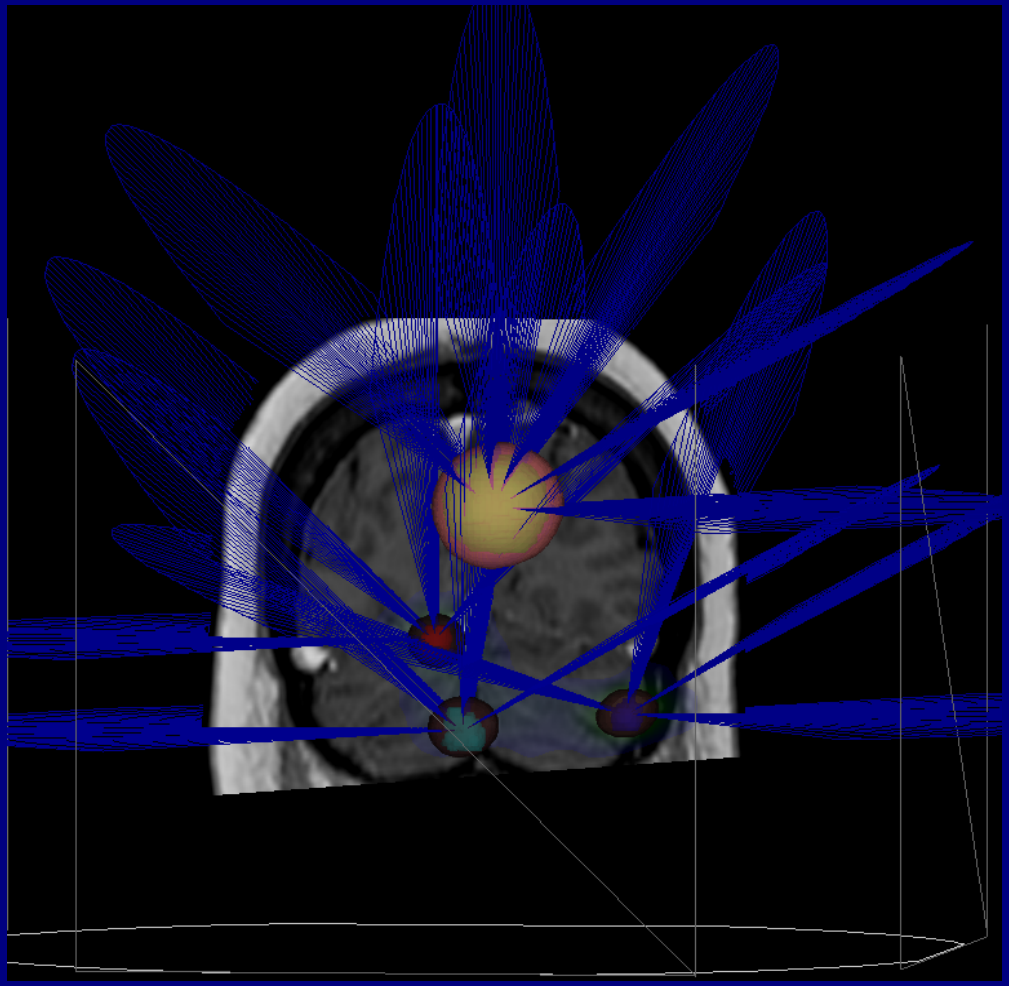
MNPS and SRS: Acoustic neuroma.

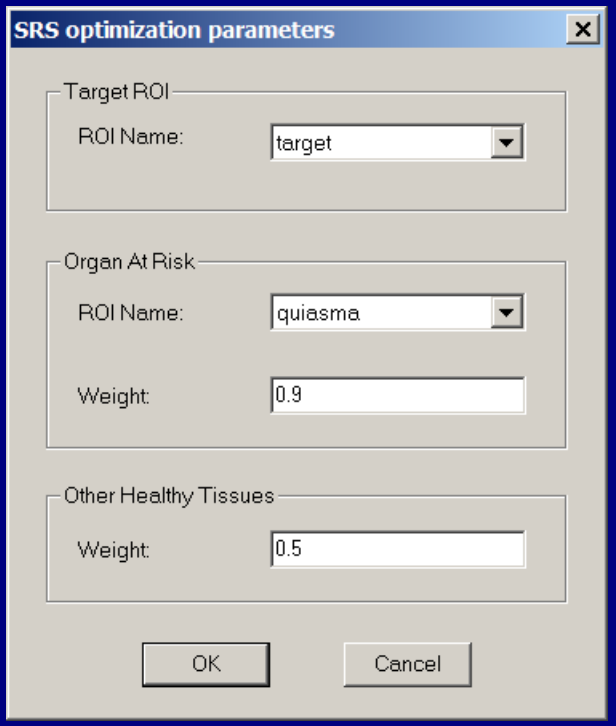


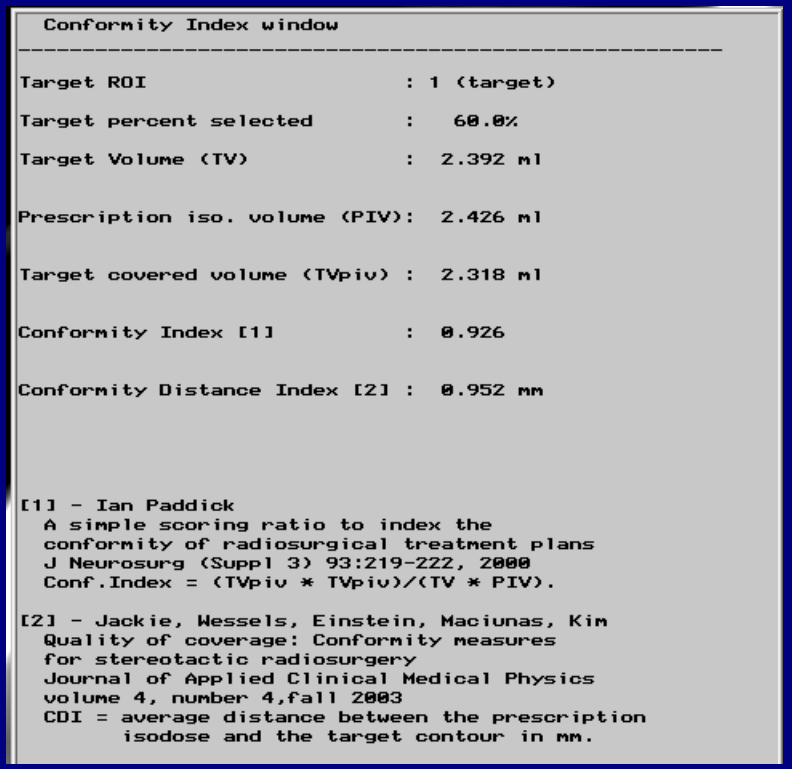


MNPS SRS: Automatic optimization tools and conformity evaluation report. Some inverse planning capabilities, optimize isocenter positions and arc weights

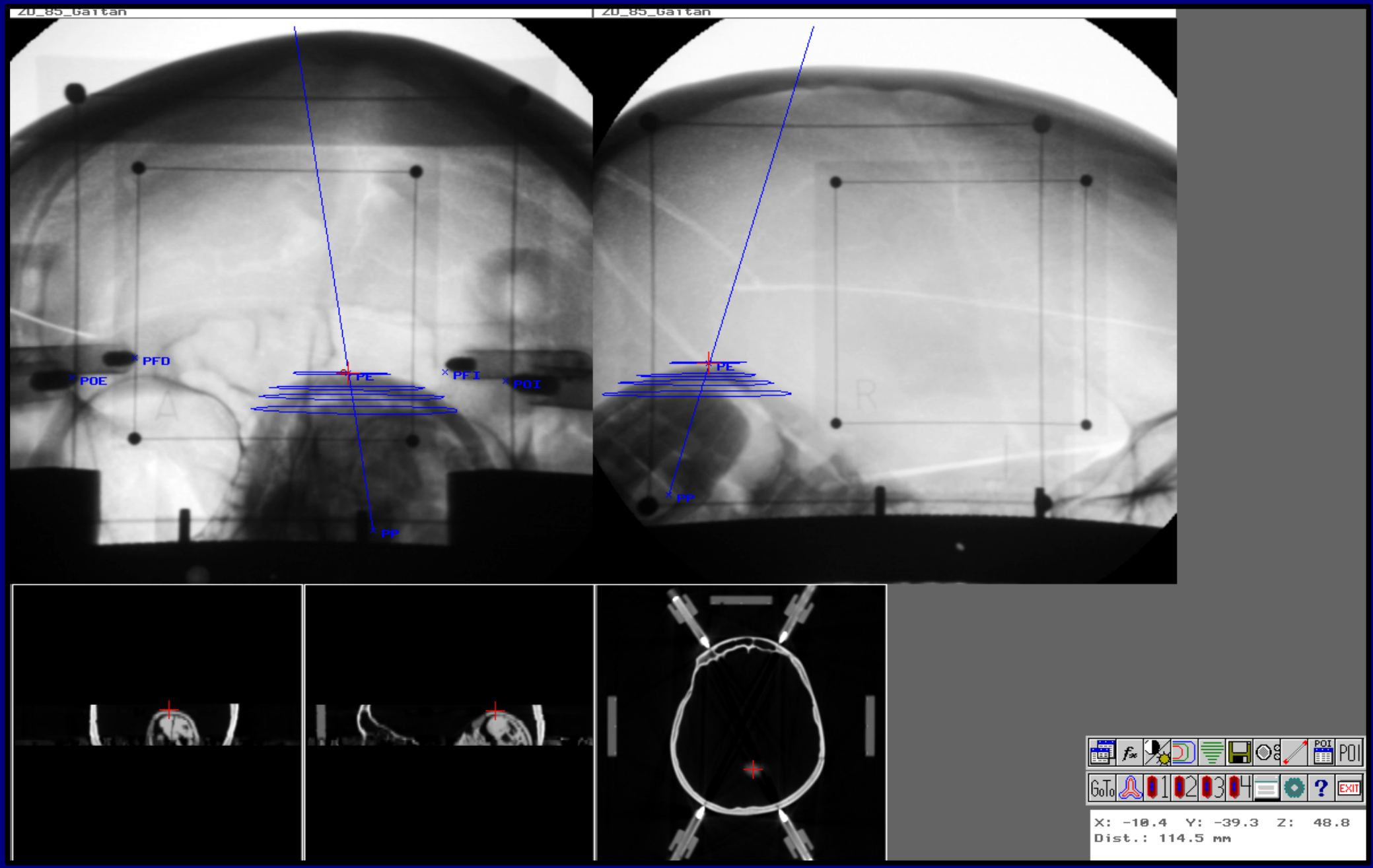
MNPS SRS, Treating multiple isocenters



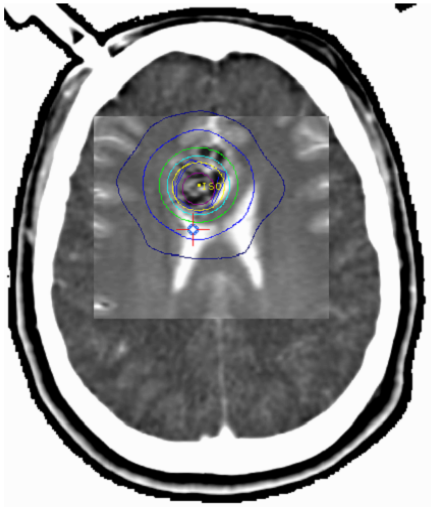


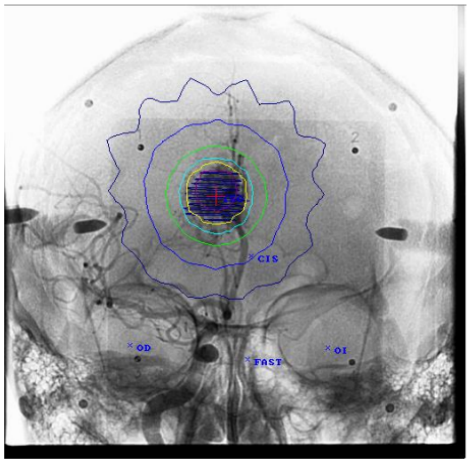


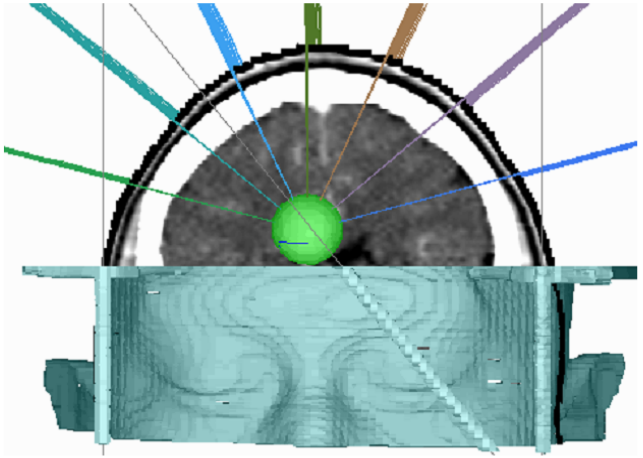
Stereotactic target localization based of orthogonal X-ray pairs. Mainly used for DSA localization and treatment with SRS. Cursor in X-rays correlated to position on CT or MRI continuously. The orthogonal setup is not mandatory, only need to “see” the 8 markers on each X-ray view. The image below shows a phantom for quality assurance with a ZD system attached.

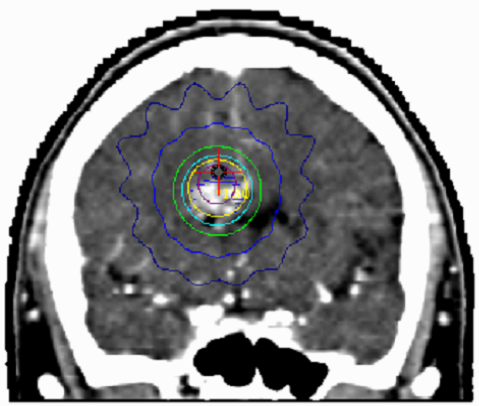


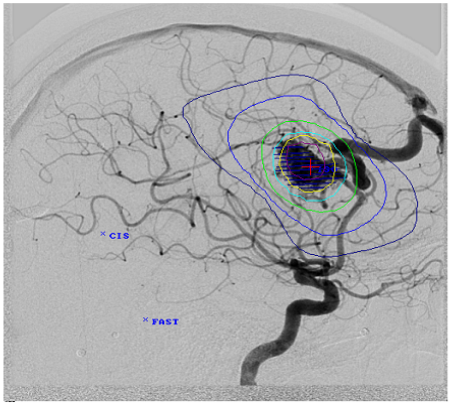
Sample AVM treatment plan with MNPS, (plan by Physicist Dra. S. Gusman, Lima, Peru)











ISODOSES	CONFIGURATION	WINDOW
Isodose: 10.0 ---		Used: YES
Isodose: 20.0 ---		Used: YES
Isodose: 50.0 ---		Used: YES
Isodose: 80.0 ---		Used: YES
Isodose: 90.0 ---		Used: YES
Isodose: 95.0 ---		Used: YES
Isodose: 100.0 ---		Used: YES

Equipment:Mevatron_6MV_Radiocirugia_Lima 1.000 cGy/MU (8/5/2003)
Target Percent Selected: 80
Target Dose [cGy]: 1800

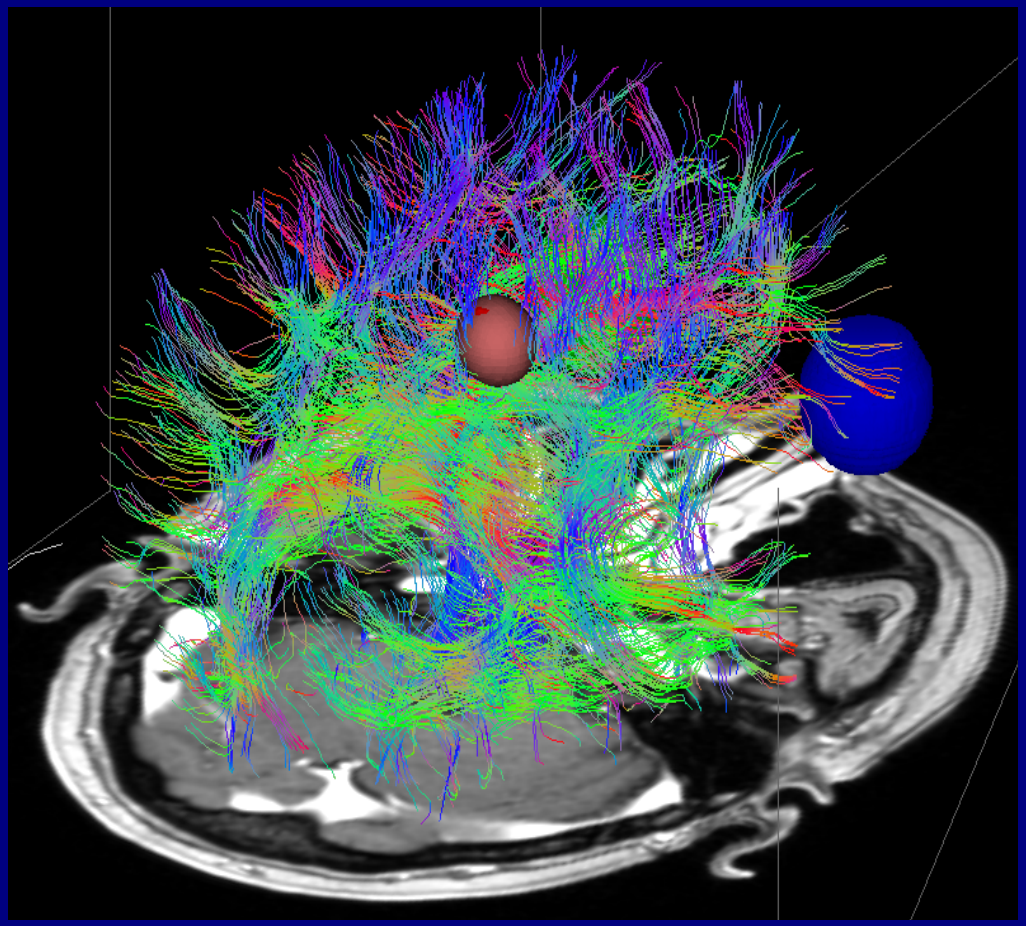
Target	X	Y	Z	CITA	PHI	ARC	COLLIM	WEIGHT	MU
ISO	8.2	29.9	91.8	15.0	70.0	90.0	24.0	1.0	412.3
ISO	8.2	29.9	91.8	40.0	70.0	90.0	24.0	1.0	412.3
ISO	8.2	29.9	91.8	65.0	70.0	90.0	24.0	1.0	412.3
ISO	8.2	29.9	91.8	90.0	70.0	90.0	24.0	1.0	412.3
ISO	8.2	29.9	91.8	295.0	200.0	90.0	24.0	1.0	412.3
ISO	8.2	29.9	91.8	320.0	200.0	90.0	24.0	1.0	412.3
ISO	8.2	29.9	91.8	345.0	200.0	90.0	24.0	1.0	412.3

Print out (Y/N):

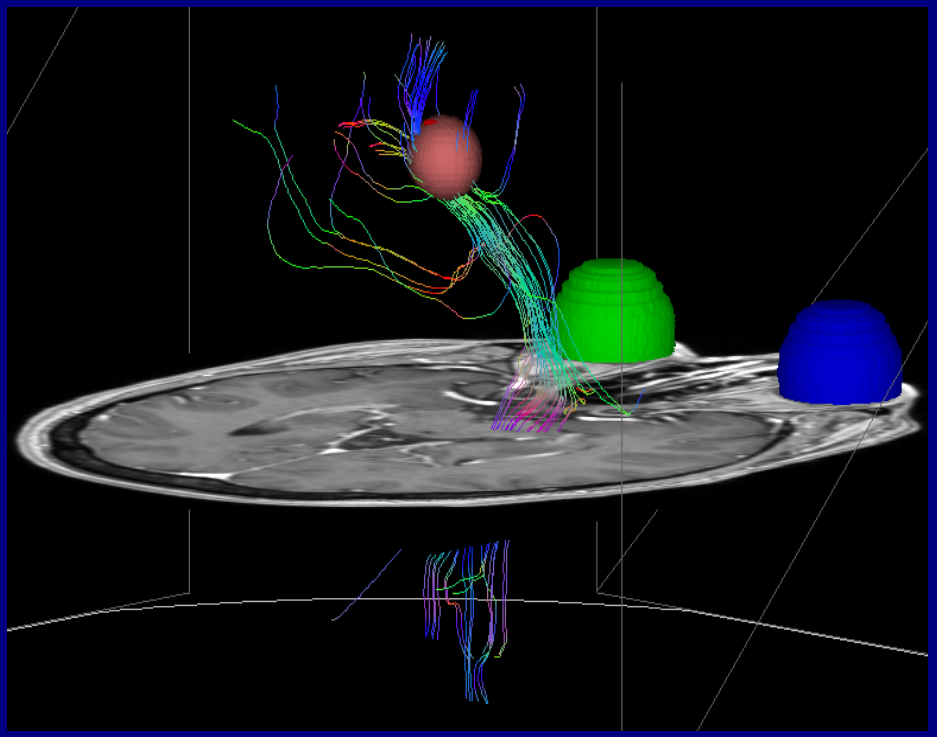
MNPS and SRS planning: Brain fibers crossing an isodose volume

TRACKS/Fibers Menu

- Translation 3D
- Select all Fibers
- Select crossing VTA
- Select crossing ROI
- Select crossing Dose
- Set Logical Operation
- Set Fiber Radius
- Invert axis X,Y
- Invert axis X
- Invert axis Y
- Save Tracks

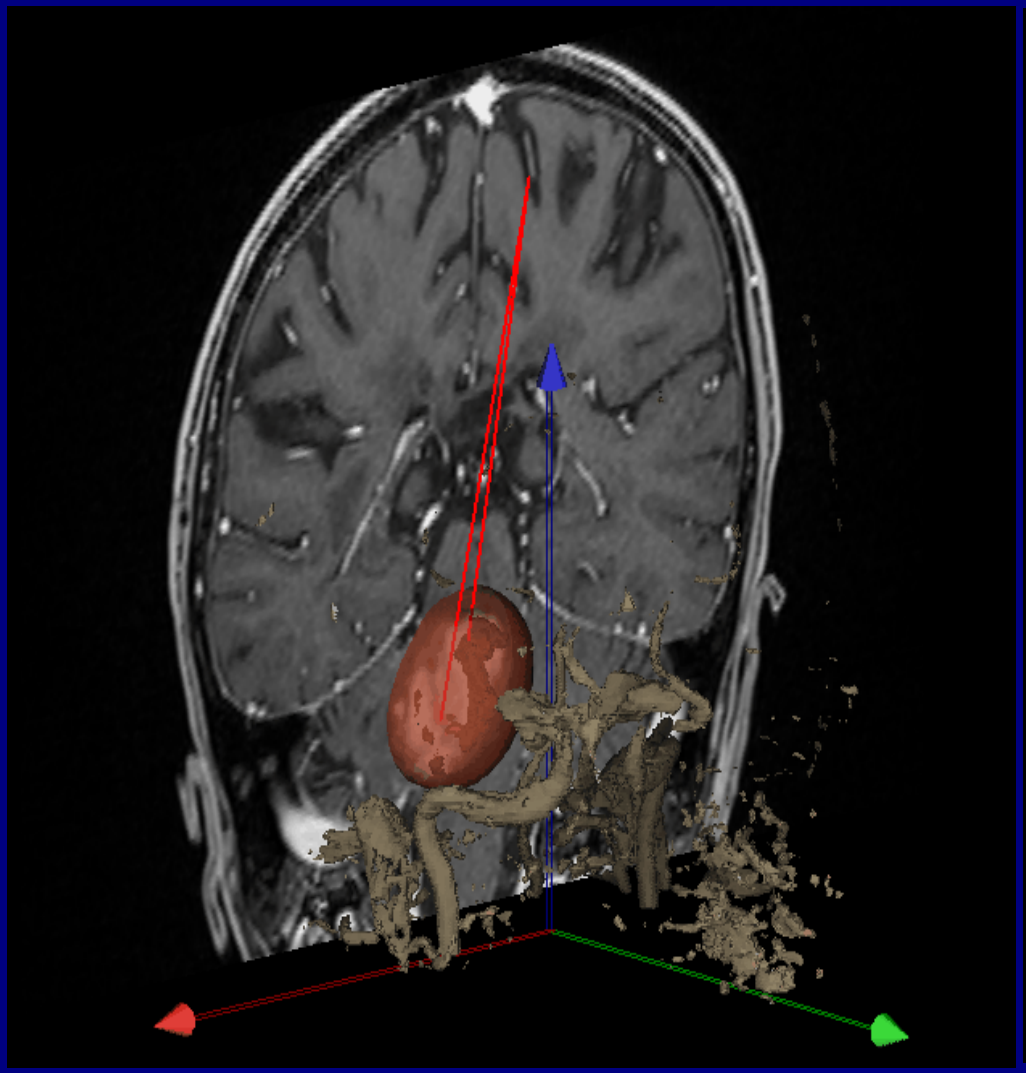


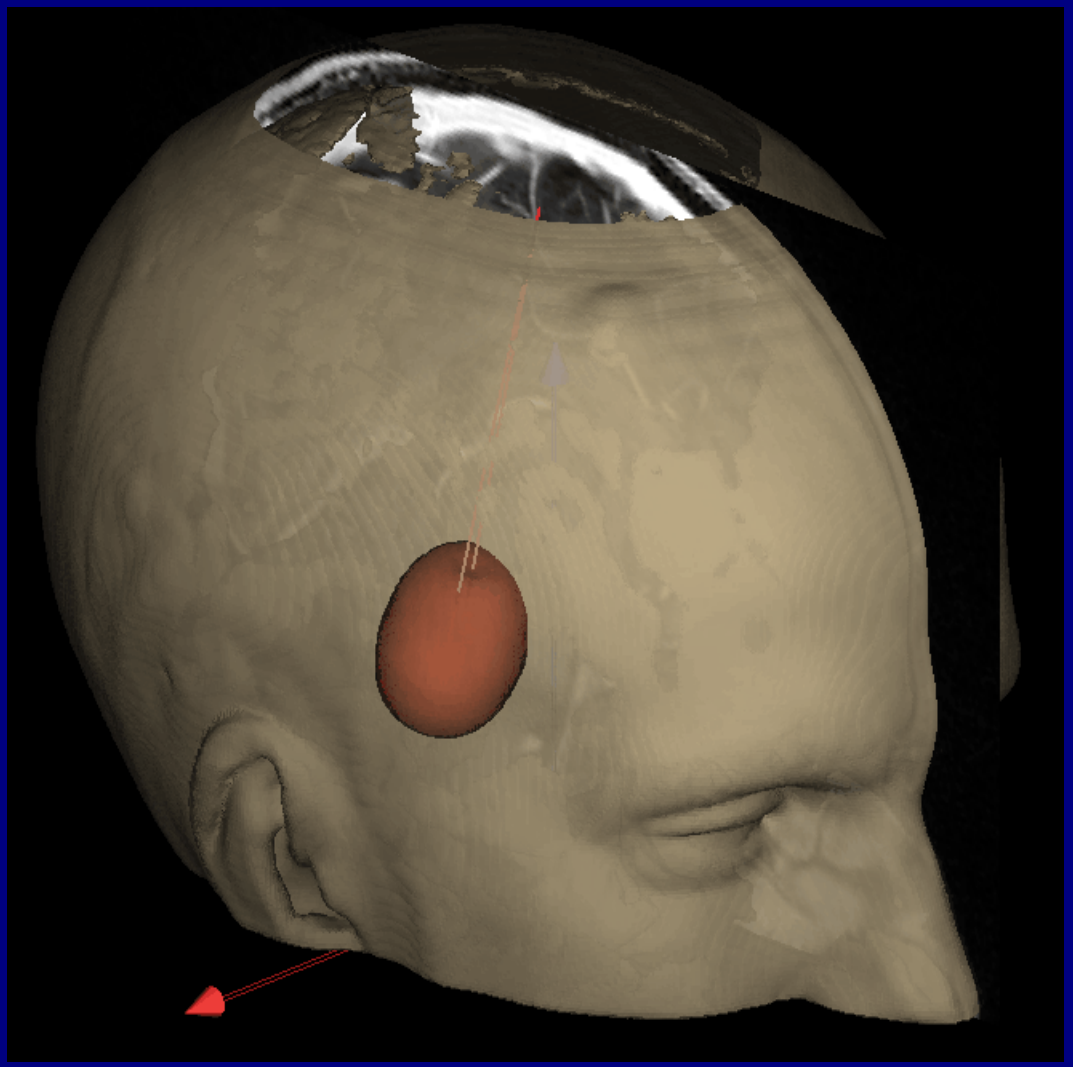
80% Isodose volume rendered with all fibers



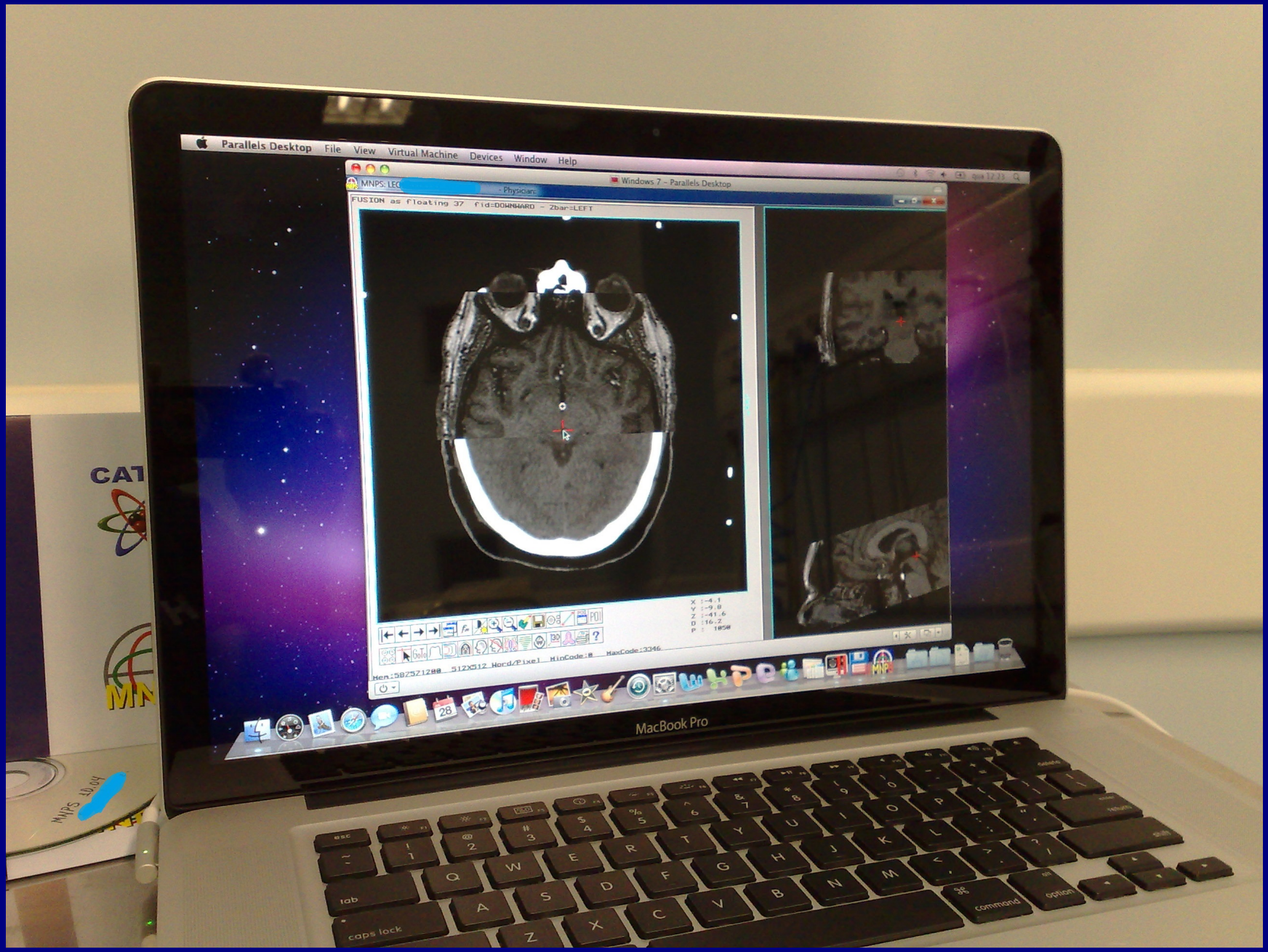
Only those fibers crossing 80% isodose

MNPS: Support for stereotactic brachytherapy with Iodine 125 seeds. Up to 256 sources per plan. Dose computation for temporary as well as permanent implants. Isodose overlays in 2D images and isodose surfaces on 3D window.





MNPS is a Windows based application, but if you want to run it on a Mac-OS there are to ways: Use a virtual machine (tested so far with Parallels and VMware Fusion) or create a Bootcamp.



Supported devices until June 2020 :

- Bramsys
- BrainLAB
- BRW (Brown-Roberts-Wells)
- CRW (Cosman-Roberts-Wells)
- EstereoFlex
- FiMe
- Leksell - G
- Macom
- Micromar
- RM (Riechert-Mundinger)
- ZD (Zamorano-Dujovny)
- MHT
- Zeppelin

Note: One MNPS license supports only one device model. If the user has several device models, more than one license will be necessary.

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