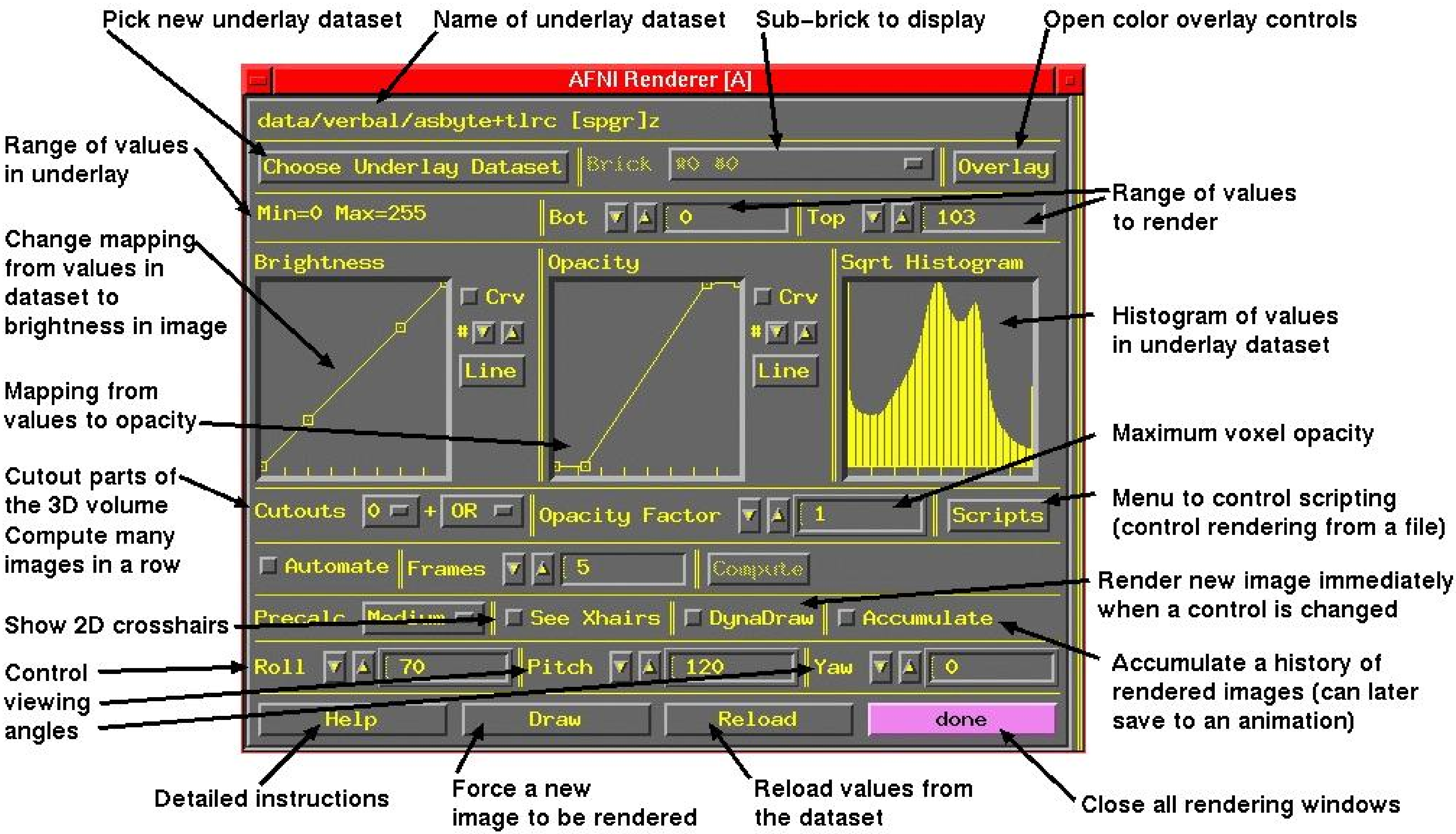
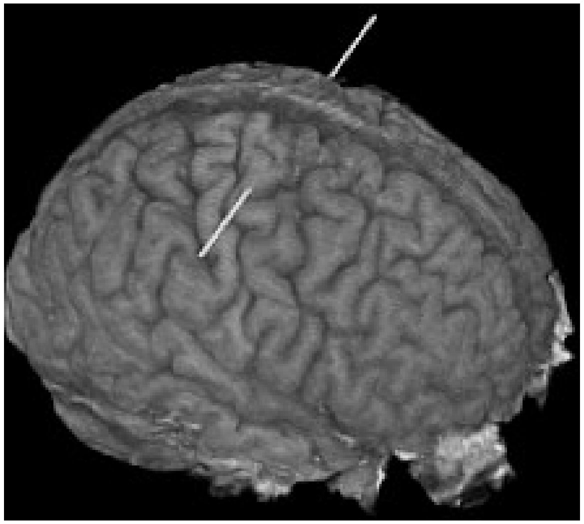
Using the Volume Rendering Plugin

- Accessed via `Define Datamode→Plugins→Render [new]`



- Volume rendering concepts:
  - ◇ Goal is to create a 2D image consisting of pixels
  - ◇ Each 2D pixel is obtained from data looking down line of sight into 3D volume:



If we looked directly from the subject's right to left, all the data along the white line would contribute to one image pixel

  - ◇ Each 3D voxel contains one numerical value
  - ◇ Voxel value determine the brightness (or color) of that voxel—if it is visible
  - ◇ Voxel value determines the opacity of that voxel:
    - ↪ Opacity $= 0 \Rightarrow$ Transparent (brightness does not contribute to image)
    - ↪ Opacity $= 1 \Rightarrow$ Opaque (nothing behind it along the line will be seen)
    - ↪ Intermediate values are translucent:
      Opacity $= 0.5 \Rightarrow 50\%$ of voxel brightness is added to pixel; voxels farther down the line will contribute to other 50% of pixel result

- ◇ 3D viewing angles:

Roll	=	angle about I-S axis
Pitch	=	angle about L-R axis (after roll rotation)
Yaw	=	angle about A-P axis (after roll and pitch)

- ◇ Rendering is CPU and memory intensive—a fast computer is very desirable

- Utility program `3dIntracranial` can be used to strip the scalp off a T1-weighted anatomical volume. In some cases, this may need to be done with the orig dataset, which may then be written out in Talairach coordinates:

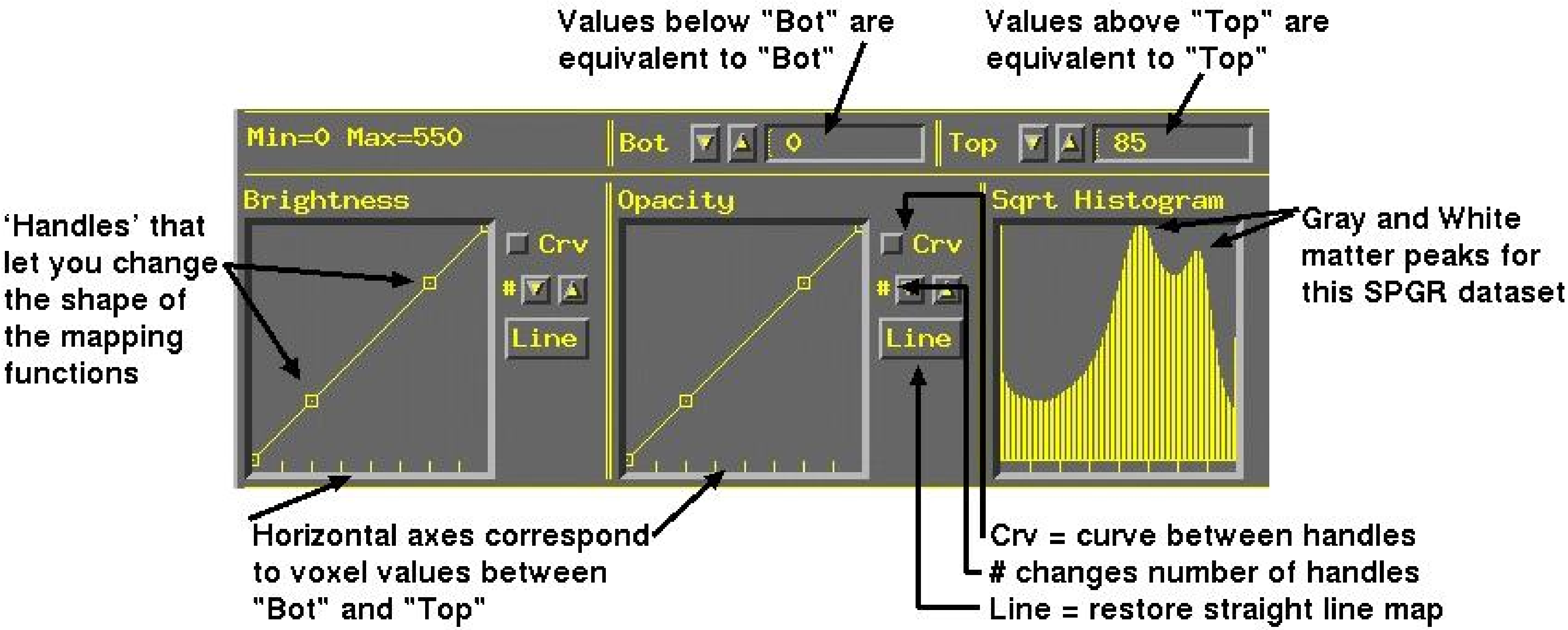
  ```
  3dIntracranial -anat anat+tlrc -prefix astrip
  ```

  (using the datasets from the Talairach transform lecture)

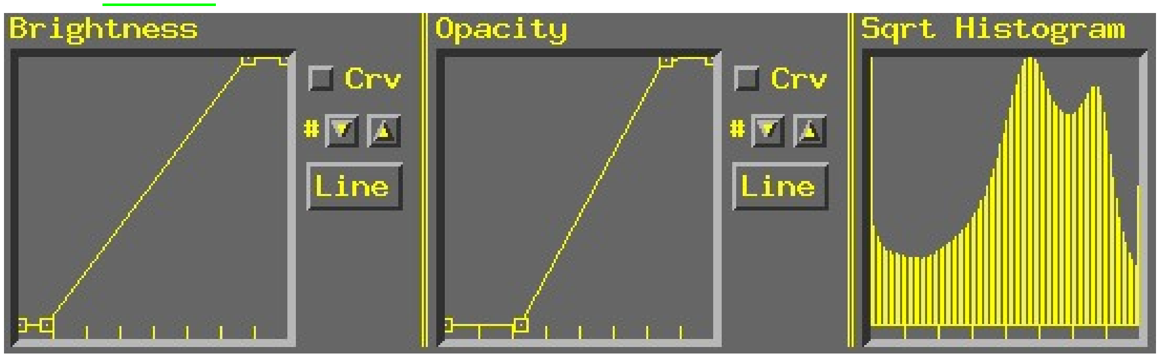
- AFNI can now render datasets that are stored with an arbitrary orientation and voxel size. However, the orientation of cuts still (incorrectly) assumes the axial slice order.
  - ◇ So making a cut "Anterior to X" might actually result in a cut "Left of X"
  - ↪ A fix for this is coming soon to an AFNI distribution near you
  - ◇ Note that axial slice order is the standard for 'warped' datasets written out to disk in `+acpc` or `+tlrc` coordinates

- In `Talairach View`, open the rendering plugin, and choose `astrip` as the underlay dataset
  - ◇ Plugin will load the voxel values, build the histogram, and then be ready to render
  - ◇ Press `Draw` to make your first image
  - ◇ Press `Accumulate`, then `DynaDraw`, then `Roll ▼` a few times
    - ↪ Will generate renderings from different view angles (lines of sight)
      - ▷ If `DynaDraw` is off, then you must press `Draw` to get a new rendering
    - ↪ `Accumulate` on ⇒ rendered images are saved, and can be reviewed by using the image viewer slider
      - ▷ This slider does not move you through slices, as it does in the 2D image viewing windows
      - ▷ It just moves you backward and forward in the history of saved rendered images
      - ▷ If you turn `Accumulate` off, then creating the next rendered image will erase the history
      - ▷ By default, the plugin's controls ('widgets') do not change as you move around in the rendering history
      - ▷ Selecting `Script->Load widgets` will make the widgets display the settings they had when the currently display image was rendered

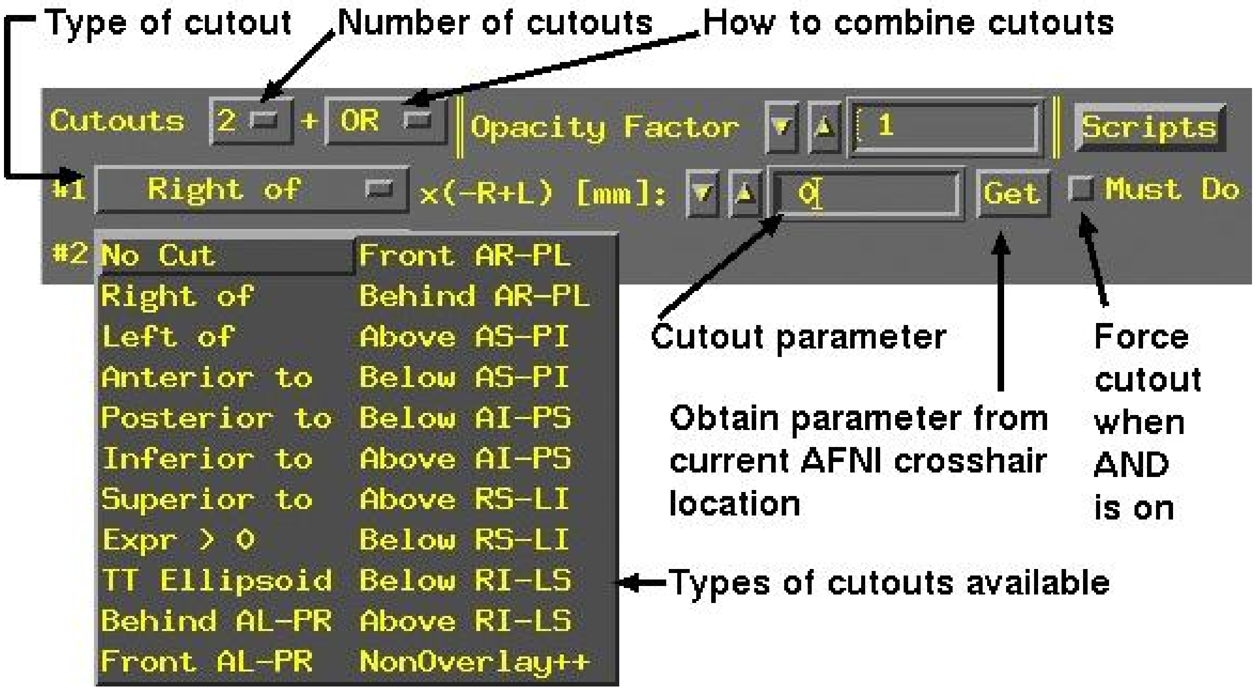
- Controlling the mappings from voxel value to brightness and opacity:



  - ◇ Probably want to make white matter be fully white
    Drag #3 Brightness handle up to top, over to white matter value
  - ◇ Probably want to reduce Opacity to 0 for all low intensity voxels
    Drag #2 Opacity handle to bottom, over to histogram trough value
    Then press `Draw` to force a re-rendering



• Cutouts are for removing parts of the volume so you can see the parts you want:



◇ Each cutout specifies a sub-volume in space that will be removed from the dataset before rendering (done by setting voxel opacity to zero inside the cutout)

◇ Multiple cutouts can be combined in two different ways:

↪ OR ⇒ all voxels in all cutouts will be removed

↪ AND ⇒ only voxels that are in every cutout sub-volume will be removed

▷ Must Do can be used to force the removal of cutout voxels even if AND is active

▷ OR is equivalent to Must Do for all cutouts

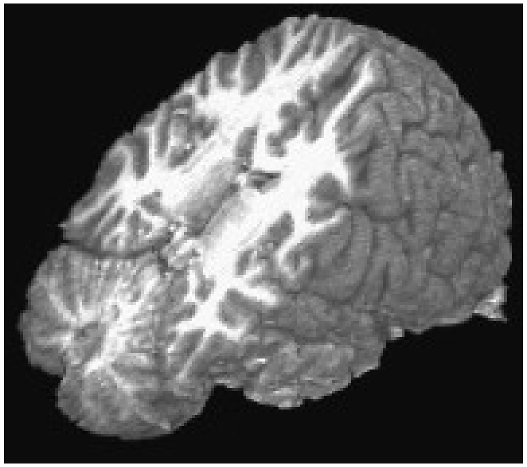
◇ Most cutout types are controlled by a single numerical parameter determining the position of the cutout

↪ `Right of` 'x' means to cut out all voxels to the right of the given x-coordinates (–x is Right, +x is Left)

▷ Similarly, can cutout everything Anterior to, or Posterior to, or Superior to, or Inferior to, or Left of a given coordinate position

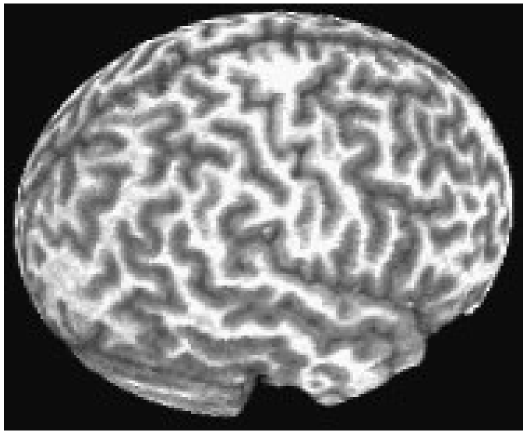
↪ `Behind...`, `Below...`, `Front...`, `Above...` cut out 45° diagonally slanted half-spaces, with respect to the listed planes:

For example, `Above AS-PI` is above a plane that slants from the Anterior-Superior front of the brain downwards to the Posterior-Inferior back of the brain—that is, halfway between a coronal and axial slice



↪ `TT Ellipsoid` cuts out the region outside an ellipsoid with the same proportions as the Talairach-Tournoux Atlas brain

This is fun, but not much use



◇ Cutout type Expr > 0 defines the region to be removed by a general mathematical expression, rather than a single parameter

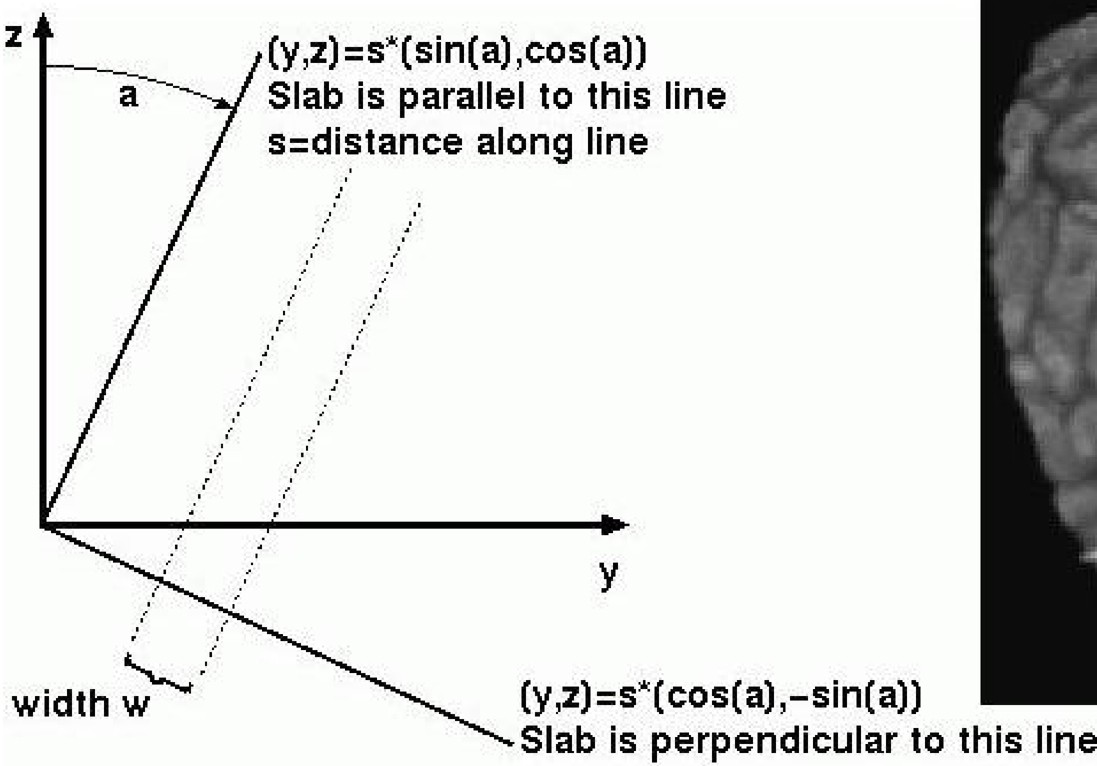
↪ The expression uses the same syntax as 3dcalc

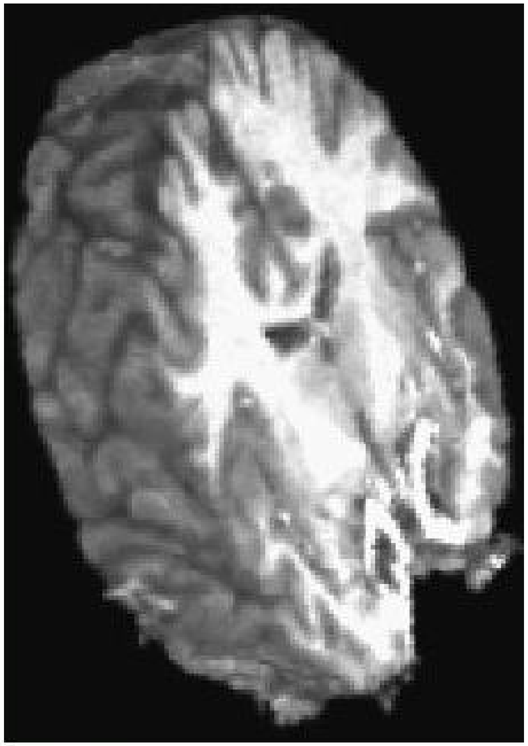
↪ Variables that can be used are 'x', 'y', and 'z', corresponding to spatial coordinates in the dataset

▷ When using Automate (infra), variable 't' can also be used

▷ The (x,y,z) locations where the expression evaluates to a positive number will be cut out

↪ Example: rendering a slab tilted at an arbitrary angle between coronal (xz-plane) and axial (xy-plane):





↪ The set of points within the slab is described by the inequality

$$|y \cdot \cos(a) - z \cdot \sin(a) - s| < \frac{1}{2}w$$

for angle$=a$, slab center offset$=s$, and slab width$=w$. To render a slanted coronal slab 30 mm thick, tilted posteriorly from the vertical by 25°, we would use this for the cutout expression:

```
abs(y*cosd(25)-z*sind(25)-20)-15
```

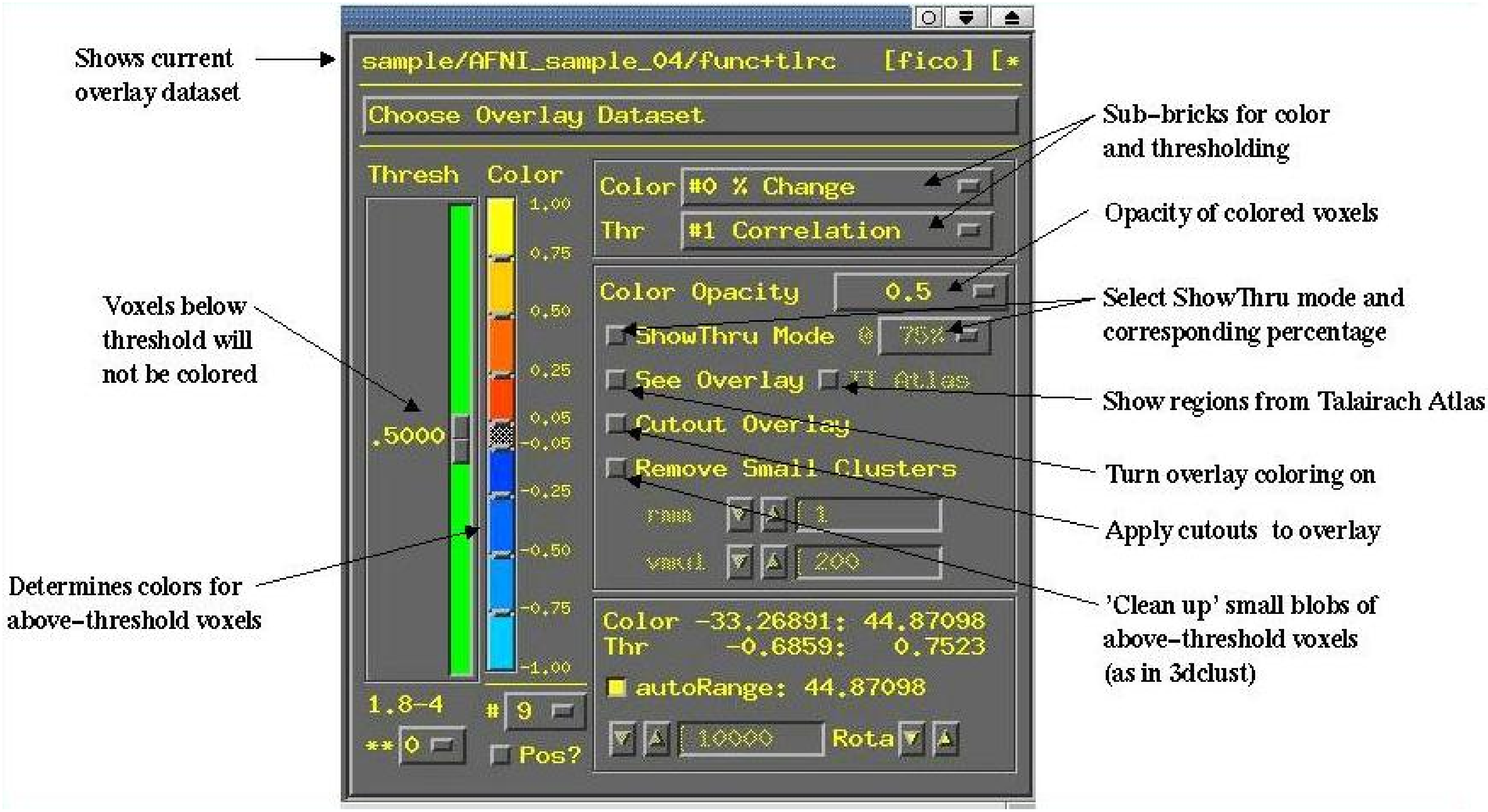
where the `sind()` and `cosd()` functions take arguments in degrees, and where I have chosen the offset to be 20 mm (you will have to alter this to get the exact position you want)

- ▷ By using `Automate` and setting the angle (25 above) and/or the offset (20 above) to depend on 't', we can make a sequence of images where the slab rotates downwards and/or moves backwards

- Automate lets you create a large number of renderings at once
  - ◇ Note that most (but not all) number entry boxes have slightly raised borders:

  - ◇ Such boxes can use an expression with the variable 't' when Automate is used:
    - ↪ Turn Automate on
    - ↪ Enter some small number in the Frames control (say 5)
    - ↪ Enter 70+5*t in the Roll control, then press Compute
    - ↪ The dataset will be rendered with the variable 't' set to 0, 1, 2, 3, 4 in turn
      - ▷ That is, t will run from 0 to one less than the number of Frames, and all the raised-border boxes that use expressions with 't' will be evaluated prior to each frame being rendered
    - ↪ In this example, this will result in a sequence of views of the dataset from different roll angles 70°, 75°, 80°, 85°, 90°
    - ↪ Can also use 't' in cutout parameters to make cutouts depend on 'time'
      - ▷ 2 cutouts, Left of=10+3*t and Right of=-10+3*t will produce a 20 mm thick slice that slides leftwards as t increases
    - ↪ Can use 't' in more than one raised-border box simultaneously to make complex animations (e.g., Roll and Cutouts together)
    - ↪ Put cursor in raised-border box and press Enter to have box reset to last numerical value used by Automate

- Color overlays (e.g., of functional activation maps)
  - ◇ Press the Overlay button to open up the panel that controls how functional overlays are generated:



  - ◇ Controls are similar to Define Function for overlaying color on 2D image viewer windows

↪ Will only discuss differences from 2D overlay control panel

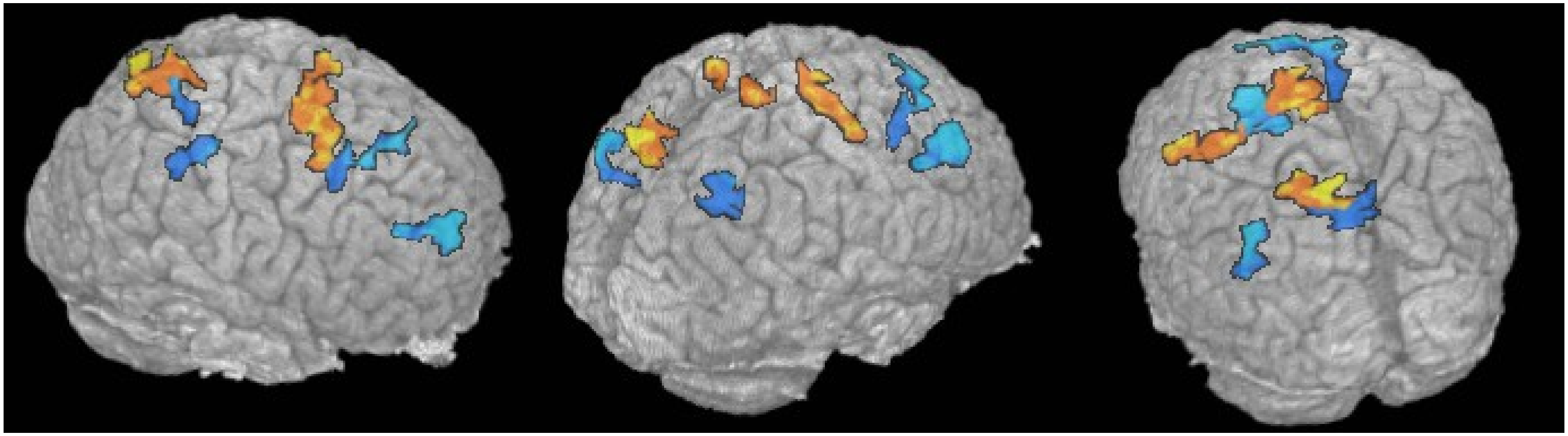
◇ Color Opacity lets you select the opacity of colored voxels (those that are above the threshold)

↪ Opacity of overlaid voxels is different from the opacity it would have from the underlay dataset at that location

↪ Usually want this to be high (0.5 or above)

↪ Two special values on this menu:

- ▷ Underlay means that the colored voxel's opacity will be determined by the opacity that it would have from the underlay image
- ▷ ShowThru means that colors voxels show through underlay voxels (the 'glass brain' effect), no matter how opaque the underlay is
  - Takes some practice to become accustomed to this type of image
  - But can be a very useful way to see lots of activation at once:



  - Seeing this animated is especially helpful (but hard to publish)