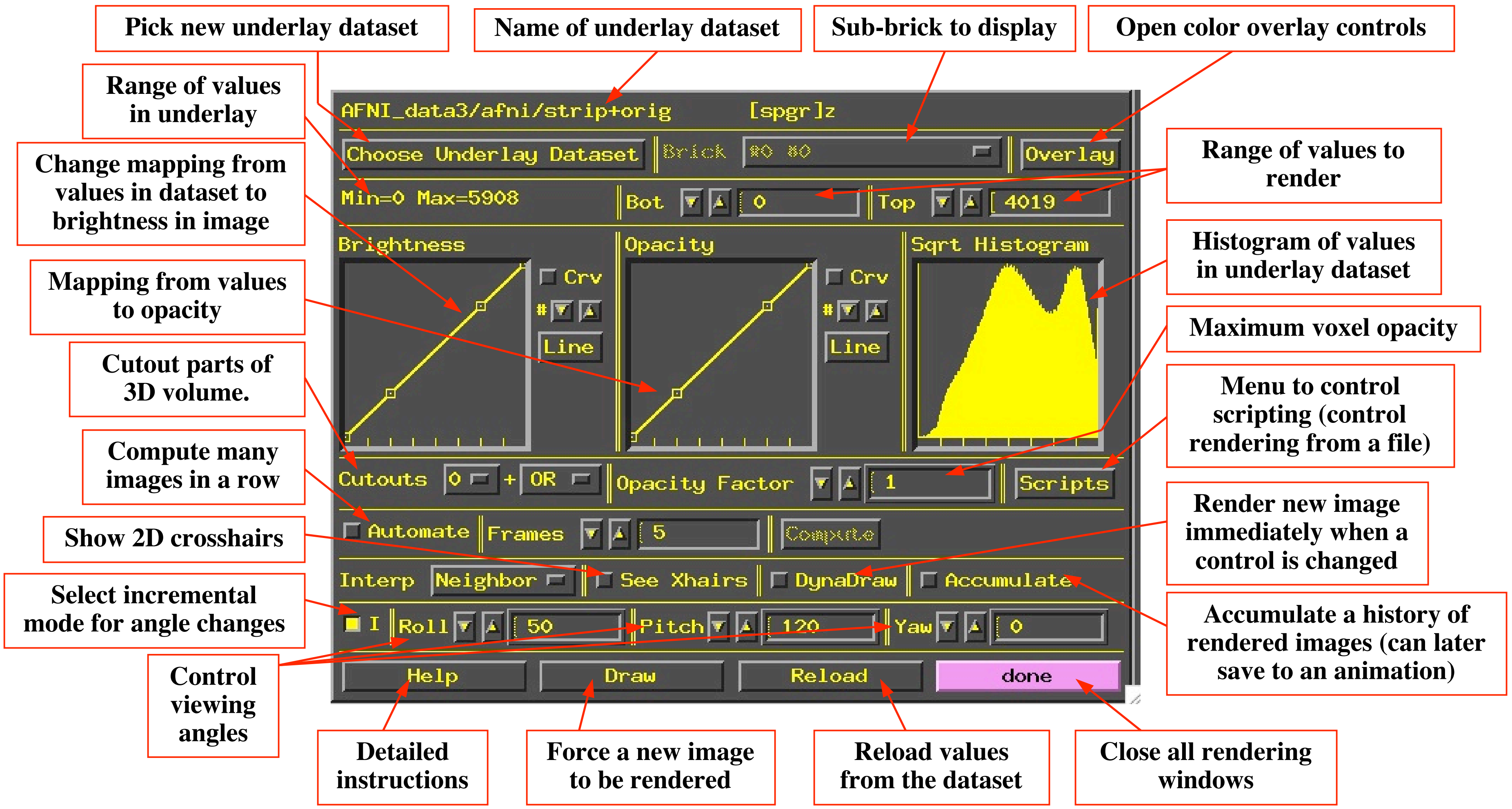
Using the Volume Rendering Plugin

- Accessed via **Define Datamode ---> Plugins ---> Render [new]**


Pick new underlay dataset
Name of underlay dataset
Sub-brick to display
Open color overlay controls
Range of values in underlay
Change mapping from values in dataset to brightness in image
Mapping from values to opacity
Cutout parts of 3D volume.
Compute many images in a row
Show 2D crosshairs
Select incremental mode for angle changes
Control viewing angles
Range of values to render
Histogram of values in underlay dataset
Maximum voxel opacity
Menu to control scripting (control rendering from a file)
Render new image immediately when a control is changed
Accumulate a history of rendered images (can later save to an animation)
Detailed instructions
Force a new image to be rendered
Reload values from the dataset
Close all rendering windows
Choose Underlay Dataset
Overlay
Brightness
Opacity
Sqrt Histogram
Crv
Line
Scripts
Compute
Help
Draw
Reload
done

AFNI_data3/afni/strip+orig [spgr]z

Brick #0 #0

Min=0 Max=5908

Bot 0 Top 4019

Cutouts 0 + OR

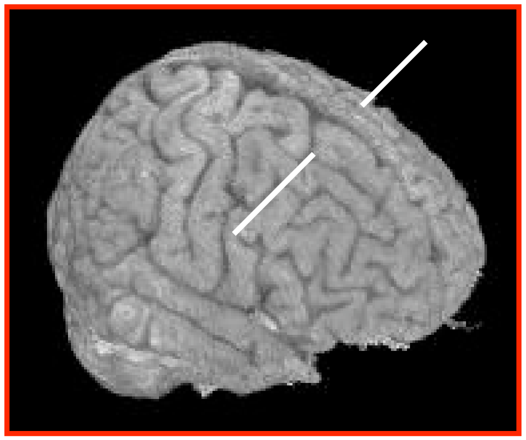
Opacity Factor 1

Automate Frames 5

Interp Neighbor See Xhairs DynaDraw Accumulate

I Roll 50 Pitch 120 Yaw 0

- 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 determines the brightness (or color) of that voxel --- if it is visible
  - ✧ Voxel value determines the opacity of that voxel:
    - ➥ Opacity = 0 ⇒ Transparent (brightness does not contribute to image)
    - ➥ Opacity = 1 ⇒ Opaque (nothing behind it along the line will be seen)
    - ➥ Intermediate values are translucent:

      Opacity = 0.5 ⇒ 50% of voxel brightness is added to pixel; voxels farther down the line will contribute to other 50% of pixel result

- Opacity examples:
  start with (remaining) opacity of 1, and apply a fraction of it at each new voxel

Values encountered	10	10	100	100	100		limit
Opacity used (@ 1.0)	1						0
Value applied	10						0
Opacity remaining	0	0	0	0	0		0
Cumulative value	10						10
Opacity used (@ 0.9)	0.9	0.09	0.009	0.0009	0.00009		0
Value applied	9	0.9	0.9	0.09	0.009		
Opacity remaining	0.1	0.01	0.001	0.0001	0.00001		
Cumulative value	9	9.9	10.8	10.89	10.899		10.9
Opacity used (@ 0.5)	0.5	0.25	0.125	0.0625	0.03125		
Value applied	5	2.5	12.5	6.25	3.125		
Opacity remaining	0.5	0.25	0.125	0.0625	0.03125		
Cumulative value	5	7.5	20	26.5	29.625		32.5
Opacity used (@ 0.2)	0.2	0.16	0.128	0.1024	0.08192		
Value applied	2	1.6	12.8	10.24	8.192		
Opacity remaining	0.8	0.64	0.512	0.4096	0.32768		
Cumulative value	2	3.6	16.4	26.64	34.832		67.6

- ✧ 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 programs **3dSkullStrip** or **3dIntracranial** can be used to strip the scalp off of 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.
  - ✧ For example:

```
3dSkullStrip -input anat+tlrc -prefix astrip
```

or

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

- AFNI can now render datasets that are stored with an arbitrary orientation and voxel size
  - ✧ Datasets are internally re-oriented (see **3dresample**) to axial slice order, so that cut directions make sense. This may take a few seconds, depending on the computer.
  - ✧ Note that axial slice order is the standard for ‘warped’ datasets written out to disk in **+acpc** or **+tlrc** coordinates.
  - ✧ The Overlay dataset may also be resampled, so that its grid spacing matches that of the Underlay dataset.

- In **Talairach view**, open the rendering plugin, and choose **astrip+tlrc** 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 angles (i.e., 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 displayed image was rendered

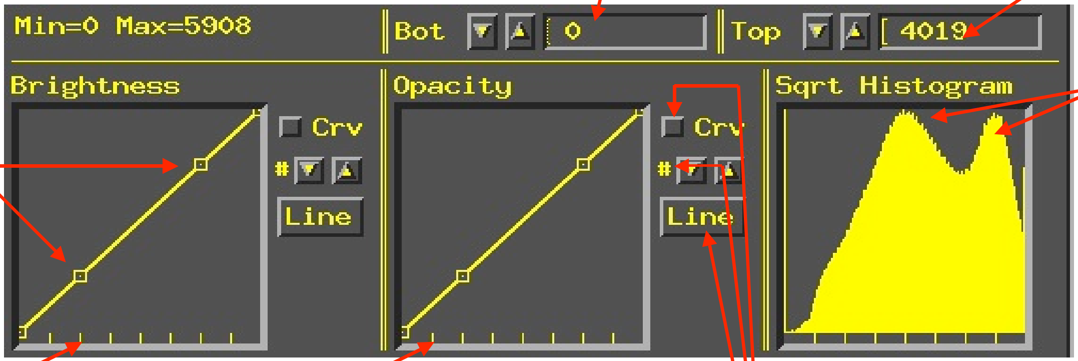
- Controlling the mappings from voxel value to brightness and opacity:

Values below "Bot" are equivalent to "Bot"

Values above "Top" are equivalent to "Top"

'Handles' that let you change the shape of the mapping functions

Gray and White matter peaks for this SPGR dataset



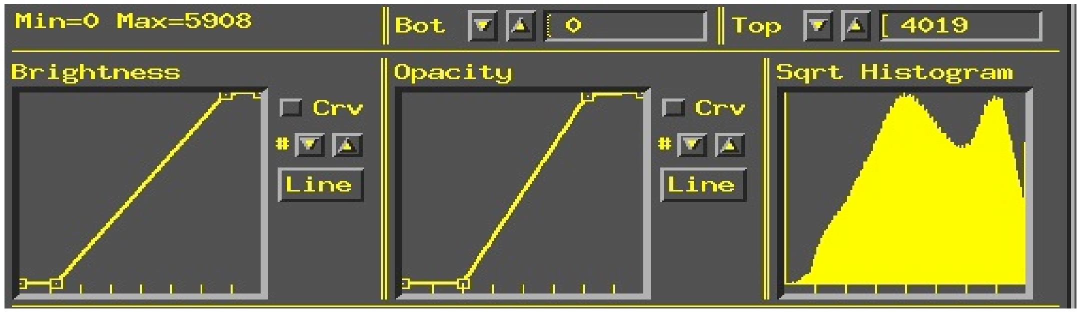
Horizontal axes correspond to voxel values between "Bot" and "Top"

Crv ⇒ curve between handles
# ⇒ changes number of handles
Line ⇒ restore straight line map

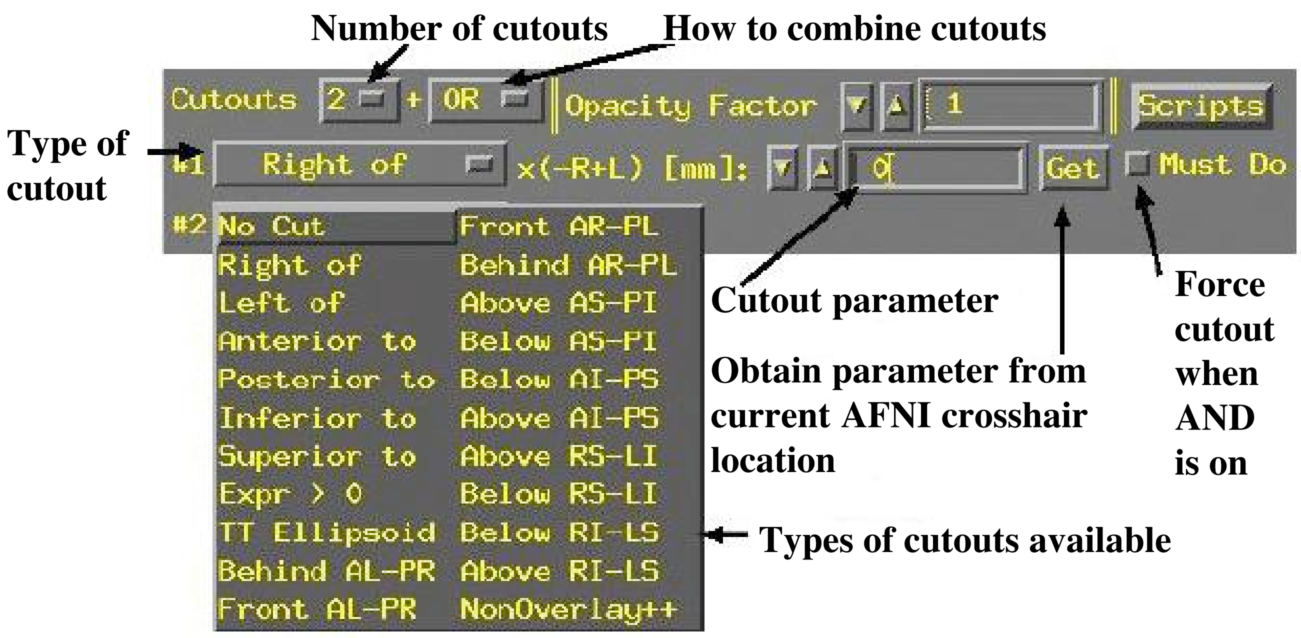
✧ Probably want to make white matter be fully white.
Drag #3 Brightness handle up to top, over to white matter value

✧ 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



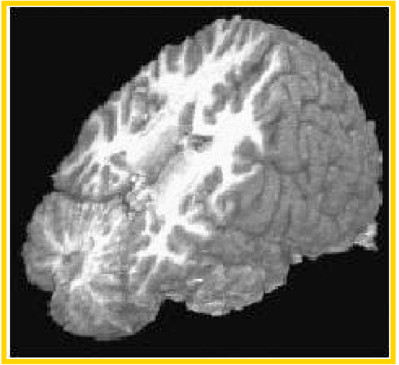
- Cutouts are for removing parts of the volume so you can see the parts you want:



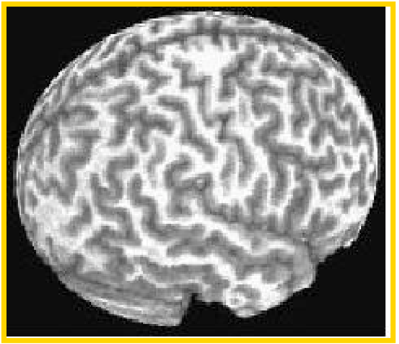
  - ✧ Each cutout specifies a sub-volume in space that will be removed from the dataset before rendering (done by setting voxel opacity to zero inside the cutout)
  - ✧ Multiple cutouts can be combined in two different ways:
    - ➥ **OR** ⇒ all voxels in all cutouts will be removed
    - ➥ **AND** ⇒ only 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, Posterior to, or Superior to, Inferior to, or Left of a given coordinate position
  - `Behind…`, `Below…`, `Front…`, `Above…` cut out 45^o 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

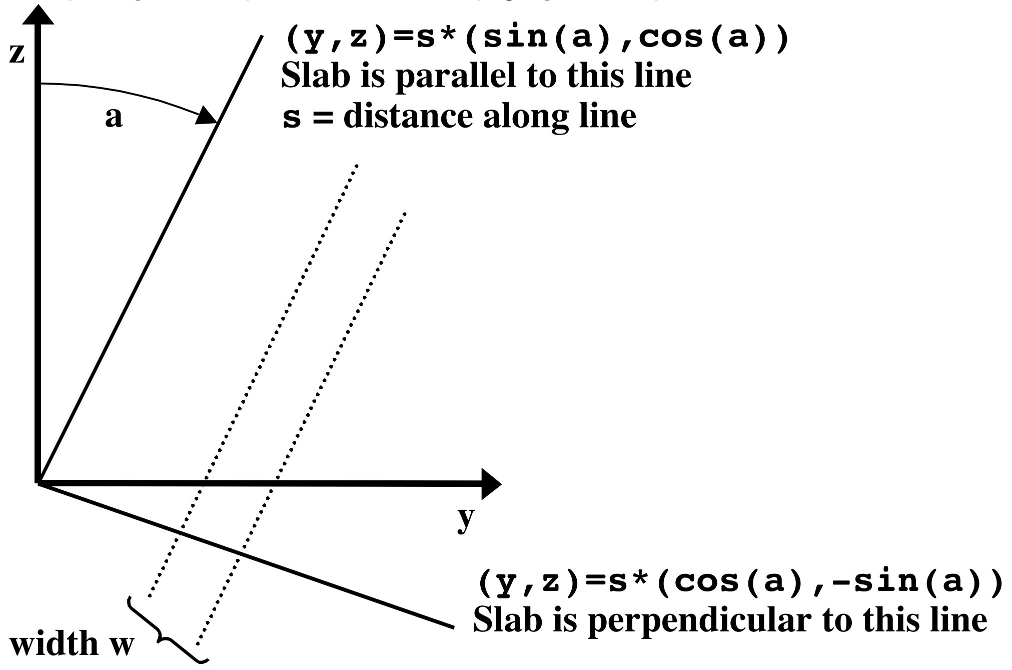


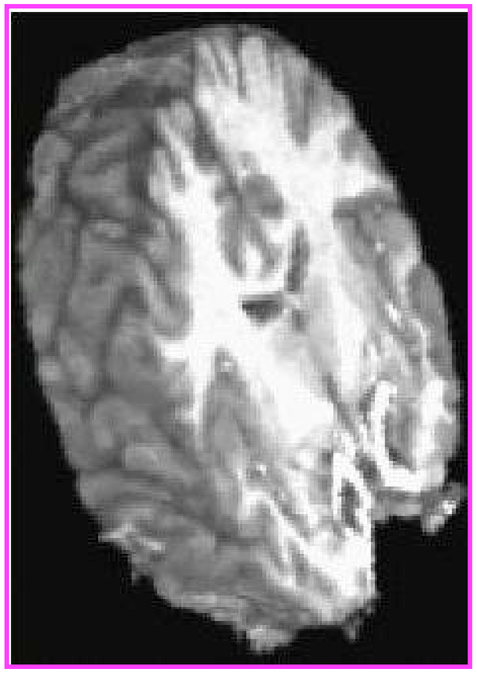
  - `TT Ellipsoid` cuts out the region outside an ellipsoid with the same proportions as the Talairach-Tournoux Atlas brain



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

$$|y \bullet cos(a) - z \bullet sin(a) - s| < 1/2w$$

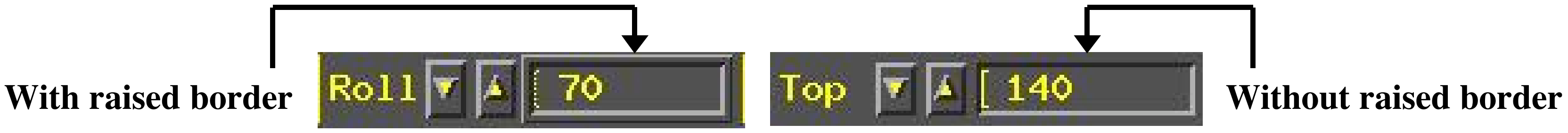
for angle=a, slab center offset=s, and slab width=w. To render a slanted coronal slab 30 mm thick, tilted posteriorly from the vertical of 25^o, we would use this for the cutout expression:

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

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

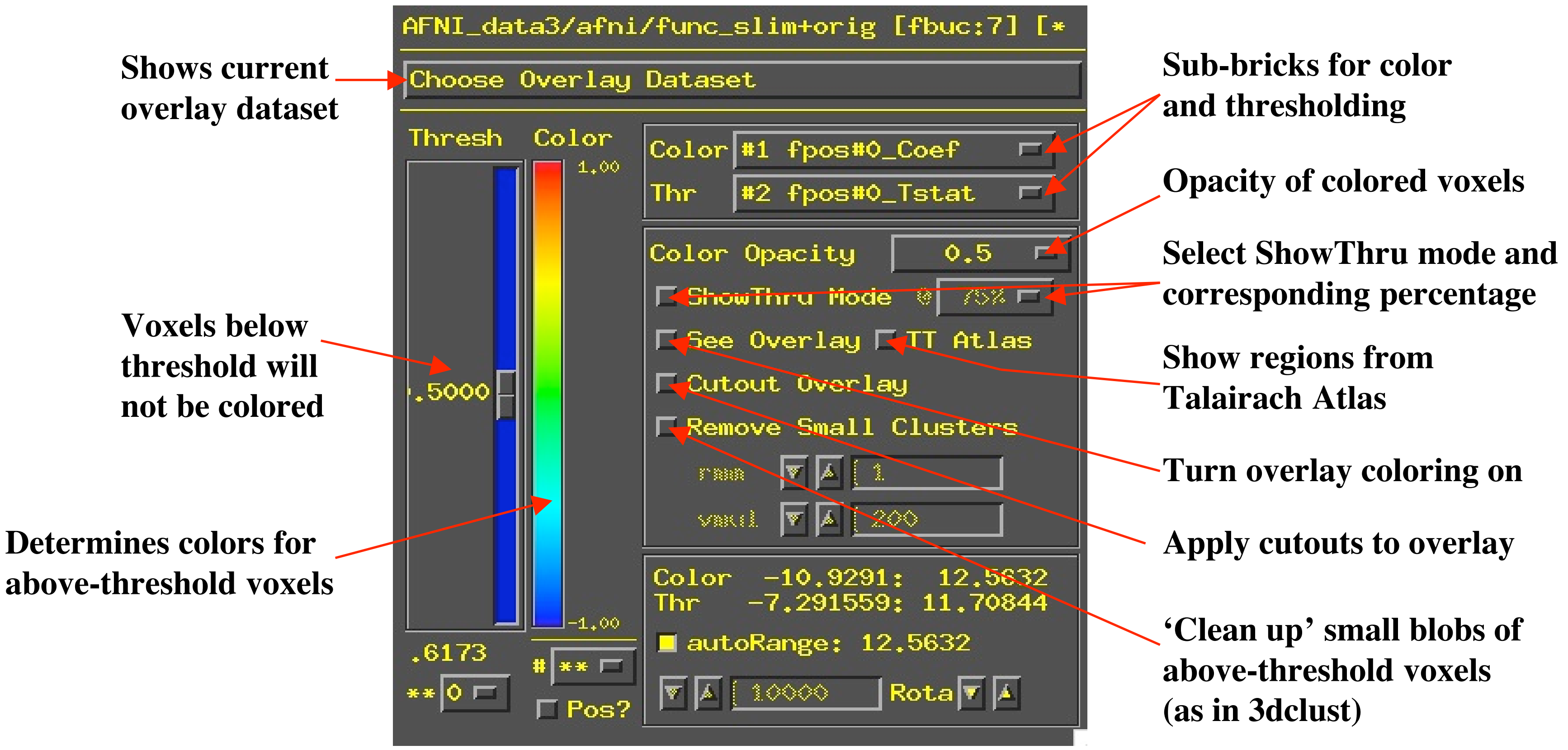
- By using **Automate** and setting the angle (25 above) and/or the offset (20 above) to depend on 't', we can make a sequence of images where the slab rotates downwards and/or moves backwards

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



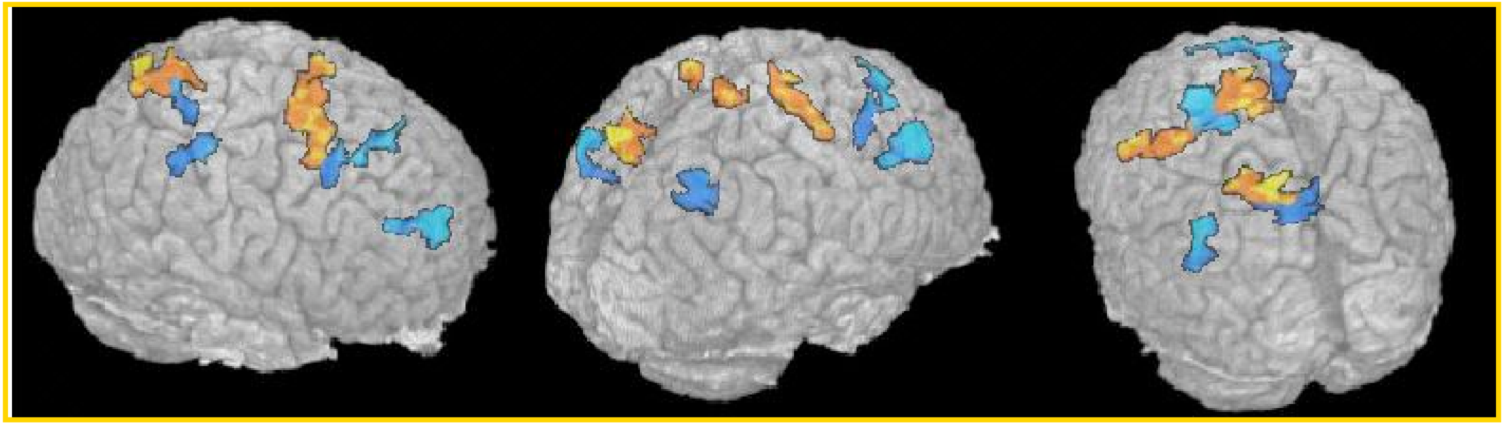
  - ✧ Such boxes can use an expression with the variable ‘t’ when **Automate** is used:
    - ➥ Turn **Automate** on
    - ➥ Enter some small number in the **Frames** control (say 5)
    - ➥ Enter **70+5*t** in the **Roll** control, then press **Compute**
    - ➥ The dataset will be rendered with the variable ‘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^o, 75^o, 80^o, 85^o, 90^o
    - ➥ 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:


AFNI_data3/afni/func_slim+orig [fbuc:7] [*
Choose Overlay Dataset
Thresh
Color
1.00
Color #1 fpos#0_Coef
Thr #2 fpos#0_Tstat
Color Opacity 0.5
ShowThru Mode @ 75%
See Overlay
TT Atlas
Cutout Overlay
Remove Small Clusters
rmm 1
vmul 200
.5000
-1.00
Color -10.9291: 12.5632
Thr -7.291559: 11.70844
autoRange: 12.5632
10000
Rota
.6173
** 0
# **
Pos?
Shows current overlay dataset
Sub-bricks for color and thresholding
Opacity of colored voxels
Select ShowThru mode and corresponding percentage
Show regions from Talairach Atlas
Voxels below threshold will not be colored
Turn overlay coloring on
Determines colors for above-threshold voxels
Apply cutouts to overlay
'Clean up' small blobs of above-threshold voxels (as in 3dclust)

  - ✧ 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)
  - Tow 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 colored 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 useful (but hard to publish)