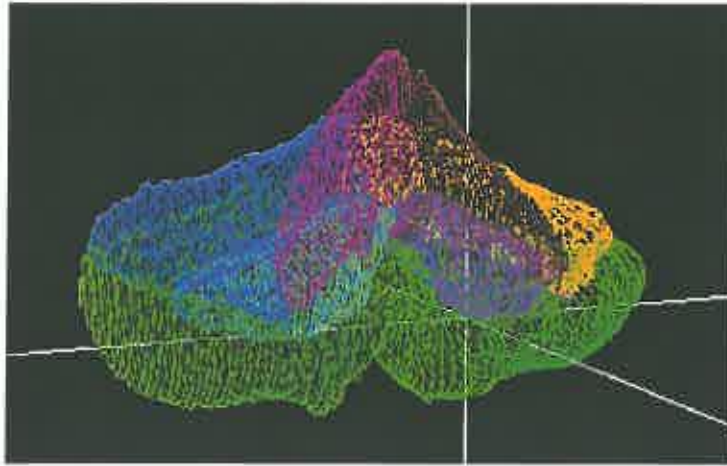


## Cerebellum Tracing Guidelines

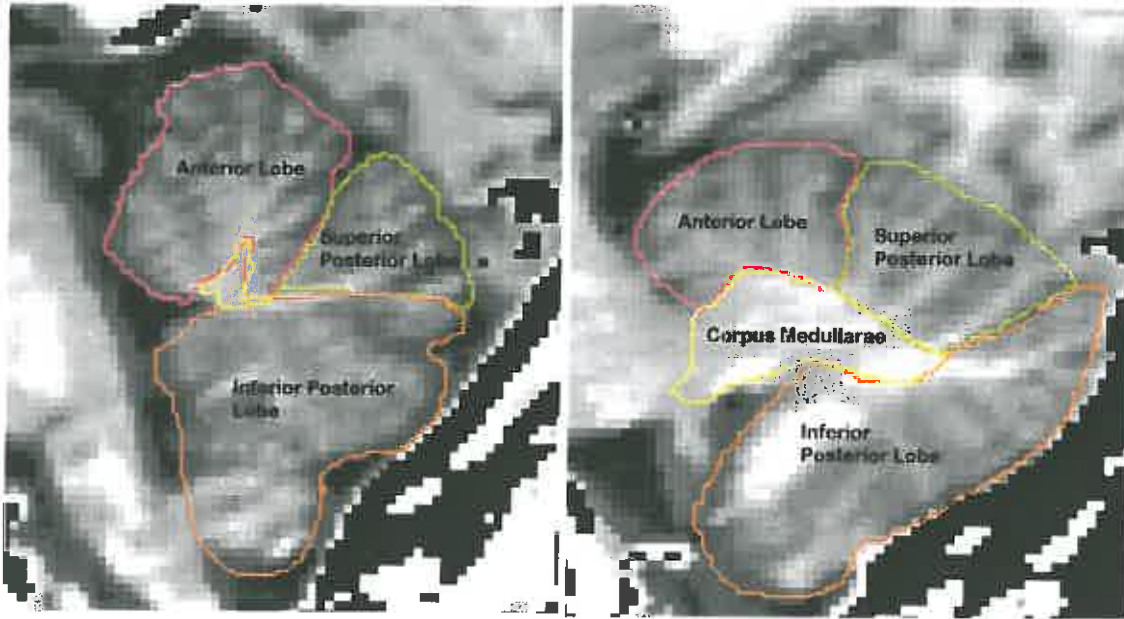


### General discussion:

The cerebellum is traced in eight parts, four on each side. On each side there are 3 major lobes defined, the anterior, superior posterior, and inferior posterior lobes, as well as the corpus medullare, which consists of central white matter and the cerebellar nuclei.

Two sagittal views of the cerebellum are shown below, one on the midline and one 10 millimeters from the midline. The white arrow points to the primary fissure, and the black arrow points to the horizontal fissure. The anterior lobe is defined as being bordered anteriorly by the CSF of the superior cerebellar cistern, superiorly by the tentorium and occipital lobe of the cerebrum, posteriorly by the primary fissure and inferiorly by the corpus medullare. The superior posterior lobe is bounded by the primary fissure, tentorium (or occipital lobe), horizontal fissure and corpus medullare. The inferior posterior lobe consists of the rest of the cortex inferior to the horizontal fissure and corpus medullare, including the flocculus and nodule. The central white matter, not including the branches into the folia, is the corpus medullare.

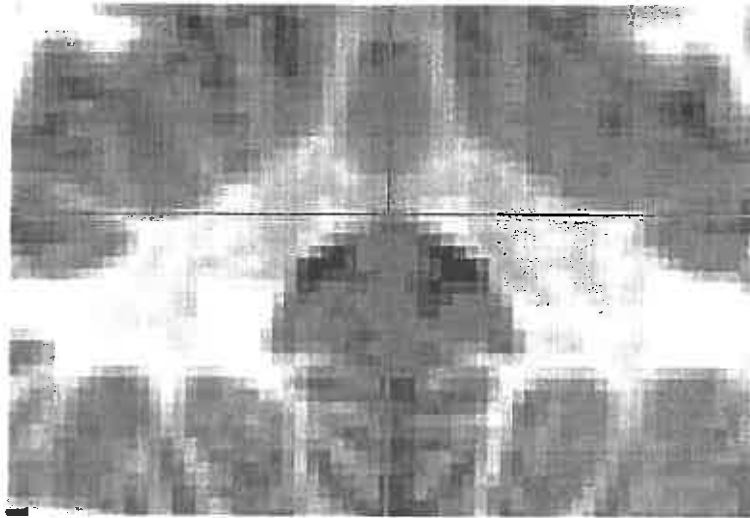
The **Brains2** software is used for this tracing project, and all measured ROI's will be traced in the sagittal plane. Guide traces are made in the axial plane for the brainstem (defining where the peduncles are "cut" from the corpus medullare) and the primary fissure (defining the border between the anterior lobe and superior posterior lobe). Another guide trace is done in the coronal plane to help define the borders of the corpus medullare as well as the horizontal fissure as it extends laterally. Substantial use is made of viewing the intersections of guide traces with the sagittal plane. When an ROI from another plane intersects with the slice in view, its intersection is shown as an X. This can be turned on and off by changing the **Display Properties** in the **Object Selector**.



1. Go to your USER directory under the 10\_ACPC directory of the MRQID that will be traced. Start Brains2 (**brains2** at the command prompt). Load the stereo image in BRAINS2, then make a discrete class image (**b2 convert class image to discrete 0** at the brains2 prompt in the shell).

Both images will be used for identification of boundaries. The stereo image will be used the most, but the discrete image is the most reliable for definition of the grey-CSF border (surface of the cerebellum where it borders on CSF) and grey-white borders (corpus medullare borders). For interfaces that are grey-grey (cerebellum-cerebrum border) or where partial voluming causes misclassification (edge of a white matter structure, such as the peduncles), the stereo image is used for definition of the border.

2. The boundary between the right and left cerebellum is identified prior to beginning tracing. Viewing the sagittal image on slice 127, place the crosshairs on the most posterior point of the 4th ventricle. Viewing the coronal image, notice where the two side of the corpus medullare come together in the midline. The 4th ventricle is an inverted V below the crosshairs, and the superior border of the corpus medullare forms a V above it. The midline is determined by placing the crosshairs at the vertex of these V's.



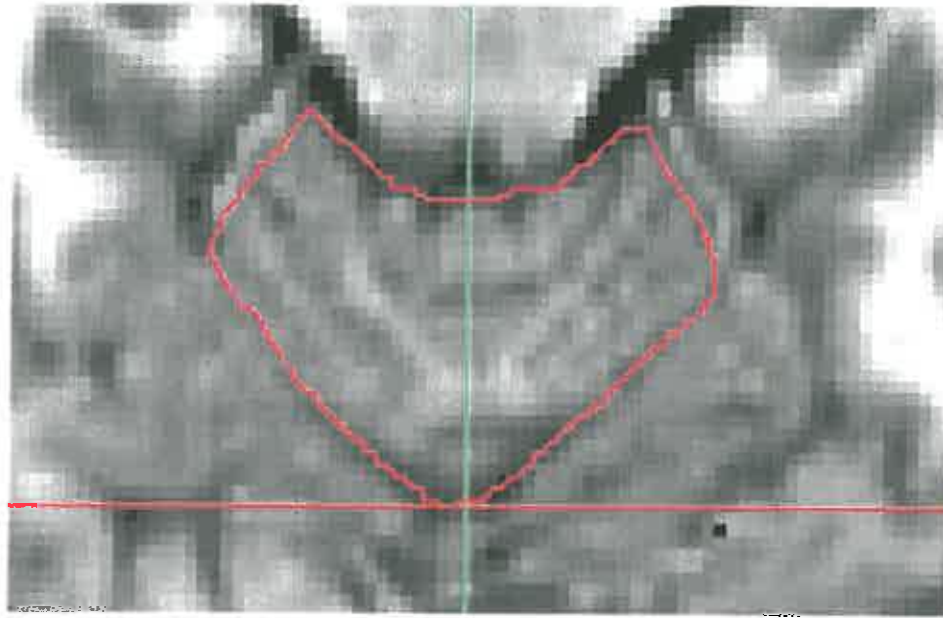
Crosshairs at the vertex of the posterior limit of the 4th ventricle, for determination of midline slice.

Slices are identified as either right or left. As a convention, the midline slice is considered to be part of the right hemisphere and will be traced with the right lobe ROI names.

### Guide traces of primary fissure

Switch the foreground ROI to `primary_rbl`. On the midline sagittal slice locate the primary fissure. Place crosshairs about 1/3 of the way in from edge of cerebellar surface in the primary fissure. Switch to axial view, and note that the crosshairs are in primary fissure. The primary fissure is more difficult to identify in the lateral areas, and it may be useful to look at a variety of levels in the axial plane to insure correct identification. This identification is necessary before beginning tracing, as this defines the border between two lobes. If the identification is difficult, place the crosshairs in what is suspected to be the fissure, and switch to the sagittal view. The fissure should be fairly clear all the way down to the corpus medullare.

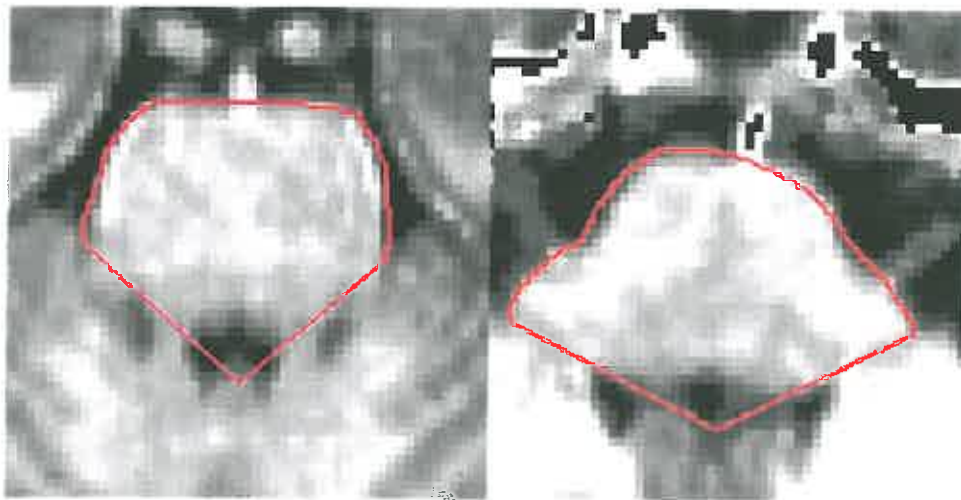
Starting at the midline, trace the primary fissure laterally and anteriorly. At the edge of the cerebellum, angle medially and anteriorly, and trace just medial to the tentorium. Continue tracing on the border of the grey matter, across the midline, then back on other side in a symmetric fashion to close the trace. Repeat this on the next inferior slices (every other or every third slice should be sufficient) until a point is reached where the fissure disappears into the corpus. A representative guide trace is shown in the next figure. Then, with all intersections turned on (in the ROI Display Properties, accessible from the Selector), look in the sagittal plane to see if the X's are in the correct fissure. If the X's are in different fissures, then the definition of the primary fissure has changed from one level to the next, and the guide traces need to be redone to correctly and consistently identify the fissure.



Guide trace in axial plane of the primary fissure.

### Guide traces of the brainstem

Switch the foreground ROI to `brainstem_rbl`. In an axial view of the cerebellum, descend from the top until the superior peduncles are seen to connect to the cerebellum. Place a single point on the midline at the anterior of the vermis grey matter. Next, select a point at the angle where the surface of the cerebellar grey meets the cerebellar peduncle on the lateral side. This places a straight cut across the peduncle. Next trace around the front of the brainstem to the other grey-white junction, and close the trace to the point at the vermis grey. Going to the next inferior slice, continue tracing. Near the inferior border of the cerebellar peduncles the lateral border of the grey recedes and the peduncle begins to naturally separate. Use this separation as the guide for cutting the peduncles.

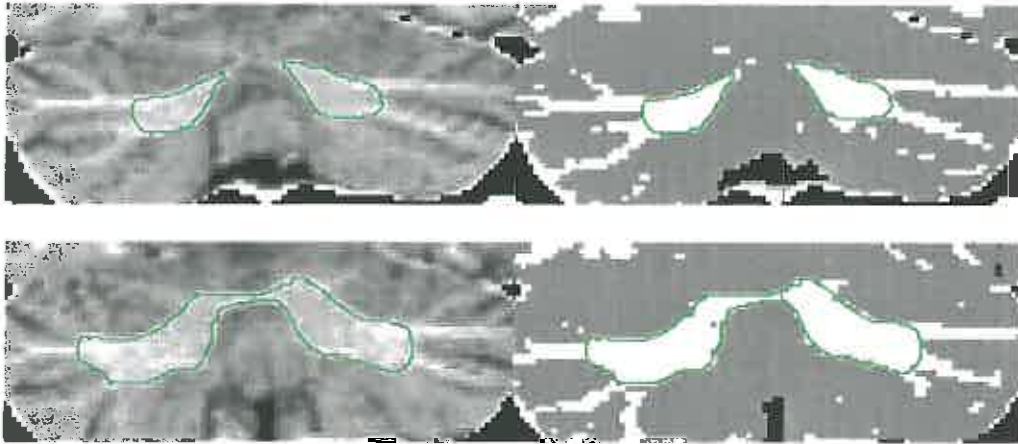


Brainstem traces to be used as guides for corpus medullare.

### Guide traces of the corpus medullare

Change the foreground ROI to `corpusguide_rbl`. In the coronal view near the posterior of the cerebellum step forward until a central white matter structure is seen. Often the corpus begins to come into view where the white matter from two folia join. The central white matter is defined as the corpus. The white matter that is branching off into the folia is defined to be part of the lobes, not the corpus medullare.

Move anteriorly several slices and trace the central white matter (the corpus) on both sides. Tracing is most reliably done with the discrete image, but the stereo image should be referred to several times on each trace to ensure the definition seems reasonable. Some images that are very bright will give an excessively large corpus trace if only the discrete image is used. Skip the next 2 slices, and on the third slice trace the corpus. Repeat this until the corpus begins to disappear on both sides. In many slices there is a bridge between the two sides. Where this is apparent, trace the corpus as one continuous ROI. Use the figure below as a reference for tracing.



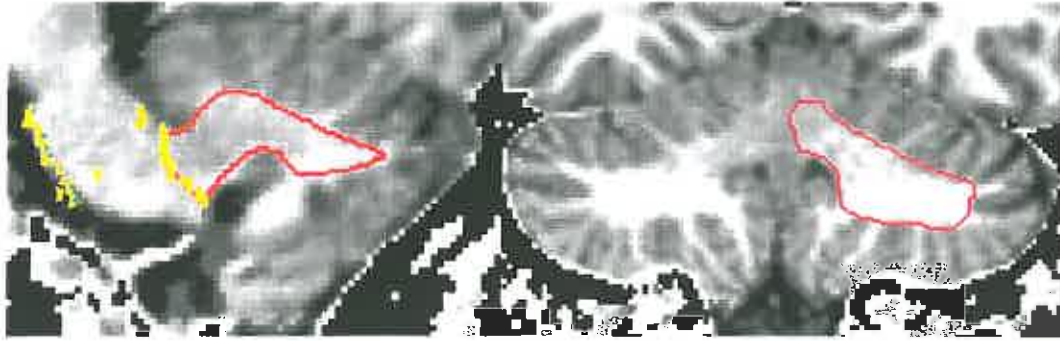
Samples of corpus medullare guide traces on both segmented and discrete images

## Corpus Medullare

When the guide traces are complete, go to the midline sagittal view. Change ROI to `r_corpus_rbl`. Trace the right corpus medullare on the discrete image using the guide traces to assist in cutting off the branches into the folia. The most important places where the branches need to be cut off are where they go into the tonsil, since here the folia are parallel to the field of view and may appear to be a larger white matter structure. The X's will show where they need to be cut.

As you go laterally, the brainstem guide traces are also necessary to cut off the peduncles. At the most lateral end, the white matter will separate into two bands of white matter, which defines where the corpus ends. The X's from the guide traces will also be useful here for the definition of the last slice of corpus medullare. Return to complete the left side.

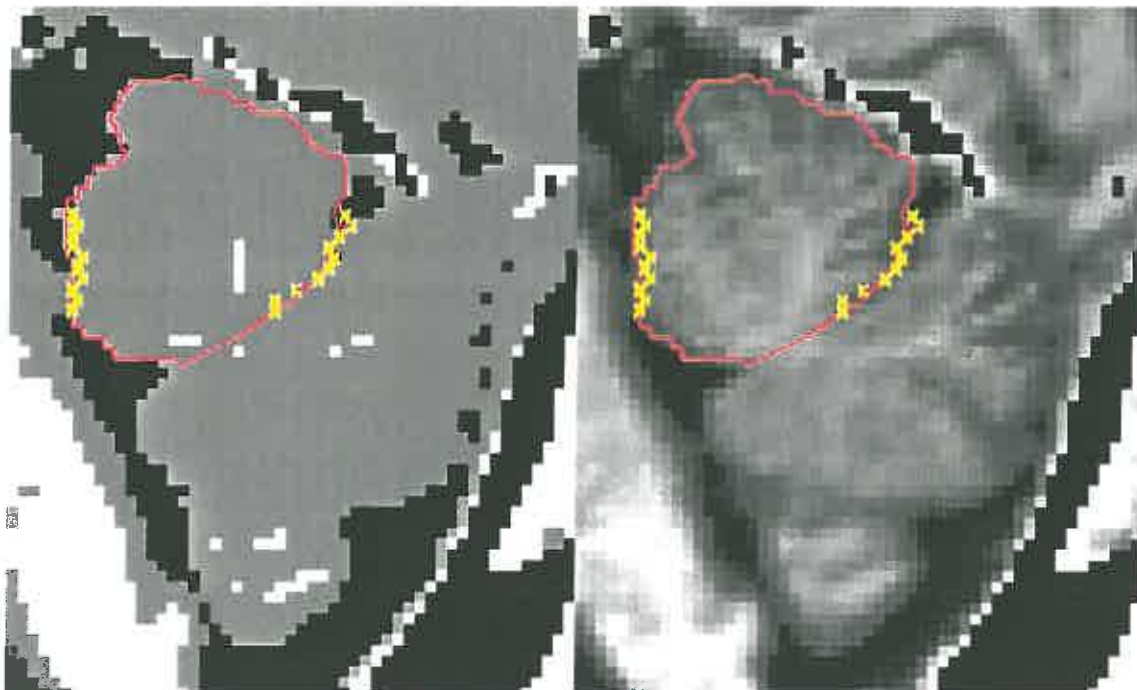




Corpus Medullare with brainstem guide traces (left, sagittal view) and a coronal guide trace showing where branches into folia are cut off (right, coronal view).

### Anterior Cerebellar Lobes

Go to the midline sagittal image. This is defined to be the start of the right lobe. With background traces on, the guide traces from the axial plane will show up as X's in this plane. They are to be used as guides in identification of the primary fissure. The actual traces for the anterior lobe need not follow the X's exactly.



Traces of anterior lobe in sagittal plane, stereo and discrete images.

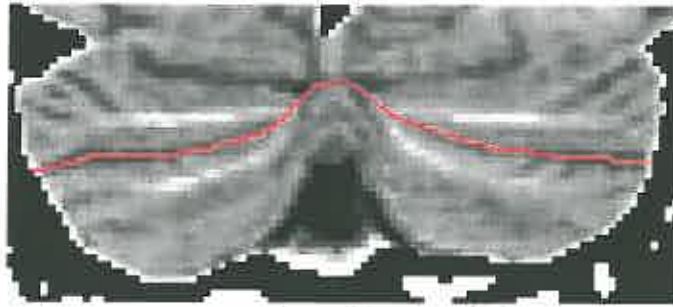
1. Using the stereo image, go to an F3 magnification. Starting at the most posterior tip of the fourth ventricle, trace the anterior lobe. As the trace goes anterior and superior, follow the border between grey matter and CSF. **The discrete image should be referred to for ultimate definition of this border.**
2. The trace should next follow the superior border of the cerebellum posteriorly to the primary fissure, taking care not to stray into the cerebral grey matter above. The stereo image is used for this section. As the trace goes into the primary fissure, the trace should exclude the surface CSF (refer to discrete image).

CSF that is not on the surface is included in the trace, and should be approximately split in half between the anterior lobe and the adjoining structure. As the trace follows the primary fissure it should descend **midway between the white matter centers of the folia** surrounding the fissure, equally dividing the grey matter. Close the trace from the bottom of the fissure to the point of the fourth ventricle.

3. Continue tracing on the next lateral sagittal slice. More laterally, the corpus will be present and needs to be excluded from the trace. The white matter that branches off of the central white matter (corpus medullare) is part of the anterior lobe, however, and needs to be included. It is important to use the X's of the intersecting corpus\_guide traces from the coronal view to determine where the white matter branches off into the folia. Make sure that the trace includes any grey matter anterior to the corpus (anything more than 1-2 pixels) but excludes the superior cerebellar peduncle. Continue tracing each slice to the right. As you reach the lateral border the anterior lobe disappears. Check the T1 image when in doubt for definition of the lateral boundary. Repeat these traces for the left anterior cerebellar lobe.

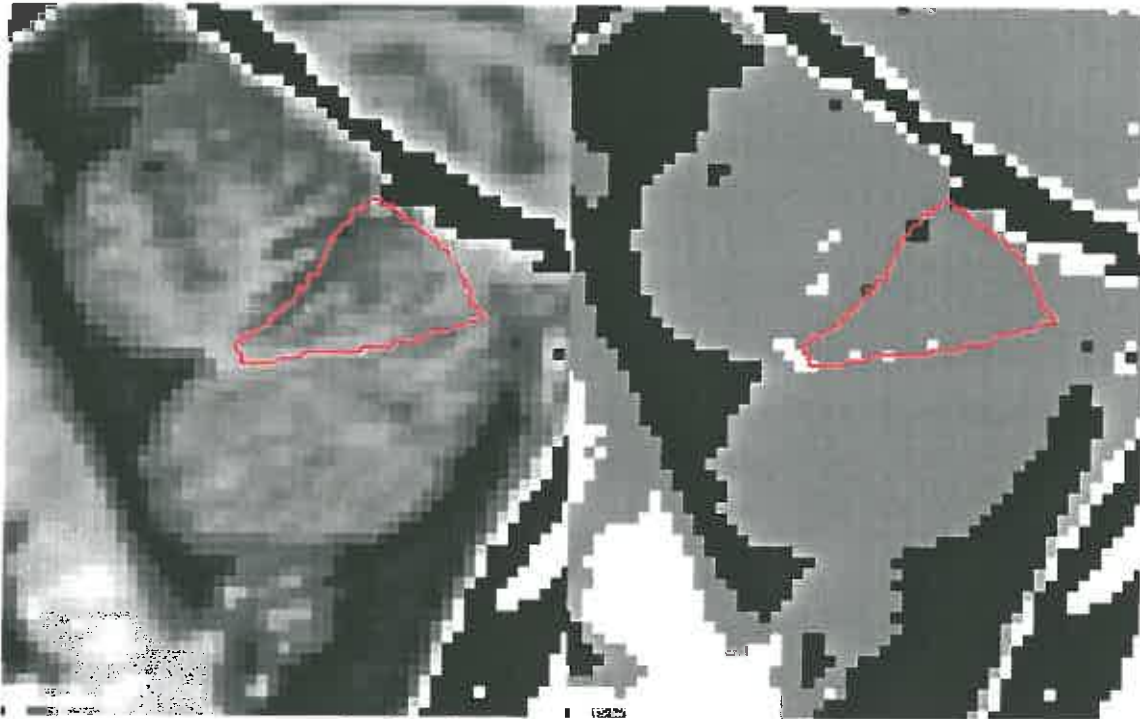
## Superior Posterior Cerebellar Lobes

Three of the boundaries for the superior posterior cerebellar lobes have been defined and used previously. The horizontal fissure is one that has not been defined. On a coronal view the horizontal fissure is quite evident, and it may be useful to refer to this plane when tracing. A guide trace may be used for cases where the fissure is not evident in more lateral areas.



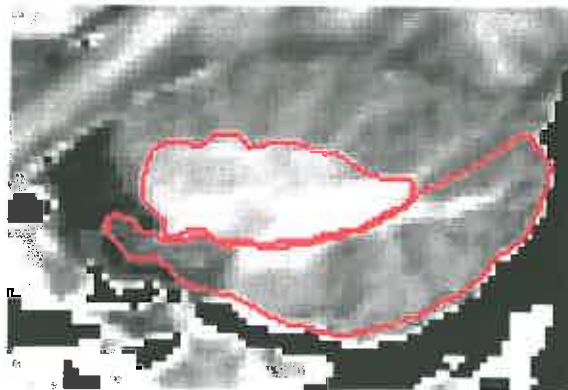
Horizontal fissure in coronal plane.

Start on the midline sagittal slice for the right superior posterior cerebellar lobe. The starting point for the trace of the superior posterior cerebellar lobe depends on whether or not the corpus medullare is present. Often in the midline traces there will be no significant central white matter present. In this case, start tracing at the posterior point of the fourth ventricle. If there is a body of white matter present, begin the trace at the posterior point of the junction of the trace for the anterior lobe and the white matter (that is, at the bottom of the primary fissure). The trace will extend up the primary fissure directly next to the anterior lobe trace until the cerebellar surface is reached. The trace will then go posteriorly and inferiorly along the border between cerebellar grey and the tentorium, CSF or occipital lobe, whichever borders the grey matter. At this point check the T1 and discrete images to assist in defining the border. At the horizontal fissure the trace turns inward and follows the fissure. As in the traces through the primary fissure, the trace should be halfway between the white matter centers of the neighboring folia. At the end of the fissure there will be white matter, which may or may not be part of the corpus. Near the median the white matter will only be a few voxels wide, and the trace should go down the center of it.



Superior posterior lobe in coronal view, stereo and discrete images.

More laterally there will be more white matter, which is part of the corpus medullare. In this case the trace should follow the top border of the corpus medullare. The trace then closes to its starting point. Check the coronal view for assistance in deciding whether the white matter is part of the corpus medullare or a branch going into the folia. Laterally the corpus medullare ends with a division into two branches that belong in the lobes. The most lateral border will show partial-voluming of the CSF and dura, which will appear to be grey matter on the stereo and discrete images. Check the T1 image when in doubt for definition of the lateral boundary. Repeat for the left lobe.



### Inferior Posterior Cerebellar Lobes

Start tracing the right inferior posterior lobe on the midline sagittal slice. Begin the trace at the point where the superior posterior lobe meets the central white matter of the corpus medullare. Follow the trace posteriorly along the horizontal fissure to the surface of the cerebellum. Trace along the border of the cerebellar grey matter, inferiorly and anteriorly, using the T1 and discrete images when needed for determination of the cerebellar surface. Proceed superiorly, including the flocculus in the inferior posterior lobe. The T1 image will be useful for delineation of the border of the flocculus. Follow posteriorly along



the border of the corpus medullare, closing the trace. Repeat these traces for the left inferior posterior lobe.

## Review of Traces

With all of the intersections displayed, view the coronal image to review the ROI's. The X's should appear to be consistent, forming a reasonable border for each of the structures. If there appears to be an outlier, click on that X and review the trace in the sagittal view to determine whether any traces need to be edited.

