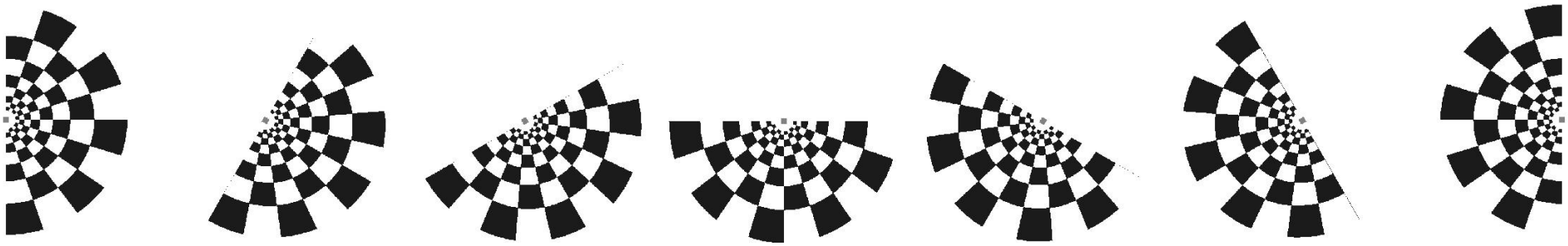
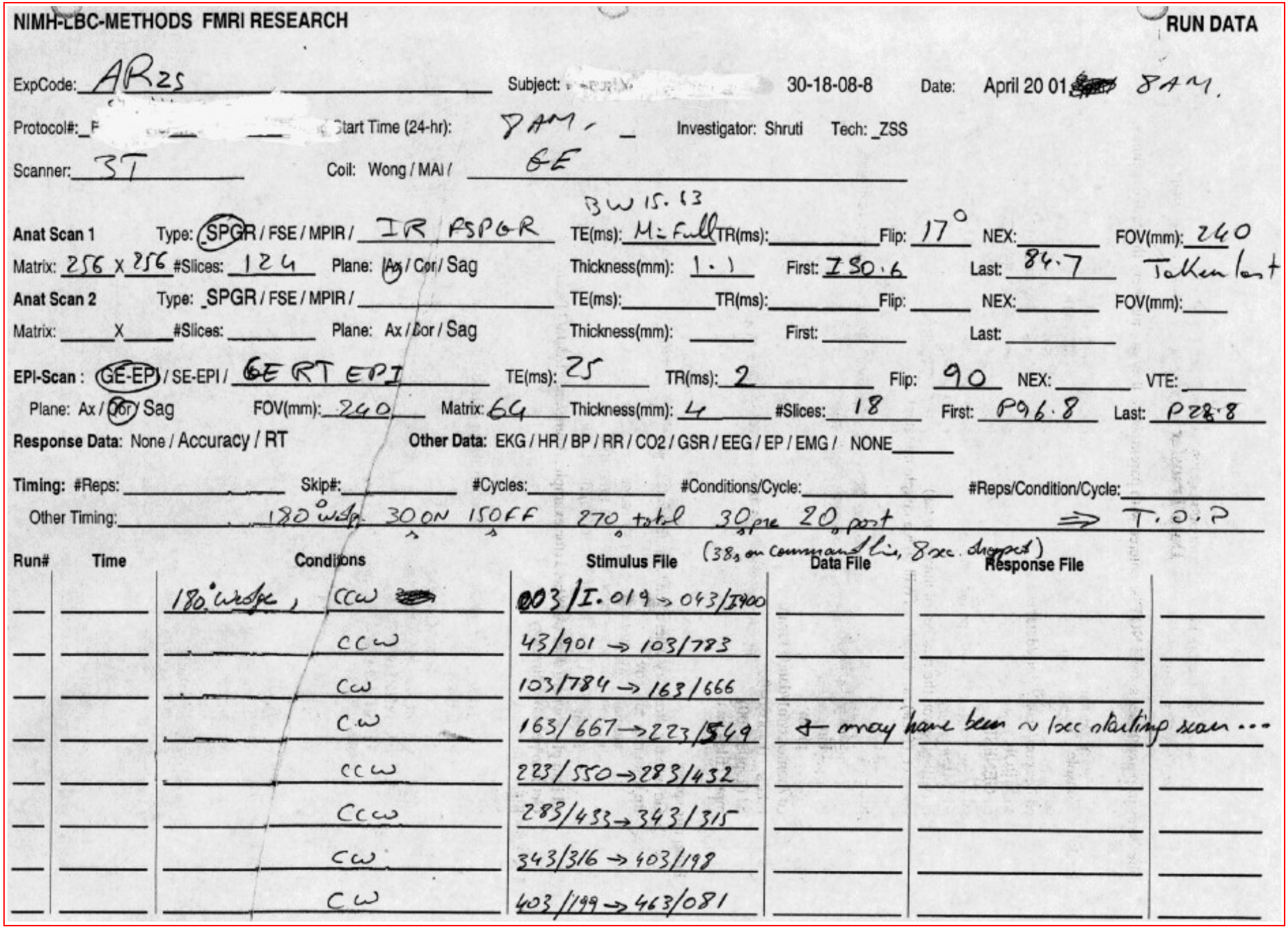
Creating Datasets with Program to3d

- to3d reads image files — each containing 1 or more 2D slices — and assembles them into AFNI datasets
- The collection of all the 2D slice data forms the `.BRIK` file
  — an AFNI dataset must have at least 2 slices!
  — if you have single slice data, you could duplicate the slices
- You must also provide to3d with some auxiliary data (for the `.HEAD` file):
  - ◇ Orientation of the slices in space
  - ◇ Size of the slices or of the voxels
  - ◇ Slice offset — where is the dataset volume located in space?
  - ◇ For 3D+time datasets, also need slice timing information
  - ◇ to3d 'knows' how to get some of this auxiliary information from image file headers for some image file formats:
    — Mayo ANALYZE files (`.hdr`/`.img` pairs) contain voxel size information
    — Siemens `.ima` image arrays contain voxel size and orientation information
  - ◇ Other image formats either don't have such information — or I just don't know how to get it from the image files (yet)

- to3d runs in two modes:
  - ◇ Command line mode: you provide all auxiliary information on command line
    — Useful to get things done fast, and for AFNI experts
  - ◇ Graphical user interface (GUI) mode: you provide auxiliary information by filling out an on-screen form
    — Useful for explaining concepts, and for AFNI neophytes
- Sample #1: data from NIH GE 3 Tesla scanner
  - ◇ Files stored in archive `AFNI_sample_01.tgz`
    — unpack with command `gzip -dc AFNI_sample_01.tgz | tar xf -`
    — unpacks into directory `AFNI_sample_01/`
  - ◇ Anatomical (SPGR) data ⇒ 3D dataset (no time; 1 sub-brick)
    — 124 axial slices in subdirectory `SPGR_anat`
  - ◇ Functional (EPI) time series data ⇒ 3D+time dataset (160 sub-bricks)
    — 2880 images (18 coronal slices, 160 reps) in subdirectory `EPI_run1`
    — Visual stimulation task: rotating hemifield flashing checkerboard



- Experiment log, taken at scanner:



NIMH-LBC-METHODS FMRI RESEARCH — RUN DATA

ExpCode: AR25 Subject: [redacted] 30-18-08-8 Date: April 20 01 8AM.

Protocol#: [redacted] Start Time (24-hr): 9AM. Investigator: Shruti Tech: ZSS

Scanner: 3T Coil: Wong / MAI / GE

Anat Scan 1 Type: SPGR / FSE / MPIR / IR FSPGR BW 15.63 TE(ms): M:full TR(ms): Flip: 17° NEX: FOV(mm): 240
Matrix: 256 X 256 #Slices: 124 Plane: Ax / Cor / Sag Thickness(mm): 1.1 First: 150.6 Last: 84.7 Taken last

Anat Scan 2 Type: SPGR / FSE / MPIR / TE(ms): TR(ms): Flip: NEX: FOV(mm):
Matrix: X #Slices: Plane: Ax / Cor / Sag Thickness(mm): First: Last:

EPI-Scan : GE-EPI / SE-EPI / GE RT EPI TE(ms): 25 TR(ms): 2 Flip: 90 NEX: VTE:
Plane: Ax / Cor / Sag FOV(mm): 240 Matrix: 64 Thickness(mm): 4 #Slices: 18 First: P96.8 Last: P28.8

Response Data: None / Accuracy / RT **Other Data:** EKG / HR / BP / RR / CO2 / GSR / EEG / EP / EMG / NONE

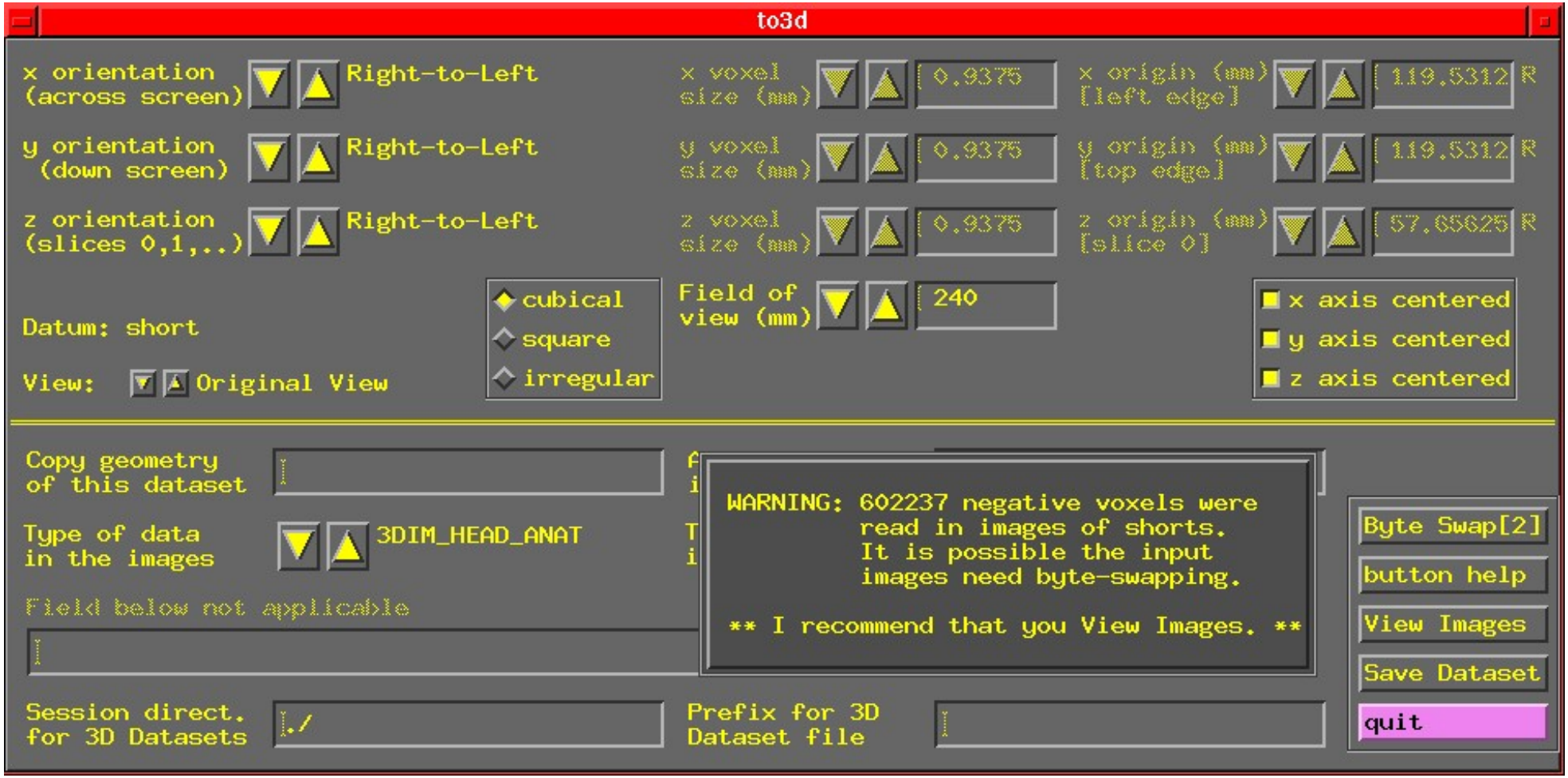
Timing: #Reps: Skip#: #Cycles: #Conditions/Cycle: #Reps/Condition/Cycle:

Other Timing: 180° wedge 30 ON 15 OFF 270° total 30 pre 20 post ⇒ T.O.P

(38s on command line, 8xc. dropped)

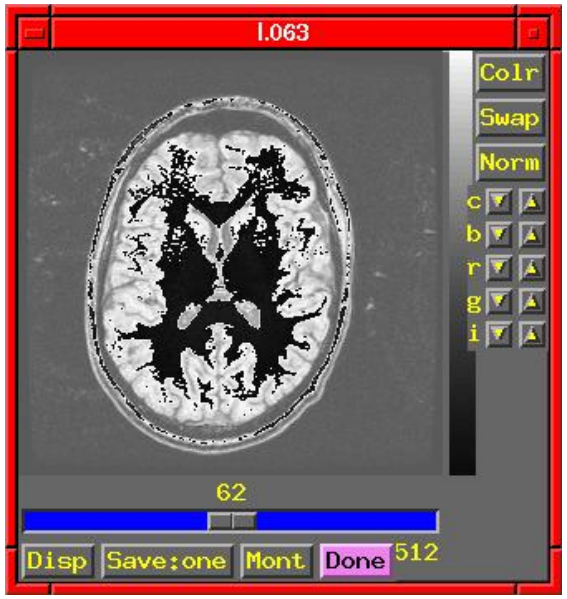
Run#	Time	Conditions	Stimulus File	Data File	Response File	
		180° wedge, CCW	003/I.019 → 043/I900			
		CCW	43/901 → 103/783			
		CW	103/784 → 163/666			
		CW	163/667 → 223/549	+ array have been ~ 1xc starting scan ...		
		CCW	223/550 → 283/432			
		CCW	283/433 → 343/315			
		CW	343/316 → 403/198			
		CW	403/199 → 463/081			

- Using to3d to assemble the SPGR dataset [this is run on a Linux machine]:
  - ◇ `cd AFNI_sample_01/SGPR_anat` — change directory, to get at images
  - ◇ `ls` — to see what files are there (should see files `I.001` ...`I.124`)
  - ◇ `to3d I.*` — run to3d, reading in all the image files — GUI pops up:

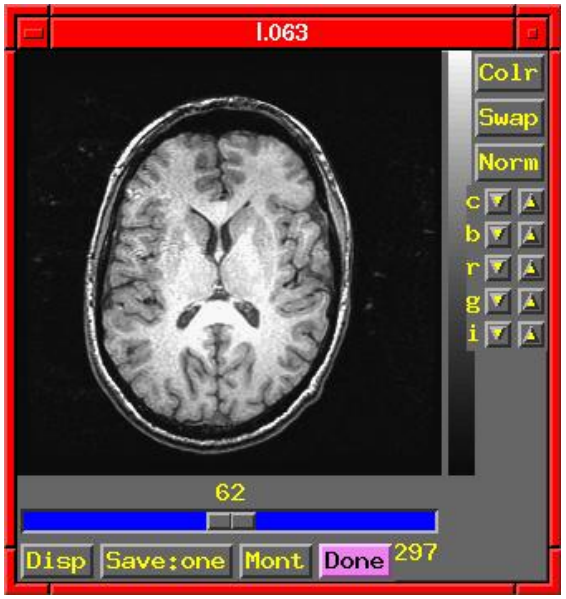


↪ N.B.: Warning about negative voxels appears for Linux/Intel computers, but not on Suns or SGIs

◇ To check images, click the `View Images` button in the to3d form:



[On Linux/Intel computers]



[On Sun or SGI computers]

◇ On Linux/Intel computers: the peculiar appearance of the image shows that something is wrong:

↪ MR images from scanners are stored as shorts: 2 bytes per number

↪ Like a 2 digit decimal number: "93" means "$9 \times 10 + 3$"

— By universal custom, we write the "9" first

— Could also write the same number as "39" (if we had a different custom)

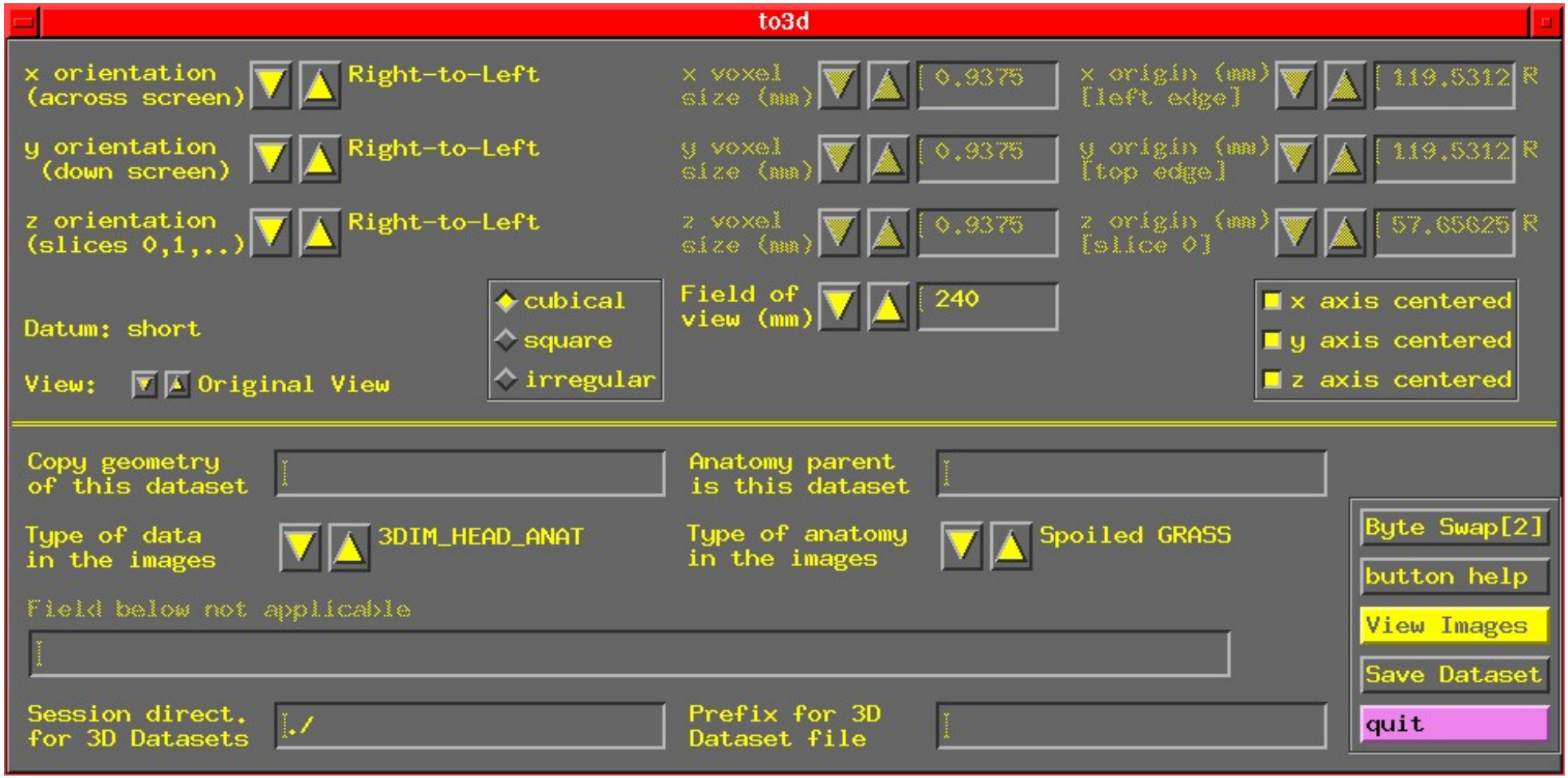
↪ Customs for computers are not so universal

— Sun and SGI systems store 2 byte numbers in reverse order from Intel

— Result is that numbers are mangled (and some show up as negative)

— Solution: press to3d's `Byte Swap[2]` button, and images are fixed!

Same to3d control panel (without the negative voxel warning):

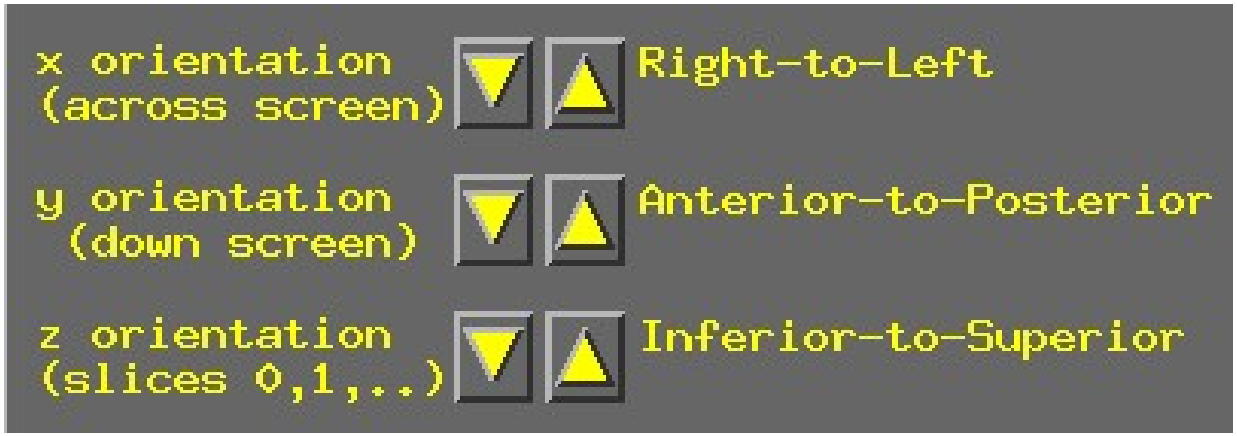


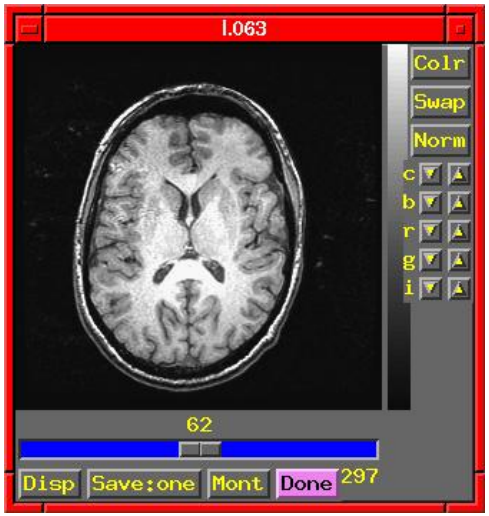
◇ Above the double line: must fill out 3 types of geometry information:

↪ Left column: orientation of the dataset axes

↪ Middle column: size of the dataset images or voxels

↪ Right column: offset of the first slice





◇ Screen shot above shows correct orientation for this dataset

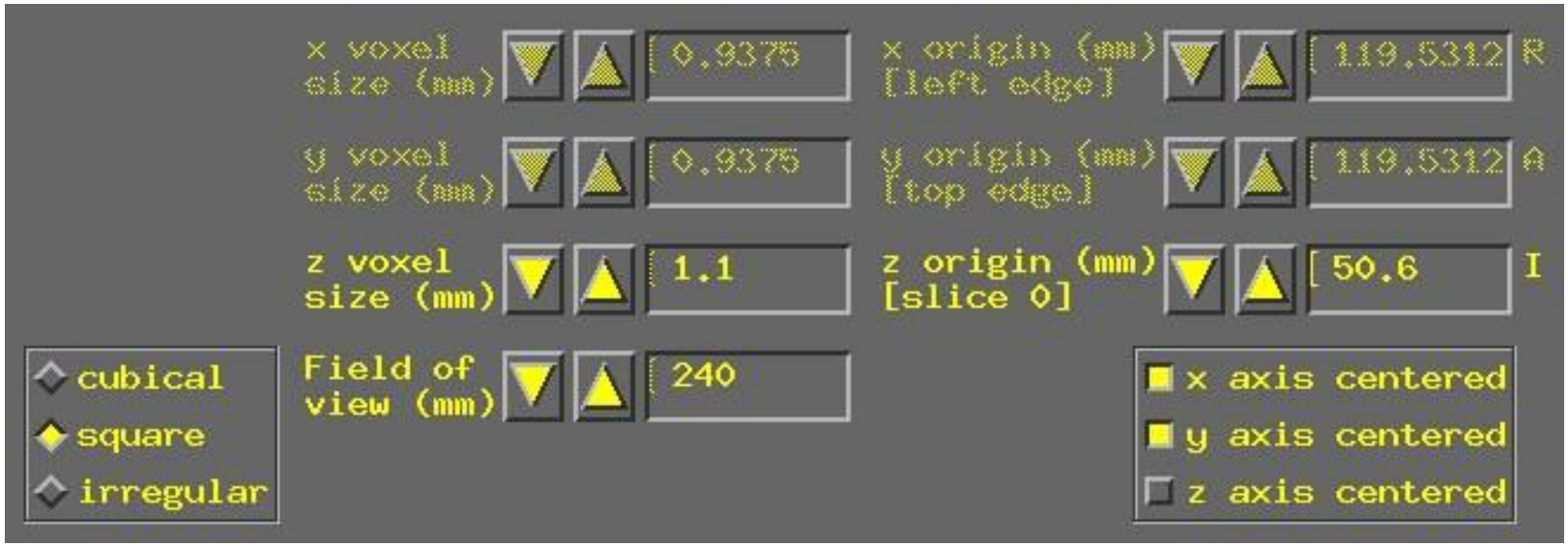
↪ Use the image viewing window to judge how images are laid out

↪ Click the arrows to scroll through the 6 possible options for each orientation to set the correct values

↪ "x orientation" of dataset is across the screen (left to right)
— item Must know subject's right from left

↪ "y orientation" of dataset is down the screen

↪ "z orientation" of dataset is in increasing slice index order
— determine this by using the slider at the bottom of image window



◇ To set dataset geometrical size/location, experiment log sheet is essential

◇ Screen shot above shows setting slice thickness to 1.1 mm

↪ Default Field of view (FOV) of 240 mm is correct for these images

↪ Default voxel geometry of "cubical" is incorrect

↪ Must set geometry to "square" (x size = y size, z size varies)

↪ Then set "z voxel size" to correct value (by typing in box)

◇ Screen shot shows setting location of center of first slice to 50.6 mm in Inferior (I) direction

↪ Default is that slices are centered in the magnet

↪ Probably not the case in the z direction

↪ Click "z axis centered" off

↪ Enter offset (here, 50.6 mm) into the "z origin" box

◇ Final required steps:

↪ Enter prefix for new dataset into "Prefix" text box at lower right of to3d control window
— Choosing a good prefix is important for keeping datasets organized

↪ Press "Save Dataset" button

↪ Press "quit" (twice) to exit to3d

↪ The new dataset files should show up when you use command `ls`

↪ You might want to move them to some other directory
— `mv *+orig.* ../afni` to move datasets to directory named `afni`, one level above
— this directory was created when you unpacked `AFNI_sample_01.tgz`; it contains pre-made AFNI datasets from EPI and SPGR images

◇ Other image sources (besides GE reconstruction):

↪ Mayo ANALYZE files (`.hdr`/`.img` pairs) contain voxel size information (orientation information not always reliable)

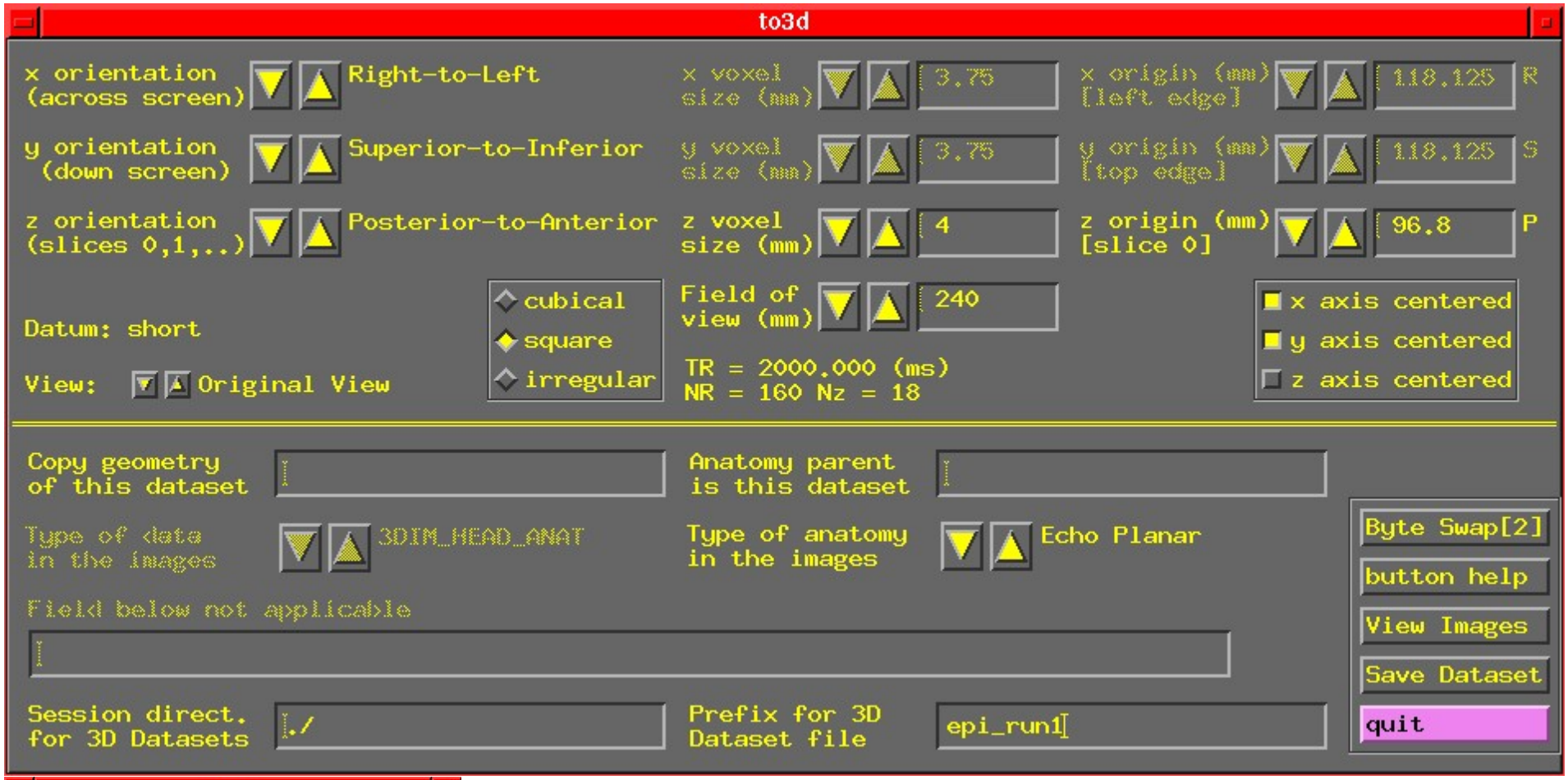
↪ Siemens `.ima` image arrays contain voxel size and orientation information

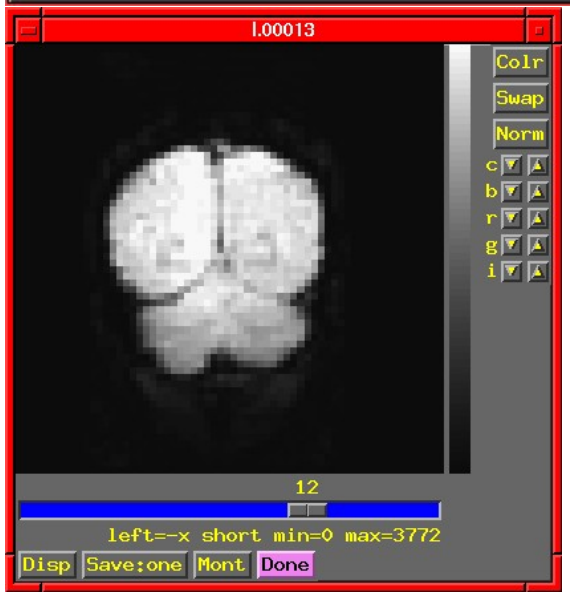
↪ Some day I may learn how to read such information from GE image headers!

↪ Can also assemble datasets of bytes and floats

↪ If all else fails when reading an image, see AFNI FAQ #66

- Using to3d to assemble the EPI dataset
  - ◇ `cd ../EPI_run1` — change directory, to get at images
  - ◇ `ls` — to see what files are there (should see files `I.00001 ... I.02880`)
  - ◇ We do not just do `to3d I.*` to create a 3D+time dataset
  - ◇ For hysterical historical reasons, the time-axis information must be given on the to3d command line
    — Cannot be modified from GUI
  - ◇ `to3d -time:zt 18 160 2000 alt+z I.*`
  - ◇ `-time:zt` means slices will be presented in order of space (z) then time (t)
    — This is the usual way slices are ordered, but -time:tz is needed at some sites
    — If in doubt, do `to3d I.*`, use viewer to look at slices and see their order
  - ◇ `18 160` means that there will be 18 slices in z, 160 in t (2880 total)
  - ◇ `2000` means that the TR for volume acquisition was 2000 ms
    — Could also do 2s to specify that TR is in seconds
  - ◇ `alt+z` means that the slices are gathered in alternating order in the +z direction
    — Most EPI acquisitions are really 2D multislice, spread out through time
    — AFNI header contains information about slice timing offsets
    — Other possible modes: `zero` (for 3D), `@filename` (to specify each slice)





- ◇ Fields in GUI screenshot above are already filled out
  — Coronal slices; will work with SPGR axials in AFNI
- ◇ Note slice thickness and slice offset ("z origin")
  — Taken from experiment log
- ◇ Time information is displayed, but not editable
- ◇ Have set "Type of anatomy" to "Echo Planar"
  — Just acts as a reminder to user (not used elsewhere)

- Geometry parent lets you copy the geometry data from a pre-existing dataset and apply it to the dataset now under construction
  - ◇ Enter name of pre-existing dataset into the "Copy geometry of this dataset" field
    - ↪ If in another directory, must include that in filename
  - ◇ When you press 'Enter' or move the cursor from the text-entry field, to3d tries to read geometry parent dataset header
  - ◇ If geometry parent has same spatial dimensions as current dataset, all geometry fields will be filled out
    - ↪ Does not affect the time fields, which must still be set using `-time:zt` or `-time:tz` on the command line
  - ◇ Geometry parent very useful when constructing EPI datasets from a single scanning session

- Using to3d in command line mode
  - ◇ You can specify all needed inputs to to3d using command line options
    - ↪ For a full list of options, type `to3d -help`
  - ◇ If enough information is present on command line to define a dataset, then the GUI will not be opened, and the dataset will be written to disk
    - ↪ If the command line is incomplete, then the GUI will be opened

◇ For the SPGR dataset example:

```
to3d -xFOV 120R-L -yFOV 120A-P -zSLAB 50.6I-84.7S
     -prefix anat -2swap -spgr I.*
```

(this is all on one command line)

↪ `-xFOV 120R-L` says that the x axis of the images runs from 120 mm Right to 120 mm Left

↪ `-yFOV 120A-P` says that the y axis of the images runs from 120 mm Anterior to 120 mm Posterior

↪ `-zSLAB 50.6I-84.7S` says that the z axis of the slices runs from 50.6 mm Inferior to 84.7 mm Superior

- ▷ FOV means the distances apply from edge-to-edge of the images in that direction (x and y, in most cases)
- ▷ SLAB means that the distances apply to the centers of the outermost voxels (z=slice direction, in most cases)

↪ `-prefix anat` gives the prefix for output dataset filenames (in this case, `anat+orig.HEAD` and `anat+orig.BRIK`)

↪ `-2swap` means to byte-swap the images while reading them

↪ `-spgr` means to label this data as being of SPGR type

↪ `I.*`, as before, means to read the images from the files whose names start with the string "I." and end with anything ("*" is a wildcard)

◇ For the EPI dataset example:

```
to3d -xFOV 120R-L -yFOV 120S-I -zSLAB 96.8P-28.8P
  -time:zt 18 160 2000 alt+z -prefix epirun1 -2swap -epan I.*
```

(this is all on one command line)

↪ Options (with their arguments) can appear in any order

↪ Input image filenames always appear last

◇ Once you get used to it, the command line usage for to3d is more useful than the GUI

↪ Usually need to create many datasets at once

↪ Can put commands in a script file and execute them

↪ Then edit that file to change a few things, and run it again

↪ Just create the file with your favorite Unix text editor (emacs, nedit, vi?), typing each command on a separate line

▷ Long commands can be split across multiple lines by ending all but the last line with the "\" character

▷ There must not be a blank after the "\"!!!

↪ You can execute a script file by typing a command like `source filename` which just means to read commands from "`filename`"

↪ As time goes on, you build up a set of scripts that automate various tasks for you, and ensure you do things the same way each time