

Instant Analyses in **AFNI** and **SUMA**: Clusters and Correlations

Data for this presentation:
AFNI_data5/ directory

All data herein
from Alex Martin,
et al. [NIMH IRP]

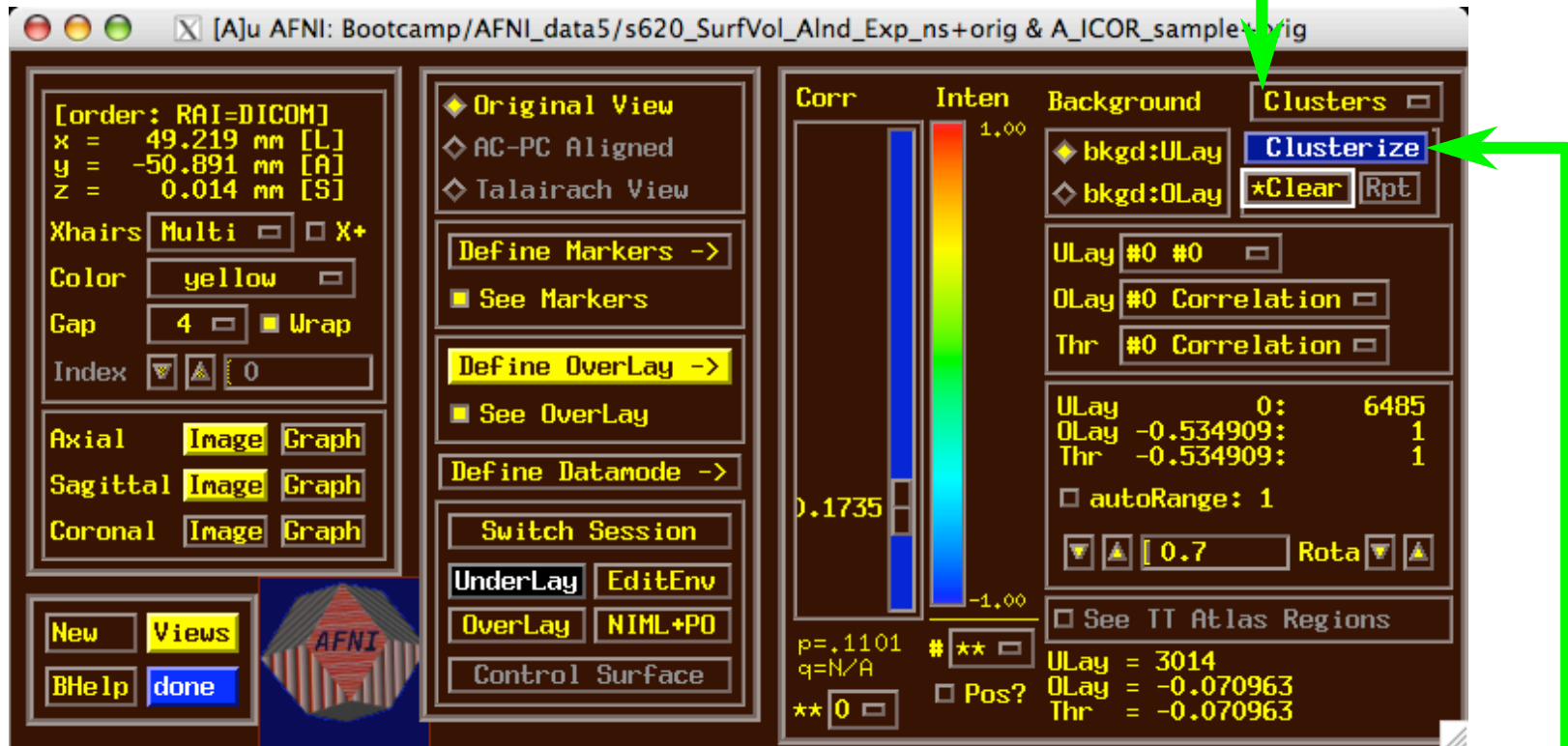


“Insta” Functions

- 3 new capabilities added to the interactive AFNI
- Each one: compute new dataset volumes **inst**antly to replace the Overlay volume for image viewing
- **Clusters** = interactive clustering
 - remove clusters below a user-chosen size
 - display a table of clusters
- **InstaCorr** = interactive exploration of inter-voxel time series correlation
 - choose a seed voxel and see correlation map
 - SUMA version also exists
- **InstaCalc** = interactive version of **3dcalc**
 - e.g., display ratio of 2 datasets

AFNI! Clusters: Setup

- Open **Define Overlay**, choose **Clusters** from menu in top right corner



- Then press **Clusterize** to get the clusters control menu

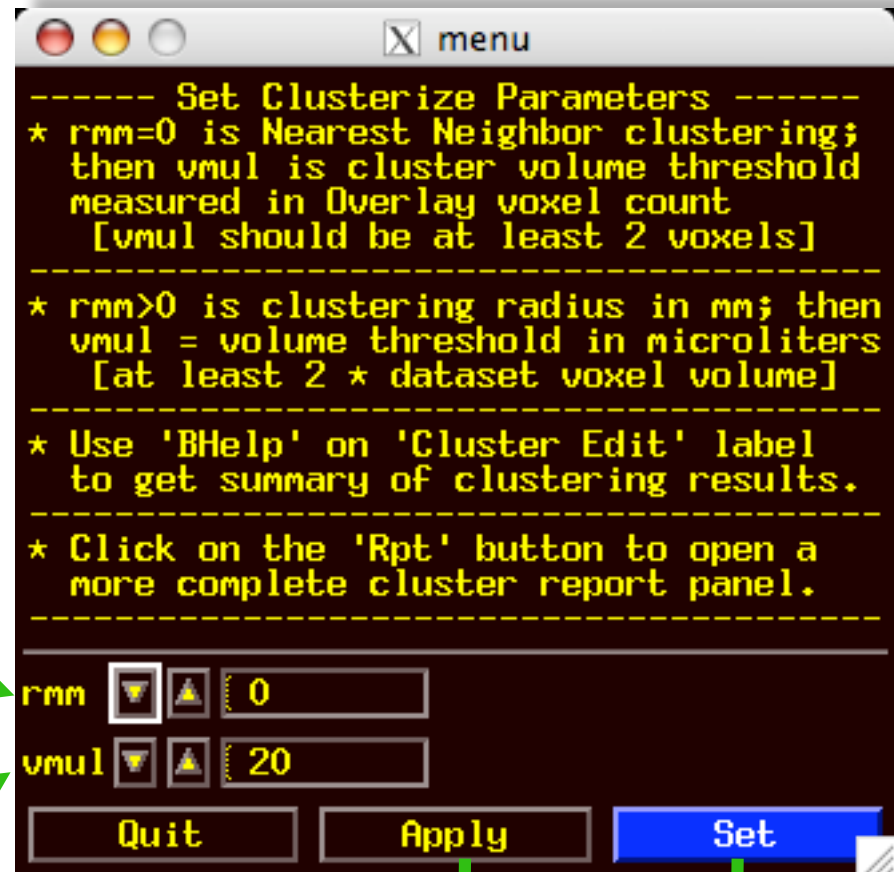
Clusters Control Menu

Operates on user's chosen **Overlay** dataset at the user's threshold;
Next slide example: **AFNI_ICOR_sample**

Default: NN clustering

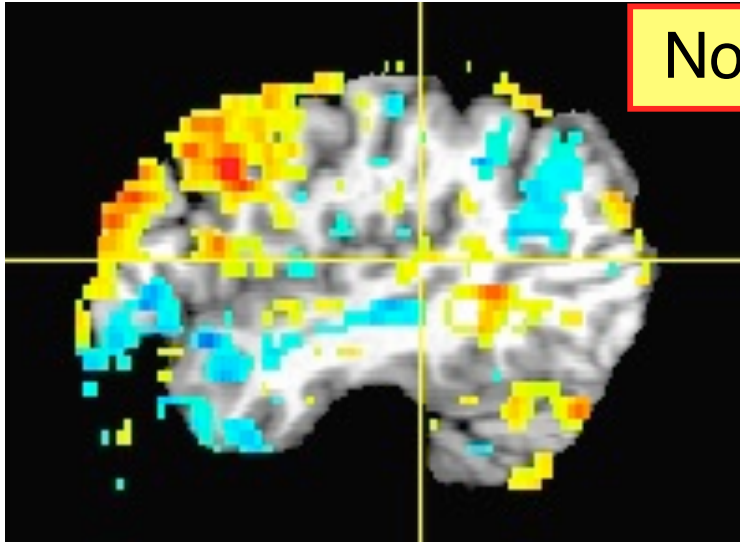
Default: 20 voxel minimum cluster size

Clustering is done in 3D

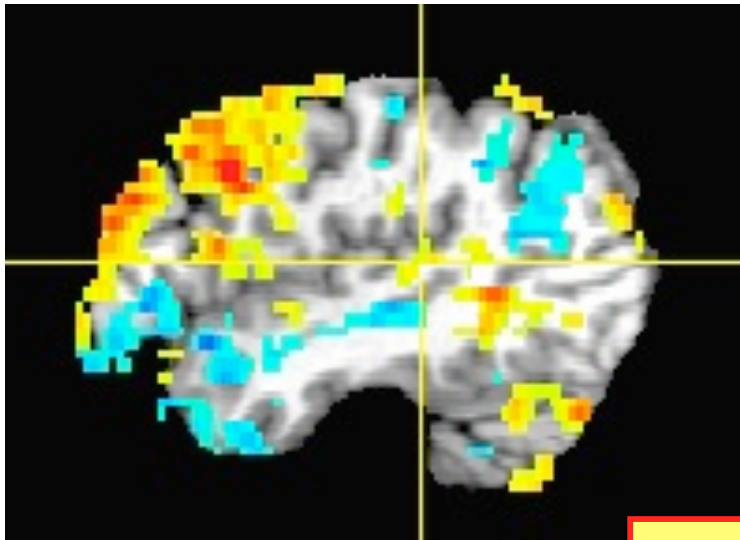


Press one of these buttons to create clusterized volume for display as new **Overlay**

Clusters Results



No clustering



With clustering

Cluster report window

Voxels survived clustering = 83470
Voxels edited out = 1759
Min cluster size (voxels) = 20
Max cluster size = 75881
Number of clusters kept = 53

#39 | xyz | Peak | 3dc lust | SaveTable | Clust | SaveMask | Done

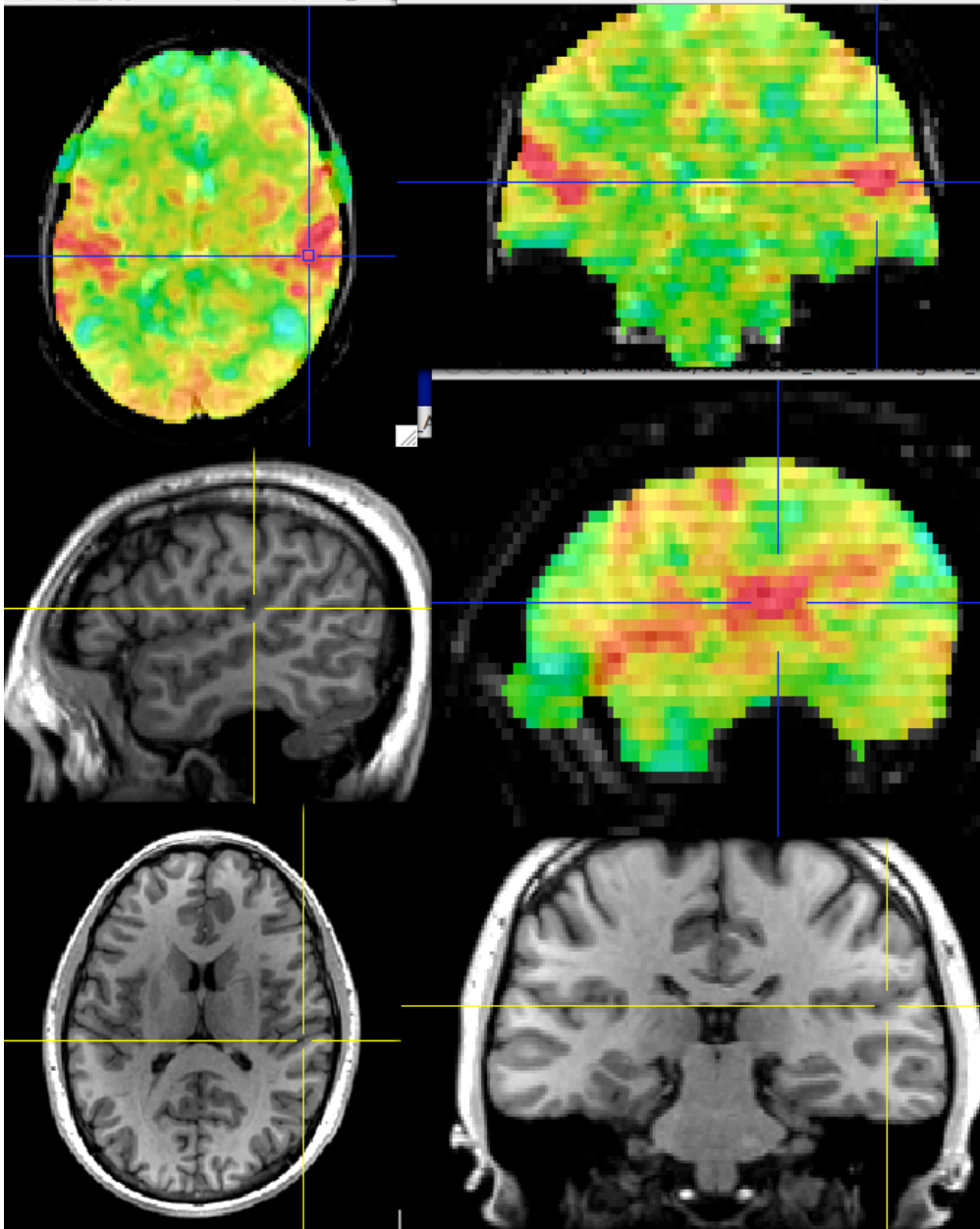
Aux Dataset From To Mean

[No Auxiliary Dataset selected yet]

1:	75881 vox	-41.0	-81.6	+29.7	Jump	Flash	Plot	Save
2:	1223 vox	+38.1	-16.2	+56.7	Jump	Flash	Plot	Save
3:	1148 vox	-66.8	-71.2	+17.7	Jump	Flash	Plot	Save
4:	781 vox	+43.2	+19.9	+32.7	Jump	Flash	Plot	Save
5:	571 vox	+31.2	-57.5	+50.7	Jump	Flash	Plot	Save
6:	549 vox	+50.1	+9.5	+11.7	Jump	Flash	Plot	Save

Jump: crosshairs move
Flash: colors on & off

AFNI! InstaCorr



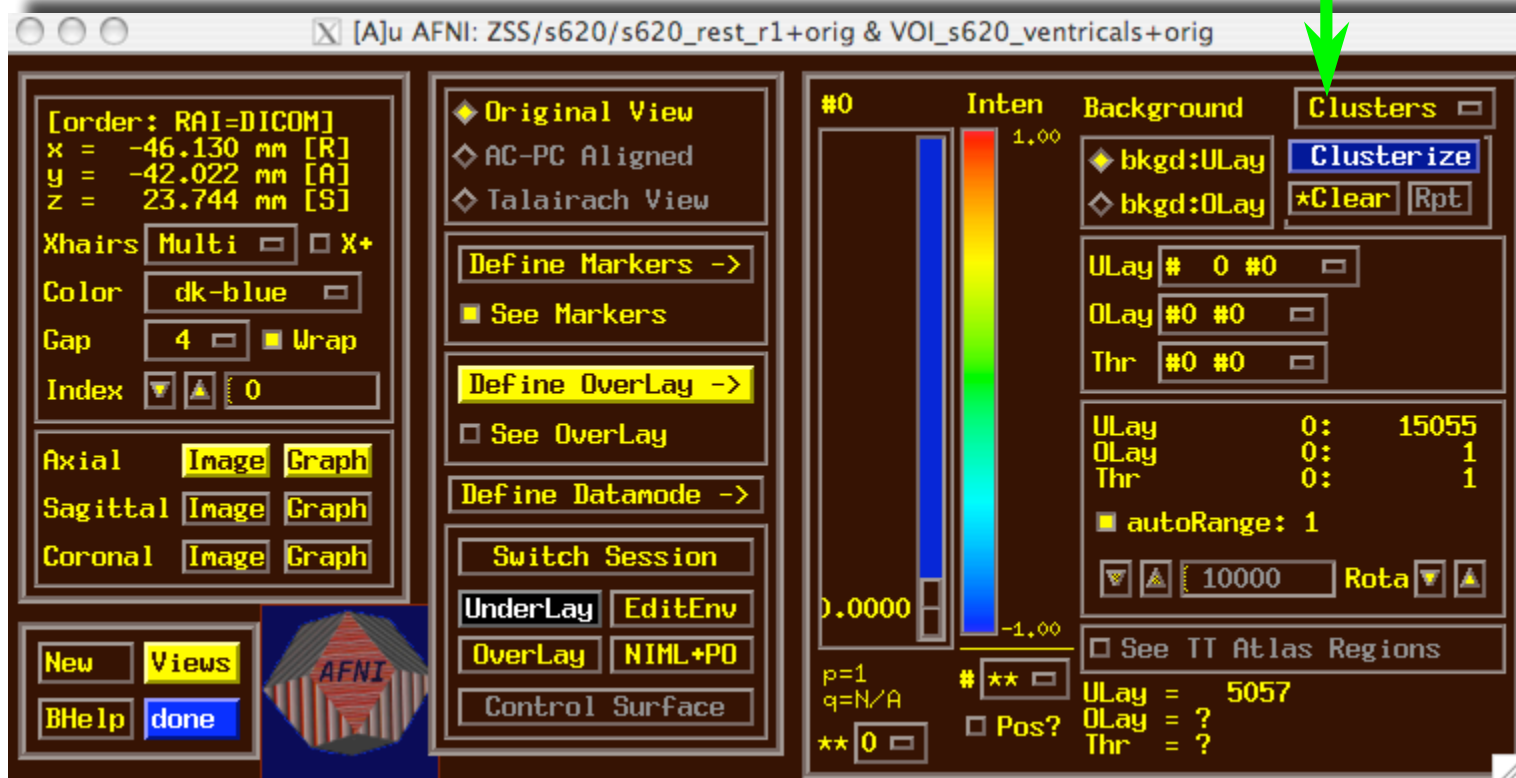
- On-the-fly instantaneous correlation map of resting state data with interactively selected seed voxel
- **Setup phase:** prepares data for correlations (several-to-10+ seconds)
- **Correlation phase:** you select seed voxel, correlation map appears by *magic*

InstaCorr: Outline of 2 Phases

- **Setup phase:**
 - Masking: user-selected *or* Automask
 - Bandpass and other filtering of voxel time series
 - Blurring inside mask = the slowest part
- **Correlation phase:**
 - Correlate selected seed voxel time series with all other prepared voxel time series
 - Make new dataset, if needed, to store results
 - Save seed time series for graphing
 - Redisplay color overlay
 - Optional: compute FDR curve for correlations
 - Calculation is slow, so FDR is not turned on by default

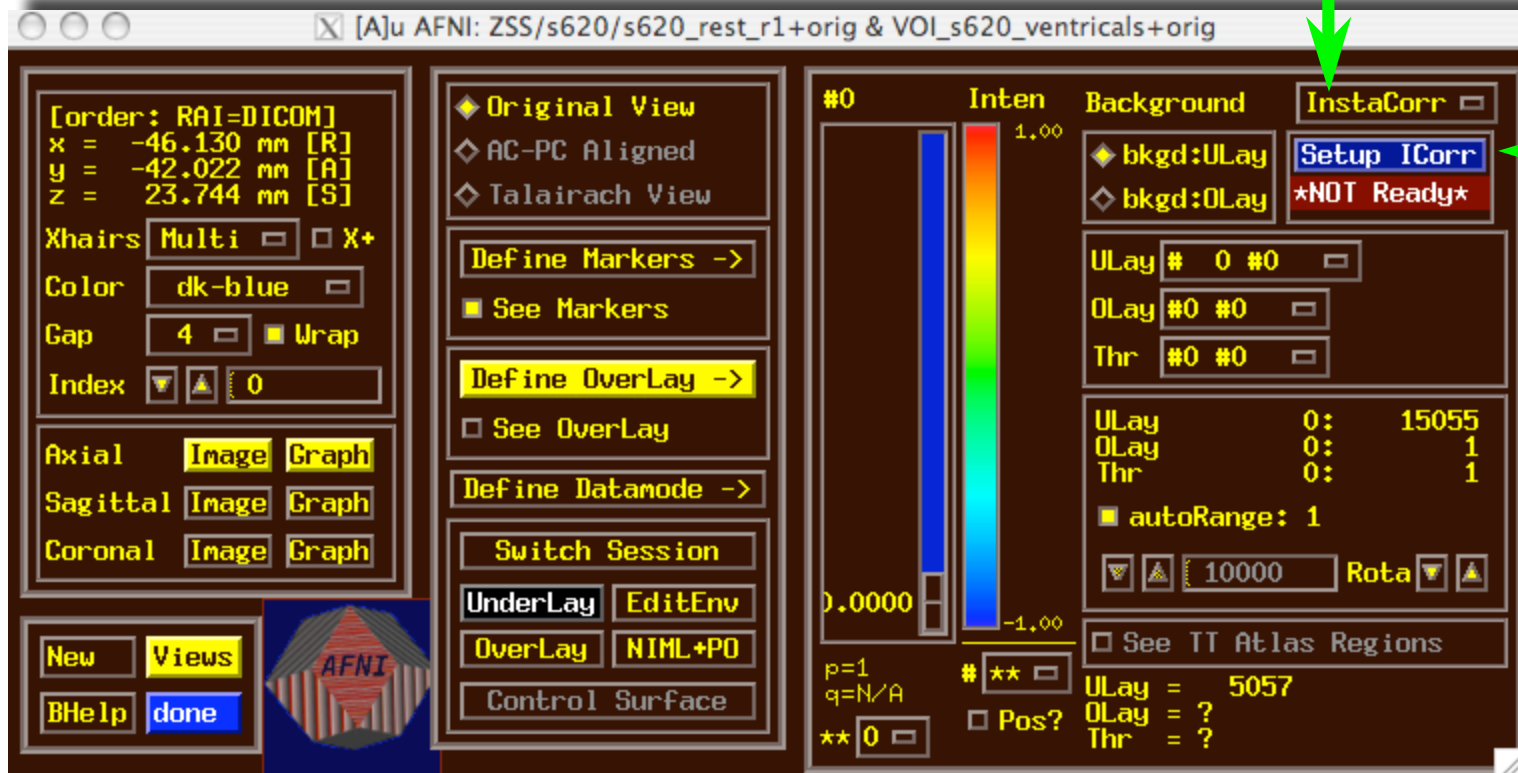
InstaCorr: Setup

- Open **Define Overlay**, choose **InstaCorr** from menu in top right corner



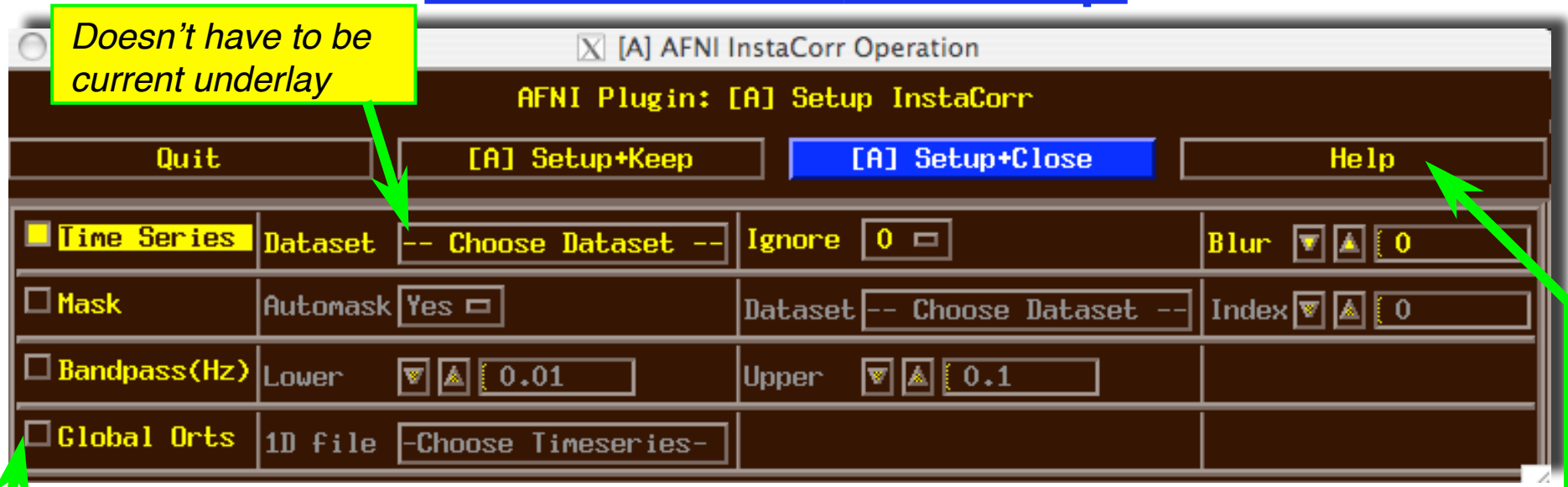
InstaCorr: Setup

- Open **Define Overlay**, choose **InstaCorr** from menu in top right corner



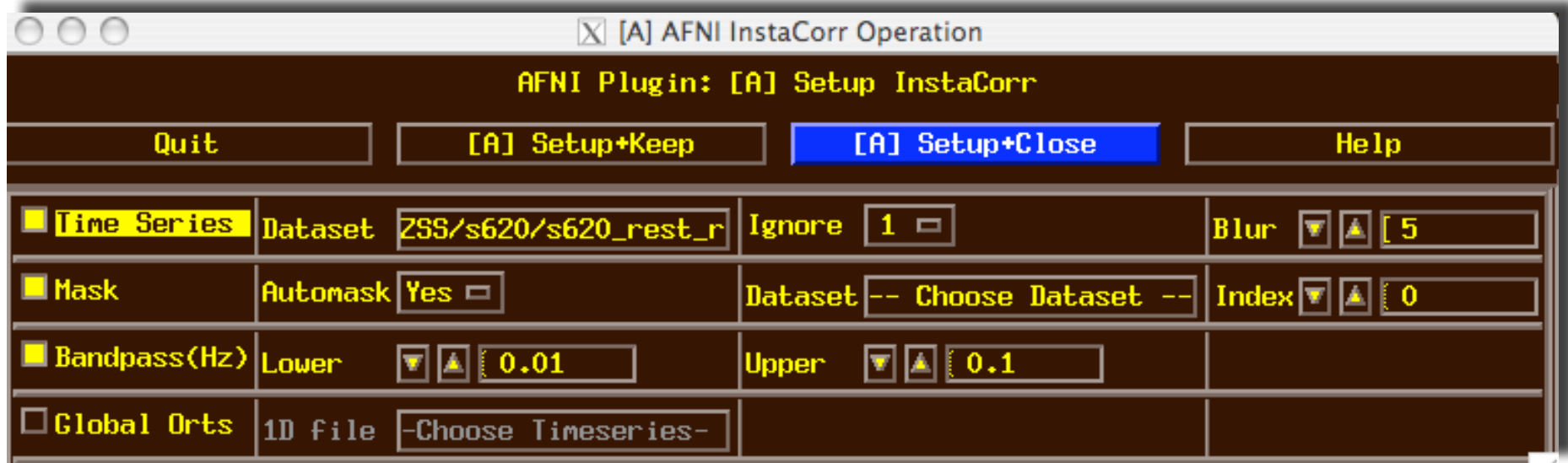
- Then press **Setup ICorr** button to get control panel

InstaCorr: Setup



- Mostly self-explanatory (I hope) — cf. **Help**
- **Global Orts** = extra time series to be projected out of dataset before correlation
 - All columns in selected 1D file
 - e.g., movement parameters
 - The first **Ignore** rows (time points) will be skipped
- When ready, press one of the **Setup** buttons

InstaCorr: Setup



- Text output to shell window details the setup procedures:

++ InstaCorr preparations:

+ Automask from

'/Users/rwcox/data/Resting/ZSS/s620/s620_rest_r1+orig.BRIK' has 197234 voxels

+ Extracting dataset time series

+ Filtering 197234 dataset time series

+ bandpass: ntime=139 nFFT=160 dt=3.5 dFreq=0.00178571

Nyquist=0.142857 passband indexes=6..56

+ Spatially blurring 139 dataset volumes

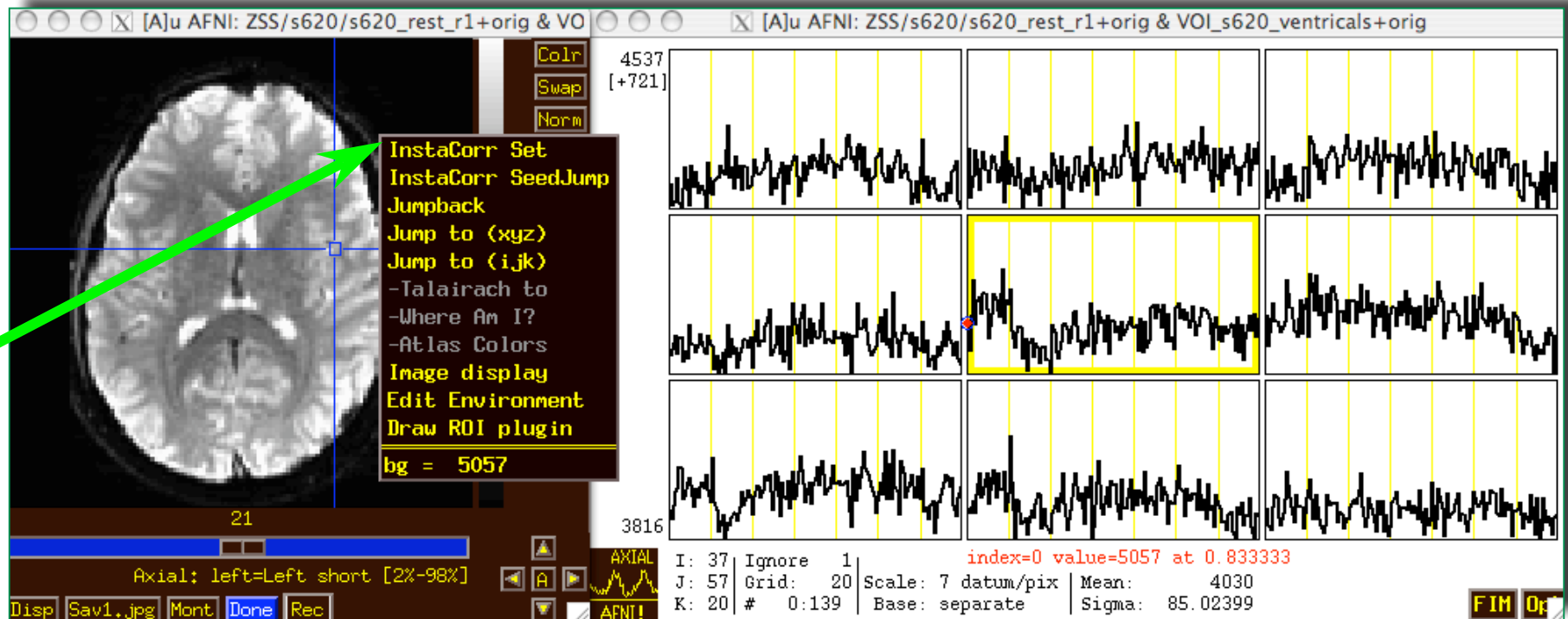
+ Normalizing dataset time series

++ InstaCorr setup: 197234 voxels ready for work: 15.43 sec

Dataset being analyzed

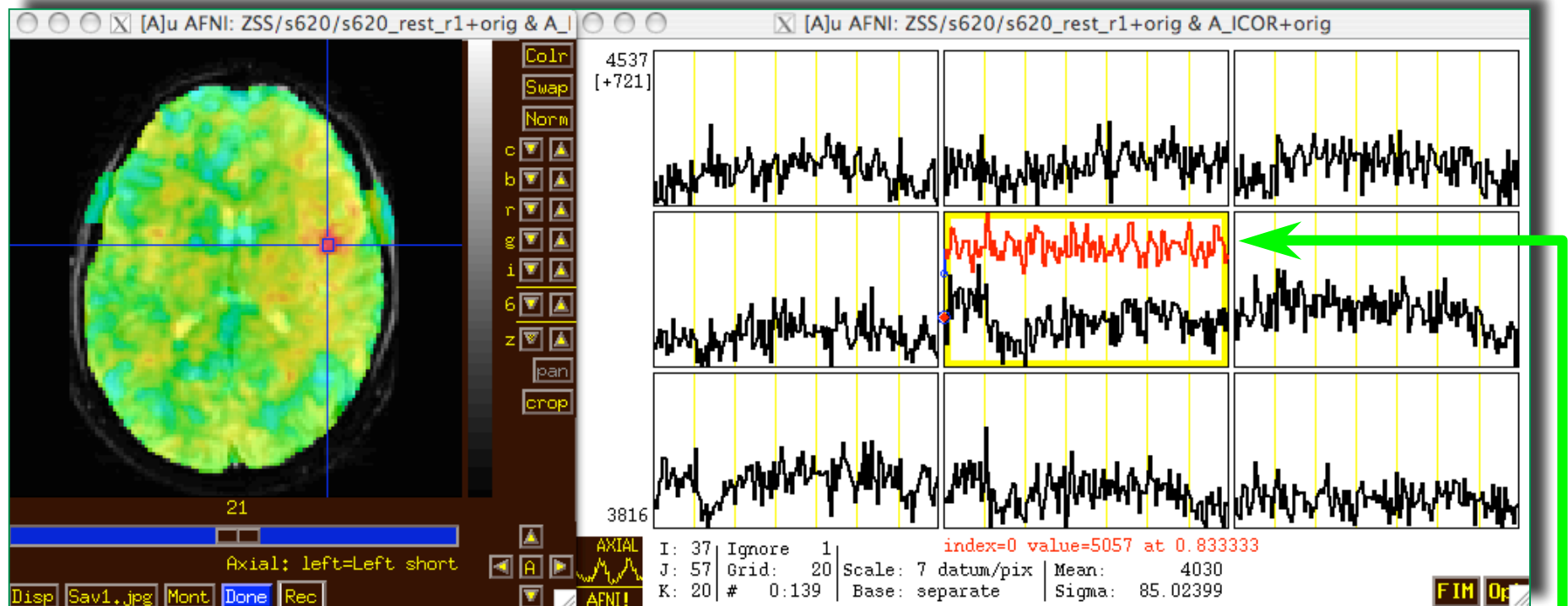
Most of the CPU time:
Uses BlurInMask

InstaCorr: The Fun Part



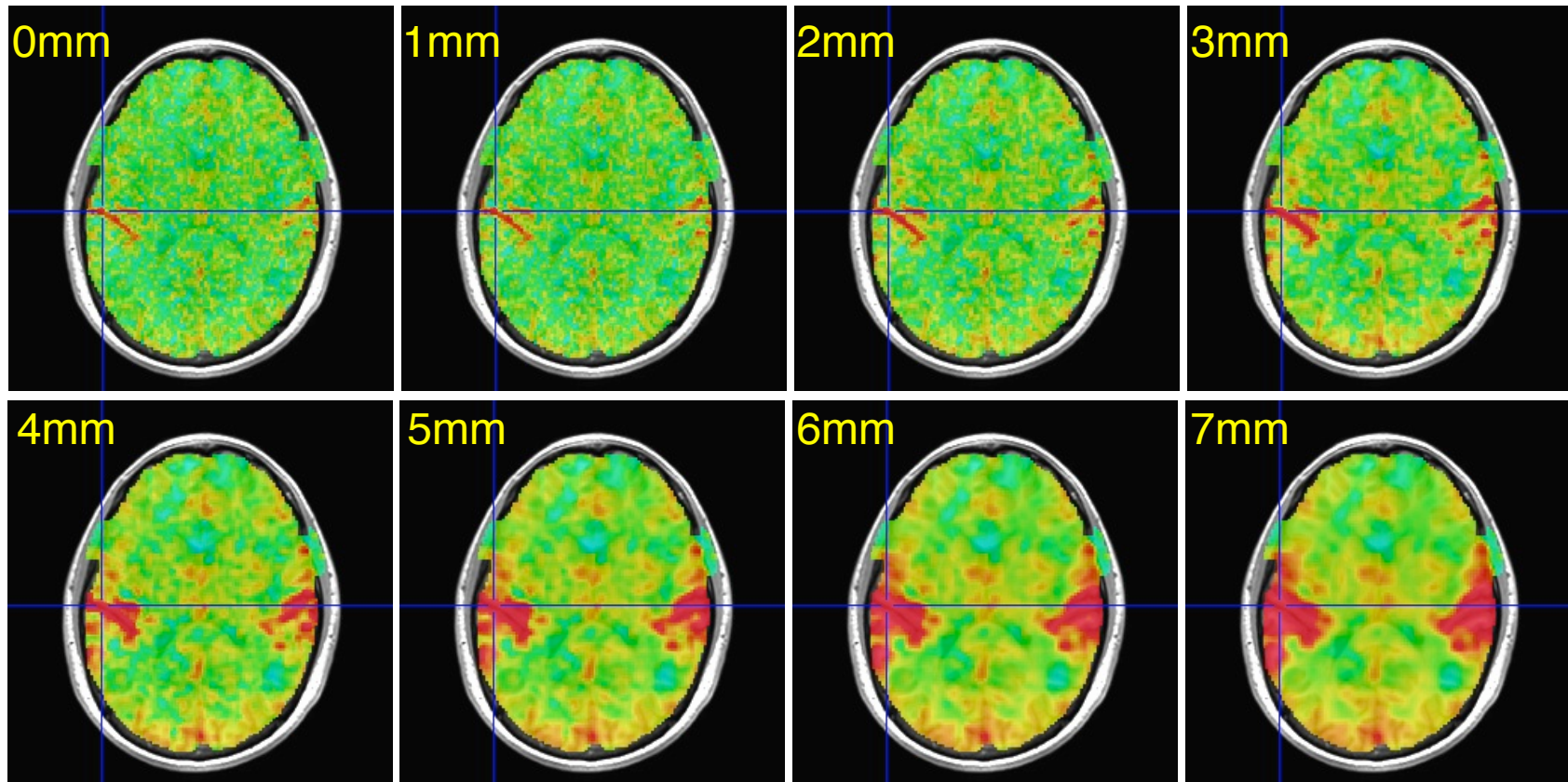
- In image viewer, set crosshairs to desired seed voxel
- **Right-click** popup menu → **InstaCorr Set**
 - Creates new dataset **A_ICOR** for Overlay
 - **Shortcut: Shift+Ctrl+Left-click** sets new crosshair location, then does **InstaCorr Set**
 - Can also hold down **Shift+Ctrl+Left-click** and drag seed around
- **InstaCorr SeedJump** jumps focus to current seed

InstaCorr: The Fun Part



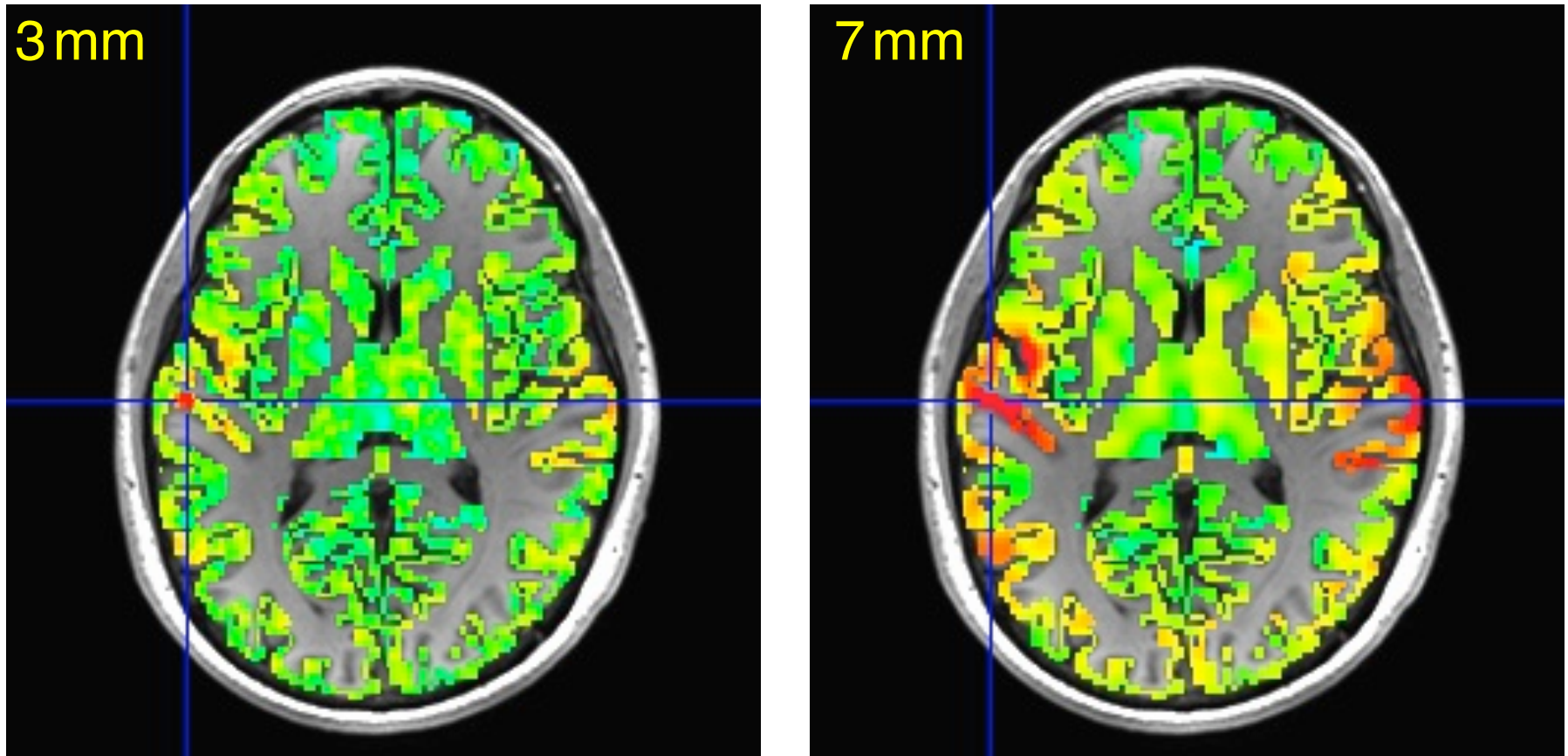
- In graph window:
 - Set Ignore with **FIM**→**Ignore** menu (or **I** key)
 - Set seed overlay with **FIM**→**Pick Ideal** menu
- When you change seed voxel, saved overlay time series will change (but you have to refresh graph to see it)

InstaCorr: Effects of Blurring



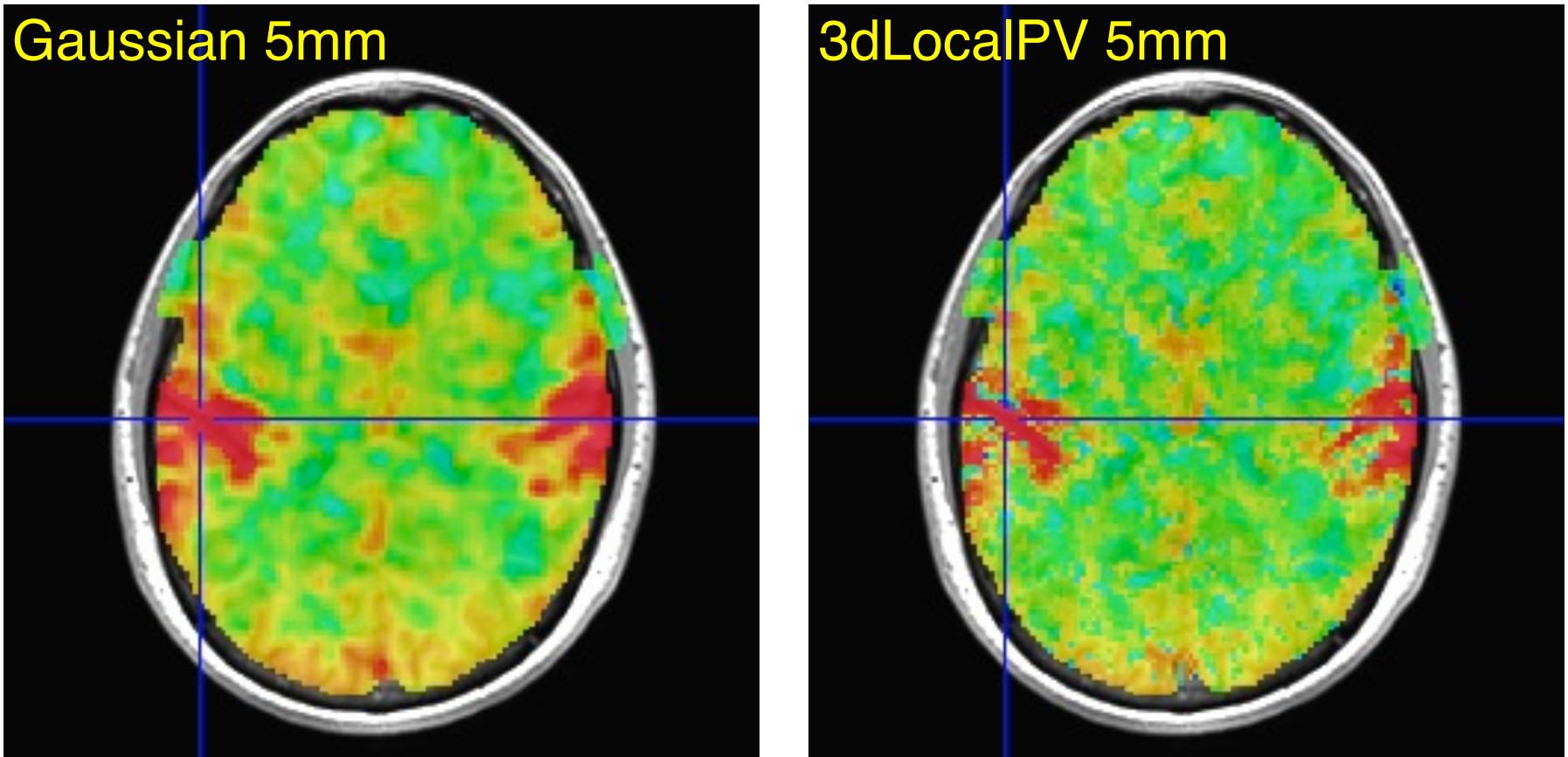
- Is this a pure vascular/cardiac effect being progressively smeared? Or real neural correlations seen via BOLD? Or some of both? *Venograms?*
 - Dataset was RETROICOR-ized; mask is whole brain

InstaCorr: Effects of Blurring



- Similar calculations, but with FreeSurfer-generated gray matter mask instead of Automask from EPI data
 - Blurring is done only inside the mask (**3dBlurInMask**)
 - Using a discrete PDE-based iterative approach

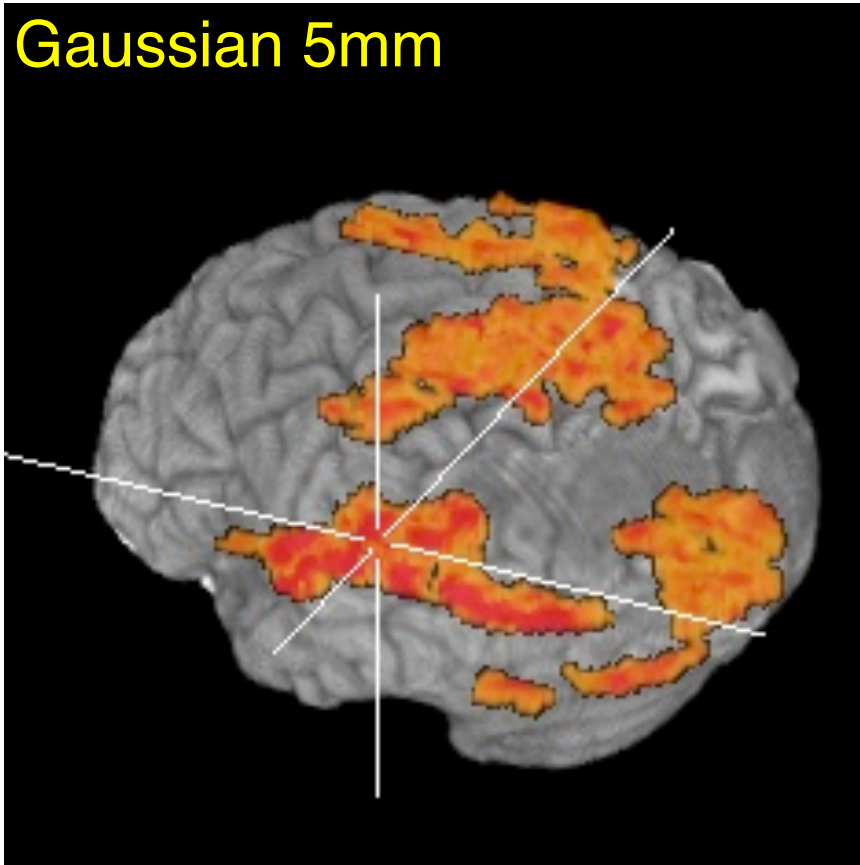
InstaCorr: SVD-based “Blurring”



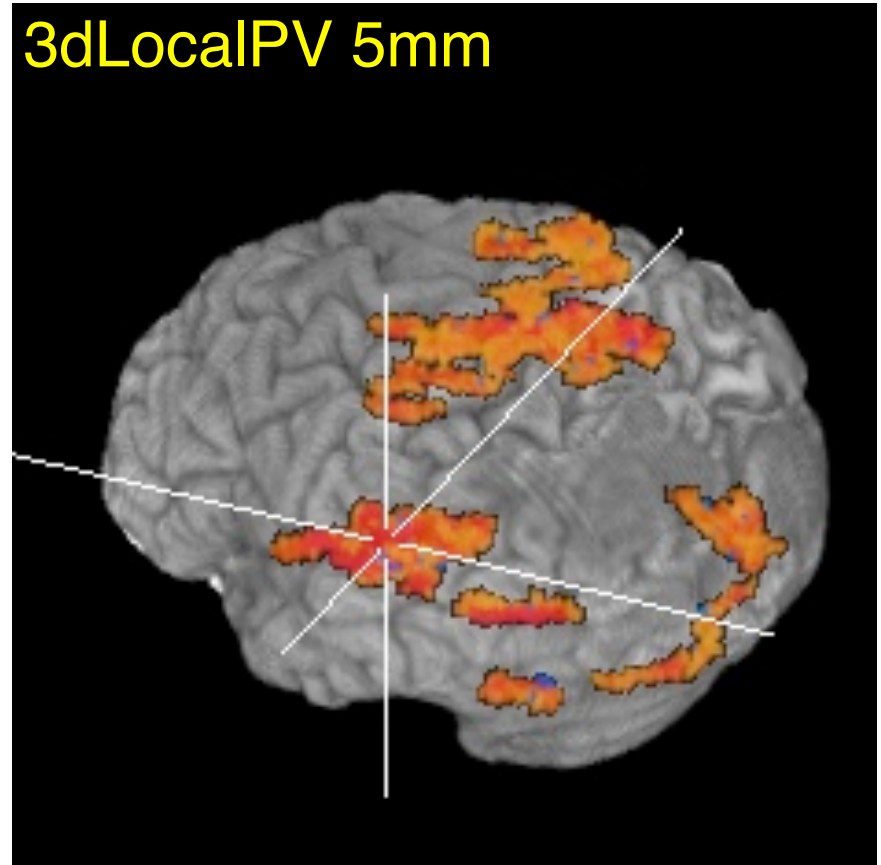
- Similar calculations, with Automask from EPI data, using **3dLocalPV** over 5 mm radius sphere (67 voxels)
 - Project each vector onto 2-dim principal subspace
 - Far too slow to calculate interactively (at this time)

InstaCorr: SVD-based “Blurring”

Gaussian 5mm



3dLocalPV 5mm



- Volume rendering of InstaCorr maps (threshold at $r=0.5$)
 - Renderer updates automatically if **DynaDraw** is on
- SVD smoothing has cleaner spatial structure?
 - Or has it lost some information? *I don't know.*

InstaCorr: Options and Plans

- Underlay doesn't have to be EPI data; could be anat
 - Can use InstaCorr in multiple AFNI controllers
 - FDR: **setenv AFNI_INSTACORR_FDR YES**
 - Will slow things down by a significant factor
 - Saving **A_ICOR** dataset: overwrites previous copies
-
- Future Possibilities:
 - Select ROI-based Orts to be detrended?
 - Based on ROIs from FreeSurfer or atlases?
 - Or multiple seeds (partial + multiple correlations)?
 - Interactive local SVD “smoothing”? (needs speedup)
 - Group analysis InstaCorr (in standardized space)
 - Not quite “Insta” any more; $\approx 0.1 \times \#Subjects$ sec per seed
 - External script to do subject setups
 - Use time series subsets? (e.g., for block design data)

Group InstaCorr

- If you have a robust enough system (multiple CPUs, several gigabytes of RAM), you can explore the *group* analysis of resting state seed-based correlations
- **Setup Phase:**
 - Unlike individual InstaCorr, the setup is done outside the AFNI GUI with command line programs
 - Step 1: transform all time series datasets to standard space = **@auto_tlrc** and **adwarp**
 - Step 2: filter and blur all time series dataset = **3dBandpass**
 - Step 3: collect groups of time series datasets into one big file = **3dSetupGroupInCorr**
- **Interactive Phase:** point-and-click to set seed voxel

3dGroupInCorr: Setup #1

- Assume datasets are named as follows:

- T1-weighted anatomical = sXXX_anat+orig
- Resting state EPI = sXXX_rest+orig

```
foreach aset ( s*_anat+orig.HEAD )
  set sub = `basename $aset _anat+orig.HEAD`
# transform anat to MNI space
@auto_tlrc -base ~/abin/MNI_avg152T1+tlrc.HEAD -input $aset
# transform EPI to MNI as well (assume anat & EPI are aligned)
adwarp -apar ${sub}_anat+tlrc.HEAD -dpar \
        ${sub}_rest+orig.HEAD -resam Cu -dxyz 2.0
# make individual subject mask
3dAutomask -prefix ${sub}_amask ${sub}_rest+tlrc.HEAD
end

# Combine individual EPI masks into group mask

3dMean -datum float -prefix ALL_am *_amask+tlrc.HEAD
3dcalc -datum byte -prefix ALL_am50 -a ALL_am+tlrc \
        -expr 'step(a-0.499)'
```

3dGroupInCorr: Setup #2

- Bandpass and blur each dataset inside mask
 - skip first 4 time points, and remove global signal
 - of course, you can choose your own options for filtering
 - Can also have **1** voxel-dependent time series to detrend, via **-dsort**

```
foreach rset ( s*_rest+tlrc.HEAD )
  set sub = `basename $rset _rest+tlrc.HEAD`
  # create global signal file for this dataset
  3dmaskave -mask ALL_am50+tlrc -quiet \
    $rset'[4..$]' > ${sub}_GS.1D
  # 3dBandpass does blurring, filtering, and detrending
  3dBandpass -mask ALL_am50+tlrc -blur 6.0 \
    -band 0.01 0.10 -prefix ${sub}_BP \
    -input $rset'[4..$]' -ort ${sub}_GS.1D
end
/bin/rm -f *_GS.1D *_amask+tlrc.*
```

3dGroupInCorr: Setup #3

- **3dSetupGroupInCorr** reads all filtered & blurred resting state EPI datasets, masks & normalizes them, and writes them to one *big* file for **3dGroupInCorr**
 - Sample below: 2 groups of subjects

```
set AAA = ( s601 s604 ... s644 s646 )
set BBB = ( s611 s612 ... s652 s654 )
set ggg = ( )
foreach fred ( $AAA )
    set ggg = ( $ggg ${fred}_BP+tlrc.HEAD )
end
```

```
3dSetupGroupInCorr -mask ALL_am50+tlrc -prefix AAA $ggg
```

```
set ggg = ( )
foreach fred ( $BBB )
    set ggg = ( $ggg ${fred}_BP+tlrc.HEAD )
end
```

```
3dSetupGroupInCorr -mask ALL_am50+tlrc -prefix BBB $ggg
```

3dGroupInCorr: Interactive Phase

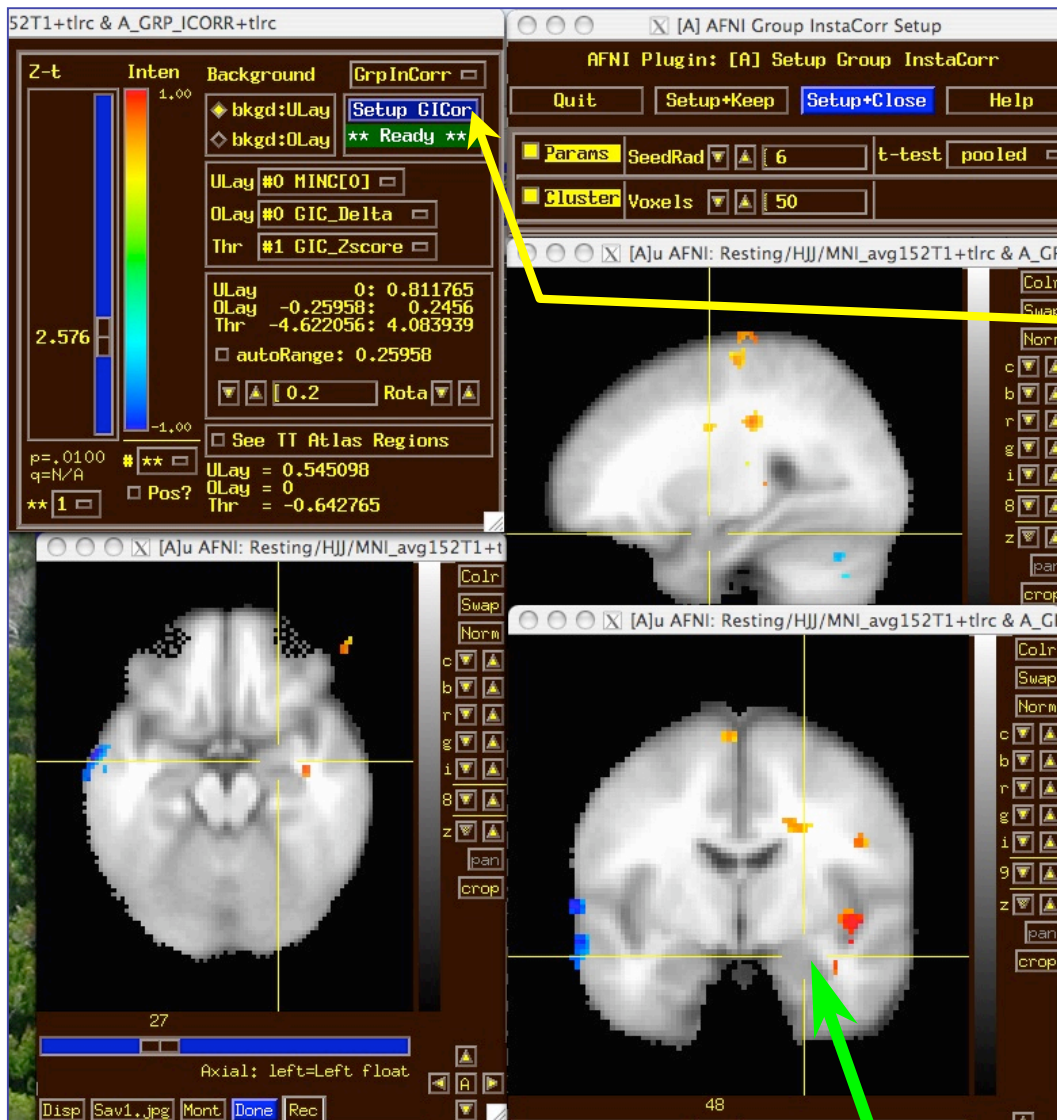
- Start server program (2-sample *t*-test here):

```
3dGroupInCorr -setA AAA.grpincorr.niml \  
              -setB BBB.grpincorr.niml
```

- Startup takes a little while, as all data must be read into RAM (in this example, 3.2 Gbytes)
 - After data is read, connects to AFNI using a NIML socket
 - Server will use multiple CPUs if compiled with OpenMP (currently on Mac OS X 10.5 and 10.6)
- In a separate terminal window, start AFNI:

```
afni -niml ~/abin/MNI_avg152T1+tlrc.HEAD
```
 - Then open the **Define Overlay** control panel
 - Select **GrpInCorr** from the **Clusters** menu

3dGrpInCorr: Interactive Results



- Use same buttons as individual subject InstaCorr to set seed
- Use **Setup GICor** panel to set the few options available interactively
 - **SeedRad** = extra smoothing radius for seed voxel time series (flat average)
 - **Cluster** = min number of voxels to keep above thresh

Seed voxel →

3dGrpInCorr: What It Computes

- Extracts seed time series from each input dataset; correlates it with all voxel time series in that dataset
 - Group analysis: t -test between correlation datasets
- 1-sample t -test (**-setA** only) gives 2 sub-bricks:
 - mean of \tanh^{-1} (correlation with seed)
 - Z-score of t -statistic of this mean
- 2-sample test (**-setA** and **-setB**) gives 6 sub-bricks:
 - difference of means (**A-B**) of \tanh^{-1} (correlation)
 - Z-score of t -statistic of this difference
 - Pooled or unpooled variance, or paired t -test (your option)
 - Plus 1-sample results for **-setA** and **-setB** separately
 - View these in AFNI **[B]** and **[C]** controllers, to see it all!

3dGrpInCorr: To Do It By Hand?

- After **3dBandpass** of all datasets, you would have to do the following steps on each resting state dataset:
 - Extract seed time series from each dataset [**3dmaskave**]
 - Correlate seed time series with all voxels from its dataset [**3dDeconvolve** or **3dfim**]
 - Convert to \tanh^{-1} (correlation) [**3dcalc**]
- Then do the following on the results from the above
 - Compute the *t*-test [**3dttest**]
 - Convert to *Z*-score [**3dcalc**]
 - Read into AFNI for display
- Even with a script, this would be annoying to do a lot
 - Just ask Daniel Handwerker!

Group InstaCorr: Final Notes

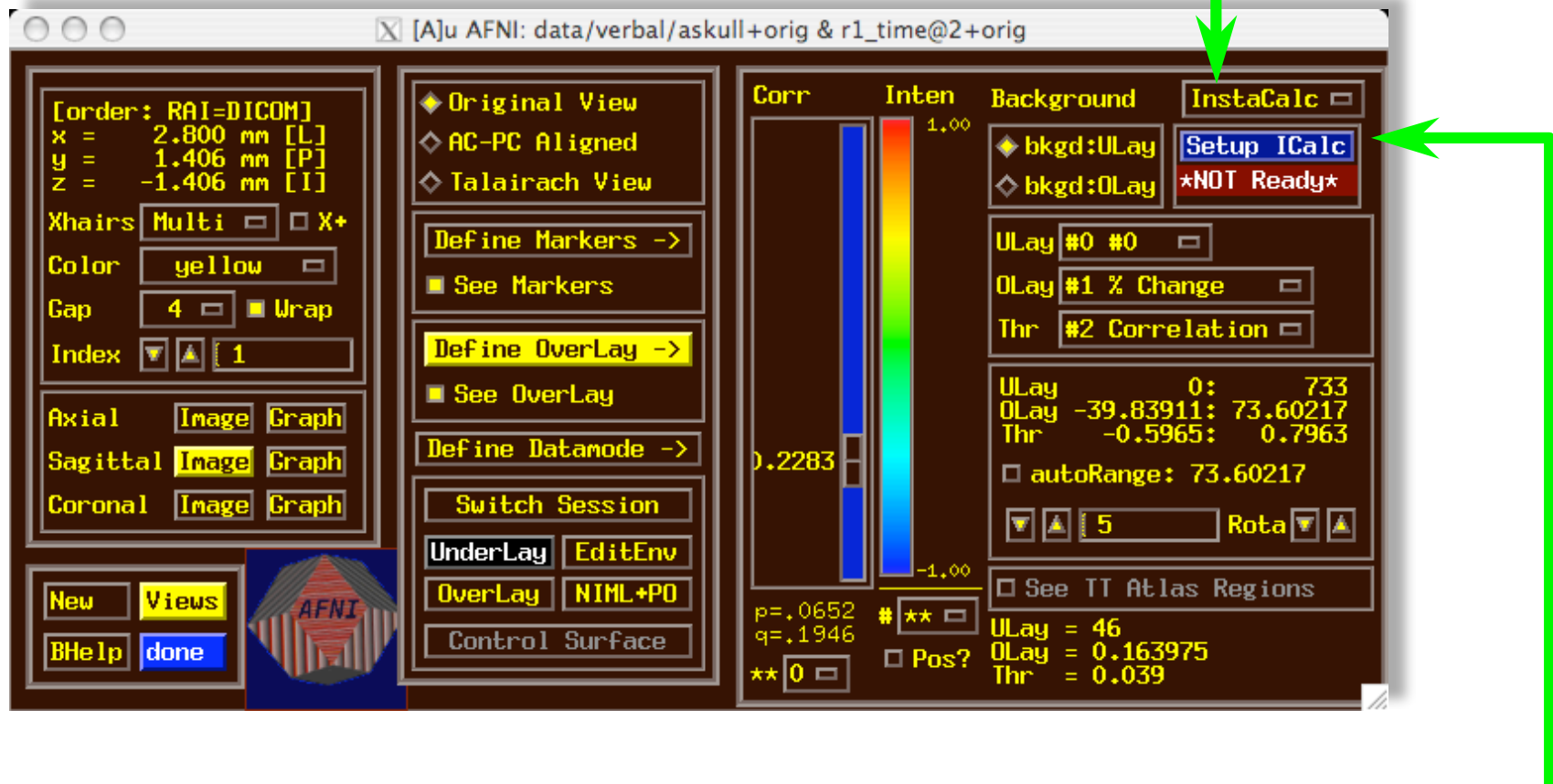
- Time series datasets can have different lengths
 - But all must have the same spatial grid and use the same mask!
- **Fun Stuff:** volume render results with **DynaDraw**
- Sometimes AFNI drops the shared memory connection to **3dGroupInCorr**
 - Due to unknown bugs somewhere in AFNI
 - Program tries to reconnect when this happens
 - If this gets bad, use the **-NOshm** option to **3dGroupInCorr** to force it to use TCP/IP only
 - Slower data transfer, but more reliable
- Brand new software = still rough around the edges
⇒ need *constructive* feedback

Group InstaCorr: Finalest Notes

- Shift+Ctrl+Click+Drag method for dynamically setting the seed voxel also works with **Group InstaCorr**
 - But speed of interaction can be slow
- Can now [*May 2010*] include subject-level covariates (e.g., IQ, age) in the analysis at the group step
 - To regress them out (nuisance variables), and/or to test the slope of $\tanh^{-1}(\text{correlation})$ vs. covariate
- Further ideas:
 - Granger-ize: correlate with lag-0 and lag-1 of seed and test Granger causality
 - Allow user to set other voxels to be "partialled out" of the analysis
 - Any suggestions?

InstaCalc: Dataset Calculator

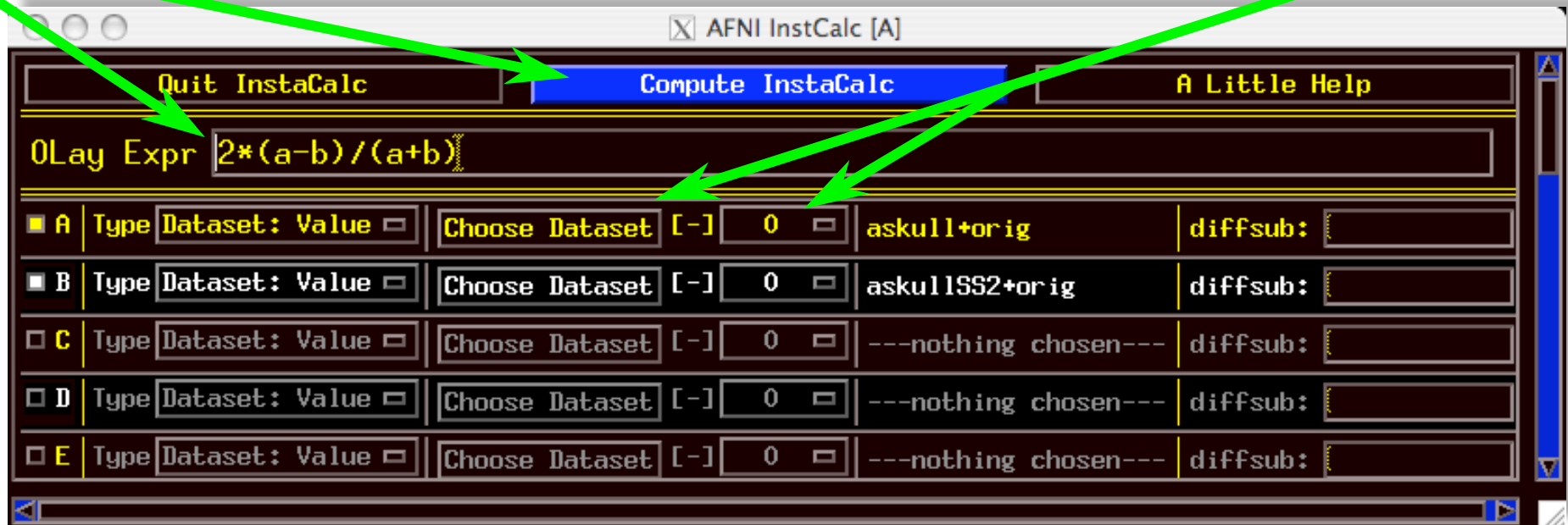
- Open **Define Overlay**, choose **InstaCalc** from menu in top right corner



- Then press **Setup ICalc** button to get control panel

InstaCalc: Setup

- Select datasets with **Choose Dataset** buttons
 - and sub-bricks with the [-] controls
- Enter symbolic expression
- Press **Compute InstaCalc**
- Creates new 1-brick dataset **A_ICALC** for Overlay
 - voxel-by-voxel calculations

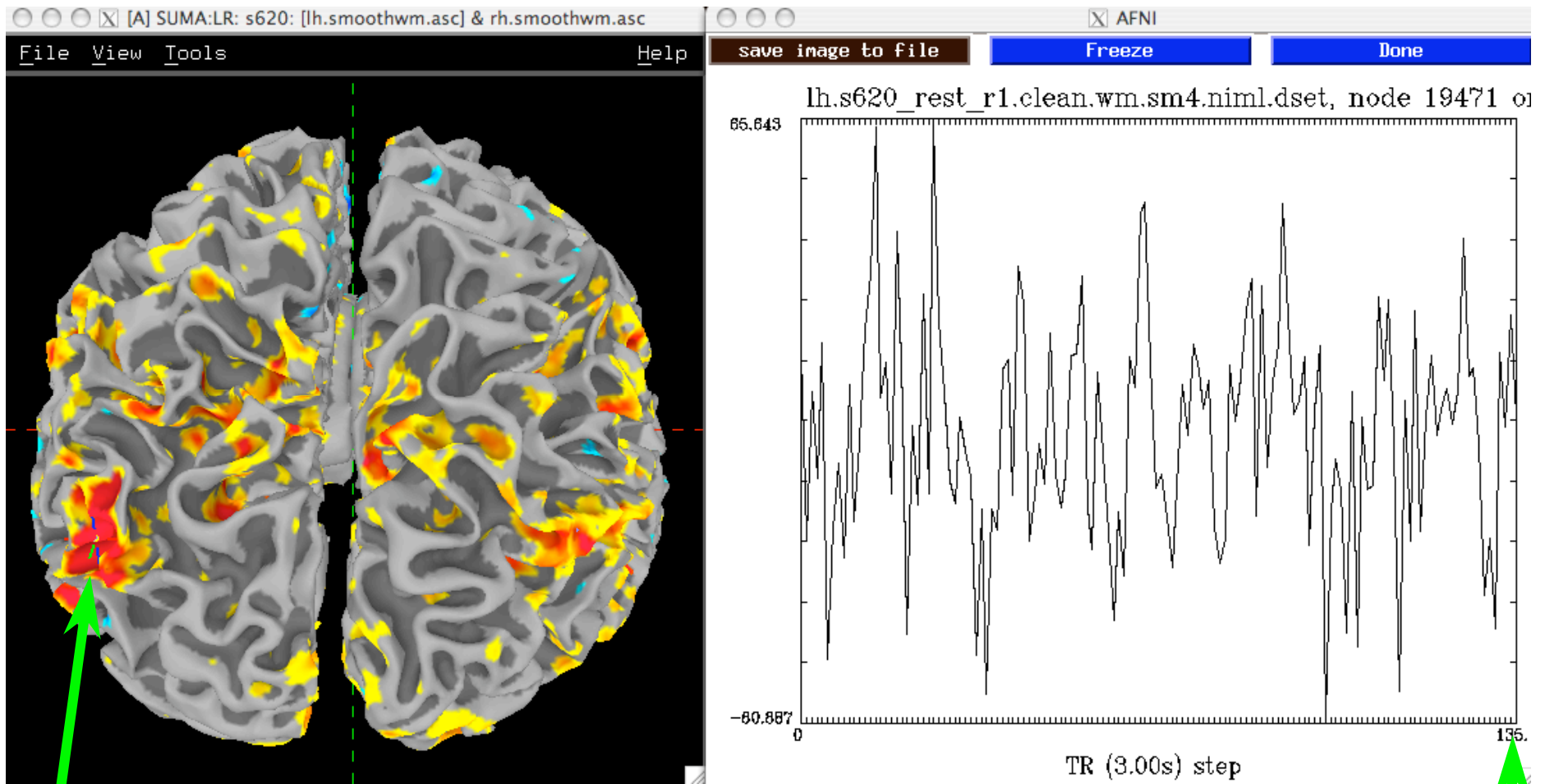


 **InstaCorr**

- Similar in concept to AFNI **InstaCorr** but requires external pre-processing of time series datasets
 - Removal of baseline, projection to surface, blurring
- In the **AFNI_data5/** directory, run the script ***tcsch ./@run_REST_demo***
 - starts SUMA with 2 hemispheres
 - loads pre-processed datasets into SUMA
 - sets up SUMA's **InstaCorr**
- After all the setup is ready, right-clicking on the surface will do the **InstaCorr** calculations
- **3dGroupInCorr** also works with SUMA



InstaCorr: Sample



• Seed voxel and Seed voxel time series graph