Aperture Photometry Tool

in a Multi-Wavelength Astronomical Observing Campaign

Douglas Streat, *Joel Barlow High School*

Background

Aperture Photometry Tool (APT):

A cross-platform java-based software package created by Russ Laher at the Spitzer Science Center at Caltech in Pasadena, CA. In development since 2007. Originally developed for analysis of images from the Spitzer Space Telescope but can be used for any *manual* exploration of the photometric qualities of astronomical images in the FITS file format. Not ideal for analyzing large numbers of images or when pinpoint accuracy is required.[1]

Background

FITS:

Flexible Image Transport System. Most commonly used image file format in astronomy. Because it was designed for scientific use it saves more than just image data—FITS images have headers with important information including telescope used, filter, date, and time.[2]

Background

Spitzer Space Telescope/Science Center:

An infrared space telescope launched in 2003. It ran out of liquid helium necessary to continue operating many of its instruments in "cool mode" in 2009, but continues to operate one remaining instrument in "warm mode" today. The Spitzer Science Center, based at Caltech, is the organization that manages the telescope. Also ran an outreach program, the Spitzer/WISE Research Program for Teachers and Students.[3]

The Campaign

This presentation focuses on the procedure for using APT with respect to a multi-wavelength observing campaign conducted at the Spitzer Science Center during the summer of 2008. This campaign was led by Varoujan Gorjian, PhD. and was sponsored by the Spitzer/WISE Research Program for Teachers and Students.

The Campaign: Detail

This campaign focused on a limited time period during which the Active Galactic Nucleus (AGN), NGC 4051, was monitored using different filters on various telescopes, both ground-based and the Spitzer Space Telescope, with hopes of capturing spontaneous light outbursts which are often emitted from Active Galactic Nuclei across the multiple wavelengths of images recorded and then using reverberation mapping to measure the size of the dust torus believed to surround the AGN. ***APT was used to manually measure and compare light output from the AGN on the various images captured to determine if a light outburst was indeed captured. What follows is the procedure used in applying APT to this task.***

Since this campaign, two posters regarding the work have been published at meetings of the American Astronomical Society (AAS).[4]

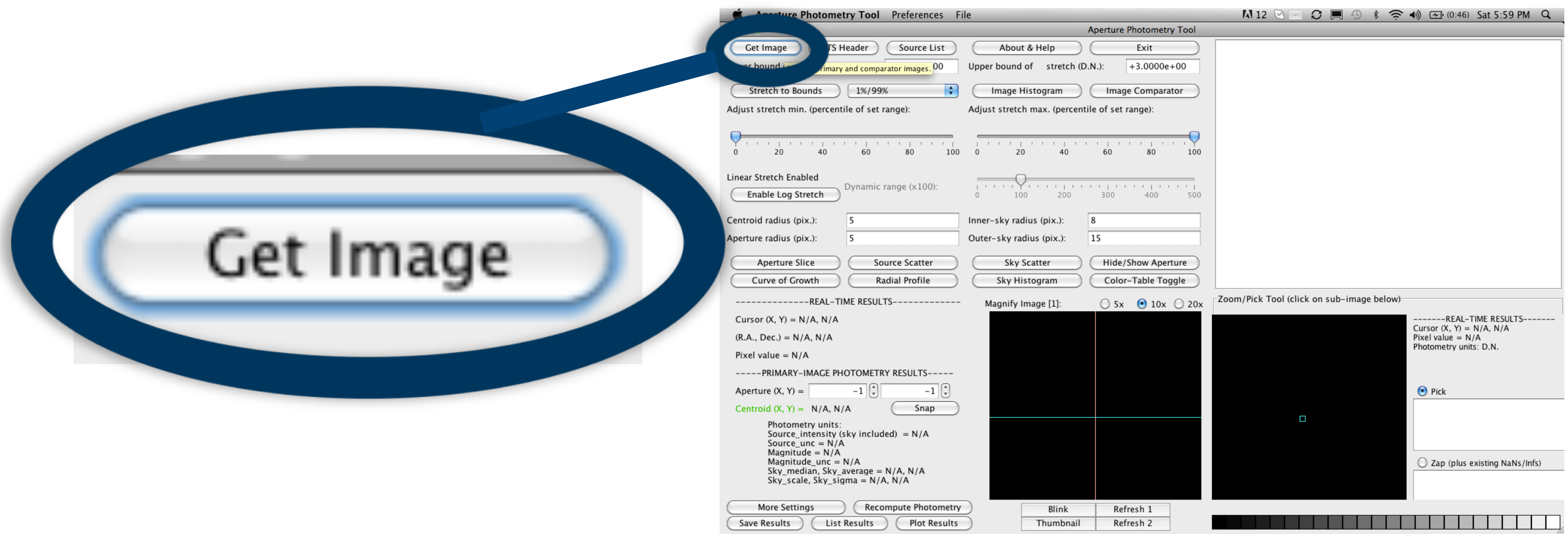
Procedure

(1) Download APT and open the application. Download requirements vary by platform. The application download page can be found by clicking the APT application logo below:

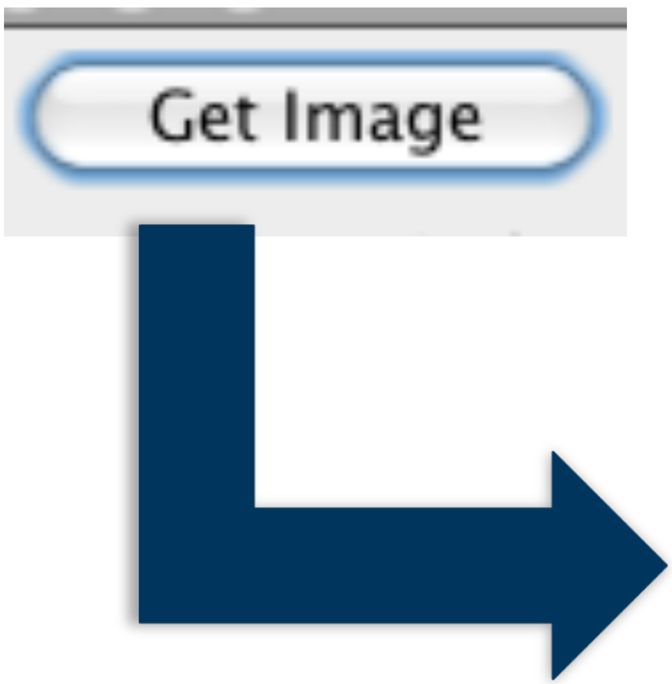
Having trouble? This is the link:
http://spider.ipac.caltech.edu/staff/laher/apt/

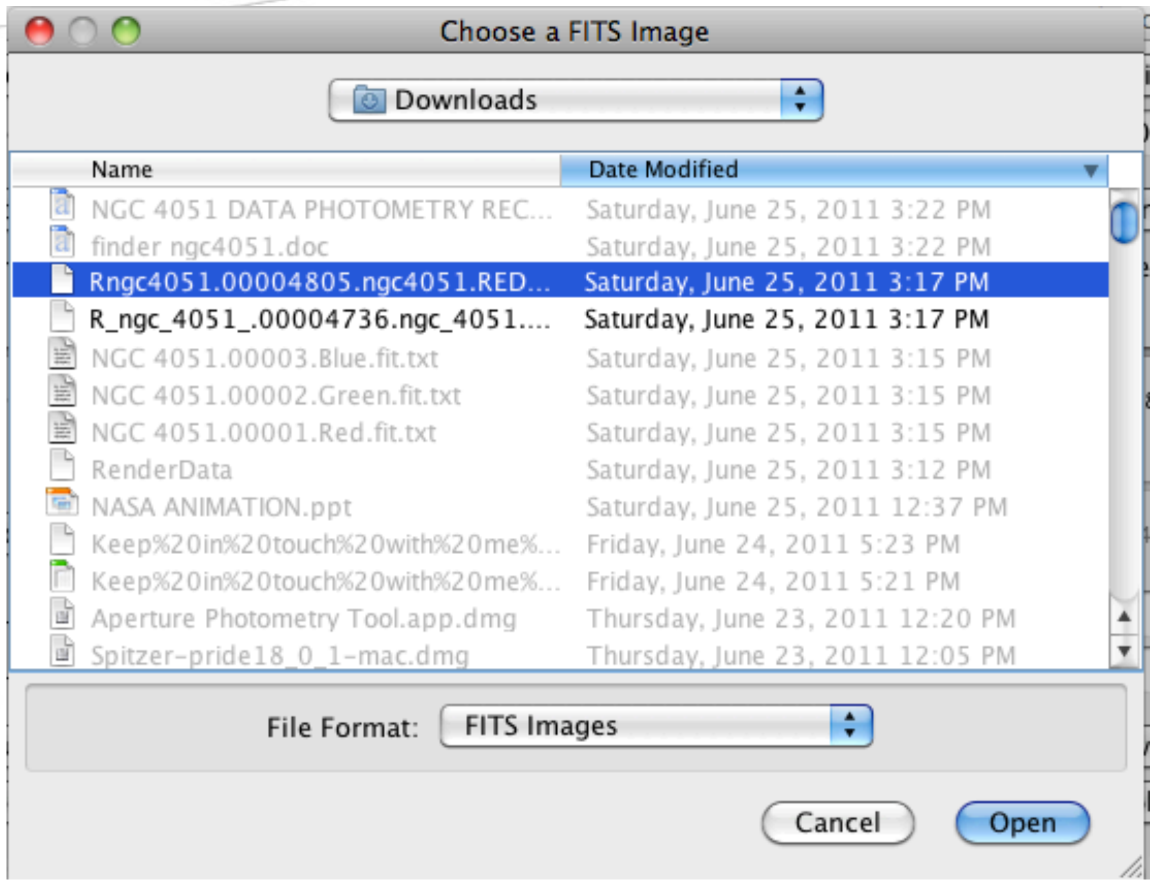
Procedure

(2) Open the FITS image that you will be working with by selecting “Get Image” and locating the file.



Procedure


Get Image


Choose a FITS Image
Downloads
Name
Date Modified
NGC 4051 DATA PHOTOMETRY REC...
Saturday, June 25, 2011 3:22 PM
finder ngc4051.doc
Saturday, June 25, 2011 3:22 PM
Rngc4051.00004805.ngc4051.RED...
Saturday, June 25, 2011 3:17 PM
R_ngc_4051_.00004736.ngc_4051....
Saturday, June 25, 2011 3:17 PM
NGC 4051.00003.Blue.fit.txt
Saturday, June 25, 2011 3:15 PM
NGC 4051.00002.Green.fit.txt
Saturday, June 25, 2011 3:15 PM
NGC 4051.00001.Red.fit.txt
Saturday, June 25, 2011 3:15 PM
RenderData
Saturday, June 25, 2011 3:12 PM
NASA ANIMATION.ppt
Saturday, June 25, 2011 12:37 PM
Keep%20in%20touch%20with%20me%...
Friday, June 24, 2011 5:23 PM
Keep%20in%20touch%20with%20me%...
Friday, June 24, 2011 5:21 PM
Aperture Photometry Tool.app.dmg
Thursday, June 23, 2011 12:20 PM
Spitzer-pride18_0_1-mac.dmg
Thursday, June 23, 2011 12:05 PM
File Format:
FITS Images
Cancel
Open

Procedure

(3) Now, with the image open, set the scope radii to these standards to eliminate variables as you continue to analyze images…

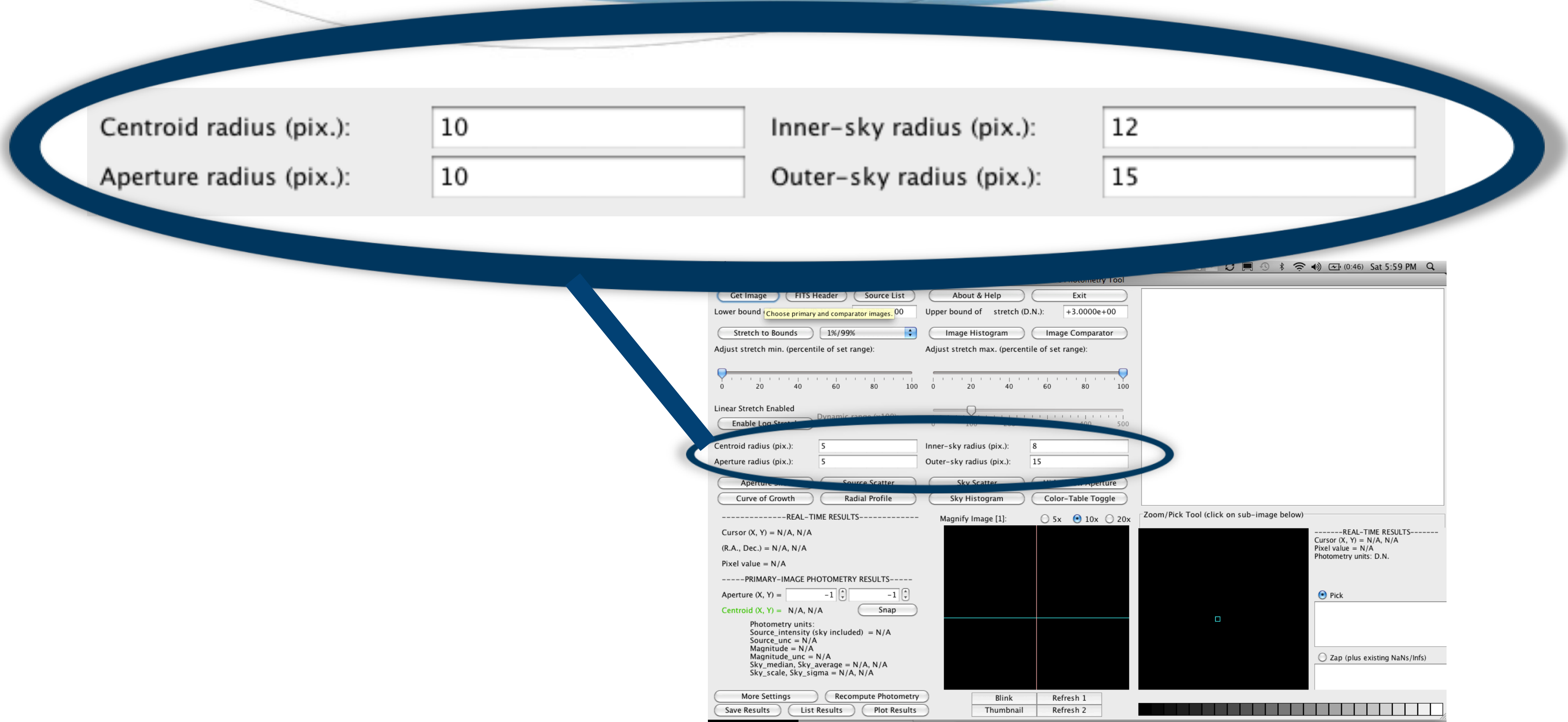
Centroid Radius = 10

Aperture Radius = 10

Inner-sky Radius = 12

Outer-sky radius = 15

Procedure

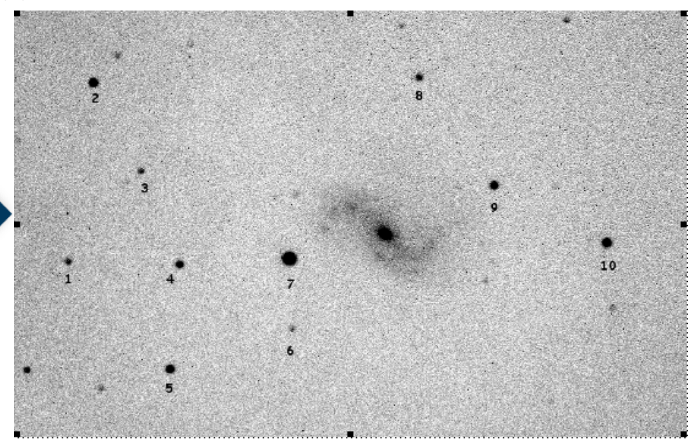


Centroid radius (pix.): 10
Aperture radius (pix.): 10
Inner-sky radius (pix.): 12
Outer-sky radius (pix.): 15
Get Image
FITS Header
Source List
About & Help
Exit
Choose primary and comparator images.
Upper bound of stretch (D.N.):
+3.0000e+00
Stretch to Bounds
1%/99%
Image Histogram
Image Comparator
Adjust stretch min. (percentile of set range):
Adjust stretch max. (percentile of set range):
Linear Stretch Enabled
Centroid radius (pix.): 5
Aperture radius (pix.): 5
Inner-sky radius (pix.): 8
Outer-sky radius (pix.): 15
Curve of Growth
Radial Profile
Sky Histogram
Color-Table Toggle
--------------REAL-TIME RESULTS-------------
Cursor (X, Y) = N/A, N/A
(R.A., Dec.) = N/A, N/A
Pixel value = N/A
-----PRIMARY-IMAGE PHOTOMETRY RESULTS-----
Aperture (X, Y) =
Centroid (X, Y) = N/A, N/A
Snap
Photometry units:
Source_intensity (sky included) = N/A
Source_unc = N/A
Magnitude = N/A
Magnitude_unc = N/A
Sky_median, Sky_average = N/A, N/A
Sky_scale, Sky_sigma = N/A, N/A
Magnify Image [1]:
5x
10x
20x
Zoom/Pick Tool (click on sub-image below)
-------REAL-TIME RESULTS-------
Cursor (X, Y) = N/A, N/A
Pixel value = N/A
Photometry units: D.N.
Pick
Zap (plus existing NaNs/Infs)
More Settings
Recompute Photometry
Save Results
List Results
Plot Results
Blink
Refresh 1
Thumbnail
Refresh 2

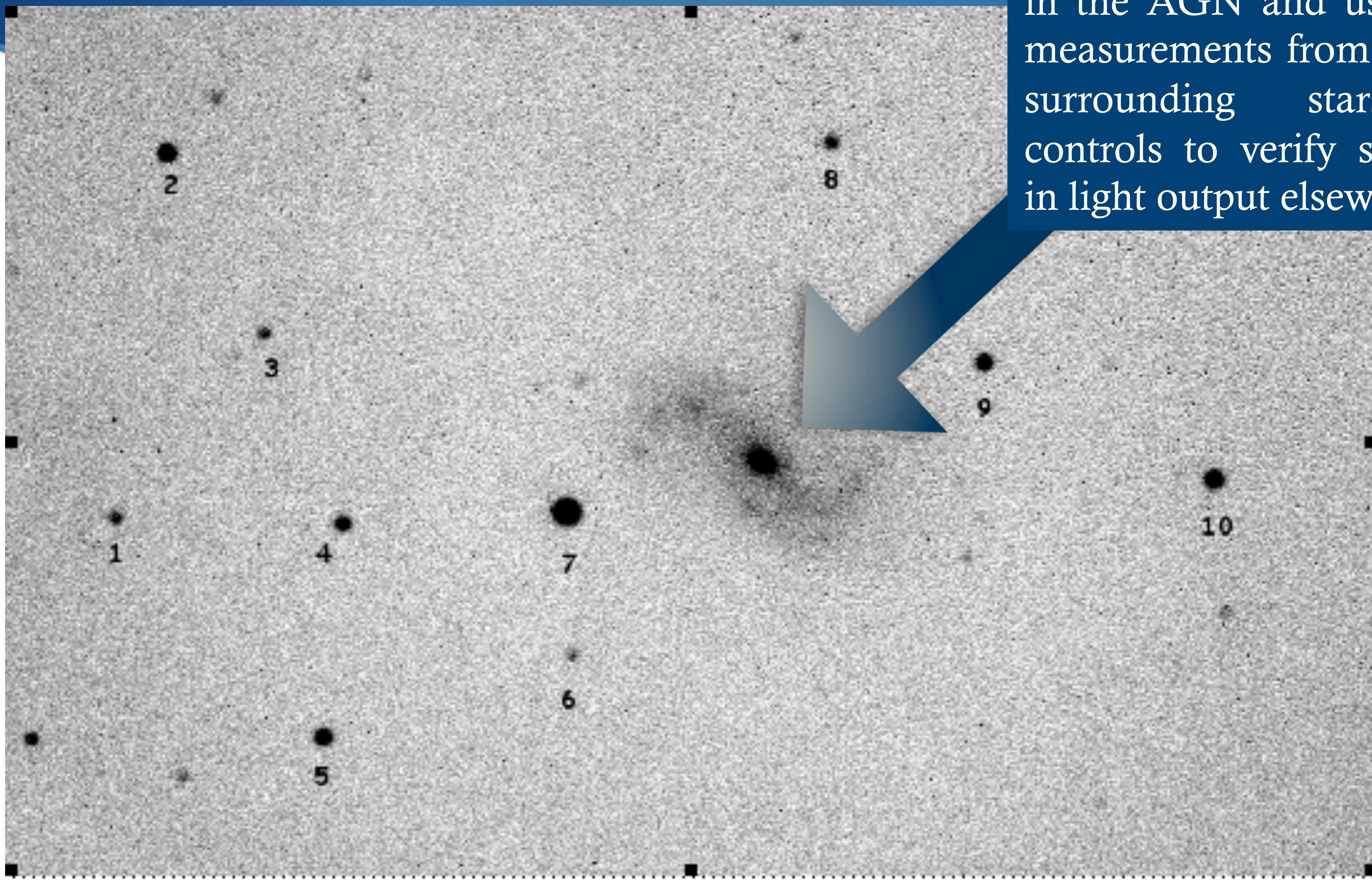
Procedure

(4) Use a finder chart to determine the order in which to compute photometry for the AGN and the 10 surrounding control stars. *Make sure to perform photometry for each of the 11 points that must be analyzed in each image in the exact numerical order outlined by the finder chart.*

Enlarged on next slide.



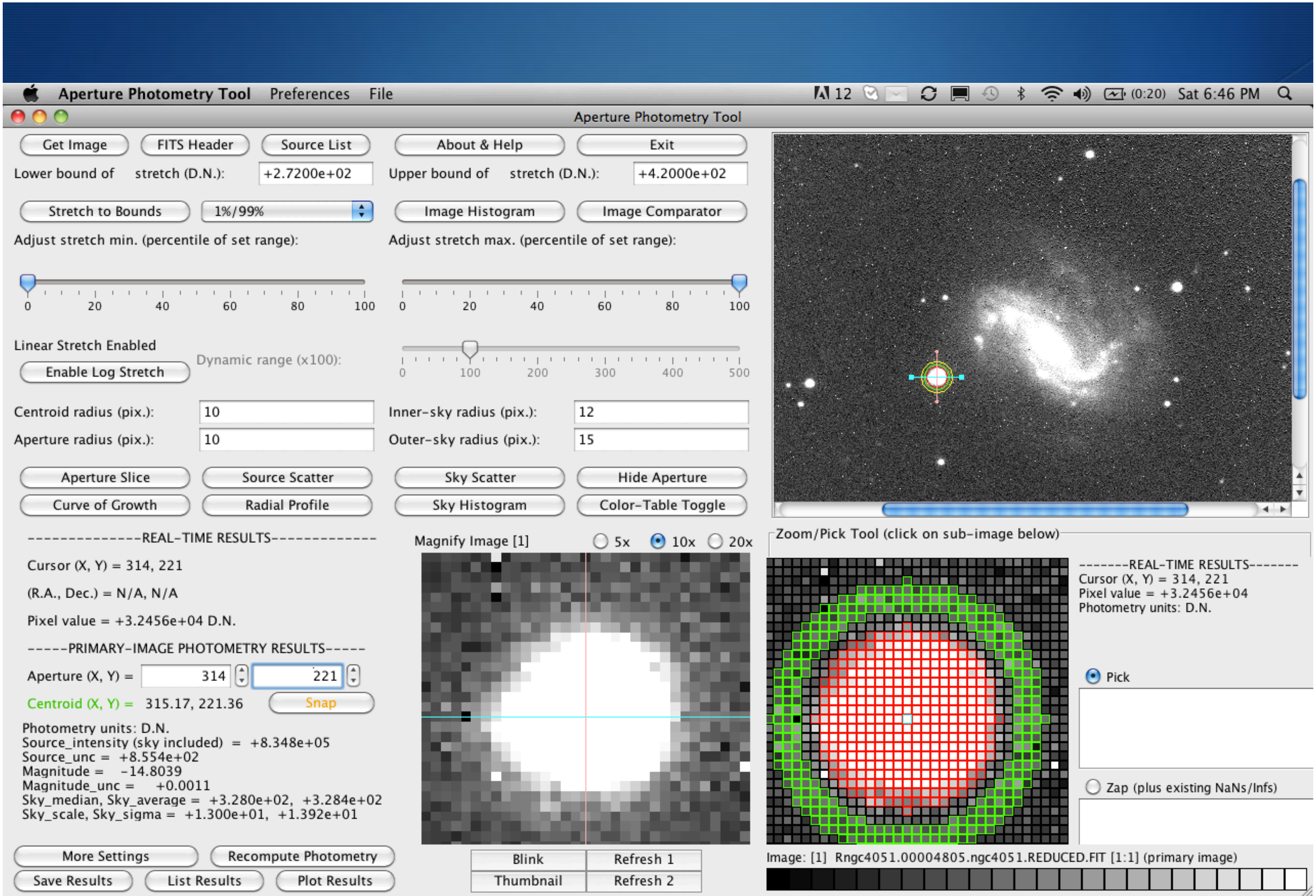
Finder Chart



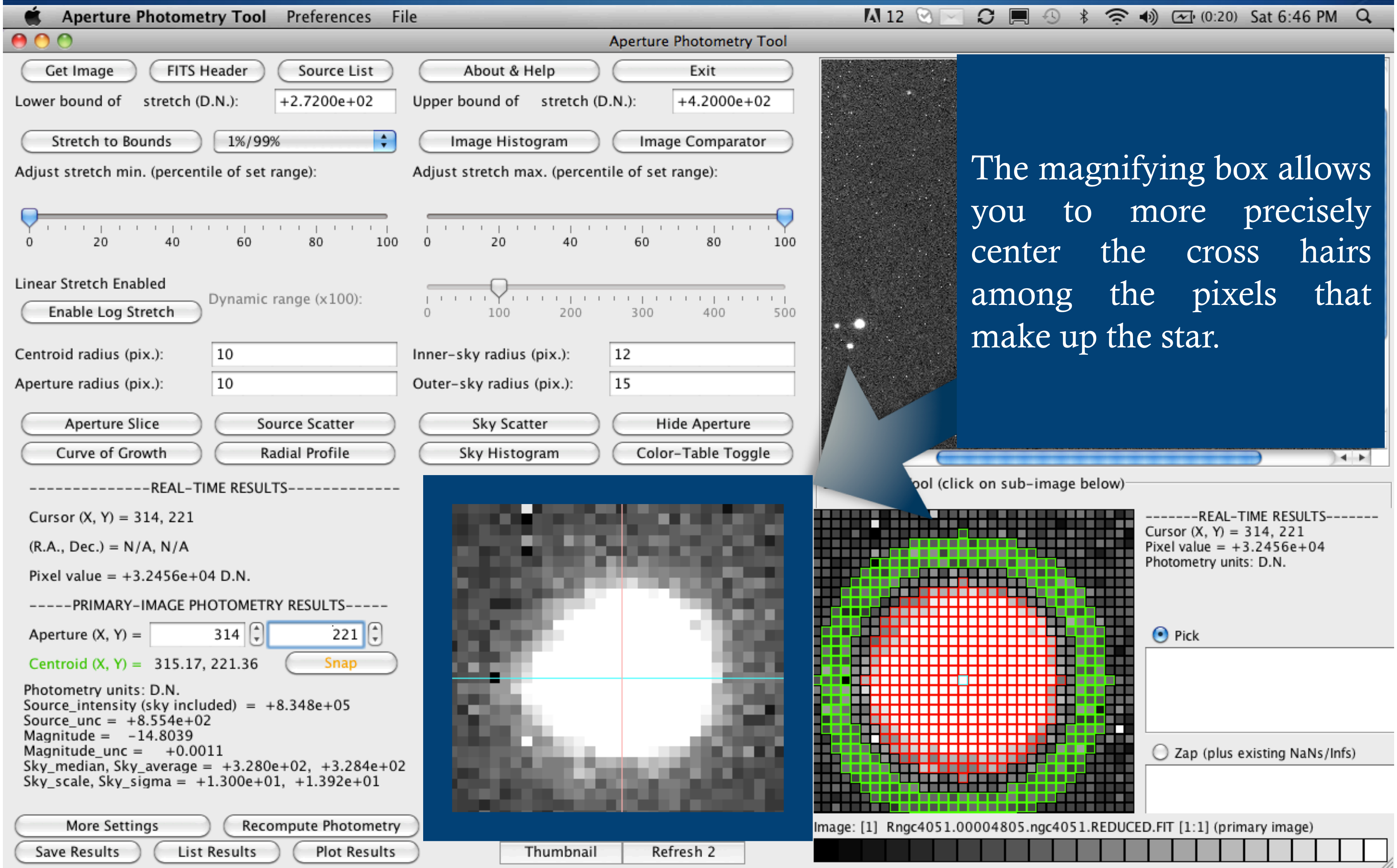
Active Galactic Nucleus is labeled as item 0. We looked for light variations in the AGN and used the measurements from the 10 surrounding stars as controls to verify stability in light output elsewhere.

Procedure

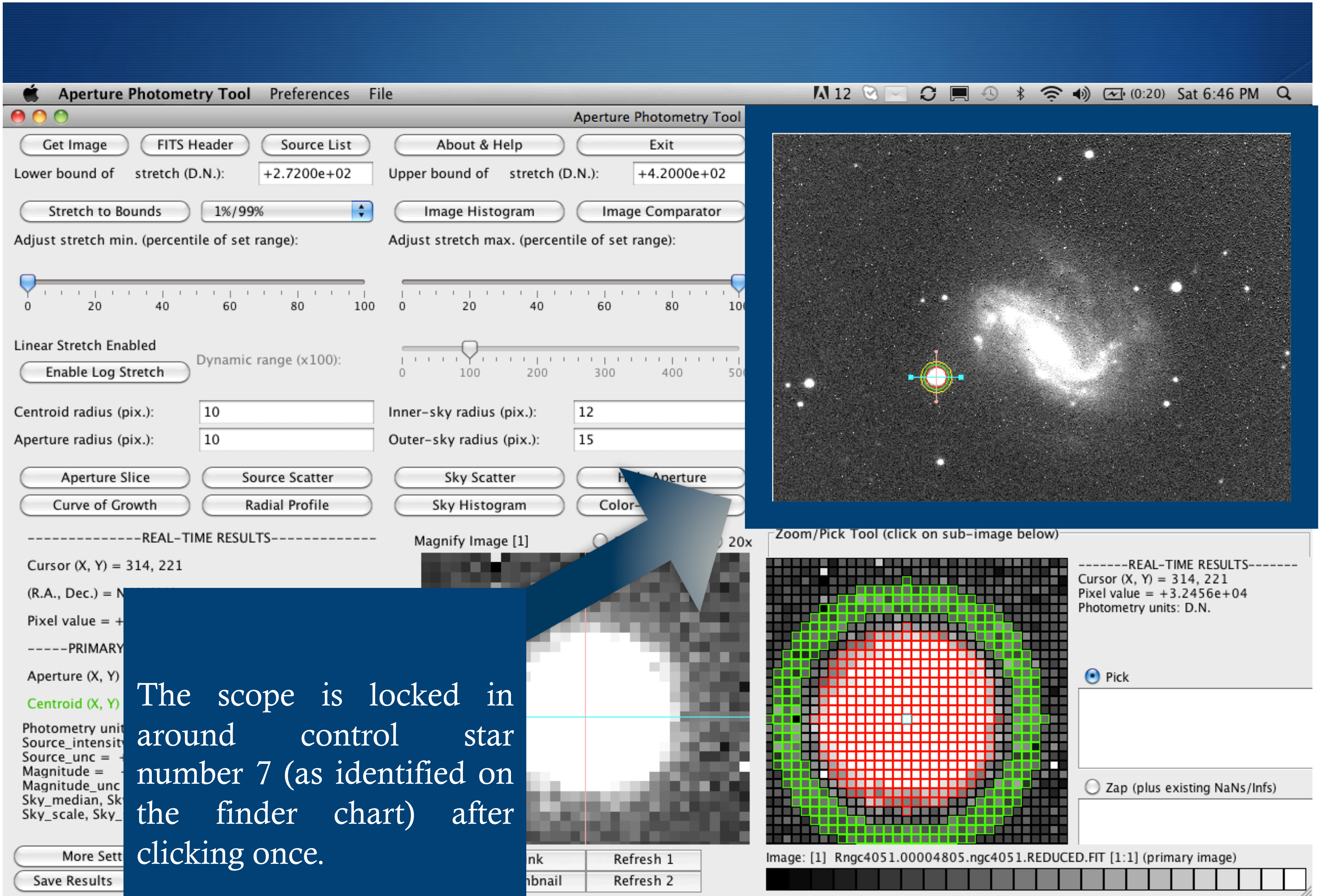
(4A) Center the scope on whichever star or galaxy that you are computing photometry for *(one of the 11 required points, which must be analyzed in order)* and click once. You can use the magnify feature to ensure that you are centering the scope.



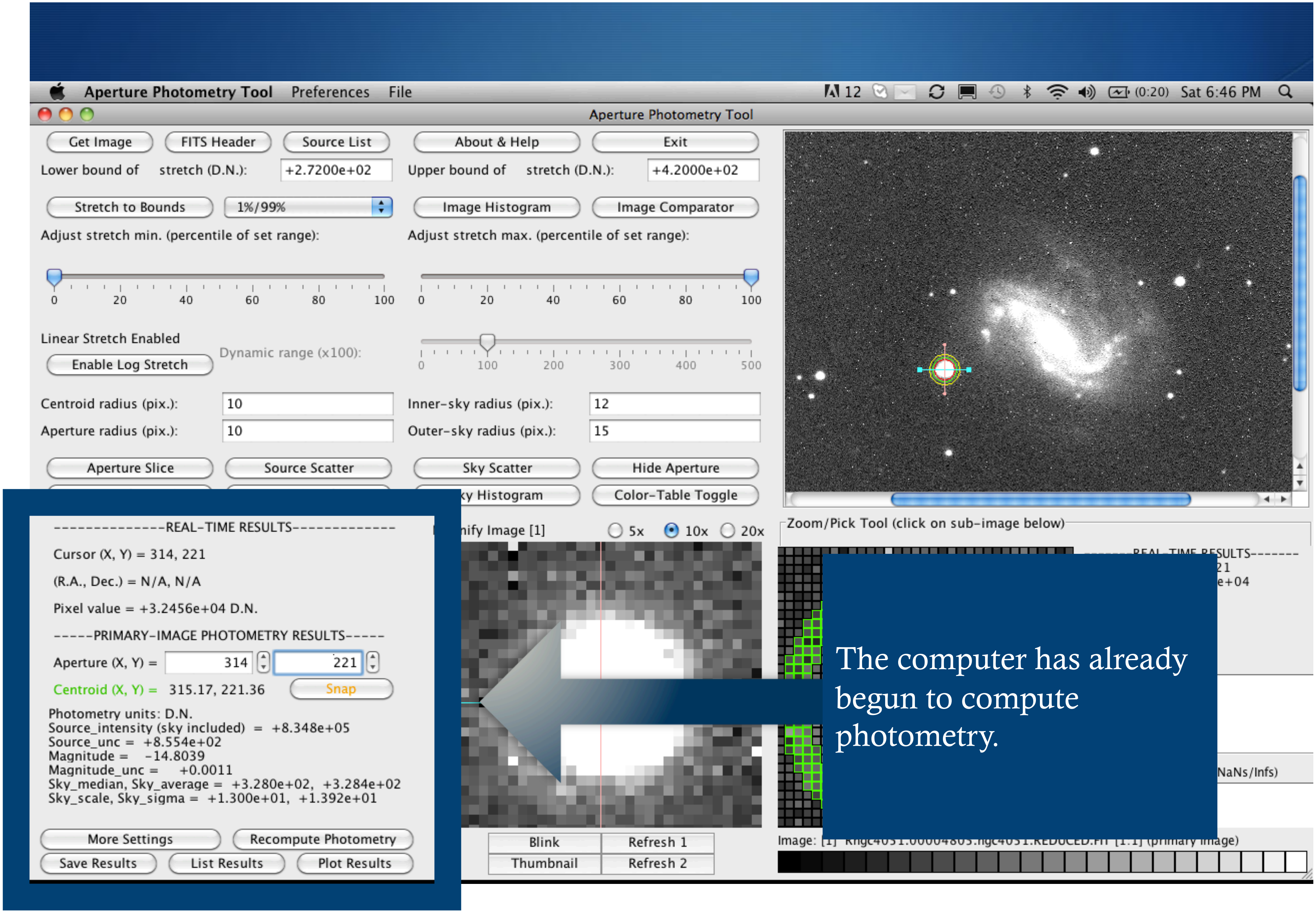
Aperture Photometry Tool
Preferences
File
Sat 6:46 PM
Aperture Photometry Tool
Get Image
FITS Header
Source List
About & Help
Exit
Lower bound of stretch (D.N.): +2.7200e+02
Upper bound of stretch (D.N.): +4.2000e+02
Stretch to Bounds
1%/99%
Image Histogram
Image Comparator
Adjust stretch min. (percentile of set range):
Adjust stretch max. (percentile of set range):
0 20 40 60 80 100
Linear Stretch Enabled
Enable Log Stretch
Dynamic range (x100):
0 100 200 300 400 500
Centroid radius (pix.): 10
Aperture radius (pix.): 10
Inner-sky radius (pix.): 12
Outer-sky radius (pix.): 15
Aperture Slice
Source Scatter
Sky Scatter
Hide Aperture
Curve of Growth
Radial Profile
Sky Histogram
Color-Table Toggle
--------------REAL-TIME RESULTS-------------
Cursor (X, Y) = 314, 221
(R.A., Dec.) = N/A, N/A
Pixel value = +3.2456e+04 D.N.
-----PRIMARY-IMAGE PHOTOMETRY RESULTS-----
Aperture (X, Y) = 314 221
Centroid (X, Y) = 315.17, 221.36
Snap
Photometry units: D.N.
Source_intensity (sky included) = +8.348e+05
Source_unc = +8.554e+02
Magnitude = -14.8039
Magnitude_unc = +0.0011
Sky_median, Sky_average = +3.280e+02, +3.284e+02
Sky_scale, Sky_sigma = +1.300e+01, +1.392e+01
More Settings
Recompute Photometry
Save Results
List Results
Plot Results
Magnify Image [1]
5x 10x 20x
Blink
Refresh 1
Thumbnail
Refresh 2
Zoom/Pick Tool (click on sub-image below)
-------REAL-TIME RESULTS-------
Cursor (X, Y) = 314, 221
Pixel value = +3.2456e+04
Photometry units: D.N.
Pick
Zap (plus existing NaNs/Infs)
Image: [1] Rngc4051.00004805.ngc4051.REDUCED.FIT [1:1] (primary image)



The magnifying box allows you to more precisely center the cross hairs among the pixels that make up the star.



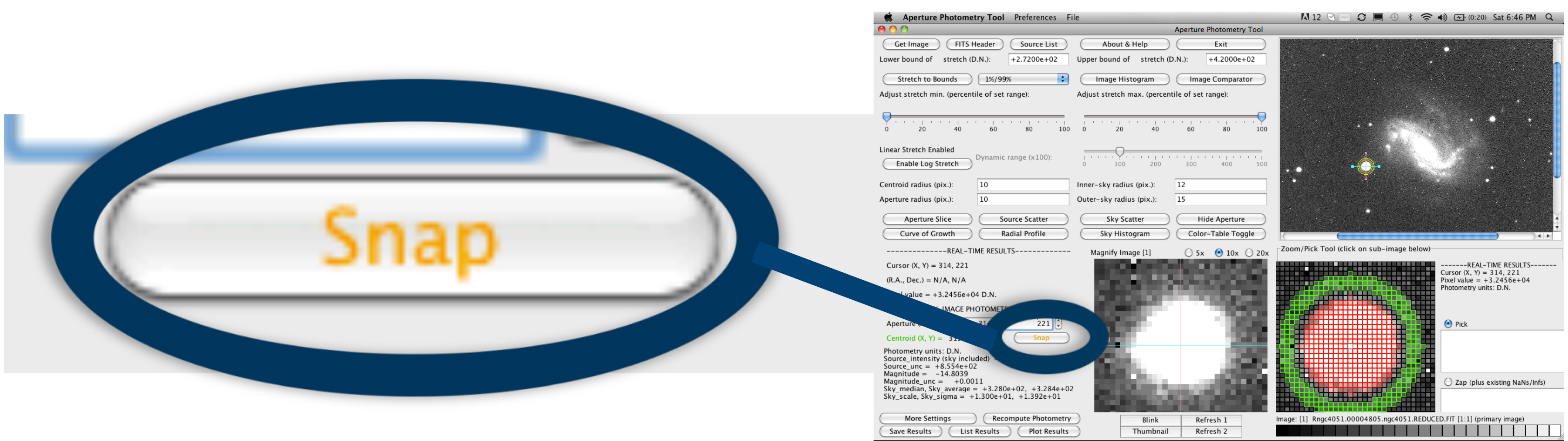
The scope is locked in around control star number 7 (as identified on the finder chart) after clicking once.



Aperture Photometry Tool
Preferences
File
Sat 6:46 PM
Get Image
FITS Header
Source List
About & Help
Exit
Lower bound of stretch (D.N.):
+2.7200e+02
Upper bound of stretch (D.N.):
+4.2000e+02
Stretch to Bounds
1%/99%
Image Histogram
Image Comparator
Adjust stretch min. (percentile of set range):
Adjust stretch max. (percentile of set range):
Linear Stretch Enabled
Enable Log Stretch
Dynamic range (x100):
Centroid radius (pix.):
10
Inner-sky radius (pix.):
12
Aperture radius (pix.):
10
Outer-sky radius (pix.):
15
Aperture Slice
Source Scatter
Sky Scatter
Hide Aperture
Color-Table Toggle
Zoom/Pick Tool (click on sub-image below)
--------------REAL-TIME RESULTS-------------
Cursor (X, Y) = 314, 221
(R.A., Dec.) = N/A, N/A
Pixel value = +3.2456e+04 D.N.
-----PRIMARY-IMAGE PHOTOMETRY RESULTS-----
Aperture (X, Y) = 314 221
Centroid (X, Y) = 315.17, 221.36
Snap
Photometry units: D.N.
Source_intensity (sky included) = +8.348e+05
Source_unc = +8.554e+02
Magnitude = -14.8039
Magnitude_unc = +0.0011
Sky_median, Sky_average = +3.280e+02, +3.284e+02
Sky_scale, Sky_sigma = +1.300e+01, +1.392e+01
More Settings
Recompute Photometry
Save Results
List Results
Plot Results
Blink
Refresh 1
Thumbnail
Refresh 2
The computer has already begun to compute photometry.

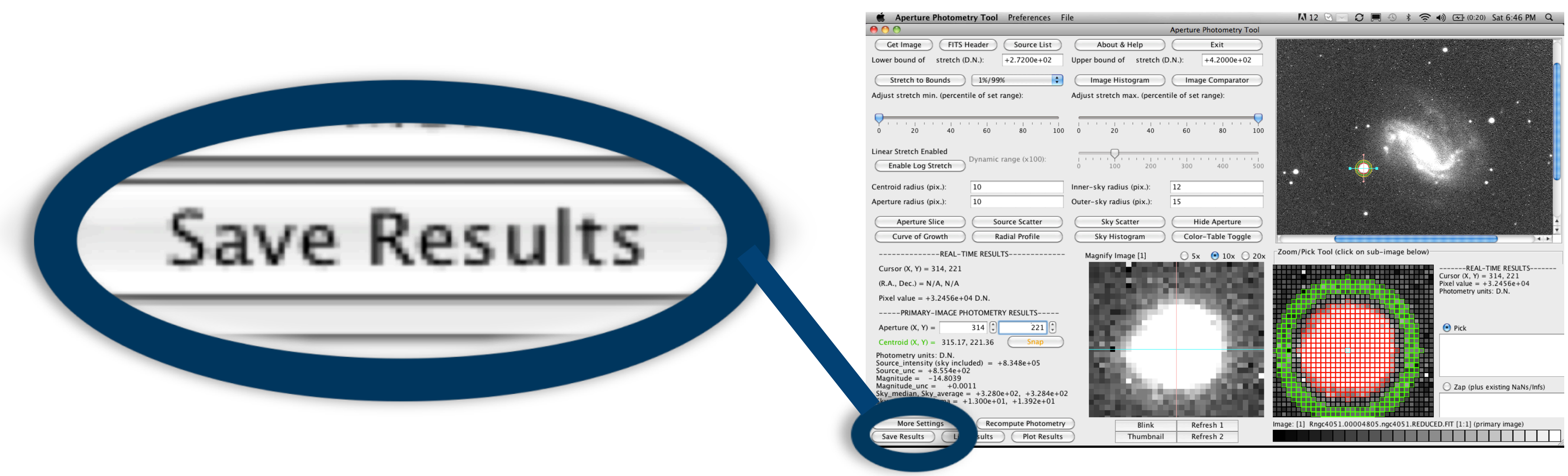
Procedure

(4B) Click the snap button. The snap feature moves the aperture to the integer pixel location that is closest to the centroid position of the object being measured. In other words, it effectively computes the center of the object that you are measuring and verifies your manual click in the center.



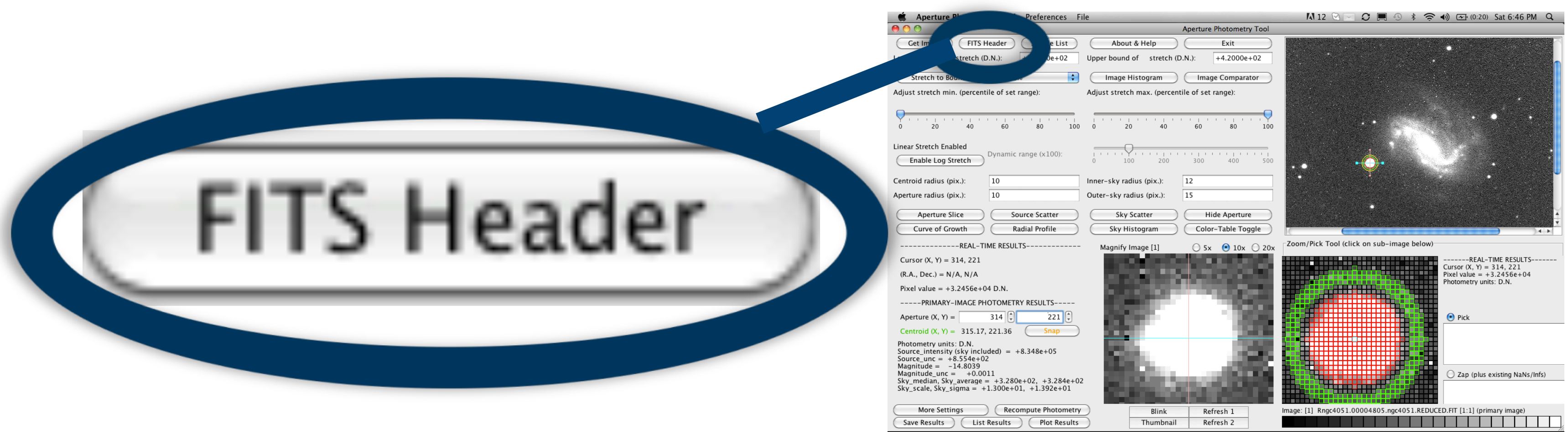
Procedure

(4C) Save Results. Clicking this button will save the photometry information for the star that you have your scope set on into the Photometry File. Continue to compute photometry for whatever points remain of the 11 that must be analyzed in each image.



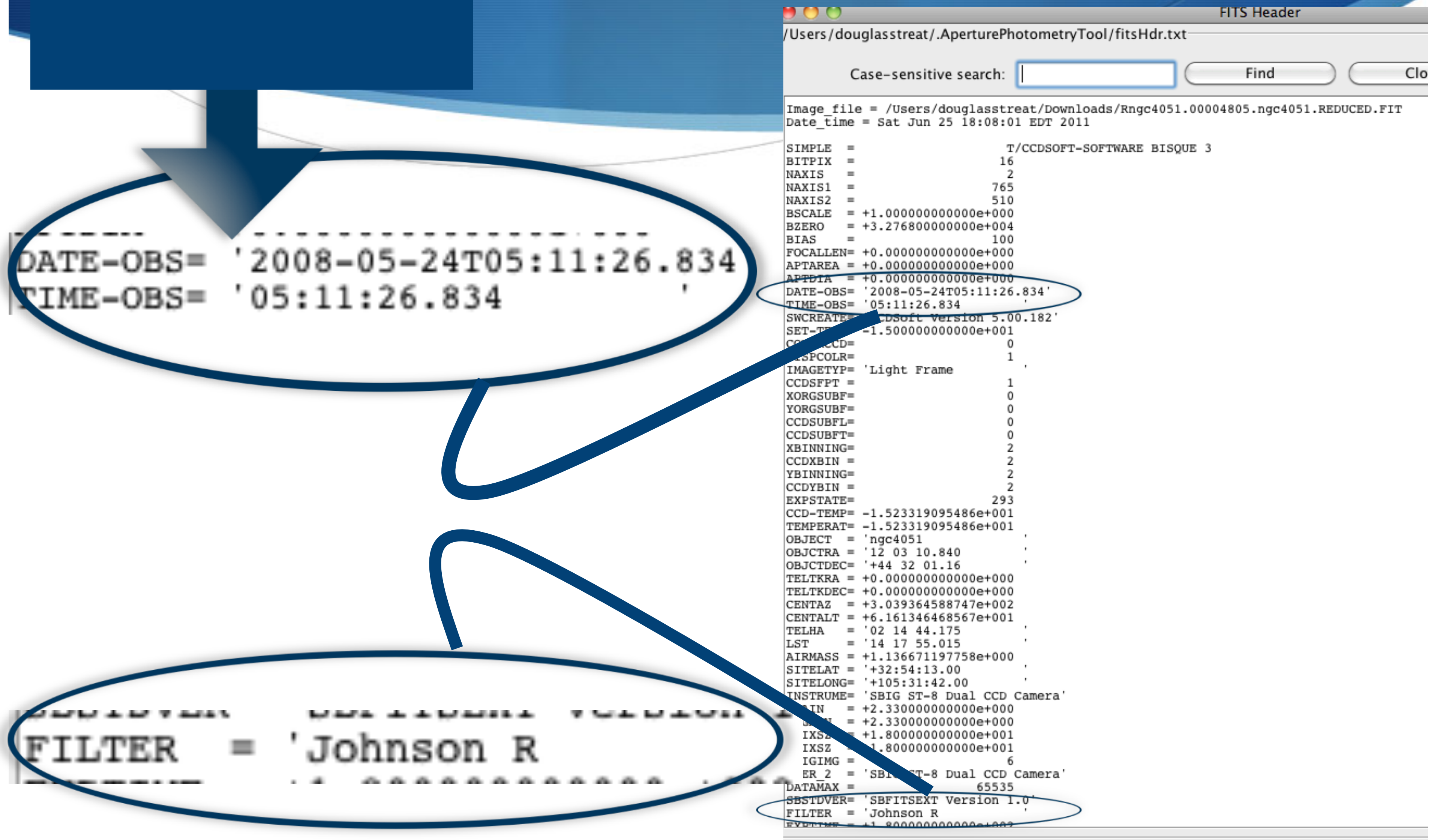
Procedure

(5) *Once you have set your scope, clicked, snapped, and saved photometry results for all 11 data points,* open the FITS header and record important and relevant information for the image such as date, time, and filter. Also convert dates to Julian dates. This information will be helpful in later analysis.



Procedure

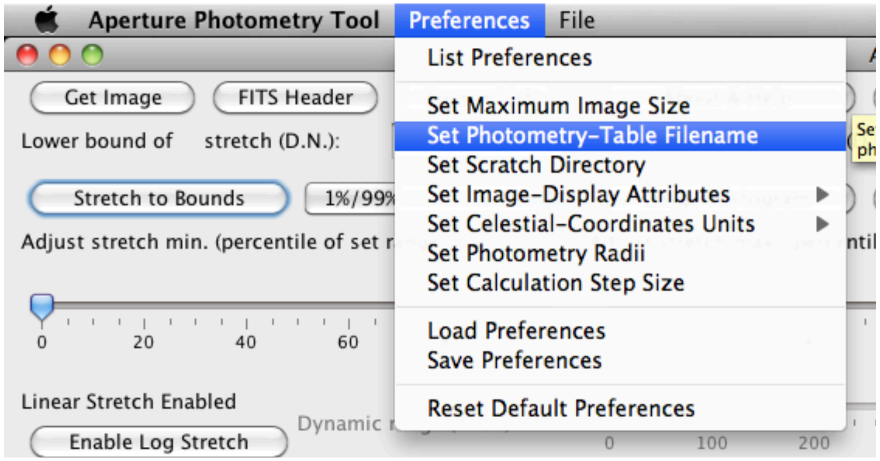
Convert to Julian dates.[5]



Procedure

(6) Repeat steps 2-5 as many times as desired. When done computing photometry, open the photometry file in Excel.

The photometry file saves as a .TBL file by default to one of the application subfolders. You can reset this at any time by going to **Preferences > Set Photometry-Table File Name**.



Procedure

(7) In Excel, manually add the important information extracted from the FITS header of each image (date, time, filter). Color code as necessary. Label rows with numbers corresponding to the stars they analyze as labeled on the Finder Chart.

Procedure

(7) The final photometry data file is now ready for analysis.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	
1	Date_time	=	Tue	Feb	10	13:39:17	CST	2009	'2008-05-20T05:28:19.887'		MJD=54606	54606										
2	Johnson R	X	Y	X_cen	Y_cen	Source_intensity	Source_noise	Data_units	Sky_model	Sky_median/pix	Sky_average/pix	Sky_RMS/pix	Sky_custom/pix	Sky_noise	Sky_scale	R_aper	R_i_sky	R_o_sky	N_aper	N_rej	N_sky	Im
3	0	421	243	421.333	243.09	3.04E+04	3.44E+02	D.N.	B	6.32E+02	6.31E+02	6.31E+02	0.00E+00	2.05E+01	1.94E+01	7	10	15	149	0	404	C:
4	1	63	211	62.532	210.59	3.14E+03	1.31E+02	D.N.	B	5.94E+02	5.95E+02	5.95E+02	0.00E+00	1.59E+01	1.60E+01	4	6	15	49	0	600	C:
5	2	91	423	91.11	422.941	2.14E+04	2.58E+02	D.N.	B	5.96E+02	5.96E+02	5.96E+02	0.00E+00	1.72E+01	1.72E+01	6	8	15	113	0	516	C:
6	3	145	318	144.897	317.809	3.11E+03	1.31E+02	D.N.	B	5.90E+02	5.90E+02	5.91E+02	0.00E+00	1.56E+01	1.60E+01	4	6	15	49	0	600	C:
7	4	189	207	188.761	207.013	1.03E+04	1.75E+02	D.N.	B	5.86E+02	5.86E+02	5.87E+02	0.00E+00	1.48E+01	1.42E+01	5	8	15	81	0	516	C:
8	5	178	83	178.073	82.517	1.70E+04	2.28E+02	D.N.	B	5.89E+02	5.89E+02	5.89E+02	0.00E+00	1.52E+01	1.52E+01	6	8	15	113	0	516	C:
9	6	315	131	315.265	131.256	1.62E+03	1.26E+02	D.N.	B	5.84E+02	5.84E+02	5.84E+02	0.00E+00	1.96E+01	1.60E+01	4	6	15	49	0	600	C:
10	7	313	214	312.598	213.612	1.84E+05	5.21E+02	D.N.	B	5.98E+02	6.27E+02	8.49E+02	0.00E+00	5.73E+02	2.40E+01	6	8	15	113	0	516	C:
11	8	460	430	459.959	429.52	5.47E+03	1.94E+02	D.N.	B	5.88E+02	5.87E+02	5.87E+02	0.00E+00	2.04E+01	1.80E+01	5	7	15	81	0	564	C:
12	9	545	301	545.033	300.851	1.39E+04	2.15E+02	D.N.	B	5.89E+02	5.89E+02	5.89E+02	0.00E+00	1.87E+01	1.80E+01	5	7	15	81	0	564	C:
13	10	673	233	672.702	232.623	2.35E+04	2.28E+02	D.N.	B	5.93E+02	5.94E+02	5.94E+02	0.00E+00	1.80E+01	1.69E+01	5	7	15	81	0	564	C:
14																						
15	Date_time	=	Tue	Feb	10	19:42:30	CST	2009	2008-05-22T04:55:41.488		MJD=	54608										
16	Johnson R	X	Y	X_cen	Y_cen	Source_intensity	Source_noise	Data_units	Sky_model	Sky_median/pix	Sky_average/pix	Sky_RMS/pix	Sky_custom/pix	Sky_noise	Sky_scale	R_aper	R_i_sky	R_o_sky	N_aper	N_rej	N_sky	Im
17	0	400	257	399.817	257.328	3.08E+04	2.61E+02	D.N.	B	4.10E+02	4.10E+02	4.11E+02	0.00E+00	2.09E+01	1.92E+01	5	8	15	81	0	516	/U
18	1	39	225	39.272	225.426	5.05E+03	1.14E+02	D.N.	B	3.64E+02	3.65E+02	3.65E+02	0.00E+00	1.29E+01	1.20E+01	4	6	15	49	0	600	/U
19	2	68	438	67.965	438.038	2.43E+04	1.90E+02	D.N.	B	3.66E+02	3.67E+02	3.67E+02	0.00E+00	1.88E+01	1.45E+01	4	6	15	49	0	600	/U
20	3	122	333	122.098	332.89	4.27E+03	9.97E+01	D.N.	B	3.61E+02	3.61E+02	3.62E+02	0.00E+00	1.52E+01	1.35E+01	3	5	15	29	0	640	/U
21	4	166	221	166.104	221.19	1.26E+04	1.48E+02	D.N.	B	3.58E+02	3.59E+02	3.59E+02	0.00E+00	1.27E+01	1.30E+01	4	6	15	49	0	600	/U
22	5	155	96	155.156	96.086	1.87E+04	1.63E+02	D.N.	B	3.61E+02	3.60E+02	3.61E+02	0.00E+00	1.19E+01	1.20E+01	4	6	15	49	0	600	/U
23	6	294	145	293.596	145.133	2.07E+03	7.85E+01	D.N.	B	3.55E+02	3.55E+02	3.56E+02	0.00E+00	1.30E+01	1.15E+01	3	4	15	29	0	664	/U
24	7	291	228	291	227.552	2.04E+05	4.73E+02	D.N.	B	3.67E+02	3.70E+02	3.71E+02	0.00E+00	2.78E+01	1.90E+01	4	6	15	49	0	600	/U
25	8	438	445	438.426	444.865	6.65E+03	1.63E+02	D.N.	B	3.59E+02	3.59E+02	3.60E+02	0.00E+00	2.84E+01	1.90E+01	4	6	15	49	0	600	/U
26	9	524	315	523.934	315.229	1.65E+04	1.86E+02	D.N.	B	3.59E+02	3.58E+02	3.59E+02	0.00E+00	2.26E+01	1.80E+01	4	6	15	49	0	600	/U
27	10	652	247	652.327	246.757	2.83E+04	2.08E+02	D.N.	B	3.61E+02	3.62E+02	3.64E+02	0.00E+00	3.29E+01	1.65E+01	4	6	15	49	0	600	/U
28																						
29	Date_time	=	Wed	Feb	11	13:57:52	CST	2009	2008-05-24T05:11:26.834		MJD=	54610										
30	Johnson R	X	Y	X_cen	Y_cen	Source_intensity	Source_noise	Data_units	Sky_model	Sky_median/pix	Sky_average/pix	Sky_RMS/pix	Sky_custom/pix	Sky_noise	Sky_scale	R_aper	R_i_sky	R_o_sky	N_aper	N_rej	N_sky	Im
31	0	424	251	424.242	251.12	8.77E+04	4.26E+02	D.N.	B	4.79E+02	4.85E+02	4.86E+02	0.00E+00	4.07E+01	4.05E+01	4	9	15	49	0	460	C:
32	1	63	219	62.723	218.713	1.58E+04	1.52E+02	D.N.	B	3.17E+02	3.16E+02	3.17E+02	0.00E+00	1.44E+01	1.15E+01	4	6	15	49	0	600	C:
33	2	92	432	91.689	432.385	6.86E+04	2.73E+02	D.N.	B	3.22E+02	3.24E+02	3.24E+02	0.00E+00	1.61E+01	1.35E+01	3	6	15	29	0	600	C:
34	3	146	327	146.09	326.919	1.40E+04	1.35E+02	D.N.	B	3.13E+02	3.13E+02	3.13E+02	0.00E+00	1.49E+01	1.15E+01	3	6	15	29	0	600	C:
35	4	190	215	189.917	214.978	3.58E+04	2.01E+02	D.N.	B	3.15E+02	3.14E+02	3.14E+02	0.00E+00	1.28E+01	1.20E+01	3	6	15	29	0	600	C:
36	5	179	90	178.998	89.635	5.39E+04	2.43E+02	D.N.	B	3.14E+02	3.16E+02	3.16E+02	0.00E+00	1.54E+01	1.30E+01	3	6	15	29	0	600	C:
37	6	318	138	317.899	138.121	7.64E+03	1.08E+02	D.N.	B	3.09E+02	3.09E+02	3.09E+02	0.00E+00	1.46E+01	1.15E+01	3	6	15	29	0	600	C:
38	7	315	221	315.174	221.361	5.79E+05	7.93E+02	D.N.	B	3.43E+02	3.85E+02	7.01E+02	0.00E+00	5.86E+02	3.99E+01	3	7	15	29	0	564	C:
39	8	463	439	463.408	438.572	2.18E+04	1.92E+02	D.N.	B	3.11E+02	3.10E+02	3.11E+02	0.00E+00	2.24E+01	1.65E+01	4	7	15	49	0	564	C:
40	9	549	309	548.766	309.02	4.97E+04	2.38E+02	D.N.	B	3.16E+02	3.16E+02	3.16E+02	0.00E+00	1.85E+01	1.50E+01	3	6	15	29	0	600	C:
41	10	677	240	677.363	240.294	8.29E+04	3.05E+02	D.N.	B	3.20E+02	3.21E+02	3.22E+02	0.00E+00	2.18E+01	1.80E+01	3	6	15	29	0	600	C:
42																						
43																						

Endnotes:
Resources and Additional Information

[1] The software documentation for APT can be found at http://spider.ipac.caltech.edu/staff/laher/apt/AboutAndHelp.html

[2] For more information about FITS files, visit the NASA FITS website at http://fits.gsfc.nasa.gov/

Endnotes:
Resources and Additional Information

[3] For more information about the Spitzer Science Center and the Spitzer Space Telescope, see the main websites at http://ssc.spitzer.caltech.edu/ and http://www.spitzer.caltech.edu/ The Spitzer Teacher program has now morphed into the NASA/IPAC Teacher Archive Research Program (NITARP), http://nitarp.ipac.caltech.edu

[4] Find the posters here:

http://coolcosmos.ipac.caltech.edu/cosmic_classroom/teacher_research/aas/konstantin_2010may.pdf

http://coolcosmos.ipac.caltech.edu/cosmic_classroom/teacher_research/r3-ngc4051/081230-WISE-Spitzer-NGC4051-science.pdf

Endnotes:
Resources and Additional Information

[5] Julian Date Converter can be found at

http://www.csgnetwork.com/julianmodifdateconv.html

For more information about and contact information for astronomer and lead researcher Varoujan Gorjian, visit http://science.jpl.nasa.gov/people/Gorjian/

To access this group's conference website for the ISTE visit http://www.wix.com/remoteobservers/iste

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Jeff Adkins prepared the Finder Chart included in this presentation.

The procedure outlined in this presentation is based on a procedure originally designed and implemented by Gorjian et al. For a full list of contributors, see the AAS poster cited in endnote 4.