Important:

Do not forget to switch to rotate vertang -44. Sometimes the OA/SA will swap it back, so check after LGS checkout.

Before you observe:

Target list preparation:

You need to submit targets for LGS ~3-4 days in advance of the night. These will be run through space command and you will be told when you can't run LGS on every target on the night of. Err on the side of including things in the LGS list if you have space, because you don't know what the conditions will be, but a general rule of thumb:

-R<13 safe NGS, even if conditions are so-so. If conditions are bad enough that you can't NGS on this the laser won't work either.

-R<14 reachable with NGS under normal conditions, consider putting in LGS list if important.

-R<15 possible NGS with good conditions and at reasonable airmass. Significant loss of strehl compared to LGS (see website for more details)

-R<16 can only be done as NGS if the target is very red (like M3 or later) and under good conditions. Fortunately many of our targets are red. I locked onto an M4 with R=15.5 once, but there was a noticeable loss of strehl.

-Eric managed to get a R~17 red (M3) star one night. The data was not high quality but usable.

It's important to have NGS backups for the *whole night*. LGS fails sometimes, and you do not want to waste one second of Keck time if it can be avoided.

Note: NGS cuts overheads from 3m to 30s, but LGS often improves strehl if the target is faint (usually around 13.5<R<14.5 is the turnover). Very bright targets have lower overheads and better strehl because the AO correction is being done on-axis and with the same color distortion as the target.

All targets ***need*** to have a decent R magnitude. The only exception is if you are using LGS with a nearby tip-tilt star. If that is the case for a large fraction of your targets then this is probably not the guide for you, since I built this with my own (mostly bright) targets in mind. I use APASS r where possible but have managed to make do with USNO R magnitudes in other cases. If the R magnitude is bad you will waste a lot of overhead while the AO system is taking new images to decide how bright the target is. Not a major disaster but not a great idea.

For faint targets you can add tip-tilt stars using the AO guide tool online (through your Keck user page). Perhaps after uploading it but before submitting it.

A sample target list for Keck AO might look like this:

KOI-0222 19 11 33.99 +39 20 20.9 2000.0 LGS=1 Kmag=12.3 Rmag=14.7
KOI-0784 19 35 53.61 +50 31 54.9 2000.0 LGS=1 Kmag=12.6 Rmag=15.4
WISE_J0642+4101 06 42 5.607 +41 01 53.44 2000.0 lgs=1 # kmag=14.3 SpT=19.0 d_phot=16.1
1310-0172927 06 42 7.897 +41 01 58.96 2000.0 sep=26.5 rmag=15.52 b-v=1.01 b-r=1.20 r-i=0.48 S=0.26 kmag=14.0
1310-0172913 06 42 4.539 +41 02 30.51 2000.0 sep=39.0 rmag=15.78 b-v=0.90 b-r=0.98 r-i=0.28 S=0.23 kmag=14.7

1310-0172915 06 42 4.755 +41 02 31.72 2000.0 sep=39.5 rmag=17.15 b-v=0.93 b-r=0.83 r-i=-0.19 S=0.19 kmag=14.7
PM_I19215+4230 19 21 32.10 +42 30 52.3 2000.0 LGS=0 Jmag=8.6 Kmag=7.8 Rmag=11.6 Vmag=12.2 pmra=0.0015 pmdec=0.160 Sep=0.126 comment=LowPriority b-r=2.0
PM_I19452+4043 19 45 12.51 +40 43 18.4 2000.0 LGS=0 Jmag=9.0 Kmag=8.1 Rmag=12.8 SRC=Calibrator
BD+45_2850 19 11 32.53 +45 31 22.6 2000.0 LGS=0 Jmag=8.4 Kmag=7.8 Rmag=10.6 SRC=Calibrator
PM_I19351+0827 19 35 06.30 +08 27 38.7 2000.0 LGS=0 Jmag=7.3 Kmag=6.5 Rmag=9.8 Vmag=10.3 pmra=-0.0028 pmdec=-0.053 Sep=0.291 comment=LowPriority b-r=2.4
PM_I20298+0941 20 29 48.33 +09 41 20.2 2000.0 LGS=0 Jmag=8.2 Kmag=7.3 Rmag=12.3 Vmag=13.0 pmra=0.0450 pmdec=0.138 Sep=0.048 comment=LowPriority b-r=2.5
PM_I20138+1323 20 13 51.80 +13 23 19.7 2000.0 LGS=0 Jmag=8.3 Kmag=7.5 Rmag=10.4 SRC=Calibrator
HC0416584981446 04 16 58.50 -14 46 18.4 2000.0 LGS=1 Jmag=10.7 Kmag=9.5 Rmag=14.5

Note the important elements in this list. The faint target (WISE_J0642) has 3 possible tip-tilt stars, so it doesn't need an Rmag. Everything has a Kmag. The tightest binaries have calibrator stars already selected for doing masking. Comments are given on the priority for targets within one of the surveys. Proper motions are provided for fast moving targets. Bright targets are marked as LGS=0, fainter ones as LGS=1.
Important: items after comment= will generally be ignored by the LGS system. This means if you put lgs=1 after the comment line you might run into a problem when getting the laser to work. Fortunately this is easy to fix, but best to do it in advance.

Selecting TT stars:

You can probably go to R~19 on axis, but since this depends on conditions, for stars fainter than R~18 you should add in TT stars. Adding TT stars for R~17 is pointless, if the conditions are that bad, the laser will not work and you will be limited to R<<17 anyway. Use the AO guide star tool for this. Closer and brighter is better. Note that you ***cannot*** do masking when using a TT star.

Other useful documents:

driving_nirc2.txt: instructions for aperture masking from the original masking team
http://www2.keck.hawaii.edu/inst/nirc2/Manual/ObserversManual.html: Keck NIRC2 observing manual. Contains the major commands you will need.

A few general principles:

Survey Speed vs precision/depth:

This guide assumes you are observing for speed, i.e., maximize the number of targets per night. If your interest is studying a small sample of targets very precisely then the advice given here is probably not as valid, since we often take shortcuts to increase the sample size at the cost of precision.

Dithering:

Dithering takes additional time, especially since the AO loops get opened for 10-30s when you move. The advantage is you can sample different parts of the distortion solution (better astrometry) and different parts of the CCD response (better flux calibration). Because the new distortion solution from Service et al. is pretty precise, in most cases dithering is not needed.

PA vs Vertical angle mode:

Vertical angle mode is generally better, although most other groups use PA mode. The advantage of PA mode is that north is always up. But the disadvantage is that your speckle pattern shifts around with the rotator, so it's hard to do PSF subtraction (which is more precise for astrometry and photometry). PA mode is better if you are lazy on data analysis and is generally not suggested if you want to do things correctly. There is no overhead cost either way.

Calibration data:

Take flats only when the instrument is released: http://www2.keck.hawaii.edu/inst/siastng/release/web/Sias/siasEh.php?host=mysqlserver&table=datebook

You should take, flats in the afternoon (after instrument release) and darks in the morning when you are done taking data. The flat field for Kcont is almost identical to Kp (same with Hcont vs H), but otherwise you should take flats in every filter you plan on using. There is a script for this that you can steal/modify. The flat field script can be found in awm or alk directories (type user awm or user alk) and is usually named flat.XXXXXX. Adjust to make sure you cover all the filters you need. This can be run as soon as the telescope and instrument are released. Somewhere on the NIRC2 website is the suggested exposure times for the flat field if you don't see it set in the script.

When run, the flat-field script might ask for your permission to go (something about the optical bench). If the instrument has been released it should be OK, but to be on the safe side check with the SA. Try to make sure this will finish before sunset, as it's annoyingly hard to cancel a script written this way.

The flat field is very stable, so flats from earlier nights can be used. Don't use flats from years ago, there have been changes in the system (e.g., earthquake).

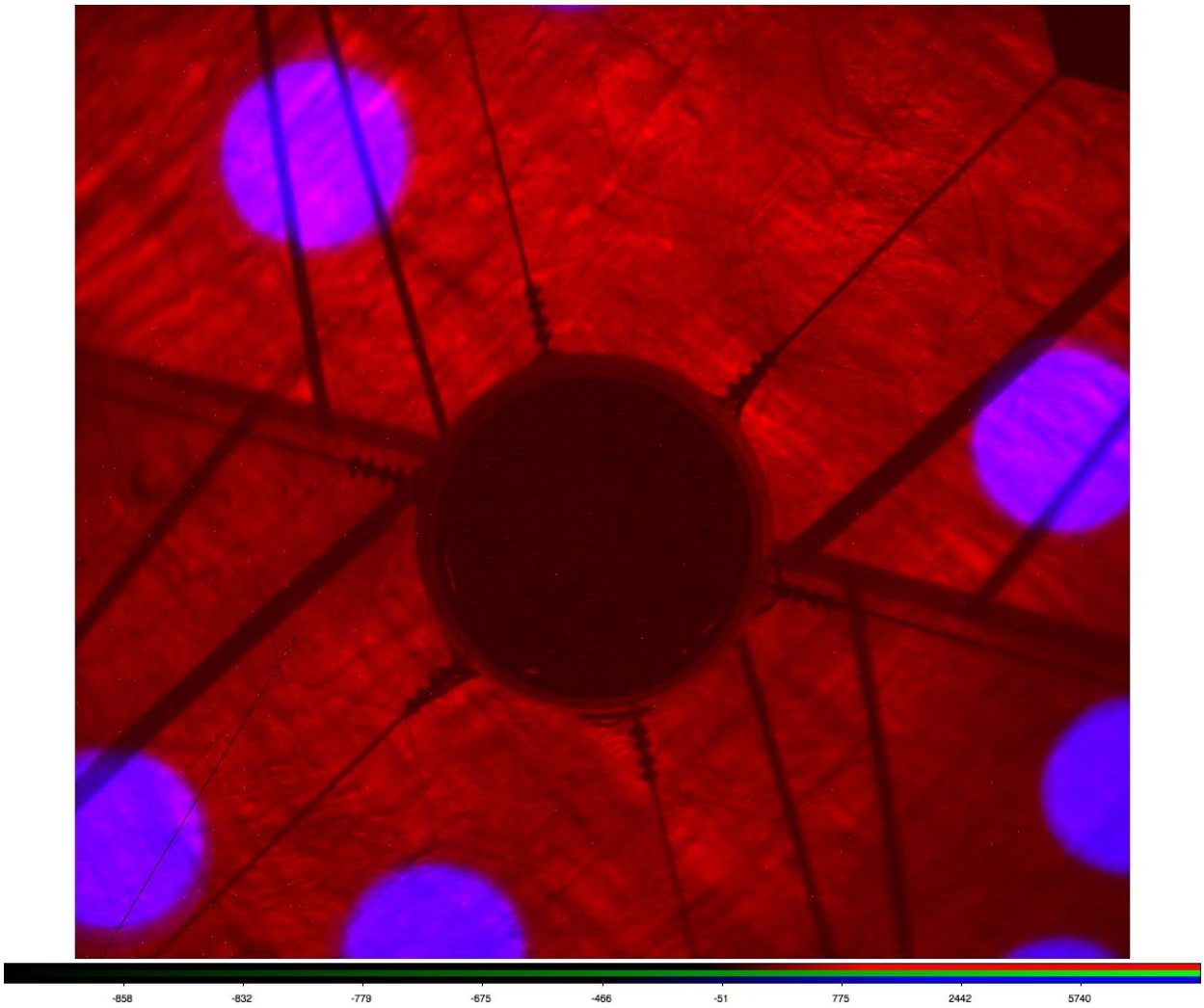
Note that if you want to use the coronagraph you need to take flats with it in the same position. Again the script should do this if you are putting the coronagraph in the same spot.

Darks should be taken in every single mode and exposure time used throughout the night. There is an IDL script for this called dark_script.pro (ask Andrew if you don't have it). This can be run with just the path to the data.

Setting up the 9 hole mask:

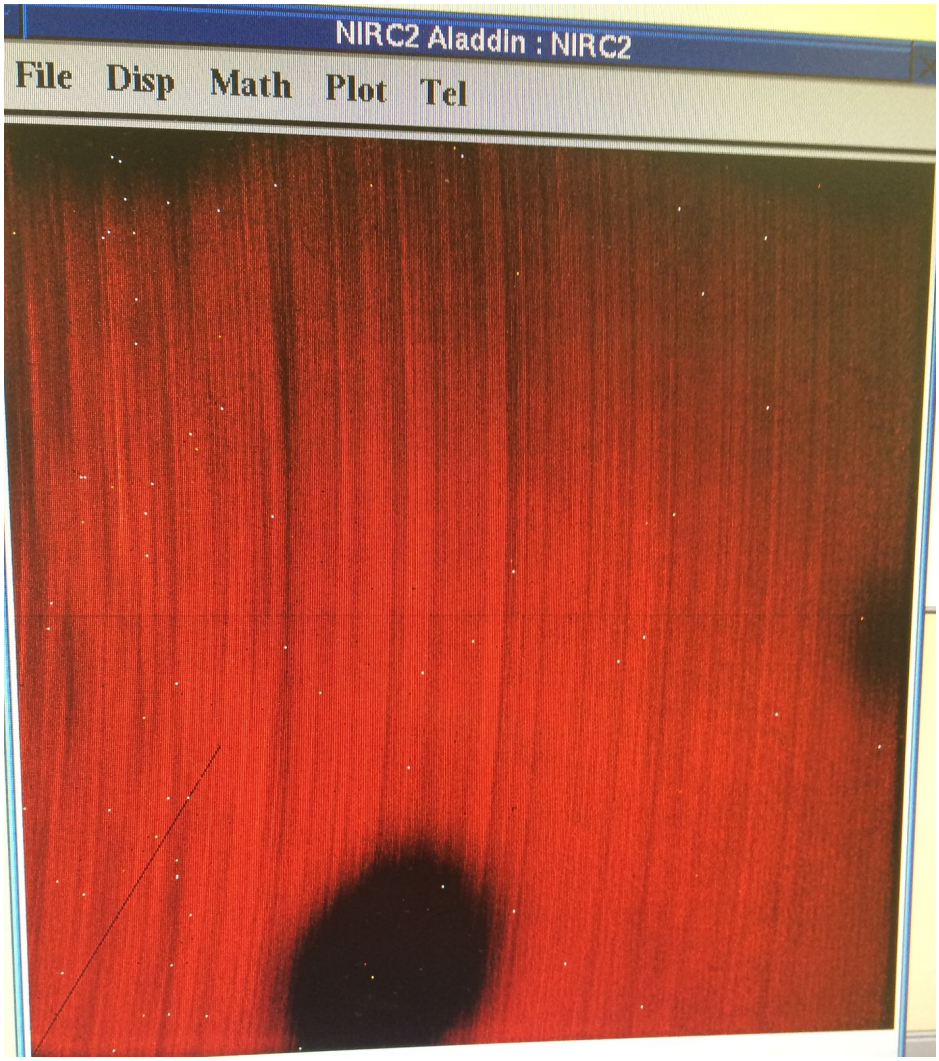
If you want to do masking you need to make sure the 9 hole mask is setup properly. Do:

Grism lens
Filt kp
Pupil open
Camera wide
tint 3 (experiment with exposure times)
goi 1
gilt 7 13
tint 10.0
goi 1
On NIRC2 image preview do sdiff
You should see something like this (but in b/w):



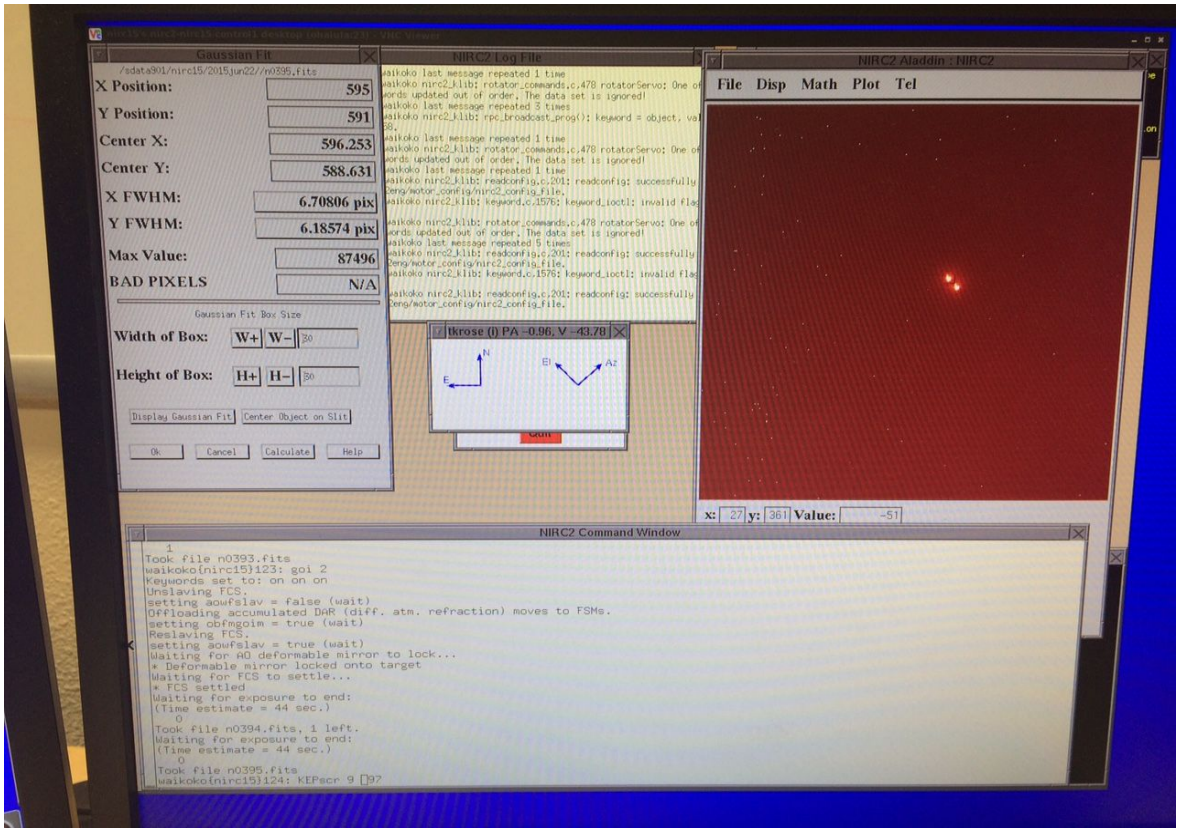
Note that this image incorrectly has the largehex in, so it looks like the apertures are being blocked. Ignore this, all that matters is that the spiders (those with windy cylinders attached near the secondary) don't cover the apertures, and that the apertures are roughly centered in the Keck segments. If the apertures cover more than 1 segment, you get 2nd order terms in the kernel phase. This particular image they are not well centered, but we didn't adjust, because we can't see if the few holes that aren't visible fall off the edge (which is much worse). Not clear how to get a larger field of view. This needs more investigation.

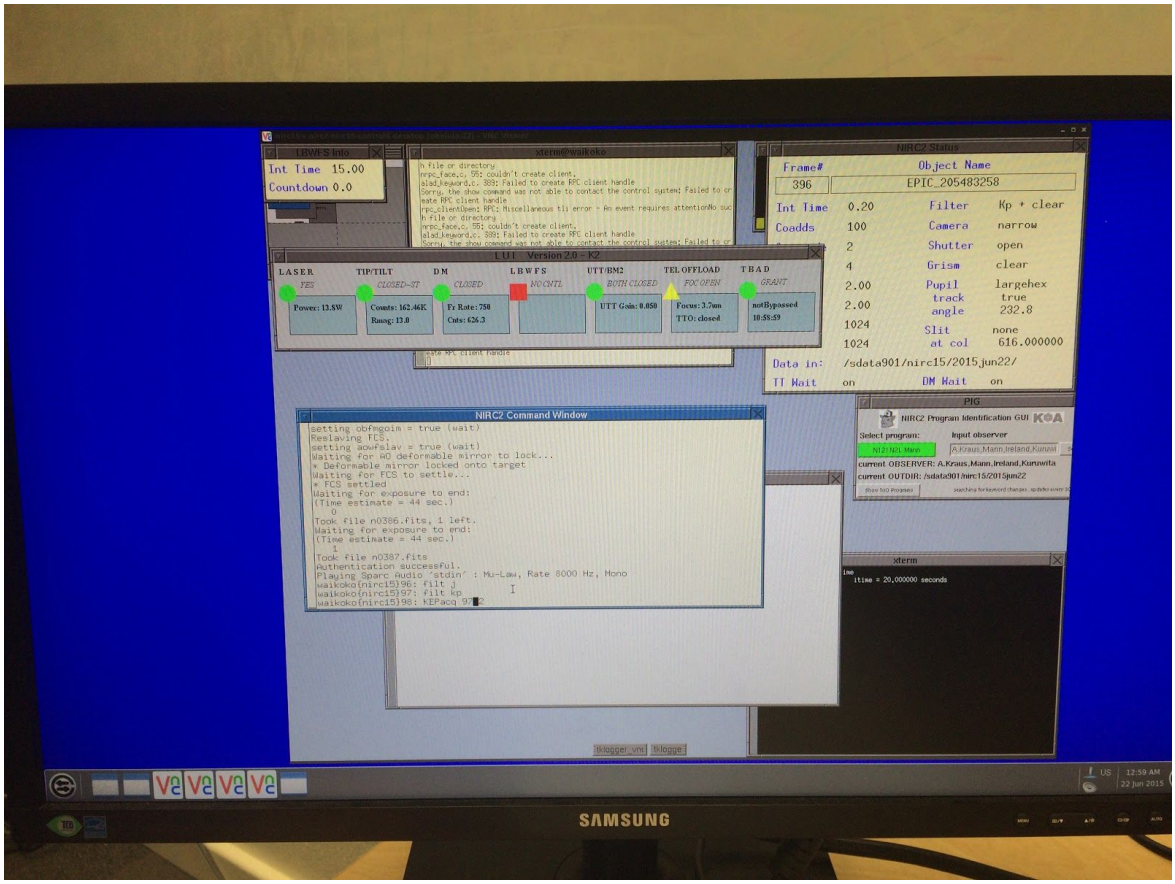
Flat field should look like this:



Setup:

You should have 3-4 screens that look like this (and yes, I took these pictures with my iPhone):


Gaussian Fit
/sdata901/nirc15/2015jun22//n0395.fits
X Position: 595
Y Position: 591
Center X: 596.253
Center Y: 588.631
X FWHM: 6.70806 pix
Y FWHM: 6.18574 pix
Max Value: 87496
BAD PIXELS N/A
Gaussian Fit Box Size
Width of Box: W+ W- 30
Height of Box: H+ H- 30
Display Gaussian Fit
Center Object on Slit
Ok
Cancel
Calculate
Help
NIRC2 Log File
tkrose (i) PA -0.96, V -43.78
N
E
El
Az
NIRC2 Aladdin : NIRC2
File Disp Math Plot Tel
x: 27 y: 361 Value: -51
NIRC2 Command Window
Took file n0393.fits
waikoko{nirc15}123: goi 2
Keywords set to: on on on
Unslaving FCS.
setting aowfslav = false (wait)
Offloading accumulated DAR (diff. atm. refraction) moves to FSMs.
setting obfmgoim = true (wait)
Reslaving FCS.
setting aowfslav = true (wait)
Waiting for AO deformable mirror to lock...
* Deformable mirror locked onto target
Waiting for FCS to settle...
* FCS settled
Waiting for exposure to end:
(Time estimate = 44 sec.)
Took file n0394.fits, 1 left.
Waiting for exposure to end:
(Time estimate = 44 sec.)
Took file n0395.fits
waikoko{nirc15}124: KEPscr 9



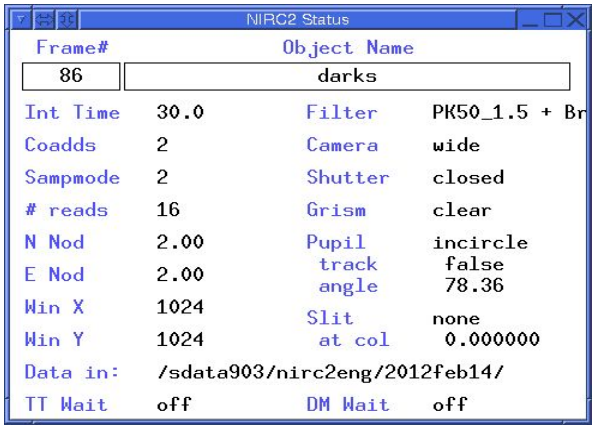
On the left screen you will see:

-The AO loop window (green/yellow/red lights), these turn green when AO loops are closed.

-PIG (tells you who you are)

-Any xterms you opened (right click, login windows -> xterm@waikoko)

-NIRC2 status with basic setup parameters. The parameters seen above are a reasonable place to start. Here's a close-up of this window:



Note that these settings are wrong in a bunch of ways. For example, you should almost always be using the narrow camera. TT wait and DM wait should probably be on, among a couple others

On the middle screen you will see:

-NIRC2 quicklook (right click->NIRC2 control->other subcomponents->something obvious)

-Gaussian fit (inside the quick look, Plot->Gaussian fit)

-Any xterms you opened

-Some junk in the background that doesn't matter

On the right screen you will see:

-Magiq (load and map star lists here). This guide will not explain how to use magiq, check the guide online.

Make sure you are logged in as the correct user, it should be nircXX (check the telescope schedule for your number). If not log out (power button in the bottom right), and log back in (password is kahoku), launch KNCGUI with your nirc account (password is wombat1).

Launch the NIRC2 software (right click, should be obvious in the menu)

On an xterm, type user pgt (gets the aperture masking scripts) and then user awm. It will tell you the path to all the scripts. You might also want user alk.

Copying over target lists is easiest done using the online web tool. Just google Keck observer login, and it should be pretty clear from there. Copy them from /kroot/starlists/web/blah to /kroot/starlists/username

Make sure your targets have rmags and kmags; Vmags are also nice but not required. Rmags are essential for the guide star to work properly.

Probably the OA already loaded your list. Try mapping their list, if not load it manually to check nothing insane is going on.

Type http://observinglogs/ into your browser for on the fly observing logs. You can add comments.

Taking data:

Some rules of thumb:

For all scripts, kmag=K magnitude*10 (because shell scripts don't like decimals)

Can use "test" to take an image but not save to disk (warning: will use the last-used setup)

Saturation is a good way to kill your astrometry and photometry. Ideally you want 3k <~ peak counts <~ 12k (note you have to divide by the coadds when using the gaussian fit tool), and peak counts > 15k (per coadd!) should be avoided if possible. Lower the exposure time and increase the coadds, or switch to the "cont" filters to lower the throughput. On a good night, a very bright (K~5) star may saturate even with sampmode 2; tint 0.2; tilt Kcont, but there's no good solution here.

For masking the range is more like 500--8000 peak counts (per coadd). Non-linearities are more annoying to calibrate out in masking so the upper limit is a bit lower. The low limit is also lower as you are limited by calibration errors, not poisson errors.

Binaries tighter than ~0.1" probably need masking. Although PSF subtraction can help a lot with elongated PSFs (slightly unresolved binaries).

The scripts are generally OK, but under unusually good or bad conditions they will overestimate or underestimate the setup. Adjust them as needed (they should be pretty clear). A simple way to adjust for counts too low or high is to just add or subtract an appropriate number (0.5, 1, etc) to the kmag used in the input values.

Start of night:

The support astronomer will run LGS checkout. This can't start until about 10-15m past twilight and will take anywhere from 10 to 45m.

The Scripts: (fill this out later, I need to make more scripts and more edits)

Useful commands:

mov currentX currentY desiredX desiredY

General Survey Strategy:

Highlight target, tell TO to slew.

Imaging:

While slewing, run *image_setup kmag*10*

When AO loops close run *goi 2*

Check counts 3k -- 12k peak per coadd, adjust tint if needed

goi 6

Masking:

Run *mask_setup kmag*10*

When AO loops close (if you did not do imaging first) *goi 2*

Check mask looks reasonable, counts 500 - 8k peak. Adjust if needed

goi 6

Select next target on list. Slew when image/mask complete.

You do not need to do imaging on masking calibrators. If done correctly, you can slew to the calibrator and just do *goi 2* (then *goi 6* after checking things are OK) since the setup should be the same.

What to do if the weather is poor:

Sometimes because of thin and/or variable cloud cover, or bad seeing, you can get AO to lock but the correction is poor, or you can get AO to lock but it gets lost easily. The solution here is essentially to do lucky imaging on your AO data. This is not scripted (yet):

Reduce the recommended coadds to 1, or at most 5.

If the binary is wide really good correction might not be needed, take a few images to see.

If the binary is tight, reduce the field of view with

subc 512 or even *subc 256* for really tight ones.

Take the number of images consistent with the coadds, or even coadds*exposures. With the smaller sub-array the overheads are not too bad, but if the full frame is needed do not take a lot of images.

If AO is losing/gaining lock a lot, you might need to switch *wait4ao off* to make sure the exposure starts (and hope the AO locks during).

In this way, usually you can get a few good images out of many.

Specific Survey Comments:

Delfosse:

If the target is not a binary in imaging (or just an elongated PSF), then switch to masking immediately. Take a calibrator after (hopefully one is on the list just below the target). If it's marginally resolved you can take a full imaging set. If you are unsure the safe move is a full imaging and masking set, but this is quite expensive. A rule of thumb is that if you see two peaks (even if they overlap a bit) then imaging will be fine. If you can't disentangle the two peaks then masking is probably required.

UV_M:

No masking required. Just 7-8 images and move on.

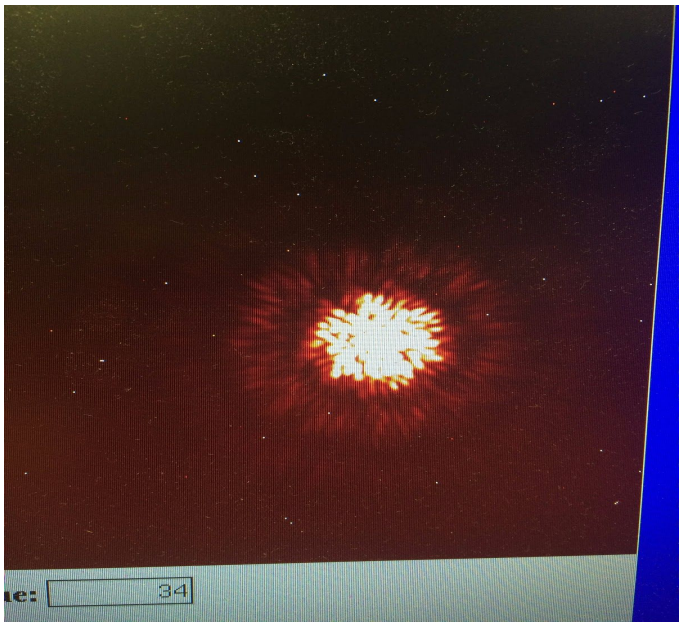
ZEIT:

All targets require both imaging (7-8) and masking (7-8). If you see a clear 0.1-1" binary in imaging skip the masking. If you do more than 2-3 together you may skip calibrators, since we can use them as calibrators for each other.

YMG:

See ZEIT.

Masking data should look like this (this is an interferogram):



Copying data:

You probably have to copy data to run the dark script at the end of the night. An alternative is to simply run a generic dark script that covers all the major modes we use. NIRC2 Status will show you where data is stored; typing "cdata" into the black xterm window under NIRC2 Status will change you into the data directory, and you can scp data from there to your computer. Rsync never works for some reason (ask the SA about this?).

End of night:

Make sure to copy over data and generate the dark script (on local machine)
aohatch close (before taking darks) (actually looks like the OA does this)
shutter close (important to do this before taking darks)
Chmod a+x dark.XXXXXX

./dark.xxxxxxx

See above for how to generate dark.xxxx script.

Save the content of /observinglogs/ as a pdf and email to self.

The Quicklook tool:

It would be nice to have some tips on how to use this, lots of cool things you can do with it!

Troubleshooting:

A doughnut PSF: this happens, not sure how to fix it.

Few random notes:

-AO setup takes longest because the OA has to get 'sky' images. But this isn't totally needed out of twilight. Ask them to turn it off if the targets are bright and conditions are good. But occasionally you will regret this decision.

-In general always use Kp+clear for fainter targets

-Use Kcont for K<7? (something around there).

-Use the following guide for sampmode/coadd/tint for masking:

K>13: *sampmode 3 64 ; coadd 1 ; tint 60*

9.5<K<13: *sampmode 3 64 ; coadd 1 ; tint 20*

7.0<K<9.5: *sampmode 3 16 ; coadd 4 ; tint 5*

K<7: *sampmode 3 8 ; coadd 10 ; tint 2*

pupil open ; subc 512 ; filter 7 13 ; sampmode 3 64 ; coadd 1; tint 20