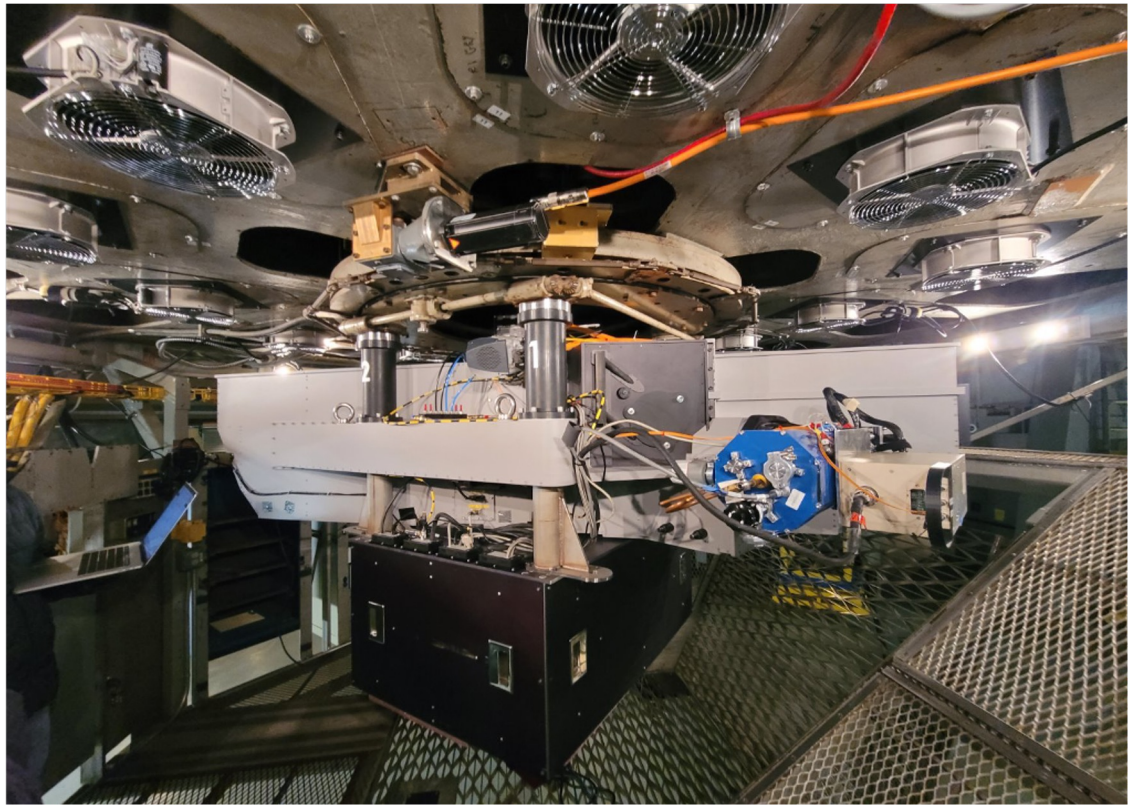
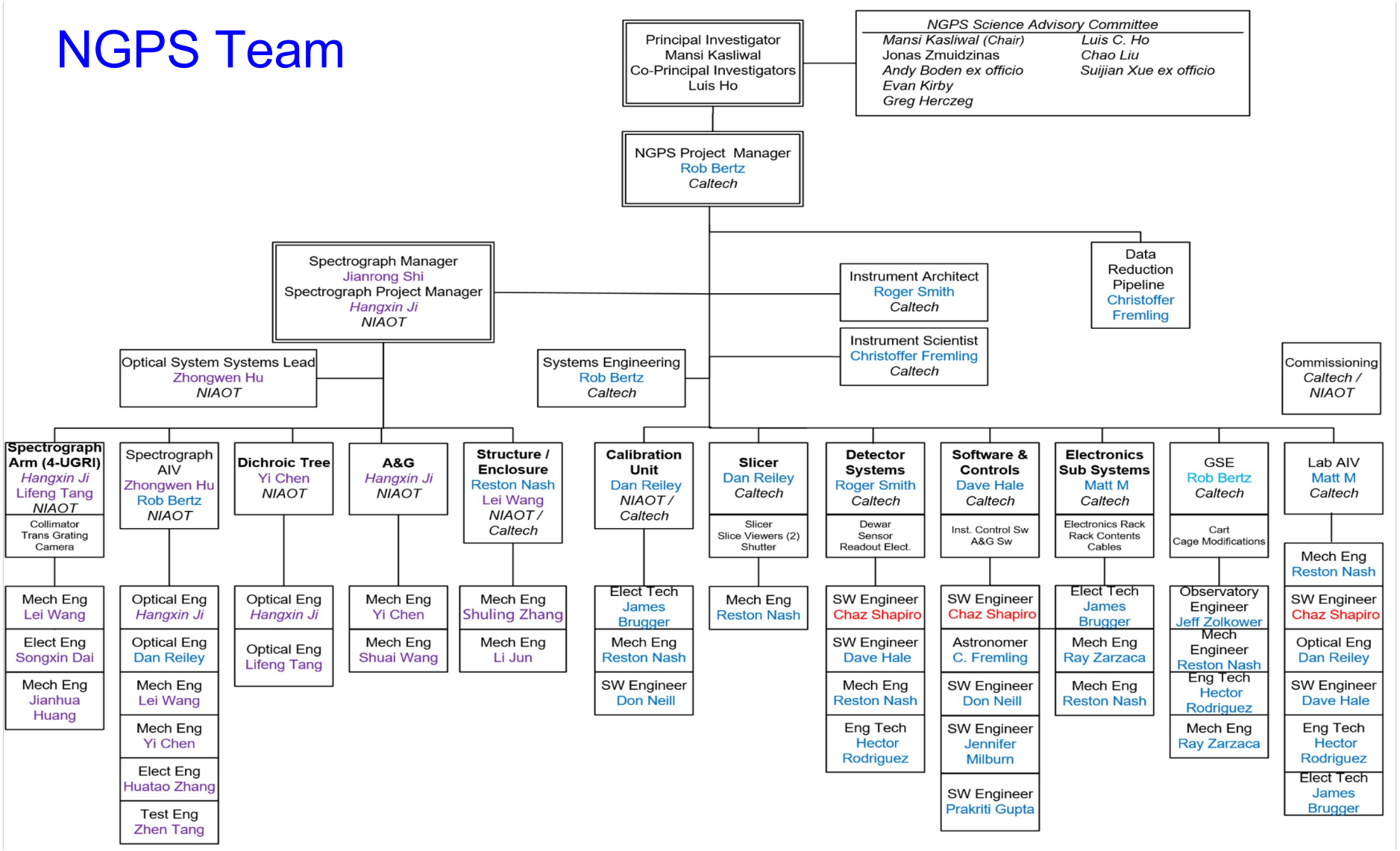
Next Generation Palomar Spectrograph on Palomar 200-in



NGPS Team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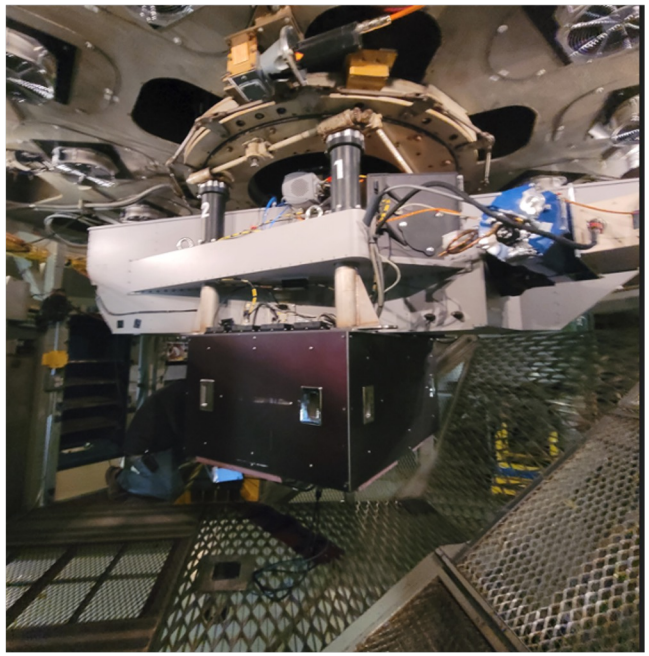
James Brugger

Commissioning began in November 2024


NGPS Commissioning: First light 11/12, First science 11/13

TRANSIENT NAME SERVER

≡ AstroNote 2024-340

AstroNotes | Stats

2024-11-16 06:40:14 Type: Object/s-D

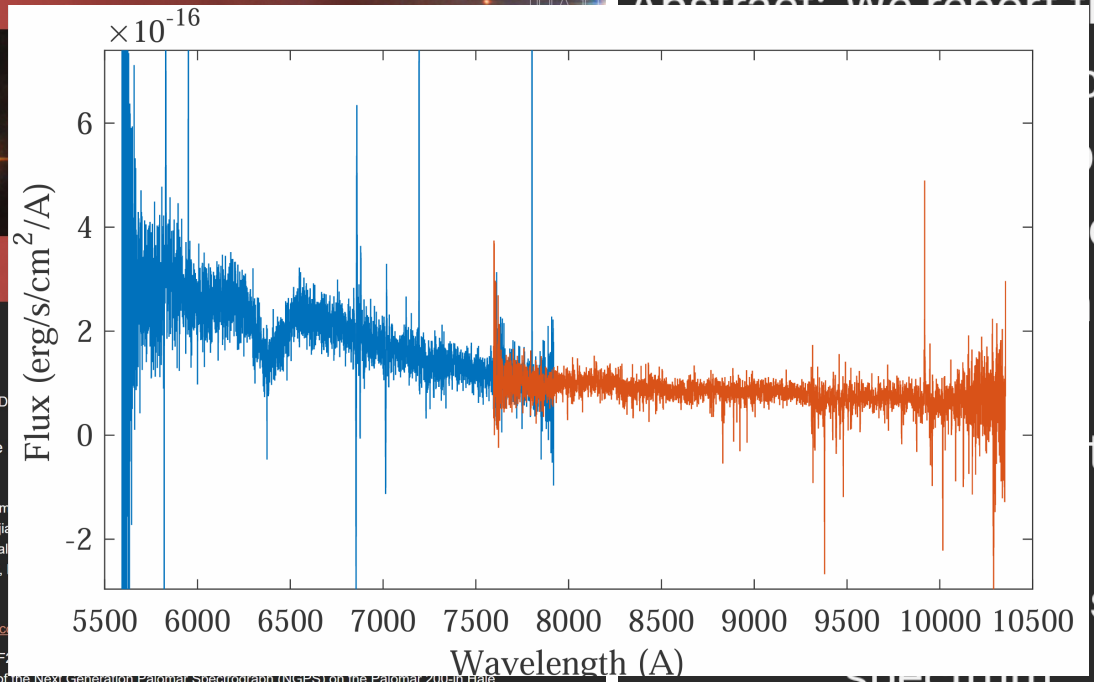
The First Science Spectrum with the
as a Type Ia Supernova

Authors: Mansi M. Kasliwal, Christoffer Frem
Evan Kirby (University of Notre Dame), Suijia
Mateusz Matuszewski, Rob Bertz, David Hal
Jennifer Milburn, Don Neill, James Brugger,

Source Group: ZTF

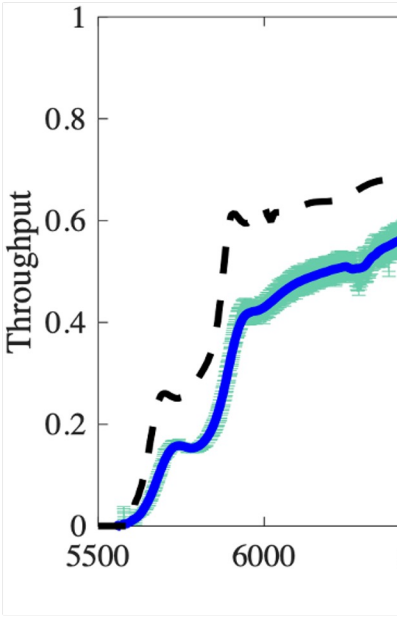
Keywords: Supernova, Transient, Spectrosc

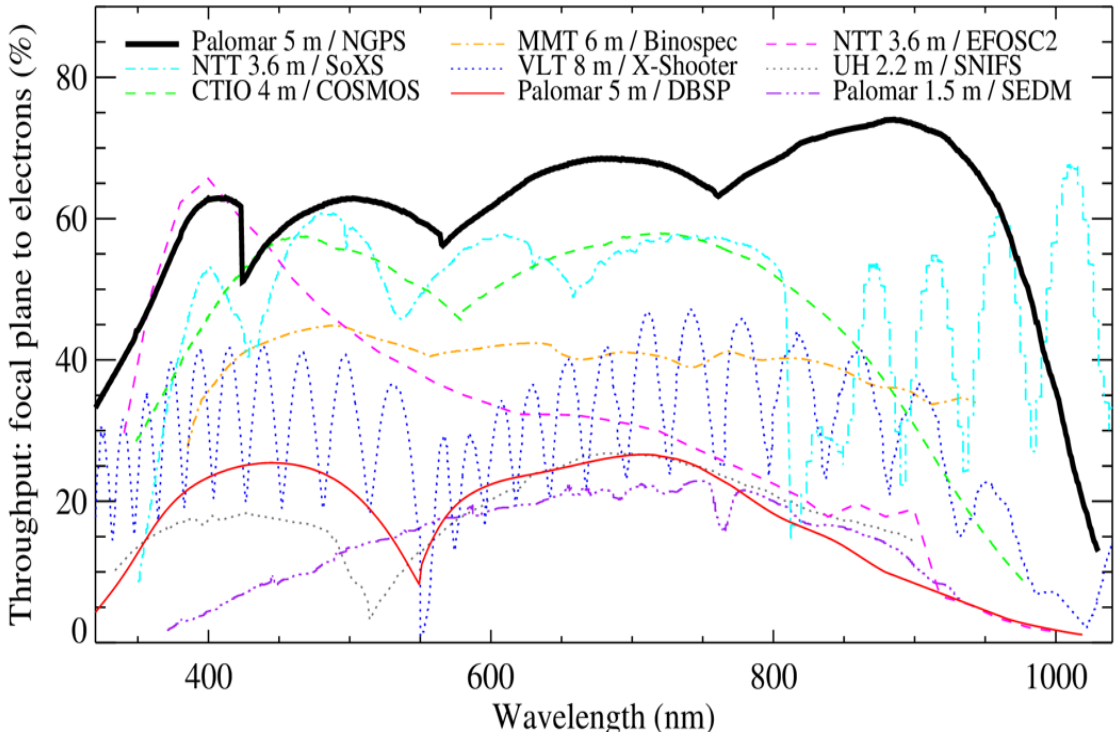
Abstract: We report the classification of ZTF
was done during commissioning of the Next Generation Palomar Spectrograph (NGPS) on the Palomar 200-in Hale
Telescope, marking the instrument's first science spectrum.

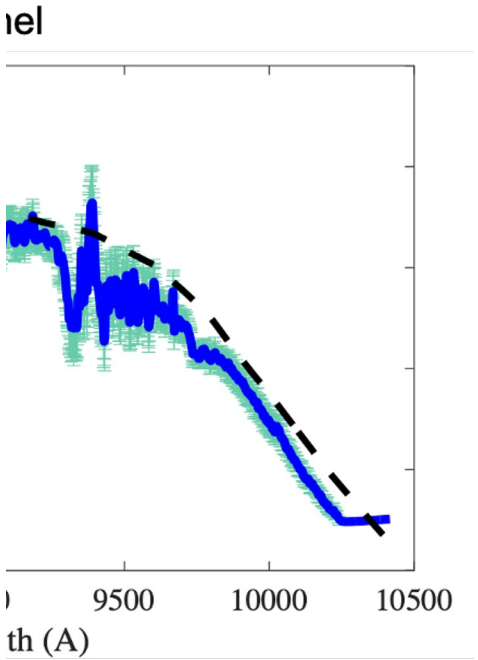


Abstract: We report the classification of
cqd / SN 2024aaqp, a
ernova at a redshift of
classification was done
missioning of the Next
Palomar Spectrograph
the Palomar 200-in Hale
marking the
s first science
spectrum.

Instrument Performance: Throughput

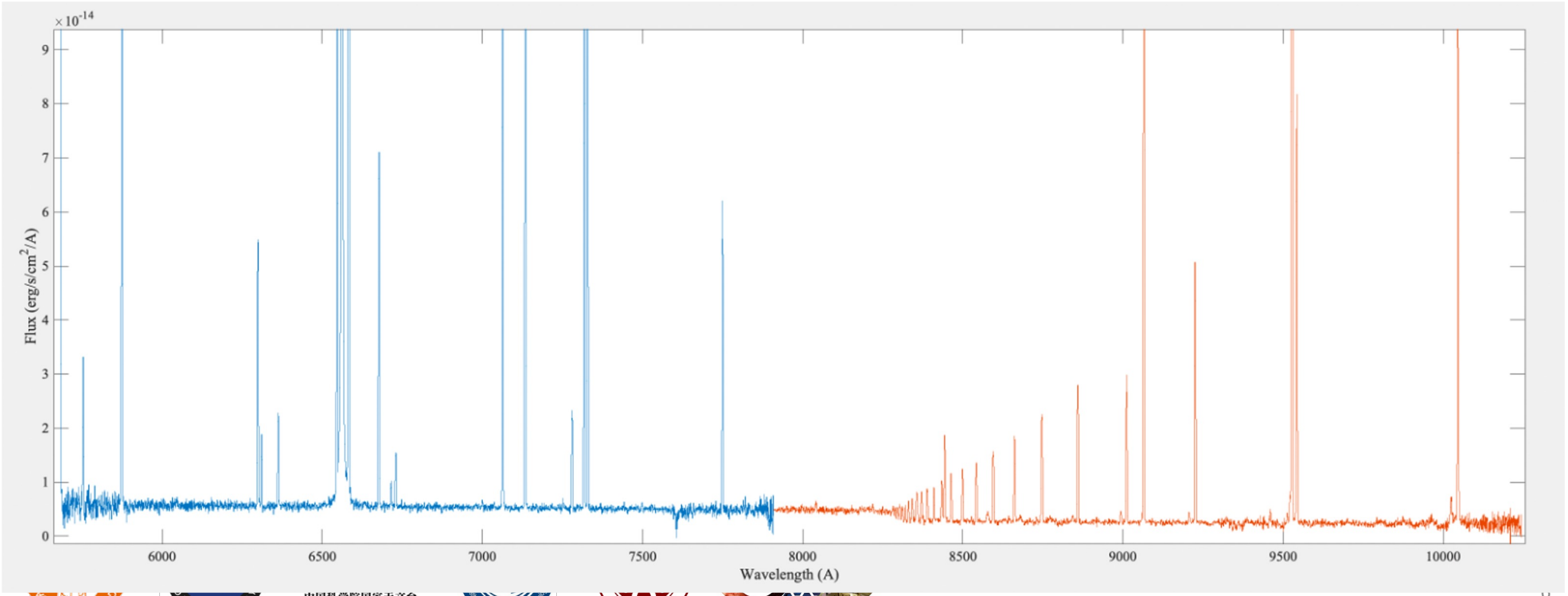






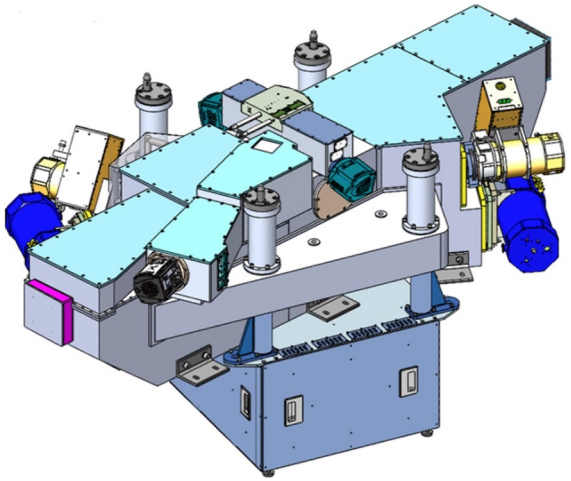
Instrument Performance: Resolution

Resolution Validated On-Sky on a Planetary Nebula. Shows R > 3500 with 0.5” slit.

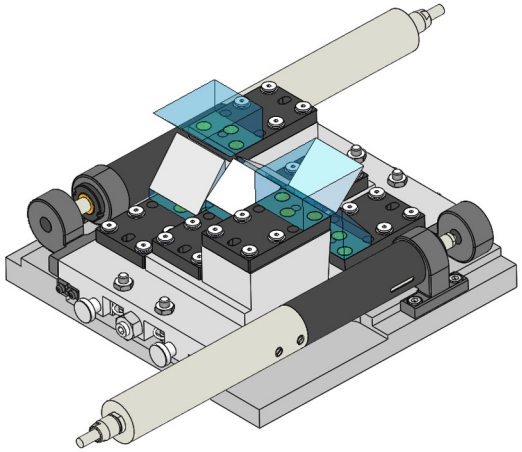


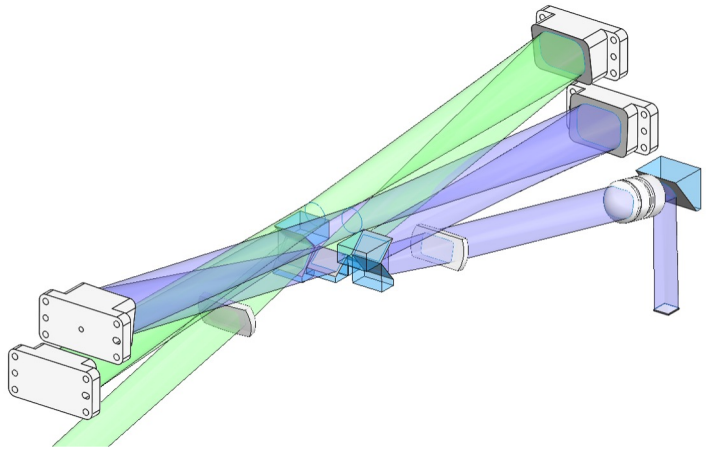
NGPS Tech Overview

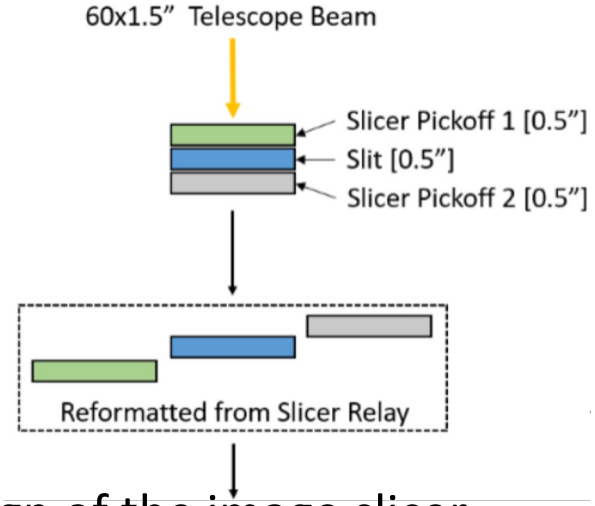
- NGPS replaces DBSP as the workhorse spectrograph on the 200” Hale telescope
- It simultaneously covers 320nm to 1030nm and can achieve R>4000 under median seeing with low slit loss (~0.5 arcsec central slit)
- **For 2025A, R and I channels are available (570 to 1030nm).**
- A key objective of NGPS is to maximize optical and operational efficiency
  - Optical efficiency
    - 4 channel VPH grating spectrograph with 16K pixels in the spectral direction
    - Image slicer to improve the tradeoff between resolution and light loss
  - Operational efficiency
    - Only slit width and exposure time needs to be adjusted (manual, auto)
    - Fixed gratings
    - Flexure compensation
    - Focus compensation
    - Exposure and observation timeline calculators



NGPS - Image Slicer







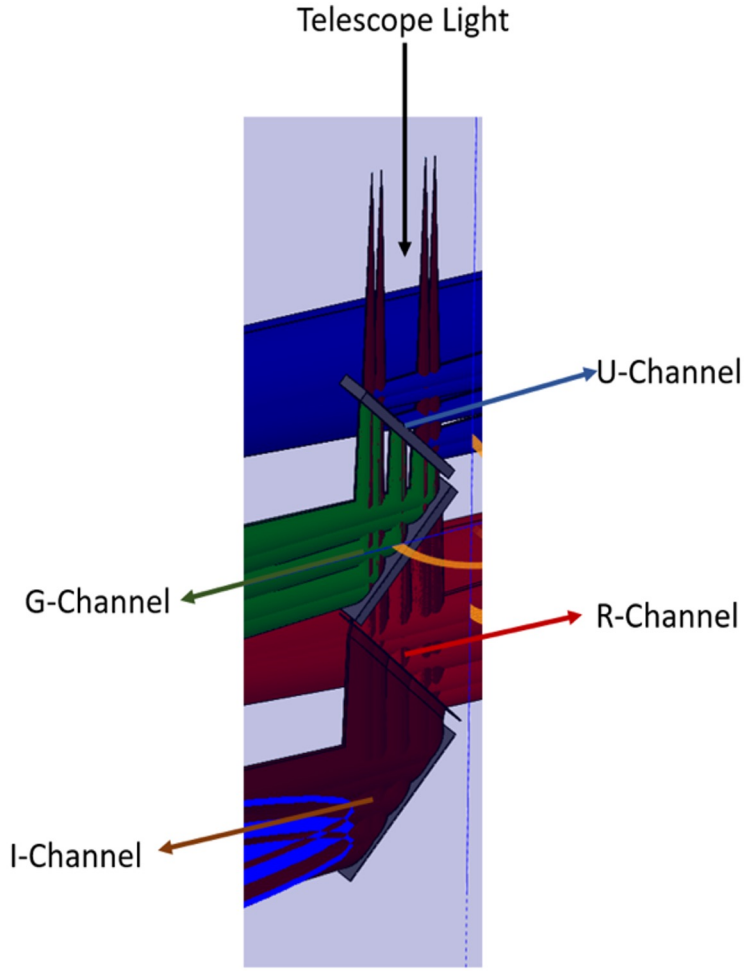
- A key element to the operational efficiency is the novel design of the image slicer
  - The image is sliced into 3 images including a narrow central slit which is passed directly to the spectrograph without losses
  - The surrounding light is redirected by 2 pickoff mirrors and captured in 2 neighboring slices that are recombined at post-processing to improve the SNR of the central slit
  - The net result is the resolution of a narrow slit without all of the losses from vignetting
  - **Usable slit length is ~45” and the width is currently adjustable from 0.36” to 10”**

NGPS – Dichroic Tree

- After the slicer, the image is separated into four wavebands using a series of long pass dichroic filters and a final mirror
- The dichroic mirrors are arranged sequentially in wavelength, maximizing efficiency at shorter wavelengths

Band	CDDD band (nm)
U	320 - 423
G	425 - 565
R	565 – 759
I	759 – 1030

Notes:
4K pixels spectral
0.6 A/pixel R-channel
0.7 A/pixel I-channel
0.185” per pixel, spatial



Handy look-up tables

Next Generation Palomar Spectrograph:

3 way slicer, VPH gratings, 4 channels, automation

➔ *High throughput, resolution and efficiency*

Band[1]	λ (Å)	R=λ/δλ @λ_{center} [2]	Line FWHM (Å)	Å/pix	Throughput NGPS[3]	Throughput DBSP[3,4]	Slit Efficiency[5] NGPS	Slit Efficiency[5] DBSP
U	3600 – 4340	4302	0.92	0.31	64%	21%	82%	36%
G	4340 – 5810	4001	1.27	0.42	62%	19%	80%	35%
R	5810 – 7820	3988	1.71	0.57	75%	23%	77%	33%
I	7560 – 10400	4281	2.08	0.69	73%	16%	75%	31%

1. Bands include contributions from overlapping channels.
2. Calculations assume 0.56" slit width (slice width for NGPS) and 1.3" seeing
3. Mean throughput; does not include telescope, atmospheric transmission efficiency or slit loss factor.
4. Newly measured DBSP values after red side CCD upgrades. I-band throughput has improved.
5. 1 minus slit loss at band center, including any slicer reflection losses

Three Example Cases:

Bright star with narrow slices for high resolution.

High SNR faint limits for a point source at medium and low resolution.

1.3" seeing with sky background 20.3 mag/arcsec² at 6204Å

Mag(r) (AB)	Slice width (")[1]	Slit loss [2]	R=λ/δλ @ λ_{center}	Å/pix	SNR per pix[3]	Exp. Time [4] (sec)	Exp. Time (sec) No slicer
15	0.37[5]	40%	5981	0.57	100	556	1365
20.5	0.56	22%	3988	0.57	5	1541	2580
20.5	1.13	4%	1329	0.57	5	1363	1544

1. Width per slice sets resolution. Light is collected from 3 times this width. Spectra from side slices are combined with central slice with weighting.
2. Slit loss includes losses from slicer optics.
3. Signal-to-Noise Ratio is per pixel along dispersion direction. SNR is fixed for calculation.
4. Exposure time calculation; assumes source at zenith
5. Slice width = 0.37" maps FWHM of line to 2 pixels (Nyquist sampling). Narrower slice width with sub-pixel dithering of slit position will be supported.

Observing Cookbook Step-by-Step

Get started…

- OPEN PALOMAR VNC
- OPEN NGPS VNC
- STARTUP
- CREATE ACCOUNT / LOGIN
- UPLOAD & LOAD TARGETLIST

Calibrations

- CALIBRATION I: INTERNAL FOCUS
- ARCS + BIAS + INTERNAL FLATS
- DOME FLATS

Science

- CONFIGURE FOR SCIENCE
- TELESCOPE FOCUS
- LOAD TARGET
- RUN ETC (optional)
- GO
- ACQUIRE
- EXPOSE

End

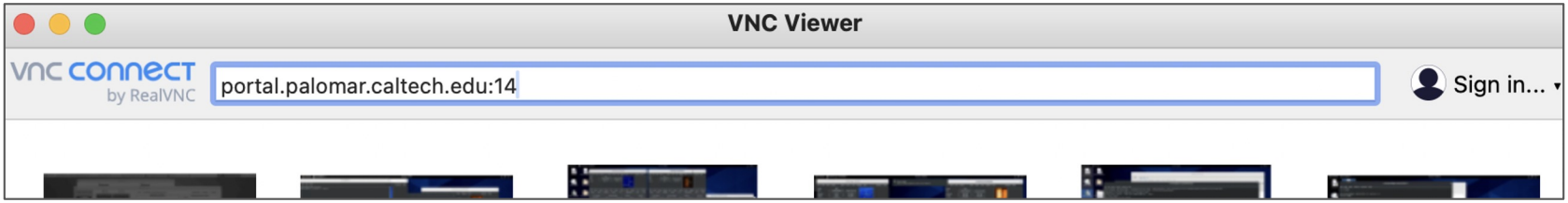
- NIGHTLY SHUTDOWN

Pre-observing checklist

- ❑ Login to Palomar VNC
- ❑ Open NGPS VNC
- ❑ Upload and load your targetlist
- ❑ Read NGPS documentation

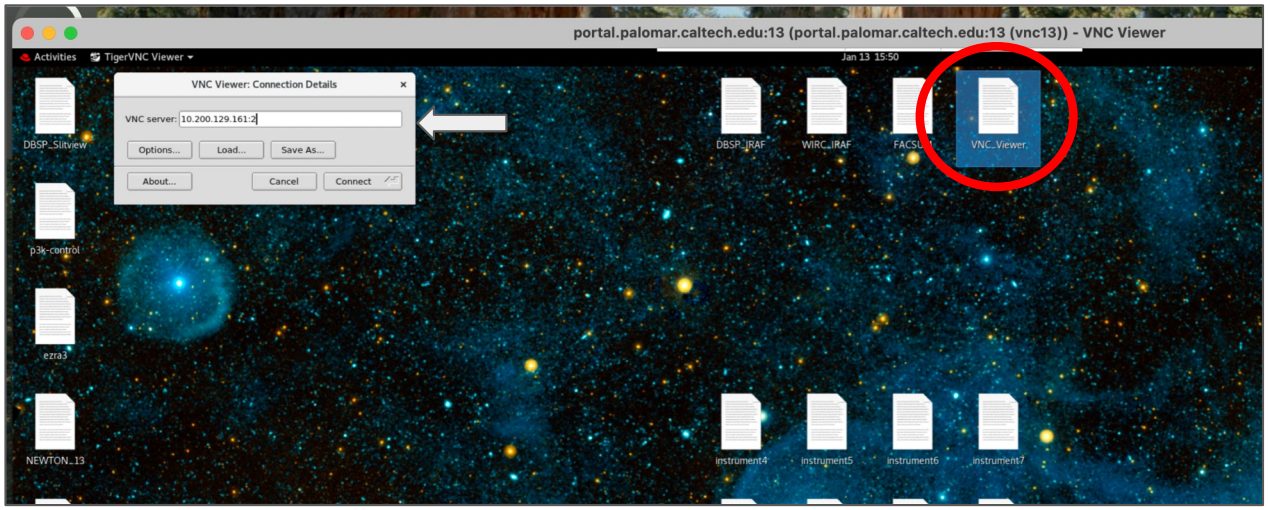
Open Palomar VNC

- ➔ Join with Caltech VPN (or Caltech Wifi)
- ➔ Install and open VNCViewer (RealVNC recommended)
- ➔ portal.palomar.caltech.edu:13 (needs password – ask SA)
- ➔ portal.palomar.caltech.edu:14
- ➔ portal.palomar.caltech.edu:15

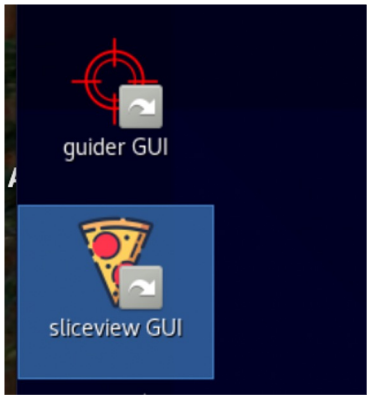


Open NGPS VNC

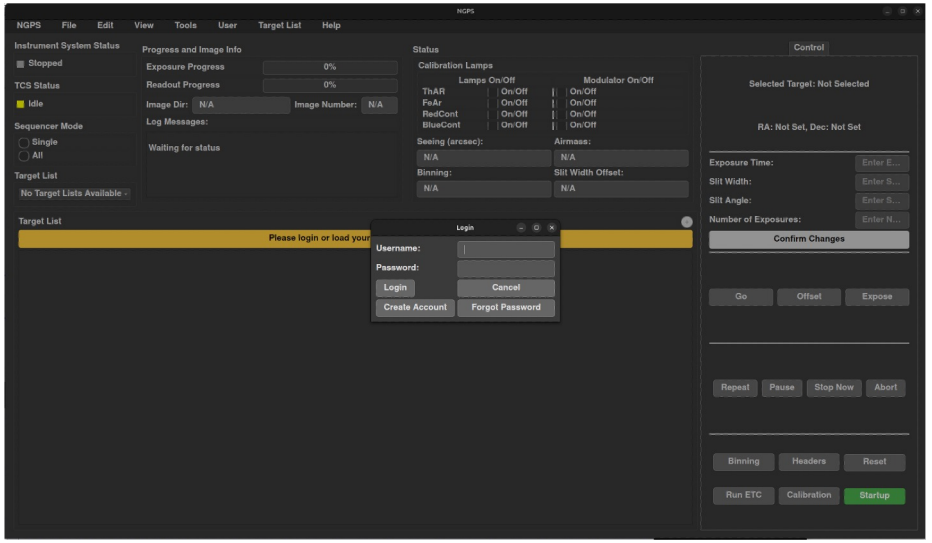
➔ **DRP and quicklook:**
portal.palomar.caltech.edu:11 > click on VNC Viewer > 10.200.129.160:5901 (separate password, ask SA)



Startup

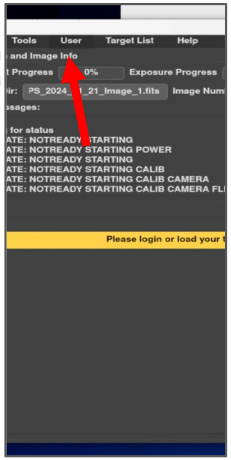


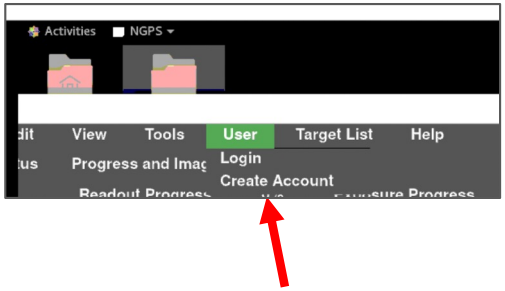
- Open “sliceview GUI” (SCAM) and “guider GUI” (ACAM) GUIs on screen 2
- Click on observing GUI button on screen 3
- There will be a login option when the GUI initially loads. Please login to your account which is usually your email, or sign up for an account
- Startup takes a few minutes. While the sequencer is starting up, login and upload your targetlist and open the cal GUI
- There will be a pop-up when startup is completed



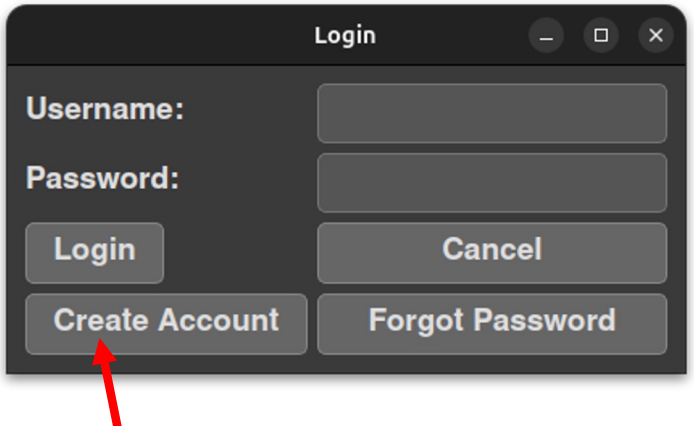
Create Account / Login

Method 1:





Method 2:



Targetlist Format

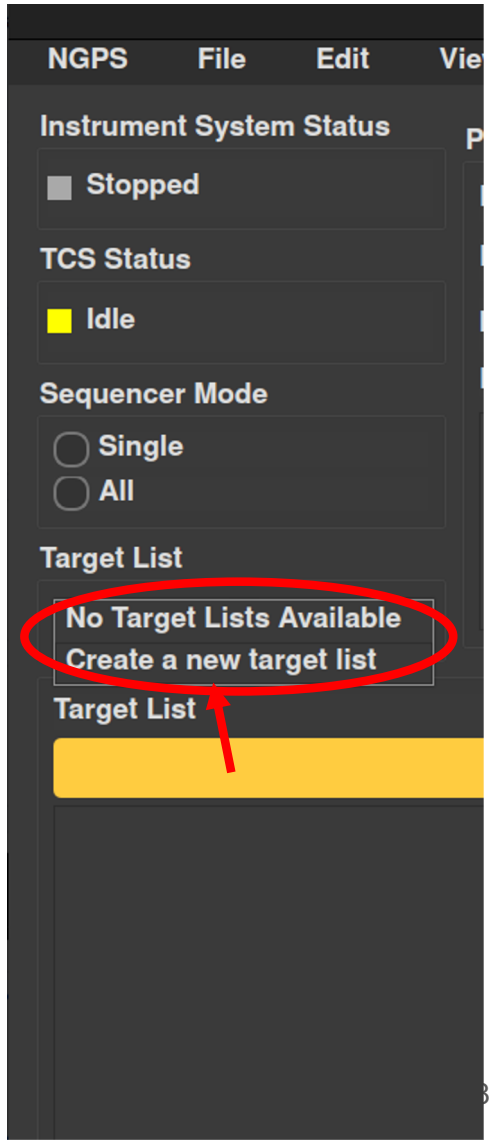
- CSV format
- Compulsory columns: NAME, RA (hh:mm:ss), DECL (dd:mm:ss)
- Space instead of colons is also supported
- Other columns used for ETC, see right
- Example targetlist: https://drive.google.com/file/d/1O6-lcv6OOLbCWNitym-bA4bRA5A8EV1P/view?usp=sharing

```
Run the Exposure Time Calculator. Outputs are SNR, EXPTIME, wavelength range, and optional plots. The model assumes that signals from 3 image slicer paths are summed
for the SNR calculation.

positional arguments:
  {U,G,R,I}                           Spectrograph channel used for SNR
  wrange                              Min and max wavelength (nm) for SNR avg, e.g. "500 510". Will be rounded up to a whole number of bins
  {SNR,EXPTIME,SET}                   Fix SNR or EXPTIME and calculate the other
  ETCfixed                            Value of the fixed parameter: SNR (dimensionless) or EXPTIME (s)

optional arguments:
  -h, --help                          show this help message and exit
  -binspect BINSPECT, -bindisp BINSPECT
                                      On-chip binning along dispersion/spectral axis
  -binspat BINSPAT                    On-chip binning along spatial axis
  -noslicer                           Only use flux from the center slit, not side slices
  -fastSNR                            Assume astronomer only uses 2 brightest pixels in center slice for SNR
  -plotSNR                            Plot SNR vs. wavelength for the solution
  -plotslit                           Make diagnostic plots
  -timer                              Print timing info
  -hires                              Use hi-res spectra calculations to improve SNR accuracy
  -hires_solve                        Increase accuracy when solving for slit width and exptime simultaneously. (slower)

REQUIRED Observation conditions:
  -slit [MODE [VALUE ...]], -slitwidth [MODE [VALUE ...]]
                                      Mode of setting the slit width (string) and value for that mode (float). Valid modes are: dict_keys(['SET', 'LOSS', 'RES',
                                      'SNR', 'AUTO'])
  -seeing SEEING PIVOT                Seeing FWHM (arcsec) defined at zenith and at pivot wavelength (nm)
  -airmass AIRMASS                    Airmass (dimensionless)
  -skymag SKYMAG                      Sky brightness magnitude per arcsec^2 (VEGA, johnson_v)

REQUIRED Source parameters:
  -mag MAG                            Source magnitude (observed at top of atmosphere)
  -magsystem {AB,VEGA,Vega}           Reference system (AB or VEGA) for source magnitude
  -magfilter {U,B,V,R,I,J,K,user,USER,User,match,MATCH,Match}
                                      Johnson filter (UBVRIJK) to define source magnitude. Use FILTER="match" to normalize to the WRANGE input

Additional source parameters:
  -model MODEL [MODEL ...]            Astronomical source model. Examples: "constant" (default), "blackbody 5000", "template spiral_001". The "constant" model ignores
                                      other parameters in this group.
  -z Z                                Redshift
  -E_BV E_BV                          Selective Extinction E(B-V); default=0
  -extmodel EXTMODEL                  Extinction model; default="mwavg" (Diffuse Milky Way, R_V=3.1)
  -extended EXTENDED                  Assume an extended source with constant surface brightness; -mag will be interpreted as mag/arcsec^2; user chooses an integer
                                      number of spatial pixels for which to extract signal (same for all slices).
```

NAME	RA	DECL	OFFSET_RA	OFFSET_DEC	COMMENT	PRIORITY	BINSPAT	BINSPECT	SLITANGLE	AIRMASS_MAX	WRANGE_LOW	WRANGE_HIGH	CHANNEL	MAGNITUDE	MAGFILTER	EXPTIME
ZTF24abvbzbd	00 00 33.40	+22 46 34.56			science	1	2	1	PA	2.5	650	680	R	19.22	1.3	SNR 5
ZTF24abvbzbd	00 00 33.39	+22 46 41.12	0.15	-6.552	offset1	1	2	1	PA	2.5	650	680	R	19.75	1.3	SET 392
ZTF24abvbzbd	00 00 29.64	+22 46 49.52	52.06	-14.956	offset2	1	2	1	PA	2.5	800	820	I	18.41	1.3	SNR 5
ZTF24abvbzbd	00 00 30.36	+22 45 55.06	42.079	39.511	offset3	1	2	1	PA	2.5	800	820	I	18.78	1.3	SET 1120

Upload Targetlist

- Transfer file to Palomar machine to this path: scp <path to targetlist in your local machine/filename>user1@observer1.palomar.caltech.edu:/observer/observer/targets/<username>/<filename> (Palomar Password: ### - ask SA)
- To grab targetlist from Palomar machine to NGPS machine, in any NGPS VNC window:
  Right click > Open in Terminal (Open it inside NGPS and not Palomar computer;observer@ngps) > scp user1@observer1.palomar.caltech.edu:/observer/observer/targets/<username>/<filename> /home/observer/targetlists/<filename> (Palomar Password: ### - ask SA)

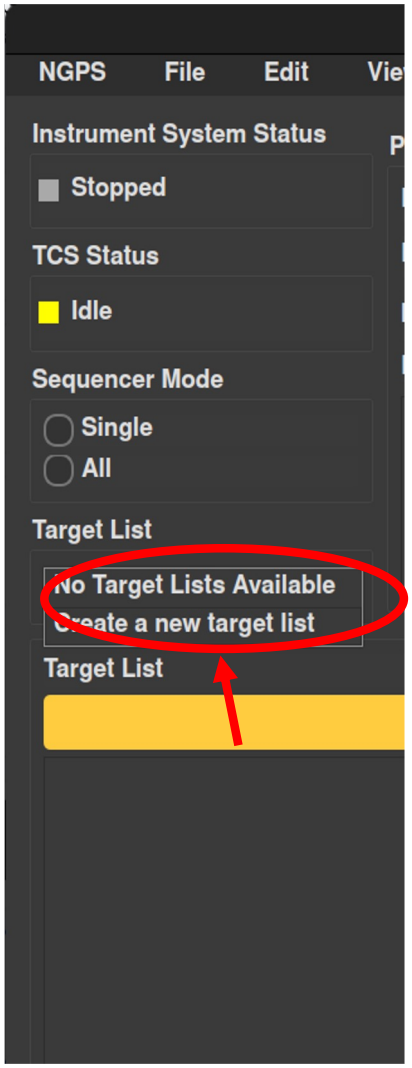


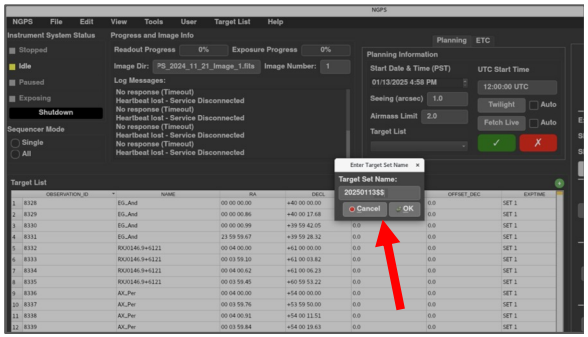
Load Targetlist

➔ Click on **‘Targetlist Dropdown’**

➔ **Load** already existing targetlist or **‘Create a new targetlist’**

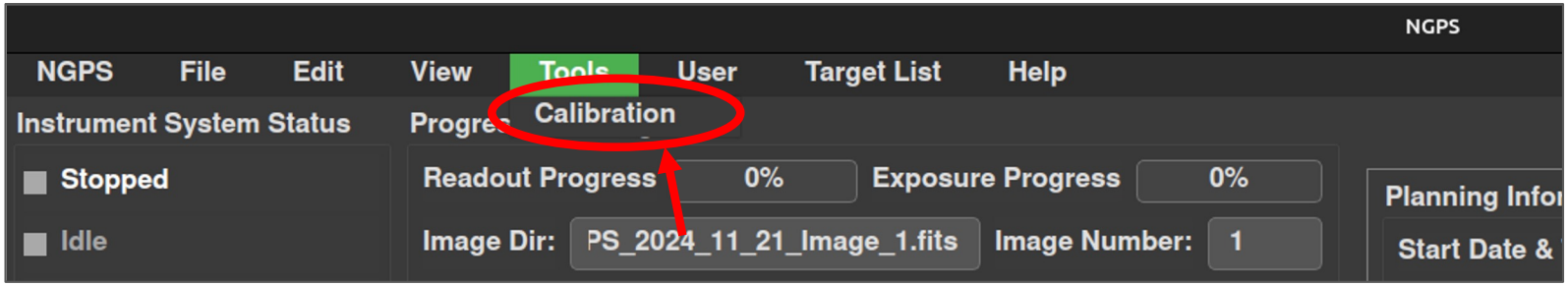
➔ Enter a name (lastname_date. E.g., Das_20250107) of your targetlist in the pop-up box





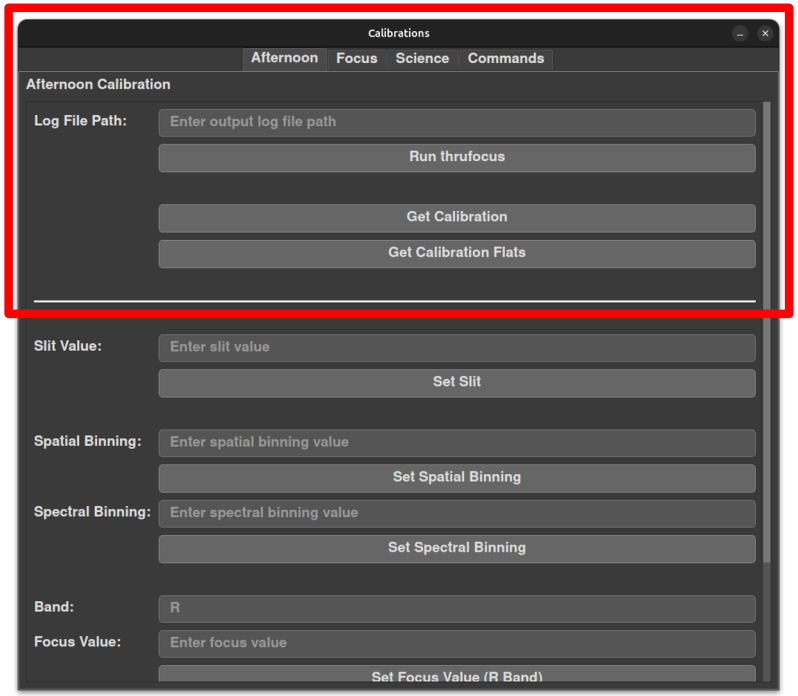
Open Calibration GUI

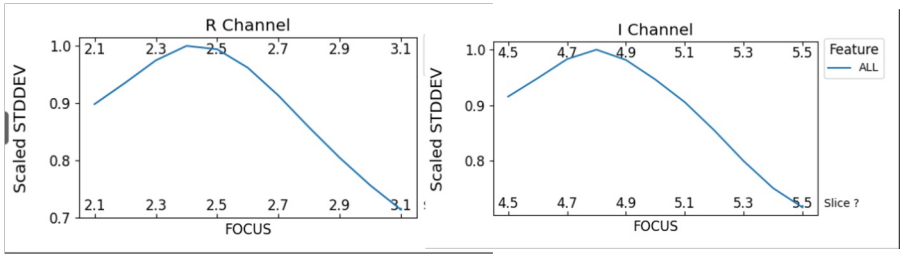
➔ Tools > Calibration



Internal focus

- Click on ‘Afternoon’ tab
- Values will be pre-filled
- Click on ‘Run thrufocus’
- Two .png files will pop up with the best fit focus values
- Under Band and Focus Value, enter the values from the .png best fit.
- Click on ‘Set Focus Value’
- Repeat the above step for R, I- band





This step will generally be performed by the Palomar support astronomers in the afternoon

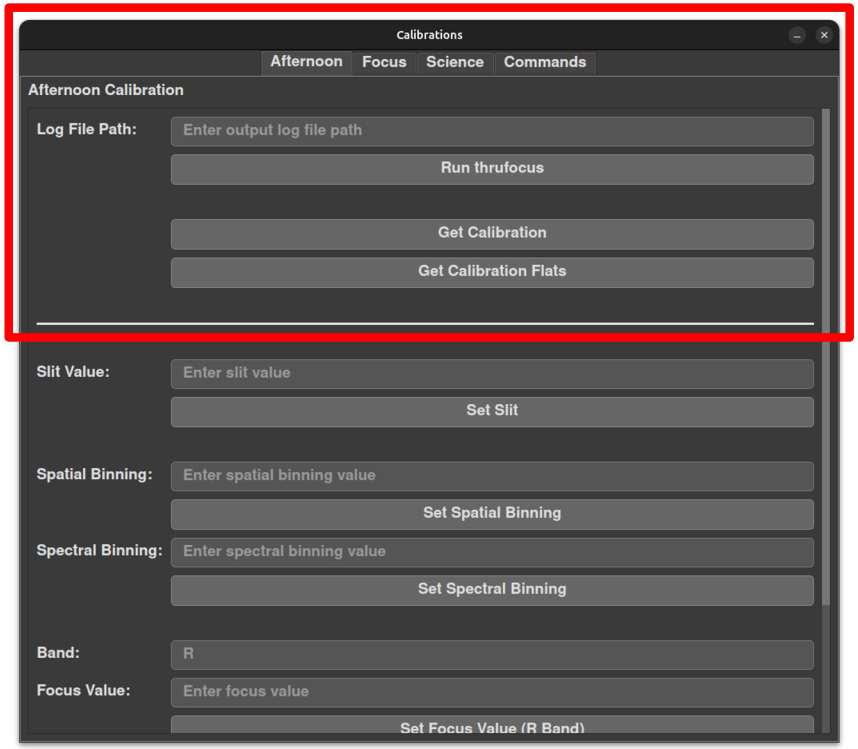
Arcs + Bias + Internal Flats

> Slitwidth Value: 0.5”; offset=3.0” Spatial: 2, Spectral: 1
(this is the nominal instrument configuration)

> Click on ‘Get Calibration’

> Arcs can be taken at a single slitwidth at 0.5” even if different slitwidths are used for science

> Repeat for each binning configuration



Dome Flats

> Set slitwidth, binning

> Confirm with SA if mirror cover is open

> Ask the SA to turn on high lamp.

> Click on “Get Calibration Flats”

> Repeat for all slitwidth and binning settings you will use in the night.

Configure Instrument for On-sky

➔ Click on **‘Configure for Science’** button

> open calibcover

> close calibdoor

> open acamcover

> turn off all lamps

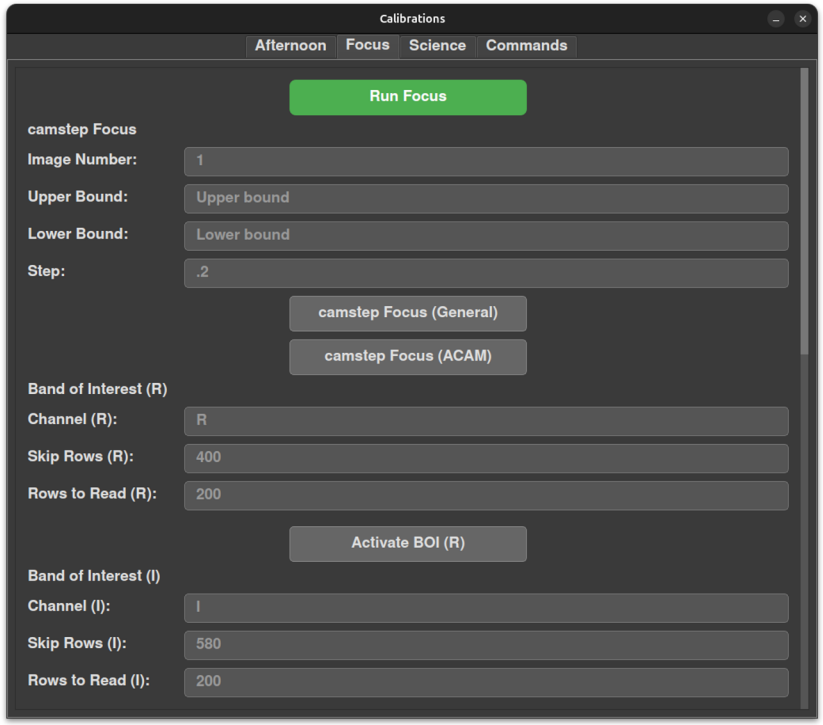
> close all lamp modulators

> set IMGTYPE = SCI

➔ Click on **‘Close Covers’** button if you need to close covers anytime during the night

Telescope Focus

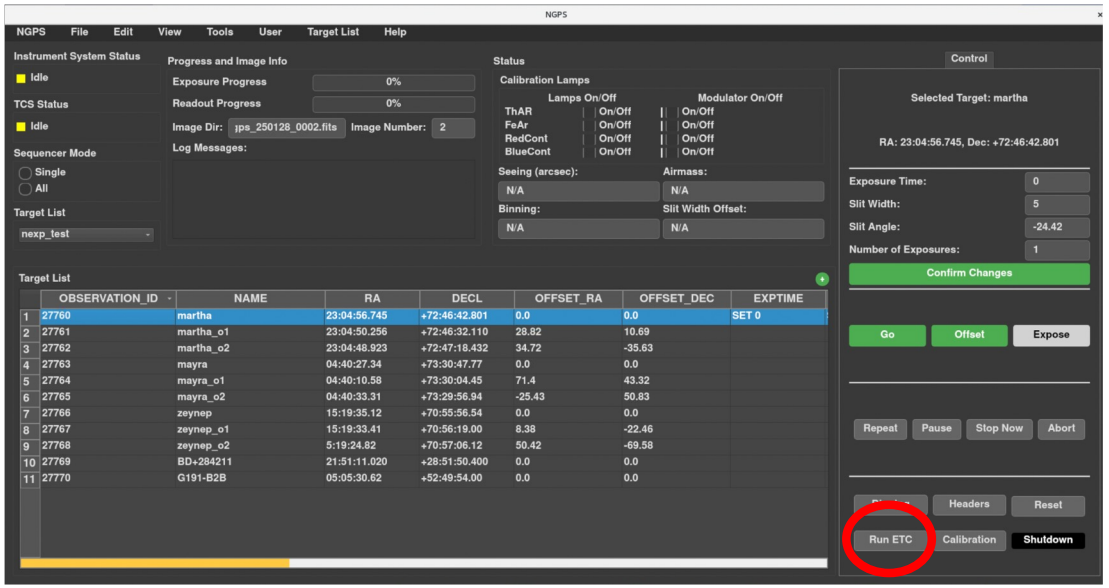
- ➔ Click on the 'Focus' tab
- ➔ Some values will be pre-filled
- ➔ Ask the TO: Go to a 10 mag SAO star
- ➔ Ask the TO: Use the previous best-fit focus value/ask the operator to get a rough value of focus. Inspect ACAM images to ensure we are close to focus
- ➔ Put the SAO star at the center of the virtual slit ('Acquire here'/jog buttons on SCAM GUI; see slide # on acquisition)
- ➔ Enter starting file number
- ➔ Upper bound and Lower Bound = rough focus - 1.2, rough focus + 1.2
- ➔ 'Focus Step' = 0.2
- ➔ Click on 'CAMSTEP Focus (General)'
- ➔ Click on 'Run focus' button
- ➔ Enter the best value in 'TCS Focus Value' Field
- ➔ Click on 'Set TCS Focus'



Load Target

> Select row with desired science target

> Optional: Click on ETC tab if you want to measure the desired exposure time

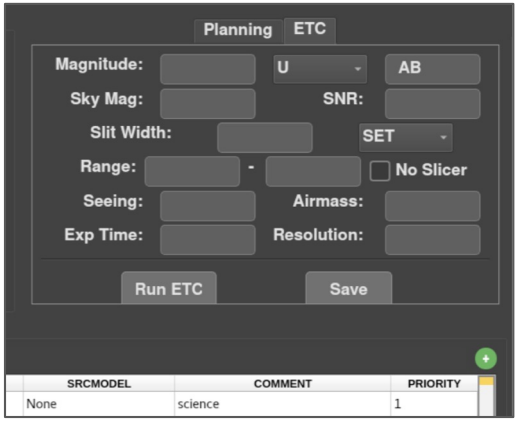


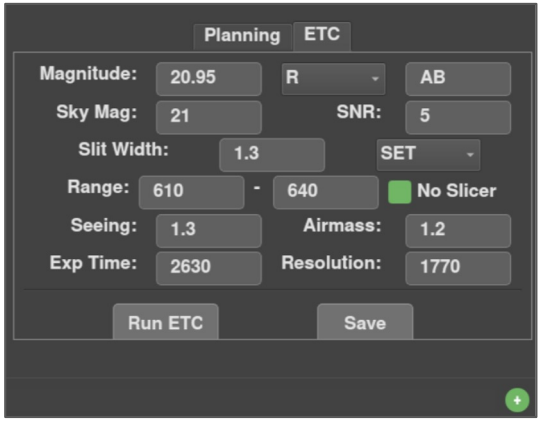
Run ETC

> Click on ETC tab. Some values will be prefilled from your targetlist.

> Click on ‘Run ETC’ to run the calculator

> Click on ‘Save’ to set the output values to the targetlist and Control panel to the right.

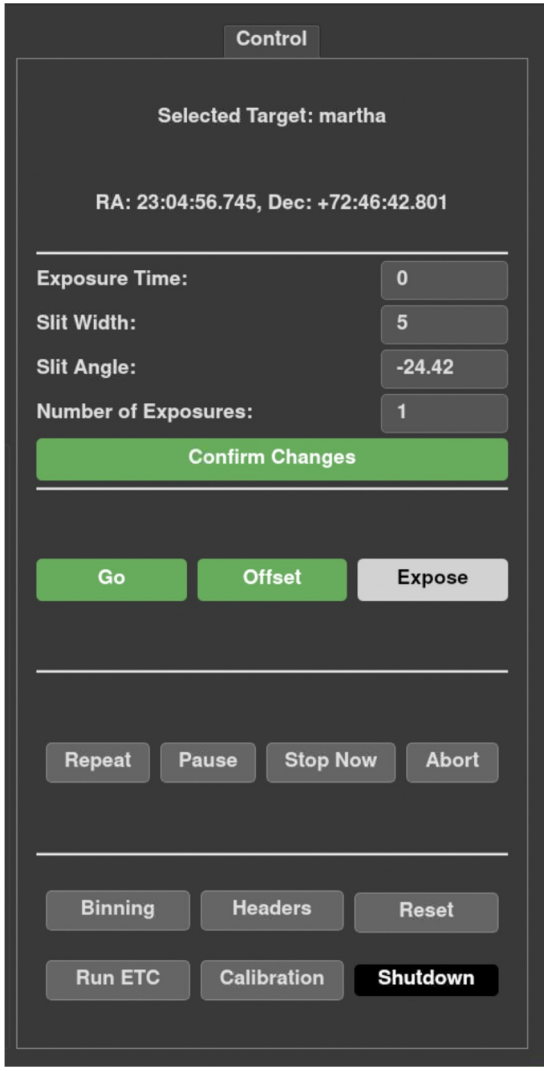





```
Run the Exposure Time Calculator. Outputs are SNR, EXPTIME, wavelength range, and optional plots. The model assumes that signals from 3 image slicer paths are summed
for the SNR calculation.

positional arguments:
  {U,G,R,I}                           Spectrograph channel used for SNR
  wrange                              Min and max wavelength (nm) for SNR avg, e.g. "500 510". Will be rounded up to a whole number of bins
  {SNR,EXPTIME,SET}                   Fix SNR or EXPTIME and calculate the other
  ETCfixed                            Value of the fixed parameter: SNR (dimensionless) or EXPTIME (s)

optional arguments:
  -h, --help                          show this help message and exit
  -binspect BINSPECT, -bindisp BINSPECT
                                      On-chip binning along dispersion/spectral axis
  -binspat BINSPAT                    On-chip binning along spatial axis
  -noslicer                           Only use flux from the center slit, not side slices
  -fastSNR                            Assume astronomer only uses 2 brightest pixels in center slice for SNR
  -plotSNR                            Plot SNR vs. wavelength for the solution
  -plotslit                           Make diagnostic plots
  -timer                              Print timing info
  -hires                              Use hi-res spectra calculations to improve SNR accuracy
  -hires_solve                        Increase accuracy when solving for slit width and exptime simultaneously. (slower)

REQUIRED Observation conditions:
  -slit [MODE [VALUE ...]], -slitwidth [MODE [VALUE ...]]
                                      Mode of setting the slit width (string) and value for that mode (float). Valid modes are: dict_keys(['SET', 'LOSS', 'RES',
                                      'SNR', 'AUTO'])
  -seeing SEEING PIVOT                Seeing FWHM (arcsec) defined at zenith and at pivot wavelength (nm)
  -airmass AIRMASS                    Airmass (dimensionless)
  -skymag SKYMAG                      Sky brightness magnitude per arcsec^2 (VEGA, johnson_v)

REQUIRED Source parameters:
  -mag MAG                            Source magnitude (observed at top of atmosphere)
  -magsystem {AB,VEGA,Vega}           Reference system (AB or VEGA) for source magnitude
  -magfilter {U,B,V,R,I,J,K,user,USER,User,match,MATCH,Match}
                                      Johnson filter (UBVRIJK) to define source magnitude. Use FILTER="match" to normalize to the WRANGE input

Additional source parameters:
  -model MODEL [MODEL ...]            Astronomical source model. Examples: "constant" (default), "blackbody 5000", "template spiral_001". The "constant" model ignores
                                      other parameters in this group.
  -z Z                                Redshift
  -E_BV E_BV                          Selective Extinction E(B-V); default=0
  -extmodel EXTMODEL                  Extinction model; default="mwavg" (Diffuse Milky Way, R_V=3.1)
  -extended EXTENDED                  Assume an extended source with constant surface brightness; -mag will be interpreted as mag/arcsec^2; user chooses an integer
                                      number of spatial pixels for which to extract signal (same for all slices).
```

Take Exposure - I. GO

1. Set exposure time, slit width, slit agle in the ‘Control tab’
2. Default values are those listed in targetlist or those from the ETC calculator
3. Click **‘Confirm Changes’** if you are happy with the values. Else enter different values and then click on ‘Confirm Changes’ (this also updates the values in the targetlist)
4. Click on **‘Go’**
5. If you need to change these values anytime after clicking on **‘Go’**, click on **‘Abort’. Changing exposure time after clicking on ‘Go’ will NOT change the exposure time!**
6. After clicking on Go, **‘Waiting on TCS Operator’** pops up. Let the operator know you are ready to slew. The popup disappears when operator approves the slew.
7. After the slew is completer, the TO will click on a **‘On Target’** button
8. Acquire target (see Slide on Acquisition)



Take Exposure - II. ACQUIRE

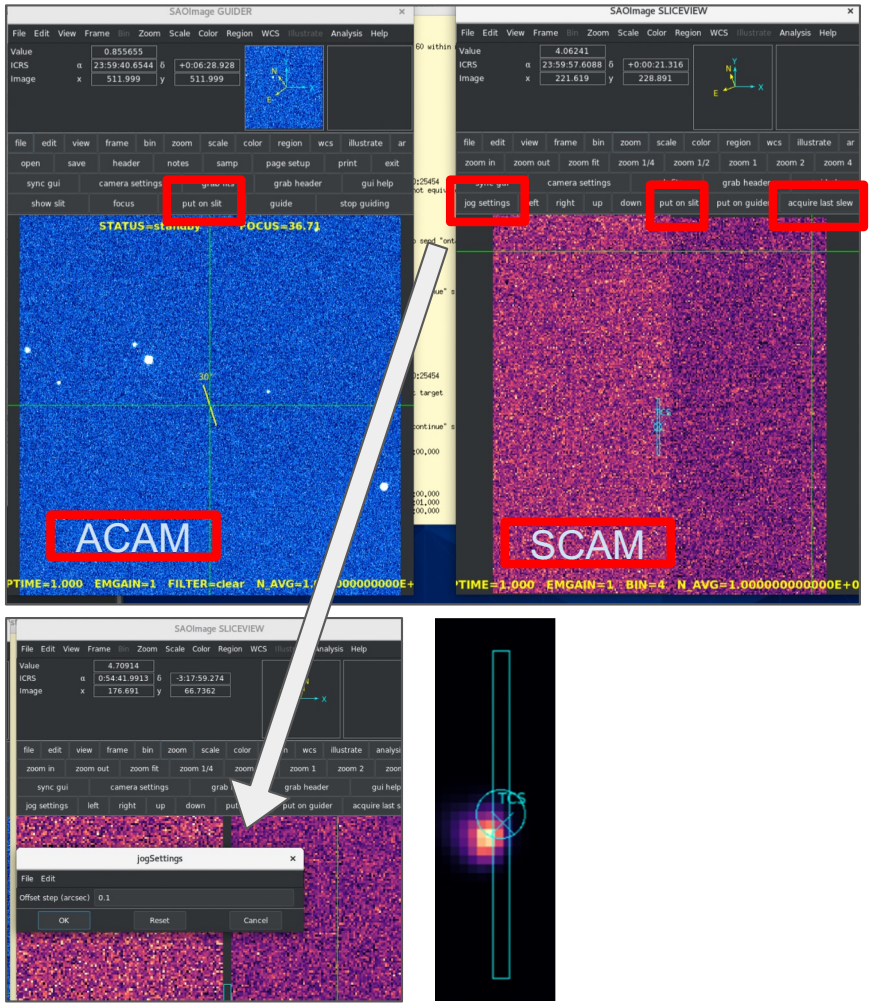
Sliceview (SCAM; orange window: FOV ~ 40”x30”) shows the view of the slit camera

Guider (ACAM; blue window FOV ~ 4’ x 4’) shows the view of the acquisition camera

In SCAM window:

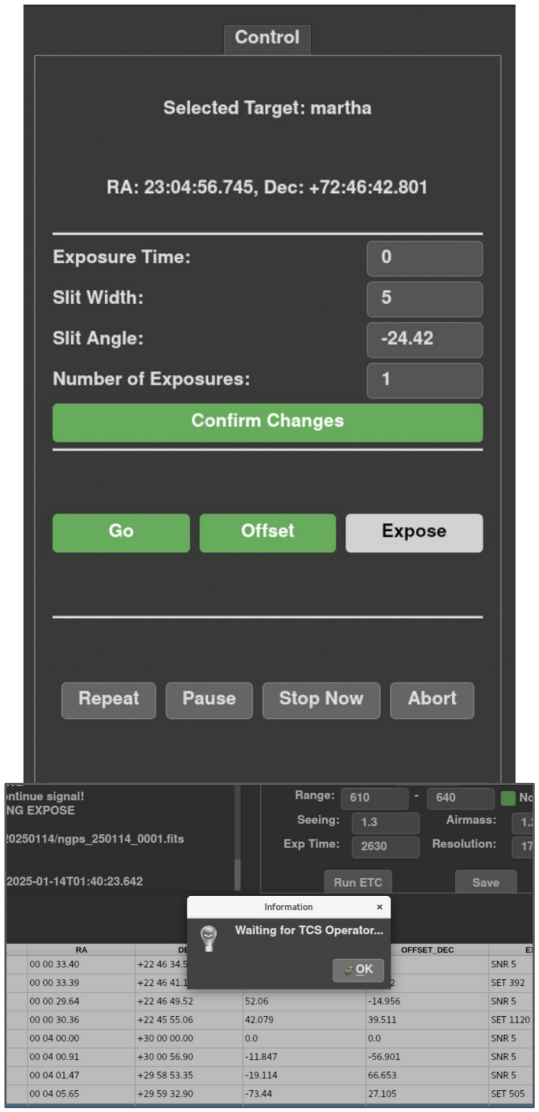
- Click on ‘acquire last slew’ (should happen automatically)
- This will put target close to virtual slit (e.g, see figure)
- If it is not in the center of the slit but very close, click on ‘jog settings’, enter jog values and jog using the ‘up/right/left/down’ buttons till it is at center of the virtual slit
- If target is far away from the slit, move the crosshair on your target with your mouse and click on ‘put on slit’ button
- If you need bigger field of view, click on ‘put on guider’ to move the field to ACAM and after confirming (put crosshairs on target) click again on ‘put on slit’ in ACAM window to move back to SCAM

NOTE: click on ‘Camera Settings’ buttons to change exposure times or stack images



Take Exposure - III. EXPOSE

1. If there are offsets, click on **‘Offset button’**
2. When you are ready to expose, click on ‘**Expose’**. This will start the exposure. **Expose is only enabled once the TCS OP approves your target.**
3. If you want another exposure at same location, click on ‘**Repeat’** button (can change Exposure Time (if required) - > Confirm change -> Repeat)
4. **‘Pause’** to pause an exposure. Button changes to **‘Resume’.** Click to resume the exposure
5. **‘Stop Now’** to stop exposure and readout
6. **‘Abort’**, aborts observing/acquisition sequence



Inspect the raw 2D spectrum

In a terminal on portal:15/ngps:4

Change directory to your nights date: cd /data/<utdate> or cd /data/latest

- ds9last (opens last image)
- ds9last2 (opens next-to-last image)
- ds9fancy <image name> (opens any image)

These commands open ds9 displays, with _rough_ wavelength solutions (+- 10 A) for quick inspection of the raw data

End of Night Procedure

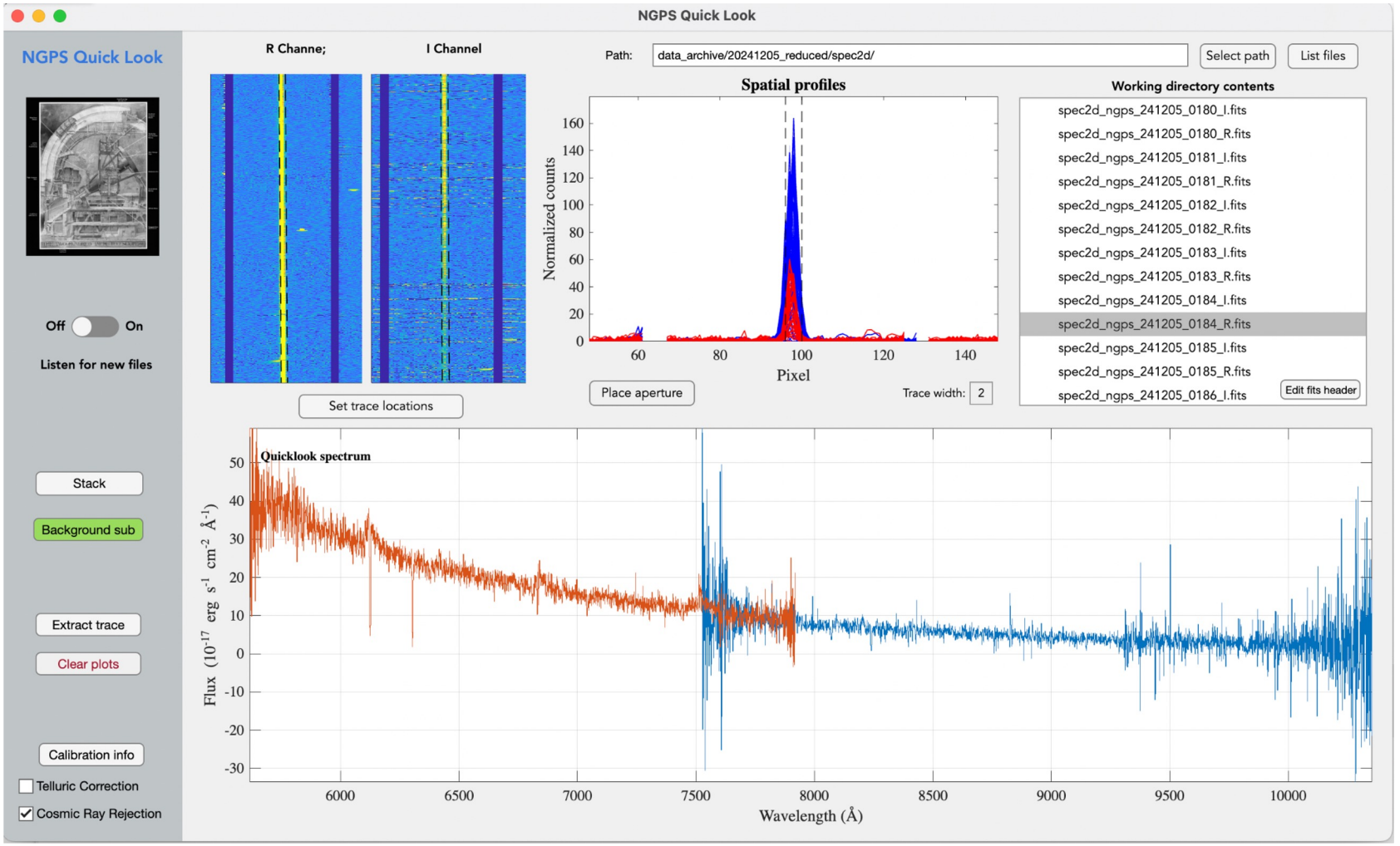
- ➔ Click on ‘shutdown’
- ➔ To get raw data:
  scp -r /data/latest <your machine>

Data Reduction and Quick-Look GUI

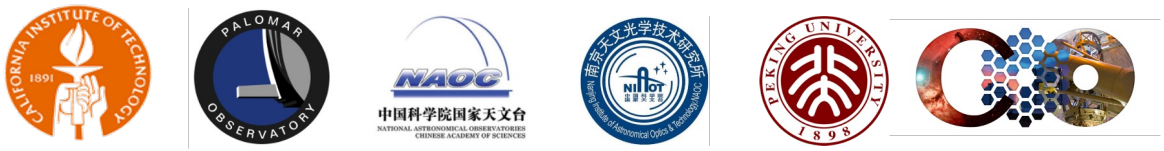
- All calibration data (bias, flats, arc solutions, sensitivity functions) are logged in a database system (sqlite).
- This allows the Data Reduction Pipeline (DRP) to perform very quick preliminary reductions based on the most recent calibration dataset that matches your science data.
- This capability is available as a dedicated GUI as part of the observing system (portal:11/quicklook).
- Within <10 seconds of a completed exposure 2d sky subtracted data and a 1d spectrum will be automatically shown on the GUI.
- The spatial position and width of the extractions on each detector can be easily adjusted.
- Reduced data can be sent from the quicklook computer to your local machine or server using scp: Data is located in /media/data_archive/<ut date>

The goal is to allow the observer to make on-the-fly decisions based on the data being collected to improve the overall observing efficiency.

Quick-Look Data Reduction and GUI



Questions?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