

Status of a JWST survey for 10km CCKBOs



*An Ultra-Sensitive Pencil Beam Search for 10 km
Trans-Neptunian Objects*

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Program 1568, 48 hours selected in JWST cycle-1



Goals:

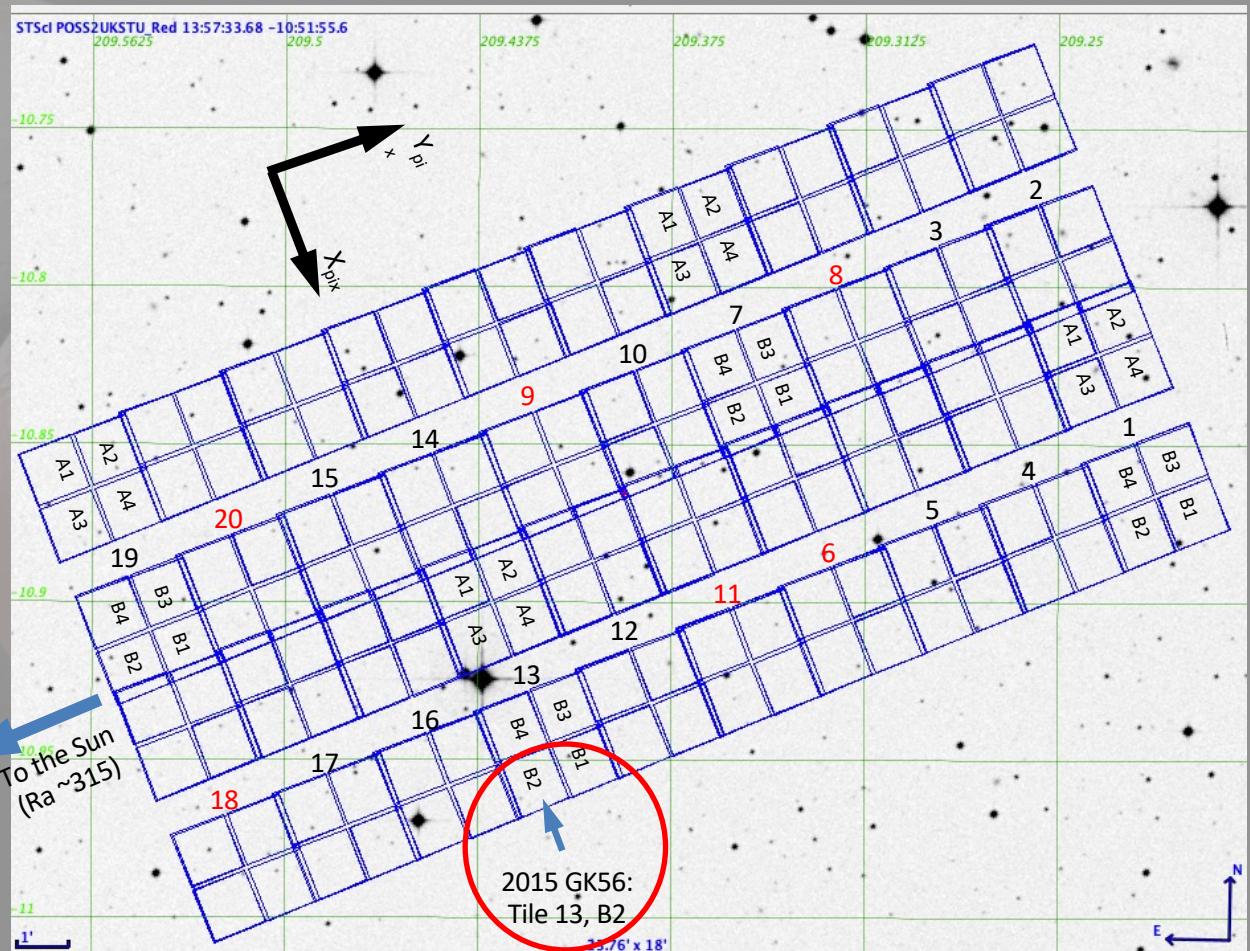
- Find 30 +/- 10 CCKBOs with $D=10$ km
- Determine the slope of the SFD at

Survey Design:

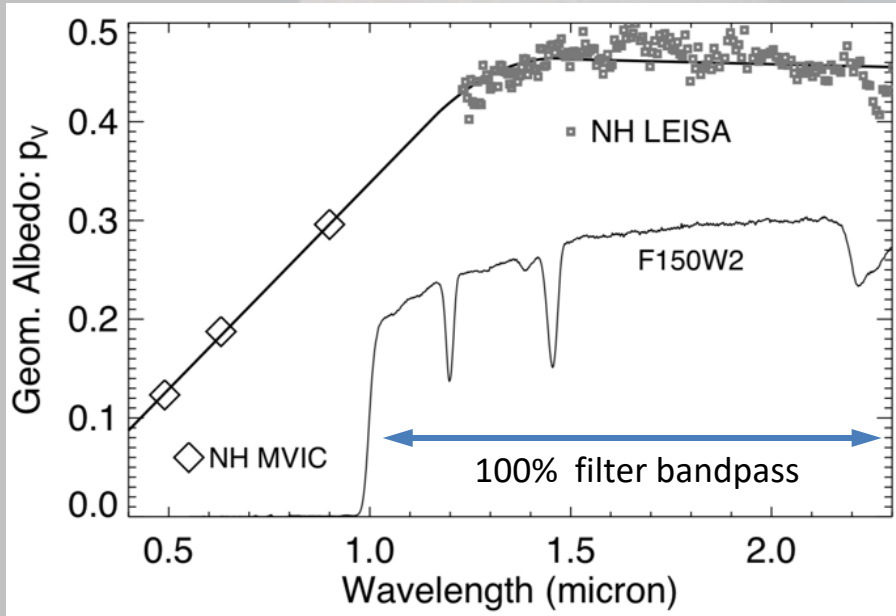
- 8 shortwave detectors per tile
 - 2040^2 0.03" pixels per detector (1'x1')
- 20 tiles → 160 square arcmin
- Each field is observed 3 times, ~5 days apart
 - Enables distance determination via measurement of reflex motion
 - 1260 seconds total depth per epoch
- On the invariable plane, long axis of the mosaic is parallel to that

The program was executed c. Feb. 1, 2023

We tweaked the footprint to include 1 known TNO: 2015 GK₅₆ mV ≈ 24.5

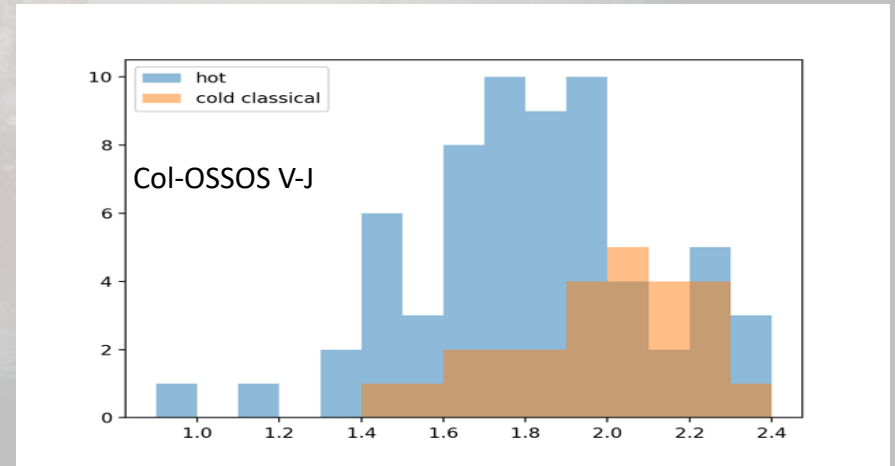


Filter Selection and Sensitivity



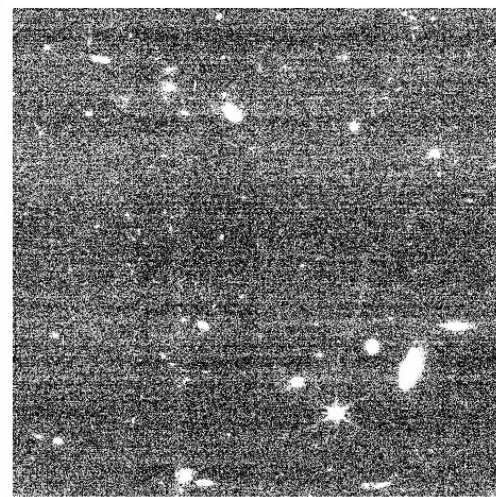
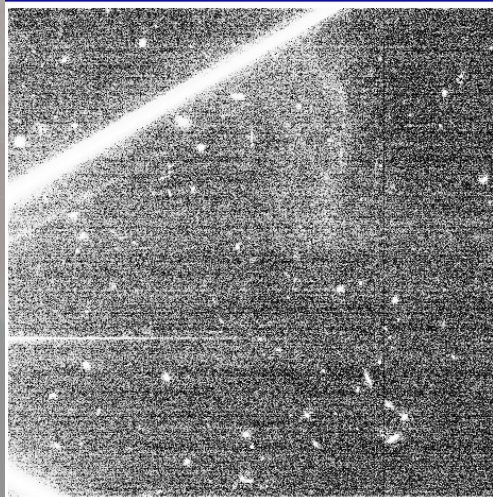
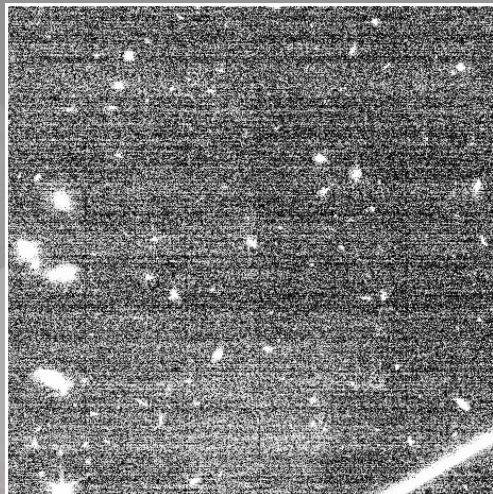
The F150W2 filter was included to support phasing of the primary mirror segments (thus the notches)

- We assumed $V-[F150W2] = \sim 1.2$ based on Arrokoth
 - Actually not as red as larger CCKBOs
 - Solar color is 1.3
- 10km TNO with $p_V = 0.15$, Arrokoth color, at 45AU
 - $H_V = 12.7$, $mV = 29.4$
 - $\rightarrow mF150W2 = 29.4 - 2.5 = \sim 27$



Typical 1st Pass Data Product

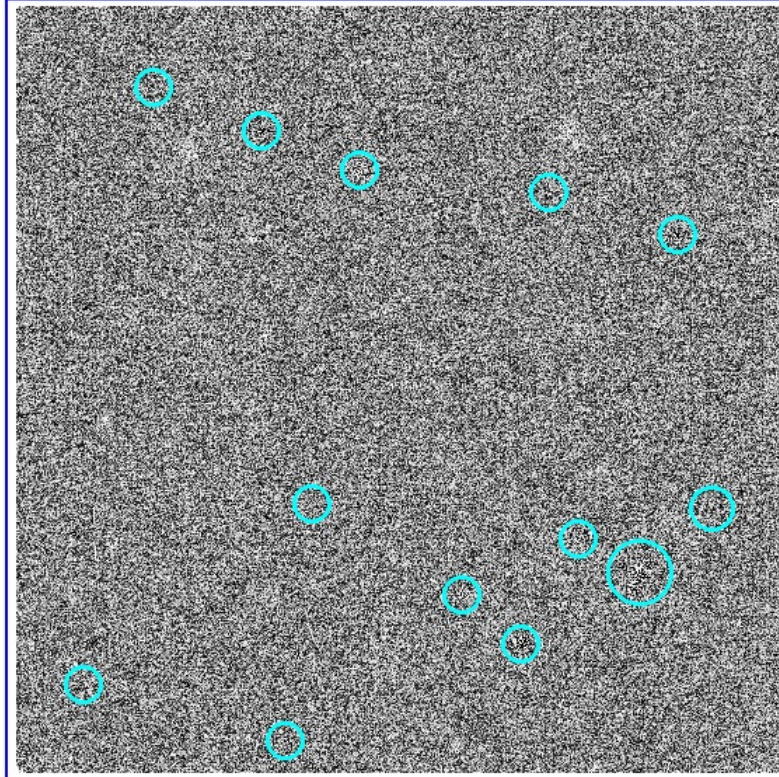
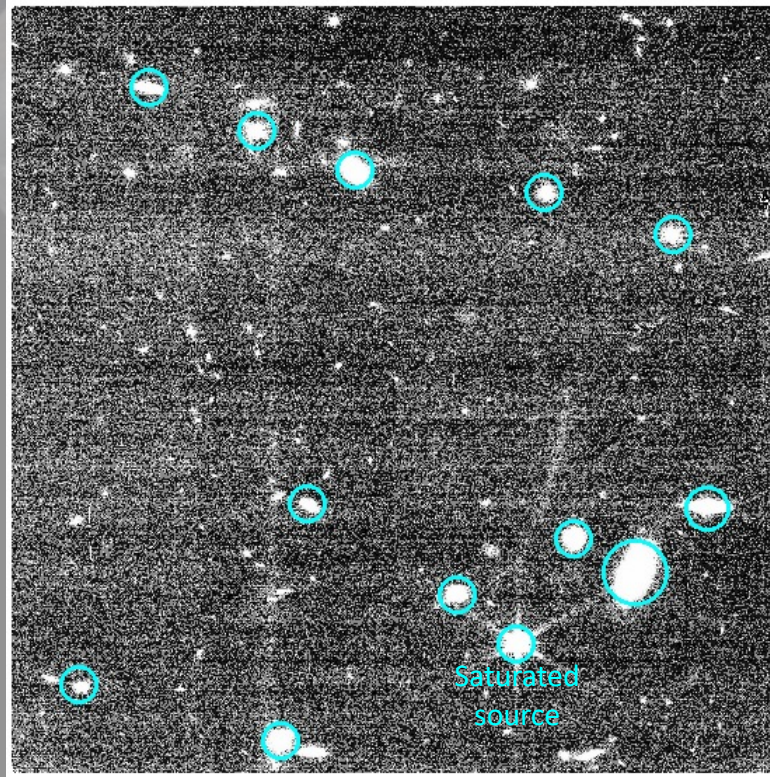
Single 220sec integration
4 detectors on module-B



Data Post-Processing

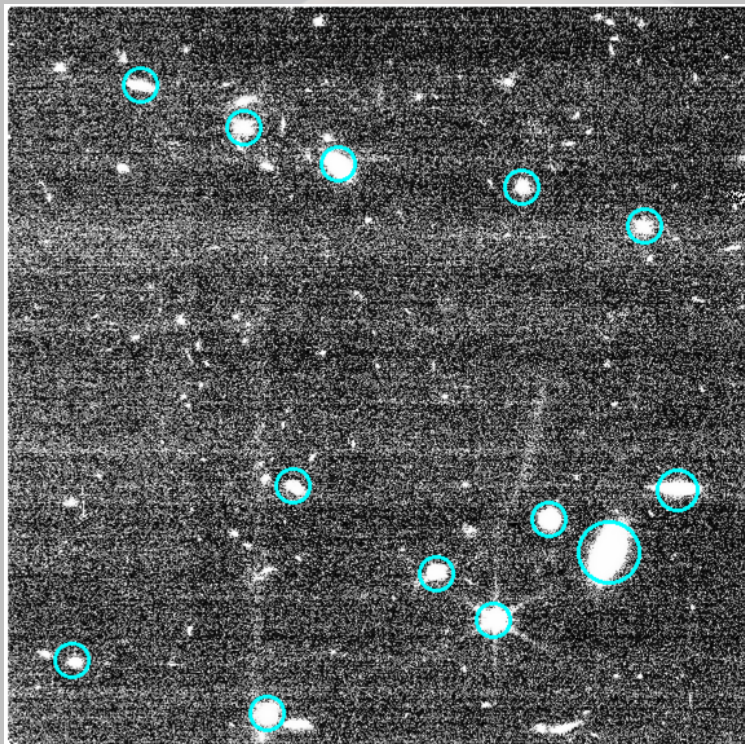
Use 'off' epochs to subtract background sources

Correct low-frequency amp drift (1/f noise)

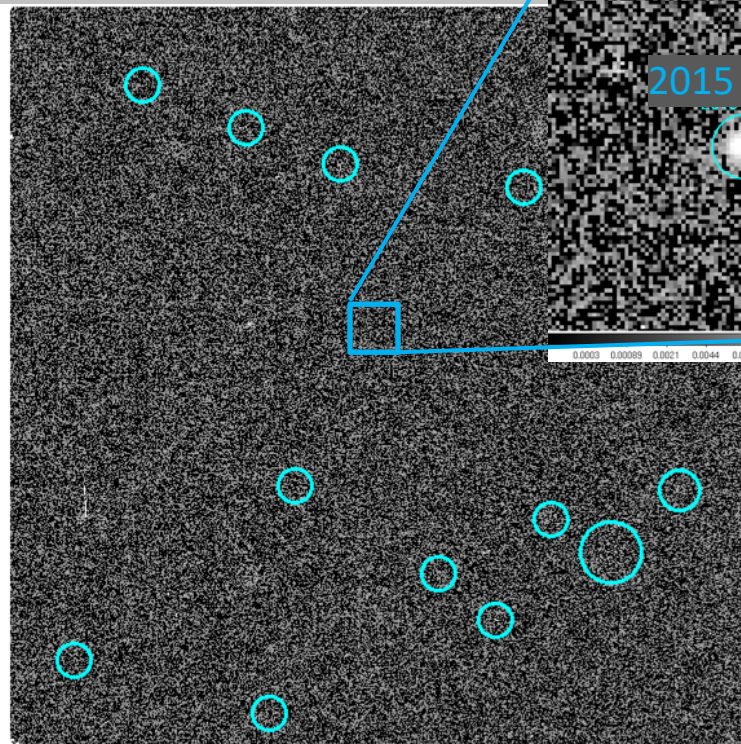


630 sec exposure (1 dither position of 2)

Detection of a 100km TNO



Single 600 sec exposure

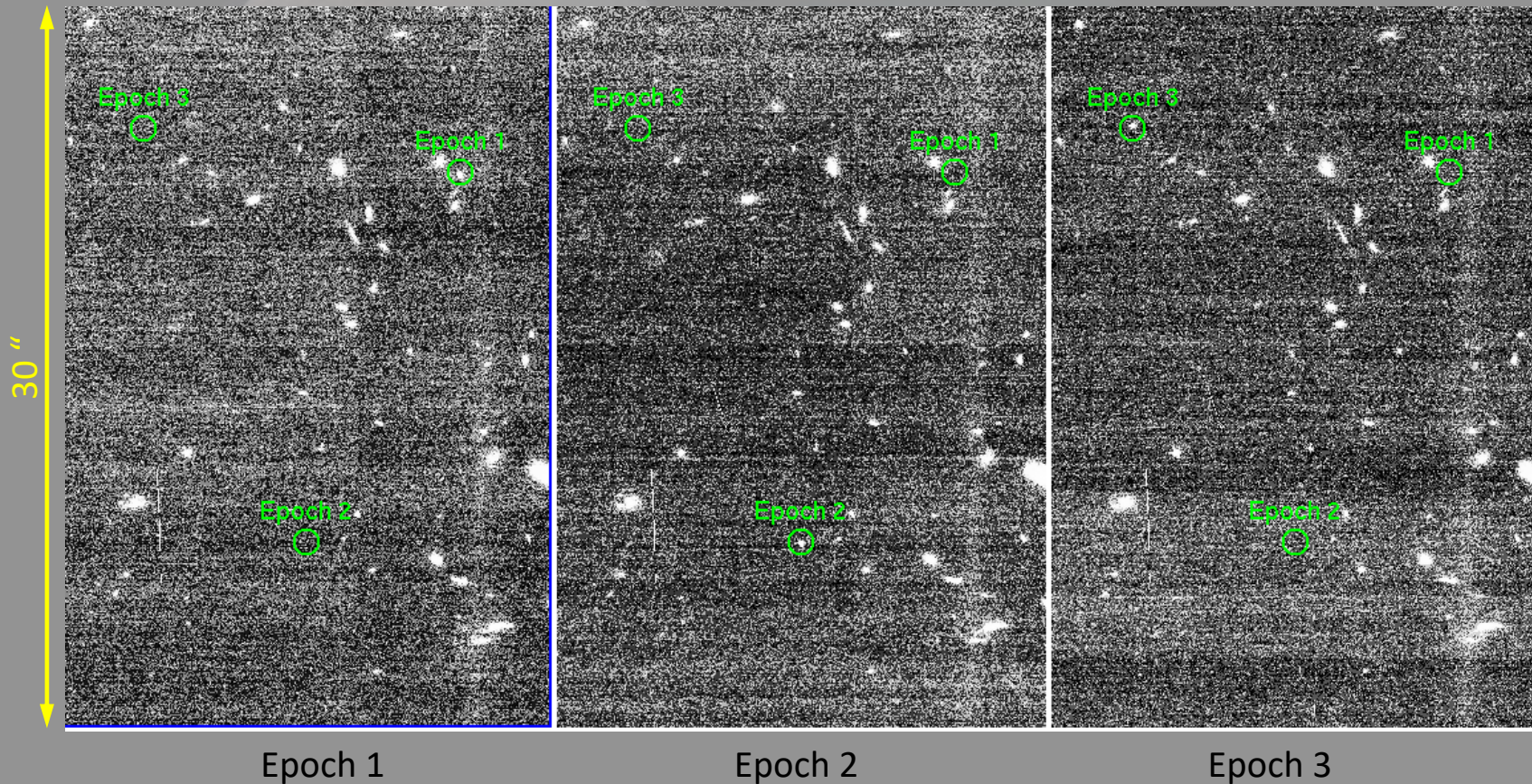


After post-processing and subtracting the mean
of 2 exposures at other epochs

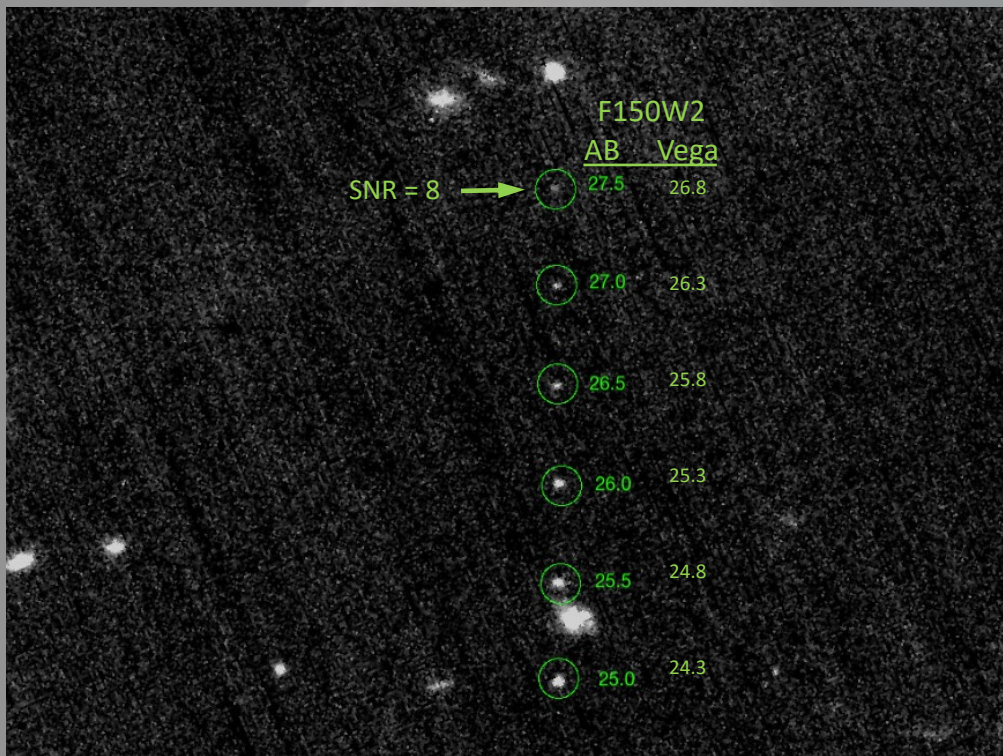


$m_V = 24.5$
 $m_{F150W2} = 22$
 $D \sim 100\text{km}$
46.4 AU
 $\text{SNR} = 100$

Motion of 2015 GK56 over the 3 epochs



Testing our Sensitivity: Implanted Objects

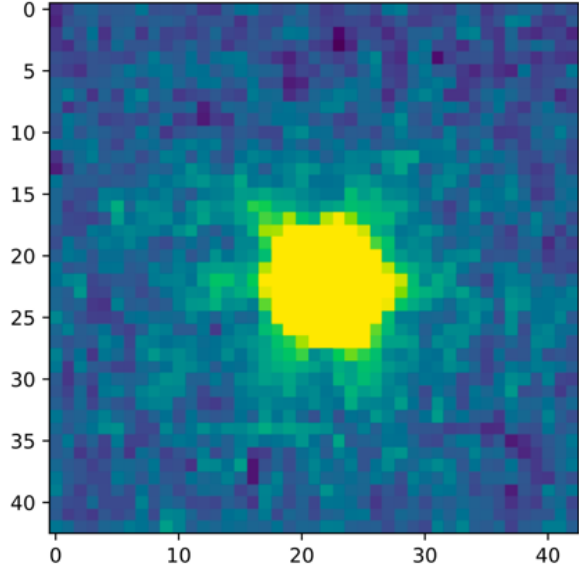


600 second exposure (1/2 full-depth)

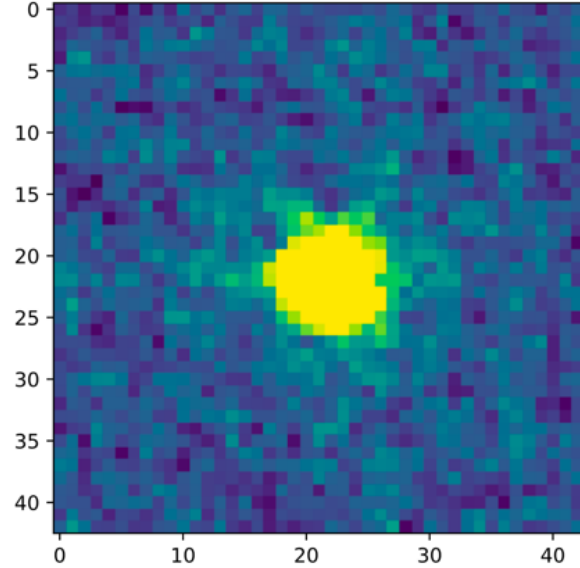
- We assumed $V-[F150W2] = \sim 1.2$ based on Arrokoth
 - Actually not as red as larger CCKBOs
 - Solar color is 1.3
- 10km TNO with $p_V = 0.15$, Arrokoth color, at 45AU
 - $H_V = 12.7$, $m_V = 29.4$
 - $\rightarrow m_{F150W2} = 29.4 - 2.5 = \sim 27$
- Implanted targets are added to the actual JWST images
 - Achieving $m_{F150W2} = 26.8$
 - *Measured on an image without background subtraction and $1/f$ noise correction*

Pushing Deeper: Shift and Stack

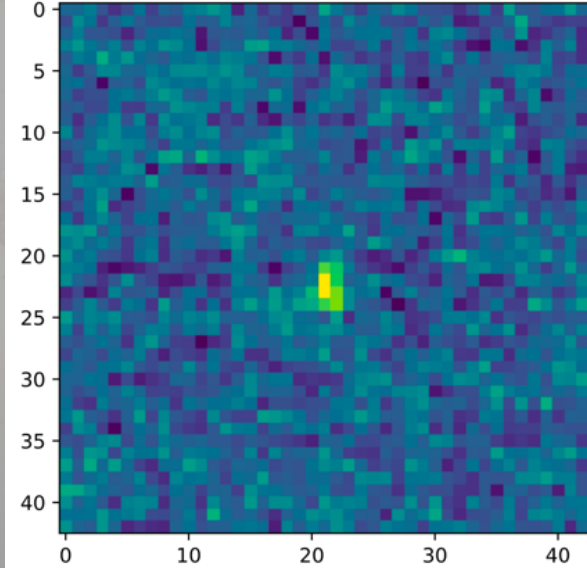
Implant, F150w = 22.5



2015 GK56



Implant, F150w = 27.1



Images show shift + stack for 1 epoch (2 dithered exposures of 630 sec each)
S + S across epochs may be possible, but isn't the basis of our project

Status



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- Initial results are very encouraging
 - Some uncertainties surrounding (of all things) magnitudes
 - AB vs. Vega
 - V vs F150W2
 - What is the correct MVIC + LEISA spectrum of Arrokoth?
 - What is the best color to assume for 10km CCKBOs?
 - We seem to be close to our expected sensitivity limit
 - We've just started testing shift + stack using implanted source
- *Where are the 1km asteroids?*

Asteroids (and other movers) are treated as Cosmic Rays

Data quality plane includes CR flags

