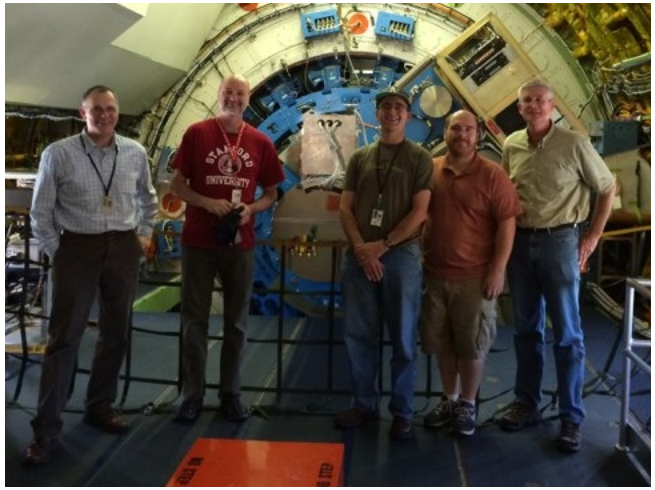
EXES on SOFIA:

Our first two flights



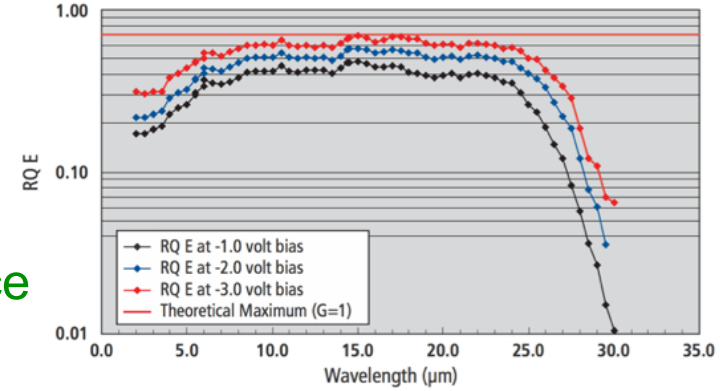
Current: Matt Richter (UCD), Mark McKelvey (Ames), Curtis DeWitt (UCD), Mike Case (UCD), Jeff Huang (Ames), Kristin Kulas (Ames), Robert McMurray (Ames), Damon Flansburg (Ames), Jeff Blair (Ames), Emmett Quigley (Ames), Reed Porter (Ames)

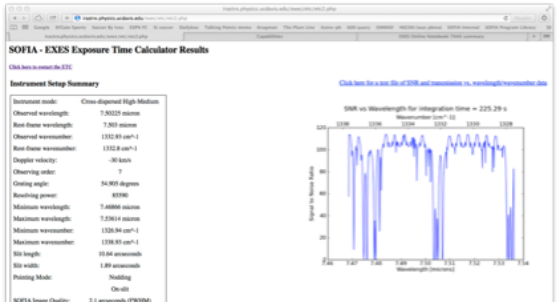
Past: Pete Zell (Ames), Andreas Seifahrt (UCD), John Reimer (Ames), Bala Balakrishnan (Ames), Dana Lynch (Ames), John Lacy (UT Austin), Doug Mar (UT Austin)

Honorary (SOFIA): Melanie Clarke, Bill Vacca, Adwin Boogert

About EXES

- EXES is a PI instrument optimized for high spectral resolution in mid-IR
  - High resolution mode:
    - cross-dispersed with R = 50,000 to 110,000 depending on slit width
    - single setting coverage of ~0.8% with 4-40” long slit or ~4% with 2-4” long slit
  - Other spectral modes
    - R ~ 10,000 to 20,000
    - R ~ 2000 to 4000
  - imaging for slit-positioning and pupil
- Wavelength range set by detector and science
  - shortest wavelength (~4.5 μm): CO Δv=1
  - longest wavelength (~28.3 μm): H2 J=2-0 - poor detector response
- Exposure Time Calculator at http://irastro.physics.ucdavis.edu/exes/etc/
  - three step process
  - full website being worked on



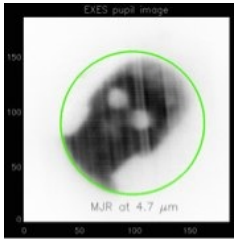


Commissioning Goals

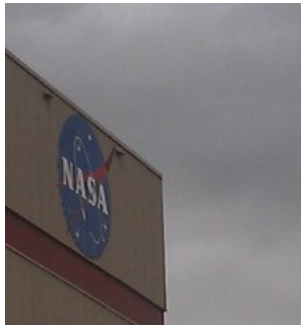
- Characterize EXES performance on SOFIA

- Successfully install
- Check noise properties
- Check TA interface
  - alignment to secondary - EXES cannot adjust alignment while cold
  - Check telescope motions - tweak, nod, map
  - Boresight and reference frame transformations
  - Focus
- Observing
  - peaking up on object
  - efficiencies
  - sky cancellation
  - sensitivity
  - blackbody flatfielding

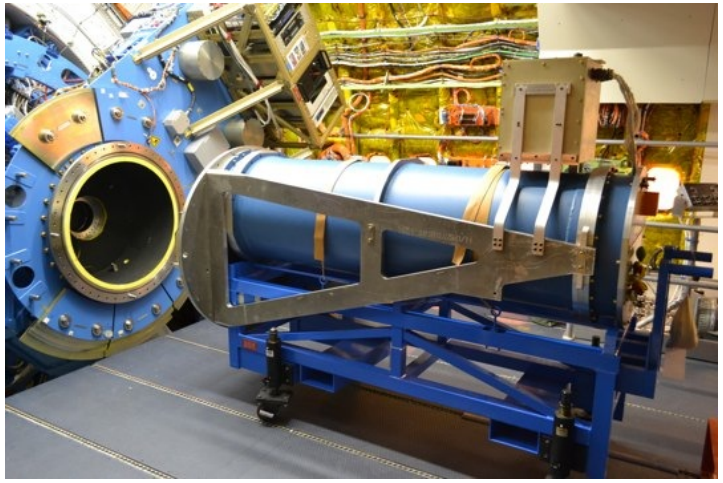
Schedule

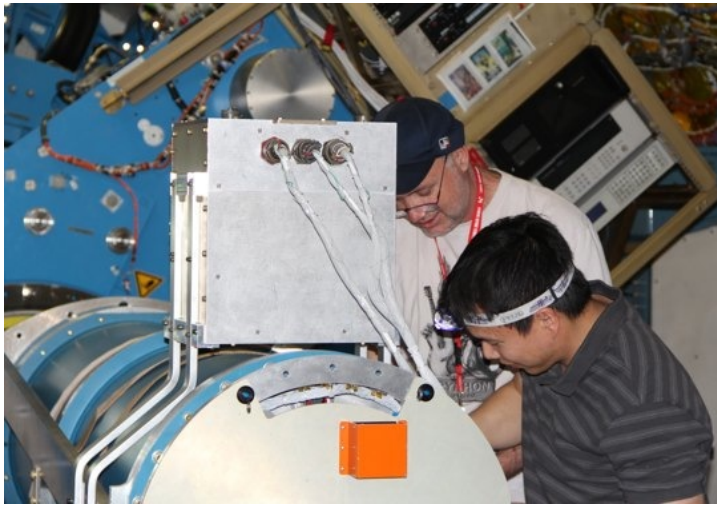


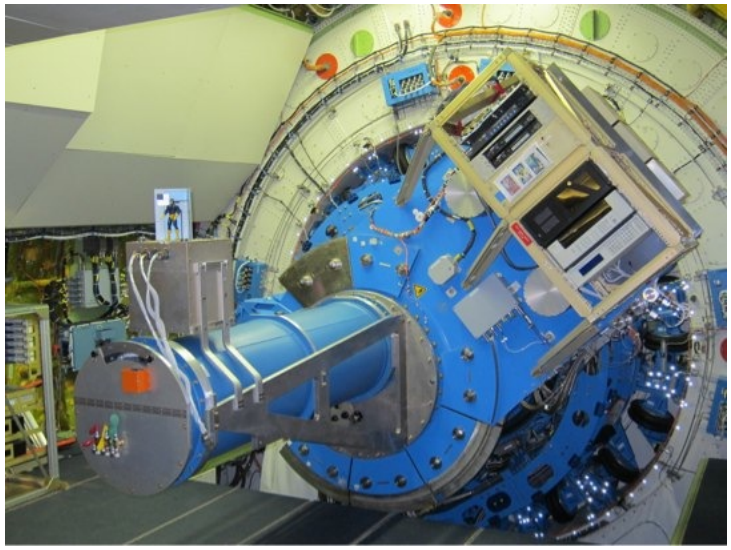
- Arrive DAOF Mar 3
  - EXES was cold
  - Verify no thermal touches, resolution, noise, and TAAS alignment
- Complete Tier IV (software) Mar 14
- Install Mar 31
- Line ops Apr 3 & 4 (clouds)
- Flights Apr 7 & 9 (PDT)

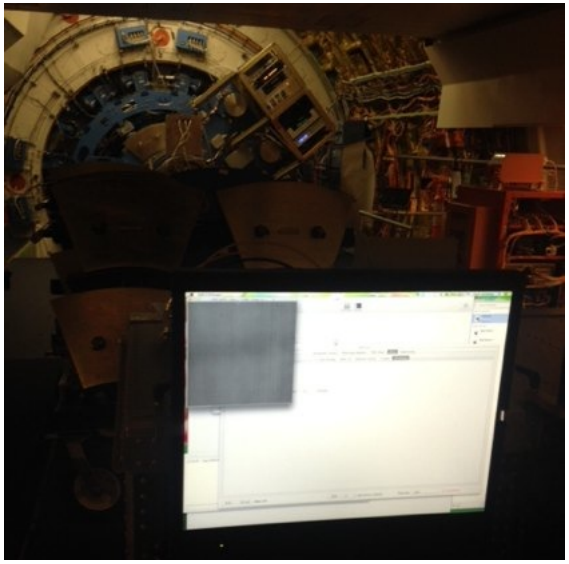


Installation

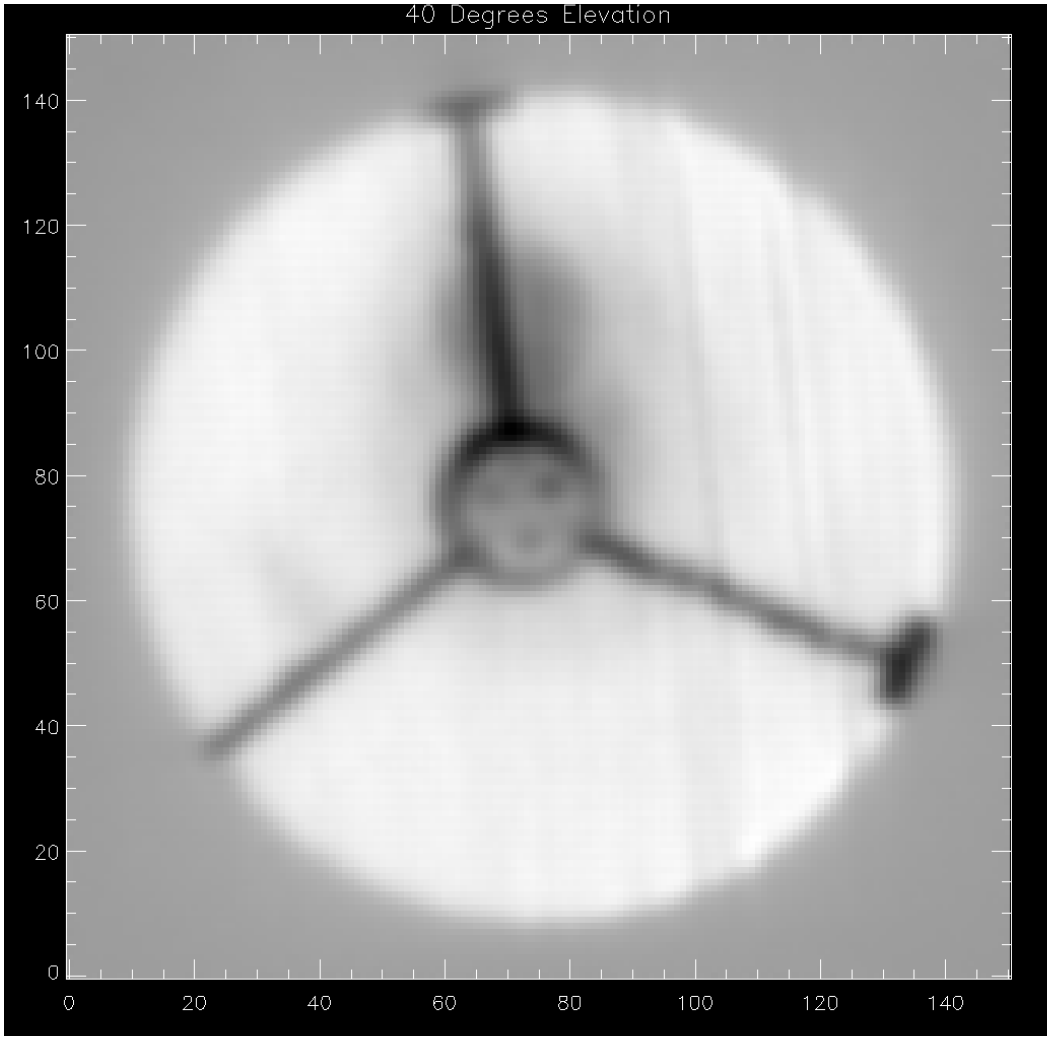








TA Interface



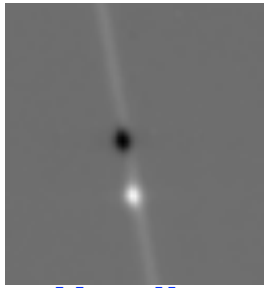
FORCAST Pupil image

EXES Pupil image

Alignment is good.
Details to be worked out

TA Interfaces

- Boresight and angles
  - Always choose center of EXES slit. Nods and maps executed by SI commands from there.
  - Tweak paddle move in SIRF from there
  - Nod while imaging through slit to verify
  - Do LOS rewinds to verify no impact

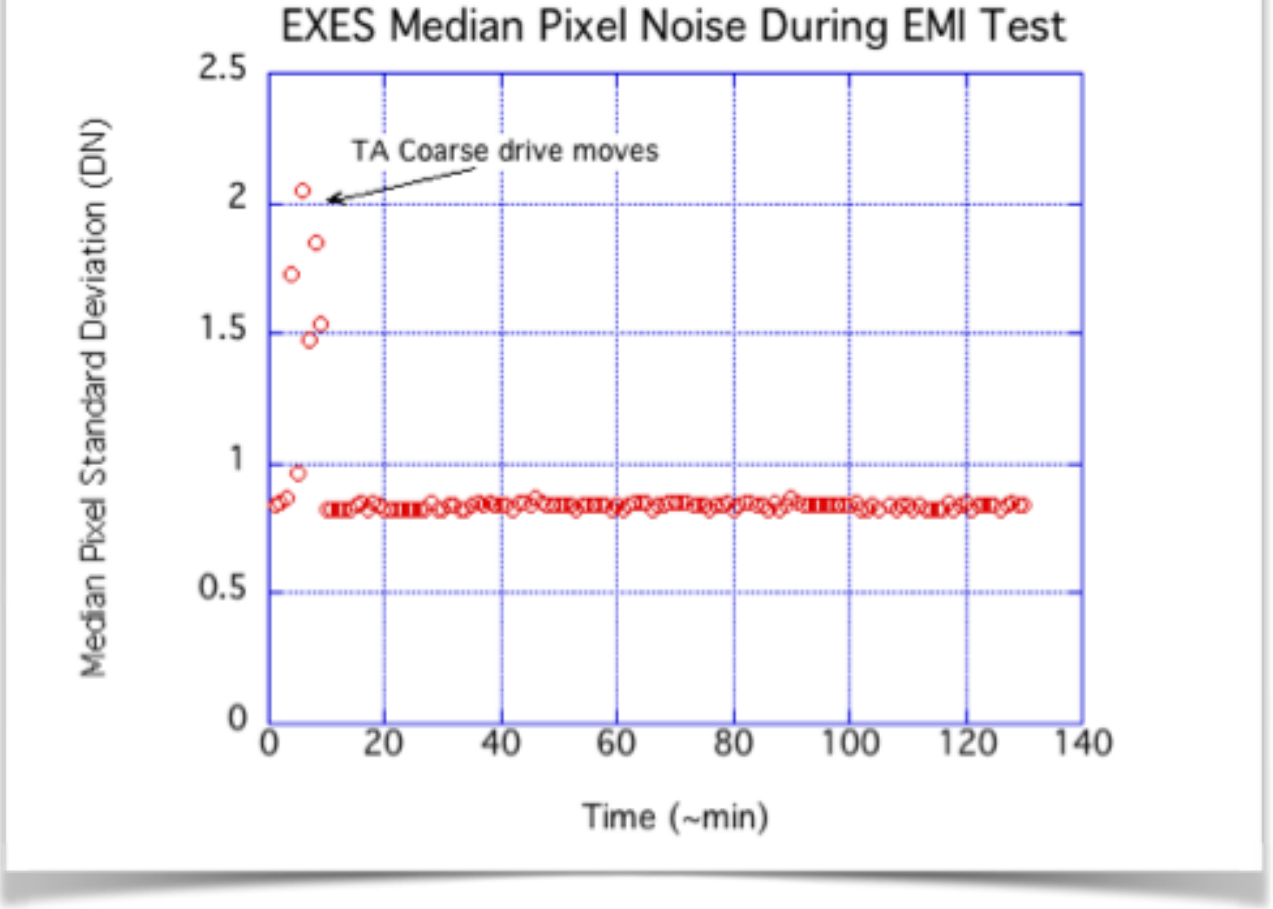


Things looked good, but detailed analysis may yield improvements. Use line ops as much as possible. Develop specific software tools.

- Focus
  - EXES imaging and spectroscopic focus close, but not same
    - Detector position and path length in long slit vs cross-dispersed
    - May work improve before next commissioning
  - Best spatial profile did not provide most light through slit. Could impact nodding on slit

Another item for next EXES line ops at wavelengths available from ground

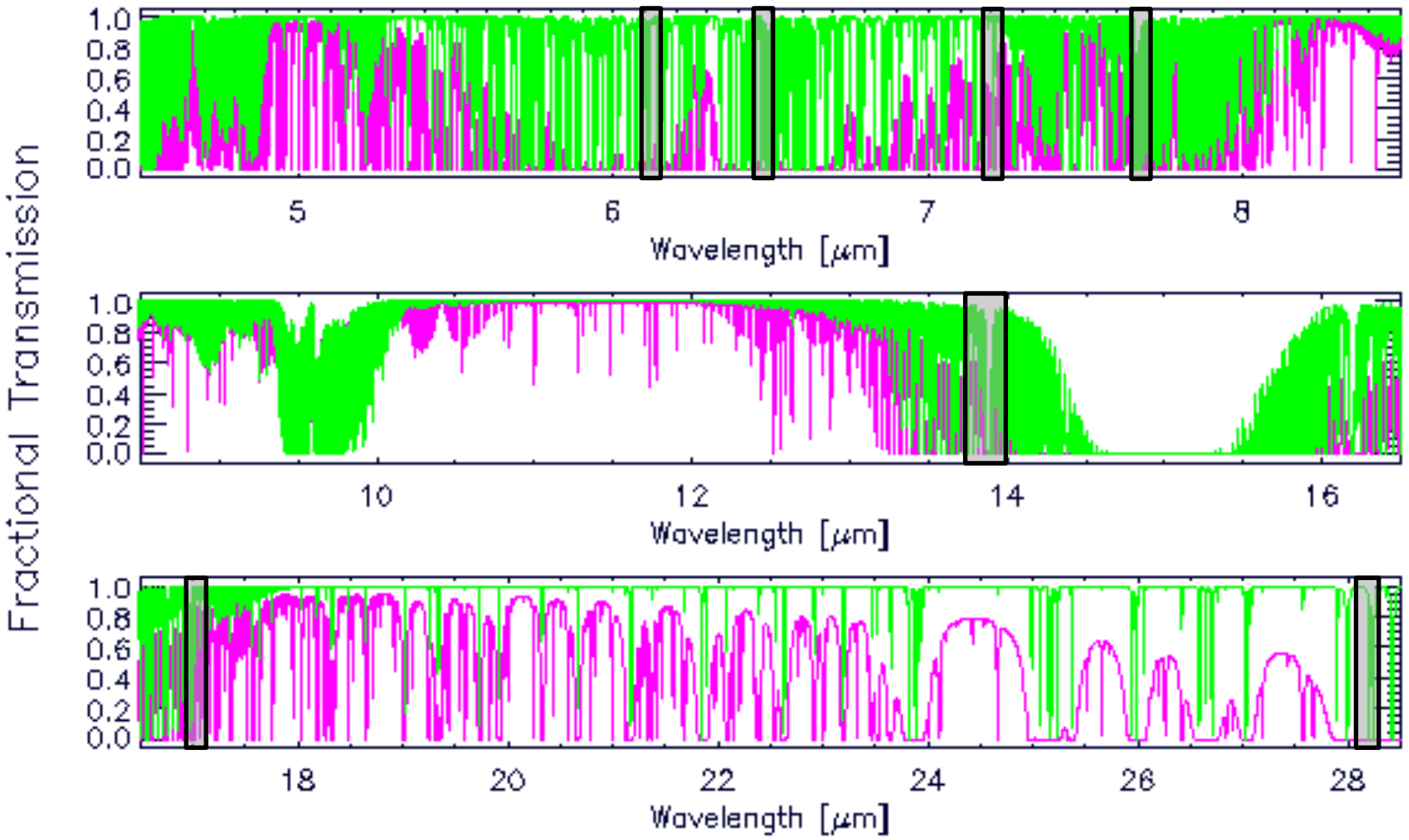
Noise on SOFIA



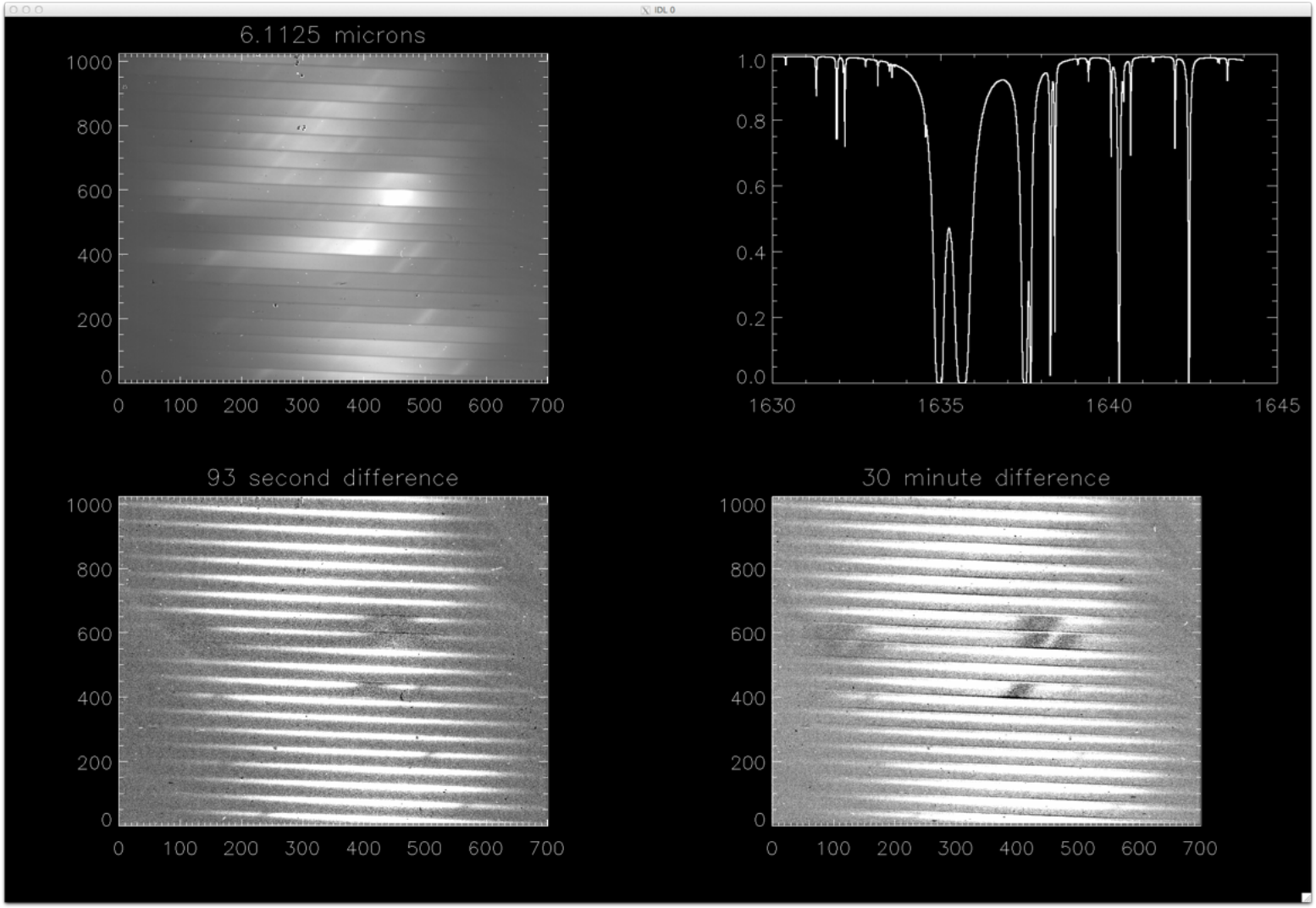
Commissioning Observations

- Targets
  - standard stars - alpha Boo, alpha Tau, alpha CMa, alpha Lyr, beta Gem, delta Vir
  - planets - Mars, Jupiter
  - Asteroid 1 (Ceres)
  - Embedded object - AFGL 2591
  - blank sky
- Observing Modes
  - nod on slit, nod off slit, map
- Instrument modes
  - mostly high resolution. Some medium resolution
    - changing modes not as easy as it should be - gear train? Have to verify change based on pupil image through instrument (>5 min).
- Wavelengths
  - 28.3 ∝m (H_2 J=2-0); 17.03 ∝m (H_2 J=3-1); 13.9 ∝m (HCN/C_2H_2 Q branches), 7.67 ∝m (CH_4 Q branch); 7.2 ∝m (CO_2, H_2O, HDO); 6.5 ∝m (H_2O), 6.1 ∝m (H_2O ground state)
  - 17.03 accessible from ground - compare with TEXES results from Feb.
  - Bootstrap sensitivity based on lab comparisons
- Unique data provided by EXES high-resolution should result in publishable results

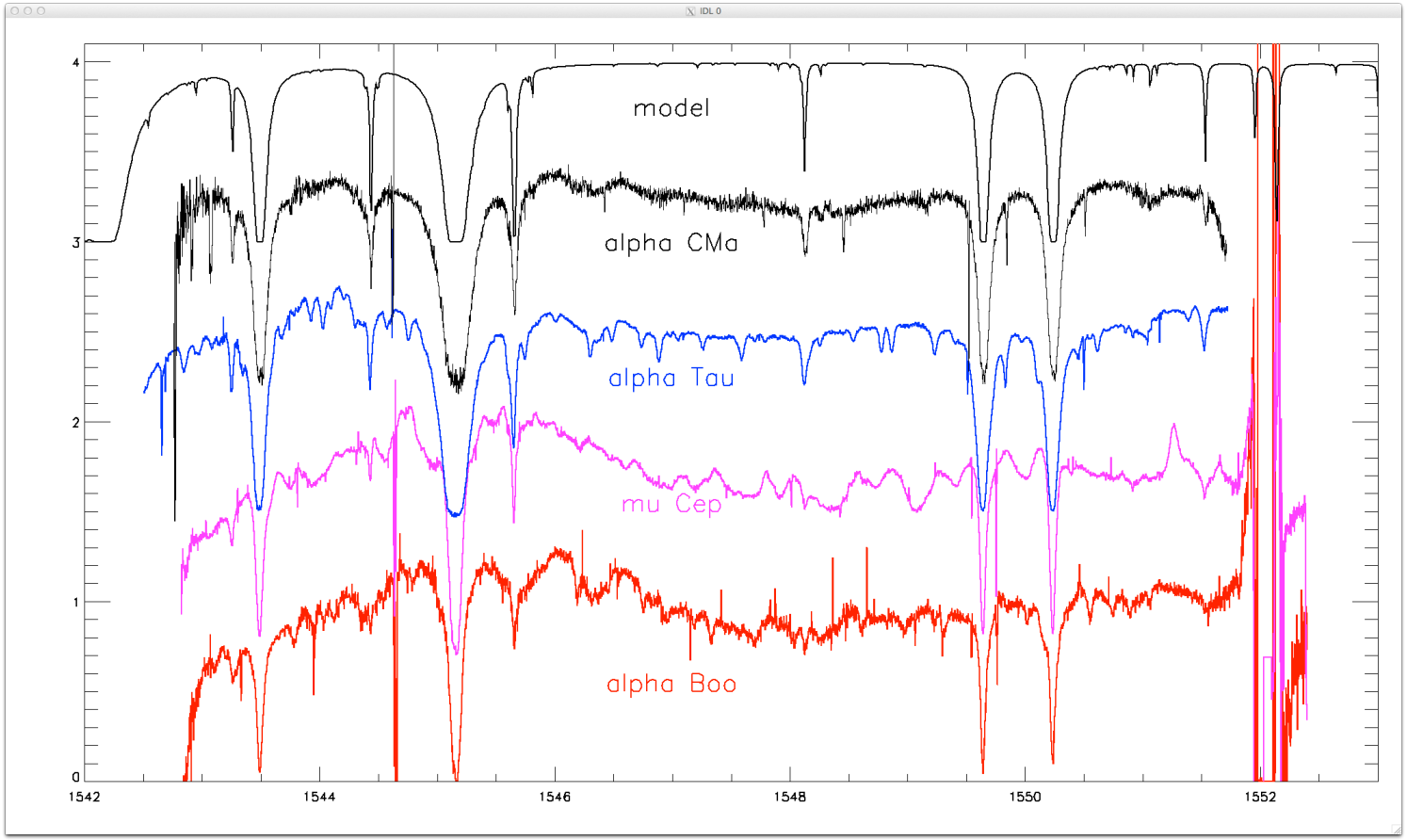
Atmospheric transmission



Highlights

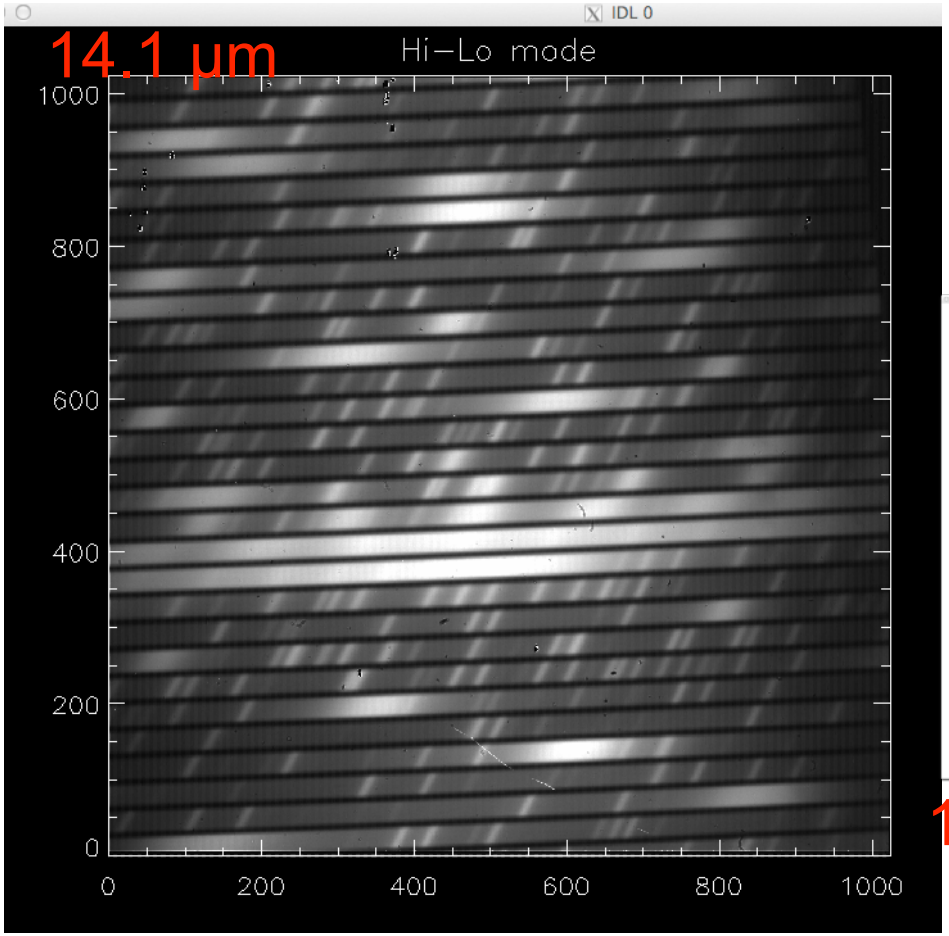

6.1125 microns
1000
800
600
400
200
0
0 100 200 300 400 500 600 700
1.0
0.8
0.6
0.4
0.2
0.0
1630 1635 1640 1645
93 second difference
30 minute difference

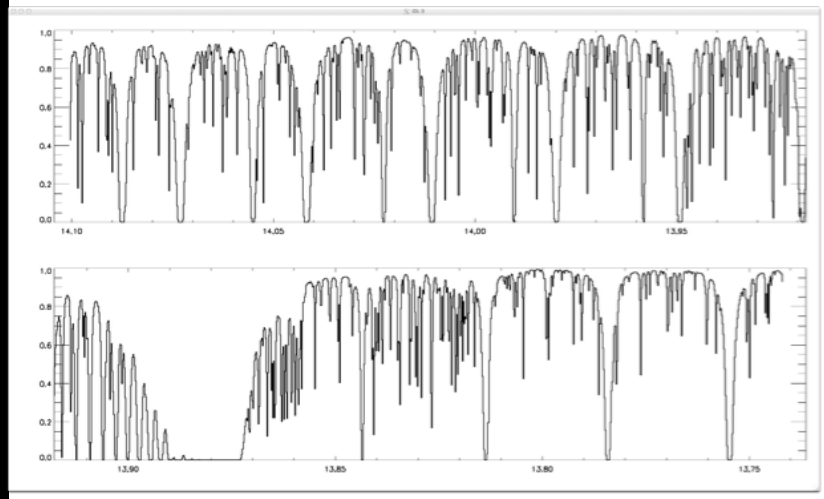
Highlights



From pipeline: Bill Vacca and Melanie Clarke

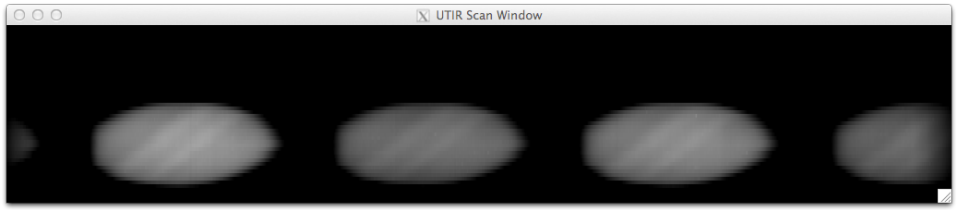
Highlights

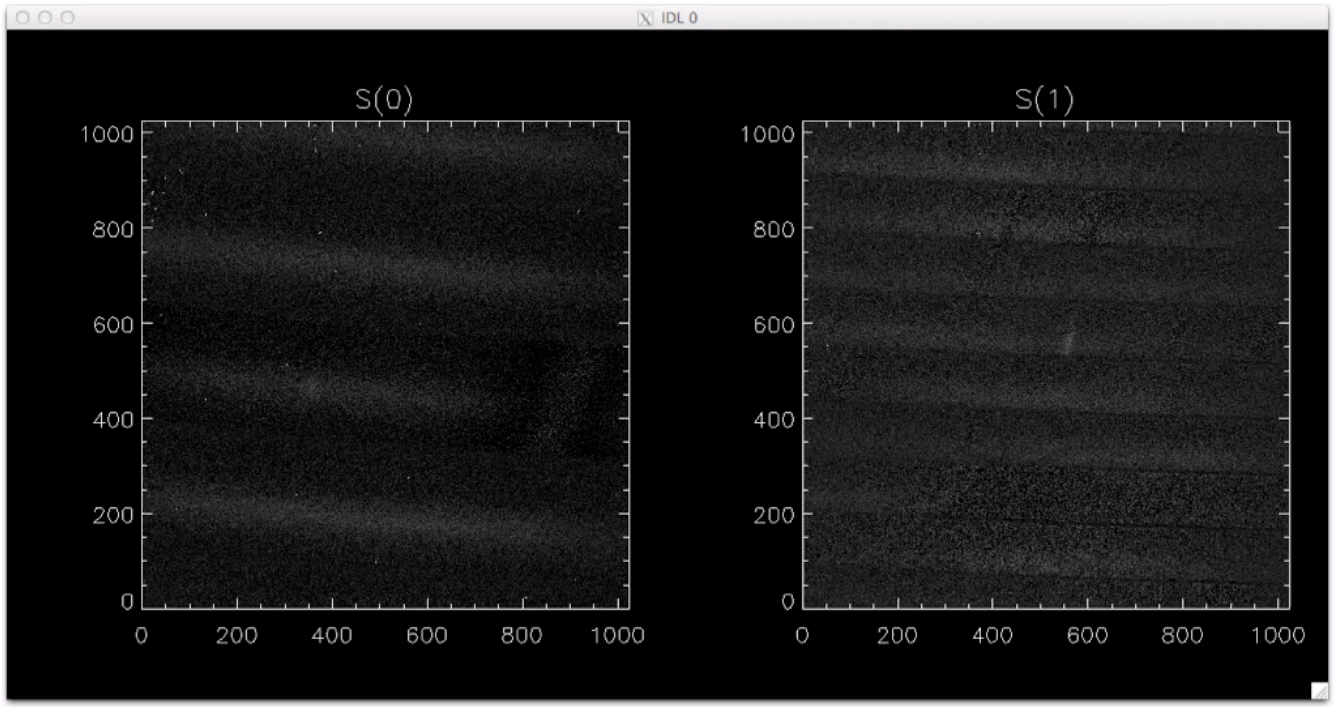


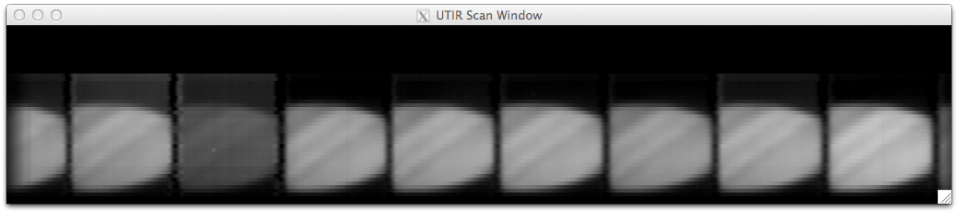


13.76 μm

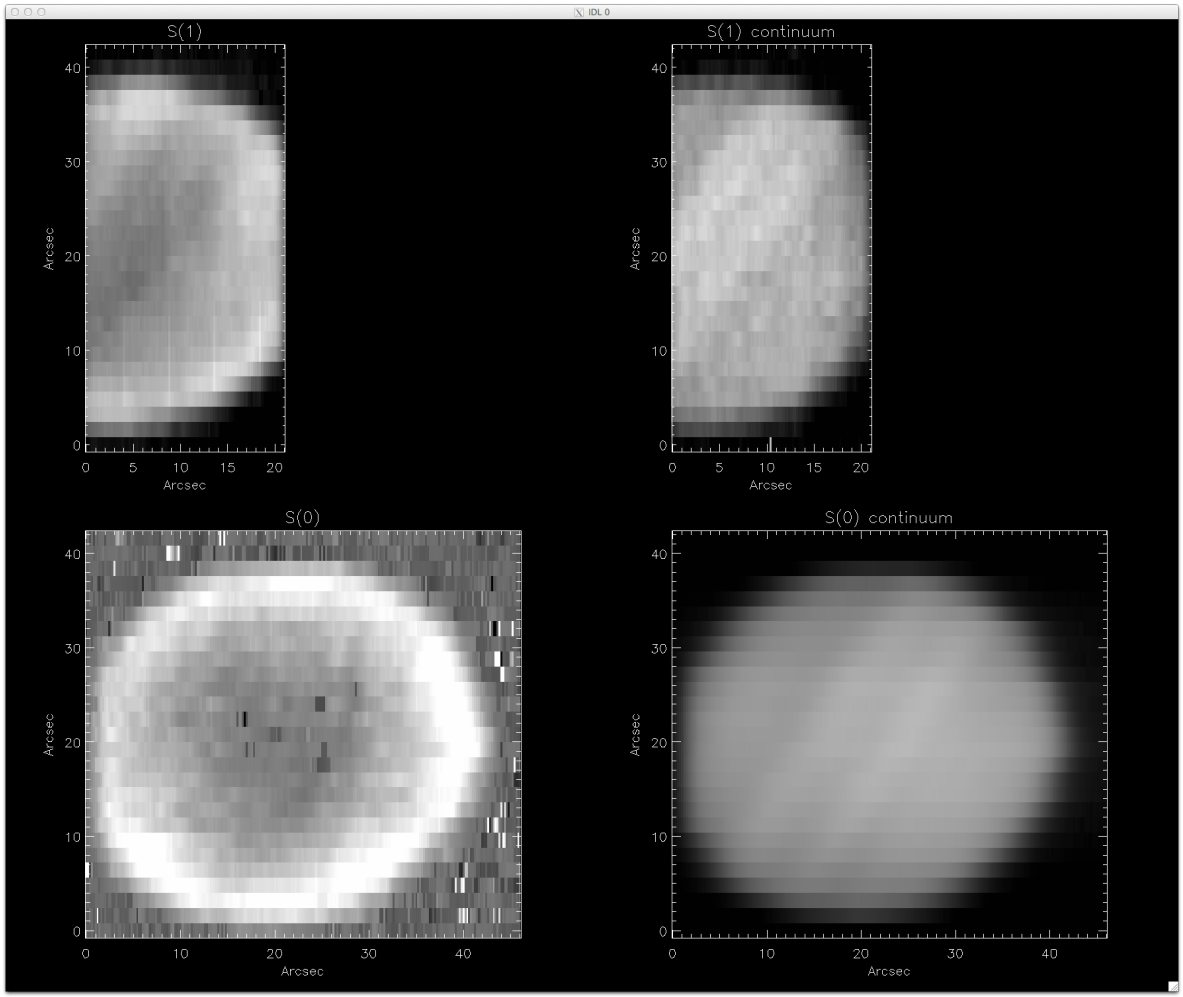
Highlights


UTIR Scan Window


IDL 0
S(0)
S(1)
1000
800
600
400
200
0
0
200
400
600
800
1000


UTIR Scan Window

Highlights


S(1)
S(1) continuum
S(0)
S(0) continuum
Arcsec
Arcsec
0
5
10
15
20
30
40