NIRCAM:
Near-IR Capability for JWST

C. Beichman (Caltech/JPL),

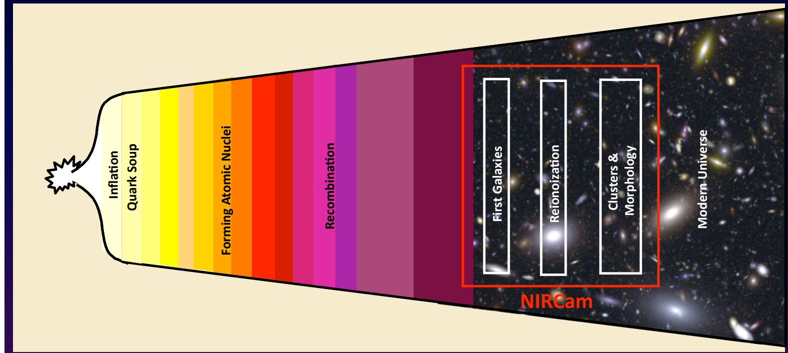
For the NIRCAM team,

M. Rieke (Univ. Arizona), PI

ESO-JWST Conference, Garching

April 13, 2010

Science Goals Require 1-5 μm Performance



The End of the Dark Ages: First Light and Reionization

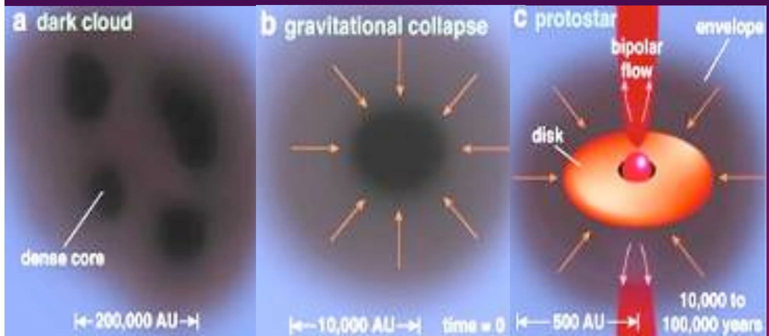
Conduct deep surveys to find and categorize objects.

Broadband, high sensitivity, large FOV, diffraction-limited PSF, multiple broadband filters

The Assembly of Galaxies

Measure shapes and colors of galaxies, identify young clusters

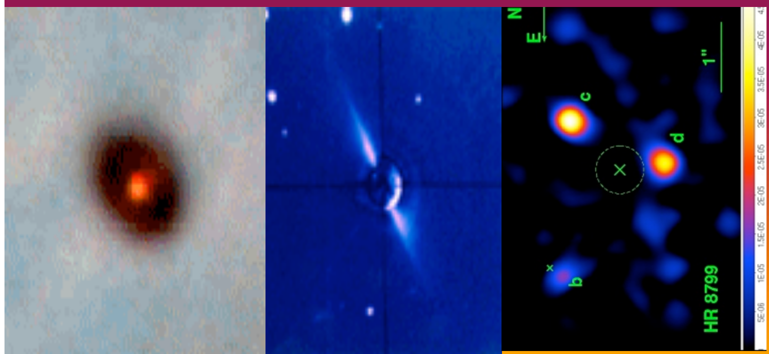
Broadband, high sensitivity, large FOV, diffraction-limited PSF



The Birth of Stars and Protoplanetary Systems

Determine colors and numbers of stars in clusters, measure extinction profiles in dense clouds

Broad and narrowband filters, high sensitivity, large FOV, diffraction-limited PSF, high dynamic range



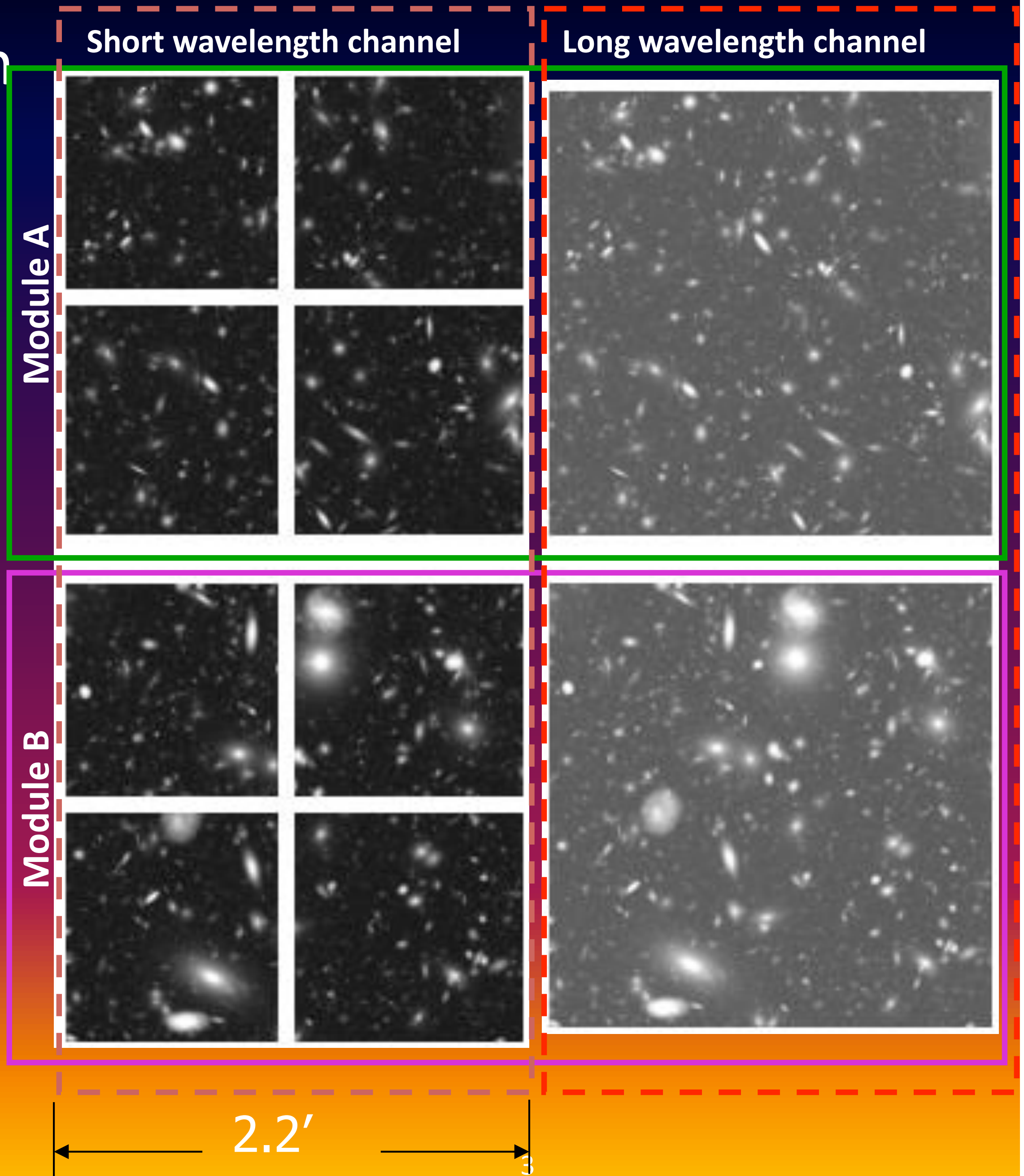
Planetary Systems and the Origins of Life

Characterize disks and planets, classify KBOs

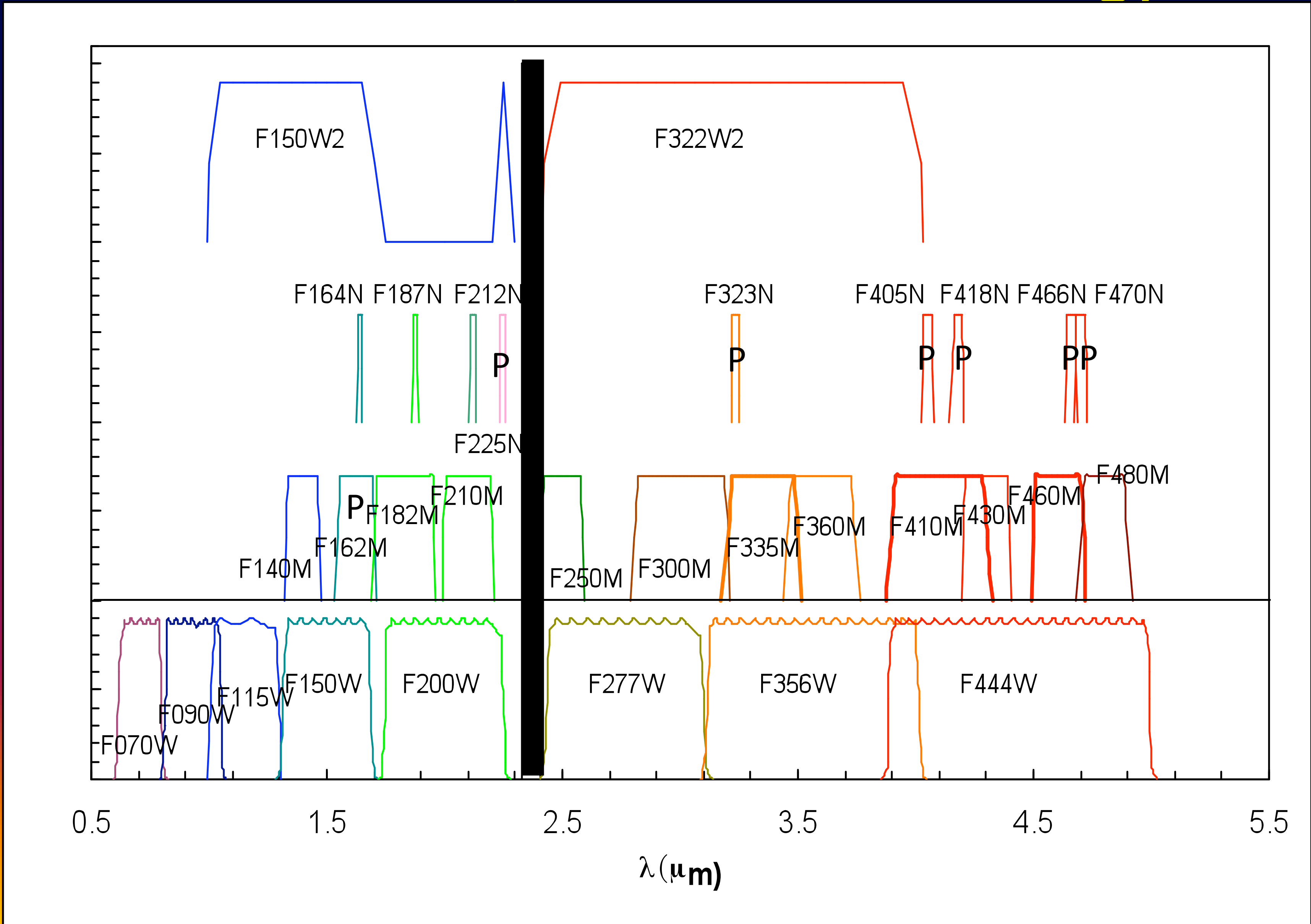
Broad and intermediate band filters, high sensitivity, coronagraphic masks, defocused images and grism spectroscopy for transits

NIRCam: Simple but Powerful Capability

- NIRCam images 0.6 - 5μm range using compact refractive optics
- Dichroic splits into short (0.6-2.3 μm) and long-λ (2.4-5 μm) sections
- Nyquist sampling at 2 μm (0.032"/pix) & 4 μm (0.064"/pix)
- 2.2 arcmin x 4.4 arcmin FOV in two colors (40 Mpixels) simultaneously
- Coronagraphs for short and long wavelengths
- Grism and defocus lens for transits

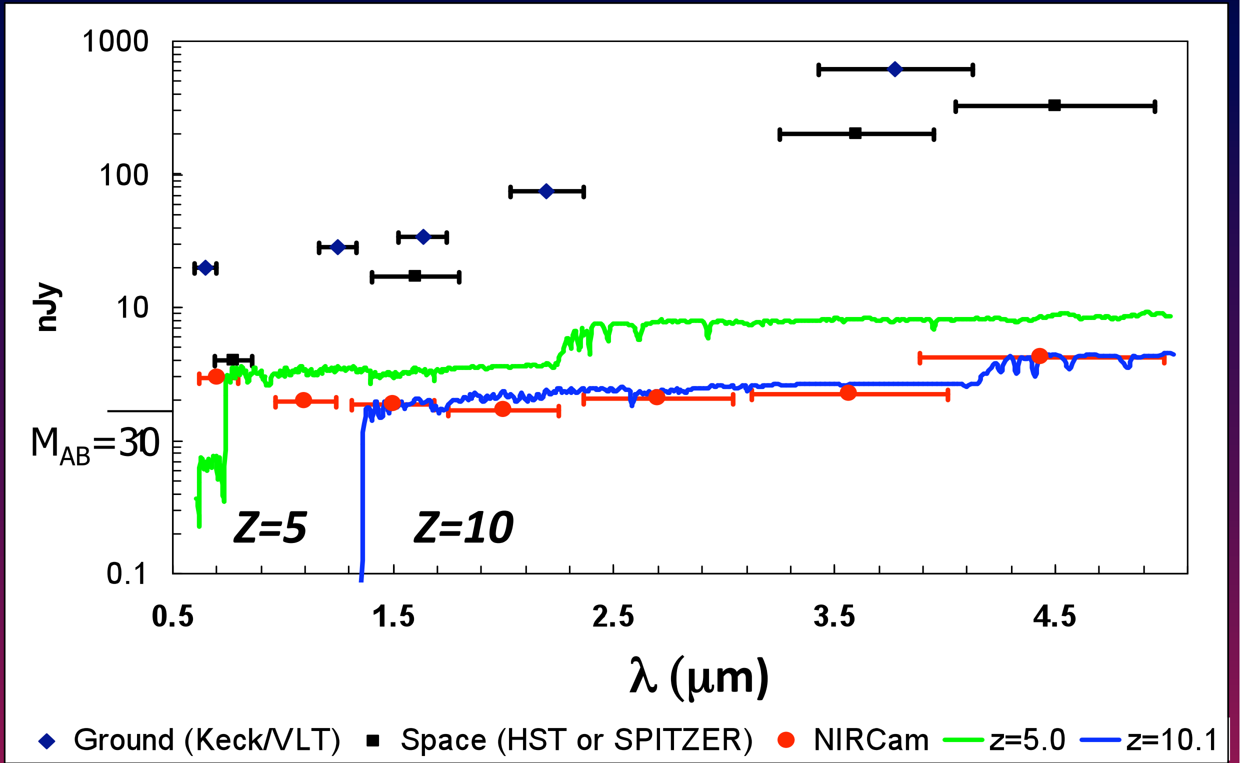


NIRCam Filters Span 0.6 - 5 μm For Photo-z , ISM and Mineralogy



High Sensitivity, Multi-λ, Deep Surveys

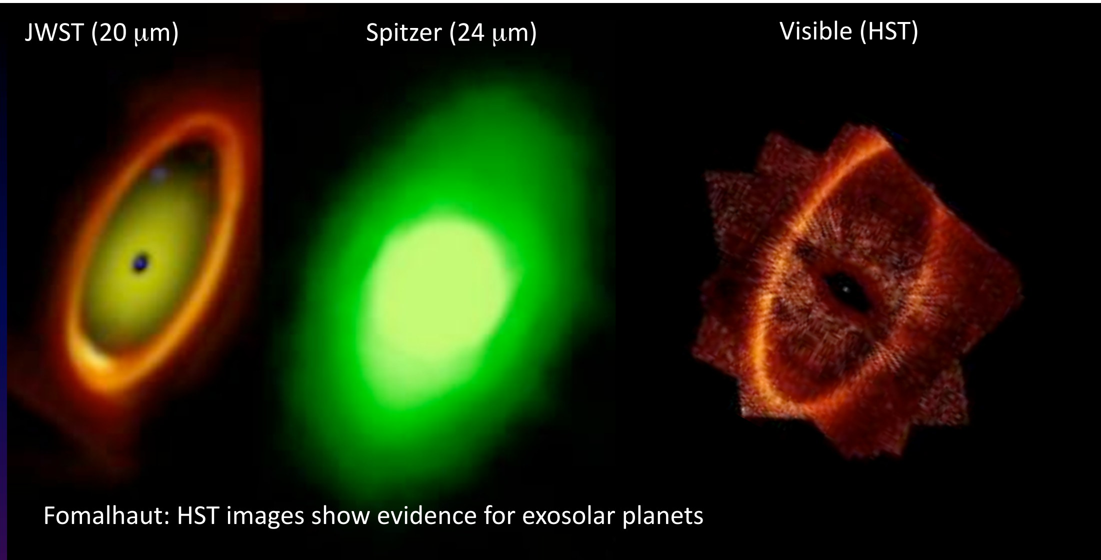
- At 3-5 μm, NIRCam can detect objects 100x fainter than Spitzer opening up new survey possibilities
- Filter set for ~4% photometric redshifts for >98% of galaxies in multi-color survey.



The z=10 galaxy has a mass of $4\times10^8 M_{Sun}$ while the mass of the z=5 galaxy is $4\times10^9 M_{Sun}$.

Above assumes 50,000 sec/filter with 2x time on longest wavelength

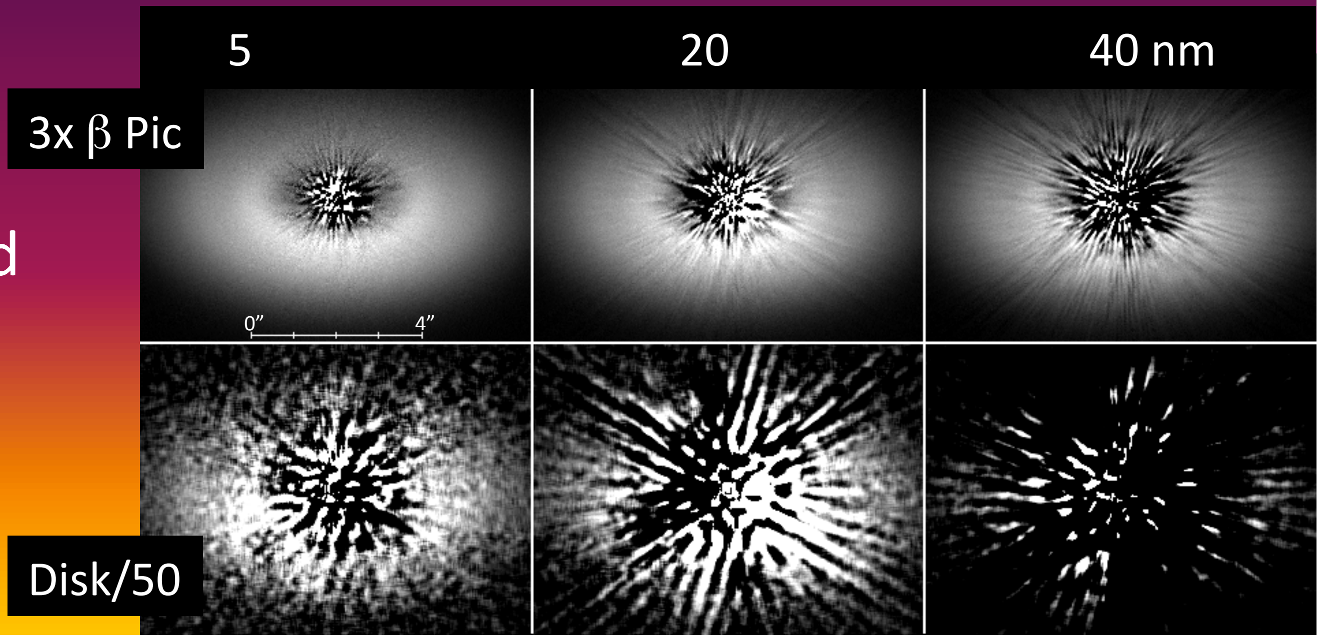
JWST Extends Spitzer/Herschel and HST Results on Circumstellar Disks



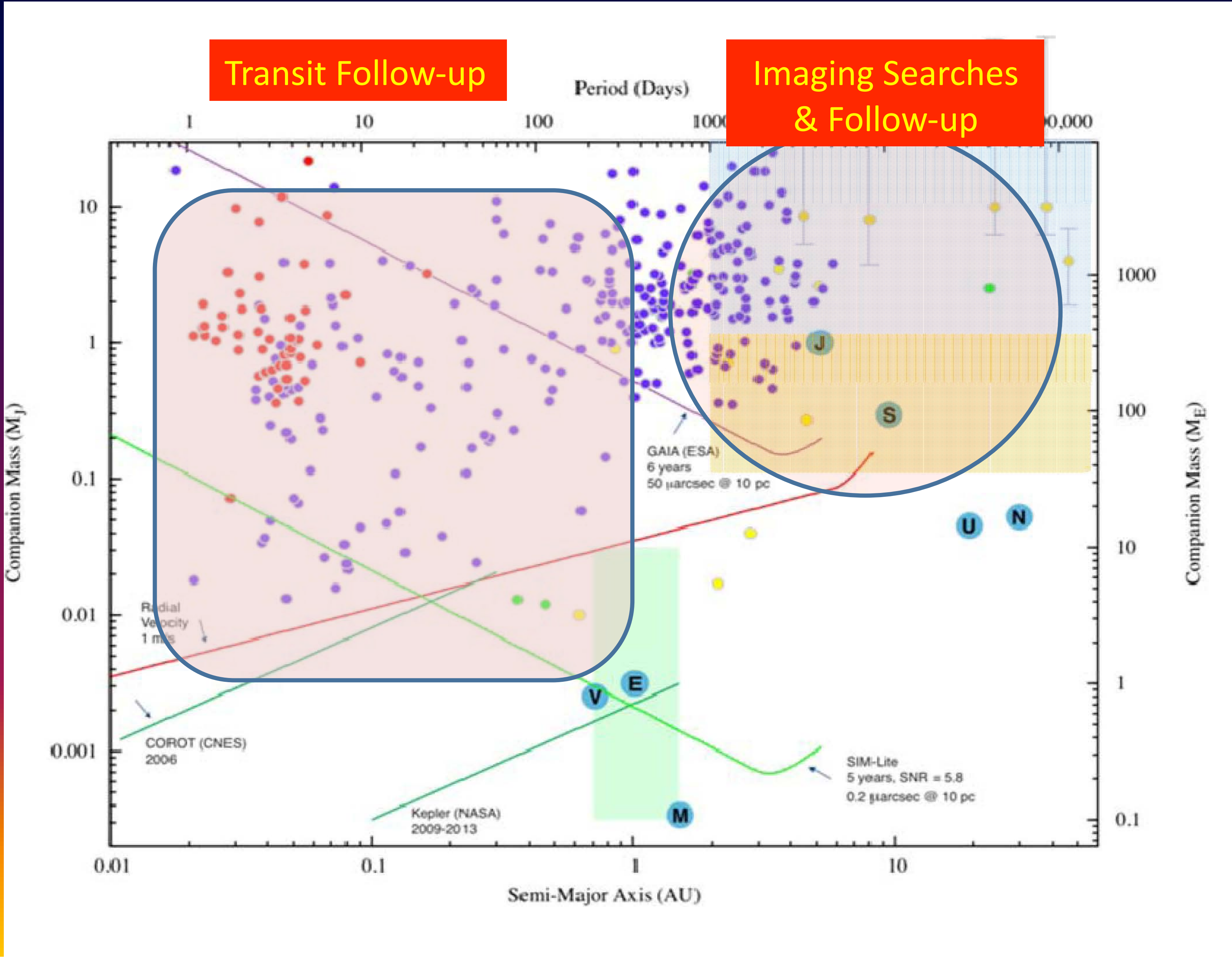
Fomalhaut: HST images show evidence for exosolar planets

- Probe dust in depleted systems, to complete picture of disk evolution
- Resolve disks & structures looking for rings, gaps, etc. Planets?
- Maps of scattered light and thermal emission to map dust populations, composition, interactions and structure

- Scattered light observations to map structures for detailed modeling
- Synergistic program with NIRCAM & MIRI



Exo-Planets With JWST



Direct Imaging of Planets

- NIRCam Sensitivity at peak brightness of hot, young planets
  - Planets down to Saturn mass
- Probe orbits from 10-500 AU
  - Infants: 1-2 Myr at 100-140 pc
  - Adolescents: 10-25 Myr at 25-50 pc
  - Nearest M stars, $\leq$ 1 Gyr at 10-25 pc
- Plan coordinated program with TFI NRM and MIRI/FQPM

20” (~12 mm)

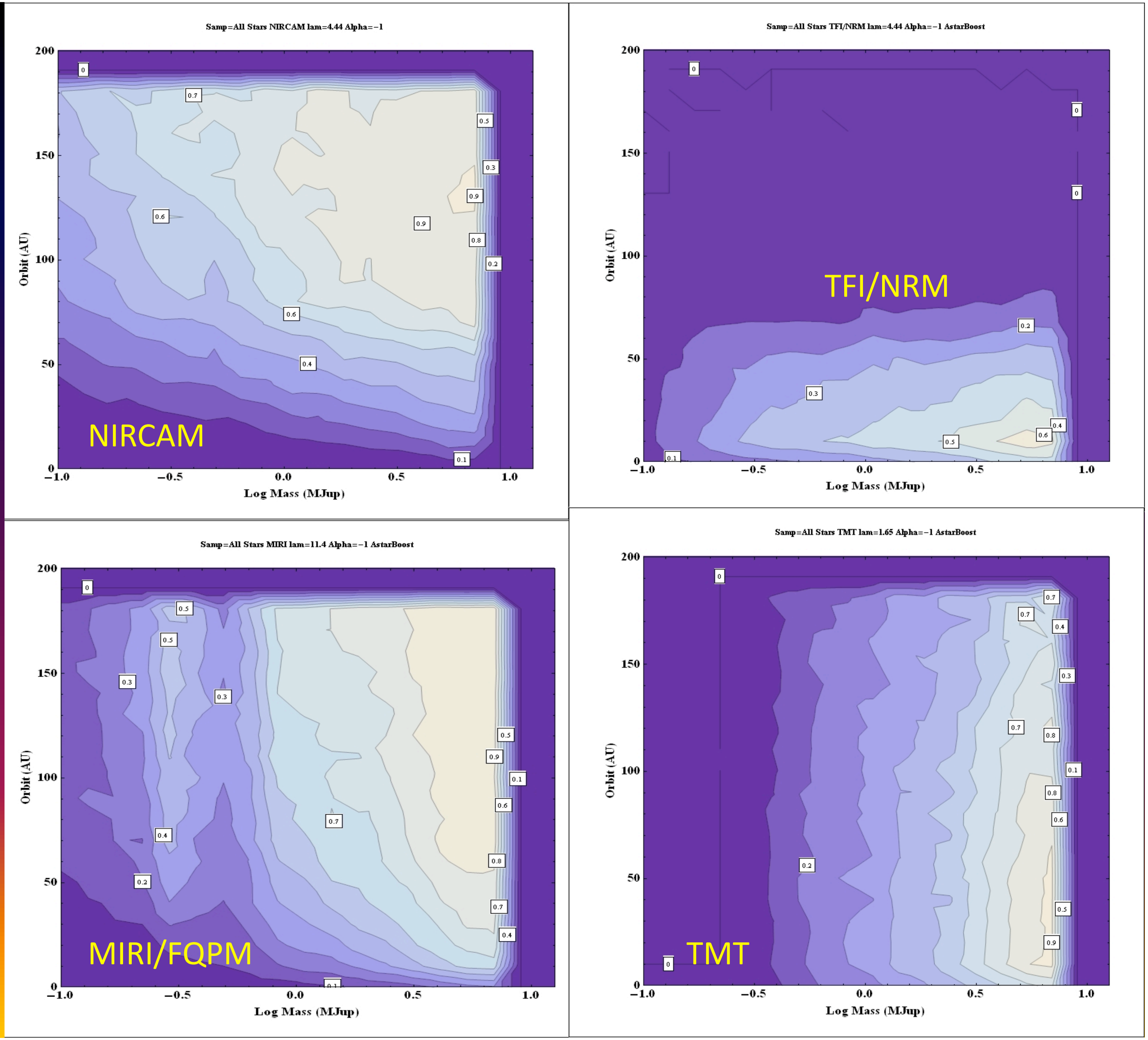
5” x 5” ND squares

HWHM = 0.40”	**HWHM = 0.64”**	**HWHM = 0.82”**	**HWHM$_c$ = 0.58”**	**HWHM$_c$ = 0.27”**
(6λ/D @ 2.1 μm)	**(6λ/D @ 3.35 μm)**	**(6λ/D @ 4.3 μm)**	**(4λ/D @ 4.6 μm)**	**(4λ/D @ 2.1 μm)**

Direct Imaging of Young Gas Giants

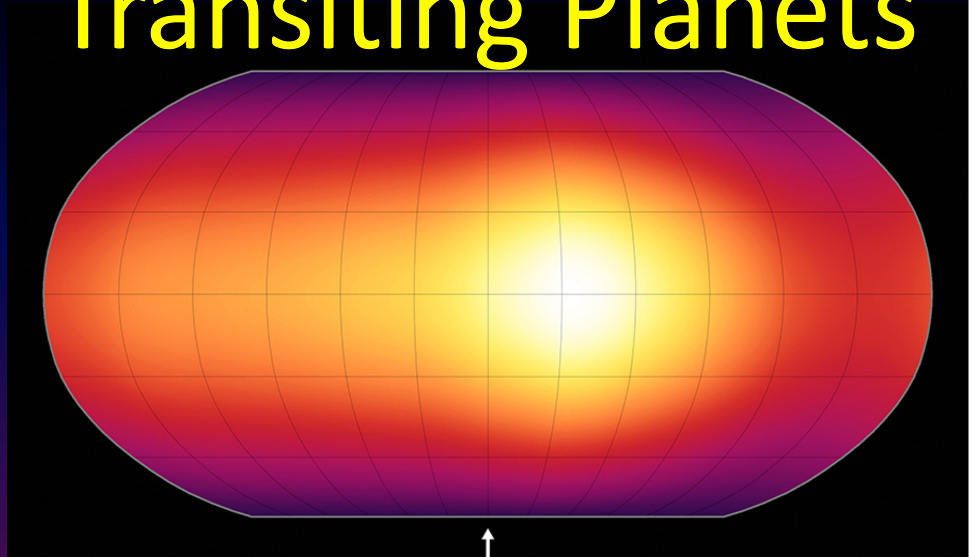
- Test Theories of Formation & Migration

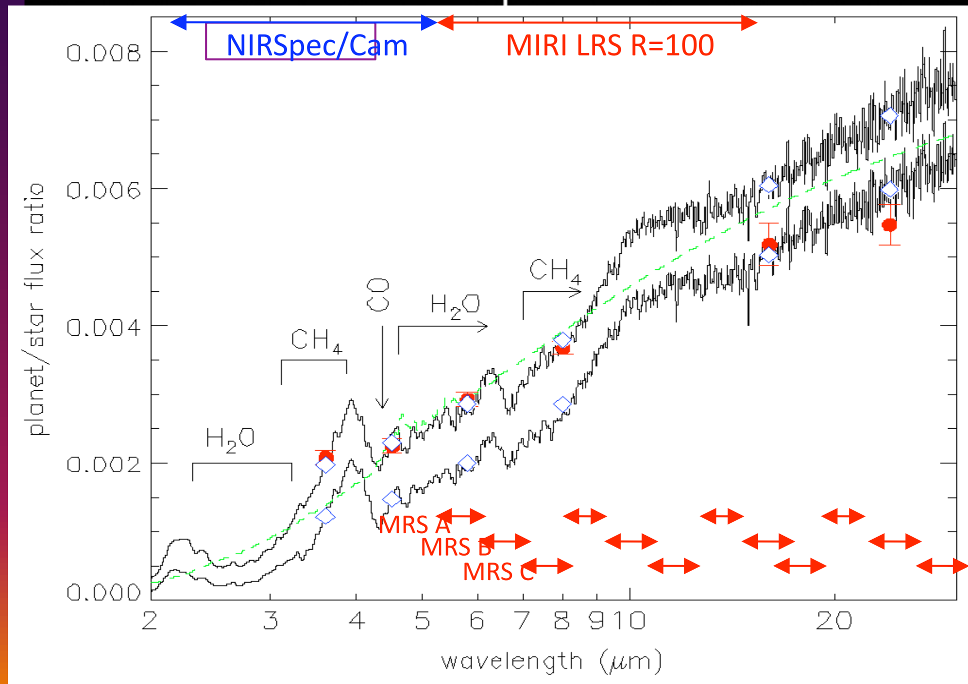
Beichman et al 2010

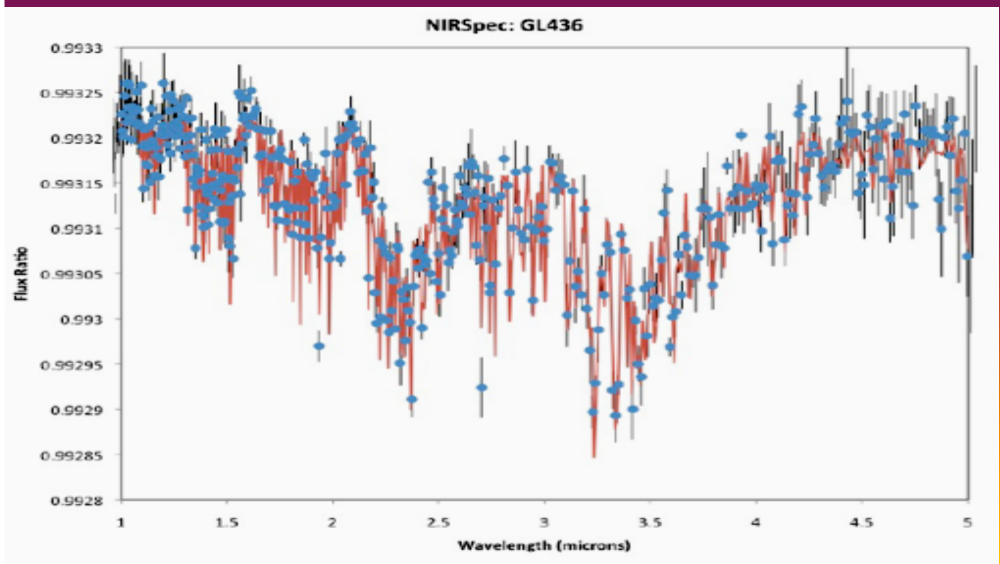


Transiting Planets

- NIRCam photometry
  - Primary and secondary eclipses for albedo, Teff, moons, rings, timing
  - Complete light curves for global circulation (weather!)
  - Earth transit of K~10 mag star will have SNR=20-30 in 6.5 hr
- Grism spectra of gas giants
  - Composition, clouds, atmospheric structure
- Spectrum of super Earth orbiting nearby M star? (Deming et al; Traub & Kaltenegger)

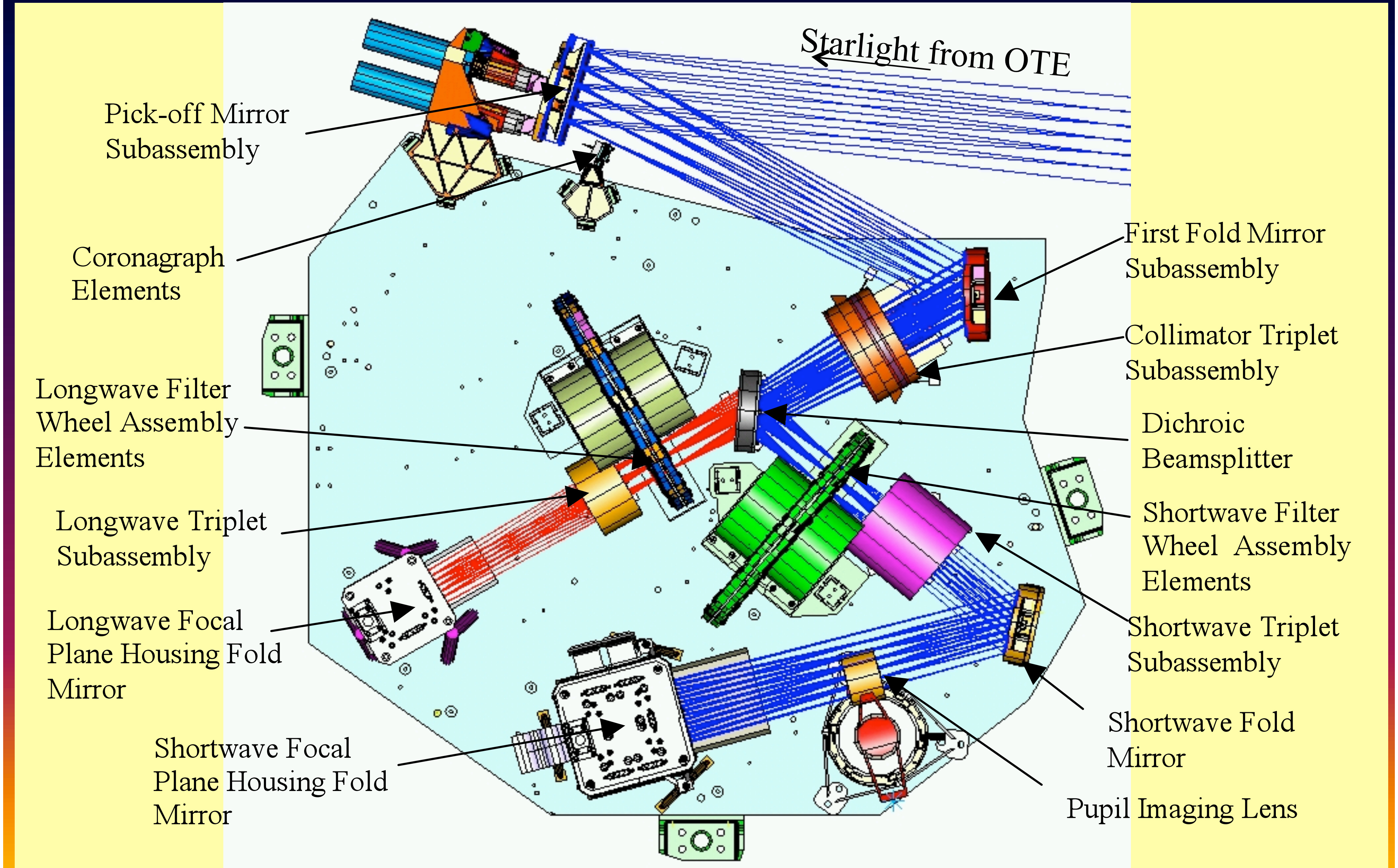




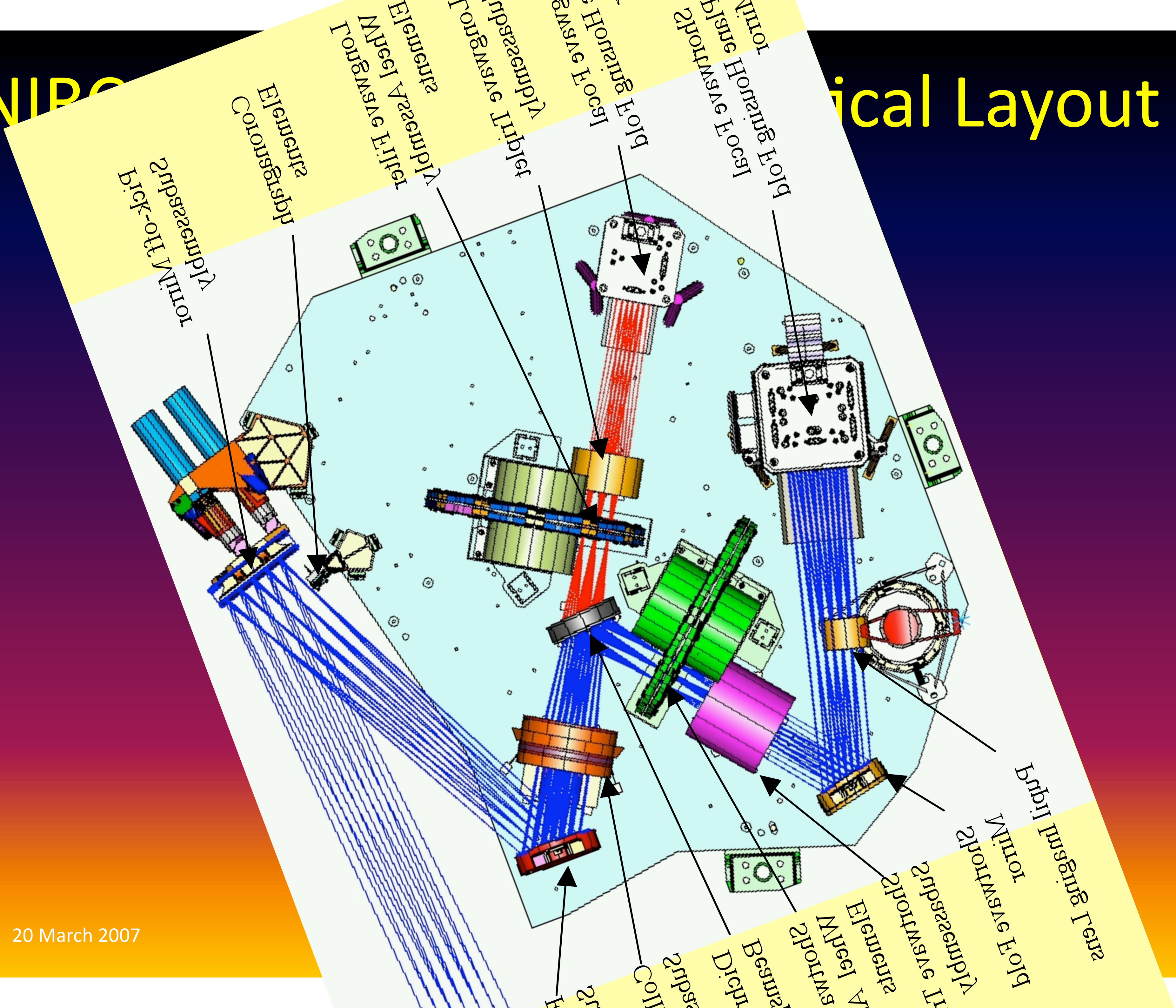


Spectrum of GL436 Hot Neptune (Seager)

NIRCam Utilizes Simple Optical Layout

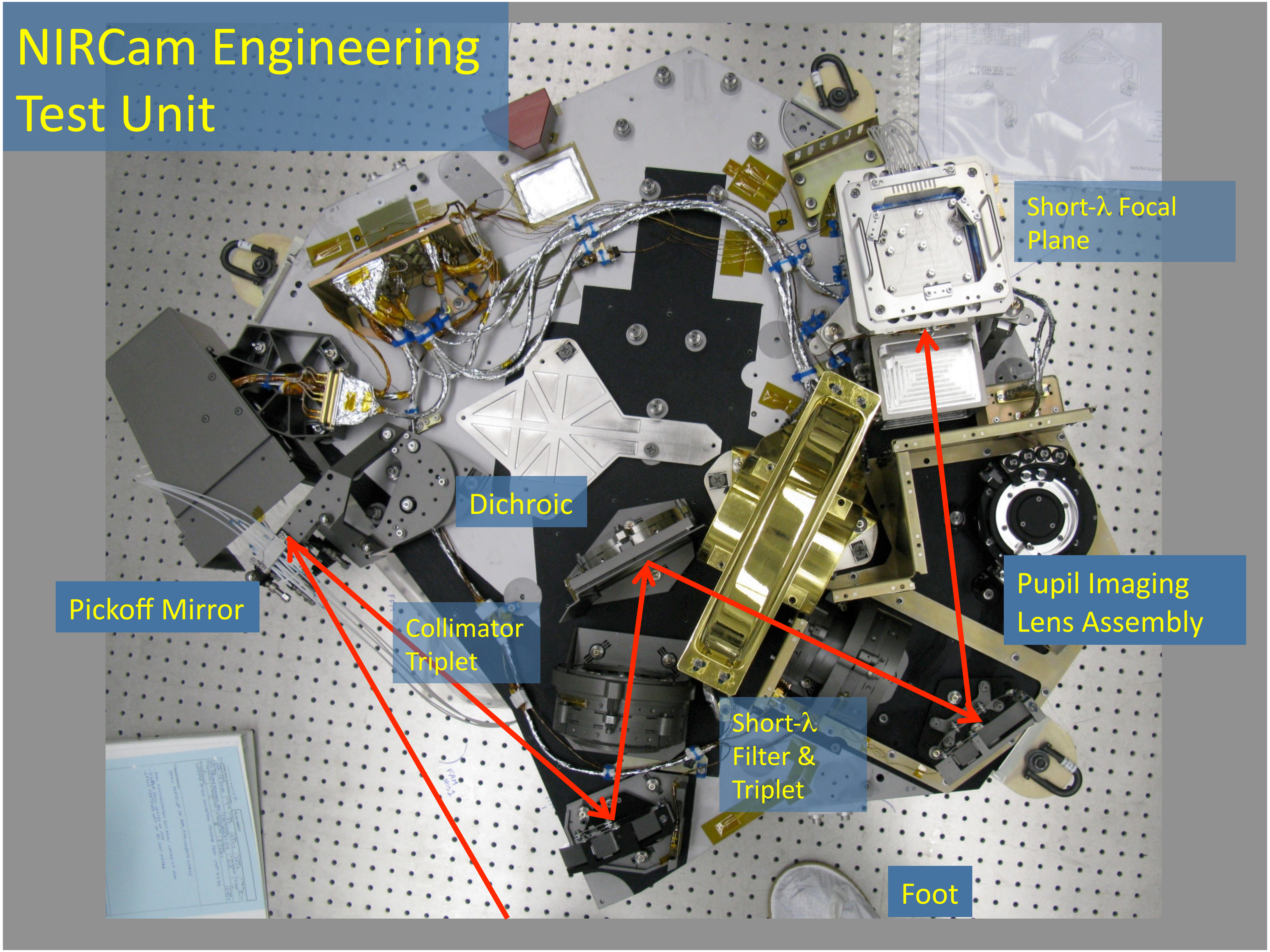


NIR ical Layout

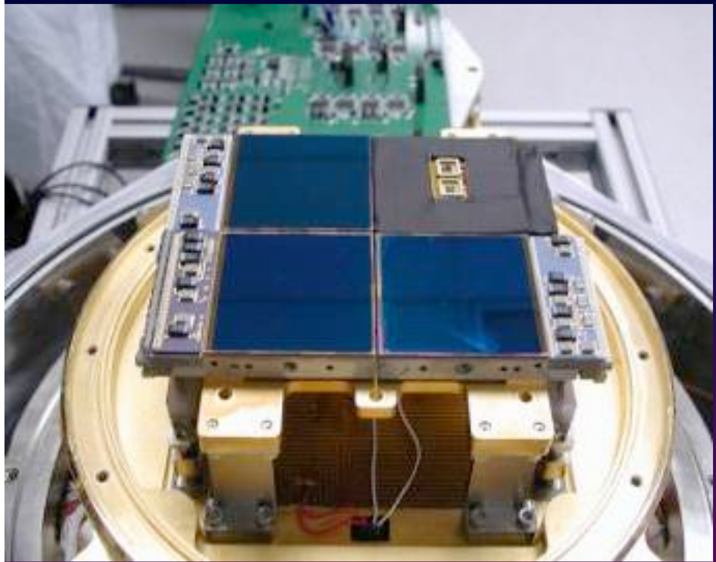


20 March 2007

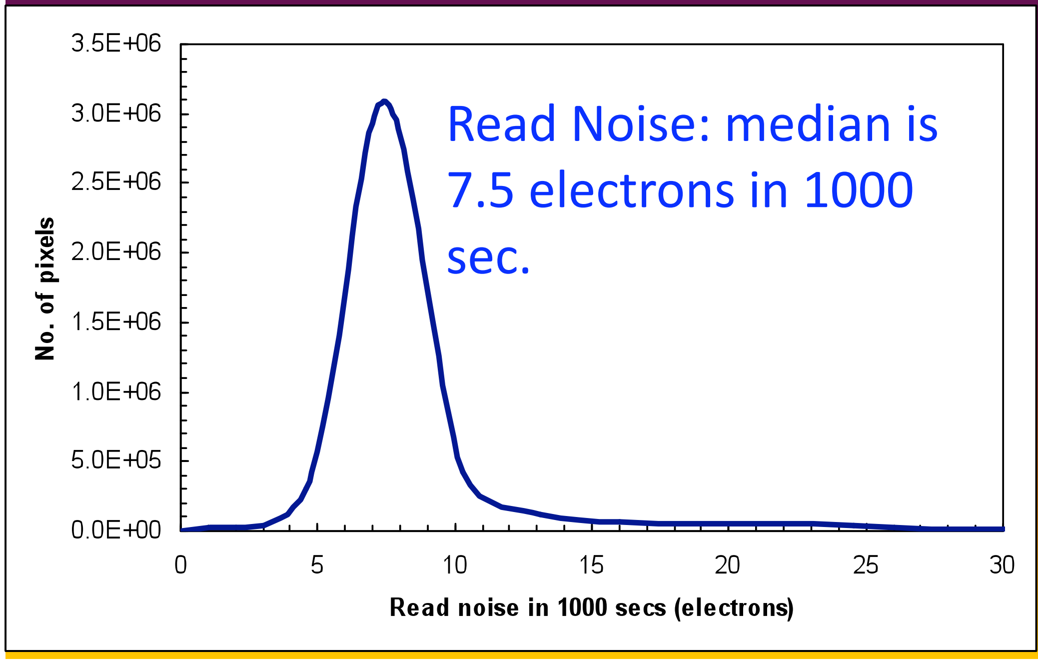
NIRCam Engineering Test Unit

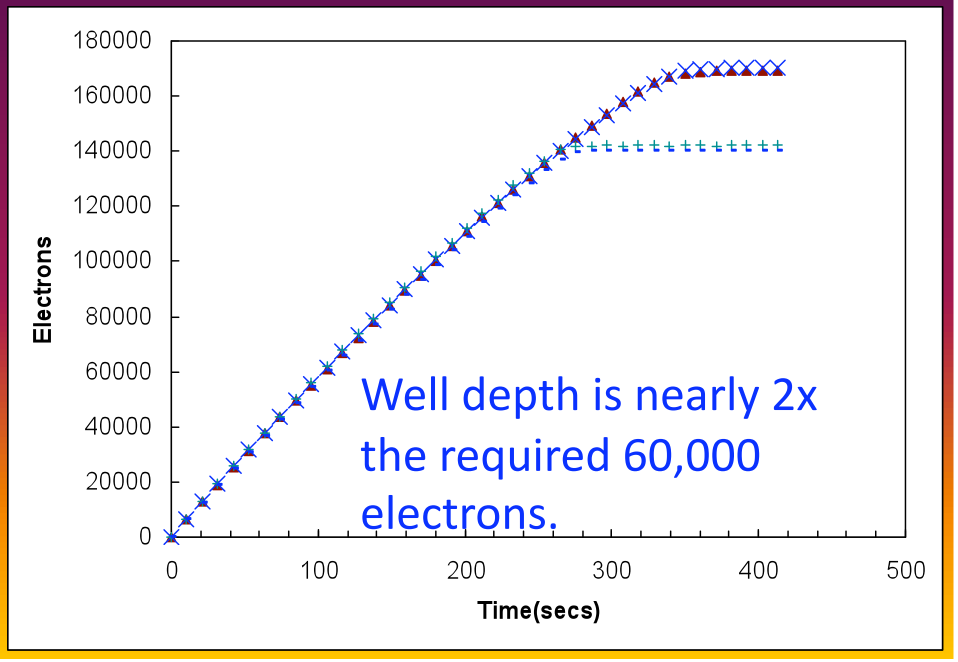


Near IR Detectors

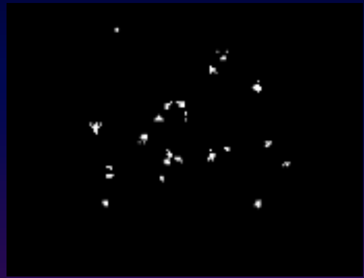


- NIRCam, NIRSpec & FGS/TFI use the same HgCdTe detectors.
- NIRCam uses 2.5 μm and 5.2 μm cut-off material.
- Format is 2040x2040 with 4 reference pixels around the periphery
- Performance is excellent– dark current at 37K is ~.005 e/sec, QE > 80% over 0.6–5 μm



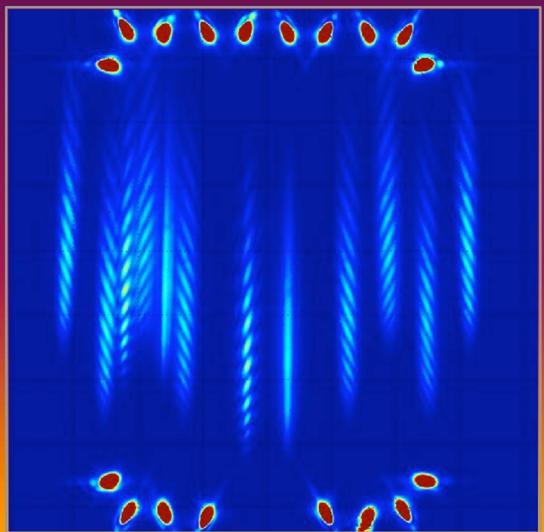


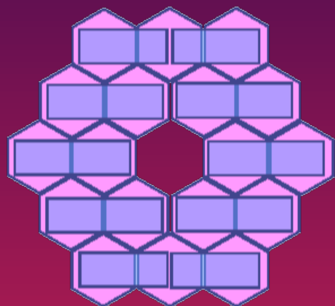
Critical Mission Role for NIRCam Enhances Science Return *(Don't Tell the Project)*



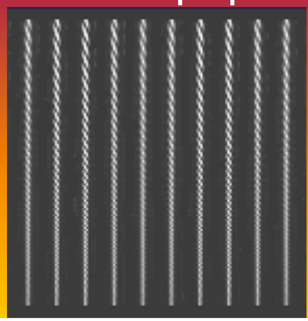
WFS Testbed at Ball.

Grism test at Keck.





DHS at pupil



- NIRCam is JWST's wavefront sensor
  - Imaging for first segment capture
  - Grisms for initial phasing of the segments (good for transit spectra)
- JWST's segmented primary will be adjusted every 1-2 weeks to compensate for slow drifts.
  - Defocusing lenses for phase retrieval (good for transit photometry).
- Fully redundant system requires two complete optical trains → 2× FOV (good for survey coverage)
- Wave Front Sensing requires good pupil alignment → articulated pickoff mirror (good for coronagraphic performance).

NIRCam Ready To Go

- All critical milestones have been met for implementation of NIRCam
- Problems with wavefront error of refractive optical system have been resolved with warm/cold testing and Monte Carlo results showing >80% of FOV will meet 69 nm requirement
- Engineering Test Unit being prepared for test and delivery to Goddard.

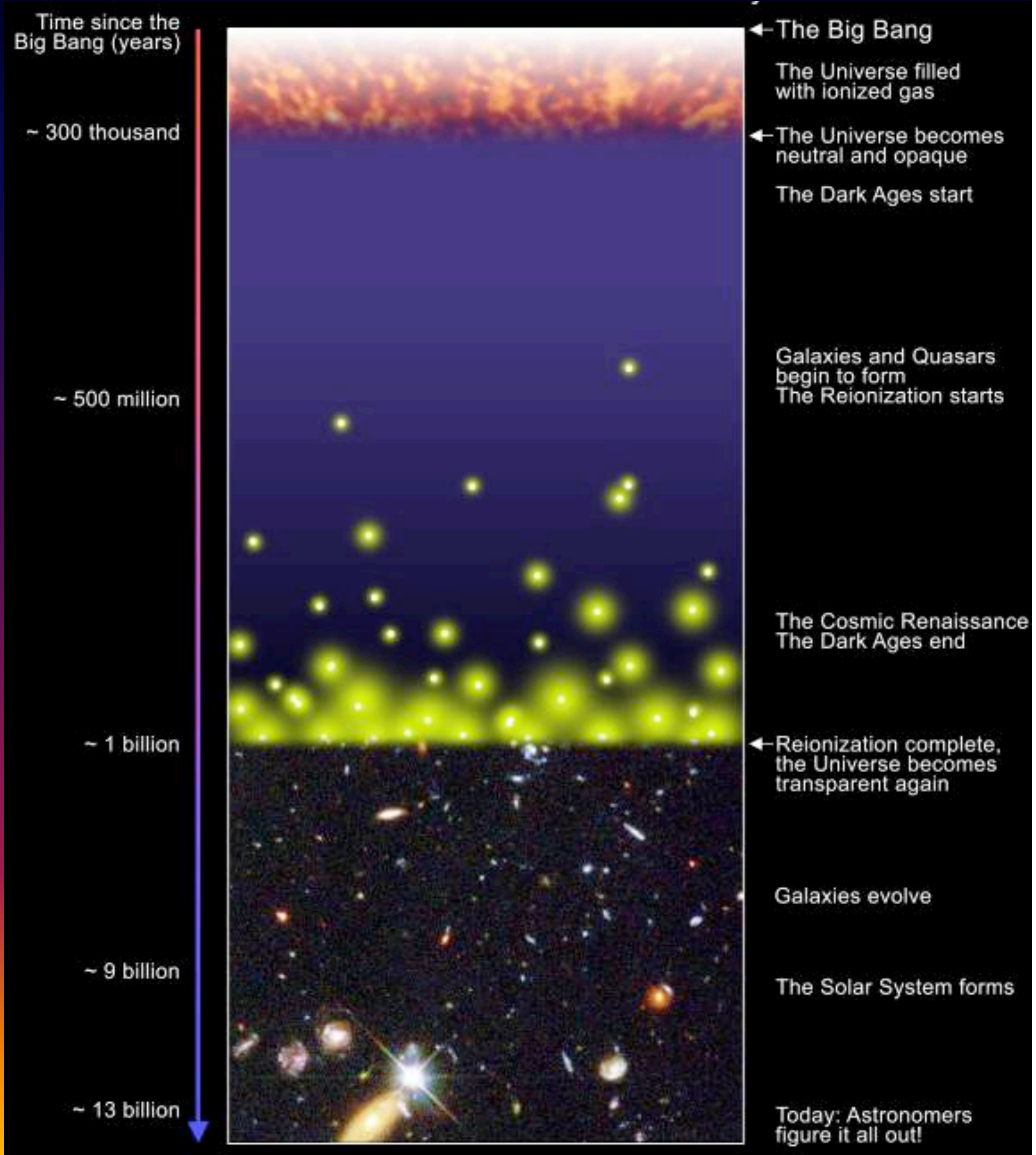
Exploring Strange New Worlds: From Giant Planets and Super Earths
6th International Conference on Exoplanets

Flagstaff, Arizona, May 2-6, 2011

- Transits, RV, Imaging, Microlensing, Theory etc.
- New Initiatives After the Decadal Review, Cosmic Vision, and the Explorer Selections
- ***Focus on use of JWST for Exoplanet Research***

Science Requirements -1

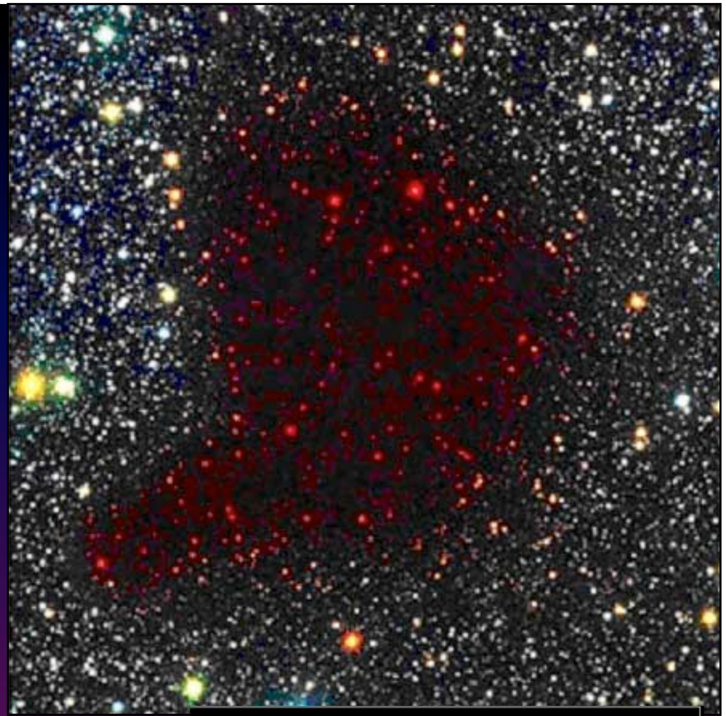
- Detection of first light objects, the epoch of reionization
  - High sensitivity – few nJy sensitivity
  - Large FOV (~10 square arcmin) to detect rare first light sources in deep multi-color surveys.
  - Filter set for ~4% photometric redshifts for >98% of galaxies in multi-color survey.
- Observing epoch of galaxy assembly
  - High spatial resolution for distinguishing shapes of galaxies at the sub-kpc scale



S.G. Djorgovski et al. & Digital Media Center, Caltech

Science Requirements -2

- Stars and Stellar Systems:
  - High sensitivity especially at $\lambda > 3\mu m$
  - Fields of view matched to sizes of star clusters (> 2 arc minutes)
  - High dynamic range to match range of brightness in star clusters
  - Intermediate and narrow band filters for reddening, disk and jet studies
  - High spatial resolution for jet structures



- Planetary systems & conditions for life:
  - Coronagraph coupled to both broad band and intermediate band filters
  - Broad band and intermediate band filters for diagnosing disk and KBO surfaces