JWST and SAFIR: Near-to Far-Infrared Observatories for Origins

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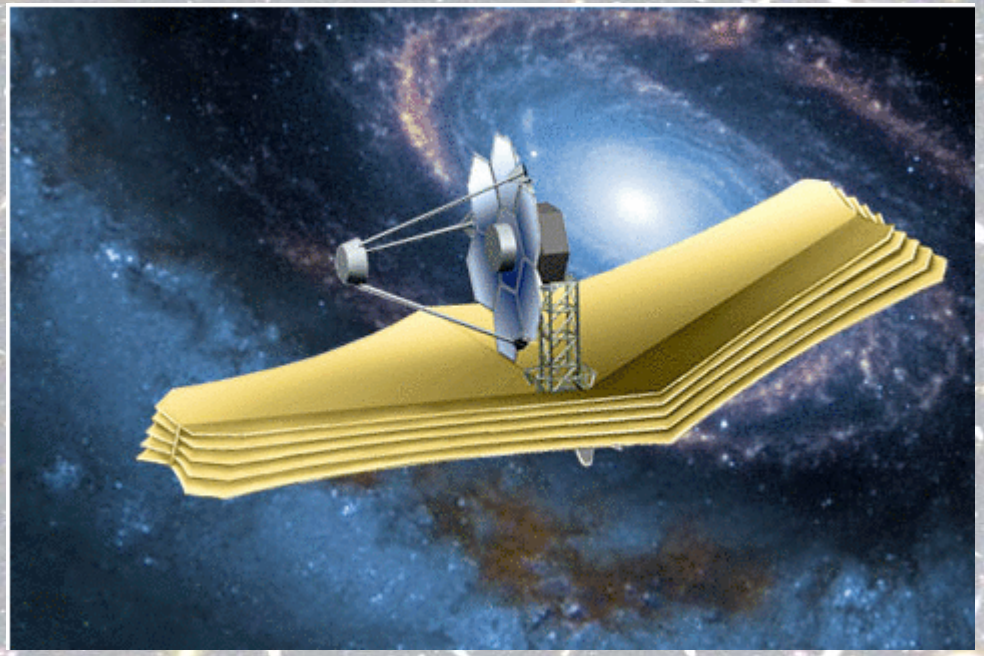
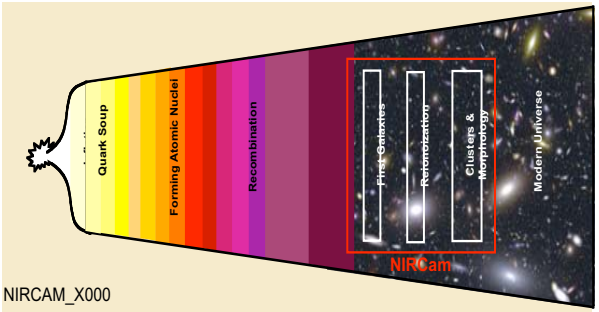
NIRCam for JWST PI

James Webb Space Telescope



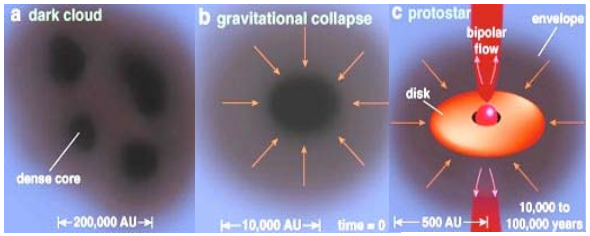
Single Aperture for Far-Infrared

JWST's Science Themes

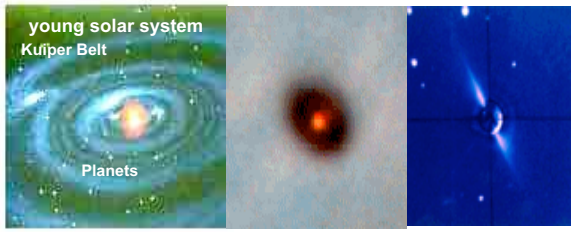


The First Light in the Universe: Discovering the first galaxies, Reionization sources

Period of Galaxy Assembly: Establishing the Hubble sequence, Growth of galaxy clusters



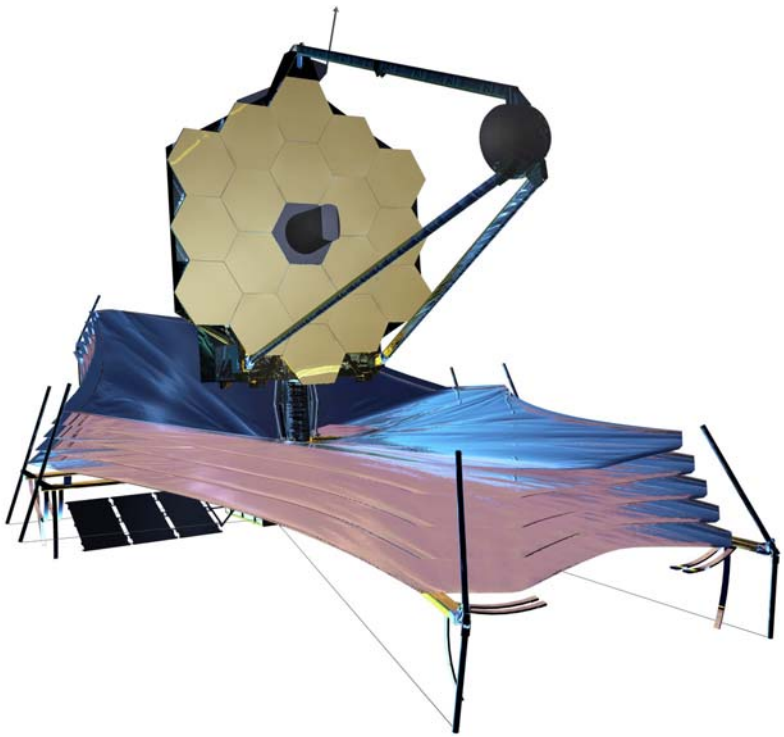
Stars and Stellar Systems: Physics of the IMF, Structure of pre-stellar cores, Emerging from the dust cocoon



Planetary Systems and the Conditions for Life: Disks from birth to maturity, Survey of KBOs, Planets around nearby stars

Summary of JWST's Capabilities

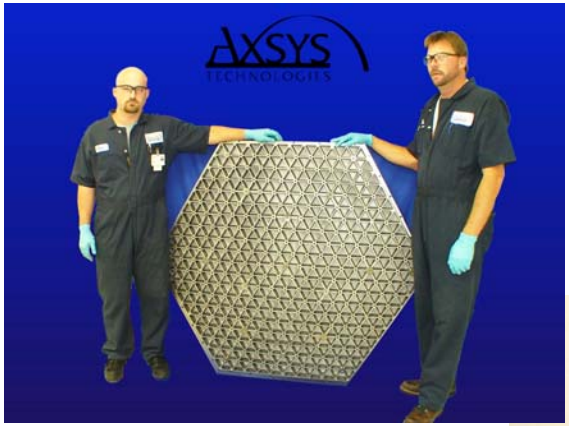
- 25 m^2 collecting area using a segmented primary with 6.6-m tip-to-tip diameter
- L2 orbit enables passive cooling to ~45K for primary mirror, ~35K for instruments
- Four instruments:
  - NIRCam, 0.6-5 μm
  - NIRSpec, 0.6-5 μm, R~100-3000 and multi-object
  - MIRI, 5-28 μm, camera + R~2500 IFUs
  - FGS + TF, 1.2-4.8 μm R~100



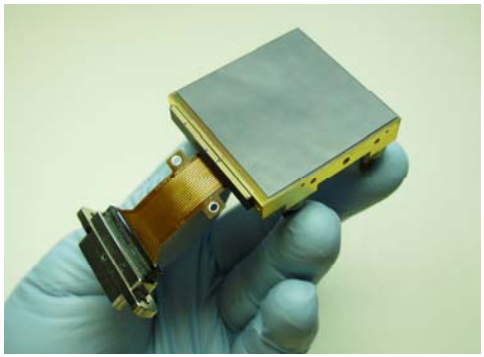
Project is moving!

- Primary mirror segments and detectors are already in production
- Instruments are prototyping optics, mounts, electronics, mechanisms

Be mirror blank

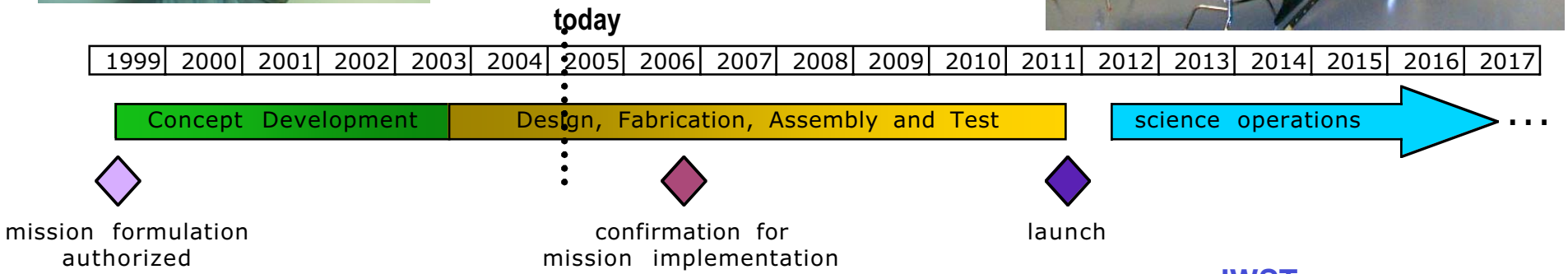


Development mirror segment



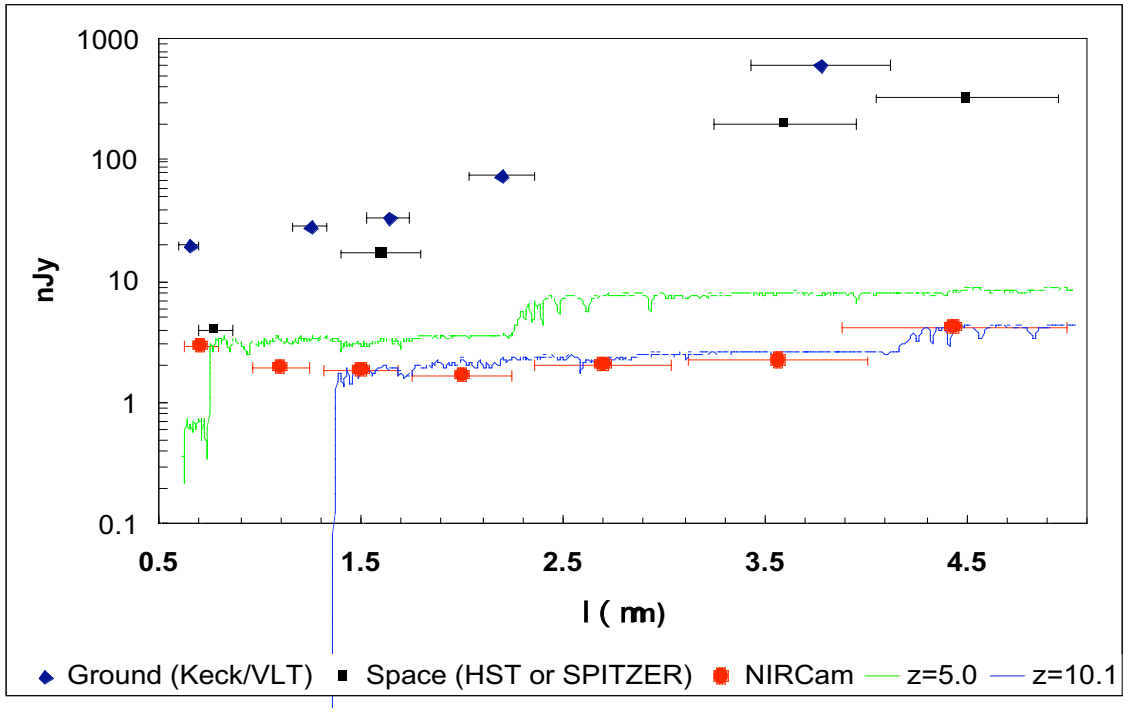
Prototype detector array - 7 electrons read noise in 1000 secs!

1/3 Scale model of sunshade



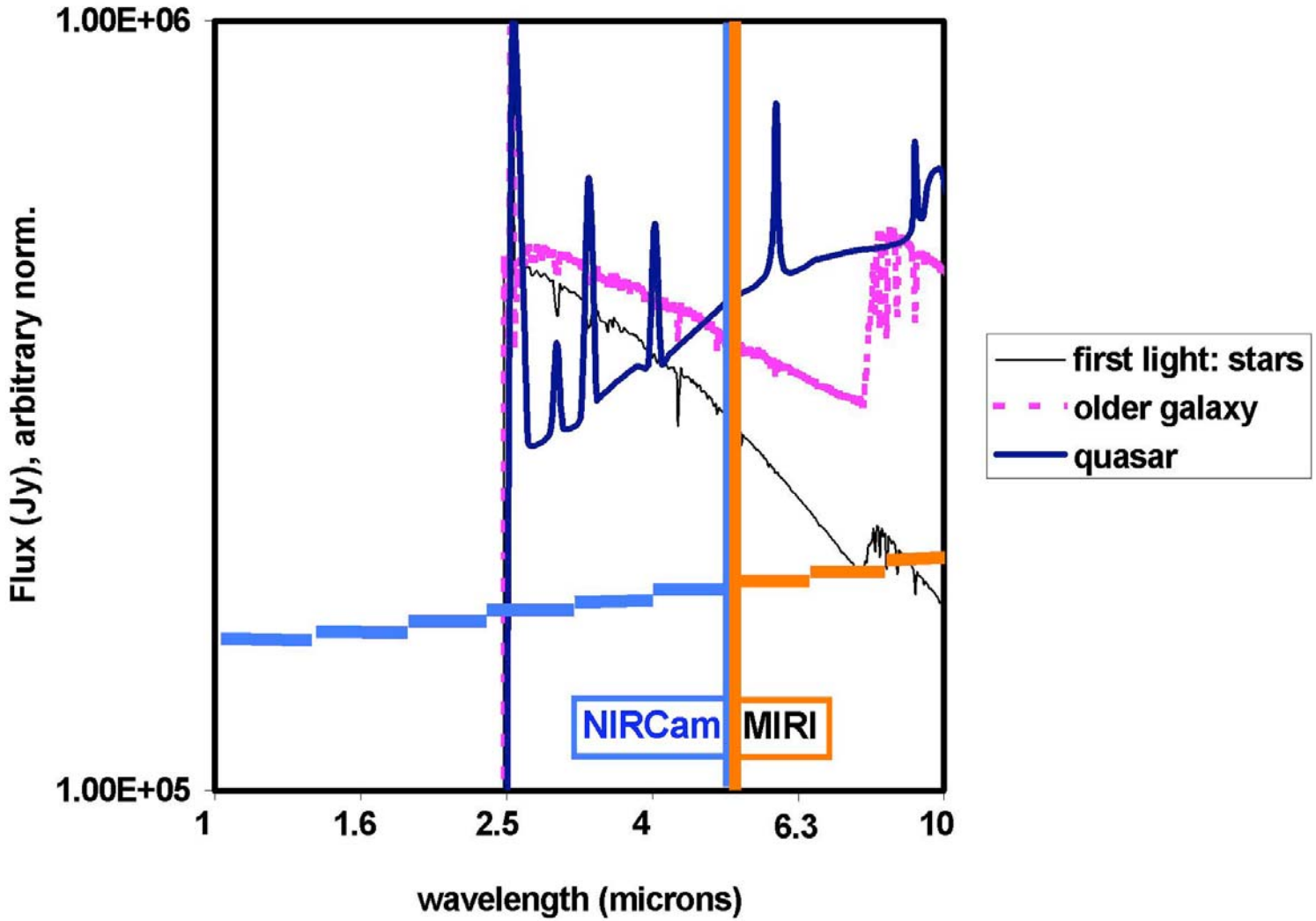
High Sensitivity is Paramount

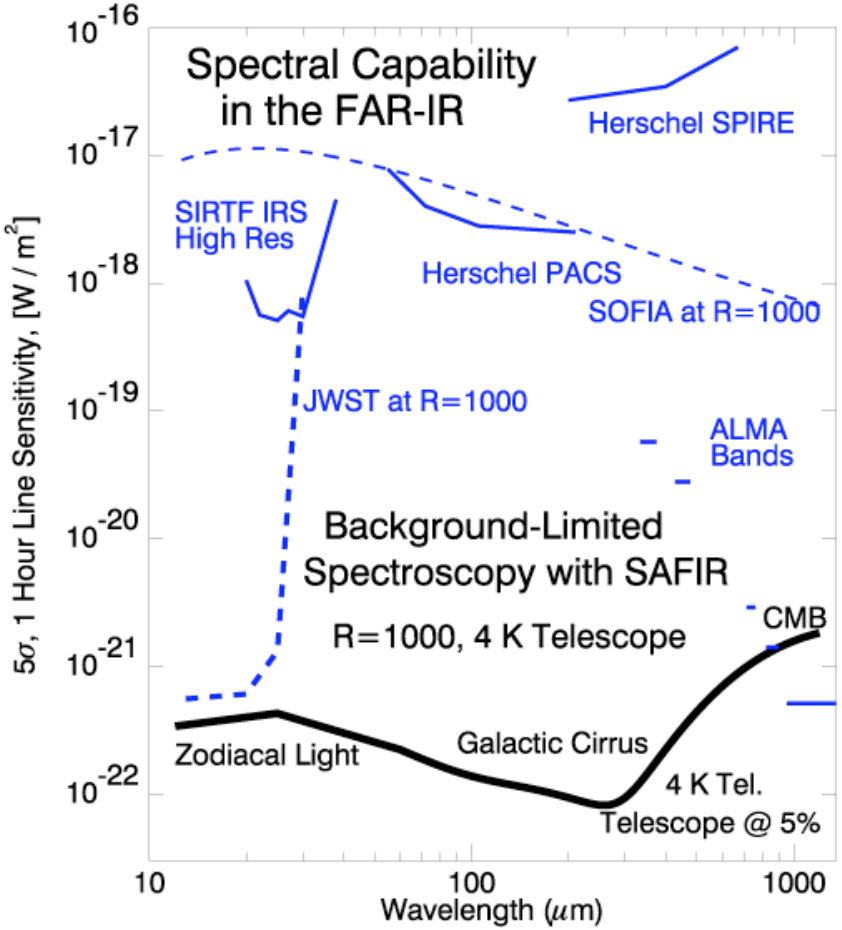
- NIRCam sensitivity is crucial for detecting "first light" objects
- At 3-5μm, NIRCam can detect objects 100x fainter than Spitzer opening up new survey possibilities



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

Broad Wavelength Range to be Sure





SAFIR = Single Aperture Far-Infrared Observatory

Science Goals:

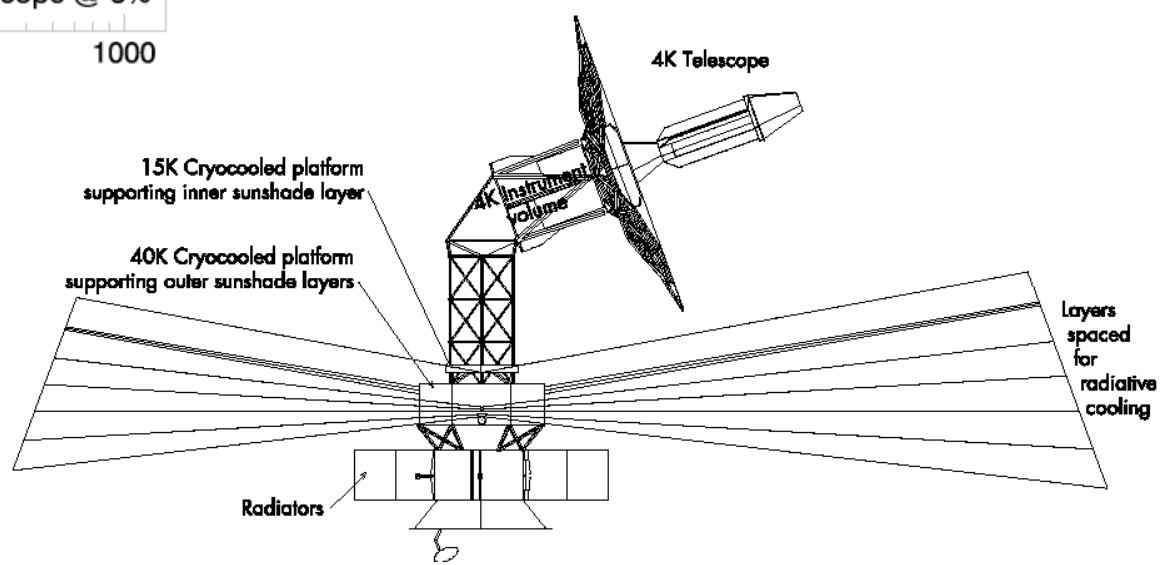
•Probe the epoch of reionization due to the first stars when the universe was less than 1/20 its present age

• Trace the formation and evolution of starforming and active galaxies since their inception.

• Explore the connection between black holes and their host galaxies.

• Reveal the details of star and planet formation in nearby debris-disk systems.

• Search for and quantify prebiotic molecules in



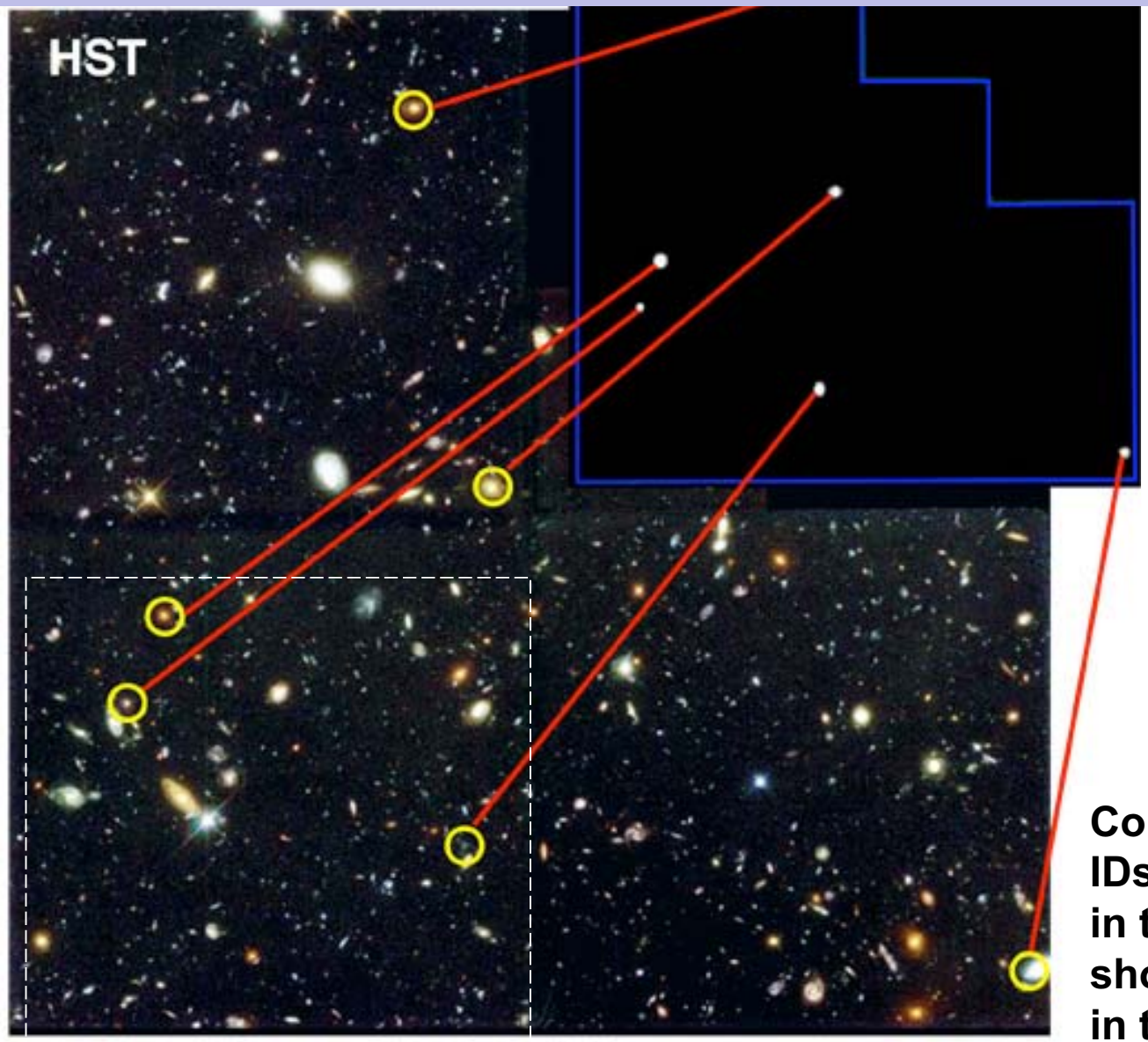
Observatory Characteristics:

Primary Mirror Diameter: 10 m

Telescope Temperature: 5 K or lower

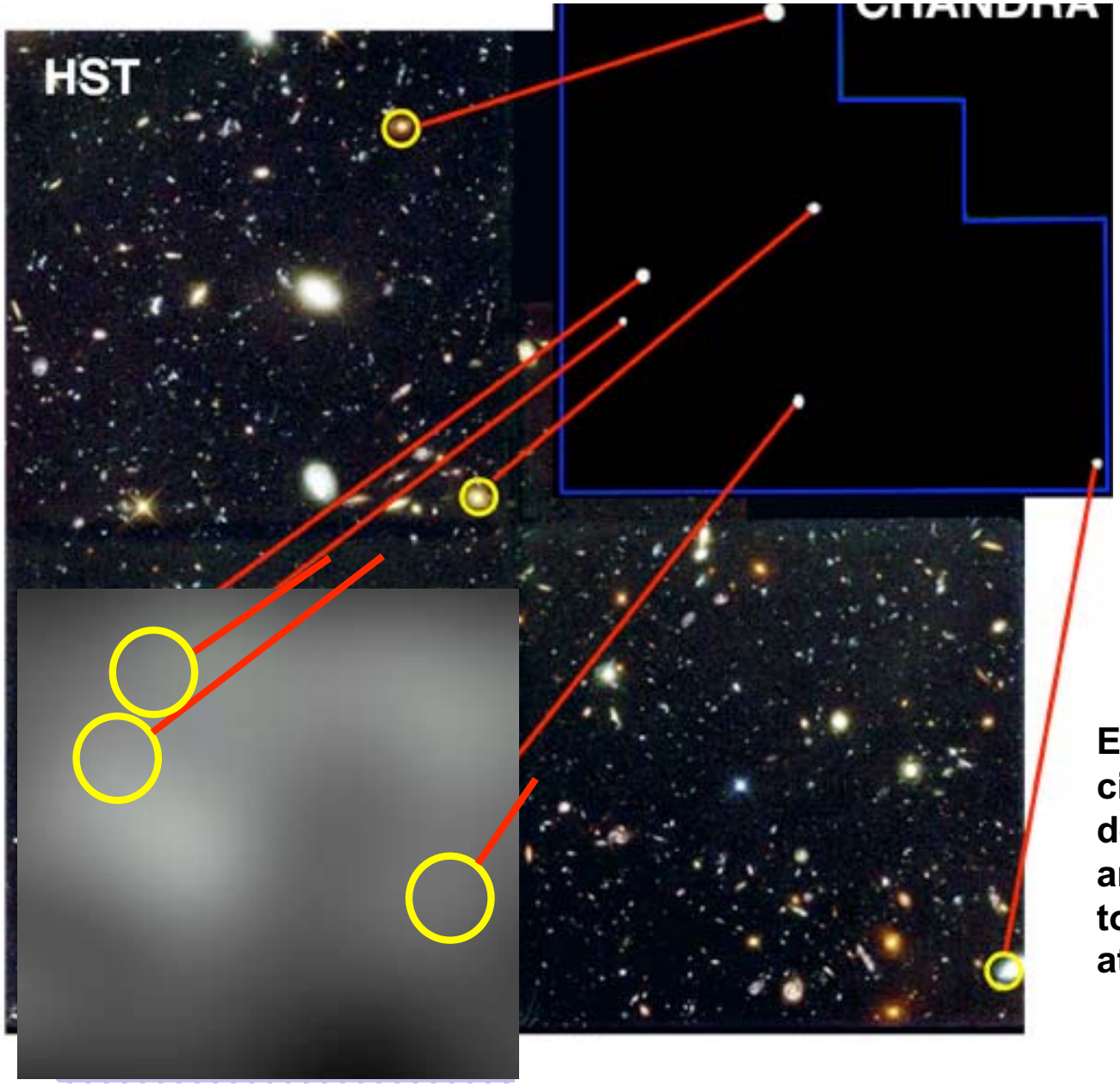
Wavelength Coverage: 20 microns to 1

The Importance of SAFIR's High Resolution:Deep Survey X-Ray Sources are Identified with Faint Galaxies



Compton-thick IDs may be faint in the optical but should be bright in the mid and far IR

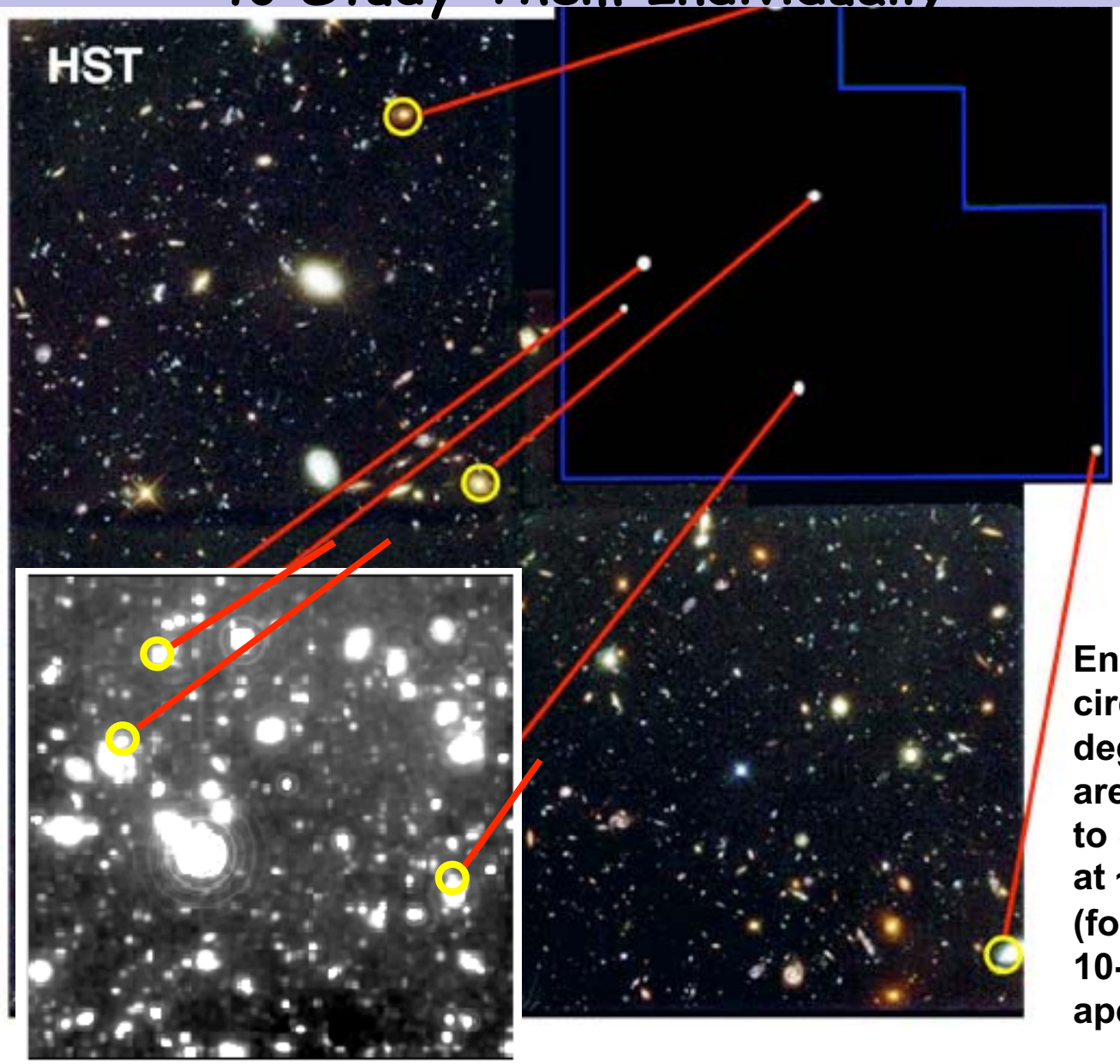
Spitzer Resolution is Inadequate to Isolate Them



Enclosed circles in degraded area equivalent to *Spitzer* beam at ~ 70μm.

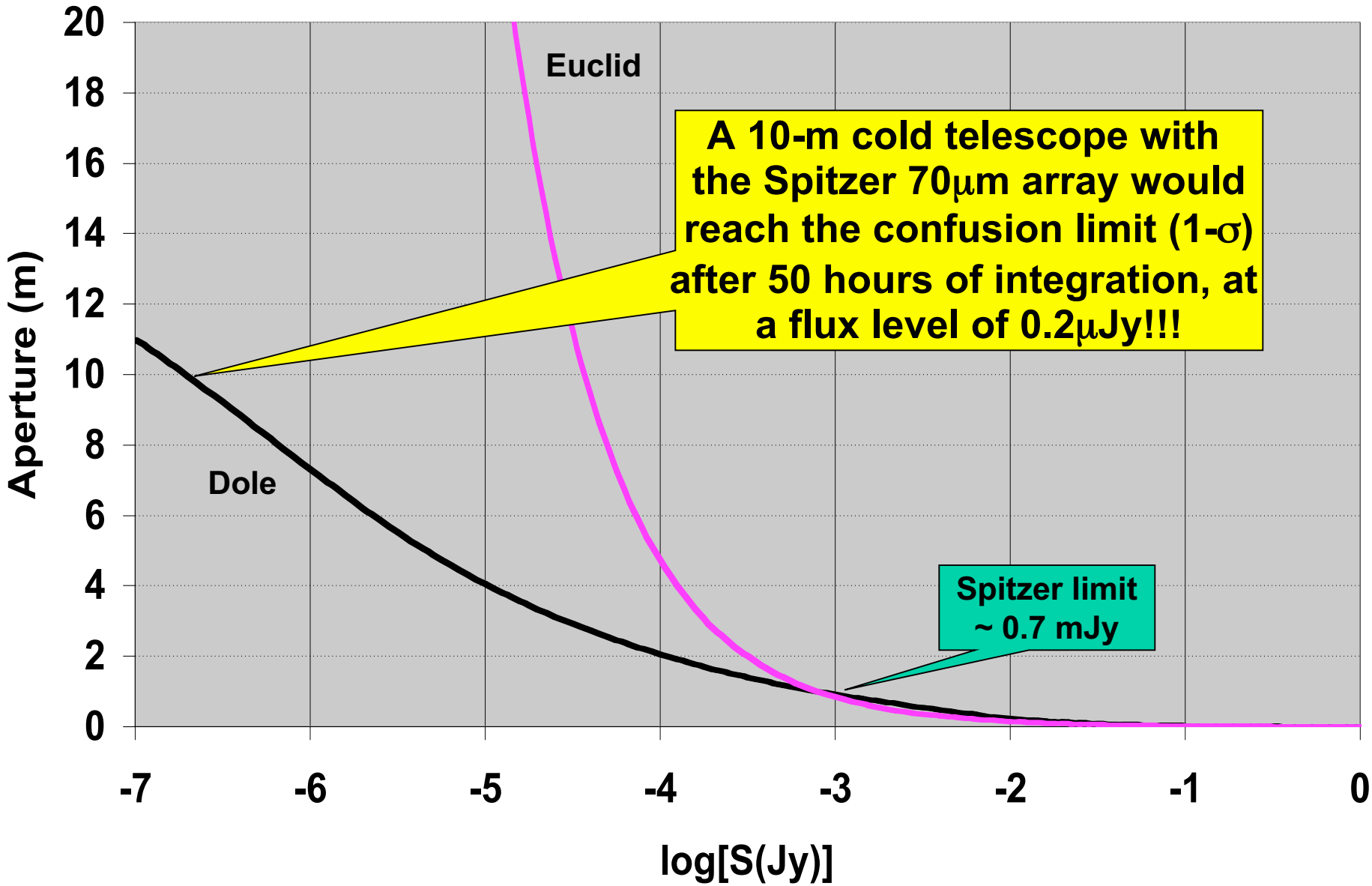
SAFIR Will Provide the Required Resolution to Study Them Individually

HST



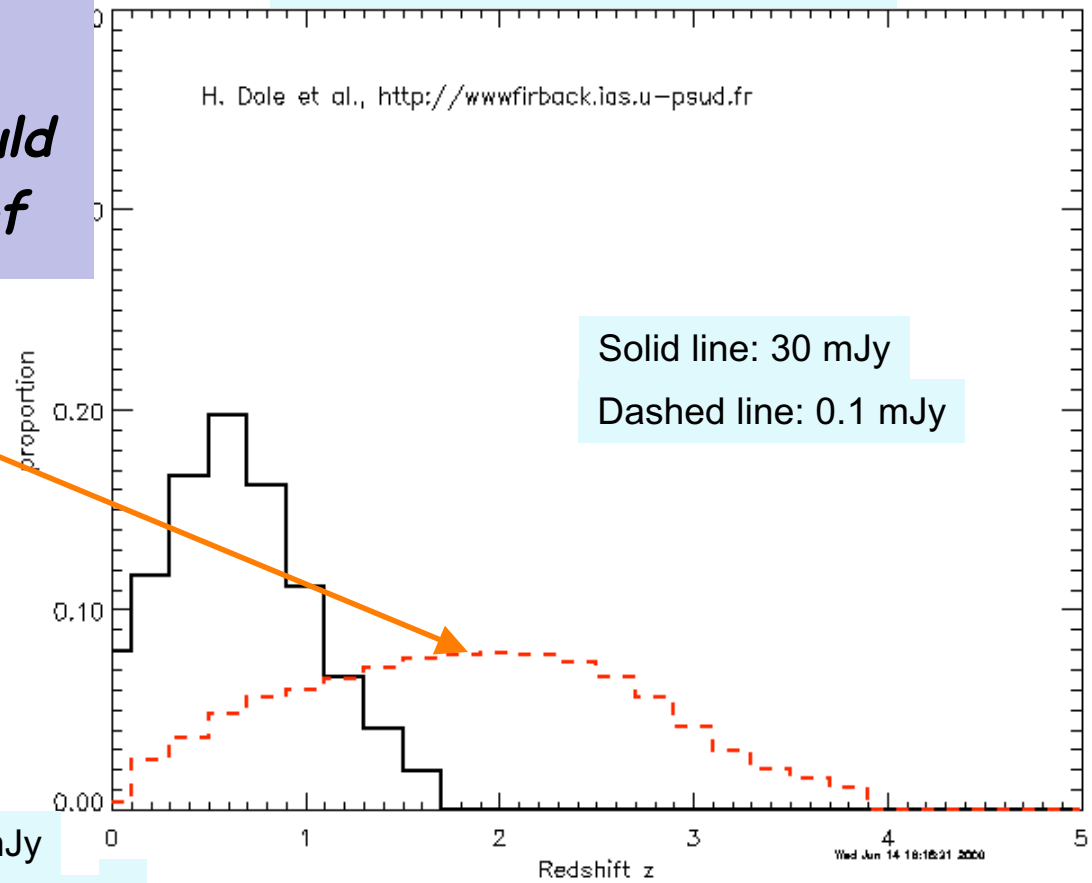
Enclosed circles in degraded area equivalent to *SAFIR* beam at ~ 50μm (for a 10-m aperture).

Because of the small beam, we gain rapidly on confusion as aperture grows larger than 1 meter (we resolve out the background)



At the sensitivites of SAFIR, the detected galaxies will be distributed out to z = 5! *Should document the entire history of massive, dusty galaxies.*

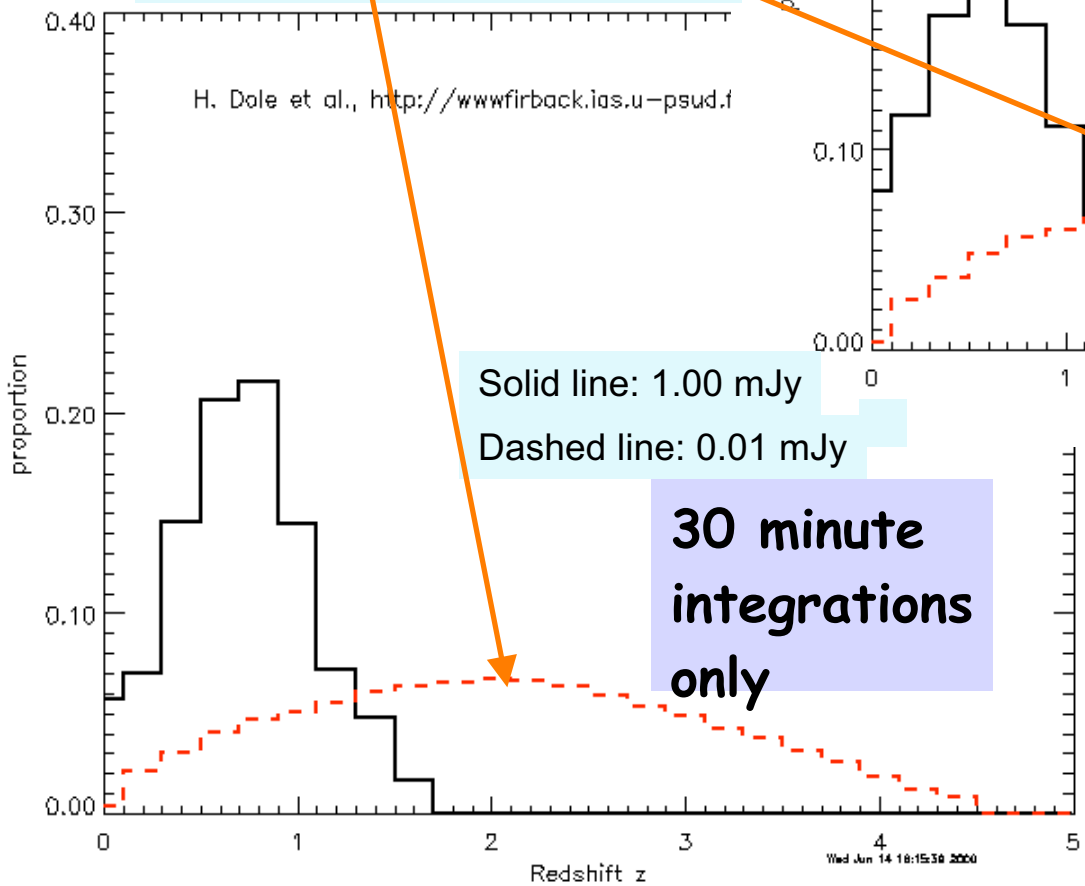
Redshift Distribution at 160 microns



Solid line: 30 mJy

Dashed line: 0.1 mJy

Redshift Distribution at 70 microns



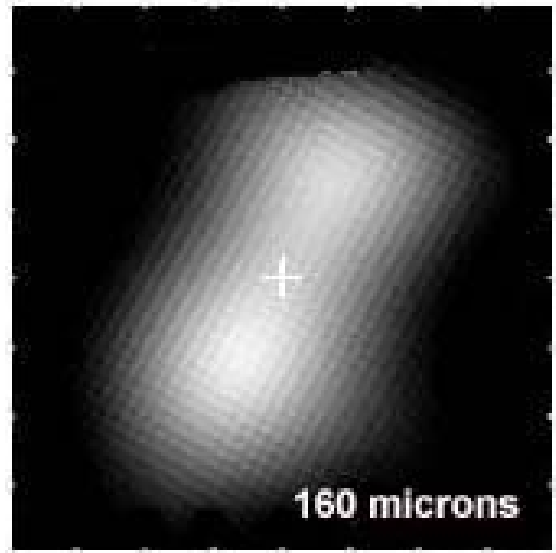
Solid line: 1.00 mJy

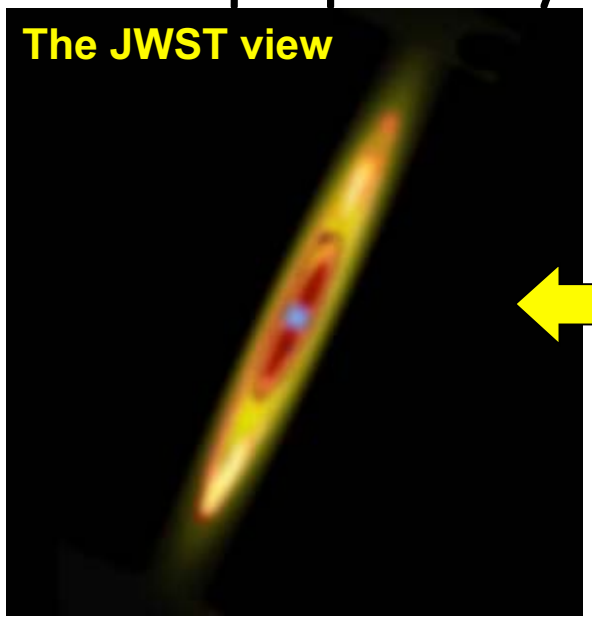
Dashed line: 0.01 mJy

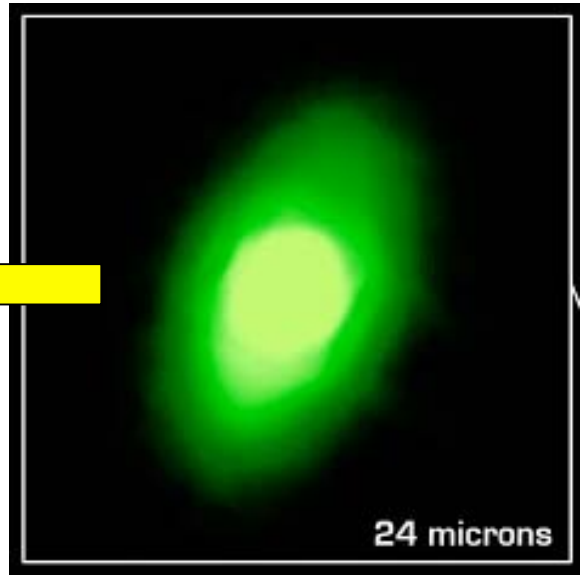
30 minute integrations only

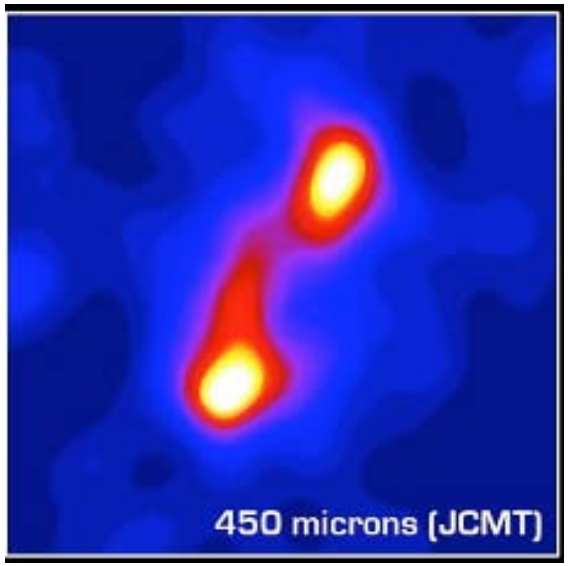
z distribution based on a model fitted to COBE background and deep ISO counts, by H. Dole.

JWST and SAFIR make major contributions to other key roadmap programs, for example planetary debris disks





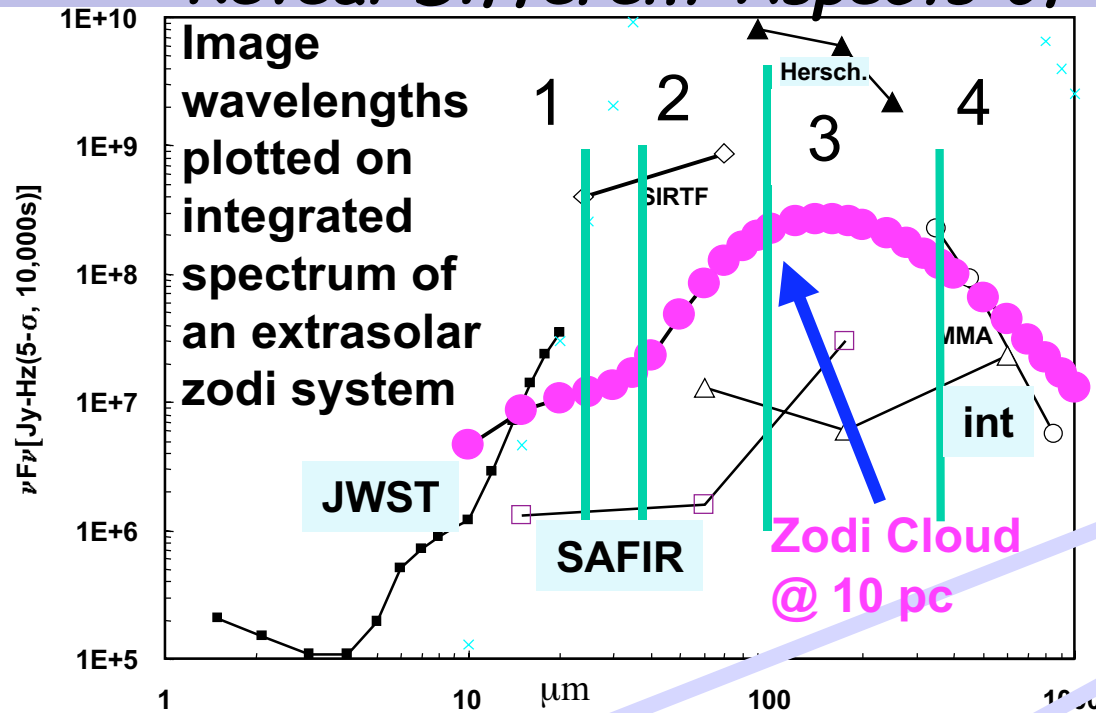
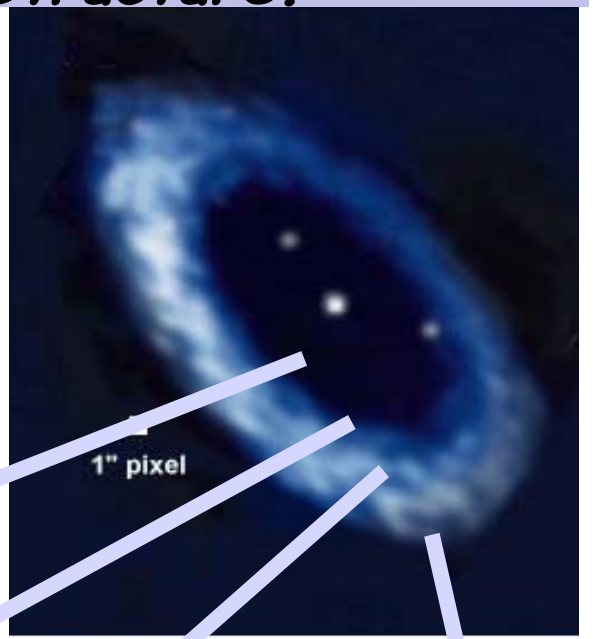
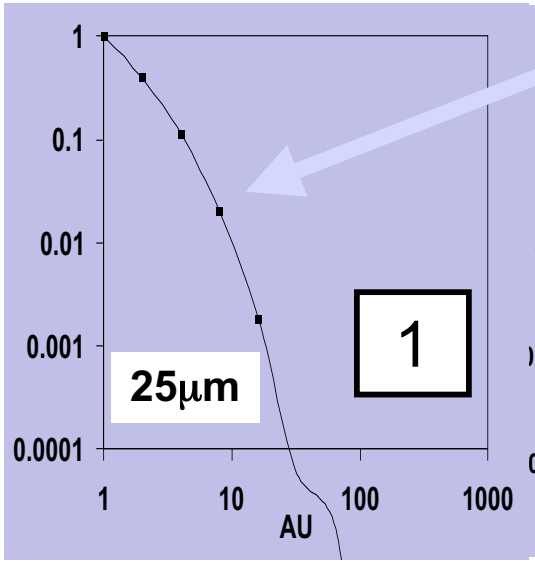
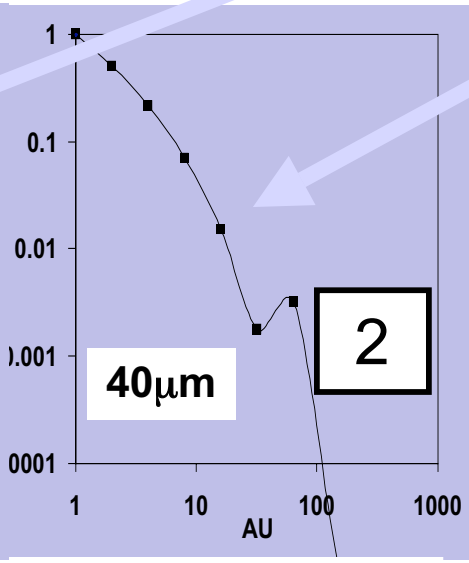
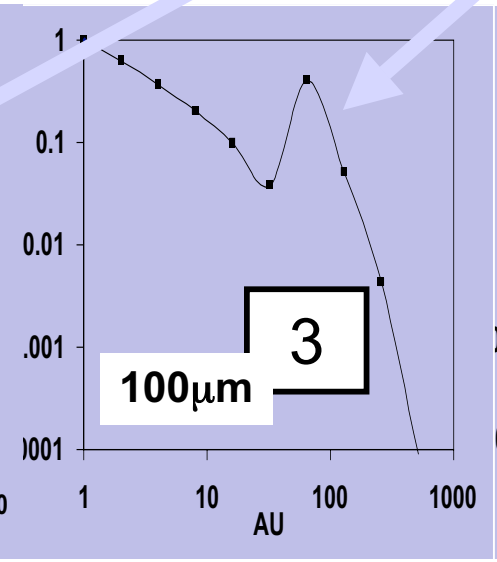
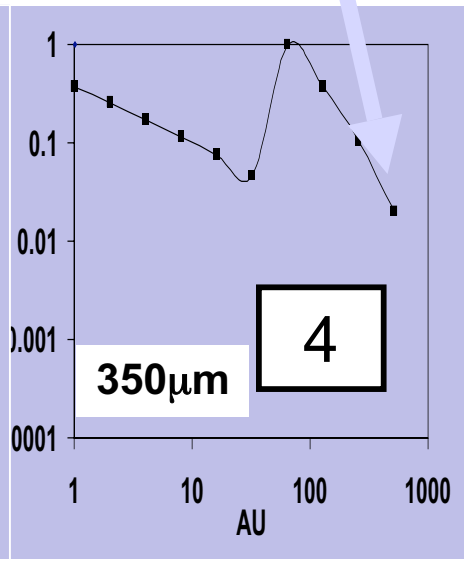




Fomalhaut disk particles would have fallen into the star due to Poynting-Robertson drag over life of the system.

They are probably the result of a collision.

Disk becomes more asymmetric from submm to infrared, then fills in at 24μm.

The asymmetry might be a resonance maintained by a massive planet.

Images of a Debris Disk at Different FIR Wavelengths Reveal Different Aspects of its Structure.