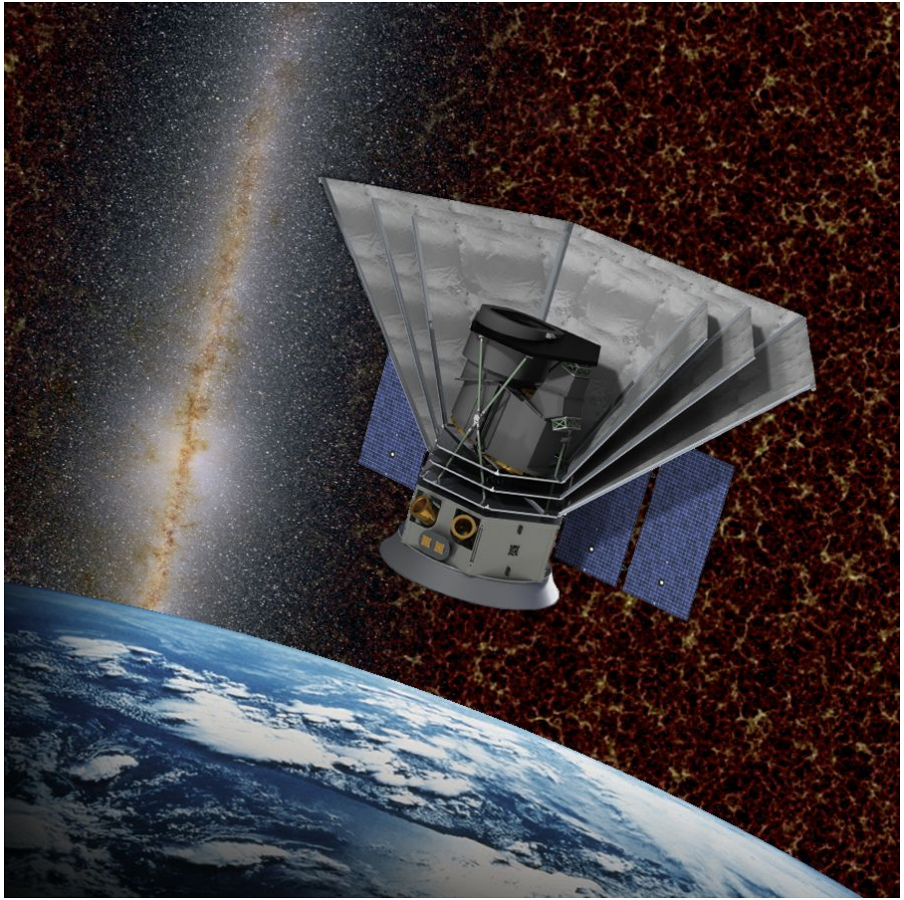
SPHEREx

An all-sky spectral survey

Ari Cukierman
Caltech
Feb. 14, 2023



Launching (relatively) soon!

Medium-class explorer (MIDEX)

PI: **Jamie Bock** (Caltech/JPL)

Selected in 2019

Targeting **launch in 2025**

The SPHEREx collaboration

Ari

What is SPHEREx?

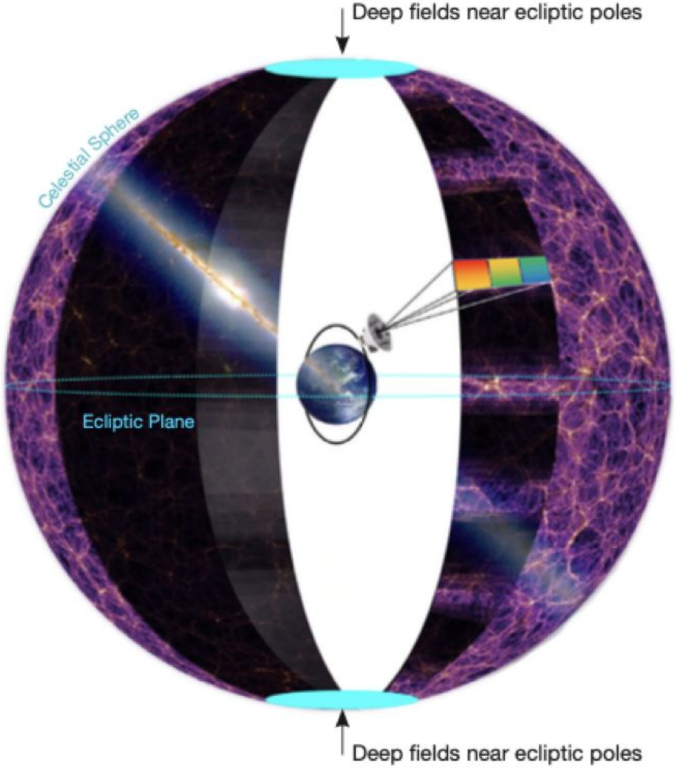
Low-Earth orbit

Near infrared (0.5-5 um)

Full sky

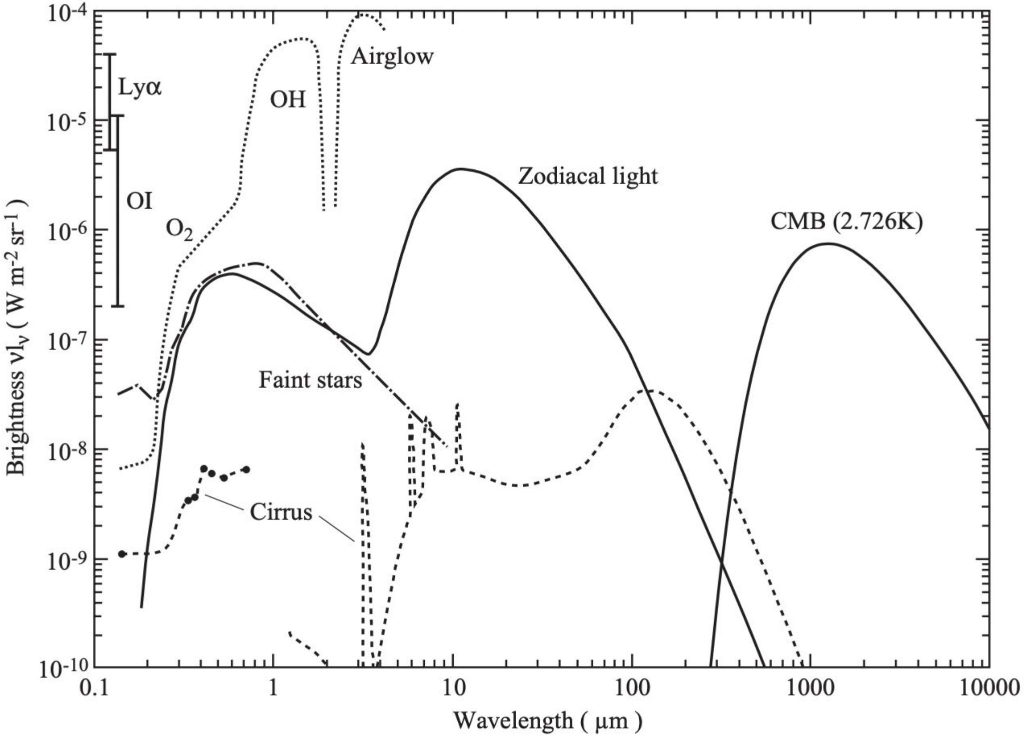
Mid-resolution

- Spatial: 6”
- Spectral: R = 40-100



Why space?

“The 1997 reference of diffuse night sky brightness”
Leinert+ 1998



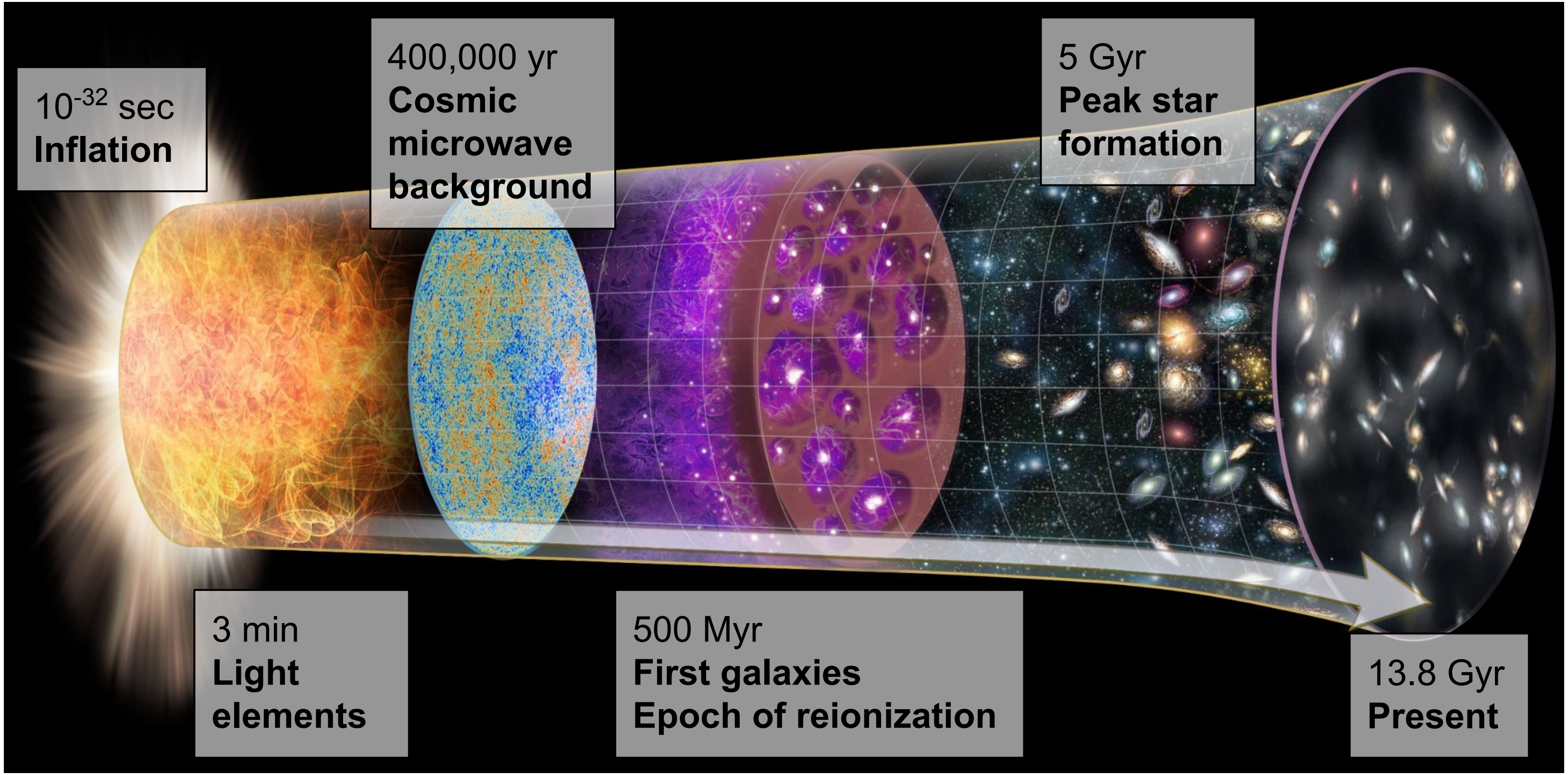
Why SPHEREx?

How did the Universe begin?

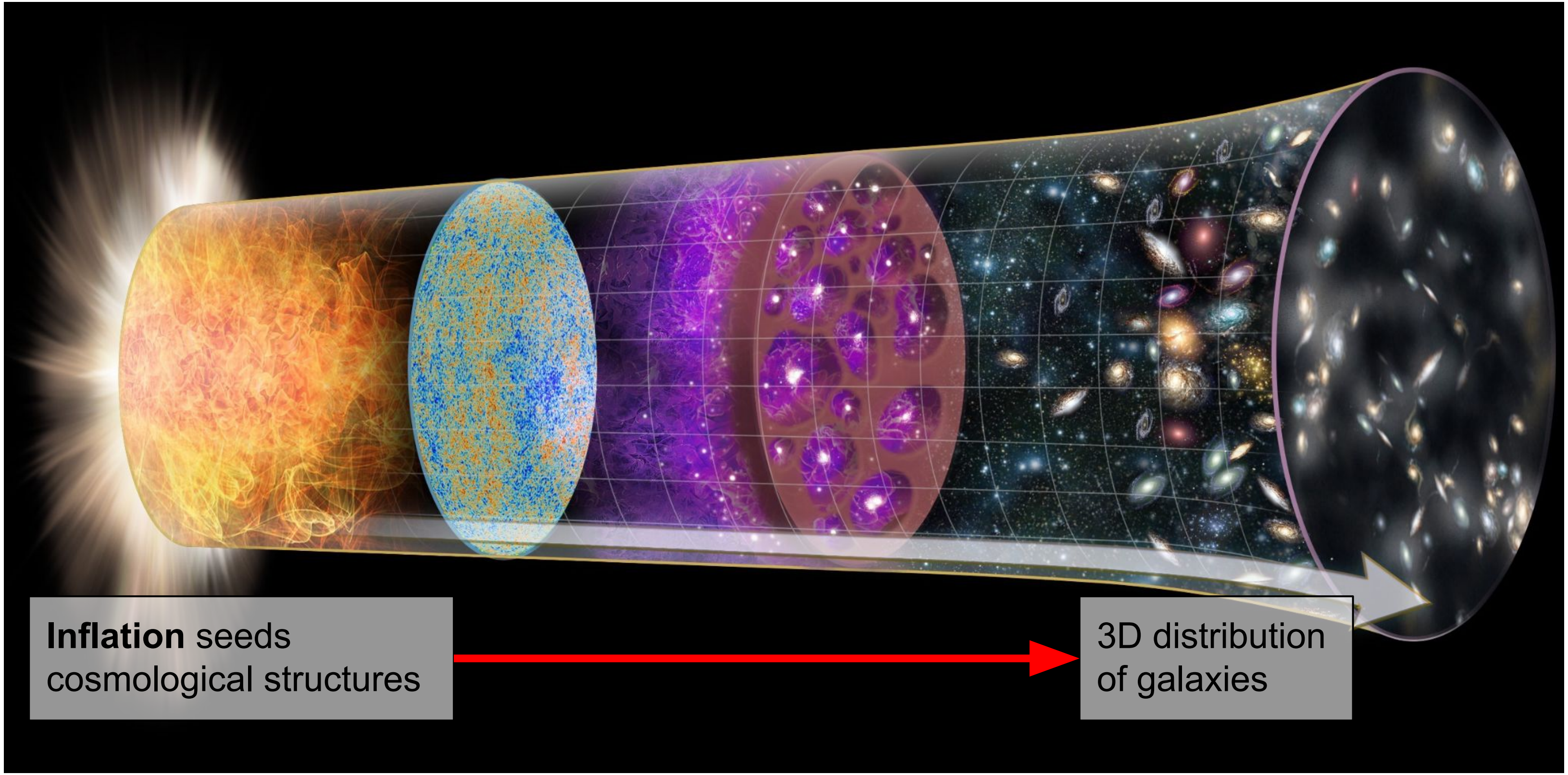
How did galaxies form?

How did life form?

A brief history of the Universe



How did the Universe begin?



Cosmic inflation

PHYSICAL REVIEW D VOLUME 23, NUMBER 2 15 JANUARY 1981

Inflationary universe: A possible solution to the horizon and flatness problems

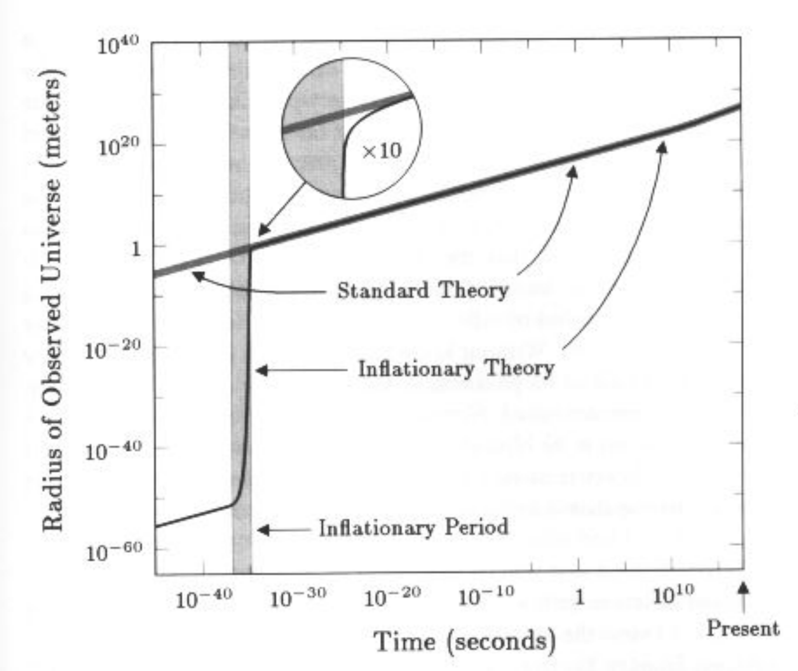
Alan H. Guth*
Stanford Linear Accelerator Center, Stanford University, Stanford, California 94305
(Received 11 August 1980)

Leading paradigm

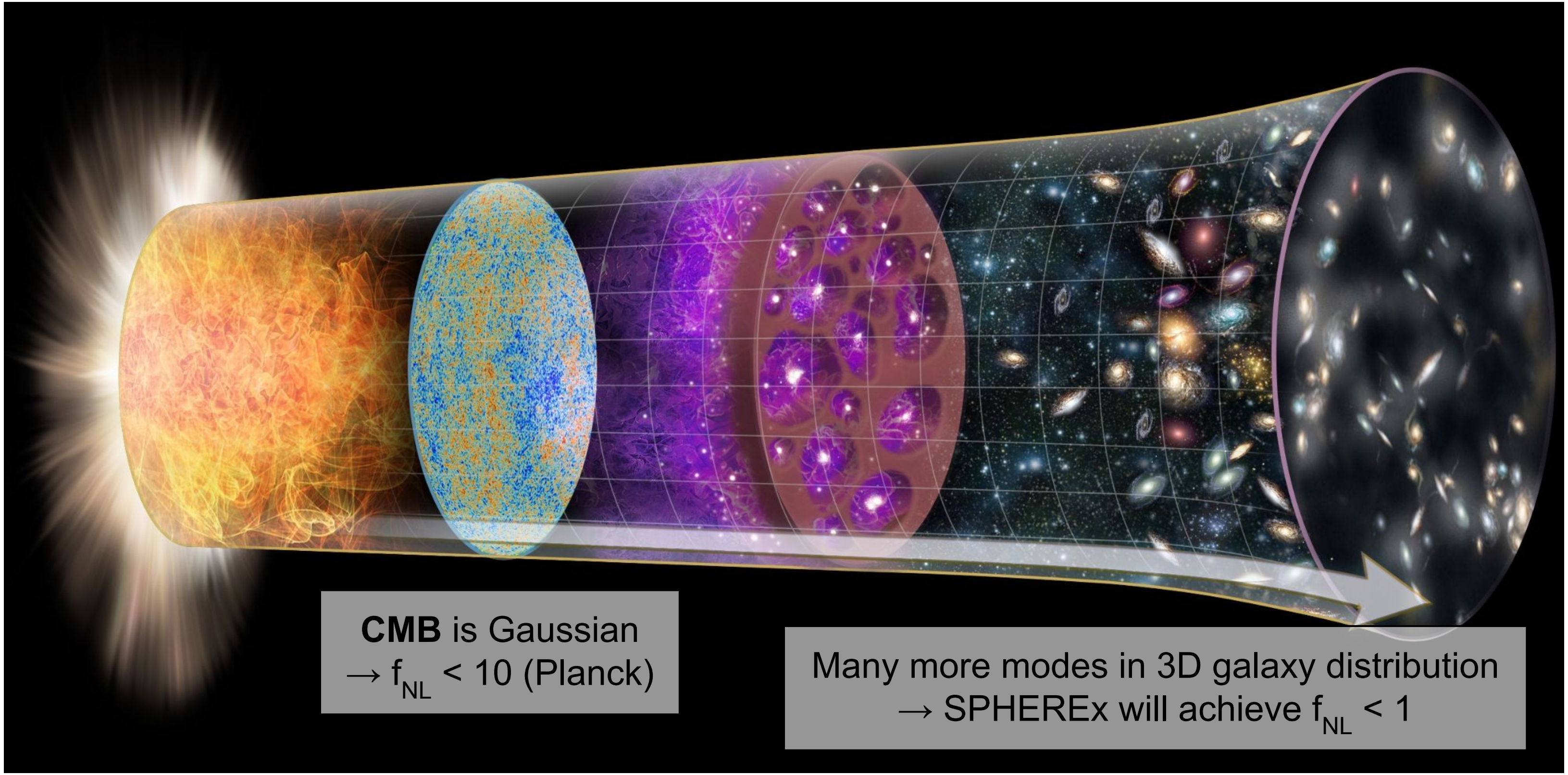
- Quantum fluctuations seed structure

Constrained through CMB polarization

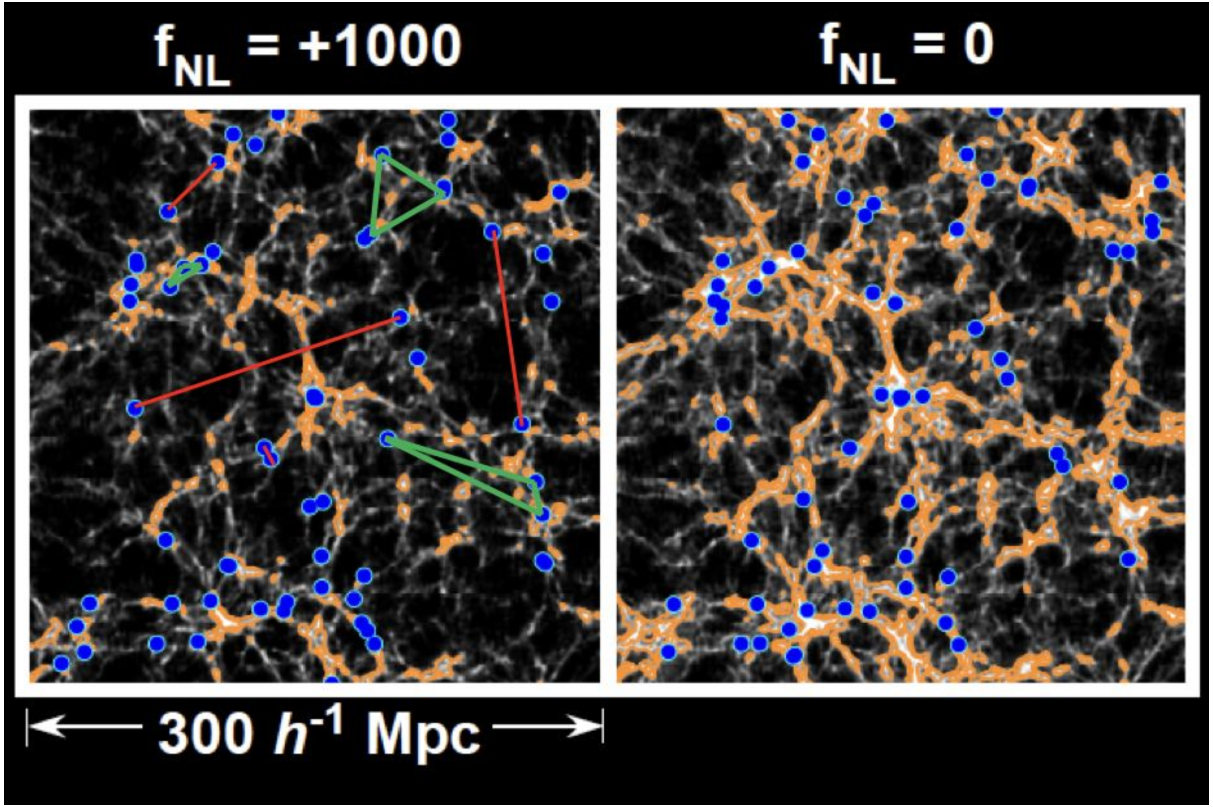
Orthogonal constraints with 3D galaxy distribution → SPHEREx



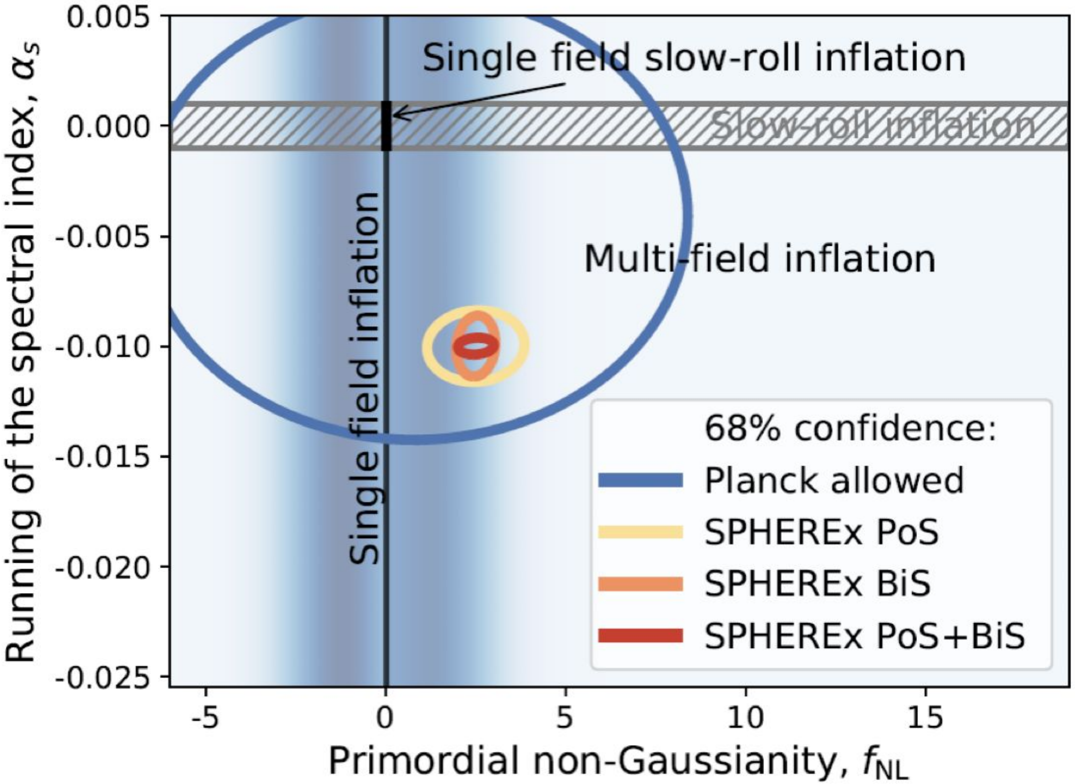
Non-gaussianity



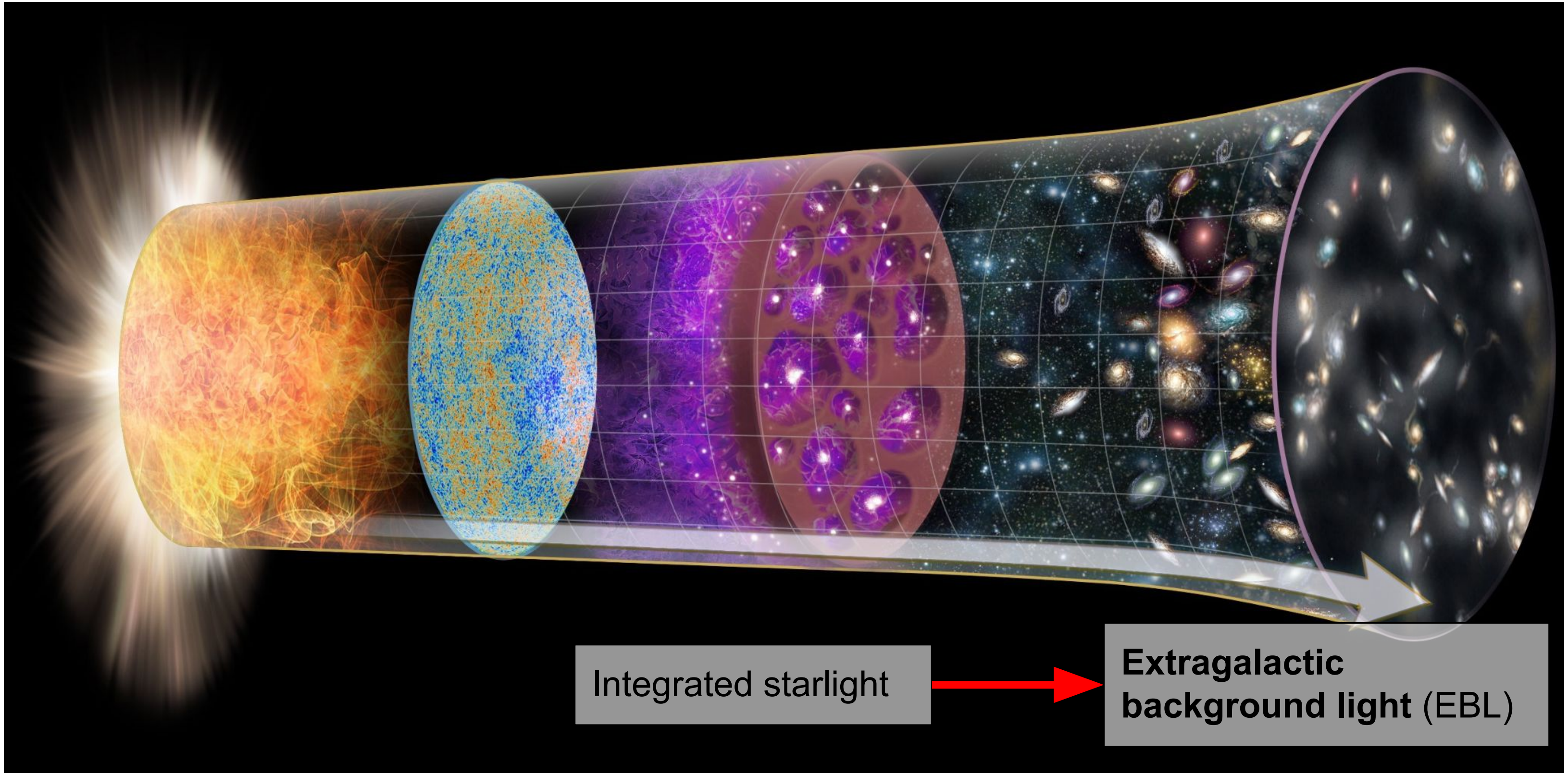
Non-gaussianity



Non-gaussianity

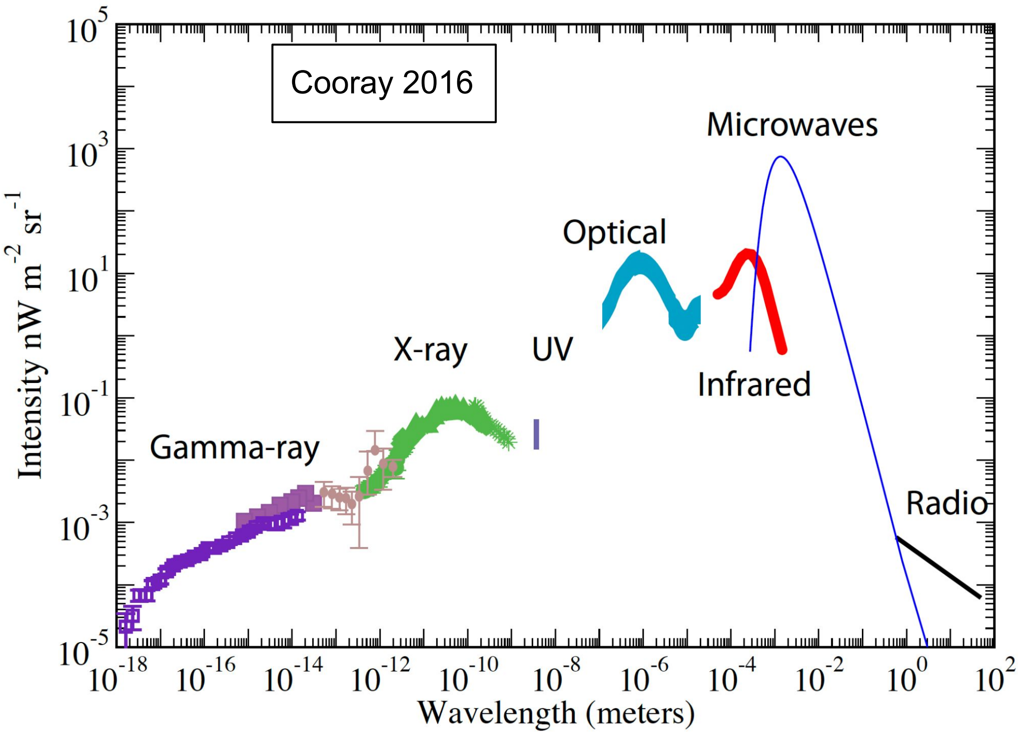


How did galaxies form?



Extragalactic background light (EBL)

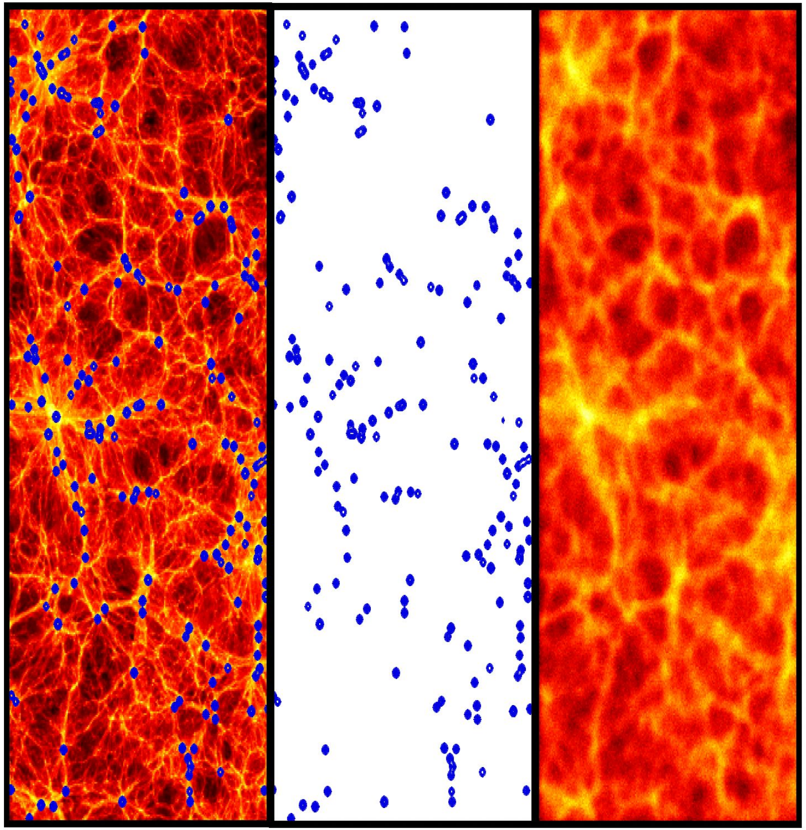
Census of cosmic light production



Intensity mapping

Integrated light from all sources
including unresolved

- Dwarf galaxies
- Stripped stars (intrahalo light)
- High-redshift galaxies

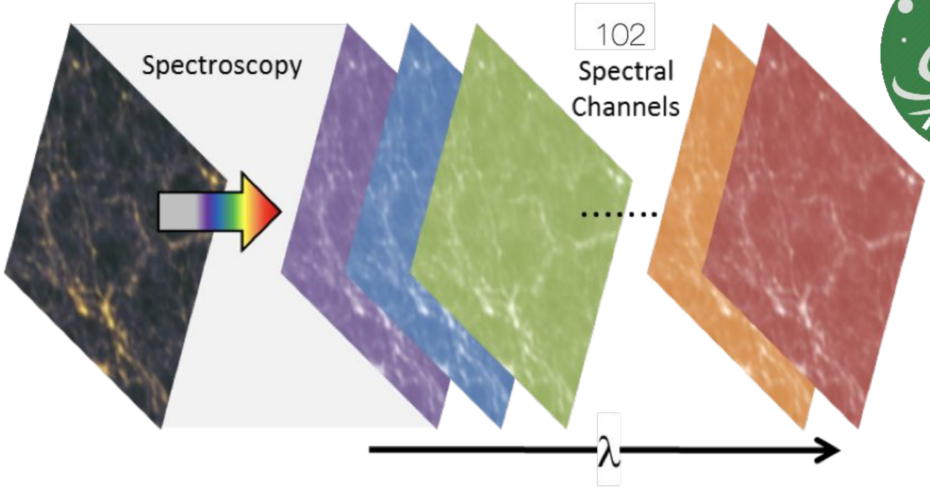


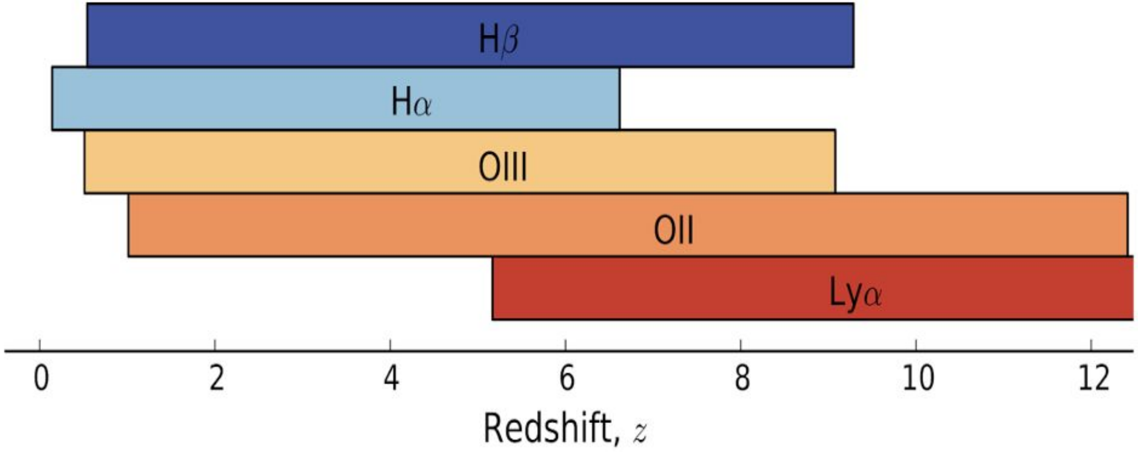
Line-intensity mapping

Separate by wavelength

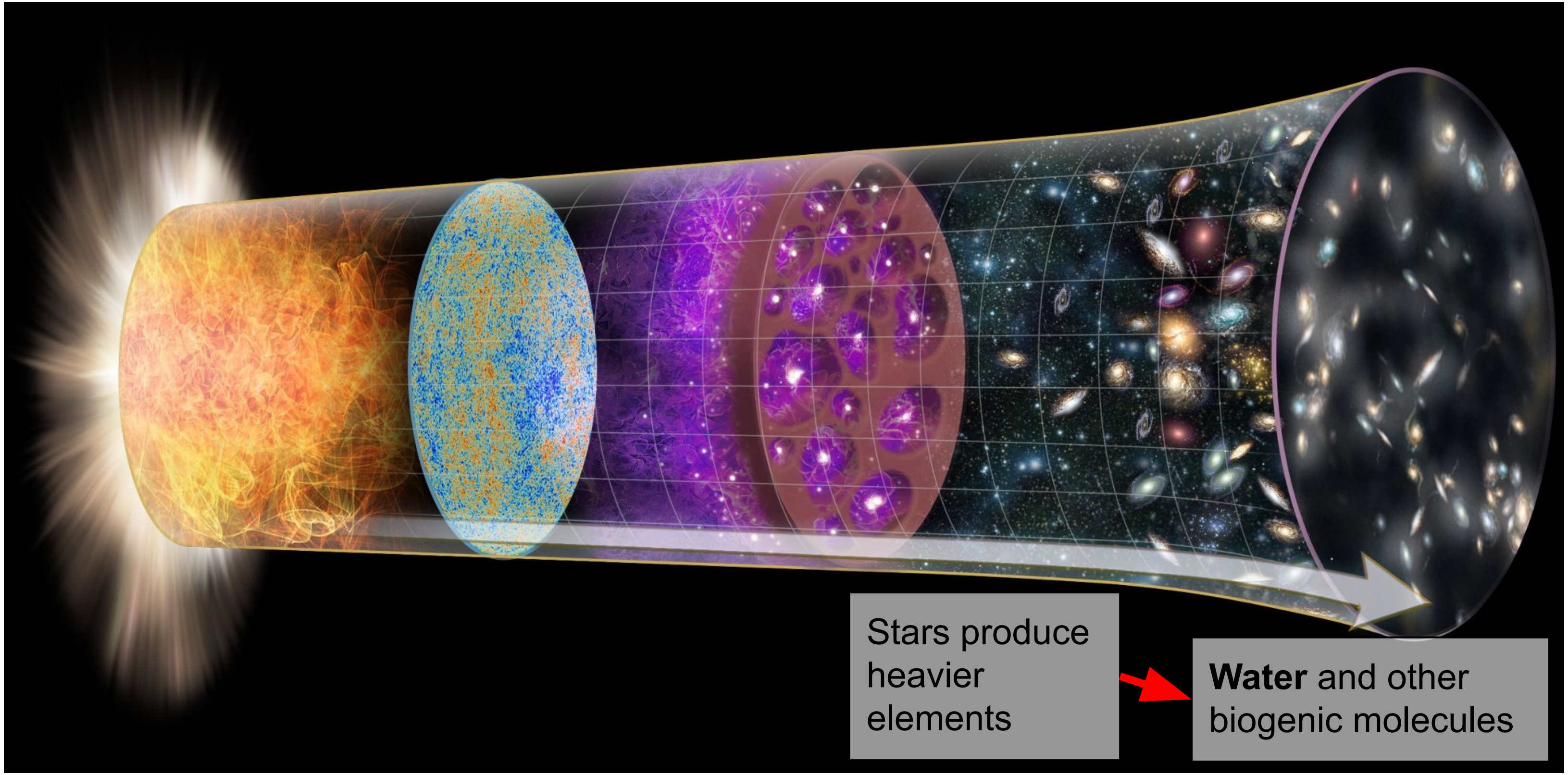
Follow atomic/molecular transition lines

Tomography of cosmic structure





How did life form?



Interstellar chemistry

Nature, Vol. 221, Feb. 15, 1969

Detection of Water in Interstellar Regions by its Microwave Radiation

From Hat Creek Observatory

by

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Department of Physics,
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A report of the detection of microwave radiation from water molecules in space, by the group which recently detected interstellar ammonia emission.

MICROWAVE emission from the $6_{16} \rightarrow 5_{23}$ rotational transition of H_2O has been observed from the directions of Sgr *B*2, the Orion Nebula and the *W*49 source. This radiation, at 1·35 cm wavelength, was detected with the twenty foot radio telescope at the Hat Creek Observatory using techniques described earlier for the detection of the NH_3 spectrum[1]. In the case of Sgr *B*2, the H_2O emission is from the same direction in which considerable NH_3 is observed (unpublished work of A. C. C. *et al.*), although there is reason to believe the two molecular species may not be closely associated. Strong H_2O radiation producing an antenna temperature of 14° K is observed from the Orion Nebula (where no NH_3 was detected), and an antenna temperature at least as high as 55° was found for H_2O radiation from *W*49.

velocity found for one of the OH emission and broad OH absorption features observed in this region[2], the 62 km s^{-1} Doppler velocity of a small nearby HII region[3], and the velocity of about 58 km s^{-1} found for NH_3 (unpublished work of A. C. C. *et al.*) observed in this direction. The results shown in Fig. 1 were obtained with filters producing a spectral resolution of about 1·3 MHz.

Fig. 2 shows the antenna temperature as a function of Doppler velocities observed in the Orion Nebula at $\alpha_{1950} = 5$ h 32 m 57 s $\pm$ 4 s and $\delta_{1950} = -5° \ 25{\cdot}5' \pm 1{\cdot}0'$. In Orion, the radiation intensity was sufficiently high to make practical the use of filters producing a spectral resolution of about 350 kHz. In Fig. 2 the solid line represents the continuum temperature as it was measured with filters of width 2 MHz; the plotted points represent

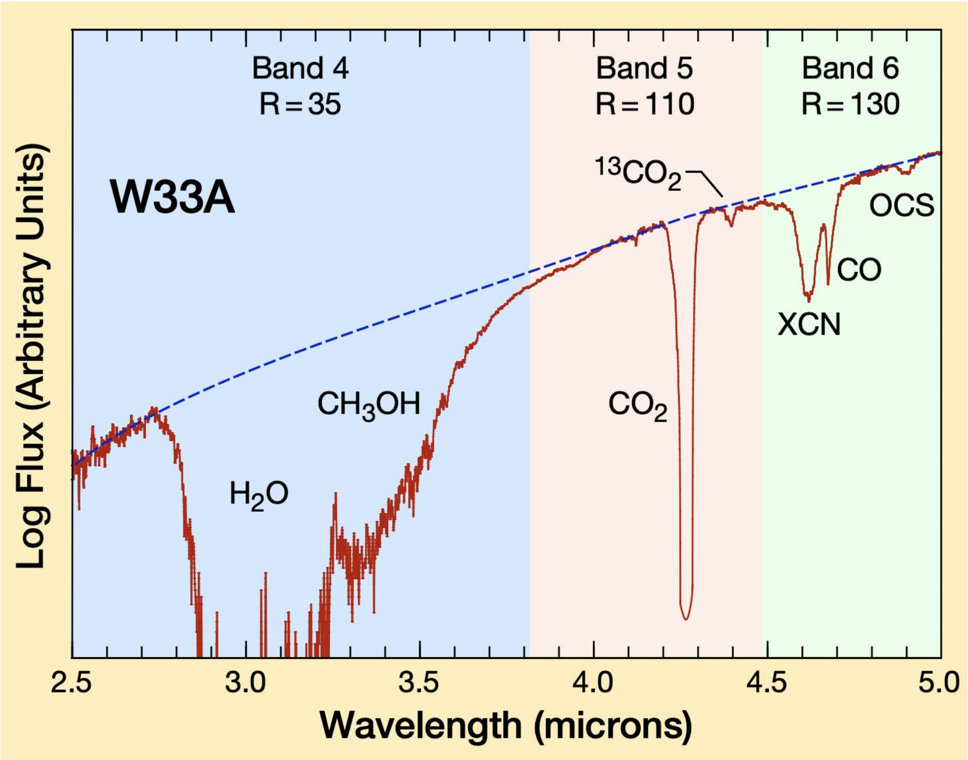
Interstellar ices

99% of interstellar water is **ice**

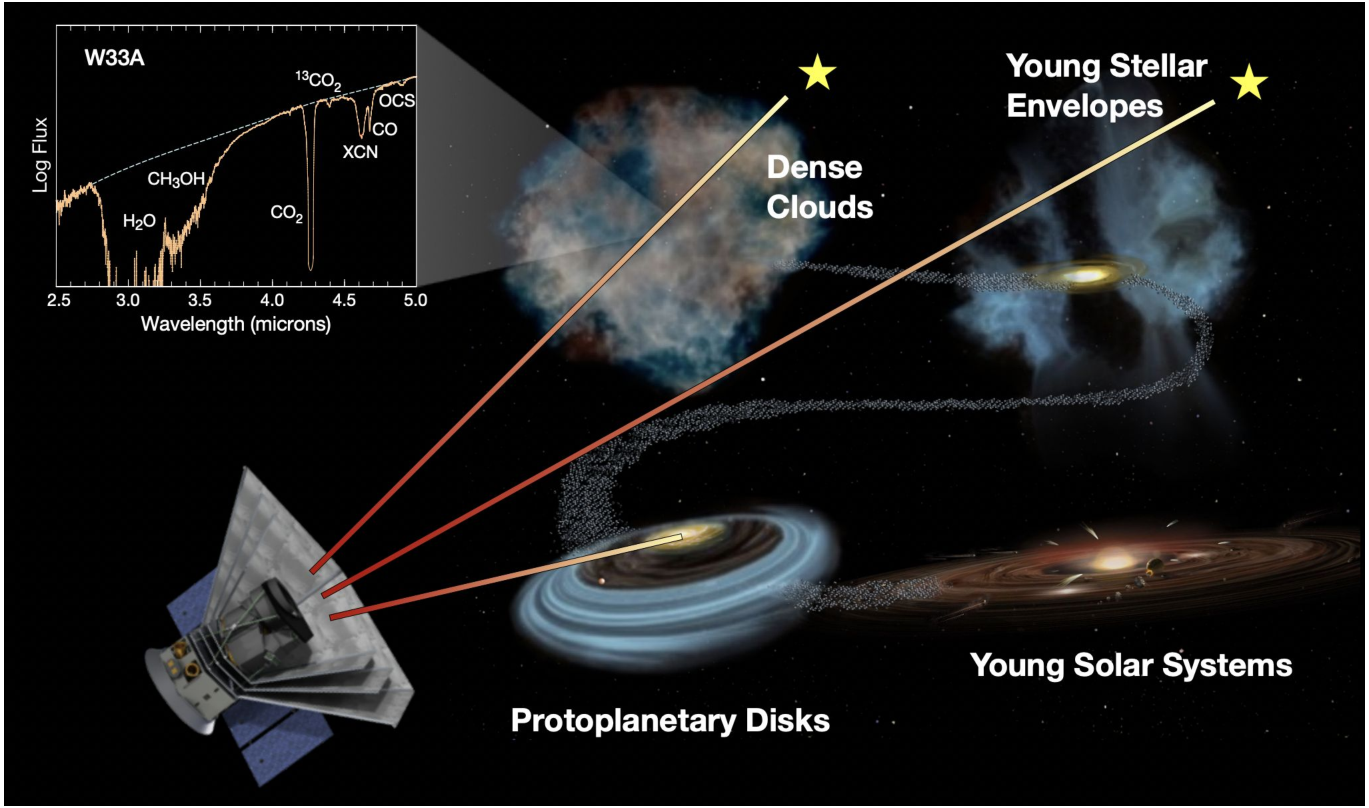
“Follow the water” → “Follow the ice”

Water isn’t the only biogenic molecule

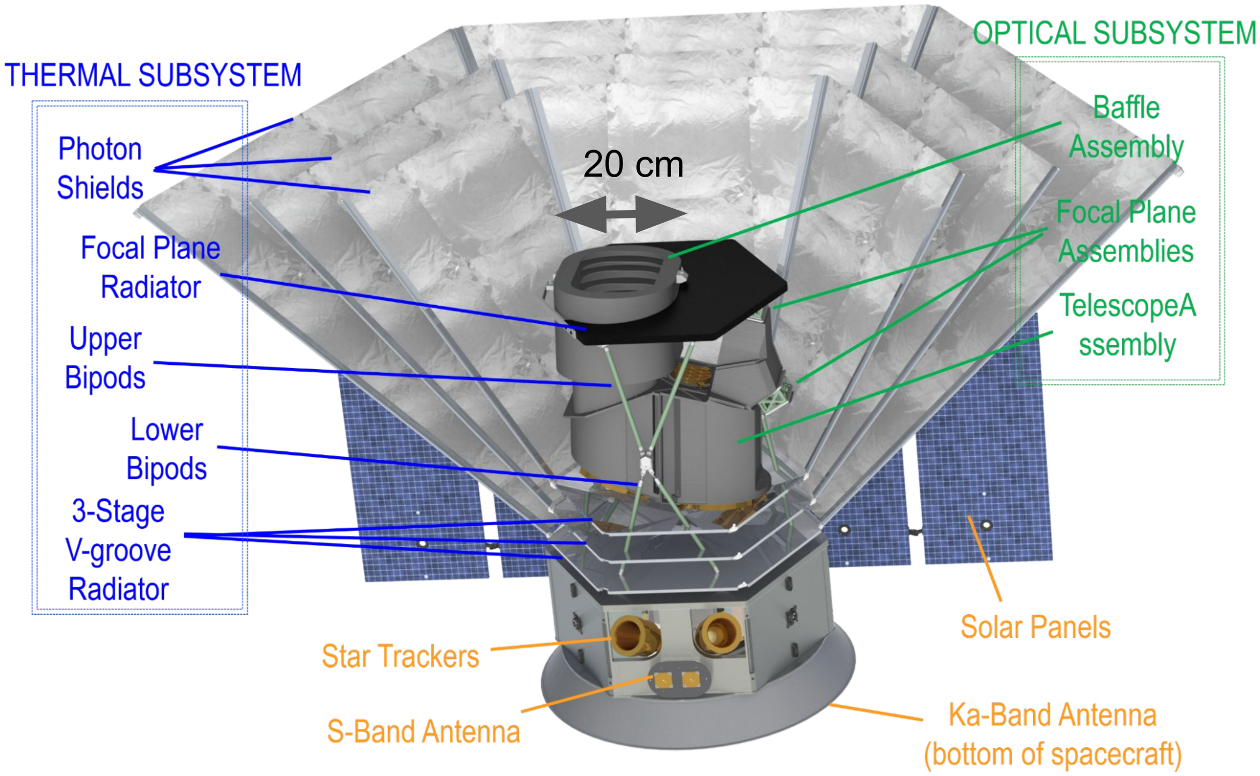
“Follow the ice” → “Follow the **ices**”



Ice absorption

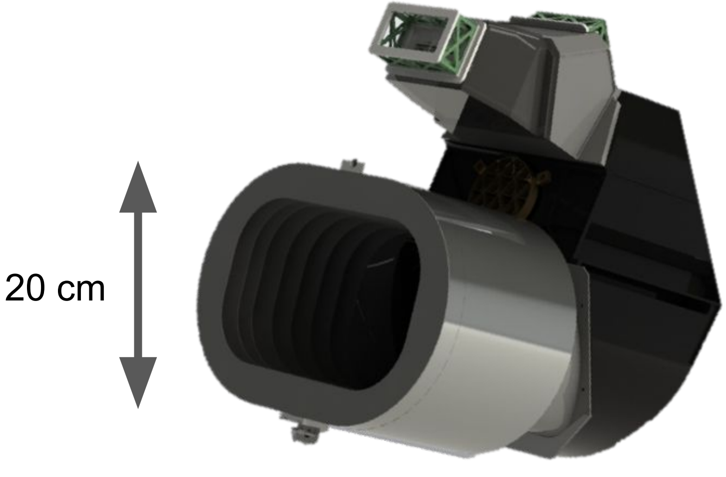


Instrument

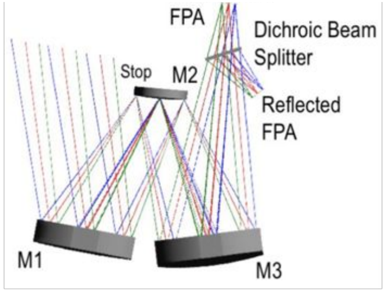


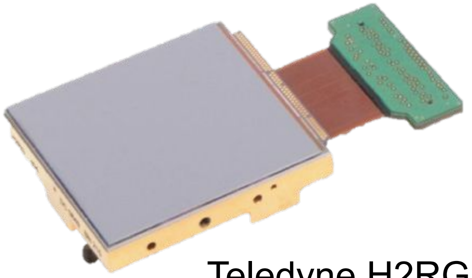
THERMAL SUBSYSTEM
Photon Shields
Focal Plane Radiator
Upper Bipods
Lower Bipods
3-Stage V-groove Radiator
20 cm
OPTICAL SUBSYSTEM
Baffle Assembly
Focal Plane Assemblies
TelescopeA ssembly
Solar Panels
Star Trackers
S-Band Antenna
Ka-Band Antenna (bottom of spacecraft)

Telescope



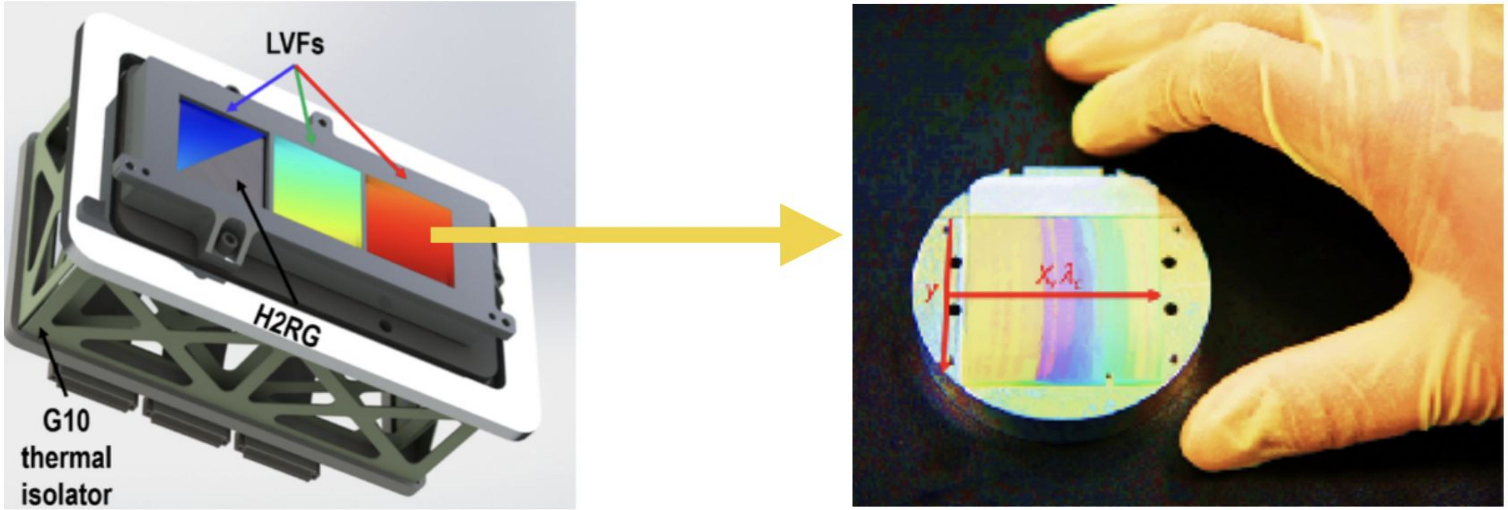
Three-mirror anastigmat
(TMA) telescope





Teledyne H2RG detectors
(also on *James Webb Space Telescope*)

Spectroscopy without a spectrometer

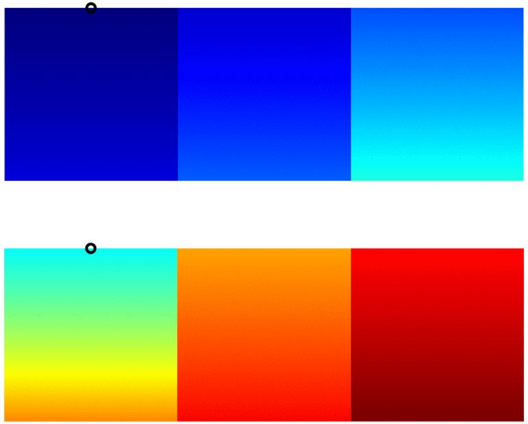


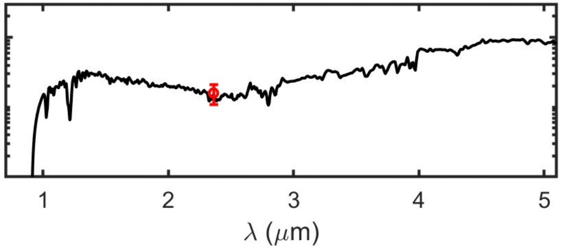
Linear variable filter (made by VIAVI)

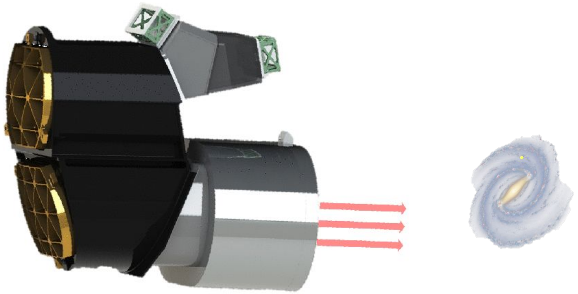
Space heritage on, e.g., *New Horizons*

How SPHEREx constructs galaxy spectra

6 detector tiles with linear variable filters







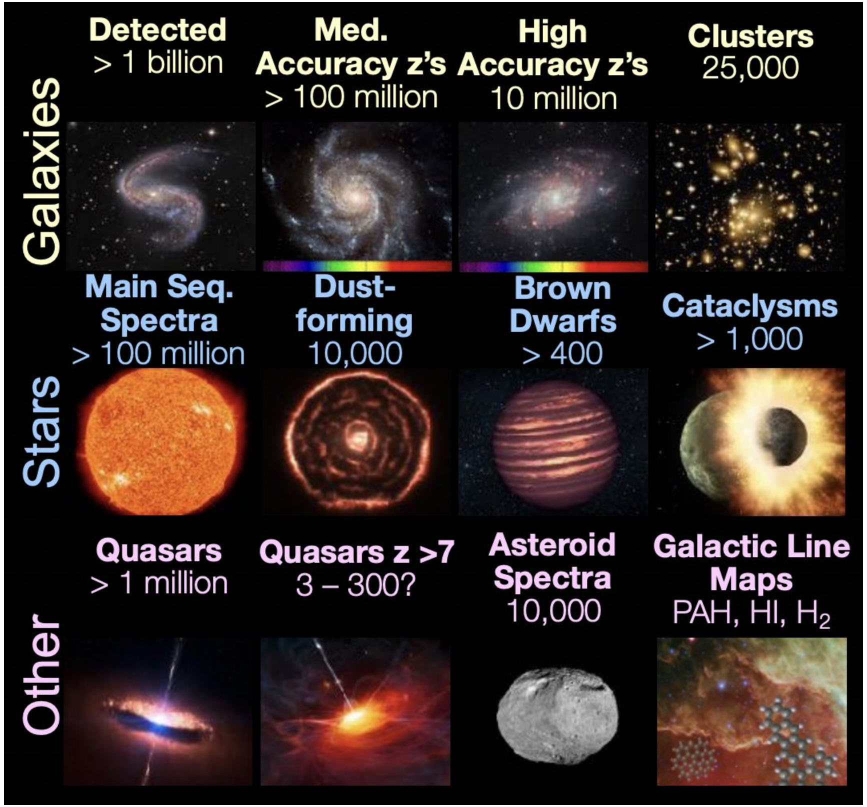
Scan to fill out spectrum

All-sky legacy archive

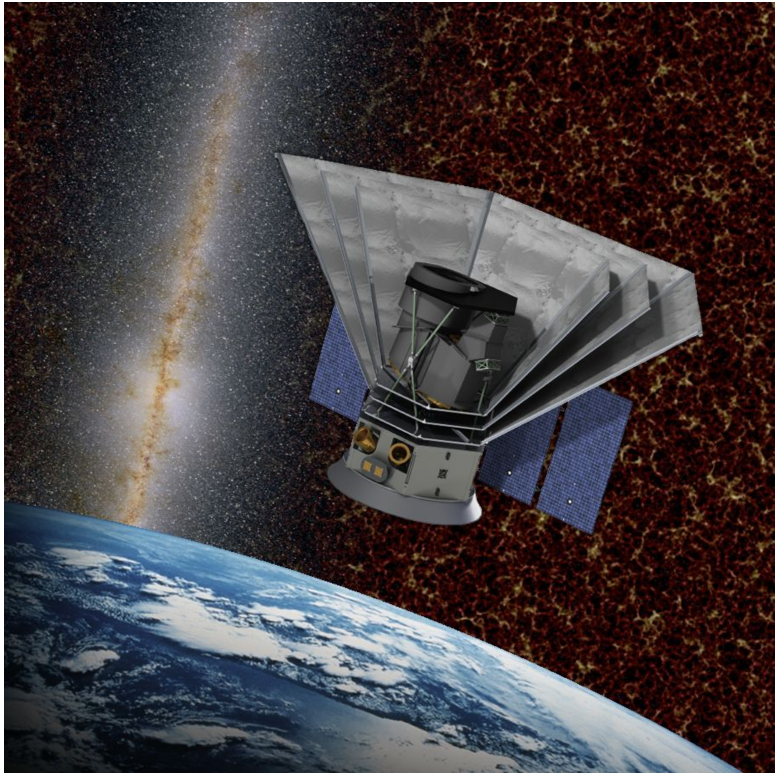
Spectrum for every 6” pixel on the sky

Identify candidates for follow-up with, e.g., *James Webb Space Telescope*

Combine with upcoming observatories, e.g., LSST, Euclid, Roman



Questions?



Learn more at **spherex.caltech.edu**