Origin and Evolution of Galaxies: GSMT and JWST

Betsy Barton, Alan Dressler
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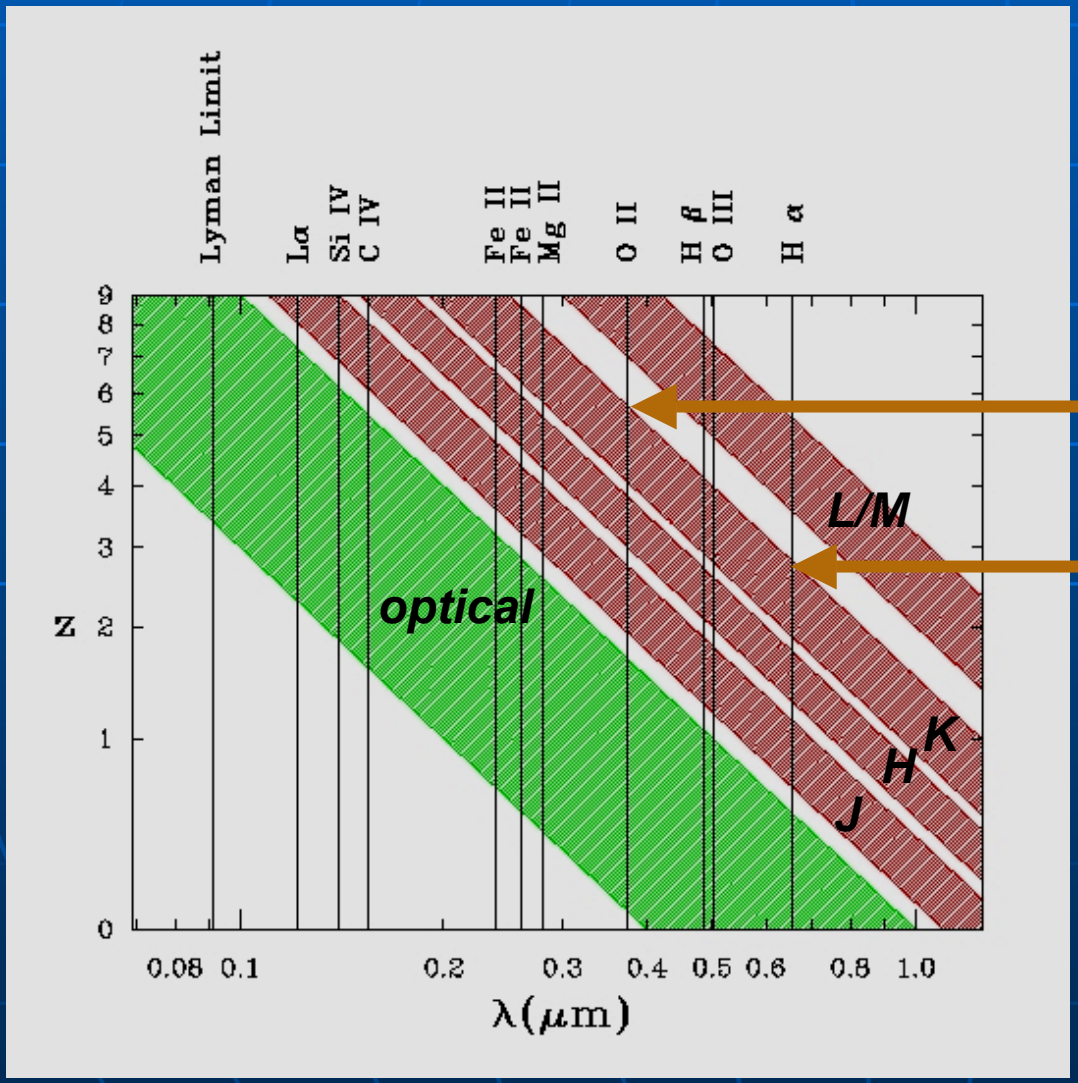
Each has unique capabilites:

- **GSMT:**
  - High spectral resolution
  - Potential for extremely high spatial resolution
  - Wide field
  - Blue sensitivity
- **JWST:**
  - Imaging without AO
    - High Strehl, high dynamic range
  - Sensitivity in IR at R=5
  - Uninterrupted IR coverage
  - Mid-IR sensitivity

Outline: Science Scenarios

- **Building the Modern Universe**
  - A large survey down the luminosity function at $z < 6$
- **Assembling Galaxies**
  - Detailed internal properties of high-redshift galaxies
- **First light**
  - Detecting star-forming objects at $z > 6$-10

Near-IR case for chemical abundances, star formation histories



GSMT: wider field, better sensitivity between OH lines

JWST: uninterrupted coverage in IR

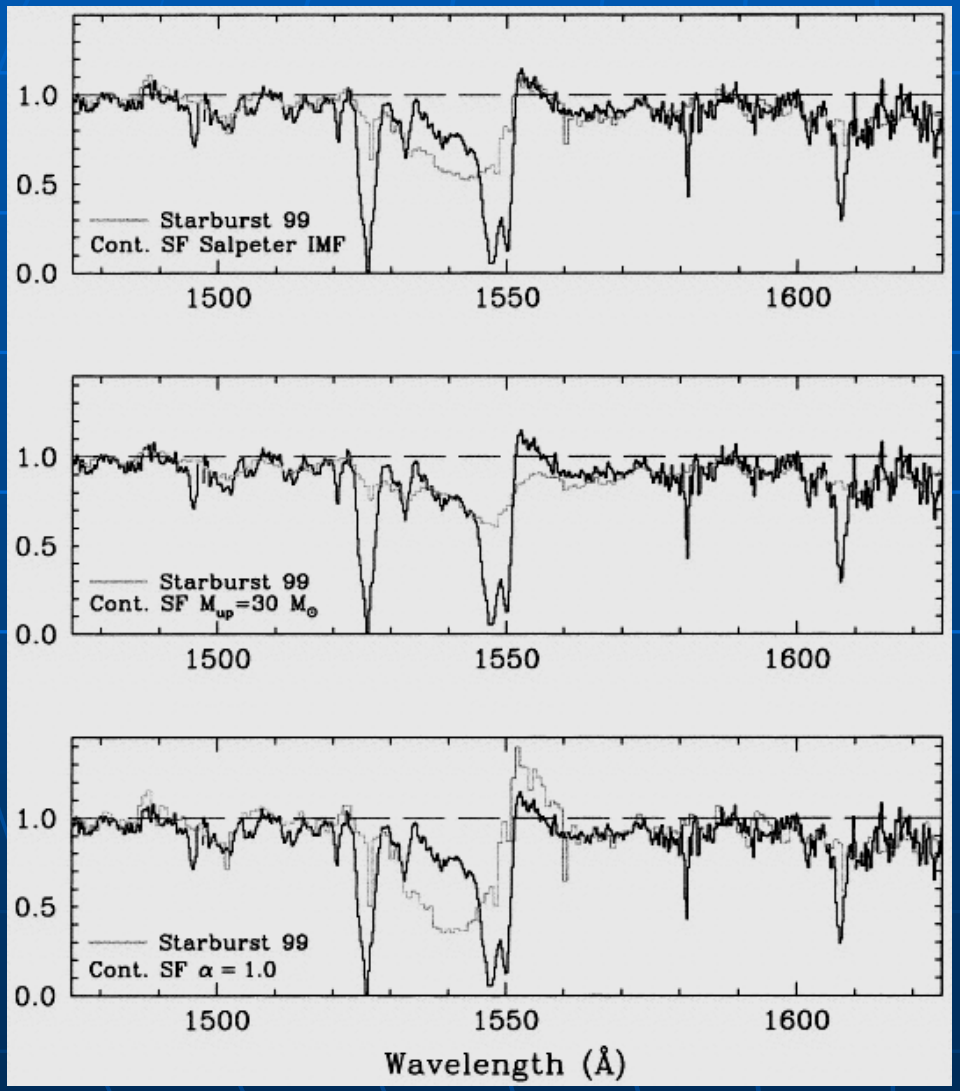
[OII] to z = 6

Hα to z = 3

- *Few strong lines in optical between redshifts of about 1 to 3*
- *NEED near-IR*

Plot from Oke & Barton (2000)

Constraints from optical spectra



At z=3-4, rest-frame UV is not available with JWST

cB58: a lensed "Lyman Break" galaxy:

Fig. shows a match of CIV (λ1549 Å) to models of a young burst of star formation

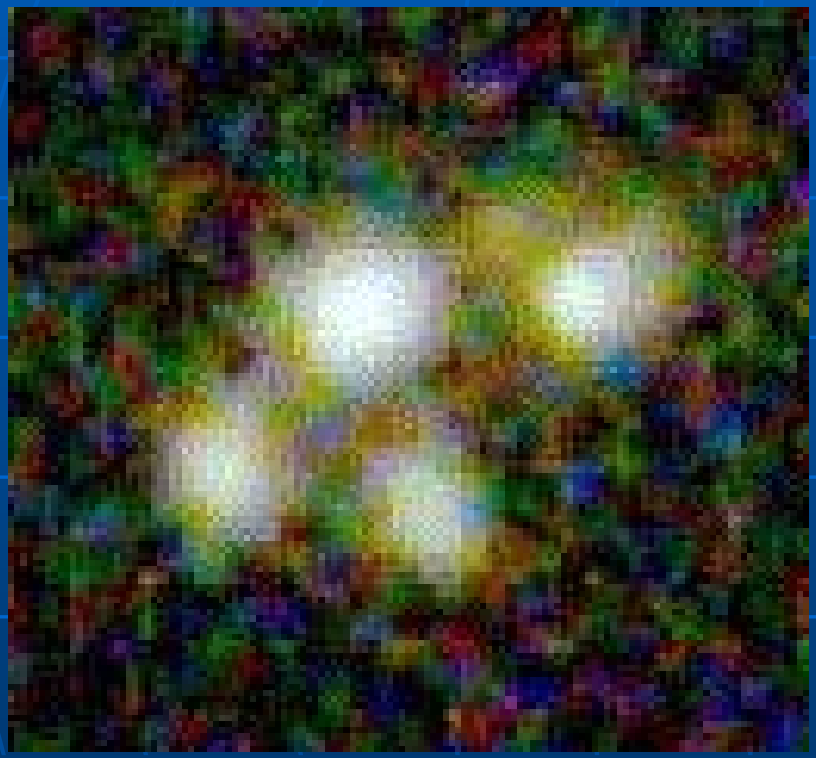
Line is sensitive to IMF

(Pettini et al. 2000)

Building the Modern Universe

- **Surveys for number counts, basic properties of large sets of galaxies**
- **GSMT:**
  - **Spectroscopy at "arbitrarily" high resolution**
  - **More sensitive spectroscopy in the near-IR (between OH lines)**
  - **Spectroscopy in the blue**
- **JWST:**
  - **"Parent" imaging survey: images with high Strehl and the full dynamic range**
  - **IR spectra at moderate resolution (R=1000) with no interruptions from the night sky**

Assembling Galaxies



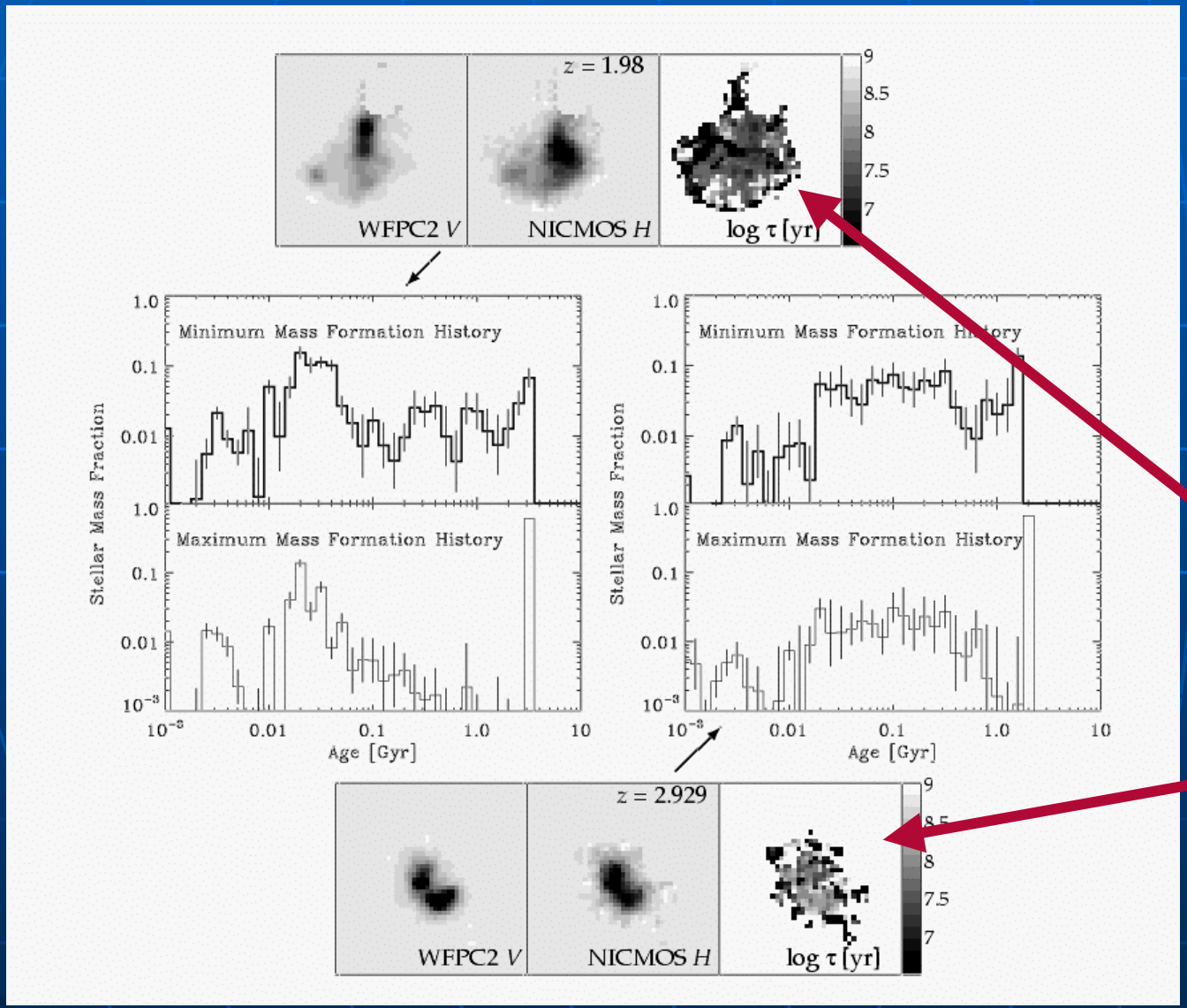
(z=3 galaxy from Hubble Deep Field; HST psf ~ 0.1" ~ 770 pc)

- **Science goals:**
  - **Dynamical masses**
  - **Enrichment and star formation history as a function of position**
  - **Direct observations of the build-up of mass through merging and star formation**

What are the "Lyman Break" galaxies?

In what kinds of galaxies did most of the stars form?

Hints of internal structure at high redshift



HST/WFPC2
HST/NICMOS
colors

JWST will
Offer mid-IR
coverage

color/age
variation
inside
high-z
galaxies

Figure from
Casey Papovich

Assembling Galaxies

- **Internal properties of high-redshift galaxies, systems of high-redshift galaxies**

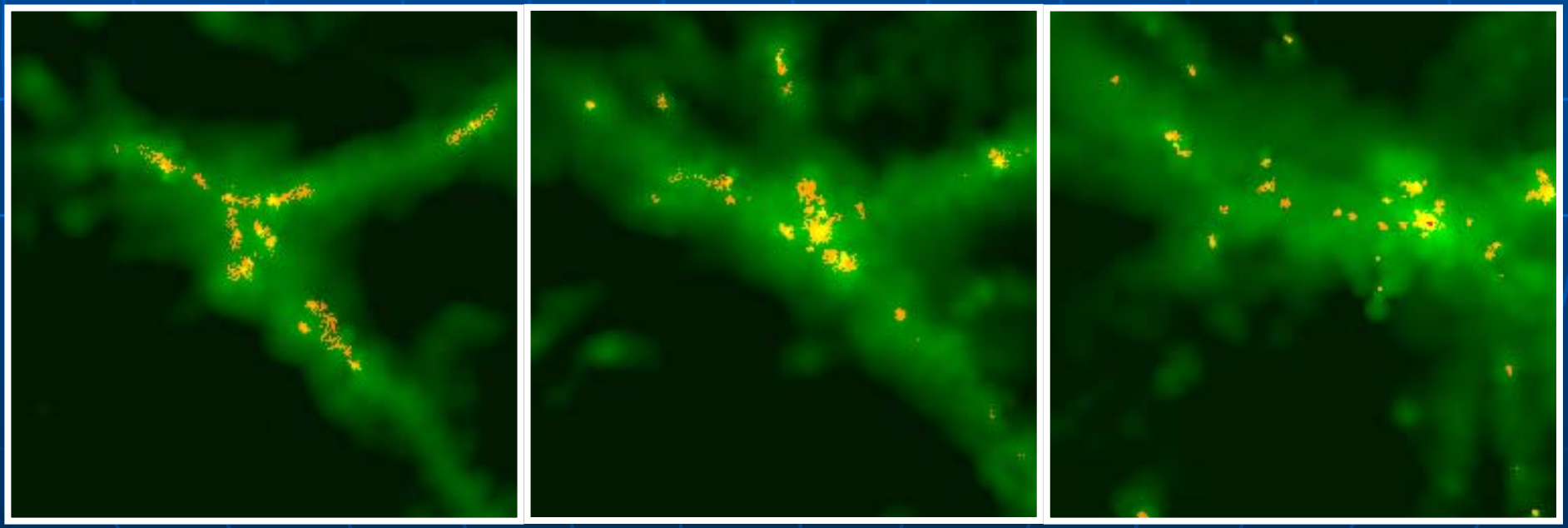
- **GSMT:**
  - **Spectroscopy at "arbitrarily" high resolution**
  - **Potential to exploit diffraction limit in near-IR for high surface brightness features (only)**
  - **More sensitive spectroscopy in the near-IR between OH lines**
  - **Spectroscopy in the blue**

- **JWST:**
  - **"Parent" imaging survey without need for AO: offers full dynamic range**
  - **IR spectra at moderate resolution (R=1000)**

Physical characterization of the first stars

- **Hydrodynamical simulations of Davé, Katz, & Weinberg**
  - **Lyα cooling radiation (green)**
  - **Light in Lyα from forming stars (red, yellow)**

z=10 **z=8** **z=6**

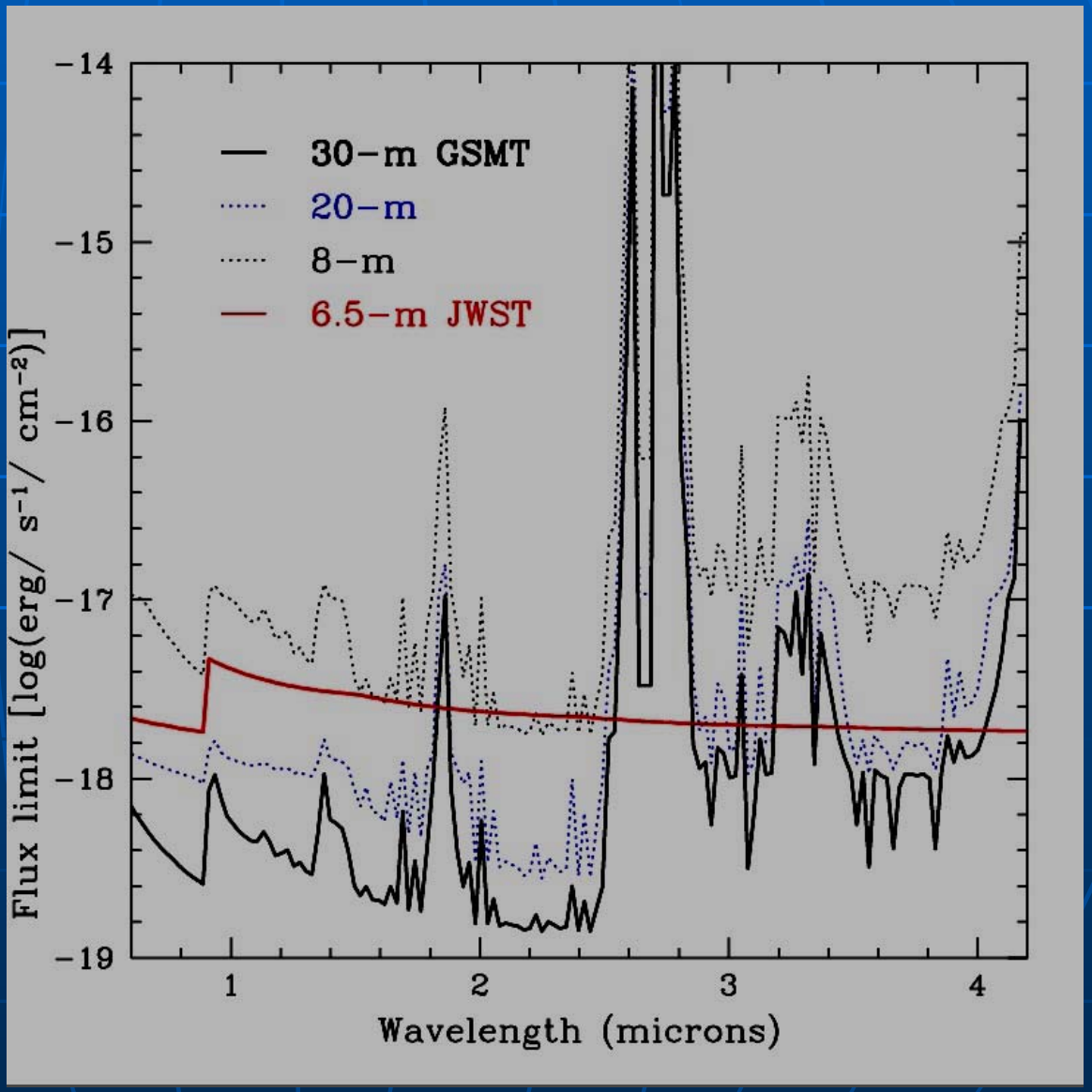


Courtesy: J.-D. Smith

Detecting and characterizing the first star formation in the universe

- **At z=6-10, Lyα is at $0.85 < \lambda < 1.4$ μm: regime where a 30-meter is much more sensitive than JWST**

Sensitivity to unresolved emission lines, R=3000, t=10,000 seconds



First Light

- **JWST:**
  - **Likely to detect the highest-redshift galaxies in broad-band continuum**
- **GSMT:**
  - **Will characterize the "first" stars**
    - **Lyα profile, strengths of other lines**
  - **Wider field will allow mapping of the structures of first-light galaxies**

First Light

- **Detection and physical characterization of the first star-forming objects**

- **GSMT:**
  - **Greater sensitivity at high spectral resolution**
    - **Line profiles; detection of fainter metal lines**
  - **Wider field**

- **JWST:**
  - **Greater sensitivity for broad-band observations**
    - **Best when there is no line emission (depends on IGM, metallicity)**
  - **Greater sensitivity past 2.4 μm (z=19 for Lyα)**

Outstanding Questions

- At what resolution will GSMT out-perform JWST in the near-IR?
- How well can GSMT measure emission that lands on a night sky line? (Systematics dominate.)
- Do the first-light objects have emission lines? (May not be answered soon.)
- How do we prepare if GSMT is late (no JWST/GSMT overlap)