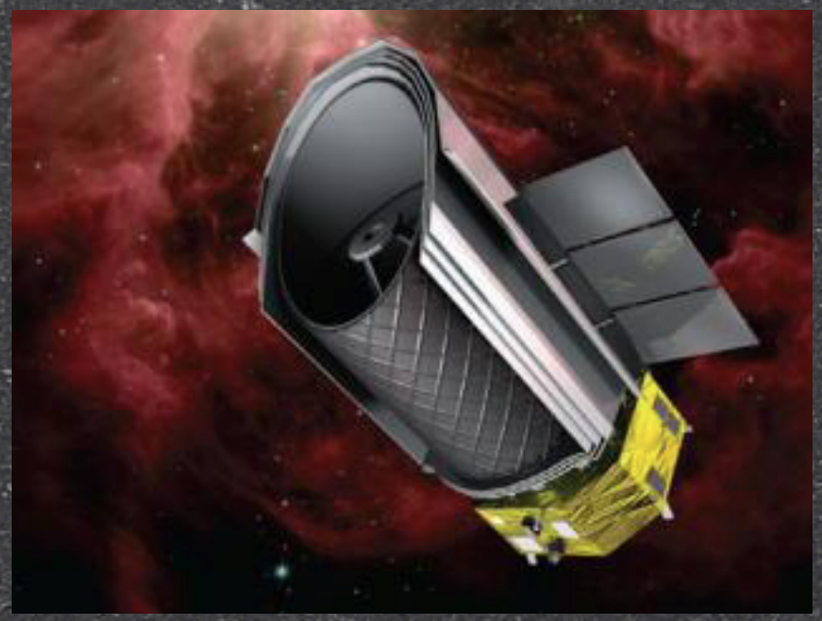
Exploring the Frontier of Redshifted & Obscured Galaxies with SPICA/MIR



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IPMU INSTITUTE FOR THE PHYSICS AND MATHEMATICS OF THE UNIVERSE

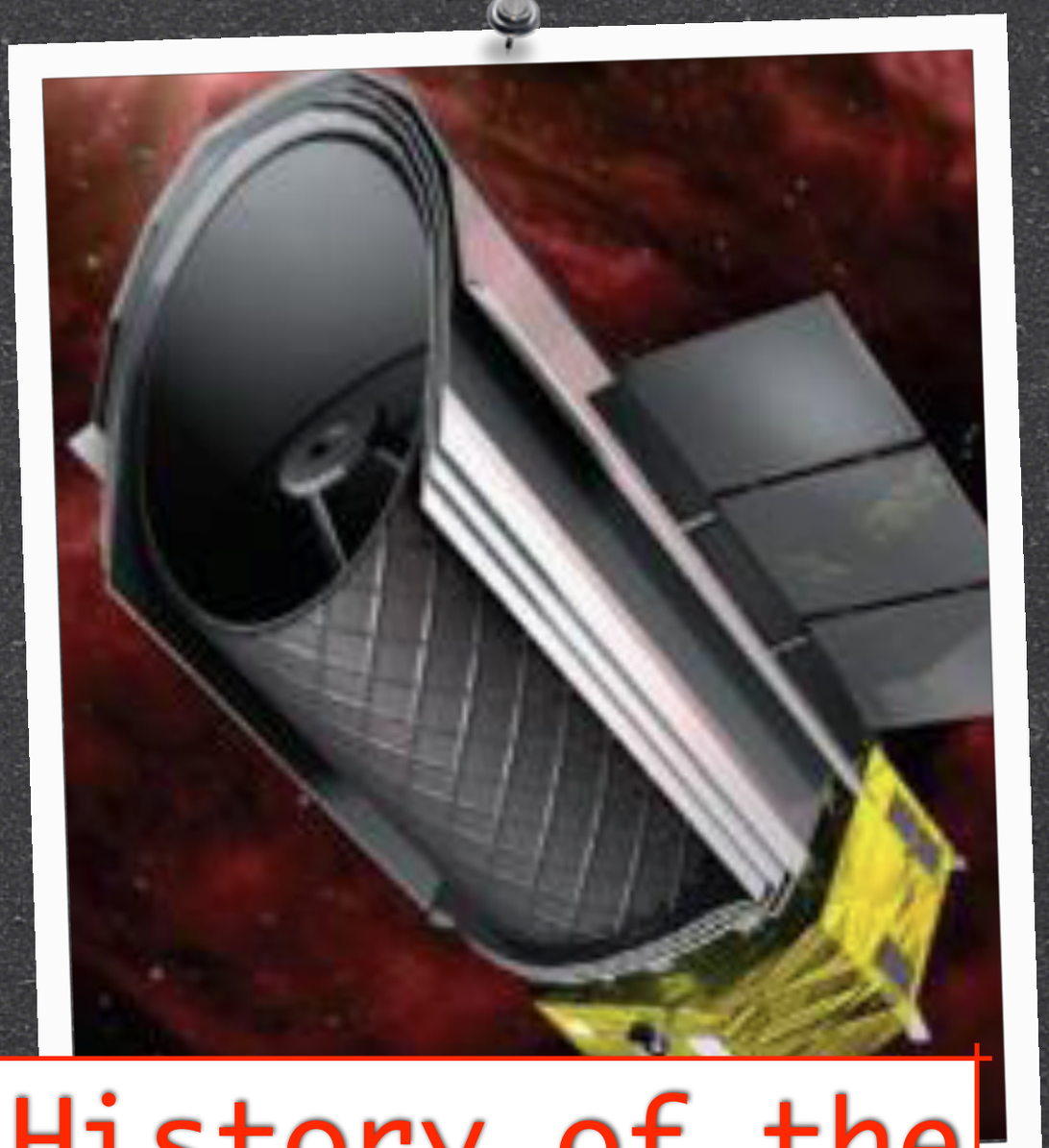
Topics

- BRIEF Introduction
  -- SPICA probing the early universe
- “Redshifted” Frontier --- z ~ 7-10
  - History of stellar mass assembly
  - Star formation & chemical enrichment
- “Obscured” Frontier --- z ~ 2-5
  - History of dust evolution

SPICA capabilities

- MIR instrument (MCS-WFC)
  - 3m cooled telescope
  - 5’x 5’ FoV
  - 5-38μm coverage

Unprecedentedly high sensitivity in MIR



- ★Redshifted galaxies
- ★Obscured galaxies

History of the Early Universe

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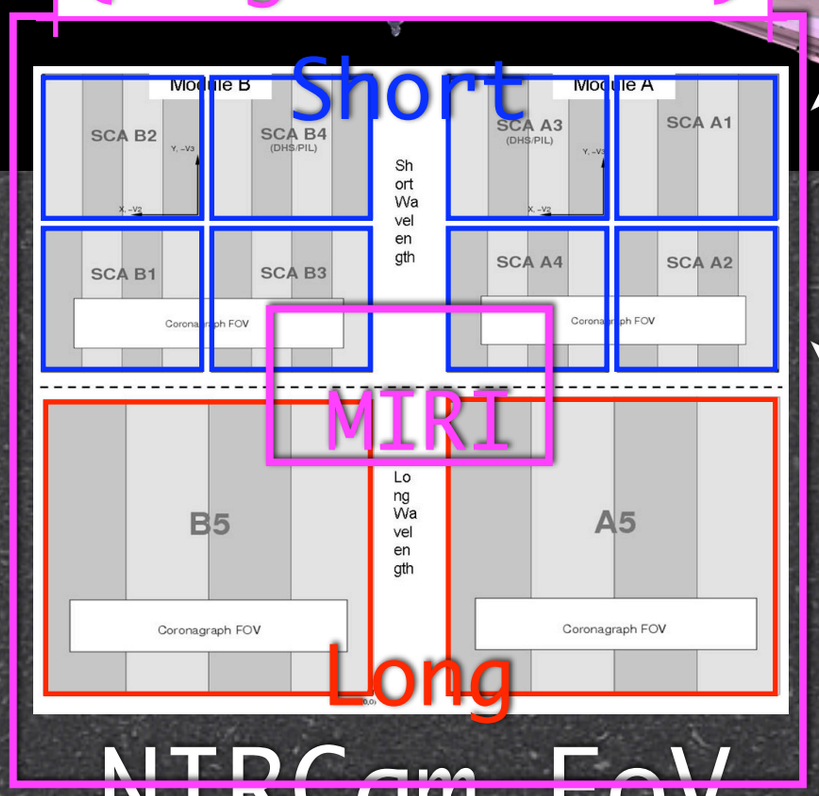
Star-forming galaxies at z>7



- JWST/NIRCam can probe SF history beyond z~7

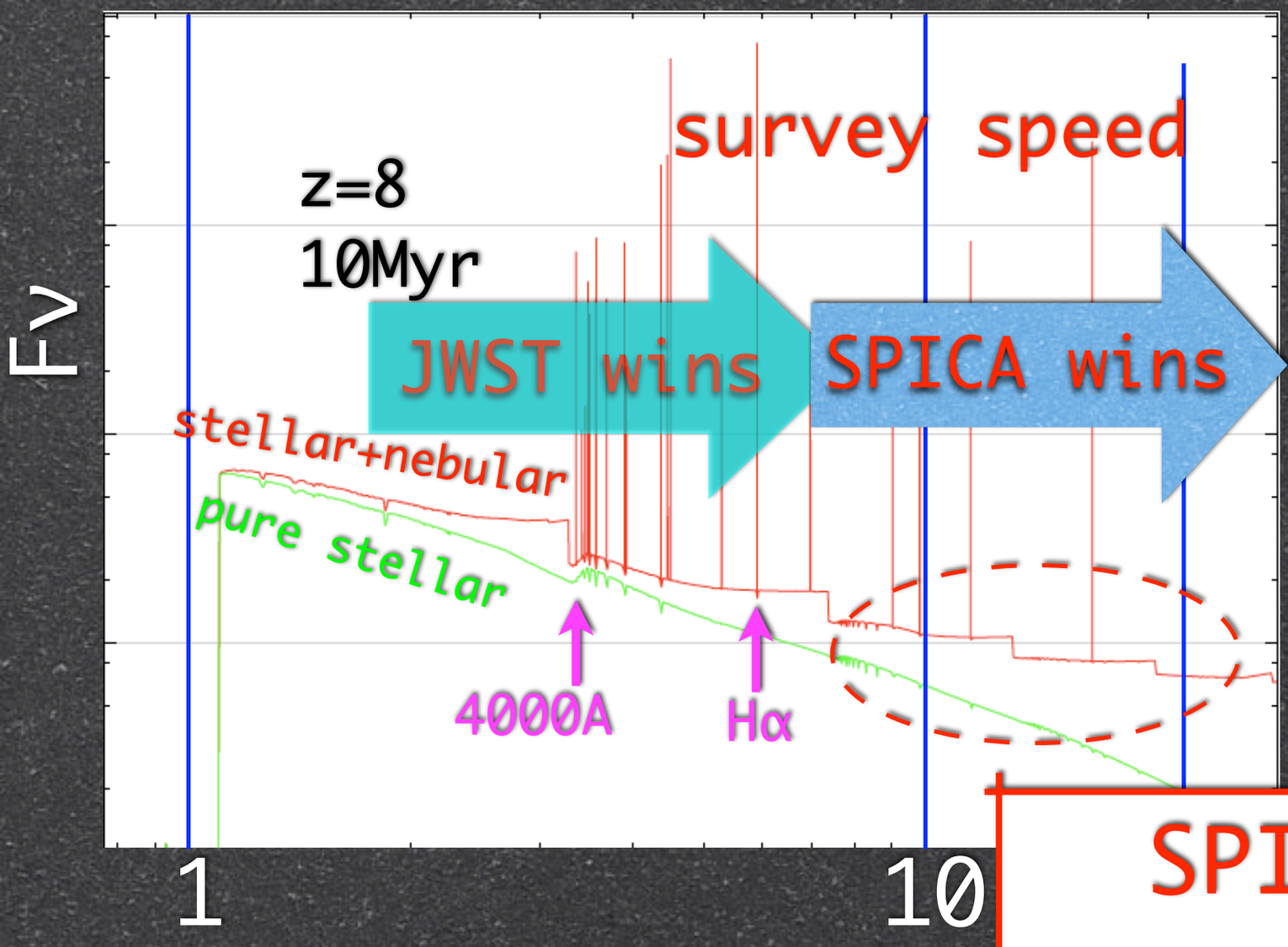
※ on-going SFH, not mass-assembly history

- JWST/MIRI is not very efficient for follow up

- SPICA/MCS has greater sensitivity @ >20μm survey speed @ >5μm

Great Synergy!
SPICA + JWST

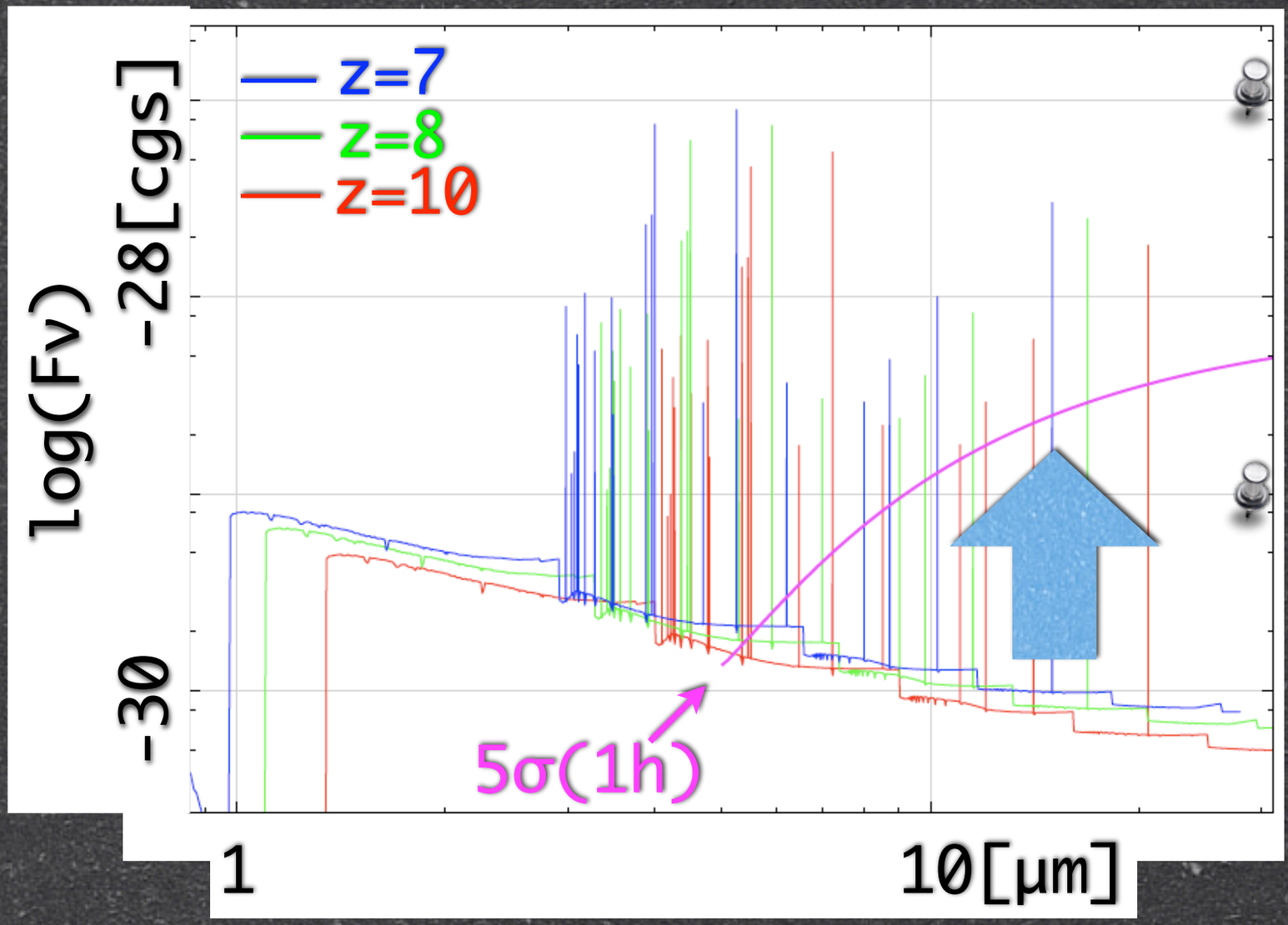
Stellar mass/age @z~7-10 w/ MIR photometry



- Photometry suffers from nebular lines, spoiling estimates of M*, age, etc.
- Continuum well beyond strong lines (Hα, etc.): ~10-20μm at z~7-10

SPICA will probe mass-assembly history at re-ionization era

Detectability



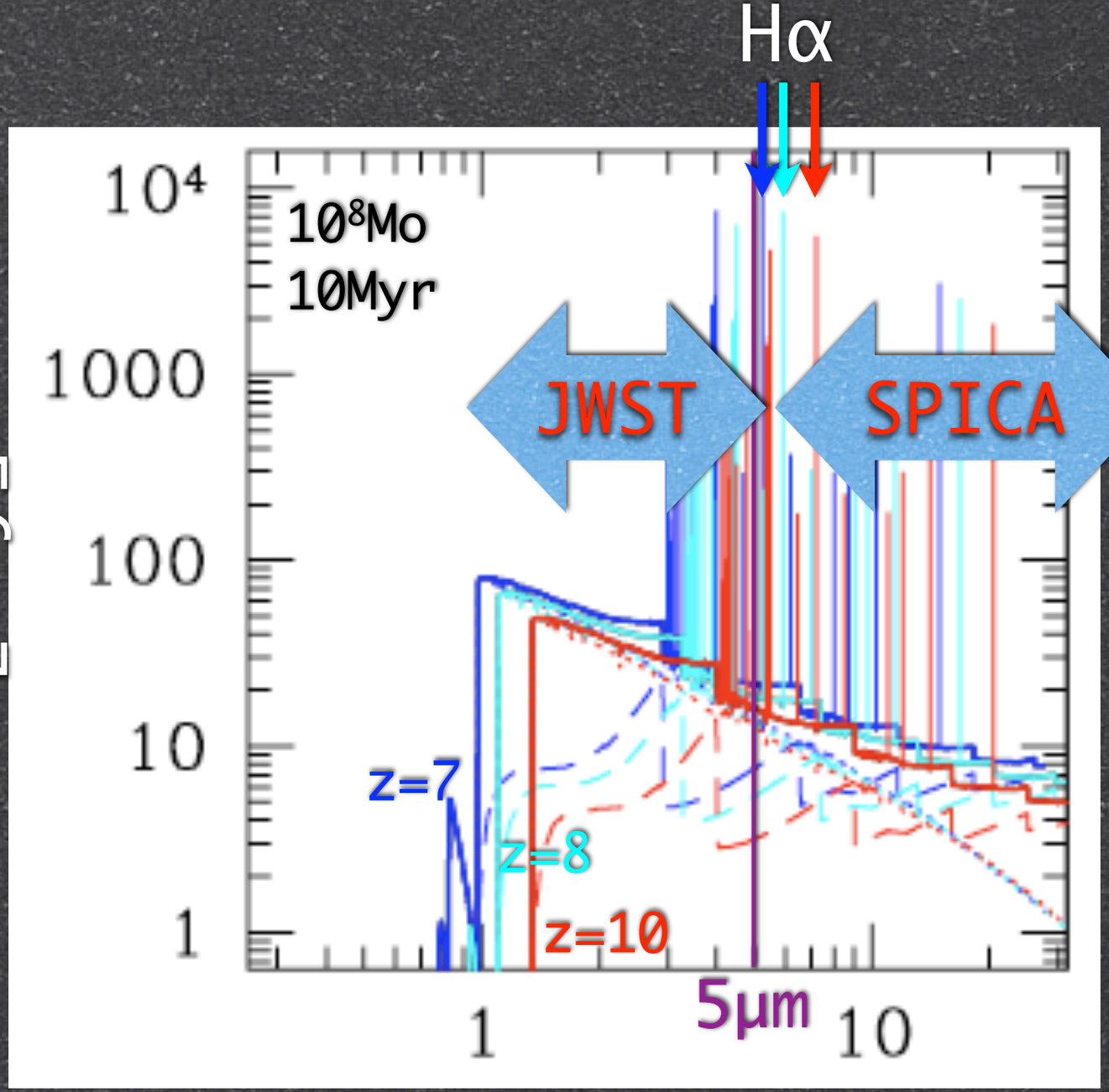
M*=10⁹Mo galaxies are factor of ~10 fainter than 5σ @10-20μm

Cosmological simulation (Shimizu) predicts 10¹obj./FoV beyond JWST-limit

=>Stack them!

Detailed stellar contents at z>7

Probing with Hα..?



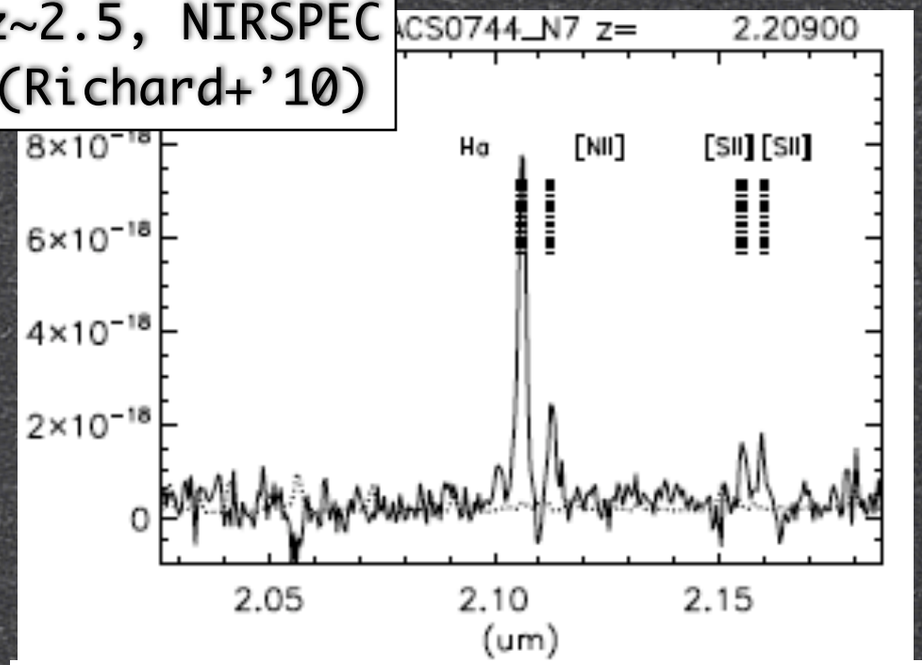
Naive ideas...:

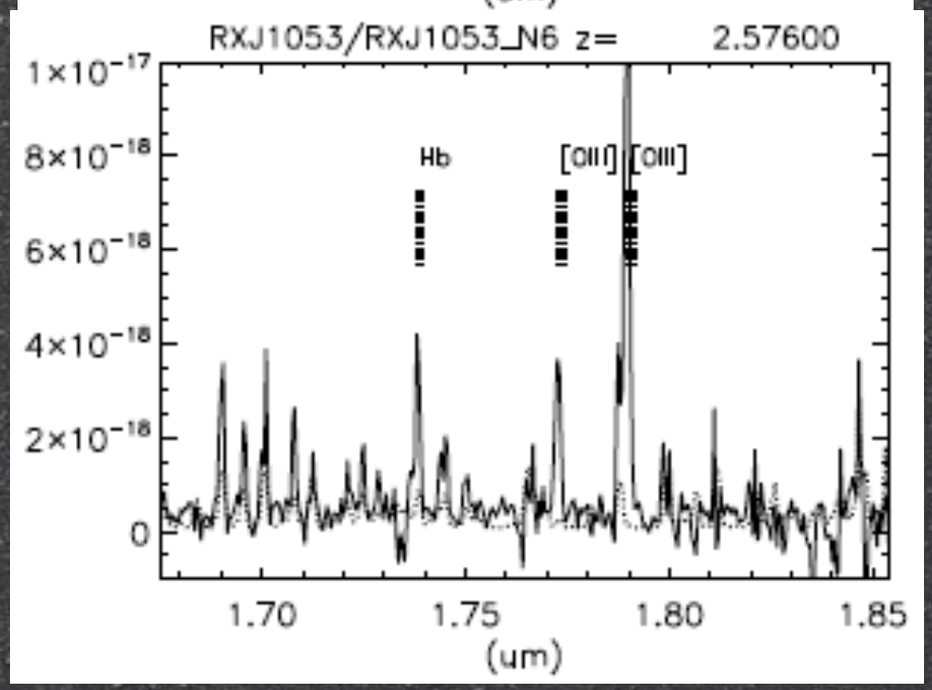
- Hα is a good tracer of star formation
- Less-sensitive to dust than Lyα
- Will be redshifted into the coverage of WFC-S at z>7

SPICA will reach z > 10 !!?

If dream comes true...
M-Z relation beyond z~7

z~2.5, NIRSPEC (Richard+'10)

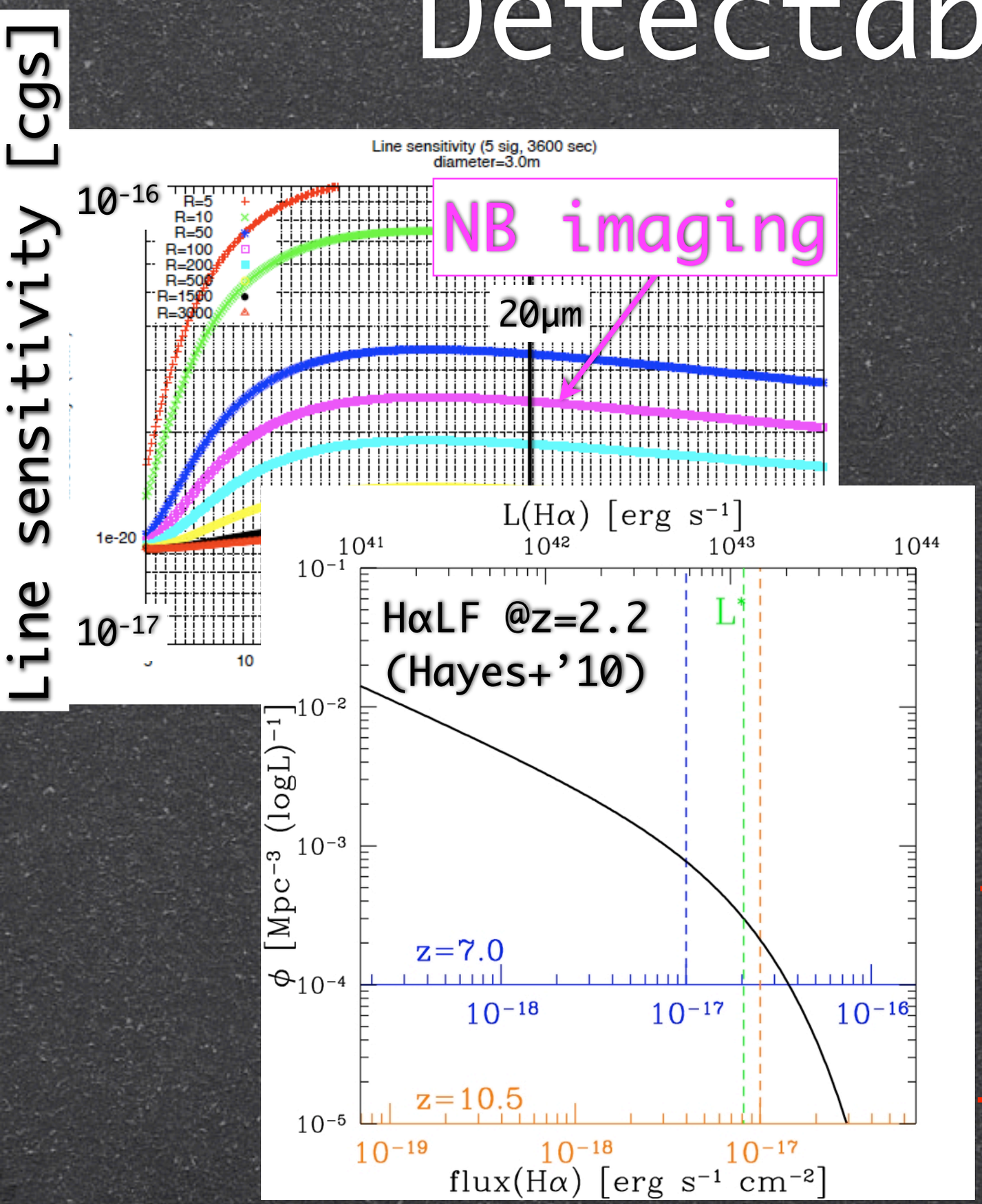




- Search for Hα with NB imaging: Hα
- Follow up with WFC low-resolution (R~500) spectroscopy mode: Hα [NII] [OIII] Hβ
- SED fit with broadband imaging (together w/JWST): Opt-NIR (rest) cont.

Chemical History of the Universe @z~7-10.5

Detectability



- Assumption
  HαLF similar to z~2
  R=100 NB filter
  No dust correction

- Results
  Estimated # of obj.:
  ~2/FoV at z~7
  ~0.4/FoV at z~10.5

Quite challenging
...Optional?

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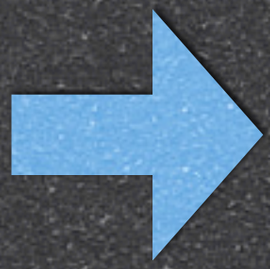
Naive ideas...again

- Wavelength longer than NIR (i.e.JWST)
  - ...can probe obscured galaxies!
- Large aperture (3m), cooled, space...
  - ...can go further distant universe!



Let's observe high-z dust!

but...

Rest-NIR dust SED depends on grain size

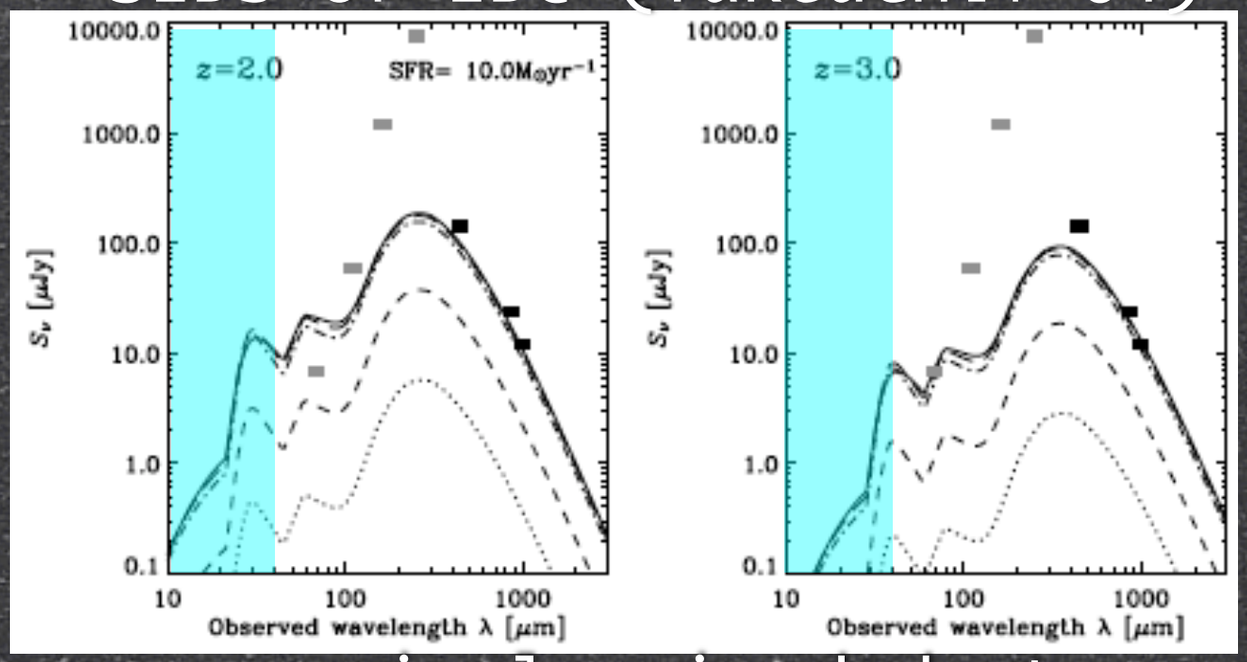
High-z dust contents are poorly known

Dust in LBGs @z~2-3

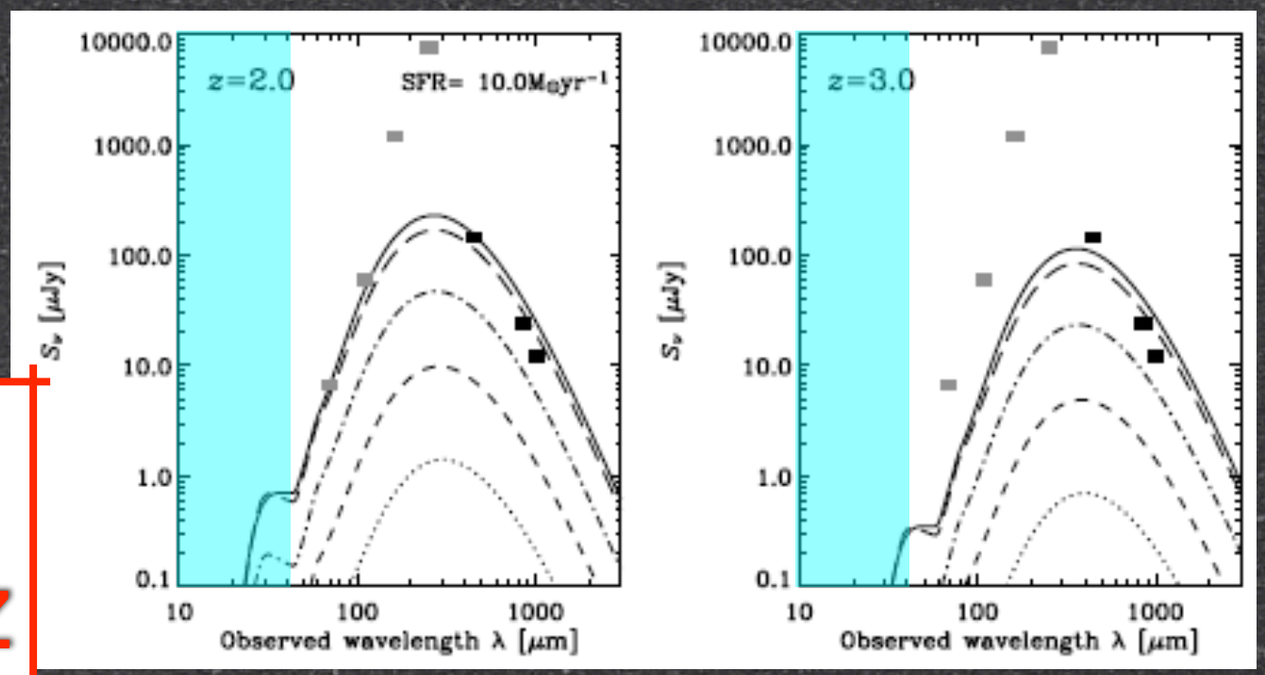
- Rest-NIR SEDs will probe small grains
- ~1μJy (5σ, 1h) is sufficient to detect small grains of:
  - ~30 Mo/yr @z=3
  - ~10 Mo/yr @z=2

Put constraints on dust size at high-z

SEDs of LBG (Takeuchi+'04)



single-sized dust

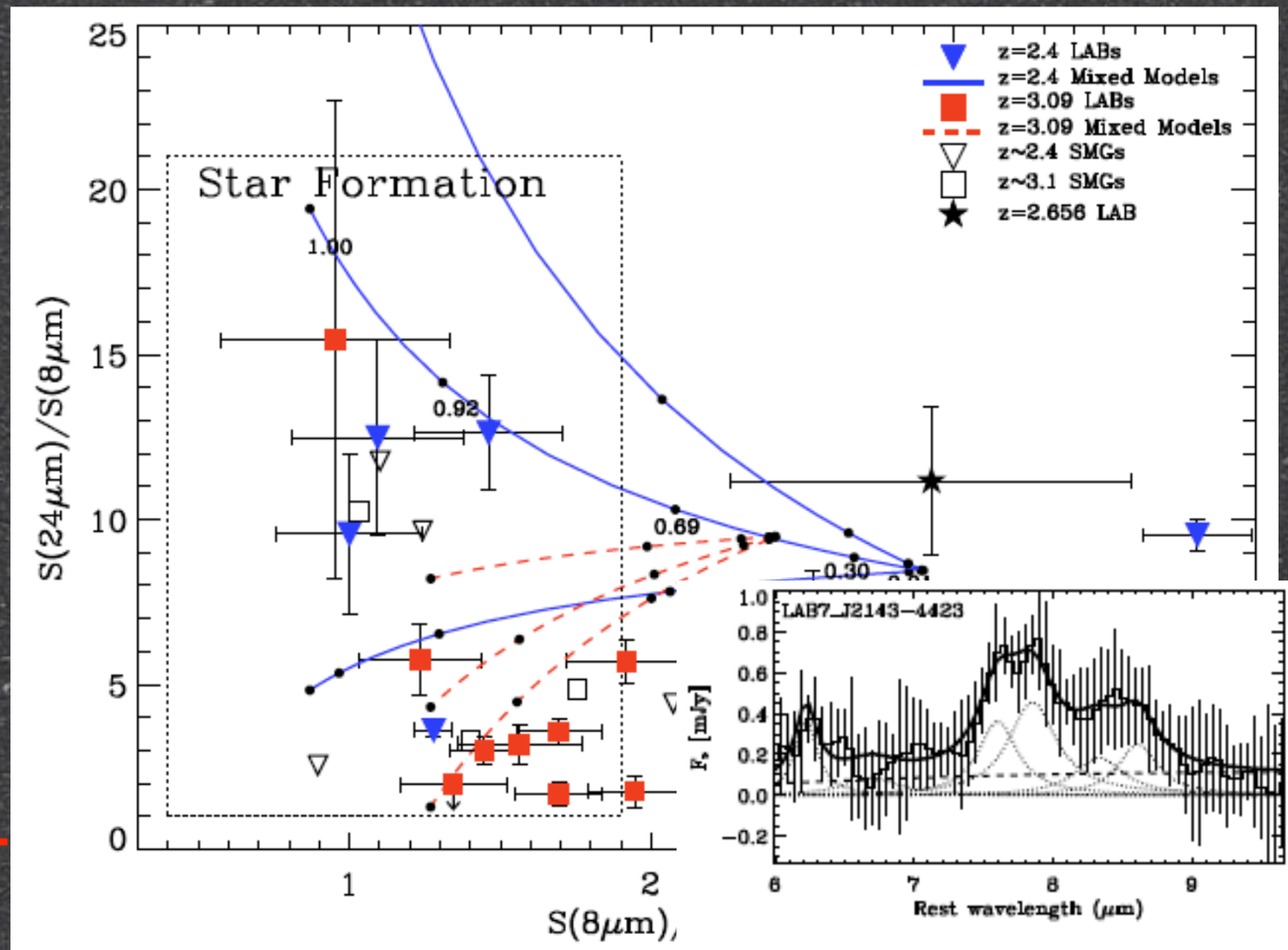


power-law dust

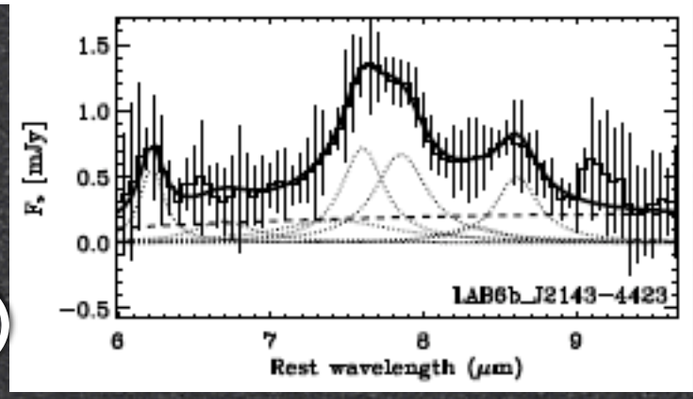
PAHs from high-z

- Determine SF/AGN with rest-NIR colour
- Follow up with low-res. spectroscopy (R~500?) =>PAH!?

Important clues to understand "high-z dust"



LABs @z=2.4 w/Spitzer (Colbert+'10)



Dust evolution @high-z w/ rest-NIR

- Small grains (a<~0.01μm) are relatively rare.
  =>‘shattering’ mechanisms
  (e.g., SN shock; turbulence)
- PAH are preferably provided by AGB stars (rather than SNe)
  =>forming mechanisms
  (related with SF activity)

Observing various galaxy populations in rest-NIR put constraints on high-z dust properties

Summary

SPICA/MCS can probe:

- Very early history of stellar-mass assembly @z~7-10, which cannot be achieved with JWST alone.
- Dust formation/evolution history @z~2-5(?), giving precise measurements of fundamental properties
  (also origins of LABs etc.)
- Star formation history & chemical evlution history w/ Hα @z>7...maybe

Complementary to JWST