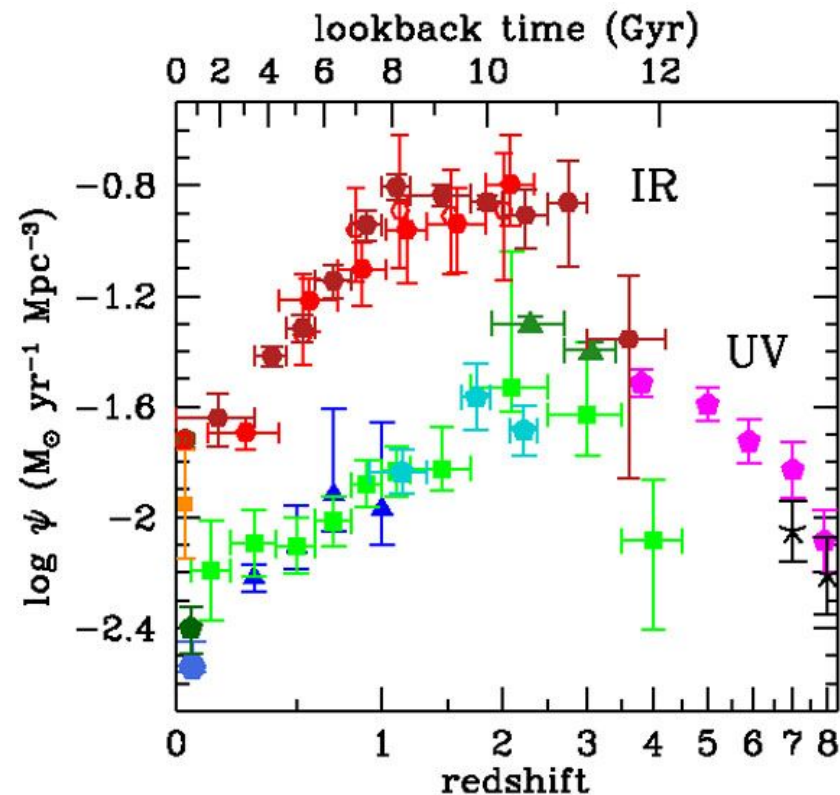
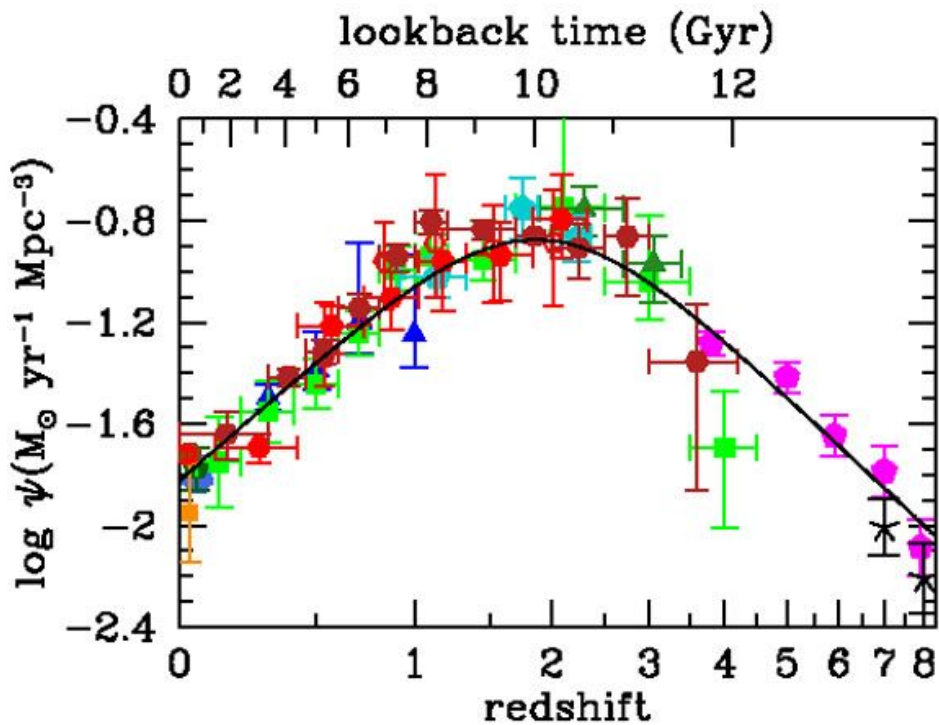


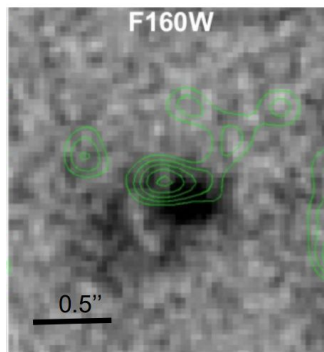
Dust and [CII] in LBGs in the epoch of reionization

*Sander Schouws, Rychard Bouwens, Renske Smit,
Mauro Stefanon and Jacqueline Hodge*

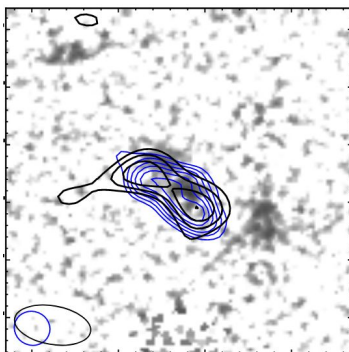
Cosmic star-formation history



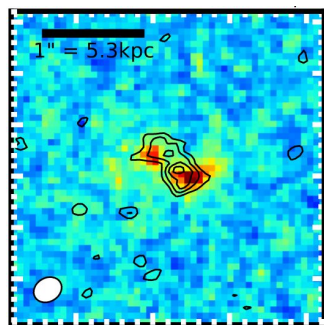
Previous Detections of Dust in LBGs at $z > 6.5$



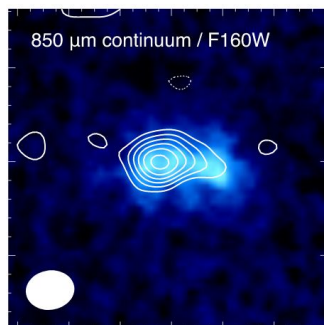
Laporte+17



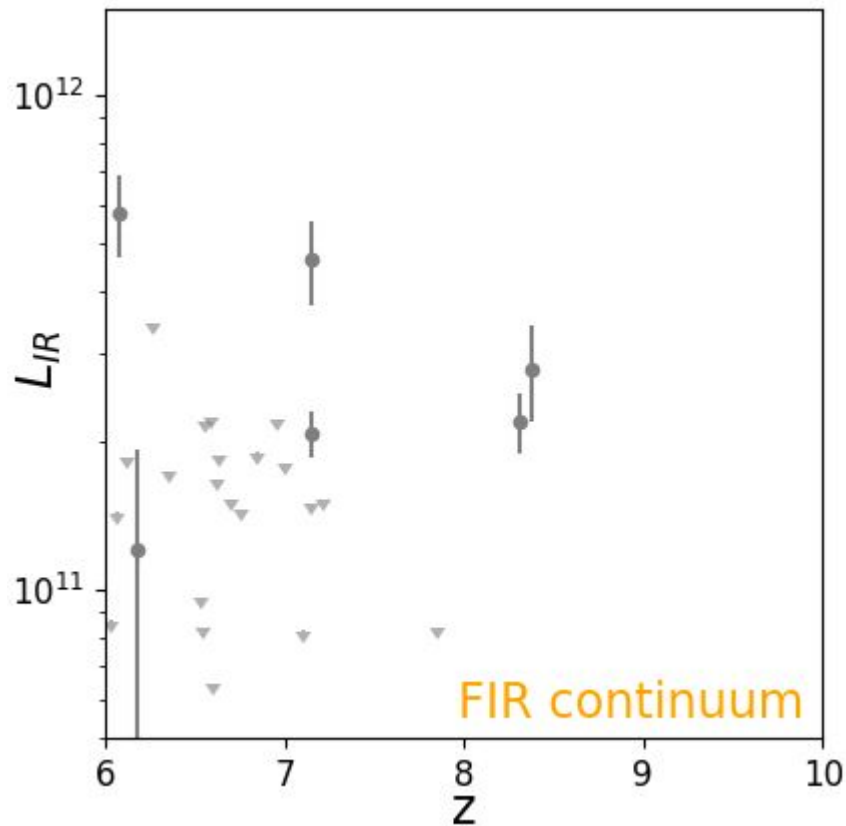
Watson+15, Knudsen+17



Bowler+18
Hashimoto+18

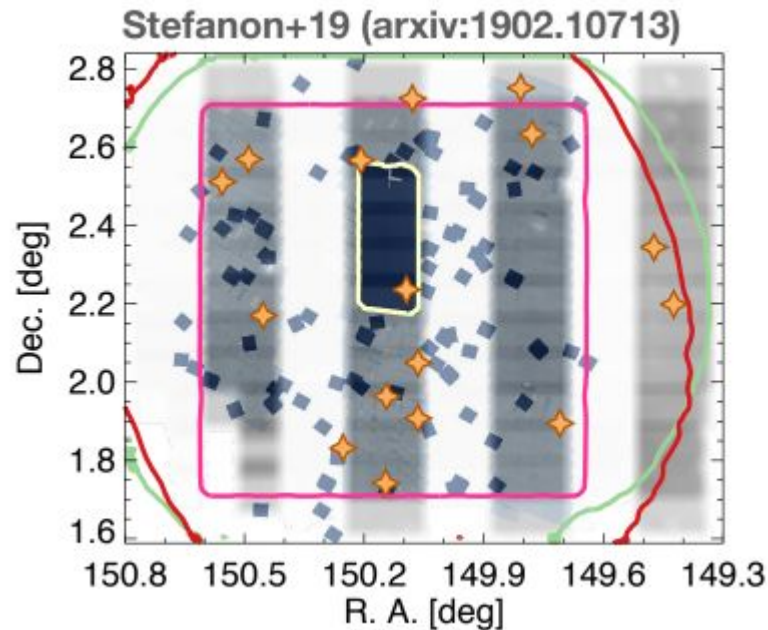


Tamura+18



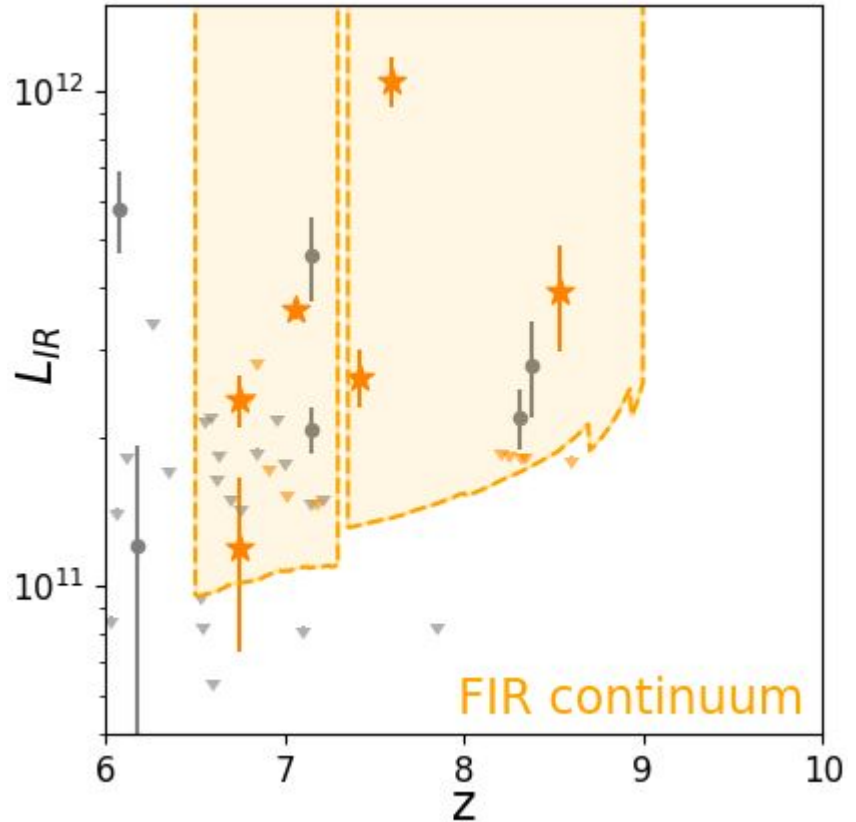
Targets

- 14 Luminous LBGs observed
 - 6 z-dropout at $z \sim 7$
 - 8 Y-dropout at $z \sim 8$



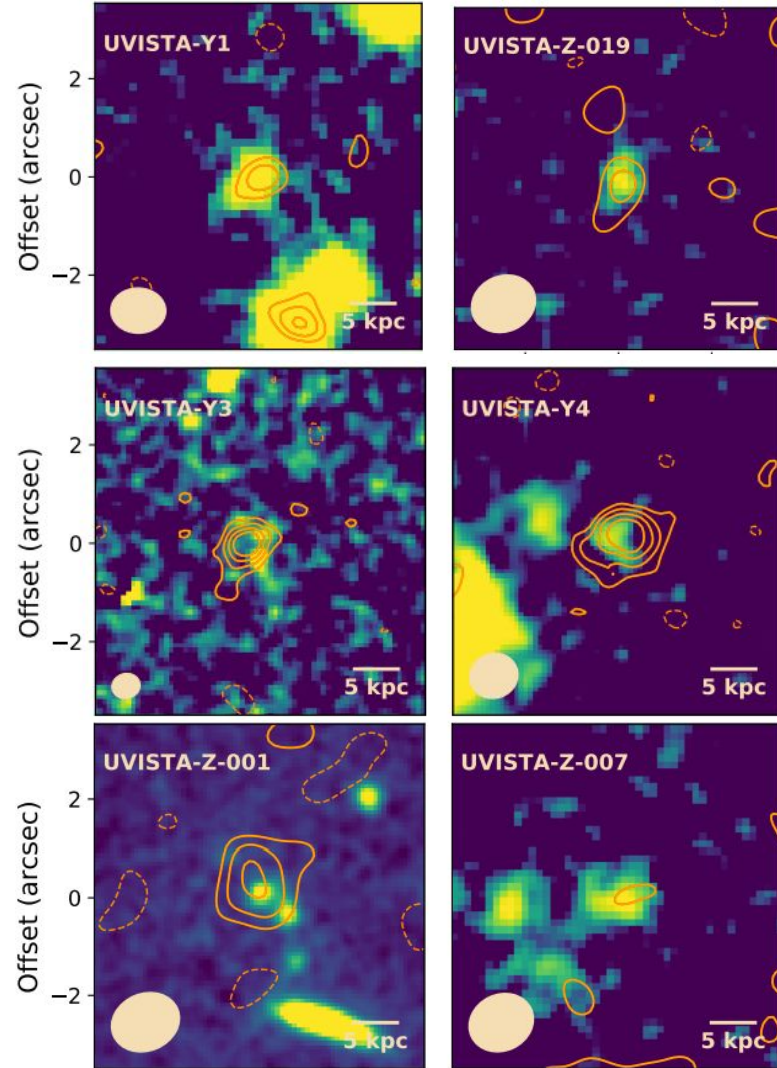
Dust Continuum Detections

- 6/14 Detected: (43%)
 - 3 detected at $z \sim 7$ (also [CII])
 - 3 detected at $z \sim 8$
- $L_{\text{IR}} > 10^{11} L_{\odot} \sim 10^{12} L_{\odot}$
 - (U)LIRG

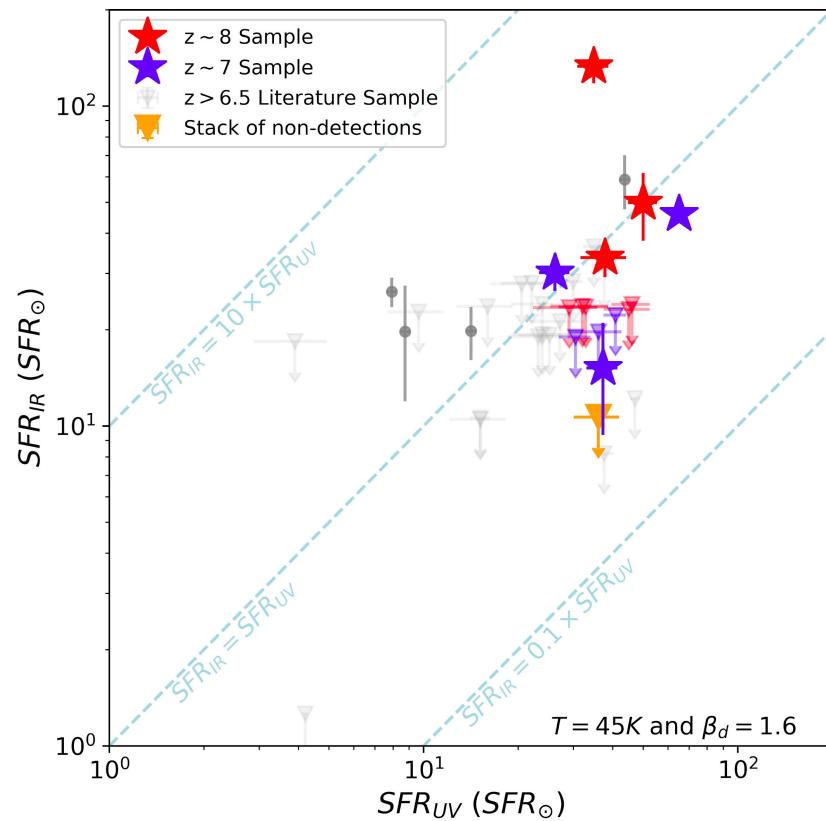


Dust Continuum Detections

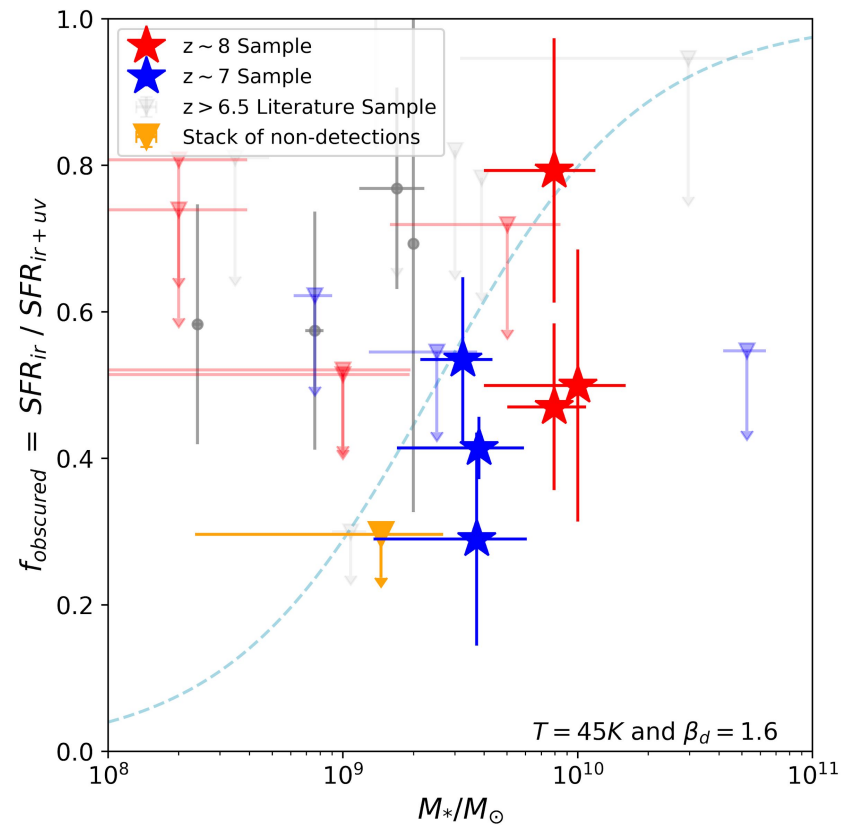
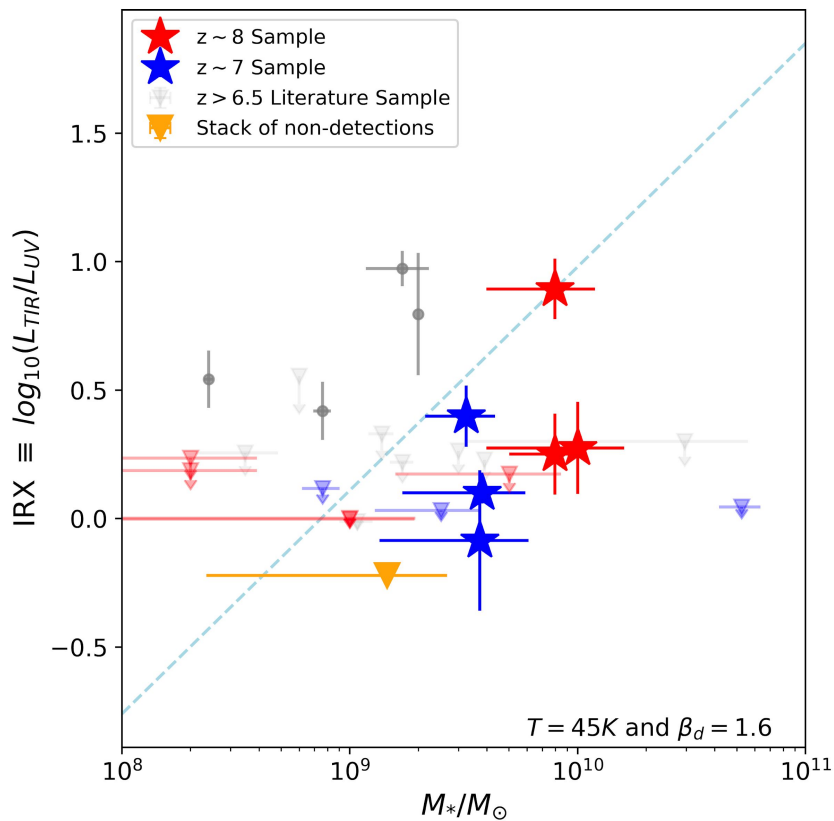
- 6/14 Detected: (43%)
 - 3 detected at $z \sim 7$ (also [CII])
 - 3 detected at $z \sim 8$
- $L_{\text{IR}} > 10^{11} L_{\odot} \sim 10^{12} L_{\odot}$
 - (U)LIRG



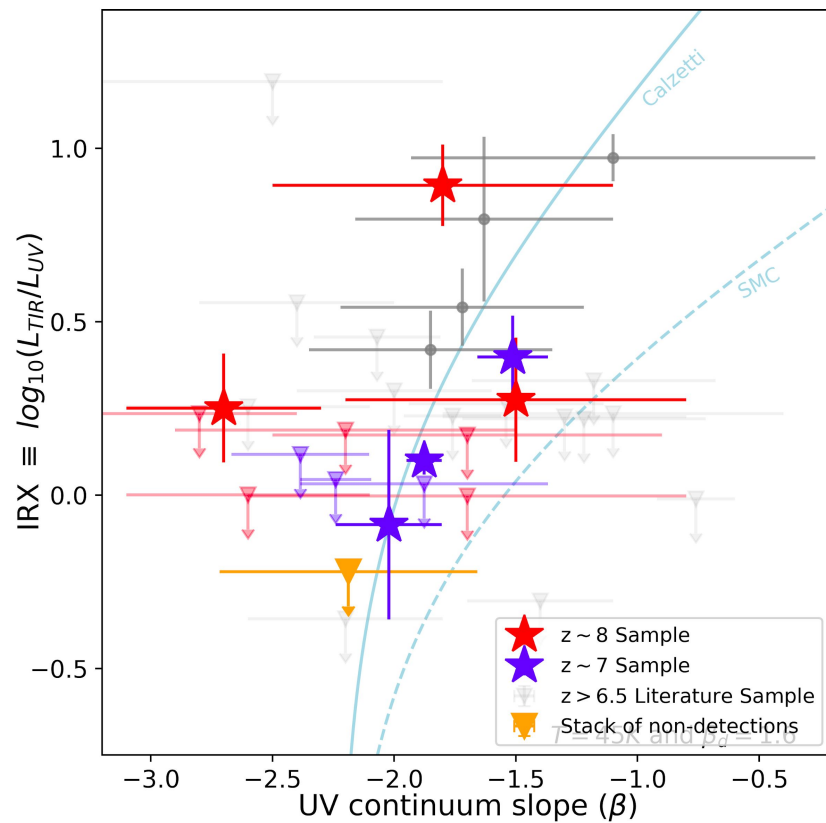
Dust Properties - SFR



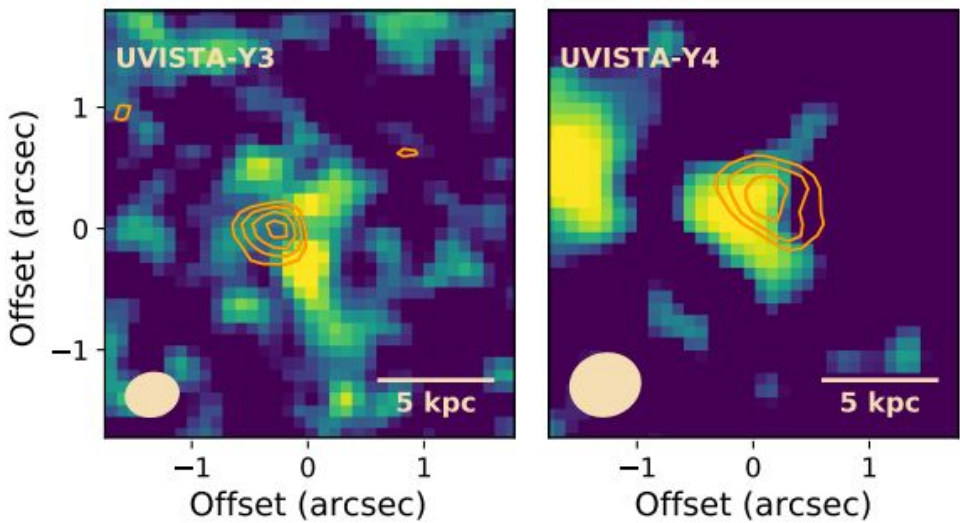
IRX-Stellar Mass relation



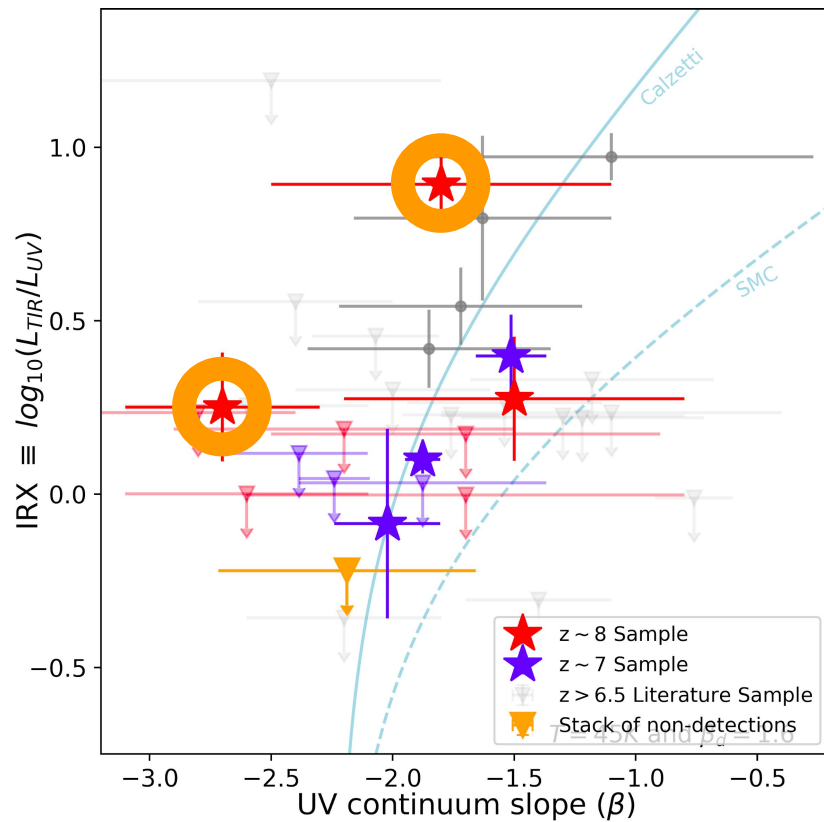
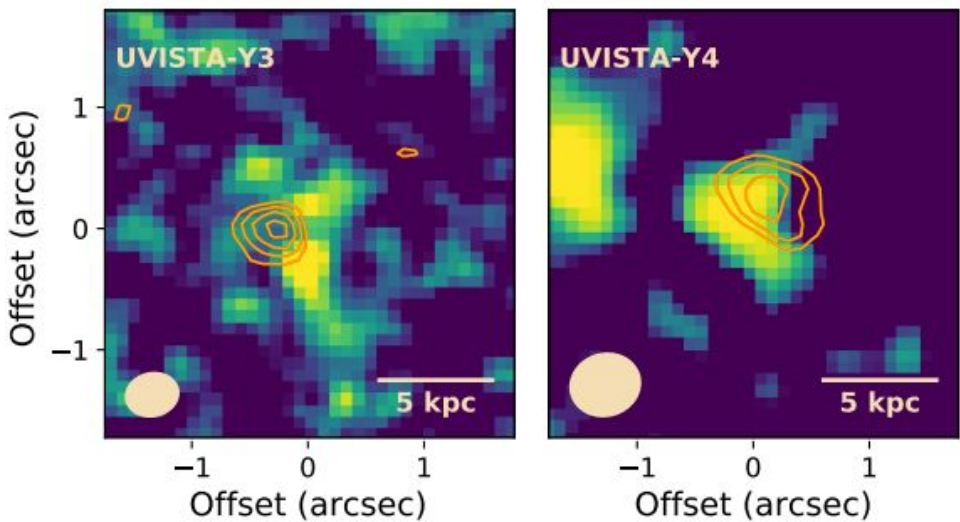
IRX-beta relation



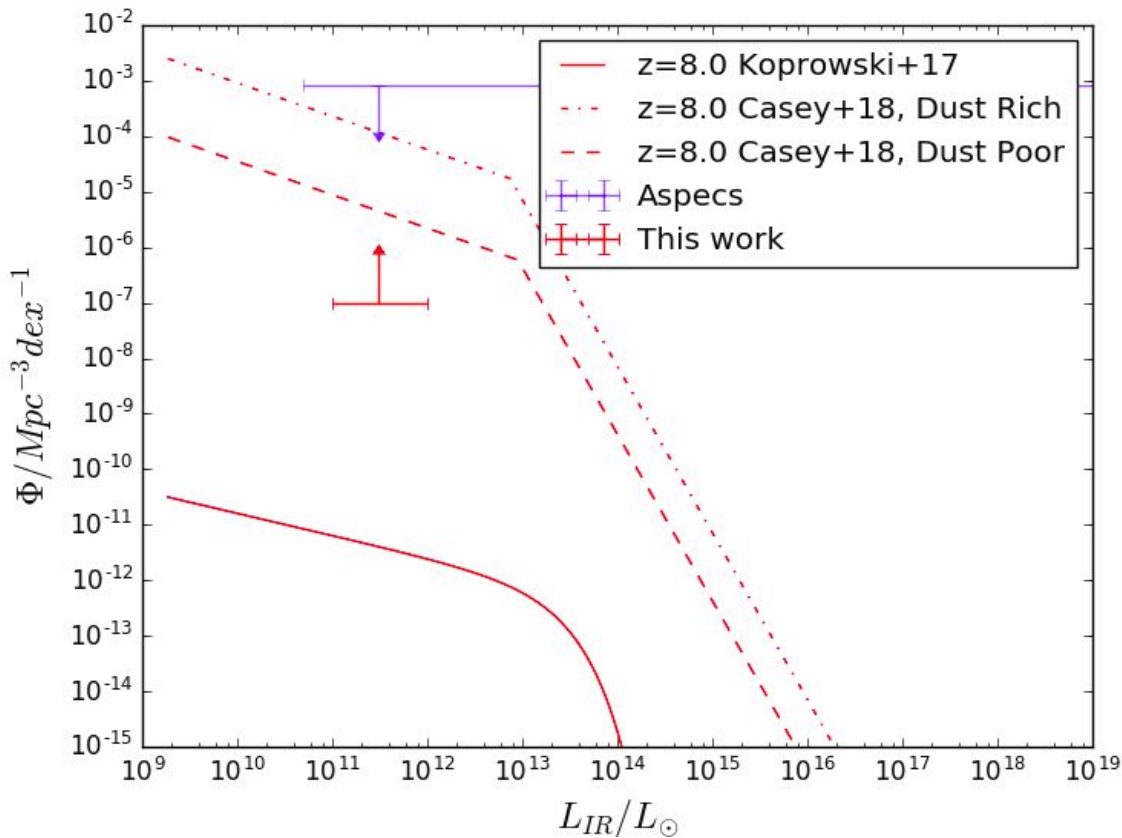
Offset between UV and Dust?



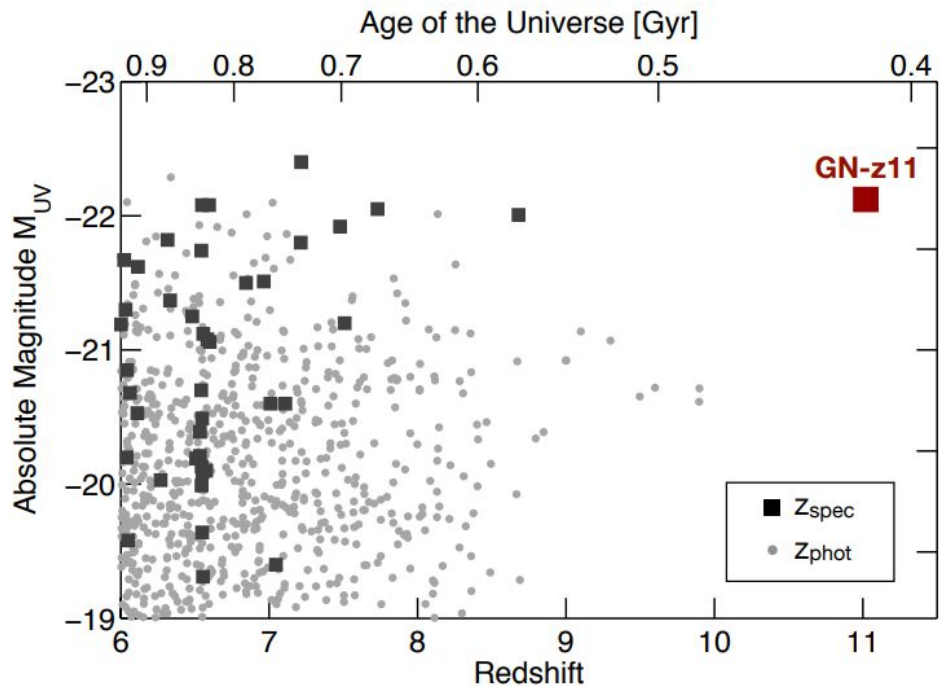
Offset between UV and Dust?



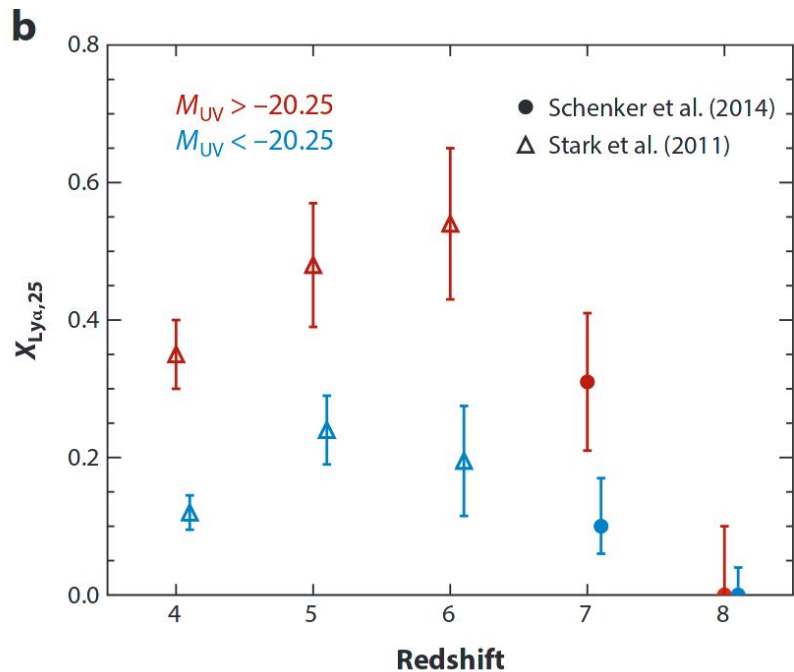
Constraints on the FIR Luminosity Function *(Preliminary)*



[CII] - ALMA as 'redshift machine'

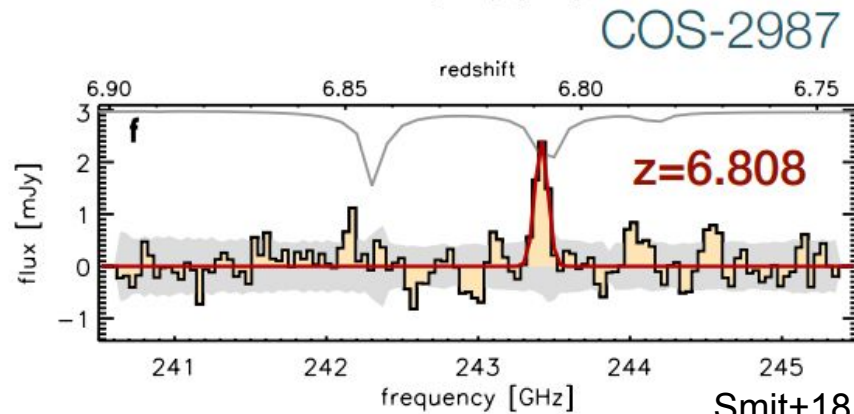
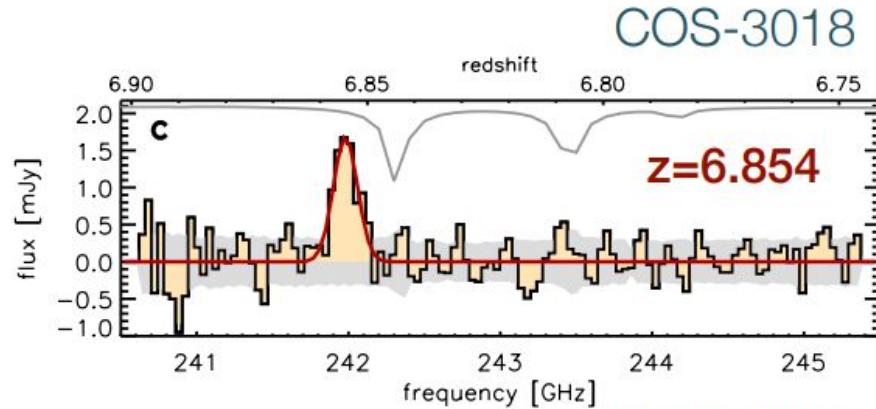


Oesch+16



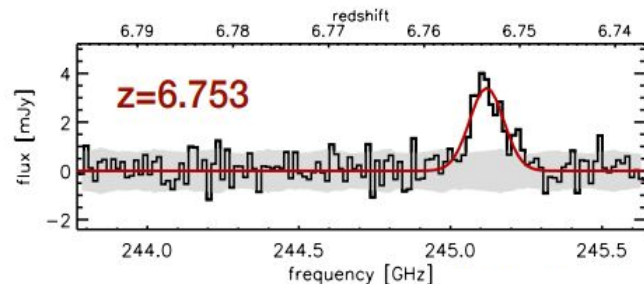
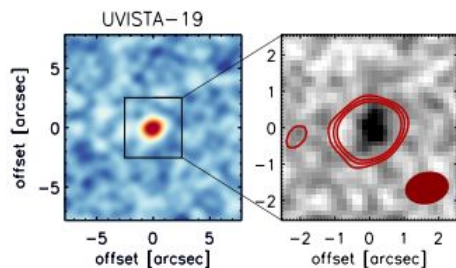
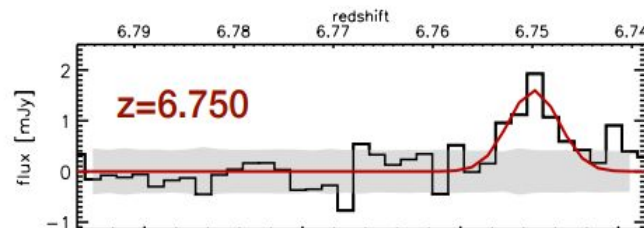
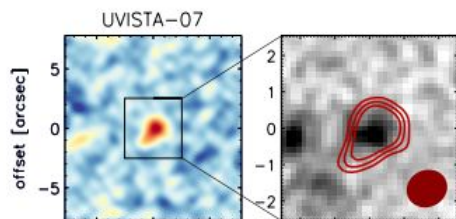
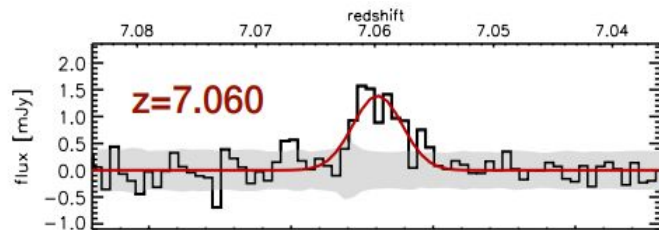
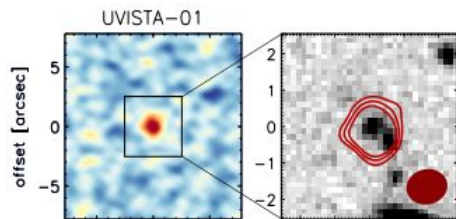
Stark, 2016, ARAA, 54, p761

[CII] - ALMA as 'redshift machine'

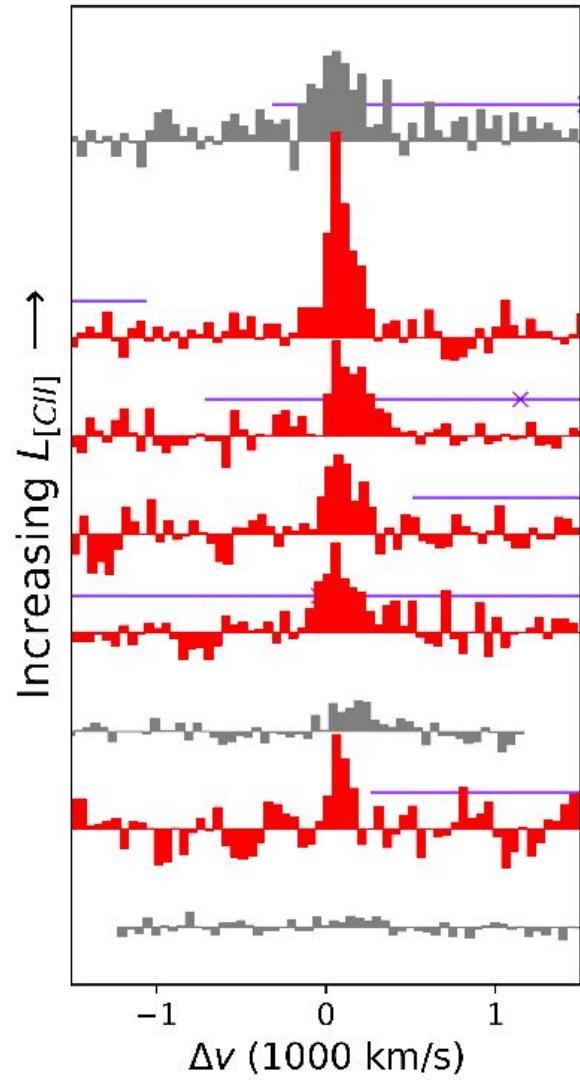
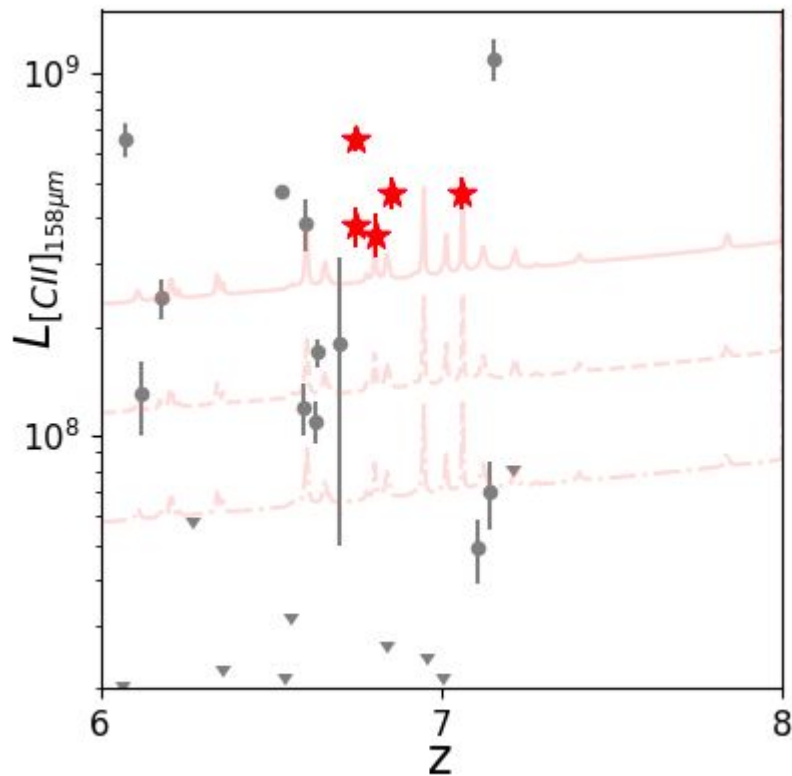


[CII] - Results

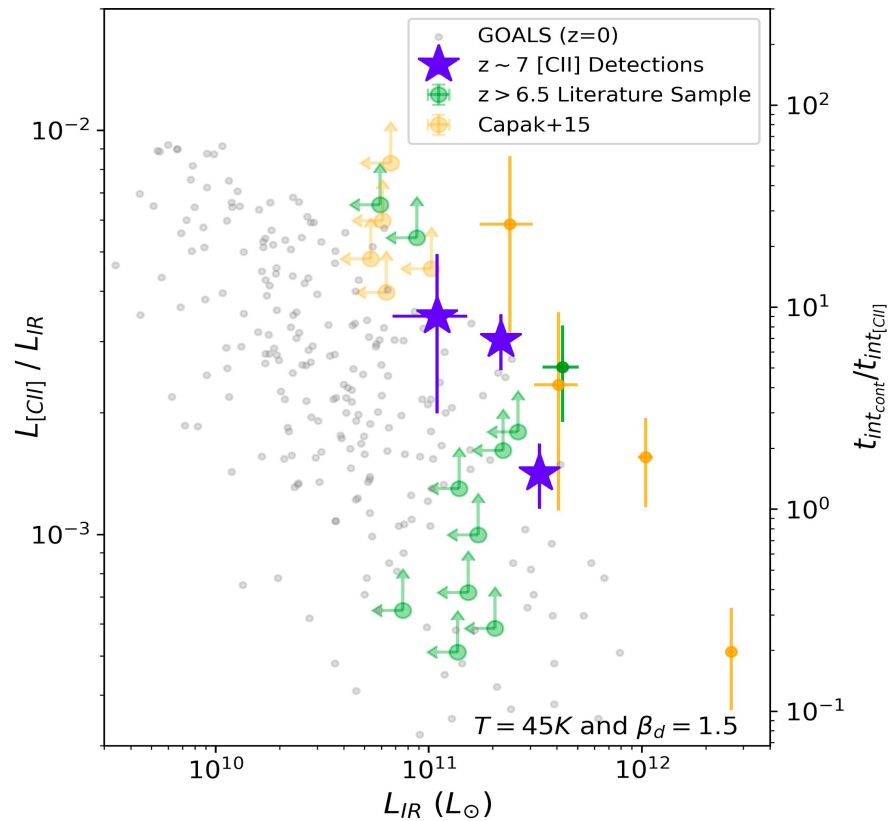
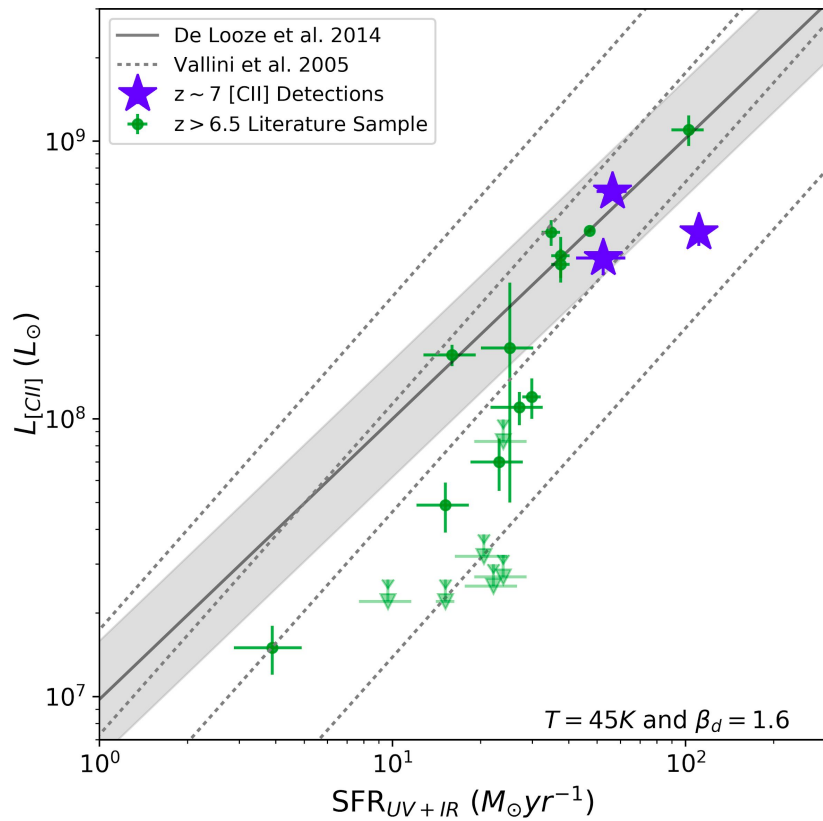
- 3 New Detections
- >8 S/N [CII]
- Also dust continuum
- 5/8 confirmed
 - 63% rate



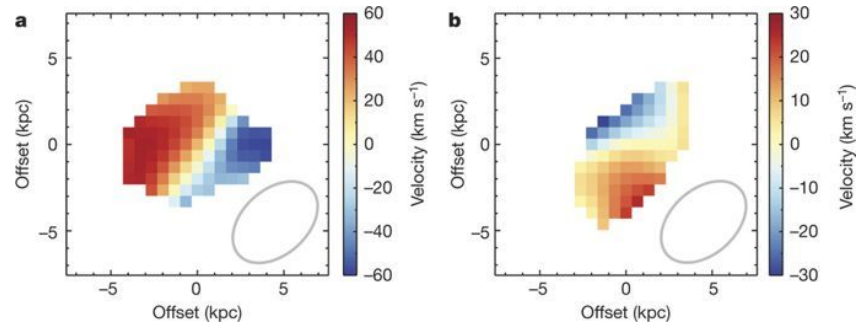
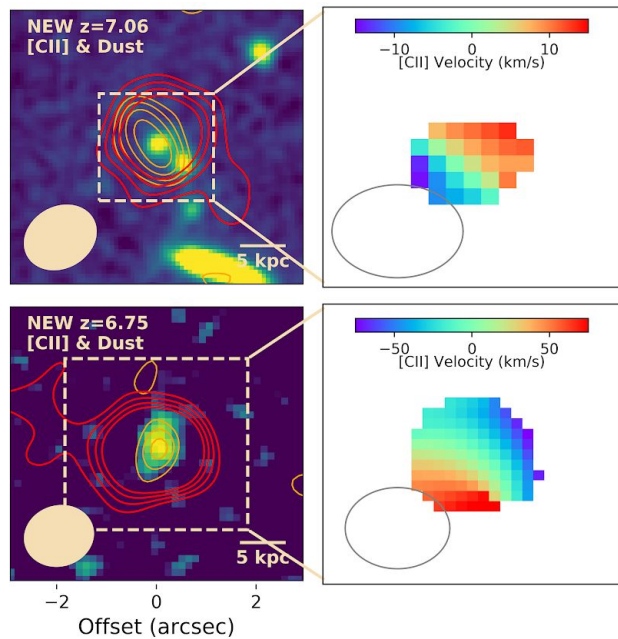
[CII] - Results



[CII] - Deficit

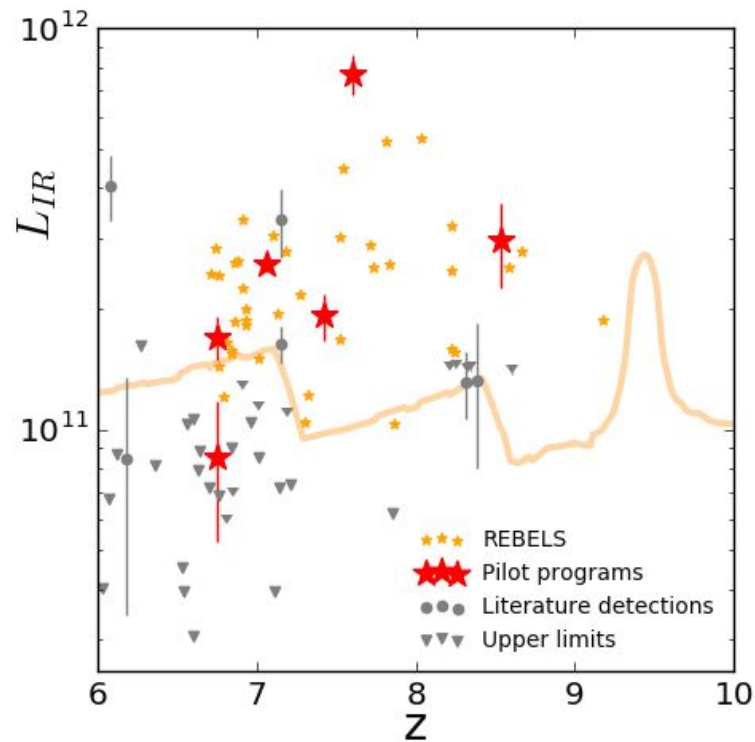
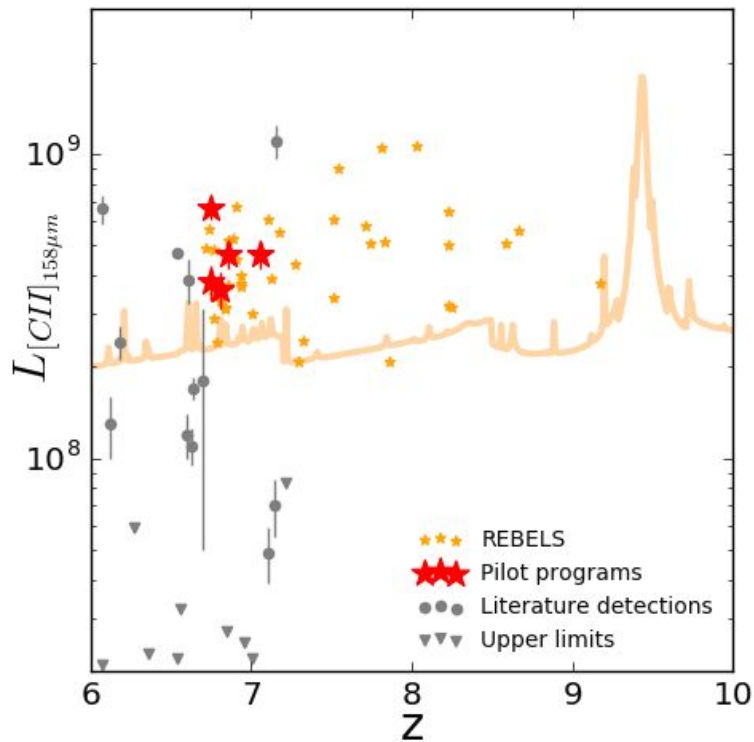
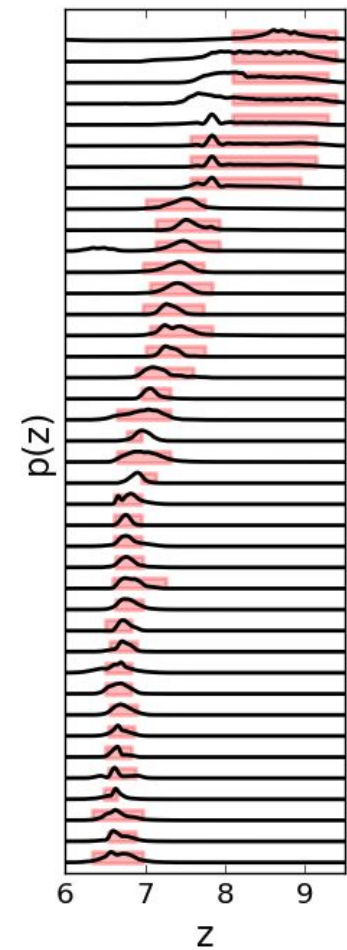


Rotation?



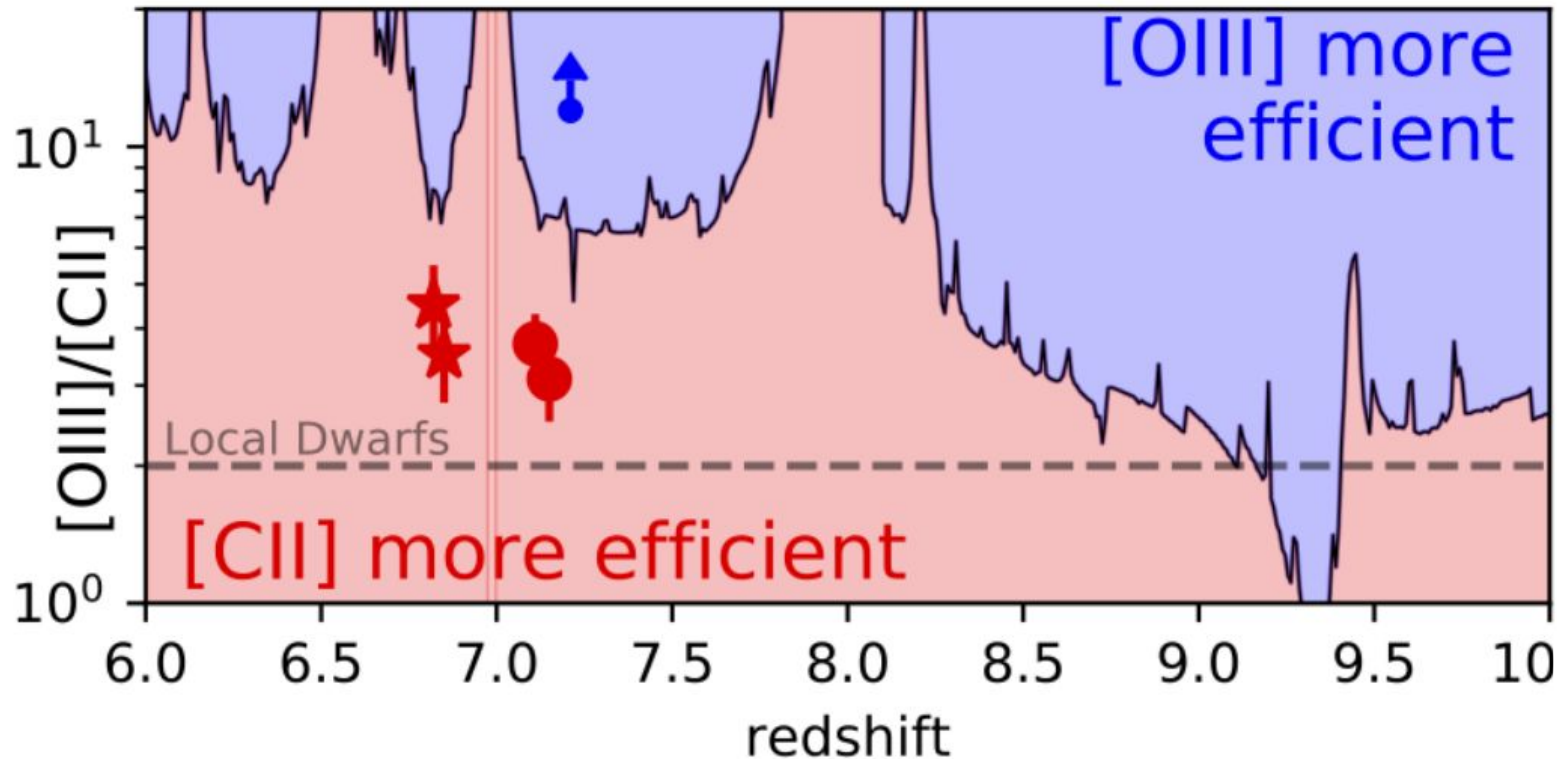
Smit+18, Nature

REBELS

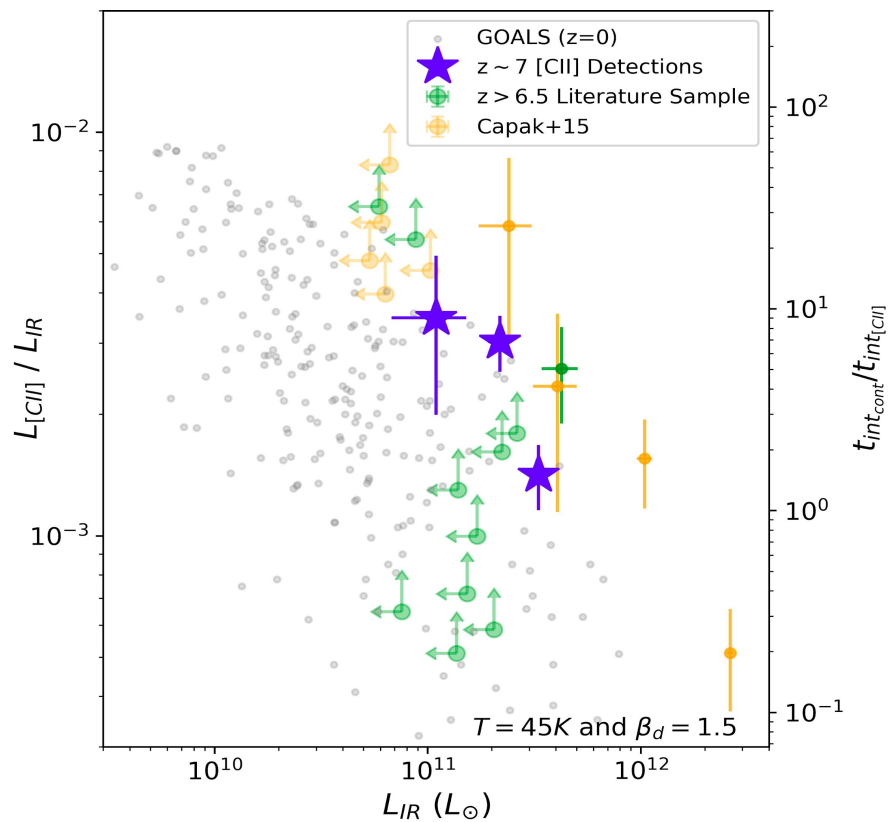




Scanning Strategy



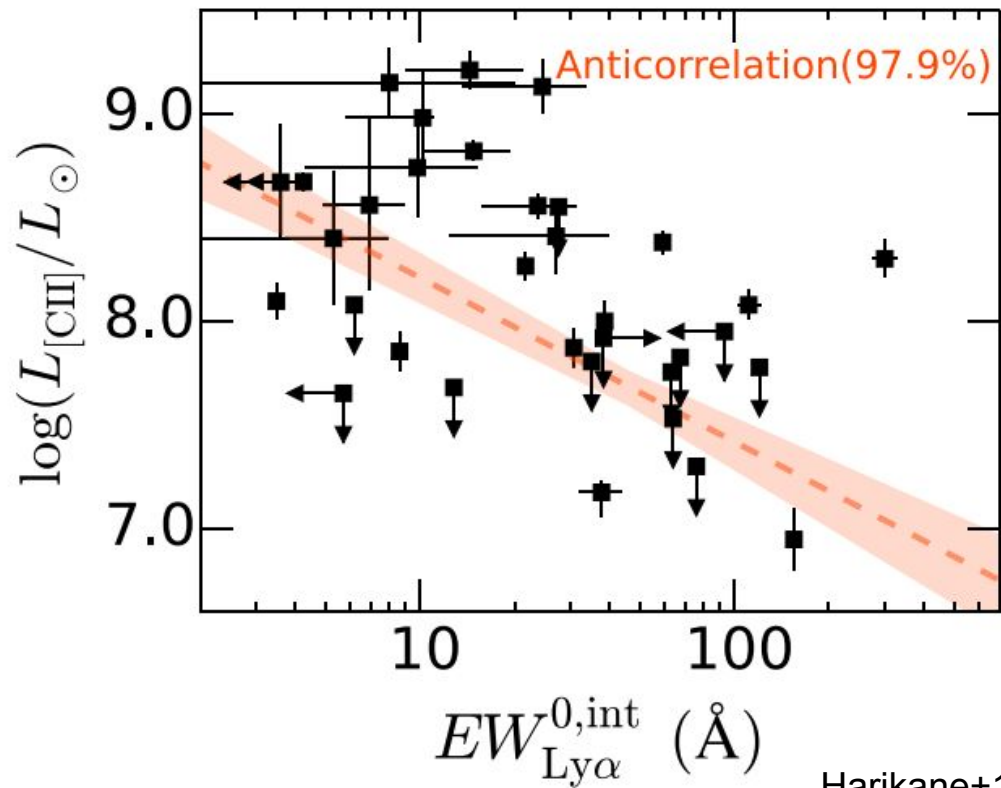
Scanning Strategy



Conclusions

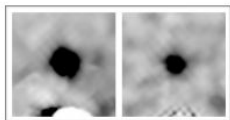
- Consistently Detect Luminous **Dust** and **[CII]** in LBGs in the Epoch of Reionization
- **Dust properties:**
 - $SFR_{UV} \approx SFR_{IR}$
 - IRX-beta -> Calzetti?
 - IRX- M_{Star} -> Dust poor?
 - Offsets...
- **[CII] properties:**
 - Luminous Lines
 - [CII] deficit
 - Possible Rotation?
- Exciting new observations in the near future from REBELS

[CII] - ALMA as 'redshift machine'

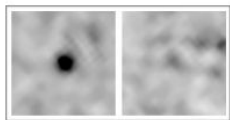


[CII] - ALMA as 'redshift machine'

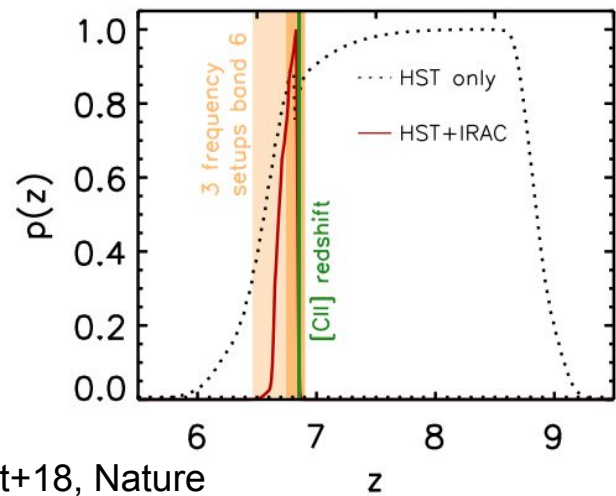
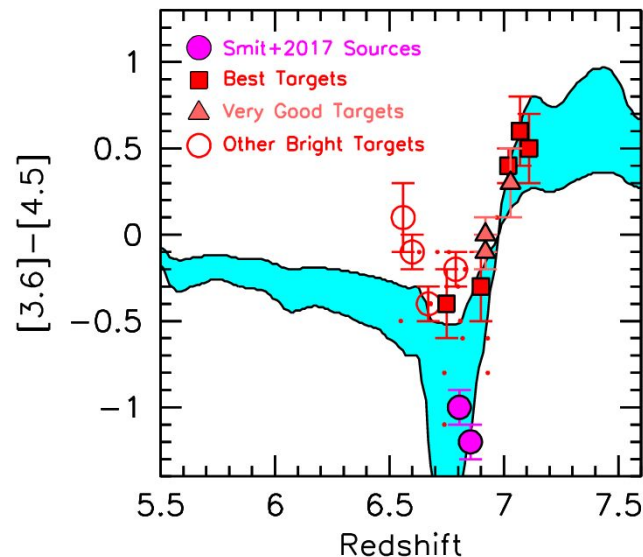
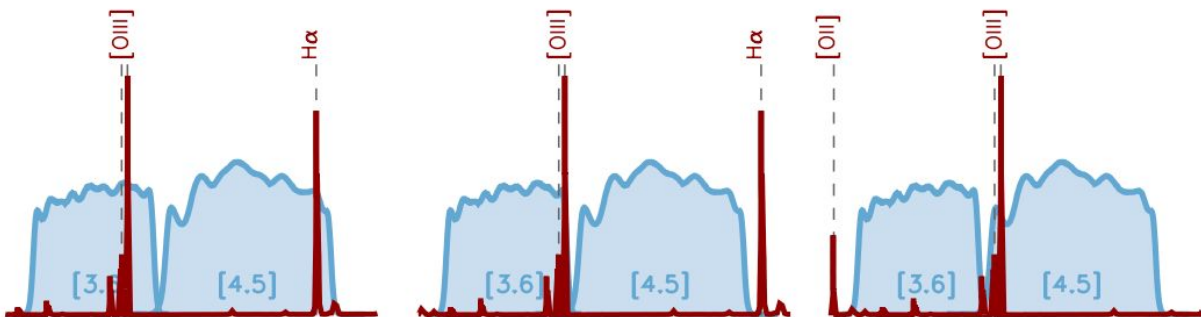
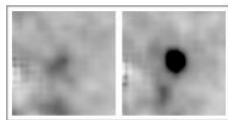
$z \sim 6.5$



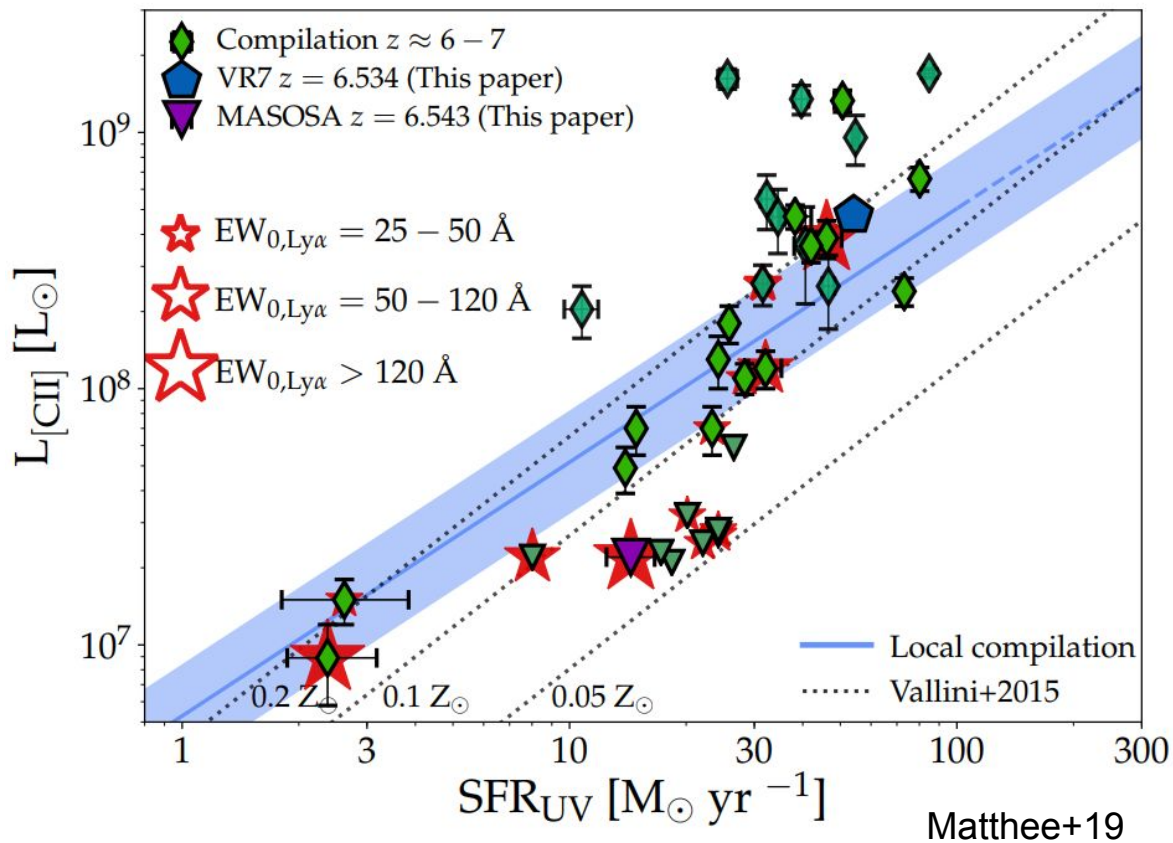
$z \sim 6.8$



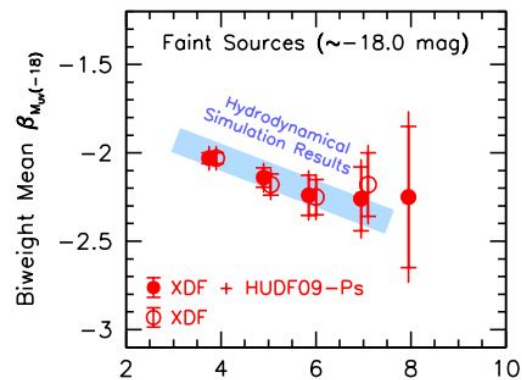
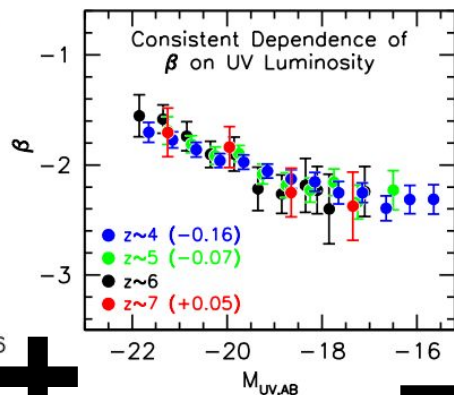
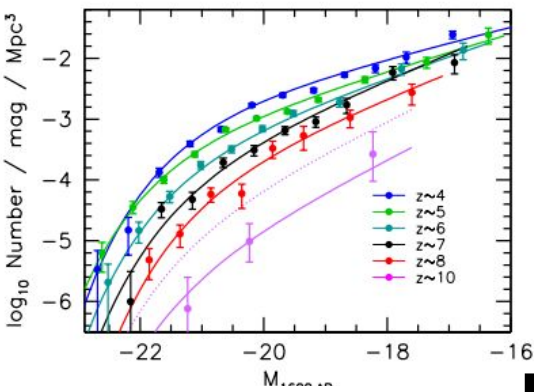
$z \sim 7.1$



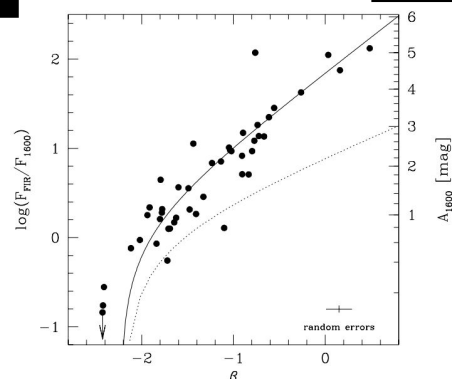
[CII] - ALMA as 'redshift machine'



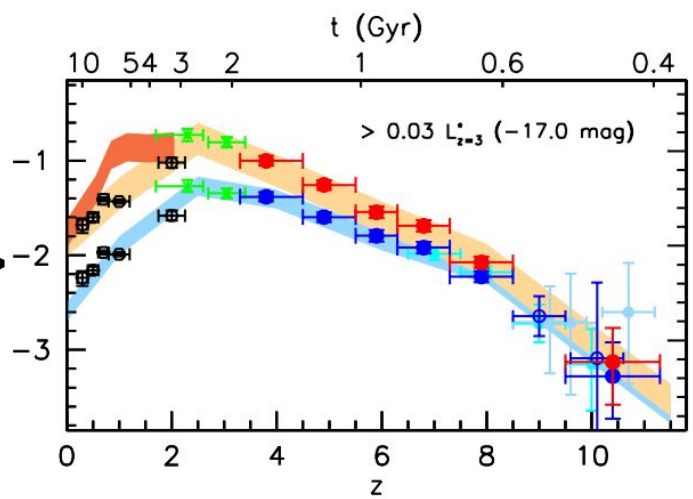
Cosmic star-formation history



+



\rightarrow $\log \rho_{SFR} (\text{Mpc}^{-3})$

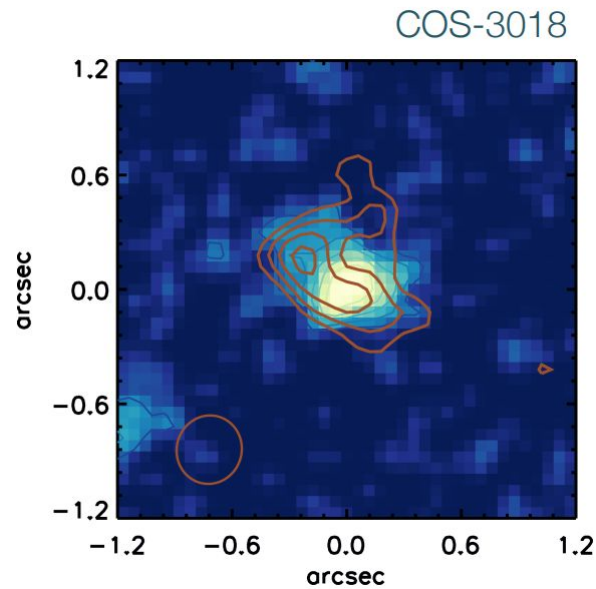
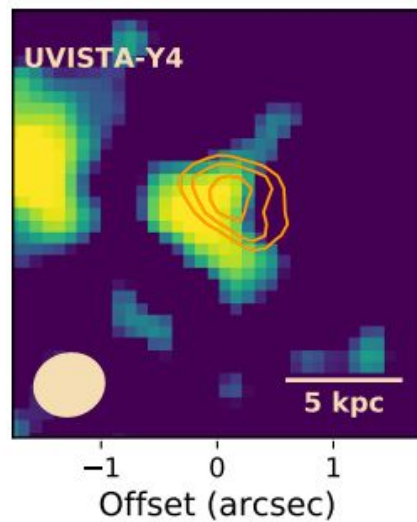
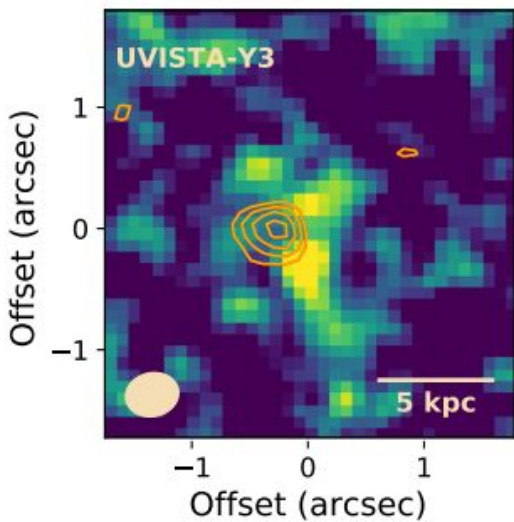


Bouwens+14a

Meurer+99

Bouwens+14b

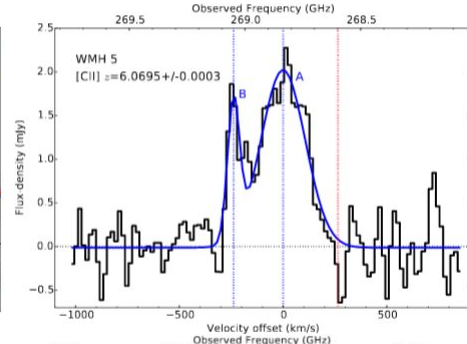
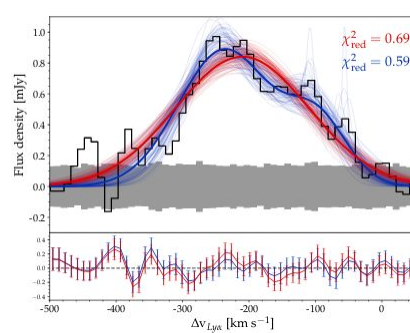
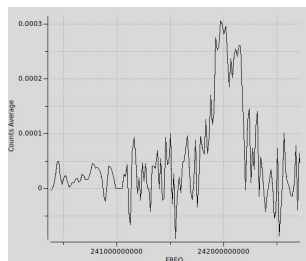
Offset between UV and Dust?



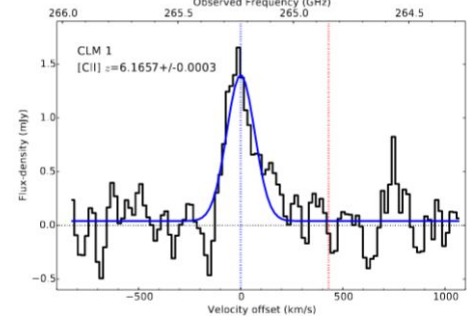
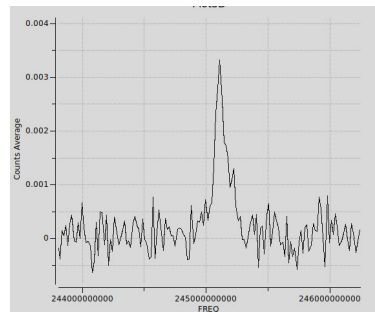
Smit et al. in prep

[CII] absorption?

1. Line profiles
 - Degenerate with kinematics



2. [OIII]/[CII] ~ 1 in simulations but ~3-5 in observations



3. FWHM [OIII] > FWHM [CII]

Problem... $1 \tau = 1.2 * 10^{21}$ hydrogen column density

