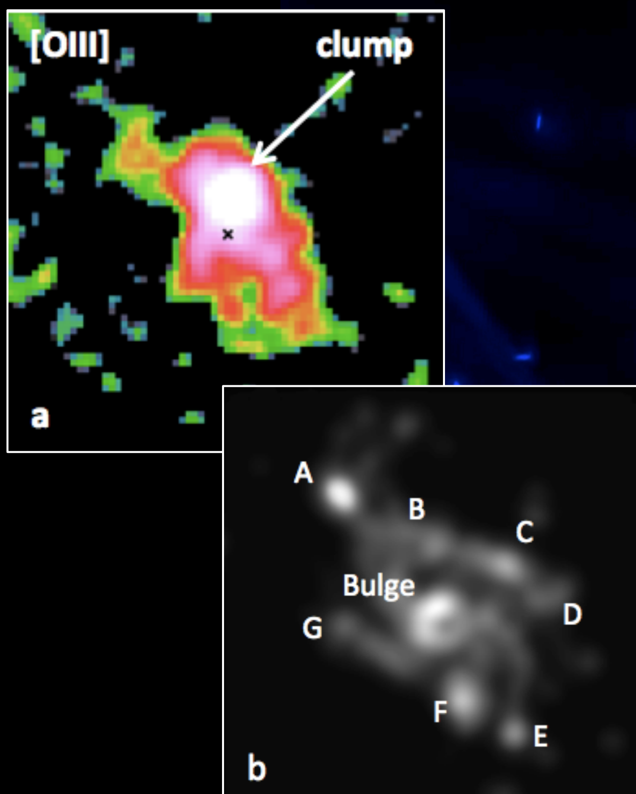
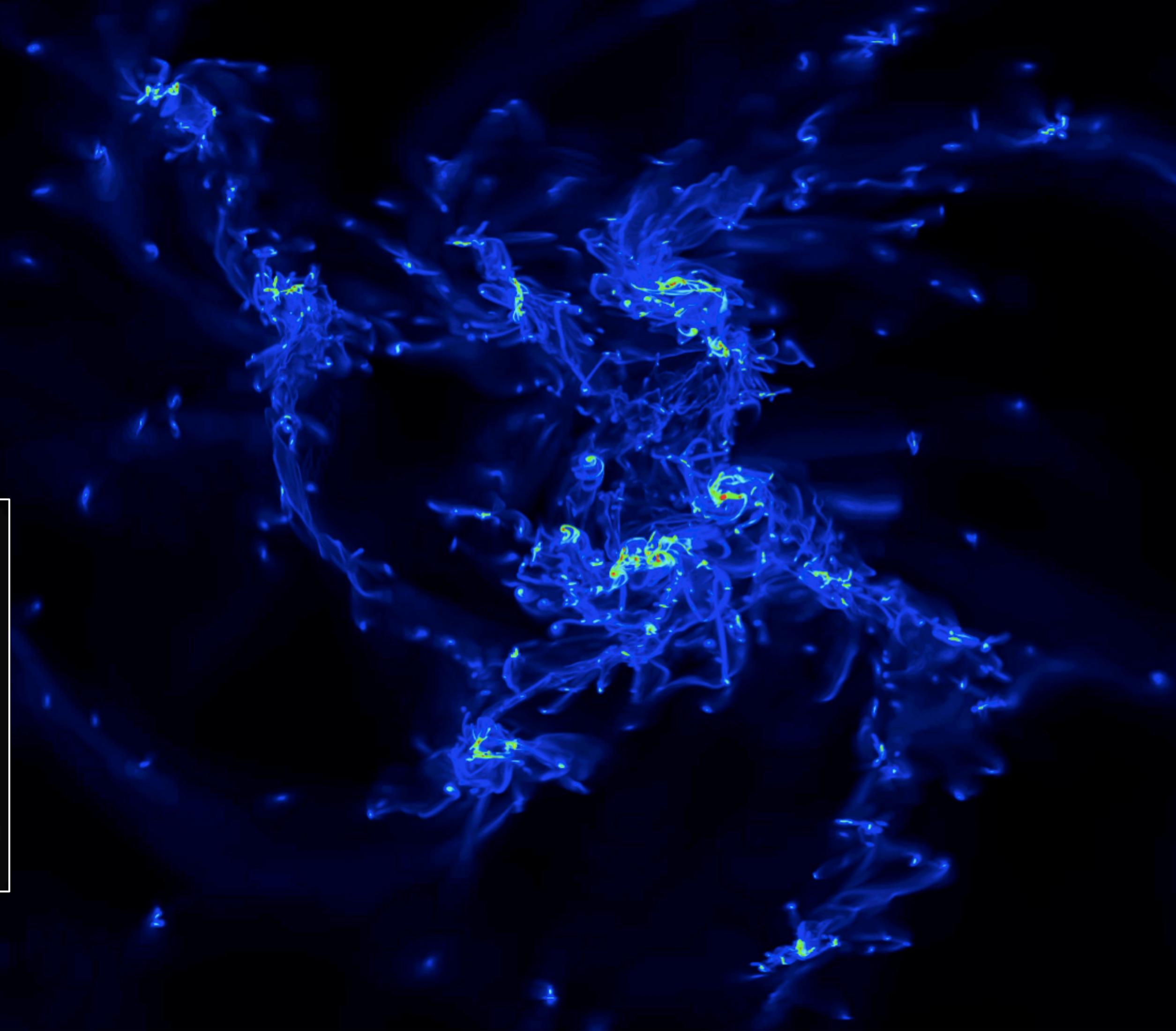
Pending issues in galaxy formation: where SVOM GRBs will help…

Emeric Le Floc'h, CEA





COAST / *Zanella et al.*

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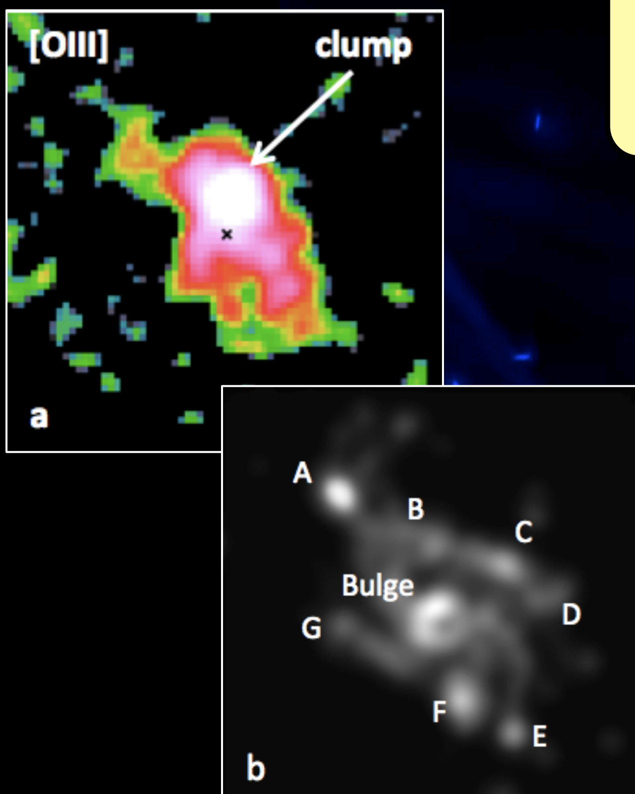
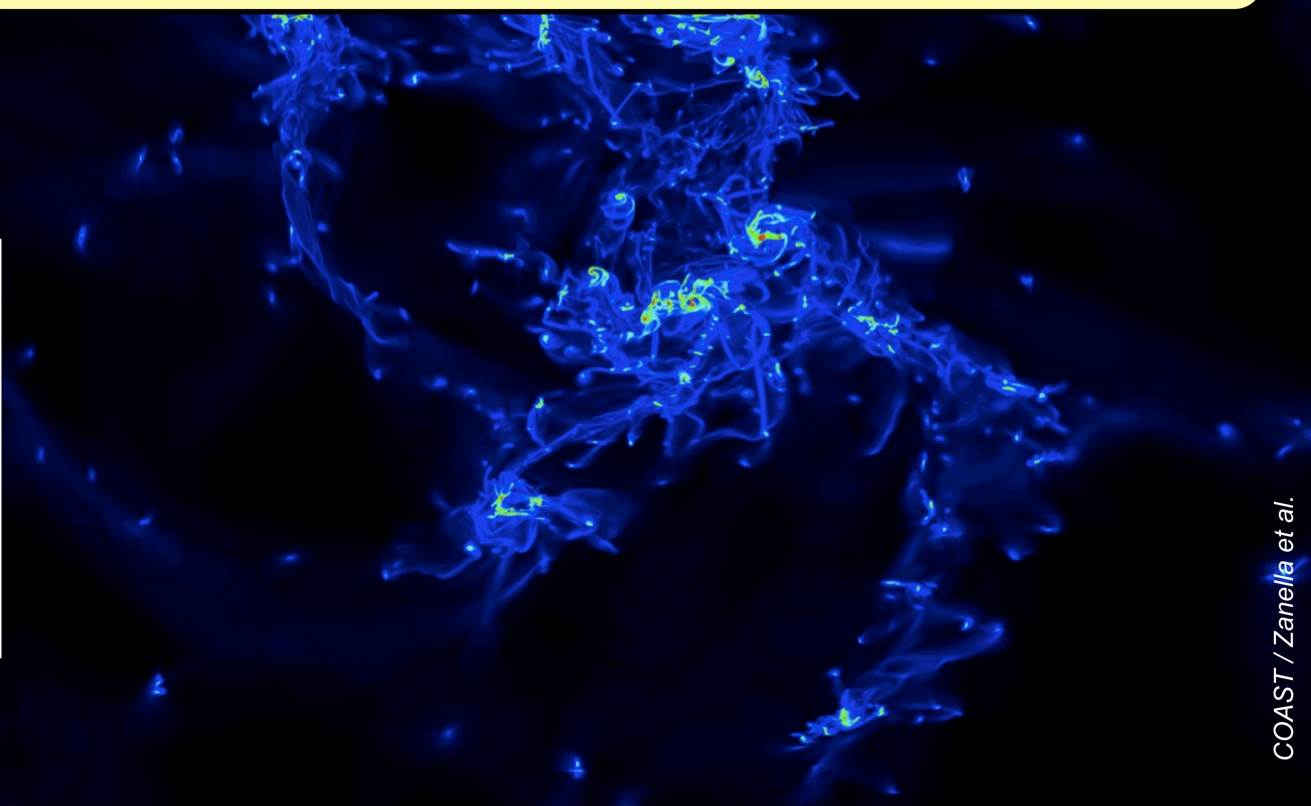
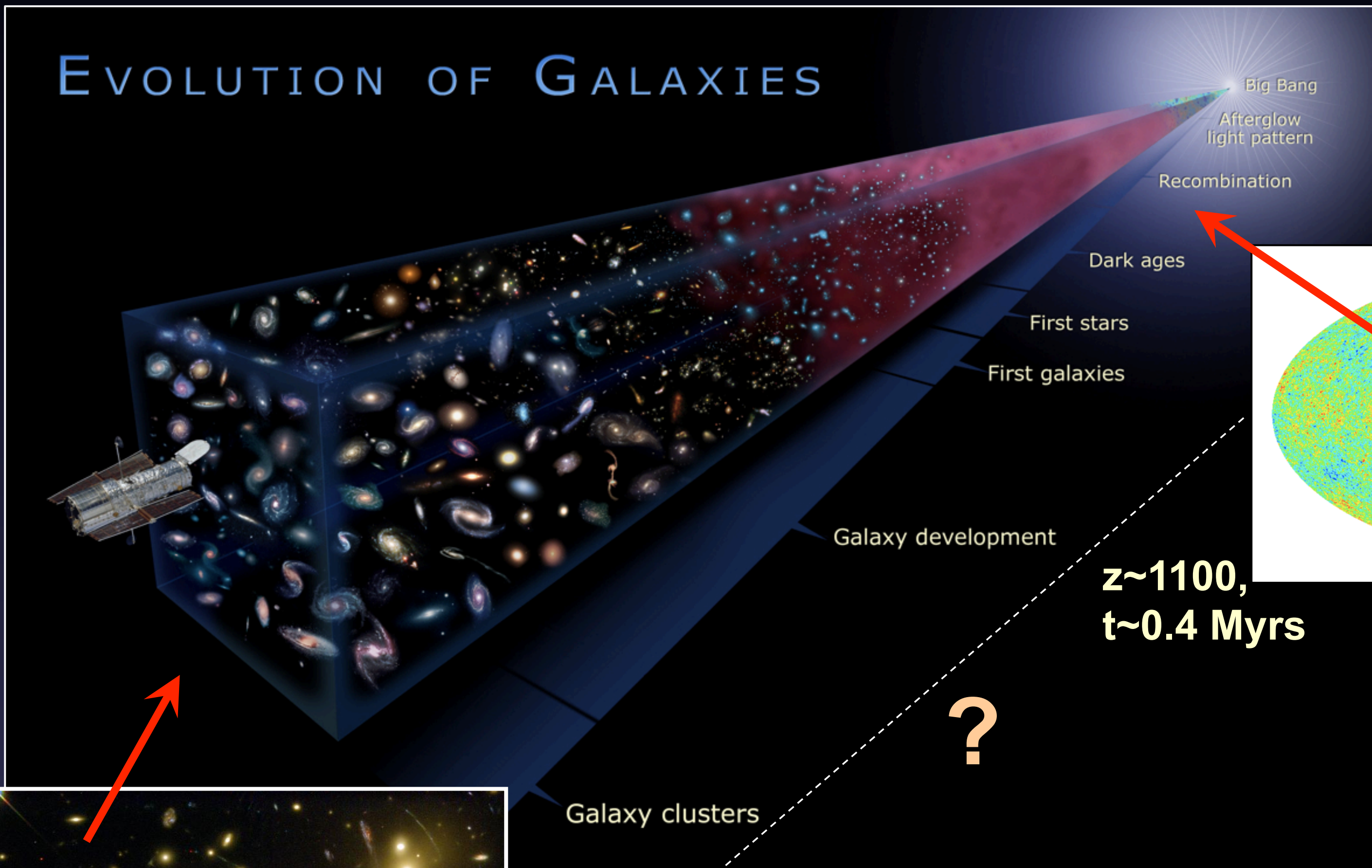
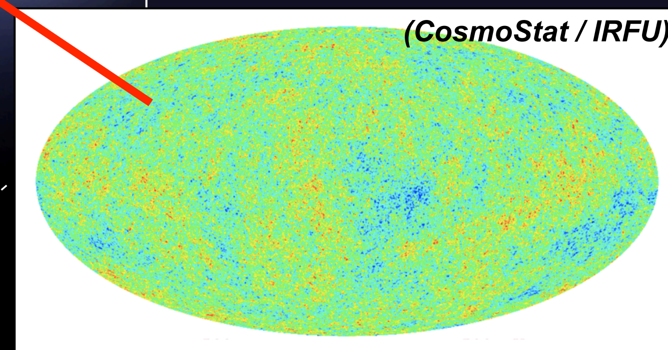
Galaxy studies to constrain GRBs / progenitors





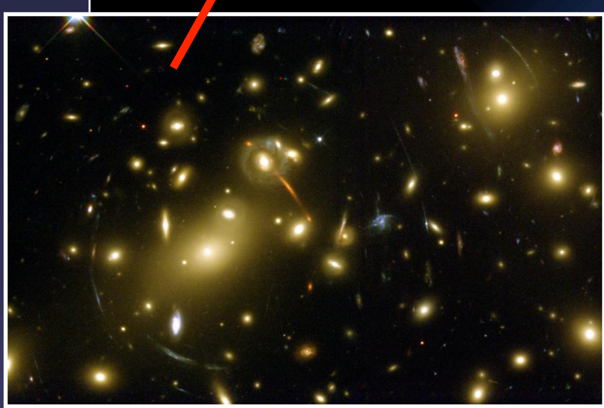
Cosmic growth of structures




(CosmoStat / IRFU)

z~1100, t~0.4 Myrs

?

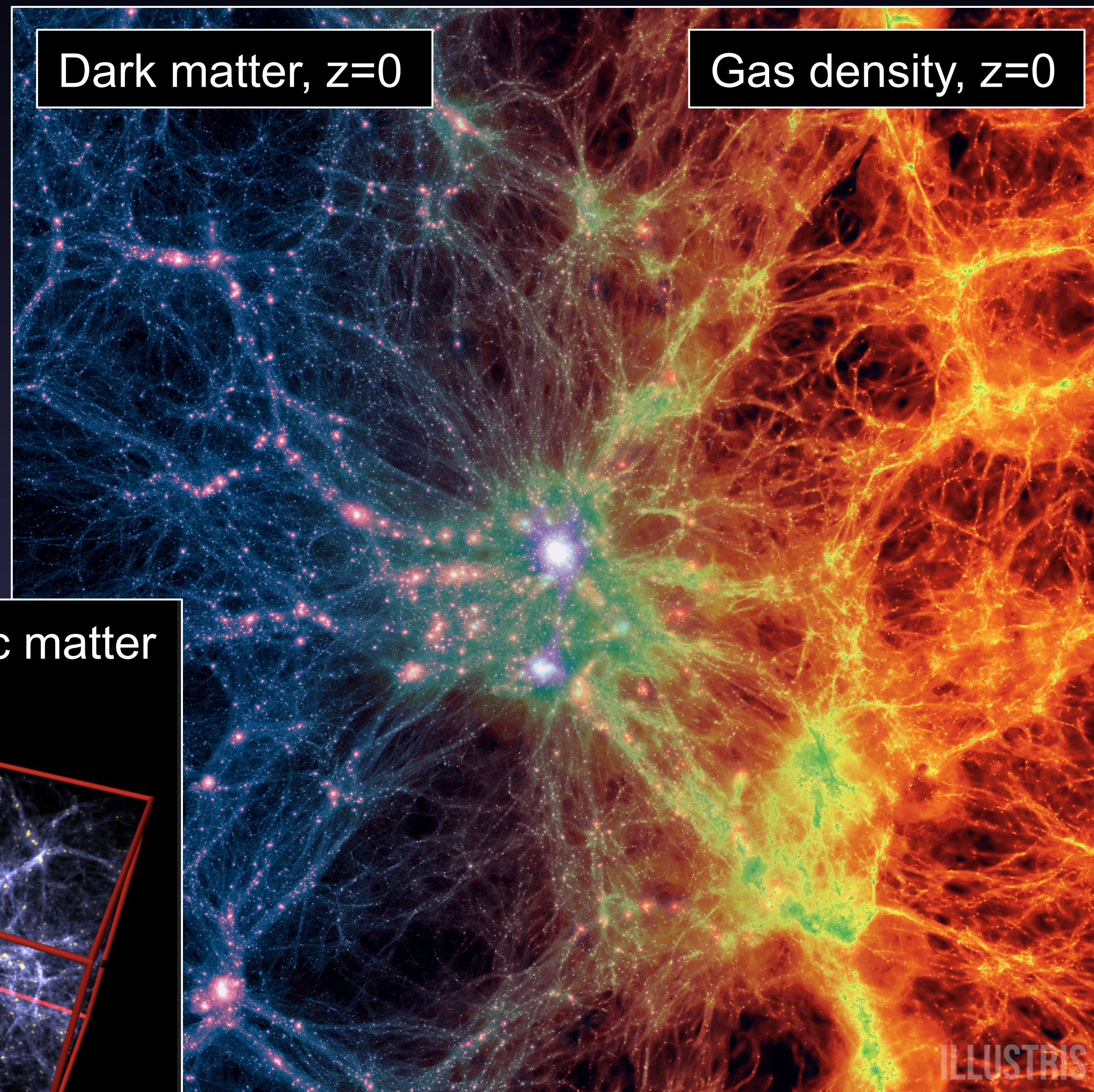

(Cr. STScI)

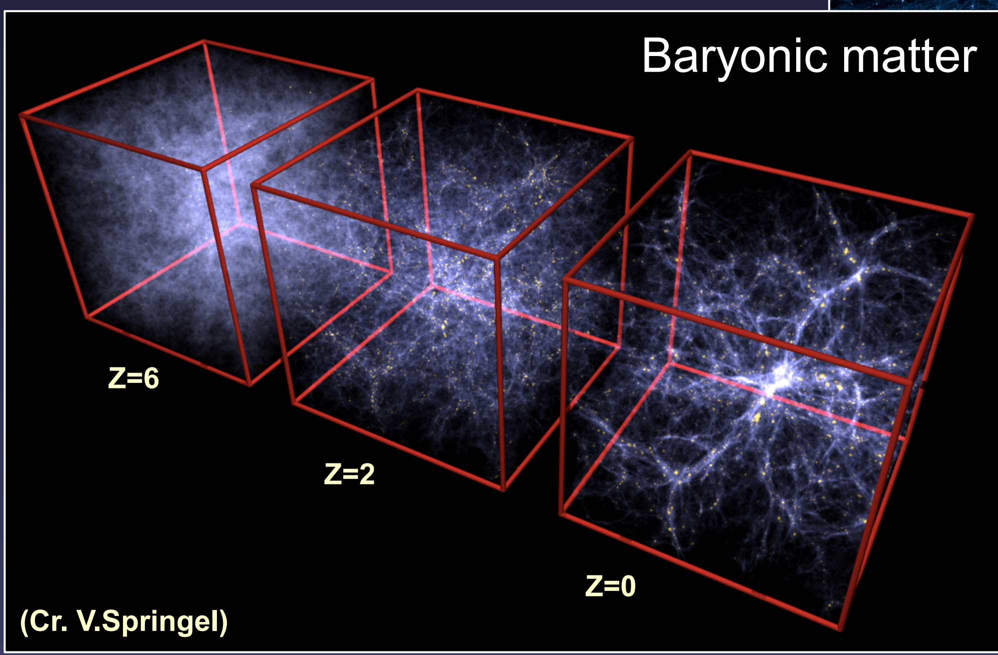
z=0, t~13.7 Gyrs

An astonishing structuration of baryonic matter over ~14 Gyrs

The hierarchical paradigm of ΛCDM

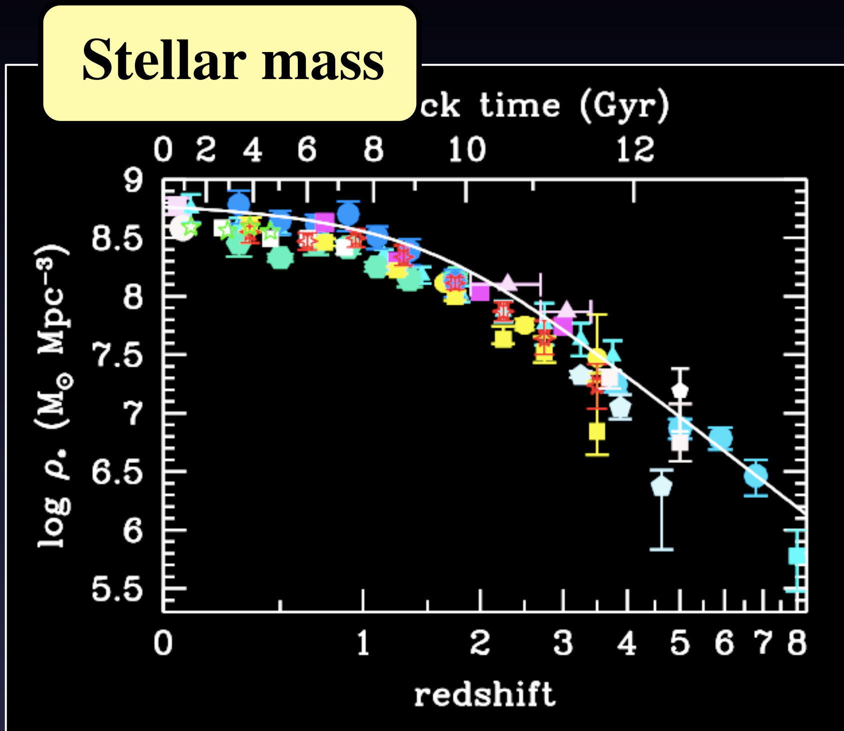
- Dark matter haloes grow by hierarchical merging
- The growth of the baryonic component is induced by gravity

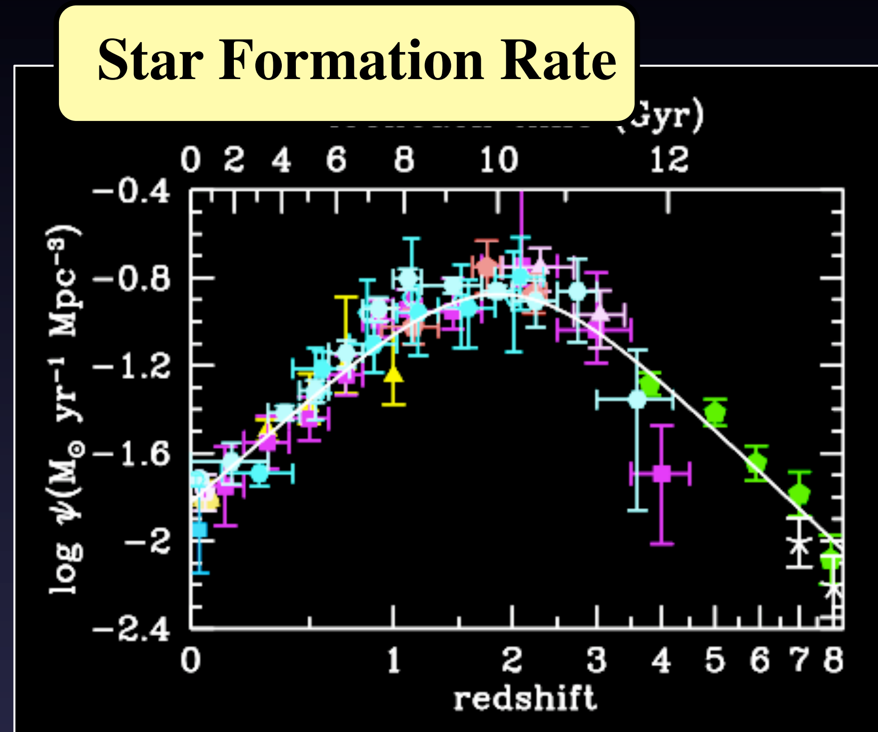




e.g., the 'Illustris' (Vogelsberger+14)

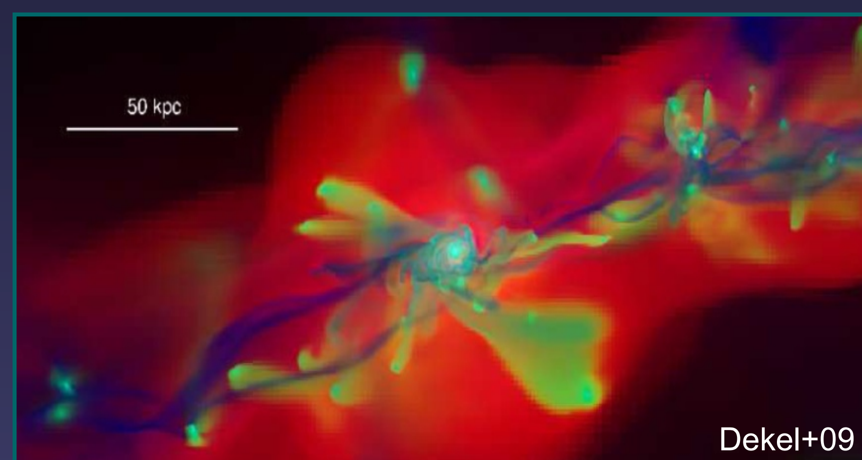
Building-up the stellar mass budget





(Madau & Dickinson 2014)

Stellar mass growth mostly driven by internal processes (secular gas consumption, Violent Disk Instabilities, …)

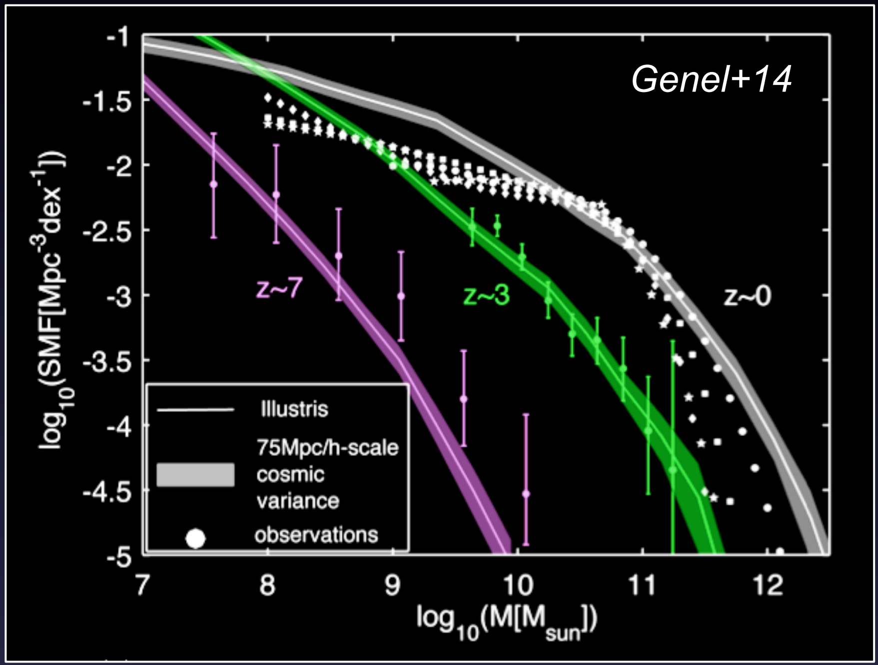


A minor contribution from externally-triggered processes (merging), at least up to z~4

Galaxy formation: some open questions

Our understanding of galaxy formation still fails at scales dominated by the baryonic physics

The first Billion years of cosmic evolution still lacks robust observational constraints



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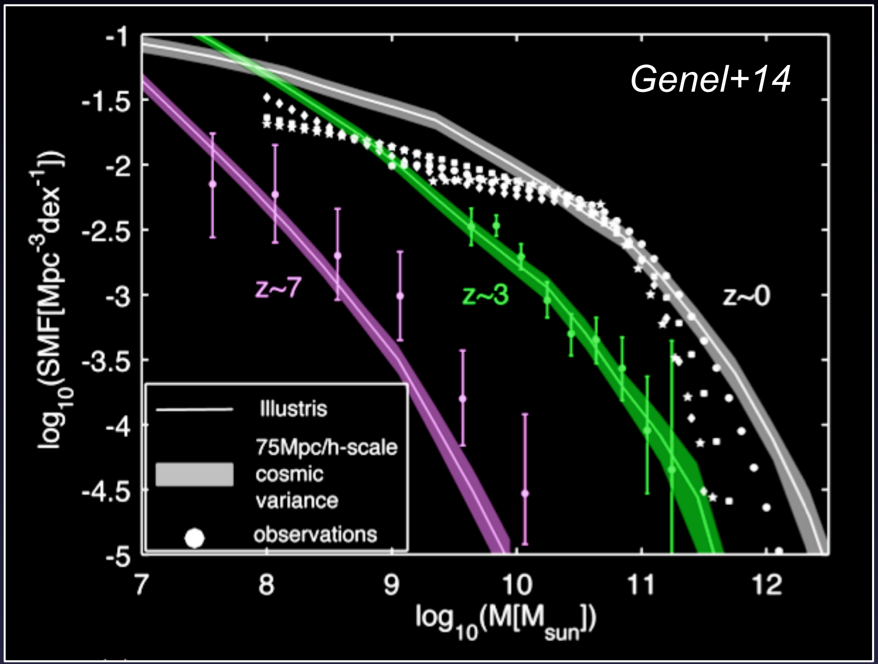


A few issues where GRBs can help:

- How does star formation proceed in galaxies ?
- Dust properties in the galaxy ISM
- Which sources did govern cosmic re-ionization ?

(with the additional benefit that SVOM will be contemporary to e.g., JWST)

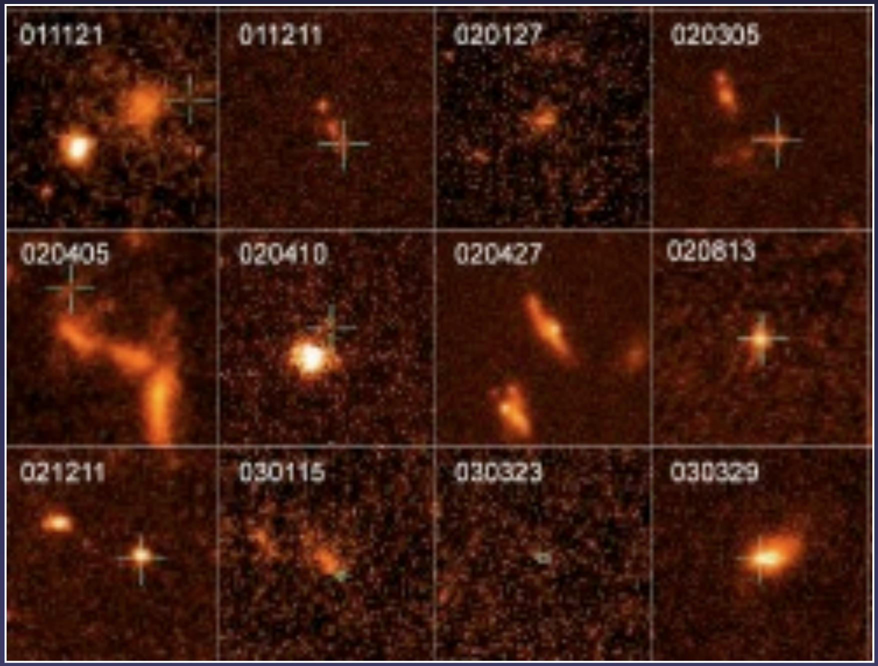
I - GRBs and Star formation processes

Early phase of star formation and gravitational collapse in molecular gas clouds still debated

LGRBs can pinpoint « early star formation » due to the short lifetime of their progenitors (< 10 Myrs), as opposed to « continuum galaxy » studies more sensitive to > 50 Myrs time-scales

GRBs as a unique tool for constraining galaxy properties in both absorption (afterglows) and emission (hosts):

- E.g., neutral to ionized gas fractions in giant clumps to probe possible top-heavy IMF

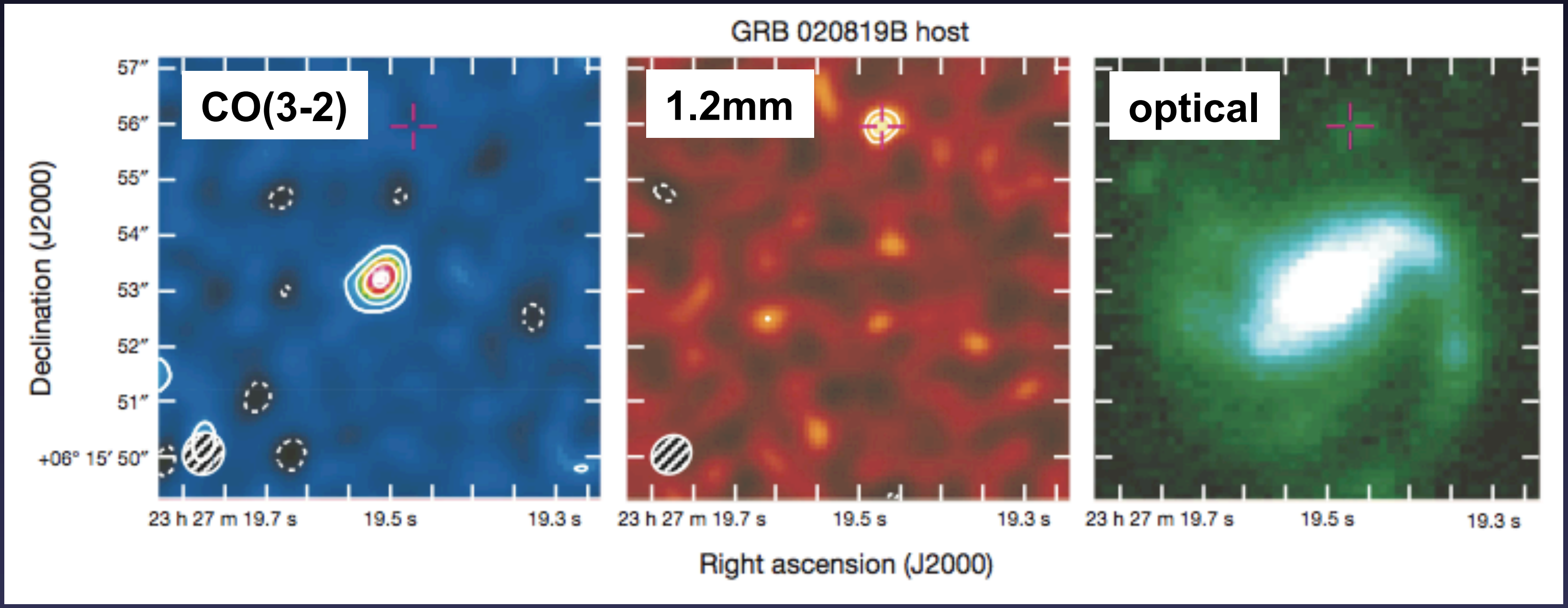


Fruchter+06

I - GRBs and Star formation processes

- E.g., possible evidence for low gas-to-dust ratio at the GRB location. Not clear if intrinsic to GRB formation or related to change of SFE at early phase of SF

Hatsukade +14

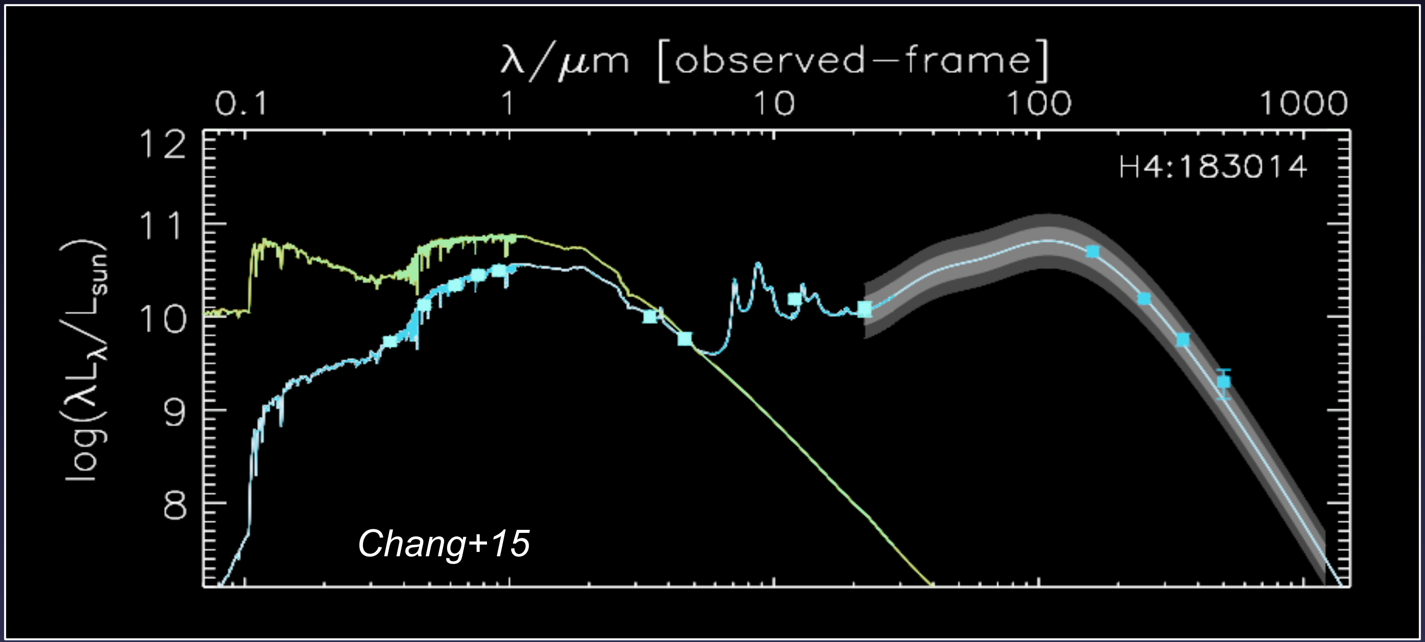


- E.g., possible deficiency of H_2 versus HI, with direct implications on the HI ←→ SF connection. To be further explored with ALMA and SKA in the SVOM era

II - GRBs and dust properties in the ISM

Dust properties, extinction laws

- Dust extinction corrections crucial for deriving galaxy properties, especially when no available constraints in the far-IR /radio



- A couple of dust extinction curves on the market, implying degeneracies in SED fitting

GRBs have sometimes revealed unusual extinction laws, pointing to different ISM conditions (possibly linked to high density SF regions)

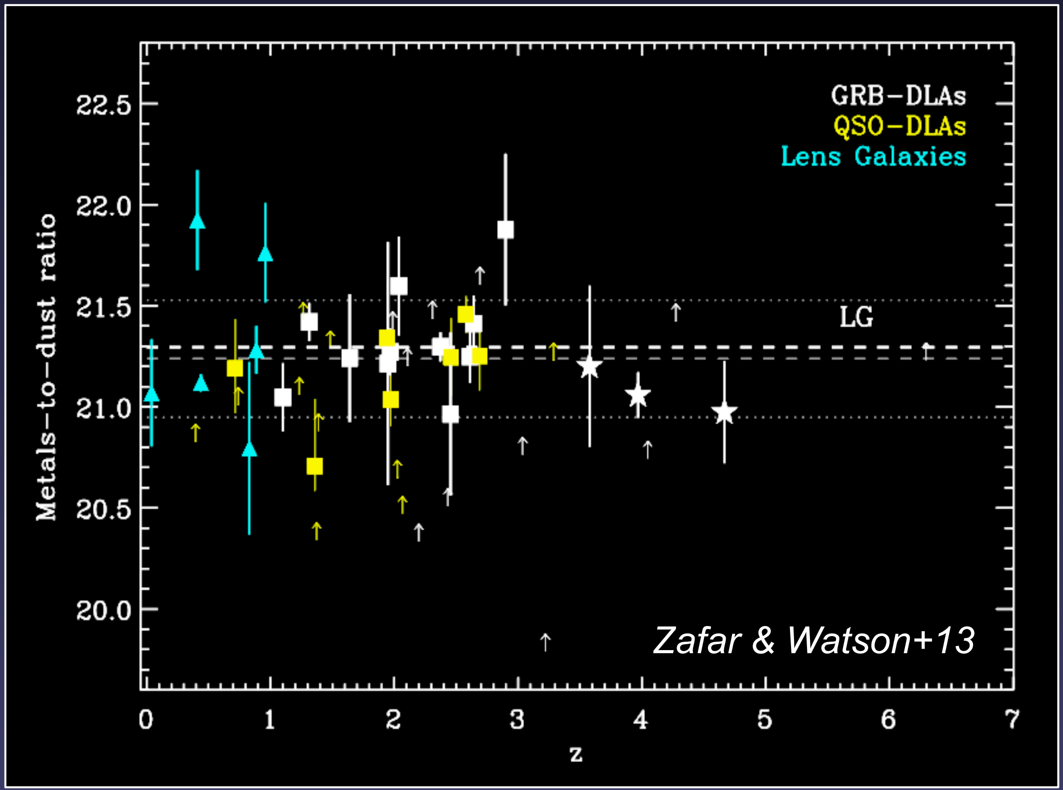
II - GRBs and dust properties in the ISM

Metal-to-dust ratio derived from afterglow spectra (using depleted element abundances)

- Provide hints on the evolution of the ISM properties with cosmic time
- Constrain cosmic dust origin and formation

→ Remarkable constant ratio across a variety of column densities, environments, metallicities, galaxy stellar masses, …

→ Suggests a close correlation between dust and metal production (e.g., as expected if dust is mostly produced by supernovae)



III - GRBs and the re-ionization epoch

- Re-ionization constrained at $6<z<15$

  (Gunn-Peterson trough in QSOs + optical depth of Thomson scattering onto the CMB)

- Nature of re-ionizing sources unknown : uncertainties on the galaxy and AGN luminosity functions at $z>6$, unknown escape fractions of ionizing Ly Continuum photons

→ But consensus that these sources are below current detection capabilities with HST

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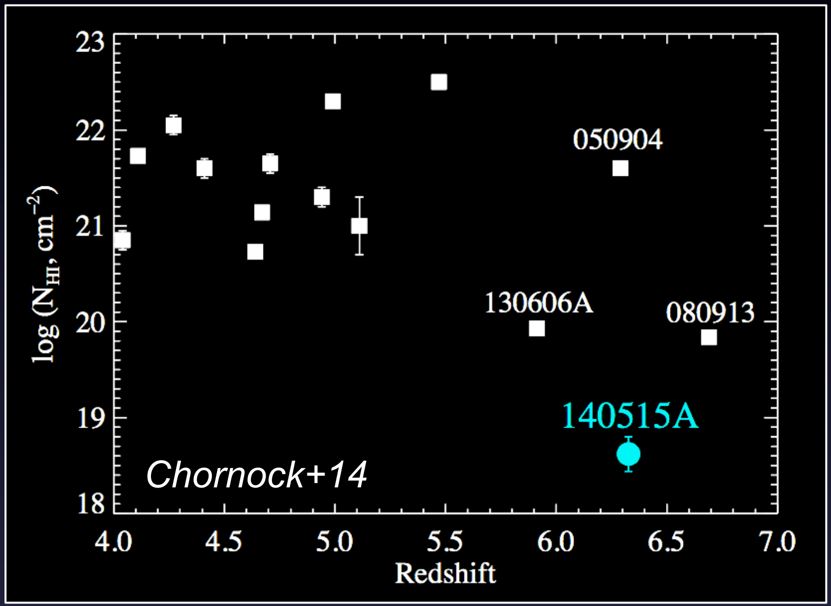
GRBs can be detected independently of their host continuum properties. Assuming « GRBs ←→ Star Formation », they provide a unique ressource to constrain the contribution of $L \ll L^*$ galaxies to re-ionization

III - GRBs and the re-ionization epoch

- Possible evidence for decreasing N_{HI} at z>6 from a few GRB afterglows

→ May indicate increasing LyC escape fraction in faint galaxies of the re-ionization epoch



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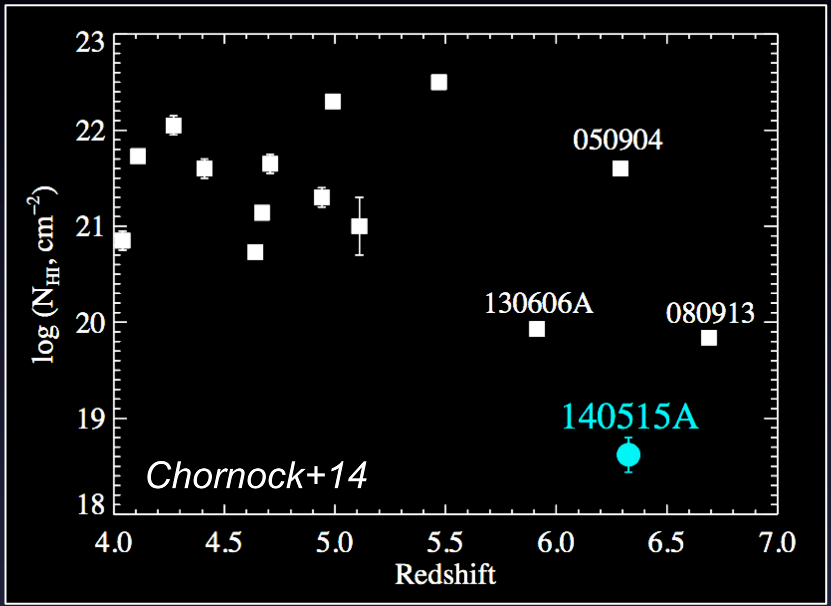

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Cons: - Need for larger GRB samples

E.g., only a few events identified at z>6 (2 host detections, ~20% L*, McGuire+16)

→ How many SVOM GRBs at z>6 ???

- LyC escape fractions impossible to measure directly at z>3.5 due to IGM opacity (→ need other diagnostics, e.g., Lyman alpha line profiles, …)