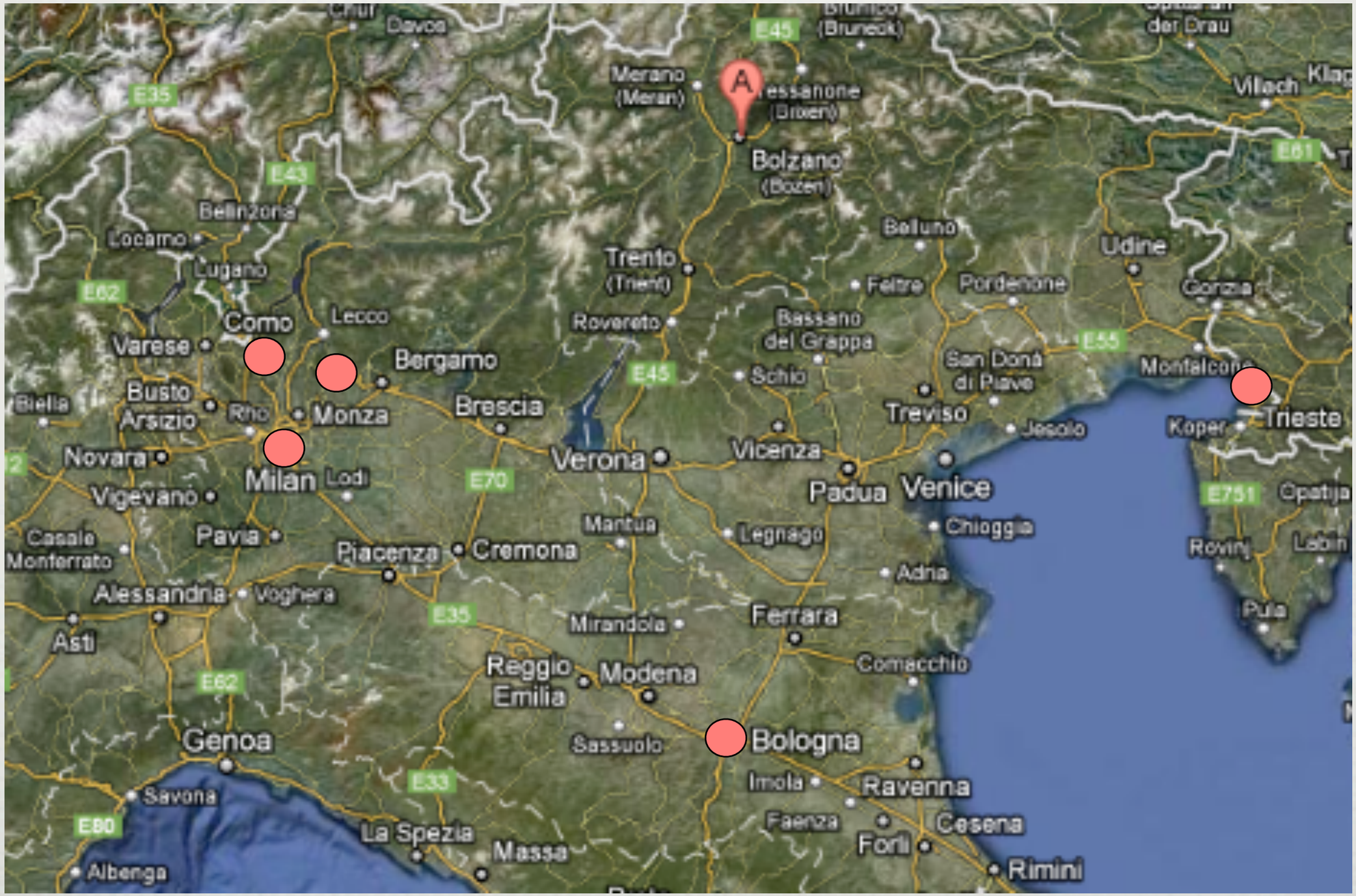
studying the high-z Universe:

a review of my scientific activity

by Ruben Salvaterra

geography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Padua
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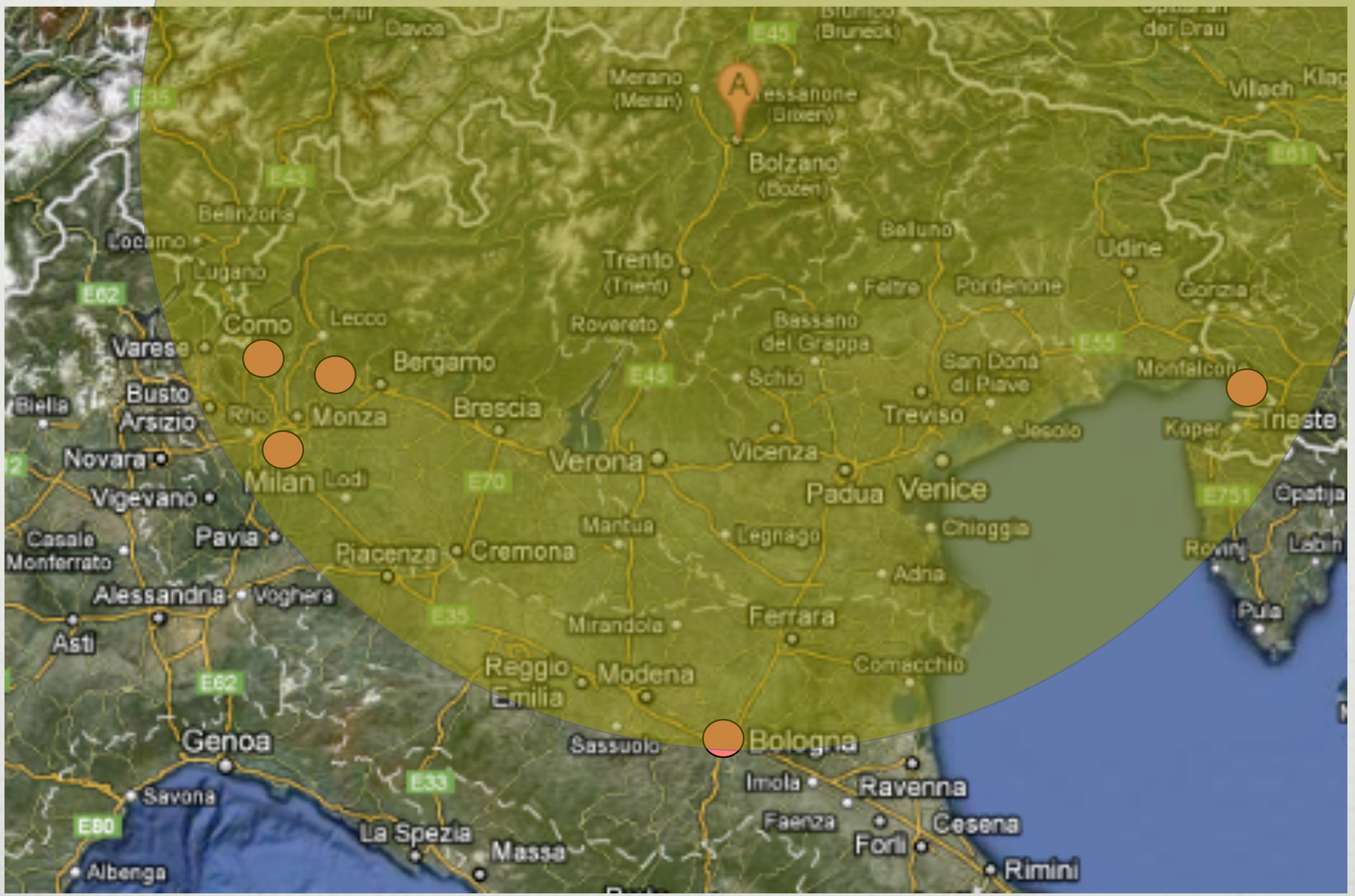
Albenga

geography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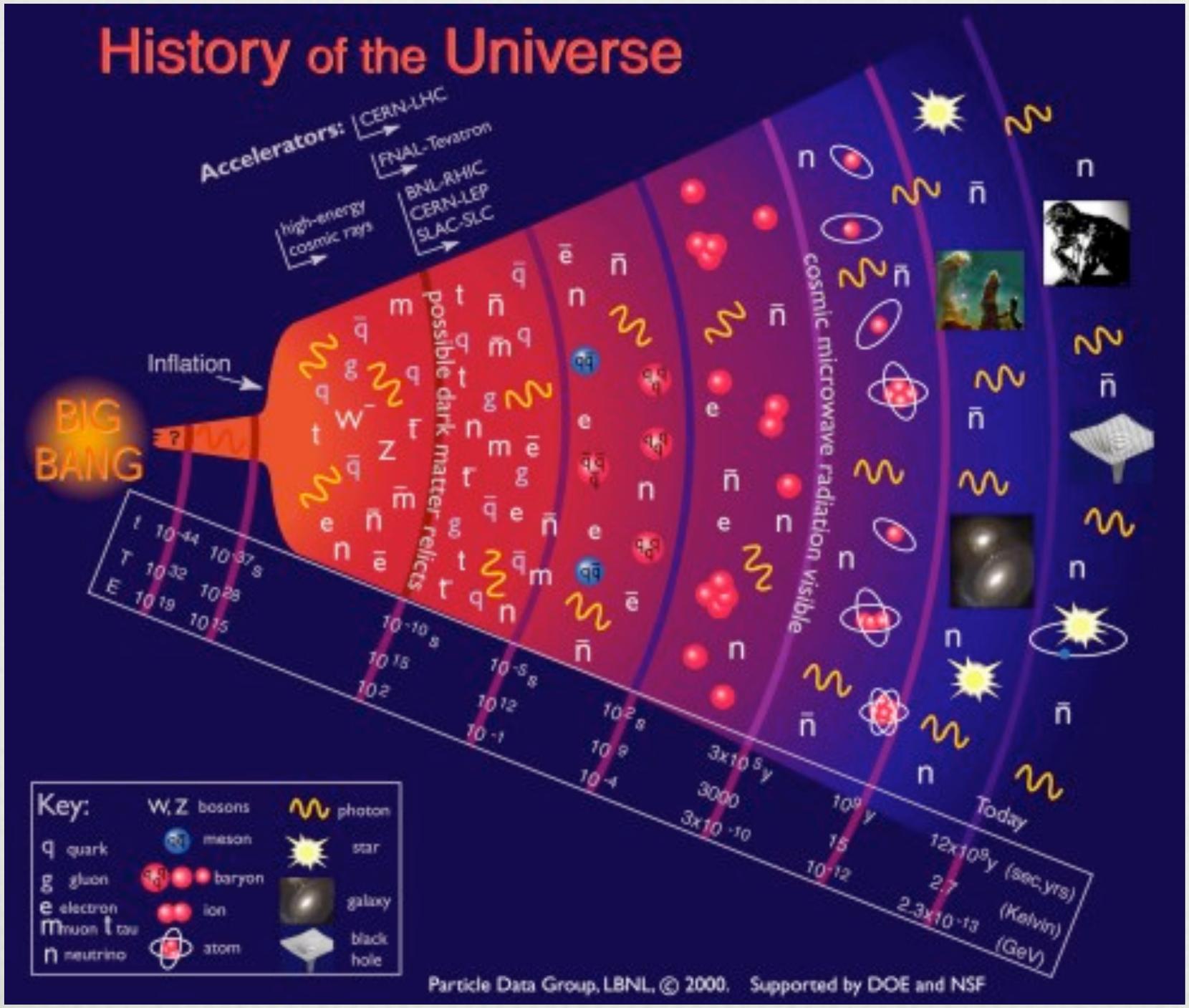
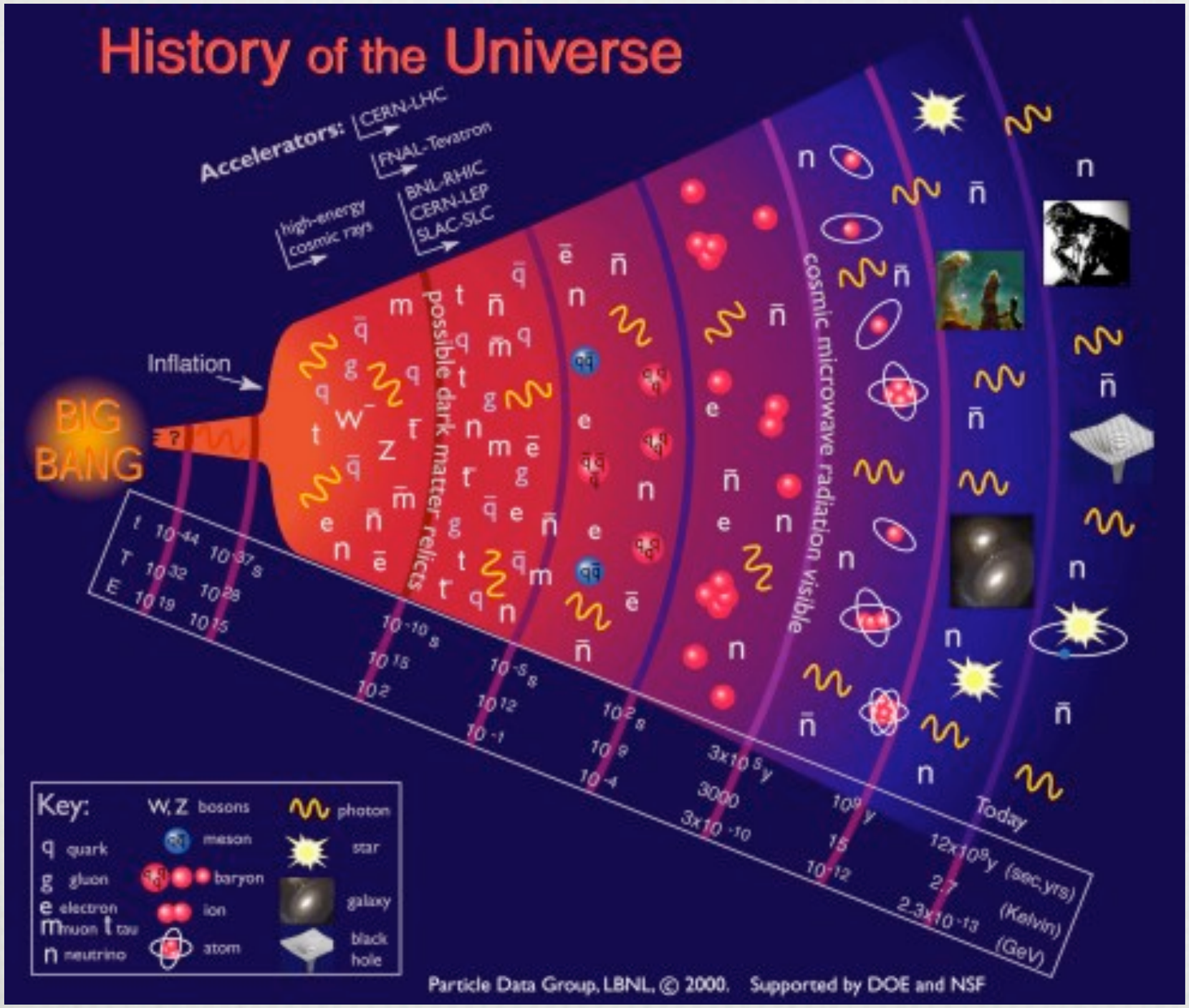
degree

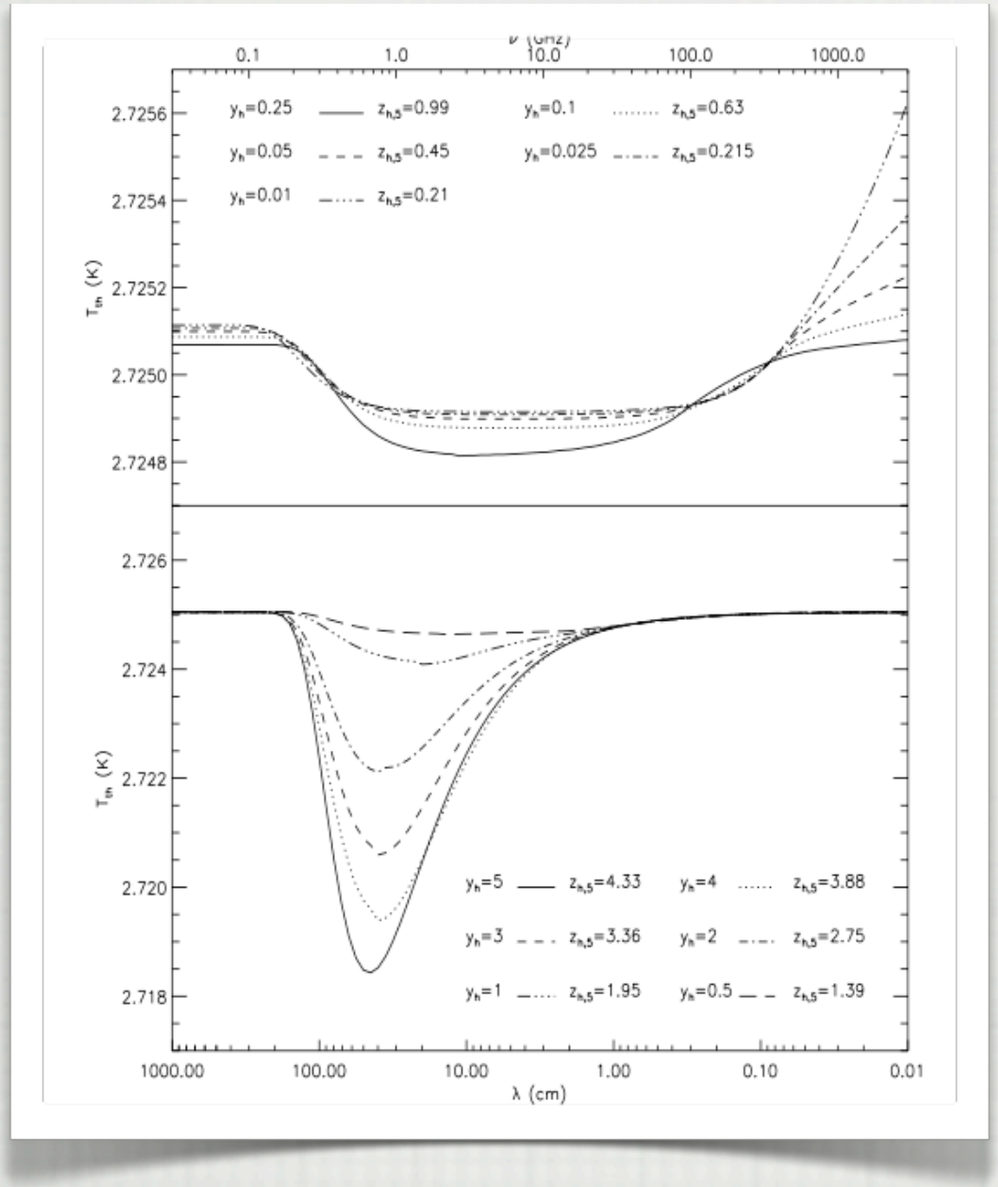
before the degree thesis

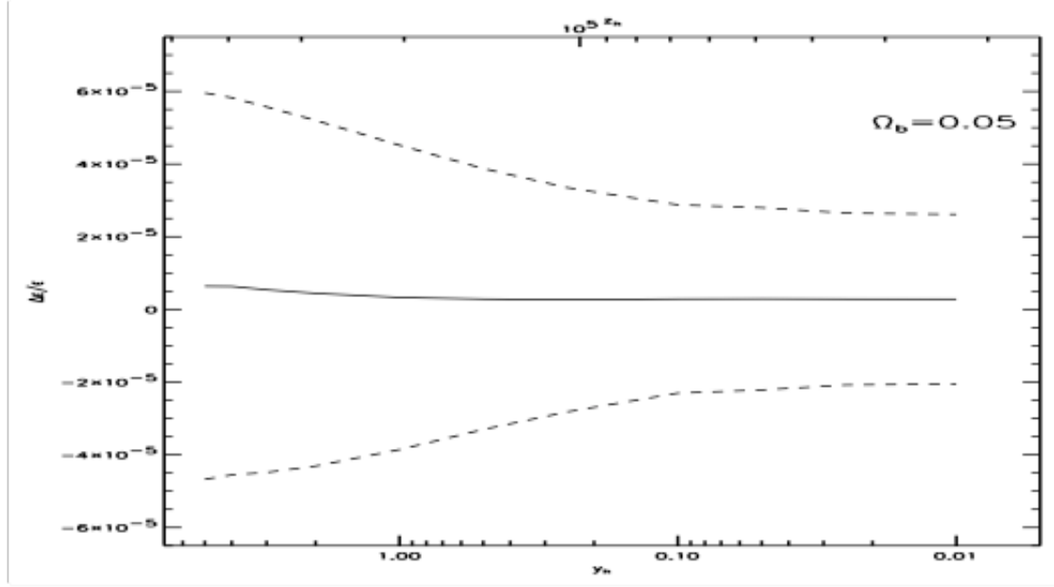


before the degree thesis



CMB spectral distortion





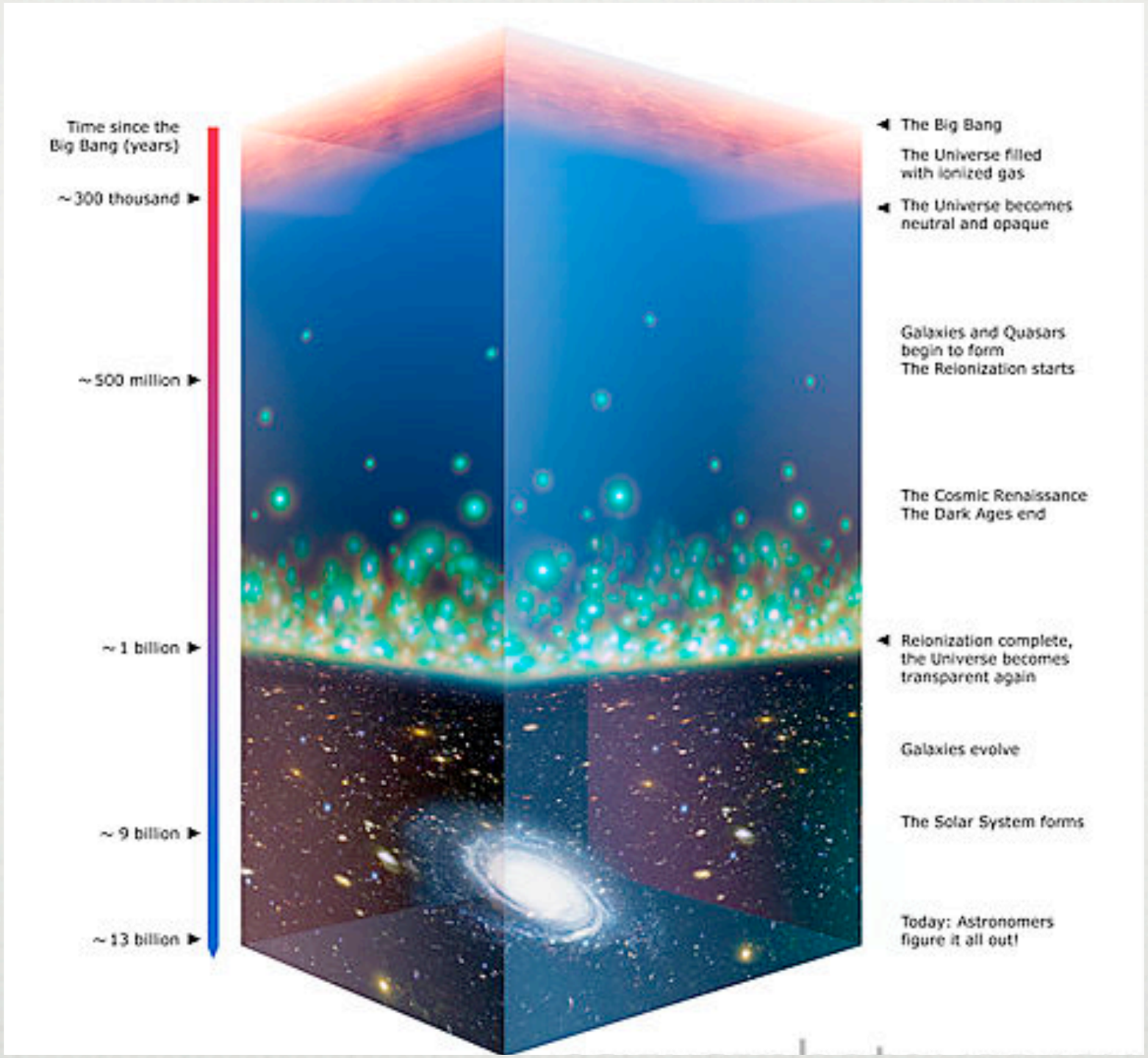
potentially allow us to study the Universe up to $z \sim 10^5$

but see ARCADE ballon (Fixsen et al. 2011) & PIXIE satellite (Kogut et al. 2011)

RS & Burigana 2002, Burigana & RS 2003

the “dark ages”

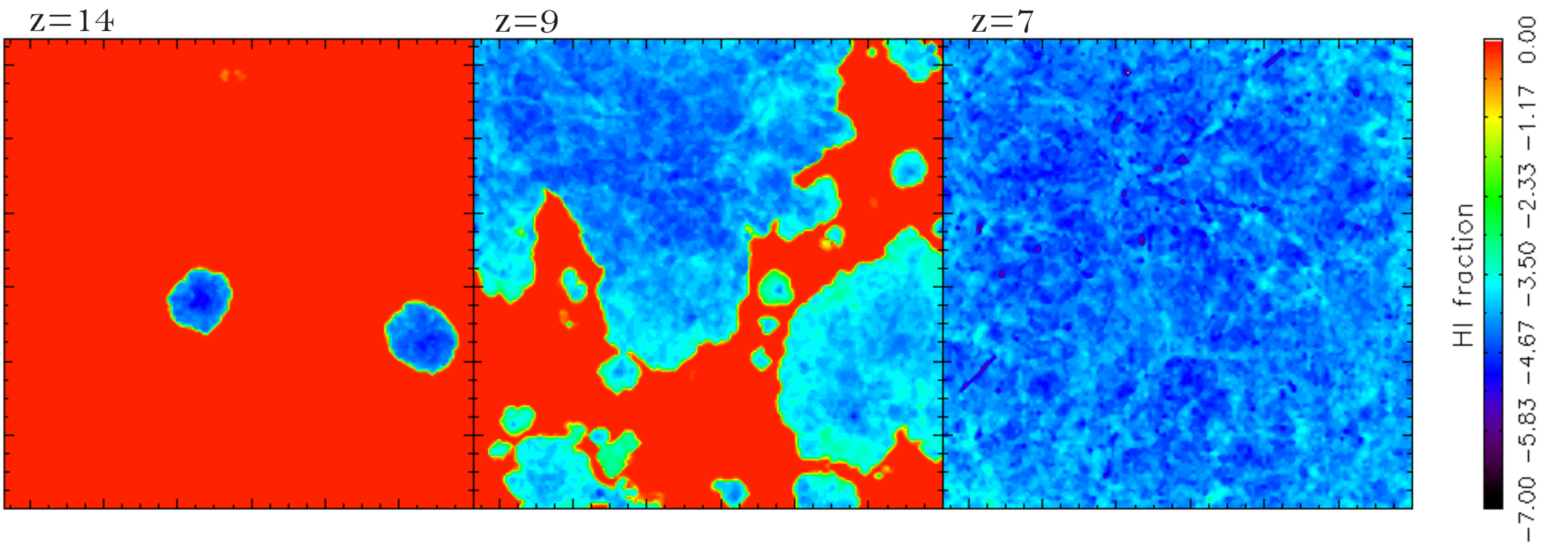
the cosmic dark ages



possible signature of first galaxies in the NIBR (RS & Ferrara 2003, 2006, Magliochetti et al. 2003, RS et al. 2006)

z=14

transition I: cosmic reionization



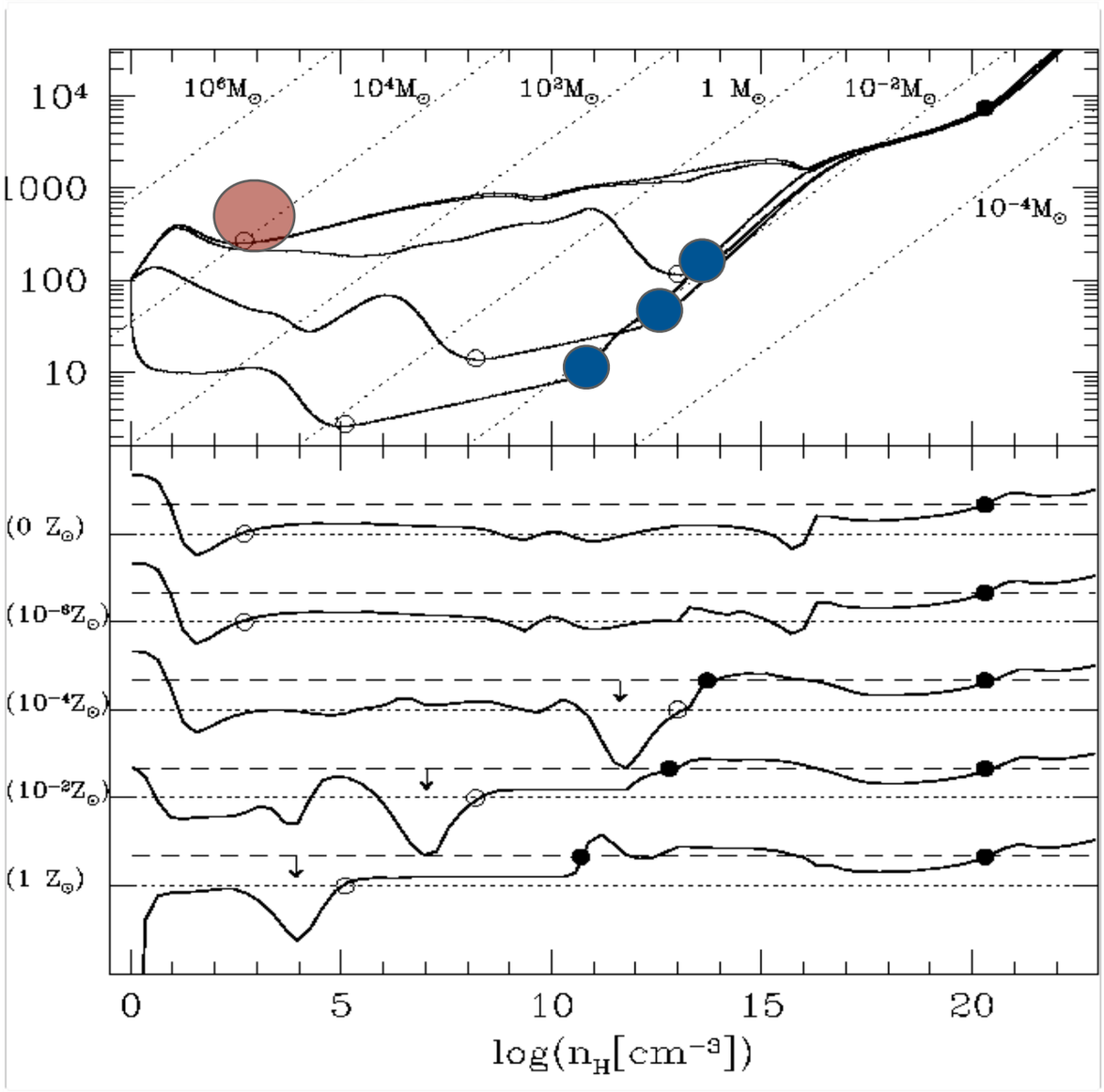
many open questions:

- when did the reionization happen?
- what are the main sources of ionizing photons?
- what is the relative contribution of PopIII/PopII stars?
- what are the feedback effect at play?

credits: B. Ciardi

transition II: from PopIII to PopII

massive stars for
$Z<10^{-6}$ Zsun



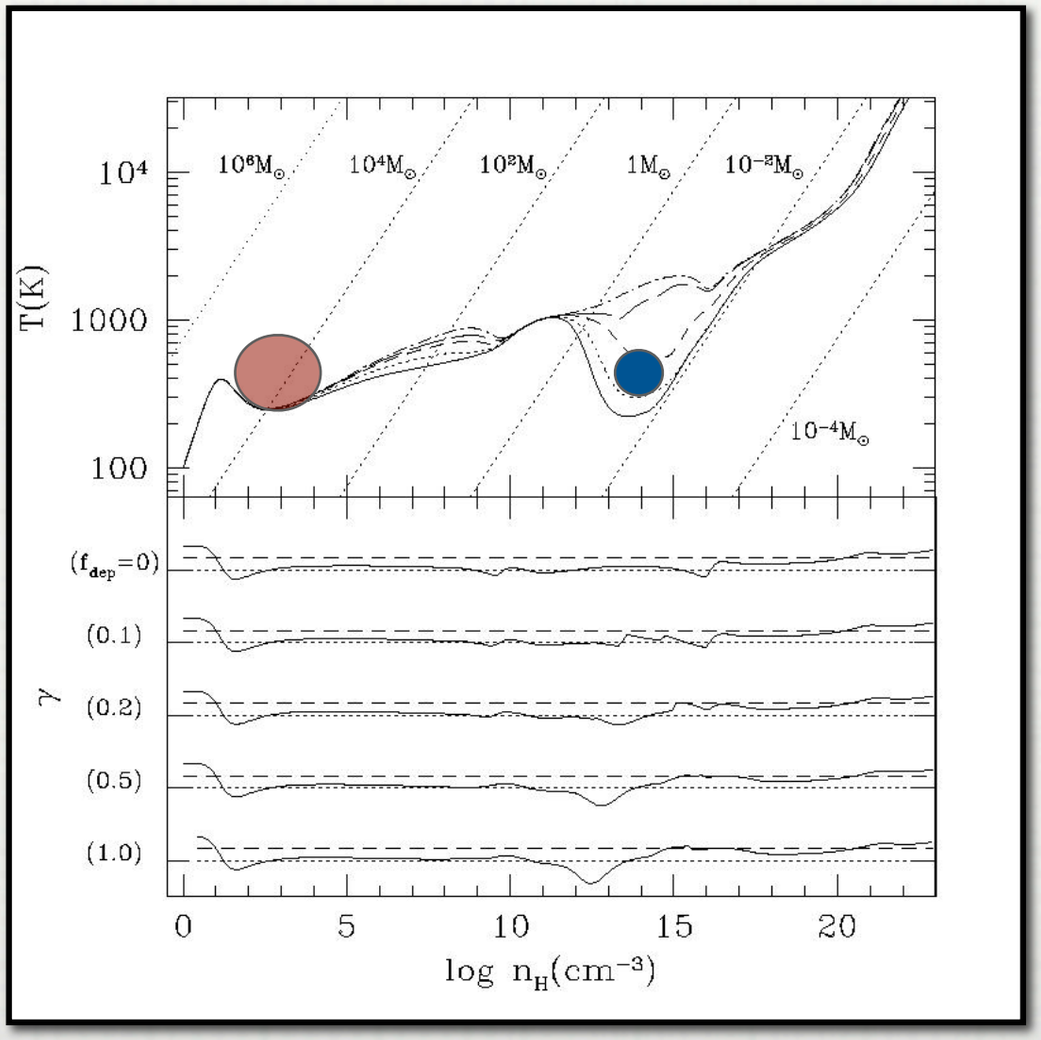
~1 Msun stars for
$Z>10^{-4}$ Zsun

there exists a critical metallicity governing the PopIII-PopII transition

Schneider et al. 2002, 2003

‘Christlieb’ star and the effect of dust

Christileb et al. (2002) reported the detection of HE0107-5240 with M=0.8 Msun and [Fe/H]=-5.3



Schneider, Ferrara, RS et al., 2003, Nature

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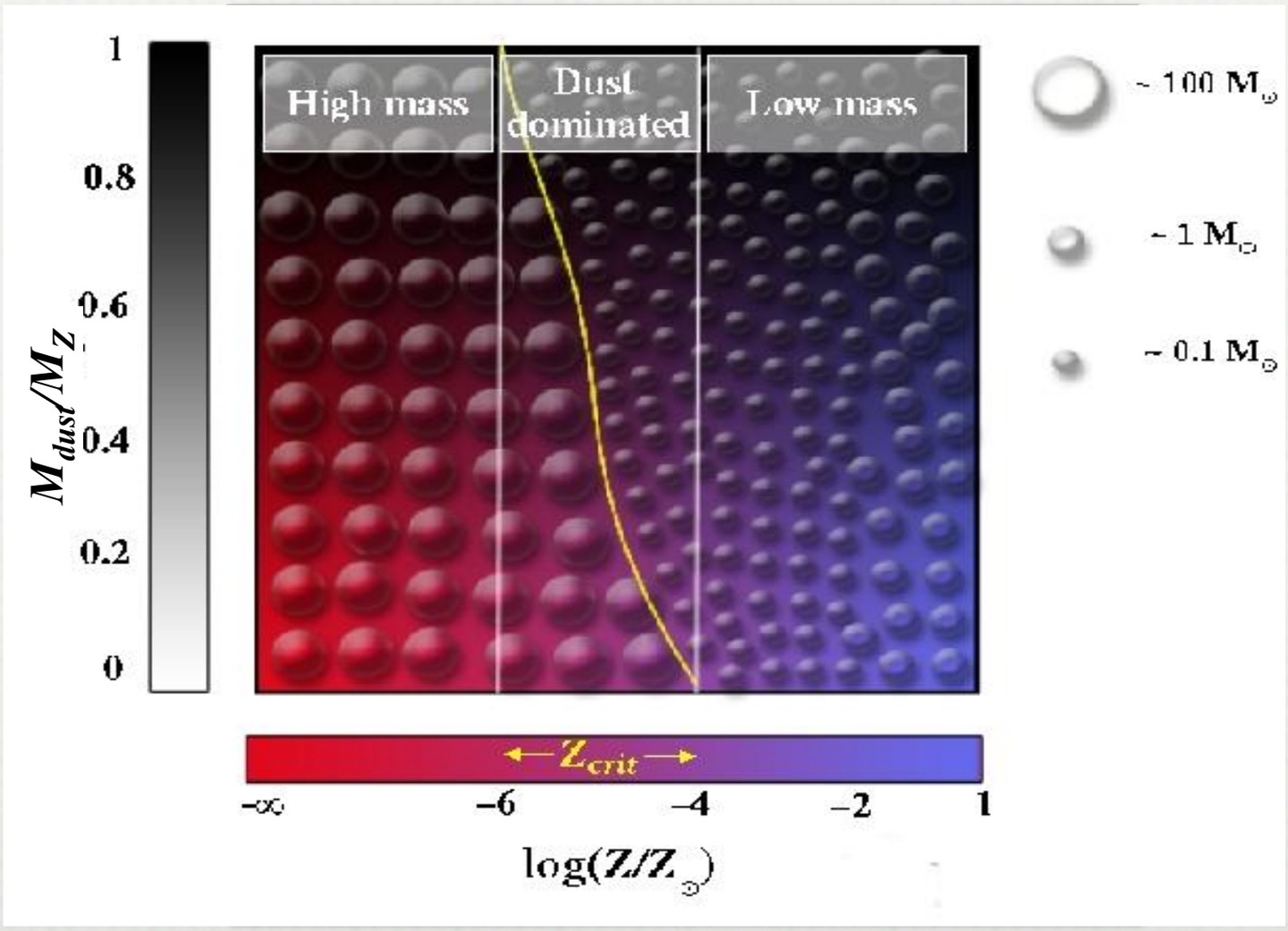
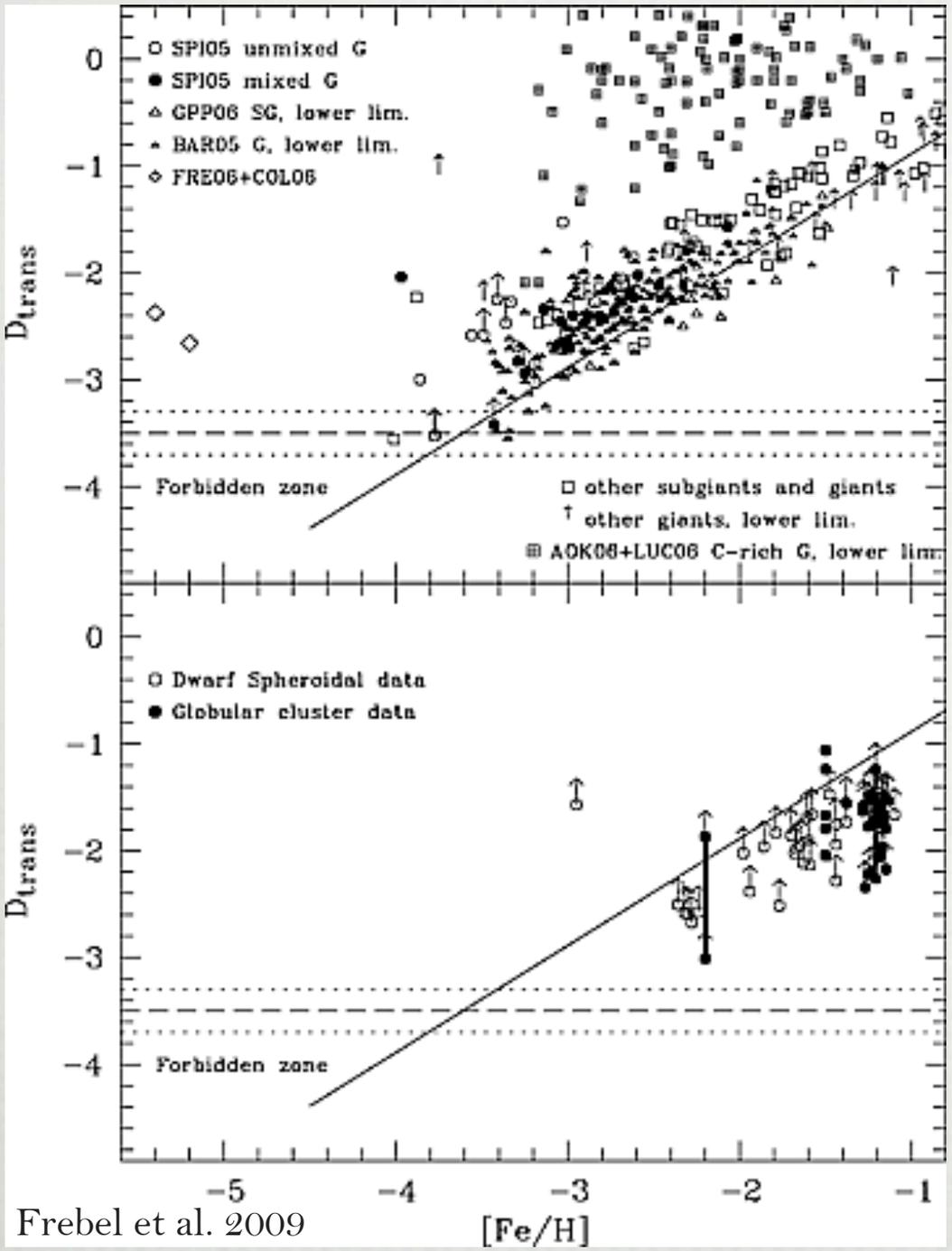
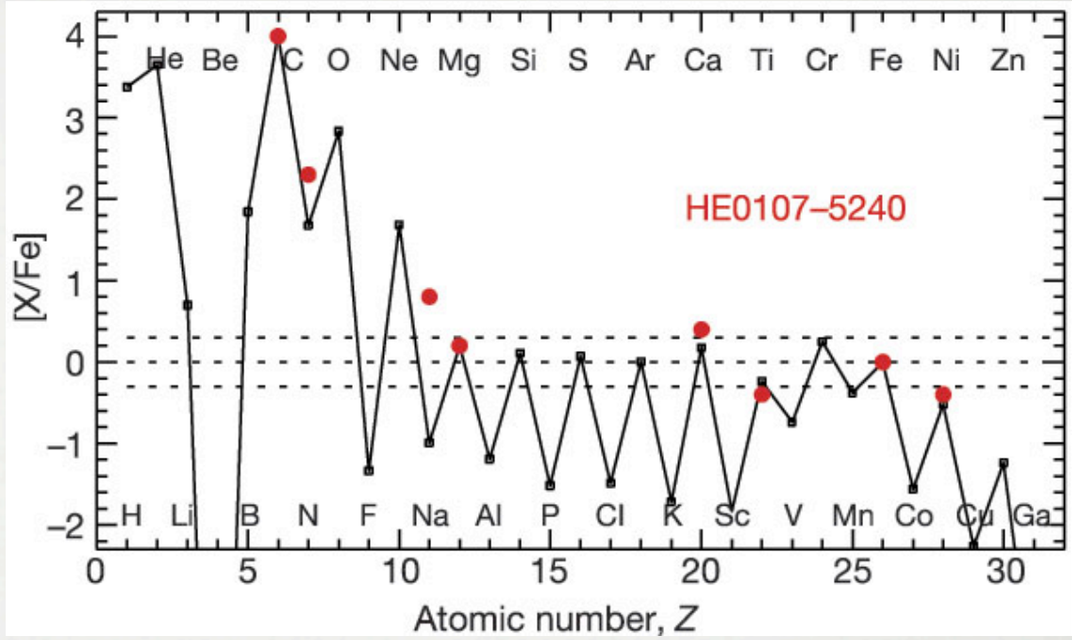


Schneider, Ferrara, RS et al., 2003, Nature

alternative explanation

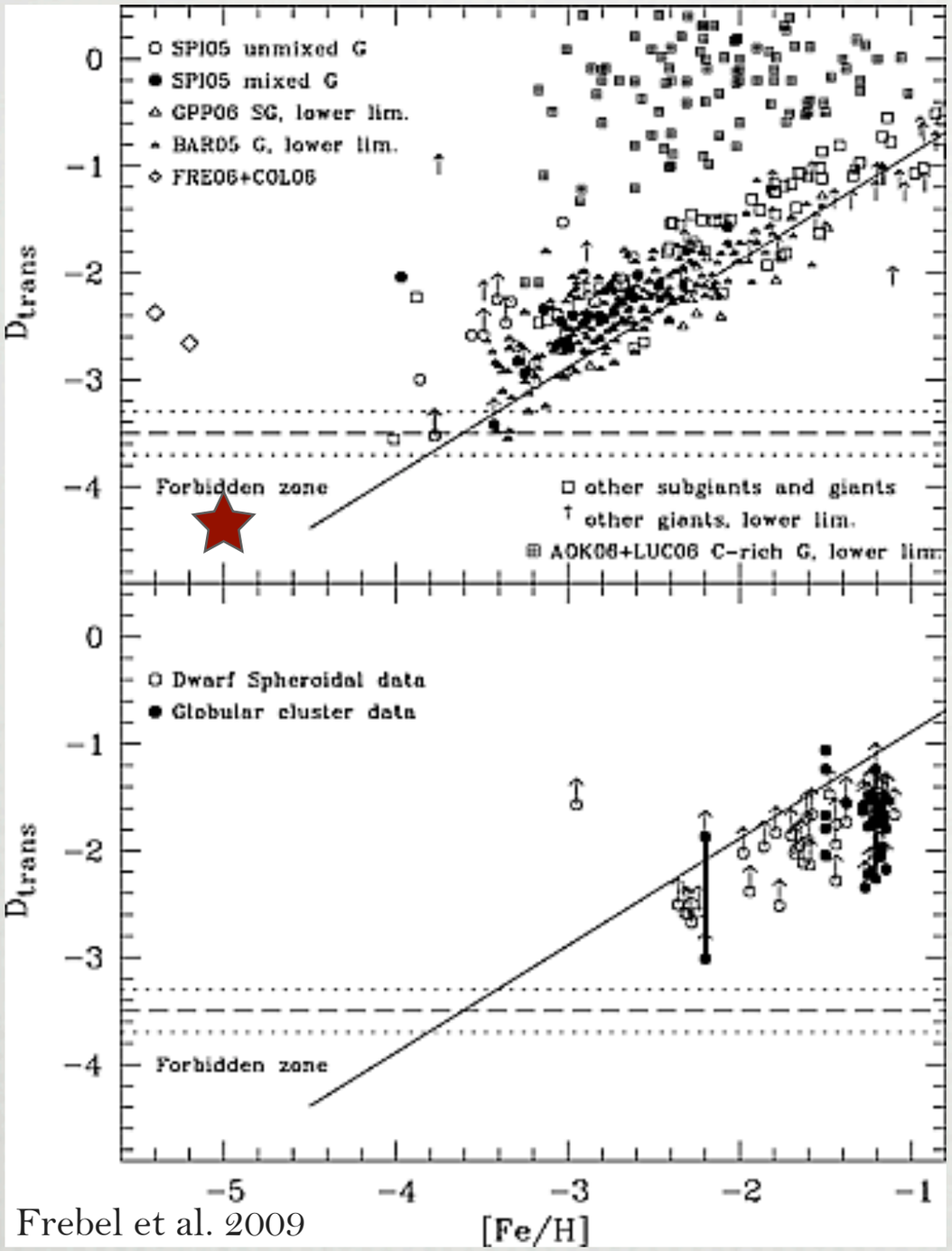


Frebel et al. 2009



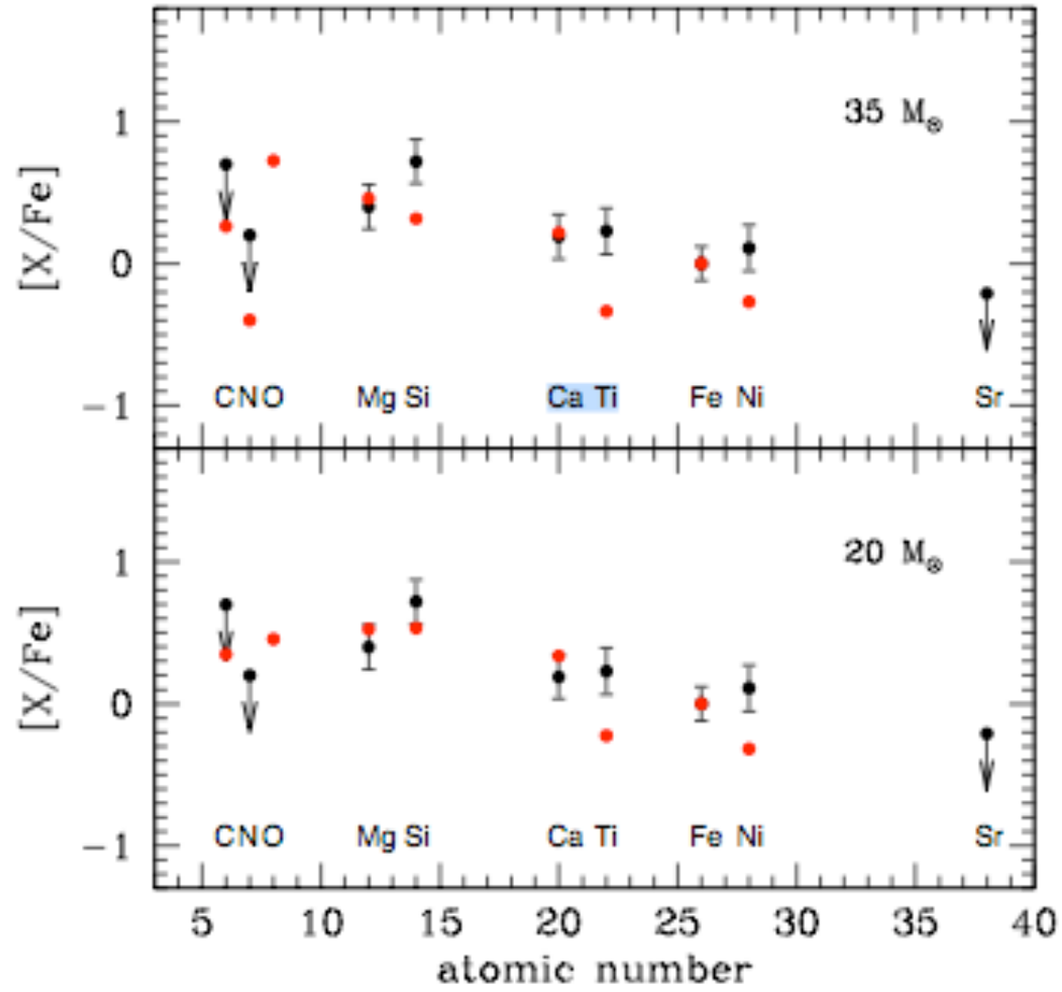
$D_{trans} = \mathrm{Log}(10^{[C/H]} + 0.3\ 10^{[O/H]}) \geq -3.5$

alternative explanation



Frebel et al. 2009

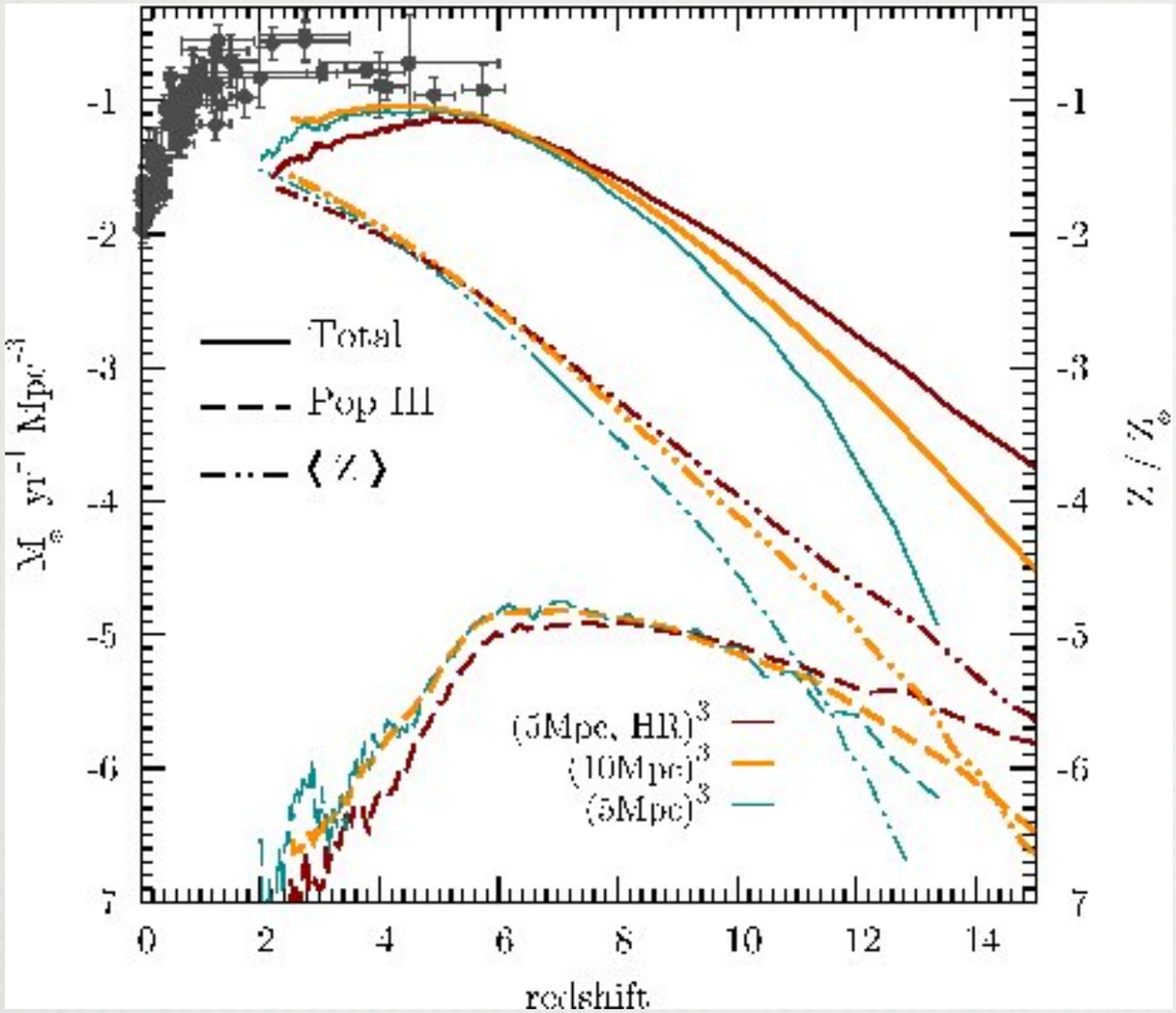
SDSS J102915+172927 [Fe/H]=-4.99 M~0.8 Msun

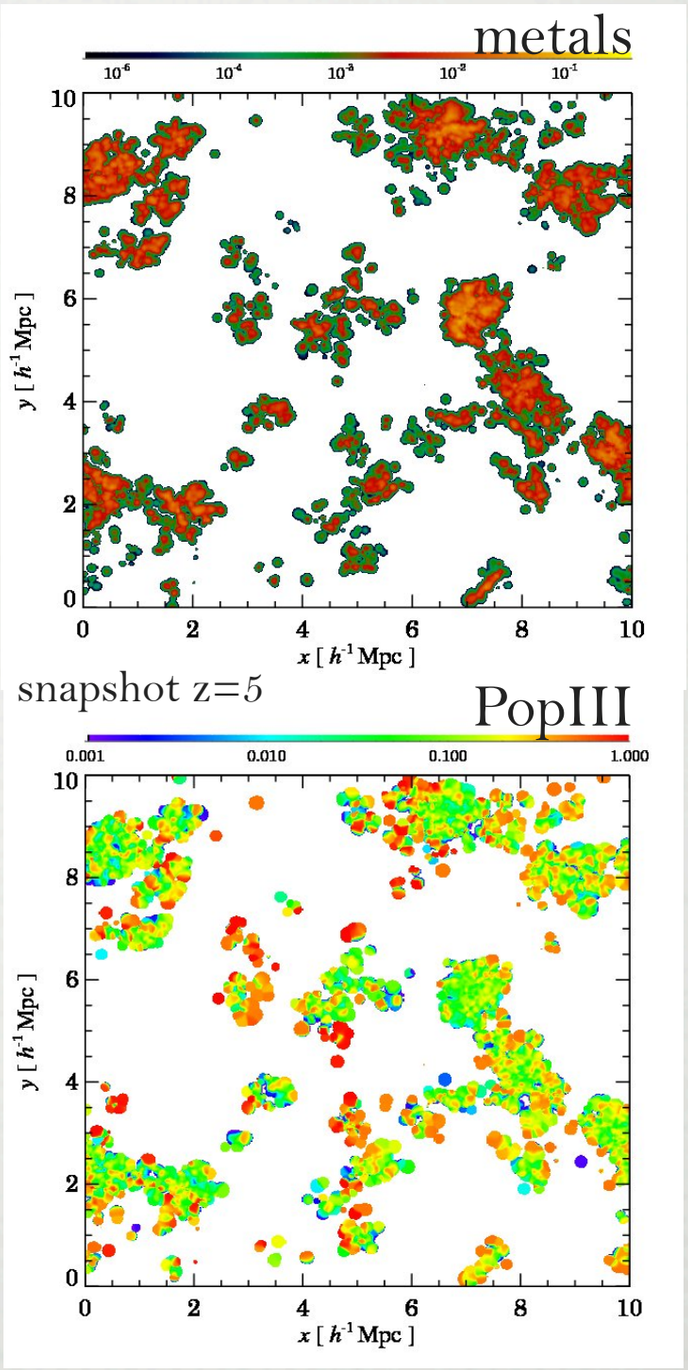


Caffau et al. 2011 Nature

$D_{trans} = \mathrm{Log}(10^{[C/H]} + 0.3\ 10^{[O/H]}) \geq -3.5$

the chemical feedback

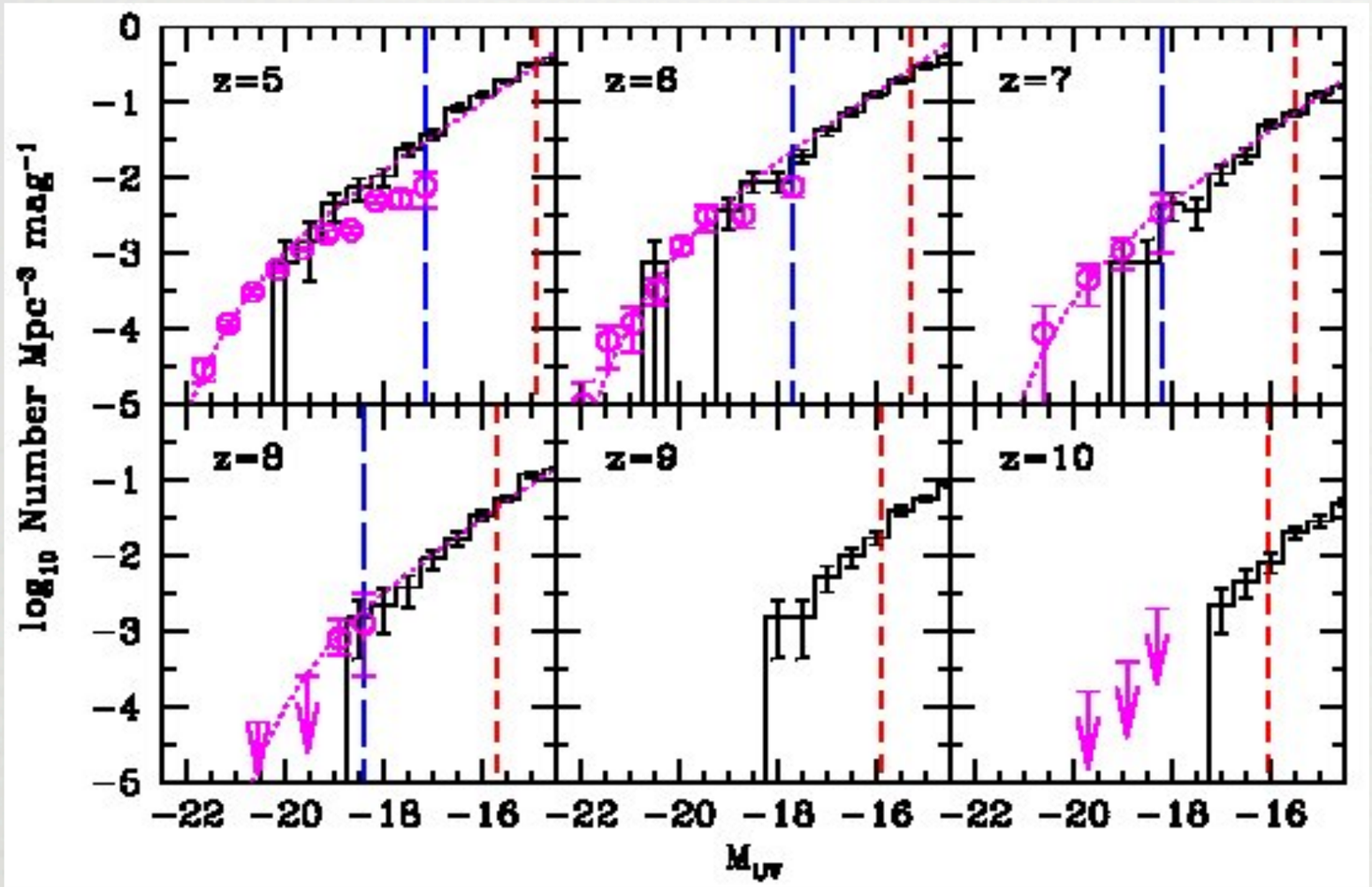


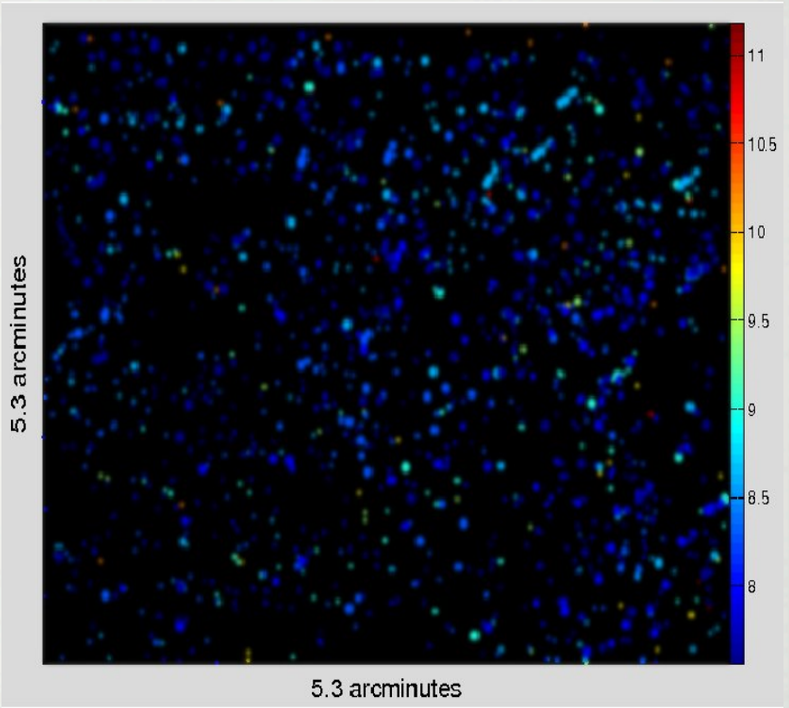


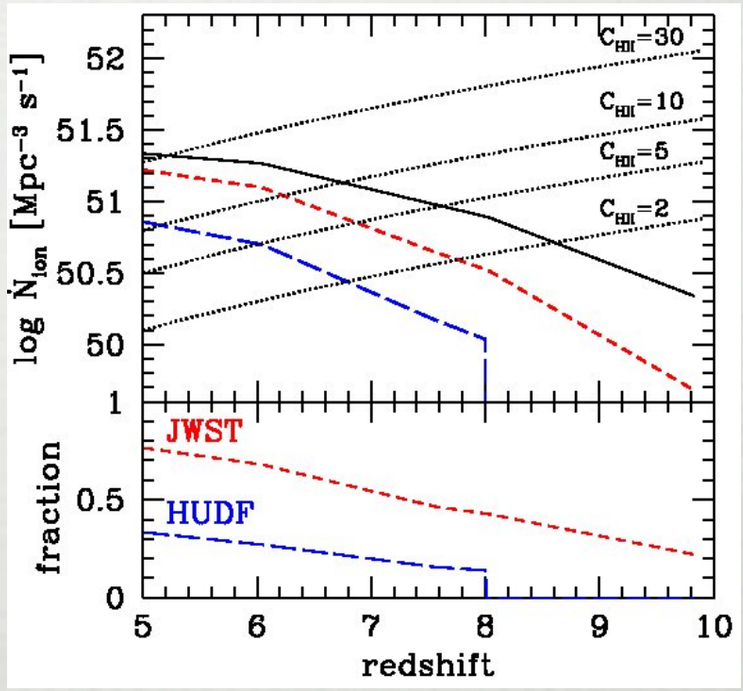
note the recent observation of two gas clouds at z~3 with $Z<10^{-4}$ Zsun (Fumagalli et al. 2011 Science)

Schneider, RS et al. 2006, Tornatore et al. 2007

simulating the high-z galaxies

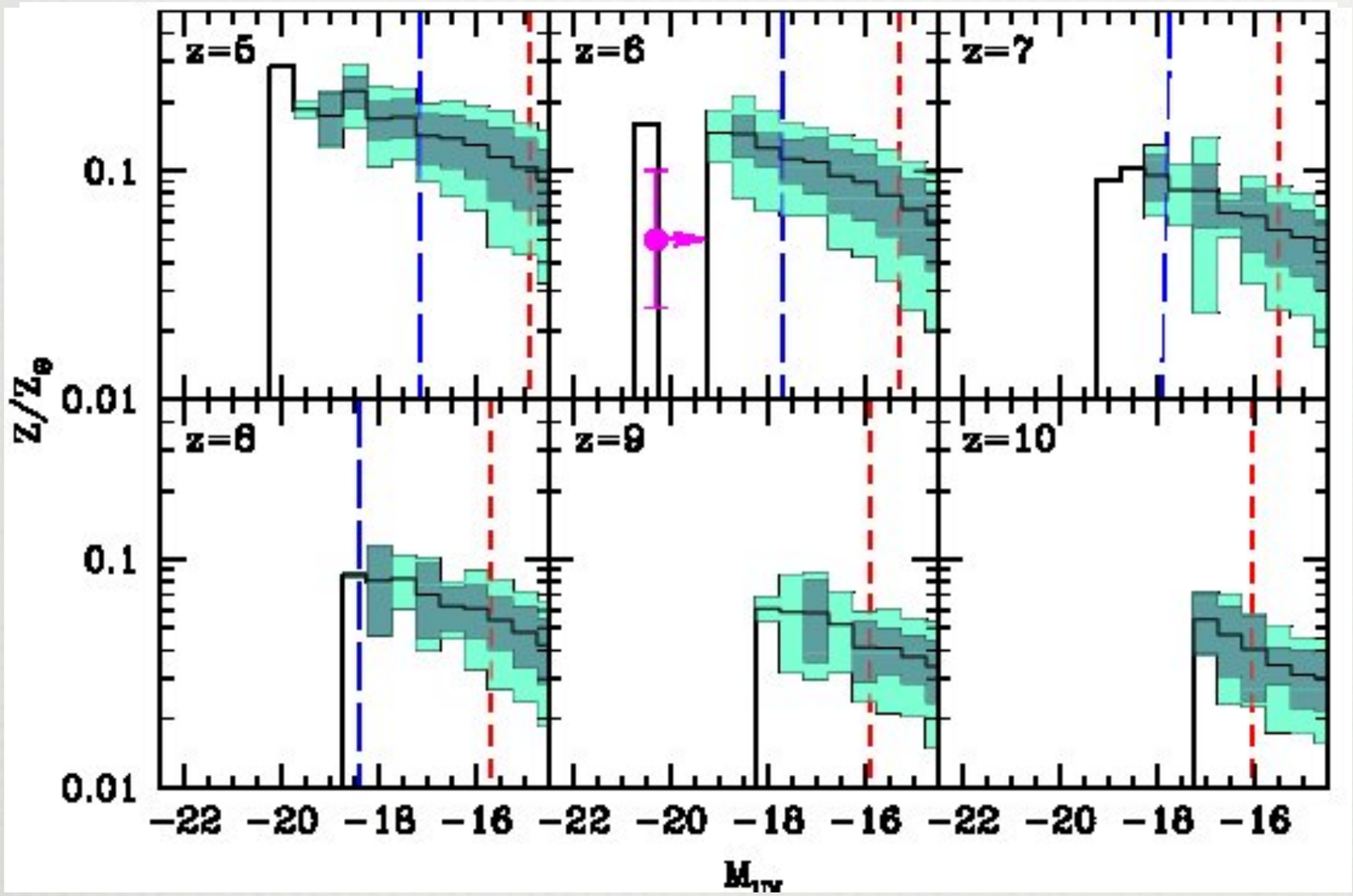


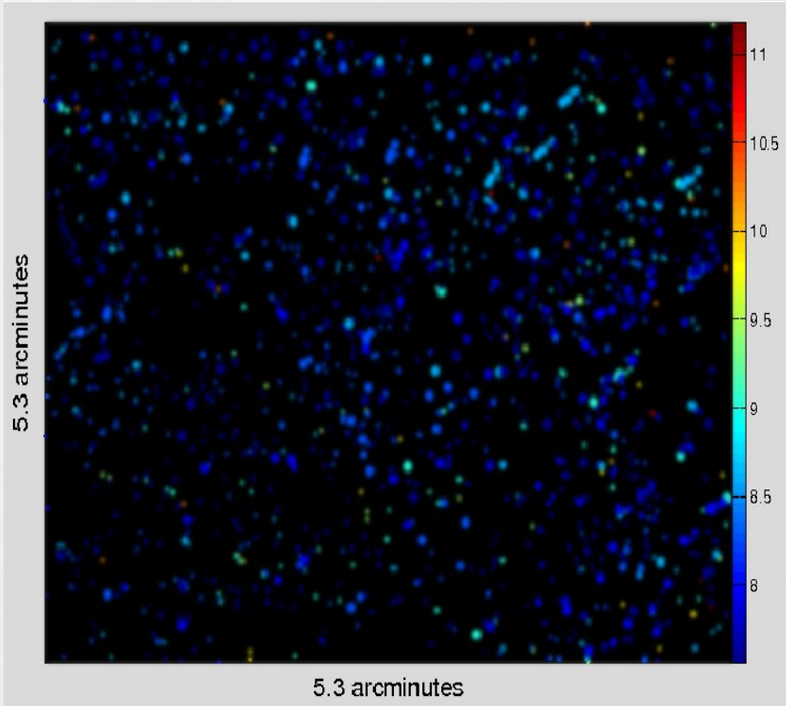


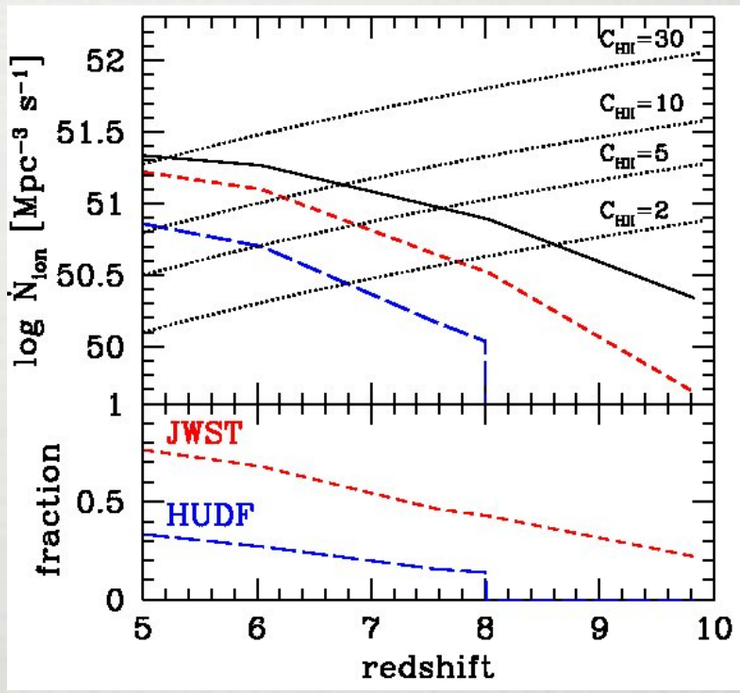


Salvaterra et al. 2011

simulating the high-z galaxies





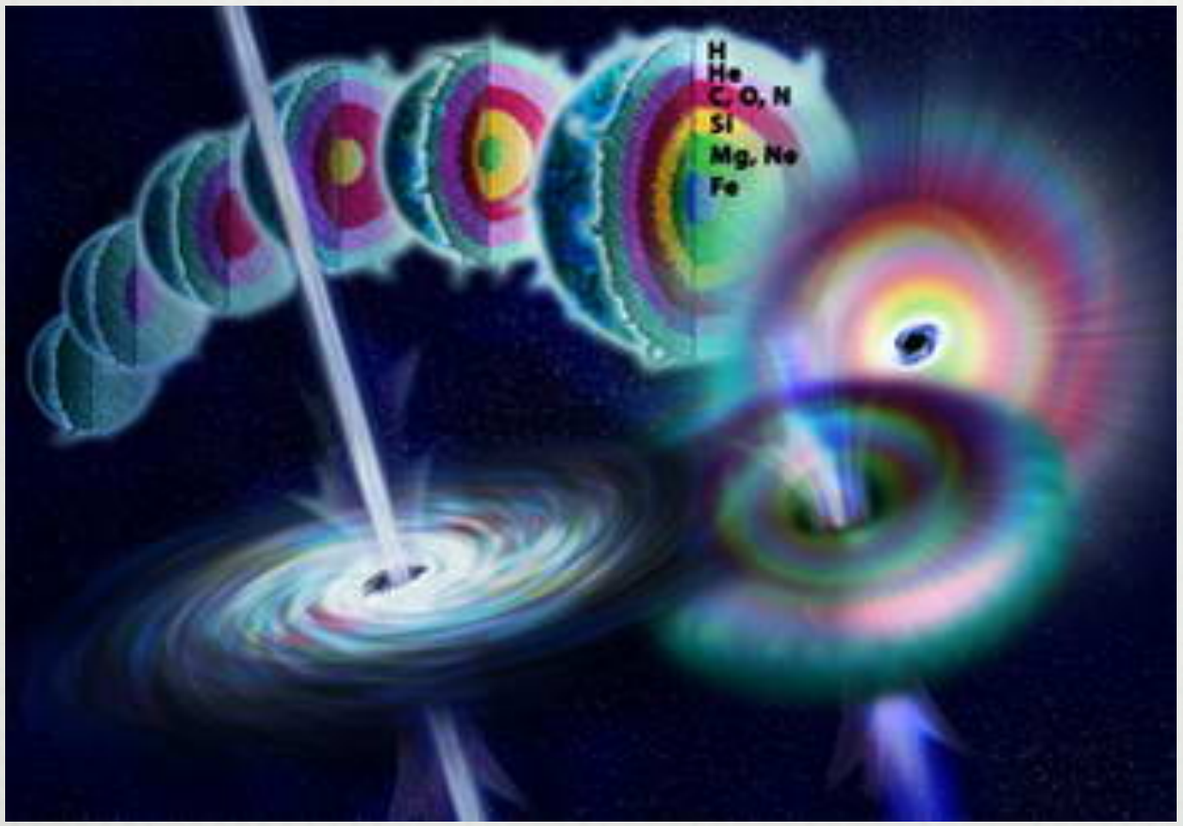


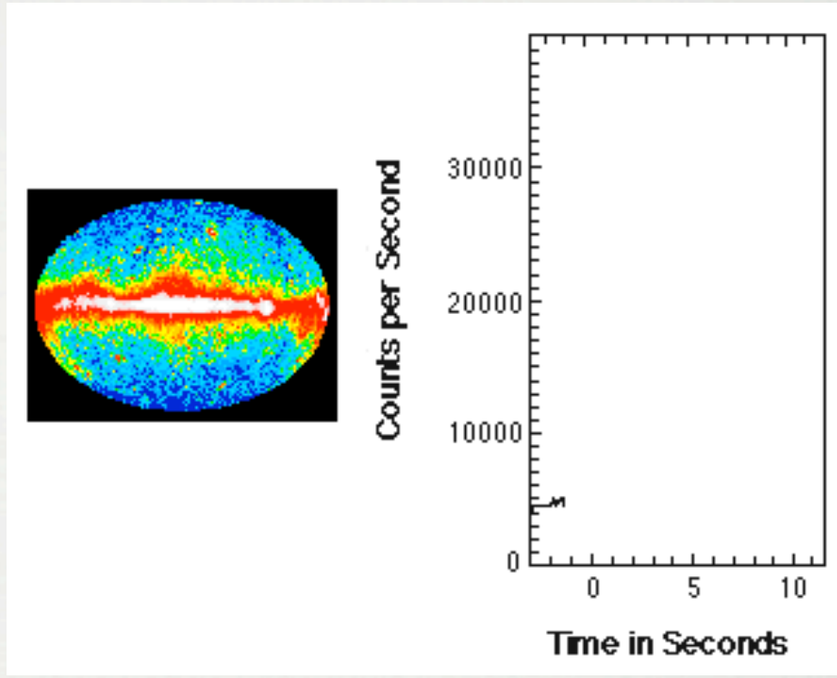
Salvaterra et al. 2011

gamma-ray bursts

gamma-ray bursts

GRBs are strong burst in the gamma-rays



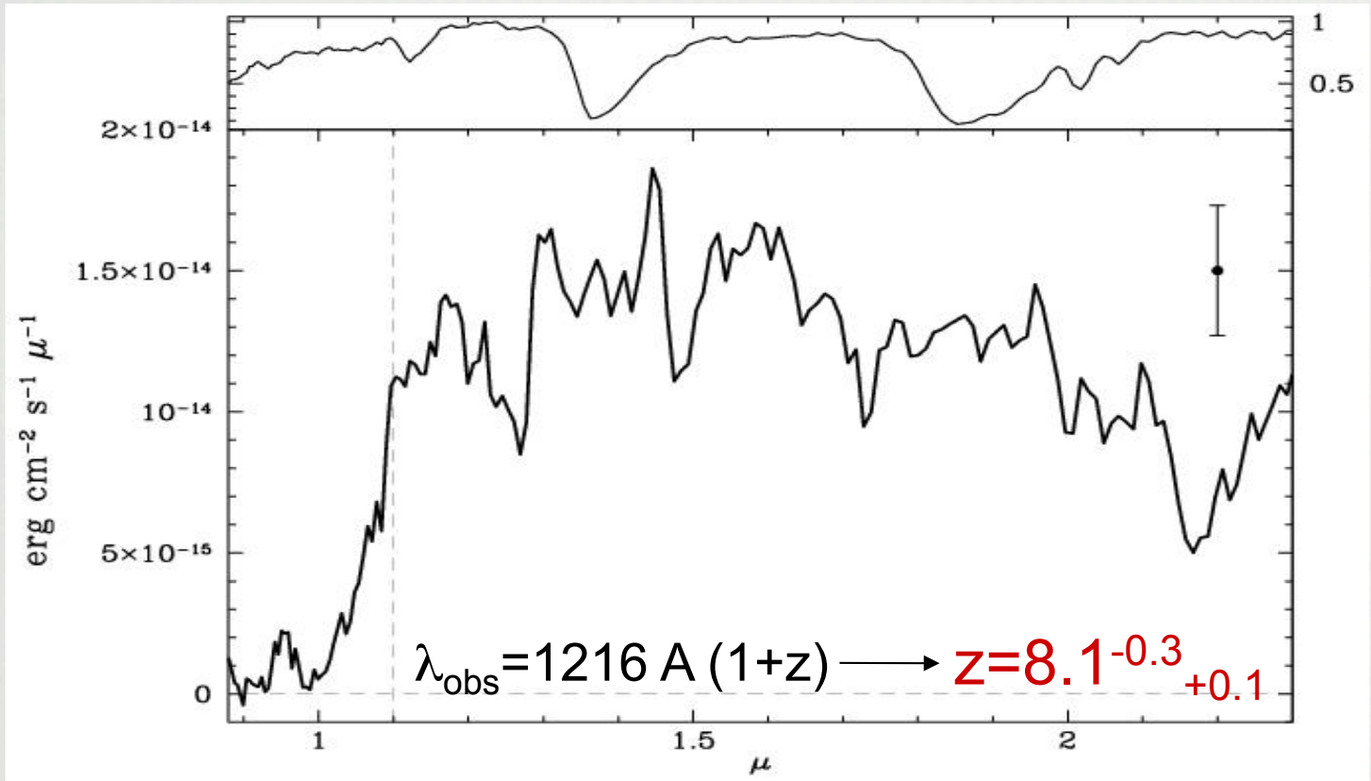


long GRBs are thought to be linked to the death of massive stars: i.e. the SN explosion of Wolfe-Rayet stars (SN I b/c), as observed is some cases

main activity: GRB luminosity function and its evolution with redshift
& estimate of the number of high-z GRBs

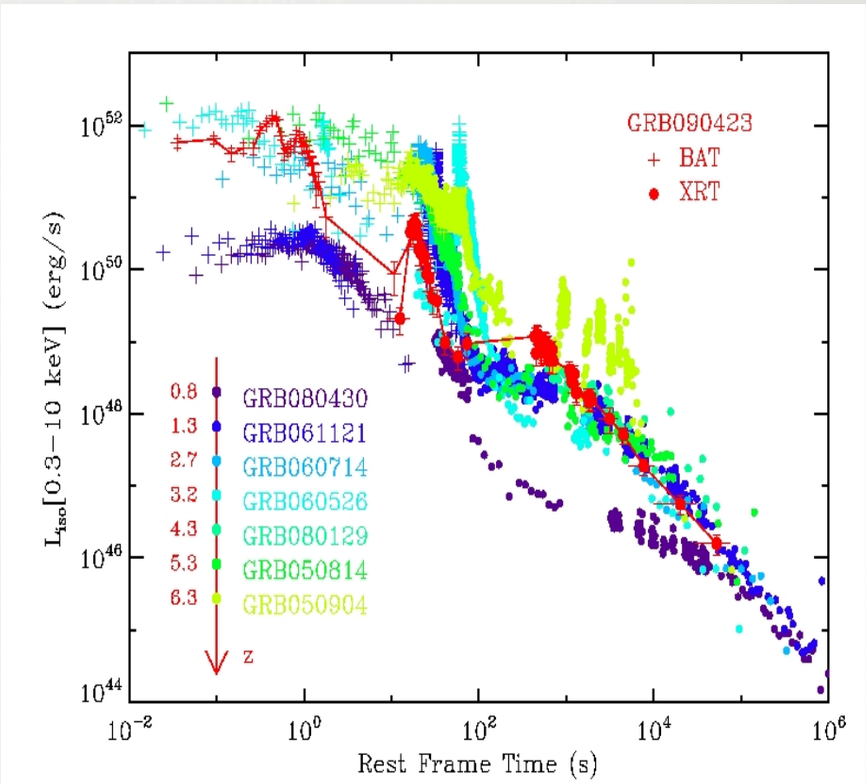
RS & Chincarini 2007, RS et al. 2007, 2009, Campisi et al. 2011

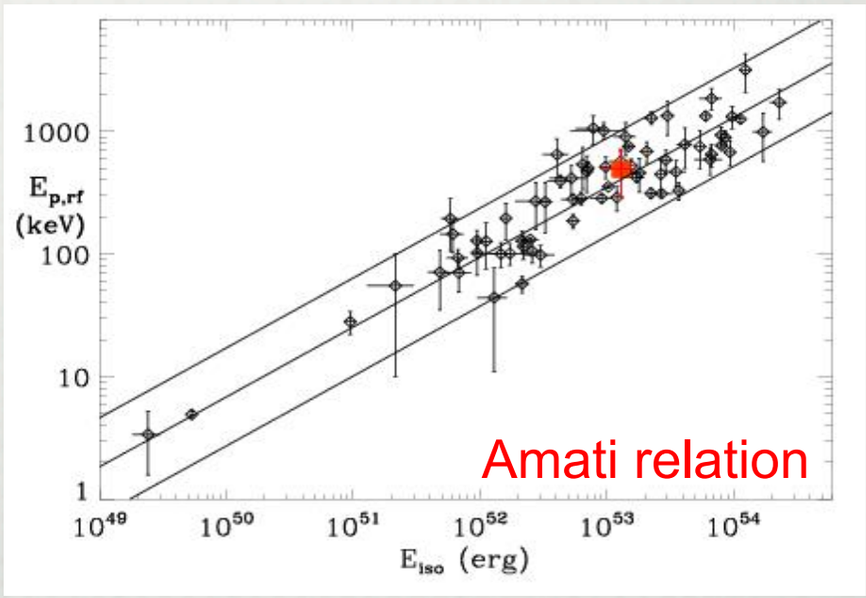
grb 090423



see also VLT obs by Tanvir et al. 2009

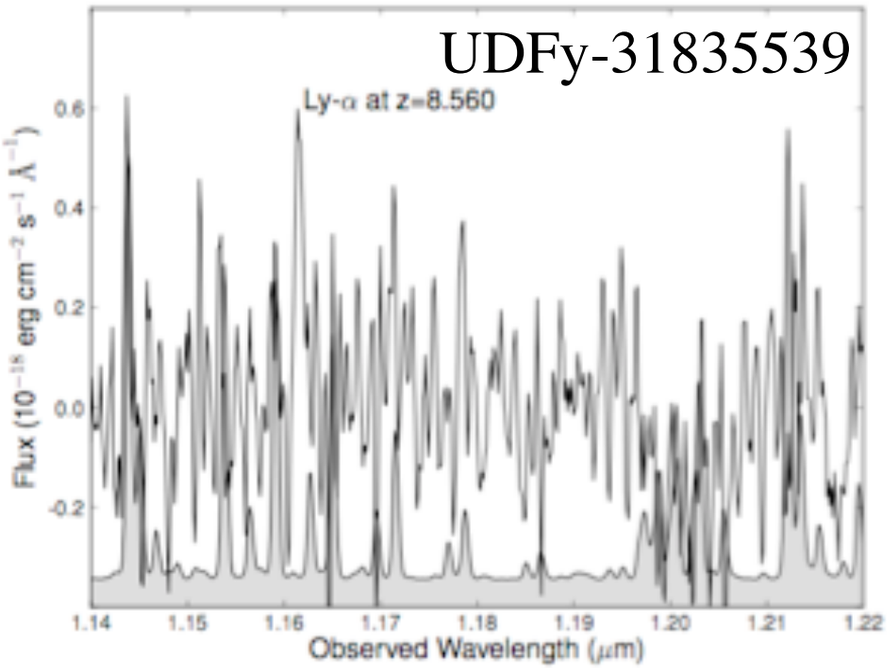
- GRBs do exist at those early epochs (and are detectable!)
- similar to lower-z GRBs



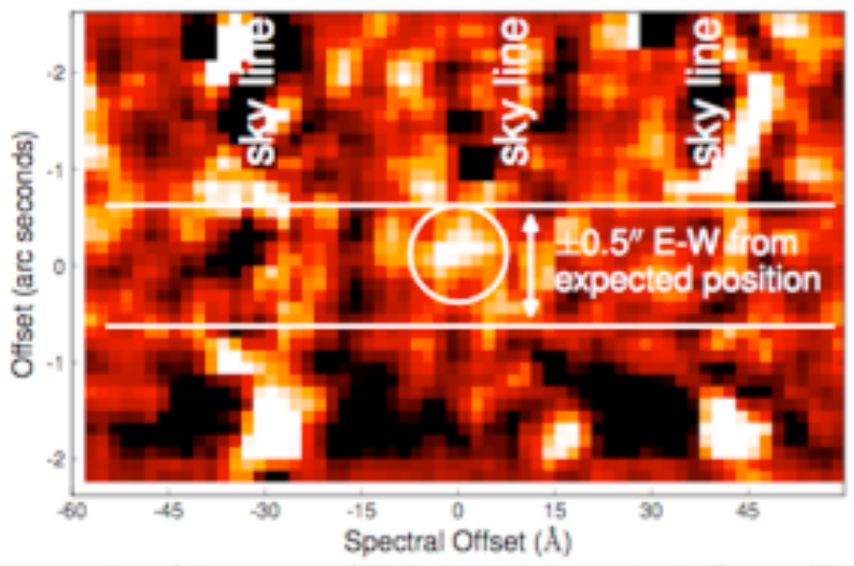


RS et al. 2009 Nature

still the most distant spectr. object!



Lehnert et al 2010 Nature

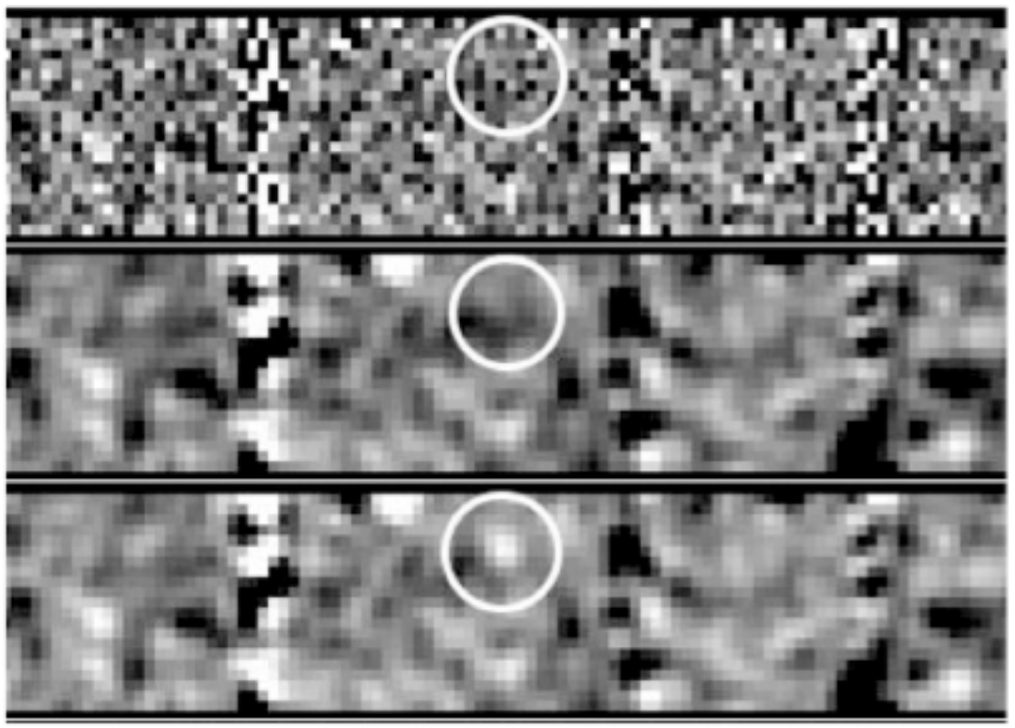


no detection in

5 h with VLT/Xshooter

11 h with Subaru/MOIRCS

Bunker et al. in prep.



grb as a tool

up-to-now 4 GRBs have been detected at z>6: 050904 (z=6.3), 080913 (z=6.7), 090423 (z=8.2) & 090429B (z=9.4)

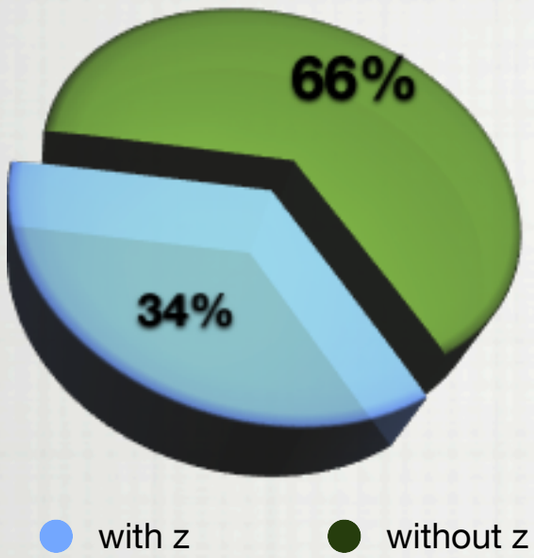
An incomplete list

- ISM metals and dust
- identify and study galaxies responsable of the reionization
- measuring the SFRD
- reionization
- direct detection of PopIII stars
- enrichment by PISN: indirect PopIII detection
- probe the intergalactic radiation field
- escape fraction
- constraints on DM
- ...

see EXIST white paper: McQuinn et al. 2010

towards a complete sample

Swift/BAT [180/540]



Salvaterra et al. 2012

towards a complete sample

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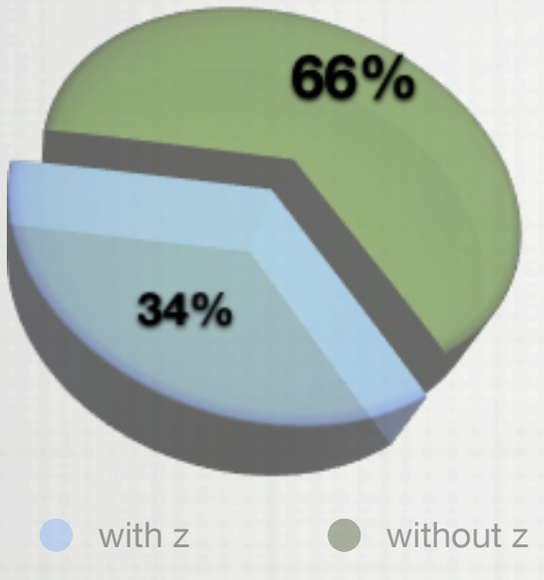
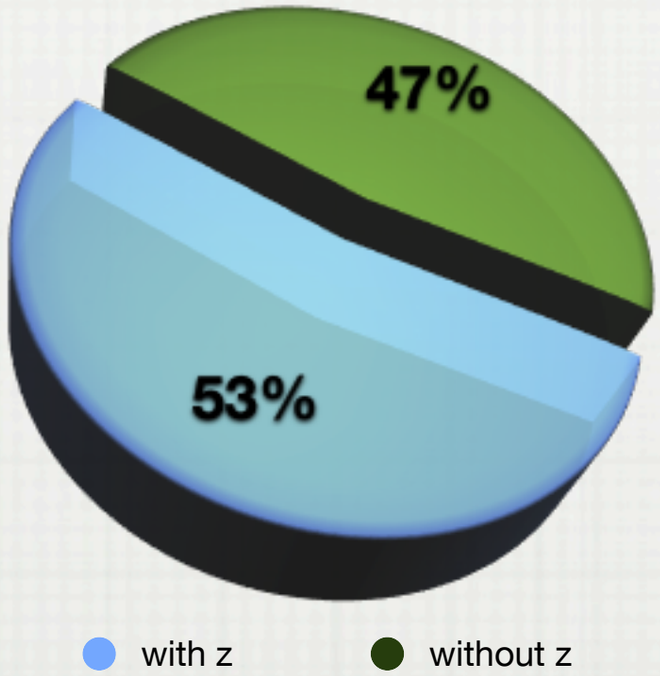


Jakobsson [132/248]



Jakobsson et al. (2004) provides some criteria to select GRBs with favorable observing condition from ground:

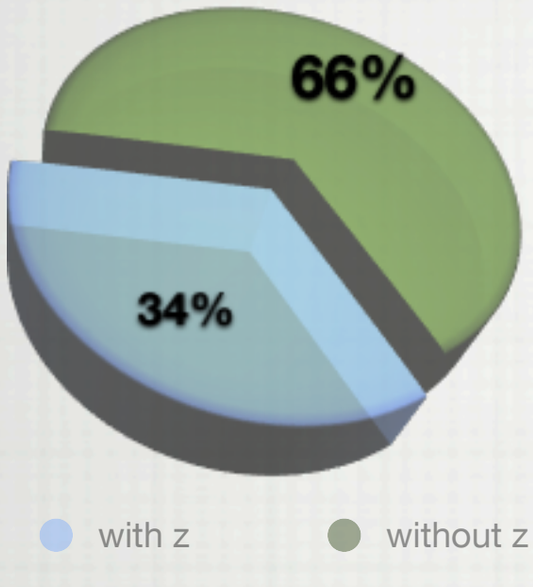
- ☐ XRT position with 12h
- ☐ low Galactic extinction: $A_V<0.5$
- ☐ declination: $-70°<\delta<+70°$
- ☐ distant from Sun: $\theta>55°$

none of these should shape the z-dist

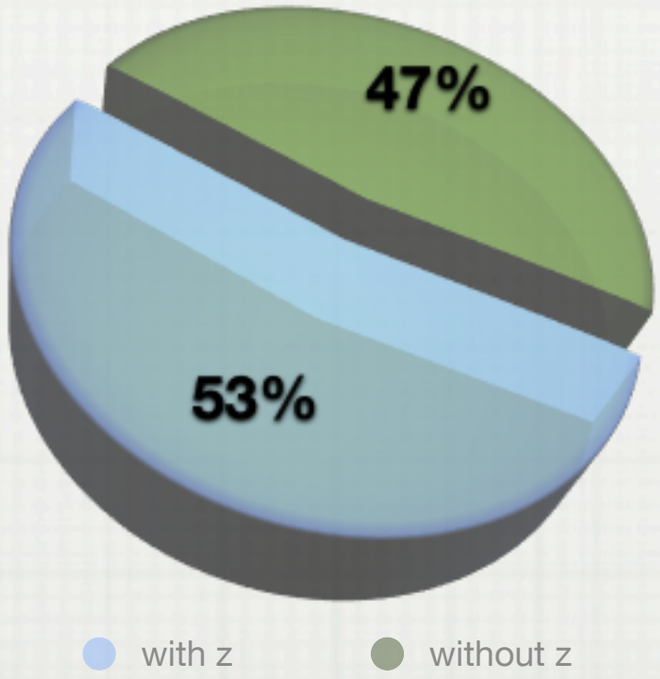
Salvaterra et al. 2012

towards a complete sample

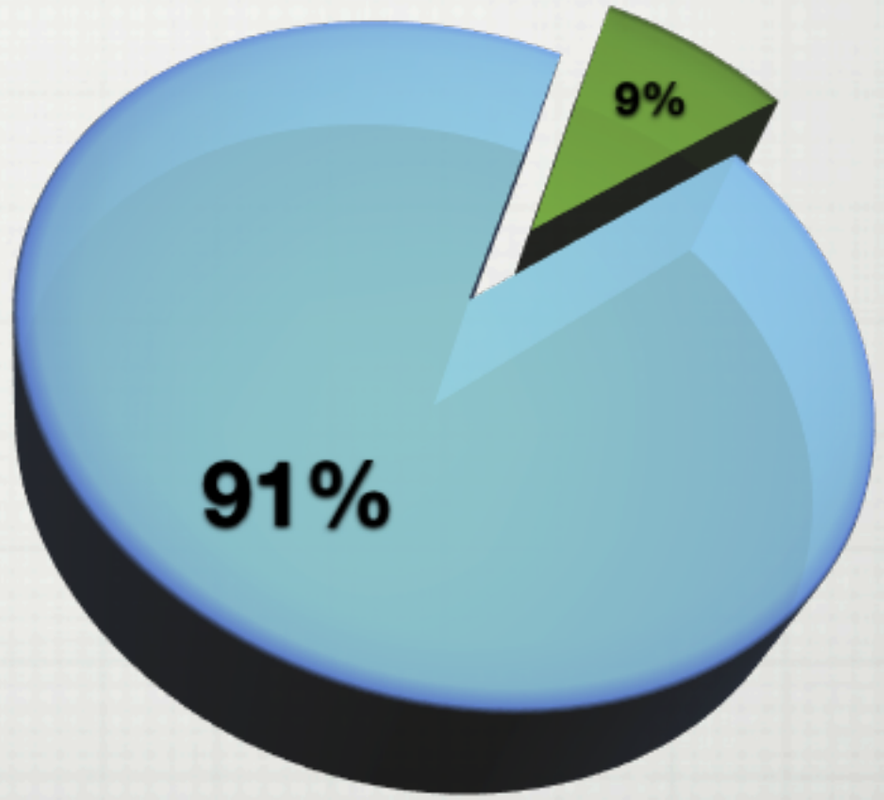
Swift/BAT [180/540]



Jakobsson [132/248]



Swift/BAT6 [53/58]



BAT6: Jakobsson criteria + bright in the BAT band

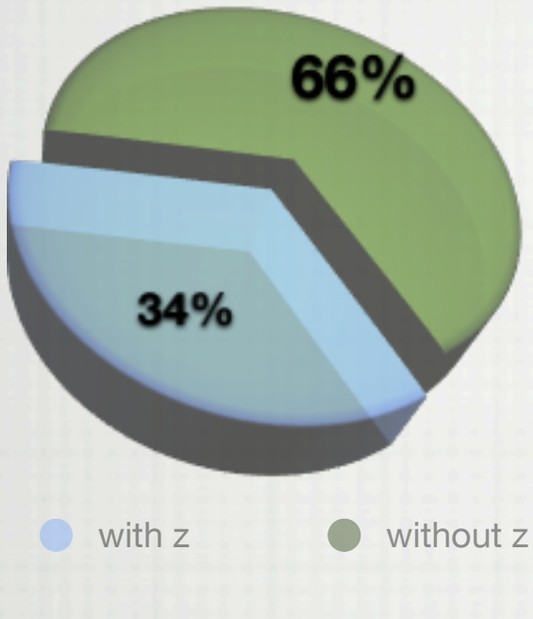
6 times worst sensitivity with respect to BAT

introduces a bias the z-dist. *in a controlled way*

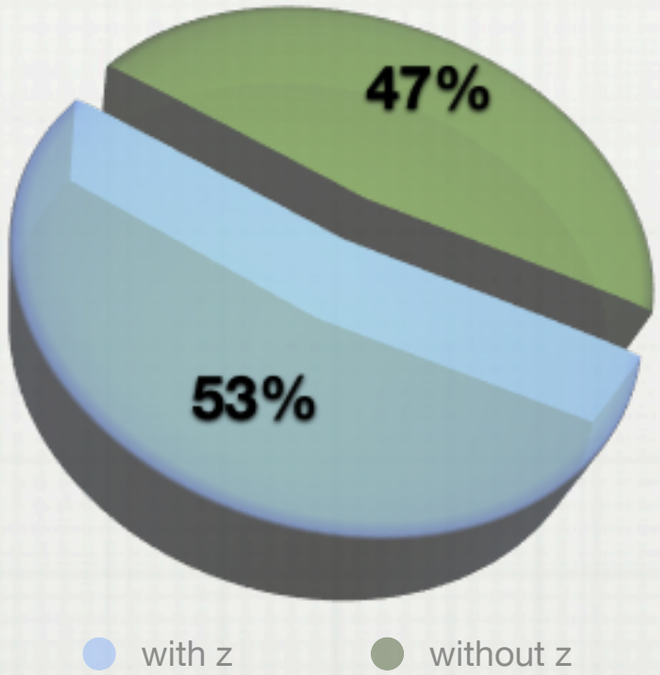
Salvaterra et al. 2012

towards a complete sample

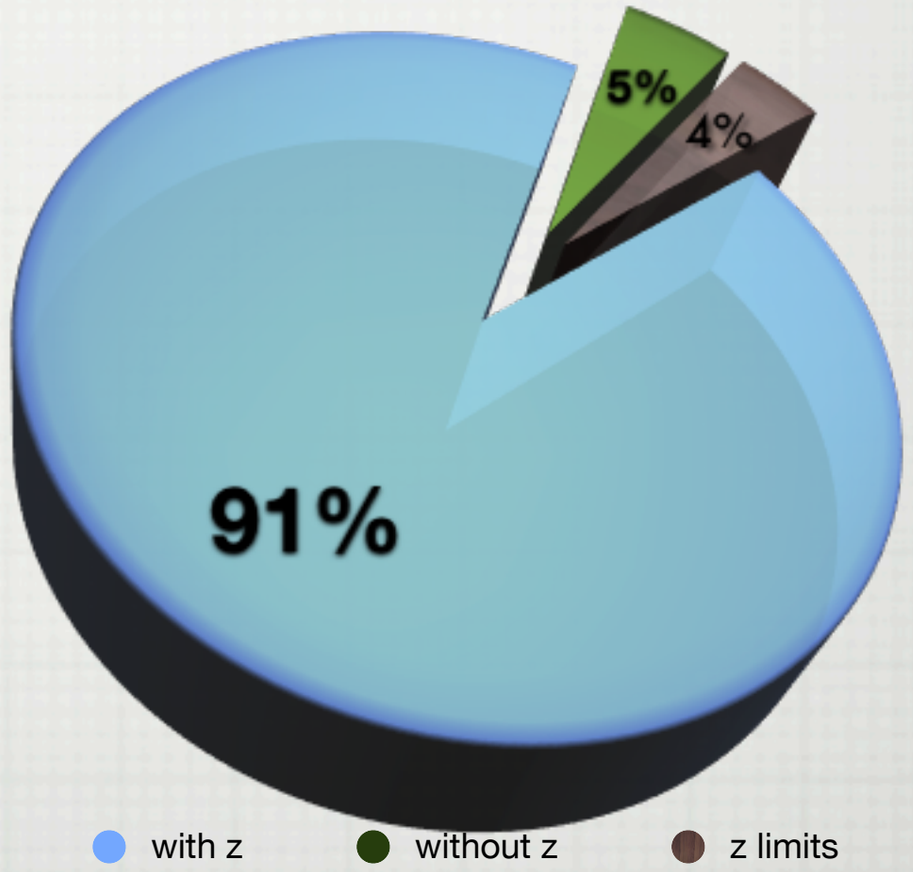
Swift/BAT [180/540]



Jakobsson [132/248]



Swift/BAT6 [55/58]



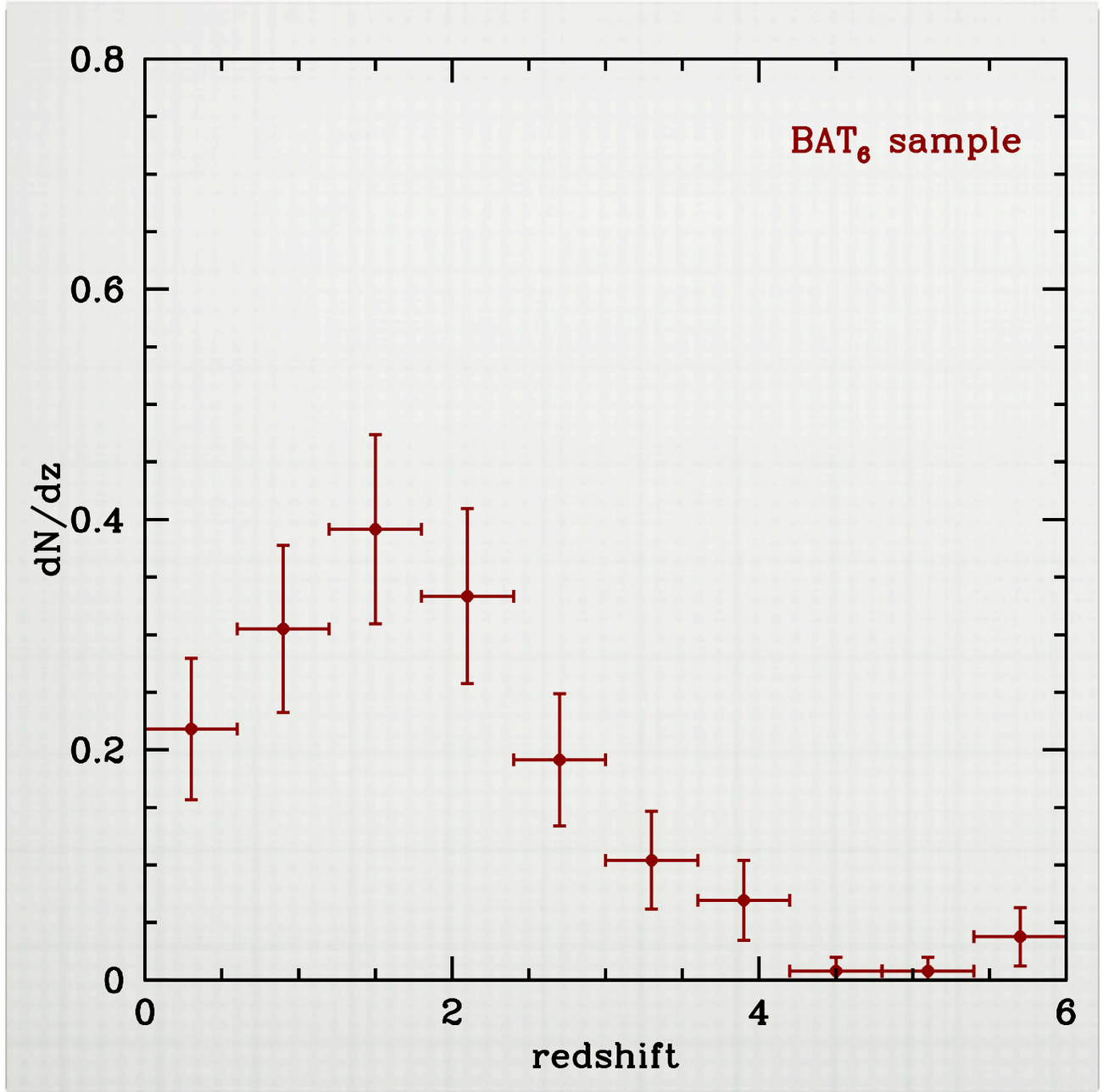
BAT6: Jakobsson criteria + bright in the BAT band

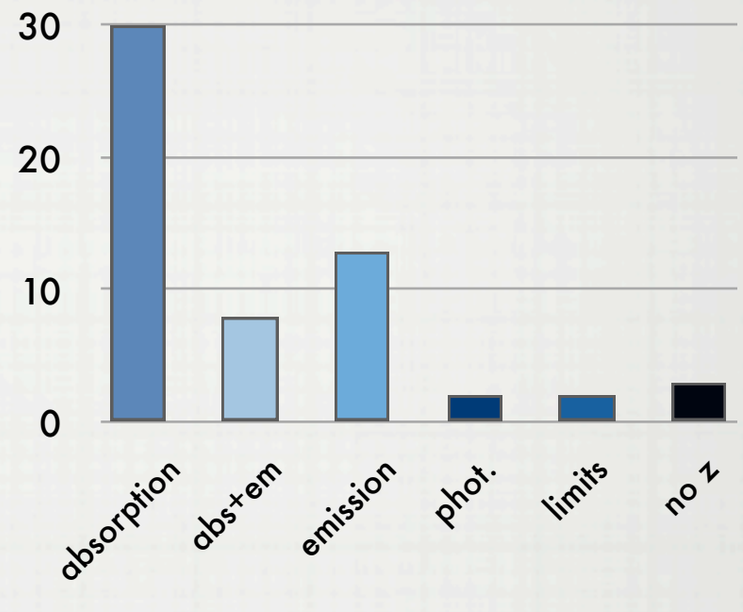
6 times worst sensitivity with respect to BAT

introduces a bias the z-dist. *in a controlled way*

Salvaterra et al. 2012

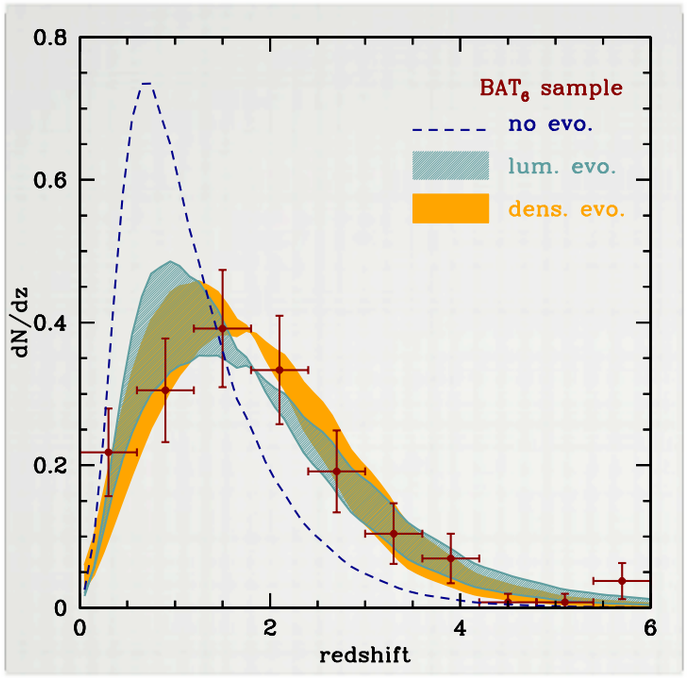
BAT_6 redshift distribution





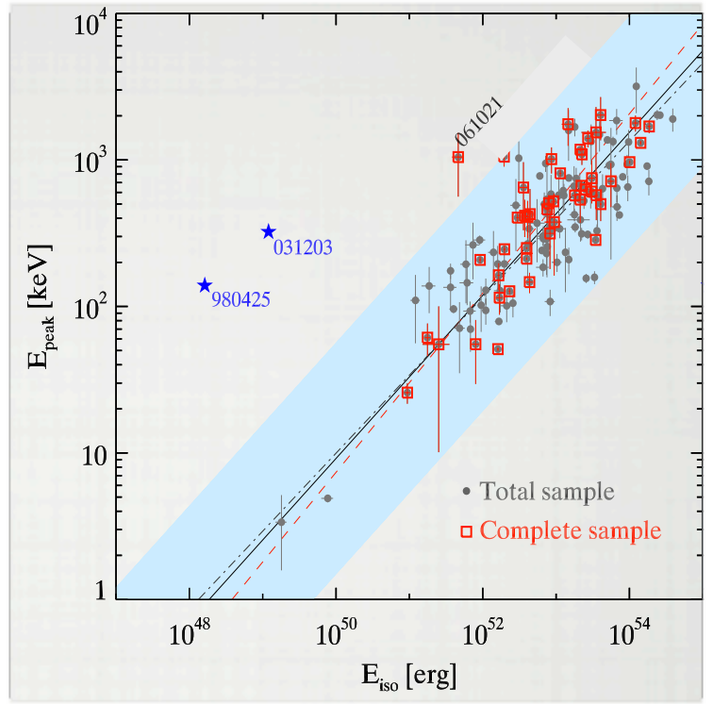
in spite of the severe cut in photon flux the mean (median) redshift is 1.82±0.14 (1.62±0.10) and the distribution extend at least up to z=5.47

Salvaterra et al. 2012

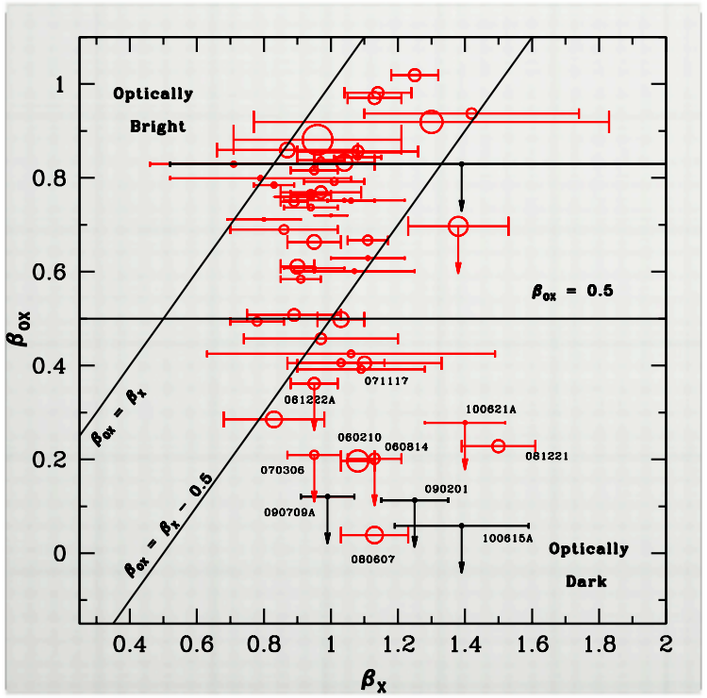


GRB LF and evolution
RS et al. 2012

prompt correlations
Nava et al. 2012

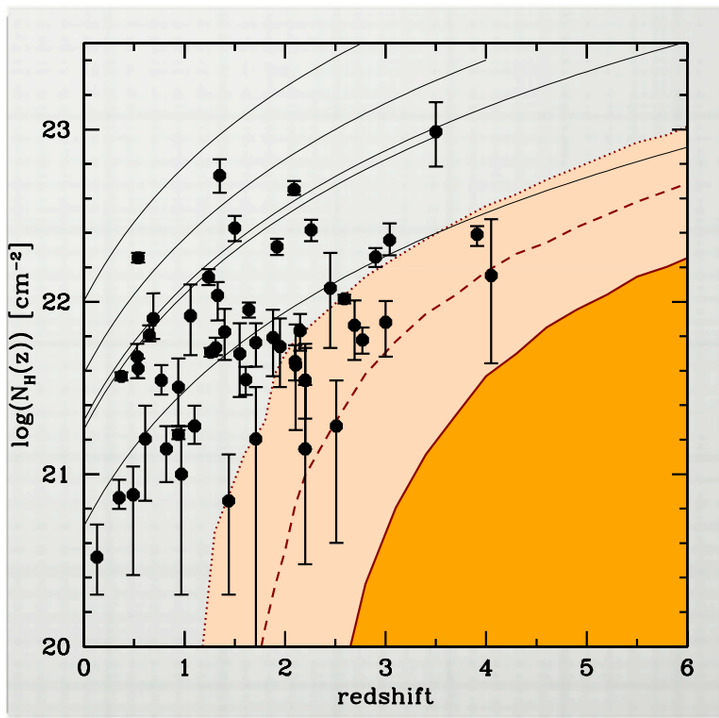


some use of the complete sample

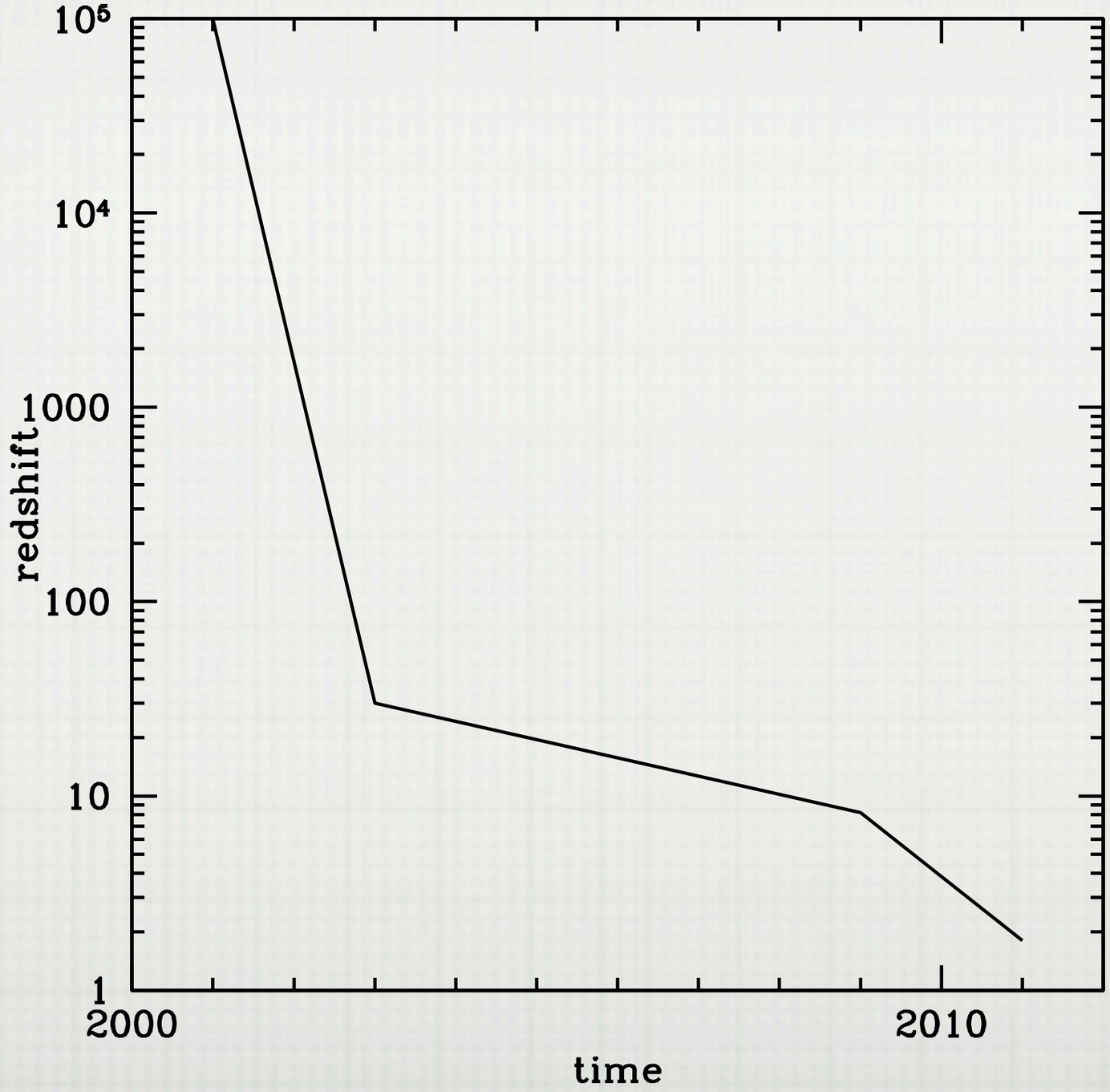


dark burst population
Melandri et al. 2012

X-ray absorption
Campana et al. 2012



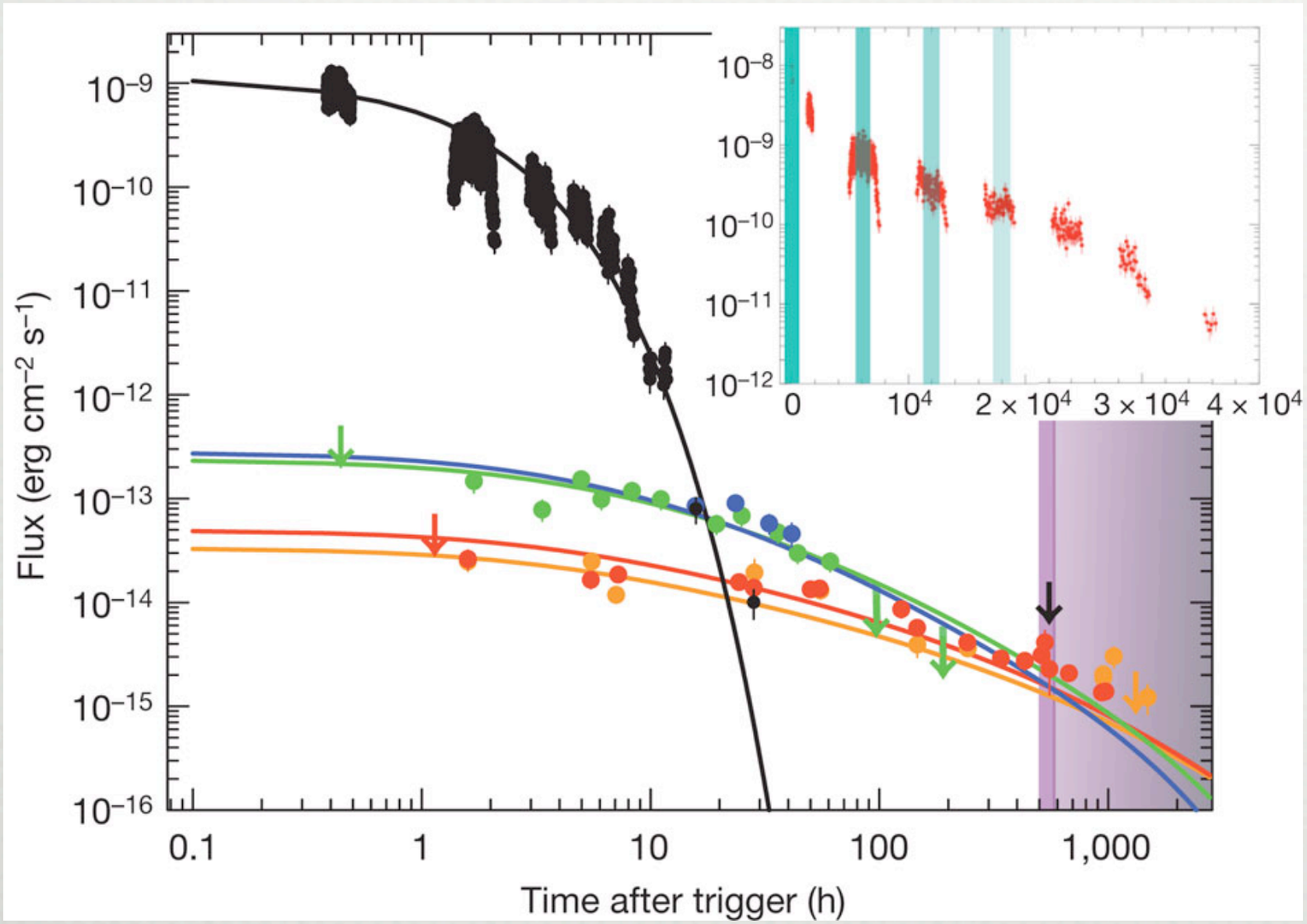
conclusion I



- ☑ stars
- ☑ dust
- ☑ GRBs

conclusion II

unusual properties of the Christmas burst (aka GRB 101225A) as due to a minor body (a comet!) falling onto a NS in the Perseus arm

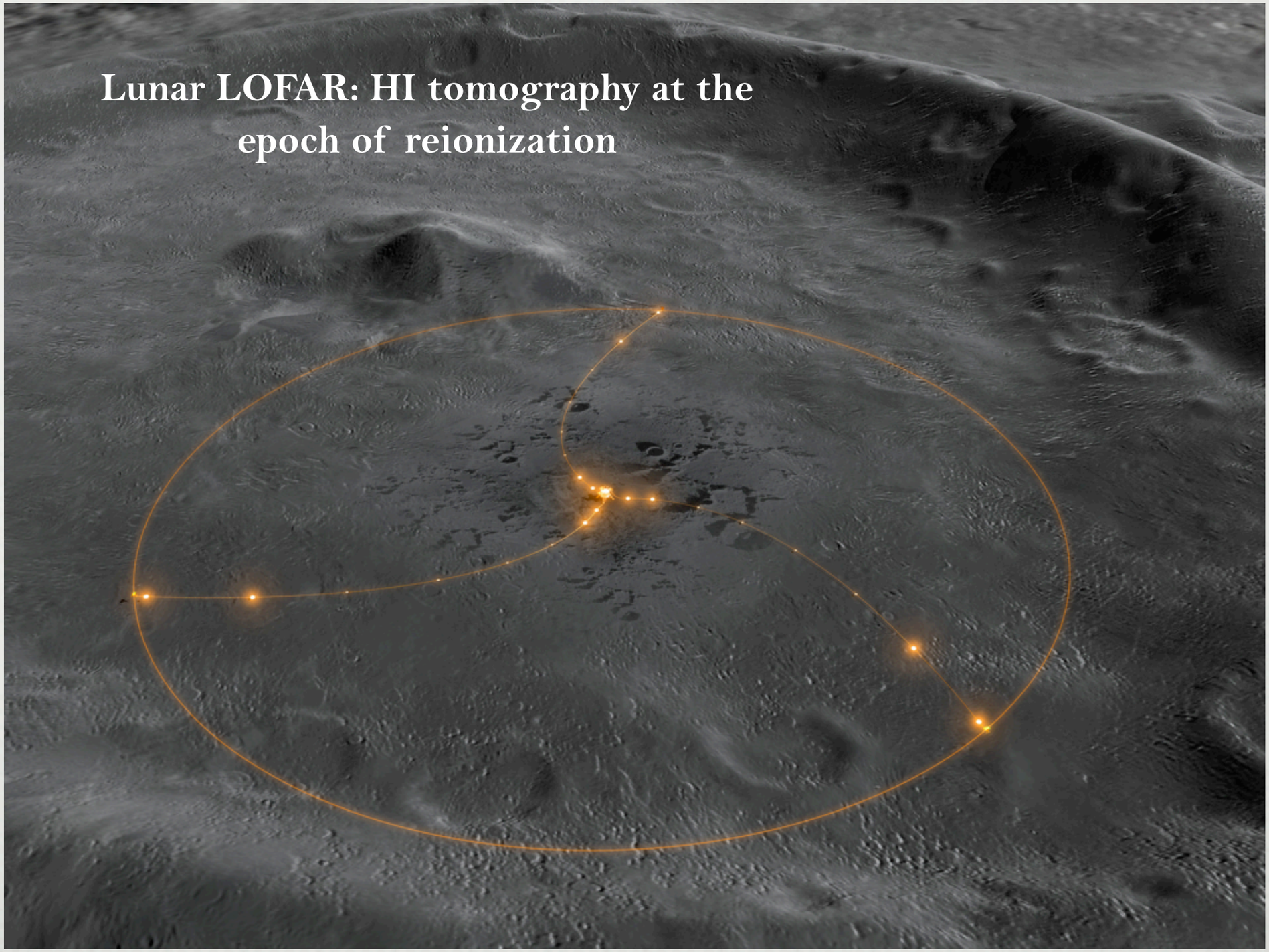


a z=0 event !

Campana et al. 2011 Nature

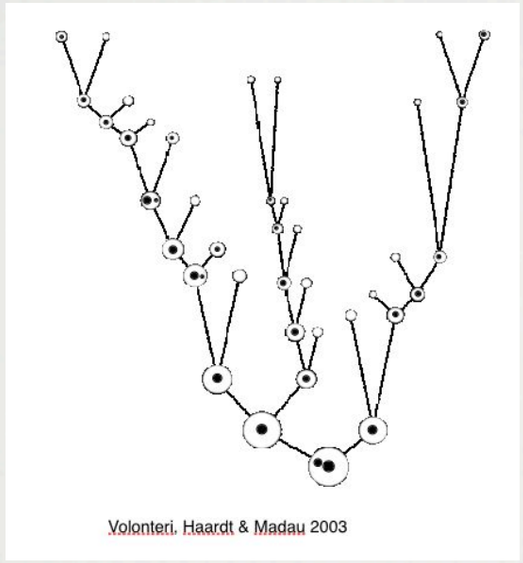
future prospects

future prospects

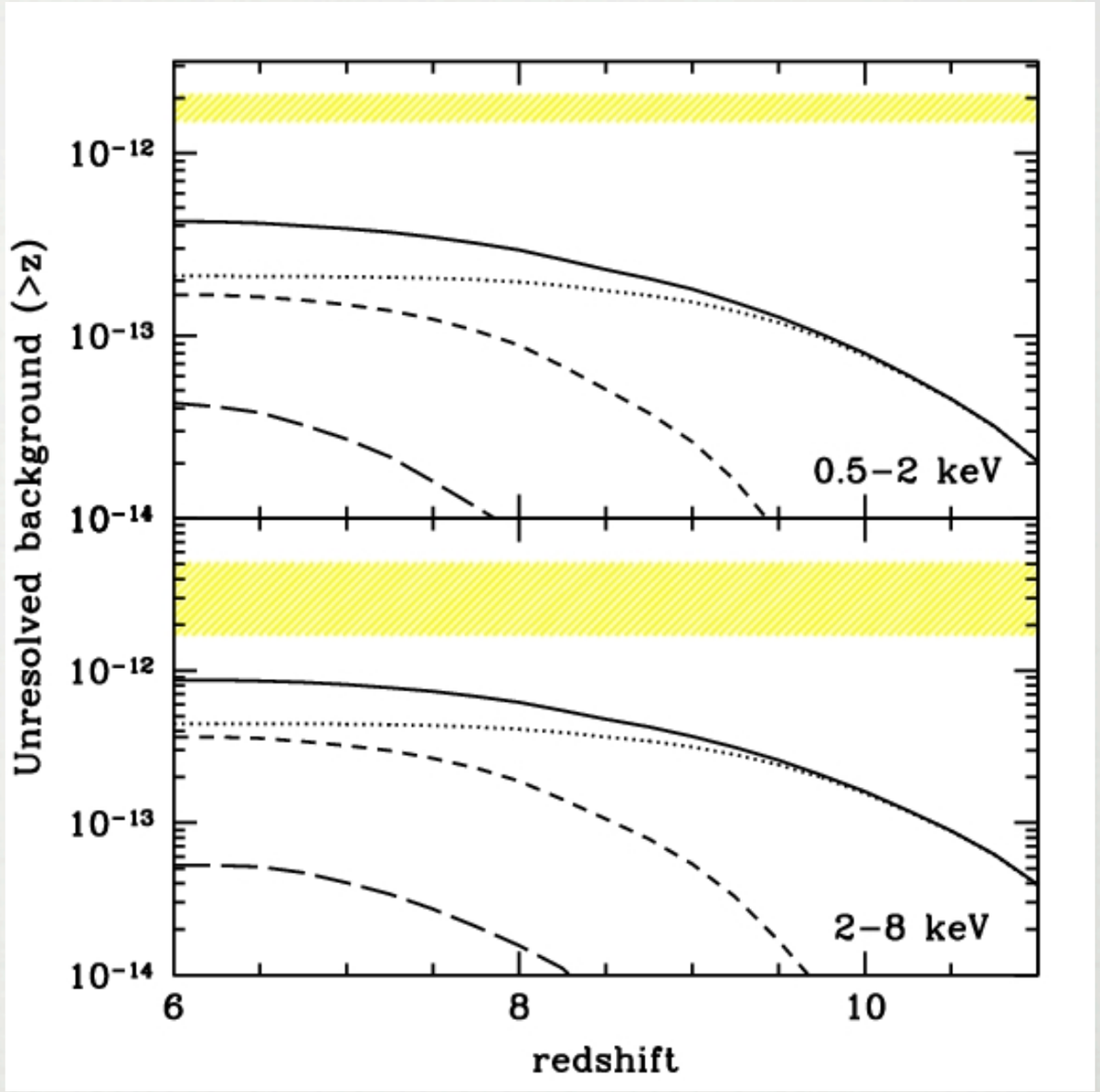


Text

high-z AGN and the unresolved



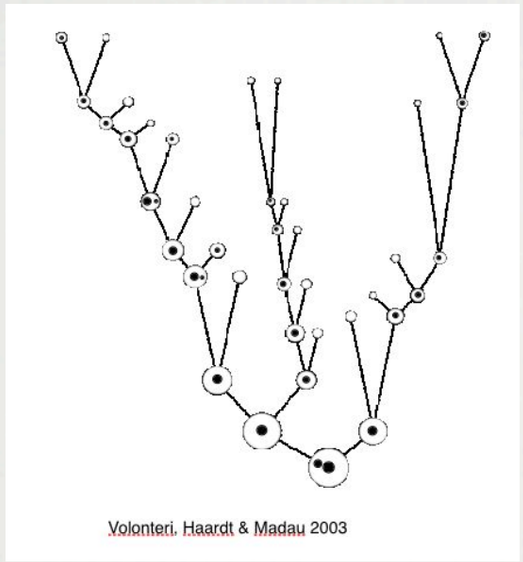
seed ~600 Msun Eddigton limited
e=0.12 for $10^{9.5}$ Msun at z=6



high-z AGN contribute up to 25% of the unresolved XRB (5% of the total XRB) mostly from M<10^6 Msun BHs and from sources at z>8-9

3-4% of the total XRB will remain unresolved even after a survey 10x deeper than CDFN

high-z AGN and the unresolved



Volonteri, Haardt & Madau 2003

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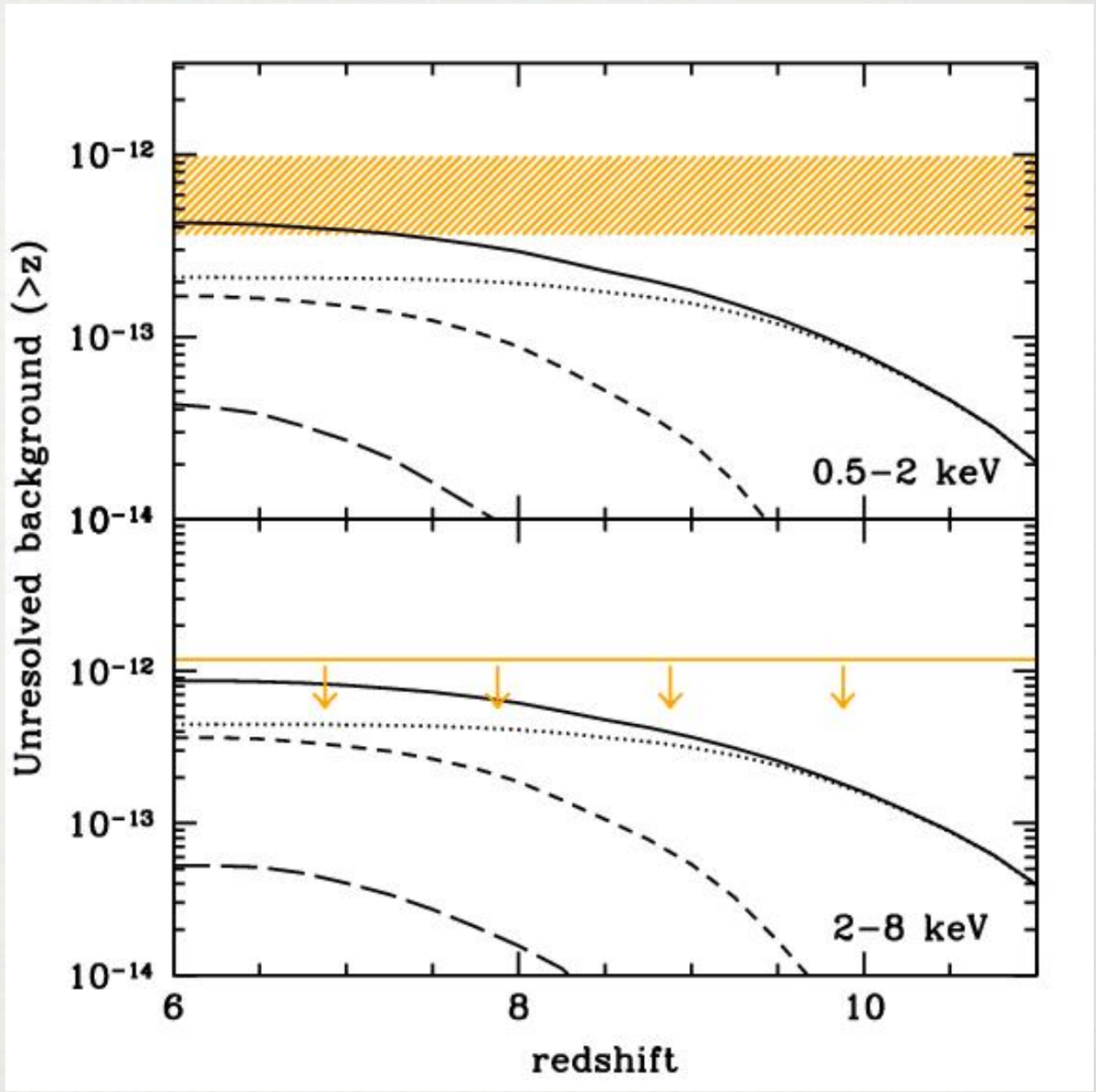

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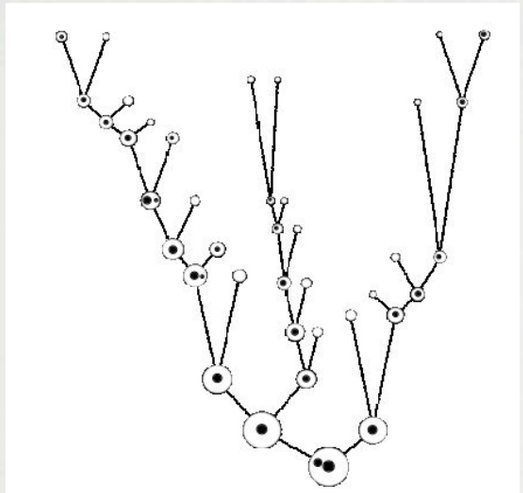

Volonteri, Haardt & Madau 2003

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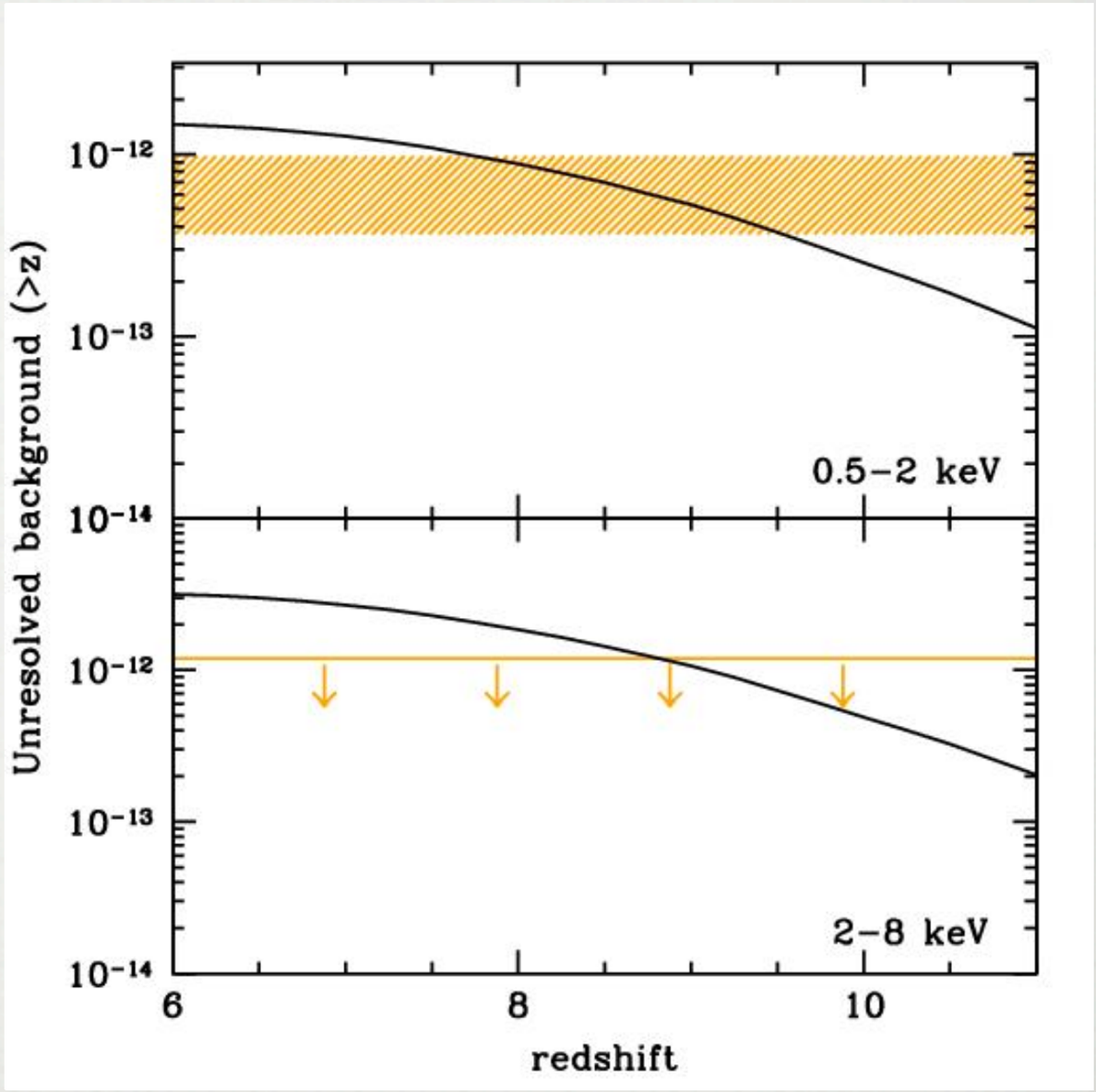
alternative models (super-Edd or massive seeds) seem to overpredict the XRB



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