“The gamma-ray bursts and core-collapse supernovae - global star forming rate at large redshifts (GRBR vs. SFR)”

GRB rate, galaxies and star forming at large red shifts. On model-independent observational tests.

-

A review on statement of some problems…

(Is evolution of anything observed as z increases?)

V. V. Sokolov

By the 2013 the state of the GRB problem and the progress in this field could be formulated in the following way:

Gamma-ray bursts belong to the most distant observable objects with measurable redshift.

Gamma-ray bursts are related to the star formation in distant (and very distant) galaxies.

Gamma-ray bursts and their afterglows also allow us seeing the most distant explosions of massive stars at the end of their evolution.

This is confirmed by observations of the "long" bursts, but, most probably, the "short" GRBs are also related to some very old compact objects formed in the course of evolution of the same massive stars.

What is the red shift z (> 10-50?) at which gamma-ray burst are not observable? - Now this is the main GRB cosmological test.

At present GRB 090429B at **z = 9.4** (Cucchiara et al. 2011) is the record object.

GRB 090423, **z = 8.26** (Salvaterra et al. 2009; Tanvir et al. 2009),

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Chandra et al. (2010) reported about discovery of an afterglow in radio (SNe?) from GRB 090423 (z=8.26), Frail et al. (2006) for GRB 050904 (z = 6.3)…

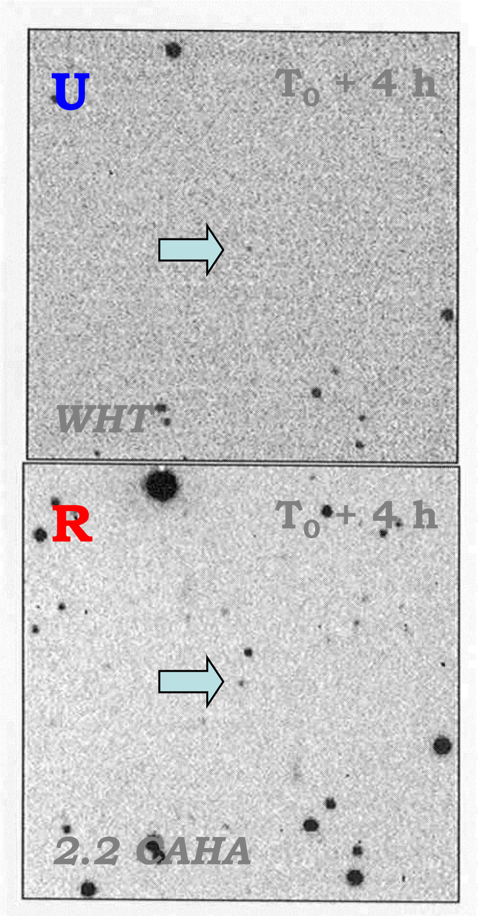
Observations of GRB-afterglows allow us determining physical properties of explosion and circumstellar matter.

It would be interesting to look for such different signs in GRB afterglows at high and low red shifts.

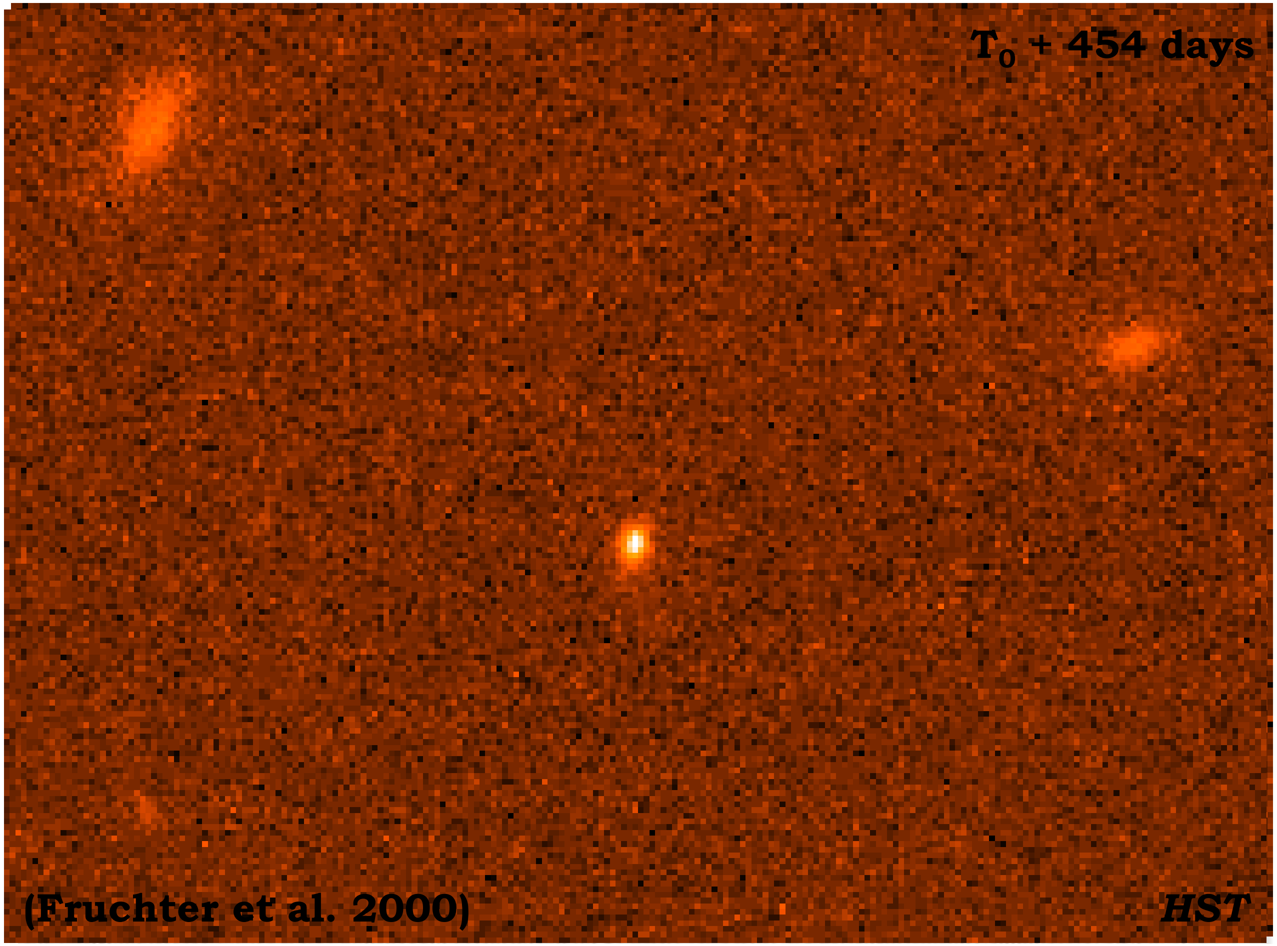
[The high red shift of quasars is z = 7.085 (Mortlock et al. 2011) and z = 6.41 (Willott et al. 2003)…]

GRBs & SFR at z ~ 10

The first afterglow spectral obs for long GRB 970508



(Castro-Tirado et al. 1998, Science 279, 1011.)



GRB 970508 at z > 0.835: First Sp cosmol. origin evi.!

The monitoring of GRB afterglows and the study of their host galaxies with the SAO RAS 6-m telescope from 1997

V. Sokolov et al.

- The **first result of the GRB optical identification** (with objects already known before): GRBs are identified with **ordinary** (or the most numerous in the Universe) galaxies up to 28 st. magnitudes and more.

- **The GRB hosts should not be special, but normal field star forming galaxies for the same redshifts and magnitudes.**

The “simple” (but brawl ☺) conclusion:

- It is shown that these **galaxies are usual ones** with a **high star formation** rate, they are mainly observed in optical at redshifts about 1 and higher.
- *V. V. Sokolov, T. A. Fatkhullin, A. J. Castro-Tirado, A. S. Fruchter et al.,* ***2001***
- GRB hosts should not to be special, but **normal star-forming galaxies** (the most abundant), detected at any z just because a GRB event has occurred
- *see S.Savaglio et al.,* ***2006-2009***

- The **first result** of the GRB optical identification (with objects already known before): GRBs are identified with ordinary (or the most numerous in the Universe) galaxies up to 28 st. magnitudes and more. The GRB hosts should not be special, but normal field star-forming galaxies at comparable redshifts and magnitudes.
- The **second result** of the GRB identification: now the long-duration GRBs are identified with (may be) ordinary (*massive)* core-collapse supernovae (CC-SNe, see in the **poster** report).
- **So, we have the *massive* star-forming in GRB hosts and *massive* star explosions –**
- **CC-SNe & GRBs**

GRBs and SNe with **spectroscopically confirmed** connection:

GRB 980425/SN 1998bw (z=0.0085),

GRB 030329/SN 2003dh (z=0.1687),

GRB 031203/SN 2003lw (z=0.1055),

GRB/XRF 060218/SN2006aj (z=0.0335)

XRF 080109/SN2008D (z=0.0065)

GRB 100316D/SN2010bh (z=0.059)

+ the numerous phot. confirmations

Searching for more Sp. confirmed pairs of GRBs (XRFs) and SNe in future observations is very important for understanding the nature of the GRB-SN connection, the nature of GRBs, and the mechanism of core-collapse SNe explosion (see more in the posters…)

astro-ph/1301.0840

On 18 February 2006 Swift detected the remarkable burst GRB 060218 that provided considerable new information on the connection between SNe and GRBs. It was longer (35 min) and softer than any previous burst, and was associated with SN 2006aj at only $z = 0.033$. SN 2006aj was a (core-collapse) SN Ib/c with an isotropic energy equivalent of a few 10^{49} erg, thus underluminous compared to the overall energy distribution for long GRBs. The spectral peak in prompt emission at ~ 5 keV places GRB 060218 in the X-ray flash category of GRBs [39], the first such association for a GRB-SN event. Combined BAT-XRT-UVOT observations provided the first direct observation of shock-breakout in a SN [44]. This is inferred from the evolution of a soft thermal component in the X- ray and UV spectra, and early-time luminosity variations. Concerning the SN, SN 2006aj was dimmer by a factor ~ 2 than the previous SNe associated with GRBs, but still ~ 2–3 times brighter than normal SN Ic not associated with GRBs [45, 46]. GRB 060218 was an underluminous burst, as were two of the other three previous cases. Because of the low luminosity, these events are only detected when nearby and are therefore rare. However, they are actually ~ 5–10 times more common in the universe than normal GRBs [47] and form a distinct component in the luminosity function [48].

TABLE II: Nearby GRBs and Supernova Detections or Limit

GRB	Redshift, z	Type[a]	SN Search
980425	0.0085	long-UL	SN 1998bw
020903	0.251	XRF-UL	LC bump & spectrum
021211	1.006	long-UL	SN 2002lt
031203	0.105	long-UL	SN 2003lw
030329	0.168	long	SN 2003dh
050525A	0.606	long- UL	SN 2005nc
060218	0.033	XRF-UL	SN 2006aj
091127	0.49	long-UL	SN 2009nz
100316D	0.059	long-UL	SN 2010bh
101219B	0.55	long-UL	SN 2010ma
120422A	0.283	long-UL	NS 2012bz
011121	0.36	long-UL	LC bump & spectrum
050826	0.297	long-UL	LC bump
060729	0.54	long- UL	LC bump
090618	0.54	long	LC bump
080120		long	LC bump GROND
081007		long	LC bump GROND
090424		long	LC bump GROND
100902A		long	LC bump GROND
110402A		long	LC bump GROND
040701	0.215	XRF-UL	no SN ($<$ 0.1 SN98bw)
060505	0.089	"long"-UL	no SN ($<$ 0.004 SN98bw)
060614	0.125	"long"	no SN ($<$ 0.01 SN 98bw)
101225A	0.40	long	no SN (GCN 11522)

[a]UL = underluminous, XRF = X-Ray Flash

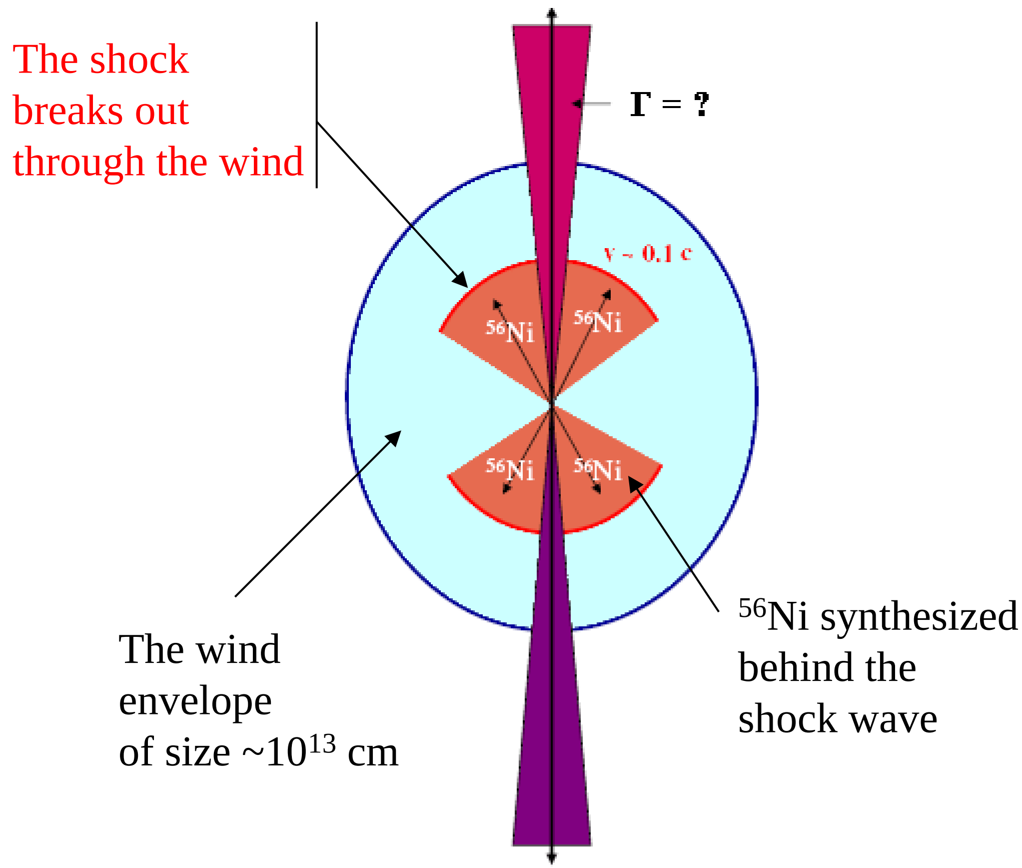
The popular conception of the relation between long-duration GRBs and **core-collapse SNe**
(the picture from Woosley and Heger , 2006)

Shematic model of asymmetric explosion of a GRB/SN progenitor

…a strongly non-spherical explosion may be a generic feature of core-collapse supernovae of all types.

…Though while it is not clear that the same mechanism that generates the GRB is also responsible for exploding the star.

astro-ph/0603297
Leonard, Filippenko et al.



Though the phenomenon (GRB) is unusual, but the object-source (SN) is not too unique.
The closer a GRB is, the more features of a SN.

So,

GRB is a start or a beginning of

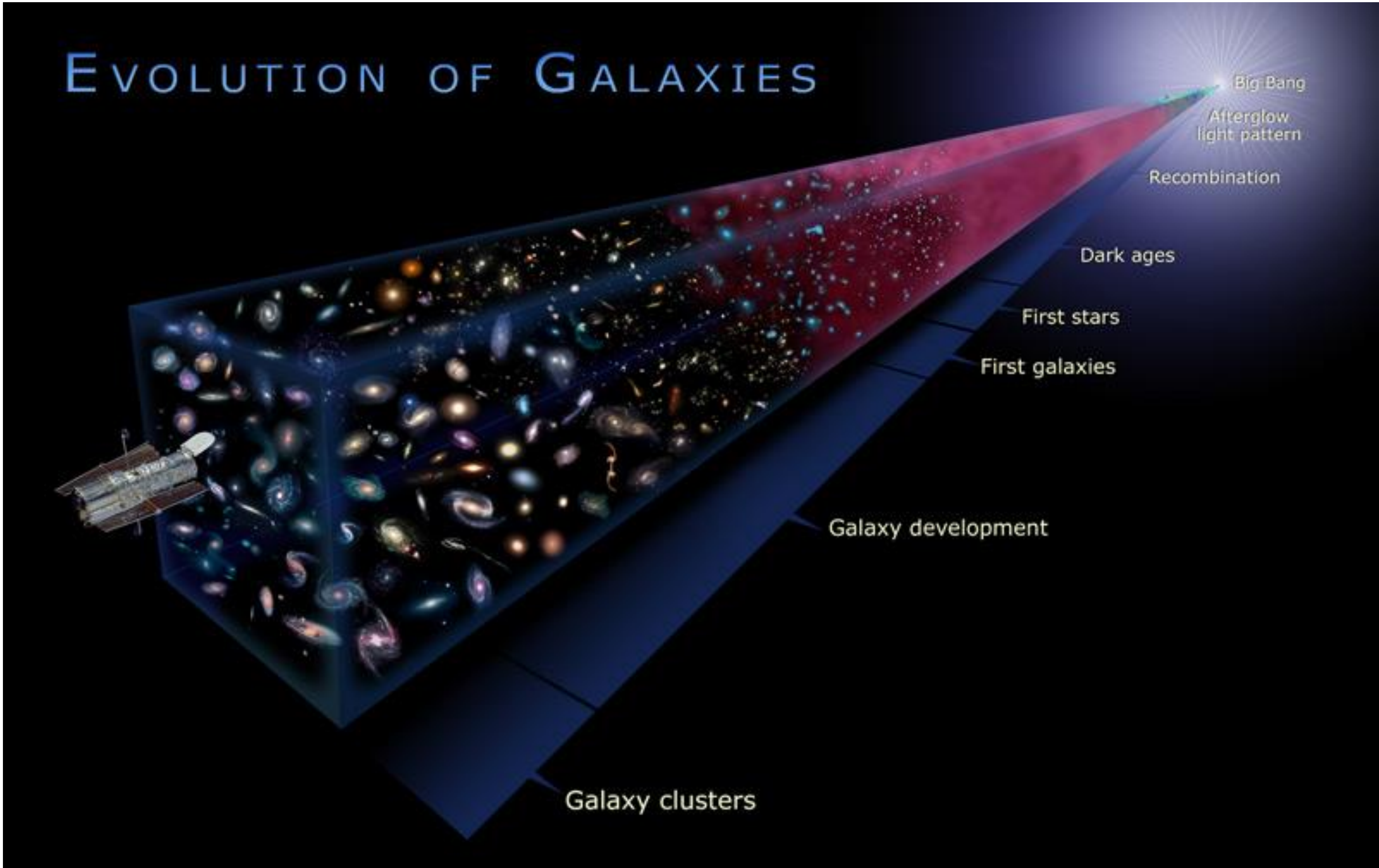
Core Collapse SN

(CC-SN) explosion,

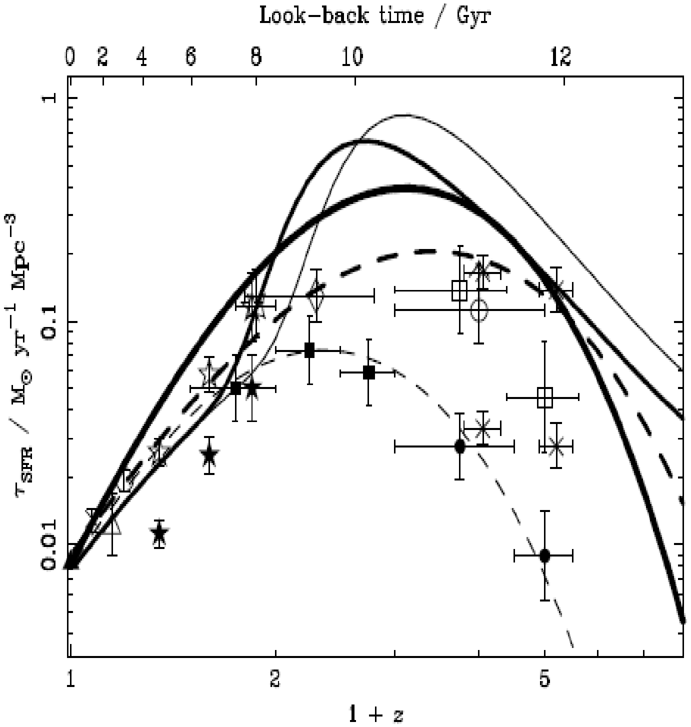
or the massive star core collapse

- The search for **differences between nearby SNe** identified with GRBs **and distant SNe** which are to be identified with GRBs can be an additional observational **cosmological test**.
- We can ask a question analogous to that on GRB hosts: **Do GRB SNe differ from usual (e.g. local) SNe?** What are redshifts at which CC-SNe are quite different from local CC-SNe?
- It **could be the third important result** of the GRB identification.

LCDM predictions



A.W. Blain and Priyamvada Natarajan: **MNRAS (2000), 312**

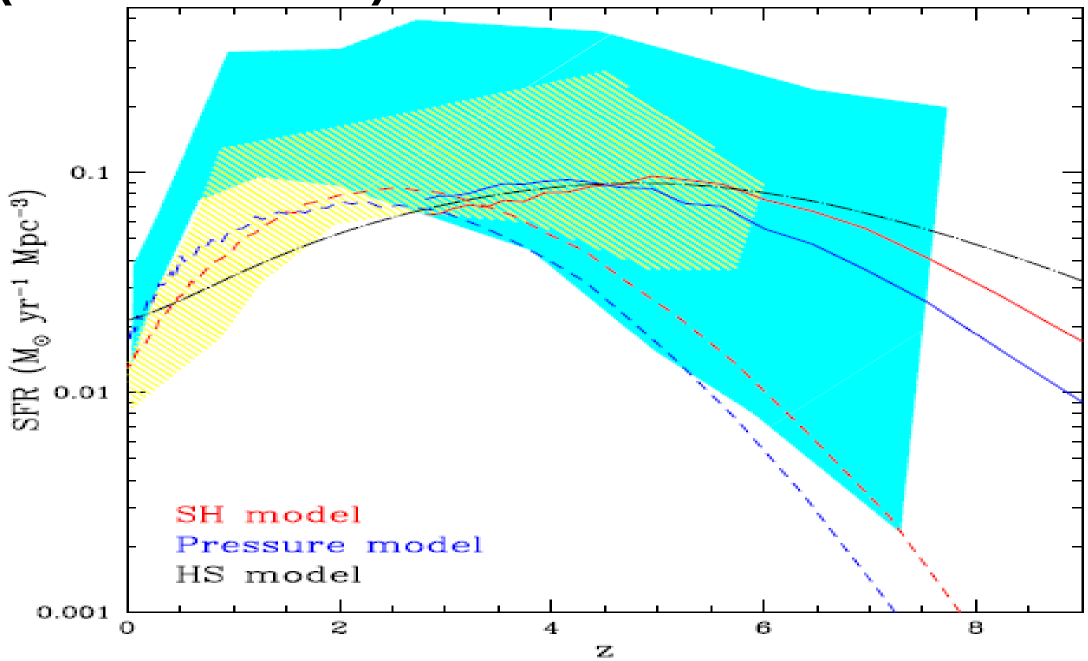


A summary (**2000**) of the current state of knowledge of the SFH of the Universe.

The data points plotted are described in Blain et al. (1999a) and Steidel et al. (1999). The thick and thin dashed curves describe models that represent the dust-corrected and non-dust-corrected histories derived from optical and near-IR observations, which are represented by data points. Where corrections have been made to the optical data to account for the estimated effects of dust extinction, the data is represented by empty symbols, and the higher pair of high-z diagonal crosses.Where no corrections have been applied,the data is represented by filled symbols and by the lower pair of high-z diagonal crosses. The solid lines represent models derived from far-IR and submm emission: a 'Gaussian model' (Blain et al. 1999c), a 'modified Gaussian model' (Barger et al. 1999b) and an 'hierarchical model' (Blain et al. 1999a), in order of increasing thickness.

2010

MNRAS.407.1464C(arXiv:0909.5425)



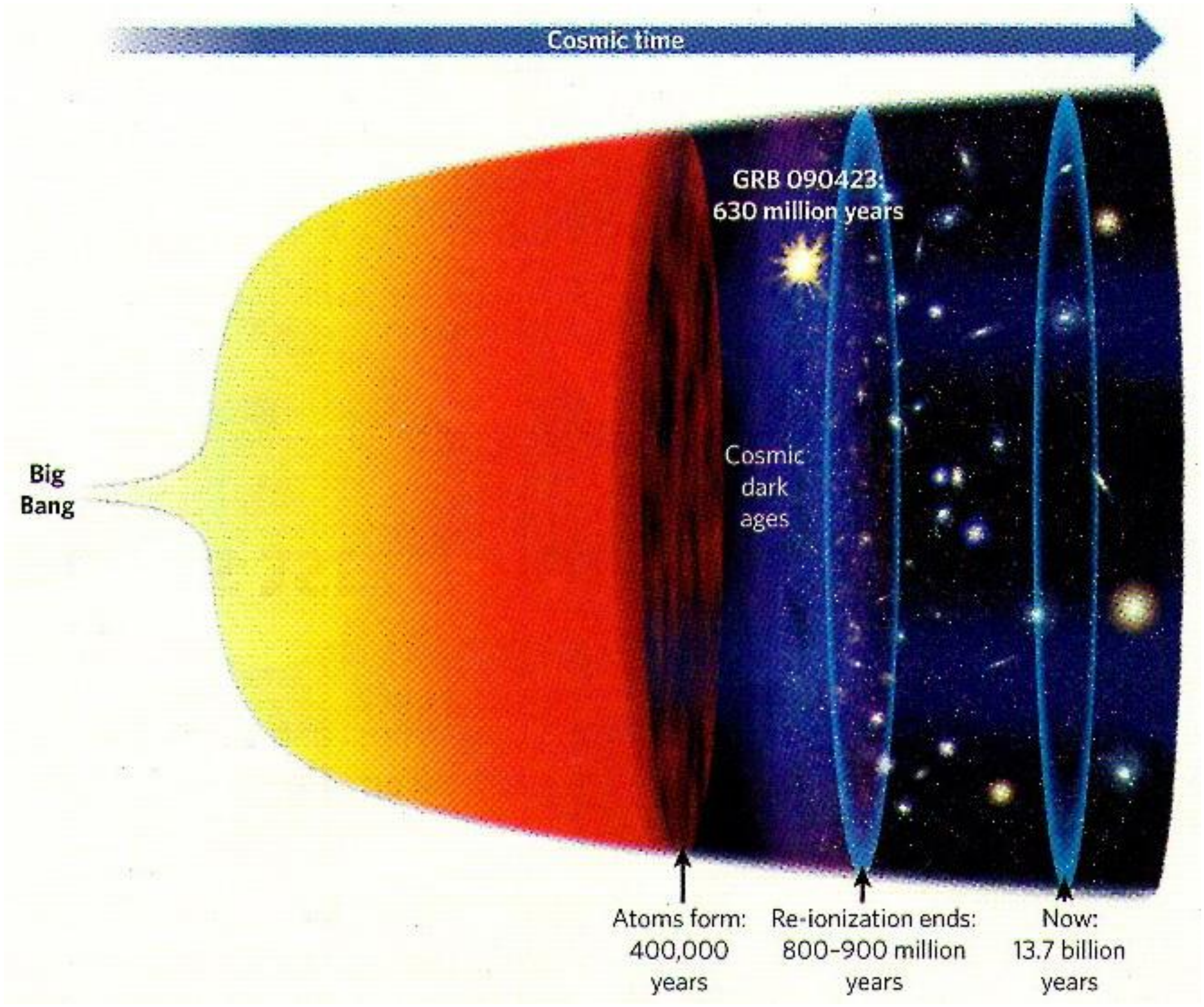
The **cyan** shading is the observed range of SF history (with GRBs) from Kistler et al. (2009)…

The cosmic star formation history from **simulations** with different SF models.

Effects of cosmological parameters and star formation models on the cosmic star formation history in ΛCDM cosmological simulations **Authors:** Choi, Jun-Hwan; Nagamine, Kentaro

Bing Zhang, Nature 461, p.1222

Z = 8.26



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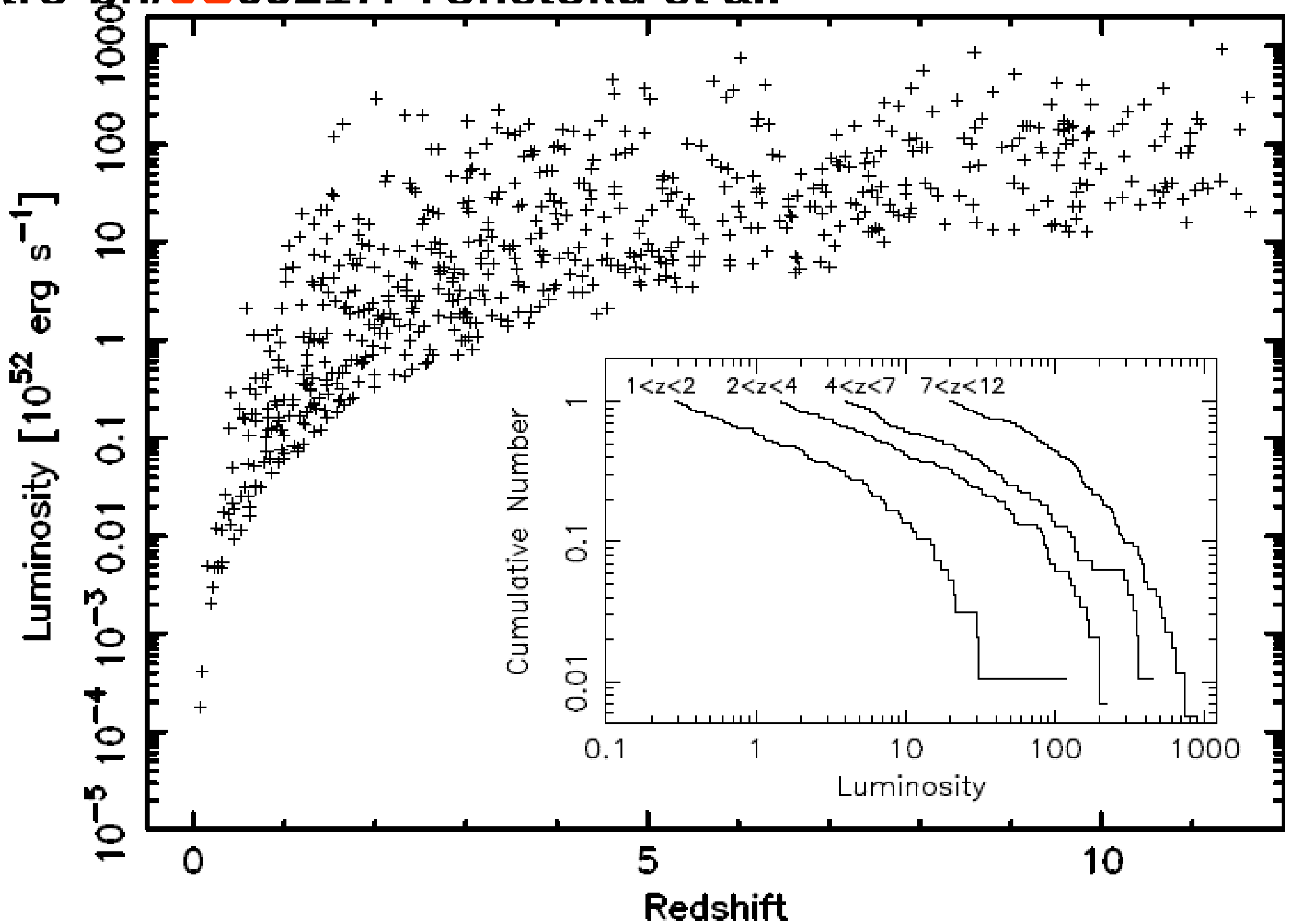
. **Spectroscopic confirmations !**

arXiv:astro-ph/0309217. Yonetoku et al.



The distribution of luminosity vs. redshift derived from the Ep–luminosity relation.

The truncation(усечение) of the lower end of the luminosity is caused by the flux limit of $F_{limit} = 1 \times 10^{-7}$ erg $cm^{-2}s^{-1}$. The inserted figure is the cumulative luminosity function in the several redshift ranges.

The luminosity “evolution” exists because the break-luminosity increase toward the higher redshift.

arXiv: 0809.5206

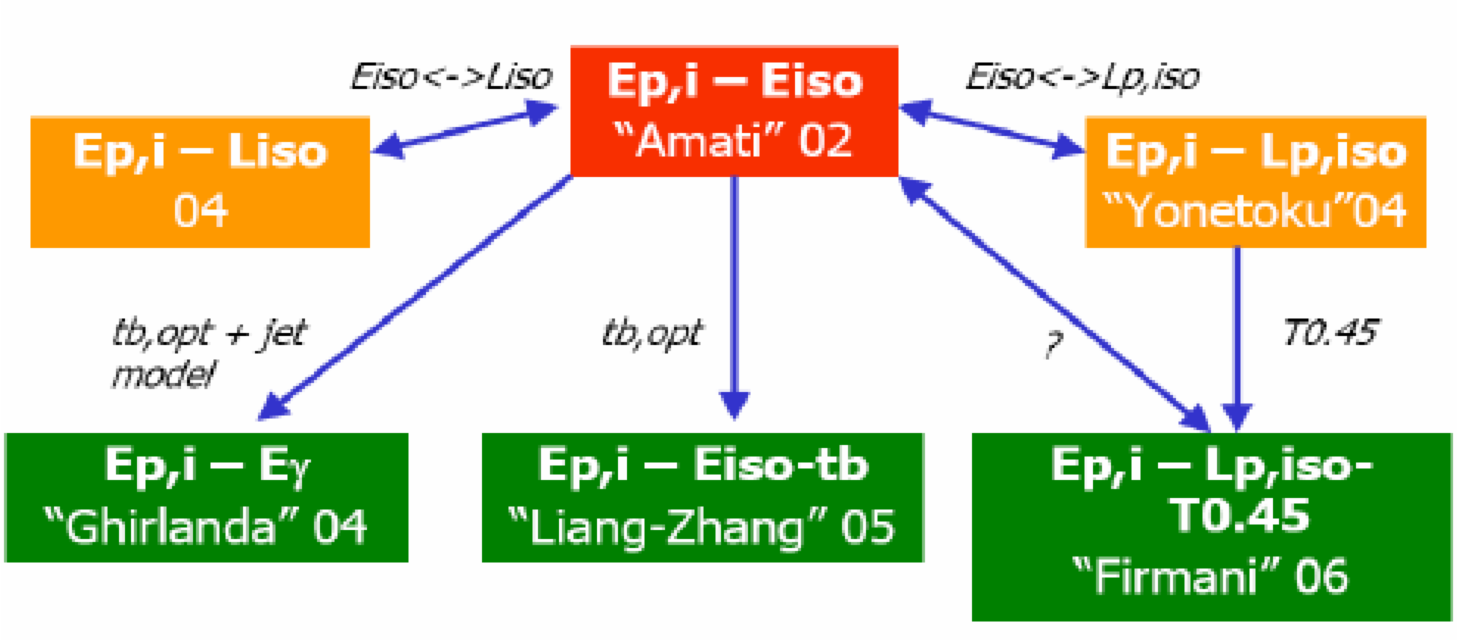


FIGURE 2. The "genealogy" of spectrum-energy correlations. The "name" often found in the literature is reported below each correlation, together with the year. Also shown are the link between the correlations (arrows) and the relevant observables.

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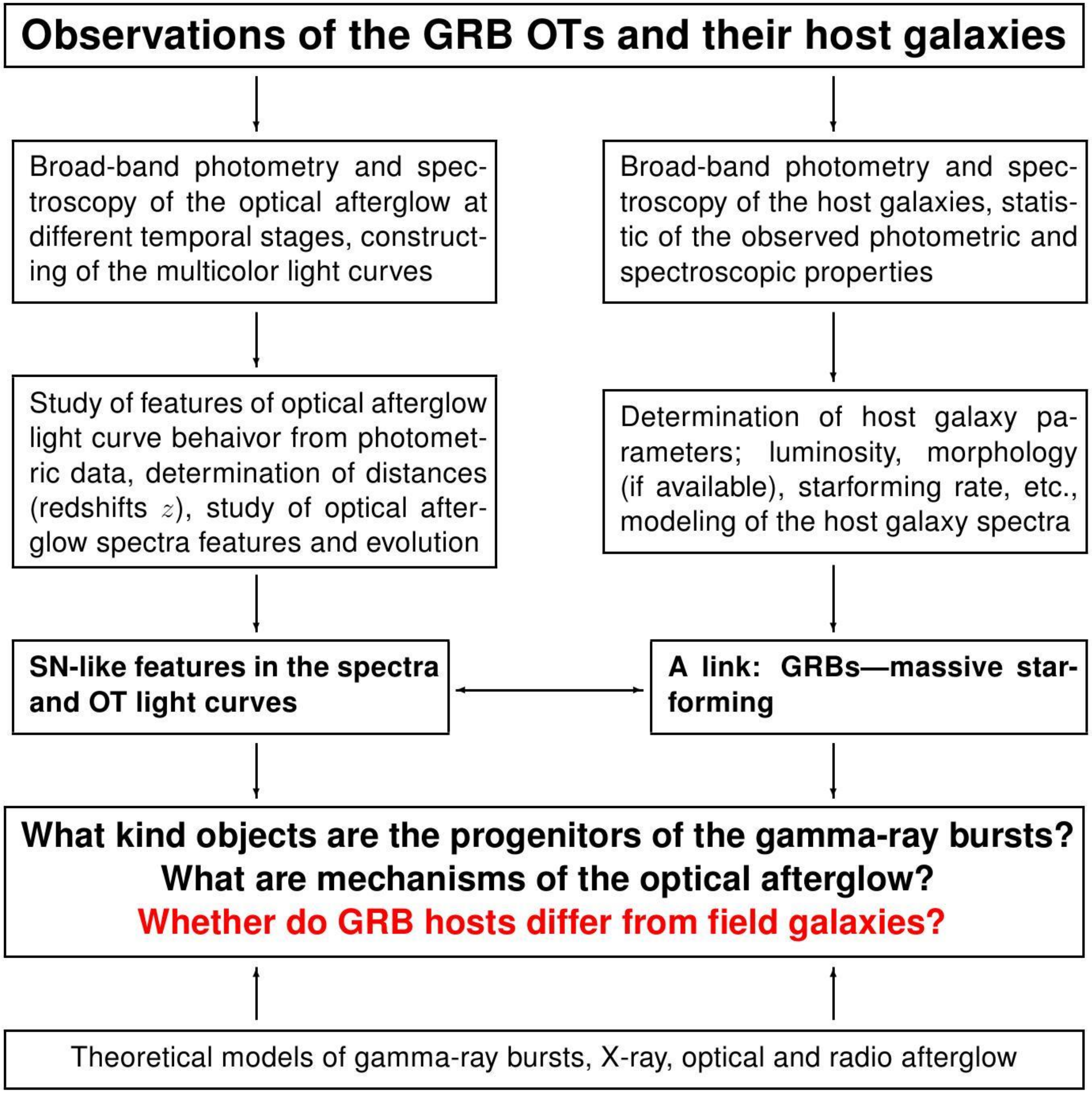
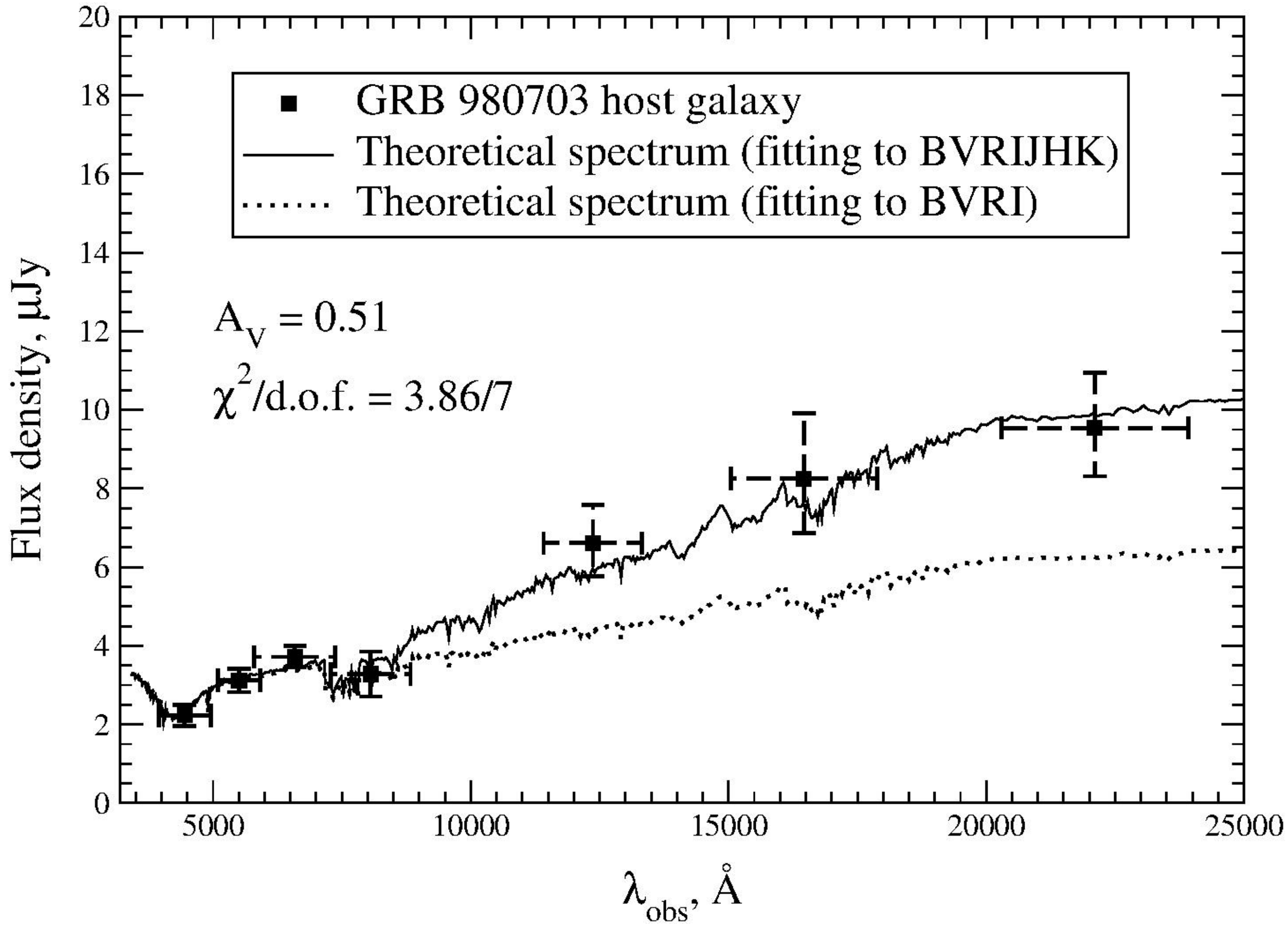
What is the red shift z (> 10-50?) at which gamma-ray burst are not observable? - Now this is the main GRB cosmological test.

And again on the GRB hosts:

!

Astronomy of GRBs with the 6-m telescope from 1998





The population synthesis modeling: Comparison of modeled and observed fluxes in the filters B, V, R_c, I_c, J, H, K for the GRB 980703 host galaxy (**z=0.9662).**

If GRBs are associated with an **active star formation**, then we might expect the light of their host galaxies to be affected by **internal extinction**.

Bull. Spec. Astrophys. Obs., ***2001***, *51*, *48-50*

Table 7: *The selected parameters of two host galaxies*

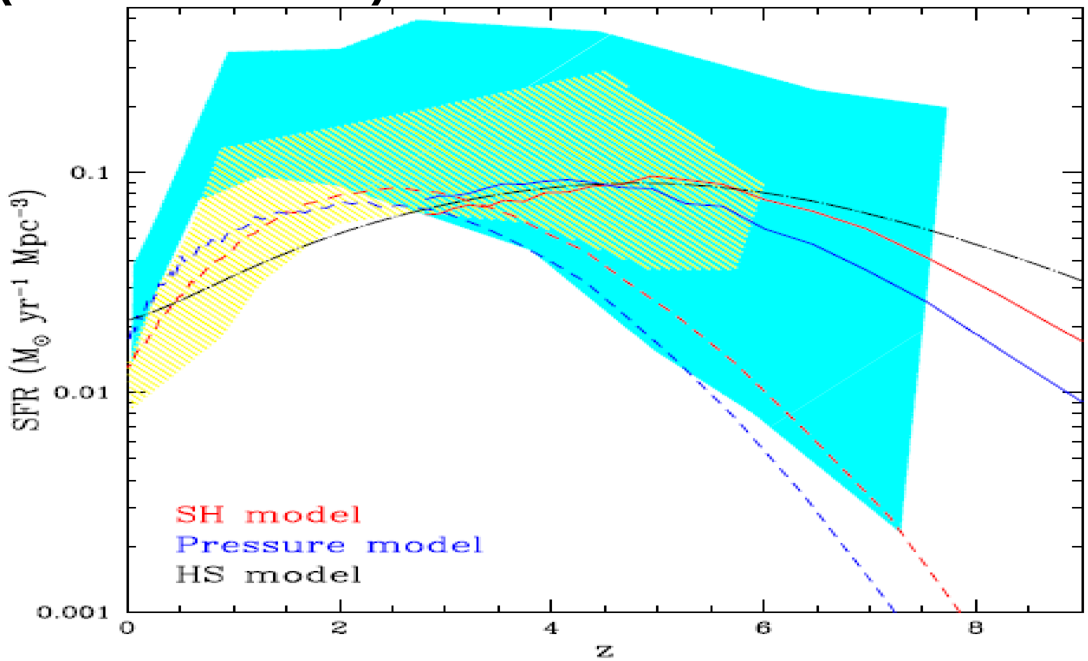
Host	Scenario	Metallicity	Total mass	Age	A_V	Observed SFR*	Corrected SFR
GRB 970508	instant. burst	$0.1 Z_{\odot}$	$3.48 \cdot 10^{8}$	160 Myr	1.6	$\geq 1.4\,M_{\odot}\,yr^{-1}$	$14\,M_{\odot}\,yr^{-1}$
GRB 980703	exp. decreasing	$Z_{\odot}$	$3.72 \cdot 10^{10}$	6 Gyr	0.64	$\geq 10\,M_{\odot}\,yr^{-1}$	$20\,M_{\odot}\,yr^{-1}$

* The SFR was recomputed following cosmology with H_0=60 km·s^{-1}·Mpc^{-1}, Ω_M=0.3 and Ω_Λ=0.7.

- GRB 970508 host, M_B rest = – 18.62
- GRB 980703 host, M_B rest = – 21.27

2010

MNRAS.407.1464C(arXiv:0909.5425)



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Effects of cosmological parameters and star formation models on the cosmic star formation history in ΛCDM cosmological simulations **Authors:** Choi, Jun-Hwan; Nagamine, Kentaro

Astro-ph/0906.0590, Kistler, et al.

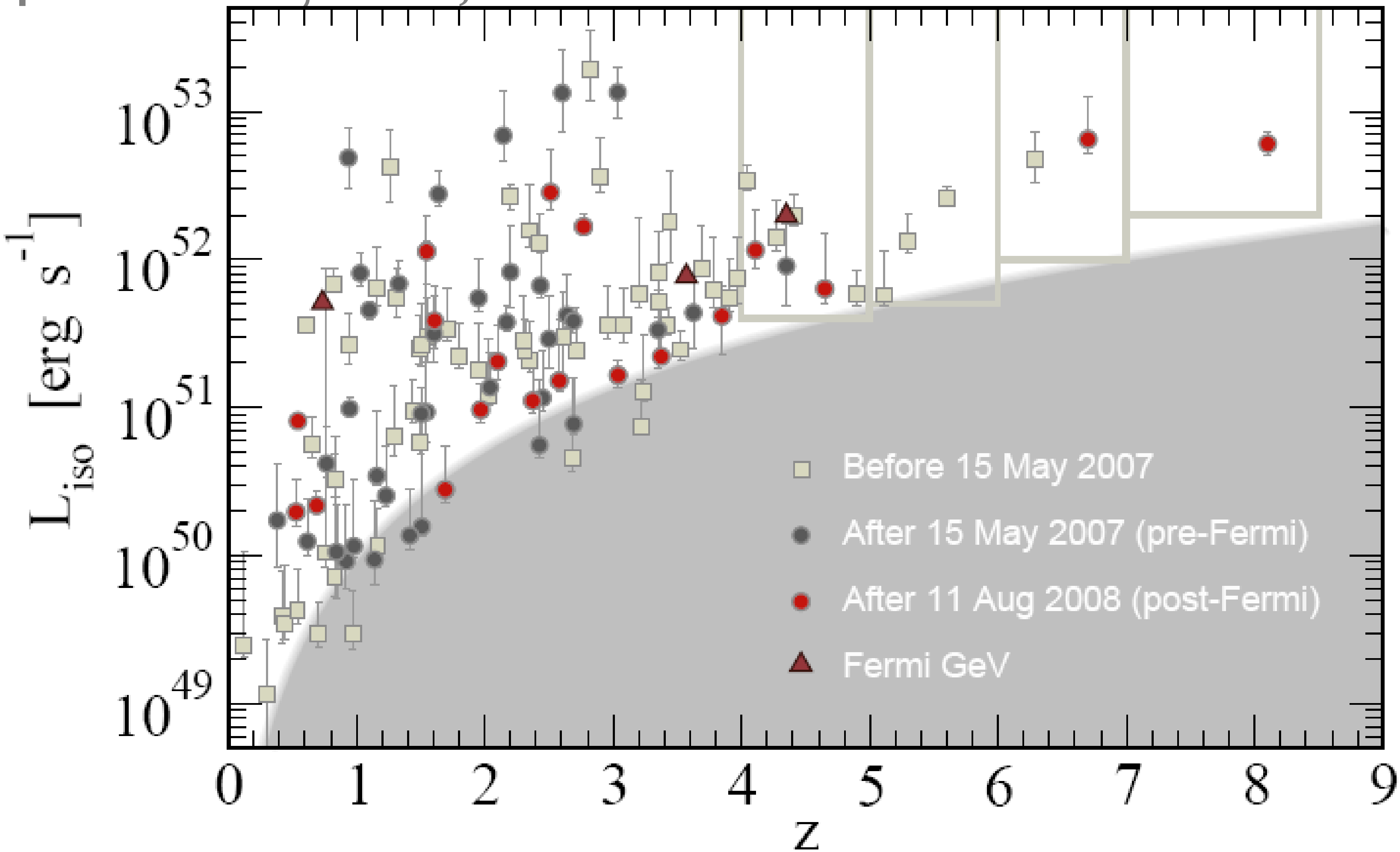
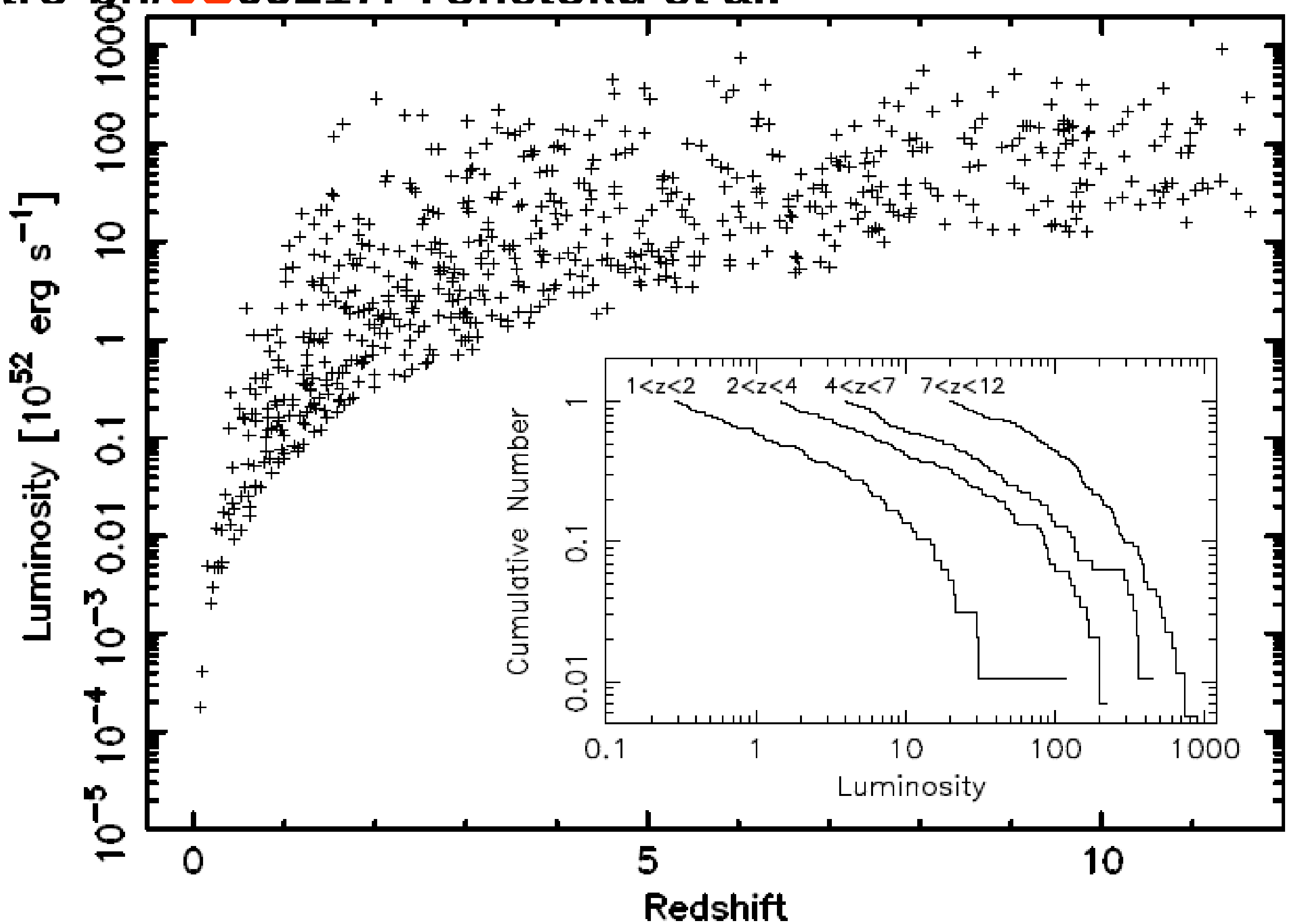


FIG. 1.— The *L_iso* luminosity-redshift distribution of 119 *Swift* GRBs, as we determine from the (updated) Butler et al. (2007) catalog. Squares represent the 63 GRBs used in Y¨uksel et al. (2008), with 56 found subsequently: before (grey circles) and after (red circles) the start of *Fermi*. Three *Fermi*-LAT GeV bursts (triangles) are shown (but not used in our analysis). **(!)*The shaded region approximates an effective threshold for detection.***

Demarcated(обведенные) are the GRB subsamples used to estimate the SFR + pseudo–redshifts Because weak low-redshift GRBs can not be seen at high redshifts, so we arXiv:astro-ph/0309217. Yonetoku et al.



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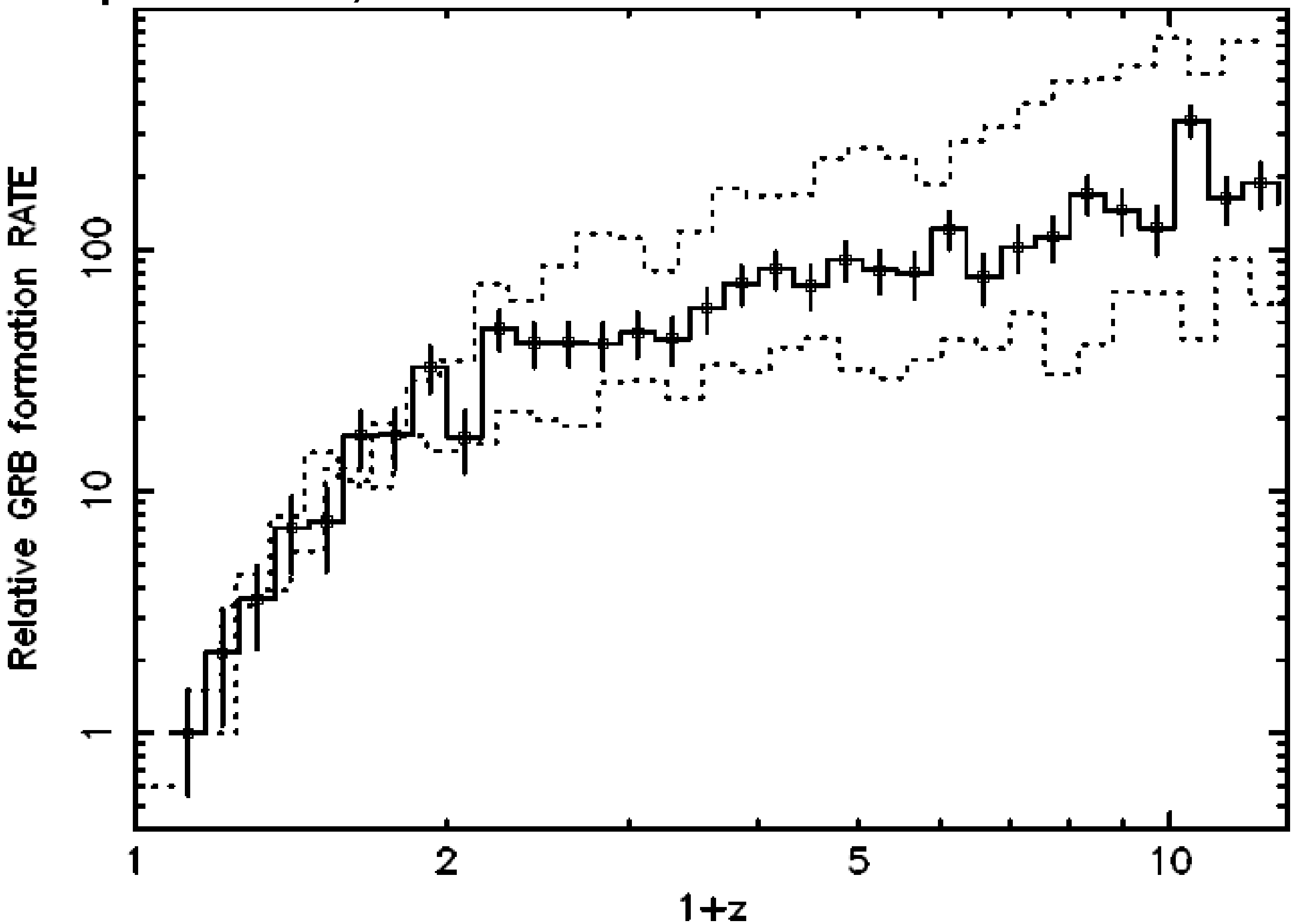


- The relative **GRB formation rate** normalized at the first point. The solid line is the result based on the best fit of Ep–luminosity relation and two dotted lines indicate the upper and lower bounds caused by the uncertainty of Ep–luminosity relation. These dotted linesare also normalized and superposed on the best result at 0 < z < 1 with the least-square method. The error bars accompanying open squares represent the statistical uncertainty of each point (the relative comoving GRB rate in unit proper volume)

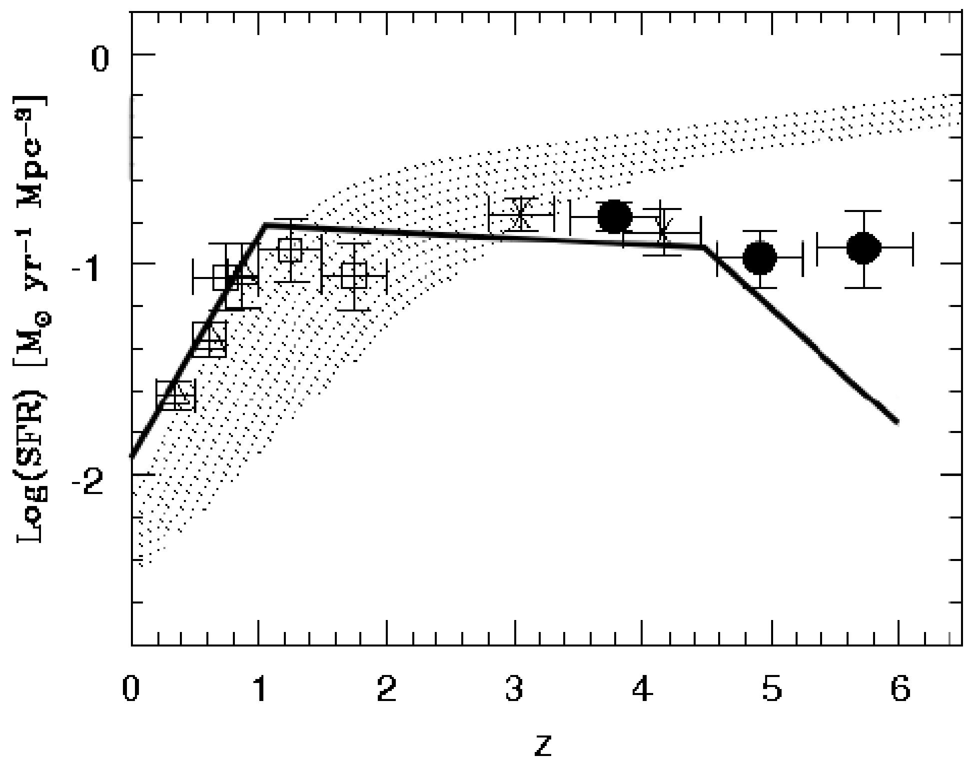
1109.0990,

The connection between the rate of GRBs [$\dot{n}_{GRB}(z)$] and SFR [$\dot{\rho}_{\star}(z)$] is:

$$\dot{n}_{GRB}(z), = \psi(z)\, \dot{\rho}_{\star}(z),$$

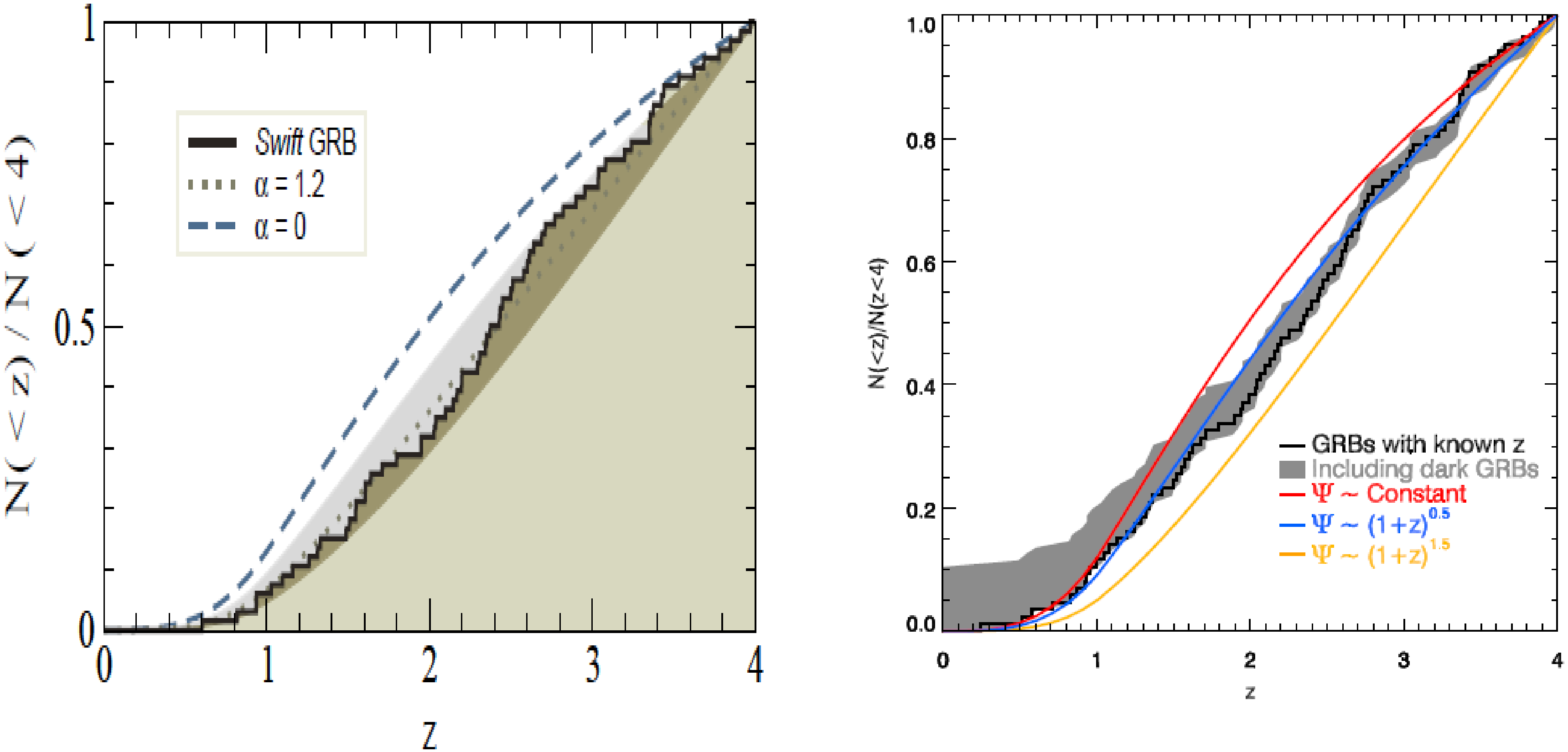
- The **second result** of the GRB identification:
- the long-duration GRBs are identified with *massive* core-collapse supernovae (CC-SNe).
- We have the *massive* star-forming in GRB hosts and *massive* star explosions.

massive SFR ~ GRBs ~ CC-SNe



As long-duration GRBs are associated with massive stars, therefore with regions of star formation, they (GRBs) are candidates to study the **SFR density** of the universe. It is based on *the idea (by Ramirez-Ruiz,Fenimore & Trenthan 2000):* The GRB rate in galaxies is proportional to the SFR and that the ratio does not change with z(?).

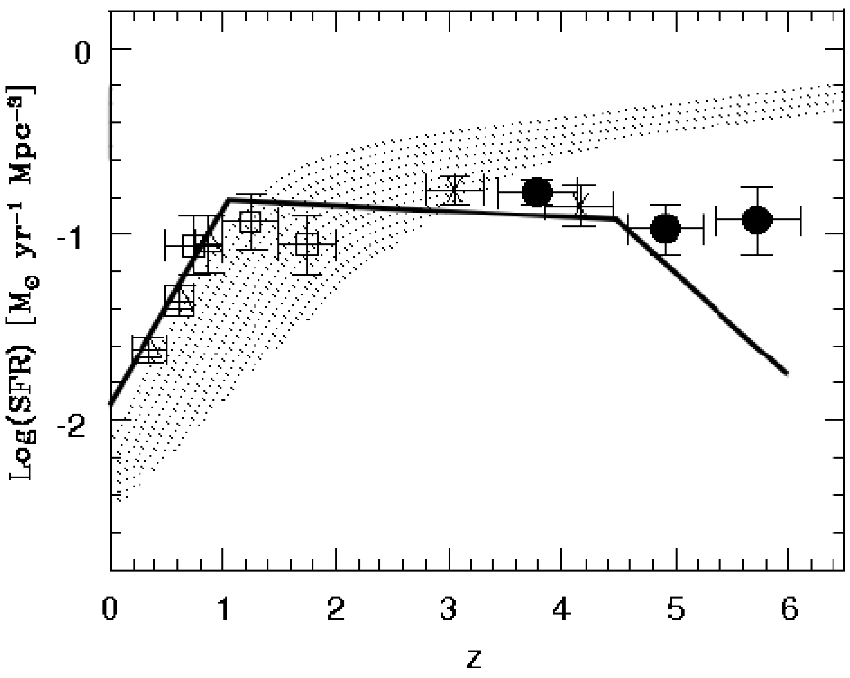
The normalization is done by taking the SFR density value at low redshift for which the density of the GRB rate is estimated.

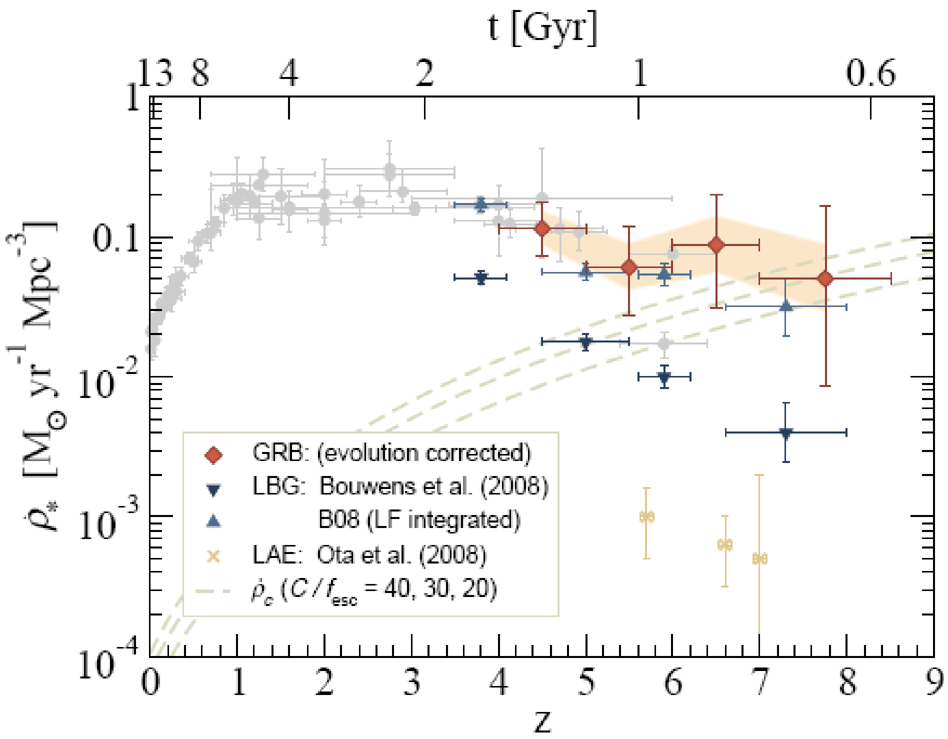


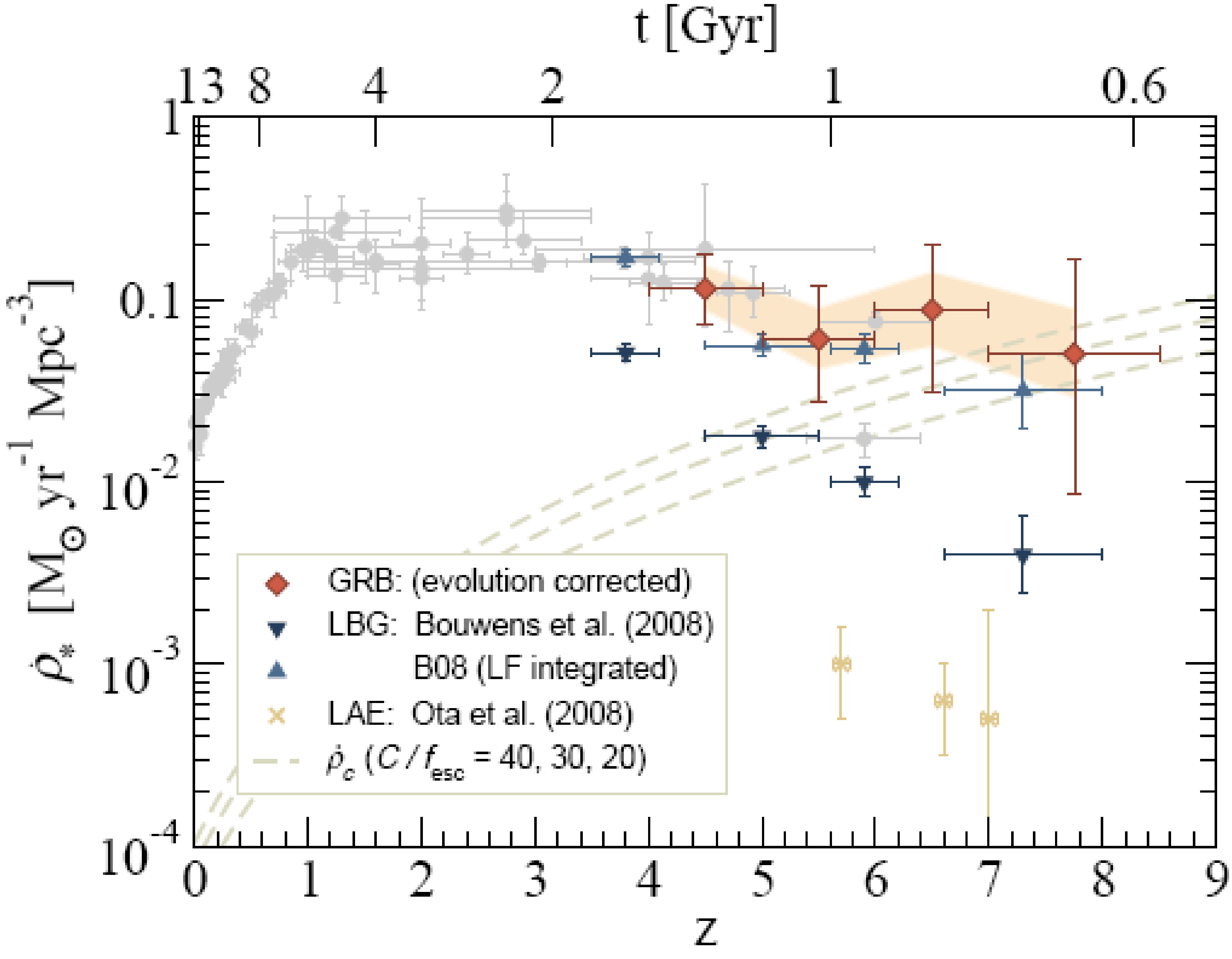
Swift GRB
α = 1.2
α = 0
N (< z) / N (< 4)
z
0
0.5
1
0
1
2
3
4
GRBs with known z
Including dark GRBs
Ψ ~ Constant
Ψ ~ (1+z)^0.5
Ψ ~ (1+z)^1.5
N(<z)/N(z<4)
0.0
0.2
0.4
0.6
0.8
1.0

Kistler made everything to "bend down" the SFR determined from GRBs (the left picture) in astro-ph/0802.2578: V.Avilla-Reese et al.

This demands some "evolution" $\psi(z)$…

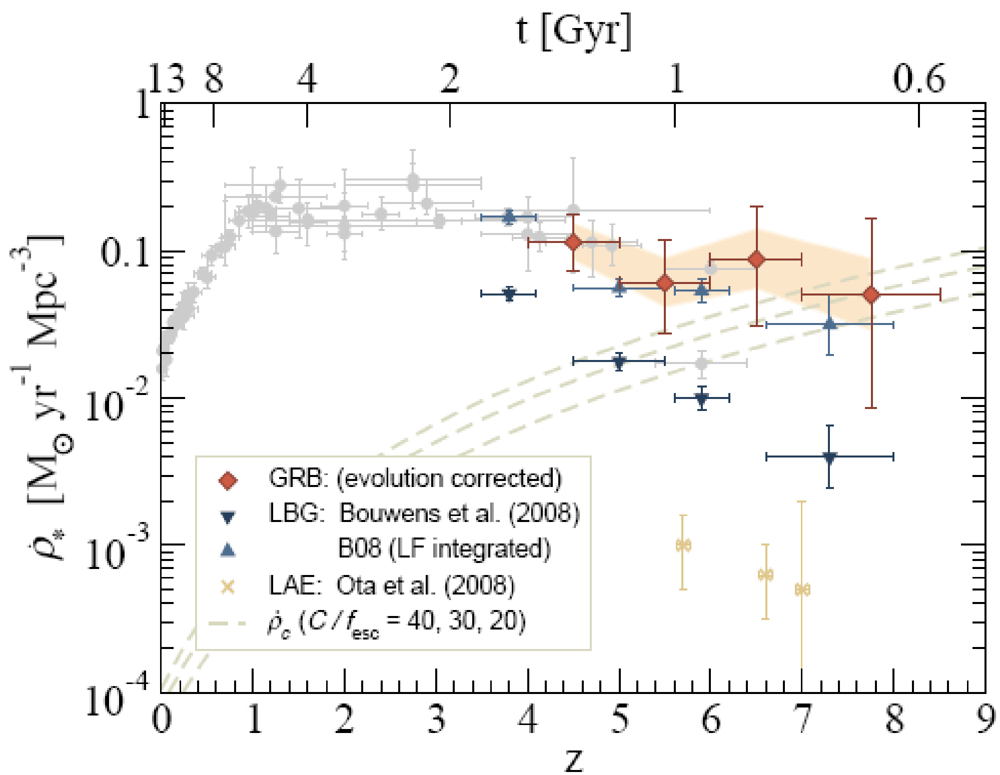






t [Gyr]
13 8 4 2 1 0.6
1
0.1
10^{-2}
10^{-3}
10^{-4}
$\dot{\rho}_*$ [$M_\odot$ yr^{-1} Mpc^{-3}]
GRB: (evolution corrected)
LBG: Bouwens et al. (2008)
B08 (LF integrated)
LAE: Ota et al. (2008)
$\dot{\rho}_c$ (C / f_{esc} = 40, 30, 20)
0 1 2 3 4 5 6 7 8 9
z

astro-ph/0906.0590, Kistler, et al. (2009)



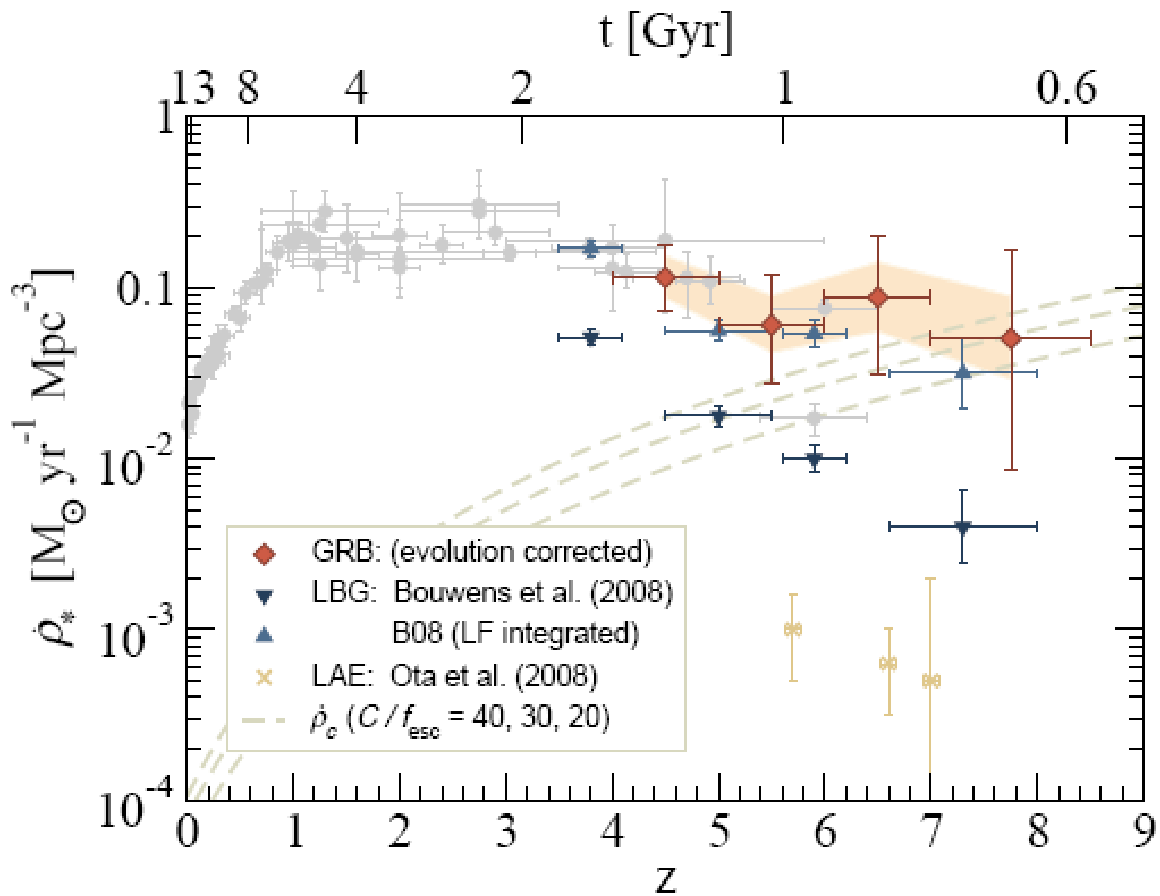
The cosmic star formation density. Light circles are the data from Hopkins & Beacom (2006). Crosses - from Lyman-α emitters (LAE). Down and up triangles are Lyman-break galaxies (LBGs) for two UV luminosity functions…

The SFR inferred from GRBs (red diamonds) ***indicate the strong contribution from small galaxies*** generally not accounted for in the observed LBG luminosity function.

The "simple" (but brawl ☺) conclusion:

- It is shown that these **galaxies are usual ones** with a **high star formation** rate, they are mainly observed in optical at redshifts about 1 and higher.
- *V. V. Sokolov, T. A. Fatkhullin, A. J. Castro-Tirado, A. S. Fruchter et al.,* ***2001***
- GRB hosts should not to be special, but **normal star-forming galaxies** (the most abundant), detected at any *z* **just because a GRB event has occurred**
- *see S.Savaglio et al.,* ***2006-2009***

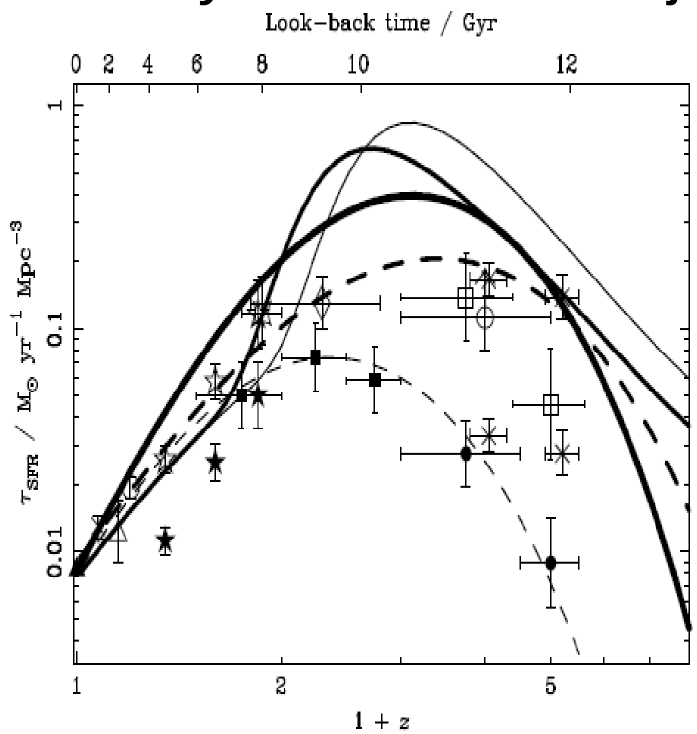
Astrophys.J.705:L104-L108,2009 , Kistler, et al. (2009)



The **SFR can remain high at least up to redshifts about 8.** The agreement with direct observations, corrected for galaxies below detection thresholds, suggests that the GRB-based estimates incorporate the bulk of high-z star formation down to the faint galaxies...

They also see no evidence for a strong peak in the SFR versus z.

A.W. Blain and Priyamvada Natarajan: **MNRAS (2000), 312**



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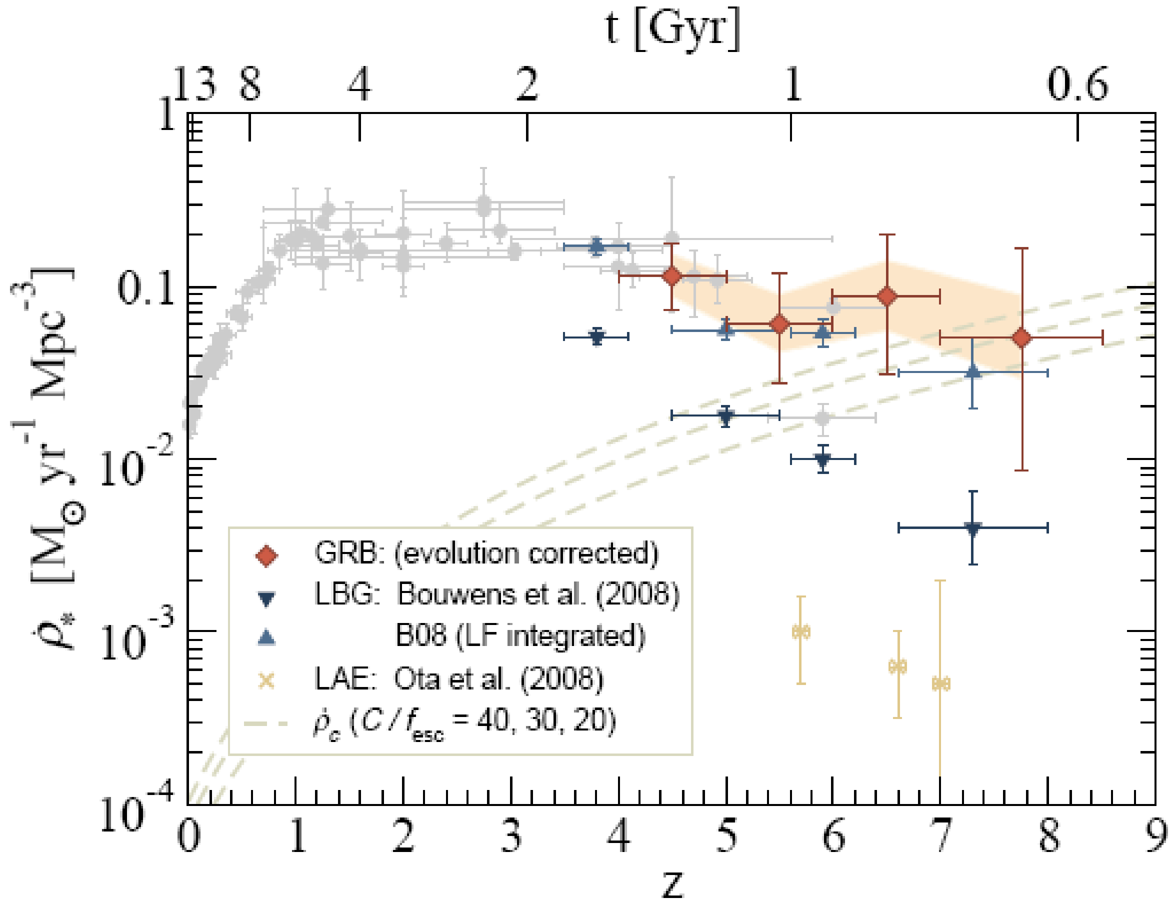
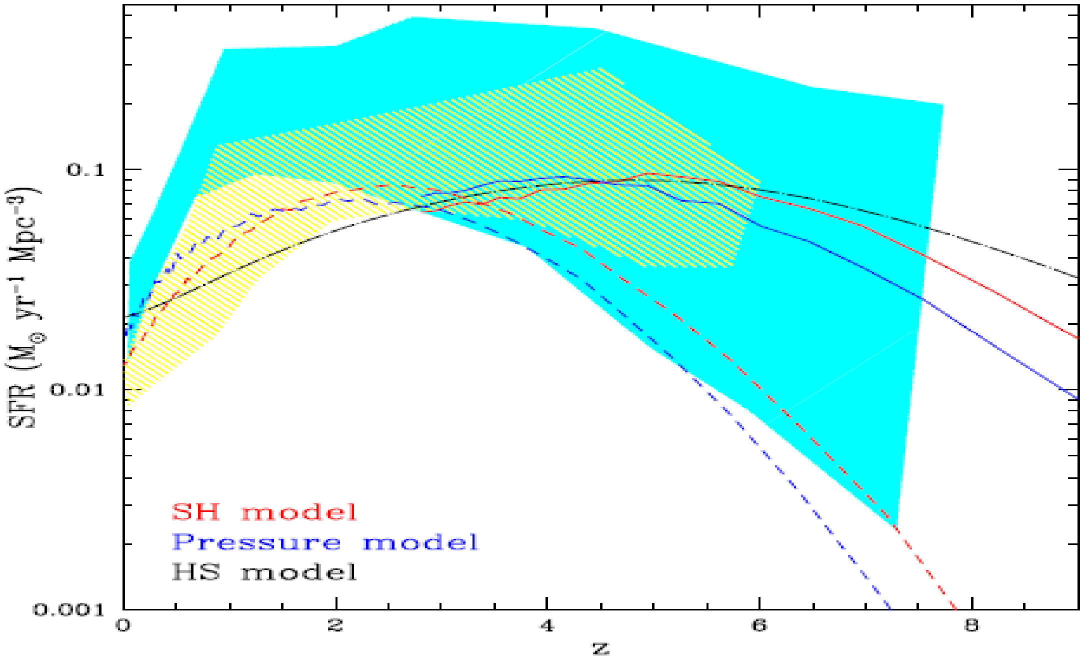
Astrophys.J.705:L104-L108,2009 , Kistler, et al. (2009)



At *z* = 8, GRB SFR is consistent with LBG measurements after **accounting for unseen galaxies** at the faint-end UV luminosity function. This implies that **not all** star-forming galaxies at these *z* are currently being accounted for in deep surveys.

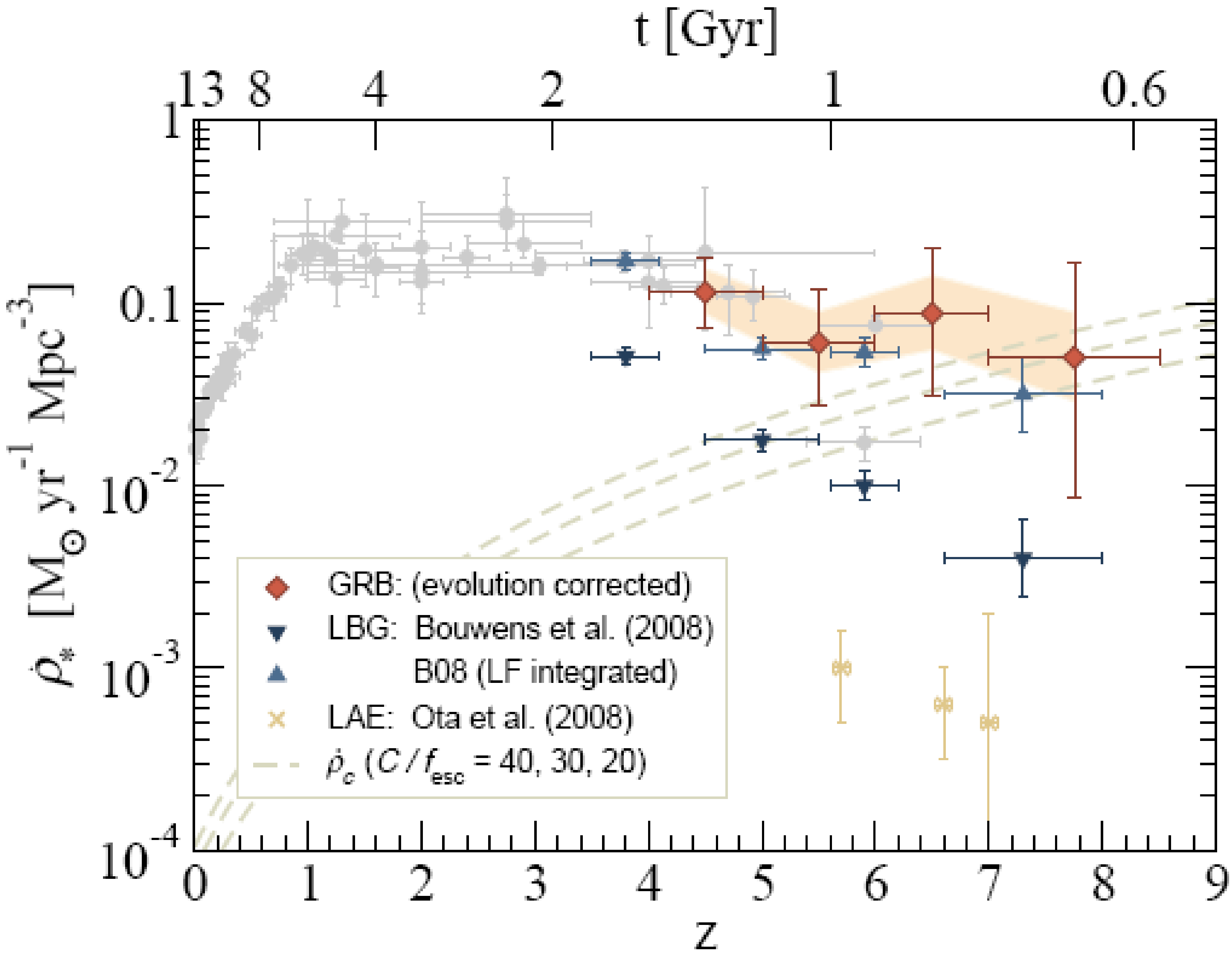
GRBs provide the contribution to the SFR from small galaxies - the typical GRB host at high redshifts might be a small star forming galaxy

2010MNRAS.407.1464C(arXiv:0909.5425

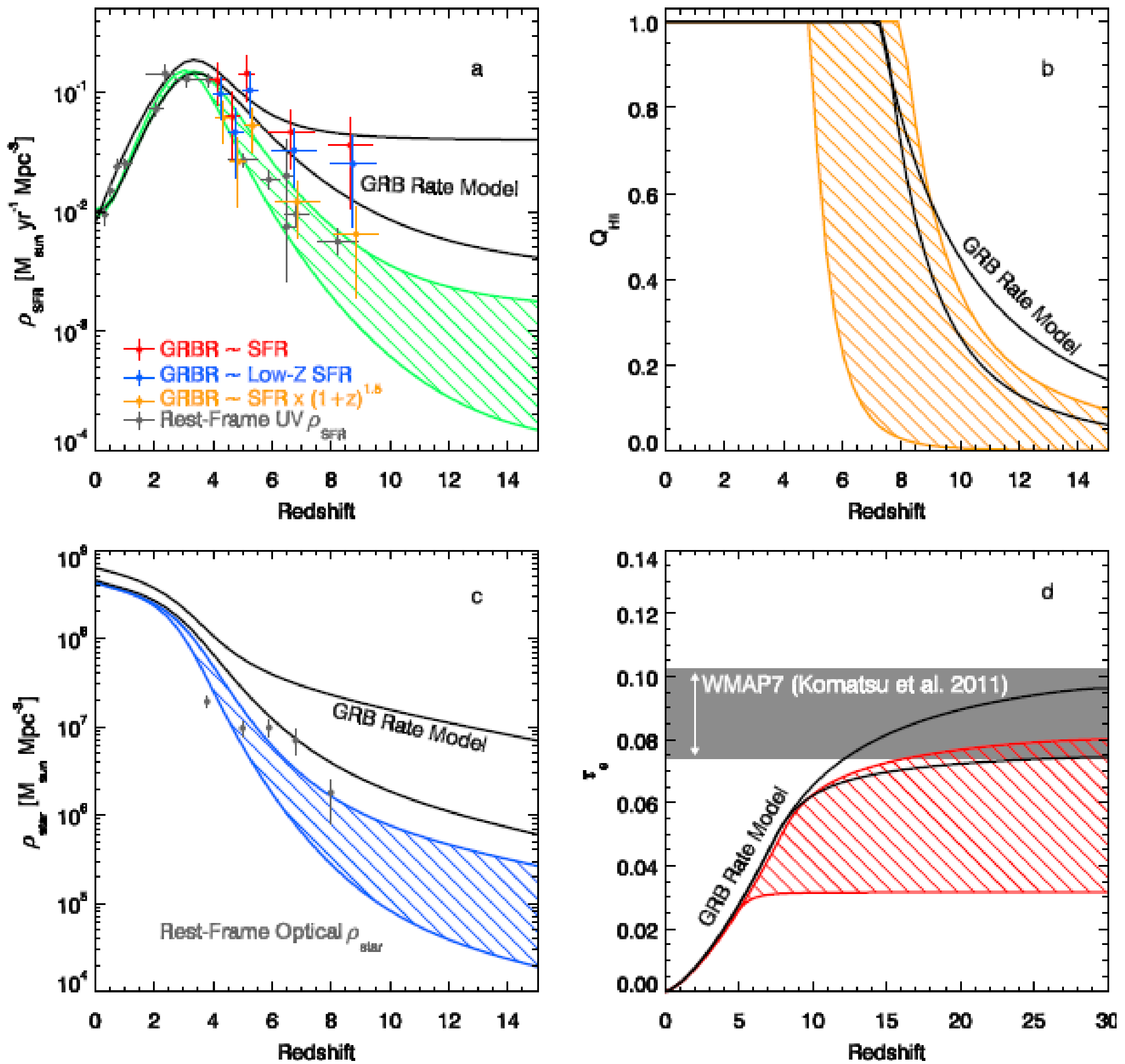


Effects of cosmological parameters and star formation models on the cosmic star formation history in ΛCDM cosmological simulations **Authors:** Choi, Jun-Hwan; Nagamine, Kentaro

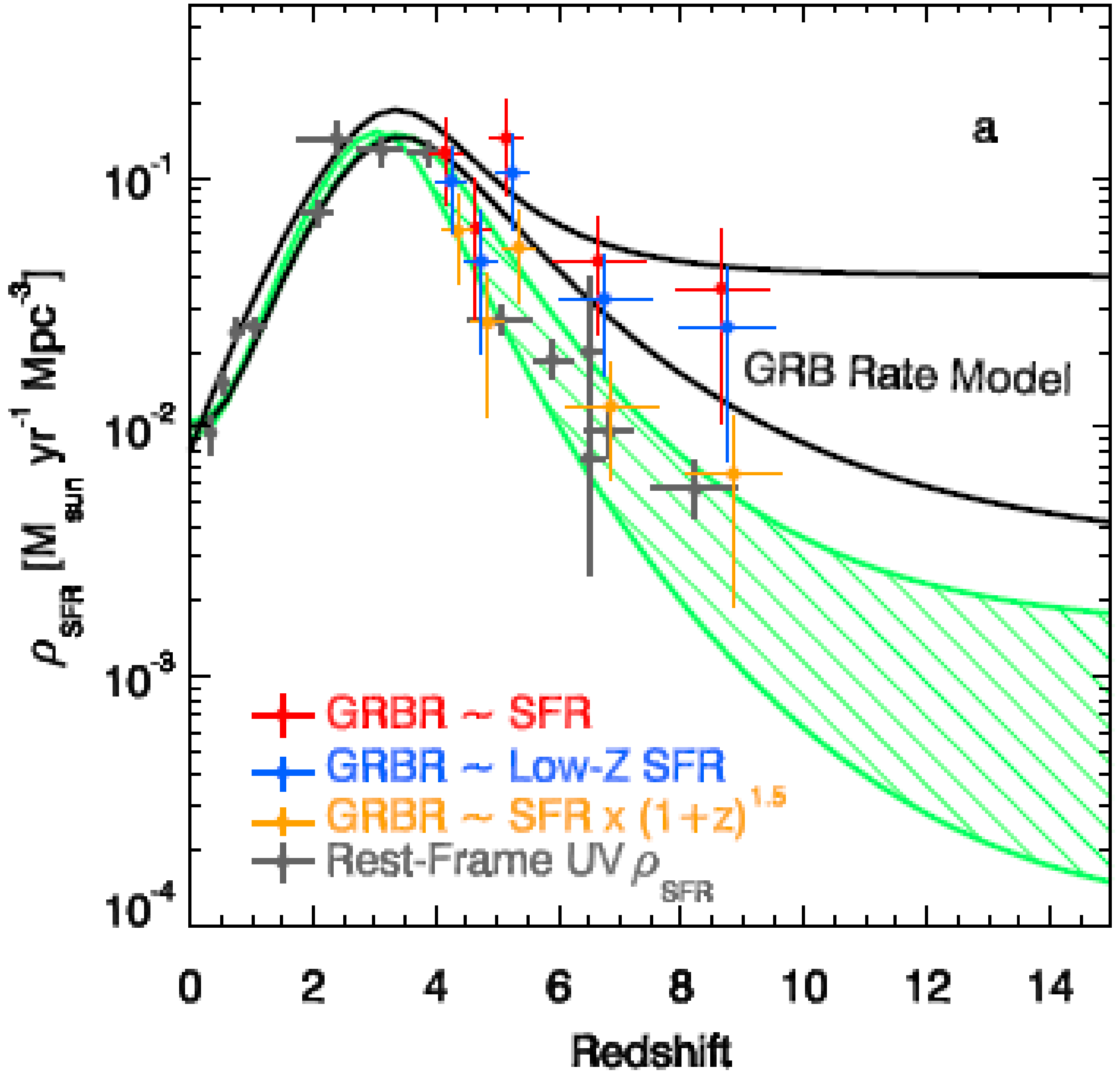
Figure 5. The cosmic star formation history from our simu- lations with different SF models. The solid lines are from the N216L10 series, and the dashed lines are from the N400L100 series. The N216L10 series represent the high-z SFR better, and the N400L100 series represent the low-z SFR better. We compare our results with the previous theoretical model of Hernquist & Springel (2003, the HS model; blue long-dashed line). The cyan shading is the observed range of SF history from Kistler et al. (2009). The yellow shading is the locus of the observed data compiled by Nagamine et al. (2006). Both compilations of data considered the dust extinction correction. This figure shows that the peak of the SFR density shifts to a lower redshift in the Pressure model compared to the SH model.


t [Gyr]
13
8
4
2
1
0.6
1
0.1
10^{-2}
10^{-3}
10^{-4}
$\dot{\rho}_*$ [$M_\odot$ yr^{-1} Mpc^{-3}]
GRB: (evolution corrected)
LBG: Bouwens et al. (2008)
B08 (LF integrated)
LAE: Ota et al. (2008)
$\dot{\rho}_c$ (C / f_{esc} = 40, 30, 20)
0
1
2
3
4
5
6
7
8
9
z

Robertson B. E. & Ellis R. C., ApJ 744, 95 (2012)



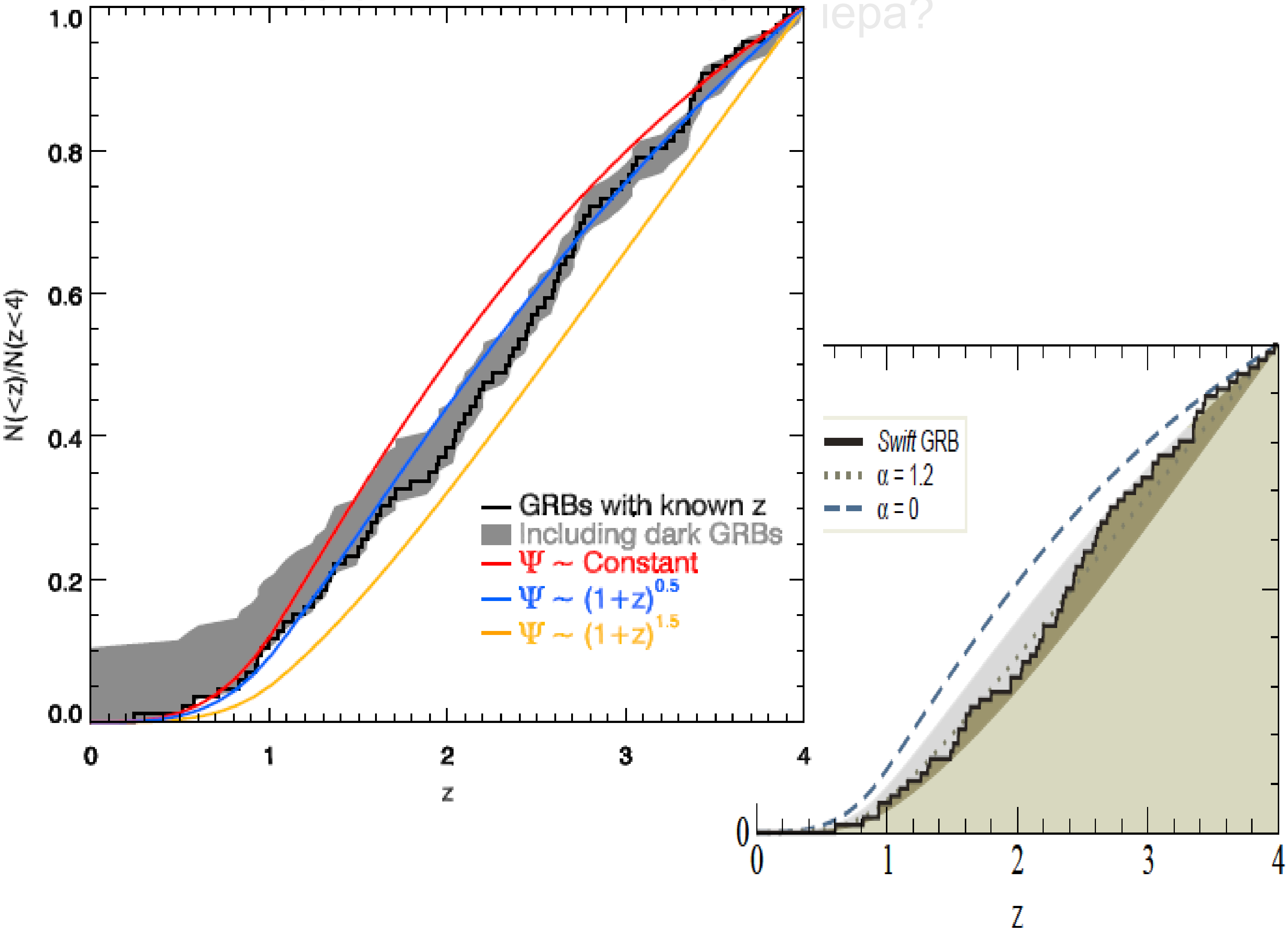
1109.0990v2, Figure 5, panel **a**



1109.0990,

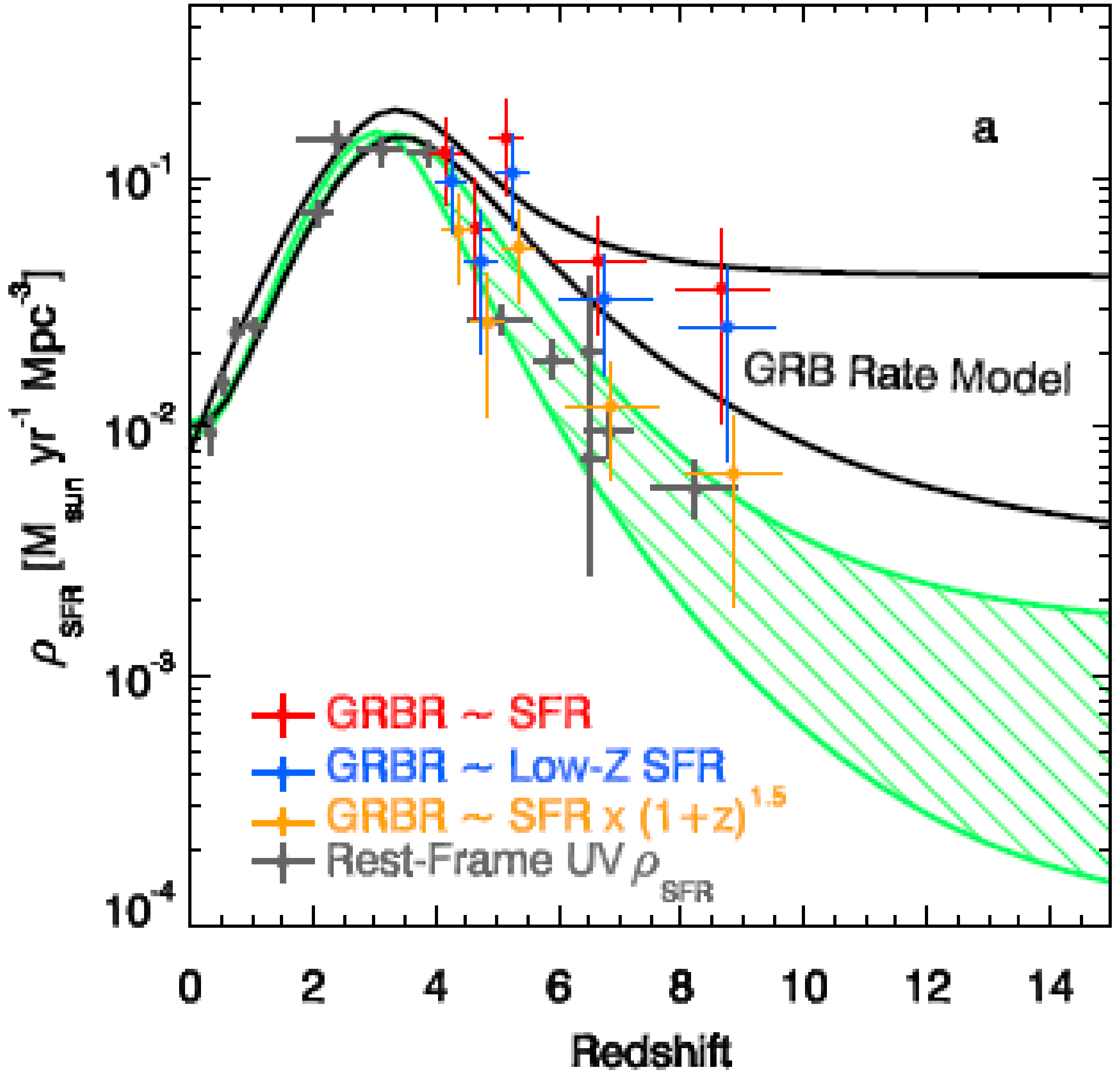
The connection between the rate of GRBs and $\dot{\rho}_\star(z)$,

$$\dot{n}_{\mathrm{GRB}}(z) = \psi(z)\,\dot{\rho}_\star(z),$$

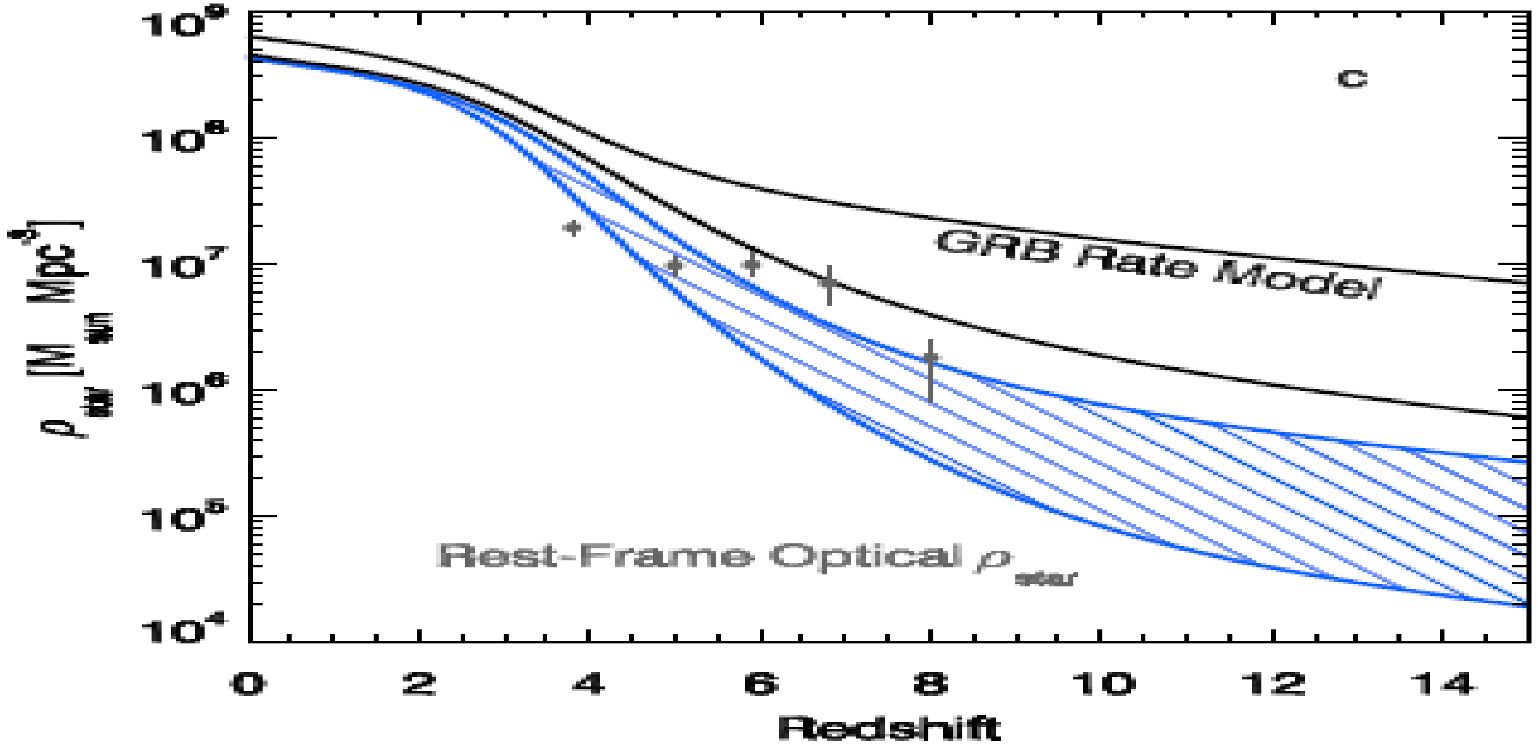


N(<z)/N(z<4)
1.0
0.8
0.6
0.4
0.2
0.0
0
1
2
3
4
z
GRBs with known z
Including dark GRBs
Ψ ~ Constant
Ψ ~ (1+z)^0.5
Ψ ~ (1+z)^1.5
Swift GRB
α = 1.2
α = 0
0
1
2
3
4
z

1109.0990v2, Figure 5, panel **a**



arXiv:1109.0990, Robertson & Ellis



…the GRB-derived star formation rate, clearly exceed the stellar mass density *ρstar* at all redshifts.

arXiv:1109.0990, Robertson & Ellis

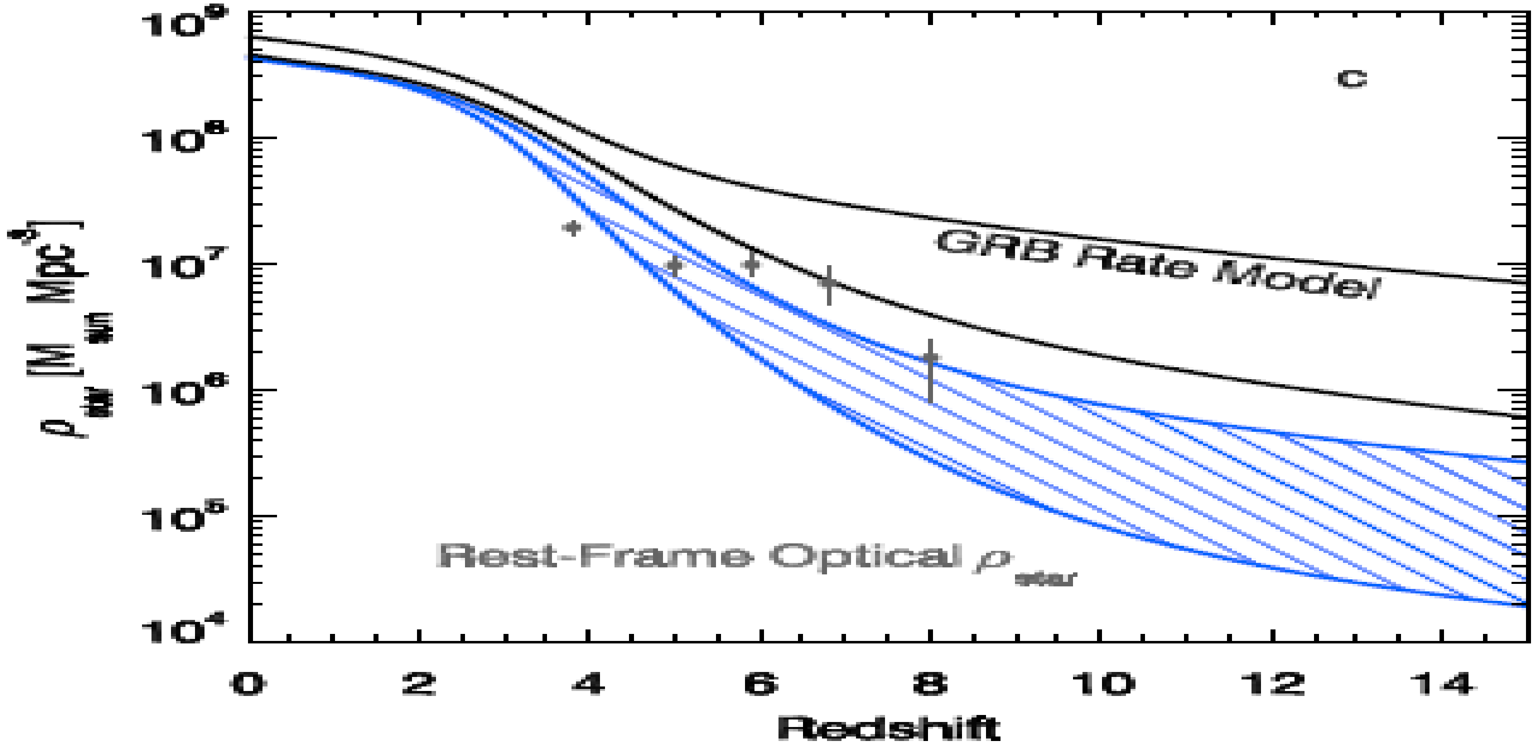


Figure 5 (panel **c**) While both the ionization history and the Thomson optical depth depend on specific model choices for f_{esc} or C, **the stellar mass density is** ρ_{star} **simply determined by the integral of the previous star formation rate density** $\dot{\rho}_{star}(z)$ (see panel **a**).

The stellar mass density ρ_{star} to $z \sim 8$ is shown as **gray points** with error bars (González et al. 2011), with the associated models by Robertson et al. (2010, **blue hatched region**).

The **black lines** in panel **c** show the stellar mass density ρ_{star} implied by parameterizations of **the GRB-derived star formation rate, which clearly exceed the stellar mass density** ρ_{star} **at all redshifts.**

1109.0990v2, …и главный вывод:

Importantly,

the $\dot{\rho}_\star(z)$ implied by

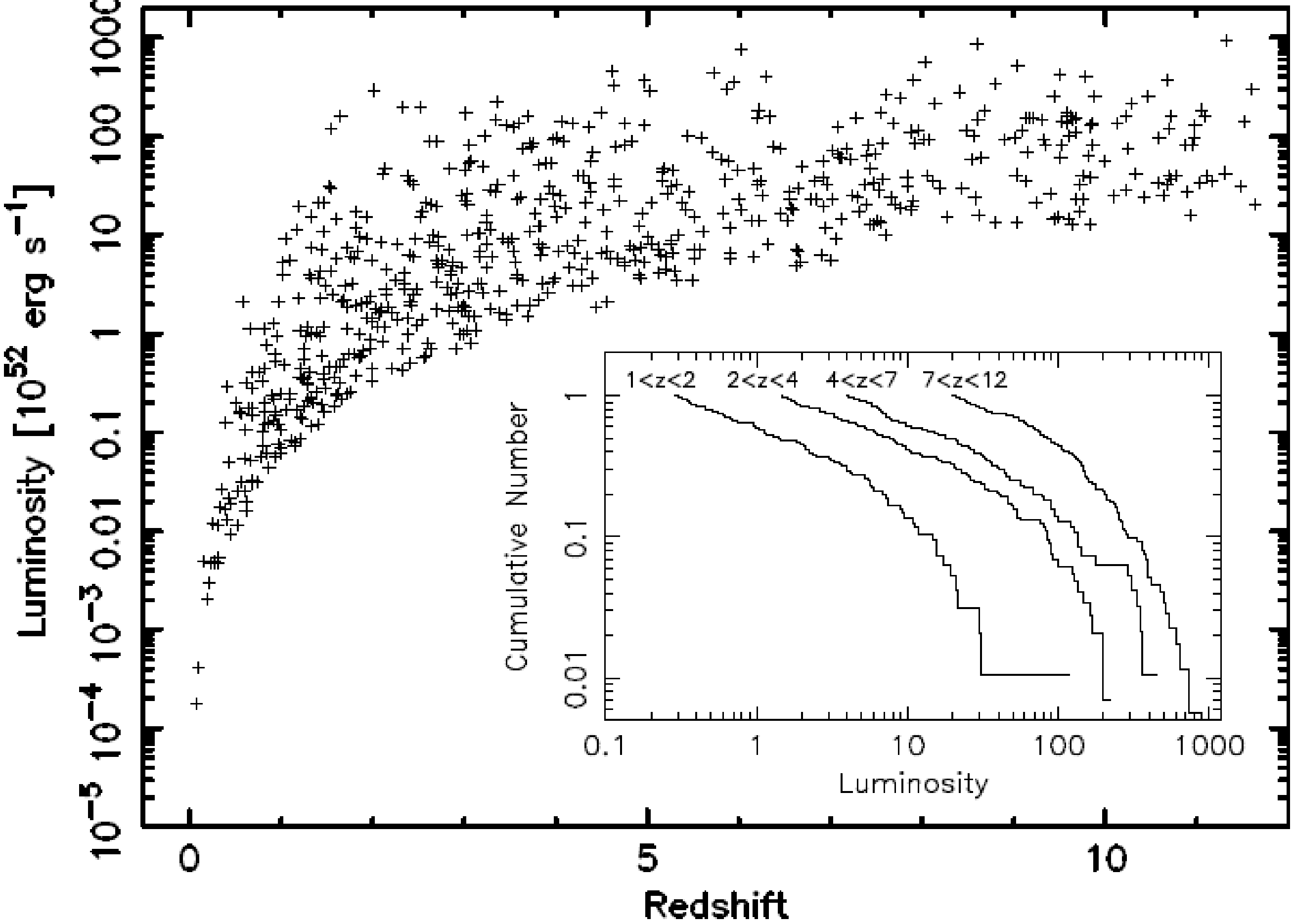
the **high redshift GRB rate**

appears unphysical in that

it [$\dot{\rho}_{\star GRB}(z)$] ***overproduces the observed stellar mass density at z >~ 5.***

That is it turned out "unexpectedly" that there are too many GRBs at high redshift...

arXiv:astro-ph/0309217. Yonetoku et al.

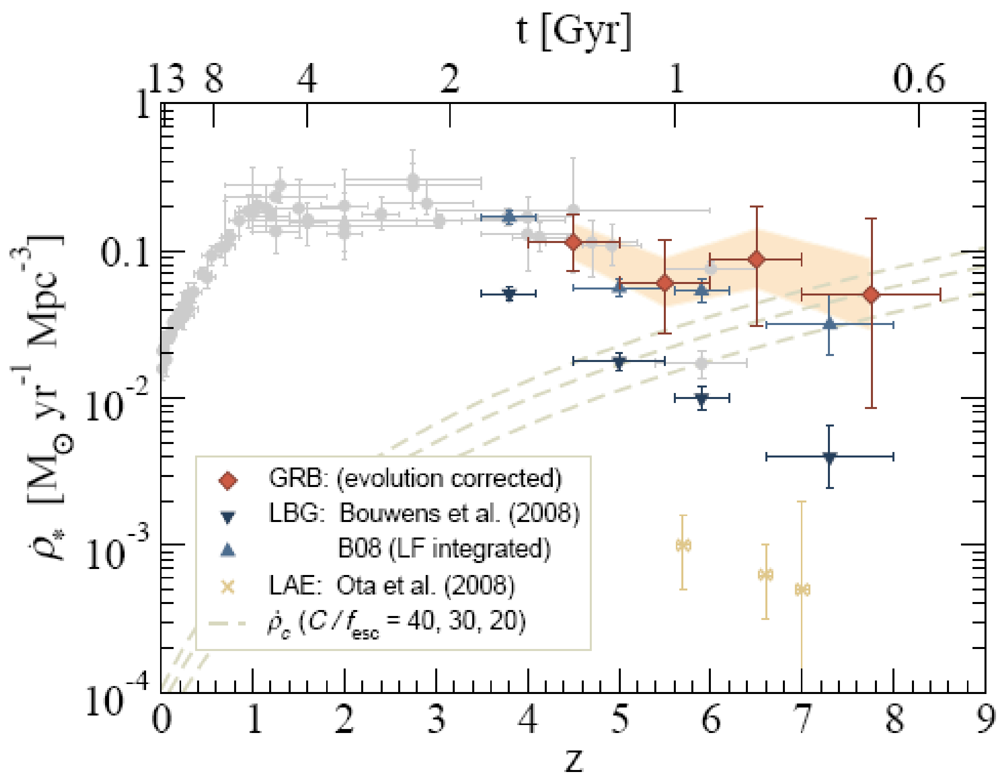


The distribution of luminosity vs. redshift derived from the Ep–luminosity relation.

The truncation(усечение) of the lower end of the luminosity is caused by the flux limit of $F_{limit} = 1 \times 10^{-7}$ erg $cm^{-2}s^{-1}$. The inserted figure is the cumulative luminosity function in the several redshift ranges.

The luminosity "evolution" exists because the break-luminosity increase toward the higher redshift.

astro-ph/0906.0590, Kistler, et al. (2009)



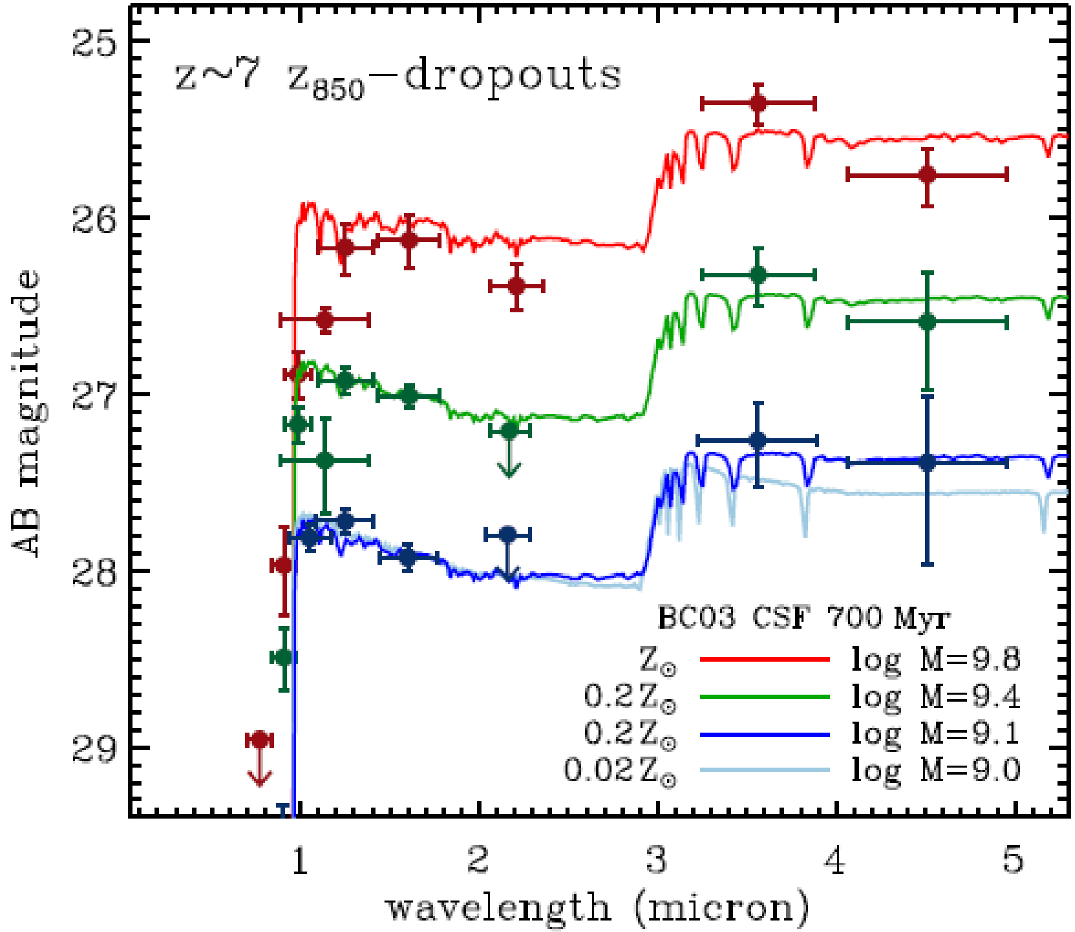
The cosmic star formation density. Light circles are the data from Hopkins & Beacom (2006). Crosses - from Lyman-α emitters (LAE). Down and up triangles are Lyman-break galaxies (LBGs) for two UV luminosity functions…

The SFR inferred from GRBs (red diamonds) ***indicate the strong contribution from small galaxies*** generally not accounted for in the observed LBG luminosity function.

And without GRBs …

The Hubble eXtreme Deep Field zooms in on a tiny patch of sky in the Fornax constellation, revealing 5,500 galaxies in a new full-color image. *NASA, ESA, G. Illingworth, D. Magee, and P. Oesch (University of California, Santa Cruz), R. Bouwens (Leiden University), and the HUDF09 Team*

arXiv:0911.1356. bv Labbe et al. **(2009)**



Broadband SEDs of the **z ~ 7** z850−dropout galaxies from our NICMOS, WFC3/UDF and WFC3/ERS samples, averaged in 1−mag bins centered on H160 26, 27 and 28. The data include HST ACS, NICMOS, and FC3/IR, groundbased K, and IRAC [3.6] and [4.5]. The best-fit BC03 stellar population models at z = 6.9 are shown. The overall SED shapes are remarkably similar, with a Balmer break between H160 and [3.6], indicative of evolved stellar populations (> 100Myr). The far−UV slope (traced by 125 − H160) bluens significantly towards fainter H160 magnitude (as found Bouwens et al. 2009b). Upper limits are 2. ACS optical measurements are non-detections fainter than 29.4 mag.

Astro-ph/**09**10.0077, by Haojing Yan et al.

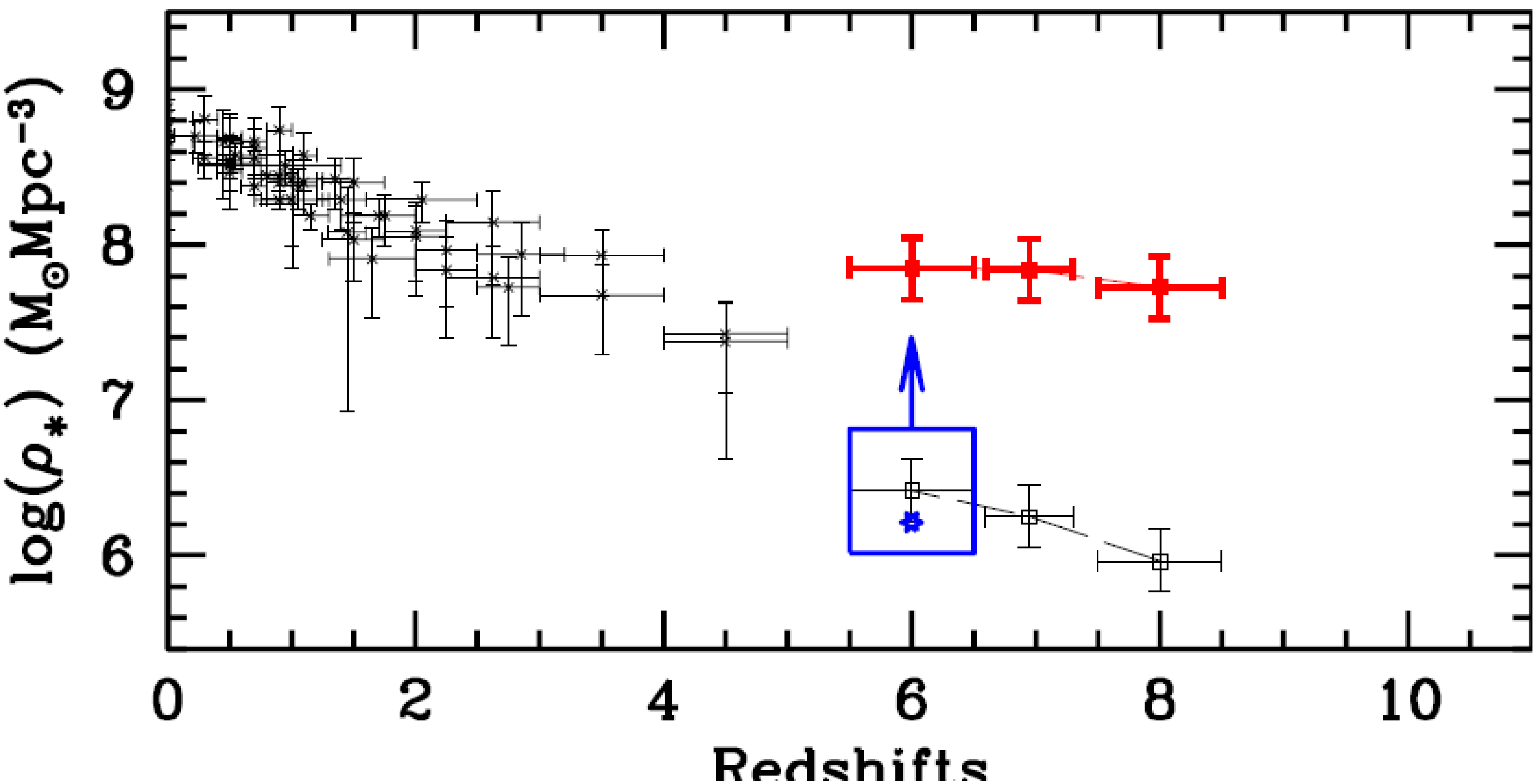
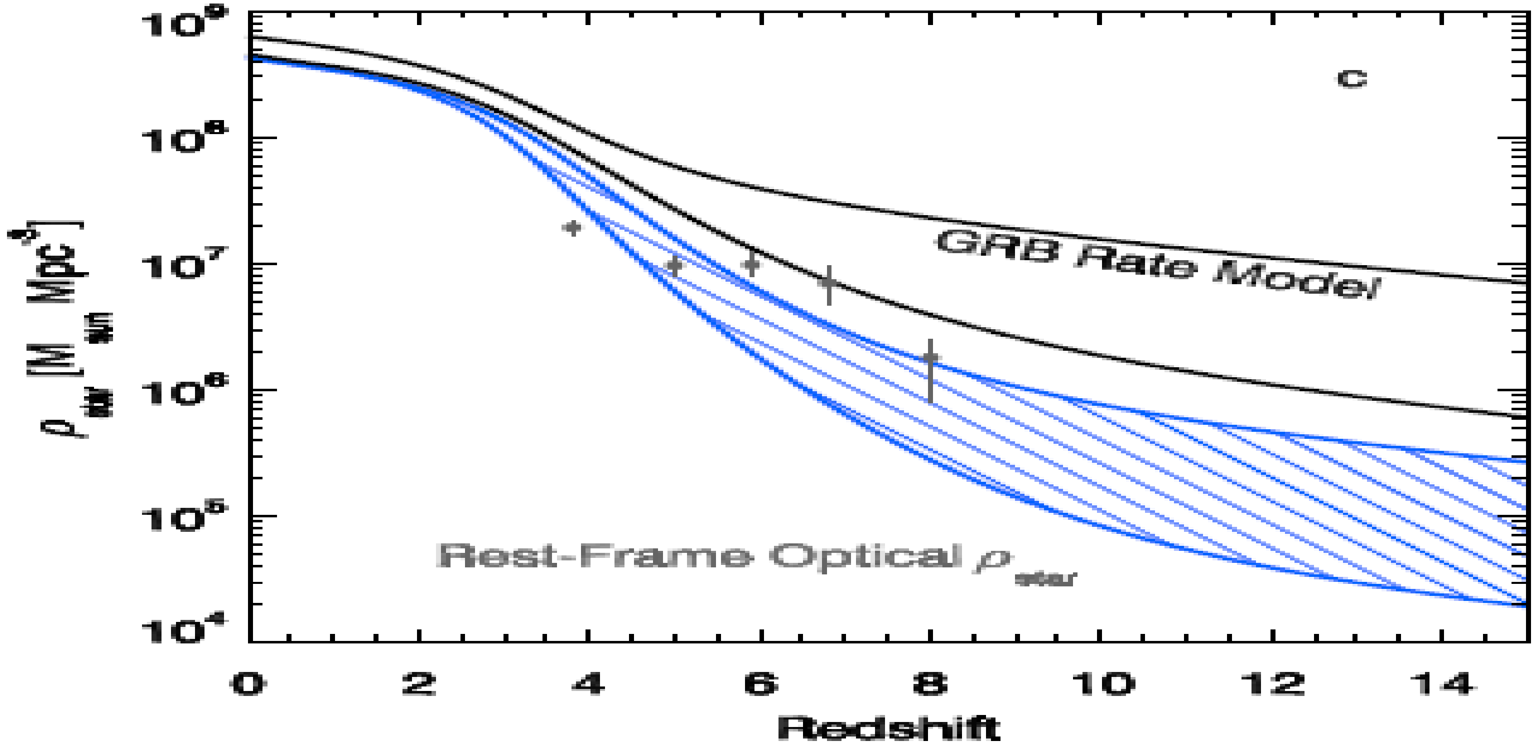


Fig. 15. (bottom) Evolution of the global stellar mass density (-*) from z~~10. The black and red data points are obtained by integrating the corresonding ˙-* values shown in the Fig.15 (top panel) over time, assuming zero stellar mass density at z = 10.

The blue star at z = 6.0 and the surrounding box, taken from Yan et al. (2006), represent the best estimate at this redshift and the *associated uncertainty*, which should be taken as a strict lower limit *because only detected galaxies were used.* The vast majority of the stellar masses assembled over the reionization epoch (as indecated by the red filled squares) thus seem still undetected at z~~6.

arXiv:1109.0990, Robertson & Ellis



…the GRB-derived star formation rate, clearly exceed the stellar mass density ρ_{star} at all redshifts.

«the GRB-derived star formation rate, clearly exceed the stellar mass density ρ_{star} at all redshifts.»

The main conclusion of the report is as follows:

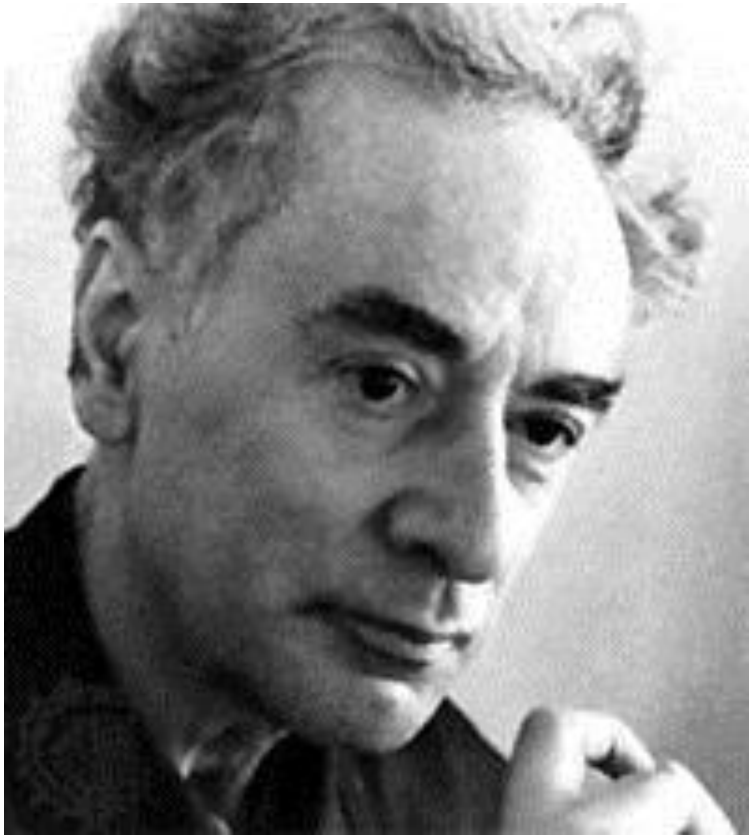
if GRBs do overproduce the stellar mass density at z>5, then

the high-z GRB production rate (per se) becomes the crucial test

for the modern cosmological ideology…

TAFN

(that’s all for now)



«Cosmologists are often in error but never in doubt»