

The Host Galaxies of Dust-Obscured Gamma-Ray Bursts

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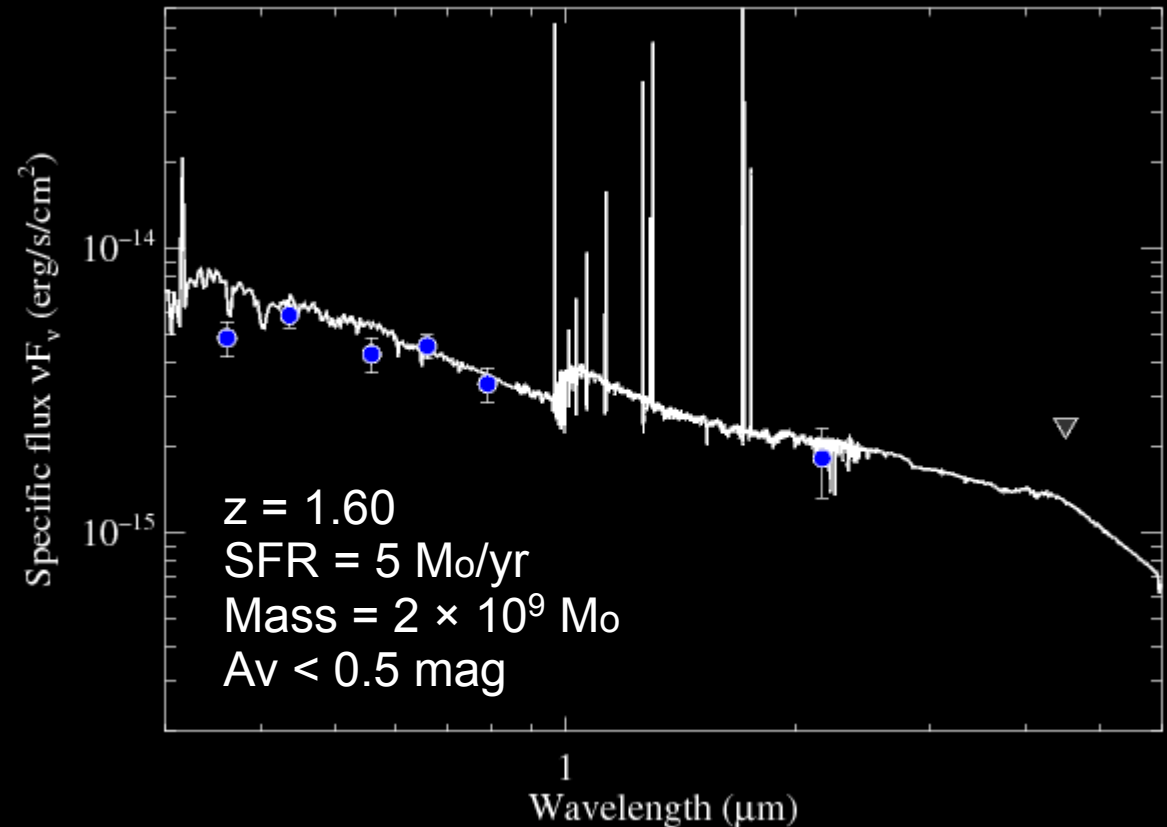
Adam Morgan

Nat Butler

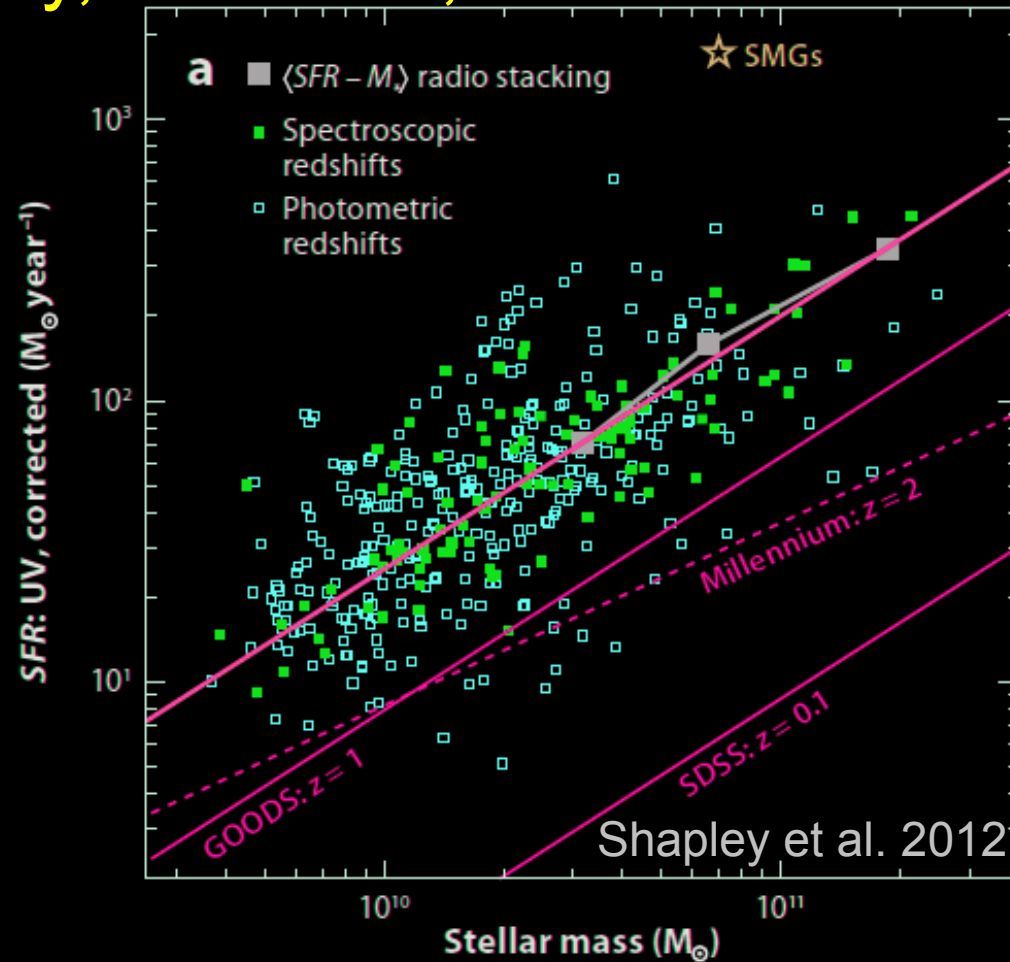
Maryam Modjaz

Where are the dusty, luminous, massive hosts?

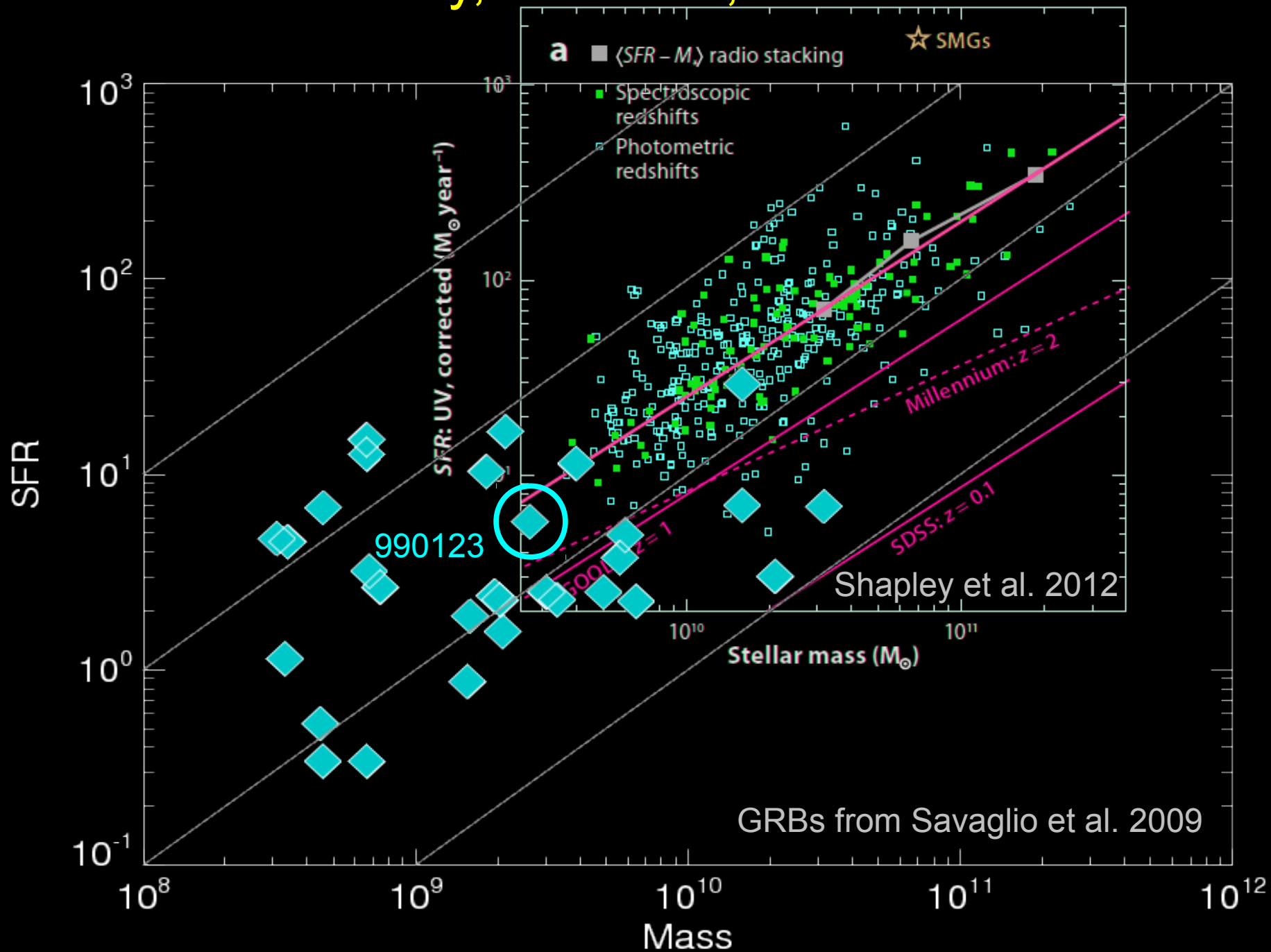
GRB 990123, a “typical” host galaxy:



Where are the dusty, luminous, massive hosts?



Where are the dusty, luminous, massive hosts?



Evidence that GRBs do not exactly trace SFR?

$$R(\text{GRB}) = \text{const?} \times R(\text{SFR})$$

e.g.,

Le Floc'h et al. 2003, 2006

Fruchter et al. 2006

Stanek et al. 2006

Wolf & Podsiadlowski 2007,

Modjaz et al. 2008

Levesque et al. 2011

but, c.f.

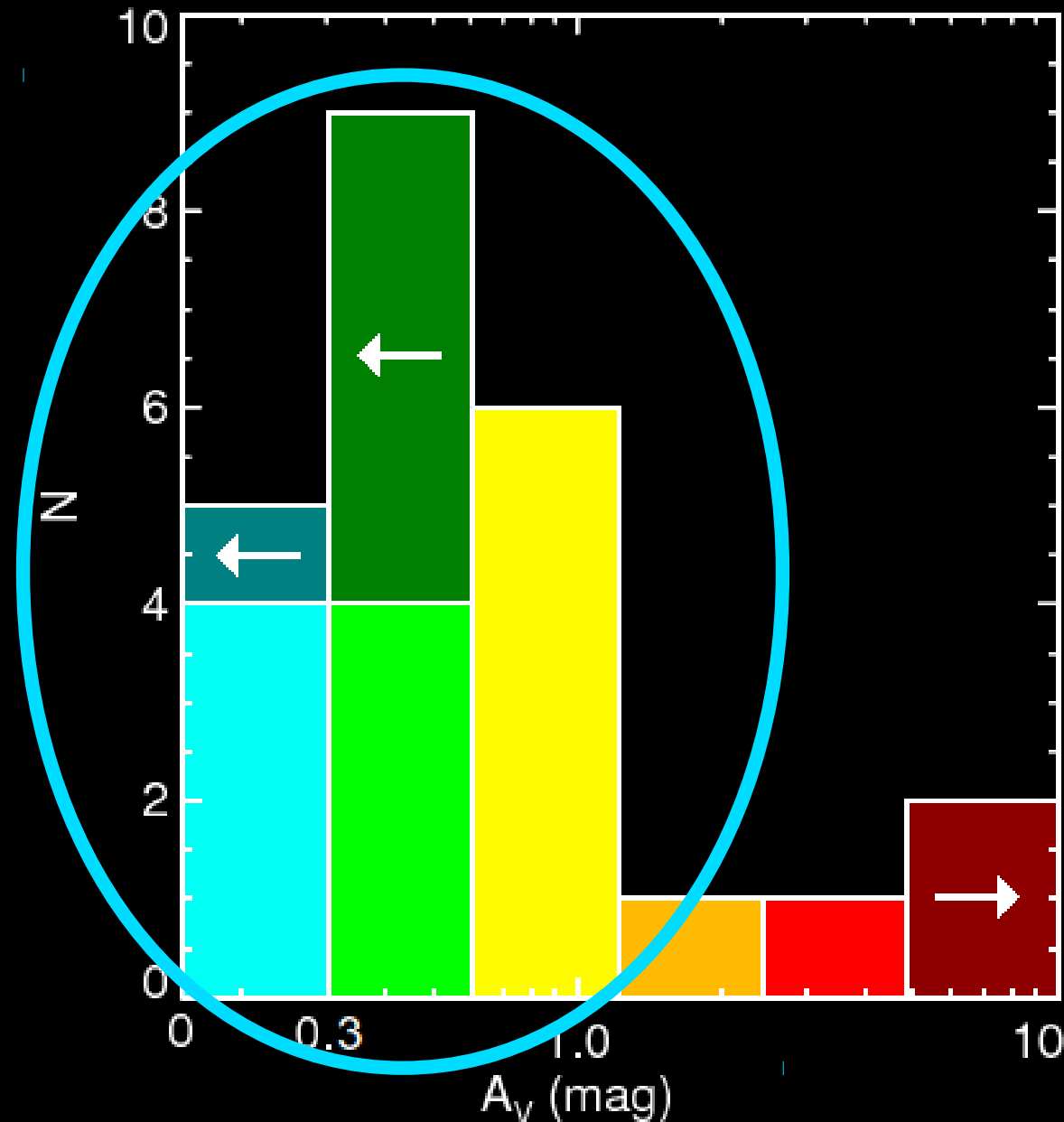
Savaglio et al. 2009

Chen et al. 2009

Kocevski et al. 2011

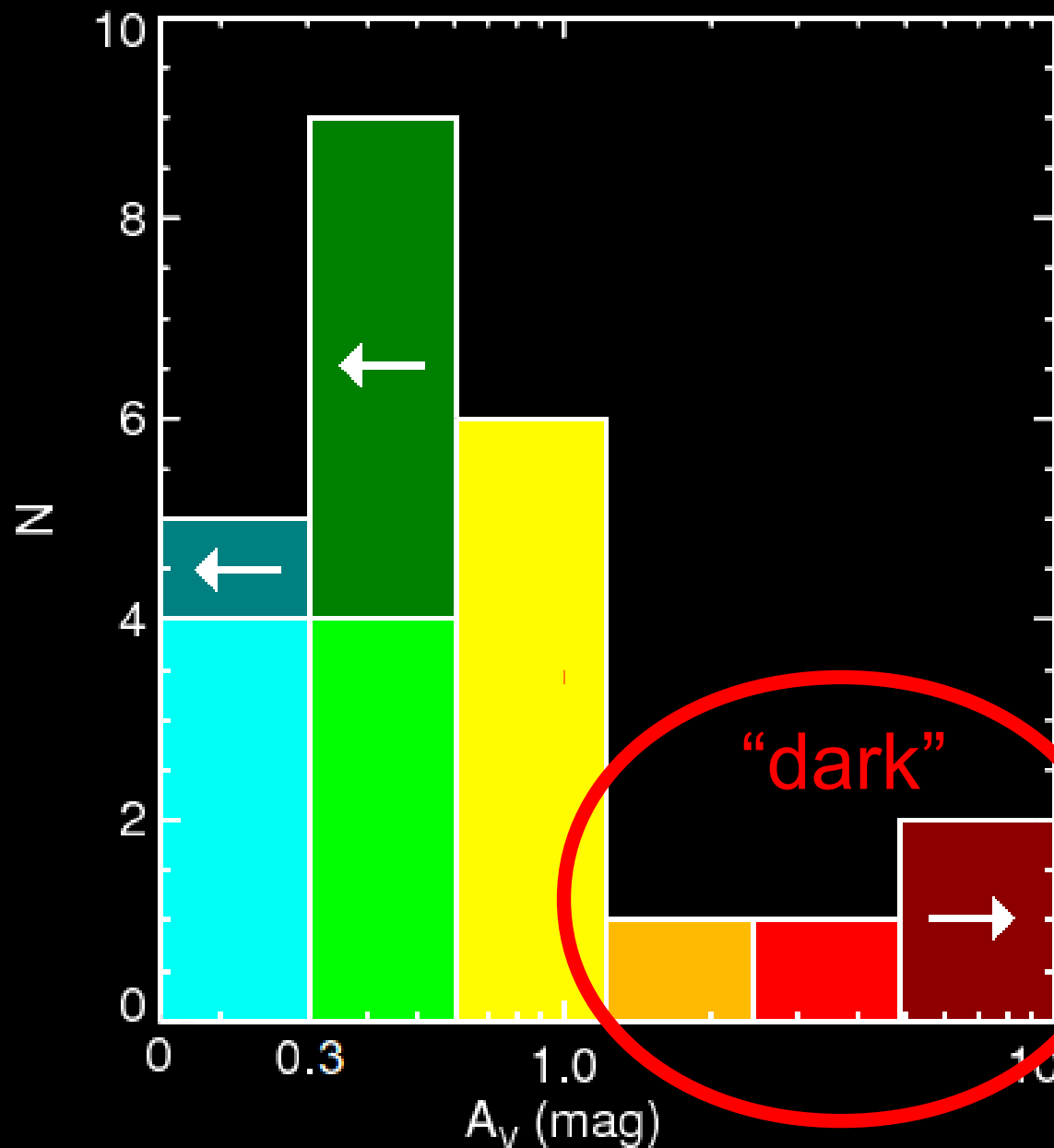
Mannucci et al. 2011

P60 GRB afterglow extinction histogram



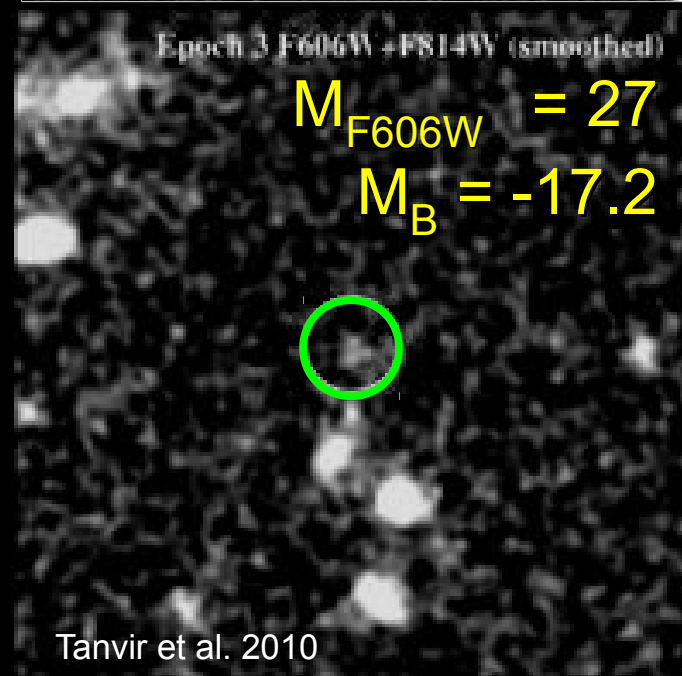
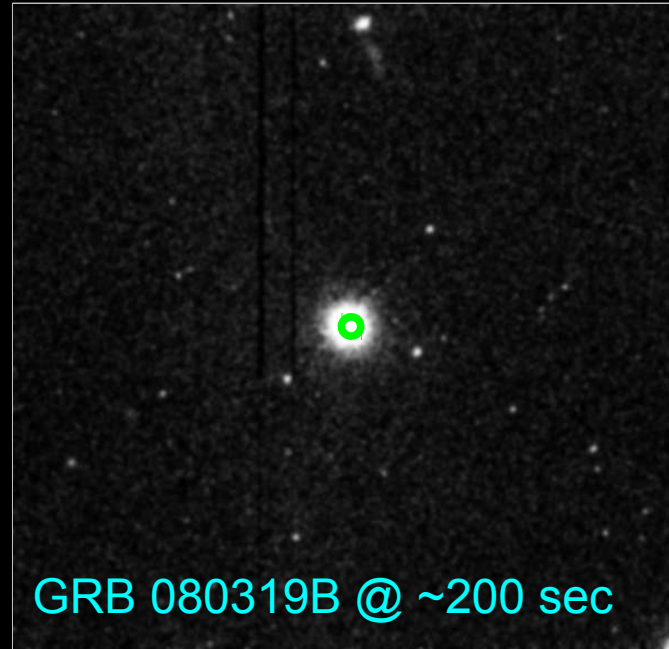
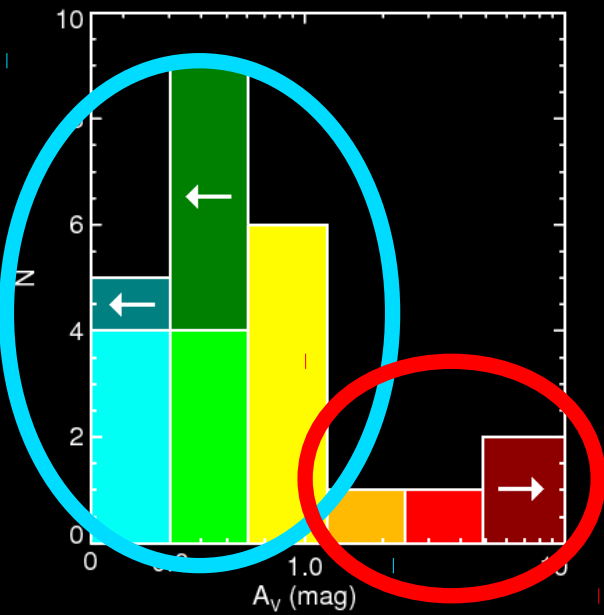
Cenko+ 2009 &
Perley+ 2009
(see also
Greiner+2011,
Krühler talk)

P60 GRB afterglow extinction histogram

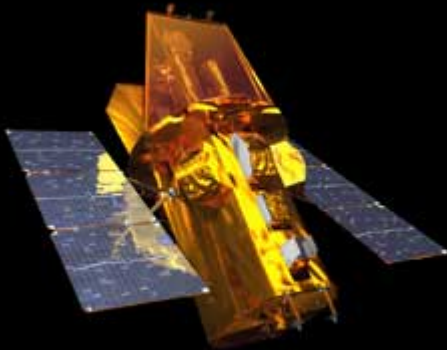
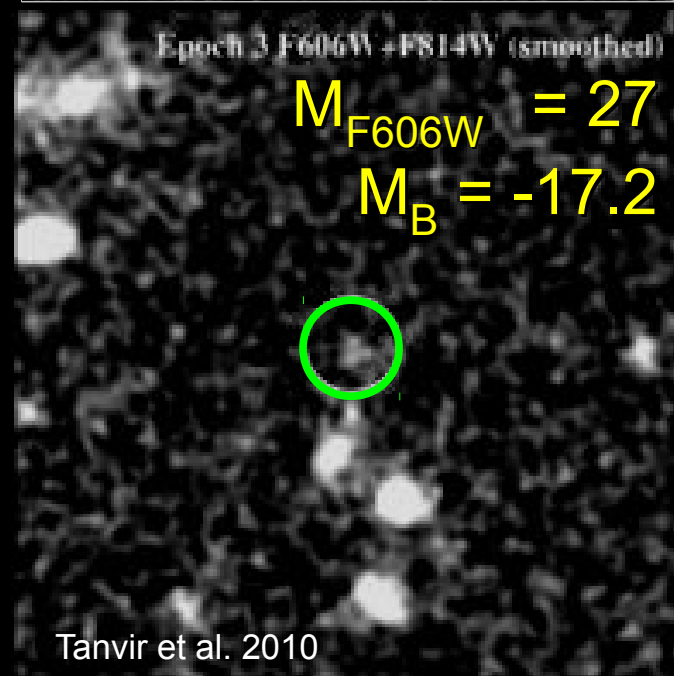
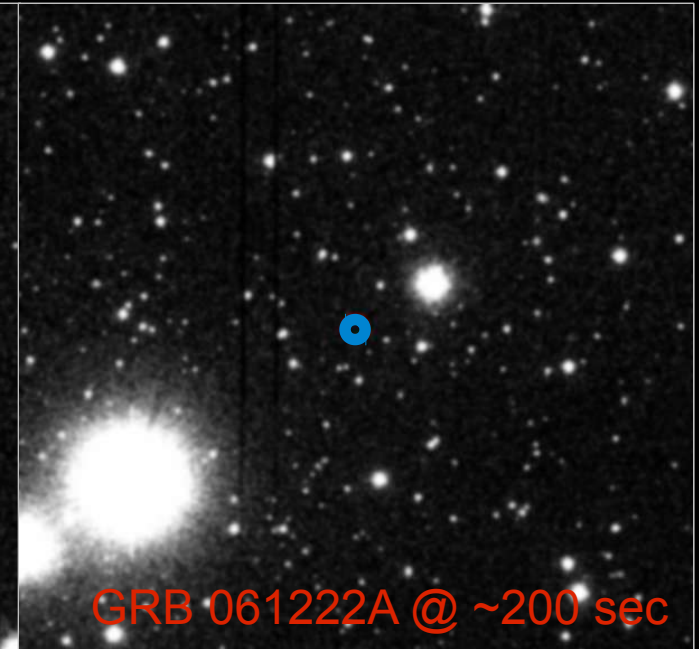
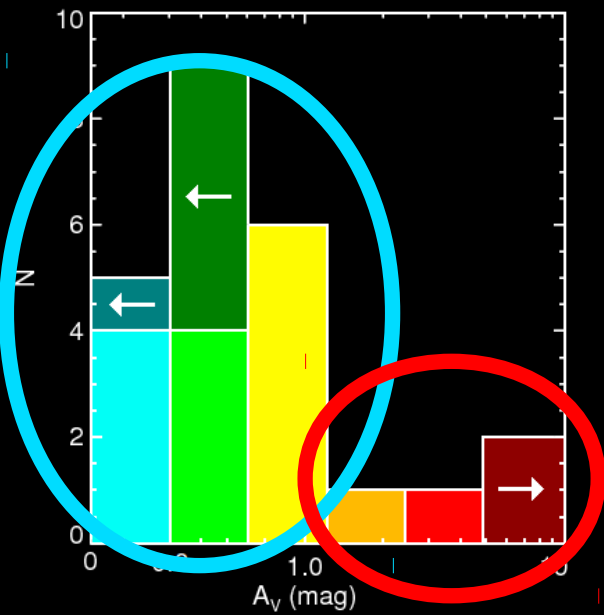


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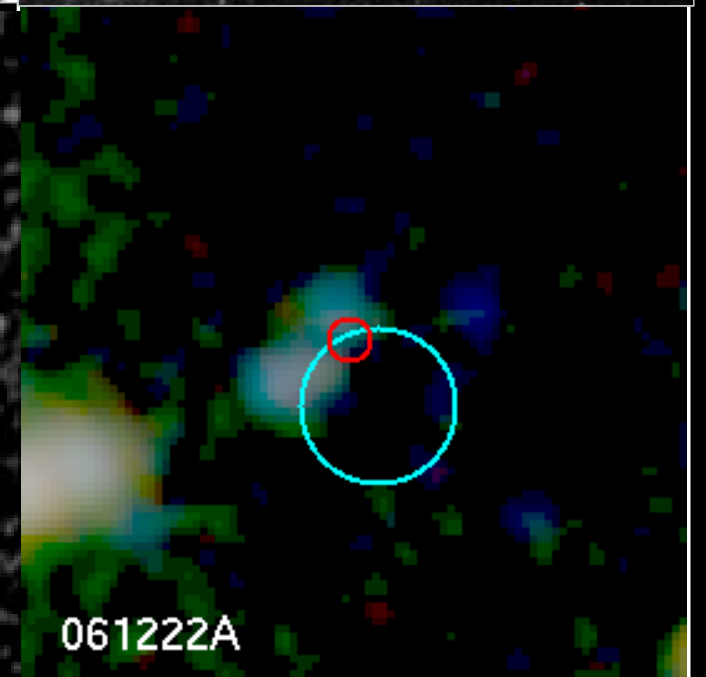
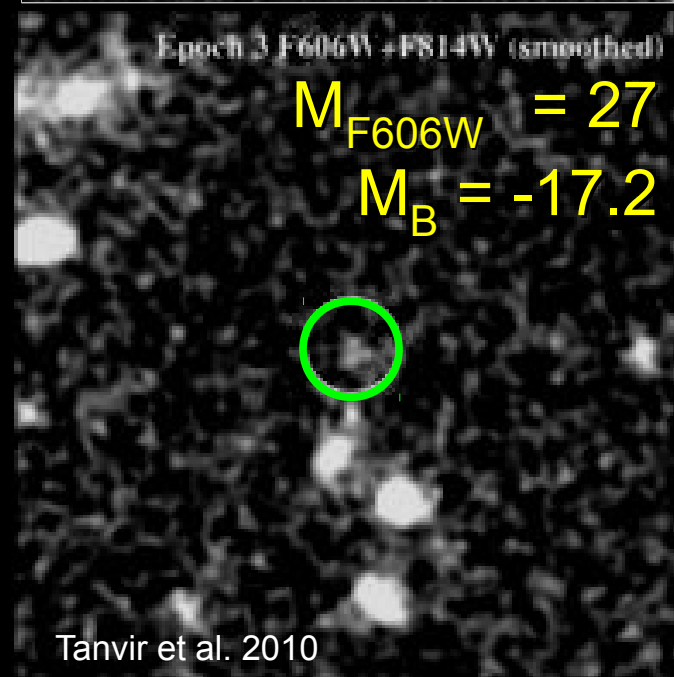
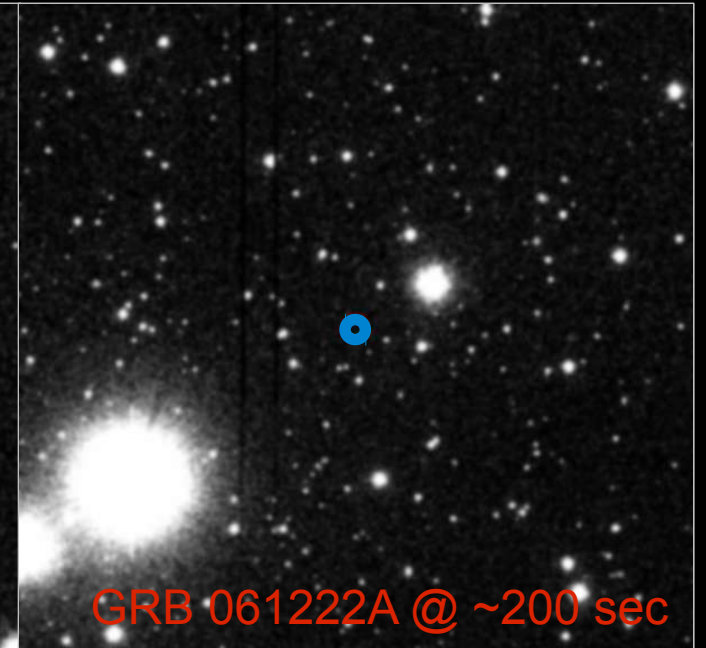
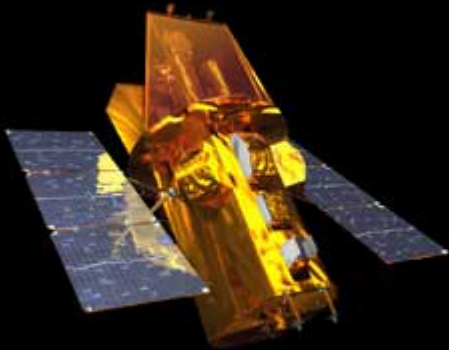
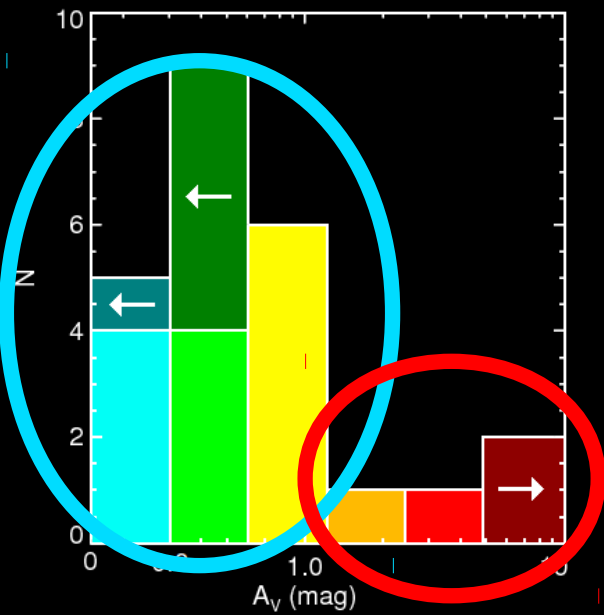
Finding host galaxies



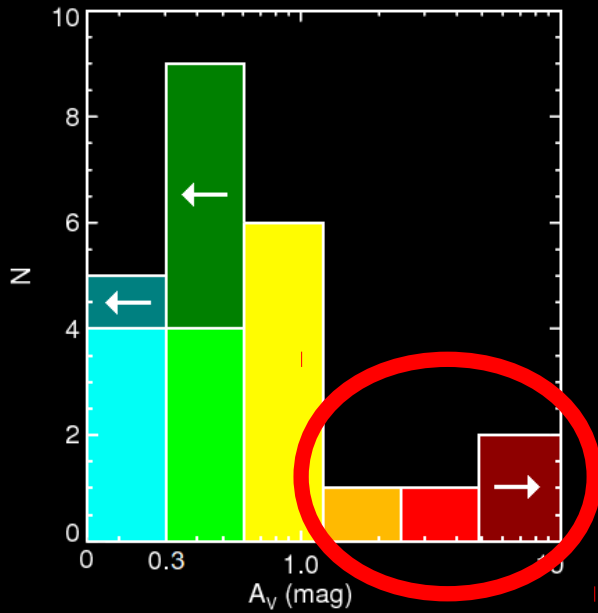
Finding host galaxies



Finding host galaxies



Dark burst host searches so far



GRB 080207 →

Svensson et al. 2012
Hunt et al. 2011

GRB 080607

Chen et al. 2011

GRB 080325

Hashimoto et al. 2011

GRB 051022

Castro-Tirado et al. 2007
Rol et al. 2007

GRB 020819

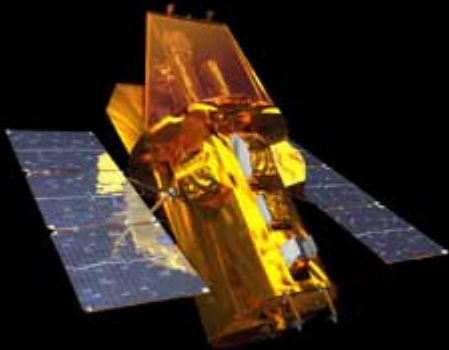
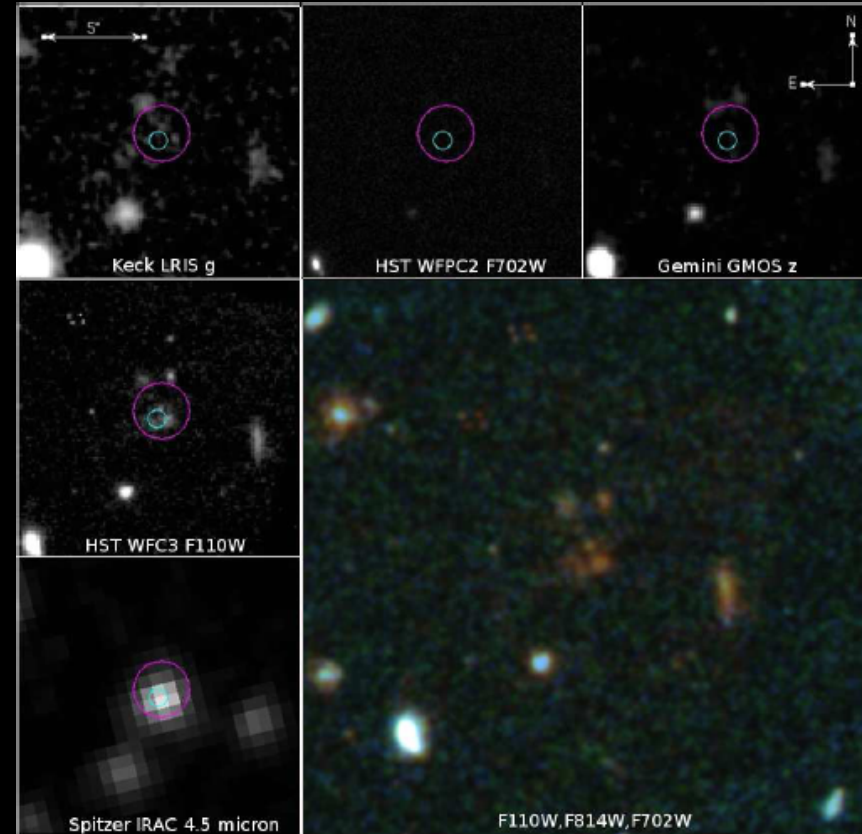
Levesque et al. 2010

GRB 070306

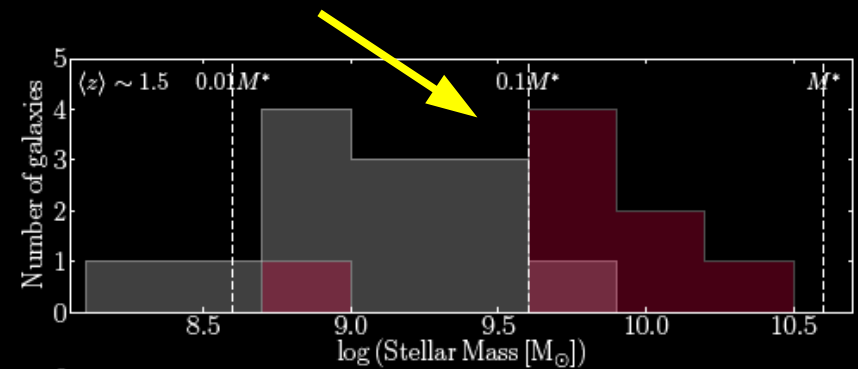
Jaunsen et al. 2008

GRBs 070802, 080605, 080805, 081109, 090926B, 100621A

Krühler et al. 2011

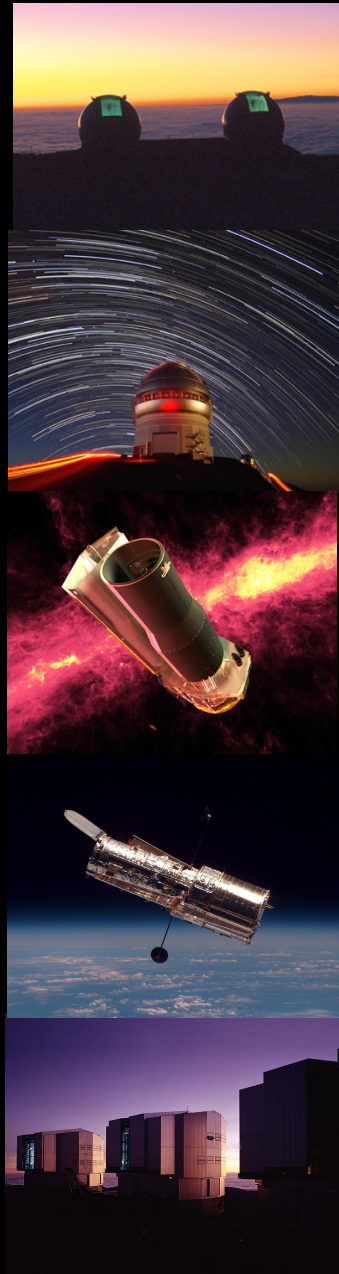


See also
Rossi et al. 2012
Klose poster (this meeting)
Hjorth talk (this meeting)



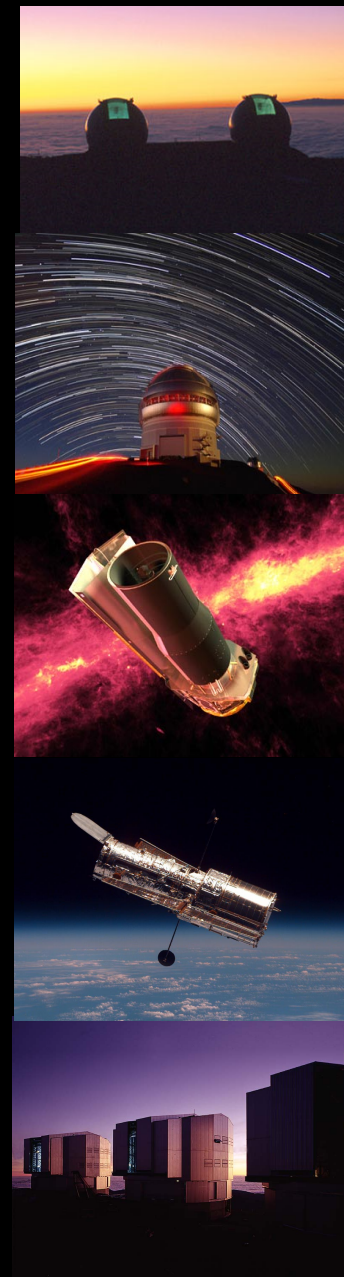
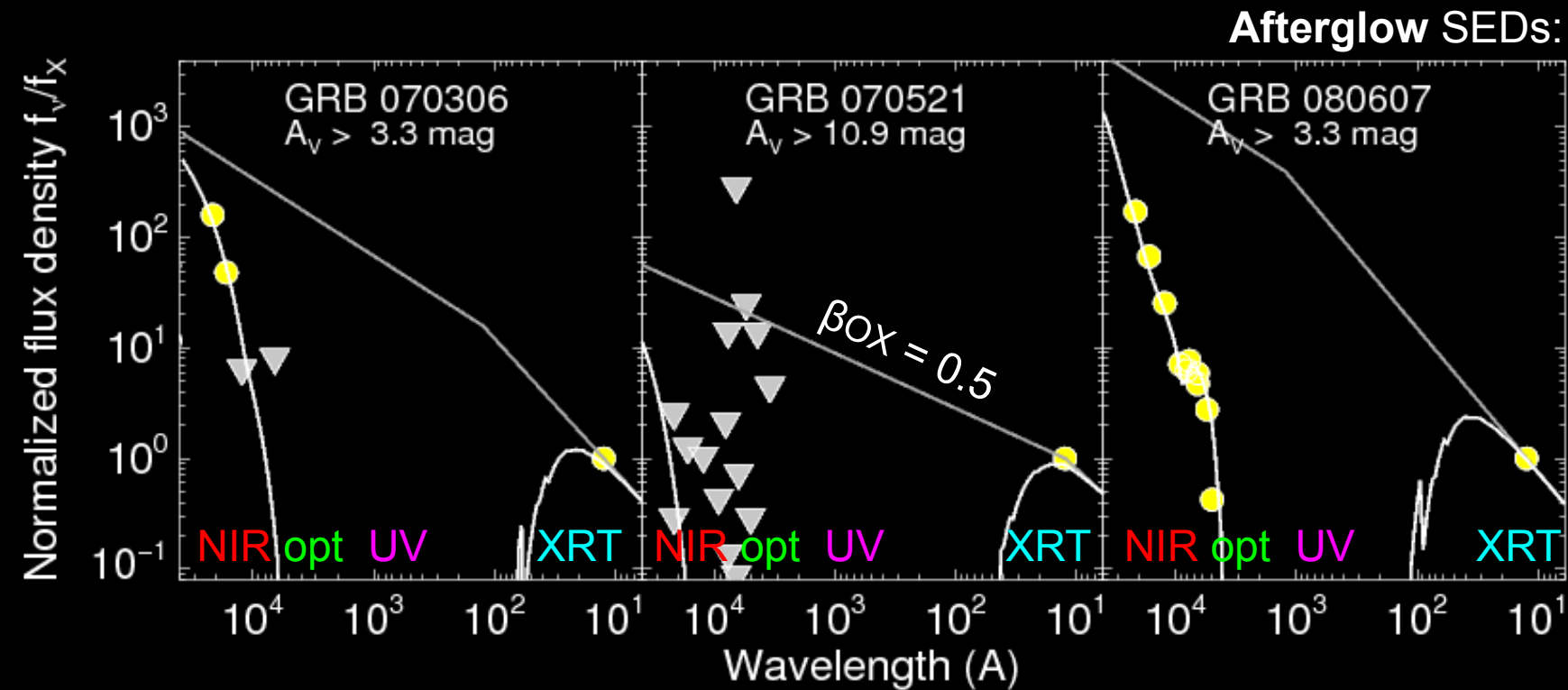
Multi-observatory dark GRB host galaxy campaign

Selection: “Every” Swift-era burst with
clear indication of $A_v > 2$ mag



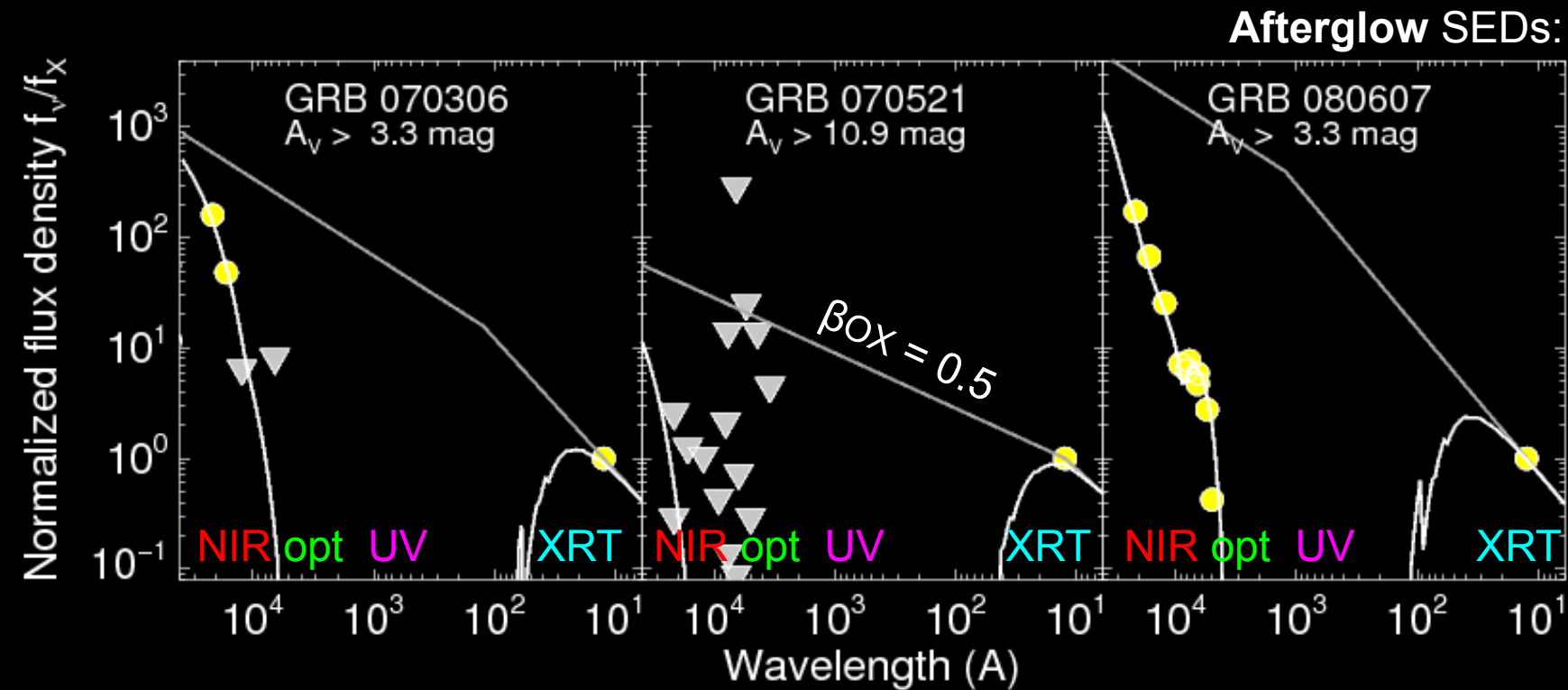
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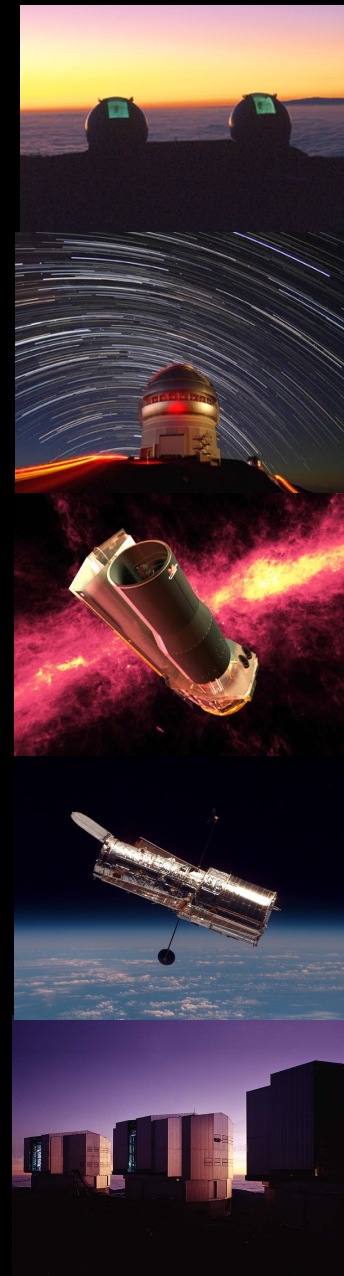


Multi-observatory dark GRB host galaxy campaign

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Majority localized by subarcsec position (a few XRT only)



Multi-observatory dark GRB host galaxy campaign

Selection: “Every” Swift-era burst with
clear indication of $A_v > 2$ mag

Acquire *at least* two optical filters (A_v + SFR)
plus at least one NIR filter (mass)

2005-2011 sample:

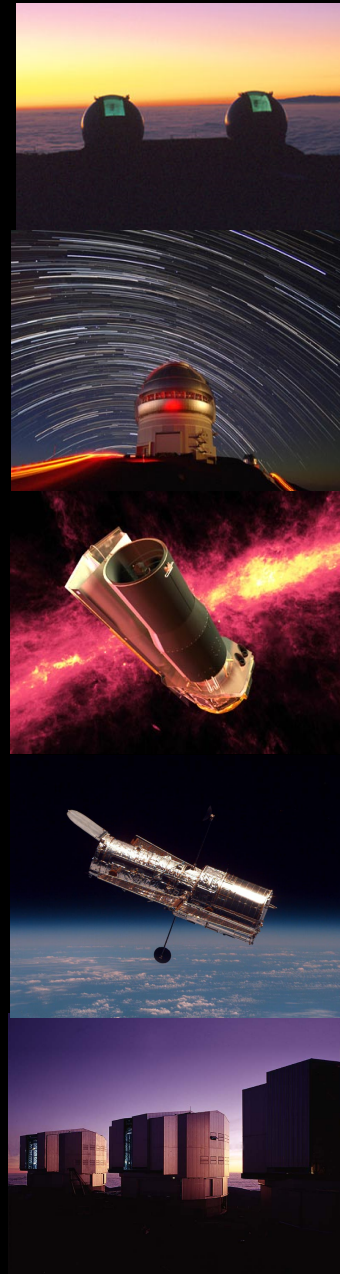
36 dark hosts, observations ongoing...

2005-2009 sample

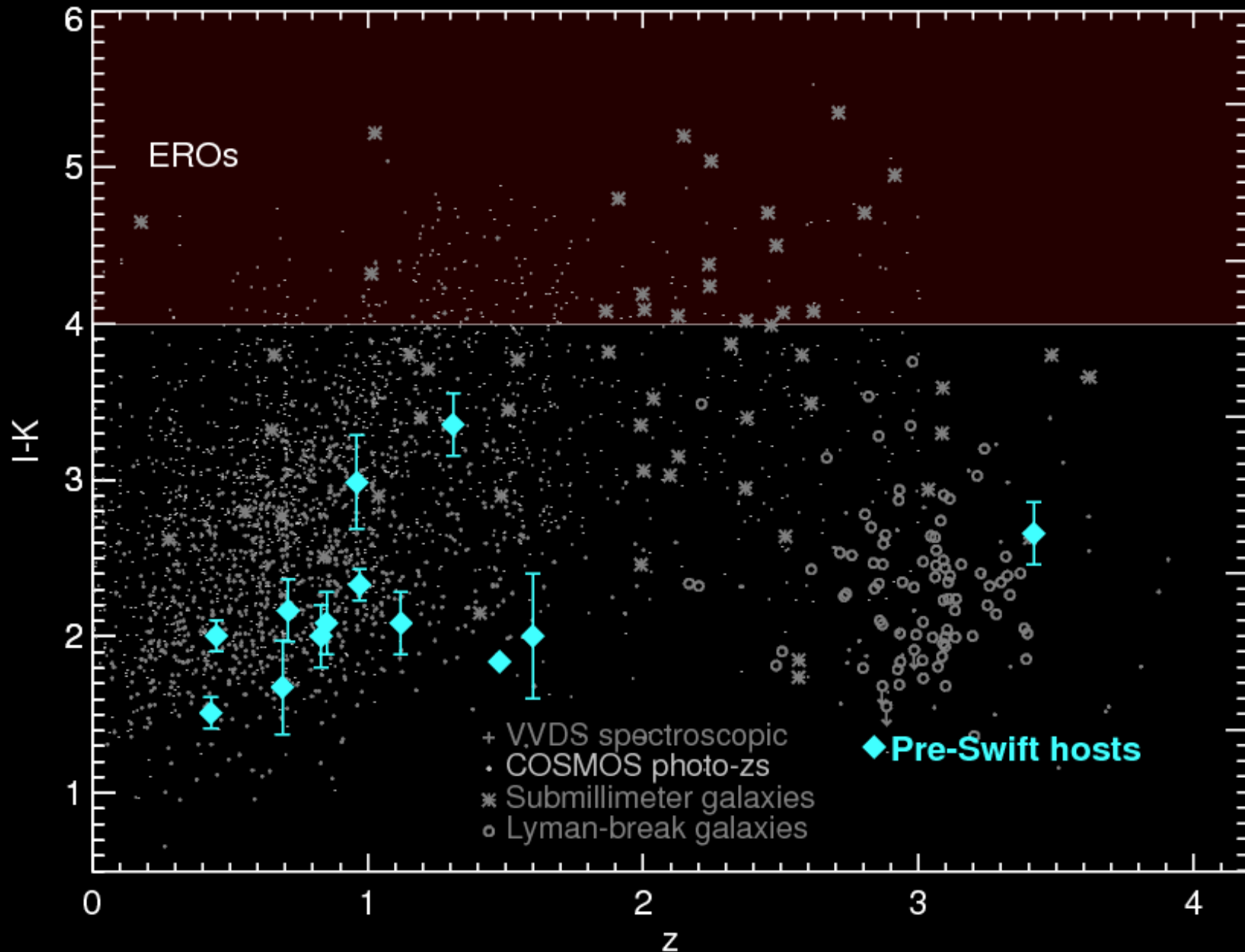
30 dark host fields (~~29~~ 30 detected!)

19 with spectroscopic redshift

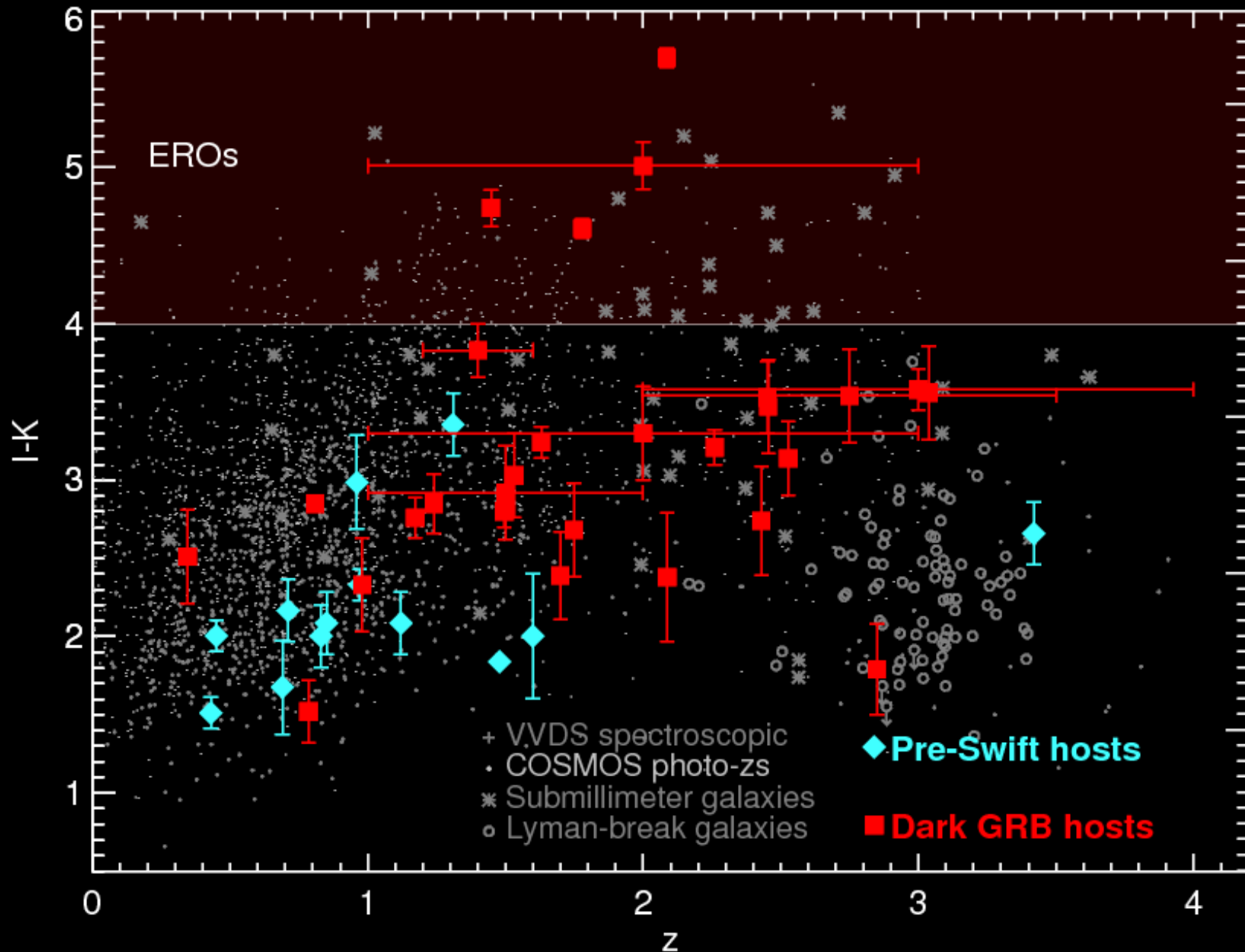
2 with photometric redshift



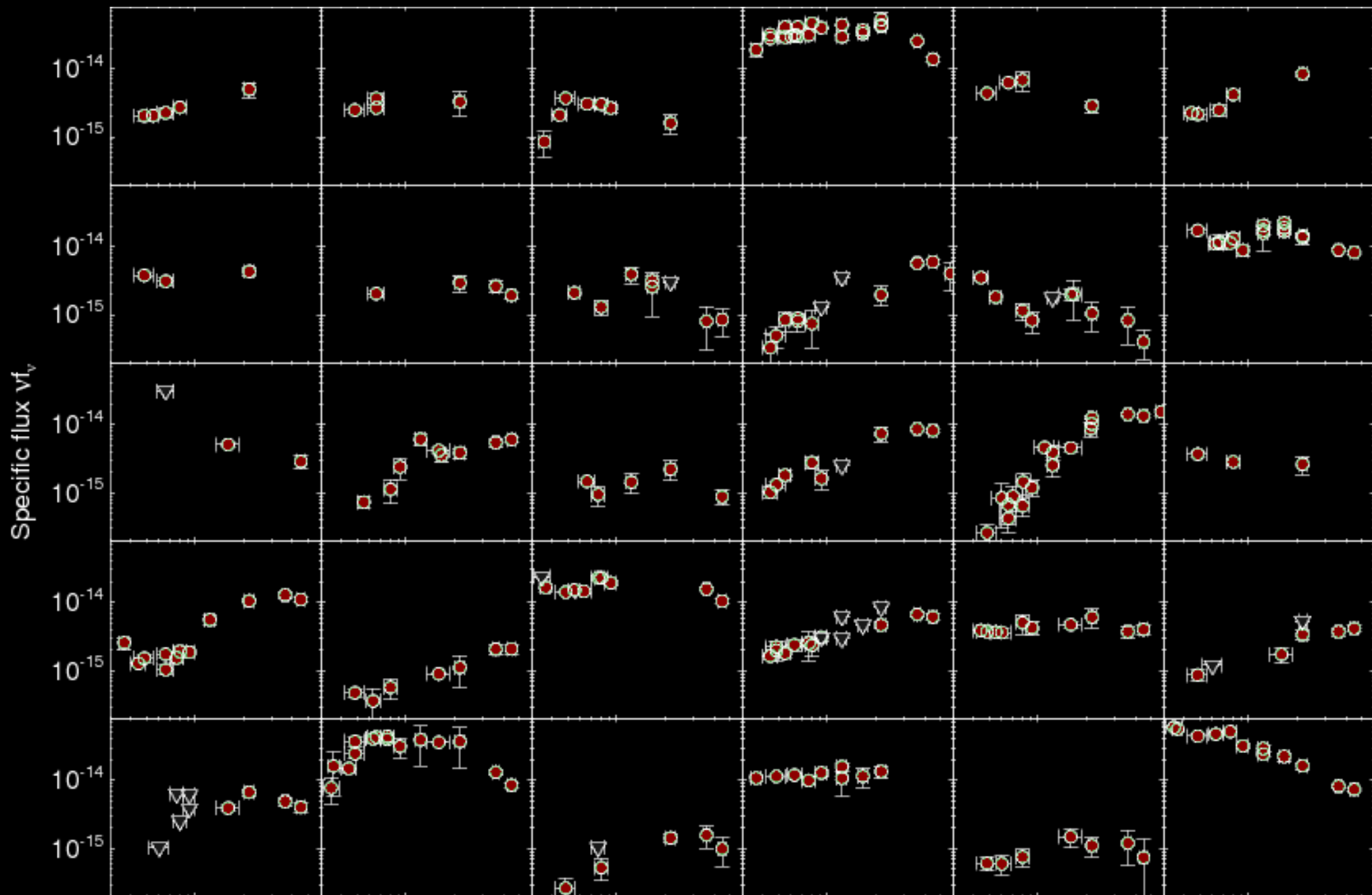
Dramatic difference in optical-NIR colors



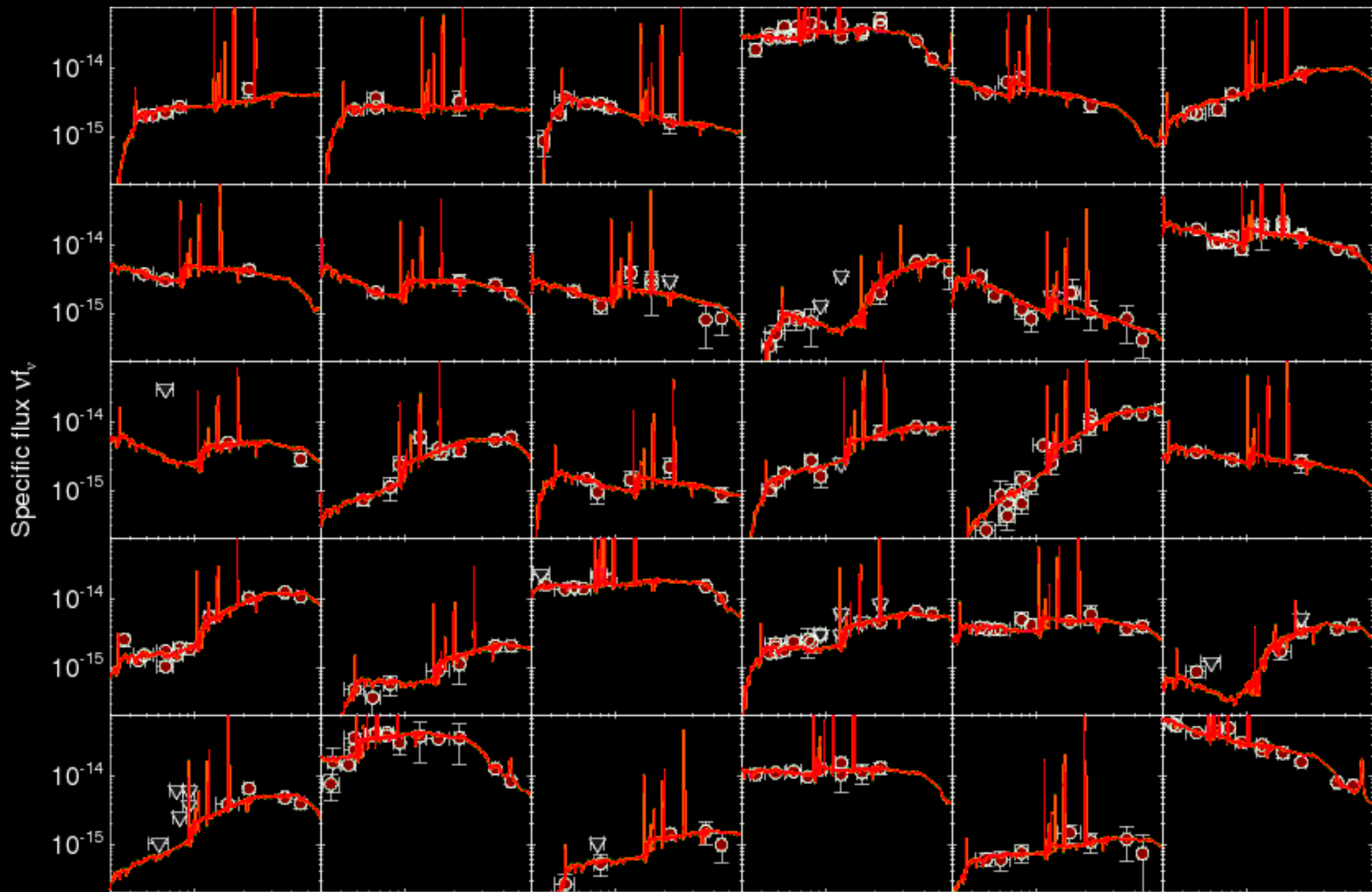
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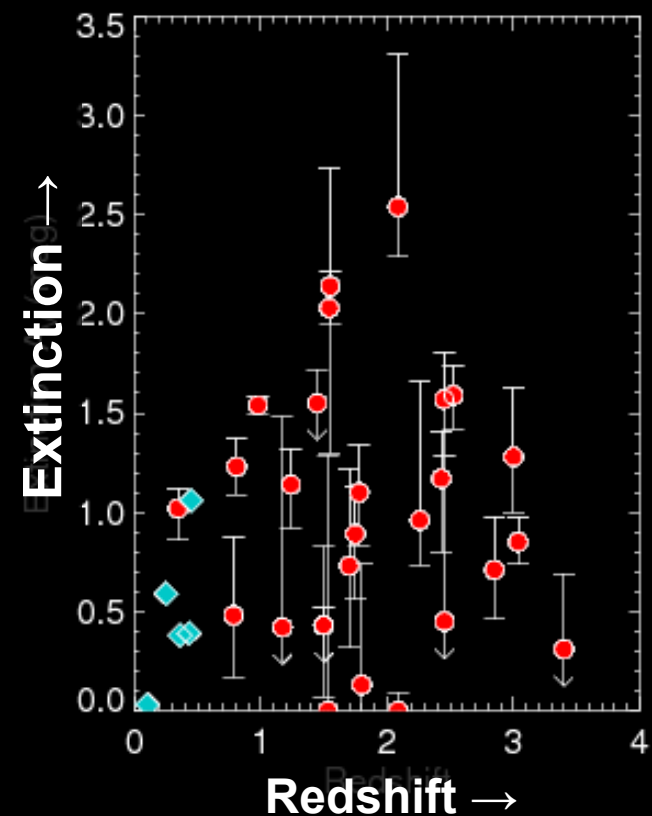
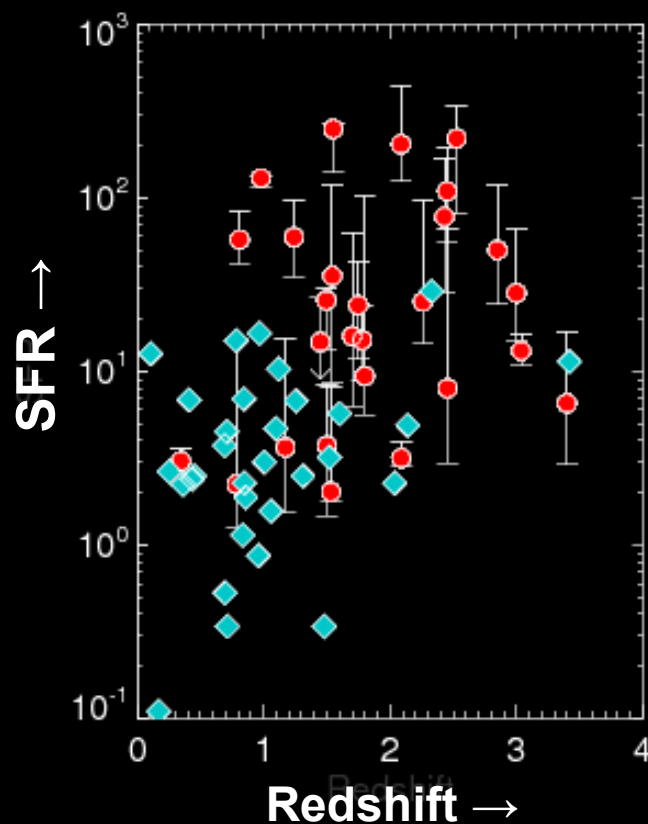
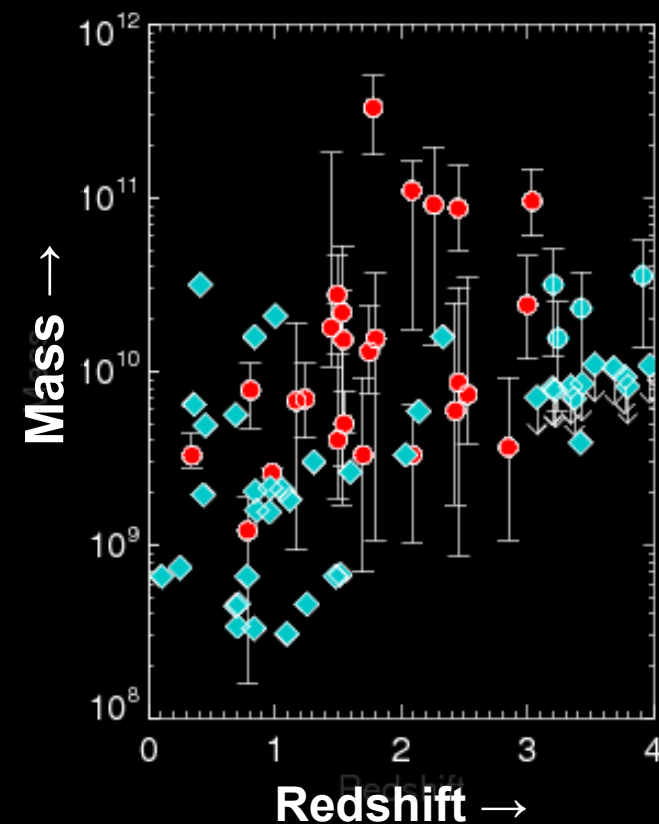
Modeling host galaxy properties



Modeling host galaxy properties



Differences in every parameter



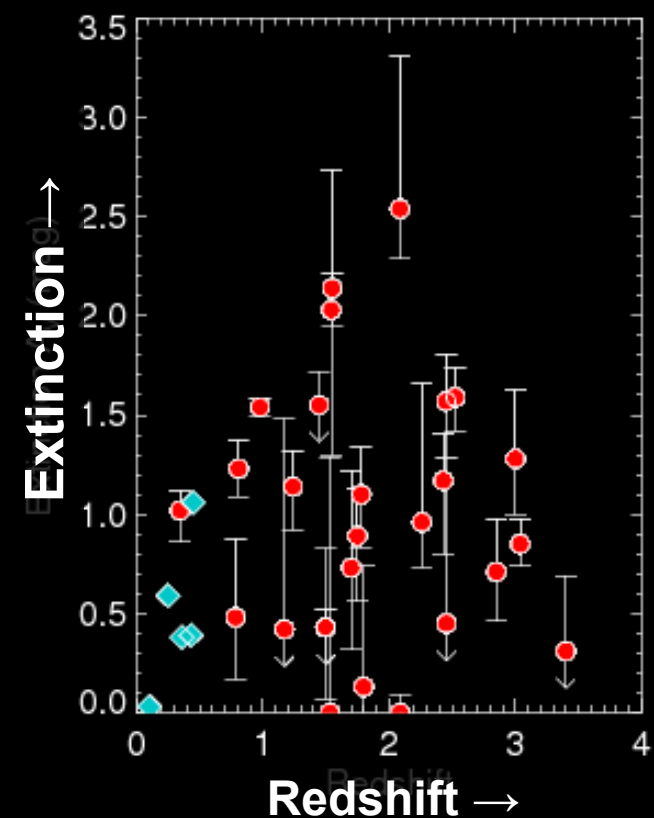
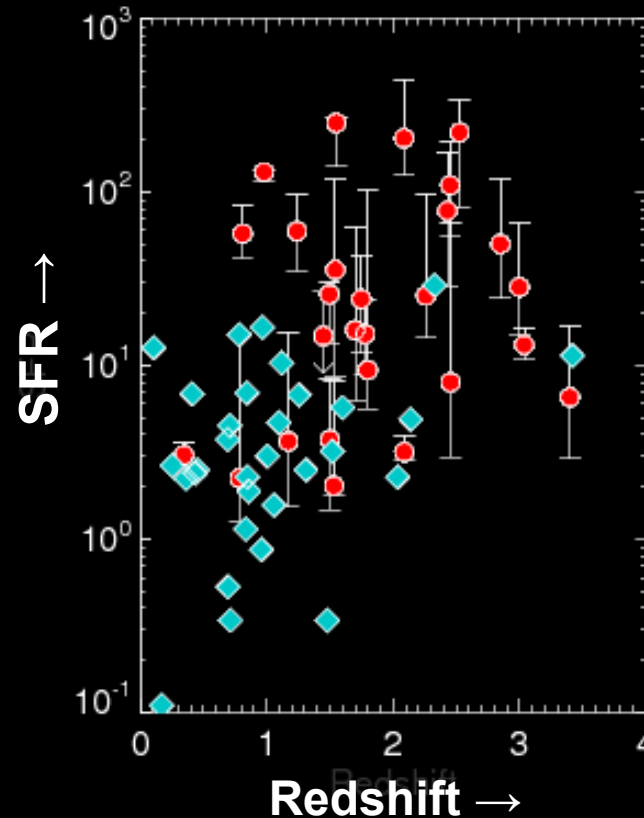
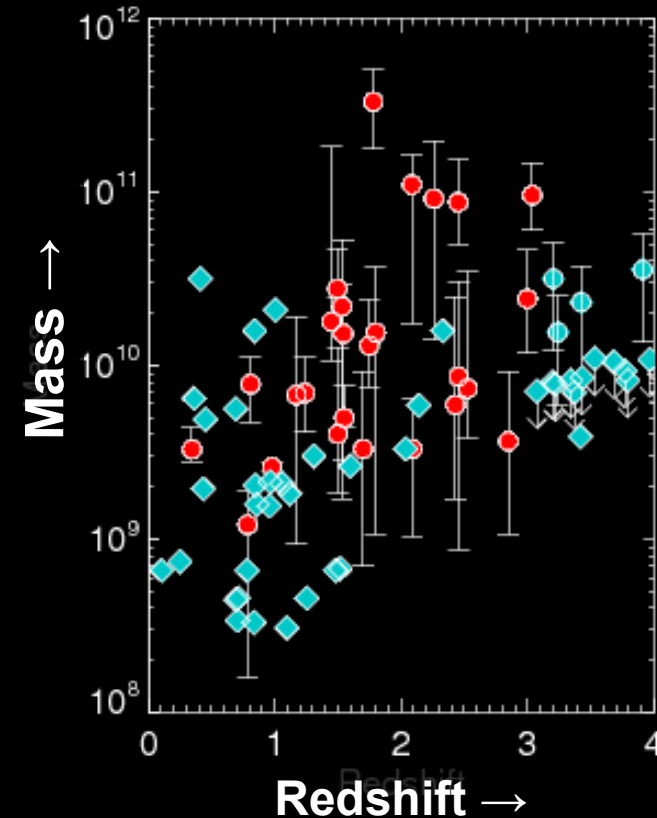
Differences in every parameter

Dark GRB hosts are...

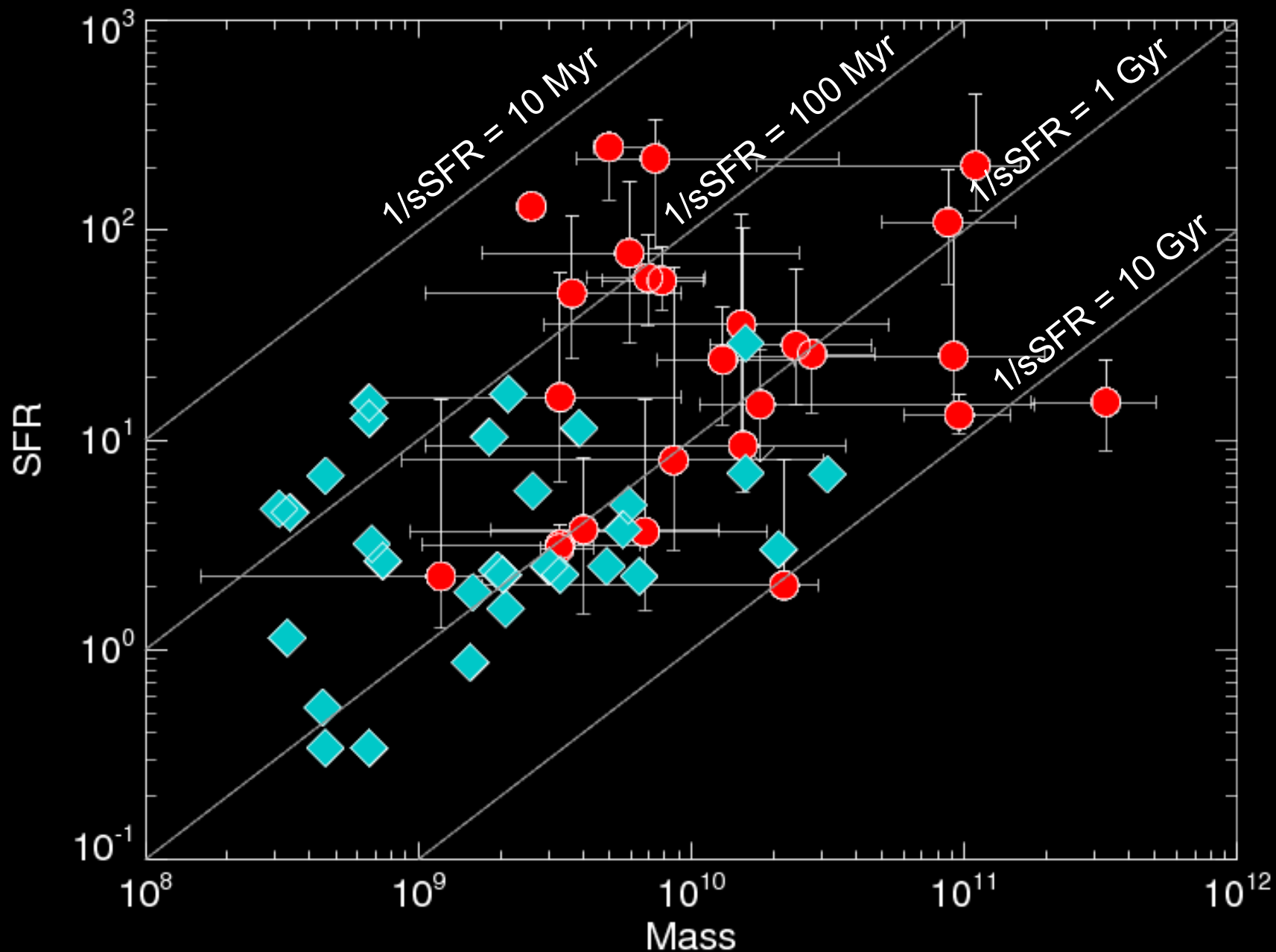
More massive

More rapidly
star-forming

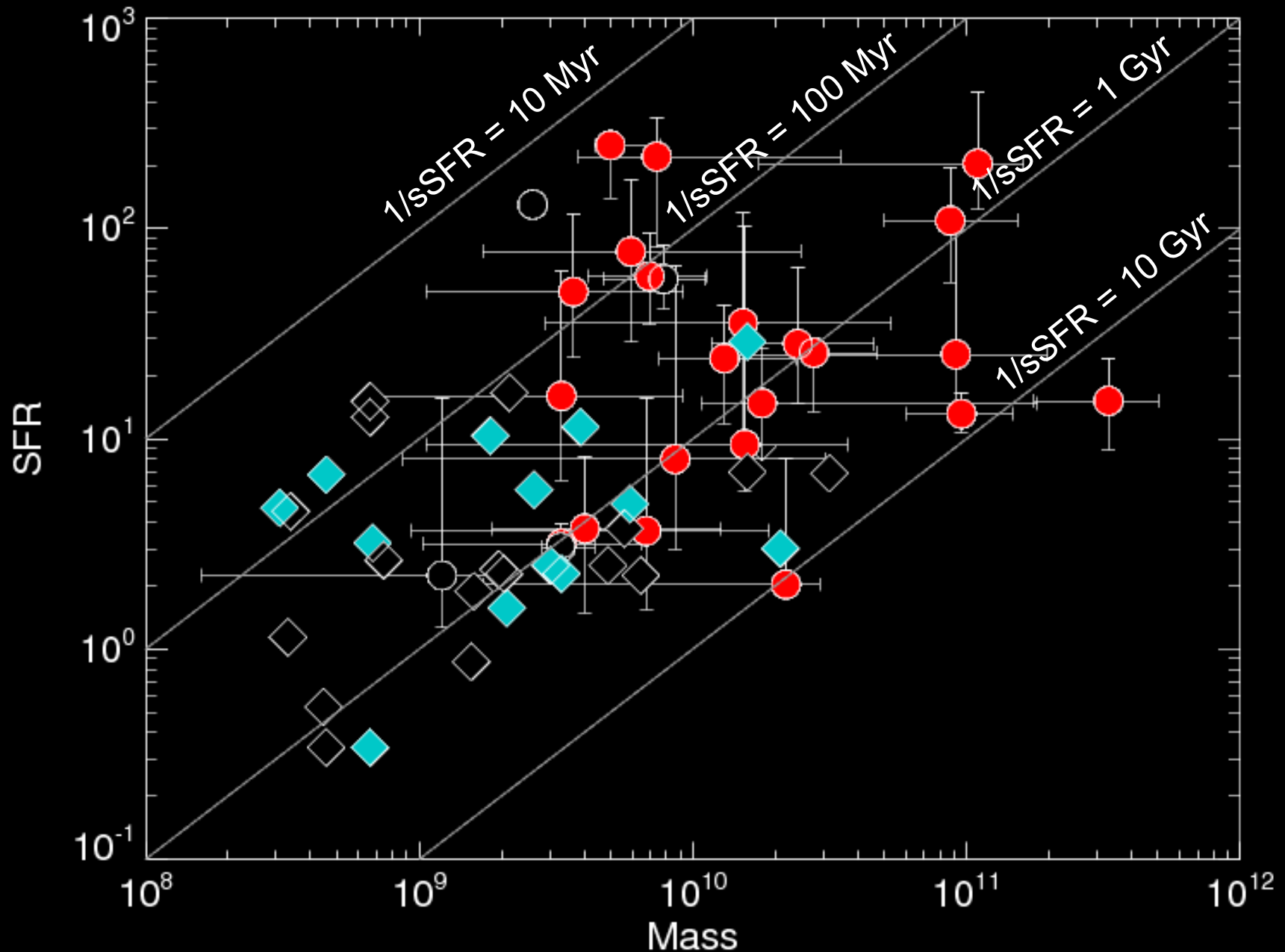
Redder and
dustier



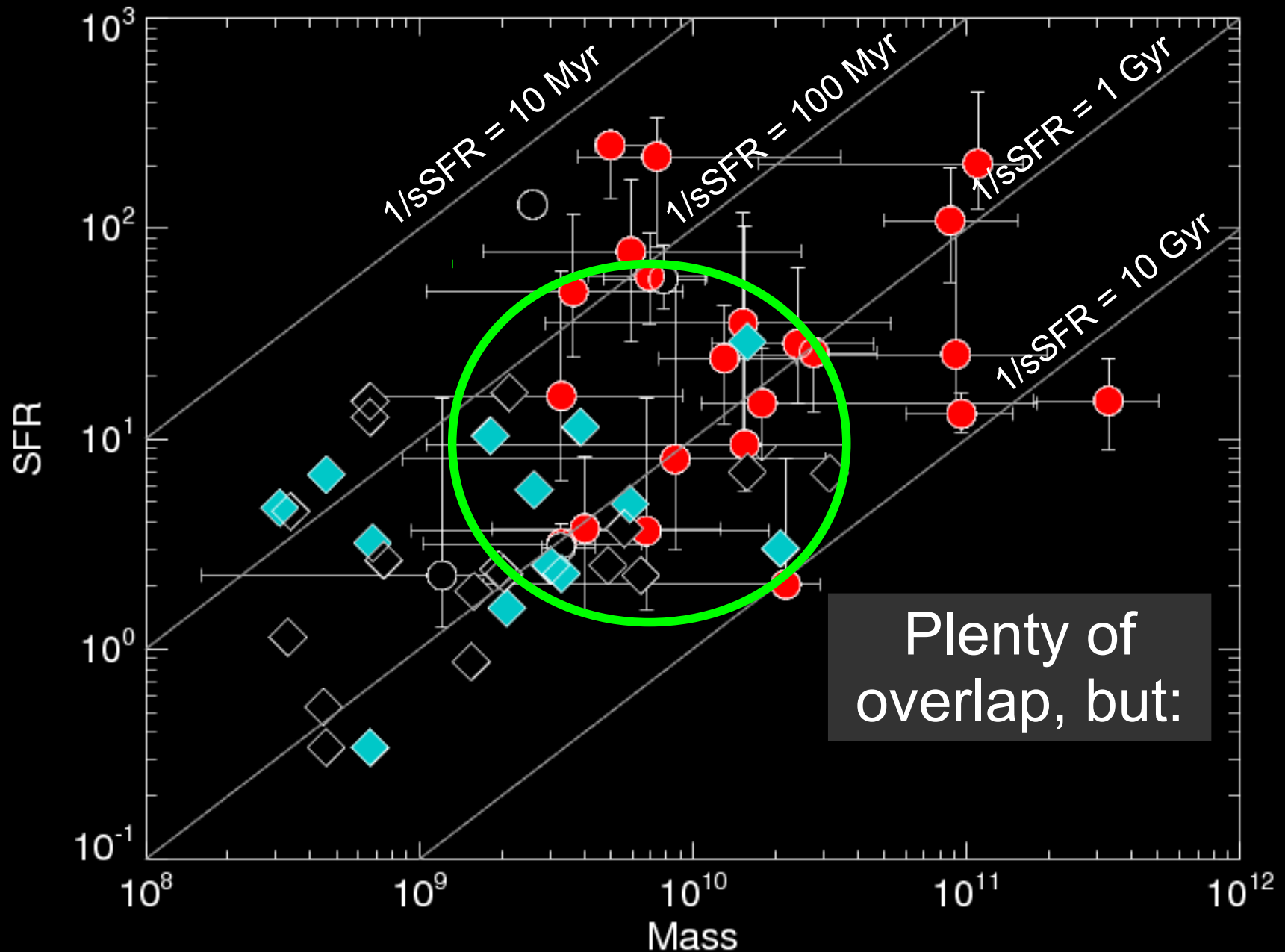
SFR vs. stellar mass



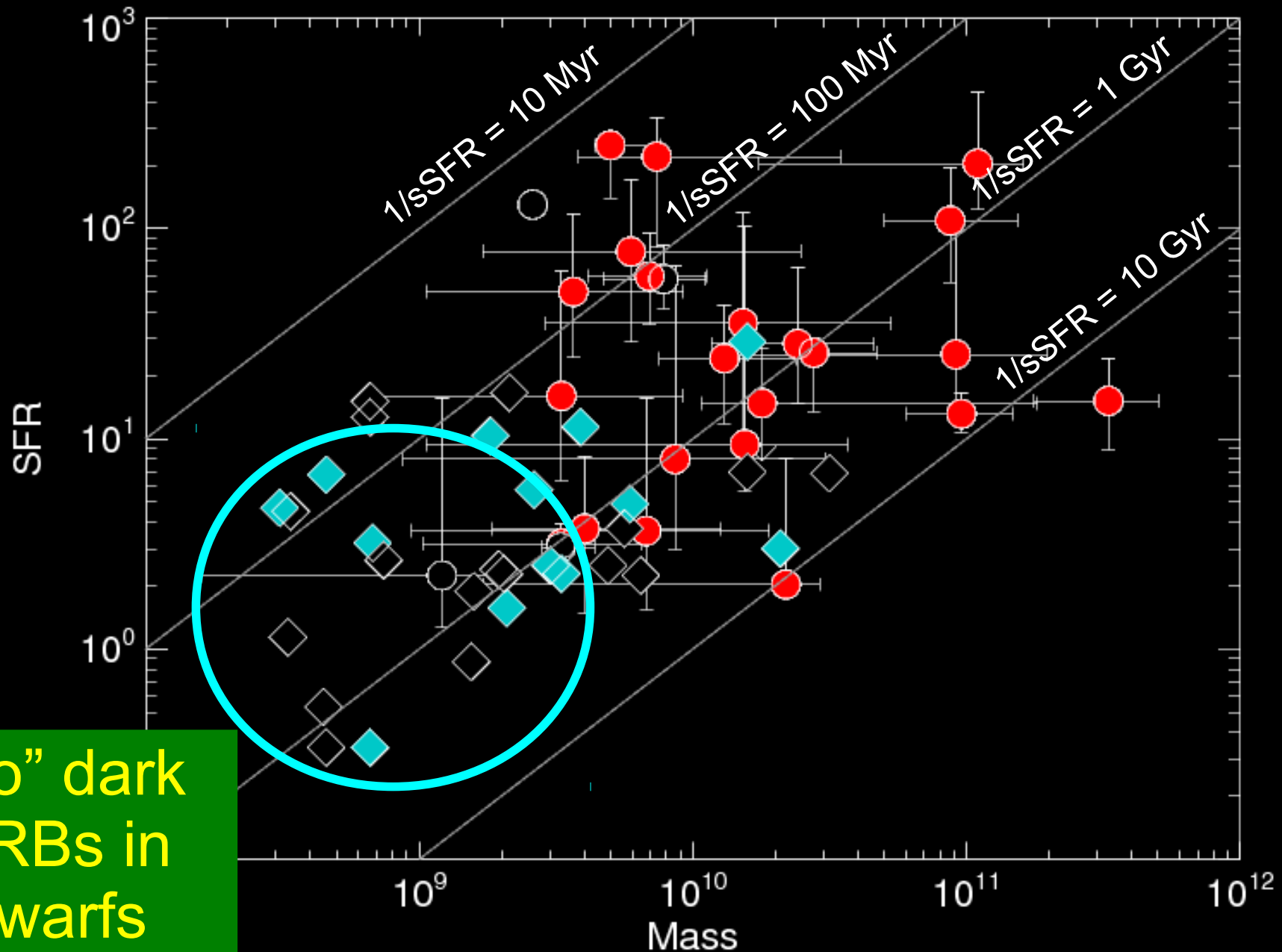
SFR vs. stellar mass ($z > 1$)



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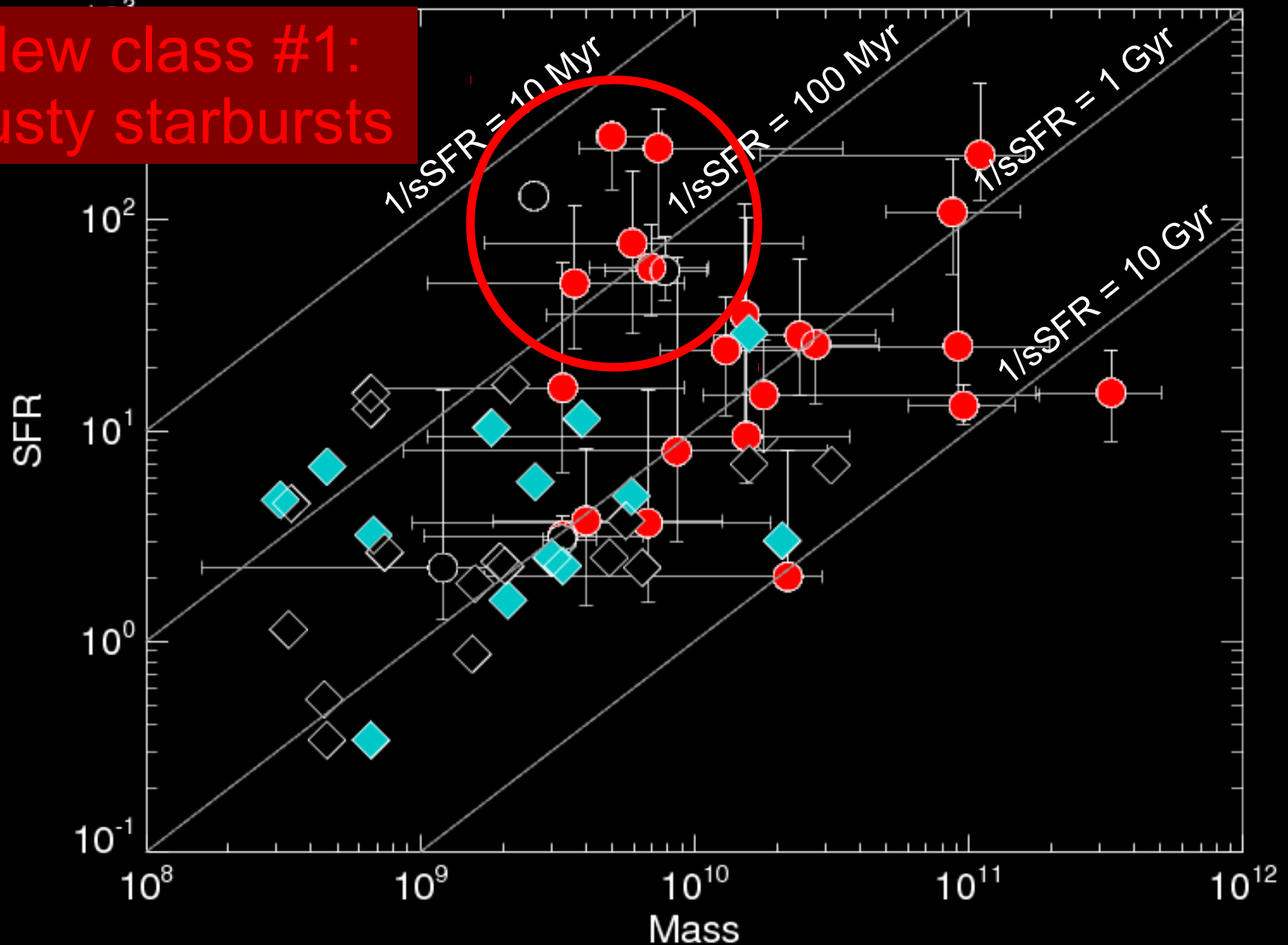
SFR vs. stellar mass ($z > 1$)



“No” dark
GRBs in
dwarfs

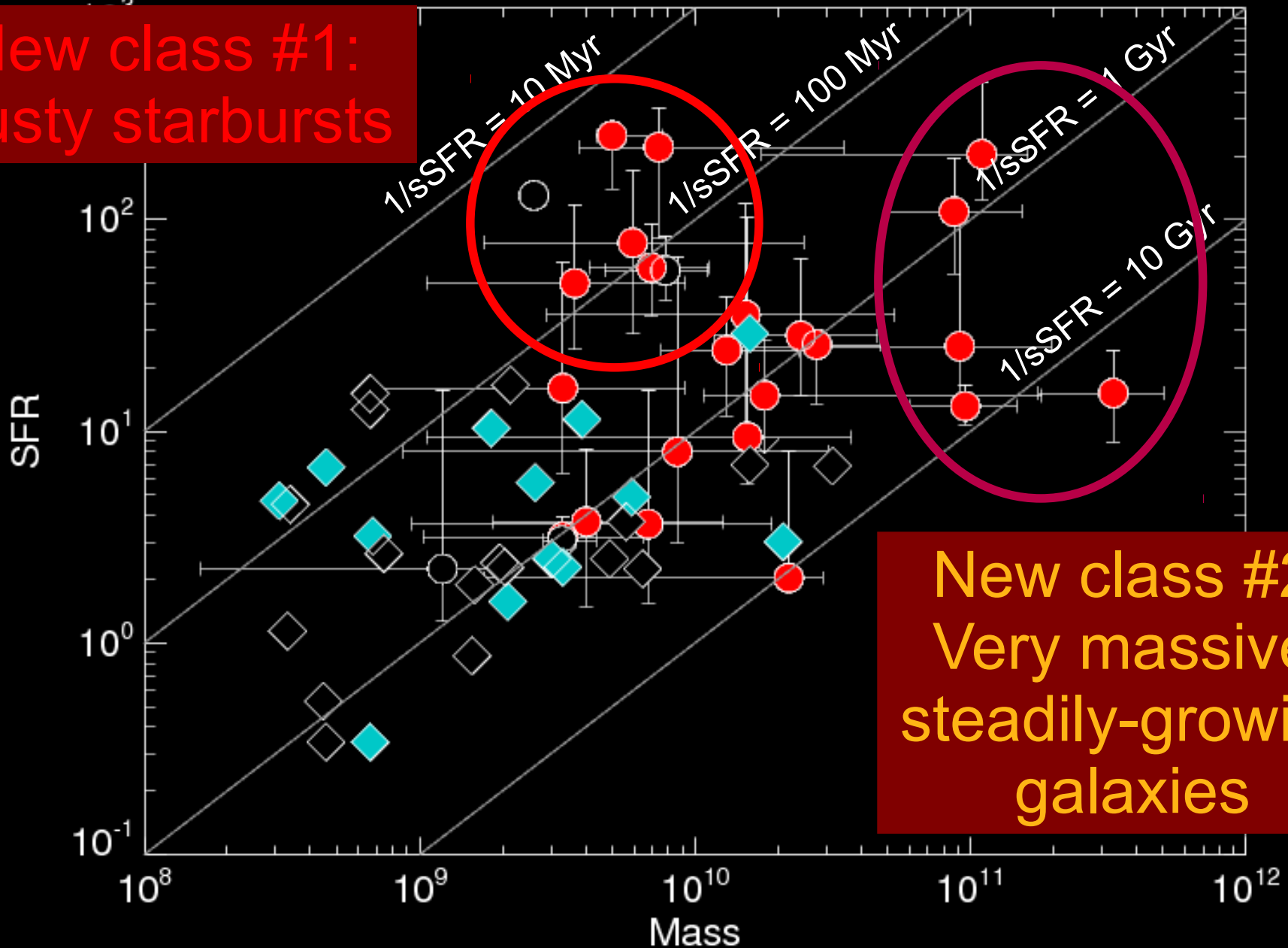
SFR vs. stellar mass ($z > 1$)

New class #1:
Dusty starbursts



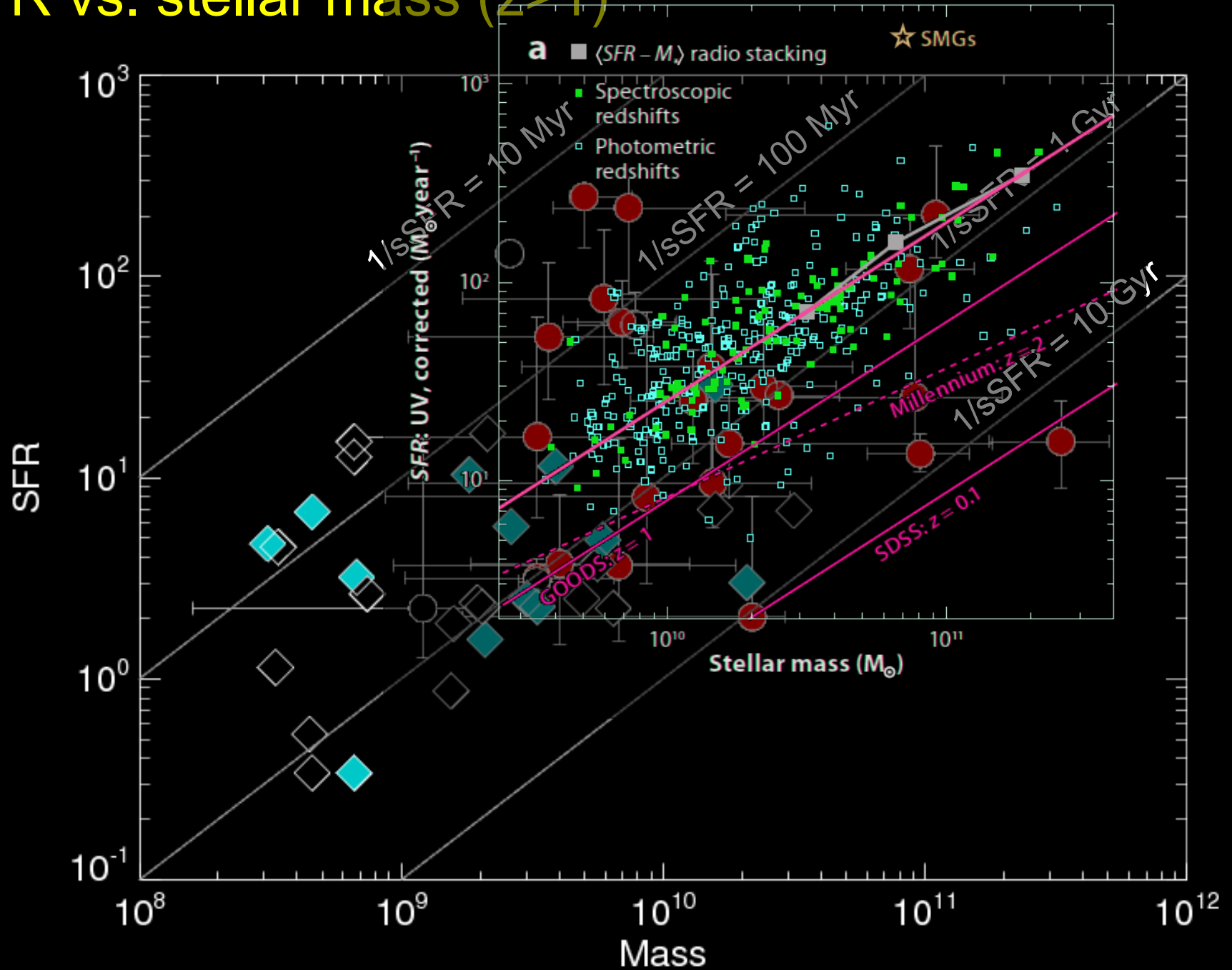
SFR vs. stellar mass ($z > 1$)

New class #1:
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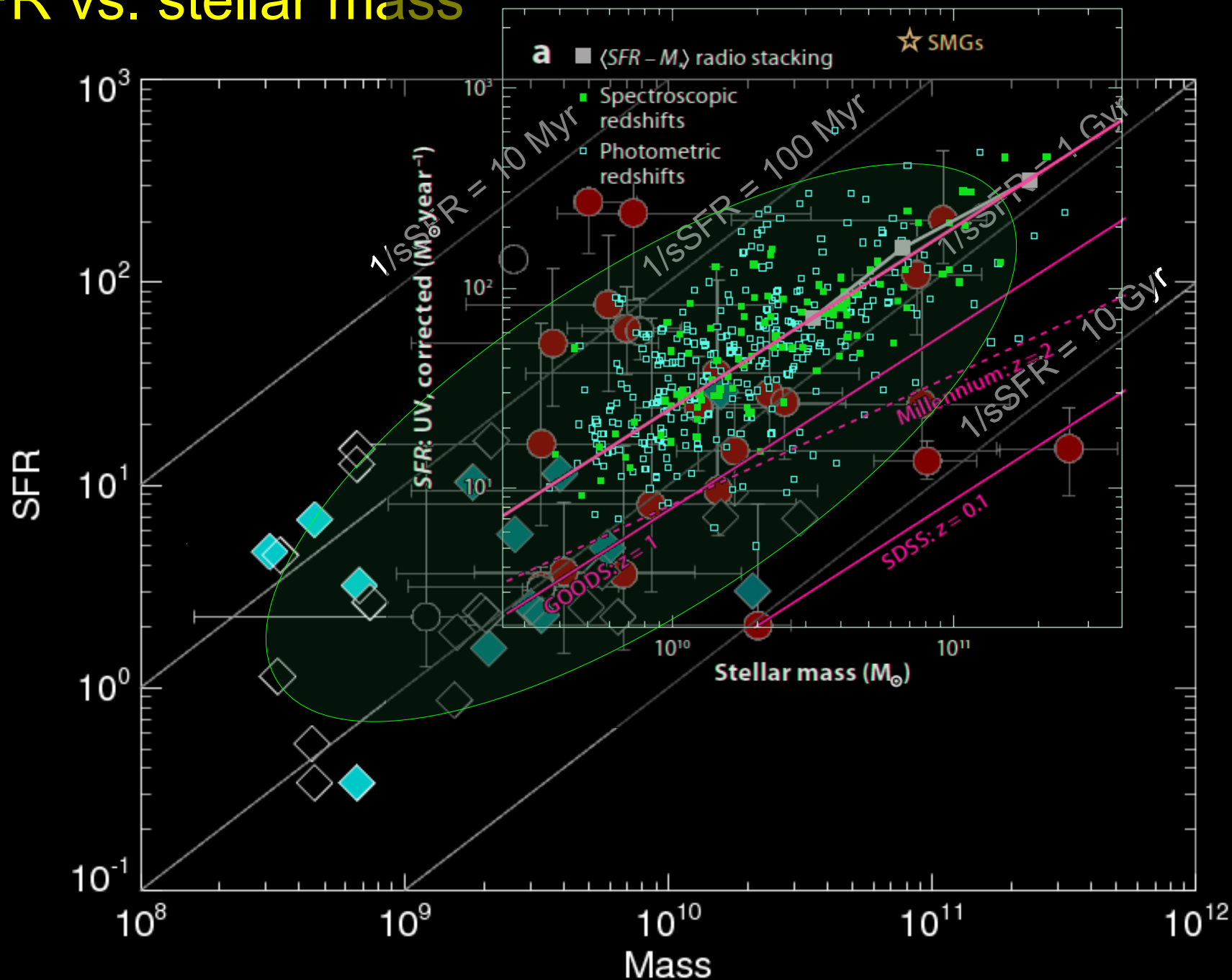


New class #2:
Very massive,
steadily-growing
galaxies

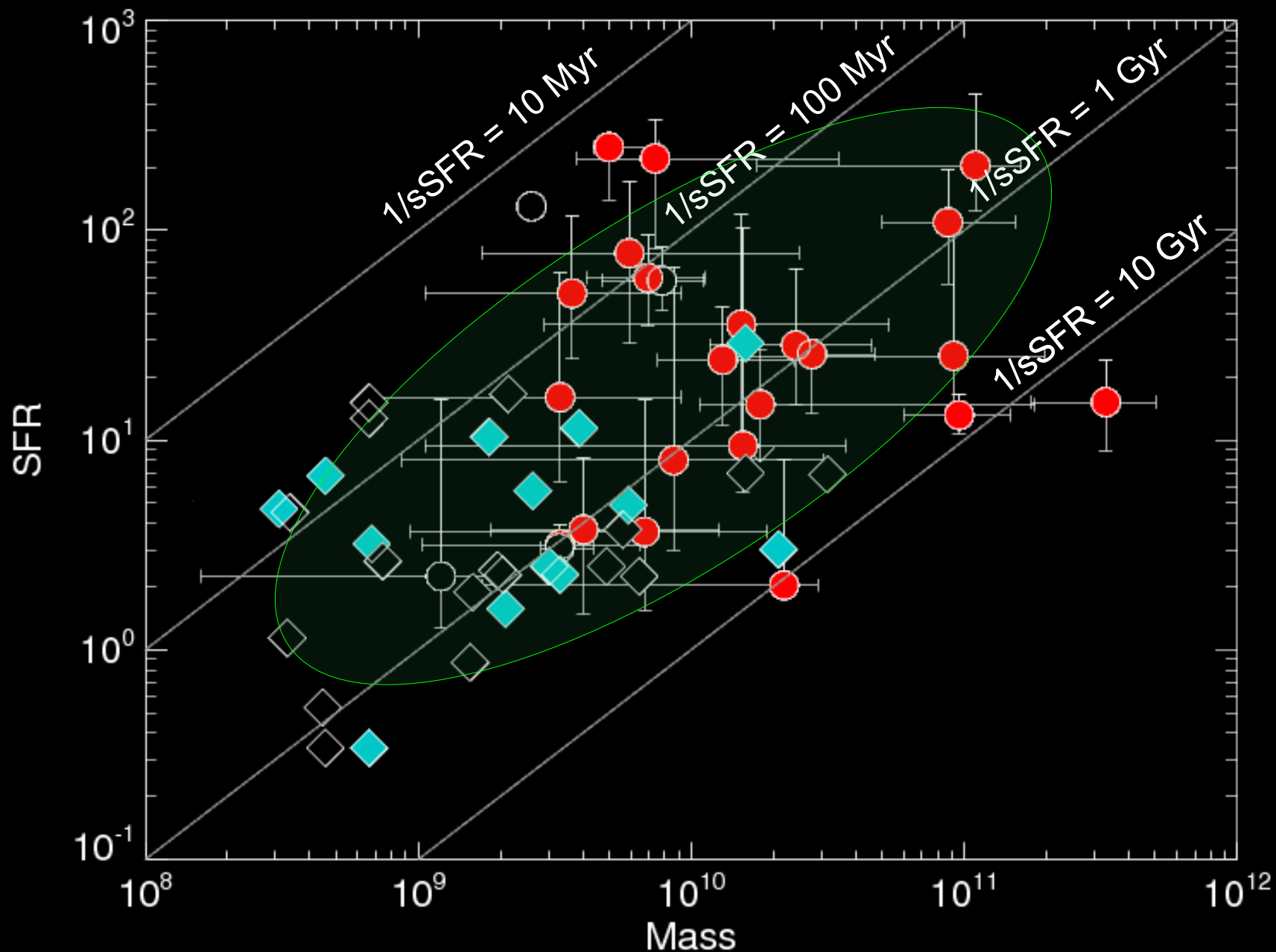
SFR vs. stellar mass ($z > 1$)



SFR vs. stellar mass



SFR vs. stellar mass



Problem solved...?

$$R(\text{GRB}) = \text{const?} \times R(\text{SFR})$$

GRBs form in all star-forming galaxies after all!

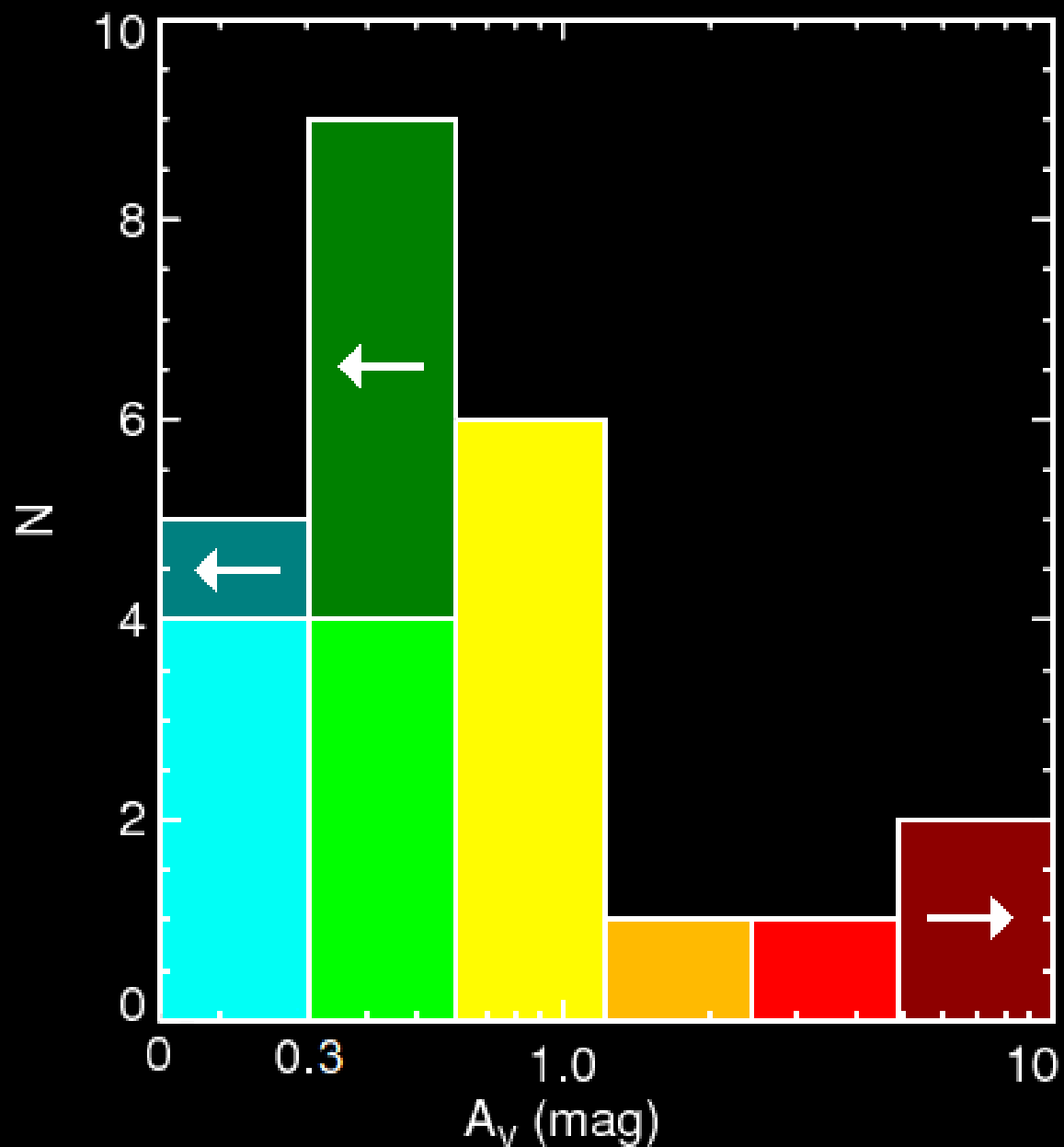
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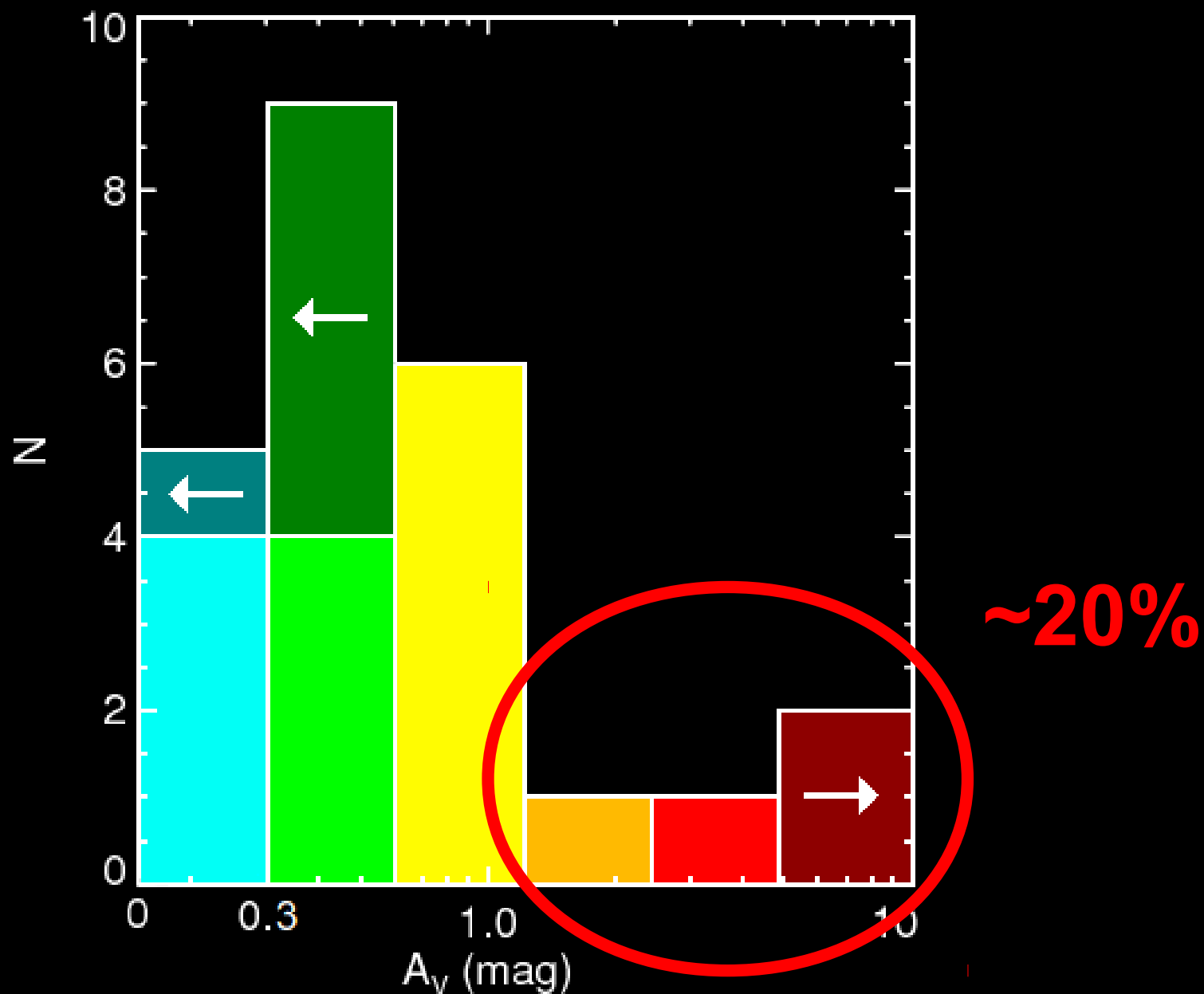
✓
?

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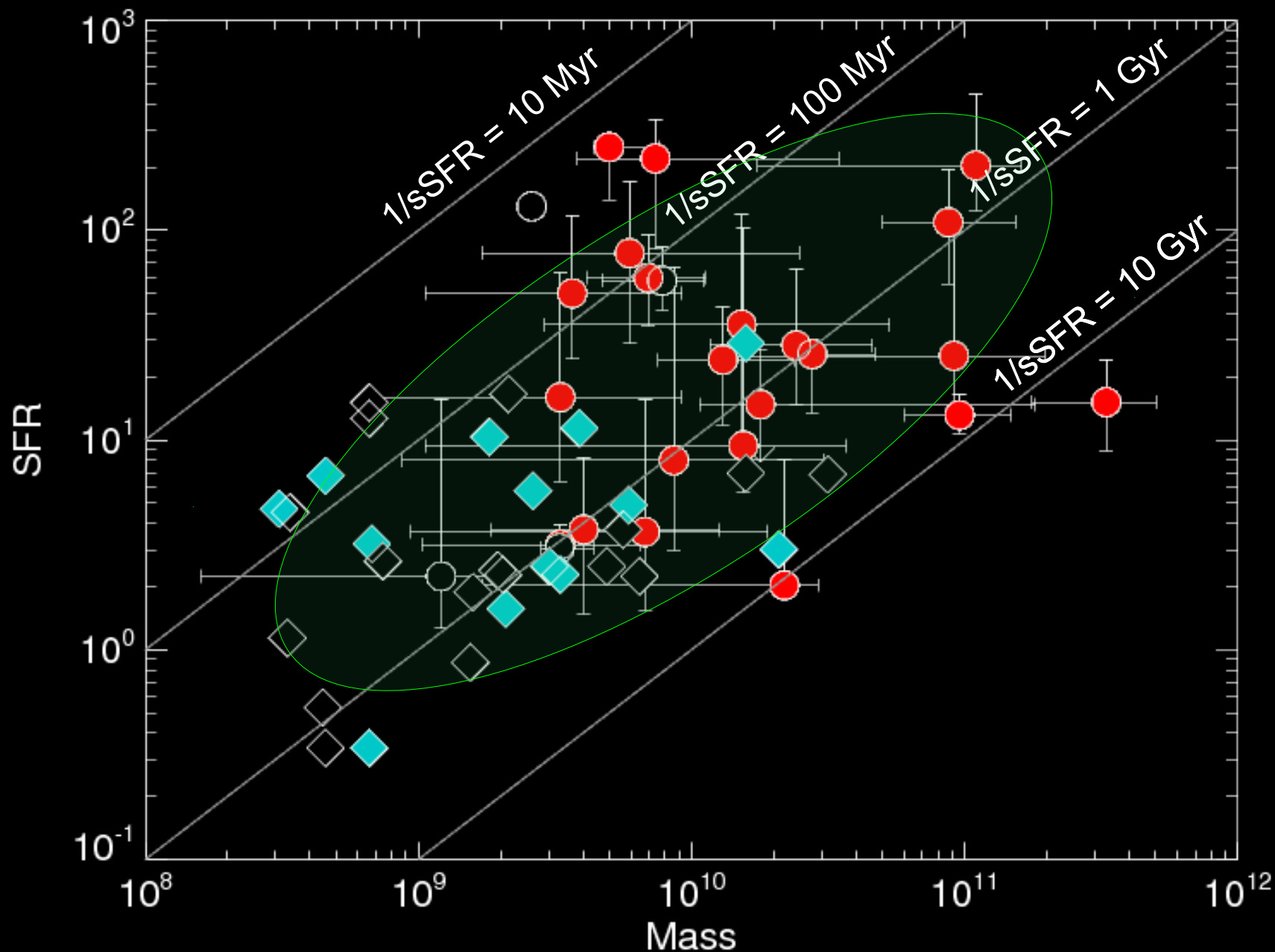
Dark bursts are a minority



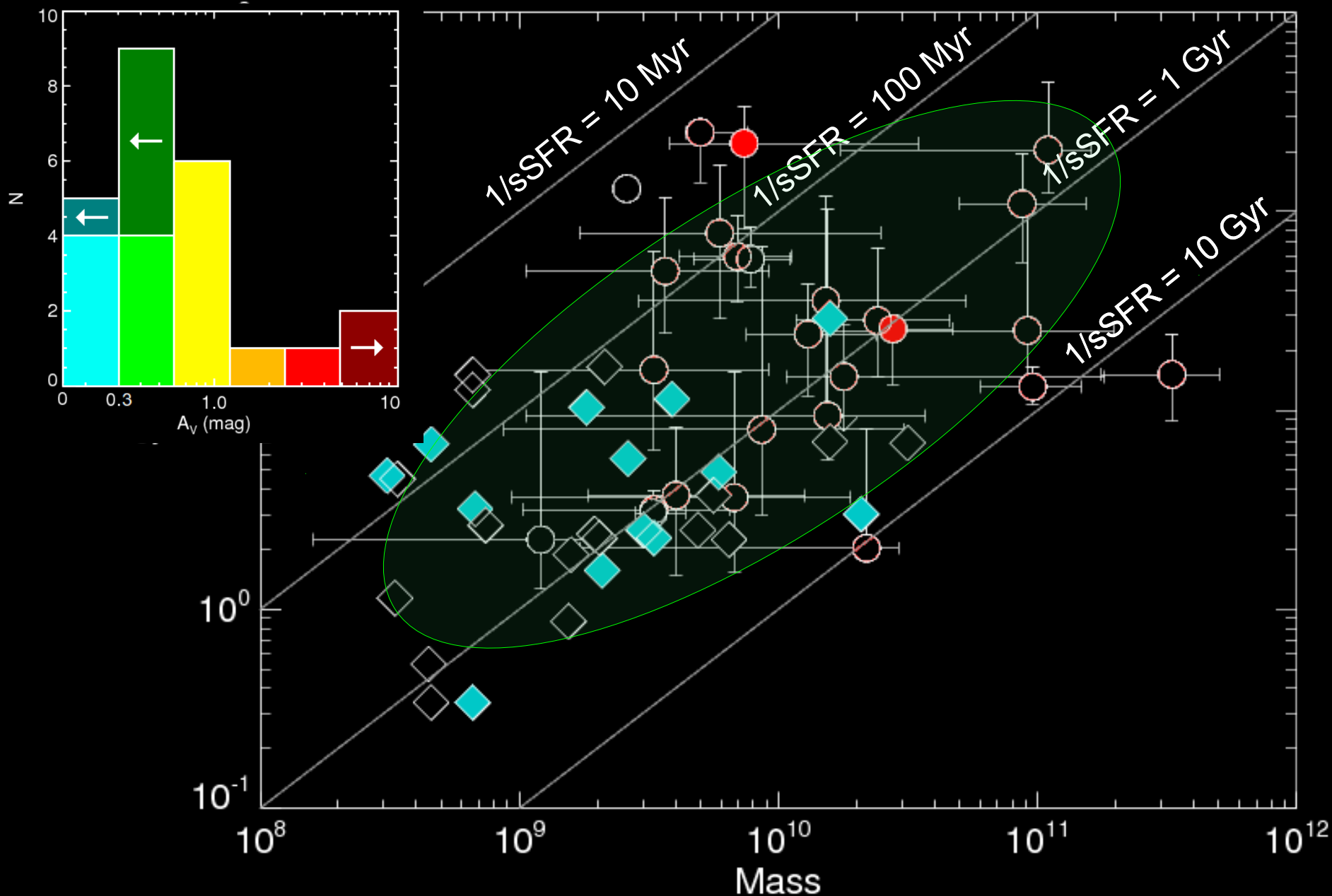
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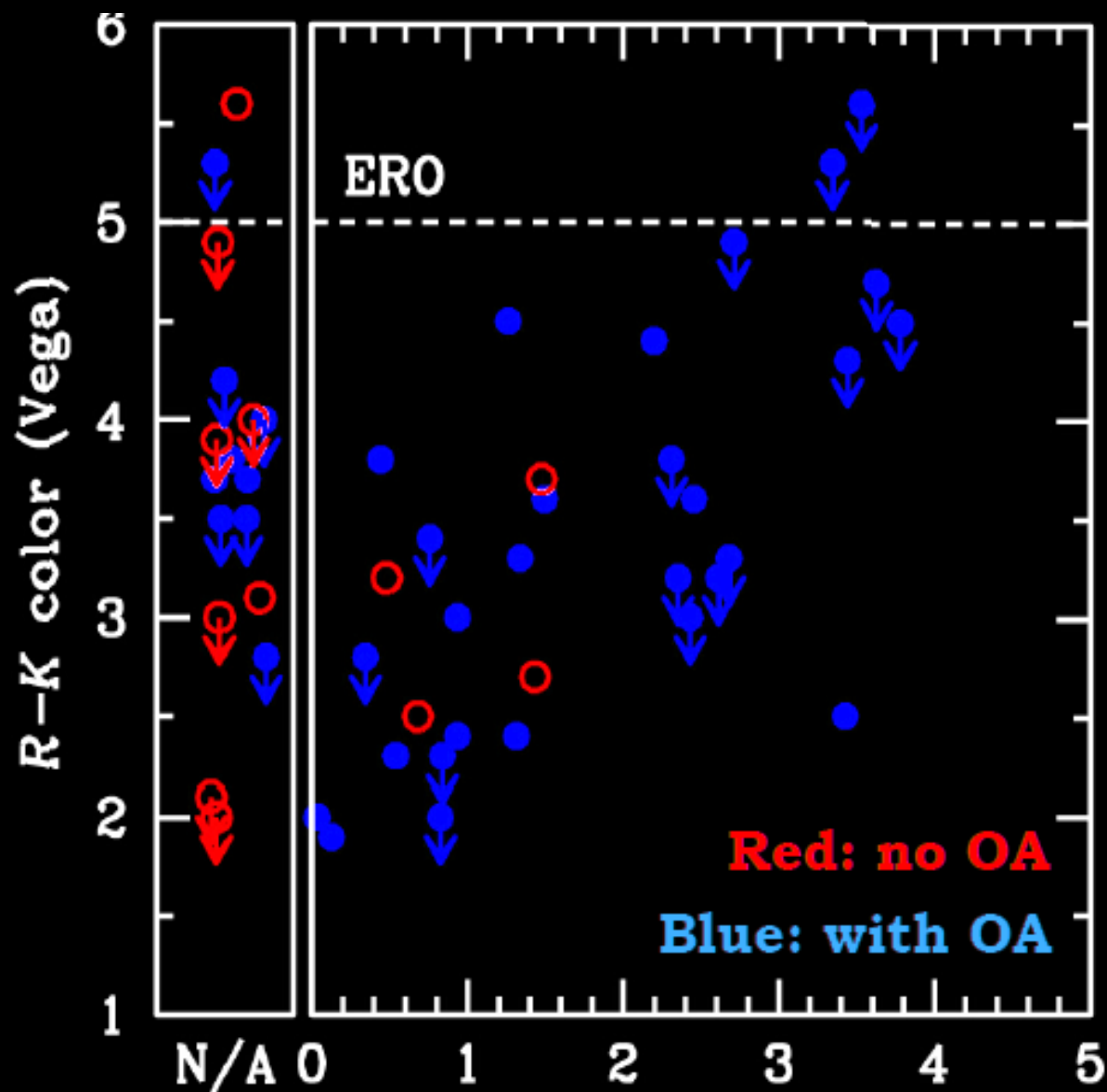
Luminous, red hosts have been found, but...



... there still aren't many.

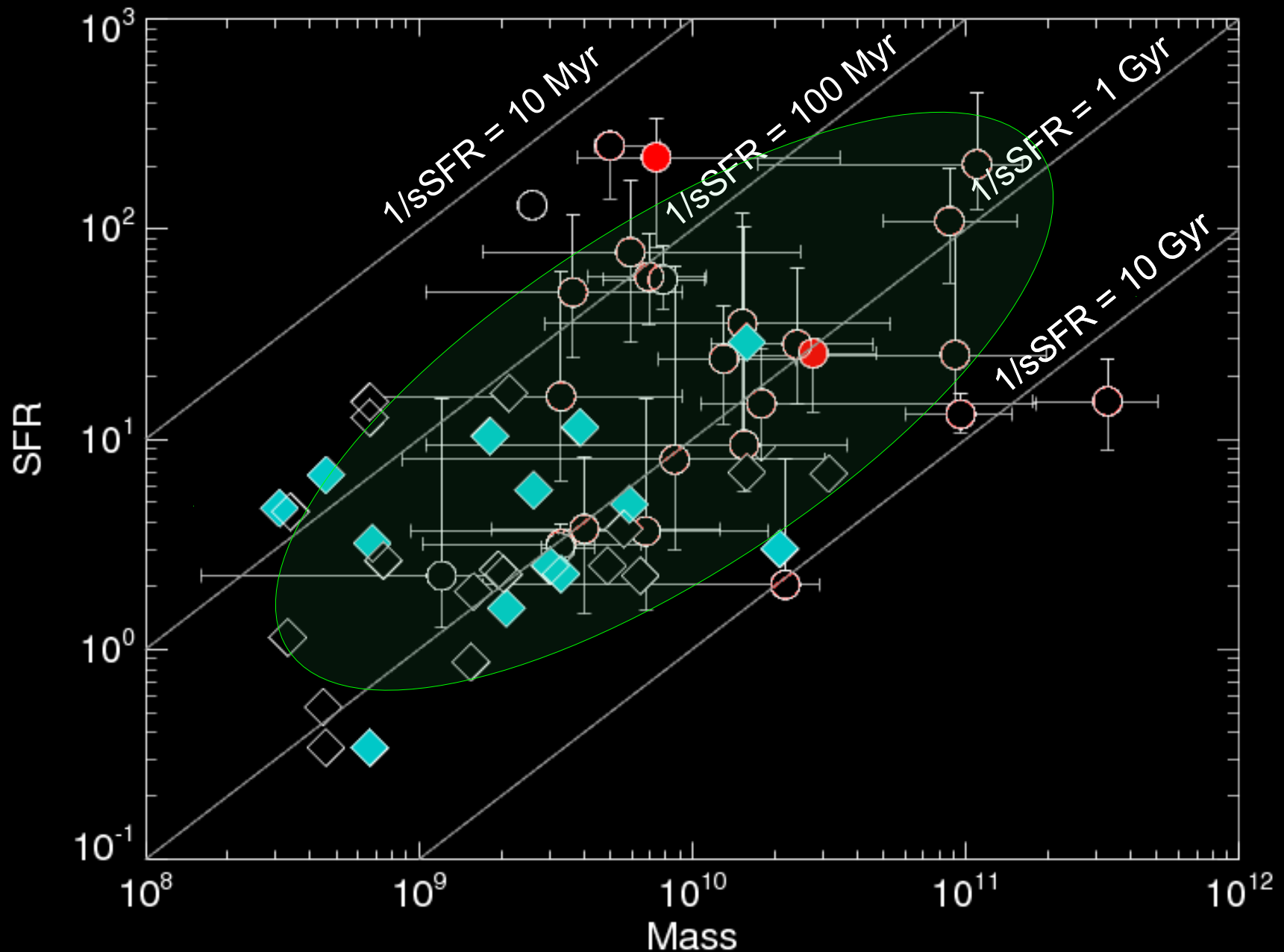


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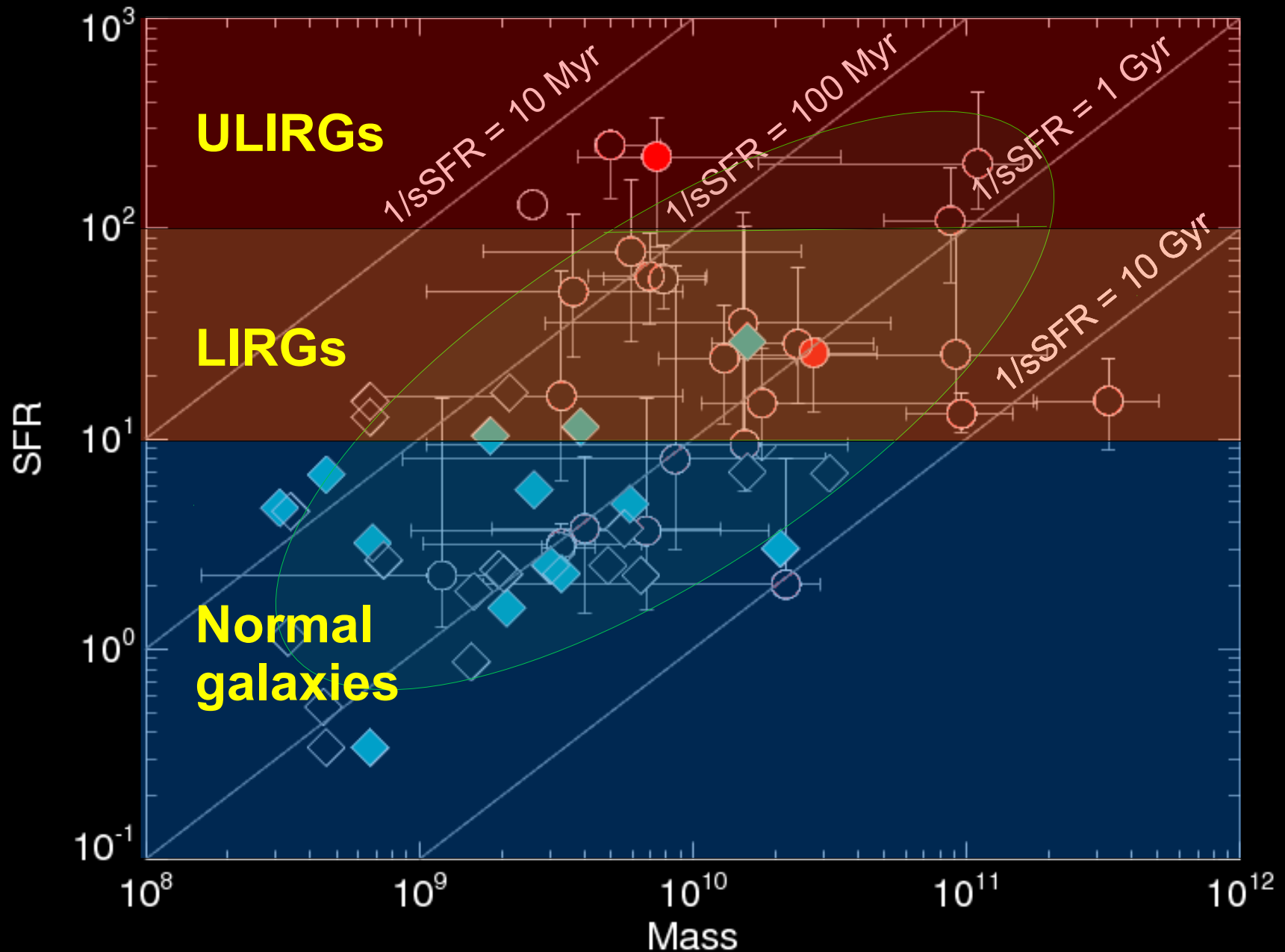


Jakobsson+2011
& Hjorth talk

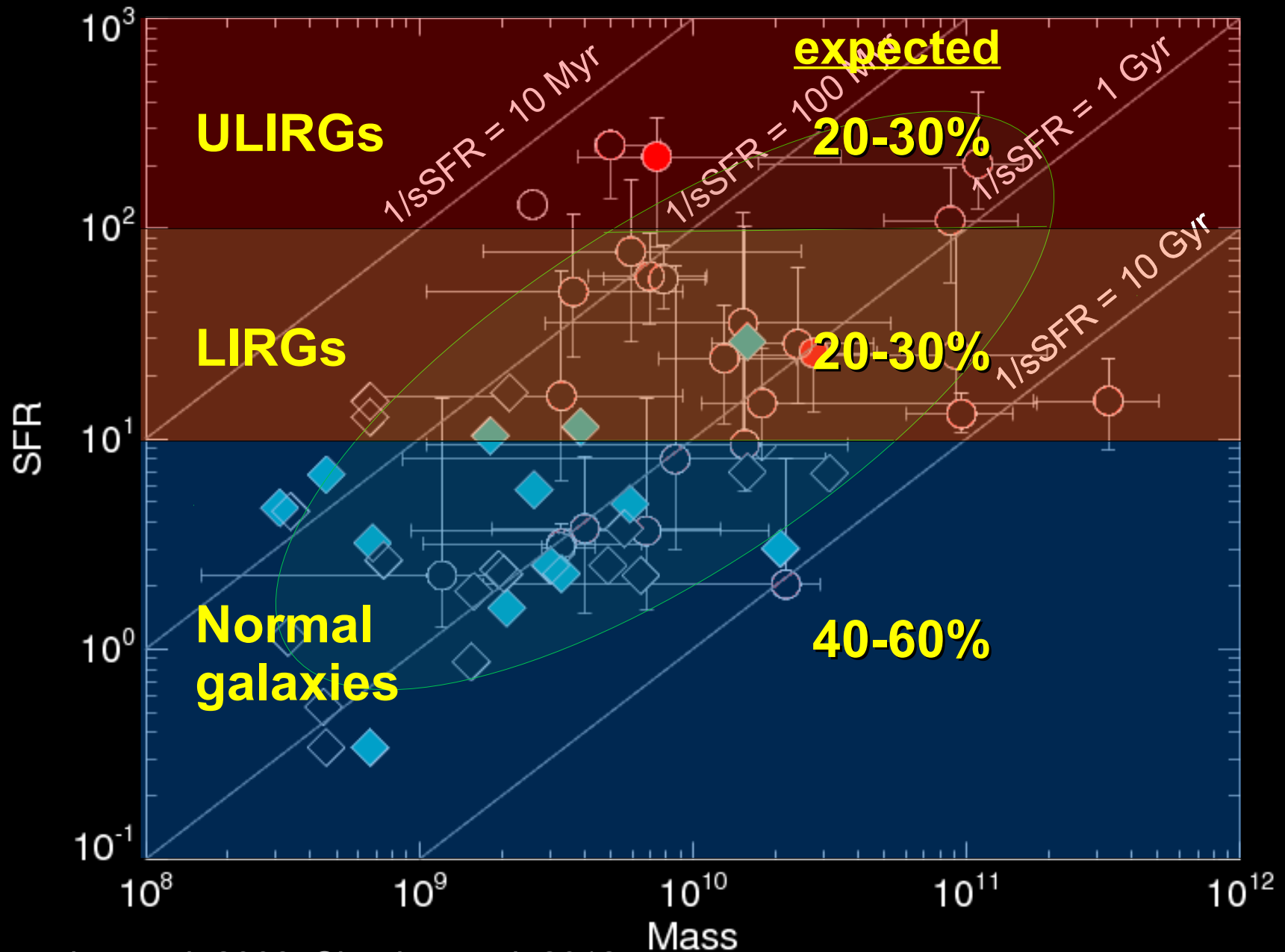
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... and there still aren't enough.

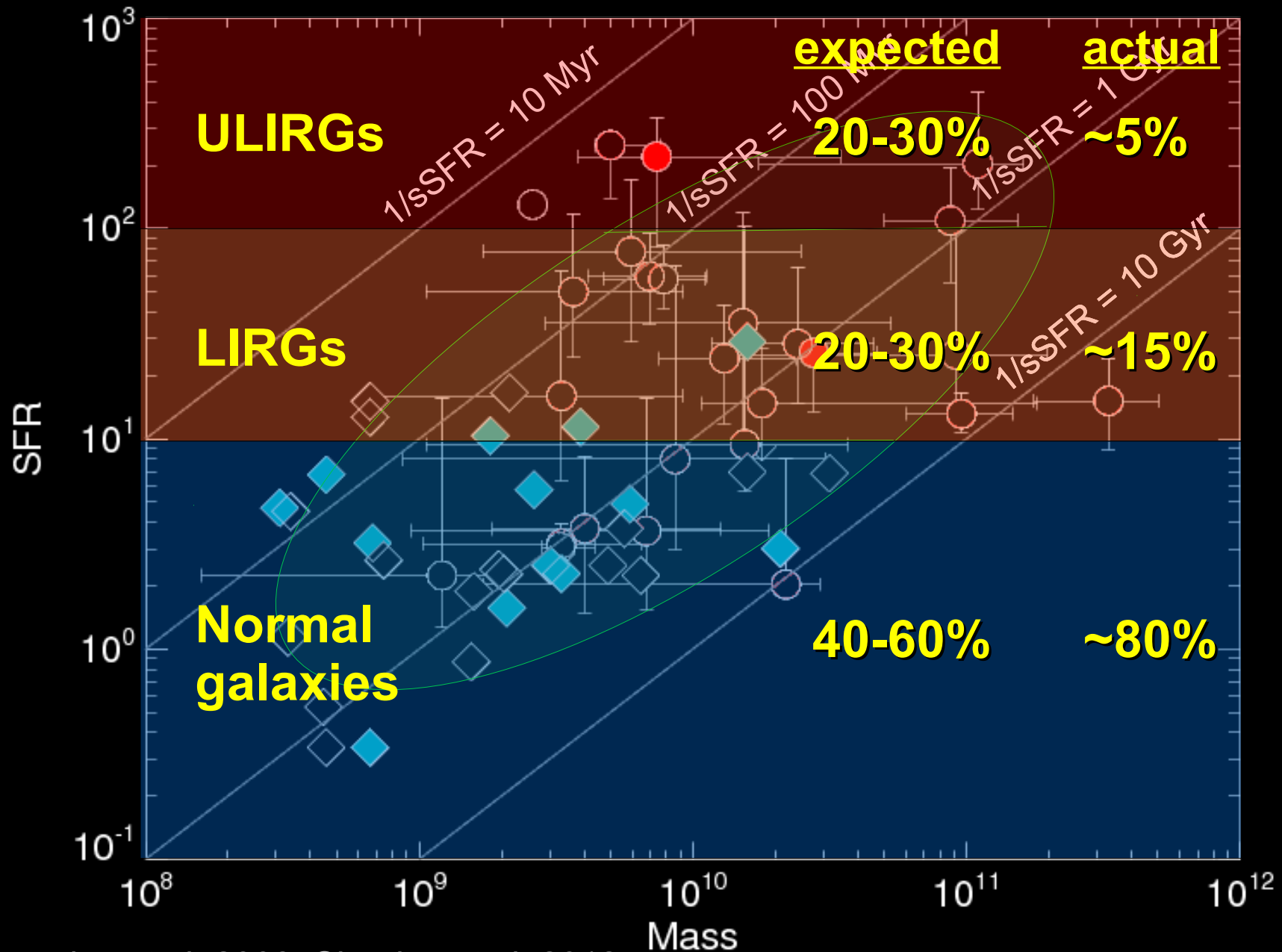


... and there still aren't enough.



Perez-Gonzales et al. 2008, Shapley et al. 2012

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Perez-Gonzales et al. 2008, Shapley et al. 2012

Implications

$$R(\text{GRB}) = \text{const?} \times R(\text{SFR})$$

GRBs form in all galaxy environments after all!

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... but not at the relative rates you would expect.

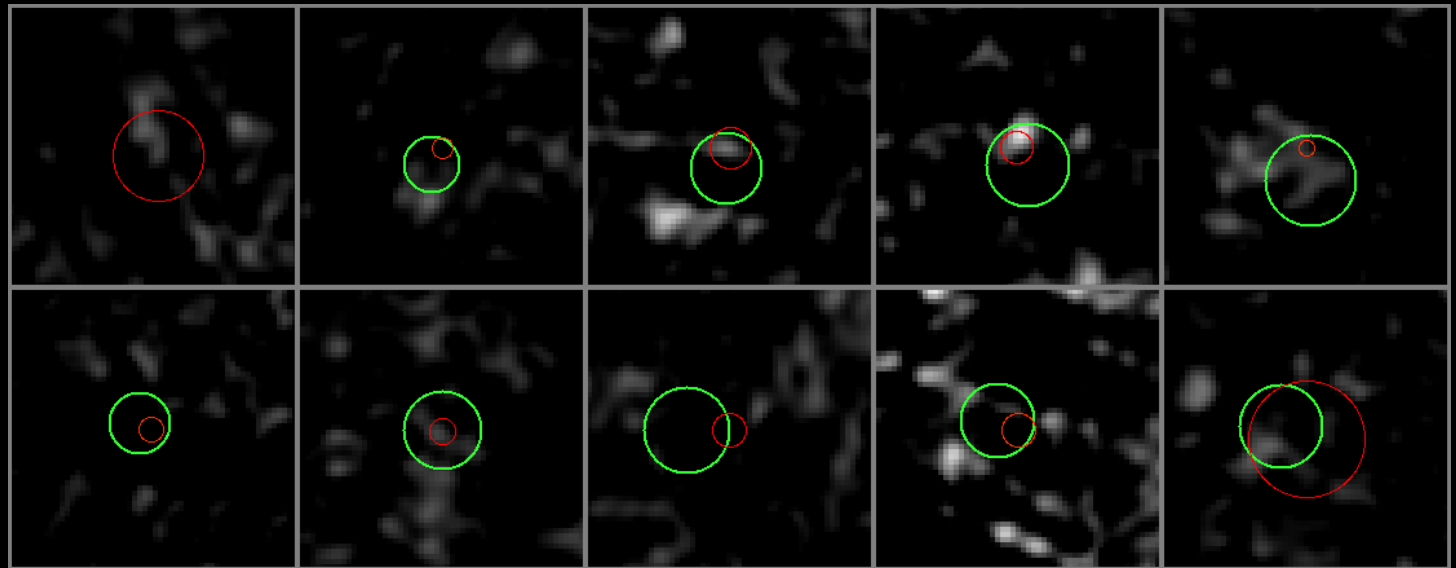
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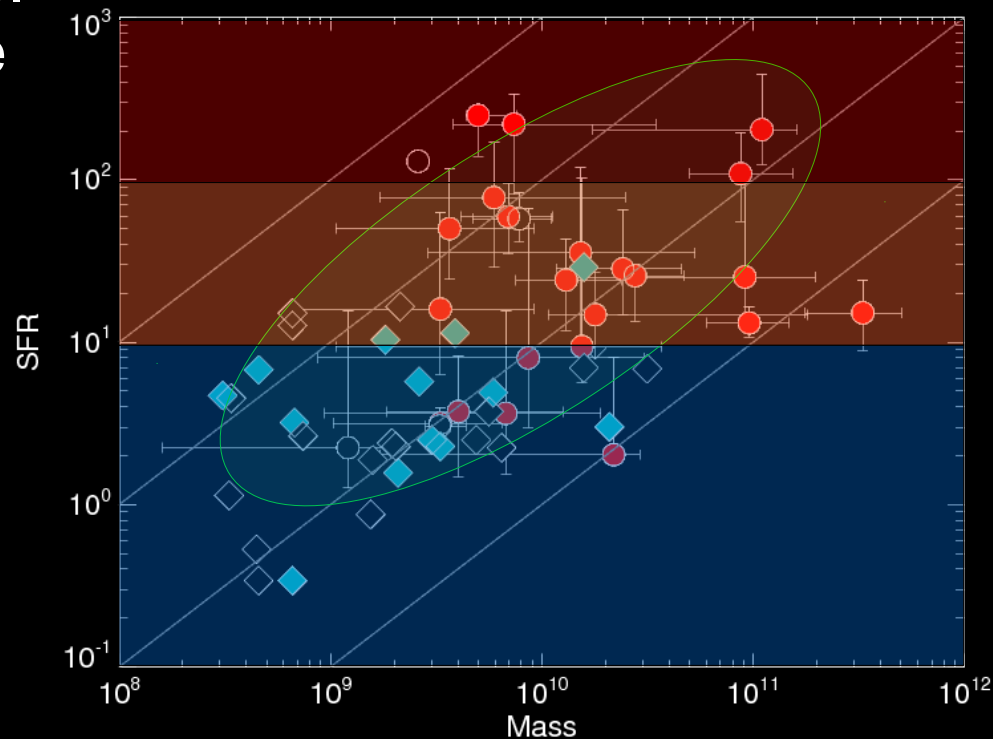
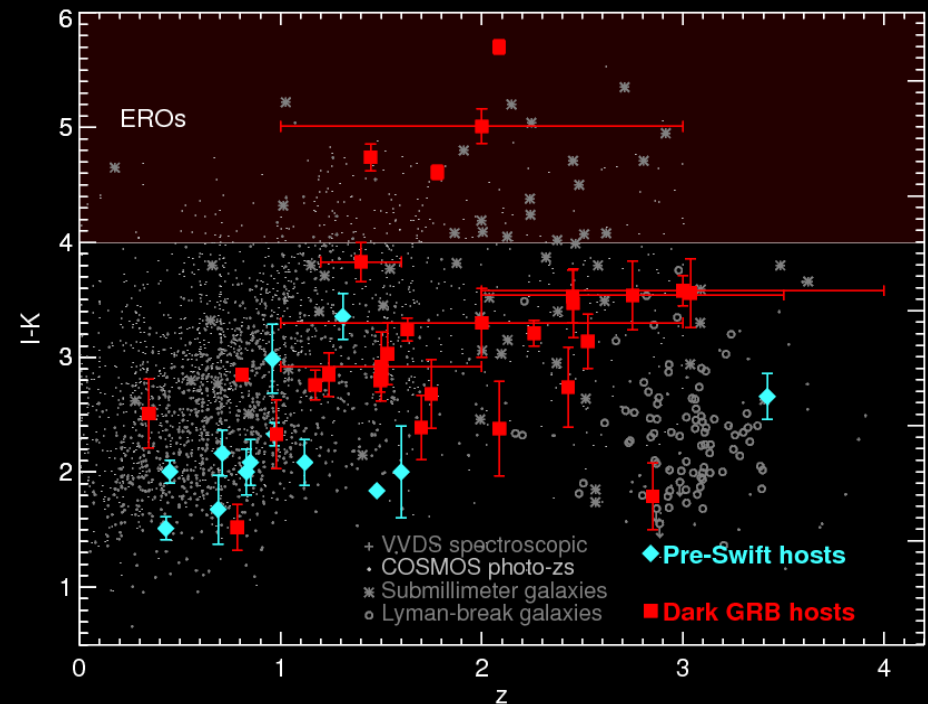
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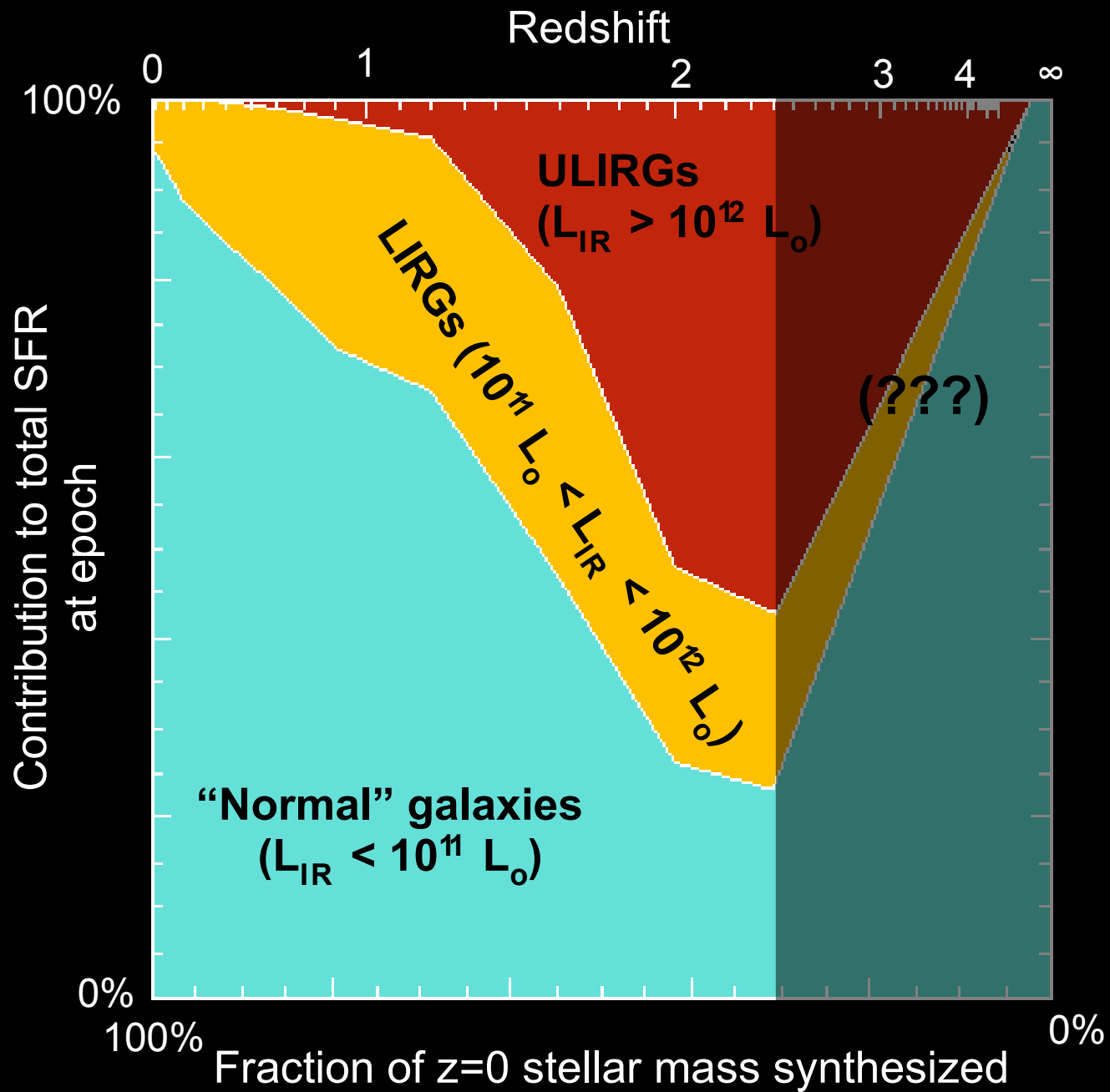
... and long-wavelength observations do not change this.



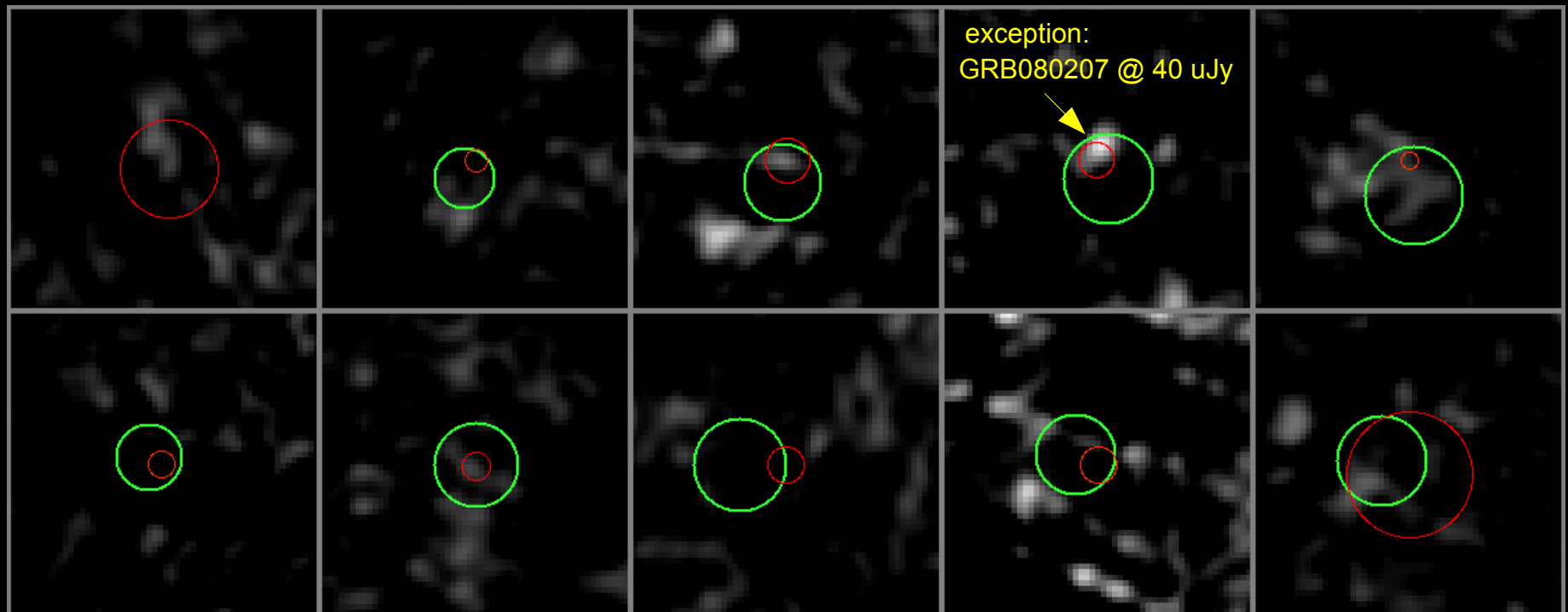
Conclusions

1. Dark GRB hosts are different: systematically higher mass, SFR, and reddening.
 - No *obscured* GRBs from ultra-faint dwarfs (SMCs) so far.
 - No *unobscured* GRBs from very massive/luminous galaxies.
 - Optical extinction is galaxy-wide (nonlocal), with few exceptions.
2. GRBs form in all star-forming galaxies at $z > 1$, but not at uniform rates.
 - Complex connection to metallicity (or other factor): no obvious “cutoff”

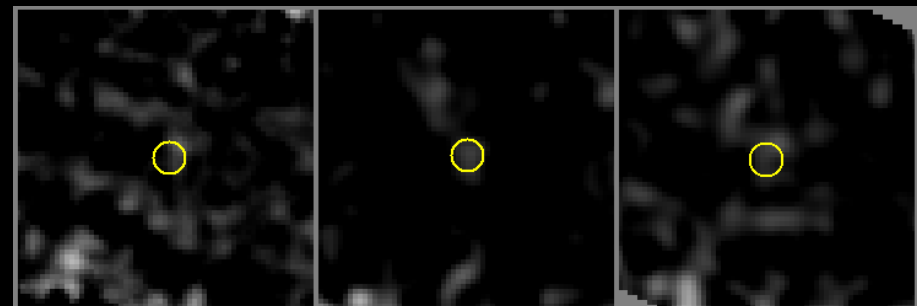




No EVLA detection (to $\sim 15 \mu\text{Jy}$ @ 5 GHz)
for 9 out of 10 hosts observed so far



No CSO detection (to $\sim 10 \text{ mJy}$)
for 3 hosts observed



5-15 hr integration/target

No EVLA detection (to $\sim 15 \mu\text{Jy}$ @ 5 GHz)
for 9 out of 10 Spitzer-brightest hosts

