

# Connecting dust and galaxy properties at high redshift

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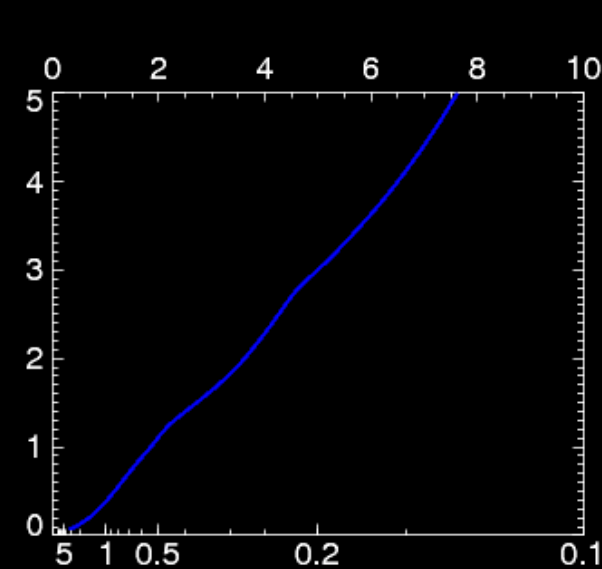
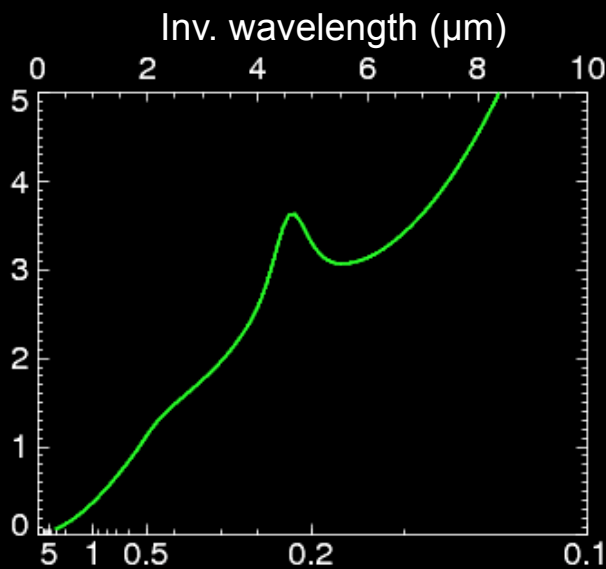
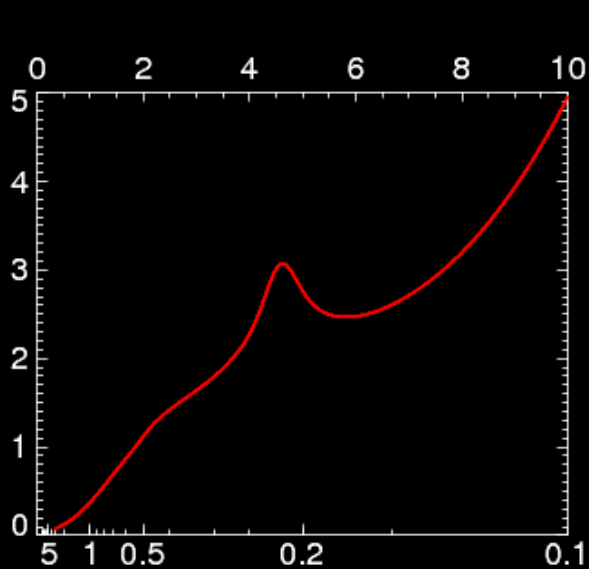
A. Morgan (UC Berkeley)

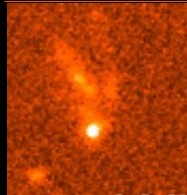
# Local Group Extinction Curves

Milky Way

LMC

SMC





What processes cause extinction to differ between local galaxies?

Metallicity?

UV radiation field?

Other ISM properties (density, shocks, etc.)?

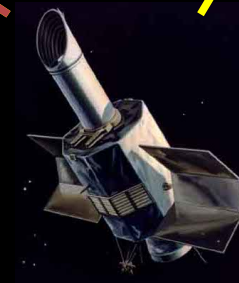
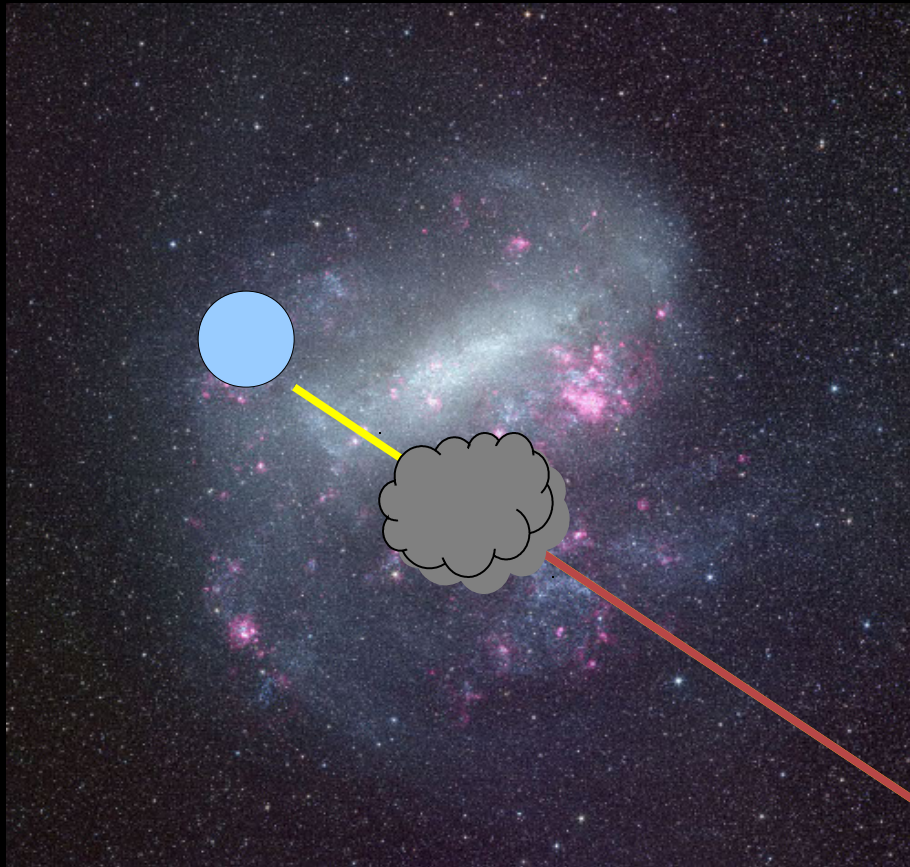
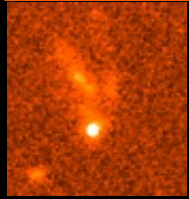
Galaxy history? (Time since production / grain growth?)

(Or is the difference significant? Only 5 SMC sightlines.)

What happens in more extreme environments?

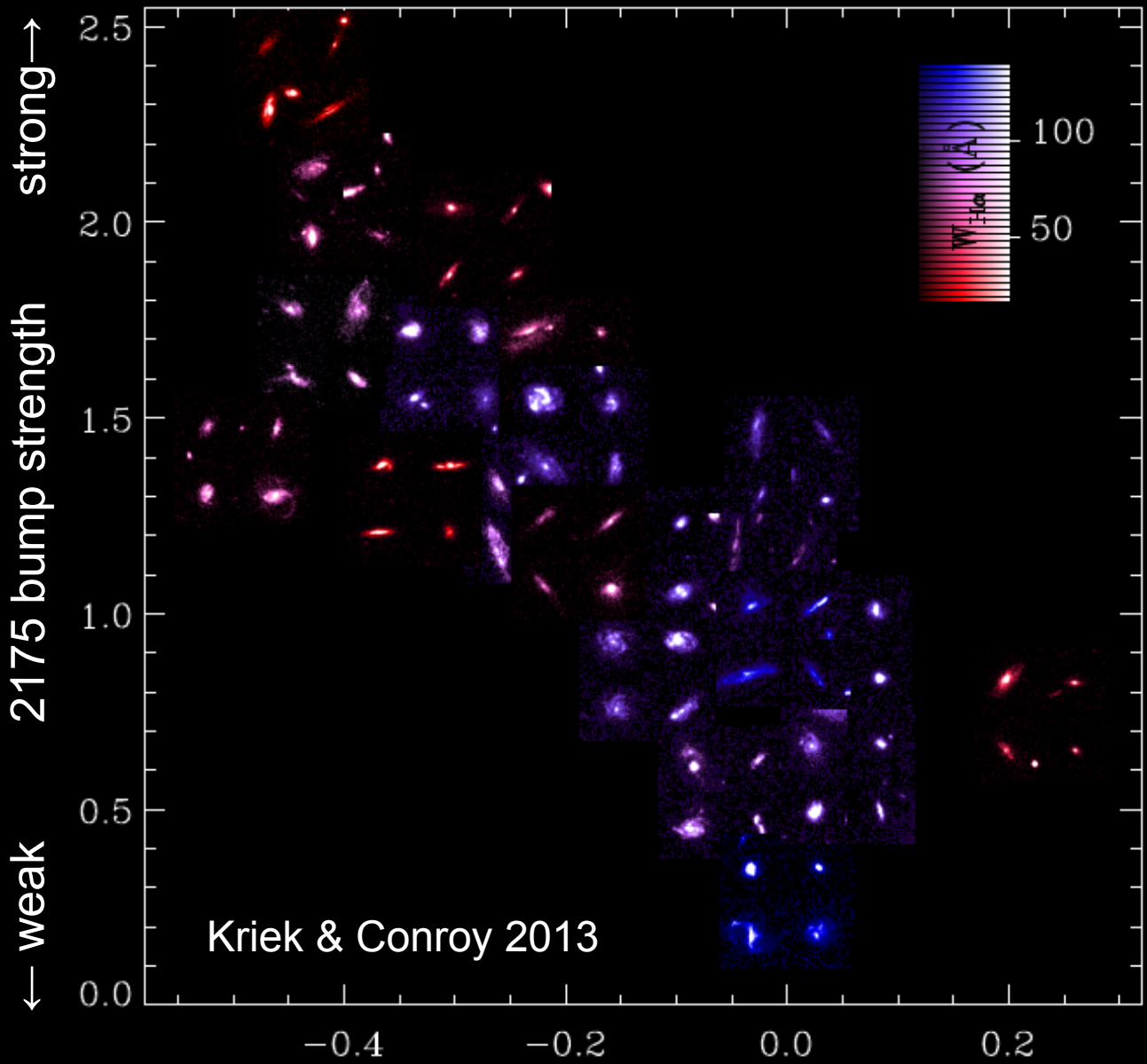
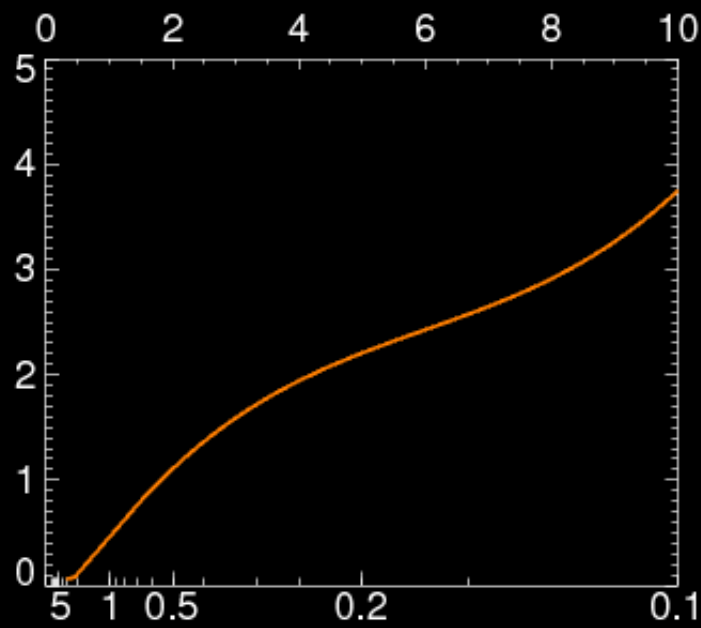
Need more than 3 galaxies!

# Measuring Extinction Curves



# Galaxy Integrated Starlight

Theoretical/template vs. observed SEDs



# Link to specific SFR?

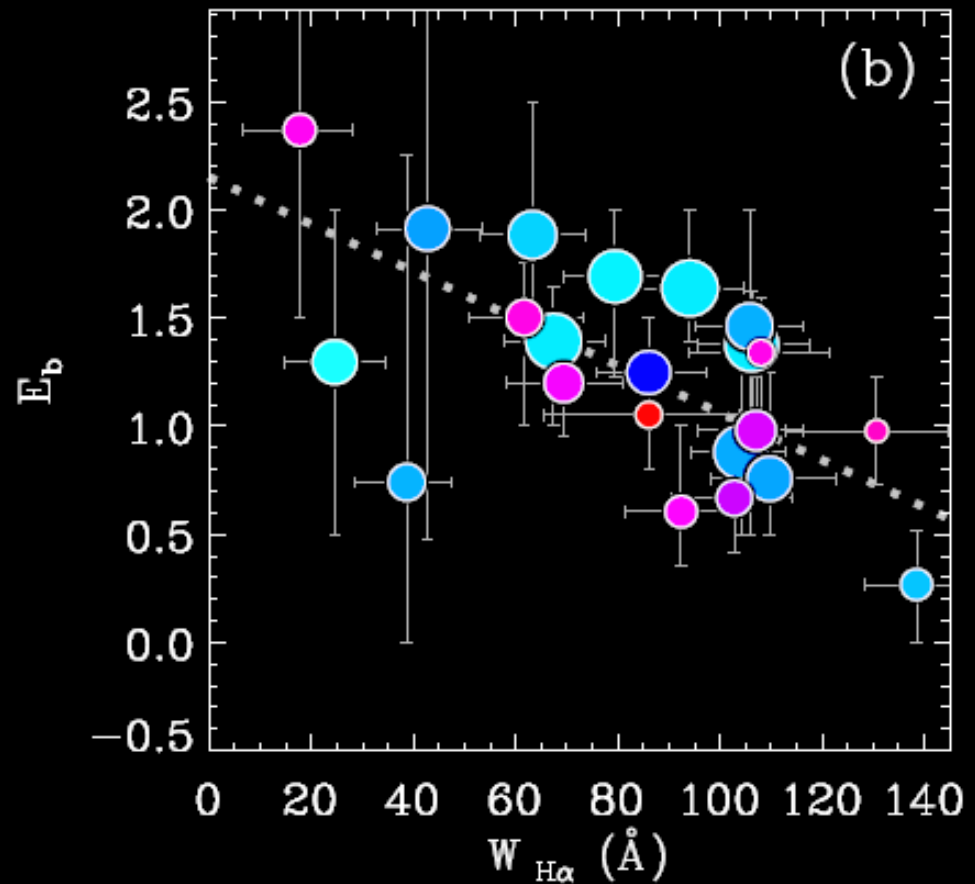
High specific SFR  $\rightarrow$  weaker bump?

2175 carrier destroyed or impeded by strong UV flux and/or shocks



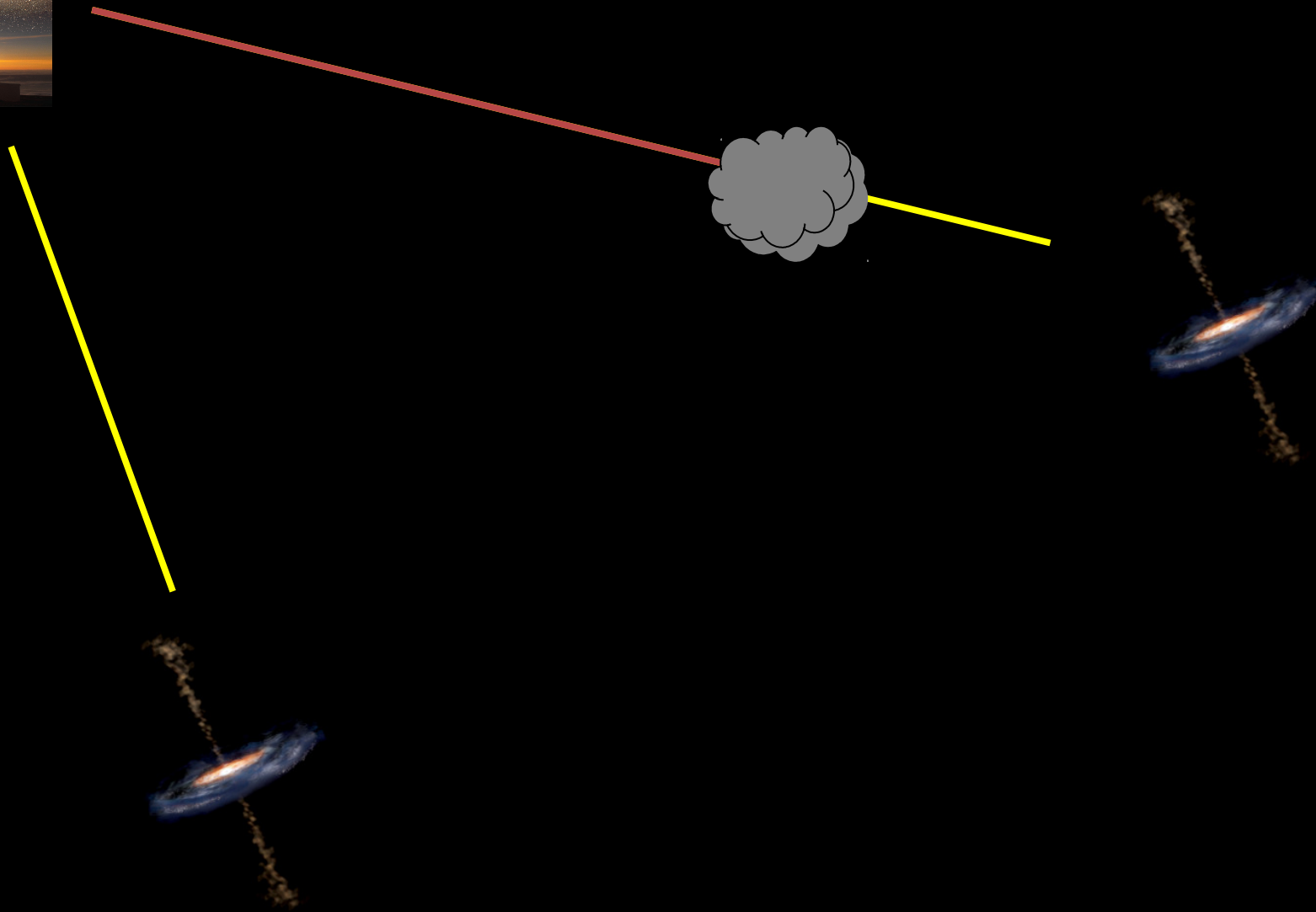
strong 2175 bump

no 2175 bump



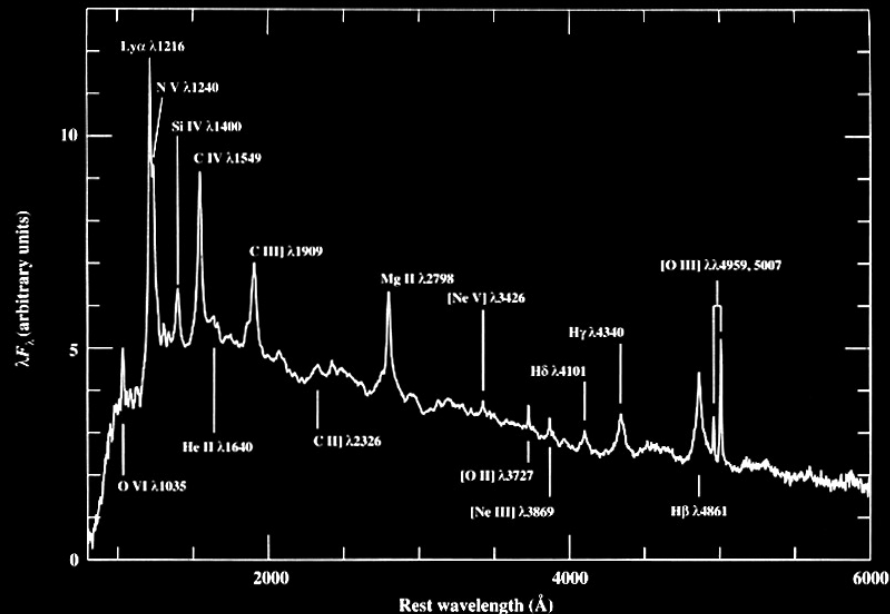
# Extinction Probes at Cosmological Distance

Bright point sources other than stars: QSOs



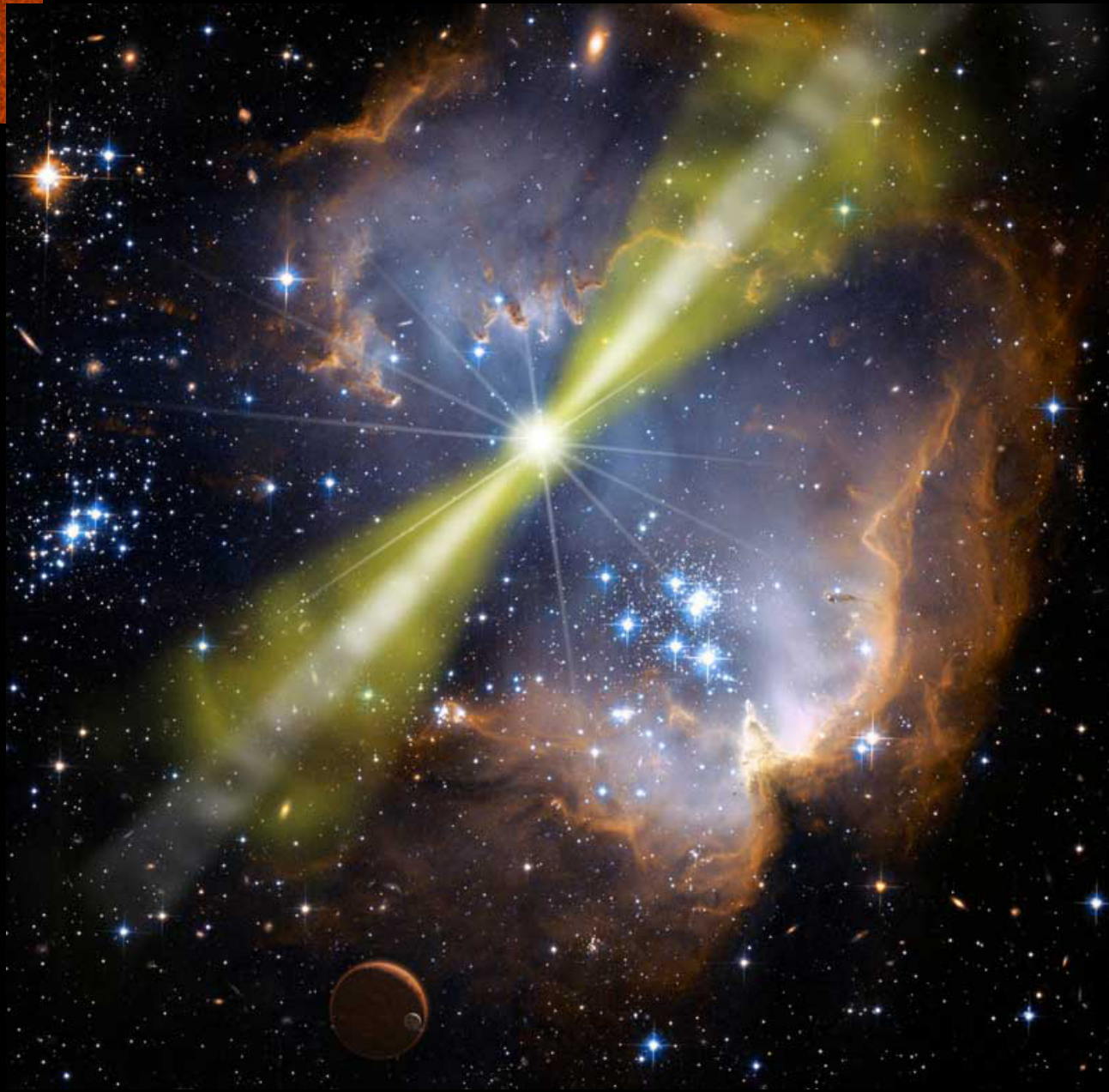
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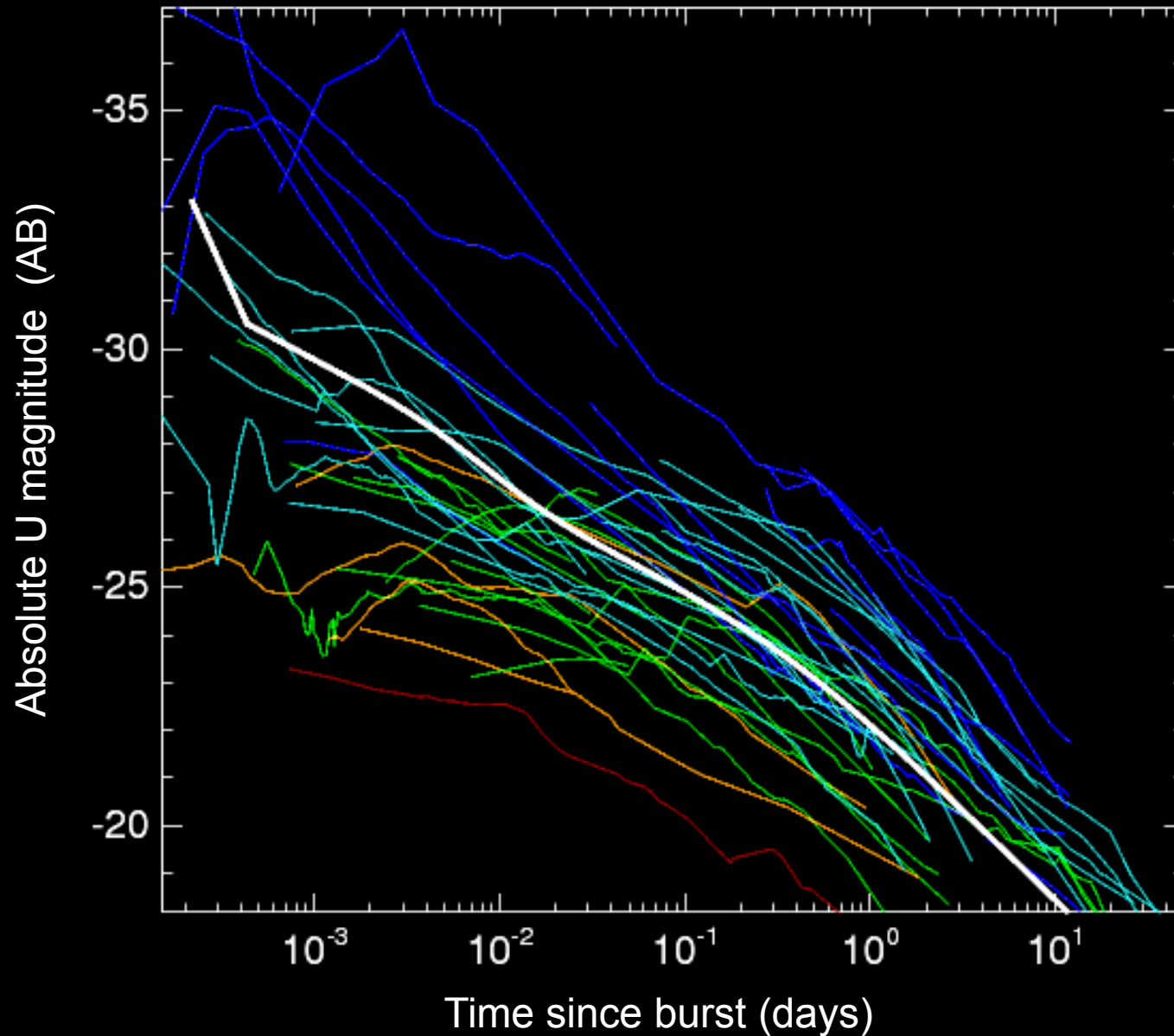
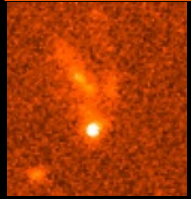




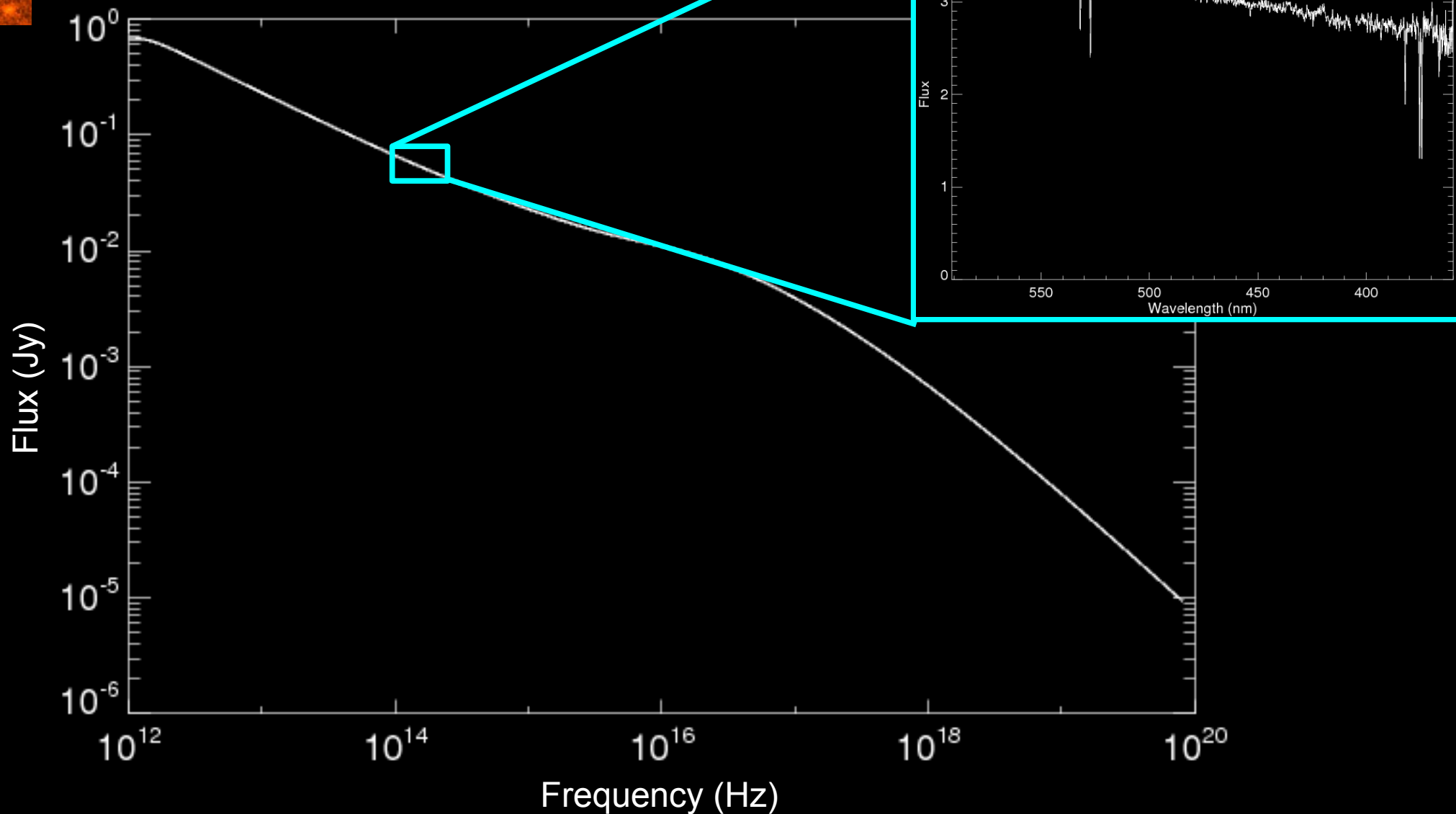
# Gamma-Ray Bursts



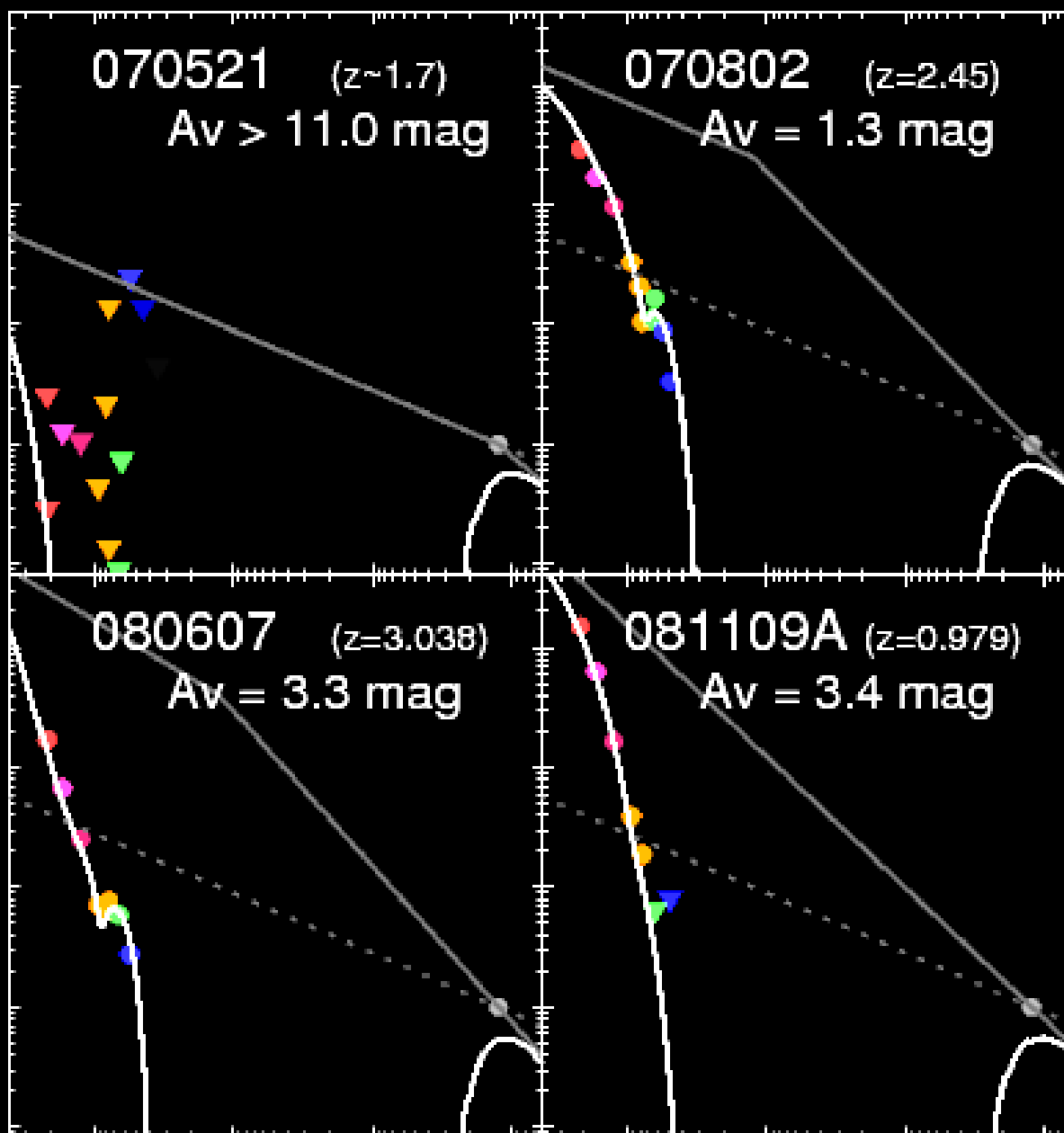
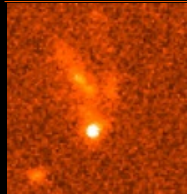
# Gamma-Ray Bursts



# Pure Power-law SEDs



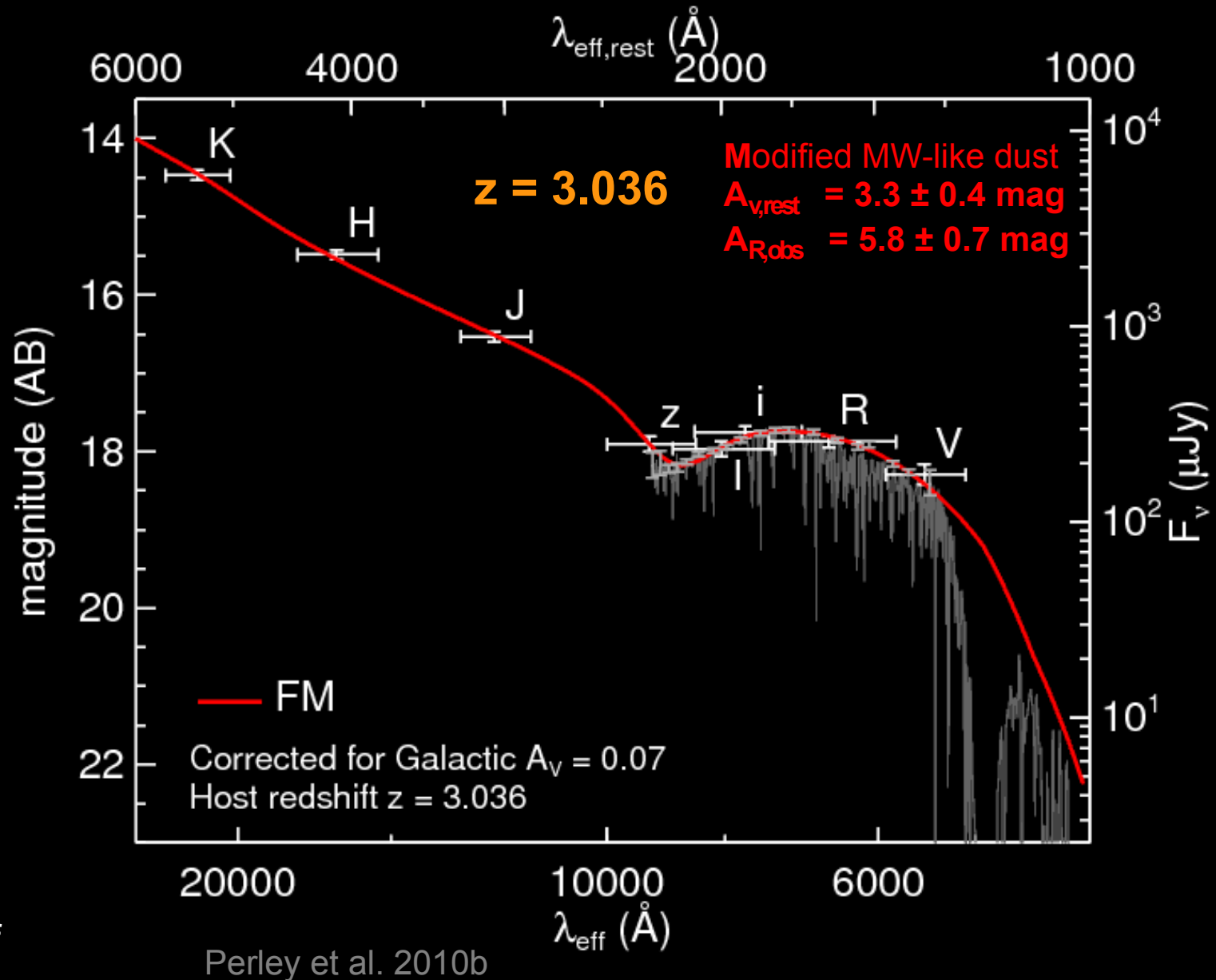
# Dust-Obscured GRBs



# Characterizing Host Dust in Detail

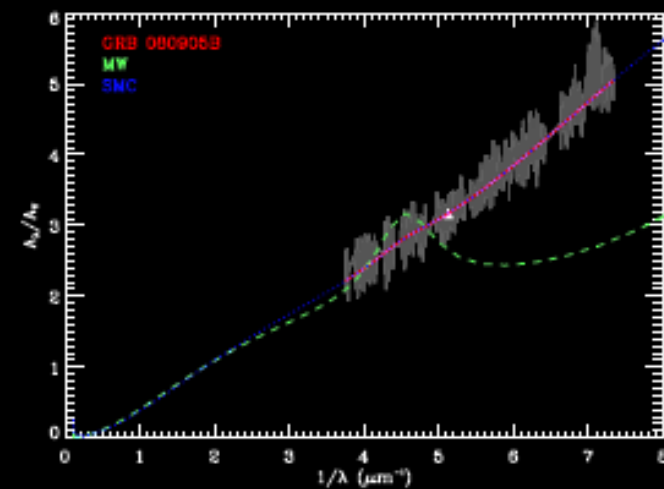
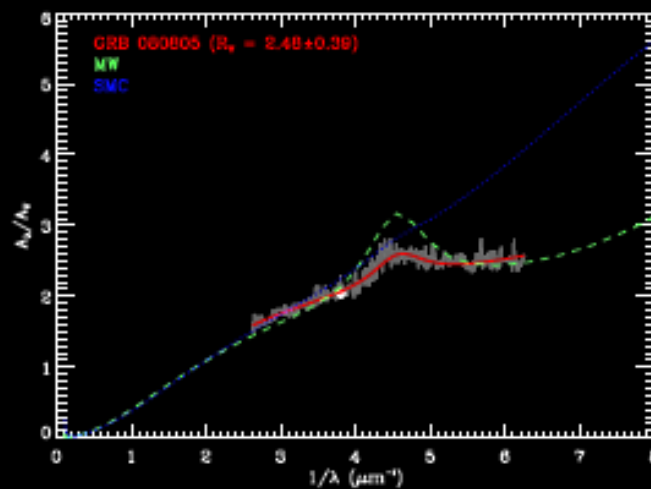
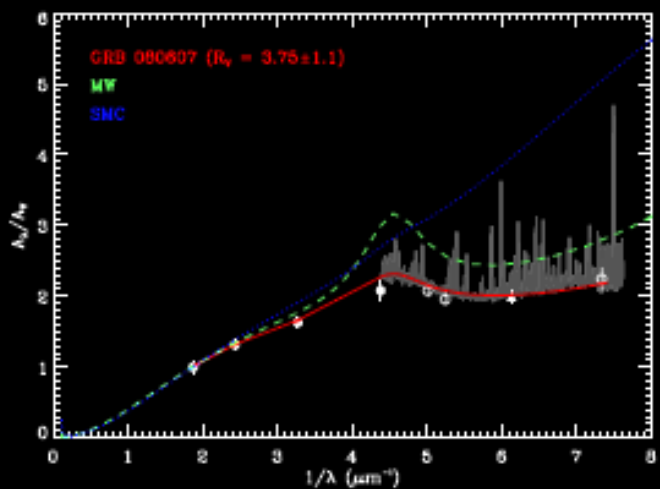
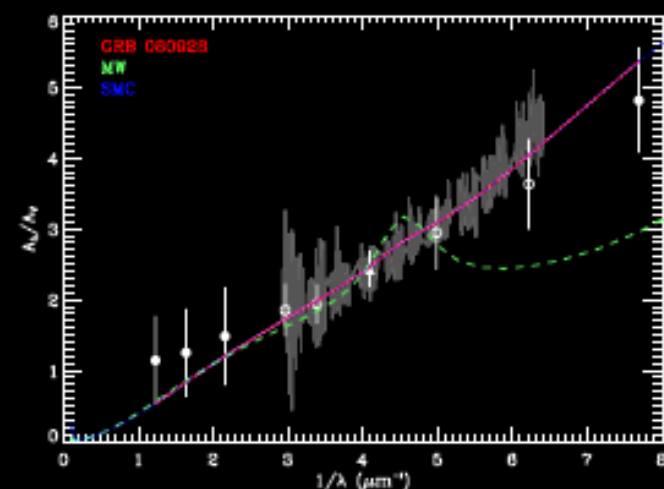
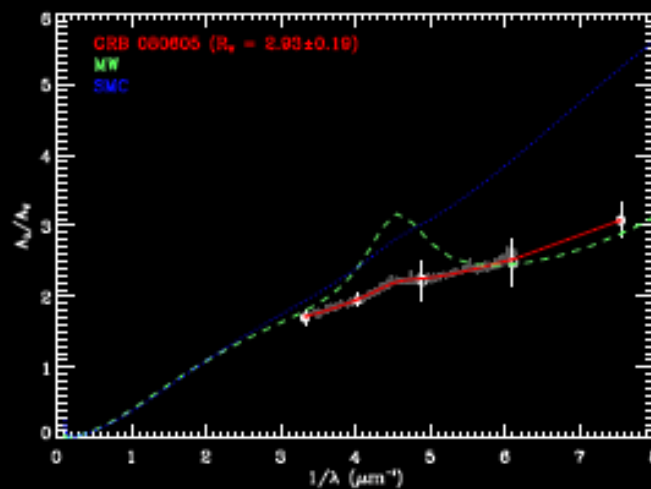
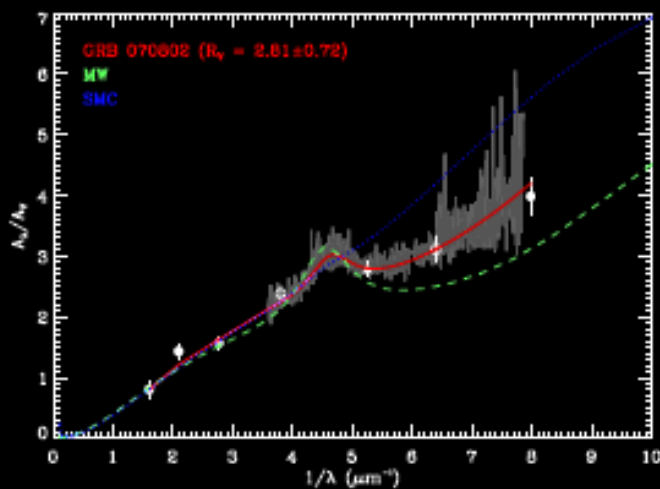


$A_V = 3.2 \pm 0.5$   
 $R_V = 4.0 \pm 0.2$   
 $c_3 = 1.3 \pm 0.3$   
 $c_4 = 0.3 \pm 0.1$



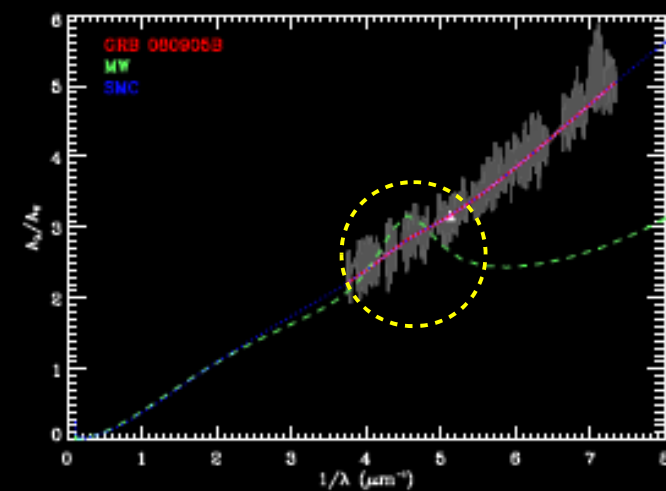
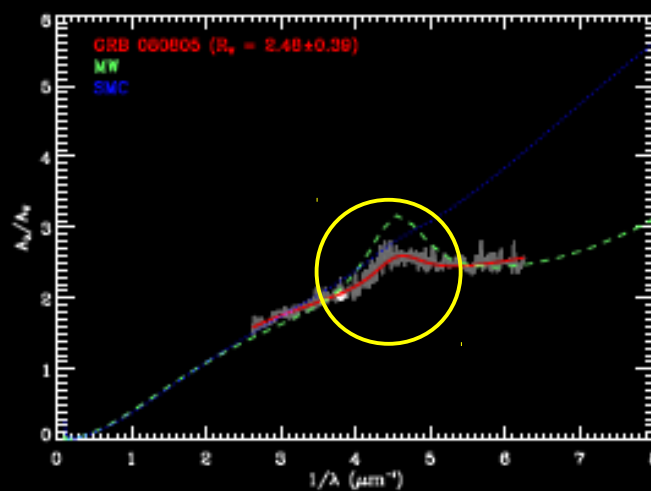
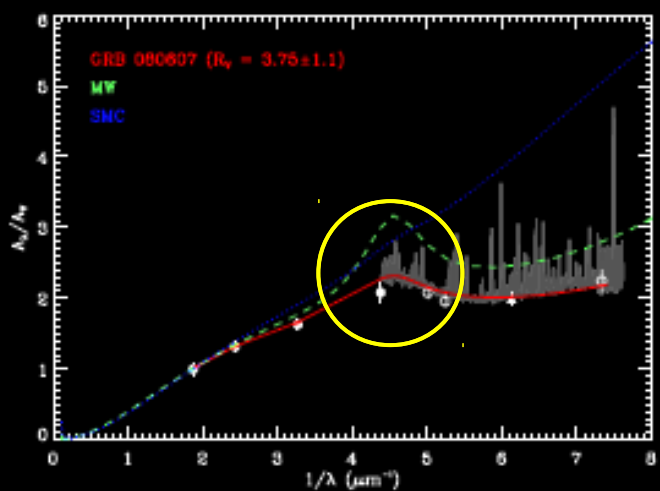
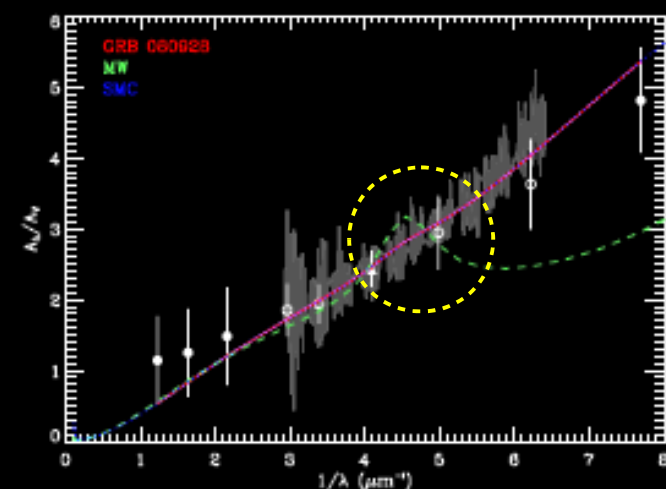
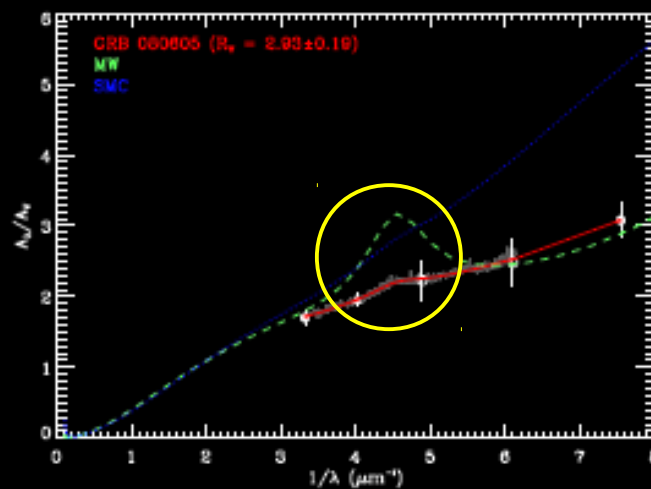
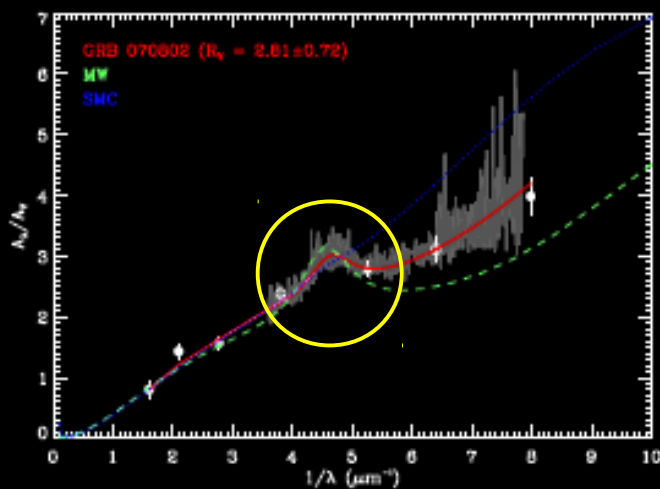
See also Sheffer+ 2011 for a detailed analysis of the ISM absorption lines

# Extinction Curves from GRBs



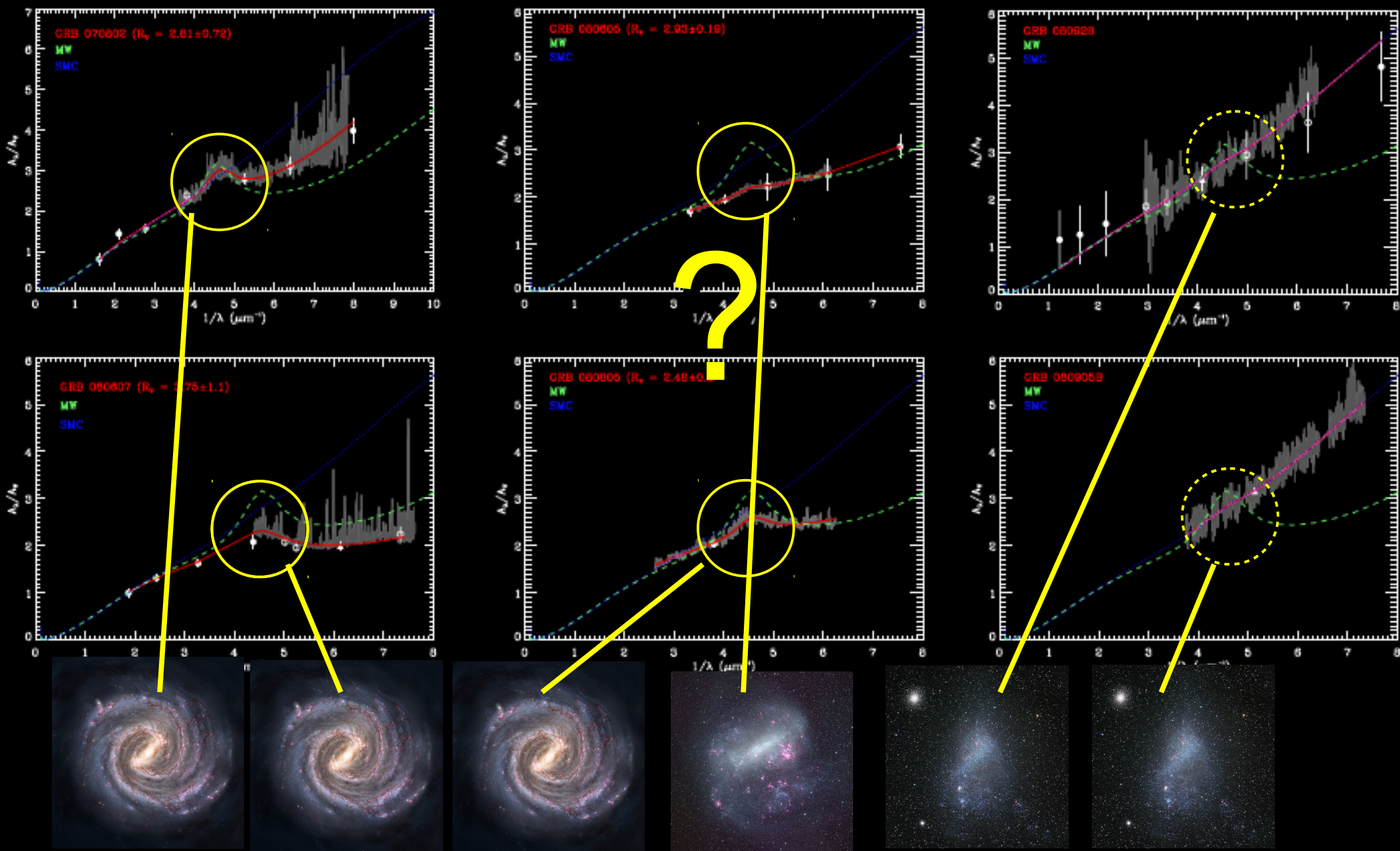
Zafar+2011

# Extinction Curves from GRBs



Zafar+2011

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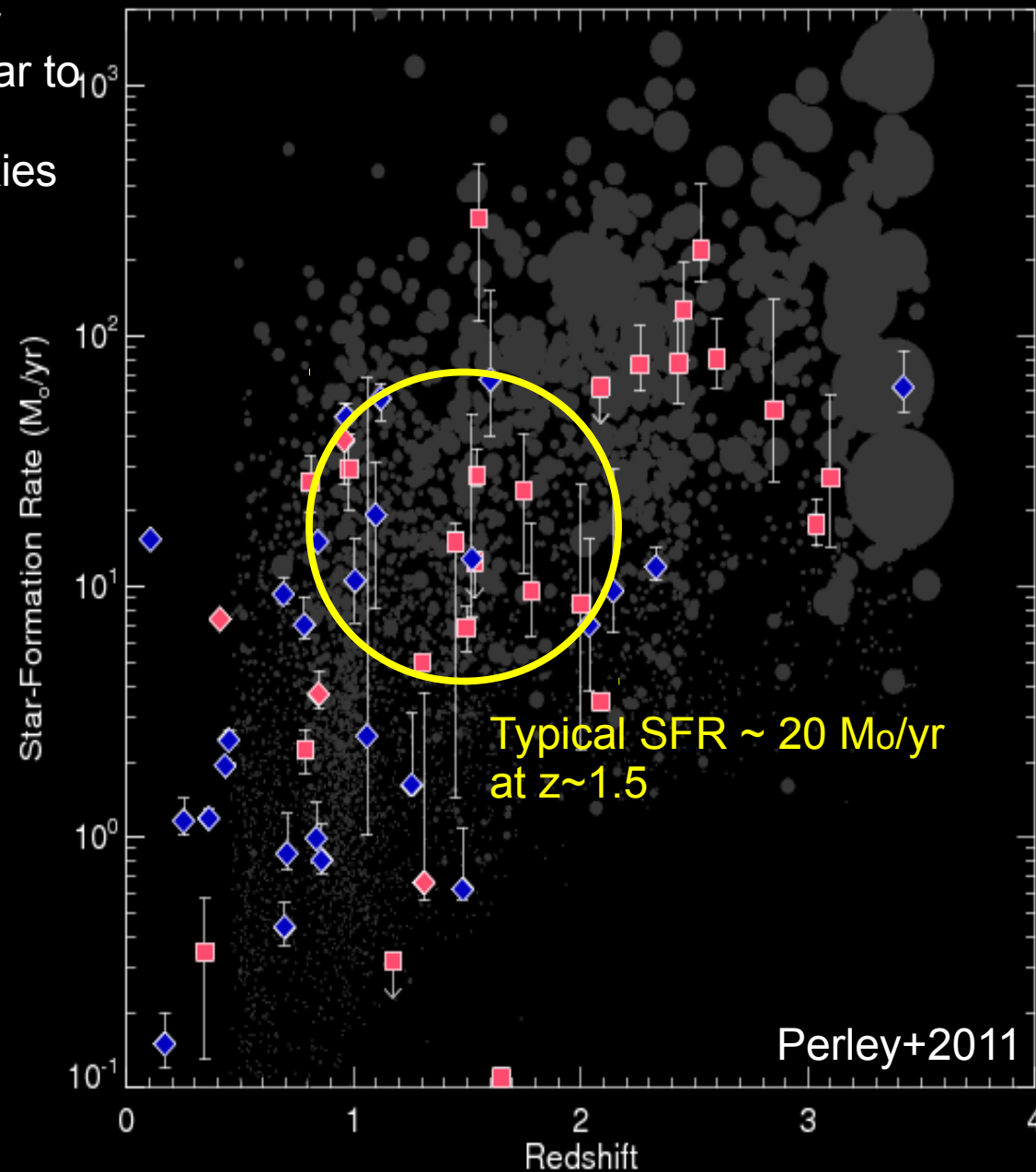
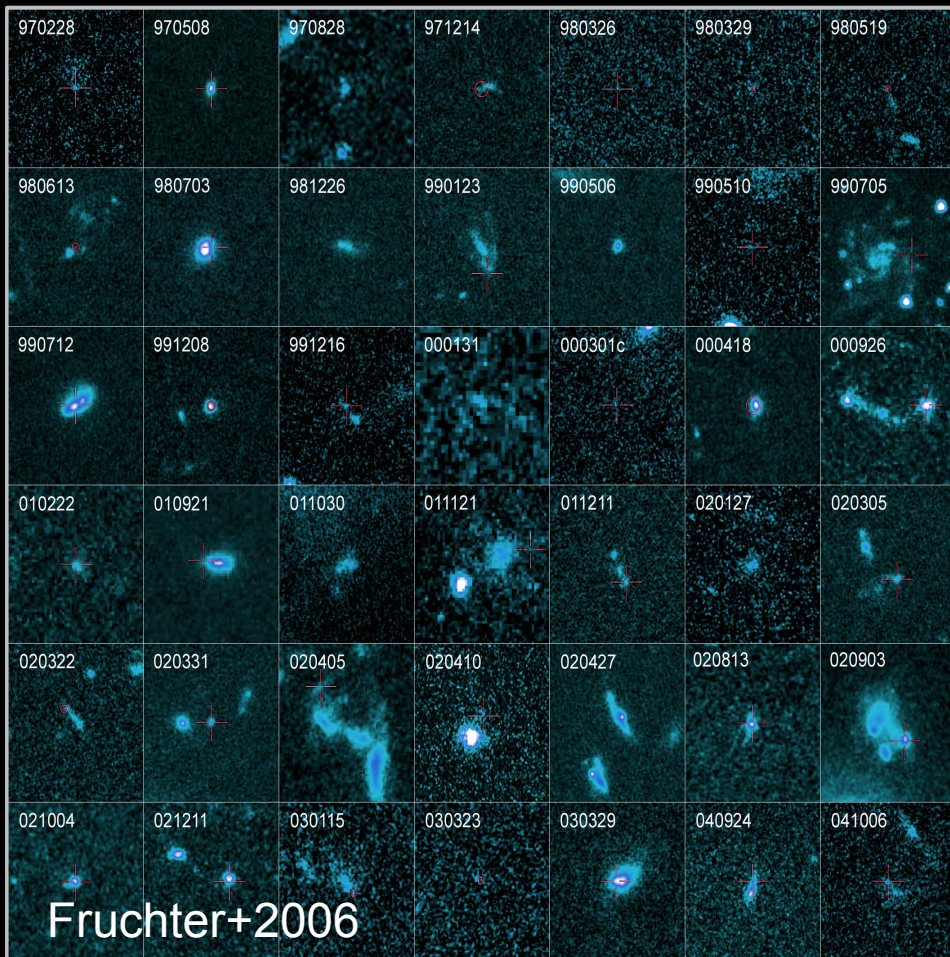
# Sample and Strategy

Select a sample of GRBs with well-constrained extinction curves and categorize their host galaxies.

	$z$	$A_v$	2175?
050408	1.236	0.7	no
051111	1.550	0.2	no
061126	1.159	$\sim 1$	no
070208	1.165	0.7	no
080605	1.640	1.2	weak
080805	1.505	1.0	no
081109	0.979	2.2	no
120119A	1.728	0.7	no
070802	2.454	1.5	yes
080603A	1.688	0.8	yes
080607	3.037	3.3	yes

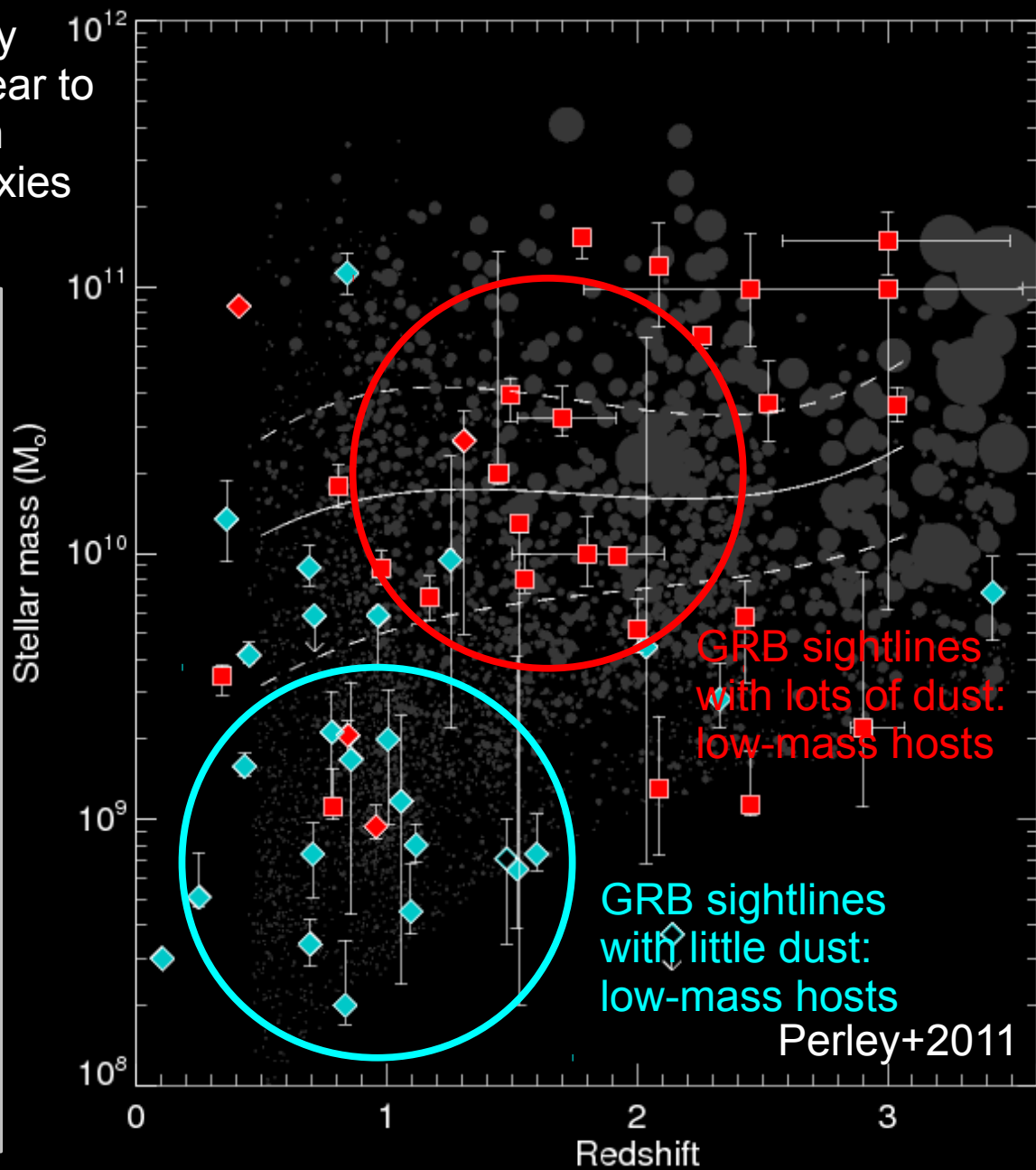
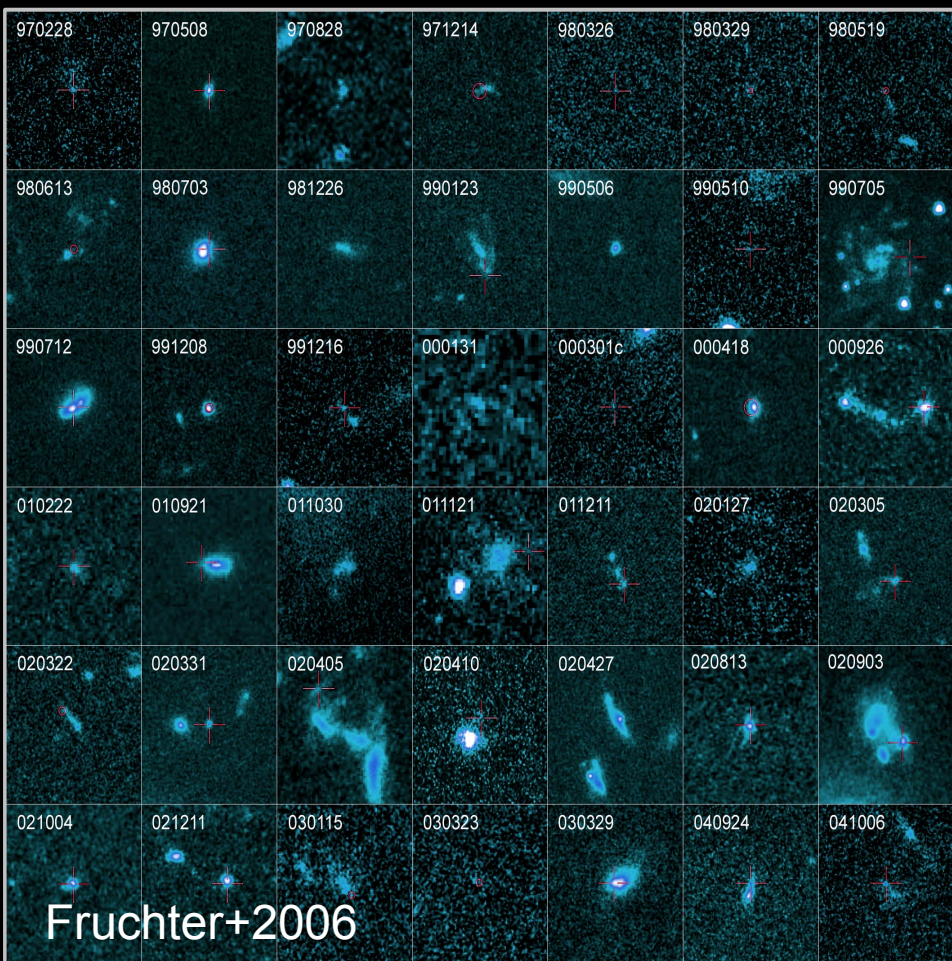
# A Brief Detour: GRBs, Hosts, Dust, & SFR

GRBs are SFR-selected, high- $z$ : probe only **actively star-forming galaxies**. Also appear to prefer low-mass, low-metallicity galaxies on average, but can occur in star-forming galaxies of all types



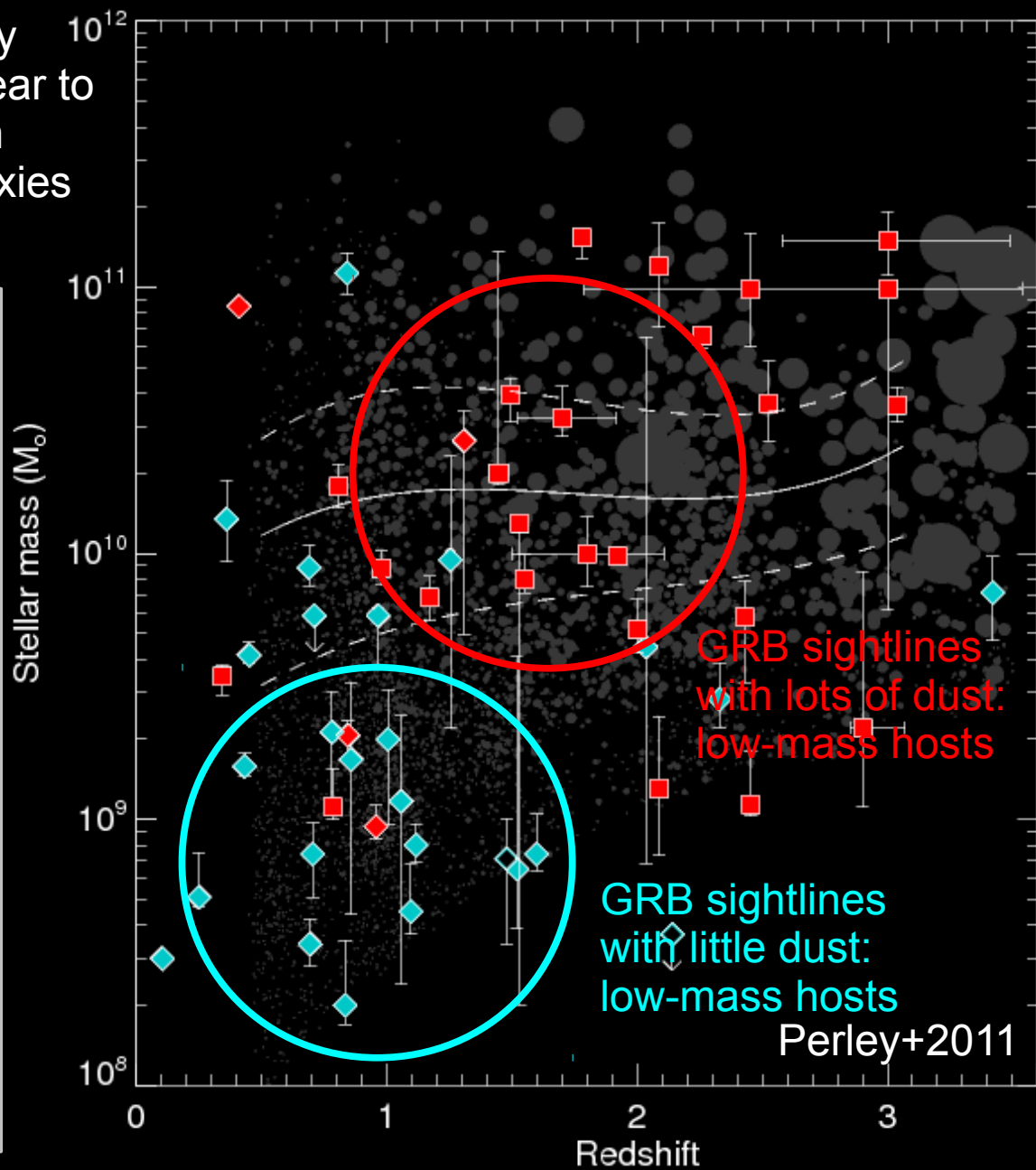
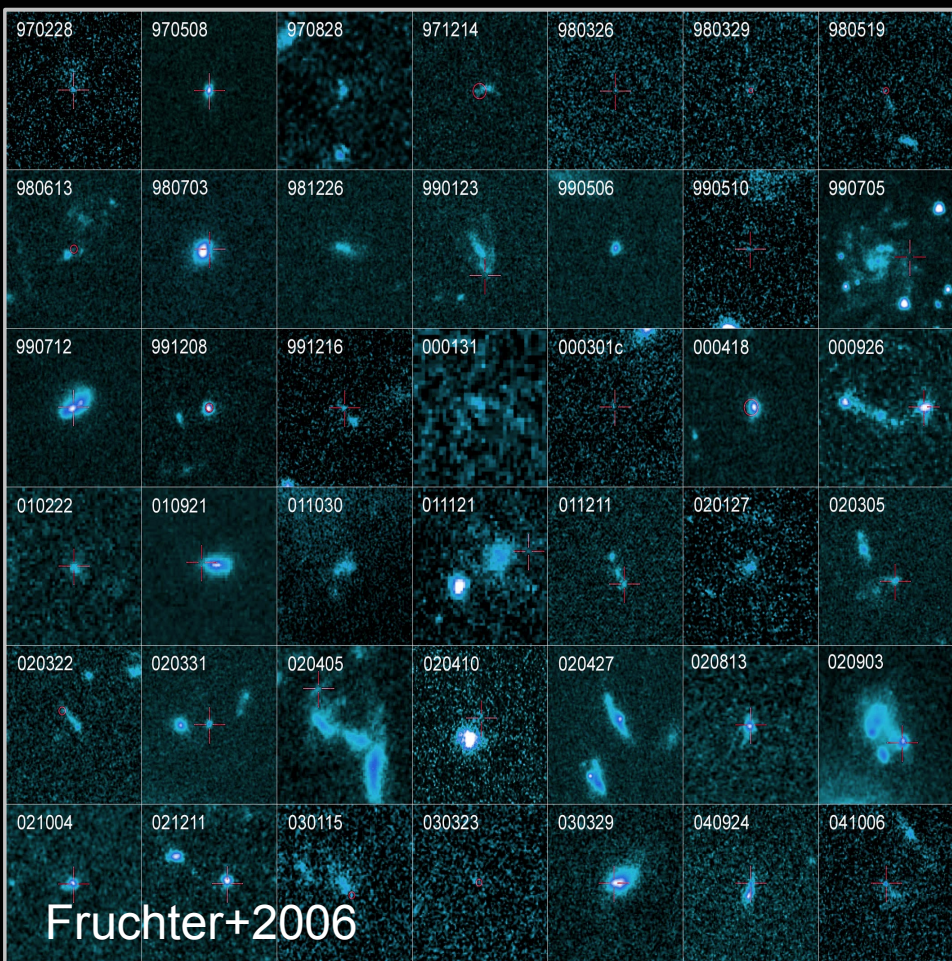
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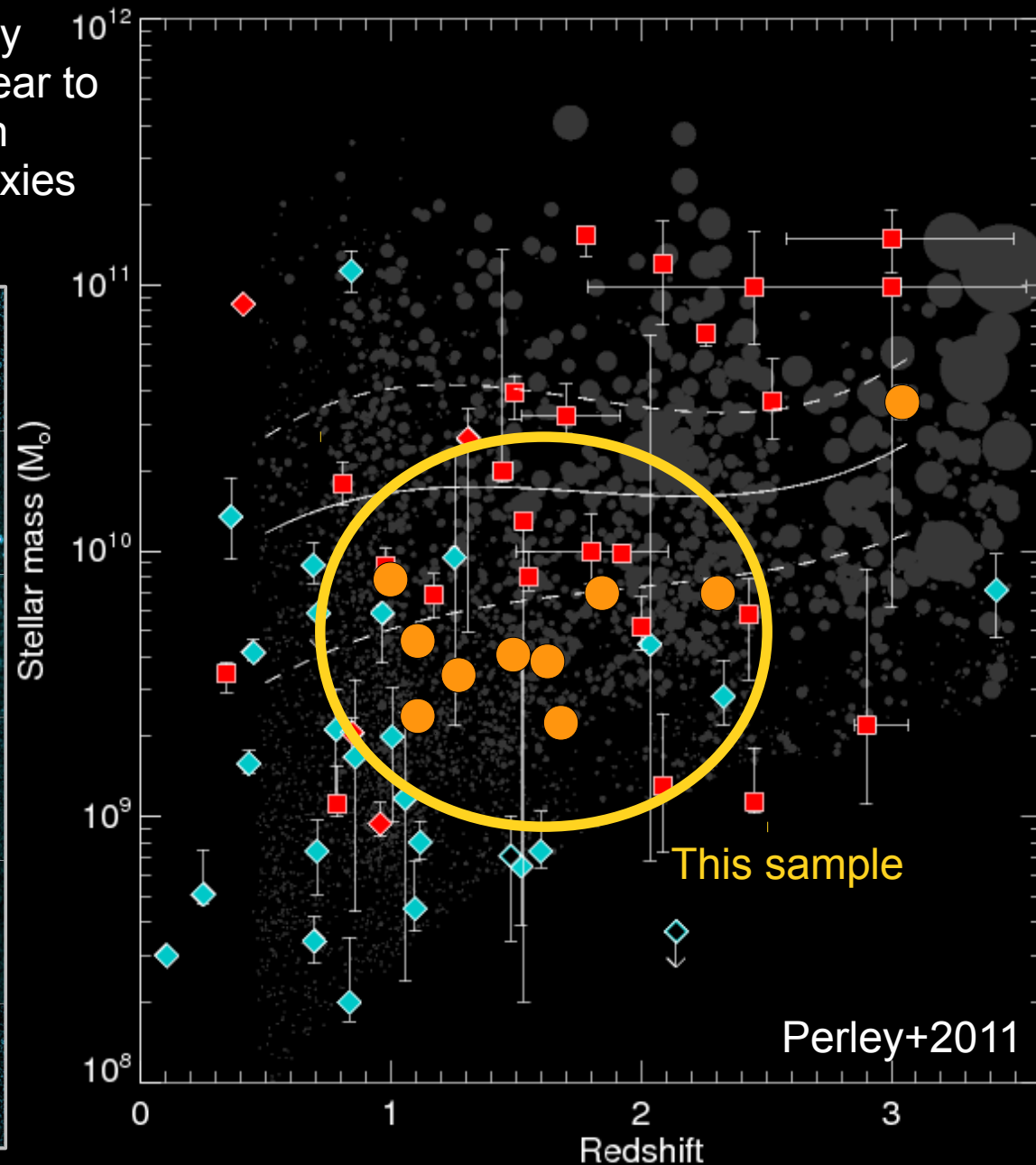
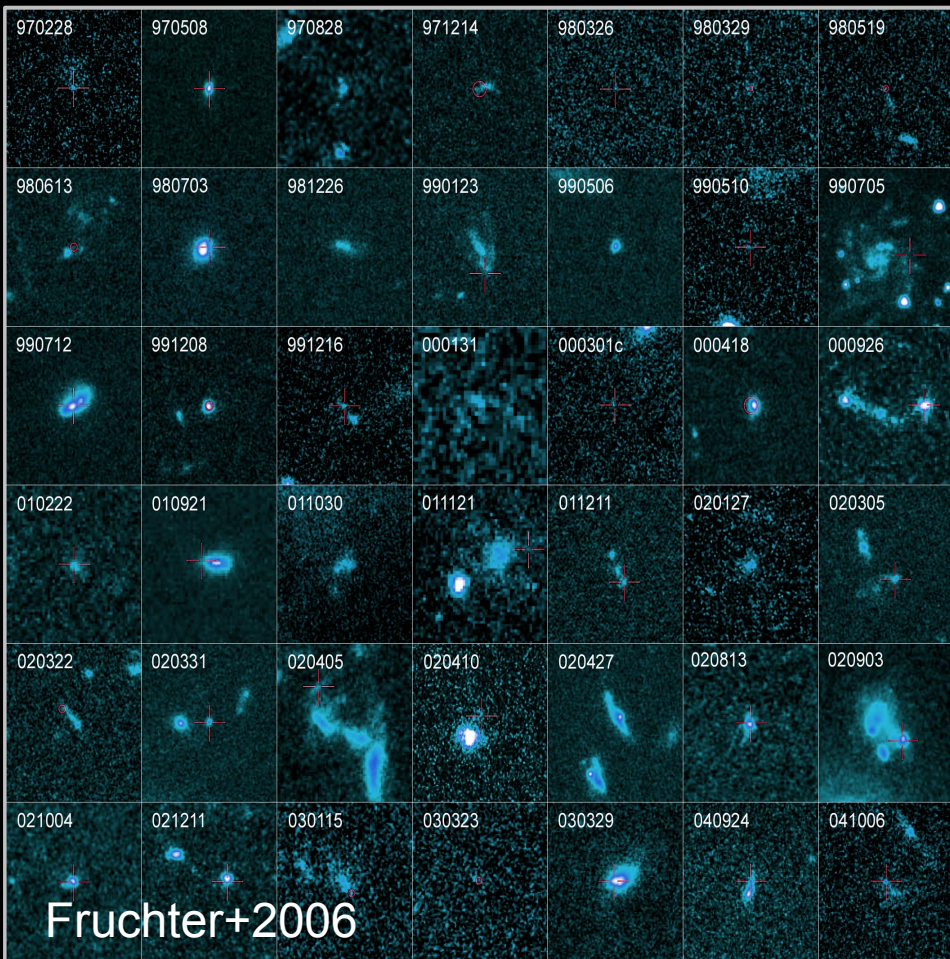
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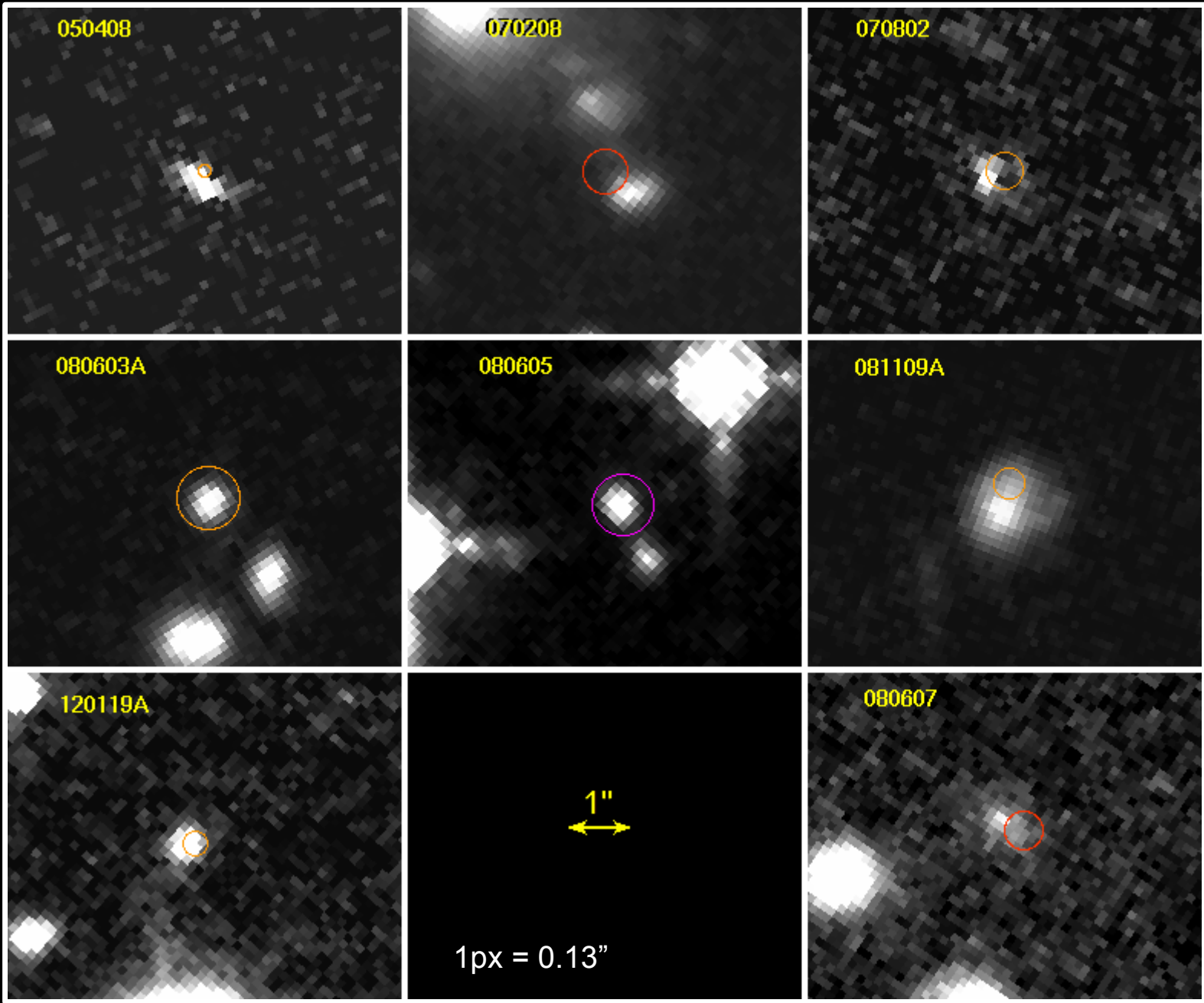
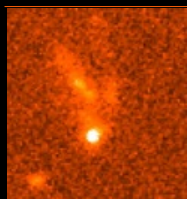


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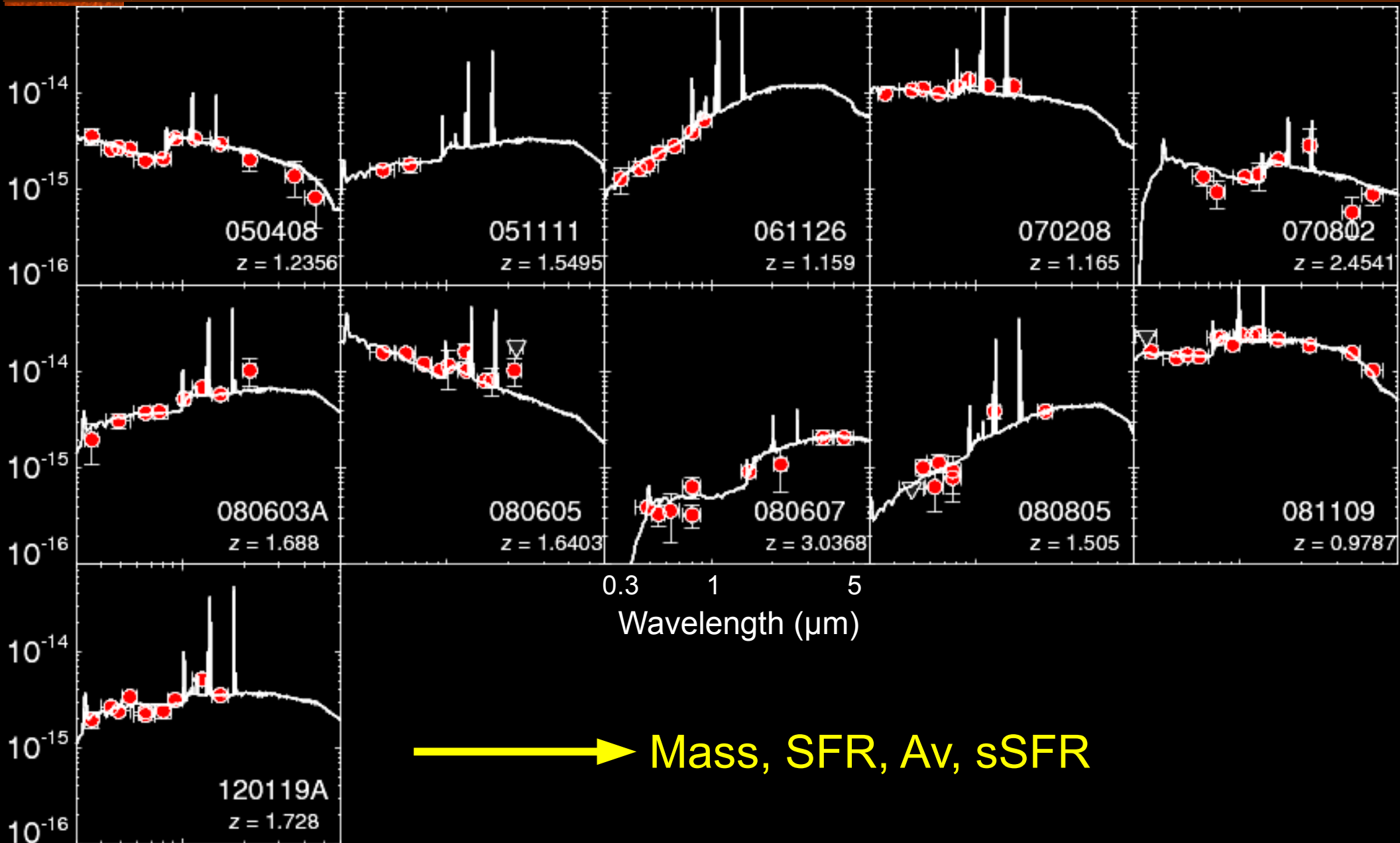
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# HST Morphologies



# SED Fitting



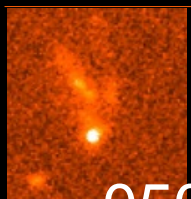
# Host Properties



	z	sightline Av (mag)	2175?	r (kpc)	SFR (Mo/yr)	mass (10 <sup>9</sup> Mo)	sSFR (1/Gyr)
050408	1.236	0.7	no	2	4	2.9	1.4
051111	1.550	0.2	no		61		
061126	1.159	~1	no		>100	4.4	>22
070208	1.165	0.7	no	2	82	2.3	35
080805	1.505	1.0	no		145	3.4	43
080605	1.640	1.2	weak	1.3	40	4.4	9
081109	0.979	2.2	no	7	50	9.3	5
120119A	1.728	0.7	no		140	2.6	54
070802	2.454	1.5	yes	1.5	12	8.1	1.5
080603A	1.688	0.8	yes	1.3	115	8.1	14
080607	3.037	3.3	yes	4	20	65	0.3
SMC	0		no	1.5	0.05	0.3	0.15
LMC	0		yes	4	0.1	3	0.03
MW	0		yes	10	1	60	0.01

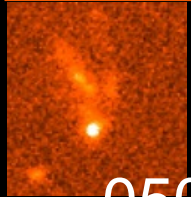


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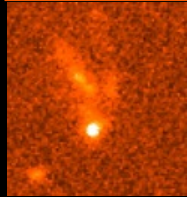


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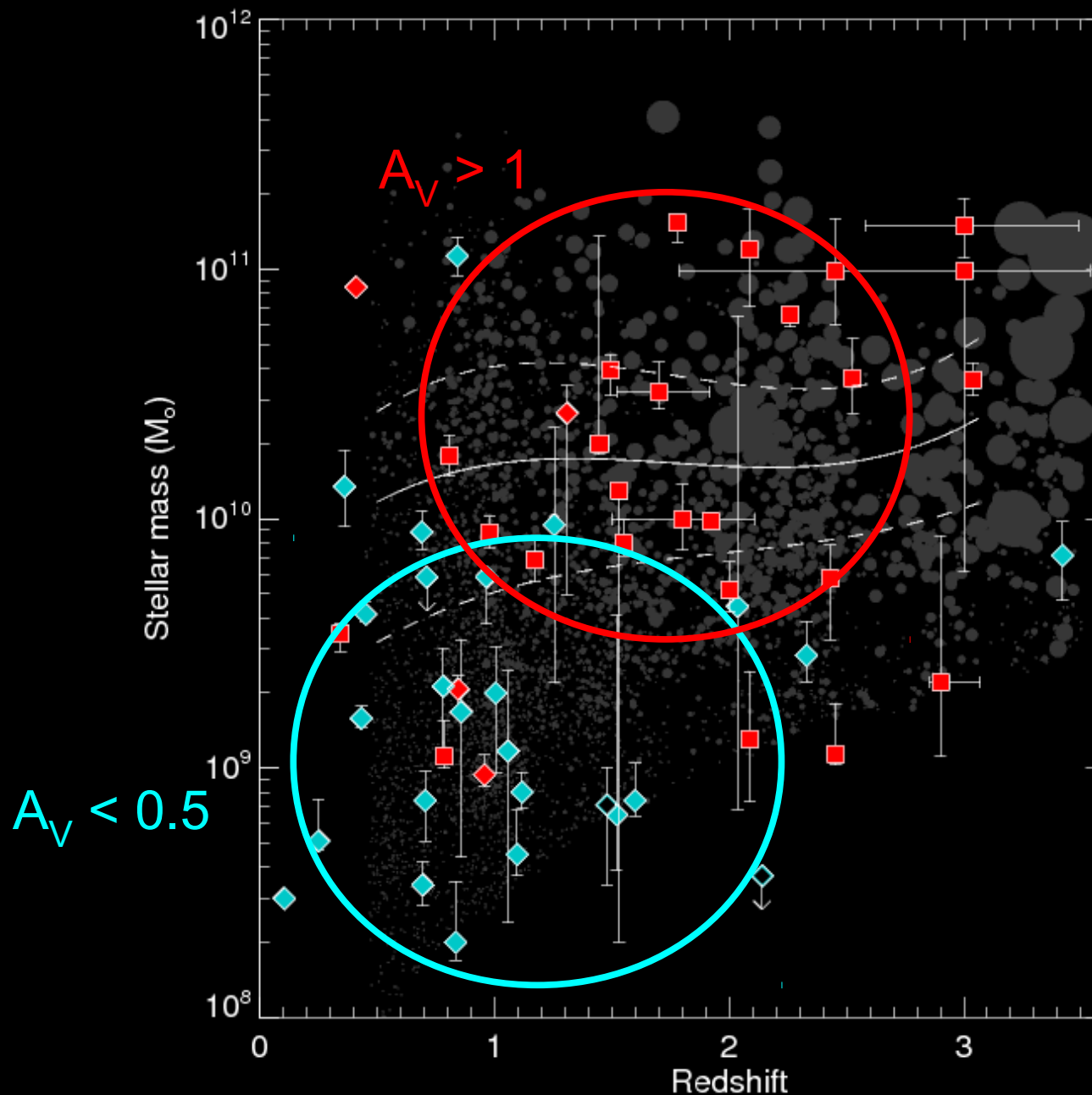
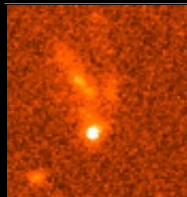
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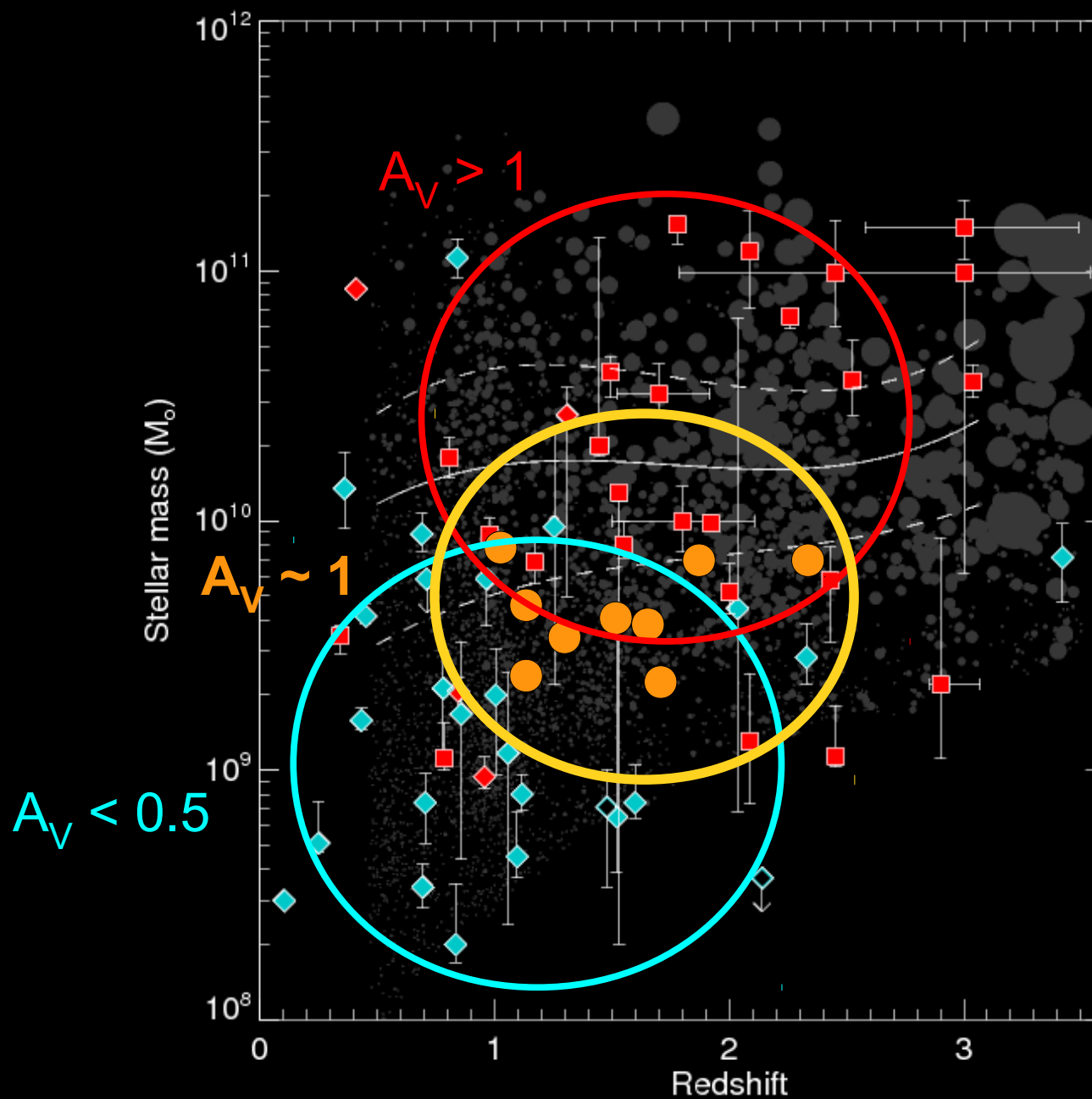
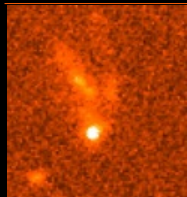
No clear correlations or separations between host galaxies with 2175 extinction and without.

2175 carrier can exist within very high-SFR galaxies.

# Mass does affect the amount of extinction



# Mass does affect the amount of extinction



- No correlations or hints of correlations between galaxy and dust properties in GRB hosts.

Diverse types of dust within individual galaxies?

2175 carrier *can* survive in low-mass, compact, high-SFR galaxies

Diverse types of dust within individual galaxies?

Amount of dust does correlate strongly with mass

Not much dust in faint galaxies: destroyed, removed, or not yet formed,

More coming: expanded sample, search for 2175 feature in integrated galaxy light

