Gamma Ray Bursts as Probes of the Dust Content of High Redshift Galaxies

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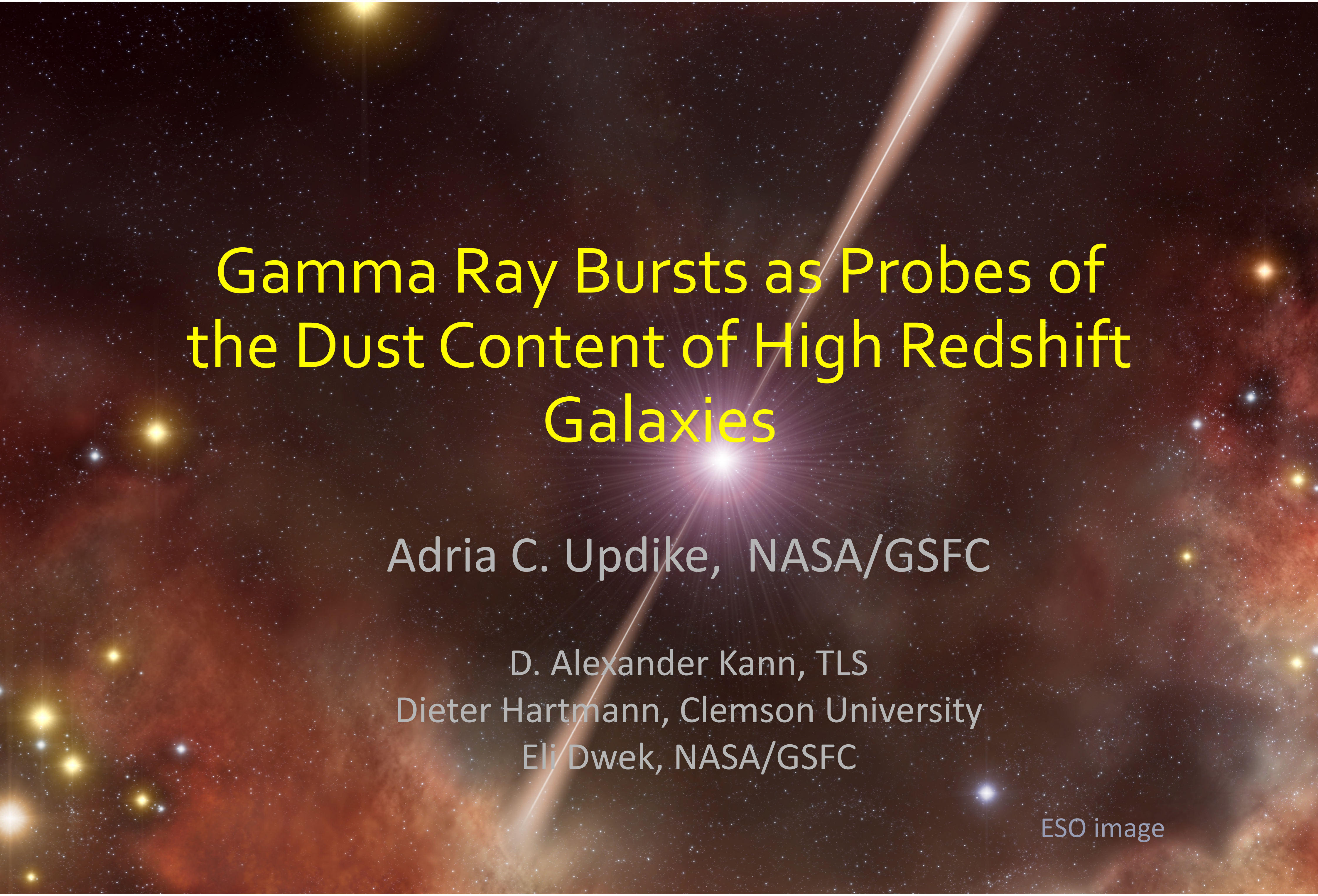
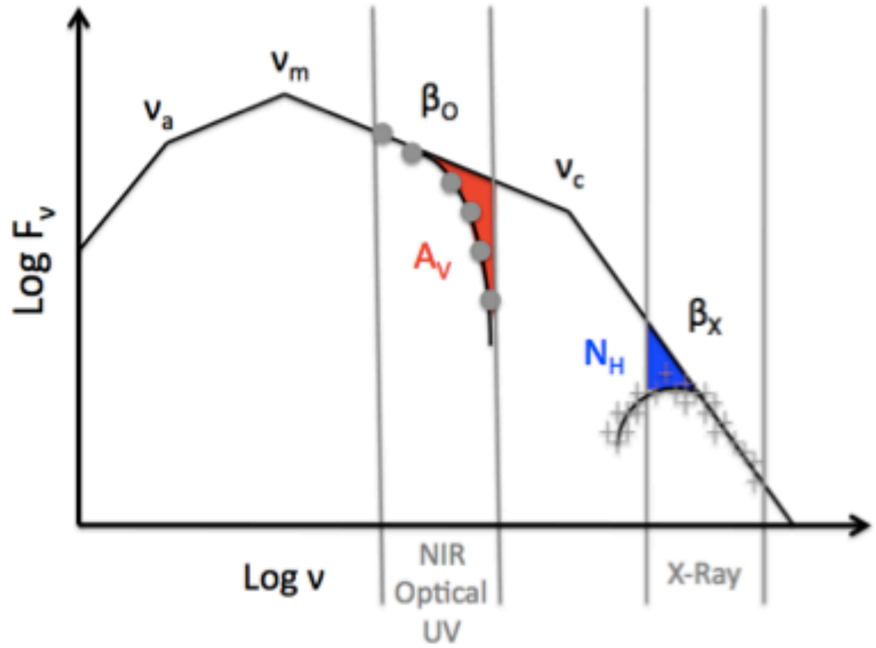


ESO image

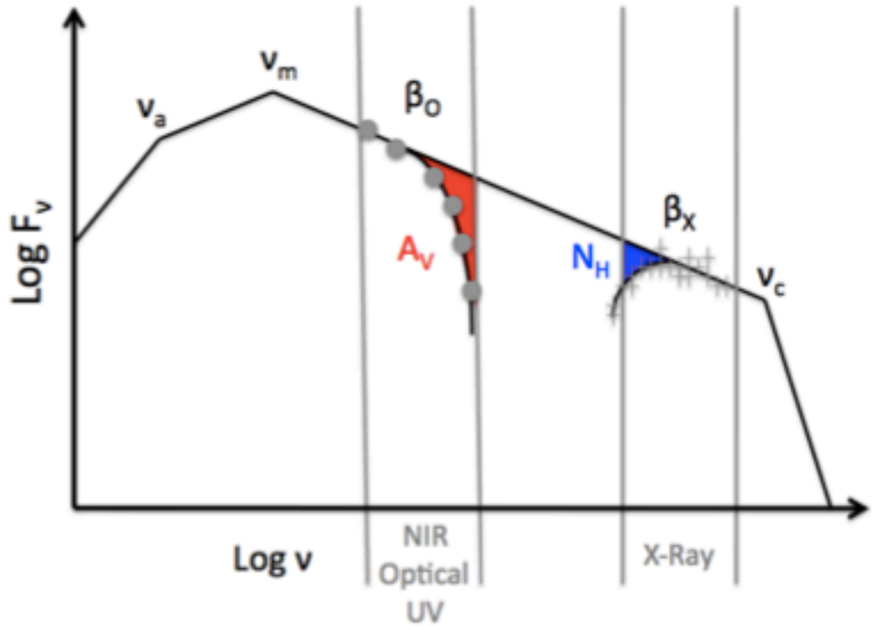
GRB SEDs

broken power law



$\beta_O = \beta_X - 0.5$

single power law

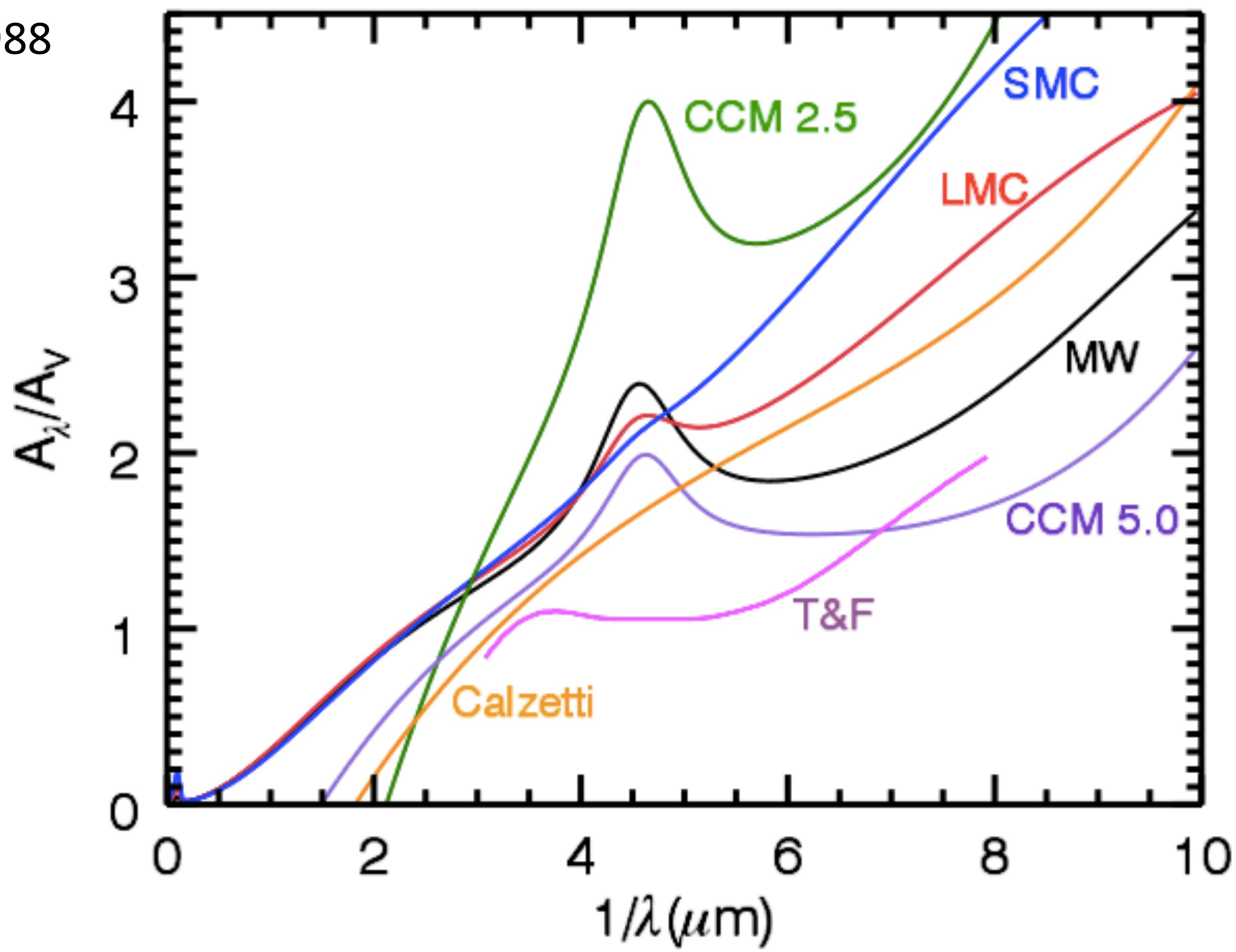


$\beta_O = \beta_X$

Dust Extinction Curves

Cardelli, Clayton & Mathis 1988
Pei 1992 (MW, LMC, SMC)
Calzetti et al. 1994
Todini & Ferrara 2001
Miaolino et al. 2004

$$R_V = \frac{A_V}{E(B-V)}$$

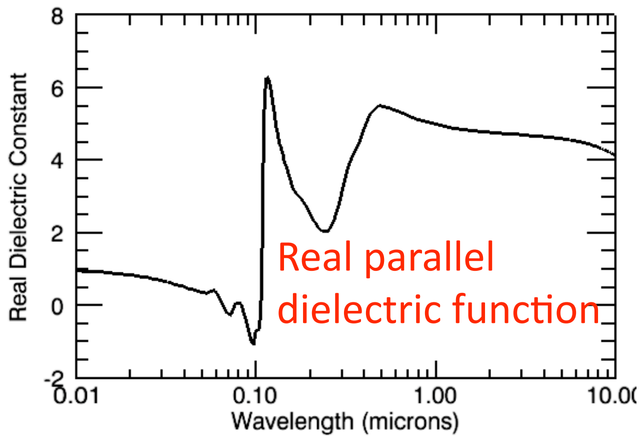


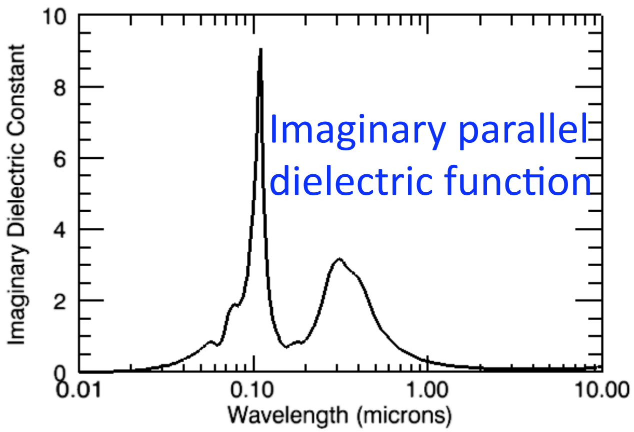
Modeling Dust Extinction

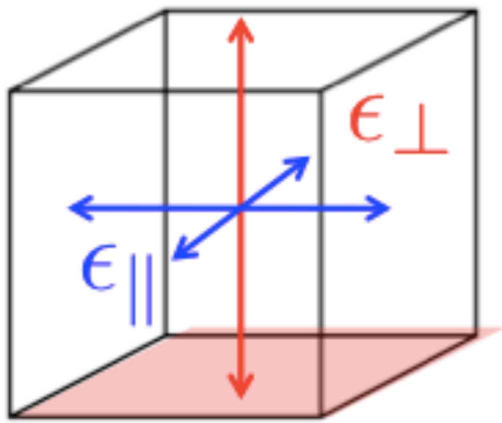
$$\tau_\lambda = \int_{a_-}^{a_+} \pi a^2 C\, \Sigma_d \left(\frac{a}{a_0}\right)^{-3.5} Q_{ext}\, da$$

$$\epsilon = 1 + \delta\epsilon^b + \delta\epsilon^f$$

Dielectric Functions of Graphite

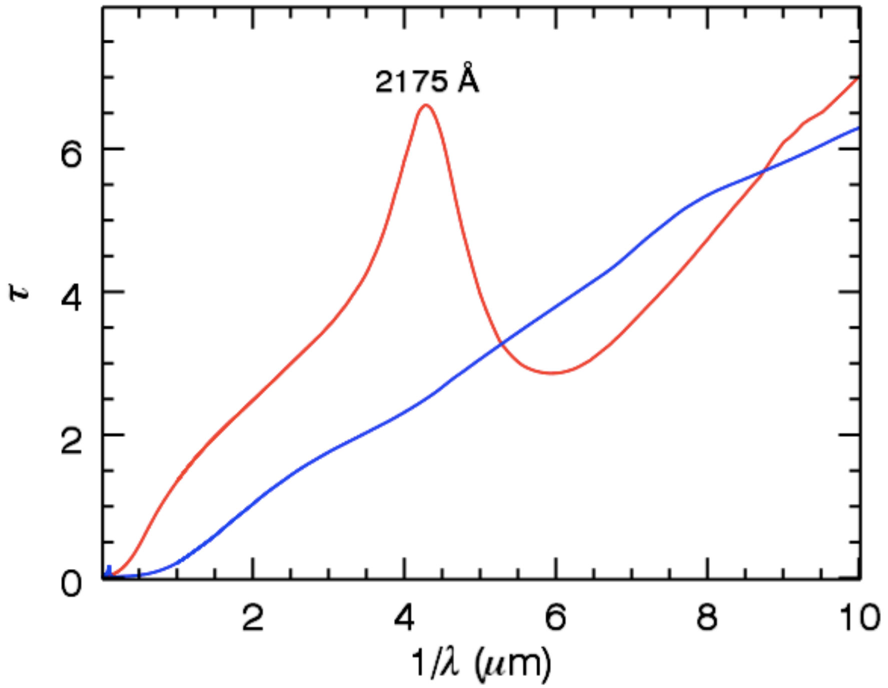






data from Draine 1985

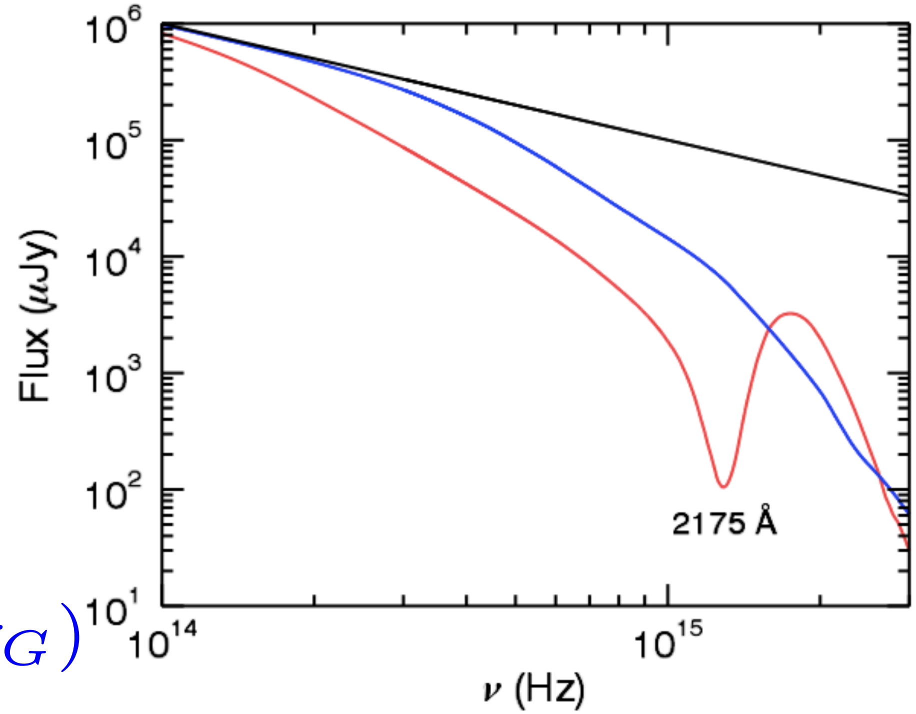
Dust Signatures in GRB SEDs



adapted from Draine & Li, 1984
and Draine 1985

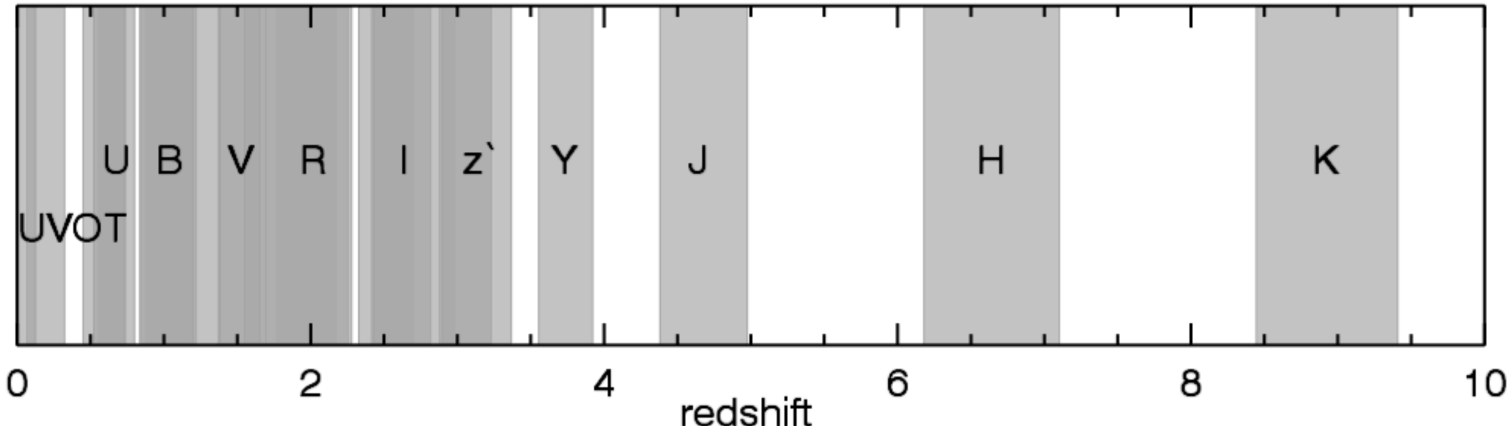
column densities of 10^{12} cm^{-2}

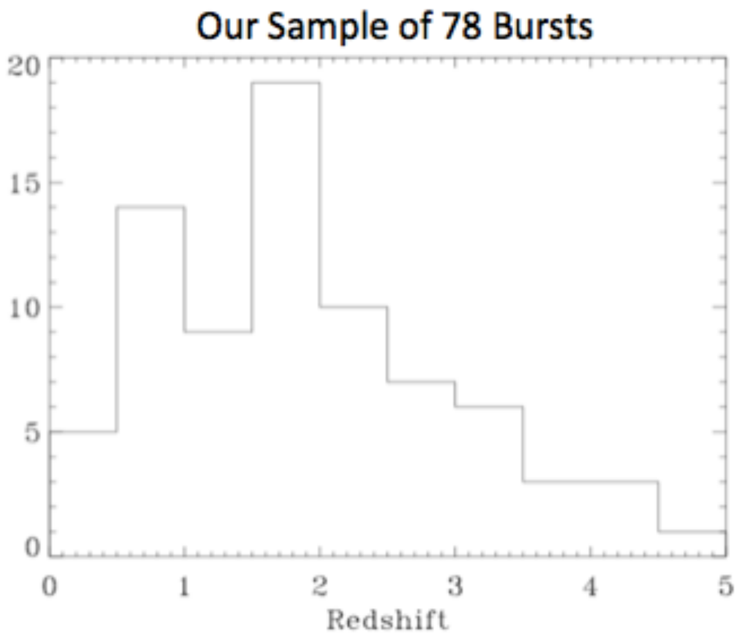
silicates
graphite

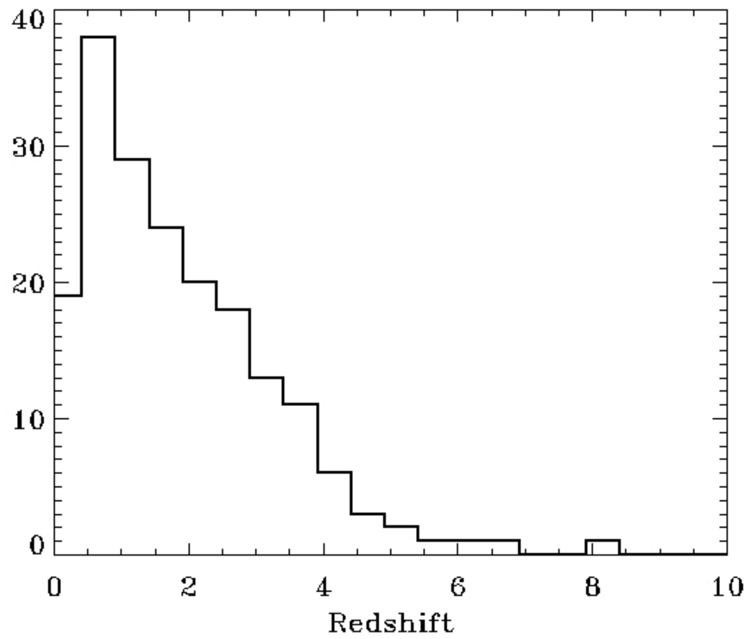


$$F = F_0\, \nu^{-\beta}\, e^{-\Sigma(\tau_S + n\tau_G)}$$

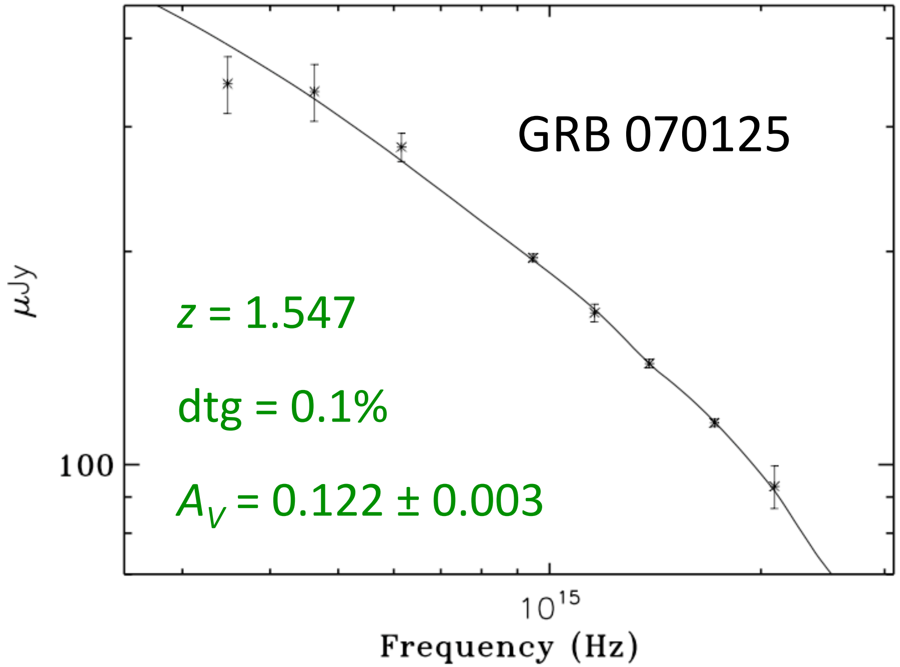
GRB SEDs


U B V R I z` Y J H K
UVOT
0 2 4 6 8 10
redshift


Our Sample of 78 Bursts
20 15 10 5 0
0 1 2 3 4 5
Redshift


40 30 20 10 0
0 2 4 6 8 10
Redshift

A Few Results of the Fit



Σ_G = 1.29 (± 0.03) × 10^{8} cm^{-2}

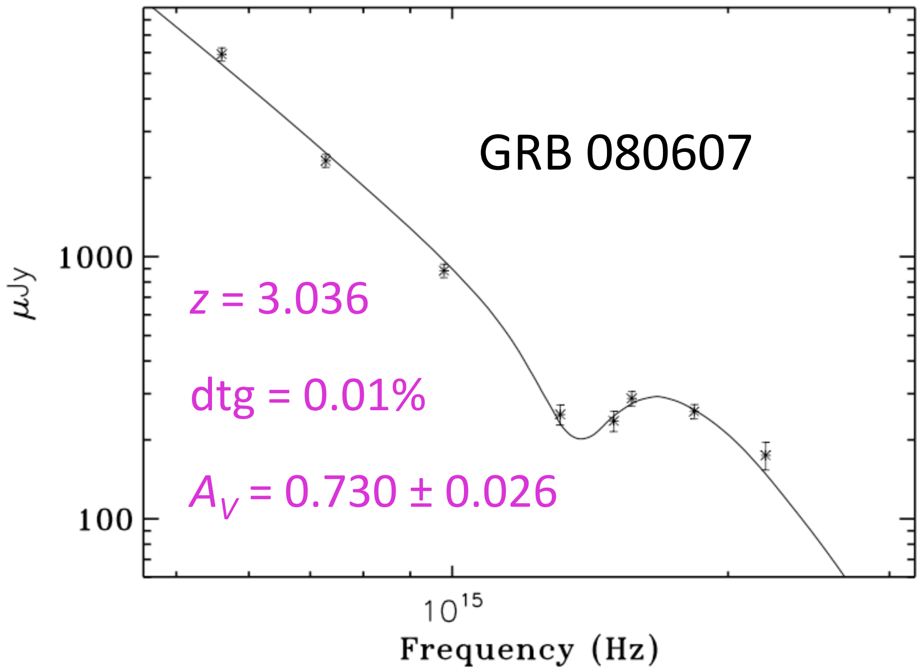
Σ_S = 1.28 (± 0.03) × 10^{11} cm^{-2}

data from Updike et al. 2008

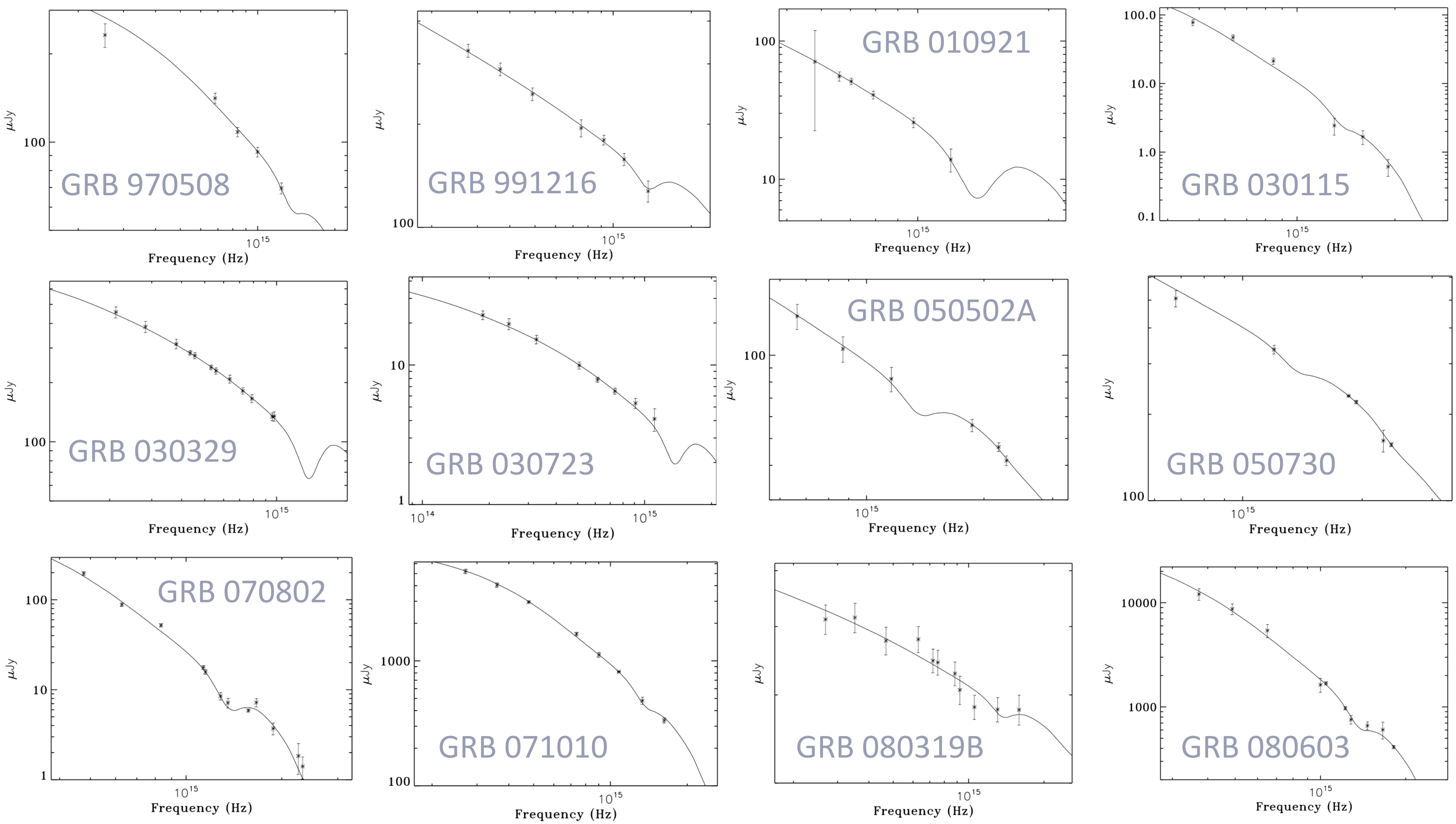
Σ_G = 1.33 (± 0.05) × 10^{12} cm^{-2}

Σ_S = 3.34 (± 0.12) × 10^{11} cm^{-2}

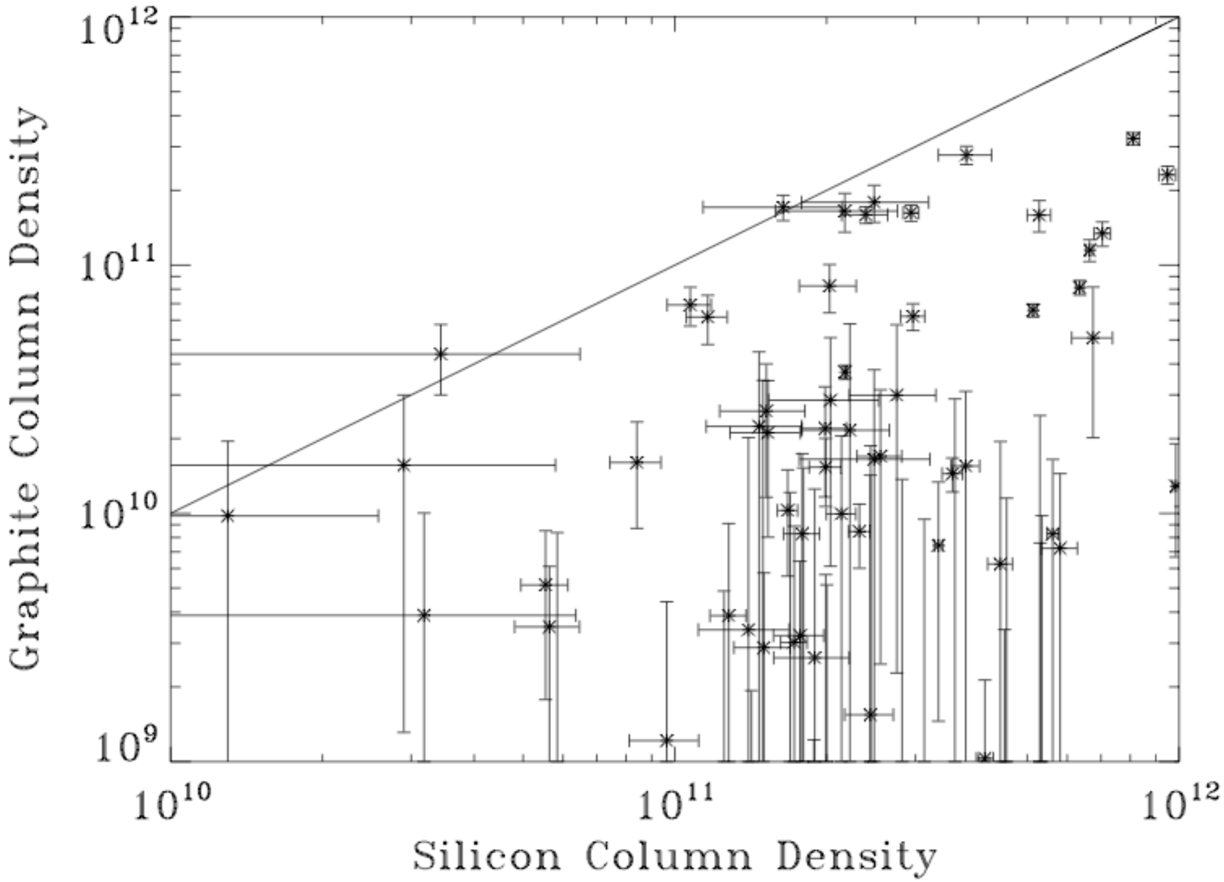
data from Perley, Morgan, & Updike et al. 2011



Graphite Detections in 17 GRB Hosts

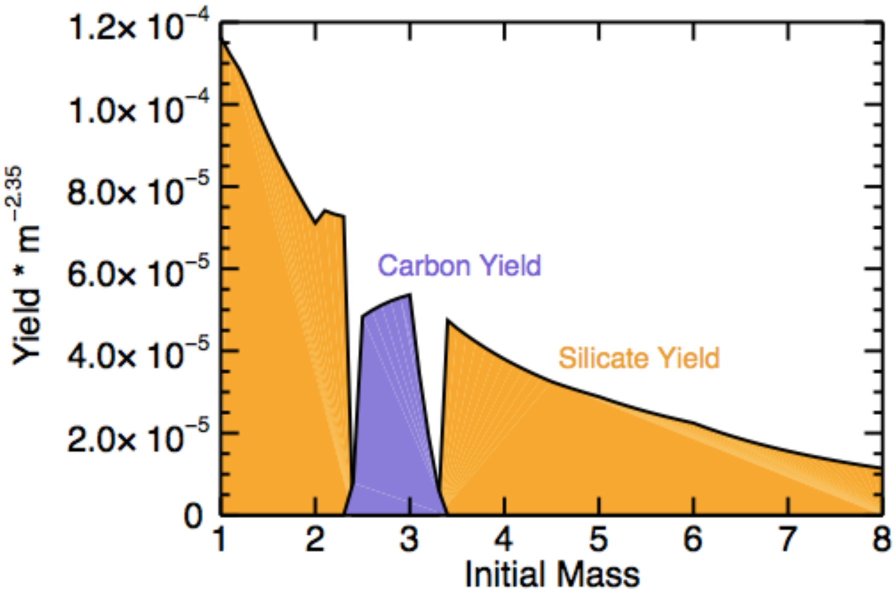


Graphite vs Silicate in GRB Host Galaxies



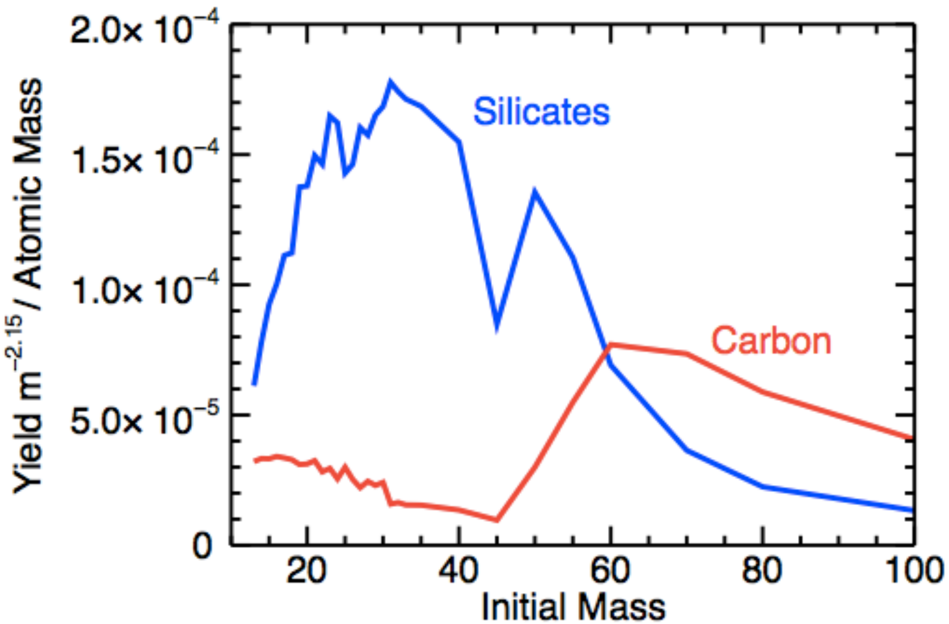
Updike, Kann, & Hartmann in prep.

Stellar Yields



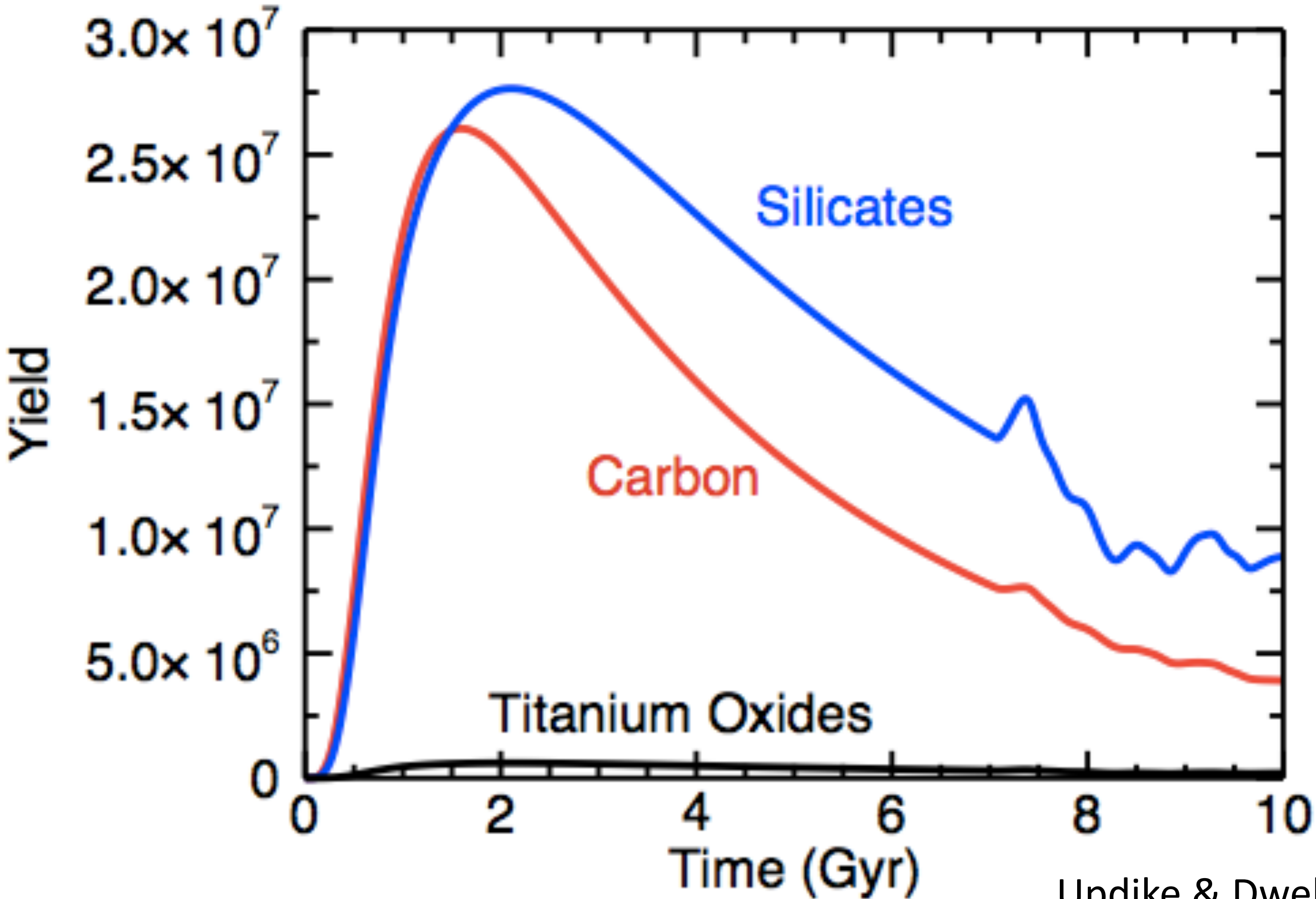
AGB yields
Karakas 2010

CCSNe yields
Joggerst et al. 2009



figures from Updike & Dwek, in prep.

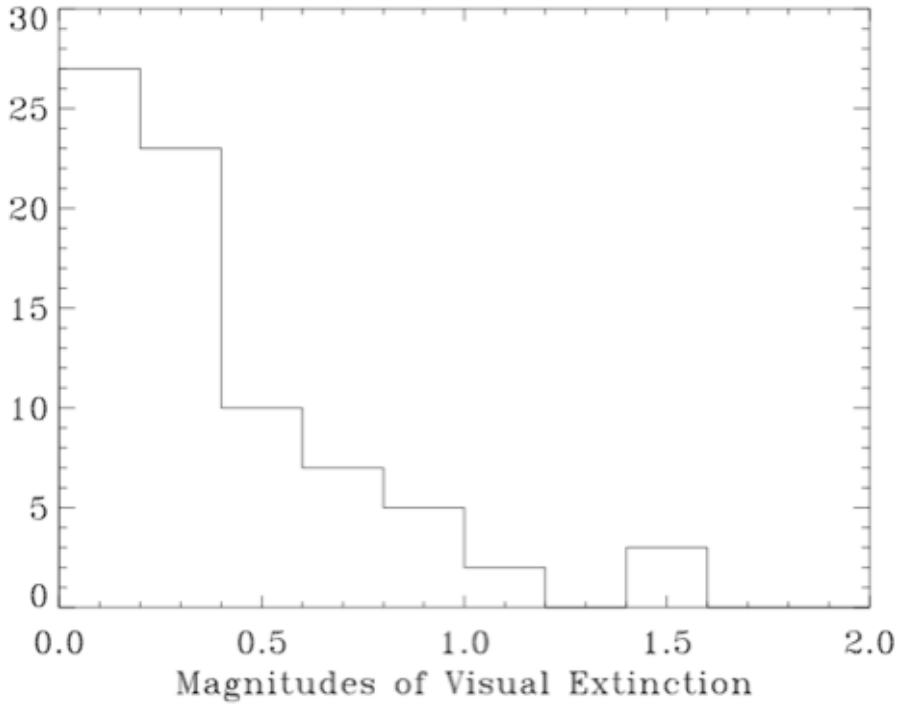
Galactic Chemical Evolution

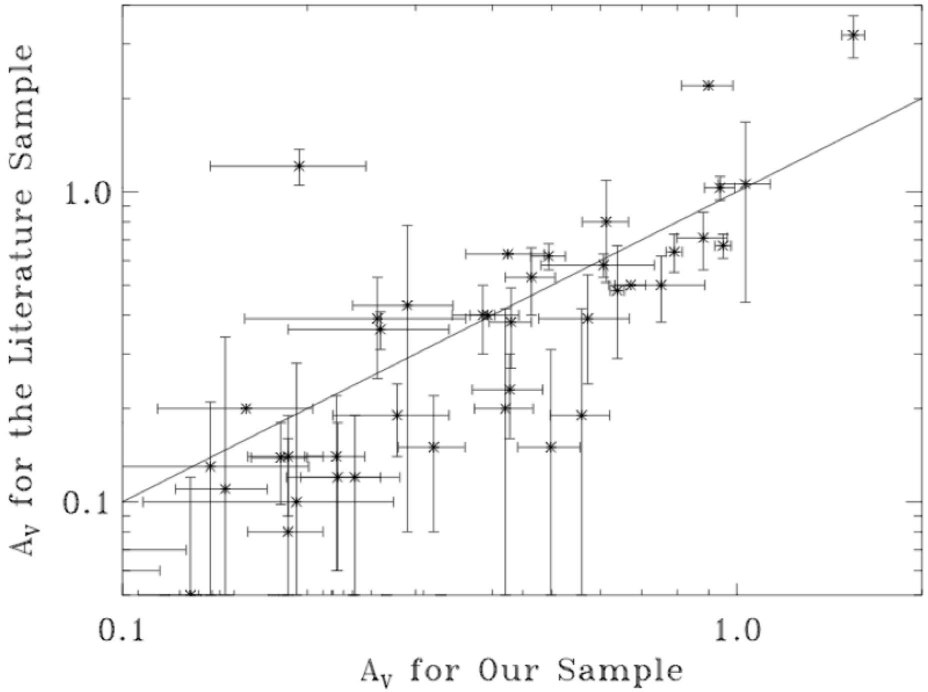


Updike & Dwek, in prep.

A_V Distribution in Our Data Set

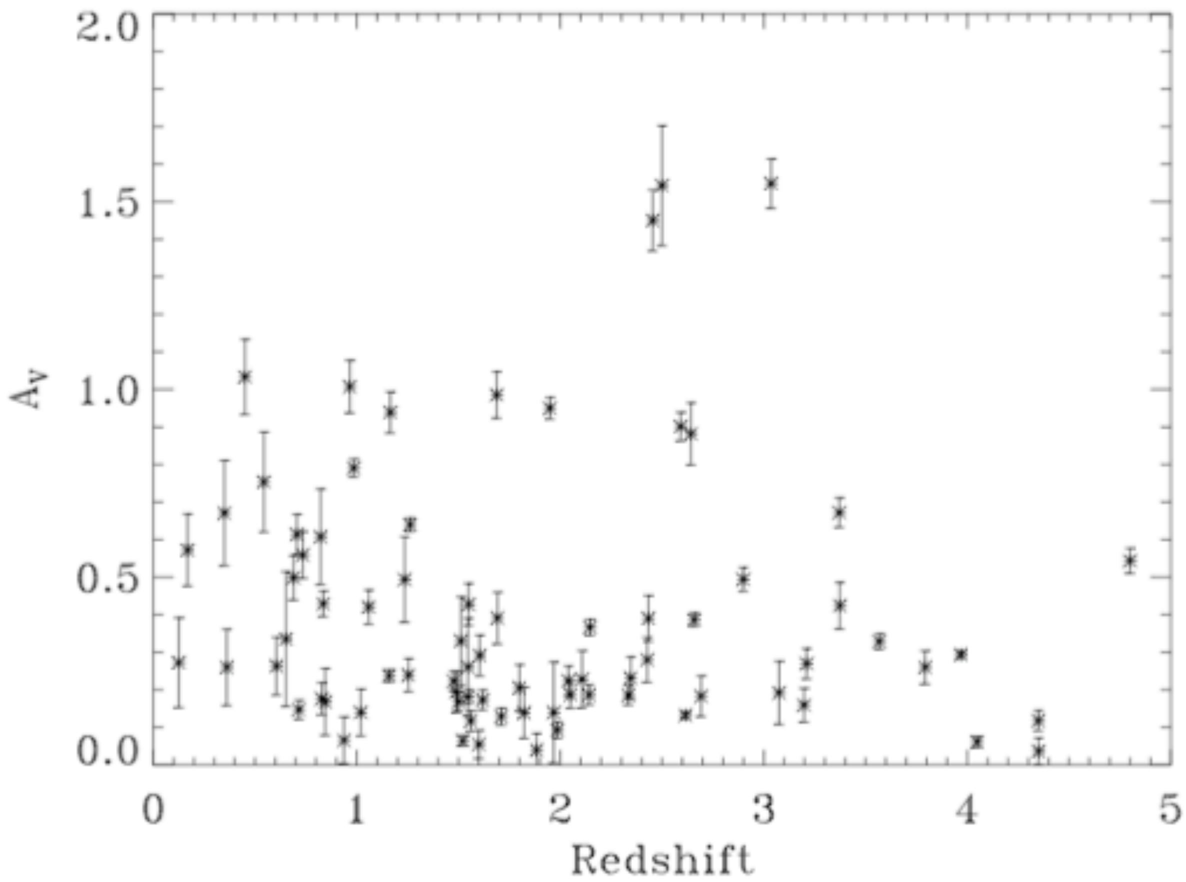
A_V distribution in our data set



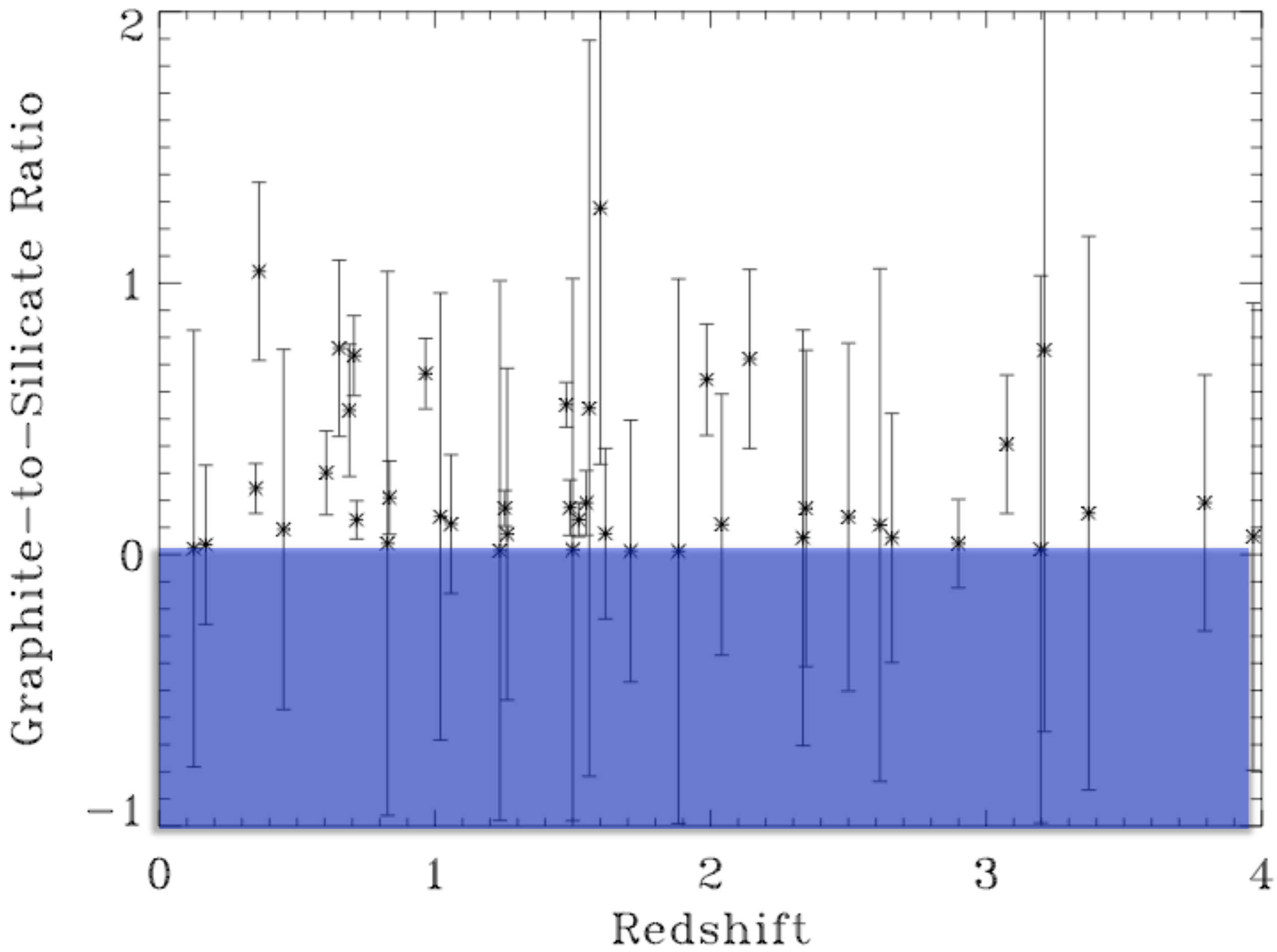


A_V distribution for our sample versus the same GRBs for which A_V values existed in the literature.

A_V as a Function of Redshift



Graphite-to-Silicate in GRB Host Galaxies



Summary

- GRBs can be powerful probes of the dust content of high-redshift galaxies
- Significant UV/optical/NIR coverage is necessary
- Chemical evolution models can make testable predictions about the dust content of evolving galaxies
- The early universe was probably dominated by silicate dust
- No clear evolutionary trends found in hosts out to a redshift of ~4