Francisco J. Virgili
University of Nevada, Las Vegas
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Collaborators: Bing Zhang, Ken Nagamine, Jun-hwan Choi

GRBS AND THE EFFECTS OF METALLICITY, REDSHIFT EVOLUTION AND HIGH-Z BURSTS

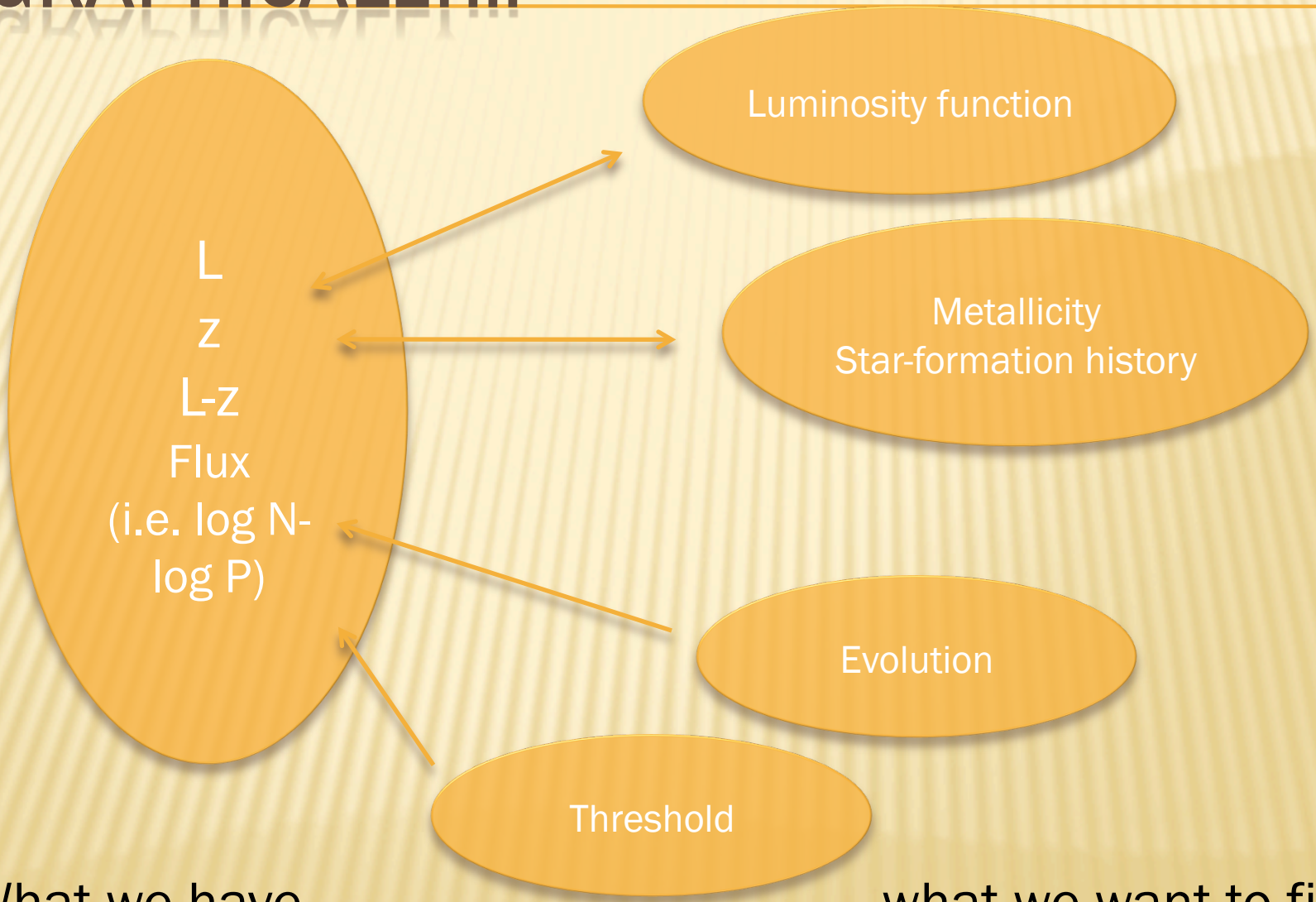
HIGH-Z EFFECTS

- Motivated by slew of high-z events
  - 050904 (z=6.3) (Kawai et al. 2006?)
  - 080913 (z=6.7) (Greiner et al. 2009)
  - 090423 (z=8.2) (Salvaterra et al. 2009, Tanvir et al. 2009)
- GRB rate seems to increase faster than cosmic SFH (Kistler et al., 2007,2009; Salvaterra et al. 2009)
- Metallicity effects? LF evolution? (Li 2007, Qin et al. 2010)

MONTE CARLO SIMULATIONS

- Test various star forming history models (analytical forms and derived from cosmological simulations)
- Add metallicity and/or evolution considerations
- Test with available observations
  - L distribution (Swift)
  - z distribution (Swift)
  - log N – log P (Swift and BATSE)
- Anderson-Darling test

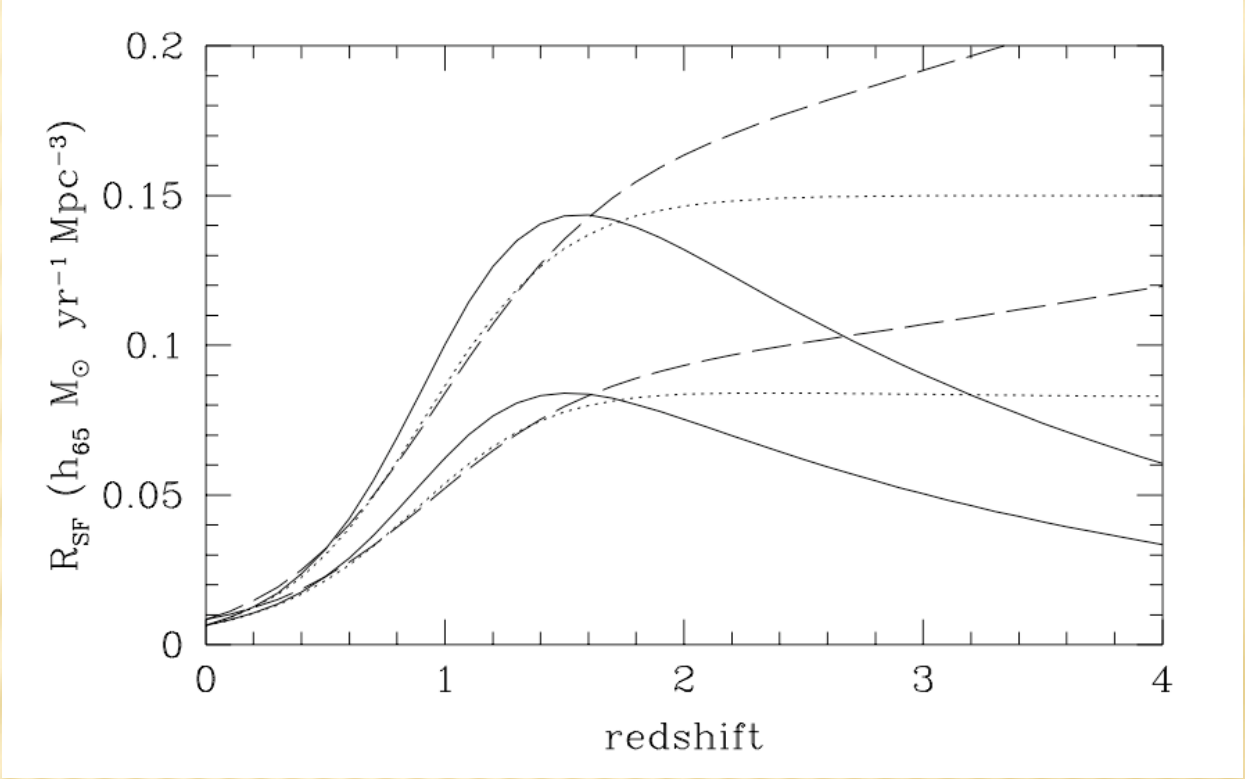
GRAPHICALLY…



What we have…

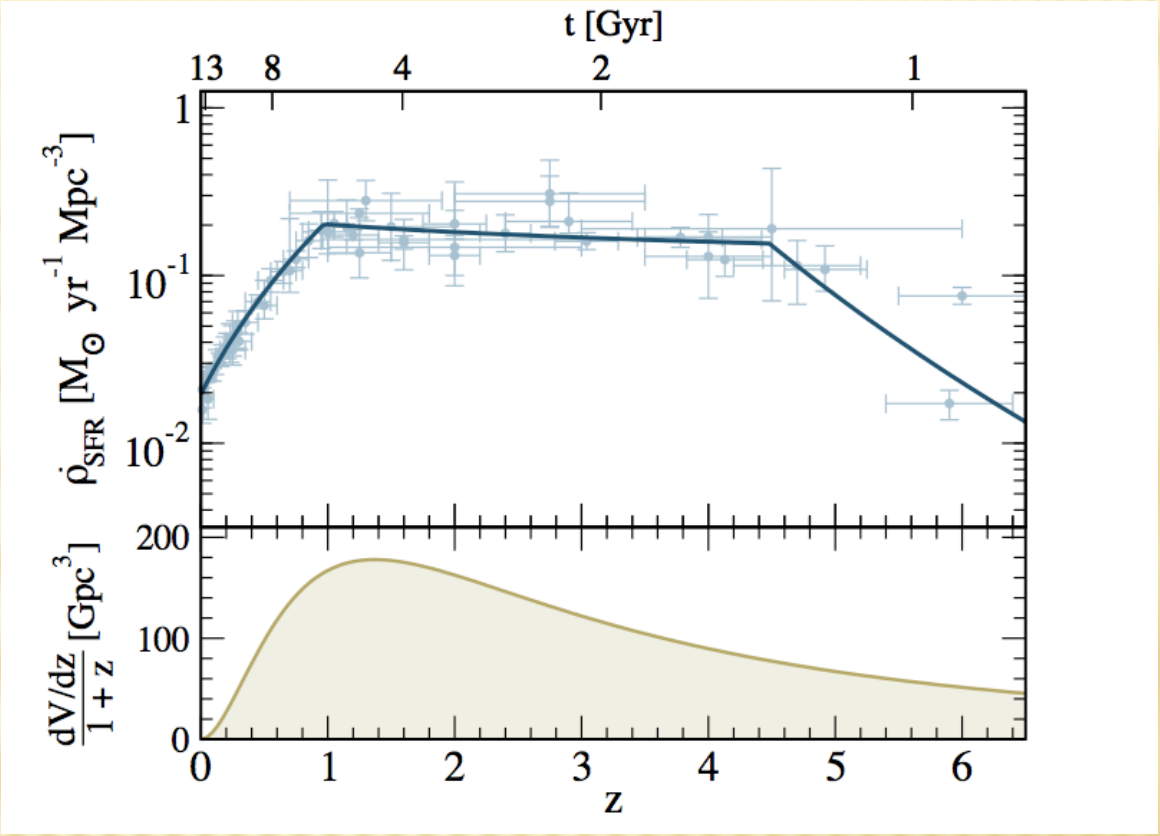
…what we want to find out

STAR FORMATION HISTORY: PORCIANI AND MADAU (2001)



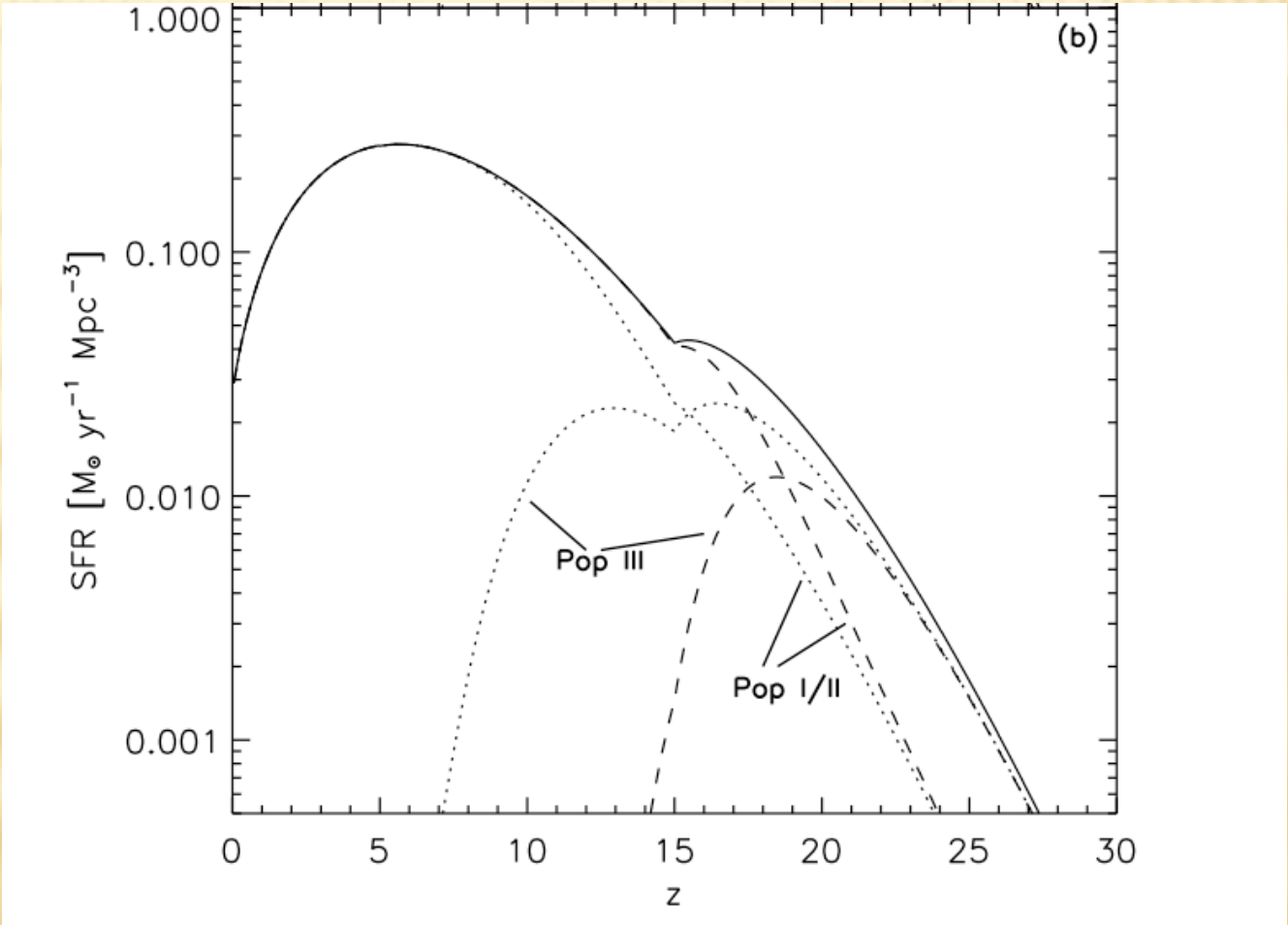
$$R_{SF2}(z) = 0.15 h_{65} \frac{\exp(3.4z)}{\exp(3.4z) + 22} M_\odot \text{ yr}^{-1} \text{ Mpc}^{-3}$$

STAR FORMING HISTORY: HOPKINS & BEACOM (2006)

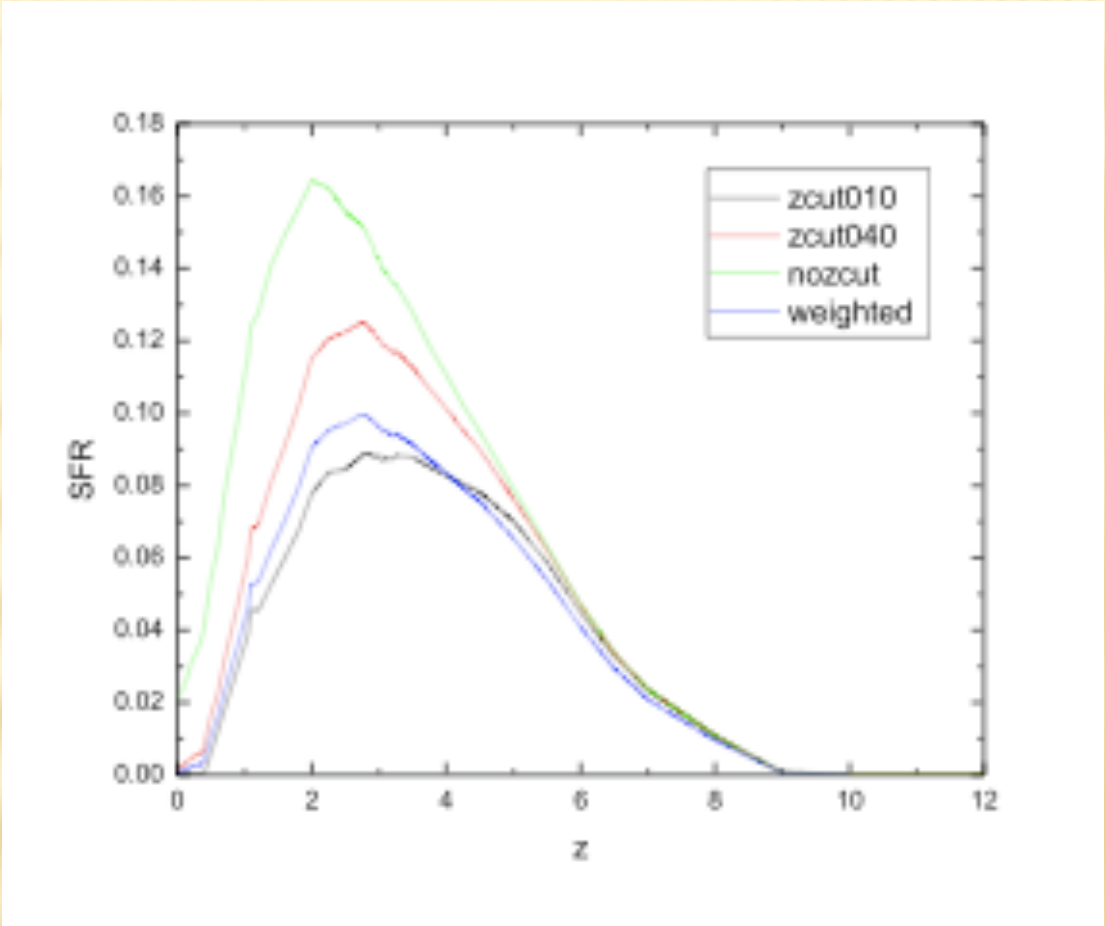


$$\dot{\rho}_{\rm SFH}(z) \propto \begin{array}{ll} (1+z)^{3.44} & : \ z < 0.97 \\ (1+z)^{-0.26} & : \ 0.97 < z < 4.48 \\ (1+z)^{-7.8} & : \ 4.48 < z\,, \end{array}$$

STAR FORMING HISTORY: BROMM & LOEB (2006)



STAR FORMING HISTORY: CHOI & NAGAMINE (2009)



- Derived from cosmological simulations (SPH)

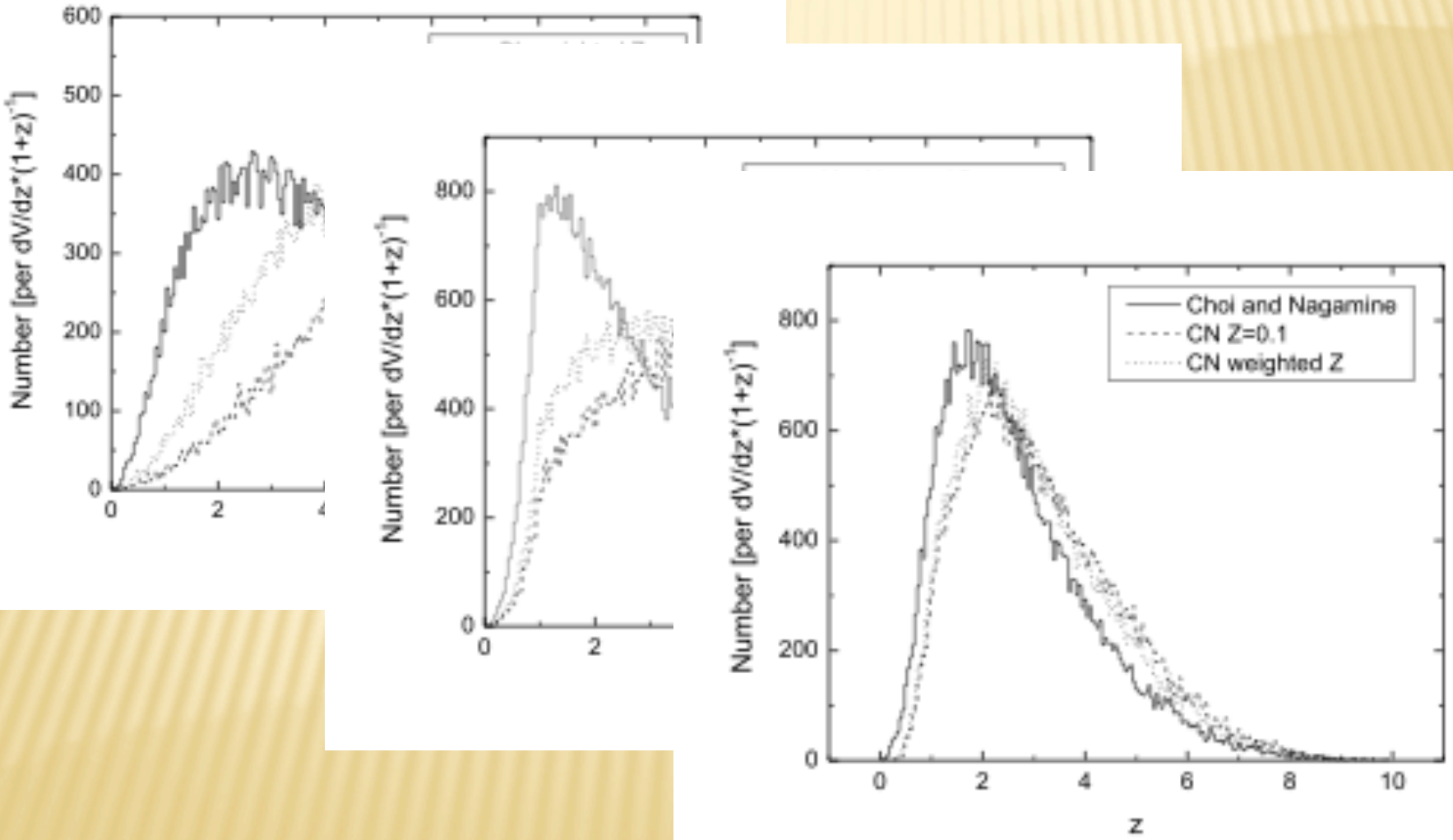
METALLICITY

- GRBs thought to occur primarily in low-metallicity environments
- Perhaps decrease in metallicity in early universe increases the GRB event rate
- Analytical formula provided by Li (2007):

$$\Psi(z,\epsilon) = 1 - \frac{\Gamma\left(\alpha+2, \epsilon^{\beta} 10^{0.15\beta z}\right)}{\Gamma(\alpha+2)}$$

- Weighting

WEIGHTING



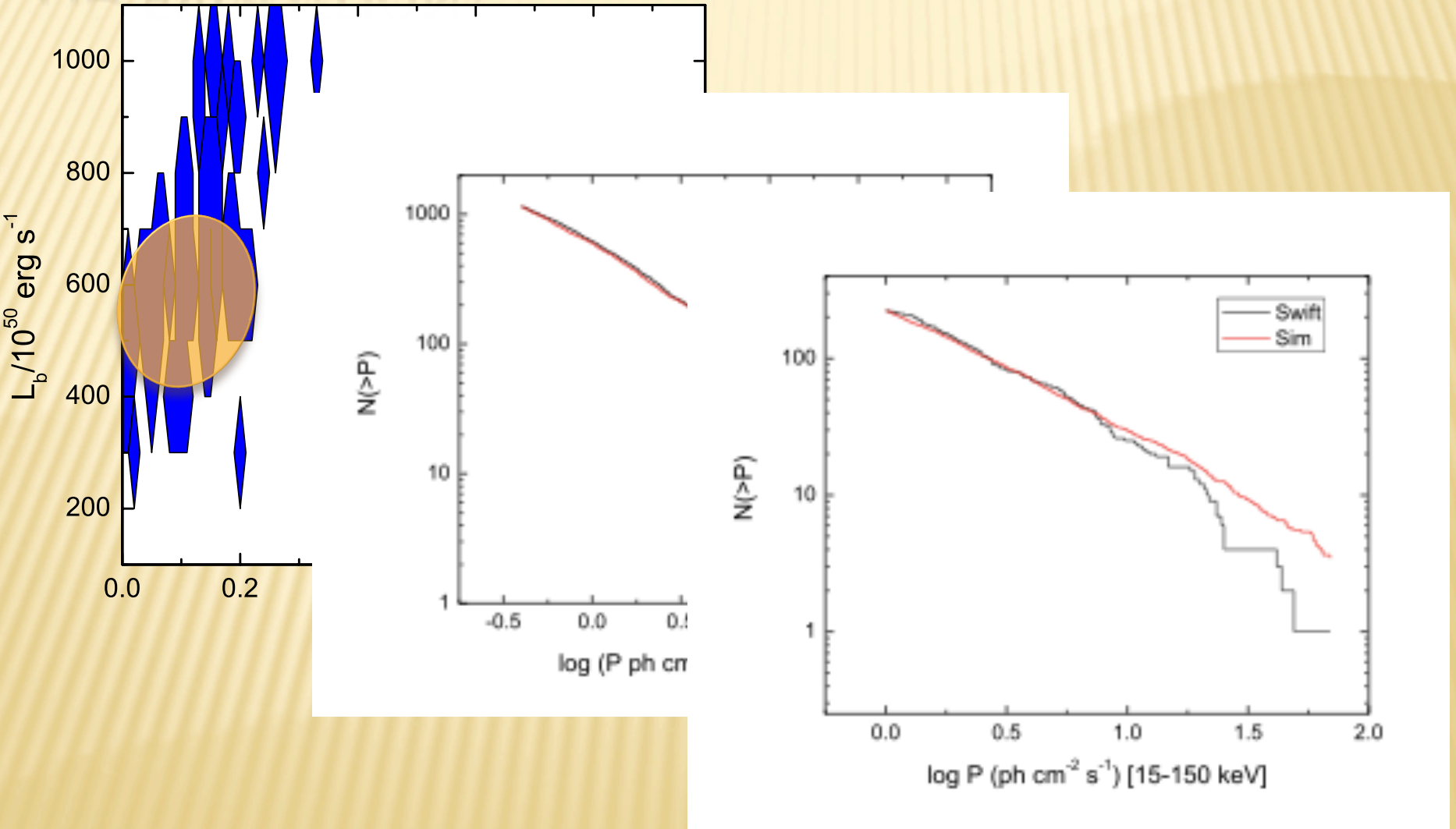
REDSHIFT EVOLUTION

- Parameterize general evolution of GRB rate as $(1+z)^{\delta}$ (Kistler 2007, Qin et al. 2010)
- Introduce to both models with and without metallicity
- $\delta = 0.2, 0.5, 0.8$

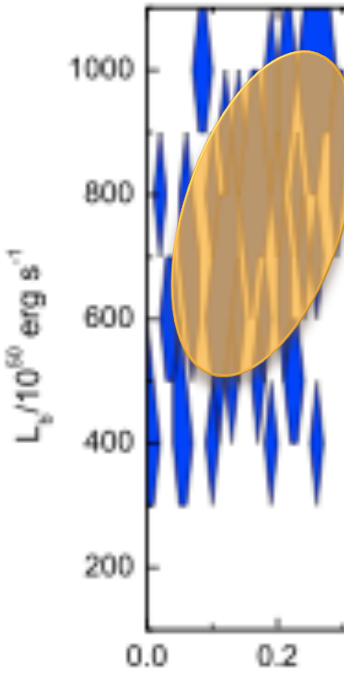
Table 1: SFH models and test statistics

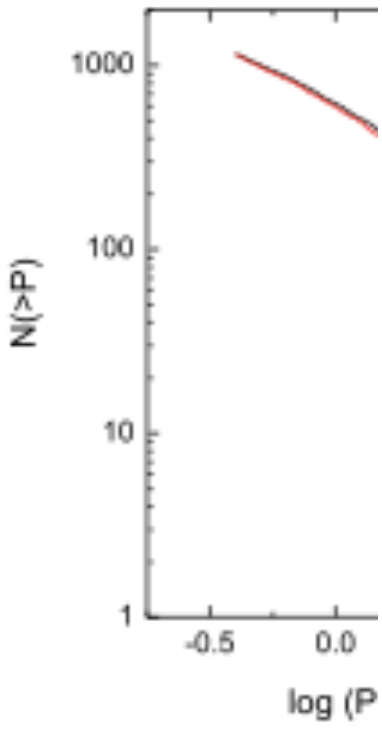
Model	LF parameters $(\alpha_1, L_B, \alpha_2)$	z Stat, P-value	L Stat, Prob	L-z Y/N	BATSE LNLP T stat, P-value	Swift LNLP T stat, P-value
HB+Liw	(0.21,600,2.5)	1.55983, 0.07386	-0.17045, 0.37932	Y	11.23178, 2.00E-05	2.04829, 0.04575
	(0.29,700,2.5)	1.84368, 0.05582	-0.49454, 0.47596	Y	9.747, 8.00E-05	0.35612, 0.24042
	(0.19,1000,2.5)	0.22553, 0.27359	-0.82349, 0.57588	Y	0.67135, 0.17822	0.41201, 0.22824
	(0.14,800,2.5)	0.35749, 0.24011	-0.23546, 0.3982,	Y	2.06092, 0.04519	-0.42692, 0.45539
BL	(0.2,1000,2.5)	1.10898, 0.11575	-0.64039, 0.5205	Y	1.60564, 0.07058	2.31001, 0.03562
	(0.11,600,2.5)	1.16638, 0.10932	-0.09277, 0.35723	Y	0.42516, 0.22544	0.57922, 0.19478
	(0.09,500,2.5)	1.8598, 0.05495	0.50674, 0.20874	Y	0.67752, 0.17715,	0.59479, 0.19189
	(0.01,600,2.5),	-0.50462, 0.47903	1.62913, 0.06896	Y	-0.07208, 0.35145	-0.02698, 0.33899
BL+Liw	(0.42,800,2.5)	-0.59403, 0.50635	0.01934, 0.32642	Y	51.30131, 0	5.18583, 0.00318
	(0.23,400,2.5),	-0.08653, 0.35548	1.13401, 0.1129	Y	56.32389, 0	6.52096 , 0.00109
	(0.5,1000,2.5)	-0.84891, 0.58345	1.22475, 0.10313	Y	50.29342, 0	11.05363, 3.00E-05
	(0.41,600,2.5)	-0.79911, 0.56859	0.57224, 0.19609	Y	57.95978, 0	7.31417, 0.0005

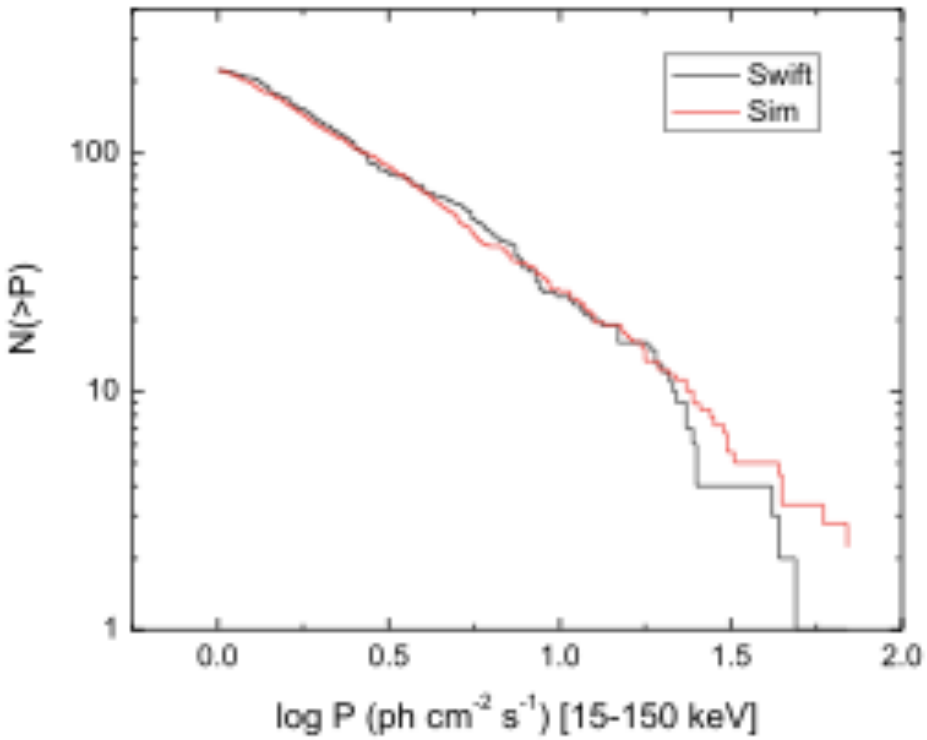
RESULTS: BROMM AND LOEB (NO METALLICITY OR EVOLUTION)



RESULTS HOPKINS AND BEACOM (WEIGHTED METALLICITY, NO EVOLUTION)







CONCLUSIONS

- Simulations show that we need an enhancement of the GRB rate with increased redshift
- Compatible solutions with the observations can be found by including a metallicity dependent term in addition to a decaying star-formation history
- We do not find evidence of the necessity for additional evolution of the rate with increased redshift