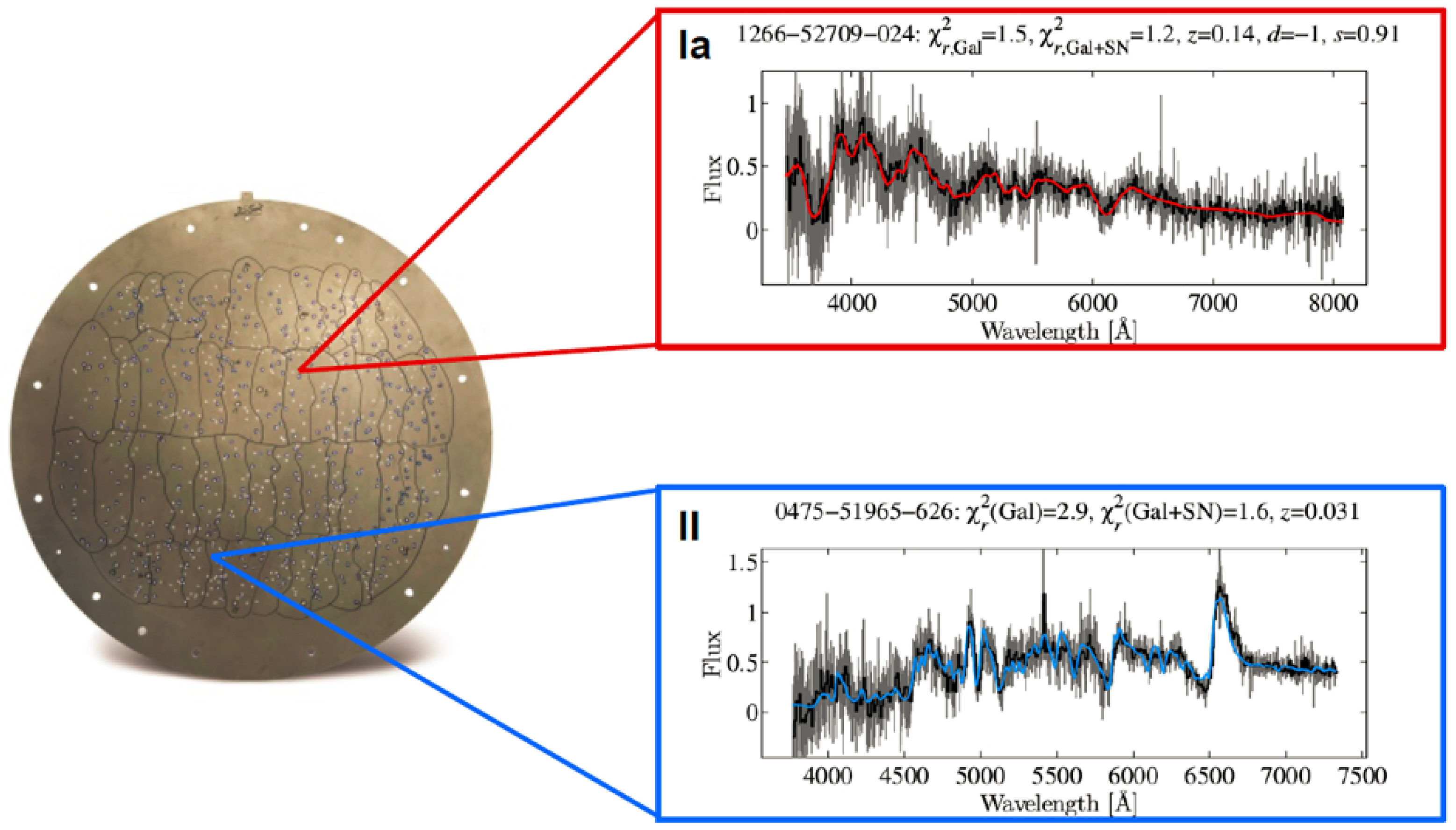
orgraur@nyu.edu

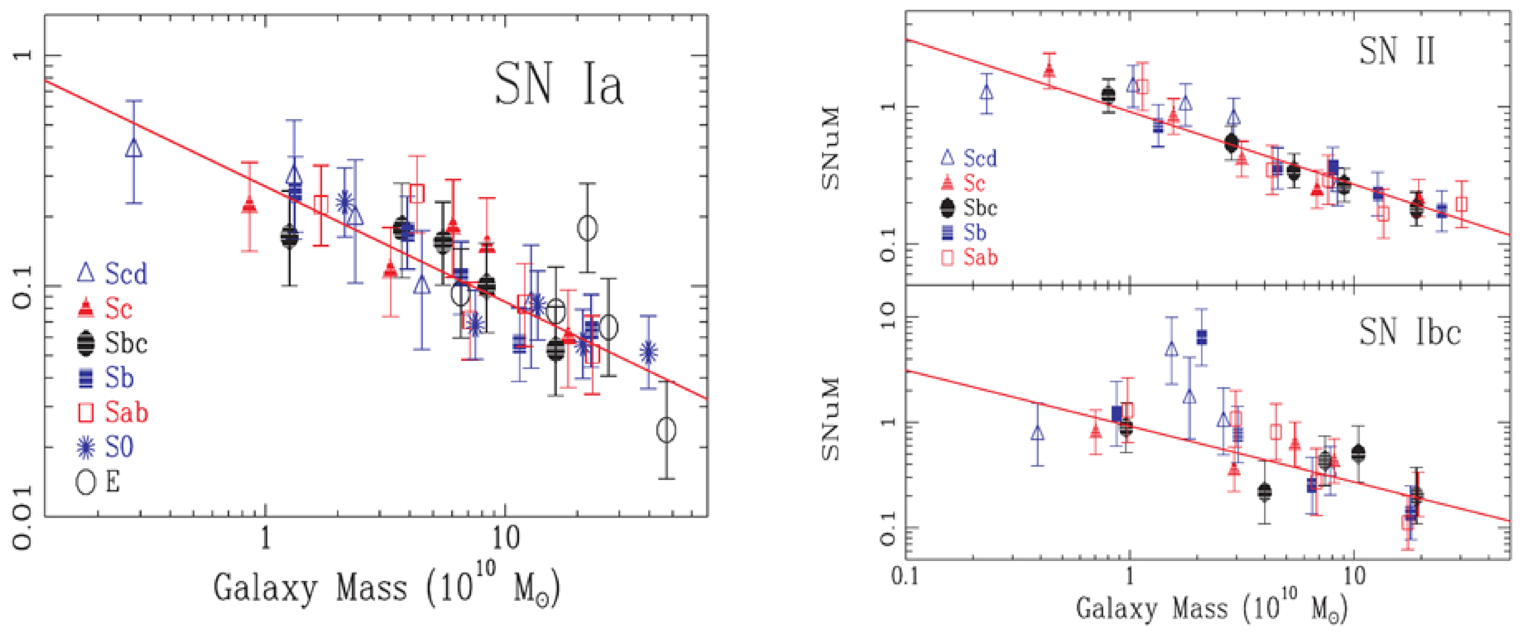
Correlations between Supernova Rates and Galaxy Properties: An Explanation for Type Ia and Type II Supernovae

Or Graur[1,2], Federica B. Bianco[1], & Maryam Modjaz[1] ([1]New York University; [2]American Museum of Natural History)

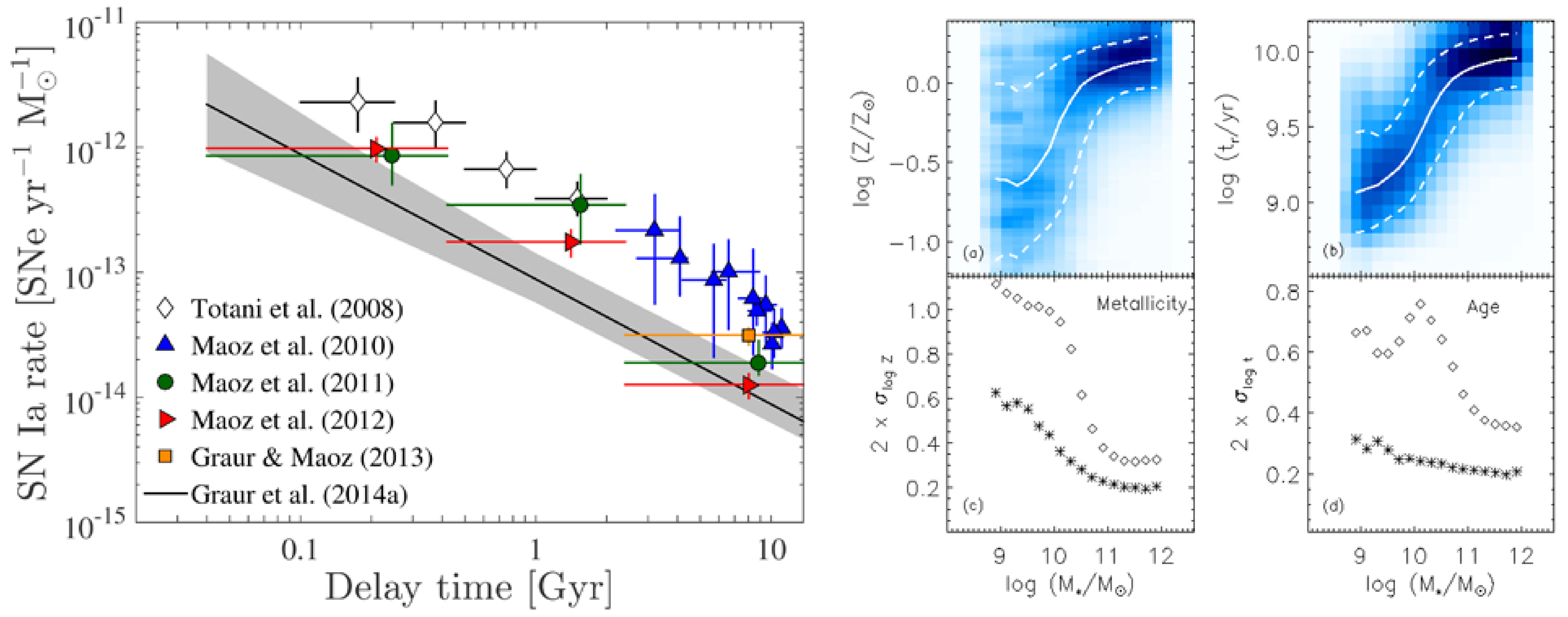
Based on Graur, Bianco, & Modjaz, 2015, MNRAS, 450, 905



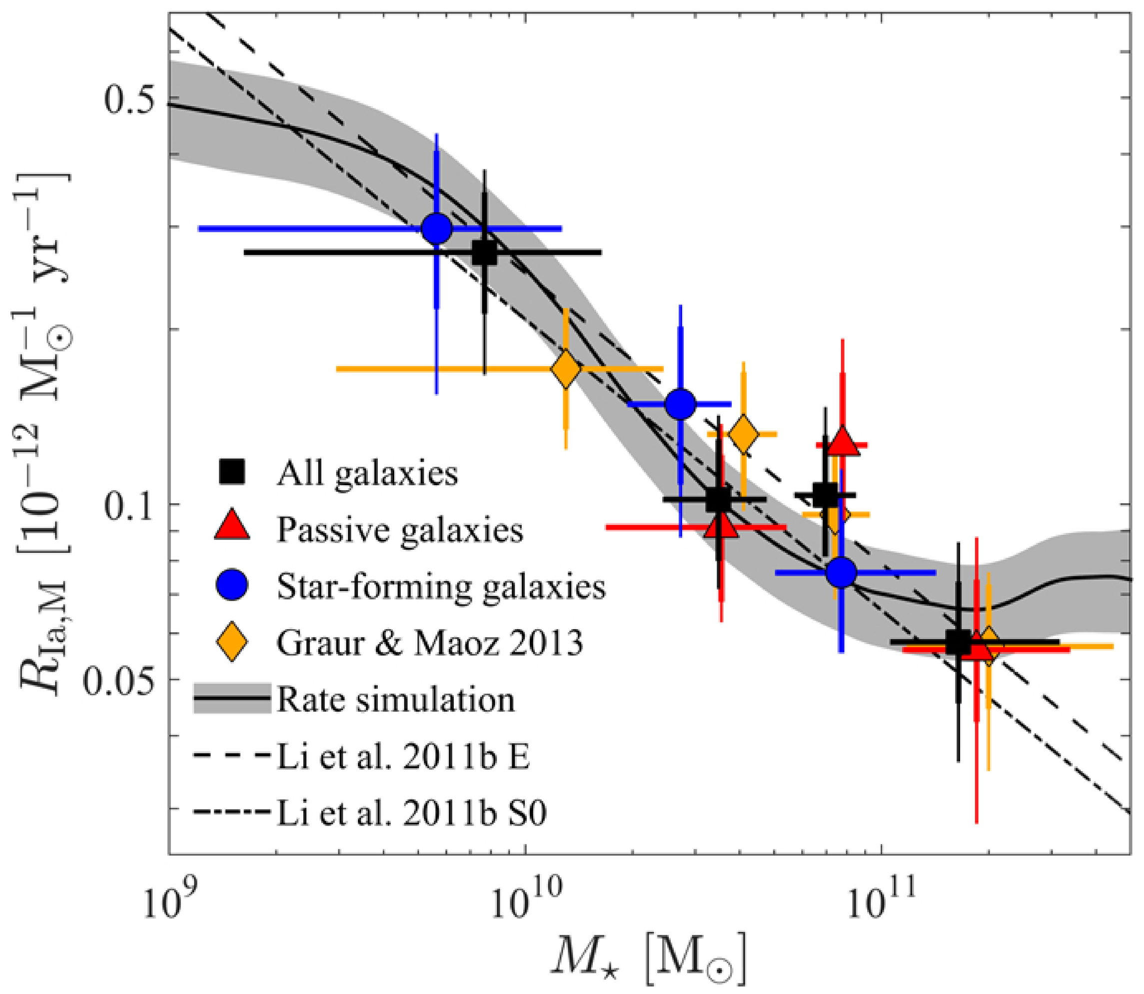
With the Graur & Maoz (2013) code to detect supernovae (SNe) in galaxy spectra, we detected 91 SNe Ia and 16 SNe II among ~740,000 galaxies from the 9th Data Release of the Sloan Digital Sky Survey.



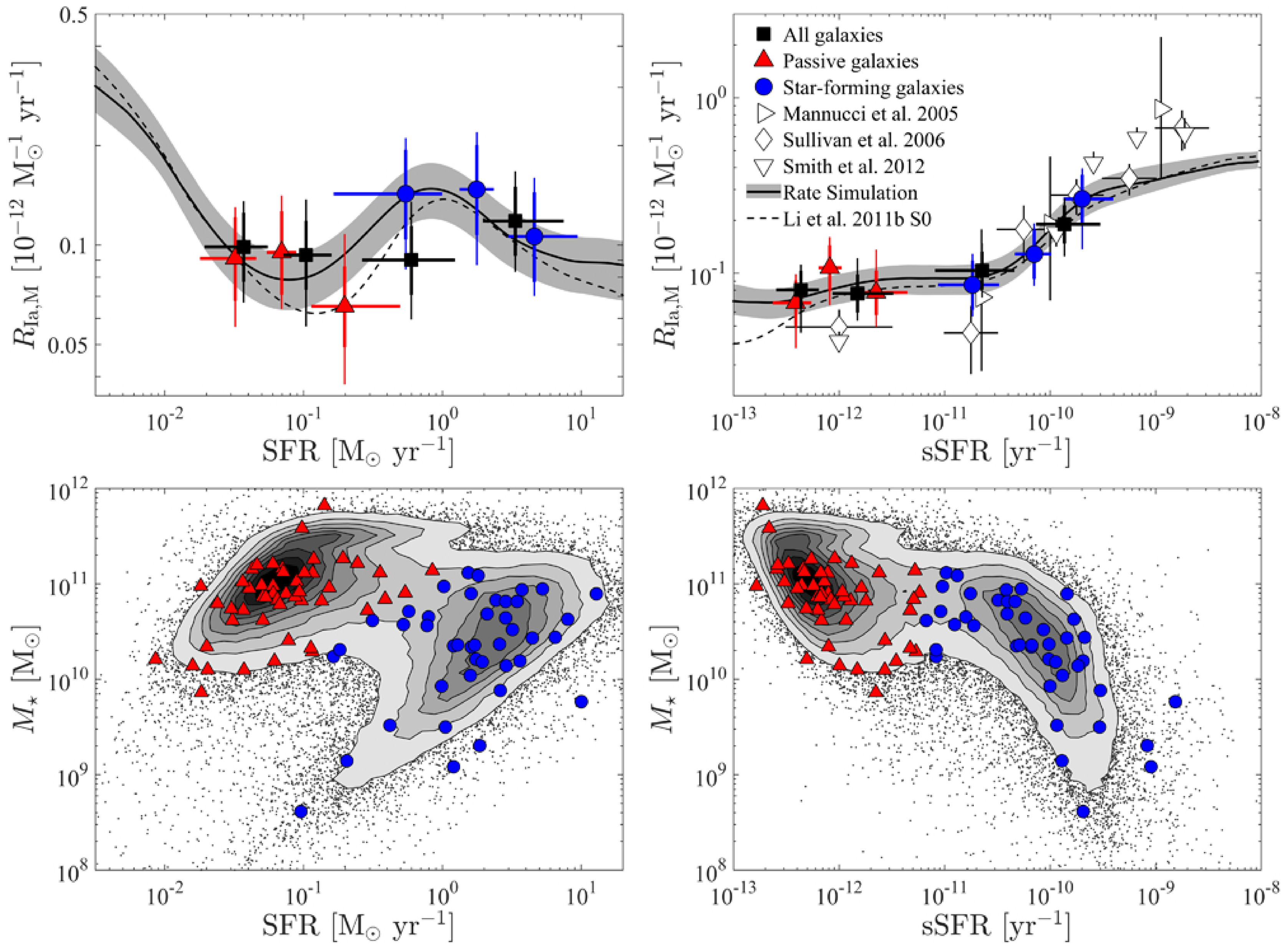
We used our SN samples to investigate the curious correlations discovered by the Lick Observatory Supernova Search (Li et al. 2011, above): mass-normalized SN rates, of all types, decline with increasing stellar mass.



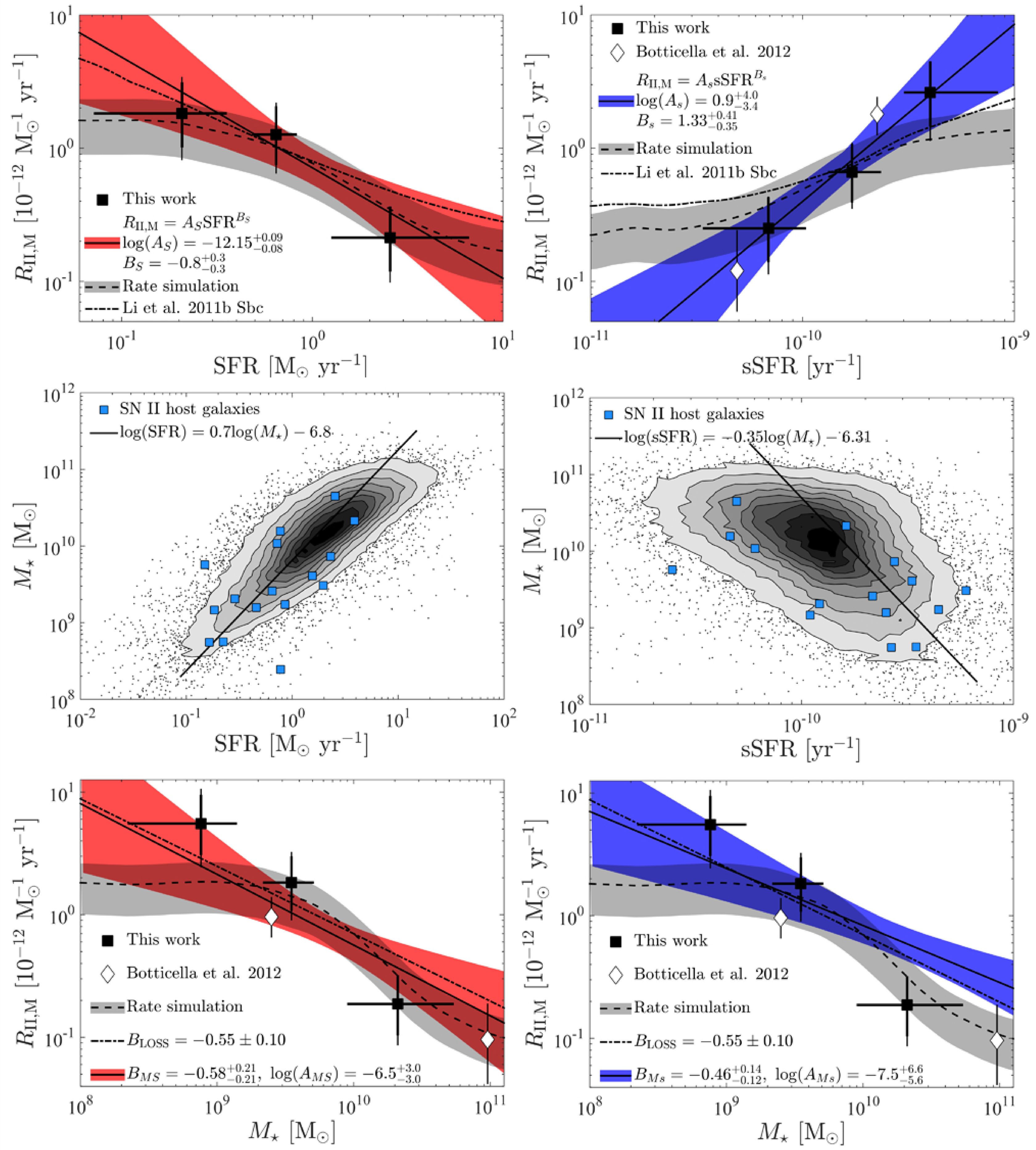
The explanation is a combination of the SN *delay-time distribution* (DTD; left: the SN Ia DTD from various observations) and *galaxy downsizing* - older galaxies are more massive than younger ones (right: the age-mass correlation from Gallazzi et al. 2005). First proposed by Kistler et al. (2013), we extend it to SNe II.



We confirm the SN Ia rate-mass correlation at a median redshift of 0.1. The grey, solid curve shows the best fit of our model (DTD + galaxy downsizing). The dot-dashed and dashed curves are power-law fits from Li et al. (2011).



Top: we find similar correlations between the SN Ia mass-normalized rates and galaxy star-formation rate (SFR) and specific SFR (sSFR). The model, as fit to the rates vs. stellar mass, has been re-binned according to the galaxies' SFR and sSFR (with no further fitting). Bottom: the distributions of galaxy properties demonstrate the behavior of the modeled rates. At $-2 < \log(\mathrm{SFR}) < -1$, we go from less-massive, young galaxies to massive, old galaxies. This moves us down the tail of the DTD, reducing the number of SNe. At $-1 < \log(\mathrm{SFR}) < 0$, galaxies get younger, so the rates increase. At $\log(\mathrm{SFR}) > 0$, galaxies again grow older and the rates decline.



The same model (grey curve) fits correlations between the SN II rates and galaxy mass, SFR, and sSFR. The DTD is a uniform distribution in the range 9-40 Myr (the lifetimes of 8-20 $M_{\odot}$ stars). The red and blue curves are fits to the rates vs. SFR and sSFR, respectively (top). When combined with fits to galaxy property distributions (center), they predict the rate-mass correlations (bottom)

We converted the above SN II rates, averaged over all masses, into a volumetric core-collapse SN rate at redshift 0.075 (red square). This rate, uncorrected for the fraction of SNe missed in highly star-forming galaxies, is consistent with other such rates (white symbols). Rates that have been corrected for this missing fraction (black symbols) are consistent with the number of SNe expected from the initial mass function and the cosmic star-formation history (blue curve).