The selection effects in the LGRB $E_{p,i} - L_{iso}$ correlation

We simulate a large LGRB population with P, z, α, $E_{p,o}$, and L_{iso} to study the impact of peak flux P on the LGRB $E_{p,i} - L_{iso}$ correlation. The mock z and L_{iso} are obtained from the redshift and luminosity distribution models (section 1) in previous work. The mock spectral parameters: $E_{p,o}$ is from the observed bivariate $(E_{p,i}\{z, E_{p,o}\}, L_{iso})$ distribution, and α is from the observed bivariate $(\alpha, E_{p,o})$ distribution. Finally, the mock P can be calculated through the above mock z, α, $E_{p,o}$, and L_{iso} data. These allow the mock data of each parameter to closely follow (section 2) the *Swift* observed distribution. However, to make the simulated P distribution consistent with the observed P distribution, the mock $E_{p,o}$ has to be obtained from the mock $E_{p,i}$ which is simulated based on the observed $(E_{p,i}, L_{iso})$ distribution. This means that **the joint $(E_{p,i}, L_{iso})$ distribution is still effective to constrain the LGRB parameters.** With this large simulated sample that can well represent *Swift* results, we find that **the $(E_{p,i}, L_{iso})$ distribution, which will directly affect the best-fitting result of the correlation, is significantly dependent on the value of P**. Moreover, **the P distribution at low-$E_{p,i}$ & L_{iso} region is different from at higher-$E_{p,i}$ & L_{iso} region, which implies that there may be a subgroup of LGRBs in the low-$E_{p,i}$ & L_{iso} region.**

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1. The basic formula for z and L_{iso} simulation

$$N_{LGRB} \propto \int_0^{z_{max}} \int_{\max(L_{lim}(z), L_{min})}^{L_{max}} \theta\big(P(L,z)\big)\varphi(z)\phi(L)\,dL\,dz$$

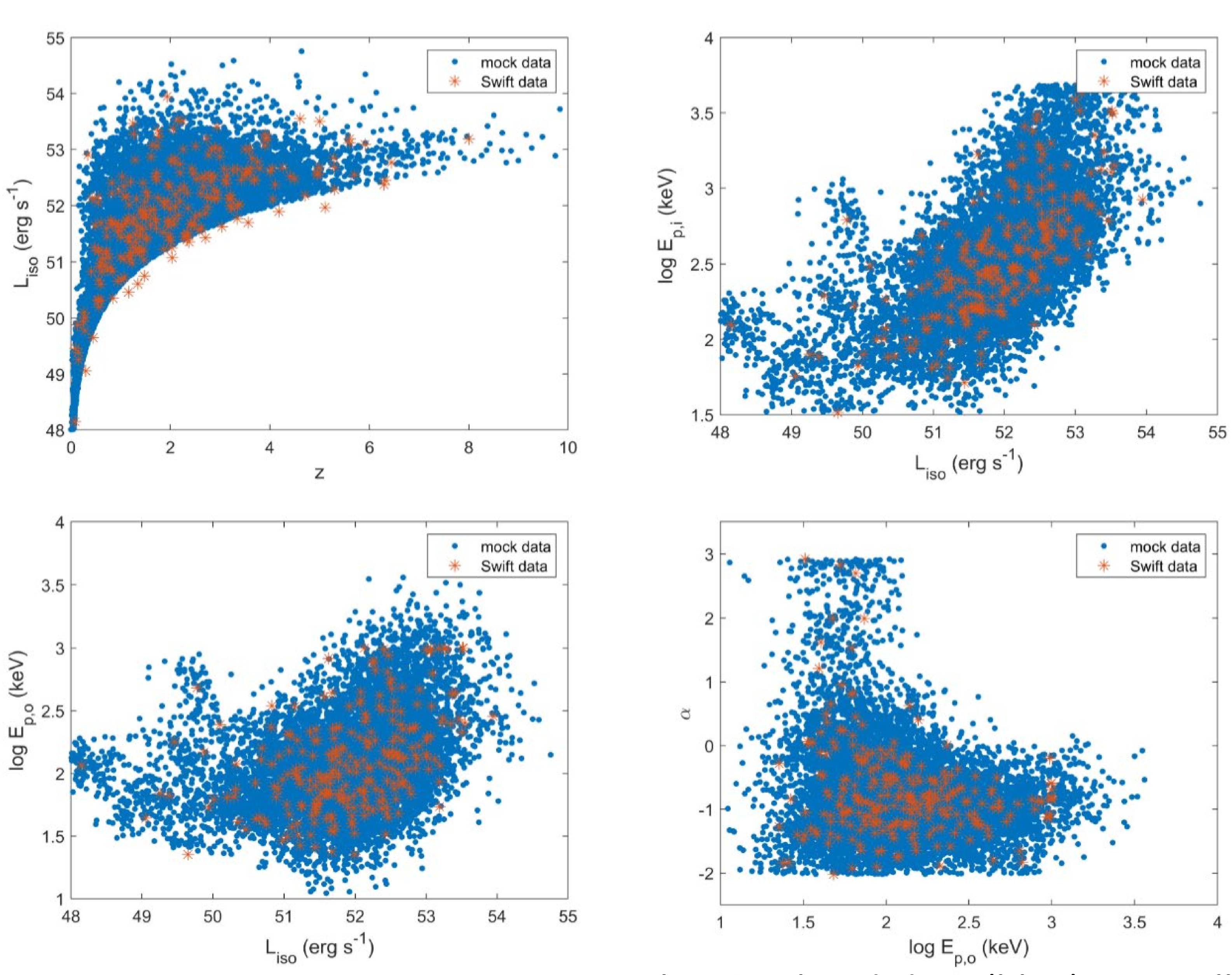
N_{LGRB}	$\theta(P(L,z))$	$\varphi(z)$	$\phi(L)$
Expected LGRB number that can be detected	Probabilities of trigger and redshift measurement to correct the intrinsic distribution (number) to the observational distribution (number)	Intrinsic redshift distribution	Intrinsic luminosity distribution

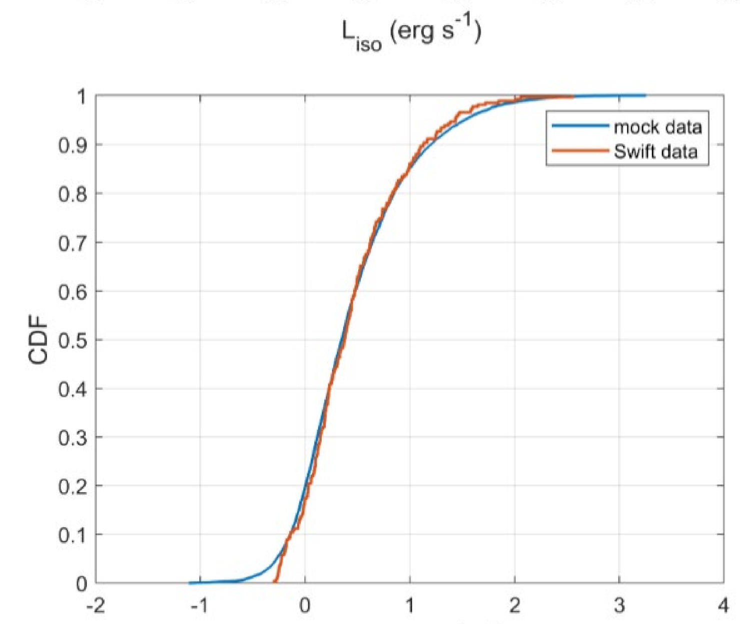
How to estimate $\theta\big(P(L,z)\big)$?

Please see:

MNRAS 508 52–68 (2021)
Lan et. al.

2. The simulated distribution vs. the observed distribution

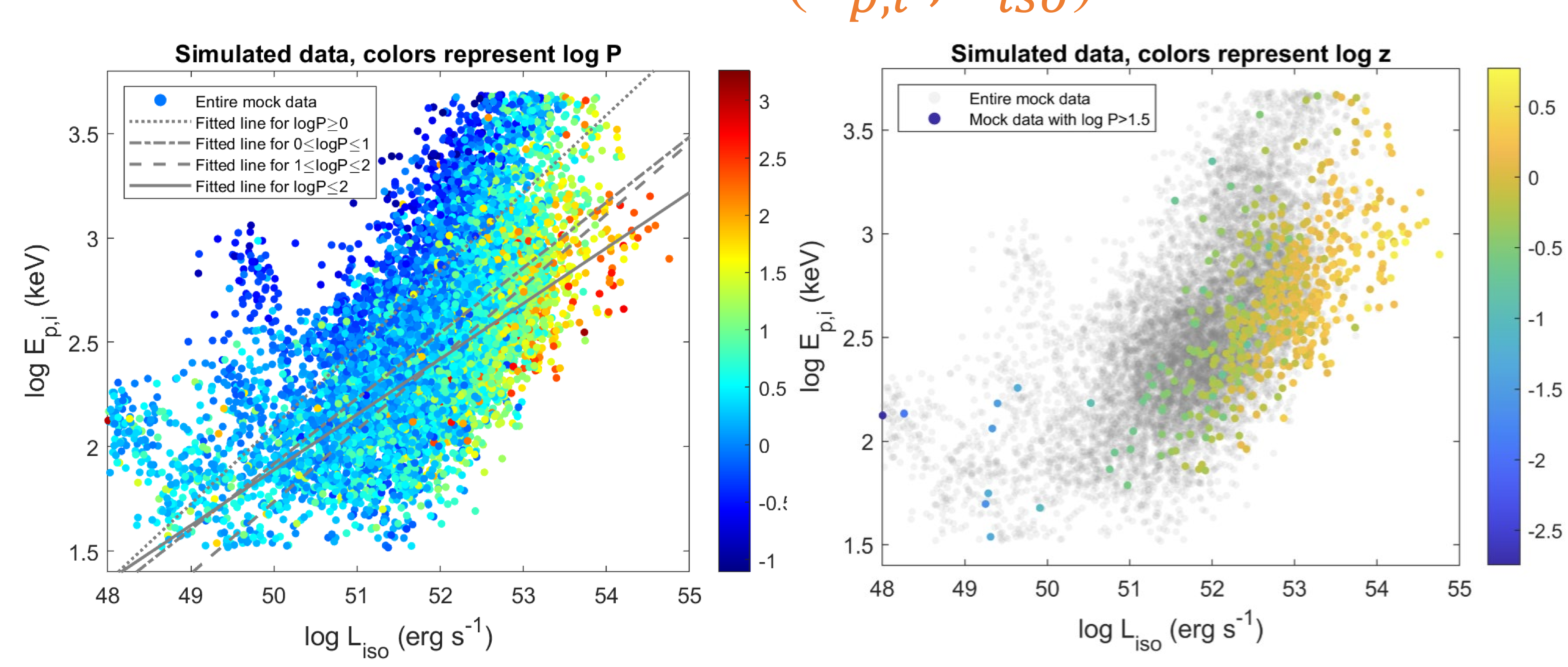




The simulated data (blue) are well consistent with the observed data (red) in both 1D-parameter and 2D-parameter distributions. The observed sample comes from The Swift/BAT Gamma-Ray Burst Catalog[1] directly, finally including 259 LGRBs with $P > 0.5\ ph\ cm^{-2}\ s^{-1}\ (15-150\ keV)$, $15 < E_{p,o} < 9000\ (keV)$ and measured z.

1. https://swift.gsfc.nasa.gov/results/batgrbcat/index_tables.html

The result of simulated $(E_{p,i}, L_{iso})$ distributions



The colour represents the value of log P. It is clear that data with different P have different $(E_{p,i}, L_{iso})$ distributions and best-fitting $E_{p,i} - L_{iso}$ correlations. In addition, the P distribution at low-$E_{p,i}$ & L_{iso} region is significantly different from at higher- $E_{p,i}$ & L_{iso} region. This is another factor that affects the slopes of different fitting lines. We suppose that sub-class LGRBs maybe exist in the low-$E_{p,i}$ & L_{iso} region. However, to clarify it, more data with low E_p are required, especially data with E_p lower than Swift's limit.

It can also be seen in this picture that the boundaries for data with log$P$>1.5 are different from the entire simulated data. The colour here represents the value of log z. It is clear that the value of z at the boundaries is not simplex, which means the impact of P is not determined by redshift. Our results can also explain why the best-fitting $E_{p,i} - L_{iso}$ correlation will change in different observed samples.

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