Testing crossing statistics on ZTF simulations: short prior on time delay, system number=31999299

In earlier studies we used a wide range for the prior on the time delay. In these studies we shorten the prior on time delay (and possibly on the relative amplification μ) by determining if the combined light curve has one or two peaks (remember we are working with only 2 image gLSNe systems). Using this short time delay prior we analyze 11 'good' systems from the ZTF-1a simulations compiled in [1] in these drafts. In this pdf file we study system number=31999299.

Please look into "Reducing_prior_on_time_delay.pdf" for the details.

1 ZTF-1a simulations

We apply Crossing statistics on 'good' 2-image light curves of ZTF-1a gLSNe simulations compiled in [1]. By 'good' we mean the system obeys the following criteria

- The light curve visually appears smooth (and the shape is like a light curve)
- The system has total 200 data points combining r, g and i bands.
- $0.5 \leq \mu \equiv \mu_2/\mu_1 \leq 2.0$
- time delay $dt \geq 10$ days.

We have identified a total of 33 such systems. Here we tested 11 of them. In this pdf file we study system number=31999299.

2 The model: Template 1 + Crossing Statistics + stretch (optional)

We consider the intrinsic light curve as a template multiplied by crossing statistics:

$$f(t) = g(t) \times C_0 \times \left[1 + C_1 t_s + C_2(2t_s^2 - 1) + C_3(4t_s^3 - 3t_s) + C_4(8t_s^4 - 8t_s^2 + 1) + ...\right] \ , \quad (1)$$

where $t_s \equiv t/t_{max} - 1 \in (-1, 0)$. The coefficients $C_1, C_2, C_3...$, describe the crossing statistics. In this report we use the template

$$g(t) = \frac{1}{2\sigma\sqrt{\pi}t} \exp\left[-\frac{(\ln t - m)^2}{2\sigma^2}\right] \qquad (\log - \text{normal}) \ , \quad (2)$$

which we call 'Template 1'.

3 Priors and setups tested

We used the following priors on the template parameters (for all bands) in (1).

- $0.1 \leq \sigma \leq 3.5$,
- $1 \leq m \leq 16$.
- We put narrow prior range on time delay = 30 days. For 1-peak light curve systems we use the prior on relative magnification $0.25 \leq \mu \leq 4.0$, but for 2-peak systems we use a much smaller prior range on μ. Please look into "Reducing_prior_on_time_delay.pdf" for the details.

For each system we test the following 2 setups of priors on the coefficients C's.

- npC: No priors on the crossing coefficients.
- pC: C_0's have no priors; other C_i's have prior: $-10 \leq C_i \leq 10$ (where $i \in (1, 2, 3, ...)$)

At last, for comparison, we also analyze the systems with the unscaled crossing coefficients defined below.

$$f(t) = g(t) \times \left[C_0 + C_1 t_s + C_2(2t_s^2 - 1) + C_3(4t_s^3 - 3t_s) + C_4(8t_s^4 - 8t_s^2 + 1) + ...\right] , \qquad (3)$$

naturally there is no prior on the C's in this case. Plots for this setup is given in figure 3. This is in principle same as nPC case, figure 1. But the sampling would be different. So the purpose of adding figure 3 here is to check if scaling the coefficients in (1) is helping or not.

On each setup we test the following crossing model:

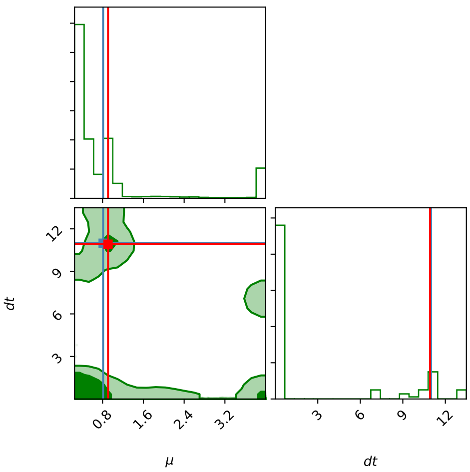
- C4 = 4th order Crossing statistics (up to C_4) + no stretch.

I also tested 2nd order crossing statistics (C2), but to avoid clumsiness I did not include those figures here.

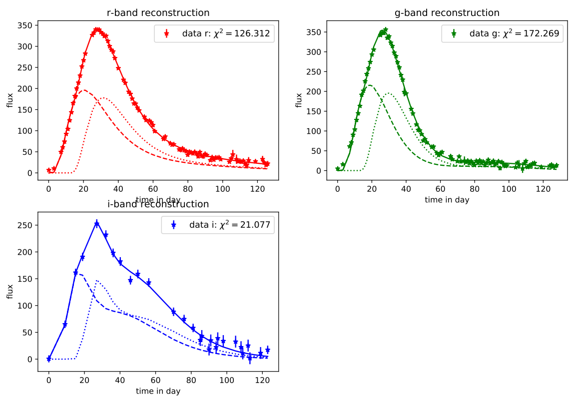
Sampling information: steps= 20000, warmup= 5000, chain= 26, thin= 3 for all the cases.

References

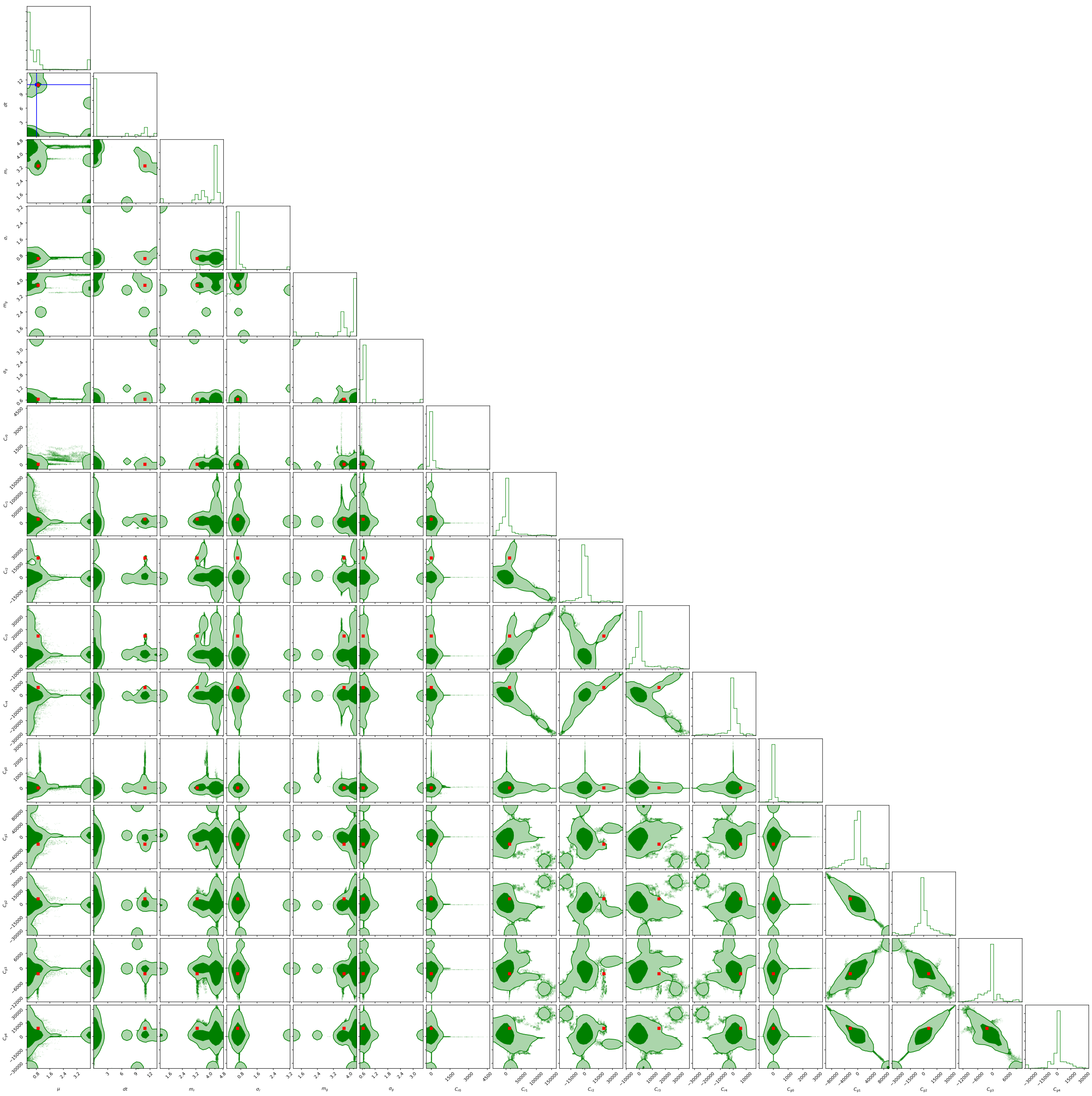
[1] D. A. Goldstein, P. E. Nugent and A. Goobar, Astrophys. J. Suppl. **243** (2019) no.1, 6 doi:10.3847/1538-4365/ab1fe0 [arXiv:1809.10147 [astro-ph.GA]].



(a) C4=4th order Crossing

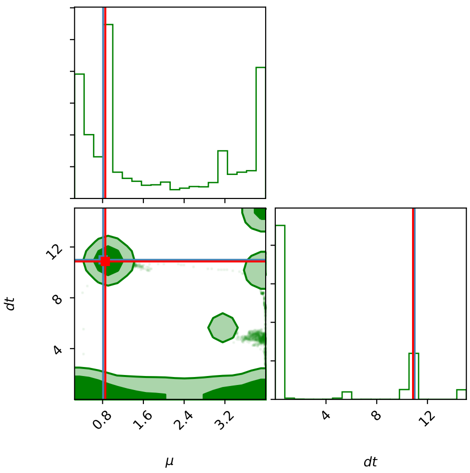


(b) C4=4th order Crossing

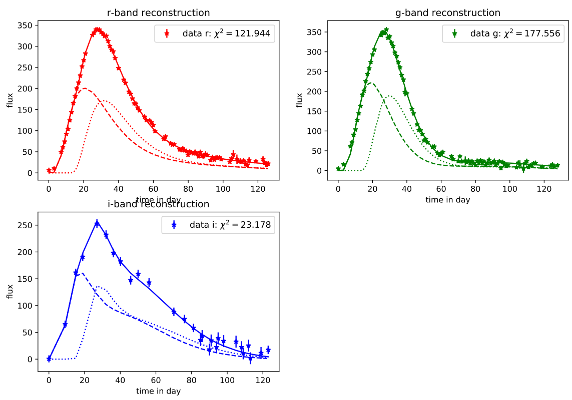


(c) C4=4th order Crossing

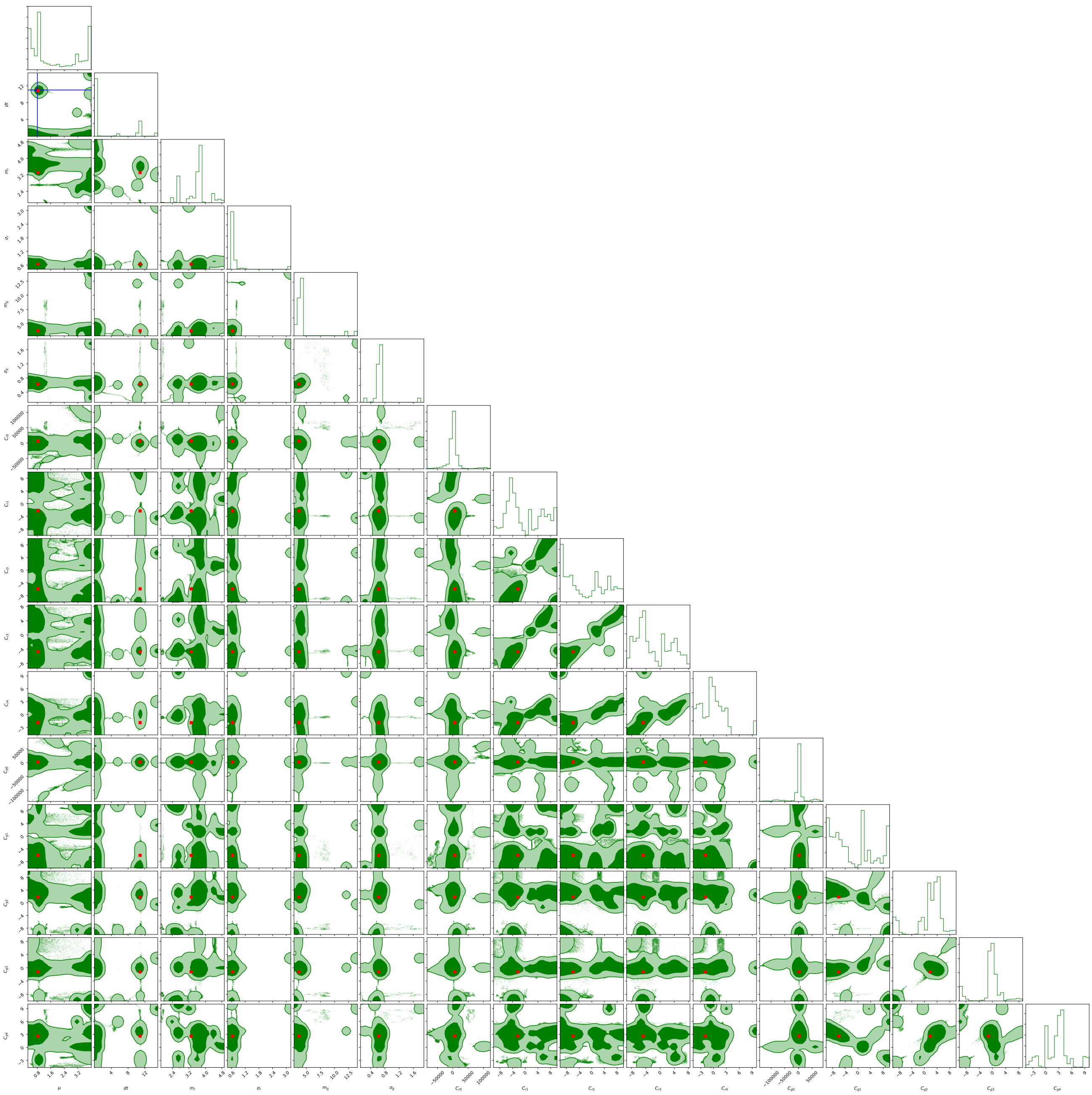
Figure 1: C4: System number=31999299. npC: Scaled but no priors on C's.



(a) C4=4th order Crossing

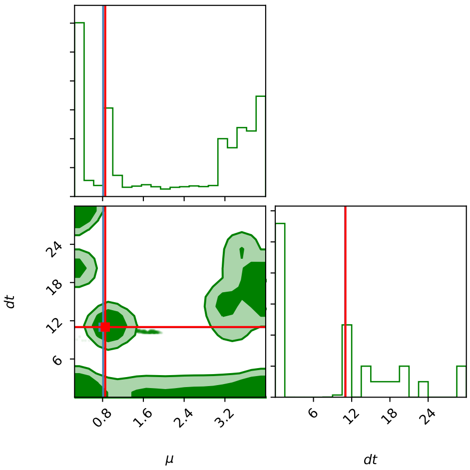


(b) C4=4th order Crossing

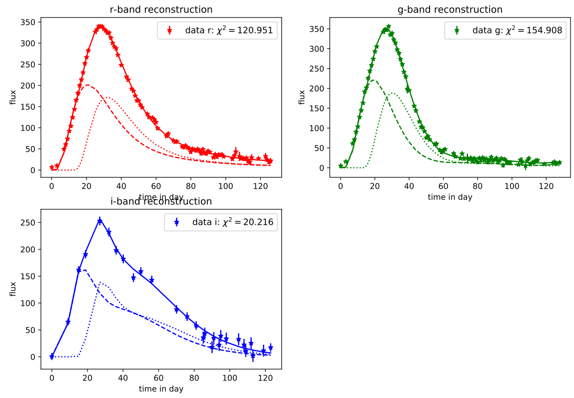


(c) C4=4th order Crossing

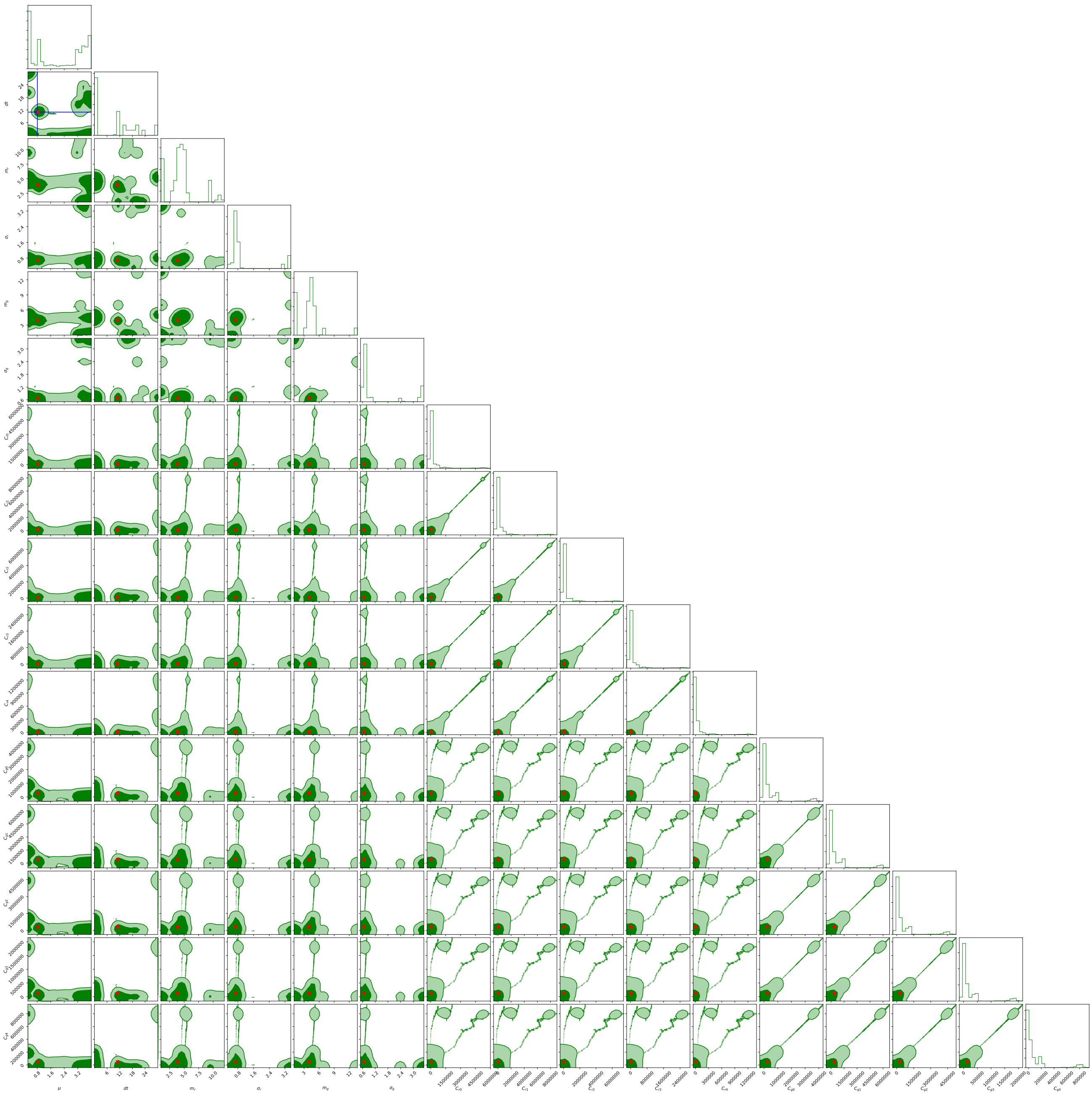
Figure 2: C4: System number=31999299. pC: Scaled and priors on C's.



(a) C4=4th order Crossing



(b) C4=4th order Crossing



(c) C4=4th order Crossing

Figure 3: C4: System number=31999299. No scaling on C's (equation (3)), no priors on them. In principle this case should be same as npC shown in figure 1, but the sampling might be different here since the parametrization is different.