Initial Attempt at the Observation Sequence Optimization of High-Redshift HST Search

Rachel Gibbons
Vitaliy Fadeyev
Rob Knop
October 17, 2003

1 Introduction

We have run the lightcurve (LC) simulation sequence provided by Rob to estimate the effects of different observing strategies on the lightcurve shape determination:

- lightcurve simulator,
- K-corrector,
- SNminuit fitter.

The inputs to the simulations were signal-to-noise estimates provided by Rachel, and variable data taking sequence.
The results are reported for Stretch, Z-band maximum m_Z, and the propagated B-band maximum m_B_corr (see Tables below). The error on m_B_corr includes propagated error on the Stretch.
The fluxes were NOT randomized around the LC according to the errors. Therefore, the procedure was essentially an error propagation device, rather than a realistic fit simulation. This has the consequence that there were not SNminuit fitting pathologies. Also, the values for Stretch, m_Z, and m_B_corr are "nominal". E.g. Stretch = 0.996 means that 1 = 1 with 0.4% precision.
Only the case of Stretch = 1 was considered in the simulations.
We considered three values of Z = 1.2, 1.3, 1.4. For each Z four data taking scenarios were simulated:

- observation days clustered at the beginning and the end,
- observation days spaced equidistantly (equitimely),
- observation days spaced equidistantly (equitimely) with additional points at the beginning,
- observation days spaced equidistantly (equitimely) with additional points at the end.

Since the time of the maximum is not known during the data taking, we considered a jitter (offset) for the first observation day from -7 to +5 days wrt to day of the maximum light. This is the reason why there is more than one entry in the tables for a given Z and data taking scenario.
An approximate tally of the observation orbits was kept for the observation sequences.

2 Conclusions

We have arrived at the following conclusions (most of them are nearly obvious in retrospect):

- There is a strong dependence of both stretch determination accuracy and maximum magnitude accuracy on the starting day of the observation. For supernova found after maximum light the SNminuit fit has only one LC slope/side at its disposal, and that strongly affects the determination of both the width and the maximum of the LC shape. It seems impossible to obtain the stretch accuracy less than 0.1 and magnitude accuracy less than 0.1 for the full range of the discovery date at $Z > 1.2$ with the available orbit budget.
- Equidistant spacing of the observation points is slightly better than clustering.
- Adding more observation points at the beginning of the observation sequence (after discovery) helps in maximum magnitude determination.
- Adding more points at the end of the observation sequence helps in the stretch determination.

Z	N orbits	Observation Sequence wrt to Day of Maximum	Stretch	*m_Z*	*m_B_corr*
Clustering at the beginning and the end					
Clustering at the beginning and the end					
1.2	9	-7,-6,-5,-4,13,14,15,34,35,36	1.003 ± 0.071	23.88 ± 0.03	25.37 ± 0.14
1.2	9	-5,-4,-3,-2,15,16,17,36,37,38	1.002 ± 0.078	23.88 ± 0.03	25.37 ± 0.15
1.2	9	-3,-2,-1,0,17,18,19,38,39,40	1.001 ± 0.084	23.88 ± 0.04	25.36 ± 0.15
1.2	11	-1,0,1,2,19,20,21,40,41,42	1.002 ± 0.088	23.88 ± 0.04	25.36 ± 0.15
1.2	12	1,2,3,4,21,22,23,42,43,44	0.999 ± 0.096	23.88 ± 0.05	25.36 ± 0.15
1.2	12	3,4,5,6,23,24,25,44,45,46	0.998 ± 0.106	23.88 ± 0.07	25.36 ± 0.14
1.2	12	5,6,7,8,25,26,27,46,47,48	0.998 ± 0.115	23.88 ± 0.11	25.36 ± 0.12
Equidistant spacing					
1.2	8	-7,-2,3,8,13,18,23,28,38	1.001 ± 0.080	23.88 ± 0.03	25.36 ± 0.15
1.2	8	-5,0,5,10,15,20,25,30,40	1.000 ± 0.080	23.88 ± 0.04	25.36 ± 0.15
1.2	9	-3,2,7,12,17,22,27,32,42	0.997 ± 0.084	23.88 ± 0.05	25.36 ± 0.14
1.2	9	-1,4,9,14,19,24,29,34,44	1.001 ± 0.088	23.88 ± 0.06	25.36 ± 0.14
1.2	9	1,6,11,16,21,26,31,36,46	1.004 ± 0.099	23.88 ± 0.07	25.37 ± 0.15
1.2	9	3,8,13,18,23,28,33,38,48	1.001 ± 0.107	23.88 ± 0.09	25.36 ± 0.14
1.2	9	5,10,15,20,25,30,35,40,50	1.002 ± 0.119	23.88 ± 0.14	25.36 ± 0.13
Equidistant spacing with initial cluster					
1.2	10	-7,-6,-5,-2,3,8,13,18,23,28,38	1.001 ± 0.076	23.88 ± 0.03	25.36 ± 0.15
1.2	10	-5,-4,-3,0,5,10,15,20,25,30,40	1.000 ± 0.078	23.88 ± 0.03	25.36 ± 0.14
1.2	11	-3,-2,-1,2,7,12,17,22,27,32,42	0.997 ± 0.081	23.88 ± 0.03	25.36 ± 0.14
1.2	11	-1,0,1,4,9,14,19,24,29,34,44	1.002 ± 0.083	23.88 ± 0.04	25.36 ± 0.14
1.2	11	1,2,3,6,11,16,21,26,31,36,46	1.003 ± 0.092	23.88 ± 0.05	25.36 ± 0.14
1.2	11	3,4,5,8,13,18,23,28,33,38,48	1.000 ± 0.100	23.88 ± 0.07	25.36 ± 0.14
1.2	11	5,6,7,10,15,20,25,30,35,40,50	1.000 ± 0.111	23.88 ± 0.11	25.36 ± 0.12
Equidistant spacing with final cluster					
1.2	10	-7,-2,3,8,13,18,23,28,34,35,38	1.002 ± 0.067	23.88 ± 0.03	25.36 ± 0.12
1.2	10	-5,0,5,10,15,20,25,30,36,37,40	1.001 ± 0.068	23.88 ± 0.04	25.36 ± 0.12
1.2	11	-3,2,7,12,17,22,27,32,38,39,42	0.997 ± 0.071	23.88 ± 0.05	25.36 ± 0.12
1.2	12	-1,4,9,14,19,24,29,34,40,41,44	0.999 ± 0.073	23.88 ± 0.06	25.36 ± 0.11
1.2	13	1,6,11,16,21,26,31,36,42,43,46	1.002 ± 0.079	23.88 ± 0.07	25.36 ± 0.11
1.2	13	3,8,13,18,23,28,33,38,44,45,48	1.001 ± 0.087	23.88 ± 0.09	25.36 ± 0.11
1.2	13	5,10,15,20,25,30,35,40,46,47,50	1.002 ± 0.098	23.88 ± 0.13	25.36 ± 0.11

Z	N orbits	Observation Sequence wrt to Day of Maximum (observer frame)	Stretch	m_Z	m_B_corr
Clustering at the beginning and the end					
1.3	12	-7,-6,-5,-4,13,14,15,34,35,36	1.000 ± 0.082	24.18 ± 0.03	25.58 ± 0.16
1.3	12	-5,-4,-3,-2,15,16,17,36,37,38	0.996 ± 0.087	24.18 ± 0.03	25.57 ± 0.17
1.3	12	-3,-2,-1,0,17,18,19,38,39,40	0.996 ± 0.097	24.18 ± 0.03	25.57 ± 0.18
1.3	12	-1,0,1,2,19,20,21,40,41,42	1.001 ± 0.103	24.18 ± 0.04	25.58 ± 0.18
1.3	13	1,2,3,4,21,22,23,42,43,44	1.002 ± 0.114	24.18 ± 0.05	25.58 ± 0.18
1.3	15	3,4,5,6,23,24,25,44,45,46	0.997 ± 0.127	24.19 ± 0.07	25.57 ± 0.17
1.3	15	5,6,7,8,25,26,27,46,47,48	0.997 ± 0.143	24.19 ± 0.11	25.57 ± 0.15
Equidistant spacing					
1.3	11	-7,-2,3,8,13,18,23,28,38	0.996 ± 0.089	24.18 ± 0.04	25.57 ± 0.17
1.3	11	-5,0,5,10,15,20,25,30,40	1.001 ± 0.092	24.18 ± 0.04	25.58 ± 0.17
1.3	11	-3,2,7,12,17,22,27,32,42	0.997 ± 0.095	24.18 ± 0.05	25.57 ± 0.17
1.3	12	-1,4,9,14,19,24,29,34,44	0.994 ± 0.109	24.19 ± 0.06	25.57 ± 0.18
1.3	12	1,6,11,16,21,26,31,36,46	1.003 ± 0.117	24.18 ± 0.07	25.58 ± 0.17
1.3	13	3,8,13,18,23,28,33,38,48	1.000 ± 0.123	24.18 ± 0.10	25.57 ± 0.16
1.3	13	5,10,15,20,25,30,35,40,50	1.008 ± 0.140	24.18 ± 0.15	25.58 ± 0.15
Equidistant spacing with initial cluster					
1.3	13	-7,-6,-5,-2,3,8,13,18,23,28,38	0.996 ± 0.085	24.18 ± 0.03	25.57 ± 0.17
1.3	13	-5,-4,-3,0,5,10,15,20,25,30,40	1.001 ± 0.088	24.18 ± 0.03	25.58 ± 0.16
1.3	13	-3,-2,-1,2,7,12,17,22,27,32,42	0.997 ± 0.092	24.18 ± 0.03	25.57 ± 0.16
1.3	14	-1,0,1,4,9,14,19,24,29,34,44	0.996 ± 0.104	24.18 ± 0.04	25.57 ± 0.17
1.3	14	1,2,3,6,11,16,21,26,31,36,46	1.003 ± 0.109	24.18 ± 0.05	25.58 ± 0.17
1.3	15	3,4,5,8,13,18,23,28,33,38,48	0.999 ± 0.116	24.18 ± 0.07	25.57 ± 0.16
1.3	15	5,6,7,10,15,20,25,30,35,40,50	1.004 ± 0.130	24.18 ± 0.12	25.58 ± 0.14
Equidistant spacing with final cluster					
1.3	15	-7,-2,3,8,13,18,23,28,34,35,38	0.997 ± 0.076	24.18 ± 0.04	25.57 ± 0.14
1.3	15	-5,0,5,10,15,20,25,30,36,37,40	1.000 ± 0.077	24.18 ± 0.04	25.58 ± 0.14
1.3	15	-3,2,7,12,17,22,27,32,38,39,42	0.996 ± 0.079	24.18 ± 0.05	25.57 ± 0.14
1.3	16	-1,4,9,14,19,24,29,34,40,41,44	0.996 ± 0.088	24.19 ± 0.06	25.57 ± 0.14
1.3	16	1,6,11,16,21,26,31,36,42,43,46	1.001 ± 0.095	24.18 ± 0.07	25.58 ± 0.14
1.3	17	3,8,13,18,23,28,33,38,44,45,48	1.000 ± 0.102	24.18 ± 0.09	25.57 ± 0.13
1.3	17	5,10,15,20,25,30,35,40,46,47,50	1.006 ± 0.117	24.18 ± 0.14	25.58 ± 0.13

Z	N orbits	Observation Sequence wrt to Day of Maximum	Stretch	*m_Z*	*m_B_corr*
Clustering at the beginning and the end					
Clustering at the beginning and the end					
1.4	15	-7,-6,-5,-4,13,14,15,34,35,36	0.993 ± 0.088	24.40 ± 0.03	25.76 ± 0.18
1.4	15	-5,-4,-3,-2,15,16,17,36,37,38	1.001 ± 0.102	24.40 ± 0.03	25.78 ± 0.19
1.4	15	-3,-2,-1,0,17,18,19,38,39,40	1.001 ± 0.111	24.40 ± 0.04	25.78 ± 0.20
1.4	16	-1,0,1,2,19,20,21,40,41,42	0.994 ± 0.122	24.40 ± 0.04	25.77 ± 0.21
1.4	18	1,2,3,4,21,22,23,42,43,44	1.003 ± 0.138	24.40 ± 0.06	25.78 ± 0.20
1.4	18	3,4,5,6,23,24,25,44,45,46	1.003 ± 0.139	24.40 ± 0.09	25.78 ± 0.17
1.4	18	5,6,7,8,25,26,27,46,47,48	0.994 ± 0.126	24.41 ± 0.11	25.77 ± 0.15
Equidistant spacing					
1.4	15	-7,-2,3,8,13,18,23,28,38	0.986 ± 0.107	24.40 ± 0.04	25.75 ± 0.19
1.4	15	-5,0,5,10,15,20,25,30,40	0.989 ± 0.103	24.40 ± 0.04	25.76 ± 0.19
1.4	16	-3,2,7,12,17,22,27,32,42	1.003 ± 0.116	24.41 ± 0.05	25.78 ± 0.19
1.4	16	-1,4,9,14,19,24,29,34,44	1.006 ± 0.122	24.41 ± 0.07	25.79 ± 0.18
1.4	16	1,6,11,16,21,26,31,36,46	1.015 ± 0.127	24.39 ± 0.09	25.79 ± 0.17
1.4	16	3,8,13,18,23,28,33,38,48	0.997 ± 0.131	24.39 ± 0.12	25.76 ± 0.17
1.4	16	5,10,15,20,25,30,35,40,50	0.982 ± 0.130	24.41 ± 0.12	25.75 ± 0.19
Equidistant spacing with initial cluster					
1.4	17	-7,-6,-5,-2,3,8,13,18,23,28,38	0.984 ± 0.096	24.40 ± 0.03	25.75 ± 0.19
1.4	17	-5,-4,-3,0,5,10,15,20,25,30,40	0.990 ± 0.101	24.40 ± 0.03	25.76 ± 0.18
1.4	18	-3,-2,-1,2,7,12,17,22,27,32,42	1.003 ± 0.113	24.40 ± 0.04	25.78 ± 0.19
1.4	18	-1,0,1,4,9,14,19,24,29,34,44	1.008 ± 0.114	24.40 ± 0.05	25.79 ± 0.18
1.4	20	1,2,3,6,11,16,21,26,31,36,46	1.015 ± 0.126	24.39 ± 0.07	25.79 ± 0.17
1.4	20	3,4,5,8,13,18,23,28,33,38,48	0.992 ± 0.122	24.40 ± 0.09	25.76 ± 0.16
1.4	20	5,6,7,10,15,20,25,30,35,40,50	0.983 ± 0.130	24.42 ± 0.11	25.76 ± 0.16
Equidistant spacing with final cluster					
1.4	19	-7,-2,3,8,13,18,23,28,34,35,38	0.991 ± 0.087	24.40 ± 0.04	25.76 ± 0.15
1.4	19	-5,0,5,10,15,20,25,30,36,37,40	0.994 ± 0.083	24.40 ± 0.05	25.76 ± 0.15
1.4	20	-3,2,7,12,17,22,27,32,38,39,42	1.000 ± 0.096	24.41 ± 0.05	25.78 ± 0.15
1.4	20	-1,4,9,14,19,24,29,34,40,41,44	1.002 ± 0.100	24.41 ± 0.07	25.78 ± 0.15
1.4	20	1,6,11,16,21,26,31,36,42,43,46	1.012 ± 0.107	24.40 ± 0.09	25.79 ± 0.15
1.4	20	3,8,13,18,23,28,33,38,44,45,48	1.001 ± 0.110	24.39 ± 0.11	25.76 ± 0.14
1.4	20	5,10,15,20,25,30,35,40,46,47,50	0.988 ± 0.101	24.41 ± 0.11	25.76 ± 0.16