European Organisation for Astronomical Research in the Southern Hemisphere

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APPLICATION FOR OBSERVING TIME

PERIOD: **99A**

Important Notice:

By submitting this proposal, the PI takes full responsibility for the content of the proposal, in particular with regard to the names of CoIs and the agreement to act according to the ESO policy and regulations, should observing time be granted.

1. Title

Category: **D–5**

The All-weather MUse Supernova Integral field Nearby Galaxies (AMUSING) survey V: Host galaxy dependences in the Near Infrared SN Ia Hubble diagram

2. Abstract / Total Time Requested

Total Amount of Time:

Optical observations of type Ia supernovae (SNe Ia) have proved essential to measure accurate cosmological distances, once their light curves have been properly standardized. However, SNIa are superior standard candles in the near-infrared (NIR), both because their light curves are intrinsically more similar in the NIR, and reddening effects are greatly reduced. SN Ia Hubble residuals using optical data correlate with global host galaxy parameters (such as total mass), and the addition of a term in the SN Ia light curve standardization accounting for these environmental parameters, has proved to reduce further the scatter in the SN Ia absolute magnitude at peak. In this proposal we aim to obtain MUSE observations of galaxies that hosted SN Ia, which were followed up in the NIR. We will reduce further the scatter in the NIR SN Ia Hubble diagram by looking for the first time for correlations between SN Ia residuals and both global and local galactic properties.

3.

Run	Period	Instrument	Time	Month	Moon	Seeing	Sky	Mode	Type
A	99	MUSE	99h	any	n	n	THN	s	

4. Number of nights/hours

Number of nights/hours	Telescope(s)	Amount of time
a) already awarded to this project:	UT4	45h in 098.D-0115
b) still required to complete this project:	UT4	99h

5. Special remarks:

This project is a ‘filler’ program, with targets across the full RA and DEC range, and that are observable in THN, bad seeing conditions, and during bright time. We understand that only part of the observations may be completed. This is a continuation of the AMUSING survey to investigate the host galaxies of SNe, where the current science case is a continuation of that from the previous semester (P98).

6. Principal Investigator: Igalbany

6a. Co-investigators:

J.	Anderson	1261
T.	Kruehler	1496
J.	Falcón-Barroso	1393
F.	Förster	5667

Following CoIs moved to the end of the document ...

7. Description of the proposed programme

A – Scientific Rationale: Optical observations of type Ia supernovae (SNe Ia) have been widely used in the last decades to measure cosmological distances, and have been key to measure the Hubble constant and demonstrate cosmic acceleration (Riess+98; Perlmutter+99; Betoule+14). Although SNe Ia show significant dispersion ∼2.5 mag in their absolute peak magnitudes in optical wavelengths, a correlation between peak brightness and both the shape of the light curve (LC) and intrinsic color, enabled their standardization and converted SNe Ia into the most precise (7%) extragalactic distance indicators. In the last years, the literature sample of optical SNe Ia at cosmological distances has grown substantially, and at this point statistical errors are comparable to systematic uncertainties (Goobar+11). Further improvement in reducing these systematic errors would require a much better understanding of the physical model of the explosion, which is still incomplete, a direct observational constraints on which kind of progenitors can produce SNe Ia, which is still lacking, as well as a better control of reddening effects due to interstellar and/or circumstellar dust.
Increasing evidence suggests that SNIa are very nearly 'natural' standard candles at NIR wavelengths, even before correction for LC shape and/or reddening, yielding more precise distance estimates to their host galaxies than optical data alone (Krisciunas+04, Wood-Vasey+08, Weyant+14, Friedman+15). Compared to the optical, SN Ia in the NIR are both better standard candles (σ_J ∼0.16), and relatively immune to the effects of extinction and reddening by dust (extinction corrections are a factor of 4-6 smaller than in the optical B-band, Stanishev+15). However, SN Ia cosmology in the NIR is still poorly developed compared to the optical, since current efforts are focused on increasing the number of objects observed in J- and H-bands, and are constrained to low redshifts (z<0.2). The next generation of telescopes (>20-30m) will be needed to get NIR observations at higher redshifts to complement the current low-z SN Ia by observing in K- or even redder bands.
Optical studies of SNIa have now been firmly established a dependence of Hubble residuals on global host galaxy parameters, such as mass, age, and metallicity (Sullivan+10, Lampeitl+10, Gupta+11, D'Andrea+11, Childress+13, Johansson+13). Moreover, these galaxy parameters might in principle affect the properties of the progenitor star, which might in turn influence the observational photometric and spectroscopic SN properties. The addition of an extra term in the standardization of SN Ia absolute magnitudes in the optical that accounts for these environmental properties, e.g., the 'mass step' or the γ metallicity term (Moreno-Raya+16), has proved to reduce further the scatter in the Hubble residuals. Most of these studies are based on analyses of the integrated or central host galaxy spectra, and broad-band or narrow-band Hα imaging. The effect of the local environment of SN Ia within galaxies in cosmological studies is almost unexplored, and the advent of Integral Field Spectroscopy (IFS) opens a new opportunity to give new insights in SN Ia magnitude standardization.
The focus of the current proposal is, for the first time, to search for correlations between SN Ia NIR Hubble residuals and the properties of both their global and local environments (e.g., metallicity, age, SFR), through observing their host galaxies with MUSE. Our SN Ia sample with available NIR light curves is compiled from three surveys: SweetSpot (Weyant+14, and unpublished data) that observed 115 SNIa at redshifts z<0.1 with the WIYN telescope (see Fig. 1); CfAIR2 (Friedman+15) with 94 objects observed with PAIRTEL; and CSP2 (unpublished) that observed more than 200 objects with the du Pont and Swope telescopes. These planned MUSE observations will allow a detailed characterization of both the global and the local environment of these SNe Ia, as well as the ability to then map galaxy-wide SN host properties, and analyze where within the overall distribution of, e.g., host metallicity (see Fig. 2) the SN environment falls.

B – Immediate Objective: We propose to obtain MUSE observations of a sample of 88 nearby (z<0.1) SN Ia host galaxies, with SN Ia NIR observations from the SweetSpot, CfAIR2, and CSP2 surveys, that are observable during P99 from Paranal. These will provide both global host properties in addition to spectral information on the immediate environments of SNe (and every single environment within the host). Using these observations, maps will be made of line-of sight ISM and stellar features, such as that of gas-phase and stellar metallicity (Fig. 2), stellar age, and star-formation rate density (see details of the data analysis in Galbany et al. 2016). This will allow a detailed study of the correlations between the SNIa residuals to the ΛCDM cosmology in the NIR Hubble digram (Fig. 1) and both the global and the local environmental properties, further reducing systematic uncertainties in the determination of cosmological distances with SN Ia observations in the NIR. The immediate goals of this proposal are:

1) Produce host galaxy maps of: age (through both stellar population modeling and Hα equivalent width measurements), metallicity (through emission line ratios, population modeling, and absorption line ratios), and SFR. SN environments will then be placed within these distributions providing further progenitor constraints;

2) Look for correlations between the SNIa residuals in the NIR Hubble digram and the local/global environmental properties, and use them to further refine the use of SNe in the NIR as precise distance indicators.

These data are also extremely useful for studies of galaxy dynamics, stellar populations, and chemical evolution. Our team is comprised of world leaders in the fields of SN environments, and galaxy IFS studies, meaning that data reduction, analysis and subsequent publications will be achieved in a timely manner, in several distinct fields. Indeed, we have already published two papers using MUSE data. In Sánchez et al. (2015) we presented one of the largest ever catalogues of HII regions obtained for a single galaxy, and in Galbany et al. (2016)

7. Description of the proposed programme and attachments

Description of the proposed programme (continued)

we showed the HII region statistics technique that will be used with the data from this proposal to constrain SNIa progenitors (Fig. 2). Finally, these data will provide a gold mine for further study. Our team is already significantly experienced in reducing and analyzing such data, and hence we expect many other projects to spawn from the proposed dataset.

References: Betoule, M. et al 2014,A&A, 568, 22; Childress, M. et al 2013, ApJ, 770, 108; D'Andrea, C.B. et al 2011, ApJ, 743, 172; Friedman, A., et al. 2015, ApJS, 220, 9; Galbany et al., 2016, MNRAS, 455, 4087; Goobar & Leibundgut, 2011, ARNPS, 61, 251; Gupta, R.R. et al 2011, ApJ, 740, 92; Johansson, J. et al 2013, MNRAS, 435, 1680; Krisciunas, K., et al. 2004, ApJ, 602, 81; Lampeitl, H. et al 2010, MNRAS, 401, 2331; Moreno-Raya, M. et al. 2016, 2016, ApJ, 818, 19; Sánchez et al., 2015, A&A, 573, 105; Stanishev et al. 2015, arXiv:1505.07707; Sullivan, M. et al 2010, MNRAS, 406, 782; Perlmutter, S. et al. 1999, ApJ, 517, 565; Riess, A. et al 1996, 473, 88; Weyant, A. et al. 2014, ApJ, 784, 105; Wood-Vasey, W.M. et al. 2008, ApJ, 689, 377.

Attachments (Figures)

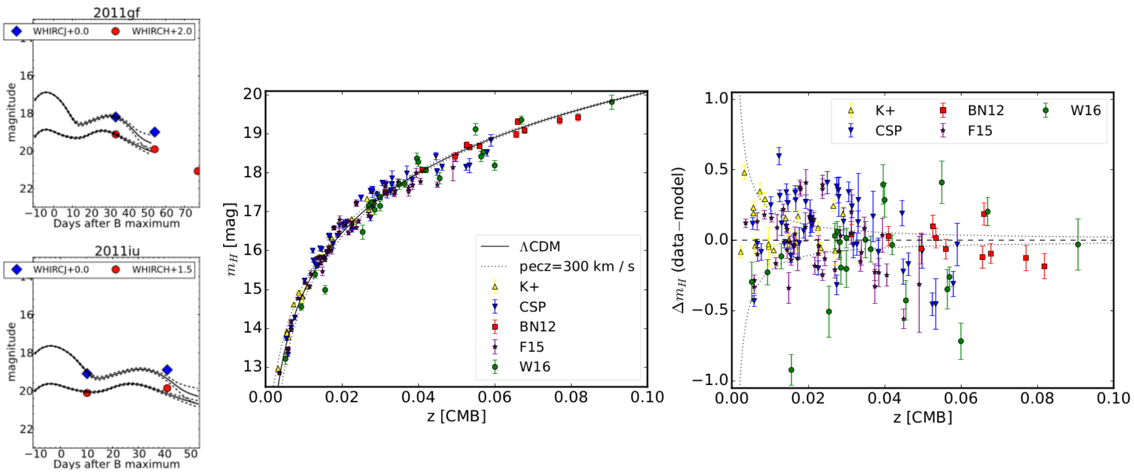

Fig. 1: (Left panels) Four SN Ia J-band (blue) and H-band (red) light-curves from the SweetSpot Survey with LC templates in black. (Right panel) H-band Hubble diagram and residual (in mag) to the ΛCDM model of SweetSpot SNe Ia (in red) with all SN Ia from the literature observed in the NIR (Weyant et al. in prep.).

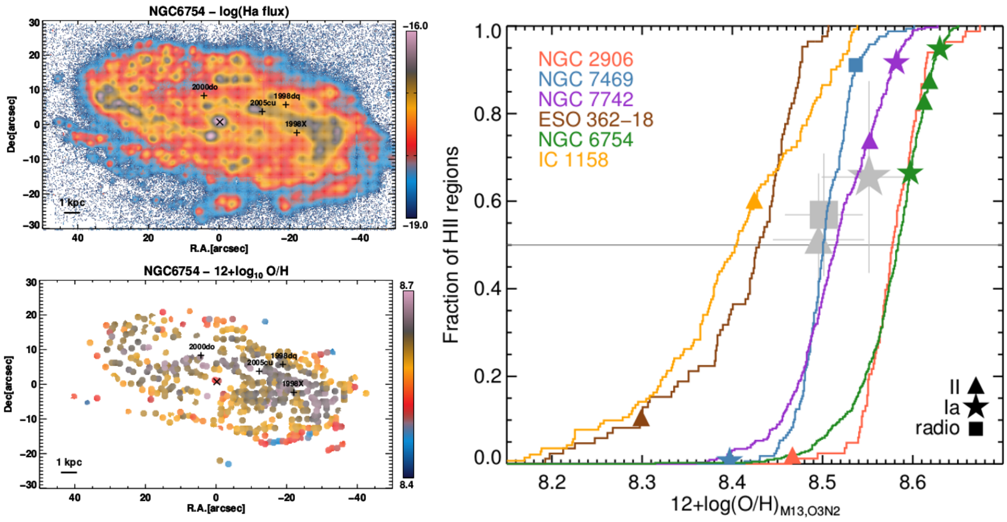

Fig. 2: (Left) Hα emission map of NGC 6754 observed during the MUSE Science Verification (PI: Galbany). The positions of the 4 SNe this galaxy hosted are marked with '+'. We run a segmentation code in this Hα map to select HII regions. Below, we show the result of stacking the spectra within each HII region, measure the oxygen abundance, and plot in a 2D map. (Right) HII region statistics for the 6 galaxies studied in Galbany et al. (2016). The distributions are constructed with the oxygen abundance values measured in all HII regions of each galaxy, and the symbols represent the parent HII region of the SNe.

8. Justification of requested observing time and observing conditions

Lunar Phase Justification: Our targets can be observed in any lunar phase as this project is a 'filler' program.

Time Justification: (including seeing overhead) Our proposed MUSE observations aim to detect and measure the strength of H II region emission lines throughout target galaxies, together with narrow absorption features seen on top of the galaxy continuum. To estimate exposure times we assume a typical r-band surface brightness of 21 mag per arcsec^2 for faint HII regions (James et al. 2004). We then use the MUSE ETC with the following parameters to estimate our required exposure times. We assume an 'Infinitely extended source' and the HII region template (at a redshift of 0.05) together with an r-band surface brightness of 21 mag per arcsec^2. As our proposal is submitted as a 'filler' we set conditions to: 7 days from new moon; airmass 1.4; seeing 1.5$''$.

In order to remove the edges of each IFU on the detector (artefacts of the image slicer) it is best to combine observations with all four 90 degree angles. With 4×550 second exposures the ETC gives a S/N of ∼5 in the continuum, which translates to a S/N of more than 100 for all the emission lines we wish to detect (e.g., Hα, [N II], [O III], Hβ). In many galaxy regions we will obtain much higher S/N in the continuum, and this will allow more detailed analysis modelling stellar populations, using absorption line indices as an indicator of stellar metallicities in the place of gas phase values. This is required for the small number of elliptical galaxies included in our sample. Together with 2×220 second sky exposures and overheads, this totals roughly 1 hr per galaxy. The extent of most galaxies in our sample is covered by one MUSE pointing, with the exception of 11 targets that need multiple pointings. Hence, we require 99 hrs to observe our sample of 88 host galaxies, however *we recall that this is a 'filler' proposal, where any amount of data obtained will be beneficial to our project.*

We previously obtained MUSE SV data, where we observed the galaxy NGC 6754. These data were obtained with very similar conditions/observing strategy to that outlined above, and show that with those exposure times we are able to make the necessary measurements. We have already published two papers based on these data (Sanchez et al. 2015; Galbany et al. 2016, +1 submitted to ApJL: Sánchez-Menguiano et al.) and submitted two more using AMUSING data (Anderson et al. sub. to Nature Astronomy; Prieto et al. sub. to ApJL). Within our team are world experts on the reduction, analysis and interpretation of IFS galaxy observations (Co-Is: Sánchez, Falcón, Pérez, Galbany, lead much of the analysis from the CALIFA program). Hence, while IFS data and their analysis can sometimes prove somewhat daunting, our team provides all the required knowledge to fully exploit this rich data set. Furthermore, these data will remain in the archive as a legacy for future extragalactic studies.

8a. Telescope Justification:

MUSE at the VLT is the only currently available IFU instrument that has a FoV of sufficient size to cover the majority of our targets, while at the same time having high spatial resolution, and being extremely efficient, hence enabling targets to be observed in a relatively small amount of time.

We stress here that even in relatively bad seeing conditions (in which the data will sometimes be observed, given the 'filler' nature of our proposal) we will still have the potential to unravel kinematic and population substructure in these galaxies over a large FoV. Indeed, even in bad seeing conditions these data will still be a better position to probe SN environments and galaxy characteristics than any current or past IFU survey (SAURON, ATLAS3D, CALIFA, SAMI, MaNGA).

8b. Observing Mode Justification (visitor or service):

Targets are observable throughout the semester, and as this is a 'filler' program, service mode is required.

8c. Calibration Request:

Standard Calibration

9. Report on the use of ESO facilities during the last 2 years

60.A-9344: 2hr SV MUSE; 1 paper in press (P.I. Kuncarayakti);
60.A.9329: 2hr SV MUSE; 2 papers published (Sanchez et al. 2015, Galbany et al. 2016), 1 submitted (Sánchez-Menguiano et al.) (P.I. Galbany);
095.D-0091: 99hr SM MUSE; data reduced, analysis underway (P.I. Anderson);
095.D-0172: 3n VM MUSE; data reduced, analysis underway (PI: Kuncarayakti);
096.D-0296: 95.5hr SM MUSE; data reduction in process (P.I. Anderson);
296.D-5003: 2hr DDT MUSE; data reduced, analysis underway (P.I. Anderson);
097.D-0408: 99hr SM MUSE; data reduced, analysis underway (P.I. Anderson);
098.D-0115: 45hr SM MUSE; data not yet acquired (P.I. Galbany);
098.D-0103: 11hr SM FORS2; data not yet acquired (P.I. Kuncarayakti);

9a. ESO Archive - Are the data requested by this proposal in the ESO Archive (http://archive.eso.org)? If so, explain the need for new data.

We checked for available observations of all of our targets on the ESO archive, and indeed in one case (SN2006X) we found one observation from last semester under our program 097.D-0408. However, this observation was aborted and it is not useful for science.

9b. GTO/Public Survey Duplications:

No.

10. Applicant's publications related to the subject of this application during the last 2 years

Anderson, J.P., et al., 2015, PASA, 32, 19: Statistical Studies of Supernova Environments

Anderson, J.P., et al., 2015, MNRAS, 448, 732: On the environments of SNe Ia within host galaxies

Catalán-Torrecilla, C., et al., 2015, A&A 584, 87: Star Formation in the Local Universe from the CALIFA sample. I. Calibrating the SFR using IFS data

Friedman, A. S., Wood-Vasey, W. M., et al, 2015, ApJS, 220, 9: CfAIR2: NIR Light Curves of 94 Type Ia SNe

Galbany, L., Anderson, J. P., et al., 2016, MNRAS, 455, 4087: Characterizing the environments of supernovae with MUSE

Galbany, L., et al., 2014, A&A, 572, A38: Nearby supernova host galaxies from the CALIFA Survey: I. Sample, data analysis, and correlation to star-forming regions

Galbany, L., et al., 2016, A&A, 591, A48: Nearby supernova host galaxies from the CALIFA Survey: II. Supernova environmental metallicity

Moreno-Raya, M. E., et al., 2016, ApJL, 818, 19: On the dependence of the type Ia SNe luminosities on the metallicity of their host galaxies

Sánchez, S., Galbany, L., et al., 2015, A&A, 573, 105: Census of H II regions in NGC 6754 derived with MUSE: Constraints on the metal mixing scale

Sánchez-Menguaino, L., et al., 2016, A&A, 587, 70: Shape of the oxygen abundance profiles in CALIFA face-on spiral galaxies

Weyant, A., Wood-Vasey, W. M., et al., 2014, ApJ, 784, 105: SweetSpot: Near-infrared Observations of 13 Type Ia Supernovae from a New NOAO Survey Probing the Nearby Smooth Hubble Flow

Ponder, K. A., Wood-Vasey, W. M., et al., 2015, ApJ, accepted, astro-ph:1511.04647: Incorporating Astrophysical Systematics into a Generalized Likelihood for Cosmology with Type Ia Supernovae

11. List of targets proposed in this programme

Run	Target/Field	α(J2000)	δ(J2000)	ToT	Mag.	Diam.	Additional info	Reference star
A	iPTF14gnl	00:23:48.25	-03:51:19.6	1			LCSBS0066P	
A	SN2014dk	00:28:11.79	+07:09:59.9	1			ANON-1	
A	LSQ13cmt	01:02:41.54	-21:52:45.2	1			2XMMJ010241.5	
A	LSQ14gde	01:00:42.51	-14:59:33.7	1			APMUKSB005813.4	
A	CSS121009011101	01:10:59.76	-17:28:51.1	1			2MASXJ01105973	
A	SN2008fr	01:11:49.19	+14:38:26.7	1			SDSSJ011149.19	
A	iPTF13dkx	01:20:52.62	+03:20:22.8	1			GALEXJ012052.72	
A	SN2008gl	01:20:53.63	+04:48:06.9	1			ANON-2	
A	PTF11pra	02:18:43.97	-06:37:57.0	2			ANON-3	
A	SN2012fk	02:30:51.02	+22:28:32.0	1			ANON-4	
A	ASASSN-15be	02:52:45.79	-34:18:52.7	1			DUKST356059	
A	PSNJ03034759	03:03:52.89	+00:24:54.7	1			CGCG389-070	
A	PS1-13dkh	03:11:16.16	+15:42:58.4	1			ANON-5	
A	PS1-13eao	03:29:56.57	-28:46:20.3	1			ANON-6	
A	2009ku	03:29:53.23	-28:05:12.0	1			GALEXJ032953.18	
A	SN2009im	03:33:23.34	-04:59:55.9	1			NGC1355	
A	SN2005ke	03:35:04.35	-24:56:40.0	3			ANON-7	
A	SN2013ad	03:38:40.86	+10:18:23.0	1			ANON-8	
A	SN2013gy	03:42:16.29	-04:43:45.4	1			ANON-9	
A	LSQ12hno	03:42:43.23	-02:40:09.3	1			GALEXJ034243.43	
A	SN2010jm	03:46:03.36	+12:42:11.1	1			2MASXJ03460336	
A	SN2009kk	03:49:43.40	-03:15:37.4	1			2MFGC03182	
A	LSQ14gov	04:06:01.42	-16:01:39.6	1			GALEXJ040601.67	
A	SN2010kg	04:40:09.12	+07:20:58.2	1			NGC1633	
A	SN2011K	04:45:30.34	-07:20:48.9	1			GALEXJ044530.36	
A	LSQ12fvl	05:00:50.62	-38:39:16.4	1			MCG-06-12-02	
A	SN2009ad	05:03:33.30	+06:39:25.7	1			UGC03236	
A	SN2005el	05:11:47.07	+05:12:02.5	1			ANON-10	
A	LSQ11ot	05:15:47.60	+06:46:42.0	1			CGCG421-013	
A	LSQ11pn	05:16:41.55	+06:29:37.5	1			2MASXJ05164149	
A	LSQ12fxd	05:22:16.99	-25:36:13.9	1			ANON-11	
A	LSQ12gln	05:22:59.52	-33:27:56.2	1			GALEXJ052259.58	
A	SN2010ju	05:41:55.52	+18:29:32.9	1			UGC03341	
A	CSP13abi	05:48:57.85	-66:40:10.5	1			2MASXJ05485782	
A	SN2015F	07:36:15.76	-69:30:22.4	1			ANON-12	

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Target Notes: All targets above are SN Ia host galaxies from the sample we compiled from SweetSpot, CfAIR2, and CSP2 that are well-observable from Paranal throughout the semester. The transient name is given in the first column, followed by the RA and Dec of its host galaxy. When available the galaxy name is also listed. For targets with multiple pointings the total time is indicated: 3hrs is 3 pointings. At phase 2 these pointings will be given priorities such that those containing SN positions are observed first.

12. Scheduling requirements

13. Instrument configuration

Period	Instrument	Run ID	Parameter	Value or list
99	MUSE	A	WFM-NOAO	-

6b. Co-investigators:

...continued from Box 6a.

S.	González-Gaitán	1822
E.	Hsiao	1970
P.	James	1134
H.	Kuncarayakti	1822
J.	Lyman	1241
J. C.	Maureira	5667
E.	Perez	1392
M.	Phillips	1086
J.L.	Prieto	8645
K.	Ponder	2034
F.	Rosales-Ortega	1401
S.	Sánchez	1774
M.	Stritzinger	1909
W. M.	Wood-Vasey	2034

11a. List of targets proposed in this programme

Run	Target/Field	α(J2000)	δ(J2000)	ToT	Mag.	Diam.	Additional info	Reference star
	...continued from box 11.							
A	ASASSN-15eb	08:06:07.50	-22:33:48.7	1			ESO561-G012	
A	SN2010H	08:06:24.14	+01:02:10.5	1			IC0494	
A	PTF15wb	08:28:17.98	+00:17:21.5	1			CGCG004-035	
A	SN2009kq	08:36:15.24	+28:03:38.7	1			KUG0833+282	
A	SN2010iw	08:45:15.70	+27:49:23.7	1			ANON-13	
A	ASASSN-15fr	09:20:20.35	-07:38:24.6	1			2MASXJ09202045	
A	SN2011at	09:28:58.80	-14:48:25.2	1			MCG-02-24-27	
A	SN2007ux	10:09:19.72	+14:59:27.2	1			2MASXJ10091969	
A	SN2002cv	10:18:02.55	+21:50:25.8	3			ANON-14	
A	LSQ13dpm	10:29:08.51	-17:06:53.1	1			GALEXJ102908.61	
A	ASASAN-15hf	10:29:31.03	-35:15:36.1	1			ESO375-G041	
A	LSQ13ry	10:32:47.79	+04:11:44.6	1			SDSSJ103247.83	
A	2015H	10:54:41.71	-21:04:16.0	2			NGC3464	
A	LSQ14ba	11:01:23.15	-15:37:06.1	1			GALEXJ110123.17	
A	LSQ14asu	11:11:36.29	-21:27:59.4	1			2MASXJ11113635	
A	SN2006ax	11:24:01.94	-12:17:50.6	2			ANON-15	
A	ASASSN-14my	11:38:30.25	-08:58:34.6	1			NGC3774	
A	PTF14yw	11:45:05.83	+19:58:24.8	2			ANON-16	
A	SN2011ae	11:54:49.43	-16:51:49.8	1			GALEXJ115449.49	
A	PTF14w	12:03:31.09	+02:02:26.2	1			SDSSJ120331.02	
A	SN2005bl	12:04:11.30	+20:24:35.5	1			NGC4070	
A	PTF13ez	12:09:51.22	+19:47:17.0	1			KUG1207+200	
A	SN2006cp	12:19:13.45	+22:25:47.7	1			ANON-17	
A	SN2006X	12:22:52.78	+15:48:27.0	3			ANON-18	
A	ASASSN-15cb	12:39:50.30	+03:47:48.6	1			VCC1810	
A	LSQ15alq	13:09:18.71	-25:52:06.2	1			ESO508-G016	
A	SN2007ca	13:31:04.33	-15:06:04.5	1			ANON-19	
A	ASASSN-15hx	13:43:16.77	-31:33:19.7	1			GALEXJ134316.80	
A	LSQ13lq	13:44:10.69	+03:03:46.2	1			SDSSJ134410.78	
A	LSQ13pf	13:48:14.19	-11:38:32.3	1			LCRSB134534.3	
A	SN2013M	13:59:57.68	-37:51:48.6	1			ESO325-G043	
A	SN2005ch	14:22:06.57	+01:59:34.4	1			SDSSJ142206.56	
A	ASASSN-15bm	15:05:51.58	-05:37:35.9	1			GALEXJ150551.56	
A	SN2005cf	15:21:33.26	-07:26:56.7	1			GALEXJ152133.23	
A	SN2010dw	15:22:40.60	-05:55:21.5	1			2MASXJ15224062	
A	PTF14aje	15:25:12.39	-01:48:40.5	1			UGC09839	
A	PTF13asv	16:22:43.04	+18:57:35.5	1			SDSSJ162243.02	
A	LSQ15aja	17:03:08.90	+12:27:41.9	1			ANON-20	
A	2014cr	19:37:05.03	-42:17:47.6	1			NGC6806	
A	SN2012bl	20:23:54.18	-48:21:26.8	2			ANON-21	
A	ASASSN-15hy	20:10:02.33	-00:44:22.8	1			ANON-22	
A	SN2009jr	20:26:25.70	+02:54:34.5	1			IC1320	
A	SN2011gf	21:12:23.18	-07:49:08.6	1			ANON-23	
A	SN2010dl	21:35:00.35	-00:30:40.9	1			IC1391	
A	SN2007cq	22:14:40.73	+05:04:42.7	1			2MASXJ22144070	
A	LSQ14fmg	22:16:46.22	+15:21:22.5	1			GALEXJ221646.26	
A	SN2012em	22:44:02.26	+15:52:10.1	1			ANON-24	
A	PTF11qnr	22:44:24.34	-00:09:42.5	1			NGC7364	
A	LSQ12fhs	22:52:23.34	-20:36:38.7	1			2MASXJ22522347	
A	SN2011io	23:02:46.95	+08:48:14.9	1			ANON-25	

Following targets moved to the next page...

11a. List of targets proposed in this programme

...continued from previous page.

Run	Target/Field	α(J2000)	δ(J2000)	ToT	Mag.	Diam.	Additional info	Reference star
A	CSS121006232854	23:28:54.50	+08:54:50.6	1			GALEXJ232854.58	
A	iPTF13dkl	23:44:57.59	+03:23:37.5	1			GALEXJ234457.62	
A	SN2005iq	23:58:31.88	-18:42:49.3	1			ESO538-G013	