European Organisation for Astronomical Research in the Southern Hemisphere

OBSERVING PROGRAMMES OFFICE • Karl-Schwarzschild-Straße 2 • D-85748 Garching bei München • e-mail: opo@eso.org • Tel.: +49 89 320 06473

APPLICATION FOR OBSERVING TIME

PERIOD: **101A**

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 VII: Continuing the survey of nebular spectra and environments of core-collapse supernovae

2. Abstract / Total Time Requested

Total Amount of Time: 0 nights VM, 99 hours SM

We propose to continue building a large sample of late-time MUSE nebular spectra of core-collapse supernovae (CCSNe) in order to constrain their progenitors. Such late-time spectra allow us to study the ejecta of CCSNe when the emission is dominated by nucleosynthesis products in the core, and the strength of spectral lines is directly related to progenitor mass. At the same time, the SN environment will be covered by the large MUSE FoV. This will be used to independently constrain the physical parameters of the progenitors such as initial mass and metallicity, through parent stellar population analysis. Together with nebular spectroscopy this will probe the full range in progenitor and explosion diversity and put strong constraints on the pre-SN characteristics of CCSN progenitors. This will be an important contribution in connecting SNe with massive star evolution.

3.

Run	Period	Instrument	Time	Month	Moon	Seeing	Sky	Mode	Type
A	101	MUSE	79h	any	n	n	THN	s	
B	101	MUSE	20h	any	n	n	THN	s	

4.

Number of nights/hours	Telescope(s)	Amount of time
a) already awarded to this project:	VLT	84h in 0100.D-0341 (filler)
b) still required to complete this project:		

5. Special remarks:

This project is a ‘filler’ program, with targets across a wide RA and DEC range, and 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. In addition to the current science goals, and given the low ratio of observations performed in P99 (30%), we add to the object list a few targets from that proposal that were not observed and are needed to finalize the analysis for the science case: correlating local environmental parameters with NIR supernova light-curve properties (run B).

6. Principal Investigator: Hanindyo Kuncarayakti, kuncarayakti@gmail.com, FI, Finnish Centre for Astronomy with ESO (FINCA)

6a. Co-investigators:

J.P.	Anderson	ESO Office Santiago,ESO
L.	Galbany	University of Pittsburg,Department of Physics & Astronomy,US
L.	Dessart	Universidad de Chile,Cerro Calan,CL
J.	Falcón-Barroso	Instituto de Astrofisica de Canarias, Headquarters,E

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

7. Description of the proposed programme

A – Scientific Rationale: Massive stars ($\gtrsim 8$ M$_\odot$) end their lives with CCSN. The characterisation of the SN explosion and progenitor star constrains stellar evolution and our understanding of extreme astrophysics. In addition, the energetics of CCSNe underpin their importance through their influence on their surrounding environments, and as probes of the overall evolution and chemical enrichment of the Universe. The most direct SN progenitor constraints are found in the direct detection of progenitor stars in pre-SN images (Smartt 2015, PASA, 32, 16). This has constrained the progenitor mass range for SNe IIP to be between 8 and 18 M$_\odot$ with a lack of high-mass progenitors (although this has been disputed by e.g. Davis & Beasor 2017, arXiv:1709.06116). For all other CCSN types the statistics are either very small or non-existent. CCSNe display a wide diversity in their light-curve and spectral evolutions, implying a wide range in progenitor diversity. However, the latter is yet to be constrained by observations. Waiting for such constraints from the direct-detection method will take many decades, especially for the rarer sub-types: we are simply limited in the number of CCSNe that occur within close proximity to Earth ($\lesssim 20$ Mpc). Alternatively, one may use the environment of SNe to put constraints to the progenitor (see Anderson et al. 2015, PASA, 32, 19 for a review). The stellar populations that gave rise to the SNe are studied to derive progenitor physical properties such as initial mass and metallicity.

Independently, radiative-transfer modelling of the SN itself, which allows a scan of the progenitor/ejecta structure from the former stellar surface down to the site of explosion at the stellar core, may provide further constraints. Spectral modelling at the nebular phase (few hundred days after explosion) is instrumental to probe the composition and explosive yields in the progenitor core, which can place tight constraints on the progenitor mass and the explosion process. The strength of nebular emission lines can be used as a diagnostic of the abundance of specific elements, with the latter being related to the initial (ZAMS) mass of the progenitor (Jerkstrand et al. 2012, A&A, 546, 28). Specifically, the strength of [O I]$\lambda\lambda$6300,6364 has been used as a direct indicator of progenitor mass. Fig. 1 shows an example in comparing observations to model spectra produced from different progenitors: the strength of the [O I] line increases with increasing progenitor mass. The flux within the [O I] line relative to the ^{56}Co power (i.e. that is powering the SN at these late stages) has also been used in comparison to model spectra (Fig. 2a). Both these model comparisons produce results that are consistent with the statistics of direct detections. Furthermore, the single/binary nature of the H-poor SN progenitors can be constrained by nebular line ratios (Fig. 2b). This is crucial for stellar evolution as a certain mechanism (e.g. wind, or alternatively binary interaction) must be at work in removing the outer layers of the progenitor star. Diversity is observed in nebular spectra, as shown in Fig. 2c: lines show different widths, the ratio of nebular lines is different from one SN to the next (also see Fig. 2b), and additionally there exist other weaker lines (see Fig. 1) that can also constrain progenitors. Fig. 2c shows a recent discovery a SN II hosted by an extremely low-metallicity host galaxy, showing an unusually strong nebular [O I] line.

In conclusion, nebular phase spectra provide strong SN progenitor constraints, however there are still only a small number of events with such high-quality data, hindering more meaningful statistical studies. Furthermore there are still significant gaps in our knowledge of both the origin of observational diversity and the uncertainties in the models (see also Dessart et al. 2010, MNRAS, 408, 827). **We will remedy this situation by obtaining a large sample of CCSN nebular spectra with MUSE.** Progenitor constraints will be made through the comparison of observed spectra with spectral modelling based on realistic explosion models, together with the characterisation of the morphology of all detected spectral lines and the relative comparison of their properties between different SN types (see e.g. Fig. 2b). **This sample will more than triple the currently available literature sample of CCSNe well observed after 250 days post explosion.**

B – Immediate Objective: We aim to obtain MUSE nebular spectroscopy of 79 CCSNe (45 SN II, 12 IIn, 4 IIb, 2 Ib, 1 Ibn, 13 Ic, 1 Ic-BL, 1 SLSN-I) at the phase of $\sim$1 year post explosion. At this late phase SNe evolve relatively slowly, and additionally any such evolution can be calibrated by comparison to well observed literature events, meaning that a consistent analysis can be achieved. These observations will enable progenitor mass constraints through direct comparison of observed spectra to models. With these data we will:

1) **Obtain progenitor mass estimates** by directly comparing observed spectra to the models. Our team has the expertise in modeling and interpreting spectra of SNe including in nebular phase. A large database of nebular spectra will provide very important feedback and enable further improvements to the model spectra, ultimately aiding our understanding of CCSN explosions.

2) **Compare the properties of CCSN from nebular spectra with those of the surrounding galaxy**. One can thus ask questions such as: do SNe that produce more nickel explode in younger (which imply shorter-lived, i.e., more massive progenitors) or more metal-rich environments?

3) **Characterise the overall observed diversity** in CCSN nebular spectra. This entails statistical comparison of emission-line ratios to search for differences between e.g. hydrogen-rich and hydrogen-poor CCSNe (Fig. 2b), investigation into differences in nebular line-widths which contain information on the size of the helium core at explosion epoch (Dessart et al. 2010, MNRAS, 408, 827), and all other observed parameters.

4) **Compare late-time observables and those during the earlier photospheric phase** (observations currently being obtained through various collaborations). Here we test to see if there are earlier-time properties that correlate with those at late times, to ask if e.g. faster-declining SNe II arise from more massive progenitors.

7. Description of the proposed programme and attachments

Description of the proposed programme (continued)

5) **Search for peculiar nebular-phase events**, such as that displayed in Fig. 2c (SN 2015bs). The discovery of additional such events is vital to enable a full understanding of massive star evolution and explosion.

The above questions and lines of investigation can only be fully achieved through a large sample of high-quality spectra as outlined in this proposal. Our sample comprises all recent CCSNe that will be observable from Paranal in P101. This will more than triple the current sample of CCSNe with nebular spectra at these epochs, enabling significant advancement in this field. In addition to constraining CCSN progenitors through these nebular spectra, the MUSE data will allow a characterisation of the local environment (while the exact explosion site will be hidden by the SN emission, we will integrate the environment in close proximity and use this as a proxy for the SN environment); properties such as the star-formation rate, metallicity, and stellar population age will be extracted. In this way the MUSE datacubes will be fully exploited to **critically constrain CCSN progenitor properties**, and contribute greatly to the fields of SN physics and stellar evolution.

We note that as AMUSING is collecting IFU spectroscopy for a large number of nearby galaxies, the data will have a significant **legacy value**. As such, these data are also extremely useful for studies of galaxy dynamics, stellar populations, and chemical evolution, as has been proved by numerous publications (see Box 9). Our team is comprised of world leading experts in the fields of SNe, galaxy studies, and IFU spectroscopy, meaning that data reduction, analysis and subsequent publications will be achieved efficiently, in several distinct fields.

Attachments (Figures)

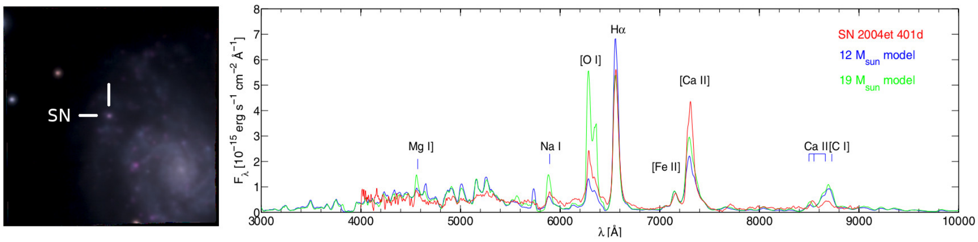

Fig. 1: *Left:* Synthesized RGB image of a MUSE galaxy with SN serendipitously observed at nebular phase. *Right:* Comparison of a nebular spectrum of SN 2004et with model spectra from distinct progenitor masses (Jerkstrand et al. 2012, A&A, 546, 28). The largest difference between models is seen in the [O I] line. Here, SN 2004et falls between 12-19 $M_{\odot}$ models. Such comparisons will be done for all SNe observed through this program.

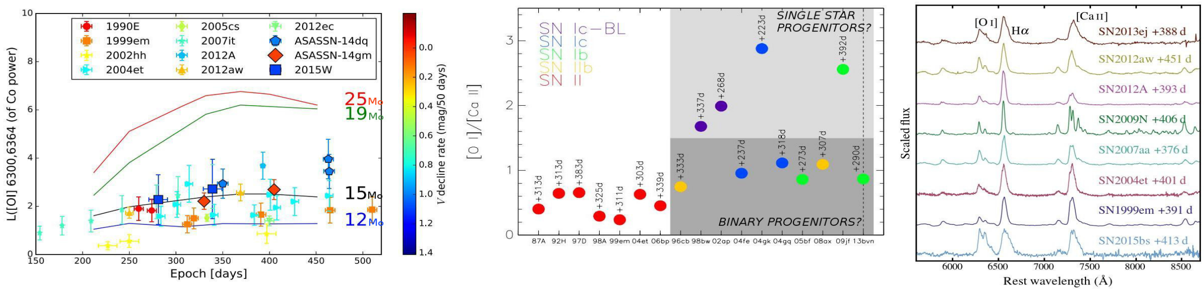

Fig. 2: *Left:* Comparison of the [O I] line flux to the ^{56}Co power evolution/individual measurements for a range of SNe II, as compared to the evolution of the same quantity using different models (Valenti et al. 2016, MNRAS, 459, 3939). *Middle:* The ratio of [O I] to [Ca II] at nebular epochs between H-rich (SNe II) and H-poor SNe. This ratio has been used as a proxy for ZAMS progenitor mass. One observes diversity in the ratio, with generally higher values for the H-poor stripped-envelope CCSNe. The possible two populations of H-poor progenitors are associated with the single/binary origins (Kuncarayakti et al. 2015, A&A, 579, 95). *Right:* Comparison of all available nebular spectra of SNe II (at 410±50 days). There is significant diversity within the width and strength of lines in each SN. Of particular interest is the spectrum of SN 2015bs (bottom) that displays a much stronger [O I] line, suggesting a significantly higher mass progenitor. Similar analyses will be produced for our proposed sample, with significantly increased statistics affording the construction of distribution functions and much more stringent constraints on progenitor properties.

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) The main aim of this proposal is to obtain nebular phase spectroscopy of SNe. We assume that our targets will be around a magnitude of 21 in the V-band at the epochs of our observations (this is estimated using the brightness of our targets at maximum light, soon after explosion, and assuming generic light-curve decline rates). Using the MUSE ETC we then assume: a point source at 21 mag in V (with a uniform spectral distribution); 3x3 spatial binning; coadded spectral pixels = 1; 7 days from new Moon; airmass of 1.5; and a seeing of 1.2 arcsec. To obtain a S/N of 5 we then require 4×550 sec exposures. This will be sufficient to analyse the properties of SN emission lines observed in the nebular phase, especially as these will be significantly brighter than the continuum level.

With a set of separate sky exposures (2×220 sec), together with telescope/instrument overheads, we can therefore observe each SN within an hour long OB. Our full target list of 99 SNe (run A+B) therefore equates to a total time request of 99 hours.

Our second goal is to extract information on the surrounding stellar populations within the SN host galaxies. Through previous time allocations we have already observed that 1 hour OBs lead to sufficient signal of unresolved stellar populations within nearby galaxies (those that will be observed here). As demonstrated in e.g. Galbany et al. 2016 (MNRAS, 455, 4087), from such data the environment of the SN can be well analysed based on the spectral continuum fit and also emission lines analysis, which should show much higher S/N ratio. Preliminary results from the previous AMUSING datacubes (and a number of other MUSE programs available in the ESO archive) are presented in this link: http://www.astroscu.unam.mx/∼sfsanchez/MUSE/list.php.

Finally, we recall that this is a filler proposal, where any amount of data obtained will be useful for our project (as already demonstrated in our previous MUSE publications), and as the acquired data will have sufficient depth and quality it would retain a high legacy value for future studies of nearby galaxies and stellar populations.

8a. Telescope Justification:

MUSE at the VLT is the only currently available instrument that has a FoV of sufficient size to cover the majority of the host galaxies of our targets, while at the same time having high spatial resolution, and being extremely efficient (in fact, the most efficient spectrograph at Paranal), 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) the nebular spectra of the SNe would not be affected as they are point sources. In the context of the host galaxy stellar populations, 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 surveys (e.g. 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

This proposal is part of a nearby SN host galaxy survey with MUSE that has been running since 2015 (095.D-0091, 096.D-0296, 097.D-0408, 098.D-0115, 099.D-0022, 100.D-0341). The obtained **dataset is actively being worked on** (see `http://www.astroscu.unam.mx/~sfsanchez/MUSE/list.php`), and **a substantial number of papers** (Sánchez et al. 2015, A&A, 573, 105; Galbany et al. 2016, MNRAS, 455, 4087; Kuncarayakti et al. 2016, A&A, 593, 78; Prieto et al. 2016, ApJ, 830, 32; Sánchez-Menguiano et al. 2016, ApJ, 830, 40; Krühler et al. 2017, A&A, 602, 85; Sánchez-Menguiano et al. 2017, MNRAS subm.) have been produced. A large number of other papers is in preparation, covering **many topics** from SNe, ISM and galaxy evolution, to machine learning and big data science. This highlights our team's ability to perform efficient data analysis and publication, and importantly the **quality and usefulness of the data**. Future public data releases from this survey are planned; parts of the data have been critical in **education activities** (several PhD projects, also Harvard-Chile Data Science School: www.hcds.cl). The members of the team are also frequent users of other ESO facilities in many different projects (098.D-0416; 099.D-0043; and specifically related to the science pursued in this proposal: 098.D-0103, FORS2 late-time spectroscopy of SNe), with excellent publication record.

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.

These observations are of transient SNe, hence there is no duplication of any previous observations.

9b. GTO/Public Survey Duplications:

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

Kuncarayakti, H. et al. 2017, A&A under review: Constraints on core-collapse supernova progenitors from explosion site integral field spectroscopy

Izzo, L. et al. 2017, MNRAS in press: The MUSE view of the host galaxy of GRB 100316D

Krühler, T. et al., 2017, A&A 602, 85: Hot gas around SN 1998bw - Inferring the progenitor from its environment

Galbany, L. et al. 2017, MNRAS 468, 628: Molecular gas at supernova local environments unveiled by EDGE

Kangas, T. et al. 2017, A&A, 597, 92K: Core-collapse supernova progenitor constraints using the spatial distributions of massive stars in local galaxies

Kuncarayakti, H. et al., 2016, MNRAS, 458, 2063: Evolving into a remnant: optical observations of SN 1978K at three decades

Prieto, J.L. et al., 2016, ApJ, 830, 40: MUSE Reveals a Recent Merger in the Post-starburst Host Galaxy of the TDE ASASSN-14li

Kuncarayakti, H. et al., 2016, A&A, 593, 78: Unresolved versus resolved: testing the validity of young simple stellar population models with VLT/MUSE observations of NGC 3603

Anderson, J.P. et al., 2016, A&A, 589, 110: Type II supernovae as probes of environment metallicity: observations of host H II regions

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

Galbany, L. et al. 2016, A&A, 591A, 48G: Nearby supernova host galaxies from the CALIFA survey. II. Supernova environmental metallicity

Heikkilä, T. et al. 2016, MNRAS, 457, 1107: Progenitor constraints for core-collapse supernovae from Chandra X-ray observations

Sánchez-Menguiano, L. et al., 2016, ApJ, 830, 40: Evidence of Ongoing Radial Migration in NGC 6754: Azimuthal Variations of the Gas Properties

Kuncarayakti, H. et al., 2015, A&A, 579, 95: Nebular phase observations of the Type-Ib supernova iPTF13bvn favour a binary progenitor

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

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

11. List of targets proposed in this programme

Run	Target/Field	α(J2000)	δ(J2000)	ToT	Mag.	Diam.	Additional info	Reference star
A	2017gaw	01:15:35.230	-00:50:40.30	1			SN II	
A	2017ful	01:35:12.391	-26:04:58.83	1			SN Ic	
A	2017eul	01:44:30.880	+04:40:05.66	1			SN II	
A	2017giu	01:47:39.840	-22:41:11.18	1			SN II	
A	2017fqo	01:53:01.510	+12:42:46.04	1			SN II	
A	2017fbu	02:11:06.936	+03:50:36.63	1			SN II	
A	2017ggw	02:30:26.880	-43:00:53.10	1			SN II	
A	2017gmr	02:35:30.150	-09:21:14.95	1			SN II	
A	2017fqk	02:54:02.094	+02:58:07.71	1			SN II	
A	2017eni	03:05:10.776	-45:33:03.49	1			SN IIn	
A	2017fvf	03:17:53.310	-07:18:00.97	1			SN IIP	
A	2017gbv	03:42:01.371	-39:19:56.11	1			SN Ic	
A	2017gax	04:45:49.430	-59:14:42.56	1			SN Ib/c	
A	2017pn	04:46:24.590	-11:59:18.25	1			SN IIP	
A	2017fvr	04:47:28.226	+23:58:57.83	1			SN IIP	
A	2017auf	05:02:19.560	-10:21:22.86	1			SN IIP	
A	2017dhu	05:16:31.937	+06:27:46.33	1			SN II	
A	2017gci	06:46:45.026	-27:14:55.86	1			SLSN-I	
A	2017cik	07:54:13.070	+21:47:36.49	1			SN IIn	
A	2017cfq	08:03:55.206	+26:31:12.73	1			SN II	
A	2017caw	08:07:50.100	-61:46:15.60	1			SN II	
A	2017aww	08:37:38.220	+19:24:13.94	1			SN II	
A	2017bel	08:56:46.740	+29:55:15.51	1			SN II	
A	2017dwq	09:03:32.200	-21:20:07.48	1			SN IIn	
A	2017ben	09:18:48.450	-12:15:33.20	1			SN IIn	
A	2017zg	09:41:54.490	+01:19:08.43	1			SN II	
A	2017civ	09:52:31.290	-21:57:54.94	1			SN IIn	
A	2017cfa	09:57:03.890	-07:52:51.14	1			SN IIP	
A	2017mw	09:57:20.966	-41:35:20.98	1			SN II	
A	2017jo	09:57:36.144	-22:10:23.91	1			SN IIb	
A	2017diz	10:34:20.120	+13:45:04.23	1			SN II	
A	2017ahn	10:37:17.450	-41:37:05.27	1			SN II	
A	2017cfo	10:38:12.920	+28:07:02.06	1			SN II	
A	2017la	10:48:26.557	-13:13:59.38	1			SN II	
A	2017blh	10:52:10.550	-27:47:51.73	1			SN II	

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

12. Scheduling requirements

13. Instrument configuration

Period	Instrument	Run ID	Parameter	Value or list
101	MUSE	A	WFM-NOAO-E	-
101	MUSE	B	WFM-NOAO-N	-

6b. Co-investigators:

...continued from Box 6a.

F.	Förster	Universidad de Chile,Cerro Calan,CL
S.	González-Gaitán	Universidade de Lisboa,P
P.	James	Astrophysics Research Institute,Liverpool John Moores University,UK
T.	Kangas	Space Telescope Science Institute,US
E.	Kankare	Astrophysics Research Centre,Department of Physics and Astronomy,Queen's University Belfast,UK
J.	Kotilainen	Finnish Centre for Astronomy with ESO (FINCA),FI
T.	Kravtsov	Finnish Centre for Astronomy with ESO (FINCA),FI
P.	Lundqvist	Stockholm University,Stockholm Observatory,S
J.	Lyman	University of Warwick,UK
S.	Mattila	Finnish Centre for Astronomy with ESO (FINCA),FI
F.	Olivares E.	Universidad de Chile,Cerro Calan,CL
E.	Perez	Instituto de Astrofisica de Andalucia, IAA-CSIC,E
J.L.	Prieto	Universidad Diego Portales,CL
F.	Rosales-Ortega	Instututo Nacional de Astrofisica Optica y Electronica (INAOE),MX
T.	Ruiz-Lara	Instituto de Astrofisica de Canarias, Headquarters,E
S.	Sánchez	UNAM,Instituto de Astronomia,MX
L.	Sánchez-Menguiano	Universidad de Granada,Departamento de Fisica Teorica y del Cosmos,,E

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	2017byz	11:23:30.780	-08:39:11.84	1			SN II	
A	2017dio	11:36:27.760	+18:17:46.92	1			SN Ic	
A	2017rt	11:43:29.260	-16:47:37.27	1			SN Ic	
A	2017cjd	11:50:30.170	-18:35:44.96	1			SN Ic	
A	2017hl	12:07:18.830	+16:50:26.02	1			SN Ib	
A	2017ays	12:12:45.990	+00:24:28.11	1			SN II	
A	2017hk	12:45:15.310	+26:05:07.10	1			SN IIP	
A	2017dcc	12:49:04.890	-12:12:22.42	1			SN Ic	
A	2017cjb	12:53:50.450	+09:42:17.70	1			SN II	
A	2017djq	13:11:33.080	-19:09:22.81	1			SN IIn	
A	2017bzm	13:15:04.160	-24:48:05.48	1			SN IIn	
A	2017faa	13:19:03.900	-02:30:45.81	1			SN II	
A	2017ckg	13:22:05.940	-13:08:09.69	1			SN II	
A	2017anf	13:33:13.420	+08:03:25.51	1			SN II	
A	2017dka	14:01:46.100	+09:29:57.40	1			SN II	
A	2017ewx	14:02:16.520	+07:40:44.21	1			SN Ib	
A	2017ecp	14:14:48.930	-29:33:36.76	1			SN Ibn	
A	2017lt	14:19:44.203	-16:50:15.75	1			SN IIn	
A	2017fav	14:32:06.160	+21:49:58.69	1			SN IIn	
A	2017fem	14:32:27.320	+27:25:36.75	1			SN IIP	
A	2017aym	14:37:41.780	+02:17:08.45	1			SN IIP	
A	2017eye	14:37:45.110	+21:20:29.02	1			SN Ic	
A	2017eca	16:04:15.700	+17:57:27.44	1			SN IIP	
A	2017cin	16:14:00.660	+26:54:58.62	1			SN IIn	
A	2017dgd	16:45:38.967	+01:37:19.70	1			SN IIb	
A	2017bif	17:26:27.119	-60:32:39.73	1			SN II	
A	2017faf	17:34:39.980	+26:18:22.00	1			SN II	
A	2017ffq	17:40:14.502	-58:25:57.11	1			SN II	
A	2017fgk	17:47:49.190	+16:08:05.18	1			SN Ic-BL	
A	2017dkb	18:14:03.430	+21:52:38.70	1			SN IIP	
A	2017fod	18:44:55.480	+27:18:25.96	1			SN II	
A	2017fwm	19:12:51.968	-60:22:58.37	1			SN Ic	
A	2017fbq	19:33:45.610	-60:58:02.20	1			SN II	
A	2017dch	19:55:35.696	-11:38:22.70	1			SN Ic	
A	2017gfh	20:03:27.400	+06:59:27.20	1			SN IIb	
A	2017dek	20:25:44.712	-21:39:39.89	1			SN II	
A	2017ggv	22:54:28.690	-13:31:50.58	1			SN IIn	
A	2017bzb	22:57:17.300	-41:00:57.60	1			SN II	
A	2017gip	23:05:00.610	+28:45:42.73	1			SN Ic	
A	2017ffm	23:18:23.020	-04:24:58.27	1			SN II	
A	2017eiy	23:49:28.272	-30:25:04.69	1			SN IIb	
A	2017gat	23:53:17.032	-32:46:32.83	1			SN Ic	
A	2017ghw	23:57:34.750	+02:05:11.18	1			SN IIn	
A	2017giq	23:57:54.730	+28:30:12.33	1			SN Ic	
B	2008gg	01:25:23.04	-18:10:20.80	1			SN Ia	
B	2007st	01:48:42.47	-48:38:57.80	1			SN Ia	
B	2008fu	03:02:28.50	-24:27:21.50	1			SN Ia	
B	2006dd	03:22:41.62	-37:12:13.00	1			SN Ia	
B	2006mr	03:22:43.04	-37:12:29.60	1			SN Ia	
B	2007on	03:38:50.90	-35:34:30.00	1			SN Ia	

Following targets moved to the next page...

11a. List of targets proposed in this programme

Run	Target/Field	α(J2000)	δ(J2000)	ToT	Mag.	Diam.	Additional info	Reference star
	...continued from previous page.							
B	2006hb	05:02:01.28	-21:07:55.10	1			SN Ia	
B	2008bq	06:41:02.51	-38:02:19.00	1			SN Ia	
B	2008O	06:57:34.46	-45:48:44.30	1			SN Ia	
B	2009ag	07:11:40.81	-26:41:06.30	1			SN Ia	
B	2008hu	08:09:14.76	-18:39:13.10	1			SN Ia	
B	2005am	09:16:12.47	-16:18:16.00	1			SN Ia	
B	2007as	09:27:36.01	-80:10:39.20	1			SN Ia	
B	2008fw	10:28:55.97	-44:39:55.60	1			SN Ia	
B	2005al	13:50:00.33	-30:34:34.20	1			SN Ia	
B	2007ai	16:12:53.74	-21:37:48.70	1			SN Ia	
B	2008fl	19:36:44.84	-37:33:04.50	1			SN Ia	
B	2008cc	21:03:29.62	-67:11:01.10	1			SN Ia	
B	2006bh	22:40:16.10	-66:29:06.30	1			SN Ia	
B	2005iq	23:58:32.50	-18:42:33.00	1			SN Ia	