APPLICATION FOR OBSERVING TIME

PERIOD: **100A**

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 VI: late-time nebular spectroscopy and environments of core-collapse supernovae

2. Abstract / Total Time Requested

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

Understanding the core-collapse supernova (CCSN) phenomenon, the explosive demise of massive stars, is one of the most important topics in modern astronomy. CCSNe serve as probes of the Universe (as tracers of star formation, metallicity and distances), and the nature of their explosions helps put constraints on stellar evolution. Here, we propose to build a large sample of late-time MUSE nebular spectra of 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. Furthermore, the SN environment obtained with the large MUSE FoV will also be used to independently constrain the progenitors. 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 CCSNe.

3.

Run	Period	Instrument	Time	Month	Moon	Seeing	Sky	Mode	Type
A	100	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:		
b) still required to complete this project:		

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 distinct from previous semesters. We note that as AMUSING is collecting IFU spectroscopy for a large number of nearby galaxies, the data will have a significant legacy value.

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
T.	Krühler	Max Planck Institut fuer extraterrestrische Physik,D
S.	Sánchez	UNAM,Instituto de Astronomia,MX

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

7. Description of the proposed programme

A – Scientific Rationale: CCSNe are the explosive deaths of massive ($\gtrsim$ 8 $M_\odot$) stars when they arrive to the end of their lives with their nuclear fuel spent. The exact nature of their transient behaviour unveils details of their pre-SN characteristics and explosion properties, therefore constraining 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 of the Universe. Currently, 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, given that more massive stars are known to exist. For all other CCSN types the statistics are either very small or non-existent. CCSNe display a wide diversity in their light-curve morphologies and spectral evolution, implying a wide range in progenitor diversity. However, the latter is yet to be significantly 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 constrained 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).

Another independent, complementary technique is 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. Spectral modelling at the nebular phase (few hundred days after explosion) is instrumental to constrain 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 directly related to the initial (ZAMS) mass of the progenitor (Woosley & Weaver 1995, ApJS, 101, 181). Specifically, the strength of [O I]$\lambda\lambda$6300,6364 has been used as a direct indicator of progenitor mass. In Fig. 1 we show an example in comparing observations to model spectra produced from different progenitors: the strength of the [O I] line increases significantly 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. Additionally, 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, while strong progenitor constraints can be made on CCSNe using nebular phase spectra, there are still only a handful of events with such high-quality data, and 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). **Here, 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 plan to obtain MUSE nebular spectroscopy of 90 CCSNe (61 SN II, 10 IIn, 7 IIb, 5 Ib, 5 Ic, 1 Ic-BL, 1 SLSN-II) at the phase of ~1 year post explosion (at these epochs 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. In particular, with these data we will:

1) Directly compare observed spectra to the models in order to: **obtain progenitor mass estimates.** 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) Proceed to **characterise the overall observed diversity** in CCSN nebular spectra. This entails 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 recently discovered CCSNe that will be observable from Paranal in P100. 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 full MUSE data cubes will be exploited to **fully constrain the CCSN progenitor properties**, and contribute greatly to the fields of SN physics and stellar evolution.

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), and will have high legacy value. 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)

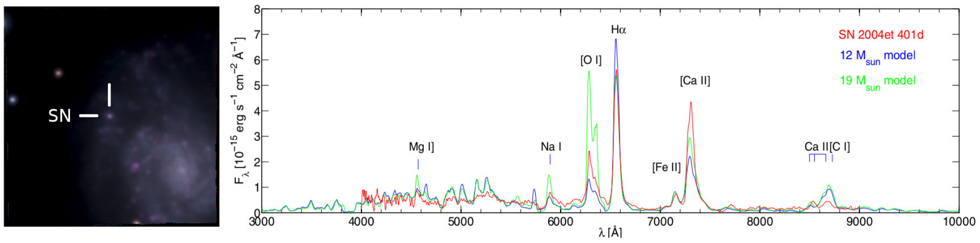

Fig. 1: *Left:* Synthesized RGB image of a MUSE galaxy with SN serendipitously observed at nebular phase. *Right:* Comparison of a nebular spectrum of SN 2004et with model spectra from distinct progenitor masses (Jerkstrand et al. 2012, A&A, 546, 28). The largest difference between models is seen in 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.

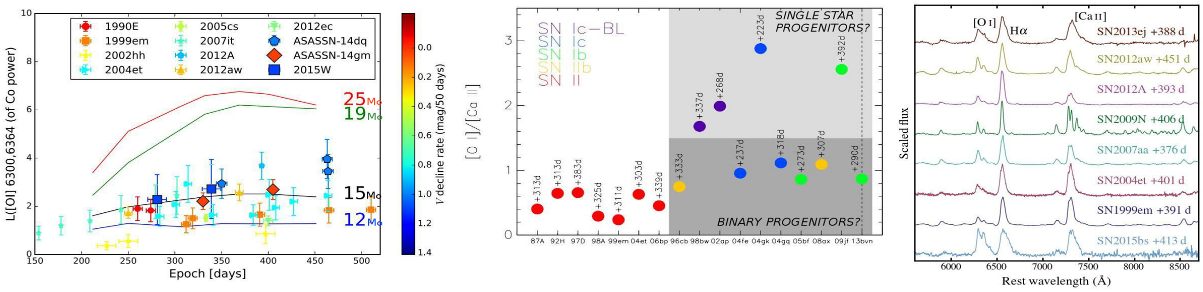

Fig. 2: *Left:* Comparison of the [O I] line flux relative to the ^{56}Co power evolution/individual measurements for a range of SNe II, as compared to the evolution of the same quantity as extracted from different models (Valenti et al. 2016, MNRAS, 459, 3939). *Middle:* The ratio of [O I] to [Ca II]λλ7291,7323 at nebular epochs between H-rich (SNe II) and H-poor SNe. This ratio has been used as a rough proxy for ZAMS progenitor mass. One observes diversity in the ratio, with generally higher values for the H-poor stripped-envelope CCSNe (however note the small statistics). 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 (at the time of Anderson et al. in prep) 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 stringent constrains 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 target list of 90 SNe therefore equates to a total time request of 90 hours. Two of the host galaxies within our target list are large and have produced multiple SNe (5 and 3 SNe each), therefore an additional mosaic observation is requested to cover the extent of the galaxies. This would require 9 MUSE pointings, which equates to 9 hours of observation and a total time for our program, 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.

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 larger survey with MUSE that has been running successfully since 2015 (095.D-0091, 096.D-0296, 097.D-0408, 098.D-0115, 099.D-0022). 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, arXiv:1702.05430) has already been published/accepted. A large number of other papers is in preparation, covering many different 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 usefulness of the data obtained in this survey. Future public data releases from this survey are planned; parts of the data have been critical in education activities (a number of PhD projects, also Harvard-Chile Data Science School: www.hcds.cl). The members of the proposing team are also frequent users of other ESO facilities in many different projects (296.D-5003; 097.D-0404; 098.D-0416; 099.D-0043; and specifically related to the science pursued in this proposal: 098.D-0103, FORS2 late-time spectroscopy of H-poor SNe), with an excellent publication record (see Box 10).

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

Krühler, T. et al., 2017, A&A accepted: Hot gas around SN 1998bw - Inferring the progenitor from its environment (arXiv:1702.05430)

Galbany, L. et al. 2017, MNRAS in press: Molecular gas at supernova local environments unveiled by EDGE (arXiv:1702.02945)

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	2016eob	00:03:07.120	-01:54:42.10	1			SN II	
A	2016egz	00:04:03.850	-34:48:51.87	1			SN II	
A	2016gft	01:21:44.060	-11:46:10.22	1			SN II	
A	2016hgm	01:22:11.730	+00:57:07.78	1			SN II	
A	2016cyw	01:25:56.250	+16:35:43.72	1			SN IIP	
A	2016gkg	01:34:14.460	-29:26:25.00	1			SN IIb	
A	2016fmt	01:34:50.520	+21:24:58.30	1			SN IIP	
A	2016ezh	01:58:04.740	-00:52:21.74	1			SLSN-II	
A	2016jga	02:05:38.640	-59:47:58.96	1			SN II	
A	2016hkn	02:08:34.230	+29:14:11.10	1			SN IIb	
A	2016ecm	02:20:14.515	-40:53:05.14	1			SN II	
A	2016cyx	02:21:22.767	+16:33:54.56	1			SN II	
A	2016cqk	02:38:54.680	-14:18:16.80	1			SN IIP	
A	2016gsd	02:40:34.440	+19:16:59.90	1			SN II	
A	2016hbd	02:56:06.210	+27:42:06.80	1			SN IIP	
A	2016exv	03:39:34.382	+20:42:30.42	1			SN IIb	
A	2016iae	04:12:05.530	-32:51:44.75	1			SN Ic	
A	2016hmq	04:25:04.920	-07:33:56.22	1			SN II	
A	2017pn	04:46:24.590	-11:59:18.25	1			SN IIP	
A	2016fqb	04:49:12.682	-62:21:40.93	1			SN IIP	
A	2016eso	04:59:30.040	-28:51:39.17	1			SN IIn	
A	2017auf	05:02:19.560	-10:21:22.86	1			SN IIP	
A	AT2016hwz	05:39:08.83	-70:37:13.6	1			SN II	
A	2016emw	05:40:53.990	-12:14:35.81	1			SN II	
A	2016iaf	05:47:04.800	-25:46:13.71	1			SN IIn	
A	2016bfv	05:51:18.06	-38:18:53.2	1			SN II	
A	2016iyz	05:52:37.430	-17:47:13.02	1			SN IIP	
A	2016blx	05:52:59.98	-17:51:44.2	1			SN II	
A	AT2016jbu	07:36:25.955	-69:32:55.26	5			SN IIn	
A	2016iyd	07:37:09.760	-52:19:04.19	1			SN II	
A	2016bas	07:38:05.53	-55:11:47.0	1			SN IIb	
A	2016iye	07:45:19.720	-71:24:17.90	1			SN IIb	
A	2016bla	07:45:26.94	+29:53:27.5	1			SN IIP	
A	2016bev	07:47:50.21	-18:44:12.8	1			SN IIP	
A	2016bll	08:33:18.30	+19:20:44.8	1			SN Ib	

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Target Notes: The above target list a total of 90 CCSNe that will be observable in P100 from Paranal. In addition, for two targets (AT2016jbu and 2016cok) we will obtain mosaic observations in order to observe the full extent of host galaxies and hence complete all of our science aims.

12. Scheduling requirements

13. Instrument configuration

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

6b. Co-investigators:

…continued from Box 6a.

E.	Aquino	ESO Office Santiago,ESO
M.C.	Bersten	Instituto de Astrofisica de La Plata (IALP), CONICET-UNLP,AR
L.	Dessart	Universidad de Chile,Cerro Calan,CL
J.	Falcón-Barroso	Instituto de Astrofisica de Canarias, Headquarters,E
G.	Folatelli	Instituto de Astrofisica de La Plata (IALP), CONICET-UNLP,AR
F.	Förster	Universidad de Chile,Cerro Calan,CL
S.	González-Gaitán	Universidad de Chile,Cerro Calan,CL
C.	Gutiérrez	School of Physics and Astronomy,University of Southampton,UK
P.	James	Astrophysics Research Institute,Liverpool John Moores University,UK
T.	Kangas	Finnish Centre for Astronomy with ESO (FINCA),FI
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
P.	Lundqvist	Stockholm University,Stockholm Observatory,S
J.	Lyman	University of Warwick,UK
K.	Maeda	Kyoto University,Department of Astronomy,JP
S.	Mattila	Finnish Centre for Astronomy with ESO (FINCA),FI
K.	Nomoto	University of Tokyo,Institute for the Physics and Mathematics of the Universe (IPMU),JP
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	Instututo Nacional de Astrofisica Optica y Electronica (INAOE),MX
T.	Ruiz-Lara	Instituto de Astrofisica de Canarias, Headquarters,E
L.	Sánchez-Menguiano	Universidad de Granada,Departamento de Fisica Teorica y del Cosmos,,E
S.	Schulze	The Weizmann Institute of Science,IL
K.	Takats	Universidad Andres Bello,CL

11a. List of targets proposed in this programme

…continued from box 11.

Run	Target/Field	α(J2000)	δ(J2000)	ToT	Mag.	Diam.	Additional info	Reference star
A	2017zg	09:41:54.490	+01:19:08.43	1			SN II	
A	2016dzw	09:52:51.20	-11:22:20.0	1			SN II	
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	2016idl	10:06:29.130	+22:26:43.80	1			SN IIn	
A	2017ahn	10:37:17.450	-41:37:05.27	1			SN II	
A	2016iyk	10:41:06.400	+06:31:42.89	1			SN II	
A	2016jby	10:52:25.890	+10:32:38.20	1			SN II	
A	2016cok	11:20:19.100	+12:58:56.01	6			SN IIP	
A	2017byz	11:23:30.780	-08:39:11.84	1			SN II	
A	2016bsb	11:34:27.63	+11:41:55.1	1			SN II	
A	2016blb	11:37:20.64	-04:54:36.8	1			SN IIP	
A	2016ase	11:42:34.65	-25:54:45.2	1			SN II	
A	2017cjd	11:50:30.17	-18:35:44.96	1			SN Ic	
A	2016hwn	12:04:16.881	+21:48:01.84	1			SN II	
A	2016cyj	12:06:57.585	+27:18:04.93	1			SN IIn	
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	2016ios	12:28:52.644	-11:38:59.71	1			SN II	
A	2016cdd	12:31:53.640	-51:44:50.83	1			SN Ib	
A	2017hk	12:45:15.310	+26:05:07.10	1			SN IIP	
A	2017cjb	12:53:50.45	+09:42:17.70	1			SN II	
A	2016jfu	12:54:42.600	+28:56:26.00	1			SN IIP	
A	2016cyk	13:02:44.260	-26:56:26.81	1			SN II	
A	2016aiy	13:08:25.40	-41:58:50.1	1			SN IIn	
A	2017bzm	13:15:04.160	-24:48:05.48	1			SN IIn	
A	SMT16atf	13:29:55.90	-32:08:26.5	1			SN II	
A	2016cce	13:33:27.20	+05:28:57.8	1			SN Ic	
A	2016ccm	14:09:58.91	+17:45:49.4	1			SN IIP	
A	2016blt	14:15:45.76	-47:38:15.0	1			SN IIb	
A	2016jag	15:23:19.790	-04:09:19.50	1			SN Ib	
A	2016afa	15:36:32.47	+16:36:36.7	1			SN II	
A	2016blz	15:40:29.23	+00:54:36.4	1			SN II	
A	2016bkj	15:59:38.96	+19:05:05.0	1			SN Ib	
A	2016cyr	17:06:27.540	+21:32:53.18	1			SN IIP	
A	2016brw	17:08:26.60	+25:30:51.5	1			SN II	
A	AT2017bif	17:26:27.119	-60:32:39.73	1			SN II	
A	2016bmi	18:34:32.19	-58:31:44.8	1			SN II	
A	2016hbb	18:35:47.170	+22:28:30.36	1			SN II	
A	2016css	20:16:53.440	-36:59:42.00	1			SN IIP	
A	2016gsk	20:41:09.960	-05:05:58.25	1			SN Ic	
A	2016grk	21:19:41.310	+21:57:56.30	1			SN II	
A	2016ieq	21:22:25.187	-11:56:54.82	1			SN IIn	
A	2016cpx	21:53:23.360	-68:57:11.30	1			SN IIP	
A	2016hpt	21:54:36.580	-42:51:01.98	1			SN II	
A	2016coi	21:59:04.140	+18:11:10.46	1			SN Ic-BL	
A	2016iyc	22:09:14.280	+21:31:17.51	1			SN IIb	
A	2016cvk	22:19:49.390	-40:40:03.20	1			SN IIn	
A	2016goj	22:33:13.730	-40:38:35.85	1			SN II	
A	2016hvu	22:35:55.560	+20:19:12.58	1			SN IIP	

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.							
A	2016dyn	22:37:45.42	+23:47:13.9	1			SN Ic	
A	2016enp	23:34:25.290	-06:34:42.29	1			SN II	
A	2016jgr	23:42:37.080	-45:41:24.72	1			SN IIn	
A	2016exa	23:47:03.840	-01:43:41.76	1			SN II	
A	2016cqj	23:56:13.740	-00:32:28.44	1			SN II	