European Organisation for Astronomical Research in the Southern Hemisphere
Observing Programmes Office • Karl-Schwarzschild-Strasse 2 • D-85748 Garching bei München • email: opo@eso.org • Tel: +49 89 3200 6473

Cycle: P111
Type: Normal
Status: Valid
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APPLICATION FOR OBSERVING TIME **111.24VQ**

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.

Environment constraints on supernovae Ibn: high or low mass progenitors?

ABSTRACT

Type Ibn supernovae (SNeIbn) are a rare type of stellar explosion, which are surrounded by a He-rich circumstellar medium (CSM) that is interacting with the SN ejecta. The stellar evolutionary paths to produce a helium-rich CSM is unclear. Thus, the study of SNeIbn can both constrain their explosion but also elucidate the origin of strong mass loss in the latter stages of stellar evolution. SNeIbn evolve fast making detailed observations of the events themselves challenging. Here we request MUSE observations of their host galaxies (once the SNe have faded) to constrain their progenitor properties. Observations of SNIbn hosts to date have revealed that some events appear to be associated with old stellar populations - bringing doubt to their assumed massive-star progenitors. We will observe all SNIbn hosts visible from Paranal to enable a statistically significant analysis of their environments, proceeding strong constraints on progenitor dependence on initial mass and metallicity.

SCIENTIFIC KEYWORDS

galaxies: ISM, galaxies: star formation, galaxies: stellar content, ISM: abundances, stars: supernovae

RUNS

Run	Period	Instrument	Tel. Setup	Constraints	Mode	Type	Propr. Time	Time Constr.	Req. Time
111.24VQ.001 • Run 1	111	MUSE	UT4	FLI: 100% • Turb.: 100% • pwv: 30.0mm • Sky: Variable, thin cirrus	SM	Normal	12m	×	54h00m

AWARDED AND FUTURE TIME REQUESTS

Time already awarded to this project

- none -

Future time requests to complete this project

- none -

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.

DESCRIPTION OF THE PROPOSED PROGRAMME

A- Scientific Rationale

Supernovae (SNe) are the end states of stellar evolution. SNe with massive progenitors are classified as core-collapse (CC) SNe and are subdivided into categories based on the presence or absence of elements (e.g. H-rich type II, H-poor type Ib and H/He-poor type Ic). Type Ibn SNe exhibit narrow emission lines of helium, which is interpreted as SN ejecta interacting with He-rich circumstellar medium (CSM).

The progenitors of CCSNe are still not well understood, but they are generally thought to be massive stars. With type Ibn SNe the discussion is still ongoing. The prototypical type Ibn SN, SN2006jc, had a luminous eruption two years prior to the SN explosion (1). It was originally hypothesised to be an exploding Luminous Blue Variable (LBV) or another type of star with a LBV companion, but later follow-up showed that a normal supergiant was still present at the SN location, excluding an LBV companion (2).

In other type Ibn SNe the progenitor has been thought to be a single evolved WR where the He-rich CSM has been produced by high mass-loss winds (3). While WR stars exhibit mass-loss rates up to 10^{-4} $M_{\odot}$, they might not be enough to explain the required dense CSM. Therefore, for some type Ibn SNe it has been suggested that the progenitor could be a close binary system, where the SN progenitor is stripped of its outer layers by the companion through Roche-lobe overflow. This interaction has been proposed to be the mechanism with SN2015G, where a non-detection of the SN progenitor in archival data excluded the possibility of a WR progenitor (4).

In contrast to these progenitor channels, some type Ibn SNe might also come from non-massive stars. PS1-12sk was a type Ibn SN that exploded in an elliptical galaxy (5) **(Fig. 1)**. These galaxies have have very little massive star formation, suggesting that the progenitor was an older progenitor system, possibly including a white dwarf (6). Similarly SN2020bqj exploded in a faint low-mass galaxy with no star formation (7). Due to the number of various suggested progenitor channels, it may be that type Ibn SNe have several different types of progenitors and stars at the lower CCSNe mass range might be more likely to produce type Ibn SNe (8).

Previously, SN hosts have been studied to constrain SN progenitors of other types of CCSNe (9, 10, 11). Because CCSNe are produced by short-lived massive stars, they can still be considered to be associated to their immediate environment at the moment of explosion. It has been shown that stars with larger initial masses tend to be associated with regions of recent star-formation (12). This has previously been used to infer a progenitor mass sequence for CCSNe (13). By studying the hosts of type Ibn SNe, we can similarly study their association to the hosts' star-forming region. This will allow us to infer if the SNe are more likely to be product of binary interactions of lower mass stars or single massive stars with high mass-loss rates.

B- Immediate Objective

We propose to build a sample of type Ibn SN host galaxy observations with MUSE. All of the target SNe have already faded below detection limits (>21 mag in optical bands), leaving only their host galaxies visible. The proposed sample includes all current hosts of type Ibn SNe visible from Paranal. This will allow us to study the host galaxy, constrain mass and metallicity estimates from the environments, and statistically infer any preferance to certain environments. Specifically, we will:

1) **Estimate progenitor masses** by measuring the Ha equivalent width (EW) of the environment. HaEW directly correlates with environment's stellar population age and allows us to constrain a minimum and maximum age of the progenitor star. This in turn is related to the initial mass of the progenitor.

2) **Study the distribution of Ha and HaEW emission in the galaxy**. Ha emission is an indication of recent star formation and is produced by ionizing photons by high-mass stars. By evaluating the SN location's Ha emission against the whole galaxy we will infer if the immediate environment of the SN is undergoing star formation. With larger sample of galaxies we will deduce if this SN type has statistically significant association with star formation and high-mass stars.

3) **Study the metallicity of the environments**. By using strong line diagnostics, e.g. O3N2, we will measure the metallicity distribution of the host galaxy. Metallicity has an implication to the late-time mass loss of massive stars through stellar winds. Type Ibn SNe require high mass losses to strip the H-rich outer layer of the progenitor and to produce the He-rich CMS. This requirement coupled with metallicity will give us an implication if the stripping is more likely due to winds or binary interactions.

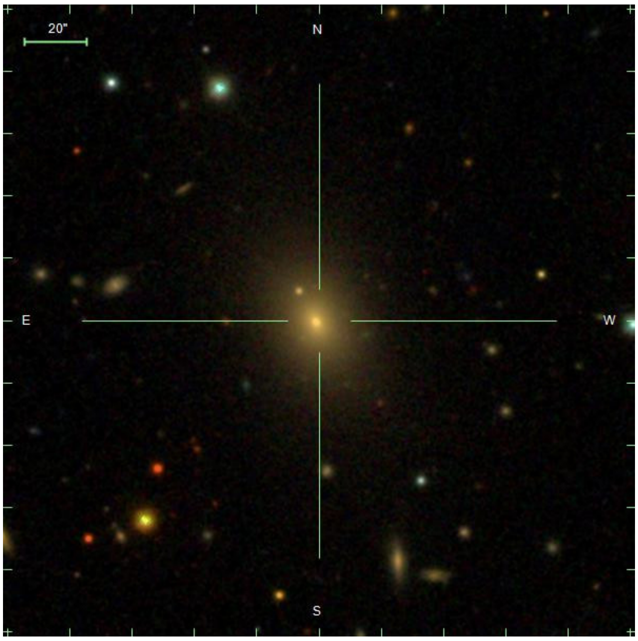
4) **Measure the ionization parameter of the environments** with strong line diagnostics that use lines visible in MUSE spectral range. Recent star formation affects the degree of ionization of the gas in environment. As such, we will use it to indicate locations of dense star formation in the galaxies.

5) **Estimate population ages of the environments from the continuum emission**. Every extracted spectrum of the host galaxy will be processed to separate the stellar continuum and gas emission components by fitting

simple stellar population models of different ages to it **(Fig. 2)**. Gas emission spectrum will be used in previous analyses, but the stellar continuum will also give us an alternative method to estimate the age of the population.

Finally, we can compare the environmental properties of SNeIbn to those of other SN types where significant numbers of MUSE observations already exist in the archive. Thus, we will provide strong constraints on whether the dominant progenitor channel for SNeIbn is high-mass or lower mass massive stars, thus additionally putting constraints on the stellar evolutionary channels required to produce stellar explosions into dense helium rich CSM.

Figures



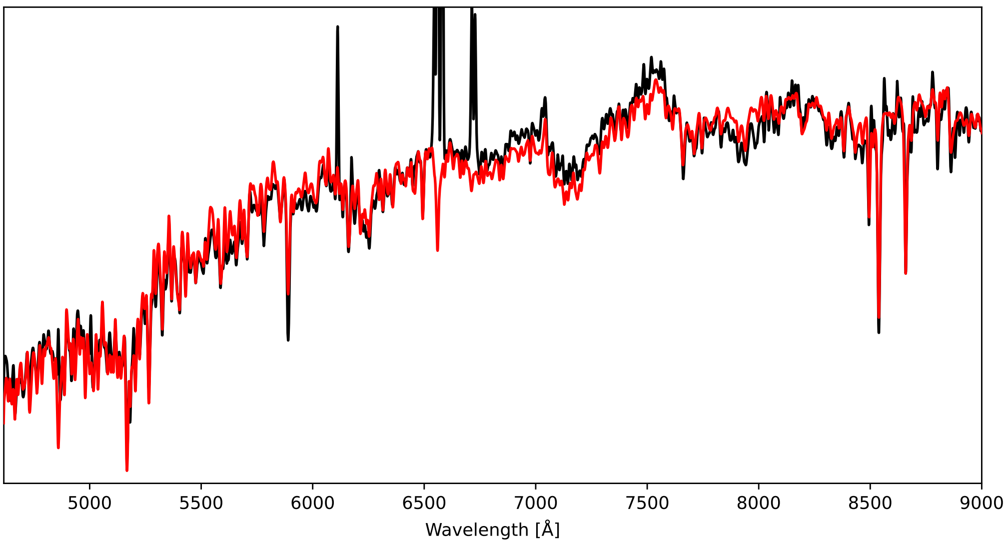


Fig.1 (Top) Host of SN PS1-12sk, an elliptical galaxy with very low star formation. **Fig.1** (Bottom) MUSE spectrum of an environment in a galaxy (black) and a simple stellar population fit (red).

References

1. Pastorello, A., et al. (2007), Nature, 447, 829 **2.** Maund, J. R., et al. (2016), ApJ, 833, 128 **3.** Pastorello, A., et al. (2015), MNRAS, 449, 1921 **4.** Shivvers, I., et al. (2017), MNRAS, 471, 4381 **5.** Sanders, N. E., et al. (2013), ApJ, 769, 39 **6.** Hosseinzadeh, G., et al. (2019), ApJL, 871, L9 **7.** Kool, E. C., et al. (2021), A&A, 652, A136 **8.** Dessart, L., Hillier, D. John, & Kuncarayakti, H. (2022), A&A, 658, A130 **9.** Kuncarayakti, H., et al. (2013), AJ, 146, 30K **10.** Kuncarayakti, H., et al. (2013), AJ, 146, 31K **11.** Galbany, L., et al. (2018), ApJ, 855, 107G **12.** Kangas, T., et al. (2017), A&A, 597A, 92K **13.** Anderson, J., et al. (2012), MNRAS, 424, 1372A

TARGETS

Name	RA	Dec	Coord	Runs	Comment
SN 2019iep	00:06:18.630	+25:27:45.51	J2000	1	
V=15					
OGLE 2014-SN-131	01:14:00.81	-77:06:16.5	J2000	1	
V=15					
SN 2018fmt	01:21:00.873	-13:51:46.65	J2000	1	
V=15					
SN 2018gjx	02:16:15.55	+28:35:28.7	J2000	1	
V=15					
SN 2000er	02:24:32.54	-58:26:17.988	J2000	1	
V=15					
PS 15dpn	02:32:59.75	+18:38:07.0	J2000	1	
V=15					
OGLE-2012-SN-006	03:33:34.8	-74:23:40.2	J2000	1	
V=15					
SN 2020big	05:01:15.822	-14:01:28.08	J2000	1	
V=15					
SN 2022eux	05:55:31.230	-15:40:34.25	J2000	1	
V=15					
SN 2022qhy	06:01:08.920	-23:39:59.83	J2000	1	
V=15					
SN 2020cwd	06:06:59.081	-49:00:23.94	J2000	1	
V=15					
SN 2018jmt	06:54:47.100	-59:30:10.80	J2000	1	
V=15					
SN 2017iwp	07:01:44.710	-55:18:20.02	J2000	1	
V=15					
SN 2015U	07:28:53.87	+33:49:10.6	J2000	1	
V=15					
SN 2019twa	07:52:06.352	+24:20:18.98	J2000	1	
V=15					
SN 2021dps	08:00:54.091	-02:13:38.46	J2000	1	
V=15					
SN 2016Q	08:10:19.860	+19:26:48.20	J2000	1	
V=15					
SN 2010al	08:14:15.9	+18:26:18.204	J2000	1	
V=15					
LSQ12btw	10:10:28.82	+05:32:12.48	J2000	1	
V=15					
SN 2021iyt	10:18:44.410	+00:03:19.43	J2000	1	
V=15					
SN 2021abcw	10:35:45.330	+21:03:19.33	J2000	1	
V=15					
SN 2021bbv	11:30:20.830	+08:55:34.68	J2000	1	
V=15					
SN 2020iic	11:44:57.390	-02:30:27.00	J2000	1	

Name	RA	Dec	Coord	Runs	Comment
V=15					
SN 2022gzg	12:43:37.526	+01:23:03.78	J2000	1	
V=15					
SN 2005la	12:52:15.68	+27:31:52.5	J2000	1	
V=15					
SN 2017jfv	13:38:25.350	-31:15:52.70	J2000	1	
V=15					
SN 2014bk	13:54:02.42	+20:00:24.3	J2000	1	
V=15					
SN 2019deh	14:05:43.577	+09:30:56.77	J2000	1	
V=15					
iPTF14aki	14:20:41.73	+03:16:01.29	J2000	1	
V=15					
SN 2002ao	14:29:35.74	-00:00:55.8	J2000	1	
V=15					
SN 2019lsm	14:35:02.553	+14:46:36.85	J2000	1	
V=15					
SN 2021jpk	14:39:00.027	+12:40:10.03	J2000	1	
V=15					
SN 2022pff	15:11:58.017	+32:50:29.68	J2000	1	
V=15					
SN 2020bqj	15:33:40.482	+34:28:44.20	J2000	1	
V=15					
iPTF13beo	16:12:26.63	+14:19:17.976	J2000	1	
V=15					
SN 2019ltw	16:18:38.54	+21:58:22.9	J2000	1	
V=15					
SN 2016edk	17:47:14.200	+30:13:29.30	J2000	1	
V=15					
SN 2020cws	17:56:49.6	-41:48:42.55	J2000	1	
V=15					
SN 2021zfx	21:09:23.743	+09:45:39.20	J2000	1	
V=15					
SN 2019rii	21:22:41.869	+22:52:54.83	J2000	1	
V=15					
LSQ13ccw	21:35:51.648	-18:32:52.08	J2000	1	
V=15					
SN 2019kbj	22:11:21.930	+19:37:03.48	J2000	1	
V=15					
SN 2020taz	22:26:06.270	+10:33:29.65	J2000	1	
V=15					
SN 2011hw	22:26:14.54	+34:12:59.112	J2000	1	
V=15					
PTF11rfh	22:35:49.58	-00:22:26.141	J2000	1	
V=15					
SN 2020nxt	22:37:36.235	+35:00:07.68	J2000	1	
V=15					

Target Notes

- none -

REMARKS & JUSTIFICATIONS

Lunar Phase and Constraints Justification

Please justify here the requested lunar phase and other observing constraints.

This proposal is intended as a filler, so the constraints are intentionally very loose.

Time Justification

Please describe here a detailed computation of the necessary time to execute the observations, including time-critical aspects if any. Parameters used in the ETC should be mentioned so the computation can be reproduced.

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 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 a ‘filler’ proposal we set conditions to 7 days from new moon with an airmass of 1.5 and seeing 1.5″. In order to remove the edges of each IFU on the detector (artifacts of the image slicer) it is best to combine observations with all four 90 degree angles. With 4×700 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 of stellar populations, using absorption line indices as an indicator of stellar metallicities in place of the gas phase values, for the small number of elliptical galaxies expected in our sample. This totals roughly 1 hr per galaxy. Most galaxies in our sample are covered by one MUSE pointing, with six exceptions, so we require 54 h to observe our sample of 46 host galaxies. We have previously obtained MUSE data with very similar conditions/observing strategy to that outlined above, and with the above exposure times we are able to make the necessary measurements. We have already published several papers based on these data (see publications section). Our team has experts on the reduction, analysis and interpretation of IFS galaxy observations, 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. These data will remain in the archive as a legacy for future extragalactic studies.

Telescope Justification

Please justify why the telescope requested is the best choice for this programme.

MUSE at the VLT is the only currently available instrument 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 resolutions, and being extremely efficient, hence enabling targets to be observed in a relatively small amount of time.

Observing Mode Justification

Please justify the choice of SM, VM or dVM.

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

Calibration Request

If you need any special calibration not included in the instrument calibration plan, please specify it here.

Standard calibration

Duplication with ESO Science Archive

If observations of the same target(s) using the same instrument(s) already exist in the ESO archive, please justify why this programme requests further observations.

None of the host galaxies have been previously observed with MUSE.

GTO Target Duplication Justification

If an instrument GTO team aims at the same target(s), please justify why this programme requests further observations.

n/a

Background and Expertise

Short description of the background, expertise and roles of the various team members in the context of the science case discussed in the proposal. For small teams the applicants may wish to provide a sentence for the qualifications of each member, while for larger teams (e.g. in Large Programmes), only the leading roles need to be specified.

PI Kravtsov works with type Ibn observations and SN host galaxy analysis. CoI Anderson specializes in core-collapse SNe and is an experienced FORS2 observer. CoI Kuncarayakti has previously on nebular late-time observations of SNe, constraining progenitor parameters through emission line diagnostics. CoI Mattila is experienced in type Ibn SNe from several papers on SN2006jc. CoIs Lyman, Galbany and Pessi specialize in SN host galaxy analysis.

REPORT ON PREVIOUS USAGE OF ESO FACILITIES

Run	PI	Instrument	Time	Mode	Comment
0104.D-0503(A)	Joseph Anderson	MUSE	50.0h	Service	Data reduced, several papers in preparation.

The All-weather MUse Supernova Integral field Nearby Galaxies (AMUSING) survey X: star formation in low-mass galaxies as traced by extra-galactic transients

RECENT PI/CoIs PUBLICATIONS MOST RELEVANT TO THE SUBJECT OF THIS PROPOSAL

1. Lyman, J. D., Galbany, L., Sánchez, S. F., et al. (2020) "Studying the environment of AT 2018cow with MUSE," MNRAS, 495, 992-999 - 2020MNRAS.495..992L
2. Brennan, S. J., Fraser, M., Johansson, J., et al. (2022) "Progenitor, environment, and modelling of the interacting transient AT 2016jbu (Gaia16cfr)," MNRAS, 513, 5666-5685 - 2022MNRAS.513.5666B
3. Srivastav, S., Smartt, S. J., Huber, M. E., et al. (2022) "SN 2020kyg and the rates of faint Iax supernovae from ATLAS," MNRAS, 511, 2708-2731 - 2022MNRAS.511.2708S

INVESTIGATORS

Timo Kravtsov, Turun yliopisto, Finland (PI)
Joseph Anderson, ESO Chile, ESO
Hanindyo Kuncarayakti, Turun yliopisto, Finland
Seppo Mattila, Turun yliopisto, Finland
Lluis Galbany, Institut d'Estudis Espacials de Catalunya - Barcelona, Spain
Joseph Lyman, University of Warwick, United Kingdom
Thallis Pessi, Universidad Diego Portales, Chile

OBSERVATIONS

In the table below, the repeat factor is applied to the complete observation on that target, including its overhead.

✔ The PI acknowledged that all the telescope times listed below include overheads.

Run 111.24VQ.001 • Run 1 • P111 • MUSE • SM — Tel. Time: 54h00m

FLI: 100% • Turb.: 100% • pwv: 30.0mm • Sky: Variable, thin cirrus • Airmass: 1.5

Target • OGLE 2014-SN-131 • 01:14:00.81 • -77:06:16.5 — Tel. Time: 01h00m

OS 1	WFM-NOAO	Observation
Tel. Time: 3600 s	Instrument Mode: WFM-NOAO-N	Integration Time: 0 s
Repeat: 1 x	Telescope Overheads: 360 s	Instrument Overheads: 0 s
Total Tel. Time: 3600s		Signal/Noise: 0.0

Target • SN 2018jmt • 06:54:47.100 • -59:30:10.80 — Tel. Time: 01h00m

OS 1	WFM-NOAO	Observation
Tel. Time: 3600 s	Instrument Mode: WFM-NOAO-N	Integration Time: 0 s
Repeat: 1 x	Telescope Overheads: 360 s	Instrument Overheads: 0 s
Total Tel. Time: 3600s		Signal/Noise: 0.0

Target • SN 2017iwp • 07:01:44.710 • -55:18:20.02 — Tel. Time: 01h00m

OS 1	WFM-NOAO	Observation
Tel. Time: 3600 s	Instrument Mode: WFM-NOAO-N	Integration Time: 0 s
Repeat: 1 x	Telescope Overheads: 360 s	Instrument Overheads: 0 s
Total Tel. Time: 3600s		Signal/Noise: 0.0

Target • SN 2020cwd • 06:06:59.081 • -49:00:23.94 — Tel. Time: 01h00m

OS 1	WFM-NOAO	Observation
Tel. Time: 3600 s	Instrument Mode: WFM-NOAO-N	Integration Time: 0 s
Repeat: 1 x	Telescope Overheads: 360 s	Instrument Overheads: 0 s
Total Tel. Time: 3600s		Signal/Noise: 0.0

Target • SN 2017jfv • 13:38:25.350 • -31:15:52.70 — Tel. Time: 01h00m

OS 1	WFM-NOAO	Observation
Tel. Time: 3600 s	Instrument Mode: WFM-NOAO-N	Integration Time: 0 s
Repeat: 1 x	Telescope Overheads: 360 s	Instrument Overheads: 0 s
Total Tel. Time: 3600s		Signal/Noise: 0.0

Target • SN 2022qhy • 06:01:08.920 • -23:39:59.83 — Tel. Time: 04h00m

OS 1	WFM-NOAO	Observation
Tel. Time: 3600 s	Instrument Mode: WFM-NOAO-N	Integration Time: 0 s
Repeat: 4 x	Telescope Overheads: 360 s	Instrument Overheads: 0 s
Total Tel. Time: 04h00m		Signal/Noise: 0.0

Target • SN 2022eux • 05:55:31.230 • -15:40:34.25 Tel. Time: 01h00m

OS 1	WFM-NOAO	Observation
Tel. Time: 3600 s	Instrument Mode: WFM-NOAO-N	Integration Time: 0 s
Repeat: 1 x	Telescope Overheads: 360 s	Instrument Overheads: 0 s
Total Tel. Time: 3600s		Signal/Noise: 0.0

Target • SN 2020big • 05:01:15.822 • -14:01:28.08 Tel. Time: 01h00m

OS 1	WFM-NOAO	Observation
Tel. Time: 3600 s	Instrument Mode: WFM-NOAO-N	Integration Time: 0 s
Repeat: 1 x	Telescope Overheads: 360 s	Instrument Overheads: 0 s
Total Tel. Time: 3600s		Signal/Noise: 0.0

Target • SN 2018fmt • 01:21:00.873 • -13:51:46.65 Tel. Time: 01h00m

OS 1	WFM-NOAO	Observation
Tel. Time: 3600 s	Instrument Mode: WFM-NOAO-N	Integration Time: 0 s
Repeat: 1 x	Telescope Overheads: 360 s	Instrument Overheads: 0 s
Total Tel. Time: 3600s		Signal/Noise: 0.0

Target • SN 2020iic • 11:44:57.390 • -02:30:27.00 Tel. Time: 01h00m

OS 1	WFM-NOAO	Observation
Tel. Time: 3600 s	Instrument Mode: WFM-NOAO-N	Integration Time: 0 s
Repeat: 1 x	Telescope Overheads: 360 s	Instrument Overheads: 0 s
Total Tel. Time: 3600s		Signal/Noise: 0.0

Target • SN 2021dps • 08:00:54.091 • -02:13:38.46 Tel. Time: 01h00m

OS 1	WFM-NOAO	Observation
Tel. Time: 3600 s	Instrument Mode: WFM-NOAO-N	Integration Time: 0 s
Repeat: 1 x	Telescope Overheads: 360 s	Instrument Overheads: 0 s
Total Tel. Time: 3600s		Signal/Noise: 0.0

Target • SN 2021iyt • 10:18:44.410 • +00:03:19.43 Tel. Time: 01h00m

OS 1	WFM-NOAO	Observation
Tel. Time: 3600 s	Instrument Mode: WFM-NOAO-N	Integration Time: 0 s
Repeat: 1 x	Telescope Overheads: 360 s	Instrument Overheads: 0 s
Total Tel. Time: 3600s		Signal/Noise: 0.0

Target • SN 2022gzg • 12:43:37.526 • +01:23:03.78 Tel. Time: 01h00m

OS 1	WFM-NOAO	Observation
Tel. Time: 3600 s	Instrument Mode: WFM-NOAO-N	Integration Time: 0 s
Repeat: 1 x	Telescope Overheads: 360 s	Instrument Overheads: 0 s
Total Tel. Time: 3600s		Signal/Noise: 0.0

Target • SN 2021bbv • 11:30:20.830 • +08:55:34.68 Tel. Time: 01h00m

OS 1	WFM-NOAO	Observation
Tel. Time: 3600 s	Instrument Mode: WFM-NOAO-N	Integration Time: 0 s
Repeat: 1 x	Telescope Overheads: 360 s	Instrument Overheads: 0 s
Total Tel. Time: 3600s		Signal/Noise: 0.0

Target • SN 2019deh • 14:05:43.577 • +09:30:56.77 Tel. Time: 01h00m

OS 1	WFM-NOAO	Observation
Tel. Time: 3600 s	Instrument Mode: WFM-NOAO-N	Integration Time: 0 s
Repeat: 1 x	Telescope Overheads: 360 s	Instrument Overheads: 0 s
Total Tel. Time: 3600s		Signal/Noise: 0.0

Target • SN 2021zfx • 21:09:23.743 • +09:45:39.20 Tel. Time: 01h00m

OS 1	WFM-NOAO	Observation
Tel. Time: 3600 s	Instrument Mode: WFM-NOAO-N	Integration Time: 0 s
Repeat: 1 x	Telescope Overheads: 360 s	Instrument Overheads: 0 s
Total Tel. Time: 3600s		Signal/Noise: 0.0

Target • SN 2020taz • 22:26:06.270 • +10:33:29.65 Tel. Time: 01h00m

OS 1	WFM-NOAO	Observation
Tel. Time: 3600 s	Instrument Mode: WFM-NOAO-N	Integration Time: 0 s
Repeat: 1 x	Telescope Overheads: 360 s	Instrument Overheads: 0 s
Total Tel. Time: 3600s		Signal/Noise: 0.0

Target • SN 2021jpk • 14:39:00.027 • +12:40:10.03 Tel. Time: 01h00m

OS 1	WFM-NOAO	Observation
Tel. Time: 3600 s	Instrument Mode: WFM-NOAO-N	Integration Time: 0 s
Repeat: 1 x	Telescope Overheads: 360 s	Instrument Overheads: 0 s
Total Tel. Time: 3600s		Signal/Noise: 0.0

Target • SN 2019lsm • 14:35:02.553 • +14:46:36.85 Tel. Time: 01h00m

OS 1	WFM-NOAO	Observation
Tel. Time: 3600 s	Instrument Mode: WFM-NOAO-N	Integration Time: 0 s
Repeat: 1 x	Telescope Overheads: 360 s	Instrument Overheads: 0 s
Total Tel. Time: 3600s		Signal/Noise: 0.0

Target • PS 15dpn • 02:32:59.75 • +18:38:07.0 Tel. Time: 01h00m

OS 1	WFM-NOAO	Observation
Tel. Time: 3600 s	Instrument Mode: WFM-NOAO-N	Integration Time: 0 s
Repeat: 1 x	Telescope Overheads: 360 s	Instrument Overheads: 0 s
Total Tel. Time: 3600s		Signal/Noise: 0.0

Target • SN 2016Q • 08:10:19.860 • +19:26:48.20 Tel. Time: 01h00m

OS 1	WFM-NOAO	Observation
Tel. Time: 3600 s	Instrument Mode: WFM-NOAO-N	Integration Time: 0 s
Repeat: 1 x	Telescope Overheads: 360 s	Instrument Overheads: 0 s
Total Tel. Time: 3600s		Signal/Noise: 0.0

Target • SN 2019kbj • 22:11:21.930 • +19:37:03.48 Tel. Time: 01h00m

OS 1	WFM-NOAO	Observation
Tel. Time: 3600 s	Instrument Mode: WFM-NOAO-N	Integration Time: 0 s
Repeat: 1 x	Telescope Overheads: 360 s	Instrument Overheads: 0 s
Total Tel. Time: 3600s		Signal/Noise: 0.0

Target • SN 2021abcw • 10:35:45.330 • +21:03:19.33 Tel. Time: 02h00m

OS 1	WFM-NOAO	Observation
Tel. Time: 3600 s	Instrument Mode: WFM-NOAO-N	Integration Time: 0 s
Repeat: 2 x	Telescope Overheads: 360 s	Instrument Overheads: 0 s
Total Tel. Time: 7200s		Signal/Noise: 0.0

Target • SN 2019ltw • 16:18:38.54 • +21:58:22.9 Tel. Time: 01h00m

OS 1	WFM-NOAO	Observation
Tel. Time: 3600 s	Instrument Mode: WFM-NOAO-N	Integration Time: 0 s
Repeat: 1 x	Telescope Overheads: 360 s	Instrument Overheads: 0 s
Total Tel. Time: 3600s		Signal/Noise: 0.0

Target • SN 2019rii • 21:22:41.869 • +22:52:54.83 Tel. Time: 01h00m

OS 1	WFM-NOAO	Observation
Tel. Time: 3600 s	Instrument Mode: WFM-NOAO-N	Integration Time: 0 s
Repeat: 1 x	Telescope Overheads: 360 s	Instrument Overheads: 0 s
Total Tel. Time: 3600s		Signal/Noise: 0.0

Target • SN 2019twa • 07:52:06.352 • +24:20:18.98 Tel. Time: 01h00m

OS 1	WFM-NOAO	Observation
Tel. Time: 3600 s	Instrument Mode: WFM-NOAO-N	Integration Time: 0 s
Repeat: 1 x	Telescope Overheads: 360 s	Instrument Overheads: 0 s
Total Tel. Time: 3600s		Signal/Noise: 0.0

Target • SN 2019iep • 00:06:18.630 • +25:27:45.51 Tel. Time: 01h00m

OS 1	WFM-NOAO	Observation
Tel. Time: 3600 s	Instrument Mode: WFM-NOAO-N	Integration Time: 0 s
Repeat: 1 x	Telescope Overheads: 360 s	Instrument Overheads: 0 s

Total Tel. Time: 3600s		Signal/Noise: 0.0

Target • SN 2016edk • 17:47:14.200 • +30:13:29.30 — Tel. Time: 01h00m

OS 1	WFM-NOAO	Observation
Tel. Time: 3600 s	Instrument Mode: WFM-NOAO-N	Integration Time: 0 s
Repeat: 1 x	Telescope Overheads: 360 s	Instrument Overheads: 0 s
Total Tel. Time: 3600s		Signal/Noise: 0.0

Target • SN 2022pff • 15:11:58.017 • +32:50:29.68 — Tel. Time: 01h00m

OS 1	WFM-NOAO	Observation
Tel. Time: 3600 s	Instrument Mode: WFM-NOAO-N	Integration Time: 0 s
Repeat: 1 x	Telescope Overheads: 360 s	Instrument Overheads: 0 s
Total Tel. Time: 3600s		Signal/Noise: 0.0

Target • SN 2015U • 07:28:53.87 • +33:49:10.6 — Tel. Time: 01h00m

OS 1	WFM-NOAO	Observation
Tel. Time: 3600 s	Instrument Mode: WFM-NOAO-N	Integration Time: 0 s
Repeat: 1 x	Telescope Overheads: 360 s	Instrument Overheads: 0 s
Total Tel. Time: 3600s		Signal/Noise: 0.0

Target • SN 2020bqj • 15:33:40.482 • +34:28:44.20 — Tel. Time: 01h00m

OS 1	WFM-NOAO	Observation
Tel. Time: 3600 s	Instrument Mode: WFM-NOAO-N	Integration Time: 0 s
Repeat: 1 x	Telescope Overheads: 360 s	Instrument Overheads: 0 s
Total Tel. Time: 3600s		Signal/Noise: 0.0

Target • SN 2020nxt • 22:37:36.235 • +35:00:07.68 — Tel. Time: 01h00m

OS 1	WFM-NOAO	Observation
Tel. Time: 3600 s	Instrument Mode: WFM-NOAO-N	Integration Time: 0 s
Repeat: 1 x	Telescope Overheads: 360 s	Instrument Overheads: 0 s
Total Tel. Time: 3600s		Signal/Noise: 0.0

Target • OGLE-2012-SN-006 • 03:33:34.8 • -74:23:40.2 — Tel. Time: 01h00m

OS 1	WFM-NOAO	Observation
Tel. Time: 3600 s	Instrument Mode: WFM-NOAO-N	Integration Time: 0 s
Repeat: 1 x	Telescope Overheads: 360 s	Instrument Overheads: 0 s
Total Tel. Time: 3600s		Signal/Noise: 0.0

Target • SN 2000er • 02:24:32.54 • -58:26:17.988 — Tel. Time: 02h00m

OS 1	WFM-NOAO	Observation
Tel. Time: 3600 s	Instrument Mode: WFM-NOAO-N	Integration Time: 0 s
Repeat: 2 x	Telescope Overheads: 360 s	Instrument Overheads: 0 s
Total Tel. Time: 7200s		Signal/Noise: 0.0

Target • SN 2020cws • 17:56:49.6 • -41:48:42.55 — Tel. Time: 01h00m

OS 1	WFM-NOAO	Observation
Tel. Time: 3600 s	Instrument Mode: WFM-NOAO-N	Integration Time: 0 s
Repeat: 1 x	Telescope Overheads: 360 s	Instrument Overheads: 0 s
Total Tel. Time: 3600s		Signal/Noise: 0.0

Target • LSQ13ccw • 21:35:51.648 • -18:32:52.08 — Tel. Time: 01h00m

OS 1	WFM-NOAO	Observation
Tel. Time: 3600 s	Instrument Mode: WFM-NOAO-N	Integration Time: 0 s
Repeat: 1 x	Telescope Overheads: 360 s	Instrument Overheads: 0 s
Total Tel. Time: 3600s		Signal/Noise: 0.0

Target • PTF11rfh • 22:35:49.58 • -00:22:26.141 — Tel. Time: 01h00m

OS 1	WFM-NOAO	Observation
Tel. Time: 3600 s	Instrument Mode: WFM-NOAO-N	Integration Time: 0 s
Repeat: 1 x	Telescope Overheads: 360 s	Instrument Overheads: 0 s
Total Tel. Time: 3600s		Signal/Noise: 0.0

Target • SN 2002ao • 14:29:35.74 • -00:00:55.8 — Tel. Time: 02h00m

OS 1	WFM-NOAO	Observation
Tel. Time: 3600 s	Instrument Mode: WFM-NOAO-N	Integration Time: 0 s

Repeat: 2 x Total Tel. Time: 7200s	Telescope Overheads: 360 s	Instrument Overheads: 0 s Signal/Noise: 0.0

Target • iPTF14aki • 14:20:41.73 • +03:16:01.29 — Tel. Time: 01h00m

OS 1	WFM-NOAO	Observation
Tel. Time: 3600 s Repeat: 1 x Total Tel. Time: 3600s	Instrument Mode: WFM-NOAO-N Telescope Overheads: 360 s	Integration Time: 0 s Instrument Overheads: 0 s Signal/Noise: 0.0

Target • LSQ12btw • 10:10:28.82 • +05:32:12.48 — Tel. Time: 01h00m

OS 1	WFM-NOAO	Observation
Tel. Time: 3600 s Repeat: 1 x Total Tel. Time: 3600s	Instrument Mode: WFM-NOAO-N Telescope Overheads: 360 s	Integration Time: 0 s Instrument Overheads: 0 s Signal/Noise: 0.0

Target • iPTF13beo • 16:12:26.63 • +14:19:17.976 — Tel. Time: 01h00m

OS 1	WFM-NOAO	Observation
Tel. Time: 3600 s Repeat: 1 x Total Tel. Time: 3600s	Instrument Mode: WFM-NOAO-N Telescope Overheads: 360 s	Integration Time: 0 s Instrument Overheads: 0 s Signal/Noise: 0.0

Target • SN 2010al • 08:14:15.9 • +18:26:18.204 — Tel. Time: 02h00m

OS 1	WFM-NOAO	Observation
Tel. Time: 3600 s Repeat: 2 x Total Tel. Time: 7200s	Instrument Mode: WFM-NOAO-N Telescope Overheads: 360 s	Integration Time: 0 s Instrument Overheads: 0 s Signal/Noise: 0.0

Target • SN 2014bk • 13:54:02.42 • +20:00:24.3 — Tel. Time: 01h00m

OS 1	WFM-NOAO	Observation
Tel. Time: 3600 s Repeat: 1 x Total Tel. Time: 3600s	Instrument Mode: WFM-NOAO-N Telescope Overheads: 360 s	Integration Time: 0 s Instrument Overheads: 0 s Signal/Noise: 0.0

Target • SN 2005la • 12:52:15.68 • +27:31:52.5 — Tel. Time: 01h00m

OS 1	WFM-NOAO	Observation
Tel. Time: 3600 s Repeat: 1 x Total Tel. Time: 3600s	Instrument Mode: WFM-NOAO-N Telescope Overheads: 360 s	Integration Time: 0 s Instrument Overheads: 0 s Signal/Noise: 0.0

Target • SN 2018gjx • 02:16:15.55 • +28:35:28.7 — Tel. Time: 02h00m

OS 1	WFM-NOAO	Observation
Tel. Time: 3600 s Repeat: 2 x Total Tel. Time: 7200s	Instrument Mode: WFM-NOAO-N Telescope Overheads: 360 s	Integration Time: 0 s Instrument Overheads: 0 s Signal/Noise: 0.0

Target • SN 2011hw • 22:26:14.54 • +34:12:59.112 — Tel. Time: 01h00m

OS 1	WFM-NOAO	Observation
Tel. Time: 3600 s Repeat: 1 x Total Tel. Time: 3600s	Instrument Mode: WFM-NOAO-N Telescope Overheads: 360 s	Integration Time: 0 s Instrument Overheads: 0 s Signal/Noise: 0.0