NOAO Observing Proposal
Kitt Peak National Observatory

Date: September 29, 1998	*TAC:* Extragalactic	*Proposal number:*

TITLE: Physical and Standard Candle Properties of Type Ia Supernovae from a Large, Homogeneous, Nearby Sample

PI: Dr. Saul Perlmutter Status: P saul@lbl.gov
Lawrence Berkeley Lab, One Cyclotron Rd., MS50-232 510-486-5203

CoI: Dr. Greg Aldering Status: P galdering@lbl.gov
Lawrence Berkeley Lab, One Cyclotron Rd., MS50-232 510-495-2203

CoI: Dr. Peter Nugent Status: P penugent@lbl.gov
Lawrence Berkeley Lab, One Cyclotron Rd., MS50-232 510-486-6942

CoI: Prof. Gerson Goldhaber Status: P gerson@lbl.gov
UC Berkeley/LBL, One Cyclotron Rd., MS50-232 510-486-6210

Abstract of Scientific Justification *(may be made publicly available for accepted proposals)*: We propose to use the KPNO 4-m, 2.1-m, and WIYN to obtain spectral and photometric time series for ~30 nearby Type Ia supernovae, to be discovered as part of a large international campaign. The goals of this campaign are to determine the luminosity function, investigate known and new photometric and spectroscopic luminosity indicators, determine better lightcurve templates and spectral time series at all optical wavelengths (especially prior to maximum light), and calculate the rates, for nearby Type Ia supernovae. This large sample of well-observed Type Ia supernovae, and the resulting improvement in our understanding of their standardized-candle properties, will immediately lower the statistical uncertainties in our current determination of the cosmological parameters, Ω_M and Ω_Λ. This sample will also allow tests for any systematic uncertainties which have not already been accounted for in the present cosmological studies based on Type Ia supernovae. KPNO facilities will be used to obtain the crucial late-time spectroscopic and photometric follow-up of the supernovae discovered in this campaign.

- *Is this proposal part of a PhD thesis? If 'Y', you must send a letter; see instructions.* N
- *Are you requesting long-term status? If 'Y', please give details on the line below.* N

Summary of observing runs requested for this project

Run	Telescope	Instrument, detectors, gratings, filters, camera optics, multislits, etc.
1	4m	RCSP + T2KB + KPC-10A or BL250
2	2.1m	CFIM+T1KA+$UBVRI$
3	WIYN	NFIM+UB

Run	No. nights	Moon age (d)	Optimal dates	Acceptable dates
1	1+2	7	Mar 15 - May 1	Feb 15 - May 15
2	6x1	10	Mar 1 - May 15	Feb 15 - May 15
3	1.0	5	Feb 15 - May 15	Feb 15 - May 15

- *Scheduling constraints and non-usable dates.*

Runs must be coordinated - please contact us before scheduling to ensure SN phase coverage.

Scientific Justification *Be sure to include overall significance to astronomy. Limit text to one page with figures (up to three), captions and references on no more than two additional pages.*

The Supernova Cosmology Project (SCP) at LBL, in alliance with scientists from CTIO, ESO, ING, EROS, and QUEST, are undertaking a large CCD-based campaign to systematically discover and follow more than 30 nearby Type Ia supernovae (SNe Ia) during the upcoming semester. This is an undertaking of unprecedented scope in the study of nearby SNe, and presents a unique opportunity in which NOAO facilities will play a key role. Our primary focus will be to determine those properties of SNe Ia affecting their use for cosmology, as follows:

• secure the low-z portion of our SNe Ia Hubble diagram (Fig 1) — which serves as the calibration for our high-z cosmological measurements — using this large, less biased, sample of nearby SNe Ia.
• obtain $UBVRI$ lightcurves beginning well before maximum — data currently available for only a handful of nearby SNe Ia, and needed to fit the lightcurves of high-z SNe Ia for which we now have extensive data prior to maximum (see Fig 2).
• test and refine the lightcurve width vs. brightness relation used to standardize SNe Ia luminosities, (to ~ 0.1 mag after extinction correction), for which a wide range of lightcurve widths is essential.
• construct a U-band template lightcurve and a U-band lightcurve width vs. brightness relation to allow U and U-B lightcurves to be used to correct $z > 0.75$ SNe Ia observed with, e.g., HST.
• obtain spectral coverage with lightcurve phase, and thereby determine accurate K-corrections as a function of lightcurve width and time (see Fig 2).
• determine intrinsic (unreddened) SNe Ia color-curves needed to establish the correct color zero-points for host galaxy extinction corrections.
• test for the existence abnormal host-galaxy extinction laws.

The resulting dataset will also allow detailed exploration of SNe Ia properties never before possible, which will almost certainly lead to a better understanding of SN physics, and may also result in means of standardizing SNe Ia in ways not previously envisioned. It will enable us to determine:

• the intrinsic luminosity function of SNe Ia
• new relations between lightcurve shapes, spectral diagnostics (such as UV continuum slope, Si5180/Si6150 line ratios), etc., and luminosity.
• SNe properties in different host galaxy environments (as a surrogate for progenitor age, mass, and metallicity).
• the rates of SNe of all types (presently uncertain by at least 2x for nearby galaxies), including rates as a function of host galaxy properties.

The SCP is a program to exploit SNe Ia as standardized candles to measure the cosmological parameters, Ω_M and Ω_Λ. Our most recent result based on 42 high-z SNe Ia (see Fig 1) excludes a simple $\Omega_M = 1$ flat universe, and presents strong evidence for the existence of a cosmological constant. We are seeking to confirm this exciting result with observations of SNe Ia at even higher redshift. However, $\sim 50\%$ of the *statistical* uncertainty in our current result stems from the small number (~ 20) of low-z SNe Ia which are suitable to serve as the zero-point for our SNe Ia Hubble diagram. Pre-max discovery and study of nearby SNe Ia will immediately reduce our measurement uncertainties. Moreover, it is now critical that SNe Ia be scrutinized even more closely to determine whether *systematic* variations not already accounted for by the lightcurve width vs. luminosity relation affect the use of SNe Ia for cosmology. Well-observed nearby SNe Ia, especially in host galaxies spanning a wide range in metallicity and star-formation histories, are essential for testing for possible systematics. Finally, our nearby SNe campaign will allow refinement of known SNe Ia luminosity indicators — and perhaps the discovery of more accurate or economical luminosity indicators — improving SNe Ia as tools for cosmology.

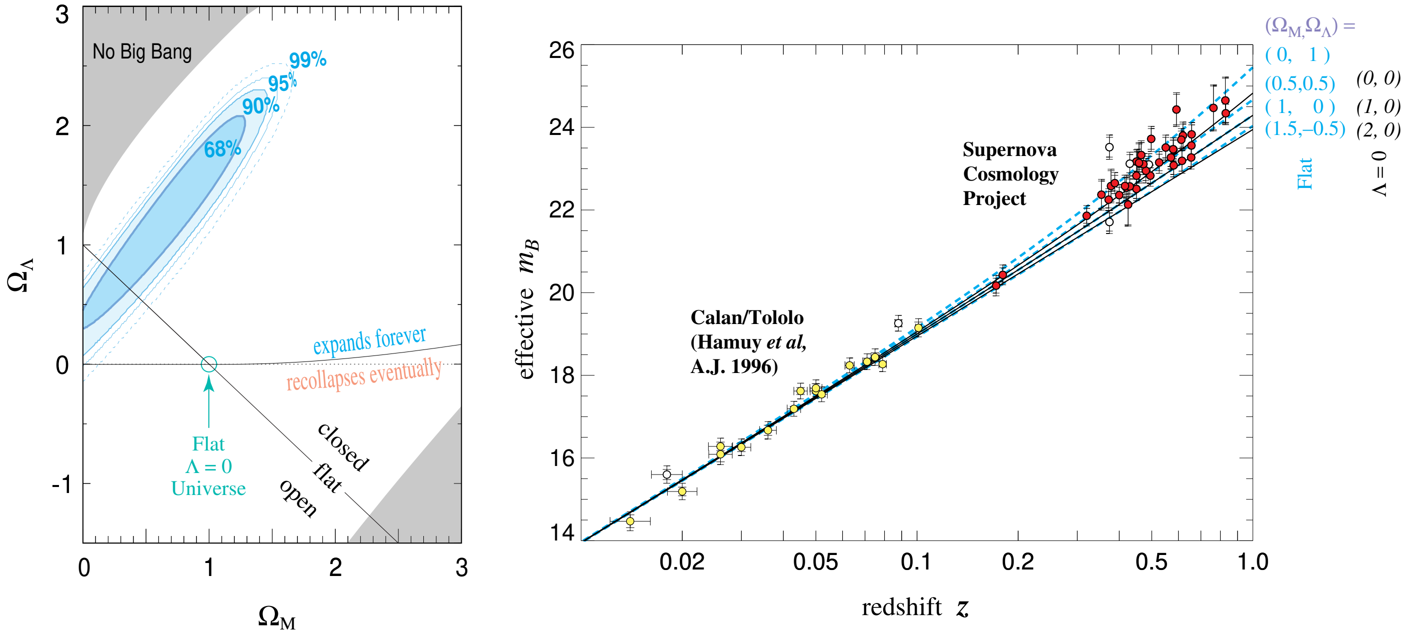

Figure 1: **Cosmological constraints from Type Ia supernovae:** Hubble diagram and resulting constraints on Ω_M and Ω_Λ from 42 high-z Type Ia supernovae from Perlmutter *et al* 1998b. At left, the 68%, 90%, and 99% confidence regions for an unconstrained fit for Ω_M and Ω_Λ are shown. At right, the low-z SNe Ia are those from Hamuy *et al* 1996a which are suitable for analysis using the same methods as used for the high-z SNe Ia.

References

Hamuy *et al* , 1993, AJ, 106, 2392.

Hamuy *et al* , 1996a, AJ, 112, 2391.

Hamuy *et al* , 1996b, AJ, 112, 2408.

Kim *et al* , 1996, PASP, 108, 190.

Pain, R., *et al* , 1996, ApJ, 473, 356.

Perlmutter *et al* , 1997, ApJ, 483, 565.

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Perlmutter *et al* , 1998b, ApJ, submitted (see www-supernova.lbl.gov).

Phillips *et al* , 1993, ApJ, 413, L105.

Riess *et al* , 1996, ApJ, 473, 88.

Tripp, 1998, A&A, 331, 851.

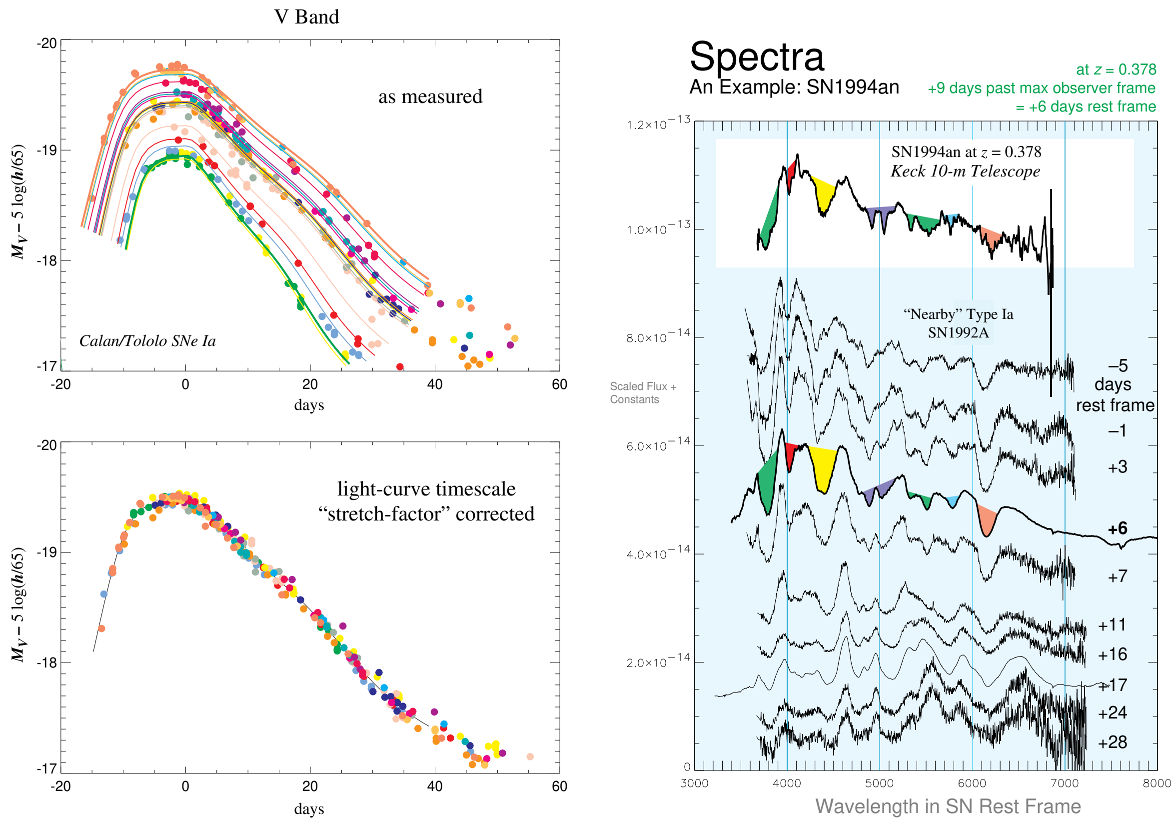

Figure 2: **Photometric and Spectral Time Evolution of Type Ia supernovae:** At left, V-band lightcurves for nearby SNe Ia from Hamuy *et al* 1996b. The upper panel shows lightcurves for individual SNe Ia, with absolute magnitudes derived assuming pure Hubble flow and $H_o = 65$ km/s/Mpc. Template lightcurves from Leibundgut *et al* 1991 have been fit to the lightcurve for each SN. Note that the brighter SNe have lightcurves which are broader and decline more slowly. Also notice that very few of these SNe have data well before maximum light. The lower panel at left shows the superposition of these data after using a linear correction for stretch, S, and scaling the time axis (with maximum at t = 0) by the same stretch-factor. We have found that the lightcurves for a given filter for most SNe Ia can be represented by a single stretched template. We have also found that this stretch factor is linearly proportional to the intrinsic luminosity (in magnitudes). At right is the evolution of the spectrum of a Type Ia supernova as the explosion ages. This was constructed using spectra from different SNe Ia obtained at different epochs. The shaded regions highlight portions of the spectra which are seen to evolve with time. Some of these can also be used as luminosity indicators.

Experimental Design *Justify the number of nights requested as well as the specific telescope, instruments, and lunar phase. If you've requested long-term status, justify why this is necessary for successful completion of the science. List objects, coordinates, and magnitudes (or surface brightness, if appropriate), desired S/N ratio, wavelength coverage and resolution (or include in Target Tables section).* **NOTE:** *If this project involves observations on other telescopes as well, list all telescopes on which you have applied for or been granted time for observations related to this project. For each, indicate the nature of the observations, and describe the importance of the observations proposed here in the context of the entire program. For WIYN proposals, see special WIYN instructions.*

A Large CCD-based Nearby Supernova Survey

During dark time in January, February, and March 1999 we will use wide-field CCD mosaics at the INT 2.5-m, EROS 1-m, and QUEST 1-m to search for supernovae. We are also cooperating with the CTIO group (see proposal by C. Smith) to help with their KPNO 0.9-m and El Roble surveys as needed, and to ensure follow-up of their SNe discoveries. Each survey will cover 100–400 $\deg^2$ each month, with January observations serving as references for discoveries in February and March. The surveys are optimized to find SNe Ia at redshift $z \sim 0.1$ approximately 10 days before maximum. The surveys will also find other types of SNe, as well as some SNe Ia already past maximum, which will be screened out (but reported in a timely manner so others can follow-up on them) based on spectra taken shortly after discovery. SNe Ia still on the rise (as determined from photometric follow-up and spectroscopic dating) will be imaged in $UBVRI$ every 3–5 days for approximately two months, using a network of queue and classically scheduled 1-m to 2-m telescopes (including KPNO 2.1-m and CTIO 1.5-m) for which some observing time has already been committed. Spectra will also be obtained periodically ($\sim$ once per week) using a network of 2.5-m and larger telescopes (including KPNO 4-m and CTIO 4-m, and possibly including UV spectra from STIS on HST). Based on our rates for SNe Ia at $z \sim 0.3$ (Pain *et al* 1996) it is expected that the combined searches will contribute ~ 30 SNe per month for two months, yielding ~ 60 SNe, of which more than 30 are expected to be SNe Ia before maximum. Thus, unlike most on-going SNe searches, all of the searching and follow-up for this campaign is concentrated into just a few months, allowing the telescope time for the entire campaign to be classically scheduled and allowing for homogeneous selection and follow-up. (We will also follow SNe Ia reported in the IAUC as a separate sub-sample, but note that these are rarely discovered before maximum).

The search and follow-up has been distributed intentionally among several telescopes in geographically diverse locations in order to make the campaign robust against bad weather or instrument failures. This is an important feature given the large amount of time being committed to discover and follow these SNe. All the data will be searched electronically, allowing the discovery efficiencies from each telescope/detector combination to be determined through computer simulations. The faintest SNe will have $B \sim 19$ at maximum light, and will be followed for about 2 months in which time they will fade by 2—3 mag. Hence the need for spectroscopic follow-up on large telescopes. Had we chosen to focus on discovering brighter SNe, the search efficiency would have plummeted due to deadtime (readout, re-positioning) between fields, as presently few of these CCD arrays are sufficiently well aligned to allow drift-scanning.

The well-sampled lightcurves resulting from this intensive follow-up campaign will allow a much better determination of lightcurve properties and how they are related to intrinsic luminosity. Very few nearby SNe have good data prior to maximum light, so these lightcurves will open new avenues of study of both the empirical and theoretical properties of SNe. Most of the SCP high-z SNe have been discovered before maximum (typically by ~ 10 days), so these early, well-sampled lightcurves can be used to create superior templates for use with high-z SNe.

We wish to emphasize the unprecedented size and uniqueness of this campaign for the study of supernovae. Observations from many different observatories are absolutely essential since no one observatory can provide all the necessary follow-up, making this an opportunity and undertaking which is unlikely to come along again in the near future.

Role of the KPNO 4m

The specific goal of the 4m observations in this campaign is to obtain one or two epochs of a spectral time series for approximately 30 Type Ia supernovae at redshifts out to $z \sim 0.1$ during the period 15—40 days after maximum, when they are too faint to observe spectroscopically with smaller telescopes. The KPNO 4m observations will be complemented by observations using the LCO 2.5m, NOT 2.6m, and Lick 3m when the SNe are brighter, and the ESO 3.6m, CTIO 4m, and WHT 4.2m when the SNe are fainter (proposals at other telescopes are pending). At the end of this intensive campaign our goal is to have one spectrum per week extending from the date of discovery (typically 1 week before maximum) through six weeks after maximum for all SNe Ia.

Instrumental Set-up: We will cover the spectral region 3800–7600Å at modest resolution (recall that the line-widths for SNe Ia are $>$ 5000 km/s) using the KPC-10A grating for bright SNe, and the BL250 grating (for higher UV throughput) for faint SNe. We require accurate (5%) relative spectrophotometry, and will therefore employ the Risley prisms to achieve atmospheric compensation. Because we require high UV throughput, Cyrocam is not suitable for our purposes, and could be considered only if absolutely necessary (e.g. to accomodate scheduling constraints).

Time requirements: During the period 15—40 days after maximum, exposure times of 1–2 hrs per SN are required to provide the necessary accuracy ($S/N > 10$ per 10A) for measuring key spectral features (UV continuum slope, Si5180/Si6150 line ratio, expansion velocity) and constructing accurate spectral series needed to determine K-corrections as a function of lightcurve phase and lightcurve width for use with our high-z SNe. To cover 30 SNe at one late-time epoch requires at least 30 hours, leading to our request for 3 nights with the RCSP on the KPNO 4m. Depending on the final magnitudes of the SNe and final allotments and scheduling at other 4m-class telescopes, it may be preferable to have one night followed 7—10 days later by two nights.

Optimal dates: The SNe will be discovered in February and March, so the February SNe will be too faint for other telescopes by mid-March, and the March SNe will be too faint for other telescopes by mid-April and continuing into May. This sets the period during which 4m time is required. Please consult with us regarding specific dates since we are coordinating scheduling among many observatories. We understand the block scheduling will impose restrictions on available dates.

Lunar phase: The SN spectral features of interest extend down to 3600Å (4000Åat $z = 0.1$; see Fig 2); the need for coverage in the blue limits the amount of moonlight that can be tolerated, however, we also wish to avoid a substantial "bright time" gap in our spectral time series. We have determined that our goals can be accomplished during lunar phase as much as 7 days from new moon in March since there will be a range of brightnesses and relative phases (wrt explosion date) for our sample of SNe, but that time allocated in April must be dark.

Role of the KPNO 2.1m

The specific goal of the 2.1m observations is to contribute to a photometric time series sampled every 3–5 days for these same 30 Type Ia supernovae during the period 15—50 days after maximum when the SNe generally become too faint to follow using the YALO 1m telescope (which will be our principle photometric follow-up telescope, with time allocated by U. Lisbon and Yale). 2.1m observations at U and B would also be useful during brighter lunar phase, when the background will make such observations with YALO difficult. We would be particularly interested in having single nights on the 2.1m placed between ordinarily scheduled changes-overs between other 2.1m observers during periods when CFIM is block scheduled on the 2.1m. Such scheduling during March and April would be ideal. Some additional photometric observations will be obtained with the CTIO 1.5m, LCO 2.5m, and INT 2.5m (pending approval), so there is no serious harm if the 2.1m is not scheduled to provide ideal phase coverage. On the 2.1m we will concentrate on observations that cannot be done effectively at YALO, i.e, those observations for which YALO requires more than ~ 30 minutes (U-band more than 15 days after maximum, and all bands more than 30 days after maximum during brighter time), since otherwise the pace is too slow to allow multi-color photometry for 30 SNe every 3–5 days. Such observations can be executed on the 2.1-m fast enough to get a new multi-color lightcurve epoch for all 30 SNe in ∼1–2 nights.

Role of WIYN

WIYN has proved invaluable in our follow-up of high-z SNe. For the nearby SNe campaign we believe that WIYN offers the best means of obtaining U and B photometry at late times in the SNe lightcurves at any lunar phase (i.e., using the dark portion of the night). At late-times (e.g. 30–50 days after max) the SNe will have U and B ∼21–22, requiring exposures of $\sim 400s$ in U and $\sim 60s$ in B with no moon, and up to 1800s in U with a 10-day moon (see exposure tables, below). In addition, although our 2.1m time request (and time at other telescopes) can handle most of the U and B photometry up to +30 days, we expect that scheduling gaps may still exist in the photometric follow-up of SNe during this early period. Therefore, we seek a modest allotment of WIYN time to obtain late-time U or B photometry and to fill-in any significant coverage gaps.

These observations can be obtained under non-photometric conditions, since we use stars in the field calibrated under photometric conditions (with other telescopes) to zero-point the photometry. Our figure of merit is $S/N > 15$ and seeing < 1.5 arcsec for the SN. We expect to have a running estimate of the brightness of each SN which we will use to suggest exposure times, as we have done for our highly successful WIYN observations of high-z SNe. 10 hrs of WIYN queue time will allow two epochs of late-time U and B photometry for the faintest half (15) of our sample. (using standard WIYN overheads, most of the time is consumed by the 10 minute overhead required to obtain U and B images of each target).

Example exposure times at U and B as a function of lightcurve phase and for new moon and 10-day moon, demonstrating that especially at U-band or with significant moon YALO photometry needs to be supplemented with observations from the 2.1m and WIYN:

Table I. Time to S/N = 20 for SN Ia at $z = 0.1$ with No Moon

Day	U	WIYN	2.1m	YALO	B	WIYN	2.1m	YALO
-5	19.3	20	60	700	18.9	10	10	20
0	18.9	15	40	500	18.8	10	10	20
5	19.3	20	60	700	18.9	10	10	20
10	19.8	35	100	1200	19.3	10	10	30
15	20.4	60	200	2300	19.9	10	10	50
20	21.0	75	400	4900	20.5	10	20	90
25	21.5	130	800	—	21.0	15	40	180
30	22.0	230	1800	—	21.3	20	50	240
35	22.1	260	2100	—	21.6	25	80	300
40	22.2	290	2400	—	21.8	30	100	400
45	22.4	380	3300	—	21.9	30	110	500
50	22.5	430	3900	—	22.0	35	130	600

Table II. Time to S/N = 20 for SN Ia at $z = 0.1$ with 10-day Moon

Day	U	WIYN	2.1m	YALO	B	WIYN	2.1m	YALO
-5	19.3	20	200	2200	18.9	10	10	20
0	18.9	10	100	1200	18.8	10	10	20
5	19.3	20	200	2200	18.9	10	10	20
10	19.8	40	450	5100	19.3	10	10	35
15	20.4	110	1300	—	19.9	10	20	70
20	21.0	300	3800	—	20.5	10	40	160
25	21.5	700	9400	—	21.0	10	80	330
30	22.0	1700	—	—	21.3	15	120	530
35	22.1	2100	—	—	21.6	25	200	900
40	22.2	2500	—	—	21.8	40	300	1200
45	22.4	3600	—	—	21.9	40	350	1400
50	22.5	4300	—	—	22.0	40	400	1700

Previous Use of NOAO Facilities *List allocations of telescope time on NOAO facilities to the Principal Investigator during the past 2 years, together with the current status of the data (cite publications where appropriate). Mark with an asterisk those allocations of time related to the current proposal.*

Demonstrated Successes.

Over the past few years we have discovered >70 SNe at redshifts $z = 0.2$–0.86. We have followed each of these SNe with photometry over the light curve (beginning before or at maximum light in every case) and spectroscopy near peak for most. Almost all of our SNe are Type Ia since SNe Ia are typically 2 magnitudes brighter than the other types. 12 SNe Ia have been observed by the HST.

$\boxed{\star}$ CTIO 4-m Dec 98/Jan 99 (Same Project) We have been awarded 5 nights of final photometric followup at the CTIO 4-m to provide high quality reference images in both R and $I-$ for most of the SNe dicovered in the previous two semesters.

$\boxed{\star}$ CTIO 4-m Mar 98/Apr 98, Keck Apr 98 (Same Project) On our third run with the BTC we were able to discover > 20 SN candidates at CTIO, 13 of which were spectroscopically confirmed including 8 SNe Ia observed with multi-color photometry onboard the HST. More than half the SNe are awaiting final reference images, particularly those at the highest redshifts which need the deepest final references.

$\boxed{\star}$ CTIO 4-m Dec 97/Jan 98, WIYN Jan 98, Keck Jan 98 (Same Project) On our second run with the BTC we were able to discover > 30 SN candidates at CTIO, 16 of which were spectroscopically confirmed including 4 SNe Ia with $z > 0.7$ and one at $z = 0.86$. More than half the SNe are awaiting final reference images, particularly those at the highest redshifts which need the deepest final references.

$\boxed{\star}$ CTIO 4-m Feb/Mar 97, WIYN Mar 97, Keck Mar 97 (Same Project) This was our first run with the BTC, which allowed us to push deeper over a wider area than possible before. We discovered > 25 SN candidates at CTIO, including another at $z = 0.83$, 13 of which were spectroscopically confirmed. Follow-up spectroscopy at Keck is finished. Follow-up photometry at CTIO and HST is completed. That at WIYN is mostly completed, however images without supernova light are still needed. Results including one of our $z = 0.83$ SNe has been completed and published in Nature, and a second paper on 42 SNe Ia has been submitted to ApJ.

$\boxed{\star}$ CTIO 4-m Dec 96/Jan 97, WIYN Jan 97, Keck Oct 96 (Same Project) We discovered ~ 19 SNe at CTIO, and confirmed 14 with spectroscopy. Follow-up spectroscopy from Keck has been reduced, and follow-up photometry at WIYN is close to completion. Detailed analysis is proceeding

$\boxed{\star}$ CTIO 4-m Feb/Mar 1996, WIYN 3.5m Mar–May 1996 (Same Project) We discovered 9 high-z SN Ia candidates at CTIO, including one at $z = 0.83$, in $\sim$3 square degrees searched (with longer exposures because of poor seeing). Final photometry points without SN light have now been obtained. Most follow-up photometry is finished. Spectra acquired at Keck have been reduced. Detailed analysis is proceeding.

$\boxed{\star}$ CTIO 4-m Nov/Dec 1995, WIYN 3.5m Nov 95–Jan 96 (Same Project) We discovered 11 high-z SNe Ia at CTIO in $\sim$4 square degrees observed in $\sim$1.5 clear search nights. Every supernova was confirmed spectroscopically at the Keck 10-m during coordinated follow-up nights scheduled during the week after the CTIO search nights. Every supernova was followed over the peak of the light curve with photometry primarily on the WIYN. The R band light curves are complete, with less continuous I and B band data near peak. Detailed analysis is in progress for Ω_M and Ω_Λ, and a paper on time-dilation is being completed.

Status of Analysis. *Light Curves:* For a number of SNe we are now waiting for the final images of the host galaxies after the SNe fade and final photometric calibration data. The seeing disk of the SN usually covers a significant fraction of host galaxy light, so these final images are necessary for precise photometry. We have now submitted for publication our results from the first 42 SNe that we have observed (Perlmutter et al. 1998; i.e., all the SNe discovered through spring 1997 and followed through spring 1998).

Spectra: Initial reductions at the telescope were sufficient to determine redshifts and spectral type of the SNe. More careful reductions have now been completed by I. Hook and other members of our group, and analysis of these spectra is underway. We are comparing the spectrum details with those of nearby SNe Ia to look for possible differences, which could indicate possible evolutionary effects.

Publications:

Measurements of Ω and Λ from 42 High-Redshift Supernovae, S. Perlmutter, *et al*, ApJ, submitted, (1998). Available at www-supernova.lbl.gov.

Discovery of a Supernova Explosion at Half the Age of the Universe and its Cosmological Implications, S. Perlmutter, *et al*, Nature, 391, 51 (1998).

Snapshot Distances to SNe Ia – All in 'One' Night's Work, A. Riess, *et al*, ApJ, 504, 935, (1998).

Measurements of the Cosmological Parameters Ω and Λ from the First 7 Supernovae at $z \geq 0.35$. S. Perlmutter, S. Gabi, G. Goldhaber, D. E. Groom, I. M. Hook, A. G. Kim, M. Y. Kim, J. Lee, C. R. Pennypacker, I. A. Small, A. Goobar, R. Pain, R. S. Ellis, R. G. McMahon, B. J. Boyle, P. S. Bunclark, D. Carter, M. J. Irwin, K. Glazebrook, H. J. M. Newberg, A. V. Filippenko, T. Matheson, M. Dopita, and W. J. Couch, ApJ, 483, 565 (1997).

The Type Ia supernova rate at $z \sim 0.4$, R. Pain, I. Hook, S. Perlmutter, *et al*, ApJ, 473, 356, (1996).

Implications for the Hubble Constant from the First Seven Supernovae of $z > 0.35$, A. Kim *et al.*, ApJ, 476, L63, (1997).

Discovery of the most distant supernovae and the quest for Ω. G. Goldhaber, B. Boyle, P. Bunclark, D. Carter, R. Ellis, S. Gabi, A. Goobar, A. Kim, M. Kim, R. McMahon, R. Pain, C. Pennypacker, S. Perlmutter, I. Small, and R. Terlevich, Nuclear Physics B (Proc. Suppl.) 38, 435 (1995).

A Type Ia supernova at $z = 0.457$. S. Perlmutter, C. Pennypacker, G. Goldhaber, A. Goobar, J. Desai, A. Kim, M. Kim, R. Muller, H. Newberg, I. Small, R. McMahon, B. Boyle, D. Carter, M. Irwin, P. Bunclark, K. Glazebrook, and R. Ellis, ApJ, 440, L41 (1995).

The distant supernova search and implications for the cosmological deceleration. A. Goobar, B. Boyle, P. Bunclark, D. Carter, R. Ellis, S. Gabi, G. Goldhaber, M. Irwin, A. Kim, M. Kim, R. McMahon, R. Muller, R. Pain, C. Pennypacker, S. Perlmutter, and I. Small, Nuclear Physics B (Proc. Suppl.) 43, 78 (1995).

Feasibility of measuring the cosmological constant Λ and mass density Ω using supernova standard candles. A. Goobar and S. Perlmutter, ApJ, 450, 14 (1995).

A generalized K correction for type Ia supernovae: Comparing R-band photometry beyond $z = 0.2$ with B, V, and R-band nearby photometry. A. Kim, A. Goobar, and S. Perlmutter, PASP, 108, 190 (1996).

K corrections for type Ia supernovae and a test for spatial variation of the Hubble constant. (The Supernova Cosmology Project: II.) A. Kim, *et al*, in Thermonuclear Supernovae, NATO ASI, eds. R. Canal, P. Ruiz-LaPuente, and J. Isern (1996).

Observation of cosmological time dilation using type Ia supernovae as clocks. (The Supernova Cosmology Project: III.) G. Goldhaber, *et al*, in Thermonuclear Supernovae, NATO ASI, eds. R. Canal, P. Ruiz-LaPuente, and J. Isern (1996).

Publications in preparation

Spectra of High Redshift Supernovae. SCP. in prep.

Observation of cosmological time dilation using Type Ia supernovae as clocks. G. Goldhaber, S. Perlmutter, *et al*, in prep.

Catalog of photometry and spectroscopy for six supernovae at $z \sim 0.4$. R. Knop, *et al*, in prep.

SUPERNOVA DISCOVERIES IN IAU CIRCULARS

Over 70 discoveries of supernovae, reported in International Astronomical Union Telegrams and Circulars, including:

Supernovae 1994F, 1994G, 1994H: Circular 5956, 24 March 1994, S. Perlmutter *et al* .

Supernovae 1993al, 1994al, 1994am, 1994an: Circular 6263, 18 November 1995, S. Perlmutter, *et al* , (The Supernova Cosmology Project; SCP).

Eleven High-Redshift Supernovae: 1995aq through 1995az, and 1995ba: Circular 6270, 6 December 1995, SCP.

Fourteen High-Redshift Supernovae: Circular 6540, 17 January 1997, SCP

Sixteen High-Redshift Supernovae: Circular 6596, 20 March 1997, SCP

Seventeen High-Redshift Supernovae: Circular 6804, 6 January 1998, SCP

Thirteen High-Redshift Supernovae: Circular 6881, 22 April 1998, SCP

Why CTIO? *(For CTIO proposals only.) Explain why access to the southern hemisphere is needed to achieve your scientific goals.*

Target Tables *Provide information for your intended observations in tabular form. This information is required for WIYN proposals but is optional for all other telescopes.*

Observations for the WIYN Imager

Obj ID	Object	α	δ	Epoch	Mag.	Filter	Exp. time	# of exp.	Lunar days	Sky	Seeing	Comment
001	SN1999-01	12:00:00	+00:00:00	2000.0	21	U	200	1	4	spec	1.5	final coor. and exptime TBD
001	SN1999-01	12:00:00	+00:00:00	2000.0	21	B	60	1	4	spec	1.5	
002	SN1999-02	12:00:00	+00:00:00	2000.0	21	U	200	1	4	spec	1.5	
002	SN1999-02	12:00:00	+00:00:00	2000.0	21	B	60	1	4	spec	1.5	
003	SN1999-03	12:00:00	+00:00:00	2000.0	21	U	200	1	4	spec	1.5	
003	SN1999-03	12:00:00	+00:00:00	2000.0	21	B	60	1	4	spec	1.5	
004	SN1999-04	12:00:00	+00:00:00	2000.0	21	U	200	1	4	spec	1.5	
004	SN1999-04	12:00:00	+00:00:00	2000.0	21	B	60	1	4	spec	1.5	
005	SN1999-05	12:00:00	+00:00:00	2000.0	21	U	200	1	4	spec	1.5	
005	SN1999-05	12:00:00	+00:00:00	2000.0	21	B	60	1	4	spec	1.5	
006	SN1999-06	12:00:00	+00:00:00	2000.0	21	U	200	1	4	spec	1.5	
006	SN1999-06	12:00:00	+00:00:00	2000.0	21	B	60	1	4	spec	1.5	
007	SN1999-07	12:00:00	+00:00:00	2000.0	21	U	200	1	4	spec	1.5	
007	SN1999-07	12:00:00	+00:00:00	2000.0	21	B	60	1	4	spec	1.5	
008	SN1999-08	12:00:00	+00:00:00	2000.0	21	U	200	1	4	spec	1.5	
008	SN1999-08	12:00:00	+00:00:00	2000.0	21	B	60	1	4	spec	1.5	
009	SN1999-09	12:00:00	+00:00:00	2000.0	21	U	200	1	4	spec	1.5	
009	SN1999-09	12:00:00	+00:00:00	2000.0	21	B	60	1	4	spec	1.5	
010	SN1999-10	12:00:00	+00:00:00	2000.0	21	U	200	1	4	spec	1.5	
010	SN1999-10	12:00:00	+00:00:00	2000.0	21	B	60	1	4	spec	1.5	
011	SN1999-11	12:00:00	+00:00:00	2000.0	21	U	200	1	4	spec	1.5	
011	SN1999-11	12:00:00	+00:00:00	2000.0	21	B	60	1	4	spec	1.5	
012	SN1999-12	12:00:00	+00:00:00	2000.0	21	U	200	1	4	spec	1.5	
012	SN1999-12	12:00:00	+00:00:00	2000.0	21	B	60	1	4	spec	1.5	
013	SN1999-13	12:00:00	+00:00:00	2000.0	21	U	200	1	4	spec	1.5	
013	SN1999-13	12:00:00	+00:00:00	2000.0	21	B	60	1	4	spec	1.5	
014	SN1999-14	12:00:00	+00:00:00	2000.0	21	U	200	1	4	spec	1.5	
014	SN1999-14	12:00:00	+00:00:00	2000.0	21	B	60	1	4	spec	1.5	
015	SN1999-15	12:00:00	+00:00:00	2000.0	21	U	200	1	4	spec	1.5	
015	SN1999-15	12:00:00	+00:00:00	2000.0	21	B	60	1	4	spec	1.5	