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High statistics SN Ia at z$\sim$1 ?

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During the fall 2002, we discovered and followed about 30 SN Ia in a very successful "rolling search" on Subaru/SuprimeCam. In this note, I explore the idea of pursuing in that direction as an option for future SCP work.

During the fall 02, we performed a rolling search at Subaru. In Figure 1 I show the number of SN Ia found during this campaign - as put together by Gerson for his study of the lightcurves of these supernovae - as function of redshift (solid points). Also shown is the prediction assuming a constant (SCP value) rate per comoving volume folded with an estimate of the efficiency from magnitude limit values quoted by Mamuro in his Stockholm presentation last year and Ariel's simulation of SN Ia lightcurves in the Subaru i' filter. I approximated the "rolling search" with 2 epochs classical search separated by 21 days.

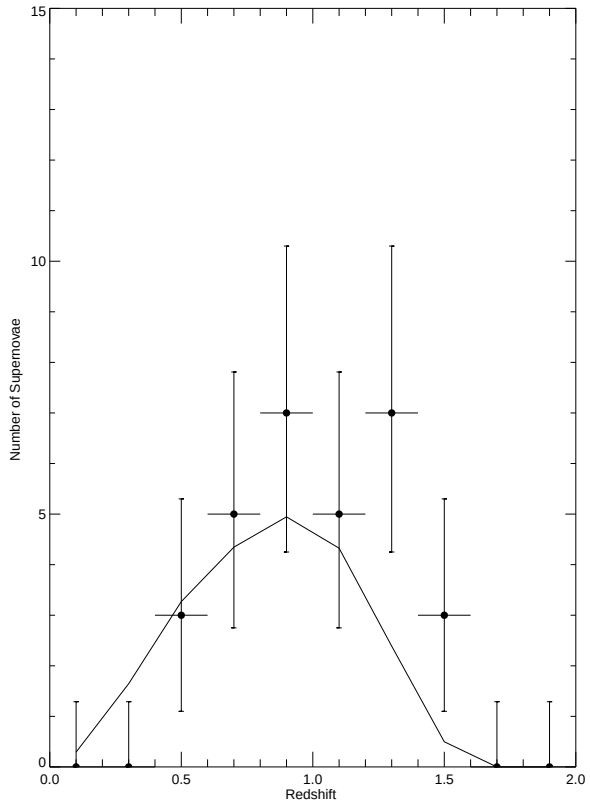

Figure 1: Fall 02 "Subaru" observed (points) and expected (solid line) number of SN Ia vs redshift (see details in text)

Some of the SNe have still rather uncertain redshift and the prediction needs to be refined but this shows that the redshift distribution is similar to the HST search performed as part of the GOODS transients survey [**?**]. In 50 minutes in i' with a 21 days baseline, Subaru does as well as HST with 40' exposure in the F850LP filter and 45 days baseline.

The idea proposed here as an option for future SCP work is to discover and follow some ~ 300 SNe Ia in the redshift range $0.8 - 1.2$ in a ~ 3 year program based on the same technique.

In this note I describe this idea and give a rough estimate of the resources (telescope, effort, ...) needed to perform it.

The context

During the 2003-2008 time period, SNLS will discover and follow about 700 SN Ia in the redshift range $0.3-0.9$. Imaging is done at CFHT in the SLOAN griz (') filters in a rolling search mode. Each SN will have well sample multicolor lightcurves. Redshift and SN id is primely done at VLT/Fors1 and Gemini.

The SLOAN group has a project aiming to discover and follow $\sim$ 300 SN Ia in the "intermediate" redshift range 0.1-0.4 in a rolling search mode. Imaging will be done in the SLOAN filter sets with their telescope. Spectroscopy will be done with the WIYN telescope. If funded this project would start in 2005.

Both projects are "2nd generation" projects in the sense that they target higher statistics and better control of some of the systematics thru the rolling search technique and multicolor observations. All together they cover the redshift range $0.1-0.9$ with about 100 SN Ia per 0.1 z bin

In this context, a higher-z search targeting the $z = 0.8-1.2$ range with similar statistics would nicely complement these efforts and lead to substantial improvement of the precision of cosmological parameters. Roughly speaking, extending the z range from 0.8 to 1.2 leads to a factor 2 improvement in the statistical precision for Ω_M and Ω_Λ (3 parameter fit) and on Ω_M and w (3 parameter fit, flat Universe). Only a strong Subaru +Keck/VLT coordinated effort could do the job in a near (enough) future.

The proposed program

The aim is to fill the restframe U+B Hubble diagram in the $0.8-1.2$ z range. An alternative (or complement) would be to do B+V but this would require wide field (0.25 sq degree) IR imaging with AO which is unlikely to be available in the near future (or is it?). I am assuming that SN Ia U-band observations will turn out to be usable as "calibrated standard candle". if not demonstrated with current nearby sample or future SNfactory SNe, both SNLS and the SLOAN intermediate z program with collect enough g' observations of intermediate z SNe to study it. If rest-frame U-band cannot be used, this program looses a lot of its interest.

Imaging: Imaging would be done at Subaru in a rolling search mode. Figure 1 and preliminary lightcurves of the fall 02 search show that $\sim$ 1h i' observations are sufficient to reach $z \sim 1.2-1.3$ SNe and even get good lightcurve measurements of these SNe from 10 days rest-frame before maximum up to 15-20 restframe days past maximum.

A precise study has to be made but a baseline of 1h in i' and 1h in z' observations 5 times per lunation of $\sim$ 20 days (dark+grey time) centered on new moons during 6 consecutive lunations would yield a minimum of 25 well measured SN Ia per SuprimeCam field in the $0.8-1.2$ z range. I assumed that the search itself would be performed during 4 of the 6 lunations leaving the first

and last lunation for follow-up only.

All together, assuming that 2 SuprimeCam fields are observed in the spring semester and two more in the fall, a total of 100 SN Ia per year will be collected with well sampled (every 4 days during the dark+grey time) lightcurves in both i'- and z'- band for a total of about 120h of SuprimeCam imaging per semester.

Possible target for these observations would be in the Groth strip in the spring semester and in the Subaru Deep field or XMM-deep/VIMOS fields in the fall. These regions have both important (galaxy) spectroscopic coverage up to $z \sim 1$ and deep additional multicolor imaging (ground based and HST) which would be very valuable for this project.

Additional Spectroscopy: It is conceivable that a fair fraction of the redshifts could come from other observations but additional spectroscopy will be needed to measure the z of the remaining (non observed otherwise) galaxies and for the typing of as many as possible SNe.

It is likely that the multicolor photometry from the rolling search will greatly help in the typing but this remains to be demonstrated and in any case calibrated against spectroscopic typing. With both improved instruments (red CCDs) and techniques (see Chris' talk) it does not seem unreasonable to target a mean exposure length of 2h per SN (or may be less) in that redshift range. This could convert into $2 \times 12 = 24$h per lunation for 4 lunations per semester. which adds up to about 10 nights per semester, a large allocation but not impossible (SNLS has currently ~ 12 nights per semester). The best telescopes for these observations would be Keck and Subaru for the north field and Keck, Subaru and VLT/Fors2 for the equatorial field.

Additional redshift could be efficiently obtained with MOS observation of the fields at the end of the program since each SuprimeCam field will contain close to 100 SNe hosts (~ 1 host per 10×10 squ. arcmin).

Manpower: Needless to say, this program would require a very significant effort during an extended period of 3-5 years in both real time work for getting the data and finding SNe and for the "offline" analysis. It could certainly benefit from experience by some of us with SNLS but would have to be ran by a team of dedicated persons working hard to process this new large data set.

Conclusion A high statistics high quality ground based measurement of SN Ia in the $0.8 - 1.2$ z range seems feasible with current existing available instruments. It is an interesting option for future SCP work. It would nicely complement what is done at low z and together with SNLS and the SLOAN SN sample produce very high confidence precise measurements of the cosmological parameters.