Berkeley, July 16, 2004

A SCP measurement of the SNIa rate at z$\sim$1 ?

R. Pain

During the fall 2002, we discovered and followed about 30 SN Ia in a ”rolling search” on Subaru/SuprimeCam. In this note, I examine the possibility of analyzing this data set to get a measurement of the Ia rate at high-redshift and of what it would take to do it.

In a recent paper[1], the HST high-Z team (HHZT) uses a sample of 25 SN Ia detected and followed as part of the HST/GOODS survey, to measure the rate of Ia at very high-redshift. The observed number of Ia they found is shown on Figure 1 as a function of redshift (solid points). It is peaked at z=1 with $\sim 80\%$ of the candidates between $z = 0.8$ and $z = 1.2$.

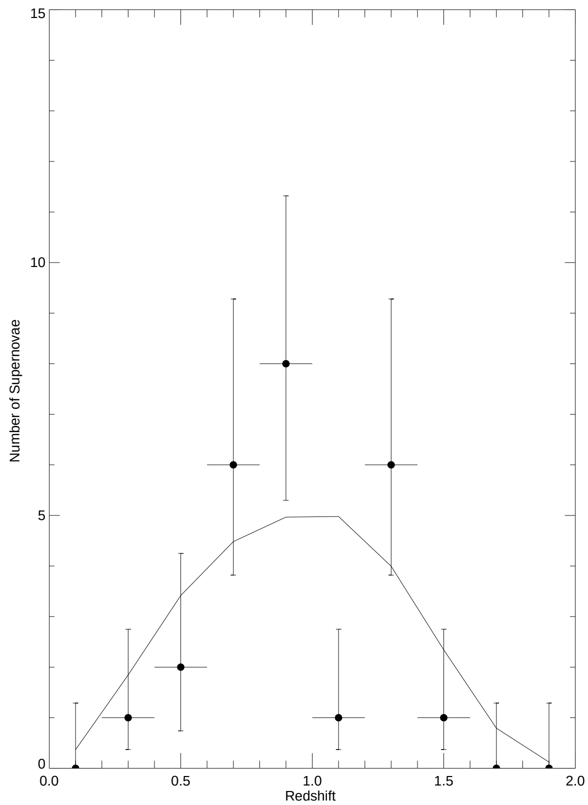

Figure 1: HST observed (points) and expected (solid line) number of SN Ia vs redshift (see details in text)

Also shown (solid line) in a prediction I computed using a constant rate per comoving volume folded with the detection efficiency quoted in their paper and using Ariel's simulation of SNe Ia Lightcurves in the HST F850LP filter. The purpose of this note is not to argue about the underlying rate function (they claim to find evidence for a "sharp increase" of the rate below $z = 1$ and a "decrease" above $z = 1$) but to assess the "quality" of the measurement (how many SNe?, what z range?, ...) and whether we can do as good or even better with the data we already have in hand.

The Fall 02 Subaru data set

In Figure 2 I show the number of SN Ia found during our fall 02 campaign at Subaru - 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.

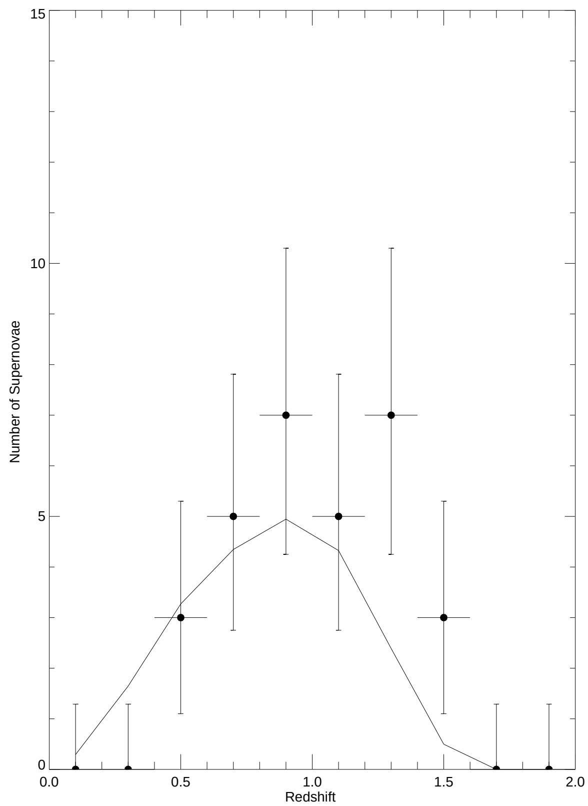

Figure 2: Fall 02 "Subaru" observed (points) and expected (solid line) number of SN Ia vs redshift (see details in text)

Some of the SNe have still rather uncertain redshift and the prediction needs to be refined but this shows that the total number of SN Ia found is comparable (we knew that) and also that their redshift distribution is similar to the HST one. 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.

Analysis of this data set would nicely complement our SCP measurement based on $\sim$ 40 SN Ia at $0.4 < z < 0.8$ discovered at CTIO and when combined with it allow us to confirm (or contradict) the HHZT claim that the SN Ia rate raises sharply to z=1.

What it would take to do this analysis

Except for the rolling search aspect of it, the method to do this analysis is known to us and we have all the tools to do it. The all process is however quite labor intensive since it requires among other things rerunning the search.

The rolling search: In a rolling search mode, it is no more trivial to compute the control times and a Monte-Carlo approach is probably required, which has to be setup (probably not from scratch) and run.

The candidates: Not all candidates have redshifts and the follow-up selection process was not intended for extensive follow-up of every candidate in the accessible redshift range. For the purpose of calculating the rate, we need to rerun the search in a different - more controlled - way. The rolling search aspect will help in that since every candidate was automatically followed by Subrau itself regardless of whether it was retained (e.g for HST follow-up) or not. It will also help to id the candidates that were not targeted in the first place. There will however be a need for additional spectroscopic observations to get the redshifts of some candidates. Photo-z may be useful since a high precision on z is not required.

Efficiencies: Since the observations where made (unlike HST) under variable observing conditions, a careful analysis of day by day detection efficiencies has to be done. This requires going thru every observed field (or a fair sample of it), adding fake supernovae and redo subtractions with fake SNe. The search covered about 50 CCDs.

Conclusion A ground based measurement of the SN Ia rate at $z \sim 1$ based on our Subaru fall 02 campaign is worth doing. It will stay unchallenged for some years (SNLS, Essence are targeting the lower z range). It can be directly compared with the rate obtained with HST data and when combined with our $z \sim 0.4 - 0.8$ measurement will do a more convincing job in constraining the behavior of the rate up to $z \sim 1.2$.

References

[1] astro-ph/0406547. see also astro-ph/0406546

[2] SCP rate paper