Nearby Supernova Factory

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The Experiment

- discover and intensively follow 300 Type Ia supernovae

Cosmology Goals

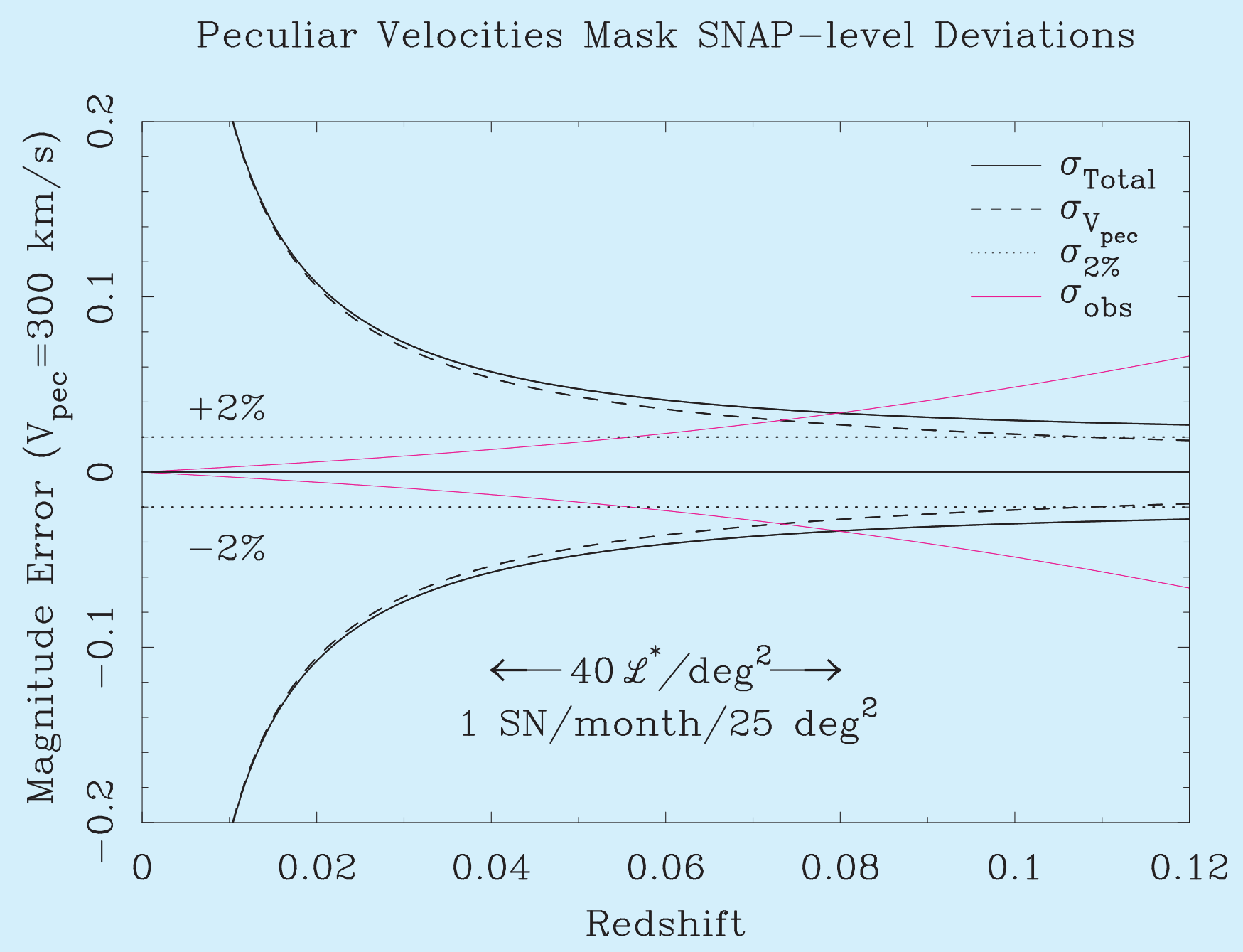
- anchor the low-z portion of the SNe Ia Hubble diagram —M
- measure Ω_M using peculiar velocities of lowest-z SNe Ia

Technical Goals Relavent to Current Techniques

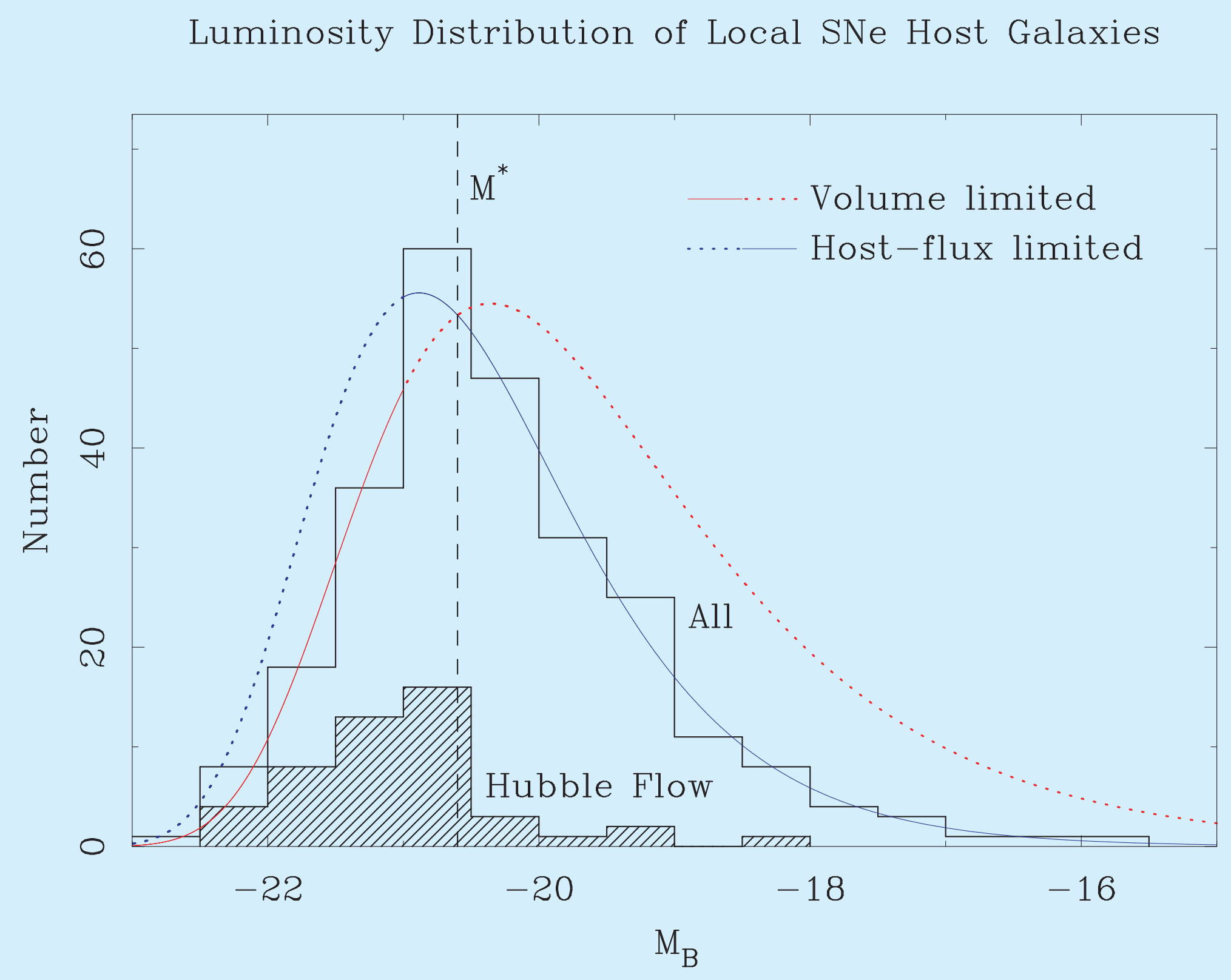
- test and refine the standard lightcurve stretch—brightness relation
- refine K-corrections as a function of lightcurve phase
- determine intrinsic (unreddened) SNe Ia color-curves
- test for abnormal host-galaxy dust extinction laws
- construct early lightcurves

SN Science Goals Relavent to Cosmological Applications

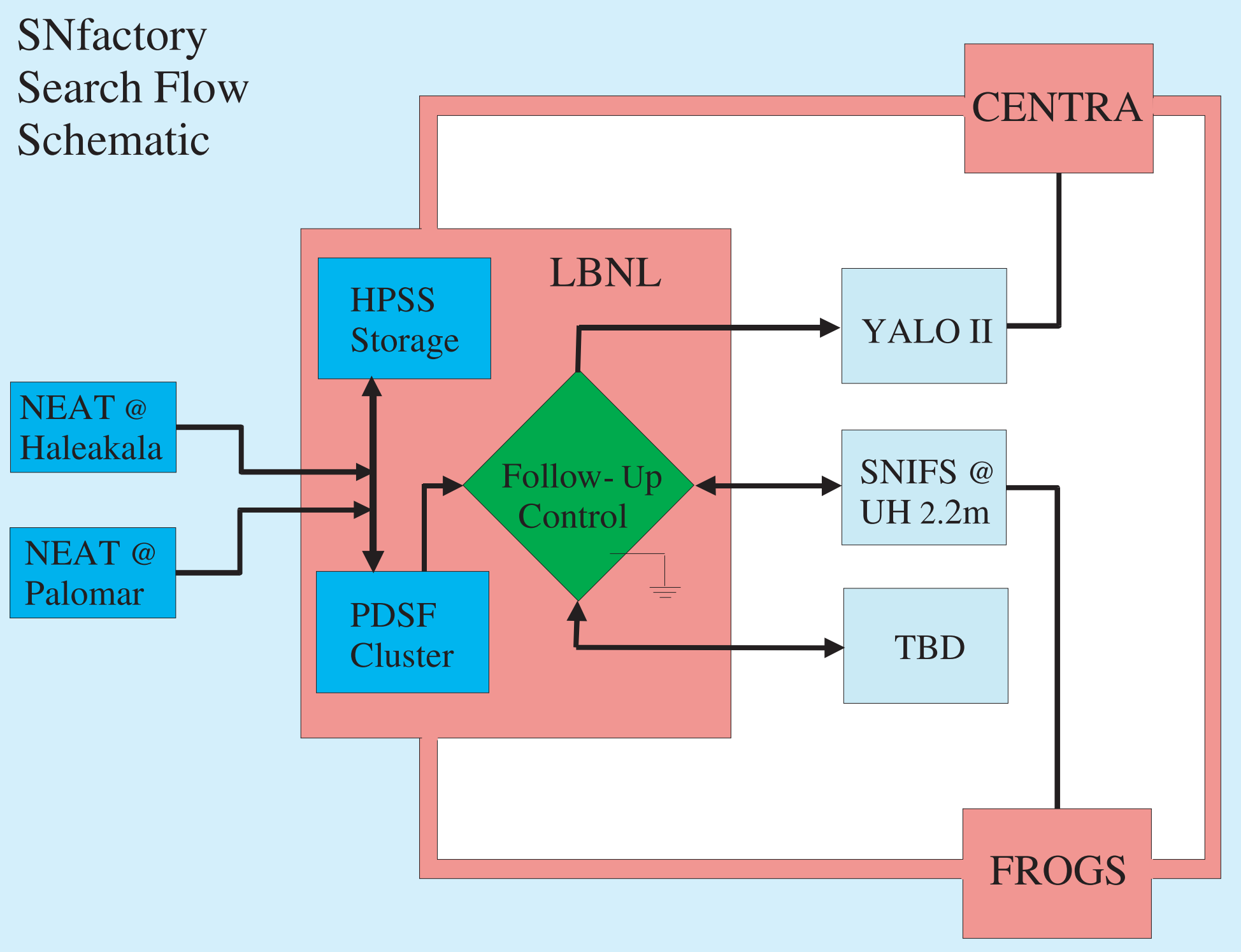
- determine intrinsic the luminosity function of SNe Ia
- establish new relations between luminosity & lightcurve shapes (risetime, tail amplitude, etc.)
- establish new relations between luminosity & spectral features (expansion velocity, UV line shifts, Si & Ca line ratios, etc.)
- correlate SNe properties with host galaxy environments



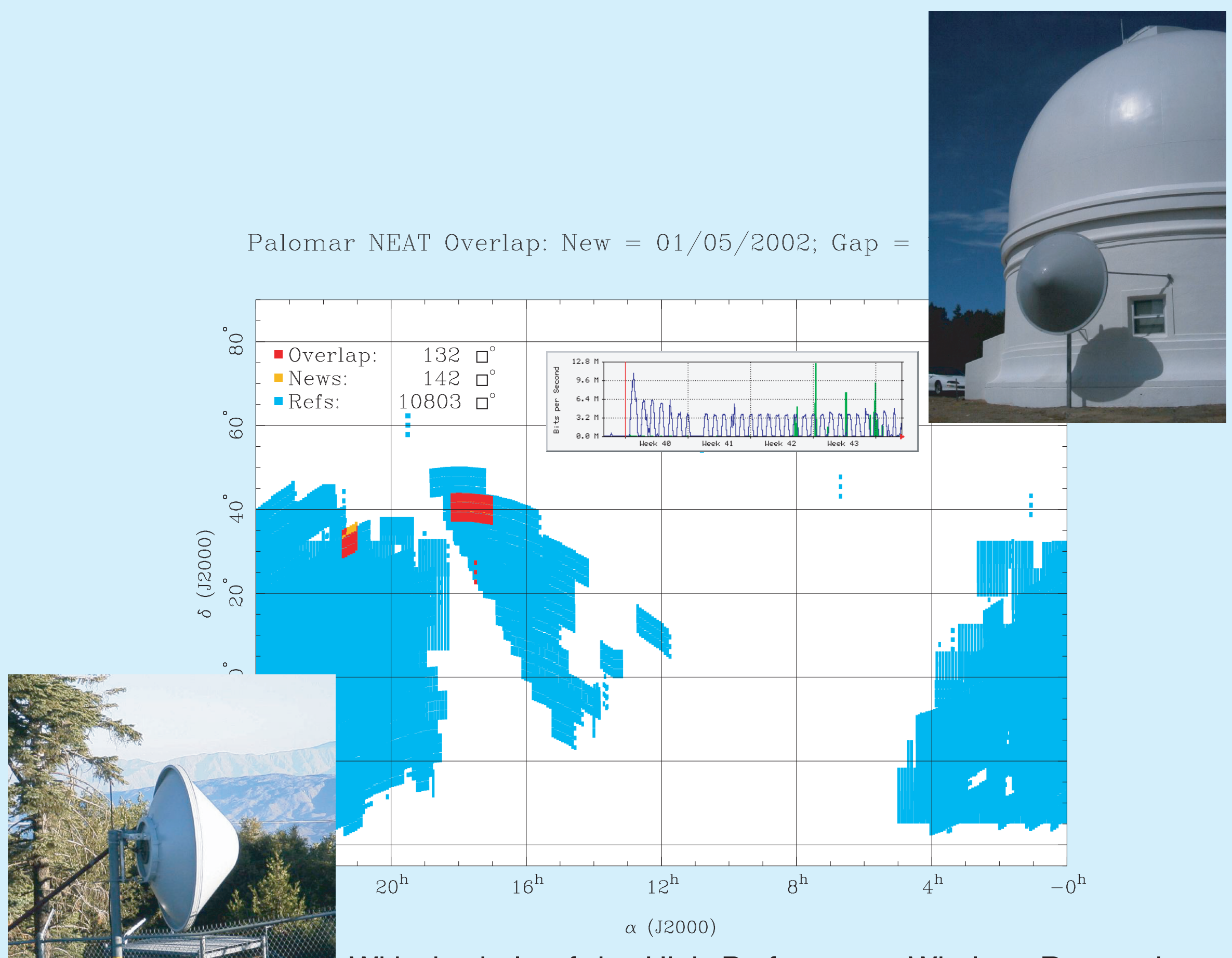
Type Ia supernovae are excellent distance indicators. After correction for the luminosity-lightcurve width relation and host galaxy extinction the distance errors for normal SNe Ia are 5% to 6%. In order to discover whether other parameters affect the SNe Ia luminosities, host galaxy peculiar velocities must be a small component of the error budget otherwise 2nd parameter effects will be swamped. In this figure the size of the peculiar velocity error component (dashed line) is shown relative to other effects – perhaps intrinsic to the SN – which would change the SN magnitude by 2%. The relative magnitude uncertainty for a given amount of observing time is also shown (solid magenta). The redshift range 0.04 < z < 0.08 provides the optimal balance between peculiar velocity and observation uncertainties. Within this range, wide-field CCD searches are effective because there are roughly 40 “typical” galaxies in a field of 1 sq deg.



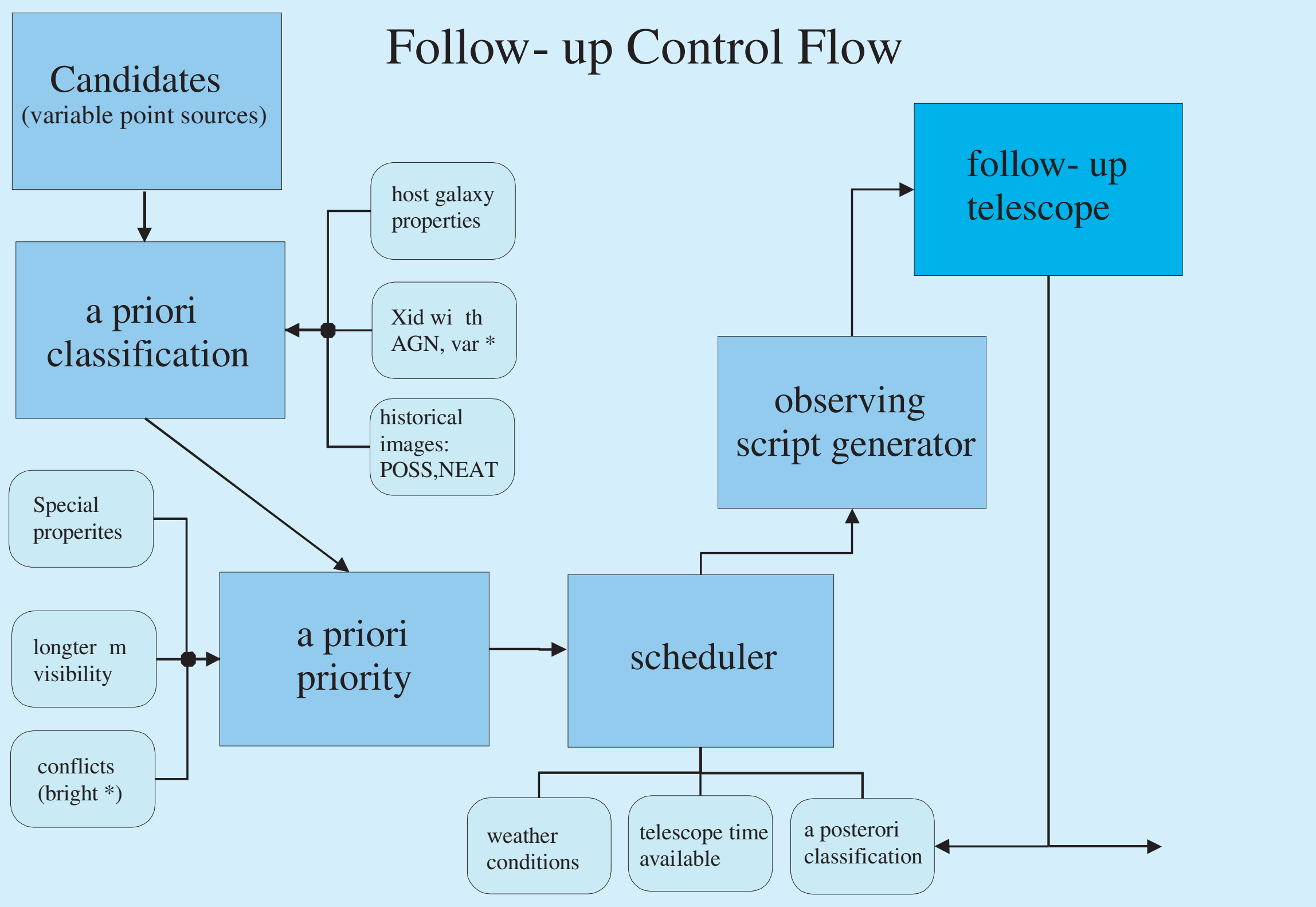
Current Hubble-flow SNe Ia samples are strongly biased towards SN occuring in luminous galaxies because many searches rely on lists of known galaxies for target lists or only consider candidates with obvious host galaxies. SNe Ia occurring in low-luminosity galaxies may be more like those at high redshift due to their lower average metallicity, so it is important to include them in studies of SNe Ia. The solid histogram shows the distribution of all SN Ia host galaxy luminosities from the Asiago catalog, while the dashed histogram shows only those in the Hubble flow. Flux-limited galaxy catalogs select on luminosity as $L^{3/2}$, while for SN-selected galaxy catalogs the selection goes as L (assuming the SN rate is proportional to L). Brighter than L^* the available galaxies limit the number of SN Ia galaxy hosts, while fainter than L^* the figure shows that the number of hosts more closely follows the limit imposed by galaxy catalogs. (Note that for the Hubble flow histogram the Asiago catalog compilation of host galaxy magnitudes is slightly incomplete.)



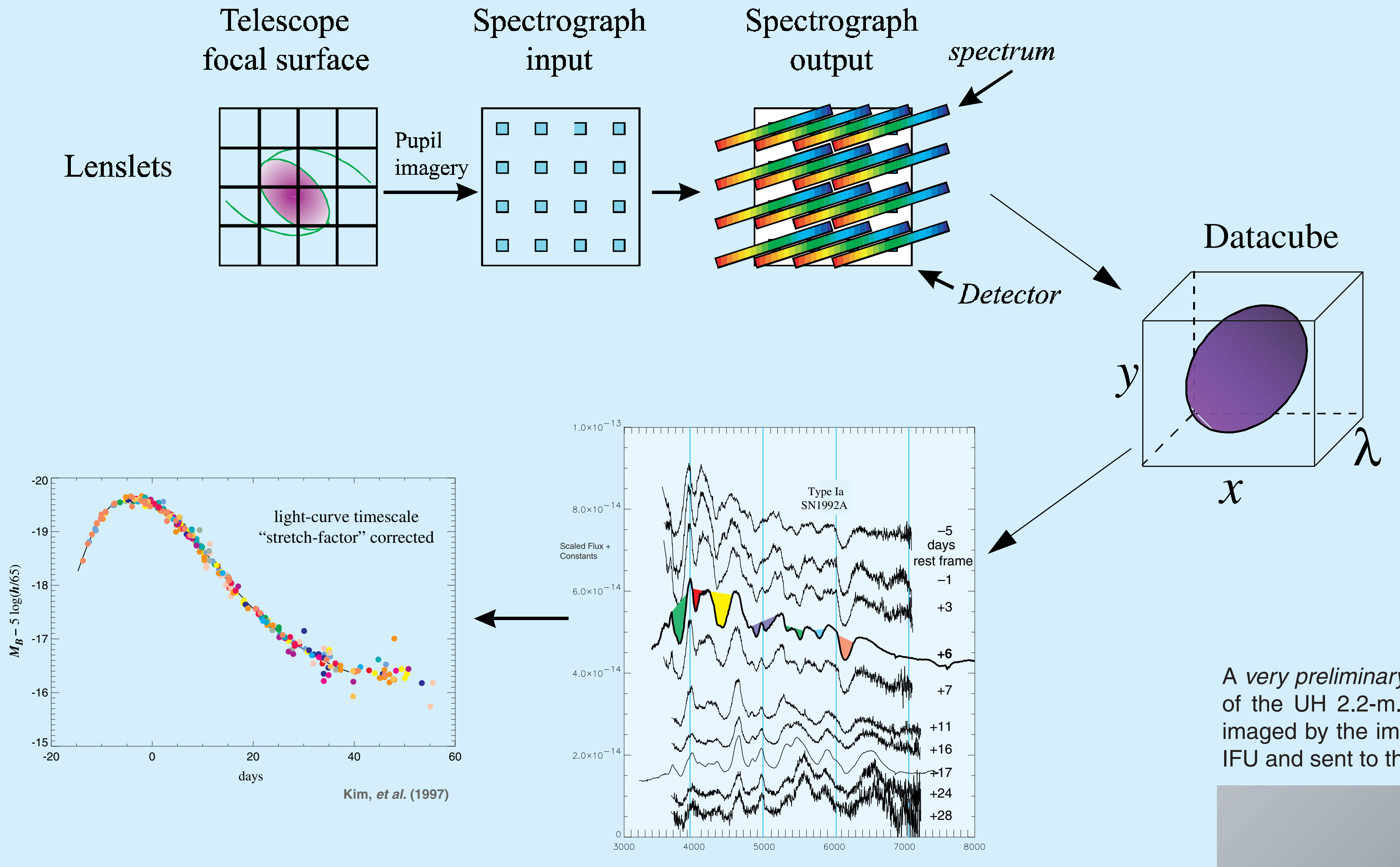
To find nearby SNe, we search wide-field images from the Near Earth Asteroid Tracking (*NEAT*) program run out of JPL. The Haleakala survey telescope has a 1 sq. deg. FOV, while the Palomar telescope has a 3 sq. deg. FOV. Both telescopes have apertures of 1.2-m. After 20-50 Gb/night/telescope of images are transfered (in near real-time) to the mass-storage facility (HPSS) at LBNL, the data are reduced and searched using a 300+ node PC cluster (PDSF). Once the IFU spectrograph is completed by our Lyon team, SN discoveries will be followed automatically at the UH 2.2-m on Mauna Kea. We also anticipate imaging follow-up with YALO II.



With the help of the High Performance Wireless Research and Education Network (HPWREN) at the San Diego Supercomputing Center, the DOE Energy Sciences Network (ESnet) and the Palomar staff we have established a high-speed network which transfers the *NEAT* data from Palomar to LBNL in real time, with the moutainous legs covered by 8 ft radio dishes. Example nightly (”News”) and total (”Refs”) sky coverage from *NEAT* is also shown. *NEAT* has covered almost 11000 sq deg to date, with a typical 10σ detection limit in the *subtracted* images of V = 19.5

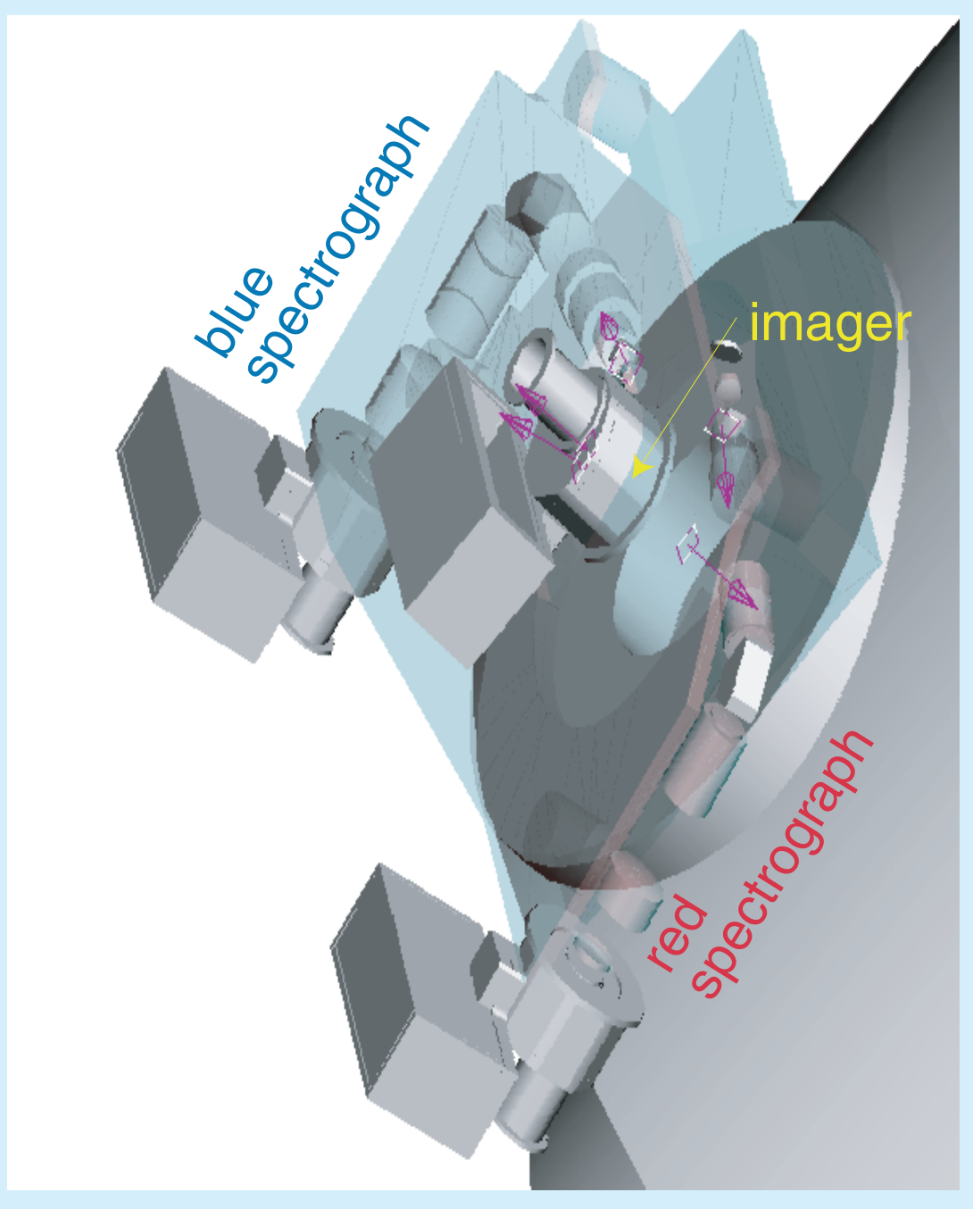


Automation of the follow-up is a key component of the *SNfactory* since otherwise the observing burden would be overwhelming. The above figure shows the control flow from generation of a candidate SN through the follow-up stage. Each candidate is examined and assigned a provisional classification and priority.. An automated scheduler then determines a schedule considering the target priorties and available observing time and conditions. An observing script which commands the UH 2.2-m telescope and the *SNIFS* instrument is generated and then executed. The classification step is intended to help weed-out Galactic variable stars, AGN, and asteroids. Note that this software is still under development.

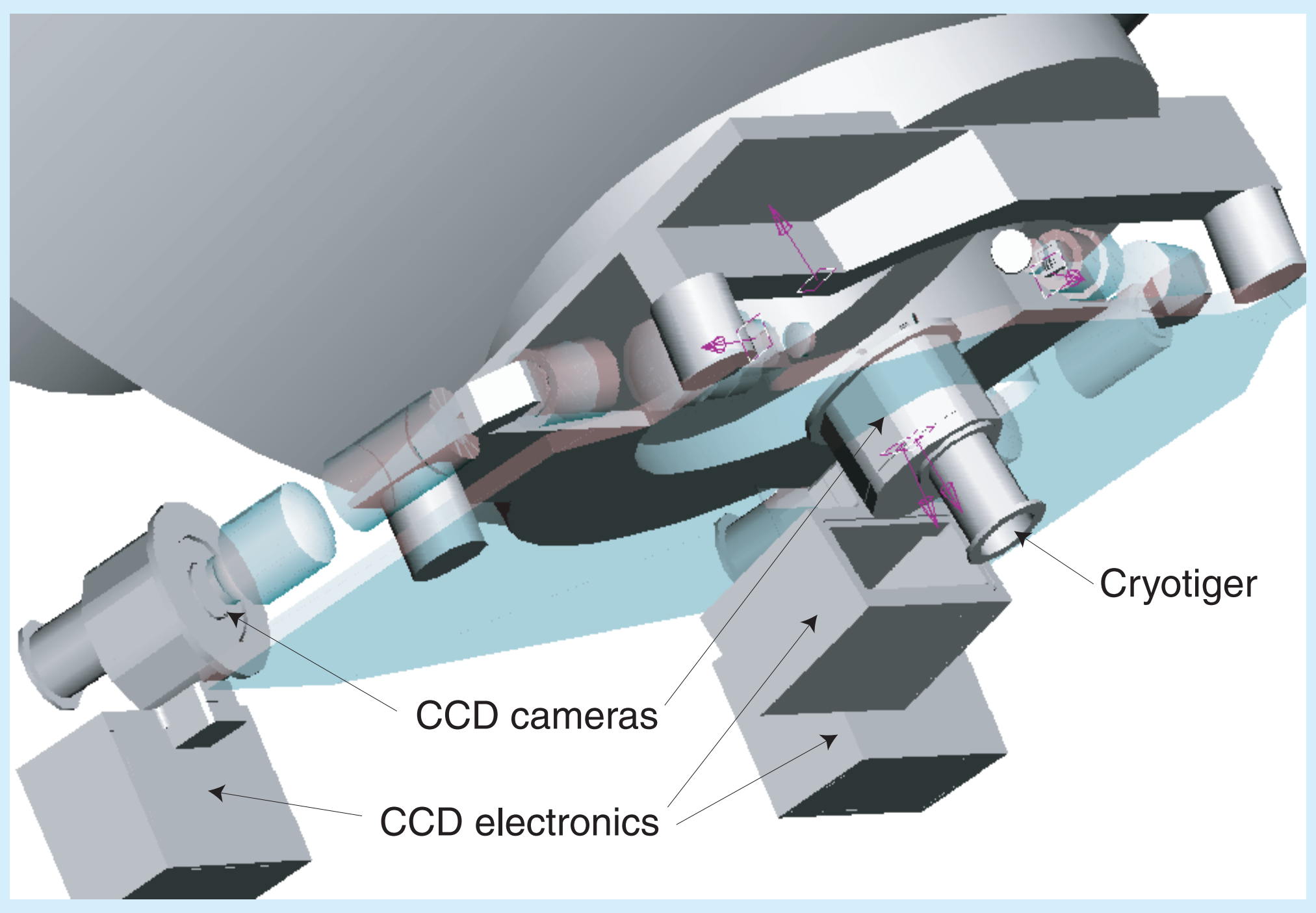


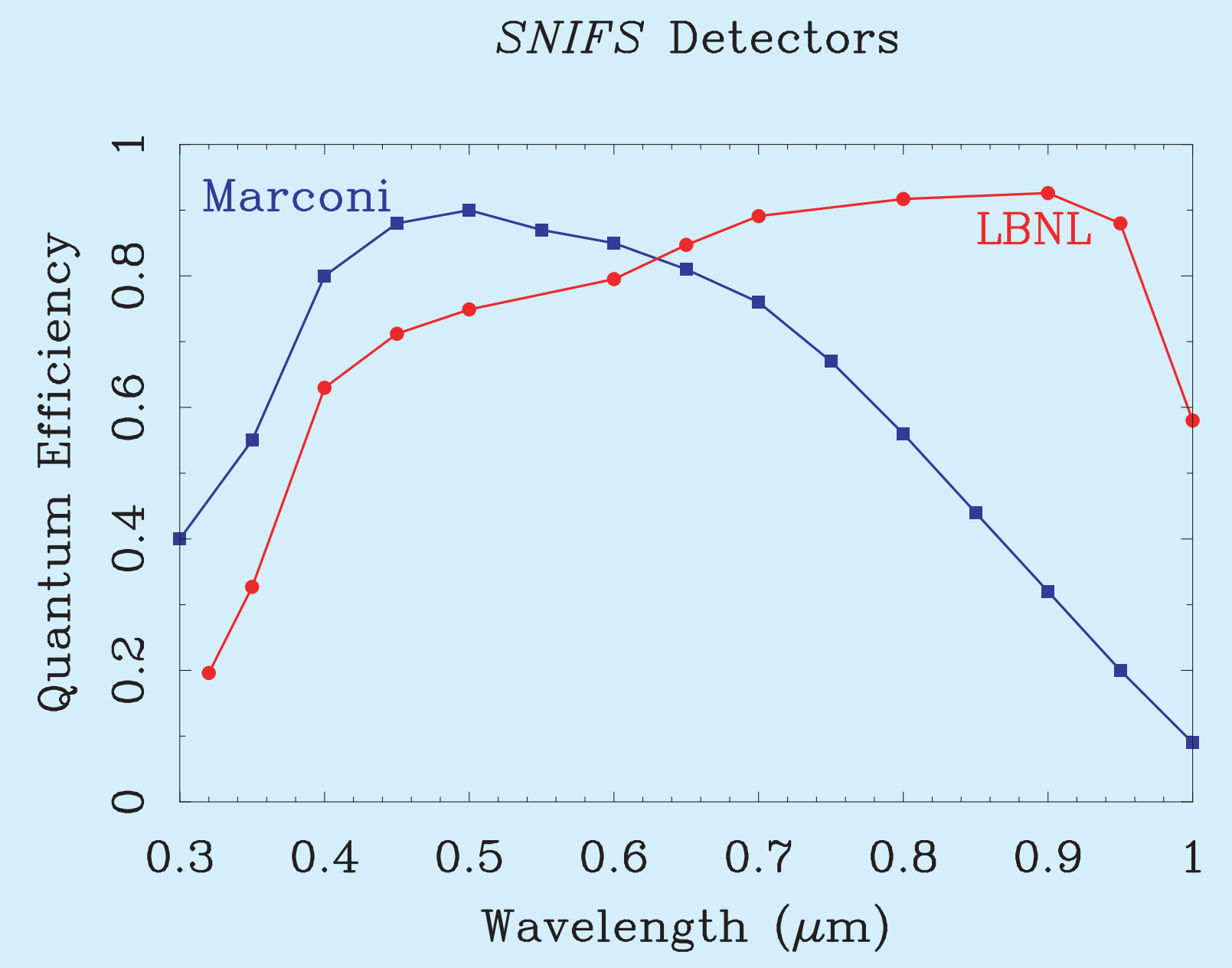
Kim, *et al.* (1997)

In addition to a blind wide-field search using CCD's, another innovation of the *SNfactory* is its use of an integral field unit (IFU) spectrograph to obtain both spectroscopy and synthetic broadband photometry simultaneously across the entire optical window. The SuperNova Integral Field Spectrograph (*SNIFS*) is being constructed in Lyon, and we expect first light at the UH 2.2-m during spring 2003. *SNIFS* utilizes a microlens IFU, with a 6x6 arcsecond field of view sampled at 0.4 arcsecond per microlens. The spectrograph forms a dispersed image of the telescope pupil, as seen by each microlens, on the CCD detectors (3rd graphic from the left in the top row of the above figure). These pupil spectra are extracted to form wavelength- and flux-calibrated spectra at each sky (also containing SN plus host galaxy) spatial location in the IFU field of view. Following background subtraction (sky plus host galaxy) after the SN has faded, only the spectrum of the SN remains. By following each SN over its lightcurve, a spectral time series is obtained which will allow detailed modeling of each SN and may reveal other indicators which can further improve SNe Ia as cosmological distance indicators. In addition, a lightcurve in any filter can be synthesized, without the need to calculate the non-cosmological portion of the K-correction, by integrating through the data cube in the wavelength direction with each wavelength weighted by the filter transmission function.
Note that spectrophotometry is quite difficult with slit spectrographs since the parallactic angle (the direction of atmospheric dispersion) is constantly changing and the seeing disk varies with time and wavelength.

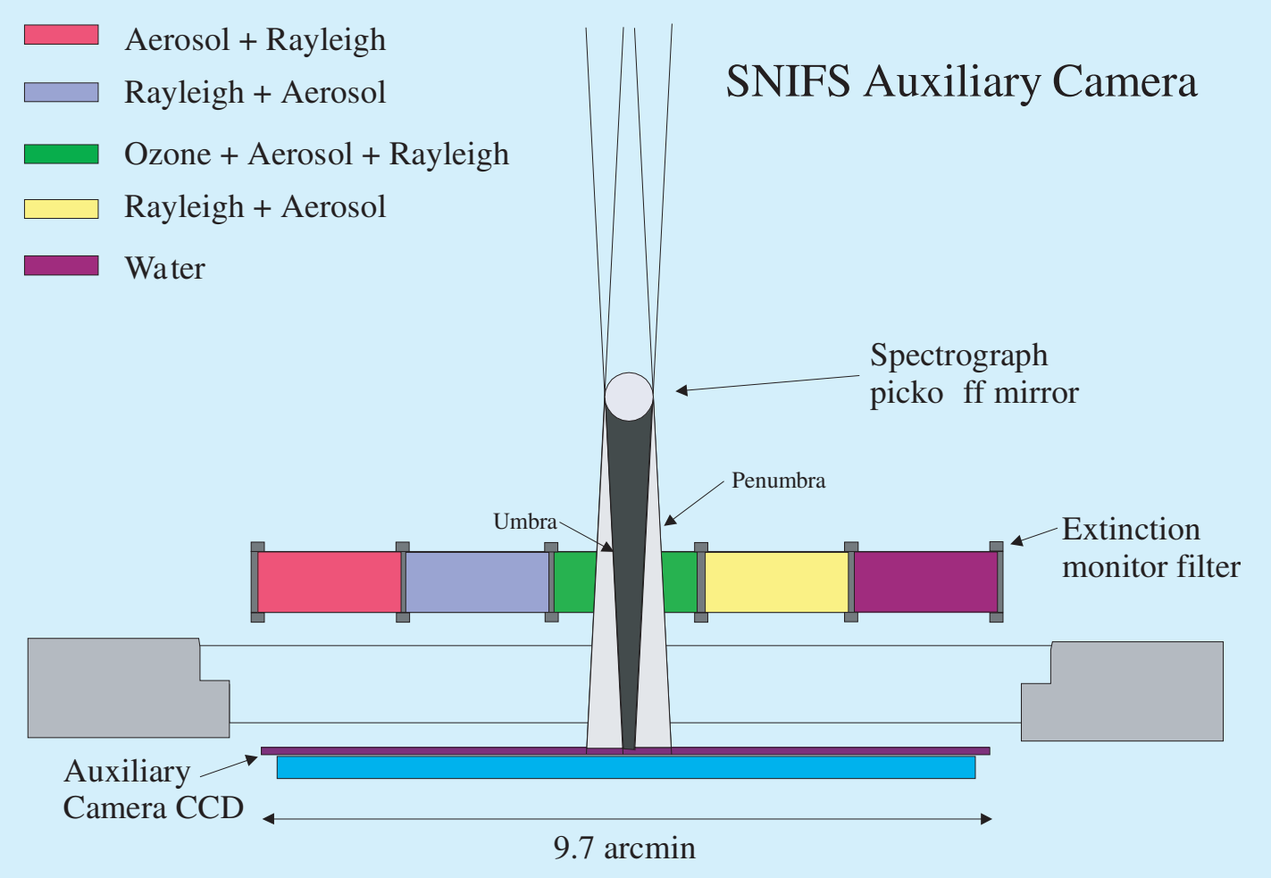


A *very preliminary* mock-up of SNIFS mounted at the bent Cassegrain focus of the UH 2.2-m. Light enters from the side of the telescope tube and is imaged by the imager and guider, while a portion of the field is seen by the IFU and sent to the red and blue spectrograph arms.





The *SNIFS* spectrograph component will have a blue arm equipped with a thinned 2k x 4k Marconi CCD with 2e⁻ RON. The red arm will be equipped with a thick fully-depleted 2k x 4k LBNL CCD. With these detectors *SNIFS* will have excellent throughput from 0.35 to 1.00 microns. Current plans also call for the imager and guider to also use 2k x 4k LBNL CCD's. The cameras are being fabricated by GL Scientific. They will be operated using Leach controllers and cooled using Cryotigers - one for each spectrograph camera and another for the image+guider.



The *SNIFS* imager will be used to acquire target fields and place the SN onto the 6x6 arcsec field of the integral field unit. While spectroscopic observations are being conducted, the imager will observe surrounding field stars using a custom multiband filter. Since the SN fields will be visited many times, the imager photometry can be used to determine the relative extinction for all wavelengths. The bandpasses of the multifilter will be chosen to constrain the principle sources of atmospheric extinction, as indicated in the figure.