

The Hobby-Eberly Telescope Dark Energy Experiment (HETDEX): searching for supernovae among spectroscopic data

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Abstract


The Hobby-Eberly Telescope Dark Energy Experiment (HETDEX) is a unique, large-scale spectroscopic survey which will scan through cca. 430 sq. degree on the northern hemisphere using a special system of fiber-fed multi-object spectrographs called VIRUS mounted on the 9.2 m Hobby-Eberly Telescope at McDonald Observatory, Texas. The main goal of the survey is to discover high-redshift Lyman-alpha emitter galaxies in order to test the current cosmological models including the ones with Dark Energy. The resulting dataset will contain medium-resolution spectra of millions of objects down to $r \sim 22$ mag. This huge, unique dataset, really Big Data, can be a plethora of new information on yet-to-be-discovered objects besides the Lyman-alpha emitters. Our team is proposing the discovery of supernovae (SNe) in the HETDEX spectroscopic dataset. This is a challenging task which requires handling of massive datasets, identifying candidate objects that were not catalogued previously from multi-million spectra, applying pattern-finding cross-correlation techniques to filter out the SNe spectra and confirm the presence of the new SNe with independent measurements. The talk will present some details on these efforts including tests of the proposed discovery technique and the expected outcome of the project.

HETDEX Illuminating the Darkness
Hobby-Eberly Telescope Dark Energy Experiment

Searching for supernovae among spectroscopic data


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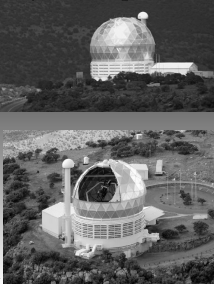
What is HETDEX ?

- collaboration of UT Austin / McDonald Obs., Univ. Sternwarte München, Penn State Univ., Texas A&M, AI Potsdam, MPI für Astrophysik
- a spectroscopic sky survey with the 9.2 m Hobby-Eberly Telescope
- aim: discovery of high-redshift ($z \sim 2$) Lyman-alpha emitter (LAE) galaxies and testing current cosmological models including Dark Energy




The Hobby-Eberly Telescope

- site: McDonald Observatory West Texas
- equivalent diameter: 9.2 m
- fixed altitude, may rotate in azimuth
- objects are followed with a tracker at prime focus





The Hobby-Eberly Telescope

present config



planned config

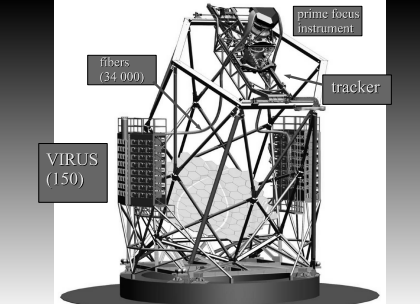




HET
Mt. Fowlkes, west Texas

HET is the world's third largest telescope. It will be upgraded with a uniquely powerful new instrument called VIRUS

VIRUS consists of 150 units mounted on HET



fibers (34 000)

prime focus instrument

tracker

VIRUS (150)

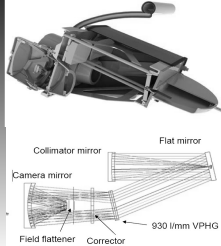
VIRUS

Visible Integral-field Replicable Unit Spectrograph

fiber-fed multi-object spectrograph (~ 224 fibers / unit)

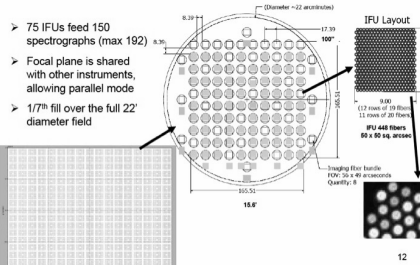
resolution $\lambda / \Delta \lambda = 780$

wavelength coverage: 3500 Å – 6500 Å



Integral-Field Unit (IFU) layout

- 75 IFUs feed 150 spectrographs (max 192)
- Focal plane is shared with other instruments, allowing parallel mode
- 17" fill over the full 22" diameter field



(Diameter ~22 arcseconds)

IFU Layout

930 (12 rows of 30 fibers)

IFU 488 fibers 80 x 80 sq. arcsec

Imaging fiber bundle 600, 24 arc arcseconds, clarity: 8

12

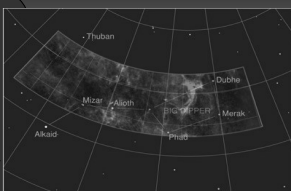
The Hobby-Eberly Telescope Dark Energy Experiment (HETDEX)...

Survey area ~ 430 sq. degree

Spring field:
13h, +53°
294 sq.deg

Fall field:
1h30m, 0°
140 sq.deg

fill-out factor: 1/7
total covered
area: 60 sq.deg



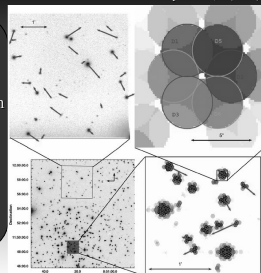
Survey strategy

Adams et al. ApJ S 192, 5 (2011)

continuous scanning
of full survey area

~ 4000 pointings with
4x5 arcmin²
field-of-view

3-point dithering
at each pointing



HETDEX Data volume

150 CCDs, 4 Mpix each, 3 shots / pointing
=> 3.4 GB / pointing raw data

Approx. 10 pts / night => 34 GB per night raw data

Total survey: ~4000 pts => 14 TB raw data

Calibrations + multiple reductions => ~500 TB total

Science data : ~200 GB / night, ~100 TB total

HETDEX is a real source of Big Data

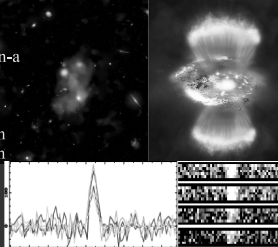
HETDEX Science

Main science goals:

discovery of Lyman- α
emitter galaxies at
 $z \sim 2$

detection of Baryon
Acoustic Oscillation
patterns

testing current
cosmology theories
including Dark Energy



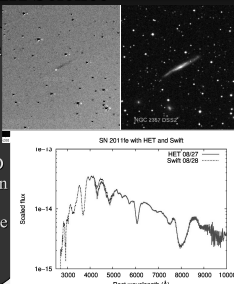
HETDEX Science

Discovery of supernovae in the HETDEX data

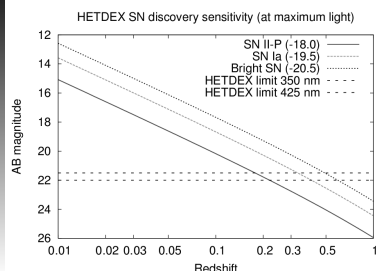
Motivation:

SN discovery requires
new object detection AND
spectroscopic confirmation

HETDEX data can provide
both simultaneously



Supernovae are bright



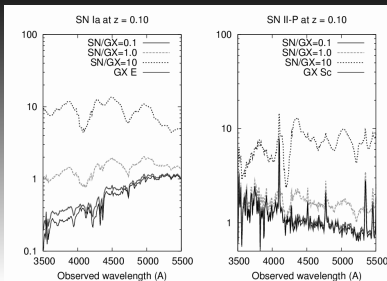
Supernovae are numerous

SN rate: Ia ~ $3 \cdot 10^{-5}$ SNe/yr/Mpc³ CC ~ $1 \cdot 10^{-4}$ SNe/yr/Mpc³
Dilday et al. ApJ 713, 1026 (2010) Bazin et al. A&A 499, 653 (2009)

	$z = 0.3$	$z = 0.2$
Survey volume	72×10^6 Mpc ³	23×10^6 Mpc ³
Covered volume	10×10^6 Mpc ³	3×10^6 Mpc ³
Number of SNe (full field, 3 yrs)	Ia: 6540 CC: 6970	
Number of SNe (covered, 3 yrs)	Ia: 934 CC: 995	
Number of SNe detectable	Ia: 12 CC: 91	

Number of expected SNe ~ 100

Supernovae show broad spectral features



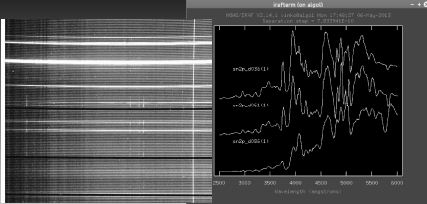
How to find SNe in HETDEX

- locate point sources ($N\sigma$ above background)
- eliminate known sources (based on catalog)
- subtract local background spectrum
- fit SN template spectra (broad features)
- select SN candidates from χ^2 statistics

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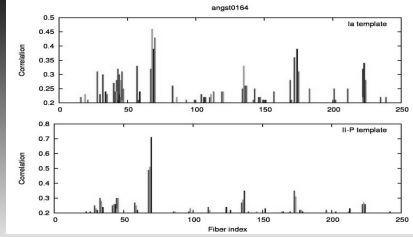
Proof of concept from VIRUS-P data



VIRUS-P spectra

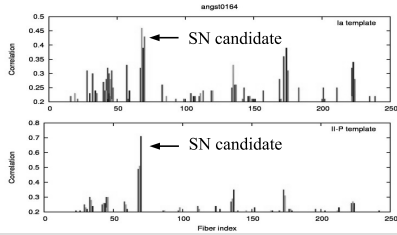
Supernova templates

Proof of concept from VIRUS-P data



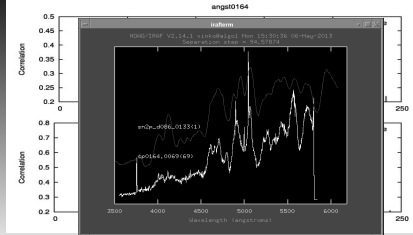
Results from cross-correlation

Proof of concept from VIRUS-P data



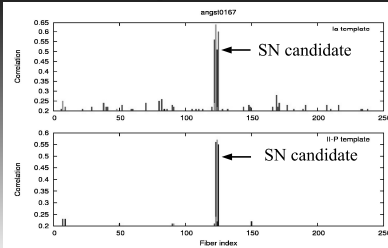
Results from cross-correlation

Proof of concept from VIRUS-P data



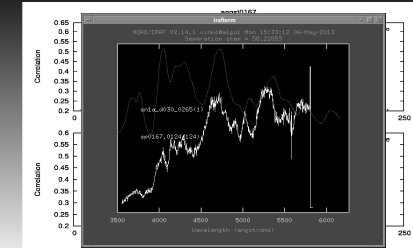
Spectrum at ccf peak and the best template

Proof of concept from VIRUS-P data



Results from cross-correlation (2nd pointing)

Proof of concept from VIRUS-P data



Results from cross-correlation (2nd pointing)

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