Searching for Transients with DESIDIFF: Spectroscopic Data Processing with NERSC

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ABSTRACT

The installation of the Dark Energy Spectroscopic Instrument (DESI) on the Mayall Telescope at Kitt Peak Observatory in Tucson, AZ, has opened up many frontiers of cosmological research. Among them is the ability to detect multi-messenger, supernovae and possibly other transient events through changes in target galaxies' spectra. One of the methods of discovery of transients is from differences of spectra of the same object taken at different times, hence the name DESIDIFF.
This conceptual method was implemented prior to this summer, via trigger algorithms applied to spectral differences optimized for different sources. Being sensitive to unknown transients, as a concept DESIDIFF flags the cataclysmic variable, H-lines, TDEs, narrow-line transients that are not easily detected in broad-band surveys.

During the "Survey Validation (SV)" phase of observing, the processing pipeline of the transient searches was working. The automated processing produced O(10) objects per night for SkyPortal (the DESI visualization and event handling app) to scan. When the survey later officially started, neither pipeline worked.

My work this summer as a CCI intern, under the supervision of Alex Kim, staff scientist in the Cosmology group at Lawrence Berkeley National Laboratory, was to re-establish a functioning pipeline of data from SkyPortal, successful processing of differenced spectra, flagging of candidate events and storing those events in DESI's API SkyPortal.

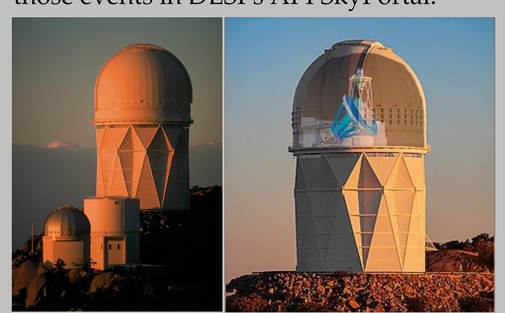

Figure 1. Exterior of Kitt Peak Observatory in Tucson, Arizona, with cutaway DESI instrument position within dome. Image: NOAO/AURA/NSF

RESEARCH QUESTION

How to produce differenced spectra and flag transient candidates?

DATA FLOW

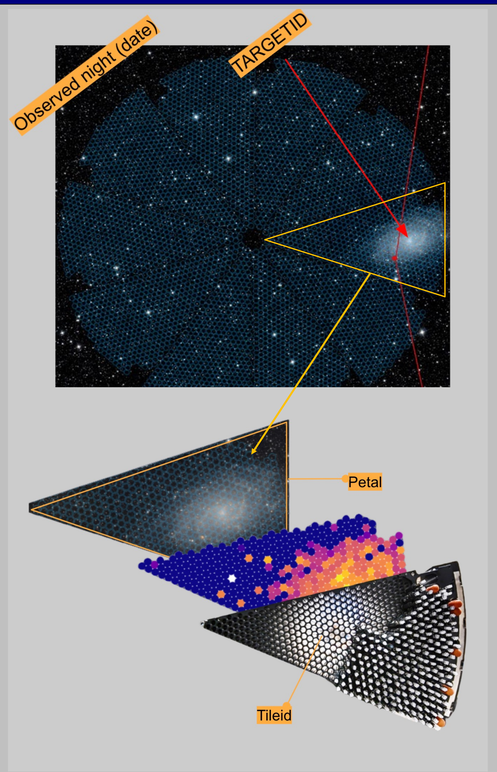

Figure 2 A portion of the night sky containing a target galaxy. DESI field of view superimposed, showing petal, tile placement. (Figure credit: Dustin Lang, Aaron Meisner, DESI Collaboration / Imagine Sky Viewer; NASA/JPL-Caltech / UCLA; Legacy Surveys project.)

The basic structure of DESI, the instrument of 5000 optical fibers, each capable of capturing a target object's spectrum, is that of PETAL, TILE, and then FIBER [2]. The positioning of this fiber referred to by right ascension and declination of the target galaxy on the night of observation. The unique identifier for each astronomical object is TARGET ID.

Data from a tile/petal/night grouping is displayed in a table format. Data pulled from one night's observation can run >10 Gb. Individual observations are around 0.25 million, with over 100,000 unique targets, and 500 target spectra per unique tile and petal pair.

PROGRAM FLOW

NIGHT
One of an array of nights
not previously processed

Read in **CURRENT NIGHT'S FILE**
Collect **z-shift, tile, petal info**

Retrieve **SPECTRA**
Specified by night, tile, petal, and **target id**

Retrieve **PREVIOUS OBSERVATION'S FILE**
Match with **current spectra** by **target id**

Perform **NORMALIZATION, MANUAL DIFFERENCING**
Returns a new **differenced spectra**

Pass through **BROADLINE** and other **FILTERS**

If passed,
Send **DIFFERENCED SPECTRA**
to DESI's API **SkyPortal** to investigate

Possible application of **machine learning** to categorize **SPECTRA**

RESULTS

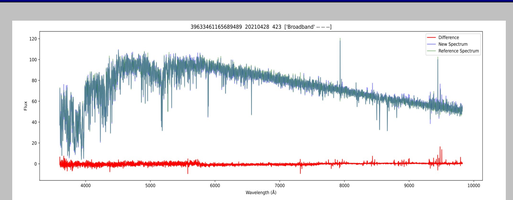

Figure 3a. Plot of wavelength vs. flux for one target for $\Delta\lambda = 7000$Å, total wavelength range. Current spectra in blue, reference spectra in green and the manually differenced spectra in red (Figure credit: DESI Collaboration, LBNL, CL, 2022.)

Plotting the current, reference and differenced spectra's wavelength vs. flux demonstrate the effectiveness of the code developed.

FUTURE

Once the pipeline is functioning nightly, triggered objects – differenced spectra that have passed various filters – are flagged in DESI's API, known as SkyPortal, where the image can be visually examined, along with additional data collected, and follow-up observations proposed.

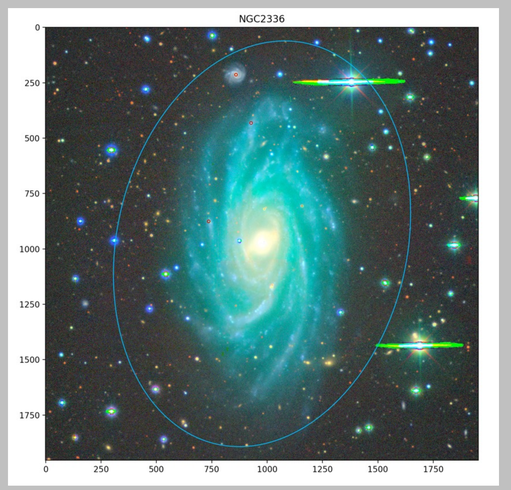

Figure 3b. Target galaxy selected from Siena Galaxy Atlas 2020 for observation by DESI (Figure credit: DESI Collaboration, LBNL, 2021.)

Going forward, we will refine filter-triggering thresholds to better identify candidate transient event spectra, and move on to the cataloging of transient events into the relevant types, e.g. type Ia Supernova. This is also a relevant application of of in-progress machine learning PAE programs.

ACKNOWLEDGMENTS

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