Time Domain Astronomy with DRAGONS at Gemini Observatory

GEMINI OBSERVATORY
Exploring the Universe, Sharing its Wonders

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THE PROJECT

Gemini Observatory's Strategic Scientific Plan aims to position its telescopes as the premier 8-m facilities for discoveries in the Time Domain era, requiring rapid response to time-critical observations and quick distribution of reduced data. As part of a project to achieve this aim, Gemini's new Python-based data reduction platform, DRAGONS (Data Reduction for Astronomy from Gemini Observatory North and South), is being enhanced with generic tools for the reduction of longslit spectroscopy, with an initial emphasis on data from the GMOS optical spectrograph. DRAGONS already handles data from all current facility imagers and allows for hands-off pipeline reduction needed to rapidly create reduced data products.

IS THIS SOURCE AS INTERESTING AS WE THOUGHT?

The software will provide near science quality calibrated products for time-domain follow-up observations within minutes of completion the observation sequence. The primary objective is to allow the Principal Investigator to make an informed decision as to whether or not more data are needed, with which instrument, and to evaluate the urgency of any new observations.

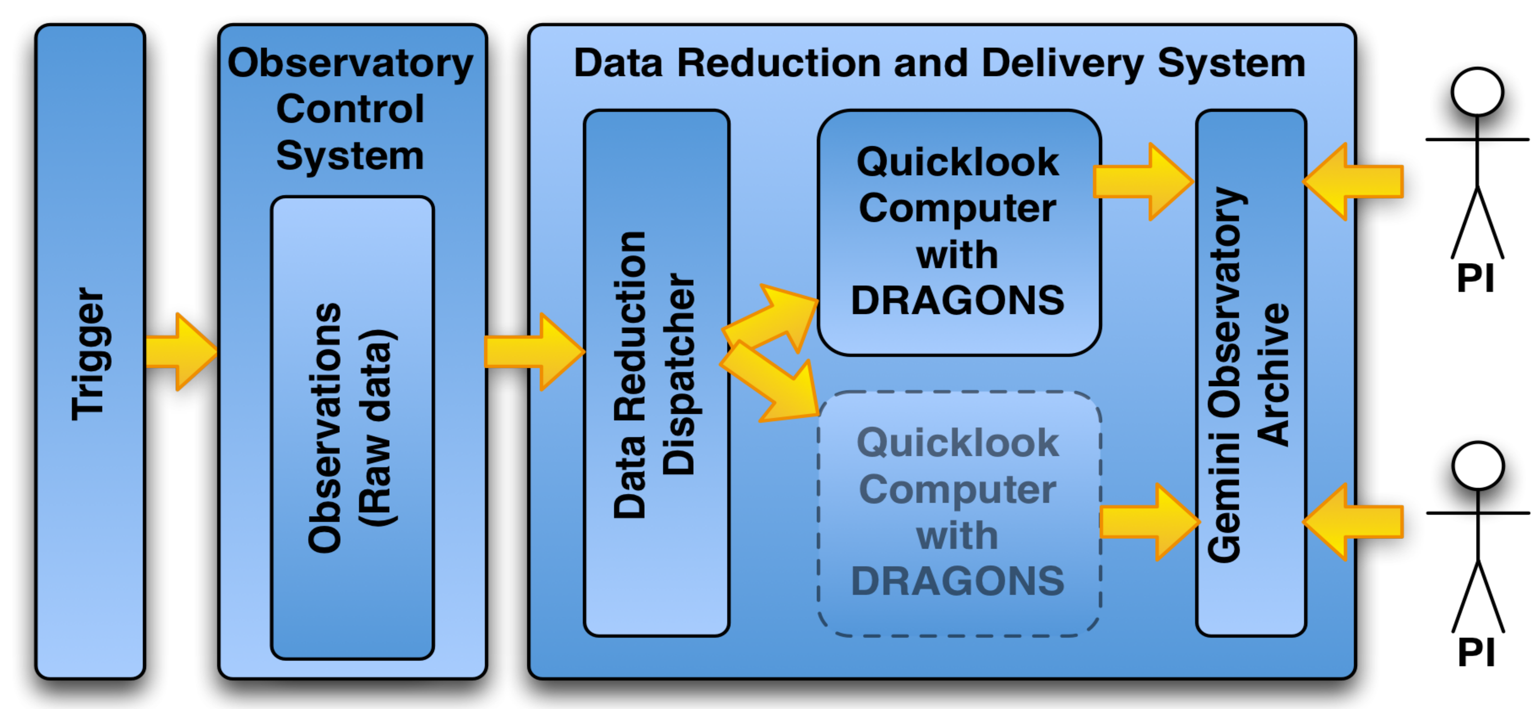
Will do:

- Imaging and longslit spectroscopy for facility instruments. Optical and near-infrared.
- Completely hands-off.
- Reduction as close to science quality as possible given quick turnaround constraints.
- Calibrated images and spectra. Sky and instrument signature removed, stacked, flux calibrated. 2-D and 1-D extracted spectra.
- Data products available for download through the Gemini Observatory Archive.

Will not do:

- Use the best calibration as it might not be available right away
- Slow computations, like cosmic ray removal.
- Photometry, redshift, EW, or any kind of measurements. This is left to the PI.

PROCESS FLOW



The triggers come from event brokers with selection criteria set by the Principal Investigator (PI), or triggered manually by the PI. The observations are taken and the Observatory Control System notifies the Data Reduction Dispatcher. The observations are processed at the end of the observation sequence and the products are uploaded to the Gemini Observatory Archive. The PI retrieves the products from the Archive. Our team works on the Data Reduction and Delivery System.

THIS IS NOT A SURVEY PIPELINE!

Automation and Robustness, obviously, but for...

➡ *Wide variety of instruments and instrument configurations.*

➡ *Wide variety of sources type and brightness.*

Calculating the wavelength solution is particularly difficult given the wide range of instruments, gratings, central wavelength, and distortion. See box below.

The extraction is problematic. Point sources or extended sources? Will there be any continuum to trace or just emission lines? Will there be multiple sources along the slit to extract? How bright is the source? See box to the right.

EXTRACTION

To improve the sensitivity to faint sources in the initial search, we determine the statistics at each row/column along the dispersion direction and identify sky lines as regions of high variance. The regions between the sky lines are then summed along the dispersion direction to produce a one-dimensional spatial profile that should maximize the signal-to-noise ratio.

The source locations are traced along the dispersion direction and one-dimensional spectra extracted using the optimal extraction method of Horne (1986, PASP 98, 609).

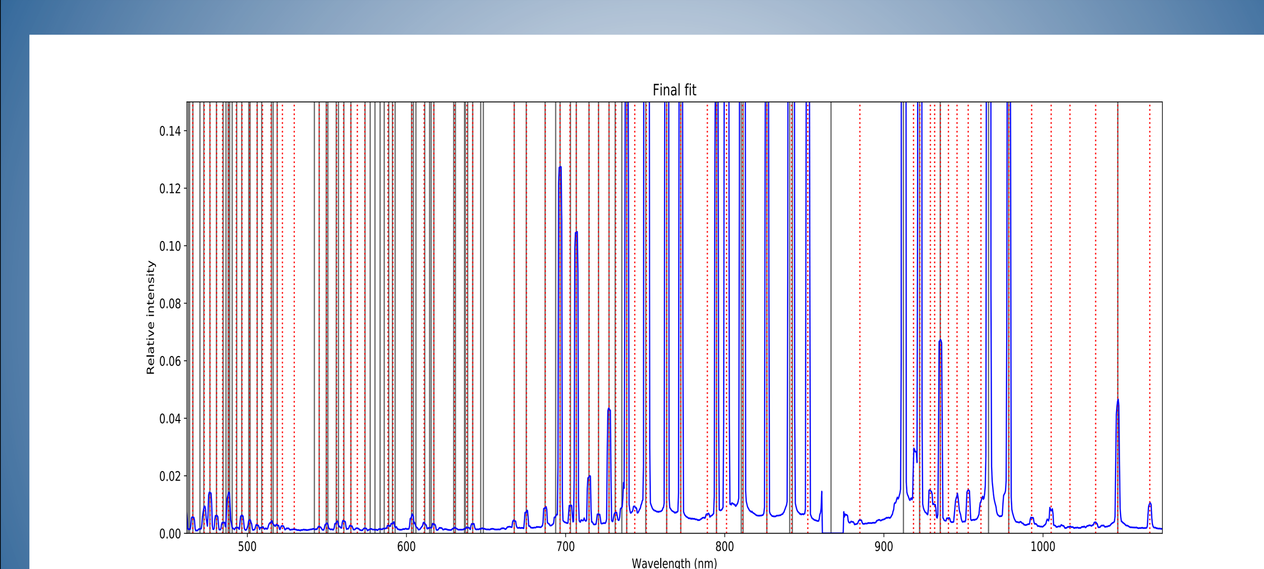
When no sources are identified, we have to assume that the very faint or no-continuum source has been centered on the hot-spot and we perform a "blind" extraction at that location.

AUTOMATED, FAST WAVELENGTH CALIBRATION

To automate the wavelength calibration, a versatile and robust algorithm has been implemented that allows line identification on wide variety of arcs with different central wavelength, line strength, resolution, from widely different instruments. The other existing algorithms are often designed for a given configuration or can require some human interaction.

The line identification is performed with a peak cross-correlation algorithm with arbitrary transformational complexity that was originally developed by us to perform alignment of two-dimensional images. It is now adapted to work on one-dimensional coordinate systems as well. The algorithm does not require a one-to-one correspondence between the input and the reference coordinates, the two lists can be of different lengths. To increase performance, the cross-correlation is performed by constructing a KDTree from the reference coordinates and only considering those input coordinates that are transformed to be within a certain distance.

The GMOS wavelength solutions are cubic or quartic polynomials and, while the correct solution is often found directly, it is not as robust as required for a reduction pipeline. We therefore use an iterative process, performing an initial linear fit with the dispersion fixed (since this is accurately known) and then allowing all parameters to vary while adding higher-order terms.



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Github: https://github.com/GeminiDRSoftware/DRAGONS

Documentation: https://dragons.readthedocs.io/

Contact during meeting

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