TMT Early-Career Initiative: Mini-Projects for 2018-2019

Use cases for the TMT data archive

Warren Skidmore (TMT Telescope Research Scientist) and Francisco Delgado (TMT Software Group Leader)

TMT is considering what kinds of data archiving and processing infrastructure will be essential to future TMT users and the broader astronomy community. Your team will consider and map out possible use cases for a TMT data archive and processing pipeline, based around science cases that could be achieved with archival TMT data. You may then draft recommendations informed by the use cases. Questions to consider include:

- What is required of the archive to enable use by teams of astronomers, toward different science cases?
- What kinds of processed data, and information about processing methods, are important?
- What operations (e.g. nightly calibrations, calibration cadences paired with observing sequences) are required to meet community needs for archived and processed data?

Detailed Science Case Tool

Warren Skidmore (TMT Telescope Research Scientist)

TMT has been developing an online tool for scientists to submit and edit science cases for the next iteration of TMT's Detailed Science Case, and flowdown from science cases to observatory and instrument requirements. We anticipate this will be a major improvement to the format used to collect individual science cases for earlier versions of the Detailed Science Case. We are seeking teams of astronomers to pilot a preliminary version of the new online tool, and give recommendations to improve its utility for astronomers spanning the worldwide community. Considerations include how the tool can support a broad range of information that may be included in a science case, and offer enough information about TMT's potential capabilities to encourage submissions from astronomers newly joining the TMT collaboration.

Use cases for WFOS observations

Kevin Bundy (WFOS Principal Investigator) and Maureen Savage (WFOS Project Manager)

The Wide-Field Optical Spectrometer (WFOS) is one of TMT's first-generation instruments. Science cases for WFOS are still being developed and refined, and specific observing requirements to achieve science goals will inform the operations and calibration modes supported by the final instrument design. Your team will create a "use case" or observing plan to achieve a specific science goal of your choosing. You will outline the specific observations required (i.e. numbers of targets, exposure times, spectral configuration, calibration sequences, data reduction capabilities), and summarize the key aspects and requirements of the observing program for the WFOS science team.

Use cases for NFIRAOS+IRIS PSF reconstruction

Jessica Lu (UC Berkeley), IRIS science team member

The NFIRAOS adaptive optics system and IRIS spectrograph on TMT will be required to deliver a point-spread function (PSF) whose measured characteristics (after PSF reconstruction) can be matched to the requirements of different science programs. However, the requirements and design for facility-class PSF reconstruction are not yet well defined. Active efforts at TMT, Berkeley, and Keck to develop and test reconstruction algorithms are in need of design and use-cases. The initial goal of this mini-project is to produce a use case document for one or more NFIRAOS+IRIS science cases. Additional goals are to apply at least three use cases to update the PSF reconstruction requirements document, and contribute to a conceptual design for a NFIRAOS+IRIS PSF reproduction facility.

Designing a pinhole mask test unit for NFIRAOS

Jessica Lu (UC Berkeley), IRIS science team member

Good calibration of the geometric distortion and the field-dependent phase aberrations are essential for precision astrometry and photometry measurements with the NFIRAOS adaptive optics system and IRIS spectrograph for TMT. The optimal way to measure optical distortions and aberrations through an instrument is to use a precise mask of pinholes at the first focus. The pinhole mask can be dithered to map the geometric distortions and shifted to different out-of-focus positions to perform phase diversity measurements and thereby map phase aberrations over the field. Although current pinhole masks are manufactured precisely enough to meet our needs, our lab tests have discovered that the mask mount can distort the intrinsic pinhole pattern. Your team will design a pinhole mask test unit, including a robust mount, for our NFIRAOS test mask, which will be deployed at Keck Observatory in order to perform tests needed for TMT. It may be useful to work with ZeMax and CAD modeling software.

PSI optical relays

Mike Fitzgerald (UCLA), Planetary Systems Imager co-lead

The Planetary Systems Imager (PSI) is a proposed second-generation instrument for TMT. In order to characterize light reflected and emitted by nearby exoplanets, PSI requires front-end instrumentation for sensing and control of aberrated wavefronts, followed by a coronagraph for the suppression of unwanted starlight, and finally back-end instrumentation for recording residual signals. Each of these stages relies on technologies that have characteristic physical size scales. The light is carried between different instrument components by a system of optical relays (often with off-axis parabolic mirrors) that additionally aim to match the beam footprint to the physical scales of each of the components. In this activity your team will provide an initial concept for the optical relays in the instrument, using the current block layout for the various modules of PSI that sense and control light.

TMT optical camera behind NFIRAOS

Jessica Lu (UC Berkeley), IRIS science team member

TMT NFIRAOS produces AO corrected images into optical wavelengths. However, there is no instrument that provides imaging at these optical wavelengths. Several very interesting science cases would benefit from near-diffraction limited imaging at 600 nm - 950 nm using low-noise CCDs. This includes (1) measuring masses of stars in very close binary systems by monitoring their orbits, (2) finding and weighing free-floating black holes and neutron stars when they gravitationally lens a background star, (3) trace jet emissions from young stars or other accreting compact objects such as quasars. Many of these science cases require high-precision astrometry. This mini-project group will produce a feasibility or pre-conceptual design for an optical camera fed by TMT NFIRAOS (the facility laser-guided adaptive optics system). The camera should enable high-resolution imaging and high-precision astrometry.

IRIS astrometry web tool

Jessica Lu (UC Berkeley), IRIS science team member

A variety of science cases for TMT IRIS will require astrometric measurements at high accuracy and precision. The IRIS team has developed a calculator for analysis of astrometry errors under different conditions and instrument modes; however, this tool needs a front-end interface to enable straightforward use by scientists across the TMT collaboration. Your team will develop a web-based tool with complete astrometry error budget analysis for different science cases.

WFOS optics finite-element analysis

This mini-project was completed during the 2018 TECI Workshop.

Renate Kupke (senior optical designer, WFOS) and Nick MacDonald (senior engineer, WFOS)

A critical aspect of instrument design is the iteration between the optical design and the opto-mechanical support system which holds the optics in place. In the early stage of an instrument design the iteration is between the optical model and the finite element analysis (FEA) which can predict the deformation of the optics under gravity loading. The primary software package for optical modeling is Zemax and the chosen opto-mechanical modeling system is Solidworks and ANSYS. For the TMT Wide-Field Optical Spectrometer (WFOS), the output from the opto-mechanical system is not directly transferable to our Zemax environment. Your team needs to develop a custom software tool (Python or Matlab) to translate the FEA output file into an appropriate format for the Zemax modeling, allowing for some flexibility.