ASTR 306/406 Observing Proposal Project

Your task is to write an observing proposal to use one the NOIRLab Gemini telescopes to do optical and/or near-infrared imaging for a scientific project. Here are the broad parameters:

- You propose for one scientific project.
- Your proposal must ask for between 6 and 35 hours of observing time.
- You can apply for at most two observing runs during the year to complete the project.
- You can ask for time on both telescopes, but they must be different times.
- There are only two instruments you can use:
  - Optical imaging: GMOS
  - Near-IR imaging: NIRI (using the f/6 camera)
- You must be doing broadband imaging (ugriz filters on GMOS, YJHK filters on NIRI)
- Assume those instruments are available at ***both*** Gemini-North and Gemini-South.

Things to consider:

- Pick an interesting scientific question. If you are having trouble choosing on a topic, there are a few possibilities at the bottom of this page. Note: You ***cannot*** pick any of these topics:
  - studying the surface brightness and color profile of a nearby galaxy,
  - searching for AGN in clusters, or
  - any topic you may be researching in real life (senior project, grad project, etc)
- What imaging data do you need to conduct your study (what filters do you need, how bright are your objects, how big of an area of the sky do you need to cover)?

- What signal-to-noise do you need for your data? (The best you can do with photometry is probably about 0.02 mags -- if you need better accuracy than this, your project isn't viable.)
- How much observing time would you need? (Use the exposure time calculators to estimate this).
- Note on exposure times:
  - If you get exposure times that are less than ~ 5 minutes, that means you are looking at very bright objects that don't need such a big telescope (and your proposal would be rejected). Instead, think about fainter objects: intrinsically fainter objects, or objects at greater distances.
  - If you get exposure time which are very long (like, it would take 20+ hours to do one observation), you are probably looking at things which are simply too faint for a good detection. Try brighter objects.
- If your object is too big to fit in the field of view of the instrument, do you only study a portion of it (with long exposures), or a cover it with many shorter exposures?
- If you are studying a single object, make sure the object is visible for your observations! Objects should only be observed when they are reasonably high in the sky (altitudes above that corresponding to an airmass of sec(z)=1.5 or so.)
- If you are studying a sample of objects, what are the properties of your sample? How many objects do you need to study?
- If you are proposing a project that need “extra data” (for example: spectroscopy to get velocities or redshifts, or imaging at other wavelengths), assume you have a collaborator who is getting that data for you. In your proposal, mention that you will be getting that other data as well, but be sure to explain why the Gemini data is important to the project!

Proposal Structure and Format

Note: the page length descriptions by section are different from what you see in the example proposals, and also don't follow the format of the actual Gemini proposal process. Follow the instructions here!

The proposal should be written single-spaced in 12 point font with 1 inch margins. Page length guidelines follow this format.

Cover Page (1 page maximum):

- Note: Do NOT include your name! We are going to do a double-blind review, so names should not be included on proposals.
- An abstract that briefly describes the project science goals.
- A summary of the observations: what telescope/instrument, which filters, how many nights, what time of year, etc.

Scientific Justification (1-2 pages). If you're writing less than this, you're not being thorough; if you're writing more, you're not editing yourself well.):

- Explain the background: why the science is important, what we want to learn.
- Pose a scientific question that you are trying to answer.
- Explain how the observations you propose will answer your question. What will you do with the data? There should be some interpretive/comparative component to your project.
- Remember that your audience is astronomers, but not necessarily a specialist in your field. You may be explaining quasar science to somebody who images exoplanets for a living, for example. So you need to convince them that your science is interesting.
- PROPER ACADEMIC REFERENCING IS REQUIRED. Poor referencing practices is a sure sign of a poorly written or poorly researched project. See the example proposal for the proper style.

Figures and References (a page or two max):

- Your reference list should follow the style of the example proposals and should have a dozen or so references that support the statements made in the proposal.
- It is usually best to include a couple of figures which illustrate the particular point you are trying to get across. They could show examples of data already taken (by you or others), or plots that show a relationship you are trying to test, etc.

Technical Description of Observations (about 1 page):

- Description of the object you are observing (size, magnitude, etc). If you have a large sample of objects, give some characteristic examples. If you are observing a variety of objects, describe how you chose those objects (why are they in your sample?). Similarly, if you are imaging many fields of a single object, how are you deciding on those fields? (center of the target vs outskirts? or are you trying to map the whole things?)
- Coordinates (if you are observing a specific object), or ranges of coordinates (if you are conducting a survey of objects)
- Explanation of which filters you are using and why.
- Justification for the choice of telescope
- Justification for the allocation request (signal-to-noise considerations, exposure times, time of year, etc)

Other Notes:

- Writing, spelling, grammar, formatting are ALL important. Pay attention to detail. Proofread, spell-check, etc. A sloppily written proposal will not do well in the review process!
- Your proposal will not only be graded by me, but also "peer-reviewed" (anonymously) by your classmates.
- There will be prizes (TBD) for the top three peer-reviewed proposals.

Possible Projects (the list is endless, these are just a few ideas)

- Finding the distance, age, and metallicity of distant Milky Way globular clusters via isochrone fitting
- Studying the properties of galaxies in clusters
- Studying the distances to a sample of Milky Way satellite galaxies using tip of the red giant branch (TRGB) estimates
- Searching for variable stars in globular clusters or satellite galaxies
- Studying the properties of the globular cluster systems around other galaxies
- Studying the chemical composition of Kuiper Belt objects (or asteroids) through their colors
- Studying low mass stars in Milky Way star clusters
- Studying the properties of exoplanet host stars
- Searching for high redshift galaxies around distant quasars
- Studying stellar populations in the Magellanic Clouds

Observing Proposal Review Criteria

Scientific/Technical Merit

- Is the science interesting? Is it clearly described?
- Has background information been provided? That is, what have other researchers done in this area? What is the broader context of scientific issue being addressed?
- Can the scientific question be answered with the observations being requested?
- Were the observational details well described?
- If you are proposing to study an individual object (or a few individual objects), have you given *quantitative* information about it (coordinates, magnitudes and/or surface brightnesses, angular size, distance/redshift etc)?
- If you are proposing to study a sample of objects, what are the sample selection criteria? What are characteristic properties (magnitudes, sizes, redshifts/distance, etc)
- What kind of data quality is needed? How well do you need to measure your magnitudes, colors, velocities, etc?
- What interpretation / analysis will you do with the results of the observations to answer you scientific questions?
- Will the proposed observing strategy deliver the necessary data quality, given the properties of your target(s)?
- (For individual objects): Are your objects observable during the time you are proposing to use the telescope?
- (For samples of objects): Have you ensured that your sample is visible using the telescope you are proposing to use?

Writing/Presentation

- Is there a succinct abstract?
- Is information (concepts, models, supporting data) appropriately cited?
- Are figures used appropriately, and explained properly in the figure captions and/or text? Are they comprehensible?
- Does the scientific presentation flow logically and smoothly?
- Is the proposal written using proper grammar and spelling?
- Does it follow the format given in the assignment? (Remember that the assigned format and page limits are slightly different from the format given in the example proposals.)
- Don’t play games with font, spacing, or page margins. Please use single-spaced, 12 point font with 1” margins. (Moderate use of bold or italics is okay, as is larger font for section headers.)

Using the Exposure Time Calculators (GMOS, NIRI)

First, have an idea of the properties of the things you are studying. For example, if you are looking at individual stars in a cluster, what is their apparent magnitude range? What type of stars are they? Or if you are looking at galaxies, how deep in surface brightness do you need to go? I can help you with this, but first you should do some work to get rough ideas! Look at science papers, look at lecture notes from other classes, think about distances, calculate some rough magnitudes.

Astronomical Source Definition

Spatial Profile and Brightness: If you are looking at individual stars or unresolved objects (globular clusters around distant galaxies, or cosmologically distant galaxies or AGN), choose "point source" and enter the apparent magnitude of the objects you are trying to study. If you are studying larger galaxies, choose "Uniform surface brightness" and enter the surface brightness you are trying to reach. Then where it says "brightness normalization" pick which filter this apparent magnitude or surface brightness is defined in.

Spectral Distribution: If you are looking at galaxies or quasars, use the menu under "Library Spectrum of a non-stellar object" that is a reasonable match to your object. If you are looking at individual stars, use the menu under "Library Spectrum of a ____ Star" to choose the kind of stars you are looking at. If you are looking at asteroids or Kuiper Belt objects, use the library spectrum of a G2V star, which is the Sun (since you are looking at reflected sunlight). *Make sure the button next to your Spectral Distribution choice is ticked!*

If you are looking at higher redshift objects ($z > 0.2$ or so), put that redshift into the "spectrum mapped to" box, otherwise leave that alone.

Instrument and Telescope Configuration

GMOS: Make sure "grating" is set to "None-imaging" and the pick the filter you want to use. Leave everything else as-is.

NIRI: Make sure "camera" is set to "f/6" and pick the filter you want to use. Leave everything else as is.

Observing Condition Constraints

- **Image Quality**: Set to 70%/Good, but if you are looking at crowded fields (individual stars in globular clusters or in nearby galaxies) you might want better image quality and can see what happens if you switch to 20%/Best. *This option only matters if you are observing point sources!*
- **Cloud Cover**: Set to 70%/Cirrus, but if you need to you can switch to 50%/Clear
- **Water Vapor**: Water vapor is unimportant for optical imaging, and is only a small effect for near-IR imaging, so set this to "Any"
- **Sky Background**:
  - GMOS: In the optical this refers mostly to moonlight. "Bright" means full moon, "Darkest" means new moon. If you are observing really faint things in optical filters, you probably want "Darkest", but run the calculator for a few different options and see what you get. Choose the brightest option that still allows you to get the data you need.
  - NIRI: In the near IR this refers mostly to emission from molecules in the atmosphere and does not depend on the phase of the Moon, so set this to "Any"
- **Airmass**: Set to 1.5

Details of Observations

Calculation Method: You want to ask what imaging time is needed to get to the S/N you want (the 3rd option). Leave everything else in this section as-is.

Then click "Calculate" -- a new window will pop up with your results.

Interpreting the results of the Exposure Time Calculator.

In the results window, scroll down to **Observation Overheads** and look at what it says for **Program Time**. This tells you how long it takes to do one observation.

Then scroll down to the bottom and look at **Likelihood of execution**: this is the probability that you will actually get the sky conditions you asked for to get your observations.

Example of Using the GMOS Exposure Time Calculator

Project: I want to image a sample of spiral galaxies, going faint enough to detect them down to a surface brightness limit of $\mu_B = 26$ mag/arcsec^2. I want to image them in both the g and r filters, so that I can make g-band surface brightness profiles and $g - r$ color profiles.

In Astronomical Source Definition, under Spatial Profile and Brightness, I choose the "uniform surface brightness" option, enter 26, and normalize it using the B band. Under Spectral Distribution I choose the "library spectrum of a non-stellar object", and then select "spiral galaxy."

In Instrument Optical Properties, I choose the g band and leave everything else as is.

Under Observing Condition Constraints, I use 70%/Good for Image Quality, 70%/Cirrus for Cloud Coverage, Any for Water Vapor, and (to start) 80%/Grey for Sky Brightness. I also check the "1.5" option for Airmass.

Under Details of Observations, I ask for the observing time to reach a S/N of 5. Then I click calculate. The answer comes back: 32min, 22sec with an observing probability of 39%.

Now I go back and do the same thing, but using the r-band instead (since I need imaging in both g and r). I get the results back: 17min, 17sec (and same observing probability).

So to observe one galaxy, it would take me 50mins of observing to get both the g and r images. If my sample was 20 galaxies, I could do it in 1000mins, or 16 hours.

If I wanted to observe more galaxies, I could ask for *more time*, or I could ask for *better time*. That is, under Sky Background I could switch to 20%/Darkest. Darker skies mean its easier to see the galaxies. If I did that, the g-band results say 10min, 38sec and the r-band results say 9min, 48sec. Nice, the observing time drops down to 20min per galaxy, great! But oops, the probability of execution is now only 10%.