Technical Justification

ASTR 240: Due April 10, 2013

In this assignment you will write a technical justification for an ALMA proposal. The ALMA proposers guide suggests that the technical justification portion of the proposal be no more than one page long (12pt font). The ALMA proposal template suggests that you divide the technical justification into the following sections:

Requested Sensitivity: Please justify the requested sensitivity. Relevant parameters to discuss here include the source flux, angular size, width of any spectral lines, desired velocity resolution (or channel width) and significance (i.e. signal-to-noise ratio).

Imaging Requirements: If maps are to be made of your targets, the most important consideration will be whether the imaging algorithms are able to reconstruct the various source components. Consider the largest and smallest angular scales in your source and the corresponding longest and shortest baselines required, and the size of the primary beam (field of view) at the frequency at which you are proposing your observations, and whether mosaicking is required. Note that the ALMA antennas are 10m in diameter.

Correlator Setup: Justify the requested correlator setup, including total bandwidth, channel spacing/velocity resolution, and spectral window placement. Note: the maximum bandwidth available on ALMA during Cycle 1 is 8 GHz per polarization. If you want to use the maximum available bandwidth (which you probably will for continuum projects, since it provides the highest sensitivity – radiometer equation FTW!), make sure that your channel spacing is fine enough to satisfy restrictions on bandwidth/field of view described in BGS 6.8.

Time constraints: Most ALMA projects are not time constrained i.e. they will be dynamically scheduled when the source is sufficiently above the horizon and the atmospheric conditions are appropriate for the wavelength being observed. However, some projects require that they be observed (scheduled) at specific times, others require regular monitoring and yet others require that a source event be observed for a particular amount of time i.e. sensitivity is not the scientific driver. If the time needed to complete your observations is different than that calculated by the sensitivity estimator, explain the time request here.

Please also pay attention to the different ALMA bands (see the table that I pasted below). Band 6 (230 GHz) and Band 7 (345 GHz) are probably the most popular, but the frequency is somewhat tunable within the bands, and you can certainly use the other bands if desired. Be sure to justify your choice of frequency band.

In class, I will assign you one of the following three scenarios (hint: a good way of preparing for the final would be to make sure you understand the technical requirements for each of the following scenarios, not just your own):

1) **How puffy is that disk?**
One interesting question about debris disk structure is how puffy they are in the vertical dimension, as seen at millimeter wavelengths (this tells us how much mass is in the disk, including whether there might be hidden planets). You are proposing to observe the disk around the star AU Microscopii (which happens to be oriented edge-on to our line of sight) to measure how puffy the disk is. You know from single-dish observations of the system that the total flux is 8.5 mJy at a wavelength of 1.3mm, and that its flux varies with frequency as roughly $\nu^{2.5}$. Previous low-resolution observations of the disk have demonstrated that it is about 9" long (in diameter). From scattered light images, you know that the disk might be as large as 0.7" in the vertical direction, but if there is very little mass in the disk, it might be much narrower in millimeter light. For this scenario, be sure to pay close attention to the size of the primary beam and largest angular scale. The longest baselines available in Cycle 1 are 1km; you probably want to take advantage of those longest baselines to place the tightest possible constraints on the mass hidden in the disk. I expect that for this scenario you will spend most of your time/writing on justifying the sensitivity and imaging requirements. Aim for a signal-to-noise ratio of at least 10 per beam.

2) **High-Resolution line spectroscopy**
You want to observe a spectral line to study the kinematics of a nearby circumstellar disk. The effect you're looking for (turbulence, in this case) has an expected line width of about 100 m/s, so you probably want your spectral resolution to be a few times finer than that. You're also interested in observing a relatively rare species of gas because it is optically thin and it will let you see close to the disk midplane, so you choose the DCO+ J=3-2 line (look up the frequency in the Splatalogue). The line's spectrum has been measured with a single-dish telescope that did not spatially resolve the disk. The line has been broadened by rotation to about 1 km/s in width and the peak flux is about 0.5 Jy. Interferometric observations of brighter lines from the disk tell you that the disk is about 3" in diameter (it is viewed nearly face-on, so you can pretend that it is circular). You're interested in resolving spatial scales smaller than the height of the disk, which works out to about 0.5" on the sky. For this exercise, I expect that you will spend most of your time/writing on justifying the sensitivity and imaging requirements.

3) **Quasar variability and superluminal motion**
In class we learned that quasars are highly variable. We also saw pictures of the beautiful jets and radio lobes that come from some quasars. You are interested in observing a quasar to look for periodicity in the light curve of the central AGN on time scales of minutes to hours. You also want to look for superluminal motion in the jets that are being ejected from the quasar; it is expected that individual knots in the jets will move at a rate of 0.1"/year (note that the time and size scales are greatly exaggerated to make this an ALMA-friendly project! Normally this sort of work would be done with the VLBA). A snapshot observation you took last year shows that the brightest knot is separated from the central source by 10" and has a diameter of 0.1" and flux of 10 mJy at a wavelength of 1.3mm with a typical synchrotron spectral slope. The central source has not been spatially resolved, but

it can be assumed to be smaller than the ALMA beam and photometric monitoring has shown that it varies in flux between 1 and 10 Jy at 1.3mm (also synchrotron spectrum). First, determine whether the source and knot fit within the primary beam in all the bands. Then, think about the timing requirements: how long must each observation be? What S/N do you need to achieve? (See information about relative astrometry below; also consider the requirement that you be able to observe variability in the central source on time scales of minutes to hours.) How far apart should the observations be to make sure you detect the motion? I expect that most of the time/writing for this project will be spent justifying the timing and sensitivity requirements of the observation.

Some things to keep in mind:

- Not every project needs to address every section in detail. (For example, if your source is not time-variable, you probably don't have much in the way of time constraints.)
- When doing relative astrometry (measuring the distance between two objects on the sky in the same field of view), the uncertainty in the location of a source can be estimated as the spatial resolution of the observation divided by the signal-to-noise ratio.
- ALMA has helpfully provided some sample angular resolutions and maximum angular scales for six different potential array configurations in Cycle 1 (note that in your technical justification, you should simply specify shortest and longest baseline rather than a particular configuration – these are just for reference, and it's OK if your observation needs to use two different configurations to meet the requirements for shortest/longest baseline):

	C32-1		C32-2		C32-3		C32-4		C32-5		C32-6	
Band (freq)	Ang Res	Max Ang Scale	Ang Res	Max Ang Scale	Ang Res	Max Ang Scale	Ang Res	Max Ang Scale	Ang Res	Max Ang Scale	Ang Res	Max Ang Scale
Band 3 (100GHz)	3.7"	25"	2.0"	25"	1.4"	17"	1.1"	17"	0.75"	14"	0.57"	8.6"
Band 6 (230GHz)	1.6"	11"	0.89"	11"	0.61"	7.6"	0.48"	7.6"	0.33"	6.2"	0.25"	3.7"
Band 7 (345GHz)	1.1"	7.1"	0.59"	7.1"	0.40"	5.0"	0.32"	5.0"	0.22"	4.1"	0.16"	2.5"
Band 9 (675GHz)	0.55"	3.6"	0.30"	3.6"	0.21"	2.6"	0.16"	2.6"	0.11"	2.1"	0.08"	1.3"

- There is also a sensitivity calculator available on the web, here: http://almascience.nao.ac.jp/call-for-proposals/sensitivity-calculator (Last I checked they seemed to be having Java issues, but hopefully these will be fixed by the time you start the project – I submitted a helpdesk ticket on April 1. If not, you must use the radiometer equation! Probably better for you to learn how to do that anyway…)