BIMA memo 93; 10 April 2003

Characterizing BIMA proposals 2000-2003

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ABSTRACT

In this memo, we characterize BIMA proposals for the period 2000–2003 into 8 categories: Science, Antenna Configuration, Help Requested, Special Needs, Observation Type, Polarization, Receiver Band, and Mosaicing. We present the data as tables and pie charts for each category. Most, $\sim$ 90 %, of the proposals requested (and observed) spectral line data. Most of the proposals requested antenna configurations, receiver bands, and observing modes in the regime where the BIMA telescope works well without any special requirements for instrument or weather.

1. Introduction

The BIMA array is a 10-antenna millimeter wavelength aperture synthesis telescope. A more complete technical description is available on http://bima.astro.umd.edu. BIMA users constitute a diverse user base with over 326 users from 117 institutions. The BIMA usage is representative of what types of astronomy the λ mm community has wanted to do. Although the BIMA observing proposals are tailored to the capabilities of the BIMA telescope and the limitations of the 1000 m altitude of the Hat Creek site, we can use these observing proposals as a guide to plan for the needs of potential users of the CARMA and ALMA telescopes. In this memo we analyze the BIMA observing proposals for the period 2000 – 2003.

The data were extracted from the electronically submitted cover sheets for all the proposals submitted. The data presented is a count of the PROPOSED observations, so they come closer to reflecting what was requested, not what was scheduled or observed. The scheduled proposals reflect the referee evaluation, institutional and visitor time allocations, time allocated to each configuration, maintenances, etc. What was successfully observed at Hat Creek is weather dependent, and is not representative of what can be done at CARMA or ALMA, so the original proposals are the right statistical data base to best represent how much time people wanted in each configuration, frequency band, mosaicing, etc.

2. Statistical Overview of Recent Observations Proposed at BIMA

The BIMA proposal coversheets contain a number of items that can be used to statistically describe the community of users and the type of science being performed at BIMA. Below we describe the results based on the proposals received for the period covering the Spring 2000 through Spring 2003 observing seasons. These results are presented both in tabular form and graphically at the end of this document and are briefly discussed below.

2.1. Science Category

The flexibility of the instrument design allows for observations of a wide variety of astronomical sources which is demonstrated by the breakdown of proposals by scientific category in Table 1. The planetary and solar science categories are not completely accounted for here as neither include the target of opportunity observations (e.g., comets and solar flares) that were attempted. It should also be noted that the BIMA SONG (Survey of Nearby Galaxies) was concluded prior to the period for which these statistics were compiled and may result in a moderate decrement to the number of extragalactic observations proposed in subsequent years.

Table 1: Science Category

planet	solar	stellar	galactic	extragalactic
5	35	425	1221	612

2.2. Antenna Configuration

The BIMA array is a 10-antenna aperture synthesis telescope with 4 standard antenna configurations providing angular resolutions from $\sim 0.2''$ to $15''$ at 100 GHz. The largest angular structures that can be imaged are about 10x the resolution in each configuration. The proposed observations subdivided by antenna configuration as much reflect user needs as they do the instrument capabilities given the atmospheric conditions of the current low-elevation site. Furthermore, the complexity of data reduction and analysis for long baseline observations almost certainly inhibits the number of requests for A-array observations.

Table 2: Antenna Configuration

Configuration	A (2km)	B (240m)	C (90m)	D (30m)
Resolution at 100 GHz	0.45 x 0.21	2.1 x 2.0	5.7 x 5.4	15.1 x 12.7
Number of tracks	100	534	993	494

2.3. Observation Type

The BIMA telescope is equipped with a 1024 channel digital correlator for spectral line observations in up to 16 spectral windows. The correlator mode is selected by the user to provide a flexible choice of bandwidths and spectral windows. There is currently no separate correlator for wideband continuum observations which are obtained by setting the spectral line correlator to provide a maximum 800 MHz bandwidth in each sideband of the 1st LO. The users select which spectral windows they wish to use. The averages for each spectral window are always written into the *uv* data.

The type of observations requested in BIMA proposals show a clear bias toward spectral line studies. This primarily reflects the wealth of information available from the molecular line transitions observable at mm wavelengths but is also due to the flexibility of the BIMA correlator design which can easily make spectral line and continuum observations simultaneously. A few projects have used Multifrequency Synthesis (MFS) using the averages for each spectral window. These are listed as continuum projects.

Table 3: Observation Type

line	continuum	both
1030	208	860

2.4. Help Requested

The Help Requested category in the proposal coversheets mostly reflects the experience with planning, reducing, and analyzing, λ mm observations by our user base. There are clearly few proposals from astronomers without experience with aperture synthesis or λ mm observations. The low numbers here might also reflect the success of the Hat Creek Summer School which provides a basic training in the techniques and software needed for using BIMA.

Table 4: Help Requested

none	some	lots
1861	233	28

2.5. Special Needs

The Special Needs category in the proposal coversheets show that users do not generally try to configure the instrument that is extra-ordinary. In fact a quick inspection shows that an overwhelming majority of the proposals which did make an indication of a special need were those that were attempting to make observations of polarized emission. VLBI observations use the telescope in a phased array mode, and require LO coherence tests and UT scheduling are handled in dedicated sessions of a few days.

Table 5: Special needs

none	some
1849	272

2.6. Polarization Observations

The BIMA receivers are sensitive to a single linear polarization, but are equipped with movable quarter wave and half wave plates to switch between circular or linear polarizations. Each receiver can be switched between orthogonal polarizations with a Walsh function pattern in order to sample all possible crosscorrelations (RR, RL, LR, LL, or XX, XY, YX, YY) on each baseline as rapidly as possible. Polarization observations are fully supported by the MIRIAD data reduction package; circular and linear polarizations, and dual polarized or switched polarization observations are supported by the software. Four sets of quarter and half wave plates are currently available. Polarization observations are obtained by time multiplexing, and require more observing time (4 times as much) as would be required with dual polarization receivers. Thus it could be argued that our data overestimate the time for polarization observations. On the other hand the additional time required for polarization observations at Hat Creek inhibits proposals, and the data are probably a reasonable estimate. Both CARMA and ALMA will be on better sites and better able to map dust polarization at λ 1mm, which may result in more polarization proposals. Polarization proposals at BIMA are roughly equally aimed at continuum (dust), and spectral line polarization.

Table 6: Polarization

none	86 GHz circular	110 GHz circular	115 GHz linear	230 GHz circular
1958	15	27	11	111

2.7. Receiver Band

There are currently three receiver bands available – λ 3mm, 1mm and 1cm. The λ 3mm/1mm receivers are removed for maintainance and special λ 1 cm receivers are installed during the summer months for a length of time determined by proposal pressure. The data do not include 1cm SZ observations by the Carlstrom group, and therefore underestimate the 1cm observations, by about 6 weeks per year for the 3 year period (i.e. $\sim$ 10% or $\sim$ 350 tracks).

Table 7: Receiver Band

3mm	1mm	1cm
1704	367	50

2.8. Mosaicing

A single pointing aperture synthesis observation makes an image the size of the primary beam (λ/diameter $\sim$ 2 arcmin at 3 mm; 1 arcmin at 1 mm) with a resolution corresponding to the maximum separations of the 10 antennas. Observations of larger sources use a mosaicing technique with multiple antenna pointings. Mosaicing is fully supported by the observing procedures and the MIRIAD data reduction package. The observations require time multiplexing over multiple antenna pointings, so there is a practical limit on the number of pointings which can be observed in an observing session. For example the M33 project with 759 pointings, typically observed 50 pointings per 8 hour track. The fraction of time devoted to mosaic observations peaked at about 45 % at Hat Creek in the previous 3 year period shortly after the mosaicing software became available in MIRIAD and it became easy to make mosaic images. The peak may have resulted from pent up demand, or the subsequent reduction in mosaic observations resulted from a change in focus of Hat Creek proposals. In any case, the larger antennas at CARMA and ALMA will require more mosaic fields for the same sources, and many observations which can be observed in a single field with the Hat Creek 6m antennas will require mosaic observations with the CARMA 10.4 and the ALMA 12m antennas. Most of the mosaic observations at Hat Creek have been made in the λ 3mm band. We expect that observers using CARMA and ALMA will take advantage of the better sites and make observations at higher frequencies. For example, a mosaic observation at 115 GHz with the Hat Creek 6m antennas would require 16x as many pointings at 230 GHz with 12m antennas. Thus we estimate that a large fraction of ALMA observations will be large mosaics.

Table 8: Mosaic Fields

1	2-10	11-100	> 100
1537	390	194	0

3. Conclusion

The BIMA observing proposals are biased to what the users perceive will yield successful observations at Hat Creek, and therefore underestimate: high frequency (1 mm for Hat Creek) because of high atmospheric opacity, high resolution (2 km for Hat Creek) because of poor atmospheric seeing, large mosaics because of the large amount of time needed and poor SNR. It is not unreasonable to suppose that the same biases will be seen for CARMA and for ALMA proposals, except that the interpretation of “high frequency” and “high resolution” will be higher for these telescopes on better sites. Most, $\sim$ 90 %, of the proposals requested (and observed) spectral line data. This was true even if the primary target was continuum; it was productive or necessary to obtain spectral line data. Polarization observations are also underestimated for CARMA and for ALMA. Polarization observations at Hat Creek are both difficult and time consuming, and will be much easier on better sites, with more sensitive telescopes and with dual polarization receivers. Mosaic observations will likely be more common with CARMA and especially with ALMA because the larger antennas and higher frequencies will require multiple pointings more frequently.

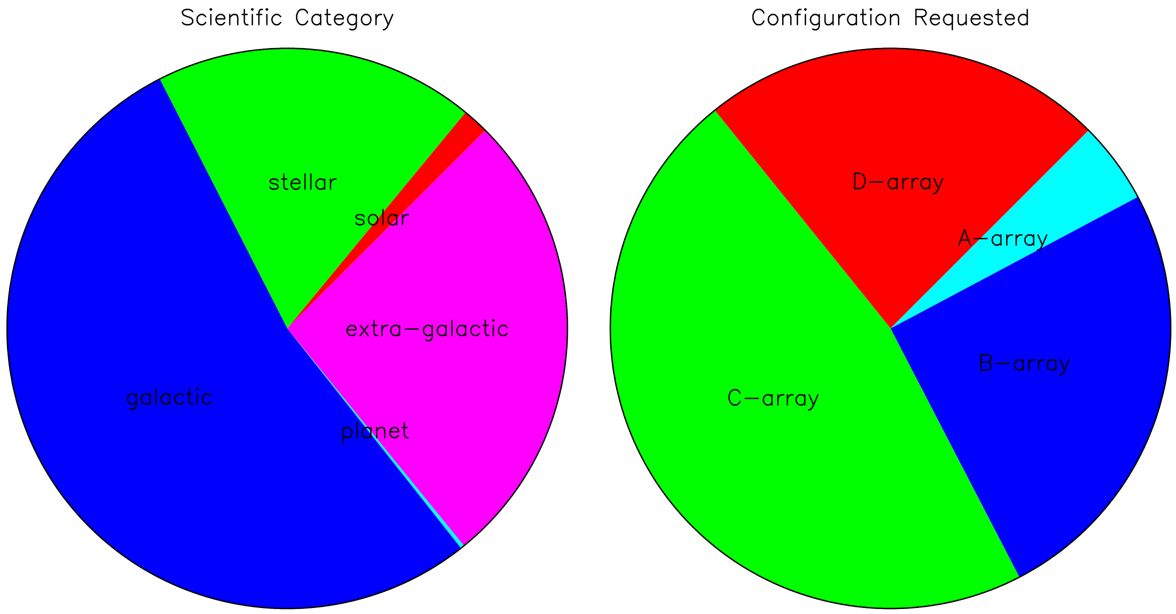

Fig. 1.— *Left:* Fraction of BIMA proposals by Science Category. *Right:* Fraction of BIMA proposals by Antenna Configuration.

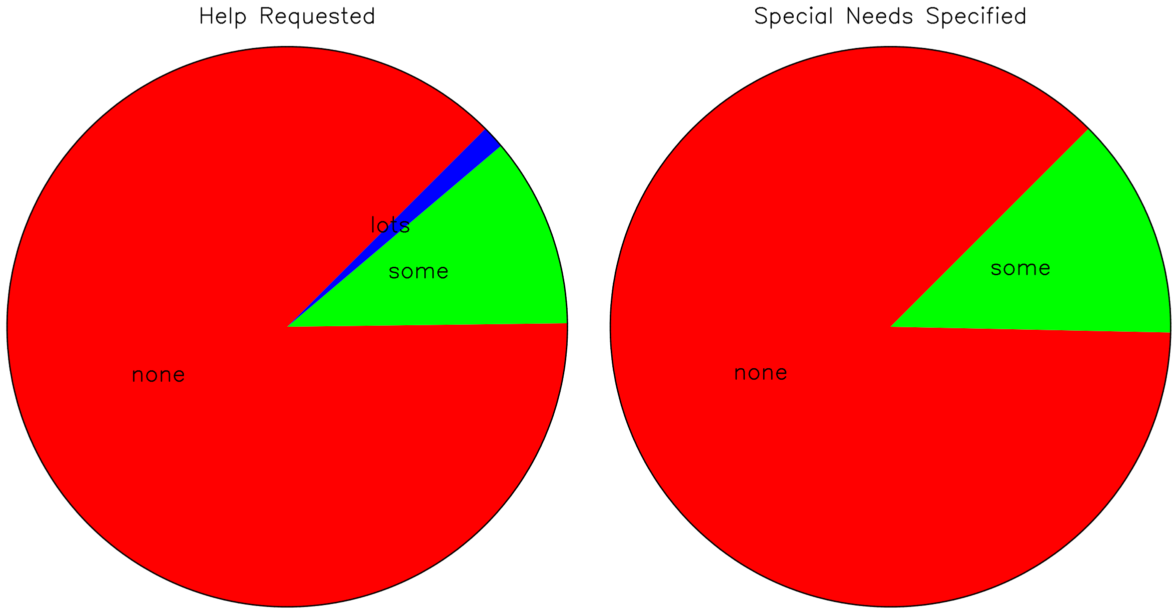

Fig. 2.— *Left:* Fraction of BIMA proposals by Help Requested. *Right:* Fraction of BIMA proposals by Special Needs.

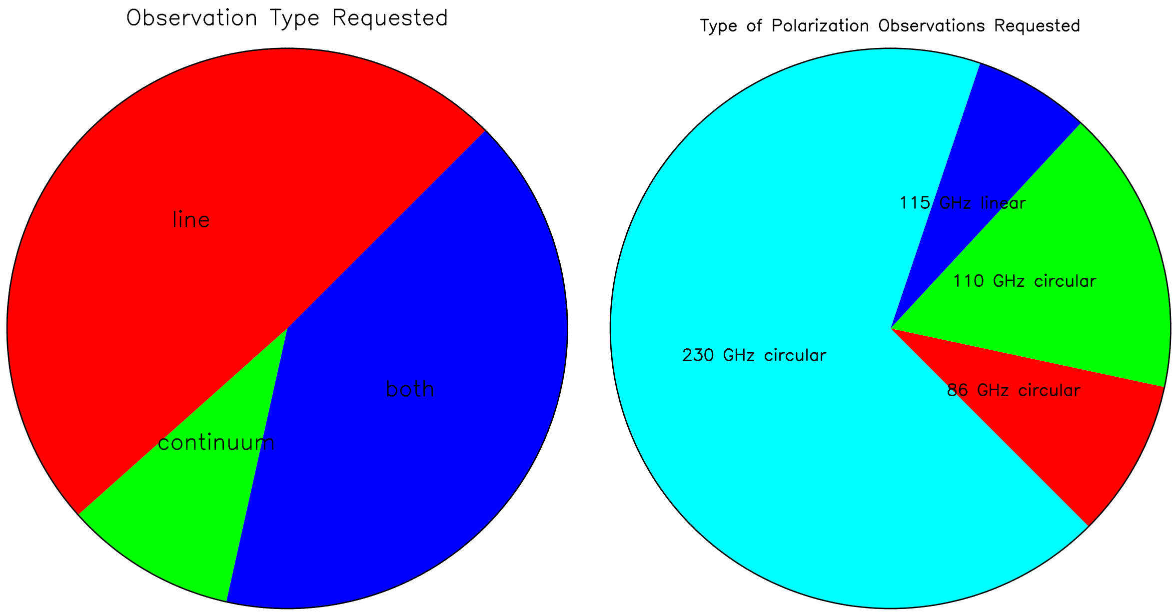

Fig. 3.— *Left:* Fraction of BIMA proposals by Observation Type. *Right:* Fraction of BIMA proposals by Polarization.

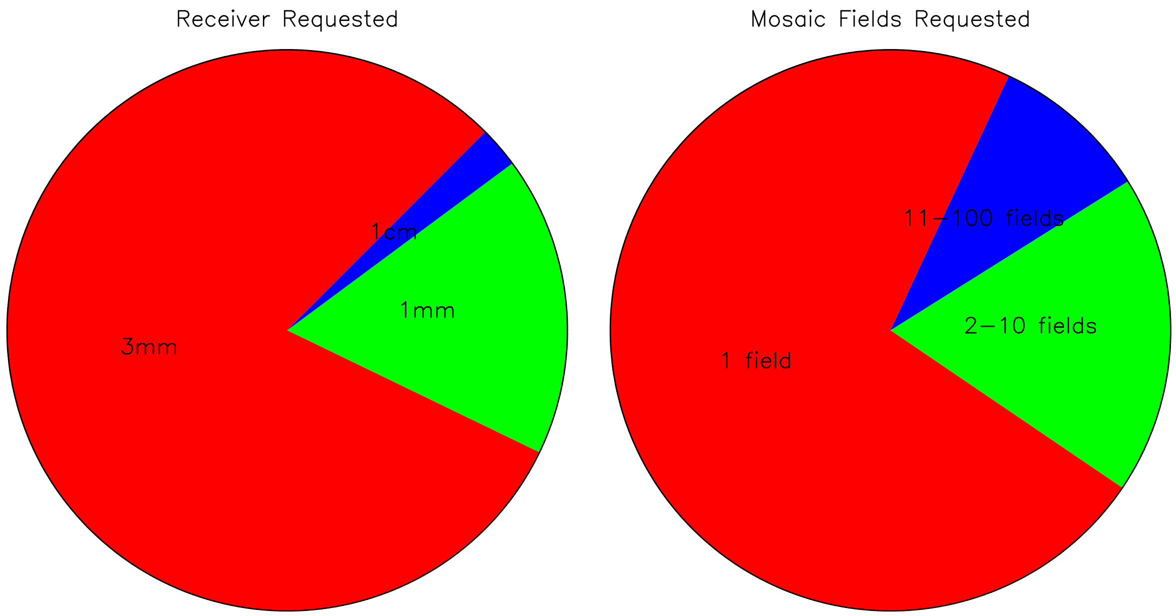

Fig. 4.— *Left:* Fraction of BIMA proposals by Receiver Band. *Right:* Fraction of BIMA proposals by Mosaic Fields.