Center for Astrophysics

Harvard College Observatory
Smithsonian Astrophysical Observatory

MEMORANDUM

MEMO #57

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To: Files

From: Paul Ho

Subject: Correlator Configurations

The scientific requirements on the correlator design is pretty straightforward. We can enumerate them as follows:

1. **Maximum Flexibility in Configuration.** This means that the design must allow the correlator to be reconfigured for different experiments. For example, sometimes, the experiment will be only continuum. Other times, we may be in the spectral line mode only. There will be many instances where we want both continuum and line simultaneously. Multiple spectral lines may also be desirable, and perhaps with different frequency resolution for each of the lines.

2. **Maximum Bandwidth Requirement.** The required bandwidth is $BW = 2\ \Delta V\ \nu_o\ c^{-1}$. The factor of 2 is for the purpose of providing sufficient line-free baseline. The maximum linewidths to be expected will be in extragalactic nuclei. We can estimate what linewidths should be expected in the usual way, $\Delta V = [G\ M]^{0.5}\ [r]^{-0.5}$. Assuming we pack 10^9 solar masses into 100 pc nuclear region, we expect a linewidth (FWHM) of about 200 km s^{-1}. Hence for a maximum linewidth (FWZP) of 400 km s^{-1}, and a maximum frequency $\nu_o = 890$ GHz, a maximum bandwidth BW = 3 GHz.

3. **Maximum Spectral Resolution Requirement.** The required spectral resolution is $\Delta\nu = 0.33\ \Delta V\ \nu_o\ c^{-1}$. The factor of 0.33 is to provide three spectral resolution elements across the spectral line of interest. The predicted linewidth (FWHM) can be estimated in two ways. First, the narrowest spectral line which has been observed in dark clouds is on the order of 0.2 km s^{-1}. Second, we can estimate the magnitude of the motion which we might be interested in detecting. $\Delta V = [G\ M]^{0.5}\ [\theta\ D]^{-0.5}$. For motions around a solar mass object, assuming an angular resolution θ of $0.2''$ at a distance D of 10 kpc which corresponds to a spatial resolution of 0.01 pc, the expected linewidth is 0.7 km s^{-1}. Thus adopting the minimum value $\Delta V = 0.2$ km s^{-1}, and the minimum frequency $\nu_o =$ 230 GHz, the maximum spectral resolution required is $\Delta\nu = 50$ kHz.

4. **Polarization Measurements.** There may be opportunities where it will be possible to measure polarization in the line mode. Hence the correlator must be able to be divided at least into four parts per baseline, in order to measure all four polarization quantities.

5. **Multiple Line Configuration.** There will be opportunities for both science and calibration purposes to observe more than one line at the same time. For example, in the shortest wavelength regime, where the atmosphere is most unstable, if a maser line can be

found in the same field of view, it will be useful to use the maser line to phase reference for the spectral line or even continuum emission of interest. There will also be occasions where there will happen to be several lines in the instantaneous receiver bandpass. In that case, it will be useful to be able to divide the correlator into differnt parts, with different bandwidths and spectral resolutions. At a minimum, one may imagine that per baseline, you will need two polarizations, with maybe six lines per polarizations. In the millimeter waves at BIMA, it is not unusual to track six lines (some in upper sideband and some in lower sideband) per polarization. At the submillimeter wavelengths where the population of spectral lines is even higher, the opportunity to study many lines simultaneously may be even greater.