National Radio Astronomy Observatory
Tucson, Arizona

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MEMORANDUM

TO: R. Brown

FROM: P. Jewell, J. Payne, C. Salter

SUBJECT: Focal-Plane Array

Following Mike Ballister's recent Memo on a focal-plane array for the 12-m telescope, it seems appropriate to consider this technical development. Clearly, a focal-plane array will be a highly desirable addition to our arsenal of observing equipment and will raise the observing efficiency of the 12-m telescope in almost every branch of research currently performed.

While multi-beaming will contribute most to the mapping of extended objects, it can even improve the quality of point source observations. If the individual polarization channels are superimposed (see below), apart from the $\sqrt{2}$ gain in sensitivity compared with a single channel system, full polarization information can be continuously available at little extra cost (ref: the Bonn continuum receivers). In addition, the central three spacings can give pointing information in the direction of extension (s) of the array.

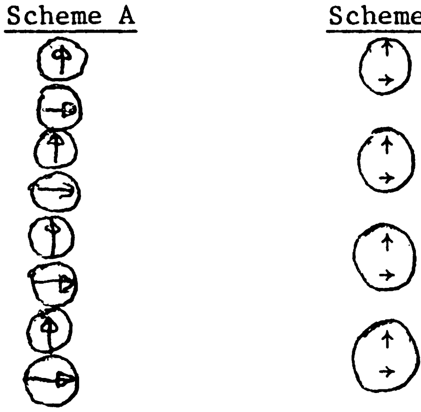
Spacing of the Beams

It is not clear that anything is gained by spacing not just the basic beams, but also the individual polarization channels. In fact, there would seem to be disadvantages in such a scheme.

For example,

Scheme A

Scheme B



We note that the combined polarization channels of scheme B would give equal sensitivity to scheme A in covering a given field at a given spatial sampling (i.e., while scheme B observes half as many points at a given instant, each point need only to be observed for half the time). However, scheme B could also have simultaneous polarization information available and would seem to have the advantage of mechanical simplicity.

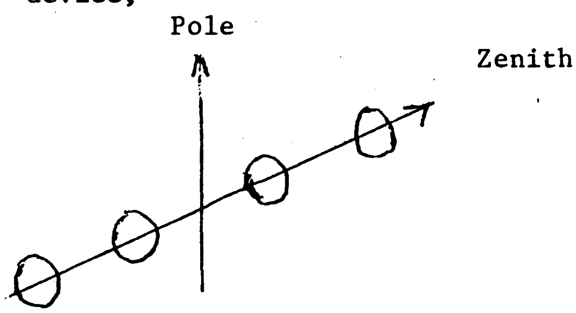
Parallactic Angle Tracking

For point source observations (see above) it would be preferable not to track parallactic angle as the pointing offsets are a function of azimuth and elevation rather than celestral coordinates.

Continuum mapping of extended sources will presumably be performed via the dual-beam restoration algorithm. In this method the dual beams should be separated in azimuth to ensure the best "weather rejection". Also the map raster should be scanned along lines of constant elevation. Both these requirements need a feed array fixed in azimuth-elevation, the rotation into celestial coordinates being achieved in software. Software is also available to deal with polarization position angle measurements.

While such techniques can also be applied to spectral line measurements, the demand in this field for parallactic angle tracking will probably be considerable. It is certainly the simplest solution where a fixed celestial reference position is used for position switching.

Considering the tracking accuracy necessary for such a device,



If the error in tracking parallactic angle is ΔP and the beams are at $(n-\frac{1}{2})$ HPBW from the array center, then the absolute pointing error of each beam is

$$(n-\tfrac{1}{2})\ \text{HPBW}\cdot\Delta P$$

If we allow a maximum pointing error of HPBW/10 then

$$\Delta P \lesssim \frac{1}{(n-\frac{1}{2})10}\ \text{rad is necessary}$$

For an eight channel system, n = 1 and 2

$$\text{and we need } \Delta P \lesssim \frac{2}{30}\ \text{rad} \sim 4°$$

<u>i.e.</u> The feed table must track parallactic angle to better than 4°.

Calibration

An initial, careful calibration of the beam positions on the sky should suffice to establish the relative pointing of the multi-beam comb.

The relative gains of the separate beams will be difficult to keep track of unless a noise source is available at the observing frequency (this is not currently the case at 240 GHz). A noise source in the subreflector is in the near-field of the array and its own response in the individual beams should occasionally be calibrated using celestial radio sources.

One factor that may limit the eventual extent of an array is the differing coma lobes on each beam. These will increase with offset from the optical axis and be assymetric with respect to this axis. Clearly this needs thinking about.