MILLIMETER ARRAY
MEMO NO. 17

NATIONAL RADIO ASTRONOMY OBSERVATORY

EDGEMONT ROAD CHARLOTTESVILLE, VIRGINIA 22901
TELEPHONE 804 296 0211 TWX 510 587 5482

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Frazer Owen
VLA

Dear Dr. Owen,

I note that one of the recommendations of the Millimeter Array Tecnical Advisory Committee is clustering of feeds for the multielement antenna. That sounds like an interesting optics problem, so I have given it some thought and come up with the enclosed plan, which places all 24x4 receivers in a cylinder at the center of the antenna. The optical path for each 3-m telescope is similar to a scheme that John Payne and I plan to use as part of a beam switcher for the 12-m telescope. Having looked into that scheme for use over the range λ = 1-3 mm, I believe that the optical performance of the plan for the multielement antenna will be good except possibly for the inner ring of dishes at λ = 10 mm.

I would like to look into this or other optics designs in more detail if it would be of use.

Yours sincerely,

Buddy Martin

Buddy Martin

A possible optics plan for the multielement antenna

Buddy Martin NRAO/Charlottesville

This note and the attached sketch describe a quasi-optical system which allows all receivers for the multielement antenna to be placed in a central cluster. Each of the 24 3-m Cassegrain telescopes produces a narrow beam waist roughly a meter below the primary vertex. The beam diverges and is refocused at the feed on the surface of a receiver cylinder. Refocusing is done with a "Gaussian beam telescope" (as described by Goldsmith, 1982) consisting of two identical offset paraboloids and one flat mirror.

For each frequency, the 24 feeds are placed around the circumference of the receiver cylinder. The rings of feeds for different frequencies are displaced vertically, so that one changes frequencies by raising or lowering the cylinder.

Some advantages and drawbacks of the plan are listed below.

Advantages

1. All receivers are located within as small a volume as possible, consistent with the aperture diameter of the feeds.

2. All 24 telescopes are identical.

3. Feeds for all telescopes are identical.

4. Refocusing of beams works independently of wavelength, except for distortions caused by the off-axis mirrors, which should be serious only for the shortest path lengths at $\lambda = 10$ mm.

5. Changing frequencies is simple.

6. Shifts of several beamwidths for the individual dishes can be achieved by moving the offset paraboloids.

Disadvantages

1. The antenna support structure must accommodate the mirrors and beam paths. This requires a central cylinder of about 5 m diameter with no vertical supports and careful placement of supports elsewhere.

2. Seventy-two mirrors must be properly aligned.

The sketch illustrates a design based on the following parameters:

24 dishes, arranged in 3 rings and spaced every 15° in azimuth as viewed from center of antenna;

opening angle of beam (1/e-amplitude half-width): 2° (similar to 12-m telescope);

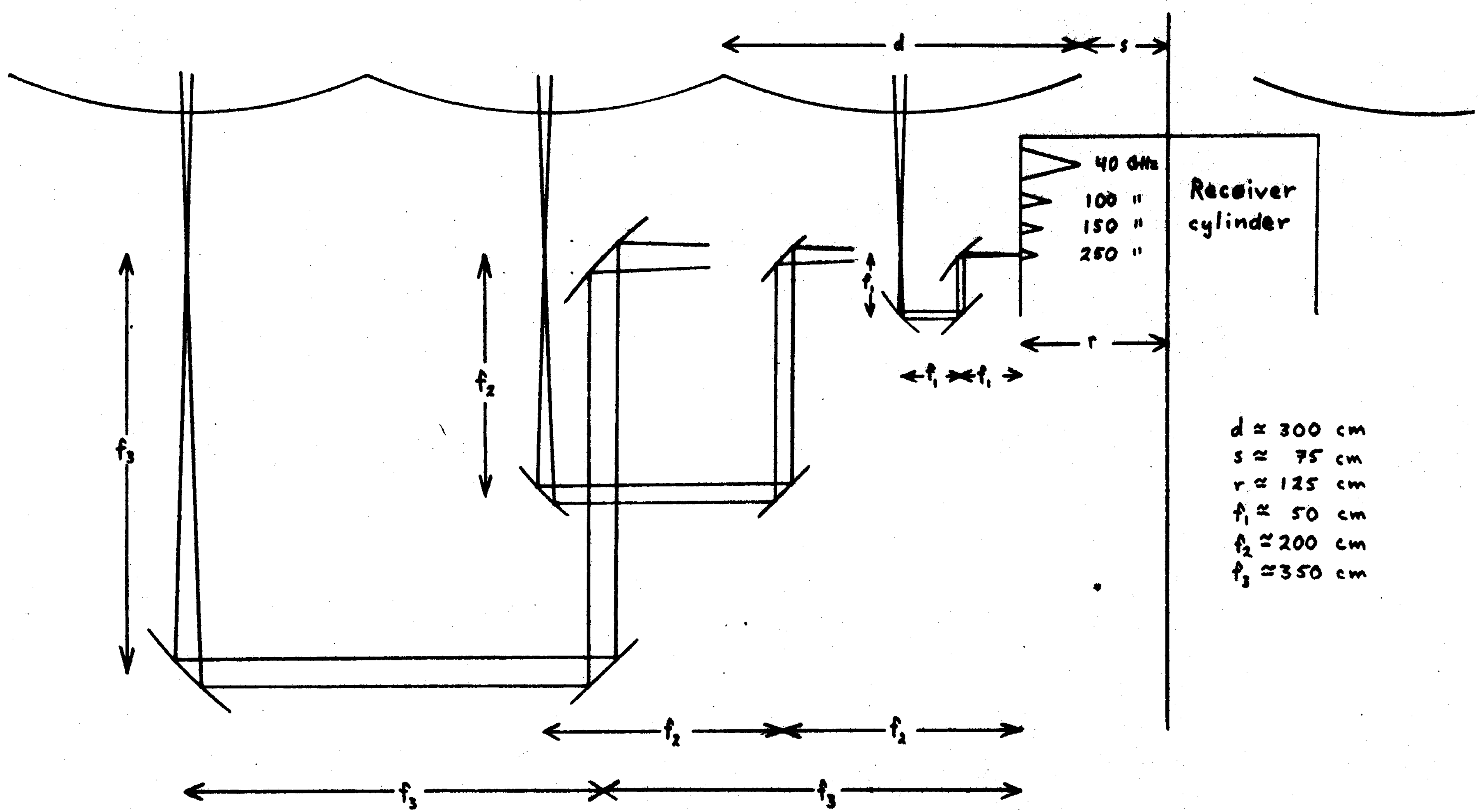
beam waist at $\lambda = 10$ mm: 9 cm;

radius of receiver cylinder: 125 cm.

The most serious difficulties for this plan are caused by the width of beams at 10 mm wavelength. The parameters used here give a tight fit at 10 mm, and some modification may be required to avoid overlapping beams, but there should be no problems at shorter wavelengths. In addition, the design could be modified to include, e.g., a two-tiered ring of feeds for each frequency, or unequal azimuthal spacing of the dishes.

Reference

Goldsmith, P. F. 1982, Infrared and Millimeter Waves, ed. K. J. Button, Vol. 6, p. 290.


d
s
40 GHz
100 "
150 "
250 "
Receiver cylinder
r
f1
f1 f1
f2
f2 f2
f3
f3 f3
d ≃ 300 cm
s ≃ 75 cm
r ≃ 125 cm
f1 ≃ 50 cm
f2 ≃ 200 cm
f3 ≃ 350 cm