DEUTERIUM ARRAY MEMO #066

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
HAYSTACK OBSERVATORY
WESTFORD, MASSACHUSETTS 01886

September 7, 2005

Telephone: 978-692-4764
Fax: 781-981-0590

To: Deuterium Array Group

From: Alan E.E. Rogers

Subject: Potential future Deuterium 327 MHz line science

1] Continuation of observation of galactic longitudes 171, 183, 195

In ApJ Letters of 1 Sep 2005 we reported the following SNRs

Galactic Latitude	SNR	Expected SNR by May 06
171	3.3	4.7
183	5.8	8.2
195	2.2	3.1

2] Proposed observations of Galactic center

The 327 MHz line is expected in absorption towards the Galactic center. Figure 3 of memo 59 I estimated a line strength of about 2 ppm but there is a large uncertainty in the estimate because some of the deuterium could be in cold clouds.

a) Tilting the frames

In December 2004 we made a test of a tilted frame with station d02. The results of the test are given in memo 64. Figure 1 shows a photo of d02 tilted by 60 degrees to point at 30 degrees. The system noise is dominated by the Galactic center (350 K on G000) so that a small loss of gain by shadowing will not have much effect on the performance. The location of the stations is shown in Figure 2. For 60 degrees tilt the shadow lengths cast by the top of the frame are as follows:

Sgr. Elevation	Sgr. Az	Shadow length (ft)	Hour angle
20	180	20	0
18	194	31	1.0
14	207	42	2.0

Figure 3 shows the extent of the shadowing for about 3 hours of the Galactic center centered on transit.

3] Other possible observations with the array at the current site

It would be of scientific interest to measure the D/H ratio in other galaxies. The nearest is the Canis major dwarf at a distance of 25,000 1yr. This is our nearest neighbor and was only discovered in 2003, however I have not been able to find any significant H1 emission from Canis major $(\ell = 240, b = -8)$ in the Hartmann and Burton data cube. The Sagittarius dwarf elliptical galaxy (sagDEG) is another nearby neighbor discovered in 1994 but also shows no significant H1 emission. The LMC and SMC dwarf galaxies have significant H1 line emission but are not visible from our latitude.

4] Comparison with other arrays

Since any D1 line observations will need a large amount of observing time it is not practical to consider the VLA or GMRT. The ATA was expected to be able to observe at 327 MHz but it looks like priorities have shifted and the ATA is unlikely to observe below 500 MHz. At present the D1 array is the only "fixed antenna" array which covers 327 MHz. LOFAR goes only up to 240 MHz and PaST only reaches 200 MHz. The LFD is designed to reach 300 MHz but might be stretched to 327 MHz. I consider 3 options for the observations of LMC/SMC:

1) The current D1 array moved to Australia
2) The D1 array moved to Australia with new larger frames $(9m \times 9m)$ and 3 more directors to go from 3 element to 6 element Yagis..
3) The LFD

Array	Station aperture (m^2)	Beamwidth (deg)	Number stations	ApXroot	T_{sys}	Relative sensitivity
Current D1	12	14	24	59	50	1
Mod D1	48	7	24	235	50	5
LFD	10	15	500	223	100	2

Notes:

1. For D1 array the frames are tilted so that the LMC/SMC is with 20 degrees of normal to frame at transit.
2. apXroot is a measure of performance and equals the station aperture times the square root of the number of stations.
3. Sens is a relative sensitivity is estimated from ApXroot divided by T_{sys}. A larger number is greater sensitivity.
4. The LFD would perform better for a D1 search in objects like the LMC which are smaller than the single tile beam if 4 tiles where placed together and phased to form a single station. However this may not be compatible with the proposed LFD configuration.
5. The LFD frames are <u>not</u> tilted. At 600 MHz the element gain drops at the zenith but is a maximum close to the 50 degree elevation of the LMC/SMC transit.
6. The LFD aperture is estimated for an elevation of 50 degrees.

Figure 1 Station d02 tilted to point at 30 degrees elevation during test made in December 2004.

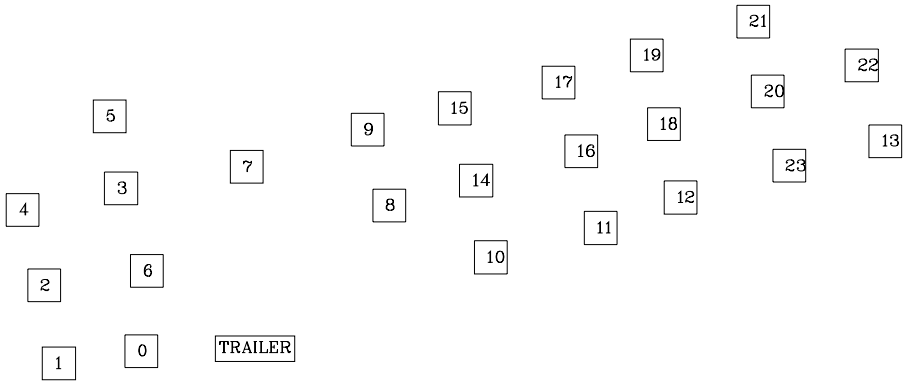

Figure 2 Layout of stations. South is to the left.

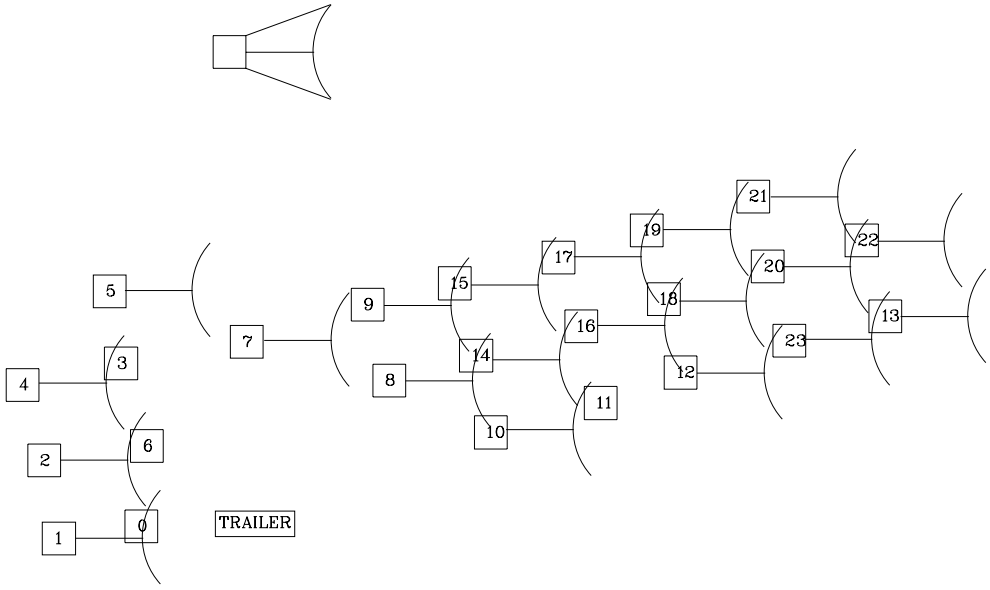

Figure 3 Illustration of the shadowing for 3 hours of observing the Galactic center. If the plotted arcs do not enter the station box there is no shading. The worst case is the shadowing of station d18 by d16. In this case about 30% of the aperture is blocked at the start of the observation and since the Galactic center contributes more than 3 times the system noise the overall effect should be small.