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To: Deuterium Array Group

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Subject: Revision of expected D1 line strength in the anti-center

In memo 11 I gave an estimate of the expected signal (in fractional units) for the D1 line in anti-center. Now that we have completed construction this can be revised based upon actual receiver noise and observing scan angles. For the Galactic anti-center the expected signal for uniform coverage over the beam and continuum behind the interstellar gas is given by

$$s = 0.27 \times (n_D / n_H) \times (T_{spin} - T_{cont}) \times \tau \big/ (T_R + T_{cont}) \qquad (1)$$

Where n_D/n_H = Deuterium abundance ratio $\left(1.5\times10^{-5}\right)$

T_{spin} = spin temperature of Deuterium (130 K)
T_{cont} = Continuum temperature (70 K)
τ_H = hydrogen 21 cm opacity (2)
T_R = receiver noise contribution (40 K)
s = signal in fractional units

If we assume the values in parentheses

$$s = 4.4\times10^{-6} \text{ or } 4.4 \text{ ppm}$$

However this estimate does not include loss due to the station beam being a little larger than the angular extent of the high opacity region in galactic latitude. Further more the station beams are a function of the scan angle. An approximate expression for the station beam is

$$\mathrm{sinc}^2\left(\pi\theta_x b_a\right)\mathrm{sinc}^2\left(\pi\theta_y b_y\right) \qquad (2)$$

where

$$b_x = 4\cos(\phi_x)$$
$$b_y = 4\cos(\phi_y)$$
$$\phi_x = \text{scan angle in } x$$
$$\phi_y = \text{scan angle in y}$$

In the revised modeling I have used a simulation of the 24 element beam of each station. In this case the beam response to a small patch of sky with temperature T_{sky} and solid angle s is given by

$$bm = \frac{\left|\sum_N e^{i\theta_k}\right|^2 |a_k|^2 s_k T_{sky}}{N\sum_K |a_k|^2 s_k} + T_R \qquad (3)$$

where $|a_k|^2$ = beam response of each dipole

θ_k = beam steering phase to k[th] sky patch

N = number of elements = 24

K = total number of sky patches

The hydrogen opacity for estimated from the calibrated hydrogen spectra taken from the CD rom of Galactic Neutral Hydrogen by Hartmann and Burton 1997.

The relation

$$\tau = -\log_e\left[1 - T_H / T_{spin}\right] \qquad (4)$$

where

T_H = hydrogen line temperature

T_{spin} = Hydrogen spin temperature

was used to obtain the opacity.

To evaluate the effects of beam dilution of both the spectral line and continuum we need to convolve

$$a = 0.27 \times (n_D / n_H) \times \left(T_{spin} - T_{cont}(l,b)\right)\tau(l,b) \qquad (5)$$

and b = $Tcont(l,b)$ with the beam. The corrected signal s' in fractional units is then given by

$$s' = (a \otimes bm)/(b \otimes bm) \qquad (6)$$

The results are as follows:

T_{spin} (K)	Continuum all behind H1 (ppm)	Continuum mixed with H1*	Continuum all in front of H1
110	1.7	3.2	4.7
120	1.7	2.9	4.1
130	1.6	2.6	3.6
140	1.6	2.5	3.3
150	1.7	2.4	3.2

*Uniform mix of continuum with H1 and 6K (3K CMB + 3K) extragalactic

I also show the effect of moving the continuum from behind to be half foreground and half background to all foreground. The sensitivity to the assumed value of T_{spin} is less severe than was apparent from expression (1) because the computed values of opacity from (3) largely compensate. That is a lower T_{spin} results in a reduction of the term $\left(T_{spin} - T_{cont}\right)$ which is compensated by a higher opacity estimate.

A region at galactic longitude of 171 degrees is also being observed. The expected peak strength for this region assuming T_{spin} = 130 K, and a uniform mix of continuum with 6 K being extragalactic, is 1.9 ppm.