

DEUTERIUM ARRAY MEMO #036

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To: Deuterium Array Group

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Subject: Tests of leakage from D1 receiver box

1] Background

Early tests of the shielding effectiveness of a closed box were made by enclosing a battery operated transmitter (Family radio at 446 MHz). From these tests it was clear that 60 dB isolation is easily achievable but no measurements of high degrees of shielding were made. Following the completion of the RFI monitor some tests of the leakage from the receiver box were made by operating the receiver in a screen room with the antenna close to the receiver box. While these tests did not easily allow an accurate measurement of the isolation it became apparent that copper tape was needed to cover the scans in the box in addition to the screws. Also it was apparent that the power line filter, (Curtis F5100G10), which is specified to have more than 70 dB isolation at 327 MHz, is not adequate and extra filtering is needed.

2] Isolation requirement

The one sigma sensitivity of the D1 array receiver is -192 dBm for a single active antenna channel in a 24 hour integration with 244 Hz resolution and a 100 K system temperature. Typical internal RFI spurs in the 327 MHz band within the box is at a level of about -90 dBm so that about 100 dB of isolation is needed between the electronics in the box and the active antennas. The receiver box is shielded by the antenna ground plane but the isolation is limited by the common mode transmission of signals from one side of the ground plane to the other on the antenna cables. "Clip-on" ferrite beads on these cables limit the isolation to about 20dB. [Increased isolation could be obtained by grounding the outer conductors to the ground screen at base of each antenna.]

The required isolation for the receiver box alone is about 100 dB in order to keep the leakage into each active dipole below -210 dBm.

3] Receiver box isolation measurements

More accurate box shielding measurements were made (at Kevin's suggestion) by placing a signal generator at 325 MHz radiating into 6 inches of wire inside the box. The isolation was measured comparing the received signal level at a spectrum analyzer a few feet away from the box with the cover removed with the signal level with the box closed up.

Isolation dB	Condition	Comments
0	Cover off	
35	Cover on without screws	
60	All 44 screws single power filter	Power cable dominates
70	All 44 screws ferrite beads added to filter	Power cable dominates
95	22 screws double power filter	
105	22 screws, double filter, tape on box seam	Limit of spectrum analyzer
80	No screws, double filter, tape on seam	
90	4 screws, double filter, tape on seam	
95	8 screws, double filter, tape on seam	
70	8 screws, double filter, Chomerics gasket	
105	8 screws, double filter, braid gasket	Limit of spectrum analyzer
105	AV 44 screws, double filter	Limit of spectrum analyzer

Notes: 1] Number 10 screws were placed at approximately 3” intervals for a total of 44 screws.

In order to lower the detection limits due to the noise in the control room, where the above measurements were made, the measurements were repeated in the screen room. However the isolation, as defined by the ratio of the signal strength with the box open to the signal strength with the box closed up, was reduced by about 20 dB in the screen room. After many tests it was discovered that the field strength within the closed box was much higher when in the screen room because the location of the transmitting probe within the box had been changed in a way that it was more strongly coupled into the resonances of the closed box. A separate test was made of the box resonances by placing 2 separated probes in the box using SMA connectors to bring the signal from an external generator in and out of the box. Resonances were found at 254, 385, 434, 495 MHz but they were relatively broad and damped by the presence of any items, like the signal generator, placed in the box. Adding an absorber inside the box further reduced the resonances, but only when a large piece (20”) was used.

#### 4] Tests in the field

Initially there was no evidence for any leakage from the receiver box of site #1 in the field. However when an active antenna was placed under the receiver there a strong signal was detected at 327.455 MHz. This signal is related to the pc clock generator’s 14.3 MHz reference and a stronger component at 300.72 MHz could be detected with a handheld receiver taken down to the field. The leakage appeared to be coming from the side rail which supports the box on the left side. Upon close examination it was discovered that a screw which holds down the disk had become “hot” and would radiate when the screw’s head made electrical contact with the side rail. Following insulation of the screw’s head from the rail the signal at 327.455 was barely detectable in a 24 hour integration with the active antenna very close to the receiver box.

#### 5] Conclusions

We need to use screws every 3” or screws every 6” with an added gasket. The braid gasket is acceptable, the Chomerics gasket is not acceptable. A double power filter is needed, whose details still have to be decided. The side rails that hold the box should be insulated to avoid contact with any screws. Or the screw heads which can contact the rails need to be insulated.