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To: Deuterium Array Group

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Subject: Some thermal considerations of receiver box cooling

A straightforward method of box cooling would be to draw in cooler outside air, circulate the air within the box and exhaust the heated air. This is the straightforward method used in virtually all the equipment housed inside. This method presents 2 problems for the D1 array:

1] There may be RFI leakage from the air input and exhaust openings.
2] Air drawn from the outside contains dirt, pollen and insects so that filtering would be required.

The method chosen [but we may need to revert to the conventional method] is to circulate air within the box and to remove the heat from the outside of the box by conduction through the box walls and subsequent loss via forced convection and radiation.

1] Internal circulation

Air is circulated internally to transfer the heat from the components to the box walls. This forced convection follows Newton's law of cooling:

$$p = Ah\Delta T$$

where A = surface area of box ≈ 2m^2
ΔT = temperature difference
h ≈ 17 $\text{Wm}^{-2}\,{}^\circ\text{C}^{-1}$ for 5 m/s
p = heat removed ≈ 170 W for 5 °C temperature rise

2] Conduction through the box walls

The bar walls are only 0.06 inches thick so that there cannot be any significant temperature drop across the wall since the thermal conductivity of aluminum is 240 $\text{Wm}^{-1}{}^\circ\text{C}^{-1}$.

3] Radiation cooling of the box
The radiative cooling of the box is

$$p = \in s\,A\left(T^4 - T_a^4\right)$$

where $\in$ = surface emissivity
≈ 0.15 for aluminum sheet

≈ 0.92 when painted with Goldstone #6

σ = Stefan-Boltzman = 5.76×10^{-8} $Wm^{-2} K^{-4}$

T = temperature ≈ 310 K

T_a = ambient ≈ 300 K

A = box surface area ≈ $2m^2$

P = 19W (unpainted), 117W (painted)

4] External forced convection

The top cover is forced cooled with 2 fans giving about 5 m/s air velocity across plate. This should provide 119W with 10°C temperature rise. There is also some convection cooling of the other 5 sides of the box which will depend on the air wind velocity.

5] Painting of the cowling

Surfaces which have a high ratio between the Solar absorption and emissivity get hot in the Sun. Unfinished aluminum is one of the worse finishes (see www.redrok.com) Titanium oxide (absorptivity ≈ 0.17, emmisivity ≈ 0.92) and paints like goldstone #6 provide a high emissivity so that they radiate into cold space and absorb a relatively small solar heat. A panel painted with Goldstone #6 remains cold in the Sun.

6] Measures being considered to improve box coding

a) use of best internal cooled heat sinks for pc processor and other chips which get hot
b) Application of Goldstone or equivalent paint to entire outer surface of box
c) Additional external fans on the bottom of the box
d) Added thermostat on the external fans to prevent extreme low temperatures in the Winter.

7] Experience with prototype (with 1 motherboard)

Out of the Sun the temperature of the air inside the box runs about 10°C above the ambient outside air. In the Sun the difference increases to about 15°C.