EDGES MEMO #458

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To: EDGES group

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Subject: Simulations of the effects of moisture on EDGES-3 at Adak

The proposed design of the ground plane for the planned deployment of EDGES-3 on Adak Island is described in memo 458. While Adak is a remote site with relatively small seasonal variation in temperature from about 33 to 51 degrees F it is a very wet environment with about 54 inches of rain and 100 inches of snow per year. It is also a very windy site with frequent gusts of 50 mph.

The EDGES-3 is a completely sealed antenna but there are 2 areas where a layer of water can have a significant effect on the antenna reflection coefficient. The first of these areas is the connection between the two boxes. The details of this connection are shown in figure 14 of memo 300 and figure 5b of memo 406 has a photo the connection between boxes of EDGES-3 at the WA.

Figure 1 shows the FEKO simulation of surrounding the connection between the boxes with a 100 micron thick square pipe with diameter and length of 35 mm. Table 1 shows the following results of comparing the average of the rms over 1-hour blocks of all GHA with 5 physical terms removed 54-102 MHz. Virtually all of the change is the result of a change in S11 with no appreciable effect on beam chromaticity.

case	dielectric	conductivity s/m	rms mK
reference	4	1e-4	
pure water	78	1e-4	29
rain water	78	1e-1	49
salt water	78	3	205

Table 1. Effect of a change in the average rms residuals due to moisture

The effect of 100 microns thick layer of pure water, rain water and salt water have been simulated and show that the largest effect on the antenna S11 is due to the high electrical conductivity of salt water so hydrophobic materials must be able to prevent any salt water getting onto the connection between the boxes.

The other areas are the plastic parts between the boxes added to ensure better control of the box separation. Figure 2 shows a FEKO simulation of the EDGES-3 side brackets used to constrain the antenna box separation as planned in memo 416 and 417 and installed in early 2024. These brackets are 8.68x4.07 inches and the effect of 100 microns layer of pure water, rain water and salt water have been simulated with the results summarized in table 2. The rms residuals in parentheses are for a layer of 200 microns showing that effect of a layer of water is approximately proportional to the layer thickness.

case	dielectric	conductivity s/m	rms mK
reference	4	1e-4	
pure water	78	1e-4	10 (27)
rain water	78	1e-1	24 (56)
salt water	78	3	380 (672)

Table 2. Effect of average rms residuals due to moisture box side brackets

Another check of the effect of moisture around and on the connector is to calculate the impedance across the connector which is connected in parallel with the pipe using the following equation:

$$1/z = 1/T + 2 * \pi * f * 1e6 * cap * I + \text{cond} * area/l$$

where z is the complex impedance
T is the complex impedance of the antenna
f= frequency in MHz
d= diameter pipe
t = thickness of the square pipe
cond = conductivity in s/m
*area = 4*d*t*
l = length of the square pipe
*cap is the capacitance = diel*eps*area/l*
diel = dielectric
eps = 8.54e-12

The results of using this analytic equation are given in table 3 of square pipe of 35 mm and thickness of 100 microns.

case	dielectric	conductivity s/m	rms mK
reference	4	1e-4	
pure water	78	1e-4	23
rain water	78	1e-1	40
salt water	78	3	525

Table 3. Simulation using analytic formula for pipe around connector between boxes

The analytic formula can be used to test the effect of MG chemicals non-melting dielectric lubricant 8462 grease on the antenna impedance. If we take a 1mm thick layer around the 141 coax with dielectric diameter of 0.1175 inches and assume the exposed length of the dielectric is 3mm. The effect of the grease, which has dielectric 2.5 and conductivity 1e-10, on the rms residual is only 11 mK. The greased connector can be covered with a "clamp on" pipe with foam to ensure the pipe stays in place. The results of FEKO simulation of a 26 mm long "clamp on" pipe around the greased connector with foam to ensure it stays in place are shown in Table 4.

case	dielectric	conductivity s/m	rms mK
reference	4	1e-4	
pure water	78	1e-4	15
rain water	78	1e-1	24
salt water	78	3	71

Table 4. Simulation using analytic formula for "clamp on" around connector

This shows that potential moisture layers on the pipe around the connector have a relatively small effect on the antenna S11 if foam is used to avoid contact with the connector and the walls of the antenna boxes. A suggested “clamp on” is a light grip ABS Snap 20mm clamp for ½ inch PVC pipe for greenhouses.

In summary the use of hydrophobic grease along with the protection of a “clamp on” pipe on the connection between EDGES-3 antenna boxes and a hydrophobic coating on both sides of the plastic parts which ensure a constant box separation should maintain a constant antenna S11 at least on the time scale of the nighttime data. Any changes which might result from some accumulation of moist salt on a longer time scale can be calibrated by running the impedance meter calibration of the antenna S11 during the day.

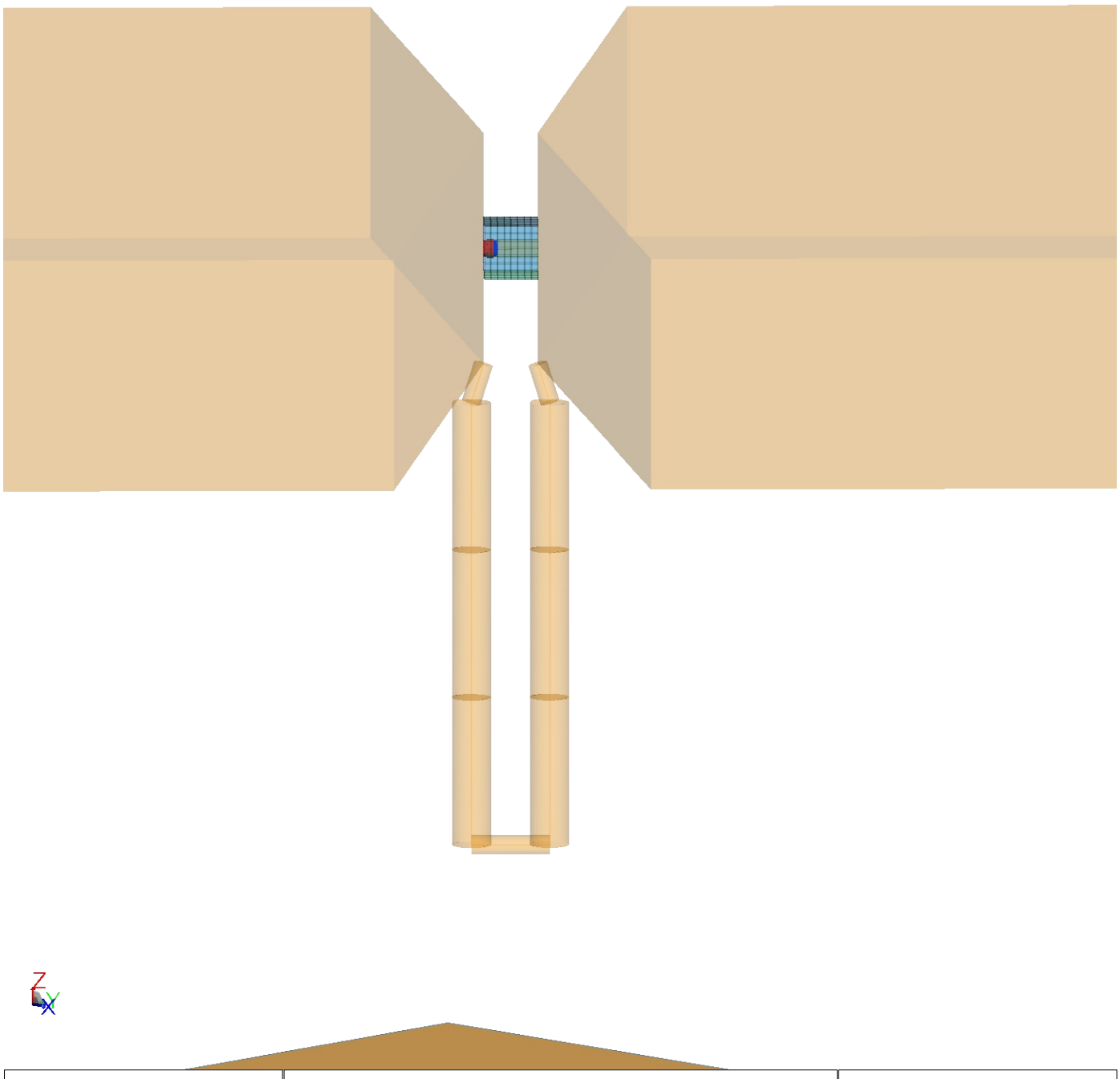

Figure 1. FEKO model of a 35 mm box with 100 micron thick walls around connection between antenna boxes

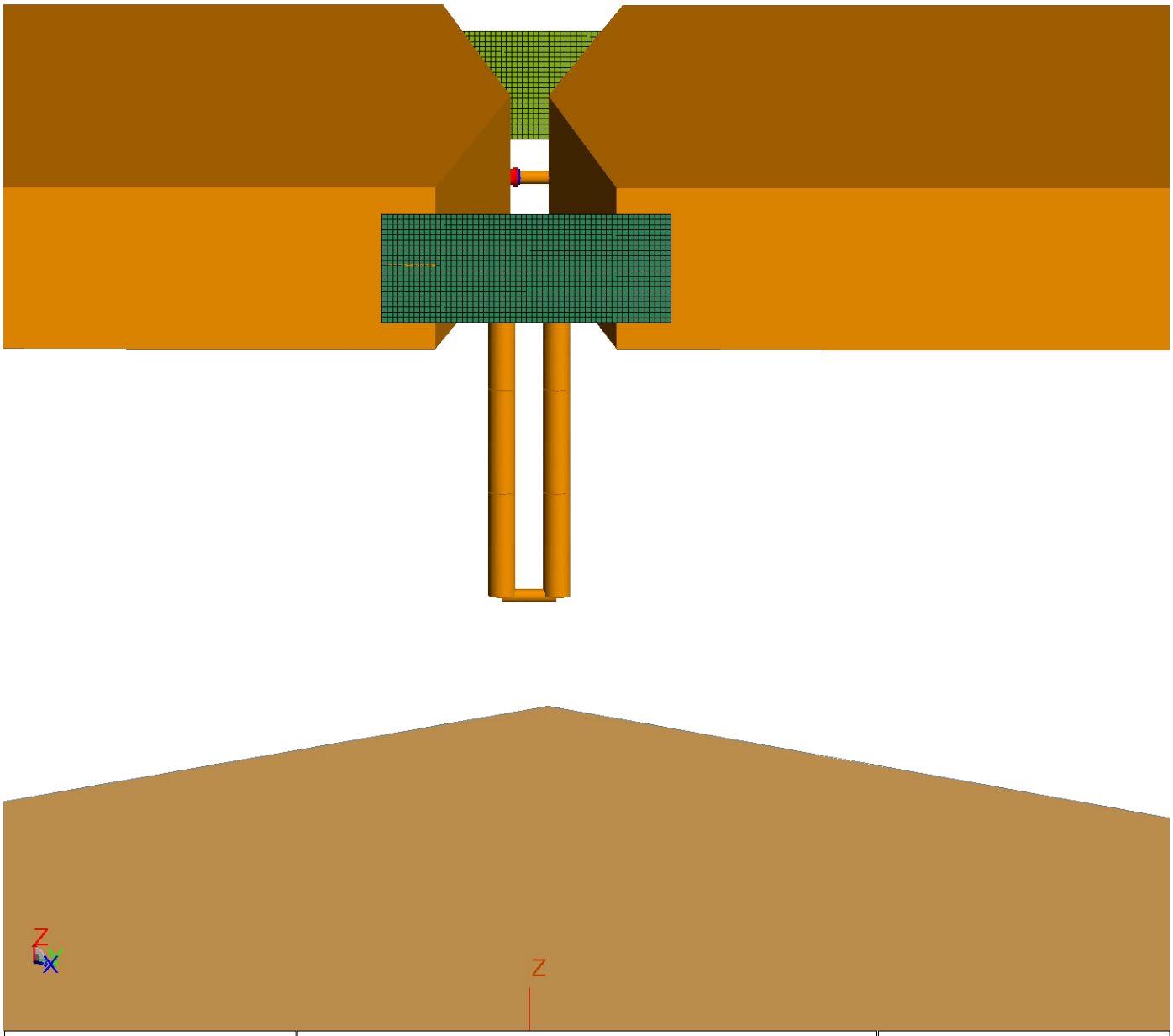

Figure 2. FEKO model of 8.68x4.07 inch plastic plates to maintain box separation between boxes