Carbon Fiber Grounding

Carbon fiber will be used for support structures in the Run 2B Silicon Tracker. Two types of carbon fiber will be employed: K13C for L0 and L1, and K139 for L2 – L5. Both types are highly conductive electrically, with K13C the more conductive of the two. The electrical properties of the carbon fiber will be critically important, both in terms of shielding and noise transmission.

Tests of some of the electrical properties of K139 carbon fiber were performed using an HP3589A network analyzer. Parallel plate capacitors were constructed with carbon fiber and copper plates, and connected to the network analyzer for measurement of transfer functions to the carbon fiber. The simple test set-up is sketched in Figure 1.

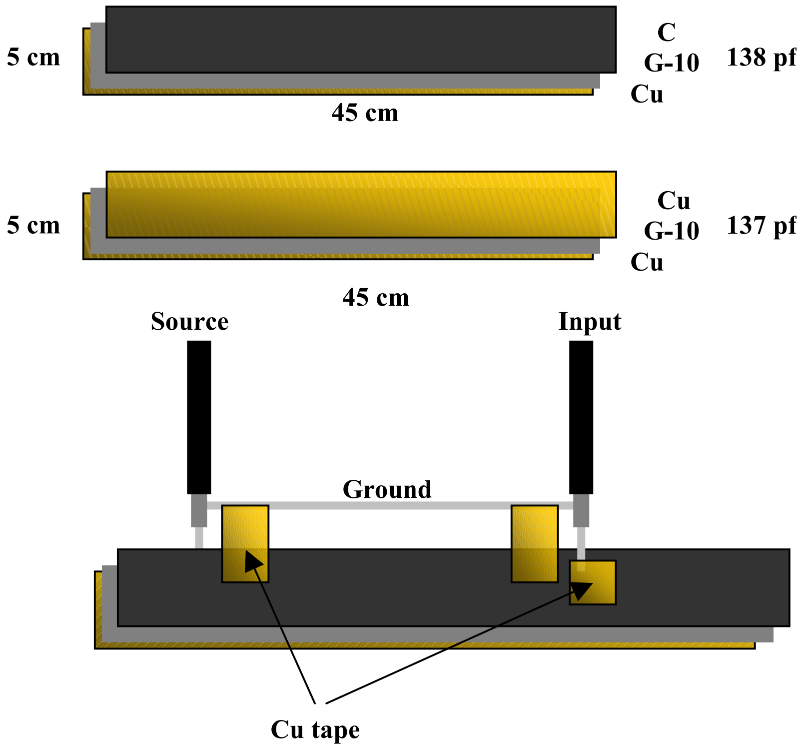

Figure 1. Carbon fiber test set-up.

The network analyzer source connection is made to the copper plate of the capacitor, and the input connection is made to the carbon fiber plate, both with RG58 coaxial cables. The inner conductors are affixed to the plates with copper tape, and the ground shields are wired together. The two connections are displaced by approximately 7 inches along the length of the rectangular capacitor. Different grounding schemes are tested by grounding the coax shields to the carbon fiber plate with various 1 inch wide strips of copper tape.

The network analyzer produces a logarithmic frequency sweep from 10 Hz – 150 MHz. With a 131 second sweep time and 1.1 Hz resolution bandwidth. The transfer function to the carbon fiber is measured by recording the frequency spectrum at the input. The measurements are normalized to the transfer function with the source and input connected through a 3 ns RG58 cable.

The test configuration is essentially a high-pass filter. With no grounding of the carbon fiber plate, the resulting input frequency spectrum exhibits the typical exponential rise and plateau of a high-pass filter. Grounding the carbon fiber with one strip of tape near the source greatly reduces the power transfer by 20 dB at 100 MHz. Grounding at the input rather than at the source produces slightly better results including a 31 dB reduction at 100 MHz. A 41 dB reduction is achieved by grounding at both the source and input. A more detailed picture of the results at a range of frequencies is shown in Table 1. No significant improvement results from adding more grounding strips between the source and input grounds. Cutting the ground braid between the source and input cables, and grounding the source and input independently make slight improvement.

GROUND LOCATION	1 kHz	10 kHz	100 kHz	1 MHz	10 MHz	100 MHz
None	-83	-63	-43	-23	-5	-1
Source	NA	-100	-79	-60	-40	-21
Input	NA	NA	NA	-80	-56	-32
Source & Input	NA	NA	NA	-89	-68	-42

Table 1. Power transfer in decibels at various frequencies with different grounding schemes.

A second capacitor was built with copper plates on both sides. The copper capacitor has virtually the same capacitance as the one with a carbon fiber plate. The two capacitors also have nearly identical input frequency spectra with no plate grounding.