## Internal Charging Mitigation Plan for the MAP Observatory

**Submit CCR #315 to establish Internal Charging Requirements**:

8.2 The observatory design shall prevent external/surface and internal charging/discharging effects that damage observatory components or disrupt observatory operations.

8.2.1 All observatory external surfaces shall be conductive (<=1E9 Ohms/sq) and grounded (resistance <= 2.5 milliOhms), excluding the solar array cover glass).

8.2.2 When modeled using a charging analysis program, the observatory, when exposed to a severe substorm in a geosynchronous environment, shall exhibit maximum differential charging less than the insulation breakdown, with a factor of 2 margin.

8.2.3 No internal discharge shall cause damage to spacecraft circuitry or shall result in an upset or soft failure that aborts a mission critical maneuver.

8.2.3.1 For materials (dielectrics) with bulk resistivity >$10^{12}$ Ohm-cm. Compile a list of dielectrics for each subsystem. Include unavoidable dielectrics such as the solar array, antennas, connectors, thermal isolators, thermistor mounting, thermal blankets, thermal blanket tape and others. Since the bulk resistivity of Kapton and Teflon insulators are much higher ($10^{18}$) then:

8.2.3.1.1 Limit the electron flux to insulators by shielding to $10^{10}$ electrons/cm$^2$ in 10 hours or:

Plate shielding or wrapping with 20 mil Al equivalent (6 mil Copper, 4 mil Lead, or 3.5 mil Tantalum). Shield to limit leakage to <10%. Shields around cables (conductors around dielectrics) wrapped to limit "gaps" to 1 sq inch, 6.5 sq cm.

8.2.3.1.2 Filter nearby circuitry to withstand a 5000 volt 20pf 10 ohm discharge or:

Detailed analysis of discharge could result in smaller or larger discharge source than above. Assess discharge threat to circuits that can not be totally shielded. Such as antennas, umbilical connector, thermistors, PRTs, heaters, Solar Array, CSS. If necessary implement filters to protect these circuits.

8.2.3.1.3 Coat the exterior surface of the dielectric with a grounded layer with resistivity <$10^9$ ohm/sq or:

8.2.3.1.4 Prevent the discharge from reaching a victim circuit by EMI shielding and or grounded conductive barrier that will safely dissipate the discharge.

8.2.3.2 No ungrounded conductors are allowed unless shielded by 110 mil Aluminum equivalent.

This includes unused wires in harnesses, unused or unpopulated circuit board traces, ungrounded IC, relay, transistor or capacitor cases, spare pins in connectors, thermal blankets, Aluminum or Copper tape, ungrounded bracketry for harness or connectors, TC105 harness tie down clips, harness P-clamps, thermostat cases, screws or nut plates.

Exceptions are allowed by waiver if analysis shows no direct or radiated path to victim circuitry exists or victim can survive discharge.

8.2.3.3 Sufficient shields around cables to protect against circuit damage or upset from EMI fields emitted from surface or dielectric discharges elsewhere on spacecraft. A 1.4 mil copper, monel wire mesh, or 4 mil lead tape over wrap serves this purpose.

8.2.3.4 No exposed voltages above 50 volts, to prevent short to ground by plasma cloud emitted by a discharge.