Notes for preliminary Chipmunk/TLM meeting ESH/AD
John Larson
October 14, 2011

This note deals only with the aspect of interfacing the Chipmunk electronics with the TLM ion chambers. Judgment of the suitability of using long Heliax cable as an ion chamber for this project still needs to be addressed. The ion chamber will have to be characterized to assure that it meets all requirements. Since the ion chamber in the proposed configuration is detached from the instrument portion, other safeguards will be required to assure that the ion chamber is functioning properly. Additionally, a means of periodic calibration will be required.

I have picked out 5 key circuit boards of the Chipmunk IVA instrument: RP325 Digitizer Control, RP326 Digitizer, RP327 Zero, RP333 Failsafe, and RP334 HVPS. This instrument was originally built in 1995, with replacement of the original HVPS and addition of the Failsafe board later. Schematics, layouts, and parts lists are provided.

The trickiest part of the circuit is the digitizer. The digitizer has the following characteristics: ultra-low leakage(< ~5 fA), ultra-low parasitic capacitance, 0.5 E-12 Coulomb / count sensitivity, 6 decade response, and temperature range of -30°C - +50°C. Empirical design techniques were required to achieve these characteristics.

Since last construction of the Chipmunk IVA's, many of the critical components necessary for construction have become obsolete (or already were). We bought up enough of these items for spares and perhaps to build another batch of Chipmunks. Among the obsolete parts are: Motorola 2N4117A n-channel J-FET (D2, used as low leakage, low capacitance diode – others do not work), Allen-Bradley 100 MΩ carbon composition resistor (R2, low capacitance, film will not work at these levels), and C1 & C2 - polystyrene film capacitors in metal cans with tabs (we have begun using Southern Electronics polypropylene models PP65 and PP6X). We can spare a few parts and maybe a few pc boards for experimentation.

Layout of the digitizer board is critical. The input signal must be completely guarded. The input signal must never touch the board. Don't put a ground plane beneath the R2 & D2 area – the parasitic capacitance will kill it. The order of R2 & D2 is important – if the order is reversed, the parasitic capacitance will kill it. During construction, keep the lead length between R2 and cathode of D2 as short as possible – more capacitance problems. Also, C1 and C2 should be annealed at 130°C overnight with both leads shorted to metal tab - relieves stresses. Every effort should be made to eliminate triboelectric and piezoelectric effects.

There have been developments that you may find useful. There is a newer electrometer amplifier now available from National Semiconductor, the LMP7721. This chip has improved specs over the LM6041AIN currently used. Also, we have been working on a thing called "digitizer extender", which could be used in conjunction with a digitizer to increase overall sensitivity by, in simplest form, attaching an ADC to the integrator output signal (ramp) and outputting a pulse whenever the ADC decrements. In this case, the native sensitivity of the digitizer (now front-end) could be desensitized and the over-all sensitivity could still be much greater than the original digitizer. This would make design of the digitizer front end much simpler because parasitic capacitance becomes much less of a problem and currently available components could be used. We do not yet have a working prototype.

Several other issues remain to be covered: Some of the digitizer components are very static sensitive. Extreme care must be taken during assembly and handling. The digitizer should be shielded, and depending on environment, possibly sealed and desiccated. Some of the components are light sensitive, so take appropriate measures. The digitizer may have to be temperature compensated. This will depend on operating temperature range and response requirements. Whatever the connection is from the TLM to the digitizer must be protected from physical stress. Also, you need to determine a full set of specifications for the digitizer.

More information can be provided during development stage.