Requirements for LET L0, L1, and L2 Trigger Thresholds

Richard Mewaldt
10/30/2012

This memo discusses requirements for the energy thresholds for the first three detectors in the LET sensors for SPP. Figure 1 shows the present makeup of the LET1 and LET2 telescopes. In the following we assume the following thicknesses for the first four detectors:

L0 = 10 microns active with a 2 micron dead-layer. Dead layer is assumed on the front.
L1 = 25 microns – dead layer was neglected
L2 = 500 microns – dead layer neglected
L3 = 1000 microns

Figure 2 shows the energy loss in L0, L1, L2, and L3 and beyond for normally incident protons. The calculations were based on the Janni range-energy tables for protons in silicon. The incident energy is at the start of L0. Also shown are various requirements and desires for threshold settings, as discussed below. These need to be compared with the noise levels expected for the new PHASIC circuits.

L0 Threshold Requirement:
The principal requirement is that we measure protons with ~99% efficiency until they are sufficiently into L2 so that there are no gaps in the spectrum. This first occurs for ~2 MeV protons when the nominal proton energy loss in L0 is ~280 keV. If we require 3 MeV to allow for a possibly thicker L0 the nominal proton energy loss is ~205 keV. However, Bohr-Landau energy-loss fluctuations in L0 at low energy amount to ~19 keV (using Equation 7 in Stone et al. 1998). Therefore, a 3-sigma detection in L1 requires a threshold of ~150 keV, which should not be a problem.

Other Goals for L0 measurements: It would be very useful to measure protons in L0 until they start penetrating to L3, so that we always have 2 delta-E measurements. Two delta-E measurements lead to better background rejection and charge resolution (especially in high count-rate situations when chance coincidences are possible). In addition, two delta-E measurements should reject all electron contamination. This implies we need to detect 9-MeV proton delta–E in L0 with ~2 sigma. For this the mean L0 delta-E at 9 MeV is only 86 keV. For a 1-sigma margin this means a threshold of ~67 keV while 2σ => 48 keV. These threshold values are not expected to be possible. However, this desire might be met if L0 turns out to be a little thicker for other reasons.

L1 Threshold Requirements: It is critical to track protons with 99% efficiency until they are well into L3 (~10 MeV). This guarantees no gaps in the energy spectrum and provides overlap with HET protons, which start at ~8 MeV. At 10 MeV the nominal L1 energy loss is 207 keV. The Bohr-Landau width is σ = 30 keV. From this the 2-sigma requirement is 147 keV, and the 3-sigma goal is 117 keV. A 2-MeV overlap is minimal. The threshold to measure 12-MeV

protons with 2-σ confidence is ~120 keV. I suggest that the design requirement should be 150 keV with a goal of 120 keV.

L2 Threshold Requirements: The L2 detector is required to detect both protons and electrons. Electrons are the main reason for a low threshold. The minimum requirement is to detect 1-MeV electrons with >90% efficiency. This requires a threshold of ~125 keV (see Figure 3). To detect 1-MeV electrons with 99% efficiency requires a threshold of ~110 keV. For protons, we would like L2 to detect protons out to the end of range of a LET. This is automatically satisfied if we meet the electron requirement of 125 keV.

L3 Threshold Requirements: In STEREO/LET the L3 thresholds are ~1.7 MeV, in order to avoid "retriggering", as I remember. This leads to a sizeable gap where up to 1.2 MeV is unmeasured for protons between ~2.5 and 4 MeV. A more reasonable goal would be a threshold ~0.5 MeV, which must be balanced with dynamic range considerations.

Summary of Suggested Threshold Requirements and Goals

LET Detector	Thickness (microns)	Threshold Requirement (MeV)	Threshold Goal (MeV)
L0	**10**	**0.150**	**0.090**
L1	**25**	**0.150**	**0.120**
L2	**500**	**0.125**	**0.110**
L3	**1000**	**Needs more work**	**Needs work**

References

E. C. Stone et al., Space Science Reviews, 96, 285, 1998
Janni, AFWL-TR-65-150 Report

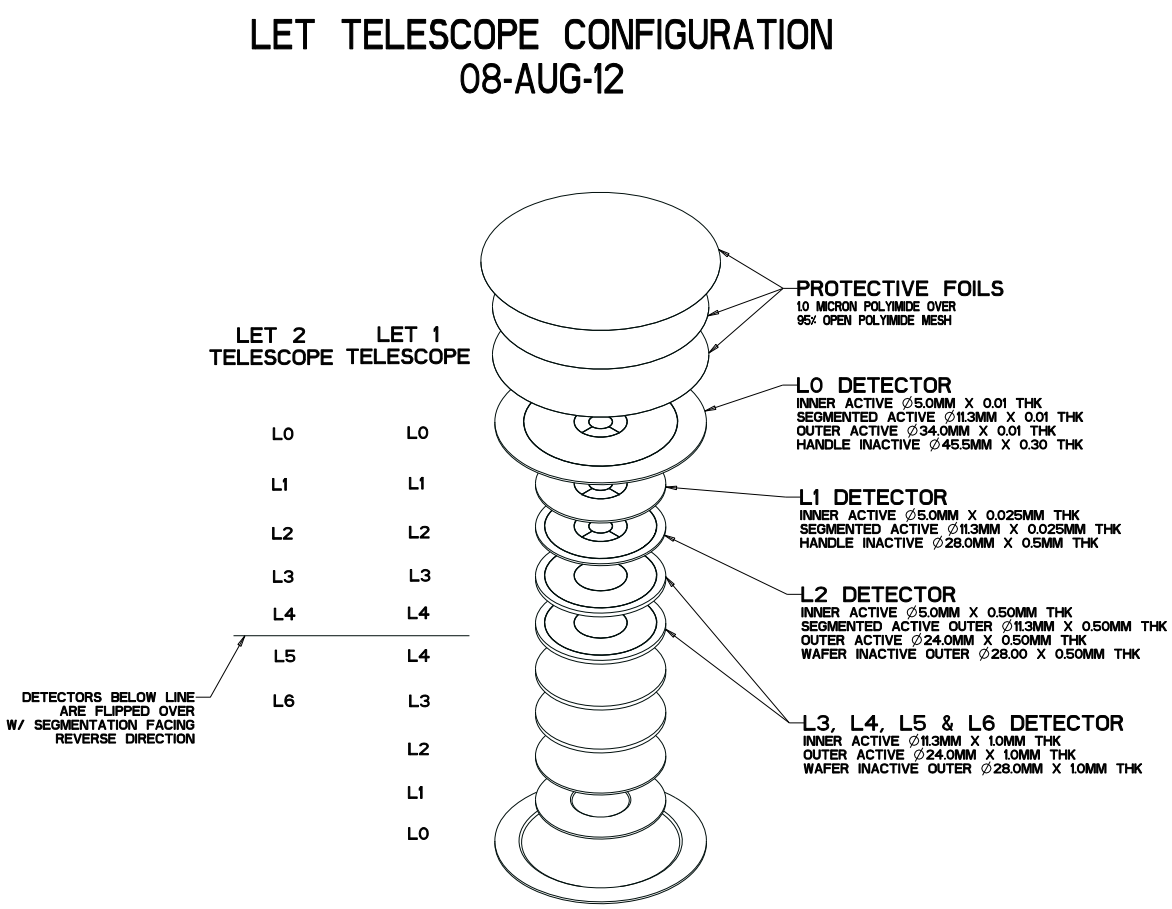

Figure 1: LET Telescope configuration for Solar Probe Plus

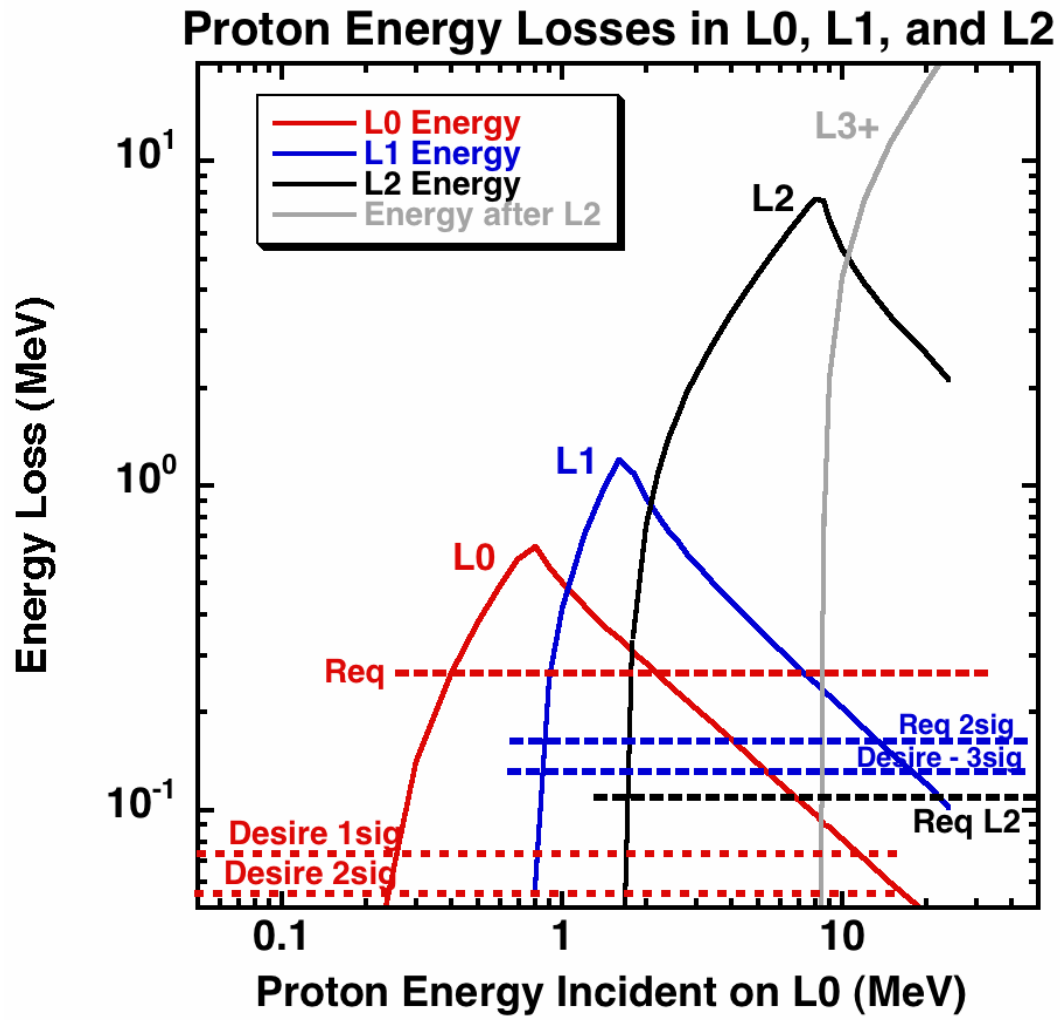

Figure 2: Energy-loss profiles for L0, L1, L2, and L3+later devices due to normally incident protons. Also shown are recommended requirements and goals for the triggering threshold for Lo, L1, and L2 (note color coding).

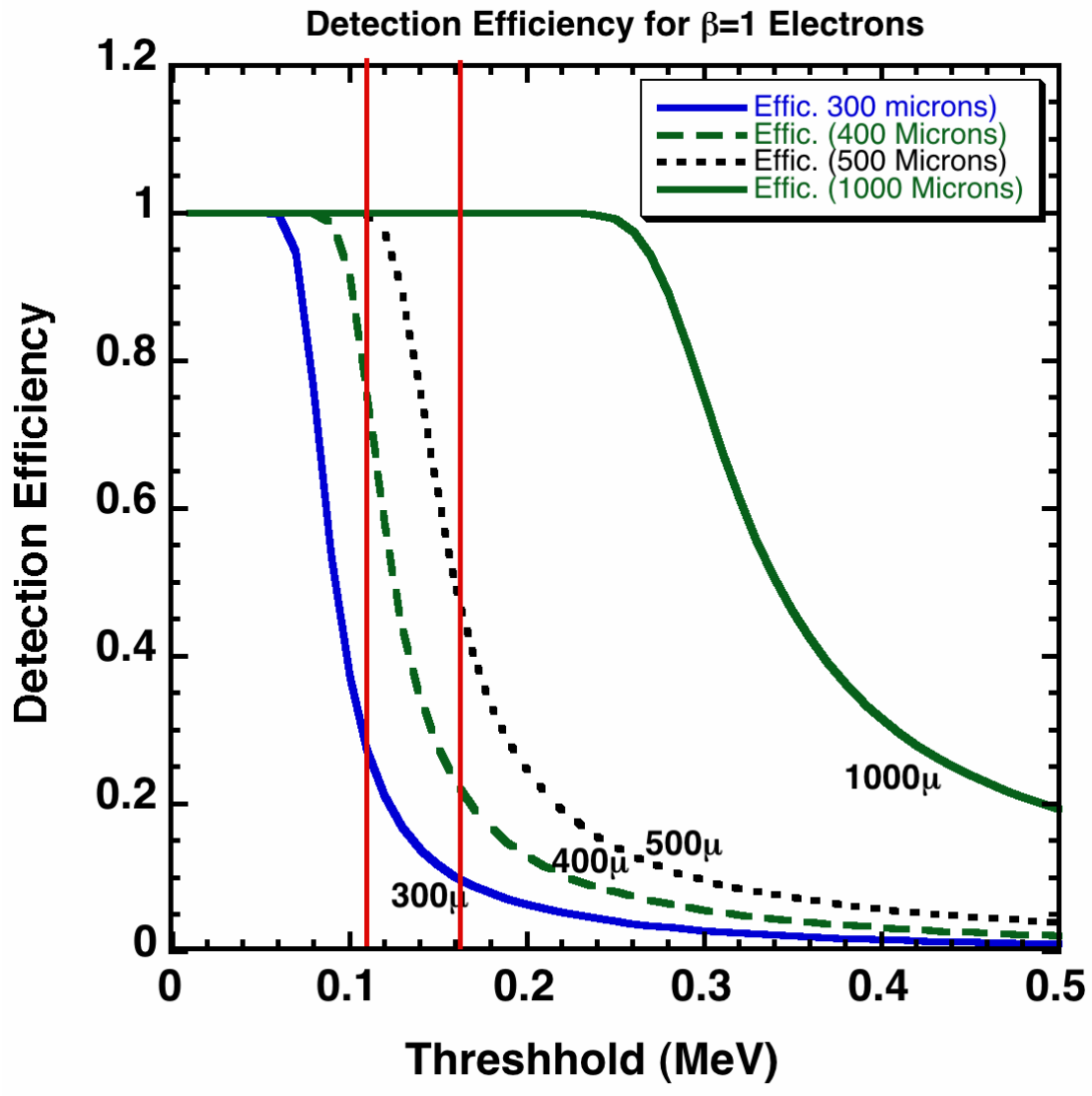

Figure 3. Electron detection efficiency for various thickness detectors as a function of the detection threshold (simulations by Allan Labrador).