# EPI-Hi/HET Rate Data for Inside 0.25 AU


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**5/19/14**


**Abstract:** This memo presents a draft version of EPI-Hi High Energy Telescope (HET) data products resulting from real-time onboard analysis during the encounter phase of the Solar Probe Plus mission. It tabulates the energy/nucleon bins that are expected to be populated by SEP and GCR ions with $1 \leq Z \leq 28$ and $Z \geq 30$ ions that stop in the HET detector stack. The 3He/4He and 22Ne/20Ne ratios should also be measureable over a portion of the geometry factor. Analysis of "penetrating particles will extend the HET energy range by as much as a factor of ~3. Electron and ion pitch-angle distributions can be measured in 25 "sectors" over two separate fields of view. A HET neutral mode can be used to detect gamma-rays and neutrons from large solar flares. The remaining data rate will be allocated to housekeeping and singles rates, and to transmitting pulse-height data from as many energetic particle events as possible. It is expected that considerable savings can be obtained by data compression techniques.

# Contents

## 1. Introduction

In this document we outline the onboard data products and Rate data that will be produced by by the EPI-HI High Energy Telescope (HET) pictured in Fig. 1, which includes 10 solid state detectors. HET is double-ended with the A-end pointed ~10° off the west limb of the Sun. It is sometimes convenient to label events by the number of detectors they trigger. Thus "Range 3" includes H1A•H2A•H3A and H1B•H2B•H3B events.

**EPI-Hi /HET Detector Stack**

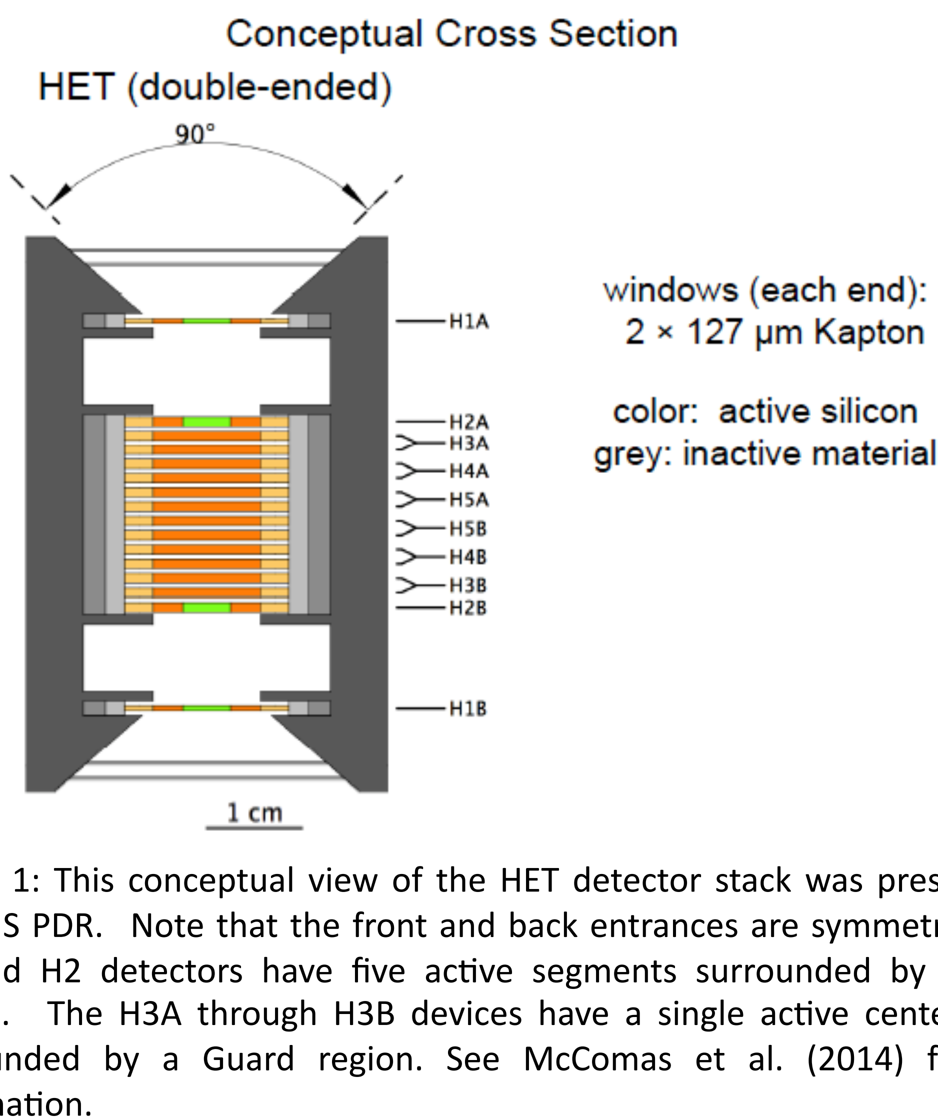


Figure 1: This conceptual view of the HET detector stack was presented at the ISIS PDR. Note that the front and back entrances are symmetrical. The H1 and H2 detectors have five active segments surrounded by a Guard region. The H3A through H3B devices have a single active center region surrounded by a Guard region. See McComas et al. (2014) for more information.

## HET Detectors:

The Table below summarizes the dimensions of the various HET detectors. Examples are pictured below.

EPI-Hi Silicon Solid-State Detector Designs

| Detector Telescope | Detector Designations | Thickness | Number of Central / Guard / Small Pixel Segments | Central Active Area | Guard Active Area | Notes |
|---|---|---|---|---|---|---|
| HET | H1A, H1B | 500 µm | 5 / 1 / 1 | 1.0 $cm^2$ | 1.73 $cm^2$ | [2] |
| | H2A, H2B | 1000 µm | 5 / 1 / 1 | 1.0 $cm^2$ | 1.73 $cm^2$ | [2] |
| | H3A, H3B | 2 × 1000 µm | 1 / 1 / 1 | 1.0 $cm^2$ | 1.73 $cm^2$ | [2] |
| | H4A, H4B | 2 × 1000 µm | 1 / 1 / 1 | 1.0 $cm^2$ | 1.73 $cm^2$ | [2] |
| | H5A, H5B | 2 × 1000 µm | 1 / 1 / 1 | 1.0 $cm^2$ | 1.73 $cm^2$ | [2] |

Notes:

[1] new technology development

[2] small pixel at edge for rate monitoring on some detectors; area: 1 $mm^2$

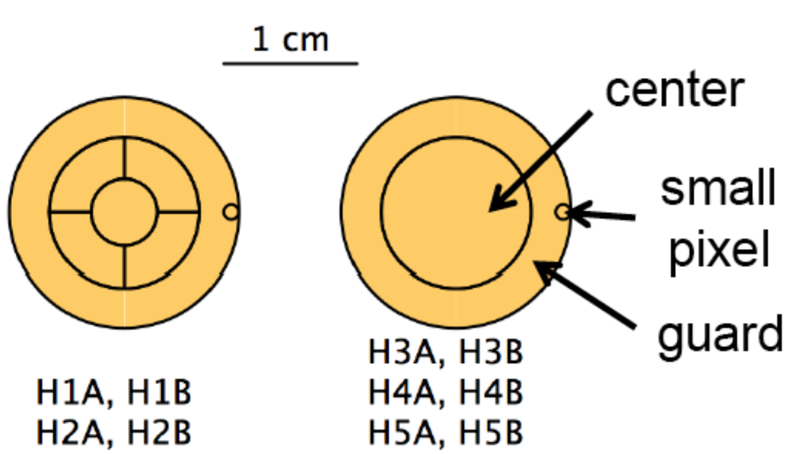


Figure 2: HET Detectors

## 2. HET Geometry Factors

Table 1 shows calculations of the geometry factor for ions stopping in at the beginning and end of each detector in the HET stack, using dimensions in the table below. The H1-H2 spacing was chosen to give a maximum opening angle of 45° for ions that traverse completely through H1 and H2 without triggering a Guard. The detector thicknesses and spacings are given below. Note that H3A through H3B are 2-mm Si in thickness, made up of two 1-mm devices spaced by 0.5 mm. Except for H1 and H2, there is a 0.5 mm gap between all detectors. The window thickness (in Si equivalent) is appropriate for 2 x 5-mil Kapton at ~30-100 MeV/nuc. From this table it is possible to calculate the minimum thickness of Si to reach a given "Range" (for 0° incidence angle), and also the maximum thickness at the appropriate "Theta max" angle.

Table 1

| | | | | | | HET Geometry Factors | | | | | | RAM |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | ISIS/EPI-Hi | | | | | | 6/16/13 |
| Item | Thick (mm) | R1 | R2 | A1 | A2 | Theta Max | Height (cm) | Sep. D | Sumsq. | term | Const | Wide Gfac (cm2sr) |
| front window | 0.210 | 1.908 | 1.254 | 11.44 | 4.94 | | | | | 22.88 | 4.935 | |
| H1Atop | 0.5 | 0.252 | 0.564 | 0.200 | 0.999 | | 0.00 | | | 0.081 | 4.935 | |
| H1Abot | | 0.564 | 0.564 | 1.000 | 1.000 | | 0.05 | | | 0.405 | 4.935 | |
| H2ATop | 1 | 0.564 | 0.564 | 1.000 | 1.000 | 46.26 | 1.08 | 1.08 | 1.80 | 0.405 | 4.935 | 0.5731 |
| H2Bbot | | 0.564 | 0.564 | 1.000 | 1.000 | 44.96 | 1.13 | 1.13 | 1.91 | 0.405 | 4.935 | 0.5380 |
| H3Atop | 2 | 0.564 | 0.564 | 1.000 | 1.000 | 43.72 | 1.18 | 1.18 | 2.03 | 0.405 | 4.935 | 0.5056 |
| H3Abot | | 0.564 | 0.564 | 1.000 | 1.000 | 38.28 | 1.43 | 1.43 | 2.68 | 0.405 | 4.935 | 0.3784 |
| H4Atop | 2 | 0.564 | 0.564 | 1.000 | 1.000 | 37.32 | 1.48 | 1.48 | 2.83 | 0.405 | 4.935 | 0.3584 |
| H4Abot | | 0.564 | 0.564 | 1.000 | 1.000 | 33.11 | 1.73 | 1.73 | 3.63 | 0.405 | 4.935 | 0.2777 |
| H5Atop | 2 | 0.564 | 0.564 | 1.000 | 1.000 | 32.37 | 1.78 | 1.78 | 3.81 | 0.405 | 4.935 | 0.2647 |
| H5Abot | | 0.564 | 0.564 | 1.000 | 1.000 | 29.07 | 2.03 | 2.03 | 4.76 | 0.405 | 4.935 | 0.2112 |
| H5Btop | 2 | 0.564 | 0.564 | 1.000 | 1.000 | 28.48 | 2.08 | 2.08 | 4.96 | 0.405 | 4.935 | 0.2023 |
| H5Bbot | | 0.564 | 0.564 | 1.000 | 1.000 | 25.84 | 2.33 | 2.33 | 6.07 | 0.405 | 4.935 | 0.1653 |
| H4Btop | 2 | 0.564 | 0.564 | 1.000 | 1.000 | 25.37 | 2.38 | 2.38 | 6.30 | 0.405 | 4.935 | 0.1591 |
| H4Bbot | | 0.564 | 0.564 | 1.000 | 1.000 | 23.22 | 2.63 | 2.63 | 7.55 | 0.405 | 4.935 | 0.1326 |
| H3Btop | 2 | 0.564 | 0.564 | 1.000 | 1.000 | 22.83 | 2.68 | 2.68 | 7.82 | 0.405 | 4.935 | 0.1281 |
| H3Bbot | | 0.564 | 0.564 | 1.000 | 1.000 | 21.06 | 2.93 | 2.93 | 9.22 | 0.405 | 4.935 | 0.1086 |
| H2Btop | 1 | 0.564 | 0.564 | 1.000 | 1.000 | 20.74 | 2.98 | 2.98 | 9.52 | 0.405 | 4.935 | 0.1052 |
| H2Bbot | | 0.564 | 0.564 | 1.000 | 1.000 | 20.43 | 3.03 | 3.03 | 9.82 | 0.405 | 4.935 | 0.1020 |
| H1Btop | 0.5 | 0.564 | 0.564 | 1.000 | 1.000 | 15.53 | 4.06 | 4.06 | 17.12 | 0.405 | 4.935 | 0.0584 |
| H1Bbot | | 0.564 | 0.564 | 1.000 | 1.000 | 15.35 | 4.11 | 4.11 | 17.53 | 0.405 | 4.935 | 0.0571 |

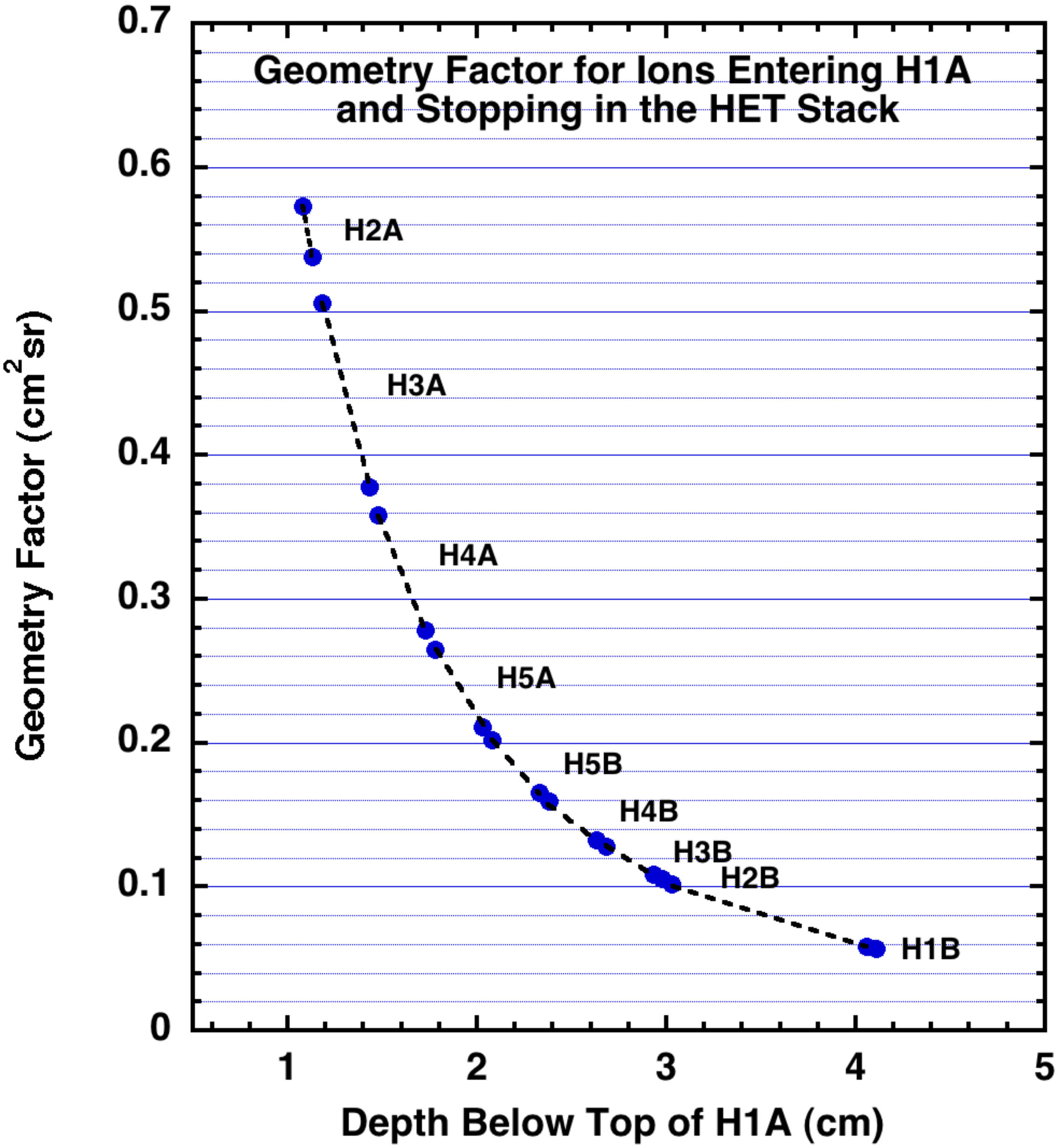


Figure 3: The total HET geometry factor for stopping ions is plotted versus the depth in the detector stack (see Table 1). Since the geometry factor varies significantly with range, it is necessary to consider each range separately (unlike most of LET).

## 3. One-Minute Composition Rates

Onboard composition analysis will follow the STEREO/LET model (Mewaldt et al. 2007). For each HET Range the energy limits for each ion of interest were calculated by determining the minimum and maximum energy/of ions stopping in the last detector, based on the allowed range of incidence angles and nominal detector thicknesses. The Table below gives the energy intervals for Range 2 as an example. The selected bins are are designed to include the effects of angle-of-incidence variations as well as isotopic variations in range vs. energy relations. Since most of these 1-minute rates will equal zero during quiet-time hours, considerable savings should be possible by compressing these rates. The Z>30 bins are notional and should be adjusted using appropriate range-energy relations.

Min and Max Energy/nuc for each Range, including Angle Variation

| Range | Theta Min | Theta Max | Thick Min mm Si | Thick Max mm Si | H, He | He3 | He 3.5 | He4 | C | N | O | Ne | Ne20 | Ne21 | Ne22 | Na | Mg | Al | Si | S | Ar | Ca | Cr | Fe | Ni |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Sum from 10s Rates | | | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 |
| 2A | 0 | 45 | 0.71 | 2.12 | 10.0 | 11.8 | 10.0 | 10.0 | 18.5 | 20.4 | 21.7 | 24.5 | 24.5 | 23.8 | 23.2 | 26.29 | 26.9 | 27.5 | 29.2 | 31.2 | 33.1 | 35.0 | 36.24 | 38.1 | 40.34 |
| | | | | | 20.1 | 22.0 | 22.0 | 20.1 | 34.5 | 37.7 | 40.6 | 45.9 | 45.9 | 44.7 | 43.5 | 49.48 | 50.7 | 51.9 | 55.2 | 59.2 | 62.98 | 66.7 | 69.8 | 73.4 | 77.69 |
| 3A | 0 | 38.3 | 1.71 | 4.46 | 16.5 | 19.5 | 16.5 | 16.5 | 30.8 | 33.4 | 35.9 | 40.6 | 40.6 | 39.5 | 38.4 | 43.8 | 44.8 | 46.0 | 48.7 | 52.4 | 52.41 | 52.4 | 61.46 | 64.6 | 68.4 |
| | | | | | 29.4 | 33.5 | 33.5 | 29.4 | 52.5 | 57.3 | 61.7 | 69.9 | 69.9 | 68.0 | 66.2 | 75.5 | 77.4 | 79.3 | 84.4 | 90.7 | 96.76 | 102.8 | 108.1 | 113.8 | 120.4 |
| 4A | 0 | 33.1 | 3.71 | 6.57 | 25.7 | 30.1 | 25.7 | 25.7 | 47.3 | 51.6 | 55.6 | 63.1 | 63.1 | 61.4 | 59.7 | 68.0 | 69.7 | 71.4 | 76.2 | 82.1 | 87.35 | 92.6 | 97.08 | 102.1 | 108 |
| | | | | | 36.2 | 41.5 | 41.5 | 36.2 | 65.3 | 71.2 | 76.8 | 87.1 | 87.1 | 84.8 | 82.5 | 94.1 | 96.5 | 98.9 | 105 | 113 | 121 | 129 | 136 | 143 | 151 |
| 5A | 0 | 29.1 | 5.71 | 8.58 | 32.7 | 38.3 | 32.7 | 32.7 | 60.4 | 65.8 | 70.9 | 80.4 | 80.4 | 78.3 | 76.2 | 86.9 | 89.1 | 91.3 | 97.1 | 105 | 112 | 119 | 125 | 132 | 139 |
| | | | | | 41.8 | 48.3 | 48.3 | 41.8 | 76.0 | 82.9 | 89.4 | 101 | 101 | 98.7 | 96.0 | 110 | 112 | 115 | 123 | 132 | 141 | 150 | 159 | 167 | 177 |
| 5B | 0 | 25.8 | 7.71 | 10.55 | 38.8 | 45.4 | 38.8 | 38.8 | 71.5 | 78.0 | 84.1 | 95.3 | 95.3 | 92.8 | 90.3 | 103 | 106 | 108 | 115 | 124 | 133 | 141 | 149 | 157 | 166 |
| | | | | | 46.8 | 54.2 | 54.2 | 46.8 | 85.4 | 93.1 | 100 | 114 | 114 | 111 | 108 | 123 | 127 | 130 | 138 | 149 | 159 | 169 | 179 | 189 | 200 |
| 4B | 0 | 23.2 | 9.71 | 12.51 | 44.1 | 51.8 | 44.1 | 44.1 | 81.5 | 88.9 | 96 | 109 | 109 | 106 | 103 | 118 | 121 | 124 | 132 | 142 | 152 | 162 | 171 | 180 | 190 |
| | | | | | 51.4 | 59.7 | 59.7 | 51.4 | 94.0 | 103 | 111 | 126 | 126 | 122 | 119 | 136 | 139 | 143 | 153 | 165 | 176 | 188 | 199 | 209 | 221 |
| 3B | 0 | 21.1 | 11.71 | 14.47 | 49 | 57.5 | 49.0 | 49 | 90.6 | 98.9 | 107 | 121 | 121 | 118 | 115 | 131 | 134 | 138 | 147 | 158 | 169 | 180 | 191 | 201 | 212 |
| | | | | | 55.7 | 64.8 | 64.8 | 55.7 | 102 | 112 | 120 | 137 | 137 | 133 | 130 | 148 | 152 | 156 | 166 | 179 | 192 | 204 | 217 | 228 | 241 |
| 2B | 0 | 20.4 | 12.71 | 15.47 | 53.6 | 60.2 | 53.6 | 53.6 | 95 | 104 | 112 | 127 | 127 | 124 | 120 | 137 | 141 | 144 | 154 | 166 | 178 | 189 | 200 | 211 | 223 |
| | | | | | 57.8 | 67.2 | 67.2 | 57.8 | 106 | 116 | 125 | 142 | 142 | 138 | 135 | 154 | 158 | 162 | 173 | 187 | 199 | 212 | 225 | 237 | 251 |
| 1B | 0 | 15.4 | 13.21 | 16.08 | 55.7 | 61.5 | 55.7 | 55.7 | 97 | 106 | 114 | 130 | 130 | 126 | 123 | 140 | 144 | 147 | 157 | 170 | 182 | 194 | 205 | 216 | 228 |
| | | | | | 58.9 | 68.7 | 58.9 | 58.9 | 109 | 118 | 128 | 145 | 145 | 142 | 138 | 157 | 161 | 165 | 177 | 191 | 204 | 217 | 231 | 243 | 257 |

Using these limits energy bins that will be populated were identified for each ion. Two bins were added above and below that would be expected to have little or no nominal counts, neglecting nuclear interactions or other deviations like multiple scattering. The Table below shows the energy bins for HET Range 2 (2 => both directions), and tabulates the resulting bit rate assuming He isotope data use 12-bit log-compressed rates and that Z≥6 ions use 8-bit log-compressed rates. In addition to 3He/4He and 22Ne/20Ne separation for narrow angle sectors there are 3.5He and 21Ne rates that monitor 4He and 22Ne spill-over. H and He events based on the full geometry are not counted here but are available from the 10s rates.

HET Range 2 (2-Detector Events)
H1A•H2A
H1B•H2B

| E1 | E2 | H, He | He3 | He3.5 | He4 | C | N | O | Ne | Ne20 | Ne21 | Ne22 | Na | Mg | Al | Si | S | Ar | Ca | Cr | Fe | Ni | 30-40 | 40-50 | 50-60 | >60 | H, He | Z≥6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6.73 | 8.00 | | 2 | 2 | 2 | | | | | | | | | | | | | | | | | | | | | | 6 | 0 |
| 8.00 | 9.51 | Get | 2 | 2 | 2 | | | | | | | | | | | | | | | | | | | | | | 6 | 0 |
| 9.51 | 11.3 | from | 2 | 2 | 2 | | | | | | | | | | | | | | | | | | | | | | 6 | 0 |
| 11.3 | 13.5 | 10s | 2 | 2 | 2 | 2 | | | | | | | | | | | | | | | | | | | | | 6 | 2 |
| 13.5 | 16.0 | rates | 2 | 2 | 2 | 2 | 2 | 2 | | | | | | | | | | | | | | | | | | | 6 | 6 |
| 16.0 | 19.0 | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | | | | | | | | | | | | | 6 | 16 |
| 19.0 | 22.6 | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | | | | | | | | | 6 | 24 |
| 22.6 | 26.9 | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | | | | | 6 | 32 |
| 26.9 | 32.0 | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 6 | 42 |
| 32.0 | 38.1 | | | | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | | | | 0 | 34 |
| 38.1 | 45.3 | | | | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | | | | 0 | 34 |
| 45.3 | 53.8 | | | | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 0 | 42 |
| 53.8 | 64.0 | | | | | | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | | | | 0 | 30 |
| 64.0 | 76.1 | | | | | | | | | | | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | | | | 0 | 20 |
| 76.1 | 90.5 | | | | | | | | | | | | | | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 0 | 22 |
| 90.5 | 108 | | | | | | | | | | | | | | | | | | 2 | 2 | 2 | 2 | | | | | 0 | 8 |
| 108 | 128 | | | | | | | | | | | | | | | | | | | | | 2 | | | | | 0 | 2 |
| 128 | 152 | | | | | | | | | | | | | | | | | | | | | | 2 | 2 | 2 | 2 | 0 | 8 |
| 152 | 181 | | | | | | | | | | | | | | | | | | | | | | | | | Rates | 54 | 322 |
| 181 | 215 | | | | | | | | | | | | | | | | | | | | | | | | | Bits | 12 | 8 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | bps | 10.8 | 42.9 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | Sum | 53.7 | |

# Matrices for Ions Stopping in Ranges 3 and 4

Shown below are the energy intervals for ions stopping in HET Ranges 3, 4, and 5. The “2’s” in the boxes indicate that particles incident from the front and back are tabulated separately. H and He are tabulated on a 10s basis and then summed on the ground to obtain 1-hr rates The intervals take into account the minimum and maximum angles of incidence as well as isotope effects and we always attempt to leave two bins expected to be empty above and below the nominal minimum and maximum energy deposits for each species. The first and last bins could be expanded lower and higher, respectively, to capture a larger fraction of possible background events due to nuclear interactions, or we could add additional broad background bins (see later).

| E1 | E2 | H,He | He3 | He3.5 | He4 | C | N | O | Ne | Ne20 | Ne21 | Ne22 | Na | Mg | Al | Si | S | Ar | Ca | Cr | Fe | Ni | 30-40 | 40-50 | 50-60 | >60 | H,He | Z≥6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 11.3 | 13.5 | | 2 | 2 | 2 | | | | | | | | | | | | | | | | | | | | | | 6 | 0 |
| 13.5 | 16.0 | Get | 2 | 2 | 2 | | | | | | | | | | | | | | | | | | | | | | 6 | 0 |
| 16.0 | 19.0 | from | 2 | 2 | 2 | | | | | | | | | | | | | | | | | | | | | | 6 | 0 |
| 19.0 | 22.6 | 10s | 2 | 2 | 2 | 2 | | | | | | | | | | | | | | | | | | | | | 6 | 2 |
| 22.6 | 26.9 | rates | 2 | 2 | 2 | 2 | 2 | 2 | | | | | | | | | | | | | | | | | | | 6 | 6 |
| 26.9 | 32.0 | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | | | | | | | | | | | | 6 | 18 |
| 32.0 | 38.1 | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | | | | | | | | | 6 | 24 |
| 38.1 | 45.3 | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | | | | | | 6 | 30 |
| 45.3 | 53.8 | | | | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 0 | 34 |
| 53.8 | 64.0 | | | | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | | | | 0 | 34 |
| 64.0 | 76.1 | | | | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | | | | 0 | 34 |
| 76.1 | 90.5 | | | | | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 0 | 32 |
| 90.5 | 108 | | | | | | | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | | | | 0 | 28 |
| 108 | 128 | | | | | | | | | | | | | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | | | | 0 | 16 |
| 128 | 152 | | | | | | | | | | | | | | | | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 0 | 10 |
| 152 | 181 | | | | | | | | | | | | | | | | | | | 2 | 2 | 2 | | | | | 0 | 6 |
| 181 | 215 | | | | | | | | | | | | | | | | | | | | | | | | | Rates | 36 | 274 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | Bits | 12 | 8 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | bps | 7.2 | 36.5 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | Sum | 43.7 | |

Range 3
H1A•H2A•H3A
H1B•H2B•H3B

| E1 | E2 | H, He | He3 | 3.5 | He4 | C | N | O | Ne | Ne20 | Ne21 | Ne22 | Na | Mg | Al | Si | S | Ar | Ca | Cr | Fe | Ni | 30-40 | 40-50 | 50-60 | >60 | Sum H,He | Sum Z≥6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 16.0 | 19.0 | | | 2 | 2 | | | | | | | | | | | | | | | | | | | | | | | |
| 19.0 | 22.6 | | 2 | 2 | 2 | | | | | | | | | | | | | | | | | | | | | | 6 | 0 |
| 22.6 | 26.9 | Get | 2 | 2 | 2 | | | | | | | | | | | | | | | | | | | | | | 6 | 0 |
| 26.9 | 32.0 | from | 2 | 2 | 2 | | | | | | | | | | | | | | | | | | | | | | 6 | 0 |
| 32.0 | 38.1 | 10s | 2 | 2 | 2 | 2 | 2 | 2 | | | | | | | | | | | | | | | | | | | 6 | 6 |
| 38.1 | 45.3 | rates | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | | | | | | | | | | | | | | 6 | 14 |
| 45.3 | 53.8 | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | | | | | | | | | | | 6 | 20 |
| 53.8 | 64.0 | | 2 | | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | | | | | | | | 2 | 26 |
| 64.0 | 76.1 | | | | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | | | | | 0 | 32 |
| 76.1 | 90.5 | | | | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 0 | 42 |
| 90.5 | 107.6 | | | | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | | | | 0 | 34 |
| 108 | 128 | | | | | | | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | | | | 0 | 28 |
| 128 | 152 | | | | | | | | | | | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 0 | 28 |
| 152 | 181 | | | | | | | | | | | | | | | | 2 | 2 | 2 | 2 | 2 | 2 | | | | | 0 | 12 |
| 181 | 215 | | | | | | | | | | | | | | | | | | 2 | 2 | 2 | 2 | | | | | 0 | 8 |
| 215 | 256 | | | | | | | | | | | | | | | | | | | | | | 2 | 2 | 2 | 2 | 0 | 8 |
| 256 | 304 | | | | | | | | | | | | | | | | | | | | | | | | | | 0 | 0 |
| 304 | 362 | | | | | | | | | | | | | | | | | | | | | | | | | Rates | 38 | 258 |
| 362 | 431 | | | | | | | | | | | | | | | | | | | | | | | | | Bits | 12 | 8 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | bps | 7.6 | 34.4 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | Sum | 42.0 | |

Range 4
H1A•H2A•H3A•H4A
H1B•H2B•H3B•H4B

# Matrices for Ions Stopping in Ranges 5, 6, and 7

| E1 | E2 | H,He | He3 | He3.5 | He4 | C | N | O | Ne | Ne20 | Ne21 | Ne22 | Na | Mg | Al | Si | S | Ar | Ca | Cr | Fe | Ni | 30-40 | 40-50 | 50-60 | >60 | H,He Sum | Z≥6 Sum |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 22.6 | 26.9 | | 2 | 2 | 2 | | | | | | | | | | | | | | | | | | | | | | 6 | 0 |
| 26.9 | 32.0 | Get | 2 | 2 | 2 | | | | | | | | | | | | | | | | | | | | | | 6 | 0 |
| 32.0 | 38.1 | from | 2 | 2 | 2 | | | | | | | | | | | | | | | | | | | | | | 6 | 0 |
| 38.1 | 45.3 | 10s | 2 | 2 | 2 | 2 | | | | | | | | | | | | | | | | | | | | | 6 | 2 |
| 45.3 | 53.8 | rates | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | | | | | | | | | | | | | | | | | 6 | 8 |
| 53.8 | 64.0 | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | | | | | | | | | | | | 6 | 18 |
| 64.0 | 76.1 | | 2 | | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | | | | | | | | | 2 | 24 |
| 76.1 | 90.5 | | | | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | | 2 | 2 | 2 | 2 | 0 | 38 |
| 90.5 | 107.6 | | | | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | | | | 0 | 34 |
| 108 | 128 | | | | | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | | | | 0 | 32 |
| 128 | 152 | | | | | | | | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 0 | 34 |
| 152 | 181 | | | | | | | | | | | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | | | | 0 | 20 |
| 181 | 215 | | | | | | | | | | | | | | | | 2 | 2 | 2 | 2 | 2 | 2 | | | | | 0 | 12 |
| 215 | 256 | | | | | | | | | | | | | | | | | | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 0 | 14 |
| 256 | 304 | | | | | | | | | | | | | | | | | | | | | | | | | Rates | 38 | 236 |
| 304 | 362 | | | | | | | | | | | | | | | | | | | | | | | | | Bits | 12 | 8 |
| 362 | 431 | | | | | | | | | | | | | | | | | | | | | | | | | bps | 7.6 | 31.5 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | Sum | 39.1 | |

Range 5
H1A•H2A•H3A•H4A•H5A
H1B•H2B•H3B•H4B•H5B

| E1 | E2 | H,He | He3 | He3.5 | He4 | C | N | O | Ne | Ne20 | Ne21 | Ne22 | Na | Mg | Al | Si | S | Ar | Ca | Cr | Fe | Ni | 30-40 | 40-50 | 50-60 | >60 | Sum H,He | Sum Z≥6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 26.9 | 32.0 | | | 2 | 2 | | | | | | | | | | | | | | | | | | | | | | 4 | 0 |
| 32.0 | 38.1 | Get | 2 | 2 | 2 | | | | | | | | | | | | | | | | | | | | | | 6 | 0 |
| 38.1 | 45.3 | from | 2 | 2 | 2 | | | | | | | | | | | | | | | | | | | | | | 6 | 0 |
| 45.3 | 53.8 | 10s | 2 | 2 | 2 | 2 | | | | | | | | | | | | | | | | | | | | | 6 | 2 |
| 53.8 | 64.0 | rates | 2 | 2 | 2 | 2 | 2 | 2 | | | | | | | | | | | | | | | | | | | 6 | 6 |
| 64.0 | 76.1 | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | | | | | | | | | | | | 6 | 18 |
| 76.1 | 90.5 | | 2 | | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | | | | | | | | | 2 | 24 |
| 90.5 | 108 | | | | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | | | | | | 0 | 30 |
| 108 | 128 | | | | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | | | | 0 | 34 |
| 128 | 152 | | | | | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 0 | 40 |
| 152 | 181 | | | | | | | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | | | | 0 | 28 |
| 181 | 215 | | | | | | | | | | | | | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | | | | 0 | 16 |
| 215 | 256 | | | | | | | | | | | | | | | | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 0 | 18 |
| 256 | 304 | | | | | | | | | | | | | | | | | | | | 2 | 2 | | | | Rates | 36 | 216 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | Bits | 12 | 8 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | bps | 7.2 | 28.8 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | Sum | 36.0 | |

Range 6
H1A•H2A•H3A•H4A•H5A•H5B
H1B•H2B•H3B•H4B•H5B•H5A

| E1 | E2 | H,He | He3 | 3.5 | He4 | C | N | O | Ne | Ne20 | Ne21 | Ne22 | Na | Mg | Al | Si | S | Ar | Ca | Cr | Fe | Ni | 30-40 | 40-50 | 50-60 | >60 | H,He Sum | Z≥6 Sum |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 26.9 | 32.0 | | | 2 | 2 | | | | | | | | | | | | | | | | | | | | | | | |
| 32.0 | 38.1 | | 2 | 2 | 2 | | | | | | | | | | | | | | | | | | | | | | 6 | 0 |
| 38.1 | 45.3 | Get | 2 | 2 | 2 | | | | | | | | | | | | | | | | | | | | | | 6 | 0 |
| 45.3 | 53.8 | from | 2 | 2 | 2 | | | | | | | | | | | | | | | | | | | | | | 6 | 0 |
| 53.8 | 64.0 | 10s | 2 | 2 | 2 | 2 | 2 | | | | | | | | | | | | | | | | | | | | 6 | 4 |
| 64.0 | 76.1 | rates | 2 | 2 | 2 | 2 | 2 | 2 | | | 2 | 2 | | | | | | | | | | | | | | | 6 | 10 |
| 76.1 | 90.5 | | 2 | | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | | | | | | | | | | | 2 | 20 |
| 90.5 | 108 | | | | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | | | | | | | | | 0 | 24 |
| 108 | 128 | | | | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | | | | | 0 | 32 |
| 128 | 152 | | | | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 0 | 42 |
| 152 | 181 | | | | | | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | | | | 0 | 30 |
| 181 | 215 | | | | | | | | | | | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | | | | 0 | 20 |
| 215 | 256 | | | | | | | | | | | | | | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 0 | 22 |
| 256 | 304 | | | | | | | | | | | | | | | | | | 2 | 2 | 2 | 2 | | | | | 0 | 8 |
| | | | | | | | | | | | | | | | | | | | | | | 2 | | | | | 0 | 2 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | Rates | 32 | 214 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | Bits | 12 | 8 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | bps | 6.4 | 28.5 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | Sum | 34.9 | |

Range7
H1A•H2A•H3A•H4A•H5A•H5B•H4B
H1B•H2B•H3B•H4B•H5B•H5A•H4A

# Matrices for Ions Stopping in Range 8

Range 8 is the last "stopping" Range. "Penetrating" ions (that trigger H1 and H2 at one end, as well as H2 at the opposite end), are tabulated separately.

| E1 | E2 | H, He | He3 | He3.5 | He4 | C | N | O | Ne | Ne20 | Ne21 | Ne22 | Na | Mg | Al | Si | S | Ar | Ca | Cr | Fe | Ni | 30-40 | 40-50 | 50-60 | >60 | H,He Sum | Z≥6 Sum |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 32.0 | 38.1 | | | 2 | 2 | | | | | | | | | | | | | | | | | | | | | | 4 | 0 |
| 38.1 | 45.3 | | 2 | 2 | 2 | | | | | | | | | | | | | | | | | | | | | | 6 | 0 |
| 45.3 | 53.8 | Get | 2 | 2 | 2 | | | | | | | | | | | | | | | | | | | | | | 6 | 0 |
| 53.8 | 64.0 | from | 2 | 2 | 2 | | | | | | | | | | | | | | | | | | | | | | 6 | 0 |
| 64.0 | 76.1 | 10s | 2 | 2 | 2 | 2 | 2 | 2 | | | | | | | | | | | | | | | | | | | 6 | 6 |
| 76.1 | 90.5 | rates | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | | | | | | | | | | | | | | 6 | 14 |
| 90.5 | 108 | | 2 | | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | | | | | | | | | | 2 | 22 |
| 108 | 128 | | | | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | | | | | | | 0 | 28 |
| 128 | 152 | | | | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 0 | 42 |
| 152 | 181 | | | | | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | | | | 0 | 32 |
| 181 | 215 | | | | | | | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | | | | 0 | 28 |
| 215 | 256 | | | | | | | | | | | | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 0 | 26 |
| 256 | 304 | | | | | | | | | | | | | | | | | 2 | 2 | 2 | 2 | 2 | | | | | 0 | 10 |
| 304 | 362 | | | | | | | | | | | | | | | | | | | 2 | 2 | 2 | | | | | 0 | 6 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | Rates | 36 | 214 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | Bits | 12 | 8 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | bps | 7.2 | 28.5 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | Sum | 35.7 | |

Range 8
H1A•H2A•H3A•H4A•H5A•H5B•H4B•H3B
H1B•H2B•H3B•H4B•H5B•H5A•H4A•H3A

In Table 2 we tabulate the bits per second required for the 3He and 4He analysis and for heavy ions with Z≥6. . The charge range over which we can identify Z≥30 elements will not be known until we decide on the PHASIC gain settings, which will depend on threshold and noise measurements in the flight electronics as well as other considerations. If we were to add 1 broad extra "background" bin at lower and higher energies for each of the four Z≥30 bins it would take an additional (2*4*8 bits/60s) x 7 ranges = 7.5 bps. This brings the total bit rate to 292.7 bps.

## Summary of 1-Minute 3He/4He and Z≥6 Rates

| Range | 3He/4He Rates | bps | Z≥6 Rates | bps | Sum bps |
|---|---|---|---|---|---|
| 2 | 54 | 10.8 | 322 | 43.0 | 53.8 |
| 3 | 36 | 7.2 | 274 | 36.5 | 43.7 |
| 4 | 38 | 7.6 | 258 | 34.4 | 42.0 |
| 5 | 38 | 7.6 | 236 | 31.5 | 39.1 |
| 6 | 36 | 7.2 | 216 | 28.8 | 36.0 |
| 7 | 32 | 6.4 | 214 | 28.5 | 34.9 |
| 8 | 36 | 7.2 | 214 | 28.5 | 35.7 |
| Sum | 270 | 54.0 | 1734 | 231.2 | 285.2 |

## 4. Penetrating Ion Rates

Penetrating ions are defined as particles that pass completely through the entire telescope. Examples of A-Side event signatures include:

H1A•H2A•H3A•H4A•H5A•H5B•H4B•H3B•H2Bc, and
H1A•H2A•H3A•H4A•H5A•H5B•H4B•H3B•H2B(n+s+e+w)

Wiedenbeck (2014) is developing a new technique to identify the nuclear charge and kinetic energy of penetrating ions. With this approach it may be possible to extend the energy range of the HET telescope by a factor of up to ~3 over that for stopping ions. Assuming this is successful, the Table below shows the energy range that could be covered for penetrating particles. Note that we are focusing on the abundant elements, that will have the best statistical accuracy and lowest background from adjacent species. Measurements of penetrating ions are needed to meet the goal of extending SEP H and He spectra to 100 MeV/nuc. The "4" in the Table indicates that there are two directions, with two coincidence signatures for each.

**HET Penetrating Ions**

| E1 | E2 | H | He | C | N | O | Ne | Mg | Si | Fe | | H, He | Z≥6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Time (sec) | | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | | | |
| 32.0 | 38.1 | | | | | | | | | | | 0 | 0 |
| 38.1 | 45.3 | | | | | Range PEN | | | | | | 0 | 0 |
| 45.3 | 53.8 | | | | | H1A•H2A•H3A•H4A•H5A•H5B•H4B•H3B•H2B | | | | | | 0 | 0 |
| 53.8 | 64.0 | 4 | 4 | | | H1B•H2B•H3B•H4B•H5B•H5A•H4A•H3A•H2A | | | | | | 8 | 0 |
| 64.0 | 76.1 | 4 | 4 | | | | | | | | | 8 | 0 |
| 76.1 | 90.5 | 4 | 4 | | | | | | | | | 8 | 0 |
| 90.5 | 108 | 4 | 4 | 4 | 4 | | | | | | | 8 | 8 |
| 108 | 128 | 4 | 4 | 4 | 4 | 4 | | | | | | 8 | 12 |
| 128 | 152 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | | | | 8 | 20 |
| 152 | 181 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | | | 8 | 24 |
| 181 | 215 | | | 4 | 4 | 4 | 4 | 4 | 4 | | | 0 | 24 |
| 215 | 256 | | | 4 | 4 | 4 | 4 | 4 | 4 | 4 | | 0 | 28 |
| 256 | 304 | | | 4 | 4 | 4 | 4 | 4 | 4 | 4 | | 0 | 28 |
| 304 | 362 | | | | | 4 | 4 | 4 | 4 | 4 | | 0 | 20 |
| 362 | 431 | | | | | | | 4 | 4 | 4 | | 0 | 12 |
| 431 | 512 | | | | | | | | 4 | 4 | | 0 | 8 |
| 512 | 609 | | | | | | | | | 4 | | 0 | 4 |
| 609 | 724 | | | | | | | | | 4 | | 0 | 4 |
| | | | | | | | | | | | Rates | 56 | 192 |
| | | | | | | | | | | | Bits | 12 | 8 |
| | | | | | | | | | | | bps | 11.2 | 25.6 |
| | | | | | | | | | | | Sum | 36.8 | |

## 5. HET 10-Second Rates

**5.1 HET 10-Second Electron Rates:** The 10-second rates are useful to timing studies of SEP events and of interplanetary structures such as shocks. On the ground these data will also be used to construct longer term averages such as 1-hour and 1-day averages. In the Table below Range 2 corresponds to H1A•H2A and H1B•H2B events and so forth down through H1A•H2A•H3A•H4A•H5A•H5B•H4B•H3B events. Electrons will be separated from ions by their location in the lower-left hand corner of a plot of the next-to-last versus the last triggered detector, with maximum energy losses of TBD MeV in any individual detector (depending on thickness). The minimum energy losses in the Table below are based on calibration data for the IMP-7 Electron/Isotope Spectrometer on IMP-7 (see Mewaldt 1975). The maximum energy losses for a given detector combination will be determined by GEANT4 simulations.

| HET 10-sec Rates | | Electrons | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Time Resolution (sec) | | 10 | 10 | 10 | 10 | 10 | 10 | 10 | |
| | | Range | | | | | | | |
| E1 | E2 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Sum |
| 0.354 | 0.42 | | | | | | | | 0 |
| 0.420 | 0.50 | | | | | | | | 0 |
| 0.500 | 0.59 | 2 | | | | | | | 2 |
| 0.595 | 0.71 | 2 | | | | | | | 2 |
| 0.707 | 0.84 | 2 | 2 | | | | | | 4 |
| 0.841 | 1.00 | 2 | 2 | | | | | | 4 |
| 1.000 | 1.19 | 2 | 2 | 2 | | | | | 6 |
| 1.189 | 1.41 | 2 | 2 | 2 | | | | | 6 |
| 1.414 | 1.68 | 2 | 2 | 2 | 2 | | | | 8 |
| 1.682 | 2.00 | 2 | 2 | 2 | 2 | 2 | | | 10 |
| 2.000 | 2.38 | 2 | 2 | 2 | 2 | 2 | 2 | | 12 |
| 2.378 | 2.83 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 14 |
| 2.828 | 3.36 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 14 |
| 3.364 | 4.00 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 14 |
| 4.000 | 4.76 | | 2 | 2 | 2 | 2 | 2 | 2 | 12 |
| 4.757 | 5.66 | | | 2 | 2 | 2 | 2 | 2 | 10 |
| 5.657 | 6.73 | | | | 2 | 2 | 2 | 2 | 8 |
| 6.727 | 8.00 | | | | | | | | |
| | | | | | | | | Rates | 126 |
| | | | | | | | | Bits | 12 |
| | | | | | | | | bps | 151.2 |

## 5.2 HET 10-Second Ion Rates

The H and He intensities are accumulated as 10-sec rates. All He ions are assumed to be mass 4. The boxed intervals are where 4He is expected and also allow for the lowest energy 3He that can trigger, which then is binned at ¾ of its actual energy/nuc. To minimize bit-rate we propose here to transmit the bins that good He events will occupy every 10s, but send down adjoining "background" bins only once per minute. If this proves too much trouble to implement, we can transmit all bins every 10s or possibly reduce the number of bits allocated to the background bits from 12 to 8.

To obtain the energy spectra from these it is necessary to sum the contributions to each energy interval weighted by the appropriate geometry factors. Thus, the 19.0 to 22.6 MeV intensity would be a weighted sum over Range 2, 3 and 4 (see below).

**HET 10-Second H and He Rates**

| | | | | | | | | | | 60 Transmit Each Minute | 10 Transmit Each 10 sec |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Last Detectors | | H2A,B | H3A,B | H4A,B | H5A,B | H5B,A | H4B,A | H3B,A | | | |
| Cadence (sec) | | 10 | 10 | 10 | 10 | 10 | 10 | 10 | | | |
| E1 | E2 | Rnge 2 | Rnge 3 | Rnge 4 | Rnge 5 | Rnge 6 | Rnge 7 | Rnge 8 | | | |
| 4.00 | 4.76 | | | | | | | | | 0 | |
| 4.76 | 5.66 | | | | | | | | | 0 | |
| 5.66 | 6.73 | 4 | | | | | | | | 4 | |
| 6.73 | 8.00 | 4 | | | | | | | | 4 | |
| 8.00 | 9.51 | 4 | | | | | | | | 0 | 4 |
| 9.51 | 11.3 | 4 | 4 | | | | | | | 4 | 4 |
| 11.3 | 13.5 | 4 | 4 | | | | | | | 4 | 4 |
| 13.5 | 16.0 | 4 | 4 | 4 | | | | | | 4 | 8 |
| 16.0 | 19.0 | 4 | 4 | 4 | | | | | | 4 | 8 |
| 19.0 | 22.6 | 4 | 4 | 4 | 4 | | | | | 4 | 12 |
| 22.6 | 26.9 | 4 | 4 | 4 | 4 | 4 | | | | 12 | 8 |
| 26.9 | 32.0 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | | 16 | 12 |
| 32.0 | 38.1 | | 4 | 4 | 4 | 4 | 4 | 4 | | 12 | 12 |
| 38.1 | 45.3 | | 4 | 4 | 4 | 4 | 4 | 4 | | 8 | 16 |
| 45.3 | 53.8 | | | 4 | 4 | 4 | 4 | 4 | | 8 | 12 |
| 53.8 | 64.0 | | | | 4 | 4 | 4 | 4 | | 12 | 4 |
| 64.0 | 76.1 | | | | | 4 | 4 | 4 | | 12 | |
| 76.1 | 90.5 | | | | | | | 4 | | 4 | |
| | | | | | | | | | Rates | 112 | 104 |
| | | | | | | | | | Bits | 12 | 12 |
| | | | | | | | | | bps | 22.4 | 124.8 |
| | | | | | | | | | Total | 147.2 | |

Boxed: Expect to be populated
Unbox: Background bins

## 6. HET 1-second Rates:

In response to a Requirement from the SPP STDT Report (McComas et al. 2005) both HET and LET will provide 1-second intensities for both protons and electrons, as summarized in the Table below. Both LET and HET data are provided in this Table to show that for electrons LET and HET compliment each other by measuring the same energy intervals, thereby enabling measurements from five points of view. For protons it is only possible to achieve LET/HET overlap over a limited energy range because it is expected that LET proton measurements will extend only to ~16 MeV (depending on noise measurements and threshold settings in the LET L1 detectors). We suggest 8-bit compressed rates be used to minimize the required bps.

| 1-Sec Electron Rates | | | | 1-Sec Proton Rates | | | |
|---|---|---|---|---|---|---|---|
| | | Electron Intensity per (cm2-sr-s-MeV) | | | | Proton Intensity per (cm2sr-s-MeV) | |
| E1 | E2 | LET | HET | E1 | E2 | LET | HET |
| 0.354 | 0.42 | | | 1.000 | 1.19 | | |
| 0.420 | 0.50 | | | 1.189 | 1.41 | 3 | |
| 0.500 | 0.59 | | | 1.414 | 1.68 | | |
| 0.595 | 0.71 | | | 1.682 | 2.00 | | |
| 0.707 | 0.84 | 3 | 2 | 2.000 | 2.38 | | |
| 0.841 | 1.00 | | | 2.378 | 2.83 | | |
| 1.000 | 1.19 | | | 2.828 | 3.36 | 3 | |
| 1.189 | 1.41 | 3 | 2 | 3.364 | 4.00 | | |
| 1.414 | 1.68 | | | 4.000 | 4.76 | | |
| 1.682 | 2.00 | | | 4.757 | 5.66 | | |
| 2.000 | 2.38 | | | 5.657 | 6.73 | | |
| 2.378 | 2.83 | | 2 | 6.727 | 8.00 | | |
| 2.828 | 3.36 | | | 8.000 | 9.51 | 3 | |
| 3.364 | 4.00 | | | 9.514 | 11.31 | | |
| 4.000 | 4.76 | | | 11.314 | 13.45 | | 2 |
| 4.757 | 5.66 | | | 13.454 | 16.00 | | |
| 5.657 | 6.73 | | | 16.000 | 19.03 | | |
| 6.727 | 8.00 | | | 19.027 | 22.63 | | |
| | | | | 22.627 | 26.91 | | 2 |
| | | | | 26.909 | 32.00 | | |
| | | LET | HET | | | LET | HET |
| | Number | 6 | 6 | | Number | 9 | 4 |
| | Bits | 8 | 8 | | Bits | 8 | 8 |
| | bps | 48 | 48 | | bps | 72 | 32 |

## 7. HET Pixel Rates

Both LET and HET have small (~1 $mm^2$) pixels (see Figures 2 and 4) that are located in the Guard regions of the detectors. If count rates get too high (e.g., trigger rates >$10^5$/sec) during a large SEP event, it should still be possible to measure heavy ions (Z ≥ 6) by raising thresholds, but it may not be possible to continue measuring H, He and electrons. The purpose of the "pixel" rates is to provide a means of monitoring the count rate of H +He at various depths in the stack under extreme conditions. Note that the pixel count rates can be calibrated against the standard H and He rates and energy spectra during smaller events and as the intensities build up to >$10^5$/s and then later as they retreat again.

The minimum threshold for reaching pixels located in H2A and the bottom layers of H3A, H4A, and H5A are ~11, ~23, ~32, and ~40 MeV/nuc for H and $^4$He. The thresholds will be set sufficiently high to prevent triggering by electrons.

The pixel count rates will be counted by scalers that are not affected by deadtime in the coincidence logic. There are a maximum of eight pixels that can be implemented, requiring a maximum of eight 16-bit rates.

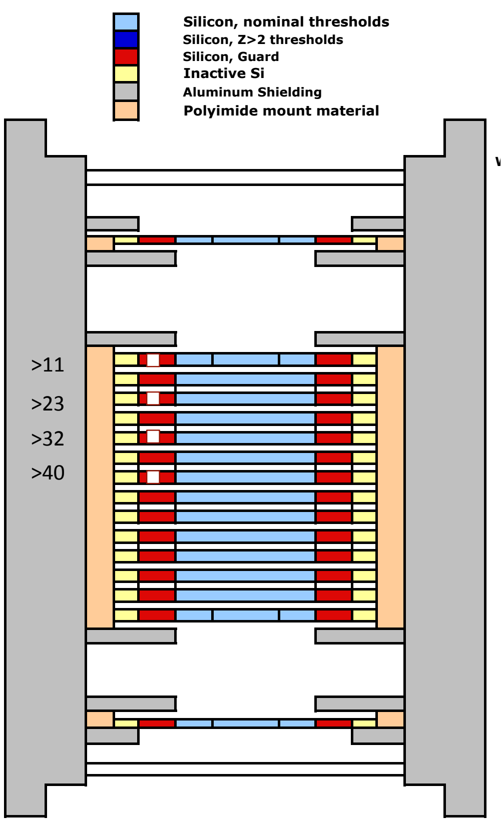


Figure 4: Drawing of the HET stack showing placement of 4 pixel detectors in L2A, L3A, L4A, and L5A. The approximate proton energy thresholds are noted at the side in MeV. The readout rate is TBD – we assume every 10 seconds.

**8. HET Anisotropy Studies:** The five segments of the H2 detectors are rotated by 45° with respect to those in the H1 detectors. This provides 25 separate view directions, as shown in the LET version of this document. The matrix below shows the species for which we will accumulate the distribution of arrival directions with 5-minute resolution. In order to improve the statistical accuracy, we have broadened the energy intervals, and also combined species with similar A/Z ratios (e.g., Leske et al. 1995). Note that the SPP thermal protection system (TPS) is within the HET field of view (FoV) over ~TBD% of its FoV. The count rates of sectors that view the TPS must be corrected for this. The chosen energy intervals are accessible with HET out to 45° incidence angle, but the geometry factor of a given sector will vary with penetration depth. Thus HET is not as well suited for anisotropy studies as is LET. We should consider treating more individual species (e.g., C, O, Ne, Mg, Si, and Fe) rather than element groups. We can also consider introducing He and heavy ion intervals in LET that match those in HET (not possible for protons). The selected intervals are all accessible over all angles from 0° to 45°.

**Angular Distributions in all 25 Detector combinations - each end**

| E1 | E2 | Elec | H | He | C | N | O | Ne | Na | Mg | Al | Si | S | Ar | Ca | Cr | Fe | Ni | | H,He | Z≥6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sectors | | 25 | 25 | 25 | | 25 | | | | 25 | | | 25 | | | | | | | | |
| Time Res | | 300 | 300 | 300 | | 300 | | | | 300 | | | 300 | | | | | | | | |
| 0.354 | 0.50 | | | | | | | | | | | | | | | | | | | | |
| 0.500 | 0.71 | | | | | | | | | | | | | | | | | | | 0 | 0 |
| 0.707 | 1.00 | | | | | | | | | | | | | | | | | | | 0 | 0 |
| 1 | 1.41 | 2 | | | | | | | | | | | | | | | | | | 2 | 0 |
| 1.41 | 2.00 | | | | | | | | | | | | | | | | | | | 0 | 0 |
| 2.00 | 2.83 | 2 | | | | | | | | | | | | | | | | | | 2 | 0 |
| 2.83 | 4.00 | | | | | | | | | | | | | | | | | | | 0 | 0 |
| 4.00 | 5.66 | | | | | | | | | | | | | | | | | | | 0 | 0 |
| 5.66 | 8.00 | | | | | | | | | | | | | | | | | | | 0 | 0 |
| 8.00 | 9.51 | | | | | | | | | | | | | | | | | | | 0 | 0 |
| 9.51 | 11.3 | | | | | | | | | | | | | | | | | | | 0 | 0 |
| 11.3 | 13.5 | | | | | | | | | | | | | | | | | | | 0 | 0 |
| 13.5 | 16.0 | | 2 | 2 | | | | | | | | | | | | | | | | 4 | 0 |
| 16.0 | 19.0 | | | | | | | | | | | | | | | | | | | 0 | 0 |
| 19.0 | 22.6 | | | | | | | | | | | | | | | | | | | 0 | 0 |
| 22.6 | 26.9 | | 2 | 2 | | | | | | | | | | | | | | | | 4 | 0 |
| 26.9 | 32.0 | | | | | 2 | | | | | | | | | | | | | | 0 | 2 |
| 32.0 | 38.1 | | | | | | | | | | | | | | | | | | | 0 | 0 |
| 38.1 | 45.3 | | | | | | | | | 2 | | | | | | | | | | 0 | 2 |
| 45.3 | 53.8 | | | | | 2 | | | | | | | | | | | | | | 0 | 2 |
| 53.8 | 64.0 | | | | | | | | | | | | | | | | 2 | | | 0 | 2 |
| 64.0 | 76.1 | | | | | | | | | | | | | | | | | | | 0 | 0 |
| 76.1 | 90.5 | | | | | | | | | | | | | | | | | | | 0 | 0 |
| 90.5 | 108 | | | | | | | | | | | | | | | | | | | 0 | 0 |
| | | | | | | | | | | | | | | | | | | | Rates | 12 | 8 |
| | | | | | | | | | | | | | | | | | | | Bits | 12 | 8 |
| | | | | | | | | | | | | | | | | | | | bps | 12.0 | 5.3 |
| | | | | | | | | | | | | | | | | | | | Sum | 17.3 | |

## 9. The HET Neutral Mode

The HET telescope includes an almost completely shielded volume that can be used to detect the interaction products of solar γ-rays and neutrons. Note that the centers of H3A through H3B comprise a volume of 1.2 $cm^3$ of active silicon that is surrounded by their Guard regions and by H2A and H2B (see Figure 1). Gamma-rays with ~0.5 to 8 MeV can be detected via Compton scattering or the photo-electric effect with efficiencies ranging from ~4% to 10%. Neutrons with ~2 to ~20 MeV can be detected when they undergo nuclear reactions with the Si detector including $^{28}Si(n,p)^{28}Al$, $^{28}Si(n,\alpha)^{25}Mg$, and $^{29}Si(n,\alpha)^{26}Mg$, with efficiencies of ~2% to 4%. The γ-ray intensity will increase as $1/r^2$ as SPP nears the Sun. The neutron intensity falls off much faster because most neutrons decay well before they approach 1 AU (mean life ≈ 886s)

The Caltech EIS instrument on IMP-7 and IMP-8 had a similar volume of 1.25 $cm^3$ that detected energy spectra of γ-ray and neutron interactions. Figure 5 shows solar quiet-time energy spectra of neutral mode events extending from ~0.16 to 100 MeV. The lower-energy peaks are due to γ-rays and the higher peaks are due to neutron interactions. This background of neutral particles is due mainly to cosmic-ray interactions with spacecraft material (see Mewaldt et al. 1977). HET will have a similar background. Solar γ-rays and neutrons will cause an increase above this steady background.

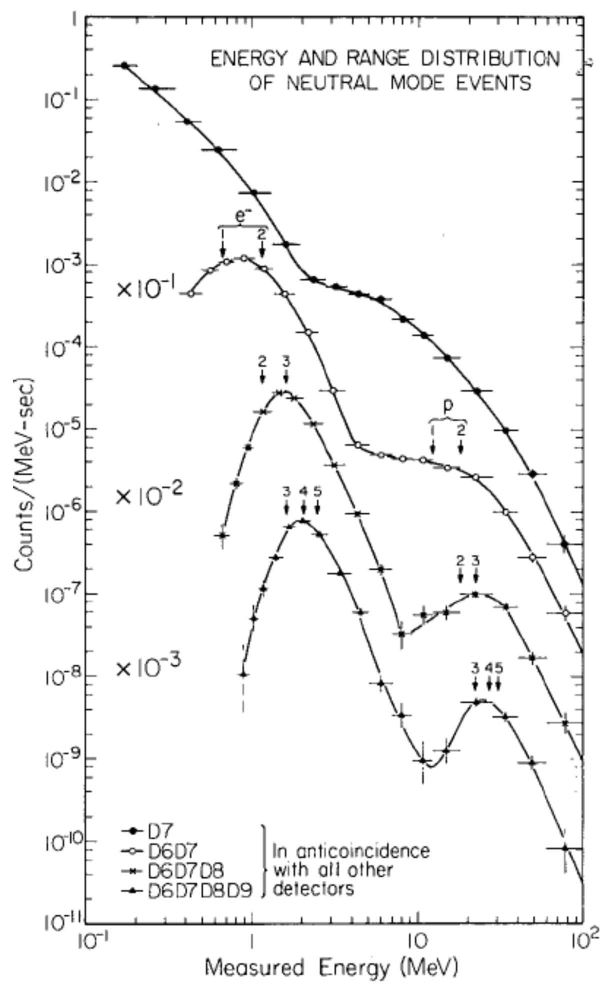


Figure 5

## 9.1 HET Neutral Mode-1:

Neutral Mode-1 allows the background rate and energy spectrum of neutral interaction products to be accurately measured for each detector and detector combination. The background will vary with time, and threshold and position in the stack. It is against this background that we look for increases (either at the times of known flares and/or CMEs, when 2 or 3-sigma increases can be meaningful), or against the quiet-time background (when 5-sigma increases may be necessary). The background (due mainly to neutral products of cosmic ray interactions with spacecraft material) will also vary over the solar cycle, and, according to Messenger, with heliographic radius. Once we know the thresholds of each detector, we can better define the minimum energy to trigger detector combinations, and eliminate some low-energy channels in the table below.

| | | Neutral Mode1 | | | | Individual Detector Combinations | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Time Res (s) | | | | | | | | | | | | | | | | | | | | | |
| | | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | |
| E1 | E2 | H3A | H4A | H5A | H5B | H4B | H3B | H3A<br>H4A | H4A<br>H5A | H5A<br>H5B | H5B<br>H4B | H4B<br>H3B | H3A<br>H4A<br>H5A | H4A<br>H5A<br>H5B | H5A<br>H5B<br>H4B | H5B<br>H4B<br>H3B | H3A<br>H4A<br>H5A<br>H5B | H4A<br>H5A<br>H5B<br>H4B | H5A<br>H5B<br>H4B<br>H3B | H3A<br>H4A<br>H5A<br>H5B<br>H4B | H4A<br>H5A<br>H5B<br>H4B<br>H3B | H3A<br>H4A<br>H5A<br>H5B<br>H4B<br>H3B | Sum |
| 0.250 | 0.30 | | | | | | | | | | | | | | | | | | | | | | |
| 0.297 | 0.35 | 1 | 1 | 1 | 1 | 1 | 1 | | | | | | | | | | | | | | | | 6 |
| 0.354 | 0.42 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | | | | | | | | | 11 |
| 0.420 | 0.50 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | | | | | 15 |
| 0.500 | 0.59 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | | 18 |
| 0.595 | 0.71 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | 20 |
| 0.707 | 0.84 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 21 |
| 0.841 | 1.00 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 21 |
| 1.00 | 1.19 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 21 |
| 1.19 | 1.41 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 21 |
| 1.41 | 1.68 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 21 |
| 1.68 | 2.00 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 21 |
| 2.00 | 2.38 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 21 |
| 2.38 | 2.83 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 21 |
| 2.83 | 3.36 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 21 |
| 3.36 | 4.00 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 21 |
| 4.00 | 4.76 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 21 |
| 4.76 | 5.66 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 21 |
| 5.66 | 6.73 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 21 |
| 6.73 | 8.00 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 21 |
| 8.00 | 9.51 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 21 |
| 9.51 | 11.3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 21 |
| 11.3 | 13.5 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 21 |
| 13.5 | 16.0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 21 |
| 16.0 | 19.0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 21 |
| 19.0 | 22.6 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 21 |
| 22.6 | 26.9 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 21 |
| 26.9 | 32.0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 21 |
| 32.0 | 38.1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 21 |
| 38.1 | 45.3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 21 |
| 45.3 | 53.8 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 21 |
| 53.8 | 64.0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 21 |
| 64.0 | 76.1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 21 |
| 76.1 | 90.5 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 21 |
| 90.5 | 108 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 21 |
| 108 | 128 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 21 |
| | | | | | | | | | | | | | | | | Neutral Mode Sum | | | | | | Rates | 700 |
| | | | | | | | | | | | | | | | | | | | | | | bits | 8 |
| | | | | | | | | | | | | | | | | | | | | | | bps | 93.3 |

**9.2 HET Neutral Mode 2:** In this mode, like detector combinations are summed and the time resolution is increased. This mode will be the most useful to search quickly for possible γ-ray or neutron increases. It also offers better timing resolution. Earlier studies show that solar neutron arrival times provide a good measurement of their energy (if the flare time profile is measured by GOES or other spacecraft).

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | **Neutral Mode 2** | | | | **Summed Combinations with 10s Time Resolution** | | |
| | | **Time Res (s)** | | | | | | |
| | | **10** | **10** | **10** | **10** | **10** | **10** | |
| | | **1** | **1** | **1** | **1** | **1** | **1** | |
| | | **Sum** | | | | | | |
| | | **H3** | **H34** | **345** | **3456** | **H3-H7** | **H3-H8** | |
| | | **H4** | **H45** | **456** | **4567** | **H4-H8** | | |
| | | **H5** | **H56** | **567** | **5678** | | | |
| | | **H6** | **H67** | **678** | | | | |
| | | **H7** | **H78** | | | | | |
| | | **H8** | | | | | | |
| **0.250** | **0.30** | | | | | | | **Sum** |
| **0.297** | **0.35** | **1** | | | | | | **1** |
| **0.354** | **0.42** | **1** | **1** | | | | | **2** |
| **0.420** | **0.50** | **1** | **1** | **1** | | | | **3** |
| **0.500** | **0.59** | **1** | **1** | **1** | **1** | | | **4** |
| **0.595** | **0.71** | **1** | **1** | **1** | **1** | **1** | | **5** |
| **0.707** | **0.84** | **1** | **1** | **1** | **1** | **1** | **1** | **6** |
| **0.841** | **1.00** | **1** | **1** | **1** | **1** | **1** | **1** | **6** |
| **1.000** | **1.19** | **1** | **1** | **1** | **1** | **1** | **1** | **6** |
| **1.189** | **1.41** | **1** | **1** | **1** | **1** | **1** | **1** | **6** |
| **1.414** | **1.68** | **1** | **1** | **1** | **1** | **1** | **1** | **6** |
| **1.682** | **2.00** | **1** | **1** | **1** | **1** | **1** | **1** | **6** |
| **2.000** | **2.38** | **1** | **1** | **1** | **1** | **1** | **1** | **6** |
| **2.378** | **2.83** | **1** | **1** | **1** | **1** | **1** | **1** | **6** |
| **2.828** | **3.36** | **1** | **1** | **1** | **1** | **1** | **1** | **6** |
| **3.364** | **4.00** | **1** | **1** | **1** | **1** | **1** | **1** | **6** |
| **4.000** | **4.76** | **1** | **1** | **1** | **1** | **1** | **1** | **6** |
| **4.757** | **5.66** | **1** | **1** | **1** | **1** | **1** | **1** | **6** |
| **5.657** | **6.73** | **1** | **1** | **1** | **1** | **1** | **1** | **6** |
| **6.727** | **8.00** | **1** | **1** | **1** | **1** | **1** | **1** | **6** |
| **8.000** | **9.51** | **1** | **1** | **1** | **1** | **1** | **1** | **6** |
| **9.514** | **11.3** | **1** | **1** | **1** | **1** | **1** | **1** | **6** |
| **11.3** | **13.5** | **1** | **1** | **1** | **1** | **1** | **1** | **6** |
| **13.5** | **16.0** | **1** | **1** | **1** | **1** | **1** | **1** | **6** |
| **16.0** | **19.0** | **1** | **1** | **1** | **1** | **1** | **1** | **6** |
| **19.0** | **22.6** | **1** | **1** | **1** | **1** | **1** | **1** | **6** |
| **22.6** | **26.9** | **1** | **1** | **1** | **1** | **1** | **1** | **6** |
| **26.9** | **32.0** | **1** | **1** | **1** | **1** | **1** | **1** | **6** |
| **32.0** | **38.1** | **1** | **1** | **1** | **1** | **1** | **1** | **6** |
| **38.1** | **45.3** | **1** | **1** | **1** | **1** | **1** | **1** | **6** |
| **45.3** | **53.8** | **1** | **1** | **1** | **1** | **1** | **1** | **6** |
| **53.8** | **64.0** | **1** | **1** | **1** | **1** | **1** | **1** | **6** |
| **64.0** | **76.1** | **1** | **1** | **1** | **1** | **1** | **1** | **6** |
| **76.1** | **90.5** | **1** | **1** | **1** | **1** | **1** | **1** | **6** |
| **90.5** | **108** | **1** | **1** | **1** | **1** | **1** | **1** | **6** |
| **108** | **128** | **1** | **1** | **1** | **1** | **1** | **1** | **6** |
| | | | | | | **Neutral Mode 2** | | |

| | |
|---|---|
| **Rates** | **195** |
| **bits** | **8** |
| **bps** | **156** |

## 10. Rate Data and Bit Rates for ≥0.25 AU:

These files are not yet defined, but the main philosophy will be to produce the same data products but with less time resolution (e.g., mostly 1-hr rates) with limited 1-minute data for SEP timing. We will also include key housekeeping data.

## 11. Quick-Look Data:

Ideally, these data would be the same content as as the ≥0.25 AU files. Then we would have a complete summary of the entire orbit available with uniform time bases that could be telemetered first and provide a summary of any SEP, CIR, or shock events, and temperature, noise, or background count-rate changes.

## 12. Summary of HET Bit Rate Estimates

The Table below summarizes the bit rates estimated in Sections 2 through 9. It also includes some quiet time count rates based on IMP-7&8 and it includes some description of what fraction of the rates will be non-zero.

Because the SPP/HET geometry factors are similar to those in STEREO/HET (and ~30 times lower than in ACE/SIS), we know that count rates due to galactic cosmic rays will be low (~1 per minute). Therefore, we should gain a lot from data compression during solar quiet times.

**HET Bit Rate Summary (≤0.25 AU)**

| Item | Time Res (sec) | bps | Comments |
|---|---|---|---|
| 1-Min Stopping Ions | 60 | 293 | Most rates typically = 0 |
| 1-Min Penetrating Ions | 60 | 37 | Most rates typically = 0 |
| 10-sec Electrons | 10 | 151 | Rate ~0.2/sec |
| 10-sec Ions | 10 | 160 | Rate typically <0.1/sec |
| 1-sec Electrons | 1 | 48 | Rate ~0.2/sec |
| 1-sec Protons | 1 | 32 | Rate typically <0.1/sec |
| HET Pixel Rates | 10 ? | 13 | Typically <.0001/sec ? |
| Sectored Ions & Electrons | 300 | 17 | Typically <5% of non-zero rates |
| Neutrals-1 | 60 | 93 | Typically ~10% of these non-zero |
| Neutral-2 | 10 | 156 | Typically ~5% are non-zero |
| Events | - | 300 | <1/sec electrons, H, He, Z≥6, and neutrals |
| History | ~hr | ~ 20 ? | More dense than above |
| Housekeeping | ~10 min? | 100 | Cadence and bit rate TBD |
| | Sum | 1420 | Typically <1000 bps? |

## 13. References


R. A. Leske, et al., "Measurements of the Ionic Charge States of Solar Energetic Particles using the Geomagnetic Field", Ap.J. Letters 452, L149, (1995).

D. J. McComas et al., "Solar Probe: Report of the Science and Technology Definition Team", NASA/TM-2005-212786, Goddard Space Flight Center (2005)

D. J. McComas, et al., "Integrated Science Investigation of the Sun (ISIS): Design of the Energetic Particle Investigation", submitted to Space Science Reviews, 2014.

R. A. Mewaldt, "Calibrations of the Electron Response of the IMP-H EIS", Caltech Space Radiation Laboratory Internal Report #53 (March, 1975).

R. A. Mewaldt, E. C. Stone, and R. E. Vogt, "Neutral Particle Background in Cosmic Ray Telescopes Composed of Silicon Solid State Detectors", Space Science Instrumentation, 3, 231 (1977).

R. A. Mewaldt et al., "The Low-Energy Telescope (LET) and SEP Central Electronics for the STEREO Mission", Space Science Reviews, 136, doi:10.1007s11214-007-9288-x, (2007).

T. T. von Rosenvinge et al., "The High Energy Telescopes for STEREO", Space Science Reviews, 136, doi:10.1007s11214-007-9300-5, (2008).

M. E. Wiedenbeck, "A Possible New Approach to ACE/CRIS Penetrating Particle Analysis", Version 4 (preliminary), May 13, 2014.