SPP/HET Dynamic Threshold Recommendations

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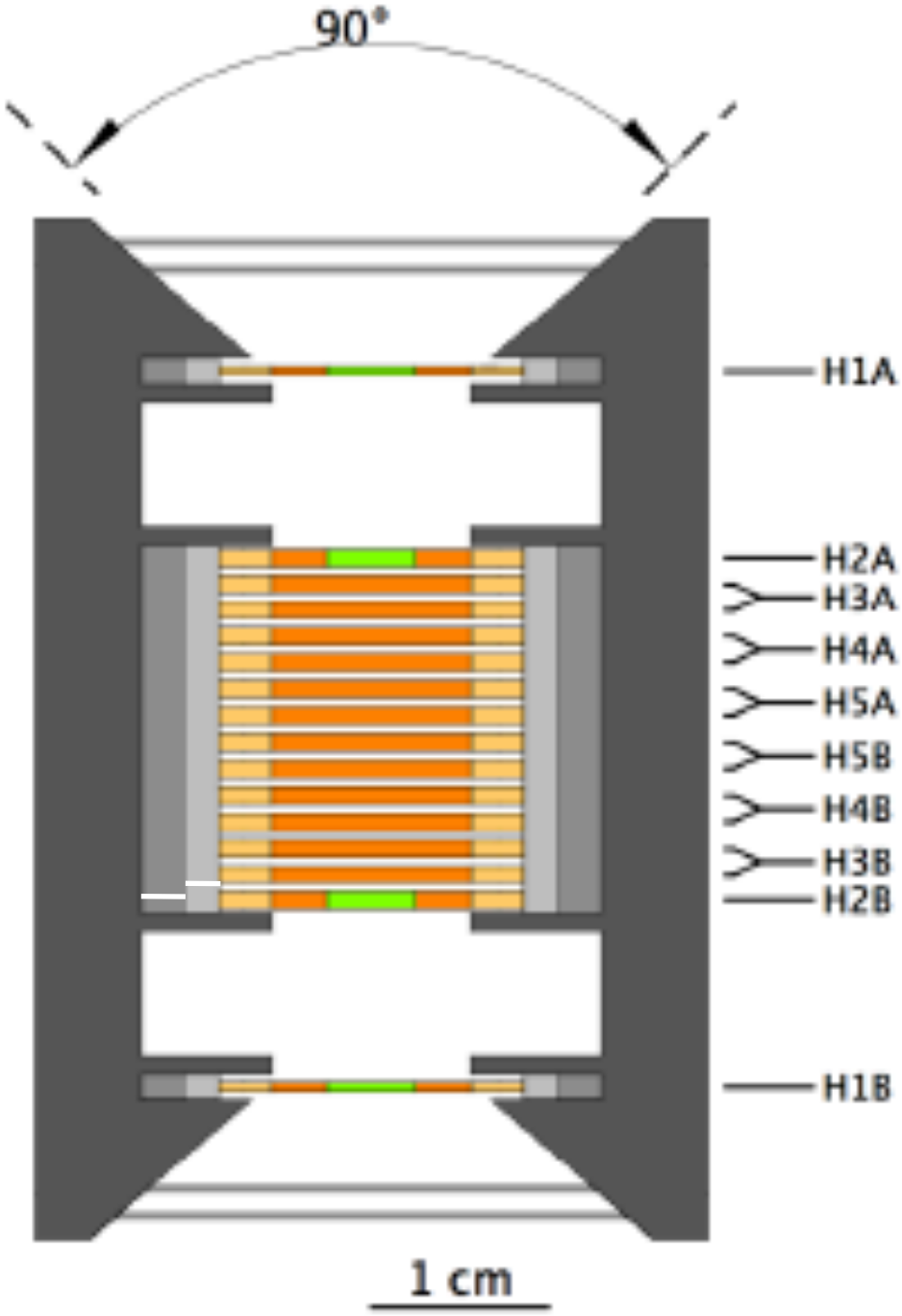
Abstract

In an earlier memo dated 11/26/13 we outlined 7 stages of dynamic thresholds for HET ranging from "Nominal" to "Pixel". The idea (based on the STEREO LET dynamic thresholds; see Mewaldt et al. SSR, 2007) is to reduce the HET singles rates due to H and He by progressively raising selected detector thresholds to Z ≥ 6 levels, thereby reducing the geometry factor for H and He single detector triggers and events. The Pixel count rates in HET serve as the "monitor" rates that trigger these successive changes (and guide the retreat to normal operations). We use the 95% "Worst-Case" spectrum defined in the EDTRD to estimate the singles count rates in counts/sec. Note that the Z ≥ 6 geometry can remain fully active in all of the "stages", although some guard thresholds will be raised and thus less effective, and the "stopping" energy range may be affected.

Clearly, 7 stages beyond the nominal mode is too many and in this memo we recommend that only 3 of these be implemented in addition to the nominal mode. Included here are the trigger modes, single detector rates, energy ranges, geometry factors, and particle identification matrices that would be needed.

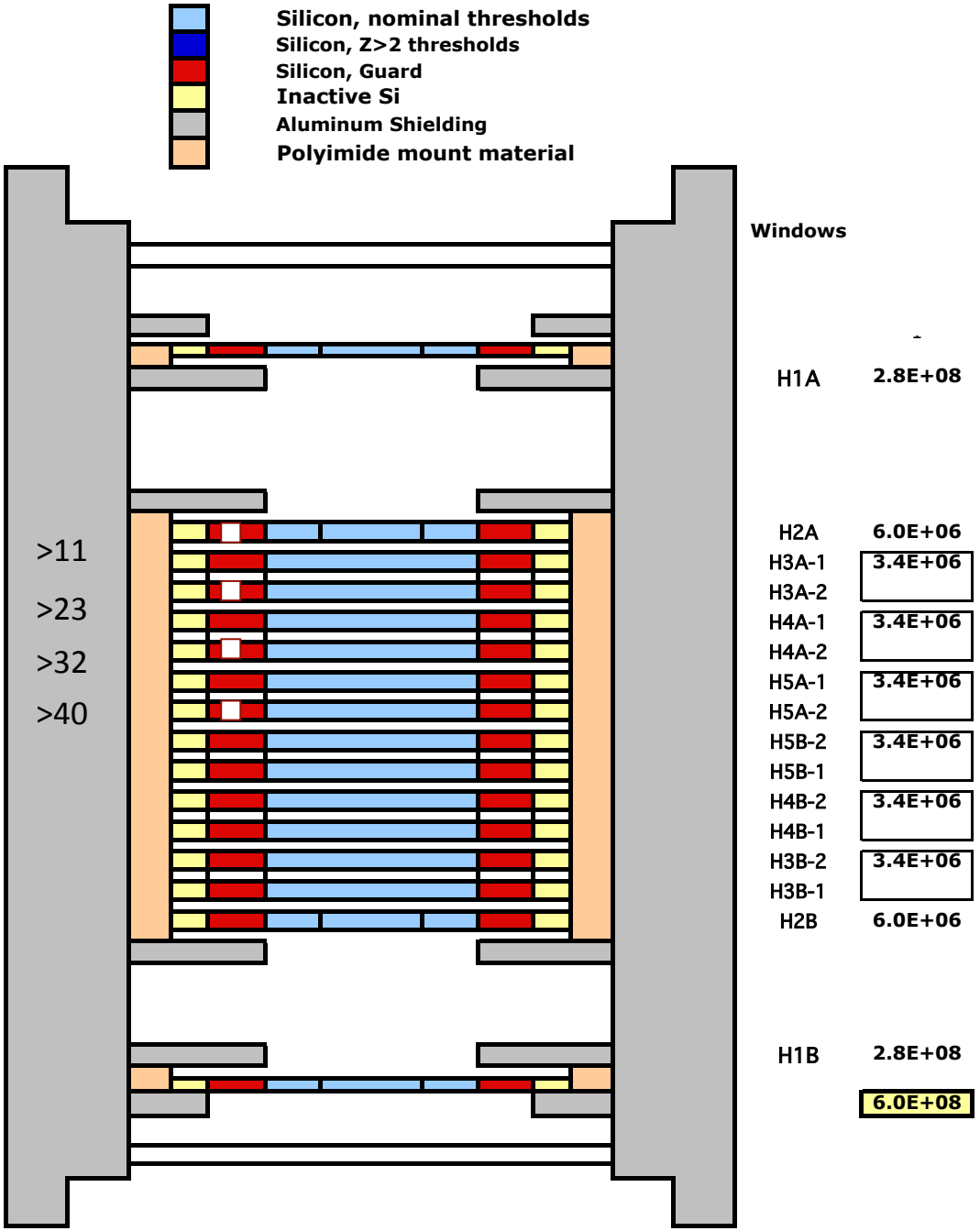


The telescope design from the ISIS PDR package is shown here. It includes some internal shielding that can reduce the singles rates of the guard and central regions due to out-of-geometry particles. The count rates are approximate estimates of singles rates for the "95%-Worst-Case" proton spectrum. They include only approximate estimates of the effectiveness of the internal shielding. The effects of particles coming through the sides have been estimated assuming a cylindrical wall that is 0.6 cm thick aluminum. Singles rates of Z≥6 ions are taken to be 0.1% of those due to protons. He is ignored but will be an additional ~3% of protons.

<u>Trigger modes:</u>
H1•H2 "Nominal"
H1A•H2A•H1B•H1B "Penetrating"
(H3+H4+H5)•(notG, notH2) "Neutral"
where H3+H4+H5 = all 6 segments

<u>Matrices:</u>
H1 vs. H2 (500μ vs. 1000μ)
H2 vs. H3 (1000μ vs. 2000μ)
H3 vs. H4 (2000μ vs. 2000μ)
(and H4 vs. H5; H5 vs. H4, etc.)

Level 0 = Nominal



In the Nominal Operation mode all thresholds are sensitive to Protons, Alphas, and Electrons.

Note the 4 "pixels" (☐) on the left side. Their energy thresholds will be set to measure protons whose end of range is near the pixel. A Monte Carlo calculation can define the mean response energy for each and we can "calibrate" them against the measured spectra.

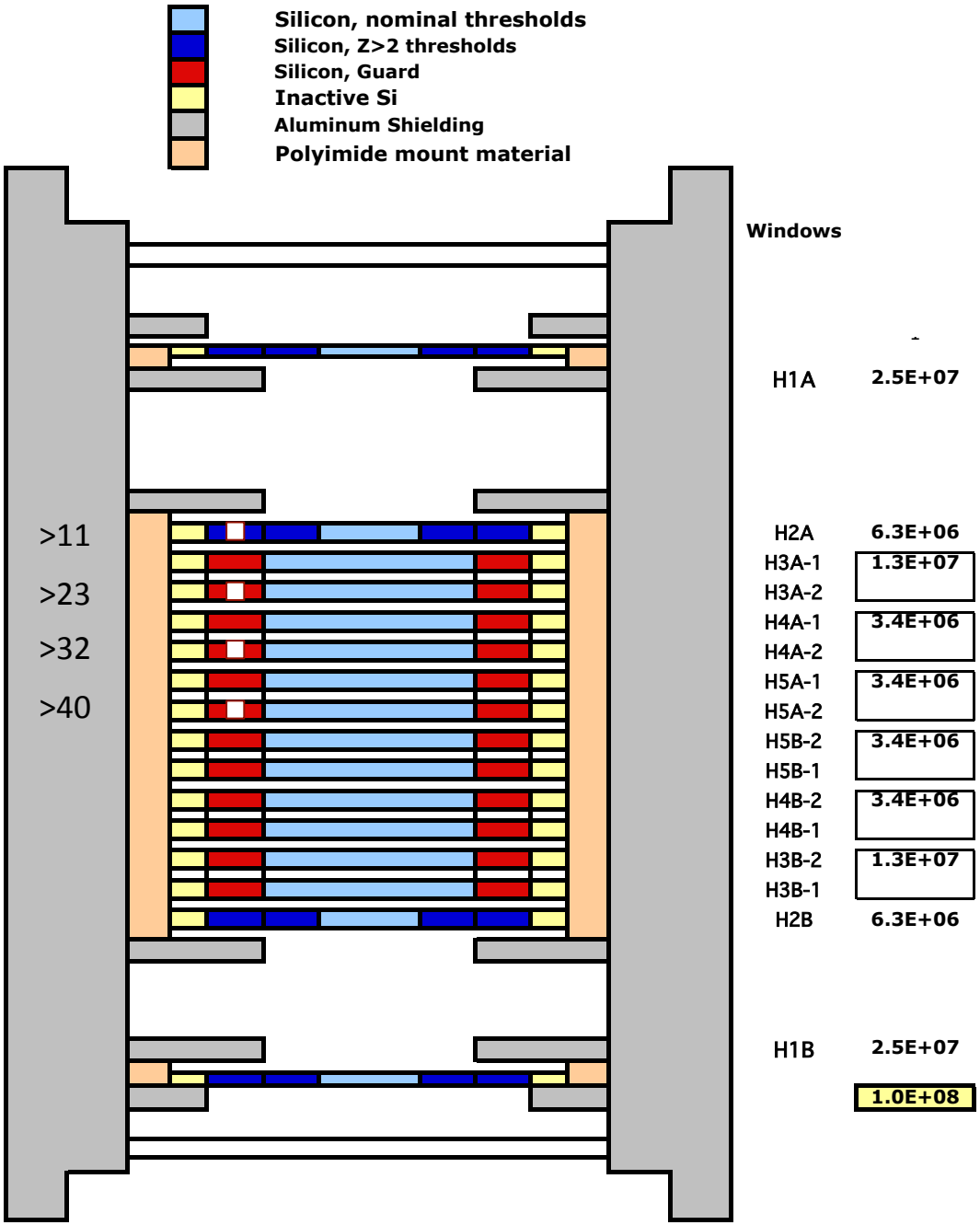
The count rates are approximate estimates of singles rates (per second) for the "95%-Worst-Case SEP spectrum

<u>Trigger modes:</u>
H1•H2 "Nominal"
H1A•H2A•H1B•H1B "Penetrating"
(H3+H4+H5)•(notG, notH2) "Neutral"

<u>Matrices:</u>
H1 vs. H2 (500μ vs. 1000μ)
H2 vs. H3 (1000μ vs. 2000μ)
H3 vs. H4 (2000μ vs. 2000μ)
(and H4 vs. H5; H5 vs. H4, etc.)

"Penetrating" Matrix is TBD. I suggest (H3A+H4A+H5A) vs. (H3B+H4B+H5B)

Level 1 = “Narrow”



In Stage-3 Dynamic Thresholds all outer segments of H1A and H1B are raised to respond only to Z≥6. The H, He, and electron energy range is the same with a reduced geometry factor.

The summed “singles” rates are estimated to be ~1/6 of their original value.

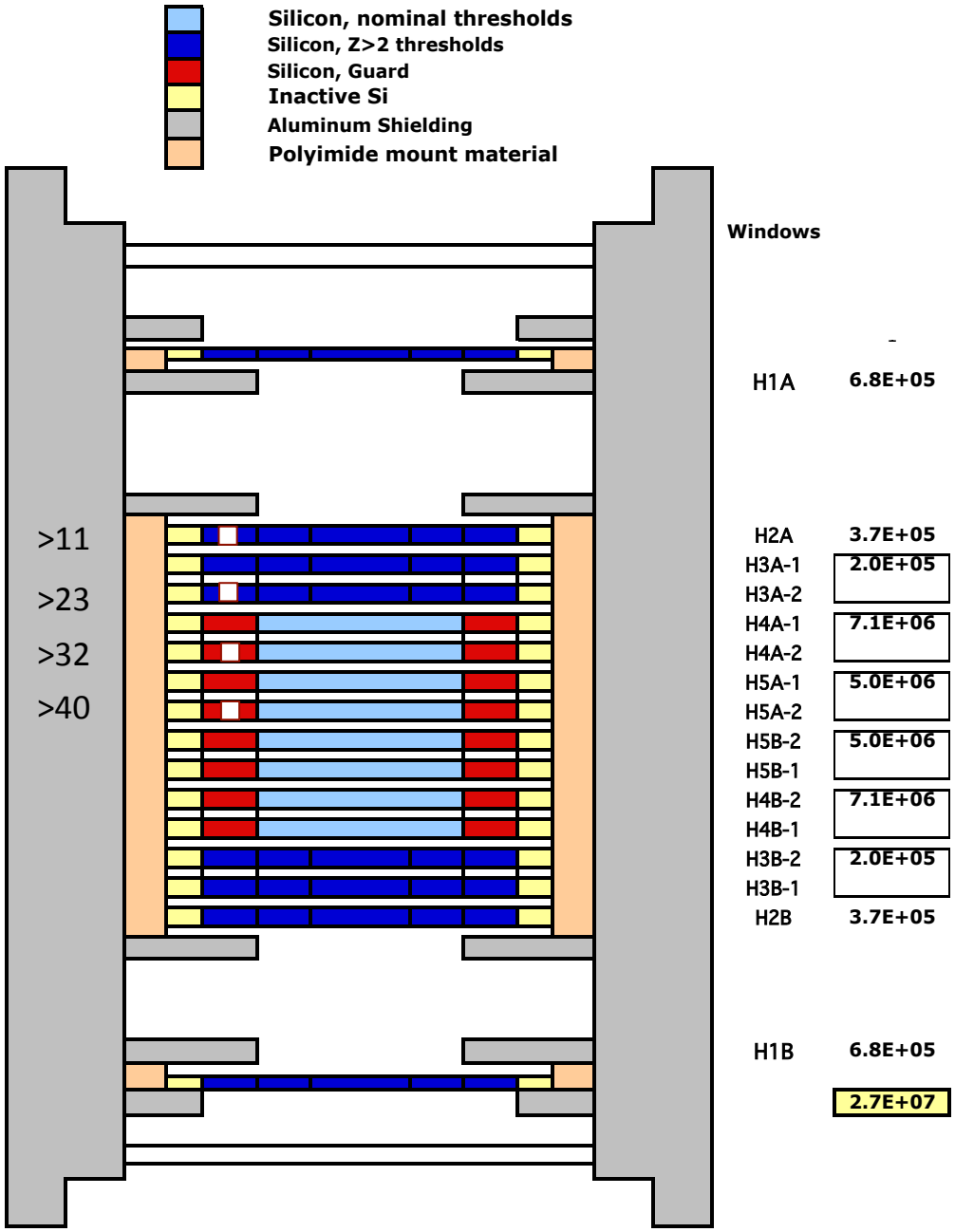
The pixel response should remain the same, including the H2A pixel.

There is no longer a viable Neutral Mode, which is ok, because γ-rays and neutrons from the spacecraft will probably dominate.

<u>Trigger modes:</u>
“Nominal”
“Penetrating”
“Neutral” (no longer viable)

<u>Matrices: Remain the same</u>
H1 vs. H2 (500m vs. 1000m)
H2 vs. H3 (1000m vs. 2000m)
H3 vs. H4 (2000m vs. 2000m)
(and H4 vs. H5; H5 vs. H4, etc.)

Level 2 = “Shielded”

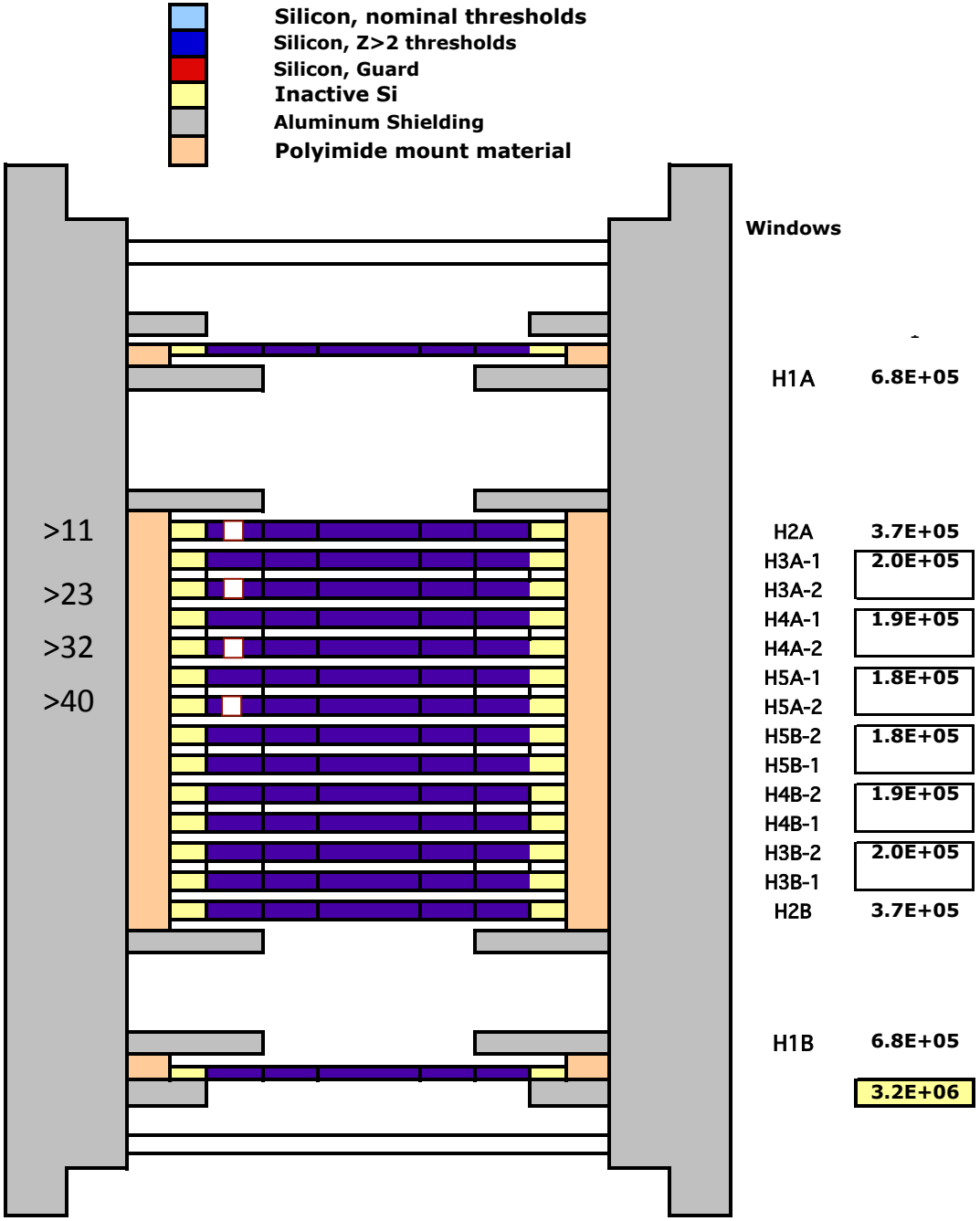


In Stage-6 all segments of H1A to H3A-2 and H1B to H3B-2 are raised to respond only to Z ≥ 6. The minimum energy H and He from either end will be ~35 MeV. Electrons will be measured from ~2 to ~5 MeV. H, and He, and e^- entering through the front and back can be identified from those through the sides by the fact that their “range” will be less for a given energy deposit (this may require corrections using event data.) However, note that the minimum energy for a proton through the side that does not trigger the H4 or H5 guards is very high (~65 MeV)

The summed “singles” rates are estimated to be ~4%-5% of their original value (a Monte Carlo calculation is needed to verify this).

There is a <u>new trigger mode</u> introduced here: H4A•H5A•notH4B•notG (from the front), and H4B•H5B•notH4A•notG (from the back)

Level 3 = “Pixel” Mode



In Stage-7 Dynamic Thresholds we rely entirely on the Pixels to get proton spectra (see approximate thresholds). We start out with all 4 pixels active but may have to raise the pixel trigger thresholds above that of protons (e.g., to ~15-20 MeV in a 1-mm thick detector) if the singles rates remain too large. We would start by raising the threshold only on the H2A pixel, and continue as needed.

The full stack should continue to respond to Z ≥ 6 ions.

HET will no longer be measuring electrons or neutrals, but can still measure the spectra of “penetrating” Z≥6 ions.

Summary of Reccommended Dynamic Threshold Modes for SPP/HET
(High-lighted Modes are Recommended)

Stage Number	Estimated Singles Rate (s^-1)	Approximate H,He Stop (MeV/n)	Electron Coverage (MeV)	O Thresh (MeV/n)	Fe Thresh (MeV/n)	H,He,e Geom (cm2sr	O, Fe Geom (cm2sr)	Neutral Volume (cm^3)	H,He Pen Geom (cm2sr)
0	6.0E+08	11-60	0.5 - 6	24-124	42-236	0.54	0.54	1.2	0.057
1	2.7E+08	11-60	0.5 - 6	24-124	42-236	0.54	0.54	0	0.0047
2	1.3E+08	11-60	0.5 - 6	24-124	42-236	0.54	0.54	0	0.0047
3	1.0E+08	11-50	0.5 - 5	24-124	42-236	0.54	0.54	0	0.0047
4	6.3E+07	11-50	0.5 - 4	24-124	42-236	0.54	0.54	0	~.002*
5	4.5E+07	18-50	1 - 4	24-124	42-236	0.54	0.54	0	0
6	2.7E+07	22-35	2 - 4	24-124	42-236	0.54	0.54	0	0
7	3.3E+06	Pix = 11-40	none	24-124	42-236	TBD	0.54	0	0

*single-ended could be implemented from top

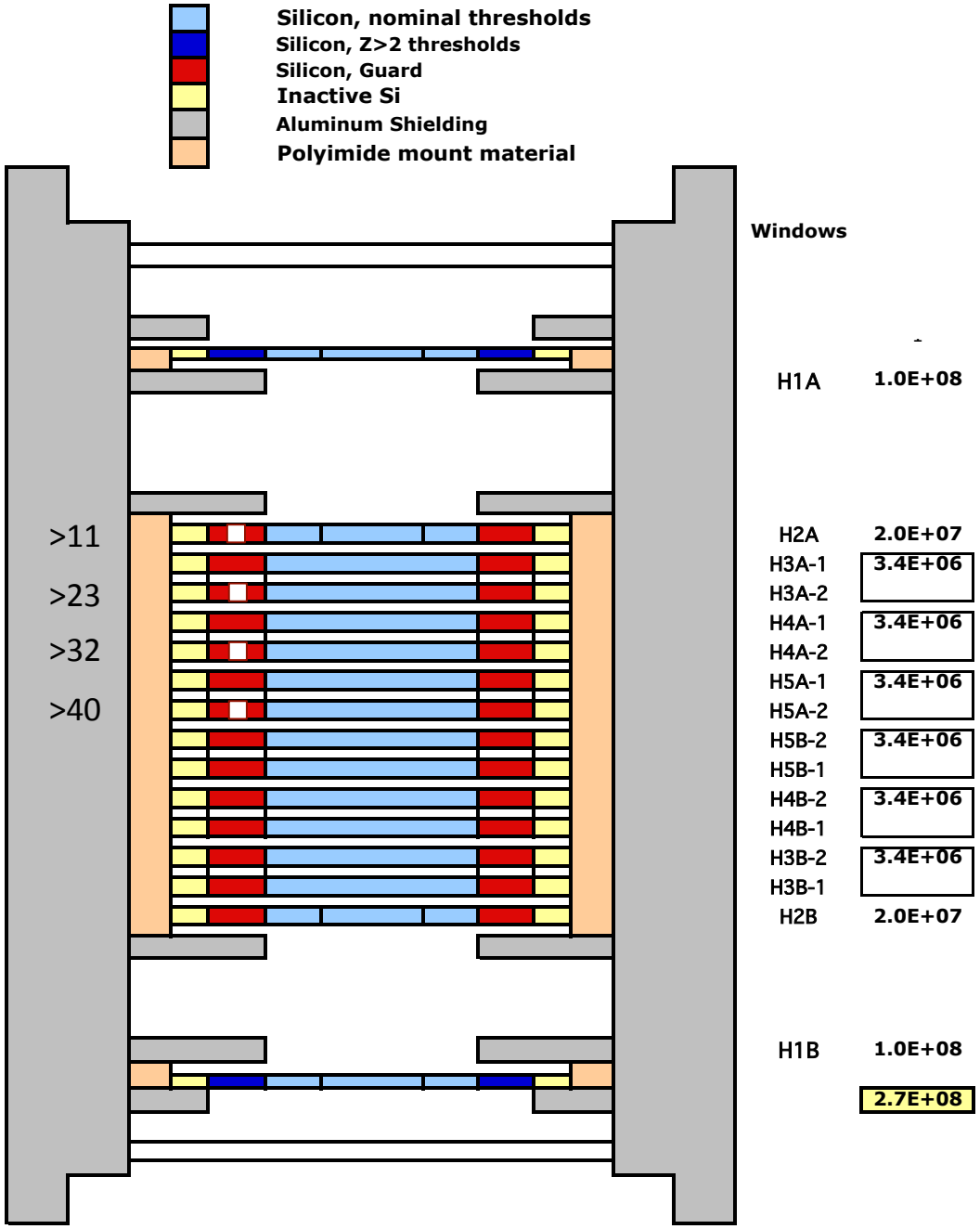
Summary

In order to reduce the complexity we have taken the 8 candidate modes of HET dynamic thresholds and reduced them to four, including the "nominal" mode, a "narrow" mode, a "shielded mode" and a Pixel mode. The Narrow mode can use all of the same particle identification matrices (although there is no longer a "neutral" mode). The "shielded" mode requires new trigger condition, but it does not necessarily require new particle identification matrices since we already need a 2mm x 2mm matrix. There will be corrections required for the overlying material in which we do not measure the energy loss.

I invite comments, corrections, and suggestions.

In the following slides I include the original possible dynamic threshold modes for HET.

Stage 1 Dynamic Thresholds



In Stage-1 Dynamic Thresholds the guard regions of the H1A and H1B devices are raised to respond only to Z ≥ 6 (see legend for color coding). Thus the H1 singles rates can be dropped by a factor of almost 3, but there will be more "edge effects" in the outer H1 segments.

The summed "singles" rates are reduced by a factor of ~2. All geometry factors and trigger modes remain the same

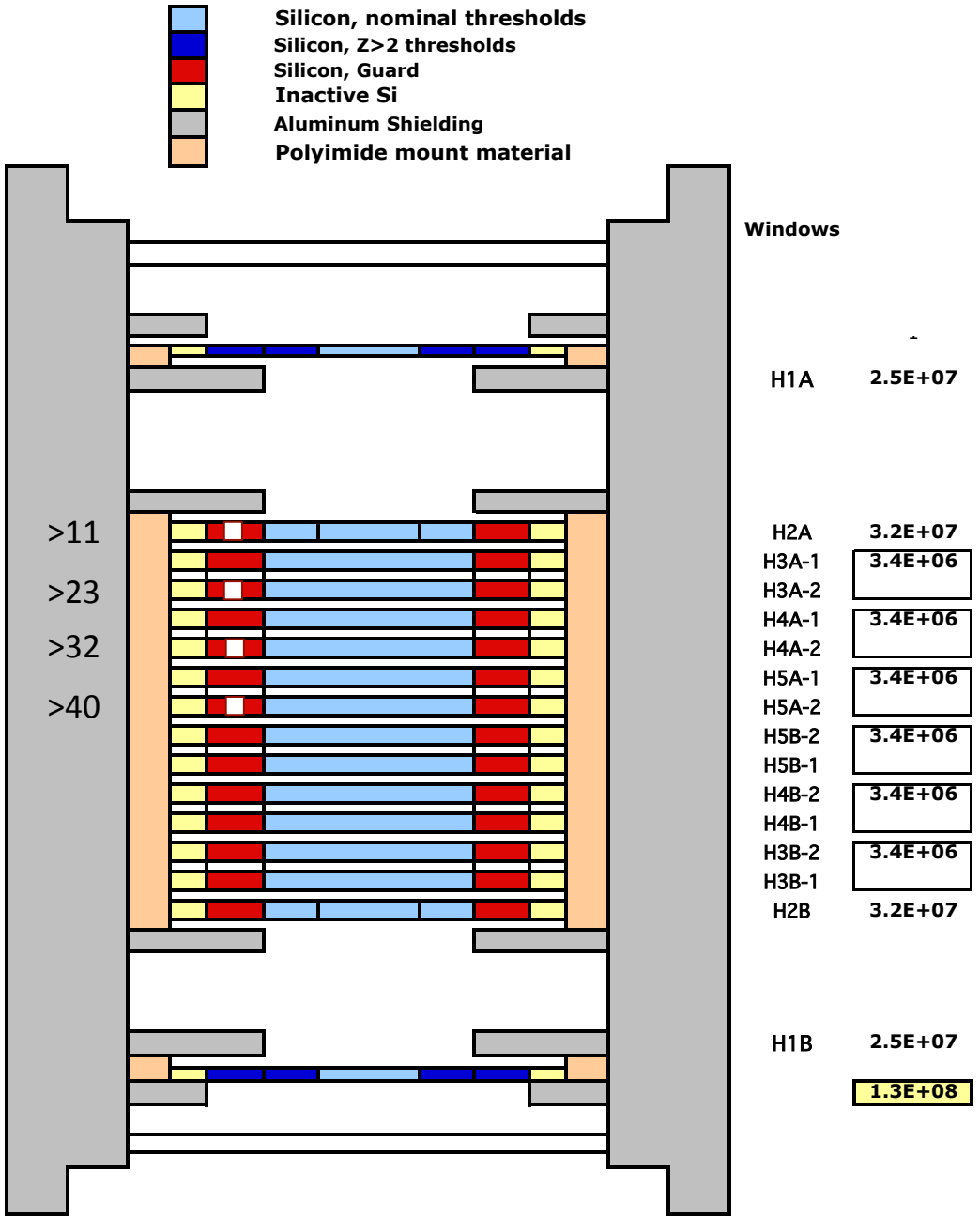
Trigger modes:

"Nominal"
"Penetrating"
"Neutral"

Matrices:

H1 vs. H2 (500μ vs. 1000μ)
H2 vs. H3 (1000μ vs. 2000μ)
H3 vs. H4 (2000μ vs. 2000μ)
(and H4 vs. H5; H5 vs. H4, etc.)

Stage 2 Dynamic Thresholds



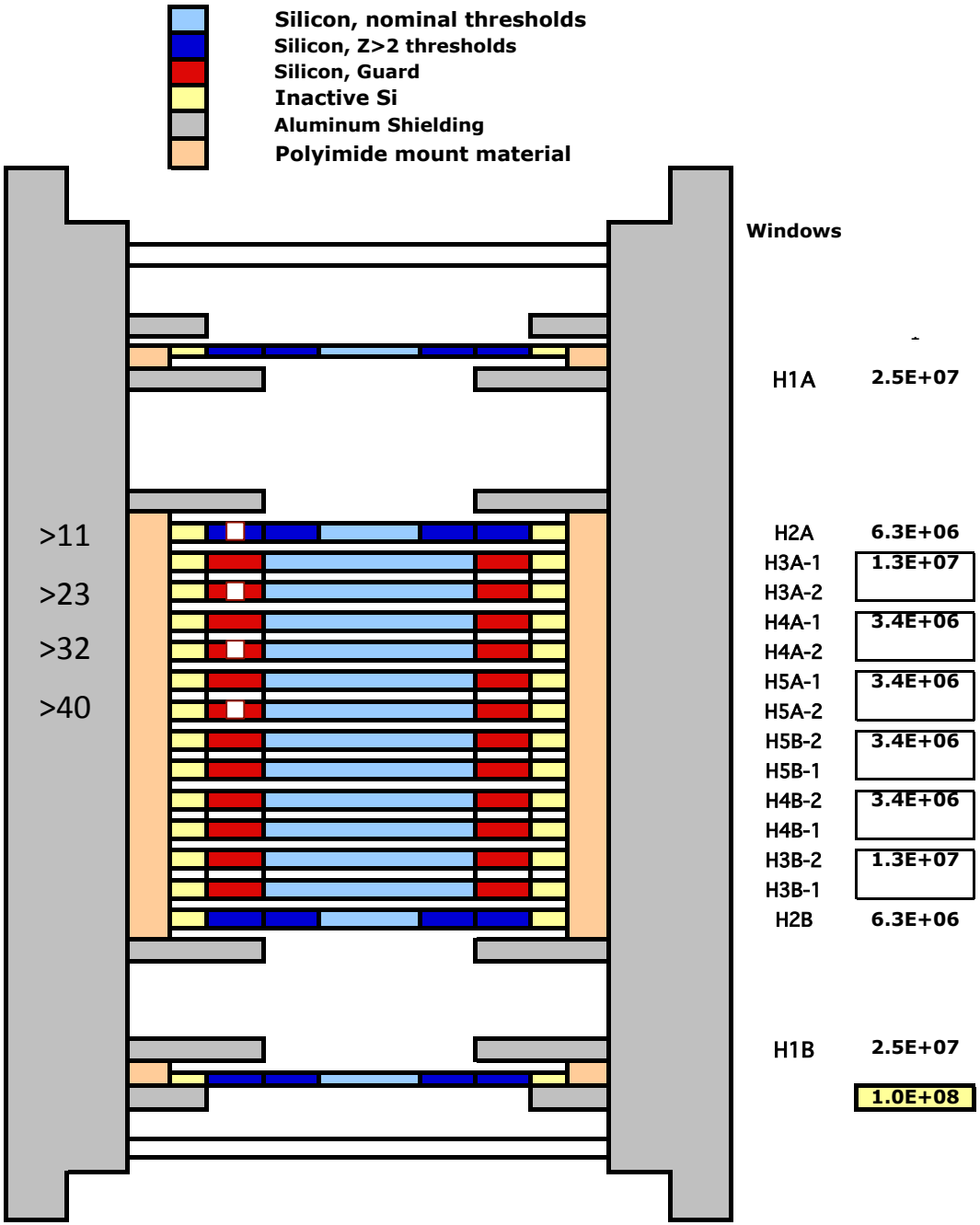
In Stage-2 Dynamic Thresholds the outer segments of H1A and H1B are also raised to respond only to Z ≥ 6. Thus the geometry factors for H, He, and e^- are reduced by a factor of ~5. The geometry for Z≥6 ions remains at the original level.

The singles rates in H2A and H2B increase because they see particles originally triggering the outer segments and guard of H1A and H2A.

The summed "singles" rates are now ~20% of their original value

All trigger modes and matrices remain the same

Stage 3 Dynamic Thresholds



In Stage-3 Dynamic Thresholds all outer segments of H1A and H1B are raised to respond only to Z≥6. The H, He, and electron energy range is the same with a reduced geometry factor.

The summed "singles" rates are estimated to be ~1/6 of their original value.

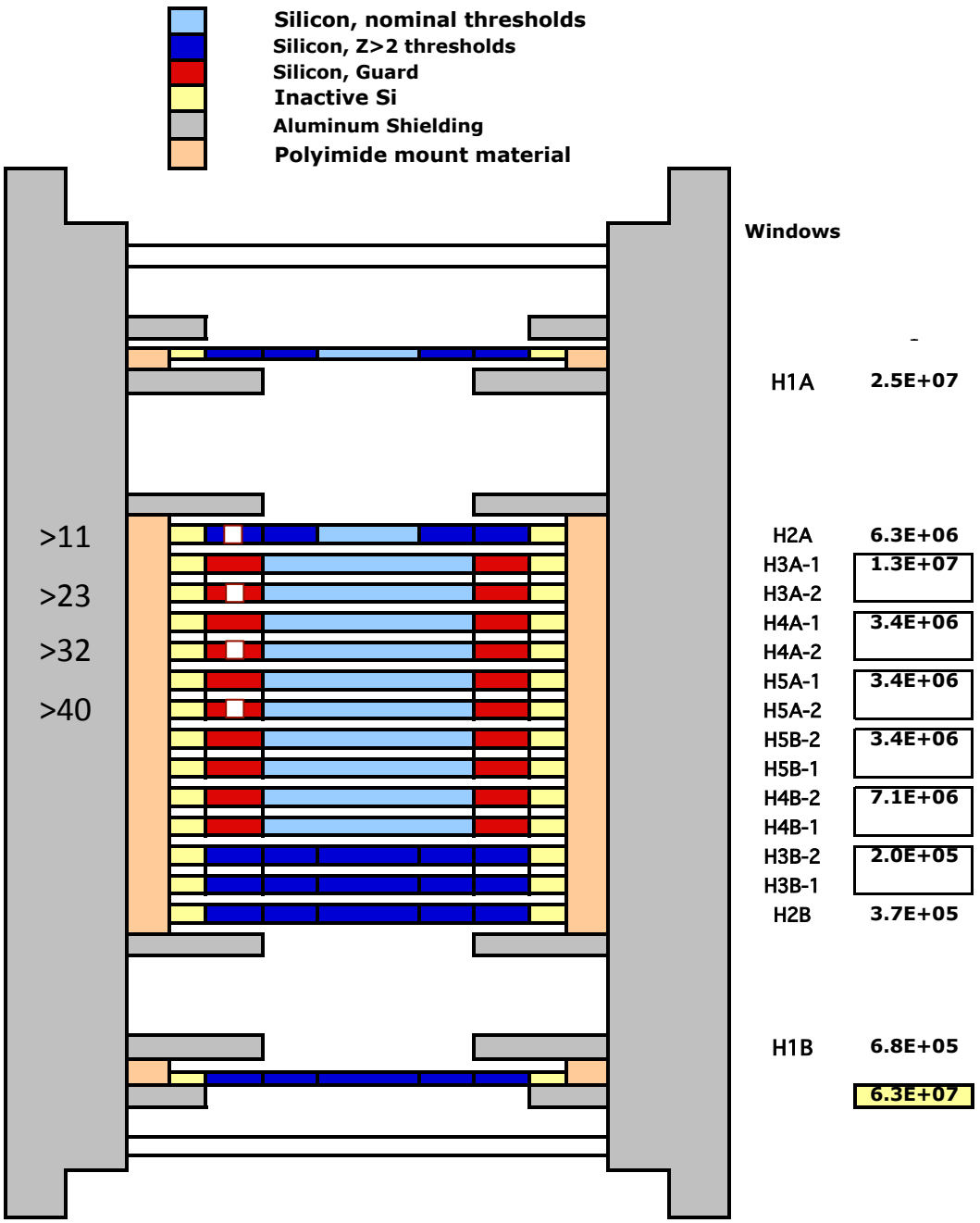
The pixel response should remain the same, including the H2A pixel.

There is no longer a viable Neutral Mode, which is ok, because γ-rays and neutrons from the spacecraft will dominate.

<u>Trigger modes:</u>
"Nominal"
"Penetrating"
"Neutral" (no longer viable)

<u>Matrices: Remain the same</u>
H1 vs. H2 (500m vs. 1000m)
H2 vs. H3 (1000m vs. 2000m)
H3 vs. H4 (2000m vs. 2000m)
(and H4 vs. H5; H5 vs. H4, etc.)

Stage 4 Dynamic Thresholds



In Stage-4 Dynamic Thresholds all segments of H1A to H3B are raised to respond only to Z ≥ 6. The B-End response to H, He, and electrons is essentially disabled, but the A-End stopping response is retained through most of the stack.

There is no viable neutral mode.

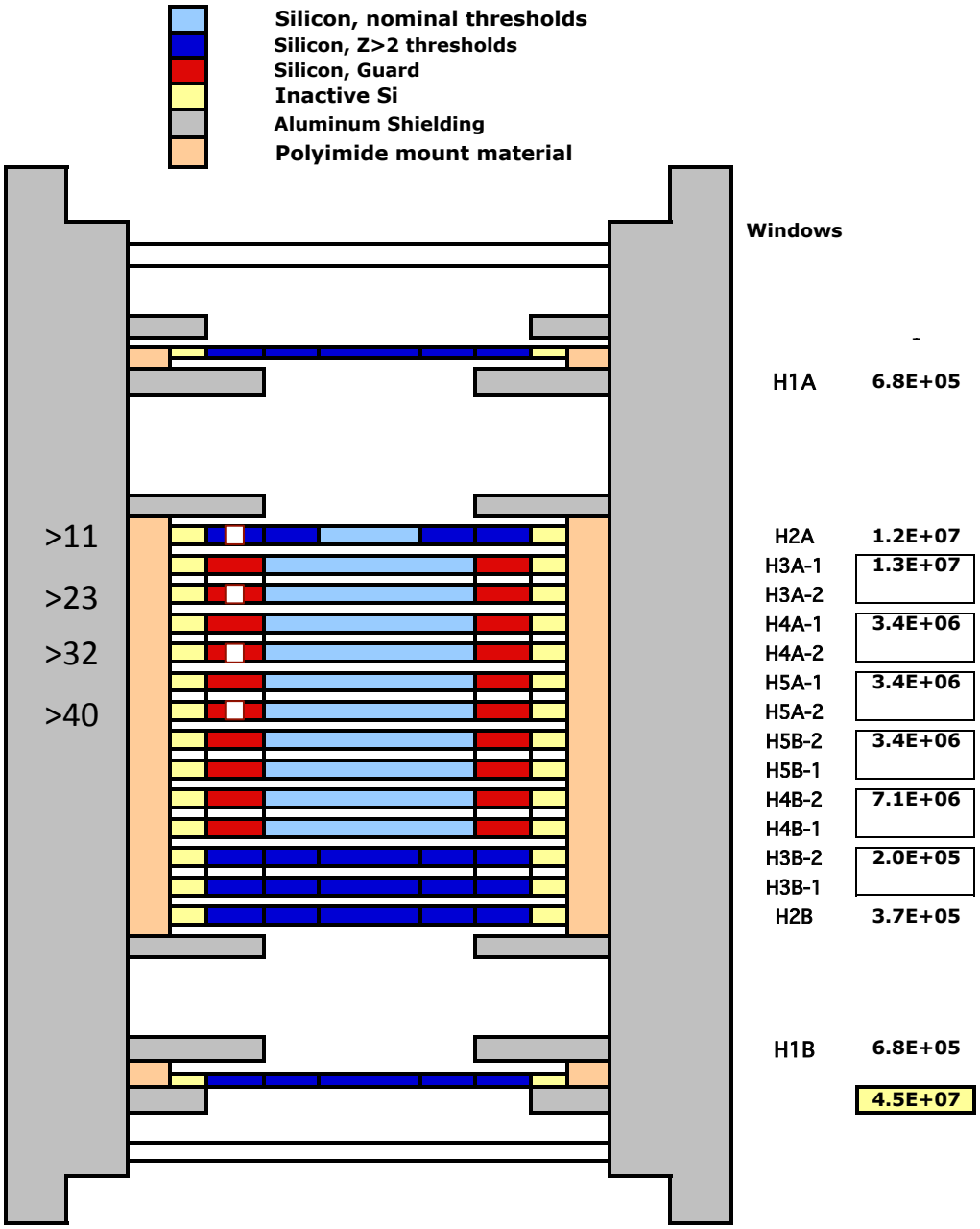
It remains to be seen if a viable "penetrating" mode can be retained. If so, it would be H1A•H2A•H4B•notG. A new Penetrating matrix might also be needed.

The summed "singles" rates are now estimated to be ~10% of their original value.

<u>Trigger modes:</u>
"Nominal"
"Penetrating" (?????)
"Neutral" (no longer viable)

<u>Matrices: Remain the same</u>
H1 vs. H2 (500m vs. 1000m)
H2 vs. H3 (1000m vs. 2000m)
H3 vs. H4 (2000m vs. 2000m)
(and H4 vs. H5; H5 vs. H4, etc.)

Stage 5 Dynamic Thresholds



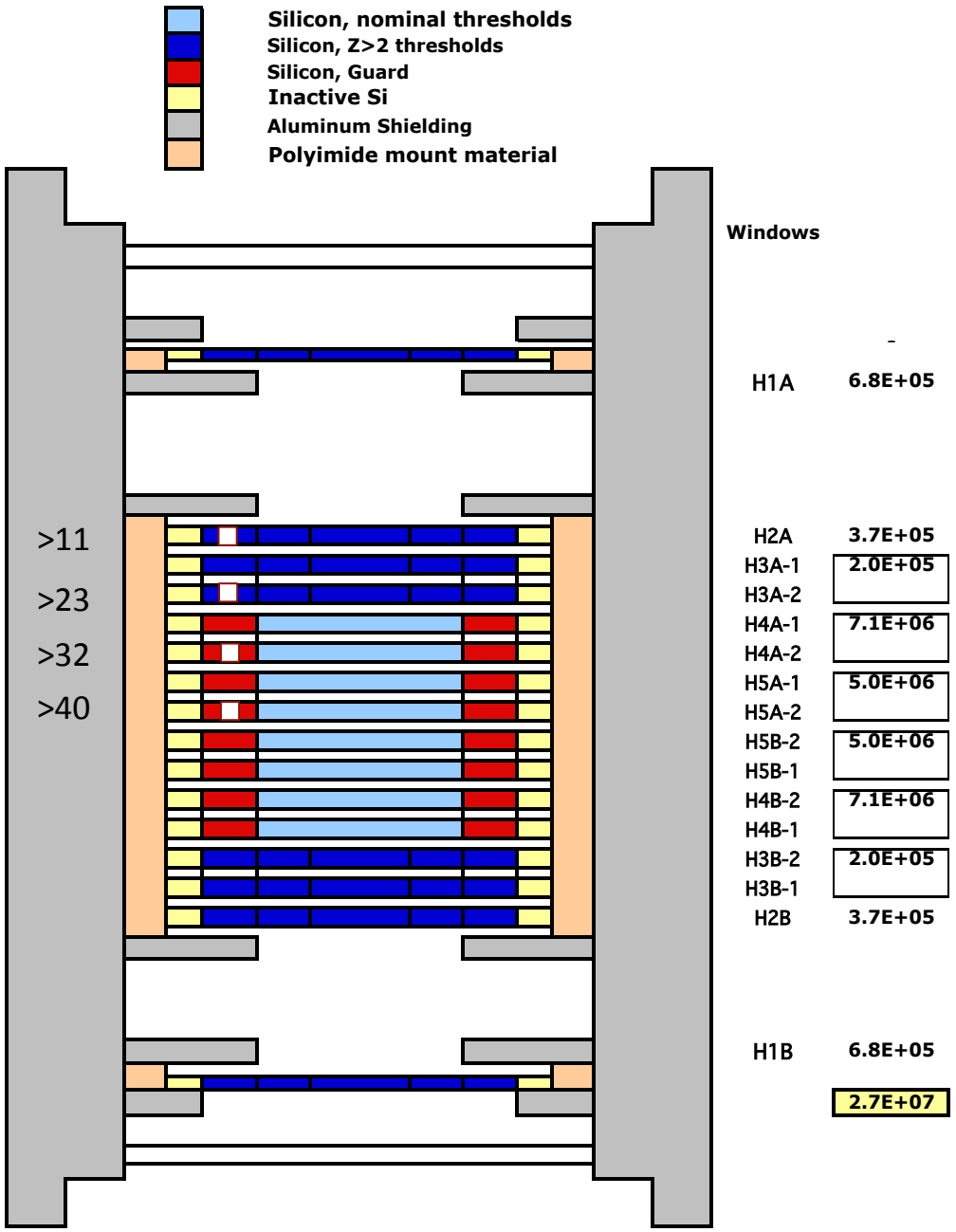
This Stage-5 concept is a minor change from Stage-4. The only difference is that the threshold for the center of H2B has been raised. The B-End response to H, He, and electrons is essentially disabled, but the A-End stopping response is retained through most of the stack. The center of H2A would be required for all H, He, and electron events.

There is no viable neutral mode.

It remains to be seen if a viable "penetrating" mode can be retained. If so, it would be H1A•H2A•H4B•notG. A revised Penetrating matrix might also be needed .

The summed "singles" rates are now estimated to be ~7.5% of their original value.

Stage 6 Dynamic Thresholds



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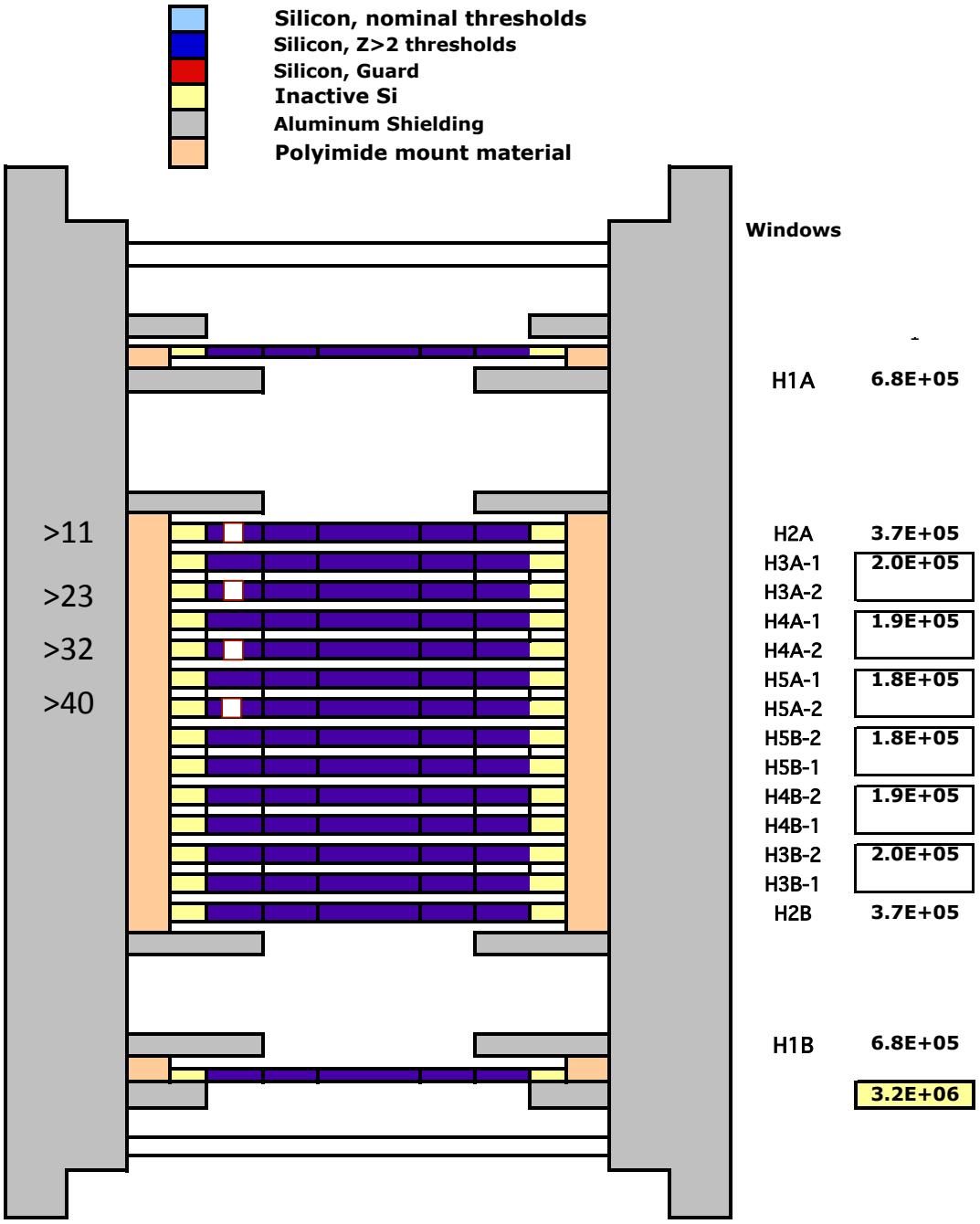
The summed "singles" rates are estimated to be ~4%-5% of their original value (a Monte Carlo calculation is needed to verify this).

There is a <u>new trigger mode</u> introduced here: H4A•H5A•notH4B•notG (from the front), and H4B•H5B•notH4A•notG (from the back)

Stage 7 Dynamic Thresholds



In Stage-7 Dynamic Thresholds we rely entirely on the Pixels to get proton spectra (see approximate thresholds). We start out with all 4 pixels active but may have to raise the pixel trigger thresholds above that of protons (e.g., to ~15-20 MeV in a 1-mm thick detector) if the singles rates remain too large. We would start by raising the threshold only on the H2A pixel, and continue as needed.

The full stack should continue to respond to Z ≥ 6 ions.

HET will no longer be measuring electrons or neutrals, but can still measure the spectra of "penetrating" Z≥6 ions.

Summary: TBD