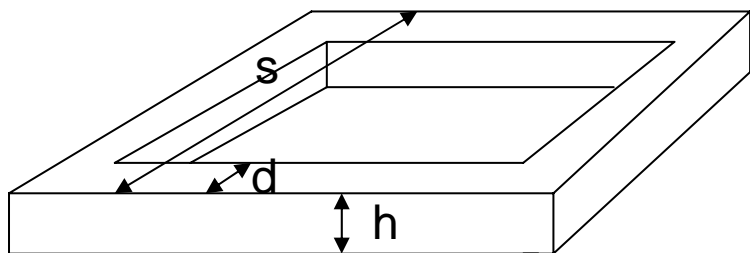


Tray Radition lenght estimation

alessandro.brez@pi.infn.it



Closeouts

$h=2.8\text{cm}$, $d=0.37\text{cm}$, $s=36.85\text{cm}$

CC mass = 279g $X_o=23.6\text{cm}$

Al mass = 12.5g $X_o=8.9\text{cm}$

Adhesive=6g $X_o=30\text{cm}$

Total mass=298g

Honeycomb

$h=2.8\text{cm}$, $s=35.1\text{cm}$

Mean density = 0.016g/cm^3 (0.048 for H/B trays)

Al mass = 55g (165g H/B) $X_o=8.9\text{cm}$

Effective thickness= 0.017cm (0.051 H/B) over 35.1^2

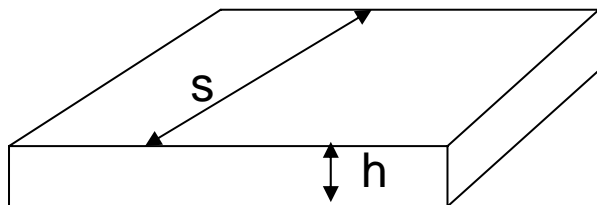
Effective thickness= 0.015cm (0.045 H/B) over 36.85^2

Cell structure

Pitch= $3/8''=0.9525\text{cm}$

Density= $1\text{lb/ft}^3=0.016\text{g/cm}^3$

Cell thickness $0.0007''=18\mu\text{m}$



Plus payload on top and bottom layers (sensors, glue, bias circuit, W) as follow

MID top side payload

| material | Thicknes real (cm) | Thickness csaed by area (cm) | Mass (g) | Xo (cm) | Xo fraction |
|--------------------------------|----------------------|------------------------------|----------|---------|-----------------------|
| Honeycomb-face sheets adhesive | 0.01 | 0.01 | 20 | 30 | 3.33×10^{-4} |
| Face sheet | 0.02 | 0.02 | 49 | 24 | 1.10×10^{-3} |
| Face-sheet – bias adhesive | 0.01 | 0.01 | 20 | 30 | 3.33×10^{-4} |
| kapton | 0.01 | 0.01 | 20 | 26.4 | 3.79×10^{-4} |
| Cu | 8.4×10^{-4} | 8×10^{-4} | 9.6 | 1.44 | 5.5×10^{-4} |
| Nusil 1224 | .015 | 7×10^{-4} | 1.3 | 30 | 2×10^{-5} |
| Nusil 2646 (silver) | 0.15 | 1×10^{-4} | 1.5 | .854 | 1.2×10^{-4} |
| Silicon layer | 0.042 | .040 | 125.4 | 9.37 | 4.23×10^{-3} |
| total | | | 244 | | 7.0×10^{-3} |

MID bottom side payload

| material | Thicknes real (cm) | Thickness csaed by area (cm) | Mass (g) | Xo (cm) | Xo fraction |
|--------------------------------|----------------------|------------------------------|----------|---------|-----------------------|
| Honeycomb-face sheets adhesive | 0.01 | 0.01 | 19 | 30 | 3.33×10^{-4} |
| Face sheet | 0.02 | 0.02 | 49 | 24 | 1.10×10^{-3} |
| Face-sheet –W adhesive | 0.01 | 0.01 | 19 | 30 | 3.33×10^{-4} |
| W tiles | 0.097 | 0.0088 | 229.6 | 0.351 | 2.50×10^{-2} |
| Face-sheet – bias adhesive | 0.01 | 0.01 | 19 | 30 | 3.33×10^{-4} |
| kapton | 0.01 | 0.01 | 19 | 26.4 | 3.79×10^{-4} |
| Cu | 8.4×10^{-4} | 8×10^{-4} | 9.6 | 1.44 | 5.5×10^{-4} |
| Nusil 1224 | .015 | 7×10^{-4} | 1.3 | 30 | 2×10^{-5} |
| Nusil 2646 (silver) | 0.15 | 1×10^{-4} | 1.5 | .854 | 1.2×10^{-4} |
| Silicon layer | 0.042 | 0.040 | 125.4 | 9.37 | 4.23×10^{-3} |
| total | | | 492 | | 3.2×10^{-2} |

Heavy top side payload

| material | Thicknes real (cm) | Thickness csaed by area (cm) | Mass (g) | Xo (cm) | Xo fraction |
|--------------------------------|----------------------|------------------------------|----------|---------|-----------------------|
| Honeycomb-face sheets adhesive | 0.01 | 0.01 | 20 | 30 | 3.33×10^{-4} |
| Face sheet | 0.029 | 0.029 | 71 | 24 | 1.60×10^{-3} |
| Face-sheet – bias adhesive | 0.01 | 0.01 | 20 | 30 | 3.33×10^{-4} |
| kapton | 0.01 | 0.01 | 20 | 26.4 | 3.79×10^{-4} |
| Cu | 8.4×10^{-4} | 8×10^{-4} | 9.6 | 1.44 | 5.5×10^{-4} |
| Nusil 1224 | .015 | 7×10^{-4} | 1.3 | 30 | 2×10^{-5} |
| Nusil 2646 (silver) | 0.15 | 1×10^{-4} | 1.5 | .854 | 1.2×10^{-4} |
| Silicon layer | 0.042 | .040 | 125.4 | 9.37 | 4.23×10^{-3} |
| total | | | 266 | | 8.0×10^{-3} |

Heavy bottom side side payload

| material | Thicknes real (cm) | Thickness csaed by area (cm) | Mass (g) | Xo (cm) | Xo fraction |
|--------------------------------|----------------------|------------------------------|----------|---------|-----------------------|
| Honeycomb-face sheets adhesive | 0.01 | 0.01 | 19 | 30 | 3.33X10 ⁻⁴ |
| Face sheet | 0.029 | 0.029 | 71 | 24 | 1.60X10 ⁻³ |
| Face-sheet –W adhesive | 0.01 | 0.01 | 19 | 30 | 3.33X10 ⁻⁴ |
| W tiles | 0.063 | 0.057 | 1567 | 0.351 | 0.162 |
| Face-sheet – bias adhesive | 0.01 | 0.01 | 19 | 30 | 3.33X10 ⁻⁴ |
| kapton | 0.01 | 0.01 | 19 | 26.4 | 3.79X10 ⁻⁴ |
| Cu | 8.4X10 ⁻⁴ | 8X10 ⁻⁴ | 9.6 | 1.44 | 5.5X10 ⁻⁴ |
| Nusil 1224 | .015 | 7X10 ⁻⁴ | 1.3 | 30 | 2X10 ⁻⁵ |
| Nusil 2646 (silver) | 0.15 | 1X10 ⁻⁴ | 1.5 | .854 | 1.2X10 ⁻⁴ |
| Silicon layer | 0.042 | 0.040 | 125.4 | 9.37 | 4.23X10 ⁻³ |
| total | | | 1853 | | 0.170 |

Masses of the trays

| tray type | closeout | honeycom | Top side payload | Bottom side payload | MCM | Total theor | Total measured |
|-----------|----------|----------|------------------|---------------------|-----|-------------|----------------|
| MID | 298 | 55 | 244 | 492 | 70 | 1159 | 1174 |
| Heavy | 298 | 165 | 266 | 1853 | 70 | 2652 | 2630 |
| Light | 298 | 55 | 244 | 244 | 70 | 911 | 931 |
| Top | | | | | | | 1215 |
| Bottom | | | | | | | 2200 |

Total X0 calculation

| Single Tray | | | | | | Tower | | | | |
|-----------------|-----------|----------|----------|----------|----------|-------------|-----------------|----------|-----------------|----------|
| | W uniform | | | W tiles | | Nb of trays | W uniform | | W tiles | |
| | cm | g/cm2 | Xo | g/cm2 | Xo | | g/cm2 | Xo | g/cm2 | Xo |
| top face | 4,00E-03 | 6,40E-02 | 1,80E-03 | 6,40E-02 | 1,80E-03 | 1 | 6,40E-02 | 1,80E-03 | 6,40E-02 | 1,80E-03 |
| honeycomb | 2,09E+00 | 3,35E-02 | 1,40E-03 | 3,35E-02 | 1,40E-03 | 1 | 3,35E-02 | 1,40E-03 | 3,35E-02 | 1,40E-03 |
| bot face | 1,01E-01 | 1,94E-01 | 7,00E-03 | 1,94E-01 | 7,00E-03 | 1 | 1,94E-01 | 7,00E-03 | 1,94E-01 | 7,00E-03 |
| W | 9,70E-03 | 1,69E-01 | 2,50E-02 | 1,87E-01 | 2,76E-02 | 1 | 1,69E-01 | 2,50E-02 | 1,87E-01 | 2,76E-02 |
| top face | 9,10E-02 | 1,80E-01 | 7,00E-03 | 1,80E-01 | 7,00E-03 | 11 | 1,98E+00 | 7,70E-02 | 1,98E+00 | 7,70E-02 |
| honeycomb | 2,80E+00 | 4,50E-02 | 1,87E-03 | 4,50E-02 | 1,87E-03 | 11 | 4,95E-01 | 2,06E-02 | 4,95E-01 | 2,06E-02 |
| bot face | 1,01E-01 | 1,94E-01 | 7,00E-03 | 1,94E-01 | 7,00E-03 | 11 | 2,13E+00 | 7,70E-02 | 2,13E+00 | 7,70E-02 |
| W | 9,70E-03 | 1,69E-01 | 2,50E-02 | 1,87E-01 | 2,76E-02 | 11 | 1,86E+00 | 2,75E-01 | 2,06E+00 | 3,04E-01 |
| top face | 1,00E-01 | 1,96E-01 | 8,00E-03 | 1,96E-01 | 8,00E-03 | 4 | 7,84E-01 | 3,20E-02 | 7,84E-01 | 3,20E-02 |
| honeycomb | 2,80E+00 | 1,35E-01 | 5,61E-03 | 1,35E-01 | 5,61E-03 | 4 | 5,40E-01 | 2,24E-02 | 5,40E-01 | 2,24E-02 |
| bot face | 1,10E-01 | 2,10E-01 | 8,00E-03 | 2,10E-01 | 8,00E-03 | 4 | 8,40E-01 | 3,20E-02 | 8,40E-01 | 3,20E-02 |
| W | 7,23E-02 | 1,15E+00 | 1,62E-01 | 1,27E+00 | 1,80E-01 | 4 | 4,58E+00 | 6,48E-01 | 5,09E+00 | 7,20E-01 |
| top face | 9,10E-02 | 1,80E-01 | 7,00E-03 | 1,80E-01 | 7,00E-03 | 2 | 3,60E-01 | 1,40E-02 | 3,60E-01 | 1,40E-02 |
| honeycomb | 2,80E+00 | 4,50E-02 | 1,87E-03 | 4,50E-02 | 1,87E-03 | 2 | 9,00E-02 | 3,74E-03 | 9,00E-02 | 3,74E-03 |
| bot face | 9,10E-02 | 1,80E-01 | 7,00E-03 | 1,80E-01 | 7,00E-03 | 2 | 3,60E-01 | 1,40E-02 | 3,60E-01 | 1,40E-02 |
| top face | 1,00E-01 | 1,96E-01 | 8,00E-03 | 1,96E-01 | 8,00E-03 | 1 | 1,96E-01 | 8,00E-03 | 1,96E-01 | 8,00E-03 |
| honeycomb | 2,80E+00 | 1,01E-01 | 4,19E-03 | 1,01E-01 | 4,19E-03 | 1 | 1,01E-01 | 4,19E-03 | 1,01E-01 | 4,19E-03 |
| bot face | 3,90E-02 | 6,62E-02 | 1,94E-03 | 6,62E-02 | 1,94E-03 | 1 | 6,62E-02 | 1,94E-03 | 6,62E-02 | 1,94E-03 |
| Total X0 | | | | | | 1,48E+01 | 1,27E+00 | 1,56E+01 | 1,37E+00 | |

Mass verification

Mass verification

| | |
|-----------------------------------|--------------|
| mass crossed by radiation | 20160 |
| sidewalls | 2480 |
| closeouts | 5364 |
| closeouts bottom | 1609 |
| MCM | 1260 |
| cables | 656 |
| screws | 224 |
| brackets | 190 |
| other | 137 |
| tower mass (gr, estimated) | 32080 |
| tower mass (gr, measured) | 32520 |