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GLAST Tray Core Material

Both aluminum and carbon-fiber honeycomb core materials are under consideration for use in GLAST trays. Mike Steinzig sent some information on a few options that exist, including a list of issues. All of the cores have 3/8-inch (0.95 cm) cell size. The prices are quoted for panels of size 38-cm square and 3.4 cm thick (thickness of the bottom tray). The resonant frequency predictions are based on a panel with XN50 carbon-fiber face sheets with 4 thin plies. The payload stiffness is not included, only the mass. I added the last two rows of the table, giving the average thickness in radiation lengths (for the standard-tray 2.8 cm thickness) and the total mass of all cores in the instrument.[1] For reference, the simulations used for our NASA proposal assumed cores of 0.2% R.L. thickness. Also, the cores used in the BTEM tracker were aluminum honeycomb of the same cell size but with 0.0010-inch thick walls and 75-micron thick carbon-fiber face sheets. A couple of early prototype trays were made with 0.0007-inch aluminum honeycomb and 0.002-inch (50-micron) thick aluminum face sheets. Quotes are not included for the aluminum cores, but they are known to be readily available at a cost that is negligible (order of magnitude lower) compared with the composite cores.

The YLA-51 is made of woven XN-50 fibers. It is very high quality and strong but is clearly out of our price range ($800/core was quoted in the cost estimates in our NASA proposal). The UCF-146 is YSH-70 fibers with 2 layers at ±45°.

	YLA UCF-146	Hexcel 5052 (.0007”)	YLA UCF-51	Hexcel 5052 (.002”)
Density (lb/cf)	.75	1.0	2.0	3.0
Cost ea. (ea. for 360)	697 618	small	1766 1541	small
Delivery (ARO)	6-12 weeks	rapid	3-6 weeks	rapid
Shear modulus (ribbon dir. Ksi)	14-20	12	60	43
Comp. Modulus (Ksi)	2	20	34	70
Fundamental Frequency	643[2]	630	712	672
RMS disp. (micro-meters)	81	83	-	75
Avg # Rad. Len.	0.077%	0.18%	0.21%	0.54%
Mass of 304 cores	14.6 kg	19.4 kg	38.9 kg	58.3 kg

[1] I assumed 24.0 g/cm^2 radiation length for aluminum and 42.7 g/cm^2 for the carbon-composite material.
[2] Assuming 14 Ksi shear modulus.

To set the scale of the radiation-length issue, below is a table with estimates of the radiation lengths of material in a standard tray, not including the converter material. Without carrying out any detailed Monte Carlo analysis, it is clear that the 2-mil aluminum would have a significant impact on performance, but the difference between the UCF-146 core and Hexcel 5052 core is minor and may not justify the approximately $200,000 increase in cost to the project for the material (and possibly even more cost to deal with space-qualification and particulate issues associated with the composite core).

Tray Component	**Thickness**
Detectors	2×0.43%
200 μm C-fiber face sheets	2×0.11%
Bias circuit	2×0.14%[3]
Core	0.077% to 0.18%
Adhesive	2×0.051%[4]
Total	**1.54% to 1.64%**

Other issues:

- Mass: the core assumed for mass estimates in our NASA proposal was 2 lb/ft^3 (as in the UCF-51 cores) for standard trays and nearly 3 times that for the thick-converter trays. Thus, the 5 kg increase from the lightest composite core to the lightest aluminum core would not represent a hit on the current mass estimates. In fact, the lightest aluminum core would save us about 20 kg with respect to the proposal mass estimate.
- Flight history. The YLA-146 has no flight history, while the UCF-51 has been on many flights.
- Surface coating: the composite core may create particulate pollution, and coating options must be considered.
- Stiffness: the requirement on minimum fundamental frequency is 527 Hz, which is met by all of the materials listed. This requirement was derived from the need to prevent touching of adjacent trays during launch vibration. Depending on how rigid is their attachment to the trays, the silicon detector ladders will provide significant additional stiffness.
- The lightweight composite core has a low compression modulus.
- The lightweight aluminum core has very thin walls, which easily bend over during handling (not a problem for the composite cores). However, John Broeder at SLAC has successfully built trays with these cores.

[3] This is for a circuit with a hatched ½-oz copper ground plane, as in the BTEM. The copper can be reduced in the future, but the polyamide will probably have to increase (IPC rules), so the total may be in this neighborhood.

[4] Assuming a solid 150-microns of adhesive on each size of the tray, with about 30 cm radiation length.