GLAST ACD Meteoroid/Debris Shielding

Initial Test and Analysis Results

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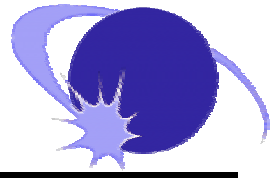
Lockheed/Dana Lear, GB-Tech/Frankel Lyons

17 July 2001

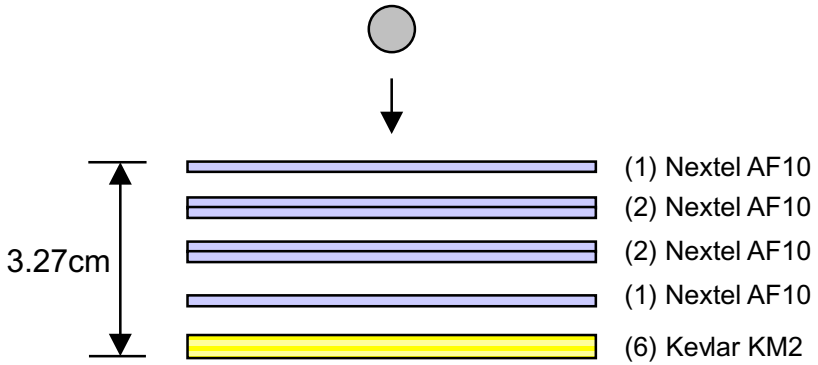


Gamma-ray Large Area Space Telescope (GLAST)
Meteoroid/Debris Risk Assessment Status

- Objective: Meet or exceed GLAST Anti-Coincidence Detector (ACD) Meteoroid/Debris requirements established by ACD Project Office: 0.95 probability of no penetration (PNP) of the ACD shielding over 5 year exposure period
- Shielding Design Constraints:
  - Mass per unit area of shielding not to exceed 0.3 g/cm^2
  - Total shield standoff not to exceed 3.27cm (desire 2cm)
- A combined hypervelocity impact test and analysis approach used to develop & verify GLAST ACD meteoroid/debris shielding
  - Hypervelocity impact testing used to assess various shielding options, determine particle size at threshold of shield failure for a limited set of impact conditions, and certify final shielding configuration
  - Ballistic limit equations developed from test data and analysis. Equations used to predict threshold particle size resulting in shield failure at all potential meteoroid/debris impact velocities, angles and particle densities.
  - BUMPER code used to assess GLAST ACD Probability of No Penetration (PNP) for a variety of operational attitudes

GLAST Meteoroid/Debris Risk Assessment Status (Continued)

- Baseline shield concept evaluated by initial hypervelocity impact tests is a Nextel/Kevlar multi-shock shield.
  - Nextel ceramic cloth bumpers are effective at projectile breakup (6 layers of Nextel 312, style AF10 fabric)
  - Kevlar (high strength to weight) rear wall provides final barrier to penetration high (6 layers of Kevlar KM2, style CS-705 fabric)
  - Open cell, solimide foam spacers used between bumper layers to maintain separation (initial tests conducted without foam)
- Tests indicate shield will stop a 1.8mm diameter aluminum sphere at 7km/s, and 0^{o} impact angle (normal to shield)



Component	Number in Shield	Thickness each (cm)	Mass per Unit Area each (g/cm^2)	Total thickness (cm)	Total Mass per Unit Area (g/cm^2)
Nextel AF10	6	0.0254	0.025	0.152	0.150
Solimide Foam spacer	4	0.66	0.0051	2.640	0.020
Thermal blanket	1	0.32	0.0368	0.320	0.037
Kevlar KM2	6	0.0254	0.023	0.152	0.138
Overall Shield				**3.26**	**0.345**

GLAST Meteoroid/Debris Risk Assessment Status (Continued)

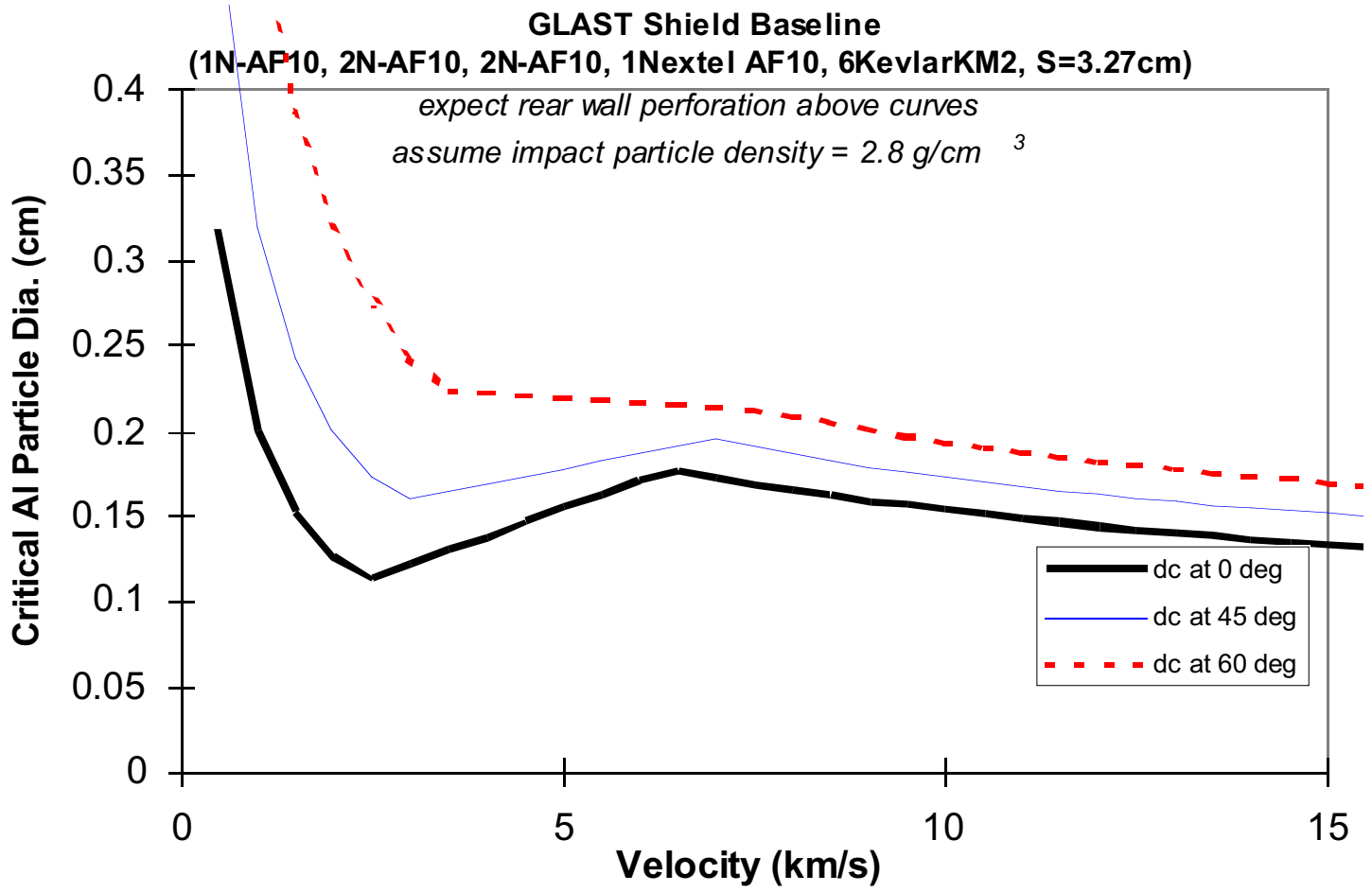
- Initial ballistic limit equations developed and coded into BUMPER program
- Preliminary PNP assessments indicate assessed PNP exceeds requirement for the 3.27cm standoff, marginally below at 2.6cm, and will not meet requirement at 2cm standoff

Standoff	5-yr PNP
3.27cm	0.963
2.6 cm	0.947
2.0 cm	0.916

  - PNP analysis indicates the sides of the GLAST ACD are exposed to 80% of the meteoroid/debris penetration threat but only represent 60% of the area. This indicates that standoff and shielding could be reduced on top and lower edge with greater savings in weight and less impact on PNP.
- Forward work:
  - Reduce shielding weight by 10% (< 0.3 g/cm^2 target)
  - Include solimide foam and thermal blanket in HVI tests
  - Develop/assess shielding techniques to reduce shielding weight and improve shielding performance

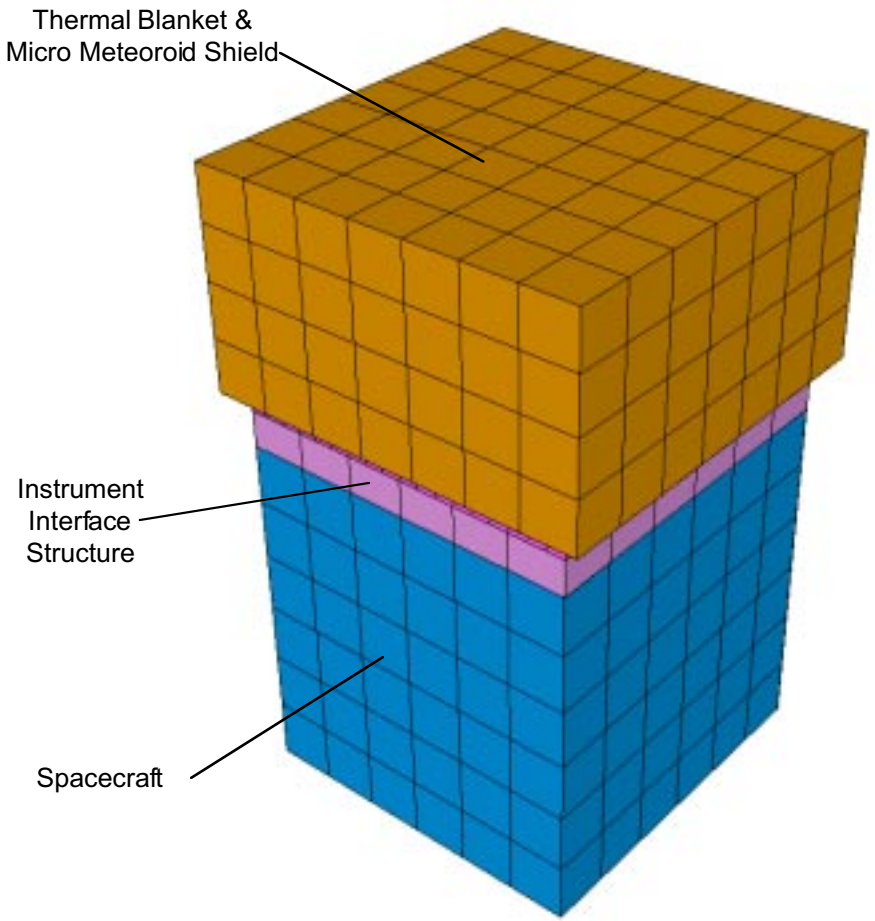
Baseline GLAST shield ballistic limits

- Preliminary ballistic limit equations developed for GLAST shielding
- Equations coded into BUMPER
- To be updated based on additional HVI test results

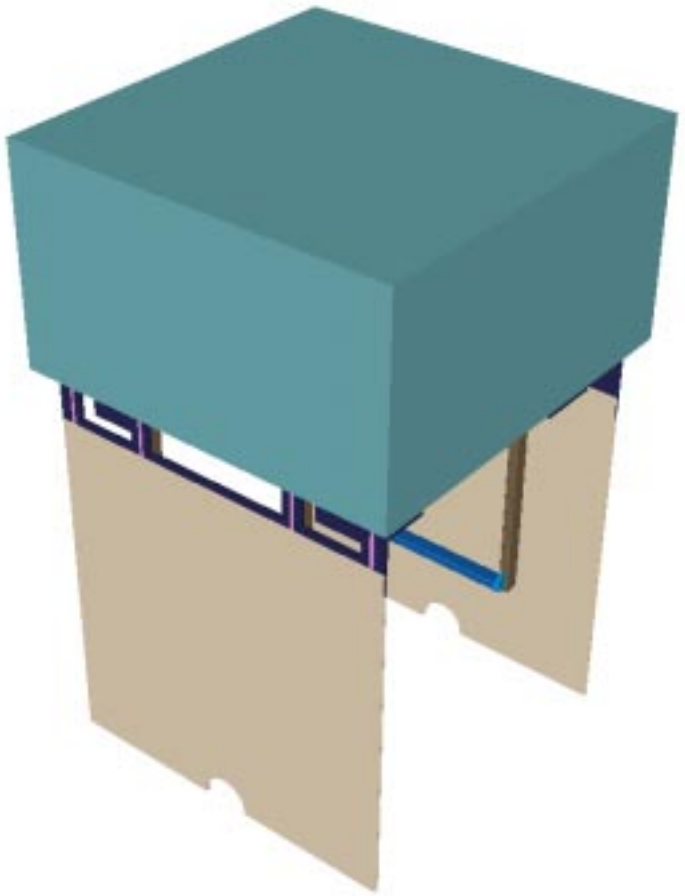


Comparison of Finite Element Model and Original Geometry Model

BUMPER Finite Element Model

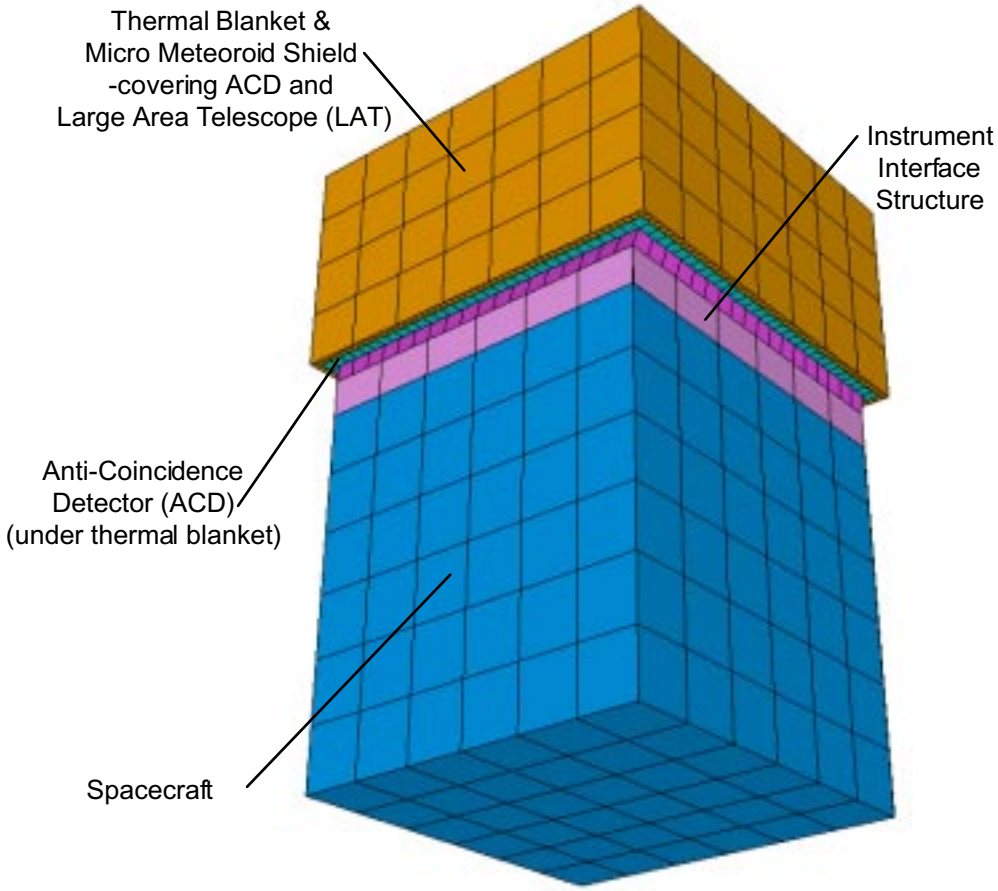


GLAST Geometry Model

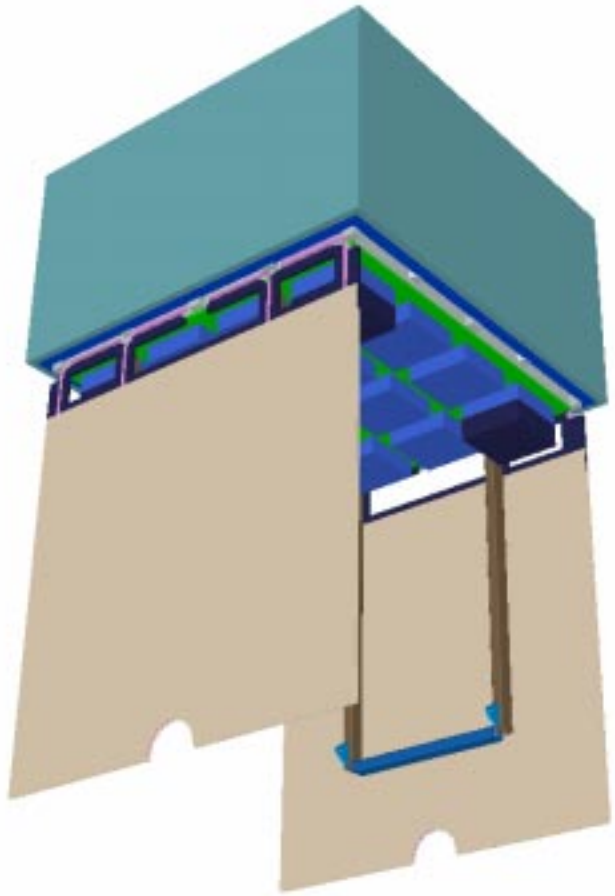


Comparison of Finite Element Model and Original Geometry Model

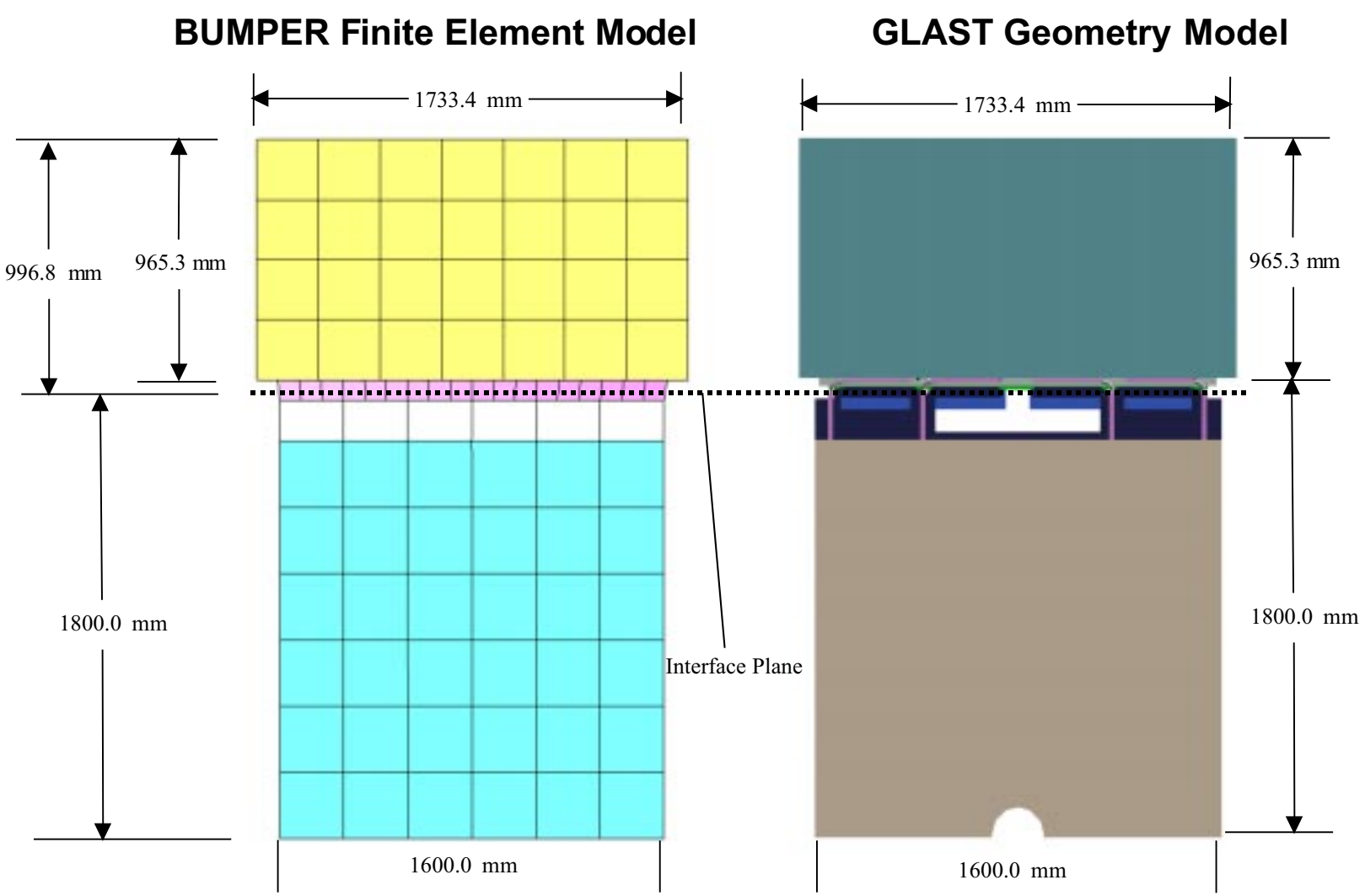
BUMPER Finite Element Model



GLAST Geometry Model

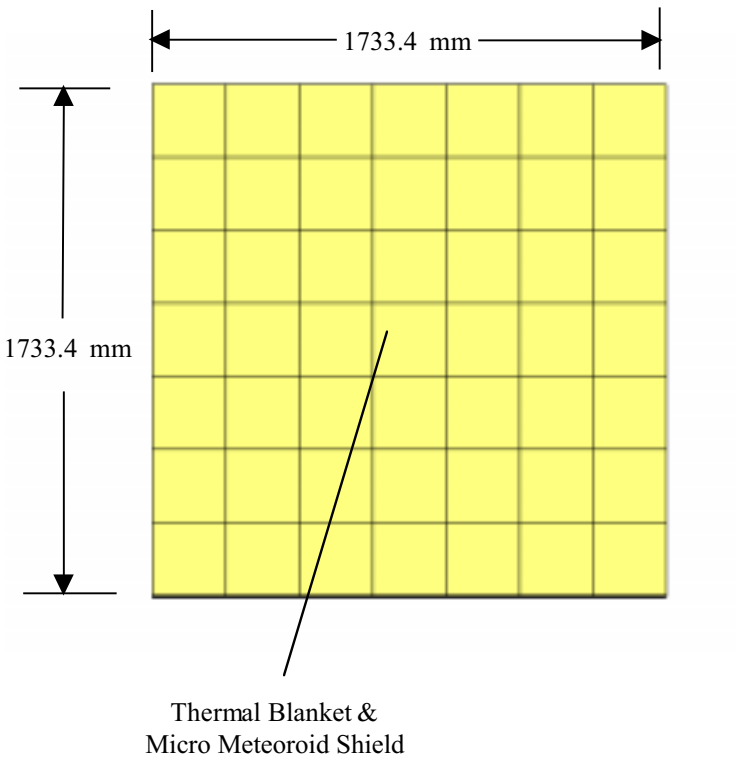


Comparison of Finite Element Model and Original Geometry Model (Side View)

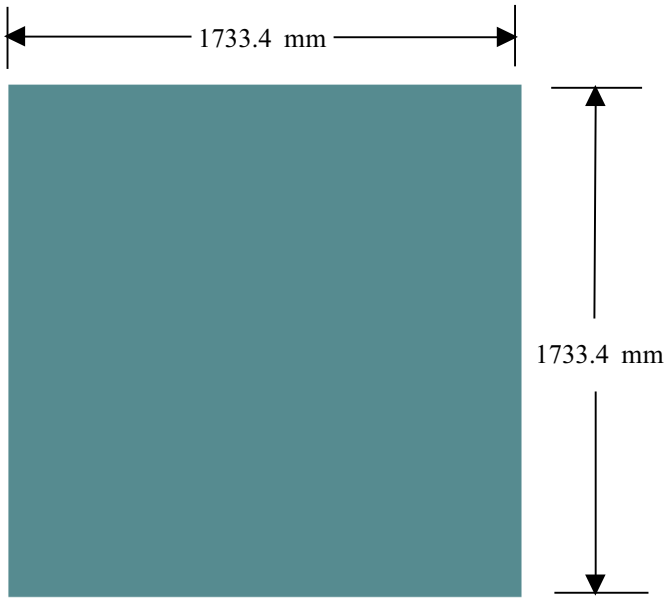


Comparison of Finite Element Model and Original Geometry Model (Top View)

BUMPER Finite Element Model



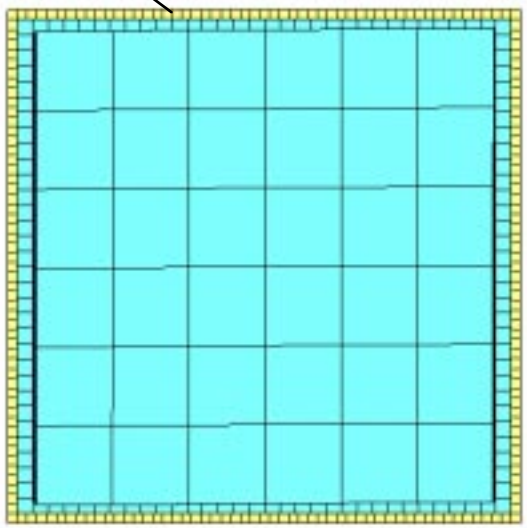
GLAST Geometry Model



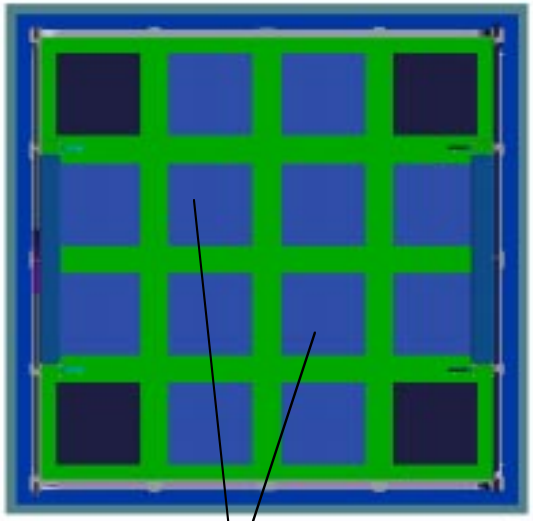
Comparison of Finite Element Model and Original Geometry Model (Bottom View)

BUMPER Finite Element Model

Thermal Blanket &
Micro Meteoroid Shield



GLAST Geometry Model

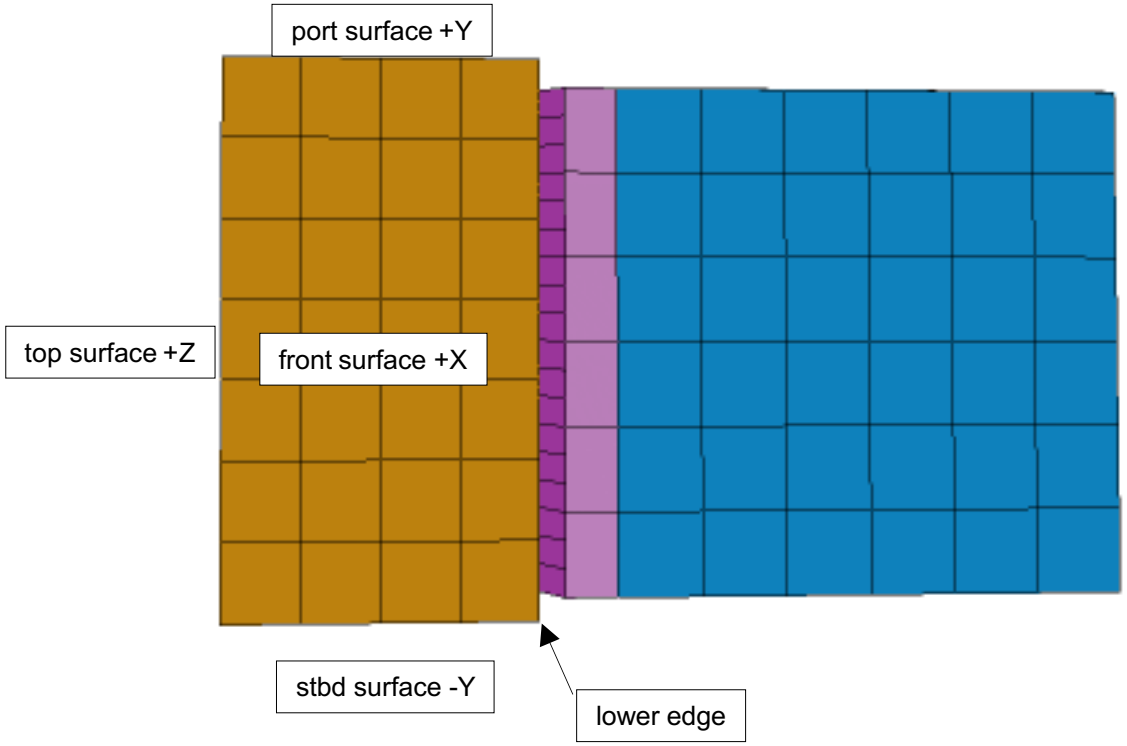


Calorimeter Electronics

GLAST Attitude 1B1 (37.50 % of mission duration)

Mode: Sky Survey (75% of mission) & Sub-Mode: Non-Step Rocking (50% of mode)

Zenith



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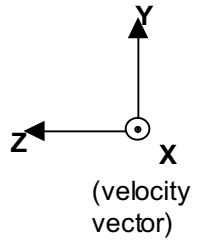
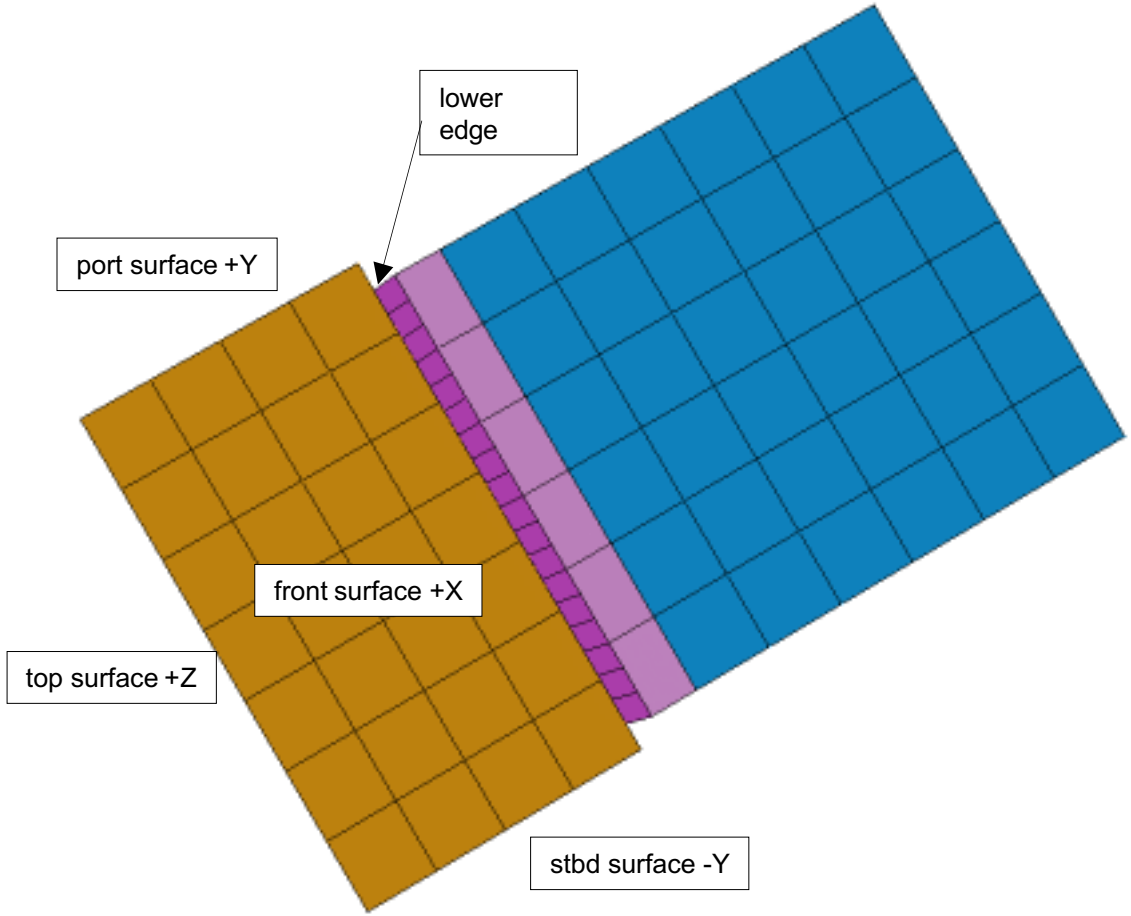
(Note: velocity vector points out of page)



GLAST Attitude 1A1 (18.75 % of mission duration)

Mode: Sky Survey (75% of mission) & Sub-Mode: Step Rocking (25% of mode)

Zenith



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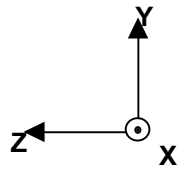


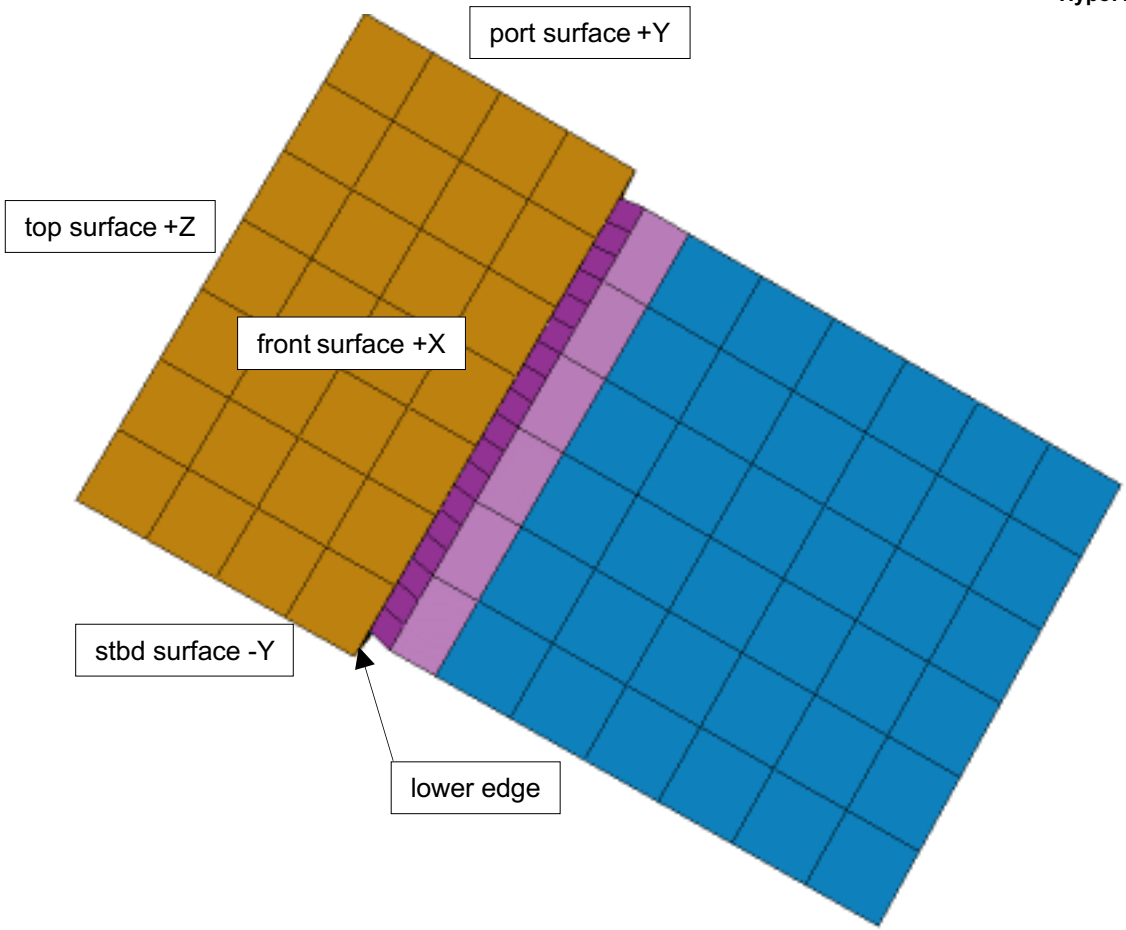
(velocity vector)

GLAST Attitude 1A2 (18.75 % of mission duration)

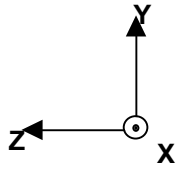
Mode: Sky Survey (75% of mission) & Sub-Mode: Step Rocking (25% of mode)

Zenith

Nadir



Note: velocity vector points out of page



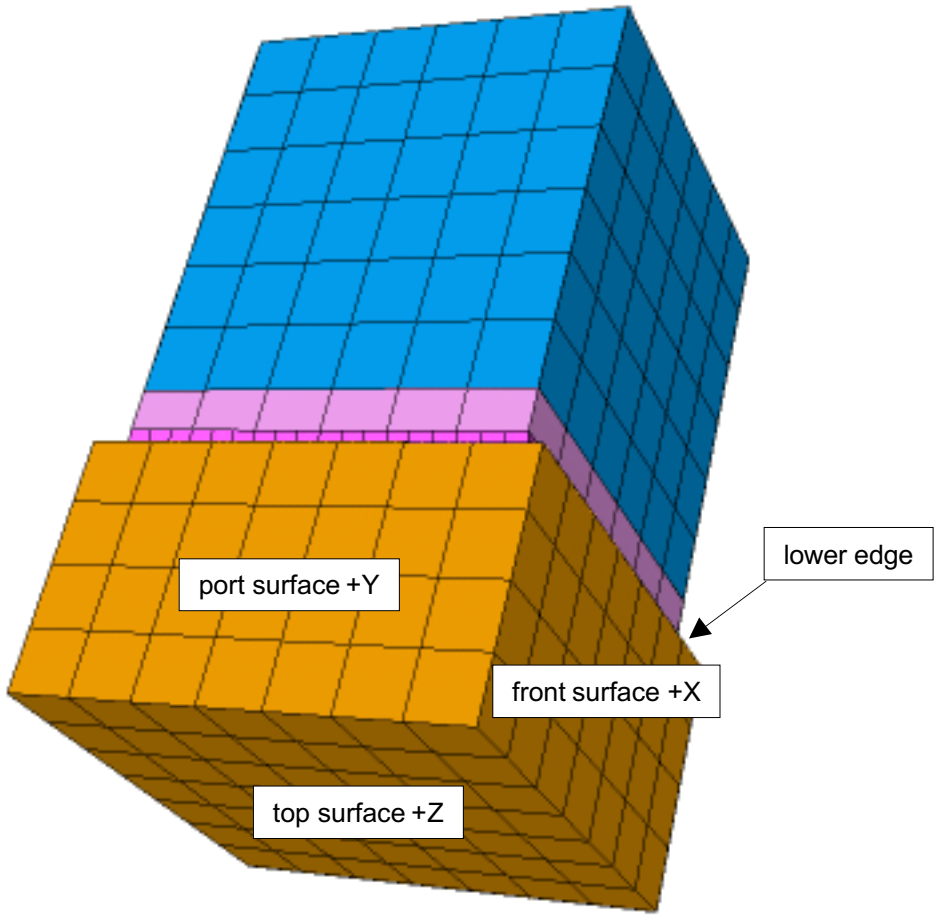
(velocity vector)

GLAST Attitude 2A1 (6.25 % of mission duration)

Mode: Pointed Observation (25% of mission) & Sub-Mode: Target Tracking (25% of mode)

Zenith

Nadir



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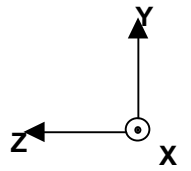

(velocity vector)

GLAST Attitude 2A2 (6.25 % of mission duration)

Mode: Pointed Observation (25% of mission) & Sub-Mode: Target Tracking (25% of mode)

Zenith

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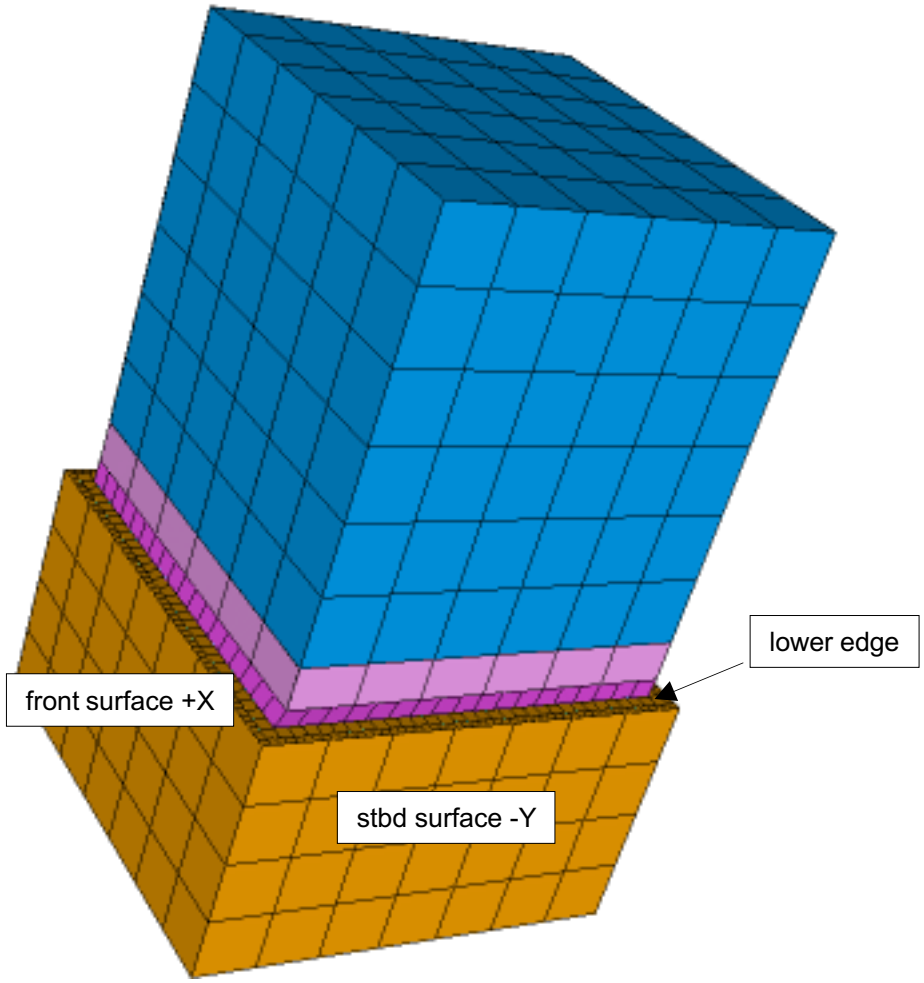

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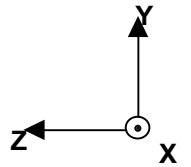
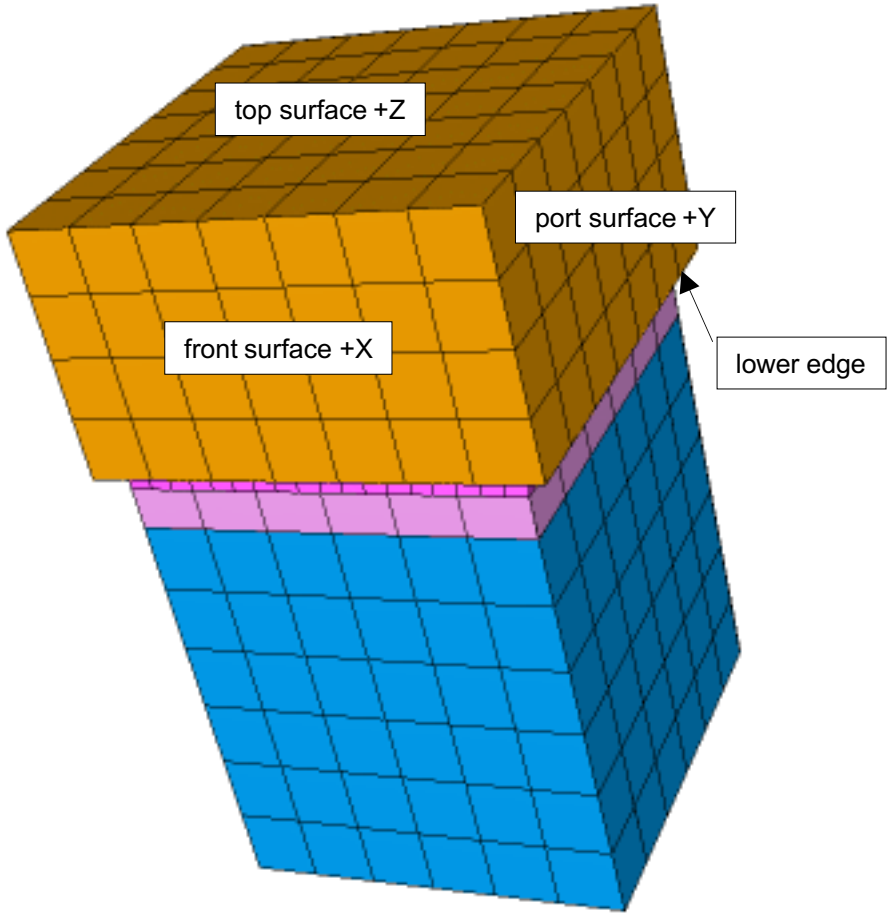


(velocity vector)

GLAST Attitude 2A3 (6.25 % of mission duration)

Mode: Pointed Observation (25% of mission) & Sub-Mode: Target Tracking (25% of mode)

Zenith



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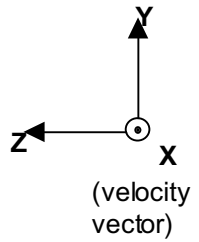
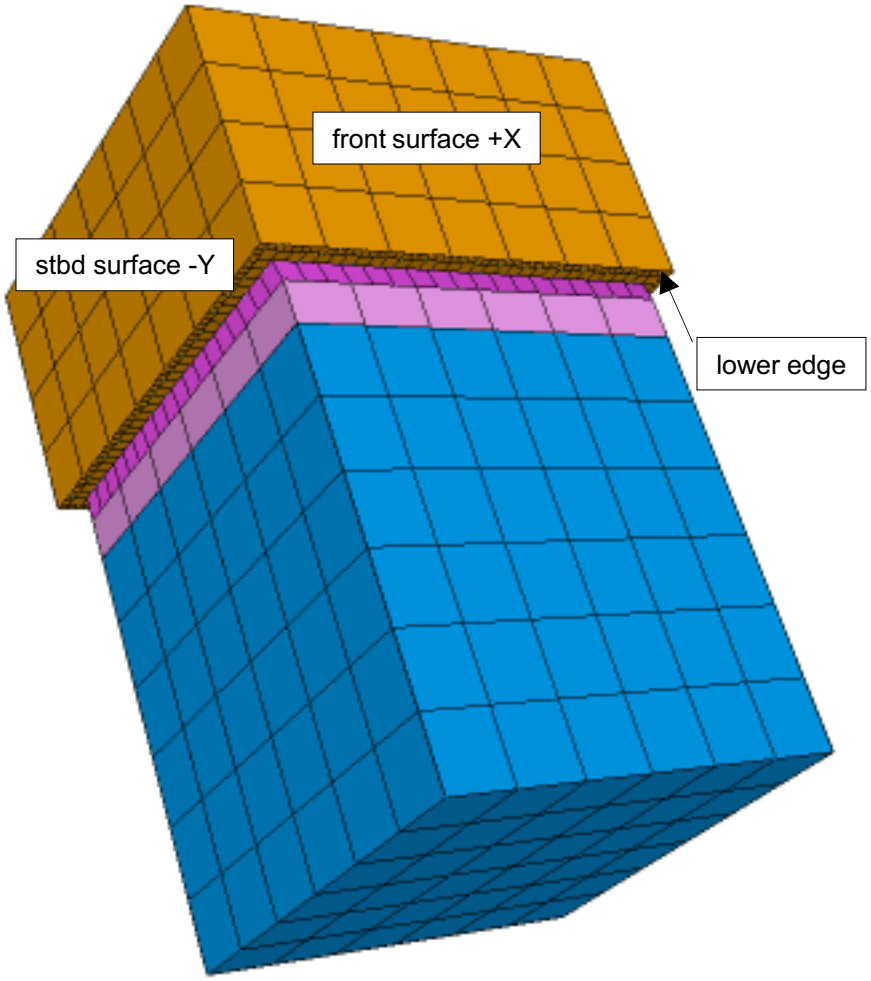
(Note: velocity vector points out of page)



(velocity vector)

GLAST Attitude 2A4 (6.25 % of mission duration)

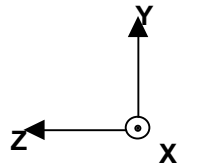
Mode: Pointed Observation (25% of mission) & Sub-Mode: Target Tracking (25% of mode)



Zenith

Nadir

(Note: velocity vector points out of page)



(velocity vector)

BUMPER GLAST Meteoroid/Debris Risk Assessment: Input Parameters

NASA Johnson Space Center

Hypervelocity Impact Technology Facility/SN3

METEOROIDS PERFORMANCE ASSESSMENT

BUMPERII VERSION 1.81
SSP 30425 FLUX EQUATIONS
NUMBER OF THREATS = 145
SPACECRAFT ALTITUDE (KM) = 550.000
SPACECRAFT EXPOSURE TIME (YEARS) = 5.0000
METEOROID VELOCITIES IN SSP 30425 REV. A
FINITE ELEMENT MODELS:
glast_v01.unv

DEBRIS PERFORMANCE ASSESSMENT

BUMPERII VERSION 1.81
TM 104825 DEBRIS FLUXEQUATIONS
SPACECRAFT ORBIT INCLINATION (DEG) = 28.5000
NUMBER OF THREATS = 90
SPACECRAFT ALTITUDE (KM) = 550.000
BEGINNING EXPOSURE DATE = 2005.5000
CURRENT SOLAR RADIO FLUX DATA, UPDATED 04/00
SPACECRAFT EXPOSURE TIME (YEARS) = 5.0000
MAN-MADE DEBRIS CONSTANT DENSITY
FINITE ELEMENT MODELS:
glast_v01.unv

ORIENTATIONS: ATTITUDES (S123)

#	MODE	ROLL	PITCH	YAW	% of Mode	Mode % of Mission	% of Mission
1A1	SKY SURV/ STEP ROCKING	30.0	0.0	0.0	25.00%		18.75%
1A2	SKY SURV/ STEP ROCKING	-30.0	0.0	0.0	25.00%	75.00%	18.75%
1B1	SKY SURV/ NO STEP ROCKING	0.0	0.0	0.0	50.00%		37.50%
2A1	POINTED OBSERVATION	60.0	60.0	0.0	25.00%		6.25%
2A2	POINTED OBSERVATION	60.0	-60.0	0.0	25.00%	25.00%	6.25%
2A3	POINTED OBSERVATION	-60.0	60.0	0.0	25.00%		6.25%
2A4	POINTED OBSERVATION	-60.0	-60.0	0.0	25.00%		6.25%
						Total:	100.00%

BUMPER Predicted Meteoroid/Debris Risk Breakdown for GLAST Shielding with 3.27cm standoff

Gamma-ray Large Area Space Telescope (GLAST)	PNP (2005.5 + 5-years)				Risk to Area Ratio				
	Meteoroid	Debris	Combined	%	Risk (1-PNP)	% of Total Risk	Area (m^2)	% of Total Area	Risk to Area Ratio
Large Area Telescope (LAT) M/OD Blanket:	0.99129	0.97157	**0.96310**	100.0%	3.7%	100%	10.26	100%	1.00
top surface (+Z)	0.99735	0.99590	0.99326	18.0%	0.7%	18%	3.01	29%	0.62
front surface (+X)	0.99669	0.99471	0.99141	22.9%	0.9%	23%	1.67	16%	1.43
port surface (+Y)	0.99878	0.99412	0.99291	18.9%	0.7%	19%	1.67	16%	1.18
stbd surface (-Y)	0.99878	0.99412	0.99291	18.9%	0.7%	19%	1.67	16%	1.18
aft surface (-X)	0.99976	0.99280	0.99256	19.9%	0.7%	20%	1.67	16%	1.24
lower edge	0.99992	0.99958	0.99950	1.3%	0.1%	1%	0.56	5%	0.25

GLAST Shield Properties for BUMPER Analysis

ISS M&D Critical Item	Surface Area	Shield		"Analysis" Shield Configuration						Critical Particle Dia
				Bumper		s.o.	inter.	Rear Wall		
Gamma-ray Large Area Space Telescope (GLAST)	(m^2)	PID	Type	(cm)	material	(cm)	layers	(cm)	material	@7 km/s (cm)
Large Area Telescope (LAT) MOD Blanket:	**24.342**	-	-	-	-	-	-	-	-	-
top surface (+Z)	3.005	2	M	0.60	(6) Nextel AF10 (b=0.162)	3.27	-	0.17	(6) Kevlar KM2 (b=0.138)	0.1731
front surface (+X)	1.673	2	M	0.60	(6) Nextel AF10 (b=0.162)	3.27	-	0.17	(6) Kevlar KM2 (b=0.138)	0.1731
port surface (+Y)	1.673	2	M	0.60	(6) Nextel AF10 (b=0.162)	3.27	-	0.17	(6) Kevlar KM2 (b=0.138)	0.1731
stbd surface (-Y)	1.673	2	M	0.60	(6) Nextel AF10 (b=0.162)	3.27	-	0.17	(6) Kevlar KM2 (b=0.138)	0.1731
aft surface (-X)	1.673	2	M	0.60	(6) Nextel AF10 (b=0.162)	3.27	-	0.17	(6) Kevlar KM2 (b=0.138)	0.1731
lower edge	0.559	2	M	0.60	(6) Nextel AF10 (b=0.162)	3.27	-	0.17	(6) Kevlar KM2 (b=0.138)	0.1731
Instrument Interface Structure Region 1	0.531	3	S	shadowing						20.0000
Instrument Interface Structure Region 2	1.025	4	S	shadowing						20.0000
Spacecraft	12.530	5	S	shadowing						20.0000