JPL

GALEX

The Galaxy Evolution Explorer

Thermal Balance Test Verification of the Galaxy Evolution Explorer (GALEX) Thermal Design

Presented by

Patrick Wu / Glenn Tsuyuki
Jet Propulsion Laboratory

Siu-Chun Lee / Chern-Jiin Lee
Applied Sciences Laboratory, Inc.

February 28, 2001

ASL

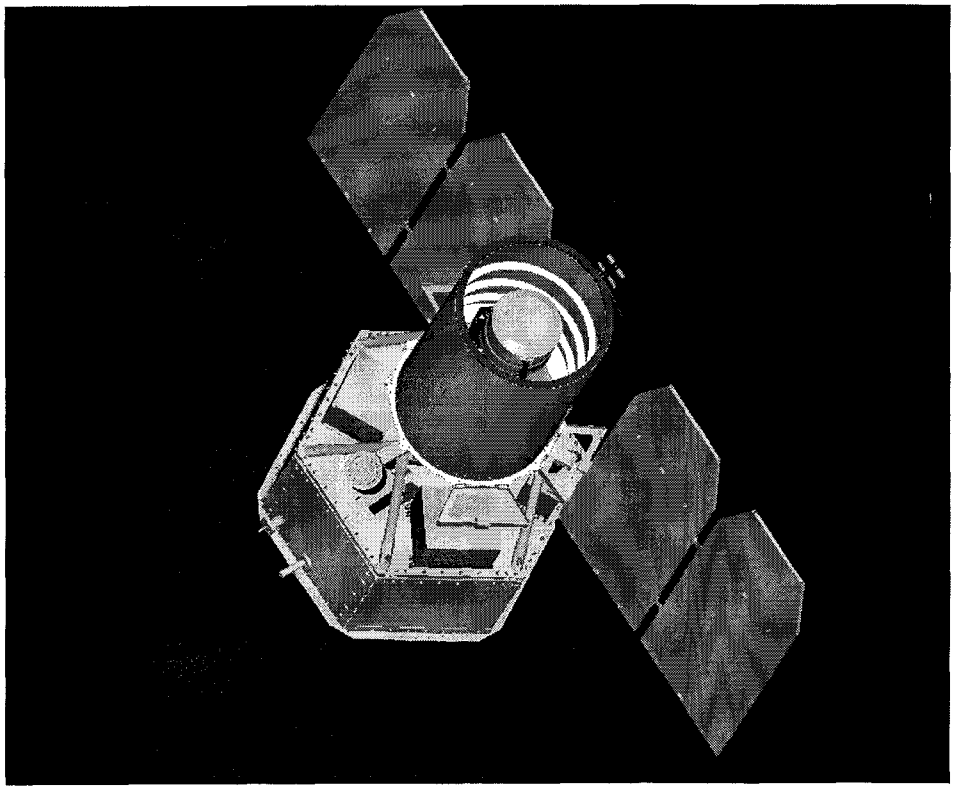
JPL

GALEX

The Galaxy Evolution Explorer

Outline

- Mission Objective
- Instrument Configuration
- Thermal Environments
- Key Thermal Design Features
- Thermal Balance Test
  - *Facility and Configuration*
  - *Test Profile*
  - *Results*
- Summary



ASL

JPL

In Mission Objective

GALEX
The Galaxy Evolution Explorer

- Scientific Objective
  - *Map the history of star formation over 80% of the age of the Universe*
    - When and where did stars and elements we see today have their origins?
  - *Generate the first map of the ultraviolet Universe*

- Approach
  - *From Earth orbit, perform ultraviolet imaging and spectroscopic surveys of tens of thousands of galaxies at varying distances*
  - *Determine the rates of star formation in each of these galaxies*
  - *Make statistical measurements of star formation as a function of*
    - galaxy age
    - galaxy type (morphology, dust content, metallicity)
    - association (clustering, interactions)

ASL

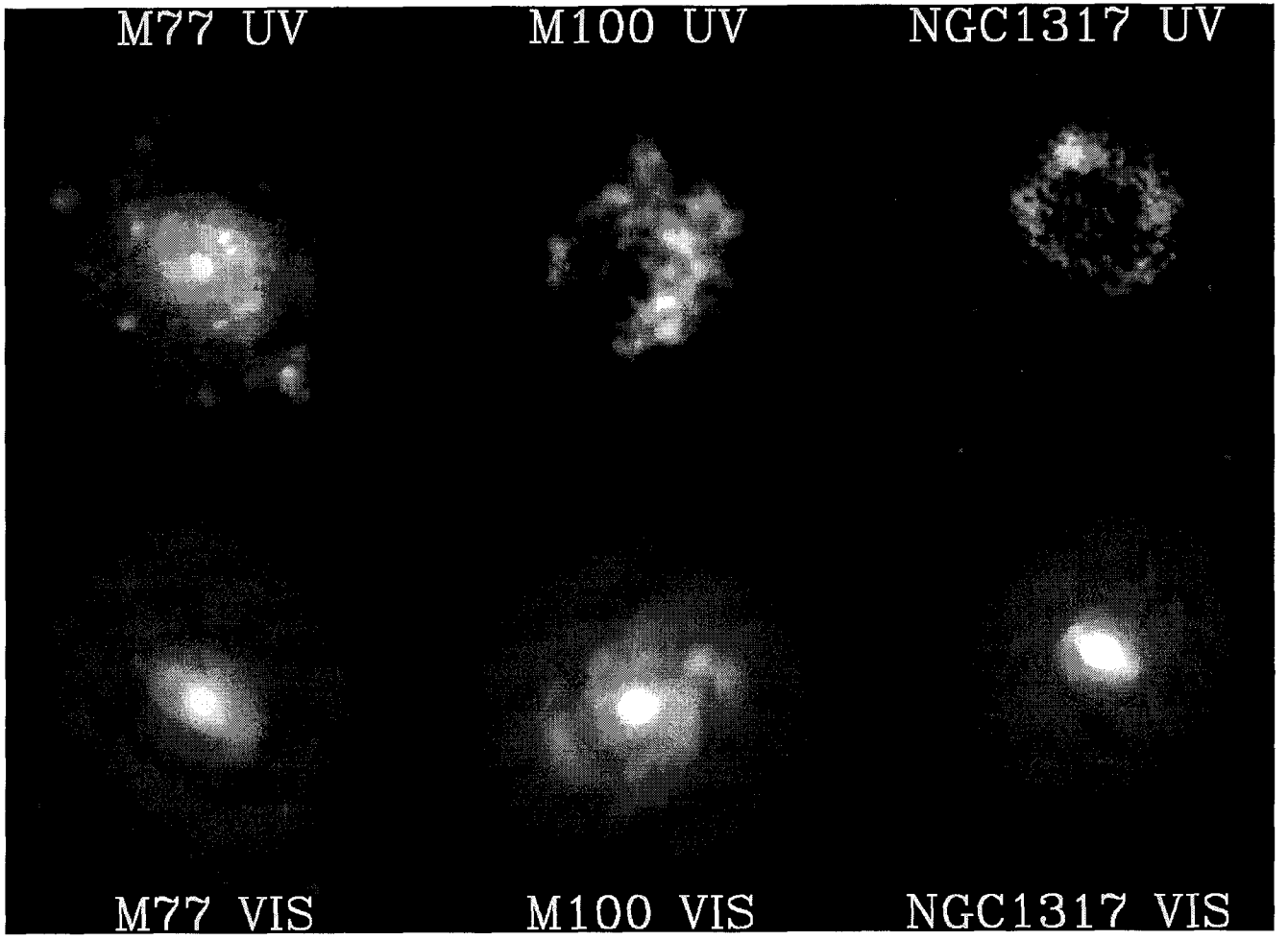
JPL

UV Images of Galaxies Reveal Regions of Active Star Formation

GALEX
The Galaxy Evolution Explorer

Ultraviolet

Visible



ASL

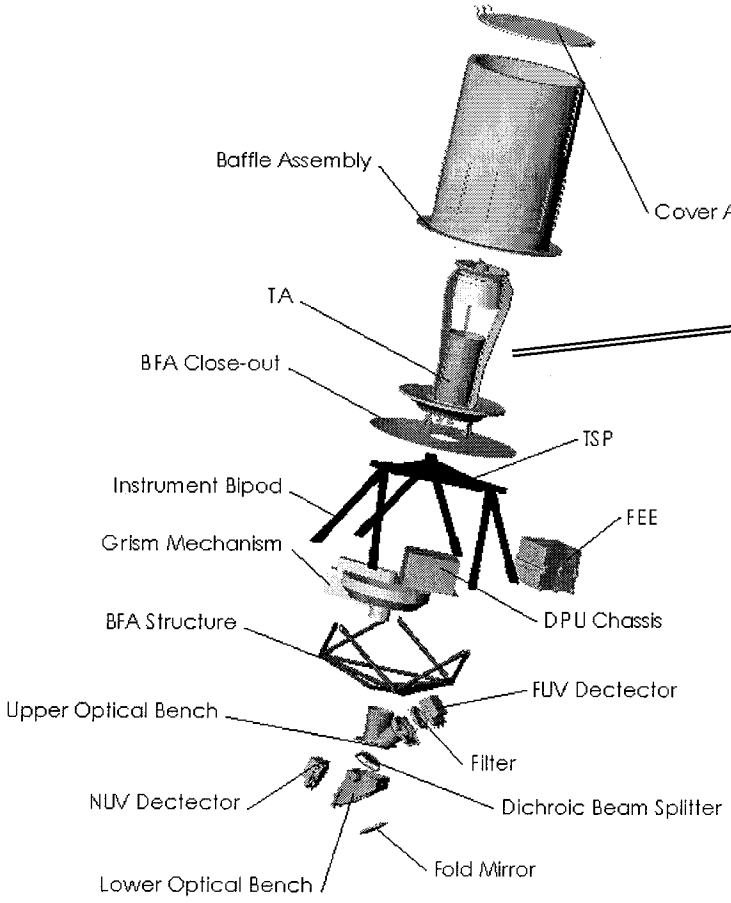
JPL

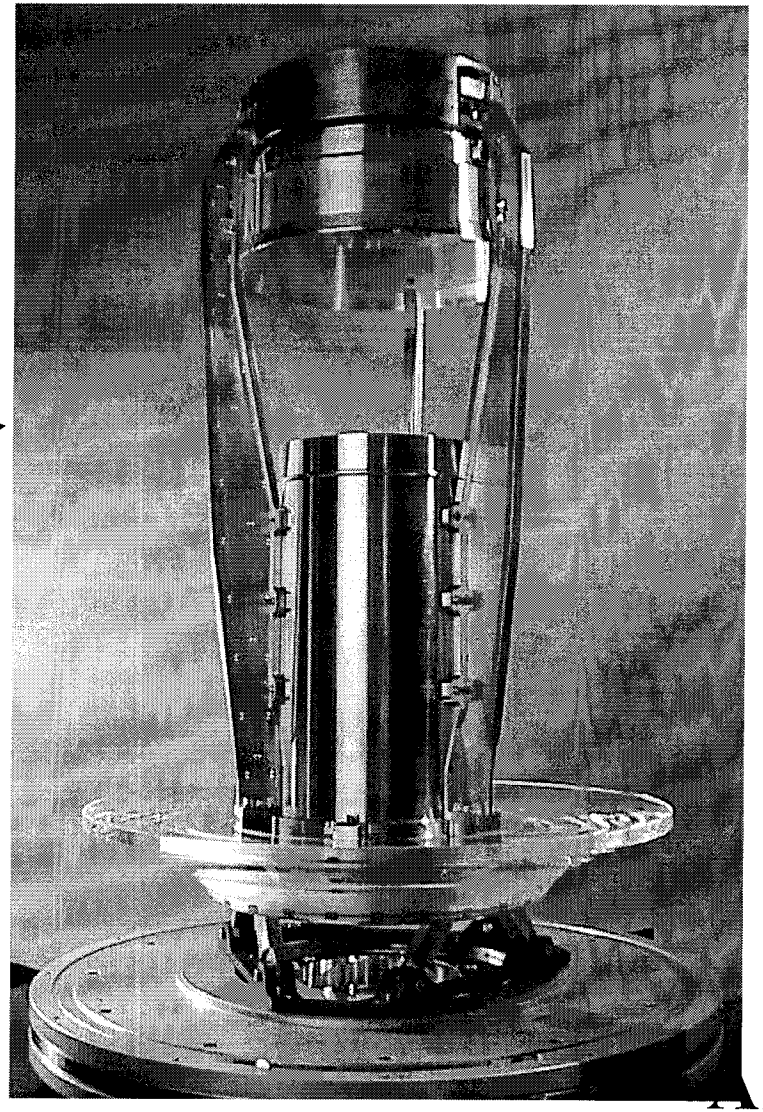
GALEX

The Galaxy Evolution Explorer

Instrument Configuration

GALEX INSTRUMENT ASSEMBLY





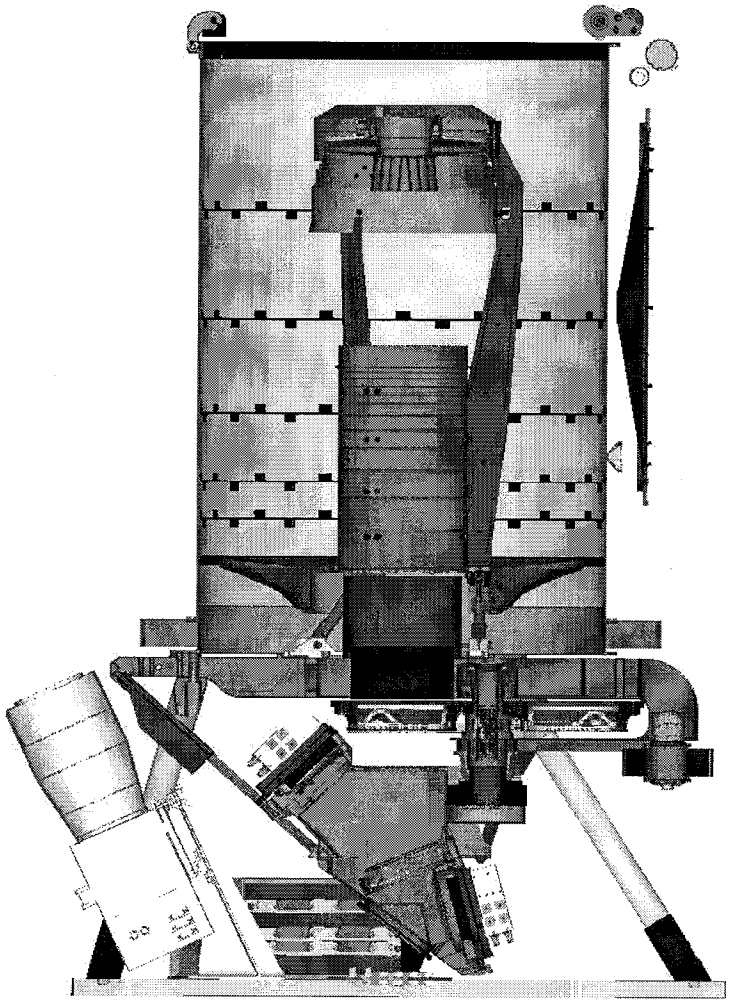
ASL

JPL

GALEX

The Galaxy Evolution Explorer

GALEX Configuration (Cont'd)



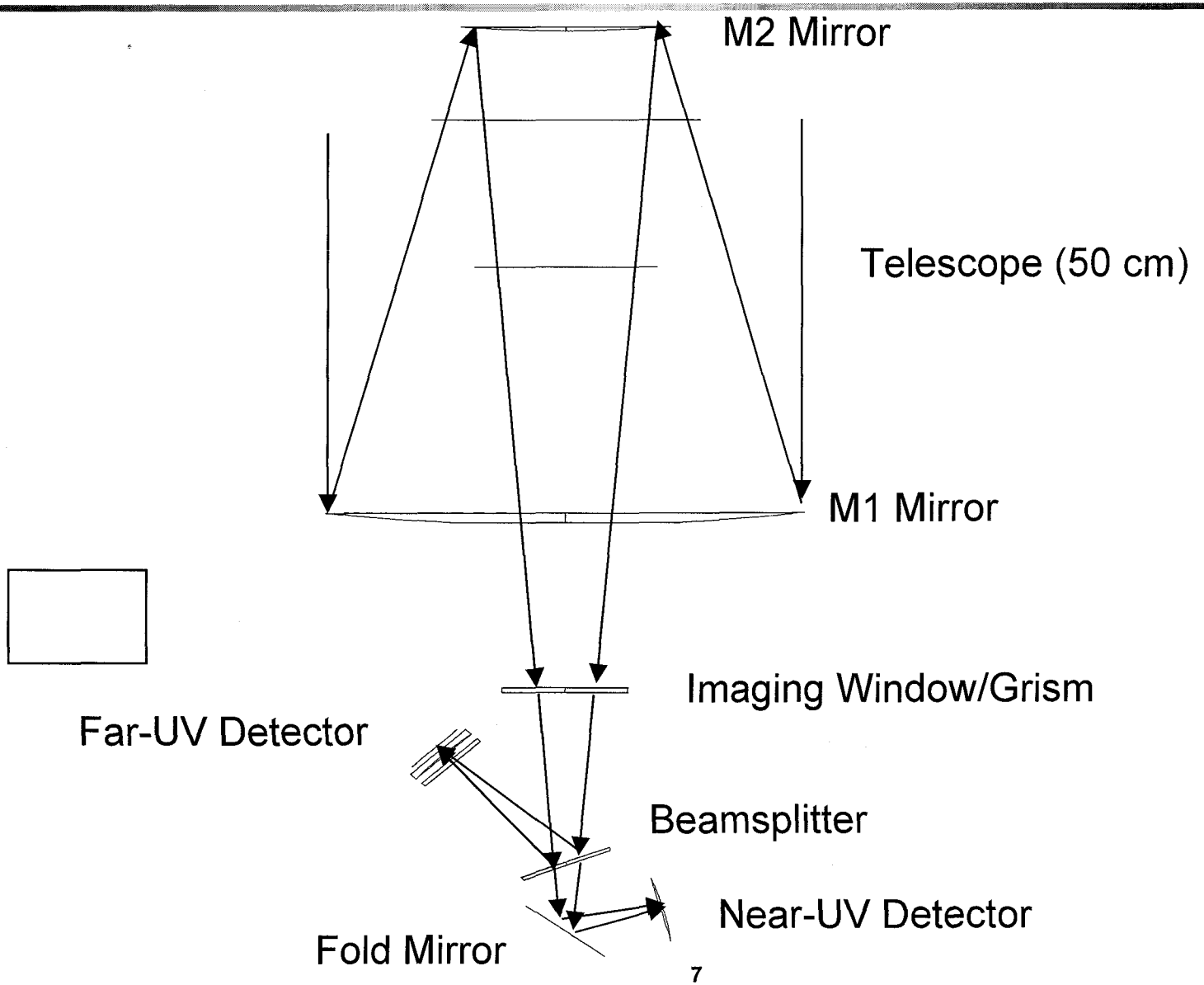
ASL

JPL

GALEX

The Galaxy Evolution Explorer

Galex Optical Design



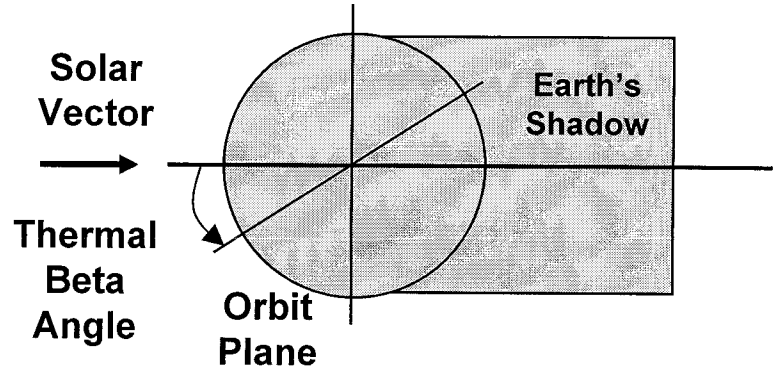
ASL

JPL

Thermal Environment for Design

GALEX

- Orbital parameters
  - *Circular orbit @ 690 km*
  - *28.5° inclination*
- Flight system attitude
  - *Solar panel perpendicular to solar vector while in the sun*
  - *Any orientation within hemisphere opposite solar vector during eclipse*
- Thermal beta angle ranges between ±52°
- Environmental parameters stacked to produce worst-hot & cold conditions



	Worst Cold	Nominal	Worst Hot
Solar Constant (W/m^2)	1287	1367.5	1420
Earth Albedo	0.2	0.3	0.4
Earth Emissive Power (W/m^2)	189	241	260

ASL

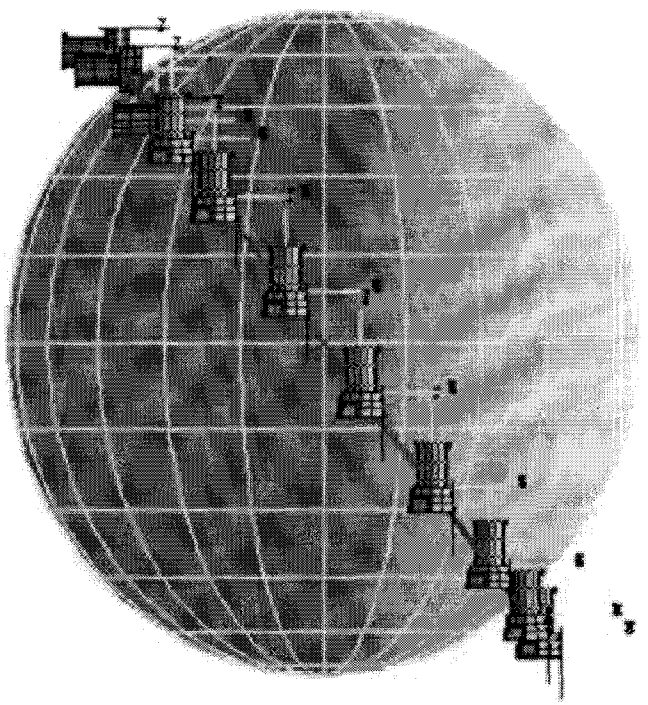
JPL

GALEX

The Galaxy Evolution Explorer

Instrument Orientation

Hot Case: β = 52°



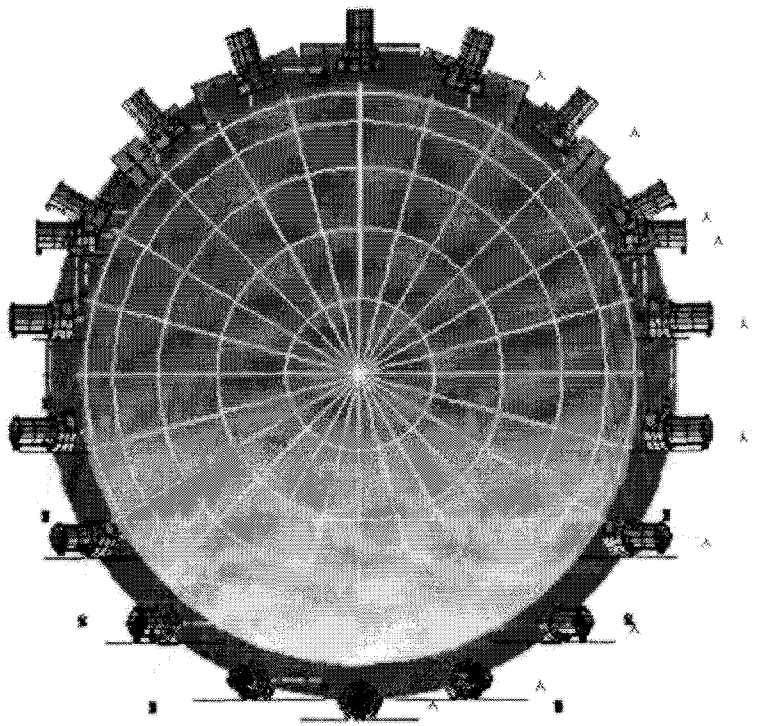
Sun

Along Ascending Node

View from Sun

Hot case: Telescope normal to sun during daytime and aligned with solar vector at night

Cold Case: β = 0°



Sun

View normal to Orbit Plane

Cold case: Telescope slewing during daytime and anti-nadir at night

ASL

JPL

GALEX

The Galaxy Evolution Explorer

Thermal Design Features

- Telescope Assembly
  - *MLI and appropriate thermal control coatings*
  - *Thermal shields with heaters for M1 and M2*
- Equipment Bay
  - *MLI around instrument deck*
  - *Black paint on all equipment*
  - *Dedicated radiators for DPU and FEE*
- Heaters & thermostats
  - *M1 & M2 survival heaters controlled by thermostats located on DPU*
  - *Operational & decontamination heaters for M1 / M2 controlled by DPU (Set points and peak power can be changed)*
  - *Instrument replacement heaters activated by thermostats located on DPU and FEE chassis*

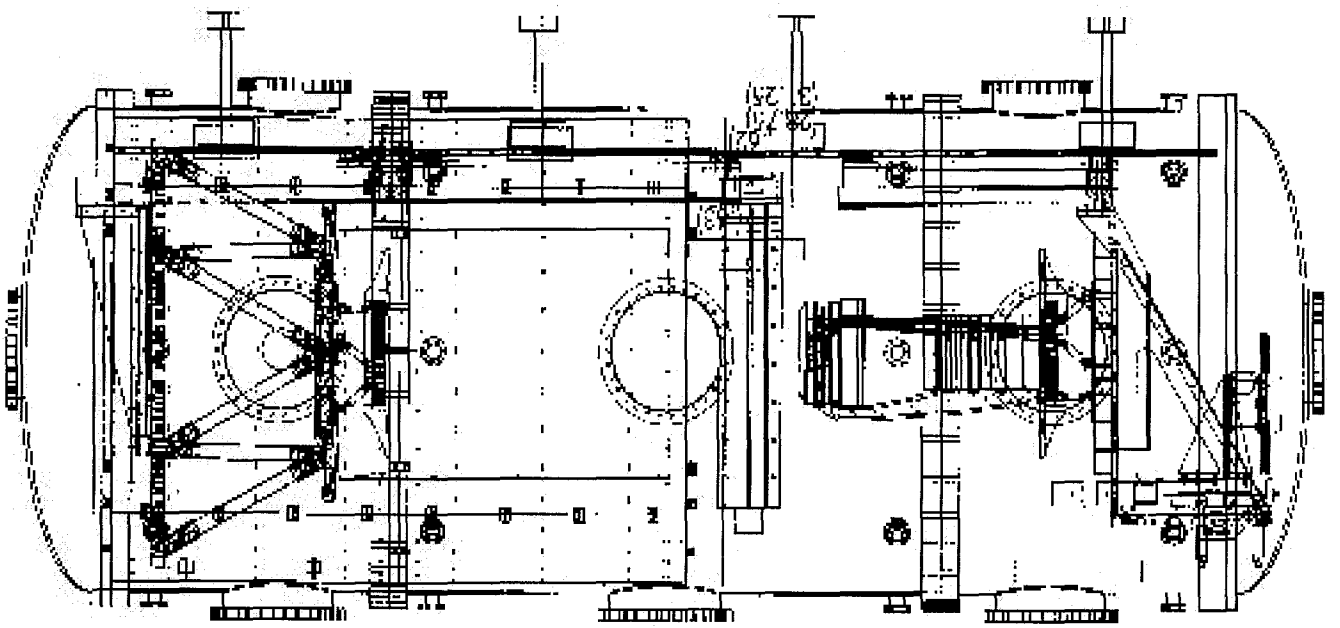
JPL

GALEX

The Galaxy Evolution Explorer

Thermal Balance Test Configuration

Thermal Vacuum Chamber



Flight Instrument **Collimator**

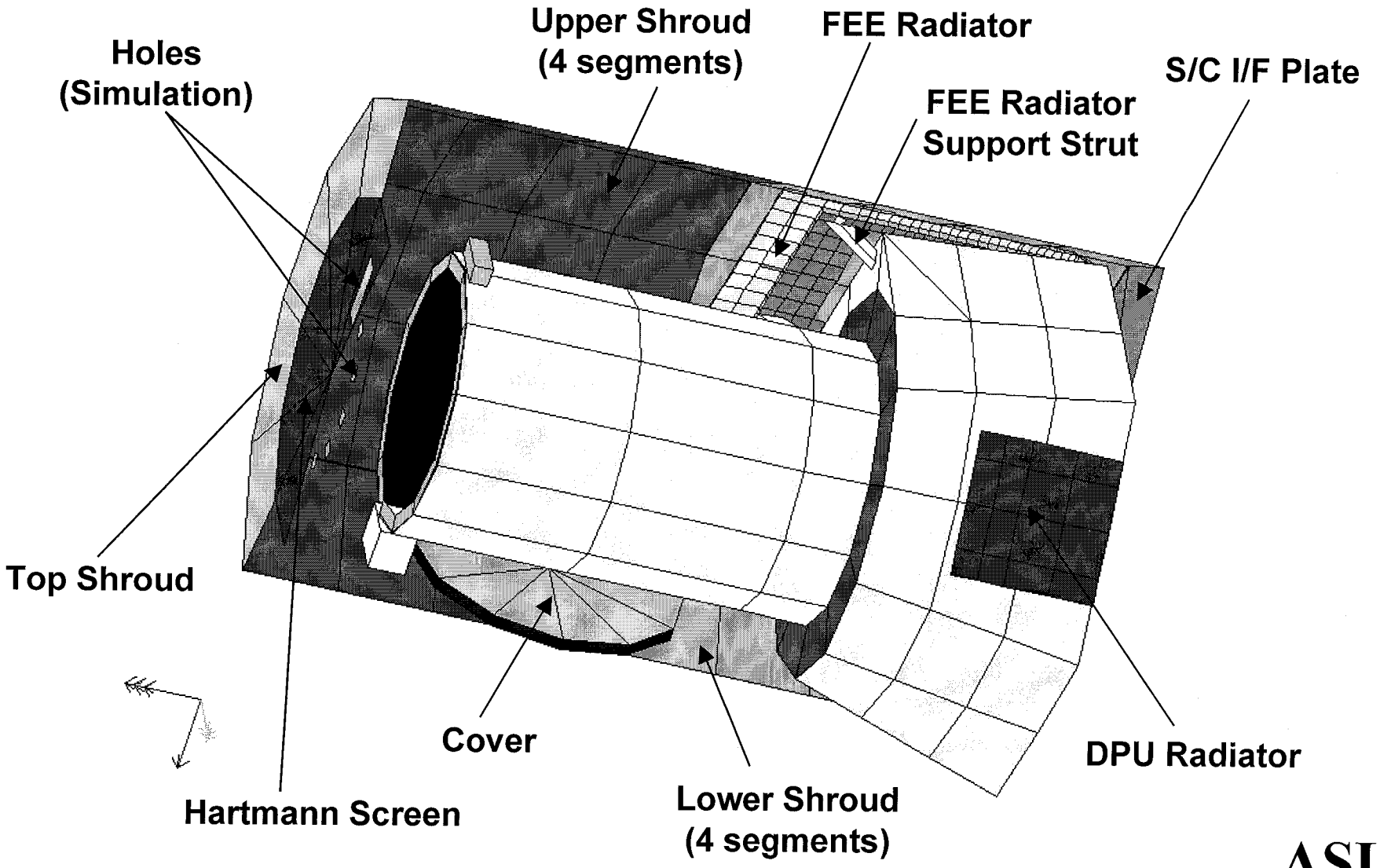
ASL

JPL

GALEX

The Galaxy Evolution Explorer

Thermal Model in Test Configuration



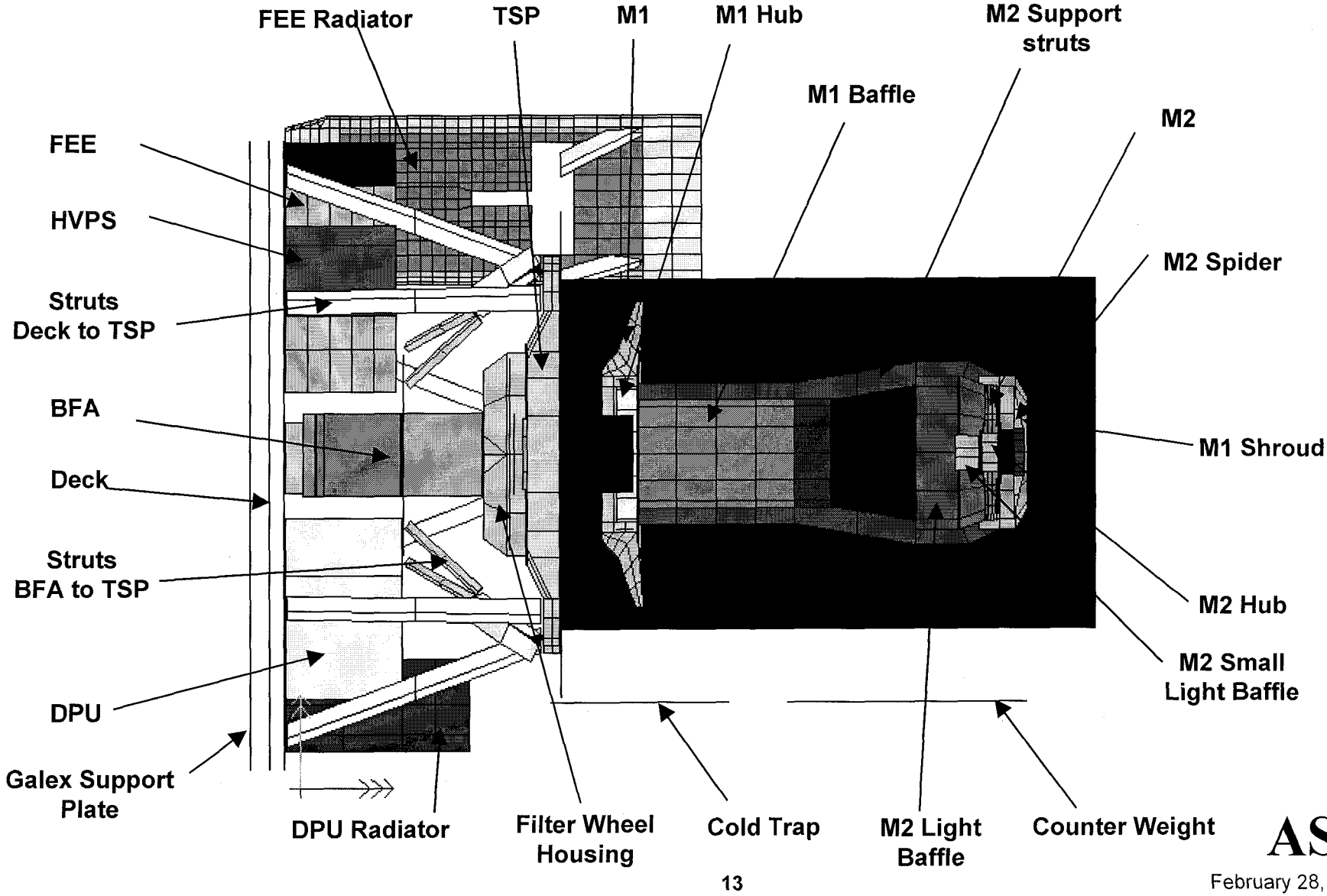
ASL

JPL

GALEX

The Galaxy Evolution Explorer

Test Configuration (Exploded View)



ASL

JPL

GALEX

The Galaxy Evolution Explorer

Test Approach

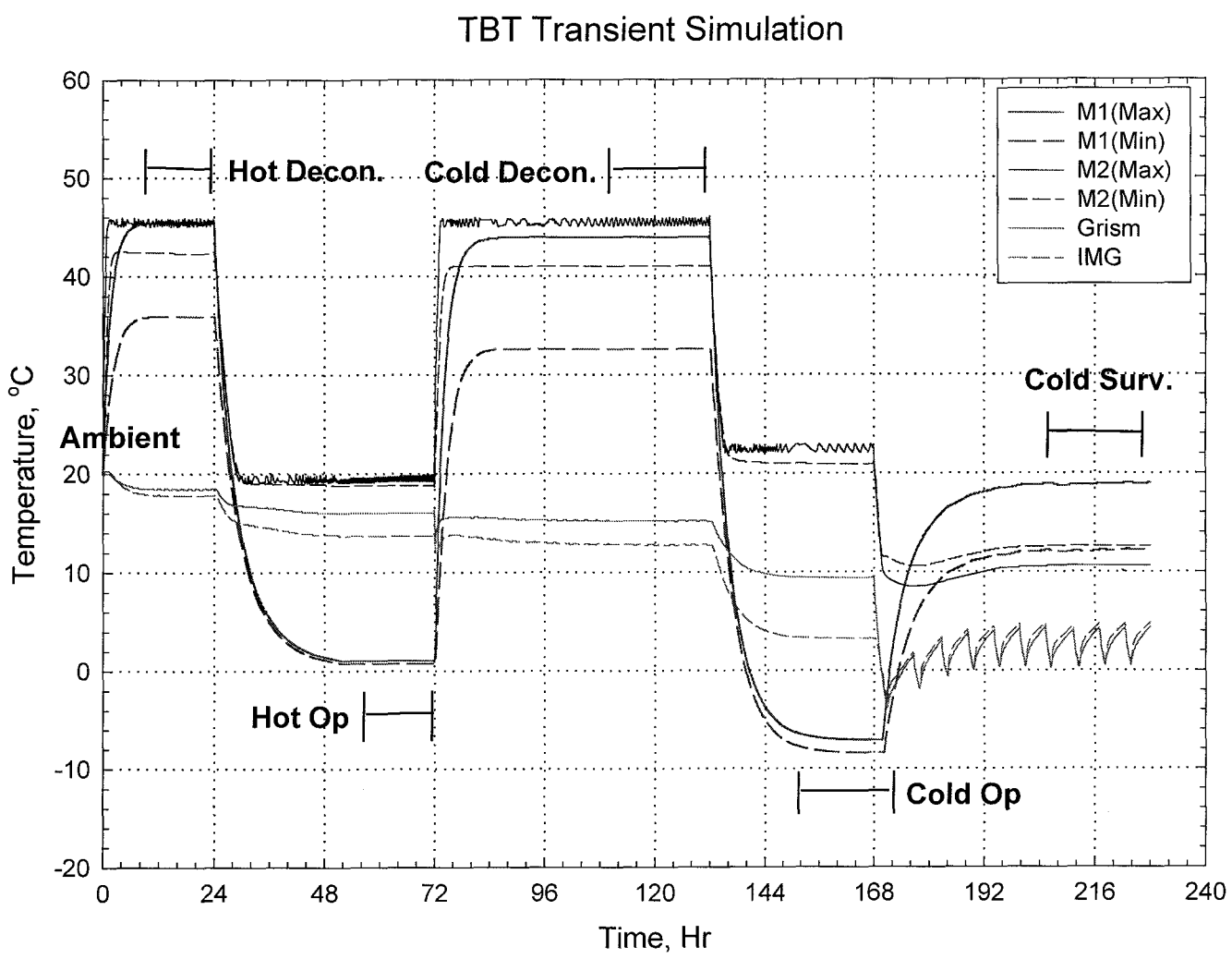
- Flight instrument is enclosed by temperature controlled shrouds
  - *Four temperature control zones consisting of two axial sections of cylindrical shrouds, a simulated spacecraft interface plate, and a Hartmann screen.*
  - *Equivalent hot and cold case flight environments are simulated by controlling the temperatures of the shroud.*
- Thermal balance test phases include: hot and cold operating modes, hot and cold decontamination modes, and a cold survival mode.

JPL

GALEX

The Galaxy Evolution Explorer

Pre-Test Simulation: Primary Optics



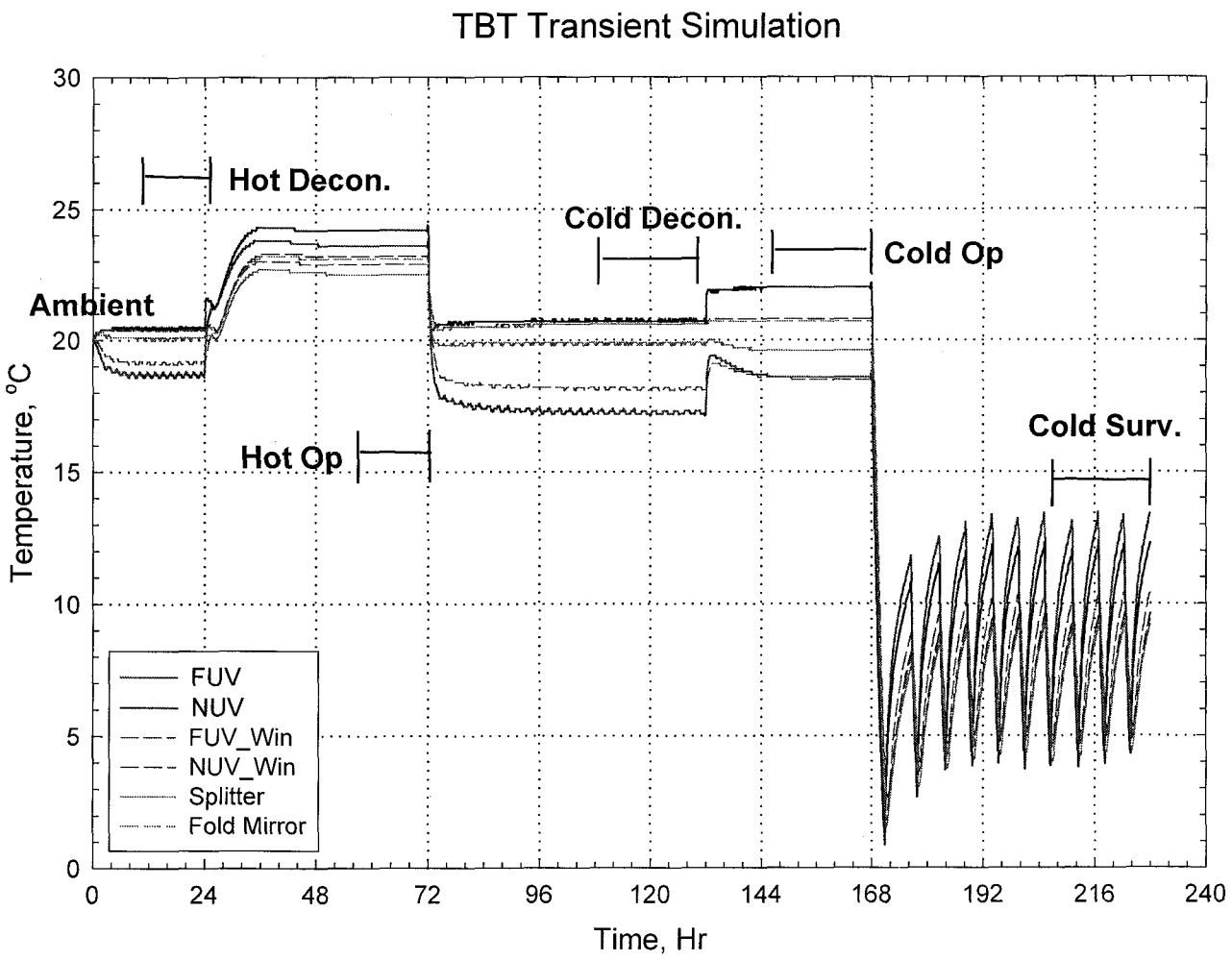
ASL

JPL

GALEX

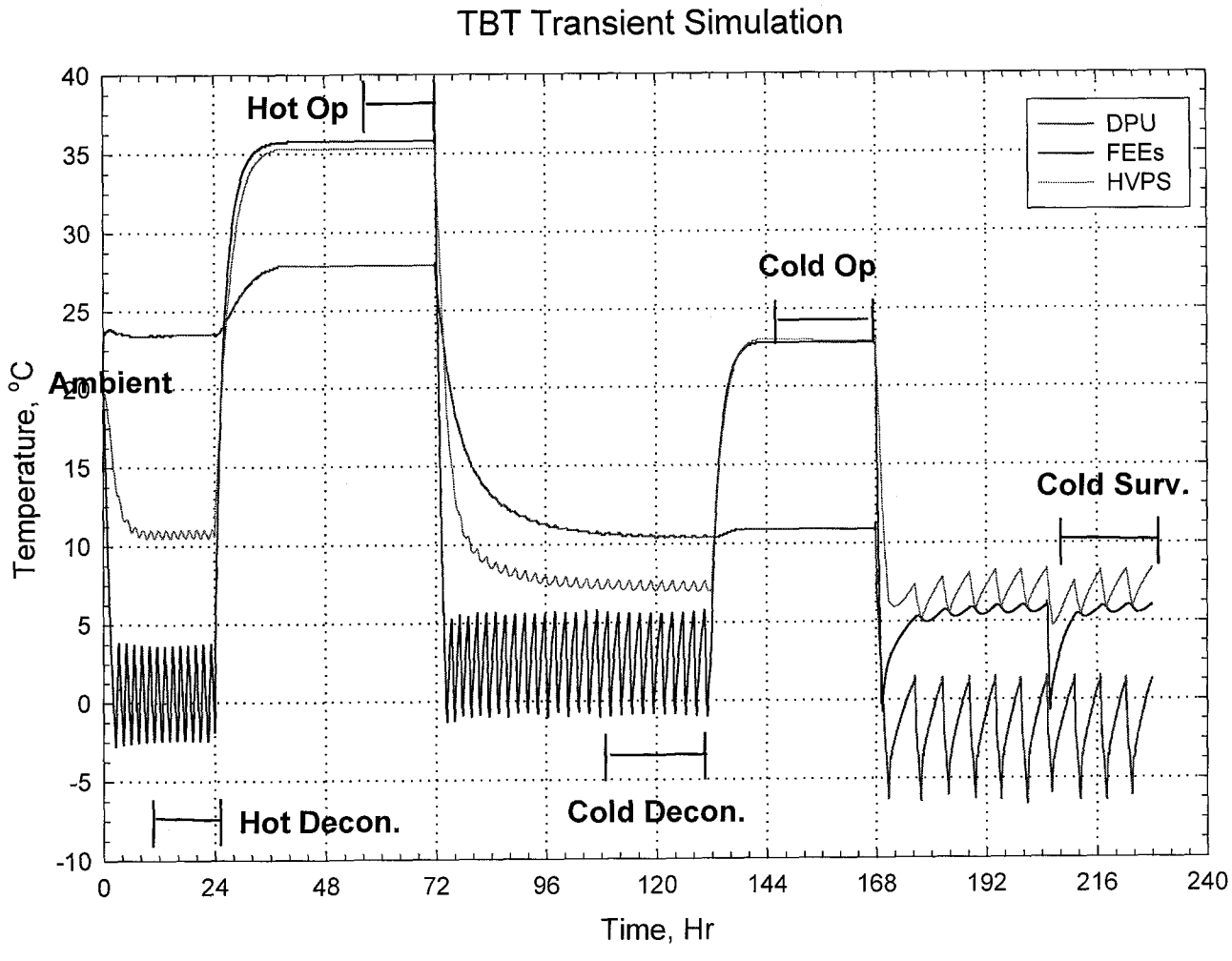
The Galaxy Evolution Explorer

Pre-Test Simulation: Detectors & Optics



ASL

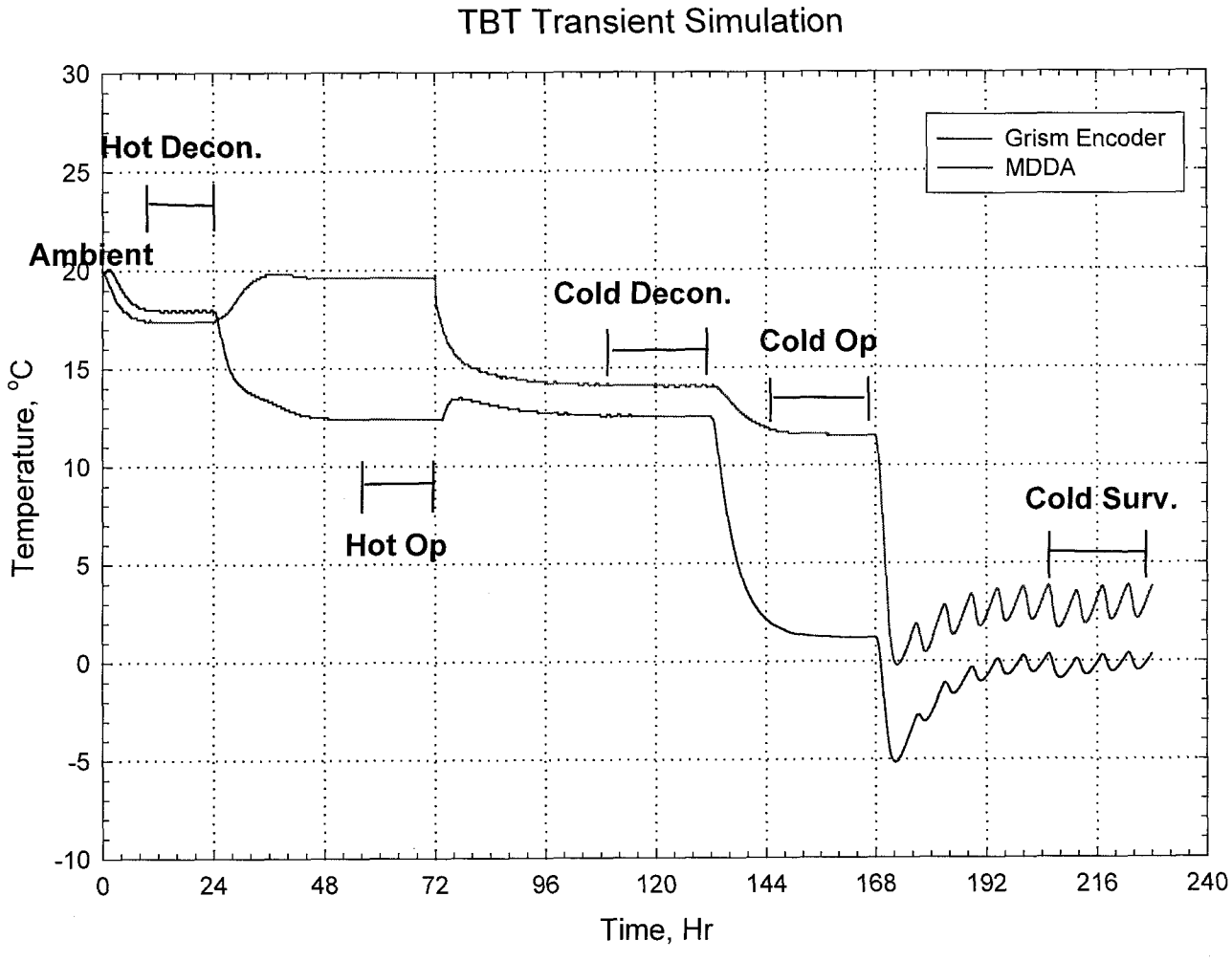
Pre-Test Simulation: Equipment



GALEX

The Galaxy Evolution Explorer

Pre-Test Simulation: Filter Wheel Mechanism



ASL

GALEX

The Galaxy Evolution Explorer

JPL

Prediction vs Test Data: Hot Operation

Component	TBT Low Bay T/C #	TBT Low Bay Temperature,C	TBT Dunes T/C #	TBT Dunes Temperature,C	TBT Avg. C	Prediction Avg. C	ΔT, C
M2 Cap			216	-16.8	-16.8	-22.6	5.8
M2 Hub	114	13.1	106	19.6	16.4	13.5	2.9
M2 Shield			109,306	28.2 / 24.7	26.5	23.5	3.0
M2			219,305	18.2 / 15.0	16.6	14.4	2.2
M2 Light Cup(Z+)			218	0.4	0.4	0.5	0.1
Struts	110,111,112	-7.2 / -8.7 / -4			-----	-16.1 / -16.7 / -11.4	8.9 / 8.0 / 7.4
Barrel			213,214	-10.6 / -3.3	-----	-19.8 / -8.8	9.8 / 5.5
M1 Hub	113	-2.8	110	-3.1	-3.0	-9.1	6.1
M1			309	-1.3	-1.3	-7.3	6.0
M1 Shield			107,307	-0.9 / -0.3	-0.6	-6.4	5.8
TSP	108	2.8			2.8	1.3	1.5
Contam Shield			215	2.2	2.2	-3.1	5.3
BFA Struts	109	11.6			11.6	8.9	2.7
BFA Housing			115	19.9	19.9	15.8	4.1
NUV Detector	102	22.5	111,112	26.1 / 20.2	23.2	17.0	5.2
FUV Detector	104	18.5	113,114	--- / ---	--- / ---	15.9	
HVPS	105	23.4	206	23.4	23.4	26.4	3.0
DPU	106	18.6	119,120	17.9 / 18.6	18.4	14.8	3.6
FEE			201,202	16.1 / 23.6	19.9	21.8	1.9
DPU Radiator			117,118	10.6 / 7.6	-----		
FEE Radiator			203,204,205	6.4 / -12.4 / -1.9	-----		
Instrument Deck	116	17.4	208,209	27.8 / 19.5	21.6	20.0	1.6
WTA	107	-39.5	116	-40.9	-40.2	-36.4	3.8

ASL

GALEX

The Galaxy Evolution Explorer

JPL

Prediction vs. Test Data: Cold Operation

Component	TBT Low Bay		TBT Dunes		TBT Avg C	Prediction Avg. C	ΔT, C
	T/C #	Temperature,C	T/C #	Temperature,C			
M2 Cap			216	-22.9	-22.9	-27.5	4.6
M2 Hub	114	14.6	106	21.5	18.1	17.8	0.3
M2 Shield			109,306	28.6 / 30.3	29.5	29.6	0.1
M2			219,305	19.4 / 17.7	18.6	18.9	0.3
M2 Light Cup(Z+)			218	0.7	0.7	3.0	2.3
Struts	110,111,112	-9.1 / -8.3 / 1.3			-----	-17.2 / -15.4 / -5.5	8.1 / 7.1 / 6.8
Barrel			213,214	--- / 3.2	-----	-14.7 / -1.4	/ 4.6
M1 Hub	113	5.0	110	5.4	5.2	4.1	1.1
M1			309	19.5	19.5	24.5	5.0
M1 Shield			107,307	30.1 / 32.7	31.4	33.9	2.5
TSP	108	6.4			6.4	6.7	0.3
Contam Shield			215	7.3	7.3	4.5	2.8
BFA Struts	109	8.2			8.2	7.9	0.3
BFA Housing			115	16.4	16.4	14.4	2.0
NUV Detector	102		111,112	22.3 / 20.1	21.2	15.8	5.4
FUV Detector	104		113,114	--- / ---	-----		-----
HVPS	105	16.2	206	16.2	16.2	17.6	1.4
DPU	106	10.1	119,120	9.4 /9.4	9.6	2.4	7.0
FEE			201,202	--- / 13.3	-----	10.5	2.8
DPU Radiator			117,118	0.1 /-2.9	-----		
FEE Radiator			203,204,205	-4.3 /-26.0 /-13.2	-----		
Instrument Deck	116	5.7	208,209	6.8 / 1.0	4.5	7.2	2.7
WTA	107	-93.5	116	-94.8	-94.2	-96.6	2.4

ASL

JPL

GALEX

The Galaxy Evolution Explorer

Summary

- Thermal balance test was successfully concluded.
  - *Met all test objectives*
  - *Optical tests performed during hot and cold operating modes provided data on the performance of the optical and detector systems.*
- Test demonstrated robustness of thermal control design
  - *Pre-test temperature predictions are generally within 5C of measured values during all test phases.*
  - *Demonstrated adequate sizing of all operational and survival heaters.*
  - *Thermostat-controlled heaters operated as predicted.*