ALI Thermal Design*

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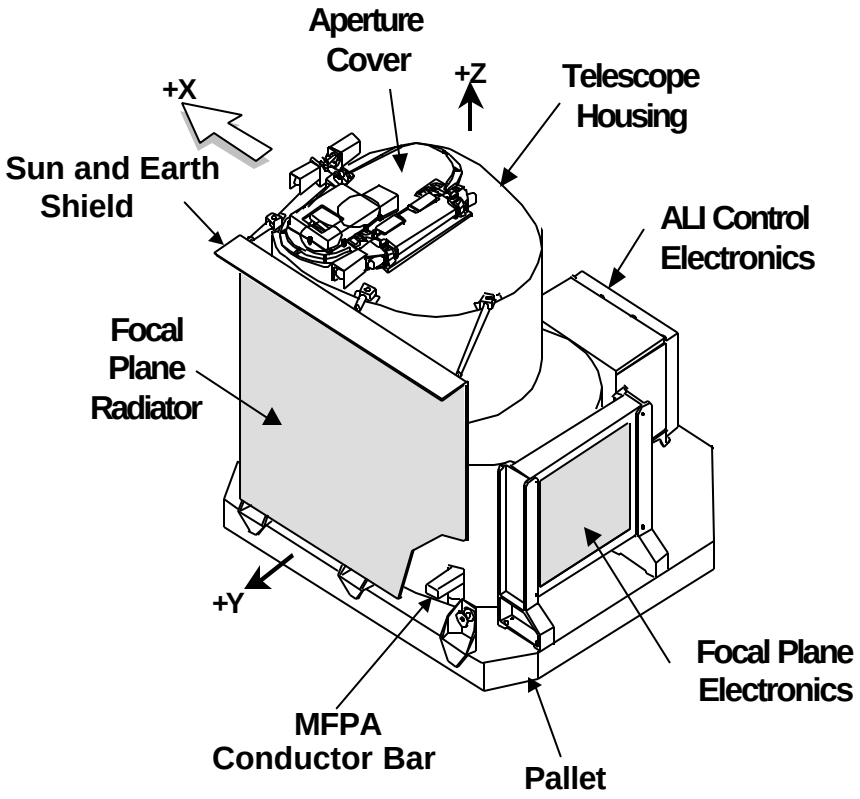
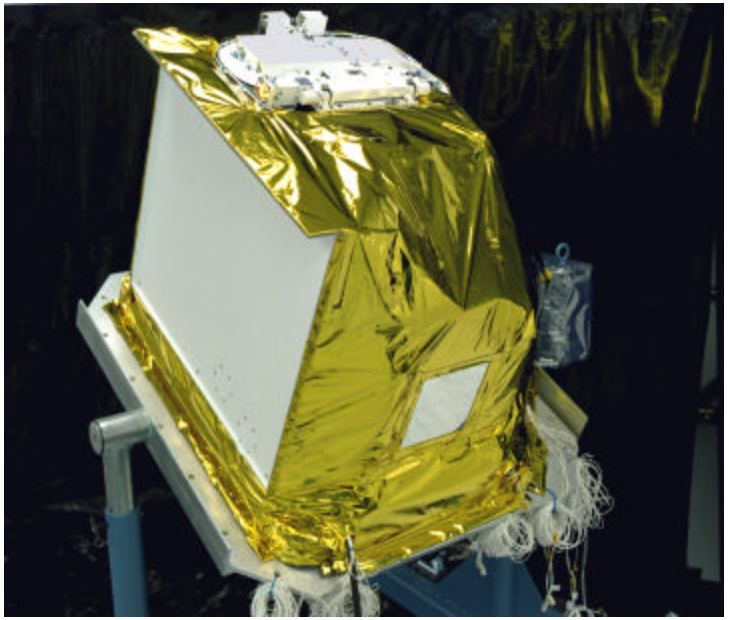
ALI Thermal Design

- Requirements
- Design approach
- Thermal analysis
- Performance on orbit
- Summary

ALI Instrument



Multi-Layer Insulation (MLI) removed



Multi-Layer Insulation installed

Orbit Requirements

- 705 km (381 nmi) sun-synchronous
  - 98.9 minute period
  - 33 minute Max eclipse
- 98.2° orbit inclination
- 10:01 AM descending node
- 3 Axis stabilized
- Earth pointing

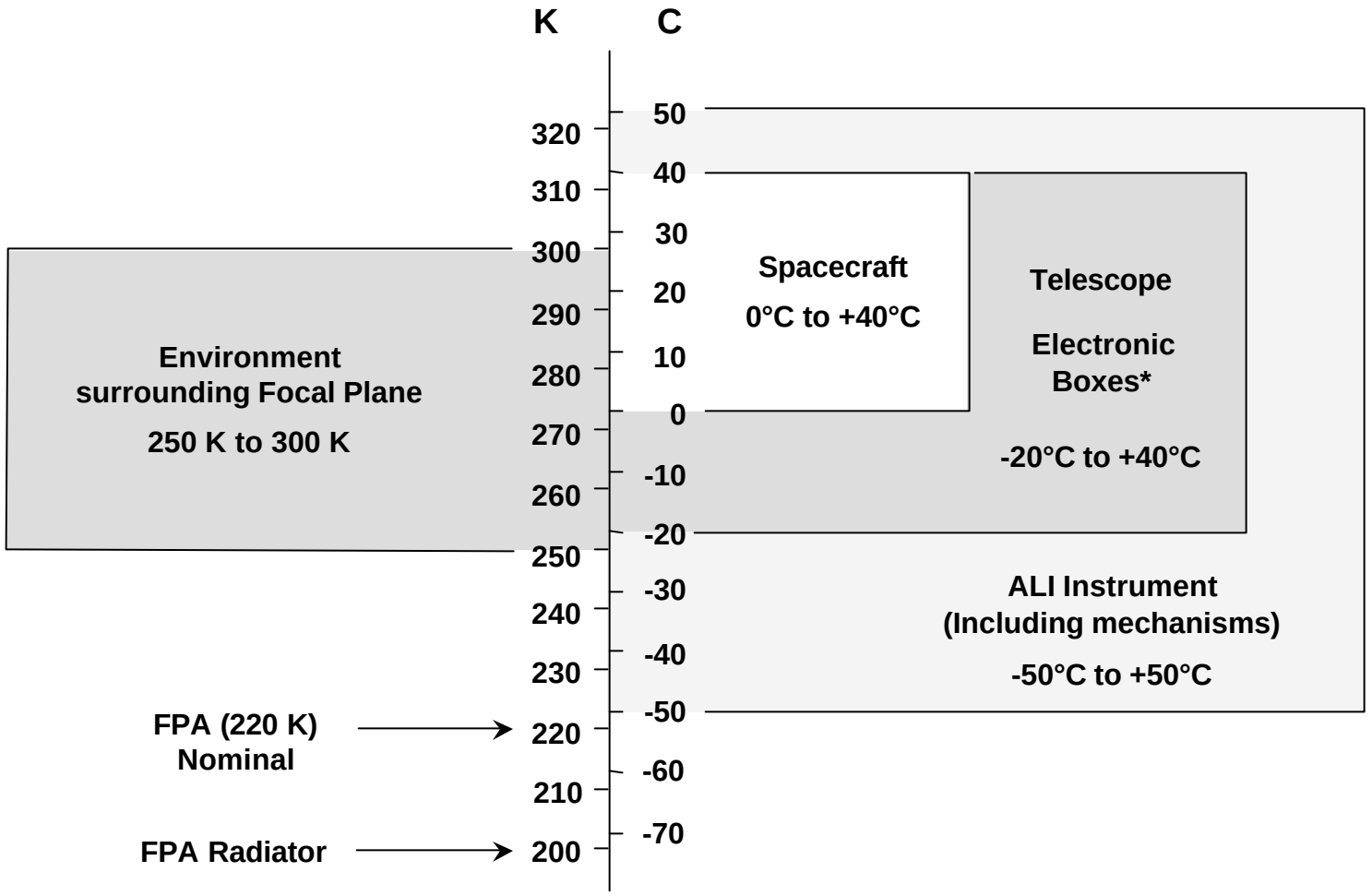
General Thermal Requirements

- **Focal Plane**
  - **Nominal set point temperature control at 220 K by MIT/LL**
  - **Temperature stability to 30 mK by Raytheon/SBRS**
- **Metering Truss**
  - **10°C maximum temperature gradient from top to bottom plate**
- **Electronics:**
  - **Limit survival temperature to –20°C**
- **Mission Lifetime: 1 Year minimum**

Operational Modes

- **Standby**
  - **FPA and instrument thermal control**
- **Idle - Data Collecting for 10 minutes per orbit**
  - **Normal operation with 10% duty cycle on FPE**
- **Calibration during data collecting**
  - **Solar pointing 7.5° about +X, diffuser activated, 1 minute duration**
  - **Flood lamp operation for 10 seconds**
- **Lunar Scanning**
  - **Maintain FPA and instrument thermal balance**
- **Safe Hold**
  - **Post launch, prior to normal operation**
  - **Abnormal operation**
  - **Survival power supplied by spacecraft**

Design Temperature Ranges

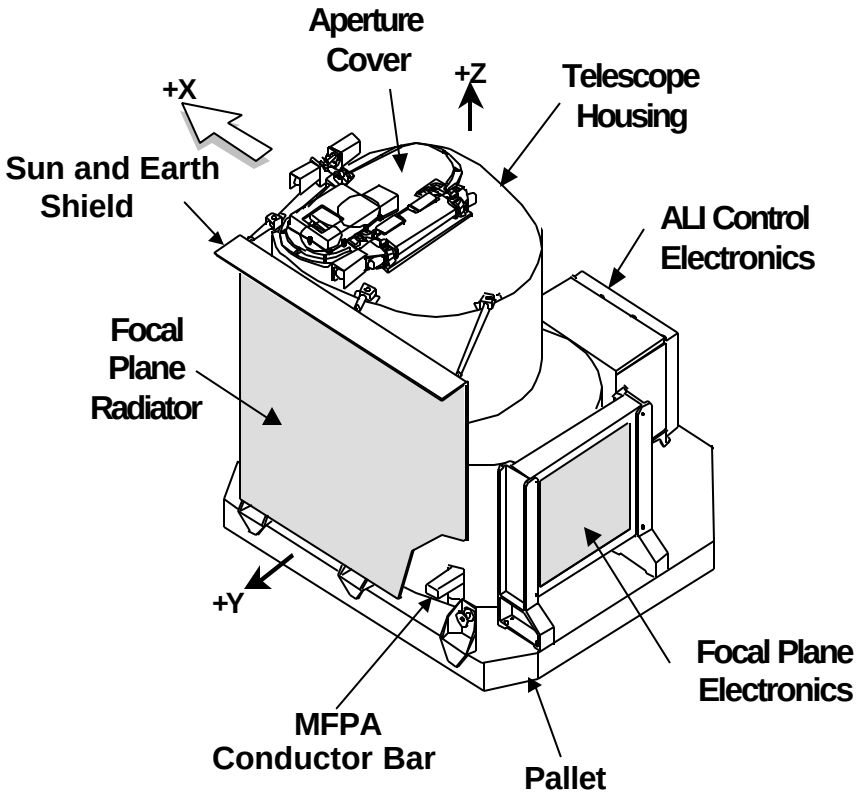


* +55°C maximum at ALICE box

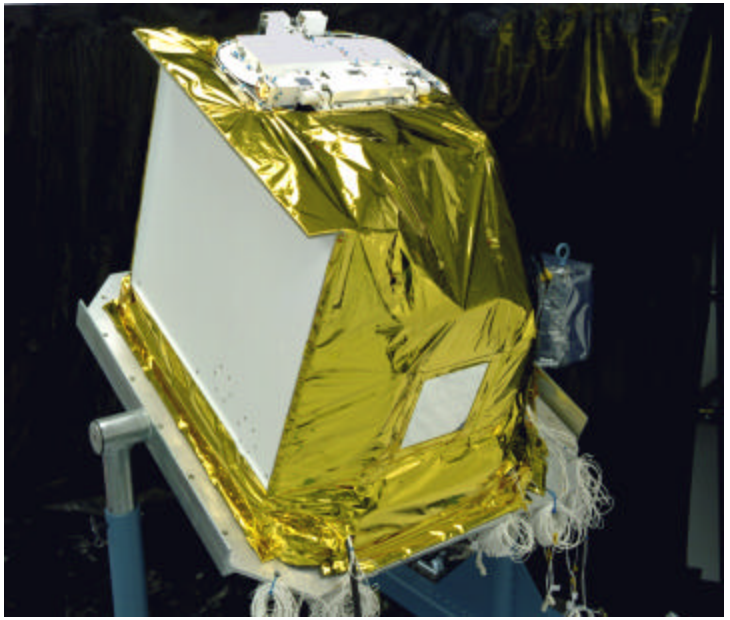
Design Approach

- 0.42 m^2 aluminum radiator (+Y)
  - Z-93P white paint
  - Sun and earth shield
- Focal Plane thermal control
  - Tailored thermal isolation
  - 6063-T5 alum. conductor bars
  - Flexible link connector
  - Temperature control loop
- Thermally isolated metering truss
  - Top to bottom gradient limited by temperature control loop
- Instrument / spacecraft interface
  - Telescope housing and pallet thermally coupled to spacecraft
- Electronics thermal control
  - ALICE
    - Packaging by MIT/LL
    - Thermally coupled to spacecraft
  - FPE
    - Packaging by Raytheon/SBRS
    - Thermally isolated from pallet spacecraft
    - Ag/Teflon radiator
    - Survival heaters and thermostats

ALI Instrument

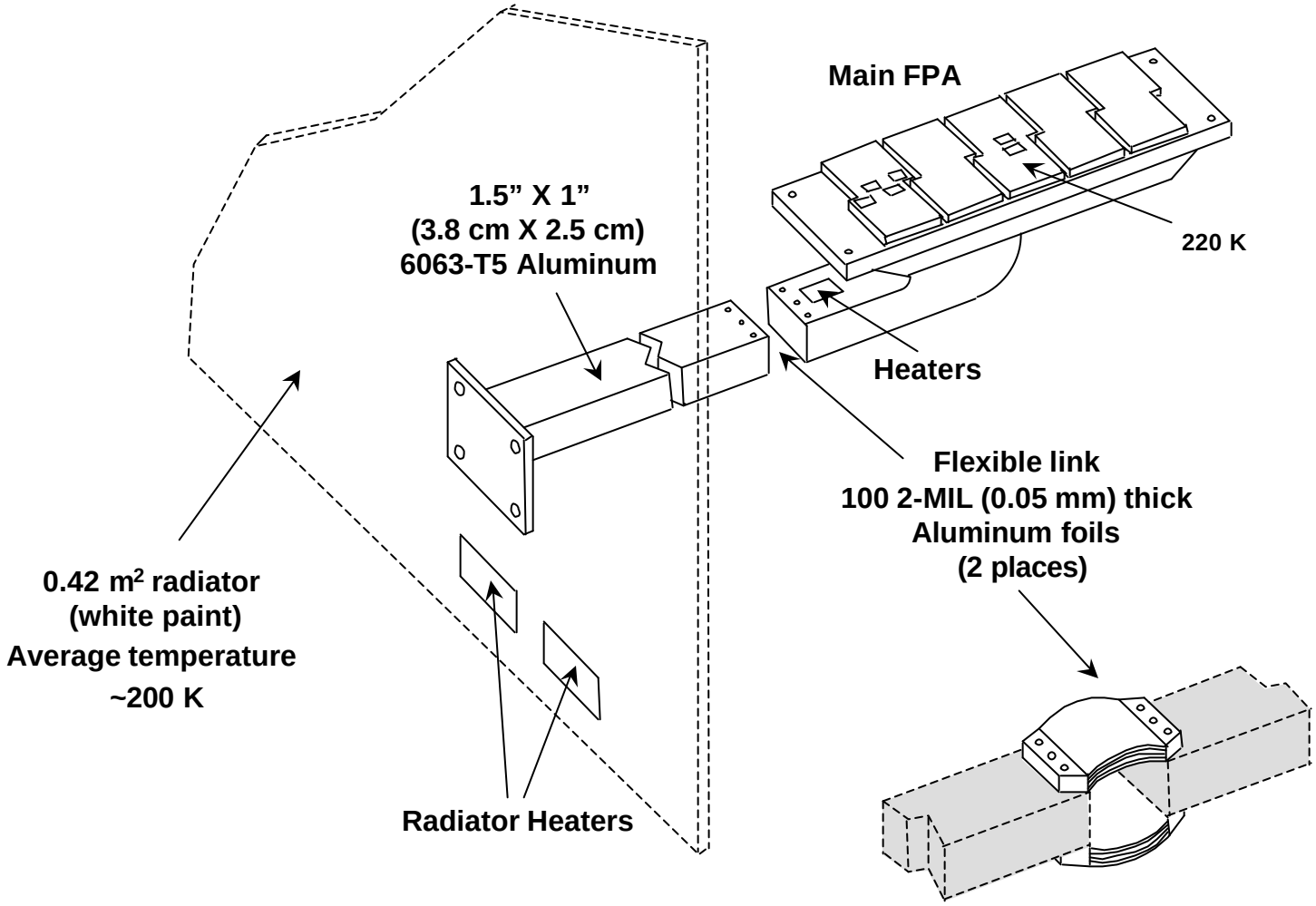


Multi-Layer Insulation (MLI) removed

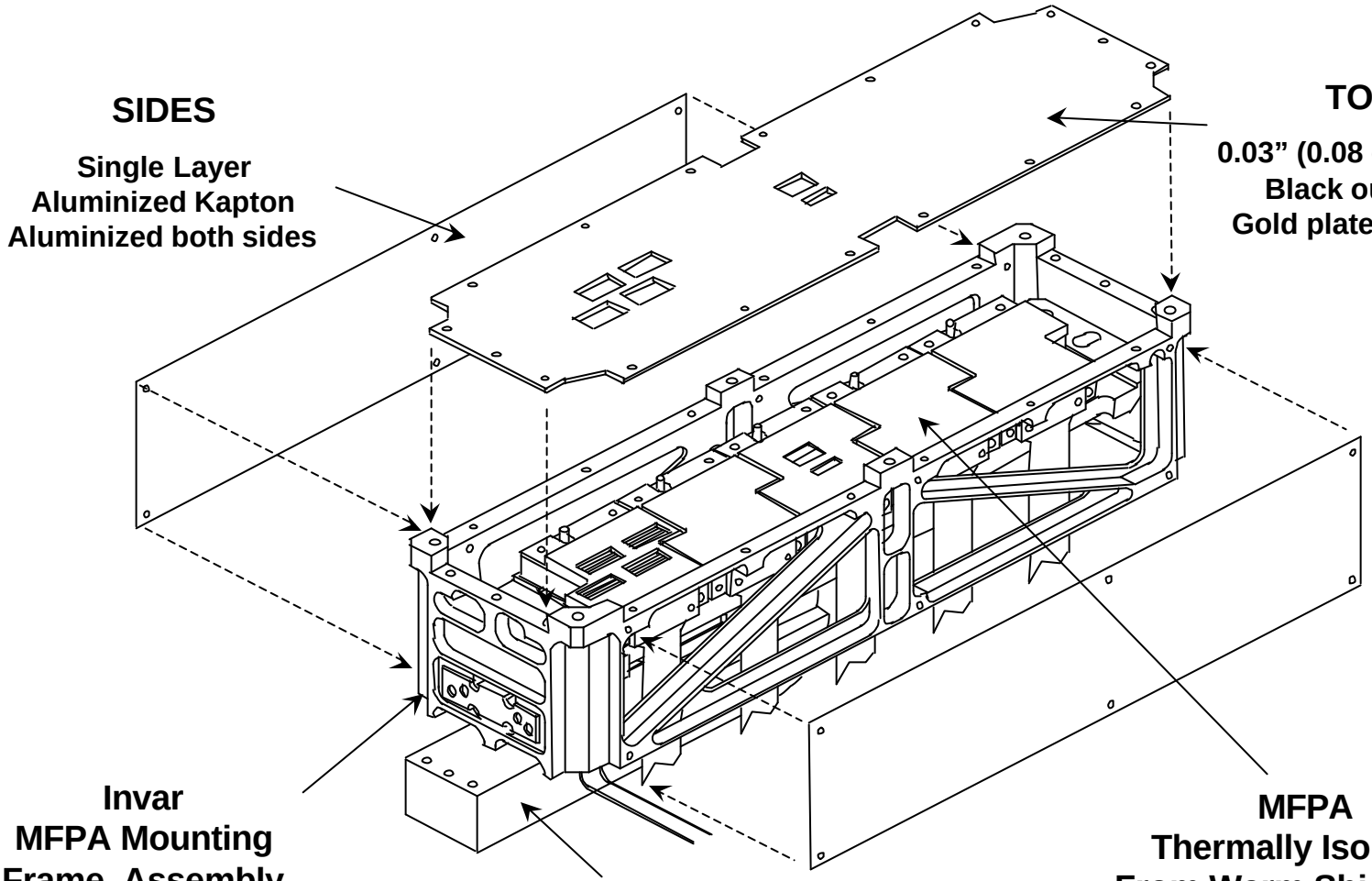


Multi-Layer Insulation installed

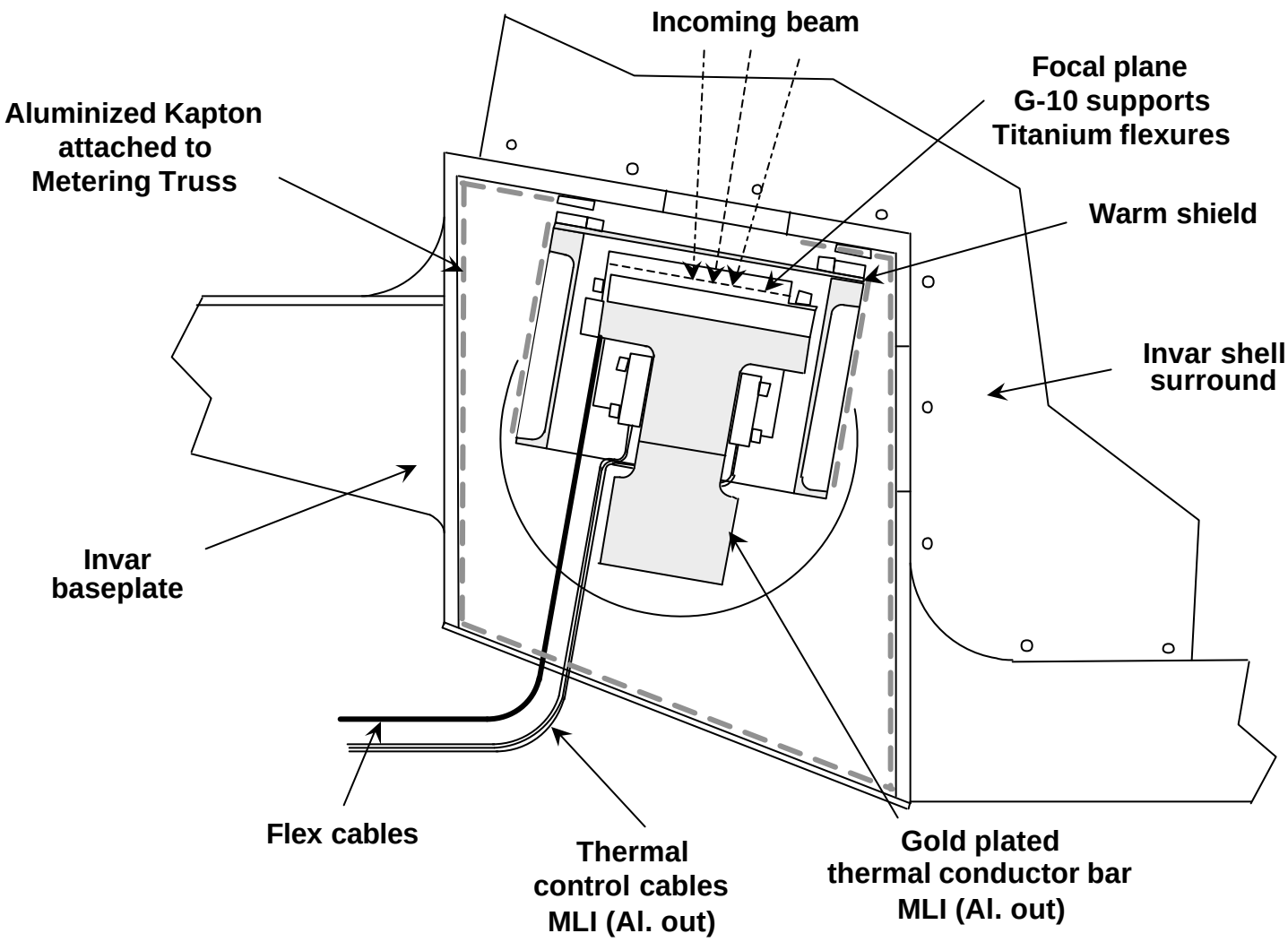
Focal Plane Thermal Control System



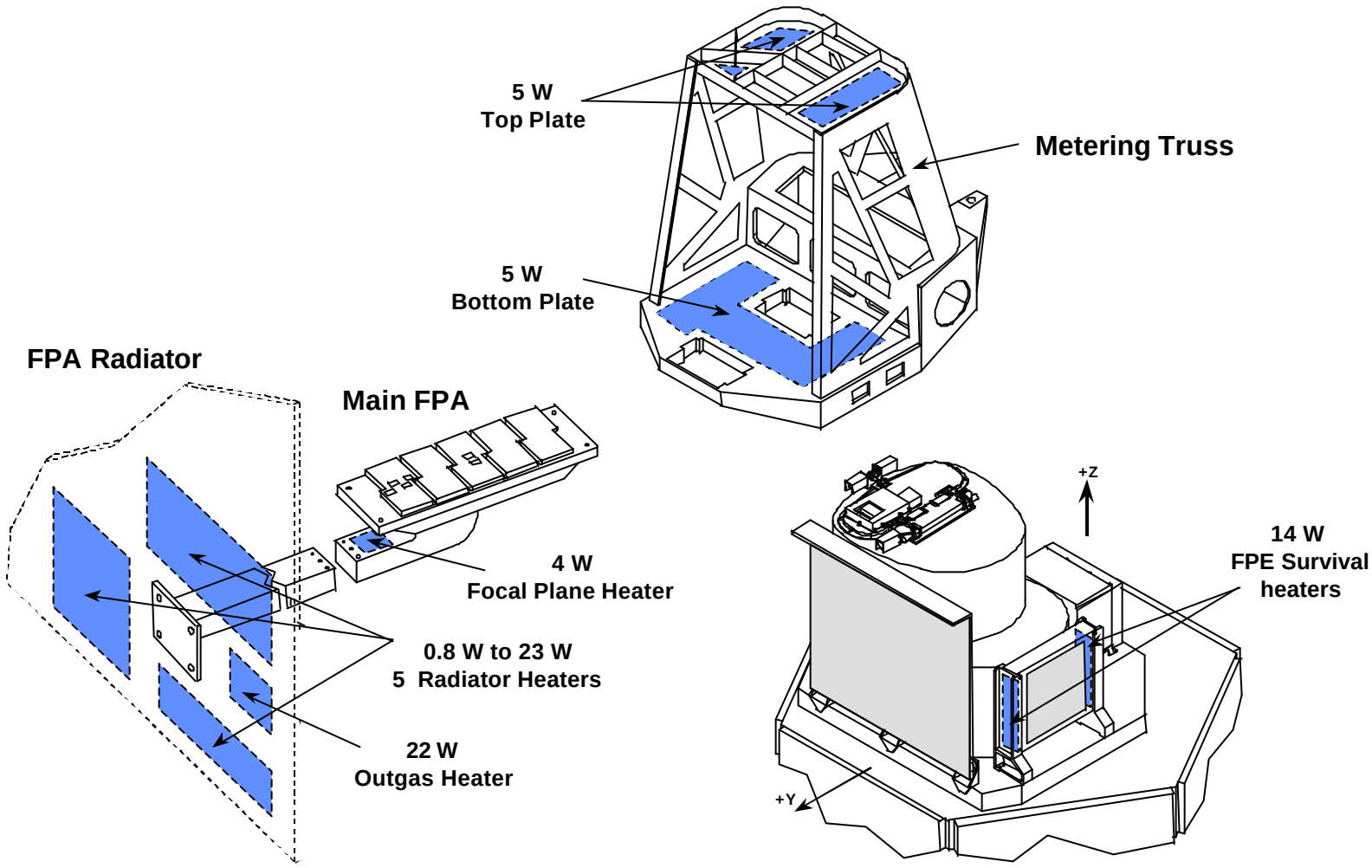
MFPA Warm Shield Arrangement



MFPA Attachment to Metering Truss



ALI Heater Arrangement



All heater power referenced to 28 V

Thermal Analysis

- **Preliminary estimates**
  - **Radiator sizing**
  - **Heater power estimates**
- **Simplified models**
  - **Simplified geometry and LLTTA (Lincoln Laboratory Transient Thermal Analyzer)**
  - **Used for quick estimates**
- **Detailed model**
  - **Detailed geometry modeling by SSPTA (Simplified Space Payload Thermal Analyzer)**
  - **Orbital heat fluxes and radiation couplings by SSPTA (RadK files to SWALES)**
  - **Transient thermal calculations by LLTTA**
  - **Used for orbital temperature predictions and heat balance verifications**

MFPA Thermal Load

Electrical Dissipation	**1.18 W**
Radiation to Rail Assembly	
Gold plated surfaces	**1.16 W**
Apertures	**0.23 W**
High e absorbing areas	**0.54 W**
Thermal conductor bar (MLI)	**0.18 W**
Cables	**0.44 W**
G-10 Support / Titanium Flexure	**0.30 W**
Total Thermal Load	**4.03 W**

Representative ALI Flight Temperatures

Temperature Sensor	Location	Observed 11/25/2000 8:38 PM EST	Nominal Steady-state Prediction	Difference
1	Truss Top Plate +Y	5.66	8.14	-2.48
2	Truss Top Plate -Y	6.09	8.40	-2.31
3	Truss Shell	8.28	9.09	-0.81
4	MFPA Frame at +Y Rail Mount	7.85	4.43	3.42
6	Baseplate, +X Flexure	13.54	14.32	-0.78
9	Pallet +X Flexure	17.48	17.52	-0.04
10	Pallet -X side	17.48	18.37	-0.89
17	Telescope Housing, -Y	4.78	5.59	-0.81
18	Telescope Housing, +Y	1.72	3.90	-2.18
28	Aperture Selector Motor	-7.04	-10.16	3.12
25	TAC Motor	-7.92	-10.49	2.57
27	Aperture Cover	-7.04	-5.38	-1.66
36	ALICE Power Module	38.94	36.11	2.83
35	FPE Radiator[1]	5.66	14.08	-8.42
19	MFPA Conductor Bar, rail I/F[2]	-51.73	-58.07	6.34
29	MFPA Conductor Bar, external[2]	-58.89	-66.39	7.50
21	MFPA Conductor Bar, internal[2]	-53.40	-58.85	5.45
33	FPA Radiator, top[2]	-68.45	-73.16	4.71
34	FPA Radiator, bottom[2]	-60.09	-67.38	7.29

Note: 1. Actual power at data scan not reported.
2. Observed under temperature control for 220K (-53°C) at detectors. Model assumes constant control power.

Summary

- ALI thermal performance in orbit is as advertised
- Successful demonstration of large focal plane array cooling at 220 K in sun synchronous orbit by passive means
- Design margin available for lower set point operation
- Comprehensive thermal model developed to accurately simulate complex telescope and focal plane system