



Hardware

– Radiators

- Radiators are required for the following sub-detectors
 - TRD (no heat pipes)
 - Tracker
 - Cryo-Cooler
 - Rich Ecal Crates
 - Crates (Upper/Lower Wake and Upper/Lower Ram)
- Radiator Characteristics and Properties are given on next pages



Radiator Characteristics

Sub-Detector	Required Heat Dissipation (W)	Shape / Location / Orientation				
			No. of Heat Pipes	Surface Finish	MLI on Back Side	Total Weight* (kg)
TRD	31**	Extension of upper TRD plate, Zenith facing	None	White paint to space, black paint to inside	No	4.0
TRACKER	192 total, 96 (Wake) 96 (Ram)	Rectangular surface viewing Wake and Ram	12	White paint to space	Yes	18
Cryo-Cooler	432 total, 216 (Wake) 216 (Ram)	Rectangular surface viewing Wake and Ram	20	OSR to space	Yes	31.2

AMS 02 –Thermal Control System Design



Sub-Detector	Required Heat Dissipation (W)	Shape / Location / Orientation	No. of Heat Pipes	Surface Finish	MLI on Back Side	Total Weight* (kg)
CRATES						
RICH ECAL	160 total, 80 (Wake) 80 (Ram)	Rectangular surface viewing Wake and Ram	TBD*** (assumed 10)	White paint to space	Yes	9,3
Upper Wake	370				Yes	13,8
Upper Ram	250	Rectangular, Upper Wake	TBD*** (assumed 10)	White paint to space	Yes	8,8
Lower Wake	315	Rectangular, Upper Ram	TBD*** (assumed 7)	White paint to space	Yes	11,0
Lower Ram	435	Rectangular, Lower Wake	TBD*** (assumed 7)	White paint to space	Yes	15,1
		Rectangular, Lower Ram	TBD*** (assumed 10)	White paint to space		



Assumptions for Radiator Mass

Item	Specific Mass
Face Sheets (2 x 0,5 mm Al)	2.7 kg/m ²
White Paint / OSR	Paint: 0.05 kg/m ² / OSR: 1.0 kg/m ² (0.3 OSR / 0.7 Adhesive)
Honeycomb (d = 15 mm)	0.67 kg/m ²
Adhesive (Face Sheet / Honeycomb)	0.1 kg/m ²
MLI (20 Layer 1/4 Mil Mylar, 1 Layer 3 Mil Kapton, 1 Layer 1 Mil Kapton)	0.44 kg/m ²
Total (Radiator Plate with MLI and Paint):	4 kg/m² (Paint) / 4.9 kg/m² (OSR)
Heat Pipe	0.3 kg/m
Brackets	20 % (on Total + Heat Pipe)



Radiator Design

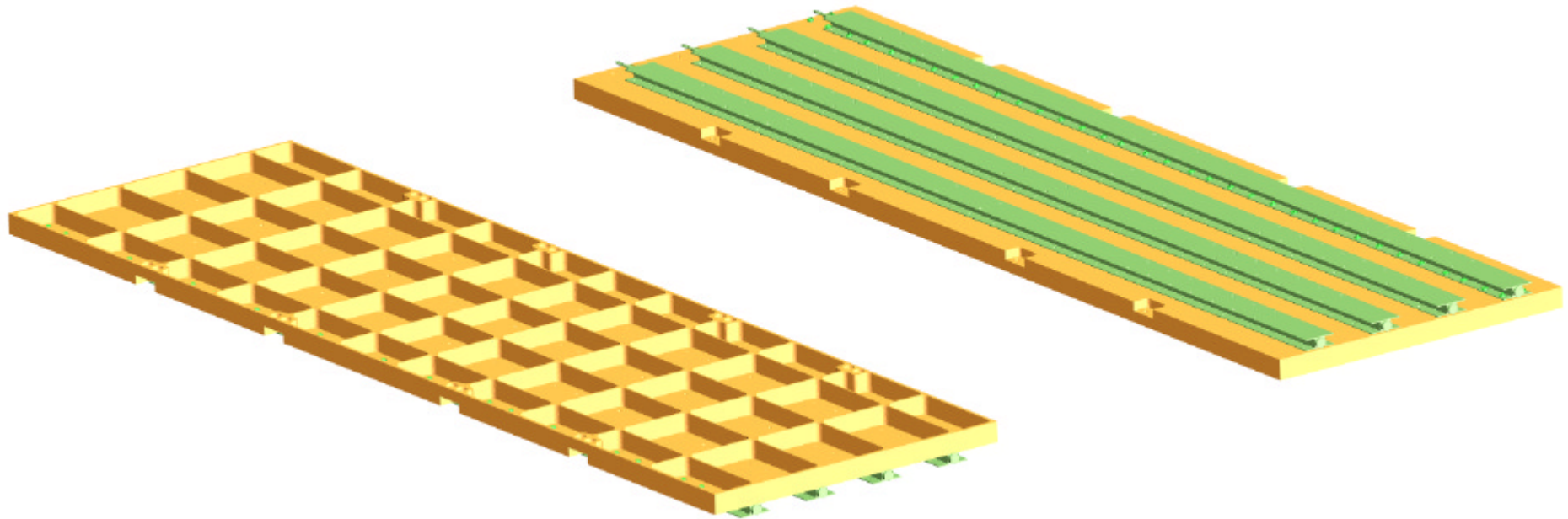
- All shapes are rectangular (except TRD)
- Trade Off between
 - Honeycomb Sandwich
 - Milled Iso-Grid Structure
 - Embedded Heat Pipes
 - Top Mounted Heat Pipes



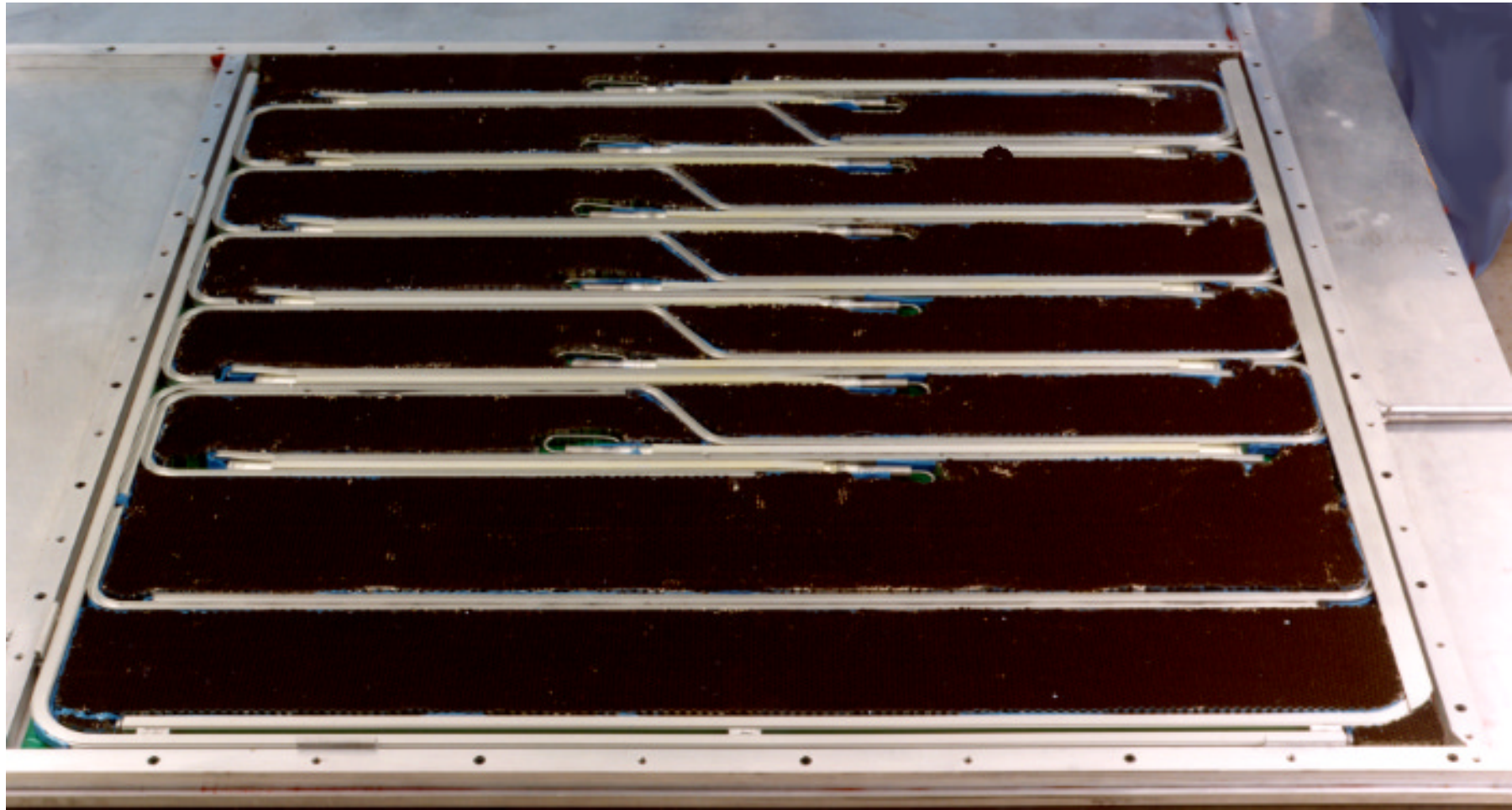
Radiator Design

- For Mass Budget the following design is assumed:
 - Al Honeycomb Panel 15 mm thick
 - Face Sheets each 0.5 mm thick
 - Embedded Heat Pipes, 70 mm pitch, 0.3 kg per Meter
 - 20 % added for Brackets to attach to USS

Iso-Grid Radiator with Heat Pipes



Honeycomb with Embedded HP





Radiator / USS Interface

- Interfaces to be defined in co-operation with Lockheed
 - Location and Dimensions of Radiator I/F to USS
 - Mechanical Load for Radiators
 - Meteorite and Debris Protection (MDP)
 - Influence of MDP on Radiator Performance
 - Lockheed MLI attachment provisions and I/F to radiators
 - Design definition (no. of layers, shape, etc.) to be provided to Lockheed for MLI manufacturing



MLI General

- All MLI to be seen from outside delivered by Lockheed Martin acc. to our specification (conductivity)
- MLI not considered under Sub-Detector Responsibility delivered by T/C System, i.e.:
 - On radiator backside (to prevent radiation to AMS subsystems)
 - On heat pipes / loops, which connect radiators with sub-detectors



MLI Design

- Type of MLI to be defined by detailed thermal analysis during next phase
- For Mass Budget the following MLI is assumed:
 - Outer foil: 3 mil Kapton / VDA, perforated
 - 20 layers PETP spacer 'Platest', 5 gr/m², interleaved with:
 - 19 foils VDA / 1/4 mil Mylar / VDA, perforated
 - Inner foil: 1 mil Kapton / VDA, perforated
 - Each MLI with 2 bonding leads AWG 22
 - Attachment by Al Stand-Offs and Vespel clip washers



Radiator Coating

- All space viewing surfaces covered by white paint or Optical Solar reflectors (OSR)
 - White Paint (lower performance but cheaper):
 - LORD A276 Reflective Polyurethane, Low Outgassing Paint
 - Solar Absorption 0.23
 - Normal Emissivity 0.90
 - OSR (higher Performance and price):
 - Rigid Solar Reflectors with very low absorption
 - Solar absorption 0.06 (0.11 degraded after 7 years)
 - Normal Emissivity 0.77
 - Decision on Coating by thermal analysis