CARLO GAVAZZI SPACE SpA

AMS-02

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TABLE OF CONTENT

1. SCOPE

The present document contains the collection of all the interface data related to the thermal design of the AMS 02 system.

2. TRD

2.1 TEMPERATURE RANGES

Operational : +10+25 °C
Non Operational -20 +40°C

2.2 SHORT-TERM TEMPERATURE STABILITY

±1°C along the orbit

2.3 TEMPERATURE GRADIENTS

±1 °C top to bottom
± 1 °C on periphery

2.4 HEAT DISSIPATION

The TRD dissipates 17 W on an octagonal ring radiator placed above the TRD on zenith of AMS.

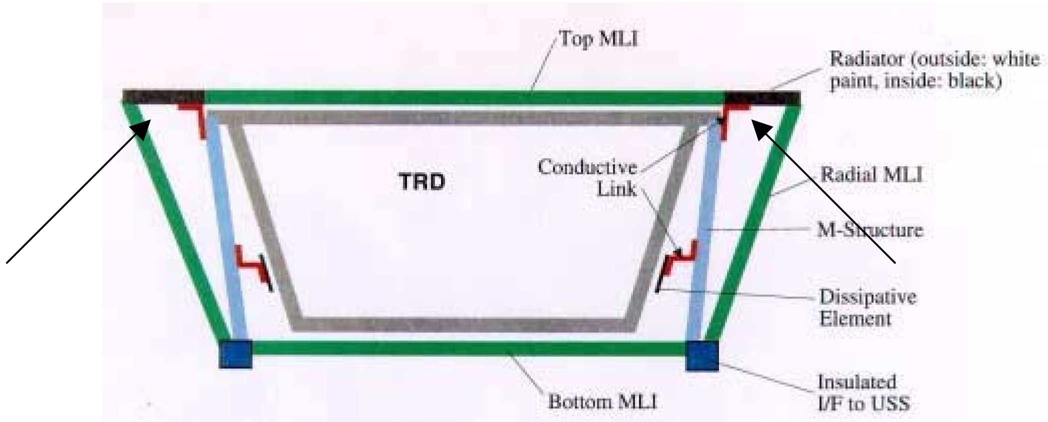


Figure 2.4-1: TRD octagonal ring radiator highlighted by arrows

2.5 SUB DETECTOR THERMAL I/F DESCRIPTION

2.5.1 CONDUCTIVE

TRD is mounted on a dedicated M structure, mechanically constrained to the USS. A thermal insulation from the USS is currently not foreseen. The conductive coupling for each one of the 4 support brackets is for

Aluminum brackets + interface conductance 1.13 W/K (TBC by OHB-system)

The additional thermal links are

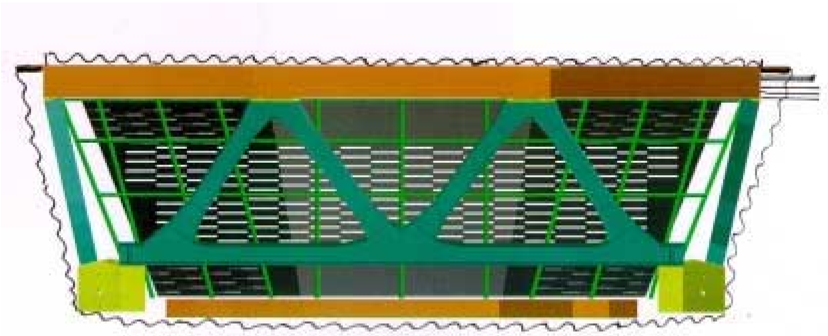
1) Gas tubes: (82 CU/Ni alloy, 4m): 0.0053 W/K

2) Cables :

TRD Signal cable	82 pieces	4 m long	total thermal conductivity:	0.06W/K
Senscable	8 pieces	4 m long	total thermal conductivity:	0.009W/K
HV Kabel	82 pieces	4 m long	total thermal conductivity	0.006W/K

2.5.2 RADIATIVE

2.5.2.1 MLI



TRD radiation to outside is minimized by means of MLI on all its surfaces.
The outer thermo optical properties of these thermal blankets are beta cloth.
TRD is completely wrapped, together with TOF, by MLI in order to minimize heat transfer with the surroundings and reduce internal gradients.
TRD top and lateral MLI is supplied by Lockheed Martin.

2.5.2.2 RADIATOR

TRD radiator is zenith pointing, consisting of a ring embedded in the LEP shield, and in the anti debris shield as well.
The total TRD radiator maximum available area is $8*0.096\ m^2 = 0.768\ m^2$.
The radiator mass is 0.003*2800* Area = 6.45 Kg
Its thermo-optical properties are white paint (TBC)
The radiator is provided by Aachen, if it serves as a radiator for the TRD and the upper TOF.
Thermal interface from the heat source to the radiator is designed by Aachen.

2.5.2.3 OTHER SURFACES

The top honeycomb panel is provided by Aachen.

2.6 HEAT EXCHANGE REQUIREMENTS WITH NEIGHBORING EXPERIMENTS

The current assumption is that 90% (TBC) of the TRD heat power shall be rejected by radiation outside AMS.
The goal is to put less than 3 W TBC (by thermal design group) watt in the nadir direction, toward the vacuum case.

3. UPPER TOF

3.1 TEMPERATURE RANGES

Operational: -20 to +40°C
Non operational: -50°C to +50°C

3.2 SHORT-TERM TEMPERATURE STABILITY

5°C stability over orbit period

3.3 TEMPERATURE GRADIENTS

10°C between structure and PMTs

3.4 HEAT DISSIPATION

3.2 W are dissipated on the TOF sides (0.8 W on each side)

3.5 MECHANICAL DESIGN

A carbon fiber box covered both internally and externally by a thin Aluminum foil (50-100 µm thick, TBD) is used to encapsulate the PMTs. The top cover of each box is made of aluminum (TBC), and its thickness will be less than 1mm (TBD by CGS). Each one of the 4 aluminum wall acts as a radiator and represents a radiative heat sink for the PMTs. The aluminum walls are oriented facing away from the vacuum case.

3.6 SUB DETECTOR THERMAL I/F DESCRIPTION

3.6.1 CONDUCTIVE

The PMT are thermally decoupled from the structure. For this reason the conductance from the TOF panels to the M structure can be realized with any particular requirement. A value of conductance of TBD W/K is obtained on each of the four feet (see figure 3.6.1-1)
TOF aluminum panel is sunk to the TRD radiator by means of a radiative link.

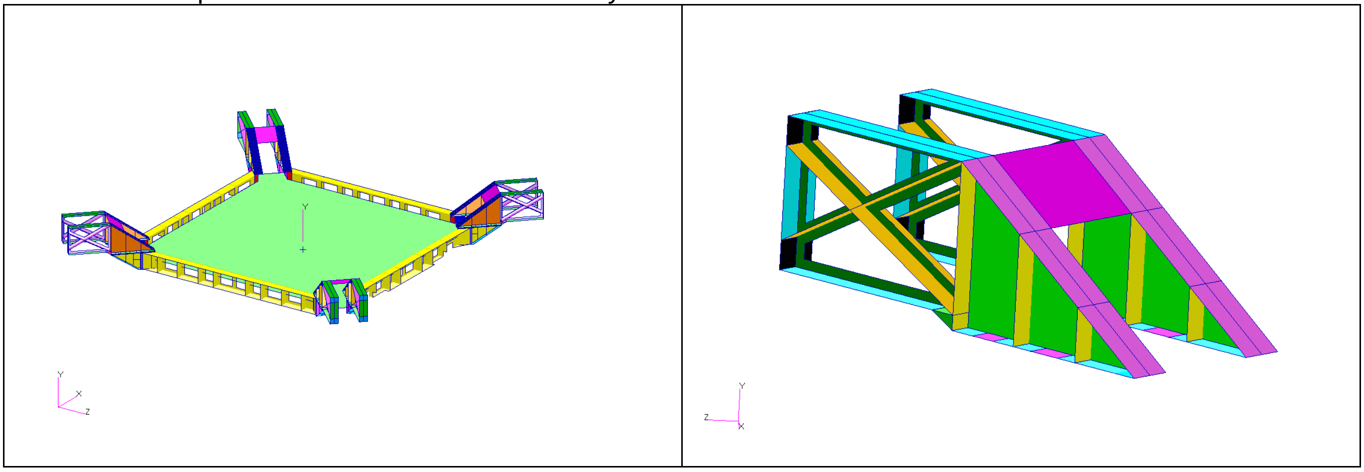


Figure 3.6.1-1: TOF brackets.

3.6.2 RADIATIVE

The TOF PMT boxes heat radiation toward the light-tightened cavity around it shall be optimized so that 90% (TBC by CGS) of the total dissipated power is transferred by direct radiation and multiple reflections to the TRD radiator.

3.6.2.1 MLI

MLI below the TOF, insulating TOF from Tracker, is provided by Aachen and its external properties are Beta Cloth.

3.6.2.2 RADIATOR

The aluminum side of the box is black painted on both sides in order to increase its heat rejection capability.

3.6.2.3 OTHER SURFACES

The other external aluminum surfaces of the PMT boxes shall be black.

3.7 HEAT EXCHANGE REQUIREMENTS WITH NEIGHBORING EXPERIMENTS

The goal is that TOF cannot exchange more than 1 W both by radiation and conduction to the neighboring experiments.

4. TRACKER

4.1 TEMPERATURE RANGES

OPERATIONAL= -10 to +25°C (silicon wafer), -10+40°C (hybrid)
NON OPERATIONAL = -20 to +40°C (silicon wafer), -20 to +60°C (hybrid)

4.2 SHORT-TERM TEMPERATURE STABILITY

3°C along the orbit
10°C long period drift

4.3 LONG-TERM TEMPERATURE GRADIENTS

10°C all over the volume

4.4 HEAT DISSIPATION

The power is dissipated on the hybrids, located on the periphery of the tracker cylindrical shape. The total amount of power generated in these hybrids is 184.2 Watt. An active cooling loop collects the heat power and brings it to dedicated Ram and Wake radiators. Extra heat generated by components of the cooling loop like pumps, will be brought via the loop to the same radiators. This extra power generated in the loop is 80 Watt (TBC by tracker group).

4.5 SUB DETECTOR THERMAL I/F DESCRIPTION

4.5.1 CONDUCTIVE

The tracker is mechanically connected to 2 (top and bottom) x 4 (around periphery) points to the vacuum case, by means of titanium support feet providing an interface conductance of 27.3 mW/K per foot resulting in a total conductance of 0.22 W/K for all 8 feet.
A thermal link from the tracker hybrids (front-end) to the 8 crates is due to the cables. Eight bundles of approx 3 meter long cables connect the tracker hybrids (front-ends) to the 8 crates. Each bundle consists of 48 flat cables with 1.1 * 39.5 mm2 cross section per cable. A well packed bundle will have a cross section of about 5cm * 4cm. The thermal conductance is estimated to 16 mW/deg for each 3 meter long bundle (total128mW/deg).

4.5.2 RADIATIVE

4.5.2.1 MLI

If needed the internal MLI to protect the upper and the lower face of the tracker is shielded by means of beta cloth.
This MLI shall be provided by Lockheed Martin.
Absorptivity OF THE INTERNAL SURFACES is put to zero in the model, assuming light tightness.

4.5.2.2 RADIATOR

Tracker allocated radiator are two pieces:
One RAM oriented, with an area of 1.62 m^2
The second one WAKE oriented, with an area of 1.62 m^2
Mass = TBD, in the range 13 to 19.5 (Kg) per radiator, possibly including its brackets.
Both have thermo-optical properties of white paint.
This radiators are tilted and they have a trapezium shape.

Radiators are provided by the Thermal Design Team.

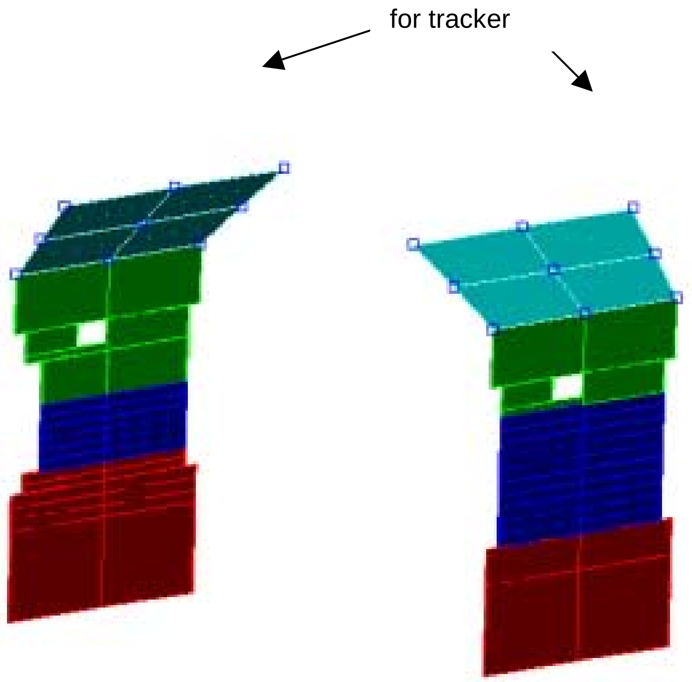


Figure 4.5.2.2-1: Tracker radiators

4.5.2.2.1 RADIATOR INTERFACES

4.5.2.2.1.1 RADIATIVE

The goal is that the radiator shall not radiate backward more than 3% of its total power collected on it.
Its rear side is covered by Betacloth MLI.
MLI is provided by Lockheed Martin (TBC).

4.5.2.2.1.2 CONDUCTIVE

Temperature uniformity on the radiator shall be lower than 5°C.
The conduction from the radiator to the USS/Main Radiators shall be lower than 0.1 W/K (TBC) for each fixation point.
A conductive interface is foreseen for Tracker CO_2 loop condenser installation, behind each radiator, two condensers, one foreseen per radiator.
The interface is provided TBD bolts, according to the following pattern:

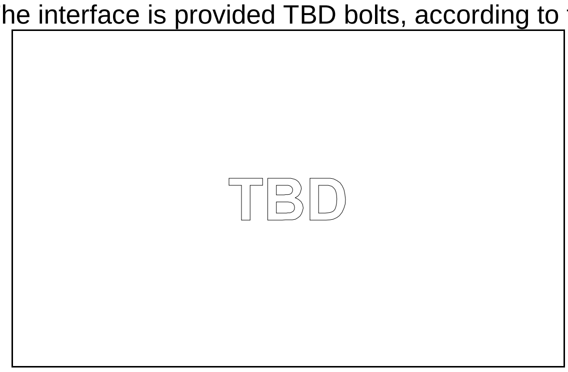


Figure 4.5.2.2.1.2-1: Tracker radiator interface control drawing

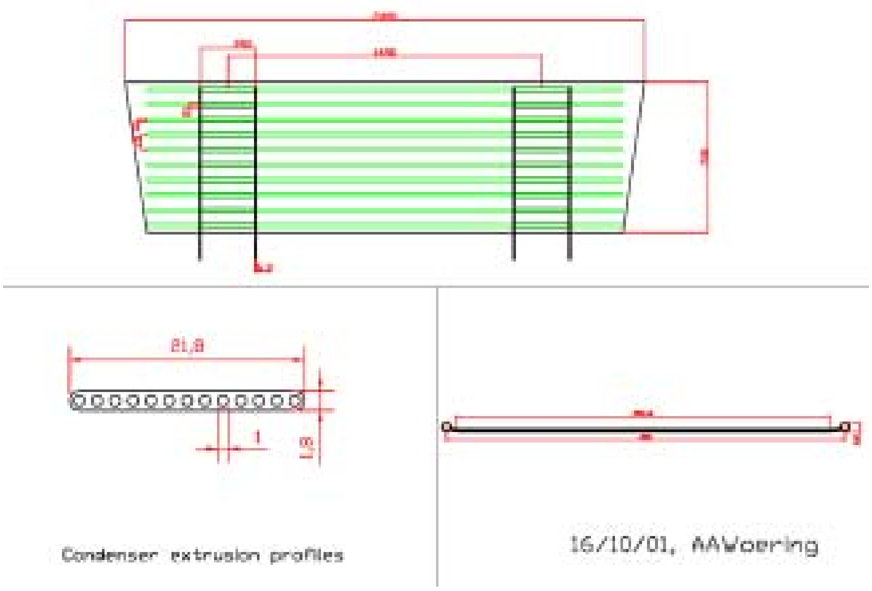


Figure 4.5.2.2.1-2:Tracker CO_2 cooling loop condenser installation on the radiator (TBC)

4.5.2.3 OTHER SURFACES

Tracker top/bottom surface radiation heat exchange shall be minimized toward Upper and lower TOF.
The goal is to have an emissivity lower than 0.1.
Coatings to make these t/o properties are provided by Tracker group (TBC by Geneva).

Towards the ACC stabilizing cylinder the emissivity shall be less than 0.1 (material TBD, e.g. aluminum deposition).

The conical support flange facing the vacuum case shall have an emissivity lower than 0.1 (where applicable, namely for the mechanical parts except for the harness).
Coatings to make these t/o properties are provided by Aachen.

4.6 HEAT EXCHANGE REQUIREMENTS WITH NEIGHBORING EXPERIMENTS

The goal is to have a negligible amount of power radiated in ZENITH – NADIR directions.

5. ACC

5.1 TEMPERATURE RANGES

OPERATIONAL = -20 to +40°C
NON OPERATIONAL = -20 to +40°C

5.2 SHORT-TERM TEMPERATURE STABILITY

N.A.

5.3 HEAT DISSIPATION

1 W is dissipated on the upper and 1 W on the lower ACC

5.4 MECHANICAL DESIGN

The PMTs location is directly mounted on the vacuum case conical flange, arranged in four couples of small boxes.

5.5 SUB DETECTOR THERMAL I/F DESCRIPTION

5.5.1 CONDUCTIVE

The scintillator modules are sectorwise in contact with the inner wall of the VC.

The PMTs boxes shall be decoupled from the vacuum case with G10 thermal washers (TBC by thermal design team) with an interface conductance lower than 0.1 W/K (TBC)

5.5.2 RADIATIVE

Outer scinitillator surface is a Polyester Fabric (Trevira) with Acrylat Foam. The CFC stabilizing cylinder will be coated on both surfaces with material TBD (e.g. polished aluminium) with emissivity $\varepsilon < 0.1$

6. CRATES

6.1 TEMPERATURE RANGES

Temperature ranges at crate level are listed in section 6.7
The maximum operational temperature limit for electronic cards is 55°C for edges of cards.

6.2 SHORT-TERM TEMPERATURE STABILITY

5°C stability on orbit period.

6.3 TEMPERATURE GRADIENTS

NA

6.4 HEAT DISSIPATION

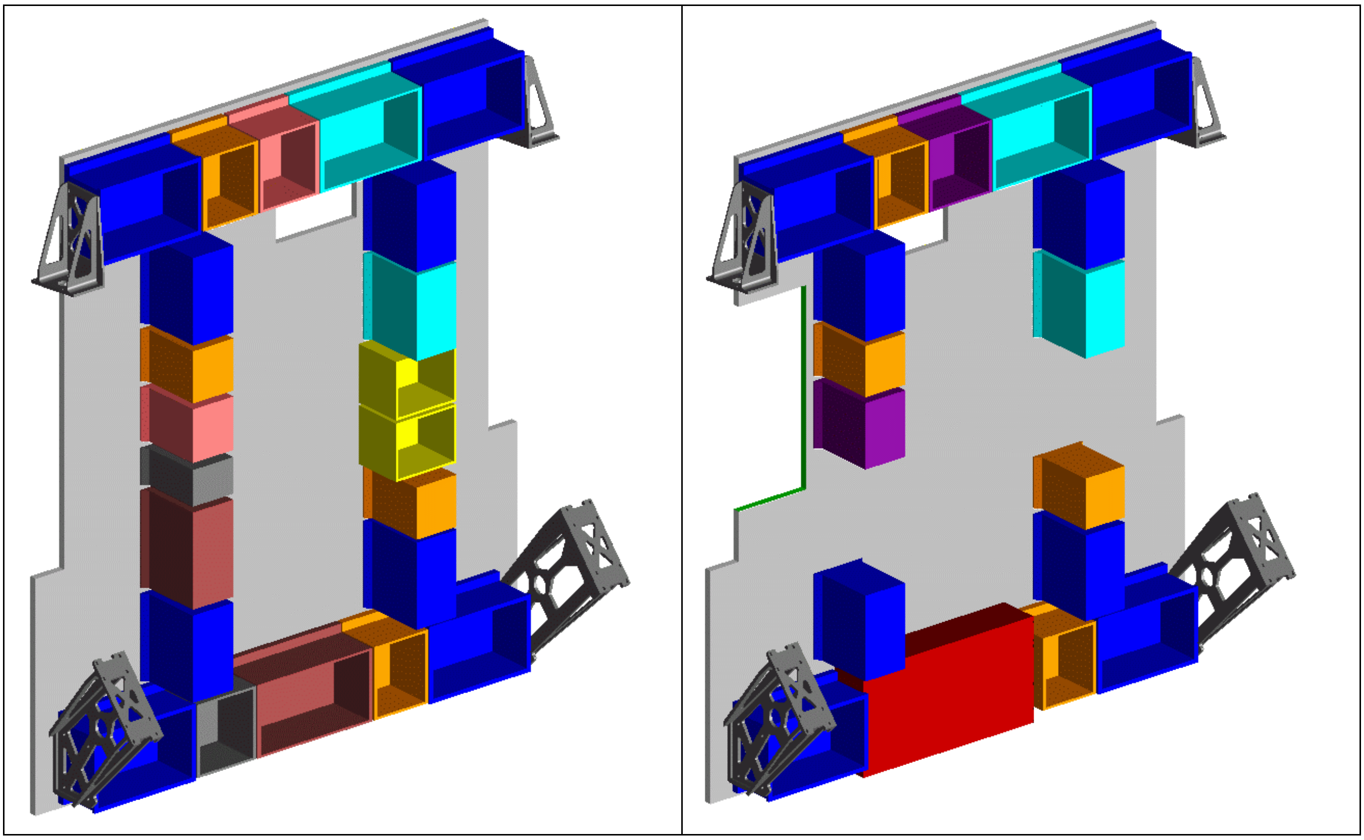


Figure 6.4 4.5.2.3-1 and Figure 4.5.2.3.4 -2: Ram and Wake radiator for crates.

The crates number power dissipations and masses are summarized in the following table.

AmsE Crate, Box Flight Design Summary

Crate	xPD	Qty	Function (tot det)	Slots	Cards	DC/DC	CAN	28V in
E		2	ECal (324 PMT)	23	14		2	
	EPD	2		6		4		1
J		1	DAQ(MDC+JxIF)	24	24		6	
	JPD	1		12		10		1
JT		1	DAQ(Trig+JINJ)	12	12		2	
	JTPD	1		4		2		1
M		1	Monitor, CC & Align.	12	12		2	
	MPD	1		6		4		1
R		2	RICH (640 PMT)	12	9		2	
	RPD	2		4		4		1
S		4	Scint (34ToF+8ACC)	11	8		2	
	SPD	4		6		3		2
T		8	Tracker (192 Ladder)	21	21		2	
	TPD	8		11		9		1
U		2	TRD (82 Module)	21	21		2	
	UPD	2		9		7		1
UG		1	TRD Gas Elec	13	13		2	
	UGPD	1		8		7		1

Table 6.4-1: Standard electronic crates: cards number

			Nominal Heat (W)		Hook Weight (Kg)	
Crate	xPD	Qty	Unit	SumBox	Unit	Subsys
E		2	23.26	65.3	22.59	51.1
	EPD	2	9.38		2.95	
J		1	46.93	69.0	16.10	21.9
	JPD	1	22.09		5.80	
JT		1	5.10	8.1	8.68	10.8
	JTPD	1	2.98		2.08	
M		1	2.68	4.6	8.72	11.8
	MPD	1	1.88		3.11	
R		2	13.26	46.6	10.08	26.1
	RPD	2	10.05		2.95	
S		4	19.67	109.0	8.55	45.4
	SPD	4	7.58		2.79	
T		8	43.91	547.6	14.67	159.0
	TPD	8	24.55		5.21	
U		2	18.90	60.5	14.67	37.9
	UPD	2	11.35		4.26	
UG		1	7.75	19.0	9.38	13.4
	UGPD	1	11.22		3.98	

Table 6.4-2: Summary of standard crates properties.

Non standard electronic crates are listed in the following table:

Non VME Crates					
ITEM	**Mass (Kg)**	**Power (W), duty cycle (%)**	**Size (mm)**	**Thermal control**	**Fixation Point**
CAB	31 Kg (TBC)	50 W (100% duty cycle) 365 W (peak) during magnet charging (2 hrs)	735 x 260 x 225 mm (L-W-H) without feet, or 750 x 290x 230 with feet/protr	Direct radiation in wake direction	USS02
CVB	15 + 2Kg	0 W	TBD	TBD	USS02
CCS 500A current measuring shunt	2.15 Kg	42 W (peak) during magnet charge / discharge (2 hrs)	200x100x45 plus screw terminations (TBC by R. Harold)	TBD	USS02 or possibly located inside CAB
ASTE	4KG	20 W Outside	TBD	TBD	TBD
ASTC	2* 2KG	2* 4W in the enclosure between vacuum case and tracker	TBD	TBD	Tracker (TBD)
TRD gas box Supply	97 Kg	average 8 W	∅ 555 x 860 mm	Conduction to USS02	USS02
TRD gas box (Circulation)	8 Kg	average 6 W	∅ 555 mm x TBD mm	Conduction to USS02	USS02
TTCS	TBD	20 W HEATER REQUIREMENTS?	TBD	Through fluid lines (TBC)	USS02
CCEB (may be in M-crate or in CCDB)	2 Kg (if not in M-crate)	10 W	260x200x120 mm	Conduction to radiator	Radiator
CCDB	6 Kg x 2 boxes	35 W x 2 boxes	260x200x200 mm	Conduction to radiator	Radiator
PDB	45 Kg	300W?	750 x 300 x 200 (TBC)	Conduction to radiator	Radiator (TBC)
CDD (ENERGY DAMPING SYSTEM)	2x5.5 Kg	5 MJ / 2 hours	2x 170x110x110	to USS02	USS02
TRACKER ALIGNMENT	1 Kg	0 W	TBD	to USS02	USS02
CUPS (CRYO UPS AND QUENCH BATTERY)	TBD	TBD	TBD	TBD	TBD

Table 6.4-3: Summary of non-standard *crates properties*

6.5 SUB DETECTOR THERMAL I/F DESCRIPTION

6.5.1 CONDUCTIVE

The Crates shall be suitably connected to the radiators by means of a good thermal interface. The conductance is a function of the length of the crate, and can be expressed by a length-normalized conductance:
K_L= 7.5 W K^{-1} m^{-1}.
The mechanical ICD of the radiators is in the following figure:

TBD

Figure 6.5.1-1: Crates radiator interface control drawing.

6.5.2 RADIATIVE

6.5.2.1 MLI

Other sides than the radiator shall be insulated by means of MLI, with external thermo optical properties as Beta cloth.
MLI is provided by Lockheed Martin (TBC)

6.5.2.2 RADIATOR

The thermo optical properties shall be white paint. The radiator area is summarized in the following table. These radiators shall be provided by the Thermal Design Team .

Radiator	m^2
RAM	3.42 (TBC)
WAKE	4.34 (TBC)

6.5.2.2.1 RADIATOR INTERFACES

6.5.2.2.1.1 RADIATIVE

The radiator shall not radiate backward more than 3% of its total power collected on it.

6.5.2.2.1.2 CONDUCTIVE

Temperature uniformity on the radiator shall be lower than 5°C.
The conduction from the radiator to the USS shall be lower than 1 W/K for each fixation point. This interface will be provided by the Thermal Design Team.
The crate is fixed to radiator using bolts going through feet obtained on plates to which electronic cards are fixed. The value of conductance between the internal part of a crate and the radiator depends, above all, on the thickness of the aluminum plates hosting electronic cards.
A layer of cho-therm is put in between crates aluminum plates and radiator. The cho-therm is provided by MIT (TBC)
The following picture shows the crate installation to radiator.

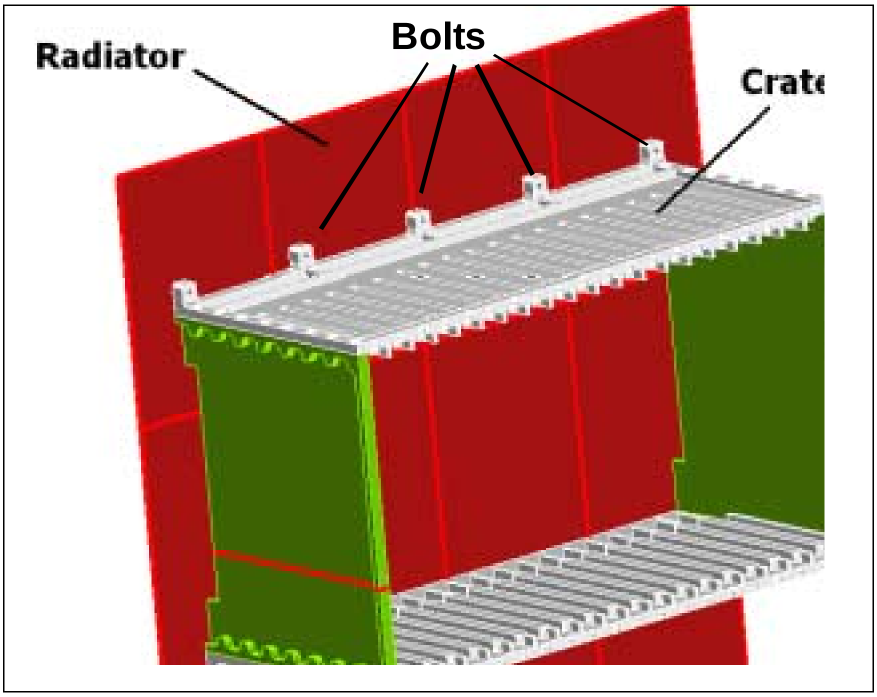


Figure 6.5.2.2.1.2-1: Interface radiator-crate.

6.6 HEAT EXCHANGE REQUIREMENTS WITH NEIGHBORING EXPERIMENTS

The radiation in the other directions than the radiator shall be minimized. No more than 3% of the totally dissipated power shall be rejected backward.

6.7 SUB-DETECTOR I/F TEMPERATURE RANGE

Item	***I/F Operational range***	***I/F Non Operational range***
Standard crates	-20°C ÷ +50°C	-40°C ÷ +80°C
Cryomagnet Avionic Box (CAB)	TBD (+60° C max)	TBD
CCS	TBD	TBD
Cryomagnet Quench Drive Battery (CQDB)	TBD	TBD
Cryo-cooler driver control box	-30°C ÷ +50°C	TBD
Laser Align Crate	+5°C ÷ +25°C TBD	TBD
Power Distribution Box	-25°C ÷ +45°C	-40°C ÷ +80°C
Warm Helium Supply	TBD	TBD
TRD Gas Box S and C	0°C ÷ +30°C	-25°C ÷ +45°C
ASTE	TBD	TBD
ASTC	TBD	TBD
Flywheel (CDD)	TBD	TBD

7. MAGNET / VACUUM CASE

7.1 TEMPERATURE RANGES

The vacuum case external temperature shall be as low as possible and the design goal is to have it (in average) colder than 10°C.

7.2 TEMPERATURE GRADIENTS

TBD

7.3 HEAT DISSIPATION

See cryos. No direct power dissipation is taking place in the vacuum case, it is assumed adiabatic.

7.4 SUB DETECTOR THERMAL I/F DESCRIPTION

7.4.1 CONDUCTIVE

The vacuum case has a mechanical interface to the USS at 8 points (4 on the upper support flange, 4 on the lower support flange), each of them having a value of 6.72 W/K.

7.4.2 RADIATIVE

7.4.2.1 MLI

The Outer Vacuum Case (VC) shell on ± Y quadrants (towards crates) will be covered with Beta Cloth.
Closeout MLI blankets in upper and lower direction will be provided by LM (between upper support ring and TRD, see figure 7.4.2.3-1)

7.4.2.2 RADIATOR

NA

7.4.2.3 OTHER SURFACES

The Outer Vacuum Case (VC) shell on ± X quadrants will be covered with Silver Teflon.
All other surfaces, including the Upper and Lower conical flanges will be anodized aluminum.
In order to protect the upper and lower flanges from radiative exposure a MLI blanket is put covering directly the upper and lower flanges of the vacuum case.
The outer thermo optical property of the covering is Beta cloth.

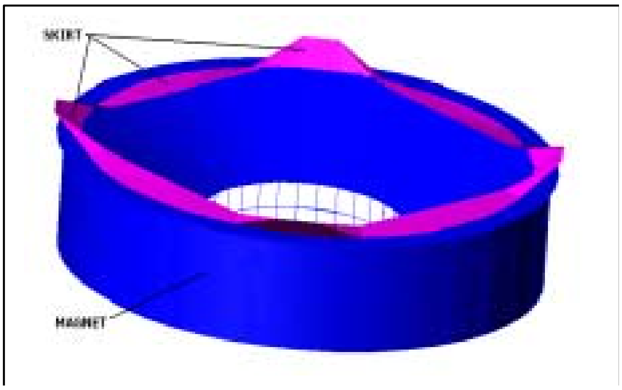


Figure 7.4.2.3 -1: The Betacloth fixed to the upper support ring (SKIRT).

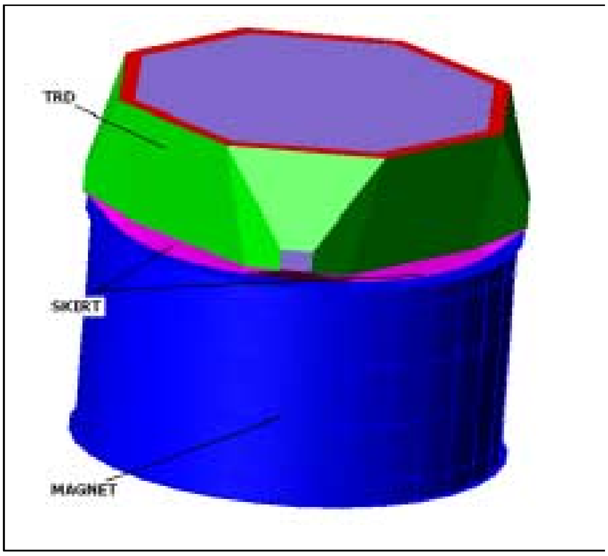


Figure 7.4.2.3 -2: The covering between TRD and MAGNET.

7.5 HEAT EXCHANGE REQUIREMENTS WITH NEIGHBORING EXPERIMENTS

NA

8. CRYOCOOLERS

8.1 TEMPERATURE RANGES

Minimum turn on mode: - 10°C
Minimum steady-state operating mode: - 10°C
Maximum steady-state operating mode: + 40°C
Design goal temperature: 0°C

The cryocoolers hot side temperature shall be as low as possible.

8.2 TEMPERATURE GRADIENTS

NA

8.3 HEAT DISSIPATION

Heat dissipation of each cryocooler is
Minimum: 60 Watts/cryocooler
Maximum: 150 Watts/cryocooler
Nominal for design: 100 Watts/cryocooler

8.4 SUB DETECTOR THERMAL I/F DESCRIPTION

8.4.1 CONDUCTIVE

The thermal interface is established on their collar, and a thermal conductance of 9.4 W/K (TBC by thermal design team) to the Capillary Pumped Loop (CPL) evaporator that will bring the heat power to its own radiators. IN the following figure the mechanical I/F of the evaporators is shown.

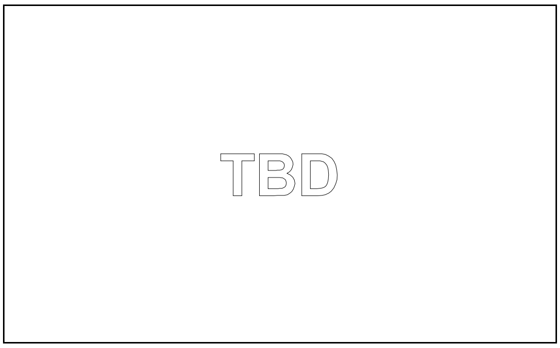


Figure 8.4.1-1: Cryocooler heat rejection collar interface.

The CPL is provided by Thermal design team.
A thermal de-coupling between the Cryo and the vacuum case shall be obtained by means of brackets, with a maximum mounting conductance of 0.01 W/K TBC by GSCF.

8.4.2 RADIATIVE

8.4.2.1 MLI

Each Cryo will be thermally insulated, by means of a suitable MLI blanket, with external thermo optical properties of aluminized polymide.

These blankets are provided by Thermal design team (TBC)

8.4.2.2 RADIATOR

The cryos are sunk to direct condensing radiators by means of CPL.
The cryos radiators are located on top of TRD (TBC) and their surface has an octagonal shape.
Zenith total cryos Radiator: Total area: 4.1 m^2
Total Mass: 25.0 Kg

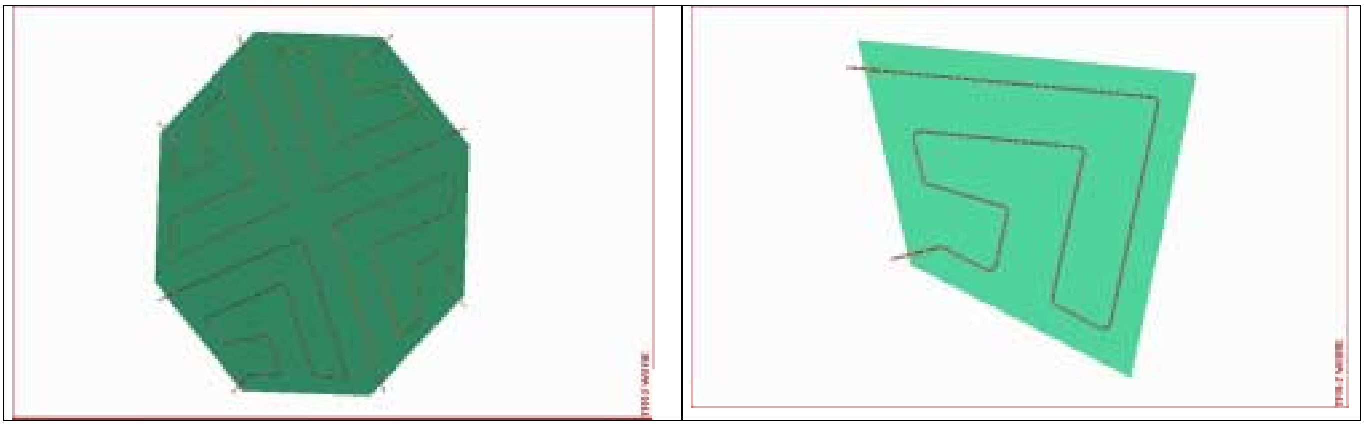


Figure 8.4.2.2.-1: Cryocoolers radiator tubes routing.

The thermo optical properties shall be White paint
These radiators shall be provided by Thermal Design Team.

8.4.2.2.1 RADIATOR INTERFACES

8.4.2.2.1.1 RADIATIVE

The radiator shall not radiate backward more than 3% of its total power collected on it.

8.4.2.2.1.2 CONDUCTIVE

Temperature uniformity on the radiator shall be lower than 5°C.
The radiator are fixed to TRD upper honeycomb panel by means of brackets and spokes, with the following conductance: TBC W/K

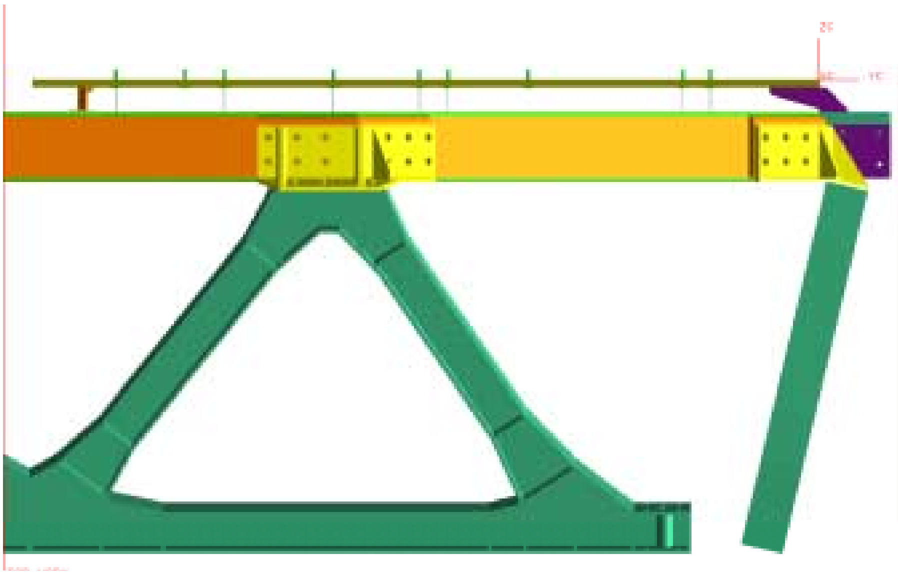


Figure 8.4.2.2.1.2-1: Cryocooler radiator side view.

8.4.2.3 OTHER SURFACES

NA

8.5 HEAT EXCHANGE REQUIREMENTS WITH NEIGHBORING EXPERIMENTS

Heat leak (both conductive and radiative) to the vacuum case shall be lower than 5 W (TBC by the magnet) per item.

9. LOWER TOF

9.1 TEMPERATURE RANGES

Operational: -20 to +40°C
Non operational: -50°C to +50°C

9.2 SHORT-TERM TEMPERATURE STABILITY

5°C stability over orbit period

9.3 TEMPERATURE GRADIENTS

10°C between structure and PMTs

9.4 HEAT DISSIPATION

3.6 W are dissipated on the lower TOF sides (0.8 x 2 W along Y direction (Ram-Wake) and 1.0x2 along X (Port-Starboard direction).

9.5 MECHANICAL DESIGN

A carbon fiber box covered both internally and externally by a thin Aluminum foil (50-100 μm thick, TBD) is used to encapsulate the PMTs. The top cover of each box is made of aluminum (TBC), and its thickness will be less than 1mm (TBD by CGS). Each one of the 4 aluminum wall acts as a radiator and represents a radiative heat sink for the PMTs. The aluminum walls are oriented facing away from the vacuum case.

9.6 SUB DETECTOR THERMAL I/F DESCRIPTION

9.6.1 CONDUCTIVE

The PMT are thermally decoupled from the structure. For this reason the conductance from the TOF panels to the USS can be realized with any particular requirement. A value of conductance of TBD W/K is obtained on attachment rod.
TOF aluminum panel is directly radiating and its thermo optical properties are white paint (eventually an other surface covering with a more favorable emissivity/absorptivity ratio could be admitted).

9.6.2 RADIATIVE

The TOF PMT boxes heat radiation takes place from the 4 radiators.
Radiation has to be minimized below 20% (TBC by CGS) of the total dissipated power.

9.6.2.1 MLI

TOF MLI is provided by Lockheed Martin and is supposed to close out from the lower magnet flange edge to the TOF edge.
Its external thermo optical properties are Beta-cloth.

9.6.2.2 RADIATOR

The aluminum side of the box is white painted on both sides in order to increase its heat rejection capability.

9.6.2.3 OTHER SURFACES

The other external aluminum surfaces of the PMT boxes shall be polished aluminum, in order to have an emissivity lower than 0.1. They shall be moreover protected by means of MLI (TBC).

9.7 HEAT EXCHANGE REQUIREMENTS WITH NEIGHBORING EXPERIMENTS

The goal is that TOF cannot exchange more than 1 W both by radiation and conduction to the neighboring experiments.

10.RICH

10.1 TEMPERATURE RANGES

OPERATIONAL -20+40°C
NON OPERATIONAL = -40 +40°C

10.2 SHORT-TERM TEMPERATURE STABILITY

7°C stability over orbit period

10.3 TEMPERATURE GRADIENTS

Temperature uniformity among the PMTs 15°C

10.4 HEAT DISSIPATION

Totally 19.7 W are dissipated on 680 PMT.

10.5 SUB DETECTOR THERMAL I/F DESCRIPTION

10.5.1 CONDUCTIVE

RICH is coupled to the USS with a conductance of 0.781 W/K on each one of the 8 fixation points.

10.5.2 RADIATIVE

10.5.2.1 MLI

Rich Mirror shall be insulated by means of dedicated MLI.
Its external t/o properties shall be Beta cloth. This MLI shall be provided by LMCO.

An other MLI blanket is in between top ECAL panel and RICH.
Its external t/o properties shall be Beta cloth
It shall be provided by INFN - BO.

10.5.2.2 RADIATOR

RICH external radiators are OSR, and are mechanically obtained from the same part as the RICH structural octagonal frame.
RICH radiator area is 0.195 m^2 x4 + 0.248 m^2 x 4, with a total of 1.774 m^2.
Radiator mass is TBD Kg.

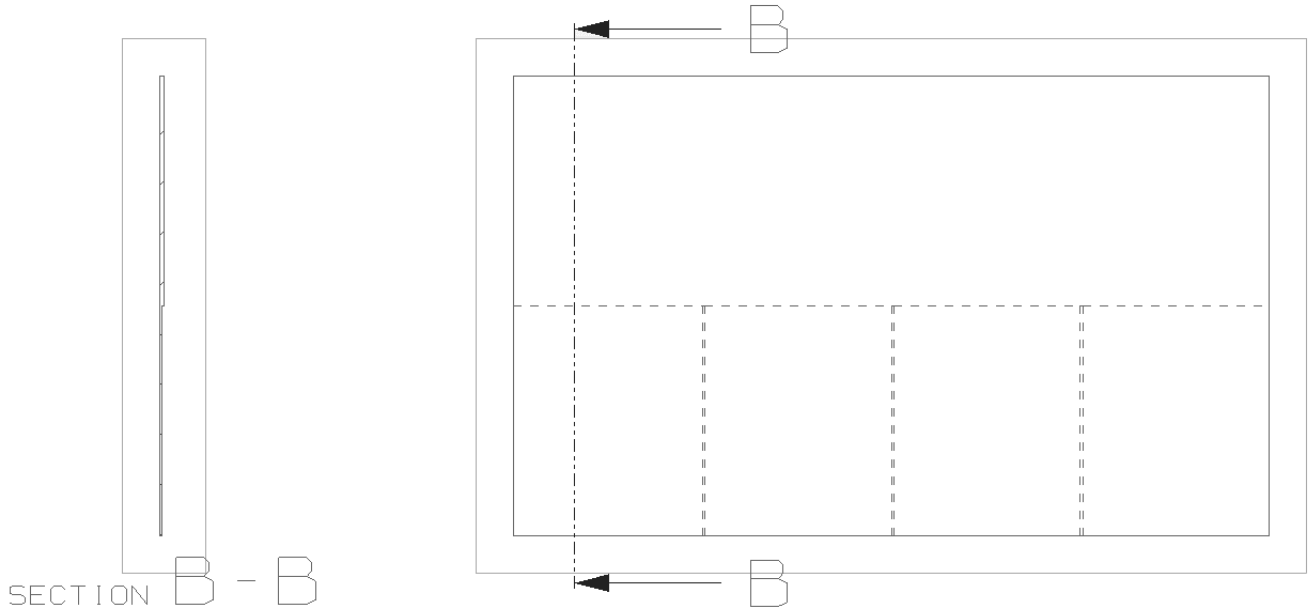


Figure 10.5.2.2-1: section of RICH radiator

These radiators are provided by INFN BO.
The rear side of the radiator shall be covered by MLI in order to prevent from back radiation.
Its external t/o properties shall be Beta cloth
This MLI shall be provided by INFN BO.

10.6 HEAT EXCHANGE REQUIREMENTS WITH NEIGHBORING EXPERIMENTS

RICH shall not reject in the ECAL direction more than 2 W TBC

11. ECAL

11.1 TEMPERATURE RANGES

OPERATIONAL -20 to + 40 °C
NON OPERATIONAL –40°C to +40°C

11.2 SHORT-TERM TEMPERATURE STABILITY

5°C over an orbit period: it is not an issue, due to the very large thermal capacitance of the subdetector.

11.3 TEMPERATURE GRADIENTS

Uniformity between pancake (LEAD) and aluminum structure in order to avoid thermal induced stresses. Up to 10°C of temperature difference are allowed.

11.4 HEAT DISSIPATION

Totally 46.7 W are dissipated on the PMTs.

11.5 SUB DETECTOR THERMAL I/F DESCRIPTION

11.5.1 CONDUCTIVE

Conductive link to the USS = 1.5 W/K for each one of the four fixation points and shall be provided by ECAL group (TBC).

11.5.2 RADIATIVE

11.5.2.1 MLI

Upper MLI: see RICH.
MLI is assumed covering the ECAL bottom panel, and the lateral walls if needed.
Its external t/o properties shall be Beta cloth
This MLI shall be provided by LMCO.

11.5.2.2 RADIATOR

Four winglets, embedded in the external ECAL structure have an area of 0.083 m^2 each, for a total 0.664 m^2.
Their thermo/optical properties are OSR
The winglets shall be provided by LAPP, the coating by INFN - PI .
ECAL Lateral panels will be white painted, and will be used ad radiators.

11.6 HEAT EXCHANGE REQUIREMENTS WITH NEIGHBORING EXPERIMENTS

ECAL is assumed to reject 60% of its power to the USS.

12.OPTICAL PROPERTIES

END OF LIFE

Beta Cloth	ε=0.87	α=0.4
White paint	ε= 0.92	α=0.23
aluminized polymide:	ε= 0.05	α=0.14
Silver Teflon.	ε= 0.88	α=0.09.
anodized aluminum	ε= 0.84	α=0.35.
OSR	ε=0.8	α=0.15.

BEGIN OF LIFE

Beta Cloth	ε=0.9	α=0.22
White paint	ε= 0.92	α=0.17
aluminized polymide:	ε=	α=
Silver Teflon.	ε= 0.92	α=0.07
anodized aluminum	ε= 0.83	α=0.38
OSR	ε=	α=