AMS02

Multi Layer Insulation (MLI) status

C. Vettore

MLI table format 1/2

ID	Item	Mass (kg) (using 0.44Kg/m2)	Reference mass budget	Buyer	Proposed Builder	H/W needed to build	Installation sequence
1	Upper Conical Flange of Vacuum Case - #1 (Tracker cables running below blanket — TTCS H/W lays underneath - ACC Upper fibre light guides + PMTs are below the blanket). The blanket shall be composed of 3 (TBC) pieces at the location of the protruding star trackers and the TTCS pipes to access the connector. **See MLI_ID#01_a.jpg, MLI_ID#01_b.jpg**	2.6m2 →1.1kg	MAGNET	LMSO/ NASA	LMSO	Connector positions; Vacuum Case (Cut-to-fit design to flight Hardware)	After ACC counters on VC and **After Tracker installing.**

MLI table format 2/2

H/W needed to build	Installation sequence	Blanket type	Holes/feed through	Mechanical fixation points	Notes
Connector positions; Vacuum Case (Cut-to-fit design to flight Hardware) 	After ACC counters on VC and **After Tracker installing.**	TBD by LMSO	Stay-out zones and late access zones to ACC PMTs and to TTCS H/W to be defined.	The MLI is fixed to the outer periphery of the VC using the M10 holes or TTCS evaporator supports. The other edge of the blanket is fixed to the TRD lower h/c by means of Aluminium stand-offs.	

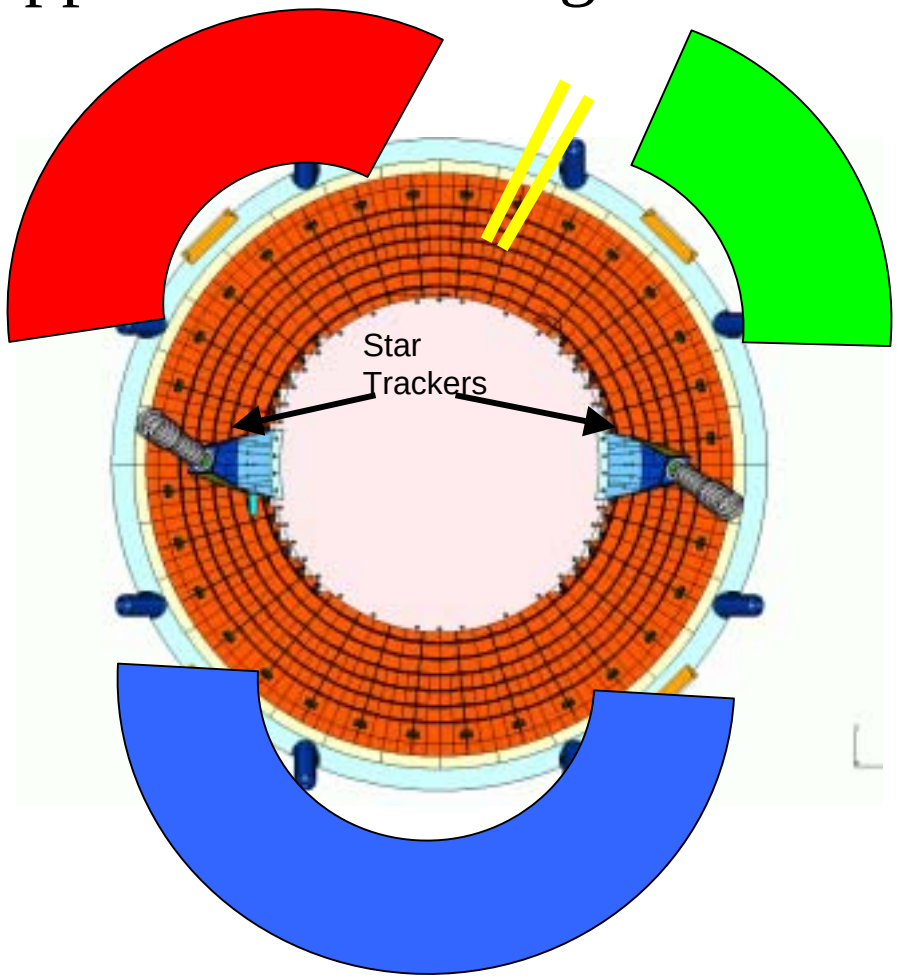
ID#1 – Upper Conical Flange of Vacuum case

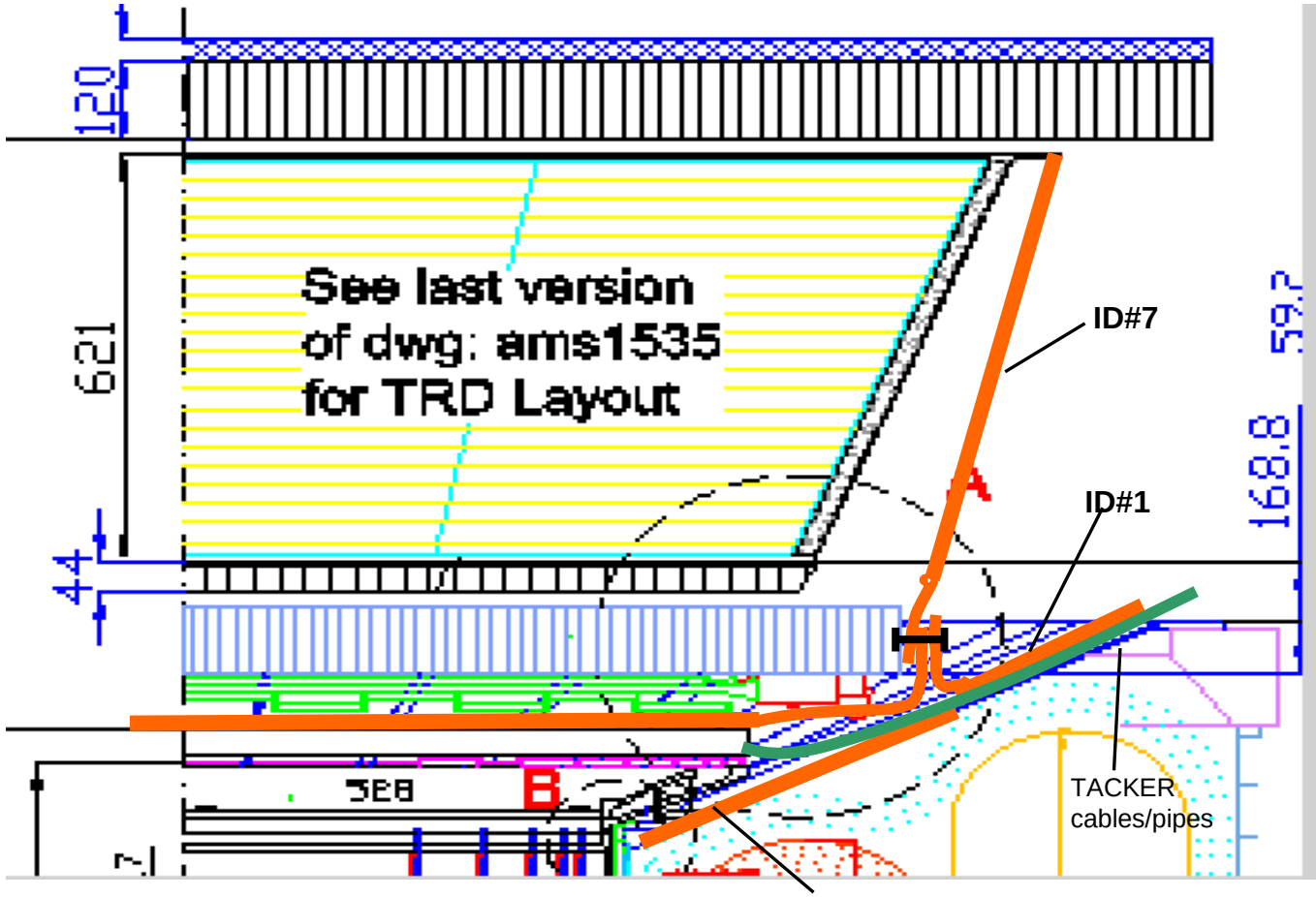
Description	Upper Conical Flange of Vacuum Case - # 1 (Tracker cables running below blanket – TTCS H/W lays underneath - ACC Upper fibre light guides + PMTs are below the blanket). The blanket shall be composed of 3 (TBC) pieces located at the protruding star trackers and at the TTCS pipes to access the connector.
Mass [kg] (using 0.44Kg/m2)	2.6m2 → 1.1kg
Reference mass budget	MAGNET
Buyer	LMSO/NASA
Proposed Builder	LMSO
H/W needed to build	Connector positions; Vacuum Case (Cut-to-fit design to flight Hardware)

ID#1 – Upper Conical Flange of Vacuum case

Installation sequence	After ACC counters on VC and After Tracker installing.
Blanket type	TBD by LMSO
Holes/feed through	Stay-out zones and late access zones to ACC PMTs and to TTCS H/W to be defined.
Mechanical fixation points	The MLI is fixed to the outer periphery of the VC using the M10 holes or TTCS evaporator supports. The other edge of the blanket is fixed to the ID#7A and ID#7A by fixed Aluminium stand-offs.

ID#1 – Upper Conical Flange of Vacuum case

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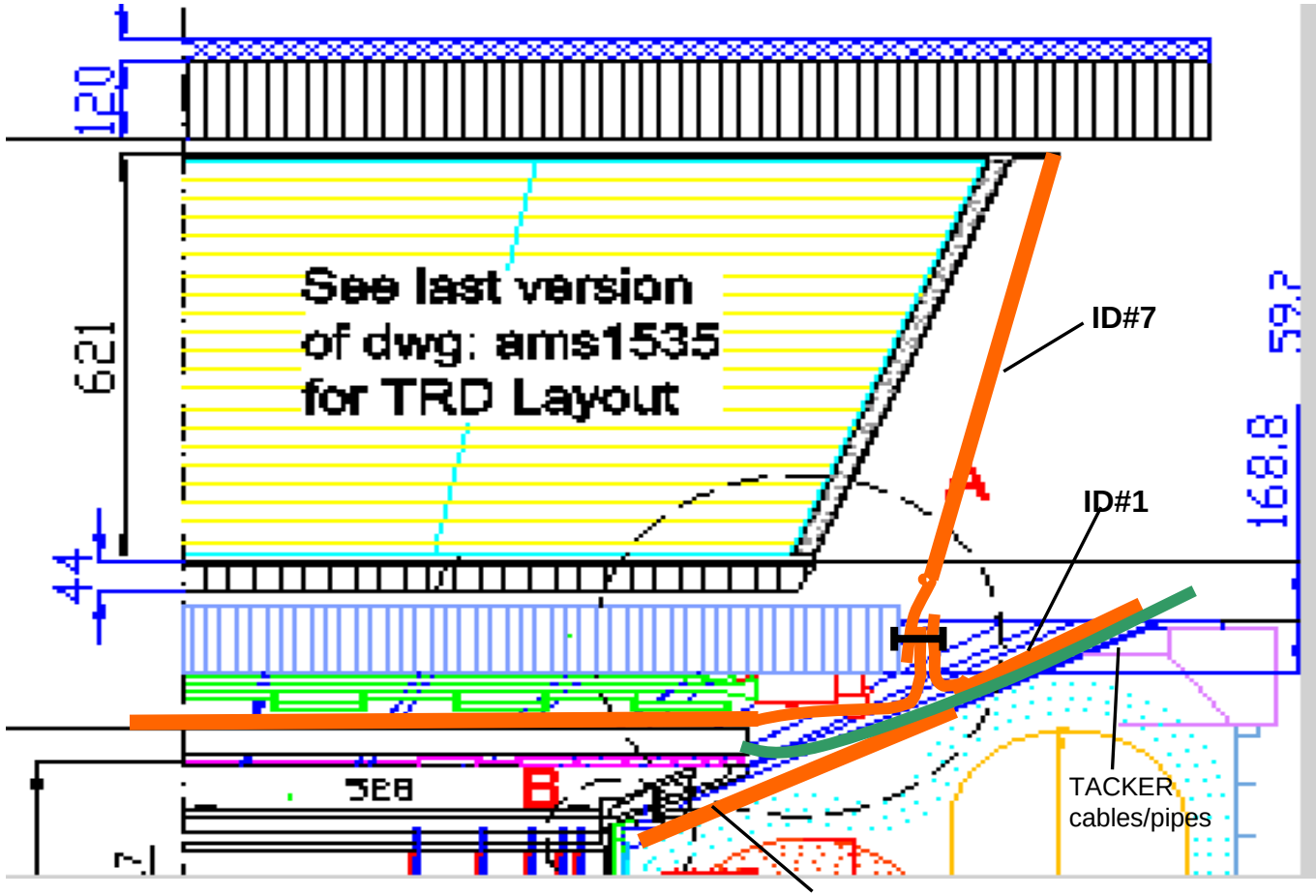
of dwg: ams1535
for TRD Layout
ID#7
ID#1
168.8
59.2
A
B
TACKER
cables/pipes
ID#2

ID#2 – Upper Conical Flange of Vacuum case

Description	Upper Conical Flange of Vacuum Case - # 2 (Tracker cables running above blanket – ACC Upper fibre light guides + PMTs are below the blanket). The blanket shall be composed of 3 (TBC) pieces.
Mass [kg] **(using 0.44Kg/m2)**	0.8m2 → 0.35kg
Reference mass budget	MAGNET
Buyer	LMSO/NASA
Proposed Builder	LMSO
H/W needed to build	Connector positions; Vacuum Case (Cut-to-fit design to flight Hardware)

ID#2 – Upper Conical Flange of Vacuum case

Installation sequence	After ACC counters on VC and Before Tracker cables and Tracker itself installing.
Blanket type	TBD by LMSO
Holes/feed through	Stay-out zones and late access zones to ACC PMTs , to TTCS H/W and to TRACKER cables connectors to be defined.
Mechanical fixation points	The MLI is fixed to the inner rim of the VC using the TBD holes or TTCS evaporator supports.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of dwg: ams1535
for TRD Layout
ID#7
ID#1
168.8
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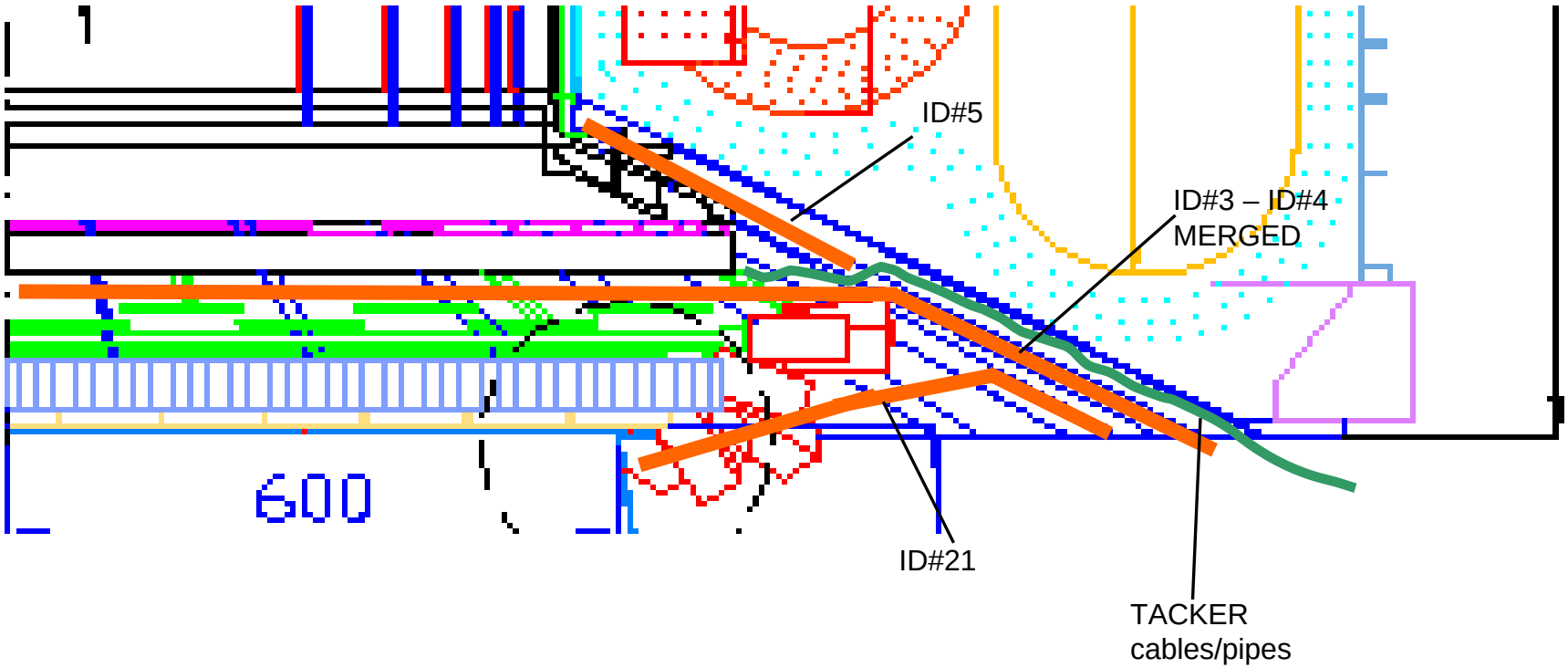
A
B
TACKER
cables/pipes
ID#2

ID#3 – Bottom tracker plane disk

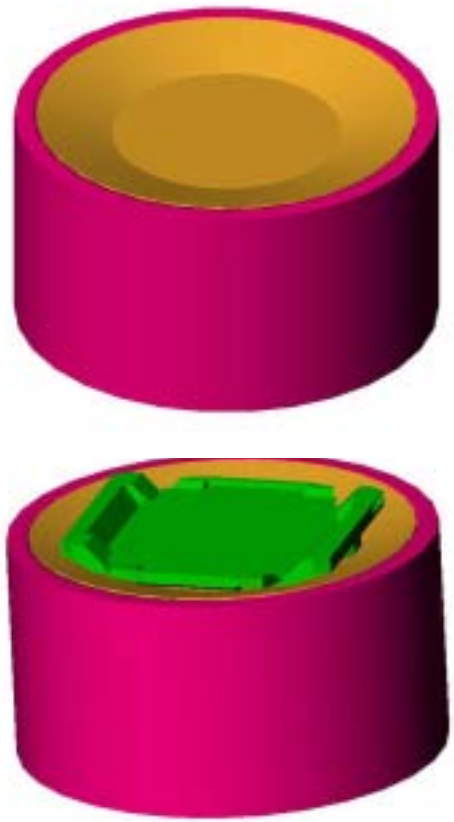
Description	Bottom TRACKER plane disk + Lower Conical Flange of Vacuum Case #1 (ID#4 has been merged to the ID#3). Tracker cables running below blanket – ACC Upper fibre light guides + PMTs are below this blanket. The blanket shall be composed of TBD pieces
Mass [kg] (using 0.44Kg/m2)	1.85m2 → 0.8 kg
Reference mass budget	TRACKER
Buyer	TRACKER
Proposed Builder	AAE
H/W needed to build	Tracker Bottom plane and Lower VC flanges to interface the MLI. (Cut-to-fit design to flight Hardware). MLI should be interfaced to ID#5 (TBC) . **Stay-out zones to have late access to LOW TRACKER to be defined by Tracker TEAM and to ACC counters.**

ID#3 – Bottom tracker plane disk



ID#3 – Bottom tracker plane disk

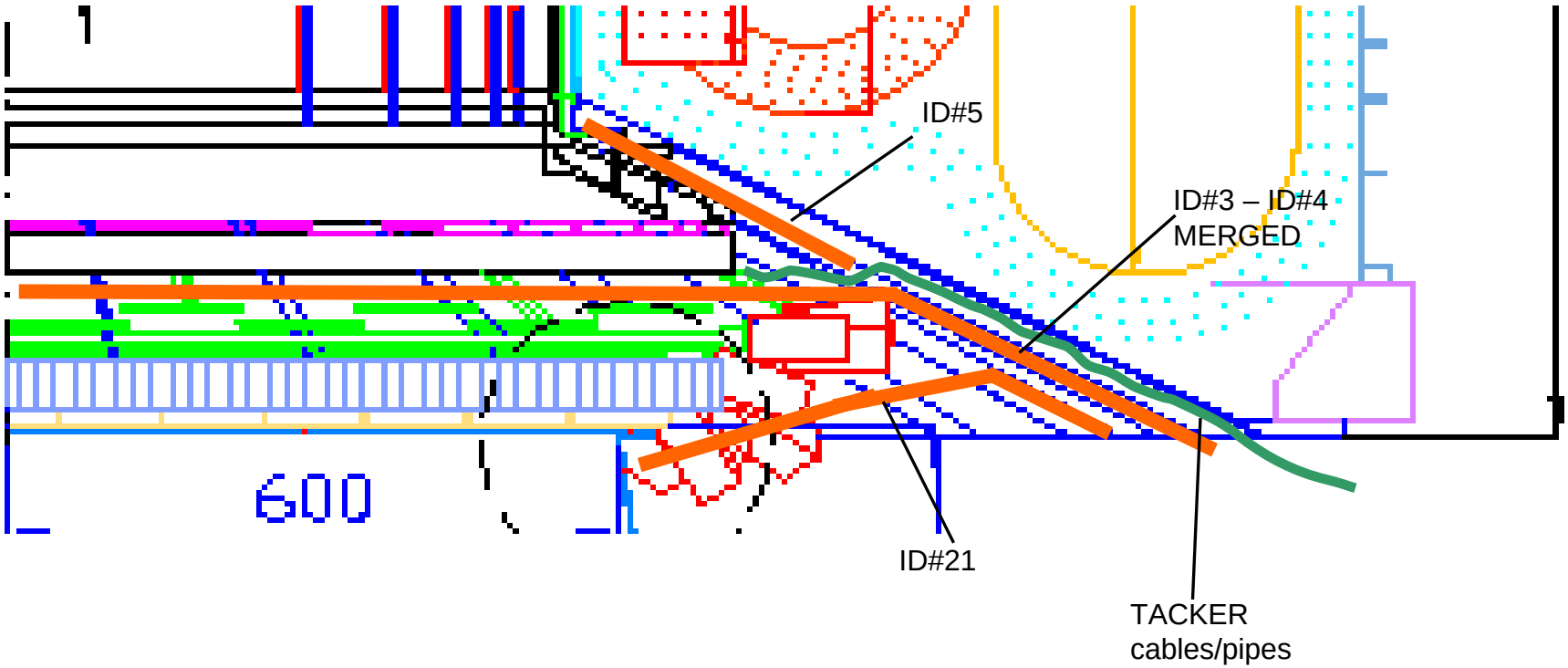
Installation sequence	After ACC counters on VC and Before Tracker cables and Tracker itself installing. After installing MLI ID#5.
Blanket type	CGS is using into the analysis the following MLI lay-up and composition : 1 x Beta-Cloth 20 x PETP spacer 'Platest', 5 gr / m², low outgassing, interleaved with 19 x VDA / 0,25 mil Mylar / VDA, perforated 1 x 1 mil VDA / Mylar / VDA, perforated
Holes/feed through	Stay-out zones and late access zones to ACC PMTs and to TTCS H/W to be defined.
Mechanical fixation points	The MLI is fixed to the TRACKER bottom plane using fixed aluminium stand-offs or already existing TBD holes. The outer edge of the blanket is fixed to the outer rim of the VC using ad hoc holes (TBC) or TTCS evaporator supports (if available)



ID#5 – Lower Conical Flange of Vacuum Case

Description	Lower Conical Flange of Vacuum Case - # 2 (Tracker cables running above blanket – ACC Lower fibre light guides + PMTs are below the blanket). The blanket shall be composed of 3 pieces (TBC).
Mass [kg] (using 0.44Kg/m2)	0.79m2 → 0.35 kg
Reference mass budget	MAGNET
Buyer	LMSO/NASA
Proposed Builder	LMSO/NASA
H/W needed to build	Connector positions; Vacuum Case (Cut-to-fit design to flight Hardware). **Stay-out zones to have late access to ACC PMTs.** **If cables running above have to be fixed on the VC surface , locations of fixing points have to be indicated (MLI windows are needed there).**

ID#5 – Lower Conical Flange of Vacuum Case

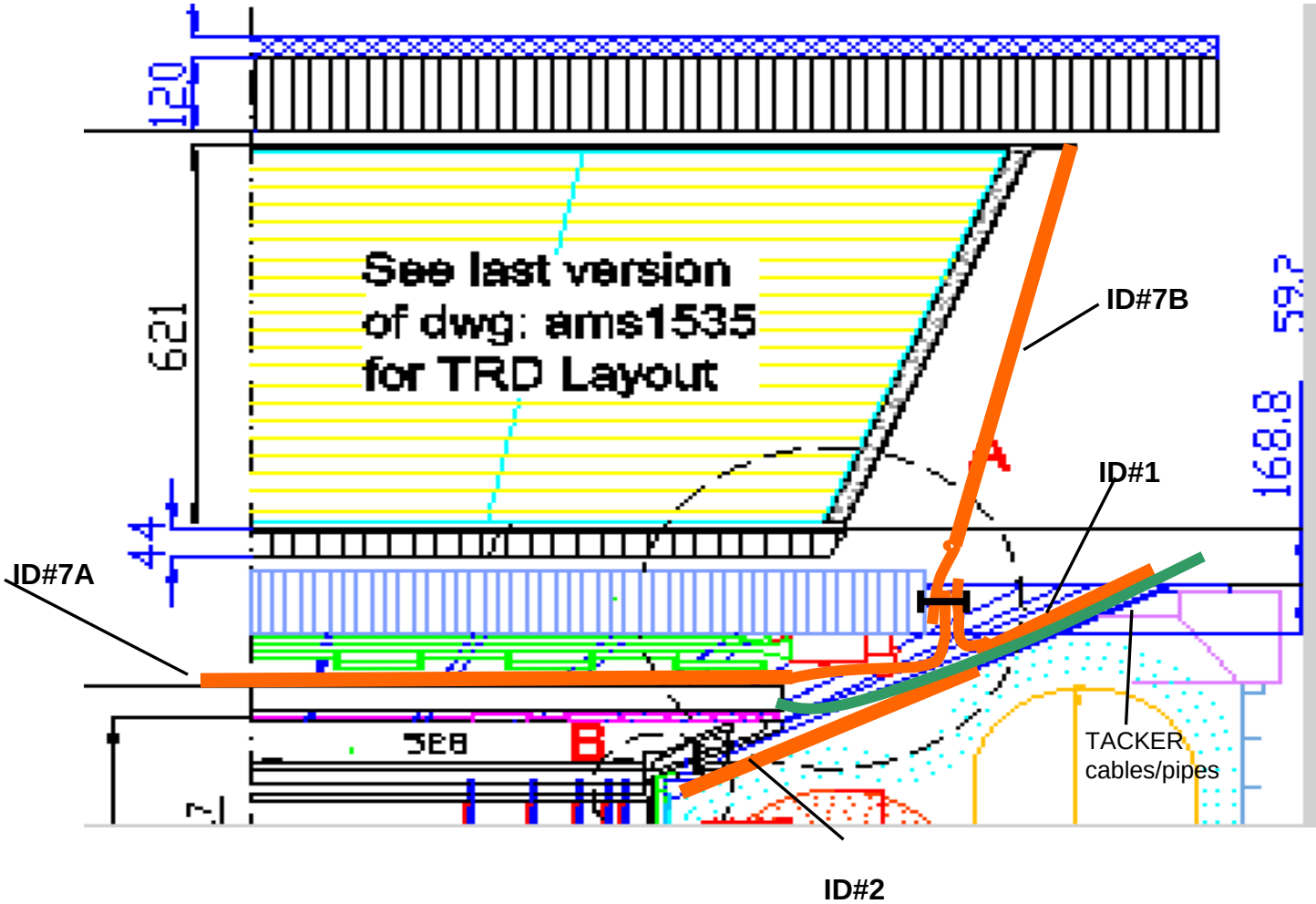


ID#5 – Lower Conical Flange of Vacuum case

Installation sequence	After ACC counters on VC and **Before** Tracker cables and Tracker itself installing.
Blanket type	TBD by LMSO
Holes/feed through	Stay-out zones and late access zones to ACC PMTs , to TTCS H/W and to TRACKER cables connectors to be defined
Mechanical fixation points	The MLI is fixed to the inner rim of the VC using the TBD holes or TTCS evaporator supports (if any). The other edge of the blanket is fixed to the middle rim of the VC by means of fixed Aluminium stand-offs (glued to the VC). Floating aluminium stand-offs may be also used to interface with the ID#3 (TBD)

ID#7A – Between upper TOF and Top Tracker plane

Description	Between UPPER TOF and Top Tracker plane
Mass [kg] (using 0.44Kg/m2)	2.83 m2 → 1.25 kg
Reference mass budget	TRD
Buyer	TRD
Proposed Builder	LMSO
H/W needed to build	(Cut-to-fit design to flight Hardware). TRD + UPPER TOF + TRACKER flight H/W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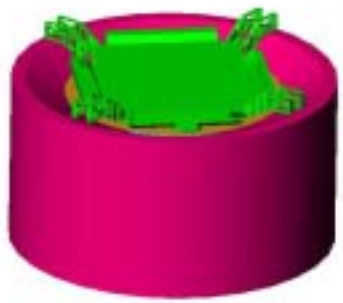
See last version
of dwg: ams1535
for TRD Layout
ID#7B
59.2
168.8
ID#1
ID#7A
A
B
TACKER
cables/pipes
ID#2

ID#7A – Between upper TOF and Top Tracker plane

Installation sequence	After TRACKER installing
Blanket type	1 x Beta-Cloth 20 x PETP spacer 'Platest', 5 gr / m², low outgassing, interleaved with 19 x VDA / 0,25 mil Mylar / VDA, perforated 1 x 1 mil VDA/ Mylar / VDA, perforated
Holes/feed through	Stay-out zones and late access zones to TRACKER top plane to be defined.
Mechanical fixation points	The MLI blanket shall be fixed to the top TRACKER plane by means of fixed aluminium stand-offs glued to the surface. The edges of the MLI bkanket shall be fixed to the TRD lower H/C panel by means of fixed aluminium stand-offs . The same standoffs shall be used to fix the lateral sides of the TRD blanket on the lower part and the ID1

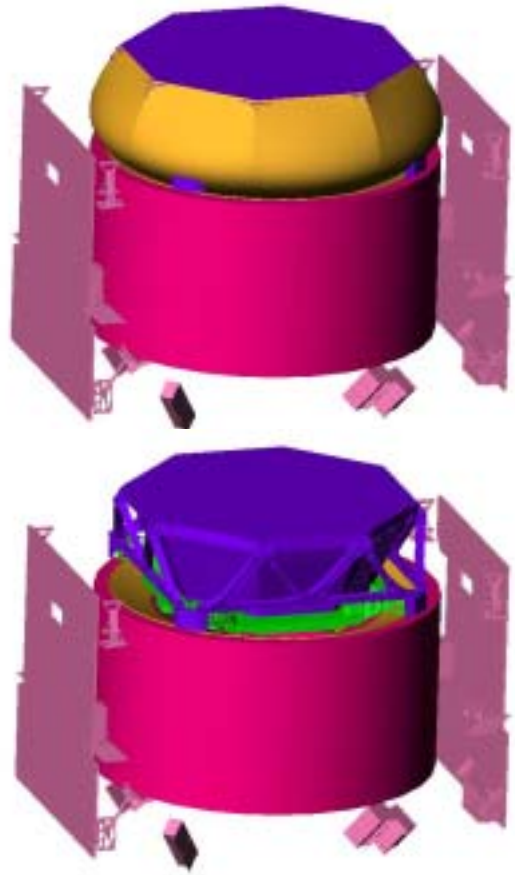


ID#7B – TRD Sides blanket

Description	TRD blankets: Sides and partially top.
Mass [kg] (using 0.44Kg/m2)	10.5 m2 → 4.6 kg
Reference mass budget	LMSO
Buyer	LMSO
Proposed Builder	LMSO
H/W needed to build	(Cut-to-fit design to flight Hardware). TRD + UPPER TOF flight H/W

ID#7B – TRD Sides blankets

Installation sequence	After UPPER TOF and TRD installing. After S-crate installing. After TRD gas box installing .
Blanket type	1 x Beta-Cloth 20 x PETP spacer 'Platest', 5 gr / m², low outgassing, interleaved with 19 x VDA / 0,25 mil Mylar / VDA, perforated 1 x 1 mil VDA / Mylar / VDA, perforated
Holes/feed through	Stay-out zones and late access zones to TRD and UPPER TOF connectors to be defined.
Mechanical fixation points	This MLI shall be overlapped in the lower part to the ID#7A using the same fixed stand-offs used for the ID#7A. The upper part of the blanket shall be fixed to the upper H/c plate.

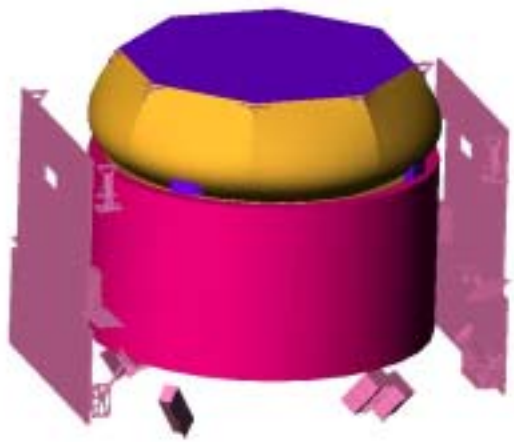


ID#7C – TRD top underneath Zenith Radiator

Description	TRD top blankets between TRD HC and Zenith radiator
Mass [kg] (using 0.44Kg/m2)	TBC
Reference mass budget	LMSO
Buyer	LMSO
Proposed Builder	LMSO
H/W needed to build	(Cut-to-fit design to flight Hardware)

ID#7C – TRD top underneath Zenith Radiator

Installation sequence	After TRD sides MLI installing. Before Zenith radiator
Blanket type	TBD by TRD
Holes/feed through	Stay-out zones and late access zones to TRD.
Mechanical fixation points	This MLI shall be overlapped in the outer part to the ID#7B using the same fixed stand-offs used for fixing the upper edge of the ID#7B.

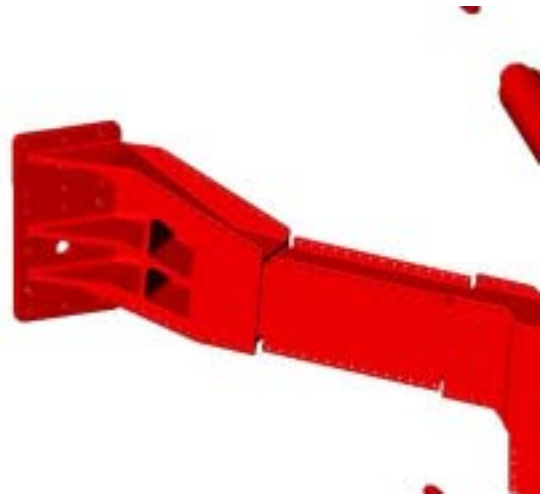


ID#8 – USS02 upper joints and upper Trunion Bridges

Description	USS02 upper joints and upper Trunion Bridges
Mass [kg] (using 0.44Kg/m2)	**To be calculated**
Reference mass budget	TRD
Buyer	TRD
Proposed Builder	LMSO
H/W needed to build	(Cut-to-fit design to flight Hardware). TRD + UPPER TOF + USS flight H/W + MAIN RADIATORS

ID#8 – USS02 upper joints and upper Trunion Bridges

Installation sequence	Before Main radiators installing. Dumbbell bracket shall be covered by MLI blanket as well since the side wall of the T-crates are supposed to be covered (TBC by analysis).
Blanket type	TBD by LMSO
Holes/feed through	Cut outs are needed in order to interface the MLI on USS with the Dumbbell bracket/T-crate MLI.
Mechanical fixation points	The MLI shall be fixed by means of fixed aluminium stand-offs (TBC). It shall be interfaced with the TRD sides MLI and Dumbbell MLI.

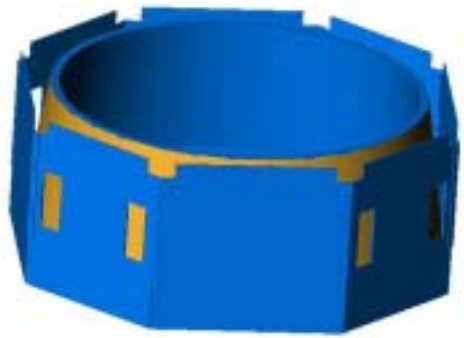


ID#9 – RICH reflector

Description	RICH reflector MLI The blanket shall be composed of TBD pieces.
Mass [kg] (using 0.44Kg/m2)	2.45 m2 → 1.1 kg
Reference mass budget	LMSO
Buyer	LMSO/NASA
Proposed Builder	LMSO/NASA
H/W needed to build	(Cut-to-fit design to flight Hardware). RICH reflector flight H/W or flight representative

ID#9 – RICH reflector

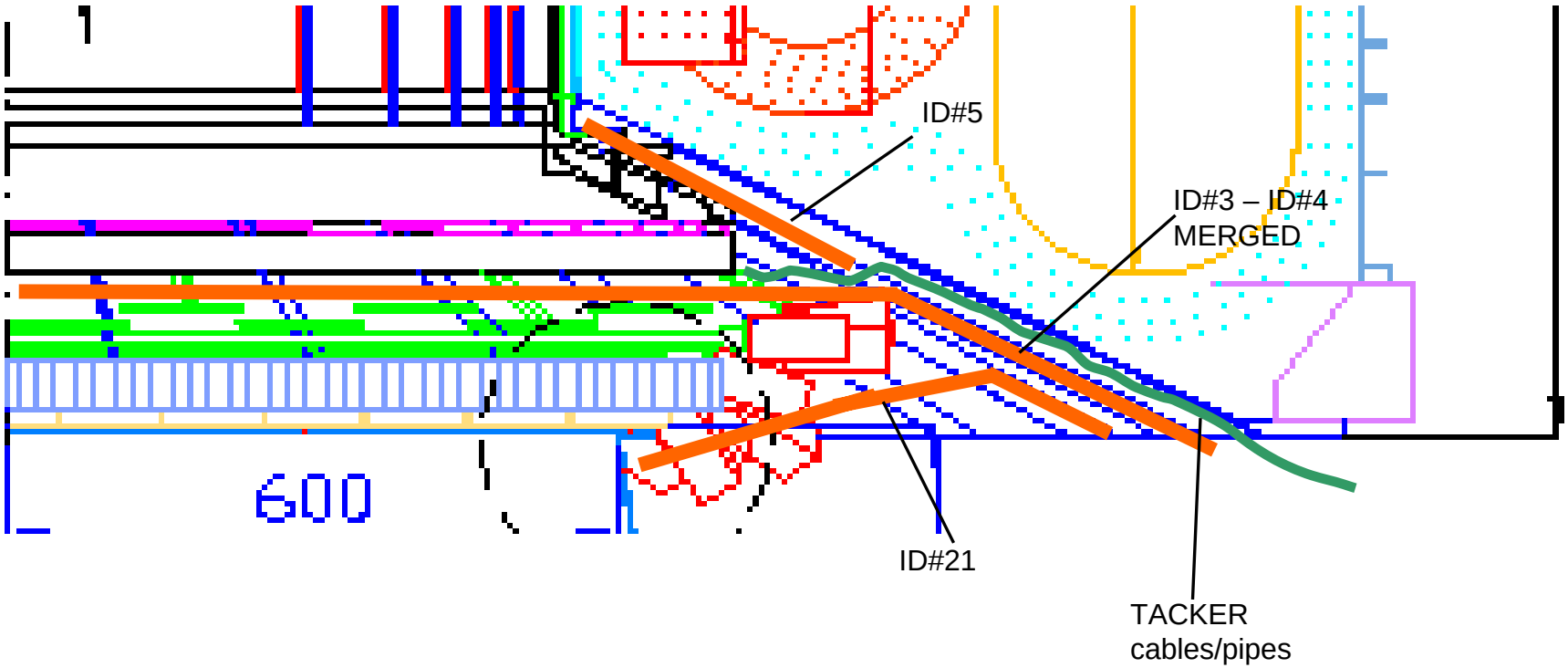
Installation sequence	After RICH mirror has been installed onto RICH secondary structure. Before installing the RICH panels.
Blanket type	CGS is using into the analysis the following MLI lay-up and composition : 1 x Beta-Cloth 20 x PETP spacer 'Platest', 5 gr / m², low outgassing, interleaved with 19 x VDA / 0,25 mil Mylar / VDA, perforated 1 x 1 mil VDA / Mylar / VDA, perforated
Holes/feed through	No cut-outs are needed.
Mechanical fixation points	The MLI shall be fixed on the lower edge to the bottom rim of the mirror by means of aluminium stand-offs. The upper edge shall be interfaced with the MLI blanket covering the LOWER TOF using stand-offs.



Notes:

Option under study: covering just the space facing side of the RICH panels and link that MLI blanket with the LOWER TOF MLI

ID#9 – RICH reflector

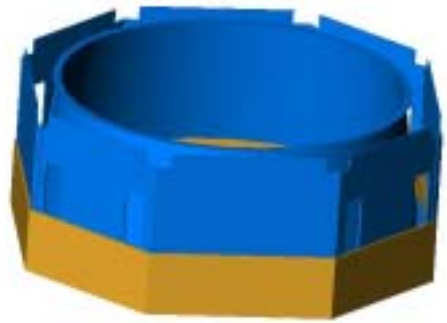


ID#10 – RICH panels

Description	RICH panels
Mass [kg] (using 0.44Kg/m2)	2.0 m2 → 0.9 kg
Reference mass budget	THERMAL CONTROL SYSTEM **(WITHIN ALLOCATED 10.5 kg)**
Buyer	CGS
Proposed Builder	AAE
H/W needed to build	(Cut-to-fit design to flight Hardware). RICH panels mounted on the RICH secondary structure or flight representative

ID#10 – RICH panels

Installation sequence	After installing the RICH panels AND before debris shield.
Blanket type	CGS is using into the analysis the following MLI lay-up and composition : 1 x Beta-Cloth 20 x PETP spacer 'Platest', 5 gr / m², low outgassing, interleaved with 19 x VDA / 0,25 mil Mylar / VDA, perforated 1 x 1 mil VDA / Mylar / VDA, perforated
Holes/feed through	Cut outs are needed to provide passage of the LOWER TOF rods.
Mechanical fixation points	The MLI shall be fixed on the lower edge to the bottom space-facing part of the RICH panel and to the bottom mirror-facing part of the RICH panel.



Notes:

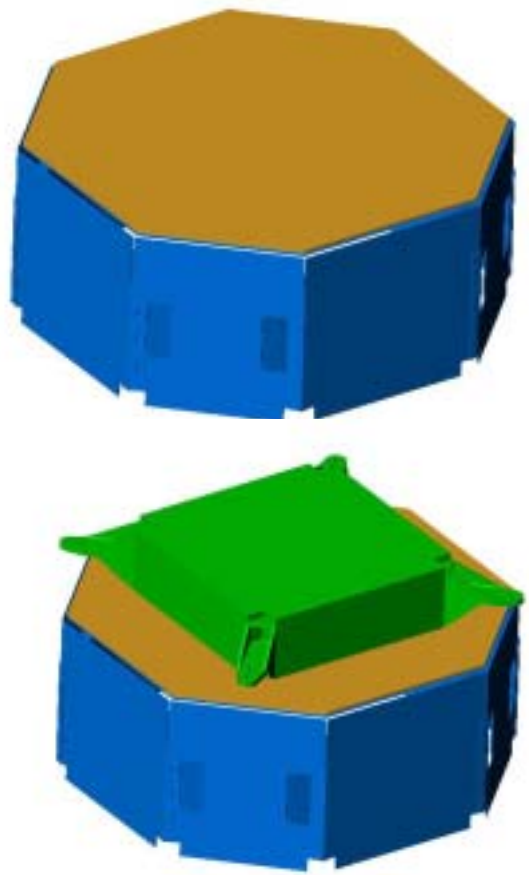
Option under study: covering just the space facing side of the RICH panels and link that MLI blanket with the LOWER TOF MLI

ID#11 – Between RICH and ECAL

Description	MLI at the Interface between RICH and ECAL
Mass [kg] (using 0.44Kg/m2)	0.78 m2 → 0.34 kg
Reference mass budget	THERMAL CONTROL SYSTEM **(WITHIN TBD MASS BUDGET)**
Buyer	CGS
Proposed Builder	AAE
H/W needed to build	(Cut-to-fit design to flight Hardware).

ID#11 – Between RICH and ECAL

Installation sequence	|To be decided according to RICH and ECAL integration sequence.
Blanket type	CGS is using into the analysis the following MLI lay-up and composition : 1 x Beta-Cloth 20 x PETP spacer 'Platest', 5 gr / m², low outgassing, interleaved with 19 x VDA / 0,25 mil Mylar / VDA, perforated 1 x 1 mil VDA / Mylar / VDA, perforated
Holes/feed through	Cut outs to be defined.
Mechanical fixation points	TBD

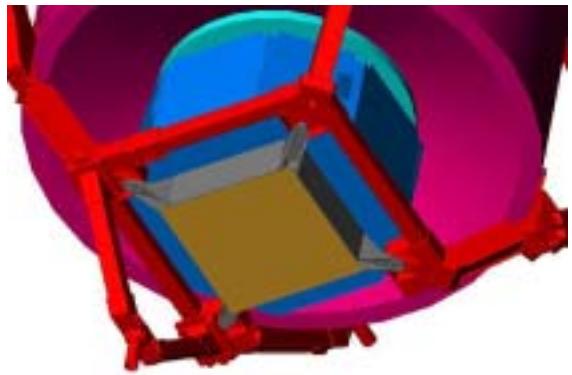


ID#12 – ECAL bottom

Description	ECAL bottom
Mass [kg] (using 0.44Kg/m2)	0.66 m2 → 0.3 kg
Reference mass budget	THERMAL CONTROL SYSTEM **(WITHIN ALLOCATED 7.8 kg)**
Buyer	CGS
Proposed Builder	AAE
H/W needed to build	ECAL flight H/W or flight representative

ID#12 – ECAL bottom

Installation sequence	This MLI blanket can be mounted After installing ECAL.
Blanket type	CGS is using into the analysis the following MLI lay-up and composition : 1 x Beta-Cloth 20 x PETP spacer 'Platest', 5 gr / m², low outgassing, interleaved with 19 x VDA / 0,25 mil Mylar / VDA, perforated 1 x 1 mil VDA / Mylar / VDA, perforated
Holes/feed through	No cut outs are needed .
Mechanical fixation points	The MLI shall be fixed by stand offs to the lower ECAL h/c plate.

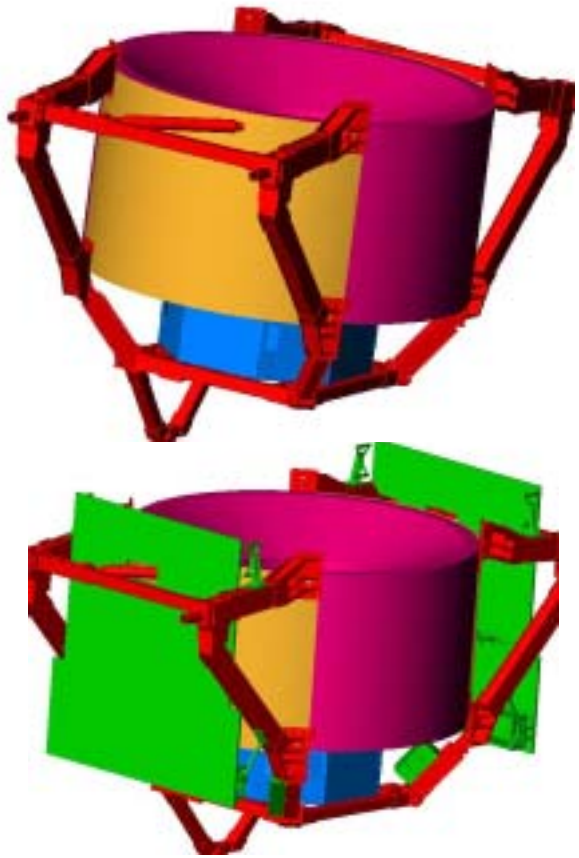


ID#13 – ±Y sides of Vacuum Case

Description	±Y sides of Vacuum Case
Mass [kg] (using 0.44Kg/m2)	7.3 m2 → 3.2 kg
Reference mass budget	LMSO
Buyer	LMSO/NASA
Proposed Builder	LMSO
H/W needed to build	(Cut-to-fit design to flight Hardware) VC flight H/W

ID#13 – ±Y sides of Vacuum Case

Installation sequence	After VC has been mounted onto USS.
Blanket type	TBD by LMSO
Holes/feed through	Cut-outs are needed for Cryo-coolers and for MAGNET out-coming cables and rods.
Mechanical fixation points	The MLI shall be fixed by stand-offs to the VC outer shell (TBC by LMSO)



ID#14 – TRDGB-S

Description	TRDGB-S
Mass [kg] (using 0.44Kg/m2)	**To be calculated**
Reference mass budget	TRD-GB
Buyer	TRD-GB
Proposed Builder	TBD
H/W needed to build	(Cut-to-fit design to flight Hardware). TRDGB H/W

ID#14 – TRDGB-S

Installation sequence	After TRDGB has been installed onto USS.
Blanket type	TBD
Holes/feed through	Cut-outs are needed for CABLES routing and attachments points.
Mechanical fixation points	The MLI shall be fixed by stand-offs (TBC by LMSO) to the TRDGB and to the USS (TBC)
Notes	Could be combined to Upper Joints MLI.

ID#15 – TRDGB-C

Description	TRDGB-C
Mass [kg] (using 0.44Kg/m2)	**To be calculated**
Reference mass budget	TRD-GB
Buyer	TRD-GB
Proposed Builder	TBD
H/W needed to build	(Cut-to-fit design to flight Hardware). TRDGB H/W

ID#15 – TRDGB-C

Installation sequence	After TRDGB has been installed onto USS. .
Blanket type	TBD
Holes/feed through	TBD
Mechanical fixation points	The MLI shall be fixed by stand-offs (TBC by LMSO) to the TRDGB and to the USS (TBC)
Notes	Could be combined to Upper Joints MLI.

ID#16 – CAB

Description	CAB
Mass [kg] (using 0.44Kg/m2)	0.8m2 → 0.352kg
Reference mass budget	MAGNET
Buyer	TBD
Proposed Builder	TBD
H/W needed to build	CAB flight H/W or flight representative

ID#16 – CAB

Installation sequence	After CAB has been mounted on the USS .
Blanket type	TBD by CRISA. CGS is using into the analysis the following MLI lay-up and composition : 1 x Beta-Cloth 20 x PETP spacer 'Platest', 5 gr / m², low outgassing, interleaved with 19 x VDA / 0,25 mil Mylar / VDA, perforated 1 x 1 mil VDA / Mylar / VDA, perforated
Holes/feed through	Cut-outs are needed for CABLES routing.
Mechanical fixation points	The MLI shall be fixed by stand-offs (TBC by CRISA) to the CAB.
Notes	

ID#17 – UPS

Description	UPS
Mass [kg] (using 0.44Kg/m2)	**To be calculated**
Reference mass budget	MAGNET
Buyer	LMSO/NASA
Proposed Builder	LMSO/NASA
H/W needed to build	UPS flight H/W or flight representative

ID#17 – UPS

Installation sequence	After UPS has been mounted.
Blanket type	TBD by LMSO
Holes/feed through	Cut-outs are needed for CABLES routing.
Mechanical fixation points	The MLI shall be fixed by stand-offs (TBC by LMSO) to the UPS.

ID#18 – CVB

Description	CVB
Mass [kg] (using 0.44Kg/m2)	**To be calculated**
Reference mass budget	TBD by ETH (J. Ulbricht)
Buyer	TBD by ETH (J. Ulbricht)
Proposed Builder	TBD by ETH (J. Ulbricht)
H/W needed to build	CVB flight H/W or flight representative

ID#18 – CVB

Installation sequence	TBD
Blanket type	TBD
Holes/feed through	TBD
Mechanical fixation points	TBD

ID#19 – TTCS box

Description	TTCS box
Mass [kg] (using 0.44Kg/m2)	**To be calculated**
Reference mass budget	THERMAL CONTROL SYSTEM **(WITHIN TRACKER ALLOCATED 72.9 kg)**
Buyer	TRACKER
Proposed Builder	TBD by Tracker
H/W needed to build	TTCS flight H/W or flight representative

ID#19 – TTCS box

Installation sequence	After TTCS has been mounted.
Blanket type	TBD by Tracker
Holes/feed through	Cut-outs are needed for CABLES routing.
Mechanical fixation points	The MLI shall be fixed by stand-offs (TBC by Tracker team) to the TTCS box..

ID#20 – Tracker radiator

Description	Tracker radiator back side MLI
Mass [kg] (using 0.44Kg/m2)	1.3m2 → 0.56kg
Reference mass budget	THERMAL CONTROL SYSTEM **(WITHIN TRACKER RADIATOR ALLOCATED WEIGHT)**
Buyer	OHB
Proposed Builder	AAE
H/W needed to build	(Cut-to-fit design to flight Hardware). Tracker radiator H/W with condenser mounted.

ID#20 – Tracker radiator

Installation sequence	After the condensers have been mounted onto the radiator
Blanket type	1 x Beta-Cloth 20 x PETP spacer 'Platest', 5 gr / m², low outgassing, interleaved with 19 x VDA / 0,25 mil Mylar / VDA, perforated 1 x 1 mil VDA / Mylar / VDA, perforated
Holes/feed through	Cut-outs are needed for pipes routing and planned cables.
Mechanical fixation points	The MLI shall be fixed by stand-offs to the back side of the radiator.

ID#21 – Crates and radiators

Description	Crates MLI . MLI is not foreseen on the back side of the radiators.
Mass [kg] (using 0.44Kg/m2)	To be calculated
Reference mass budget	THERMAL CONTROL SYSTEM **(WITHIN MAIN RADIATOR ALLOCATED WEIGHT)**
Buyer	OHB
Proposed Builder	AAE
H/W needed to build	(Cut-to-fit design to flight Hardware). Ram and wake radiator H/W mounted – Crates mounted onto radiators.

ID#21 – Crates and radiators

Installation sequence	After crates mounting onto radiators
Blanket type	1 x Beta-Cloth 20 x PETP spacer 'Platest', 5 gr / m², low outgassing, interleaved with 19 x VDA / 0,25 mil Mylar / VDA, perforated 1 x 1 mil Mylar / VDA, perforated
Holes/feed through	Cut-outs are needed for CABLES routing.
Mechanical fixation points	The MLI shall be fixed by stand-offs to the crates boxes.
Notes	Crates main walls shall be covered by MLI. Port and starboard walls of xPD boxes shall be covered by MLI. Coverage of VC facing xPD walls is under study.

ID#23 – Cryo-coolers + LHP lines

Description	Cryo-coolers + LHP lines
Mass [kg] (using 0.44Kg/m2)	To be calculated
Reference mass budget	THERMAL CONTROL SYSTEM **(WITHIN ZENITH RADIATOR ALLOCATED WEIGHT)**
Buyer	OHB
Proposed Builder	AAE
H/W needed to build	(Cut-to-fit design to flight Hardware). Cryo mounted onto VC. LHP and zenith radiators in place.

ID#23 – Cryo-coolers + LHP lines

Installation sequence	After LHP mounting.
Blanket type	TBD by OHB
Holes/feed through	Cut outs are needed on the LHP lines in order to interface the MLI blanket with the support vertical beam (TBD).
Mechanical fixation points	TBD by OHB.

ID#24 – Tracker cooling lines

Description	Tracker cooling lines
Mass [kg] (using 0.44Kg/m2)	To be calculated
Reference mass budget	THERMAL CONTROL SYSTEM **(WITHIN TRACKER ALLOCATED 72.9 kg)**
Buyer	TRACKER
Proposed Builder	TBD by NLR/ZSU
H/W needed to build	(Cut-to-fit design to flight Hardware). Tracker cooling lines routing

ID#24 – Tracker cooling lines

Installation sequence	TBD by Tracker TEAM
Blanket type	TBD by Tracker TEAM
Holes/feed through	TBD by Tracker TEAM
Mechanical fixation points	TBD by Tracker TEAM

ID#25 – CABLES MLI/PROTECTION

Description	CABLES MLI/PROTECTION
Mass [kg] (using 0.44Kg/m2)	To be calculated
Reference mass budget	ELECTRONIC
Buyer	TBD
Proposed Builder	TBD
H/W needed to build	(Cut-to-fit design to flight Hardware). All CABLES and CABLES supports.

ID#25 – CABLES MLI/PROTECTION

Installation sequence	After the electronic is mounted, cables shall be insulated and / or protected (TBC BY MIT)
Blanket type	TBD by MIT
Holes/feed through	TBD by MIT
Mechanical fixation points	TBD by MIT

Conclusions

- **PROVIDE AS MANY COMMENTS/REMARKS/SUGGESTIONS AS POSSIBLE**
- **REMOVE AS MANY TBD/TBC AS POSSIBLE**