

TRD – AMS02 thermal interactions

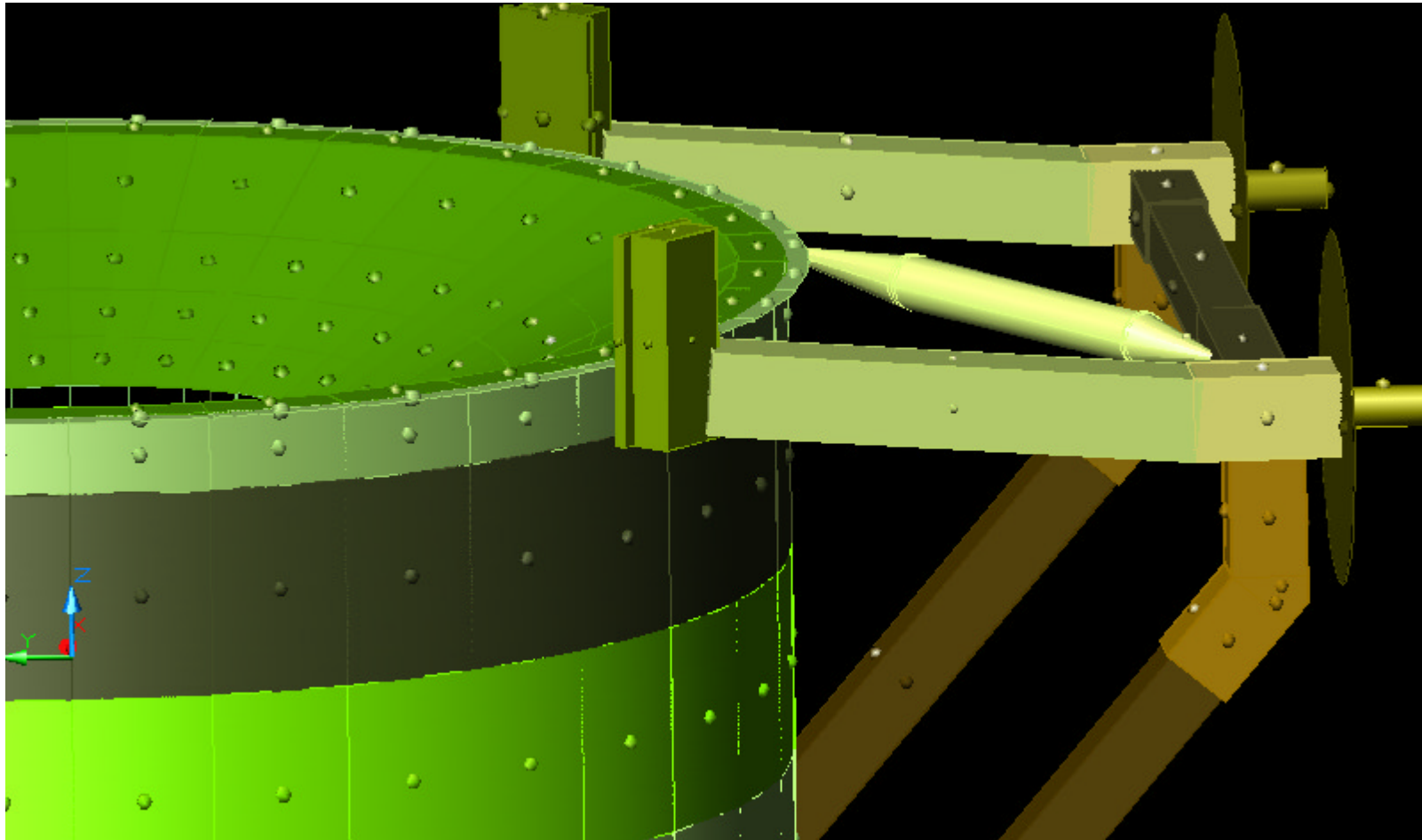
Marco Molina
Alberto Franzoso



Table of content

- CGS – LMSO model alignment
- MLI effects
- TRD model translation, check and inclusion
- Further steps

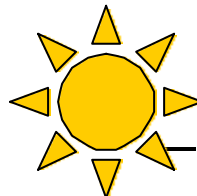
AMS 02 –Thermal Control System Design



Case Beta=75°, YPR –15-20-15 CGS-LMSO data comparison

 Vacuum case

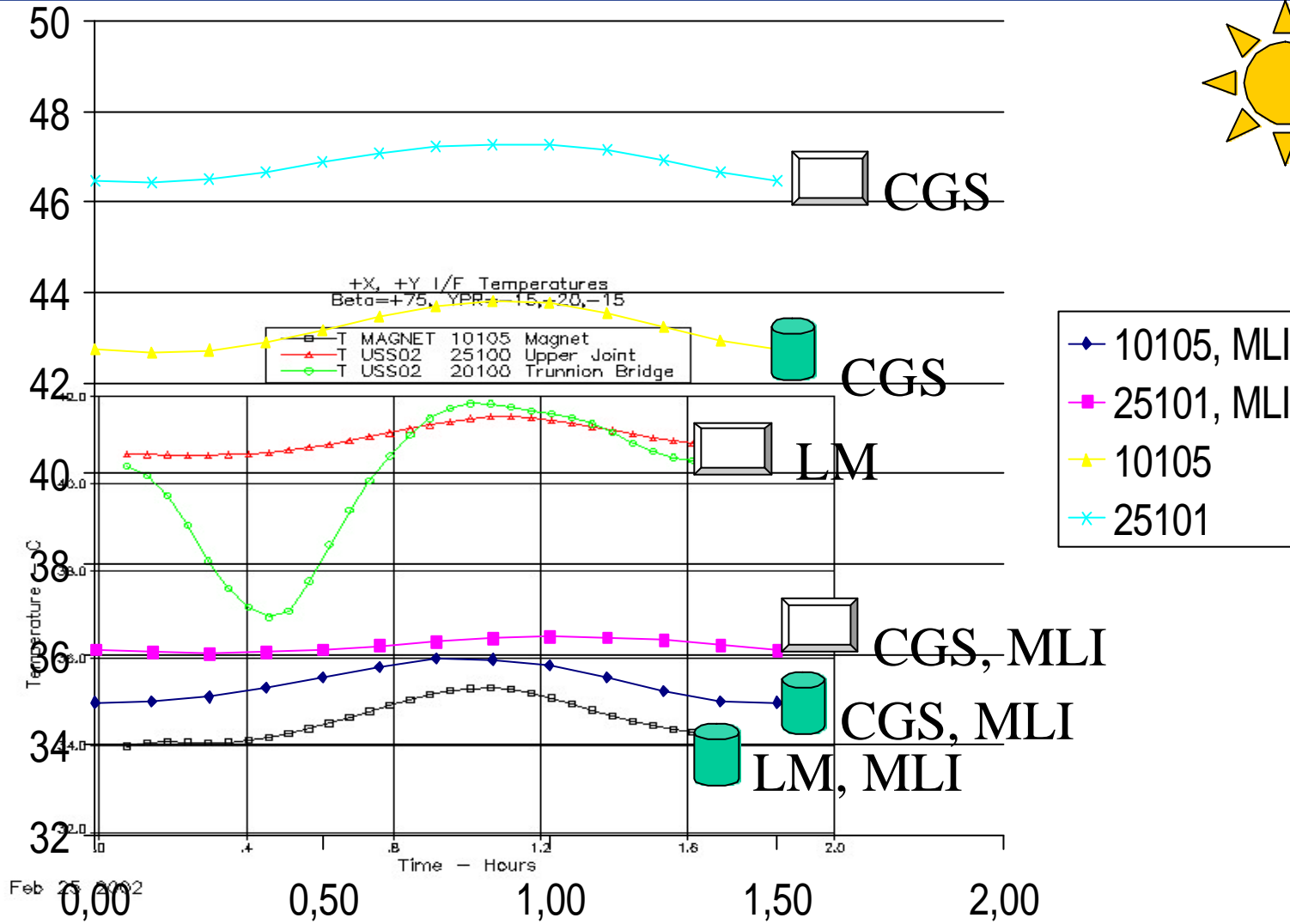
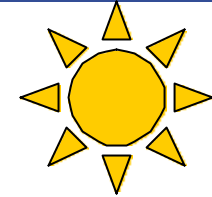
 USS02

 Data relevant to the sunny (=PORT) side

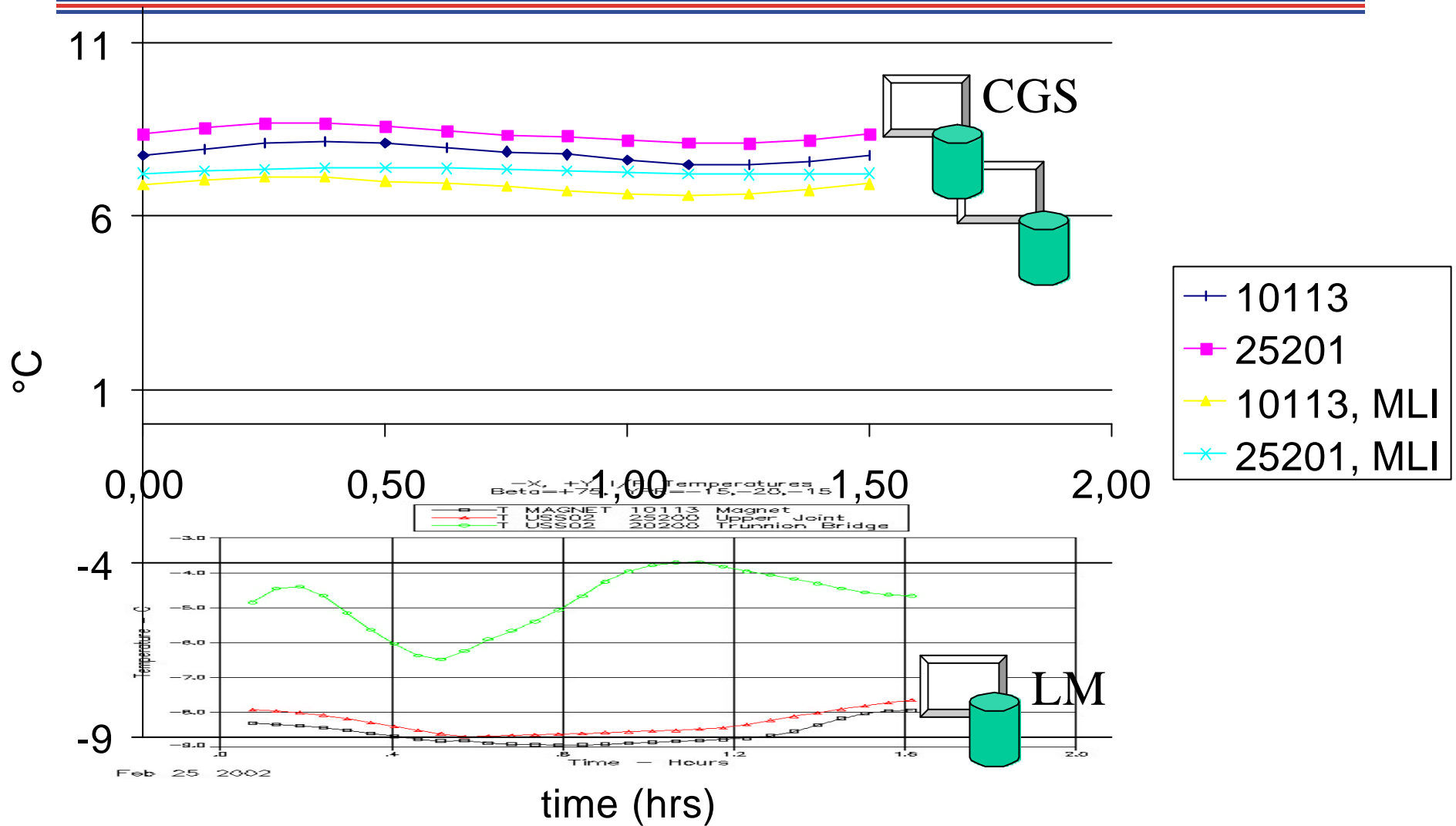
CGS
– Who calculated the data

LM

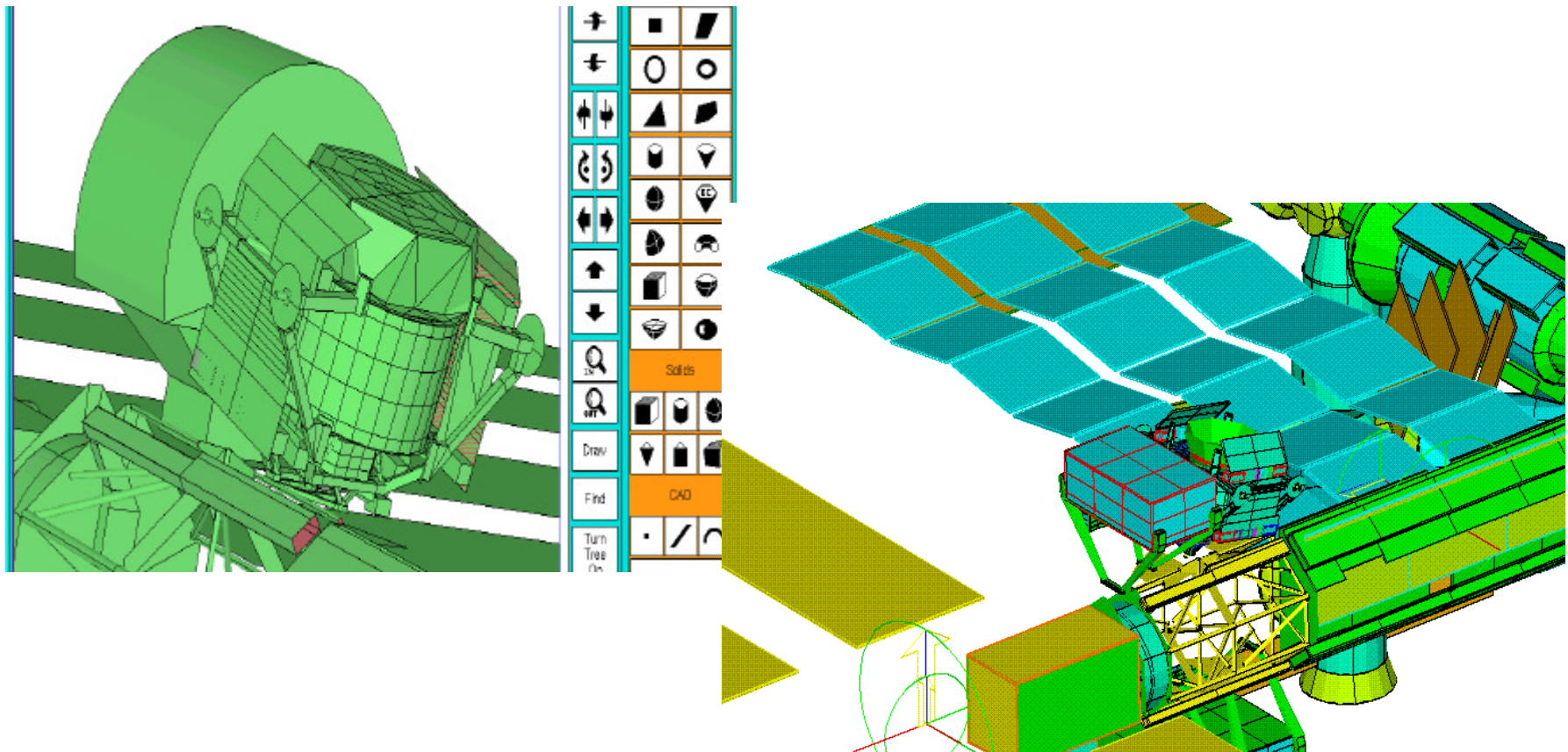
AMS 02 –Thermal Control System Design



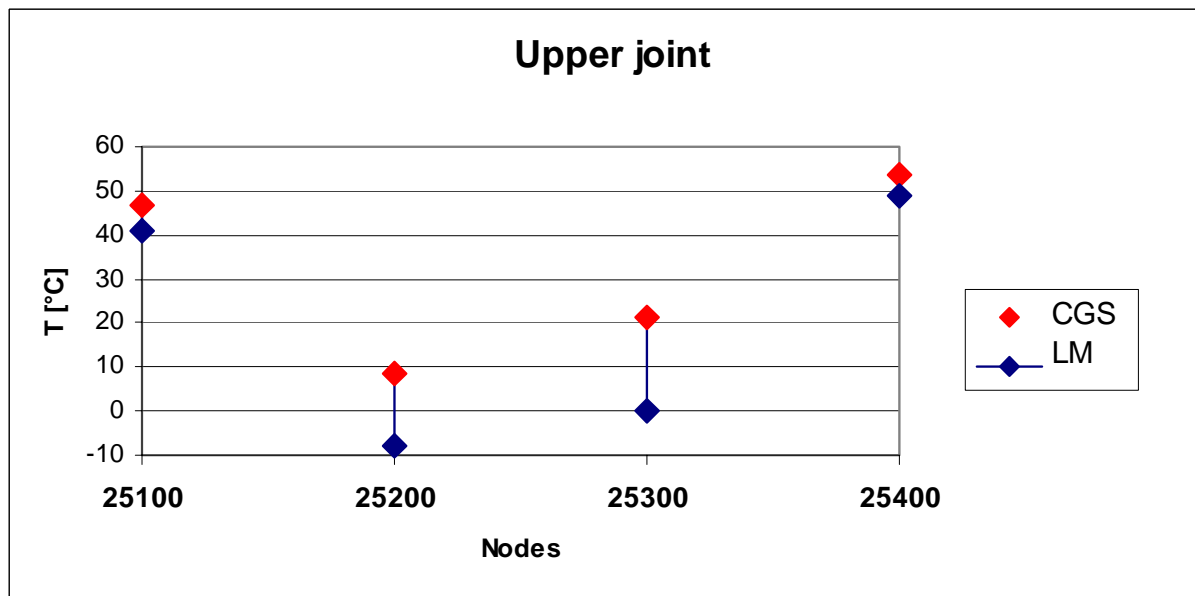
AMS 02 –Thermal Control System Design



Adjacent payload



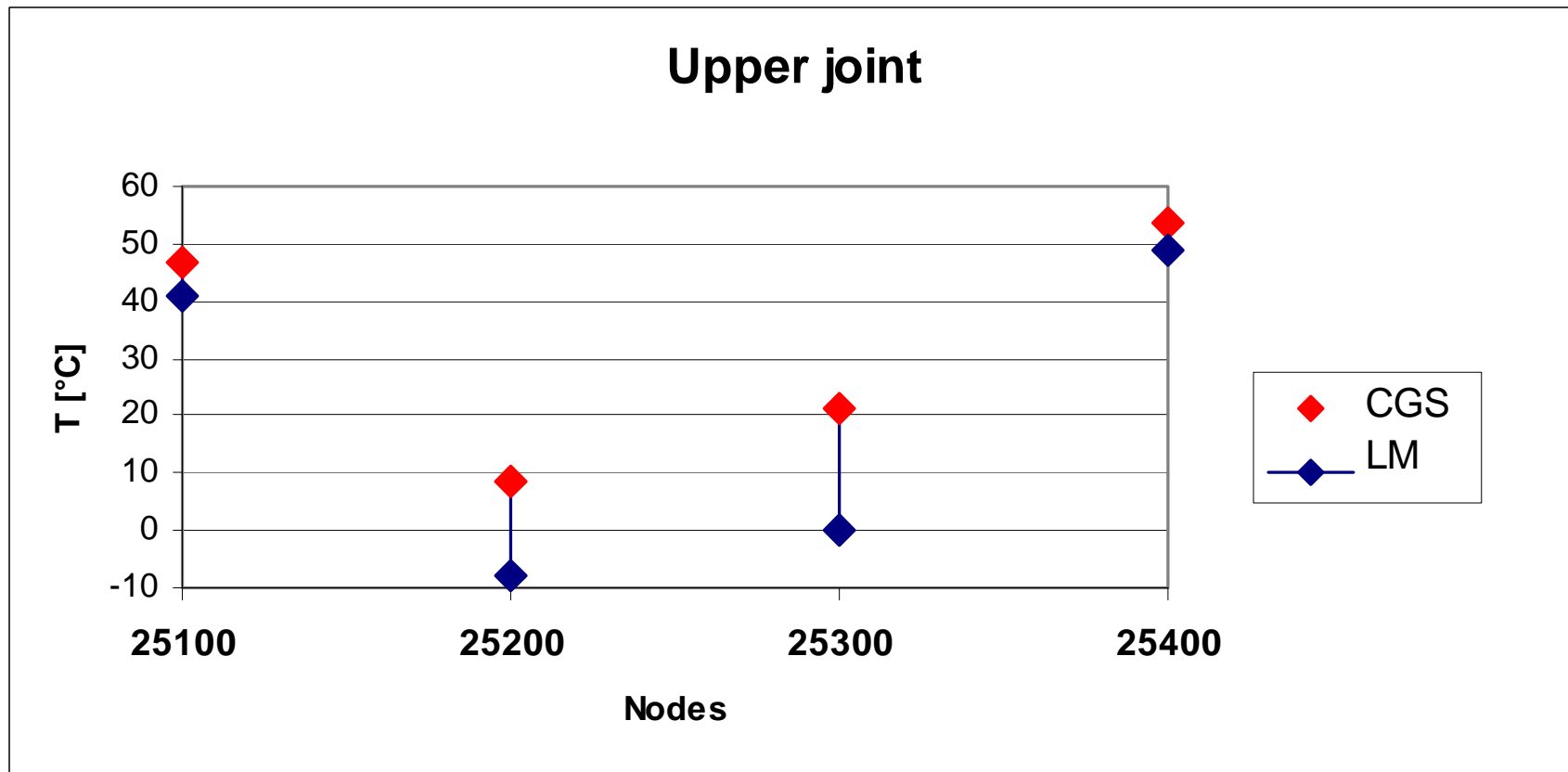
LMSO - CGS comparison Aachen



$\beta=+75^\circ$ YPR=-15-20-15

- G10 shim thickness
- Natural Env vs. Hot Env
- Shuttle docked vs. undocked
- Adjacent payload vs. no adjacent payload
- Adjacent express pallett
- Insulated VC conical vs. non-insulated VC conical
- BOL vs EOL properties

LMSO - CGS comparison Aachen



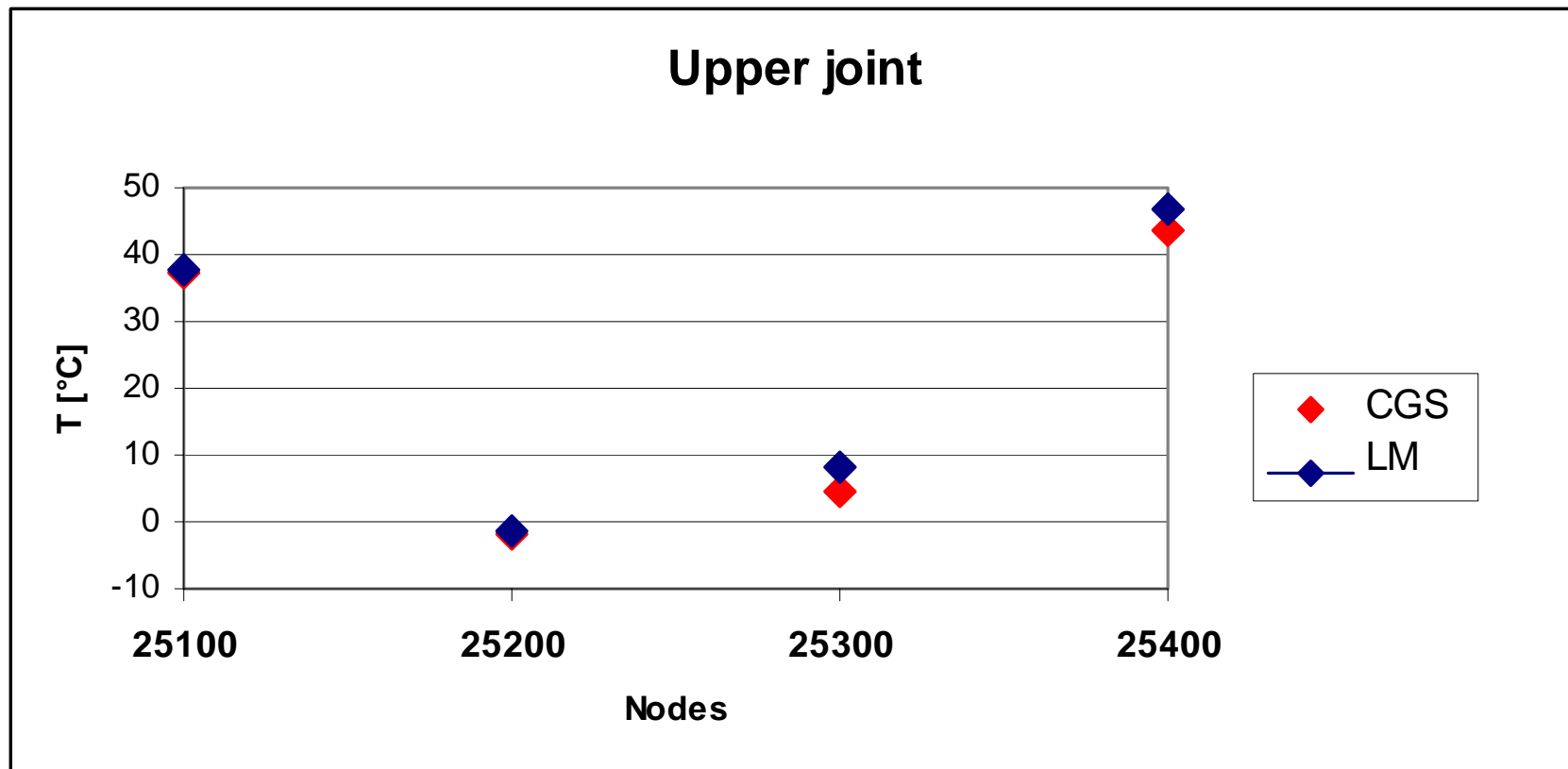
LMSO - CGS model alignment

- Agree a standard configuration to be compared
- Check temperature on corresponding nodes:
success criterion = 5°C
- In case of failure: check orbital sources leading
to these temperatures

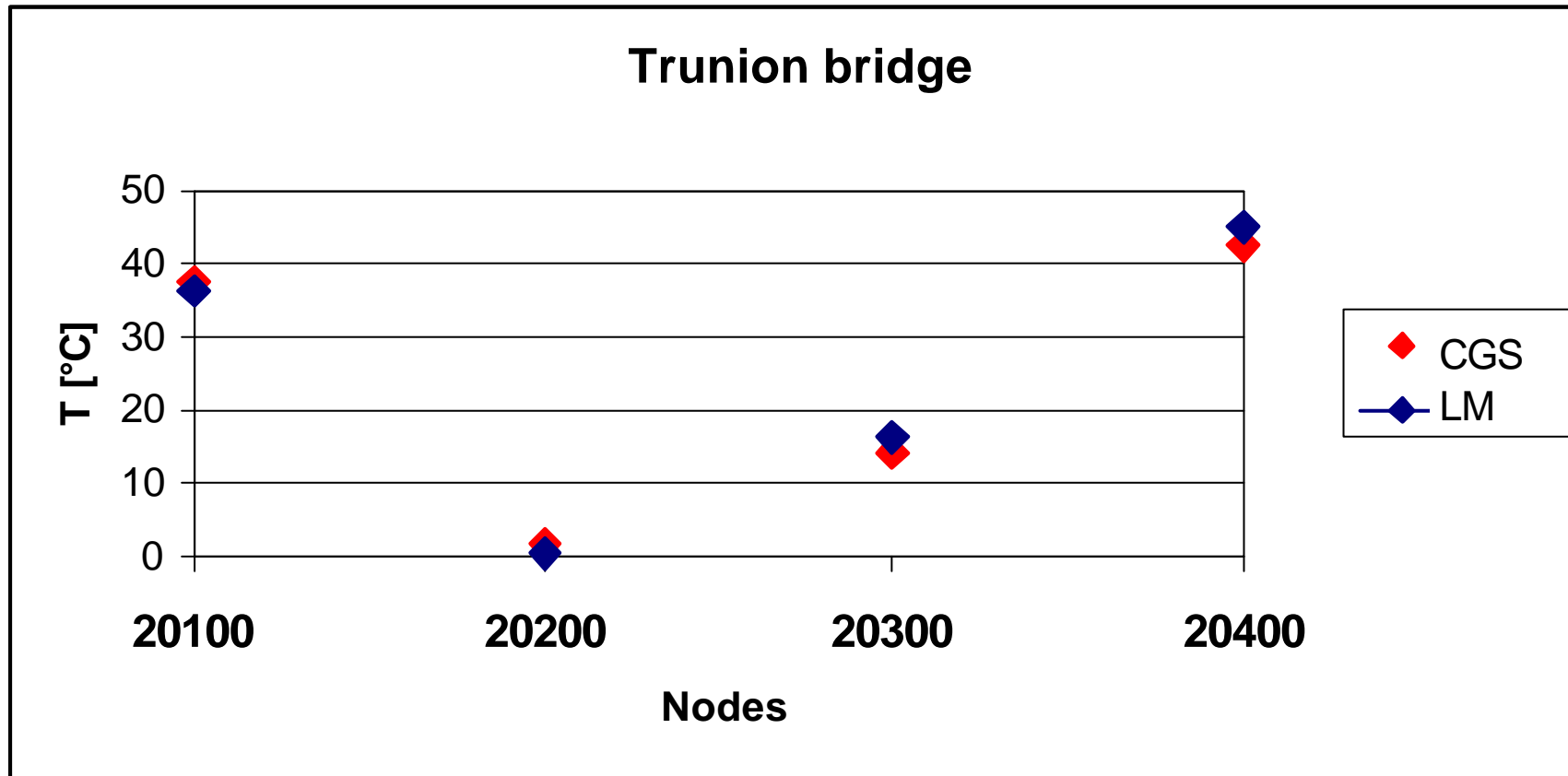
LMSO - CGS model alignment CONFIGURATION

- $\beta=+75^\circ$ YPR=-15-20-15
- TRD model not in place
- G10 shim thickness 1/8"***
- 13 orbit point
- Hot Natural Env
- EOL ISS Properties
- No Shuttle docked
- No adjacent payload
- No adjacent express pallett
- Insulated VC conical
- No “triangles” on +Z radiators
- MLI (beta cloth outer properties) on upper joint and trunion bridge.

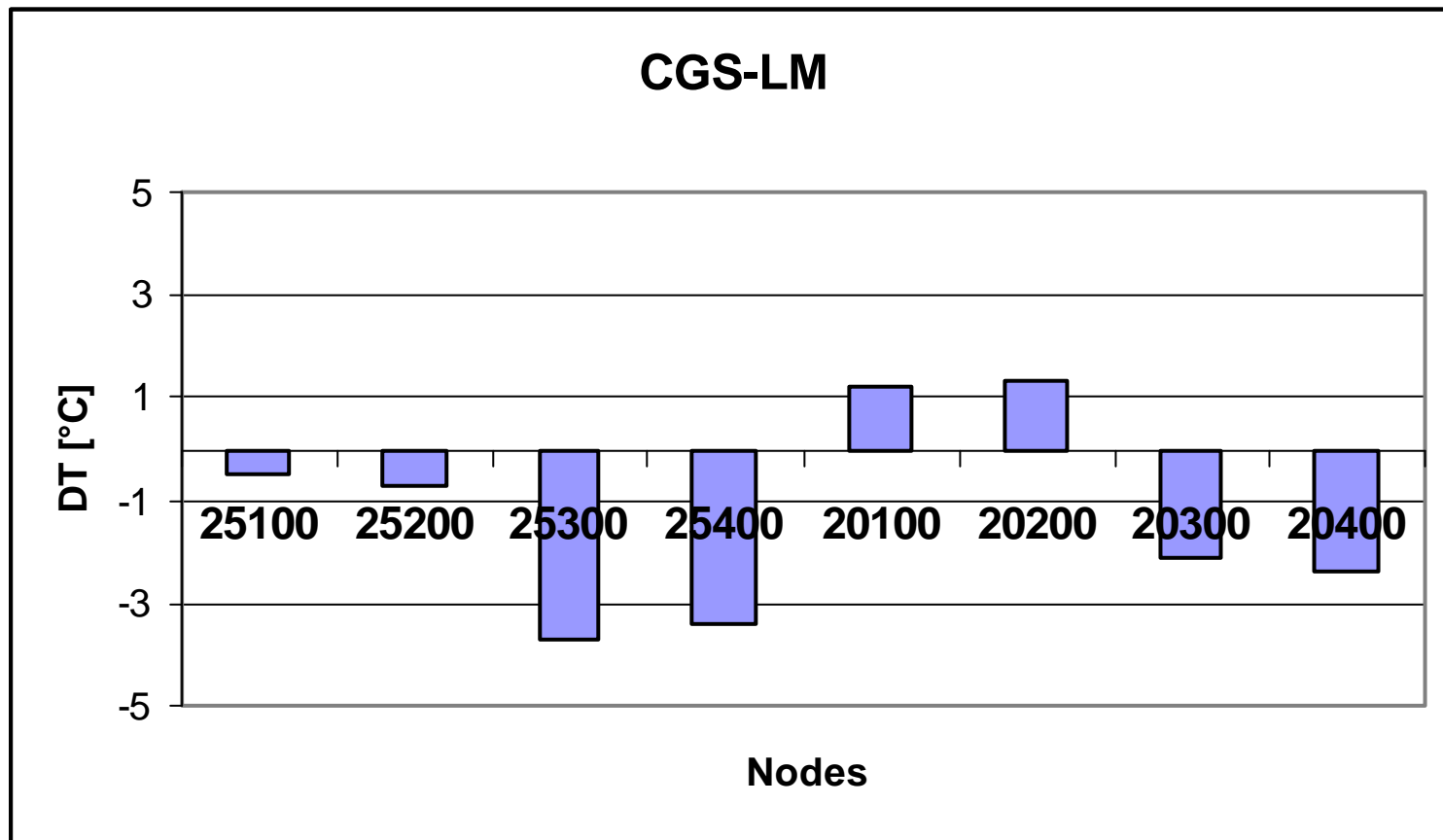
LMSO - CGS model alignment results on the upper joints



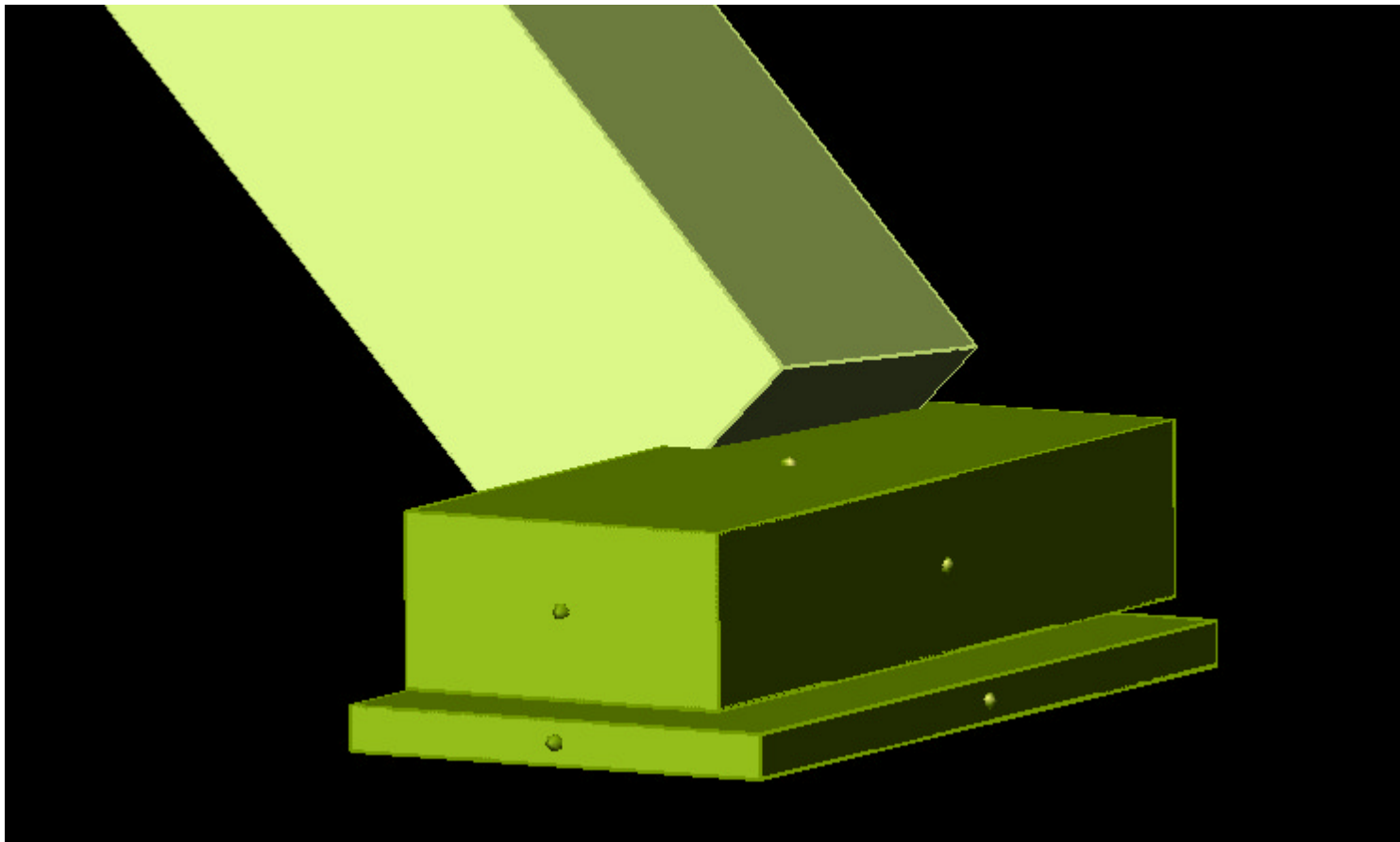
LMSO - CGS model alignment results on the trunion bridge



Did we achieve the goal?



MLI effects on Upper Joint/Trunion bridge

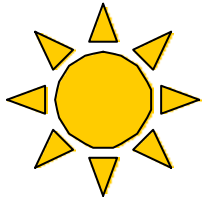


$$\beta = 75^\circ$$



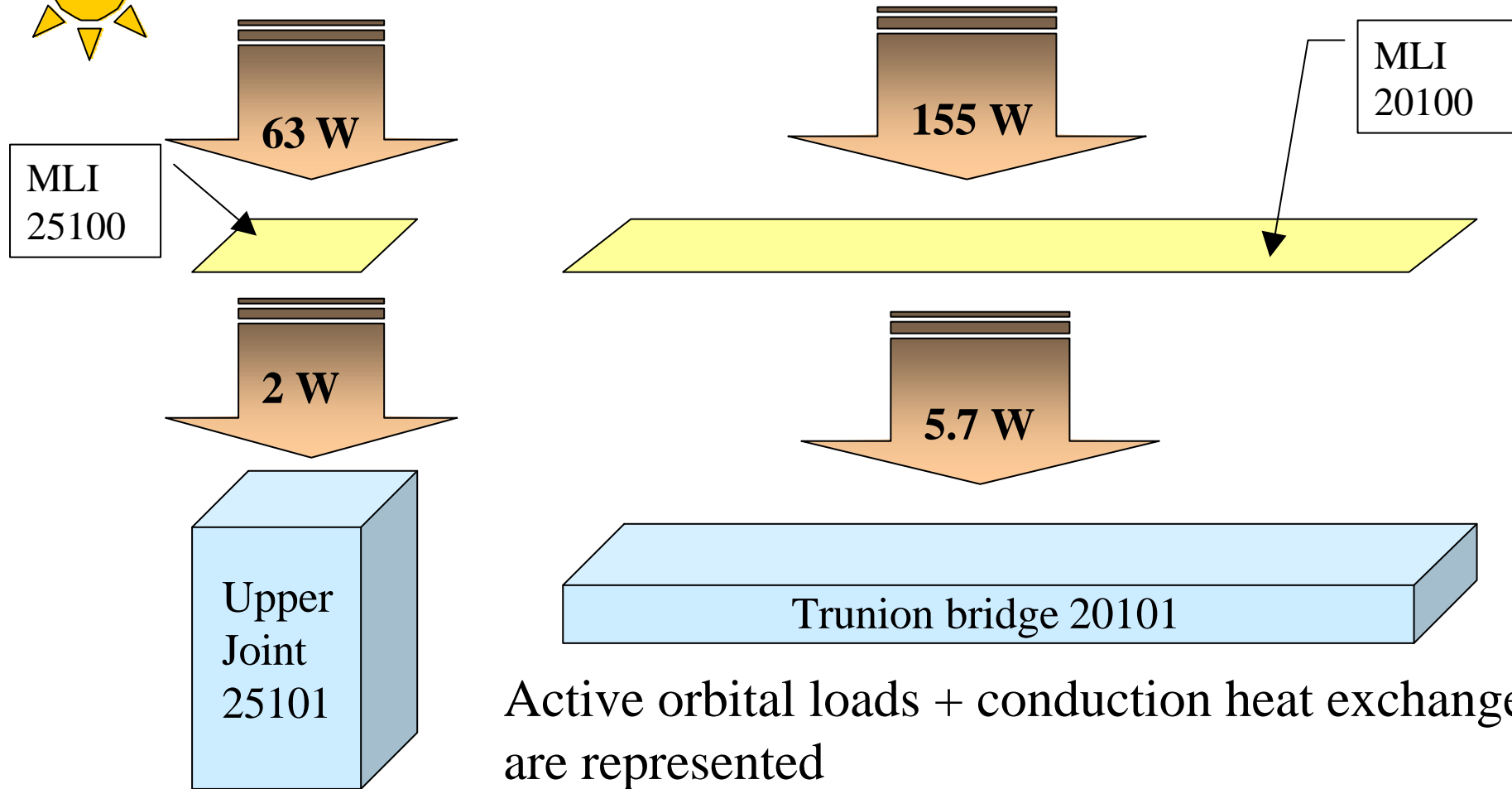
MLI effects on Upper Joint/Trunion bridge

- Beta angle
- Active orbital loads + conduction heat exchange are represented
- Shadow or sunny side? (For Beta =0° there is no “sunny” side)
- Orbital average is shown



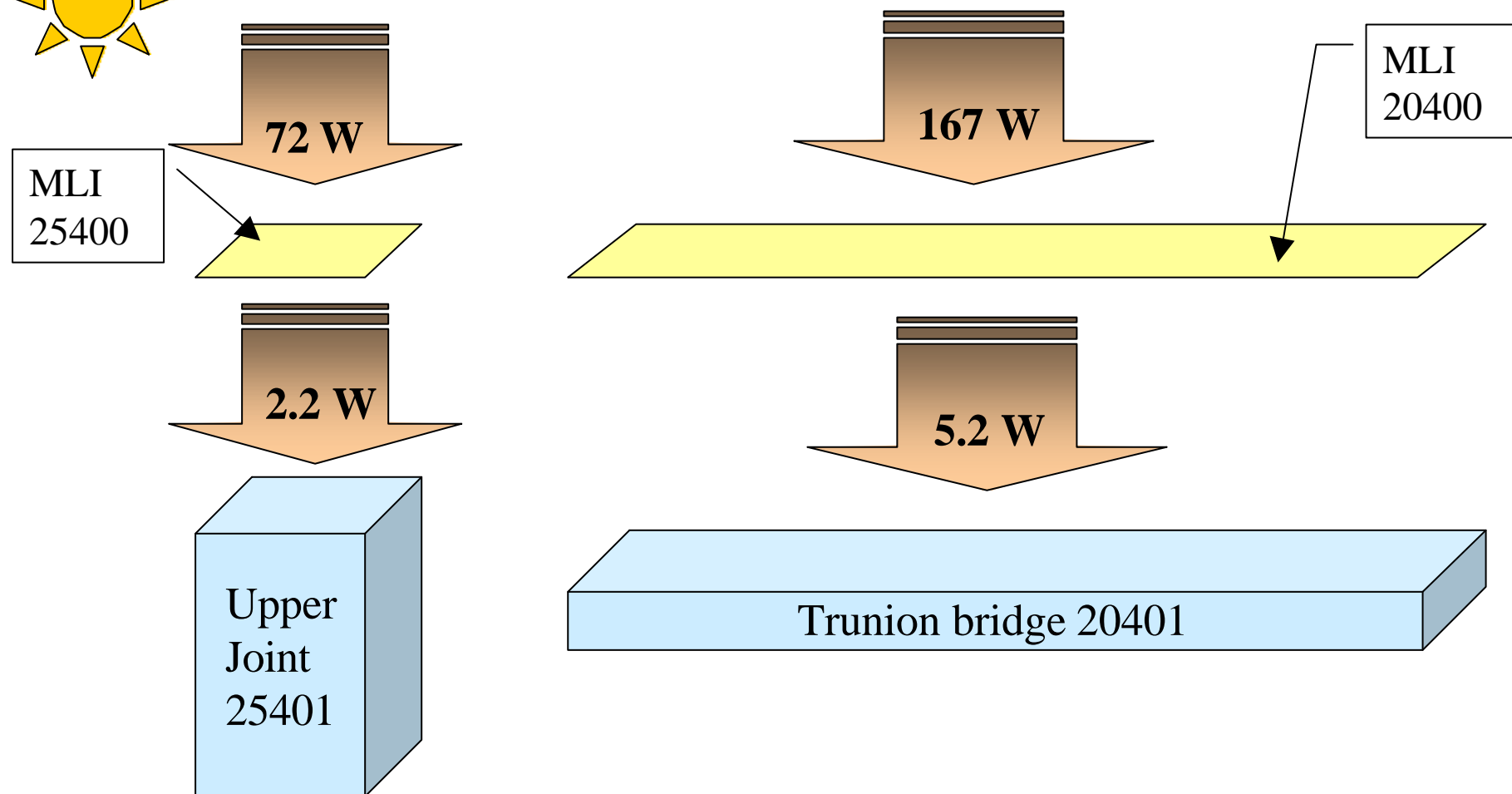


MLI effects on Upper Joint/Trunion bridge

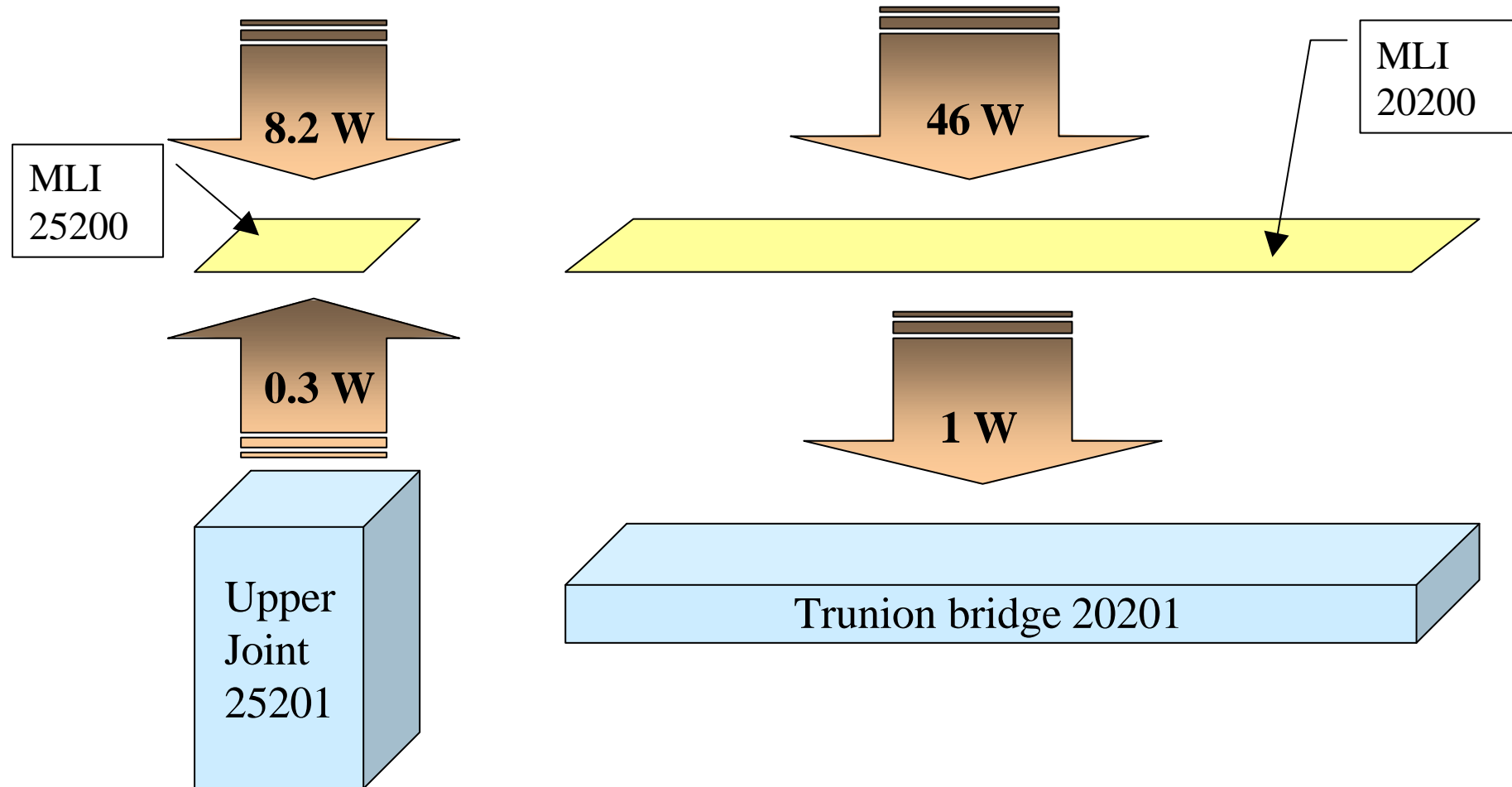




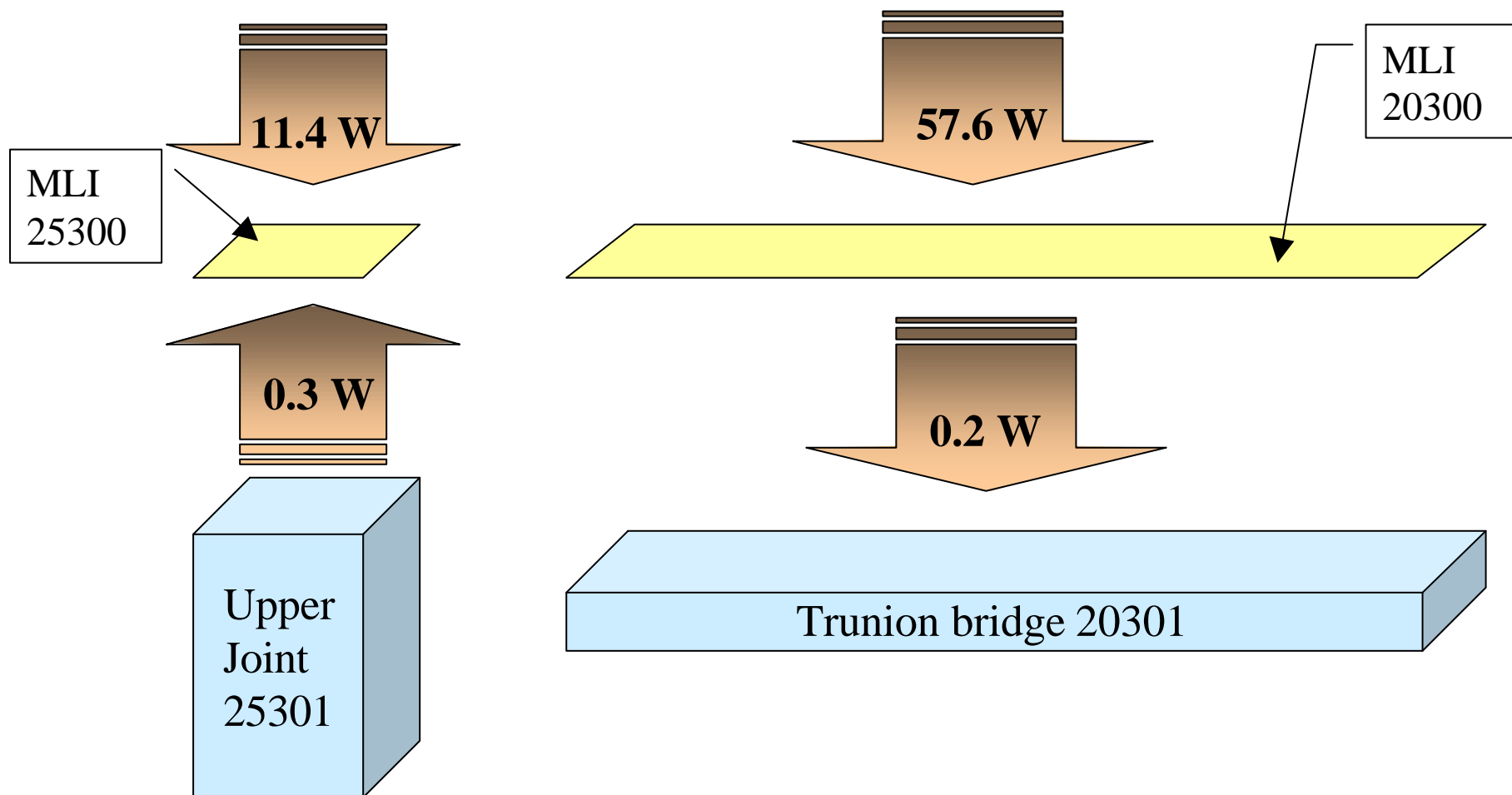
MLI effects on Upper Joint/Trunion bridge



MLI effects on Upper Joint/Trunion bridge



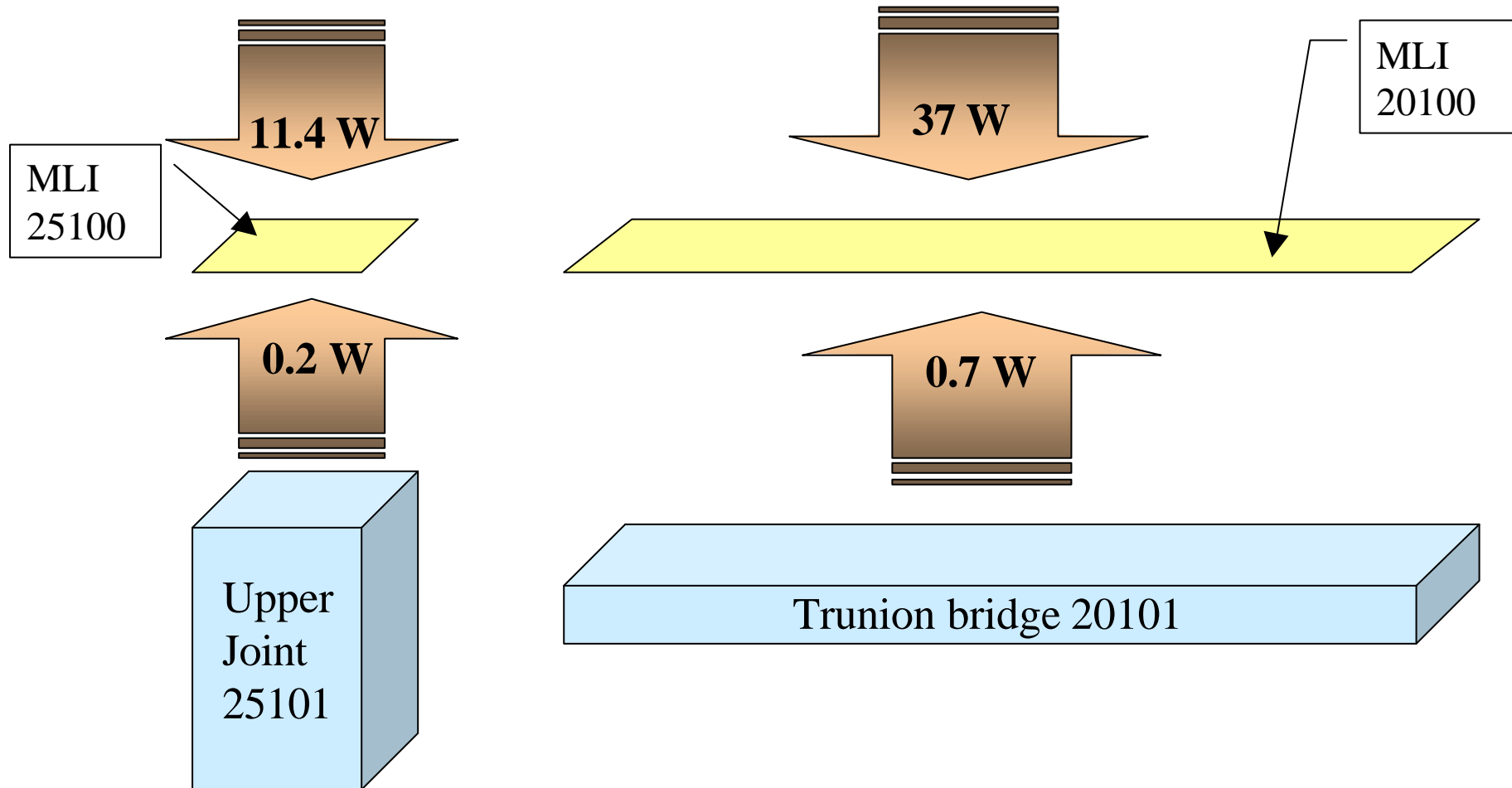
MLI effects on Upper Joint/Trunion bridge



$$\beta = 0^\circ$$



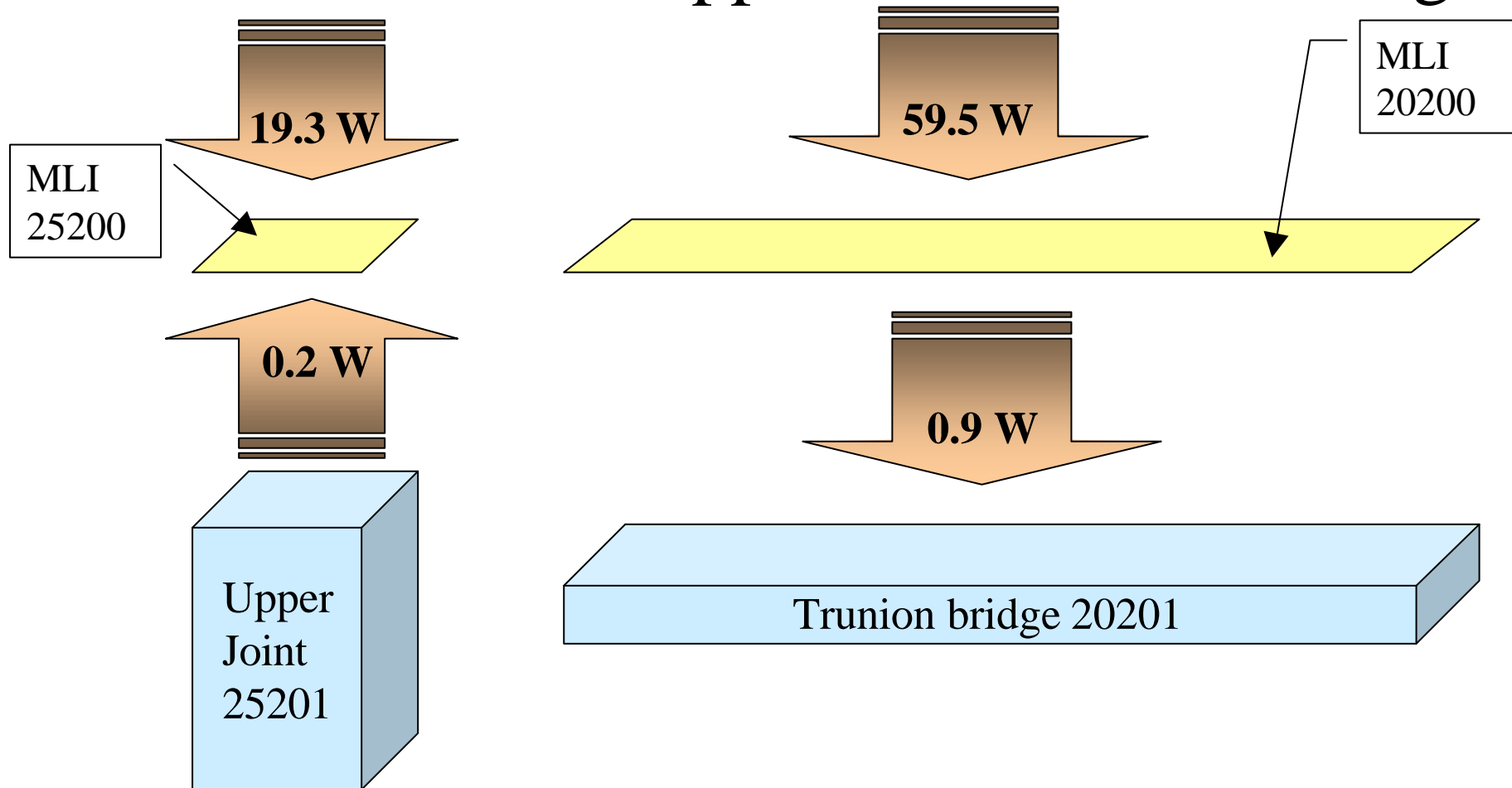
MLI effects on Upper Joint/Trunion bridge



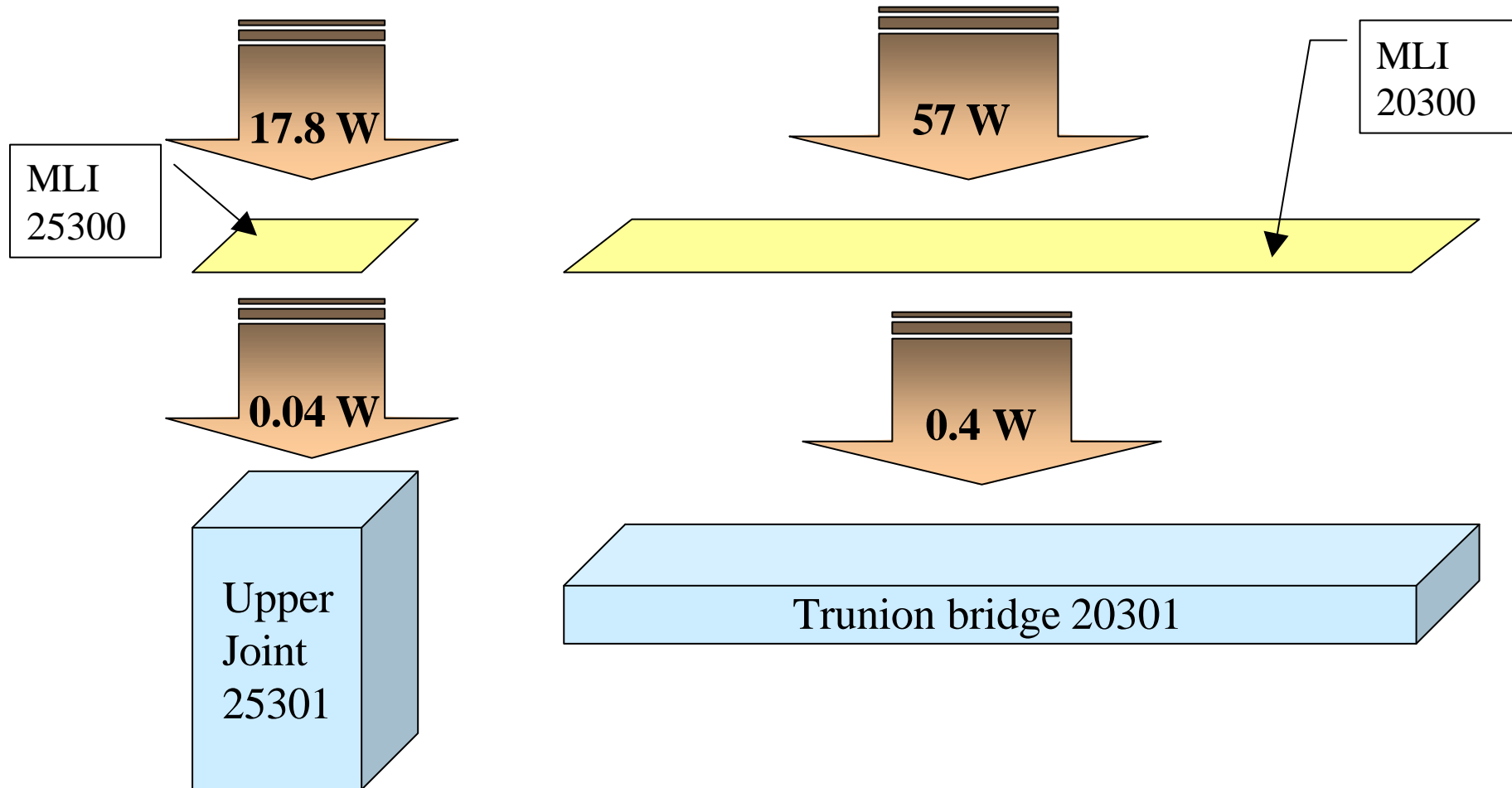
$$\beta = 0^\circ$$



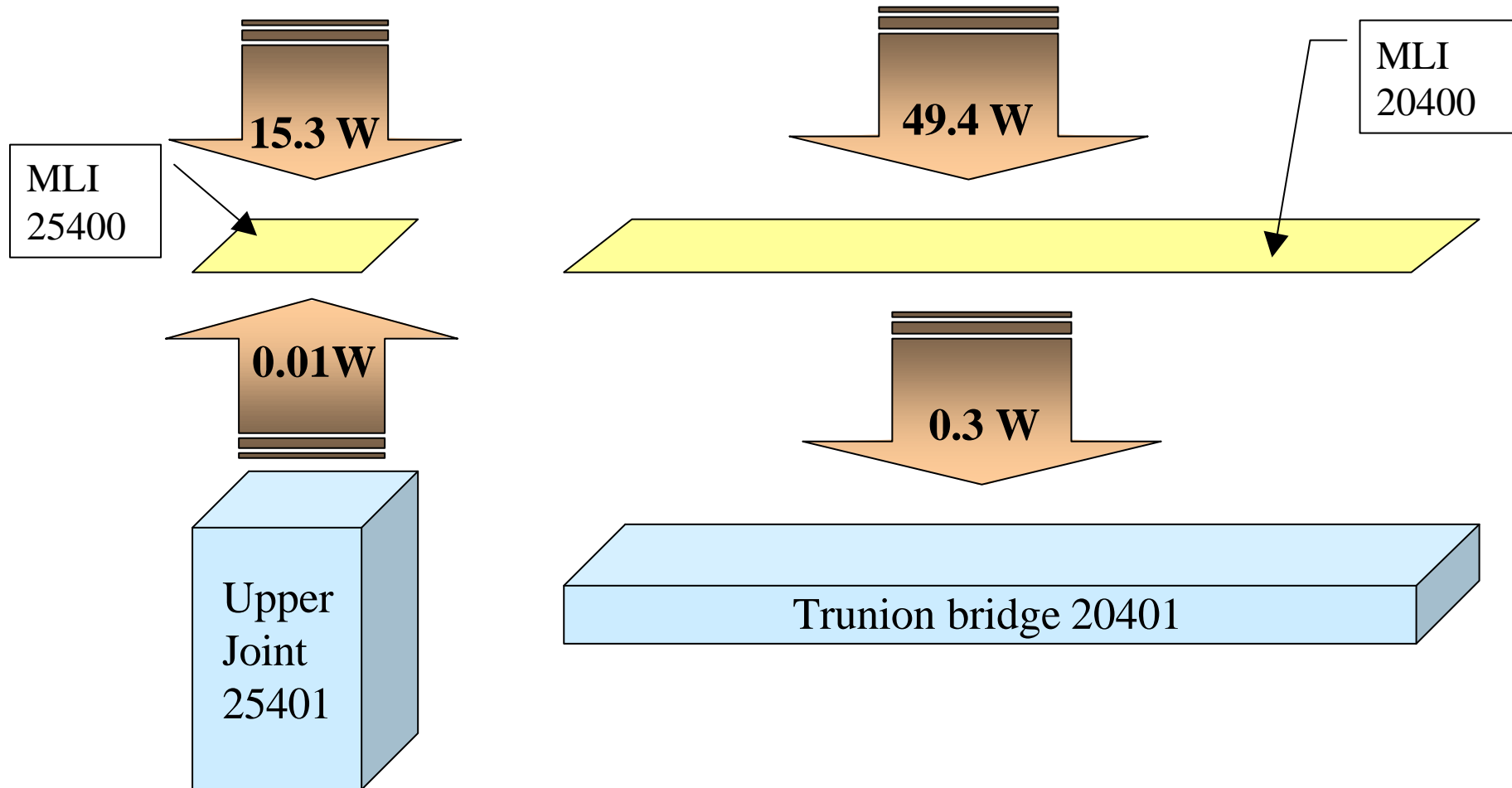
MLI effects on Upper Joint/Trunion bridge



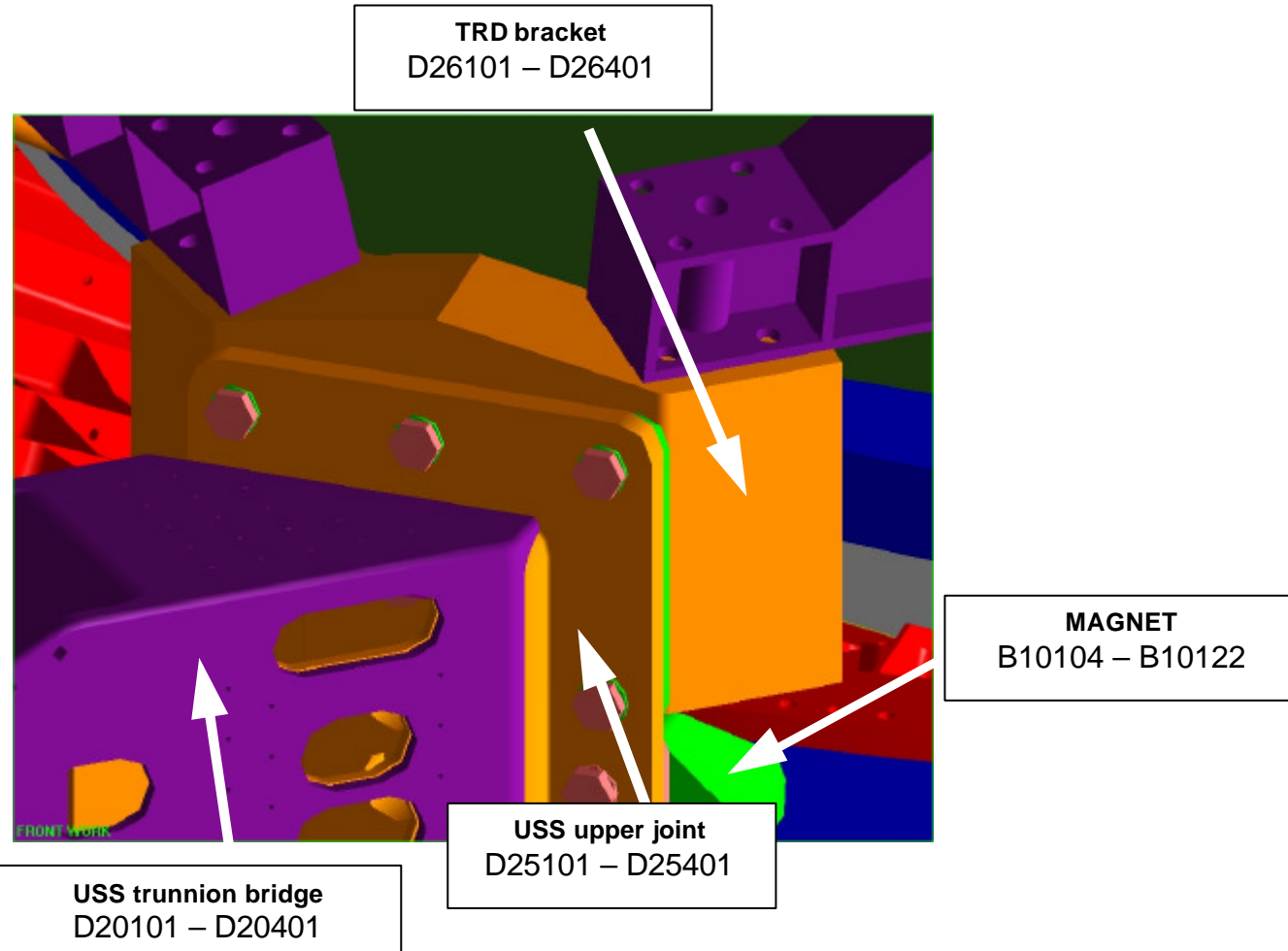
MLI effects on Upper Joint/Trunion bridge



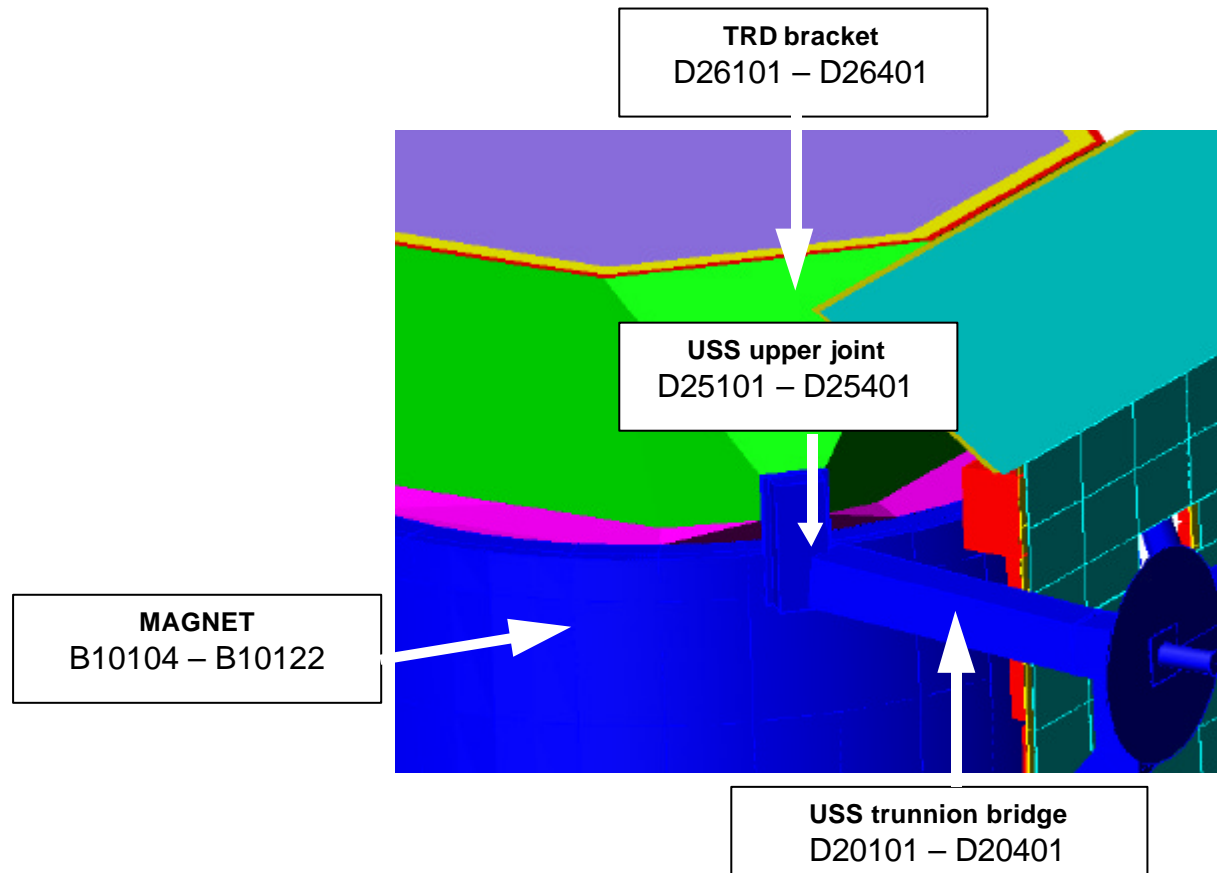
MLI effects on Upper Joint/Trunion bridge



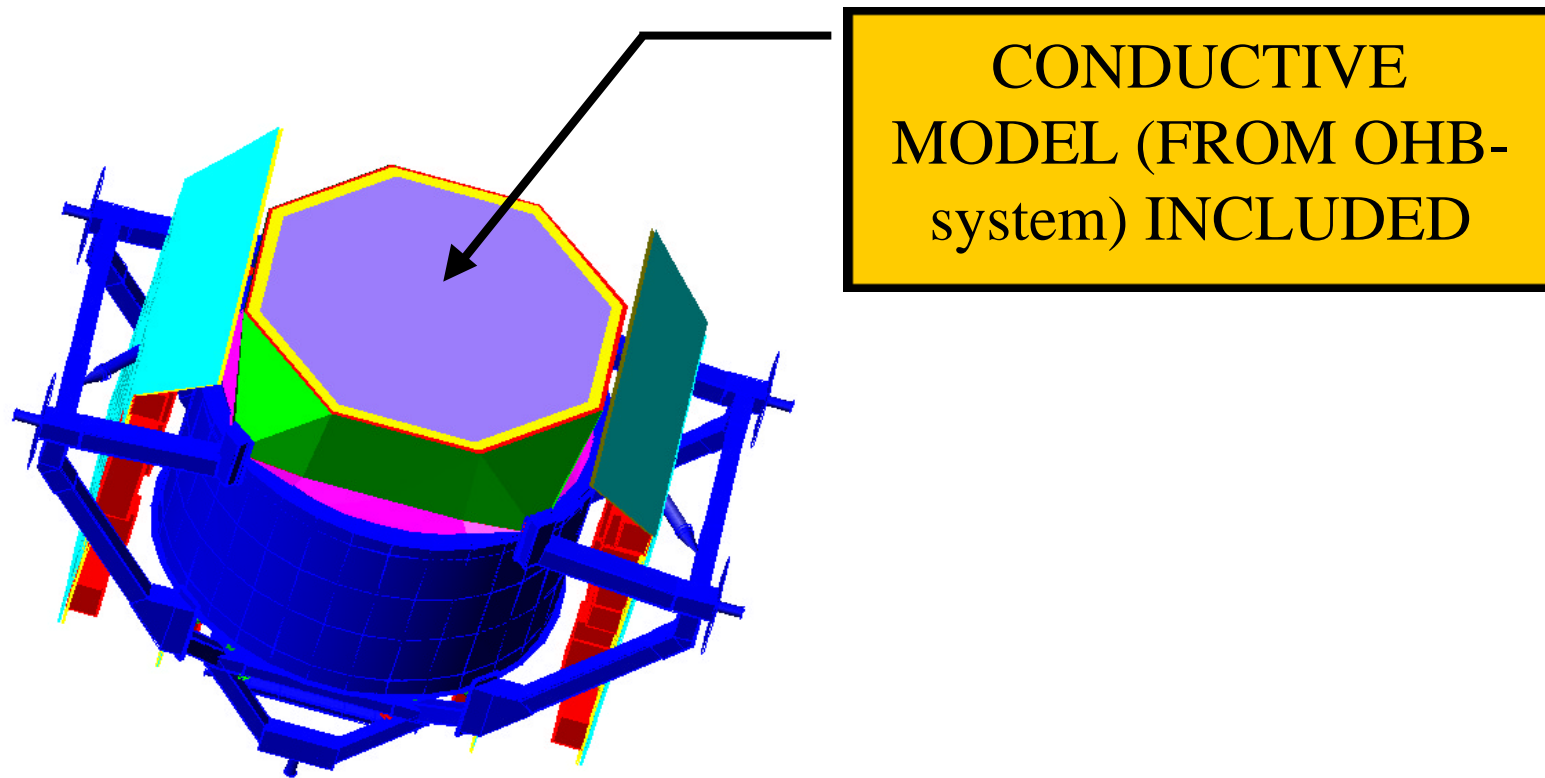
USS02 I/F Thermal Mathematical Model



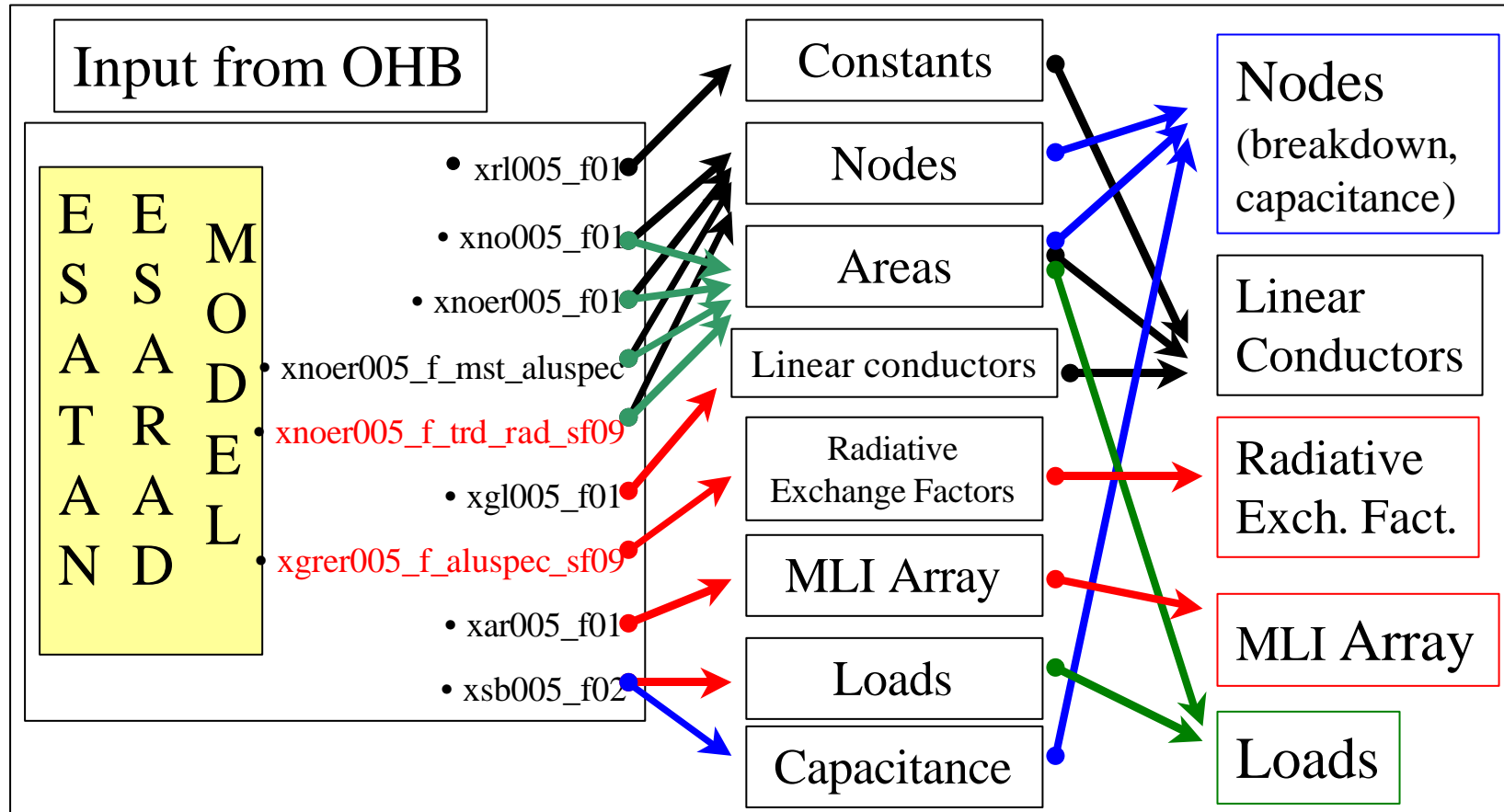
USS02 I/F Thermal Mathematical Model



TRD



TRD model translation (1)



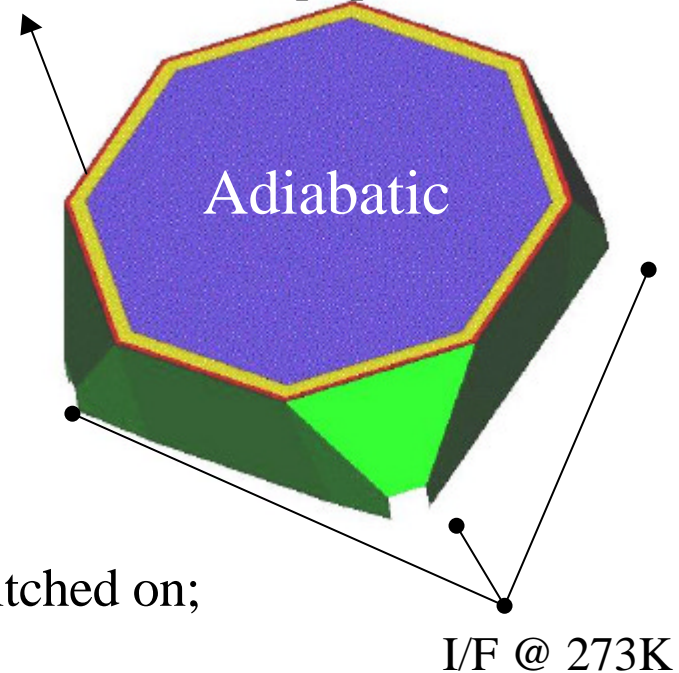
TRD model translation (2)

- In order to obtain a SINDA/FLUINT code:
 - Editing of expressions (i.e. 1.0D0 \Rightarrow 1.0E0; comments...)
 - Extraction of variables and calculation of expressions (i.e. A##### \Rightarrow area of node #####) \rightarrow Excel + Matlab
 - Editing of syntax
- Additional debugging:
 - Node numbering mismatch (~130 nodes to rename)
 - Addition of mathematical nodes (16 nodes)
- Elapsed time: **~10 days**; next time: **~3 days**

TRD model translation check

Ring Radiator (red) to “deep space” (0 K)

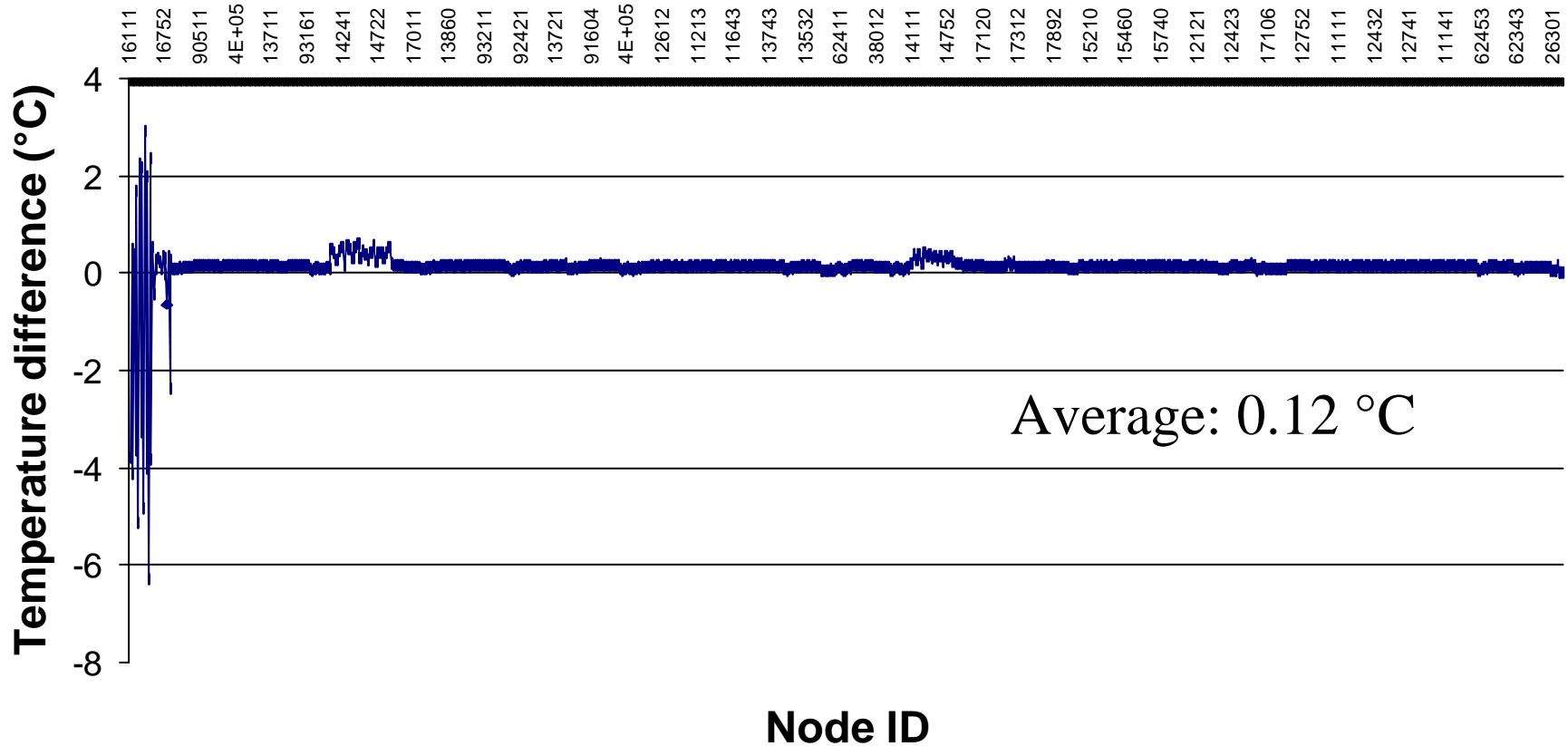
- Test case #1 definition:
 - Standalone TRD, steady state;
 - Connections to USS02: 4 boundary nodes, kept at 0 °C;
 - Ring Radiator: radiatively connected to a boundary node (at 0 K), viewfactor = 1;
 - All other external surfaces: Adiabatic;
 - Upper ToF PMTs and TRD-PCB power switched on;
 - Cryocooler heat sources switched off;
 - No external fluxes impinging on the TRD;





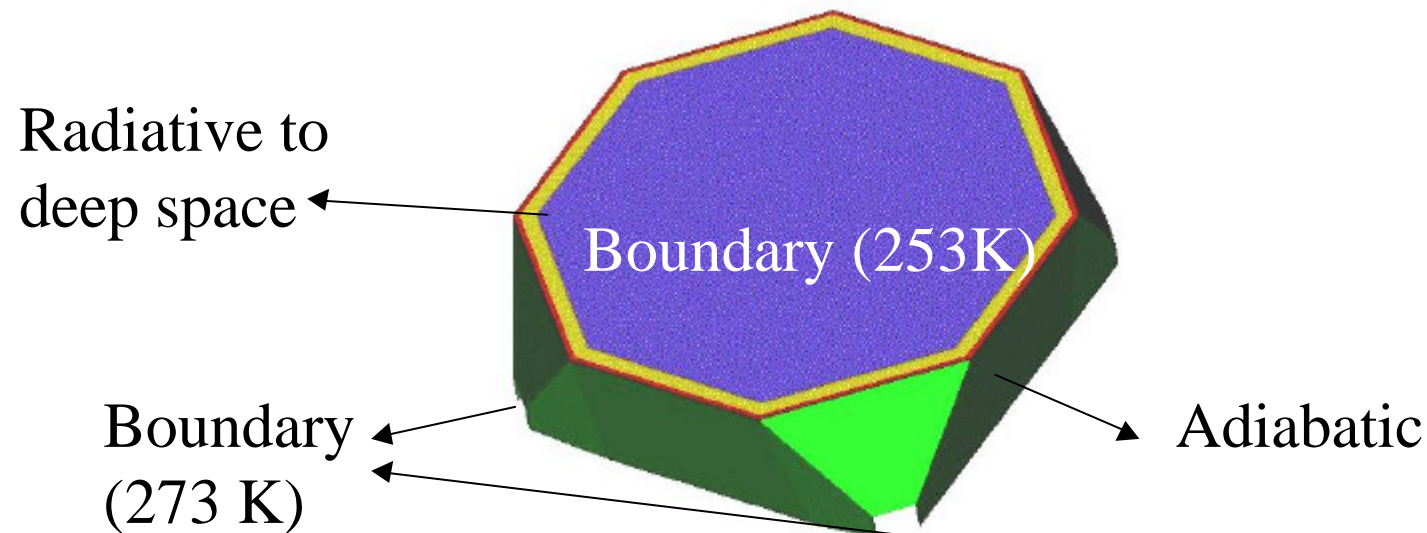
TRD model translation check

Test Case 1



TRD model translation check

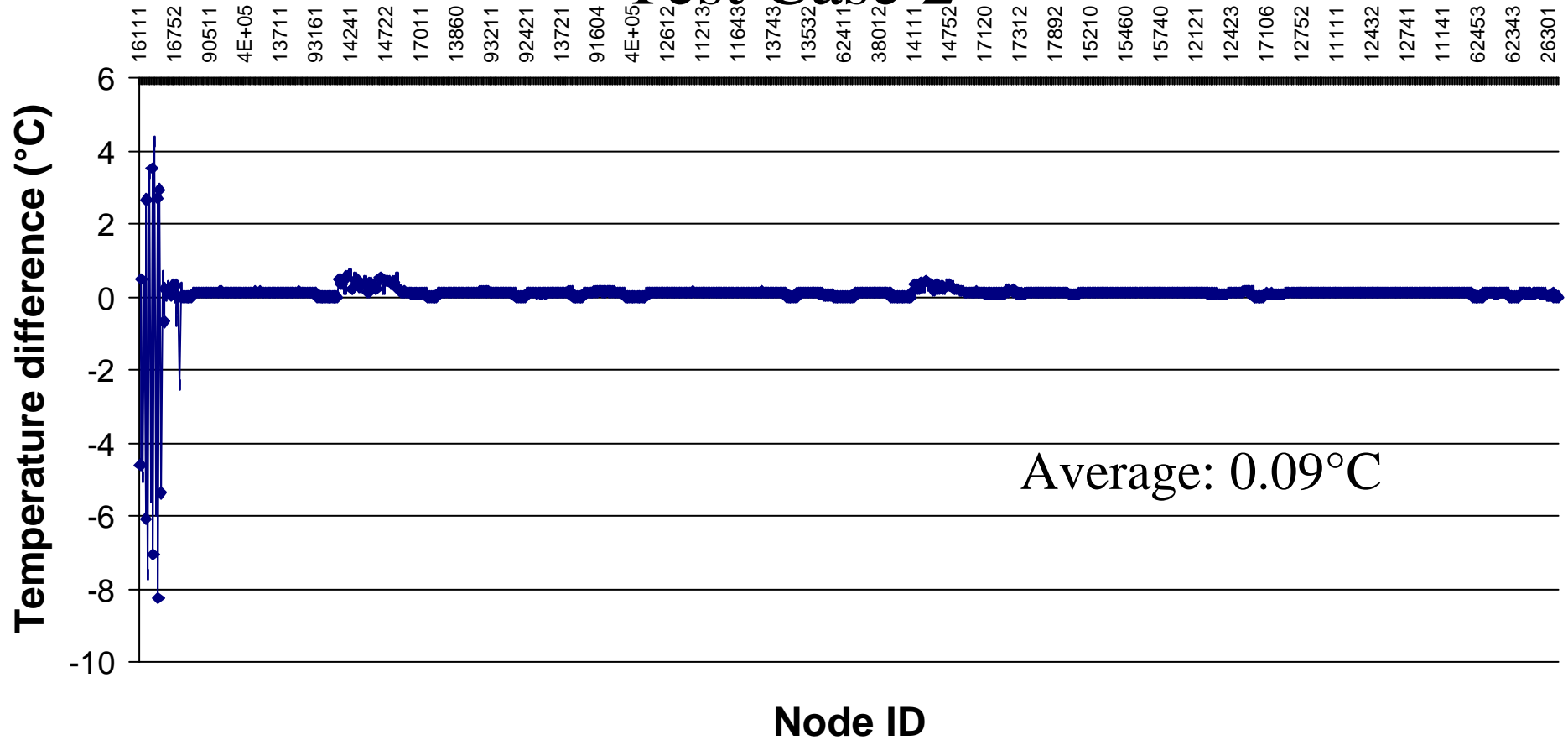
- Test case #2 definition:
 - As Test Case #1, additionally:
 - 32 nodes of the cryocoolers radiator become boundary nodes at 253 K.





TRD model translation check

Test Case 2

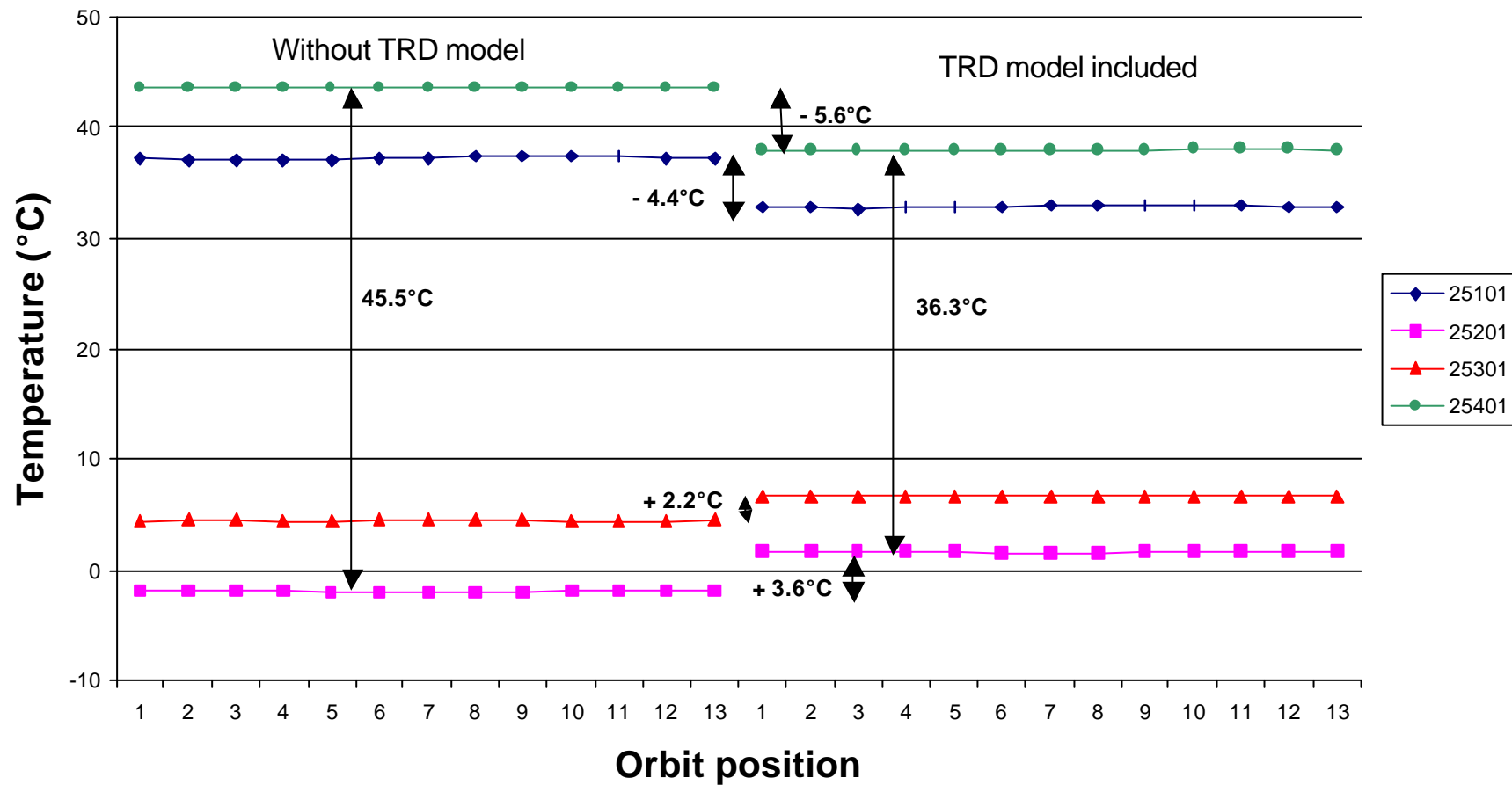


Thermal Analysis results

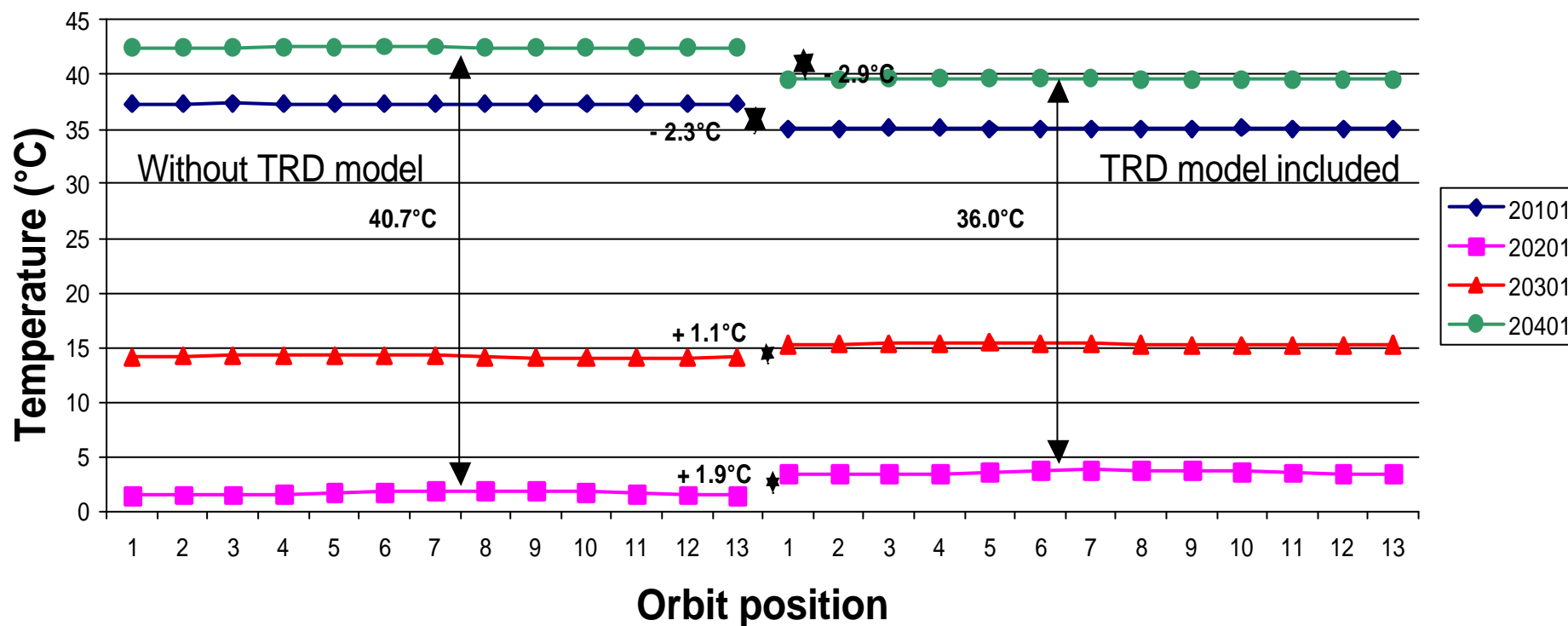
- Results after TRD submodel inclusion are presented for a couple of orbital cases:
 - beta=75°, YPR= – 15°, –20°, –15°
 - Maximum gradient
 - Beta=0°, YPR= –2°, –10°, +1°
 - ‘Typical’ orbit and attitude (MPA)

Orbit: $\beta=75^\circ, -15^\circ -20^\circ -15^\circ$ (y,p,r)
(Maximum gradient)

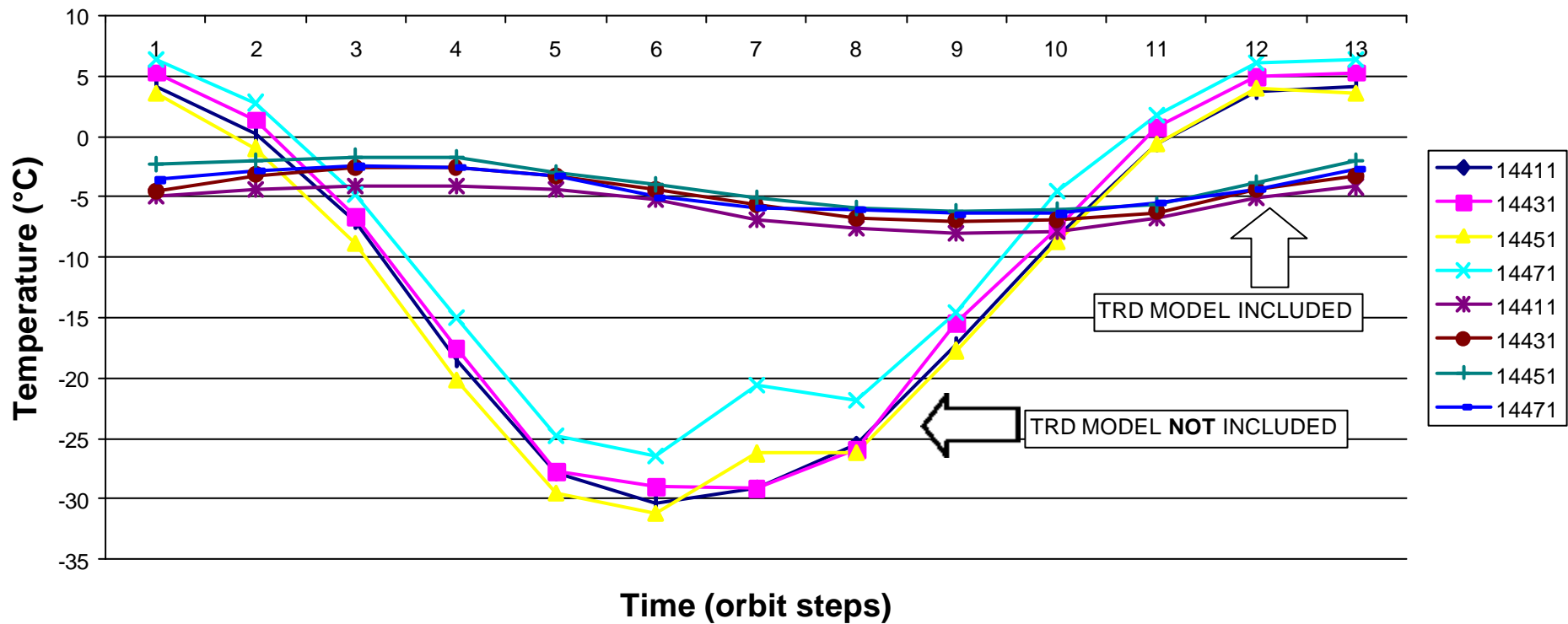
TRD model inclusion effects on Upper Joints



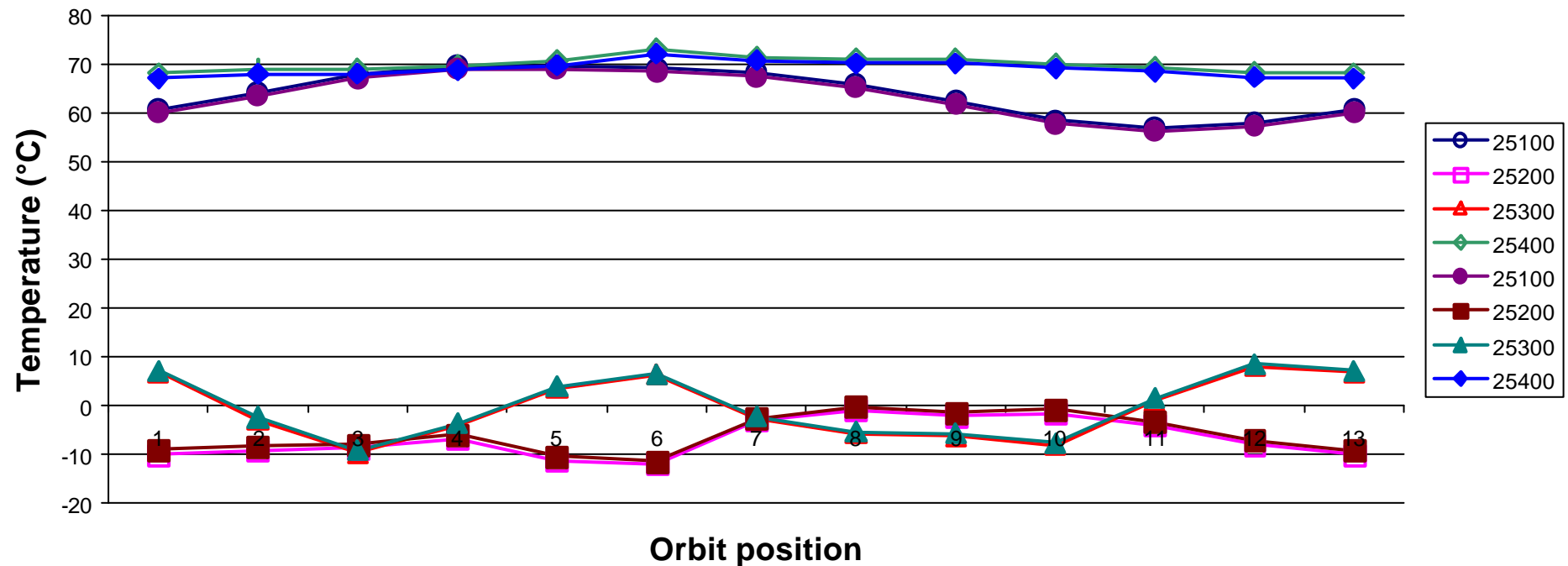
TRD model inclusion effects on Trunnion Bridge



TRD model inclusion effects on Ring Radiator

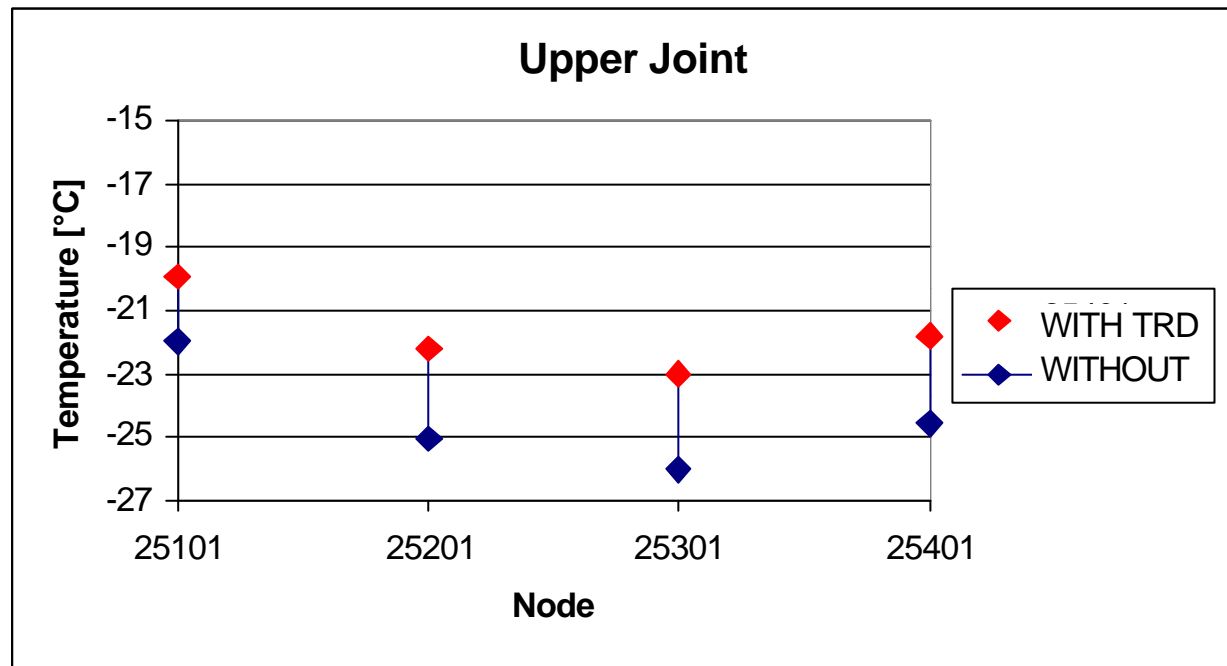


TRD model inclusion effects on Upper Joint MLI

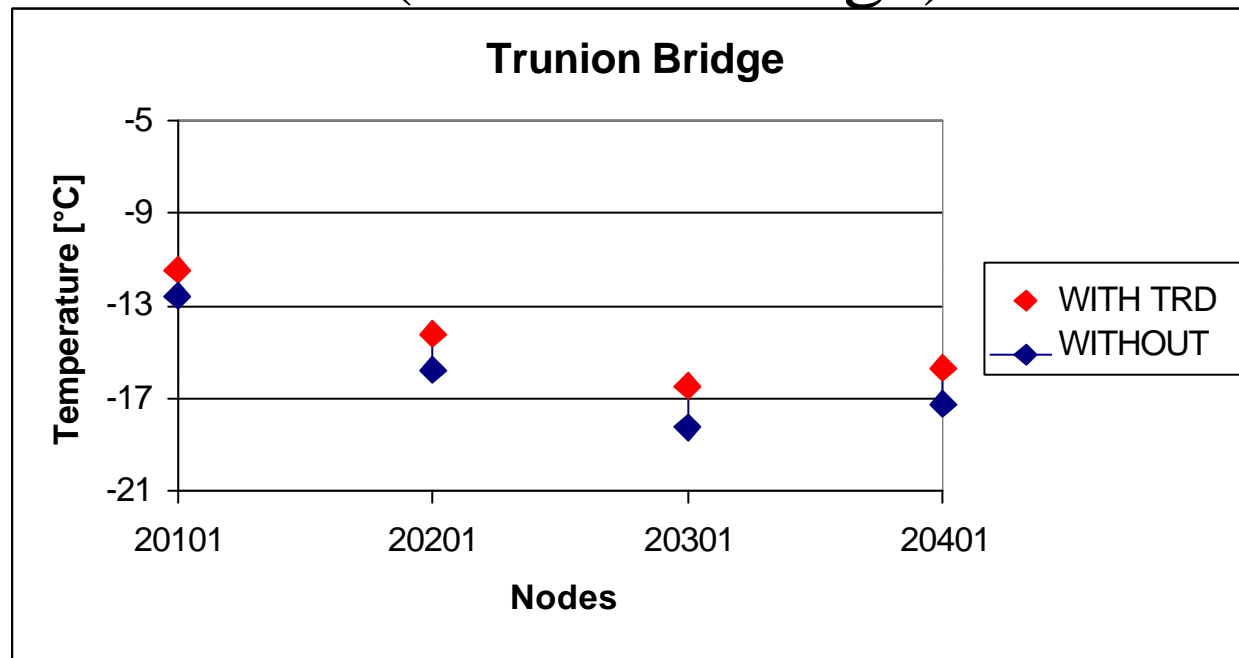


Orbit: $\beta=0$, MPA
'Typical' orbit and attitude

Upper joint with & without TRD (orbital average)



Trunion Bridge with & without TRD (orbital average)

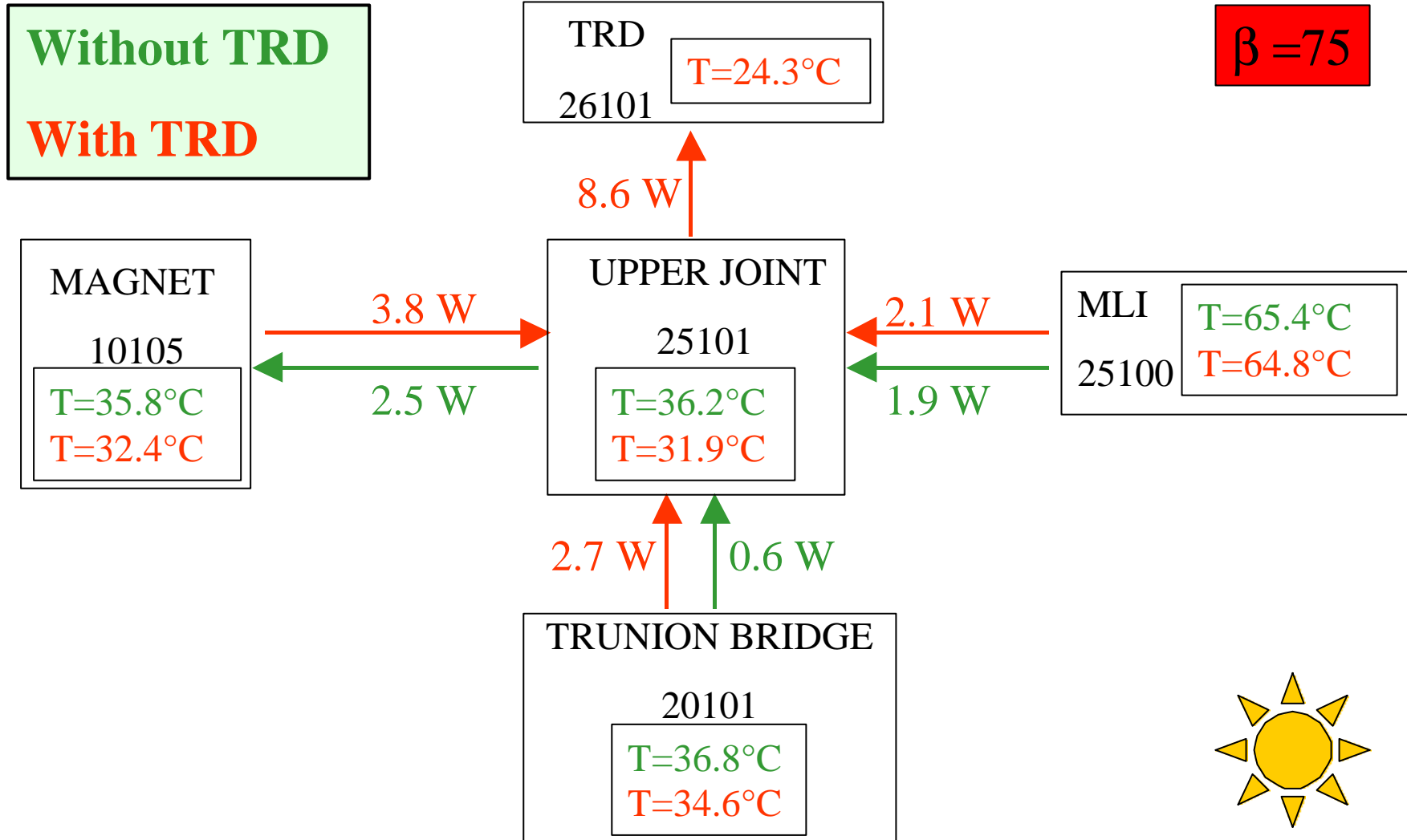


Upper joint heat flow map For
both cases ($\beta=75$ and $\beta=0$)

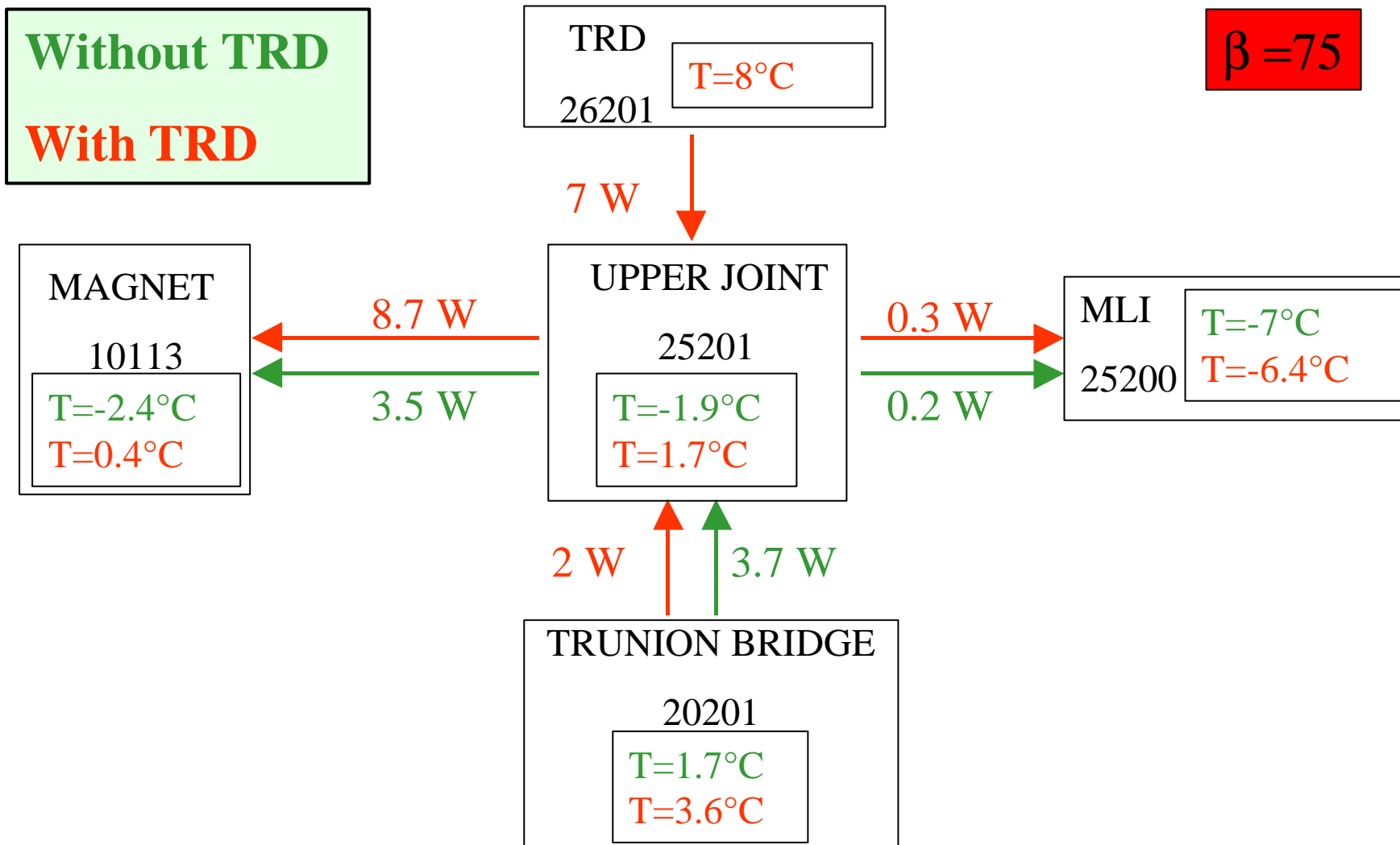
Purpose: to understand thermal
heat exchange among:

TRD, USS, Vacuum case

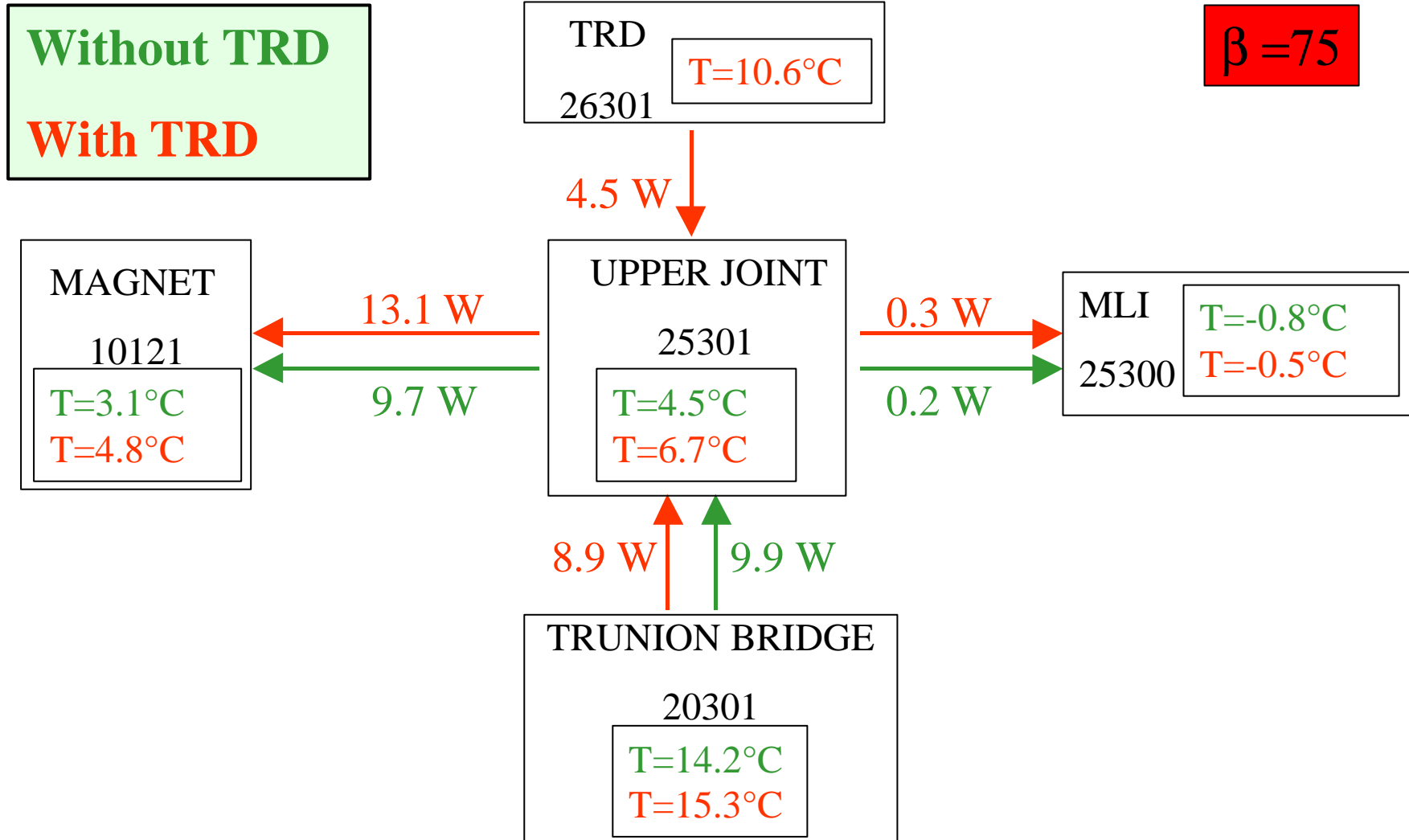
AMS 02 –Thermal Control System Design



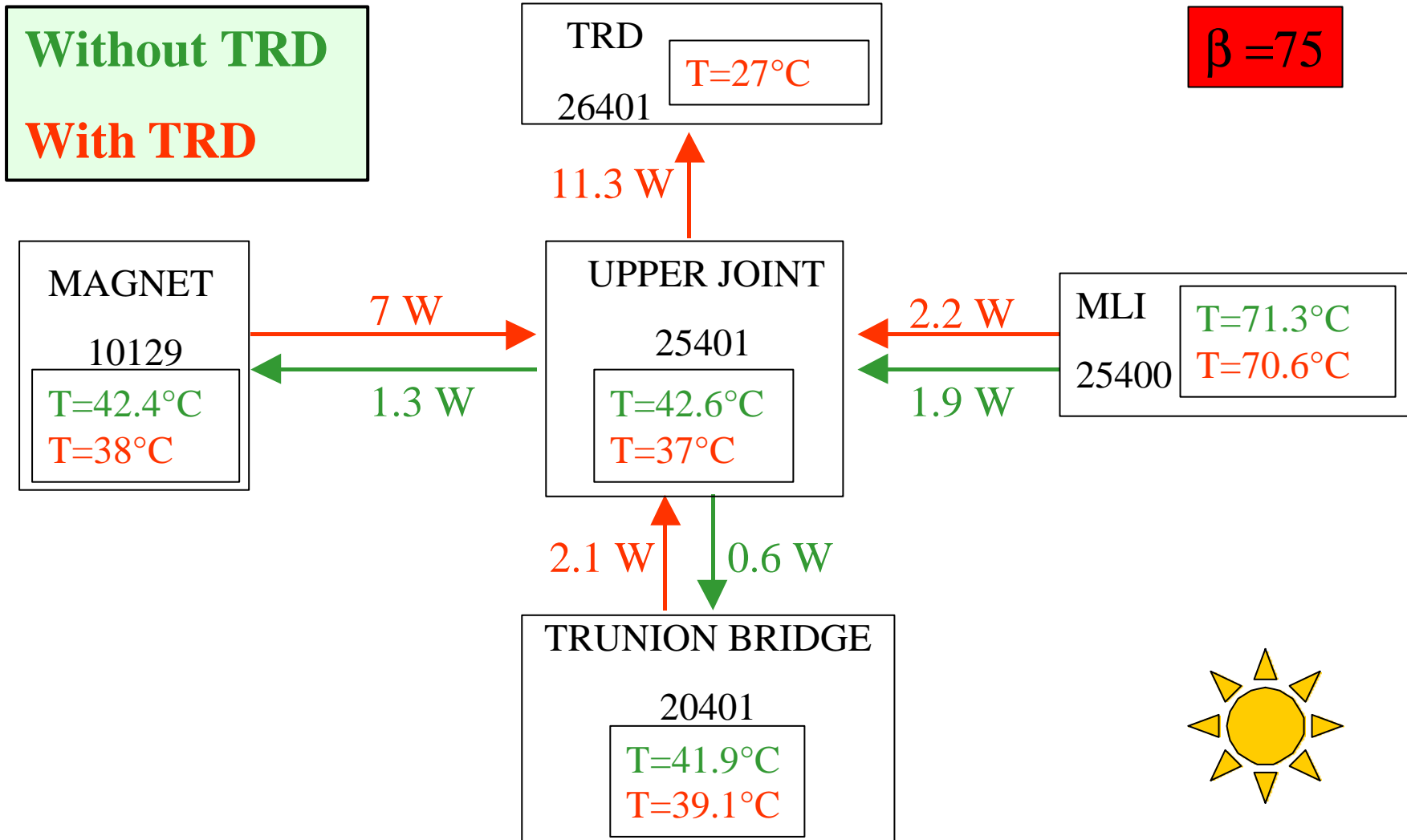
AMS 02 –Thermal Control System Design



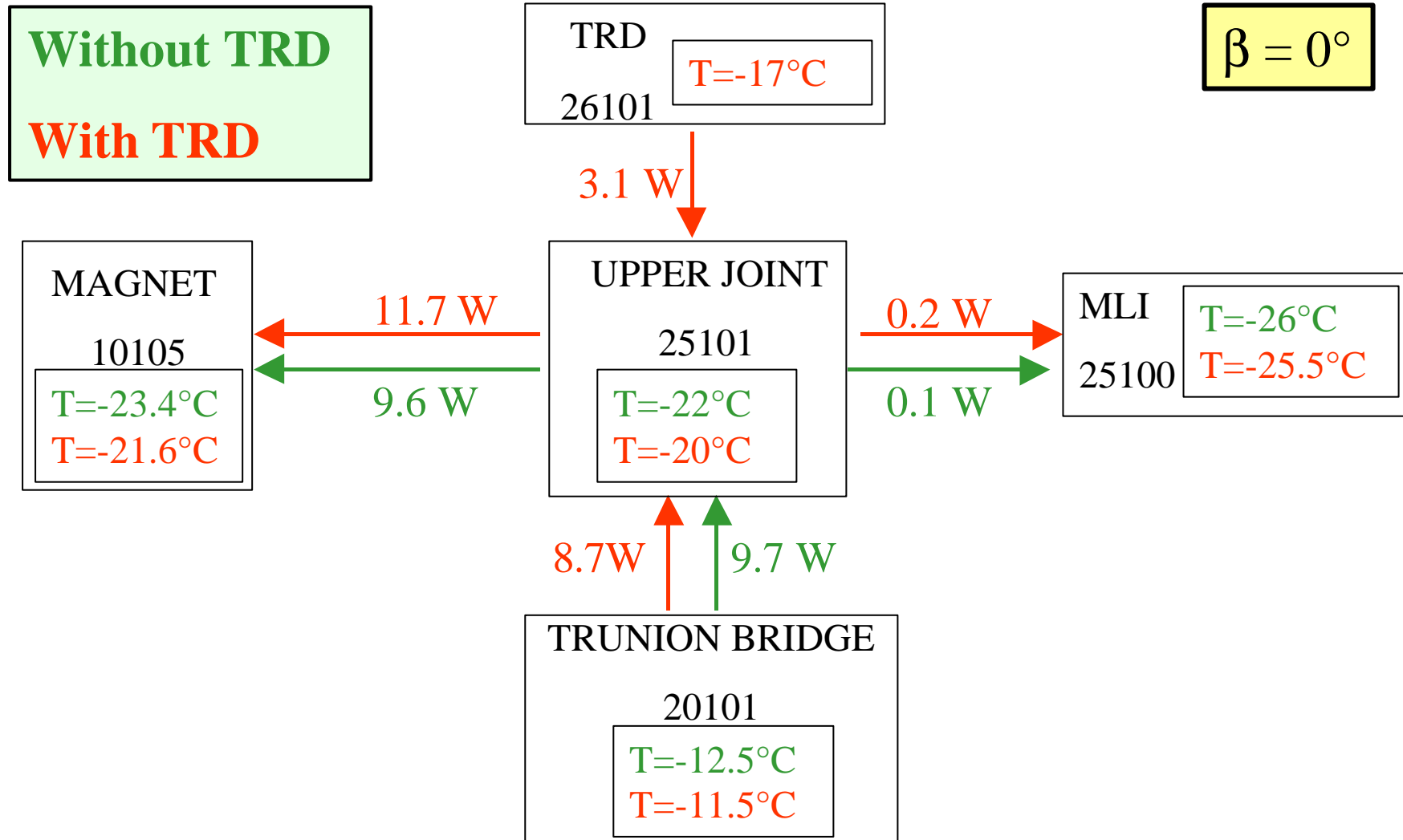
AMS 02 –Thermal Control System Design



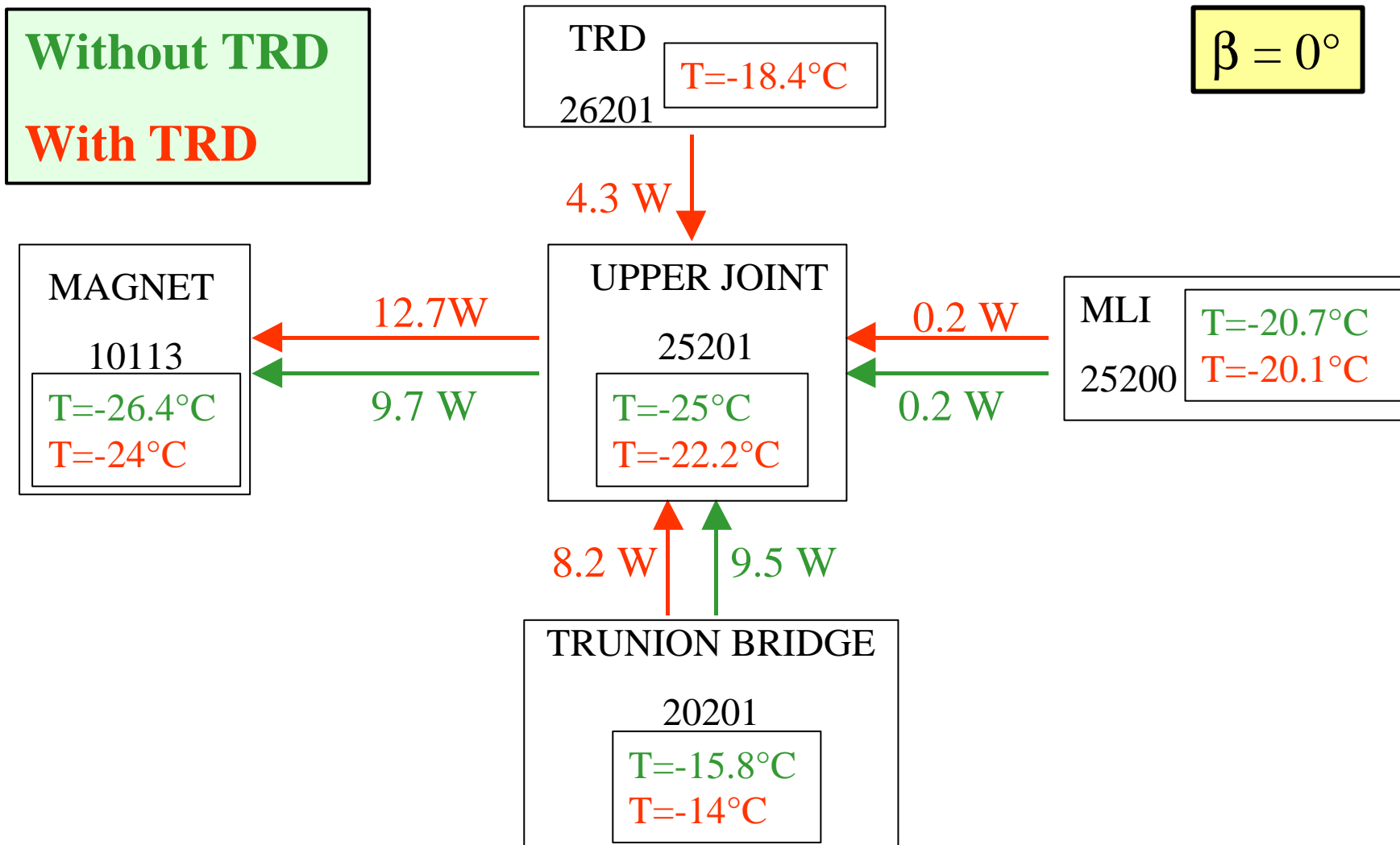
AMS 02 –Thermal Control System Design



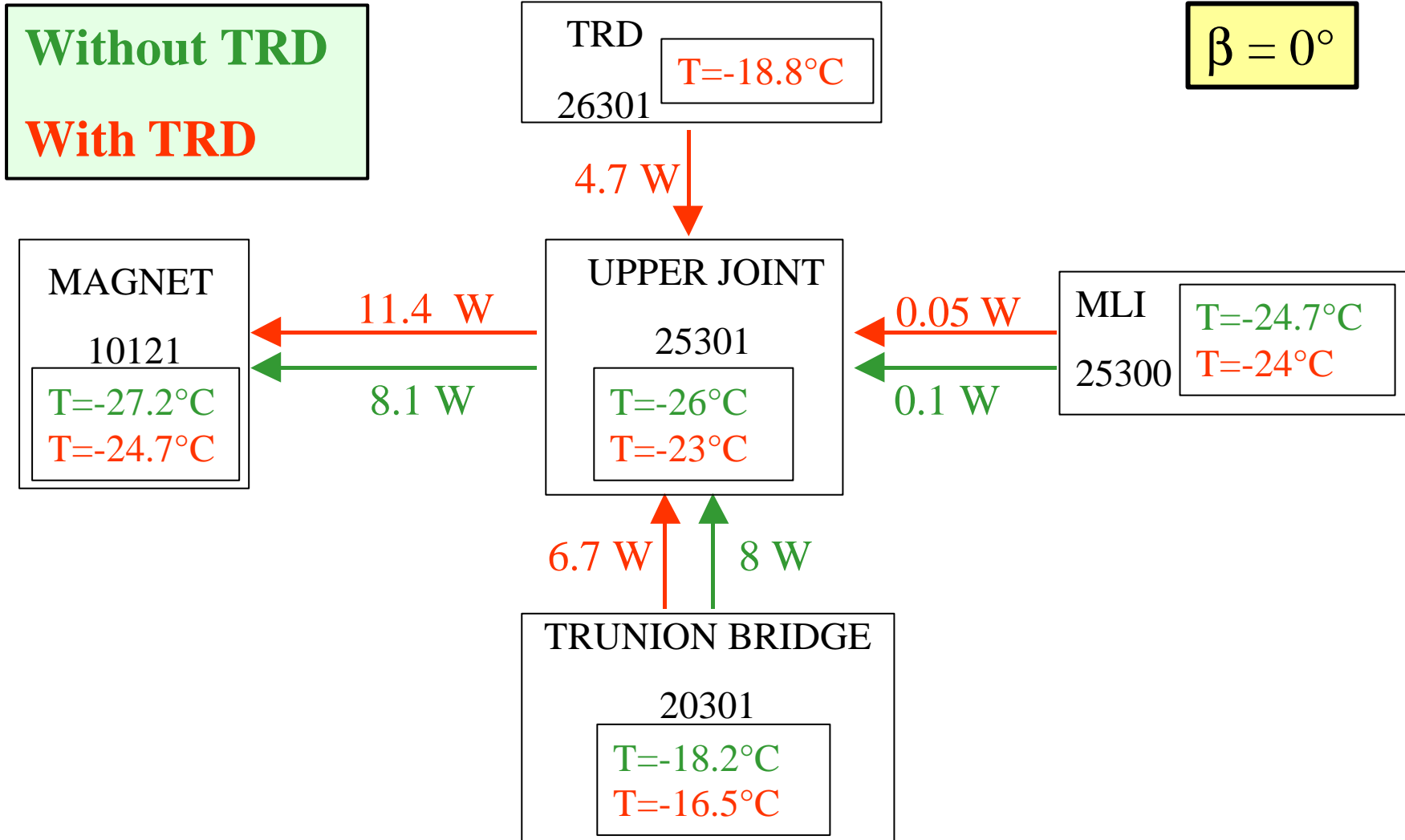
AMS 02 –Thermal Control System Design



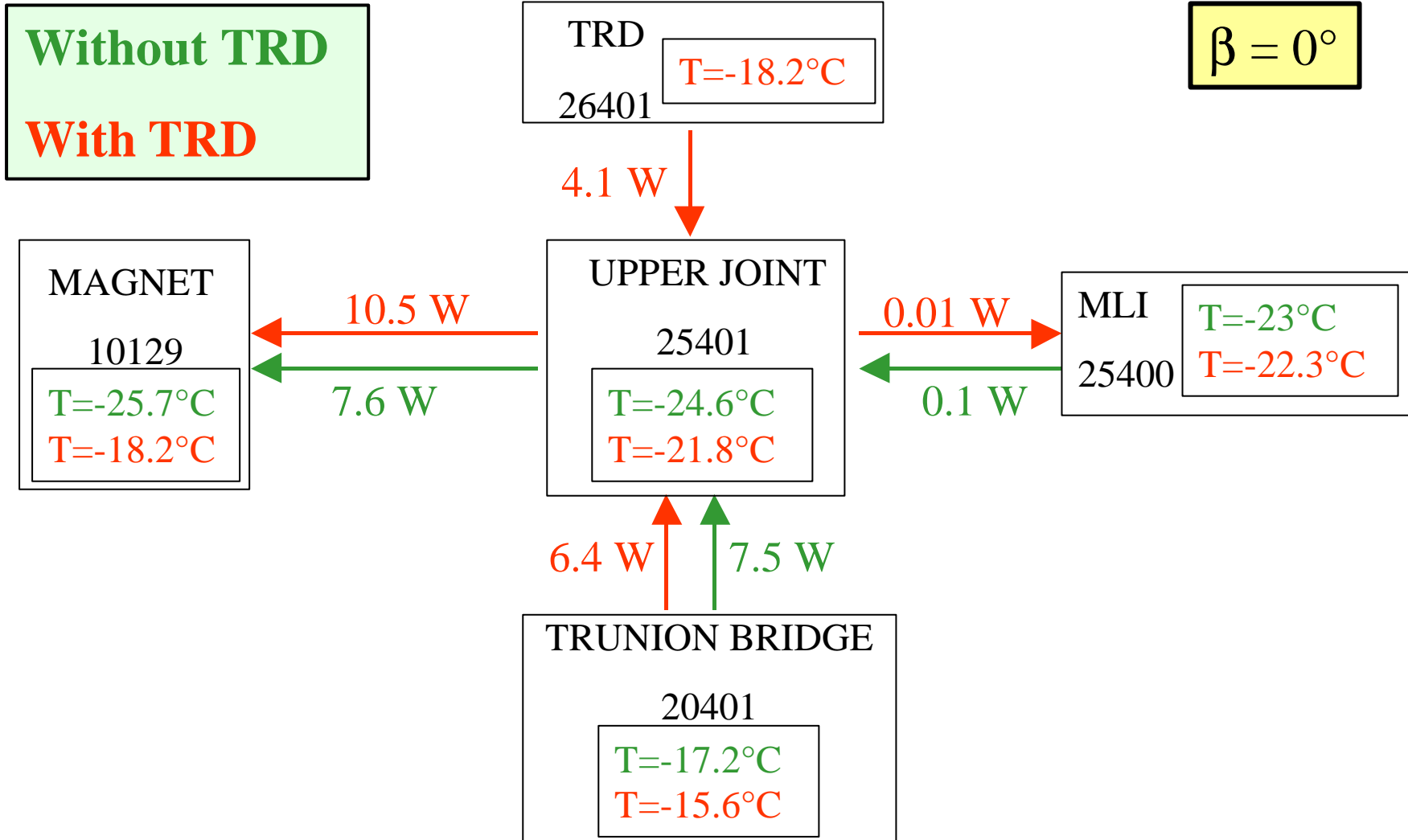
AMS 02 –Thermal Control System Design



AMS 02 –Thermal Control System Design



AMS 02 –Thermal Control System Design



Do we need a TRD Thermal Model in the AMS02 model?

If yes: with which features?

Nodes

Format

Test cases

Updated TOF dissipation

- $0.8 \times 4 \text{ W} = 3.2 \text{ W}$ (was 14.4 W)

