Update on ATCA cooling and noise reduction in ATLAS

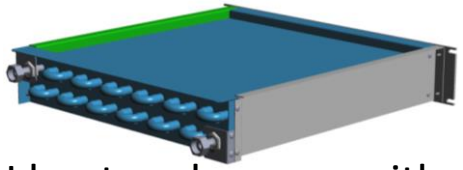
Claudio Bortolin EP-ADO-PO

With the great help of:

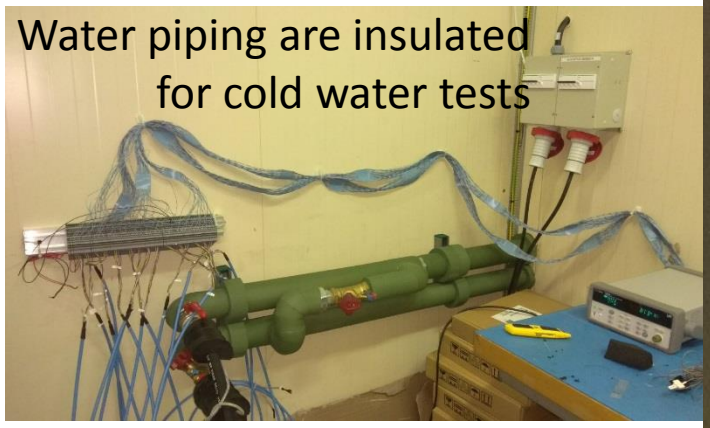
Michal Kalinowski now member of the TE-MPE-MI section

Barbara Ułaszewska now member of the ALICE DCS team

15th meeting of the xTCA interest group

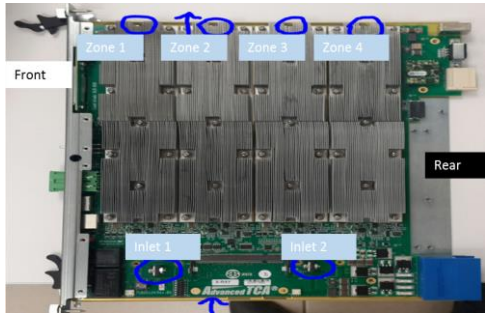


Rack configuration

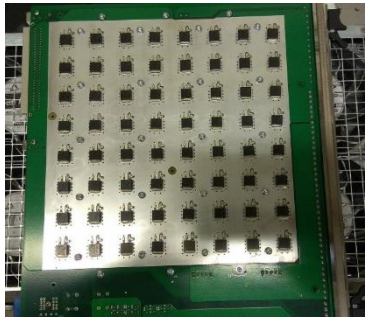


- 3x 2U heat exchangers with max. cooling capacity of **7.9 kW** each
- 3x ATCA shelves– 2x CERN standard Schroff unit + 1x ASIS
- Water chiller: max. cooling capacity **25kW**

- 3x different set of load blades (LB):
  - 14x ASIS LB, max power dissipation: **600W** only front
  - 14x New type Comtel LB, max power dissipation: **800W** only front
  - 14x Old type Comtel LB, max power dissipation: **50W** RTM+ **300W** front



ASIS LB (6 T sensors)
High air resistance



New type Comtel LB
(no T readout)

Old type Comtel LB (6 T sensors)
Low air resistance

Important notes: 1) The power dissipation on the load blades is spread equally on the whole board
2) To increase the life time of the boards in the ATCA shelves, maximum target temperature is **50C.**

Hardware used and cooling principal

- 2x **CERN standard Schroff ATCA crate** – each equipped with 2 fan trays (1 top and 1 bottom

- 1x **NOT** CERN standard ASIS ATCA crate – equipped with 3 fan trays on the top and one on the bottom

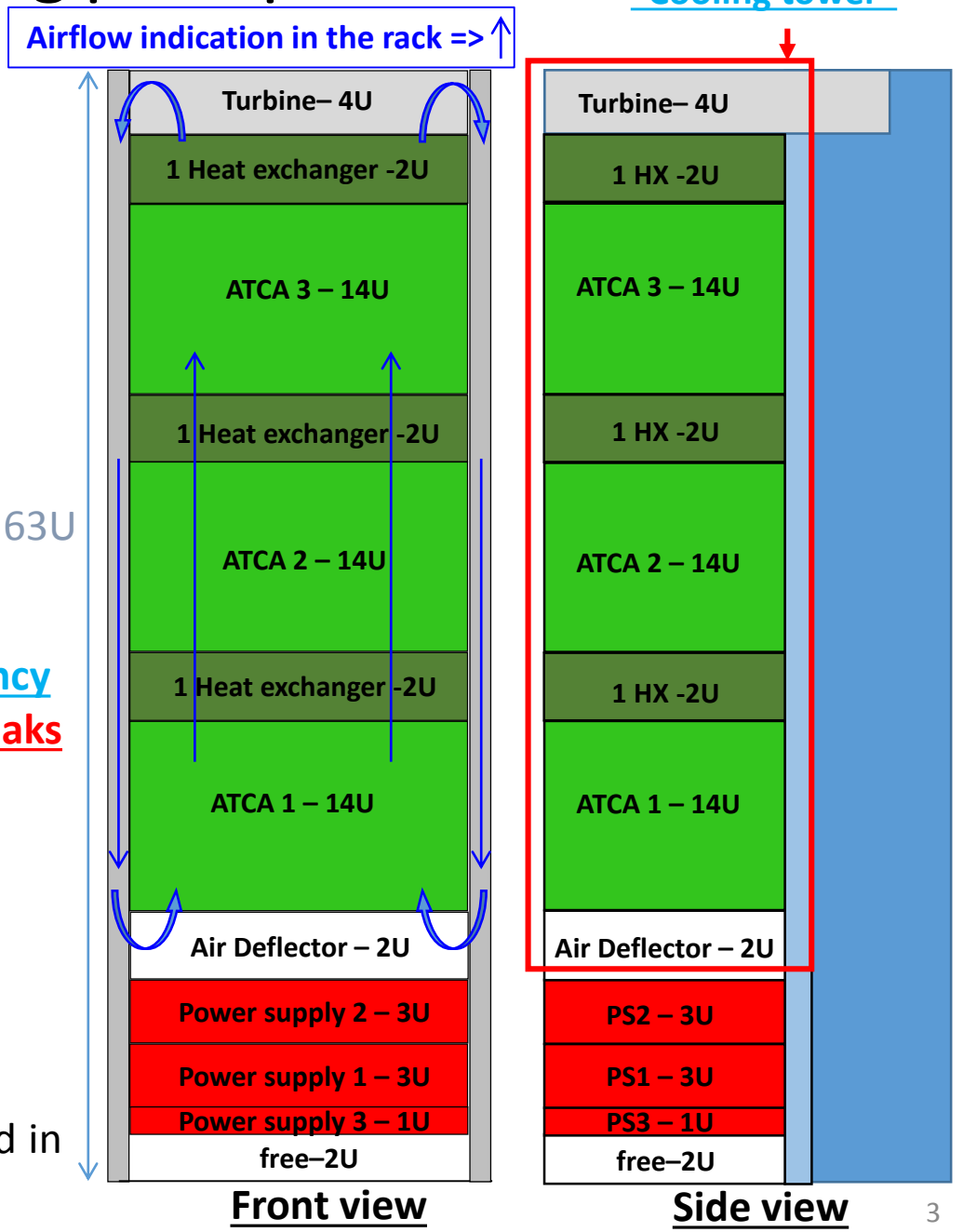
- Different LB sets => different cooling efficiency:

ASIS LB = a lot of heat sinks => higher air resistance => **better cooling efficiency**

Old Comtel LB = no heat sinks => low air resistance => **high temperature peaks on axis of the fans**

New Comtel LB = not equipped with any sensors => **no readout**

Important note: To prolong the life time of the electrical equipment installed in the ATCA shelves, maximum target temperature on boards is **50C.**



Test conditions

Regarding the volumetric flow we equipped the test facility of water flow counters in order to crosscheck TA scope measurements.

The laboratory is equipped with HVAC unit which reduces the impact of forced convection on the test environment

Parameters measured and calculated during the tests:

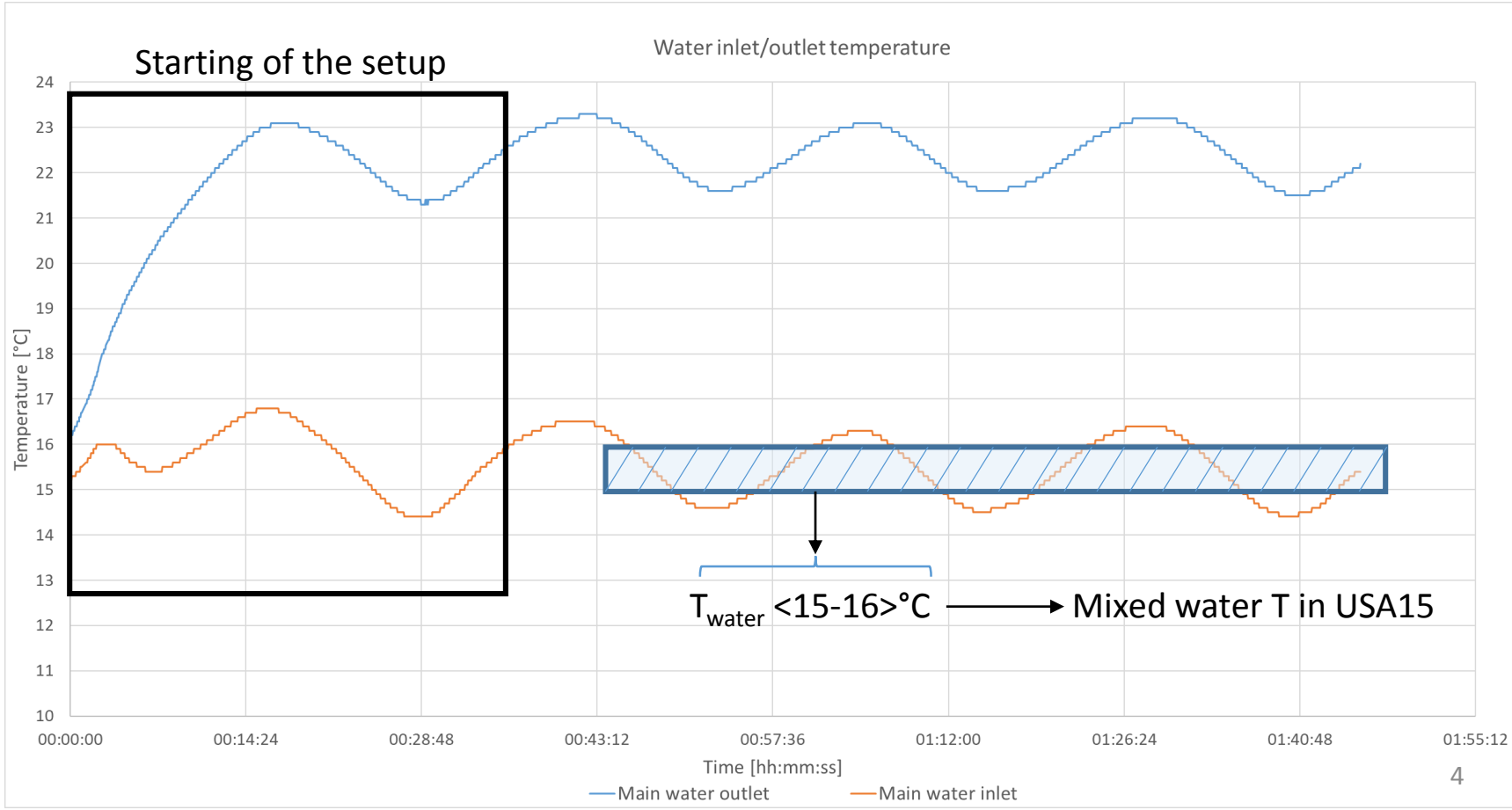
P_e – electrical power in the rack (measured on the outputs of PS)

$\dot{V}$ – volumetric water flow

ΔT – temperature difference between water inlet and outlet

Q_r – heat removed from the rack

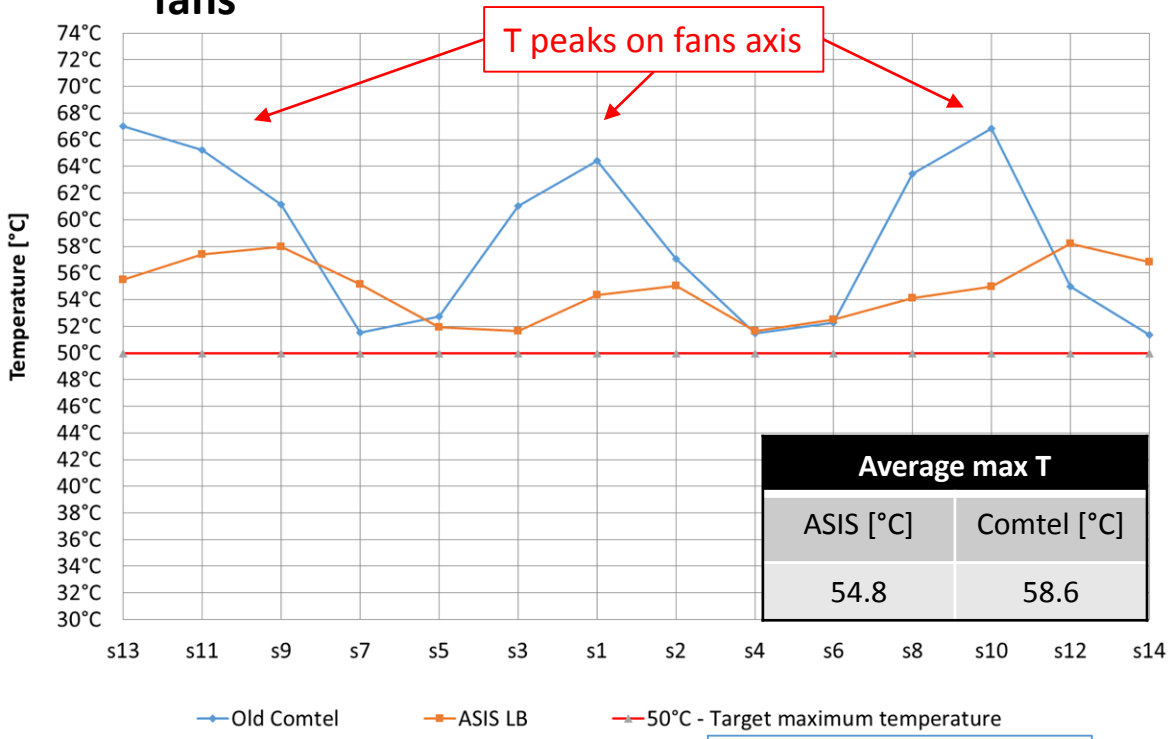
P – % of total power removed



Test results with 400W average per blade

With Bottom fans

14x450W New Comtel LB (ASIS)
14x(300+50)W Old Comtel LB (Schroff)
14x400W ASIS LB (Schroff)



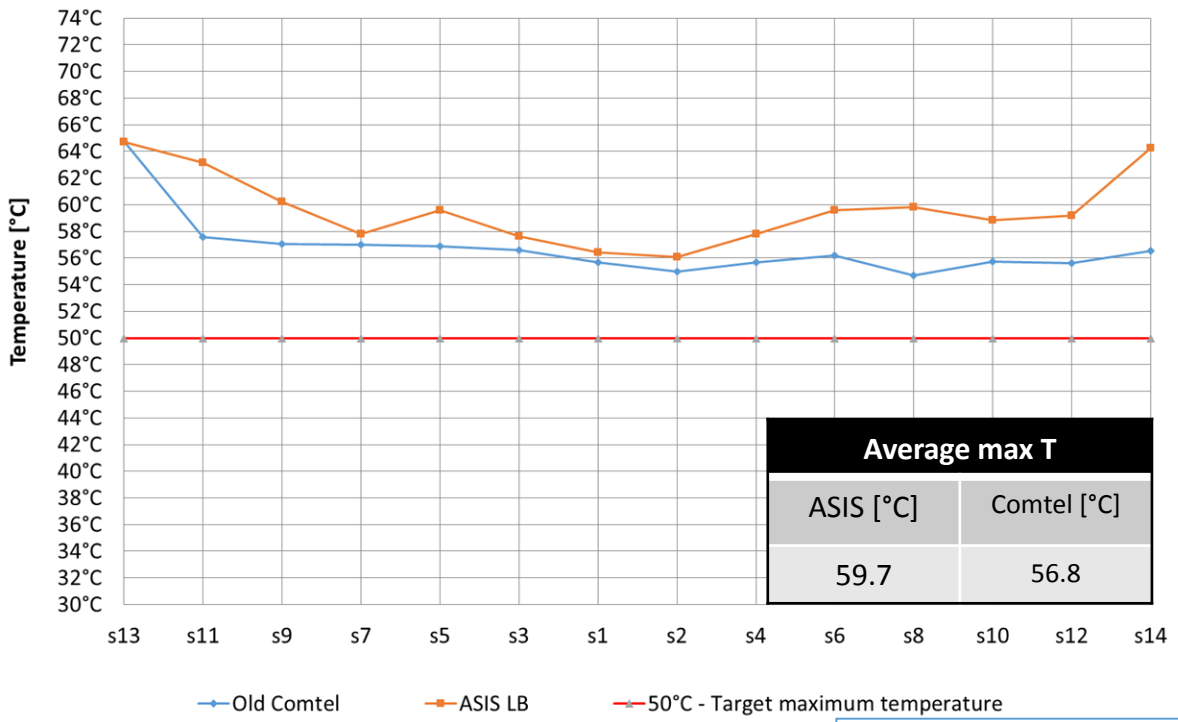
Average max T	
ASIS [°C]	Comtel [°C]
54.8	58.6

Total measured power in the rack 23.4 kW

Flow 2.4 m^3/h
ΔT = 7°C
Q_r = 19.5 kW
P = 83%

Without Bottom fans

14x450W New Comtel LB (ASIS)
14x(300+50)W Old Comtel LB (Schroff)
14x400W ASIS LB (Schroff)



Average max T	
ASIS [°C]	Comtel [°C]
59.7	56.8

Total measured power in the rack 20.6 kW

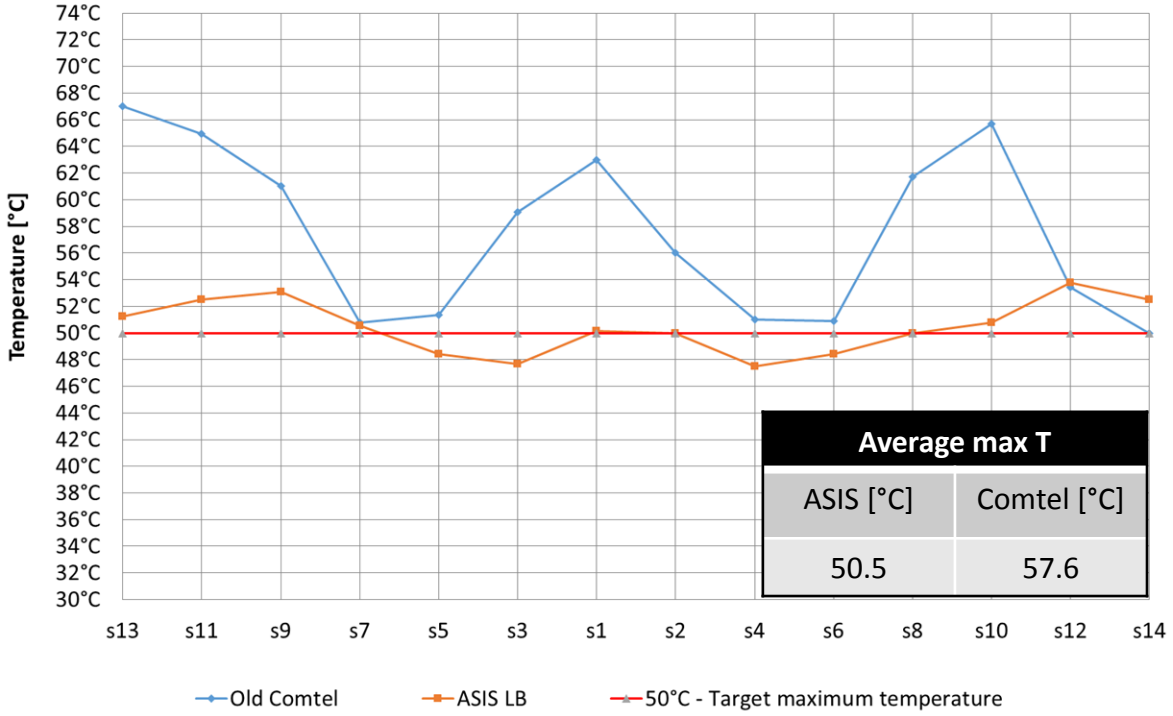
Flow 2.4 m^3/h
ΔT = 6°C
Q_r = 16.7 kW
P = 81%

Bottom fan tray removal: more homogeneous distribution on blades with low air resistance, significant increase of max T on blades with high air resistance

Test results with 350W average per blade

With Bottom fans

14x350W New Comtel LB (ASIS)
14x(300+50)W Old Comtel LB (Schroff)
14x350W ASIS LB (Schroff)



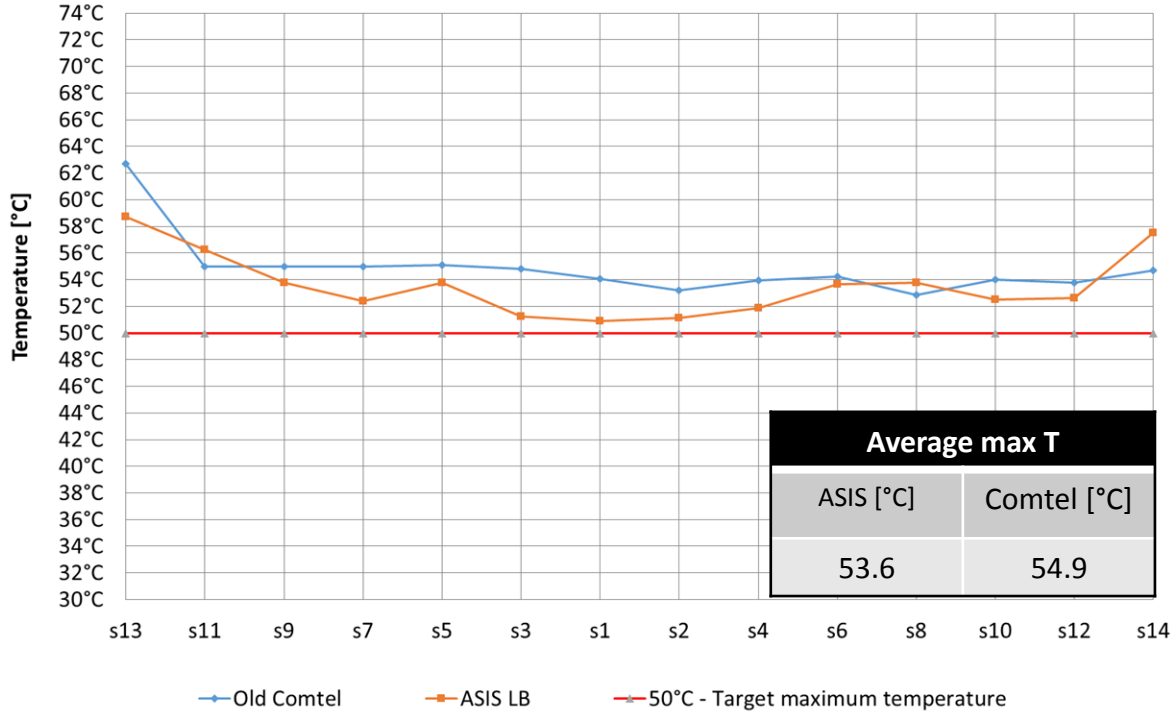
Average max T	
ASIS [°C]	Comtel [°C]
50.5	57.6

Total measured power in the rack 21.3 kW

Flow 2.4 m^3/h
$\Delta T = 6.4°C$
$Q_r = 17.9kW$
$P = 84\%$

Without Bottom fans

14x350W New Comtel LB (ASIS)
14x(300+50)W Old Comtel LB (Schroff)
14x350W ASIS LB (Schroff)



Average max T	
ASIS [°C]	Comtel [°C]
53.6	54.9

Total measured power in the rack 18.4 kW

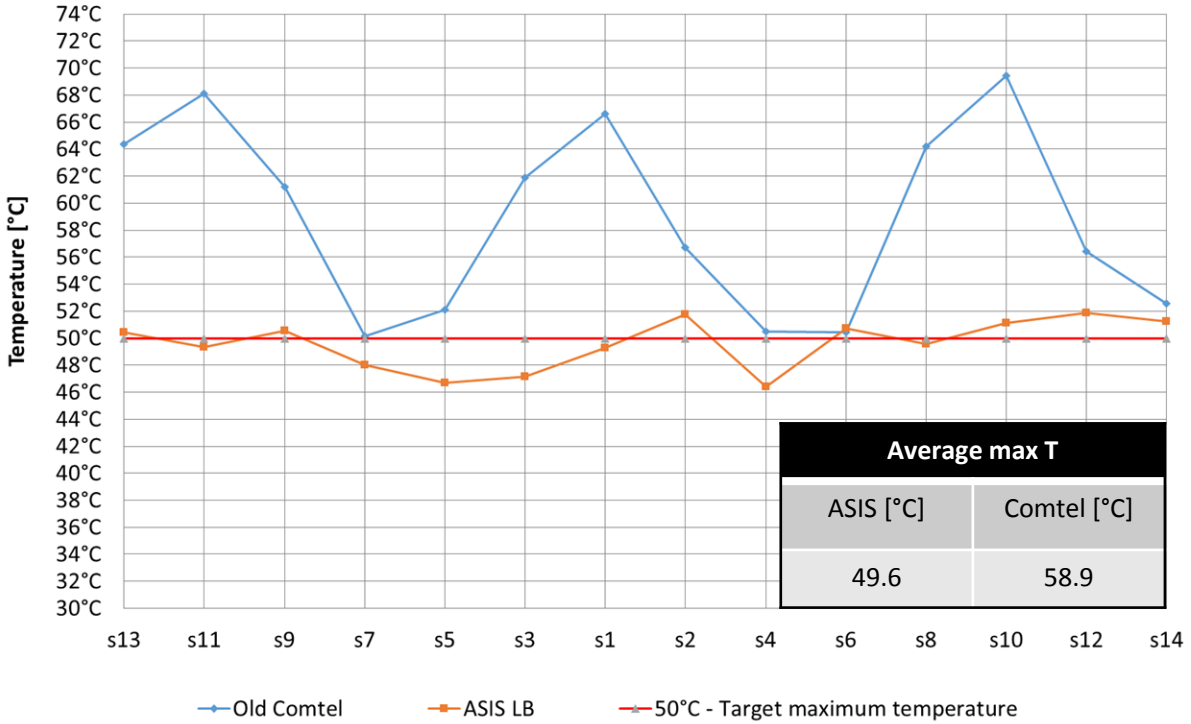
Flow 2.4 m^3/h
$\Delta T = 5.4°C$
$Q_r = 15.1$ kW
$P = 82\%$

In push-pull configuration the ASIS blades are able to stay within the target of 50C

With RTM vs without RTM

With Bottom fans

14x350W ASIS LB (Schroff)
14x(300+50)W Old Comtel LB (Schroff)
14x350W New Comtel LB (ASIS)



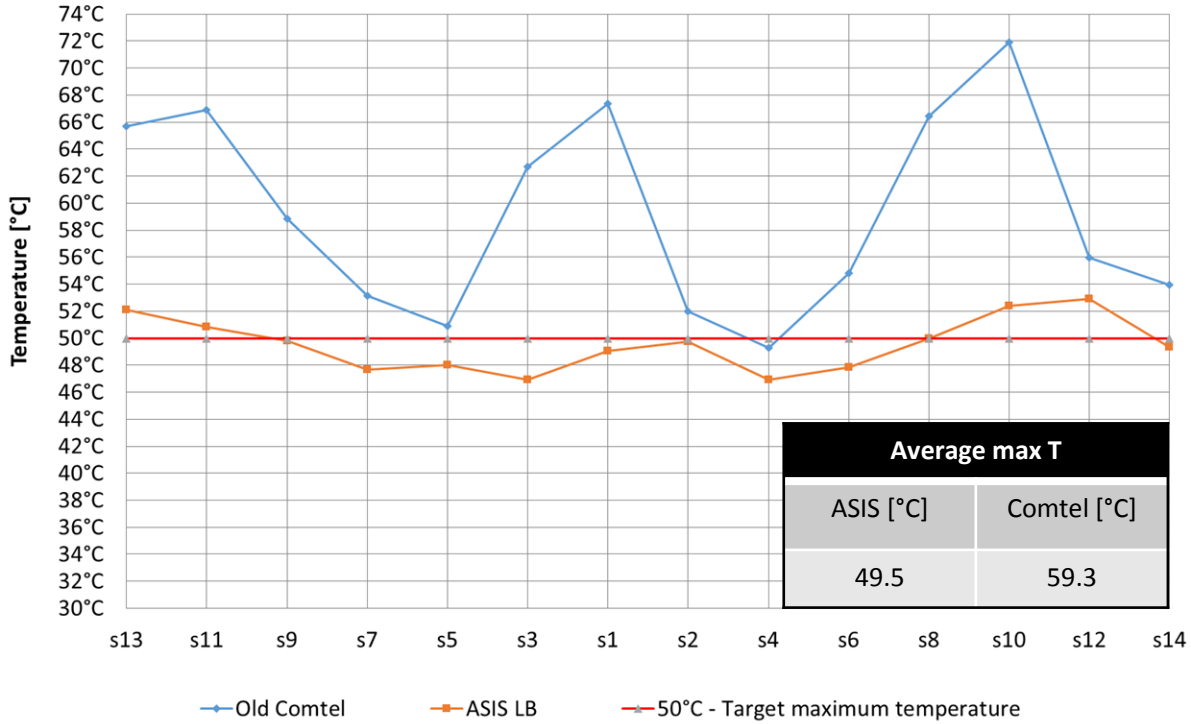
Average max T	
ASIS [°C]	Comtel [°C]
49.6	58.9

Total power in the rack 21.2 kW

Flow 2.4 m^3/h
ΔT = 6.4°C
Q_r = 17.9 kW
P = 84%

With Bottom fans

14x350W ASIS LB (Schroff)
14x(300+0)W Old Comtel LB (Schroff)
14x350W New Comtel LB (ASIS)



Average max T	
ASIS [°C]	Comtel [°C]
49.5	59.3

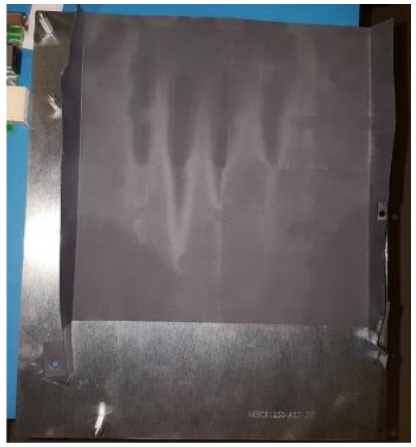
Total power in the rack 20.5 kW

Flow 2.4 m^3/h
ΔT = 6.1°C
Q_r = 17 kW
P = 83%

Conclusion: additional 50W on the RTM has negligible influence on cooling performance of the front of the board

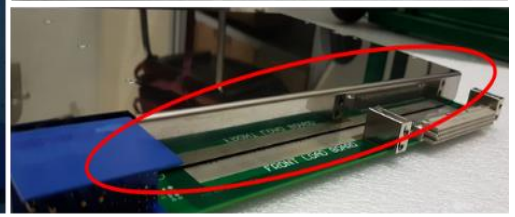
Heat radiation to the room – thermal camera studies

- Measured cooling efficiency of 80-85% **=>** ~3kW heat released to the environment
- Different board design **=>** different frontal heat radiation

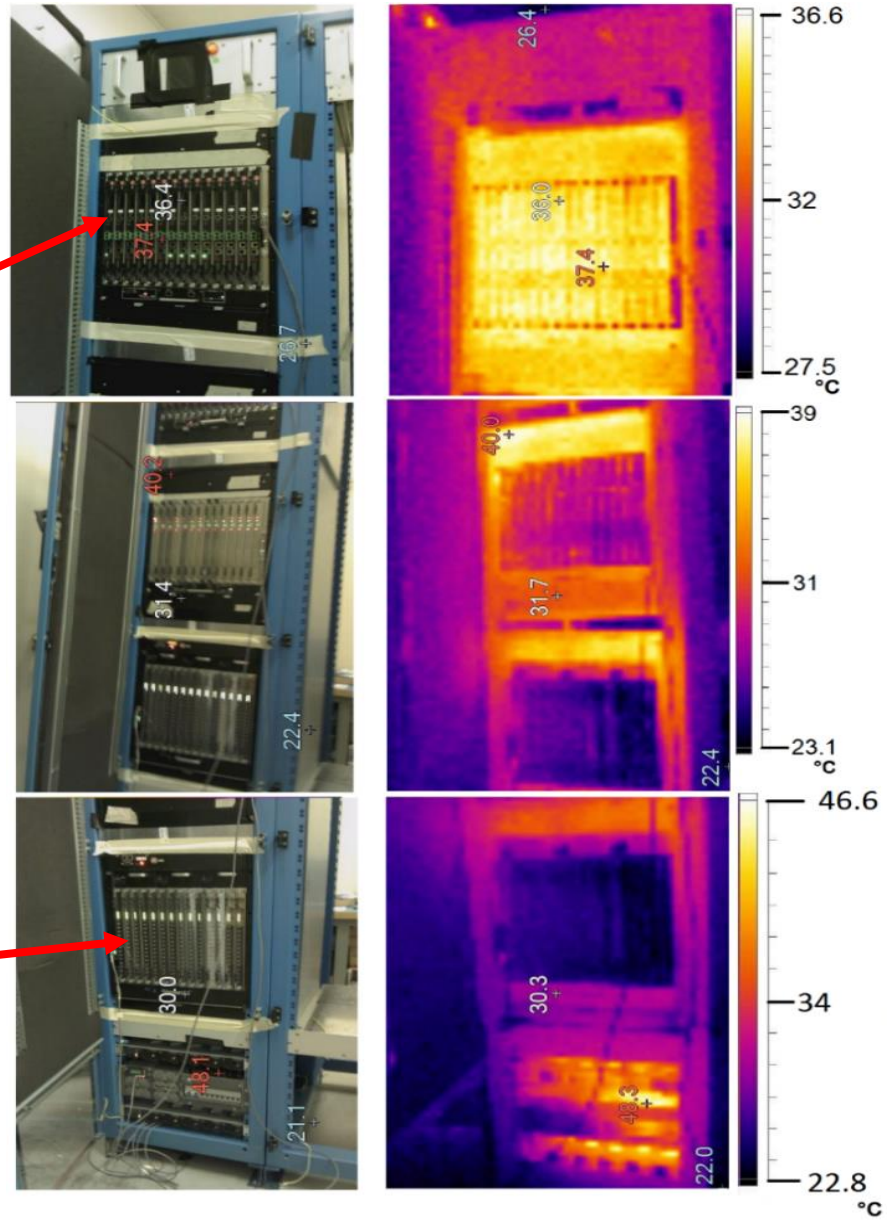



Heat sinks close to the face of the board, lack of air duct





Special design to drive air mostly through the dissipating part



Designing a board with a proper heat sink can make a significant difference for the board and general the infrastructures.

Heat radiation to the room – thermal camera studies

- Room temperature ~20°C, rack rear and sides T 27-33°C

- Significant amount of heat radiated to the environment

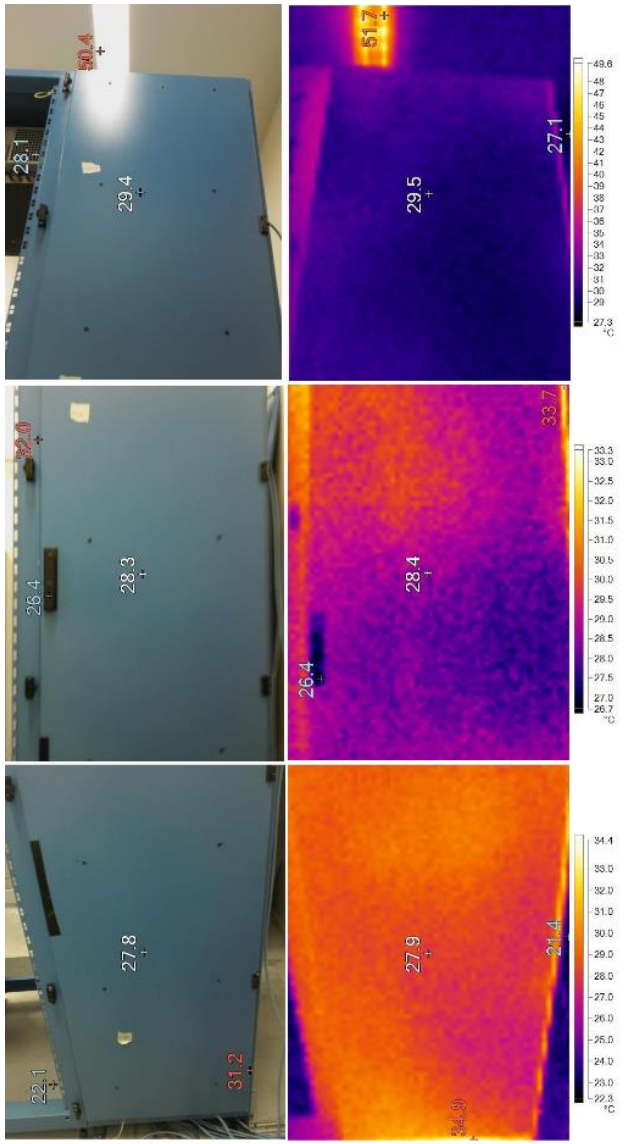
- Rear doors temperature lowered by noise insulation material

Masse lourde :

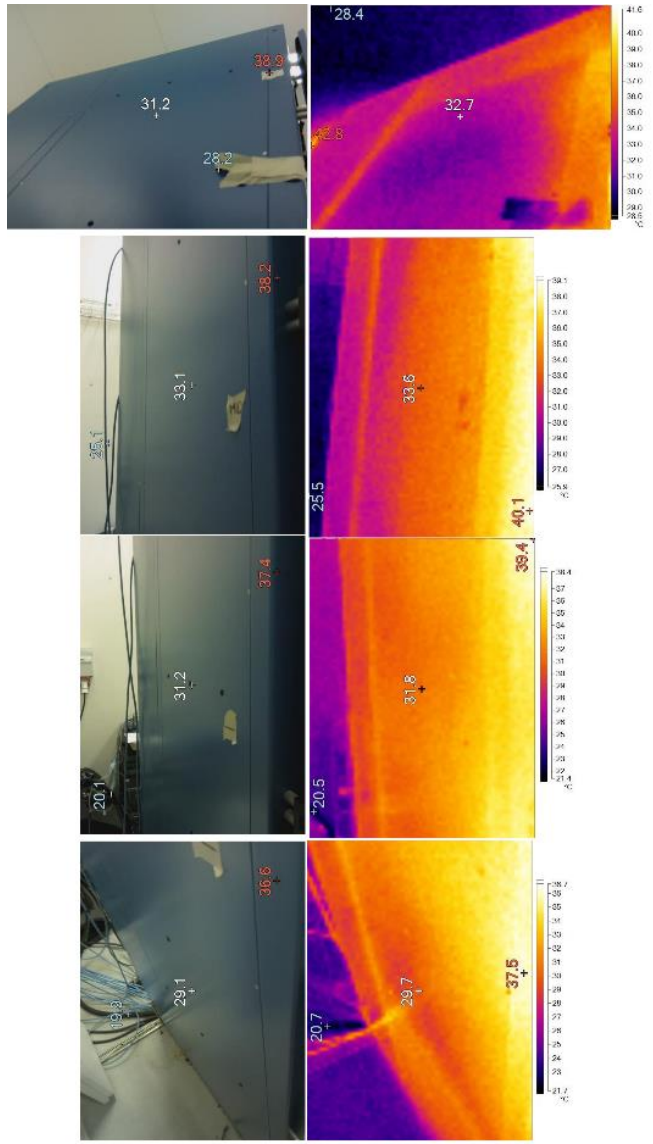
- ✓ Masses synthétiques polymères
- ✓ Sans bitume, haute densité
- ✓ 7 kg/m²
- ✓ Classement au feu : B s2 d0
- ✓ Une face adhésive acrylique
- ✓ Epaisseur : 3.6mm

Mousse polyuréthane :

- ✓ Mousse PU souple ignifugée
- ✓ Environ 30 kg/m3
- ✓ Classement au feu / fumée : M1
- ✓ Une face adhésive
- ✓ Epaisseur : 25 mm



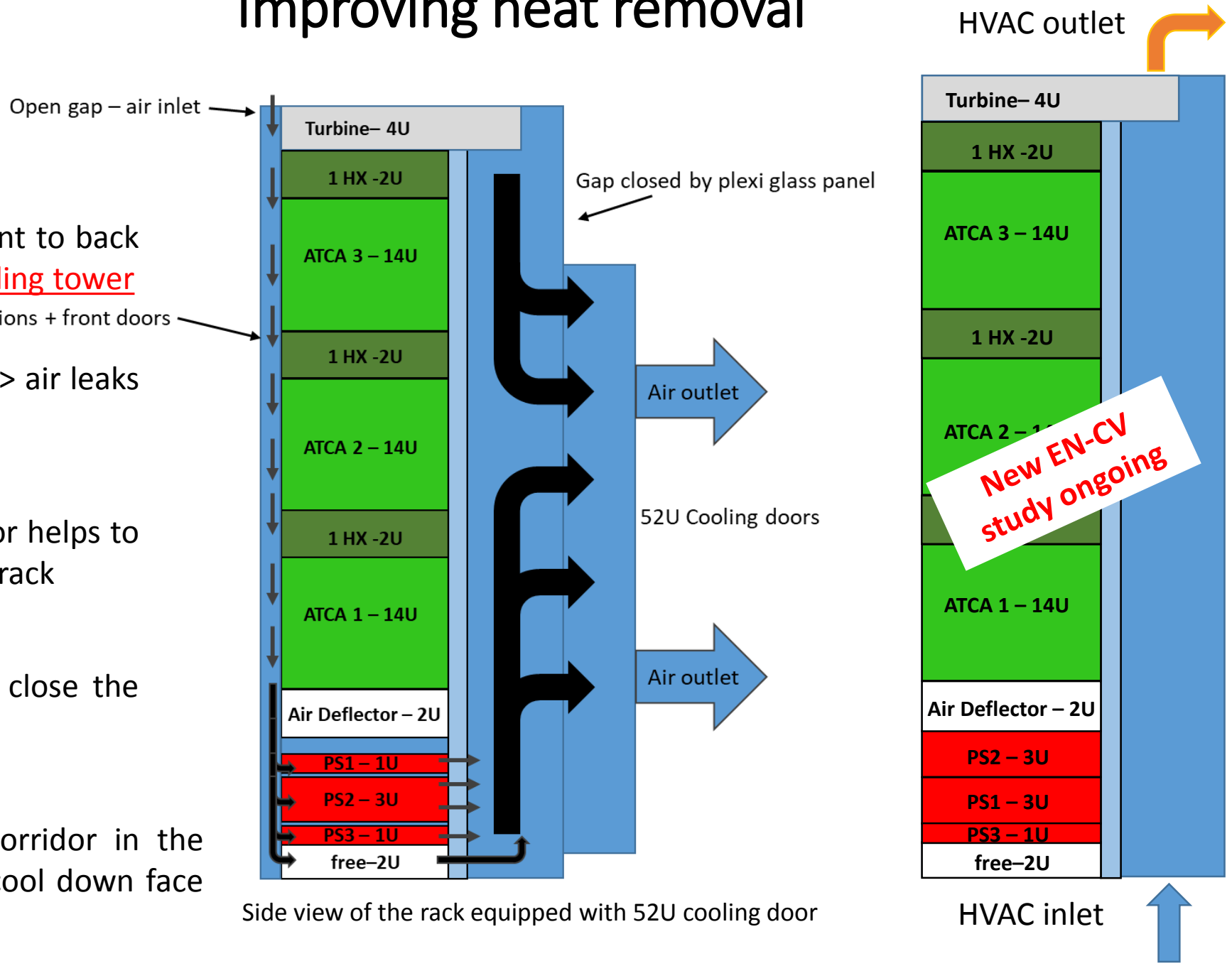
Rear of the rack



Side of the rack

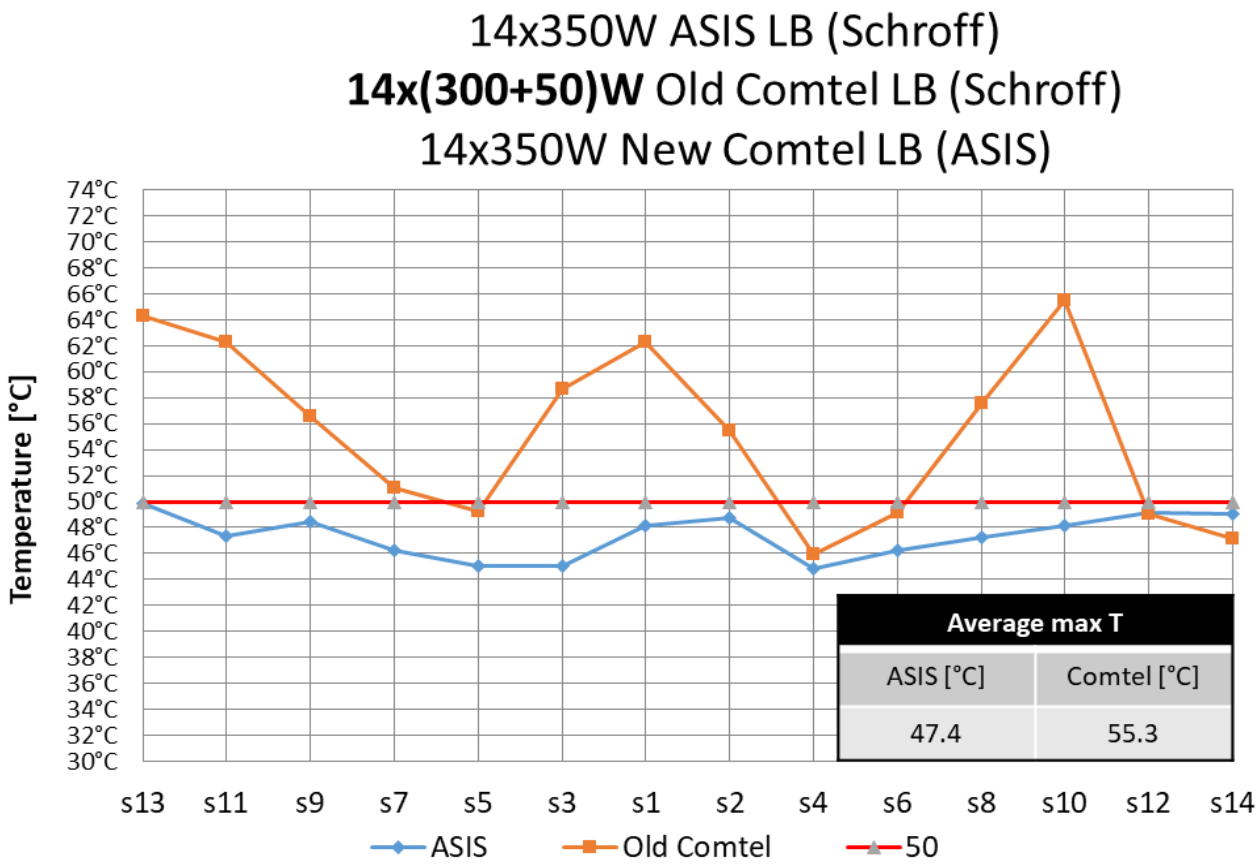
Improving heat removal

- Power supply units are cooled front to back
  => heat is not removed by the cooling tower
- The cooling tower is not air tight -> air leaks to the back of the rack
- Installation of the 52U cooling door helps to remove heat from the back of the rack
- Plexi-glass panel was installed to close the gap in the back of the rack
- C-shape extensions creates air corridor in the front of the rack which helps to cool down face of the boards



Side view of the rack equipped with 52U cooling door

Test results with 350W average per blade + cooling door



Total measured power in the rack 21.3 kW

CT = Cooling Tower
CD = Cooling Door

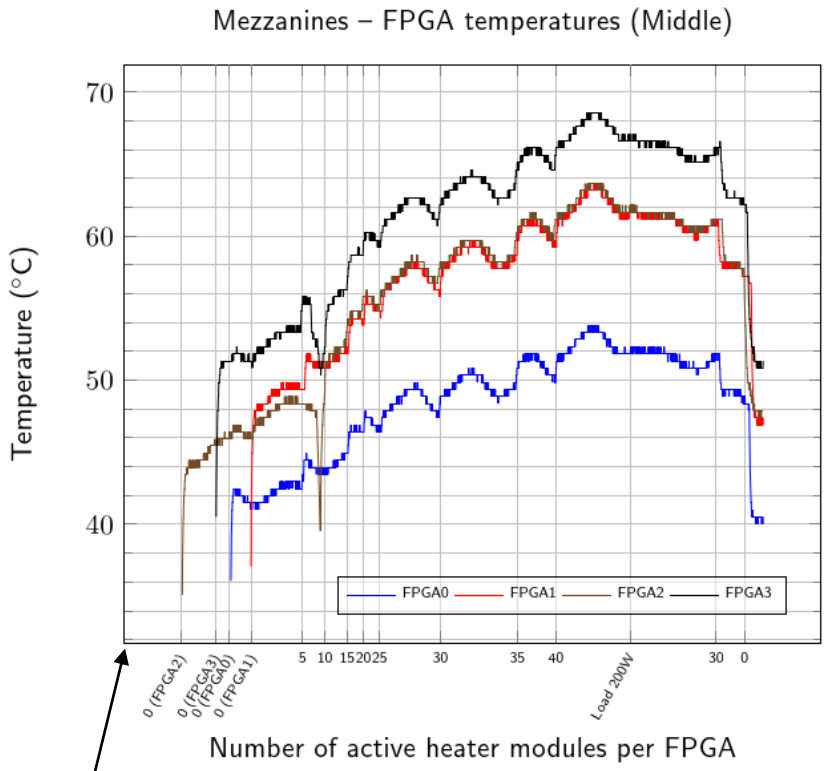
CT flow = 2.8 m^3/h
CD flow = 0.7 m^3/h
ΔT_{CT} = 5.4°C
ΔT_{CD} = 3.1°C
$Q_r = Q_{CT} + Q_{CD}$ = 17.6 + 2.5=20.1 kW
P = 94.4%

The 52U cooling door, helps to keep the cooling efficiency above **90%**

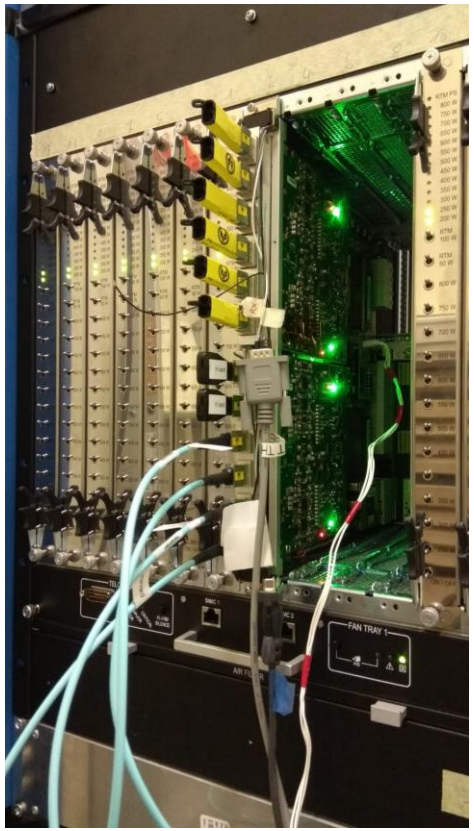
Test setup availability

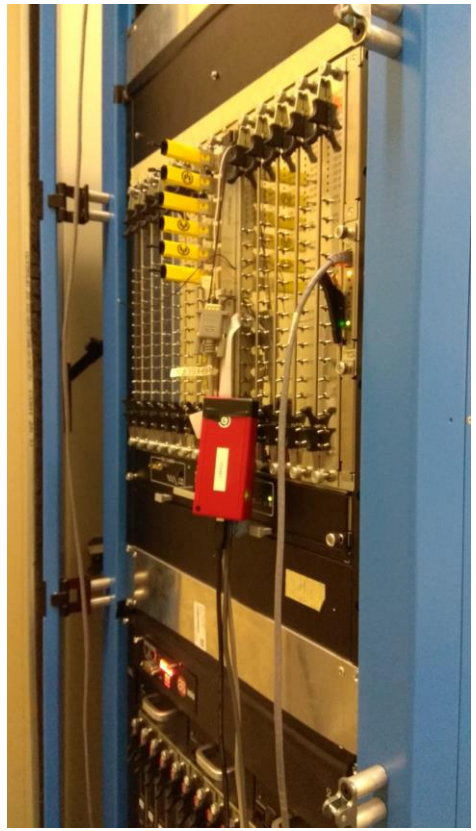
- The ATCA test setup is available for testing the real boards prototypes
- To minimalize the impact of different air resistance between the real boards and the load blades it is advised to test the batches of minimum 3 pieces.

New Comtel LB 13x200W+Real board up to ~23W per FPGA



Thiago Costa de Paiva from University of Massachusetts Amherst results.

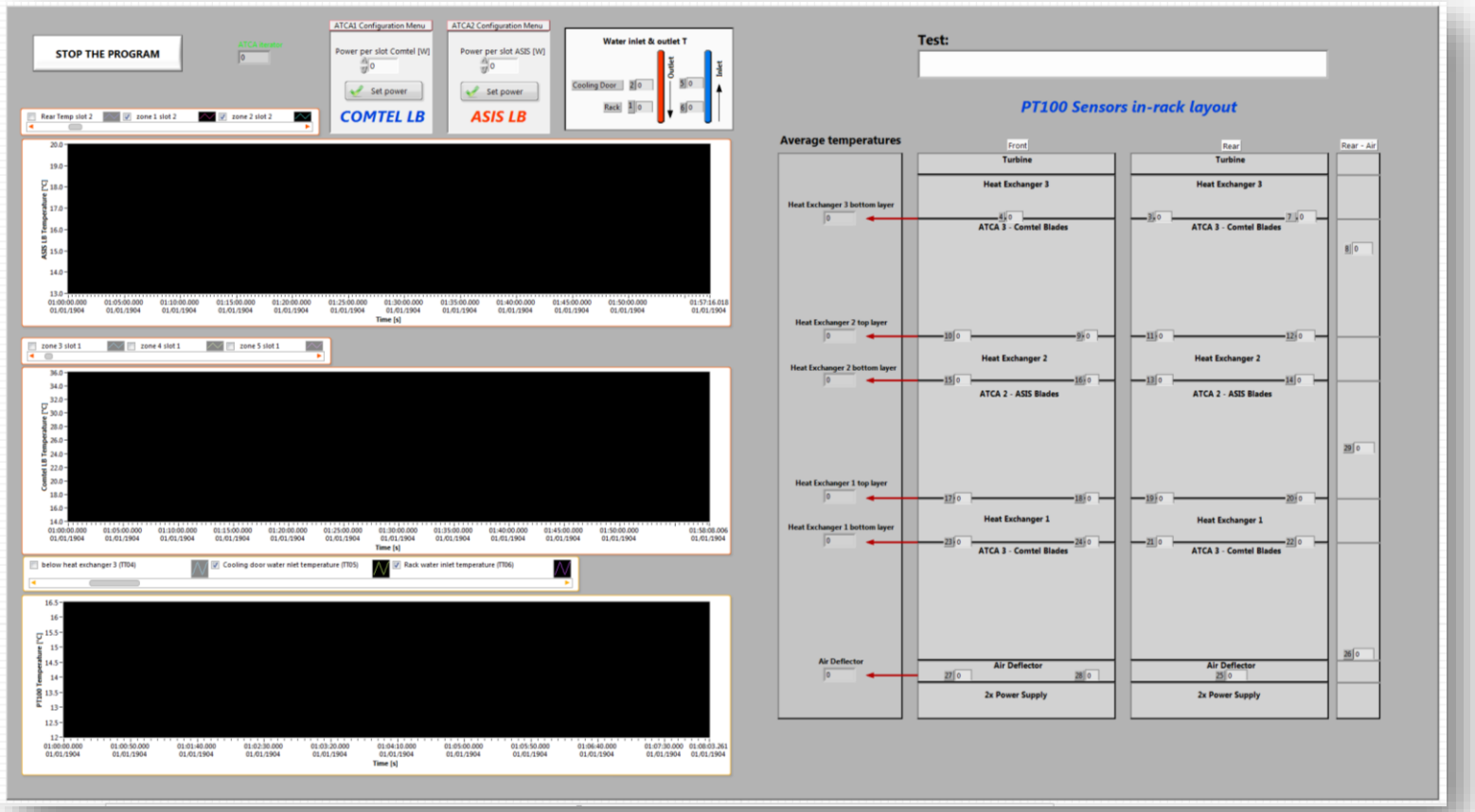




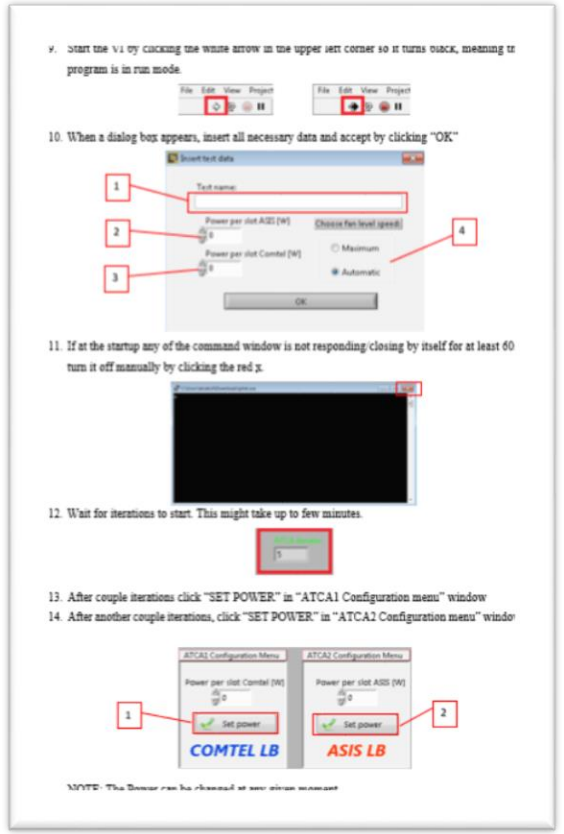
First 4 racks (63U) were successfully installed in USA15 Counting room and they are operative.

Upgrading LabVIEW User Interface

User-friendly interface is now ready to be used by anyone



Provided step-by step instructions on how to start the test



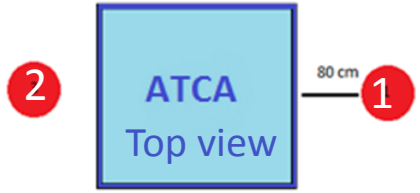
https://edms.cern.ch/document/1609794/1

Noise reduction: soundproofing and impact on cooling

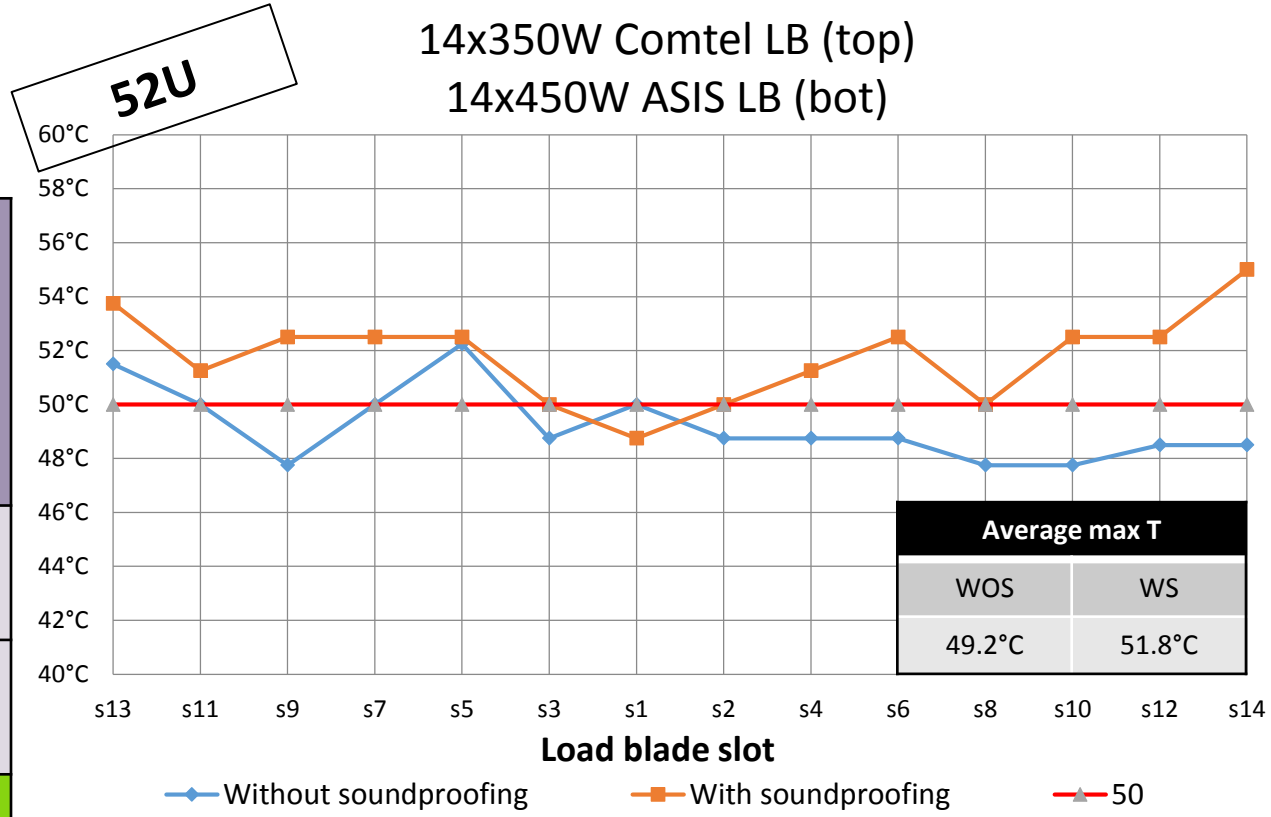
J. Minier (HSE) new consultant

ATCA fans working at max speed ⟶ Over 100 [dB(A)]! -> needs soundproofing

Soundproofing material installed in the air corridors reduces its width from 65 [mm] to 37 [mm] – **impact on cooling?**



Noise values (52U)	Pos. 1 Door open [dB(A)]	Pos. 1 Door closed [dB(A)]	Pos. 2 [dB(A)]	Av. max T ASIS [°C]	Av. max T Comtel [°C]
Without insulation	102.8	90	87.5	49.2	53.1
With insulation		86.3	84	51.8	49.4
Difference		-3.7	-3.5	2.6	-3.7



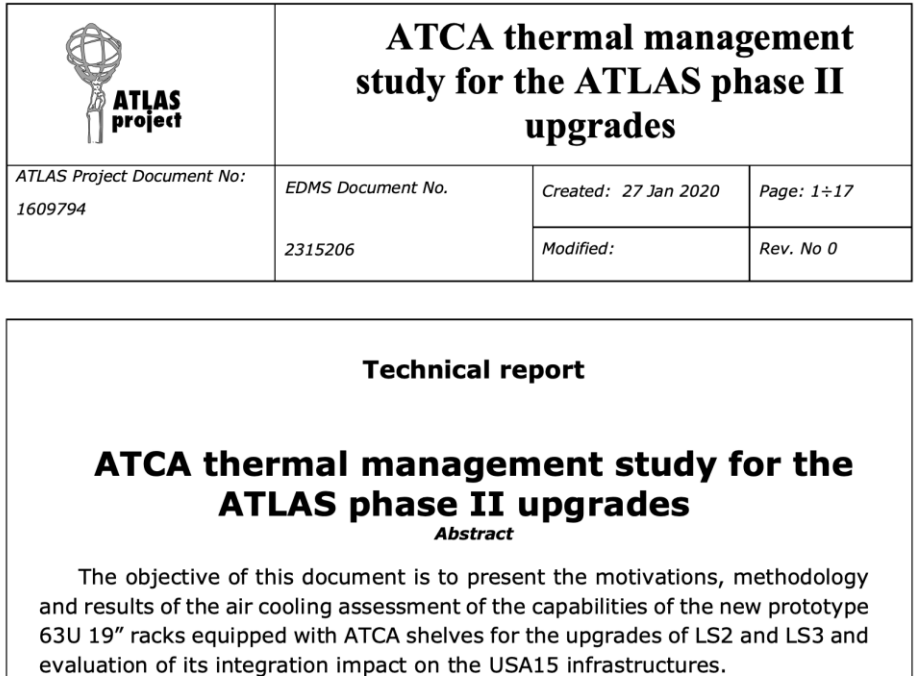
Measured in ASIS shelves – non standard for CERN

The av. max. T is increased by 2.6K, which is not a big price to pay for reducing the noise by 3.7 [dB(A)] on the level of the rack.

Simulations could not be very realistic because of various noise leaks (i.e.: false floor) but noise confinement walls installation is still under consideration. Collaboration with external companies ongoing.

ATCA cooling study conclusions

- Design target for boards in 63U ATCA crate is a maximum of 350W + (50W on RTM), it is important to remember that necessary margins should be taken into account
- It is important to remember that each of the load blades sets consists of 14 identical pieces with the heat dissipation spread equally on the whole surface – there are no hot spots on the blades which may not be the case for the real boards.



ATLAS project

ATCA thermal management study for the ATLAS phase II upgrades

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		Modified:	Rev. No 0

Technical report

ATCA thermal management study for the ATLAS phase II upgrades

Abstract

The objective of this document is to present the motivations, methodology and results of the air cooling assessment of the capabilities of the new prototype 63U 19" racks equipped with ATCA shelves for the upgrades of LS2 and LS3 and evaluation of its integration impact on the USA15 infrastructures.

- To reduce the heat radiated to the room by the front of the boards it is advised to design air corridors on the board which will drive the air mostly though the heat dissipating part which will also increase the overall board cooling efficiency
- While operating in proper conditions the cooling efficiency of the rack can be kept above 90%, reducing the heat released to the counting rooms. EN-CV is studying a possible air duct circuit to remove warm air from back of the rack
- Noise reduction at rack level gave good results, the idea of installing confinement walls is still under evaluation.