Investigation of ATCA vertical cooling capabilities

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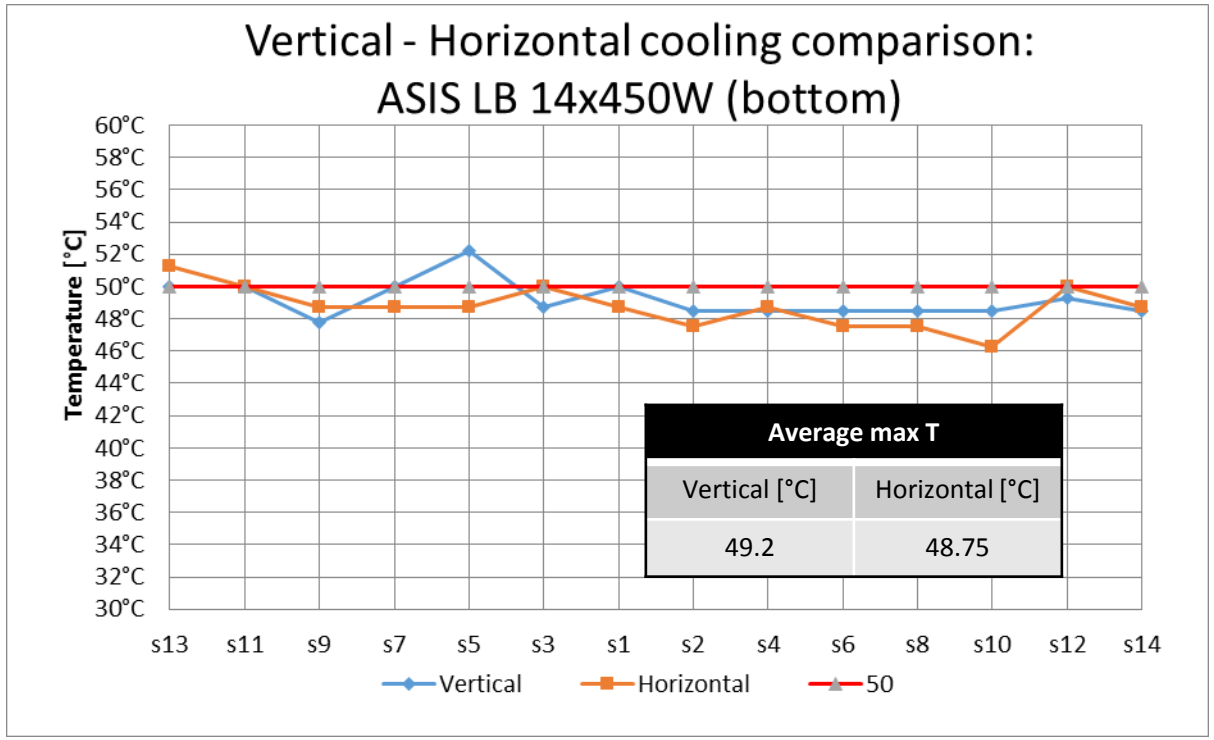
Quick recall

The outcome of the thermal behaviour studies of the standard 52U LHC rack equipped with 2 ATCA crates, was that both vertical and horizontal cooling configurations have similar efficiency. Either of them had their advantages and disadvantages, which taken under consideration pointed in the direction of the crates with open bottom to top airflow.



<u>The cooling performance is very similar</u>

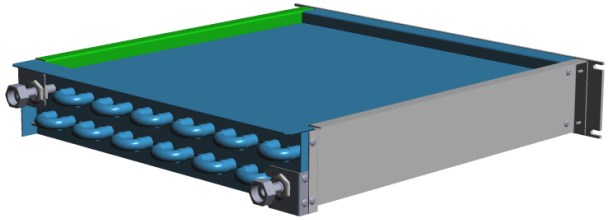
Project motivations

3 stocked vertically cooled crates tests in a prototype 63U rack

- Limited dimensions of the counting rooms forces to look for new solutions in terms of saving space.
- Cooling capabilities of a 63U prototype rack equipped with 3 vertically cooled ATCA crates, needs to be assessed before installation in the counting rooms.
- To evaluate efficiency of installed soundproofing material and further investigate its impact on the cooling capabilities of the rack.
- To assess aftermath of possible electronics failure between the installed ATCA crates.
- To evaluate cooling efficiency of the new prototype 2U heat exchangers with reduced exchange surface.
- To identify mechanical restrictions of the rack and to introduce improvements (i.e. using reinforced distances instead of cable trays, gluing side panels, etc.)

Rack configuration

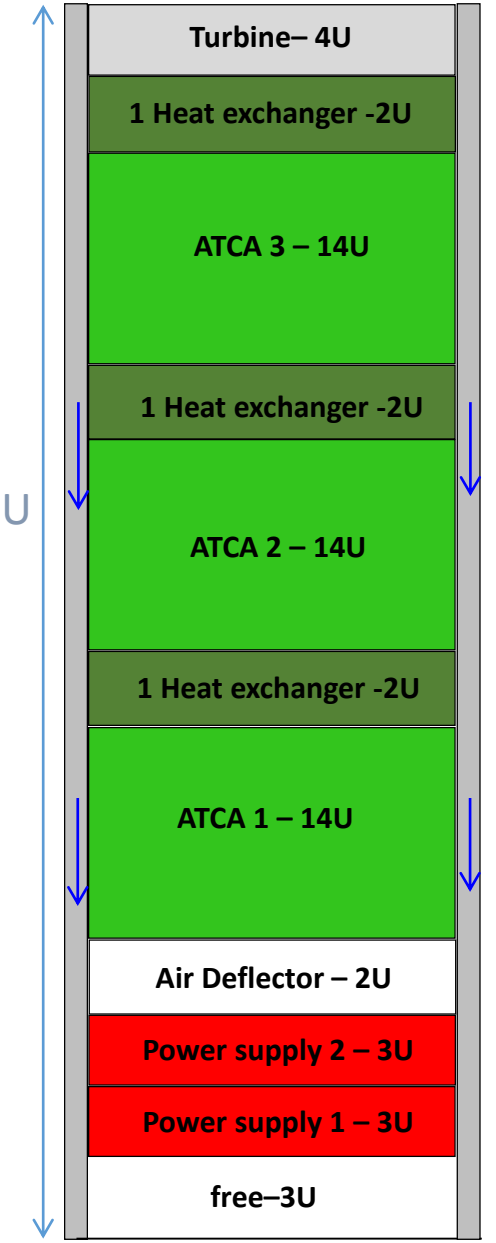
- New prototype 2U heat exchangers with reduced exchange surface were ordered and will be installed in the rack, due to delivery delay the rack is now equipped with 6 standard 1U HXs.



- The rack is equipped with 3 ATCA shelves, from which one is the new Schroff crate chosen as the common standard for the LHC experiments.

- The cooling water for the rack, is provided by new dedicated chiller with maximum cooling power of **25 kW.**

- 20T sensors were installed across the rack, to observe the thermal behavior between the crates.

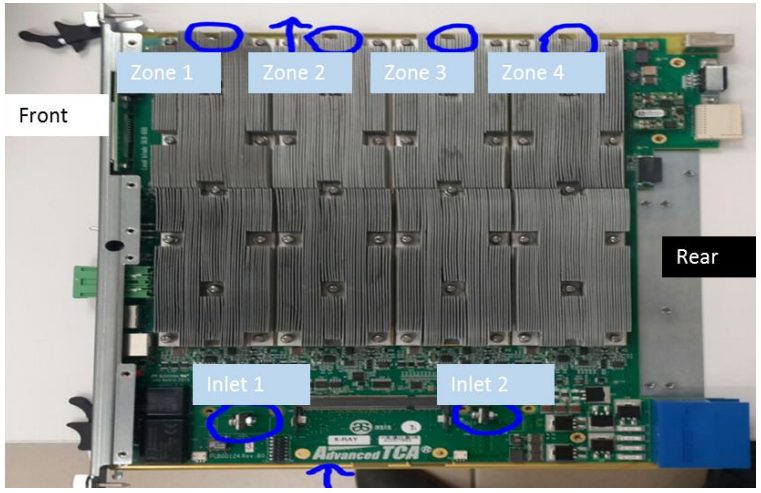


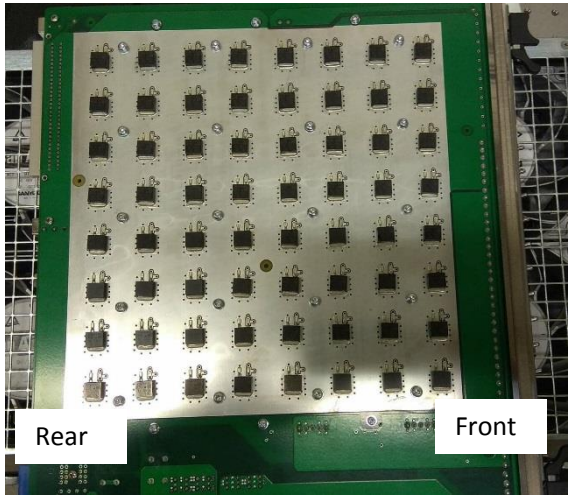
Inside the shelves

ASIS load blades: maximum power 600W

Comtel load blades (old type): maximum power 350W

Comtel load blades (new type): maximum power 800W





<u>14 x Comtel blades (old type)</u>: 6* Embedded Temperature sensors (green) + 6 air T sensors (blue)

<u>14 x ASIS blades</u>: 6 Temperature sensors (inlet and outlet)

<u>14 x Comtel blades (new type)</u>: Not equipped with any sensors

New Comtel LB in the new Schroff crate

Cooling tests results (with bottom fans)

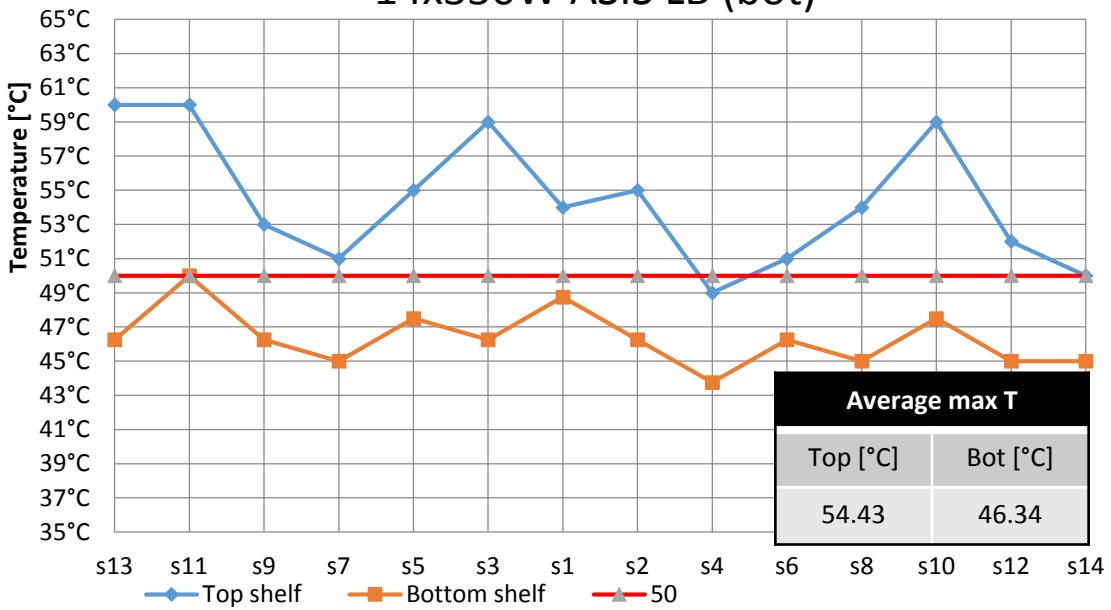
The test was carried out in following configuration

- ATCA 3 (top crate) – 14x350W on Comtel LB (old type), top and bottom fan trays working on maximum speed
- ATCA 2 (middle crate) – 14x350W on Comtel LB (new type), top and bottom fan trays working on maximum speed
- ATCA 1 (bottom crate) – 14x350W on ASIS LB, top and bottom fan trays working on maximum speed

Total power in the rack 20.8kW

14x350W Comtel LB (top)
14x350W NComtel LB (mid)
14x350W ASIS LB (bot)

Water inlet temperature: 15°C
Flow: 4.5m^3/h



Average max T	
Top [°C]	Bot [°C]
54.43	46.34

Due to the poor power distribution across the power supply circuit breakers, the tests with higher power in this configuration couldn't be carried out. The matter is under investigation, and the solution will be soon implemented.

The air flow on the blades with lower resistance (Comtel LB) is less homogeneous and the cooling is less efficient

Cooling tests results (without bottom fans)

The test was carried out in following configuration

- ATCA 3 (top crate) – 14xComtel LB (old type), top fan trays working on maximum speed
- ATCA 2 (middle crate) – 14xComtel LB (new type), top fan trays working on maximum speed
- ATCA 1 (bottom crate) – 14xASIS LB, top fan trays working on maximum speed

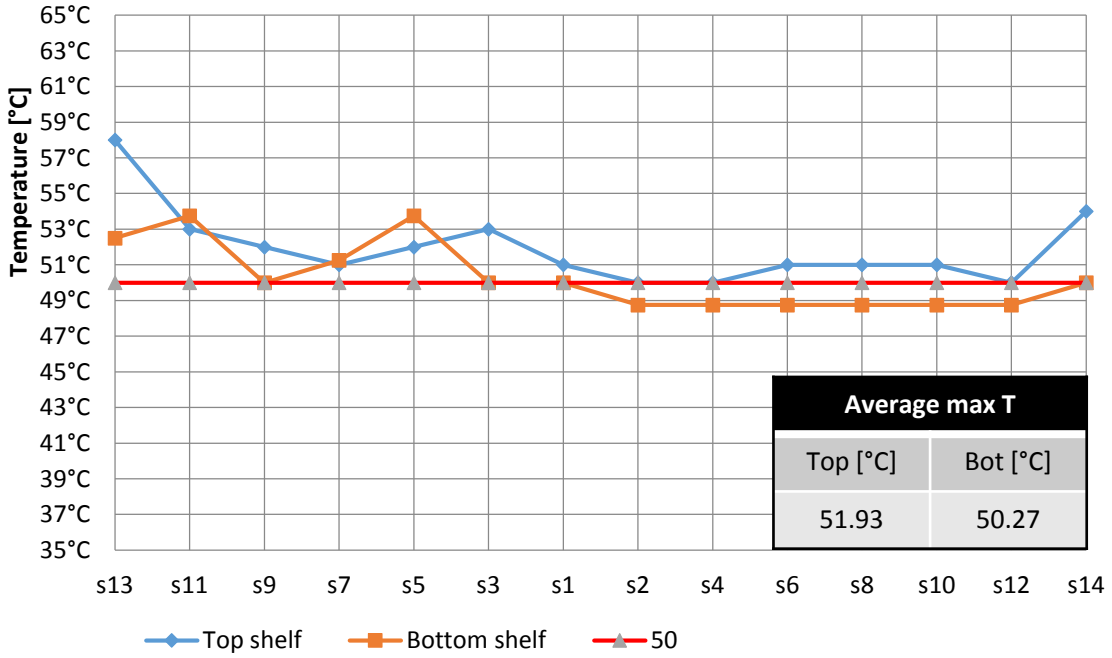
Total power in the rack 18.4kW

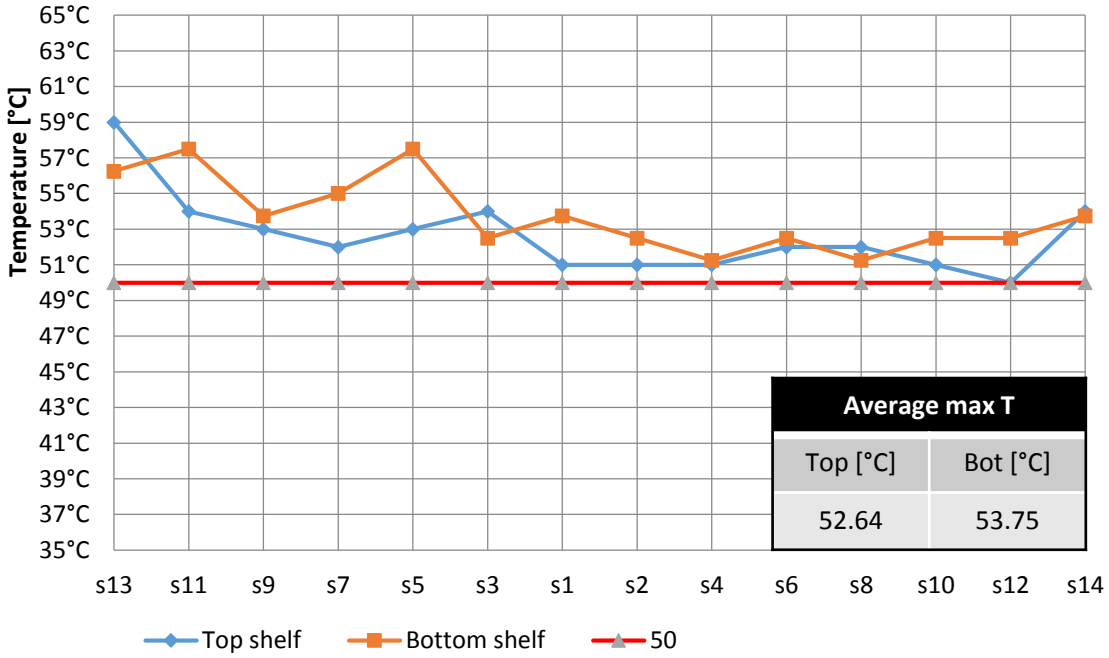
14x350W Comtel LB (top)
14x**350W** Comtel LB (mid)
14x**350W** ASIS LB (bot)

Water inlet temperature: 15°C
Flow: 4.5 m^3/h

14x350W Comtel LB (top)
14x**400W** Comtel LB (mid)
14x**400W** ASIS LB (bot)

Total power in the rack 19.8kW





With the inlet temperature of water at 15C, the average maximum temperature on the blades is slightly above 50C.

Comparison between tests with and without bottom fans

Water inlet temperature: 15°C
Flow: 4.5 m^3/h

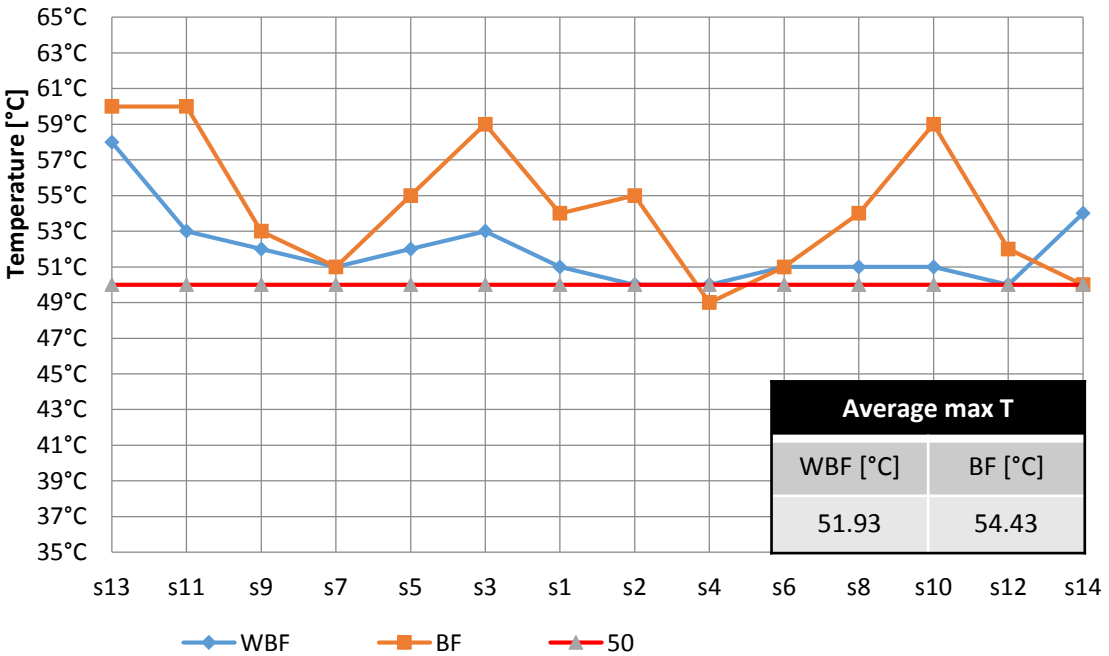
The test was carried out in following configuration

- ATCA 3 (top crate) – 14x350W on Comtel LB (old type)
- ATCA 2 (middle crate) – 14x350W on Comtel LB (new type)
- ATCA 1 (bottom crate) – 14x350W on ASIS LB

WBF – without bottom fans
BF – with bottom fans

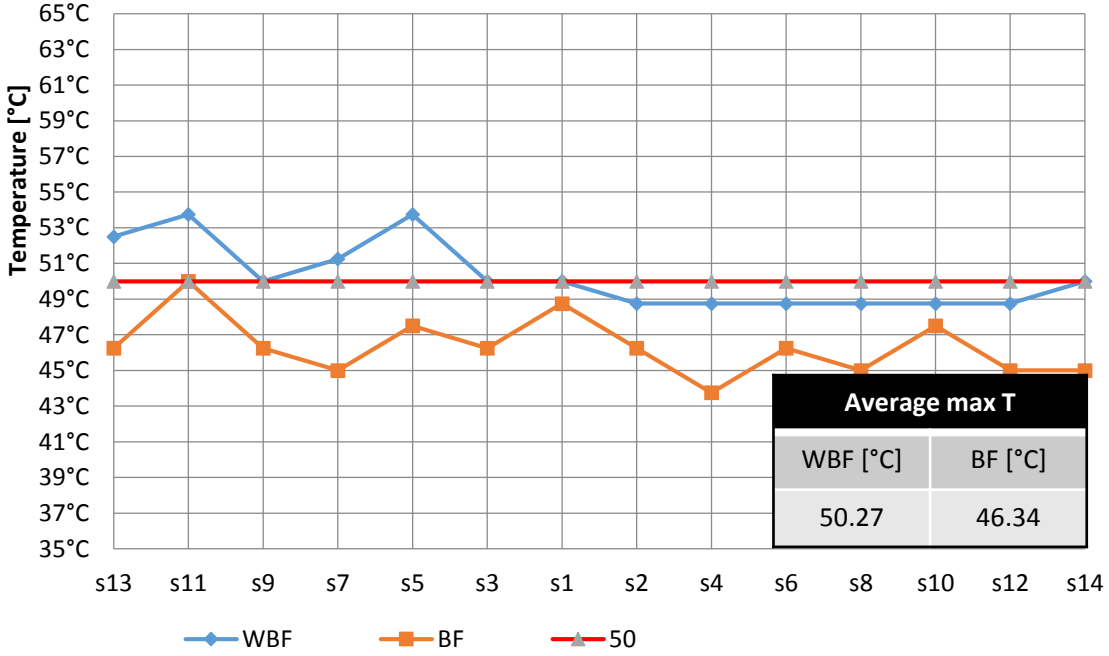
14x350W Comtel LB. Different fans setup comparison

2.5kW consumed only by the BF!



Average max T	
WBF [°C]	BF [°C]
51.93	54.43

14x350W ASIS LB. Different fans setup comparison



Average max T	
WBF [°C]	BF [°C]
50.27	46.34

- On the less air resistive blades (Comtel – old type), it can be seen that the airflow is much less homogeneous and the overall average max T is higher by 2.5K when the bottom fans are in use.
- In case of LB with high air resistance (ASIS) we can see that the cooling performance is better when the bottom fans are used.

Noise reduction: Soundproofing of the 52U rack

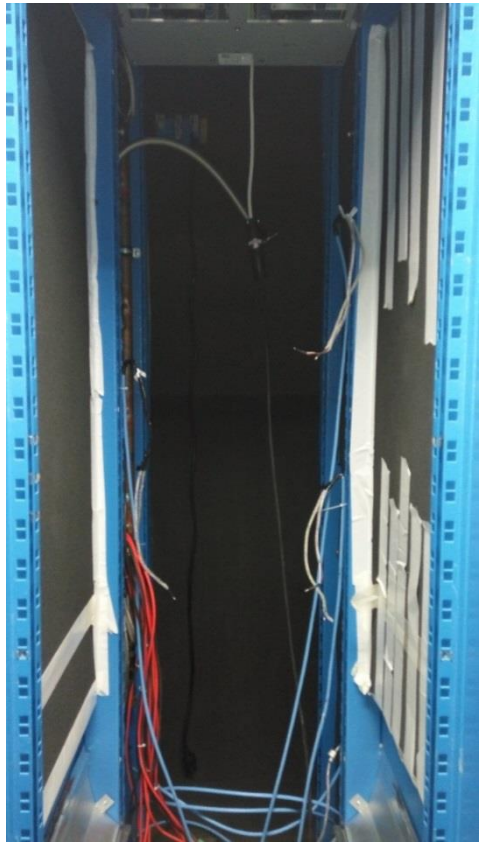
Since the noise generated by the fans in the ATCA crates is a very significant factor in terms of the work safety, the racks equipped with this hardware will have to be soundproofed. After discussion and approval of the HSE group at CERN the following material was chosen and installed in the rack.

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 (NF P 92-501), F1 (NF F 16 101)
- ✓ Une face adhésive
- ✓ Epaisseur : 25 mm



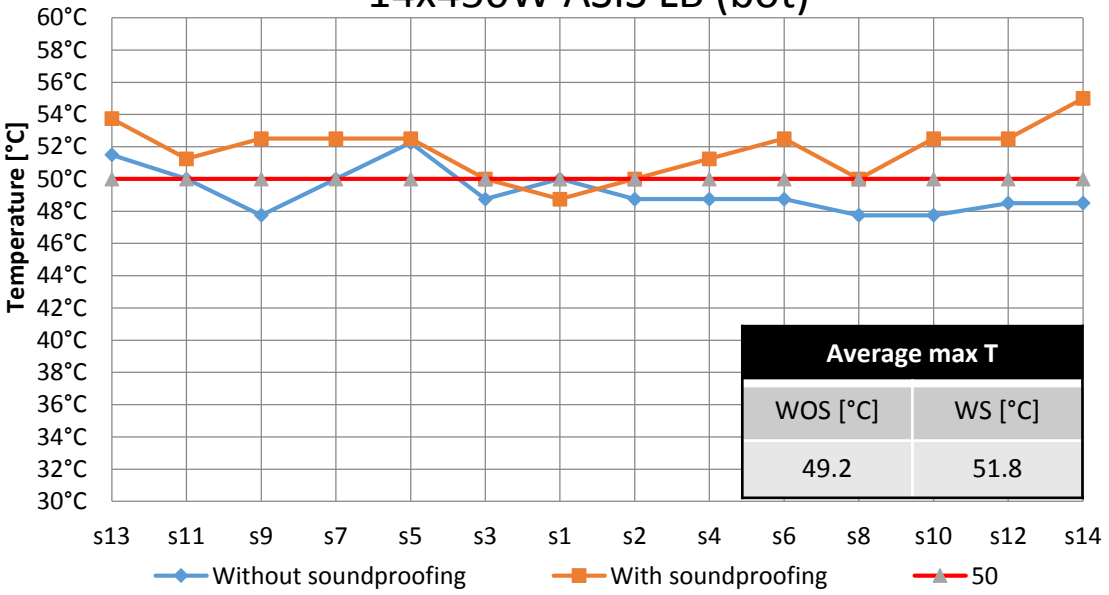
Since the soundproofing material reduces the width of the air corridors by almost 30mm (total width of the air corridor – 68mm), the tests were carried out to check the soundproofing influence on the cooling performance of the rack.

Noise reduction: Influence of the soundproofing material on the cooling performance in the 52U rack

Here below you can see the comparison between the cooling performance of the rack equipped with soundproofing material and the rack without soundproofing material:

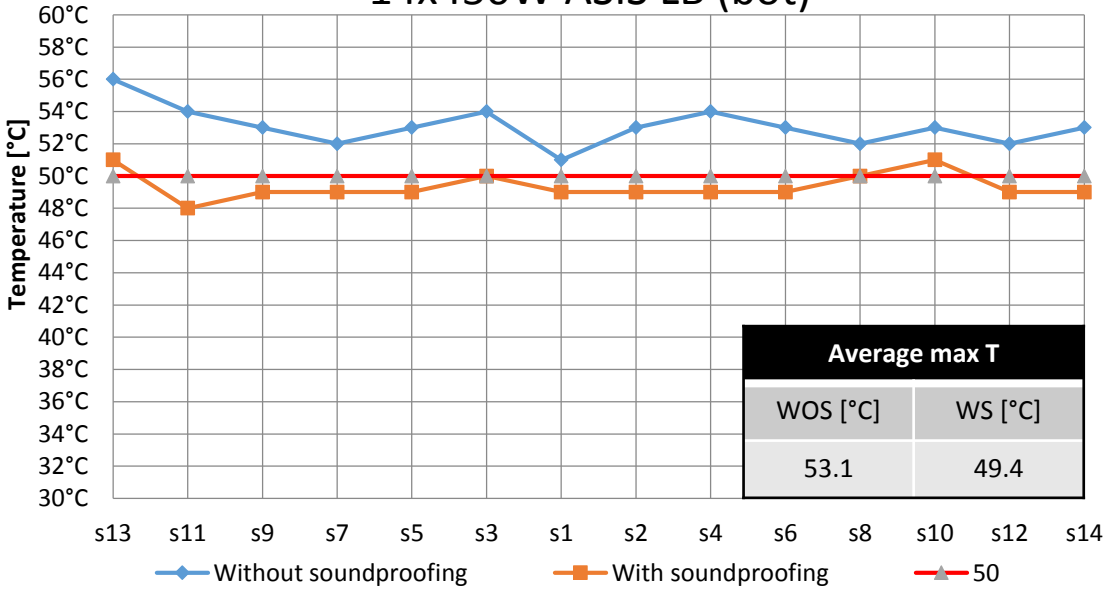
WS – With Soundproofing
WOS – Without Soundproofing

14x350W Comtel LB (top)
14x450W ASIS LB (bot)



ASIS load blades

14x350W Comtel LB (top)
14x450W ASIS LB (bot)



Comtel load blades

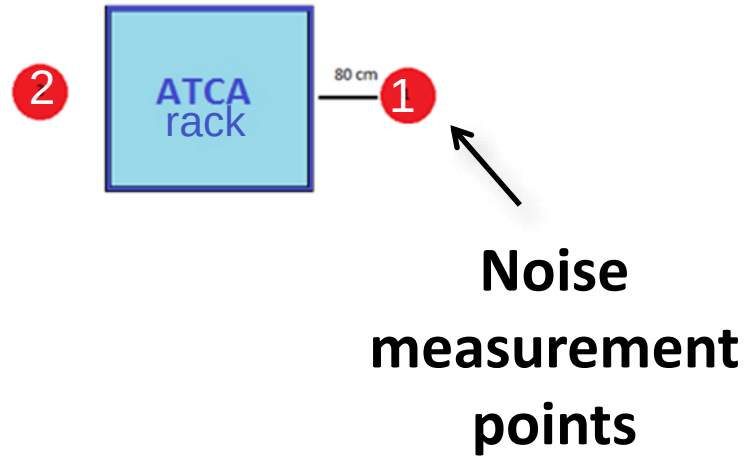
As you can see the difference in cooling performance is not negligible:

- Comtel load blades average maximum temperature difference is 3.7K in favour of soundproofed rack
- ASIS load blades average maximum temperature difference is 2.6K in favour of not soundproofed rack

Noise reduction: Measurements for the 52U rack

Here below you can see the table with noise measurements results performed before and after soundproofing of the rack.

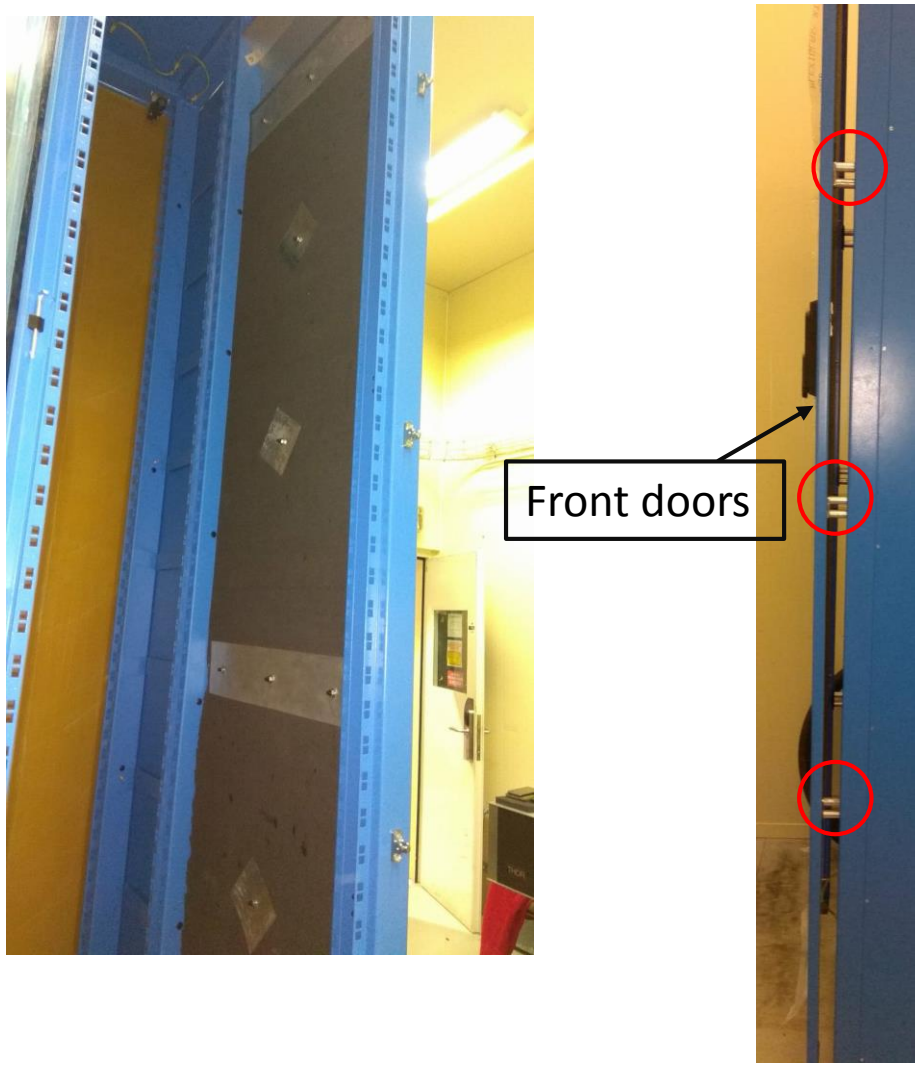
Noise measurements	Pos. 1 Door open [dB(A)]	Pos. 1 Door closed [dB(A)]	Pos. 2 [dB(A)]	Av. max T on ASIS LB [°C]	Av. max T on Comtel LB [°C]
Without insulation	102.8	90	87.5	49.2	53.1
With insulation		86.3	84	51.8	49.4
Difference		-3.7	-3.5	2.6	-3.7



As can be seen, only closing the doors (equipped with soundproofing material) reduces the noise level significantly, installing the material on the side panels and the rear doors, reduces the noise by additional ~3.6 dB(A). Further investigation in terms of reducing the noise is in order to be able to provide safe working environment in the counting rooms.

Soundproofing of the 63U rack and mechanical issues

Since it was determined in the previous studies that the installation of the soundproofing material has no big impact on the cooling performance of the rack, the same material was mounted in the new prototype 63U rack.



During the soundproofing of the rack few mechanical flaws of the rack were already discovered:

- Front access to the rack is not rectangular.
- Side panels are quite thin and easily to fall into vibrations
- ½ cable trays are not strong enough to hold the weight of the front door

The supplier is being informed of the flaws in the prototype.

Heat removal with soundproofing: 52U vs 63U

52U total power 13.9kW 63U total power 20.5kW	Water flow $3m^3/h$		Water flow $1.8m^3/h$ (same as in USA15)	
	52U	**63U**	**52U**	**63U**
ΔT of the water	3.2°C	4.9°C	4.9°C	7.9°C
Power removed	11.15kW	17.07kW	10.28kW	16.51kW
% of the total power	79%	83%	73%	80%

In May 2018 evaluation of the new 2U heat exchangers will start…let's see if the results can be improved.

What's next?

Next steps for the project along many others includes:

- Evaluating the efficiency of the new 2U HX, including the comparison with the old 1U HX (i.e. air pressure drop, heat removal, rigidness etc.)
- Further investigation of the mechanical aspects of the new 63U racks – and possible improvements.
- Carrying out different failure modes test, to asses their aftermath, as well as identifying possible countermeasures that can be taken to prevent them.
- Testing different inlet water conditions to keep the boards in the lowest temperature possible.
- Carrying the test to optimize the power distribution across the rack.