General Assembly & Executive Board

Tests at CERN

(Panagiotis Kalaitzidis)

Scope

The final AM system will consist of eight 9U VME core crates, each one with 16 AMBLSPs and on each AMBoard will be mounted 4 LAMBSLPs. Totally, 512 LAMBSLPs installed on 128 AMBSLPs. The power dissipated on each LAMB is really high.

We must understand:

a) the maximum level of T on the boards,

b) the area on the LAMBs with the highest T and

c) which is the most appropriate rack layout for the final system.

Works that had been made before the tests

The system has been optimized using:

- CFD simulation software that allowed us to predict, with reliability, the impact of fluid flows on our system
- thermo-camera to measure the temperature on the package of an AM chip

Simulation shows us that:

- For the AM chip, the temperature of the die is almost the same of the temperature of the top of the package (42 ^{o}C in a uniform air flow of 4 m/s) and just few degrees higher than the temperature on the PCB (39 ^{o}C on the top of the PCB and 36,7 ^{o}C on the bottom side).
- For the air flow, there are some points with insufficient air flow in the crate. The flux of air in fact appears quite not uniform, especially if a single fan tray placed below the bin is used to produce the air movement. It was also been observed that components with high height can affect to the air flow.
- Using a single fan, we should expect too high temperatures (~99 ^{o}C) also for the new AMBSLP, in the upper part of the board in particular slots.

Request

Perform real measurements in the final racks at USA15, where FTK will be commissioned, to compare two different setups:

A. one single fan tray placed below the bin,

B. two fans tray, one below and one above the bin.

Structure

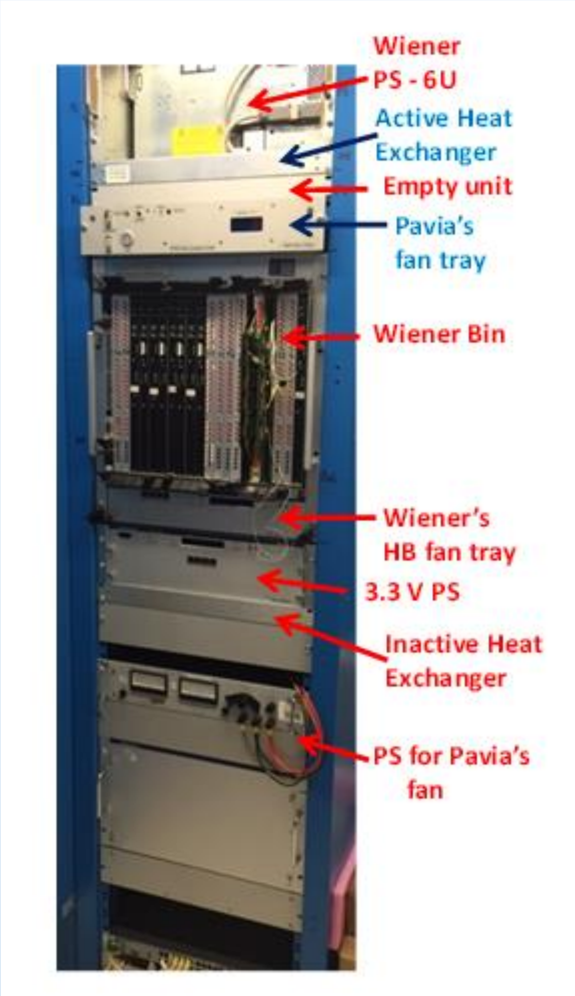
The test setup uses four old boards built in the past.

They are assembled with AMchip03 built for the CDF experiment.

The consumption of the old chip is adequate to simulate the consumption of the final FTK chip, AM06, not yet available.

Most of the power is provided from 48 V and part of it from 3.3 V PS.

We used one active heat exchanger.



Tests

We used 2 types of boards:

- ✓ type-1 with 96 AMchips for a total consumption of 240-280 W,
- ✓ type-2 with 64 AMchips for a total consumption of 185-190 W.

For type-1, the two LAMB mezzanines near the front panel have chips on both top and bottom sides (32/LAMB, 64 chips near the front panel) while the two LAMBs on the rear side, near the VME connectors, have chips only on the top side (16 chips/LAMB, 32 chips in total).

Type-2, has chips only on the top side everywhere, like the uniform future board, but the total measured number of watts is somehow lower than the expected future 240 W.

Tests

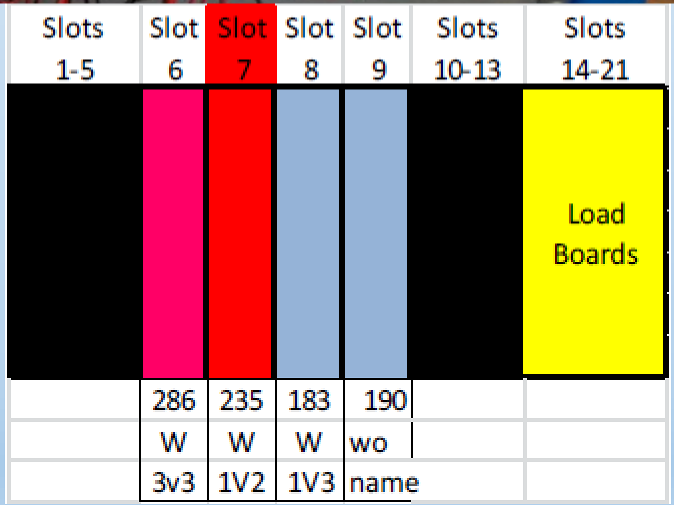
The test setup has 4 AMBslims, one near the other.

On the left are the two type-1 boards, on the right the two type-2 ones.

We fill the rest of the crate with old CDF boards (black in the figures) with 64 AMchip03 each one, and load boards full of resistors (yellow in the figure), however no one of them is connected at power, we used them just to produce the correct resistance to the air.

The only boards connected to power are the 4 AMBslims.

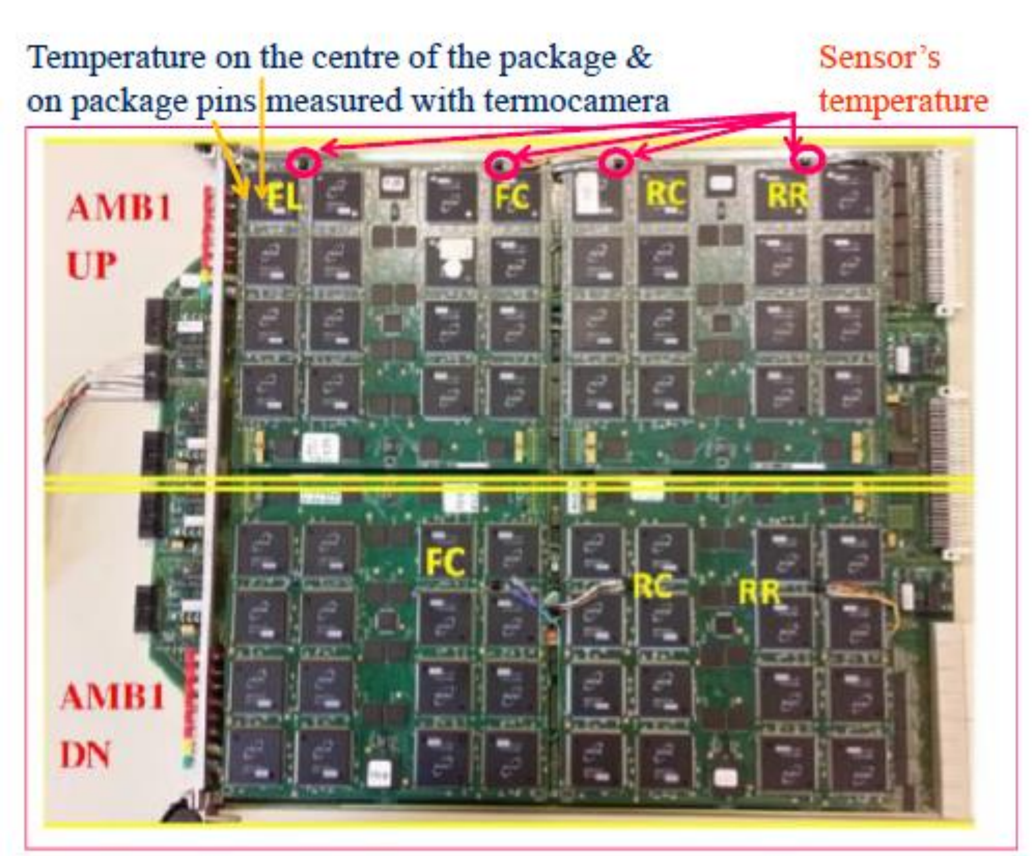
The crate measures a total current of 15 A on 48 V and 48 A on 3.3 V.



Measurements

We perform 2 types of measurements:

- We used temperature sensors glued on the LAMB PCBs. The most important are the ones in the red circles on the top of the board, where less cold air arrives (in particular the one in the left top corner, FL, is predicted by the T-simulation with a single fan to be the hottest corner of the board)
- We measured the temperature on the top left corner AMchip package using a termo-camera: on the pins and in the center of that package. The temperature on package was ~20 ^{o}C higher than on pins, and the temperature on pins is ~6 ^{o}C higher than on PCB. The large temperature differences are due to the fact that the AMchip03 has a plastic PQFP208 package with much worse dissipation capability compared to the new flip chip BGA package chosen for AM06.



Measurements

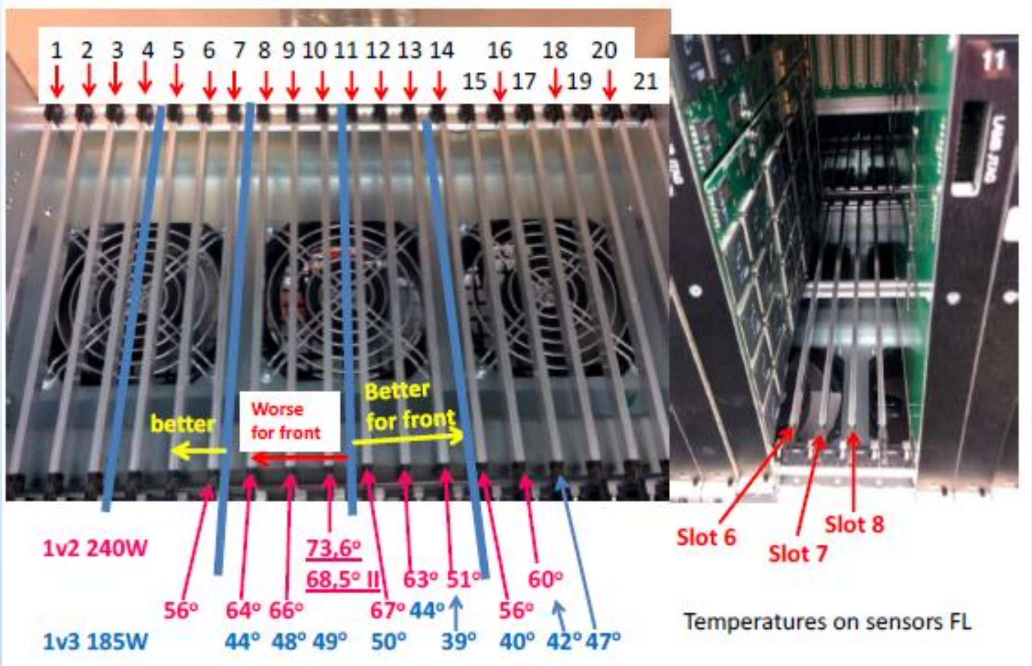
The figure shows clearly that different slots are not equivalent.

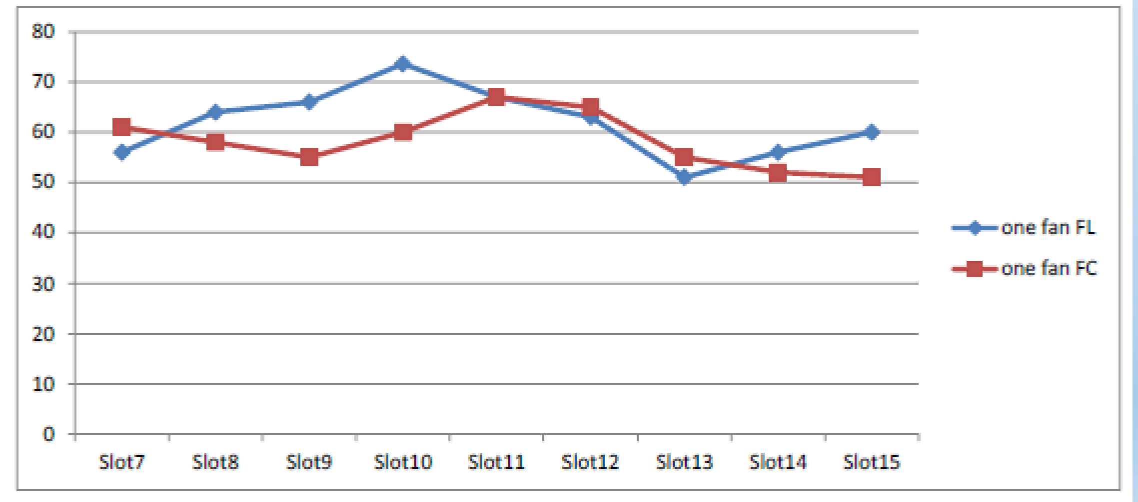
In the figure are reported all the FL sensor measurements from slot 7 to slot 14 for the red board (1v2 type 1) and from slot 8 to slot 15 for the blue board (1v3 type 2).

Simulation predicted that the highest temperatures would have been in the left top corner of the slots that overlap the metal between 2 wheels, like for example slot 8 (photo on the right).

The measurements are reported below the figure for each slot and reveal a different behaviour. The worse temperatures correspond to the left part of the wheel and the maximum is near the centre of the wheel (slot 10 in the figure).

The red board has systematically higher temperatures since in the left top corner are 2 chips for a total local delivery of power of 5 W. The blue board has half chips and half consumption in that area.





Using second fan unit

Since, these temperatures are the ones on the PCB, the temperatures on the package, roughly 26 ^{o}C higher, are not acceptable (~99 ^{o}C) for the type-1 board and near the limit for the type-2 in the slots 10-11 (~76 ^{o}C).

So we decided to insert a second fan tray on the top of the bin to perform equivalent measurements in these new conditions. The fan tray below the bin is the Hyper Blower (HB) fan from Wiener while the fan on the top is a custom fan produced at INFN Pavia.

The HB fan controlled by a Wiener PS could not reach fan speeds higher than 5000 rpm, while the custom fans could run at speeds above 6000 rpm (each row in the custom tray can work at independent speed).

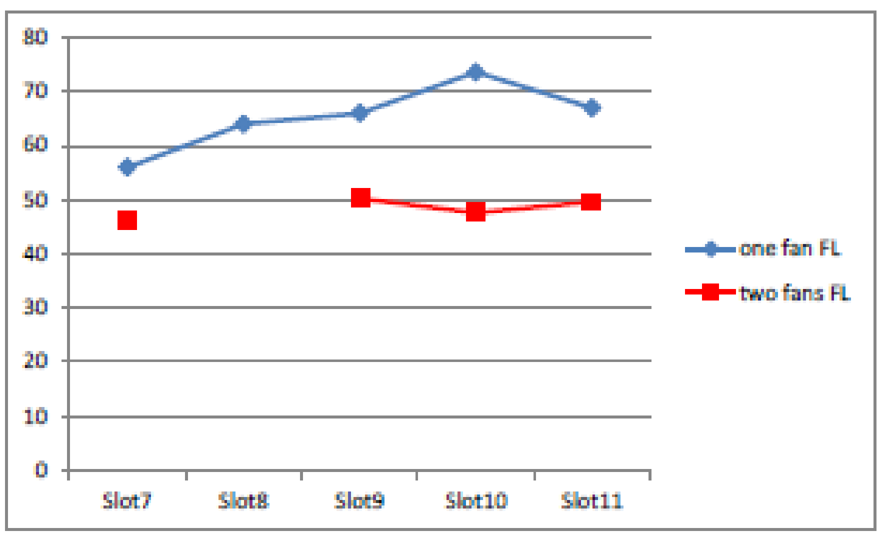
The first raw of 3 fans of the custom tray are prominent outside of the rack, on the front, to better cover the points found hot in the T-simulation. The rows of custom fans are not aligned with the HB rows.

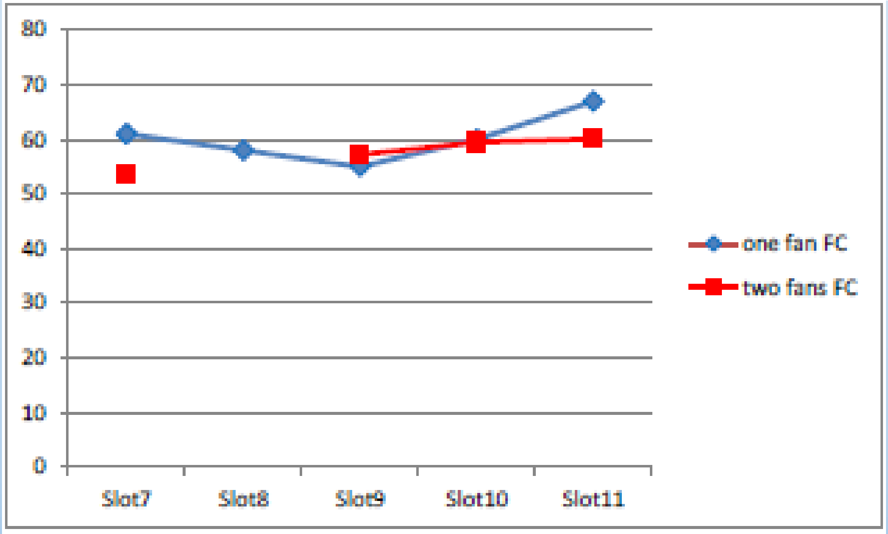
Using second fan unit

The first plot shows for the FL sensor (the one on the top left corner of the board) a comparison of the measurements performed with one and two fans working in the same conditions for all the other system parameters.

The results are good because the temperature seems to be much more flat as a function of the slot # and the value in slot 10 is decreased of 26 ^{o}C.

The effect of the second fan on the FC sensor (placed on the top centre of the board) is not important (second plot), but in this case the temperature was acceptable already with a single fan.

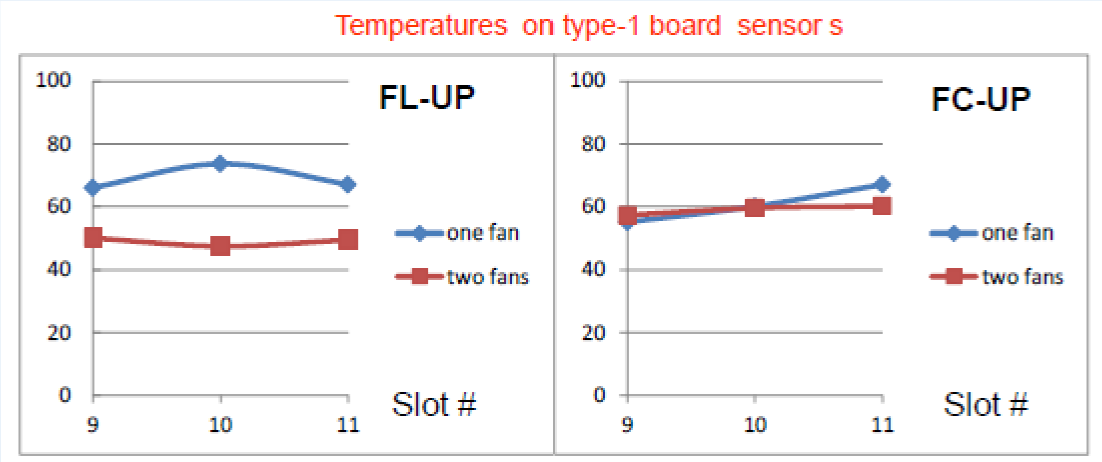




Using second fan unit

Third plot compares the hottest temperatures in the crate for the two configurations of the test stand, cooled by one or two fans.

It is clear that two fans make the temperature uniform across the slots and reduce the maximum temperature at 60 ^{o}C on the PCB, ~86 ^{o}C on the package.



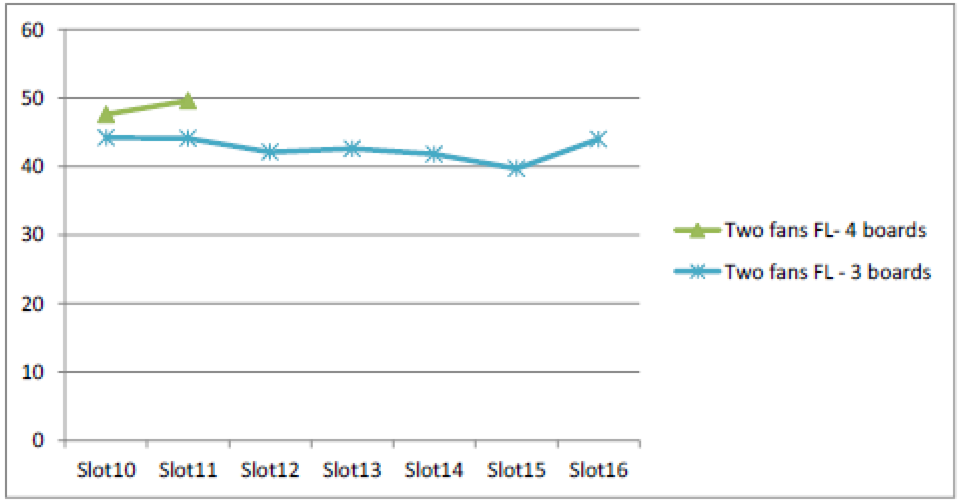
Testing more slots

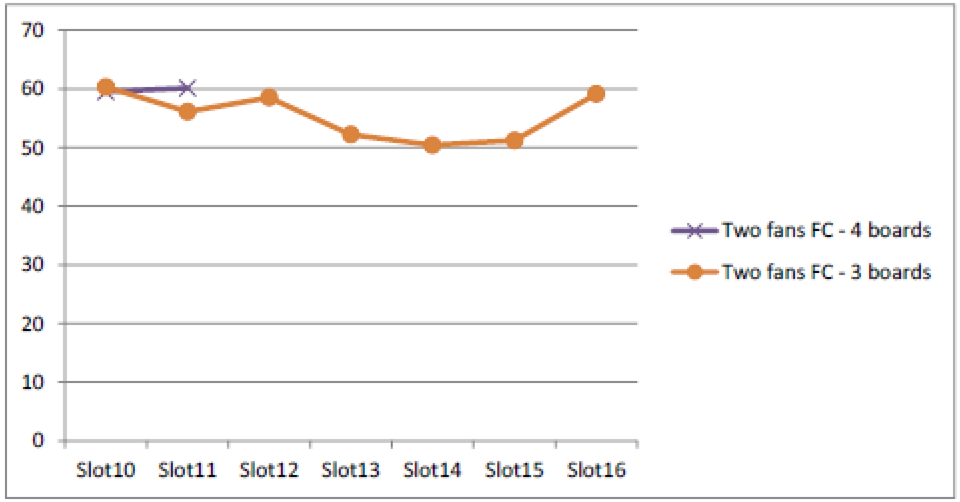
We tested more slots using only 3 boards instead of 4.

We expect the results are similar, since the test board (1v2) was still in the middle of the 3, the only change was 190 Watts on the right instead of 183 Watts.

The plots show the behaviour of the temperature in other slots, for both the FC and FL sensors.

The temperatures are never above 60 ^{o}C.





Conclusion

Using two fans, the temperature is :

slightly higher at the centre of the board (~60 ^{o}C in the centre and ~50 ^{o}C in the top left corner),

much more uniform as a function of the slot #, and

acceptable even if:

1. The HB fan was running at 5000 rpm
2. The Heat Exchanger below the bin was not active
3. Two extra PS where placed below the bin, one to provide the 3,3 V to the old boards and one to give power to the custom fan.

Final structure

The plot represents the proposed rack layout for the final AM system.

A custom PS has been built by CAEN.

A single 9U box is able to power 2 crates and 4 fans trays, two for each crate.

We have reserved enough space for two fan trays per crate and three heat exchangers.

Thank you for your attention!

Panagiotis Kalaitzidis

Prisma Electronics

Production Manager