6th Workshop
Energy for Sustainable Science
at Research Infrastructures

Free Air-Cooling Solution for the Data Centers

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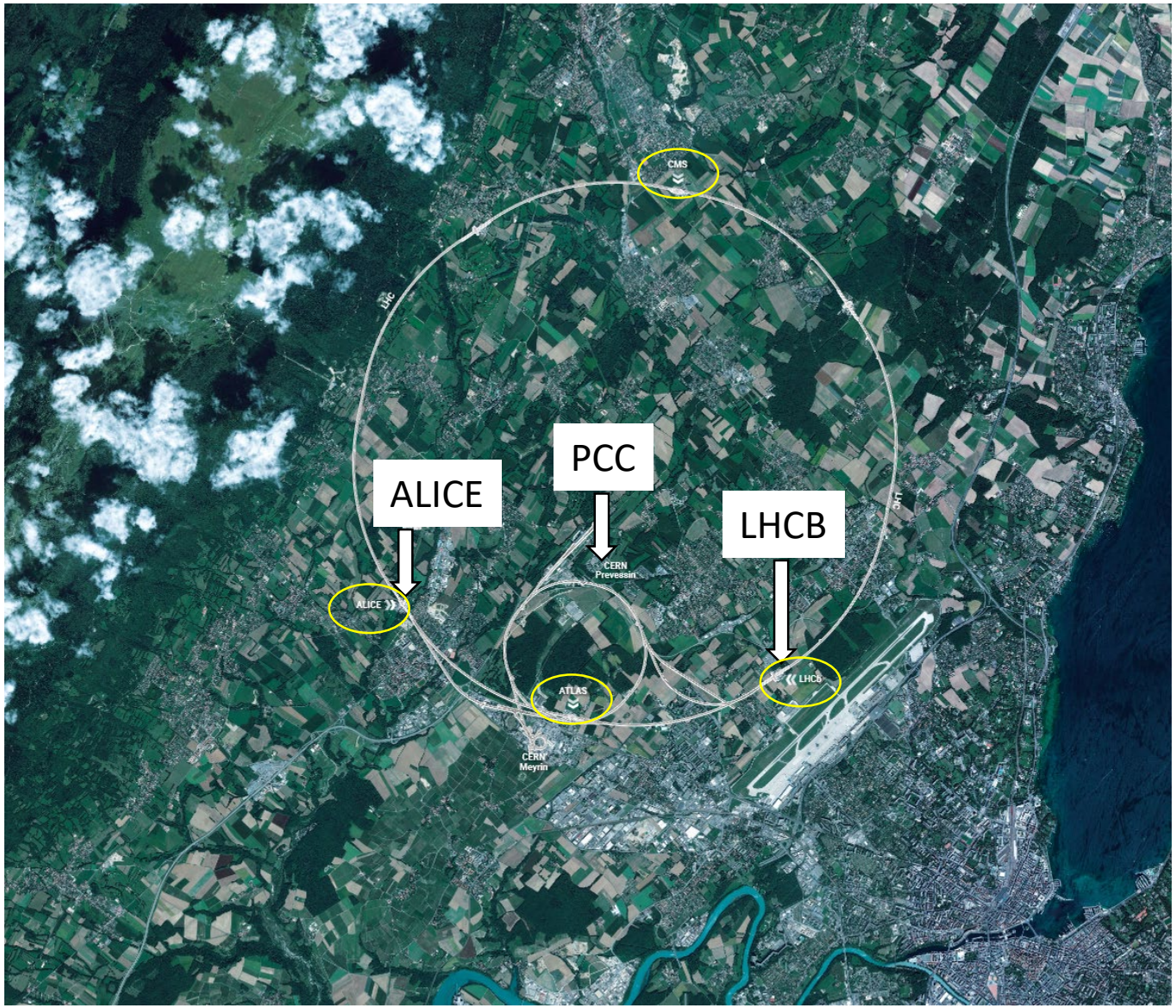
Location of new Data Centers at CERN



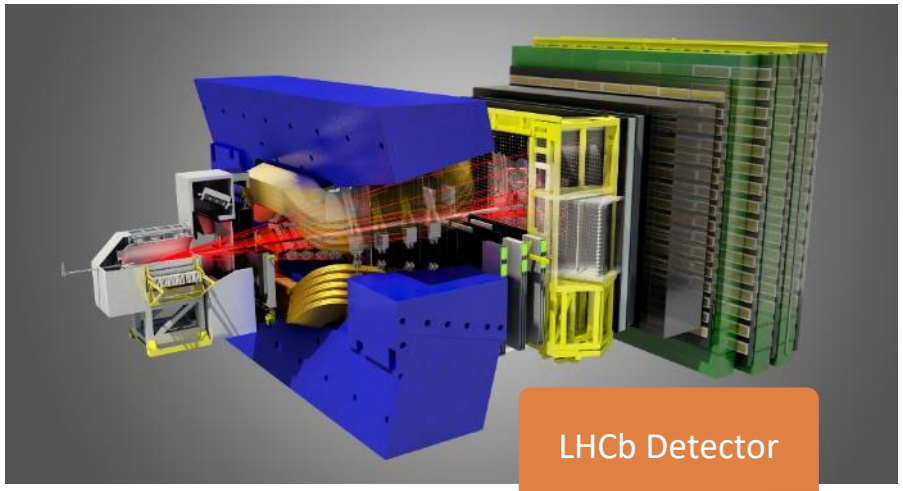
LHCb and ALICE: two of the four large LHC Experiments

→ Data Centres recently put into Operation

Prevessin Computer Centre (PCC)

→ Under construction

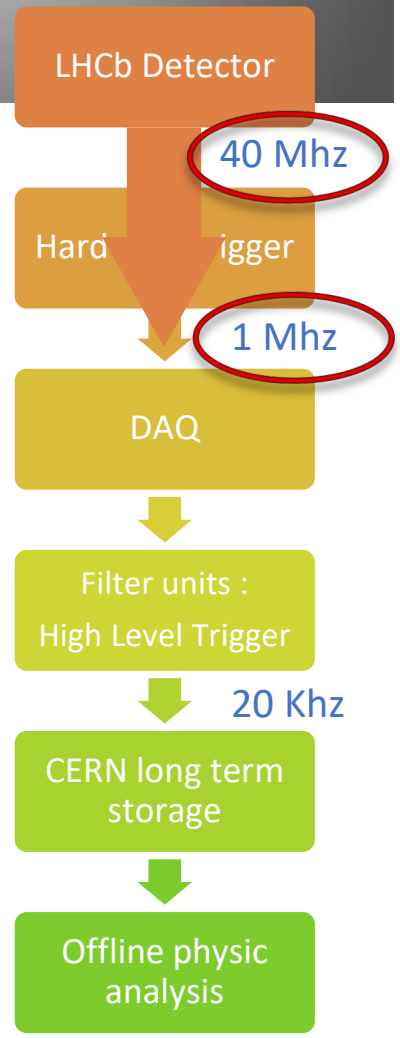
More computing power needs



LHCb example

- Major update of sub-detectors and their electronics in LS2 (end in March 2022)
- Removal of the ‘hardware trigger’ (FPGAs)
- Much more data for DAQ & Trigger (~ x80)
  Larger **event rate** (1 Mhz to 40 Mhz)
  Larger **event size** (50 KB to ~100 KB)

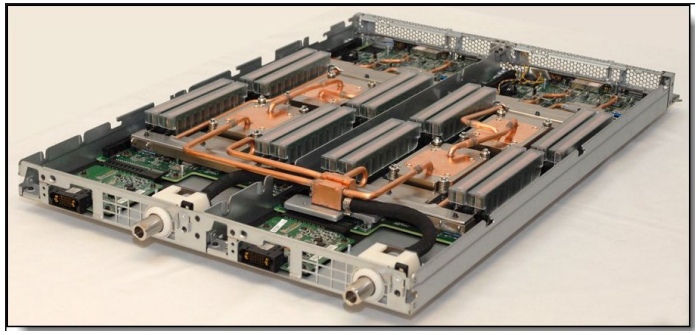
→ More computing power needed = more servers

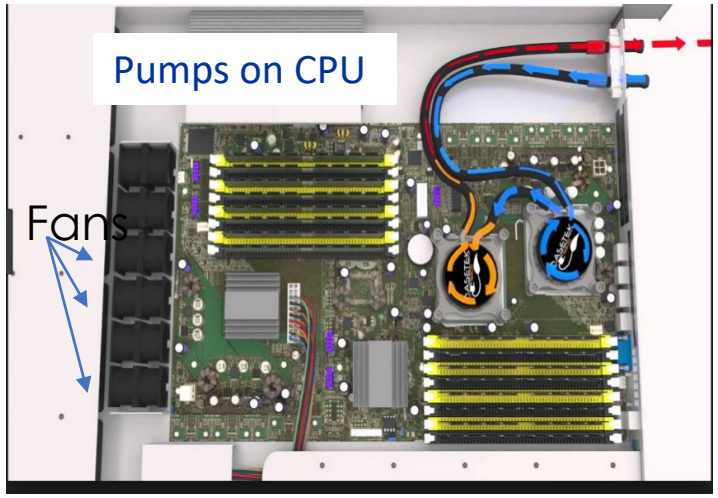


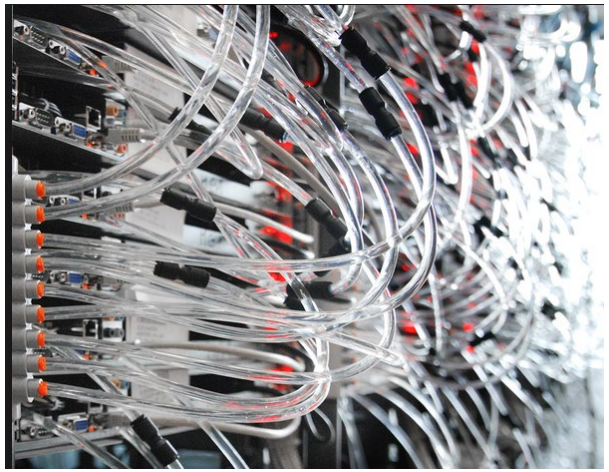
Different cooling systems for servers studied

- **Direct Contact Liquid Cooling**

water (pb with leaks…)
pipes management (in addition of power + IT cables)





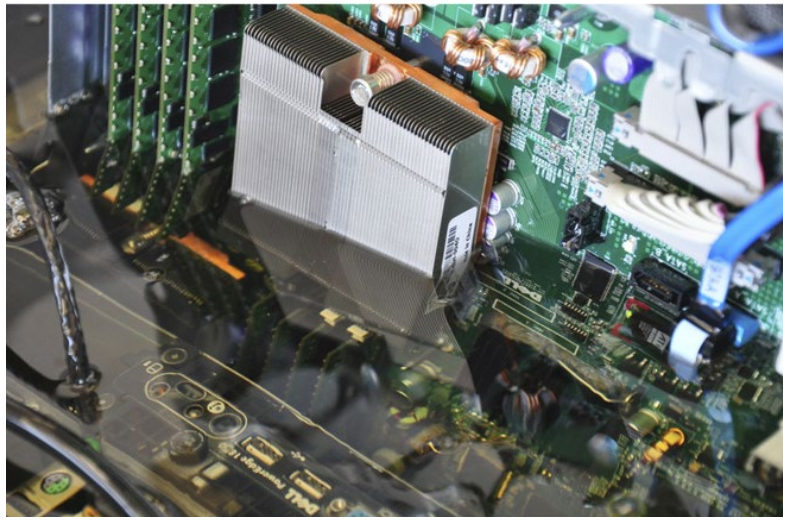


- **Immersion Cooling**

special coolant (no electrical conduction)

a good solution for very ‘high densities’

> 40kW/rack



Different cooling systems studied

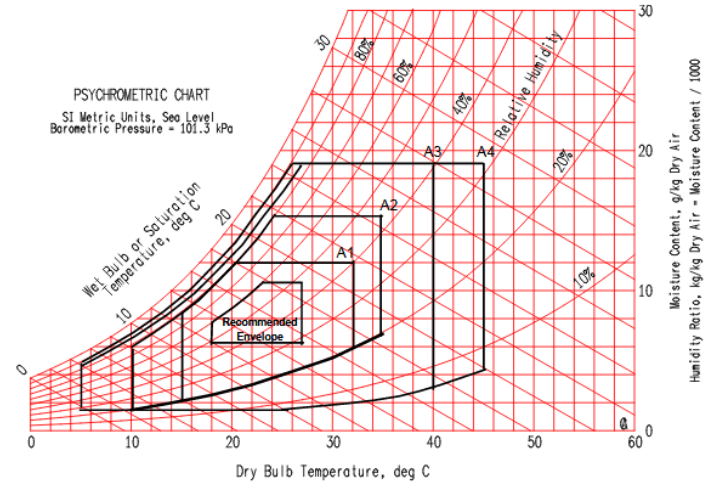
- **Water** passive or active (with fans) **doors** mounted on the rear of racks

For the three technologies the use of **dry coolers** or **evaporative towers** + pumps are needed

The new servers generation can run with higher air inlet temperatures (30-45 °C) than in the past (20-25 °C).

ASHRAE (American Society of Heating, Refrigerating and Air Conditioning Engineers) recommends a maximum of 27 °C (minimize the risk of failures).
But have also defined environmental envelopes (Class A1, A2, A3, A4)
The manufactures use the Class to defined their specs.
Many servers are today 'ASHRAE Class A3 and A4 compliant'

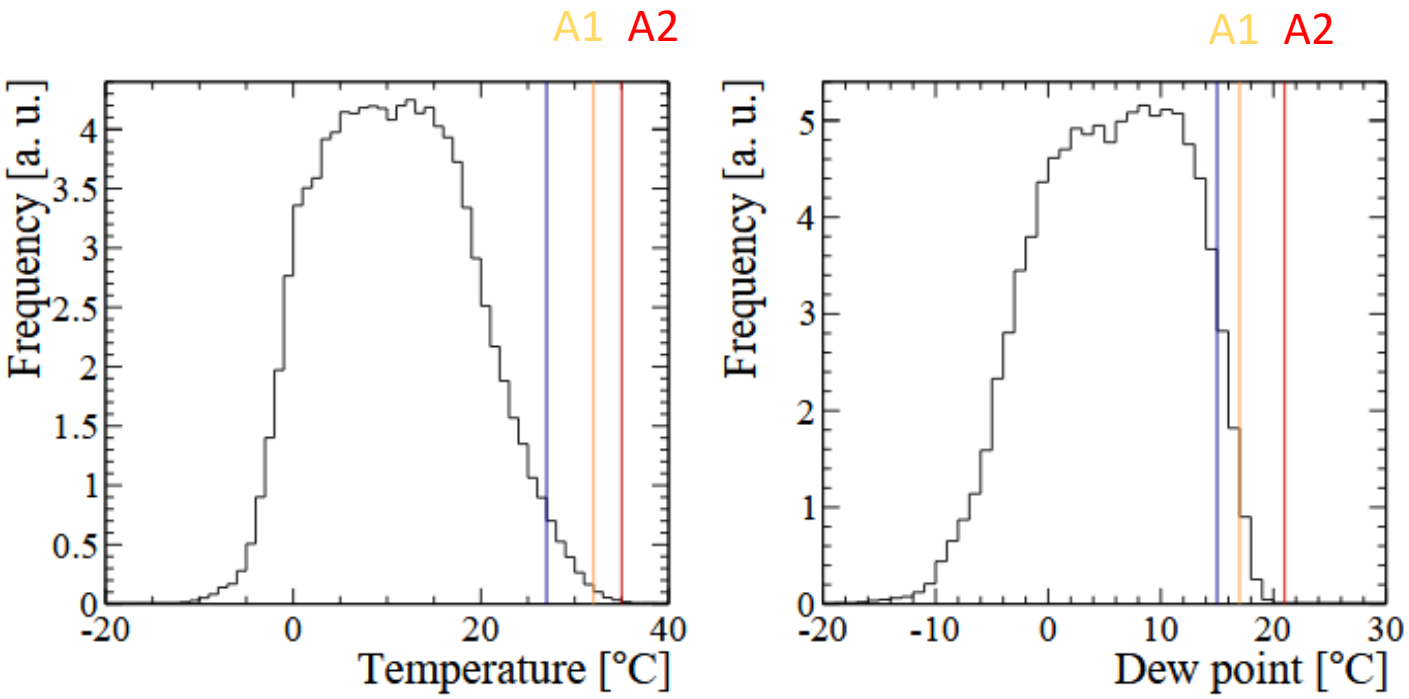
	Temperature range [°C]		Humidity range		Max. dew point [°C]
Recommended	18	27	5.5°C DP	60% RH, 15°C DP	
A1	15	32	20% RH	80% RH	17
A2	10	35	20% RH	80% RH	21
A3	5	40	-12°C DP, 8% RH	85% RH	24
A4	5	45	-12°C DP, 8% RH	90% RH	24



But to take in consideration: 1) can be more expensive
2) a server consume a little extra electricity at higher temperatures

Geneva outside AIR conditions

Distribution for 1 year

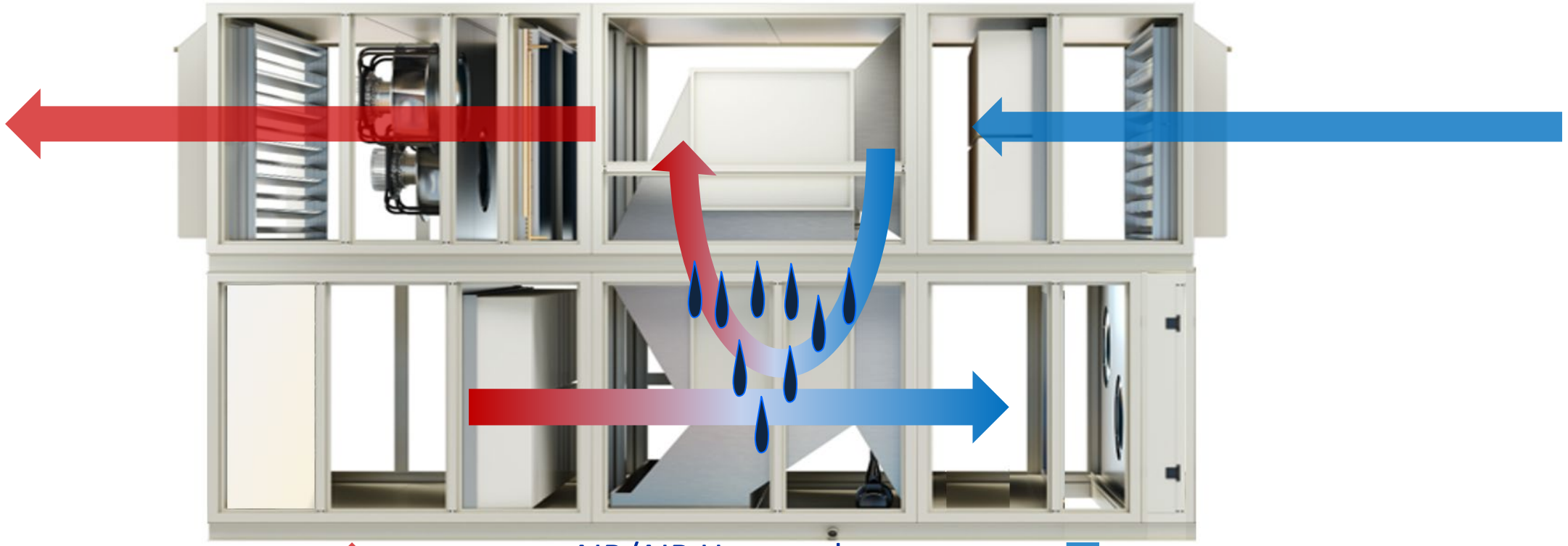


- Always below the maximum temp. of the A2 envelope
- Compatible with 'Direct Free AIR cooling'
- Compatible with 'Indirect Free AIR cooling' (with additional adiabatic cooling for summer)
  → advantages with 'Indirect' solution: Air filtration easier, better control of the air temperature inlet.

Indirect Free Air-Cooling principle

3 'Outside' Fans running 0-20% - 70%

If 'outside Fans' not enough, water is sprinkled on the heat exchangers ***when outside air T > ~ 20 °C***



Return Air ~40°C

Supply Air ~ 27°C

'Inside loop': 3 Fans running according DC Load

The needs

We went for '**Modular** Data Centres'
1 row of racks, Cold aisle, Hot aisle

LHCb: 7 Modules
6 IT: 18m x 4m x 6,5m height
1 Power + Water : 18m x 3,5m x 3m height

- Up to ~ 20kW/rack (85%)
- Up to ~ 40kW/rack (15%)

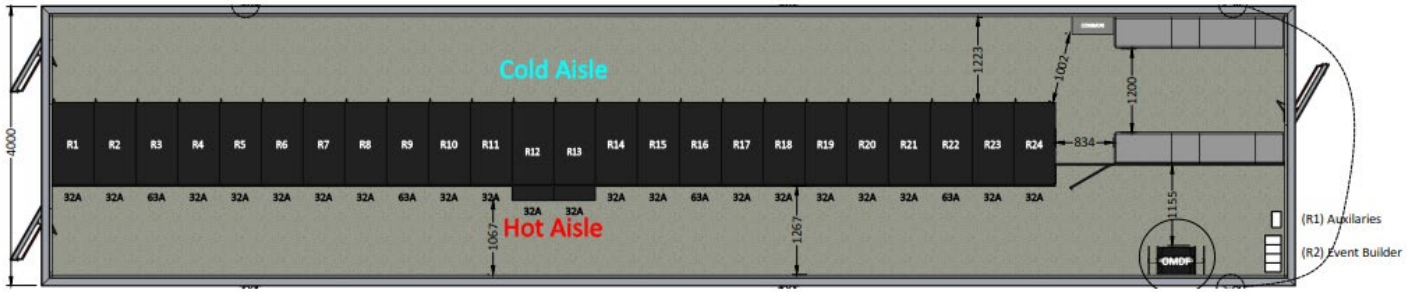
- Design for a total power of **2 MW**

2 full redundant Power supplies
(2 transformers 3.15 MVA, 2 main switchboards, 2 secondary switchboards, 2 PDU per rack)

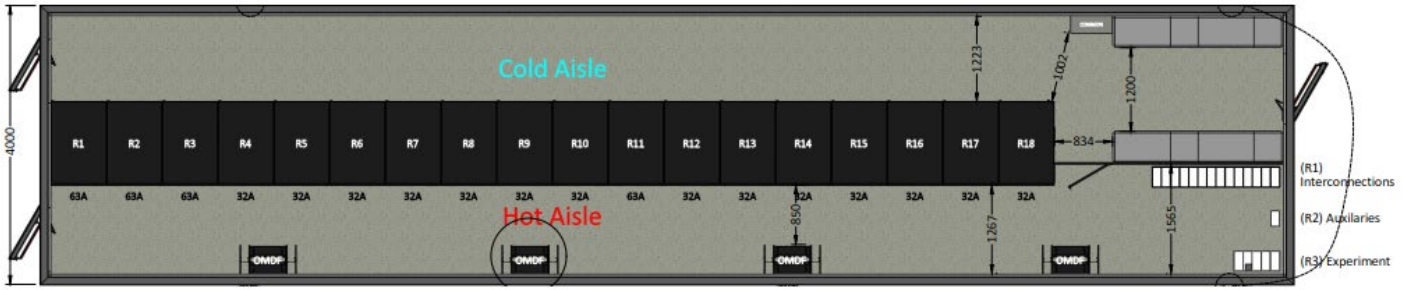
ALICE: 5 Modules
18 racks (~128 servers) / IT Module

Layout

- Two event-builder modules with 18 racks (800 mm wide).
- Four event-filter modules with 24 racks (600 mm wide).
- 132 racks in total (6336 rack units).



Event-filter module.



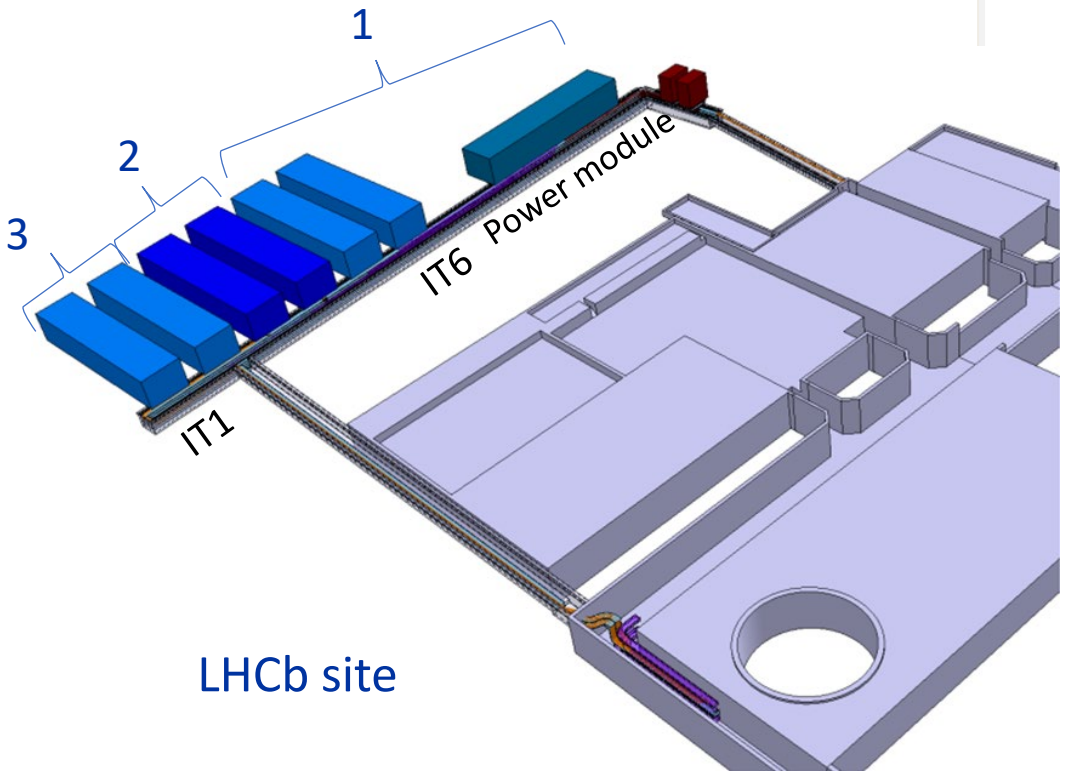
Event-builder module.

Installation

Several manufactures on the market of Modular Centers:
DELL, HP, Schneider….

Delivery possible in few steps → investment staggered
Preparation and tests in factory → fast deployment

The bidder selected was ‘Automation’ company (BE)
A common tender Alice + LHCb (12 Modules)



LHCb site

<u>Deliveries / Experiments need:</u>

First 3 LHCb Modules: Nov 2018 (phase 1)
First 3 ALICE Modules: Dec 2018
2 additional LHCb Modules: March 2019 (phase 2)
2 last LHCb Modules: Nov 2019 (phase 3)
2 additional ALICE Modules: Dec 2019

Transformers & Power module

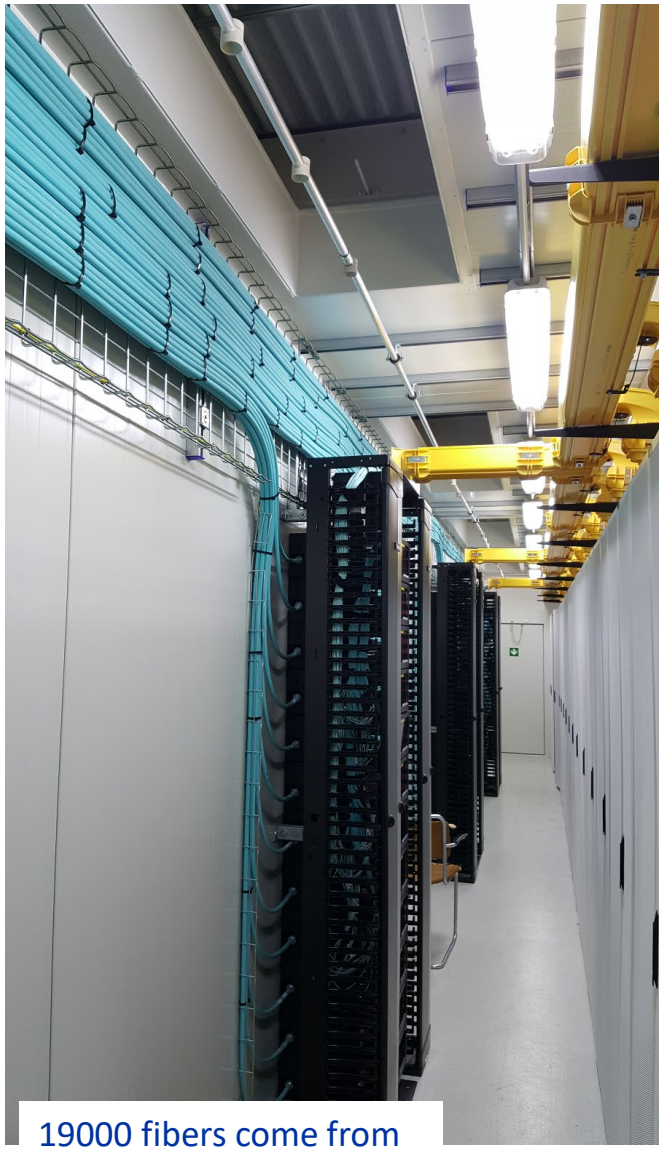
LHCb site

Air Handler Units

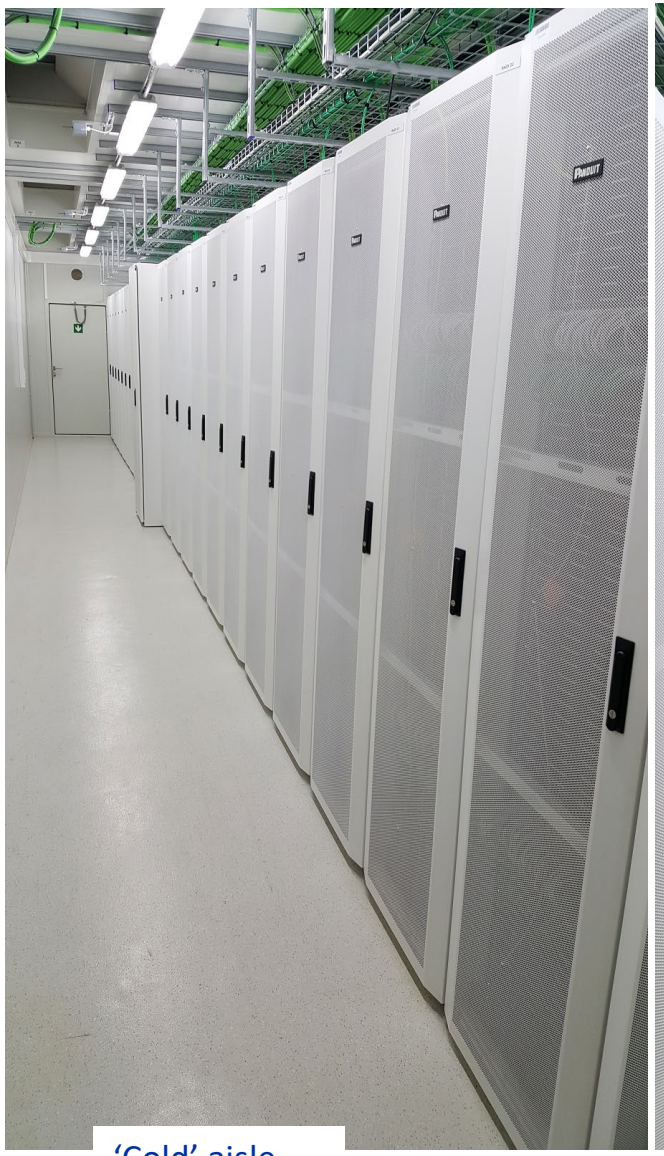
Up to 125 kW each

Inside the IT modules

Air Unit Controller



19000 fibers come from LHCb Experiment (250m)

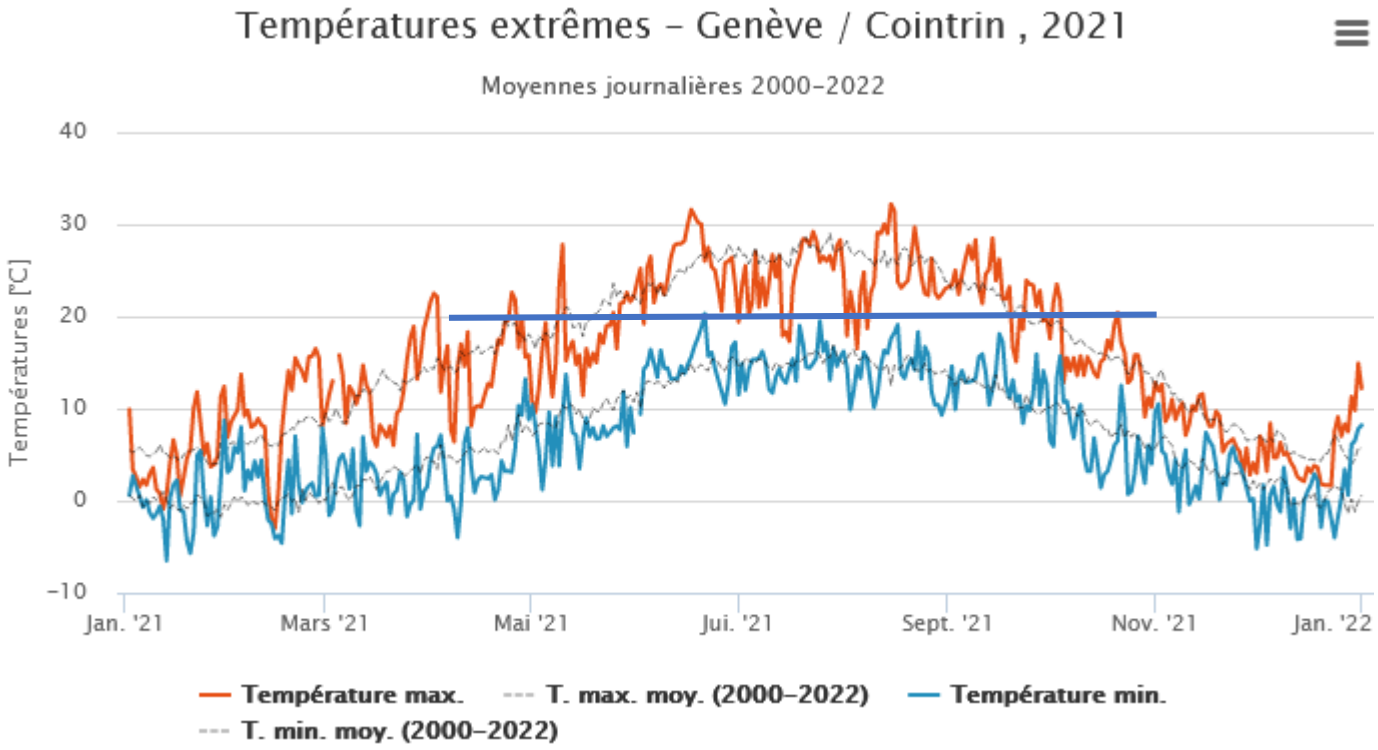


'Cold' aisle

2 secondary switchboards
Smoke detection

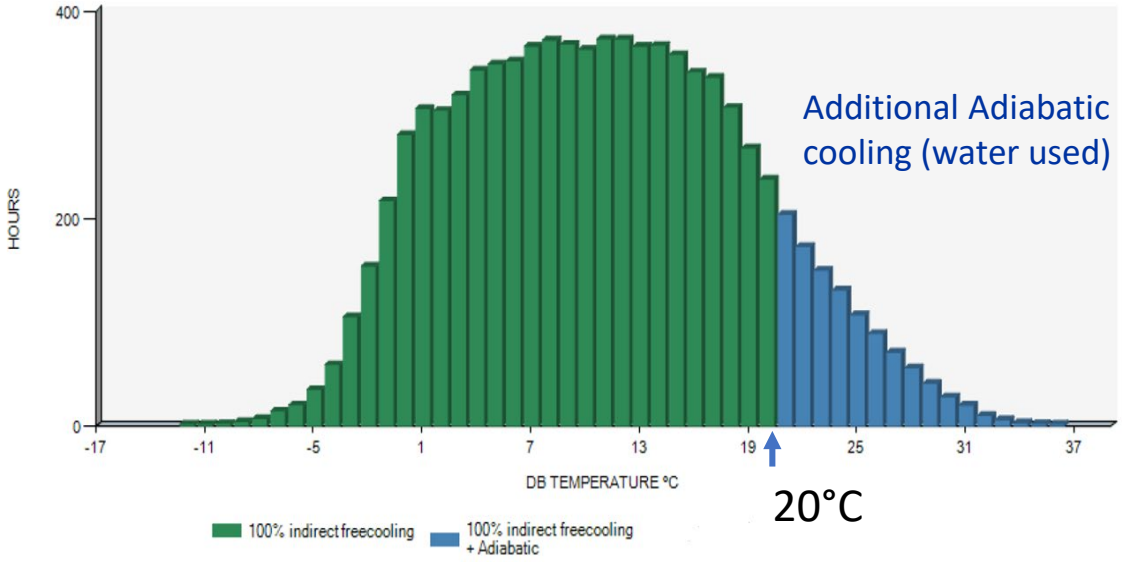
ALICE site

Temperatures in Geneva



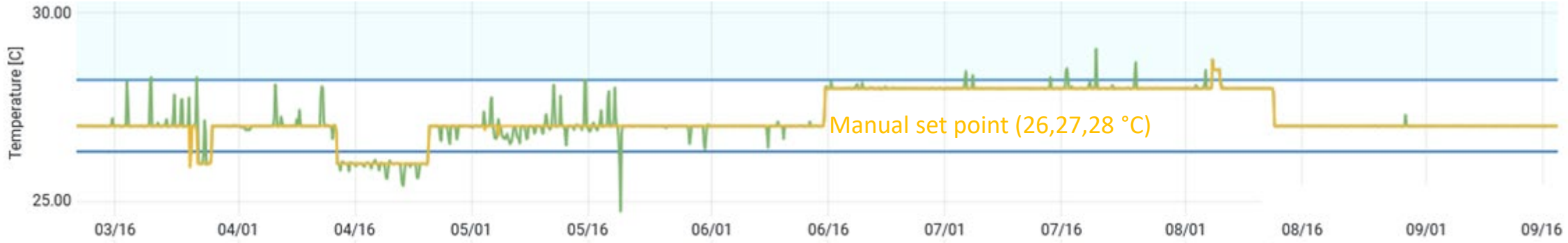
For a full year, the outside air is below 20 °C most of the time

→ 'Dry mode' (without water) is the most used

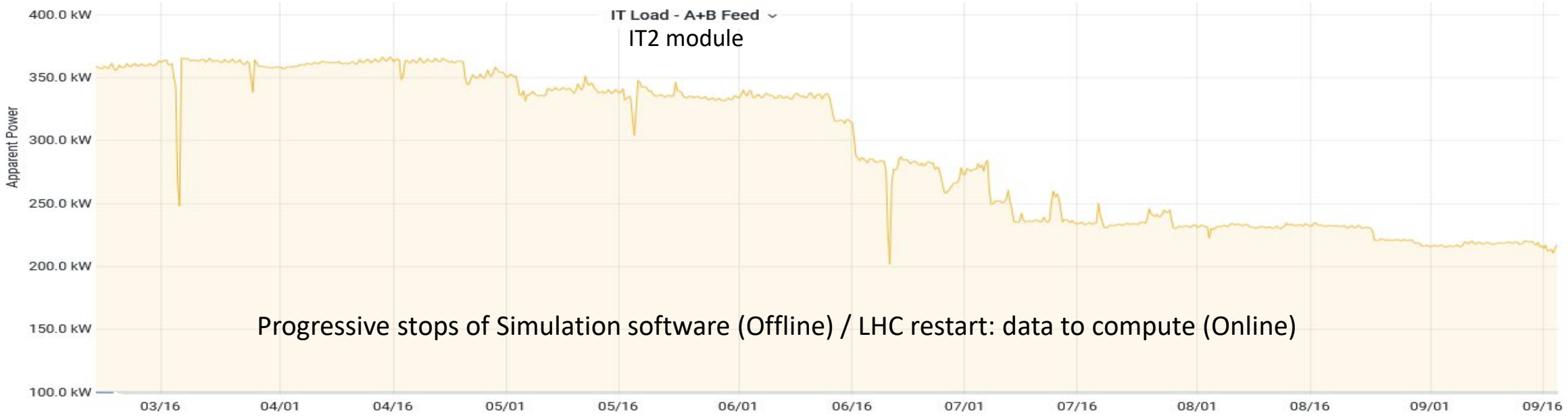


Temperature stability

Ex: air supply in IT2 module in 2022



Temperatures relatively stables (+/-1°C) , independently of the load

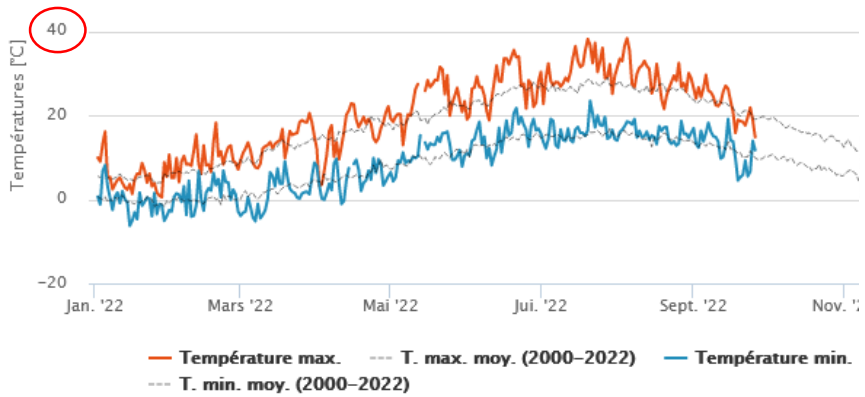


Trends

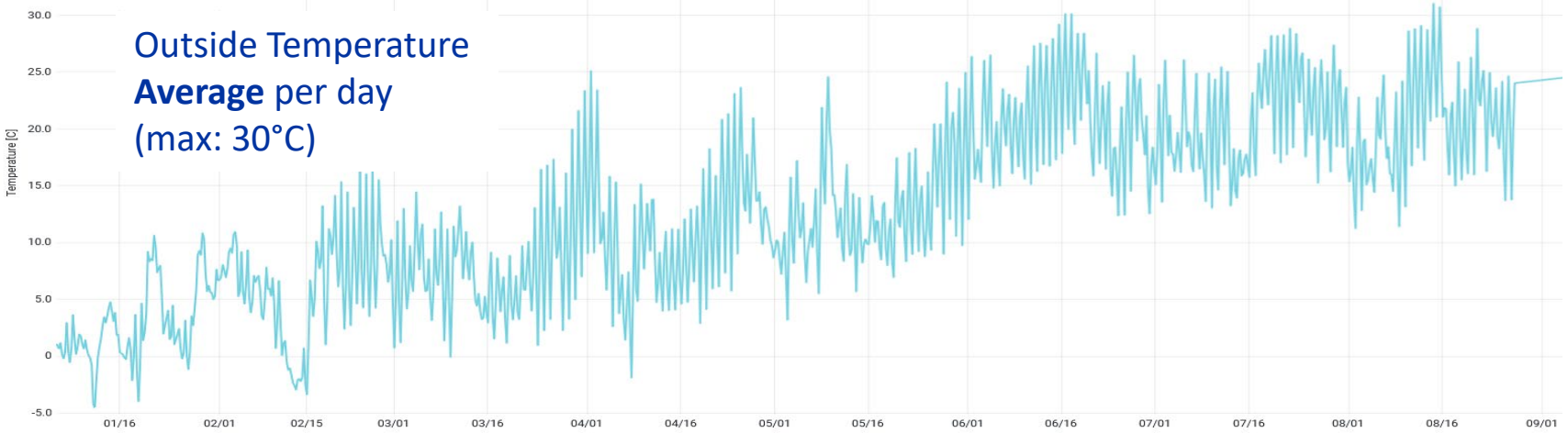
Period: Jan - Sept 2022

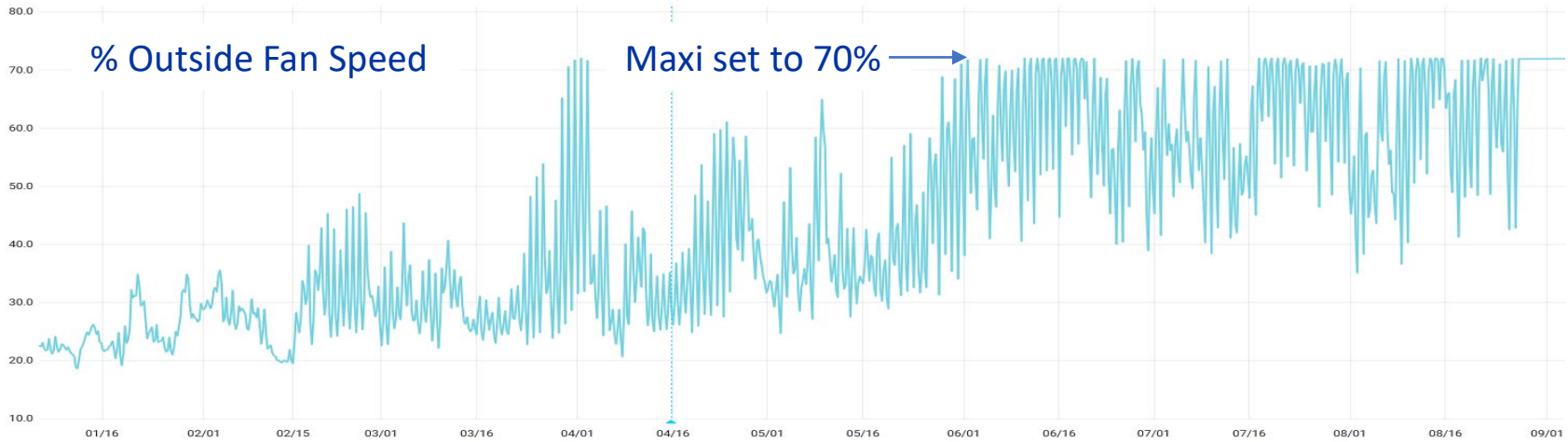
Exceptionally hot during summer

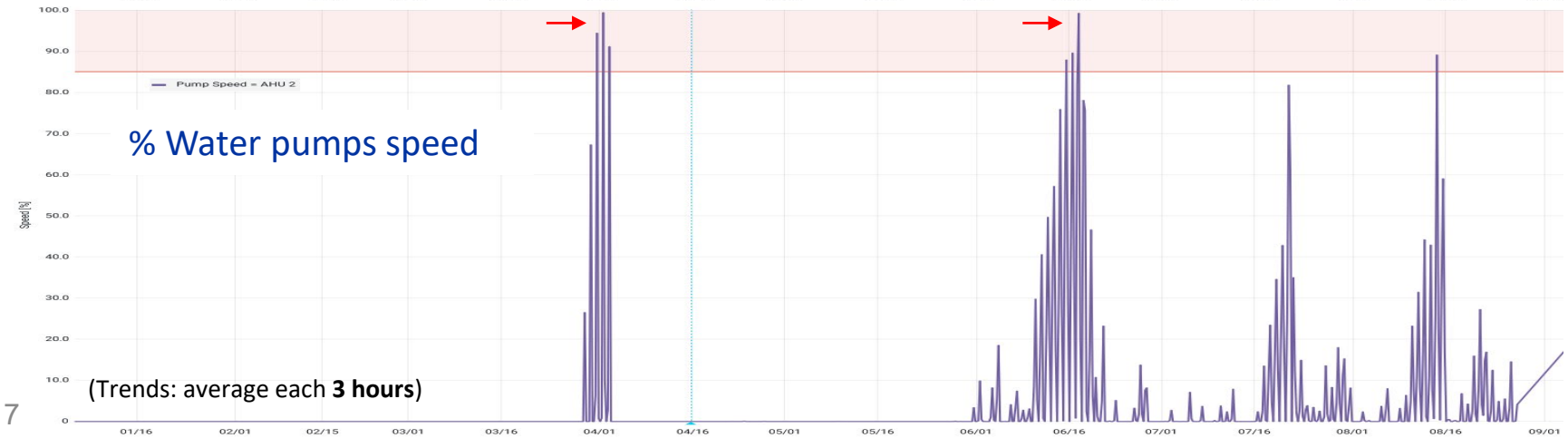
Ex: IT2 module



Fans speed + water pumps at the maximum punctually







(Trends: average each **3 hours**)

Regulation

Goal → have a 27 °C inlet server temperature, as stable as possible

Independently of **Outside temperature**, humidity & **Load of servers**

Parameters for each AHU:

- Outside fan speeds

minimum 0% or 20%(wet mode), high speeds clog more quickly the air filters

- Inside fan speeds

adjusted to have a good delta T temperature for the best Air/Air exchanger efficiency

- Water pumps speeds (in wet mode)

enough to well cover the heat exchanger but not too high (pump energy consumption)

- Influence of the air filters status

regular maintenance needed

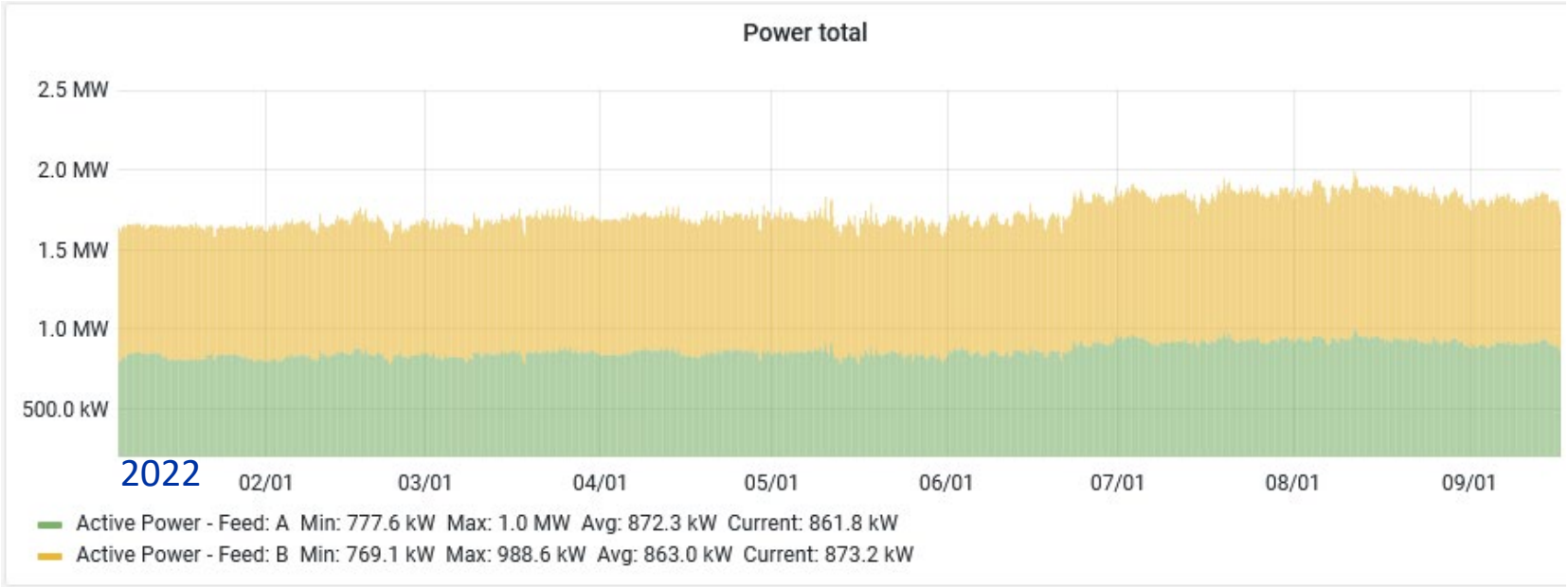
→ better knowledges after 2 years of operation but the 'tuning' is still on going to reach the ideal 'operating point' in term of Energy efficiency.

Air filters improvement

Total Power, water consumption

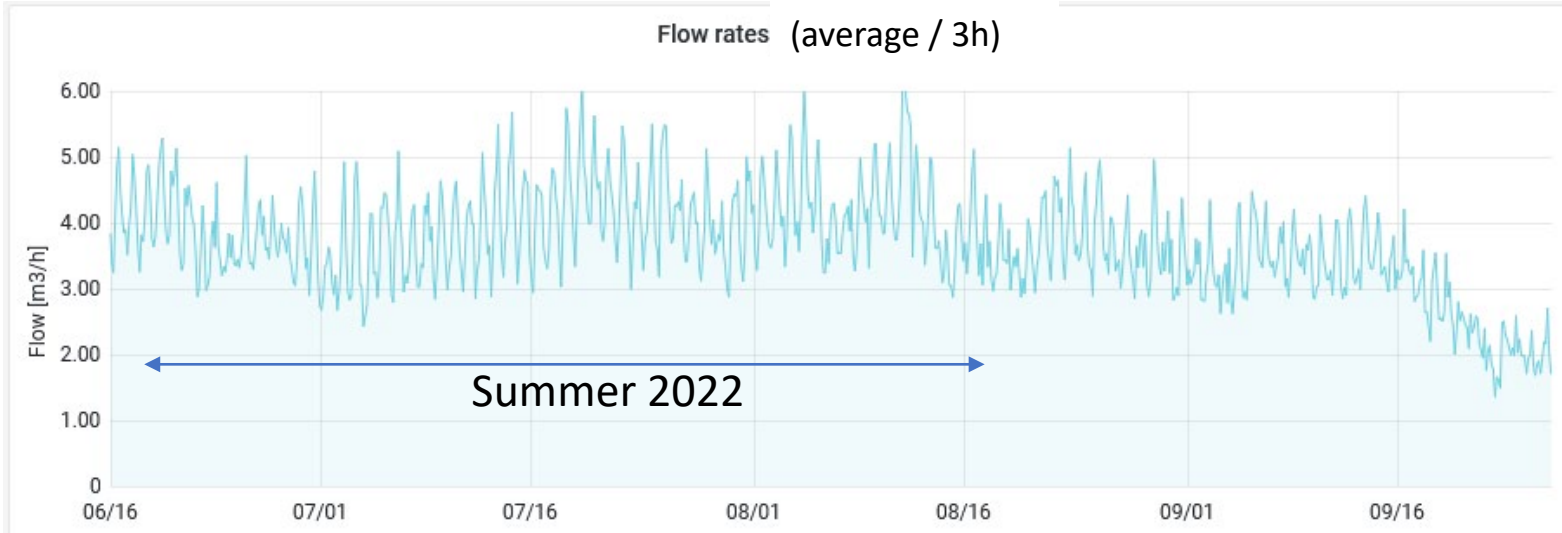
Power ~ 1.6 - 1.9 MW

Average 2022: 41.3 MWh /day
~ 15 GWh /year



Total water consumption:
~ 3 - 6 m3/h

Total ~ 9 500 m3 /year
(row water from the lac)

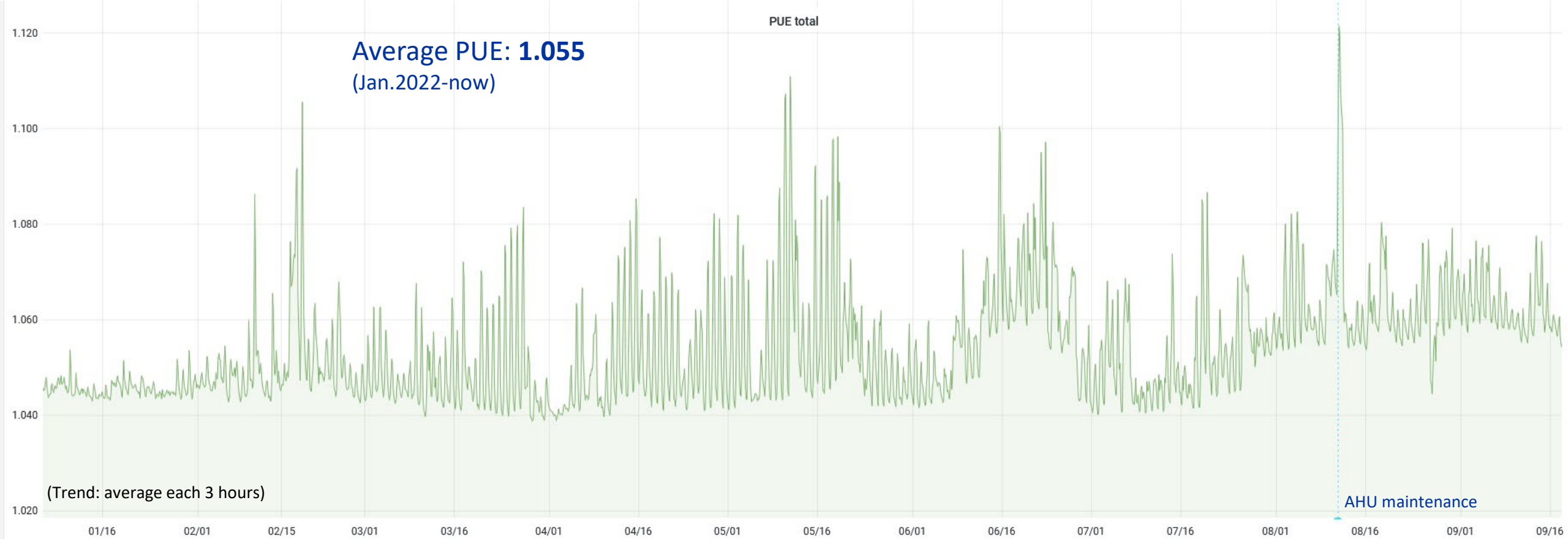


PUE

A commonly used metric is the Power Usage Effectiveness (PUE), which is defined as the ratio of the total amount of energy used by a data centre to the energy delivered to the IT equipment,

$$\mathrm{PUE} = \frac{\text{Total data centre energy}}{\text{Total IT energy}}$$

IT energy + **Cooling** + minor consumers (electrical cables, lightning…)



2022

Prevessin Data Center

- Under construction: operational end of 2023
- Initial capacity, top floor: **4 MW**
  According to the needs:
  2 lower floors up to a total of **12 MW**
- 3 Phases deployment (Oct. 2023 / 2025 /2030)
- Very efficient cooling system
- Power Usage Effectiveness (PUE) contractual < 1.15
  CERN objective ~ 1.10

Prevessin Data Center

Occupied ground area: 2250 m2
Height: 19,15 m
Total surfaces: 6400 m2

Power per IT Rack: 20-25 kW

A **heat recovery** system is foreseen up to 3 MW to heat the entire site

Vegetation will cover half the roof

Conclusion

- ALICE and LHCb Experiments had need to increase significantly their computing facilities for the next years.
- Considering the **energy efficiency,** modular Data Centers with **indirect free air cooling** have been adopted.
- The two computing facilities have been delivered at CERN in time and without extra cost.
- By using the outside air, the **cooling efficiency** has been drastically reduced to compare with the previous Data Centers underground.
- The PUE is well below the 1.10 foreseen. Traditional DC (using expansion cooling) have their PUE from ~ 1.30 to 1.50. The recent heat wave of summer 2022 (40°C peak) did not cause problems for the cooling system.
- A new Data Center up to 12 MW is in construction at CERN, same approach: to have a high energy efficiency by using outside air but also by recovering part of the heat in winter.

END