RICH700

- Photon Detector Status
- SRC@HADES
- Electronic Cooling Aspects
- Assembly Tools

250 days to go

Cooling Aspects

- Thermo-Coupling of Materials
- Board Temperatures
- Air Cooling & FAN Arrangement
- Additional Heat Sink ?

Some Ideas only !!!
Finite Element Simulations with COMSOL 5.2

Cooling Aspects

Rough Estimates

MAPMT Carrier Board ⟷ Alu flange

Heat transport: Direct contact (?), Screws, O-Rings, Thermo cond. foils

$(dQ/dt = \lambda \times A \times \Delta T/D)$

Material (# per board)	Isol. [kV]	Heat cond. λ [W / m*K]	Thickness D [mm]	Area A [mm²]	Power P/ΔT [W/K]
Circ. Board (FR4)	> 1	0.3	0.5 (?)	1300	~ 0.8
Therm. Foil	0 – 1	2.0	0.5	2100	~ 8
Kapton M	> 2	0.5	0.25	2100	~ 4
Screws (Steel)	0	40	> 3.0	80	~ 1
O-Ring (15% C)	> 1	0.8	~ 1.4	750	~ 0.5

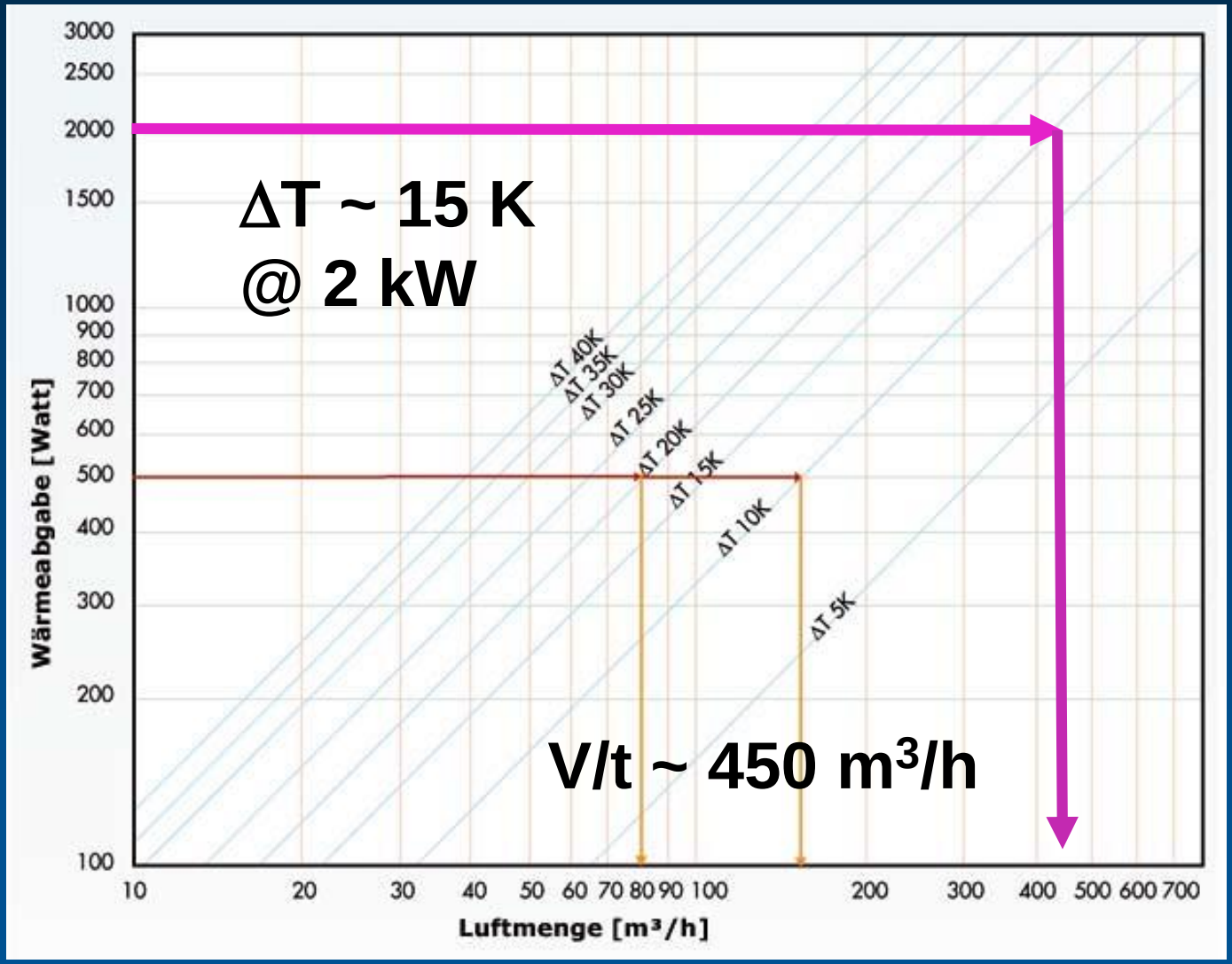
Expectation: 1 Board : P = 30 W $\Delta T \leq 30$ K needed

Board : T ~ 293 K + 30K ~ 320 K

Air Cooling

Temperature rise $\Delta T \sim 15$ K:

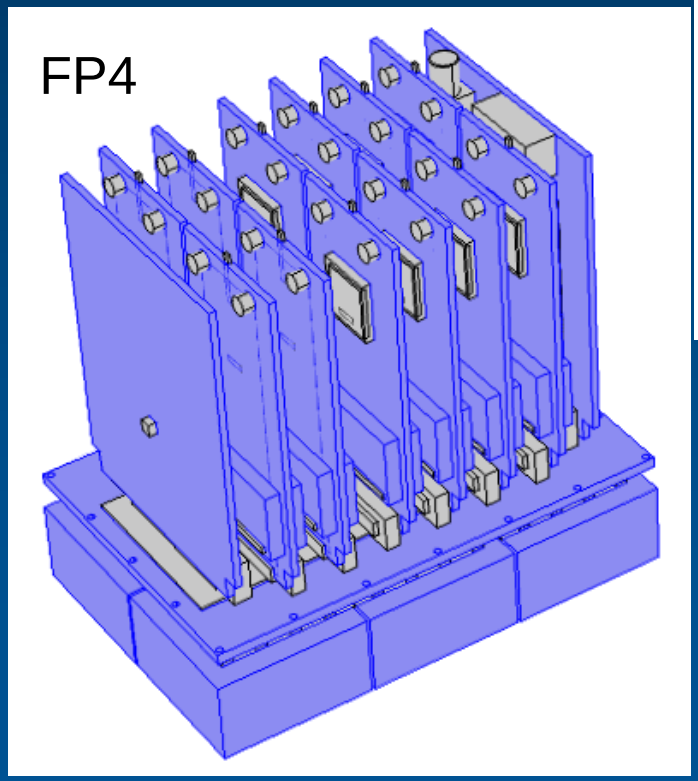
Air needed: V/t ~ 400 - 500 m³/h
Typical fans: V/t ~ 200 - 800 m³/h



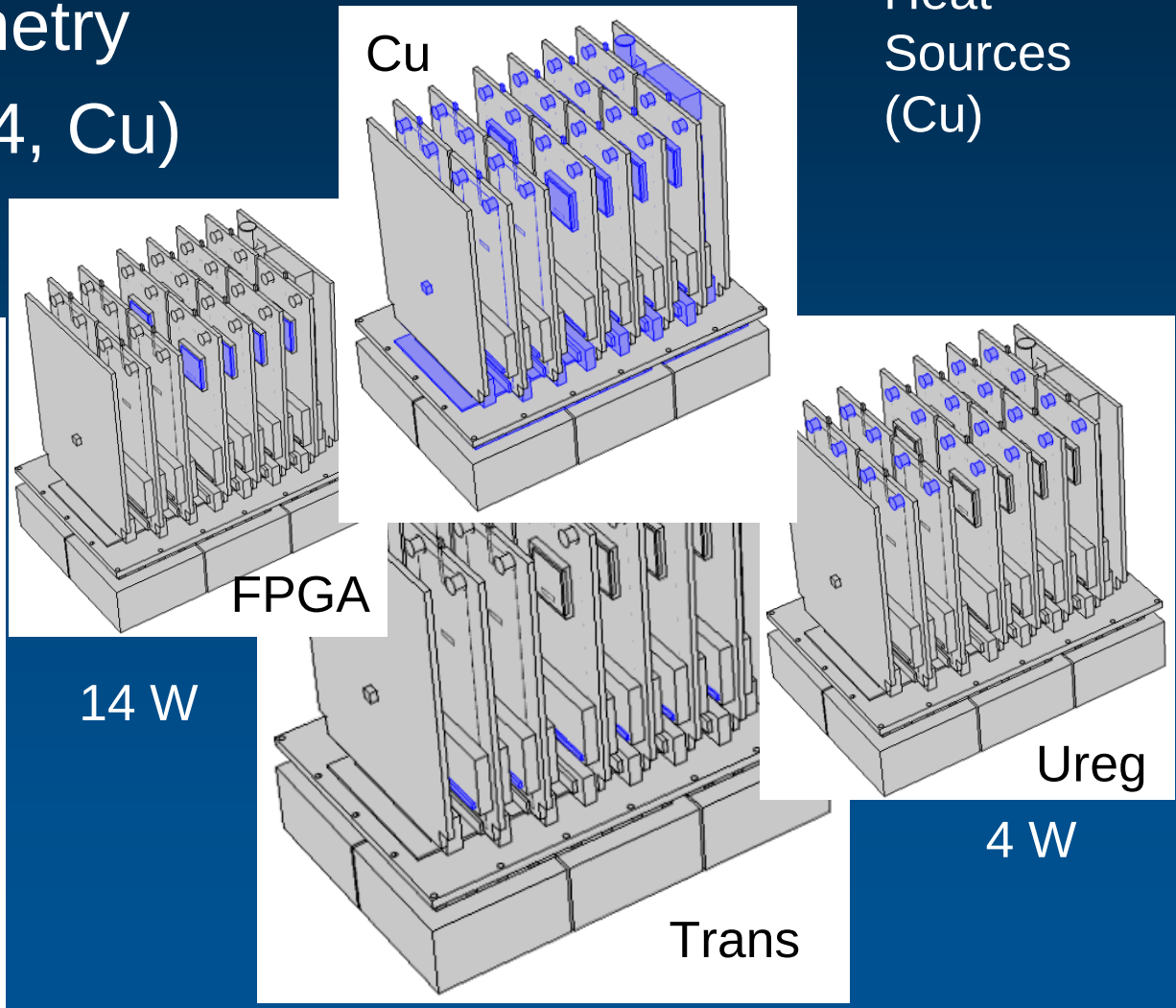
How to Airflow ??

Simulation Model

- ✓ 1 board 3x2 MAPMTs
- ✓ Simplified geometry
- ✓ 2 Materials (FP4, Cu)
- ✓ P = 30W

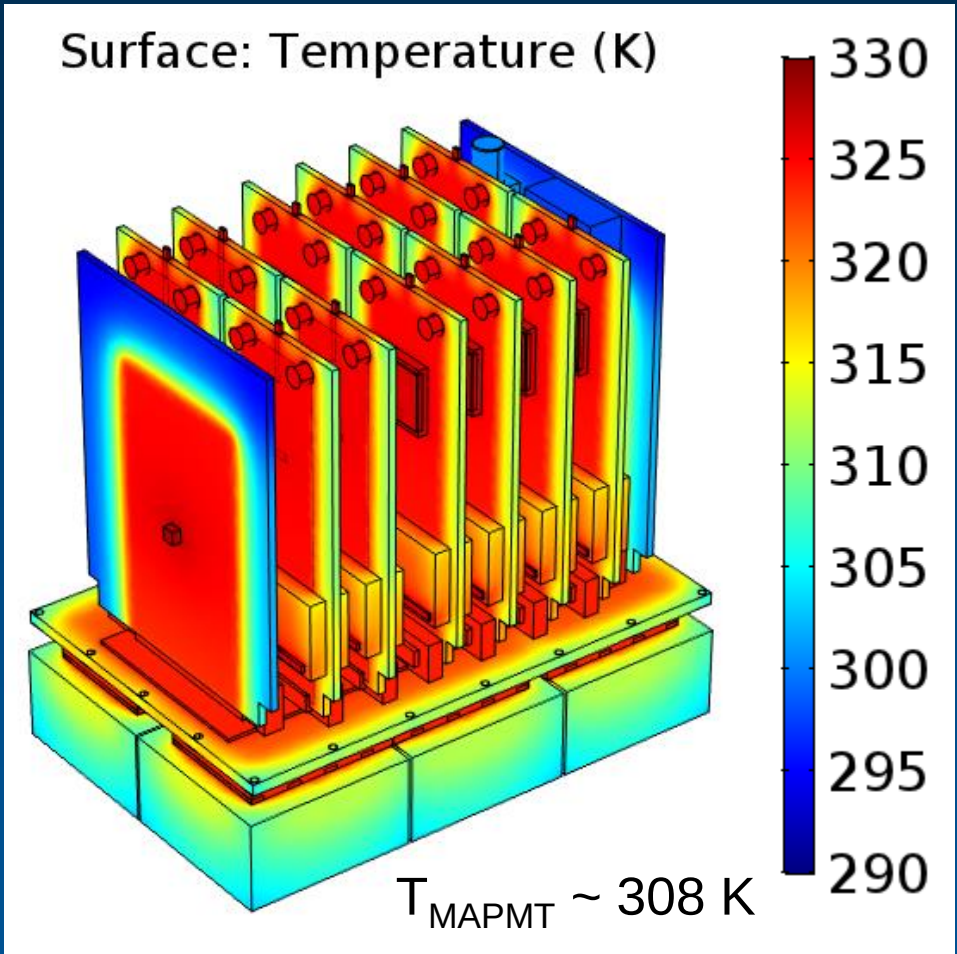


Heat Sources (Cu)



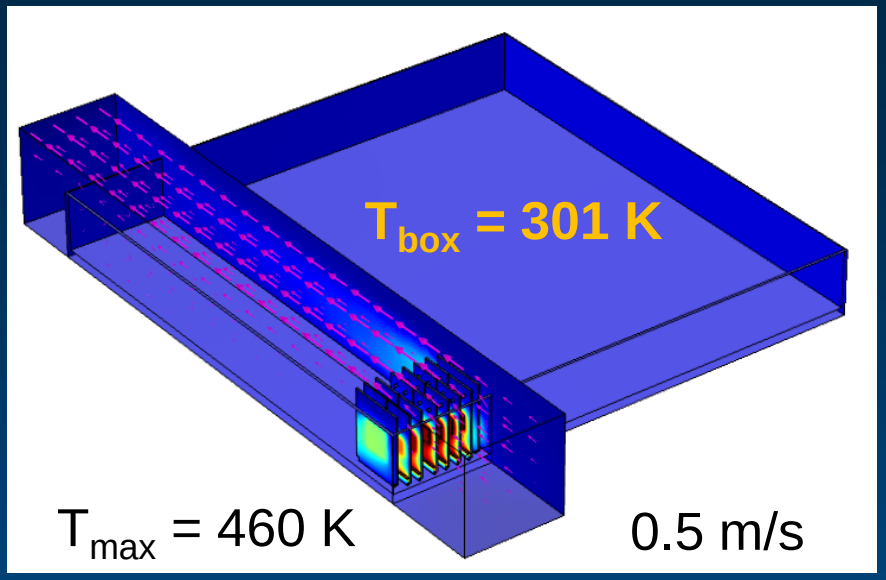
1 Carrier Board

Stand alone board, no additional cooling: T_{max} ~ 329 K



- ✓ 12 DiRICH boards
- ✓ 2 Power & DAQ boards
- ✓ FP4 + Cu layer
- ✓ P = 30W
- ✓ Convection only
- ✓ No airflow
- ✓ No Radiation

Boards in Flange Box



1 - 2 FP4 boards

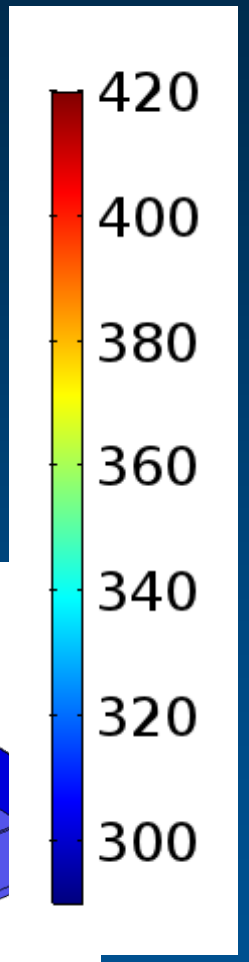
P = 30W / board

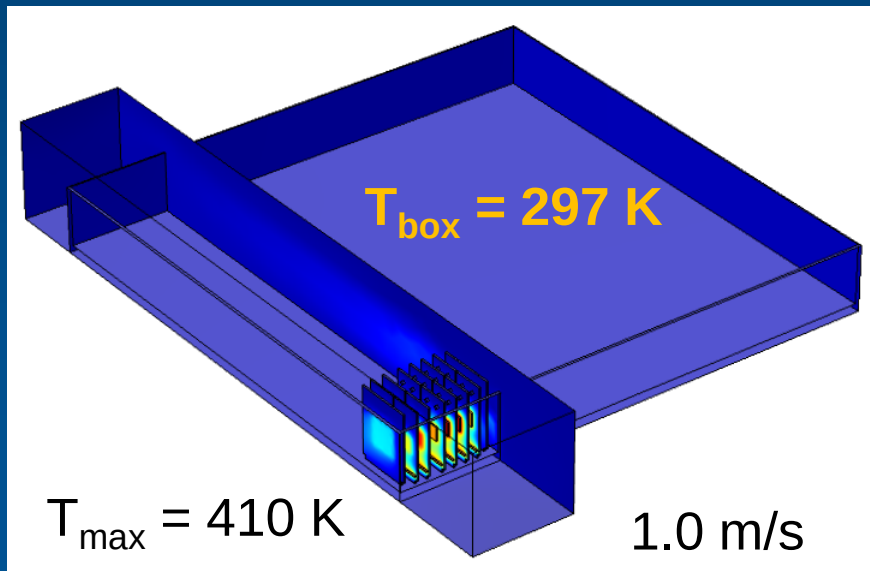
Ideal coupling to flange

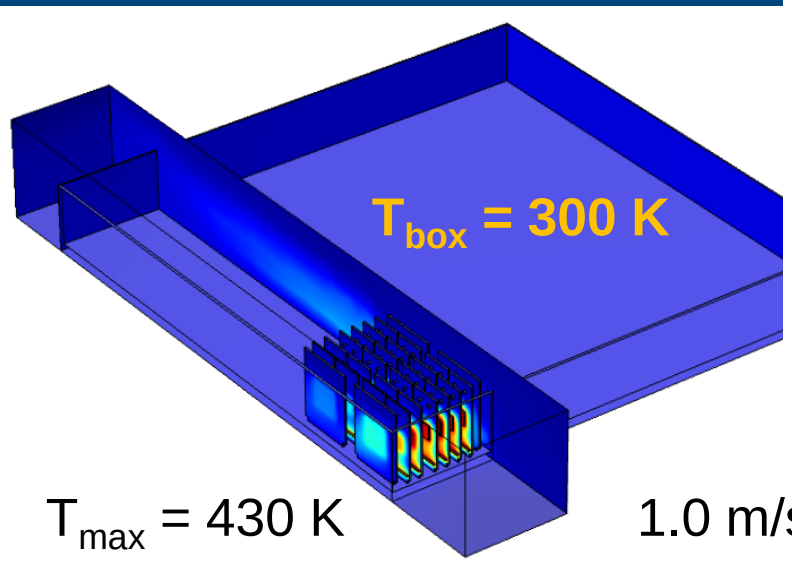
Airflow :

from side

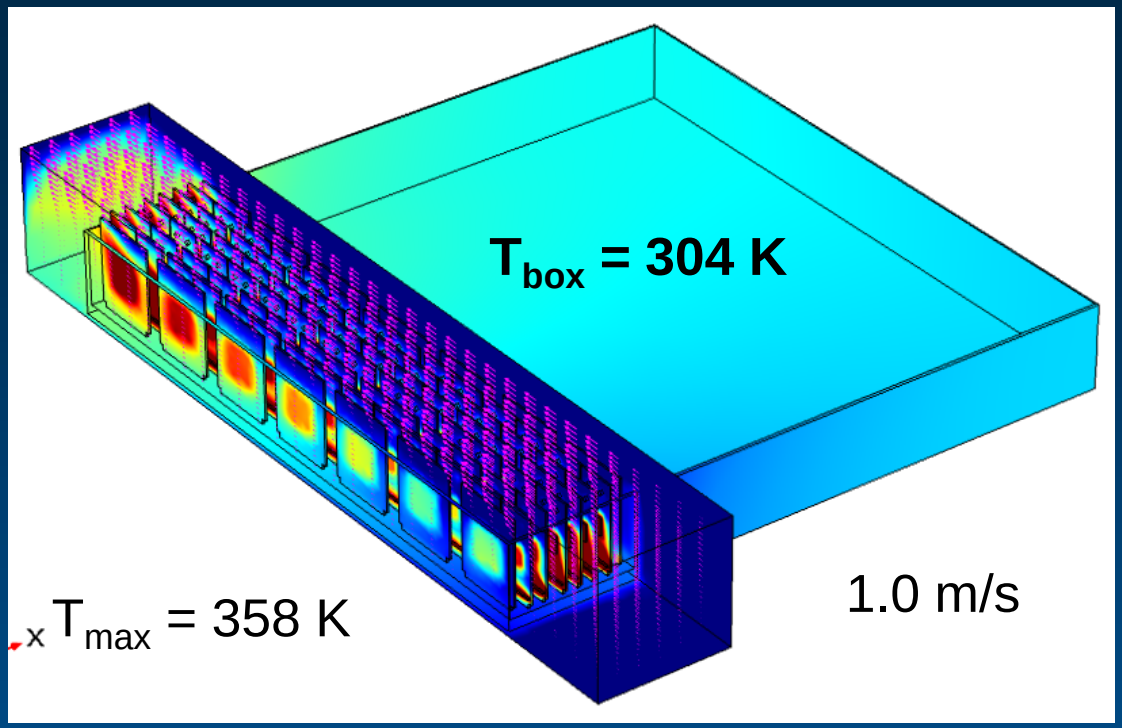
V/t ~ 40 - 80 m^3/h







Side Fan



7 FP4 boards

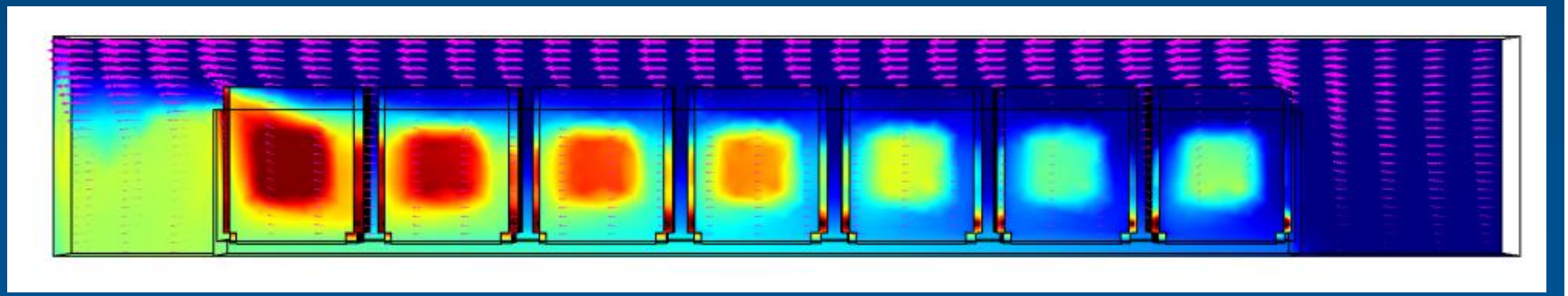
P = 30W / board

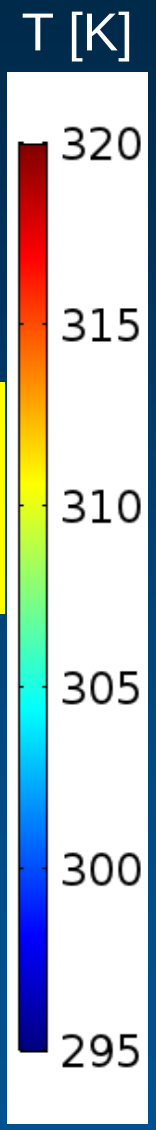
Ideal thermo coupling

Airflow :

from side

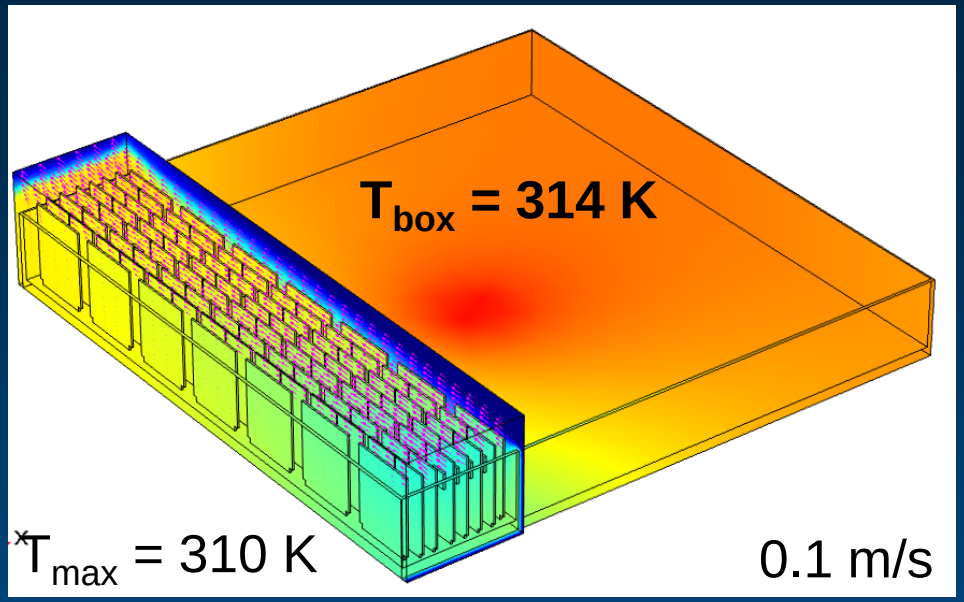
V/t ~ 40 - 80 m^3/h

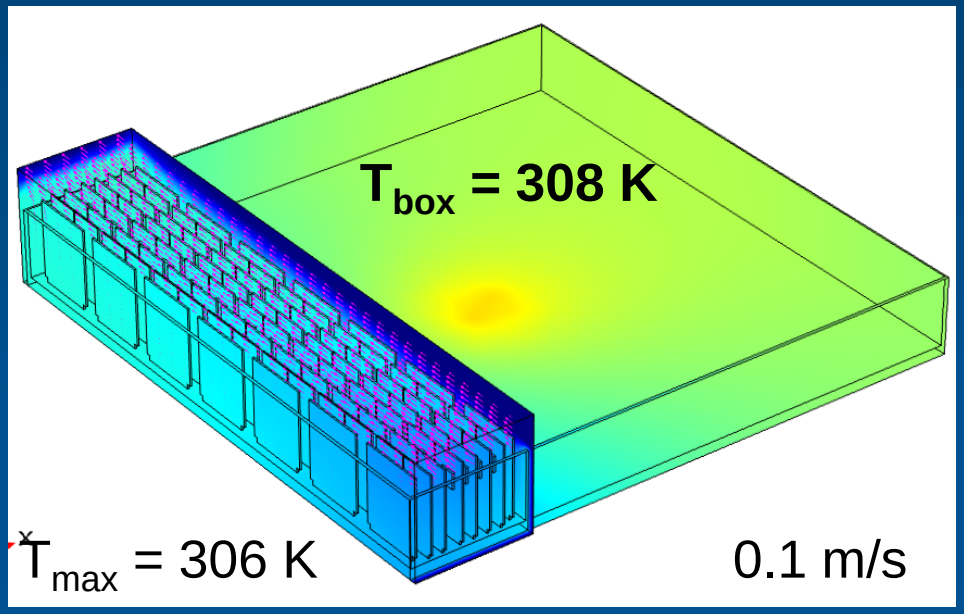




Side flow blocked by boards on flange !!!

Radiation cooling ?





7 Cu boards

P = 30W / board

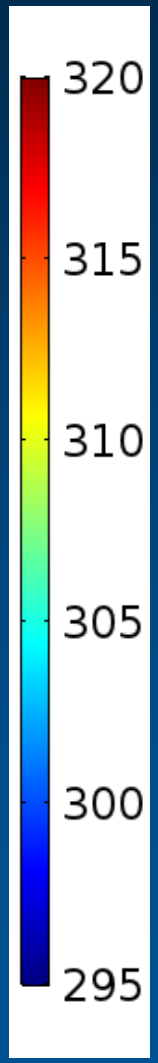
Ideal coupling to flange

Airflow :

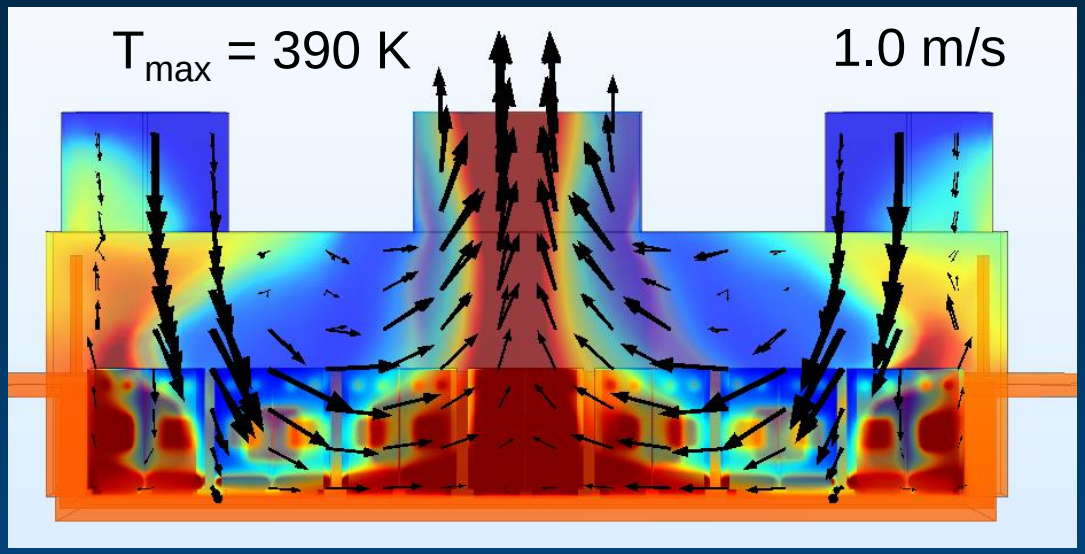
from side

V/t ~ 8 m^3/h

- ✓ No Convection
- ✓ Slow airflow
- ✓ Radiation



Top Fan: Corners

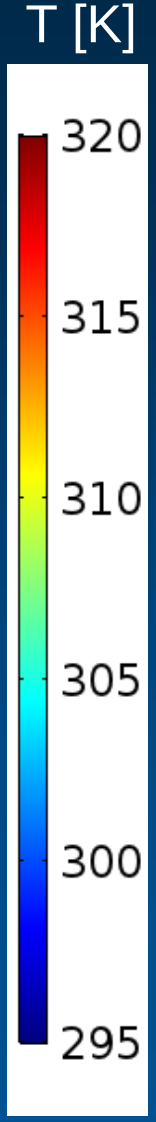


T_{box} = 313 K

7 FP4 boards
P = 30W / board
Ideal coupling
Airflow :

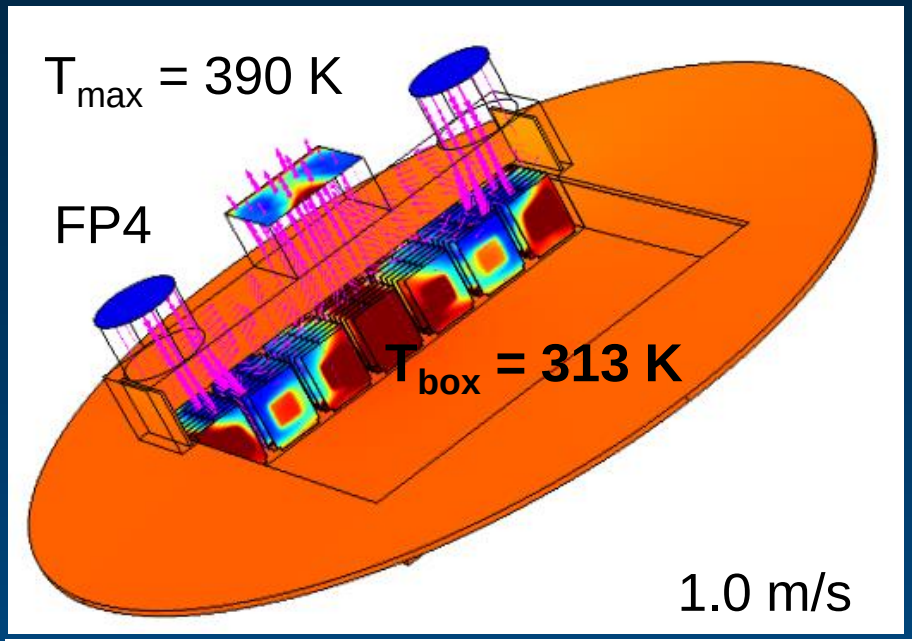
from top
in corners

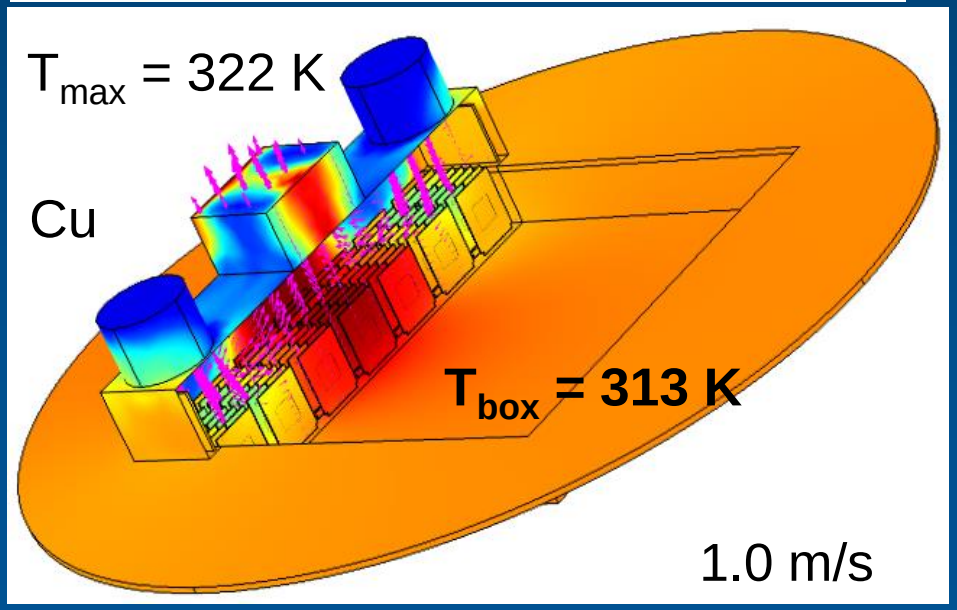
V/t ~ 110 m^3/h



- Short circuit for cool air
- Hot spots in center and corners

Top Fan: Corners





FP4 vs. Cu boards

7 boards

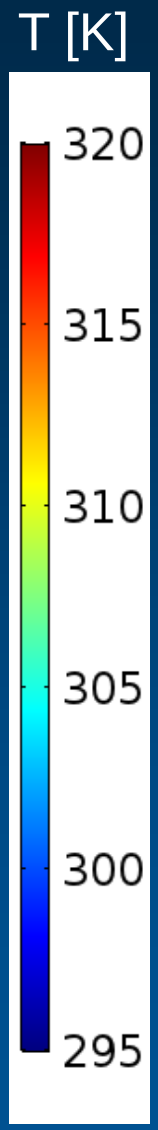
P = 30W / board

Ideal coupling

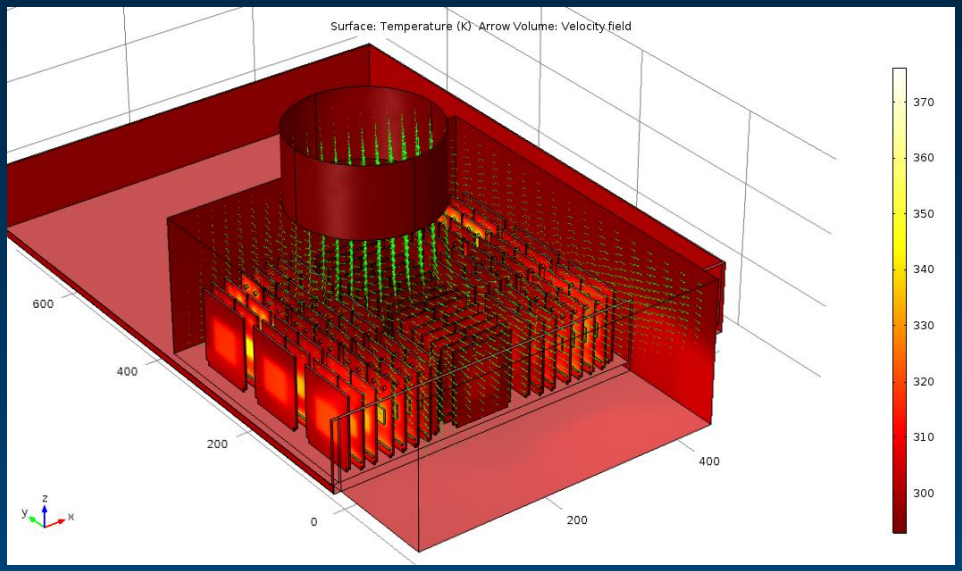
Airflow :

from top
in corners

V/t ~ 110 m^3/h



Top Fan: Center



8 boards

P = 210 W

Ideal coupling

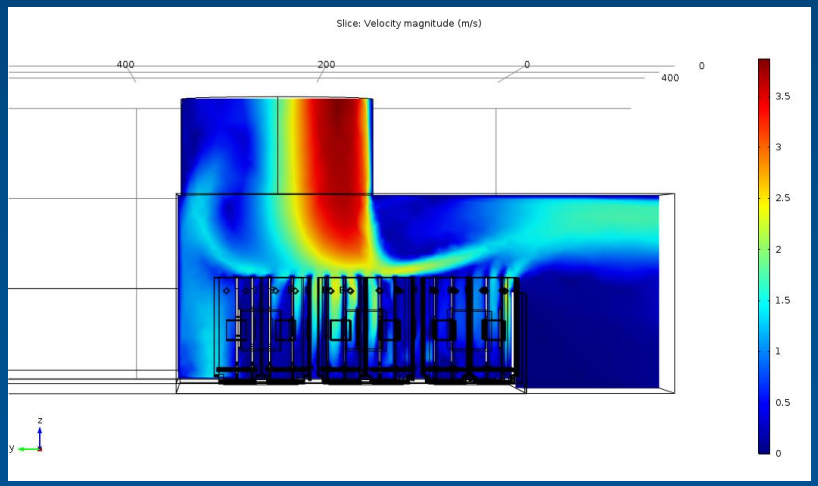
Airflow :

from top

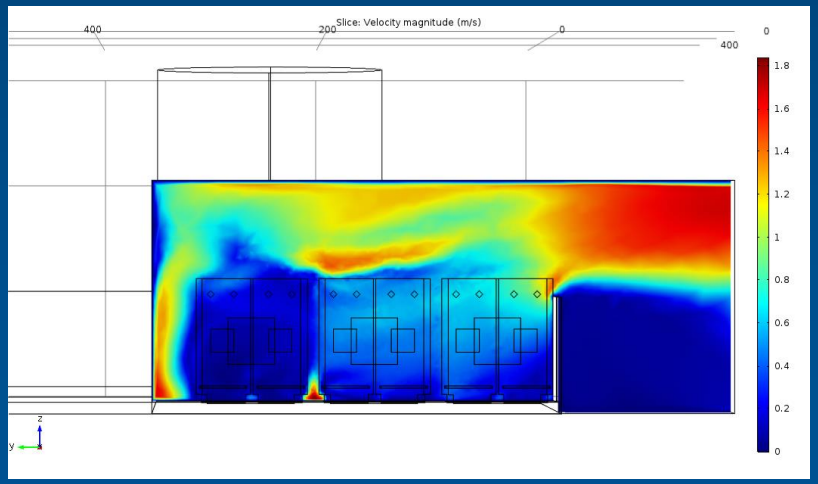
in center

u = 1.5 m/s

Airflow Pattern

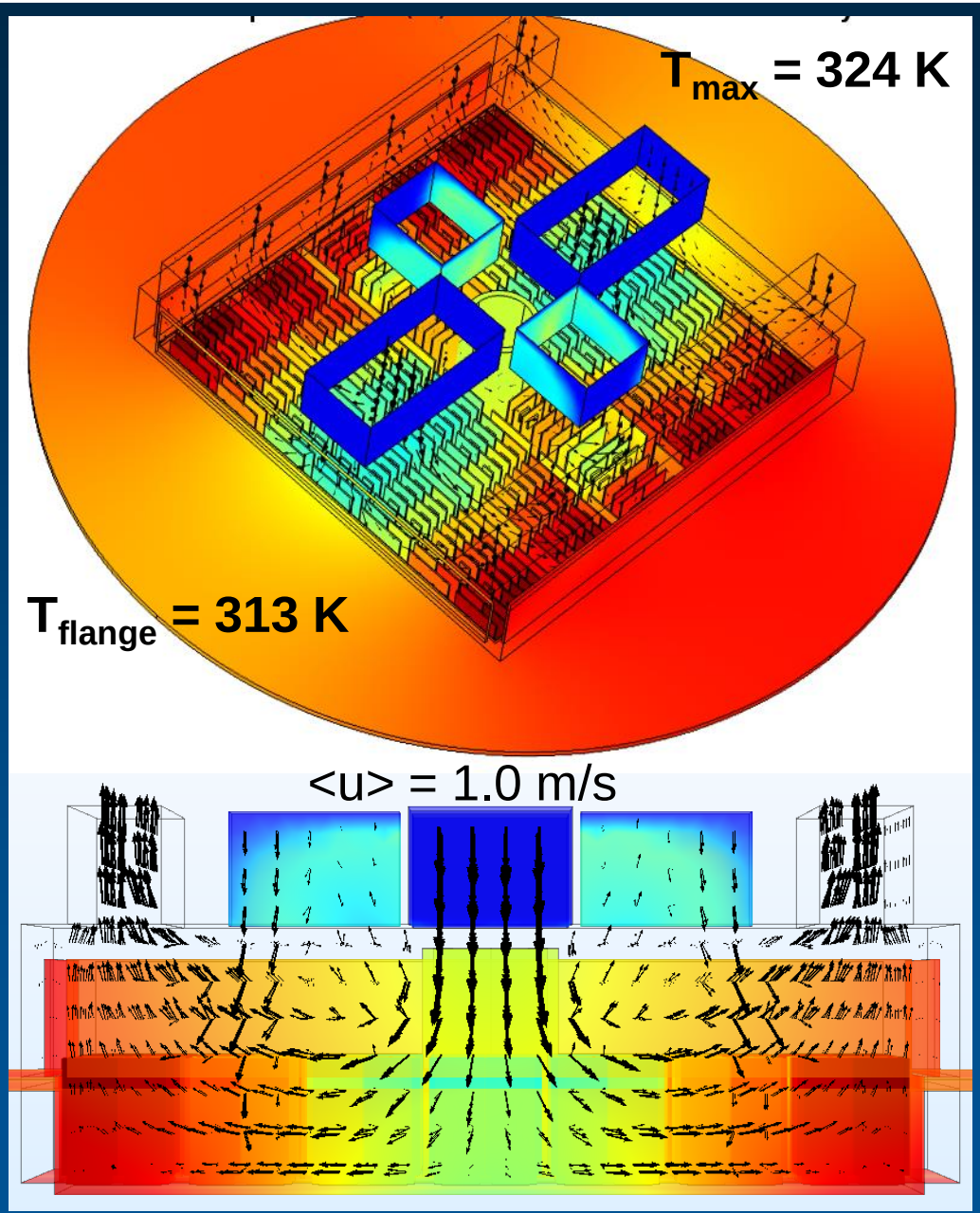


Middle Row



Side Row

Full Box



32 boards
P = 1000 W
Ideal coupling
Airflow :

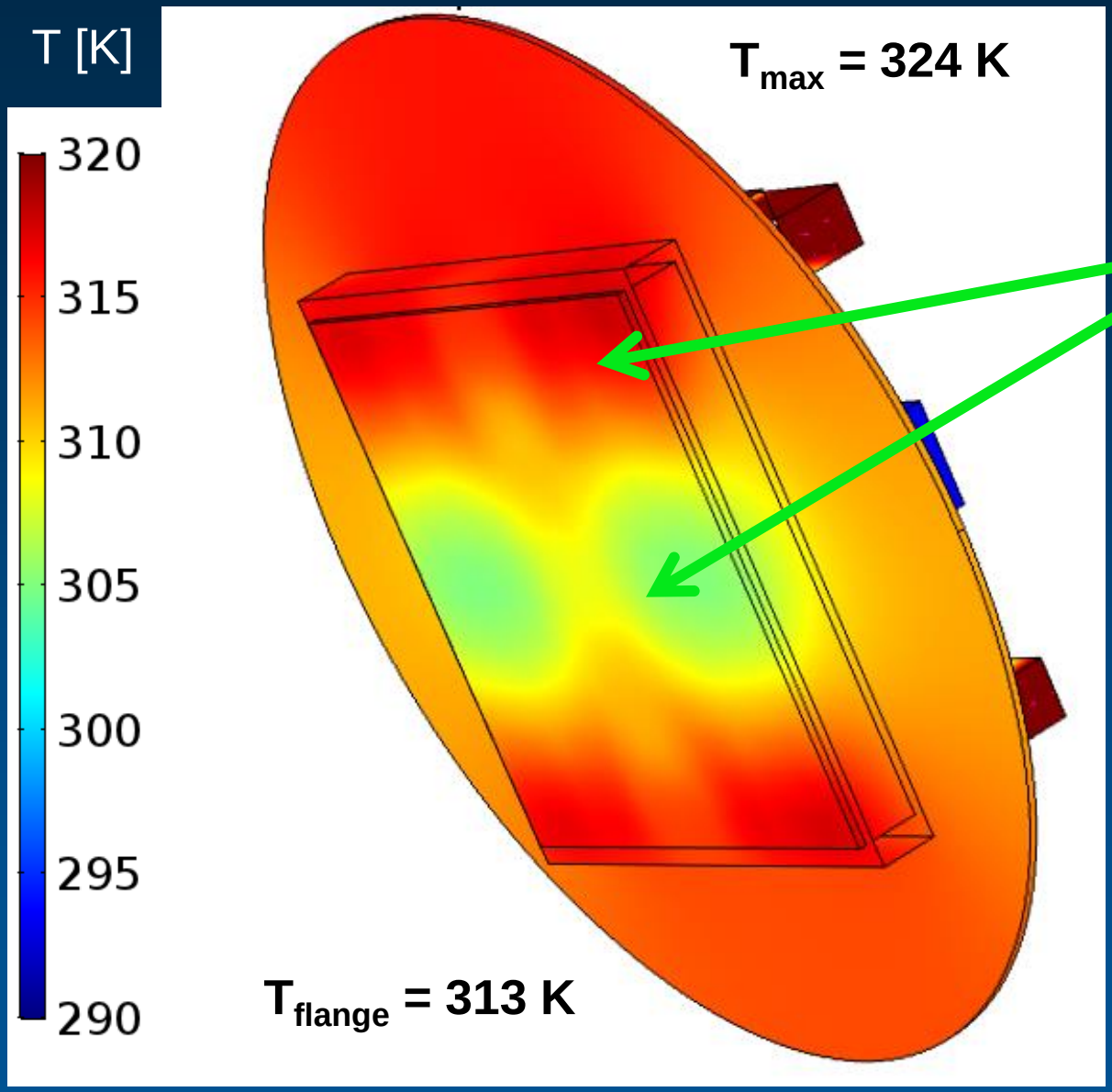
from top
in center

V/t ~ 430 m^3/h

Mesh : 1.5 * 10^7 dom.
Laminar flow
Heat transport
15 iterations
No convergeance yet.

1 Sim : 20 - 40 h

Full Box



MAPMT side

$\Delta T \sim 15$ K

32 boards

P = 1000 W

Ideal coupling

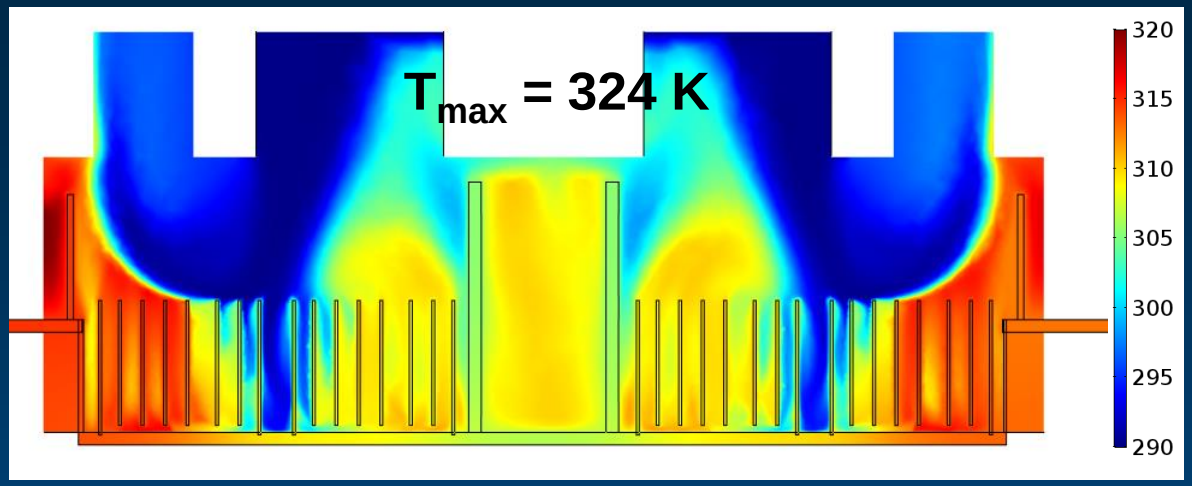
Airflow :

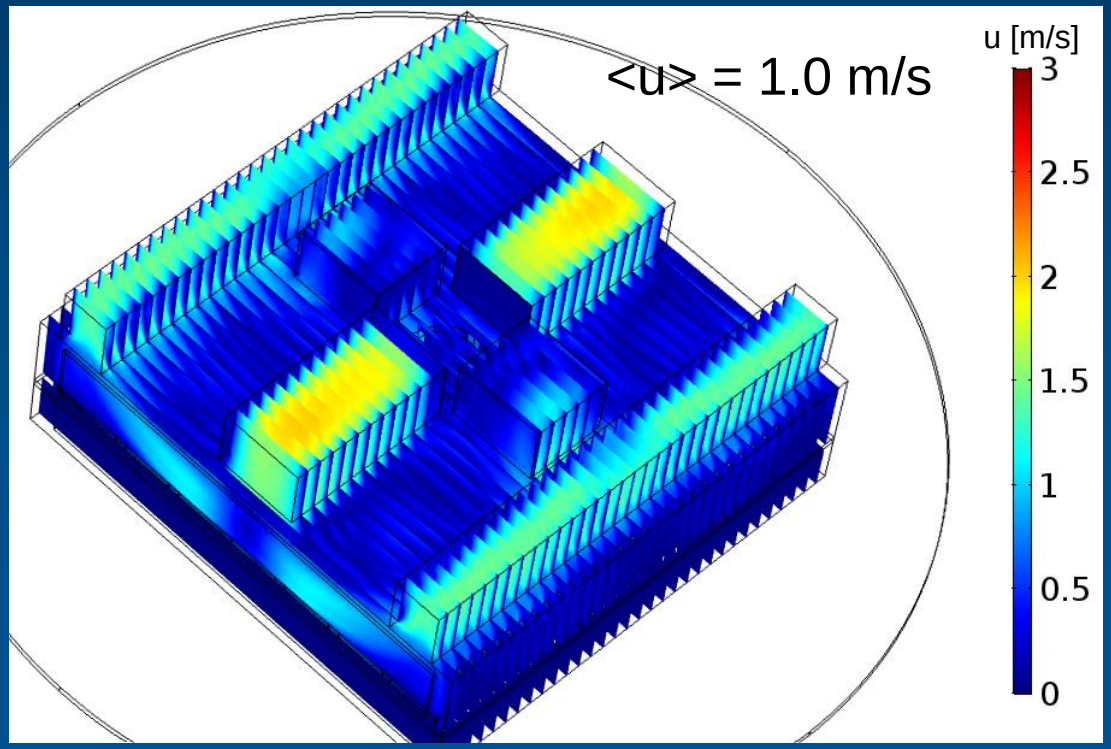
from top

in center

V/t ~ 430 m^3/h

Full Box





Temp. & Velocity Profile

32 boards

P = 1000 W

Ideal coupling

Airflow :

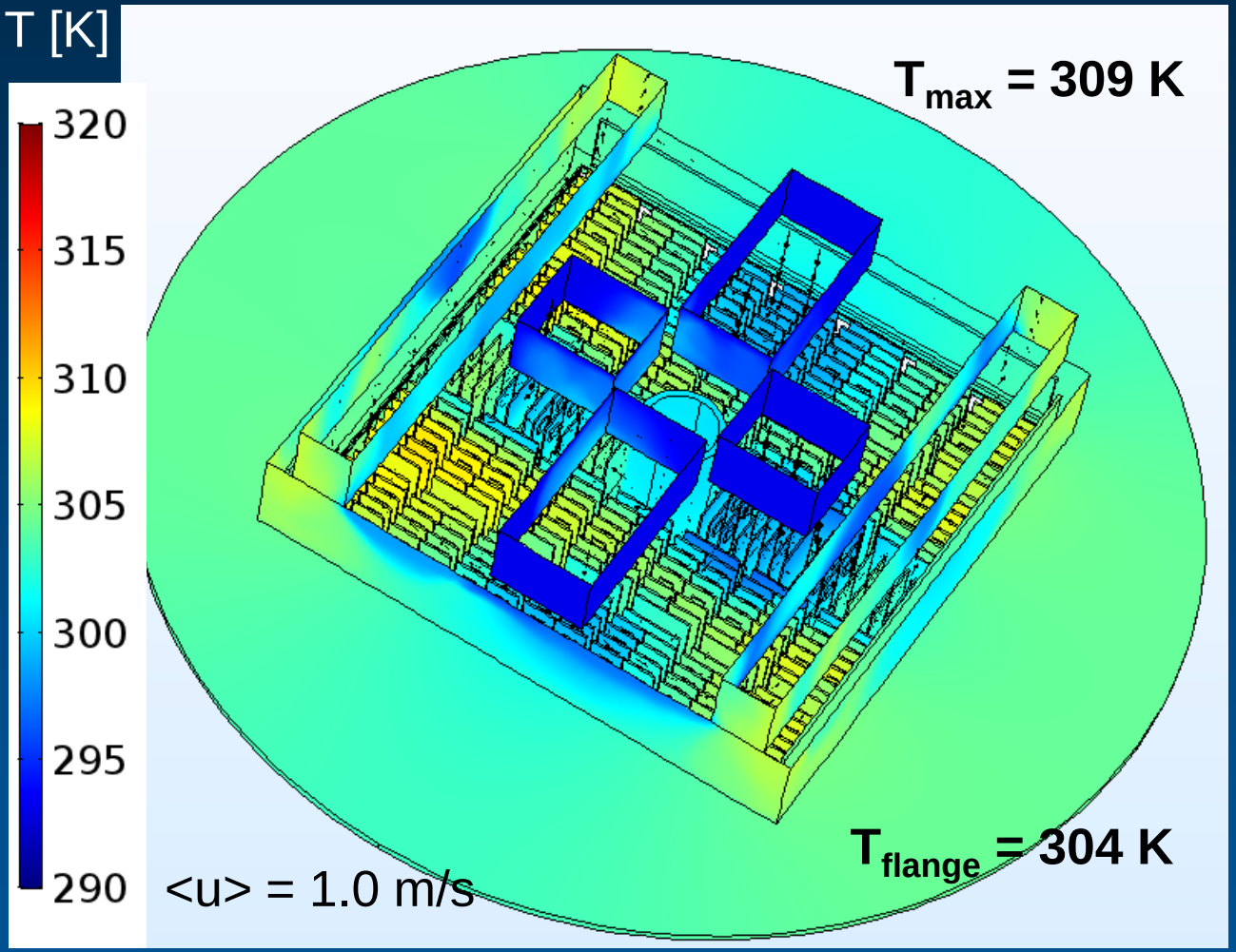
from top

in center

V/t ~ 430 m^3/h

Full Box

@ 30 iterations No convergeance yet



?????

32 boards

P = 1000 W

Ideal thermo coupling

Airflow :

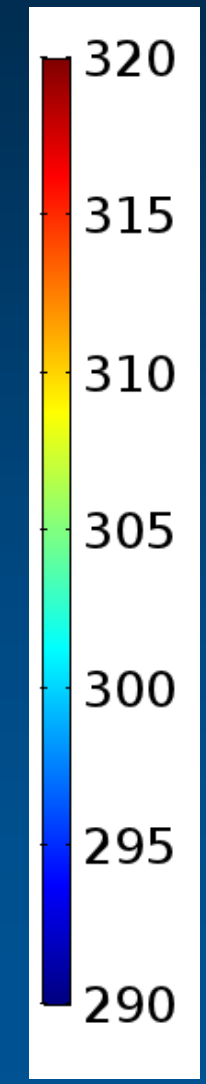
from top

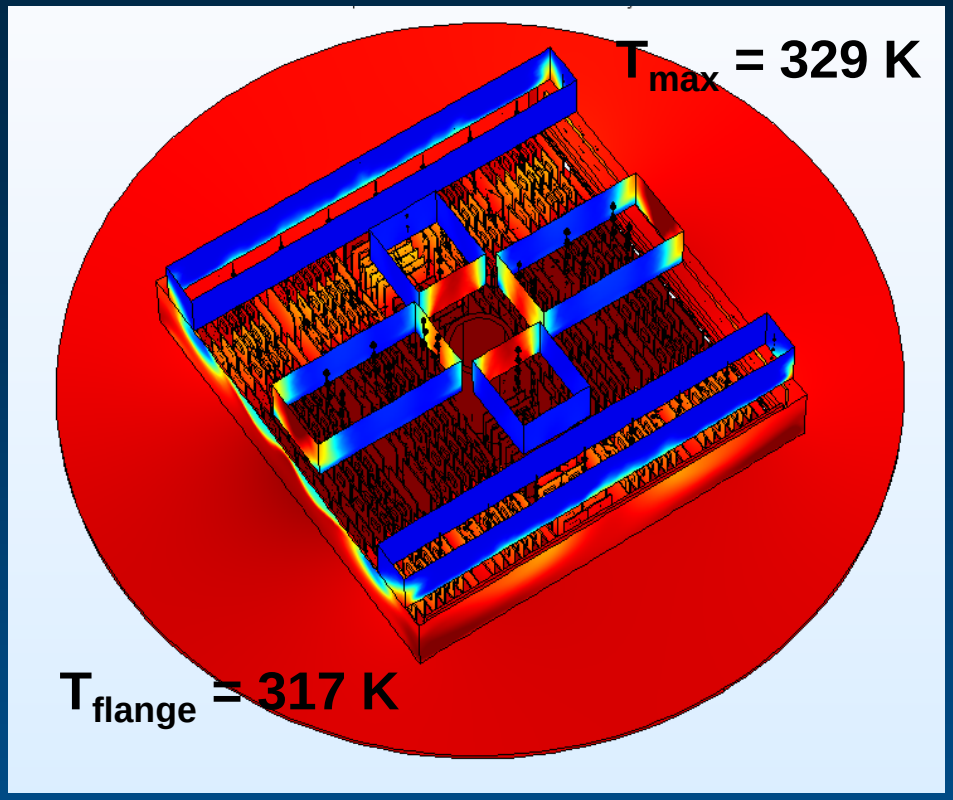
in center

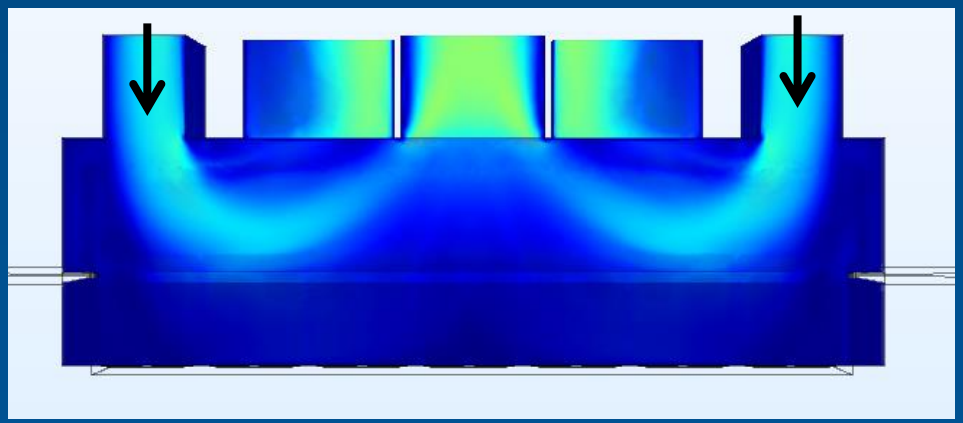
V/t ~ 430 m^3/h

<u> = 1.0 m/s

Full Box @ Reverse Flow







32 boards

P = 1000 W

Ideal coupling

Airflow :

from top

in corner

V/t ~ 430 m^3/h

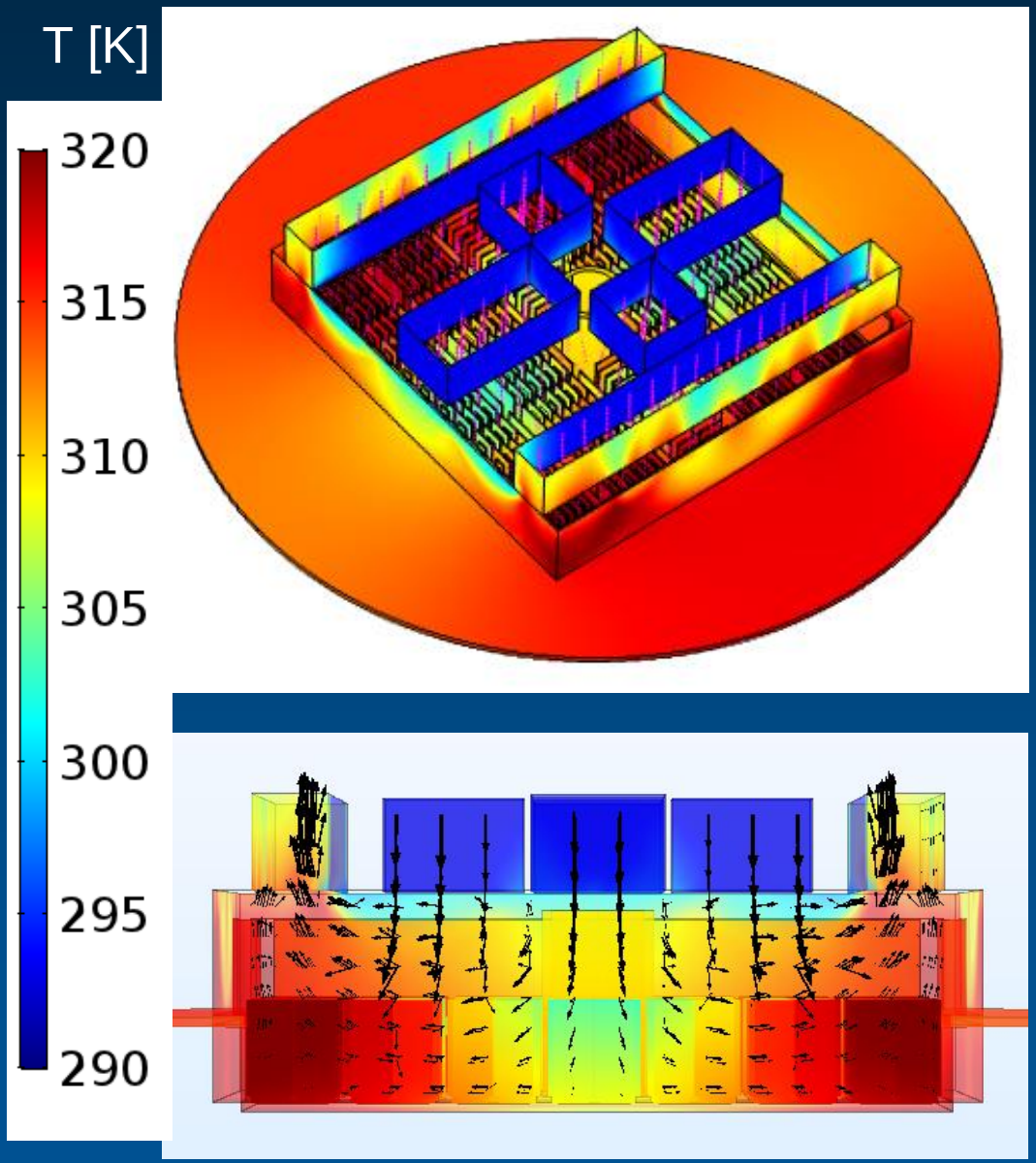
<u> = 1.0 m/s

11 iterations

No convergeance yet.

1 Sim : 20 - 40 h

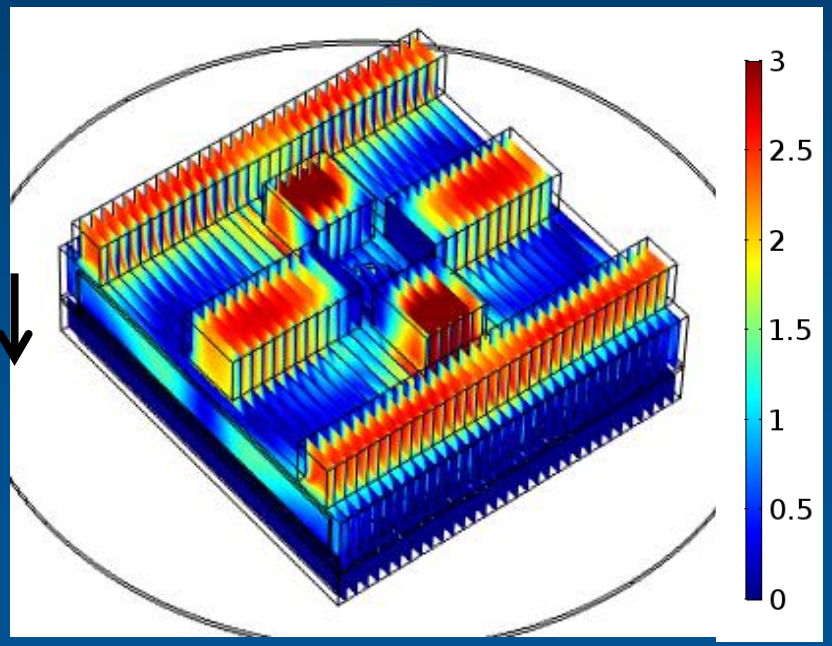
Cooling aspects



V/t = 860 m^3/h

<u> = 2.0 m/s

v_{max} = 3.9 m/s



Cooling Aspects

Summary & To Do´s

- T_{flange} < 40 C @ reasonable air flows (2 fans ?)
- Air flow design to be optimized
- Thermal coupling of PCBs to Alu flange ?
- Thermal expansions and tensions ?
- Additional heat sink on flange/tank (water pipe) ??