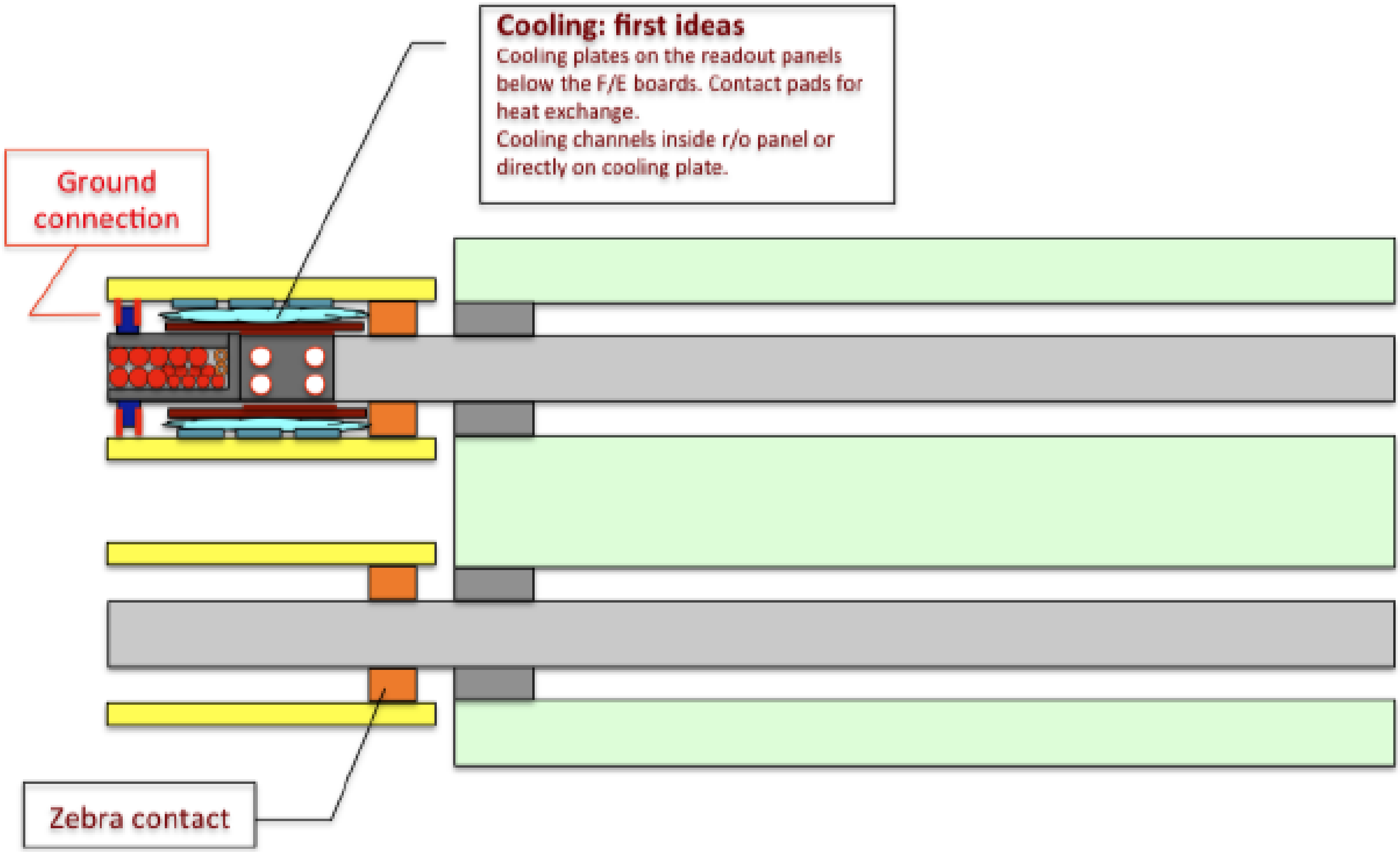
A Cooling System for NSW Micromegas

Starting Point: Conceptional drawing from Jörg:



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Input for the conceptual design:

- Dimensions of FE boards 50mm x 150mm
- Thickness of readout panel 10mm(+Skins?)
- Guessed from sketch: hight of Zebra connector (=6mm)
- Length of Chamber edges 3.6/3.7 m (small/large sector)
- Thermal budget (input from electronics group):

Unit	contains	Power VMM	Total Power
channel		8 mW	13 mW
chip	64 channels	512 mW	800 mW
FE-card	8 chips	4.096 W	6.4 W
plane	16 FE-cards	66 W	133 W
cooling pipe	2 planes	131 W	266 W
quadruplet	2 cooling pipes	262 W	532 W
sector	2 quadruplets	524 W	1.064 kW
wheel	16 sectors	8.389 kW	17.0 kW
SW system	2 wheels	16.8 kW	34.1 kW

VMM only!

includes trigger and data link electronics

Numbers doubled this week because power converters etc. were not yet included!

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Calculate required cooling:

$$\frac{dV}{dt} = \frac{dQ/dt}{c_m \cdot \rho \cdot \Delta T}.$$

dQ/dt: rate of heat generation = electrical power
c_m : heat capacity of water
ρ: density of water = 1 kg/ℓ
ΔT: water warming up temperature difference

Initial temperature of cooling water: 17°C

Assume max water temperature: 20°C ⇒ ΔT = 3K

Water flow for 1 cooling pipe: 266 W ⇒ 21.5 mℓ/s = 77.4 ℓ/h

(here I assume that the pipe runs down one side of the chamber and back up on the other side)!

Additional input:

- Try to avoid the Reynolds limit of turbulent flow to dimension cooling channels

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Transfer of heat from the chip to the water:

- need to traverse several materials:
  - wall of cooling pipe (copper)
  - nonconducting elastic medium with good thermal conductivity
- materials act as „heat flow resistors“, arranged serially
- thermal conductivities of some materials:
  copper: 400 W/mK
  typical plastic material: 0.2 W/mK
  special „gap pads“ for electronics: 1...6 W/mK

soft ... hard

➡ thermal resistance of copper negligible

➡ 800 mW/chip + 1mm soft material + $(1.3\text{cm})^2$ chip area ⇒ $\Delta T = 4$ K

➡ additional temperature drop by thermal „contact resistances“!

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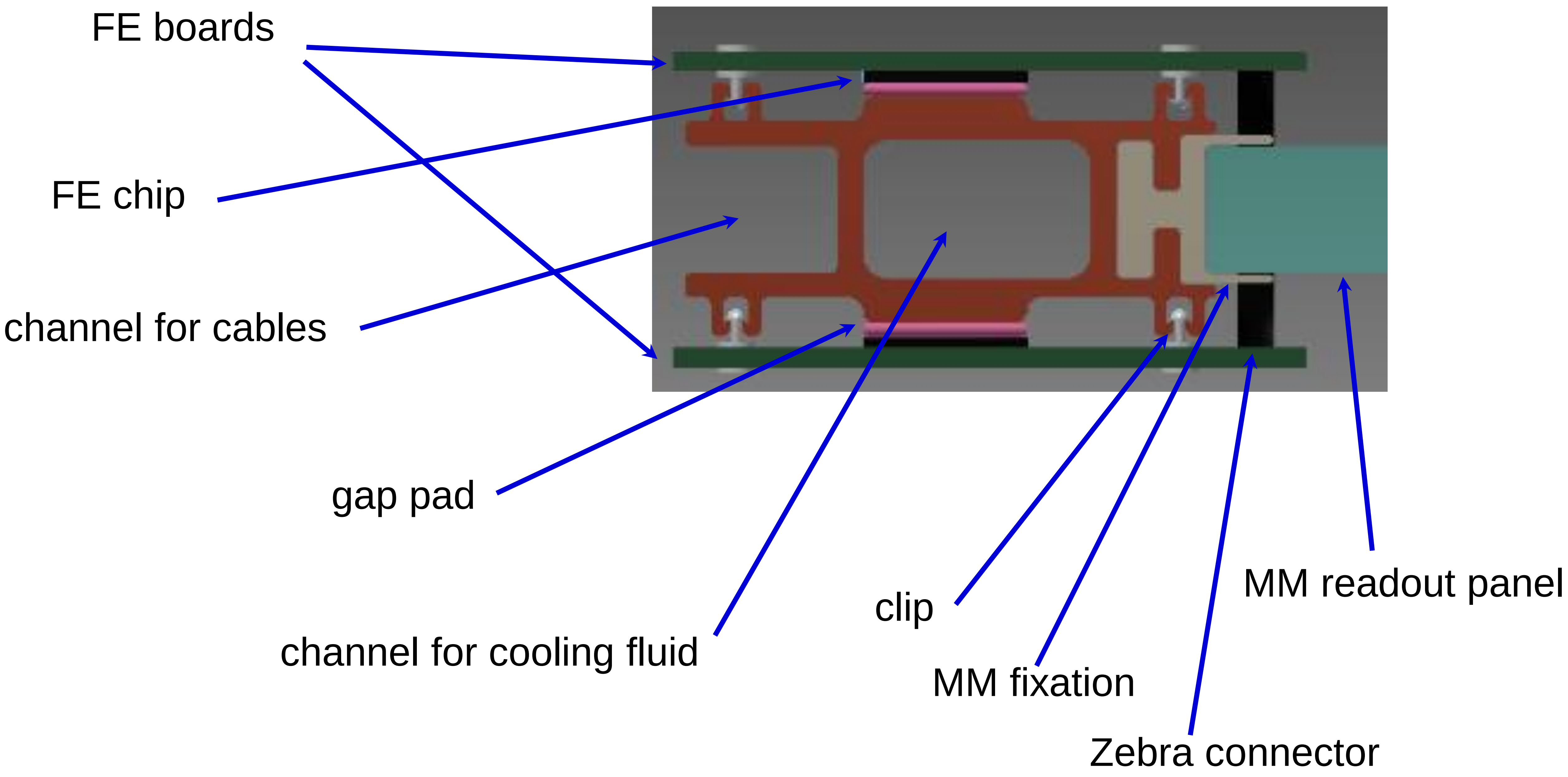
Proposed conceptional solution with a copper profile:



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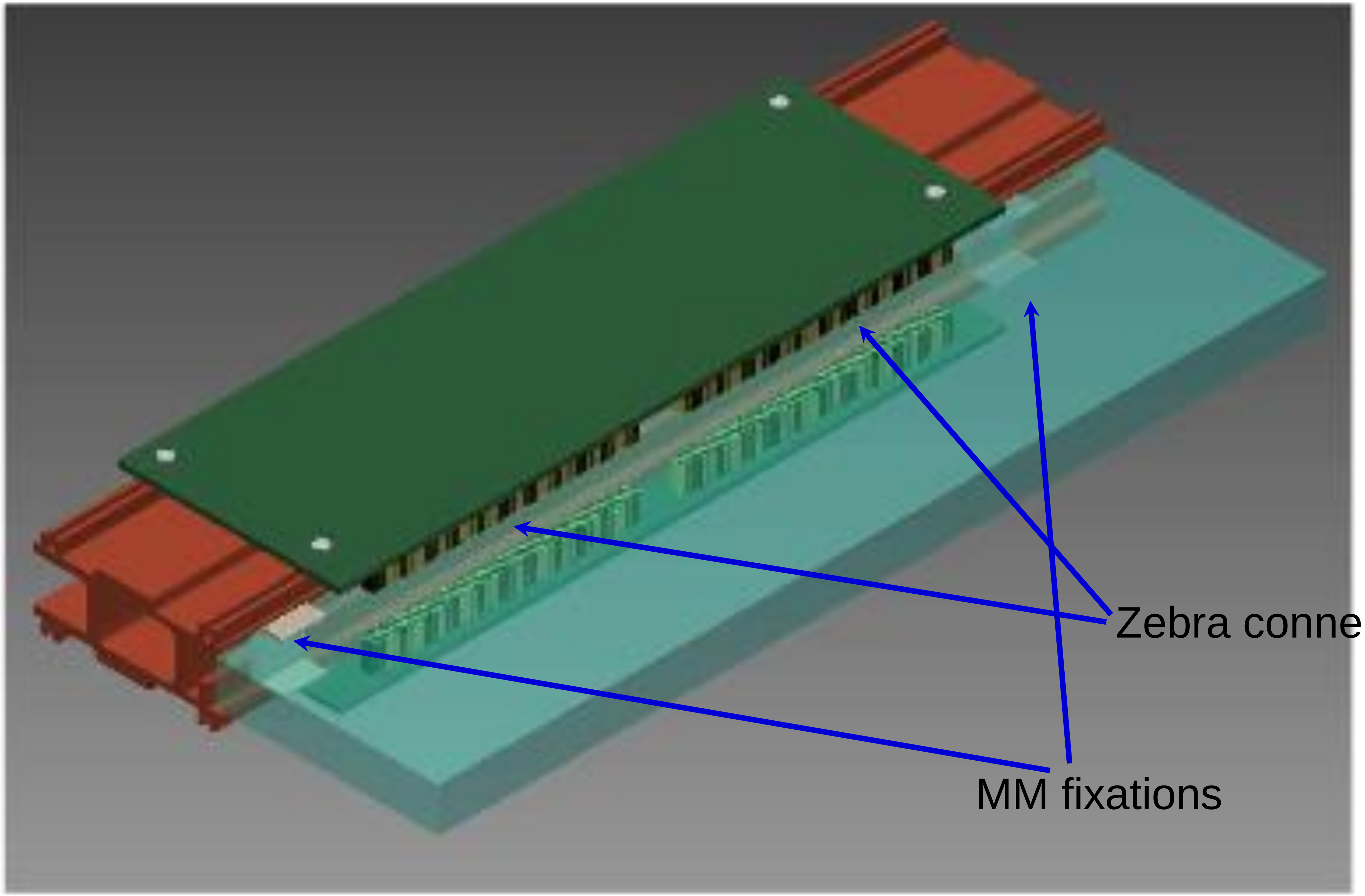

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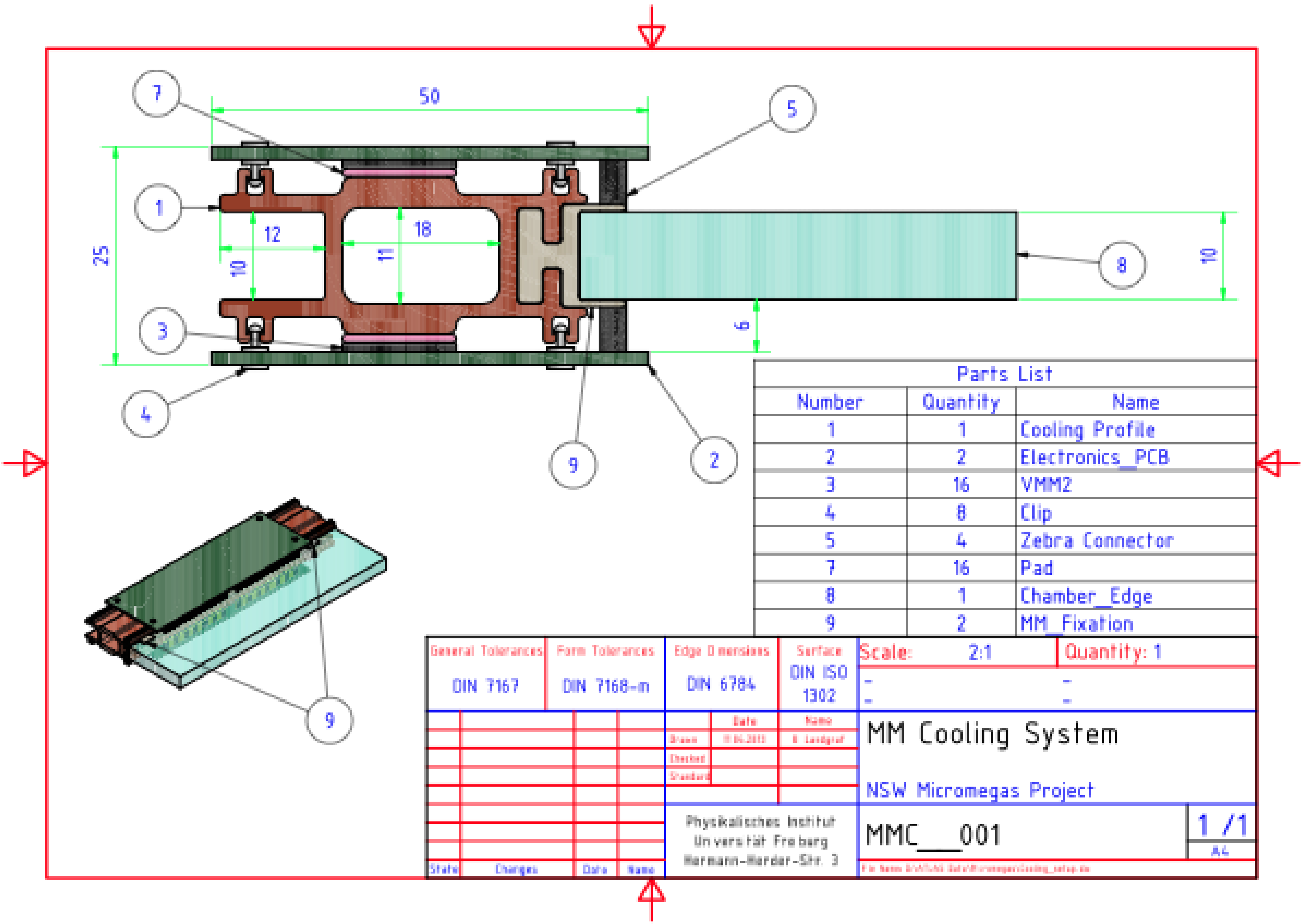

Parts List		
Number	Quantity	Name
1	1	Cooling Profile
2	2	Electronics_PCB
3	16	VMM2
4	8	Clip
5	4	Zebra Connector
7	16	Pad
8	1	Chamber_Edge
9	2	MM_Fixation

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<u>Concluding remarks:</u>

- Loose connection to RO plane to avoid forces due to thermal expansion (with small clearance to position zebra connectors properly)
- Clips have to provide some pressure to make good contact with gap pads and with Zebra connectors (elastic materials)
- Current profile design: 2,5 kg/m

  ⇒ total mass 9.25 kg/channel + water weight

  ⇒ need some other fixation than RO plane!
- Many dimensions not yet final, need to wait for design of FE electronics card to proceed