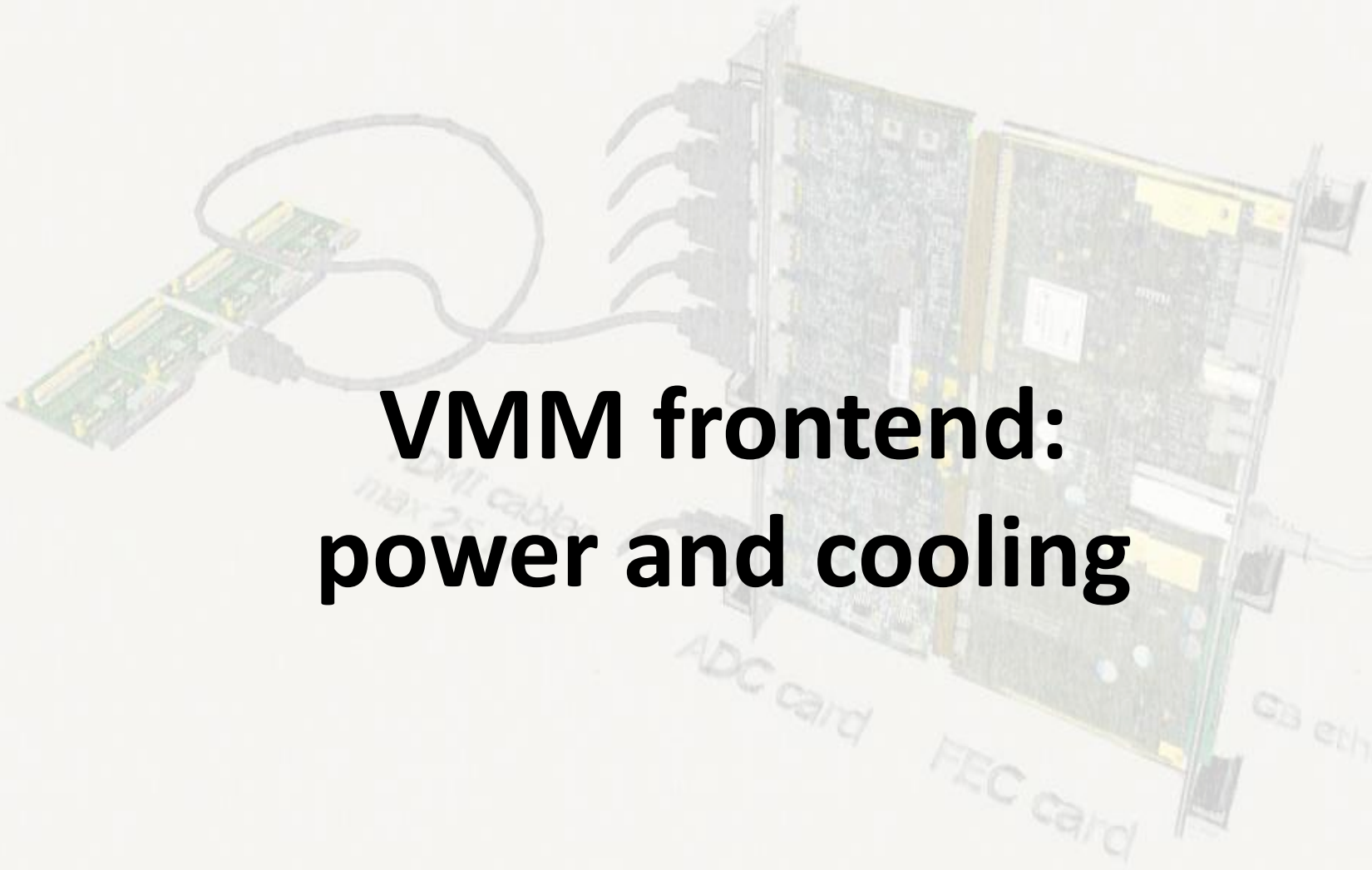


VMM frontend: power and cooling

SRS frontend status

VMM3a SRS hybrid:

- 25 hybrids pilot production received (for GDD users)

- 25 Wafers ordered with shared contributions from RD51-CERN, Bonn Univ, ESS -Lund

- minor PCB revisions (PCB thickness) for mass production 4Q19

- Addition of VMM cool wrapper (this talk)

-SAMPA SRS hybrid:

-Collaboration was set up between S.Paolo and CERN GDD

-start with 64-channel version same footprint as APV/VMM

VMM3a pilot production

4 pre-production already in use, 20 under acceptance test

Power consumption VMM hybrid

- **Chip Power 1 x VMM3a**

  1.2V @ ~ 800mA from external P2 power line through 4 LDO's

  Σ ~ 1 Watt

- **Chip power Spartan FPGA + Flash**

  2.5V @ 120mA from external P1 power line through 1 LDO

  Σ ~ ¼ Watt

- **LDO linear power converters + uPower ADC**

  2V(P2) -> 1.2V : 0.8V*800mA =0.64W

  3.3V(P1)->2.5V : 0.8A*120mA = 0.1 W

  2 x uADC 2.5V * 1mA -> neglegible

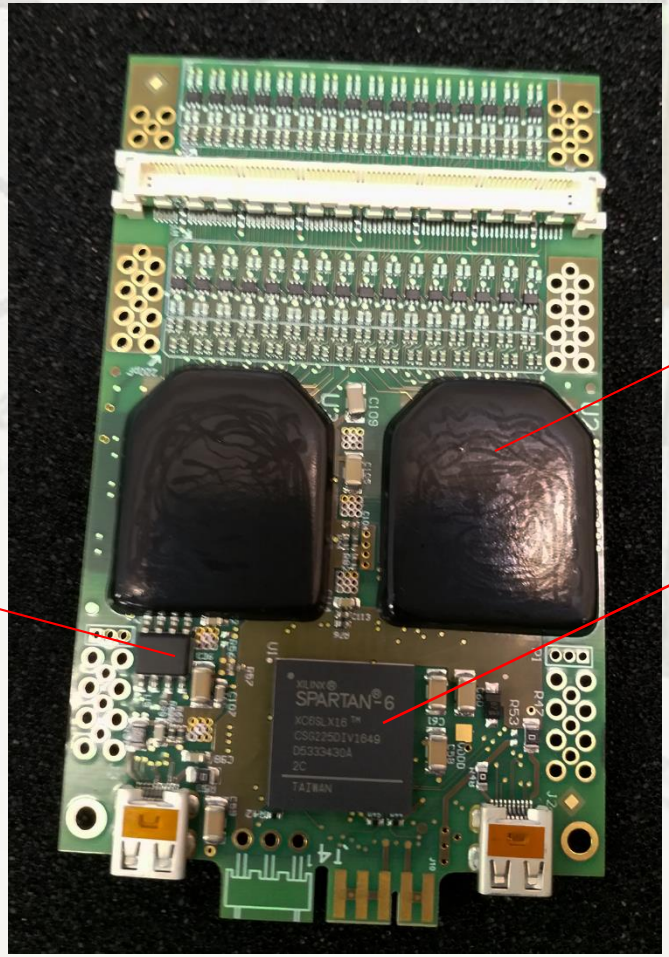
  Σ ~ ¾ Watt

- **Single VMM3 hybrid (total nominal):**

  2 x VMM3 + Spartan + LDO's + uADCs

  Total: ~ 3 W

Bottom side dissipation



2x VMM3a ASIC
below Globtop (2W)

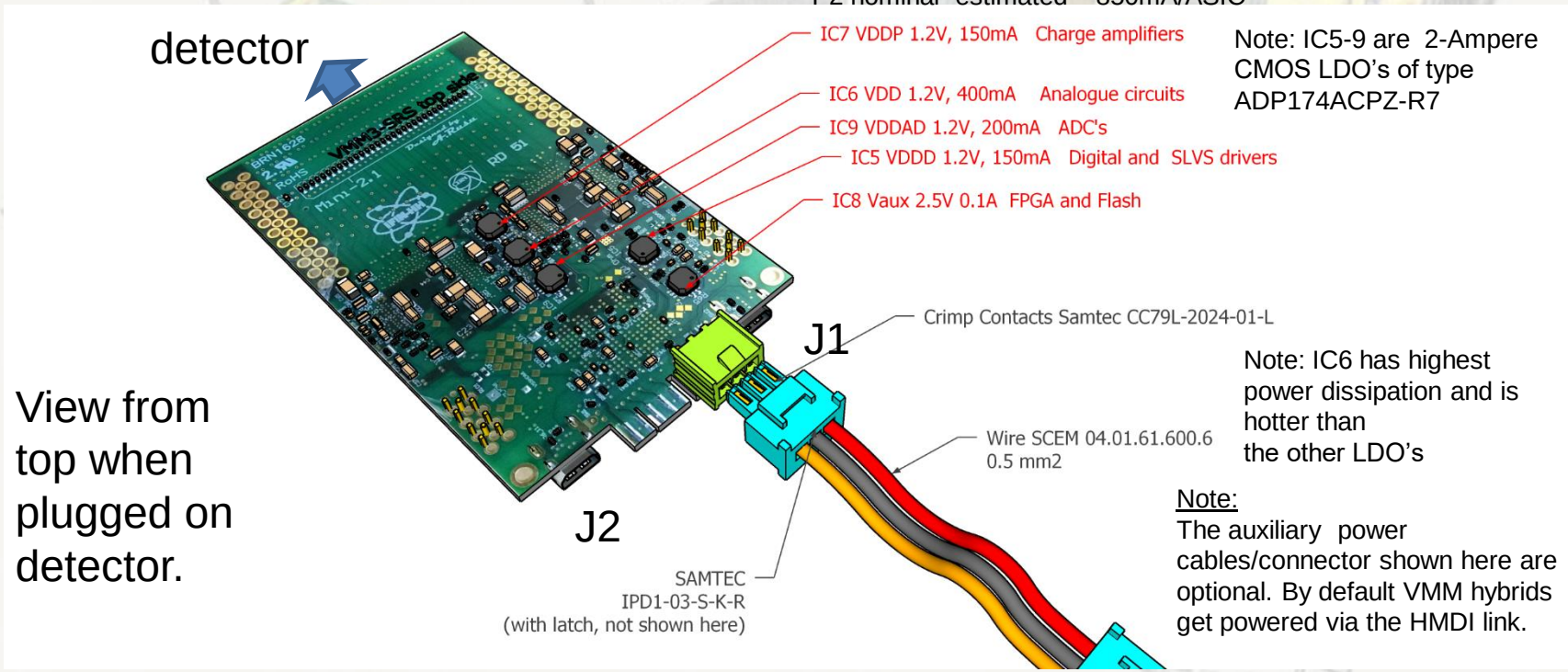
Spartan FPGA
(1/4 W)

Flash
(1/10W)

Bottom-side dissipation O(2 ¼ Watt)

TOP side dissipation: 5 x LDOs

P2 nominal estimated ~ 850mA/ASIC



Top-side dissipation O(¾ Watt)

Cooling motivations

- ASIC lifetime

  (exponential) function of die temperature

  main factor electromigration fail fraction

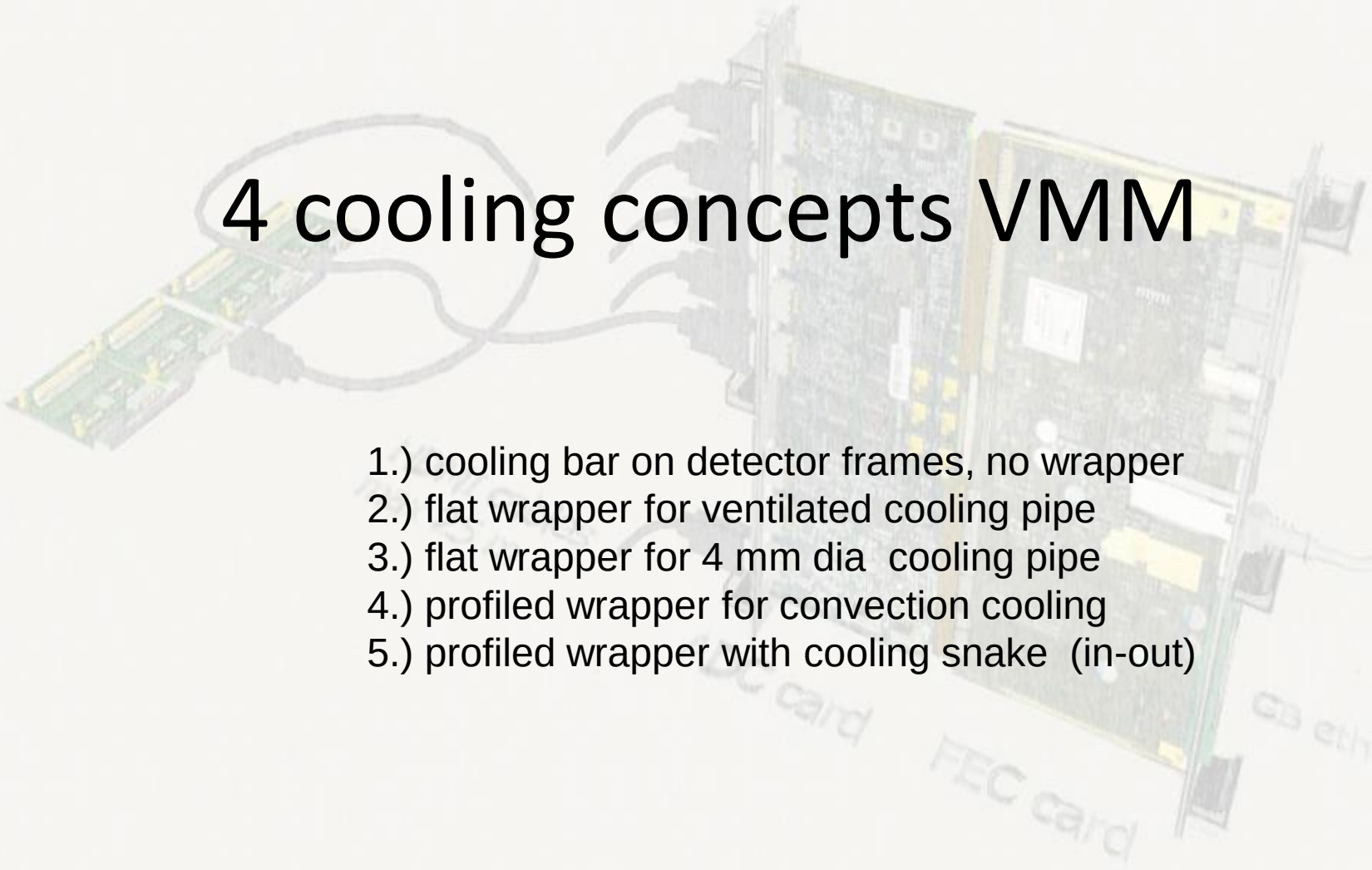
  VMM specs recommended operation below 50 C
- Noise & gain

  ENC @ preamplifier, leakage currents increase with T

  gain defining capacitor changes with T
- Detector gain

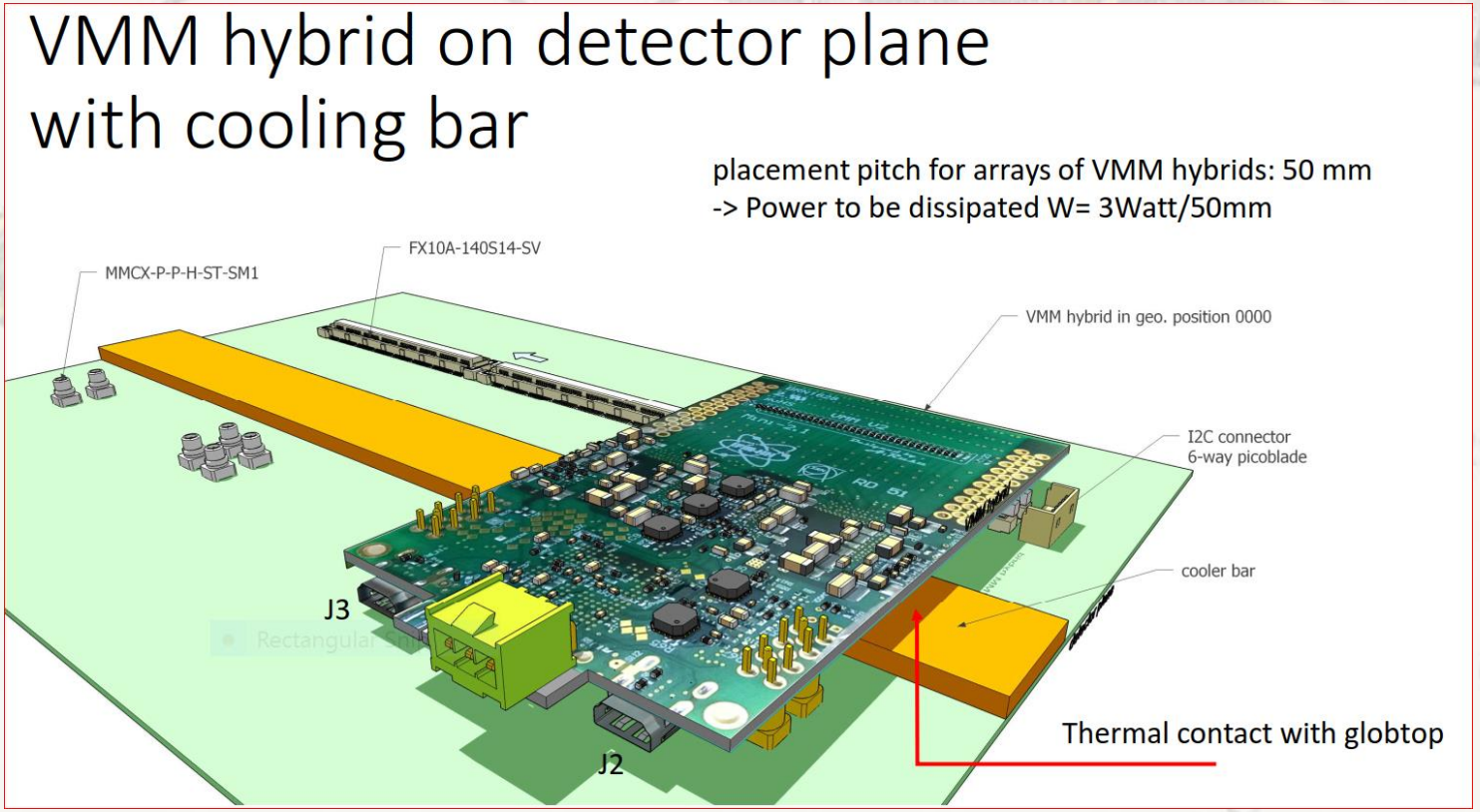
  keep constant and in ambient range (20C)

4 cooling concepts VMM



1.) cooling bar on detector frames, no wrapper
2.) flat wrapper for ventilated cooling pipe
3.) flat wrapper for 4 mm dia cooling pipe
4.) profiled wrapper for convection cooling
5.) profiled wrapper with cooling snake (in-out)

1- cooling bar below hybrid (without wrapper)



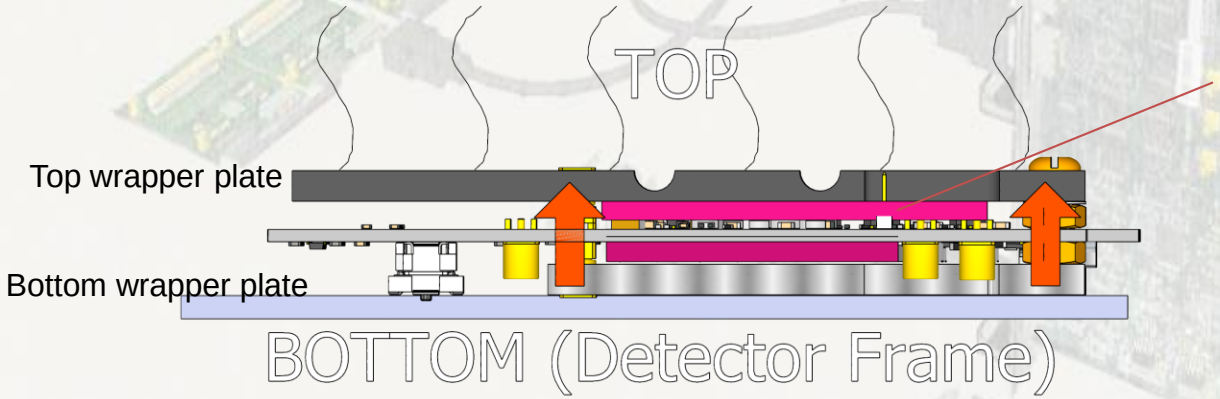
so far no known detector implementation

VMM cool wrapper concept

heat transfer bottom to top

- Heat from VMMs transferred from bottom to top side via:

  4 metal heat contacts + heat conductive tape/ Si compound



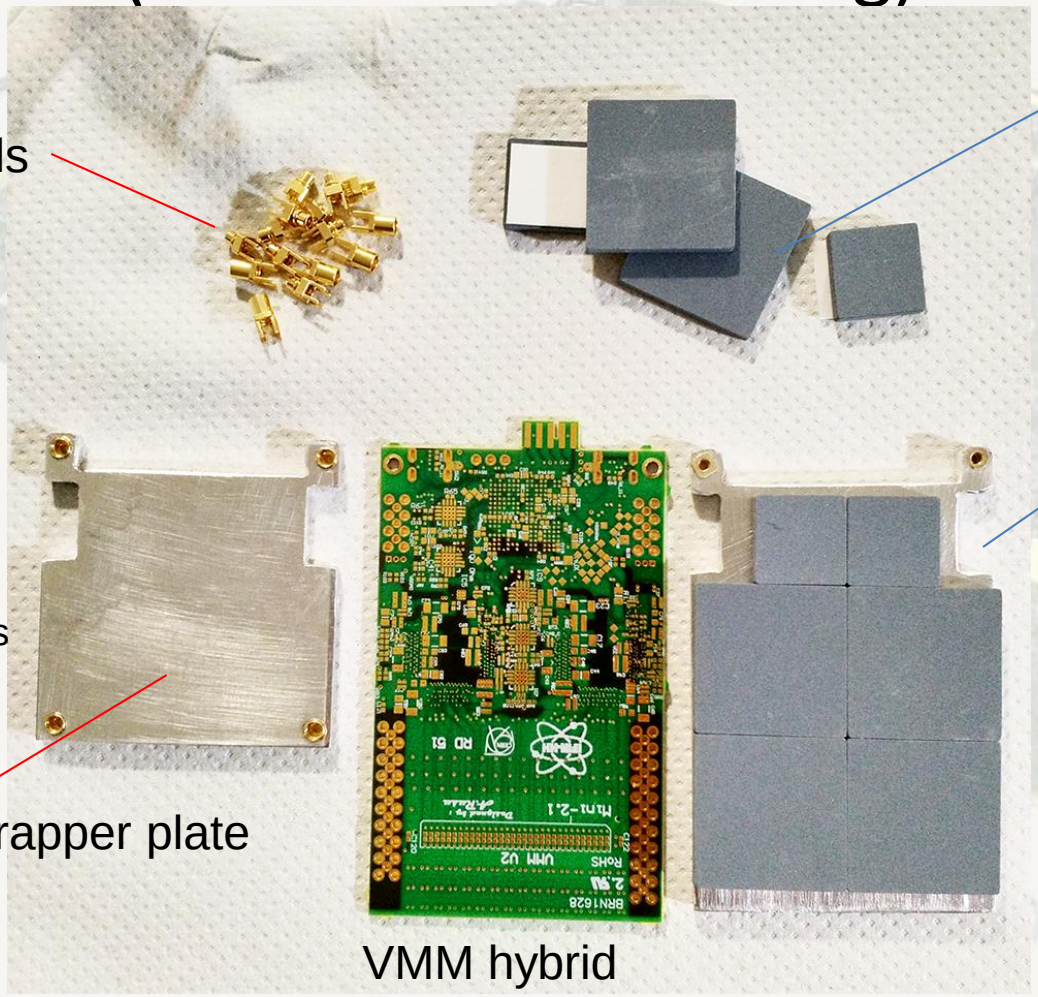
- VMM junction temperature stabilizes at O(45..55 C) with

  a.) ventilated flat wrapper: T_{junct} ~ 47 C

  b.) profiled, black wrapper, convection-only: T_{junct} ~ 55 C max

flat wrapper parts

(ventilated air cooling)



MMCx shells

flat
ceramic coolers
5..6 W/mK
if ventilated

Si-grease on hot chips
2-3 W/mK

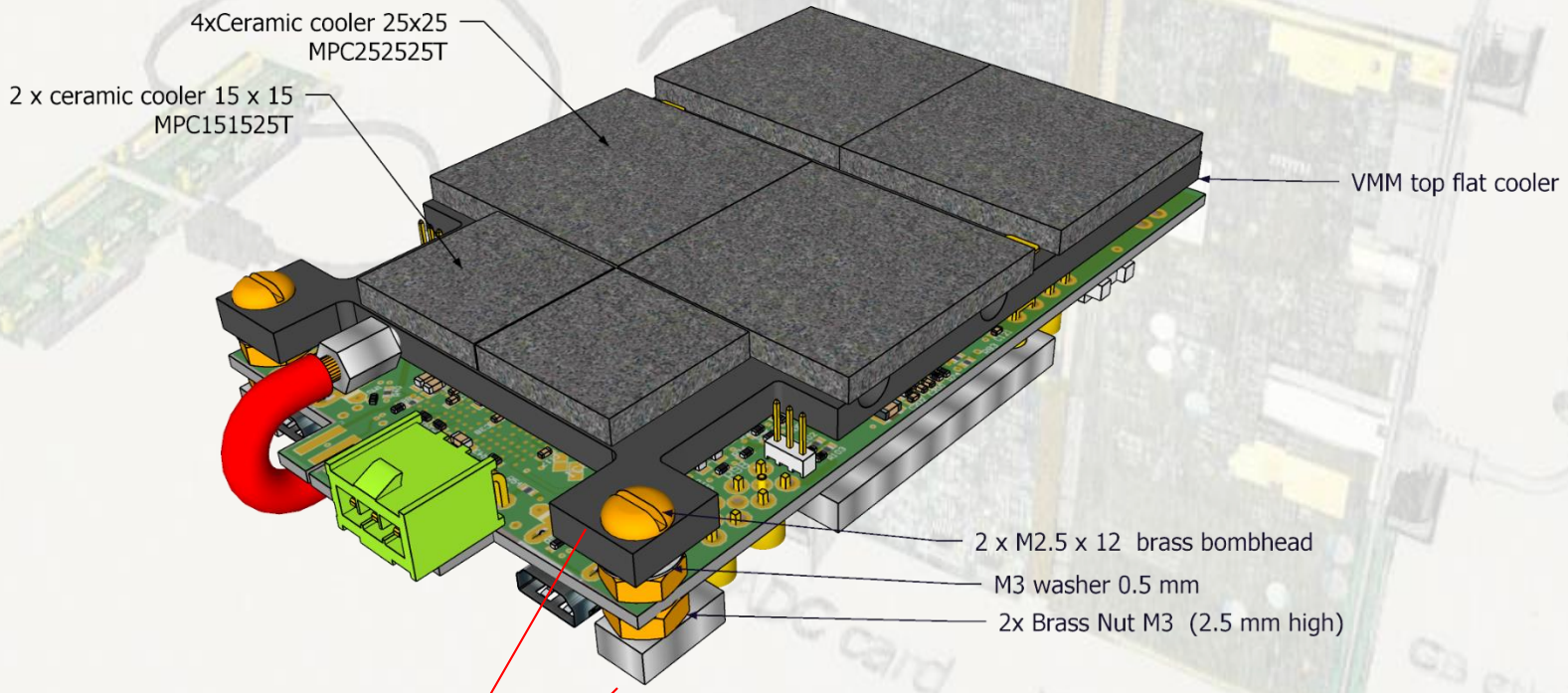
Ceramic coolers
tape-glued on
top ALU wrapper

Bottom ALU wrapper plate

VMM hybrid

flat wrapper topside assembled

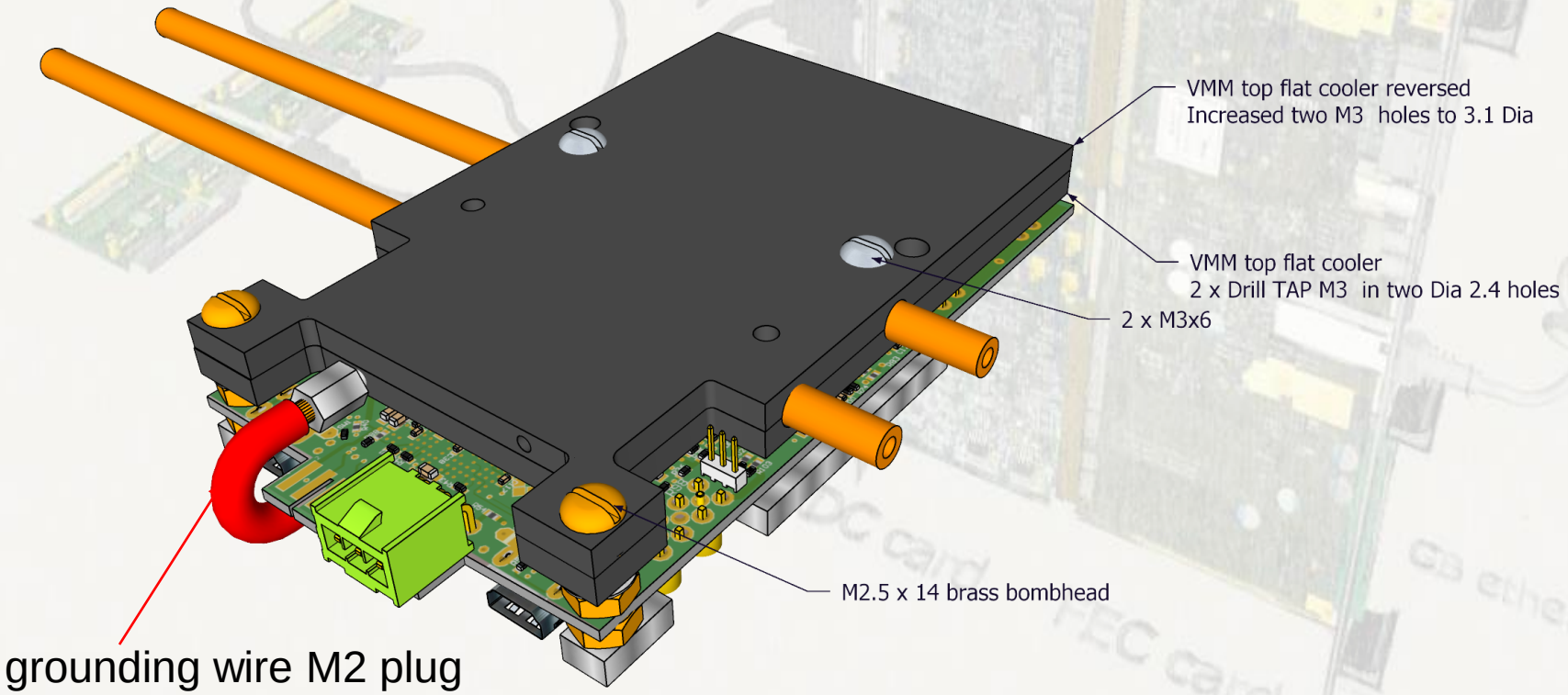
(for ventilated airflow)



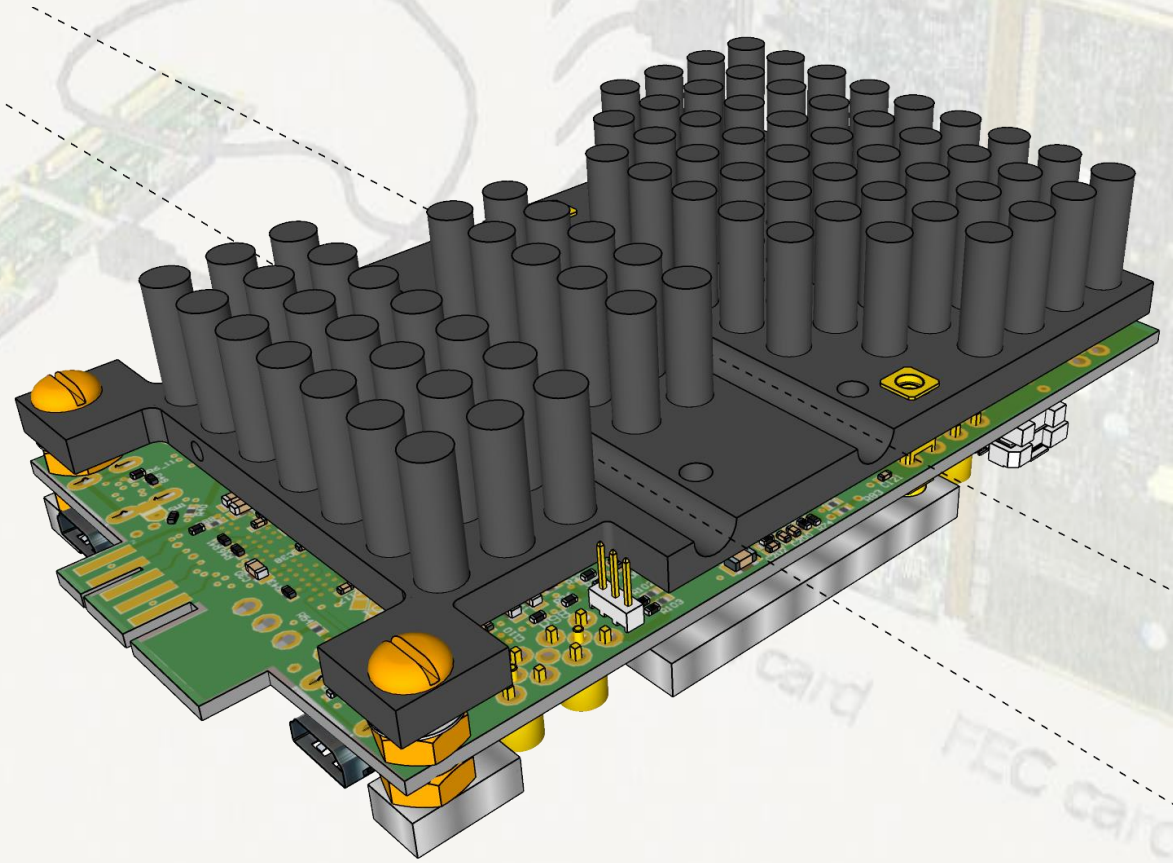
Top wrapper plate

Bottom wrapper plate

flat wrapper sandwich
(4 mm dia cooling pipe)



profiled wrapper
(convection cooling)

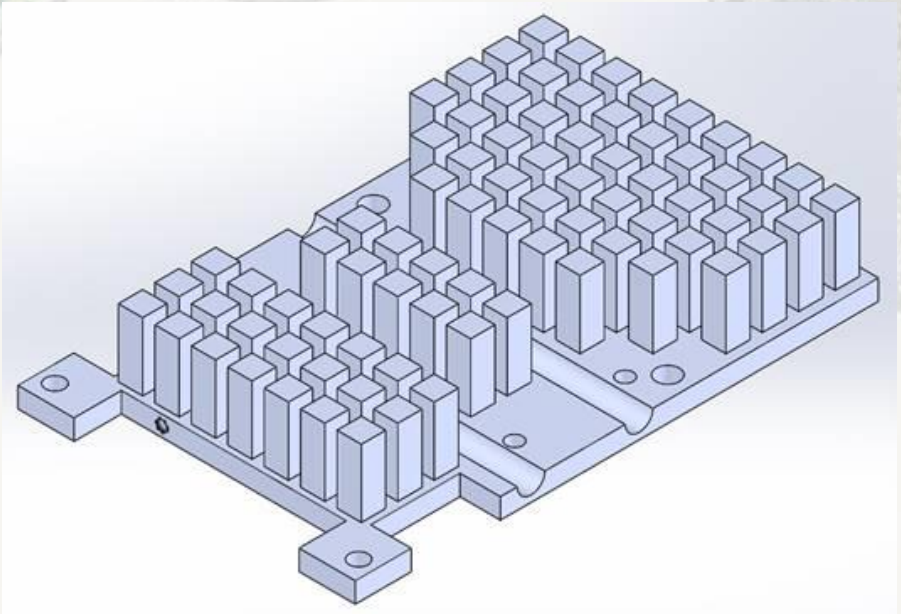


Preferred solution without ventilation

profiled wrapper
= custom production

Top side profiled cooler

commercial offer (Radian Heatsinks) modified from round to square pillars (cost reason) :



NRE ~ 1kFs
~ 5 Fs/cooler > 500

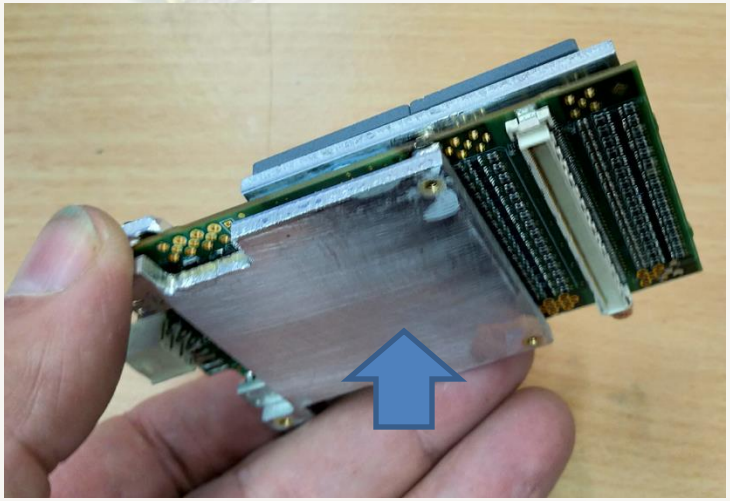
Order 5 samples (NRE free)
for tests

bottom plate for all wrappers

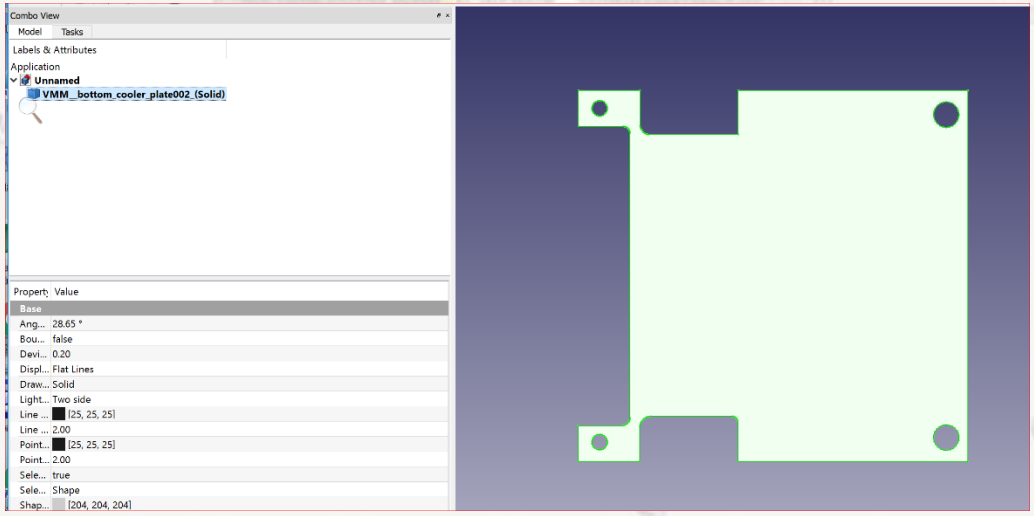
bottom side plate: only holes, no profiles

ALU prototype designed and 10 pc produced at CERN with water cutting

~ 15 Fs/ pc , try to find cheaper for volume (500+) production

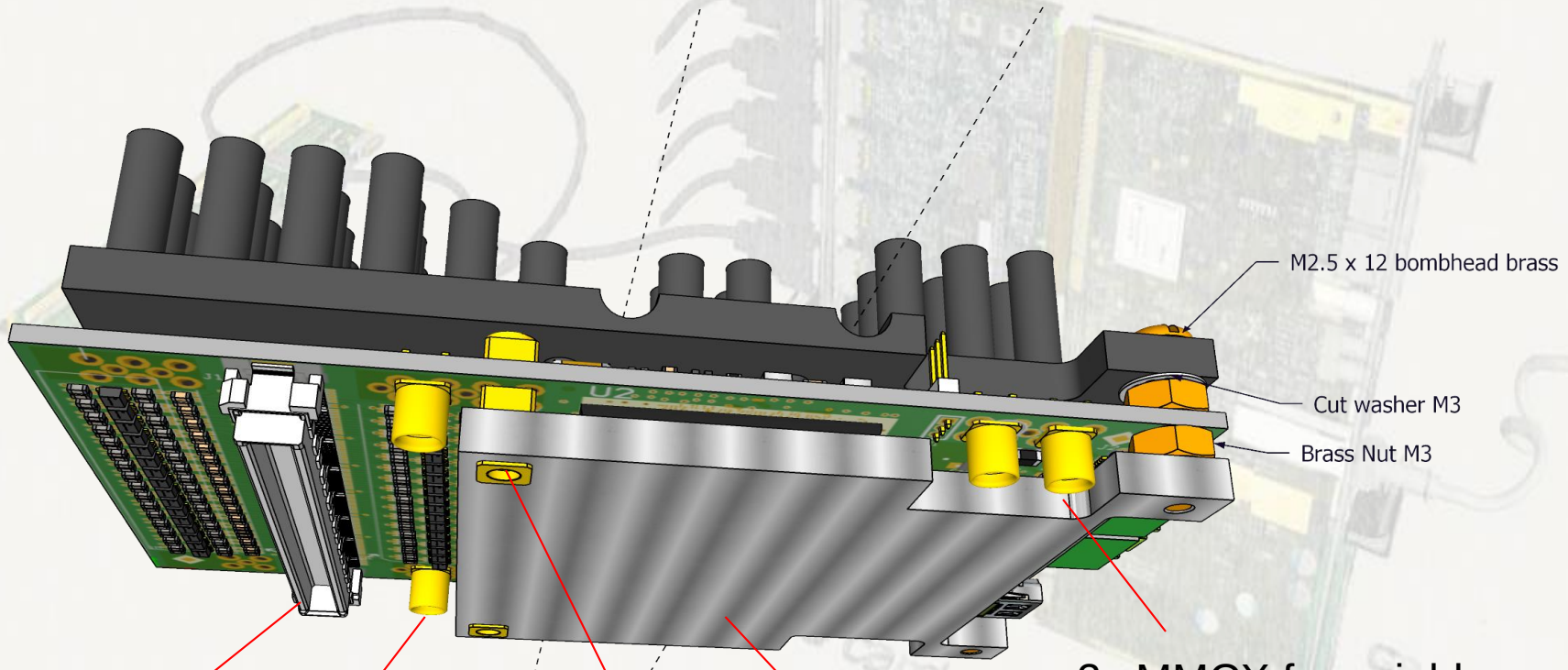


Bottom plate



.dxf file for water cutting machine

Bottom side hybrid with VMM wrapper



HRS connector

MMCX grounding shell

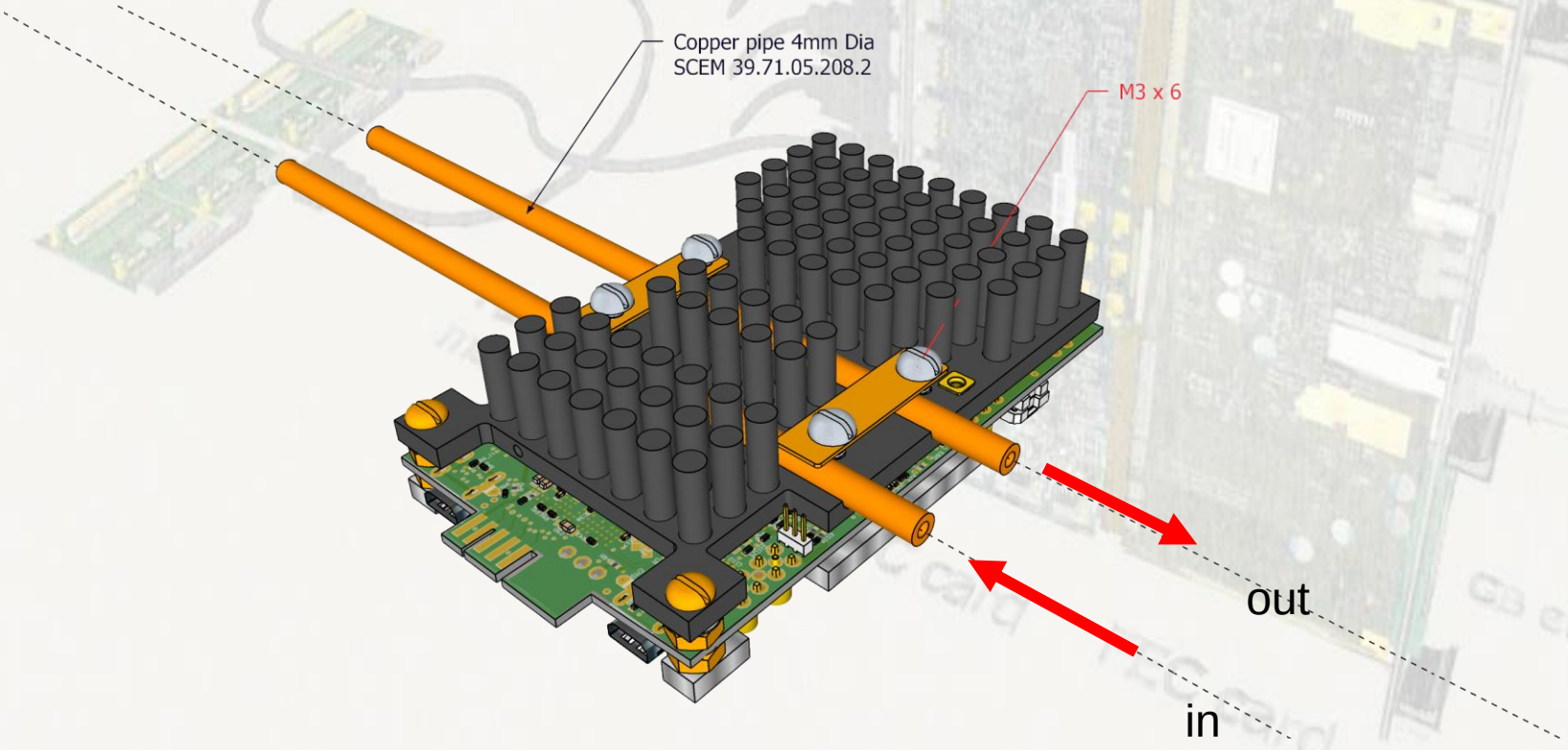
Pressfitted
MMC shells

2x MMCX for neighbor
VMM cluster feature

3mm ALU wrapper bottom plate
(direct thermal contact with VMMs)

profiled VMM wrapper Plus

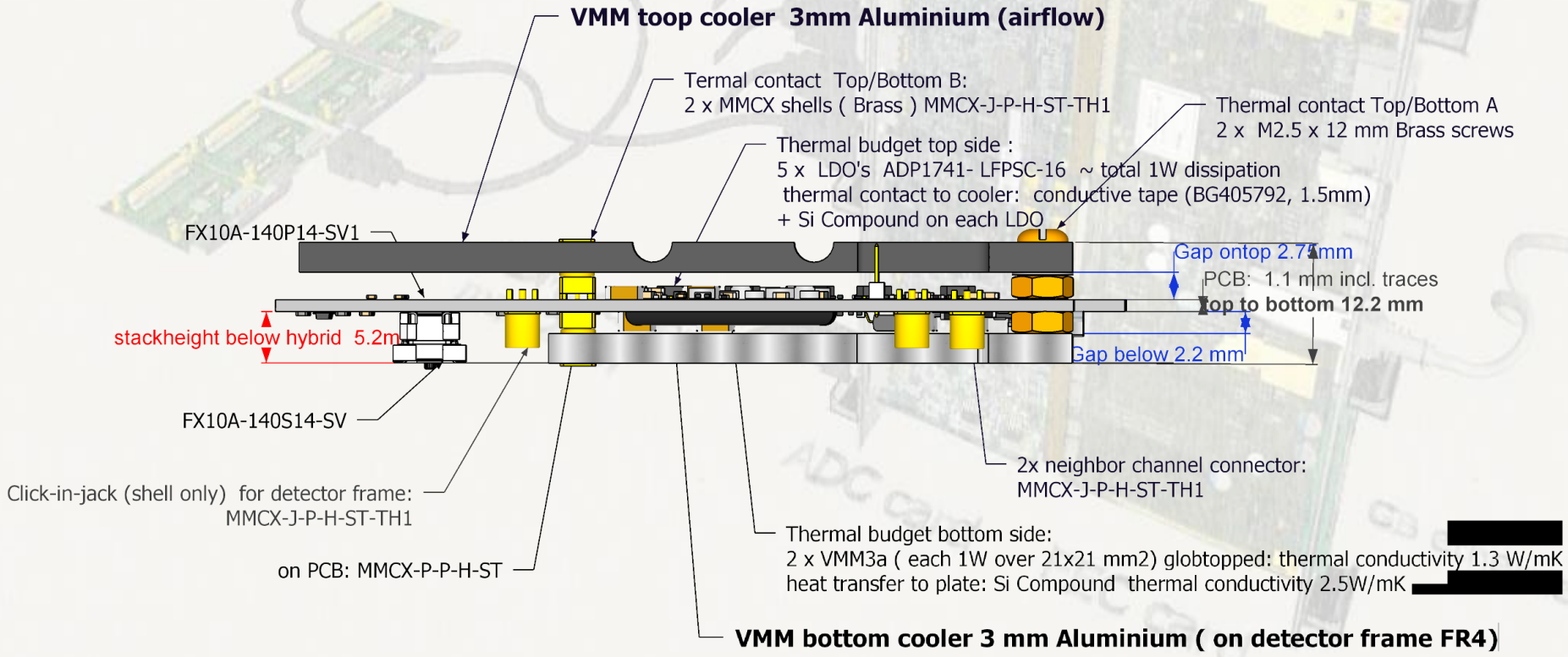
(cooling towers + cooling snake I/O)



Probably onlt solution to keep VMM junctions at recommended O(40C)

➔ will be tested when custom profile cooler will be receicved

VMM cool wrapper
(all details)



Cooling tests

(Eraldo and Yan)

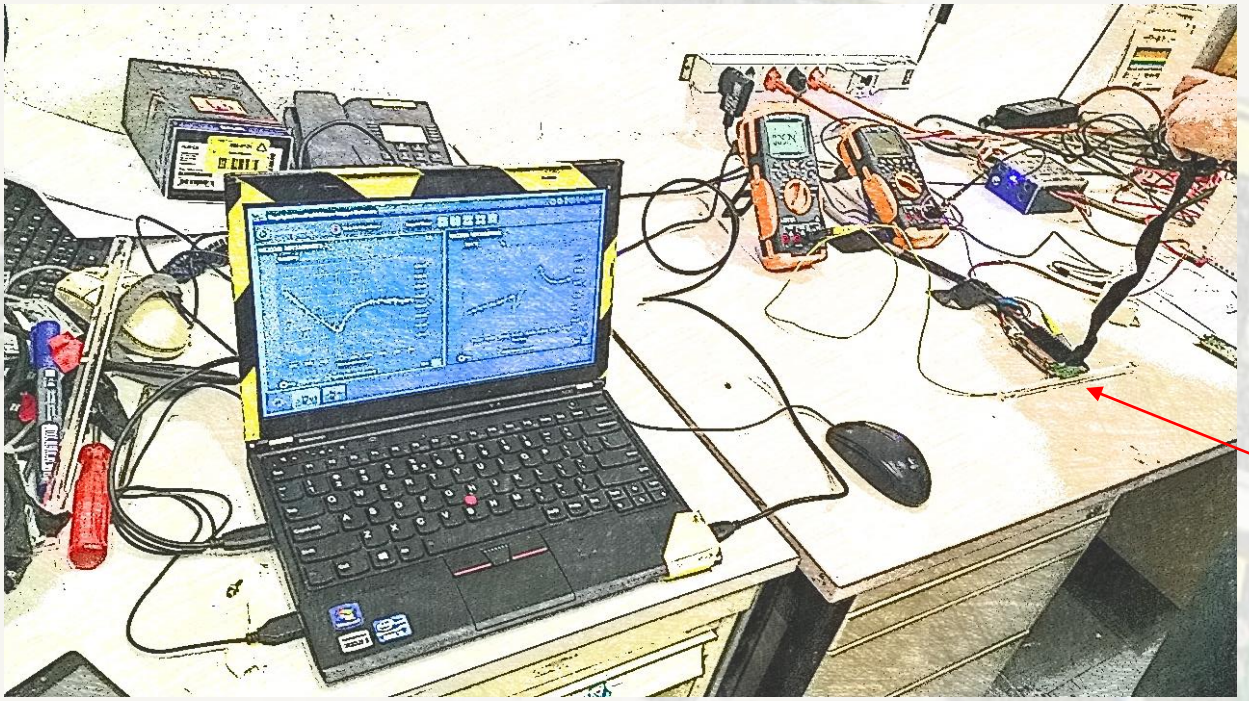


Photo: trending curves of internal + external temperatures

Temperature probes: Top, Bottom
VMM junction temperature via I2C readout of micro ADCs on VMM3a

Conclusions

VMM hybrids should not be used without cooling

A variety of VMM cooling solutions, tests ongoing, custom cooler parts on or

Small systems : convection cooling with profiled wrapper recommended

Medium size systems: ventilated flat wrapper appropriate

Larger systems: cooling pipes (4 mm Dia) with waterflow

Low noise systems: profiled wrapper with waterflow