Module cooling test and 2PCO2 system at ILC

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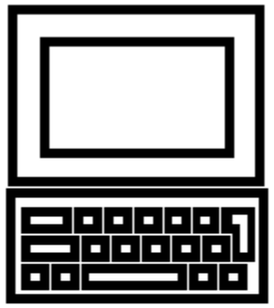
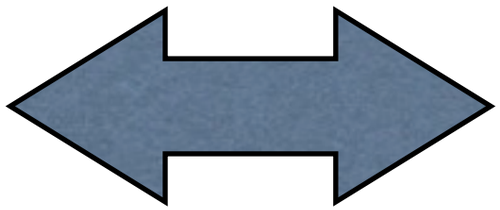
2012.3.26 LCTPC Collaboration MTG @ DESY

Contents

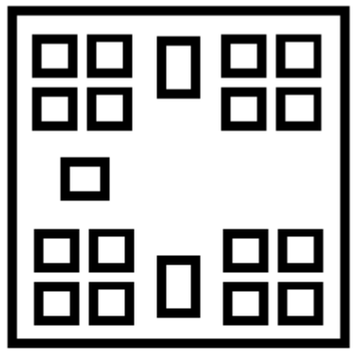
Thermal Test with AEP TB



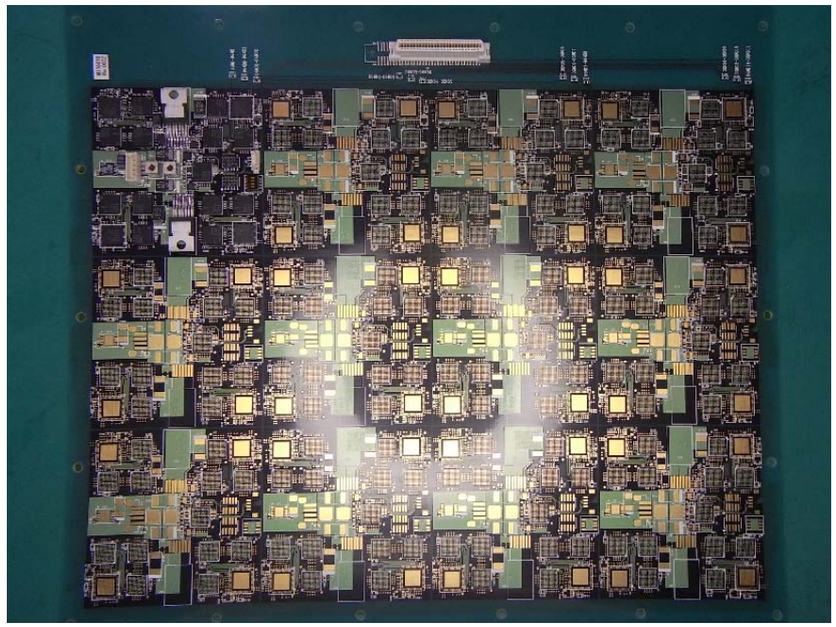
AEP TB
Simulation



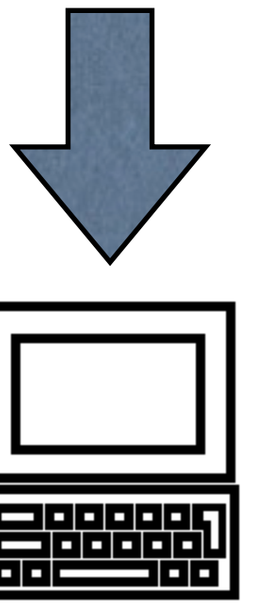
Establish
simulation
technique

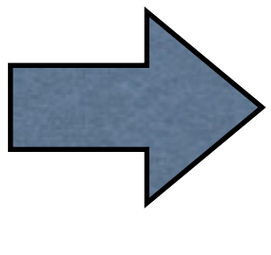


AEP TB
Measurement

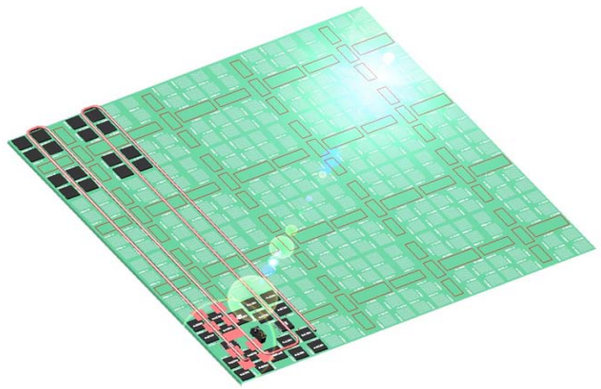


1-SModule mounted TB

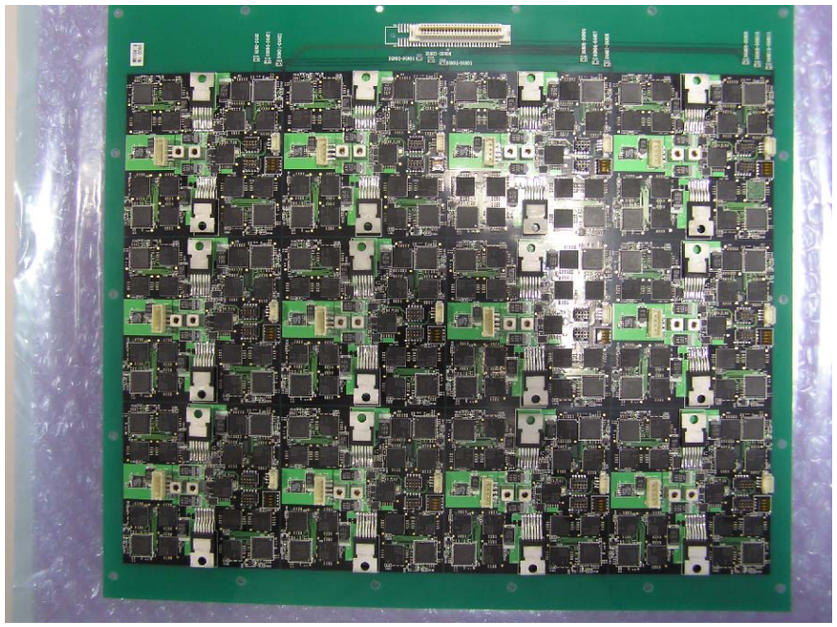




Real-AEP
Simulation



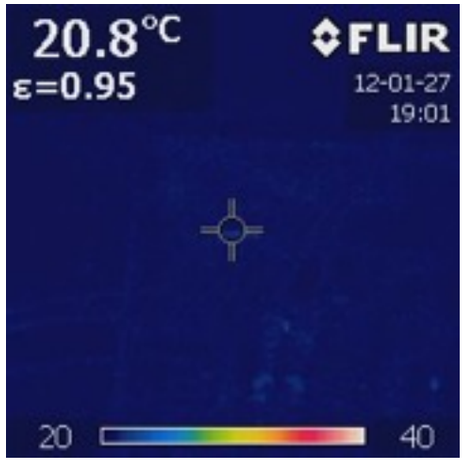
Real-AEP
Estimation



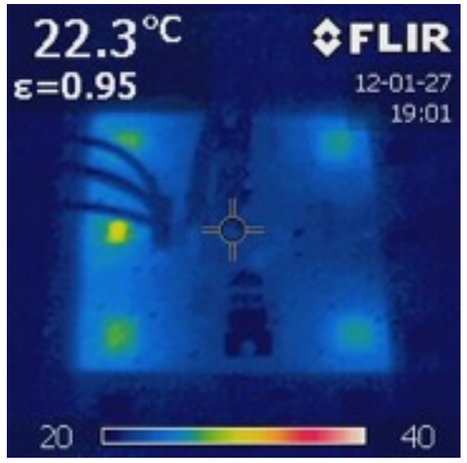
Fully mounted TB

Temperature Observation

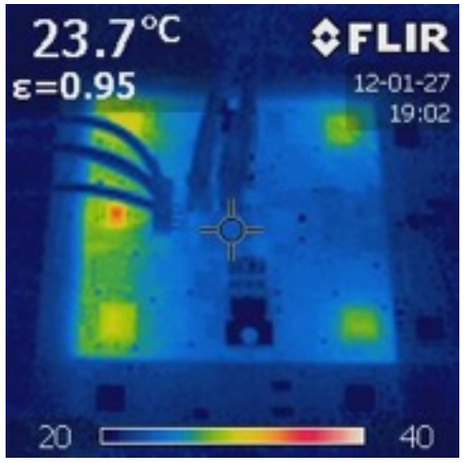
✓ Only ADC powered on.
✓ No power pulsing.
✓ No cooling devices.



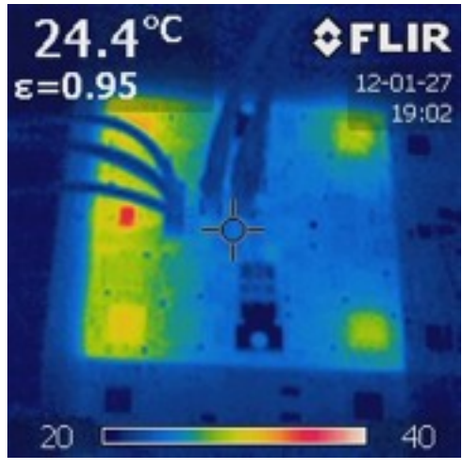
0 sec



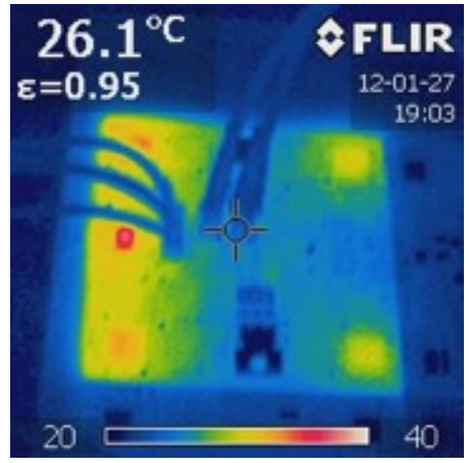
30 sec



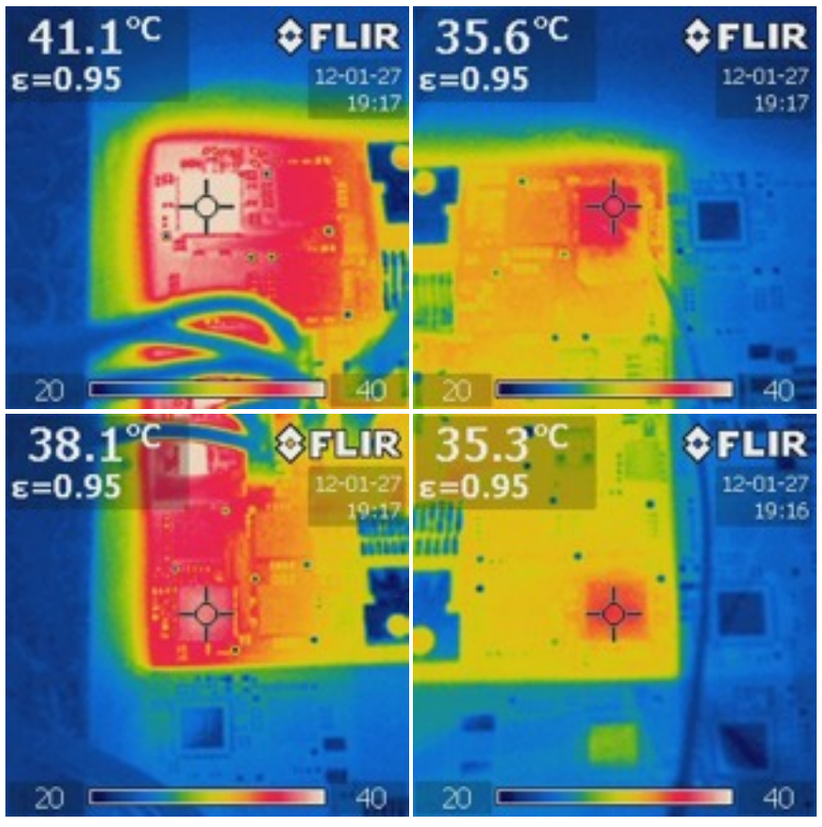
60 sec



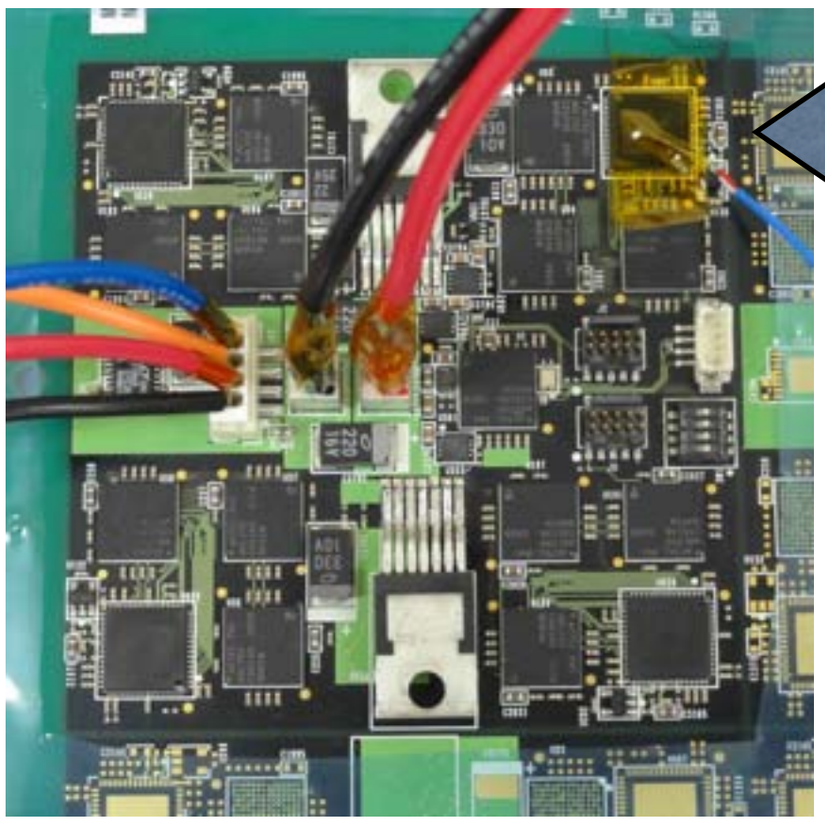
90 sec



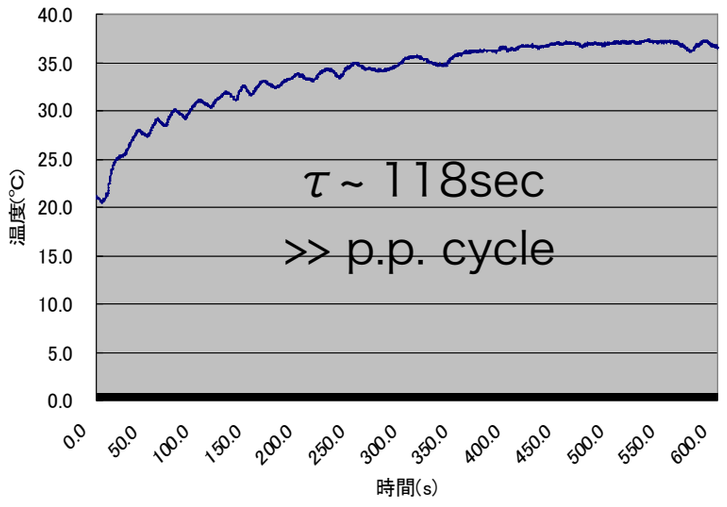
120 sec



after enough time (>5min.)



thermocouple

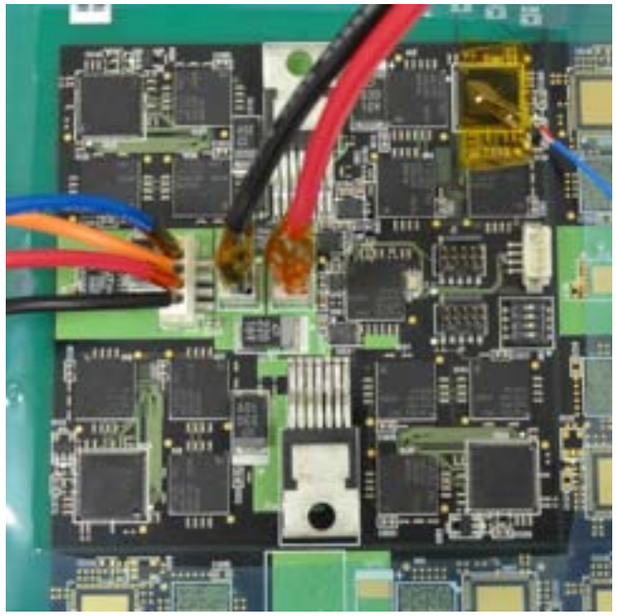


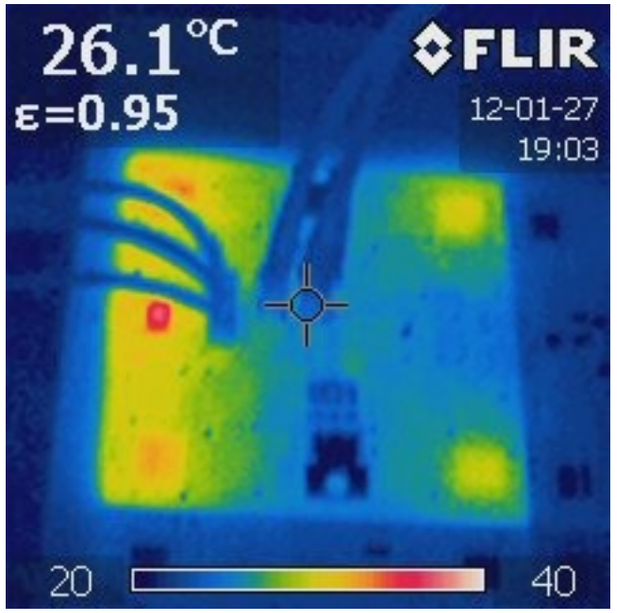
Comparison with simulation

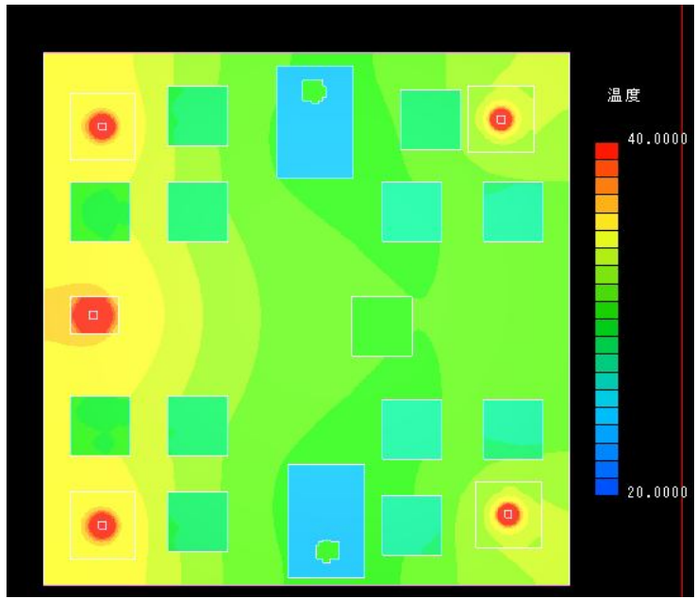
Observation

Simulation

Part side

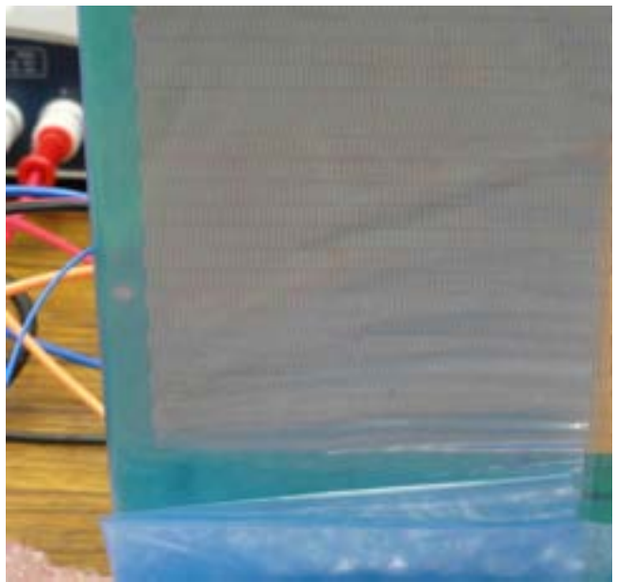


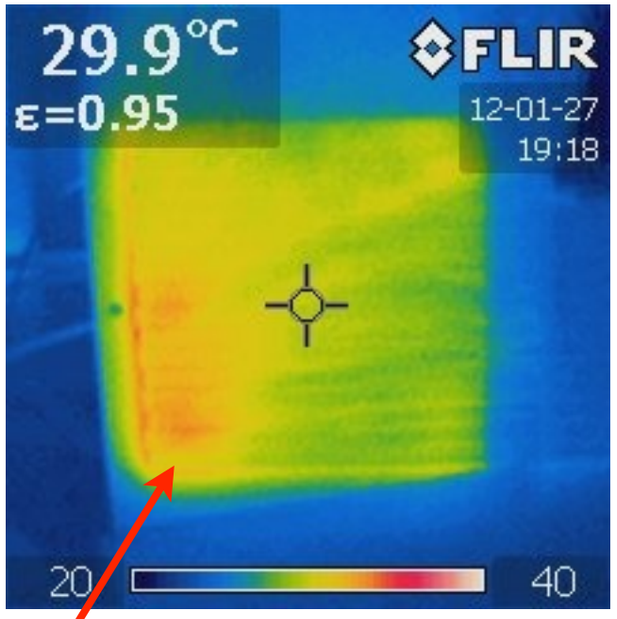


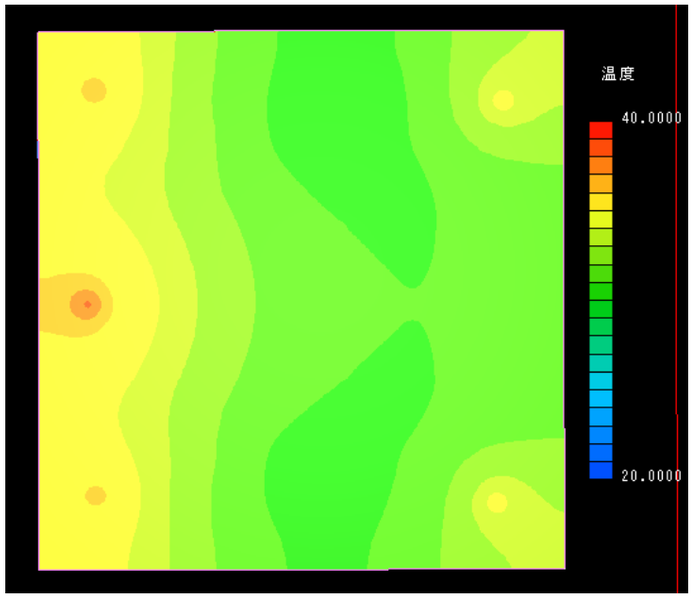


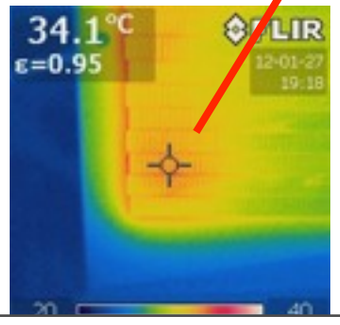
P_{tot} = 1.44W

Pad side





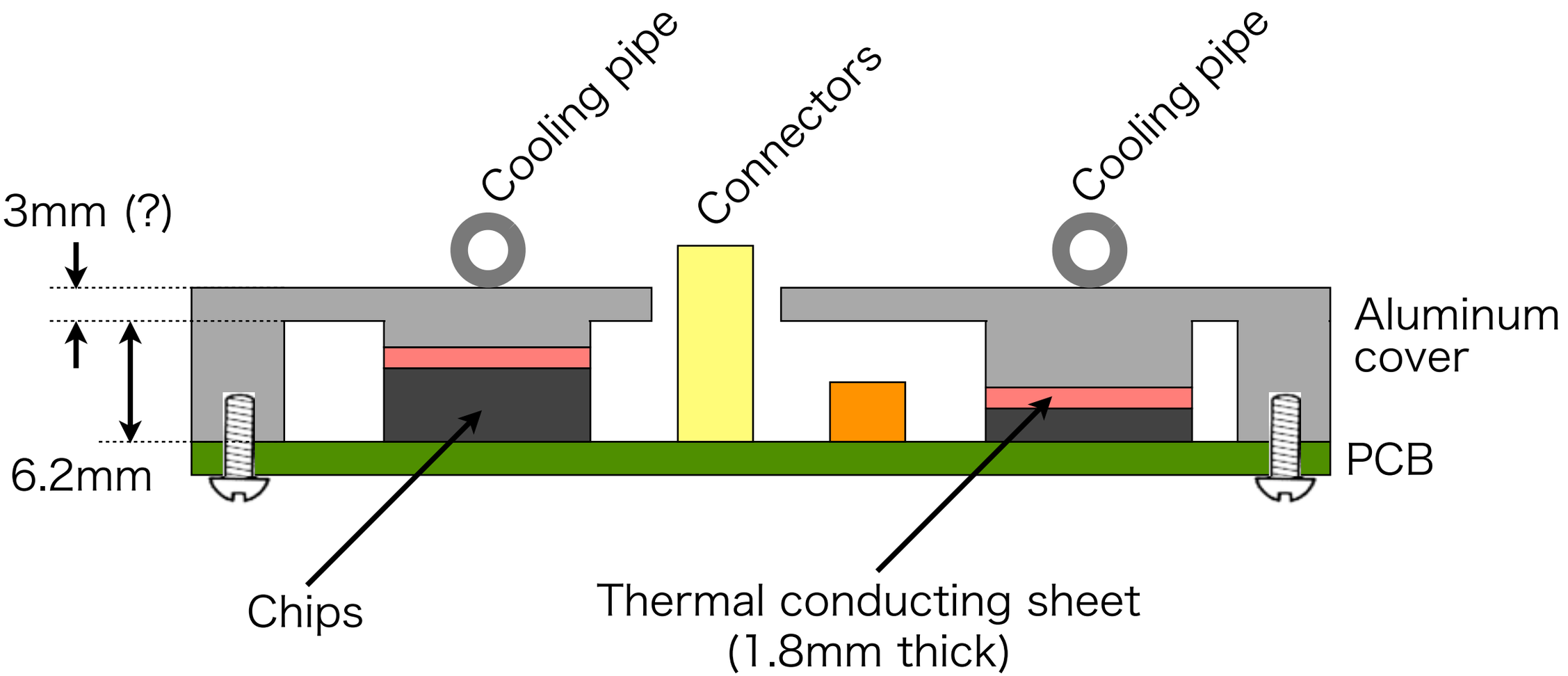




$$\Delta T \text{ will be } > 10\ [\mathrm{K}] \times \frac{57\ [\mathrm{W}]\ (16\ \mathrm{SALTRO's})}{1.44\ [\mathrm{W}]\ (\text{this experiment})} \times 1.5\ \%\ (\mathrm{PP}) = 5.9\ [\mathrm{K}]$$

(extrapolation to the case w/o cooling, w/ PP, w/ SALTRO64)

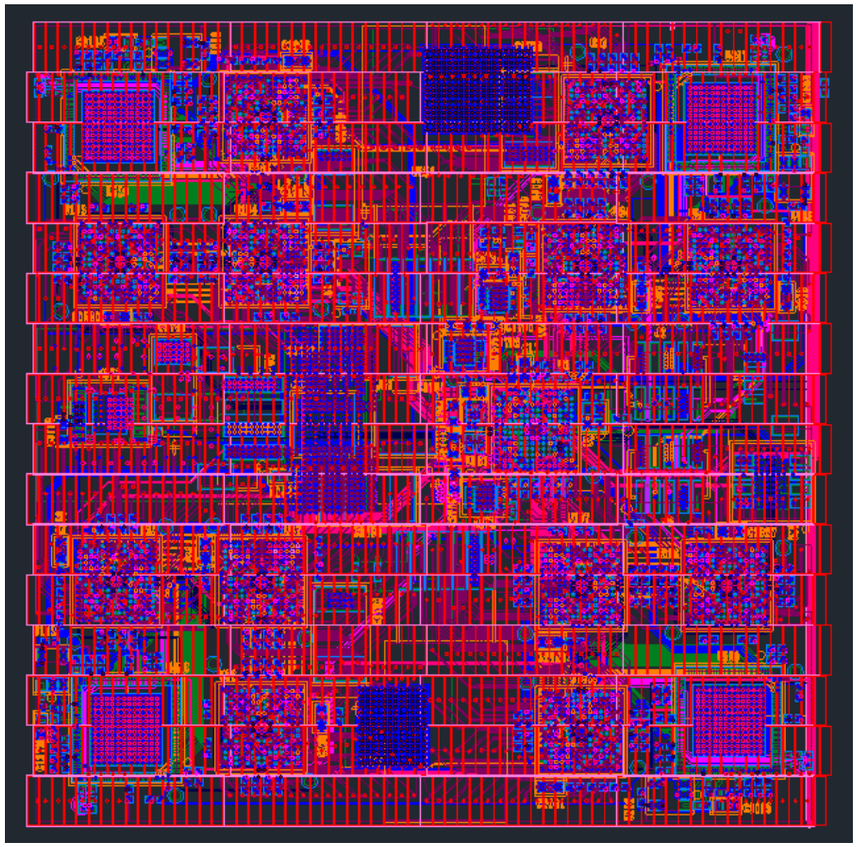
Cooling Device Specification



Contents

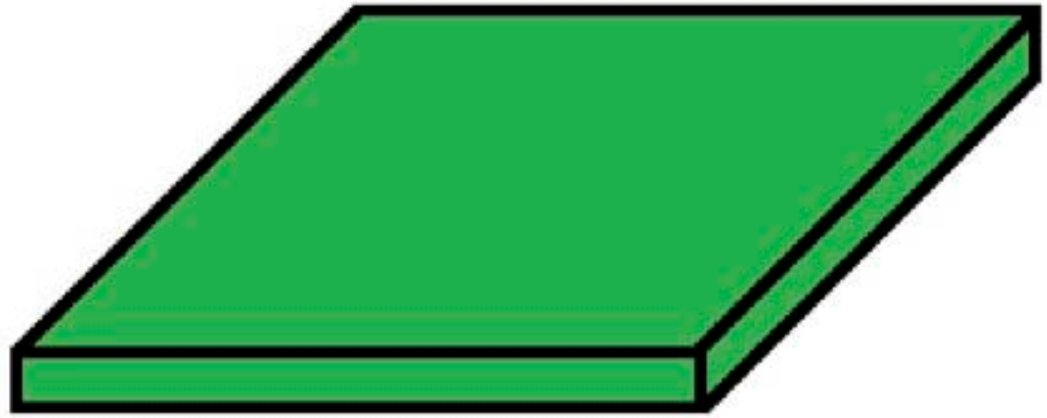
1. Thermal test with the test board
2. Thermal simulation
3. 2PCO2 circulation system

Simulation Modeling of PCB (1)



Complex layout design

→ precise simulation is difficult



Uniform heat conductivity

k_{PCB}

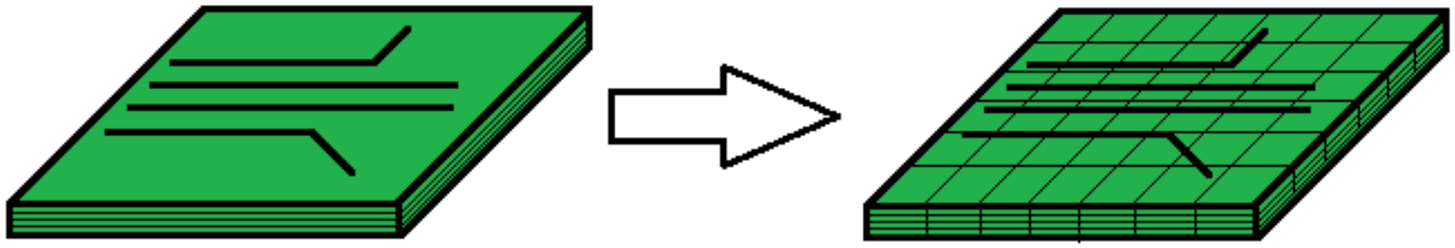
$$k_{PCB} = \alpha \cdot k_{Cu} + (1-\alpha) \cdot k_{FR5}$$

where α is copper volume ratio in PCB.

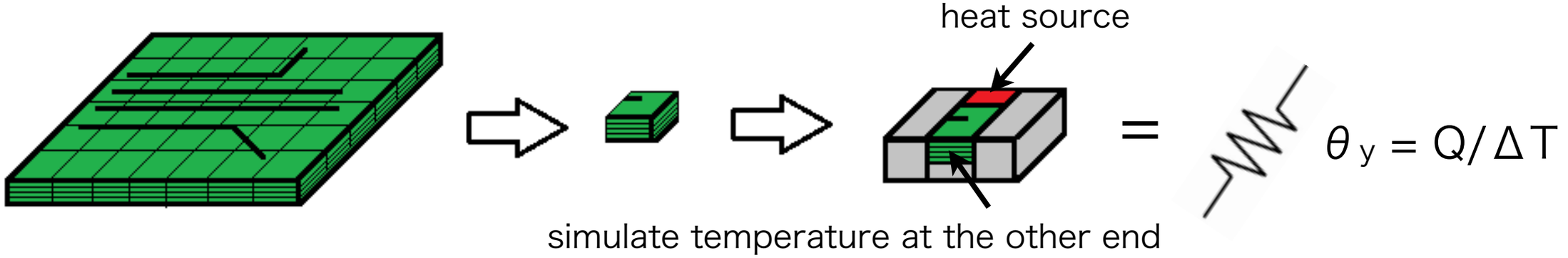
This method is used in the recent simulation

Simulation Modeling of PCB (2)

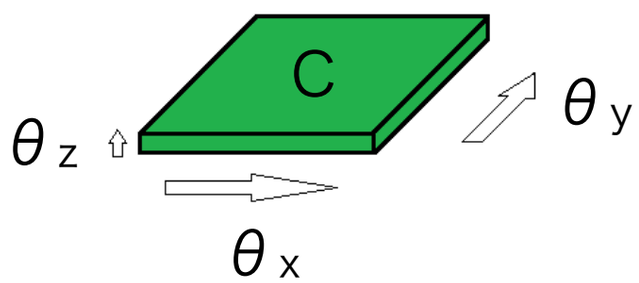
1. Divide PCB into “regions”



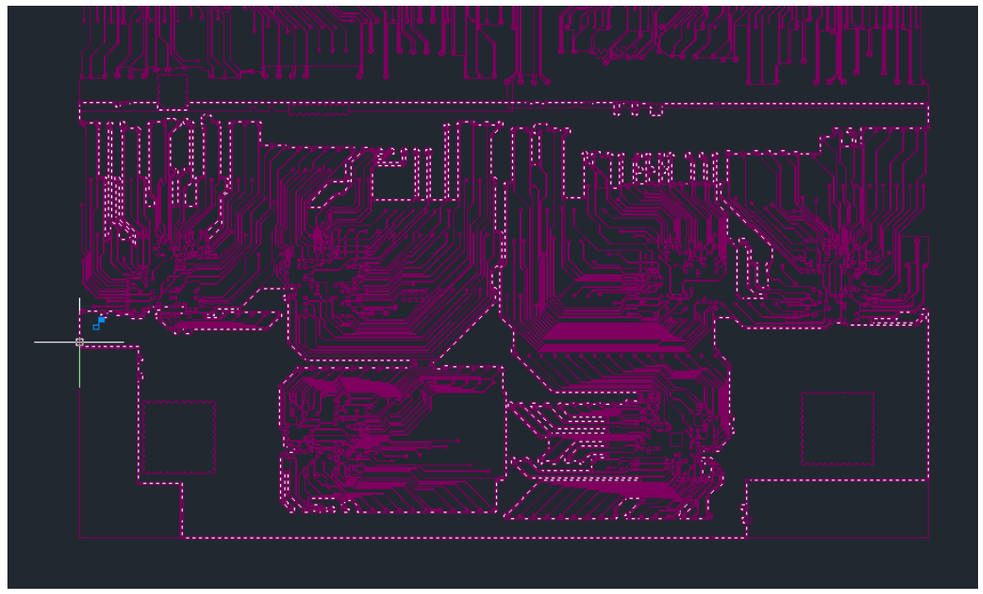
2. Obtain thermal resistance of each region from simulation

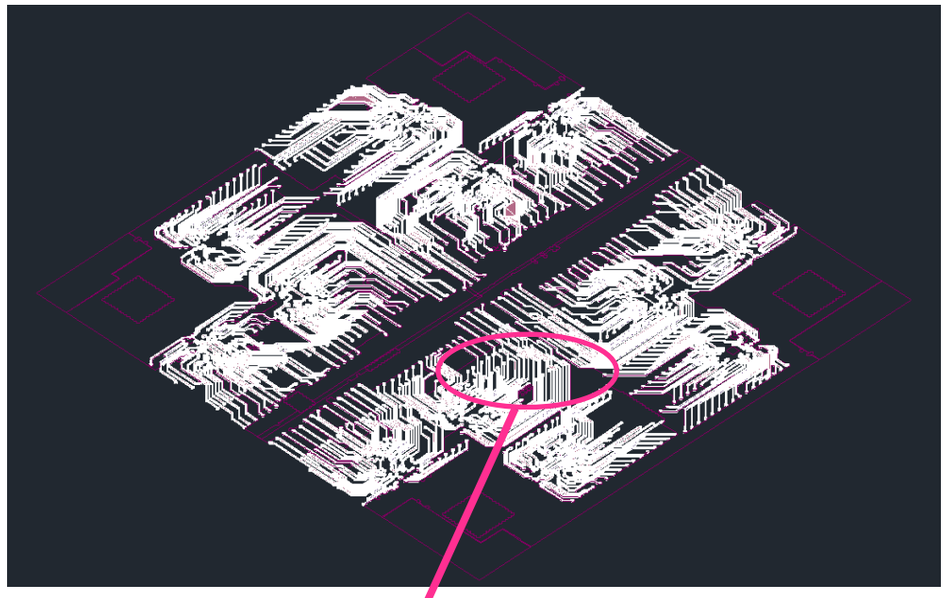


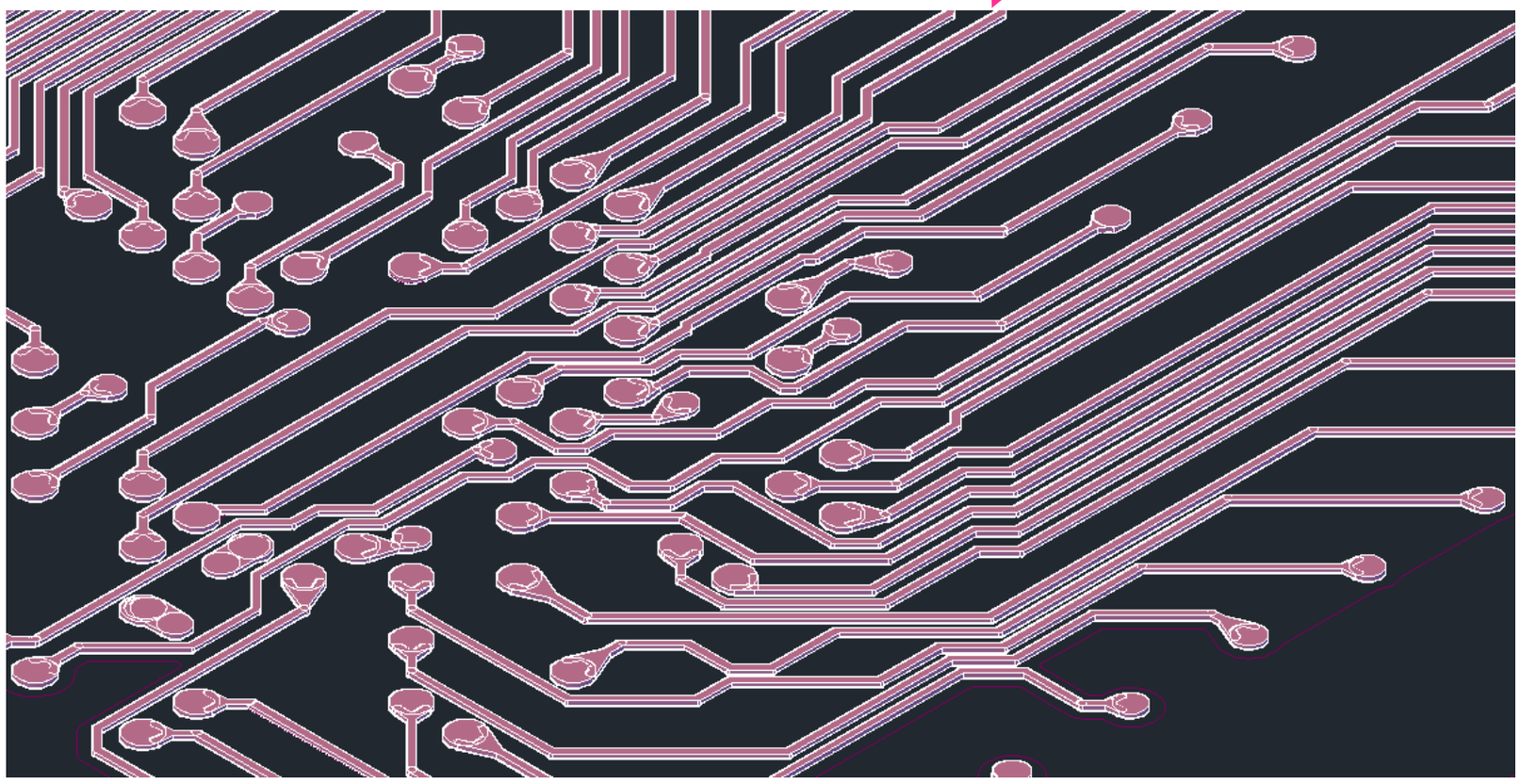
3. One region is translated to
   3 heat resistances and a heat capacity (θ_x, θ_y, θ_z, C)



2D → 3D Conversion (Layer 9)

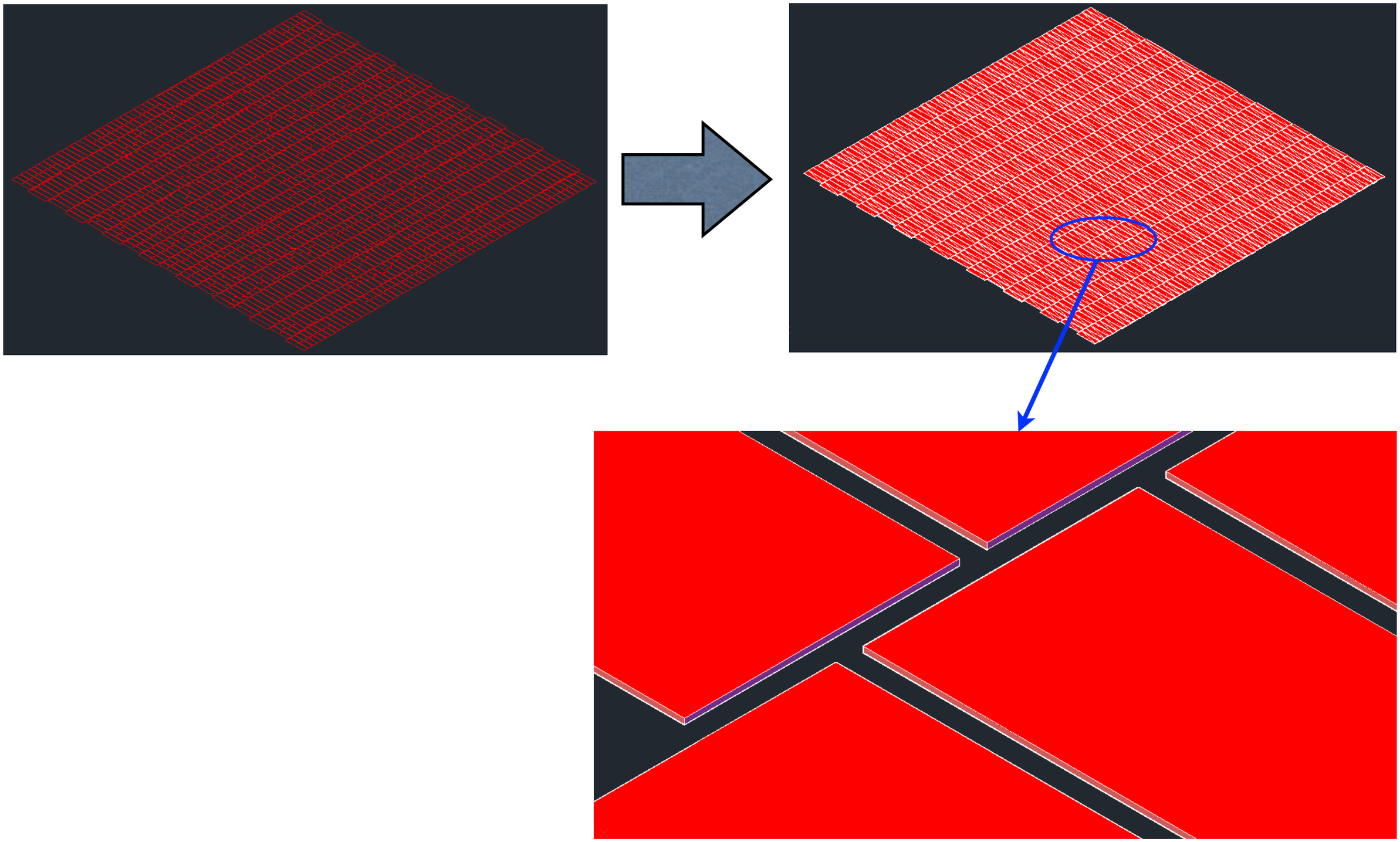






PCB layout design:
Each layer is 2D.
↓
Add thickness to extend the design to 3D (AutoCAD)

2D → 3D Conversion (Pad Layer)



2D → 3D Conversion

- There are still some problem in 2D→3D conversion.
  (Some parts are not extended correctly)
- We would like to establish the simulation method by the blow-system test at KEK (May-Jun/2012).

Contents

1. Thermal test with the test board
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Choices of CO2 cooling bench

1. The blow system. This is the simplest and has been constructed in KEK. Test with VTX dummy ladder as a heat source is ongoing.
   → AEP TB test follows. Because of high-pressure security, we must stop the system by ~mid/2012.

2. Construct small power unit (100-300W) called TRACI.
   → Planning to construct in DESY (~end/2012).

3. Construct large power unit (1-2kW) called MARCO.

4. Hire one of existing systems (NIKHEF, CERN, etc.)

bverlaat@nikhef.nl

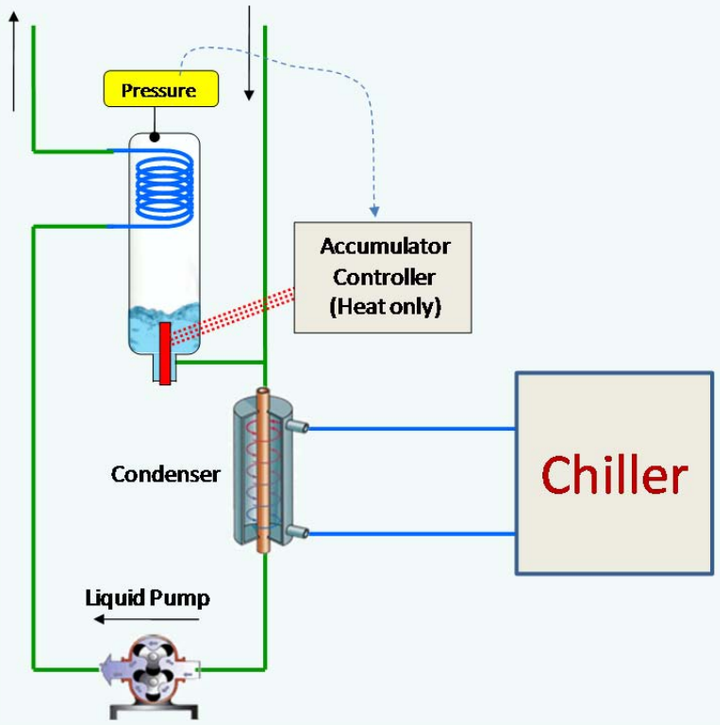
TRACI:

Transportable Refrigeration Apparatus for Co_2 Investigation.

- TRACI is a simplified concept of the 2PACL principle (LHCb/ Cryolab).
- To simplify the concept the internal heat exchanger function and the accumulator cooling function are integrated by cooling the accumulator with the pump outlet flow. The concept is called Integrated 2PACL (I-2PACL)
- 2 units (Traci-1) build, 2 under construction (Traci-2)
- I-2PACL concept is patented
- Investigating possibilities of developing the Traci concepts for series production

Slide by Bart Verlaat @ CERN

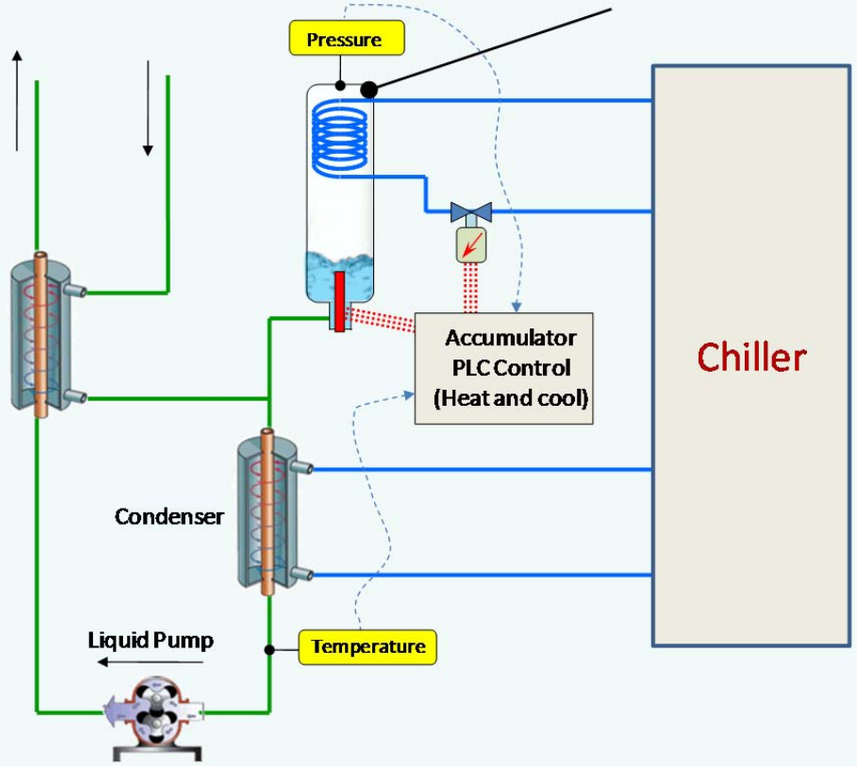
Integrated 2PACL



- Simple control
  - 1 heater with standard controller
  - Simple interlocking with conditioners and relays to guard pump sub cooling
  - Start-up procedure within interlock logic
- Single chiller loop
- Small size
- Large possible operating range (-40 to +25°C)*

* Depending on primary chiller used

Traditional 2PACL

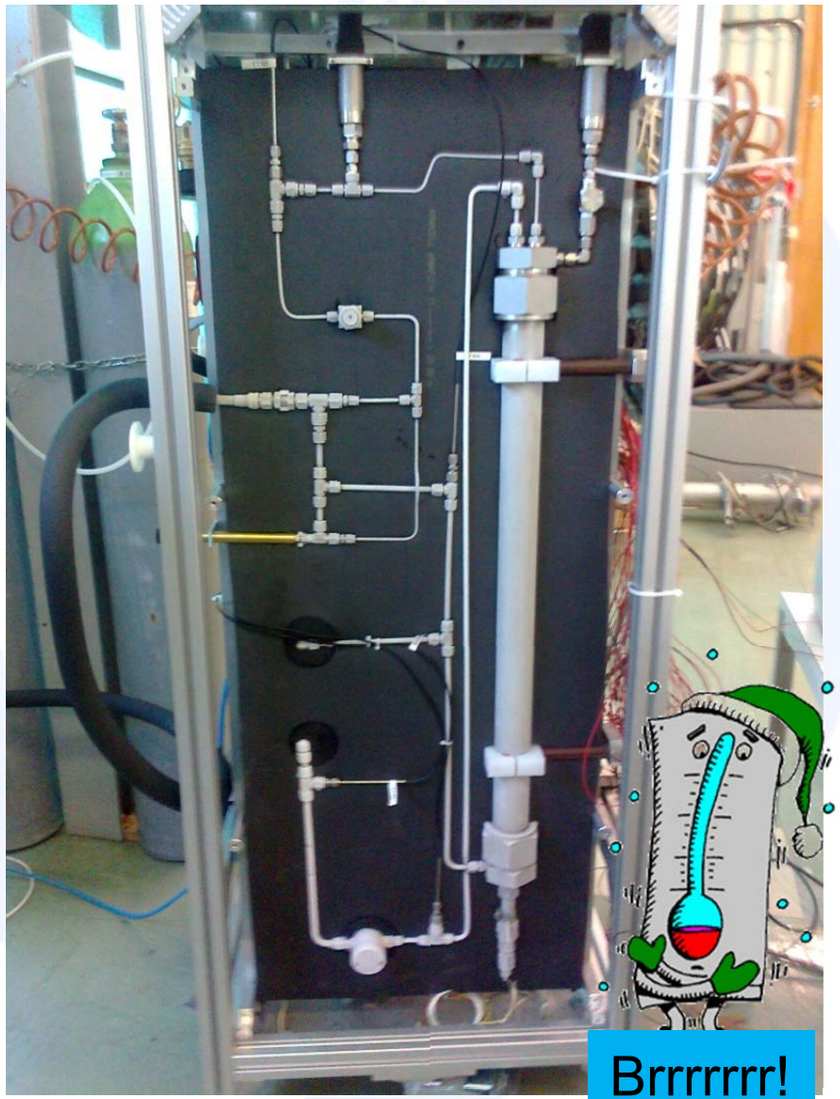


- Complicated control (PLC)
  - Combined accumulator heating/cooling control
  - Sub cooled liquid protection
- 2 Chilling loops
- Large size
- Limited temperature range in standard configuration.

Slide by Bart Verlaat @ CERN

bverlaat@nikhef.nl

TRACI & TRACI



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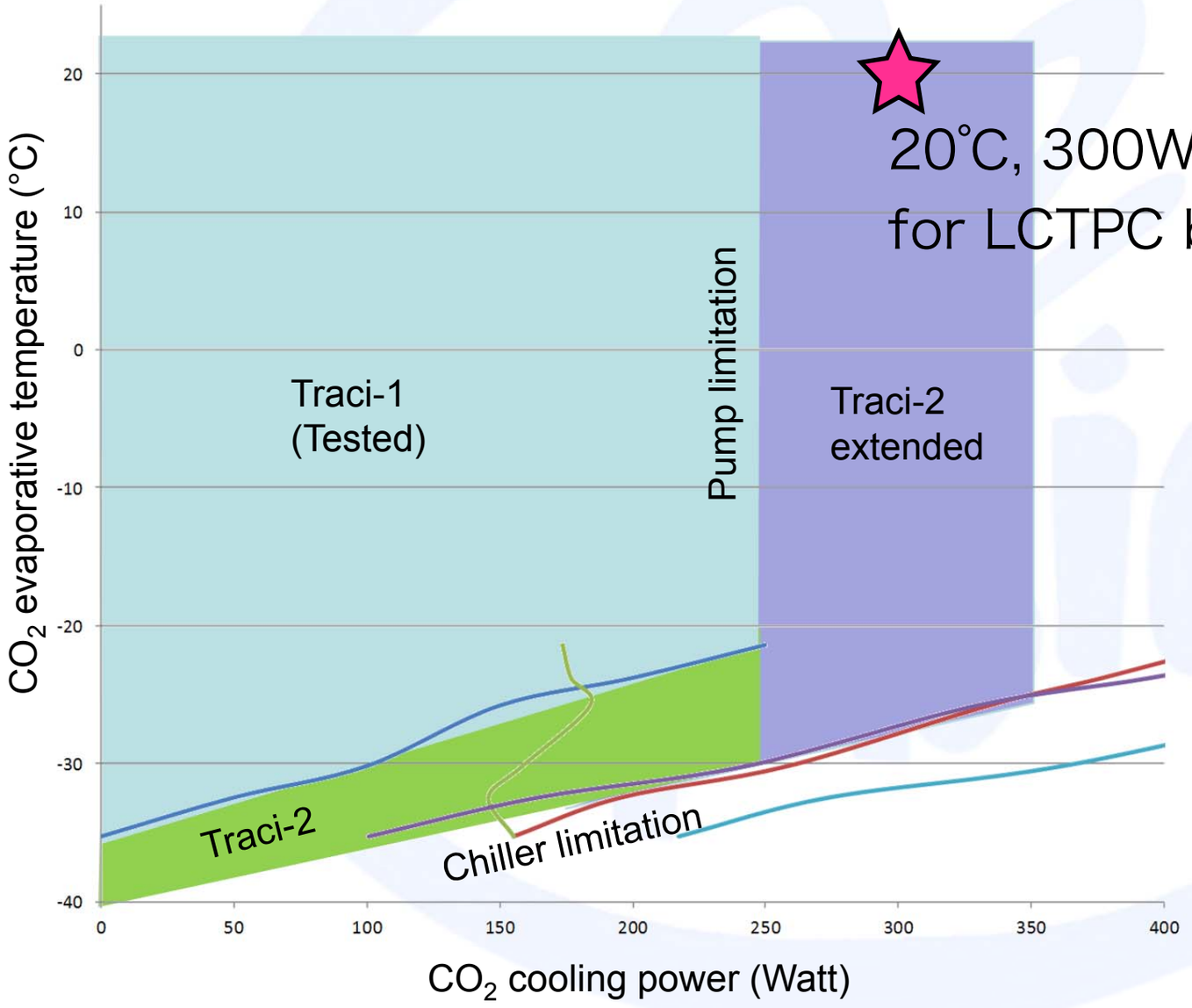
Traci-2 expectations

Chiller=1.5x capacity, Insulation 40% better



20℃, 300W(max)
for LCTPC bench @ DESY

※ S-ALTRO16 readout electronics:
200W/Module(5,000ch) w/o p.p.
<20W/Module(5,000ch)? w/ p.p.

※T2K readout electronics:
30W/Module(1,700ch) w/o p.p.

Summary

1. Thermal test with the AEP test board has started (very slowly...).
   We are planning a blow-system test at KEK in May-Jun/2012.

2. Thermal simulation is important for real-case estimation
   and is being tried.

3. 300W 2PCO2 system TRACI will be constructed in DESY in 2012.