Readout electronics cooling system for ILC-TPC

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Saga-Yonsei Workshop@YSU
2015.12.20-24

Outline

1. Introduction
2. Advanced design concept
3. Cooling test with mockup
4. Summary and Future

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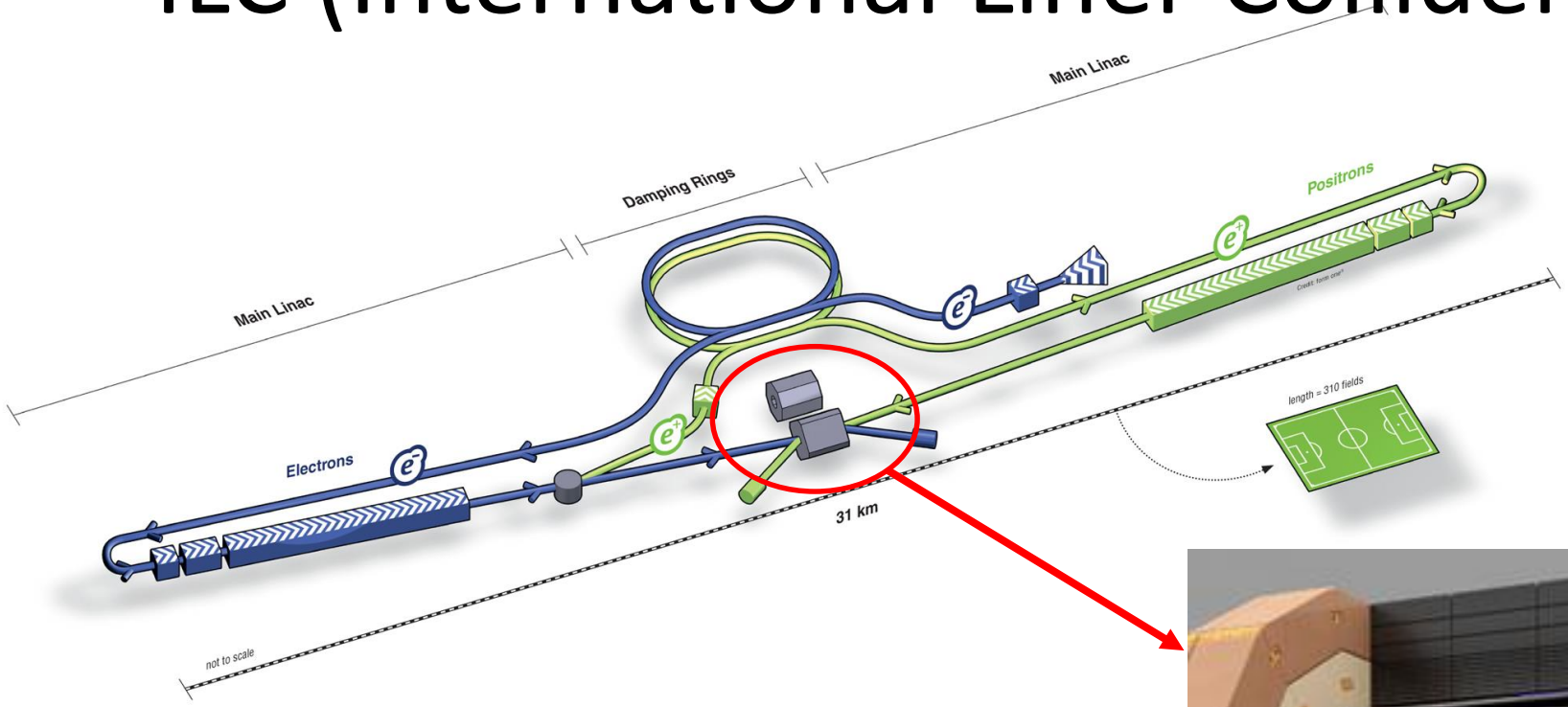
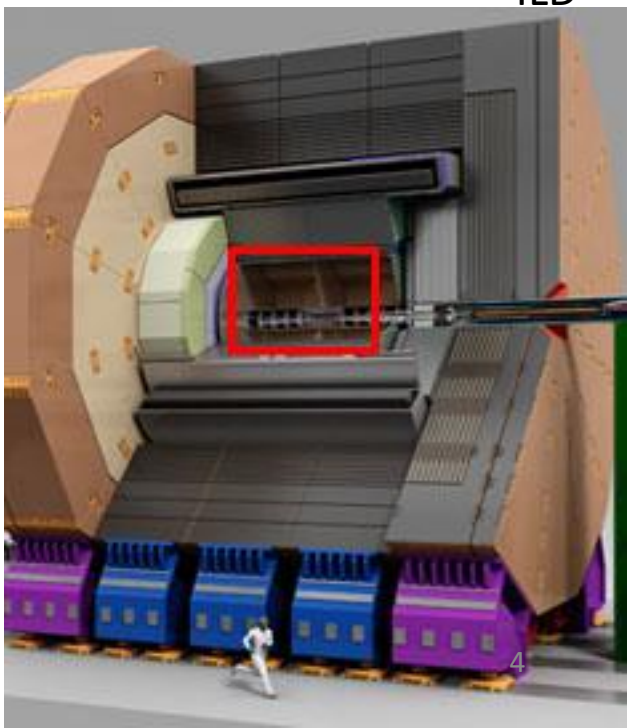
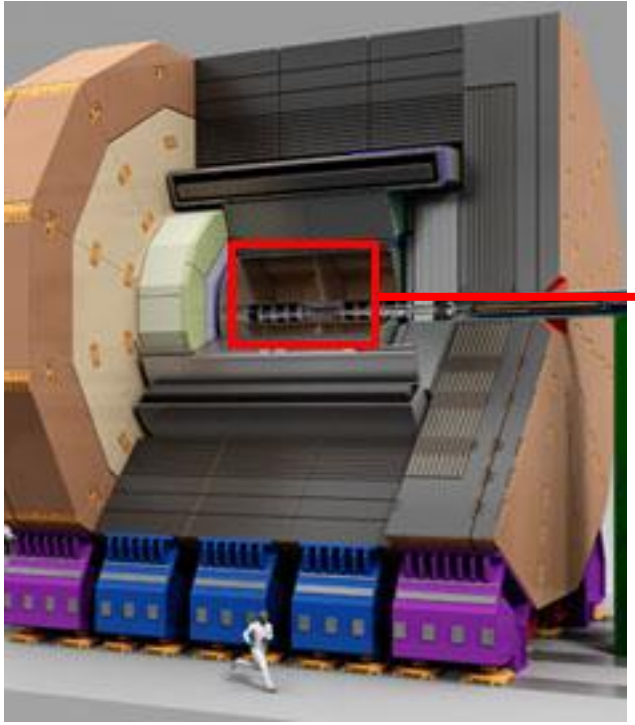
ILC (International Liner Collider)



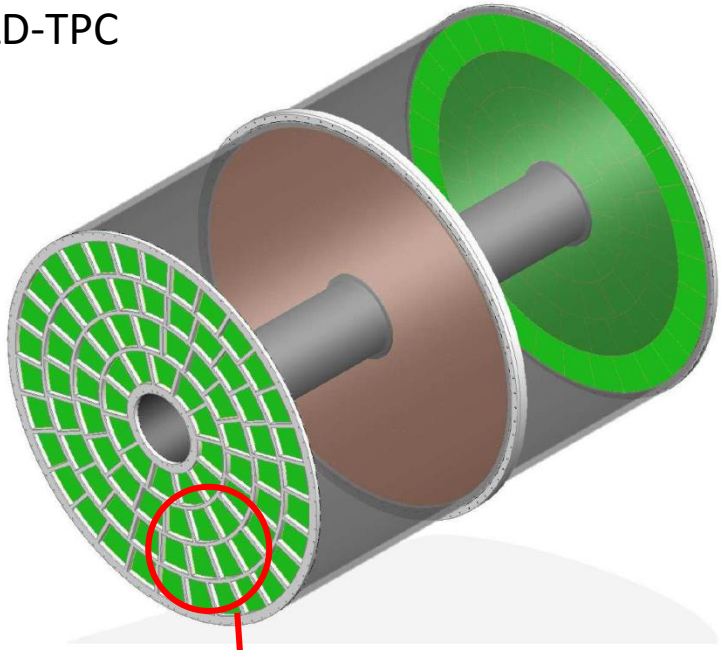
ILD



- We are working for realizing ILC.
- In particular , we participating with ILD and developing gaseous tracking detector now!

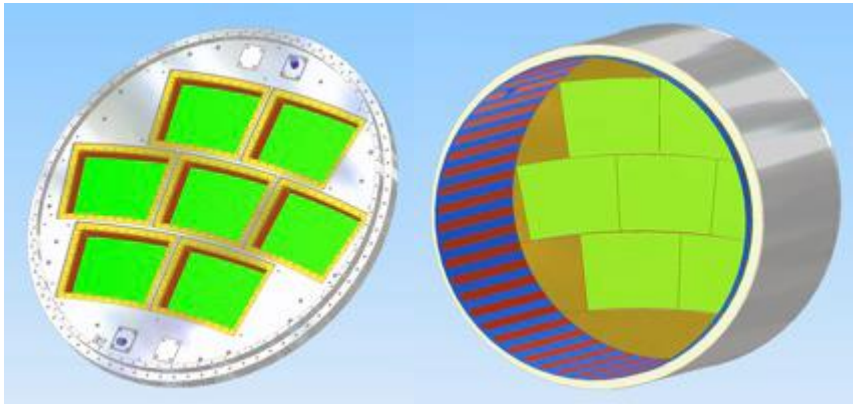


ILD-TPC

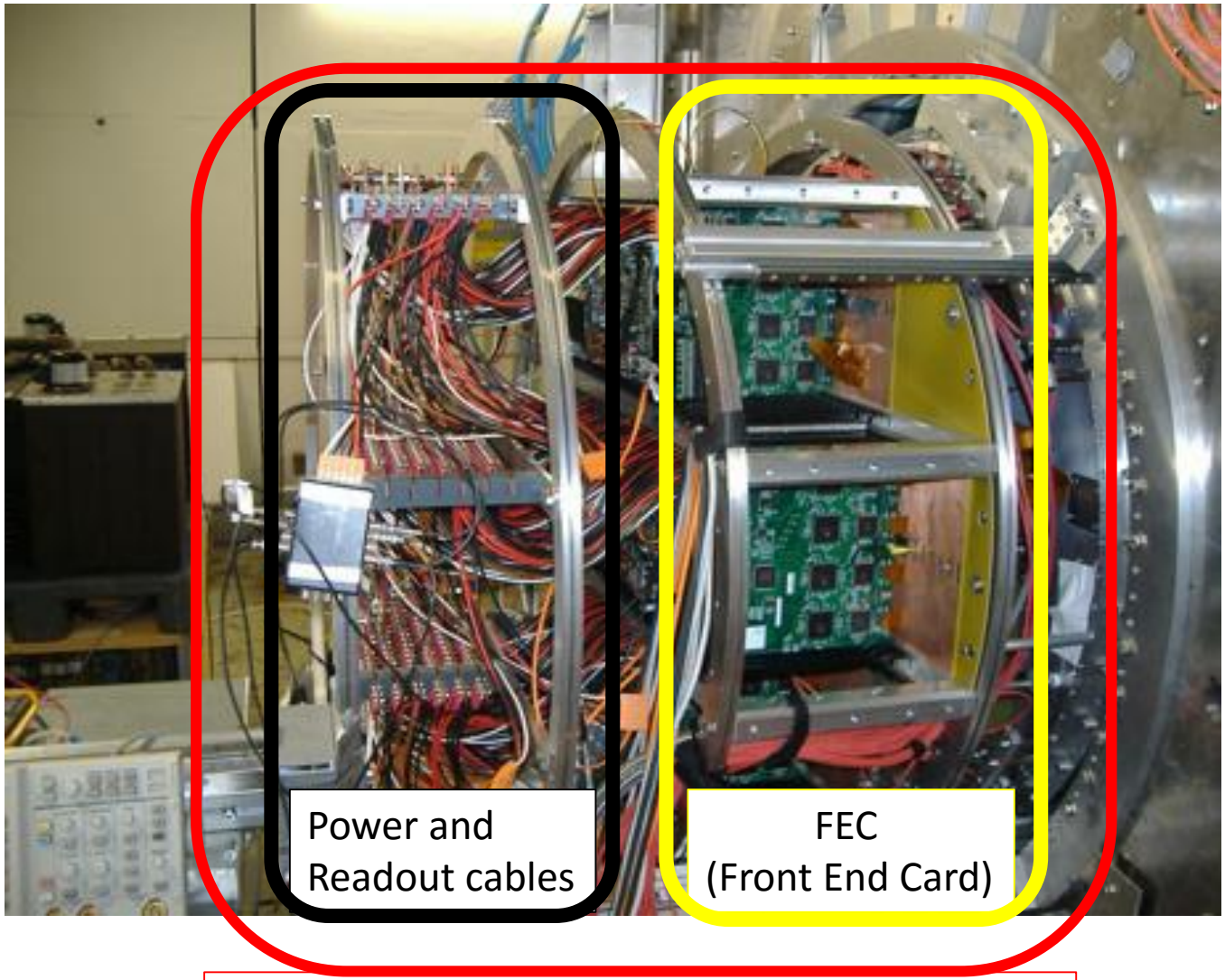


- Details→presentation
  by Yoshiyuki Nagasaki
- TPC endplate < 25%X0 for PFA
- Thin electronics required

TPC LP1

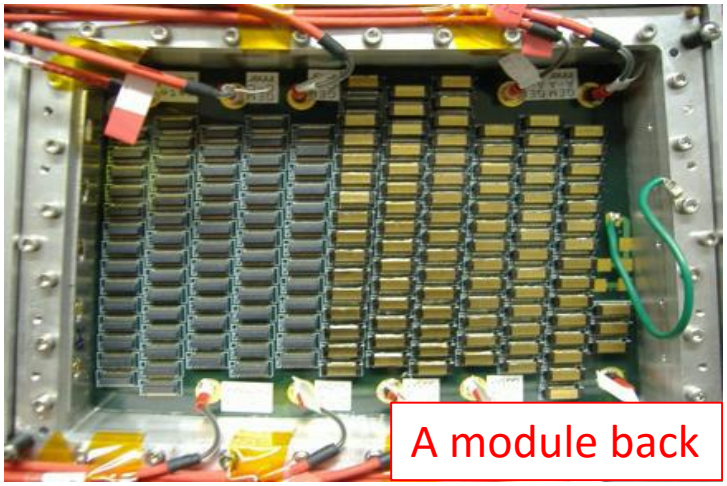


Electronics for Large Prototype1



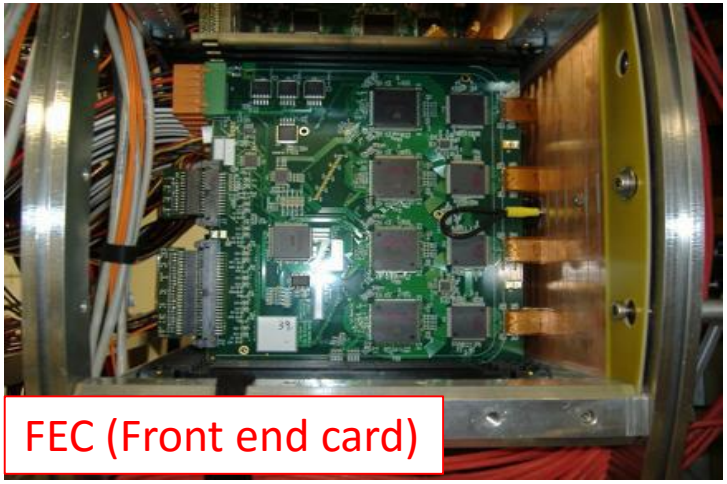
Electronics was occupied so much of the space !

- Electronics for Large Prototype1

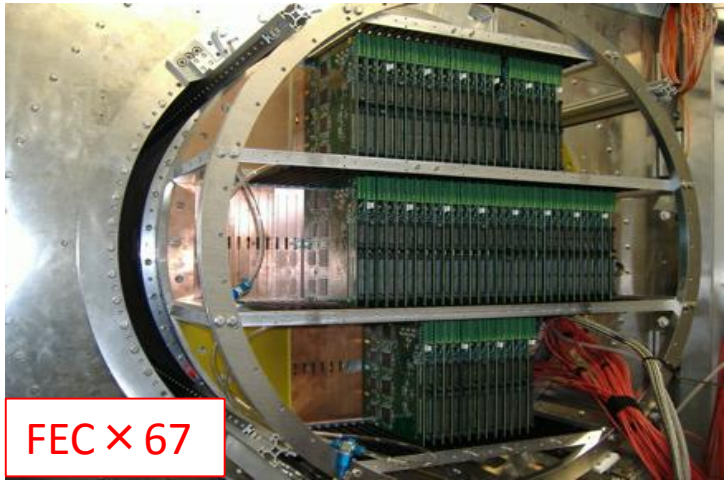


A module back

Kapton cables are connected to FECs



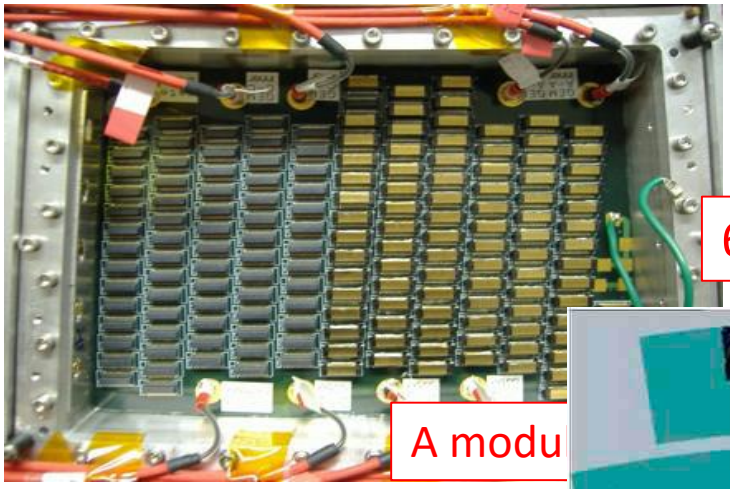
FEC (Front end card)



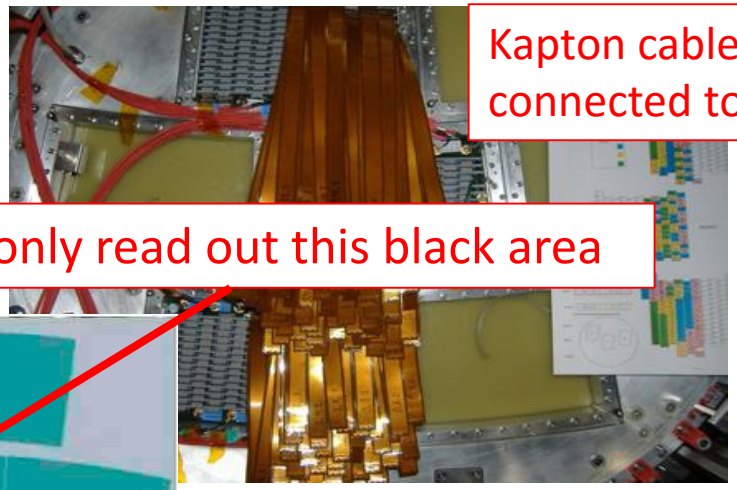
FEC × 67

We need more thin and compact electronics.

- Electronics for Large Prototype1

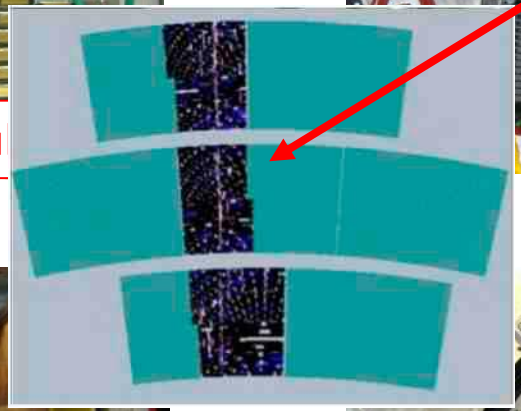


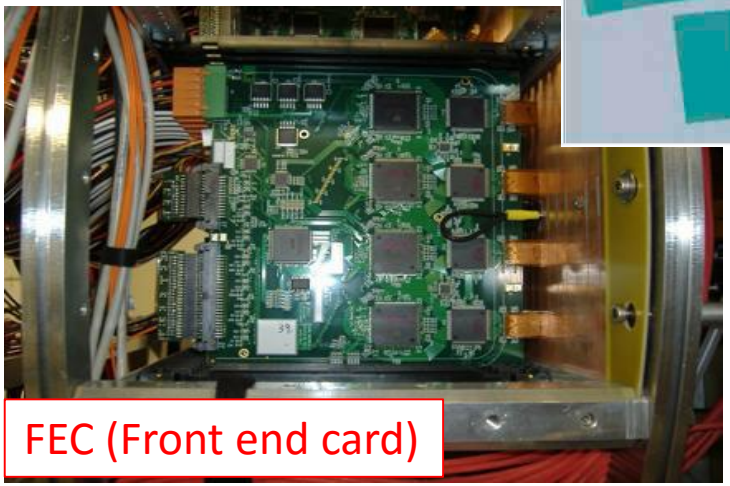
A modu



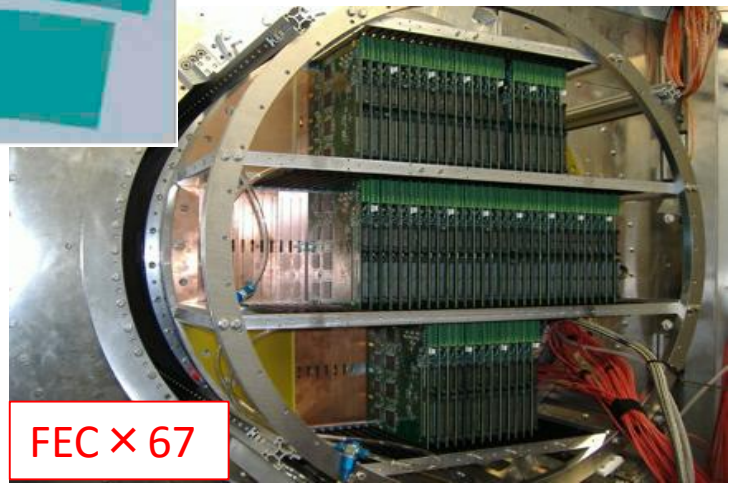
Kapton cables are connected to FECs

67FECs only read out this black area





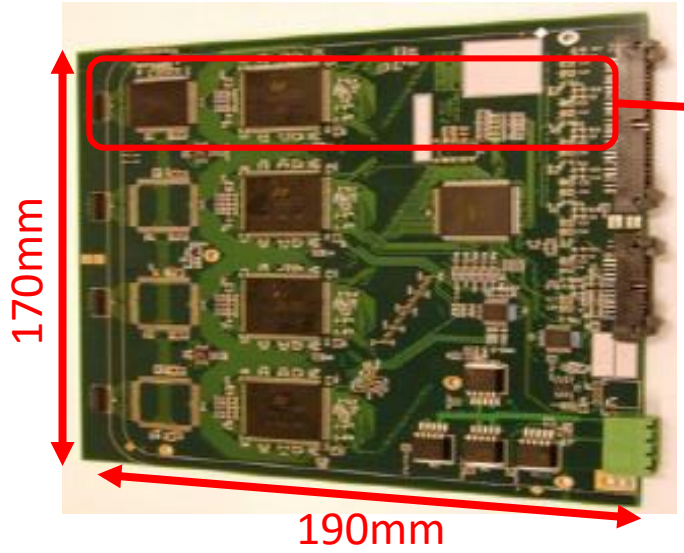
FEC (Front end card)

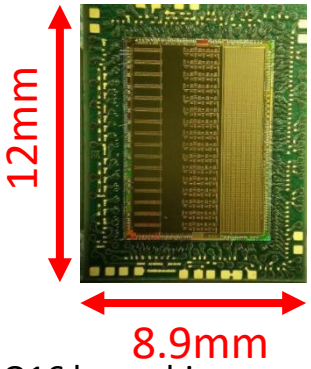


FEC × 67

We need more thin and compact electronics.

FEC → S-ALTRO16





S-ALTRO16 bare chip on carrier board

・inner ADC10bit
and max sampling rate 40MHz

FEC
PCA16
- Programmable charge sensitive amplifier
- Gain: 12, 15, 19, 27 mV/fC
- Shaping time: 30, 60, 90, 120 ns
- Can also be run in non-shaping mode with variable decay time

ALTRO
- ADC digitizes the PCA16 analogue signal of 1.2 V to a 10 bit digital value
- Sampling frequency: 20 MHz (40 MHz)
- Buffers data while waiting for store/discard decision
- Perform pedestal subtraction and zero suppression

・S-ALTRO16 has FEC's function.
We consider the next electronics that based on it.

The important thing is that
the amount of heat does not decrease!

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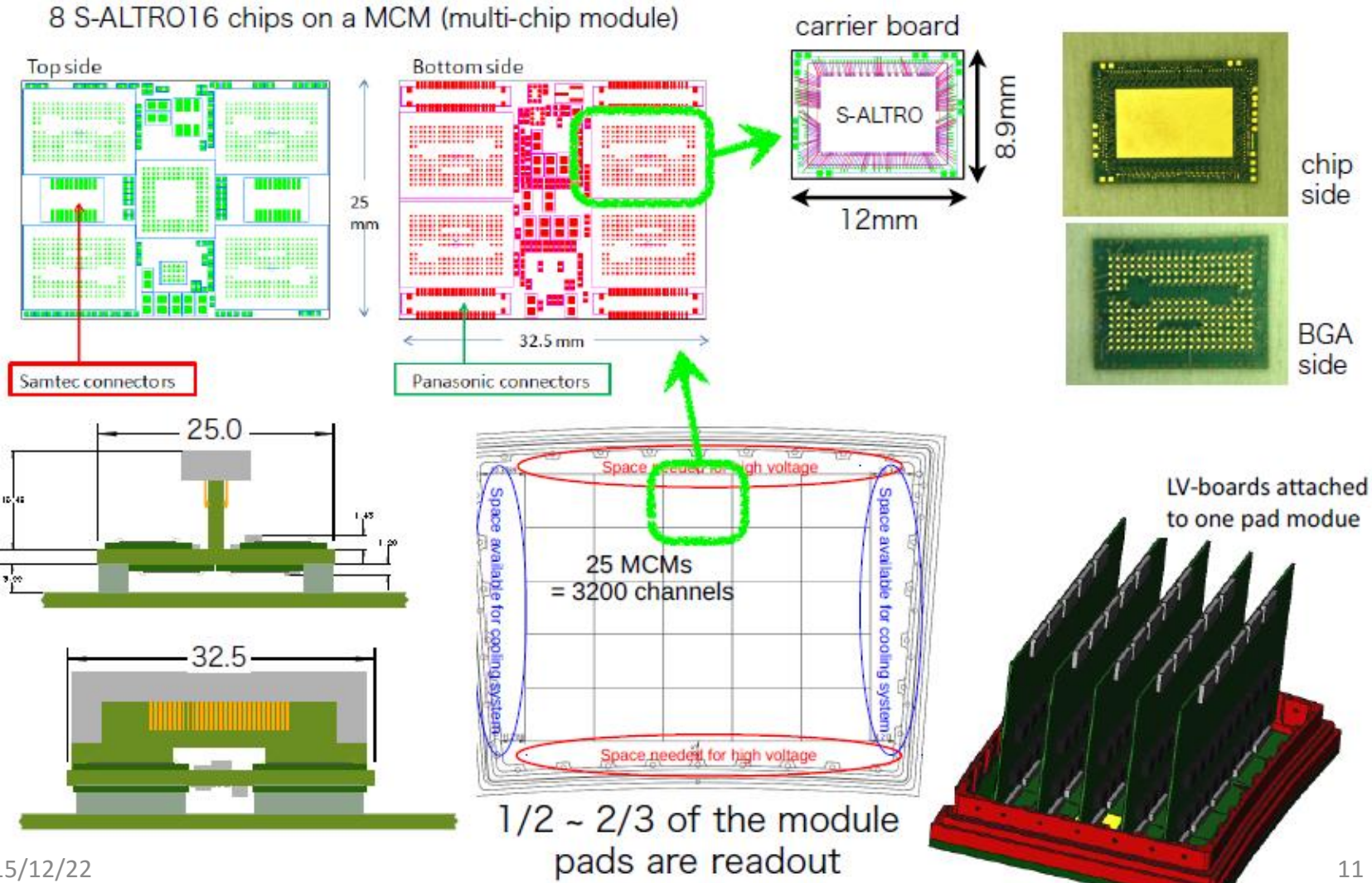
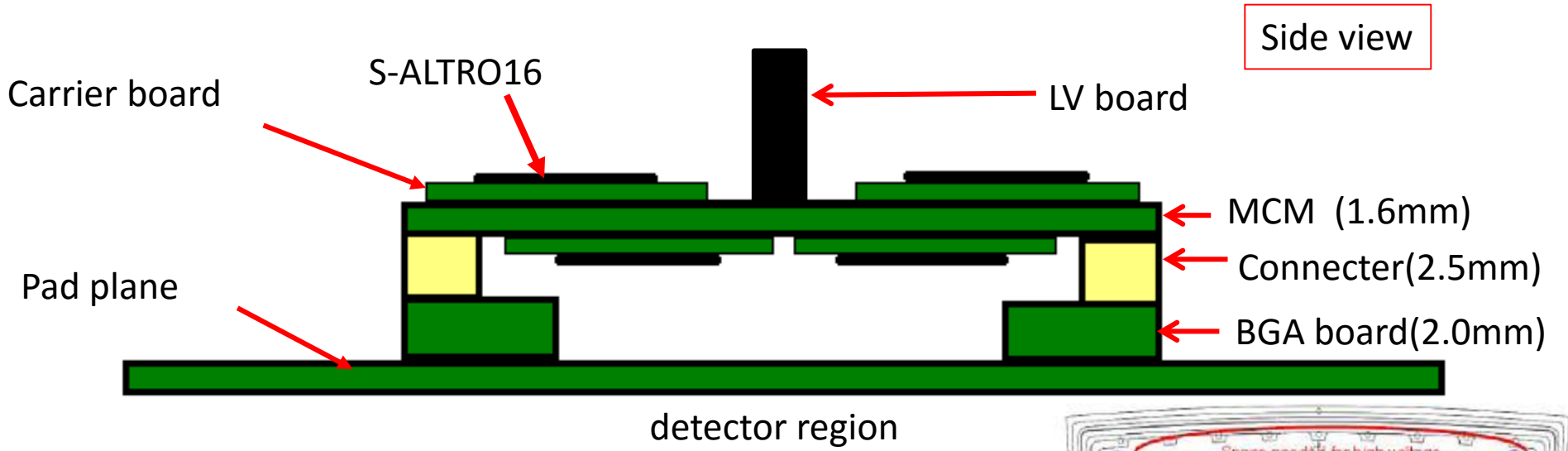
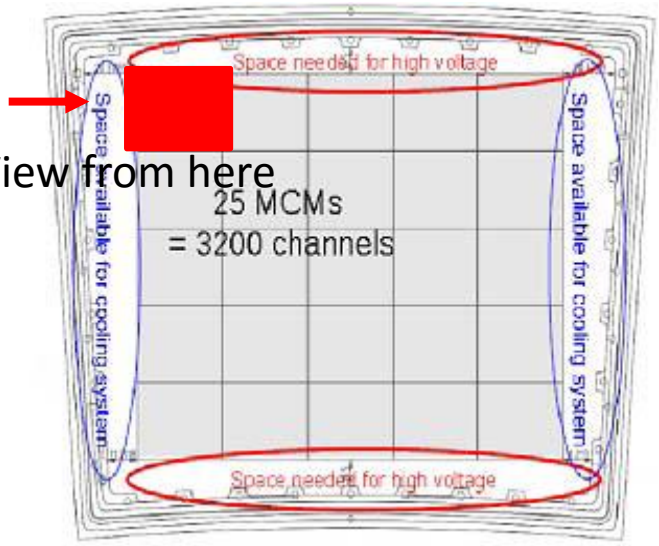
Advanced Endplate

Design Concept: Readout electronics based on S-ALTRO16



Figures from "Front-end electronics for the TPC in ILD; a status report April 2014," etc. by the Lund group





- S-ALTRO16@40MHz

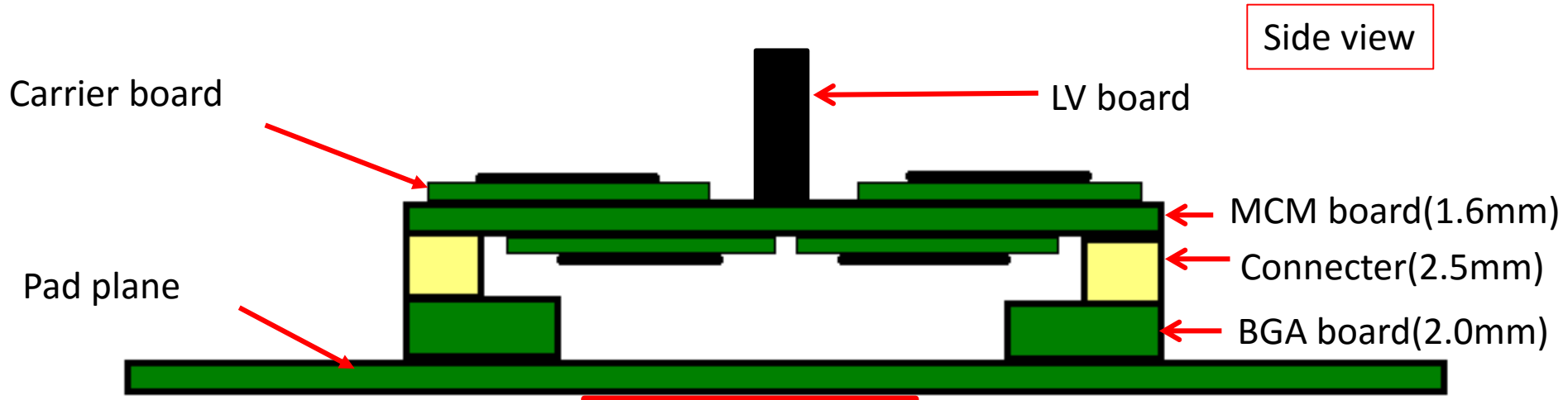
  Power consumption 0.94W

  →188W in total of a module

If there are heat flow to the pad plane and detector region ,

TPC gas properties are changed.

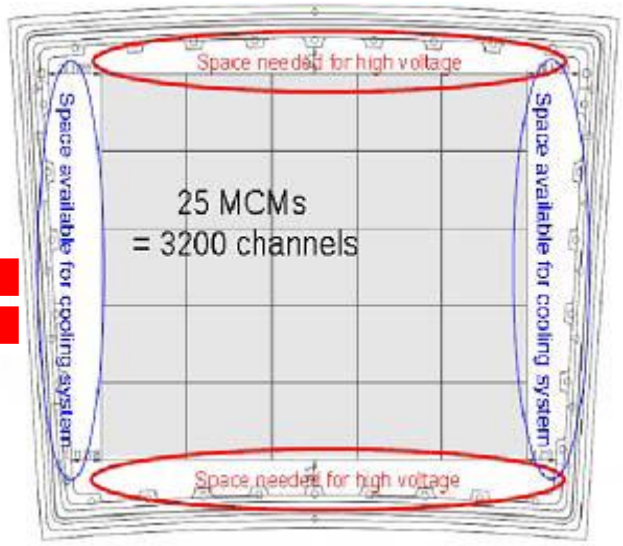
→Serious problem for high performance of TPC



- S-ALTRO16@40MHz

  Power consumptio

  →188W in total of



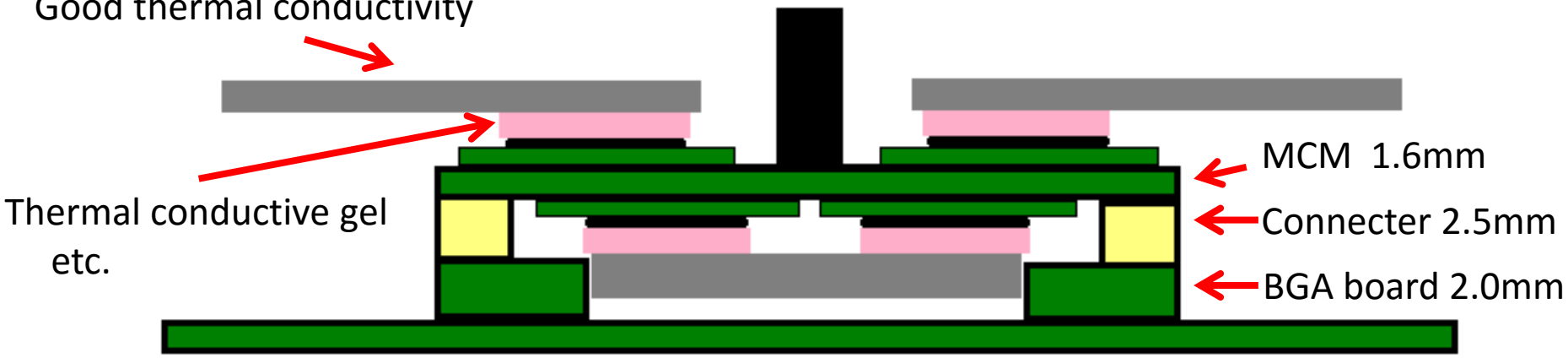
If there are heat flow to the pad plane and detector region ,

TPC gas properties are changed.

→ Serious problem for high performance of TPC

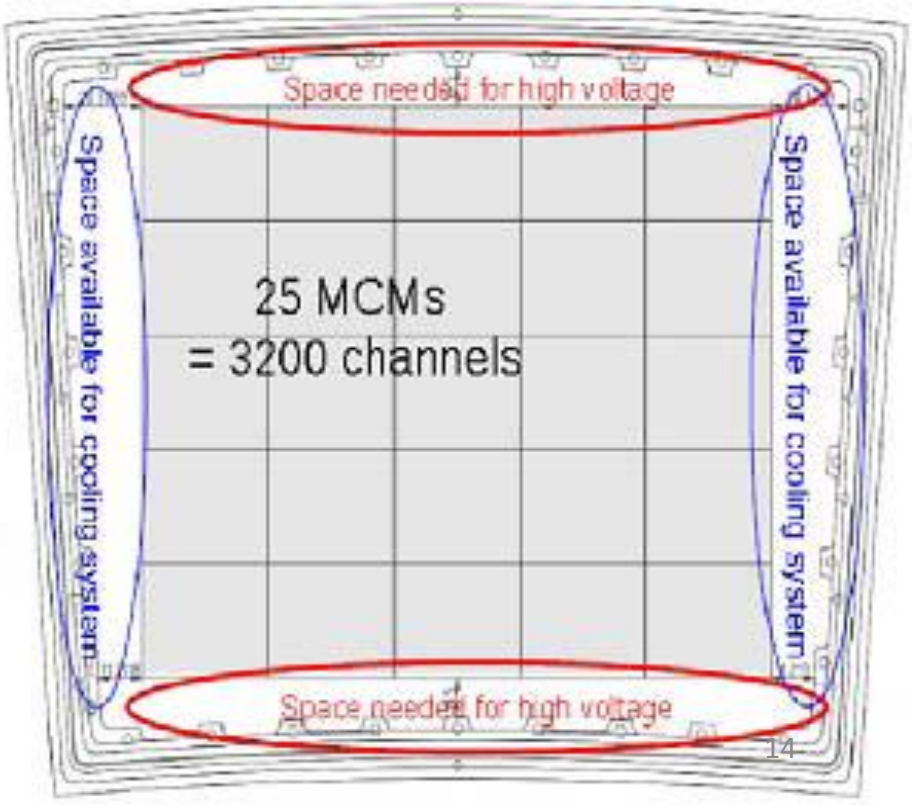
TPG (Thermal pyrolytic graphite)
Good thermal conductivity

Side view



- 2 phase CO2 cooling

→Thermal conductive materials (TPG and GEL) are incorporated directly on S-ALTRO16 in order to remove heat efficiently.



TPG(thermal pyrolytic graphite)

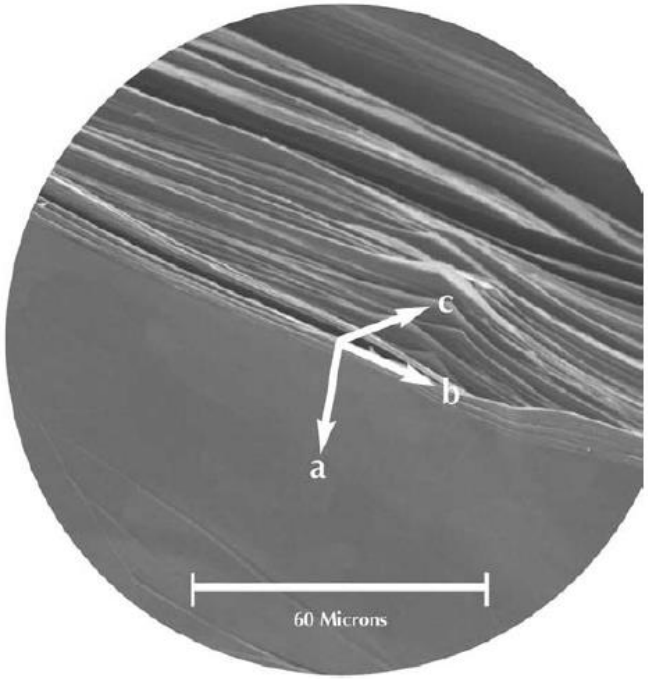
・thermal conductivity

～1500W/(m・K) to a-b

20W/(m・K) to c

Ex) Cu 386~402W/(m・K)←generally good

・Al is laminated both surface.



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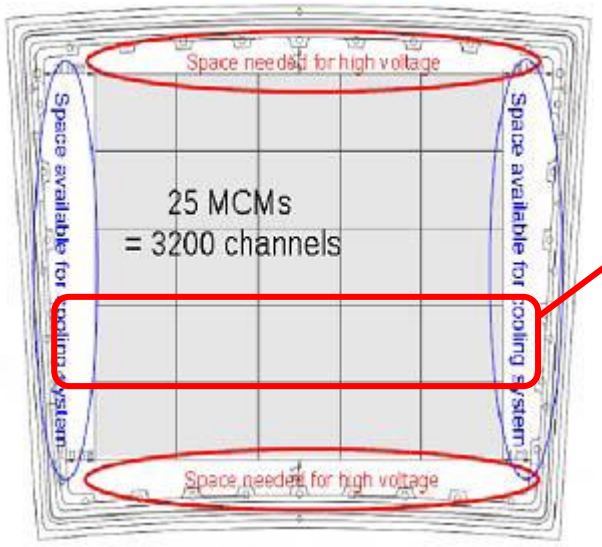
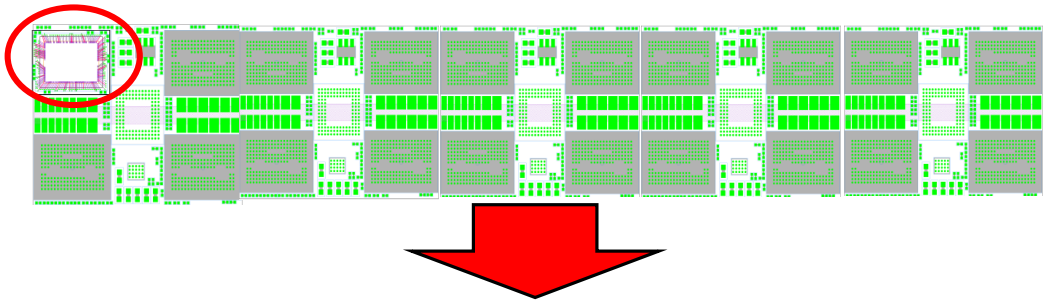




・Mockup board

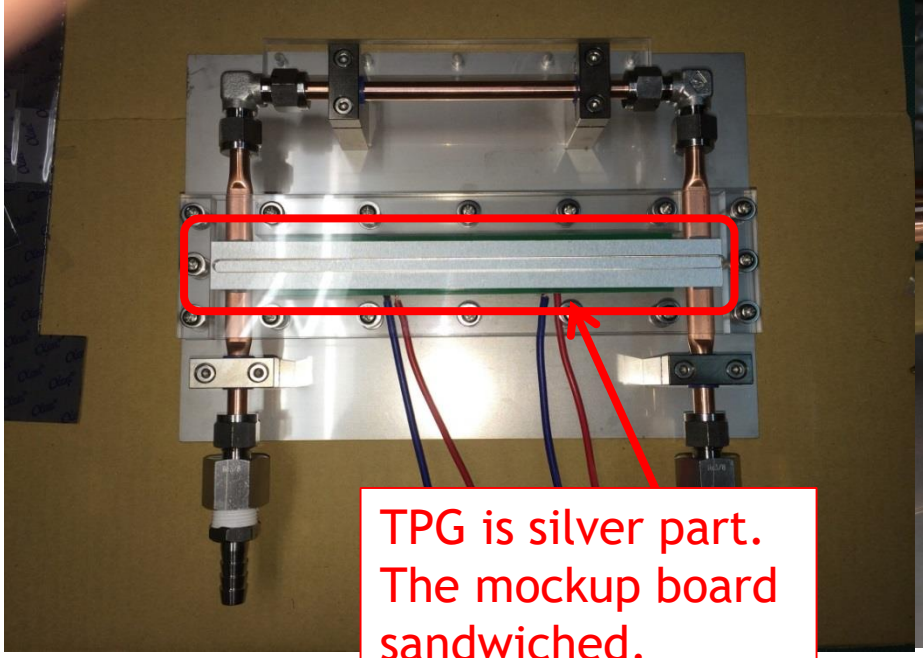
162.5 × 25.0mm　1.6mm(thick)

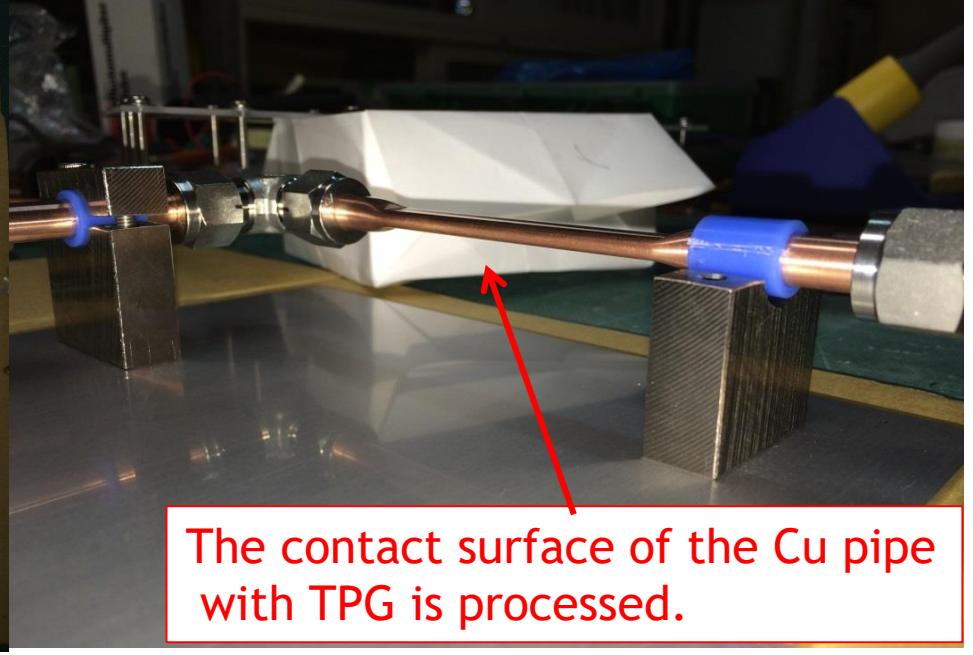
surface mount 1kΩ　chip resistor

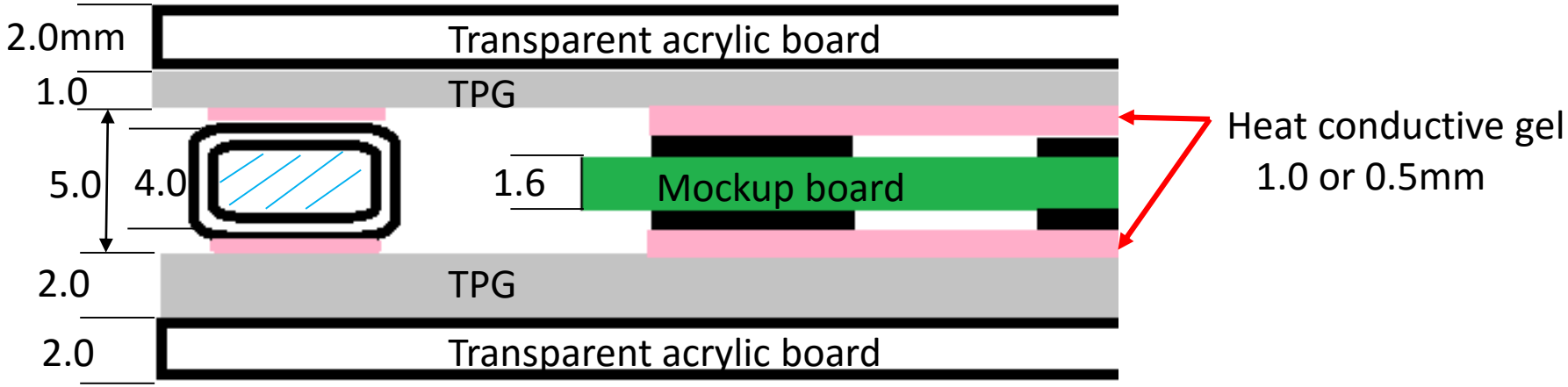
S-ALTRO16(40MHz)　0.94W

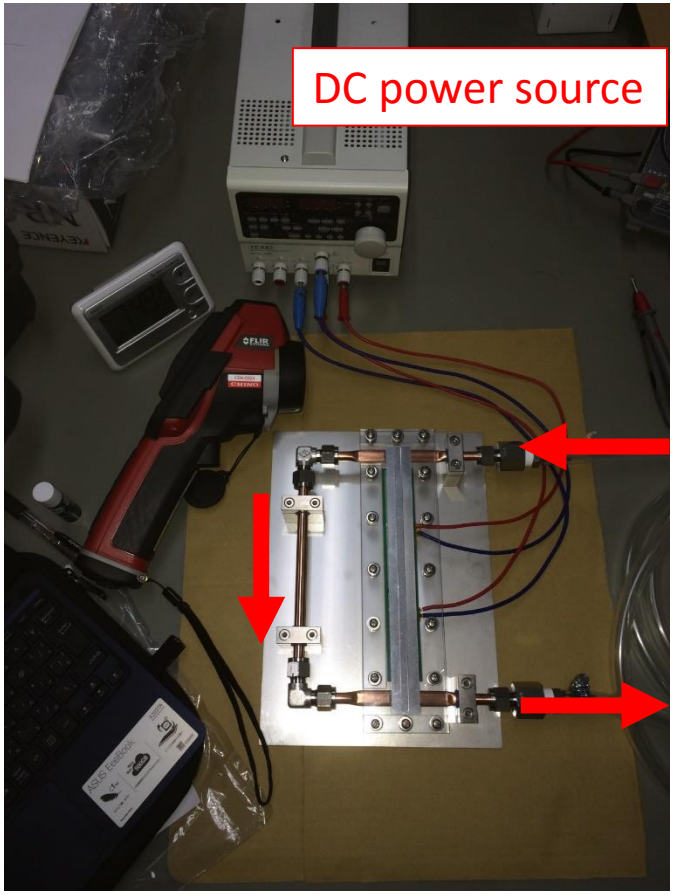
Mockup board (17.7V)　0.313W × 3 = 0.939W

→appropriate on this condition.


TPG is silver part.
The mockup board
sandwiched.


The contact surface of the Cu pipe
with TPG is processed.


2.0mm
Transparent acrylic board
1.0
TPG
5.0
4.0
1.6
Mockup board
Heat conductive gel
1.0 or 0.5mm
2.0
TPG
2.0
Transparent acrylic board



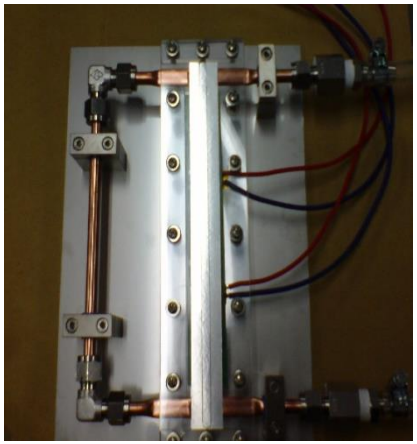
The picture is the set up

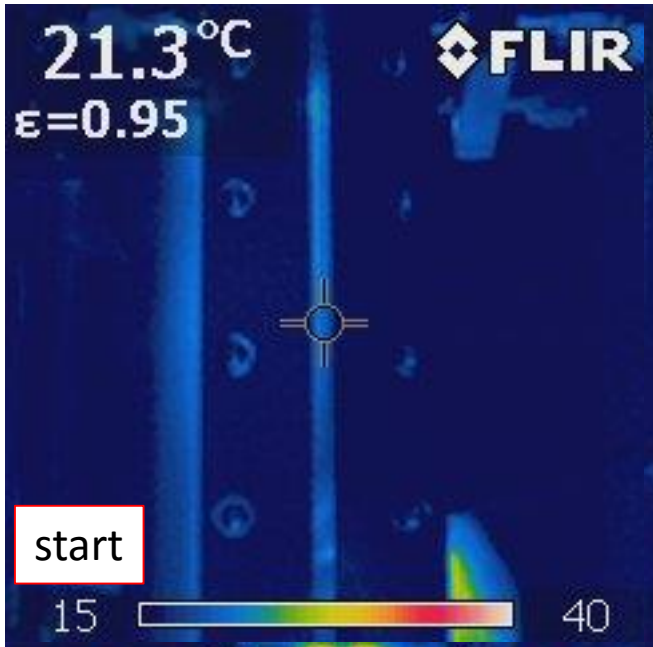
The cooling test – water set to 20 degrees .
Measured by thermometer

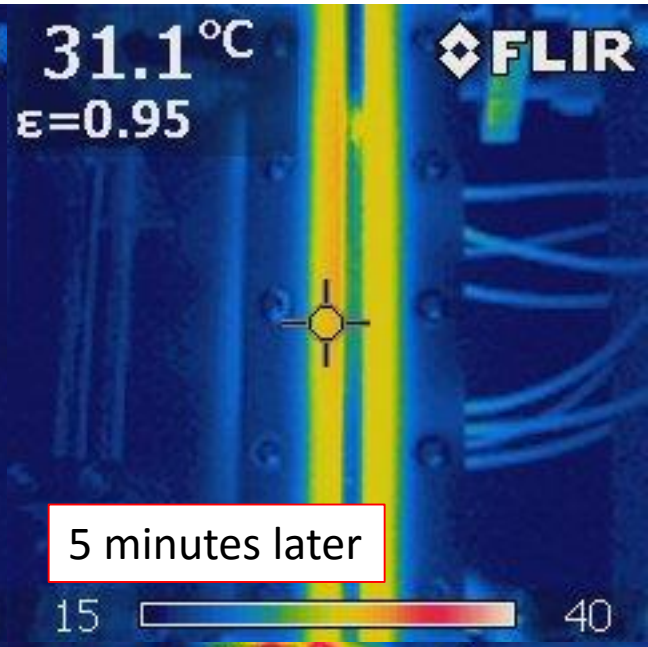
The room temp 15.5℃

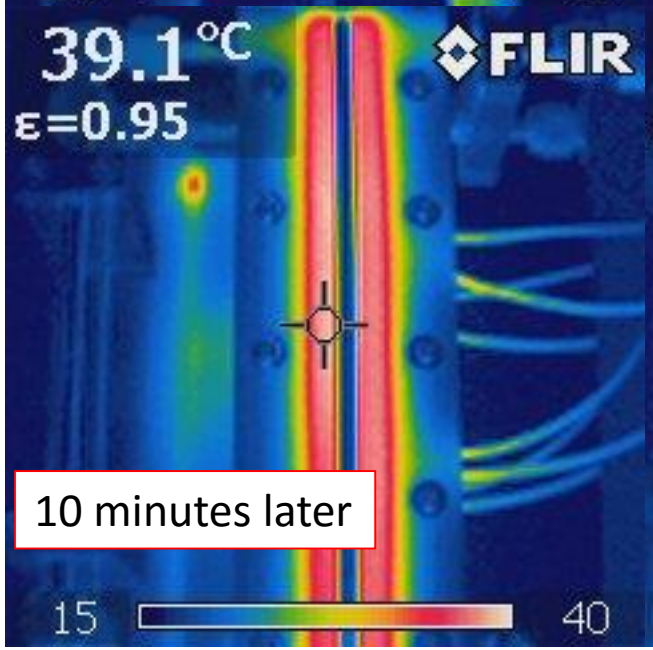
V = 10V

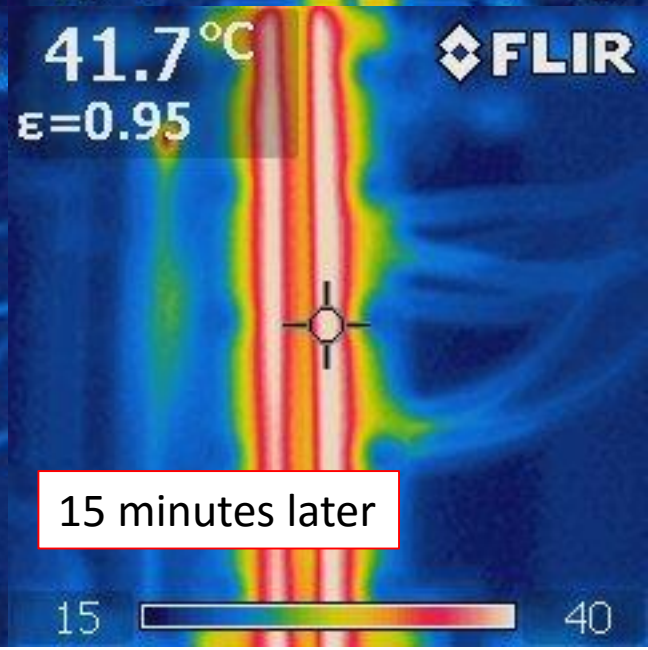
without cooling

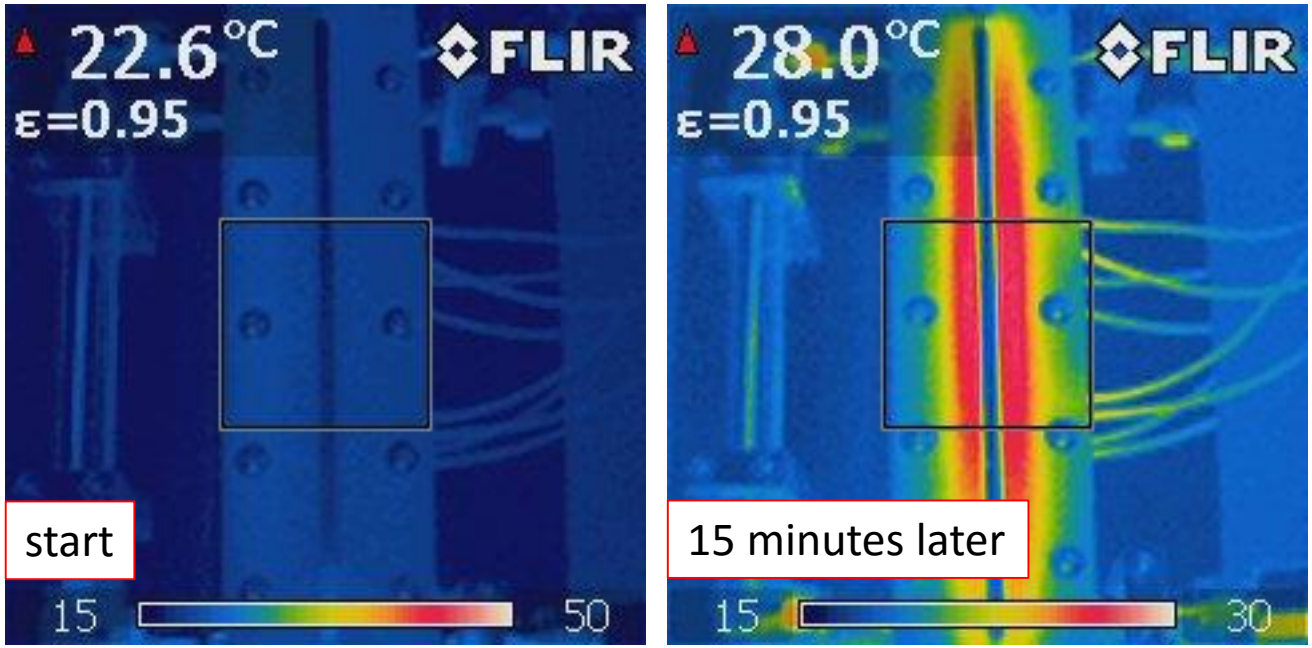








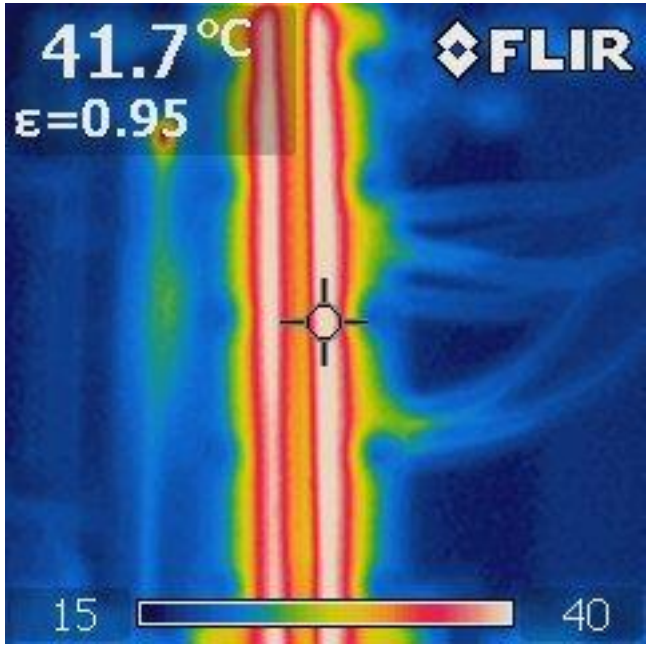




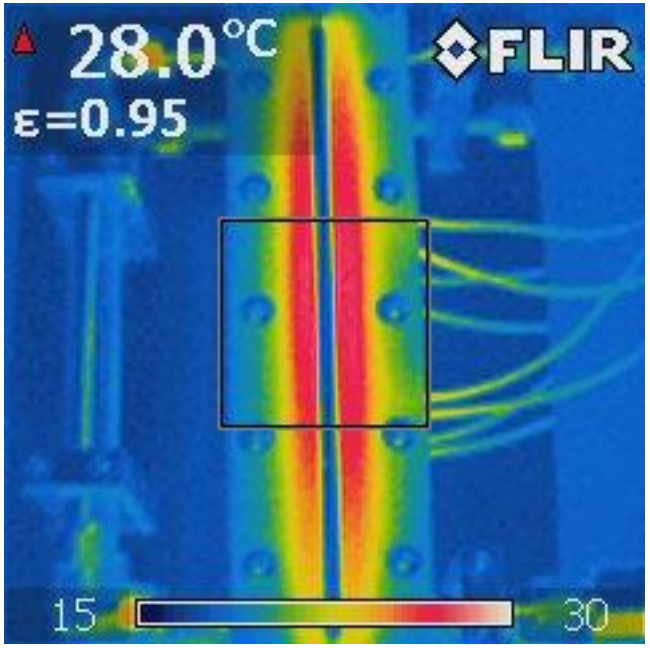
The room temp　16.0℃ , V = 10V , Cooling at 20℃ water

→compared with the figure of without cooling

Both 10V



Without cooling



Cooling at 20℃ water

Obviously , cooling system is working.
The max degree 41.7℃ → 28.0℃

Despite using TPG , there is a heat gradient.
We do not know whether the result is reasonable.
→We have to do thermal simulation.

Summary

- Made a mockup like a next module.
- Cooling test in water at 10V.
- Cooling system is working and the max degree is falls.

Future

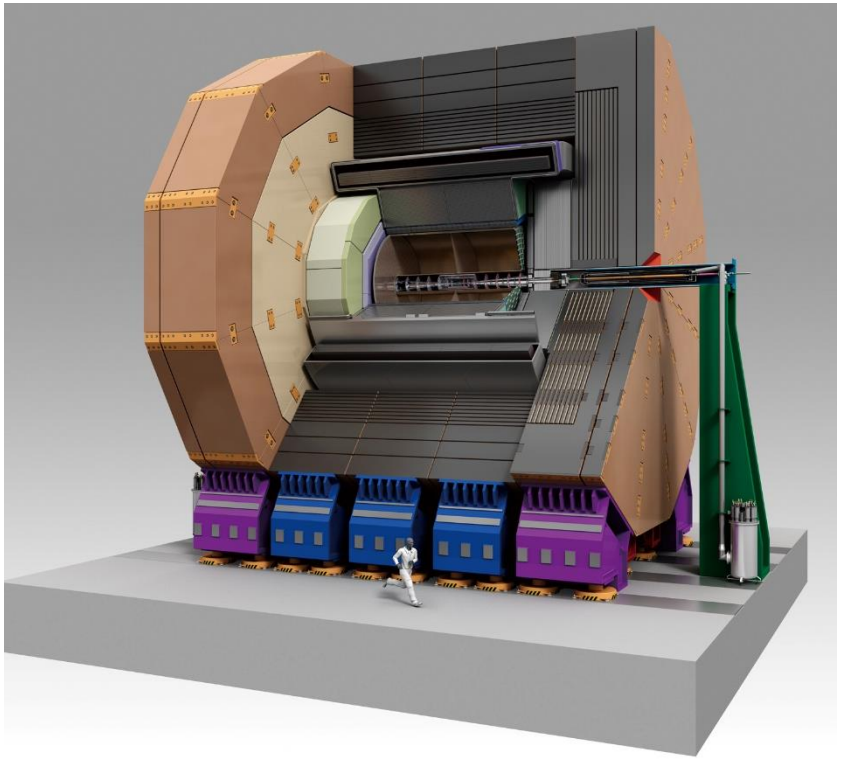
- Test at 17.7V.(≈ S-ALTRO16@40MHz)
- Compared with its thermal simulation.
- More detailed inspection with a thermocouple.

I would like to continue to study for realizing the next module.

END

Back up

ILD



- Vertex detector
  It follows the trajectory of the particle in reverse.
  →Get the identity of the elementary particles.

- TPC
  SAGA-HEP is developing now!
  tracking detector

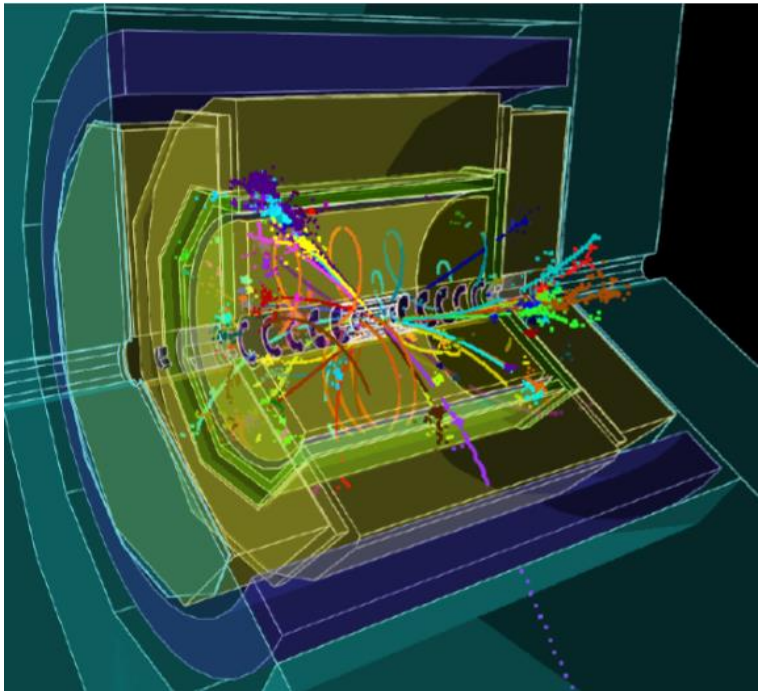
- ECAL,HCAL
  energy measurement
  ECAL – has transparent crystal
  HCAL – has block of tungsten
  →e convert to lights

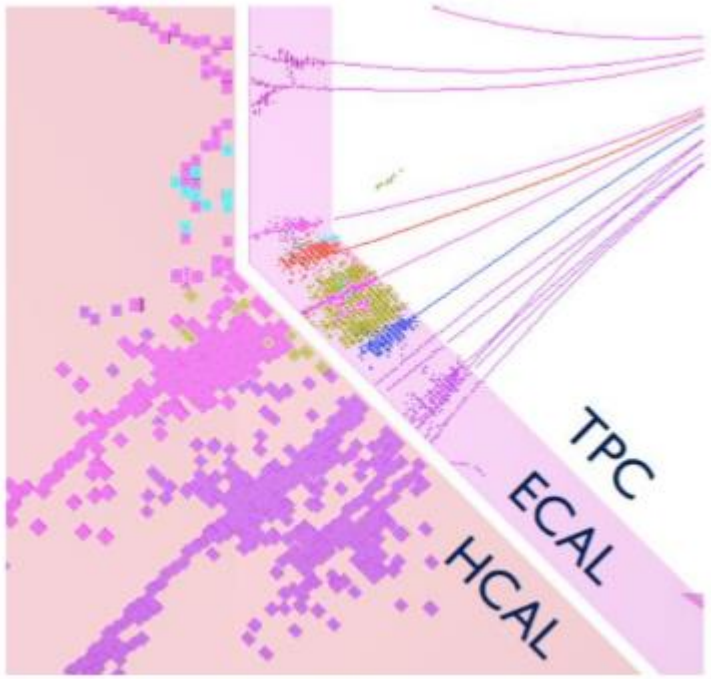
- Cryostat
  Super strong electromagnet
  →4T
- Muon tracker
  electric signal of muon

PFA Particle Flow Algorithm

- The method of jet energy measurement
- reconstructs of jets

→Incident particle track of TPC and cluster of Calorimeter one to one correspondence





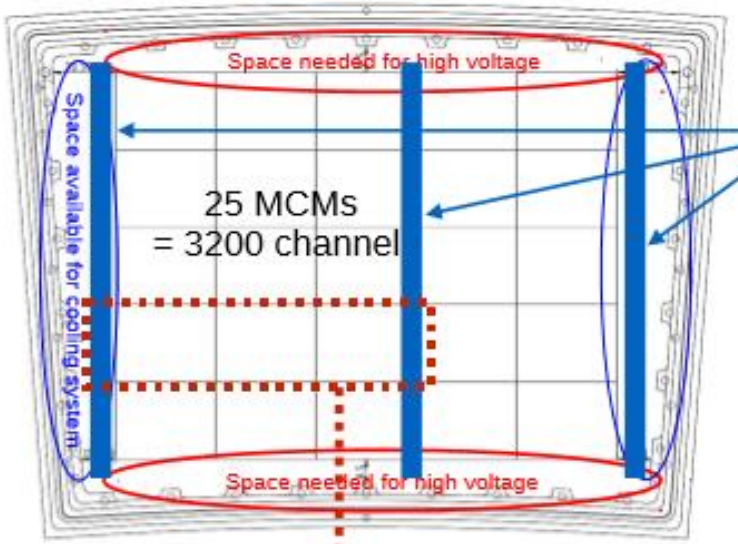
ILC summer camp 2015 Figure by Kyusyu univ.

Power estimation

	W/resistor	W/saltro	W/board	A/board
16V	0.256	0.768	30.72	1.92
17.7V	0.313	0.94	37.59	2.124
20V	0.4	1.2	48	2.4
SALTRO @40MHz	-	0.94	37.6	-

3D Thermal Modeling of the Readout Module

Two cooling pipes at the module sides and one near the middle.



cooling pipes

Taking into account the symmetry, minimum simulation area is chosen so that the hottest part is included.

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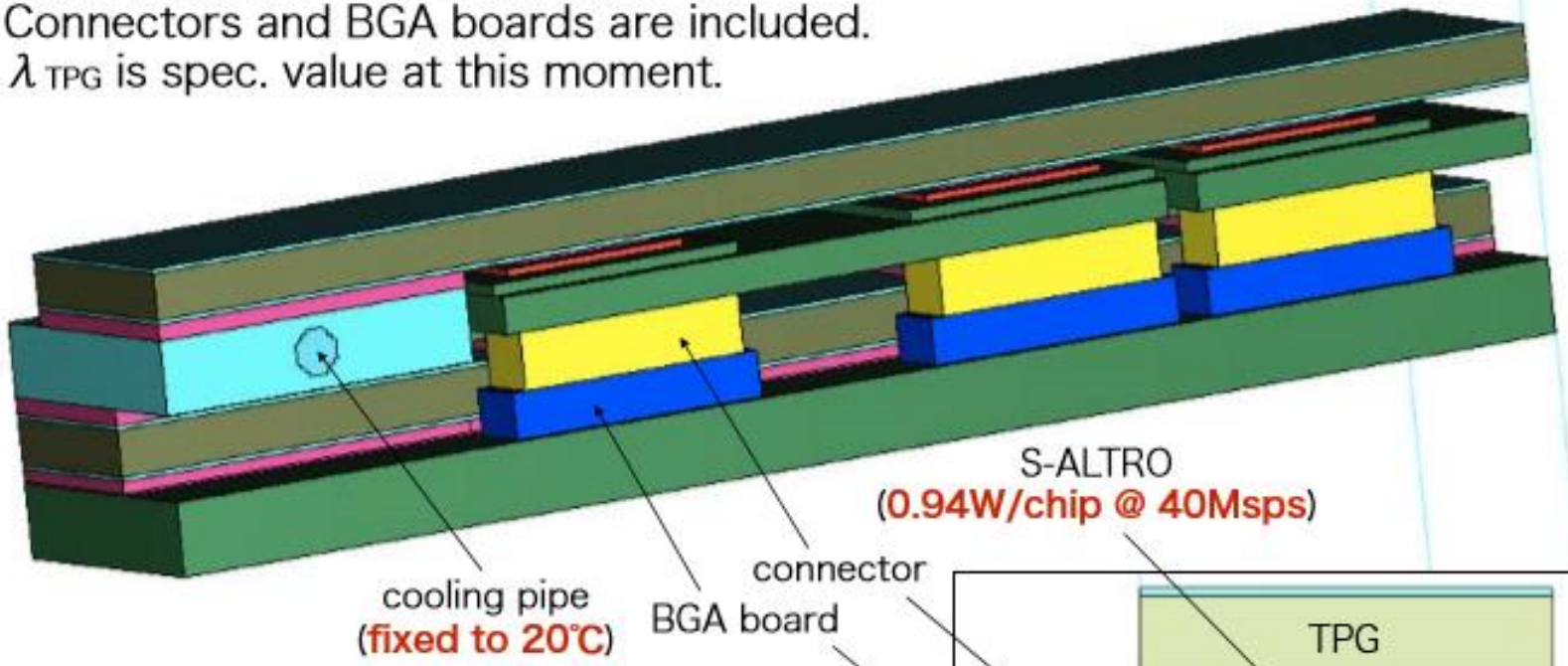
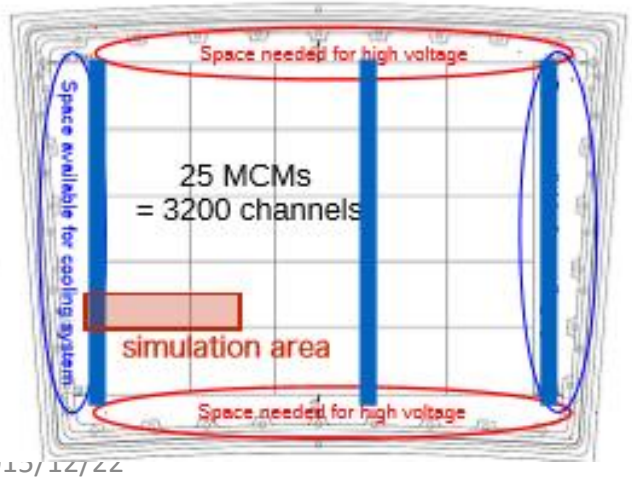
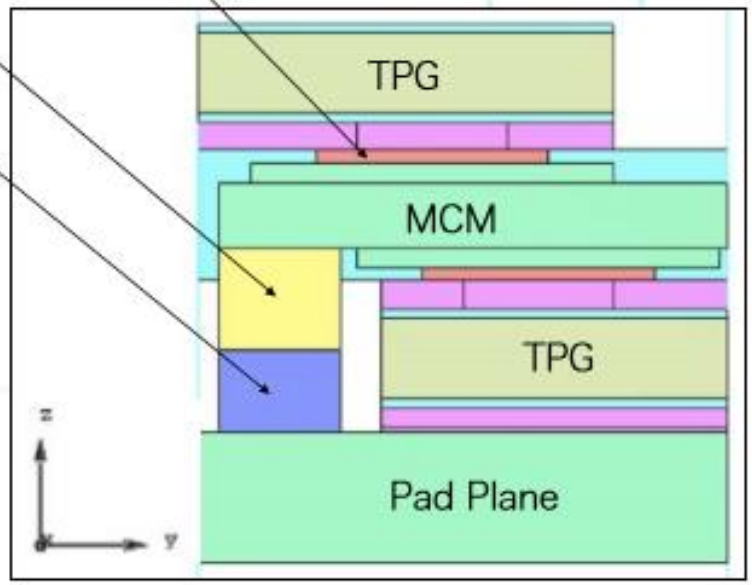
3D Thermal Modeling of the Readout Module

More precise modeling than before.
Connectors and BGA boards are included.
λ_{TPG} is spec. value at this moment.

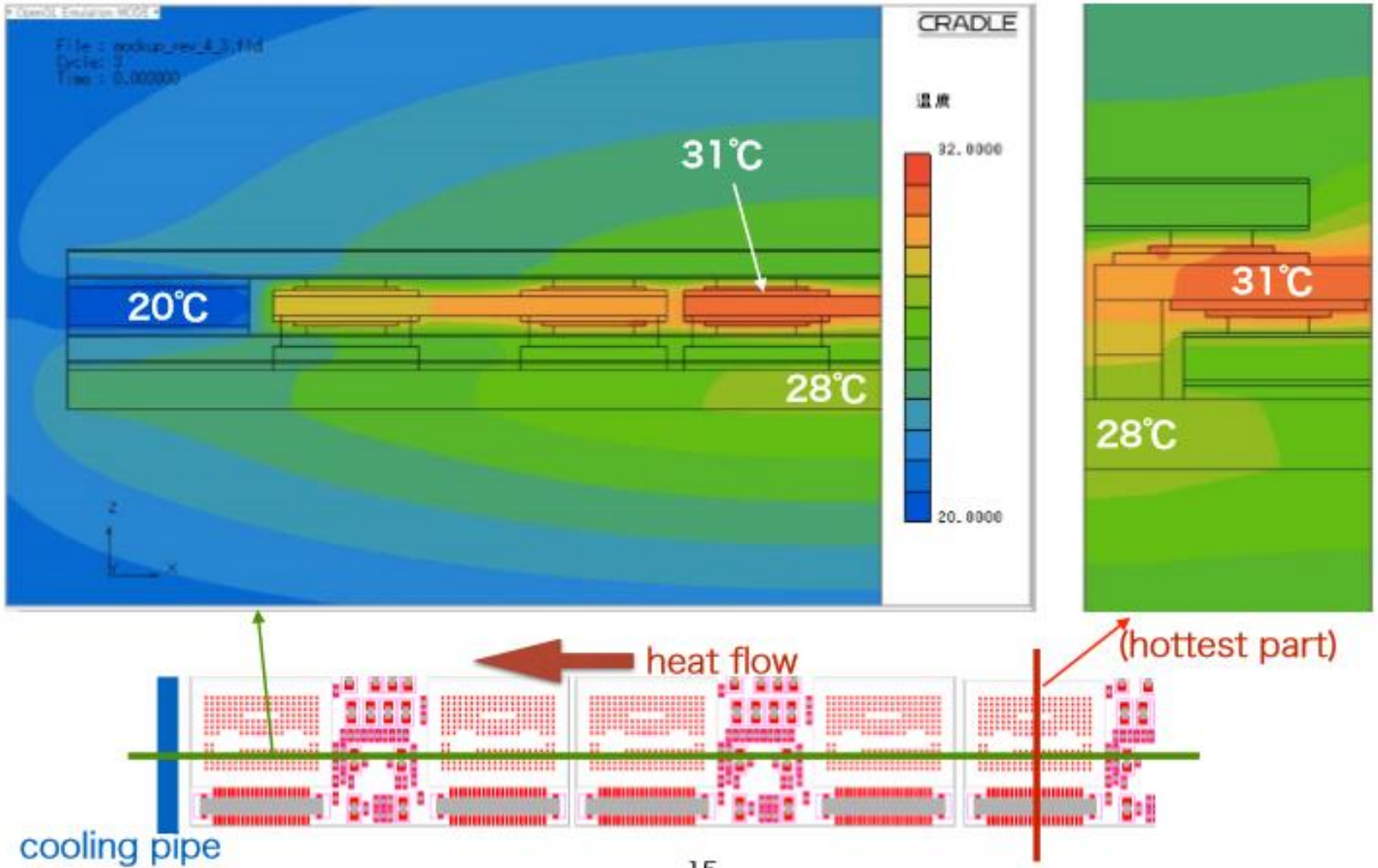






Heat Simulation of the Next Module

T(S-ALTRO) ~ 31℃ → acceptable for the chip operation
Tmax(Pad Plane) ~ 28℃ = T(pipe) + 8℃ → NOT acceptable for the final LCTPC



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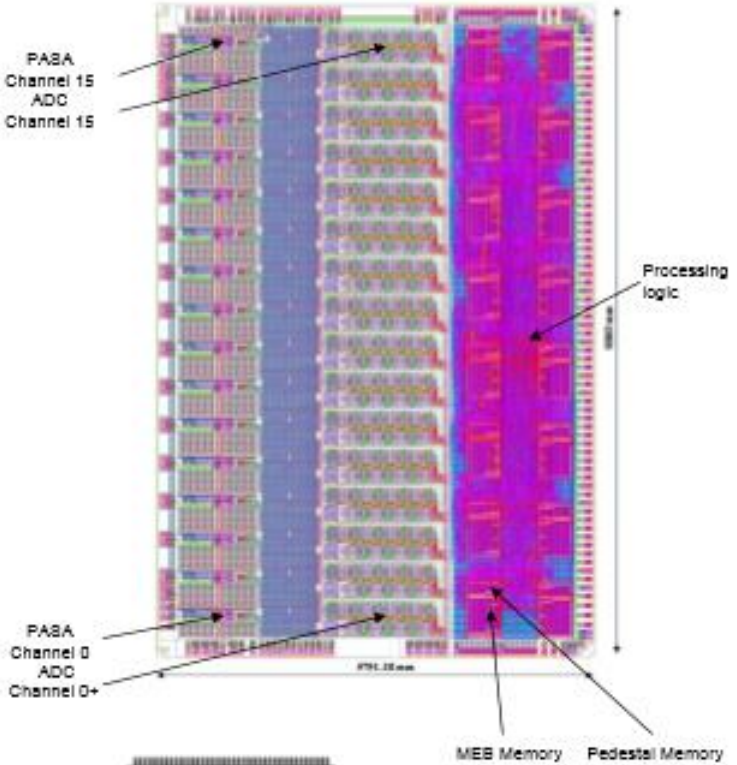
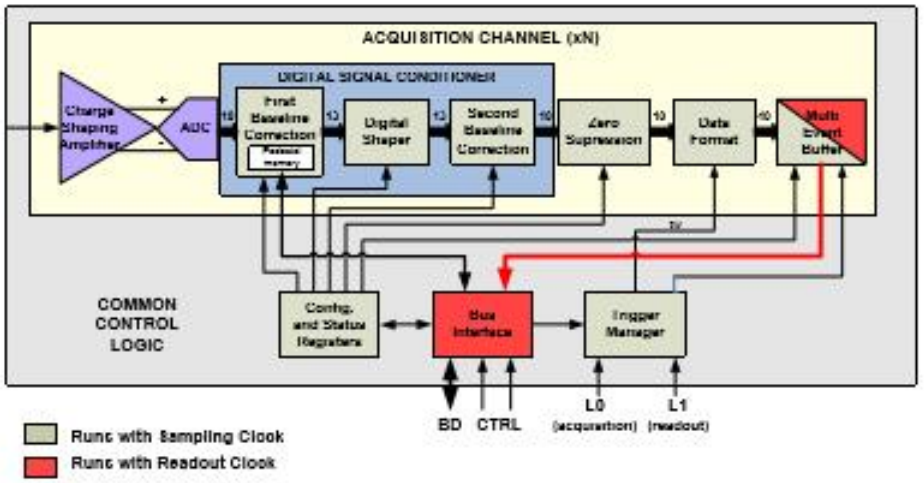
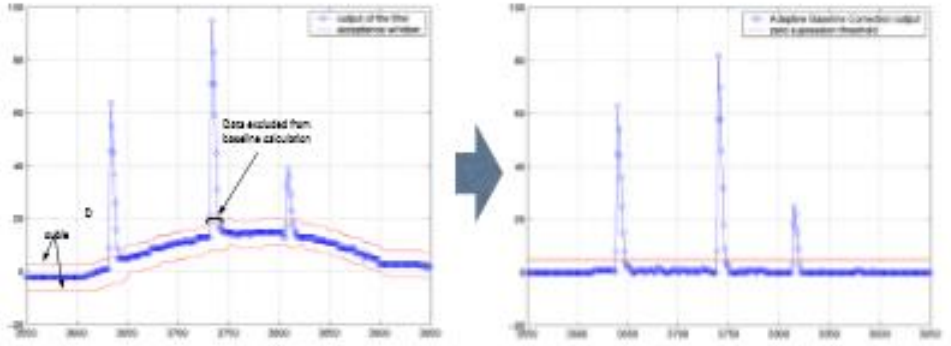
16ch S-ALTRO Demonstrator (CERN)





Wire bonding package
24mm x 24mm x 1.4mm



Example of baseline correction

- Successfully fabricated May/2011
- Ok, now extend to S-ALTRO"64"?

Reference:
"S-ALTRO prototype" 27.07.2010

Thermocouple – 熱電対

an electrical device consisting of two different conductors forming electrical junctions at differing temperatures.