Cooling Structure of ILC-TPC Readout Electronics

Keiichiro higuchi

Outline

- ILC

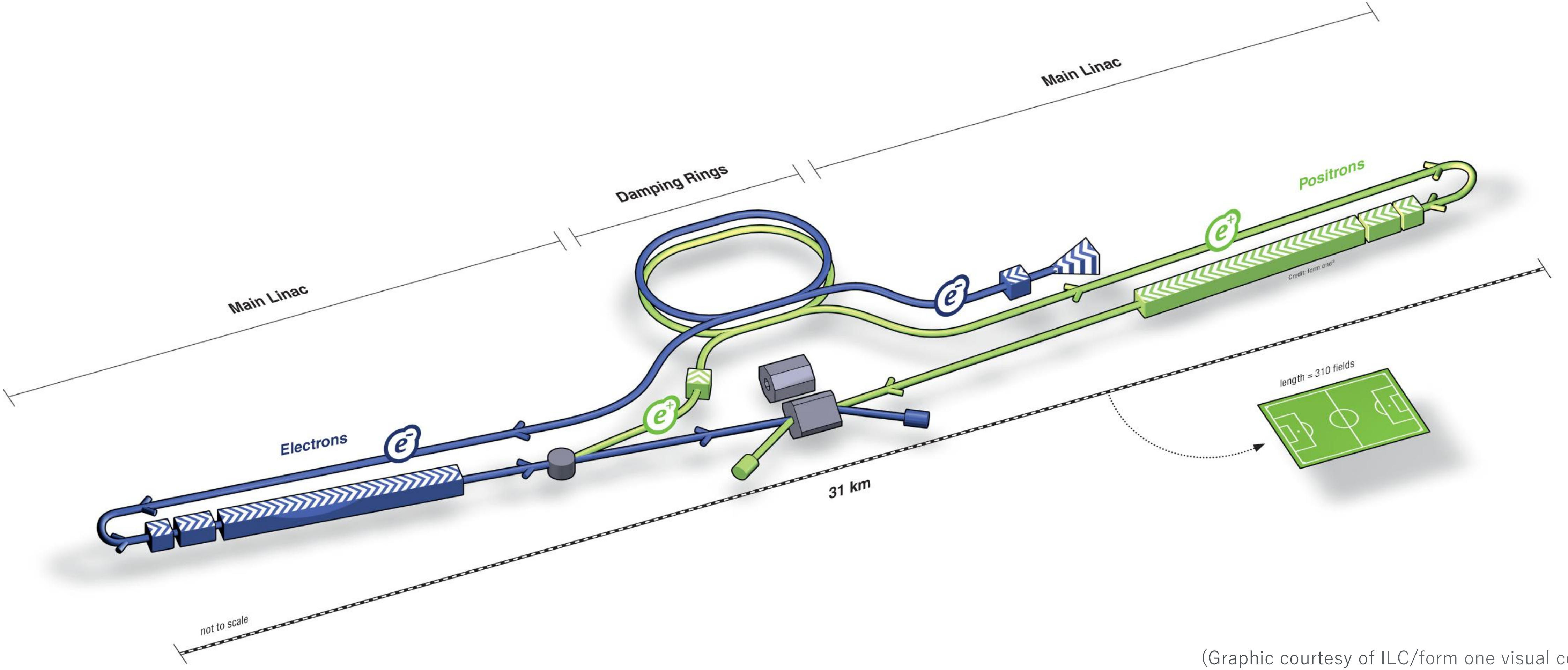
TPC
  -principle
  -requirement

Electronics
  -problem
  -In order to solve the problem

- Past research(based on Kawakami`s study)
- Future research

ILC(International Linear Collider)

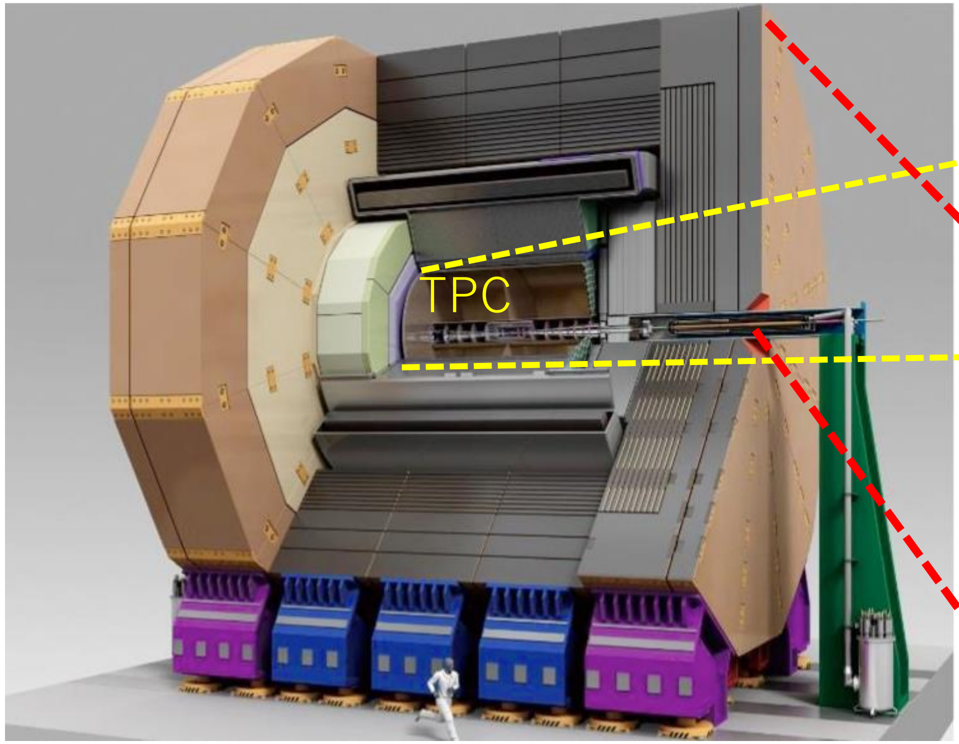
ILC is electron and positron accelerator and collider. The purpose of it is to learn more about the Higgs boson particle.



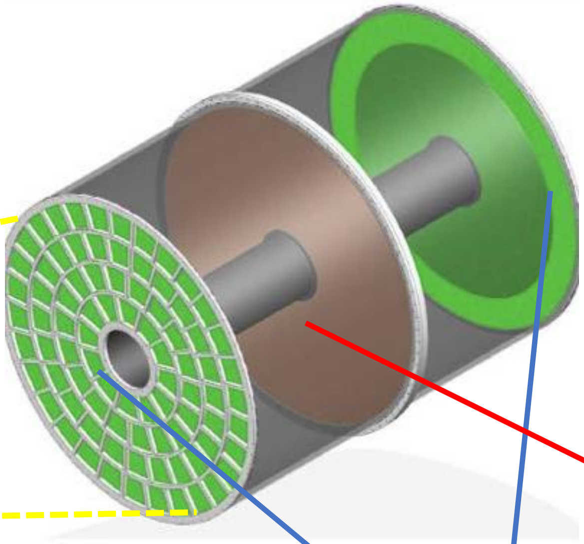
(Graphic courtesy of ILC/form one visual communication)

TPC(Time Projection Chamber)

ILD

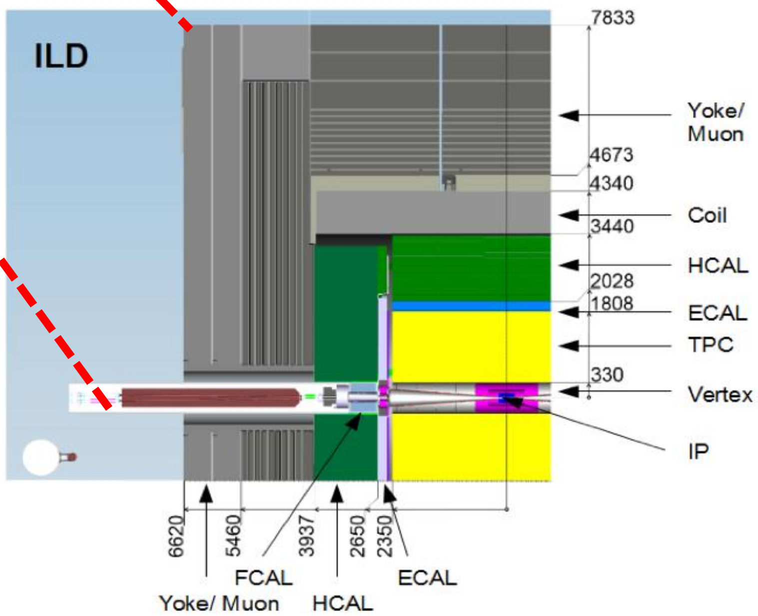


TPC



cathode

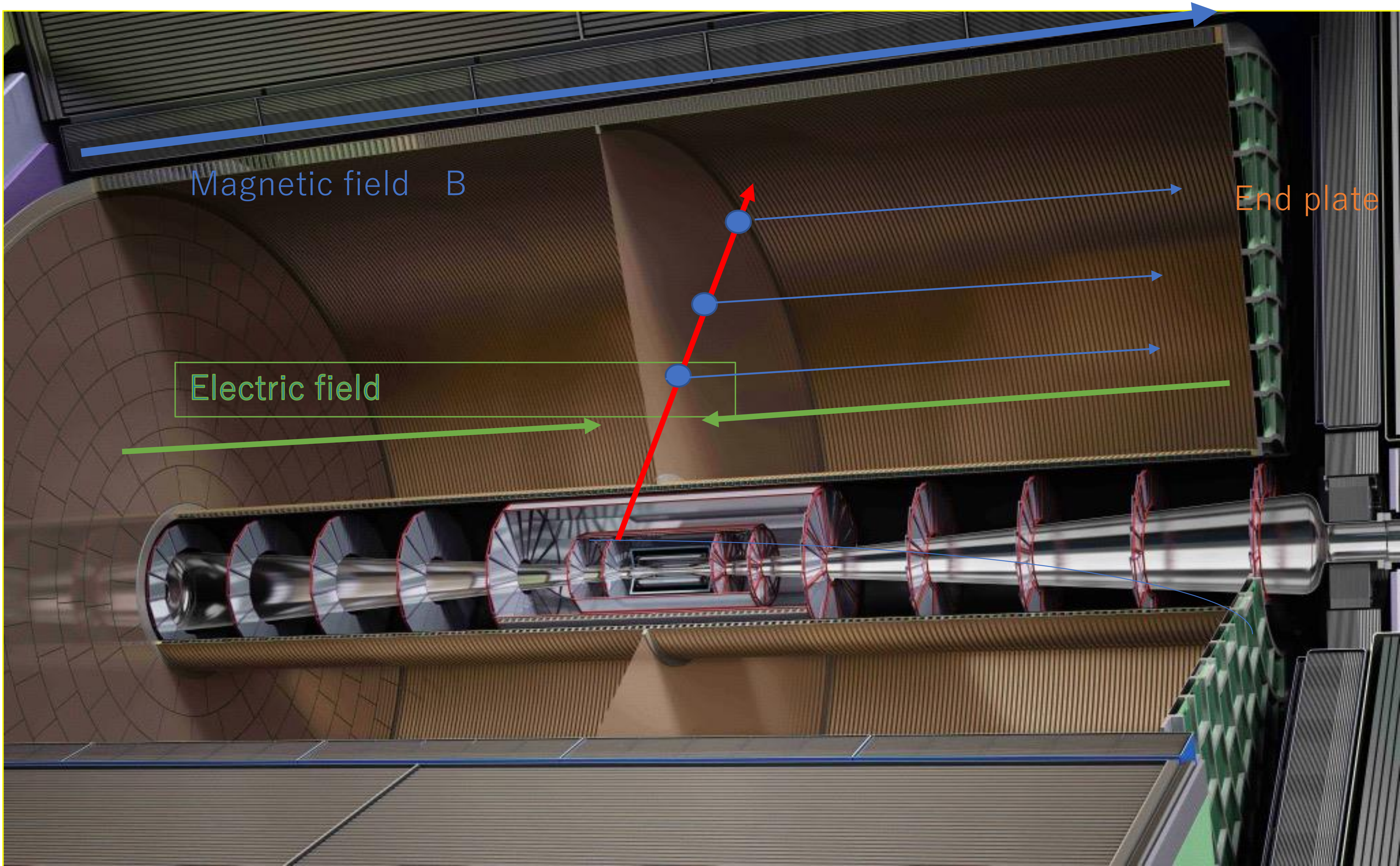
End Plate
(Readout Modules)



TPC-principle

Inside of TPC

End plate

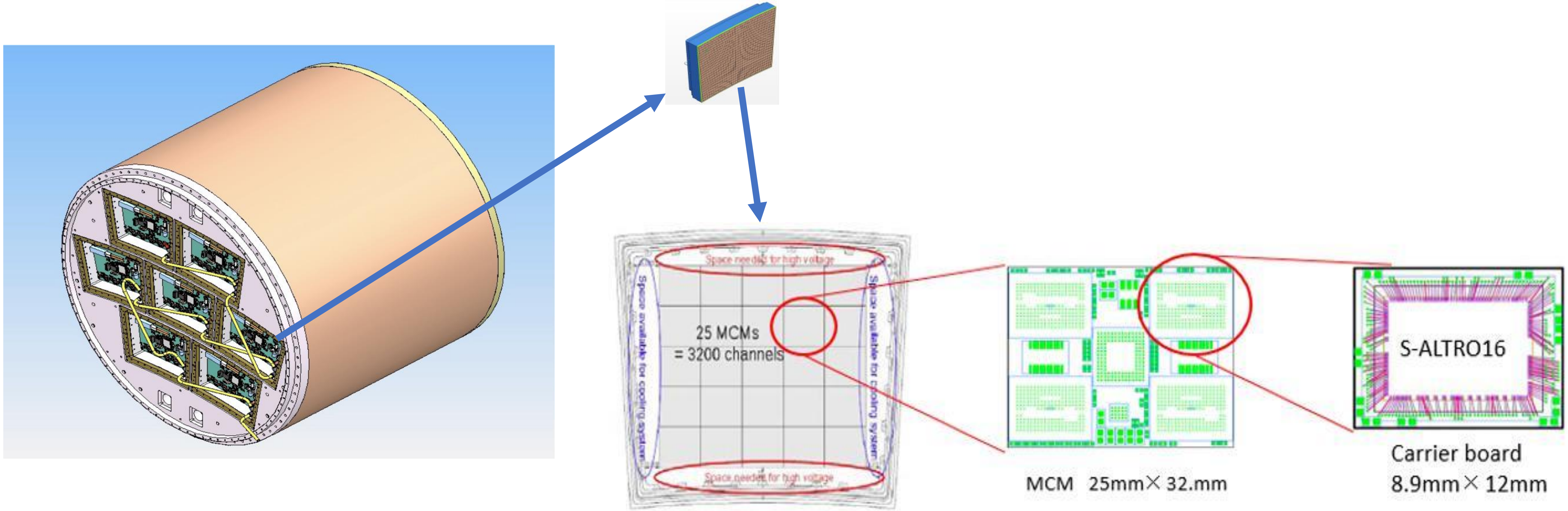


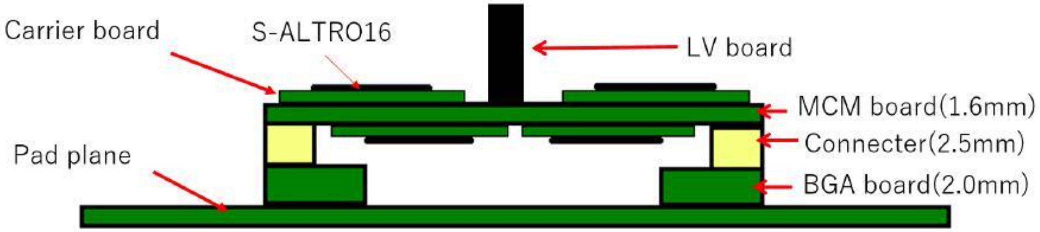
TPC -Requirement

Requirements of TPC from ILC TDR vol. 4

Parameter	
Geometrical parameters	r_{in} r_{out} z 329 mm 1808 mm $\pm$ 2350 mm
Solid angle coverage	up to $\cos\theta \simeq 0.98$ (10 pad rows)
TPC material budget	$\simeq 0.05\ X_0$ including outer fieldcage in r $< 0.25\ X_0$ for readout endcaps in z
Number of pads/timebuckets	$\simeq$ 1-2 $\times 10^6$/1000 per endcap
Pad pitch/ no.padrows	$\simeq 1\times$ 6 mm^2 for 220 padrows
σ_{point} in $r\phi$	$\simeq 60\ \mu$m for zero drift, $< 100\ \mu$m overall
σ_{point} in rz	$\simeq 0.4 - 1.4$ mm (for zero – full drift)
2-hit resolution in $r\phi$	$\simeq 2$ mm
2-hit resolution in rz	$\simeq 6$ mm
dE/dx resolution	$\simeq 5$ %
Momentum resolution at B=3.5 T	$\delta(1/p_t) \simeq 10^{-4}$/GeV/c (TPC only)

Electronics





読み出しエレクトロニクス

引用：ILC-TPC 次期プロトタイプ読み出し エレクトロニクスの冷却構造研究
佐賀大学大学院工学系研究科物理科学専攻 15572007 戸田大輔

Problem of electronics

1.High temperature from electronics→

- Unstable chip operation
- Heat flow to gas volume, which causes

    -unstable drift velocity

    -gas convection

2. Because of PFA (Particle Flow Algorithm), which requires high resolution also at CAL, TPC endplate must be < 25% X0 in z.

In order to solve the problem

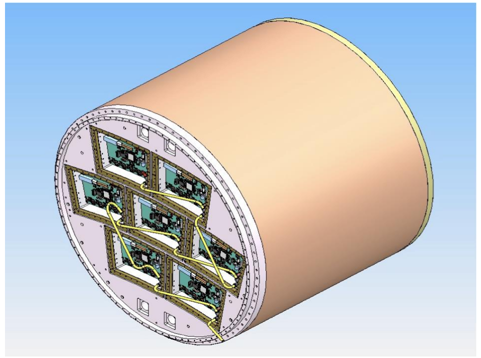
1. Development of chips with reduced chip power

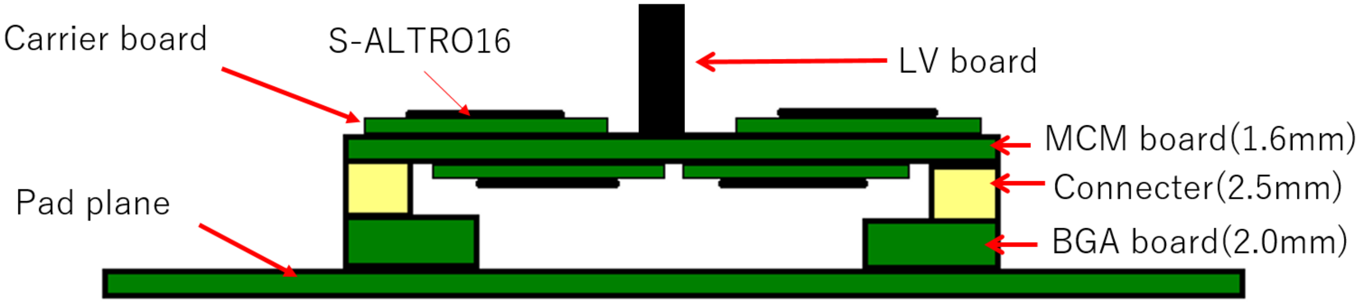
2. Power pulsing

3. Efficient cooling structure with low mass

Past research

Pad board

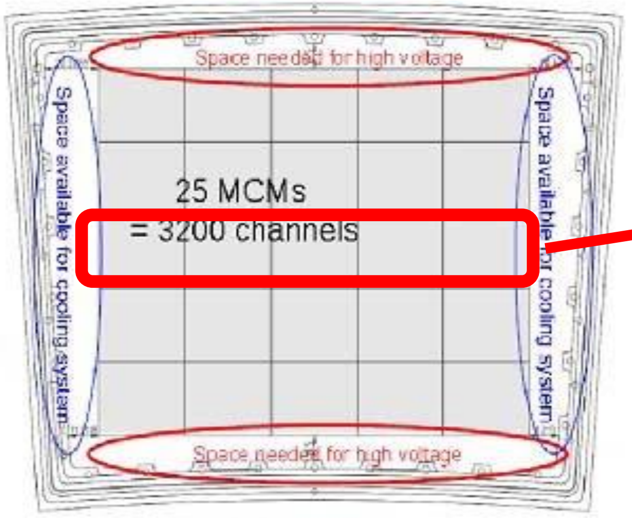




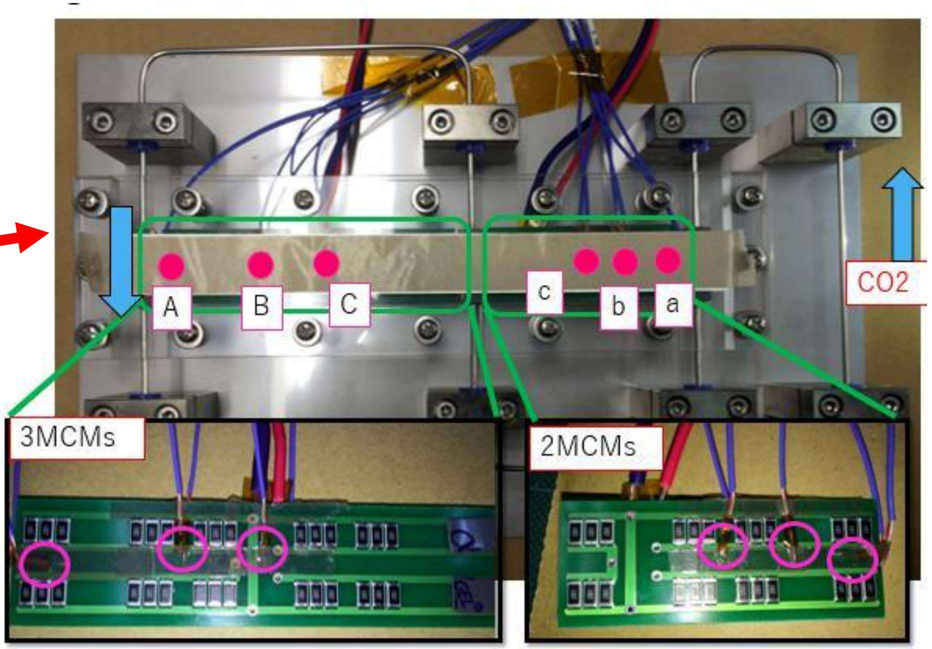
Aim for a temperature gradient of ~1° C or less

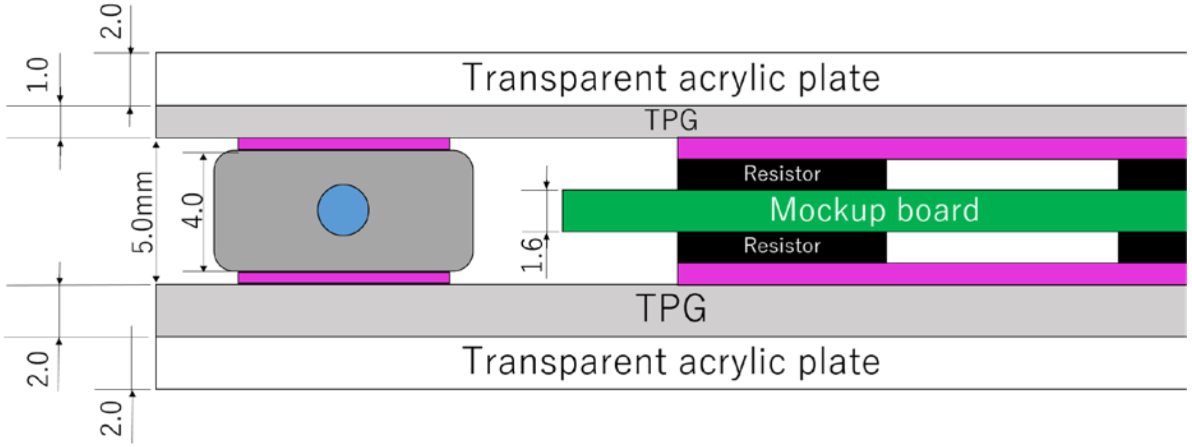
「Quote Daisuke T

Past research

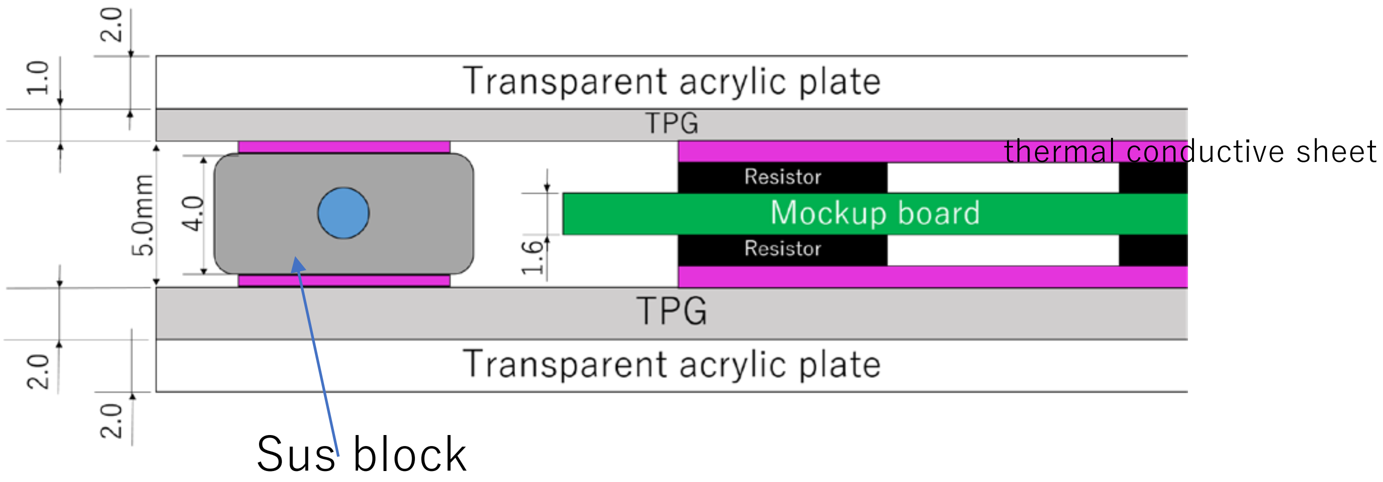


5 MCMs



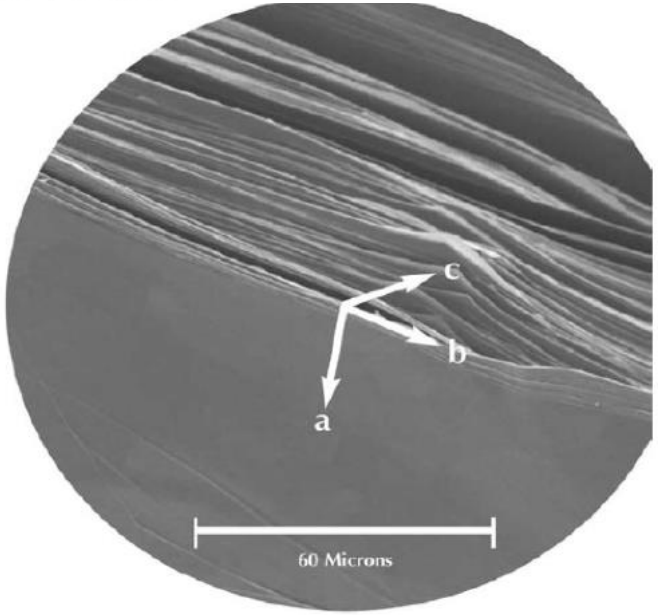


Past research



	Estimation for 1MCM		Mockup test under CO2 cooling
	Top side	Bottom side	Power supply Voltage
MCM continuous operation	3203mW	3028mW	16.34V
Test beam bench At DESY	343mW	168mW	5.35V
ILC power pulsing	223mW	48mW	4.31V

MOMENTIVE performance materials



TPG(thermal pyrolytic graphite)

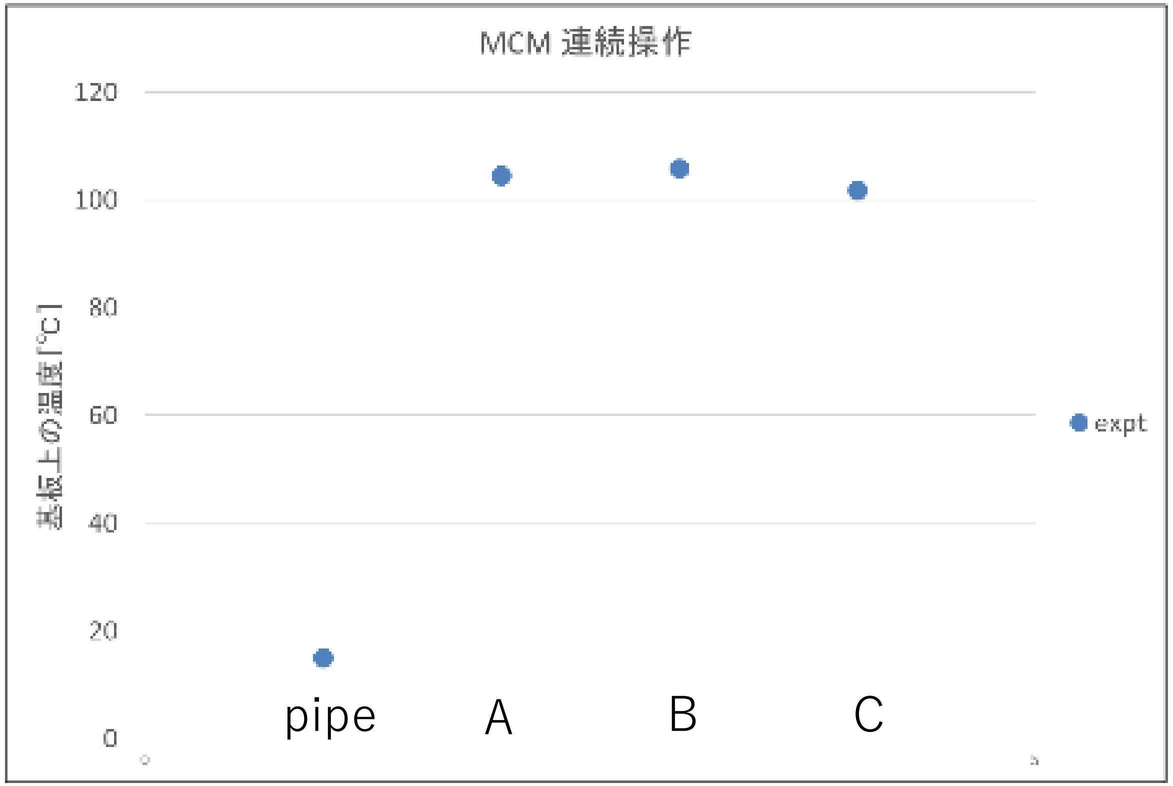
・Thermal conductivity
λ ~1500W/(m・K) a-b
~20W/(m・K) c

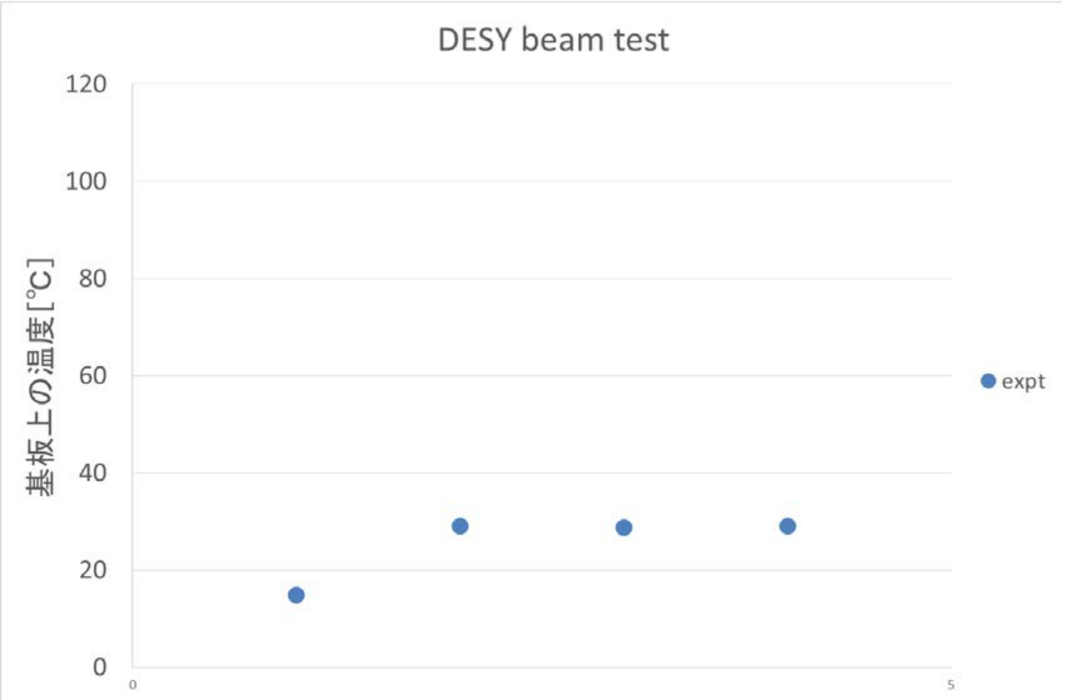
conductivity of copper
386~402W/(m・K)

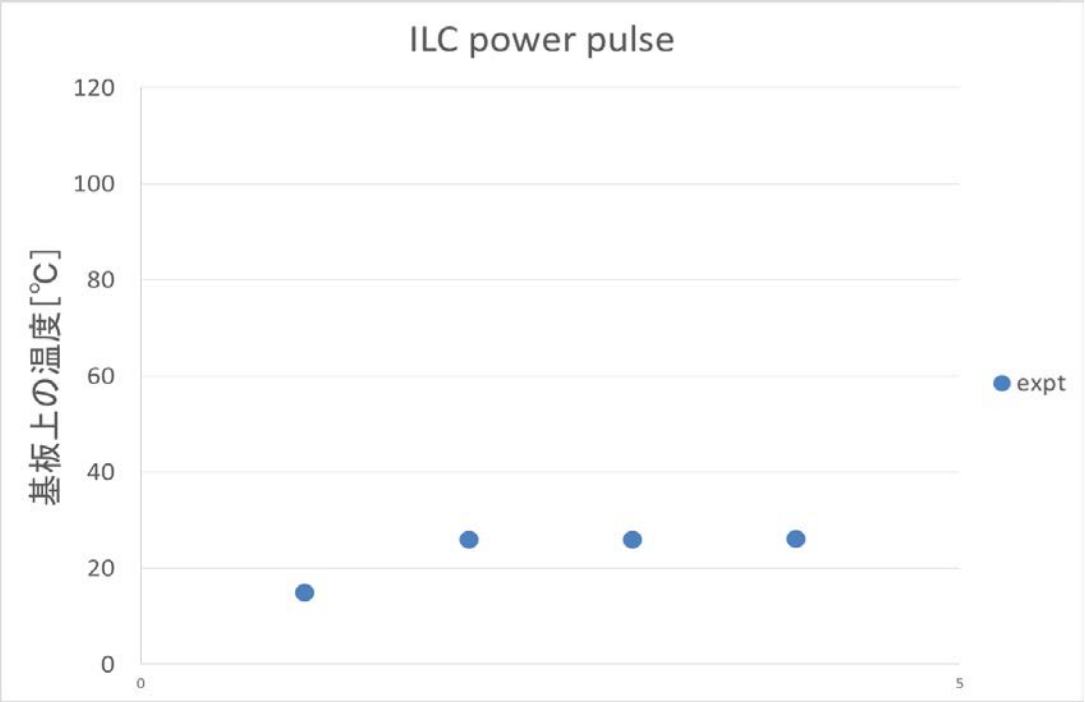
Past research

3MCMs 1mm-thick-TPG side

MCM continuous　operation

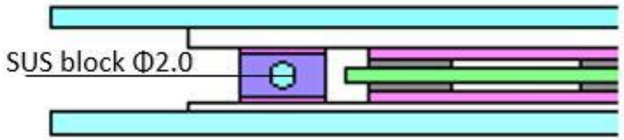






Past research

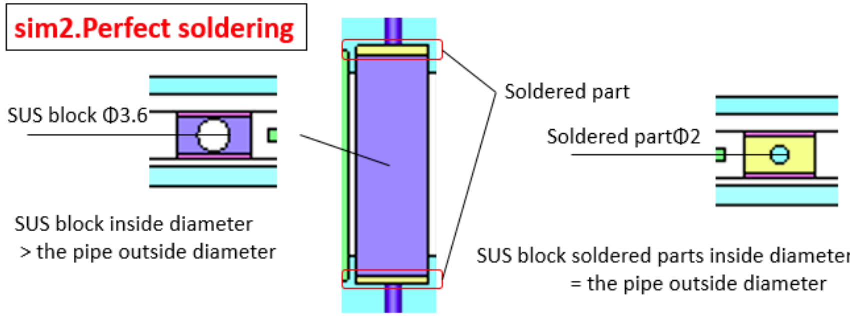
sim1.Seamless



SUS blocks inside diameter
= the pipe outside diameter

SUS block completely comes in contact with the pipe.

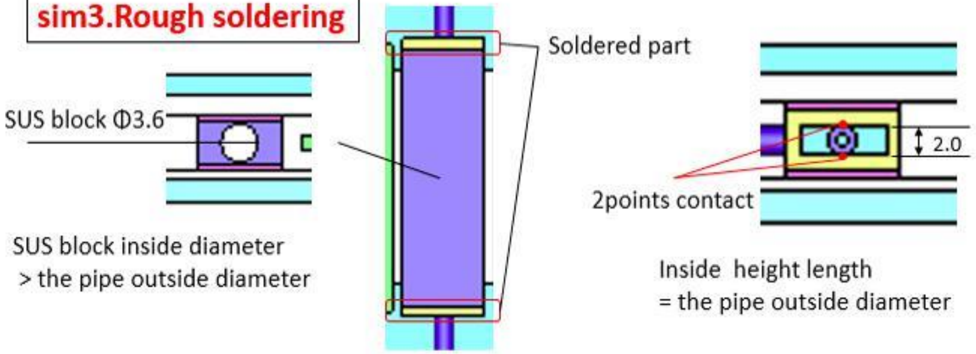
sim2.Perfect soldering



SUS block inside diameter
> the pipe outside diameter

SUS block soldered parts inside diameter
= the pipe outside diameter

sim3.Rough soldering

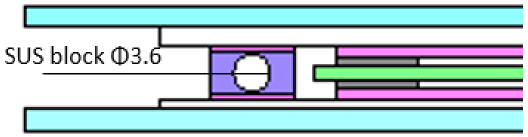


SUS block inside diameter
> the pipe outside diameter

Inside height length
= the pipe outside diameter

sim4.No contact with the pipe

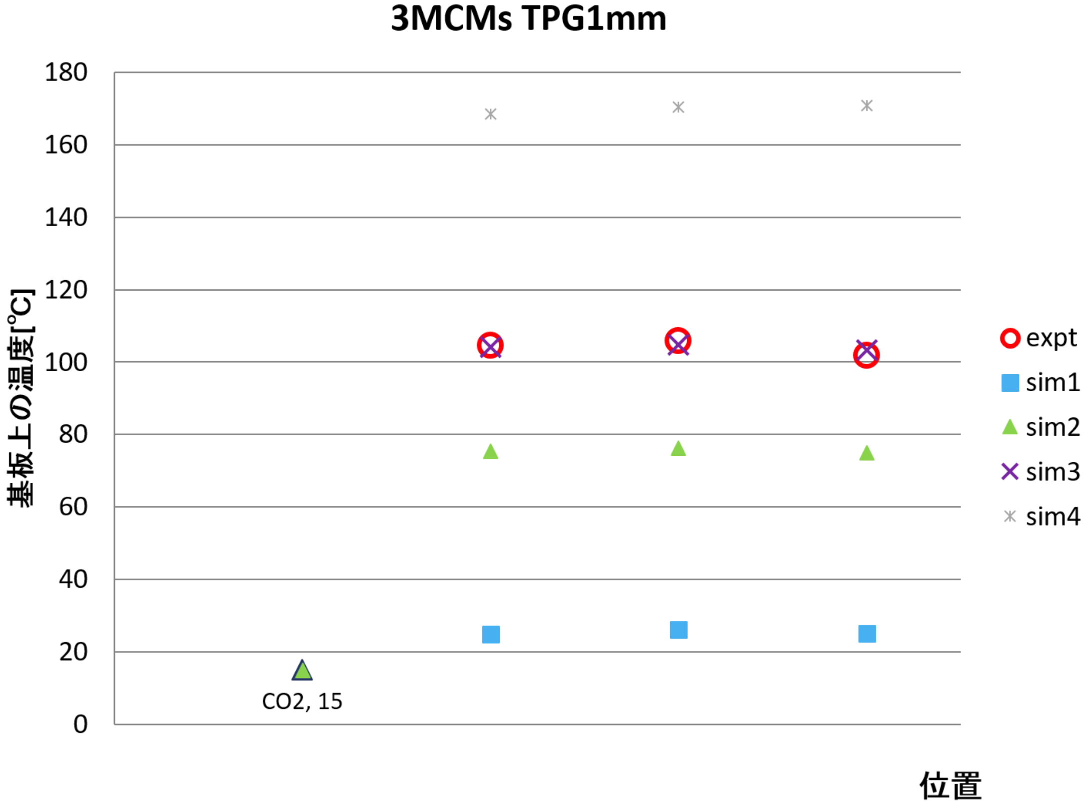
SUS blocks inside diameter
> the pipe outside diameter



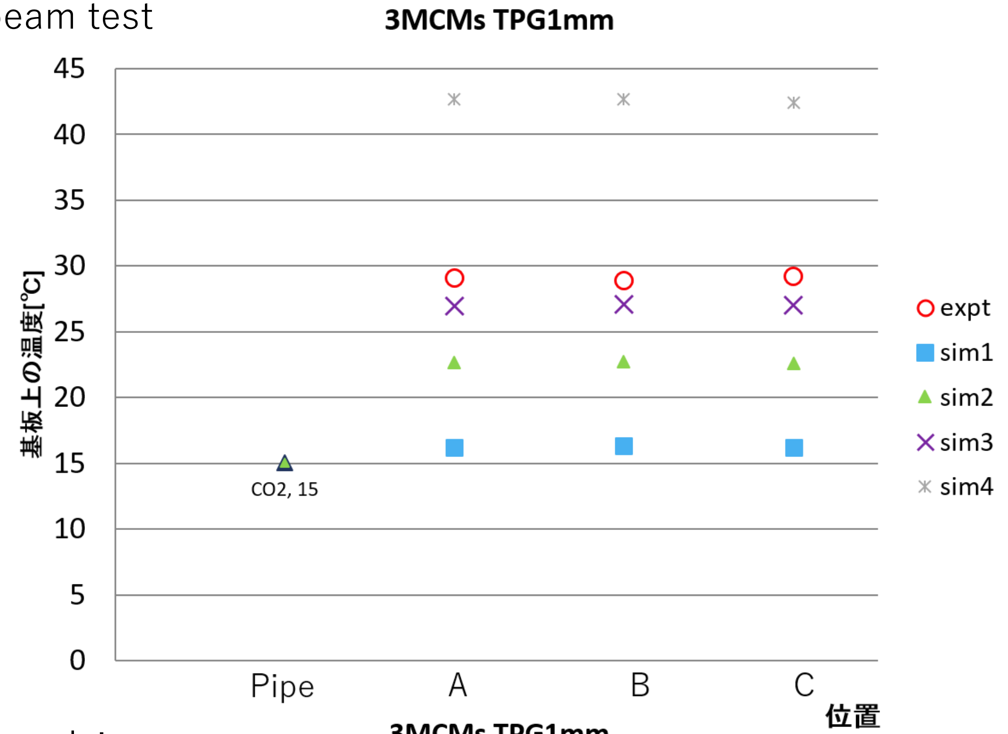
SUS block does not come in contact with the pipe.
There is no soldering part .

Past research

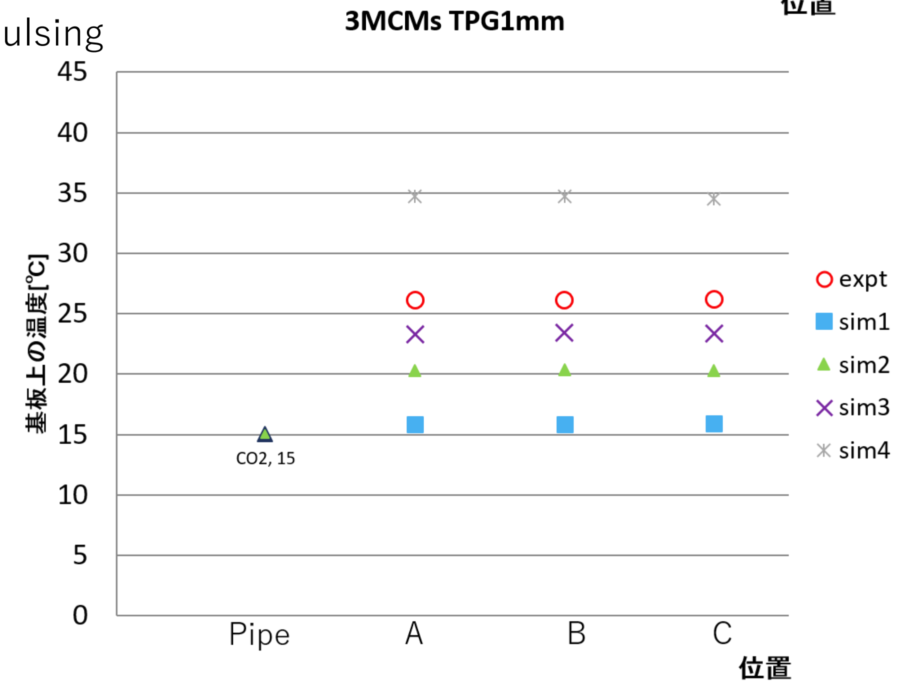
MCM continuous　operation



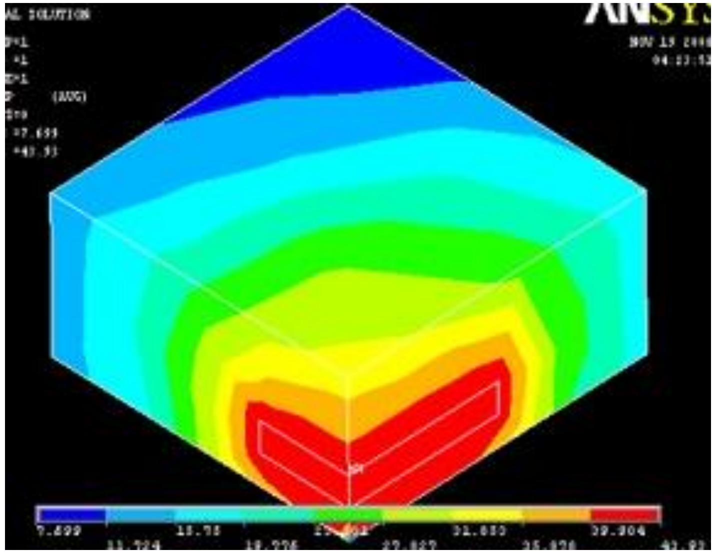
DESY beam test



ILC power pulsing

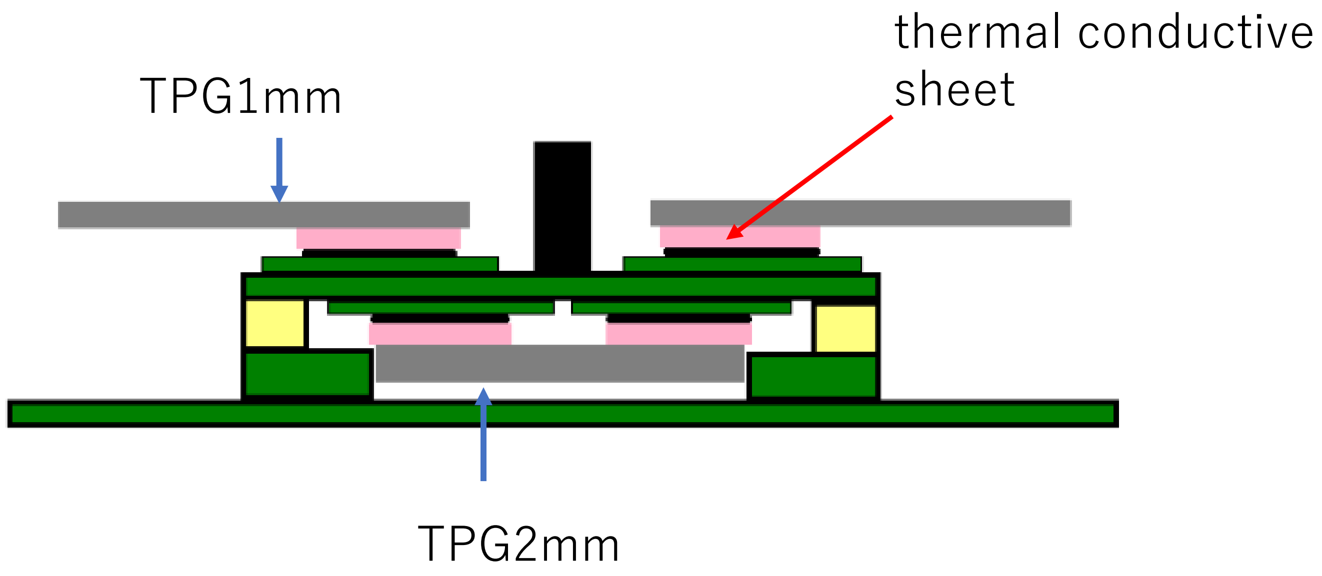


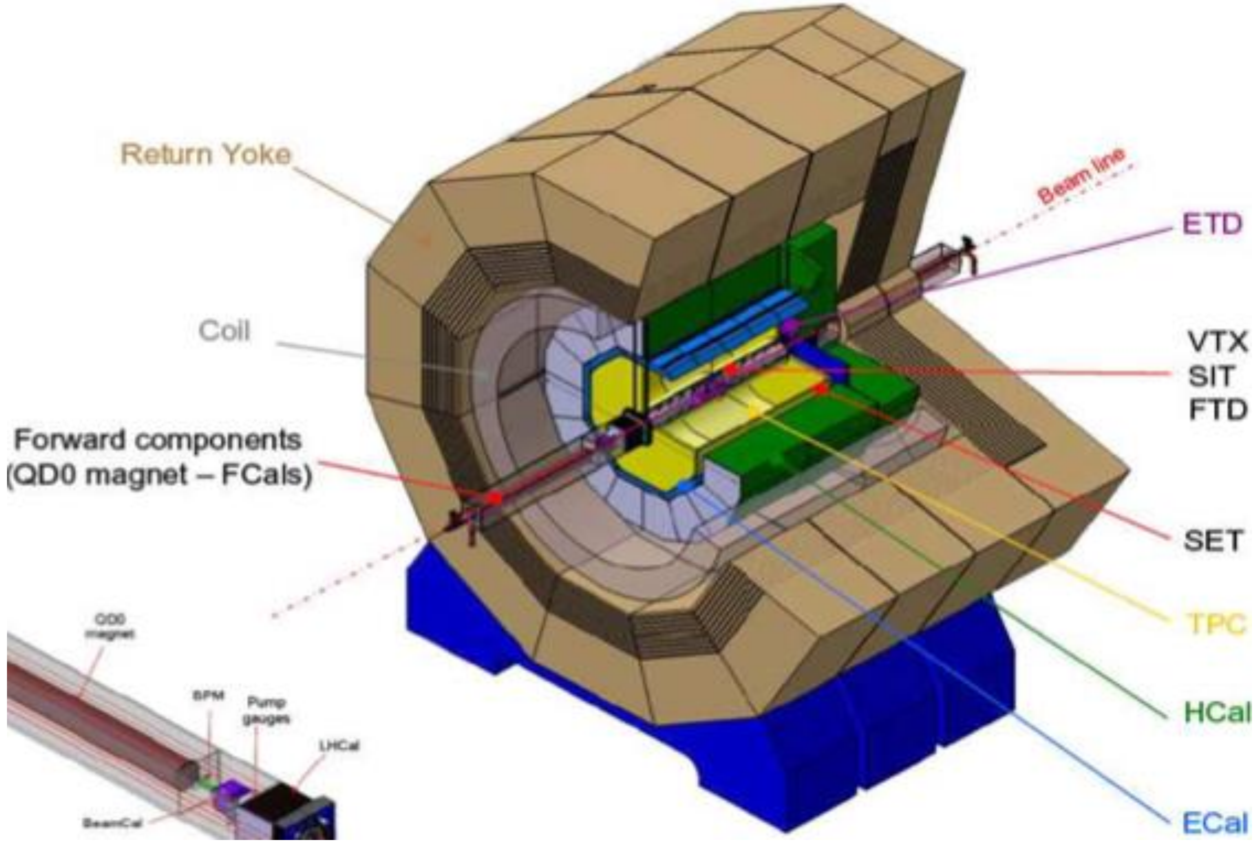
Future research



Test of a 3D-printed cooling plate for a TPC using 2-phase CO_2
By university Paris Sacrly and DESY

Thank you for listening


thermal conductive
sheet
TPG1mm
TPG2mm


Return Yoke
Coil
Forward components
(QD0 magnet – FCals)
Beam line
ETD
VTX
SIT
FTD
SET
TPC
HCal
ECal
QD0 magnet
BPM
Pump gauges
LHCal
BeamCal