High heat resistant front-end XY slit at SPing-8

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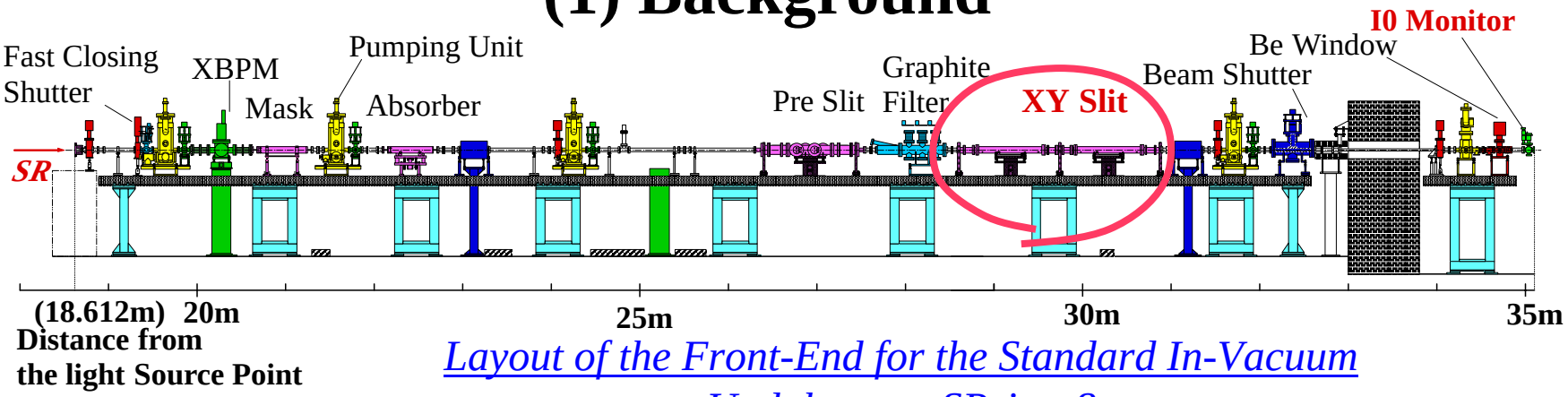
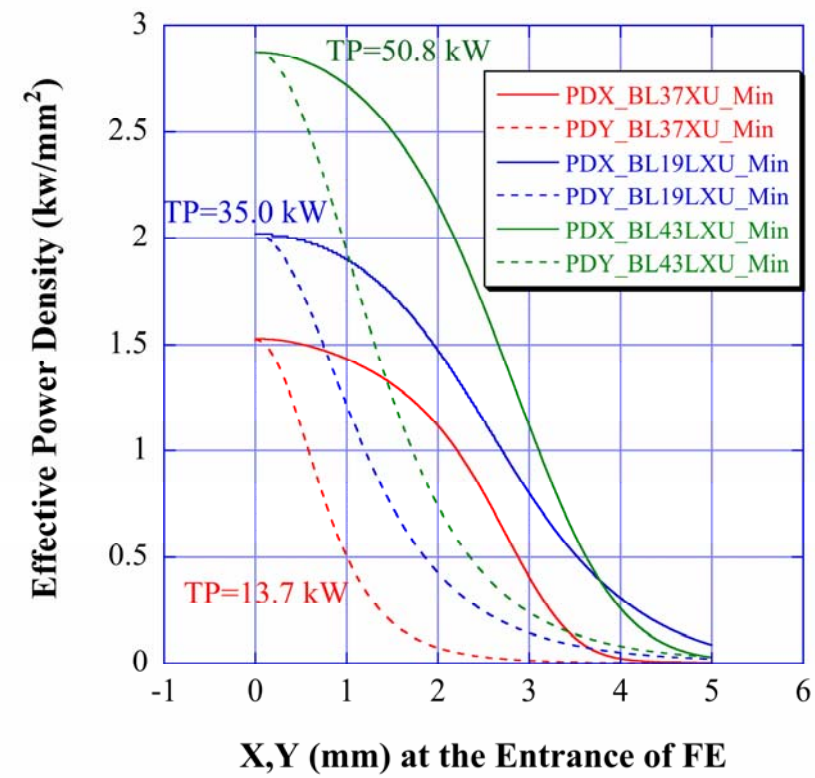
Contents

1) Background
2) Experiment
3) FEM analysis
4) Summary

(1) Background



Layout of the Front-End for the Standard In-Vacuum Undulator at SPring-8



Spatial Distribution of Effective Power Density at the entrance of FE

At the beginning stage : 13.7 kW & 1.5 kW/mm^2

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Latest target value : ***50.8 kW & 2.7 kW/mm^2***

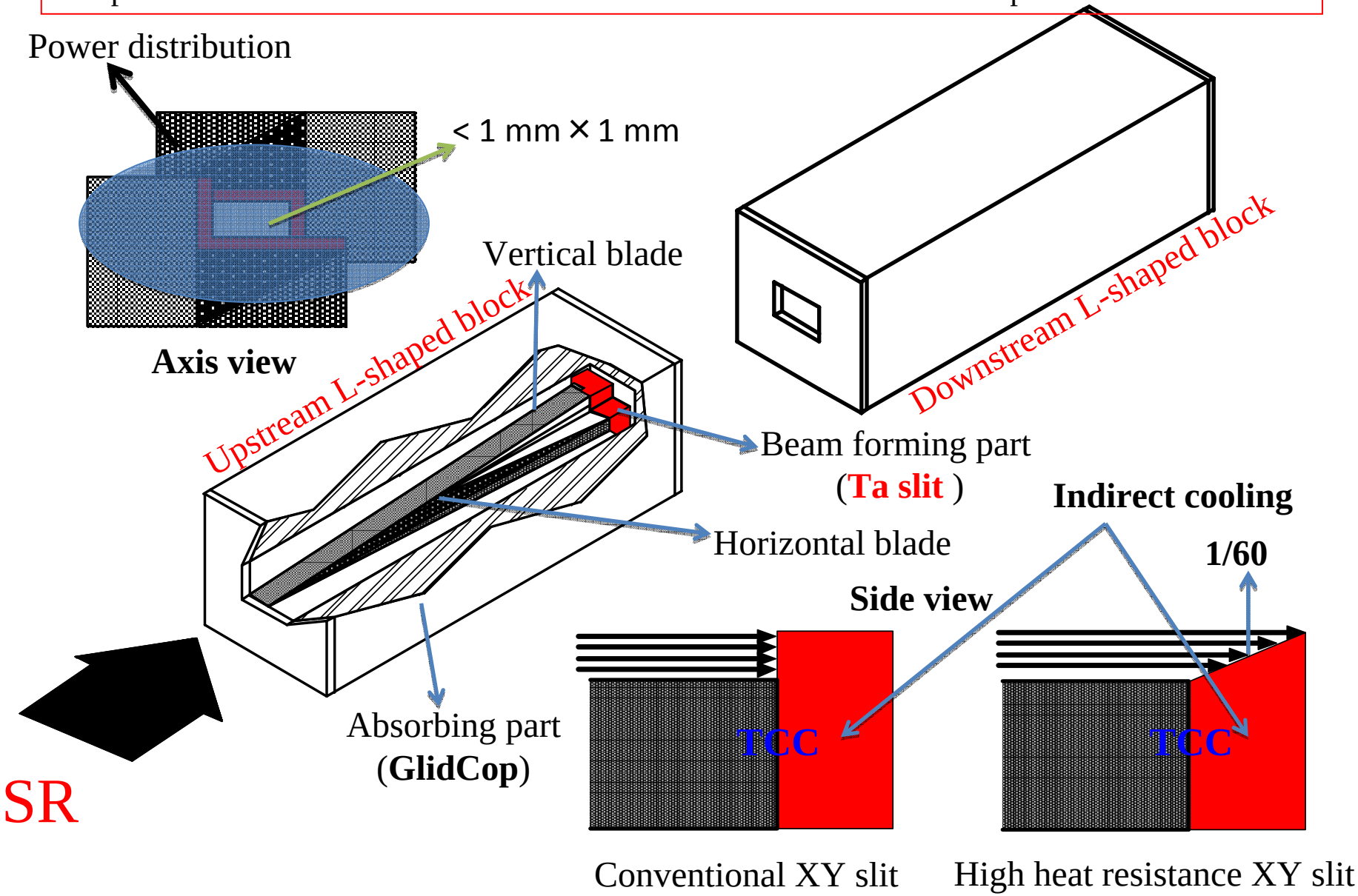
We have been wrestling with investigation into thermal limitation of the high-heat-load components.

So far, we successfully established a procedure to predict the fatigue life of base materials, namely ***GlidCop*** and ***OFC***, within a factor of 2 by employing an elastic-plastic analysis.

In this study, we approached the increase in heat-resistance of the XY slit as a whole apparatus.

Front-end XY Slit

Front-end XY slit works to cut the off-axis power so as to reduce the heat load on downstream components without considerable loss of fundamental radiation used for experiments.

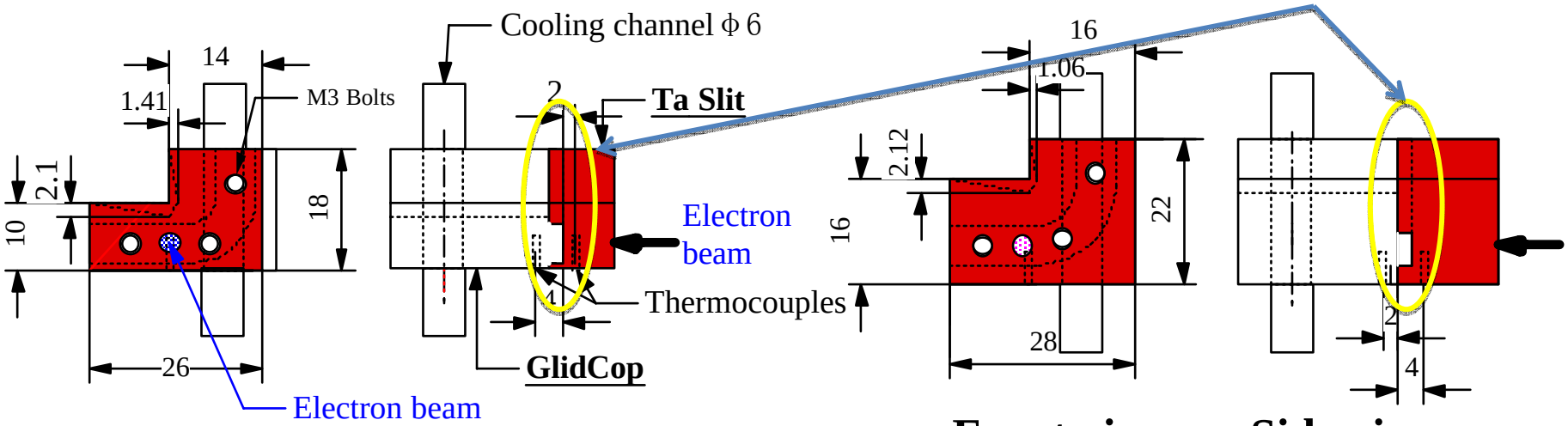


Procedure to examine the Thermal contact conductance (TCC)

1. **Experiment**
   - The test piece was heated by the electron beam.
   - The temperature drop between the interfaces was measured.

2. **Finite Element Analysis**
   - Surface-to-surface contact element, for which TCC can be defined directly, was put on the interface.
   - The beam profile from the experiment was used as the boundary condition.
   - The thermal analyses were carried out for various TCC.
   - The actual TCC could be estimated comparing the temperature drop from the experiment with the analytical result.

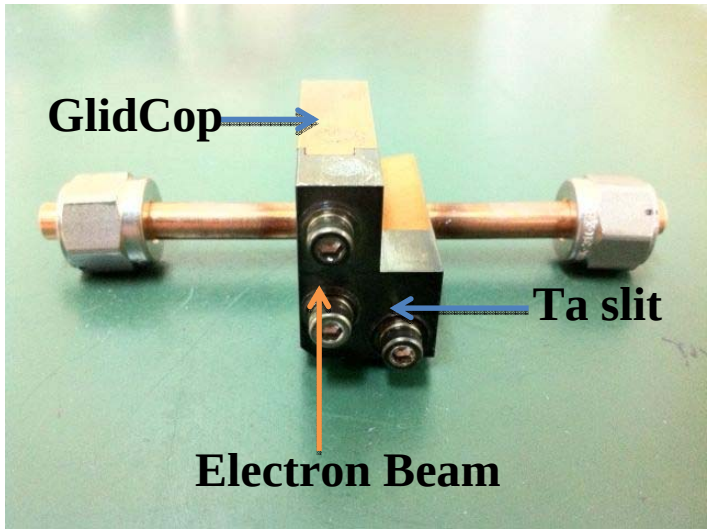
(2) Experiment



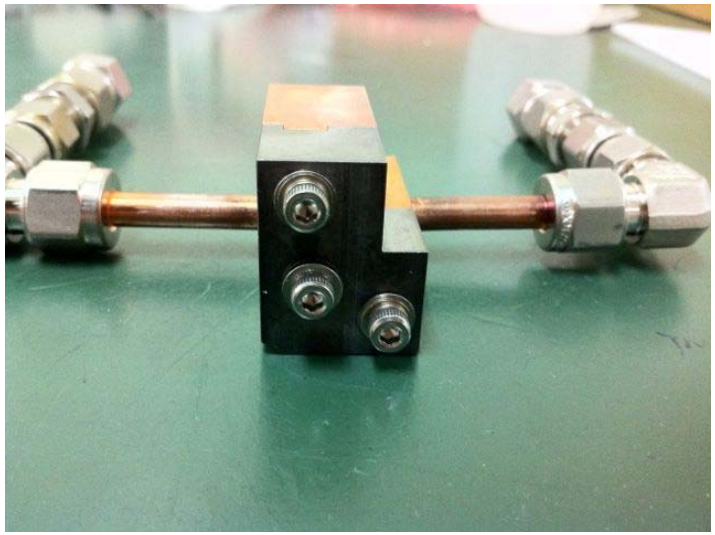
Front view **Side view**

Front view **Side view**

Conventional XY Slit

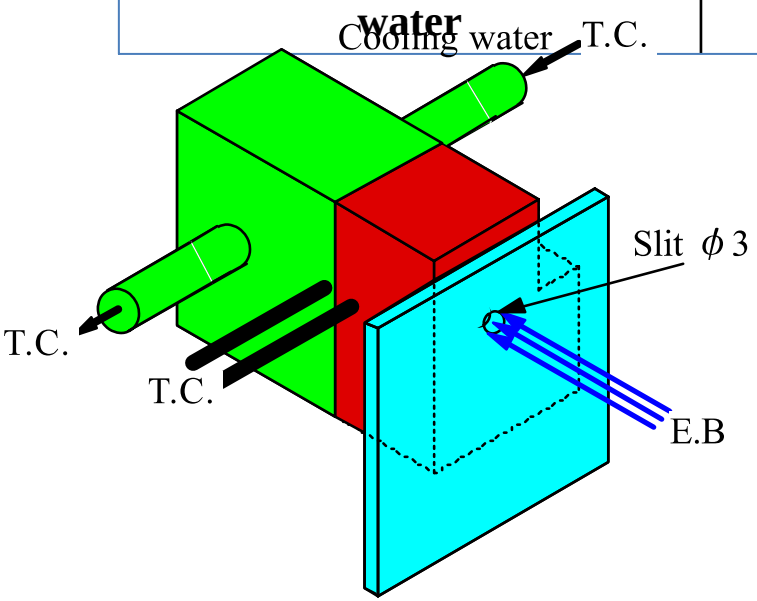


HHR XY Slit

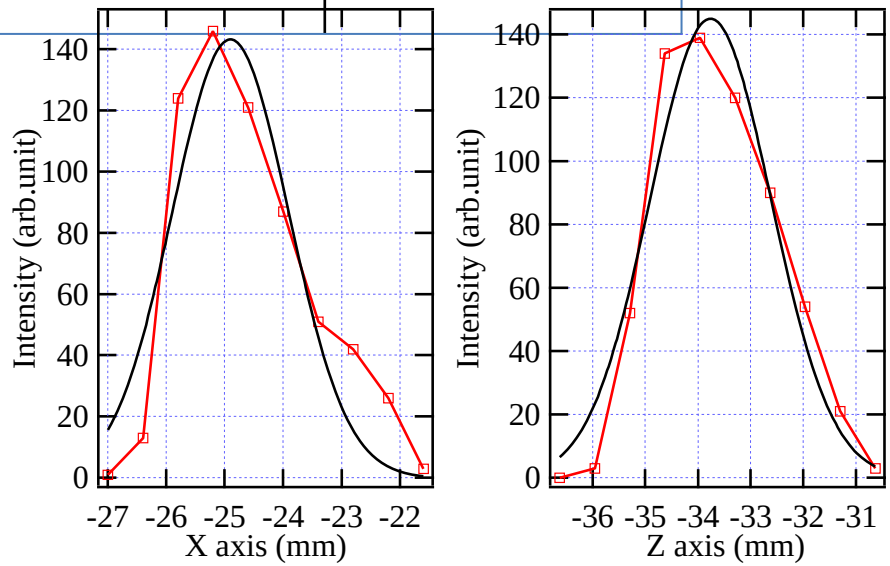


Experimental conditions

	Conv. XY Slit	HHR XY Slit
Interstitial material	Ag 50μm-thick, Nothing	Ag 50μm-thick, Nothing
Fasting torque	0.63 N•m, 1.4 N•m	1.4 N•m
Absorbed power	50 W	50 W
Flow rate of the cooling water	3 liter/min	3 liter/min

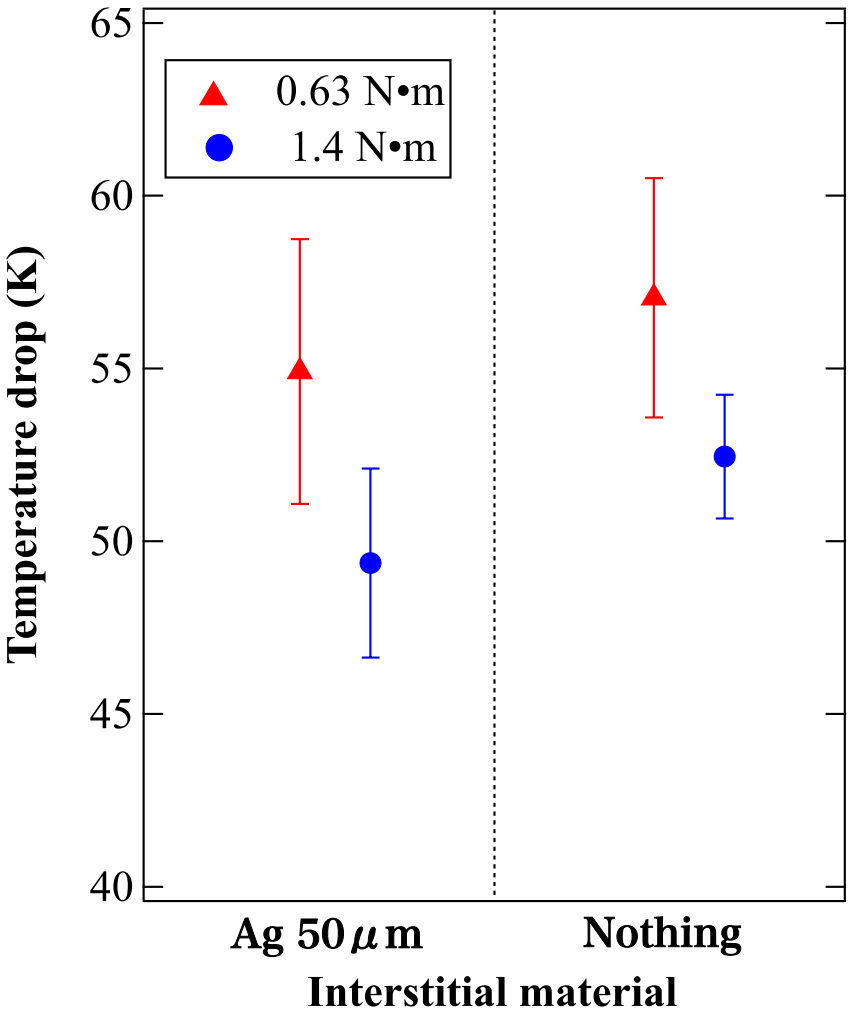


Experimental Setup inside the Sample Chamber

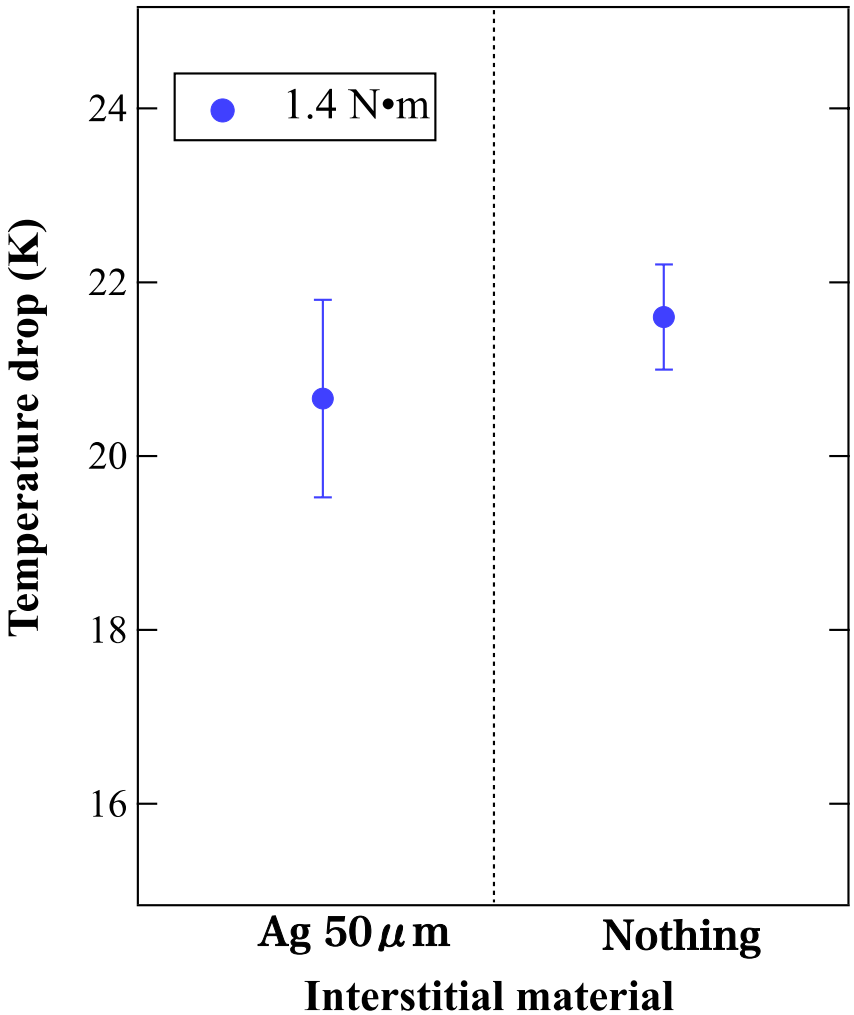


Electron beam profiles in the horizontal and vertical direction. These profiles were fitted by Gaussian functions.

Experimental results



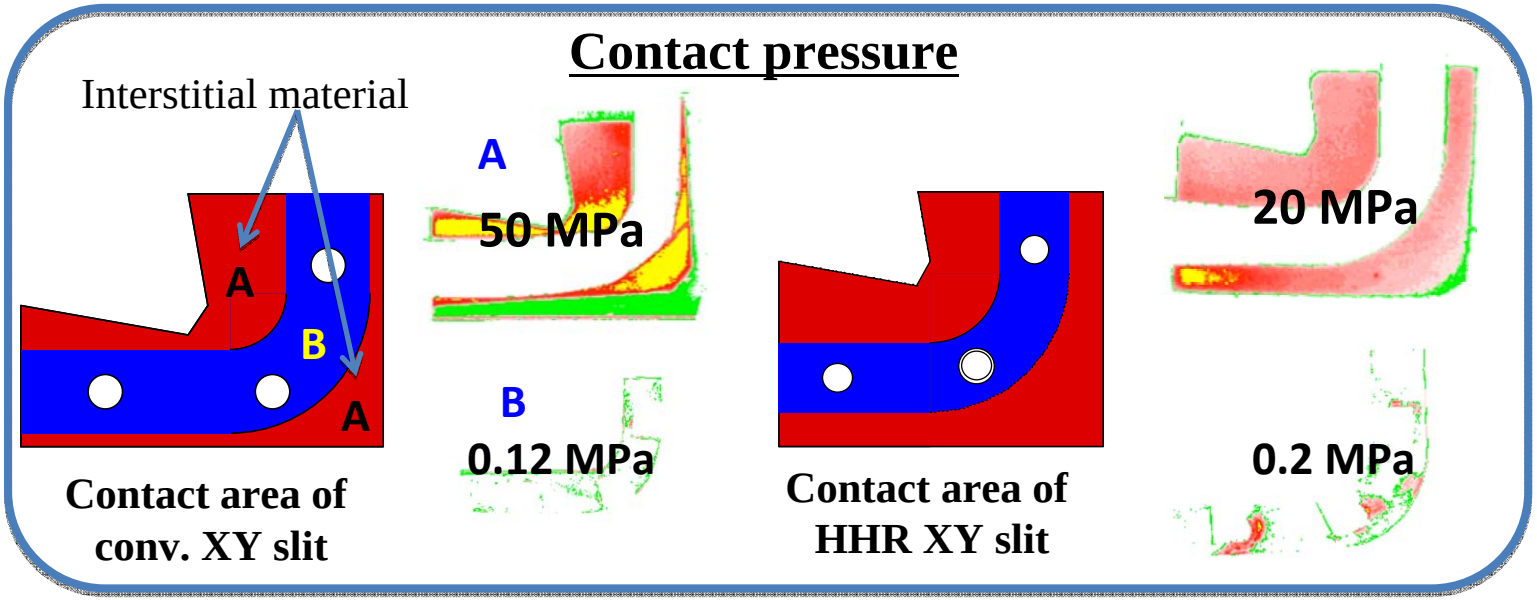
Conv. XY Slit



HHR XY Slit

(3) FEM analysis

Contact pressure



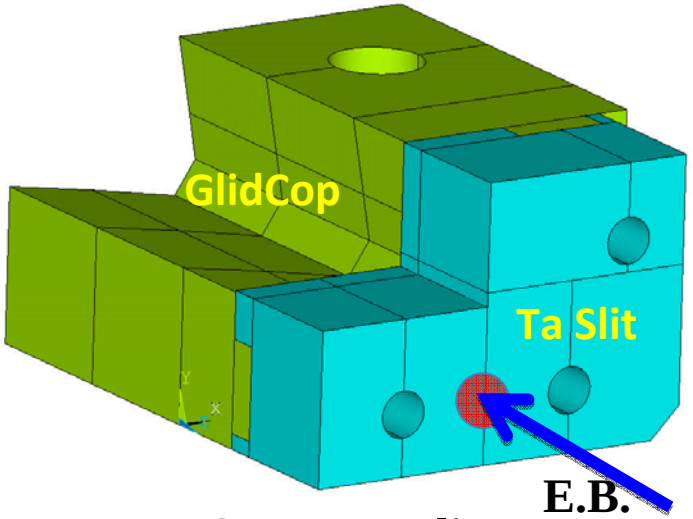
TCC	A : B
Conv.	400 : 1
HHR	100 : 1

Boundary conditions

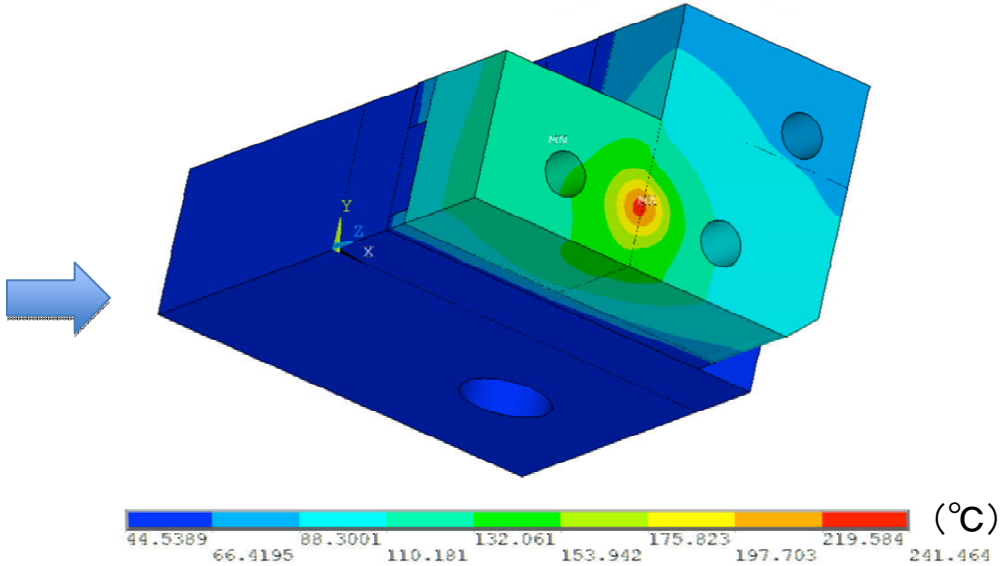
	CONV.	HHR
Absorbed power	50 W	
Area of the input power	Φ3 mm	
Heat transfer coefficient	9200 W/m^2 / K	
Water temperature	30 ℃	
TCC of area A	10,000 ~ 600,000 W/m^2 / K	100,000 ~1000,000 W/m^2 / K
TCC of area B	25 ~ 1,500 W/m^2 / K	1000 ~ 10,000W/m^2 / K

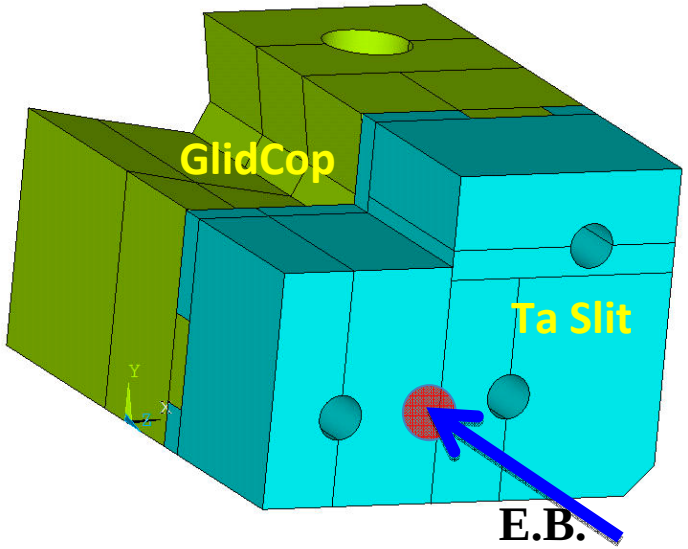
FEM model

Temperature distribution from the nodal solution

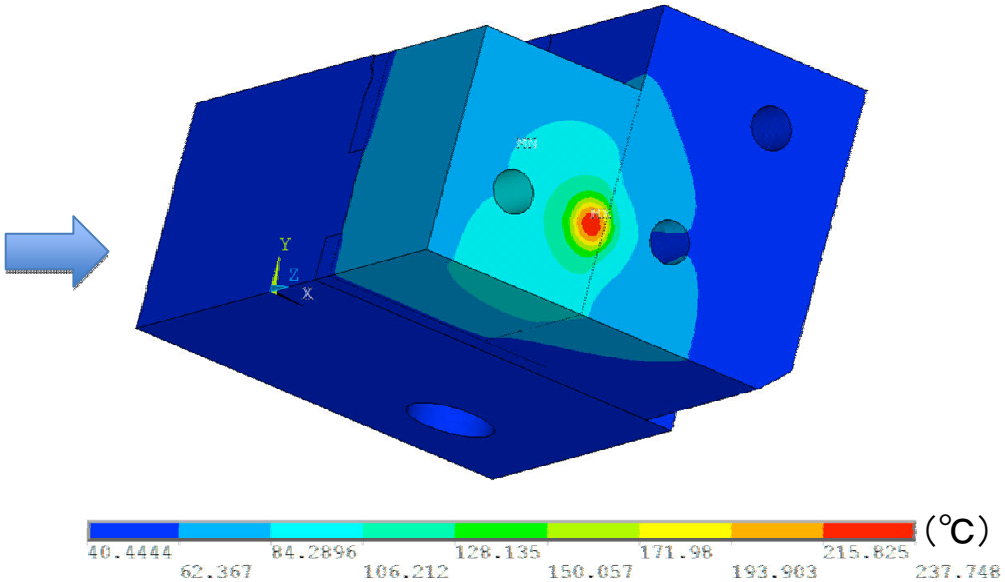


Conv. XY slit

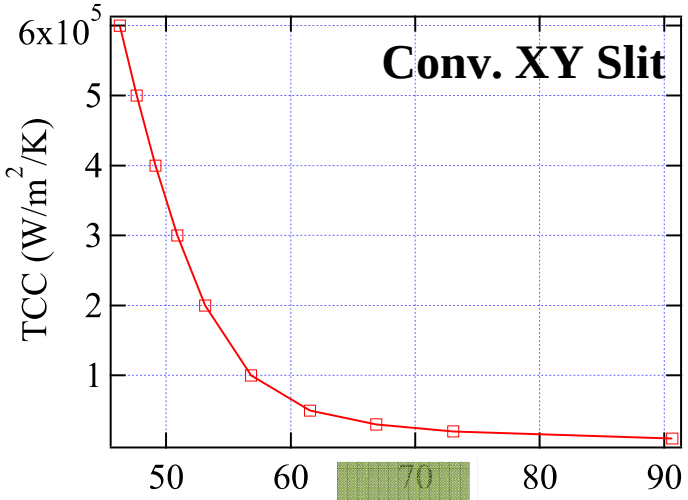


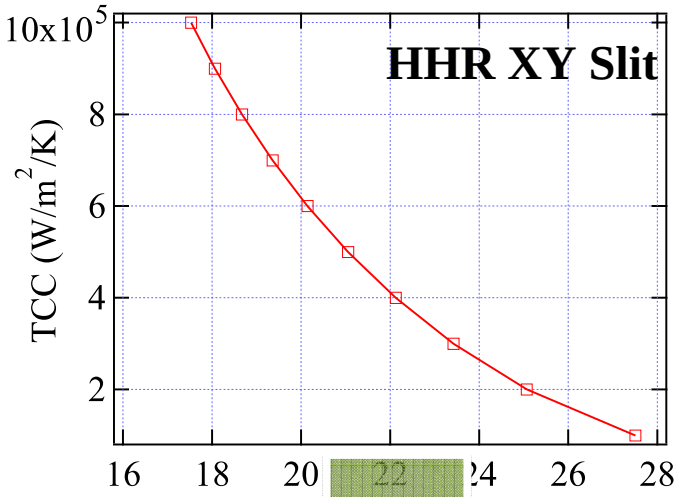


HHR XY slit

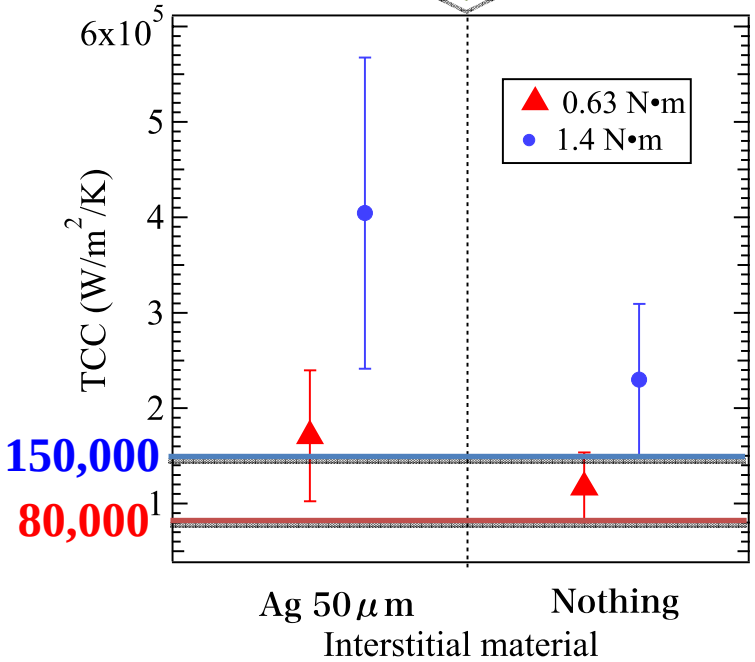


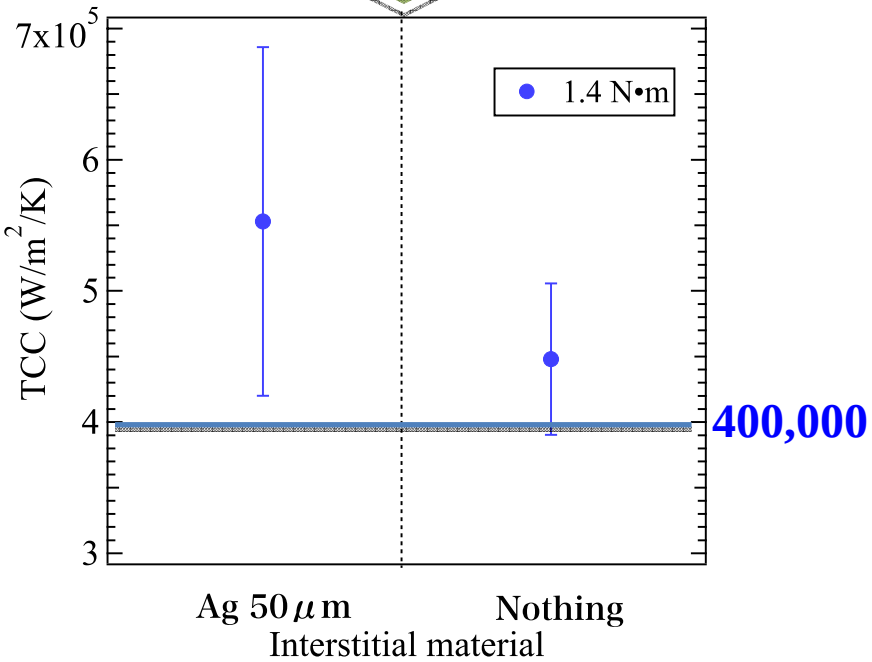
Calculated results





Relationship between TCC of area A and the temperature difference at the real thermocouples locations





TCCs for each interstitial materials and the fastening torque

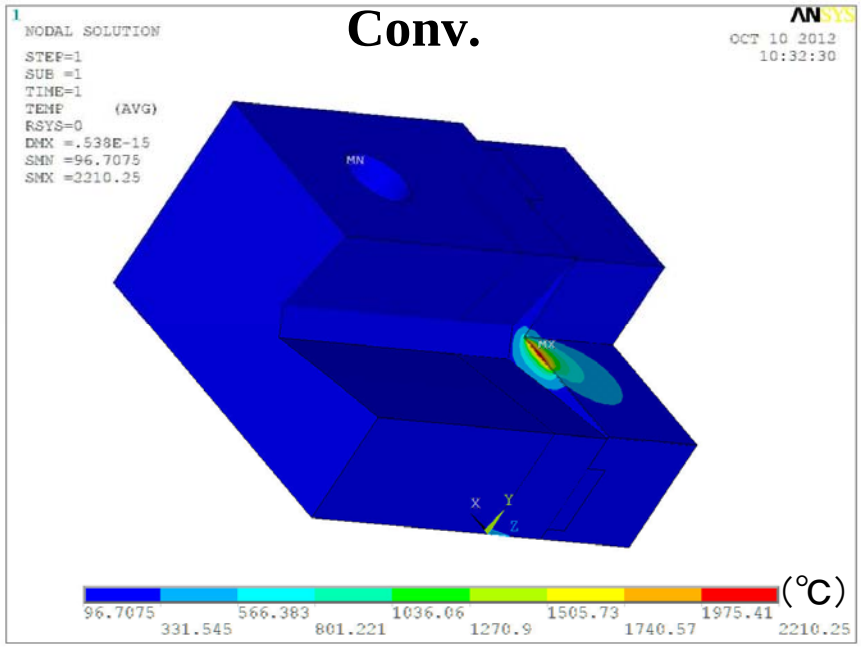
Preliminary estimation of Maximum temperature of Ta slit

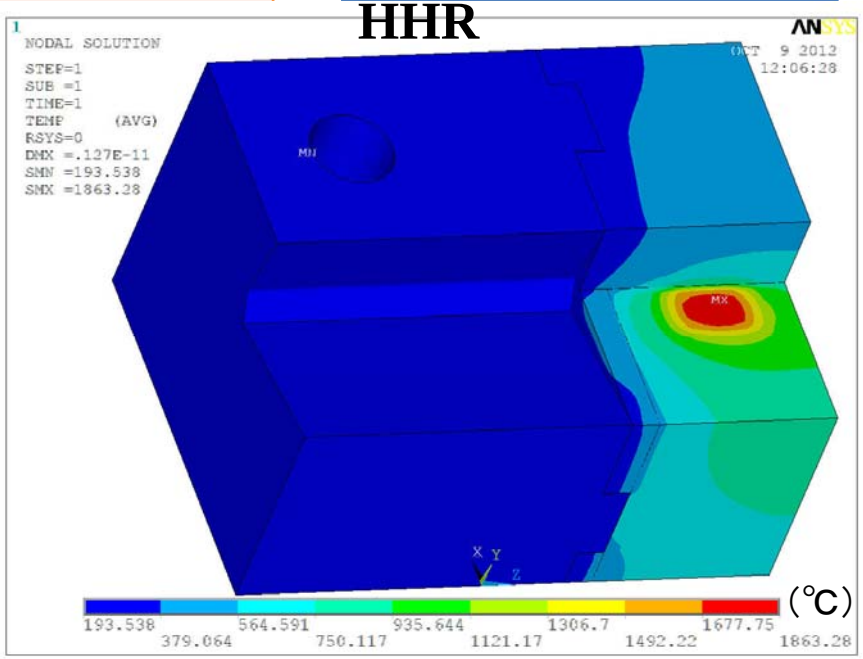
Example

	Conv.		HHR
Beam line	BL37XU		BL43LXU
Total Power	13.7 kW		50.8 kW
Absorbing area on Ta slit	H:4mm,V:0.1mm		H:4mm,V:6mm
Absorbing Power of Ta slit	228 W		667 W
TCC of area A	80,000	150,00	400,000
TCC of area B	250	500	4,000
Heat transfer coefficient	9200 W/m² / K		

Result

	Maximum Temperature (℃)	
BL	Conv.	HHR
37XU	2238	-
	2210	
43LXU	-	1863





(4) Summary

- We investigated the thermal contact conductance of the front-end XY slit both of the conventional type and the high heat resistant one in order to predict the maximum temperature.
- The minimum TCCs were obtained under the various conditions.
- Maximum temperatures of the Ta slit were predicted from the prelininary estimation.
- We confirmed that both types of the XY Slit were operational.

Future plan

- ◆ Full model calculation will be carried out in order to predict the maximum temperature more precisely.
- ◆ Another type of the interstitial materials such as the gold foil or thinner foil will be examined in the experiment.