Target R&D for JHF neutrino

KEK Yoshinari Hayato

(JHF Target/Monitor group)

Introduction

Target for K2K

Al 3cmϕ x 660mm (Embedded in the horn)

→ Heat was generated by the horn-current

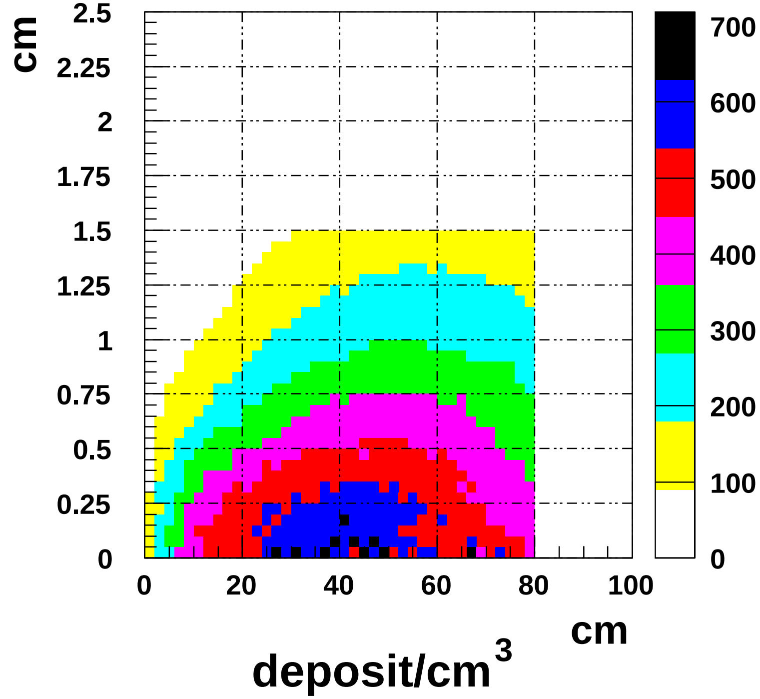
At JHF

If we use Al target (3cmϕ)

Maximum energy deposit

→ ~ 700J/cm^3/spill

Al target (3cmϕ)



Target for JHF neutrino

Requirements

Solid target　　Easy to handle

melting point should be high enough.

Thermal shock resistance

Candidate

→ Carbon Target

Melting point	$\sim 3550^{\circ}\mathrm{C}$
Thermal conductivity	$\sim 115\mathrm{W/m \cdot K}$
Thermal expansion	$4.2 \times 10^{-6}/^{\circ}\mathrm{C}$
Young's modulus	10.8GPa

Determination of the size (radius) of the target

Yield of pions (=neutrinos)

Smaller is better (pion absorption)

Energy concentration (heat & thermal shock)

Larger radius is easier to handle

Other limitations $\sim 1\text{cm}(\text{for } 24\pi \text{ mm} \cdot \text{mrad})$

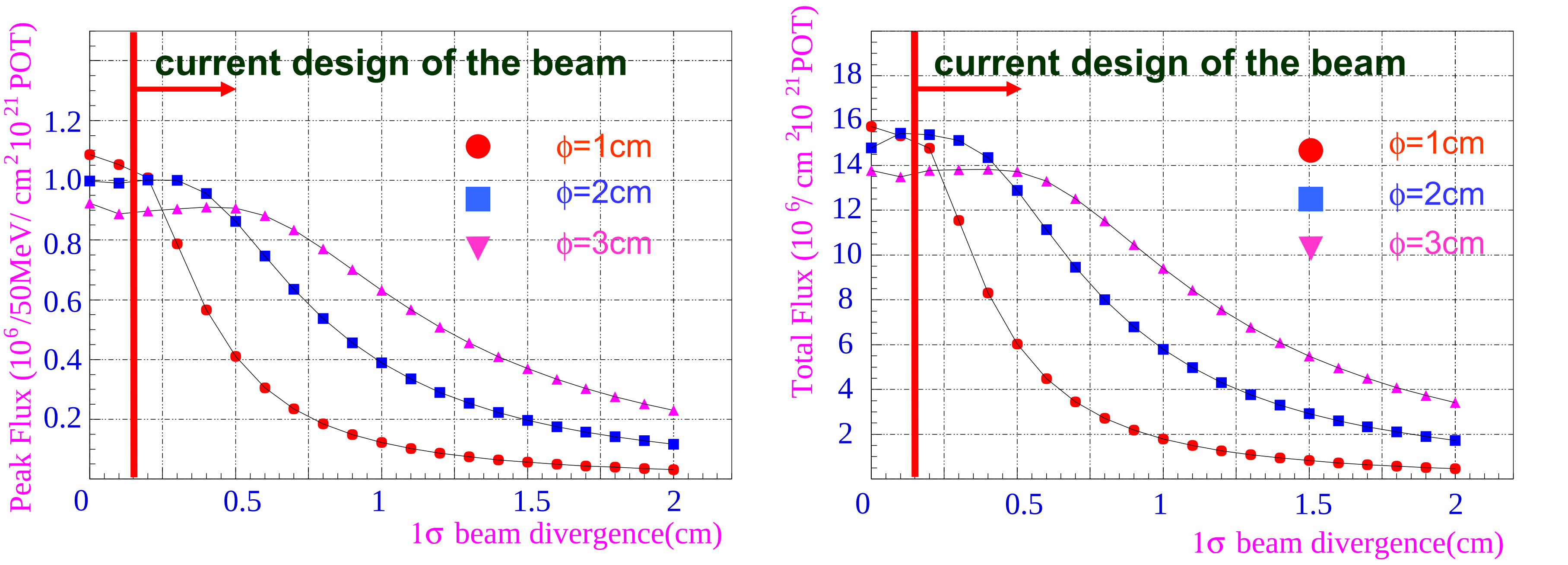
Inner radius of the horn (<~6cm)

Size of the beam

Larger than ~1cm(for 24π mm mrad)

Size (radius) dependence of neutrino yield

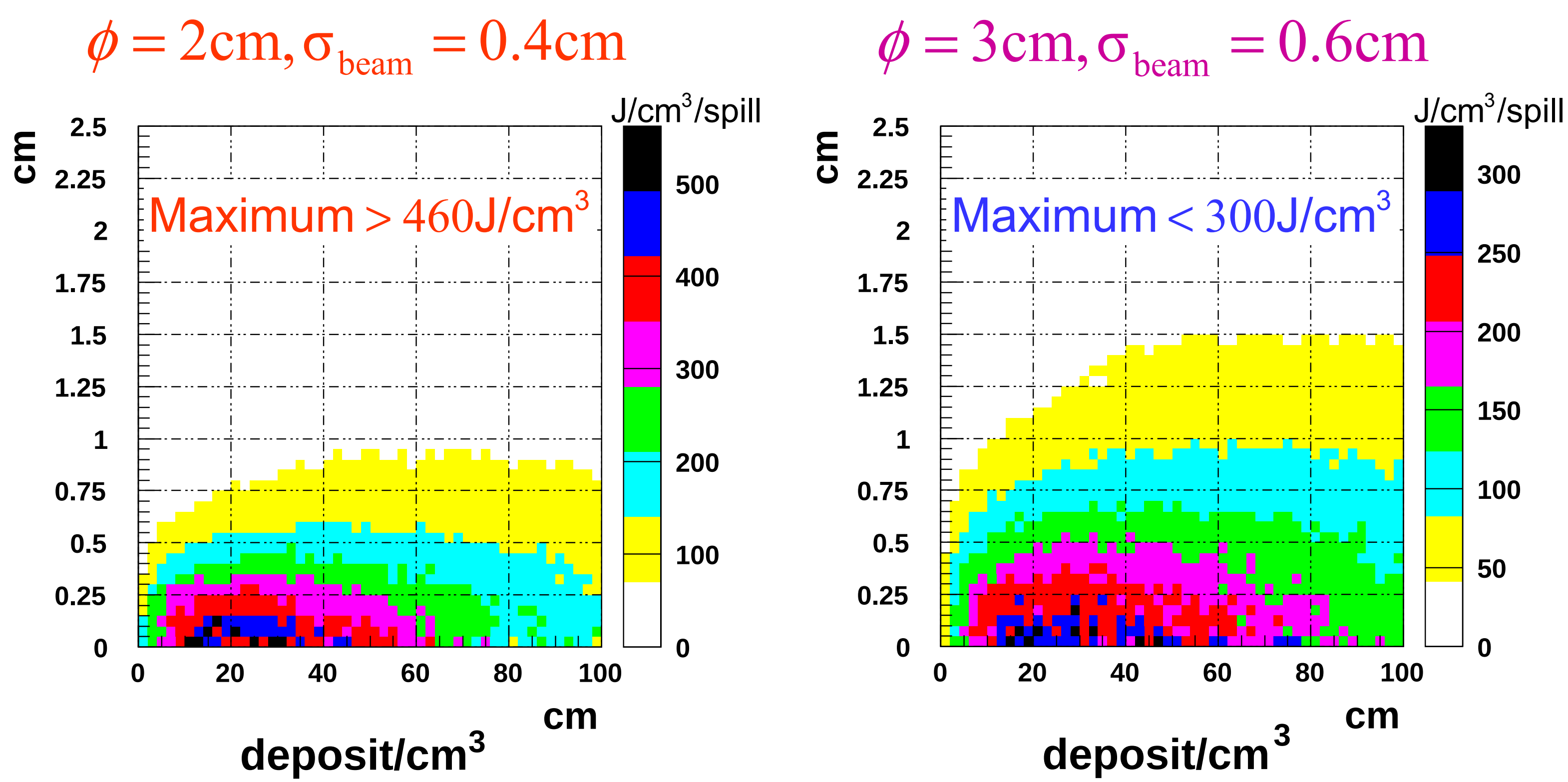
Effect of the absorption of pions is fairly small.



Energy deposit in the target

Target and beam size dependence

Carbon (density $1.81 g/cm^3$)



Heat generation in the target

Parameters used in the simulation
(incl. material properties of Carbon)

Density

$1.81 g/cm^3$

Specific heat

$0.71 J/cm^3/K$

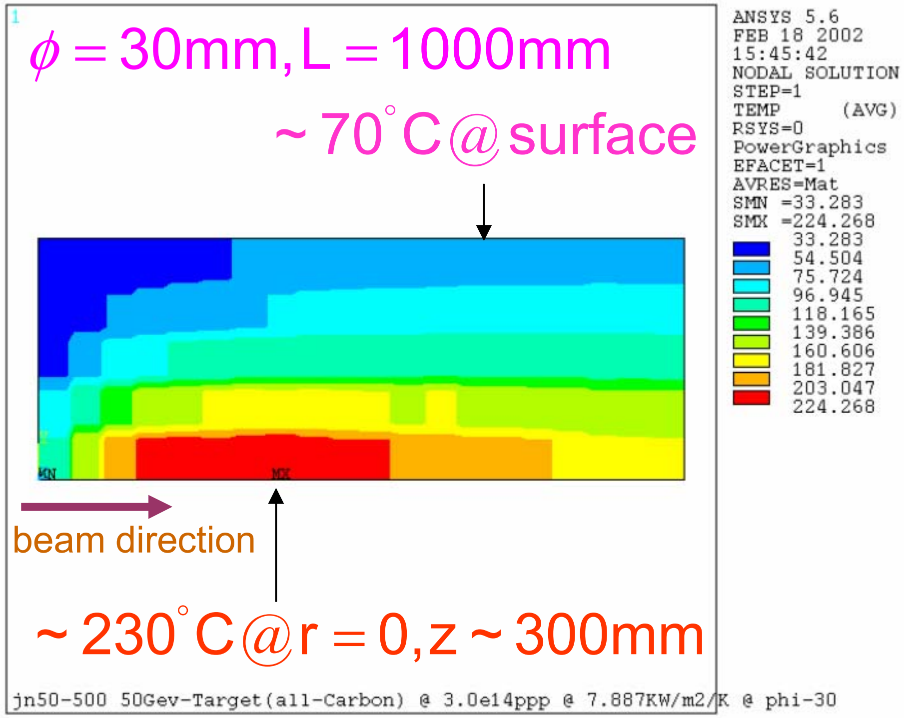
Thermal conductivity

116 W/m

Thermal convection coefficient at the surface

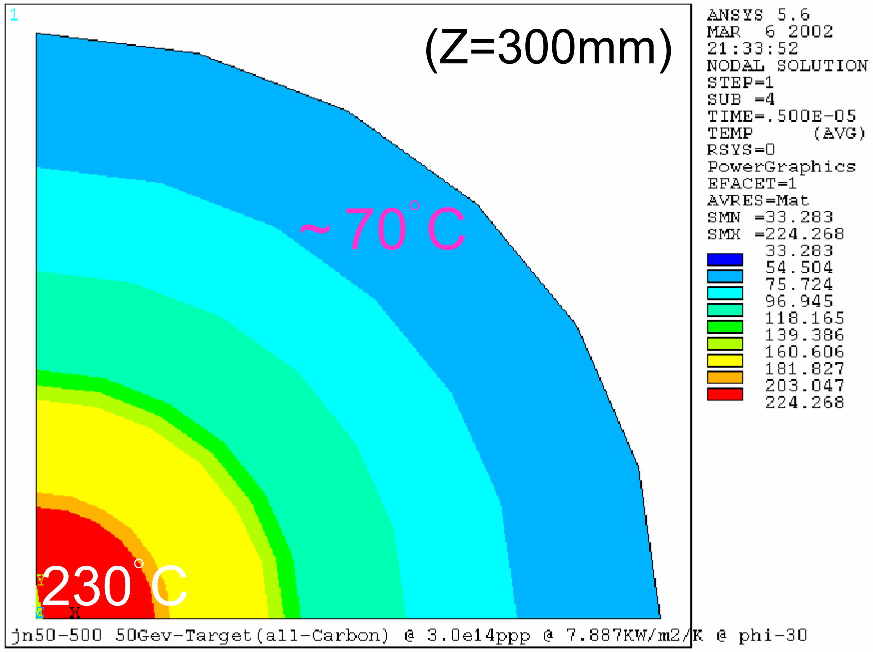
$7.887 kW/m^2/K$

@5μsec (just after the spill)

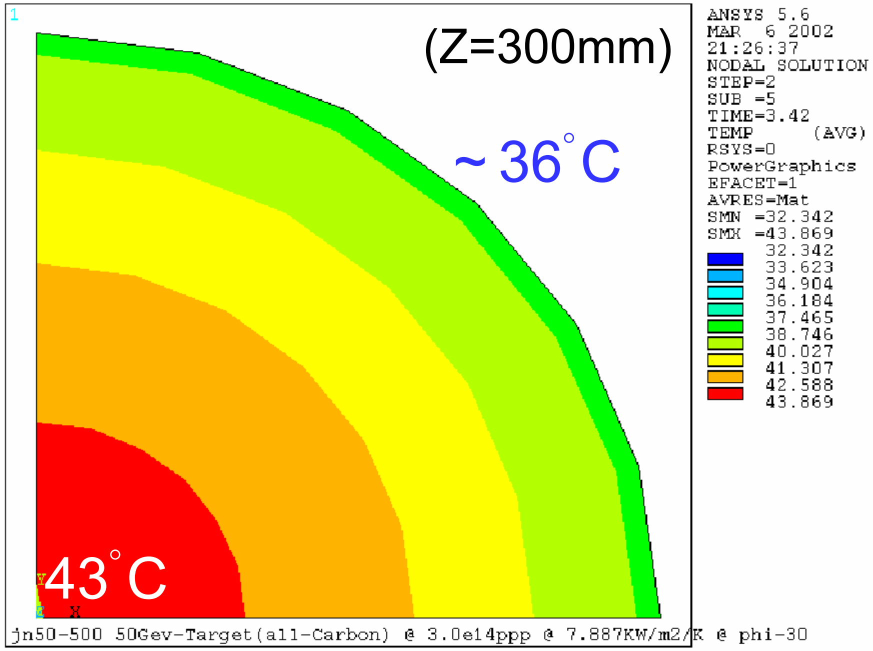


Temperature in the target

After 5μsec (just after the spill)



After 3.42sec (just before the next spill)



Time dependence of temperature

Maximum temperature

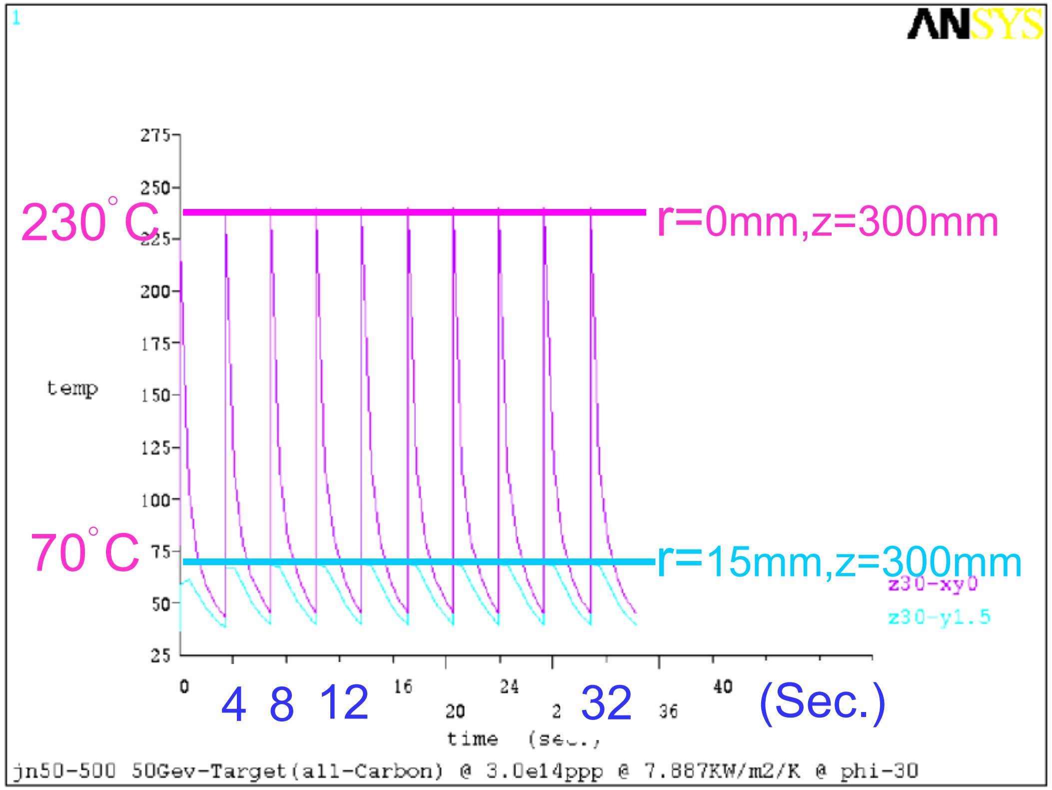
At the center

~230°C

Far below the melting temperature

On the surface

~70°C



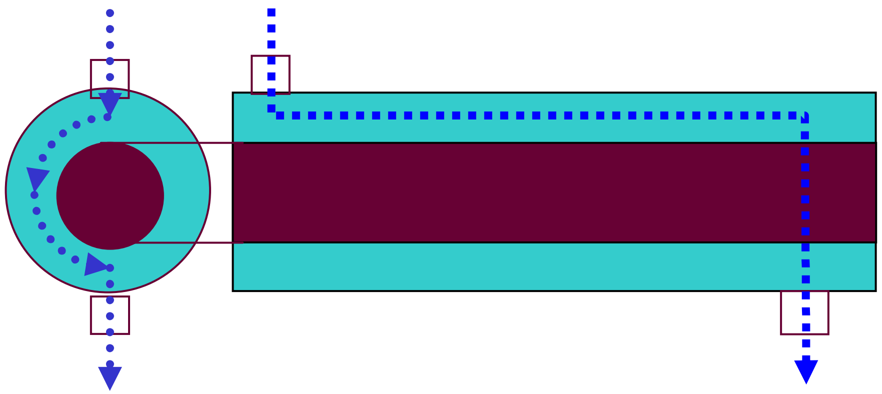
This should be lower than 100°C for water cooling.

Thermal convection coefficient on the surface should be larger than ~3000 $W/m^2/K$ to satisfy this condition.

Cooling test (in preparation)

According to the results from ANSYS,
heat transfer rate should be
larger than 3000W/m^2/k.

➔ Put the target in the case
and try to cool by the flowing water.



Carbon 30mmϕ

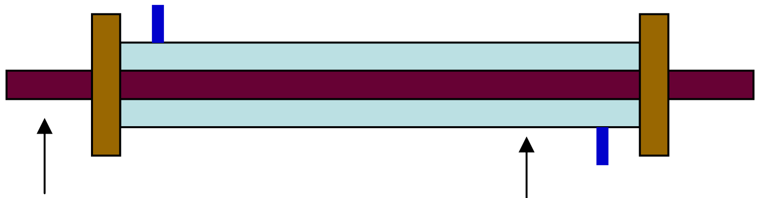
Case 40mmϕ

measure flow rate and temperature difference.

→ estimate the heat transfer rate.

Cooling test (in preparation)

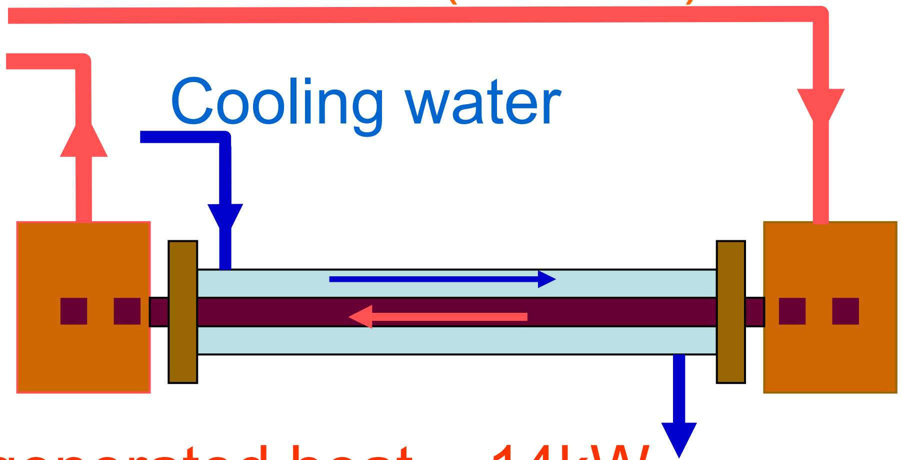
Use electric current
to heat the target.



Carbon 30mmϕ Case 40mmϕ

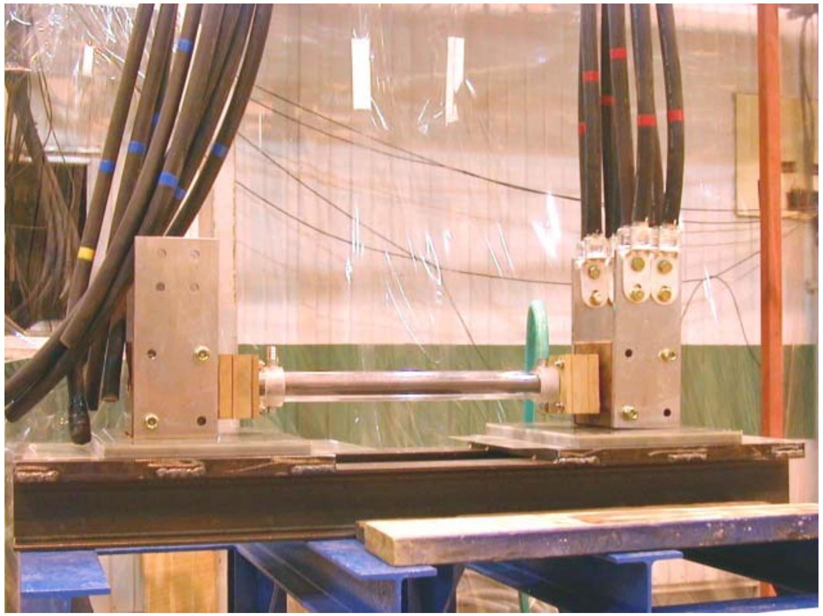
Current (~1200A)

Cooling water



generated heat ~ 14kW

Try to cool by the water.



Thermal stress

Evaluation by a simple formula

$$P = \frac{E}{1\text{-}2\nu} \cdot \alpha(T - T_0)$$

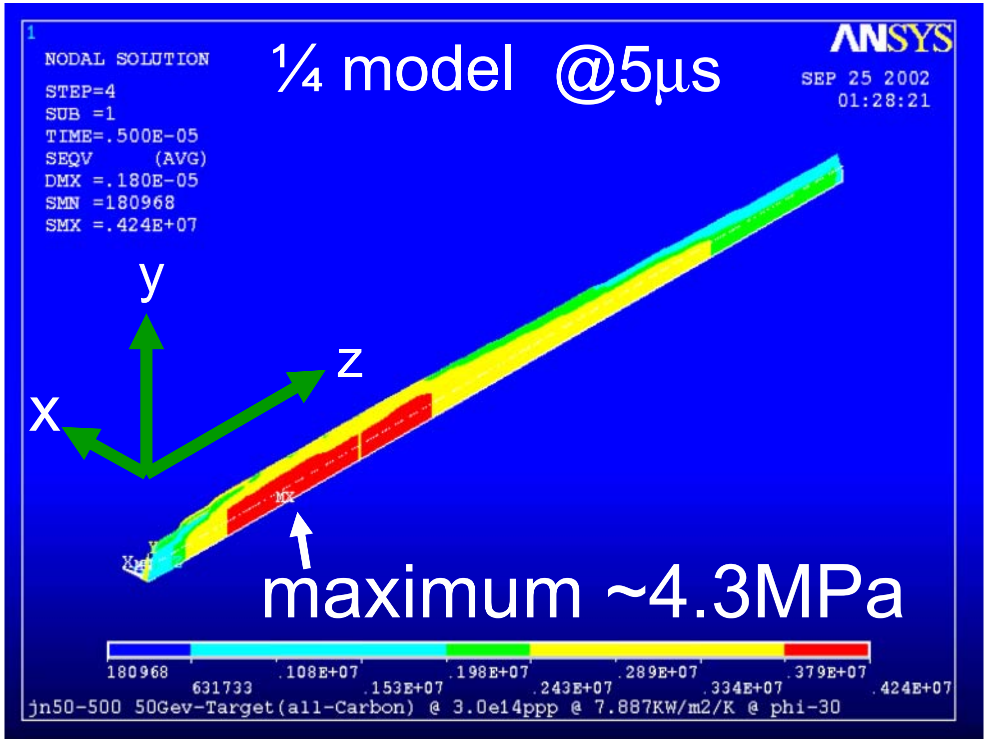
P	Pressure	
E	Young's modulo	10.8GPa
ν	Poisson ratio	0.2
α	Linear expansion rate	$4.2 \times 10^{-6} / ^{\circ}C$
$T, T0$	Temperature	$(230\,^{\circ}C, 27\,^{\circ}C)$

→ P ~ 11 MPa

Simulation by ANSYS

→ just started

→ Necessary to evaluate (quasi-)static and dynamical stress.



Summary

Target for JHF neutrino project

Material	**Carbon**
Size	**30mm ϕ x 800mm L**
Cooling method	**directly cooled by water**

Assumption: thermal convection coefficient

~8KW/m^2/K

Maximum temperature

core (@r=0mm)	$\sim 230^{\circ}C$
on the surface	$\sim 70^{\circ}C$

Thermal stress

Seems to be ok (static).

But need the detailed simulation.

What have to be done...

Cooling test

measurement : start in the beginning of Oct.

analyze the data within this year.

(In case, consider the surface engraving etc.)

Detailed simulation of the thermal stress.

(especially the dynamical stress)

Start designing the target

Includes split-target

(depend on the simulation results.)

case (water container)

and so on...