

# Status of T2K Horn Prototypes

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for T2K Target & Horn Group

## Outline

- 1<sup>st</sup> Horn Prototype
  - Operation Test
  - Cooling Test.
  - Displacement Measurement.
- Other Prototypes
  - 3<sup>rd</sup> Horn, Support Module, etc.
  - Operation Test.

# 1<sup>st</sup> Horn Prototype

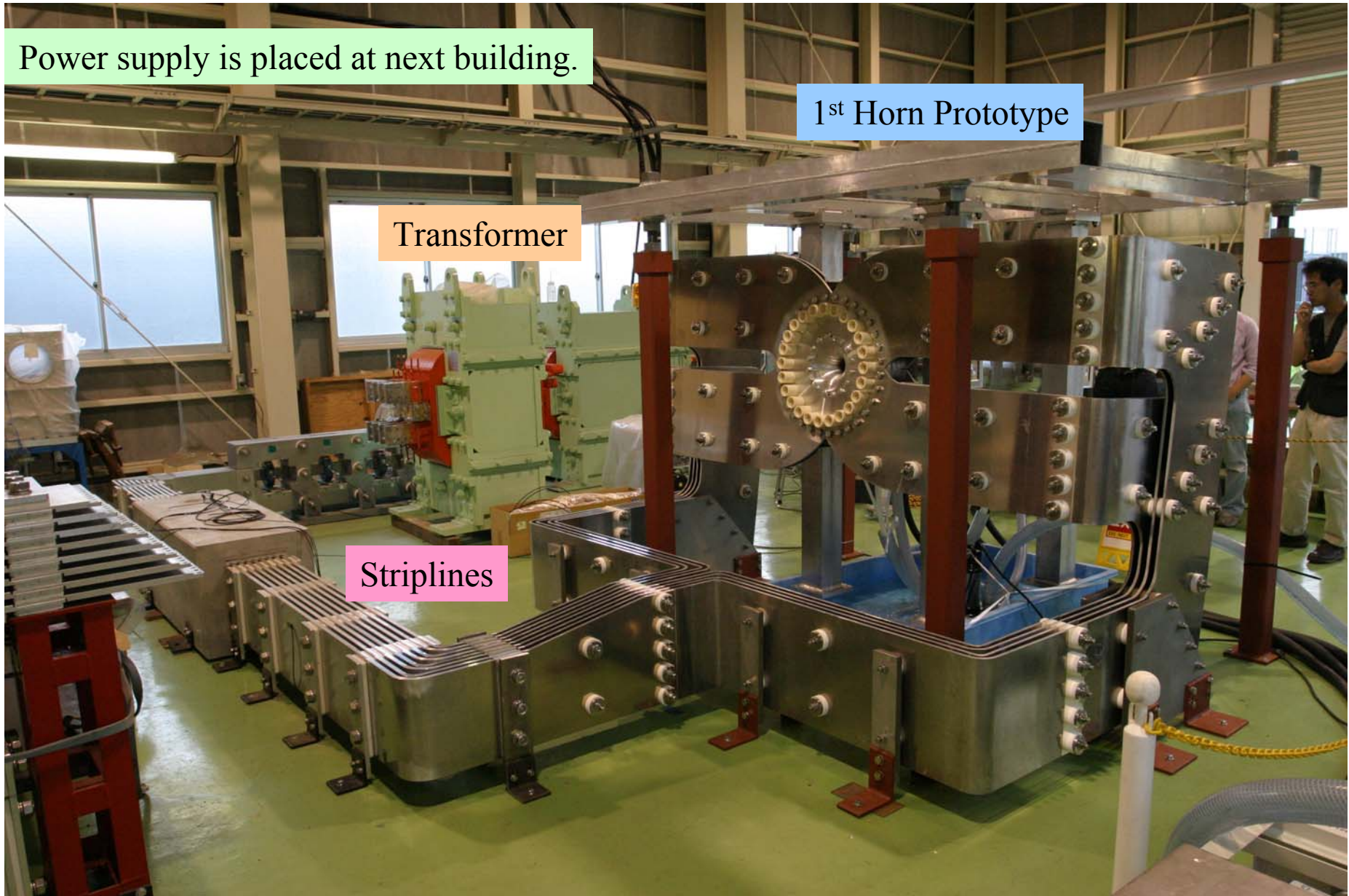
# Horn Test Facility

Power supply is placed at next building.

1<sup>st</sup> Horn Prototype

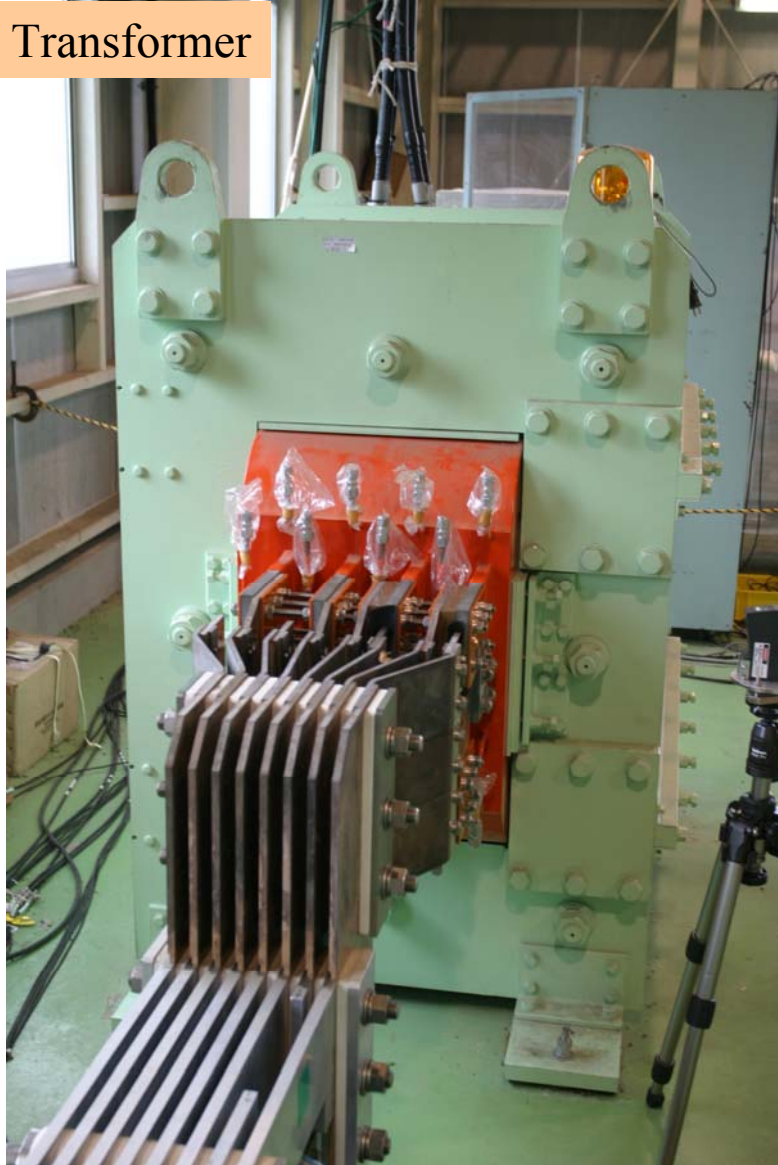
Transformer

Striplines

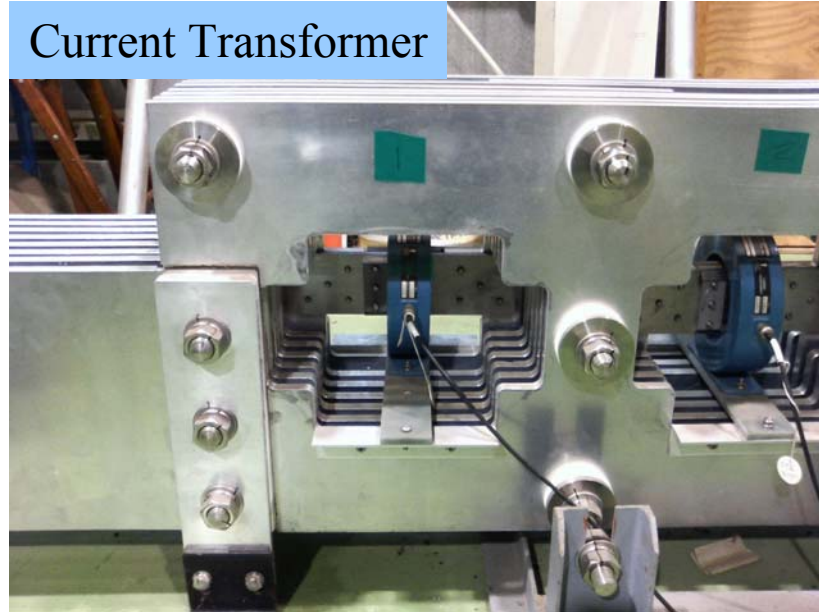


# Horn Test Facility

Transformer



Current Transformer



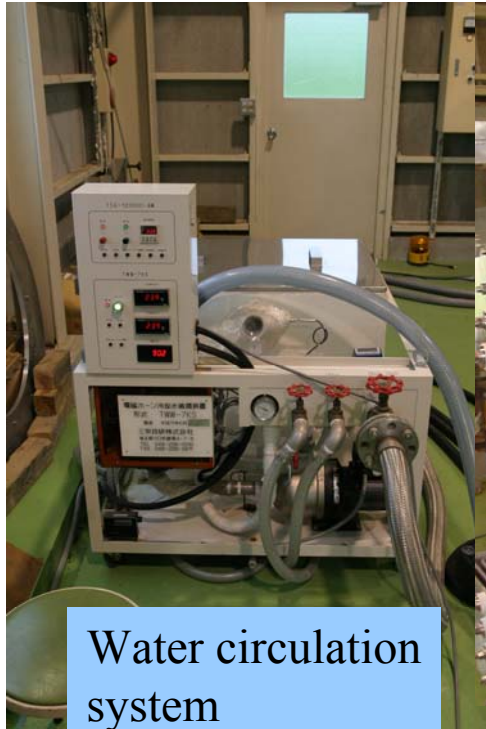
Current Monitor



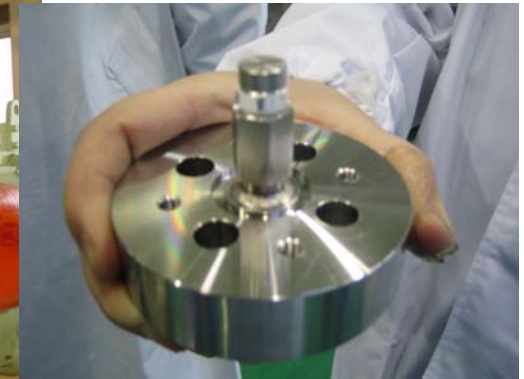


# Water Circulation System for Prototype

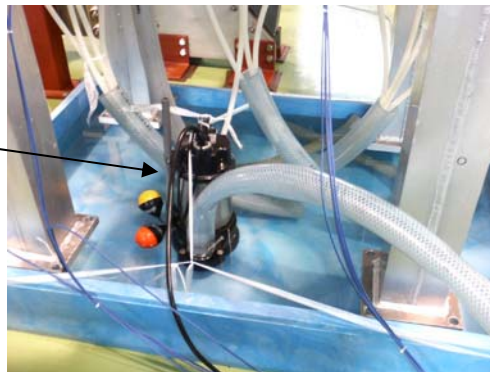
Drain tank is not completed yet. It will be attached in early October.



Water circulation system



Water nozzle

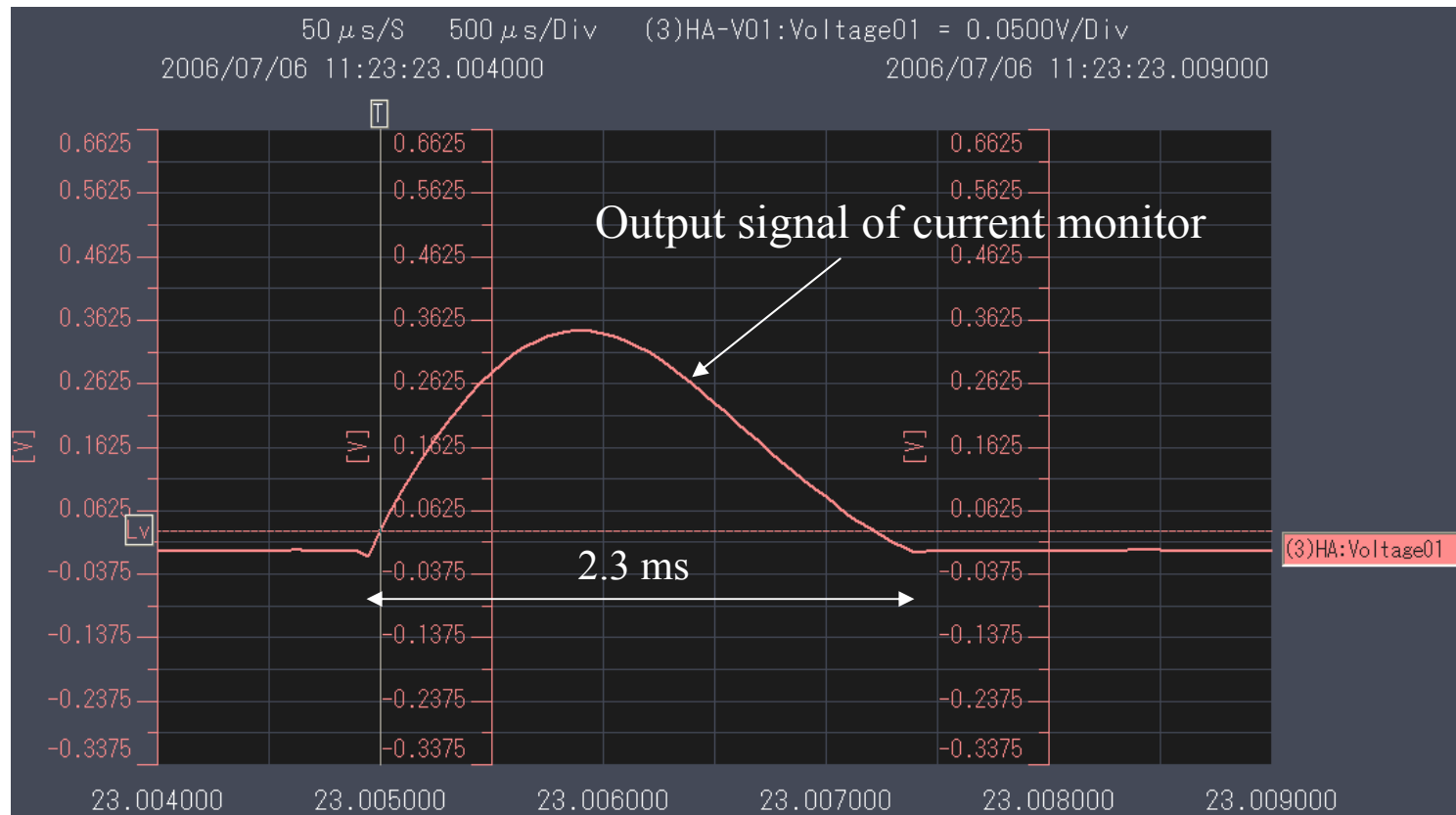


Pumping up water to the buffer tank

Temporary drain tank

# 1<sup>st</sup> Horn Operation

- May 24<sup>th</sup>: First excitation
  - Pulse width  $\sim 2.3$  ms  $\Leftrightarrow 0.7$  ms (spec.)
- $\Rightarrow$  Need to change capacity of power supply.

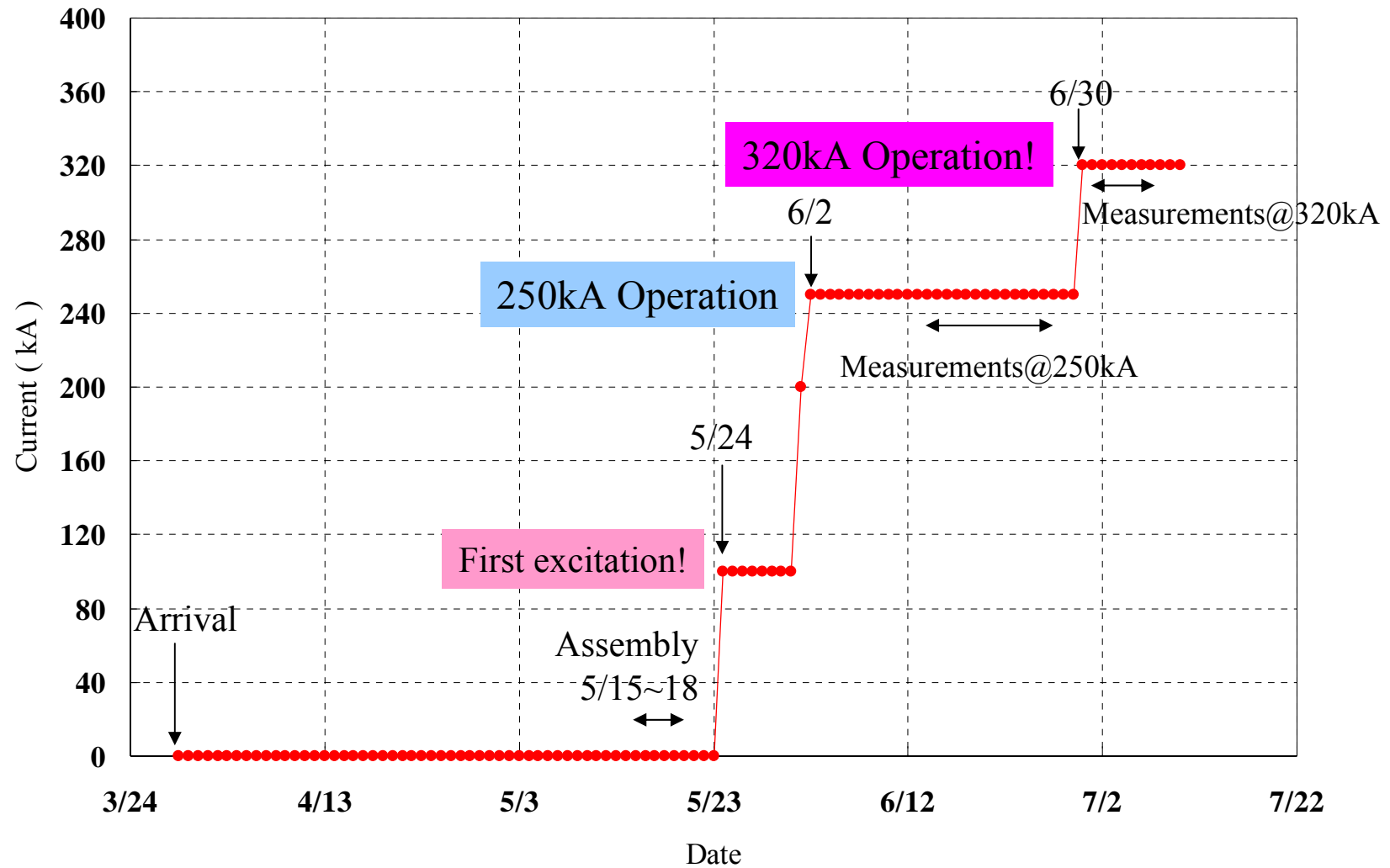


# Horn Sound



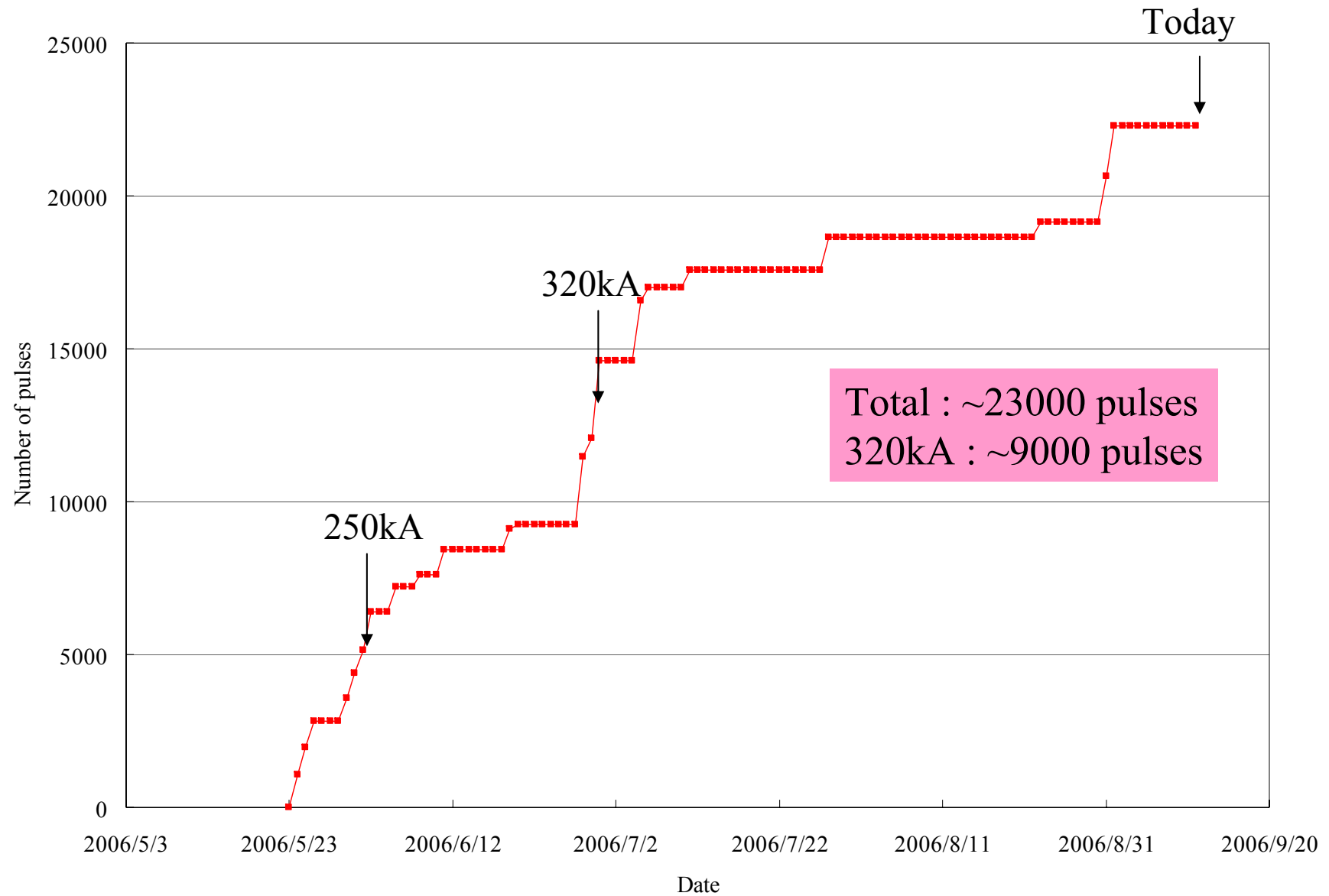
Note: 100 kA operation

# Horn Current





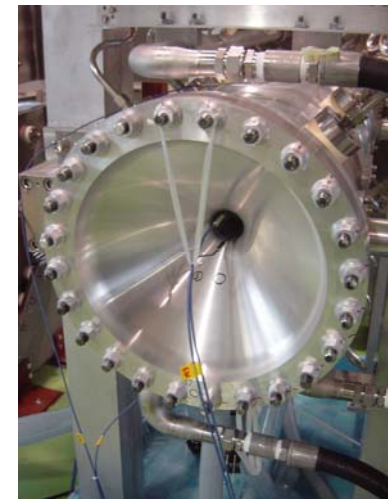
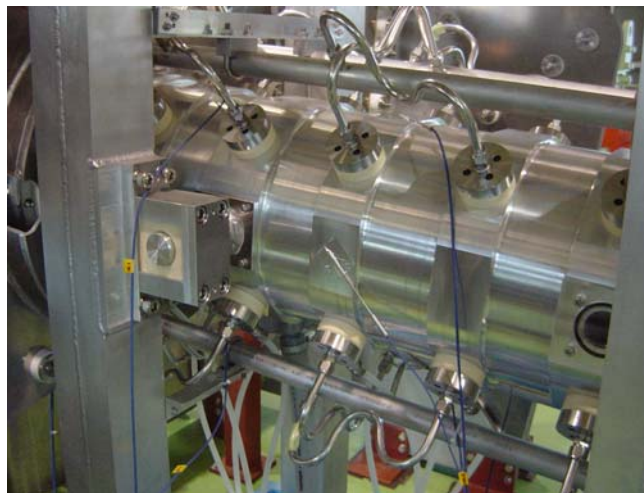
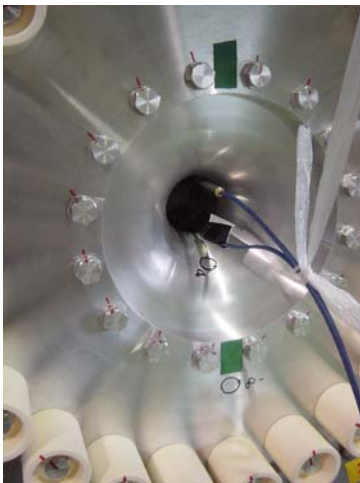
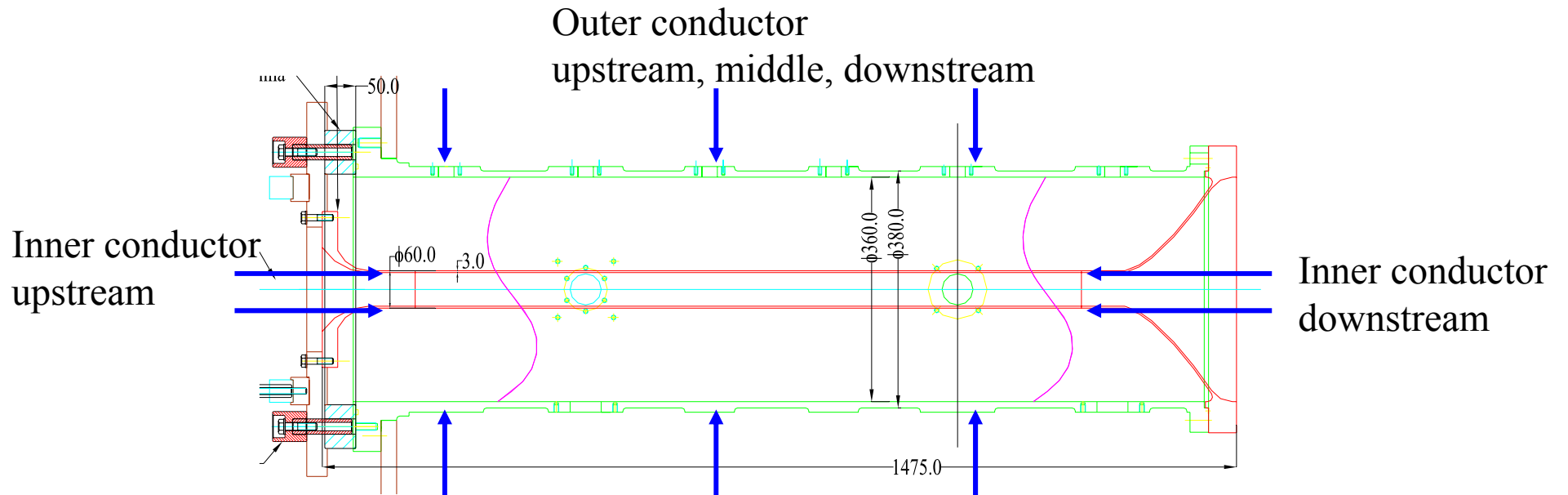
# Accumulated Number of Pulses



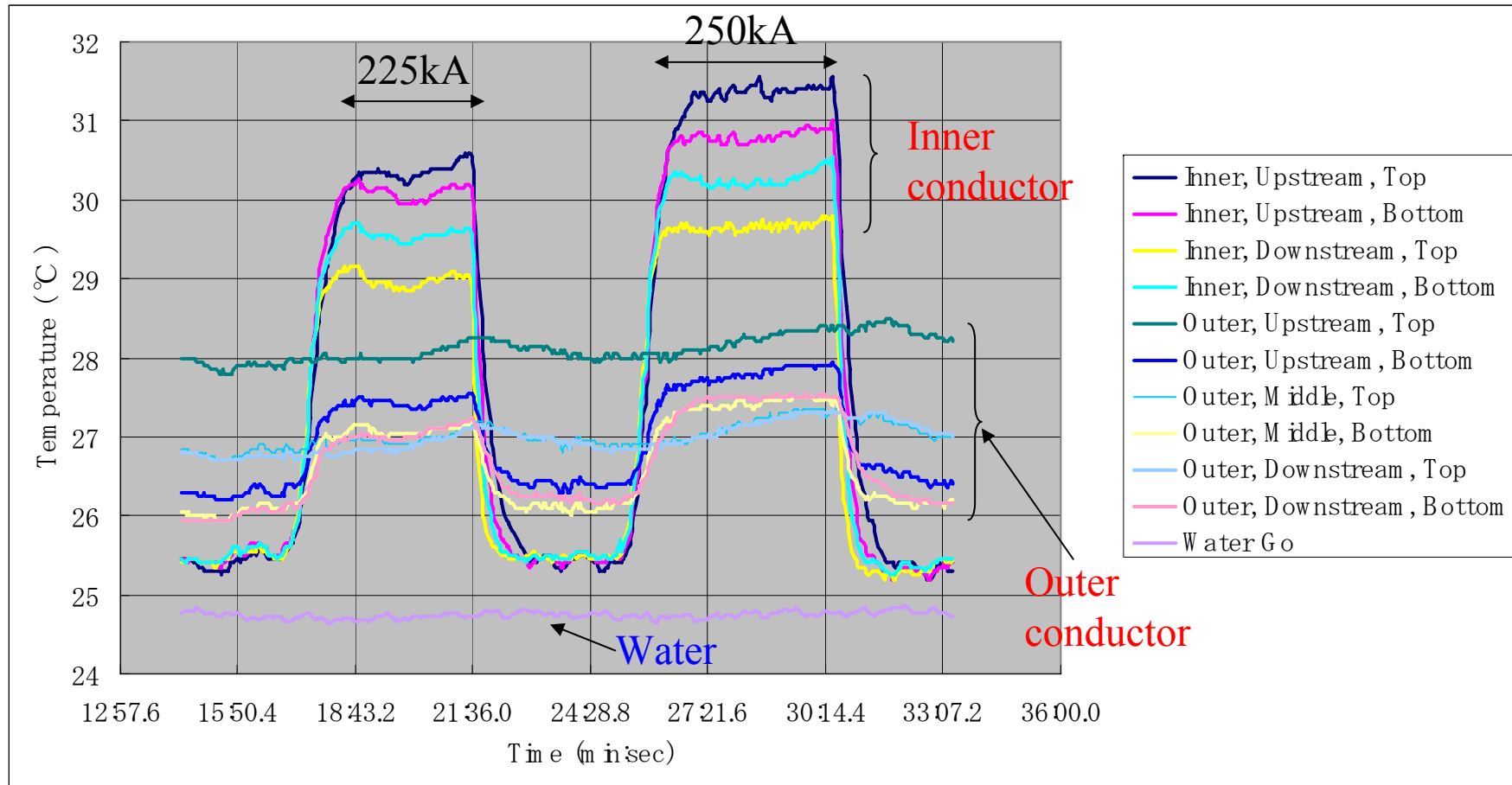
# Cooling Test

# Temperature Measurement

Temperature measurement with thermocouples



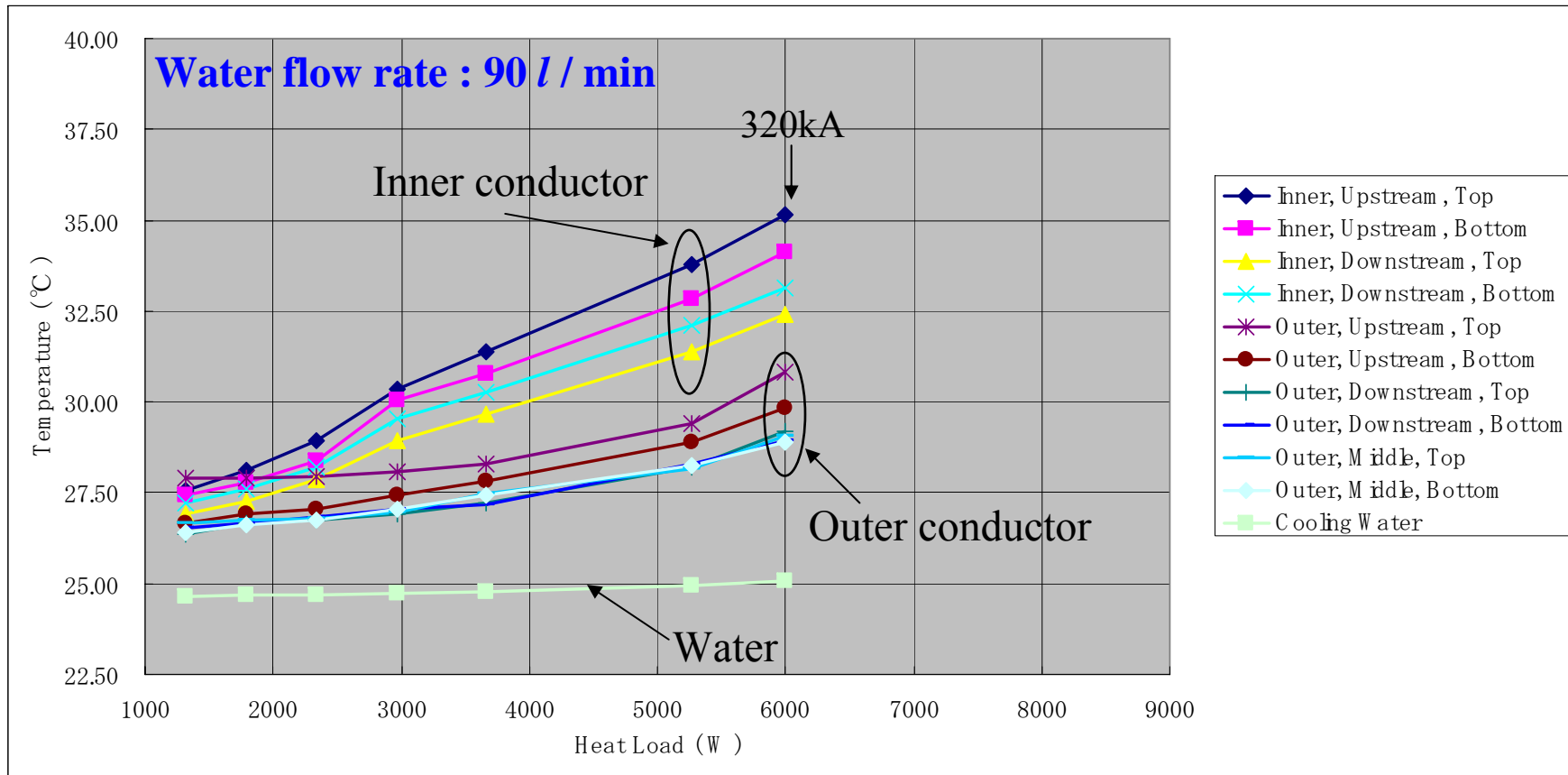
# Temperature vs. Time



Top part of outer conductor is not cooled by water.

# Heat Load vs. Temperature

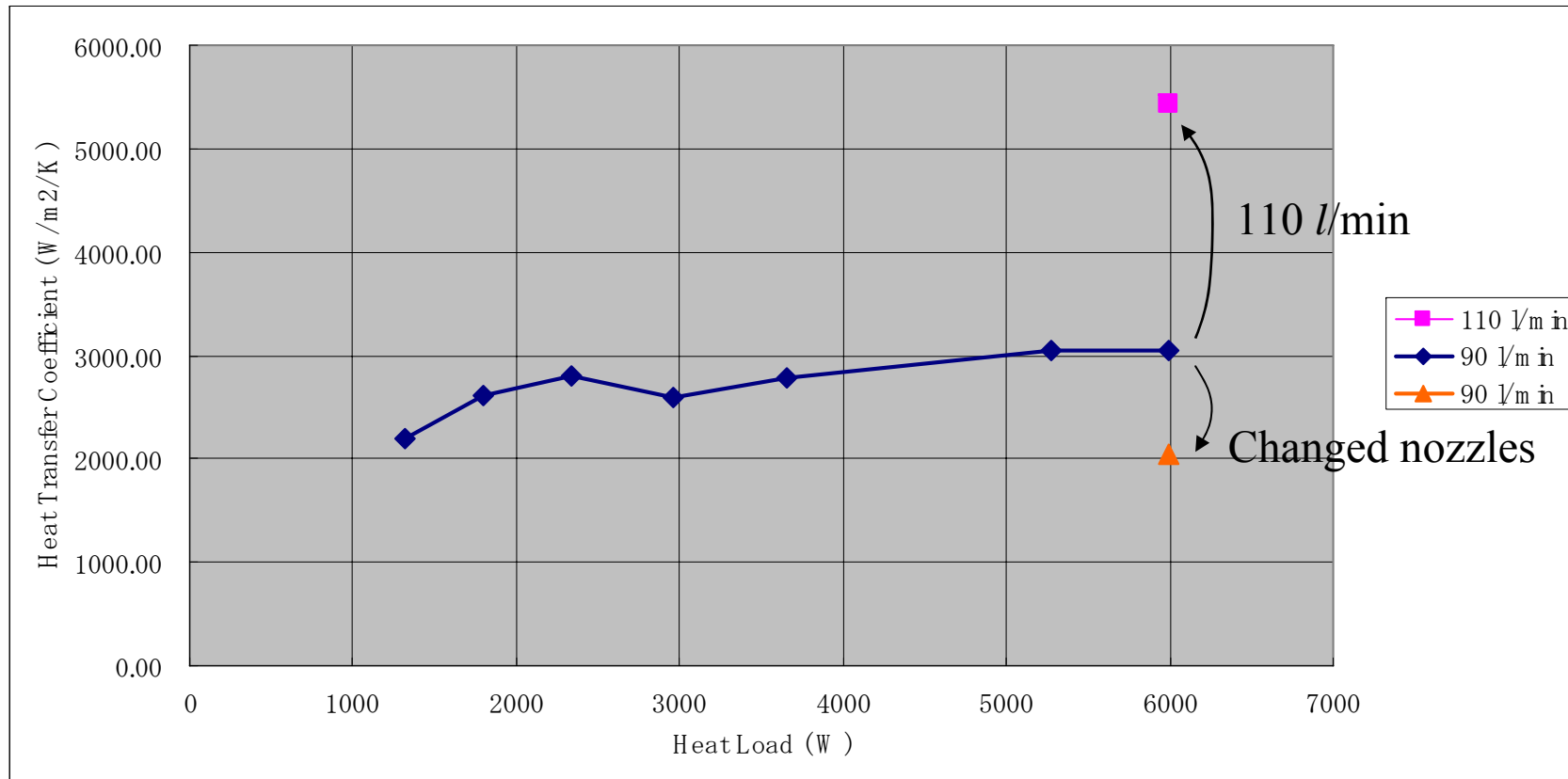
Heat load at inner conductor: ~95 % of total  
outer conductor: ~5 % of total



Temperature increase linearly to heat load.



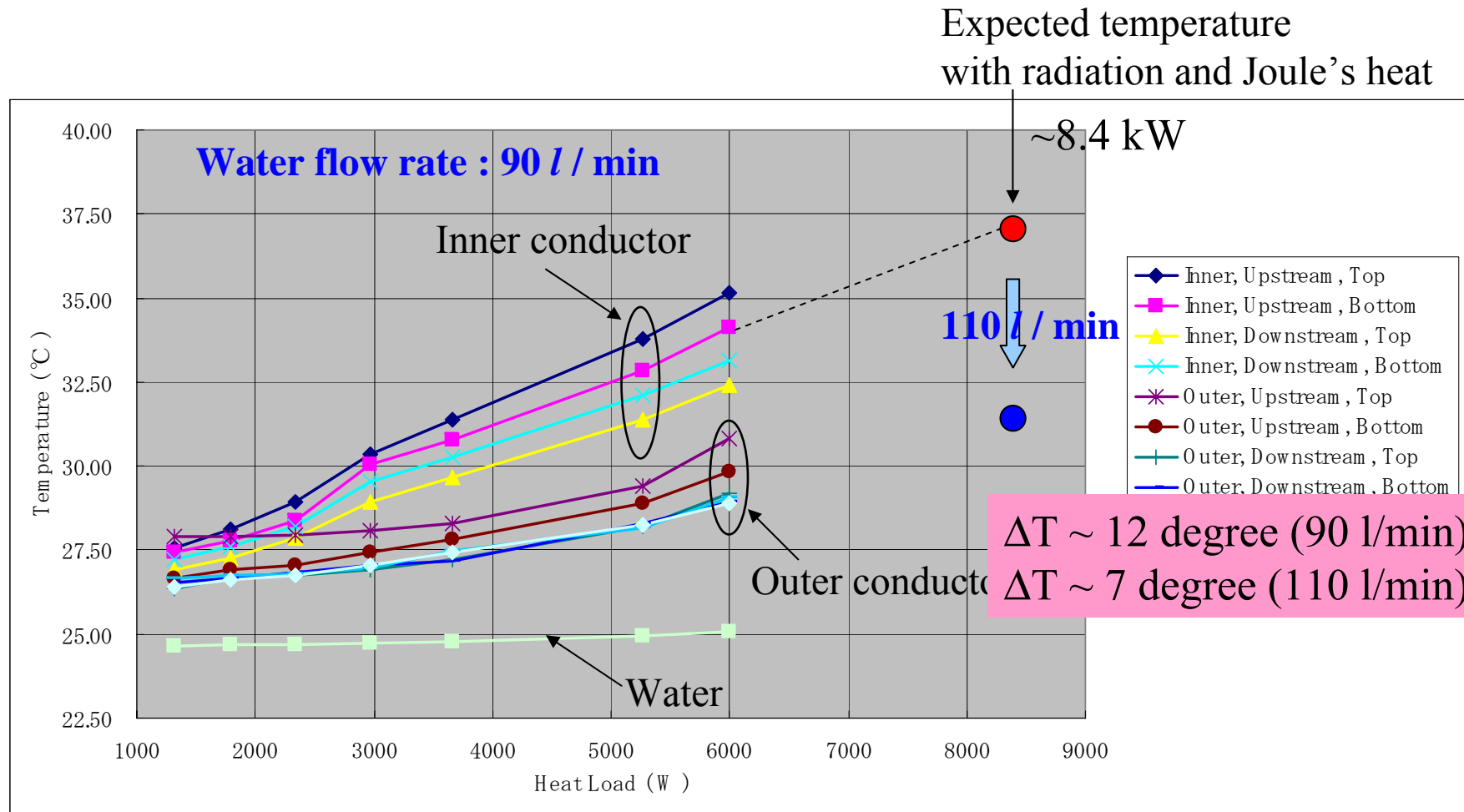
# Heat Load vs. Heat transfer coefficient



## Heat transfer coefficient

- 90 l / min (default nozzle) : ~3 kW/m<sup>2</sup>/K
- 110 l / min (default nozzle) : ~5.4 kW/m<sup>2</sup>/K
- 90 l / min (small diameter nozzle) : ~2 kW/m<sup>2</sup>/K

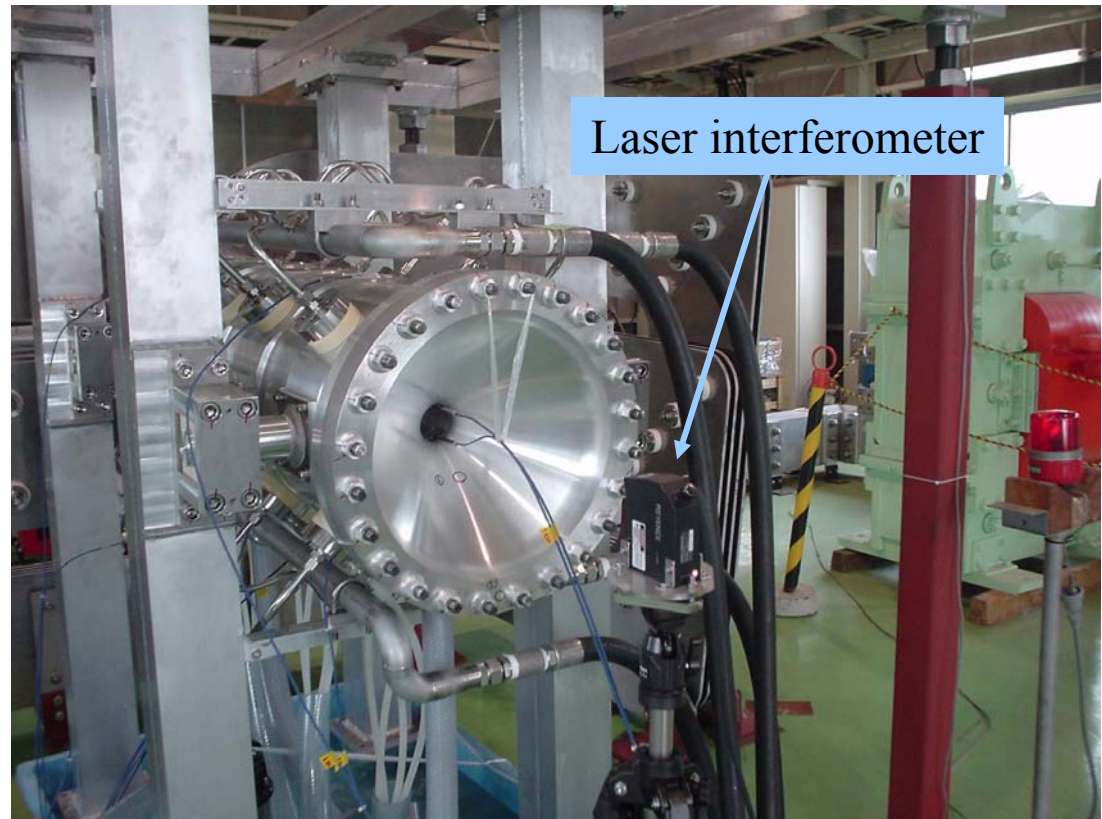
# Temperature Estimation for Real Condition



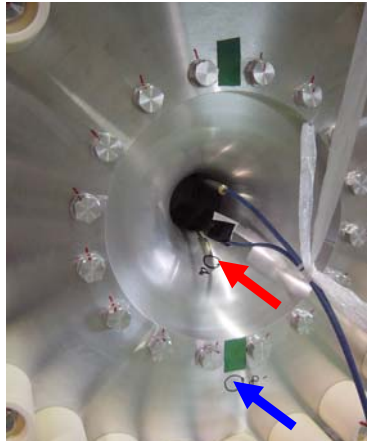
# Displacement Measurement

# Displacement measurement

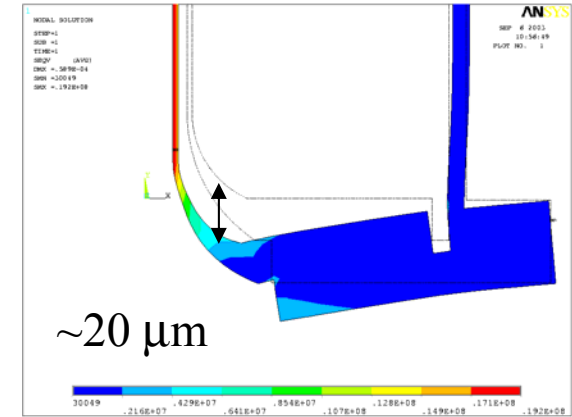
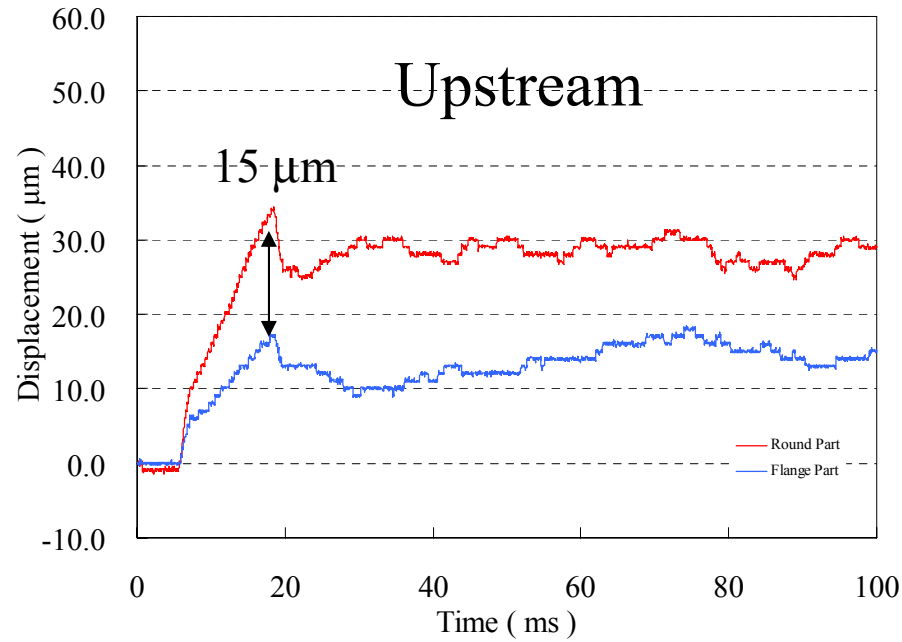
- Motivation is to check the mechanical strength of the horn.
- Pressure due to Lorentz force
  - 2.5 MPa at inner conductor
  - 0.05 MPa at striplines
- Instrument for the measurement
  - Laser interferometer
    - 50 kHz sampling rate
    - 2  $\mu\text{m}$  resolution



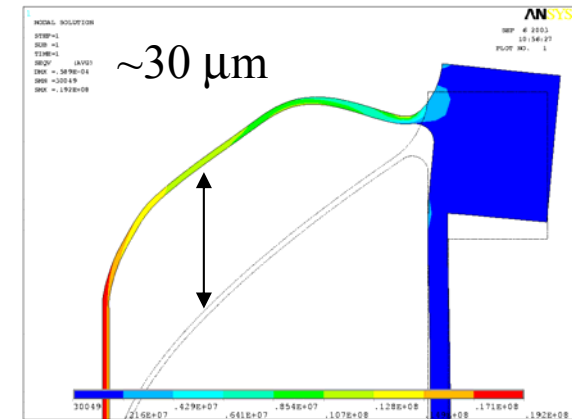
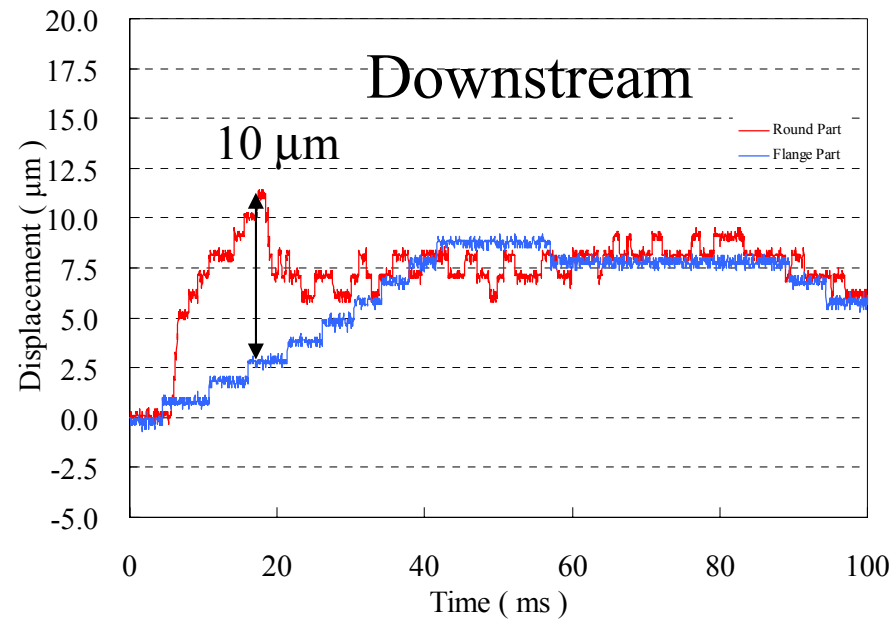
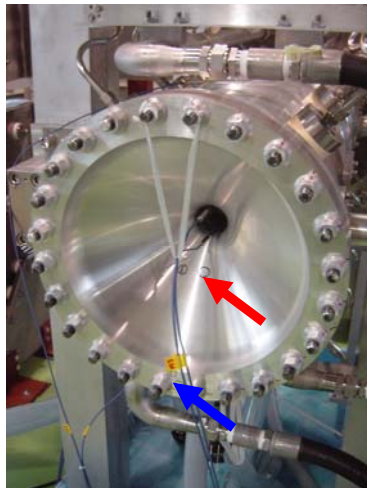
# Inner Conductor



Reference point



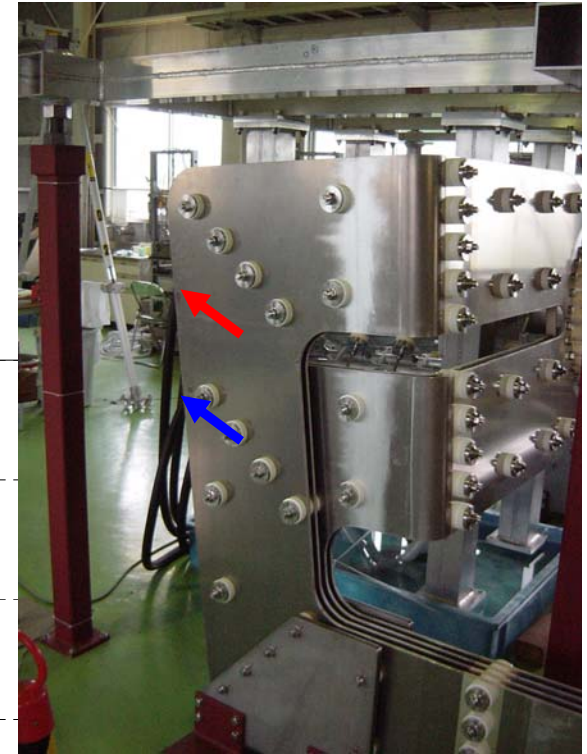
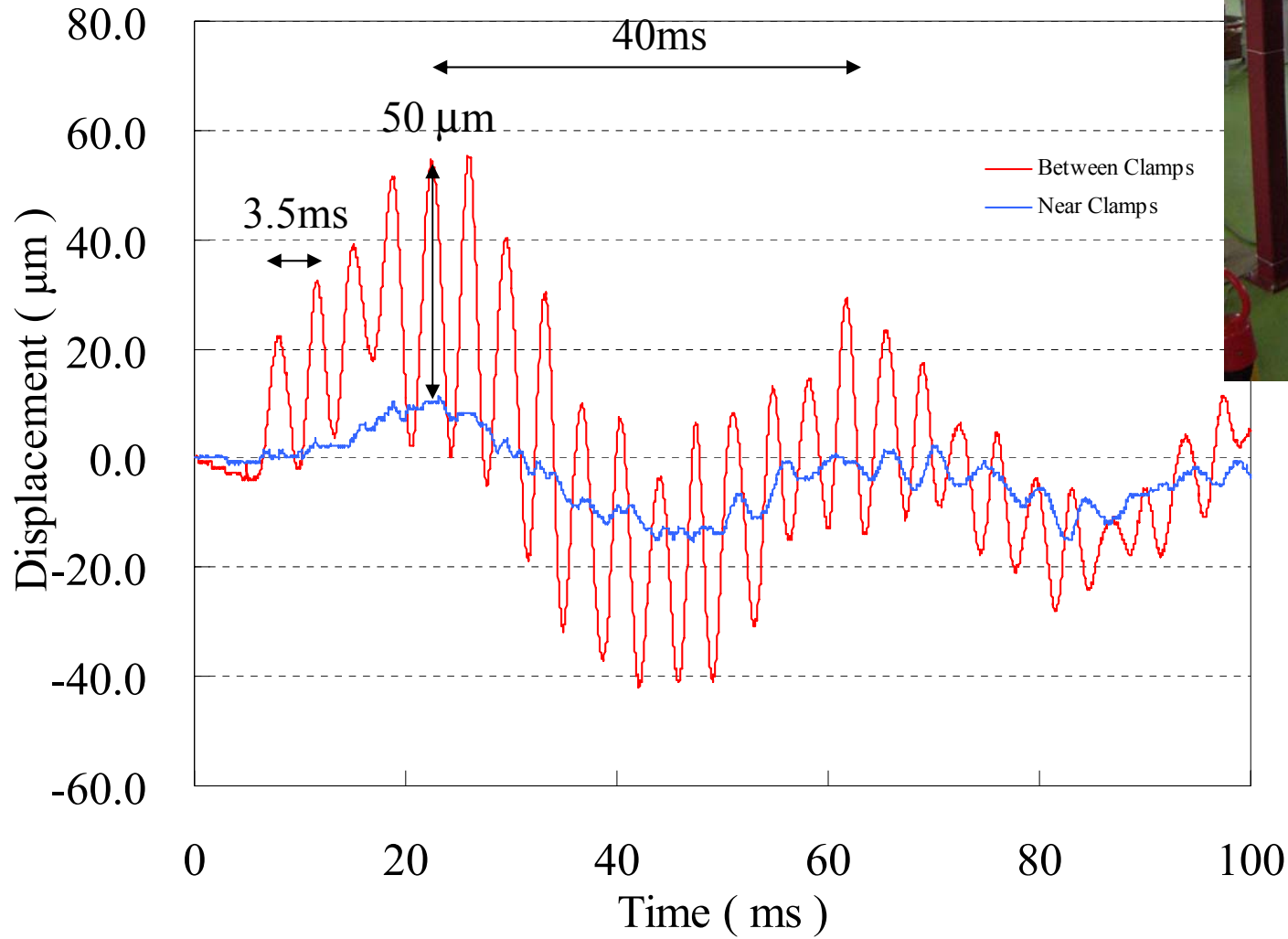
FEM analysis



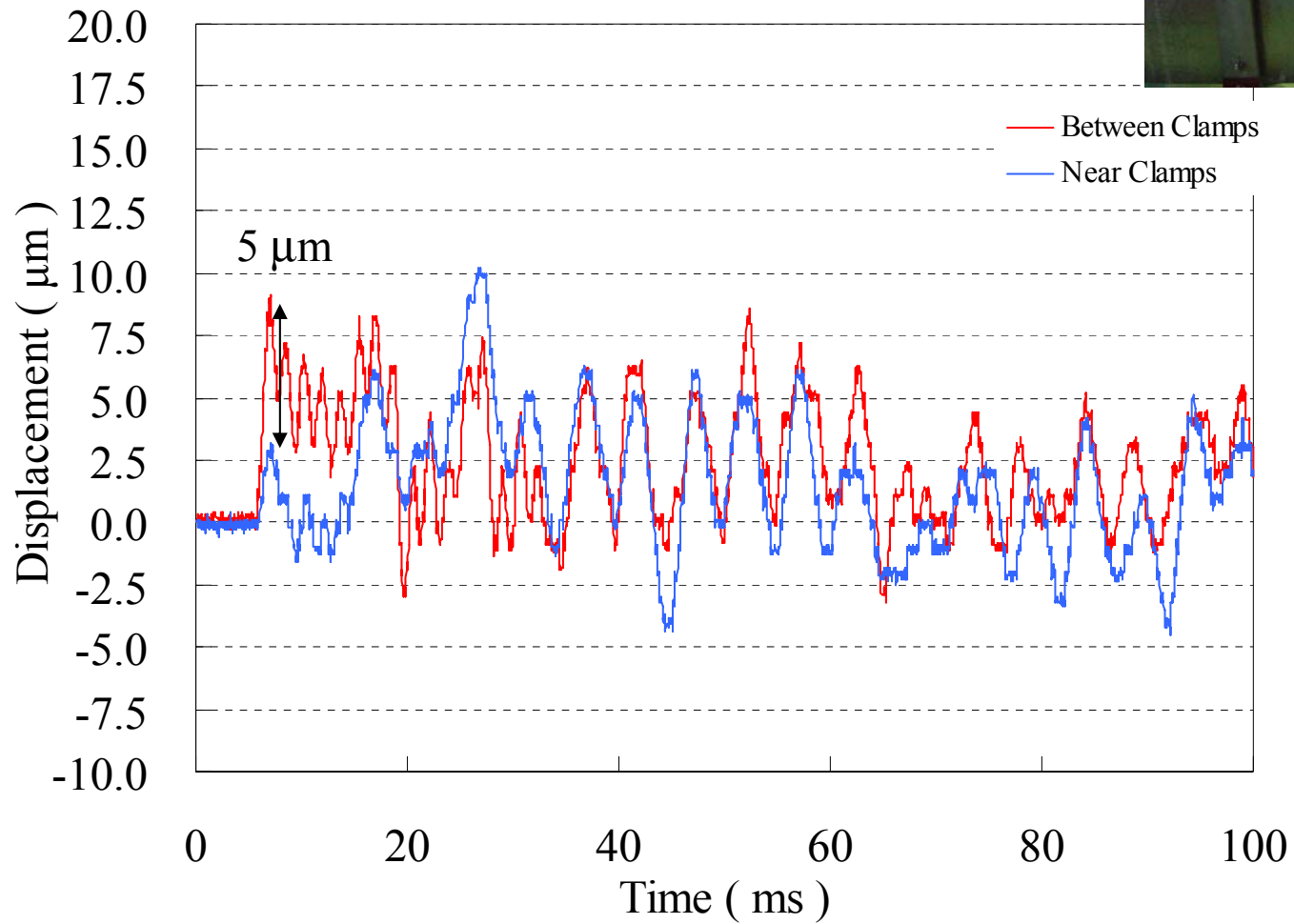
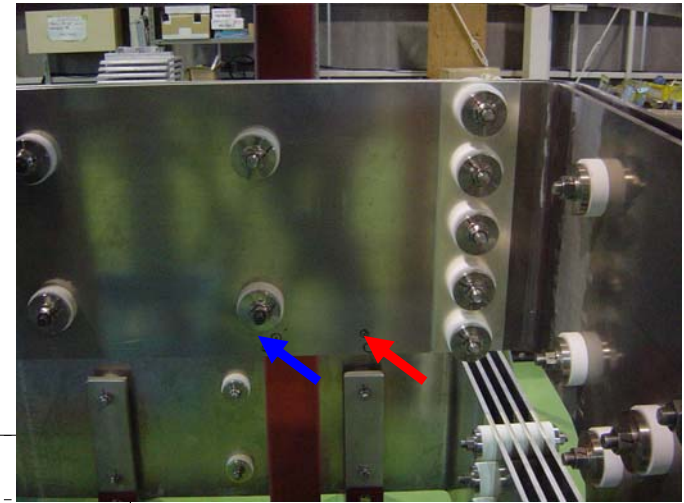


# Stripline ( Vertical Part )

Long term vibration ( $\sim 1.5$  s),  
but gradual dumping by next pulse.



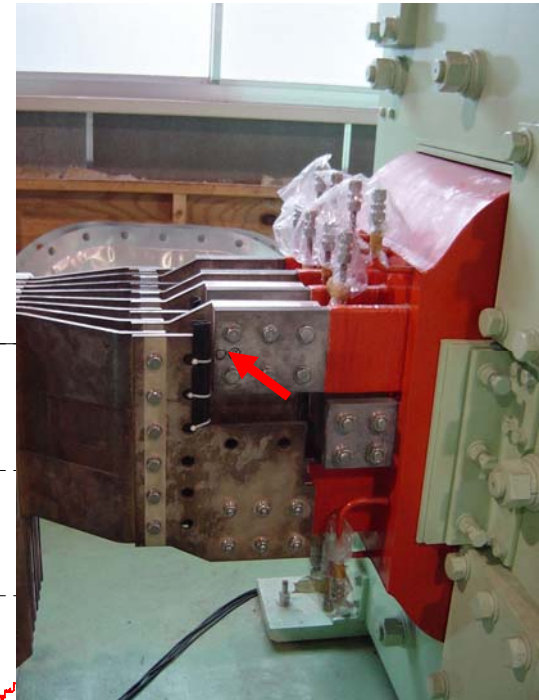
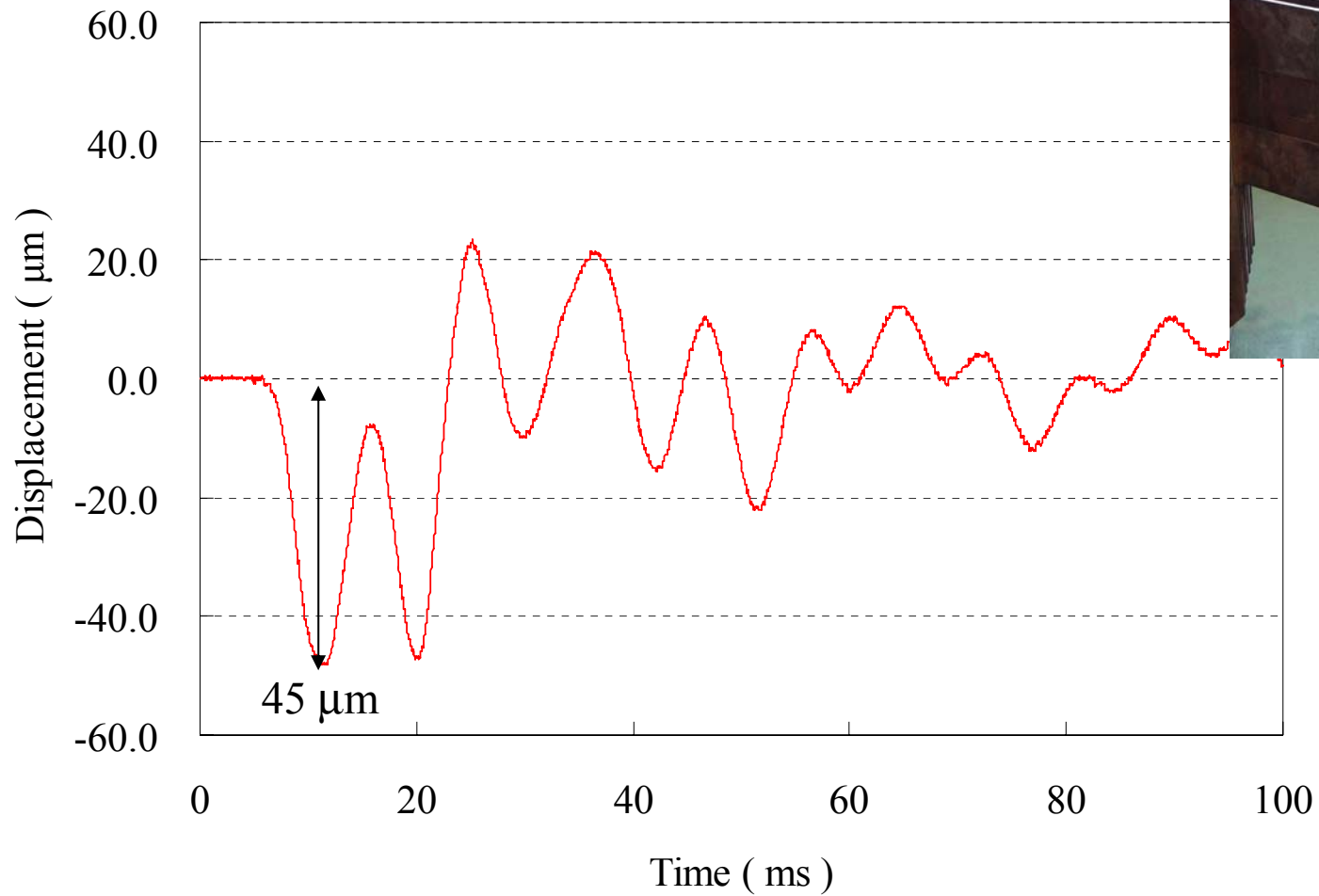
# Stripline ( Ear Part )



# Transformer

Large distortion at the transformer

Bad situation, since we will use this transformer at physics run.

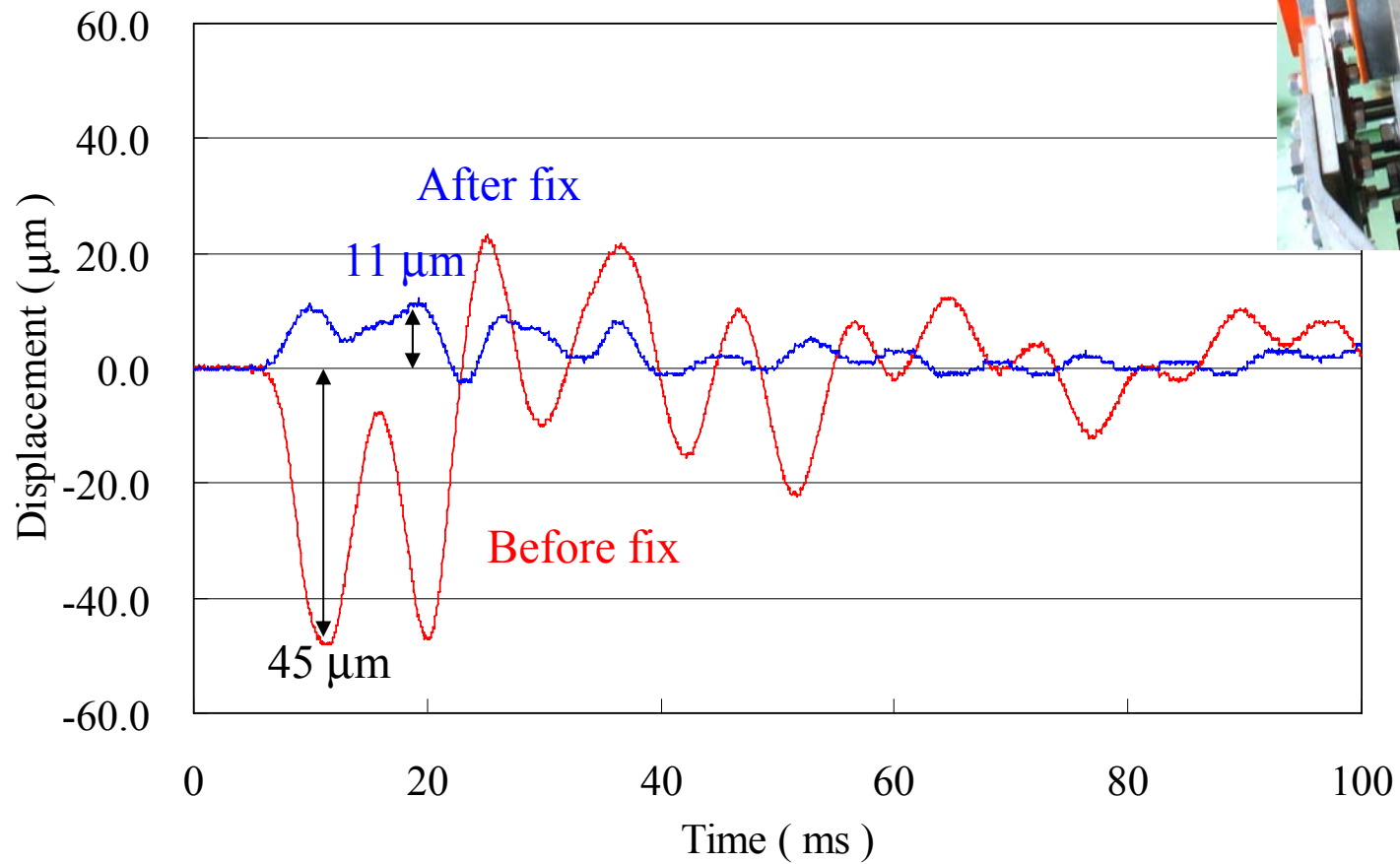


# Transformer

Fix the transformer plates with long bolts.



Magnitude of the distortion reduced.



# Measurement vs. Expectation

Expectation from FEM analysis (ANSYS)

Position	Measurement	Expectation
Upstream	~10 $\mu\text{m}$	~30 $\mu\text{m}$
Downstream	~15 $\mu\text{m}$	~20 $\mu\text{m}$
Stripline (vertical)	~50 $\mu\text{m}$	~500 $\mu\text{m}$ ? ←
Stripline (Ear)	~5 $\mu\text{m}$	~300 $\mu\text{m}$ ? ←
Transformer	~45 $\mu\text{m}$	-
Frame	~5 $\mu\text{m}$	-

These two numbers need to be checked.

- Inner conductor is sufficiently strong.
- Results of FEM analysis for stripline distortion need to be checked.



# Plans for Prototyping

# 3<sup>rd</sup> Horn Prototype

Inner conductor

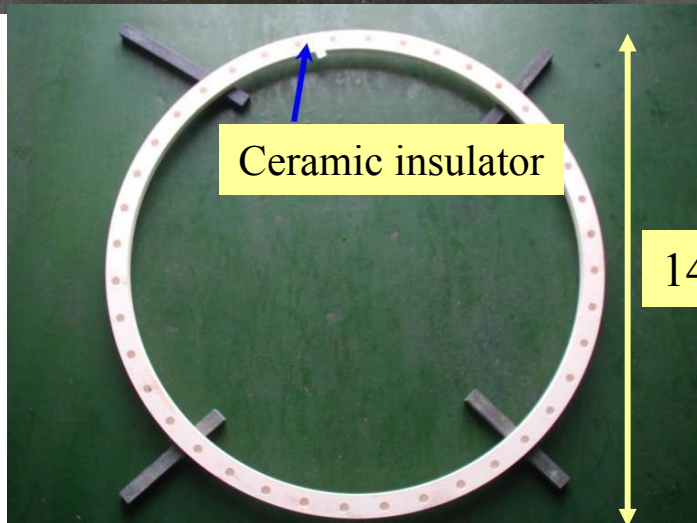


Outer conductor



2500mm

Ceramic insulator



1440mm

Assembling will be done within this fiscal year

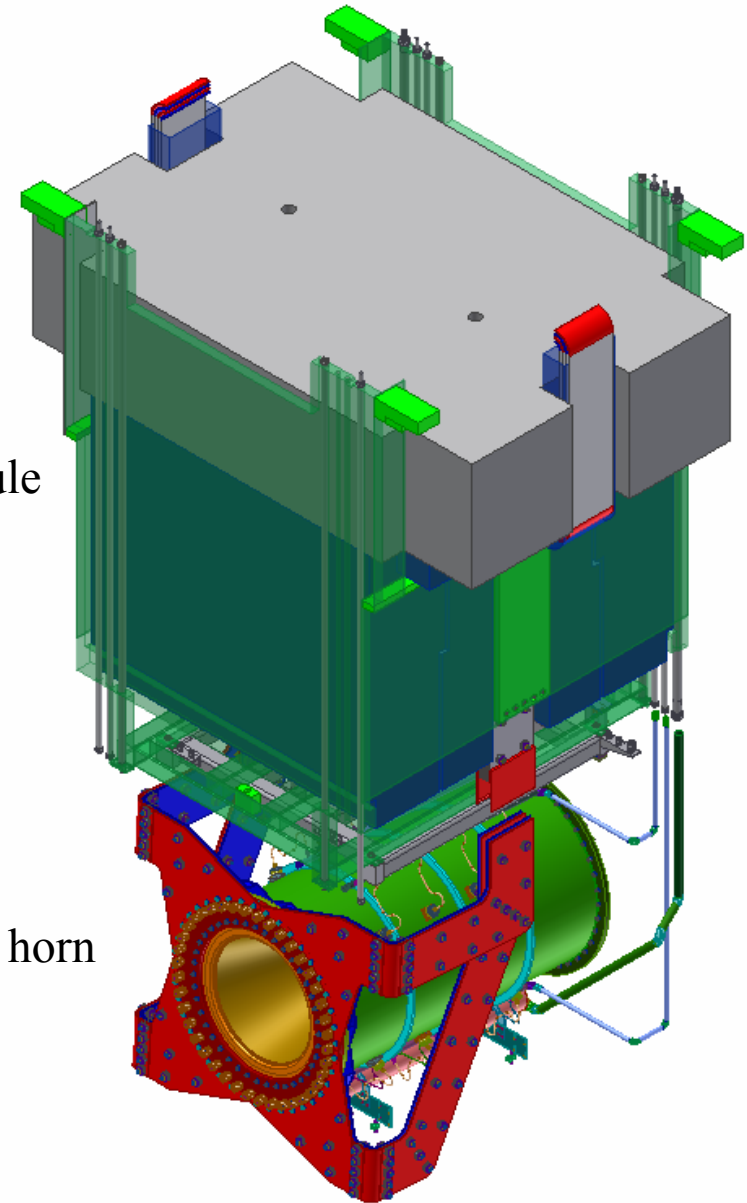
# Current Operation with Full Setup

3<sup>rd</sup> horn and its support module will be produced in this fiscal year.

Support module

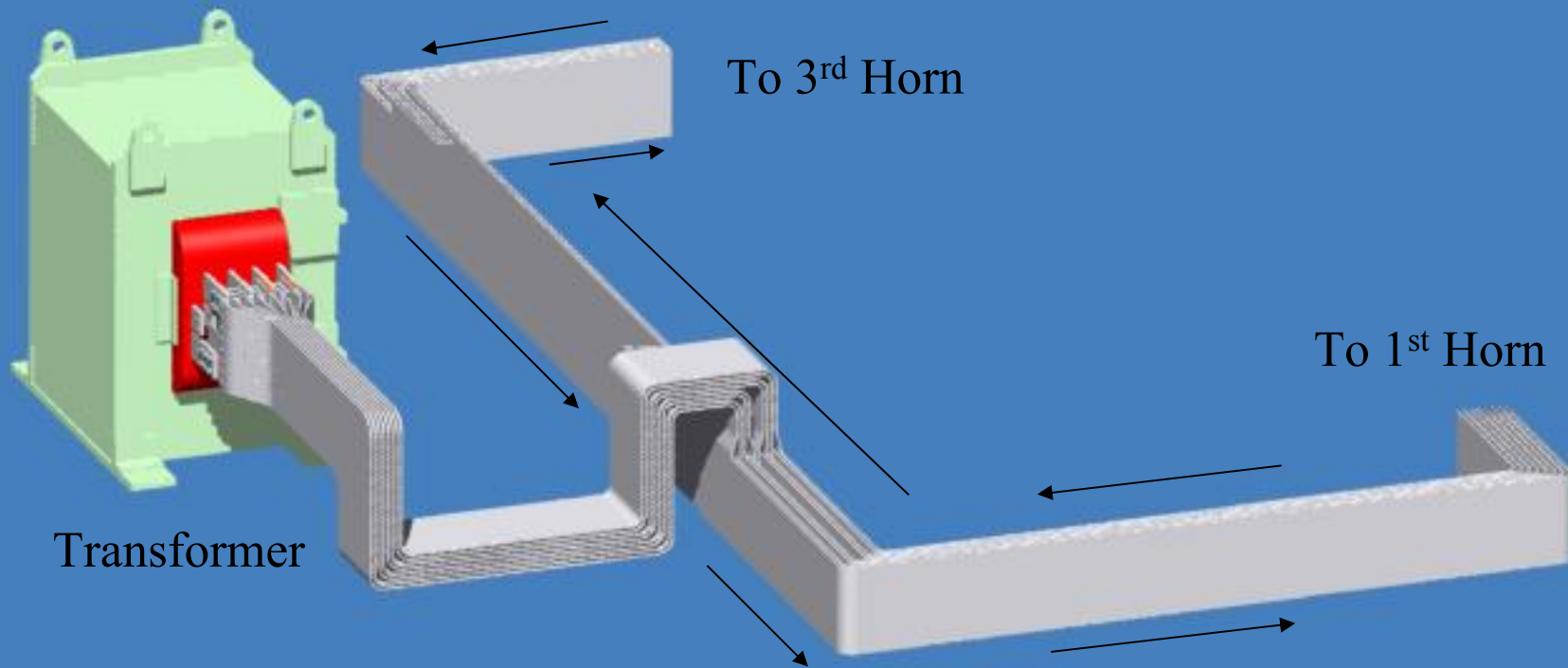
Test operation will be performed with full 3<sup>rd</sup> horn configuration.

3<sup>rd</sup> horn



# Two Horn Serial Connection

2<sup>nd</sup> and 3<sup>rd</sup> horns will be connected serially.  
In horn test facility, 1<sup>st</sup> and 3<sup>rd</sup> horns will be connected for test.



# Summary

- 1<sup>st</sup> horn prototype was manufactured.
- 320 kA operation was succeeded.
- Cooling power is not enough. Still under study.
- Distortion was small compared to the expectation.

## Schedule in FY2006

- Prototype production
  - 3<sup>rd</sup> horn
  - Support module
- Current operation
  - Long term operation (1<sup>st</sup> horn, 3<sup>rd</sup> horn).
  - Full configuration (3<sup>rd</sup> horn). **←** Will be done in FY2007
  - Two-horn serial connection (1<sup>st</sup> horn, 3<sup>rd</sup> horn).