Study Plan of Clearing Electrode at KEKB

Y. Suetsugu, H. Fukuma (KEK),
M. Pivi, W. Lanfa (SLAC)

Background

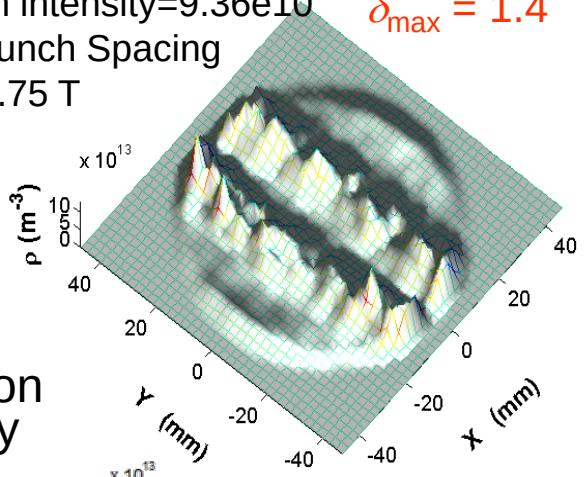
- A possible solution to suppress electron cloud in magnets.
  - Drift space :Beam duct with antechamber (photoelectrons) + TiN coating (Secondary electrons) + Solenoid will be OK.
- Experimental study on a clearing electrode using KEKB positron ring is planed, as a chain of ILC DR R&D study.
- Goal
  - Establish the technique of clearing electrode for ECI, which is available for high current machine and with a low beam impedance.
  - Demonstrate the effect on electron cloud formation.

Clearing Electrode

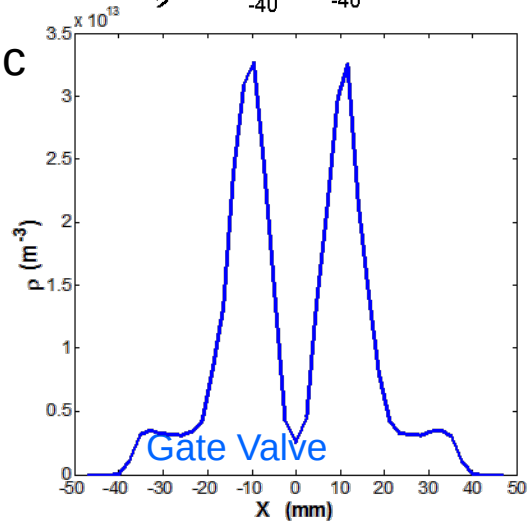
- Simulation (by L. Wang)

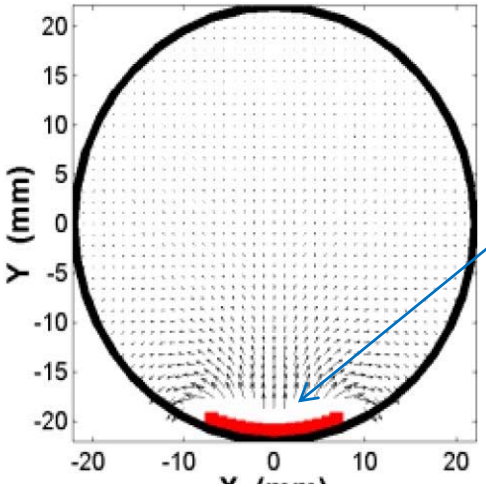
R-pipe=38mm
bunch intensity=9.36e10
3.5 Bunch Spacing
B = 0.75 T

$\delta_{max} = 1.4$

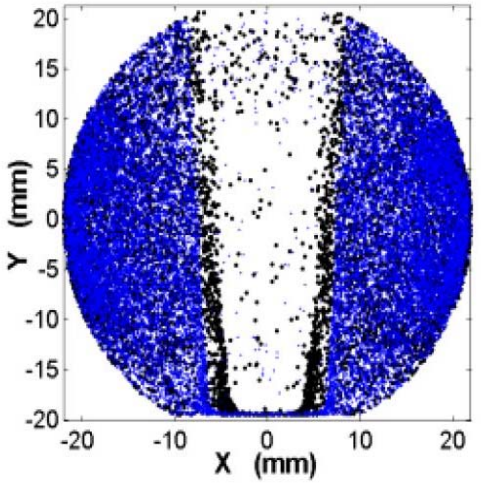


Electron density in magnetic field





Electrode (+)



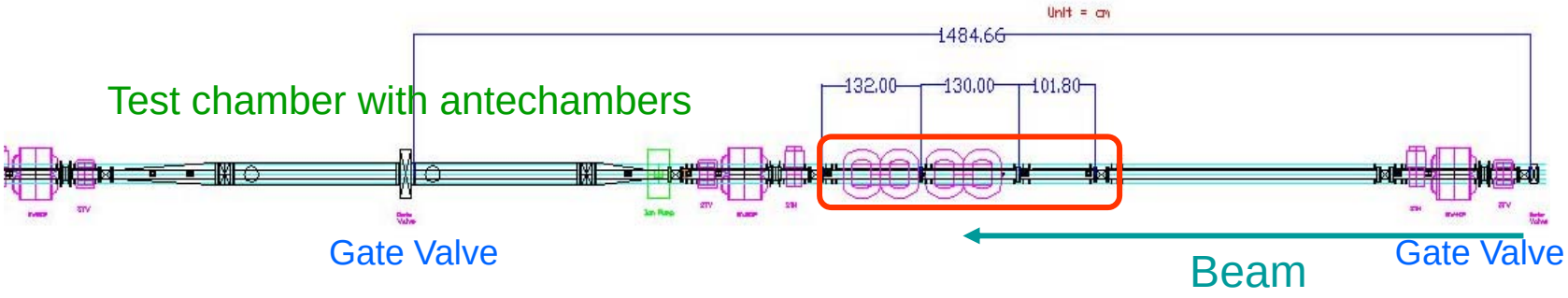
ate Valve

L. Wang et al, EPAC2006, p.1489

Test plan

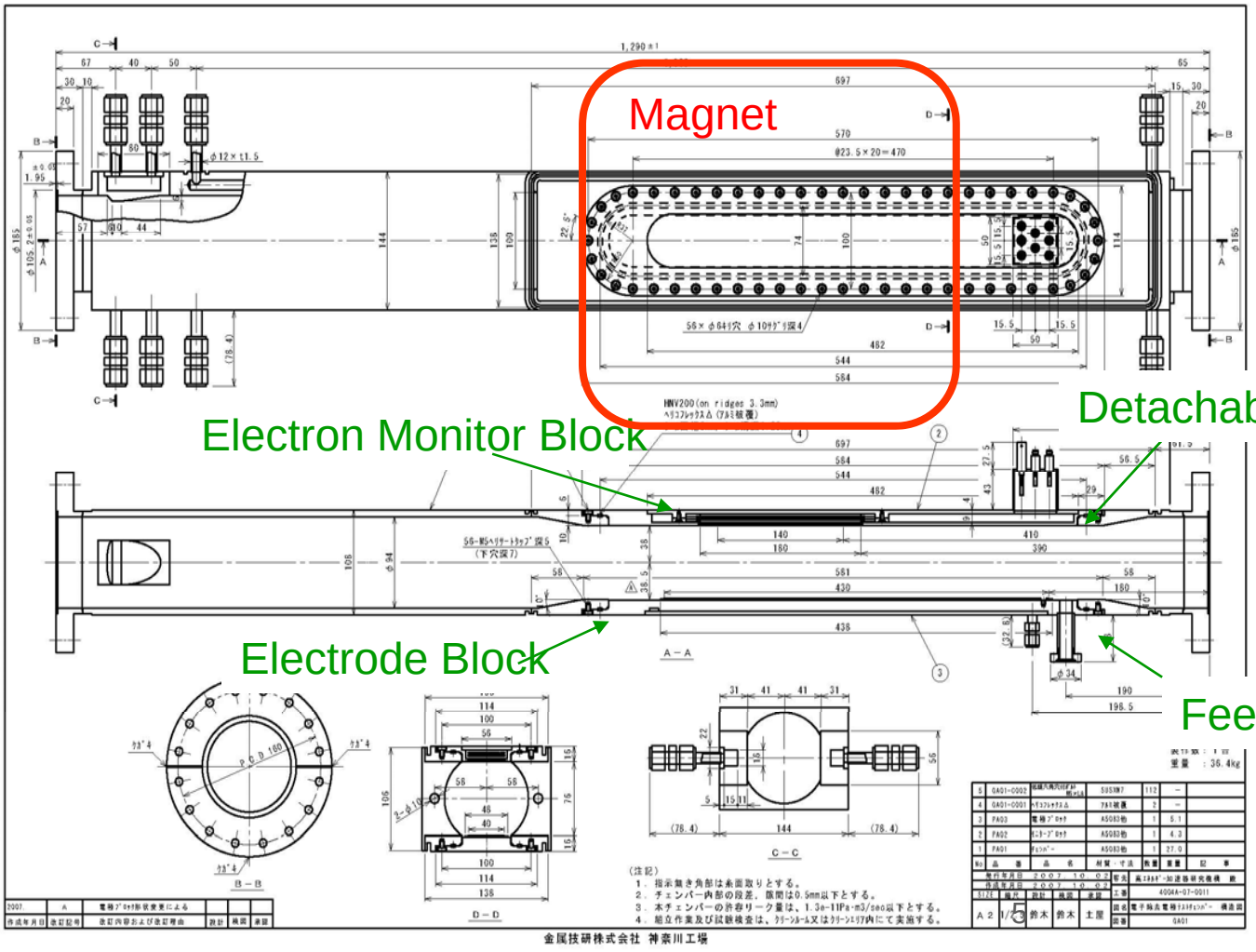
- Install a test chamber with an electron monitor and a clearing electrode into a wiggler magnet of LER (Oho straight section).
  - At the most upstream side of wigglers
    - Very weak SR
  - Magnetic field: 0.75 T
  - Effective length: 346 mm
  - Aperture (height): 110 mm

Wiggler magnets



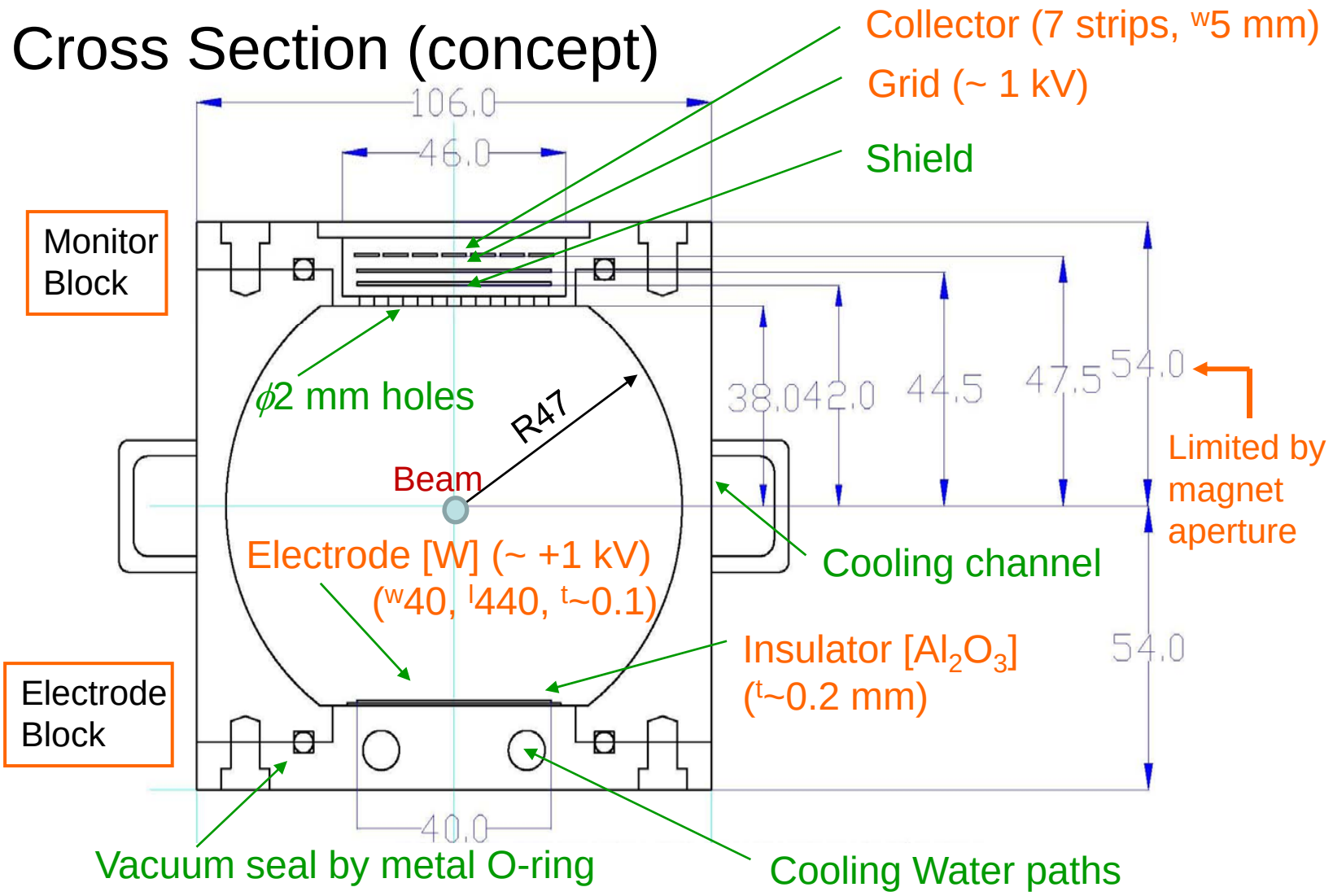
Test Chamber

- Over all design of the test chamber



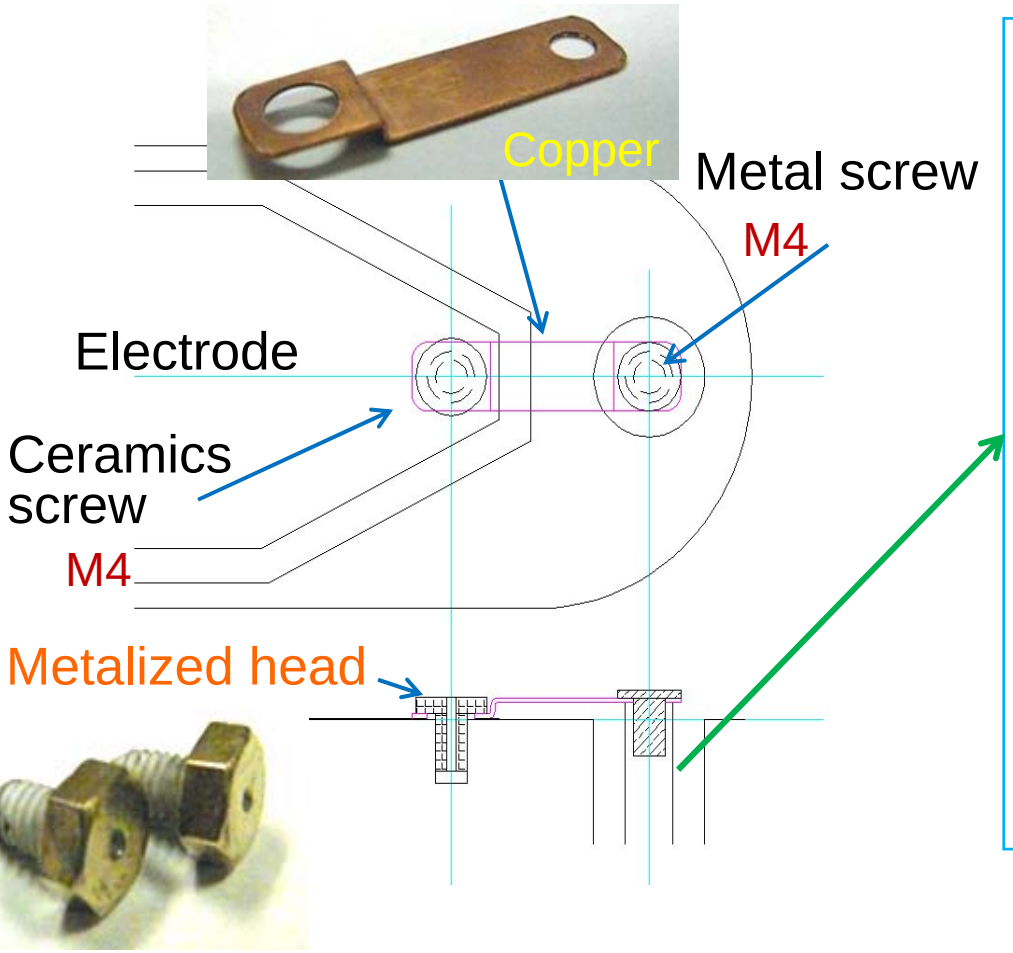
Monitor and electrode

- Cross Section (concept)

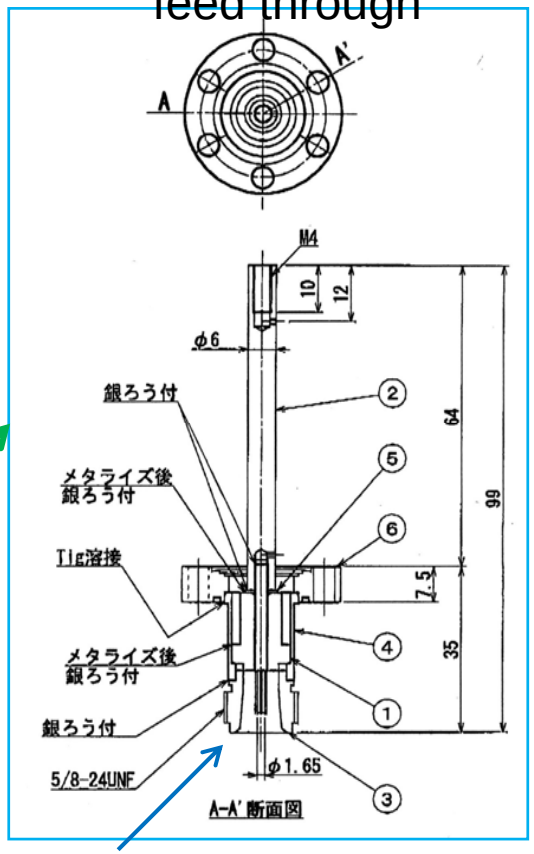


Feed through

- Copper bridge to connect feed-through and electrode was manufactured.



Non-magnetism feed through



N-type connector

Features of the test chamber

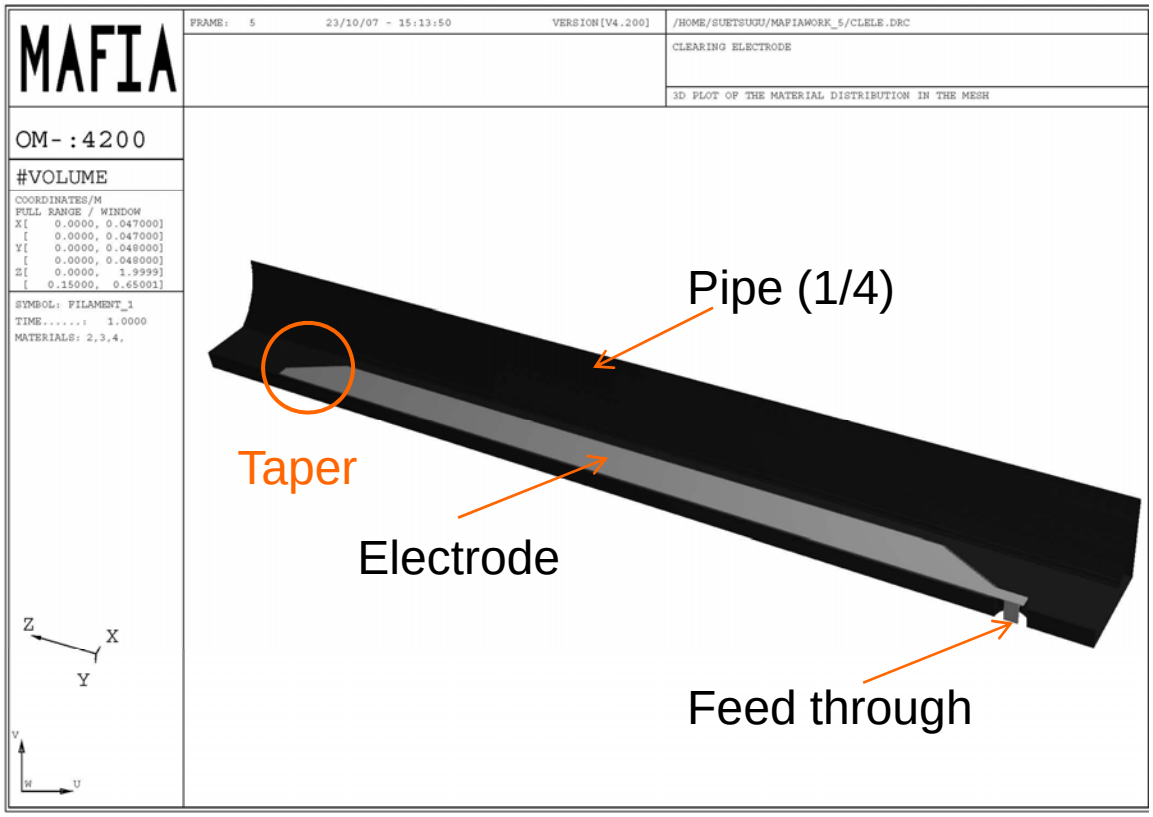
- Strip type electrode.
- Monitor and electrode are exchangeable.
- Electron collectors are seven strips to measure the spacial distribution.
- Very thin electrode and insulator.
  - Electrode: ~0.1 mm, Tungsten, by thermal spray.
  - Insulator: ~0.2 mm, Al_2O_3, by thermal spray.

  $\rightarrow$Small beam impedance.
- Water cooling just behind of the electrode.
  - Absorb dissipated power in the electrode and the insulator.

RF calculation

- Model (By Mafia)

- Length = 2 m
- 1/4 model
- Electrode position =
  195-625 mm (430mm)
- Width = 40 mm
- Mesh sizes =
  0.5 x 0.1 x 0.4 mm
- Bunch length = 6-8 mm
- Electrode thickness =
  0.2 mm
- Alumina thickness =
  0.2 mm
- Alumina ε_r =9.9
- Port = 14 mm (o),
  6 mm (i) (50Ω)

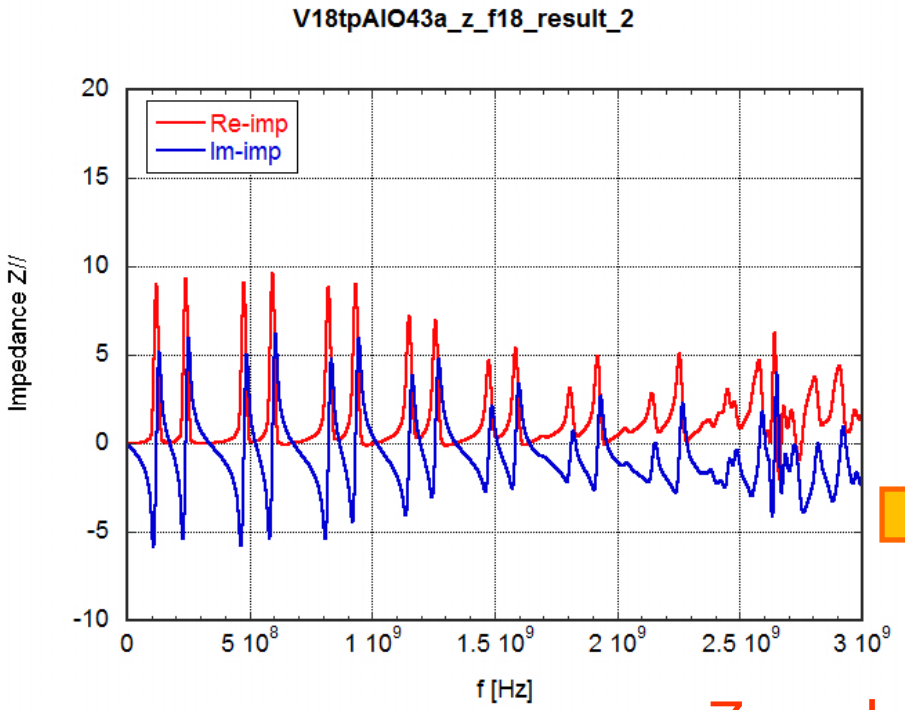


Embedded + Taper + Feed through

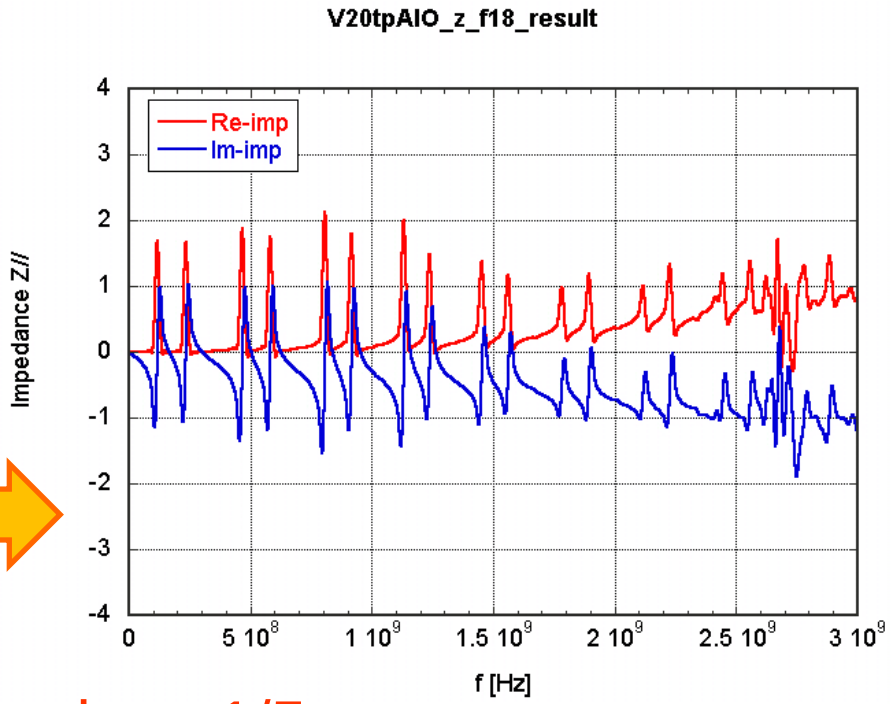
RF calculation

- Impedance($z_{//}$)
- σ_z = 20 mm (to calculate wakes for long distance)

• 0.5 mm electrode
• 1.0 mm Al_2O_3



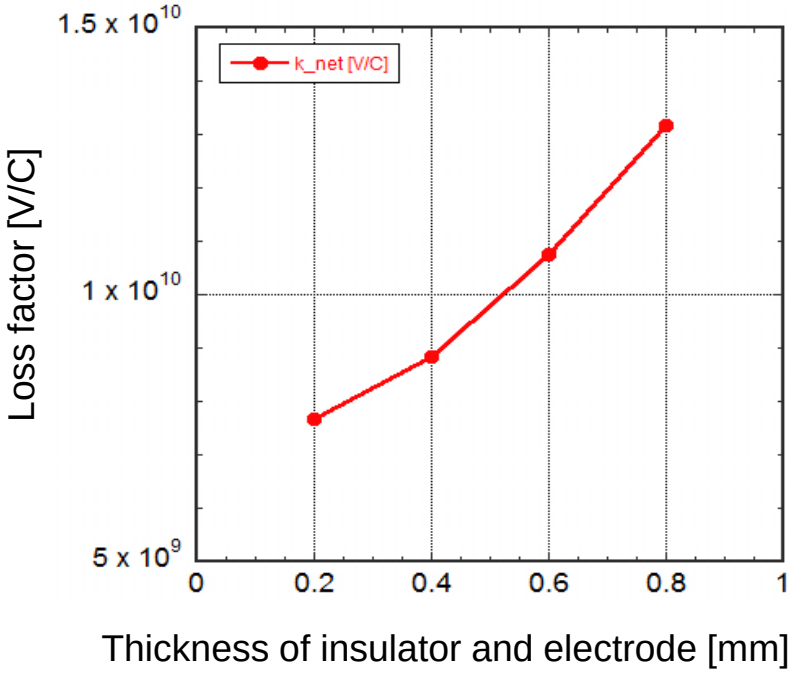
• 0.2 mm electrode
• 0.2 mm Al_2O_3



$Z_{//}$ reduced to ~1/5

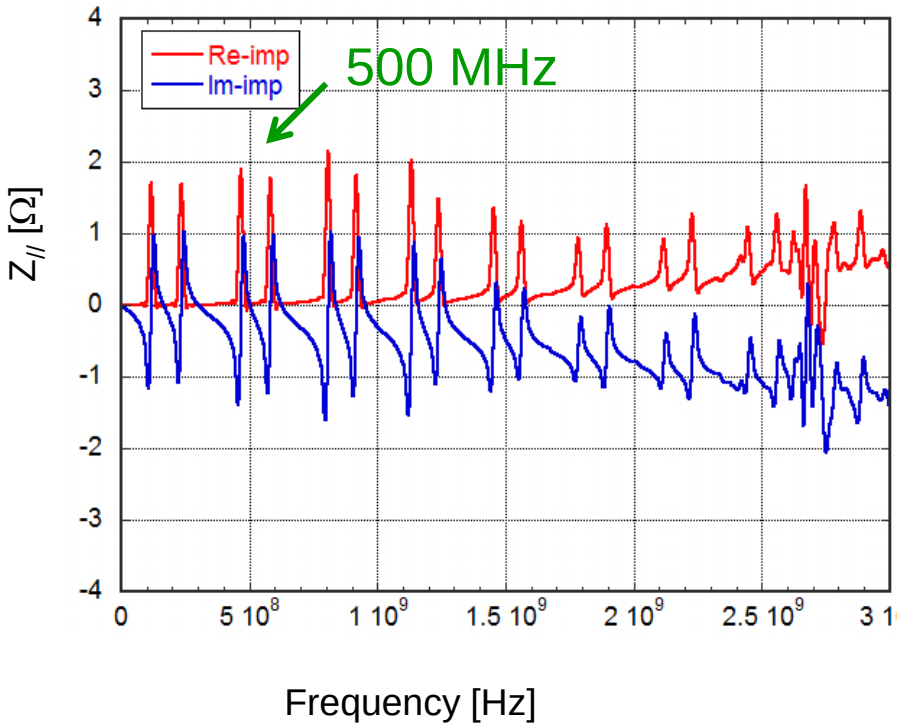
RF calculation

- Loss factor
  - $k = 7 \times 10^9$ V/C, and Input power is ~ 150 W for 2 electrodes. (1.7 A @1389 b)
  - Most of input power into electrode will be dissipated by electrode and chamber.



RF calculation

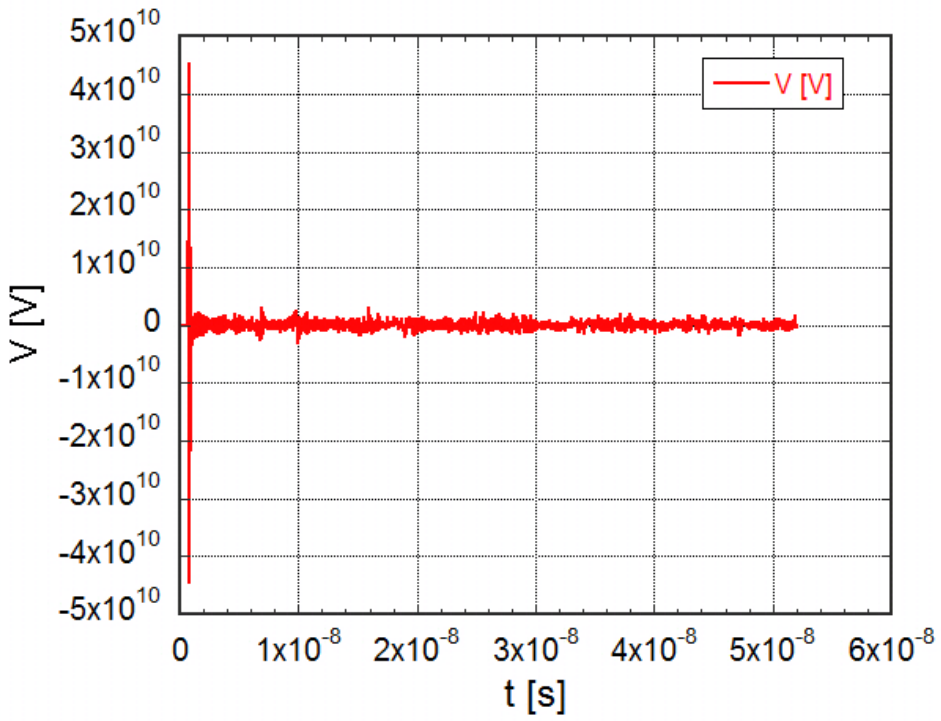
- Longitudinal impedance
  - Length is 440 mm to avoid resonance with RF frequency.
  - a few Ω



RF calculation

- Voltage at feed through by MAFIA
  - σ_z = 6 mm

Voltage at the end of port @ 1C



at 1.7 A (1389 bunches),

- Output voltage is
  V_O ~ 600 V (If no resonance)
- Output power from feed-through
  P_O ~ 60 W,
  if R=50Ω and no loss
- Voltage between electrode and chamber is
  V ~ 12 V (If no resonance)

Thermal calculation

- Assumption
  - Power loss in the electrode (insulator):
    - 100 W for 1.7 A, 1389 bunches
  - Power loss on the electrode (copper):
    - 10 W for 1.7 A, 1389 bunches
    - From a formula

$$P' = \frac{\Gamma(3/4) I_b^2 C}{4\pi^2 a \sigma_z^{3/2} \sqrt{2\mu\sigma_c / Z_0}}$$

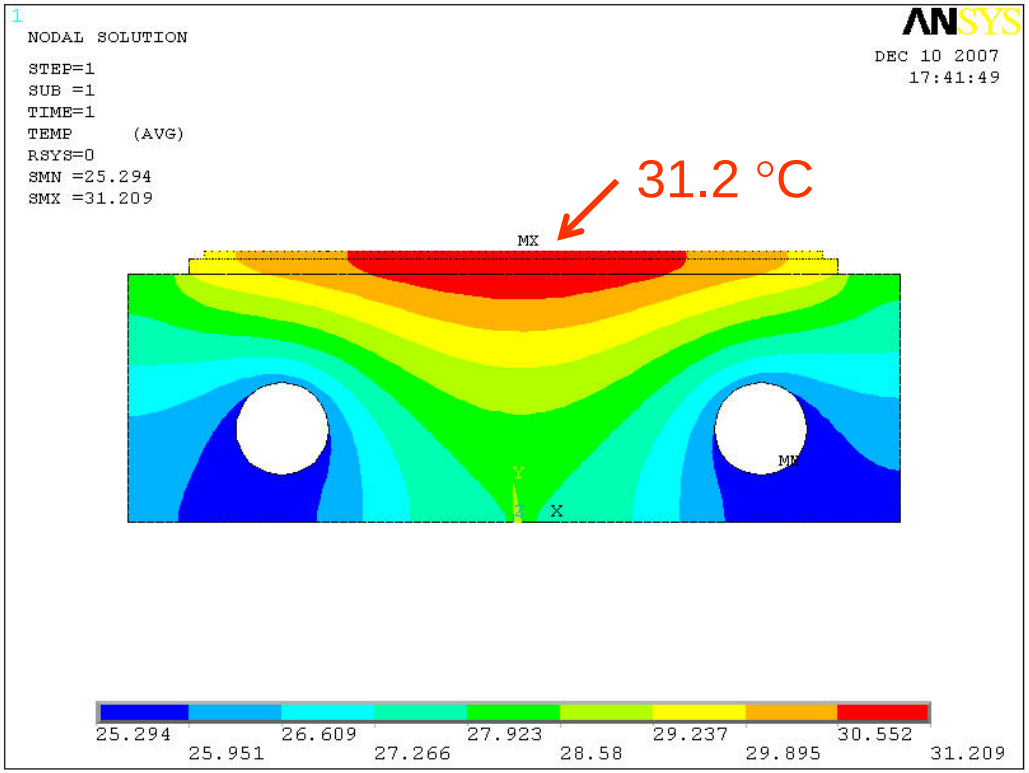
For 1.7 A 1389 bunches,

$\Gamma(3/4) = 1.225$
I_b = Bunch current [A]
C = Circumference =3016 m
$Z_0 = 377\Omega$
σ_z = bunch length = 6 mm
σ_c = Conductivity= 1.8×10^7 1/Ωm (W)
$\mu = 1$
a = radius = now 38 mm

$$P = P' \times 1389 \times 0.4\ [\mathrm{m}] \times 0.5(\text{one side}) = 7.13 \sim 7\ \mathrm{W}$$

Thermal calculation

- Result



0.5 mm electrode
1.0 mm Al_2O_3

- Heat transfer coefficient between chamber and water = 0.01 W/mm^2/K
- Temperature of water = 25 degrees.

Material	Thermal Conductivity [W/mm/K]
SUS	0.017
Al_2O_3	0.03

Test schedule

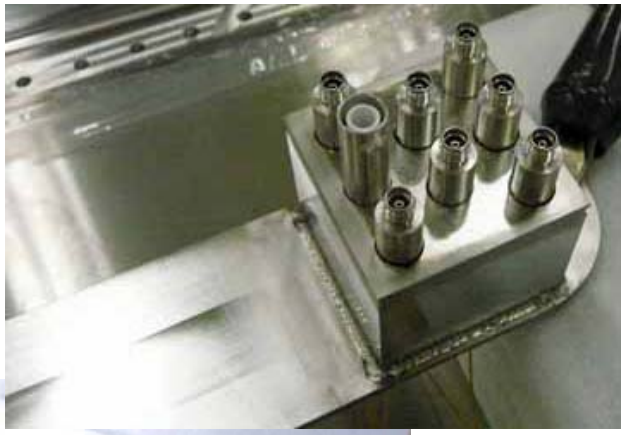
- First step (from February, 2008)
  - Install outside of magnet (upstream side)
  - Check the heating of electrode
  - If possible, with electron monitor and Measurement without magnet.
- Second step
  - Install into the wiggler magnet with electron monitor
- Third step
  - Groove surface, Rough surface, and other promising methods.

Manufacturing

- Machining and assembling are undergoing.

Monitor part

Output feed-through

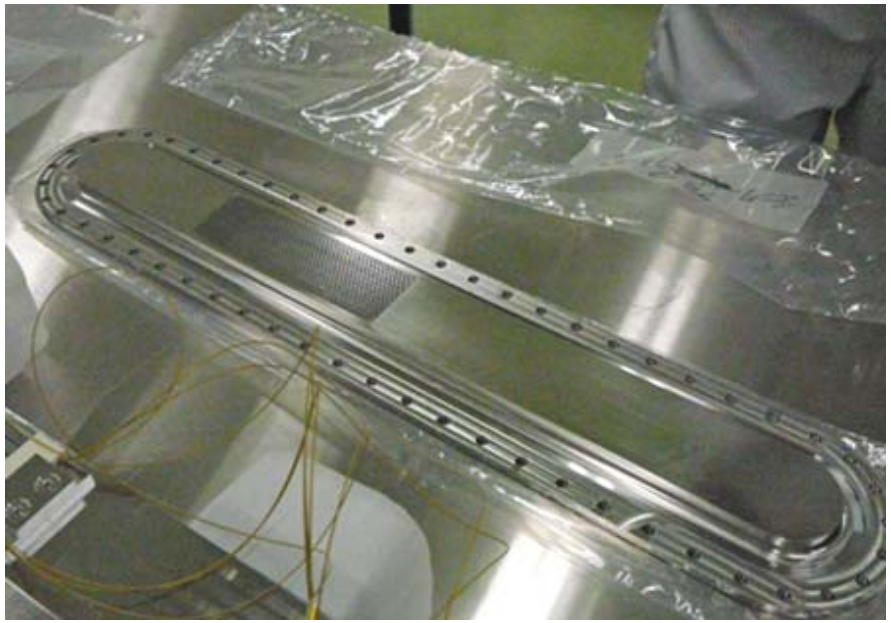


Collector (strips)

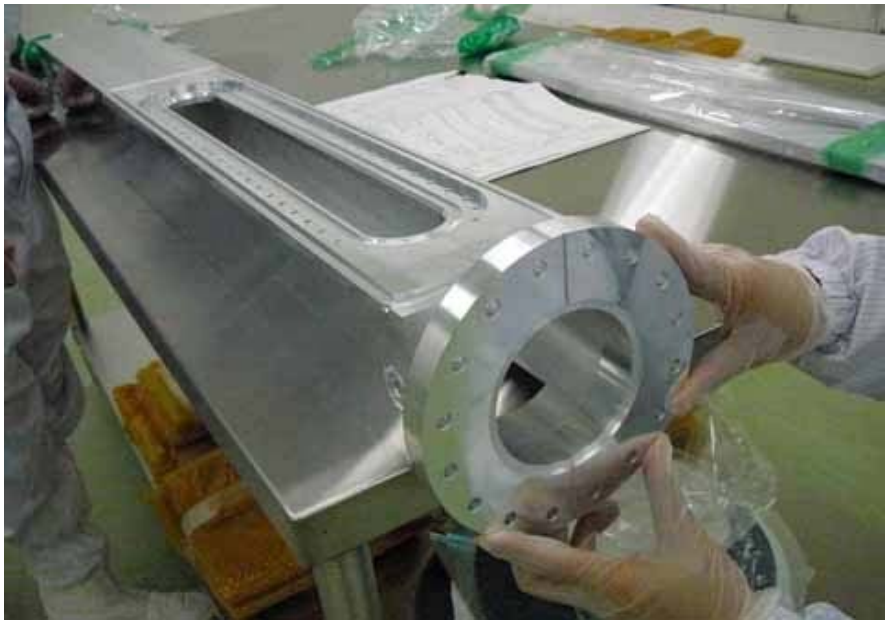
Manufacturing

- Machining and assembling are undergoing.

Flange



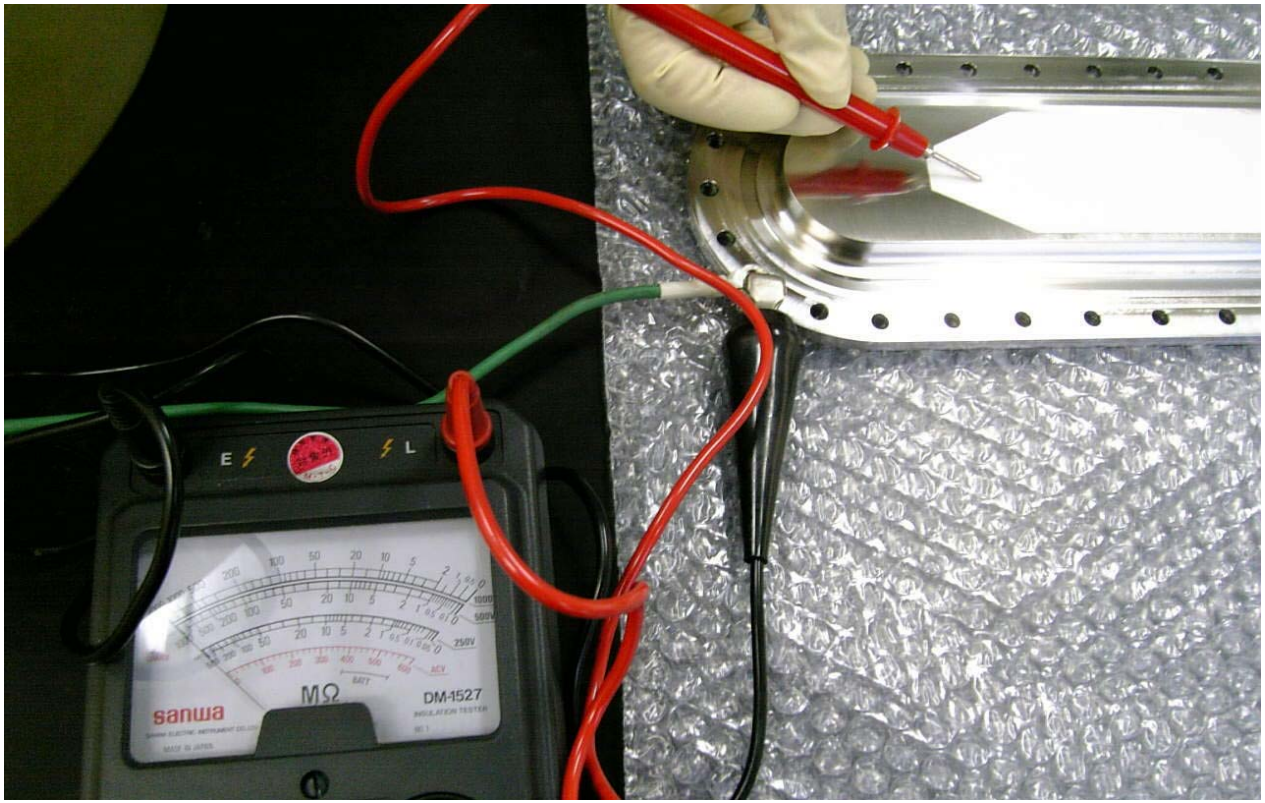
Chamber



- Hot spray of Al_2O_3 and W: Next week

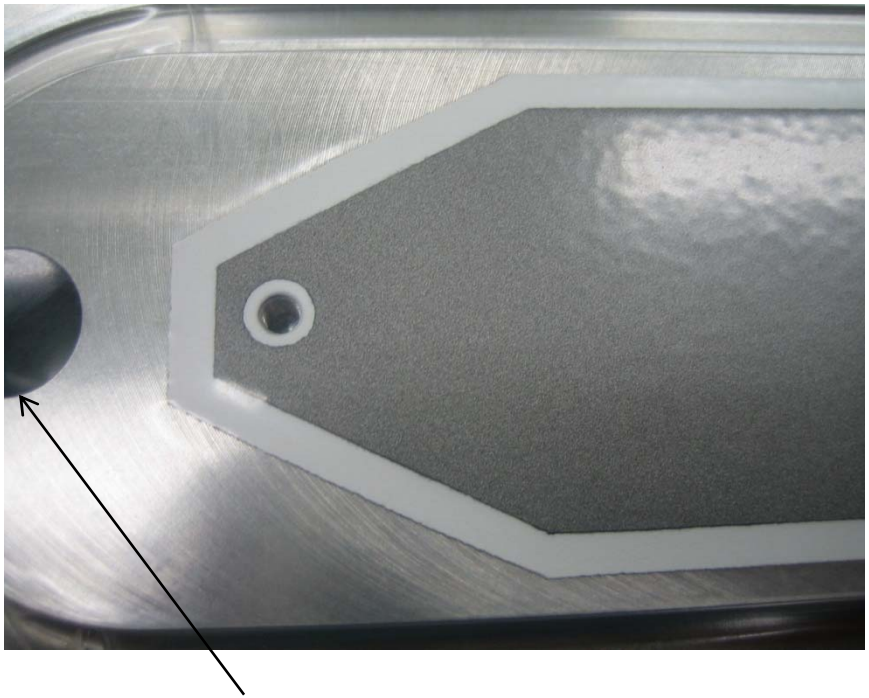
Manufacturing

- Hot spray of Al_2O_3 and insulation test (1kV)

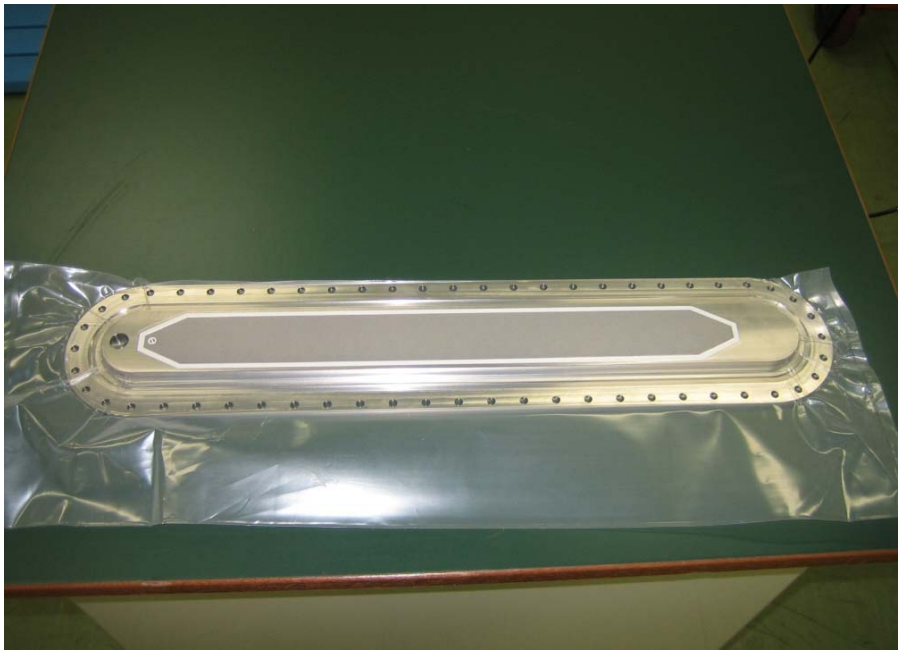


Manufacturing

- Hot spray of tungsten (electrode)

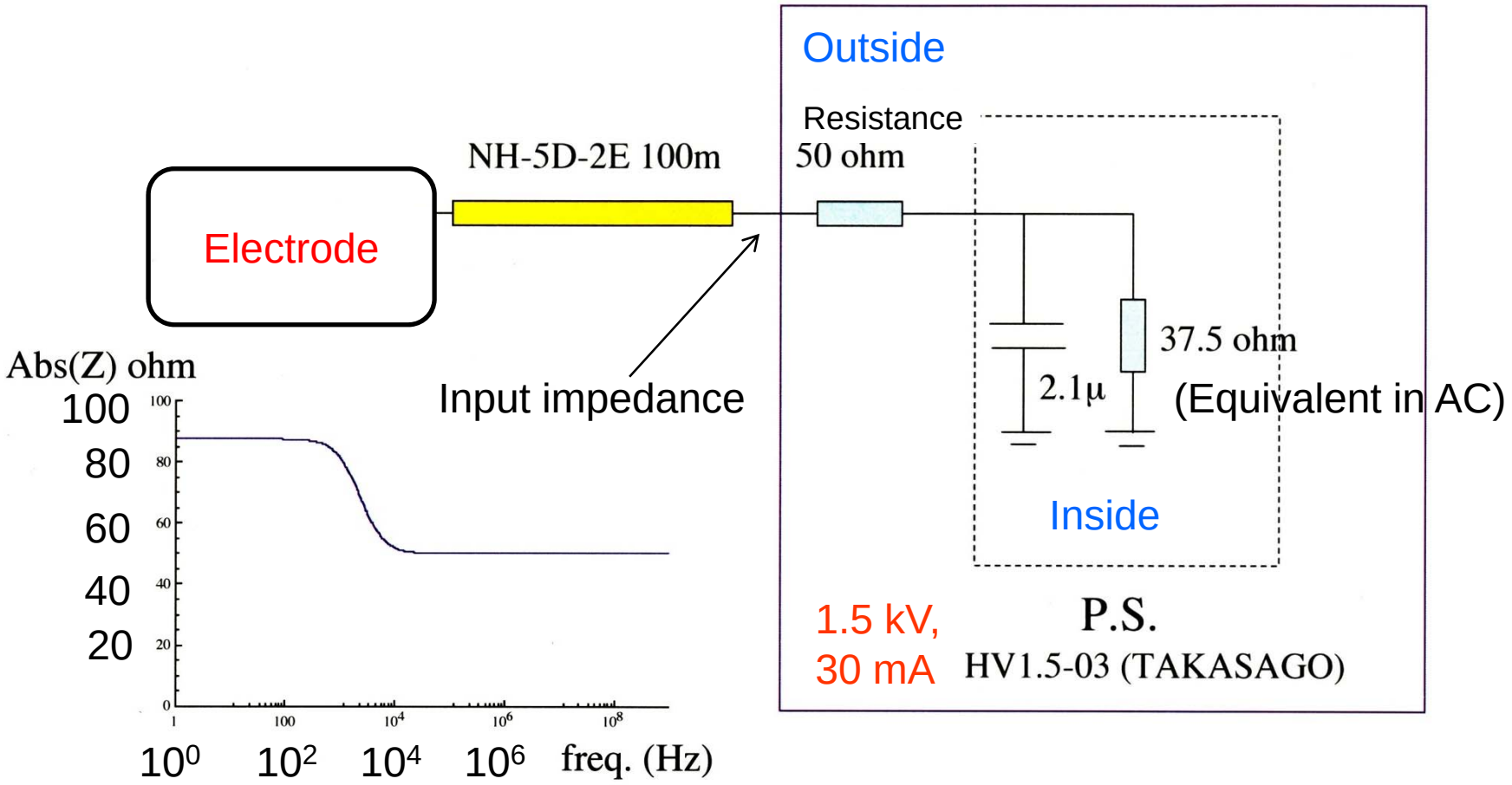


For feed-through



Power Supply

- Power supply for electrode (Fukuma-san)



Summary

- Clearing electrode has been studied for a cure of EC in magnets.
- Manufacturing of test chamber is undergoing.
- Thin electrode and insulator contribute to decrease the impedance.
- Input power into the electrode can be treated by water cooling.
- Beam test will start from next February beginning with checking of heating.

References

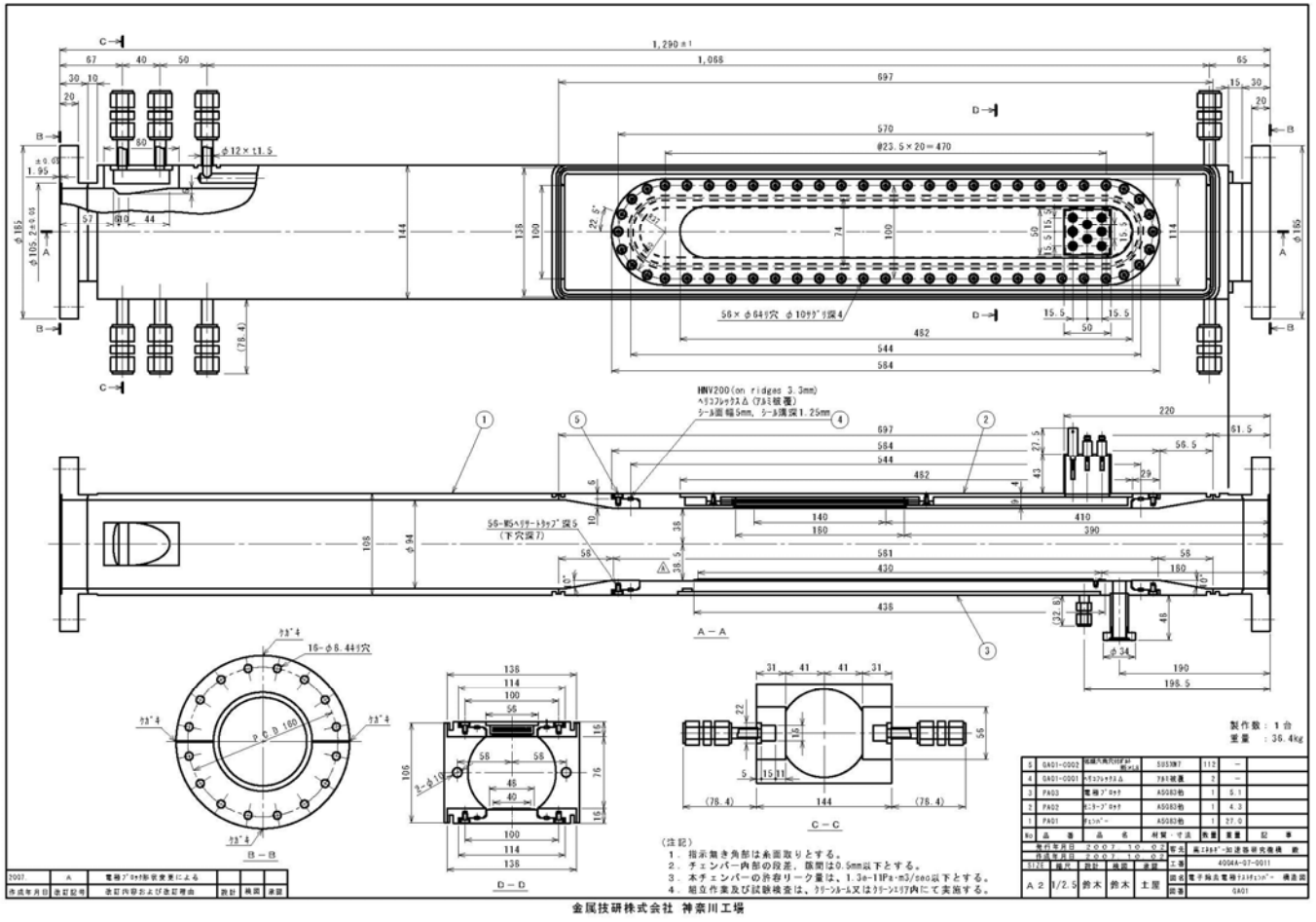
Materials

- Properties

	Cu	W	Stainless Steel (SUS304)	Al_2O_3 (96%)
Electric Conductivity [1/W/m]	5.8×10^{7}	1.8×10^{7}	1.4×10^{6}	-
Thermal conductivity [W/m/K]	400	150	15	24
Linear expansion coefficient [1/K]	1.7×10^{-5}	4.4×10^{-6}	1.7×10^{-5}	6.4×10^{-6}
Relative dielectric constant	-	-	-	9.9

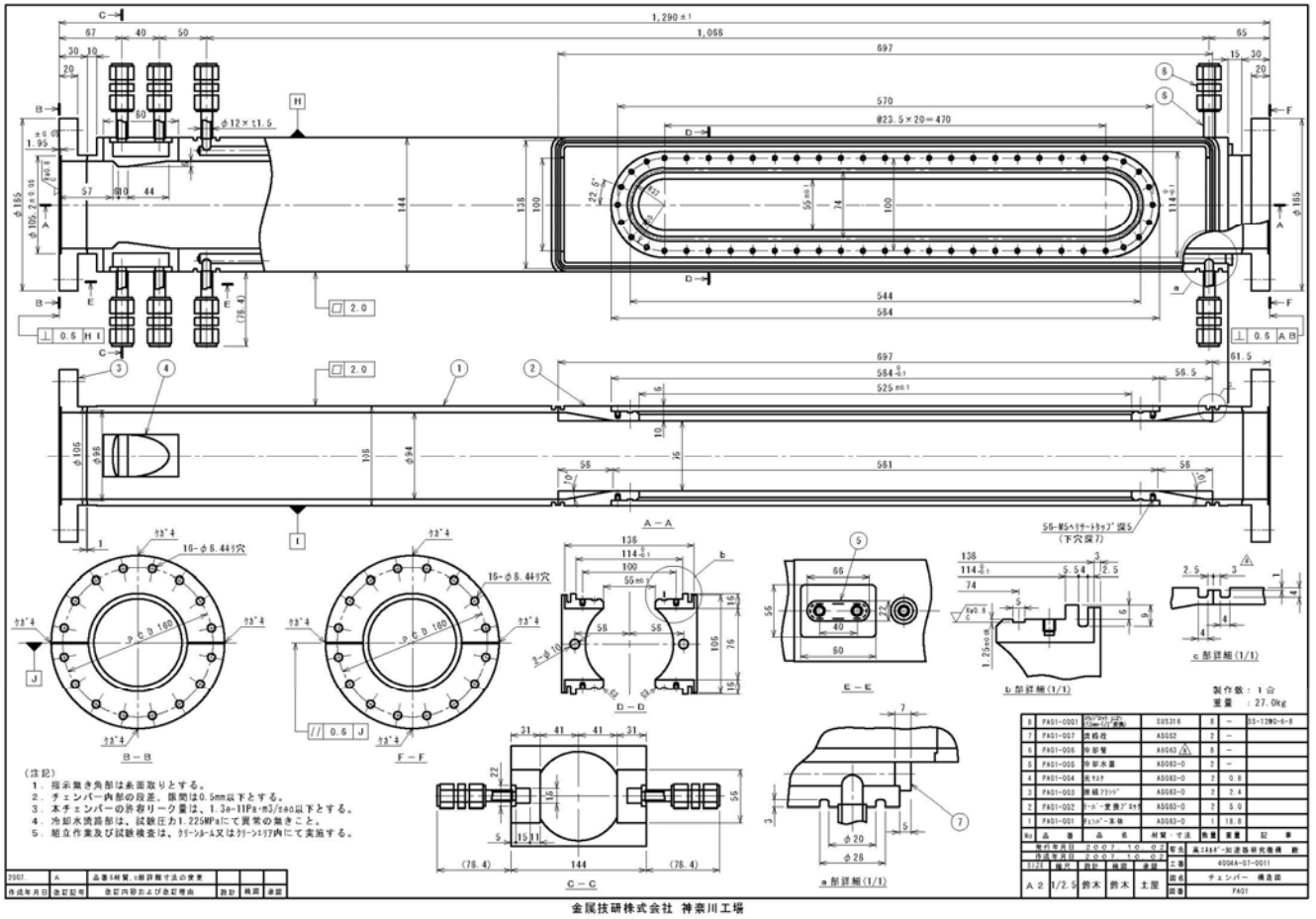
Structure

- Overall



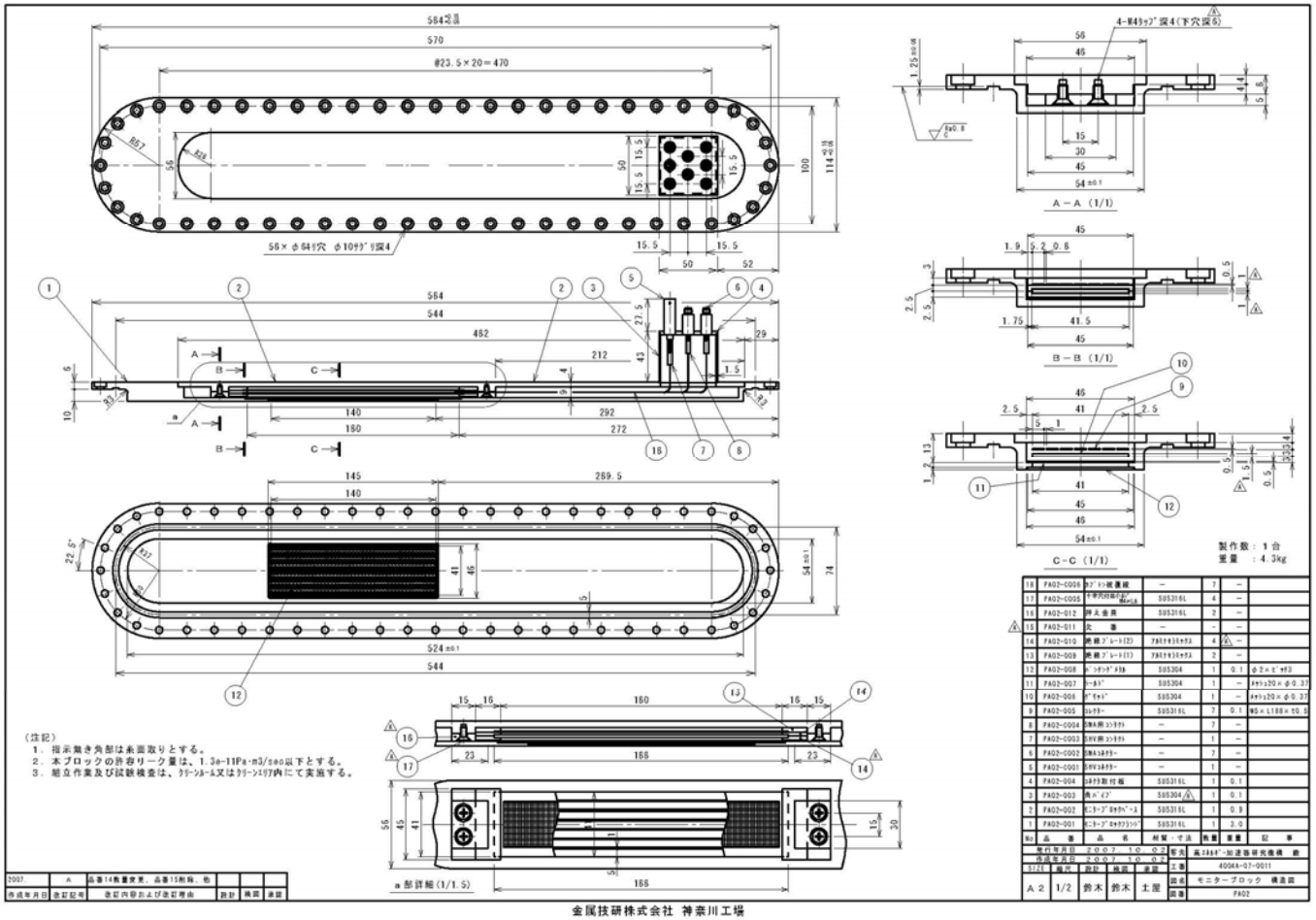
Structure

- Chamber (aluminum alloy)



Structure

- Monitor block (stainless steel)



Structure

- Electrode block (stainless steel)