P8-08

Probing of toroidal electron plasmas confined on helical magnetic surfaces

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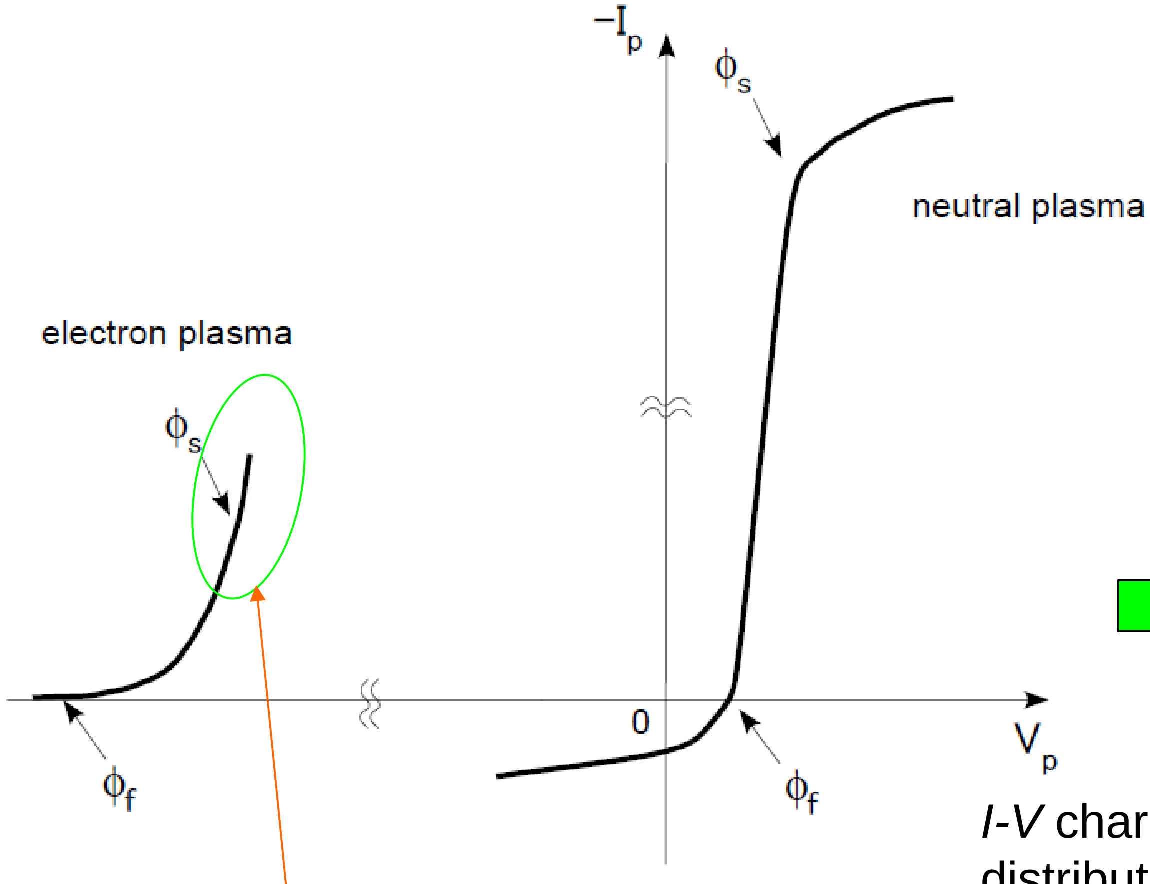
Non-neutral plasma property



Neutral plasma

$$-100\,\mathrm{V} \le \phi_s \le 100\,\mathrm{V}$$

$$n_e \sim 10^{19}\ \mathrm{m}^{-3}$$

Non-neutral plasma

$$-1.5\,\mathrm{kV} \le \phi_s \le -250\,\mathrm{V}$$

$$n_e \sim 10^{11-13}\ \mathrm{m}^{-3}$$

→ Depend on initial injection energy and confinement condition

No electron saturation current

→ Orbital motion limited regime

I-*V* characteristic shows non-Maxwellian distribution

↓

Non-neutral plasma possess strong **E**, corresponding fast **E**×**B** flow is generated in magnetic surfaces.

Backgroud

Target plasma : Large ϕ_s plasma with low n_e

ϕ_s ~ 1kV, I_p ~ μA

For electron flux Γ measurement

high voltage between the probe and bias power supply (~1kV)

↓

exceed permissible differential voltage of OP amp (~10V)

↓

Divide voltage (ϕ_s / 1000)

↓

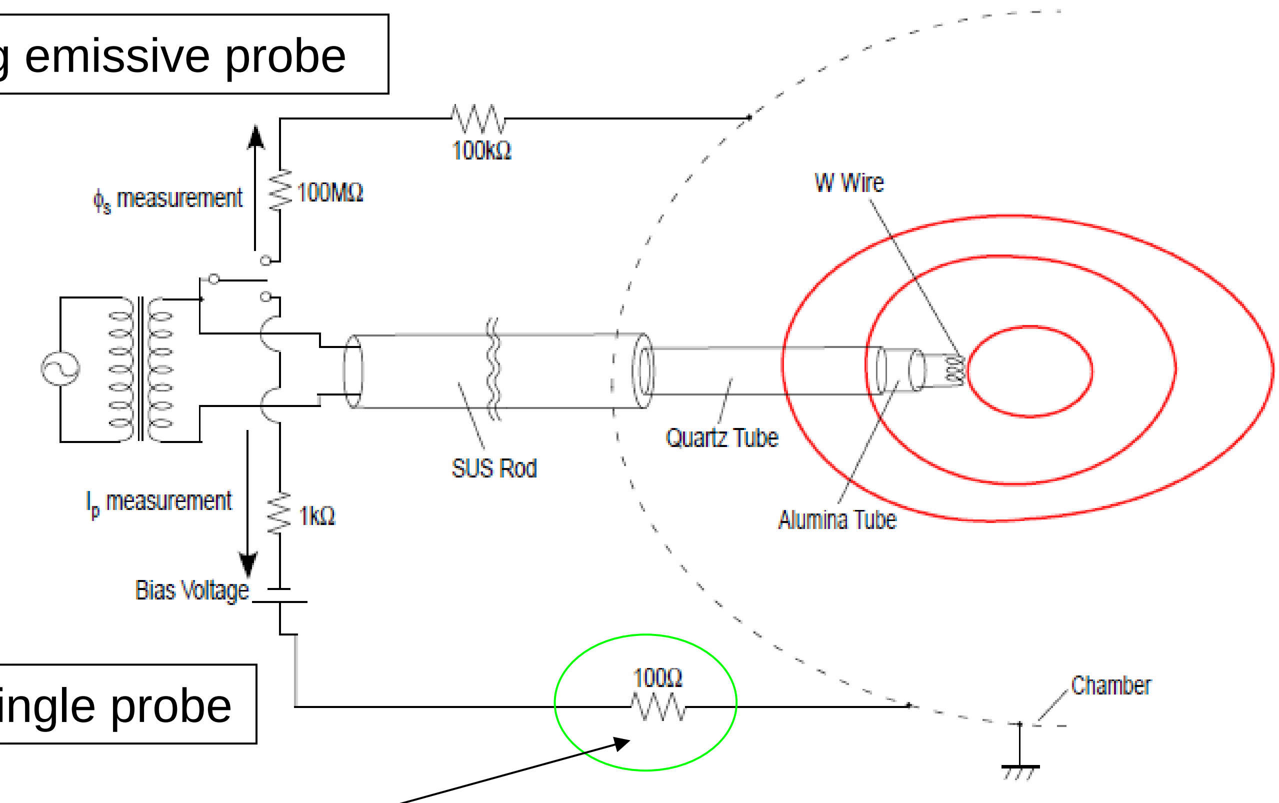
Flux Γ can't be detected.

⇒ New measurement method

Measurement setup

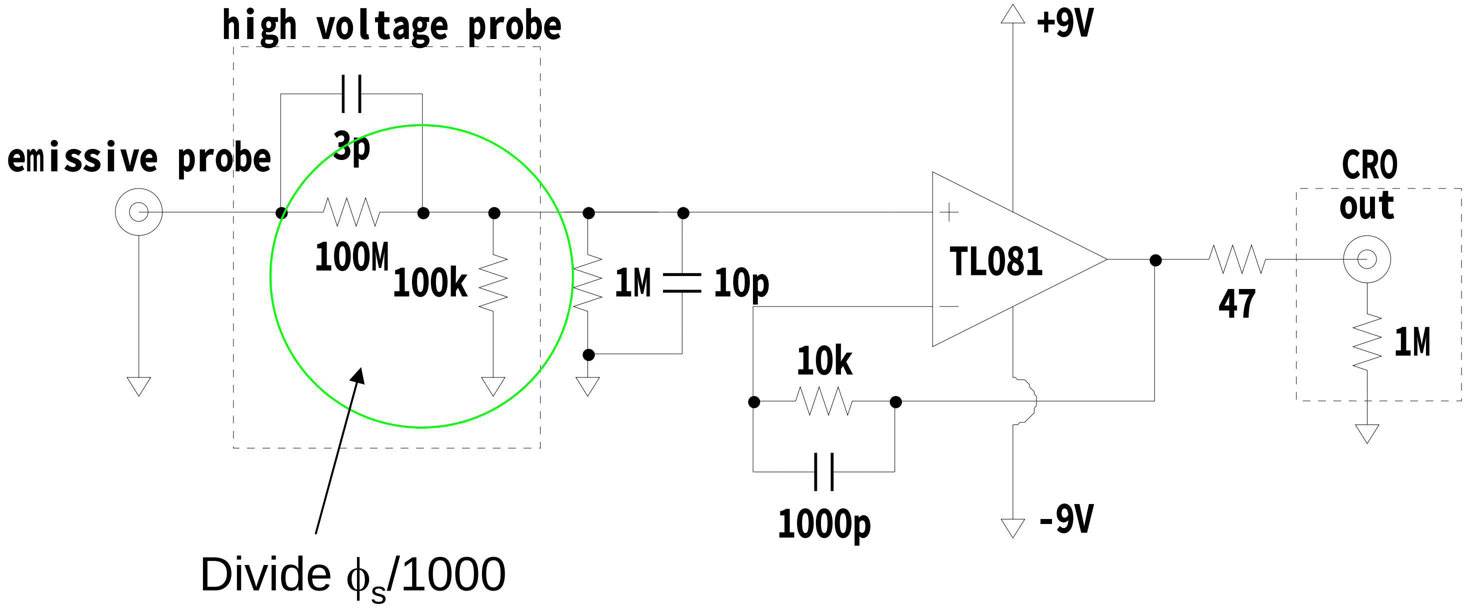
1. Floating emissive probe

2. Single probe



The reason why 100Ω is used is that the probing circuit suffered from substantial noise due to the ground loop on CHS. To alleviate the noise, the small resistance is installed in the probing circuit.

Impedance converter

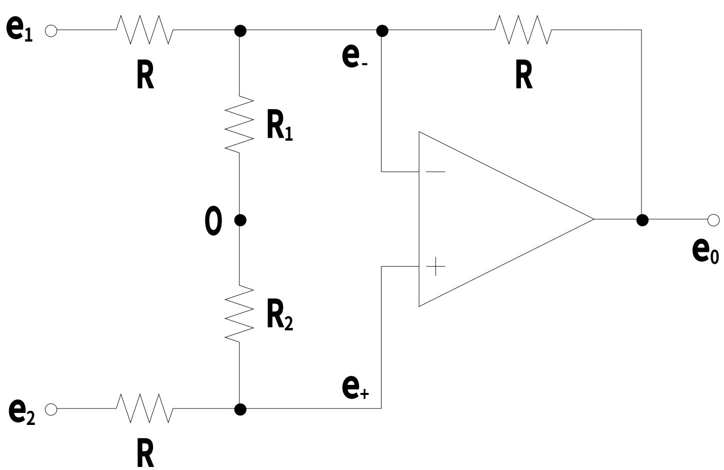


High impedance causes the probe signal to be transmitted with slow speed due to the large time constant (= *RC*).

OP amp works as a buffer.

Non-inverting amplifier converts the large resistance to ideally small one.

Schematic diagram of Γ measuring



The input voltage of OP amp

$$e_- = \left(\frac{e_1 - e_-}{R} + \frac{e_0 - e_-}{R} \right) R_1,$$

$$e_+ = \frac{e_2}{R + R_1}$$

$$e_+ = e_- = \frac{R_1 / R}{1 + R_1 / R},$$

$$e_0 = \frac{R_2 / R_1 + 2 R_2 / R}{1 + R_2 / R} e_2 - e_1$$

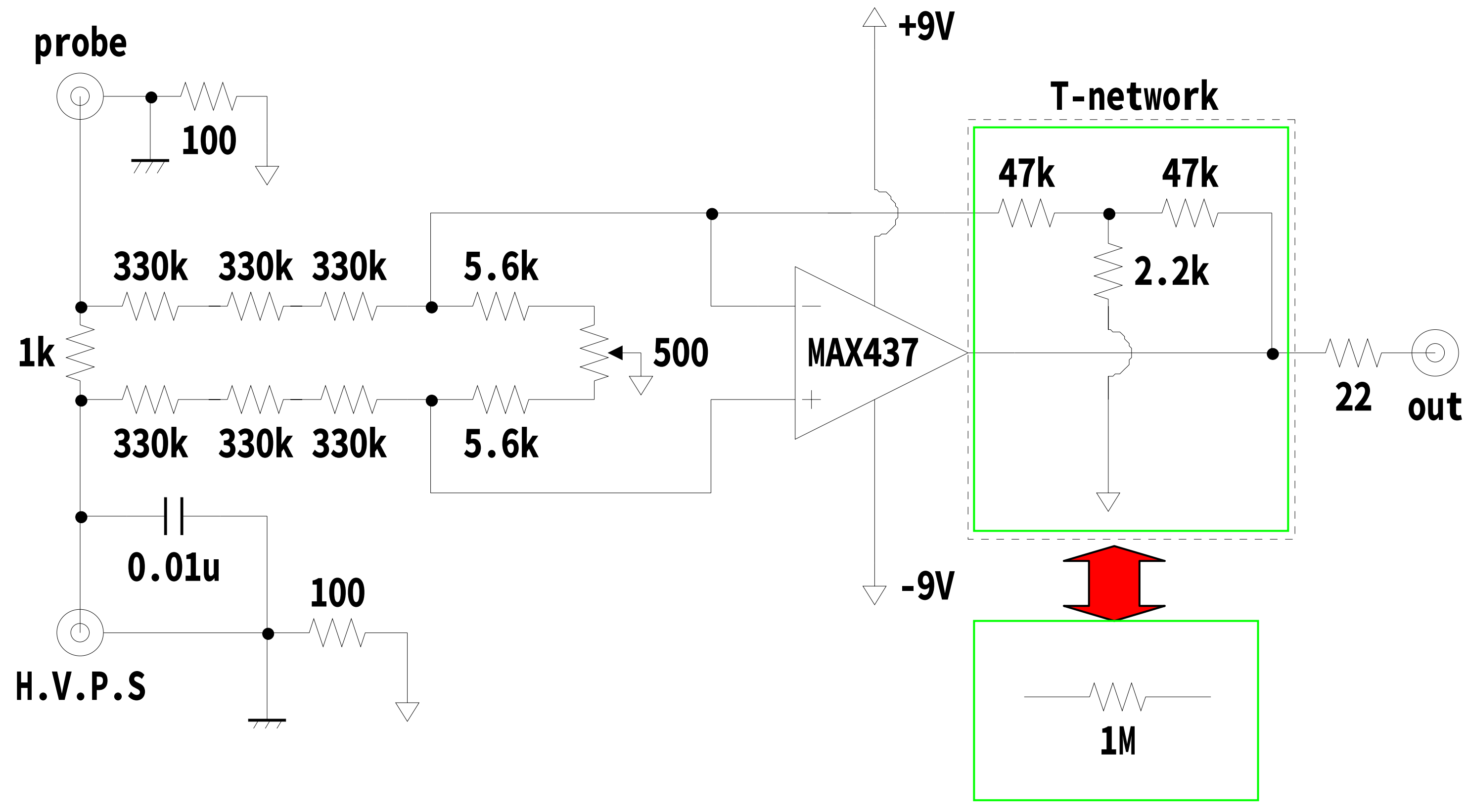
$R_1 = R_2$ and $R_2/R = 1/1000$

$$e_+ = e_- \cong \frac{1}{1000} e_2,$$

$$e_0 \cong e_2 - e_1$$

The input voltage of OP amp is ϕ_s / 1000.
The output voltage is a small voltage (e_2 - e_1) of signal.

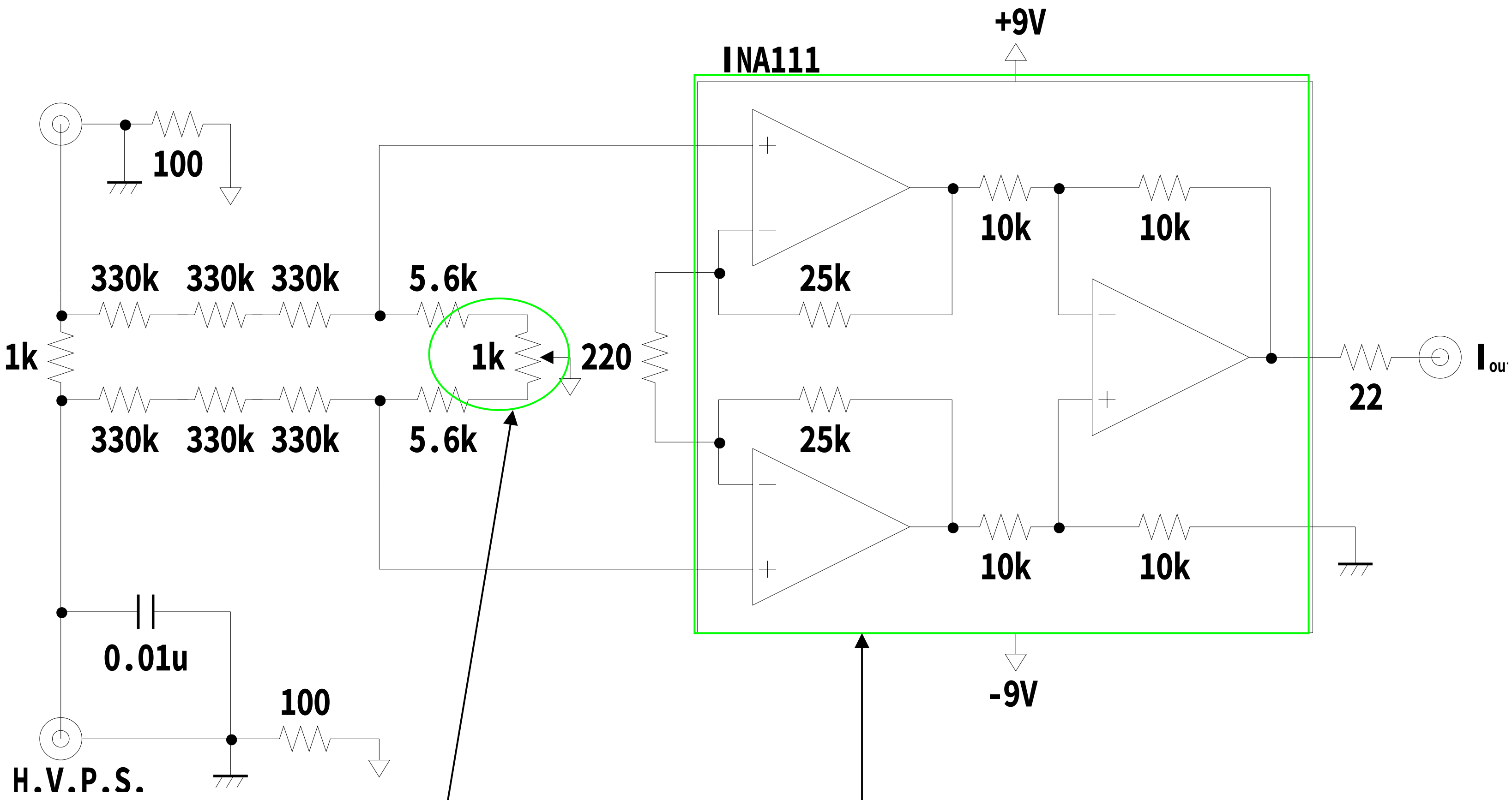
Γ measurement method(MAX437)



T-network can equivalently treat a small resistance as a large one in the feedback network.

reduce the effects of thermal noise.

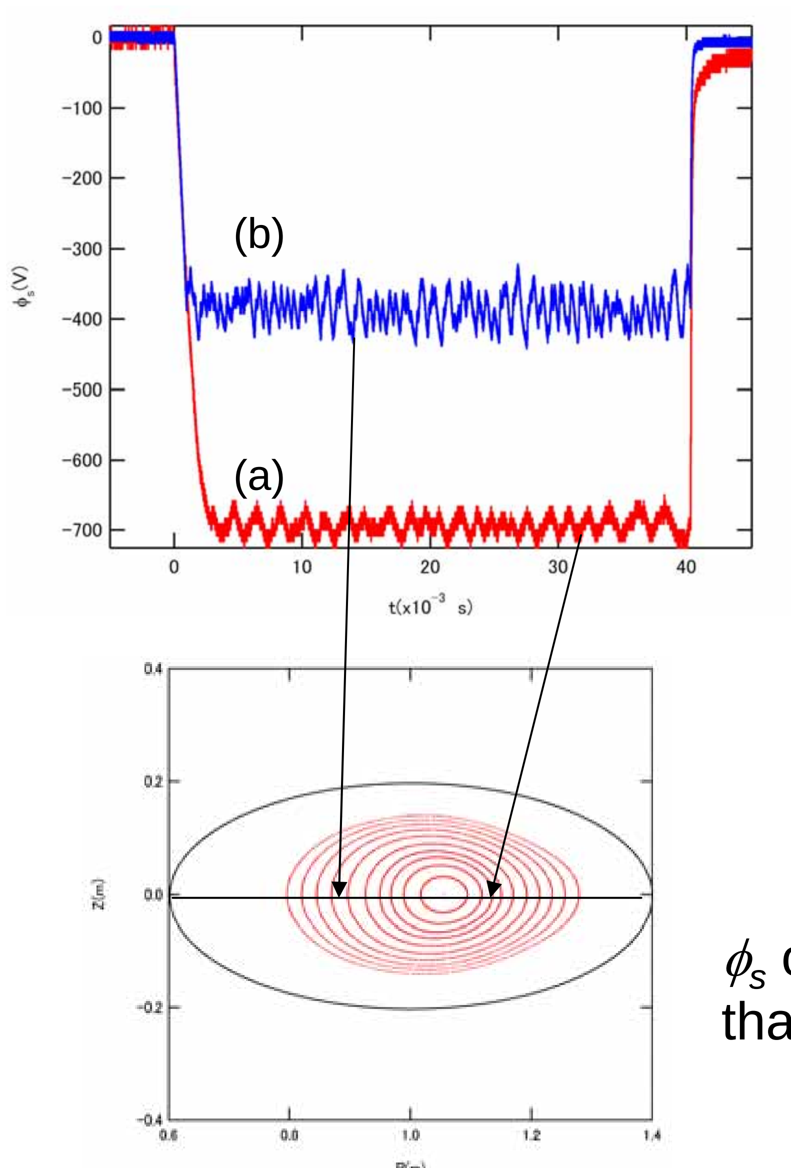
Γ measurement method(INA111)



achieve high common-mode rejection ratios

adjust the value of the differential input resistance accurately without using a single precise resistor

Typical data (ϕ_s)



These data are measured at *r* = 114 cm (a) and r = 89cm (b) in the 5O horizontal cross-section of CHS.

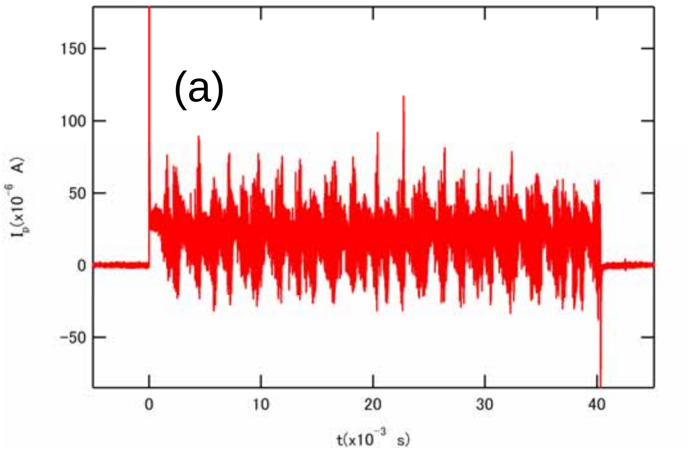
When Vacc=1kV, ϕ_s measured on magnetic surfaces are showed.

The fluctuation seen in the measured $\phi_s(t)$ reflects a disruptive instability of helical non-neutral plasmas on CHS.

(a) ϕ_s ~ -700V
(b) ϕ_s ~ -400V

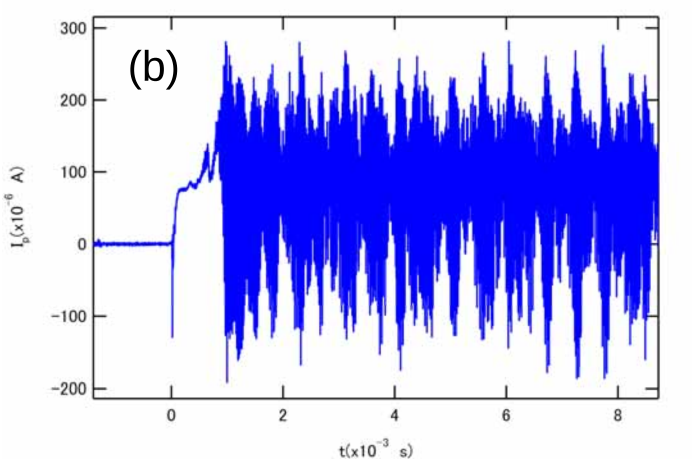
ϕ_s of inner side magnetic surface is larger than ϕ_s of outer side magnetic surface.

Typical data (I_p)



Probe current I_p is shown when $V_p = \phi_s$.

(a) I_p ~ 35µA
(b) I_p ~ 80µA



After 1ms, disruptive signals are measured.

I_p of inner side magnetic surface is smaller than I_p of outer side magnetic surface.

Summary

- The probing system measured a high space potential ϕ_s of non-neutral plasma was improved by impedance converter.
- The probing system measured a small electron particle flux Γ_e was developed by a various of tricks such as T-network.
- A significant ground loop current was removed by 100 Ω between a reference potential and GND.