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JT-60SAに向けた長パルス負イオン源の開発
Development of long-pulse negative ion source for JT-60SA

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The negative-ion-based neutral beam injector for JT-60SA is required to provide 500keV, 10 MW D^0 beams for 100s in order to obtain steady-state high β plasmas. Toward this requirement, 500 keV, 22 A negative ion sources have been developed in Japan Atomic Energy Agency. Since achievement of the 500 keV, 3 A negative ion beams by improving voltage holding capability in 2009, the R&D is focused on long pulse operations. Recently, a test stand with the JT-60 power supplies was constructed (see Fig .1), and then we started the experiments aiming to the long pulse production of 22 A negative ion beams for 100s. A key issue toward long pulse operations is steady-state and uniform production of negative ions over the large ion extraction area (45cm ×110cm) .

As for steady-state production of the negative ions, the high-temperature control of the cesium-seeded surface of a plasma grid is essential technique to keep a stable long-pulse production of the negative ions. In order to realize this technique, a prototype plasma grid with cooling/heating by circulating a high-temperature fluorinated fluid has been developed. A key factor to design the controllability is the coefficient of heat transfer between cooling pipes and the fluorinated fluid. The estimation of heat transfer coefficient from the physical property shows the prototype grid have a capability to control the temperature with a time constant of 10 s which is sufficiently faster than that of the degradation of the negative ion production. The design and basic experiments for the cooling/heating system is reported in this paper.

As for the uniform production of negative ions, the uniform plasma production by controlling grad-B drifts of primary electrons emitted from the filaments is the key factor. In the past results using smaller ion source, a symmetric magnetic field configuration, so-called tent-shaped filter, was found to be effective to achieve the uniform plasma production. A similar configuration is applied to the JT-60 negative ion source whose plasma size is 1220 mm x 564 mm.

To obtain the reference data for comparison with tent-shaped filter, we started the initial experiment with an original magnetic configuration of the JT-60 negative ion source, namely, with the PG magnetic filter degrading the uniformity. The measured profiles showed that the non-uniform plasma was reproduced in the PG filter field and qualitatively agreed with the estimation from the calculated populations of the primary electrons as shown in Fig. 2. After this initial experiment, the magnetic configuration will be changed to the tent-shaped filter.

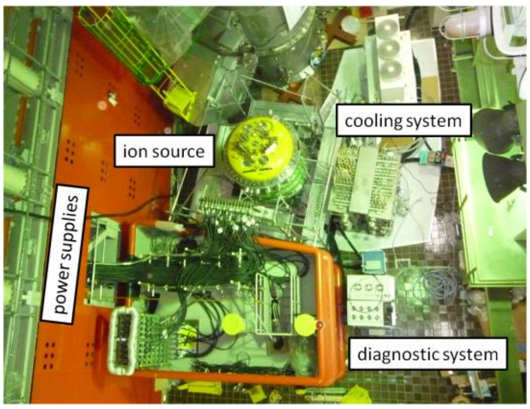

Figure 1. A long pulse test stand for JT-60 negative ion source

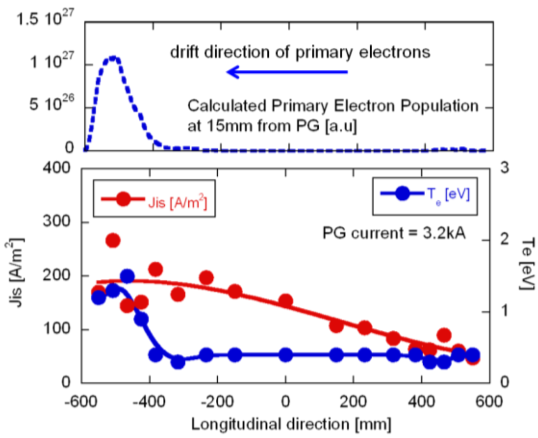

Figure 2. Longitudinal profiles of calculated electron populations, ion saturation current and electron temperature.