§ 4. Two-Stage CT Acceleration Experiment on SPICA

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SPICA (SPheromak Injector using Conical Accelerator) is a compact toroid (CT) injector developed for LHD [1]. Here, the results of two-stage CT acceleration experiment are described. SPICA consists of a conical acceleration electrode of 2.6 m long (Fig. 1). The inner radius of the outer electrode changes from 0.172 m to 0.075 m to compress the CT. Among the existing CT injectors aiming at fueling, SPICA is the largest machine in the world.

To investigate the performance of SPICA, we have carried out various systematic scan of the pre-fill pressure, the biasing magnetic field strength, B_{bias}, and the charging voltage of the acceleration bank, V_{acc} [2]. The results of V_{acc} scan experiment are shown in Fig. 2. The CT velocity, v_{CT}, is determined from the time-of-flight of the magnetic and/or the density signals measured at different axial location. A remarkable increase in v_{CT} with V_{acc} is seen in the high V_{acc} region of V_{acc} > 7 kV (Fig. 2 (a)). This suggests that v_{CT} exponentially increases with V_{acc}. Other than v_{CT}, the CT magnetic field strength and the CT density also depend on V_{acc}. As shown in Fig. 2 (b), B_{pa} at the port **H** begins to increase at V_{acc} > 10 kV, and finally exceeds B_{bias}. This indicates the compression effect by the conical acceleration electrode. At the port **D**, which locates at less than a half of the acceleration electrode (see Fig. 1) and therefore a significant compression effect is not expected, B_{pa} tends to saturate at a value similar to B_{bias}, in the range of V_{acc} > 9 kV. As for the density shown in Fig. 2 (c), it increases in the range of V_{acc} < 10 kV and then begins to decrease with V_{acc}. However, the compression effect on the CT density cannot be recognized; i.e. there is no significant difference in $\bar{n}_e$ measured at various axial location. To achieve the density increase by the compression, the particle confinement time of the CT, τ_p, should be large enough compared with the CT compression time, τ_{comp}, which is not the case here. In other words, it is suggested from the result that τ_p is similar or less than τ_{comp} ~ 20 μs.

Reference
1) Miyazawa, J. et al., Fusion Eng. Des. **54** (2001) 1 – 12.
2) Miyazawa, J. et al., Rev. Sci. Inst., to be submitted.

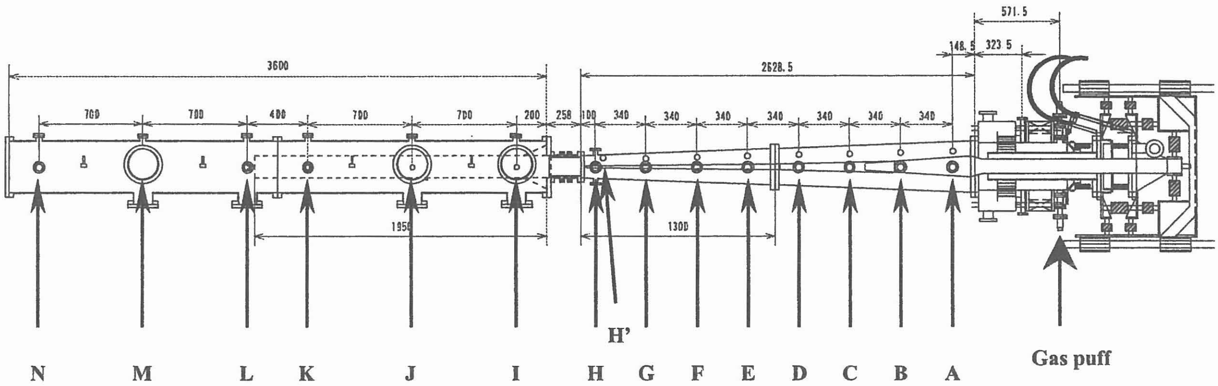

Fig. 1. Schematic view of SPICA and the test chamber of 3.6 m long. A drift tube is installed inside the large test chamber (drawn by broken lines).

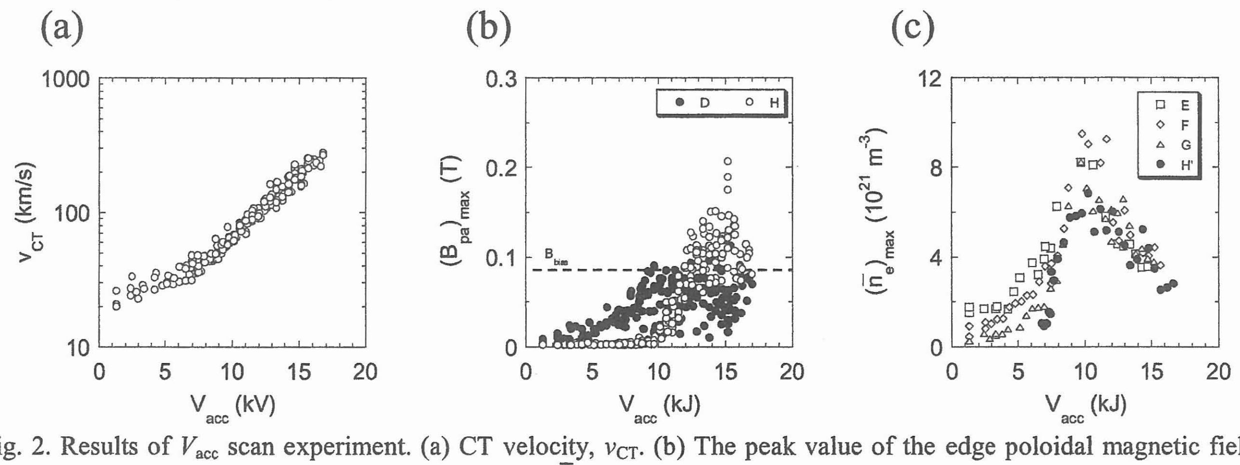

Fig. 2. Results of V_{acc} scan experiment. (a) CT velocity, v_{CT}. (b) The peak value of the edge poloidal magnetic field measured at the port **D** or **H**. (c) The peak value of $\bar{n}_e$ measured at **E**, **F**, **G**, and **H'**. Control parameters other than V_{acc} are fixed; i.e. V_{gen} = 9.0 kV, I_{bias} = 180 A, τ_{puff} = 6.0 ms, and τ_{delay} = 15.9 μs.