§7. Neutral Particle Analyzer for LHD

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Neutral particle measurement is one of the important diagnostics for an ion temperature, a high energy particle confinement analysis at a neutral beam injection (NBI) and an ion cyclotron range frequency (ICRF) heatings on LHD. We have plans of 180 keV hydrogen beam as NBI at Phase I, 360 keV deuterium beam at Phase II. The hydrogen and helium-3 as minorities will be used at the ICRF heating experiment. It is important to observe the pitch angle of the orbital particle to investigate the confinement of the high energy particle. For these purposes the neutral particle analyzer should have a wide energy range up to the maximum energy of NBI, the light weight which can be easily moved, the ability of the particle species separation of hydrogen, deuterium and helium-3 and the high noise reduction ability for the radiation especially neutron from D-D reaction. We have been improving the time-of-flight neutral particle analyzer which was developed in ENEA Frascati,[1] for LHD under the collaboration with ENEA Frascati group. The schematic picture is shown in Fig. 1. The neutral particles from plasma are ionized in the stripping cell. The energies of the particles are separated at the cylindrical electrode not by their species but only their energies. The species can be separated by their different flight times in the time-of-flight tube. The radiation noise can be instrictively reduced by using the coincidence technique.

The 16th flight tube was added to observe the high energy beam up to 370 keV. The energy is estimated not only by the deflection at the cylindrical electrode but by the flight time because the energy resolution is not good for this channel. Incident particle in the tube hits its inner walls and produce secondary electrons due to the particle divergence and the scattering in the foil. The electron is delayed to enter the channeltron because the electron speed is lower than the particle one. Therefore the hydrogen signal is delayed and overlapped with the deuterium signal, and the mass rejection factor becomes worse. To reduce the effect, we set an aperture at the center of the flight path. The diaphragm of the stop channeltron is biased to suppress such virtual signals. The foil in front of the start channeltron is also biased to accelerate the secondary electron. The secondary electron energy is very low and wide. Then the start trigger timing has jitter by the flight time from the foil to the start channeltron. We could obtain the mass rejection factor of < 1/1000. Now we are preparing the driving stage for measuring the pitch angle, the vacuum system, the data acquisition system and the automatic control system.

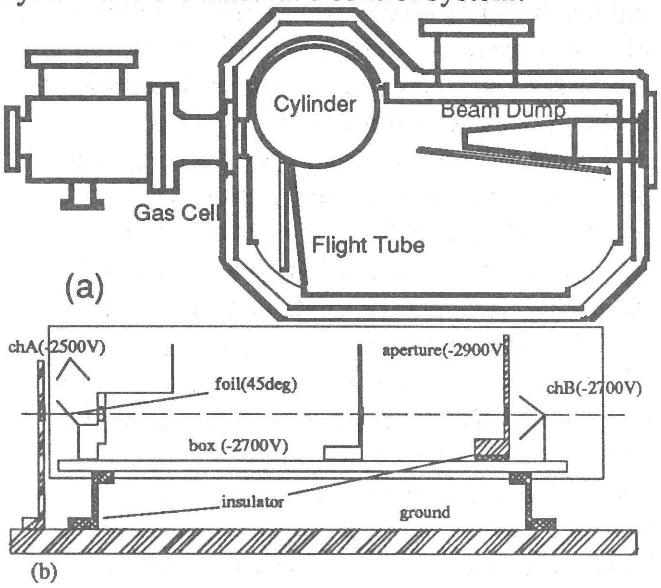

Fig. 1. The schematic picture of the time-of flight neutral particle analyzer. (a) analyzer box, (b) flight tube.

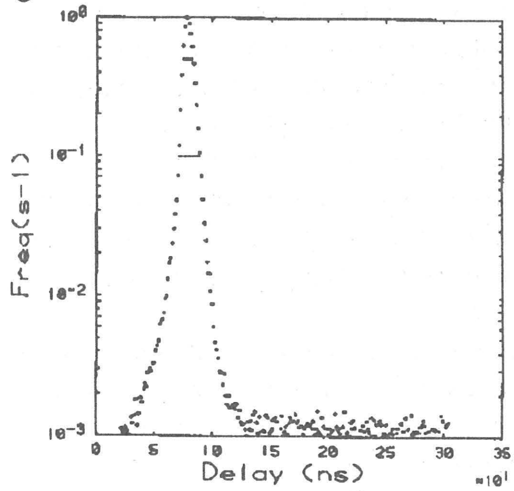

Fig. 2. Typical delay scan for H beam (Channel 5, E=20keV).

References
1) Bracco, G. et al., RSI 63 (1992) 5685.