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Residual Gas Effect in LEBT on Transverse Emittance of Multiply-Charged Heavy Ion Beams Extracted from ECR Ion Source

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Emittance of multiply-charged heavy ion beam extracted from ECR ion source should be matched with the acceptance of the following low energy beam transport (LEBT) and accelerator in order to improve transport efficiency. The more beam brightness increases, the more important space-charge effect is because it induces the spatial aberration of beam optics components, e.g. dipole magnets and quadrupole and solenoidal lenses, especially for LEBT. The aberration causes the beam emittance enhancement and degrades the emittance matching condition. Electrons generated from the collisions between the ion beam and residual gas of the LEBT are considered to partially neutralize the space-charge effect. Thus, we intend to confirm the residual gas effect on space-charge effect of heavy ion beam through the measurement of the transverse four-dimension (4-D) phase-space distribution by controlling the residual gas pressure of LEBT with neutral gas (Ar, Kr and so on) through a variable leak valve.

To observe of the transverse 4-D phase-space distribution, namely transverse emittance, we have developed an on-line pepper-pot emittance meter, which is a suitable device because we can obtain the transverse emittance from only one picture of beamlets passing through the well-aligned pinholes. The emittance meter consists of a plate with 24×24 pinholes (0.1 mm diameter each), which are aligned in a grating pattern with 2 mm pitch. The pinhole plate is mounted on the movable holder along the beam axis in front of an imaging screen (P46) with a MCP. By adjustment of the drift distance between pinhole plate and MCP, the angular resolution is able to be optimized with in the limit of separation of the neighboring beamlets.

By using the pepper-pot emittance meter, we have measured the transverse emittances of multiply charged ^{18}O and ^{40}Ar beams with changing the residual gas pressure in the LEBT by injecting neutral gas. We used O_2, Ar and Kr gases as injection gases as a systematic investigation of the residual gas effect. The 4-D distribution is sensitive to the spatial aberration caused by the higher order harmonics of magnetic field of beam optics component. We will discuss about how the residual gas affects the transverse emittance taking the beam optics components of the LEBT into account.

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