Vacuum Improvements for Ultra High Charge State Ion Acceleration*

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The installation of a second cryo panel has significantly improved the vacuum in the 88-Inch Cyclotron at Lawrence Berkeley National Laboratory. The neutral pressure in the extraction region decreased from 1.2×10^{-6} down to about 7×10^{-7} Torr. The vacuum improvement reduces beam loss from charge changing collisions and enhances the cyclotron beam transmission, especially for the high charge state heavy ions. Tests with improved vacuum, see Figure 1, show the cyclotron transmission increased more than 50% (from 5.7% to 9.0%) for a Xe^{27+} at 603 MeV, more than doubled for a Bi^{41+} beam (from 1.9% to 4.6%) at 904 MeV and tripled for a U^{47+} beam (from 1.2% to 3.6%) at 1115 MeV. At about 5 MeV/nucleon 92 enA (2.2 pnA) for Bi^{41+} and 14 enA (0.3 pnA) for U^{47+} were extracted out of the 88-Inch Cyclotron.

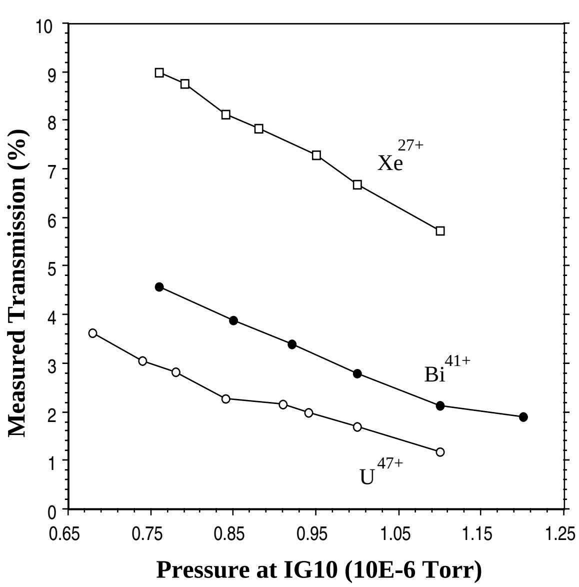

Fig. 1. Measured acceleration transmission versus pressure in the 88-Inch Cyclotron for Xe^{27+}, Bi^{41+} and U^{47+} ion beams.

Listed in Table 1 are ion beams with charge states as high as U^{64+} produced by the LBNL AECR-U ion source and accelerated through the cyclotron. The acceleration of U^{64+} ions sets records of both the energy and the beam charge state for the 88-Inch Cyclotron.

The beam losses for a variety of ultra high charge state ions were measured as a function of cyclotron pressure and compared with the calculations from the existing models. The existing models predict that if the vacuum of the 88-Inch Cyclotron can be further improved to 1 to 2×10^{-7} Torr, the transmission for the heaviest ion beams could be again tripled.

Table 1. Ultra high charge state heavy ion beams accelerated by the 88-Inch Cyclotron.

ION	E/A (MeV/n)	E (MeV)	Iex (enA)
$^{209}Bi^{41+}$	4.31	904	92
$^{238}U^{47+}$	4.68	1115	14
$^{238}U^{49+}$	5.09	1211	4
			(pps)
$^{238}U^{60+}$	7.62	1814	507
$^{238}U^{61+}$	7.88	1875	427
$^{238}U^{62+}$	8.13	1936	110
$^{238}U^{63+}$	8.40	1999	24
$^{238}U^{64+}$	8.67	2063	10

Note: A particle detector was used to identify the ultra high charge state ions.

Footnotes and References

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