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First on-line test of the LINAC superbuncher at Nuclear Science Centre

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Abstract. An on-line test of the LINAC superbuncher at Nuclear Science Centre has been successfully performed. DC O^{7+} beam of nominal energy 92 MeV was accelerated through the superbuncher resonator, operating at a field of 4.54 MV/m. The total energy gain of the beam was measured to be 4.5 MeV. For the pulsed beam test a phase locked bunched beam of O^{7+} of nominal energy 92 MeV, FWHM 1.3 ns from the pre-tandem multiharmonic buncher was injected into the superbuncher. By properly adjusting the phase and amplitude of the resonator, the best FWHM of the bunched beam was measured to be 185 ps near the entrance of the first LINAC module. Fully depleted cooled surface barrier detector was used for measuring the time width. In a separate experiment the intrinsic time resolution of the same detector was measured to be 134 ps. Consequently the intrinsic time width of the bunched beam, after correcting for the detector resolution, would be 127 ps. Details of the experiment and results are presented.

Keywords. Superconducting LINAC; niobium resonator; beam bunching; beam acceleration.

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1. Introduction

A superconducting linear accelerator booster [1] for the existing 15 UD Pelletron accelerator [2] at Nuclear Science Centre is presently under construction. The Pelletron is equipped with a pre-tandem multiharmonic buncher (MHB) [3] providing heavy ion beams of FWHM 1–2 ns with a repetition frequency 12.125 MHz. A phase detector [4], installed in the high energy section of the Pelletron, is used to phase lock the beam from MHB. The acceptance of the LINAC, operating at 97 MHz, requires the time width of the bunched beam to be less than 150 ps. Hence it is necessary to further compress the beam before injection into the LINAC. The prototype resonator [5] is used as the superbuncher for the LINAC. DC and phase locked pulsed beams were used to investigate the performance of the resonator working as an accelerating structure and superbuncher.

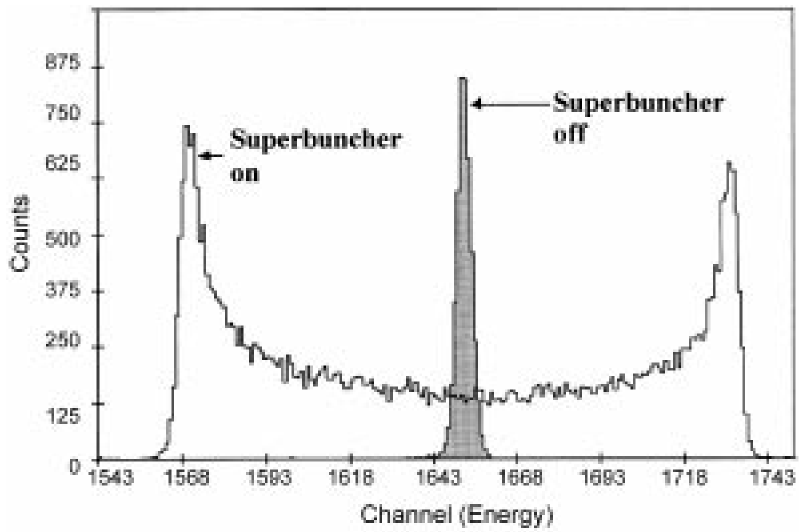

Figure 1. The monoenergetic peak with resonator OFF splits into a broad band with two peaks when the resonator is turned ON.

2. On-line test of the resonator

2.1 *Experimental set up*

The on-line test was conducted by injecting ^{16}O beam (6^+ and 7^+) of nominal energy 80 and 92 MeV into the superbuncher resonator. The beam was further transported to a small scattering chamber located 8.2 m down stream, which is the point of time focus of the superbuncher and also the entrance of the LINAC. A 100 μm fully depleted surface barrier detector was used to detect the elastically scattered beam from a thin gold target.

2.2 *DC beam test*

The DC beam was first injected into the resonator in 'RF OFF' condition and the elastically scattered beam was detected by the detector. The energy spectrum of the scattered oxygen beam is shown in figure 1, which shows a single peak corresponding to the energy of the elastic scattering. When the resonator is turned ON and kept at its highest attainable field, the single peak split into a broad band with two separate peaks at the two ends. This happens because half of the portion of the DC beam is decelerated and the remaining half is accelerated while passing through the resonator. The difference between the centroids of the two peaks gives twice the maximum energy gain through the resonator, from which the accelerating field of the resonator was calculated to be 4.54 MV/m.

2.3 *Pulsed beam test*

During the test of the resonator as superbuncher, bunched beam of FWHM 1.3 ns was produced by the pre-tandem multiharmonic buncher. The beam was phase locked with

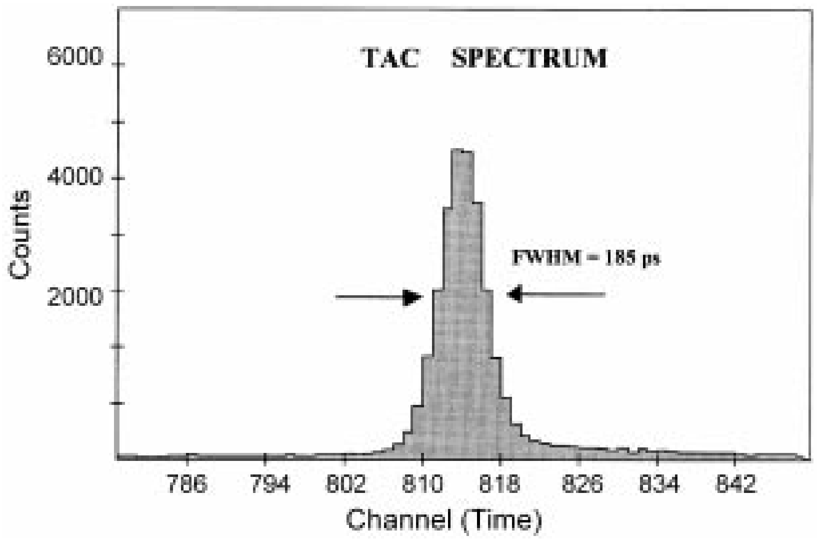

Figure 2. The TAC spectrum of the time bunch from the superbuncher (FWHM=185 ps).

the help of the phase detector and injected into the superbuncher. The elastically scattered particles of a gold target were recorded in 100 μm surface barrier detector. The detector was cooled to -3°C to reduce the noise and improve time resolution. The fast timing signal from the detector was used as the start pulse and the rf signal of multiharmonic buncher was used as the stop pulse of a time-to-amplitude converter (TAC). The TAC spectrum was recorded in a PC-based multichannel analyzer. By properly adjusting the phase and amplitude of the resonator, the best FWHM of the time bunch measured was 185 ps (figure 2) in the TAC spectrum.

In order to determine the intrinsic time width of the bunched beam, the time resolution of the detectors had to be measured separately. This was done in a separate experiment using a 40 μm and 100 μm detector, both fully depleted, installed together to form a ΔE–E telescopic set up. The time resolution from the cooled ΔE–E telescope was found to be 190 ps. Assuming both the detectors contribute equally, the intrinsic time resolution of individual detector is 134 ps. Consequently, the intrinsic time width of the bunched beam, after correcting for the detector resolution, turns out to be 127 ps.

3. Future plan

Future test of the superbuncher is planned along with the high energy sweeper, which has been recently installed in the post analyzer section of the Pelletron. This would remove the dark current between the bunches of the pulsed beam. Incorporation of a microchannel plate detector for beam detection is also planned as it has better time resolution compared to a surface barrier detector. Long term stability of the superbuncher will also be tested during the experiment.

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References

[1] P N Prakash *et al*, *Proc. Second Asian Particle Accelerator Conference – APAC01*, 17–21 September 2001, Beijing, China, p. 115

[2] D Kanjilal, S Chopra, M M Narayanan, I S Iyer, V Jha, R Joshi and S K Datta, *Nucl. Instrum. Methods* **A328**, 97 (1993)

[3] A Sarkar, S Ghosh, P Barua, R Joshi, R Ahuja, S Rao, S A Krishnan, A J Malyadri, R Kumar, S Gargari, S Chopra, D Kanjilal, S K Datta, A Roy, R K Bhowmik, I R Tilbrook and B E Clifft, *8th Int. Conf. on Heavy Ion Accelerator Technology*, 5–9 October 1998, Argonne, Illinois, p. 272

[4] S Ghosh, R Ahuja, S Rao, A Sarkar, D K Avasthi, D Kanjilal, A Roy and R K Bhowmik, *Nucl. Instrum. Methods* **A356**, 185 (1995)

[5] K W Shepard, A Roy and P N Potukuchi, *Proc. 1997 Particle Accelerator Conference*, 12–16 May 1997, Vancouver, B.C., Canada, p. 3072