7.0 VAN DE GRAAFF, SUPERCONDUCTING BOOSTER AND ION SOURCES

7.1 Van de Graaff accelerator operations and development

D.T. Corcoran,* G.C. Harper, C.E. Linder, A.W. Myers and T.D. Van Wechel

On 3/19/96 a Pelletron terminal pick-up pulley was found to have lost its tire. It was replaced, and the two remaining pick-up pulleys that were still original were also replaced at this time, for reasons of preventative maintenance. One of these replacement pulleys threw its tire before 4/3/96, requiring the tandem to be shut down once more for repair. At this time an idler pulley in the LE mid-section was also found to have bad bearings and replaced. On 11/6/96 the lower HE end pick-up pulley had to be replaced again. This time the tire was intact but the ball-bearing was damaged. On 1/23/97 the HE chain drive motor had to be replaced due to a seized bearing. On 2/25/97 another idler pulley in the LE mid-section was replaced because of a totally destroyed bearing.

The problem of tank spark damage to the pelletron charging resistors, high voltage charging supplies, and RG-8/U cables at the low energy end that was mentioned last year has apparently been eliminated by the fixes listed at that time, plus the additional fix of shortening of some insulating stand-offs and rerouting a high-voltage cable.

The thoriated tungsten corona points mentioned in last year's report have run all year without having to be replaced. Ultimate life of these points is still unknown.

The tandem terminal ion source was installed once for developmental purposes. Its history is covered in a separate section.

During the year from March 1, 1996 to February 2, 1997 the tandem pellet chains operated 3075 hours. Additional statistics of accelerator operations are given in Table 7.1-1.

Table 7.1-1. Tandem Accelerator Operations
March 1, 1996 to February 28, 1997

Activity	Days Scheduled	Percent
A. Cluster Ion Physics Research, Ion Sources Alone	57	16
B. Nuclear Physics Research, Tandem Alone		
Light Ions†	95	26
^{3}He Terminal Ion Source	0	0
C. Nuclear Physics Research, Booster and Tandem Coupled		
Light Ions	6	2
Heavy Ions	49	13
Subtotal	207	57
D. Other Operations		
Tandem Development	20	5
Tandem Maintenance	79	22
Unscheduled Time, working days	17	5
Unscheduled Time, weekends or holidays	46	13
Subtotal	162	45
Total	369††	102††

† Light = ^{4}He and below.
†† Greater then 365 (100%) since some days of cluster research were done during tandem maintenance.

* Now at InControl, 6675 185th NE, Redmond, WA.

7.2 Booster operations

J.F. Amsbaugh, D.T. Corcoran,* G.C. Harper, M.A. Howe, D.W. Storm, D.I. Will and J.A. Wootress†

During the period March 1, 1996 to Feb 28, 1997, the booster was operated for 55 days. This is less than the 69 days operated last year. The month of August was spent overhauling the three resonator systems which had been inoperable because of various failures of equipment inside their cyrostats. All resonators are presently operable, and an energy of 218 MeV was obtained for an ^{18}O beam.

Beams ranged in mass from ^{4}He to ^{40}Ca, and included ^{12}C, $^{16,18}O$, ^{7}Li, and ^{11}B, as well.

We continue to operate the low beta resonators at an average field of 3.0 MV/m and the high beta ones at an average of 2.4 MV/m.

The helium compressors continued to run with no failures this year. Our oldest compressor now has run for 89k hours, and the other two have run for 58k hours in one case and 30k hours in the other case.

* Now at InControl, 6675 185th NE, Redmond, WA.
† Retired.

7.3 Tandem terminal ion source

G.C. Harper, C.E. Linder, A.W. Myers and T.D. Van Wechel

The terminal ion source was not scheduled for use in an experiment during the last reporting period. It has been, however, scheduled for a three week run using $^{3}He^{+}$ in March of this year. Requests have been made for different ion species and lower terminal voltages for future runs. In response to these requests part of this year has been devoted to development work on the source optics.

A spherical, double-focusing electrostatic deflector was designed and built for use with the terminal source to provide mass independent deflection. This project was motivated by requests for experiments using other ion species, in particular $^{1}H^{+}$ for the $^{7}Be(p,g)^{8}B$ experiment. An electrostatic deflector with a bending radius, R, of 14 cm was specified. The radius chosen was equal to that of the deflection magnet so that it could be mounted in the same space in the foil stripper box as that occupied by the deflection magnet. The deflection angle of 60° was of course also retained.

The foci for a 60° spherical electrostatic deflector occur at $\sqrt{3}R$ from the deflector edges, much closer than the 3.46R for a double-focusing deflection magnet with the same bending angle. The beam profiles at various points along the trajectory are necessarily different for the two configurations. The apparent object for the electrostatic deflector is close to the source canal whereas for the magnet the virtual object is outside of the source region. Since the foci are much closer, the beam reaches a much larger diameter as it passes through the electrostatic deflector due to its larger divergence. Because the beam exiting the electrostatic deflector forms a waist before reaching the accelerator tube, it is diverging at the tube entrance rather than converging like the beam exiting the magnet.

Tests of the deflector both inside and outside of the tandem indicated that it was not double-focusing and consequently produced an elliptical beam profile at the image. In tests conducted outside of the accelerator the horizontal size of the beam measured about twice that of the vertical size at the theoretical image point. When tested in the accelerator the ion beam in the vertical plane was divergent to the extent that it interfered with transmission by striking and loading down the beam tube. Poor transmission was seen at all terminal voltages when using protons with the electrostatic deflector.

Concurrent with development of the electrostatic deflector, a new gradient scheme was developed for the high energy tube that would theoretically allow operation down to 50 kV terminal voltage. In practice it was found that satisfactory operation was extended down to 800 kV, a substantial reduction from the 1.8 MV achieved with the previous gradient scheme. This test was made using $^{3}He^{+}$ and the deflection magnet to ensure that the ion beam transported was at least cylindrical. It is believed that reducing the beam diameter and removing the halo with a small aperture may improve transmission at lower terminal voltages. Beam transport with a reduced diameter will be tested later this year. In addition, further studies of the electrostatic deflector will be made.

7.4 Cryogenic operating experience

M.A. Howe, D.I.Will and J.A. Wootress*

The booster linac is cooled by liquid helium which is thermally shielded by liquid nitrogen.[1]

The following table summarizes our maintenance for 1996 January 1 to 1996 December 31:

Item	In Use	Major Services	Times Performed
Refrigerator			
Cold Box	97%	warm/pump/purge	2
Main Dewar	100%	warm/pump/purge	0
Top Expander	~7500 Hrs[2]	warm/pump/purge	8
	~130 RPM	valve rod and valve seals	1
		wristpin, crank, and cam follower bearings	2
		flywheel bearings and belts	2
		main seals	3
Middle Expander	~7500 Hrs[3]	warm/pump/purge	6
	~100 RPM	valve rod and valve seals	1
		wristpin, crank, and cam follower bearings	1
		flywheel bearings and belts	1
		main seals	2
Wet Expander	3843 Hrs	warm/pump/purge	5
	~50 RPM	main seals	1
Distribution System	99%	warm, pump, purge lines	7

This final table shows screw compressor history here as of 1997 March 6:

Item	Total	1996	Status	Maintenance
RS-1	88,600 hours	8609 hours	running	none
RS-2	55,958 hours	0 hours	phases shorted	core removed 1993
RS-2a	29,544 hours	8782 hours	running since 1993	none
RS-3	22,752 hours	0 hours	shorted to ground	core removed 1990
RS-3a	57,905 hours	8783 hours	running since 1990	none

Mean RS compressor pump core lifetimes are as follows: all five cores listed above, 51,270 hours; those four cores operated to minimize starts (RS-1, RS-2, RS-2a, RS-3a), 58,399 hours.

* Retired.

[1] Nuclear Physics Laboratory Annual Report, University of Washington (1996) p. 65.

[2] This time is estimated due to the failure of the elapsed time hour meter for this engine.

[3] This time is estimated due to the failure of the elapsed time hour meter for this engine.

7.5 Improvements to the linac control system

M.A. Howe

A terminal ion source was added to the tandem recently. A full description of the ion source, its installation, and operating experience can be found elsewhere in this report (see Section 7.3). In order to control the source a new page was added to the linac control system (CSX). When the terminal ion source is in place the regular tandem terminal page which shows steering and foil controls is replaced by the new ion source page by either modifying the CSX initialization data file or by entering a simple typed command.

The new page shows a rendering of the ion source, with the extraction electrodes, einzel, gas bottle, and deflector shown in typical CSX schematic form. All of the relevant control values are shown as both set-point dac values and read-back adc values. All dac control parameters can be controlled from either the touch screens, console knob boxes, portable knob box, or the keyboard. The on/off parameters, such as the gas valve can only be controlled from the touch screens. Also shown and controlled on the page are the horizontal and vertical steerers. Other things displayed are the terminal voltage and gas valve position. In addition, the ion source turns pink when the extraction current indicates that a plasma has been formed.

The terminal ion source parameters are fully integrated into CSX and can be logged and restored.