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Improvement in performance and operational experience of 14 UD Pelletron Accelerator Facility, BARC–TIFR

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Abstract. 14 UD Pelletron Accelerator Facility at Mumbai has been operational since 1989. The project MEHIA (medium energy heavy ion accelerator) started in 1982 and was formally inaugurated on 30th December 1988. Since then the accelerator has been working round the clock. Improvement in accelerator performance and operational experience are described.

Keywords. Pelletron accelerator; accelerator tank; charging chain; shorting rod; harmonic buncher; rotating shaft; heavy ion.

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1. Introduction

The 14 UD pelletron accelerator has been working round the clock since its inception in 1989. The accelerator is housed inside a tank, which is 6 m in diameter and 25 m long. The tank is filled with SF_6 gas at 80–100 psig. The schematic diagram of the accelerator complex is shown in figure 1.

The injector system consists of high voltage deck (-300 kV), ion source, pre-accelerating tube and injector magnet, which is located at 40 m elevation in accelerator tower. The SNICS source is used for routine heavy ion operation and rf source is used only for alpha particles. An indigenously designed double harmonic buncher is located between injector magnet and tank top. The pulsing system is designed for ω_1 at 10 MHz and ω_2 at 20 MHz. An rf sweeper is installed after the analyzing magnet. A beam chopper to produce pulses longer than 100 ns seperation is installed just after the injector magnet. With the two way analyzing magnet (90°), the beam can be switched to either the experimental hall #1 or to LINAC hall, where a superconducting linear accelerator is being installed. The particle beam from the accelerator is transferred to the five experimental stations through a switching magnet.

2. Operational experience

There are two charging chains in accelerator column. During initial years the charging chain used to break after a clock time of 3000–5000 h. After a thorough investigation it was

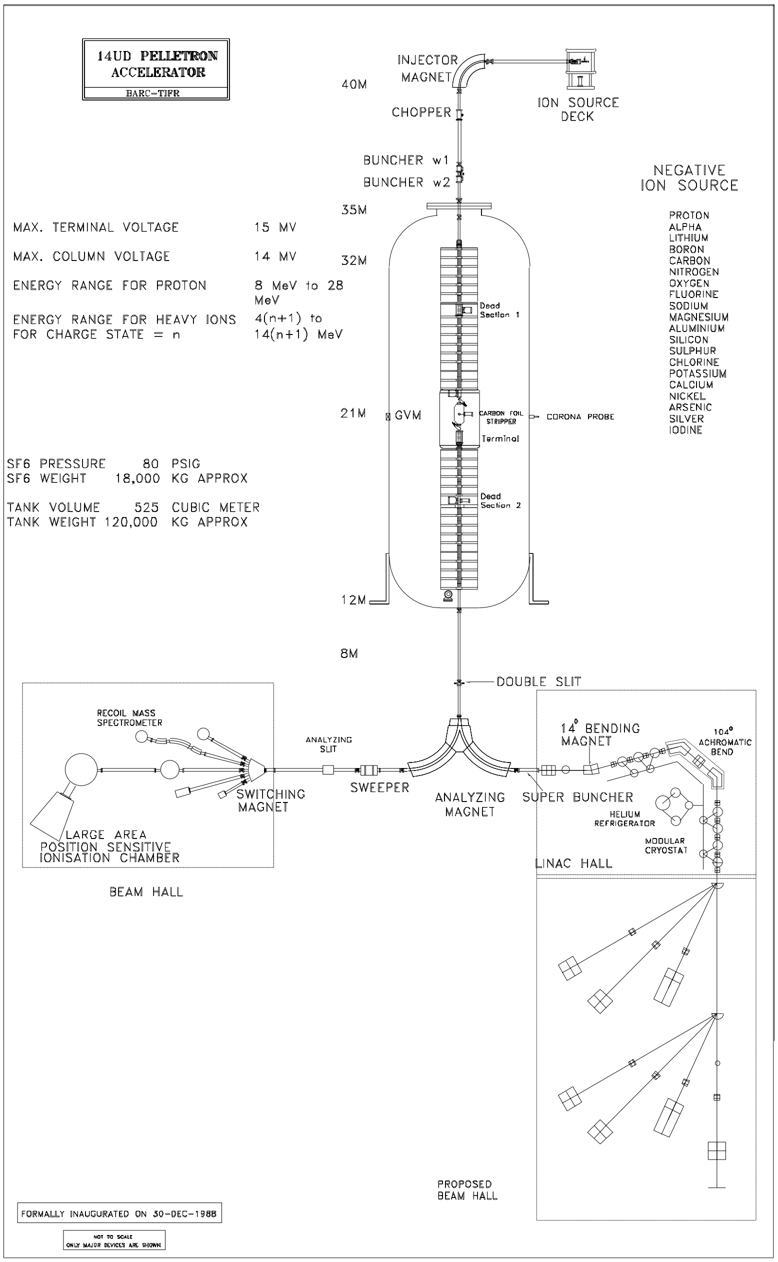

Figure 1. Schematic diagram of pelletron accelerator.

realized that both chains were rotating at 730 rpm instead at 600 rpm. The micro switch was incorporated in each chain to control the chain elongation, it avoided a few breaks; however, the problem was solved only after changing motor speed to lower (600) rpm.

There are two dead sections in accelerator column located at 5th module in low energy section and 6th module in high energy section. The devices inside the dead sections and terminal are powered by 120 V, 400 Hz alternators, which are connected by an insulating (Perspex) shaft operating at 1450 rpm. There used to be a casting generator (200 VA) in each module. The permanent magnets of this generator used to load the bearing and flexible coupler and it used to reduce the lifetime of bearing and coupler. After removing the permanent magnets of casting generator, the shaft is quite stable and we have not had any tank opening for the last six years due to bearing or coupler failure. We also had trouble with foil stripper belt. The foil holder, which used to be a spot welded design, is replaced by a riveted one. Our experience with shorting rod mechanism is not very satisfactory. On a number of occasions it was noticed that the nylon rod used to break. A guide was installed on top of column in low energy section to control its movement. However, these days unless it is very essential, we avoid usage of shorting rod. The fiber optic cables in low energy module once failed as they got entangled with rotating shaft, and subsequently the bunch of cable is re-routed to avoid any such failure. The preventive maintenance is a key factor for improvement of accelerator operation. There are a number of power supplies which are required to be maintained on routine basis. The cooling channels of transistor banks in high current magnet power supplies, particularly injector magnet, analyzing magnet and switching magnet, used to get choked quite often. Cleaning of these channels, once in two months, has improved the performance of these power supplies. In order to protect vacuum of accelerating tube, in addition to a fast acting valve which already exists above analyzing magnet, an additional fast acting valve has been installed and commissioned before switching magnet to protect vacuum failure from experimental side. The new turbo pumps were procured, installed and commissioned in ion source section of the accelerator. A new 300 kV power supply with interlock for the ion source has been installed and commissioned; the old NEC supply is in stand by mode. In gas handling system the SF_6 compressor supplied by M/s. Joy, USA had developed some mechanical problem after 15 years of useful service. It was giving abnormal knocking sound from cylinder head and pressure leakage through suction/delivery valve which was leading to inefficient operation. The compressor maintenance was undertaken and various parts were replaced. After overhauling, compressor was run for more than 24 h. It was found that there is no pressure loss and no leakage of SF_6 through piston gland packing and any of the gasket. Its operation was very smooth and delivering required displacement of SF_6 gas at reated pressure.

3. Performance

In order to improve the performance it is necessary that all the devices should perform reliably, particularly devices inside the tank. The tank opening due to a fault inside the tank will affect the operation at least by a few days. The year-wise performance is shown in figure 2. As one can notice, there is gradual improvement in the performance since 1993. By this time the problem of chain break and bearing/flexible-coupler failure was taken care. Performance for the year 2001 is shown in figure 3 and ion beam accelerated in year 2001 is shown in figure 4. Out of the total 8760 h, 6162 h (70.35%) were used for accelerator operation, 585 h (6.68%) were used for scheduled maintenance, 503 h (5.75%) were used for conditioning and 1508 h (17.22%) were lost due to unscheduled maintenance. There were only three tank openings during this year; two scheduled and one unscheduled. A significant development was carried out at ion

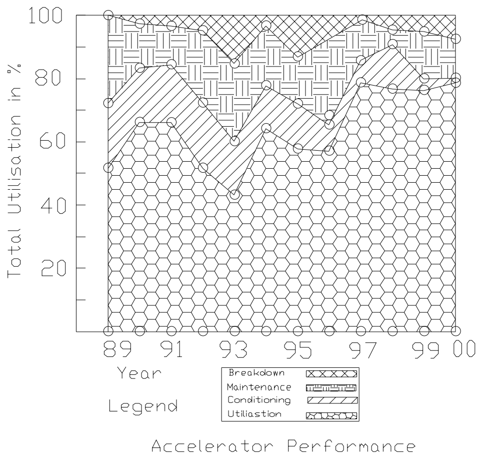

Figure 2. Performance curve year-wise.

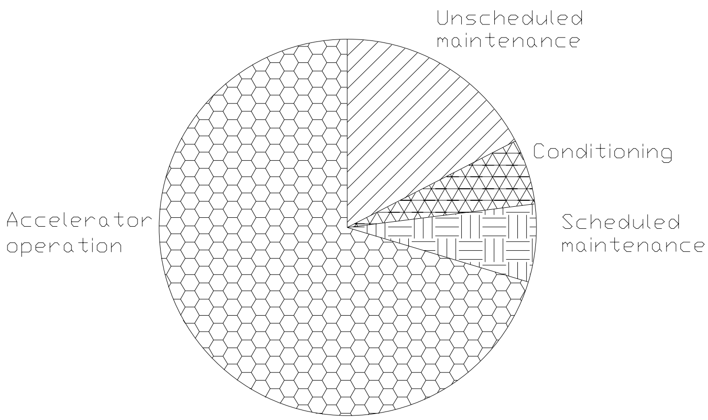

Figure 3. Performance pie chart for the year 2001.

source test bench. We have developed a multi element cathode sample and successfully tested in regular operation. Depending on user's requirement various ions can be extracted from one sample. Table 1 shows details of various ions, which are accelerated so far. The accelerator can be operated either in GVM or slit control mode. This year a new TPS system was installed which has improved the voltage stability in GVM mode. Recently we have carried out AMS experiments and successfully detected ^{14}C.

4. Installation of resistances

In order to run the machine efficiently, various developmental programs are taken up. Installation of resistances for producing the voltage gradient in the accelerator structure is

Table 1. Beams injected into the 14 UD pelletron accelerator facility using multi-elemental cathodes.

Nature of negative ion species	Composite sample content	Yield
$^{7}Li + ^{19}F + ^{18}O$	LiF + FeO + graphite	
$^{7}Li + ^{19}F + ^{12}C$	LiF + graphite	
$^{1}H + ^{12}C + ^{19}F + ^{16}O$	TiH+LiF+FeO+graphite	In the
$^{12}C + ^{18}O + ^{19}F + ^{32}S$	Graphite+FeO+LiF+FeS	range
$^{1}H + ^{18}O + ^{19}F + ^{32}S$	TiH+FeS+LiF+FeO	of
$^{12}C + ^{18}O + ^{19}F + ^{28}Si$	Graphite+FeO+LiF+Si powder	nA
$^{1}H + ^{18}O + ^{32}S + ^{37}Cl$	TiH+FeO+FeS+AgCl	to
$^{11}B + ^{12}C + CN + ^{28}Si$	BN powder+graphite+Si powder	μA
$^{58}Ni + ^{107}Ag + ^{28}Si + ^{16}O$	Ni metal+silver+Si+FeO	
$^{1}H + ^{24}MgH + ^{63}Cu$	Mg-alloy+TiH	
$^{19}F + ^{40}CaF + ^{107}Ag$	CaF powder+Ag	
$^{1}H + ^{12}C + ^{28}Si$	SiC+TiH	
$^{7}Li + ^{12}C + ^{19}F + ^{28}Si$	SiC+LiF	
$^{28}Si + ^{38}Cl + ^{107}Ag$	Si powder+AgCl	
$^{12}C + ^{31}P + ^{70}Ga$	Graphite+GaP	

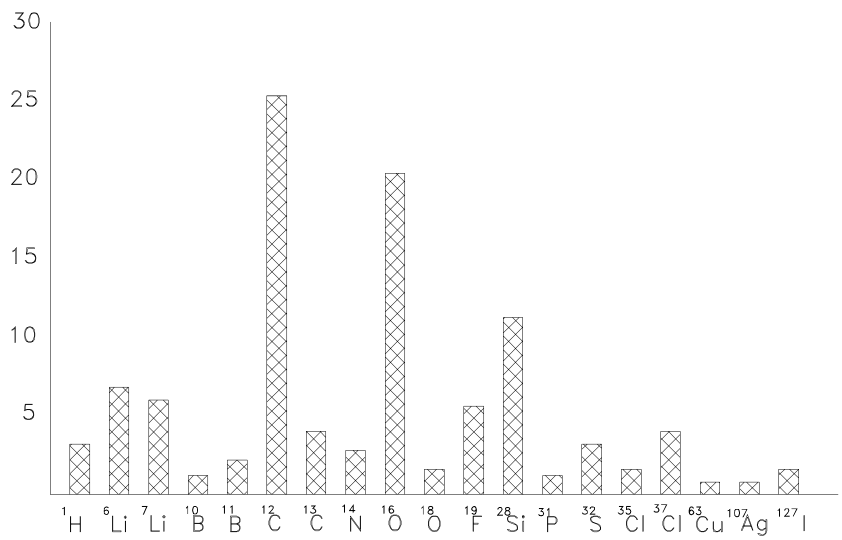

Figure 4. Ion beams accelerated in 2001.

being carried out in a phased manner. Corona needles in high-energy column were replaced by the resistances. There are 18 spark gaps in each column post and two resistances (1 GΩ each) are connected in series in each spark gap, except in the last gap where only one resistance is connected. Thus, accelerator column has 503 GΩ resistance on either side of the terminal. The performance of accelerator has improved after the installation of

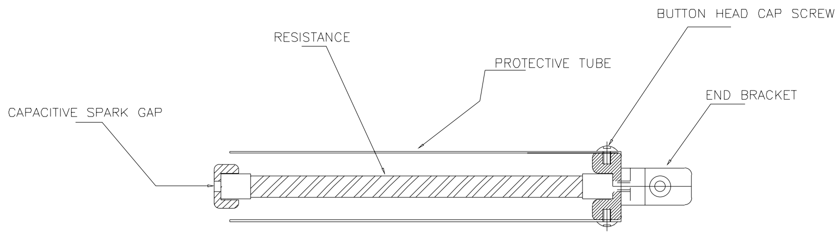

Figure 5. Details of resistance mount assembly.

resistances in both the columns. Details of resistance mount assembly are shown in figure 5. Installation of resistances in accelerating tube will be completed by this year.

5. High voltage

The accelerator is routinely operated at 12.5 to 13 MV. We expect to go further high on voltage after increasing the gas pressure. After installation of resistances in both columns it is possible to operate at lower voltages and recently beam has been delivered at 5 MV for the experiments. The isolation transformer for injector system used to fail and it was difficult to do maintenance on this transformer. An indigenously developed transformer is housed in two different insulating vessels filled with oil and is working satisfactory for the last few years.

6. Conclusion

As discussed above, the machine uptime for pelletron user has been very high for nearly 12 years. The majority of the users are from nuclear and atomic physics. The facility has been used regularly for the preparation of track-etch membranes. Since the last couple of years the accelerator is also being used for AMS and material science experiments. The highlight of last year was the use of this facility for nearly two months for the first national clover array experiments by scientists from DAE and different universities of the country.

Acknowledgement

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