Status Report on RIKEN Heavy Ion Linac

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Abstract

The RILAC has been operated for nearly 19 years and has been accelerating various kinds of ion beams for various experiments. Many improvements and replacements were carried out.

1 Introduction

The RIKEN heavy ion linac (RILAC) started to supply beams for experiments in 1981 [1] and to inject them to the RIKEN ring cyclotron (RRC) in December 1986. A PIG ion source installed in the 450 kV Cockcroft-Walton injector was replaced with an 8-GHz ECR ion source (NEOMAFIOS) in fall of 1990 [2]. A new system consisting of a variable-frequency folded-coaxial RFQ linac [3] and an 18-GHz ECR ion source [4] was installed as the second pre-injector to the RILAC in 1996. The both pre-injectors had been used depending on requirement of experiments since January 1997. A No. 6 rf system and three sets of plate power supply for the final vacuum tubes were replaced with new ones in May 1999. A Charge-State Multiplier system (CSM) is planned to be placed between the existing RILAC and the RRC [5].

2 Operation

Figure 1 gives the statistics of the RILAC operation from 1989 through 1998. The percentage of the beam time was approximately 45 % per year. The "overhaul and improvement" in Figure 1 includes the installation work of the NEOMAFIOS in 1990 and the installation work of the new pre-injector system in 1996. Figure 2 summarizes the beam time allotted to individual research groups. Total beam acceleration time was approximately 4000 hours per year. This time has been shared for users of the RILAC and injections to the RRC, as well as machine studies, initial settings, and beam tunings. The about 50 % of the beam time have been used for injections to the RRC.

3 Ion source

The PIG ion source which was used initially was replaced with the NEOMAFIOS in 1990. The NEOMAFIOS has been used for users since January 1991. The beam extraction voltage has been raised from 10 kV to 13 kV in August 1997. As the result, the beam intensity has increased by about 30 %. The 10 kinds of ions of gaseous elements and 51 kinds of those of solid elements have been produced by the NEOMAFIOS so far.

The 18-GHz ECR ion source was installed in the new pre-injector in 1996 and has been used since January 1997. The maximum extraction voltage of the 18-GHz ECR ion source has been raised from 10 kV to 20 kV in order to upgrade the intensity further since August 1997. We obtained the beam intensity of approximately 50 p μA for Ar^{8+} and 20 p μA for Ar^{11+}.

Figure 3 shows the statistics of the number of days of the ion beams delivered using the old pre-injector with the NEOMAFIOS and those delivered using the new pre-injector, respectively. The 36 kinds of ions have been accelerated with the RILAC so far.

4 Rf system

The RILAC consists of six resonators of variable frequency type, having a tuning range from 17 to 43 MHz. The resonator is a $\lambda/4$ mode coaxial type and has two movable tuning devices. Each power amplifier uses a tetrode (RCA-4648) as the final stage (300kW). The rf power is fed to each resonator through a 60 Ω feeder.

In the rf system of six resonators, a wide band amplifier (500W), and both of power supplies of the control grid (250V, 2.5A) and the screen grid (1.5kV, 2.2A) for the final vacuum tube were replaced with new ones in 1994. The servo motor controllers driving the capacitive trimmer, and both automatic tuning and amplitude controllers were replaced with newly designed ones in 1995.

To use efficiently the spare parts and to accord with the remote control system for the CSM, the No. 6 rf system was replaced with a newly designed one in May 1999. The power amplifier chain of the new No. 6 rf system has a solid state amplifier (1kW) as the first stage, a tetrode (SIEMENS-RS2012CJ) as the second stage (15kW), and a tetrode (SIEMENS-RS2042SK) as the final stage (300kW). The basic design is similar to those of the RRC. The frequency range is from 18 to 40 MHz. The No. 5 rf system will be replaced with a newly designed one until the end of 1999.

Three sets of plate power supply for the final stages were replaced with newly designed ones in May 1999. Rated output power is 480 kW for the No. 1 and the No. 2 rf systems , 700 kW for the No. 3 and the No. 4 rf systems, and 1120 kW for the No. 5 and the No. 6 rf systems, respectively. Maximum output voltage is 12 kV, 14 kV, and 16 kV, respectively. The ripple voltage at the rated full load is 0.5 % peak to peak.

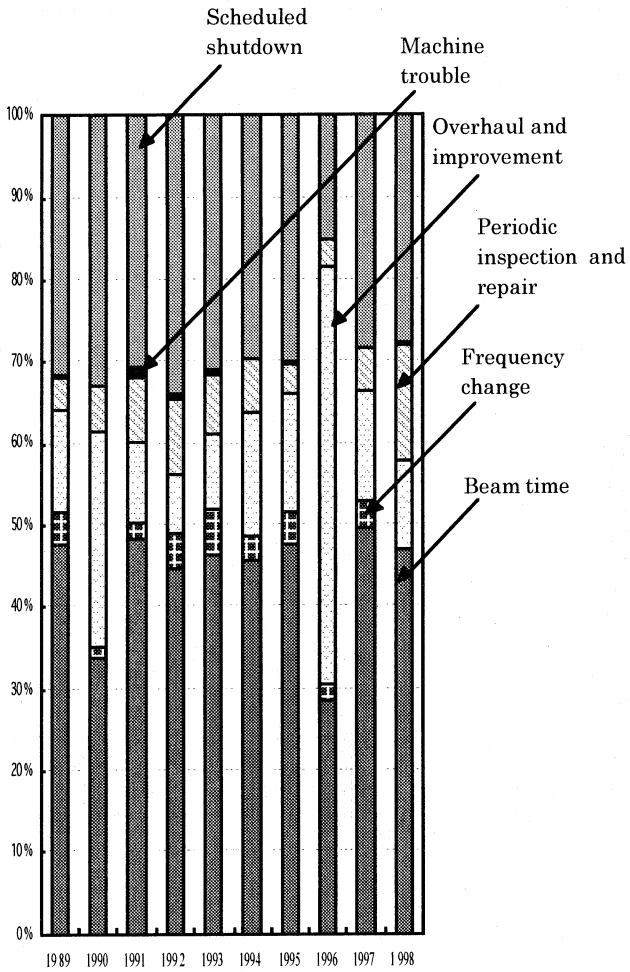

Fig.1 The statistics of the RILAC operation from 1989 through 1998.

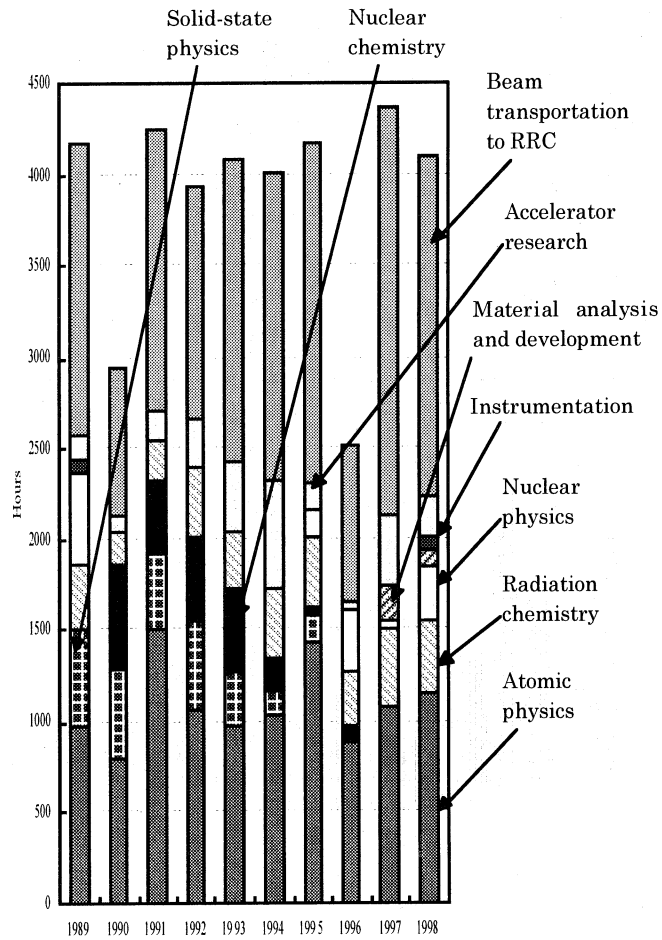

Fig. 2. The beam time allotted to individual research groups from 1989 through 1998.

A second-harmonic buncher was installed in the beam transport line from the Cockcroft-Walton injector in March 1993 [6]. Using both the fundamental-frequency and the second harmonic bunchers, we got about 50 % increase of beam intensity at the exit of the RILAC compared to that with only the former.

The RFQ linac equipped with the 18-GHz ECR ion source was installed as the new pre-injector in 1996 and has been used since January 1997. The RFQ vanes were re-designed and replaced in August 1997, because the maximum extraction voltage of the 18-GHz ECR ion source has been raised from 10 kV to 20 kV. The maximum transmission efficiency through the RILAC was 62%. It has become 1.5 times larger than that using the Cockcroft-Walton injector.

The CSM consists of accelerators, a charge stripper and decelerators. In case of the heavy ion beam, it compensates the beam loss in charge stripping due to the fact that the stripped ions with a most probable charge state cannot be accepted by the RRC. The three resonators of the first unit of the CSM will be installed and tested in the beam transport line between the existing RILAC and the RRC in December 1999.

5 Magnet power supply

The power supplies for magnets used in the six resonators and for the quadrupole magnets of the beam transport line were remodeled by replacing the obsolete power transistors with the modern ones from 1991 through 1994.

The power supplies for the bending magnet and the quadrupole magnets of the beam transport line from the Cockcroft-Walton injector will be replaced with new ones in the autumn of 1999.

6 Control system

The computer control system (a HP-1000 computer of Yokogawa-Hewlett-Packard Ltd.), which had been used since November 1979, was replaced with a MELCOM 350-60/500 (M-60) computer of Mitsubishi Electric Corp. in November

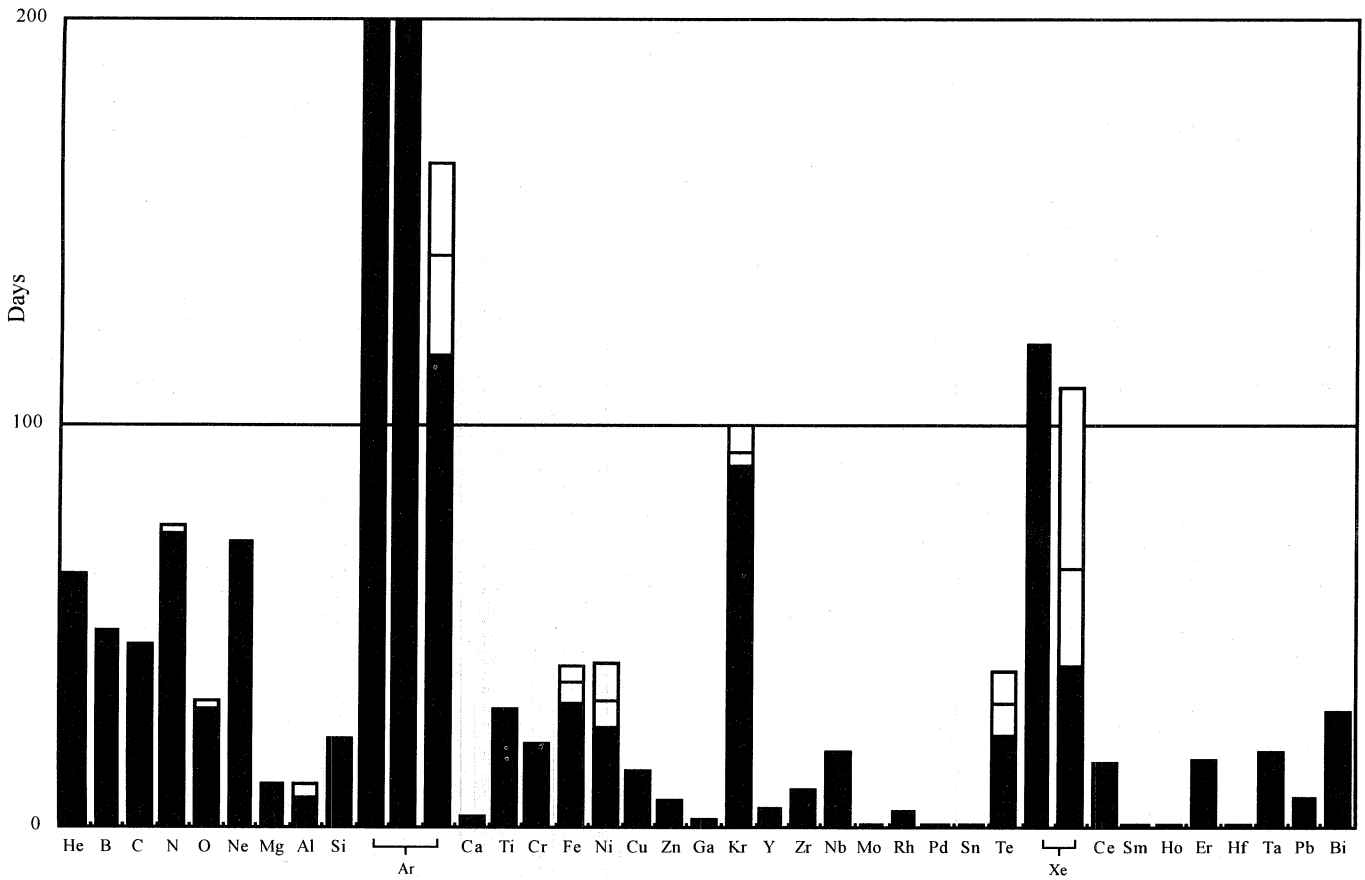

Fig. 3 The statistics of the number of days of the ion beams. The black marks (■) and the white marks (□) represent the number of days of the ion beams delivered using the Cockcroft-Walton injector with the NEOMAFIOS from1989 through 1998, and those delivered using the new pre-injector consisting of the RFQ linac and the 18-GHz ECR ion source from 1997 through 1998, respectively.

1985 [7]. The M-60 computer has been used for the operation since September 1986. The control units(HP2240A), which is connected through the GPIB to the RILAC control computer system, was replaced with a new type in 1990.

The PC-based control system for the new No. 6 rf system has been adopted and has been used for the new rf system. The Windows NT is used as an operating system of the personal computer. The system communicates with programmable logic controllers by the InTouch software.

The PC-based control system for the new magnet power supplies is being developed. This new system uses a personal computer with the Windows NT operating system and an application program (HP-VEE) running on the PC. Each new magnet power supply has a GPIB interface module, and is controlled with the PC through the LAN and the GPIB bus. The system will be installed in the autumn of 1999.

References

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