RIKEN VARIABLE FREQUENCY LINAC,RILAC

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Abstract

Intention of design, technical developments which have been carried out, description of the facility status and progress in near future are given.

Intention of design

In order to extend our research activities being conducted using the light heavy ions accelerated by the Riken cyclotron, we proposed a heavy ion accelerator complex composed of an injector linac and a separated sector cyclotron in 1971.[1] Its design goal is acceleration of all elements in the periodic table with the energies high enough to initiate nuclear reactions between any combinations of the projectiles and target elements. As is well-known, it is desirable to use accelerating gradient as high as possible to make flight length short for the acceleration of the heavy elements. By use of the multiply-charged ions, acceleration rate in the linacs can be made high, and because of simplicity in injection and extraction of beam we can expect high intensity required as a prestripper accelerator.

However, the linacs hitherto built have some inherent difficulties in acceleration of the wide range of ions of varying charge to mass ratios with the same structure. In order to keep synchronized acceleration condition for heavier as well as for light ions, accelerating voltage across drift tube gaps must be proportional to mass to charge ratio of the ions under acceleration. That means a large voltage of by nearly a factor of six or seven is required for the heaviest when compared to the carbon or lighter ions, considering the state of art of the ion source technology in 1971. Sparking in the accelerating gaps and/or transversal focusing difficulty of ions against defocusing effect at the gaps make multi-particle operation of the fixed frequency linacs somewhat awkward. Therefore, we have determined to introduce the variable frequency scheme into the linac technology to ease those difficulties. The scheme, if achievable, is also convenient for pairing of the linac with the cyclotrons. Of course, the linac is desired to work with continuous duty factor (macroscopic) as the cyclotrons do. By choosing the same frequency for r.f. of the both machines, an efficient beam transfer between pre- and post-stripper accelerators becomes possible.

The variable frequency scheme results in producing the relatively higher energy for light elements, than for the usual fixed-frequency prestripper linacs. It is planned to use the characteristics in favor of the multi-disciplinary researches without waiting completion of the poststripper cyclotron. Table-1 shows an example of ions and energies obtainable.[2)]

Table-1 Example of ions and energies

Ion	Ne-20	Ar-40	Cu-63	Kr-84	Xe-132	U-238
Charge state	5	7	6	8	9	10
Frequency(MHz)	45	39	31	31	25.5	20
Energy(MeV)	80	120	119.7	160	179.5	199.9

Technology

Following R&D have been done.

1. Development of a low loss variable frequency resonator suitable to be used as the variable frequency accelerating structure.
2. Variable frequency high power amplifiers capable to deliver up to 300 kW CW for frequencies between 17 and 45 MHz.
3. Simultaneous operation of the six power amplifiers coupled with six accelerator cavities of high quality factor. Relative amplitudes and phases of the accelerating voltage of the resonators must be well regulated and stabilized.
4. Determination of region of the variation of parameter values to be expected by variable frequency and voltage operation.
5. Realization of the compact-sized drift tubes to maximize the quality factor of the Wideröe cavity, whereas the built-in quadrupole magnets within drift tubes must be able to give the large field gradients to focus the heavy and slow ions. On the other hand, the apertures of the drift tubes must have a reasonable size to assure good transparency for beams.
6. An optical link system to enable subtle control of the heavy ion sources on the high voltage terminal.
7. Variable frequency version of the beam buncher, chopper and the beam diagnostic elements.
8. Computer-oriented control system to cope with the complex parameter handling requirements for the variable frequency multi-particle operation.
9. Development of the reliable ion sources which can produce ions in charge states as high as possible. Further, the sources must be stable and have a long life for operation on the high voltage terminal.

Status and studies in progress

Items-1, 4, 5, 6, 7, have been completed. Item-2; the power amplifiers coupled with the cavities are working upto 30 MHz. Ions are being accelerated by the first cavity. The multipactoring phenomenon and vacuum sparking are not serious. Increase of the frequency region is being tried.

Circuits and soft-wares for items 3 and 8 are under preparation and will be completed in September.

The last item 9, the multiply-charged ion source development has been successful as far as getting charge states of design goal for the gaseous elements. It is stable and reproducible. Centering of beam extracted in the accelerating column is good. The type is the indirectly-heated cathode PIG source familiar to us. Acceleration of solid elements using the sputtering technique will begin from the fall this year.

We are now planning to begin development studies of the new type ion sources. Intention is further lengthening of the time between maintenance work as well as drastic increase of the charge states of the ions of heavy elements. ECR type is the first candidate.

Since the seperated sector cyclotron project has been approved in FY 1980, works connected with preparation of the linac beam for injection are under study. At present, possibility of beam sharing between the post-stripper accelerator and the experiments satisfied using the low energy linac beam using otherwise waste ions after charge-stripping is being investigated.

Figure 1 shows the plan drawing of the RILAC facility, and Fig. 2 is a photograph taken from the upstream end of the accelerator vault. Figure 3 shows one of three experimental areas.

References

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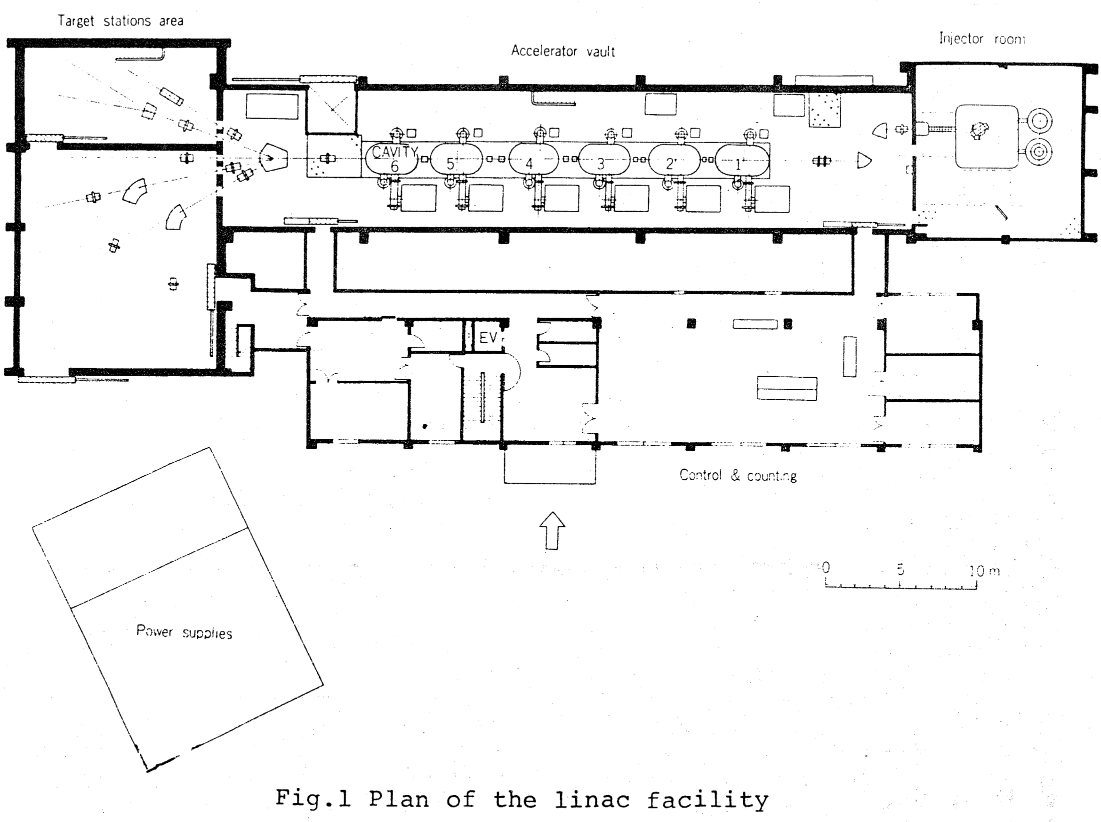

Fig.1 Plan of the linac facility

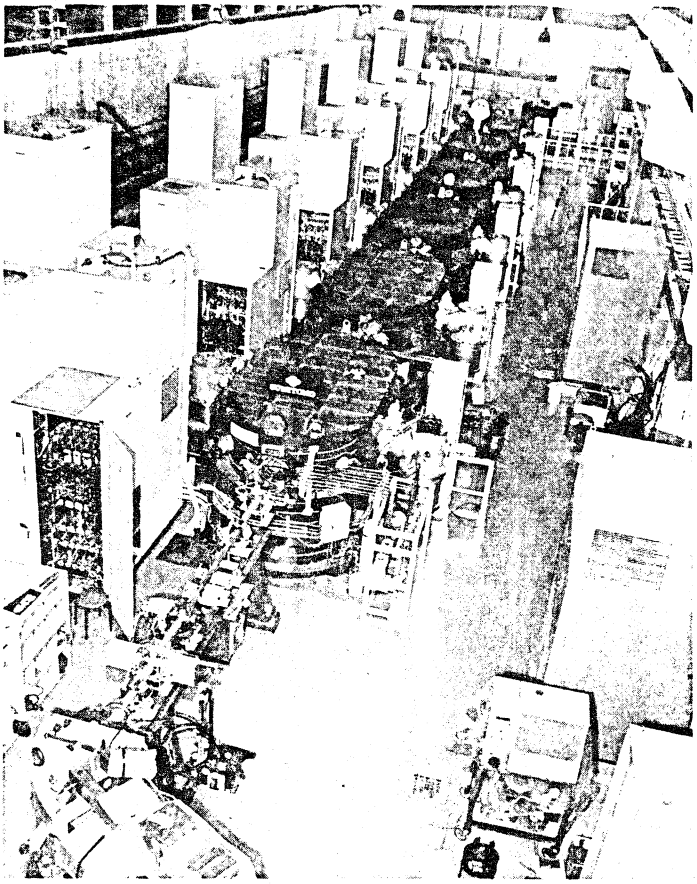

Fig.2 Linac array seen downstream from injection-side

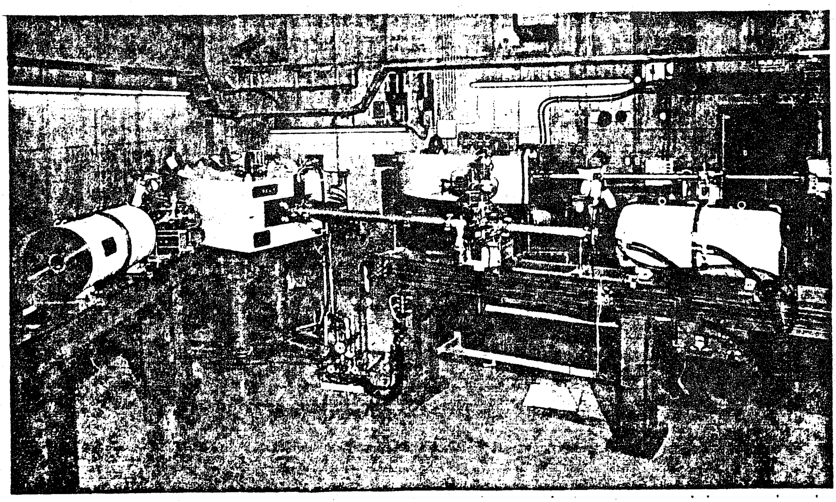

Fig.3 One of the experimental areas. Beam analyzing magnets and quadrupoles use copper tape wound coils