Proposal of Radioactive Isotope and Nuclear Structure Study Facility (RINSS)

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INTRODUCTION

In order to promote peaceful use of nuclear technology, fundamental and applied research of nuclear physics in this foremost frontier, Radioactive Isotope and Nuclear Structure Study Facility (RINSS) has been proposed by China Institute of Atomic Energy (CIAE). The facility is an extension of the existing HI-13 tandem accelerator that put into operation in 1986. A high intensity 100 MeV proton cyclotron will be adopted for the purpose of R & D of radioactive isotope production, study of nuclear structure and radiation physics. Also it will be used for the production of radioactive nuclei to be isotopically separated by an on-line mass separator and injected into the pre-existing HI-13 tandem accelerator. A superconducting heavy ion linear accelerator (LINAC) will be used for post-acceleration. Thus, high intensity and high energy resolution RNBs of A~up to 140 can be obtained with energies above the Coulomb barrier.

Investigation has shown that the RINSS is technologically feasible by China Institute of Atomic Energy. The RINSS is an advanced and competitive facility on the world. It is a major tool for searching new radioactive isotopes and used for study of nuclear structure physics, nuclear astro-physics, nuclear reaction mechanisms, atomic physics, material science, life science as well as other applications of nuclear physics. The RINSS will be a facility belonging to a national laboratory accessible for users in China as well as from foreign countries. The RINSS will be built in a five-year construction period after fund.

TECHNICAL CONSIDERATIONS

The plan view of RINSS is shown in Fig.1.

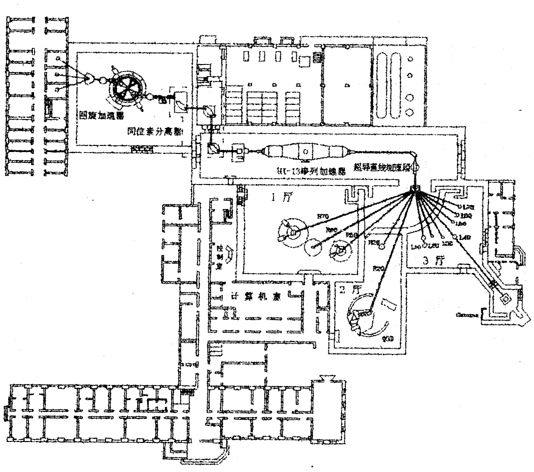

Fig. 1 Layout of RINSS

Proposed RINSS is a hybrid project consisting of three accelerators: The pre-accelerator is a 100 MeV high beam intensity proton compact cyclotron, then there is a existing 13MV tandem and final post accelerator is a superconducting linac. The part of reason of choosing a cyclotron for the pre-accelerator is CIAE has good experience for cyclotron[1].

The proposed proton cyclotron will provide 100MeV, 200μA proton beams, as shown in Fig. 2. It is a compact machine accelerating negative hydrogen and 70 to 100 MeV proton will be extracted by a stripper. The machine combines the advantages of solid pole and separate sector cyclotrons. Accuracy positioning and high flutter to keep stronger focus. There is no face coils needed since the energy of the extracted proton is controlled by the position of stripper. Also the extraction of beam is accomplished by change of the sign of Charge State of accelerated particle.

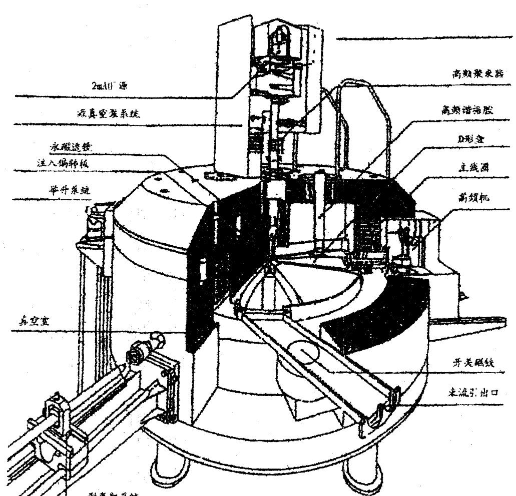

Fig. 2 100MeV, 200 μ A cyclotron

The loss of the beam will be negligible in this way when the beam is extracted. The parameters of the machine are listed on table 1.

Table 1, Parameters of CYCIAE100

extracted	proton
accelerated	minus hydrogen
Extracted intensity	200 μ A
Exit port	2
energy	75-100 MeV
Magnet structure	4 sectors
Field under hill	1.45T
Field between valley	0.15
Radius of Pole	1920 mm
Weight of magnet	475 T
Magnet coil	50000 AT
Weight of coil	12 T
Number of dee	2
R F frequency	49.6 MHz

The extracted beam will be used either for the experiments to do R&D study of isotope production or to bombard a thick targets for producing radioactive nuclei, then isotopically separated by an on-line mass separator. Charged ions of the selected isotopes will be produced by a target/source. The ions become negatively charged after passing through an ion exchange canal. The negative ions will be injected into the pre-existing HI-13 tandem accelerator. A superconducting heavy ion linear accelerator with energy increase of 17MeV/charge will be used for post-acceleration. This device is calculated to be able to deliver radioactive nuclei of 10^9-10^{11} ions/sec. Both radioactive nuclei and stable nuclei in the energy range from 14.5MeV/A (^{12}C) to 4.9MeV/A (^{133}Cs) can be obtained with high resolution and variable energies.

One of the purposes of the facility is used for the production of radioactive nuclei, which will then be isotopically separated by an on-line mass separator and injected into the HI-13 tandem accelerator. The isotope separation on line (ISOL) technology has been developed in many laboratories in the world. Successful experiences are expected to be used in this equipment. ISOL system consists of target/ion source, charge exchange canal, accelerator tubes, mass spectrometer and transportation line. In order to reduce the loss of the radioactive nuclei, except transportation time must be kept as short as possible since the isotope lifetime is limited, good quality of the beam is also expected. Good quality and enough intensity of negative ion injected into the tandem will ensure enough amounts of the particles to meet the needs of physics experiments.

The target/source used in the facility must possess small emmittance, high efficiency, variety of ions, remote assembling and disassembling. The exotic radioactive nuclei are generated by the reaction of high-energy proton beam from the cyclotron and target material. To make the exotic radioactive atoms diffuse easily from the target material, opposite physical and chemical properties of the exotic atoms to the target material are expected. The temperature on the target/ion-source is about 1300℃-2000℃.

The mass spectrometer consists of two sections. One of them separates useful nuclei from other foreign ion. This section consists of a 90° dipole bending magnet with radius 1.3 m. Its mass resolution will be 1300. The other section is an isobar separator with resolution 20000. The structure of the equipment is shown as Fig. 3

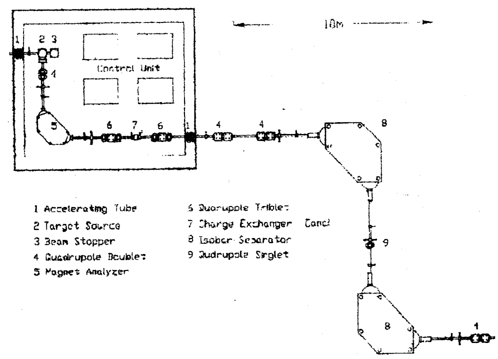

Fig. 3 The layout of ISOL

HI-13 tandem accelerator put into operation ten years ago. 5 MeV/Amu beams up to around mass A<40 can be accelerated. In order to extend the region of stable and radioactive ion species with energy high than relative coulomb barrier, a superconducting linac after the tandem will be built as a booster with RF 108 MHz

FEATURES OF RINSS

RINSS is multi-purpose plan.

1) Used for RNBs

The energies of the exotic beams from the RINSS compares favorably with all of the existing and planned ISOL facilities, except for the IsoSpin Lab (ISL) in the mass range of A>40 and Japanese JHP in the mass range of A>70. Therefore, RINSS will be a very competitive world-class radioactive nuclear beam facility.

2) Operation in five different modes.

a) Single cyclotron operation. In this mode 70-100MeV high intensity proton beams will be available for the first time in China. Fast neutrons can be produced with intensity up to 1×10^{14} neutrons/sec .

b) Single tandem operation.

c) Combination of tandem and linear accelerator. The energy range of stable beams can be increased greatly.

d) Combination of cyclotron and tandem. Radioactive nuclear beams with A<40 can be provided for nuclear physics research.

e) Combination of three accelerators. The mass range of the accelerated radioactive beams with energy above the Coulomb barrier can be increased from 40 to 140.

Fig.4 shows the main research areas that can be reached with the different operation modes. The facility will not only make the world -class capability of the radioactive nuclear beams, but also improve the performance of the stable nuclear beams. Therefore, RINSS will greatly extend the opportunities available for the researches in nuclear structure, nuclear reactions and application of nuclear technique.

REFERENCE

Mingwu Fan, Initial operation of CYCIAE 30, Proc. of China-Japan accelerator symposium, 1996

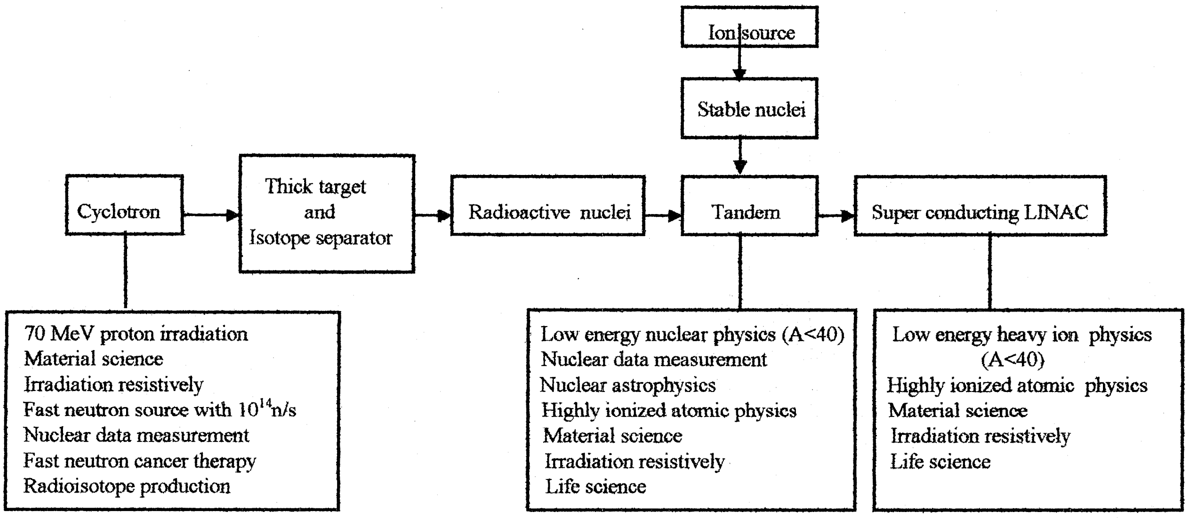

Fig.4 Main research areas of RINSS.