

Recent research activities of nuclear astrophysics in University of Tsukuba

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Abstract:

Since University of Tsukuba is located about 200 km from epicentre of the Great East Japan Earthquake at 11th March 2011, the strong quake hit the 12UD Tandem Accelerator and completely destroyed its inner structure. However, another small IMV Tandetron survived, then reaction studies with this small machine have been started. Whereas a support of the reconstruction budget has been approved to bring new 6MV tandem accelerator. The construction of the new accelerator is scheduled in spring 2014. Furthermore a new project of collaboration to build Rare-RI Ring has been started at RIKEN. This huge project is aimed at very precise mass measurements for the fundamental study of r-process.

*XII International Symposium on Nuclei in the Cosmos
August 5-12, 2012
Cairns, Australia*

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1. Introduction

Since 1975, wide spreading researches by use of 12 UD Pelletron tandem accelerator at University of Tsukuba had been proceeding which include studies of reaction mechanism with polarized beam, nuclear level structures with gamma-ray spectroscopy, environmental science with accelerator mass spectroscopy, and other applicational studies. These days the researches have been extended to quark glueon plasma at Brookhaven/CERN and unstable nuclear science at RIKEN.

However, the tremendously strong earthquake, The Great East Japan Earthquake, hit Tsukuba on 11th March 2011, the 12 UD Pelletron tandem accelerator has been completely collapsed. In this paper, present activities on the astrophysics and the status of the facilities will be described.

2. Damage of 12 UD Tandem Accelerator by Great East Japan Earthquake

Since epicenter of the Great East Japan Earthquake was about 200 km from the University of Tsukuba, the strong shocks hit this area. It caused to slip down many slate plates on traditional Japanese roofs and make cracks on many buildings in this area. The accelerator building which was made as 9 floors height vertical design was shaken. The damage was more serious on the higher floor. On top room of the building where ion sources are located, a 1500 kg Wein filter of the polarized ion source was moved by 50 cm with breaking the fixing bolts. Several cabinets were overturned there. Pressure tank of 12 UD Tandem Accelerator located between 4th and 7th floor was also strongly shaken and the inner acceleration structure was completely collapsed. At the moment of the earthquake, the accelerator was running by remote operation system inside the radiation shielding wall without anybody nearby. Fortunately there were no casualties in the laboratory.

Fig.1 shows a photo of the destroyed structure of the 12UD tandem accelerator. This photo was taken from a manhole on the 7th floor viewing down the dropped structure. No radiation is detected from the wreckage. The residual radio isotope which is mostly ⁵⁶Co around the charge exchange system of the high voltage terminal is estimated to be a few MBq and will be extinct in a couple of years.

3. New plan of 6 MV tandem accelerator

The damage of the 12UD is serious and the operation of the repair is assumed to be dangerous since the dropped cylindrical structure slanted. Any reuse of parts such as accelerator tube are hopeless. Then, we decide to abandon the old machine and build new one.

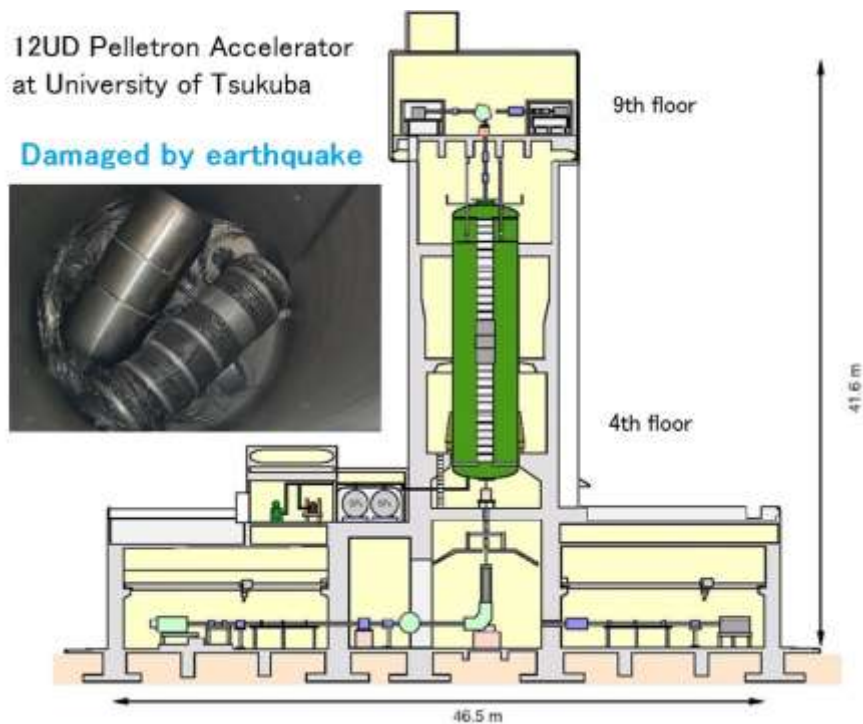


Fig. 1. Damage of 12 UD Pelletron Tandem Accelerator

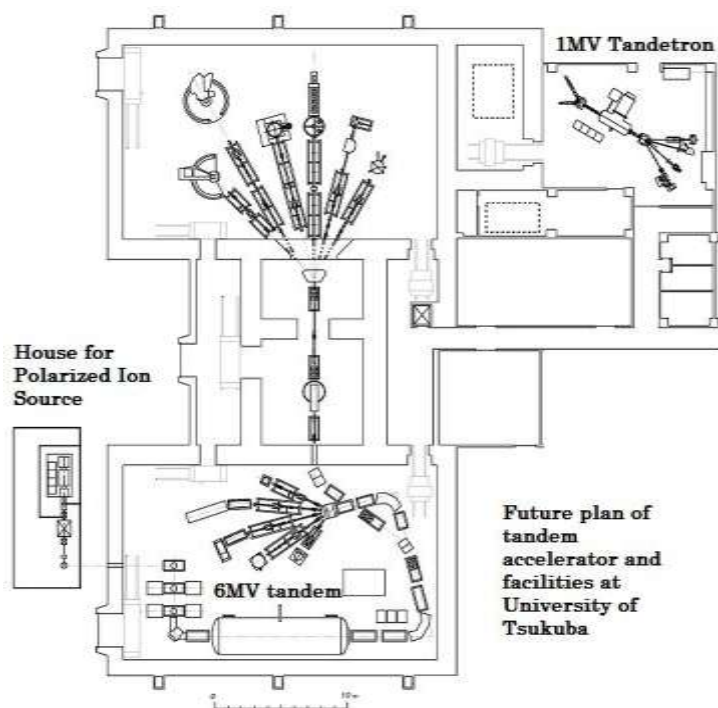


Fig. 2. Plan of new 6MV tandem accelerator

Our new plan is a 6MV tandem accelerator with horizontal structure as shown in Fig.2. The lower terminal voltage of 6MV might be more suitable for the study of reaction rate measurements for astrophysically interest for the lower bombarding energy. The new machine is having a special design for Accelerator Mass Spectrometry including a sequential injection system for different isotopes. The vacuum chamber of the injection magnet will be connected to switching high voltage. The new machine will be offered by National Electrostatic Corp. USA, which is the same company brought the 12 UD Pelletron Tandem Accelerator.

We really appreciate the full-covered reconstruction budget by Ministry of Education, Culture, Sports, Science and Technology of Japan (MEXT).

4. Survived research facility: 1 MV Tandetron

In the Research Facility Centre for Science and Technology, Tandem Accelerator Complex we have another research facility which is a 1MV Tandetron accelerator. Fortunately, it survived without any damage.

We started new experiments using this small accelerator for the astrophysical interest. One project is the measurement of reaction cross sections around scandium45 which is a bottleneck nucleus of silicon burning. Another is aimed at to solve the problem of lithium production in big bang nucleosynthesis.

5. Rare-RI Ring project at RIKEN

New project of Rare-RI Ring has been approved and its construction has been started in this fiscal year at RIKEN under a collaboration of University of Tsukuba, Saitama University, Nagaoka University of Technology and RIKEN. This project is aimed at the nucleosynthesis in r-process achieved by precise mass measurements in the region of neutron rich side of nuclear chart. Rare-RI Ring is located downstream of SHARAQ spectrometer as shown in Fig. 3. Design value of mass resolution is $\delta m/m = 10^{-6}$ which corresponds to 100 ~ 200 keV for mass region of $A=100\sim 200$.

Injection energy has been chosen to be 200 A MeV and the revolution time is 335 nsec for the 60.35 m circumference. Rare isotopes whose half-lives are longer than 1 ms could be the object which could cover most of nuclei concerning to the r-process.

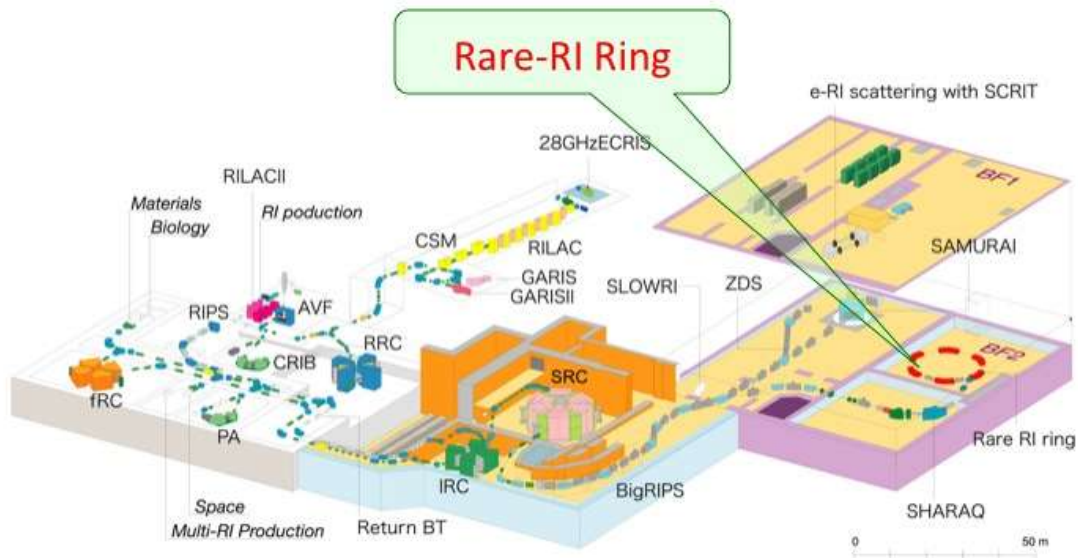


Fig. 3. Bird's eye view of RI Beam Factory in RIKEN.
Rare-RI Ring is shown by the arrow.

6. Summary

The researches of nuclear astrophysics are proceeding at University of Tsukuba by use of 1MV Tandatron accelerator, however, the main machine 12UD Pelletron accelerator has been destroyed by the Great East Japan Earthquake. We are expecting new machine of 6MV tandem accelerator in spring 2014. Furthermore, a new project for the basic study of r-process has been started to construct Rare-RI Ring at RIKEN combined to the RI-Beam Factory. This project is operating under collaboration with RIKEN, University of Tsukuba, Saitama University and Nagaoka University of Technology.