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Nano Second Beam Bunching System of KIGAM

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1. Introduction

The Korea Institutes of Geoscinece and Mineral Resources (KIGAM) has done the studies based on electrostatic accelerator such as nondestructively analysis of proton induced X-ray emission (PIXE), proton induced gamma-ray emission (PIGE), Rutherford backscattering (RBS) and elastic recoil detection-time of flight (ERD-TOF)[1]. Current KIGAM is interested in measurement of neutron cross section data at energy ranges of 1 MeV to 2 MeV[2], which corresponds to field of fusion reaction. So KIGAM designed the nano-second beam bunching system and manufactured them for obtaining the accurate nuclear data by removing neutron backgrounds and by obtaining the accurate neutron energy. By using this system, we produced the pulsed beams with small width, and investigated their characteristics by time-of–flight (TOF) method. Their results are presented in this paper.

2. Methods and results

KIGAM has a 1.7 MV Tandem accelerator with the source of negative ions by cesium (SNICS) and the RF source. The beam energy calibration (<±1 keV) was established using the resonances at 991±1 keV in ^{27}Al(p,γ) reaction and at 3047±1 keV in ^{16}O(α ,α ') reaction. Bunching system is positioned at front of acceleration tank because it is easy to control incident particles and these have a small energy of 28 keV.

Beam chopping technique and double bunching method by RF field[3] are applied to bunching system of KIGAM. High power RF generating system is fabricated for a beam chopping and a beam bunching.

Figure 1. Structure of buching system

Converting circuit of RF high power to RF high voltage by induction method and impedance matching circuit for transferring high voltage to electrodes by LC resonance method is also constructed. Fig. 1 and Fig. 2 show a structure of KIGAM bunching system and a high power RF generating system. Stability of this system was checked for 5 hours at RF high voltage of about 2 kV for bunching.

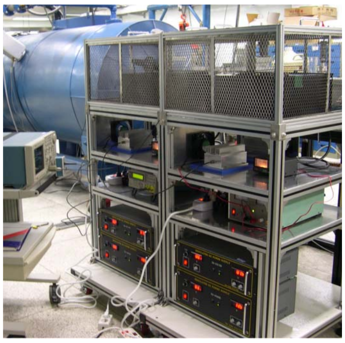

Figure 2. RF power system of KIGAM

RF high voltage with frequency of 4 MHz is applied vertically to continuous beam direction (CBD), two pulsed beams with a few tens of width can be obtained in one chopping period by the applied voltage when continuous beam passes through slit with small hole distant from electrode. Beam shape of incident particle is very important factor to obtain pulsed beams with a small width. Beam shape was confirmed to be a Gaussian shape with a deviation of 2.15 mm by downing slit position and measuring beam current at faraday cup, which was positioned at 2 m distant to chopping electrode. Beam size is 3.1 mm because hole size of slit is 4.0 mm. The available maximum beam current is within 6 uA. The beam width is observed by TOF method as a function of chopping voltage. This is found to be inverse proportional to chopping voltage. Bunching electrode consists of three stage cylinders. Fist and third electrode is connected to ground because it is easy for incident particle with charge to enter into them and exit from each electrode. RF high voltage with frequency of 8 MHz is applied parallel to CBD on bunching electrode to form RF electric field between each electrode gap. In first gap, the gradually decreasing push force and gradually increasing pull force for a bundle of beam can happen in a bundle of beam by controlling the phase of the bunching voltage. First bunching can be obtained in this point as the pass time of the chopped beam elapsing. Also the middle electrode is long not to change RF polarity and the same force to first gap happens at second gap. Double bunching can be obtained in bunching electrode. Beam width is also measured by TOF spectrum for gammarays from Al(p,p'g) reaction as functions of bunching voltage, phase of bunching voltage, and pre-acceleration energy of incident particle. At conditions of chopping voltage of 220 V, bunching voltage of 2kV, relative phase of -55^{o} in bunching voltage to chopping voltage and pre acceleration energy of 27 keV, the pulsed beam with the shortest width can be obtained like Fig. 3. In measurement of TOF, 2"x2" BC-501 liquid scintillation detector is used. This signal is a start signal and stop signal is a TTL signal of bunching voltage. The distance from Al target to detector is 2.1 m. Figure 4 shows neutron experimental room with TOF measurement system. A FW1/10M of g-ray in Fig. 2 is found to be 2.353 ns. Time deviation of detector size is calculated to be 0.17 ns. And a FW1/10M of time resolution on BC-501 scintillation detector obtained by 0.511 MeV g-ray of ^{22}Na is found to be 2.113 ns. So beam width is determined to be 1.04 ns by removing these factors from time width of gamma-ray on TOF spectrum.

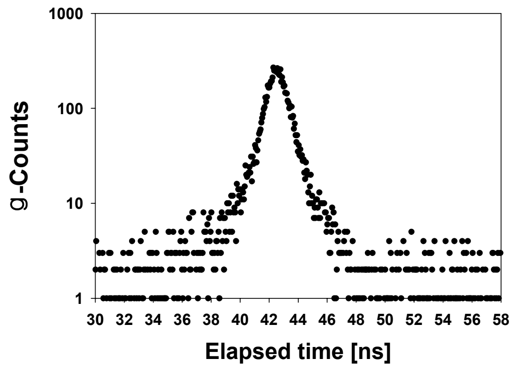

Figure 3. TOF spectrum of gamma-ray on Al(p,p'g) reaction

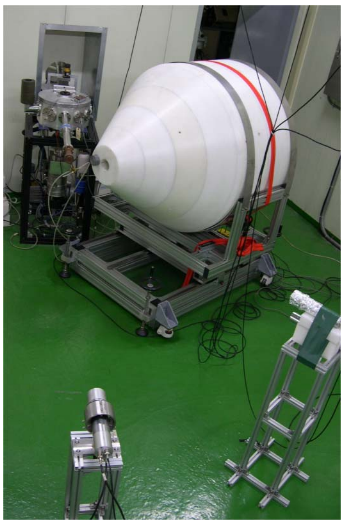

Figure. 4. Neutron experimental room with TOF system

To confirm the beam repetition rate, time pick-off module is also fabricated by toroidal coil with inductance of 200 uH. Fig. 5 shows repetition rate of pulsed beam to be measured by this module. This is found to be 125 ns. This has a good agreement with period of the applied bunching voltage.

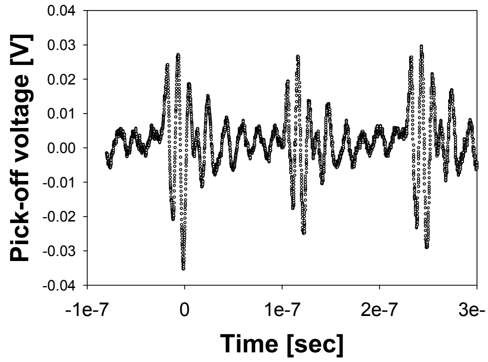

Figure 5. Repetition rate of pulsed beam

3. Conclusions

We fabricated nano second beam bunching system for obtaining an accurate neutron capture cross section data. And we produced nano second bunched beam as functions of sweeping voltage, bunching voltage, phase of bunching voltage, pre-acceleration energy with this system. We confirmed bunched beam with width of 1-2 ns by TOF and with repetition rate of 125 ns by time pick-off module, and obtained optimum conditions for pulsed beam with the shortest beam width. We will measure neutron spectrum on $^{3}H(p,n)^{3}He$ reaction., total cross-section for ^{197}Au, and capture cross-section for ^{197}Au as standard sample

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