

ENERGY CALIBRATION AND ENERGY SPREAD MEASUREMENTS OF THE 1 MV TANDEM ACCELERATOR AT ALMA-ATA

A. Arzumanov, A. Borisenko, S. Lysukhin

Institute of Nuclear Physics, Kazakhstan Academy of Sciences
Alma-Ata, 480082, Republic of KazakhstanAbstract

A simple energy spread measurements system with target potential modulation which may suitably be used at any electrostatic accelerator is described. Measurements were carried out using gamma rays yield functions of (p,γ) and $(p,\alpha\gamma)$ resonance reactions. The energy spread of the proton beam was found to be lower than 200 eV at 1 MeV. The latest data on ion beams accelerated at tandem are also presented.

Introduction

The purpose of this contribution is to present main features of the 1 MV heavy ion tandem accelerator and to give a short description of the energy spread measurements system and high voltage fluctuations decreasing set up.

Multipurpose tandem UKP is in operation at the Institute of Nuclear Physics in Alma-Ata for some years¹ (Fig. 1). The main feature of this Cockroft-Walton type accelerator is two accelerating beam lines with one high voltage source. It allows to carry out target irradiation with two beams simultaneously. The accelerator is mainly used in:

- material science and material modification based on MeV ion implantation and ion mixing.
- elements analysis with NRA, RBS, PIXE methods,
- atomic physics,
- few-body nuclear physics.

In material analysis experiments a highly defined beam energy is necessary as this energy is directly related to the depth profiling and depth resolution in the investigated sample for resonance reactions. Additional requirement is the quick change of energy without changing the stability conditions. For this purpose an energy spread measurement system and a set up for decreasing of high voltage ripples were developed and put into operation.

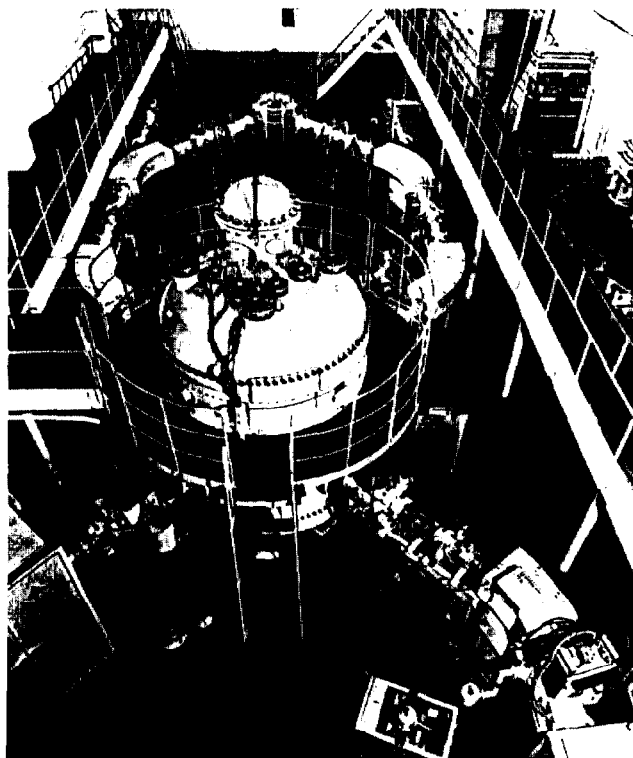


Fig. 1. General view of the two-beam heavy-ion tandem accelerator

Energy Calibration System

Usually for rapid energy calibration and energy spread measurements with acceptable accuracy some kind of target potential modulation as a rule of triangular waveform is used with strict demands to linearity of potential changing². In another case a rather sophisticated beam deflection system is employed^{3,4}. In this paper a very simple and reliable beam energy scanning system based on applying sinusoidal target potential modulation is presented.

Fig. 2 represents the block diagram of the system. The output of the hv sinusoidal waveform generator $V_{pp} = 7$ kV, 280 Hz is connected in parallel to the isolated target holder and to a voltage divider. A signal, proportional to the instantaneous voltage, is taken from the low value resistor and fed to a analog

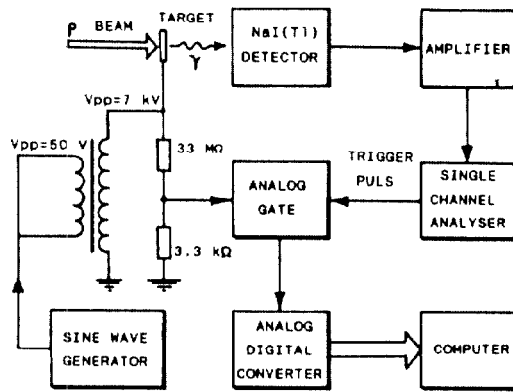


Fig. 2. Block diagram of the energy scanning system for the automatic excitation function measurements

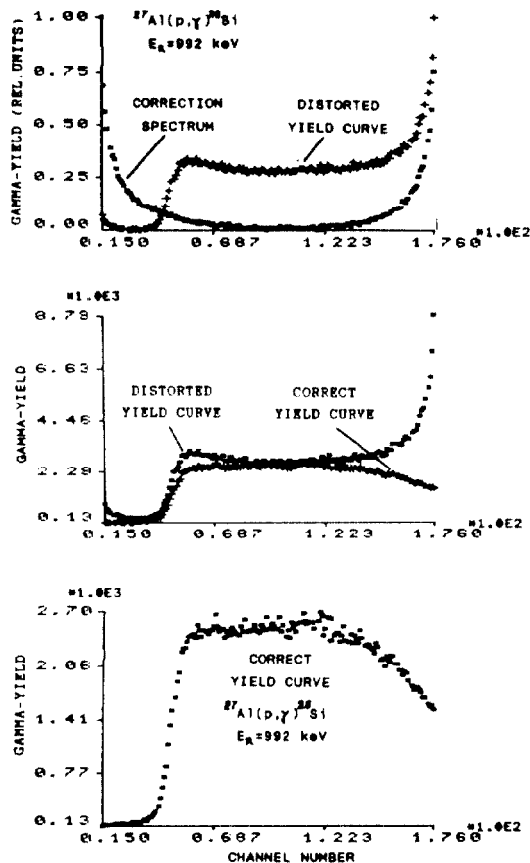


Fig. 3. Determination of excitation function $^{27}\text{Al}(p,\gamma)^{28}\text{Si}$ resonance at $E_R=992\text{keV}$. The energy sweep is 6,4 keV, the energy scale is 35 eV per channel, the energy interval between the points of 1/8 and 7/8 of yield curve is 350 eV.

gate circuit. Pulses from NaI(Tl) detector, after suitable amplitude selection, trigger the gate. The gate output pulses are analyzed with multichannel analyzer. Only gamma rays produced at the target are correlated with the applied voltage waveform. The spectrum obtained is a distorted excitation function (Fig. 3). At the next stage the calibration spectrum is obtained using random counts from a detector produced with a radioactive source without beam on the target. After that the distorted excitation function is corrected by taking into account a correction spectrum. Scanning frequency should not be multiple of beam intensity variations frequency. In this case the obtained excitation functions are not depend on scanning frequency up to 1 kHz. Fig. 3 illustrates the processing of excitation function for $^{27}\text{Al}(p,\gamma)^{28}\text{Si}$ reaction at $E_R = 992\text{keV}$. Fig. 4 shows the excitation functions for targets of different thickness for the same reaction. Such kind of measurements were carried out in the wide energy

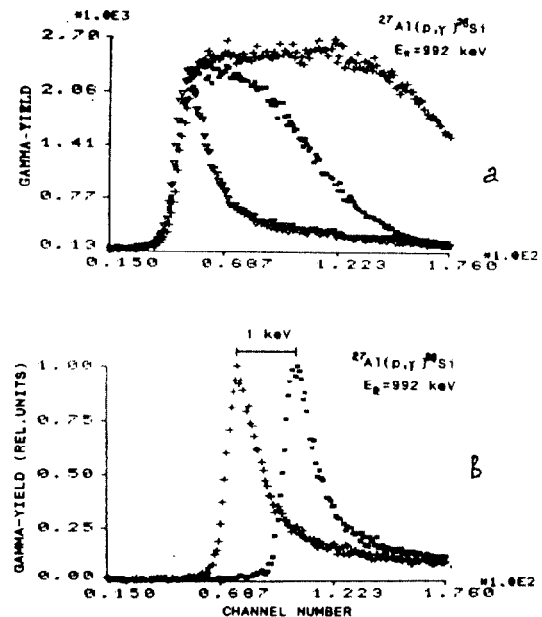


Fig. 4. Excitation function for $^{27}\text{Al}(p,\gamma)^{28}\text{Si}$ resonance at 992 keV. The energy sweep is 6,4 keV, the energy scale is 35 eV per channel, a) for targets of different thickness b) for different proton beam energy.

range using the reactions $^{19}\text{F}(p,\alpha)^{16}\text{O}$
 $E_R = 224 \text{ keV}, 340 \text{ keV}, 872 \text{ keV}; ^{27}\text{Al}(p,\gamma)^{28}\text{Si}$
 $E_R = 992 \text{ keV}, 1388 \text{ keV}; ^{58}\text{Ni}(p,\gamma)^{59}\text{Cu}$
 $E_R = 1424 \text{ keV}$. This allows to calibrate an
 analyzing magnet in the beam transporting
 system. Using NMR signal it is possible to
 set the mean beam energy with accuracy 200 eV
 The energy spread was estimated as in ref. 5
 and it's value was found to be about 200 eV.

High Voltage Ripples Decreasing System

The energy spread is determined substantially
 by the ripples induced by the hv cascade
 generator. These ripples were observed with
 a pick-up plate installed near the terminal.
 Different methods of hv ripple eliminations
 for such accelerators are considered in ref.6
 The simplified lay out for ripple reduction
 for UKP accelerator is shown in Fig. 5.
 A signal proportional to the output voltage
 of power converter is fed to an adjustable

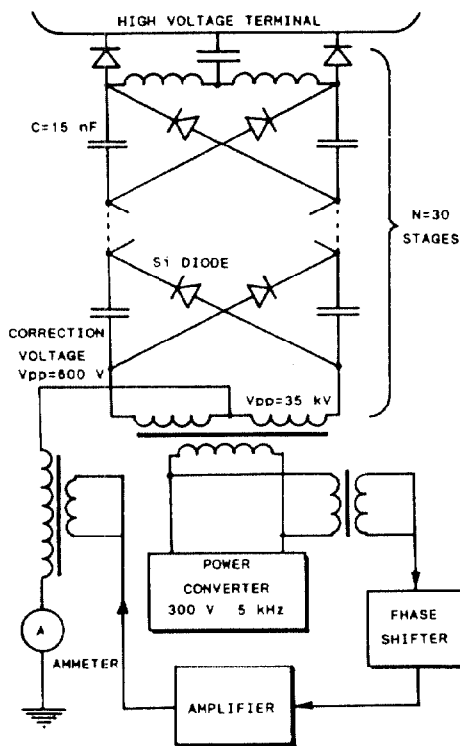


Fig. 5. Simplified block diagram of the
 electronic set up for decreasing
 high voltage ripples

phase shifter. After a proper amplification,
 correction voltage $V_{pp} = 600 \text{ V}$ at $U_T = 0,5 \text{ MV}$
 is applied to the middle point of the hv
 transformer. The ripples were decreased by a
 factor of the order of 3. The ripples at the
 main frequency of 5 kHz were eliminated al-
 most completely. The remaining ripples are
 $V_{pp} = 30 \text{ V}$ at the frequencies multiple the
 5 kHz.

Conclusion

The developed systems were found to be
 very reliable and effective tool for beam
 energy spread investigations.

References

1. Golubev V.P., Ivanov A.S., Nikiforov S.A.
 et al. "Design features and operational
 parameters of charge-exchange heavy ion
 accelerator UKP-2-1". Proc. of the 2-nd
 EPAC, Nice, France, June 12-16, 1990,
 v. 2, pp. 1852-1854.
2. J.M. Morris and T.R. Ophel, "Nuclear
 spectroscopy measurements employing
 modulation of target potential", Nucl.
 Instr. Meth., v. 40, pp. 245-253, 1966.
3. G. Amsel, E. d'Artemare and E. Girerd,
 "A simple, digitally controlled,
 automatic, hysteresis free, high preci-
 sion energy scanning system for Van de
 Graaf type accelerators", Nucl. Instr.
 Meth., v. 205, pp. 5-26, 1983.
4. G. Amsel and B. Maurel, "High resolution
 techniques for nuclear reaction narrow
 resonance width measurements and for
 shallow depth profiling", Nucl. Instr.
 Meth., v. 218, pp. 183-196, 1983.
5. Kangropol Yu.V. et al. "Determination of
 energy homogeneity of proton beam, acce-
 lerated on electrostatic accelerators",
 Preprint, Dubna, JINR, P 15 - 11362, 1978
6. S. Wüstenbecker, H. Elling, W.H. Schulte
 "Improvements in targetry and high
 voltage stability for high resolution
 ion beam experiments", Nucl. Instr. Meth.
 A 279, pp. 448-466, 1989.