# Research Results on Development and Construction of Cyclic Electron Accelerator – MT22

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This paper is dedicated to 50th anniversary of Joint Institute for Nuclear Research.

*Abstract.*

In this paper we have presented the operation of the cyclic electron accelerator- microtron "MT-22" which constructed in cooperation with specialists of Joint Institute for Nuclear Research and Mongolia. We are reached the research level results improving the radiation and technical characteristics of the microtron.

## 1. Introduction

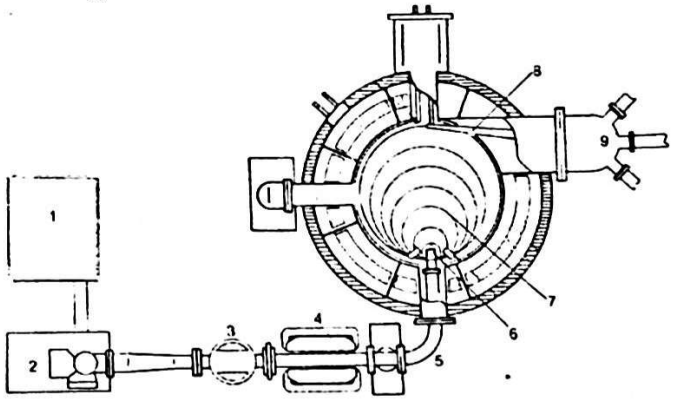
Nowdays there is widely used a high intensity gamma-quantum and neutron beams for both fundamental and applied research for some goals in nuclear physics. One of the basic equipment for this source is cyclic electron accelerator-microtron MT-22. The accelerators are constructed in 1944 by the initiatives of prof. S.P.Kapitza and prof. V.I.Melekhin on the basis of V. I. Veksler principle that electrons accelerated in resonator, excited by the ultra-high frequency electro-magnetic wave. There are about 30 microtrons built and distributed over the 10 countries of the world.

In 1997, Cyclic Electron Microtron MT-22 were set up in operation at the National University of Mongolia with cooperation of JINR specialists. The microtron MT- 22 runs in a wide range of energy varied stepwise from 3,5 to 22 MeV.

## 2. The run of the microtron and auto-phase principle

The microtron is an equipment designed for acceleration of electrons and positrons in the cross magnetic field of the high frequency resonator of the uniform transverse magnetic chamber in a vacuum. The very high frequency electromagnetic wave excite the resonator in chamber through transferring system. The electrons emmited by cathode, are accelerated by the electromagnetic field and moving to the next orbit. This

**Fig.1** Schematic view of the MT - 22:



1, 2 – very high frequency electromagnetic system
3 – phase rotator,
4–pherrite straighter,
5-wave transferring system,
6 - resonator
7- electron orbit,
8 - output system for electrons,
9 – electron split tube

step is repeating, while the electrons accelerated more and more. The accelerated electrons will out through the special channel while the electrons reached enough energy (see fig.1)

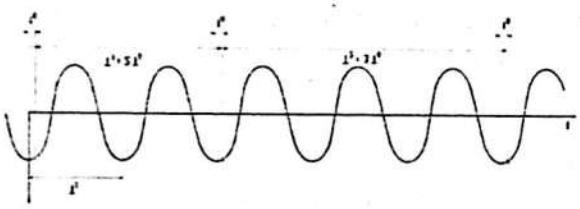


**Fig. 2** Dependence on between electron rotating period and accelerating field period

Phase stability principle for the microtron is following:
Difference of electron rotating period is expressed by the integer numbers of very high frequency electromagnetic wave as following:

$\Delta T = T_n - T_{n+1} = g \cdot T_0$

where g = 1, 2, 3, ...

n – number of orbits, $T_n$ – rotating periods for the n-th orbit.

$T_0$ – accelerating field period.

### 3. Development and Construction of the Microtron MT22

The construction work of the first cyclic electron accelerator of Mongolia were going under supervision of academicians G. N. Flerov and N. Sodnom in 1985-1992. In this research team members were A. G. Belov, P. G. Bondarenko, D. Baatarkhuu and B. Sergelen.

We have constructed and installed control panel, alarm system, stabilized power system, systems for distribution of electron flux, focusing, tilting and adjusting an orbit, magnetic systems, pherrite directed, phase adjusting, electron outgoing mechanism. Some parts of the accelerator such as measuring standard instrument, computer, graphite and uranium targets were donated by the IAEA technical cooperation project.

The MT22 microtron has three output channels for accelerated electrons. At the end of the first and third channels the high and low energy series gamma-quantum lines are available. The microtron scheme is presented in the figure 3.

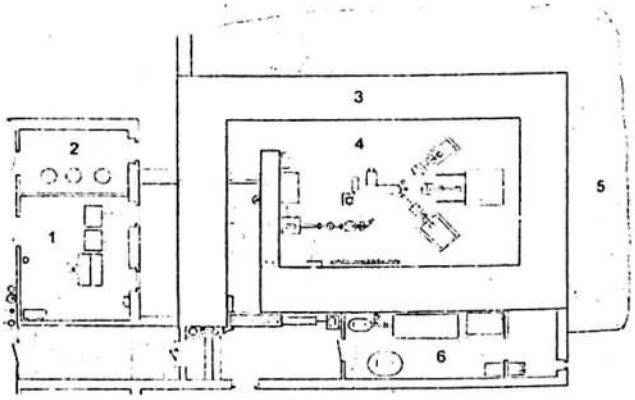



**Fig. 3** Main scheme for microtron position

1 - controlling room, 2 – measurement room, 3 – protection gear, 4 - main room, 5 – gravel gear, 6 - room for technology

The specifications of the microtron

- Maximum energy..... 22 MeV and 14 MeV, depending on the accelerating mode
- Number of orbits..... 22
- Incident electron energy on target.....5.0 - 22 MeV and 3.5-14 MeV
- Average current of electron.....10 - 50 μA
- Electron pulse curren.....10 - 50 mA
- Current pulse timing.....2.5 - 3.0 μs
- Pulsed eam power.....220 - 1100 kW
- Average beam power.....220 - 1100 W
- Parameter omega...0.9 - 1.1; 1.9-2.1
- Repetition frequency..... 50, 100, 200, 400 1/s
- Magnetic field.....1.7 and 3.5 kGs
- Coil current.....180-350 A
- Flux density of gamma quantum (On the direction of electron beam) .....$(7.2\text{-}1.5)\cdot10^{10}$ $1/(s\cdot cm^2\cdot\mu A)$
- Neutron flux density with resonance energy.....$10^8$ $1/(s\cdot cm^2\cdot\mu A)$
- Neutron flux density with thermal energy.....$10^7$ $1/(s\cdot cm^2\cdot\mu A)$
- Pulse power of the magnetron.....2 MW
- Polar external diameter.....1300 mm
- Outside orbit diameter ..... 800 mm
- Gap ..... .... 100 mm
- Working vacuum.....$10^{-6}$-$10^{-7}$ Torr

## 4. Improvement of the accelerator characteristics and supply of normal operation

We were carrying out technical controlling, construction and improvement of the MT22 technical characteristics during the 1995-1997.

After installation the MT-22, we have developed following on:

- The electron scattering outgoing were in the acceleration chamber, describing the electron orbit by add shunt method including positioned median plate
- The electron acceleration characteristics for each resonator, and each electron acceleration mode and described for electron orbit distribution in the chamber [6]

- Due to focusing pair lens and correctioning the electro-magnetic effective region, were decreased high vacuum lose and increased the electron beam output.

- Described the acecelerated electron characteristics into target on the ten orbit for 13-22 th outer orbit

- Possibility to provide investigation for wide energy regions, relatively high intensity accelerated electrons into 5-th orbit to target due to transferring the electro-magnetic transferring system into centre of the chamber [6,7].

- On the basis of electron beam to target, were positioned the electrons, relatively high and low energy gamma quantum line and photo-neutron research equipment in technology mode [7].

- On the basis of electron beam at target, adjusted suitable technological mode for γ-quantum high and low energy series and photo neutron research equipment

- Power supply system stability and linking improvement, were installed

synchronizator-generator block in controlling system. On this basis were adapted
synchronizing run with the computing system and other instrumental system

- Stability level for power supply system computing system and possiblity to run with other physics equipmens [8].

- Established the vacuum system run adapted into high vacuum stability mode due to
decreasing the inner electron scattering system and disappering the flux in vacuum volume. Therefore were increased the microtron run stability and other technical characteristics. During the last 7-8 years, the microtron runs in middle and high vacuum modes [9]

Due to installing the alarm system and radiation protection for the microtron chamber and gamma quantum beam line in the microtron hall, there were possibility to control
on radiation protection, establishing the environment radiaton background level and providing radiation experiment [10].

- Providing experiment on gamma quantum flux, distribution and gamma active study to establish for radiation structure [1,11,12].

- Established the photo-neutron equipment with neutron-stop, graphite moderator $Ta^{181}$ - $U^{238}$ target.

- Study on establishing the thermal and resonance energy neutron flux and distribution
experiment were provided by neutron-activation and nuclear track dielectric-detector
method in this channel of the equipment [12].

In fig. 4 is presented the microtron parts and equipment position.

## Conclusion

An application of cyclic electron accelerator – MT 22 is very important both for fundamental and applied physics research, and also training, preparation for young researchers in Mongolia. Using the microtron MT 22, there is more useful application
for the further developing of nuclear research and technology in our country. We need further development and widening of MT- 22 for application of other natural sciences.

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