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RESEARCH PROGRAMME FOR THE 660 MEV PROTON ACCELERATOR DRIVEN MOX-PLUTONIUM SUBCRITICAL ASSEMBLY

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1. Description of the experimental set up

As a first step in the studies of characteristics of ADS, a metallic plutonium fuel was proposed. ("Pluton" project [1-3]).

However, the results of calculations have shown [4] that MOX fuel would be a better option.

The proposed ADS facility consists of:

- 660 MeV proton accelerator,
- beam bending magnets ,
- spallation target with different material (Pb, W, Pb-Be, Hg)
- the blanket based on MOX fuel of BN-600 type Russian Fast Reactor
- beryllium reflector and concrete shielding,
- control systems.
- measuring systems

The following measurements on the test assembly are planned: energetic gain and its variation for different target material compositions, neutron multiplication k_{eff} and its variation, neutron generation, neutron spectra, reaction rates. The kinetic of the processes in the subcritical assembly by the proton-neutron flash in the target inside the MOX fuel zone from 660 MeV protons, will be investigated. One of the interesting questions is the stability of the neutron multiplication coefficient value for the subcritical assembly at the various energy and intensity of the proton beam.

The proton beam is transported horizontally to the target by bending magnets and through a vacuum track provided by a concrete shielding. Proton beam interactions at the target placed in steel tube. The target is surrounded with a blanket of mixed-oxide (MOX) fuel. The fuel is placed in a stainless steel vessel. A beryllium reflector and a concrete shield surround the blanket. The target and fuel elements are cooled by a flow of air.

The schematic layout of the subcritical assembly is presented in Fig. 1.

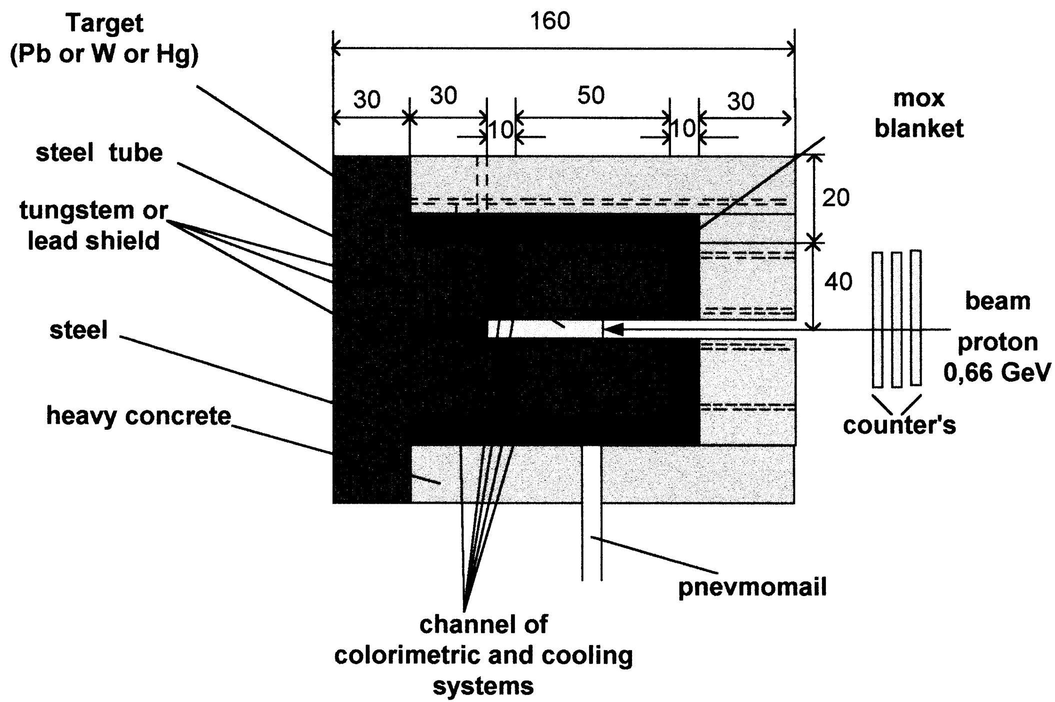

Fig.1. Subcritical assembly scheme

Parameters of the ADS facility are presented in Tab.1.

Table 1. Main parameters of the ADS facility:

Fission power	15 kW
Average intensity of produced neutrons	1.51 10^{15} n/s
Energetic gain	30
Factor k_{eff}	0.945
Fissile material	PuO_2 (25%), UO_2 (75%)
Density of fissile material	8.64 g/cm^3
The full length of a fuel element	70 cm
Core length of a fuel element	50 cm
Core diameter (with beryllium)	80 cm
Fuel load	250 kg

2.Results of Monte Carlo Calculations

We have performed a Monte Carlo study of the main parameters of the proposed system. The Dubna Cascade model has been used.

The calculated quantities were the neutron multiplication coefficient, neutron production and the heat generation in the system. The dependence of the energetic gain and neutron production at various protons beams energies T for k_{eff}=0.945 is presented in Fig. 2. Energetic gain G is the ratio of the energy produced in the device to the energy delivered by beam.

The maximum of energetic gain G is observed for incident proton energy about of 1.5 GeV [5]. A decrease in energy gain observed at law energies results from ionization losses of primary protons. For the suggested 660 MeV energy of protons the energetic gain is only 20% less than for 1.5 GeV. Energetic gain for a lead target is 20% greater than for a tungsten target.

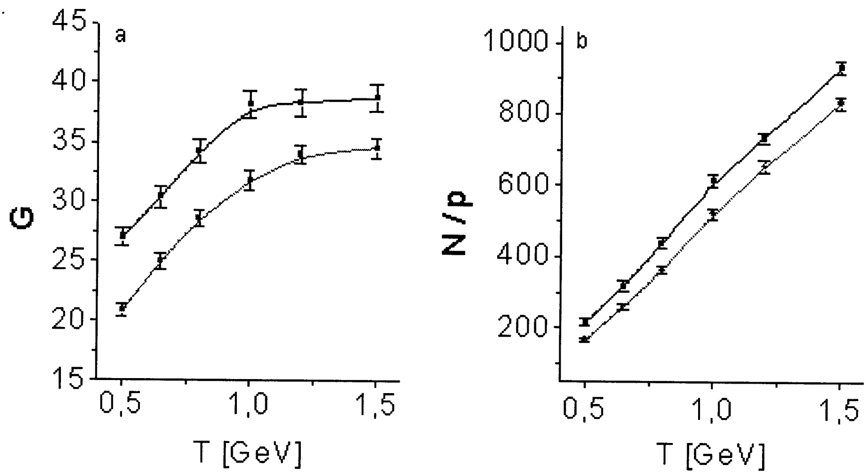

Fig.2. Energetic gain G and the number of neutrons per proton produced in the system N/p vs. incident proton energy T for k_{eff}=0.945 /0.003/ (The upper curve-for the lead target, the lower- for tungsten one)

3. Research programme

The programme of experimental research consists of the following two parts:
1. Research in the characteristics and parameters of the electronuclear installation: generation and spectrum of neutrons heat production per unit of beam power, yield of radioactive isotopes.
2.Obtaining of nuclear data required for designing a full-scale industrial electronuclear system for energy production and nuclear power radioactive waste transmutation; optimization of unit power; sizes and design of the future energy systems and transmutes; research in material properties connected to the creation of a new type of nuclear energy systems.

In order to perform this program, the following measuring systems have been adopted:
1) the neutron spectrometer on time of slowing down in a leaden column;
2) the gamma spectrometry complex with a pneumatic-mail for the express analysis of the radioactive isotopes formed in the field of electronuclear neutrons;
3) the calorimetric system on the basis of metal thermometers of resistance, sensitive micro thermocouples and infra-red sensors for measuring the teat production rate in the assembly;
4) the operation modes automatic control system of the experimental installations

In order to measure the spectra of the neutrons leaving the plutonium assembly and the shielding, it is offered to use a method of spectrometry on time of slowing down the neutrons in a leaden column. This method is used for the measurement of neutrons spectra at the meson factory of the INR AS Russian

Federation. The fast neutrons generated in a primary target from lead and tungsten (see Fig.1) by a 660 MeV proton beam of an the JINR phasotron, interacting with plutonium are bred as a result of fission. These neutrons passing through a steel cover, get in the leaden column placed in lead shielding (see Fig.1). On slowing down time in lead, the spectrum of neutrons taking off the limits of the steel shielding of the assembly is measured. The time of slowing down neutrons that is inversely proportional to $\sqrt{E_n}$, is measured by detectors from boron, lithium and isotopes of uranium and plutonium. The 660 MeV extracted proton beam from the phasotron will be controlled with the help of external start-up. The phasotron operation in the mode of the external start-up is provided by a package of impulses which emitted by the switching system from the pulse generator of the accelerator start-up and allows one to select the needed time interval. The time interval is determined by the slowing down time of the neutrons having the least energy in the spectrum.

To investigate the neutron spectrum in the electronuclear installation, to irradiate and measure the samples, in neutron reactions, a pneumatic-mail channel of the POLON brand and a stationary gamma spectrometer of CANBERRA-PACKARD type with a Accu Spec/B card and an integrated signal processor will be installed. In order to deliver the samples of various materials in the active zone (core) of the installation, the tungsten shielding will be provided with a special channel (see fig.1). The gamma-spectrometer with high efficiency precision resolution is expected to be used for studying the effective cross-section of transmutation of long-living radioactive isotopes in the field of electronuclear neutrons. The results of these studies are of special interest for creation in the future of an industrial scale ecological transmuter.

The automated infrared information- measuring detection system is intended for measurement of heat production in the subcritical assembly. Infrared sensors will be used as detectors. They possess high sensitivity and possibility of performing a study of space and temporary distribution of heat production in the assembly. In addition to the infrared sensors for calorimetric, other thermometric gauges and detectors such as micro-thermocouples, thermo-resisters, etc., can be also used. However, the infrared methods are selected only from the viewpoint of convenience when working in high radiation conditions. The jamming- protected precision device for measuring the thermal radiation intensity is intended for registration of spectra and measurement of the radiation intensity in the infrared spectrum under the conditions of strong electromagnetic and radiation jamming. It can be used for measurement of one- dimensional structures and the sizes of objects under study such as emitters and beams of radiation.

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Барашенков В.С. и др. E1-2000-64
Исследовательская программа на подкритической МОХ-плутониевой сборке, управляемой пучком протонов с энергией 660 МэВ

Представлена исследовательская программа на подкритической МОХ-плутониевой сборке, управляемой пучком протонов фазотрона ОИЯИ с энергией $E_p = 660$ МэВ.

В подкритической сборке планируется применить топливо МОХ (25% PuO_2 + 75% UO_2), используемое обычно в реакторах БН-600. Предлагается создать подкритическую сборку на МОХ-плутониевом топливе, охлаждаемую воздухом, с коэффициентом мультипликации $k_{eff} = 0{,}945$, энергетическим усилением 30, мощностью пучка протонов 0,5 КВт и мощностью сборки 15 кВт.

Работа выполнена в Лаборатории физики частиц и Лаборатории вычислительной техники и автоматизации ОИЯИ.

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Barashenkov V.S. et al. E1-2000-64
Research Programme for the 660 Mev Proton Accelerator Driven MOX-Plutonium Subcritical Assembly

The paper presents a research programme of the Experimental Acclerator Driven System (ADS), which employs a subcritical assembly and a 660 MeV proton acceletator operating at the Laboratory of Nuclear Problems of the JINR, Dubna. MOX fuel (25% PuO_2 + 75% UO_2) designed for the BN-600 reactor use will be adopted for the core of the assembly. The present conceptual design of the experimental subcritical assembly is based on a core of a nominal unit capacity of 15 kW (thermal). This corresponds to the multiplication coefficient $k_{eff} = 0.945$, energetic gain G = 30 and the accelerator beam power 0.5 kW.

The investigation has been performed at the Laboratory of Particle Physics and Laboratory of Computing Techniques and Automation, JINR.

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