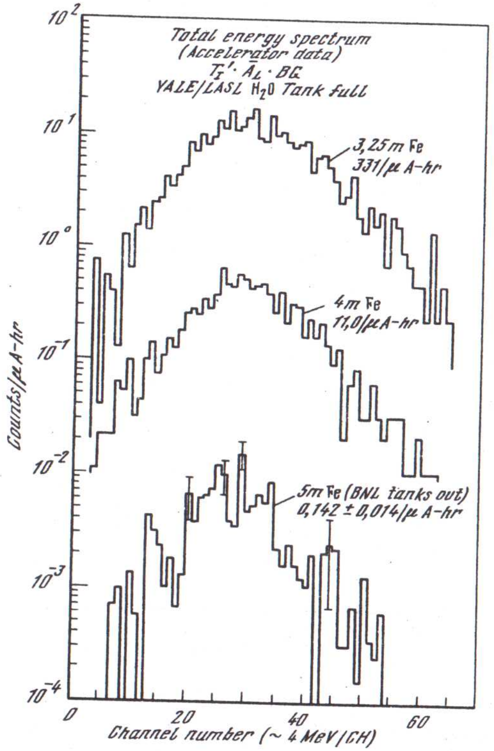

Figure 2. Accelerator recoil "proton" spectra for $3\frac{1}{4}$ m, 4 m, and 5 m Fe shielding against the beam stop. This demonstrates that the attenuation length of energetic neutrons from the beam stop is about 170 gm/cm^2.

NEUTRINO LABORATORY IN THE ATOMIC PLANT(FUNDAMENTAL AND APPLIED RESEARCHES)

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1. In the last decades the neutrino reserches influence more and more intensively the various branches of physics and technology. First of all the neutrino is used as a tool for investigating some other objects, e.g. the sun and the nuclear structure. On the other hand the neutrino researches stimulate designing high-sensitive detectors for nuclear radiation to be used in the other branches of science and technology. As to the direct use of the neutrino radiation in technology it was commonly believed to be unapplicable due to negligible cross-sections.

In connection with the development of nuclear energetics and construction of nuclear reactors their power being of the order of thousands MW's in the I.V.Kurchatov Institute of Atomic Energy some problems of utilizing neutrino radiation in the nuclear energetics are considered. At present in one of the building atomic plants the construction of the neutrino laboratory for carrying out the necessary researches is planned.

Alongside with the applied researches some fundamental experiments (neutrino oscillations, scattering on electrons and nucleons) are planned. Since the projects of such experiments have been already discussed for sake of time I'll touch upon possible technical applications of neutrino radiation discussed in such representative meeting of the neutrino-physics specialists for the first time.

2. Let us begin with the brief characteristics of the laboratory. It is (see fig.1) situated under the reaction zone and is shielded from the nuclear-active component of the cosmic radiations and from the reactor itself by the shetter thicker than 1.5 kg/cm^2. Really, almost in every direction shielding is essentially better. The room for neutrino detectors has the square 50 m^2 and is 3.5 high, in this room 2-3 experiments can be carried out simultaneously. The walls are covered by steel sheets for suppressing the γ-radiation produced in the concrete by radioactive admixtures. Besides each experimental device will have individual passive and active shielding.

3. I want to talk about the development of the new technique of the remote reactor diagnostics by the neutrino radiation. Due to the novelty of the problem the consideration naturally will be incomplete and limited by two questions only:

- determination of the reactor power production and in prospect
- determination of the dynamics of the fissing isotopes burning-out and accumulation (mainly ^{235}U and ^{239}Pu).

The principle promises of the proposed technique seem to be the remote analysis and fixing the plutonium accumulation immediately in the place of its production. This technique (if developed successfully) will be sufficiently important from the point of view of the control on the leakage of fissing materials and on the non-proliferation of nuclear weapons, and also for the economics of nuclear fuel recycling. More detail consideration of these problems on this conference seems to be irrelevant.

4. The neutrino flux f is determined by the reactor power and the geometry of the device

$$f = Q \cdot 1.6\ 10^{15}/R^2\ \mathrm{cm}^{-2}\mathrm{S}^{-1}$$

where Q is the power in thousands MW'S and R is the effective distance in meters.

For $\tilde{\nu}_e$ detection we suppose to use the reaction

$$\tilde{\nu}_e + p \longrightarrow n + e^+ \qquad (1)$$

discovered by Reines and Cowan about 25 years ago (see e.g./1/). The spectrum of positron kinetic energies found from eq./2/ spectrum is given in fig.2. For detector we plan using gadelinium-filled liquid organic scintillators and shifted in time coincidences. Unfortunately, the use of toluene based standard scintillators in the reactor plant is excluded and we develop new less flamable compounds. For solving the limited problem - the determination of power production - more simple detector registering $\tilde{\nu}_e$ by reaction (1) neutrons only by gas-filled counters penetrating hydrogen - containing material seems to be sufficient. We proposed /3/ such detectors for neutrino researches almost 10 years ago and in 1974 it was tested by Reines and collaborators with promising results /4/. In our laboratory we plan development of both detector.

In the detector with the 1m^3 net volume of the organic material (liquid scintillator, polyethylene) located in the 10-15m, distance from the center of powerful reactor the expected number of events in the reaction (1) is of the order of 10^4 per day, it enables obtaining of the 1% statistical accuracy in several days of measurements.

5. The net effect N in the detector for some period of time is related with the power production W for the same time by:

$$N = \varepsilon A W \qquad (2)$$

where ε is the detection efficiency and A accounts for geometry, detector net volume, etc.

If as it usually takes place the power production is contributed by several fissing isotopes e.g. by uranium-235 and plutonium-239 than the eq.(2) should be modified

$$N = A\,\varepsilon_5\left[1 + (\varepsilon_9/\varepsilon_5 - 1)\frac{W_9}{W}\right]W \qquad (3)$$

where ε_5 and ε_9 are the detection efficiency for $\tilde{\nu}_e$ produced by fission fragments of these isotopes, W_9 is the contribution of plutonium in the total power production.

One readily sees from the eq.(3) that the deviation from linear dependence is due to different sensitivity of the detector to uranium and plutonium neutrino radiation when $\varepsilon_9/\varepsilon_5 \neq 1$. The estimate for VVR - and RBMK - type nuclear plant reactors shows however that when detecting positrons from reaction (1) in the wide energy range the correction term in the square brachets (3) is small (0.03-0.06) and besides it can be estimated by independent data so that the corresponding error is less than 1%.

6. More accurate determination of the reactor power production enables (in the frameworks of the existing calculation programs) more precise determing of the plutonium amount accumulated in the reactor zone. There is however a possibility for the direct determination of the plutonium - accumulation dynamics basing on the essential difference of the plutonium and uranium $\tilde{\nu}_e$-spectra and hence reaction (1) positron spectra in the high-energy region.

In the fig.3 the ratio of the reaction (1) positron spectra in the $\tilde{\nu}_e$ flux from ^{235}U and ^{239}Pu fission is given. One sees that the above-mentioned difference at sufficiently high energies amounts to 2. ^{239}Pu (and ^{235}U) $\tilde{\nu}_e$ spectra used in calculations are obtained from existing data on β-chains of fission products. At present the measurements of uranium and plutonium fragments beta-spectra are in preparation.

In conclusion I would like to list the main participants of the preliminary researches for the neutrino laboratory:
V.F.Apalin, A.I.Afonin, A.Ya.Balysh, A.A.Borovoy, V.I.Kopeikin, V.I.Lebedev, V.P.Martemyanov, A.N.Kheruvimov.

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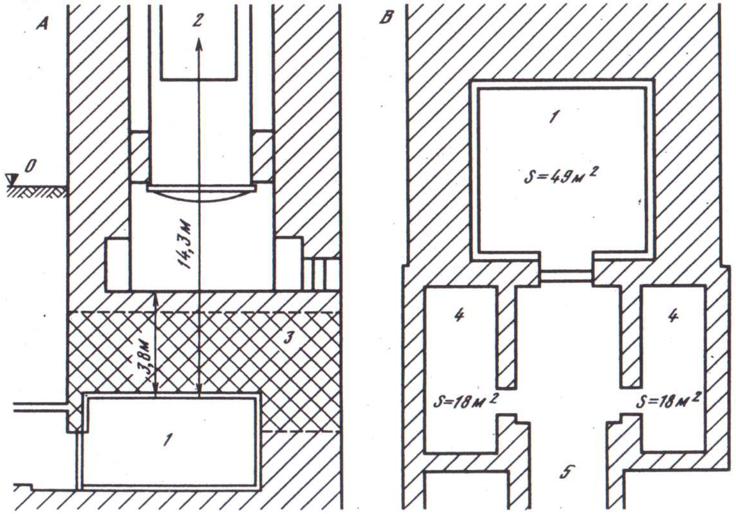

Fig.1. Neutrino laboratory in the atomic plant
A - vertical section, B - plan.
2 - reactor zone
1 - room for detectors
3 - shielding from heavy concrete
4 - room for electronic devices
5 - transport coridor.

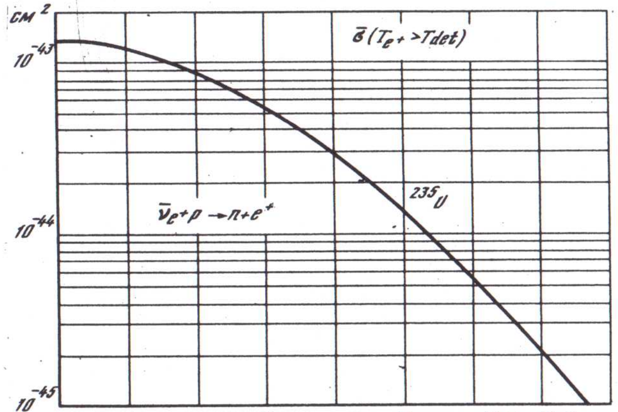

Fig.2. The cross-section of positron production with the kinetic energy exceeding the given value.

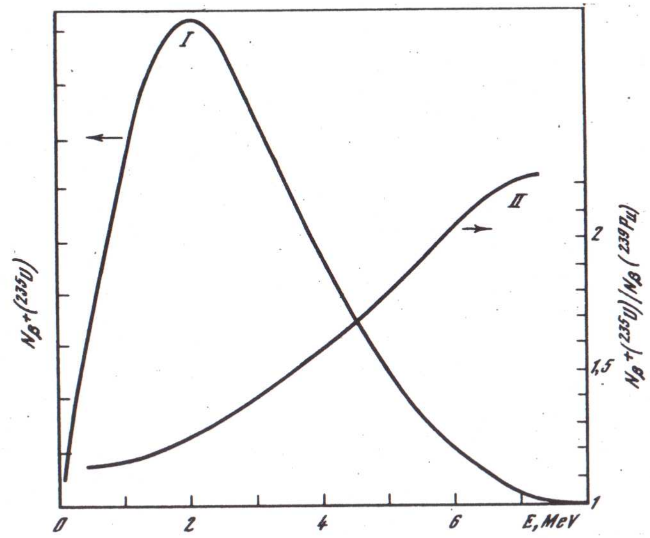

Fig.3. I. Differential spectrum of positrons from the reaction (1) in ^{235}U fission $\tilde{\nu}_e$-flux
II. The ratio of positron differential spectra for ^{235}U and ^{239}Pu.