1-1. Dear colleagues, dear participants of the conference, let me present you a report NEUTRON FLUX ESTIMATION IN THE SPALATION EXPERIMENT AT THE PNPI SYNCHROTRON.

2-1. Before I begin, I would like to mention important event for me that is directly related to our conference.

2-2. This year we marks the 100th anniversary of the birth of my teacher Mikhail Abramovich Listengarten who was the closest assistant to Boris Sergeyevich Dzhelepov, who created this conference.

2-3. The photo was taken in 1944, when Mikhail Abramovich served in the army and defended our country from the fascist invaders.

3-1. My report is devoted to the work that was performed simultaneously with the work of the GNEISS experimental stand and uses part of its equipment.

3-2. The fission of elements by neutrons of different energies is studied at the GNEISS stand.

3-3. An internal synchrotron beam is used as a neutron source, which is periodically directed at a massive lead target.

3-4. A time-of-flight technique is used to determine the neutron spectrum.

3-5. In our experiment, the equipment is located directly under the lead target.

4-1. On the photo is the space under the synchrotron chamber directly under the target, where the neutron moderator and monitors were placed.

5-1. As a neutron source in the experiment an internal target in the form of a lead brick is used to which a proton beam with a proton energy of 1 GeV is periodically directed.

5-2. Above the target is a polyethylene moderator, which is necessary for some experiments.

6-1. The duration of the entire deflected proton beam is – 10 ns at a repetition rate of ≤50 Hz.

6-2. The internal current – 2.3 μA (a maximum value - 3 .3 μA has been reached) and the number of accelerated protons is – 3×10^{11} protons per pulse (1.5×10^{13} per second).

6-3. In the spallation several neutrons are separated from the lead nucleus at once, in this configuration the average value of the multiplicity of neutrons is about 20.

6-4. So this source gives 3×10^{14} neutrons per second in all directions.

7-1. Preliminary calculations before the experiment say that the source provides the necessary neutron flux spectrum and intensity for activation analysis.

7-2. After that, it was decided to test the fluxes for different layers of the moderator experimentally.

8-1. The initial goal of this experiment was to find the optimal moderator configuration for the activation analysis.

8-2. After performing the calculations, conducting the experiment and analyzing the data, it became clear that the application of this installation can be much wider.

8-3. Using various moderator configurations, it is possible to simulate the spectrum of any of the existing nuclear reactors, both those that are being designed, and those that cannot be built at all.

9-1. Directly under the target is a set of rectangular 24-l canisters with light water;

9-2. Thin foils (monitors) are placed between them at the same height and on the same axis;

9-3. After irradiation, the foils are examined using a gamma spectrometer with a HPGE detector.

9-4. This is a very simple and cheap, almost free experiment, if you have a working synchrotron and a gamma-ray spectrometer with an HPGE detector.

10-1. The intensity of the neutron flux at a given point can be determined using pieces of thin foil (monitors) according to the formula:

$$Fluence = \frac{I M_N e^{\frac{\ln 2}{T_{\frac{1}{2}}} t_{lag}}}{\mathrm{mk}\sigma N_A \left(1 - e^{\frac{\ln 2}{T_{\frac{1}{2}}} t_{exp}}\right)}$$

I is the partial activity of the isotope in the monitor, M_N is the mass of the nucleus of the taget in atomic mass units, $T_{1/2}$ – the half-life of the product, t_{lag} – the measurement delay time after the synchrotron stops, t_{exp} – the time of irradiation of the sample in the neutron flux, m—the mass of the sample, k – the product of the content of the corresponding element and the percentage of the parent isotope in it, σ – the cross section of the reaction, N_A – the Avogadro number.

10-2. Масса измерялась при помощи аналитических весов, активность определялась по гамма-спектрам.

10-2. The mass was measured using analytical scales, the activity was determined by gamma spectra.

11-1. We had in the presence of annealed stainless foil, 25 microns thick.

11-2. The composition of this foil was determined by X-ray fluorescence analysis: Fe — 61%; Cr-26%; Ni-7%; Mo-about 6%.

11-3/12. When interacting with thermal and high-energy neutrons, there are many reactions with these elements, but all the products of these reactions are short-lived, and while papers were being drawn up for the transfer of activity from one building to another, only three isotopes remained: Cr-51 and the Mo99/Tc99 pair.

13-1. Since both reactions have a resonant fashion with an energy of several keV, we can only estimate qualitatively the ratio between high-energy and thermal neutrons (in this particular case);

13-2. For the last (fourth) sample, the value of the thermal neutron flux can be estimated ~10^8 n/sec/sm^2.

14-1. We have now conducted experiments with a threshold nuclear reaction, but we have not treatment of the results yet.

14-2. We plane experiment by transmutation of fission products and transuranic elements.

14-3. We suppose that this stand give us possible for new reactions data search.