Current projects and recent results

A computer program for the energy-depended phase-shift analysis (PSA) of the pp-scattering in the energy range from 100 to 1300 MeV was developed. The solution has been found by step-by-step method and corresponds to $\chi^2 = 1.155$ per point at 12841 experimental points. Real part of phase shifts has been varied for states with the orbital momentum up to $L_{max} = 9$, imaginary one up to L = 5. Inelastic thresholds have been chosen for each state separately, and were quite different one from another.

We have analyzed all available experimental data of differential cross sections, total cross sections of elastic and inelastic scattering, polarization parameters, including recent data, got at PNPI and other accelerators.

On base of this analysis was obtained the dependence of spin-dependent amplitudes from proton energy in a whole angular region as well as at 0°. Method and results were published as PNPI laboratory reports and at: “Jadernaja Fizika (Yad. Fiz.)”journal. (YF 2010, v 73,N3, pp.446-458)
Group has developed a new method of measurement of total fission cross sections. It based on the registration in coincidence of both fission fragments by two parallel plate avalanche counters. Measurements have carried out for the wide set of nuclei from gold to plutonium such as ^{197}Au, ^{205}Te, ^{206}Pb, ^{207}Pb, ^{208}Pb, ^{nat}Pb, ^{209}Bi, ^{232}Th, ^{233}U, ^{235}U, ^{238}U, ^{237}Np, ^{239}Pu at the proton energy range 200-1000 MeV.

Obtained results allow us to compare the energy dependence of fission cross section with the nucleon-nucleon one in a proton energy region above pion production threshold. Analysis of the energy dependence of fission cross section was performed. Calculations were made in frame of cascade-evaporation model with a single set of the parameters for all nuclei. Results for actinides are in a good agreement with the experimental points. However, for pre-actinide nuclei: bismuth and lead, the model fails to describe the energy behavior of the cross sections. Therefore, we have made the phenomenological approximation for energy dependence of total cross sections in the 50MeV-30GeV region. Analysis was based on conception two-mode fission by relativistic particles. Calculation revealed that the energy curve for heavy nuclei has two maximums. First maximum, near 50Mev, is associated with the fast direct fission, studied more than 60 years ago. Another maximum is associated with pion production and absorption inside the nucleus and with recoil nucleons after quasi-elastic scattering on nucleons inside nuclei. As a result, fission total cross section energy curve for heavy nuclei, copies energy dependence for nucleon-nucleon scattering, also, exists minimum at 100-200MeV, maximum near 500-600 MeV, than low droop after 1000MeV. Experimental data for actinide fission cross section confirm the above consideration.

Cross section increasing when mass number drops, is termed the “isotopic effect”. It was demonstrated that the isotopic effect for uranium, is (3±1)% per nucleon i.e. 20 – 30 mbrn. For the lead isotopes this effect is 10 times larger than for uranium, because the difference of fission cross section for isotopes of lead is the same 20-30mbrn, but cross section of lead is 10 times smaller than for uranium.

Analysis of the fission cross section for ^{197}Au, ^{203}Tl, ^{209}Bi, Pb-isotopes showed that the isotopic effect exists due to dependence of fission cross sections on fissionability parameter Z^2/A.

Experimental results and data analysis were reported on international conferences and were published in Physical Review C , “JadernajaFizika (Yad.Fiz.)” and “Izvestija RAN (F) (News of RAS (Ph))”.

For more detail review see the article - «**STUDY OF ENERGY DEPENDENCE OF PROTON-INDUCED FISSION CROSS SECTIONS FOR HEAVY NUCLEI IN THE ENERGY RANGE 200-1000 MeV**» - L.A. Vaishnene, V.G. Vovchenko, Yu.A.Gavrikov, A.A. Kotov, V.V. Polyakov, M.G. Tverskoy, O.Ya. Fedorov, Yu.A. Chestnov.

- in PNPI report of the High Energy Physics Division **"Main Scientific Activities 2002-2006"** - page 192).

Presently, group prepares to measure the cross sections of fission the actinides by neutrons with energies 200 –1000MeV. In frame of this project, group designs

a technique for the neutron beam monitoring;

a beam-line to get and transport neutrons with energies 400.1000MeV.