# 2 DEPARTMENT OF NUCLEAR SPECTROSCOPY AND TECHNIQUE



Head of Department: Dr. Jan Sernicki
phone: (22) 718-05-54
e-mail: sernicki@ipj.gov.pl

## Overview

Research activities in our Department in the last year were focused on traditional domains of nuclear physics: heavy-ion reactions and nuclear spectroscopy, but also on medium-energy elementary particle physics, neutrino physics, as well as atomic physics. Along with the group of nuclear and atomic physicists, our Department encompasses a team working on medical physics and another team engaged in ecology and environmental physics.

We maintain our collaboration with FZ Jülich (Germany) continuing experiments on the COSY storage ring, aimed at studying heavy hyperons produced in pp collisions. Recently, evidence for a new hyperon has been obtained.

At PSI Villigen (Switzerland) rare pion- and muon decays have been studied using the large PIBETA detector. The branching ratio for the pion beta decay was measured with six times better accuracy than previously. From the precise measurements of the radiative pion decay the pion axial form factor was evaluated (four times more precisely). Some anomaly, which can not be explained by the Standard Model, was observed in this process.

In the field of neutrino physics, data collected with the T600 module of the cosmic ray detector ICARUS in Pavia (Italy) have been analysed. In collaboration with the Department of Nuclear Theory, conditions to observe the fascinating process of neutrino-less double electron capture were further examined from the point of view of the fundamental question of the neutrino nature and mass.

Our involvement in the CHIMERA/ISOSPIN Collaboration resulted in interesting studies of semi-peripheral nucleus-nucleus collisions at the Fermi energy range. In particular, a new method of determination of the time scale of the emission of intermediate mass fragments was developed.

We continued the collaboration with LBNL Berkeley (USA) and IEP Warsaw University on a theoretical model of the synthesis of super-heavy elements. A comprehensive description of the model with extensive predictions of the production cross sections and optimum bombarding energies for "cold fusion" reactions (used to produce transfermium elements) has been published.

Our nuclear spectroscopy studies concentrated on life-time measurements of low energy levels and high spin states in various nuclei. The experiments were carried out in collaboration with the ISV Studsvik (Sweden), ISOLDE at CERN and with Warsaw University. Nuclear shapes, octupole correlations and other properties of nuclei in excited states have been examined.

Two subjects have been pursued by the high energy atomic physics group. Studies of multiple inner shell ionization in medium Z atoms have been continued in collaboration with groups from the Universities of Fribourg (Switzerland), Toruń and Kielce. Of particular interest are the lifetimes of "hollow atoms" (atoms doubly ionized in the K shell) which were found to be nearly independent of the strong hindrance of the $K_\alpha^h$ transition. The other subject concerns interactions of semi relativistic helium ions with solid targets, studied in collaboration with the RCNP, Osaka. Cross sections for electron capture to the vacant state of $He^{++}$ ions as well as for stripping of the last electron from $He^{+}$ ions were determined for targets ranging from carbon through gold.

The team working on medical physics has developed a method of dose rate anisotropy reduction for X-ray beams produced in the *Photon Needle* generators. The X-ray dose-rate angular distributions have been measured and simulated in Monte Carlo calculations.

The environment protection group of our Department participated in the state-wide system of air sampling stations. Radioactivity measurements of nuclides in the ground level airborne dust were carried out. Filters from the air sampling station in Hornsund (Spitsbergen) are systematically analysed. Measurements of the underground water radioactivity in our institute have also been carried out by the group. In collaboration with local authorities, the group constructed a mobile air sampling station (AZA-400) for suspended dust measurements. The group elaborated and investigated a model of short-time variation of pollutants concentration based on the wavelet analysis algorithms and neural networks method.

No-carrier-added $^{18}F$ fluorine was produced using our C-30 cyclotron for applications in nuclear medicine. Tests of the avalanche photo-diodes, expected to be applied in the PANDA project at GSI Darmstadt (Germany), were continued.