Annex

Information on REC "Pamir-Chakaltaya"

REC "Pamir-Chakaltaya" is an X-ray emulsion chamber of a large area (up to 3000 sq. m.), located at an altitude of 4370 m above sea level (Eastern Pamir, Republic of Tajikistan) and intended for nuclear and astrophysical studies of ultrahigh-energy cosmic rays in a wide range of primary energies (E 0 = 10 ^ 14-10 ^ 18 eV). The registration of cosmic radiation is carried out passively on the X-ray film of the RT-6 brand, the total exposition of which reaches several thousand square meters per year. The manufacturability of the installation and the ease of operation of the REC, which consist of an annual replacement of exposed materials for new ones during a seasonal expedition of a small number (25 people, two-thirds of which are students of local universities), is associated with the availability of autonomous sources of electricity, the use of electric and mechanical installation, vacuum systems for manual laying of lead plates, and also with high quality of construction materials.

Processing and analysis of the experimental material is carried out in laboratory conditions with the help of automatic CCD scanners and semi-automatic photo-densitometry devices using data from detailed computer simulation of the experiment. The high resolving power of the X-ray film and its sensitometric characteristics make it possible to determine the coordinates and angles of arrival of particles with an accuracy of 10 μm, 3 ° and 15 °, respectively. The dynamic range of the measured energies of the electron-photon cascades is three orders of magnitude with a relatively high absolute detection threshold of 2-4 TeV and a relative accuracy in the determination of energy of 20-30%.

The X-ray emulsion chamber (REC) of the Pamir-Chakaltaya experiment, which is a solid track camera located at an altitude of 4370 m above sea level, is intended for nuclear and astrophysical studies of ultrahigh-energy cosmic rays. The setup provides unique information on the characteristics of particles produced in the fragmentation region of the incident hadron at energies that exceed the capabilities of modern collider accelerators. Unparalleled plant parameters - large installation area (up to 3000 m2), high hadron registration efficiency (60-75%) and relatively small thickness of the nuclear target (590 g / cm2), representing the air layer above the chamber, are due to the design features of REC, which uses 1,500 tons of lead rolled products of high purity and precision and 620 tons of carbon-containing materials, as well as a large installation height (4370 m above sea level).

Unique characteristics of the facility allow: a) to study nuclear interactions of hadrons at energies exceeding the capabilities of modern accelerators (E0 = 10-1000 PeV); b) investigate the entire fragmentation region of the incident particle, which is practically inaccessible to modern collider accelerators, in particular, to study spatial and space-energy correlations at particle production; c) already now have 60-70% of the world statistics of ultrahigh energy events recorded in emulsion experiments; d) study the energy spectrum and mass composition of primary cosmic radiation in a wide (4 orders of magnitude) energy region in the region and behind the kink of the primary spectrum; e) to conduct a purposeful search and detailed study of a whole series of new phenomena observed in cosmophysical experiments at energies above ~ 3-4 PeV that do not fit into the Standard Model of Interactions (coplanar production of high-energy hadrons, a long-range component of cosmic rays, events of the centaur type and "Anti-centaur" with an anomalous ratio of charged and neutral components, events with "halo", etc.).

The analogous experimental installations existing in the world (Japan, Bolivia, China, Kazakhstan, Armenia) are considerably inferior in scale and a number of essential parameters to the Pamir-Chakaltaya installation, which causes foreign colleagues' interest in carrying out joint research, which led in the late 1980s to the unification of efforts of Russian, Tajik, Polish, Japanese, Brazilian, Bolivian, Georgian, Kyrgyz and Uzbek physicists in the framework of the joint International Emulsion Experiment "Pamir-Chacalte th ", in which 17 scientific centers took part.

Main directions of scientific research

- study of nuclear hadron interactions at energies exceeding the capabilities of modern accelerators (E0 = 10-1000 PeV);
- refinement of the parameters of phenomenological models of nuclear interactions at ultrahigh energies in the kinematic fragmentation region, which are necessary for accurate determination of the energy transfer efficiency of cosmic-ray cosmic rays of ultrahigh energies deep into the Earth's atmosphere and estimation of the degree of ionization of air masses caused by them;
- study of new processes in the interactions of ultrahigh-energy cosmic ray particles (E0 = 1015-1018 eV), which are not described by the Standard Model;
- study of the energy spectrum, mass composition and anisotropy of primary cosmic radiation in a wide (4 orders of magnitude) energy region in the region and behind the kink of the primary spectrum;
- establishment of the nature of space objects-sources of ultra-high-energy PKL and mechanisms for the acceleration and propagation of PKL;

- obtaining a unique experimental material with data on the angular dependences and altitude variation of the hadron intensity of cosmic rays;
- determination of the length of absorption of hadrons of cosmic rays of ultrahigh energies in the Earth's atmosphere;
- study of regularities and accurate assessment of the energy transfer of PKL into the interior of the Earth's atmosphere and lithosphere;
- conducting interdisciplinary research related to the impact of primary cosmic radiation on global natural processes occurring in the atmosphere, hydro-, litho- and biosphere of the Earth, and in particular, studying the influence of SCL on global climate change;
- forecasting of the state of the earth's atmosphere, taking into account the FL flows;
- assessment of natural risks associated with the impact of CR on the objects of the biosphere, processes of formation of glaciers at mountain heights, thunderstorm activity, seismic activity;
- study of the influence of CR and extreme high altitude conditions on new materials, including the work of semiconductor devices, solar energy installations, strength and durability of polymer materials, etc.

The most important scientific research results

1) Development and refinement of the parameters of the phenomenological model of hadronic interactions based on the mechanism of quark-gluon strings (the CGS model), and also taking into account the production of hard jets for describing the processes of multiple production of particles in the energy region exceeding the accelerating potential;

2) An estimate of the inelastic cross section for the production of hadrons at p14N carbon nuclei equal to 360 ± 40 mb at an energy E0 ~ 1 PeV;

3) Conclusion on the growth of the inelasticity coefficient in the p14N reactions from K = 0.5 at E0 = 1011 eV to K = 0.78 at E0 = 1016 eV;

4) Conclusion on the violation of scaling in the fragmentation region of kinematics at the birth of pions, leading to a steepening of inclusive spectra 2-3 times at x = 0.3 with an increase in energy by 5 orders of magnitude;

5) Estimate of the production cross section for hard quark-gluon jets (sjet = (24 ± 7) with large transmitted transverse momenta ptjet ³ 3 GeV / c and X|F> 0.05;

6) Confirmation of the existence of the Landau-Pomeranchuk-Migdal effect in a lead absorber;

7) Occurrence of unusual events and processes at energies E0 => 10 PeV, evidencing the existence of "new" physics outside the Standard Model: - coplanar emission of the most energetic hadrons and gamma quanta, leading to linear

alignment of the particles on the target diagram; - the processes of multiple production of hadrons with violation of isotopic invariance, leading to the formation of events with an anomalous ratio of charged and neutral components (events such as "Centaurus" and "Anti-Centaurus "); - processes responsible for the generation of events of the "Chiron" type, characterized by the presence of hadron-containing electromagnetic miniclasters and large transverse momenta; - high intensity of events of large multiplicity with "halo", i.e. the region of the increased background energy concentration in the central part of the event, leading to the formation of macroscopic spots of blackening on the X-ray film; - generation of events of large multiplicity and with large transverse momenta, which may indicate the formation of a quark-gluon plasma in the collision of relativistic ultrahigh-energy nuclei;

8) Conclusion on the charmed nature of the "long-range" cosmic-ray component, which characterizes the anomalously weak absorption of hadrons in lead; the cross section for the production of charmed particles should be at least $spp \rightarrow cc > 2,3$ mb at $E0 \sim 75$ TeV.