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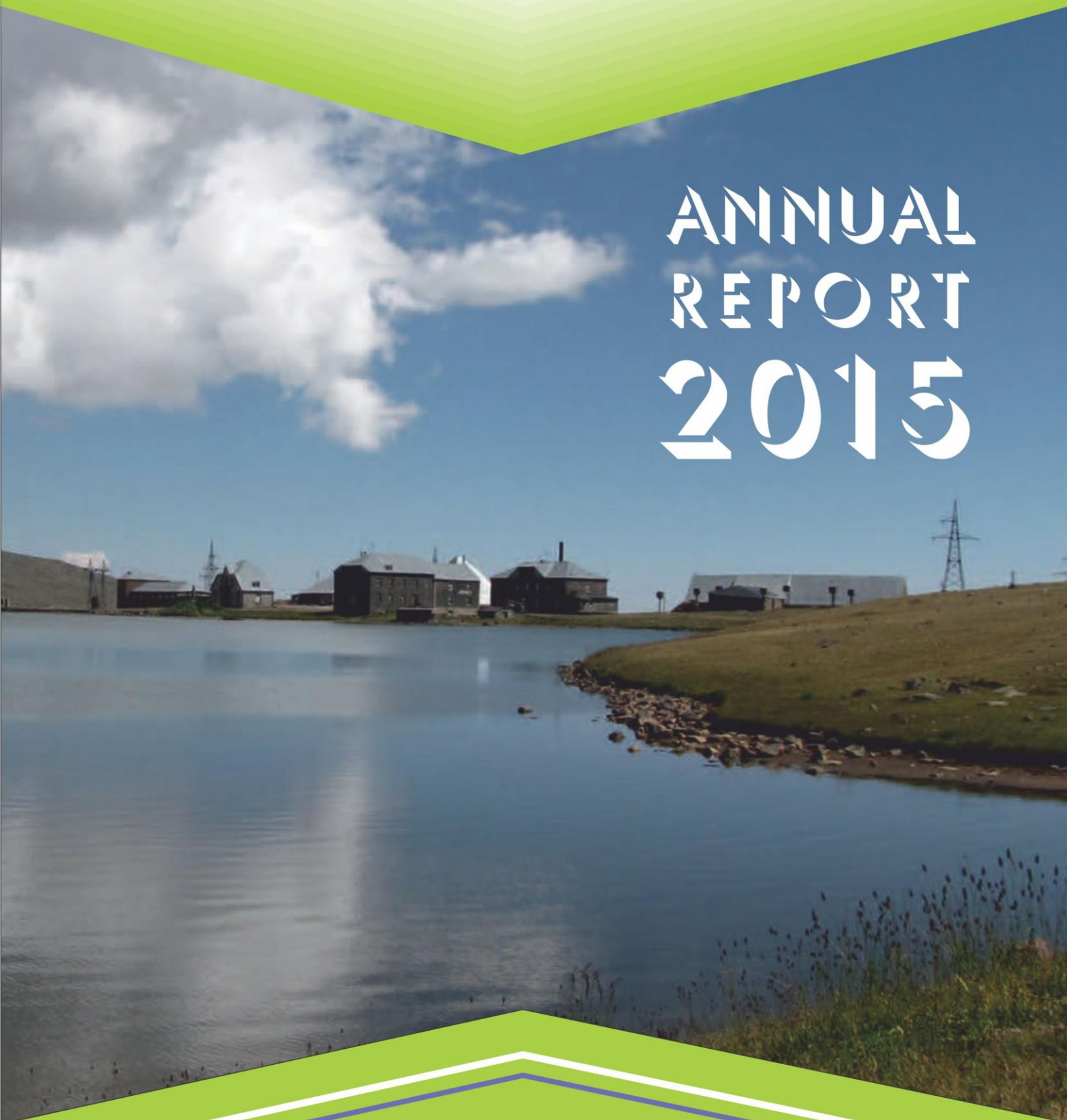
National Laboratory



ANNUAL REPORT 2015

Artem Alikhanyan National Lab (AANL)
Yerevan Phsics Institute (YerPhI)

CONTENT

Annual Report, Artem Alikhanyan National Lab (AANL) 2015

2015 STATUS REPORT

A. Alikhanyan National Laboratory (AANL)
(Yerevan Physics Institute, YerPhI)

1. INTRODUCTION

Vision: *A. Alikhanyan national lab has distinctive expertise and insights relating to high-energy physics and astrophysics, nuclear physics, scientific instrumentations and multivariate data analyses, as well as in education. National lab should serve for the positive influence and impact to national values through research, education and innovation programs. National lab provides opportunities for intellectual, personal and professional growth. Learning and working at national lab will foster high professionalism, quick, well-rounded minds, well equipped to succeed in our fast-changing world.*

Mission: *Perform world-class research in Armenia, participate in world-biggest scientific collaborations, and offer scientific instruments and services for Armenian nuclear medicine, industries and cultural studies. Establish high standards of education in master and PhD courses; demonstrate that science and education can really provide development of Armenia.*

In 2015 the AANL strengthened its scientific activity in traditional scientific directions and increased activity in the high-energy atmospheric physics, create a new department of Informational technologies and continues preparations of experiments in nuclear physics. Cosmic Ray division for the first time establishes relation of particle fluxes from thunderclouds and lightning occurrences on a microsecond time scale. Thus, making significant progress in understanding physical model of Thunderstorm ground enhancements (TGEs), a phenomenon discovered by YerPhI physicists. Experimental physics division physicists started to analyze data from new runs of LHC experiment now operated with central mass energy of 13 TeV. Also experimental physics division's physicists with experts from the Joint Institute of Nuclear research in 2015 perform calibration of CsI crystals to be used in the experiment Mu2e (FNAL, USA). Further calibration tests are dependent on possible JINR funding for modernization of 50 years old linear accelerator. Theory department continue research in traditional topics of phenomenology, quantum field theory and integrable models. Isotope physics department prepare technological infrastructure for obtaining Te isotope with new method using proton beams. Applied physics department continues research of silicon crystals and develops new methods of the accelerator beam diagnostics. New established IT department enlarge computing and networking services for YerPhI departments by installing new servers, new networking equipment and updating operating software. The equipment located in the salt mine was attached to Internet; that gives possibility to start monitoring of particle fluxes also underground.

In addition of 4 projects in nuclear physics in 2015 National committee of science approved 11 new project submitted by the physicists of the National lab on theoretical

physics and experimental physics and astrophysics including for the first time 2 projects on supporting collaborations of YerPhI physicists at CERN and DESY (|see attachment 7).

The program of the innovation projects in 2015 was changed according to past experience. Only after finishing the project and demonstrating results the group can be encouraged.

A novel equipment for the elemental analysis the ARL QUANT'X Energy-Dispersive X-Ray Fluorescence Spectrometer from Thermo Electron Corporation (USA) installed in 2014 was used for analysis of superconductors, archeology materials, concentration of METALS from the UNDERGROUND resources of Armenia and others (see attachment 12).

Number of publications in peer reviewed journals and participation in international forums continue to be high greatly enlarging bibliometric parameters of Armenian science. A new collaboration agreement was signed with DESY on participation of CRD scientists in the European largest astroparticle physics project CTA. New collaboration agreement was signed with National University of Mexico on monitoring of lavas in surrounding Mexico-city volcanoes. Cooperation agreements were renewed with a number of Russian institutions.

Institute seminar actively operates; institute employees presented twenty-one talks and invited lecturers see attachment 5.

Program to support and motivate young scientists was successfully continued; it helped to mitigate aging profile of the AANL. The age structure of institute has improved with employing in 2011-2013 40 master students from Yerevan universities. Some of them enters PhD program in institute, different departments of institute hired some of students. Unfortunately due to overall decay of high education in Armenia number of students in 2013-2015 diminished, we have problems to attract new talents for work in our collaborations in CERN, DESY and Jlab. Number of PhD students and PhD defenses also were less in 2015 comparing with previous years. Master courses started operation in national lab in 2014. Programs were prepared and lectures started to educate students in the field of the experimental high-energy physics and astrophysics (see attachment 11). Emphasis is made on working in labs with particle detectors and electronics, data analysis, writing and presenting reports.

25 students of Yerevan State University and other universities attended the Summer school on Space science. Students attended lectures and labs of national center as well as the Aragats research station. New classes equipped with modern electronics and particle detectors started to operate in education center of national lab.

Directorate of AANL establishes special regulation for hiring new employees by competition and examination. 2 young scientists and 5 engineers were employed in 2015 according to this procedure. Repairing the AANL campus's infrastructures and high altitude research stations was continued. The international conference center in Nor Amberd was

innovatively repaired and now meets stringent international standards for holding workshops and small-scale symposiums. The floor and walls of second and third floors of the administrative building were completely repaired. 4 new rooms were repaired and refurbished at Nor Amberd international conference center; that help to successfully hold TEPA-2015 international symposia. The infrastructure repairs continued: the Building N 4 was attached to water pipe system to have full day water supply.

The Video control and security systems with appropriated software were installed in Nor Amberd and Yerevan that allows firing 10 guards.

There were several drawbacks in 2015. Due to absence of yang physicists and engineers and failure to demonstrate chances to re-operate old synchrotron division of accelerator physics was closed and electron synchrotron was put in conservation regime. Unfortunately, due to delays in nominating the operator of Diagnostic center, the experiments with 18-MeV proton beam of new IBA cyclotron were not started and the State Science Committee postponed 4 projects. The IBA engineers cannot come to put already installed accelerator into operation. Beam is not available and the administrative collapse in diagnostic center is continued.

In spite that directors board each month on special session discussed attendance of YerPhI employees the situation is far of being satisfactory. The overall situation with international collaboration isn't the best one. Jlab employees cannot continue experiments they design and construct due to rejection in US enter visas. The group of 15 qualified physicists lost their intellectual property. Physicists of both CERN and Jlab groups practically are not involved in any other activity in home institution. It once more proves necessity to develop the experimental facilities in Armenia both in accelerator and astroparticle physics. Using opportunity to participate in CERN Recourses Review Meeting RRB-2016 AANL director met with LHC and COMPAS experiments spokespersons. Armenia participation is highly appreciated, however several problems exist: group leaders excessive age, lack of students, rather weak activity of the Armenian scientists in various collaboration commissions and in scientific papers preparation, and absence of special topics where our scientists are among collaborations leaders. For Armenia as developing country is very important to use the possibilities offered by CERN in education, industrial development and innovation. Unfortunately use of these possibilities is far from being satisfactory. CERN collaboration leaders ask to pay more attention to participation of young scientists and students in instrumentation and data analysis. AANL director promise to organize data analysis groups in IT department and support it with new servers and large memory storage and spent for it a part of current AANL contribution to CERN experiments funding.

2. SUMMARY OF THE SCIENTIFIC ACTIVITIES OF AANL DEPARTMENTS

2.1. Experimental Physics

In the reporting period, the research groups of the department have been taking part in the high-energy physics experiments carried out at CERN-LHC. JLAB groups work mostly in Yerevan due to difficulties in obtaining USA entry visas.

After the first two-years-long shutdown of CERN-LHC (Long Shutdown 1: LS1), it is

running again, and for the coming three years, it is planned to provide all the experiments on pp-collision with an unprecedented energy of 13 GeV.

In the CMS experiment, our group continued to work on the investigation and more precise determination of the properties of the newly discovered Higgs boson. In three years of measurements the Higgs bosons mass is found to be 125.09 ± 0.24 GeV, the error being 0.2%. Our group is a participant in finding of the rare B-meson decay into a muon pair – $B_s \rightarrow \mu^+\mu^-$.

For the CMS Phase 2 Upgrade we have developed a method for optimization of the transverse segmentation of the end hadron calorimeter in the pp-collision experiments in the mode of high luminosity of LHC (Pile Up being above ~140).

The ATLAS group continued the processing of the data from 8-TeV proton-proton collisions; in particular, they calibrated the energy of the multi-jet-balance hadron jets and measured their inclusive cross-section. The group's postgraduate student, G. Vardanyan, on June 16 2015 successfully defended his thesis on "Hadron Jets Energy Calibration and Cross-Section Measurement in ATLAS Experiment".

The ALICE group has been a party in the processing of the data. They also took part in the creation and updating of software packages for the experiment. In the ALICE experiment, they continued the processing of the data on the muon pair production in the invariant mass range of $M<1.5\ GeV$ at 8 GeV *pp*-collisions. The functionality of the Grid System of ALICE Experiment has been improved as well as the "File Access Monitoring Service" (FAMoS) software updated.

In 2015, the JLAB Hall A, B, C and D groups continued to take part in the interpretation of the data as well as in the designing of the new equipment. In particular, they took part in the preparation of a coordinate detector to be used in the GEP (proton's electrical form factor) experiment, in the preparation of the high-threshold Cherenkov counter for installation of its mirrors, in the testing of the preshower counter of SHMS magnetic spectrometer and neutral particle spectrometer (NPS). There was developed and proposed a Compton scattering experiment for the study of the generalized proton distribution, GPD. They wrote a computer program for the control of the EPICS IOC servers. They continued the work on creating of software for controlling of the low- and high-voltage power supply units of CEAN and WIENER. The work related to the "Decayed particles spectrometer" and radio-controlled PMTs have been continued. A detailed study of the spectra of the α-decay of the ^{250}Cf and ^{252}Cf nuclei allowed them to estimate the upper limit of the relative probability (as compared to α-decay) for sextaneutron and octaneutron radioactivity of these nuclei to be $4 \cdot 10^{-6}$ and $6.3 \cdot 10^{-7}$, respectively. Using TALYS 1.6, TENDL2014, EMPIRE 3.2 and MENDL2P programs, they computed the excitation functions of the nuclear reactions induced on tungsten targets by the proton beam of C18/18 cyclotron.

Together with the experts from JINR, Dubna, Russia, on the linear electron accelerator of

ANAL, Yerevan, they calibrated the CsI crystals to be used in the experiment Mu2e (FNAL, USA); the low intensity of the 10-40 MeV beam (single electron mode, 10-20 e-/sec, 50 Hz) meets the requirements to the calibration of such crystals. A stretcher design has been considered and method for restoration of magnetron cathodes has been developed.

2.2. Cosmic Ray Physics (CRD)

Recently established high-energy processes in the lower atmosphere, i.e. Thunderstorm Ground Enhancements (TGEs) – sizable long-lasting fluxes of electrons, gamma rays and neutrons detected on Earth's surface continue to be in the center of CRD research in 2015. After measuring energy spectra of the several large TGE events in 2014, Chilingarian, Chilingaryan and Hovsepyan, 2015 use this "gamma ray beams" for the calibration of Cosmsic Ray (CR) detectors. Experiments in CR physics lasting many years and it is very important to keep parameters of particle detectors stable during whole period of measurements. The applied new methodology of the detector calibration does not require additional instrumentation we use the TGEs to monitor the energy threshold of particle detectors. Another application of TGEs is to get clues how lightning is initiated inside thunderclouds. This problem is not only one of the biggest unsolved problems in lightning physics; it is also probably one of the biggest mysteries in the atmospheric sciences. One of most intriguing opportunities opening by observation of the high-energy processes in the atmosphere is their relation to lightning initiation. We consider very interesting TGEs abruptly terminated by a lightning (Chilingarian, et al., 2015). Using these dramatic events CRD physicists try to establish relationship between thundercloud electrification, lightning activity, wideband radio emission and particle fluxes. In another publication appears in the Journal of Geophysics Research summarizing the model of TGE developed of Armenian physicists. Next 2 papers to appear in 2016 are devoted to low energy TGE particles researched in 2015 with network of NaI spectrometers and another exciting topic – relation of Cosmic Rays and lightnings. CRD physicists find ways to connect strong cloud-to-ground lightnings and Extensive Air Showers (EASes) occasionally hitting the clouds and opening the path to lightning leader.

Despite severe weather conditions of 2015 winter particle detectors, field meters, lightning detectors and weather station located on the slopes of Mt. Aragats in Armenia provide work 24/7 whole years. The radio emission detector, installed in September 2014 at Aragats was improved with new high frequency (1 GHz) oscilloscope allowing registering in 2015 the waveform of HF radio emission with temporal resolution of 5ns, and data capture length of 500 ms, this 100 time enhancing the information from atmospheric discharges in atmosphere. In 2015 new Data Acquisition Electronics (DAQ) based on myRio boards from National Electronics Company was installed on Aragats. It already proves proves high effectiveness for the lightning-TGE research. DAQ electronics provides 50 msec time series of count rates of 10 particle detectors. The time stamp from the external trigger provides

synchronization of the particle fluxes and fast waveforms of electric field with an uncertainty of less than of 1 μsec. The dynamics of the TGE events will be registered with all necessary details. For the first time it will be possible to solve long standing problems of the particle-lightning relations:

- Do particle born in the lightning bolt?
- Do lightning follows the path of Extensive air showers (EASes)?
- On which stage of development lightning abruptly ceases the particle fluxes?
- Do particle avalanches from the thundercloud initiate lightning?

Achieved synchronization accuracy will be very helpful in lightning initiation research.

In 2015 in CRD was continued master classes now with 5 students. Electronics and experimental physics classes were equipped with modern electronics purchased from US with aids of "CRD friends" foundation and with help of physicists from Max Plank Institute of Physics, Munich, Germany.

In new repaired Center of International Conferences in Nor Amberd was hold the annual conference on Thunderstorms and Elementary Particle Acceleration – TEPA-2015. Thirty scientists and students from the United States, Japan, France, Germany, Israel, Russia, and Armenia attended. Presentations focused on observations and models of high-energy emissions in thunderclouds; on the termination of particle fluxes by lightning; multivariate observations of thunderstorms from the Earth's surface and from space; radio emissions produced by atmospheric discharges and particle fluxes; the influence of the Extensive Air Showers (EASes) on lightning initiation and others. The workshop participants agreed that it would be useful to compare the vast amount of experimental data on TGEs observed in Armenia, Japan, Slovakia, Russia and USA in various conditions by different particle detectors to check the models of particle origin in thunderclouds. Armenian physicists suggested the location of sensors developed by other groups at Aragats Space Environmental Center (ASEC) where large TGEs are very frequent in spring and autumn.

2.3. Theoretical Physics

Theory Division consists of several small groups, working on different problems of modern theoretical physics. Currently we have 17 doctors of science, 21 Ph.D. and 4 students.

The activities of the members cover a large area from mathematical and theoretical high-energy physics to the condensed matter theory, statistical physics, quantum mechanics and thermodynamics. The main directions of investigations in 2015 were:

Theoretical high-energy physics: phenomenology, quantum field theory and integrable models.

Weak radioactive decays of the B mesons belong to the most important flavor changing processes that provide constraints on physics at the TeV scale. In the derivation of such

constraints, accurate standard model predictions for the inclusive branching ratios play a crucial role. In the current Letter we present an update of these predictions, incorporating all our results for the O(αs2) and lower-order perturbative corrections that have been calculated after 2006. New estimates of nonperturbative effects are taken into account, too. For the CP- and isospin-averaged branching ratios, we find Bsγ=(3.36±0.23)×10-4 and Bdγ=(1.73-0.22+0.12)×10-5, for Eγ>1.6 GeV. Both results remain in agreement with the current experimental averages. Normalizing their sum to the inclusive semileptonic branching ratio, we obtain Rγ≡(Bsγ+Bdγ)/Bcℓν=(3.31±0.22)×10-3. A new bound from Bsγ on the charged Higgs boson mass in the two-Higgs-doublet-model II reads MH±>480 GeV at 95% C.L.

We construct black holes with a Ricci-flat horizon in Einstein–Yang–Mills theory with a negative cosmological constant, which approach asymptotically an AdS d spacetime background (with d≥4). These solutions are isotropic, i.e. all space directions in a hypersurface of constant radial and time coordinates are equivalent, and possess both electric and magnetic fields. We find that the basic properties of the non-Abelian solutions are similar to those of the dyonic isotropic branes in Einstein–Maxwell theory (which, however, exist in even spacetime dimensions only). These black branes possess a nonzero magnetic field strength on the flat boundary metric, which leads to a divergent mass of these solutions, as defined in the usual way. However, a different picture is found for odd spacetime dimensions, where a non-Abelian Chern–Simons term can be incorporated in the action. This allows for black brane solutions with a magnetic field which vanishes asymptotically.

We invoke universal Chern-Simons theory to analytically calculate the exact free energy of the refined topological string on the resolved conifold. In the unrefined limit we reproduce non-perturbative corrections for the resolved conifold found elsewhere in the literature, thereby providing strong evidence that the Chern-Simons / topological string duality is exact, anti in particular holds at arbitrary N. In the refined case, the non-perturbative corrections we find are novel and appear to be non-trivial. We show that non-perturbatively special treatment is needed for rational valued deformation parameter. Above results are also extended to refined Chern-Simons with orthogonal groups.

We study chiral deformations of N = 2 and N = 4 supersymmetric gauge theories obtained by turning on tau(J) tr Phi(J) interactions with Phi the N = 2 super field. Using localization, we compute the deformed gauge theory partition function Z((tau) over right arrow vertical bar q) and the expectation value of circular Wilson loops W on a squashed four-sphere. In the case of the deformed N = 4 theory, exact formulas for Z and W are derived in terms of an underlying U(N) interacting matrix model replacing the free Gaussian model describing the N = 4 theory. Using the AGT correspondence, the tau(J)-deformations are related to the insertions of commuting integrals of motion in the four-point CFT correlator and chiral correlators are expressed as tau-derivatives of the gauge theory partition function on a finite Omega-background. In the so called Nekrasov-Shatashvili limit, the entire ring of chiral relations is extracted from the epsilon-deformed Seiberg-Witten curve. As a byproduct of our

analysis we show that SU(2) gauge theories on rational Omega-backgrounds are dual to CFT minimal models.

Using the thermodynamic Bethe ansatz, we investigate the topological Kondo model, which describes a set of one-dimensional external wires, pertinently coupled to a central region hosting a set of Majorana bound states. After a short review of the Bethe ansatz solution, we study the system at finite temperature and derive its free energy for arbitrary (even and odd) number of external wires. We then analyse the ground state energy as a function of the number of external wires and of their couplings to the Majorana bound states. Then, we compute, both for small and large temperatures, the entropy of the Majorana degrees of freedom localized within the central region and connected to the external wires. Our exact computation of the impurity entropy provides evidence of the importance of fermion parity symmetry in the realization of the topological Kondo model. Finally, we also obtain the low-temperature behaviour of the specific heat of the Majorana bound states, which provides a signature of the non-Fermi-liquid nature of the strongly coupled fixed point.

The magnetic-dipole form factor and the ratios R-EM and R-SM for the gamma*N -> Delta (1232)3/2(+) transition are predicted within the light-front relativistic quark model up to photon virtuality Q(2) = 12 GeV2. We also predict the helicity amplitudes of the gamma*N -> Delta(1600)3/2(+) transition assuming that the Delta(1600)3/2(+) is the first radial excitation of the ground state Delta(1232)3/2(+).We report on the determination of the electrocouplings for the transition from the proton to the N(1675)5/2(-) resonance state using recent differential cross section data on ep -> e pi(+) n by the CLAS collaboration at 1.8 <= Q(2) < 4.5 GeV2. The data have been analyzed using two different approaches, the unitary isobar model and fixed-t dispersion relations. The extracted gamma* p -> N (1675)5/2(-) helicity amplitudes show considerable coupling through the A(1/2)(p) amplitude, that is significantly larger than the predicted three-quark contribution to this amplitude. The amplitude A (3/2) (p) is much smaller. Both results are consistent with the predicted sizes of the meson-baryon contributions at Q(2) >= 1.8 GeV2 from the dynamical coupled-channel model.

The critical two-dimensional Ising model is studied with four type's boundary conditions: free, fixed ferromagnetic, fixed antiferromagnetic, and fixed double antiferromagnetic. Using bond propagation algorithms with surface fields, we obtain the free energy, internal energy, and specific heat numerically on square lattices with a square shape and various combinations of the four types of boundary conditions. The calculations are carried out on the square lattices with size N x N and 30 < N < 1000. The numerical data are analyzed with finite-size scaling. The bulk, edge, and corner terms are extracted very accurately. The exact results are conjectured for the corner logarithmic term in the free energy, the edge logarithmic term in the internal energy, and the corner logarithmic term in the specific heat. The corner logarithmic terms in the free energy agree with the conformal field theory very

well.

2.4 Computational Physics And IT Division

During the reported period the following **routine** tasks were performed:

- Systematic technical support of networking equipment, servers and user workstations;
- day-to-day technical support of VOIP/IP phone service with the full PBX integration for 400 registered service users;
- support of the world-wide Eduroam authentication service;
- Technical support of the workstations and servers of the HERMES/OLYMPUS experiments software packages including ROOT, HMC – HERMES Monte Carlo (digitization of charged tracks), HRC (reconstruction of tracks);
- Consulting of Batch Cluster users.

UPGRADES/UPDATES:

- Upgrade of the Fiber Optic segments of AANL Local area Network. (Aragats, Isotope R&P)
- Redesign the administration of the in-doors networks, change of old switches to the new manageable Laer2 switches;
- additional 20 workstations were added to the AANL network
- Super-Micro 7047GR-TRF server was installed as Primary Worker Node of Butch Cluster. All necessary software packages for TH Physics calculations: "Wolfram Mathematica" GEANT4, CERNLIB, ALPS were installed and tested. Now 10 user accounts are opened and they are regularly running jobs on Butch Cluster
- Wi-Fi network coverage is now extended, including six main YerPhI buildings
- Upgrade the GRID system from EMI-2 to EMI-3 stage. Include of all underlying software, services libraries, etc. with consideration and requirements of ALICE and ATLAS groups. Upgrade of all Grid worker nodes OS, Kernels.

Mailing related activities

- OS upgrade spam control and virus scanning software update
- Increased mail system security checks for spam, phishing and other type of known attacks (added rate limit for ssh authenticated users, etc.).
- The new cloud server running "OwnCloud" software installed for mail user

New services:

Installation of Yerphi and Amberd Buildings Video control and security systems

21 video cameras were installed for five buildings (3 at YerphI area and 2 at Amberd station area).

Appropriate monitoring and video management software was installed at both Amberd

and Yerphi control points. That provides multiple functionalities, including real-time live view, video recording, remote search and playback, file backup, alarm receiving, etc., for the connected devices to meet the needs of monitoring and security task.

Starting from Nov. 2015 **IT** department takes responsibility for full hardware and software support of **CRD** network

- Necessary works to optimize and upgrade the network devices to increase reliability and manageability of CRD Network were started
- Enlarged and refined a failover system related to servers, network switches and services.
- **Sky monitoring** with optical cameras (Like AllSkyCam).

Set up the cameras at Aragats Research Center provided with the appropriate software based on Linux system to get physical phenomena in a visual form for research of lightings and other transient luminous events. The set of scripts were written to connect already installed cameras capture moment with the Electric Field Measurement (EFM) detectors and capture with maximum Frames Per Second (FPS) to decrease the probability of losses of significant visual phenomena.

Activities on computational physics and data analysis.

- Statistical analysis to check the new pseudo-random numbers generator MIXMAX with the use of powerful test like multidimensional Kolmogorov-Smirnov discrepancy tests (under Horizon-20 Project)
- Analysis of the experimental data accumulated by HERMES and OLYMPUS collaborations including massive Monte Carlo studies

2.5. Applied Physics

Department main scientific direction is research of solid state materials with application of high-energy particle irradiation and accelerated particle beam diagnostics:

Luminescence and Absorption Properties of Wide-Gap Materials in Wide Temperature Range

The luminescence and optical properties of Li2MoO4 cryogenic scintillator single crystals grown by different methods have been studied. Absorption and reflection spectra are measured for these materials. The band gap of Li_2MoO_4 is estimated from the analysis of transmission, luminescence excitation and reflectivity spectra.

Luminescence mechanisms in these and similar compounds at low temperatures are explained. Influence of electron and neutron irradiation on defect creation processes is studied in α-Al_2O_3 single corundum crystals grown by two different methods (horizontally oriented crystallization and Vermeil method).

Clusters of Radiation Defect Formation in Electron Irradiated Silicon Crystals

While considerable progress has been achieved in radiation influence on the solid states,

the quantitative assessment of defect production is very scarce. In this report radiation defects studies in silicon crystals are comprehensively analyzed depending on irradiation energy and dose, paying special attention to electron irradiation in wide energy spectrum when crystal lattice disordered regions (clusters) occur. The following results are important from scientific and practical view:

1. Energetic circumstances were analyzed in silicon irradiated by electrons with energy 50 MeV for point and cluster radiation defects creation and energy thresholds were determined about 145 keV and 9-10 MeV, accordingly, while E_d for Fp and cluster formations were estimated: 25eV and 7keV, accordingly.
2. An important parameter in high-energy particle interaction with material atom, the cross- sections of the processes (σ_d) when $E_A \geq E_d$, and $\sigma_{(cl)}$ for formation of clusters $E_A >> E_d$, were determined in silicon: approximately $10^{-24}cm^2$ and $10^{-22}cm^2$, respectively.
3. The role of di-vacancies in cluster formation was emphasized, their quantitative presence in the disordered region was defined which is important for irradiated material characterization.
4. Energetic losses per one 1cm of the incidence particle penetration were determined in silicon irradiated by electrons with energy 50 MeV.

The Influence of Different Type Irradiations on the Surface States Parameters of Si-SiO_2 Structures

The results of experimental research of some effects in metal-insulator-semiconductor (MIS) structures induced by different types of radiation (50 MeV electrons, 12 keV gamma-quanta, 10 and 40 keV arsenic ions) are presented. It is found that there is a significant difference between the characters of radiation surface states (SS) formed by ionization and impact actions of the MIS structure irradiation at the insulator-semiconductor (I-S) interface. It is shown that the SS generation rate is increased in electric fields and depends on the MIS structure field electrode material. In the case of aluminum electrode is higher by a factor of 3-4 than that in the case of Au, Ag, Cu, Ni, Zn.

The study of electrical transport processes in polycrystalline high-temperature superconductors

By measuring the current-voltage characteristics, some electrical transport processes in bismuth- and yttrium-based polycrystalline high-temperature superconductors (HTS) of various compositions are investigated after high temperature treatment in air. Later on, the so-called "ageing effect" is observed in these samples as a dependence of their characteristic parameters on the exposure time. It is found that with increase in the aging time, the normal state resistivity r_n of the yttrium sample changes from the metallic type to semiconductor one. As for the bismuth sample, r_n reveals a transition from weakly to strongly expressed semiconductor type is observed. For the bismuth sample, the resistivity, depending on the transport current (on the self-magnetic field) shows "negative" electrical resistance, which is

determined to a large extent by both the initial impurity content of the sample and the measuring temperature. The results of X-ray diffraction and electron microscopic studies have shown that increase in the boron atom concentration in bismuth samples actually leads to both increase of the volume proportion of high-temperature superconducting phase and semiconducting phase, which is accompanied by the grain size change.

The study of the number of different microbes in extreme growth conditions

During the reporting period the key experiments on the influence of insecticide actara and separately its active component: neonicotinoid thiamethoxam on a growth of the number of strains were carried out. To provide the authenticity of the results the carefully washed agar-agar for preparation of the nutrient media was used. The data obtained previously were confirmed, and maximum permissible concentrations of thiamethoxam, in the presence of which strains, which are susceptible to it, still able to grow were verified.

Charged Particle/Photon Beam Transversal Profile Diagnostics

Two types of neutron monitors with fine spatial resolutions are proposed based on vibrating wires. In the first type, neutrons interact with a vibrating wire, heat it, and lead to the change of its natural frequency, which can be precisely measured. To increase the heat deposition during the neutron scattering, the use of gadolinium layer that has the highest thermal neutron capture cross-section among all elements is proposed. The second type uses the vibrating wire as a “resonant target.” Besides the measurement of beam profile according to the average signal, the differential signal synchronized with the wire oscillations defines the beam profile gradient. The main advantage of the proposed instruments is that they allow measuring profiles of thermal neutron fluxes with excellent spatial resolutions. At the same time, they are simple, robust, and radiation-resistant devices that can operate in difficult conditions. It is important to note that properly constructed vibrating wire monitors have inherent long term stability, negligible zero drift, high precision and resolution, good reproducibility, and small hysteresis. Vibrating wire monitors produce frequency signals that are interference-protective and can be transmitted over long cables without loss or degradation. Taking into account that monitors cancovera wide range of neutron beam flux intensities, one can confidently state that the proposed vibrating-wirebased neutron monitor scanbe wide lyusedinall applications of neutron beams. Further, small- scale monitors maybe used in the field of nuclear safetya portable, high-speed environmental monitor.

A new type of wire scanner for beam profile measurements, based on the use of a vibrating wire as a scattering target is proposed. Synchronous measurements with the wire oscillation allow to detect only the signal coming from the scattering of the beam on the wire. This resonant method enables fast beam profiling in the presence of a high level of background. The developed wire scanner, called resonant target vibrating wire scanner, is applied to photon beam profiling, in which the photons reflected on the wire are measured

by a fast photodiode. In addition, the proposed measurement principle is expected to monitor other types of beams as well, such as neutrons, protons, electrons, and ions. The main advantage of the proposed resonant target vibrating wire scanner is the significant decrease in the scan time compared with the previous models of the vibrating wire monitor, in which the beam profile signal was obtained from the precise measurements of the vibrating frequency shift caused by changes in the equilibrium temperature.

For beam 2D-profile reconstruction filtered back-projection algorithm for recovering of complex proton beam profile by mean of vibrating wire monitors is proposed. Method is based on the set of projections correspond to different angles. First experimental results are obtained by new type of wire scanner, based on the use of a vibrating wire as a scattering target. The time for each scan is less than 100 ms

2.6. Isotope Investigation and Production

An alternative way of accelerator production of ^{99m}Tc on cyclotrons for medical purposes is under active consideration in recent years in the world. The technique of direct production (bypassing the intermediate phase of the parent ^{99}Mo isotope) of ^{99m}Tc on cyclotron proton beams is actively developed in many scientific centers in recent years.

This method promised to be successful especially taking into account a huge number of medical cyclotrons around the world. The serious technology problems for powdered molybdenum use as target material, expensive enriched ^{100}Mo recovery for multiple times irradiation, high power target module extensive cooling requirement should be resolved. Technologies of above mentioned procedures have been developed to provide higher efficiency of ^{99m}Tc direct production.

The C18 cyclotron (produced by IBA, Belgium) is in the stage of installing in the Isotope Production Center in Armenia. An appropriate technology of ^{99m}Tc production on its proton beam has been developed at the National Science Laboratory after. A. Alikhanyan (Yerevan Physics Institute). There is an opportunity to develop the technology of ^{99m}Tc direct production using parallel beam from that cyclotron. Three tasks of that activity namely Mo target preparation technology development, target cryogenic cooling and Molybdenum recovery for multiple uses were investigated during 2015.

Mo target preparation technology development.

For irradiation of solid targets in the standard specification of the C18 cyclotron a targets module is used, in which the target itself is fixed by pneumatic clamps. During the irradiation, the target is cooled by a helium flow on the front side and by a water stream under a pressure of about 8 bars on the rear side. The target itself is a metallic disk with a central deepening in which the material for irradiation is located.

^{100}Mo or natural molybdenum ^{nat}Mo fine powder is used as material for irradiation in order to produce ^{99m}Tc. It is required to make a solid disk from the powder to place it in the target area. We have developed a natural molybdenum powder compression method using a press that can exert a force of ~40000 N. The increase the mechanical durability, we have developed a tablet surface burning method using a focused laser beam. The molybdenum powder is melted in trace of laser, creating a solid strip of molybdenum with a width of a few hundred micrometers. After such processing, the mechanical strength of tablets should increase. The reason for such an increase is that the melted stripes of metallic molybdenum on the surface of the tablet play the role of steel fittings. For objective estimation of such assumption, a device for the measurement of the relative strength of tables is made. The strength of tablets was measured with and without processing. The mechanical strength increased more than 1.5 times after laser treatment. The developed technique of laser treatment of the surface of compressed molybdenum powder tablets can be used to make real solid targets for irradiation by proton beam of the cyclotron.

Using the above-mentioned technique the disk targets were made. The fine powder of natural molybdenum was compressed in the central part of the disc. Further, to increase the surface strength of the molybdenum pressed in the center of the target disk, its surface was treated similarly as in case of individual tablets. As a result the mechanical strength and thermo conductivity of Mo increased dramatically and will utilize higher proton beam intensity during irradiation.

Cryogenic cooling

As it was mentioned above the NIRTA solid target technology provides the target cooling by a helium flow on the front side and by a water stream under a pressure of about 8 bars on the rear side during the irradiation. That provides around 500 W thermal power utilization which means for beam energy Ep=18 MeV the maximum intensity Ip~30 μA while the C18 cyclotron could provide up to 100 μA. One of the ways to increase the cooling efficiency is to decrease the temperature of cooling element dramatically – e.g. up to liquid nitrogen temperature.

The ideology of that is the following. The thermal stream is an equivalent of electric current in Ohm's low. While our task is increasing the thermal stream for better cooling there are only 2 ways namely to increase the thermal conductivity or to increase the potential is equivalent of difference between warm and cold parts. Because development of thermal conductivity is limited due to powder consistence the only way is increasing of difference between heated target and cooler. The liquid nitrogen could be a good alternative to simple water cooling.

For that a test layout has been mounted using solid state CW laser with wave length 1.06 μm. The laser beam with a maximum power 50 W was directed to the front face of target prepared from Mo pressed powder. The temperature of face was measuring by infrared

thermometer - pyrometer.

Test shows the following results.

1. Without cooling the face temperature of target under laser heating is rising up in the time and achieves the plateau with value of 500 degree centigrade.
2. While liquid nitrogen cooling has been on the face temperature of target under laser heating is rising up in the time and achieves the plateau with value of 320 degree centigrade.
3. No cooling has been applied directly to the front of target.

Resume of this test is the following:

1. This was simply qualitative test to show that cryogenic cooling could work in general.
2. The effective cooling decreases the temperature of target front for 180 degrees centigrade (from 500 to 320 degrees centigrade – for about 1.5 times).
3. The simulation of heating by means of laser beam is not absolutely correct because during irradiation under proton beam the evolution of heat takes place along the beam direction on whole length while under irradiation under laser beam it happens only on the very thick slice of target. So the way of thermal stream in the second case is much longer and total thermal resistance is higher. It can suggest that under proton beam the efficiency of cryogenic cooling would be higher.

Preliminary estimation shows that for such a cooling will spent 5-7 liter of liquid nitrogen per hour which is a good price for more effective cooling and therefore much more output of final product.

These investigations should be continued under CO_2 laser beam with a maximum beam power up to 500 W.

X-Ray Instrumentation

Investigation of influence of gamma radiation to YAG и YAG:Ce (Ce~0.12 и~0.2%) crystals spectral properties. Crystals were irradiated under ^{60}Co source with 3 different dosages namely (1.13, 3.10 and 5.50 x 10^7rad) with rate 28 rad/s.

All activity has been done under state scientific budget and CRP IAEA Research Contract No: 18029 Research Project title -'Technetium 99m Production Using Proton Beam from C18 Cyclotron', the Chief Scientific Investigator - Dr Avetisyan, Albert. Results were reported in 3 international conferences, 5 articles have been published.

2.7. Center for Cosmology and Astrophysics

The studies were focused on the following main directions (details in: http://cosmo.yerphi.am)

1. PLANCK satellite detecting galactic haloes and point sources;
2. LARES satellite: obtaining of the accurate parameters of the orbit;

3. dynamical systems: advanced numerical methods for description of the evolution of perturbed Hamiltonian systems;
4. conformal cyclic cosmology and time arrow;
5. statistical features of coding and mutations in genomic sequences;

Published in 9 journal papers (including 4 in journals with impact factor > 5) and in 2 proceedings papers.

Letter-of-intent has been submitted to *Jefferson National Laboratory* "Compton Edge probing basic physics at JLab: light speed isotropy and Lorentz invariance" by V.Gurzadyan, D.Gaskell, C. Keppel, A.Margaryan, D. Dutta, B. Vlahovic, S.Wood. JLab's Program advisory committee (PAC43) "encourages the submission of a full proposal."

PLANCK. The halos are the least studied subsystems of spiral galaxies as compared to their other substructures (disk, spiral arms, bulge, bar), also the parameters of halos are important for the recovering of the structure formation during the cosmological evolution. Using the Planck microwave data the halos have been detected for two nearby galaxies (2 papers in *Astronomy & Astrophysics,* impact factor = 5.084*).*

Planck data towards the active galaxies Centaurus A and M82 were analyzed in the 70, 100 and 143 GHz bands. It was found that a temperature asymmetry of the northern radio lobe with respect to the southern one that clearly extends at least up to 5 arc degree from the Cen A center and diminishes towards the outer regions of the lobes.

For M82 a substantial temperature asymmetry was found, extending up to 1 arc degree from the galactic center. Being almost frequency-independent, these temperature asymmetries are indicative of a Doppler-induced effect regarding the line-of-sight dynamics on the halo scale, the ejections from the galactic center and, possibly, even the tidal interaction with M81 galaxy. Planck's LFI 70GHz data have been used also to further probe the point source detection technique in microwave sky maps. The method developed by Tegmark et al. for foreground reduced maps and the Kolmogorov parameter as the descriptor were adopted for the analysis of microwave data. Most of the detected points coincide with point sources already revealed by other methods, however, 9 source candidates still no counterparts are known.

LARES. The LARES satellite was successfully launched in 2012 for tests of General Relativity and gravitational physics including the accurate measurement of frame-dragging. It is currently very well observed all over the world by the stations of the International Laser Ranging Service. Its preliminary orbital analysis show that LARES behaves as the best test particle today available in the Solar system to perform a geodesic motion of General Relativity. On the basis of a test using the first period of observations of LARES, it was concluded that LARES, together with the LAGEOS and LAGEOS 2 satellites, provides high accuracy preliminary results.

Dynamical systems. Extensive N-body simulations are among the key means for the study

of numerous astrophysical and cosmological phenomena, so various schemes are developed for possibly higher accuracy computations. We demonstrated the principal possibility for revealing the evolution of a perturbed Hamiltonian system with an accuracy independent on time. The method is based on the Laplace transform and the derivation and analytical solution of an evolution equation in the phase space for the resolvent and using computer algebra.

The developed method enabling one to investigate the evolution of dynamical systems with an accuracy not dependent on time was then developed further. The classes of dynamical systems which could be studied by that method are much extended, now including systems that are; (1) non-Hamiltonian, conservative; (2) Hamiltonian with time-dependent perturbation; (3) non-conservative (with dissipation). These systems cover various types of N-body gravitating systems of astrophysical and cosmological interest, such as the orbital evolution of planets, minor planets, artificial satellites due to tidal, non-tidal perturbations and thermal thrust, evolving close binary stellar systems, and the dynamics of accretion disks (2 papers in *European Phys. J. C. ,* impact factor=5.436).

Conformal cosmology. Within the scheme of conformal cyclic cosmology information can be transmitted from aeon to aeon. Accordingly, the Fermi paradox as a search of non-random subsignals within the generally Gaussian CMB signal has been examined from a novel perspective, as an information encoded in the cosmic microwave background. The current empirical status of CCC has been also discussed.

Genome coding. The Kolmogorov–Arnold stochasticity parameter technique was applied for the first time to the study of cancer genome sequencing and to reveal mutations. Using data generated by next-generation sequencing technologies, the exome sequences of brain tumor patients with matched tumor and normal blood were analyzed. It was show that mutations contained in sequencing data can be revealed using this technique, thus providing a new methodology for determining subsequences of given length containing mutations. A potential application for this technique involves simplifying the procedure of finding segments with mutations, speeding up genomic research and accelerating its implementation in clinical diagnostics. Moreover, a prediction based purely on the value of the Kolmogorov function indicates that this marker may detect mutations of extremely low abundance and reveal new types of mutations (published in *Royal Society Open Science).*

Talks at conferences, seminars at several Universities, as well as lectures in series *Frontiers of modern physics* and *ANNL Summer school* have been delivered.

3. IMPROVING THE AGE STRUCTURE OF THE AANL

The administrative structure of AANL after intense hiring of master students in 2011-2015 was significantly improved. Total number of employees above 70 years is 15; below 35 years – 70. See, age distribution in Figure 1 and Table 1. The employee age based Key

performance indicators (KPI, see attachment 2) equals K = N <35 / N>70 = 70/15 = 4.6.

Before major modernizations this number was below 1.

Overall number of employees decreases from 2009 to 2015 by 158 persons: 499 in 2009, 416 – in 2013, 367 – 2014. 341 – 2015.

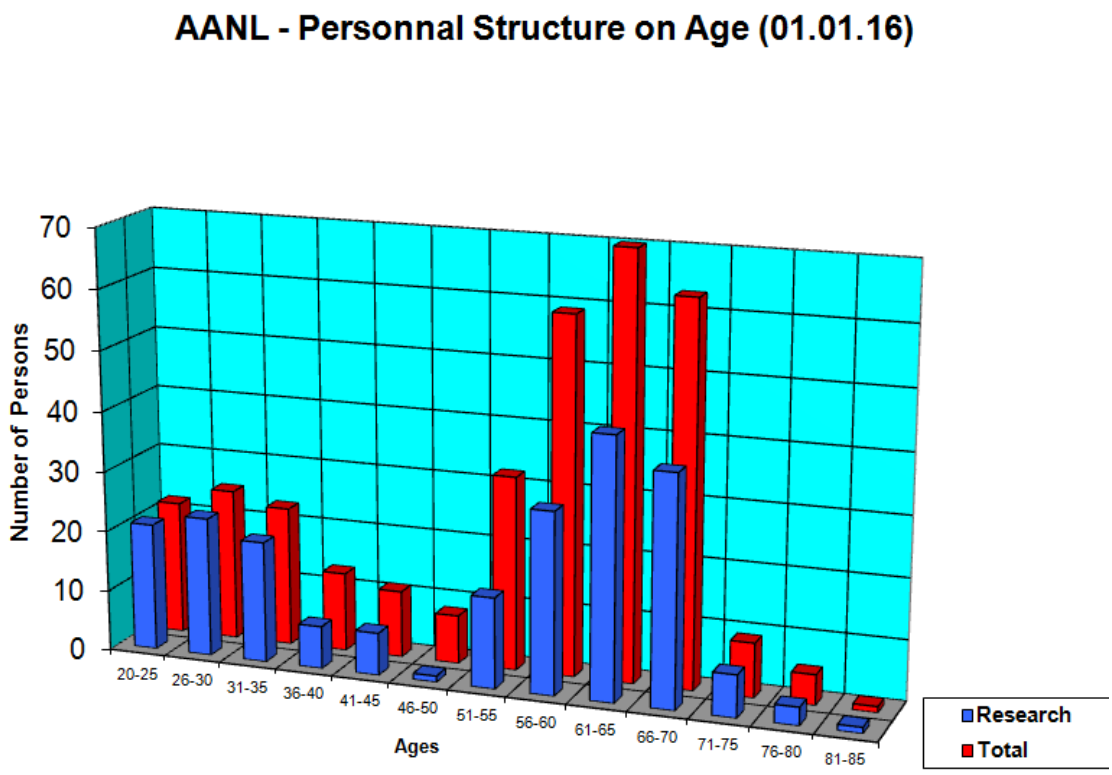


Figure 1. AGE distribution of the AANL employees

PERSONAL STRUCTURE OF AANL ON AGE
(as of 01.01.2016)

№ n/n	Division (department, service)	Breakdown on age												TOTAL (person)
		till 35 years	36-40 years	41-45 years	46-50 years	51-55 years	56-60 years	61-65 years	66-70 years	71-75 years	76-80 years	81-85 years	over 86 years	
1	Directorate	1	0	0	0	0	0	0	3	0	0	0	0	4
2	Administration	5	0	2	0	5	4	3	5	0	1	0	0	25
3	Experimental Physics Divizion	22	2	1	0	4	11	15	12	5	1	1	0	74
4	Theoretical Physics Divizion	13	2	1	0	6	7	7	4	1	0	0	0	41
5	Cosmic Ray Division	7	4	2	2	0	7	11	11	0	0	0	0	44
6	Computational physics and IT division	6	0	1	0	1	1	1	1	0	0	0	0	11
7	Applied Physics Department	3	0	0	0	1	3	8	4	0	1	0	0	20
8	Isotope Research and Production Department	6	0	0	0	1	2	4	4	1	0	0	0	18
9	Cosmology and Astrophysics Centre	4	0	0	0	0	1	0	0	0	0	0	0	5
10	Industrial and household services	2	4	4	3	11	15	14	12	2	2	0	0	69
11	Security guard	1	1	0	3	3	8	7	7	0	0	0	0	30
	IN TOTAL:	70	13	11	8	32	59	70	63	9	5	1	0	341

Table 1. Breakdown on age as it is on 1.04 2015

4. AANL PUBLICATIONS AND CITATIONS

Government administrators need reliable and comprehensive bibliometrics to measure and promote unique strengths of scientific and educational institutions, understand opportunities for improvement and collaboration, as well as monitor their progress.

The mission of A.Alikhanyan national laboratory as it was declared in its strategic plan is to perform world-class research in Armenia in the field of high-energy particle physics and astrophysics, in theoretical physics and material science. To achieve these goals scientists of the national laboratory perform sophisticated experiments on own experimental facilities and participate in world's biggest scientific collaborations. In the future will be offered scientific means and services for Armenian nuclear medicine, industries and cultural studies. Established high standards of education in PhD program that are offered by national laboratory scientists demonstrate that science and education can really promote development in Armenia.

A. I. Alikhanian National Science Laboratory (Yerevan Physics Institute) in recent years has significantly enhanced its status as a leader in the science of Armenia.

Number of articles published in peer review journals by YerPhI annually is the more 35% of the country's overall published articles and what is more essential according Thomson Reuters prestigious journal over 76% of citations of Armenia's scientific results goes to YerPhI. The institute for its international recognition of its scientific potential and the scope and quality of work occupies a special place in the unique research infrastructure of the organization that proposes ways to develop science and science-based technologies in various fields of modern physics.

According to the international standards, the journals classified by the Thomson Reuters (Web of Science) should be used both for counting publications and citations. In Table 1 we put the all-Armenia and YerPhI citations and publications from 2008 till 2015 years.

Year	2010		2011		2012		2013		2014		2015	
	Pub.	Cit.	Pub.	Cit.	Pub.	Cit.	Pub.	Cit.	Pub.	Cit.	Pub.	Cit.
Armenia	**700**	**4800**	**750**	**7000**	**910**	**11100**	**820**	**13200**	**810**	**14000**	**900**	**15600**
YerPhI	**160**	**3000**	**230**	**4700**	**325**	**8400**	**290**	**9800**	**270**	**10200**	**301**	**11000**

%	23%	63%	31%	67%	36%	76%	35%	74%	33%	73%	33%	70,5%

We can see from the Table 1 that in recent years, the growth rates of Armenia is mainly due to Yerevan Physics Institute scientists' impressive results.

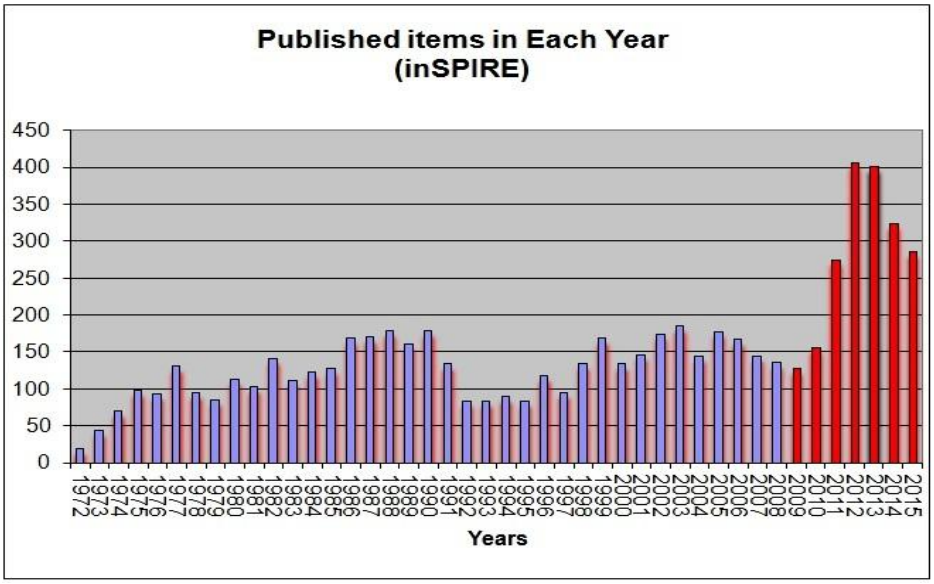


Figure 1. Distribution of the published papers in peer review journals, inSpire

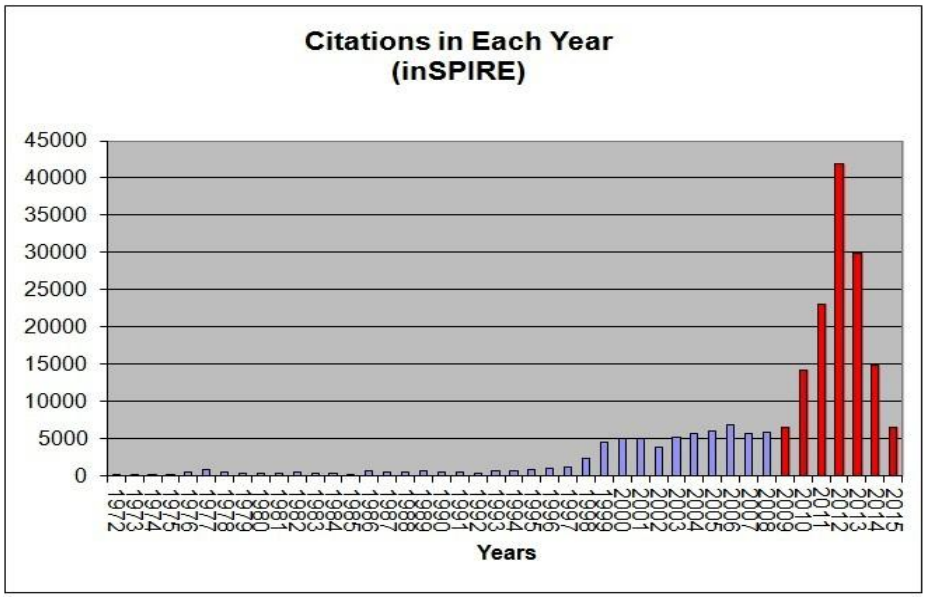


Figure 2. Number of citations to the national lab employee`s papers, inspire

5. AANL SCIENTIFIC COUNCIL MEETINGS, SEMINARS, PHD DEFENDS, BUSINESS TRIPS, AGREEMENTS

In 2015 AANL Scientific Council held 8 meetings. In 2015 AANL`s Professional Council # 024 listed and approved 2 PhD theses, the titles of which are presented in the attachment 4.

In 2015 AANL`s seminars were very active, see the list in attachment 5.

Among 85 business trips made by AANL employees in 2015: 23 were to CERN/DESY/JLab according to program of mutual research, 18 – participation in conferences, summer schools.

New agreements for the joint research were signed in 2015 with a number of international and Armenian institutions, see the list in attachment 6.

6. AANL BUDGETARY ISSUES

Table 2. National lab income from state, own profits and international grants

YERPHI INCOME **ԵՐՖԻԻ ԵԿԱՄՈՒՏՆԵՐ**	**2015;AMD; 1$=477.83AMD**	**2014;AMD; 1$=415.65AMD**	**2013;AMD; 1$=409.03AMD**
Base funding **Բազային ֆինանսավորում**	**835,500,000** AMD **1,748,500$**	**752,000,000** AMD **1,809,200$**	**808,300,000** AMD **1,976,200$**
Scientific conf. Գիտաժողով	2,340,000 AMD 4,900$	-	5,488,000 AMD 13,420$
Project funding Թեմատիկ ֆինանսավորում	73,158,800 AMD 153,100$	73,317,600 AMD 176,400$	41,807,800 AMD 102,200$
DESY	30,450,000 AMD 63,73$	31,687,400 AMD 76,20$	38,530,000 AMD 94,20$
ISTC	-	-	24,460,800 AMD 59,800$
Applied radiation processing	-	1,302,000 AMD 3,100$	7,955,500 AMD 19,450$
Rent of space Տարածքի վարձակալություն	30,419,000 AMD 63,660$	29,710,600 AMD 71,500$	30,865,000 AMD 75,460$
Sales Վաճառք	3,050,000 AMD 6,400$	94,497,200 AMD 227,300$	12,402,000 AMD 30,320$
YERPHI INCOME	**2015;AMD; 1$=477.83AMD**	**2014;AMD; 1$=415.65AMD**	**2013;AMD; 1$=409.03AMD**

ԵՐՖԻԻ ԵԿԱՄՈՒՏՆԵՐ			
Other Այլ	25,538,000 AMD 53,450$	21,765,800 AMD 52,400$	20,639,500 AMD 50,460$
Base +project **Ընդ. Բյուջեից**	**911,000,000** AMD **1,906,500$**	**825,300,000** AMD **1,985,600$**	**855,600,000** AMD **2,091,800$**
Own profits **Ընդ. սեփական եկամուտ**	**89,457,000** AMD **187,220$**	**178,963,000** AMD **430,600$**	**134,852,600** AMD **329,700$**
State + own **Ընդ. Բյուջե + սեփական**	**1,000,450,000** AMD **2,093,750$**	**1,004,300,000** AMD **2,416,100$**	**990,400,000** AMD **2,421,300$**

Table 3. National lab expenditures

YERPHI EXPENDITURES **ԵՐՖԻԻ ԾԱԽՍԵՐ**	**2015;AMD; 1$=477.83AMD**	**2014;AMD; 1$=415.65AMD**	**2013;AMD; 1$=409.03AMD**
Salary Աշխատավարձ*	625,287,000 AMD 1,308,600$ (65.3%)	632,714,800 AMD 1,522,230$ (62.0%)	590,653,400 1,444,030$ (66.0%)
Electricity Էլեկտրաէներգիա	69,875,000 AMD 146,230$ (7.3%)	65,659,000 AMD 157,970$ (6.4%)	43,471,000 AMD 106,280$ (4.9%)
Gas Գազ	21,865,400 AMD 45,760$ (2.3%)	18,271,200 AMD 43,960$ (1.8%)	12,487,000 AMD 30,530$ (1.4%)
Phone Հեռախոս	2,893,000 AMD 6,050$ (0.3%)	3,594,000 AMD 8,650$ (0.3%)	2,629,000 AMD 6,430$ (0.3%)
Water Ջուր	11,746,000 AMD 24,580$ (1.2%)	13,087,000 AMD 31,480$ (1.3%)	9,386,000 AMD 22,950$ (1.0%)
Internet Ինտերնետ	1,826,000 AMD 3,820$ (0.2%)	3,692,000 AMD 8,900$ (0.4%)	4,620,000 AMD 11,300$ (0.5%)
Taxes Հարկեր	34,473,000 AMD 72,140$ (3.6%)	21,972,600 AMD 52,860$ (2.1%)	21,117,000 AMD 51,630$ (2.4%)
Business Travel Գործուղում	34,685,900 AMD 72,590$ (3.6%)	40,083,000 AMD 96,430$ (3.9%)	44,119,600 AMD 107,860$ (4.9%)

Fuel Վառելիք	10,415,500 AMD 21,800$ (1.1%)	13,805,800 AMD 33,210$ (1.3%)	9,800,000 AMD 23,960$ (1.1%)
Materials and equipment Նյութեր և սարքավորումներ	95,985,700 AMD 200,880$ (10.03%)	144,525,200 AMD 347,700$ (14.1%)	84,242,000 AMD 205,950$ (9.4%)
Capital & current repairs Կապիտալ և ընթացիկ վերանորոգում	14,433,000 AMD 30,210$ (1.5%)	19,587,500 AMD 47,120$ (1.9%)	26,868,000 AMD 65,680$ (3.0%)
Fees Անդամավճար	-	20,000,000 AMD 48,100$ (1.9%)	15,962,000 AMD 39,000$ (1.8%)
Scientific conf. Գիտաժողով	2,340,000 AMD 4,900$ (0.2%)	-	5,488,000 AMD 13,400$ (0.6%)
Other Այլ ծառայություններ և ծախսեր	31,213,500 AMD 65,330$ (3.3%)	29,079,300 AMD 69,960$ (2.8%)	24,106,000 AMD 58,900$ (2.7%)
Total **Ընդամենը**	**957,037,000** AMD **2,002,890$**	**1,026,071** AMD **2,468,600$**	**894,949,000** AMD **2,188,000$**

The remainder on 01.01.15 was M111, 267.000 AMD, on 01.01.16– M154, 686.5000 drams

The AANL budget is more or less stabilized in last 4 years. Huge losses due to finishing of international grants support (mostly ISTC and CNCP) were compensated by the RA funding.

AANL scientists are making efforts to win scientific grants (RA thematic funding and "best" scientists awards). Own profits of AANL are only ~15% of RA funding however there is tendency of rise. There is also tendency to allocate lager portion of funds to employee salaries in promised attempt to enlarge mean salary and make it close to mean salary in RA. Apparent growth of mean month salary was achieved reaching ~142,000 drams. Along with enlarging of mean salary the fraction of funds spent for equipment and materials also rose reaching 16% of budget. Communal expenses also are stabilized on the level of 8%. Simultaneously the quality of water supply, Internet speed, phone connections and other is significantly improved in 2015.

ATTACHMENT 1. Strategic Plan for A.Alikhanyan National Laboratory (Yerevan Physics Institute)

Executive summary

The Strategic Plan of the A.Alikhanyan National Laboratory aimed at the declaring the mission of the national lab, developing of increased laboratory capacity; requiring policy adoption and strategic planning and implementation of activities appropriate for Armenia.

The development of laboratory capacity within Armenia is a long-term endeavor, which requires the support of the government and industry, as well as in- country stakeholders, multilateral agencies, donors, the private and public sectors, communities, and others.

Vision: A. Alikanyan national lab has distinctive expertise and insights relating to high-energy physics and astrophysics, nuclear physics, scientific instrumentations and multivariate data analyses, as well as in education. National lab should serve for the positive influence and impact to national values through research, education and innovation programs. National lab provides opportunities for intellectual, personal and professional growth. Learning and working at national lab will foster high professionalism, quick, well-rounded minds, well equipped to succeed in our fast-changing world.

Mission: Perform world-class research in Armenia, participate in world-biggest scientific collaborations, and offer scientific instruments and services for Armenian nuclear medicine, industries and cultural studies. Establish high standards of education in master and PhD courses; demonstrate that science and education can really provide development of Armenia.

The key components of overall strategy:

- Focus on high impact research that advances knowledge and its application, and in which national lab has major achievements having international recognition and leadership.
- Inject a spirit of enterprise into education and research, and develop impactful between education and research, within a dynamic “no-walls” environment.
- Develop advanced services for the Armenia industry, environmental monitoring and preserving cultural heritage.
- Develop advanced technological processes and high productivity computation facilities for Armenian science and industry.
- Nurture committed alumni to be key members of the lab community, who will actively support national lab towards its Vision and Mission.

- Adopt and adapt best practice governance and management, for optimal administration, management of resources, staff and student services.

Brief summary of the scientific activities

Brothers Abraham Alikhanov and Artem Alikhanyan founded in 1943 Yerevan Physics Institute (YerPhI) as a branch of the Yerevan State University. Later high-altitude Cosmic Ray stations were founded on the slopes of Mount Aragats. Among the key results of YerPhI in the early years were the discovery of protons and neutrons in cosmic rays, and the establishment of the first evidence of existence of the particles with masses between that of muons and protons. The high altitude research stations have remained the main research base of the Cosmic Ray Division (CRD) of YerPhI until now. Among the CRD achievements there were: discovery of sharp knee in light components of primary cosmic rays, detection of the highest energy protons accelerated on the Sun, and the creation of the Aragats Space environmental Center in 2000 for studies of the solar-terrestrial connection, where CRD becomes one of the world's leaders.

The 6 GeV electron synchrotron was accomplished in 1967. During 1970-1991 synchrotron was operated with energies up to 4,5 GeV and in Experimental Physics Division were obtained significant results, including: hadronic properties of photons in π- meson photo-production on nuclei; structures of nucleon resonances in multi-polarization experiments, structure and characteristics of nuclear matter, important properties of X-ray transition radiation and channeling in monocrystals. Thanks to these achievements physicists from Yerevan Physics Institute started from 1985 are successfully participating in the large international collaborations.

Traditional topic of YerPhI is the development of new particle detectors. Wide spark chambers and transition radiation detectors are examples of the experimental techniques developed and implemented in YerPhI. During the last years groups of scientists from Yerevan Physics Institute have actively participated in intermediate and high energy physics experiments abroad (JLAB, DESY, CERN-LHC, MAX-lab, MAMI), exploring the meson and nucleon

structures, electromagnetic interactions of the nucleon, quark-hadron duality, short range nucleon-nucleon correlations, quark hadronization in nuclear medium, physics beyond standard model, Higgs boson searches, quark-gluon plasma, fission and fragmentation of nuclei and hypernuclei and many other topics, as well as constructing experimental hardware and develop the software for data acquisition and analysis.

The theoretical department assure major achievements in the following areas: B-meson

physics, QCD and Related Phenomenology, Neutrino physics, Quantum Field Theory, String/M-theory, Integrable Models, Statistical physics, Condensed Matter and Quantum Information. These results are internationally recognized and highly cited.

In the mid-1980s in YerPhI was developed the concept of stereoscopic approach in Very High Energy gamma-ray astronomy using multiple Imaging Atmospheric Cherenkov Telescopes (IACT). This concept was materialized in the very successful IACT system (HEGRA). After first success, Armenian physicists successfully participate in operation of the IACT systems on the Canary Islands (MAGIC) and in Namibia (H.E.S.S.).

In the course of many years, the Applied Physics Department of YerPhI successfully investigates electron-energy structure of new wide-band laser materials using synchrotron radiation in various spectral regions. The investigations were carried in DESY and will be continued in MaxLab- II (Sweden).

Organization structure and human recourses management

1. Lab board appoints director of national lab and chair of the board signs contract with director for 5 years.
2. Director of the national lab appointed 2 deputies, chief accountant, scientific ecretary and five assistants of director (human recourses management, security, economics, office management, international connections) and sign contract with them.
3. National lab adopted two-level internal organizational structure, consisting of departments where relevant scientific and technical groups operate.

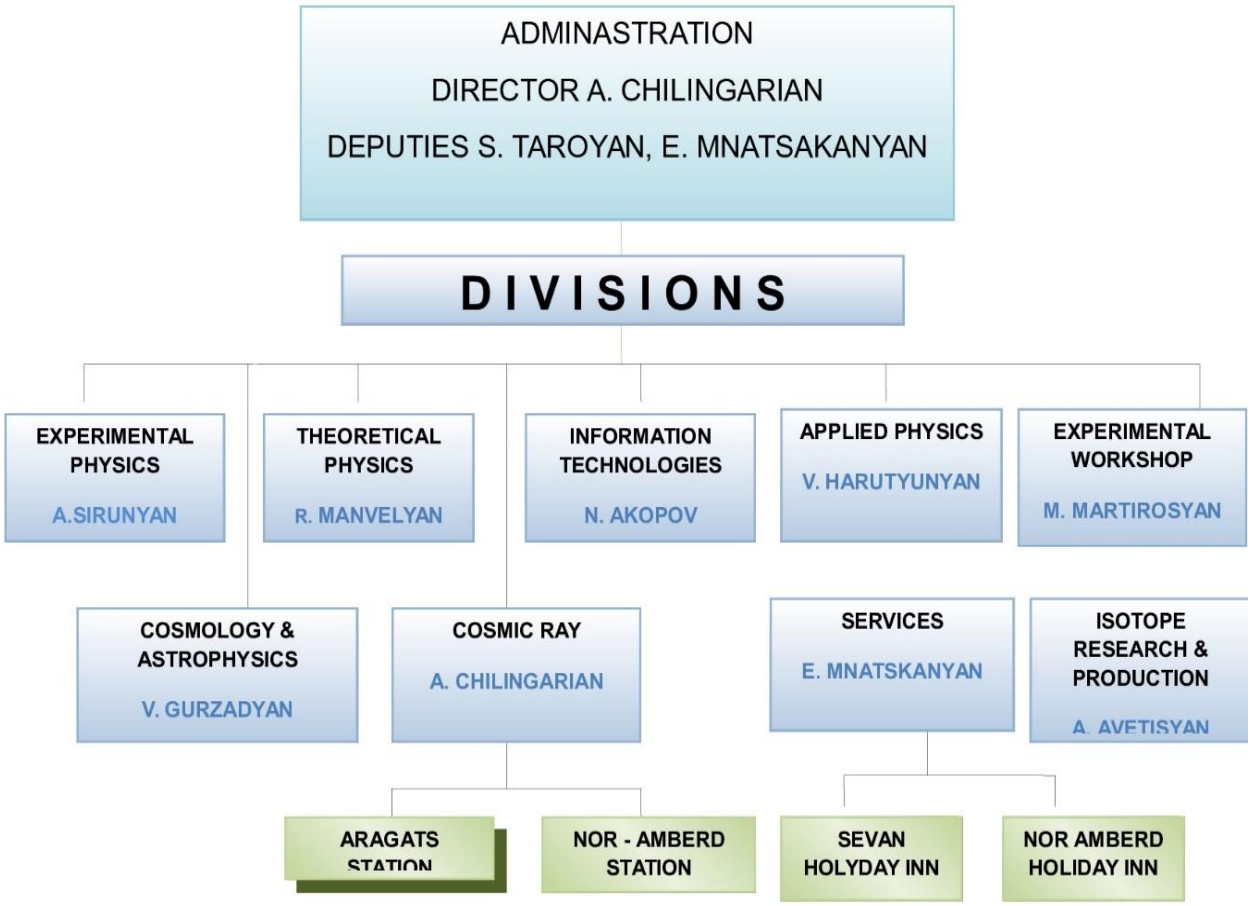


Figure 4. Administrative structure of AANL

4. The appointment to the position of the heads of departments should be realized for up to 5 years period and they should sign contracts with national lab director. The contract with heads of groups is realized for up to 3 years.
5. The age limit of 65 years is stated for the heads of departments and groups; in exceptional cases (started from 2014 no contracts are signed with older candidates to group or department leader positions) until the age of 70. The limiting age for other national lab employees is 65 years, for doctors of science–70
6. The age limit for consultants/advisers is 85 for academicians and 75 for doctors of science.
7. National lab adopted following list of scientific positions.
    - intern
    - researcher
    - senior researcher
    - leading researcher
    - Scientific /Consultant-Advisor Notification:

    a) Intern position is assigned to the young professionals currently engaged in higher Educational system (master courses) and those who are doing their PhD in national lab.
    b) Intern-researcher position («Postdoc» status) is assigned by competition to young scientists, having PhD degree; prior to postdoc competition the competition for opening postdoc position should be hold in the national lab departments.
    c) Lab's director in accordance with the recommendations of the Scientific Advisory Committee decides distribute the intern-researcher positions among lab departments.
    d) Researcher, senior and leading researcher positions are assigned by depending on the overall score based on several criteria (H-index, leadership, work with students, etc.).
    e) To the scientific /technical/consultant position are appointed scientists and engineers with age above 65 years old (no more than 5 persons in each department).
8. Special commission appointed by lab's director makes the attestation of the national lab employees periodically. Each employee should present to commission following documents:

    - Filled standard attestation form
    - List of publications with abstracts during last 5 years Best 3 publications (according to author's opinion) List of graduate students
    - List of reports on the international conferences, invited talks List of organized conferences
    - Title and date of last thesis, place of defense
    - Total list of publication
    - List of managed grants.

9. In exceptional cases department leaders can employ personnel for the period up to 6 months for work of strategic importance (not more than 2 employees).
10. Director reserves the right to appoint his advisors, doctor of science, academicians.
11. The business trips of national lab employees to foreign countries are organized according special regulation; duration of business travel should not exceed 6 months.
12. The hours of workweek are fixed to 40. Automatic system is calculating the working hours according to which the actual salary is assigned.
13. According to the national regulations administration provides 24-day vacation to all employees; vacation may be provided in two parts; in exceptional cases vacation can be given additional vacation without payment.
14. National lab affords all measures to increase the professional skills of young scientists (send them to summer schools and conferences, invite professor for lecturing, organize summer schools in Armenia) and to provide proper working conditions (repair office, seminar rooms, provide modern computers).

Administration obligations, economical and property management issues

1. Provide full and timely logistical support for the implementation of the linear functions of the National Lab, such as:
2. Ensure efficient utilization of the office spaces, carrying out necessary aintenance and repairing activities
3. Purchase modern equipment for high precision measurements.
4. Install modern security equipment for the offices and experimental laboratories.
5. Organize the efficient provision of irrigation water for the whole territory of the National
6. Lab to guarantee the green and clean environment.
7. Select an operator, through a competitive tender, for establishing restaurants and cafes on the lab's premises.
8. Optimize and manage the vehicles' park, giving priority for smaller number of cars but with appropriate power and environmentally friendly engines.
9. Optimize the workshops and provide it with modern tool kits and technological equipment.
10. Organization of workshops and conferences (logistics).
11. Develop and implement non-current assets (immobile property) management strategy:
12. Establish criteria for selecting the buildings requiring capital restoration and build up a renovation and restoration long-term master plan.
13. Ensure energetic efficiency of the buildings.
14. Establish procedures for providing the premises for short-time (up to 1 year) lease to the third parties.

2. Provide assistance to CRD employees in preparing grant applications and develop a sustainable fundraising strategy:
    - Provide timely information to the staff about relevant funding opportunity announcements.
    - Negotiate with Republican agencies to open funding possibilities for the researchers.
    - Reduce dependency on a single income stream; improve chances to operate independently.
    - Create a sustainable funding base and build up reserves to safeguard financial future.
3. Organize international expertise of the projects submitted for funding, form commissions and project accepting committees; provide recommendations for republican funding bodies for selected projects.
4. Implement the financial management of the National Lab:
    - Prepare annual budget. Discuss with national board the priorities, and due to the board decision decide ongoing expenditure, which must be met from ongoing income streams, and reserves.
    - Provide accounting and material resources "house-keeping" according to the best corporative standards.
    - Each year prepare comprehensive report for the annual audit.
5. Provide access to national lab information, Internet recourses, high productivity computing, scientific publications, and libraries of applied programs, printers, and telephones.
6. Establish small business innovation research (SBIR) and small business technology transfer competitive funding.
7. Provide secure storage of the isotopes and radioactive materials according to MAGATE standards.
8. Providing touristic and recreation services

Key performance indicators (KPI) for organizational performance evaluation

The national lab is guided by a sharp programmatic vision, by a strategic plan formed by this vision, and by a constant striving for managerial excellence and effectiveness in implementing the plan. A systematic program to refine work processes is underway with the aim of achieving the greatest programmatic output for a given funding level. Management has renewed their efforts to continuously strengthen a culture of high performance that extends to all areas of work, and underscores the importance of safe operation as a core institutional value.

Among the major KPIs to be used to evaluate the national lab performance are:

- ✓ Number of publications in the peer reviewed journals each year and the sum of the impact factors of the journals.
- ✓ Number of citations made to publications of national lab employees made in the assessed year.
- ✓ Number of master and PhD students, defends of PhD theses.
- ✓ The ratio of the numbers of employees under 35 years old to number of employees above 70 years old.
- ✓ The percent of the funds spent to the new equipment and materials relative to the total budget.
- ✓ The percent of funds spent on business travel relative to the total budget. The percent of funds spent for repairs relative to the total budget.
- ✓ Total income from high technology services.
- ✓ Number of new agreements with Armenian and international organizations.

ATTACHMENT 2. Thematic and International Grants

2015 թ. Ա. Ալիխանյանի անվան Ազգային Գիտական Լաբորատորիայում գործող դրամաշնորհների ցուցակ

Հ/Հ	Թեմայի համարը	Ֆինանսավորող կազմակերպություն	Ղեկավարի անուն, ազգանուն, հայրանուն	Թեմայի անվանումը	Կատարման ժամկետ
1	13-1C023	ՀՀ ԳՊԿ գիտական եւ գիտատեխնիկական գործունեության պայմանագրային ֆինանսավորման թեմա	Ազնաուրյան Իննա Գեւորգի	Սպինային հետազոտությունները ՔԽԴ-ի շրջանակներում Jlab-ի տվյալներից մինչեւ LHC Ֆենոմենոլոգիա	2013-2015
2	13-1C137	ՀՀ ԳՊԿ գիտական եւ գիտատեխնիկական գործունեության պայմանագրային ֆինանսավորման թեմա	Ահանիկյան Ներսես Սիրեկանի	Ցածր չափանի և ռեկուրսիվ սպինային Ցանցերի մագնիսական հարթակները ֆլանտային խճճվածությունը եւ դինամիկ համակարգերի մեխանիզմը	2013-2015
3	13-1C153	ՀՀ ԳՊԿ գիտական եւ գիտատեխնիկական գործունեության պայմանագրային ֆինանսավորման թեմա	Ասատրյան Հրաչյա Մանվելի	ՔՔԴ Ուղղումները B մեզոնների հազվագյուտ տրոհումների համար ստանդարտ Մոդելում եւ ՄՍՍՄ -ում	2013-2015
4	13-1C245	ՀՀ ԳՊԿ գիտական եւ գիտատեխնիկական գործունեության պայմանագրային ֆինանսավորման թեմա	Գուլբանյան Հրանտ Ռուբենի	Ծանր Միջուկների ճեղքման հազվադեպ կանալների որոնումը	2013-2015

Հ/Հ	Թեմայի համարը	Ֆինանսավորող կազմակերպություն	Ղեկավարի անուն, ազգանուն, հայրանուն	Թեմայի անվանումը	Կատարման ժամկետ
5	13-1C080	ՀՀ ԳՊԿ գիտական եւ գիտատեխնիկական գործունեության պայմանագրային ֆինանսավորման թեմա	Իզմախլյան Նիկոլայ Շահենի	Ընդհանրությունը և վերջավոր չափի հետեւվանքները վիճակագրական մեխանիկայի երկչափ մոդելներում	2013-2015
6	13-1C232	ՀՀ ԳՊԿ գիտական եւ գիտատեխնիկական գործունեության պայմանագրային ֆինանսավորման թեմա	Մանվելյան Ռուբեն Պետրոսի	Բարձր Սպինների փոխազդեցություն եւ ունիվերսալություն տրամաչափային / լարային տեսություններում	2013-2015
7	13-1C275	ՀՀ ԳՊԿ գիտական եւ գիտատեխնիկական գործունեության պայմանագրային ֆինանսավորման թեմա	Զիլինգարյան Աշոտ Աղասու	Ամպրոպային Վերգետնյա Անեքի հետազոտությունները տարբական մասնիկների դետեկտորների , էլեկտրական եւ գեոմագնիսական դաշտի եւ օպտիկական գրանցիչների օգնությամբ	2013-2015
8	13-1C278	ՀՀ ԳՊԿ գիտական եւ գիտատեխնիկական գործունեության պայմանագրային ֆինանսավորման թեմա	Պողոսյան Ռուբիկ Հրաչիկի	N=2 Սուպերսիմետրիկ Յանգ - Միլսի Տեսություն կապը երկչափ կոնֆորմ դաշտի տեսության եւ ինտեգրվող մոդելների հետ	2013-2015

Հ/Հ	Թեմայի համարը	Ֆինանսավորող կազմակերպություն	Ղեկավարի անուն, ազգանուն, հայրանուն	Թեմայի անվանումը	Կատարման ժամկետ
9	13-1C001	ՀՀ ԳՊԿ գիտական եւ գիտատեխնիկական գործունեության պայմանագրային ֆինանսավորման թեմա	Սահակյան Վարդան Հայաստանի	Գերբարձր Էներգիաների գամմա ճառագայթների աստղաֆիզիկա ՊՄՀԴ - ների օգնությամբ	2013-2015
10		ՀՀ ԳՊԿ գիտական եւ գիտատեխնիկական գործունեության պայմանագրային ֆինանսավորման թեմա	Սեդրակյան Արա Գրիգորի		
11		ՀՀ ԳՊԿ Նյութատեխնիկական բազայի արդիականացման համար գիտական սարքավորումների և ենթառուցվածքի ձեռքբերման դրամաշնորհ	ՀՀ ԿԳՆ «Ա. Ալիխանյանի անվան ազգային գիտական լաբորատորիայի (ԵրՖԻ) հիմնադրամ		
12	612707, DIONICOS	Marie Curie Actions, FP7-PEOPLE-2013-IRSES	Անանիկյան Ներսես Ս.	Dynamics of and in Complex Systems	2013-2017
13	13RF-022	Հայ-ռուսական հիմնարար գիտական հետազոտությունների համատեղ նախագծերի «ՀՀ ԿԳՆ ԳՊԿ-ՀՀՌՀ - 2013»	Պողոսյան Ռուբիկ Հ.	"Itegrable Models in Quantum Field Theory and Moduli Spaces of Instantons".	2013-2015
14	YSSP-13-02	The National Foundation of Science and Advanced Technologies (NFSAT), YSSP and CRDF Global Young Scientists Support Program (YSSP-13) 2013	Հովհաննիսյան Վահան	Քվանտային սպինային համակարգերի խճճվածությունը, մագնիսական հատկությունները, վիճակագրական գումարի զրոները և Լյապունովի ցուցիչները)	2013-2014

Հ/Հ	Թեմայի համարը	Ֆինանսավորող կազմակերպություն	Ղեկավարի անուն, ազգանուն, հայրանուն	Թեմայի անվանումը	Կատարման ժամկետ
15	295302, SPIDER	Marie Curie Actions, FP7-PEOPLE-2012-IRSES,	Իշմաիլյան Նիկոլայ Շ.	Statistical Physics in Diverse Realizations, within the 7th European Community Framework	2012-2016
16		VOLKSWAGEN FOUNDATION	Ասատրյան Հրաչյա Մ.	The B mesons' Inclusive Rare Decays and Oscillations	2012-2015
17		VOLKSWAGEN FOUNDATION	Մանվելըան Ռուբեն Պ.	Infinite-Dimensional Symmetries, Gauge/String Theories and Dualities	2012-2015
18	CNRS IE-017	Հ ՀԿԳՆ ԳՊԿ – ԳՀԱԿ **(France)**	Անանիկյան Ներսես Ս.	Classical and Quantum Chaos (CLASSQUANT)	2012-2013
19	CNRS IE-028	ՀՀ ԿԳՆ ԳՊԿ – ԳՀԱԿ **(France)**	Մարտիրոսով Ռոմեն Մ.	Study of fine structure of the primary cosmic ray energy spectrum with the GAMMA experiment at Mt. Aragats	2012-2013
20	12GE-012	ՀՀ ԿԳՆ ԳՊԿ – **BMBF (Germany)**	Ռեյմերս Արթուր	ՎԵԲ Տեխնոլոգիաների վրա հիմնված տիեզերական եղանակի դիտման համակարգ	2012-2013

ATTACHMENT 3. List of the Theses Defended in AANL (2015)

		Name	Academic Degree	Title of PhD and supervisor's name
1.		Vardanyan Gagik Hovhannesi	Ph.D	"Energy measurement and calibration of Hadron jet birth in the Atlas experiment", Supervisor: Doctor of Science Akopyan G.
2.		Vardanyan Tigran Levoni	Ph.D	"The study of wigglers' effects and undulator radiation in an electron accelerator", Supervisor: Doctor of Science Tsakanov V. M.
3.		Hrachya Maruqyan	Doctoral Dissertation	"Deeply Virtual Compton Scattering (DVCS) process on a transversely polarized hydrogen target"

ATTACHMENT 4. List of AANL Seminars 2015

1. Thermal neutron flux monitors based on vibrating wire by Arutyunyan S.
2. Testing random number generator with multidimensional Chi-square by Narek Martirosyan
3. Numerical methods in cosmology III: data mining techniques by Harutyun Khachatryan
4. Cosmic microwave background radiation and Plank 2015 by Gegham Yegoryan
5. An introduction to the 1D Ising Model by Vahan Hovhannisyan
6. Electric structure of thundercloud and particle flux enhancements during thunderstorm by Vahan Hovhannisyan
7. Dimuon low invariant mass region in Alice experiment by Vardanush Papikyan
8. Atmospheric lidar studies at LATMOS by Alain Hauchecorne.
9. Olympus cosmic muon simulator by Gevorg Karyan
10. Front-end electronics and the readout systems of contemporary high-energy physics experiments by Razmik Mirzoyan
11. Wide-field optical monitoring and independent search for fast optical transients by Sergey Karpov
12. Instrumentation for large-scale research at the Karlsruhe Institute of Technology by Andreas Kopmann
13. Advanced Algorithms for Tomography by Suren Chilingarian
14. On the nature of Cold Spot by Vahagn Gurzadyan
15. Review lecture on dark matter and dark energy and fitting cosmological parameters with observational data by Sergey Pavluchenko
16. Neutrino physics at DUNE (Deep Underground Neutrino Detector) by Ara Ioannisian
17. Alternative theories of gravity by Sergey Pavluchenko
18. Light Meson Portal to Dark Matter by Moskov Amaryan
19. DESY's research activities by Manfred Fleischer
20. Cosmological Tests of Gravity by Levon Poghosyan
21. ARCHAEOLOGY AND INTERDISCIPLINARITY: Current Trends in Studies of the Armenian Past And Portable X-ray Spectrometry (pXRF) in Archaeology by Gregory E. Areshian And Kristine Martirosyan-Olshanski
22. Dynamics of Semiflexible Polymers with Branches and Loops by Maxim Dolgushev
23. Thundercloud electrodynamics and its influence on high-energy radiation enhancements and lightning initiation by Evgene Mareev

ATTACHMENT 5. List of Scientific Institutions with whom YerPhI Has Signed Agreements or MOU on 2015

1. Thomas Jefferson National Accelerator Facility
2. Deutsches Elektronen-Synchrotron (DESY)
3. The European Organization for Nuclear Research (CERN)
4. Stanford Linear Accelerator Center (SLAC)
5. Notre Dame University
6. Cherenkov Telescope Array Consortium (CTA)
7. Institute for Structure and Nuclear Astrophysics (University of Notre Dame, USA)
8. *Warsaw* University of Technology
9. Heidelberg Ion-Beam Therapy Center (HIT)
10. Объединенный Институт Ядерных Исследований (ОИЯИ, Дубна)
11. Московский Инженерно-Физический Институт (МИФИ, Москва)
12. Armenian Anti-hailing center of ministry of Emergency.
13. 13 Armenian meteorological center of ministry of Emergency.
14. Lund University – MAX Lab accelerator center.
15. El Instituto de Fisica de la Universidad Nacional Autonoma de Mexico (IFUNAM)
16. Научно-исследовательский институт ядерной физики имени Д.В.Скобельцына (МГУ Москва)
17. HERA/H1 Collaboration Agreement (DESY)
18. Collaboration Agreement Reference KF 2886 (CERN)

ATTACHMENT 6. List of the Winners of Thematic Funding 2015

1. Ազնաուրյան Իննա Գևորգի. Նորագույն սպինային տվյալներ JLab-ից և LHC-ից. տեսական վերլուծություն և մեկնաբանում
2. Ակոպով Նորայր Զավենի. Պարտոնային բաշխվածության և ֆրագմենտացիայի ֆունկցիաների ուսումնասիրությունը HERMES գիտափորձում՝ նուկլոնի և միջուկի վրա էլեկտրոծնման պրոցեսներում
3. Անանիկյան Ներսես. Սիրեկանի Սպինային համակարգերի ջերմային խճճվածությունը, մագնիսական պրոցեսները, կանոնիկ, միկրոկանոնիկ ֆորմալիզմը և գերկայուն կետերը
4. Ասատրյան Հրաչյա. Մանվելի B մեզոնի B→Xsγγ տրոհման և օսցիլյացիաների ՔՔԴ հաշվարկներ
5. Իզմաիլյան Նիկոլայ Շահենի. Երկչափ մոդելների ճշգրիտ և թվային հետազոտությունները վիճակագրական ֆիզիկայում
6. Մանվելյան Ռուբեն Պետրոսի. Տրամաչափային/Լարային դուալություն տոպոլոգիական և բարձր սպիններով կոնֆորմ տեսություններում
7. Չիլինգարյան Աշոտ Աղասու. Բարձր էներգիայի ֆիզիկան մթնոլորտում և կայծակնային երևույթները
8. Պողոսյան Ռուբիկ Հրաչիկի. Ճշգրիտ արդյունքներ քառաչափ և երկչափ դաշտի տեսության և տոպոլոգիական Կոնդոյի մոդելներում
9. Սիրունյան Ալբերտ Մկրտիչի. Ետնային եզրային հադրոնային կալորիմետրի լայնական սեգմենտացիայի օպտիմալացում «CMS դետեկտորի արդիականացման երկրորդ փուլ» նախագծի շրջանակներում
10. Ամուր Մարգարյան, «ՏՀց ժամանակային պրոցեսոր՝ ընդլայնված դինամիկ տիրույթով»
11. Արա Սեդրակյան, «Մատրիցական մոդելներ և եռաչափ ինտեգրելիություն»

ATTACHMENT 7. List of Young Scientists/Students Who Were Supported For Participating In Conferences And Summer Schools

1. **Mkrtchyan Hripsime**
2. **Roza Avetisyan**
3. **Arthur Reimers**
4. **Yeranuhi Ghandilyan**
5. **Eduard Aleksanyan**
6. **Vahan Hovhannisyan**
7. **Gevorg Karyan**
8. **Davit Pokhsraryan**

ATTACHMENT 8. Press Releases of AANL of 2015

1. The leading scientists of YerPhI have been elected as foreign members of National Academy of Sciences of Armenia

On 27th of December, the National Academy of Science of RA (NAS RA) held a general meeting, where two former scientists of YerPhI Razmik Mirzoyan /High Energy Astrophysics, Germany/ and Alexander Khodjamirian /Theoretical Physics, Germany/ have been elected as foreign members of NAS RA.

Razmik Mirzoyan is a senior astrophysicist from the Max-Planck-Institute for Physics in Munich, Germany. He is the chairman of the MAGIC collaboration, operating one of the most successful facilities in Gamma ray astronomy. After leaving YerPhI in early 90-ths Dr. Mirzoyan took a leading role in the design, construction, and operation, of the six imaging telescopes of HEGRA collaboration on Canarian islands and after closing HEGRA experiment in creating the system of the MAGIC- telescopes. Now Prof. Mirzoyan actively participates in design of the Cherenkov Telescope Array project, the leading astrophysical project in Europe and he is PI of the TAIGA experiment near Baikal lake in Russia. Prof. Mirzoyan often visited Armenia delivering lectures to YerPhI young scientists and consulting Cosmic Ray division experts in various topics of particle experimental physics.

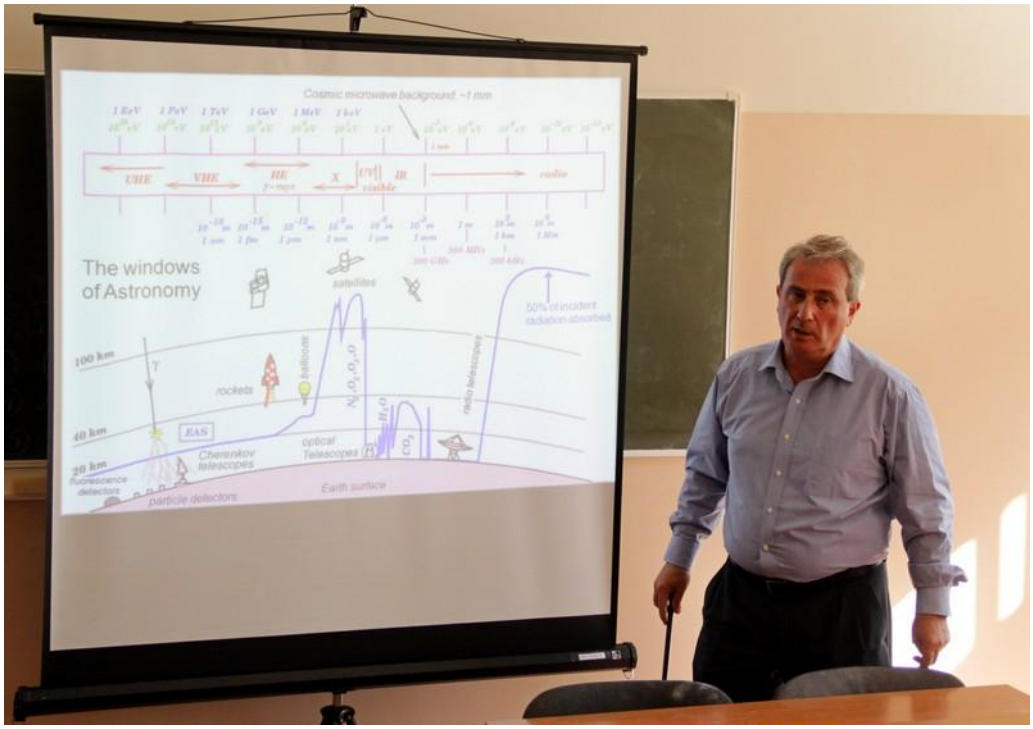


Figure 1. Razmik Mirzoyan

Prof. Alexander Khodjamiryan has worked at Theoretical Physics division of Yerevan Physics from 1973 to 1992. In 1992 he moved to Germany, where he continued his research in theoretical elementary particle physics. He worked in Universities of Munich, Würzburg,

Karlsruhe, while also was invited to a number of European research centers, including the Niels Bohr Institute in Copenhagen and since 2009, Alexander Khodjamiryan is a professor of the University of Siegen, Germany. He is in close scientific relations with the Armenian physicists especially with former YerPhI colleagues. He conducted a series of scientific seminars and lectures for Armenian scientists, participated in various theoretical physics conferences in Armenia.

Figure 2. Alexander Khodjamirian

We congratulate our colleagues for this election and wish them further fruitful cooperation with YerPhI scientists.

2. Former PhD of Prof. Ashot Chilingarian, Dr. Bagrat Mailyan got a NASA funded postdoctoral research associate position at University of Alabama

Former PhD of Prof. Ashot Chilingarian, Dr. Bagrat Mailyan got a NASA funded postdoctoral research associate position at University of Alabama in Huntsville. He will work in Fermi Gamma ray Burst Monitor (GBM) team analyzing and interpreting GBM data. Currently, Fermi is the best space-borne instrument for the investigation of so-called Terrestrial Gamma ray Flashes (TGFs) - high energy particle fluxes coming from thunderstorms. Using his experience in studying Thunderstorm Ground Enhancements (TGEs) observed by surface detectors at Mount Aragats, Bagrat Mailyan will work with recognized NASA professors to improve the understanding of the high energy atmospheric phenomena. High-energy physics in the atmosphere is a new science branch investigated fluxes of elementary particles originated from the relativistic electrons accelerated in strong electric fields of the thunderstorms. Fluxes of particles are directed both to open space where

they are detected by orbiting gamma ray observatories and to the Earth's surface. The largest facilities on the earth's surface detecting electrons, gamma rays and neutrons (TGEs) as well as radio bursts, electric fields, lightnings are located on Aragats in Armenia, NASA is most active in TGF research with LAT and GBM spectrometers on board of FERMI gamma ray observatory.

Figure 1. Bagrat Mailyan at AGU fall meeting, 2012

3. Severe April snowstorms did not disturb operation of Aragats research station: A super event of 20 April shed new light on atmospheric physics

Lightning has been around since the dawn of time, but what triggers it is still an enigma. Now, researchers propose that the answer could lie in high-energy particles that are accelerated in the atmosphere and ionize the air, releasing free electrons and leading to a massive discharge. Thunderclouds become electrically charged from the collisions of microscopic ice particles in their midst, and from the moisture currents that push the negative and positive charges apart. The air is a good insulator, keeping the clusters of positively and negatively charged layers apart in this way generating huge electrostatic fields. Cosmic ray electrons plenty on the mountain altitudes are accelerating in these fields gain additional energy, knock on from atoms new electrons and so on. As a result electron-photon avalanche is developed in atmosphere making a pathway for lightning leader

culminating in a lightning bolt. However scientists are still not sure of the conditions initiated the electron-photon avalanches. Aragats physicists started research of particle fluxes from thunderstorms 7 years ago when suddenly measure huge fluxes of electrons, gamma rays and neutrons at Aragats. After checking all possible sources of radiation (including Metcamor nuclear power plant) they discover TGEs- thunderstorm ground enhancements intense and brief bursts of radiations from the thunderclouds. Plenty of TGE events was observed, classified and explained during last years, numerous papers were published and reports presented on international forums. Cosmic Ray Division (CRD) of the Yerevan physics Institute hold special symposia on Thunderstorms and elementary particle acceleration. This year they plan 5-th symposia in Nor Amberd - TEPA- 2015. However the question remains how lightning is initiated and what is relation of TGE and lightning. New precise particle sensors and field meters was installed on Aragats. Now physicists are measuring tens of parameters including radio, ultraviolet and infrared emissions from the atmospheric discharges. All these measurements by radio-modems are sending to CRD for immediate analysis and distribution to colleagues worldwide. April is a month when strong thunderstorms started on our mountains. The buildings and houses are under a thick layer of snow, the roads are closed, sever wind cut electricity lines. All these create a uniquely challenging conditions for the stable and safe operation of the equipment and registering most interesting events that are coinciding with violent weather conditions. These days the station employees Samvel Parsamayan, Ara Babayan and Karen Asatryan ensure the reliable operation of all sensors registering 5 year largest flux of particles 20 times enhancing fair weather values. Along with particles huge radio burst, ultraviolet light surge, electric field disturbances were detected. Aragats has now world best equipment for research of new fast developing field of high-energy physics in atmosphere. And what is more valuable – has devoted staff operated this equipment day and night 12 months a year. According to order of director of national lab. prof. A.Chilingarian the station staff was granted by premium for detecting this extra ordinate event with all sensors located on high altitude research station.

Figure 1. Opening the door of experimental hall after snowfall

Figure 2. Ara Babayan and Karen Asatryan checking operation of the particle spectrometers

4. The Mars One Mission Member visits Aragats for conquering its Summits

In the top list of 100 candidates for the flight to Mars as part of the project Mars One proved three residents of Russia. They include 50 men and 50 women from around the world who still have to go the final stage of selection scheduled for 2025 expedition to the Red Planet.

Mars One believes that human settlement on Mars will be the most profound and

influential event of the 21st century. It will be the first established colony beyond Earth.

Mars One project promises to turn the flight to Mars in an exciting reality show. The ultramodern shuttle will land on the planet's surface with 24 crewmembers, which will win the primacy in the competition.

Fitness center employee Ekaterina Ilinskaya-Saribekyan is ready to go to Mars not out of love to the cosmos but to the extreme. Ekaterina has visited Aragats on July 5th for climbing its summits and brought a flag with the emblem of MARS-1 mission to the top of Aragats. During her visit to Aragats Ms. Ilinskaya was hosted by Aragats Research Station of Yerevan Physics Institute where station employees has guided her to South and North peaks of the mountain.

5. Exploring the Origin of Lightning Initiation and Particle Showers in the Atmosphere

Despite lightning and thunderstorms being a rather common phenomenon, the underlying physics is still not well understood. It remains an enigma how lightning strikes are initiated at electrical field strength well below the break-through voltages needed in the lab to create a spark. Just recently another high-energy phenomenon in the atmosphere has been found. It is the acceleration of electrons in the strong electric fields of the thunderclouds. As a consequence, increased fluxes of electrons, gamma rays and neutrons can be detected on the earth’s surface, in the atmosphere and in space. Such high-energy particle fluxes are often accompanied by disturbances of the near-surface electric field, by high-frequency radio emissions, extensive air showers and impressive lightning discharges. A number of experiments record all these features simultaneously, together with relevant meteorological parameters. The combined analysis of these parameters and their correlations is the basis for developing new models of particle acceleration, emission of radiation and lightning initiation. About twenty scientists from the Armenia, Germany, Japan, Kazakhstan

and Russia met to discuss these phenomena at a workshop on Lightning initiation, Electron acceleration and Atmospheric Discharges (LEAD) that was held at the Nor Amberd International Conference Center of the Yerevan Physics Institute (YerPhI) in Armenia, from 9-12 June 2015. The Cosmic Ray Division of YerPhI and International Science and Technology Center (ISTC) organized and sponsored the workshop. Presentations and extensive discussions covered: - the extensive research programs in high-energy atmospheric physics in Armenia and Japan, - detection of atmospheric phenomena using particle detectors, electric field meters, radio receivers, weather stations and fast cameras including methods of the remote sensing of thundercloud structures and electric fields and international networks for accurately locating lightning strikes, - estimation of the size of the emission region in the thundercloud and identification of the origin of lightning and enhanced particle fluxes through radio signatures and the relation between the two; - the role of the atmosphere in air shower and Cherenkov experiments in astroparticle physics, - archiving and multivariate analysis methods for atmospheric data. There was general agreement that the vast archive of observations of strong thunderstorms with the facilities of the Aragats Space Environmental Center (ASEC) is unique and valuable and should be analyzed thoroughly by experts in the field. The data archive is publically available at http://www.crd.yerphi.am/adei/ and participants have been invited to use the data. Eventually, also the relevance of the field for astroparticle physics experiments has been recognized and the inclusion of atmospheric physics as one of the key topics in the interdisciplinary program of the Astroparticle Physics European Consortium (APPEC) has been discussed.

Figure 1. Participants of the 2015 LEAD workshop at the Nor Amberd International Conference Center of the Yerevan Physics Institute (YerPhI) in Armenia.

6. Summer School At A. Alikhanian National Science Laboratory

Yesterday on August 17 a Summer School titled "High-Energy Physics in Atmosphere and Cosmic Rays" launched and will be carrying out from August 17 through August 20 in seminar halls and teaching classes of A. Alikhanyan National Laboratory – Yerevan Physics Institute (YerPhI). 15 lecturers are introducing the students the hottest topics of cosmic ray and atmospheric physics, cosmology, applied research and IT technology and others. 24 students from Yerevan State University, Armenian State Pedagogical University are participating in this summer school.

During laboratory works students assemble systems of particle detectors; measure elemental composition of artifacts; become acquainted with modern JPU servers and calculate proportion of generated medical isotopes.

The last day of school students will visit high altitude research station of YerPhI. On altitude of 3200 m world-largest center for monitoring of the secondary cosmic rays is located. Students will be demonstrated the networks of particle detectors registering charged and neutral components of cosmic rays and other precise equipment for research in the fields of Galactic cosmic rays, Solar physics, Space Weather and atmospheric physics including investigations of enigmatic lightning initiation.

The practical orientation of summer school emphasis that physics is experimental discipline and the route from measurements to models and theories proofs to be very effective in last and present centuries instrumenting the powerful infrastructures of our civilization and explaining micro and macro cosmos. A.Alikhanyan national lab provides to student modern experimental facilities encouraging them to be a part of scientific endeavor. Mission of the National lab includes as one of most important segments anticipates establishment of the high standards of education in Master and PhD programs for demonstrating that science and education can really provide development of Armenia. National lab has already started Master courses in 2014 for physics students. The formal aim of the MSc in Physics is: "To provide a high quality education in Physics which prepares students for research in an academic environment, national research laboratories and industry."

The official webpage of our summer school: http://www.yerphi.am/index.php/young-scientists-and-students/summer-school-2015

Figure 1. The participants of YerPhI summer School

7. Lightnings and Particle fluxes from the Thunderclouds

Thunderstorms and Elementary Particle Acceleration; Yerevan, Armenia, 5-9 October 2015 The problem of how lightning is initiated inside thunderclouds is probably one of the biggest mysteries in the atmospheric sciences. The relationship between thundercloud electrification, lightning activity, wide-band radio emission and particle fluxes has not been yet unambiguously established. One of the most intriguing opportunities opened by the observation of the high-energy processes in the atmosphere (so-called Thunderstorm ground enhancements – TGEs) is their relation to lightning initiation. Lightnings and TGEs are alternative mechanisms for discharging of the atmospheric "electric engine" and synchronized observation of both phenomena helps to understand better the both. To discuss these high-energy phenomena, the conference on Thunderstorms and Elementary Particle Acceleration was held at the Nor Amberd International Conference Center of the Yerevan Physics Institute (YerPhI) in Armenia. The Cosmic Ray Division of YerPhI and Skobeltsyn Institute of Nuclear Physics of Moscow State University organized the workshop; YerPhI and the Armenian State Committee of Science sponsored it. Thirty scientists and students from the United States, Japan, France, Germany, Israel, Russia, and Armenia attended. Presentations focused on observations and models of the high-energy emissions in thunderclouds; on termination of particle fluxes by lightnings; multivariate observations of thunderstorm atmospheres from the earth's surface and from the space; radio emissions produced by atmospheric discharges and particle fluxes; influence of the Extensive air showers (EASes) on lightning initiations and others. Discussions covered questions such as

the following: Do particle fluxes initiate lightnings? Do EASes helps to unleash -CG lightnings? Is TGE and TGF currents competitive with lightning current? What is mechanism of particle flux termination? The workshop participants agreed that it would be useful to compare vast amount of experimental data on TGE observed by Armenia, Japanese, Slovakian and USA in various conditions by different particle detectors to check the models of particle origin in thunderclouds. Armenia physicists suggest to locate sensors developed by other groups at Aragats where large TGEs are very often in Spring and Autumn. With installing of new fast electronics at Aragats it became possible to relate lightning initiation, fast and slow changes of the electric field and particle fluxes on the millisecond scale. Various particle detectors and field meters now are synchronized by GPS receivers providing time stamp with accuracy not worse than few tens of nanosecond. The first large TGE was observed with renewed ASEC facilities at 7 October 2015 during the workshop. The natural "electron accelerator" on Aragats provides several interesting events, which was intensively discussed by participants. During the most interesting 7 October TGE for the first time particle fluxes and lightning were detected on millisecond time scale. On the one-second time scale the termination looks like immediate decline due to deposition of large negative charge into the cloud by the return stroke of lightning. However, on the millisecond time scale it was evident that particle flux was declining successively along with distribution of the deposited charge in the cloud. The presentation slides and discussion videos are available on the conference website, http://crd.yerphi.am/Conferences/tepa2015/home. More details can be found in the supplemental information in the online version of this meeting report.

TEPA 2015 participant

ATTACHMENT 9. The Board of Trustees of AANL

1. **N. Yeritsyan –** Deputy president of Central Bank of RA (Executive board member)
2. **K. Harutyunyan –** Deputy minister of Science and Education (Board member)
3. **S. Harutyunyan** - Chairman of the State Committee on Science (Board member)
4. **A. Ghukasyan** – Chief executive officer of "Byblos Bank Armenia" CEO (Board member)
5. **A. Papoyan** - Director of Institute for Physical Research of the National Academy of Sciences of Armenia (Board member)
6. **Kh. Nerkararyan** – Professor at Faculty of radio physics of Yerevan Physics Institute (Board member)
7. **Z. Baghdasaryan** – The President and CEO of "Tahoe Associates", a private investment entity in USA (Board member)
8. **A**. **Kaplanyan** - The Chief Executive Officer of Memoir Systems (Board member)
9. **R**. **Strauch** - Chairman of The Roda Group (Board member)

ATTACHMENT 10. The List of YerPhI PhD And Master Students

Ցուցակ

01.01.16

Ա. Ի. Ալիխանյանի անվան ազգային գիտական լաբորատորիա

Ասպիրանտները

Առկա ուսուցում

1. Գյուրջինյան Արմեն Վարդանի 2013-2016 Ռ. Ավագյան ֆ.մ.գ.դ., Ա.04.16

2. Հարությունյան Գևորգ Սուրենի 2013-2016 Ա.Ավետիսյան ֆ.մ.գ.թ., Ա.04.16

3. Բաբաջանյան Սանասար Գարնիկի 2014 – 2017 Ա.Ալլահվեռդյան, ֆ.մ.գ.թ., Ա.04.02

4. Մարտիրոսյան Նարեկ Հենրիկի 2014 – 2017 Ն. Ակոպով, ֆ.մ.գ.դ., Ա.04.16

5. Էլբակյան Հայկ Վաչագանի 2014 – 2017 Ա. Մարգարյան, ֆ.մ.գ.թ., Ա.04.16

6. Պողոսյան Հայկ Ռուբիկի 2015 – 2018 Ն. Անանիկյան, ֆ.մ.գ.դ., Ա.04.02

7. Պողոսյան Գաբրիել Ռուբիկի 2015 – 2018 Ռ.Մանվելյա, ֆ.մ.գ.դ., Ա.04.02

Հեռակա ուսուցում

1.Պողոսյան Արմեն Ռուբիկի 2012-2016 Ն.Իզմաիլյան, ֆ.մ.գ.դ., Ա.04.02

2.Պողոսյան Հասմիկ Ռուբիկի 2013-2017 Գ. Սարկիսյան ֆ.մ.գ.թ., Ա.04.02

3. Մկրտչյան Հռիփսիմե Վարդանի 2013-2017 Ա. Չիլինգարյան, ֆ.մ.գ.դ., Ա.04.16

4.Ապրեսյան Ելենա Անդրանիկի 2014-2018 Ա. Սեդրակյան, ֆ.մ.գ.դ., Ա.04.02

Մագիստրոսները

Առկա ուսուցում

1. Բադալյան Անուշ Հովիկի 2015 – 2017
2. Գրիգորյան Արմինե Աշոտի 2015 – 2017
3. Մանթաշյան Միեր Արարատի 2015 – 2017
4. Մանուկյան Անդրանիկ Արմենի 2015 – 2017

ATTACHMENT 11. Elemental Composition Studies Performed With ARL Quant'X X-ray Flourescence Analyser During 2015

The instrument was put into operation in February 2014. Three months later the energy resolution of the detector starts to deteriorate, and full operation of the instrument became impossible. In August 2015 the warranty replacement of the instrument's detector was performed. At present time the energy resolution of the detector meets the specified value of 163-164eV.

During 2015 the following studies of elemental composition were performed:

1) For the clients from Yerevan Physics Institute departments
   High-temperature superconductors (S. Nikoghosyan)
   Aluminium and copper foil samples (I. Kerobyan)
   Yttrium-aluminum garnets (E. Aleksanyan,
   Carbon powders with trace metals (L.Poghosyan)
   Molibden samples (A.Avetisyan)

2) For the clients from from other institutions
   Carbon nanostructures with possible trace metals (A. Manukyan. M.Ter-Mikaelyan Insitute for Physical Research of Armenian National Academy of Sciences),
   Ore samples (A. Danagulyan. Physics Department of Yerevan State University).
   In scientific collaboration with M. Mavelyan Institute of General and Inorganic Chemistry of Armenian National Academy of Sciences the study of elemental composition of zinc silicates, zirconium silicates, perlites, quarzites, potasium and sodium "waterglass" is performed.