Project submitted for the base funding of Artem Alikhanyan National Laboratory (ANL)

Principal Investigator: Albert Sirunyan

TITLE: Development of experimental nuclear physics on base of ANSL accelerator complex and High Energy Physics in collaboration with international centeres (CERN-LHC, DESY-H1)

Experimental Physics Division: groups 111, 113, 115
Accelerator Division: LUE-75 operational group

The Project will be performed in collaboration with CERN-LHC (ATLAS and CMS experiments), DESY (H1 experiment), Department of Nuclear Physics (Yerevan State University)

DURATION: 2011-2013 (3 years)

Estimated total cost of the project (US $) **566,100**

Including:

Payments to Individual Participants	**315,000**
Equipment	**210,000**
Materials	**28,600**
Other Direct Costs	**0**
Travel	**12,500**

PROBLEMS:

Within the framework of a theme it is planned to realize researches in following directions:

1.Development of experimental methods and start-up of low energy nuclear physics research on the base of ANSL's accelerator complex (electron linac, microtron , synchrotron)

a) Design and construction of experimental ISOL type setup for production of low energy radioactive beams of neutron-rich nuclei on base of electron linac LUE-75 or microtron MT-25 and assembly of β, n, γ - detectors arrays. . The modernization of the electron linac aimed to suppress of electro-technical noise background and create possibility for experimental apparatus to work in counting mode. The spectroscopy of neutron – rich isotopes in the range of Z = 30-60 [1] as a first subject of investigations. The completion of three year program by setup calibration and tests using reference neutron-rich nucleus.

b) The investigation of cluster structure of excited states of light nuclei (He, Li, Be) isotopes in photo-disintegration processes with three particles final states in the energy range of 50-250MeV [2]. Design, procurement and assembly of Si detectors array.

c) Investigation of the multi nucleon correlations in photo-absorbtion process on nuclei at energies up to meson production threshold [3] (collaboration with Yerevan State University).

2. Creation of projects for the long-term scientific program of researches for the nuclear physics on a planned ANSL accelerator ions complex.

a) The design and feasibility study of the nuclear magnetic moments measurements within the POLAREX type experimental setup [4] exploring the existing apparatus of ANSL polarized target systems (PPT) [5]. The neutron-rich short-living nuclei with non-known magnetic moment are very numerous and can be measured with OLNO experimental technique [6].

b) The project of accelerating complex to accelerate the electrons with energy up to 250 MeV on base of synchrotron ring.

3. The elementary particles physics in the foreign accelerators beam (collaboration with CERN – LHC (ATLAS, CMS), DESY (H1)).

Since 1995 ANSL groups contributed visibly to these experiments, actively participating in the detectors design and construction, software development as well as test beam data taking and analysis. Now ATLAS and CMS groups will continue the works in ongoing LHC physics program (shifts, data taking and analysis) and also in detectors Upgrade [7-9].

The ANSL group in H1 collaboration will investigate multijet events in e^+p и e^-p DIS at low Q^2[10].

OBJECTIVES

1. a) The goal of proposal is twofold. The first one is to learn and develop the experimental methods used with low energy beams of short lived isotopes. The second one is to start the nuclear physics research program, beginning from relatively simple task of decay modes, spins, parity, energy levels of excited states measurement. The basic experimental setup of ISOL type consisting from entrance beam line, (UC_x) target , ionizer with 40kV acceleration of single charged exotic atoms flow, mass-separator, moving plastic tape in the magnet's focal plane to embed the ions and the detectors array will be designed and constructed. Such setup will allow to begin researches of short living isotopes and observe their subsequent β decay, registering the β particles with or without accompanied neutron(s) emission and subsequent de-excitation of daughter nuclei through γ-rays emission registered in three layer coaxial detector structure. Looking to a nuclear levels chart studied so far, one can see a numerous neutron-rich short-living nucleus($T_{1/2}$>1s) with only few energy levels measured in restricted energy range, mostly below 1 MeV . The spectroscopy of neutron – rich isotopes in the range of Z = 30-60 will be a first subject of investigations. The completion of three year program will be with setup calibration and tests using reference neutron-rich nucleus.

It is assumed that the part of components might be designed and constructed at ANSL workshop. Some other components should be procured abroad.

b) The structure of excited states for the light nuclei is a subject of increasing interest and is widely discussed in the modern theoretical analyses [2] that correspond to the existence and manifestation of cluster structures in ground and excited states inside these nuclei.

It is proposed to develop the experimental method and begin the investigation of cluster structures of excited states of the light nuclei in photodisintegration processes with three-body final states in the photon energy range 50-250 MeV using beams of electron linac (Ee < 75MeV). As a first it is planned to investigate the excited states of ^{6}He isotope in the photodisintegration reaction $\gamma + {}^7\text{Li} \rightarrow {}^6\text{He}^* + p$ at energy Eγ = 75 MeV with subsequent decay of ^{6}He* to t+t. The experimental data on the existence of two-cluster state (t+t) in the excited ^{6}He* obtained so far by two various methods: with ions beam (^{7}Li (^{6}Li,^{7}Be) ^{6}He) and π – mesons(^{9}Be (π, ^{6}He) t) gave a different results concerning the number, energies and widths of excited states in ^{6}He*[2].

For these investigations with bremsstrahlung and linearly polarized photon beams we are plan design and creation of semiconductor detectors with corresponding electronics. These detectors also will be necessary for researches in low energy nuclear physics.

c) The main contribution in photoabsorbtion process at photon energy E > 50 MeV will define the multinucleon formation inside the nuclei (as deuterons or alfa particles). In this energy range the quasi deuteron model is applied for description of the photon absorption mechanism [3]. The number of the virtual deuterons in target nucleus is defined via the semi empirical parameter. The dependence of this parameter from mass, charge and isotopic characteristics of the target will be studied in these experiments.

2. a) The design and feasibility study of the nuclear magnetic moments measurements within the POLAREX type experimental setup [5] exploring the existing apparatus of ANSL polarized target systems (PPT)[6] will be carried out . The neutron-rich short-living nuclei with non-measured magnetic moment are very numerous and can be measured with OLNO experimental technique [7].

b) For nuclear physics experiments will be developed project for transition electron synchrotron in a low energy mode : non-acceleration (50-75 MeV) and acceleration (< 250 MeV). The extracted photon beam should have a good time stretching (> 2-3 msec).

3. a) Since April 2010 LHC(CERN) operates in a regime of protons collision with total energy $\sqrt{s}$ = 7.0 TeV [8]. ATLAS and CMS groups will be participate in the ongoing LHC physics program (shifts, data taking and analysis) and also in detectors upgrade works.

CMS group will continue investigations of hard diffraction events [9] in single and double Pomeron exchange processes (data analysis) using information from CMS, CASTOR and ZDC detectors and determine contribution of gluon component in Pomeron. For hard diffractive interactions of pp with $\mu^+ \mu^-$ and γ -Jet production will be studied diffractive structure function of Pomeron [10] and for examination of factorization scheme data of cross-section in QCD, SPE(single) and DPE (double Pomeron exchange) processes in same kinematical range will be selected.

Recently the first results of data analysis with Di-muon for an integrated luminosity of 36 pb^{-1} are received. Within the framework of theme data analysis with Di-muon in hard diffractive processes will be continued.

b) DESY-H1 group will be studied in deep-inelastic e^+p and e^-p scattering multijet events [11] at $5<Q^2<100$ GeV^2 and elasticity y = 0.2-0.65 using data recorded in the years 2005-2007, corresponding to an integrated luminosity ~ 300 pb^{-1}. Also will be carried out investigation of event shape for study the differential distributions of event shape variables. These variables will be used for extracting of strong coupling independently of any fragmentation model.

TASK 1 ***Development of experimental methods and start-up of low energy nuclear physics research on the base of ANSL's accelerator complex (electron linac, microtron , synchrotron)***

Task description and main milestones	Participating Institutions

Task 1 a) Design, construction and assembling of the experimental setup, which includes electromagnetic mass-separator (electrostatic lenses (2 pc), electrostatic 90^0 filter, 90^0 bending magnet) and vacuum system - using ANSL`s mechanical workshop. ^{238}U target (UC5 target, container and ionisation chamber) will be ordered at PNPI - Design and construction of segmented detectors: plastic scintillator, NaJ(Tl)-detectors, neutrons –detectors and electronics(CAMAC apparatus for data handling, low noise amplifiers) – at ANSL. --- Modernization of the electron linac (power supply for improvement of noise immunity level of equipment. - Setup calibration and tests using reference neutron-rich nucleus (short –lived isotopes with $T_{1/2}$> 0.3 msec)	ANSL (Yerevan Physics Institute) Accelerator Division of ANSL (Yerevan Physics Institute) PNPI (Gatchina)

Task 1 b) - Transition electron synchrotron in a low energy mode : non-acceleration (50-75 MeV) and acceleration (< 250 MeV). The extracted photon beam should have a good time stretching (> 2-3 msec). - Design, construction and assembling of the experimental setup, which includes 15 silicone strip detectors of three types: with thickness δ= 50 μm , 150 μm , 1 mm. and corresponding electronics with power supply, ADC, ..-They will be ordered at LHEP-JINR (semi-conductor detectors department) or temporarily used from NLR –JINR (collaboration with LNR JINR). - Monte Carlo simulations and preparation of a proposal. - Experimental studies the excited states of $^6He^*$ (t + t) isotope in reaction $\gamma + {}^7Li \rightarrow {}^6He^* + p$ at energy $E\gamma$ = 75 MeV.	Accelerator Division of ANSL (Yerevan Physics Institute) LHEP-JINR LNR - JINR
Task 1 c) Measurements of photonuclear reaction at photon energies E > 40-50 MeV using activation method.	Accelerator Division of ANSL (Yerevan Physics Institute) Department of nuclear physics (Yerevan State University)

Description of deliverables	
	Reports, Proposals, Publications

TASK 2: ***Creation of projects for the long-term scientific program of researches for the nuclear physics on a planned ANSL accelerator ions complex***

Task description and main milestones	Participating Institutions
Task 2 a) - Development and begin of construction ^{3}He-^{4}He dilution refrigerator on the base of existing ^{3}He - ^{4}He continuous flow cryostat of polarized target facility. - Design and construction of gas system with ^{3}He and ^{4}He pump-down system in experimental hall at ANSL. - Development of cold finger with ferromagnetic foil for implantation of nuclides. - Checking of a superconducting magnet and its power supply	ANSL (Yerevan Physics Institute) NSC KIPT (Kharkov)
Task 2 b) -Project of transition electron synchrotron in low energy mode with a good time stretching (> 2-3 msec).	Accelerator Division of ANSL (Yerevan Physics Institute) LHEP-JINR LNR - JINR

Description of deliverables	
	Reports, Proposals, Publications

TASK 3: ***The elementary particles physics in the foreign accelerators beam (collaboration with CERN – LHC (ATLAS, CMS), DESY (H1)).***

Task description and main milestones	Participating Institutions
Task 3 a) – Participation in the ATLAS and CMS ongoing LHC physics program (experimental shifts, data taking and analysis) and detector upgrade works. -Creation of GRID-cluster with using capacities of ANSL computer center. - Calculations of Hard Diffractive Interactions of pp with $\mu+$ $\mu-$ and γ -Jet production on the basis of PYTHIA, POMWIG , HERWIG and CMSSW programs. -Analysis of Di-muon experimental events in hard diffractive processes using information from CMS, CASTOR and ZDC detectors. - Studying parton structure of Pomeron and «factorization» scheme	CERN-LHC, ANSL

Task 3 b) - Study in deep-inelastic e^+p and e^-p scattering multijet events at $5<Q^2<100$ GeV^2 and elasticity y = 0.2-0.65. - Investigation of event shape	DESY-H1, ANSL

Description of deliverables	
	Reports, Presentations, Publications

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    A.Bunyatyan et al. Eur. Phys. J. C41 (2005) 273-286 .

Personnel Commitments:

A)Experimental Physics Division

	Name	Task	Staff	Position
1	Sirunyan Albert	1,2,3	1.0	Corr.Member of NAS RA
2	Vartapetian Hamlet	1,2	1.0	Academician of NAS RA
3	Adamyan Feliks	1,3	1.0	Minor scient. research
4	Hakobyan Hrachya	1,2,3	1.0	PhD, Leading scient.research
5	Demekhina Nina	1	1.0	Doctor of Science
6	Manukyan Zhanna	1,2	1.0	Minor scient. research
7	Oganezov Robert	1,3	1.0	Engineer-electronic
8	Sargsyan Laura	3	1.0	Engineer-programmer
9	Chatrchyan Sergej	3	1.0	PhD, Senior scient.research
10	Movsesyan Grigor	1,2	1.0	Senior- engineer
*11	Khachatryan Vardan	3	1.0	PhD, Senior scient.research
12	Ajvazyan Robert	1,2	1.0	Senior- engineer
*13	Tumasyan Armen	3	0.5	Post-graduate
14	Bagdasaryan Artem	3	1.0	PhD, Senior scient.research
15	Astabatyan Razmik	1	1.0	PhD, Senior scient.research
*16	Khnkoyan Manvel	3	0.5	Magistr YSU
17	Sargsyan Galust	1,3	1.0	Engineer
18	Vinnitski Oleg	1,2	1.0	Senior- engineer
*19	Grigoryan David	2	0.5	Senior laboratorian
20	Zohrabyan Hamlet	3	0.5	Minor scient. research
21	Badalyan Hamlet	1	0.5	PhD, Senior scient.research
22	Nersesyan Yasha	1	0.5	Minor scient. research
23	Mikayelyan Mikayel	1	1.0	Minor scient. research
24	Beglaryan Juleta	1	0.5	Minor scient. research
*25	Arzumanyan Irina	3	0.5	Magistr
26	Ayvazyan Garnik	1,2	1.0	Minor scient. research

(18x 1.0 + 8x 0.5)

The mean age of participants : 56
The number of participants younger than 35 year: 5
The number of participants of pension age: 13

B) Accelerator Division

1	Sadoyan Karen	1,2	0.5	Senior- engineer
2	Khachikyan Aram	1,2	0.5	Engineer
3	Zakharyan Stepan	1,2	0.5	Engineer
4	Oksuzyan Garegin	1,2	0.5	PhD, Senior- engineer
5	Hakobyan Ashot	1,2	0.5	Engineer
6	Arutjunyan Gena	1,2	0.5	Engineer
7	Avagyan Ashot	1,2	0.5	Technician
8	Avagyan Sergej	1,2	0.5	Technician
9	Grigoryan Vardkes	1,2	0.5	Technician
10	Martirosyan Hamlet	1,2	0.5	PhD, Senior- engineer

(10x 0.5)

The mean age of participants : 68
The number of participants of pension age: 10

Equipment

Equipment description	Cost (US $)
<u>Experimental setup for production of radioactive beams</u> Electromagnetic mass-separator (electrostatic lenses (2 pc), electrostatic 90^0 filter, 90^0 bending magnet) - construction in ANSL ^{238}U target (UC5 target, container and ionisation chamber) order at PNPI Detectors parts (Plastic Scint.,NaJ,n(He3) counters,PMT's) in ANSL HPGe detector(1pc) Electronics,digital equipment <u>Experimental setup for cluster structure</u> 15 silicone strip detectors(δ=50,150 μm,1mm)-order at LHEP-JINR ^3He- ^4He dilution refrigerator - order at NSC KIPT	40,000 40,000 10,000 20,000 5,000 80,000 15,000
Total **210,000**	

Materials

Materials description	Cost (US $)
Vacuum system at ANSL	15,000
Power supply (LUE-75) ANSL	10,000
Liquid N_2 (300 l) cryogenic lab ANSL	600
Liquid He (150 l) cryogenic lab ANSL	3,000

Total **28,600**

Travel costs (US $)

CIS travel	International travel	Total
10,000 (JINR,PNPI, KIPT)	2,500 ALTO (Orsay)	**12,500**

Technical Approach and Methodology

1. **a) Design and construction of experimental setup for production and study with low energy radioactive beams of neutron-rich nuclei** (on basis of injector LUE-75 or microtron MT-25)

The possible development of experimental nuclear and particle physics program at ANSL before construction of ions accelerator complex might be also based on the use of existing park of small electron accelerators with energy above 25 MeV which includes the linac LUE-75 (E_e =20-75 MeV, I = 5-15 μA) and microtron MT-25 (E_e =25MeV, I=25 μA) . The LUE-75 might be a useful tool for generation of low energy radio-isotope beams (RIB) according to ISOL technology exploited more than 30 years at ISOLDE (CERN) and other worldwide ISOL factories[1]. This technology is exploiting the fission of U-238 nuclei and extraction of selected fragments through their thermo-diffusion path from porous high temperature (2300^0 C) target made of uranium carbides (UC_x). The recent studies of the low energy (25-50 MeV) electron beams ability for the uranium fission had shown their well applicability even at moderate beam intensity I ≥ 10 μA, comparable with performance of used hadron beams (p,d) with energies range between 50 to 200 MeV. The high cross-section (~0.5 bn) of Geant Dipole Resonance excitation is exploited as well as the interactions of the secondary neutrons, having a MeV energy range that is well adapted to the fission of ^{238}U. The electron energy range of 40-50MeV as is shown[2] is optimal for this task and from the other hand the photo-fission of U-238 allow to generate practically full chart of neutron-rich nuclides up to a mass of the fission target. The spectroscopy of neutron-rich nuclei is the subject of significant interest of the nuclear physics community due to the following observations:

- with increase of neutron numbers the known shell structure of nuclei may be transformed to another one, with change of nuclear levels structure and magic numbers
- an extraordinary structure is observed in light so called halo nuclei where an additional neutrons preferably fill an external shells having radius significantly greater than the mean one of core nuclei.

This process is mostly controlled by residual pair forces leading to a situation when for example the filling of p-shell for He-6,8 is permitted for di-neutron binding, while suppressed for a single neutron.

The goal of proposal is twofold. The first one is to learn and develop the experimental methods used with low energy beams of short lived isotopes. The second one is to start the nuclear physics research program, beginning from relatively simple task of decay modes, spins, parity, energy levels of excited states measurement. The basic experimental setup of ISOL type (Fig.1) consisting from entrance beam line, (UC_x) target , ionizer with 40kV acceleration of single charged exotic atoms flow, mass-separator, moving plastic tape in the magnet's focal plane to embed the ions and the detectors array will be designed and constructed. The target container has a triple layer structure: the internal target holder is made of graphite, second layer is made of tungsten plates and third layer made of stainless steel. For the proposal it is suggested to design and construct the hot filament structure ion source, more known as a Bayard-Alpert or Nudi type as a simplest approach. The electrons emitted by the hot filament are accelerated (E_e <100 eV) and strike the neutral atoms entering into the ionization chamber, knocking mostly a single electron. The mass separation is allowed to sort out ions of necessary isotopes. An entrance of mass-separator will contain the focusing electrostatic lenses and electrostatic deflector. The use of 90º bending magnet with rigidity BL = 0.54 Tl× m provides mass separation up to A = 200. As is seen from Fig.1 the detectors array is purposed to contain three layers of counters. The internal layer is built of thin plastic scintillator to register the electrons of β-decay. The second layer built of 15pc of NaJ(Tl) crystals ($10x10x20cm^3$) and single Ge-crystal (app.$10x10x5cm^3$) register photons, where the Ge-detector is responsible for high resolution of photon's spectra, while the faster NaJ(Tl) counters are responsible for angular coverage and coincidences at a moderate energy resolution. The external layer is purposed for neutron registration and consists of 18 atm. pressure He-3 neutron counters. In institute there is practically all necessary to construct these arrays: plastic scintillator strips, NaJ(Tl) crystals and

He-3 filled counters.

Such setup will allow to begin researches of short living isotopes and observe their subsequent β decay, registering the β particles with or without accompanied neutron(s) emission and subsequent de-excitation of daughter nuclei through γ-rays emission registered in three layer coaxial detector structure. Looking to a nuclear levels chart studied so far, one can see a numerous neutron-rich short-living nucleus($T_{1/2}$>1s) with only few energy levels measured in restricted energy range, mostly below 1 MeV. The spectroscopy of neutron – rich isotopes in the range of Z = 30-60 will be a first subject of investigations.

The proposal contains the few separate parts and each of them requires an allocation of manpower, apparatus and funding. Part of components might be designed and constructed at ANSL workshop. Some other components should be procured abroad.

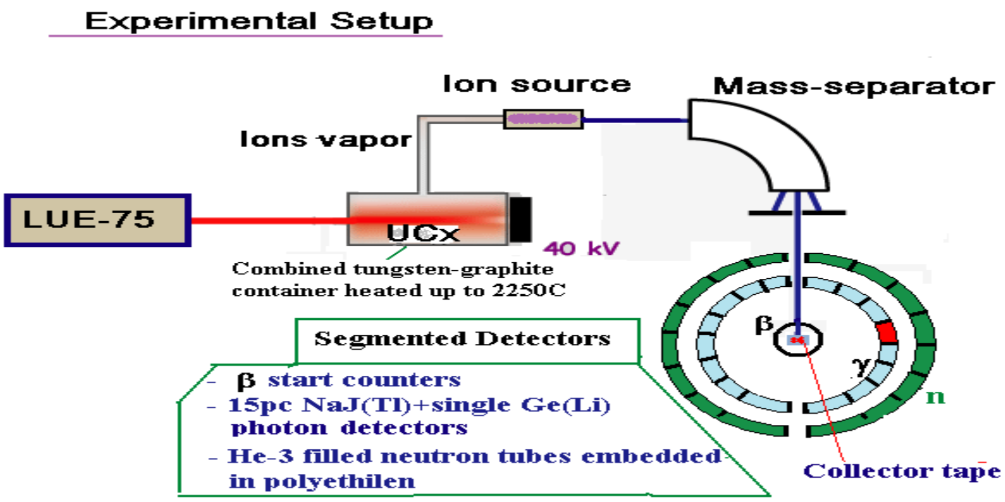

Fig.1

It is necessary to notice that there is a lack of modern digital apparatus including digital oscilloscopes, magnetometers, multi-meters, micrometers, even dosimeters. There is also need in modern apparatus for physical laboratory for data acquisition and analysis in base of VME bus, slow control and power distribution system in the base of CANBUS and others. The completion of three year program will be with setup calibration and tests using reference neutron-rich nucleus.

b) The investigation of cluster structure for the light nuclei He, Li and Be isotopes in three-body final states photo-disintegration processes in the energy range of 50-250MeV [2].

It is proposed to develop the experimental method and begin the investigation of cluster structures of excited states of the light nuclei in photodisintegration processes with three-body final states in the photon energy range 50-250 MeV . Many experimental and theoretical works have been performed to study the light nuclei structure. The structure of excited states for the light nuclei is a subject of increasing interest and is widely discussed in the modern theoretical analyses [3] that correspond to the existence and manifestation of cluster structures of excited states inside these nuclei [4,5]. Investigations of three-body photodisintegration processes of the light nuclei (He, Li, Be) with bremsstrahlung beam of the Yerevan synchrotron, including polarized photon beam, allow to study the cluster structures of excited states of seven isotopes ^{5}He, ^{6}He, ^{5}Li, ^{6}Li, ^{7}Li, ^{8}Be and ^{9}Be in the energy range E_γ = 50 - 250 MeV,.

As a first it is planned to investigate the excited states of ^{6}He isotope in the photodisintegration reaction $\gamma + {}^7\mathrm{Li} \rightarrow {}^6\mathrm{He}^* + p$ at energy Eγ = 75 MeV with subsequent decay of ^{6}He* to t+t. The experimental data on the existence of two-cluster state (t+t) in the excited ^{6}He* obtained so far by two various methods: with ions beam (^{7}Li (^{6}Li,^{7}Be) ^{6}He) and π – mesons(^{9}Be (π, ^{6}He) t) gave a different results concerning the number, energies and widths of excited states in ^{6}He*[2]. For study of this reaction the production angles and the kinetic energy of the particles (t, t) are measured in coincidence in two detectors of the setup. These measurements are able to determine the energy (E_γ) of incident photon on the target, effective mass (M_{12}) of excited states of two clusters (t, t), the parameters of the unregistered particle (p) and the Dalitz plot of the studied reaction.

The basic requirement of the planned experiment is to provide a necessary accuracy of determination at various levels of excited $^6He^*$nuclei and corresponding cross- sections. For this purpose the analysis of three-body process data using the effective masses spectrum of two tritons is most straightforward. The full Monte-Carlo simulation and subsequent reconstruction of kinematics allow to define an experimental resolution of the effective masses M_{12} . Experimental setup registers two tritons in coincidence and it consists of two telescopes of silicon detectors, allowing to identify the particles' type, measure their kinetic energy and production angles, as well as completely restore the kinematics of three-body reaction. Each telescope consists of two thin (dE/dx), 2 mm strip size Si sensors and single thick (E) Si detector. The first detector has horizontal strips and measures the horizontal coordinates and the second – vertical coordinates, that allows to define polar and azimuthal angles of emitted tritons with good accuracy. The choice of thicknesses for lithium target (200 μm) and Si detectors (50,150 and 1000 μm respectively) allows to measure the tritons' kinetic energy in the range of E_t = 4.5 -18 MeV. Geometrically the telescopes are located at a distance of 20 cm from a target, covering a solid angle app.0.1 sr each.

To determine the kinematical distributions, to elaborate the requirements to the experimental setup for the measurements' accuracy of the photon energy and effective masses of two tritons the Monte Carlo calculations were carried out for the average energy E_γ = 75 MeV of photon beam. In calculations, the experimental data on the energies and widths of three levels (a, b, c) of excited ^6He [7] were used :

E_a=15.8±0.6MeV, Γ=1.0±0.6MeV (a),

E_b=20.9±0.3MeV, Γ=3.2±0.5MeV (b),

E_c=31.1±1.0MeV, Γ=6.9±2.3MeV (c) .

Fig.2 shows the Dalitz plots for two tritons registered in coincidence, where T_1 and T_2 correspond to the kinetic energy in the CM system, and for two different channels of ^7Li photodisintegration ($^6He^*$+ p) and ($^4He^*$+ t), which corresponds to three levels (a,b,c) and level E_x= 28.3 ± 9.8 MeV, respectively.

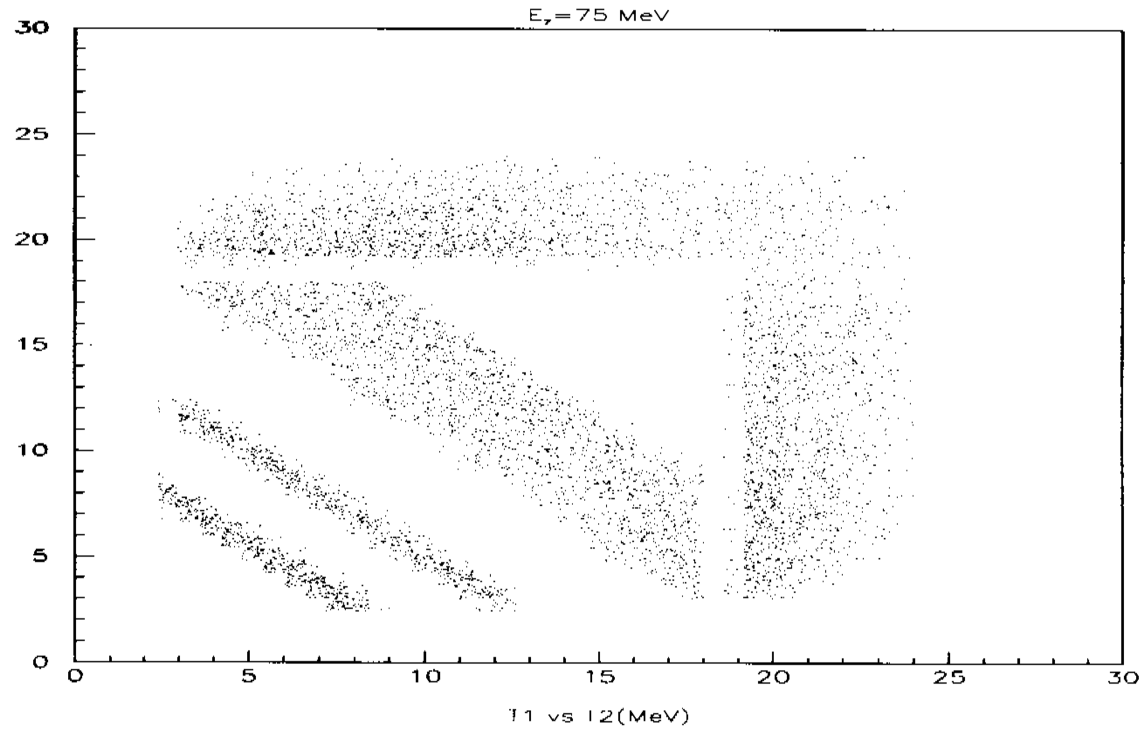

Fig.2

For these investigations with bremsstrahlung and linearly polarized photon beams we are plan design, procurement and assembly of Si detectors array . These detectors also will be necessary for researches in low energy nuclear physics.

Presently the preliminary agreement with LHEP-JINR (semi-conductor detectors department) is reached concerning possibilities to order 15 silicone strip detectors of three types: with thickness δ= 50 µm , 150 µm , 1 mm. and corresponding electronics with power supply, ADC, ..

c) Investigation of the multi nucleon correlations in photoabsorbtion process on nuclei at energies up to meson production threshold (collaboration with Yerevan State University).

At low energies ($E_\gamma \leq 20$ MeV), when the photon wave length is comparable with the nuclear dimensions, the nuclei participate in the absorption process as whole and generate the giant dipole resonance (GDR). Above GDR , at higher energies $20 \leq E \leq 140$ MeV (smaller photon wave length) , the mechanism of photoabsorption changes and main contribution in this process bring the multinucleon formation inside of nuclei (as deuterons or alfa particles). In this energy range the quasi deuteron model is applied for description of the photon absorption mechanism [8]. The cross section in this energy range can be expressed in form:

$$\sigma_{КД}(E_\gamma) = L\frac{NZ}{A}\sigma_d(E_\gamma) f(E_\gamma).$$

where L-Levinger parameter, $\sigma_d(E_\gamma)$- deuteron photodisintegration cross section, $f(E_\gamma) = e^{-D/E_\gamma}$ - Pauli blocking function , $L\frac{NZ}{A}$ - is introduced to account only correlated neutron –proton pairs.

The number of the virtual deuterons in target nucleus is defined via the semi empirical parameter. The dependence of this parameter from mass, charge and isotopic characteristics of the target will be studied in these experiments.

In the frames of the proposed project the study of the photonuclear reaction yields is planned at photon energies up to 75 MeV on the electron linac of ANSL by using activation methods. The identification of the residual nuclei should be carried out with HpGe-detectors while the outgoing fragments can be measured by using Si –detectors. The reactions with emission of more than four nucleons will be investigated. It is supposed to use as a targets the nuclei with

mass numbers in the large mass space (58-197 a.m.u) and different isotopic composition ($^{58-64}$Ni, $^{112-124}$ Sn, ^{197}Au,^{181}Ta). This target set allows to estimate the mass and isotopic dependence of the quasi deuteron structure of the nuclei.
The measurements are planned to carry out in collaboration with the Yerevan State University. The development of the chamber method for registration and identification of the emitted light particles is planned for application in present and future experiments.

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2. a) Study of polarized exotic nuclei at low temperatures (project of facility**)**

The measurement of nuclear properties (such as spin, magnetic moment, half life and mass) is a key to understanding of nuclear interactions. In the seventies and eighties years the moments of radioactive nuclei close to valley of stability have been measured in ground and excited states [1]. Since the middle of eighties new opportunities have arisen to measure the nuclear moments of many exotic nuclei far from stability through development of On-line facilities such as ISOLDE at CERN. It has become possible to produce and select exotic nuclei in quantity (flux > 10^2 - 10^5 ions/s^{-1}).
On-Line Nuclear Orientation (OLNO) facilities[2] have been created and operated in NSF Daresbury, LISOL Leuven, NICOLE ISOLDE (CERN), OSIRIS Studsvik (Sweden), HHIRF UNISOR Oak Ridge and TRIUMF Vancouver. They have given impulse to next generation isotope production facilities (SPIRAL-2, EURISOL, GSI-FAIR, ALTO) which need other experimental techniques.
Project POLAREX in ALTO (Orsay) [3] new facility for polarization of exotic nuclides. New facility ALTO will be competitive with NICOLE at ISOLDE. Also it is planned to use it on SPIRAL-2.
POLAREX (POLARization of EXotic nuclei [4]) is part of the new program of group CSNSM (Orsay) for study the nuclear moments and decay modes of exotic neutron rich nuclei produced by electrons from linear accelerator (10-50 MeV, 10 μA). It will be used (OLNO) method for observation the decay of spin oriented ensemble of nuclei. This method combines on-line implantation of a radioactive beam with the “Low Temperature Nuclear Orientation” (LTNO) technique [5].
For study of nuclear magnetic moments and decay modes of exotic nuclei, radioactive beam of interest is implanted into ferromagnetic foil held at a temperature of the order of 10 mK attached to the cold finger of an ^{3}He- ^{4}He dilution refrigerator. Applied magnetic field app.0.5 Tl magnetizes the foil and implanted nuclei are oriented through an internal hyperfine field of order of hundreds Tl. Angular distributions (anisotropy) of the decay products of the polarized nuclei are measured. Exact values of the nuclear moments are measured by means of NMR (nuclear magnetic resonance).

The POLAREX facility comprises besides beam line of exotic nuclei from the following elements:

- ^{3}He - ^{4}He dilution refrigerator to provide temperature about 10 mK,
- a thermometer to determine the temperature in the 10 mK region,
- a pure ferromagnetic foil for implantation of isotopes,
- a superconducting magnet for magnetization the foil,
- RF generator and coil for production of the RF variable frequency at the foil,
- detectors for registration gamma and beta anisotropies.

Within the framework of the nuclear physics methodical works the project of new facility POLAREX type will be developed and begun the preparation of its separate parts on the basis of existing in ANSL polarized target facility (PPT) [6] (see Fig.3):

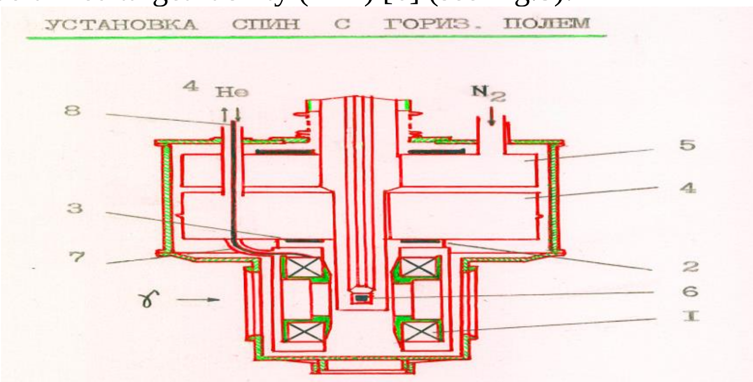

Fig.3

with a ^{3}He - ^{4}He continuous flow cryostat (cooling power of 200 mW) and ^{3}He and ^{4}He pump-down system, with superconducting solenoid (field of 2,7 Tl) in volume to 50 cm^3 and power supply for magnet as well as with polarization measurement system (a NMR -spectrometer).

It is planned to modernize a cryostat with addition of ^{3}He - ^{4}He dilution part.

For comparison the ^{3}He-^{4}He dilution refrigerator of POLAREX facility (TRIUMF - Oxford Instrument) costs 400 kEuro.

The region of exotic nuclei accessible on planned accelerating complex of ions at ANSL in Armenia, should closely to production of isotopes on next generation facilities (SPIRAL-2, EURISOL, GSI-FAIR, ALTO). For successful OLNO experiments the following isotopes production rates and implanted ions energy are required: minimal flow of oriented nuclei for measurements of gamma anisotropy 10^3 ion/sec is necessary, that provide for detector rate

1 sec^{-1} . The maximum flow is limited by 10^7 ion/sec, because there are heating of refrigerator. For achievement of high quality implantation in cold ferromagnetic foil is required ions energy of 40 KeV. If even-even nuclei and isotopes with production rates 10^4 ion/sec and lifetimes $<$ 1 sec are excluded, it remains about 300 nuclides. Besides more than 200 have unmeasured nuclear magnetic moment [4] (see Fig.4).

Nuclei that can be measured with OLNO experiments. In blue are the ones whichnuclear magnetic moments are already known, in red the yet non-measured ones.

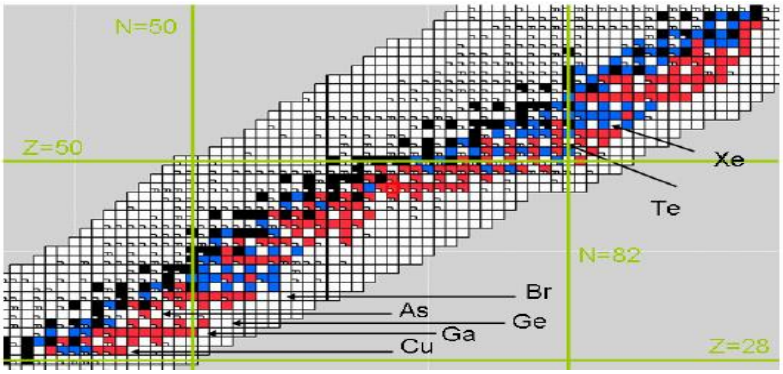

Fig.4

b) Development of electrons and protons accelerating complex project with energy to 250 MeV on basis of YerPhI`s synchrotron.

It is planned to study of possibility for transition electron synchrotron in a low energy mode : non-acceleration (50-75 MeV) and acceleration (< 250 MeV). The extracted photon beam should have a good time stretching (> 2-3 msec) for nuclear physics experiments (studying of nuclei structure, nuclear reactions etc.).

With purpose of minimization of resources and terms is supposed the detailed technical-financial study of synchrotron transition in a low energy mode.

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3. a) **Participation in international collaborations CERN – LHC (ATLAS, CMS)**

Since April 2010 LHC operates in a regime of protons collision with total energy $\sqrt{s} = 7.0$ TeV. ATLAS and CMS groups will be participate in the ongoing LHC physics program (shifts, data taking and analysis) and also in detectors upgrade works.

ATLAS experiment is planned to participate in following works:

- experimental data analysis in GRID with using capacities of YerPhI computer center establish of Tier-3 infrastructure

- - precise measurement of light yield from scintillation plates of hadron calorimeter
- - measurement of natural aging of hadron calorimeter scintillator
- - participation in shifts on the ATLAS detector and data analysis
- -. modeling of increase in light yields and segmentations of hadron calorimeter.

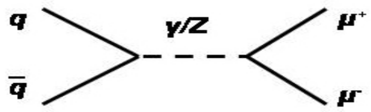
<u>CMS experiment</u> is planned to investigate Hard Diffractive Interactions of **pp** with $\mu^+ \mu^-$ ***and*** ***γ -Jet*** in single and double Pomeron exchange processes [1] for studying

a) parton structure of Pomeron and diffractive structure function [2]

$$\mathbf{F_2^{\,D}\,(x,t,Q^2,\xi) = F_{pom/h} \cdot G_{p/pom}}$$

where $\mathbf{F_{pom/h}}$ - hadron- Pomeron coupling, $\mathbf{G_{p/pom}}$ - parton distributions in Pomeron

b) «factorization» scheme of $\mu^+ \mu^-$- production



(DPE): $p + p \to p + \mu^+ + \mu^- + X + p$

(SPE): $p + p \to p + \mu^+ + \mu^- + X$

(QCD): $p + p \to \mu^+ + \mu^- + X$

If factorization is true, this ratio of cross-section QCD, SPE(single) and DPE (double Pomeron exchange) processes in same kinematical range must be equal

$$\mathbf{d\sigma^{SD} / d\sigma^{QCD} = d\sigma^{DD} / d\sigma^{SD}}$$

For this will be carried out calculation of these processes on the base of generation events by means of PYTHIA, POMWIG and HERWIG program and reconstruction on the base of CMSSW software package.

It is planned to calculate gluon contribution in parton structure of Pomeron by program CMSSW. For this purpose heavy quark-antiquark pairs process (for example, b - anti b) in single and double Pomeron exchange reactions is chosen. Such process is caused by that at enough large invariant mass of native two-jet system.

Recently the first results of data analysis in experimental measurements on CMS detector are received [3-6]. CMS group actively participated in data analysis.

For 2010 CMS- LHC experimental data (36 pb^{-1}) was selected only few hundred events-candidates of SPE process (where only 7 Z^0 enents). In analysis of Di-muon was used the information from CMS, CASTOR,HF and ZDC detectors.

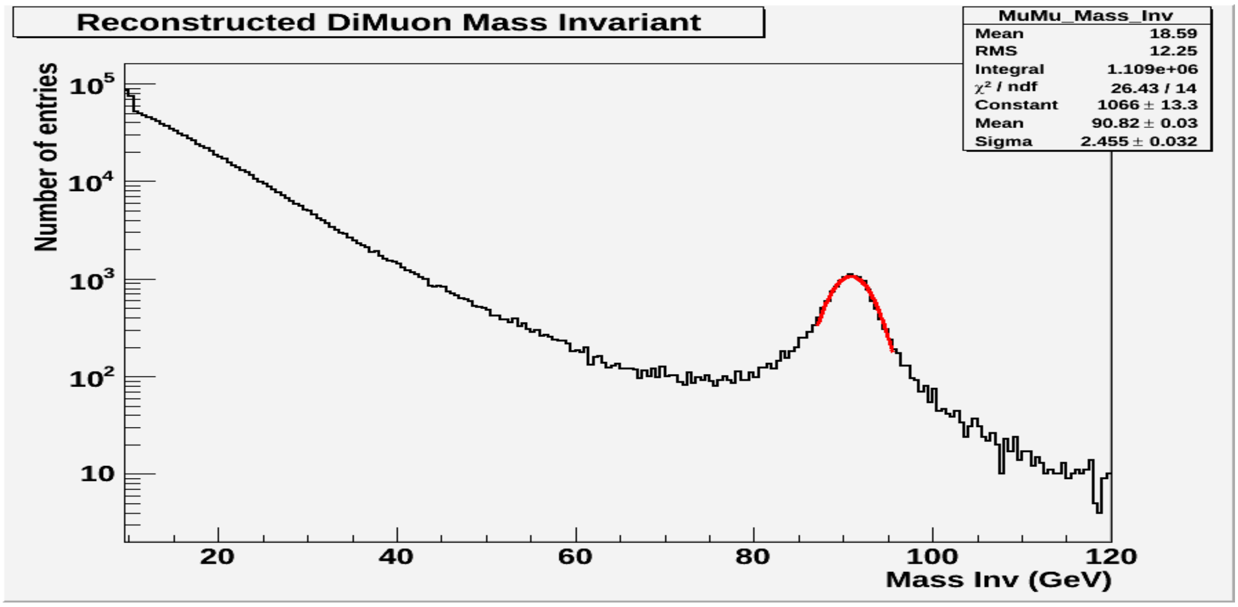


Fig.5 shows CMS Calorimetry energy after the various cuts.

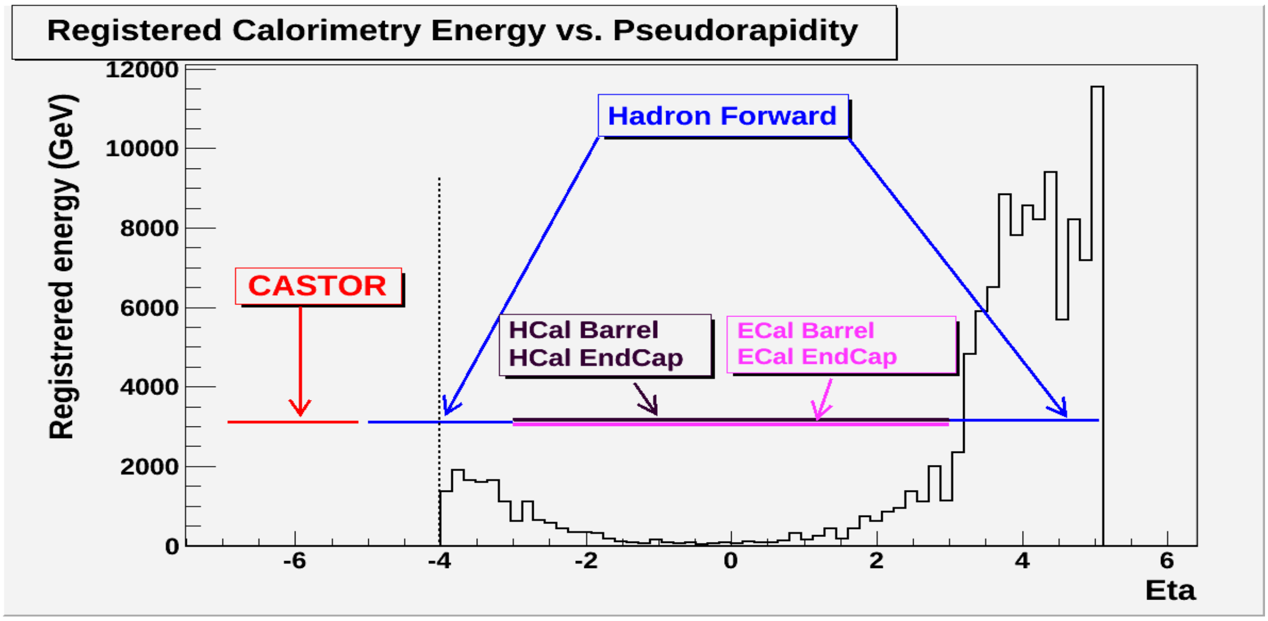


Fig.5

Comparison MC and experiment is presented in Fig.6. Require higher statistics for final conclusion about Pomeron's quark structure.

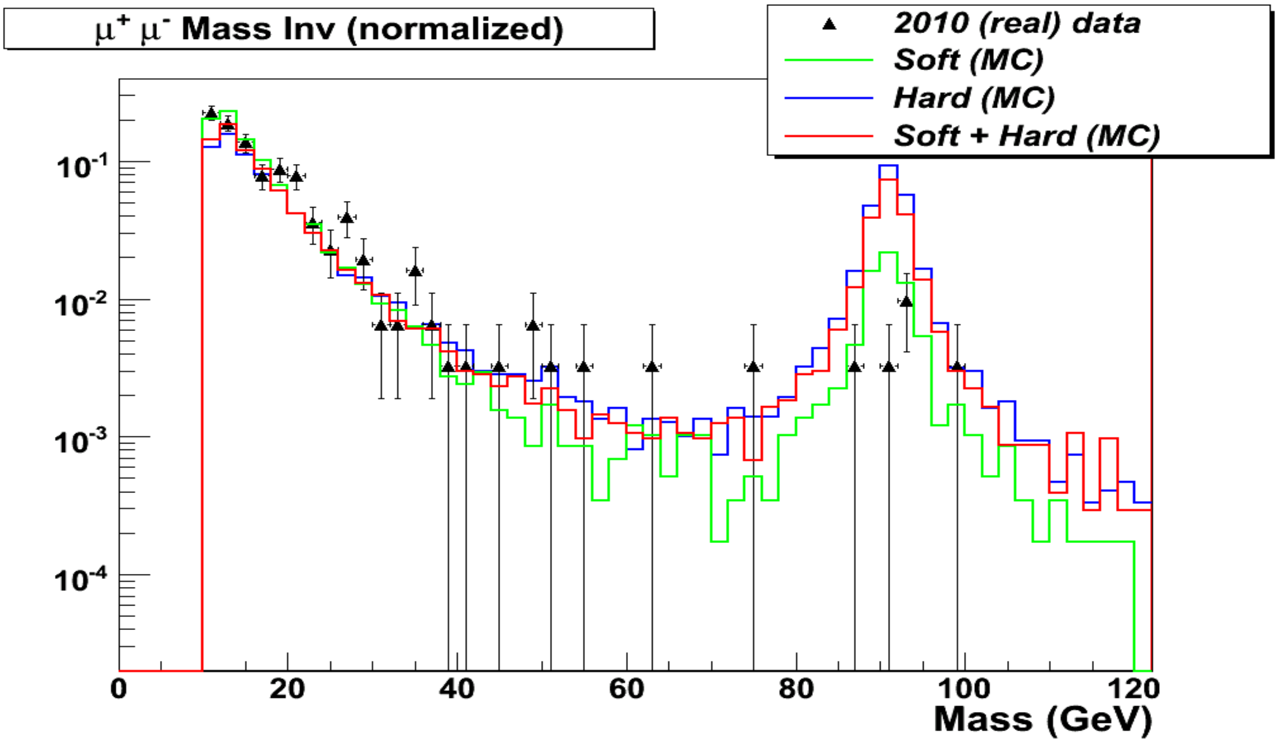


Fig.6

Within the framework of theme will be continued data analysis with Di-muon in hard diffractive processes .

For performance of works in YerPhI it is necessary:

- start the GRID- cluster for data analysis
- creation of calculation center for data processing with high-speed communication
- for meetings and audio-conferences equip the room with a projector and screen-monitor

- for inclusion of participants in authors lists and visits of students and post-graduate students in CERN it is necessary annual financing by Government RA at level of 35 mil. drams

Investigation within DESY-H1 Collaboration

b)Investigation of multijet events in e^+p и e^-p DIS at low Q^2 and event shape investigation

In the past the DESY- H1 group actively participated in measurements and the analysis of the experimental data [7]. In the framework of theme will be studied in deep-inelastic e^+p and e^-p scattering multijet events at $5<Q^2<100$ GeV^2 and elasticity y = 0.2-0.65 using data recorded with the H1 detector at HERA in the years 2005-2007, corresponding to an integrated luminosity ~ 300 pb^{-1}. For the first time single and double differential cross sections for inclusive jet, 2-jet and 3-jet as well as their multiplicities normalized to the neutral current deep-inelastic scattering (DIS) cross sections will be measured. Large statistics and cross section normalization will essentially reduce statistical and systematical uncertainties. These measurements will be subsequently used for precision determination of the strong coupling. This investigation will be helpful for LHC. Deep-inelastic e^+p и e^-p scattering data also will be used to study the differential distributions of event shape variables.

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