PERSPECTIVE SCIENTIFIC PLANS of EPD for period 2013-2016.

Scientific Council(SC) of EPD within August – September 2012 realized 7 meetings on which long-term plans of 8 groups were in detail presented and discussed

The proposed program consists of two parts. One part concerns planned investigations on the basis of ANSL's accelerator complex (electron linac, synchrotron) and preparation of the scientific proposals for experiments with proton beam on CYCLONE C-18 another is focused on continuation of researches within the frames of existing international collaborations with CERN, TJNAF, DESY, HESS, JINR.

Part 1. Low energy nuclear physics .Experimental program on the basis of YerPhI`s accelerators and CYCLONE C-18 :

a)cluster structure of excited states of light nuclei (He, Li, Be) ,

b)Carbon ^{12}C disintegration into three alphas by using γ - beam

c)photonuclear reactions in quasi deuteron absorption energy range

d) proton-nuclei interactions

a) Study of cluster structures of excited states for the light nuclei He, Li and Be in three-body photodisintegration processes.

- **The structure of the excited states of light nuclei is a subject of increasing interest and is widely discussed in the modern theoretical analyses, that corresponds to a possible existence of cluster structure inside of these nuclei.**
- **The experimental studies of the excited states of light nuclei are performed by different methods and use ion-Japan, π-meson-Los-Alamos hadron factory (LAMPF) and photon (electron)-(KhIPT, SACLAY, LUND) beams .**
- **It is proposed to realize the experimental program and begin the investigation of cluster structures of excited states of the light nuclei (He, Li, Be) in photodisintegration processes with three-body final states (two clusters and single nucleon) using photon beam in the energy range 30-75 MeV.**

- **will be studied for the first time.**

- ***An advantage of three particle final state reactions as compared with two particle final state γ+A → 1+2 is the possibility to investigate not only two cluster structure of excited state of the stable targets but also an excited states of the unstable isotopes:*** **^{5}He, ^{6}He, ^{5}Li, ^{6}Li, ^{7}Li, ^{8}Be, ^{9}Be** ***, according to a scheme γ + A → (1,2)* + 3 with the formation and decay of the excited state (1,2)* → 1+2***

For the case where 3 targets are ^{6}Li, ^{7}Li , ^{9}Be we can observe 7 reactions of photodisintegration

$\gamma + {}^{6}Li \rightarrow t + d + p$ $\gamma + {}^{7}Li \rightarrow t + t + p$

$\gamma + {}^{6}Li \rightarrow {}^{3}He + d + n$ $\gamma + {}^{7}Li \rightarrow {}^{3}He + t + n$

$\gamma + {}^{6}Li \rightarrow \alpha + p + n$ $\gamma + {}^{7}Li \rightarrow \alpha + d + n$

$\gamma + {}^{9}Be \rightarrow \alpha + \alpha + n$

For these seven photodisintegration reactions we present the cluster structures of 22 excited states of seven isotopes: ^{5}He, ^{6}He, ^{5}Li, ^{6}Li, ^{7}Li, ^{8}Be, ^{9}Be and the used targets:

- **$^{5}He \rightarrow (t+d)^{*}, (\alpha+n)^{*}$ targets ^{6}Li, ^{7}Li, ^{9}Be**
  $^{6}He \rightarrow (t+t)^{*}$ target ^{7}Li
- **$^{5}Li \rightarrow (^{3}He+d)^{*}, (^{4}He+p)^{*}$ target ^{6}Li**
- **$^{6}Li \rightarrow (^{3}He+t)^{*}, (^{4}He+d)^{*}$ target ^{7}Li**
  $(^{3}He+d+n)^{*}, (t+d+p)^{*}, (^{5}He^{*}+p)^{*}, (^{5}Li^{*}+n)^{*}, (\alpha+p+n)^{*}$ target ^{6}Li
  $^{7}Li \rightarrow (^{6}He^{*}+p)^{*}, (t+t+p)^{*}, (^{6}Li^{*}+n)^{*}, (\alpha+d+n)^{*}, (^{5}He^{*}+d)^{*}, (t+n+^{3}He)^{*}$ target ^{7}Li
- **$^{8}Be \rightarrow (\alpha+\alpha)^{*}$ target ^{9}Be**
  $^{9}Be \rightarrow (^{8}Be^{*}+n)^{*}, (\alpha+\alpha+n)^{*}, (^{5}He^{*}+\alpha)^{*}$ target ^{9}Be

Photodisintegration of ^{7}Li target in the photon energy range up to E_{γ} =75 MeV

As a first it is planned study of the cluster structures of 3 excited states of these nuclei:

^{6}He*(t+t), ^{7}Li* (^{6}He*+p), ^{7}Li* (t+t+p)

- **The results of experimental studies of two-cluster (t+t) excited states of ^{6}He* nucleus obtained so far by two various methods differ, concerning the number of excited states of ^{6}He*, as well as the values of the energies and widths.**

1) ^{7}Li+ ^{6}Li→ ^{7}Be+ (^{6}He*(t+t)) the results are:

E=18,0±0.5MeV, Γ=7.7±1.1MeV [H. Akimune et al. Phys. Rev. C 67, 051302 (R), 2003]

E=18,0±1.0MeV, Γ=9.5±1.0MeV [T. Yamagata et al., Phys. Rev. C 71, 064316, 2005]

2) π^{-} + ^{9}Be→ ^{6}He*(t+t)+t the results are:

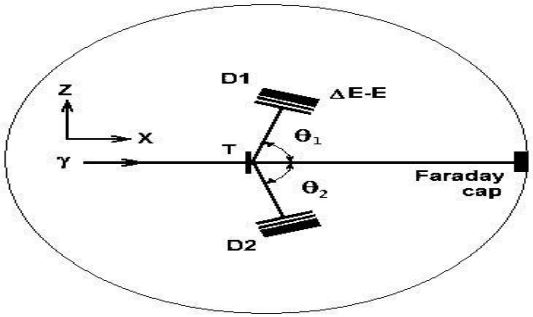
E=15.8±0.6MeV, Γ=1.0±0.6MeV (a)

E=20.9±0.3MeV, Γ=3.2±0.5MeV (b)

E=31.1±1.0MeV, Γ=6.9±2.3MeV (c)

[Ю. Гуров и др., Письма в ЖЭТФ, т. 84, 3, 2006]

Experimental setup



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 in the range of E_t = 4.5 - 18 MeV. The thicknesses for lithium target (200 μm) . Geometrically the telescopes are located at a distance of 20 cm from a target, covering a solid angle app.0.25 sr each.

Monte Carlo calculation

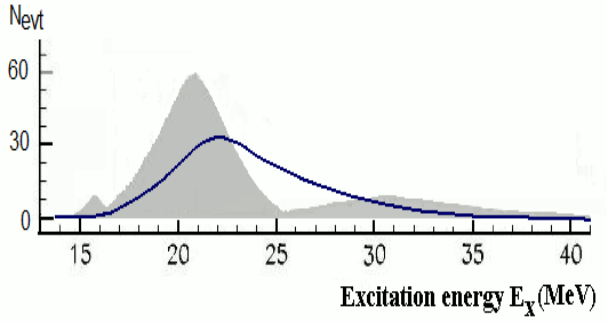
Setup configuration parameters

$E_x \pm \Gamma/2$ (MeV)	$\langle\theta_{t1}\rangle$ (deg)	$\langle\theta_{t2}\rangle$ (deg)	$\langle\varphi_1-\varphi_2\rangle$ (deg)	$\langle T_t\rangle$ (MeV)	$\langle\theta_p^{cm}\rangle$ (deg)	$\langle T_p\rangle$ (MeV)
20.9±1.6	83	83	120	5.7	82	15.7 (b)
31.1±3.5	87	87	150	9.9	76	8.1 (c)

Contributions of experimental uncertainties on the energy resolutions

	Multiple scattering in target	Uncertainties of ionization losses in target	Beam spot size in target (10x10)mm²	Detector granularity (10x10)mm²	Detectors energy resolution	All factors together
σ_{Ex} (MeV)	0.08	0.19	0.21	0.23	0.08	0.38
$\sigma_{E\gamma}$ (MeV)	0.47	0.28	1.22	1.28	0.08	1.71

- quasi-two-body disintegration process $\gamma + {}^7Li \rightarrow {}^6He^* + p$ with subsequent decay of excited $^6He^*$ states ($^6He^* \rightarrow t+t$)
- quasi-two-body disintegration process $\gamma + {}^7Li \rightarrow {}^4He^* + t$ with subsequent decay of excited $^4He^*$ states ($^4He^* \rightarrow t + p$)
- three-body disintegration process $\gamma + {}^7Li \rightarrow t + t + p$



MC results

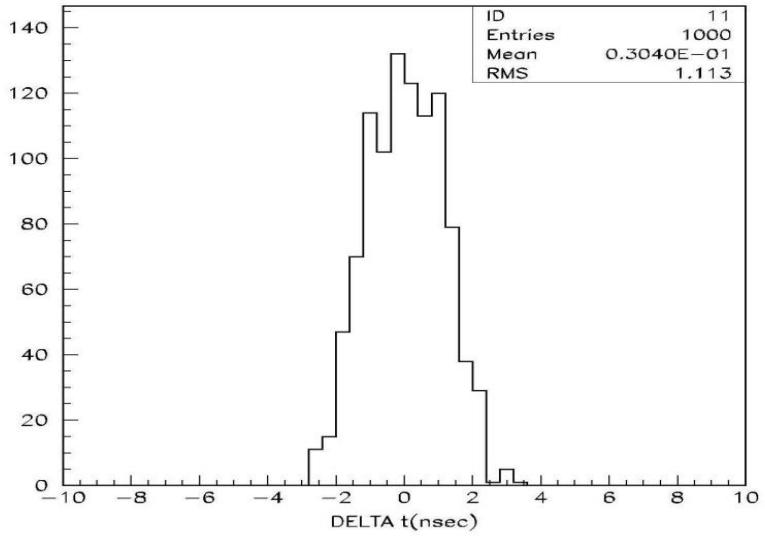
	mass
^{6}He -	5603,2 Mev
^{6}He*	
«a»	5619 Mev
«b»	5624,1 Mev
«c»	5634,3 Mev

$N_{evt}=N_t * N_{\gamma *} <d\sigma/d\Omega>_* \Delta\Omega_* \varepsilon_{MC}$

- $N_{Li}= (\rho d/A) \times N_A =(0.534\times200\times10^{-4}/7) \times6.02\times10^{23} = 0.92 \cdot 10^{21}$
- $N_\gamma = 10^8\ \gamma$/sec
- $d\sigma/d\Omega$ = 3.0 mkb/sr
- (a) $\varepsilon_{MC} = 5_*10^{-5}$ *N = 0.2 evt/h*
  (b) 0.7_*10^{-3} *7.2evt/h*
  (c) 6_*10^{-3} *32evt/h*

- ***The distribution of time-of-flight difference measured and reconstructed between two arms of telescopes***

for separation of the accidental background in t+t events



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Synchrotron at low energies

For realization of the coincidence experiments with γ-beam up to energy 75 MeV will be developed and used for the first time :

the new non-acceleration mode of synchrotron with electron energy 70-75 MeV

Electron beam with pulse duration 0,7 μsec from an injector will be directed to an accelerator ring. The extracted photon beam should have a good time stretching (> 2-3 msec).

Required parameters of synchrotron:

non acceleration mode , energy of electrons	70 – 75 MeV
photons energy spread , ΔE/E	1-2 %
slow extracted γ-beam, beam pulse duration	2-3 msec
photon intensity	10^9 - 10^{10} / sec

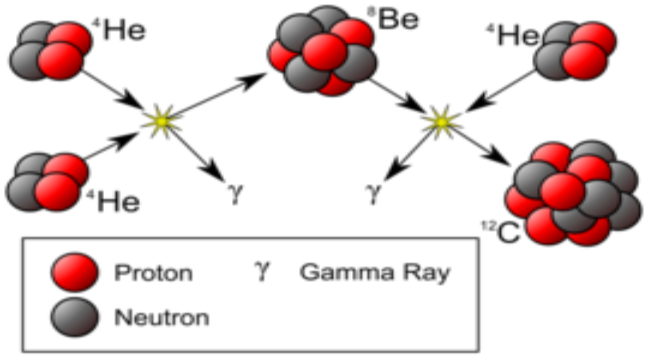
Necessary resources for detection system

For practical realization of this program is necessary except obtaining required parameters of synchrotron to create experimental setup. Presently the preliminary agreement with LHEP JINR (semi-conductor detectors department) is reached concerning possibilities to order silicone strip detectors of three types: with thickness δ= 50 μm ,150 μm , 1 mm and width of strip 2 mm using *Si-wafer n-type, FZ-Si, Ø4´´, P ~ 3-5 kOhm ·cm*. Also they will develop and create corresponding electronics with power supply, ADC, ..

Duration of production	1 year
for 15 detectors (5 in each nominal)	
Total cost	app. $ 80K (35 mln dr.)
(including purchase Si – wafer material for 15 detectors	

b) Carbon ^{12}C disintegration into three alphas by using γ- beam

$^{12}C(\gamma, 2\alpha)\ ^{4}He$ reaction is interesting in connection with 3α reaction, which plays a crucial role in stellar helium burning [L. R. Buchmann and C. A. Barnes, Nucl. Phys., A 777 (2006) 254].



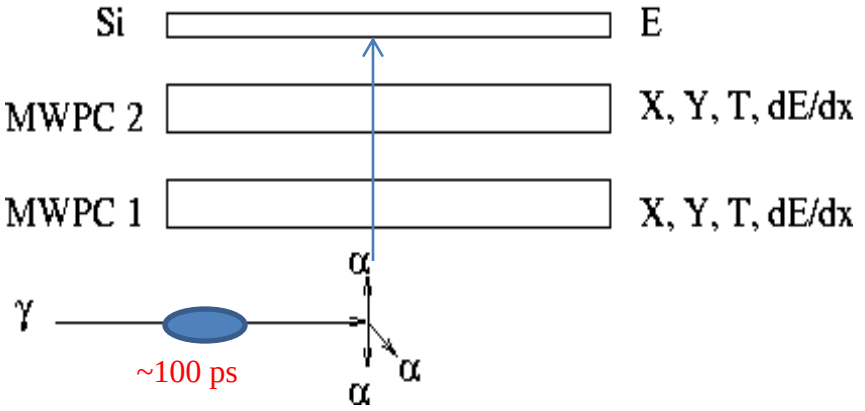
$^{4}He + {}^{4}He = {}^{8}Be$,
$^{8}Be + {}^{4}He = {}^{12}C$.

Most important resonance in ^{12}C *for astrophysics is situated 7.65 MeV above the ground state, and has spin and parity 0^{+}

so-called Hoyle resonance

Measuring cross section of the $^{12}C(\gamma,3\alpha)$reaction near threshold by using 50 MeV bremsstrahlung photon beam and active target based on 3 Torr heptane (C_7H_{16}) filled low pressure MWPCs and Si detectors.

Schematic representation of the α detector single module



The threshold energy for detection of alpha particles is ~100 keV

By using MWPCs and Si detectors, position, time, ionization energy loss (dE/dx) and energy (E) of produced charged particles will be measured.

Range of 100 keV α particle in a 2 Torr heptane is about 10 cm within error of about 1 mm

In the past was investigated by using photon beams and different experimental technique such as photo-emulsion technique , time projection chamber, diffusion chamber placed in the magnetic field. Obtained experimental results are very contradictory

c)Photonuclear reactions in quasi deuteron absorption energy range up to meson production threshold

(collaboration with Yerevan State University)

- At low energies (E_γ ≤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)
- At higher energies 20≤ E≤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.
- cross section $\sigma_{КД}(E_\gamma) = L\frac{NZ}{A}\sigma_d(E_\gamma)f(E_\gamma).$
- L - Levinger parameter

  $\sigma_d(E_\gamma)$ - deuteron photodisintegration cross section

  $f(E_\gamma) = e^{-D/E_\gamma}$ - Pauli blocking function

$L\frac{NZ}{A}$ account only correlated neutron –proton pairs

➡ *dependence of parameters (L,D) from mass, charge and isotopic characteristics of the target will be studied in these experiments*

- *It is supposed to use as a targets the nuclei with different isotopic composition ($^{58-64}$Ni, $^{112-124}$Sn, ^{197}Au,^{181}Ta)*
- *Theoretical calculation is planned with San Paulo University (Brazil)*
- ***identification of the residual nuclei should be carried out with HpGe-detector** using activation method*
- ***experimental investigation of the photonuclear reactions in quasi deuteron absorption range are planned at maximum bremsstrahlung energy 75 MeV on linear electron accelerator(injector).***

Talks (Conferences)

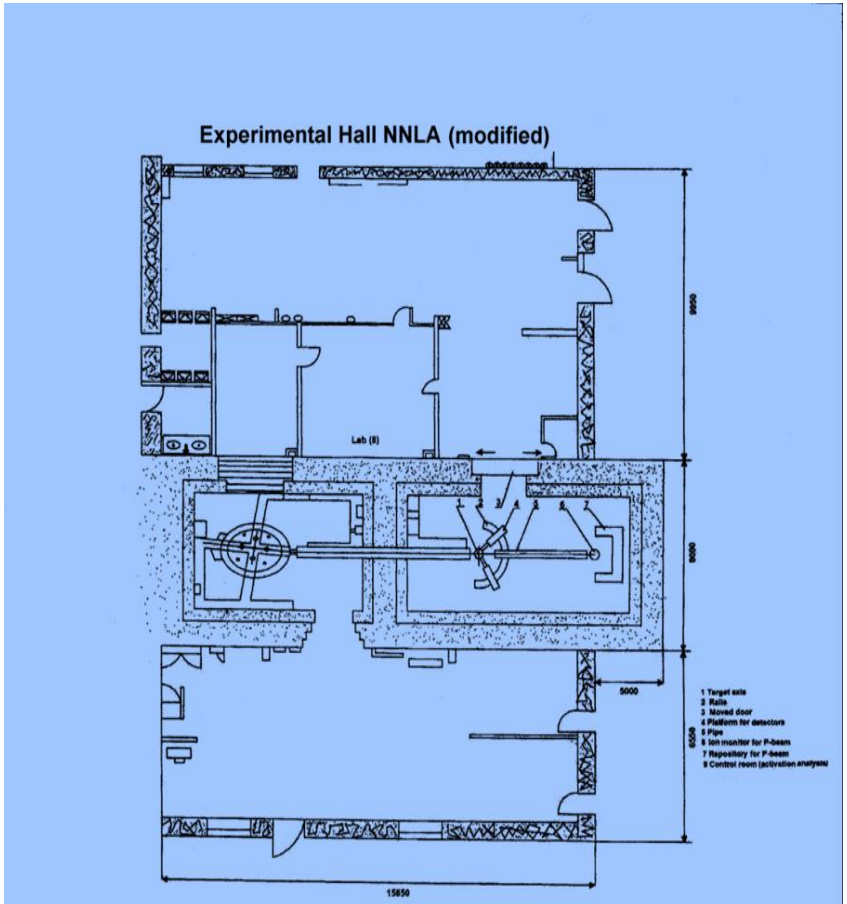
1. **LX International Conference on Nuclear Physics " Nucleus 2010 "**
A.R. Balabekyan, A.S. Danagulyan, J.R.Drnoyan, N.A.Demekhina et al.
Systematization of cross sections of residual nuclei formation on the separated tin isotopes in reactions with protons of different energies.
G.Hovhannisyan, A.Danagulyan, A.Balabekyan,N.Demekhina et al.
Interaction of ^{12} C ions with the enriched isotopes ^{112,118,120,124} Sn
A.A. Kulko, N.A. Demekhina, R.Kalpakchieva et al.
Isomeric ratio for ^{196,198}Tl and ^{196,198} Au from fusion and transfer reaction of ^{6} He with ^{197} Au .
2. **INIR-2011 , Petergof 4-11 July 2011, Sanct Peterburg**
N.A.Demekhina et al. Isomeric cross section ratios in the reactions with D and 6He beams at energies near and above Coulomb Barrier
3. **LXI International Conference on Nuclear Physics " Nucleus 2012"**
Demekhina N.A. , Kulko A.A., Skobelev N.K. et al Исследование реакций ^{6}He+^{197}Au в области энергий 40-114МэВ.

$\sigma_{qd} = (61.2/E_\gamma^3)(E_\gamma - 2.224)^{3/2}$

d) Proton-nucleus interactions CYCLOTRON C-18

- *General view of the cyclotron with external beam line*

Energy **18 MeV proton**
Beam current proton
- High current - 150 µA
- Standard (ST): 100 µA ~ 6x 10^{14}/s
Acceleration plane Horizontal
Extracted ions H+ (proton)
Extraction / target port 8 independent



We suggest several modification, as follows:
-The Experimental Hall EH of IBA proposal is 5x5 m^2 size, which is not enough for installing sophisticated physical equipment. A rotating platforms, various targets for beam experiments, a beam dumping system, vacuum pumps and other scientific instrumentation needs more room for proper operation. Therefore, we suggest increasing the size of that hall to 50 m^2. Also cable vaults should be provided in EH for power and signal cables.
- The area of the control rooms should be not less than 30 m^2 each – one on the ground floor as close as possible to EH – for controlling of radioactivation experiments, and second one – on the first floor for controlling target experiments. Control rooms should be provided by water, communications and air-conditioning system.

Experimental program (*preliminary)*

Despite of a large amount of the existing experimental data on low-energy proton-nuclear interactions, new experimental data are still needed for decision unsolved problems, in particular:

- **the stellar nucleosyntesis,**
- **the structure of the resonance (excited) states of light nuclei,**
- **the underlying mechanisms of the (p,xn) and (p,α) reactions**
- **the nuclear isomeric states production.**

The lack of the experimental data on these topics can be, to an essential extent, complemented in the considered below experiments with the 18 MeV proton beam of the C-18 cyclotron.

For suggested experiments will be prepared physical proposals and carried out Monte Carlo simulation

1)stellar nucleosyntesis - synthesis of the avoided nuclei

(p,n), (p,γ) , (p,2n) electromagnetic acceleration of protons in stellar atmospheres

^{74}Se, ^{78}Kr, ^{80}Kr, ^{84}Sr, ^{92}Mo, ^{94}Mo, … ^{196}Hg ~ 35 nuclei

at E_p> 10 MeV (p + 2n) dominant process and data are rather scarce

p + ^{93}Nb → ^{92}Mo + 2n - n-detector

p + ^{93}Nb → ^{94}Mo + γ - (HPGe) ORTEC

Of particular interest are the (p, γ) and (p,n) reactions producing an intermediate radioactive isotope followed by its participation in the next (p, g) and (p,n) reactions, respectively, leading to the formation of an avoided nucleus.

Residual avoided nucleus	Intermediate reaction	Half-life	Isomer Half-life	Available data, E_p (MeV)
^{74}Se	^{72}Ge (p,γ) ^{73}As	80.3 d		no data
^{78}Kr	^{76}Se (p, γ) ^{77}Br	57 h	4.3 m	1.3 – 1.5
^{84}Sr	^{82}Kr (p, γ) ^{83}Rb	86.2 d		no data
^{92}Mo	^{90}Zr (p, γ) ^{91}Nb	680 y	60.9 d	no data
^{96}Ru	^{94}Mo(p, γ) ^{95}Tc	20 h	61 d	no data
^{98}Ru	^{96}Mo(p, γ) ^{97}Tc	4.2·10^6 y	91 d	no data
^{102}Pd	^{100}Ru (p, γ) ^{101}Rh	3.3 y	4.3 d	no data
^{106}Cd	^{104}Pd(p, γ) ^{105}Ag	41.3 d	7.2 m	2.6– 7.2
^{112}Sn	^{110}Cd(p, γ) ^{111}In	2.8 d	7.7 m	no data
^{120}Te	^{118}Sn(p, γ) ^{119}Sb	38,2 h		no data
^{124}Xe	^{122}Te(p, γ) ^{123}I	13.3 h		no data
^{126}Xe	^{124}Te(p, γ) ^{125}I	59.4 d		no data
^{130}Ba	^{128}Xe(p, γ) ^{129}Cs	32.1 h		no data
^{132}Ba	^{130}Xe(p, γ) ^{131}Cs	9.7 d		no data
^{136}Ce	^{134}Ba(p, γ) ^{135}La	19.5 h		no data
^{138}Ce	^{136}Ba(p, γ) ^{137}La	6·10^4 y		no data
^{144}Sm	^{142}Nd(p, γ) ^{143}Pm	265 d		no data
^{156}Dy	^{154}Gd(p, γ) ^{155}Tb	5.3 d		no data
^{158}Dy	^{156}Gd(p, γ) ^{157}Tb	71 y		no data
^{162}Er	^{160}Dy(p, γ)^{161}Ho	2.5 h	6.8 s	no data
^{164}Er	^{162}Dy(p, γ) ^{163}Ho	4570 y	1.1 s	no data
^{168}Yb	^{166}Er(p, γ) ^{167}Tm	9.3 d		no data
^{174}Hf	^{172}Yb(p, γ) ^{173}Lu	3.3 y		no data
^{180}W	^{178}Hf(p, γ) ^{179}Ta	1.8 y	9 ms; 52 ms	no data
^{184}Os	^{182}W(p, γ) ^{183}Re	70 d	1.0 ms	no data
^{190}Pt	^{188}Os(p, γ) ^{189}Ir	13.2 d	13.3 ms; 3.7 ms	no data
^{196}Hg	^{194}Pt(p, γ) ^{195}Au	186 d	30.1 s	no data

cont

2) Investigations of nuclear excited states in pC interactions

Li, Be and B isotopes in pC interactions was extensively studied at energies ***E_p > 25 MeV*** *with* check the predictions of the theoretical models .

- **It is assumed to study these processes in interactions of protons with the carbon nuclei at E_p = 18 MeV.**

  $p + {}^{12}C \rightarrow {}^{3}He + {}^{10}B$

  $p + {}^{12}C \rightarrow {}^{6}Li + {}^{7}Be$

- **Excited states of the $^{12}C^*$ nucleus play a crucial role in the stellar helium burning proceeding via 3α fusion**

  $^4He + {}^4He \rightarrow {}^8Be \qquad {}^8Be + {}^4He \rightarrow {}^{12}C$

It is planned to perform high – precision measurement of excitation levels of $^{12}C^*$ - **excited Hoyle states**

$p + {}^{12}C \rightarrow 3\alpha + p \quad E_x$= 7.654 ; 9.6 MeV

using → low-pressure MWPC with heptane (C_7H_{16}) at 3 Torr

3) The underlying mechanisms of the (p,α) and (p,xn) reactions

(p,α)-reactions

- At low energies, E_p<10MeV, and comparatively higher excitation energies of the residual nucleus the formation and evaporation of a compound nucleus is the dominant mechanism of the α-particle emission.

- With increasing E_p, the role of the direct α production gradually increases and becomes predominant

- In the energy region E_p = 15-18 MeV the actual theoretical models *(full excitation, cascade and Weisskopf-Ewing)* fail are describing the experimental data.

- Data are rather scarce for elements with atomic number Z >8. It should be also noted, that for a number of nuclides (e.g. ^{28}Si, ^{32}S,^{45}Se, ^{89}Y, ^{127}I, ^{175}Lu) the data on (p,α) reactions are absent at any E_p

New experimental data on angular and energy spectra of α-particles from (p,α) reactions will be obtained in the range of E_p=15-18 MeV for a wide range of isotope masses

cont

4) The nuclear isomeric states production

The measurements of the cross sections, related to the production of the reaction products in the states with different angular momentum are the one of the main directions of the study of nuclear structure.

- ***It is suggested to study several reactions of the isomeric pair production in the energy range of E_p = 10-18 MeV at which the experimental data are rather scarce or even absent at present***
- ***The activation analysis method will be applied to measure the cross sections of the isomeric pair production***

  $p + {}^{124}Sn \rightarrow {}^{124m.g}Sb + n$

  $p + {}^{nat}Mo \rightarrow {}^{93m.g}Tc, {}^{94m.g}Tc, {}^{95m.g}Tc$

- ***Some of these reactions have of radiomedical interest (^{124}Sb, ^{111}In, ^{117m}Sn)***

Conclusion

The suggested scientific program on the C-18 cyclotron is aimed the extraction of a large bulk of new experimental data on proton-nucleus interactions. This knowledge will be useful for a better understanding of the nuclear structure and the mechanisms of the cosmic nucleosynthesis, as well as for testing and improvement of various theoretical models on the low-energy nuclear reactions.

- ***The nuclear model calculation carry out in the frame of various codes (ALICE-IPPE, EMPIRE-II,..}***

- ***Experimental methods***

1)→ activation analysis method

High Purity Germanium detector (HPGe)ORTEC
n- detector (plastic scintillators with PMT)
dE/dx,E- Si-microstrip detectors

2)→ ***LPMWPC - low-pressure multi-wire proportional chamber (E , TOF - MS)***

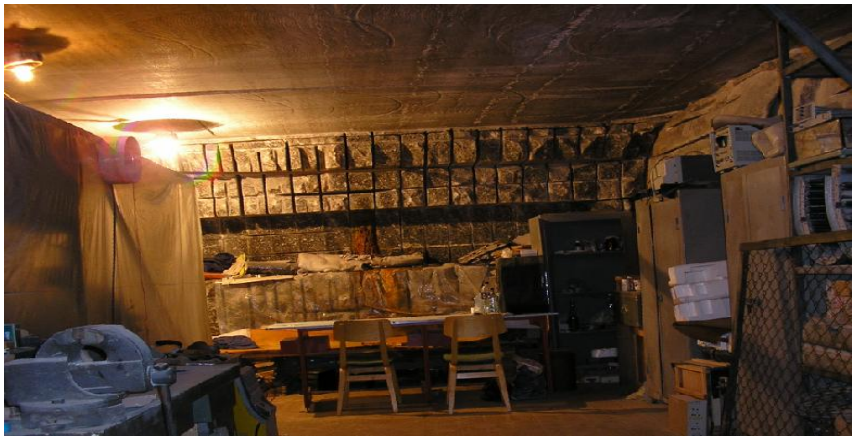
3)→ ***LPMWPC(measuring angular and energy distributions of α)***
dE/dx,E- Si-microstrip detectors

4)→ activation analysis method

(HPGe)ORTEC

Low background measurements in the YerPhI underground laboratory

- The low-background laboratory of YerPhI is located at the depth of 660 of water equivalent (240 m underground) in Yerevan salt mine.
- The natural conditions in the mine (the humidity is about 35%, temperature 20-21 ^{0}C) are very comfortable both for people and electronic devices and the natural background in salt mines is exceptionally low.



- The main current activity is the study of conditions for preparing of competitive experiment on the Relic WIMPs (Weakly Interacting Massive Particles) search.

- **Now we concentrate our activity on the following questions:**

1. **The continuation R&D for NaI(Tl) scintillator detector technique having a goal to decrease energy threshold comparing to DAMA detectors (< 2 KeV). In the case of success we could construct the set-up for WIMPs searching, which is based on the several hundreds kilograms of NaI(Tl) crystals available in Yerevan Physics Institute.**
   - *increase in a light collection as much as possible by placing NaI crystal into transparent envelope and applying PMTs to each side of crystal*
   - *development of low noise electronics for performing of one-photoelectron regime*
   - *development of PMTs cooling system (to reduce thermo-emission noises)*
   - *development of the data acquisition system, including hardware and software*
   - *measurements of high energy neutrons (>1 MeV) background in our underground laboratory, because neutrons can imitate WIMPs scattering events.*
2. **Another point of our activity was the determination of suitability of our salt mine for the detection of ultra-high energy (UHE) neutrinos through their radio Cherenkov signature (Askarian method).**
   - *determine the attenuation lengths of radio waves in 100 – 1000 MHz frequency range. Corresponding R&D were provided, and are continuing now.*

The positive results in any (or both) of this directions will make our mine attractive for international cooperation.

R&D works for other low background measurements

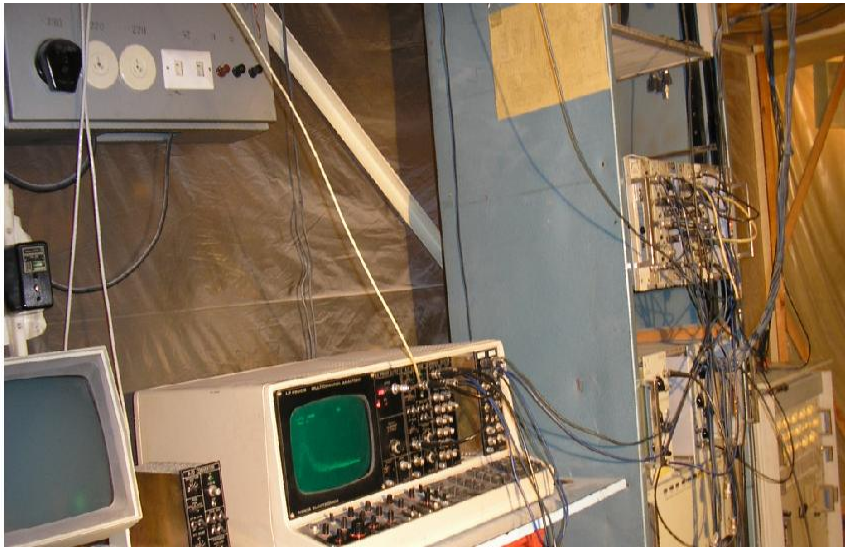
1. **In a frame of a collaboration with JINR (DUBNA) we participated in GEMMA experiment, which was performed at Kalinin nuclear power plant (NPP) having the aim to measure neutrino magnetic moment.**

- **first stage is finished. The obtained value of an upper limit $\mu_\nu/\mu_B \leq 2.9*10^{-11}$ (μ_B – Bohr magneton) is twice lower than the best in the world. Results entered in Particle Data Group.**
- **second stage of GEMMA experiment is preparing now. It will allow to achieve the limit $\mu_\nu/\mu_B \leq 1.0*10^{-11}$.**

2. **It's supposed to use our low-background setup also for activation analysis in nuclear physics experiments being planned to perform on low-energy beams.**

3. **Multifragmentation of bismuth nuclei in the fission processes, occurred by means of GeVphotons(**byproduct)

The measurements were carried out by us in 90-th on the bremsstrahlung beams of Yerevan synchrotron at different maximal energies (2 GeV, 3 GeV, and 4.5 GeV) of photon spectrum. Nuclear photoemulsions, which were implanted by bismuth nuclei, were used. The data handling of the results of the experiment of bismuth nuclei fission into two and three fragments with comparable masses is performed now.



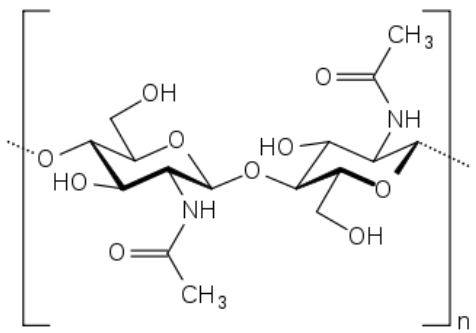
1. Upper limit on the neutrino magnetic moment from three years of data from the GEMMA spectrometer.
A.G. Beda (Moscow, ITEP), V.B. Brudanin, V.G. Egorov, D.V. Medvedev (Dubna, JINR), V.S. Pogosov (Yerevan Phys. Inst.), M.V. Shirchenko (Dubna, JINR), A.S. Starostin (Moscow, ITEP). **arXiv:1005.2736 [hep-ex] 2010.**

2. Исследование процесса расщепления ядер висмута на три соизмеримых по массе осколка ГэВ-ными фотонами.
О.Ф.Погосова, В.С.Погосов. Известия НАН Армении 46, N3, 217, 2011.

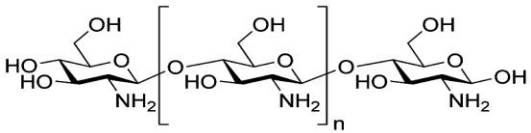
3. Inwestigation of Applicability of the Askarian Method for High-Energy Neutrino Detection in the Avan Salt Mine.
Pogosov V.S, Pogosova O.F., Poghosyan L.A. and Reimers E.E.. Armenian Journal of Physics, 4 (1), pp. 1-3, ISSN 1829-1171, 2011.

4. The Results of Search for the Neutrino Magnetic Moment in GEMMA Experiment. A.G. Beda (Moscow, ITEP), V.B. Brudanin, V.G. Egorov, D.V. Medvedev (Dubna, JINR), V.S. Pogosov (Yerevan Phys. Inst.), M.V. Shirchenko (Dubna, JINR), A.S. Starostin (Moscow, ITEP). Advances in High Energy Physics (2012), v 2012

Development of prototypes for production of chitin/chitosan systems, synthesis and research of their new derivatives



structural formula Cn



structural formula Csn

Cn as biopolymer is a part of integumentary fabrics of mollusks, arthropods, wings of insects, Cn contains in micelles, mushrooms etc. it is not dissolved in usual solvents, whereas its N-deacetylation product – chitosan (Csn), is well dissolved in many water solutions of organic and inorganic acids. Generally, seafood production wastes are the main source of getting Cn.

<u>They found wide application</u> in medicine, agriculture, the food and textile industry, pharmaceutics and cosmetics, ecology etc.

- ***Recently interest to creation selective Csn increased for targets of radionuclides and use in practical radiomedicine, biology, agriculture, ecology, food and light industry, etc.***
- **Raw materials for production Cn will be the waste, which will delivery from organization (JSC Dimitrii). Csn will be received on the same production equipment as Cn, by N-deacetylation of Cn in the alkaline environment.**

1 part. Development of prototypes for production

- **From one ton of a waste of river crayfish (armors) cleared of pectins, it is possible to allocate near 250 kg Cn, and from it 175 kg Csn.**
- **On the basis of chemical laboratory it is possible to organize production of 500kg Csn/ year** (cost ***1g Cn – $2,***

1g Csn – $3)

2 part. Investigation of new chemical derivatives of Csn

- **In particular will be syntheses new chemical modification of Csn (Schiff bases), connections containing radionuclides , new affine sorbents, etc.**

For practical realization of this program is necessary to find sponsor and making of contracts

Today there are only letters from JSC "Dimitri" and Scientific center of radiation medicine and burns of RA with wishes for discussion of collaborations

For beginning research work and production of prototypes about 10 k$ is required (laboratory equipment and necessary reactants)

1. Electro-physical properties of super- thin basalt fiber chemically modified by sulfuric acid, **Journal of Modern Physics, N12, 2011, pp.1450-1454.**
2. The Influence of Hydrochloric Acid Treatment and Temperature on the Electro-Physical Properties of Super-Thin Basalt Fibers, **Central Europian J of Physics, in press ,Accepted 18 July 2011, 5pp 2011.**
3.Գազերի և ռադիոակտիվ աէրոզոլերի կլանիչի ստացման եղանակ, ներկայացված է 17.02.2011,
Որոշում 07.06.2011, *ՀՀ Հայտ* (***Patent RA***), *Հայտի համարը* **AM 20110016.**

Part 2. Participation in international collaborations with TJNAF, CERN, DESY, HESS, JINR

The reputation of the Institute as the nuclear-physics and accelerator center allows us to develop international collaborations with scientific centers of USA, Germany, Switzerland and others

TJNAF

- **Last activities carried out by three YerPhI groups (for Hall A,B,C) included a wide range of experiments with the goal to study the quark structure of hadrons, their production and interaction mechanisms.**
- **YerPhI groups in collaboration with other groups in JLab carried out an experimental studies of electromagnetic form-factors of proton, neutron and pion, short range correlations of nucleons, quark-hadron duality, real and virtual Compton scattering.**
- **YerPhI groups made a valuable contribution in the construction and development of detectors at JLab, proposed and carried out experiments.**

Contribution of YerPhI groups in development of hardware :

Hall A

- **The 704 channel Lead-glass calorimeter and 214 channel Veto detectors with electronic read-out system and HV system.**
- **Design and construction of two lead-glass calorimeters (shower and pre-shower) for the BigBite spectrometer and BigHand neutron detector (224 main array modules, 194 veto modules)**
- **A large solid-angle electromagnetic calorimeter BigCal (consisted from 1744 TF-1 type lead-glass blocks) was built by YerPhI-Protvino-JLab collabor.**

Hall B

- **Design and construction Pre-shower calorimeter (PCAL) for CLAS12**

Hall C

- **Design and construction two versions of Aerogel Cerenkov detector for HMS spectrometer (index of refraction n=1.030 and 1.015) with an effective area of 120×100 cm2;**
- **Design and construction Shower and Pre-shower lead-glass detectors for SHMS spectrometer**

Achievements of YerPhI groups during 2009-2012

Here are presented only those experiments in which participation of YerPhI groups was essential and on the basis of the obtained results the thesises are defended

Hall A : Multichannel detectors for investigation structure of nucleons

704 channel lead glass calorimeter,
BigHand neutron detector,
BigCal calorimeter

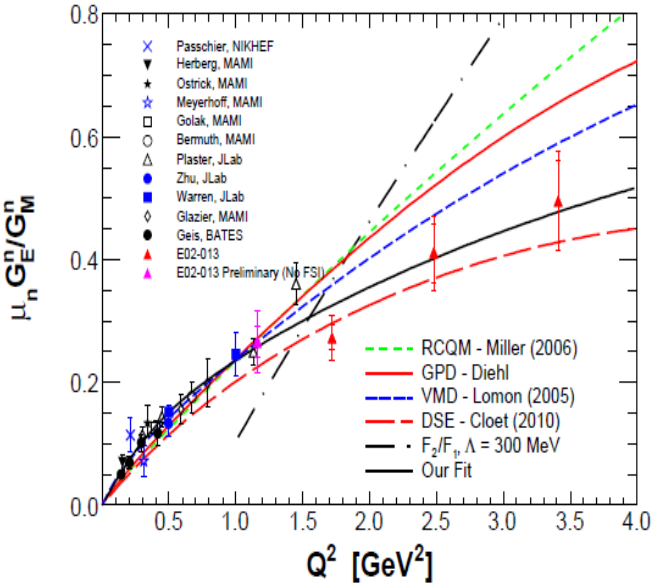
(A.Shahinyan, PhD-thesis)

Measurement of the Neutron Electromagnetic Form Factor Ratio at High Q^2

Asymmetry of reaction $^3\overrightarrow{\mathrm{He}}(\vec{e}, e'n)pp$

MC calculations,data taking and analisys

(S.Abramyan, PhD-thesis)

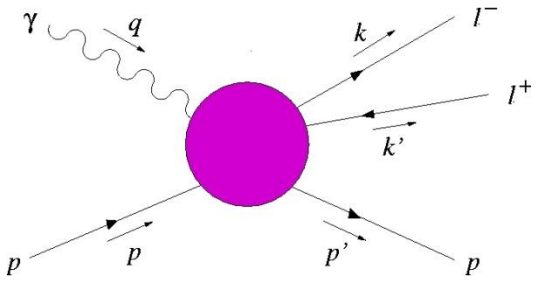


Achievements of YerPhI groups

Hall B : Time-like Compton Scattering

photoproduction of lepton pairs (e^+e^-), events with electrons scattered at very small angles will be selected. The invariant mass distributions of the (e^+e^-) pairs shows peaks corresponding to $\omega(782)$ and $\phi(1020)$ mesons decaying to e^+e^-.

(R.Paremuzyan,PhD-thesis)



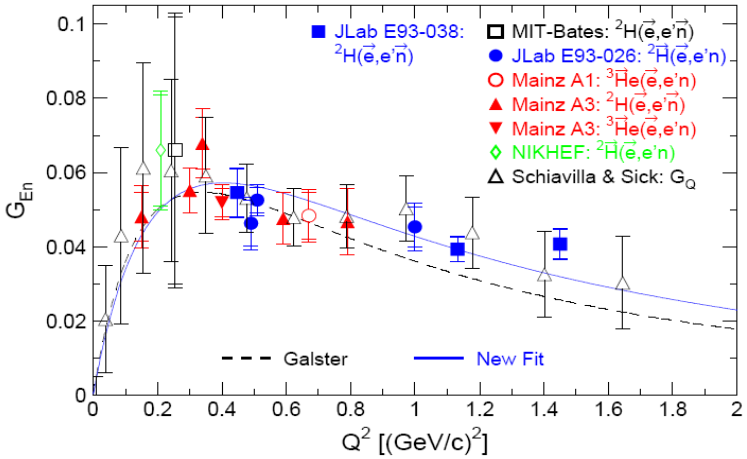
Hall C : Study of elementary particle form–factors and quark-hadron duality

1. Measurement of the pion electric form-factor

For the first time the most accurate data set for F_π at Q^2= 0,6- 2,5 $(GeV/c)^2$ has been obtained in experiment of exclusive pion electroproduction from hydrogen.

2. Measurement of the Neutron Electric Form Factor at High Q^2 (quasi-elastic scattering pol. e^- on pol. deuterium)

The neutron electric form factor G_E^n with the world best data.



3. Quark-Hadron Duality

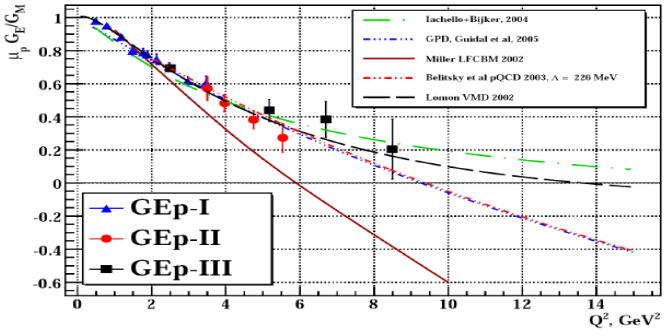
For the first time were observed the low energy factorization and duality in processes of semi inclusive electroproduction of charged pions from proton and deuterium.

(H.Mkrtchyan,Doctor thesis)

Measurements of the Proton Electromagnetic Form Factor Ratio From Elastic Scattering at Q^2 = 2.5, 5.2, 6.7,8.5 $(GeV/c^2$

recoil polarization methods in elastic scattering $\vec{e} + p \rightarrow e' + \vec{p}'$

(A.Mkrtchyan,PhD-thesis)



Participation of YerPhI groups in planned experiments for the next 2013- 2016 (TJNAF)

Currently YerPhI groups participated in collaboration with JLab consist of 14 members, of which one Doctor, four Candidates of Science and one PhD student

YerPhI groups will participate in many experiments, proposed also by themselves. They will participate effectively in data taking and analysis of following experiments:

Hall A

- **Search for a New Vector Boson A′ decaying to e+e–, "dark matter"(APEX)**
- **Proton Form Factor Ratio Measurements at 13 and 15 $(GeV/c)^2$ via Recoil Polarimetry;**
- **Neutron Electromagnetic Form Factor Ratio at High Q^2**
- **Neutron Magnetic Form Factor up to $Q^2 = 18.0\ (GeV/c)^2$**

Hall B

- **Study of A-dependence of the scaling effect of the ratio of inclusive electron scattering cross sections for heavier nuclei and deuterium in the region $x_B>1$ and $Q^2>1.5\ GeV^2$**
- **Study of photo-production of the $a_0(980)$ and $f_0(980)$ scalar mesons with CLAS**
- **Analysis of coherent meson photo-production on ^4He using data from experiment E07-009. Search for exotic mesons in the final state $\pi^o\eta$ and $\pi^o\eta'$.**
- **Coherent photo-production of proton anti-proton pair on deuterium with CLAS**

Hall C

- **Measurement of the ratio $R = \sigma_L/\sigma_T$ in Semi-Inclusive Deep-Inelastic Scattering;**
- **Transverse Momentum Dependence of Semi-inclusive Pion Production;**
- **Measurement of the charged pion form factor for**

The projects proposed by YerPhI groups for 2013-2015:

- **Meson spectroscopy in the Coherent Production on ^4He with CLAS (TJNAF experiment E-07-009, I. Aznauryan, H. Fenker, S. Stepanyan, C. Salgado, P. Eugenio spokespersons, approved by PAC31 with A priority for 45 days in hall B);**
- **Measurement of the ratio $R = \sigma_L/\sigma_T$ in Semi-Inclusive Deep-Inelastic Scattering (TJNAF experiment E12-06-104, R. Ent and H. Mkrtchyan spokespersons, approved by PAC30 in hall C);**
- **Transverse Momentum Dependence of Semi-Inclusive Pion Production (TJNAF proposal PR12-09-017, H. Mkrtchyan, P. Bosted, R. Ent spokespersons, conditionally approved by PAC34 in Hall C).**

Yerevan groups is participating in the development and construction of the experimental apparatus for 12 GeV upgrade:

- **Hall A- for SBS (Supper BigBite Spectrometer) HCal simulations and prototype tests, HRS Calorimeter calibration, Focal Plane Polarimeter upgrade**
- **Hall B- Design and construction of a pre-shower calorimeter for CLAS12, Slow Control**
- **Hall C- Design and construction of SHMS spectrometer (assembly, testing, calibration)**

The elementary particles physics in the foreign accelerators beam collaboration with CERN – LHC (ATLAS,ALICE, CMS)

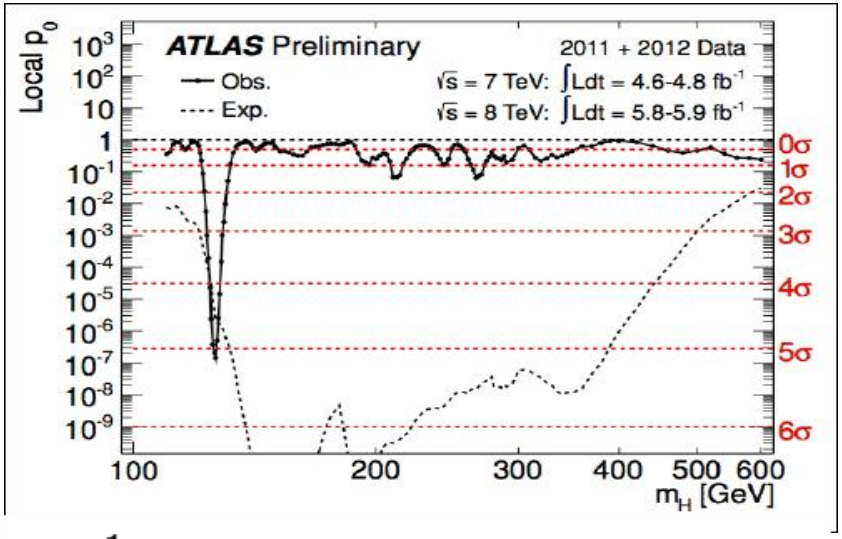
Currently YerPhI groups participated in collaboration with LHC consist of 14 members, of which two Doctor, five Candidates of Science and one PhD student

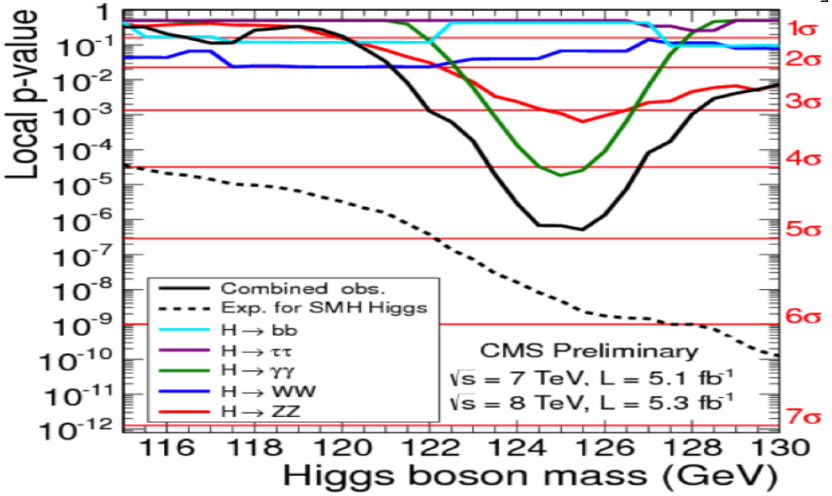
Since 1995 ANSL groups contributed visibly to these experiments, actively participating in the detectors design and construction, software development as well as test beam data taking and analysis.

Now ATLAS and CMS groups will continue the works in ongoing LHC physics program (shifts,data taking and analysis).

- ***4th July 2012*** ***in a joint ATLAS and CMS seminar at CERN and the "ICHEP 2012" conference in Melbourne, researchers of these experiments at the Large Hadron Collider (LHC) presented their preliminary results on the search for the standard model (SM) Higgs boson in their data recorded up to June 2012.***
- ***ATLAS and CMS concentrated its efforts on two complementary channels: Higgs decays to either two photons or to four leptons.***

Both channels show a statistically significant excess at about the same place: a mass of around 125-126 GeV.





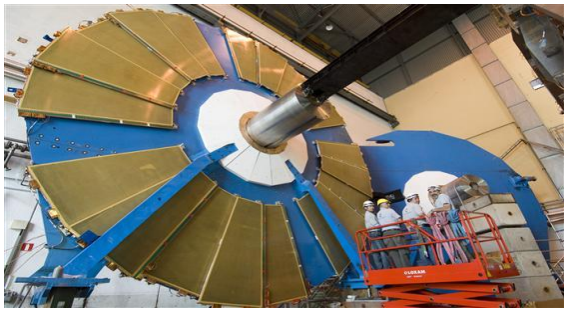
the significance of the signal at 5 sigma (ATLAS) and 4.9sigma (CMS) above background expectations

ATLAS experiment

The calibration of ATLAS p-p collision data using multijet balance technique and measurements of inclusive single jet and di-jet cross-sections at centre-of-mass energy s = 8 TeV

Since 1995 has been participating in Tile Hadron Calorimeter of ATLAS experiment : (their contribution)

- ***design and construction of 7 robots for high-precision cutting of WLS fiber bundles***
- ***development and construction of 10,300 magnetic shields for PMT***
- ***construction of bronze radiation***



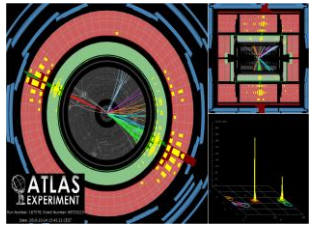
- ***shielding components***
- ***- main achievement in data analysis: the detailed study of the hadrons (proton, pion) shower profiles and their leakage for TileCal, used for GEANT4 simulation and precise energy reconstruction***

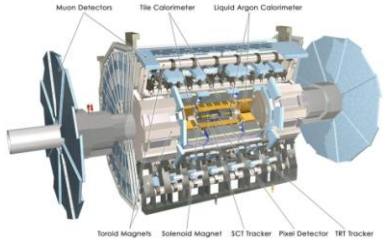
(M.Simonyan,PhD thesis)

- (Now group has 1 PhD student)

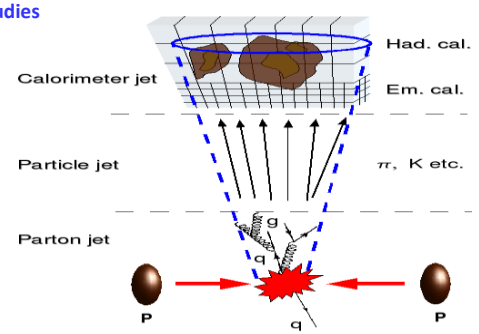
- Jet production at LHC
  - Process with dominant cross-section
  - Test of pQCD
  - New physics searches
- Recent results on 2010 data
  - Jet substructure measurements
- 2011 data
  - Extended kinematic range
  - High pile-up environment

High mass (2.6 TeV) dijet event



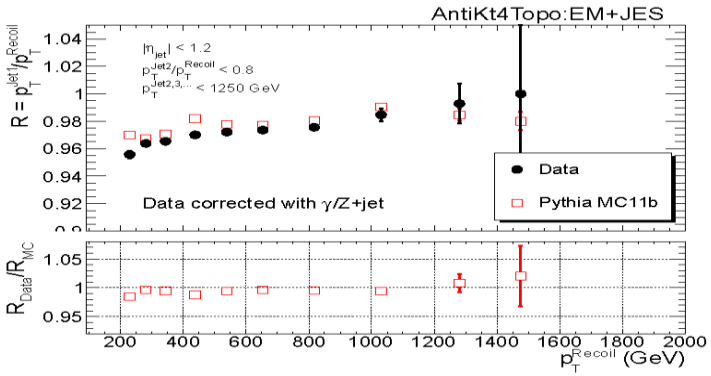


The high energy and transverse momentum(Pt) jets produced at LHC are central elements of the signature for many new physics searches, and play an important role in many physics channels, such us inclusive jet and dijet cross-section measurements, dijet mass and angular spectra studies

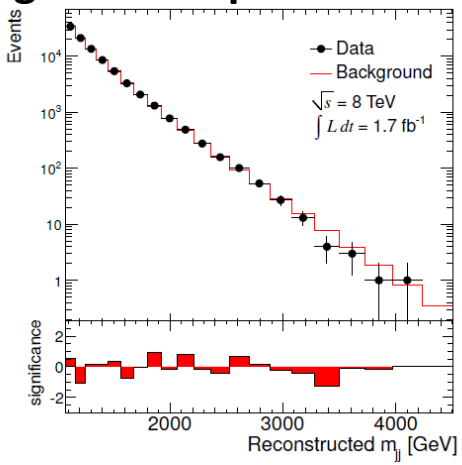


The ATLAS-group research program for 2013-2016

Multi-jet balance(MJB) technique, where the ensemble of lower-scale calibrated sub-leading jets is chosen as a reference object, allows the extension of the calibration up to and above TeV scale exploiting the abundance of events with multi-jet production.



The dijet invariant mass distribution using data sample of 2012



1.Development and optimisation of multijet balance technique adopting it for the 2012 LHC running conditions , having doubled pile-up contribution. The MJB calibration has a highest priority for the data reconstruction needs and will be carried out within coordination of JetEtmis Combined Performance Group .

2. Data analysis of single and di-jets cross-sections at centre-of-mass energy s = 8 TeV, using full 2012 dataset allowing to test QCD predictions at very short distances with significantly increased statistical accuracy and also look to a possible signatures of new phenomena behind of SM.

3. hardware-software for detector maintenance :

a) repair of Tilecal Low voltage power supply

b) computing engineering work for ATLAS sub-detectors' monitoring software development

c) precise measurement of light yield from scintillation plates of hadron calorimeter

d) measurement of natural aging of hadron calorimeter scintillator

ALICE experiment

Since 1996 has been participating in ALICE experiment

-design, construction and installation of the Geometry Monitoring System for Muon Spectrometer (GMS)

-development of the software for analysis of the alignment of the GMS optical components

-participation of ALICE detector performance studies. A detailed analysis of the heavy quarkonia detection capability of ALICE Muon Arm was performed on the base of fast simulation code

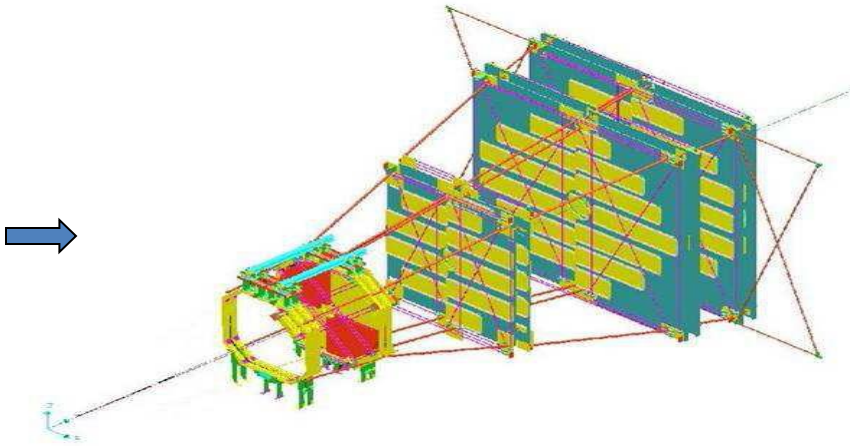
- manufactured in YerPhI and installed at CERN of a 4.7 tons Aluminium Ring as a supplementary absorber

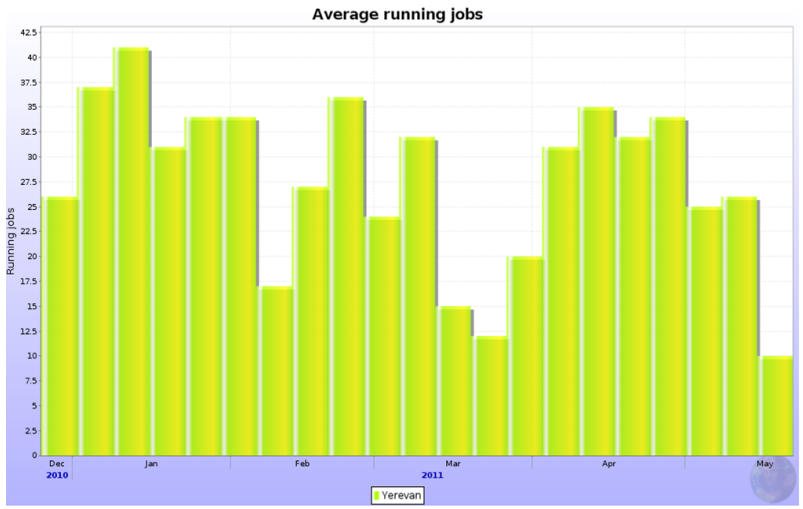
-development of Grid technology and has already implemented AliEn (ALICE Grid environment) locally

-in 2006 the group has integrated in the largest in the world Grid/e-Science infrastructure

and YerPhI site has been officially certified as production site of EGEE (Enabling Grid for E-science)

(A.Harutyunyan,PhD thesis)





ANSL cluster has become an intensively exploited computational resource of ALICE Collaboration

Time dependence of the number of running jobs on the ANSL cluster over period December 2010 – May 2011

ANSL/ALICE team: Planning for 2013-2017

- **Analysis of the low-mass region (from threshold to 2.0 GeV) of the dimuon pairs produced in *pp*, *pPb* and *PbPb* collisions**

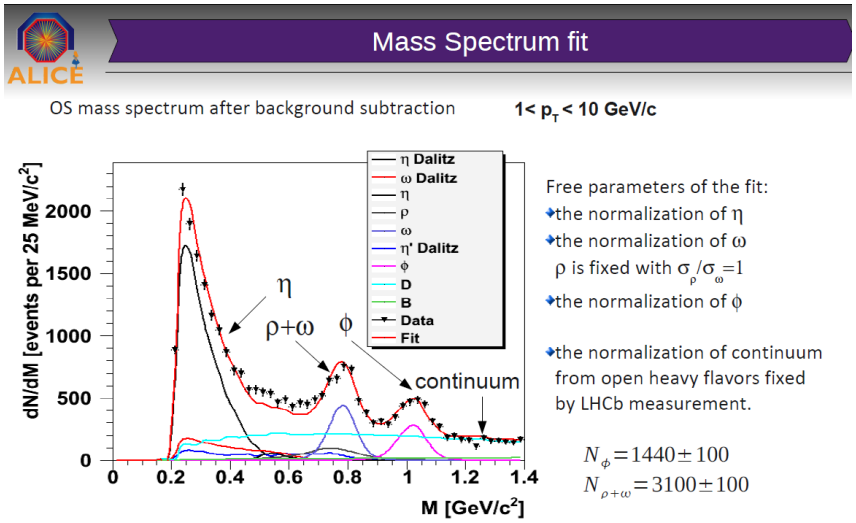
The work will be done in collaboration with the groups from IPNL (Lyon, France) and INFN/Cagliari University (Cagliari, Italy).

- **Development and upgrade of the GRID infrastructure of ALICE**

The team will continue long cooperative work with the computing group of ALICE Collaboration on the development and upgrade of the ALICE data processing environment: AliEn, AliRoot

ANSL-JINR-ALICE Collaboration

- **Analysis of anomalous suppression of the yield of heavy quarkonium states (J/ψ, ψ', Υ, Υ', Υ") in the $\mu^+ \mu^-$ channel.**



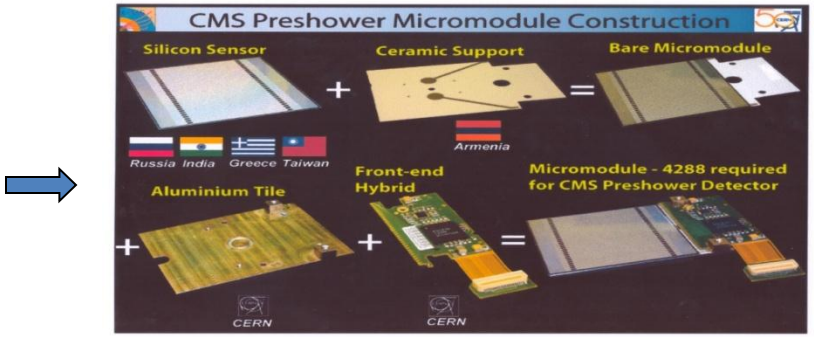
Recent reports by young students

1. N.Manukyan, "**ANSL site of LHC and ALICE computing Grids. Deployment and operation**"
2. A. Abramyan, "**Unified Modeling Language Diagrams for Grid Middleware of CERN ALICE Experiment**". *Proceedings of 8th International Conference on Computer Science and Information Technologies, 2011 September, Yerevan, Armenia*
3. A. Abramyan,..., N. Manukyan et al., "**AliEn Extreme job Brokering**"
4. A. Abramyan, ...,N. Manukyan et al., "**ALICE Environment on the GRID**". *International Conference on Computing in High Energy and Nuclear Physics (CHEP), 2012 May, New York City, NY, USA*

CMS experiment

participating via RDMS (Russia and Dubna Member States)

- *participated in Preshower detector construction : -development of the technology of thick film printing on a ceramic PCB with several metallic pastes and laser cutting technique with MARS factory (Yerevan)*
- *large-scale production (5000 units) of the ceramic PCBs -financial contribution of Armenia has made 90 kCHF*



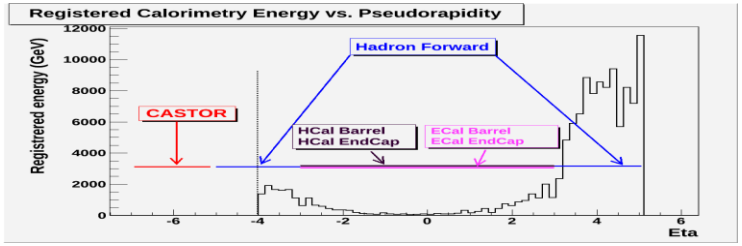
- *-in physics analysis: investigation the structure of hard double and single Pomeron exchange processes in proton – proton collisions at the LHC:*

$$pp \rightarrow p + \gamma/Z\,(\rightarrow \mu^+\mu^-) + X + p$$

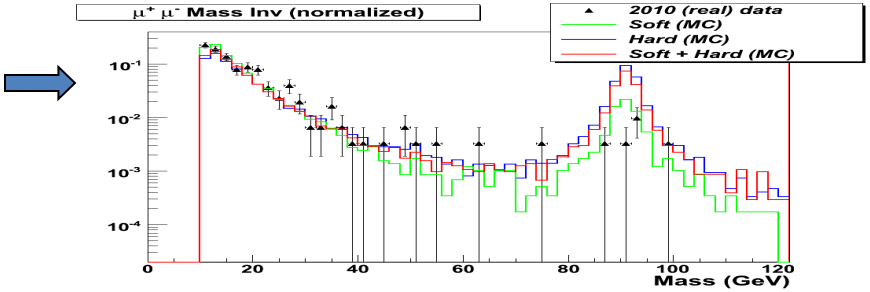
- *participation in CMS- "DPG" and test CMS Endcap (HE) calibration on the basis of CMS CRUZET (Cosmic Runs at Zero Tesla), CRAFT (Cosmic Runs at Four Tesla)*

(V.Khachatryan PhD thesis)

For 2010 CMS- LHC experimental data (36 pb-1) was selected only few hundred events-candidates of SPE process (where only 7 Z0 enents). In analysis of Di-muon was used the information from CMS, CASTOR, HF and ZDC detectors.



Now YerPhI group actively participates in the CMS experimental physics program, mainly in the studies of the diffraction processes with Di-muon events.

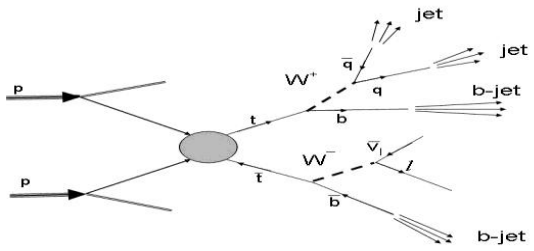


The calibration of absolute jet energy scale in CMS experiment using W → qq

(Data sample at 7 TeV with an integrated luminosity of 3 fb $^{-1}$)

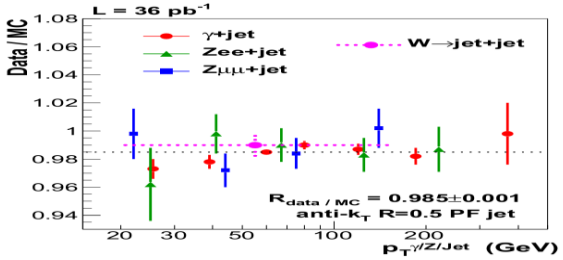
$$pp \to t\bar{t} \to bW^{+}\bar{b}W^{-} \to bl\bar{\nu}_{l}\bar{b}q\bar{q}$$

Method based on comparison between invariant mass of jets produced from W decay with W-boson mass: $M_{jj} = M_W$



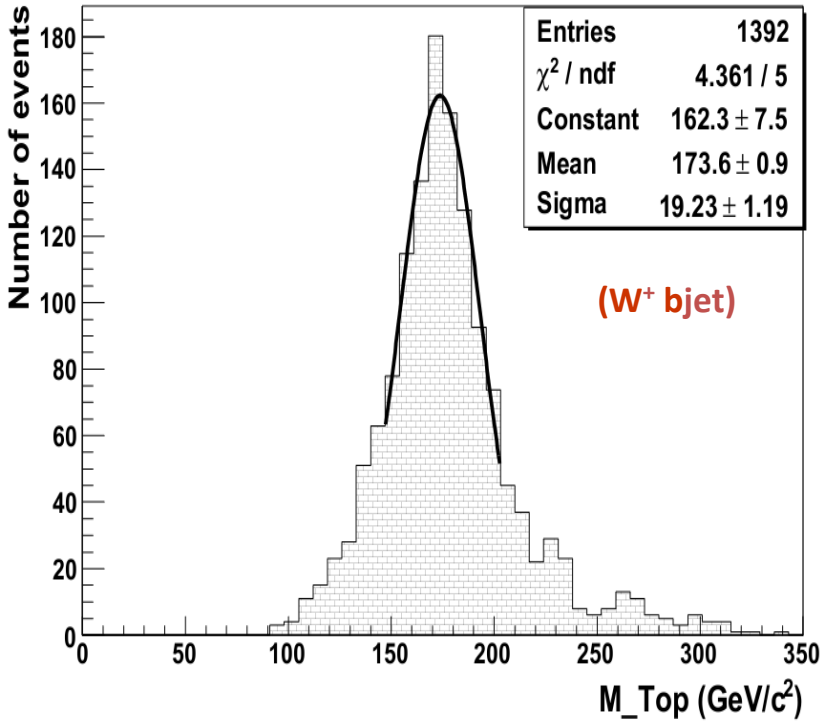
$$k_{jet} = \frac{E_T^{jet}}{E_T^{q}}$$

Calibration is performed for calorimetric, "Jet-Plus-Track" and "Particle-Flow" jets of light quarks reconstructed using of anti-kt and iterative cone algorithms of jet finder with parameter R= 0.5. The calibrated region includes intervals of pseudorapidity $|\eta| < 2.5$ and transverse energies $20 < E_T < 150$GeV.



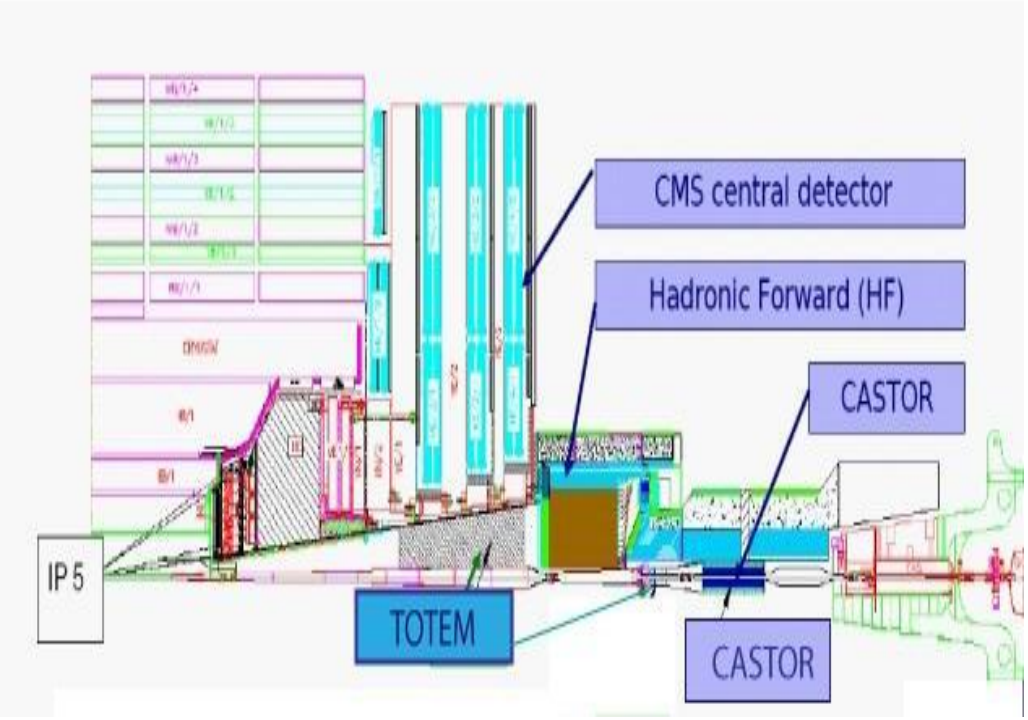
Reconstruction of top quark

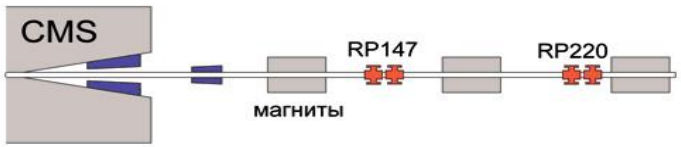
Dataset	Runs	Lumi
Run2011B-PromptReco-v1/RECO	175832 – 179431	2.192 фб$^{-1}$



(A.Tumasyan, PhD thesis)

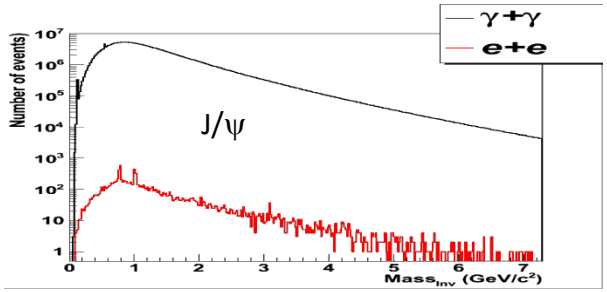
Participation in CASTOR upgrade (DESY-JINR-ANSL)

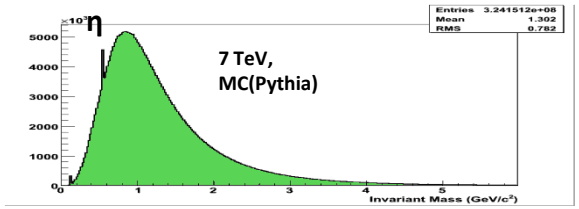


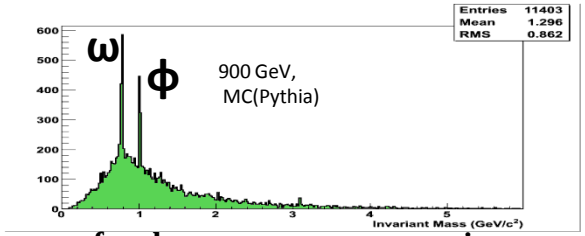


Calibration of CASTOR

γ+γ and e+e invariant mass







for the γ+γ events η meson is the most suitable choise

Physics research program on CMS for 2013-2016 years

ANSL (Yerevan Physics Institute), Armenia
A.Sirunyan, S.Chatrchyan, V.Khachatryan, A.Tumasyan, 2 students

1. Investigation of parton structure of Pomeron in hard diffractive processes (QCD,SPE, DPE) with μ+μ- , Jet-Jet , bb (jet) , γ/Z+jet production. **2012-2015**

Results : MC simulation. Development of muon and jet reconstruction algorithms .Improvement of Diffractive events selection metodology to increase a statistics .Measurement of hard and soft parton (quark- antiquark) and (gluons) contribution .

2. Study of "factorization scheme" breakdown **2013-2015**

Results: Calculation of ratio R = $d\sigma^{SD}$ / $d\sigma^{ND}$ = $d\sigma^{DD}$ / $d\sigma^{SD}$ (SD- single, DD- double, ND- no diffraction processes with μ+μ- , Jet-Jet, etc production) in the same kinematic area.
MC simulation.
Diffractive events selection for the analysis.

*3. **Study of jet events and calibration of jet energy scale*** **2012-2014**

Results: Improvement of MC parametrization and jet reconstruction algorithm. Increase of statistic at larger integrated luminosity.

*4. **Investigation of Coherent hard diffractive interactions of ions (SPE, DPE)*** **2015-2016**

Results: Calculation and measurement of the heavy ions interaction cross sections Coherent Pomeron flow
Measurement of parton distribution in Coherent (nuclei) Pomeron.

5. Participation in CASTOR upgrade and Higgs analysis (DESY) **2012-2014**

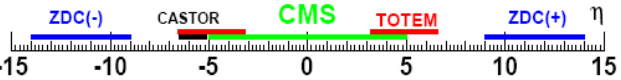
Results: Analysis for γγ and ee events in HF and Castor analysis Higgs production with W or Z: VH ➔Vbb,

1.Separation of hard and soft parton (gluon) contribution in Pomeron at $\sqrt{s}$ = 7 TeV

With this purpose we consider the $b\bar{b}$ pair production in hard DPE process:

$p + p \rightarrow p + b + \bar{b} + X + p$

Structure (η,φ) of bb pair production events in DPE

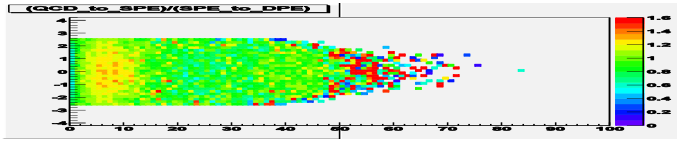


2. For examination of factorization scheme

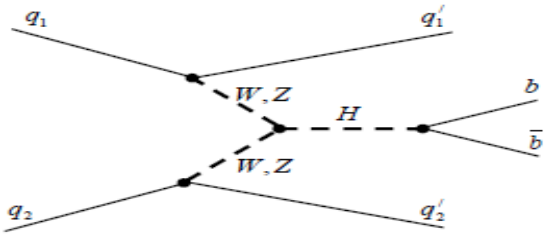
$$F_2^D(x,t,Q^2,\xi) = F_{pom/p}(\xi, t) \cdot P_{g/pom}(x,Q^2)$$

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

$d\sigma^{SD}/ d\sigma^{QCD} = d\sigma^{DD}/ d\sigma^{SD}$ (?)



5. Vector boson fusion (VBF) $\sqrt{s}$ = 8 TeV



International collaborations (DESY)

HERMES/YerPhI group

Since 1993 has been participating in construction of the HERMES facility

- essential role in construction of electromagnetic calorimeter, especially in providing of high quality lead glass blocks

•Last activities includes wide range of experiments with the goal:

-study the spin structure functions of nucleons in inclusive, semi-inclusive and exclusive processes in deep-inelastic lepton scattering

(E.Avetisyan,PhD-thesis)

-study hadronization in nuclear medium

(Z.Akopov, PhD-thesis)

- measurements of g1 structure function

- participation in measurements and analysis the DVCS and another exclusive reactions to test generalized parton distributions GPD's

(A.Movsisyan, PhD-thesis)

N. Akopov together with few scientists from Dubna (including famous S. Gerasimov) in 2008 was awarded Scientific Prize of JINR for series of measurements of g1 structure function

Hadron physics: nucleon structure and hadronization 2013-2017

1. **Continuation of the analysis based on the data accumulated by HERMES Collaboration:**

- ***GPDs related physics including DVCS and exclusive vector mesons (like , φ and ω mesons), nuclear transparency of electro-produced rho mesons.***
- ***Studies of hadronization phenomena in electro-production and quasi-real photo-production of identified hadrons on nucleon and nucleus: hadrons ratios, multiplicities.***

The HERMES based results together with the Jlab and COMPAS results will allow to perform a global fit to adjust the differnt GPD based structure functions and make a big step towards to the clarification of famous old problem which is called the "spin crisis".

$Sz=1/2=1/2(\Delta u+ \Delta d+ \Delta s) + Lq+ \Delta G + Lg$

DESY-OLYMPUS

2. Analysis of the data collected with the OLYMPUS detector on DORIS.

- ***Monte Carlo studies to estimate possible systematic uncertainties***
- ***Development of the effective approaches based on the usage of the information from all detectors (TOF+MWPC) to select the elastic events.***
- ***Drafting of papers related to the electron/positron elastic scattering cross sections asymmetry***

Is planned to participate in data taking ,analysis of obtained data to extract the cross sections ratio for elastic scattering with electrons/positrons on hydrogen .
Goal of this experiment is the study of the cross sections asymmetry in the elastic electron-proton and positron-proton scattering and check the possible contribution of two photon exchange diagram in the interpretation of well known essential difference in the ratio of electric to magnetic form factors observed by using the Rosenblut separation method and measurements of the recoil proton polarization.

3.Possible inclusion to the analysis of data from COMPASS experiment

- ***It is supposed to apply the rich experience accumulated in our group to analyze the DVCS related data from COMPASS, also to study various azimuthal asymmetries for muon-production of identified hadrons , as well to analyze the future Drell-Yan spin physics related items.***

Talks

1.H. Marukyan, " DVCS overview", presented on XVIII International Workshop on Deep Inelastic Scattering and Related Subjects (DIS-2010), Apr. 19-23, 2010, Florence, Italy

2.G. Elbakian, "Hadron attenuation", presented on 21-th European Conference On few-Body Problems In Physics (EFB21), Aug. 29-Sep. 3, Salamanca, Spain

3.A. Movsisyan "DVCS overview", presented on XIX International Workshop on Deep Inelastic Scattering and Related Subjects (DIS-2011), Apr. 10-15, 2011, Newport News, USA

4.G. Karyan "2D hadron attenuation", presented on 19-th Particles&Nuclei International Conference (PANIC-2011), Jul. 24-29,2011, MIT, Cambridge, USA

5.G. Karyan "Multiplicities on nuclei", presented on 50-th International Winter Meeting on Nuclear Physics, Jan. 22-27, 2012, Bormio, Italy

6.G. Karyan "2D attenuation", presented on XX International Workshop on Deep Inelastic Scattering and Related Subjects (DIS-2012), Mar. 26-30, 2012, Bonn, Germany

7.A. Movsisyan "Overview Exclusive Physics at HERMES", presented on 6-th International Conference on Quark and Nuclear Physics (QNP2012), Apr. 16-20, 2012, Palaiseau, France

International collaborations (DESY)

H1/YerPhI group

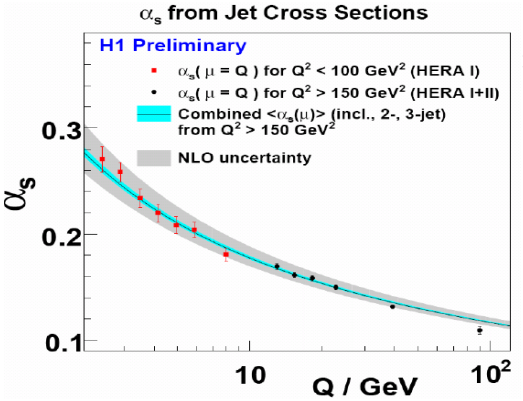
Since 1999 **has been participating** in H1 collaboration.

YerPhI group has involved primary in hardware development, support and maintenance and later in data physics analysis

- During the period from 2004 to first half of 2007 (HERA shutdown) group was fully responsible for Time-of-Flight (TOF) system
- *The main efforts of the group are focused on the analysis of following processes:*

-Jet Production at Low Q^2 in DIS (strong coupling constant α_s)

- Measurement of Leading Neutron Production in DIS (pion structure function F_2)



Running α_S (from high Q^2).
- NLO and $<\alpha_S(\mu)>$ extrapolated from high (>150GeV^2) to low (<100GeV^2) Q^2 region.
- α_S from Low Q^2 added to high Q^2 curves. A striking agreement between low and high Q^2 data observed.

YerPhI-H1 group activities during 2013-2016

Group starts a new analysis of parton distribution function (pdf) and multijets (four and more) production at Low Q^2 based on data of jet production and DIS recorded in the years 2005-2007, corresponding to an integrated luminosity ~ 300 pb-1

1.Jets at Low Q2 for HERA and aplha_s extraction

2.Joint H1-ZEUS Jet Analysis at Low Q2

These analyses are aimed to precise alpha_s extraction and PDF for gluon and see-quarks determination.

3.LHeC project: lepton-nucleon scattering at CERN. *The aim of the project is with LHC facilities at large energies and luminosity to produce massive new electron-quark bound states and to other new physics.*

Talks and Proceedings

1.Jets and alpha_s from the H1 experiment at HERA. Physics in Collision 2009, Kobe, Japan. Proceedings

αs measurements in DIS at HERA. Lepton Photon, 2009, Hamburg

2. Jet Production at HERA and Determination of alpha_s with H1. EPS-2011, Grenoble, France, 20.07.2011-27.07.2011.

3. Jet Production at Low Q^2 at HERA. DIS2011, Newport News, Virginia, USA, 10.04.2011 – 15.04.2011.

4. ***Measurement of Photon Production in the Very Forward Direction in Deep-Inelastic Scattering at HERA. DIS-2012 workshop, Bonn, March 2012***

Fission and fragmentation of nuclei with real and virtual photon beams

Experimental studies related to the following approved experiments at MAX-lab Sweden and Jlab, USA:

- **Photofission of heavy actinide nuclei, MAX-lab Experiment 04-08, 2004;**

The total photofission cross section of U-238 and Np237will be measured in the energy range 50-200MeV
(PAC –1 week of beam time is recommended)

- **Photo-fission Studies of Nuclei by Virtual Photon Tagging at MAX-lab (2008)**

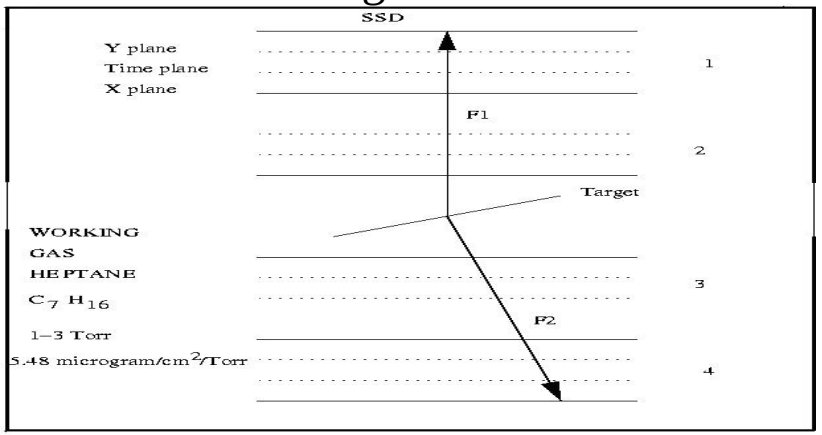
The proposed experiment would provide detailed measurements of the photo-fission cross section, including fragment mass and velocity distributions, for a range of nuclei.

- **Study of light hypernuclei by pionic decay at JLab**, Proposal: PR-10-001, 2010. (conditionaly)

Is proposed to investigate high resolution decay pion spectroscopy for light hypernuclei with the (e, e´, K^+) reaction using the high resolution kaon spectrometer (HKS) and high resolution pion spectrometer (*HπS*) on two targets ^{7}Li, and ^{12}C and measure precisely binding energies and lifetimes of produced light hypernuclei or at about 2 GeV electron beam.

$$e + {}^{12}C \rightarrow {}_{\Lambda}{}^{12}B + e' + K^+$$

Fission Fragment Detector



Low-Pressure MWPC

- **Position Resolution: FF 350 μm (α-particles < 1mm);**
- **Time Resolution FF: 150 ps (α-particle 0.4-1.0 ns)**

dE/dx(FF)/dE/dx(α)~ 90 close to theory

Stable operation

Electron beam 300 nA

Photon beam 10^11-10^12 photon/s

Methodic studies *related to the developing, manufacturing and investigating of a new radio frequency, RF phototube (new photon device with high resolution (~20 ps for single photons) and high rate (≥ 1 MHz) and detectors based on low-pressure MWPC technique, for low-energy protons, deuterons and alpha particles (nuclear studies and spectroscopy applications)*

Very high energy gamma-ray astrophysics

YerPhI /HESS group

HESS (High Energy Stereoscopic System)

was built in 2001-2003 by the international collaborations with the participation of YerPhI's group (one of the initiators was F. Aharonian)

HESS - four imaging atmospheric Cherenkov telescopes installed at an altitude of 1800 m above sea level in the Khomas Highland of Namibia

- *YerPhI's group participated in several stages of HESS experiment:*

- construction of telescopes
- determination on the base of MC-sim.of response function and main characteristics of the system
- investigation of methods for the data analysis
- *YerPhI provided a 400 high-quality mirrors and developed a mirror protective coating technology (with joint stock company Galaktika)*
- members of group: A.Akhperjanian and V.Sahakian as well as F.Aharonian (from MPIK, Heidelberg) were awarded in 2005 by President's Prize of Republic of Armenia for the outstanding contribution to physics research within the framework of the HEGRA and HESS collaborations
- HESS collaboration, including YerPhI, has won the European Union Descartes Research Prize for 2006 as a world first in the field of gamma astronomy.

The four 12m diameter telescopes of Phase-I of H.E.S.S project were operational in December 2003 and thefifth telescope (diameter-28m) is H.E.S.S-II since July 2012

Group activities during 2013-2017

1.Participation in the program of the H.E.S.S - II

- Participation in data analysis and studies of the mathematical methods for gamma-images extraction and primary particle energy reconstruction at sub-50-100 GeV energy region
- The studies of new image parameters using their distribution forms
- The studies of the possibilities to use Cherenkov pulse timing information for improving the useful signal extraction efficiency
- The studies of the possibilities to improve the technology for Cherenkov mirror production in order to provide the stable coefficient of reflection for relatively large period -5-7 year (with GALAKTIKA JSC)

2.The Cherenkov Telescope Array (CTA) project is the next generation ground-based very high energy gamma-ray instrument, with a factor of 5–10 improvement in sensitivity in the 100 GeV–10 TeV range and the extension to energies well below 100 GeV and above 100 TeV

- Development of full Monte-Carlo simulation package (including the ray-tracing part and image analysis procedure) using MOCCA package for three different designs of telescopes: with field of view (FoV) 4-5^0, 6-8^0 and 10 ^{0}.
- Simulation of the basic parameters of telescopes (collection, areas, detection rates, etc.) and studies of analysis peculiarities at lower (tens GeV) energies including the influence of cosmic-ray electrons for case of large size telescope.
- Participation of the development of electronic system of registration.
- Participation of the mirror production technology improvement (with GALAKTIKA).

Participation YerPhI/High Energy Nuclear Physics group in collaboration with JINR (Dubna)

- **BECQUEREL Collaboration**

In the framework of the BECQUEREL Collaborations the interactions of relativistic nuclei (including radioactive ones) in the nuclear track emulsions will be investigated at the Dubna Nuclotron (JINR, RF). The unprecedented spatial resolution (0.5 μ) of the method of nuclear track emulsion opens a unique possibility to study the multi-cluster structure and low-laying excitations of nuclei which can be observed in the coherent dissociation of relativistic nuclei in photoemulsions. The experimental study of the coherent dissociation processes can, therefore, have important astrophysical applications.

O. Krivenkov et al. Phys. Atom. Nucl. 73 (2010) 2103

- ***"Coherent dissociation of relativistic nuclei ^{9}C"***

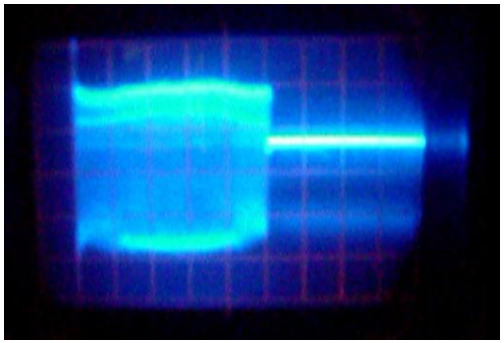
Conclusion (1)
Experimental program on the basis YerPhI`s accelerators

All projects of experiments are actual and interesting

a)most acceptable version using of synchrotron - transition to small energy range up to 75 MeV with extracted photon beams. During the 2013 it is necessary to check a possibility of realization small energy mode in stretcher regime (2-3 msec) without acceleration and begin photodisint.exp.on ^{7}Li

b) is necessary to check working possibilities of low-pressure MWPC detector in the conditions of accelerator and begin measurement cross section of the ^{12}C(γ,3α) reaction using 50 MeV bremsstrahlung photon beam.

c) is necessary for suggested experiments on CYCLONE C-18 to prepare physical proposals with Monte Carlo simulation and begin creation of experimental setups



Required funding for nearest 3 years

1. Experiment on synchrotron +injector

a)non-acceleration mode of synchrotron - 25 k$

b) 15 silicone strip detectors (SSD) - 80 k$ (synchNM and C-18)

c) Cluster structure (experiment) - 25 k$

d) ^{12}C(γ,3α) (experiment) - 10 k$

2. Experiments on injector

a) photonuclear reactions - 10 k$

3. CYCLONE C-18

a) creation of Equipment and Setup - 60 k$ (including detectors)

b) electronics , codes (MC) - 60 k$ (including Analisator)

TOTAL 270 k$ for 3 years

It is necessary to make a decision!

Conclusion (2)
concerning International collaborations

- **It is necessary to continue and develop further activities with CERN, TJNAF, DESY, HESS, including students and post-graduate students - one of the important perspective directions of scientific activity of EPD**
- **For preparation of students in Nuclear Physics Department of the Yerevan State University it is necessary to add special courses of lectures with thematic of CERN, TJNAF, DESY,.. and also connected with low energy nuclear physics**
- **It is necessary assistance for students YSU additional visiting quota to CERN and for the involvement of students in various summer programs (Summer student, school)**
- **<u>Required funding for 1 year</u>**
- **It is necessary to continue annual funding of LHC program at level of 75 k$**

  ➡ **(separate of institute budget)**
- **It is necessary to support of TJNAF and DESY teams for participation in international workshops and conferences (~10 k$/year)**
- **It is necessary to support of HESS team for participation in the experimental observations and collaboration meeting (4.5 k$/year)**

TOTAL: 14.5 k$/year

Conclusion (3)
concerning low – background and chemical laboratories

Low – background laboratory

- it is necessary to finish R&D works of the threshold energy decrease for NaI(Tl) scintillator detectors comparing with DAMA experiment (< 2 KeV)
- it is necessary construct the full scale experimental setup on the base of existing several hundreds kilograms of NaI(Tl) crystals
- it is necessary to sign the with management of Avan Salt Mine agreement for use in other purposes, in particular, for activation analysis in nuclear physics experiments, for cosmic ray,..
- **Required funding for 1 year**

mainly for electronics block - 5 k$

Chemical laboratory

- it is necessary to develop of prototypes chitin/chitosan systems
- for practical realization of this products is necessary to find sponsor and making of contracts
- **Required funding for 1 year**

for beginning research work and production of prototypes is required (laboratory equipment and necessary chemicals) *about 10 k$*

TOTAL FUNDING FOR EPD in 2013

(1)+(2)+(3) 120 k$ → 48 mln drams

out of budget 75 k$ → 30 mln drams

THANKS

- **I wish to thank my colleagues**

  H.Vartapetyan, R.Avakyan, G.Gulkanyan, Hakobyan H., Markaryan A.,V.Pogosov, Mkrtchyan H., Grigoryan A., Akopov N., Sahakyan V., Akhperdjanyan A.,V.Gavalyan

  who helped me in report preparation.They are present here and can participate in discussion