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Новые направления в физике электромагнитных взаимодействий ядер

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14-й международный Семинар «Электромагнитные взаимодействия ядер» Москва 5-8 Октября 2015 г. www/cpc.inr.ac.ru/~pnlab/emin2015 посвящен памяти Л.Е.Лазаревой, 100 лет со дня рождения

QCD and Hadron Physics.

JLAB & SINP MSU JINR, Dubna, RCNP, Osaka University

Polarization phenomena, spin physics.

Lebedev Institute, INR RAS, JINR & Mainz *University, BINP Novosibirsk, Japan Atomic Energy Agency*

Fragmentation of nuclei by real and virtual photons.

INR RAS & Bonn University, JINR, FAIR , Kioto University

Giant resonances and collective excitations of nuclei.

SINP, MEPHI, FTI Obninsk, RCNP, Osaka University

New developments and perspectives

SINP & ELI-NP Bukharest, BINP Novosibirsk, Japan Atomic Energy Agency

QCD and Hadron Physics

Summary of the DNP Town Meeting
Temple University, 13-15 September 2014

- 12 GeV CEBAF at JLAB

Understanding the fundamental nature of hadrons and nuclei in terms of QCD, the strong interaction piece of the Standard Model, is a central goal in the field of nuclear physics. The last decade has seen the development of new experimental and theoretical tools to quantitatively study the nature of confinement and the structure of hadrons comprised of light quarks and gluons.

The SoLID (Solenoidal Large Intensity Detector) program is designed to fulfill this need.

A unique capability for reconfiguration in order to optimize capabilities for either Parity-Violating Deep Inelastic Scattering (PVDIS) or Semi-Inclusive Deep Inelastic Scattering (SIDIS), and threshold production of the

J/. meson.

RECOMMENDATION II

A high luminosity, high-energy **polarized Electron Ion Collider (EIC**) is the highest priority of the U.S. Nuclear Physics QCD community for new construction after FRIB (Facility for Rare Isotope Beams).

The Electron Ion Collider (EIC) will image the gluons and sea quarks in the proton and nuclei with unprecedented precision and probe their many-body correlations in detail, providing access to novel emergent phenomena in QCD.

•How are the gluons and sea quarks, and their spins, distributed in configuration- and momentum-space inside the nucleon?

•What happens to the gluon density in nuclei at high energy? Does it saturate? How does this phenomenon manifest itself in nucleons?

•How does the nuclear environment affect the distributions of quarks and gluons and their interactions in nuclei? How does nuclear matter respond to a fast moving color charge passing through it? How do quarks dress themselves to become hadrons?

EIC

Two independent designs for the future EIC have evolved over the past few years. Both use existing infrastructure and facilities available to the US nuclear scientists. At Brookhaven National Laboratory (BNL), the eRHIC utilizes a new electron beam facility based on an Energy Recovery Linac (ERL) to be built inside the RHIC tunnel in order to collide electrons with one of the RHIC beams.

At Jefferson Laboratory the Medium Energy Electron Ion Collider (MEIC) employs a new electron and ion collider ring complex, together with the 12 GeV upgraded CEBAF in order to achieve similar collision parameters.

ELISe at GSI , ..

- Why now?

Preliminary Program – emin2015

QCD and Hadron Physics.

V.D.Burkert, Jefferson Lab, Status and Prospects of the studies of excited nucleons and their structure

Sergo Gerasimov. JINR, Dubna, Hadron photo-absorption sum rules σ-1 in different environments.

Igor Anikin, JINR, Dubna. Building a bridge between hadron structure from QCD and the observables of meson photo-electroproduction.

Hideki Kori. RCNP, Osaka University, Comparison between $u\bar{u}$ and $d\bar{d}$ productions by the $\gamma p \rightarrow \pi^- \Delta^{++}$ and $\pi^+ \Delta^0$ reactions at forward π angles at $E\gamma$=1.5-3.0 GeV.

Evgeny Golovach. Moscow State Univ, Russia. New results on N* parameters from reactions of two pion photo and electroproduction off proton.

Ralf Gothe (Univ of South Carolina, USA) "N* physics with the CLAS12"

Evgeny Isupov. Two pion electroproduction at large virtualities.

Meriem Benali. IN2FR3, France, Internal Structure of the Nucleon (Proton / Neutron) by Virtual Compton Scattering at Low and High Energy.

RECOMMENDATION III

Strong support for other existing facilities, such as the polarized proton facility at **RHIC**, university-based laboratories, and the scientists involved in these efforts, in order to guarantee the effective utilization of such resources for continued scientific leadership and discovery, and for educating the next generation of nuclear scientists in the USA.

Other examples on a smaller scale are also readily identified: a polarized Drell-Yan program at **FermiLab**, which will present exceptional opportunities to measure nucleon valence and sea quark spin distributions with high precision; the High Intensity Gamma-Ray Source **(HIGS**) at the Triangle Universities Nuclear Laboratory (**TUNL**), which is the world's most intense polarized .-ray source with wide applications in low-energy hadron physics; and US leadership of programs at numerous other facilities worldwide.

RECOMMENDATION IV

The hadron **theory** program be increased, in a balanced manner and in proportion to new and continuing investment in experiment. This will both guarantee that all aims of the existing program can most rapidly be achieved and secure a promising future for the next generation of nuclear scientists and the nation.

Realizing the scientific potential of current and future experiments demands large-scale computations in nuclear theory that exploit the US leadership in high-performance computing.

Polarization phenomena, spin physics.

D.M.Nikolenko, BINP, Novosibirsk, Experiments with tensor polarized deuteron target at VEPP-3 storage ring.

A.I. L'vov, M.I. Levchuk, Lebedev Phys. Institute, Polarizabilities of nucleons from new data on proton and deuteron Compton scattering.

Lev Fil'kov. Lebedev Institute, Moscow. Dipole polarizabilities of charged pions.

Takehito Hayakawa. Japan Atomic Energy Agency, Neutron angular distributions of (γ, n) reactions with linear polarized photons generated by laser Compton scattering.

Fragmentation of nuclei by real and virtual photons.

NK Kornegrutsa JINR, Dubna, Featuresof peripheral fragmentation of the relativistic nucleus 7Be.

V.Lisin, G.M.Gurevich. *INR RAS, Moscow, Fragmentation of light nuclei by intermediate energy photons.*

Takahiro Kawabata. University, Kyoto, Photodisintegration of 4He measured by the MAIKo active target.

K. Z. Mamatkulov, JINR, Dubna, Investigation of coherent dissociation 10C nuclei at an energy of 1.2 GeV per nucleon.

Zaitsev, JINR, Dubna, The first results of analysis of nuclear track emulsion exposed to relativistic nuclei 11C.

Preliminary Program – emin2015

Giant resonances and collective excitations of nuclei

Ishkhanov, A.I. Davydov, N.N. Peskov, V.N. Orlin, M.E. Stepanov, V.V. Varlamov. SINP MSU, Moscow, Photoneutron reaction cross sections in the region of giant dipole resonance - analysis and evaluation using physical criteria.

Nikolay Arsenyev, JINR, Dubna, The 2p-2h study of low-energy dipole states in neutron-rich nuclei.

Mazur I, PNU, Khabarovsk, Description of resonant states in the shell model.

M.L.Gorelik, S.Shlomo, B.A.Tulupov, M.H.Urin. INR RAS, MEPHI, Texas University, Properties of high-energy isoscalar monopole excitations in medium-heavy mass spherical nuclei.

Oleg Achakovskiy. IPPE, Obninsk. Impact of phonon coupling on the radiative nuclear reaction characteristics.

Nikita Fedorov. SINP MSU, Moscow. Effect of neutron pairs on E1 resonance features.

Natalia Goncharova. SINP MSU, Moscow. The Influence of Surface Tension on Nuclear Collective Properties and Resonance Structure.

Valentin Nesterenko. LTP JINR, Dubna. Skyrme-RPA description of isoscalar E0 giant resonance in spherical and deformed nuclei.

Preliminary Program – emin2015

New developments and perspectives.

D.M.Filipescu. ELI-NP, IFIN-HH, Bucharest. Future prospects of nuclear reactions induced by gamma-ray beams at ELI-NP.

A.B. Saveljev-Trofimov. MSU, Moscow, Toward positron production with table-top femtosecond lasers.16-00. *Mamoru Fujiwara. RCNP, Osaka.* Production of Medical 99mTc isotopes via Photoreaction and Neutron Absorption

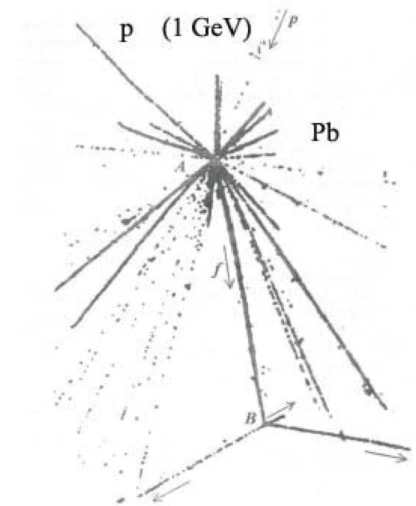
Yu.V.Shestakov. BINP, Novosibirsk, Tagging system of almost-real photons for photonuclear experiments at VEPP-3.

V. Afanasiev et al. JINR, Dubna, Project SCAN-3 of studying eta-mesic nuclei and other forms of excited nuclear matter at the JINR Nuclotron.

Fragmentation of light nuclei by real and virtual photons

300 GeV p + W (66 tracks) Akhorov O. e.a. **JINR** R1=9963 (1976)

1 GeV p + Pb,Th,U Gorshkov B.L.,e.a. Ecplosion reaction in 238-U, 232-Th and 197-Au by 1 GeV protons. JETF letters,37.60-63, (1983). ***LPI***

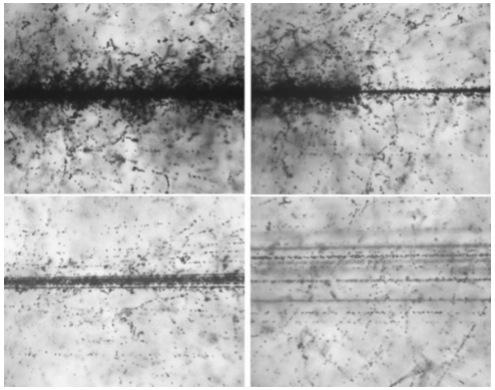


p, α-particles Lips V.,e.a. ***FASA.*** JINR, TH, Darmstadt (1993), IKDA 3/7, p1-11 (1993).

Relativistic ions

Au + emulsion target

[http://**becquerel**.jinr.ru.]



A.S.Botvina e.a. ***ALADIN*** collaboration @ SIS, Multifragmentation of spectators in relativistic heavy-ion reactions, NP A 584 , 4 (1995) 737.

Theory interpretation :

Phase transition between nuclear matter and gas of nucleons

Threshold behavior : E* is comparable to binding energy

A.S.Botvina, A.S.Iljinov, I.N.Mishustin. Multifragmentation of nuclei by high energy protons. JETF letters, 42, 11, 462-464 (1985).

Kamaukhov V.A. On nuclear liquid gas phase transition via multifragmentation and fission. ЯФ. 1997. Т. 60. С. 1780-1783.

RELDIS Cascade Evaporation MODEL :

I. Pshenichnov et.al., Physical Review C57 (1998) 1920. , Physics of particles and nuclei, 42 (2011) 215, Eur. J. Phys. A 24 (2005) 69.

A2 : Double photoproduction off nuclei – are there effects beyond final-state interaction arXive:1304.1918v1 [nucl.ex] 6 Apr 2013

Study of $\eta n \rightarrow \pi^- p$ reaction in ^{12}C nucleus using recoil protons as a tagger , based on photo-multi-disintegration measurement

A.Lapik, A.Mushkarenkov, V.Nedorezov, A.Turinge, N.Rudnev
for GRAAL & BGO-OD collaborations

Institute for Nuclear Research, RAS, Moscow

GENERAL MOTIVATION

- To answer the question :

- How unstable mesons (π^0, η, ρ, ω etc) interact with nuclear media, in what reactions, what are the interaction products etc ?
-
- Different theoretical models are trying to subtract such information .
-
- We propose to study elastic and inelastic interactions of unstable mesons with nuclear media by the model independent way, directly in the experiment.

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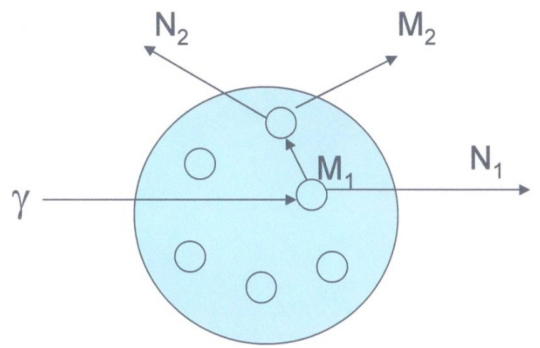


Short living mesons:

Meson type	Life time τ (s)	Relativistic range in vacuum $c\tau$ (fm)	Width Γ (MeV)
π^0	$8 * 10^{-17}$	$2.5 * 10^7$	$8 * 10^{-6}$
η	$5 * 10^{-19}$	$1.5 * 10^5$	10^{-3}
η'	$3 * 10^{-21}$	$0.9 * 10^3$	0.2
ρ	$4 * 10^{-24}$	1.2	149
ω	$7 * 10^{-23}$	20	8.43

Transparency in **Glauber model with eikonal approximation**

[P.Muhlich, U.Mosel, NP A 773 (2006) 156]

Definition
$$\tilde{T}_A = \frac{\sigma_{\gamma A \to \eta' A'}}{A\sigma_{\gamma N \to \eta' N}} .$$

Normalized to ^{12}C

$$T_A = \frac{\pi R^2}{A\sigma_{\eta' N}} \left\{ 1 + \left(\frac{\lambda}{R}\right) \exp\left[-2\frac{R}{\lambda}\right] + \frac{1}{2}\left(\frac{\lambda}{R}\right)^2 \left(\exp\left[-2\frac{R}{\lambda}\right] - 1\right) \right\}$$

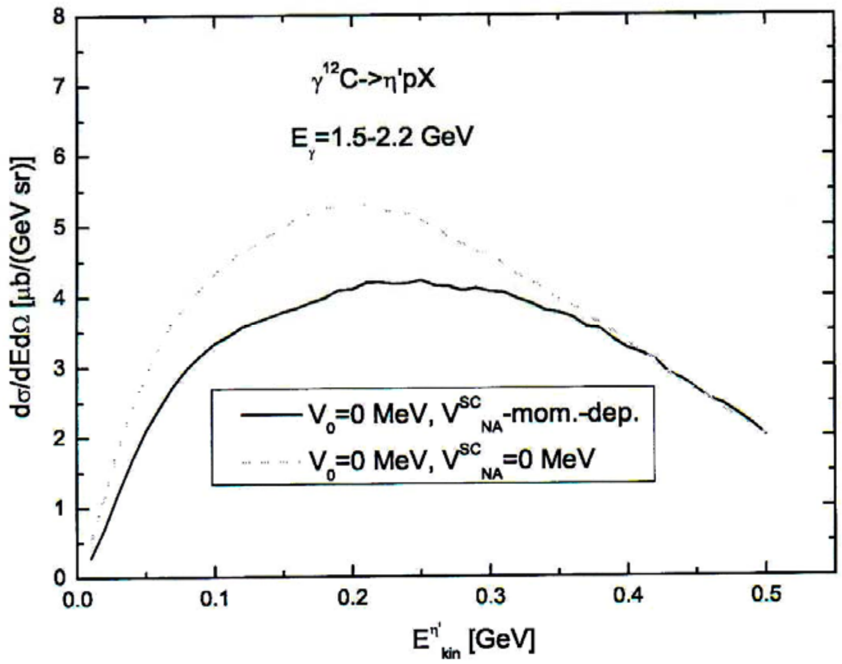
Evaluated inelastic $\sigma_{\eta' n}$ = 10.3 ± 1.4 mb.

[M.Nanova e.a.(BGO-OD collaboration) Phys.Lett. B710 (2012) 600-606]

Numerous data on A-dependence of meson photoproduction are available : V.Nedorezov, Yu.N.Ranyuk. Photofission above the giant resonance. Naukova dumka, Kiev, 1989.

Differential cross section for η’ + ^{12}C in the full solid angle vs $E^{\eta'}_{kin}$
for momentum dependent nuclear potential
(in coincidences with protons within $\theta = 1^0 - 11^0$)

E.Ya.Paryev, Study of in-medium η’ properties in the (γ,η’p) reaction on nuclei.
arXiv:1503.09007 [nucl-th], Mar 31, 2015

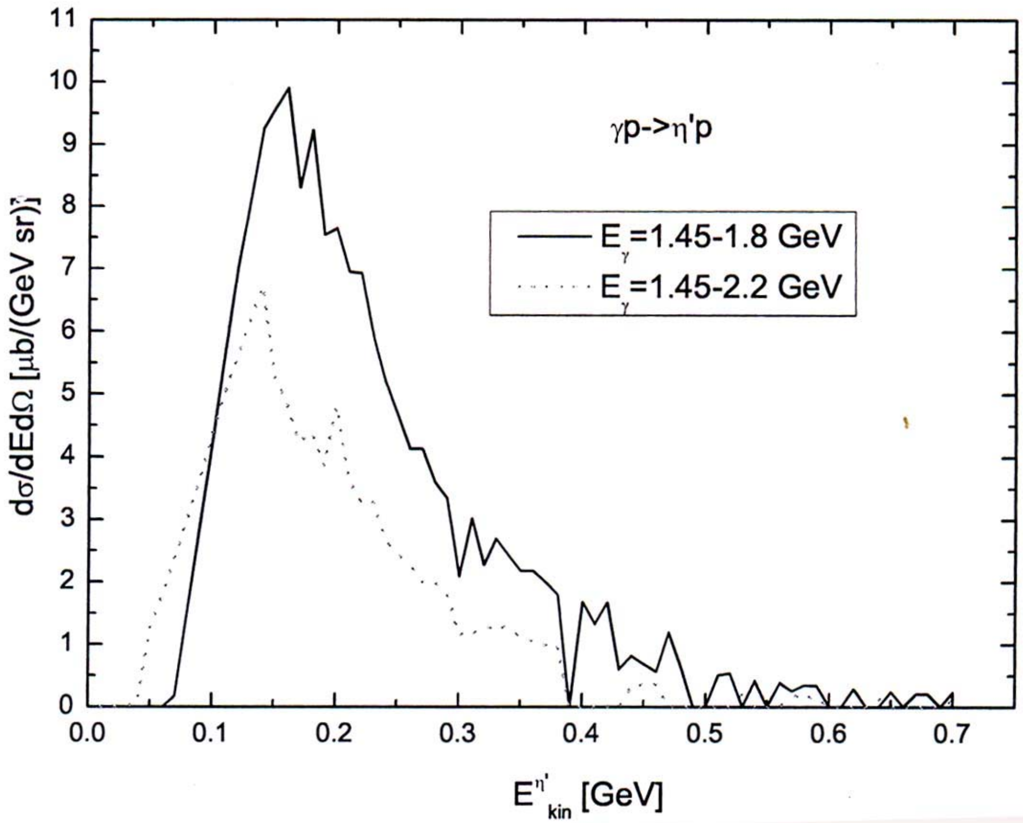


Differential cross section for η' + ^{12}C in the full solid angle vs $E^{\eta'}_{kin}$

(in coincidences with protons within $\theta = 1^0 - 11^0$)

Vo = - 50 MeV

E.Ya.Paryev, Study of in-medium η' properties in the (γ,η'p) reaction on nuclei. arXiv:1503.09007 [nucl-th], Mar 31, 2015

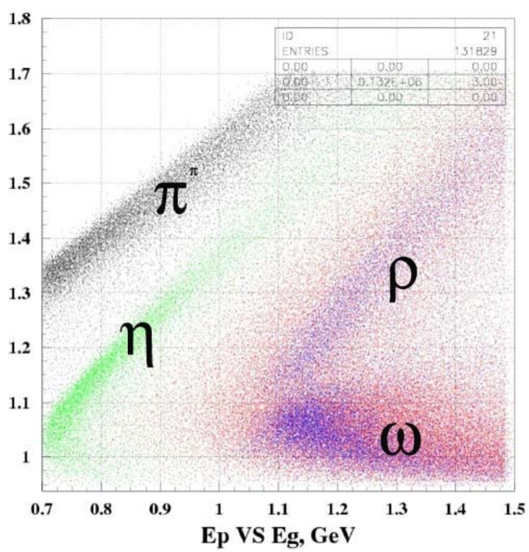


Meson Tagging by recoil protons: Simulation for ^{14}N

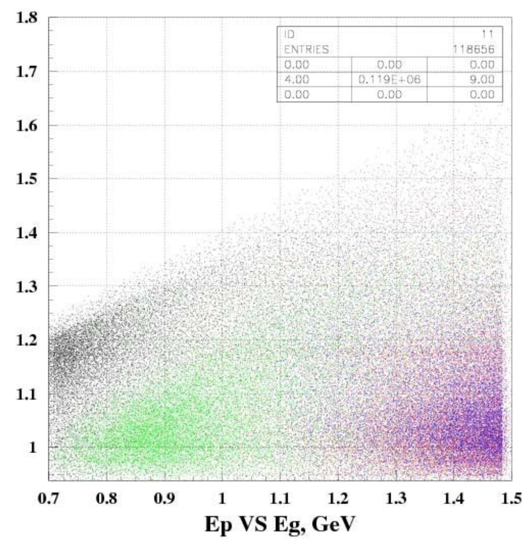
Variable parameters Ep, Eγ , Fixed parameter θ_p

Ideal case: (no backgrounds, ideal resolution but intranuclear cascade is included) :

- $2^0 < \theta_p < 10^0$



- $2^0 < \theta_p < 40^0$



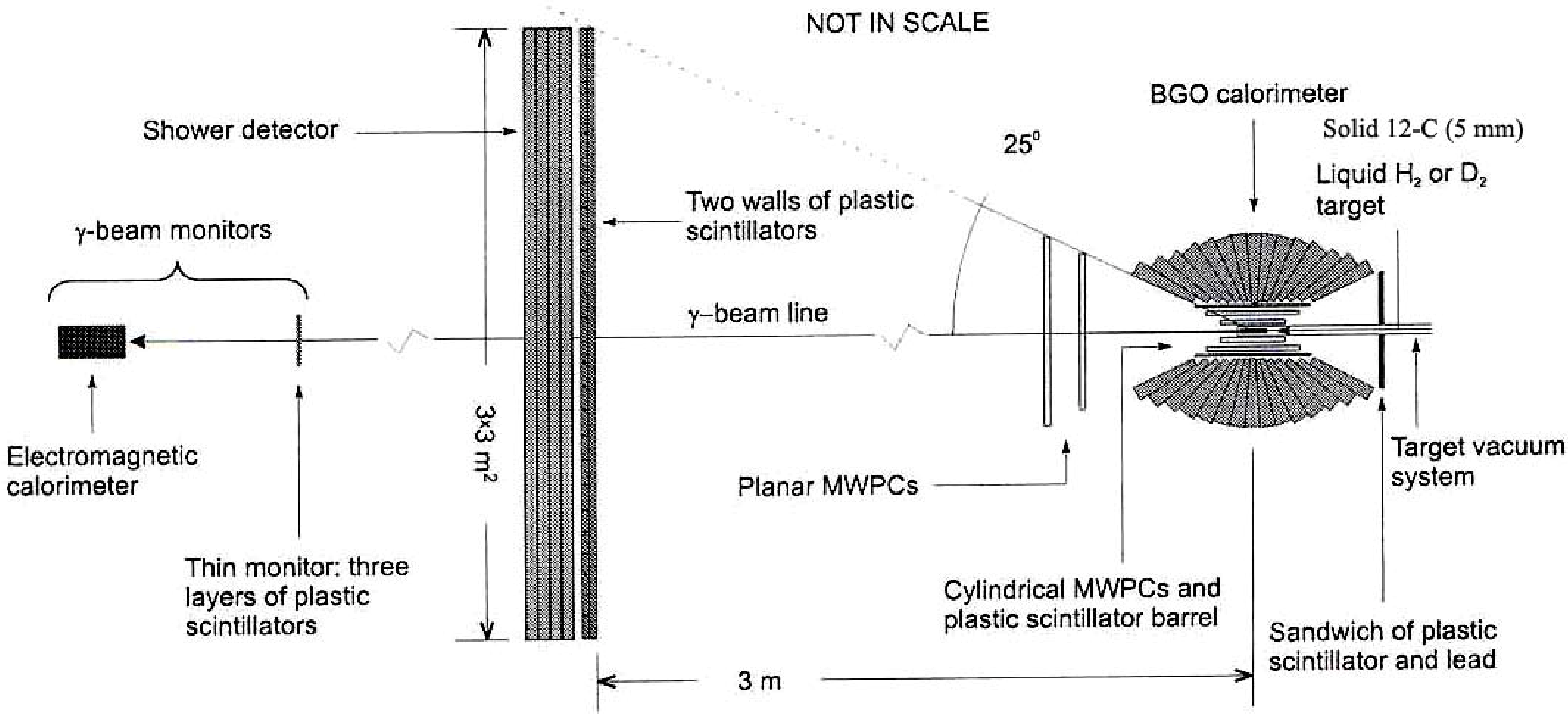
- Multiple (n ≤4) meson production and INC is included
- A.Ignatov e.a. New experimental and simulated results on nuclear media effects in meson photoproduction off nuclei. Prog.Part.Nucl.Phys.(2008) 61:253-259,2008.

Positive features and principal problems

- **Why the PHOTON beam?**
- **a nucleus is transparent for photons (universal curve) ,**
- **background reactions (elastic and multiple scattering of projectiles) are negligible,**
- **multiplicity of products is relatively small to identify them completely,**
- Optimal kinematics conditions (simulations)
- Multifragmentation of nuclei – how to distinguish the primary and secondary recoils ?
- Probability of cascade interaction for primary nucleon does not exceed 20%, probability of multifragmentation is small.
- Energy and angular distributions of primary and secondary nucleons are different.

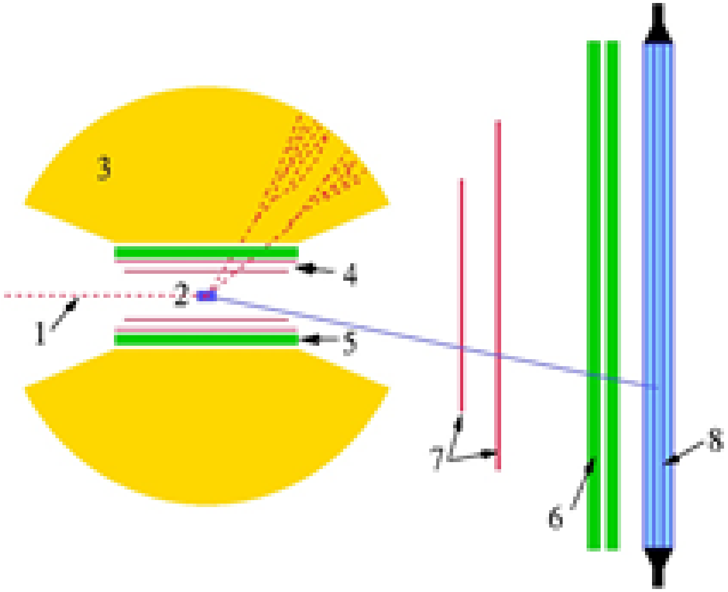
- [V.Nedorezov e.a. (GRAAL collaboration). Disintegration of ^{12}C nuclei by 800 – 1500 MeV photons. Nuclear Physics, Section A (2015), pp. 264-278]

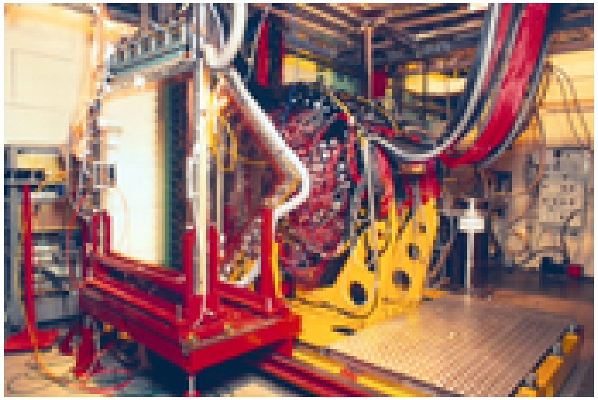
GRAAL experiment



LAGRANγE Detector

1: Compton gamma beam , 2: Liquid H2/D2 target , 3: BGO Calorimeter
4: Cylindrical MWPC's , 5: Plastic Barrel , 6: Plastic Wall, 7:Plane MWPCs, 8: Shower Wall



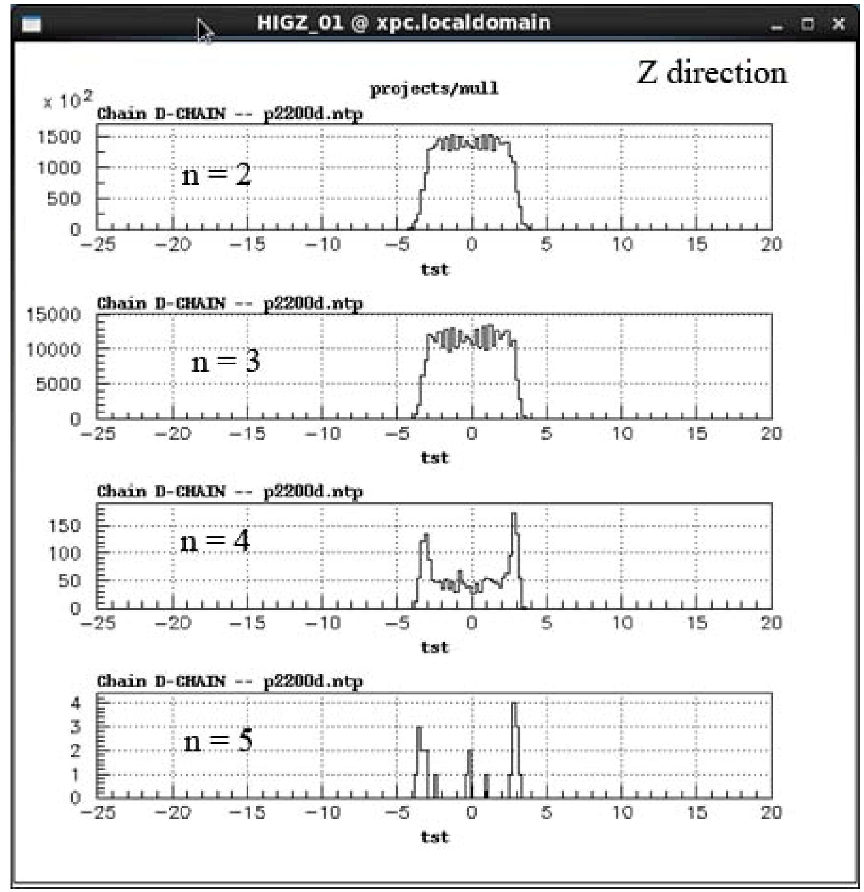


- Shower Wall
- neutron efficiency 20 %
- γ / neutron PID

•VERTEX : Yield of charged particles from the mylar windows with different multiplicity (n=2,3,4,5)

- Target : 8 cm LD + 100 μm mylar windows ($C_{10}H_8O_4$)

□ Beam $E\gamma$ = 0.6-1.5 GeV



- Cylindrical 4π MWPCs
- of the detector LAγRANGE:

- for n = 5 measured particles
- are not mesons, not primary
- recoils,

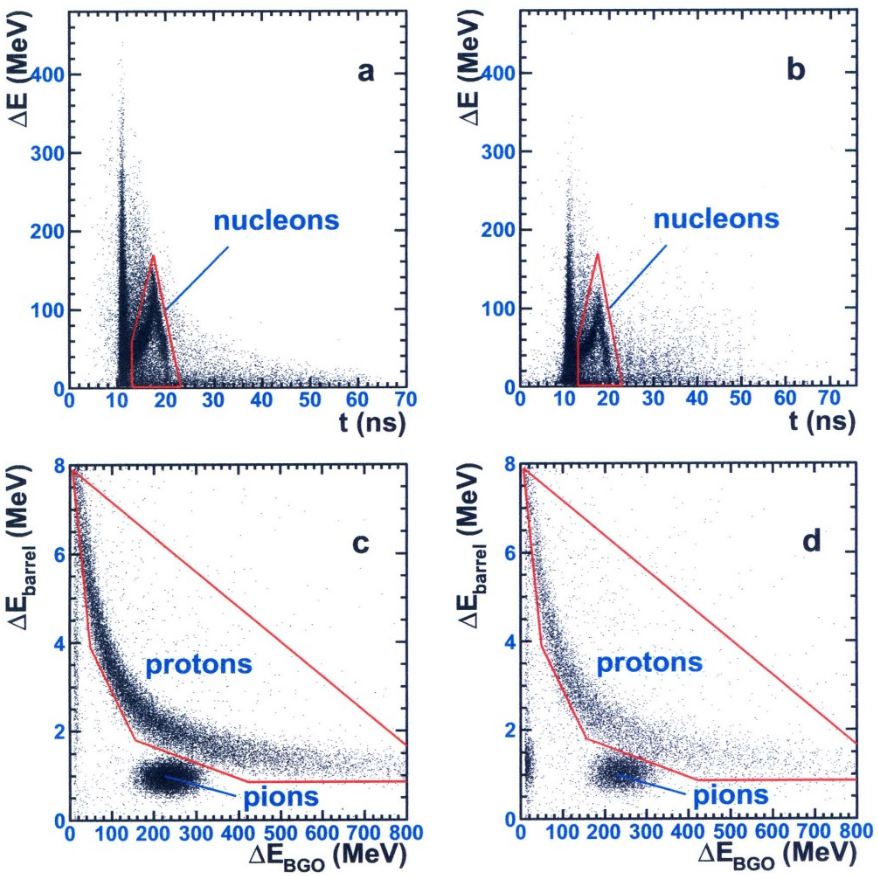
- Most probably they are cascade
- protons from intra-nuclear
- interaction

Separation of charged particles in the GRAAL experiment
[V.Nedorezov e.a. (GRAAL collaboration) NP, A (2015), pp. 264-278]

a – simulation,   b – experiment

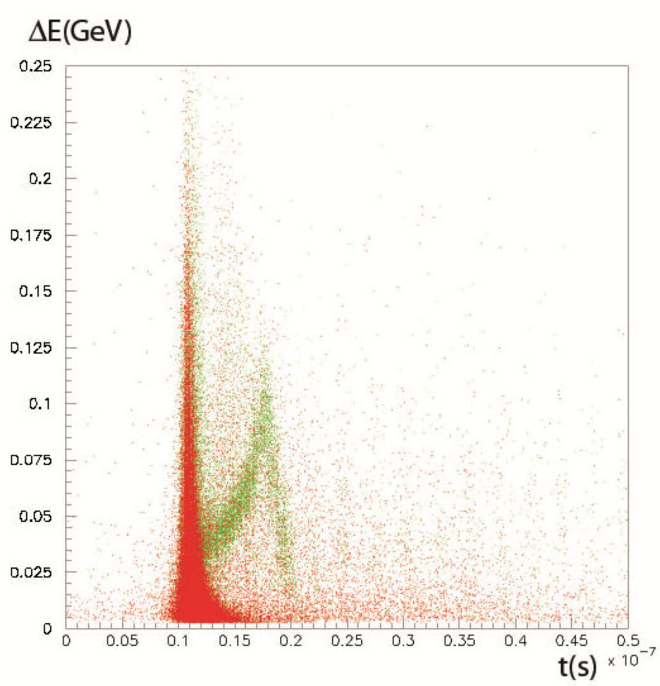
- *Forward detector*
- *(plastic wall   (ΔE – TOF)*

- *ΔE (barrel) – ΔE (BGO)*

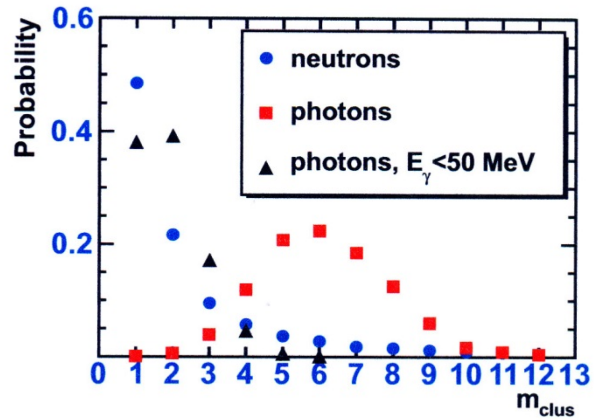


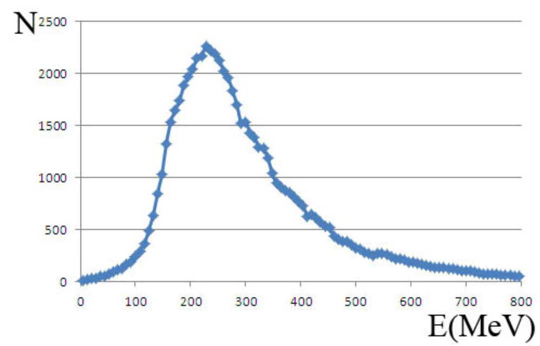
Additional efforts to identify charger particles in BGO :
vertex : star picture from the target, selection of files

Separation of neutral particles in the GRAAL experiment [1]:



Mclus dependence:





Eγ energy spectrum from all partial channels

In forward direction (EM-calorimeter) TOF-ΔE Is similar to protons but Efficiency is in 5 times less

Expected contribution of low energy photons (E_γ < 50 MeV) does not exceed 2%

Additional efforts to exclude complementary neutral clusters in BGO : *TOF in BGO*

Magnetic spectrometer

- Separation of charged particles (pions, kaons, protons, light nuclei) in forward direction

  $\theta = 1^0 - 11^0$

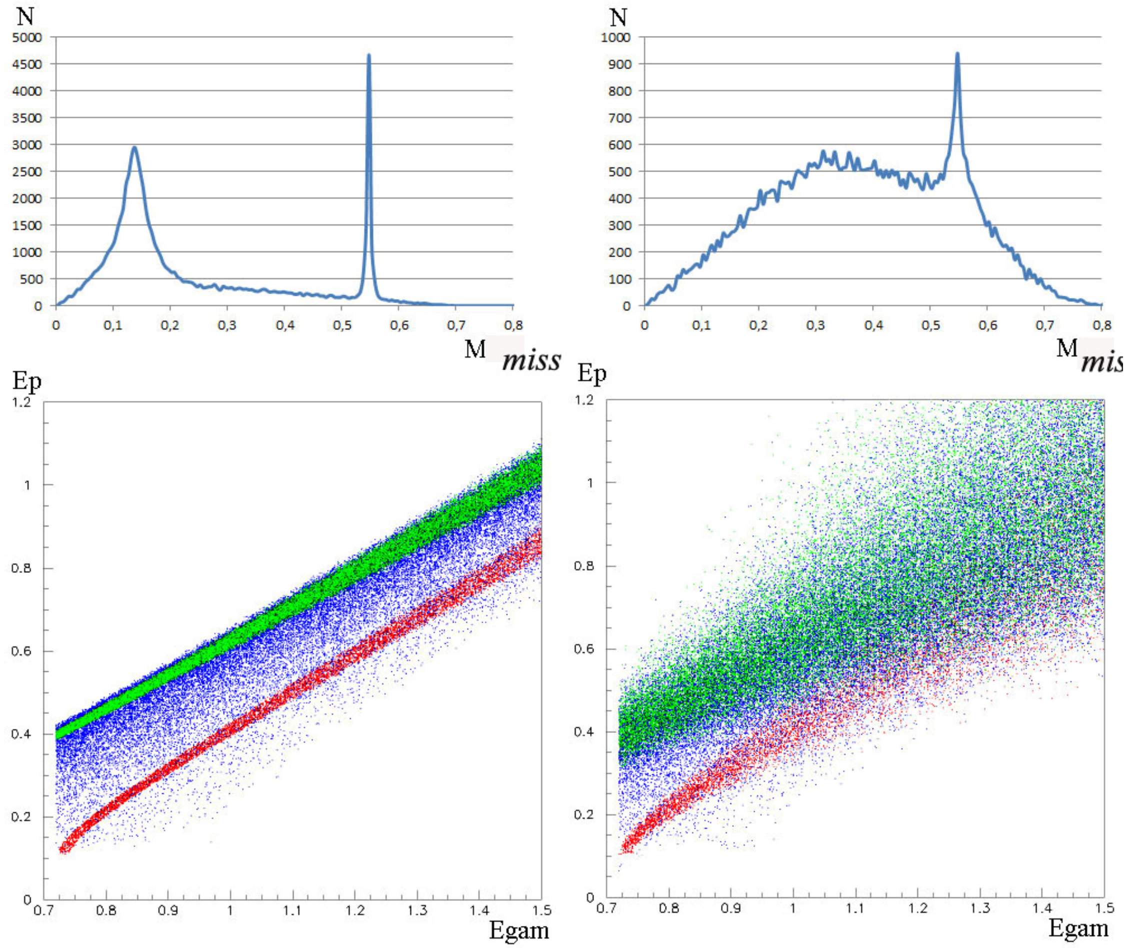
  $\Delta P/P$ = 1% is much better than at GRAAL (10%)

TOF in BGO

1 ns would be enough to distinguish p,d, a particles because the energy of secondary particles is relatively small

Complementary neutral clusters from neutron scattering can be rejected

Simulation:
Left panel: resolution of 0.5% (BGO-OD)
Right panel: resolution of 10% (GRAAL)



Selection of the primary recoil nucleon: angular distributions (data for C-12 from the GRAAL experiment [1])

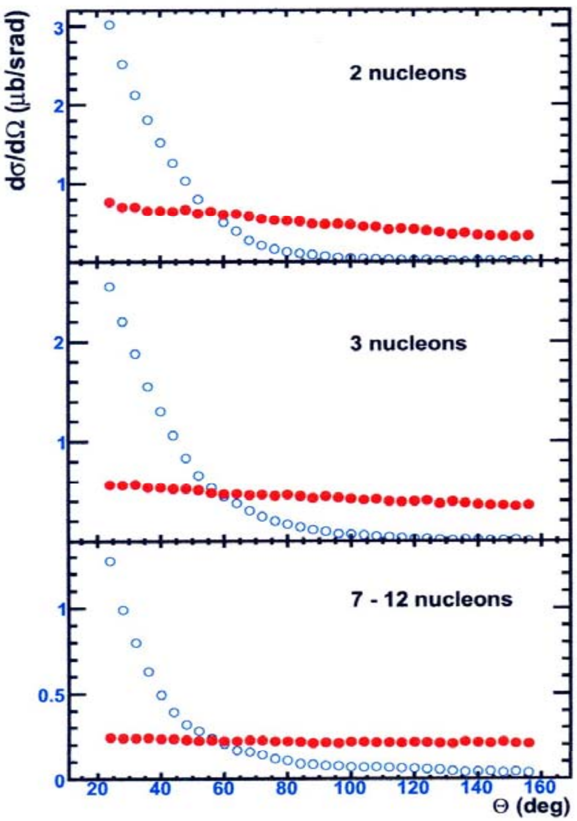


Figure 6: Measured angular distributions of nucleons produced in photodisintegration of ^{12}C in the laboratory system in events with two (top panel), three (middle panel), seven and more fragments (bottom panel). In all cases the angular distribution for the leading most energetic proton in each event is presented by open circles, while the distributions for all other nucleons in the same event are presented by solid circles.

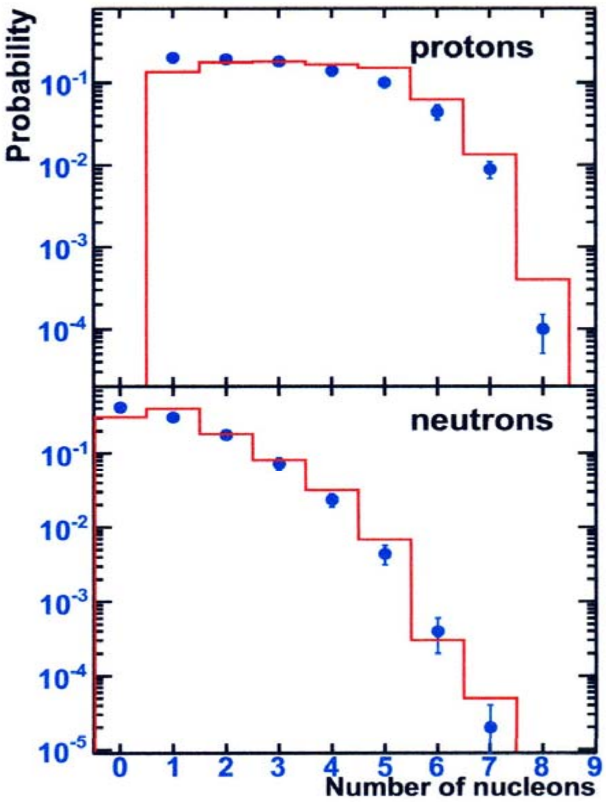
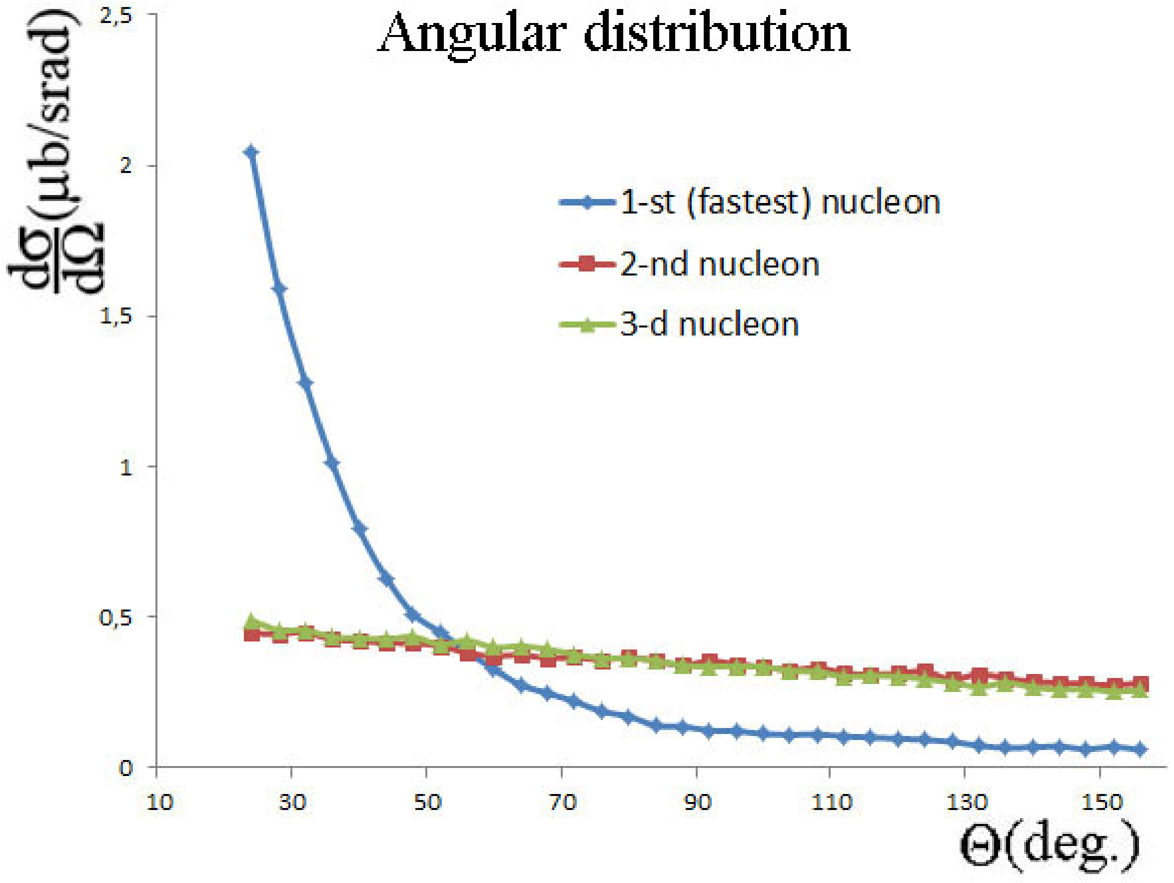
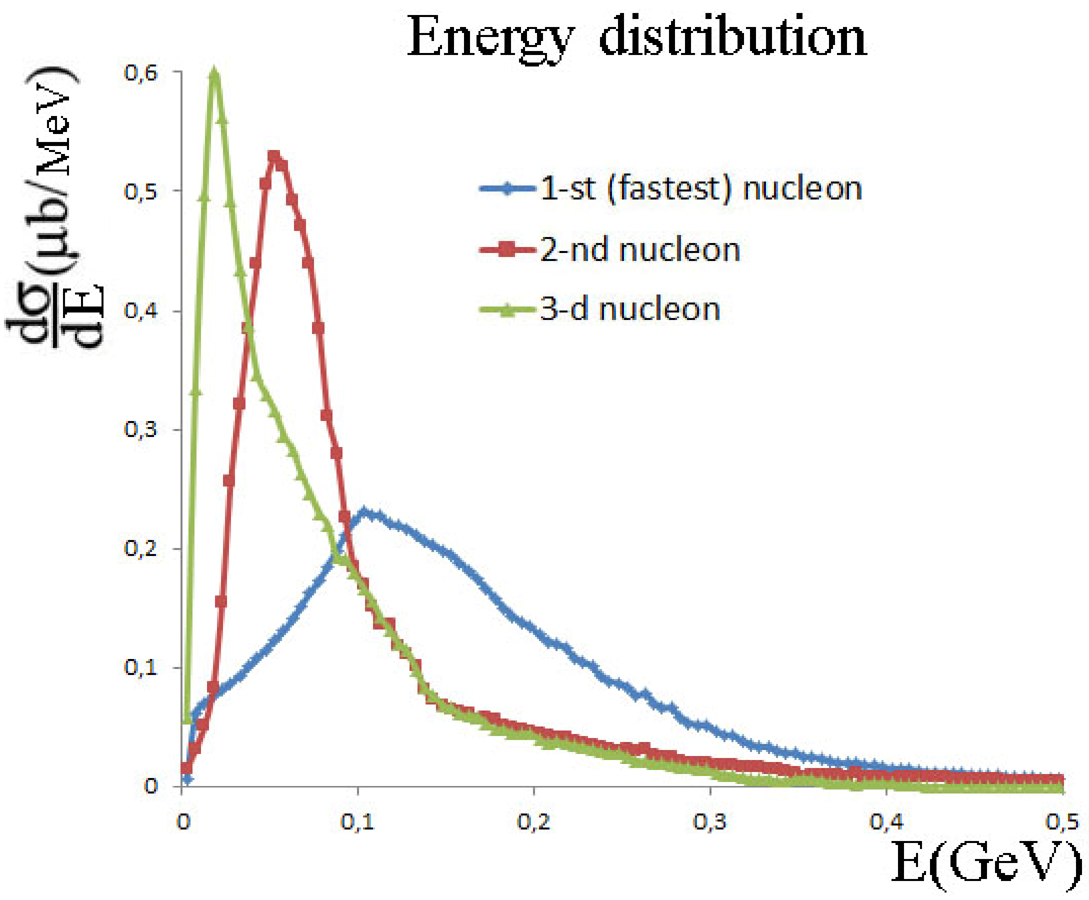


Figure 8: Measured (points) and calculated (histograms) probabilities of photodisintegration events of ^{12}C at 0.7–1.5 GeV with a given number of protons (top) and neutrons (bottom). Only statistical uncertainties of measurements are shown.

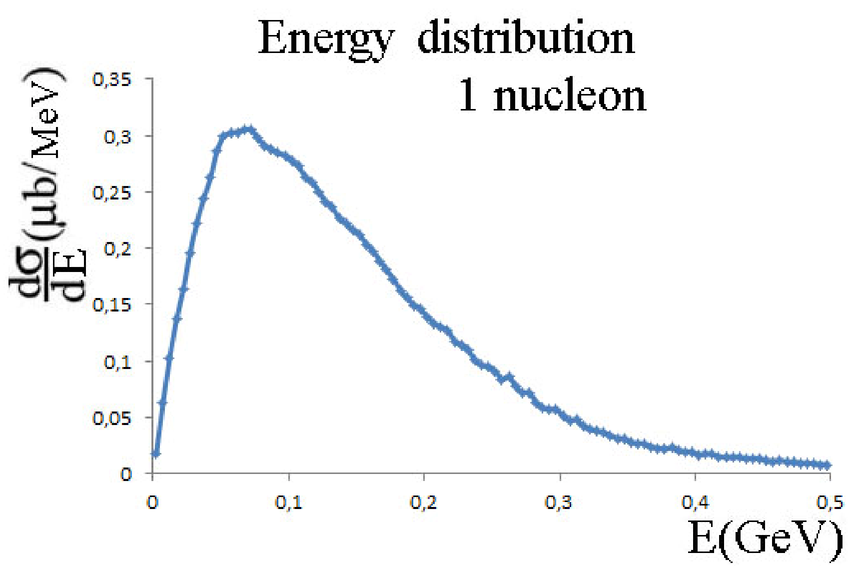
Selection of the primary recoil nucleon: angular distribution

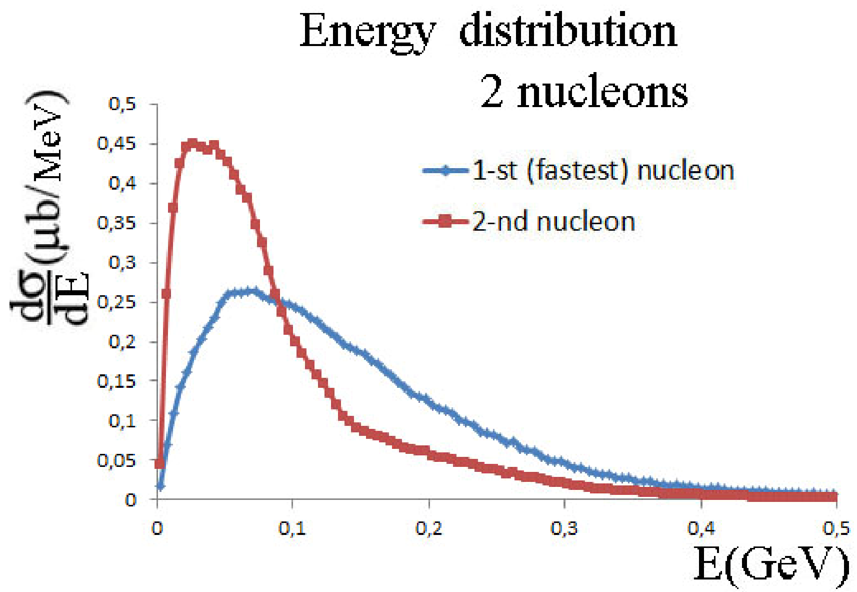


Principal feature to select the primary recoil proton: BGO energy loss distribution

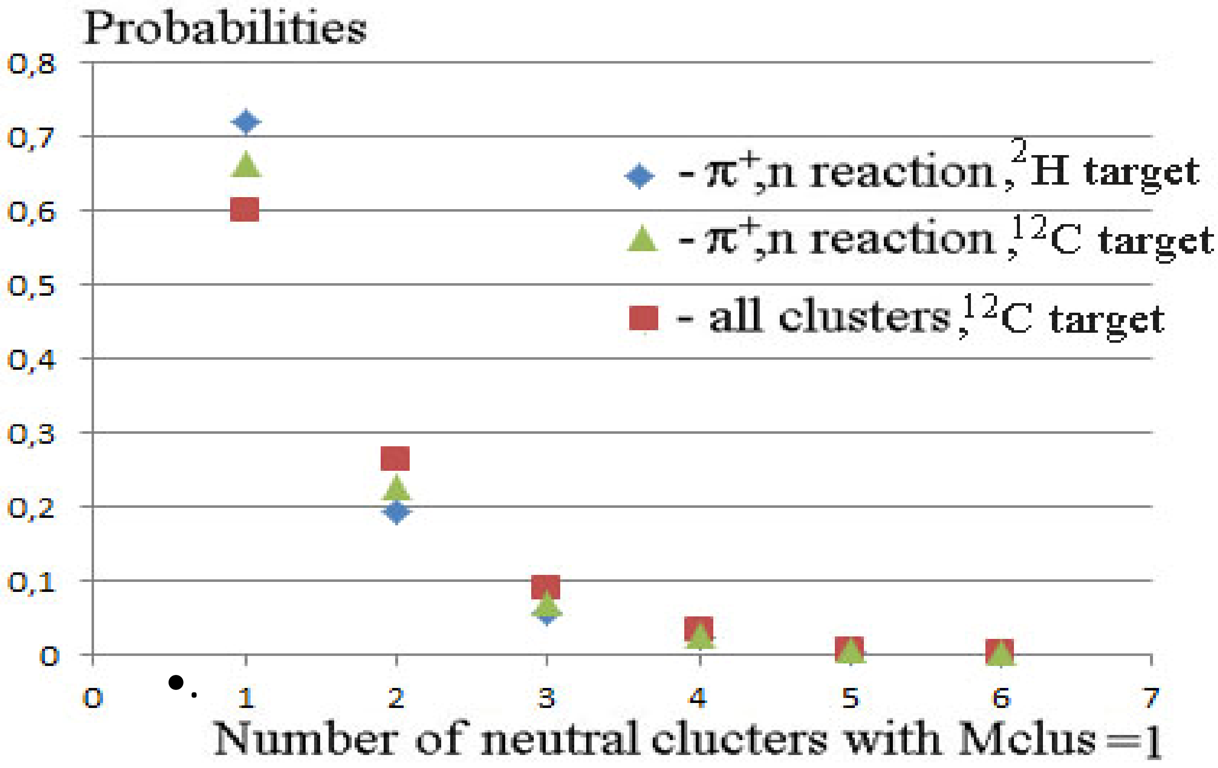


Principal feature to select the primary recoil proton:
BGO energy loss distribution

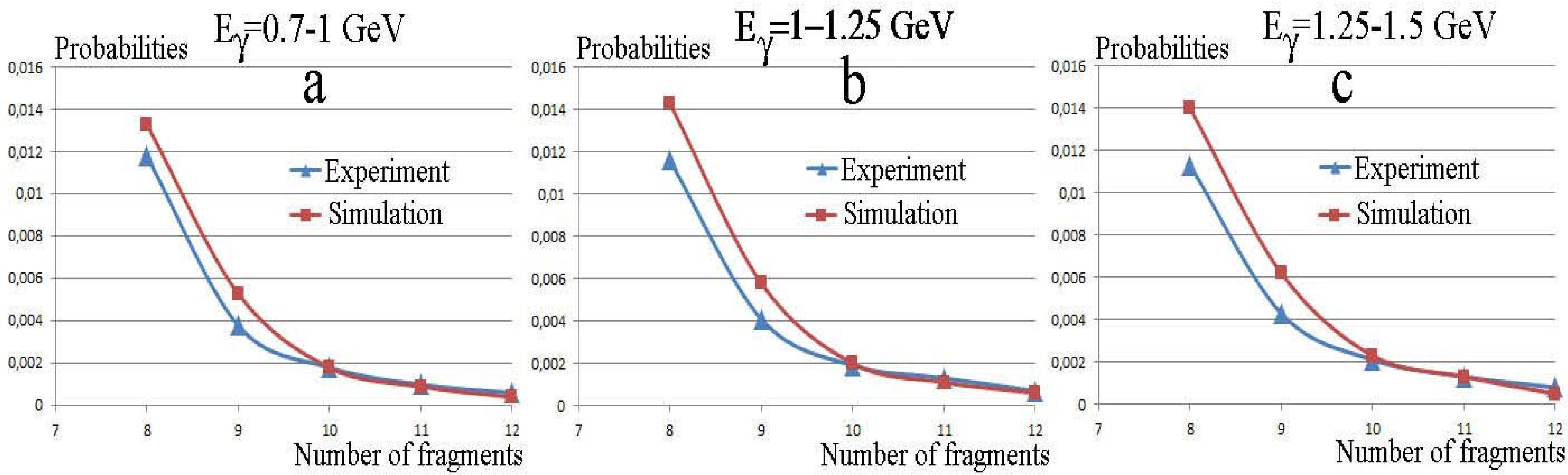




Probability of neutral cluster (neutron) production in different partial reactions [GRAAL results]

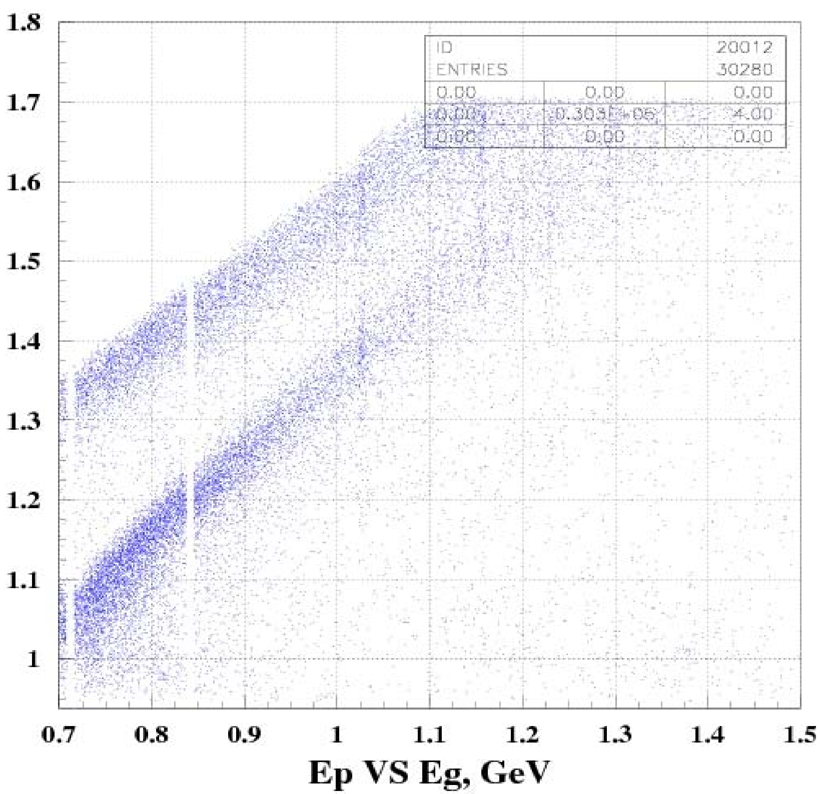


^{12}C multi-fragmentation probabilities (n = 8 – 12) at different $E\gamma$ energies in comparison with RELDIS predictions

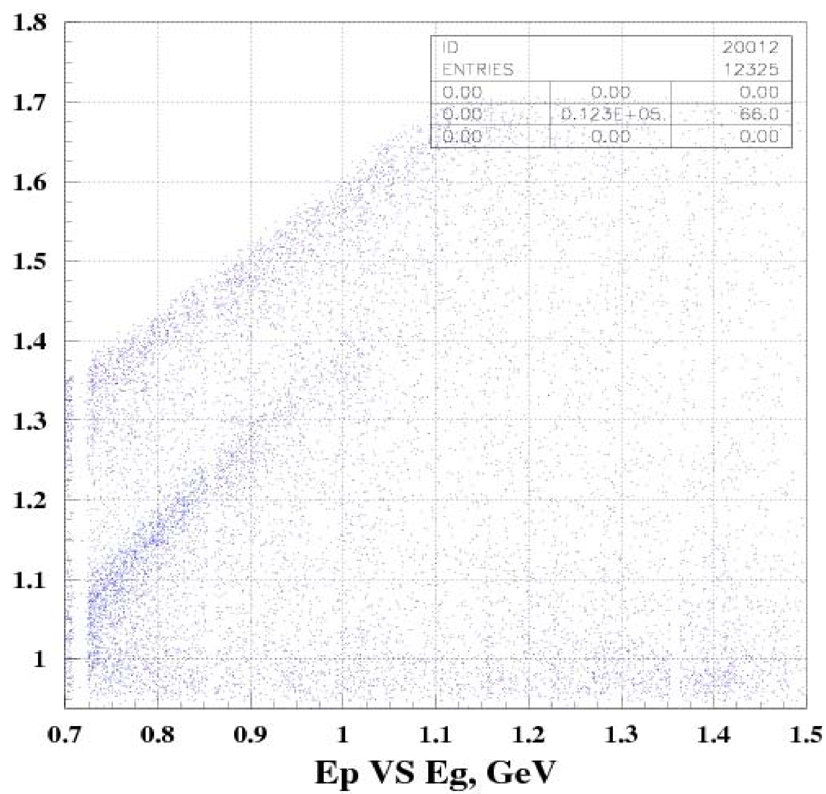


- First GRAAL experimental results
- Deuteron target
- 2^0<theta<10^0

- simulation



- Experiment
- Kinematics is not included

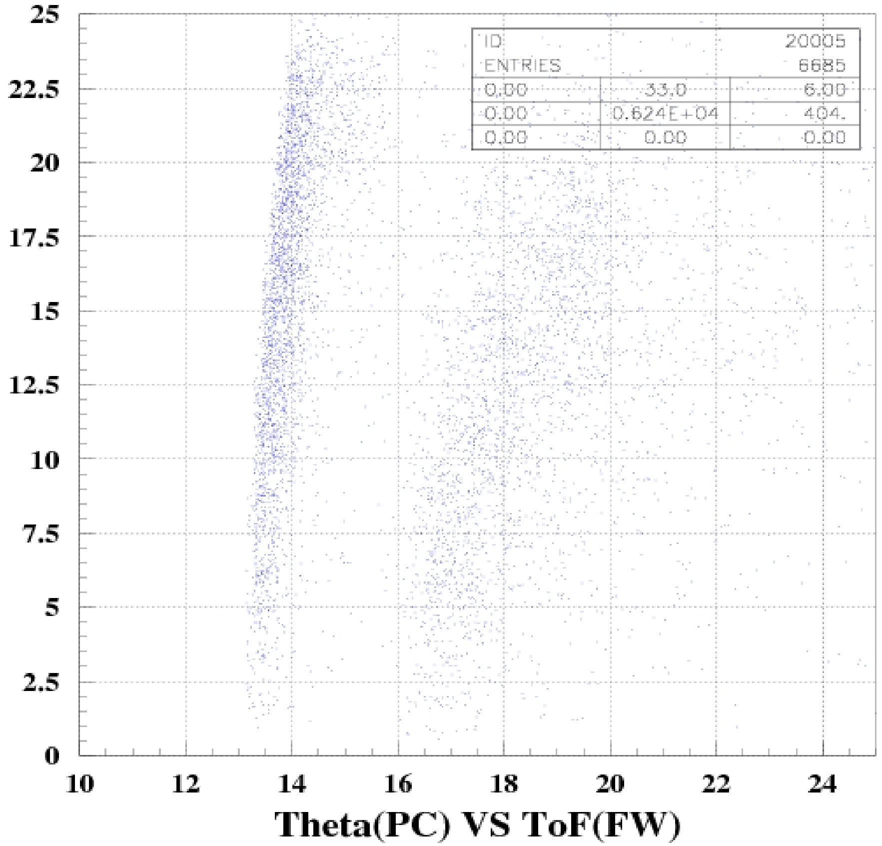


Separation of π^0 and η meson production by the recoil proton

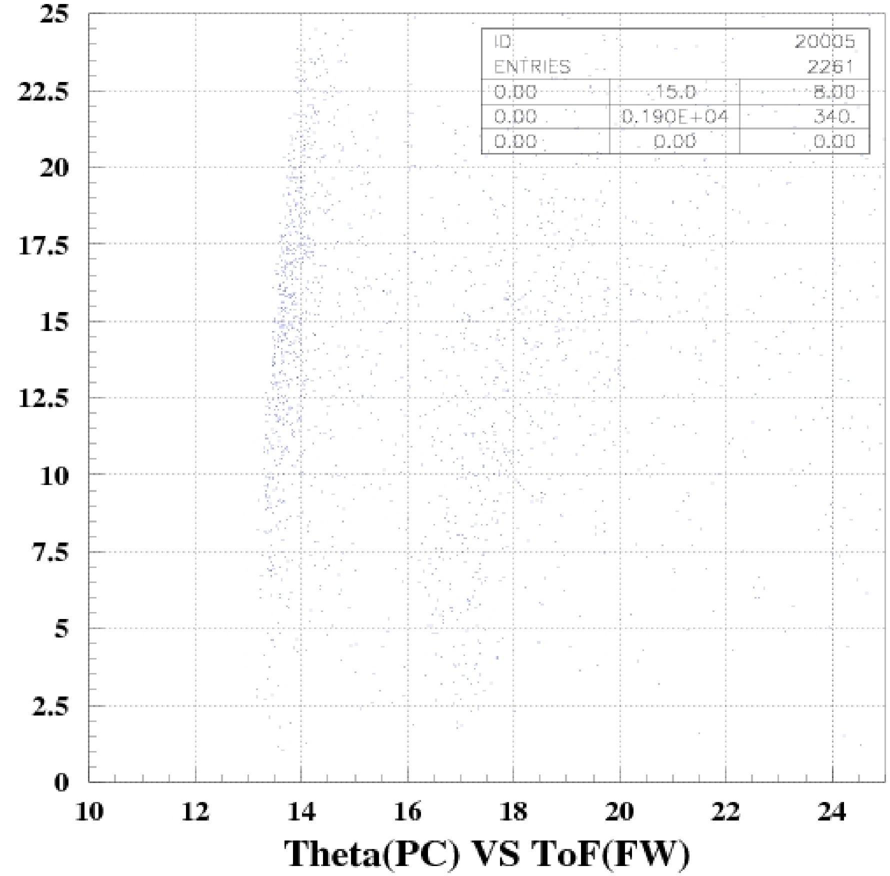
Number of the charged tracks in forward >= 1 Number of the neutral clusters in BGO = 2

Egamma = 790-810 MeV

simulation



experiment

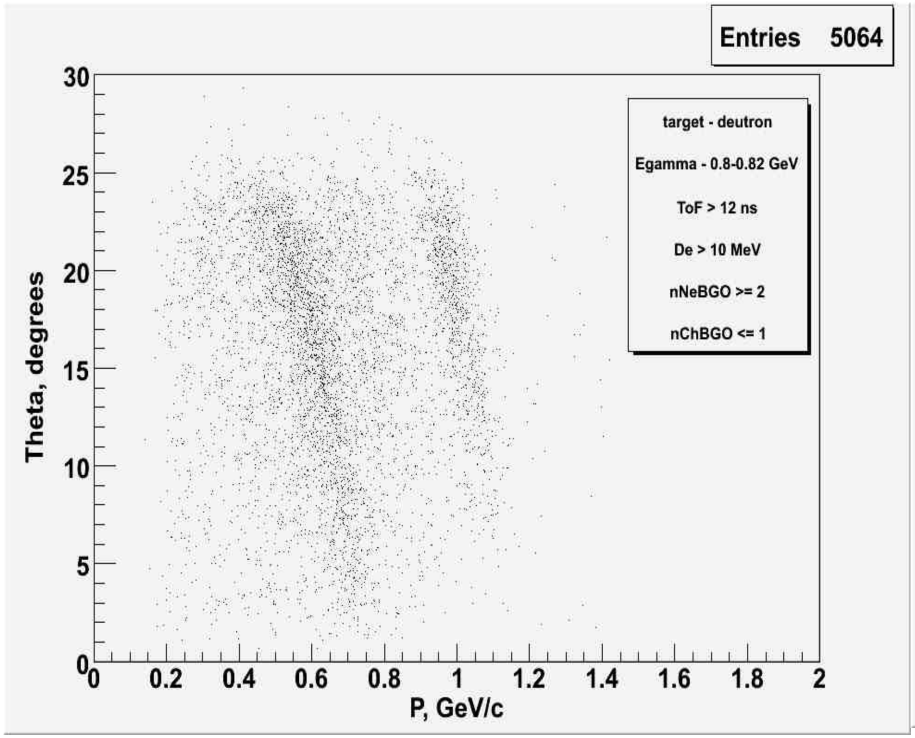


Separation of p0 and h meson production by the recoil proton

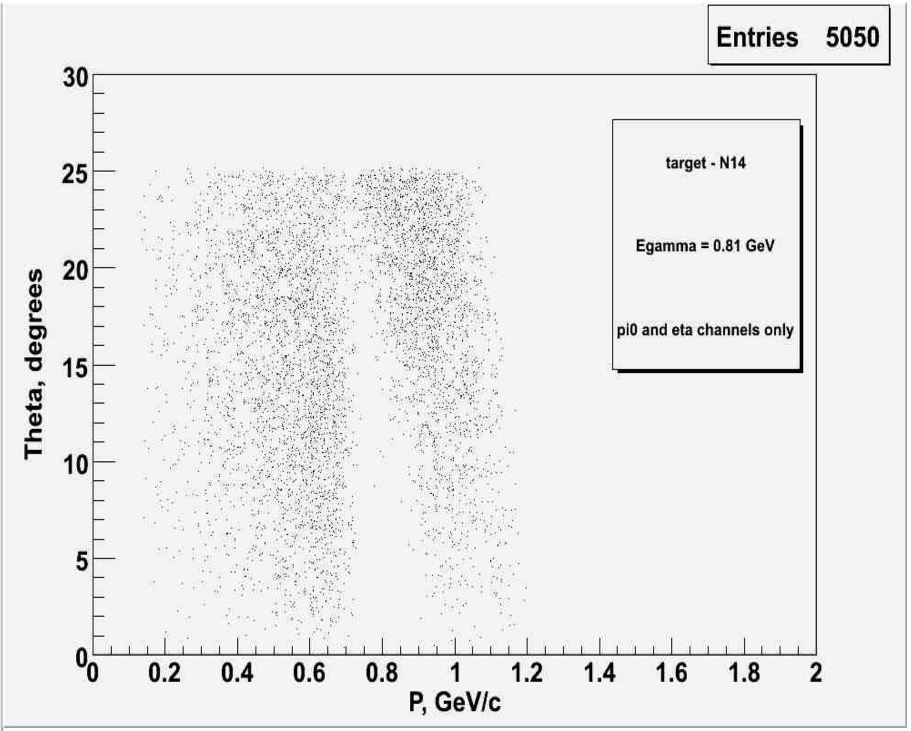
Number of the charged tracks in forward = 1 Number of the neutral clusters in BGO = 2

Angle vs momentum correlation of primary recoil proton

Experiment on deuteron



Simulations with INC code on ^{14}N nucleus



INC prediction for different cascade steps

[Moscow, EMIN-2001, p.170]

Table 1: Particle emittion probability from nucleus ^{14}N on different steps of reaction initiated by photoproduction of π^0 and η mesons on intranuclear proton (%).

particle	reaction step	$\gamma p(^{14}N) \to \pi^0 p$	$\gamma p(^{14}N) \to \eta p$
p	1	95	95
π^0	1	80	0
η	1	0	70
p	2	22.0	20.8
n	2	23.7	22.1
π^0	2	8.7	8.6
π^+	2	8.67	9.1
π^-	2	7.84	6.78
p	3	8.85	7.15
n	3	8.90	7.05
p	4	2.61	2.17
n	4	2.90	2.02

$E\gamma$ = 1 GeV

Perspectives

- Selection of priority in the wide experimental program based on the tagging recoil nucleon method.
- Study of nuclear disintegration with different multiplicity can give new fundamental information about meson photo-production reactions. BGO-OD is suitable to solve the assigned task. Specific fundamental problems can be studied :
- **Multiplicity n = 1**
- Nuclear elastic scattering reactions induced by unstable mesons,
- The case when the recoil nucleon is emitted from the back surface of nucleus in forward direction (along the beam axis) is preferable.
- **n=2**
- Inelastic two particle kinematics reactions; first candidate could be $\eta n \;\; \text{->} \;\; \pi^- p$,
- search for bound states of mesons with a nucleus.
- **n > 2**
- The multifragmentation phenomenon which is considered as a phase transition between nuclear matter and gas of nucleons and fragments. Most of results on this subject were obtained with protons and relativistic ions by photo-emulsion method. They clearly demonstrate the events but do not provide detailed information about their properties. So, the photonuclear data are required.
- **n = 0**
- Coherent interactions can give information about exotic (for this moment) mechanisms of photonuclear interactions . Expected non linear effects in photonuclear excitations at low angles of emission (Delbruck scattering, low energy and momentum transfer photofission reactions etc). Particularly, we would explain the JLAB and BINP data on the excess in the total photoabsorption cross sections (20% above the universal curve for heavy nuclei), in the nucleon resonance energy region [8].

- Polarization effects can play an important role in such kind experiments.

Laser Compton scattering photon beams and other gamma-ray sources:

Project for coherent gamma-ray source on basis of femtosecond laser at ILC MSU

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, Rusakov A.V.[1], Djilkibaev R.M.[1], Bychenkov V.Yu[3]
3 – Lebedev Institute of Physics RAS

Compton back scattering history

1963 – F.Arutunyan, V.Tumanyan. JETF 44 (1963) 6, 2100.
R.H.Milburn, Phys.Rev.Lett. 10 (1963) 3, 75

- 1964 – Moscow (Lebedev FIAN) – first experimental evidence
- 1976 - Frascati (LADONE - ADONE) – photonuclear physics
- 1984 - Novosibirsk Budker INP (ROKK – 1,2 – VEPP 3,4) meson photoproduction
- 1988 – Brookhaven BNL (LEGS - NSLS)
- 1995 – Grenoble (GRAAL – ESRF)
- 1998 – Osaka (LEPS - Spring-8)
- 2000 – Duke (HIgS -)

- New history: FEMTOSECIND LASER DRIVEN GAMMA SOURCES

Relativistic electromagnetic fields produced by femtosecond laser

Mourou G., Tajima T., Bulanov S.V. // Review of Modern Physics. 2006. V.78. P.309-371

- **Time duration — to 10^{-15} s (femtosecond)**
- **Wave packet length — to 10 μm (10 wave lengths)**
- **Pulse energy - to 100 J, power - to 10^{15} Wt (petawatt).**
- **Focus on radius of 10 μm provides W = 10^{20} Wt/cm^2**
- **Electric field strength E = 10^{12} V/cm**
- ***(For comparison: in the hidrogen field E = 10^9 V/см., at mica breakdown - 10^6 V/см***
- ***Uranium field E = 10^{11} V/cm, with relativistic compression – up to 10^{12} v/cm) .***

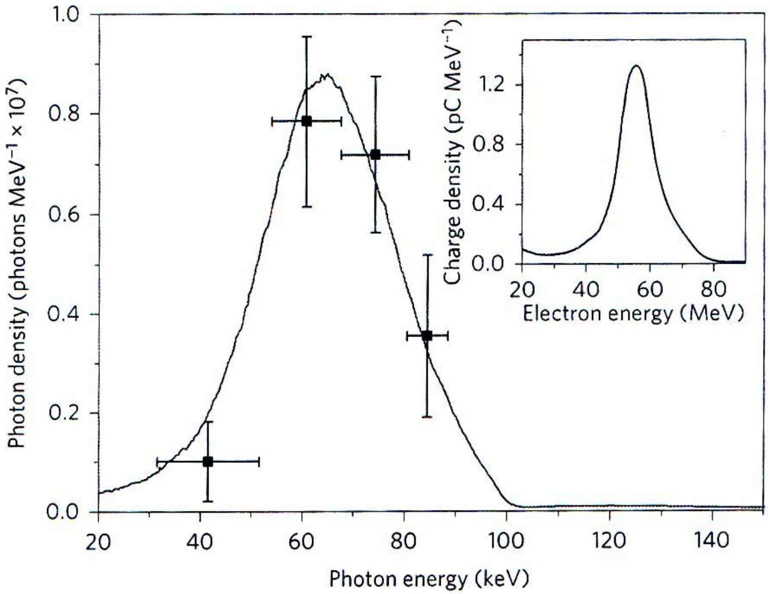
- At E ~10^{11} V/cm, respectively W ~10^{18} Вт/см^2 ($\lambda = 1$ μm) electron is accelerated to relativistic velosity being closed to the light one. Therefore such field is defined as the relativistic one .
- Nevertheless, direct photonuclear reactions (nuclear excitations) are forbidden.

1) 10^{22} ph/s/mm$^{2/}$mrad^2/0.1% bandwidth, 10 mrad, collimation of 4.5 mrad

X-ray phase contrast imaging of biological specimens with femtosecond pulses of betatron radiation from a compact laser plasma wakefield accelerator . S. Kneip, C. McGuffey, F. Dollar, M. S. Bloom, V. Chvykov et al. Appl. Phys. Lett. 99, 093701 (2011)

2) 3×10^{18} photons s^{-1} mm^{-2} mrad^{-2} (per 0.1% bandwidth), 5–15 mrad. Quasi-monoenergetic and tunable X-rays from a laser-driven Compton light source N. D. Powers, I. Ghebregziabher, G. Golovin, C. Liu, S. Chen, S. Banerjee, J. Zhang and D. P. Umstadter* Nature photonics letters (Nov. 2013) p.1-4.

1)

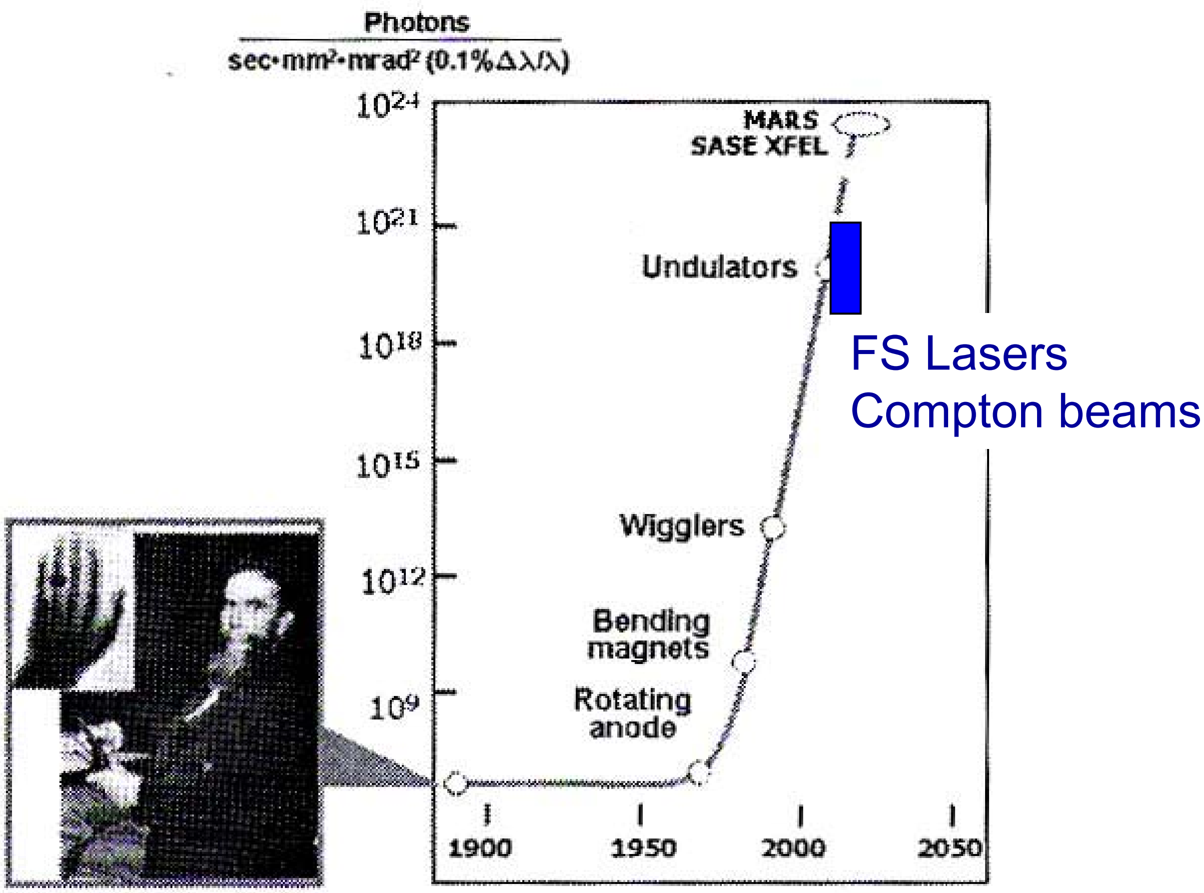


-
- 2)

- A broad synchrotron like spectrum with average photon
- energy (critical energy) of Ecrit ’
- 10 keV like ESRF.

Synchrotron radiation at storage rings

Brightness and total intensity



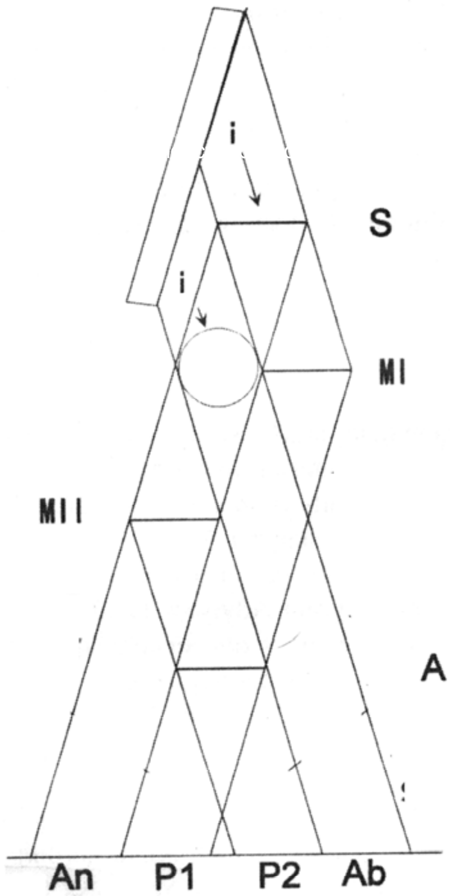
X-Ray imaging: Three color optics

Medical Applications of Synchrotron Radiation / Eds M. Ando, C. Uyama. Tokyo, 1998

- *Simultaneously:*

- *Absorption (Ab)*
- *Refraction (An - "Dark field")*
- *Phase contrast (P1,P2),*

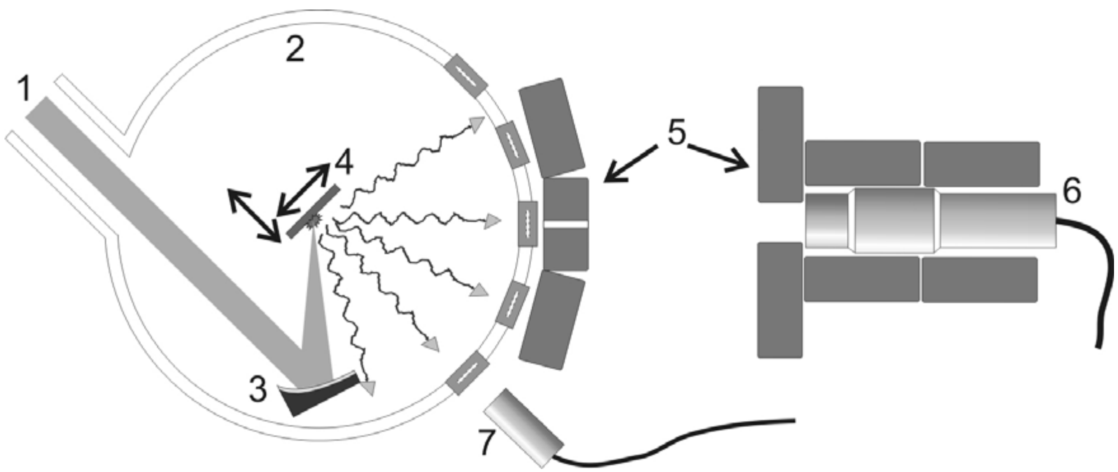
- *S – splitter*
- *MI, MII – mirrors*



Experimental setup:
ILC MSU[1] , INR RAS[2], FIAN [3]

Ivanov K.A., Shulyapov S.A., Turinge A.A., Brantov A.V., Uryupina D.S., Volkov R.V., Rusakov A.V., Djilkibaev R.M., Nedorezov V.G.,Bychenkov V.Yu, Savel'ev A.B.

Contributions to Plasma Physics, 53, 2 (2013) 116-12



- 1 – laser radiation, 2 – vacuum chamber, 3 – off-axis parabola, 4 –target on a motorized 3D translation stage, 5 – lead blocks and collimator, 6 – X-ray detector in single quantum regime, 7 – X-ray yield monitor

- Laser parameters: 50 fs, 10mJ, 800 nm, 10Hz, peak intensity $2{\cdot}10^{18}$ W/cm^2
- contrast on the nanosecond time scale - 2.10^{-6}

14-й международный Семинар «Электромагнитные взаимодействия ядер» Москва 5-8 Октября 2015 г. www/cpc.inr.ac.ru/~pnlab/emin2015 посвящен памяти Л.Е.Лазаревой, 100 лет со дня рождения

QCD and Hadron Physics.

JLAB & SINP MSU JINR, Dubna, RCNP, Osaka University

Polarization phenomena, spin physics.

Lebedev Institute, INR RAS, JINR & Mainz *University, BINP Novosibirsk, Japan Atomic Energy Agency*

Fragmentation of nuclei by real and virtual photons.

INR RAS & Bonn University, JINR, FAIR , Kioto University

Giant resonances and collective excitations of nuclei.

SINP, MEPHI, FTI Obninsk, RCNP, Osaka University

New developments and perspectives

SINP & ELI-NP Bukharest, BINP Novosibirsk, Japan Atomic Energy Agency

Preliminary Program – emin2015

New developments and perspectives.

D.M.Filipescu. ELI-NP, IFIN-HH, Bucharest. Future prospects of nuclear reactions induced by gamma-ray beams at ELI-NP.

A.B. Saveljev-Trofimov. MSU, Moscow, Toward positron production with table-top femtosecond lasers.16-00. *Mamoru Fujiwara. RCNP, Osaka.* Production of Medical 99mTc isotopes via Photoreaction and Neutron Absorption.

Mamoru Fujiwara. RCNP, Osaka. Production of Medical 99mTc isotopes via Photoreaction and Neutron Absorption

Yu.V.Shestakov. BINP, Novosibirsk, Tagging system of almost-real photons for photonuclear experiments at VEPP-3.

V. Afanasiev et al. JINR, Dubna, Project SCAN-3 of studying eta-mesic nuclei and other forms of excited nuclear matter at the JINR Nuclotron.

- Спасибо за внимание