International Symposium on Mesic Nuclei

Jagiellonian University Cracow, 16 June 2010

Sergey Afanasiev

"Search for eta-mesic nuclei at the JINR LHE nuclotron"

LHEP JINR Dubna

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Motivation

- In the present project, a possibility of carrying out an experiment on a search for and study of η-mesic nuclei, a hadronic system of a new kind, in which the η -meson and a nucleus form a quasi-stationary bound state.
- Last years active preparations for experiments on a search of η -mesic nuclei and searching this formation
- A possibility to perform studies on physics of η- mesic nuclei at the JINR nuclotron internal beam
- reaction $p+A \rightarrow n+p+ {}_{\eta}(A-1)$
- elementary process $p+n^* \rightarrow n+S^+_{11}(1535)^* \rightarrow n+p+\eta^*$

Physical aims

- a new field in studies on nuclear and particle physics.
- new data on the η-meson and the $S_{11}(1535)$ resonance interactions with nucleons
- determination of the energy levels E_g (S_{11}) and E_g(η) and their widths $\Gamma_g(S_{11})$ and $\Gamma_g(\eta)$ in the η-nucleus
- determine mass shift $\Delta m(S_{11})$ and $\Delta m(\eta)$ in the nuclear medium
- a study $N\eta \rightarrow \eta N$ (for example, determination

  of real part of the scattering length process)
- determination of the amplitude of the reaction $S_{11}\,N \rightarrow NN$

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ОБЪЕДИНЕННЫЙ ИНСТИТУТ ЯДЕРНЫХ ИССЛЕДОВАНИЙ

ПОИСК И ИССЛЕДОВАНИЕ η-МЕЗОННЫХ ЯДЕР
В pA- РЕАКЦИИ НА НУКЛОТРОНЕ ЛВЭ ОИЯИ

Труды 1-го рабочего совещания,
Дубна, 10 мая 2006г.

Search for and study of η-mesic nuclei
in pA-collisions at the JINR LHE nuclotron

Proceedings of the Workshop
Dubna, May 10, 2006

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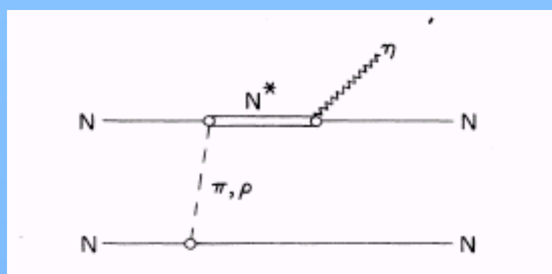
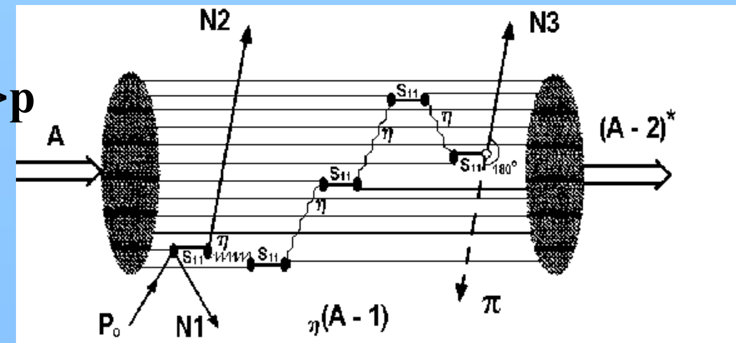
Formation, evolution an decay

- **Proposed formation in NN interaction p+A→p +n+ $_\eta$(A - 1)** (^{13}C- prefer) **n +A→n+p+ $_\eta$(A - 1)**
- **Investigate d+A$_1$→ $_\eta$A$_2$(S$_{11}$) → π+p+...**
- **Evolution in the elementary process S$_{11}$(1535) *→ N + η**





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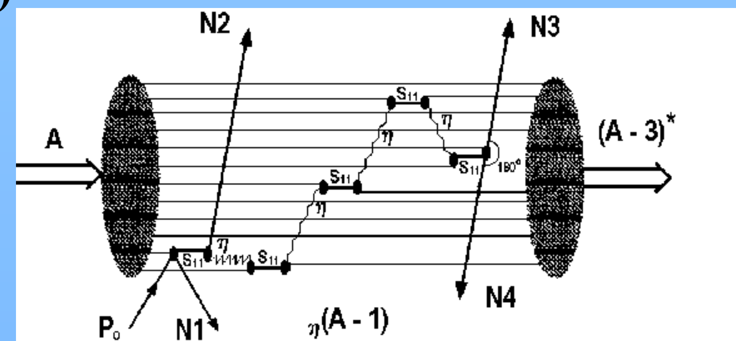

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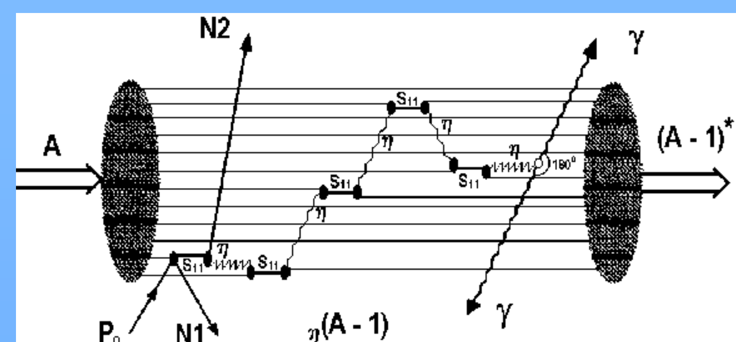

10^{-5}

L.C.Liu Phys. Rev. C 40 p.832

Scheme of the resonance formation
In the elemental NN interaction produced
η or π mesons at 180^o.

N(1535)S$_{11}$ I(J^P)=1/2 (1/2$^-$) L(η,π) =0
Mass m=1520 to 1550 (≈1535) MeV
Full width Γ=100 to 250 (≈150) MeV

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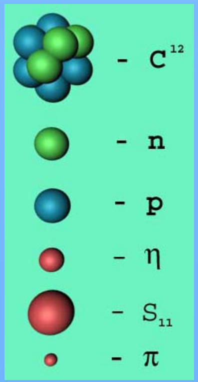
- **Formation in pn or np interaction in the reaction +A→n+p+ $_{\eta}$(A - 1)**
- **Evolution in the elementary process p +n*→ n+S^{+}_{11}(1535)* → n+ p + η***
- **Decay to the π-N, N-N and γ -γ channels**



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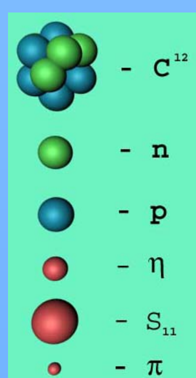
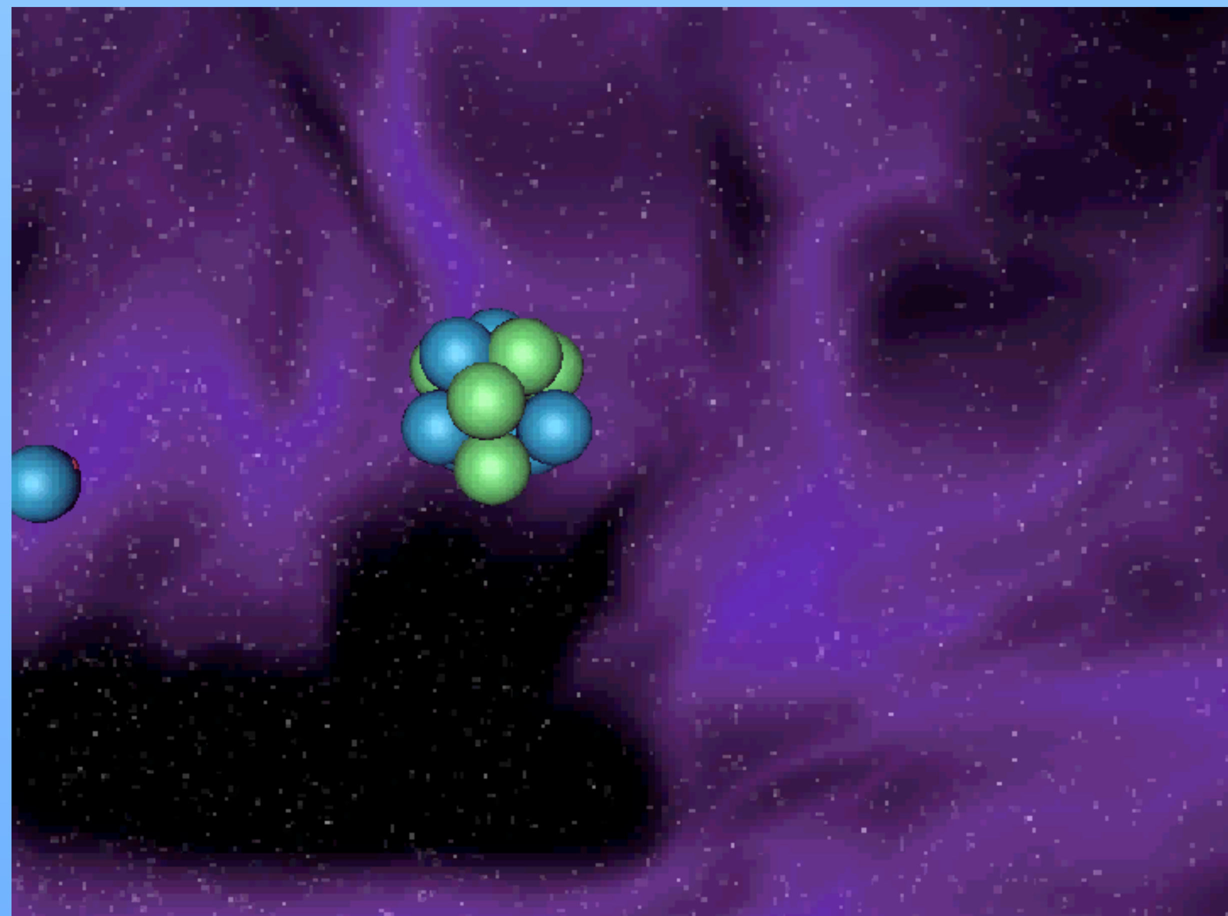
- **Formation in pn or np interaction in the reaction** $+A \rightarrow n+p+ {}_{\eta}(A - 1)$
- **Evolution in the elementary process** $p + n^* \rightarrow n + S^{+}_{11}(1535)^* \rightarrow n + p + \eta^*$
- **Decay to the** π**-N, N-N and** γ **-**γ **channels**





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Bounding energy

$d + A \rightarrow t + \eta_{p=0} + (A-1)_{p=0}$

$p + A \rightarrow d + \eta_{p=0} + (A-1)_{p=0}$

$P_p = P_d \quad E_d = 2.22 MeV$

$P_d = P_t \quad E_t = 6.25 MeV$

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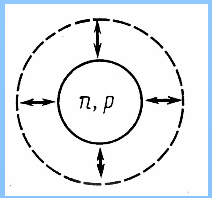
Nuclei exitation

$Pi/Pf=(-1)^{-L}$

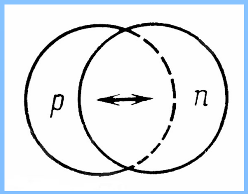
$Pi/Pf=(-1)^{-L+1}$

E0



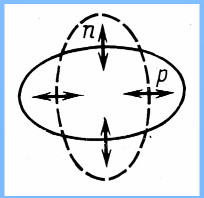
W=80A$^{-1/3}$MeV

E1



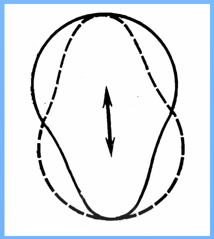
W=78A$^{-1/3}$MeV
Γ=3 -10MeV
9<A<203

E2



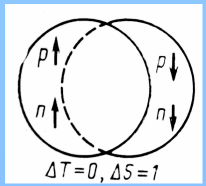
W=63A$^{-1/3}$MeV
Γ=6 - 3MeV
14<A<208

E3

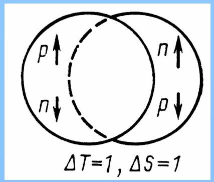


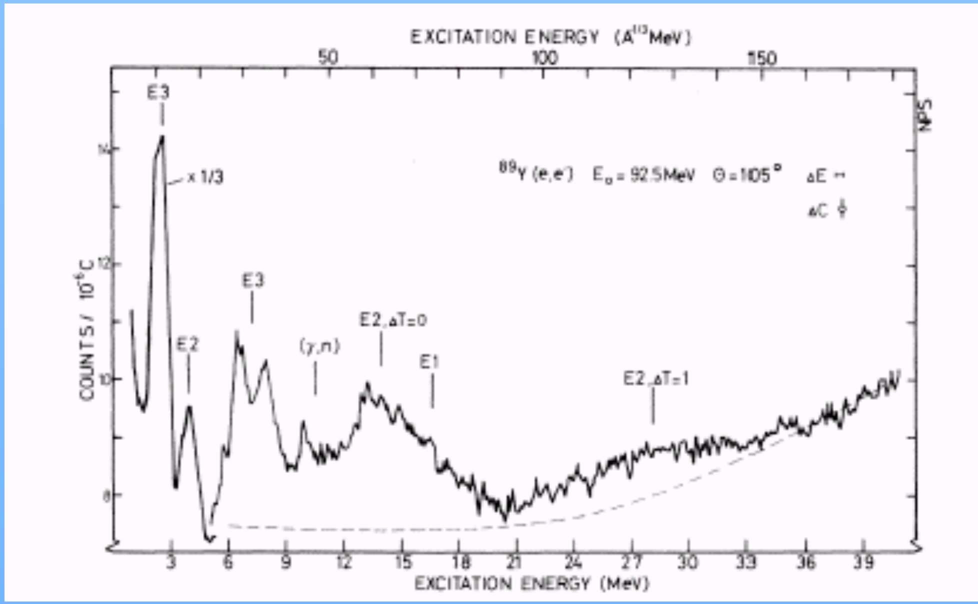
W=32A$^{-1/3}$MeV
Γ=2.2MeV
60<A<208

M1



M2





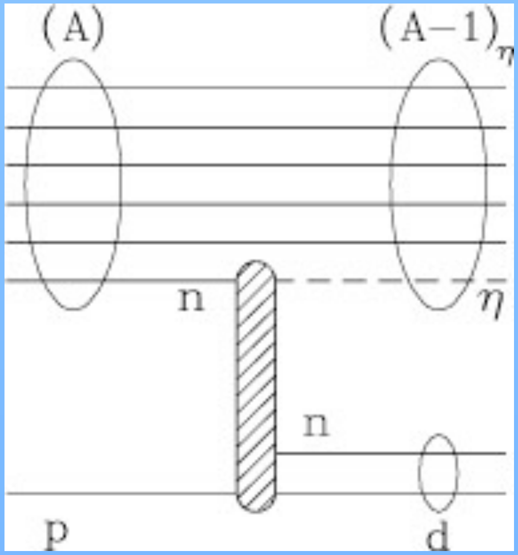
Spectrum of 92.5-MeV electrons scattered at 105°

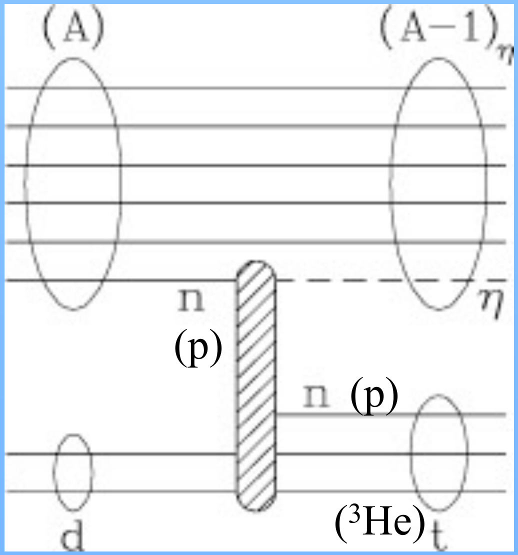
Numerical calculation

$$p+A \rightarrow d+\eta_{\,p=0}+(A\text{-}1)_{p=0}$$

$$d+A \rightarrow t+\eta_{\,p=0}+(A\text{-}1)_{p=0}$$

$$d+A \rightarrow {}^{3}He+\eta_{\,p=0}+(A\text{-}1)_{p=0}$$





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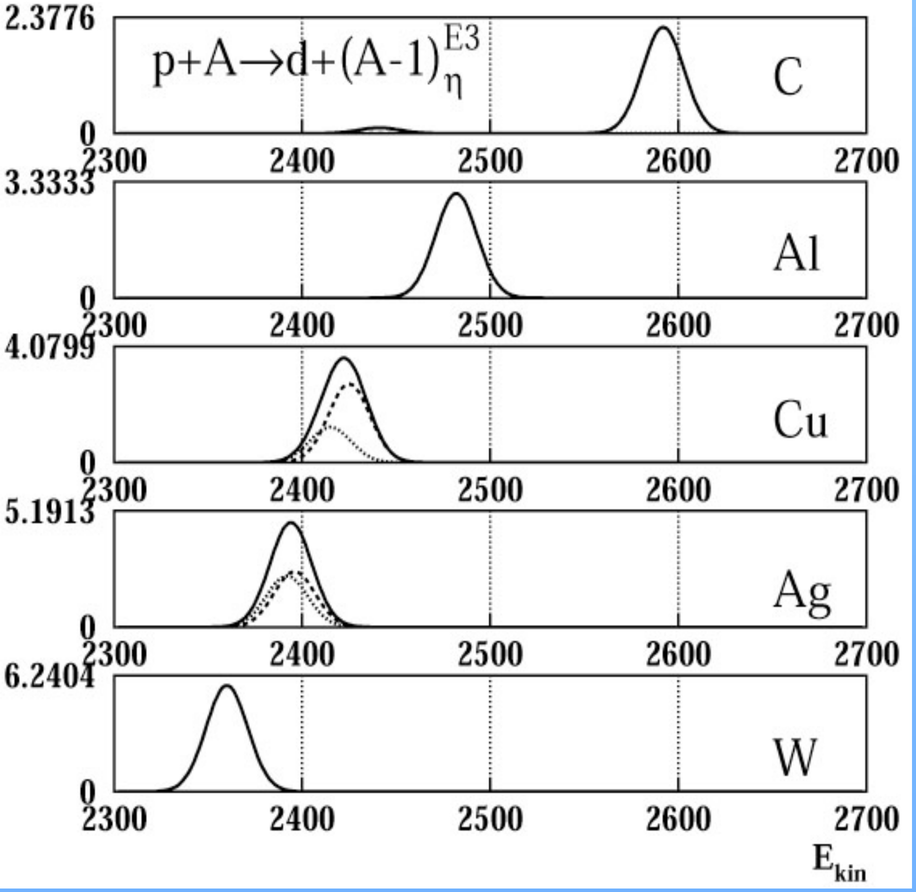
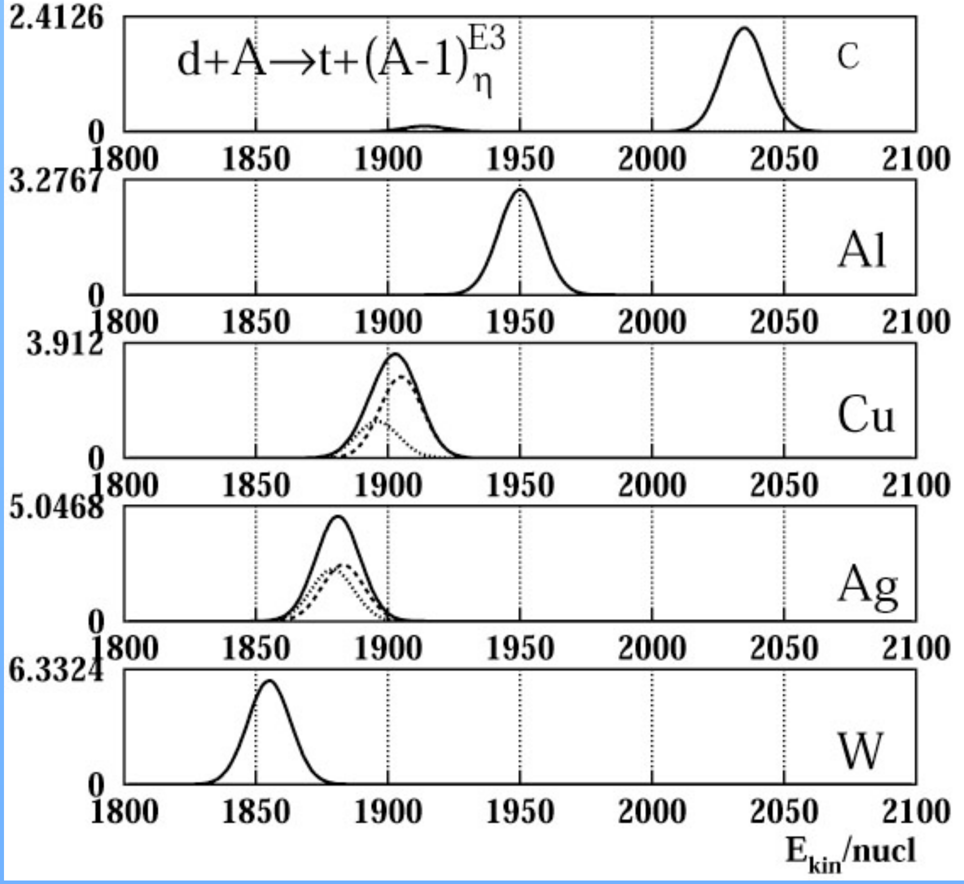
Numerical calculation

$p+A \rightarrow d+\eta_{p=0}+(A\text{-}1)_{p=0}$

$d+A \rightarrow t+\eta_{p=0}+(A\text{-}1)_{p=0}$

$d+A \rightarrow {}^3He+\eta_{p=0}+(A\text{-}1)_{p=0}$





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Parity conservation

$$p+A \rightarrow d(0^o)+\eta_{p=0}+(A\text{-}1)_{p=0} \rightarrow d(0^o)+(A\text{-}1)_{\eta}^{*}(P,S)$$

$$d+A \rightarrow t(0^o)+\eta_{p=0}+(A\text{-}1)_{p=0} \rightarrow t(0^o)+(A\text{-}1)_{\eta}^{*}(P,S)$$

$$P_p P_A(-1)^{L0}=(-1)P(-1)^{L}=(+1)P_{(A-1)}P_{GR}P_{(Res.)}$$

A	E(MeV)	Pd/Pp	L_0	L	Resonas
12	2592	1.00066	6	4	?
13	2441	1.00070	6	4	
27	2482	1.00052	4	4	
63	2425	1.00040	3	3	
65	2415	1.00040	3	3	
107	2396	1.00034	3	3	
109	2392	1.00034	3	3	
182	2368	1.00029	3	3	

A	E(MeV)	Pt/Pd	L_0	L	Resonas
12	4070	1.00024	5	4	?
13	3828	1.00026	5	4	
27	3899	1.00019	2	4	
63	3810	1.00015	0	3	E1,E3, S_{11}
65	3793	1.00015	1	3	
107	3765	1.00012	0	3	E1,E3, S_{11}
109	3758	1.00012	0	3	E1,E3, S_{11}
182	3724	1.00011	1	3	

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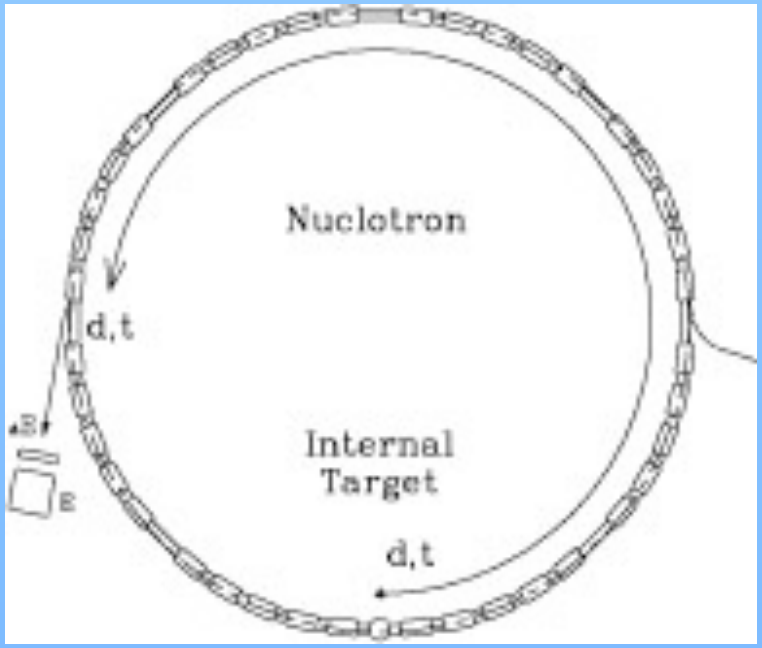
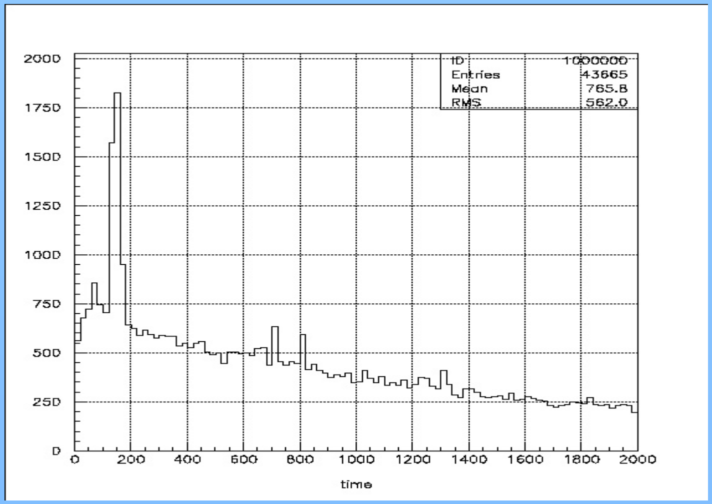
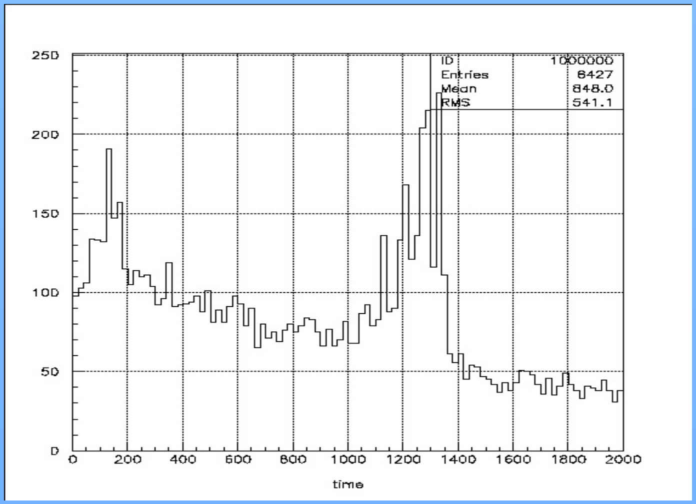
$dP/P<10^{-4}(10^{-3})$

$p+A \rightarrow d+_{\eta}(A-1) \rightarrow p+p(\pi)+d+\ldots$





Efficiency $\approx 10^{-5}$



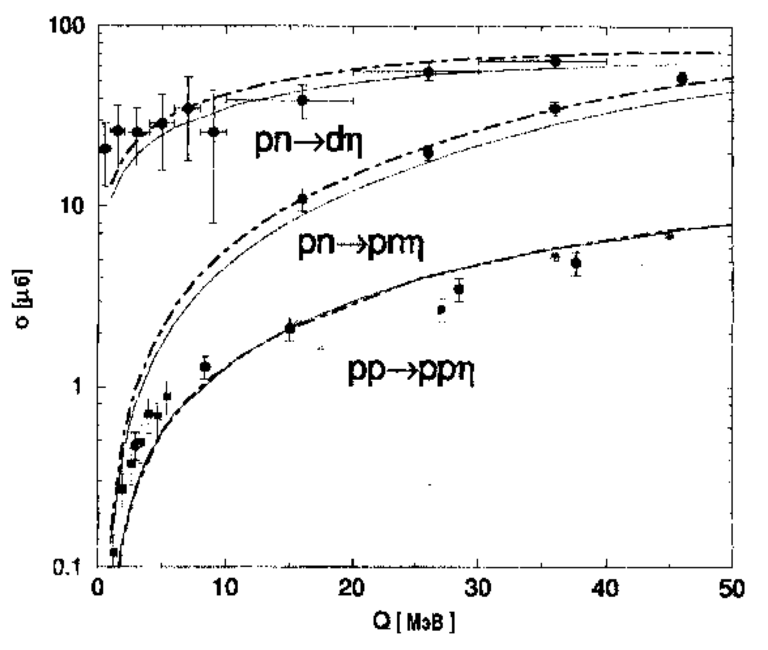
Estimates of the effect yield

$$Y(p,\pi^-) = L \cdot \sigma_\eta(p^{12}C \rightarrow p_1 p_2 n_\eta (A-1)) \cdot Br(\pi N) \cdot \xi \cdot \Omega_\pi \cdot n_c \cdot f(\Omega_p/\Omega_\pi)$$

σ_η - total cross section of eta-nuclei formation;
L - luminosity;
Ω_π - the solid angle;
ξ - the probability to have the πp pair
$f(\Omega_p/\Omega_\pi)$ - a geometric fraction;
$Br(\pi N)$ - the branching ratio of $S_{11}(1535)$ decay;
n_c - accelerator cycles per hour;

$Y(p\pi) \approx 1400$ events
$Y(pp) \approx 230$ events
$Y(p\pi p) \approx 250$ events
$Y(ppp) \approx 40$ events
$Y(pnp\pi) \approx 35$ events
$Y(pnpp) \approx 6$ events

Production of η-mesons in nucleon-nucleon collisions
V. Baru,
PHYSICAL REVIEW C 67, 024002 (2003)



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Signal and Background

The π^-p pairs with $\Theta_{p\pi^-}$=180° and flying transversely to the beam cannot be produced in an direct reaction N+N→R*+N → N+π+N ($\Theta_{p\pi^-}$<100°).

Signal and random-coincidence background rates for different variants of coincidences at the full luminosity of 10^9 initial protons at the accelerator and a 10μm carbon fiber target.

Detection mode	Signal events	Background events
$Y(p\pi^-)$ $\Theta_{p\pi^-}=180°$;	1400	650
$Y(pp)$ $\Theta_{pp}=180°$;	230	-
$Y(p\pi^-p)$ $\Theta_{p\pi^-}=180°$; $\Theta_p=15\div40°$;	250	30
$Y(ppp)$ $\Theta_{pp}=180°$; $\Theta_p=15\div40°$;	40	-
$Y(p\pi^-pn)$ $\Theta_{p\pi^-}=180°$; $\Theta_p=15\div40°$; $\Theta_p=7\div11°$	35	1
$Y(pppn)$ $\Theta_{pp}=180°$; $\Theta_p=15\div40°$; $\Theta_p=7\div11°$	6	-

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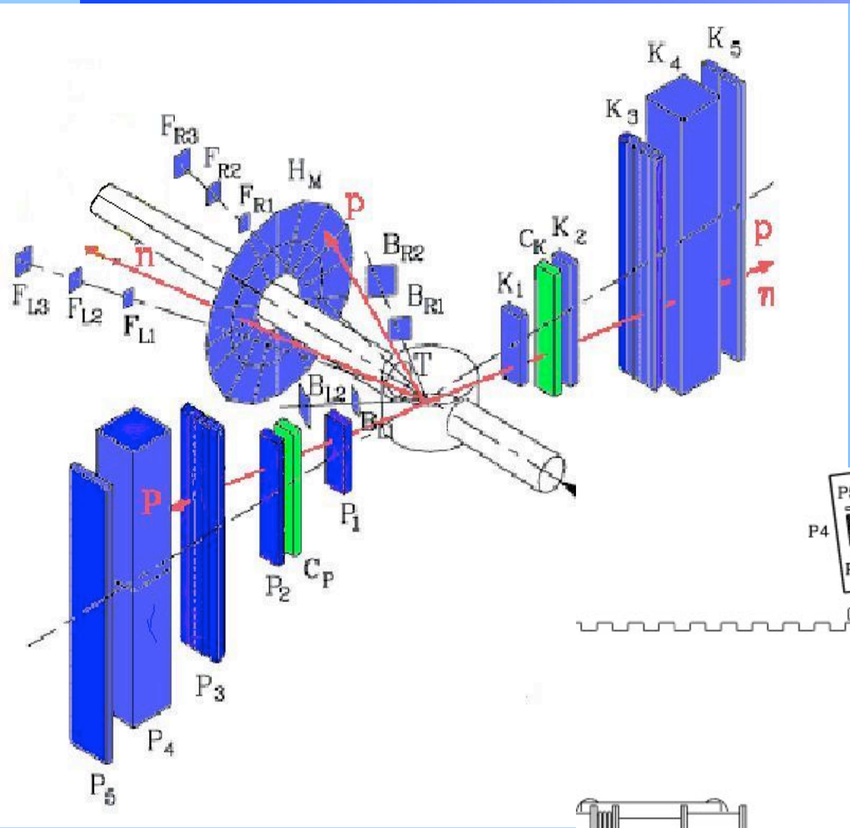
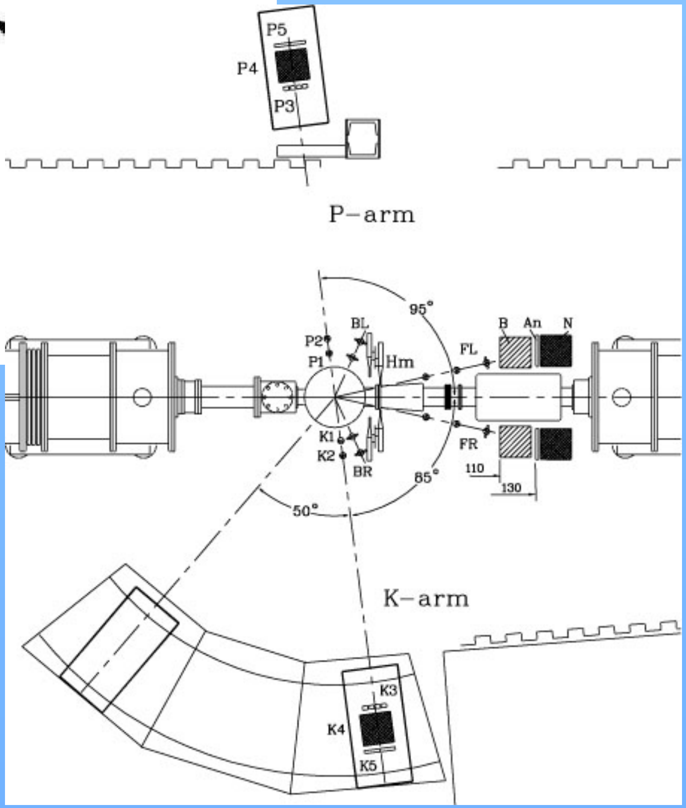
Experimental setup





K-arm

K1 - Start counter
K2 - Trigger & Cherenkov counters
K3 - TOF - wall
K4 - E-counter
K5 - Veto counter

P-arm

P1 - Start counter
P2 - Trigger & Cherenkov counters
P3 - TOF - wall
P4 - E-counter
P5 - Veto counter

Hm - Ring counter
N - Neutron detector
An - Neutron-Veto

FL,FR,BL,BR - Monitors

S_{11} ® πp

$$\Theta_{\pi p} = 180^0 \pm 10^0$$

$$T_p \approx 110 \pm 10 MeV$$

$$T_\pi \approx 350 \pm 30 MeV$$

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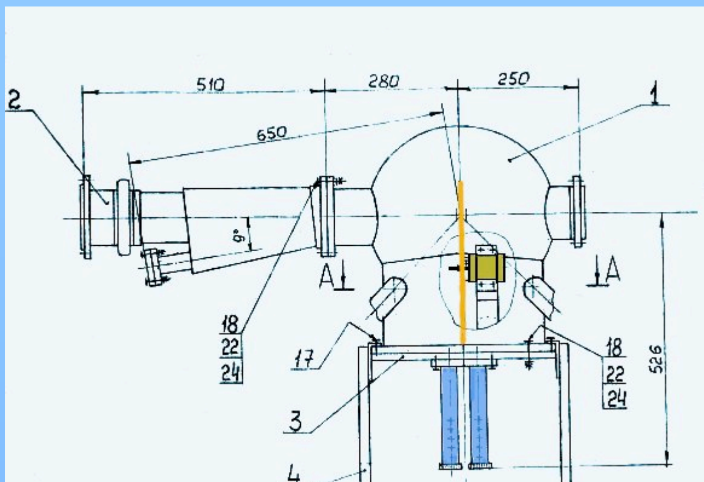
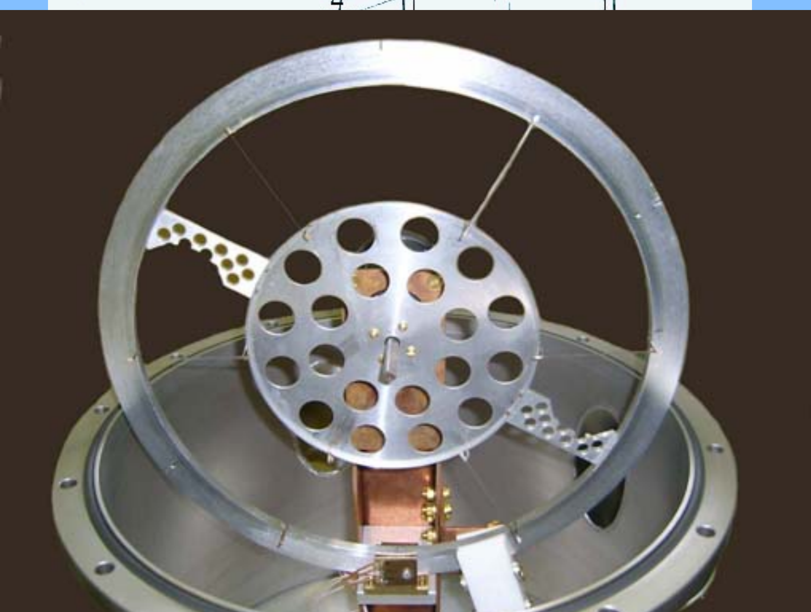
Construction of the Internal Target Station

Dimension of the target region





Target -1 -- ^{12}C, 8 wires x 8 mkm

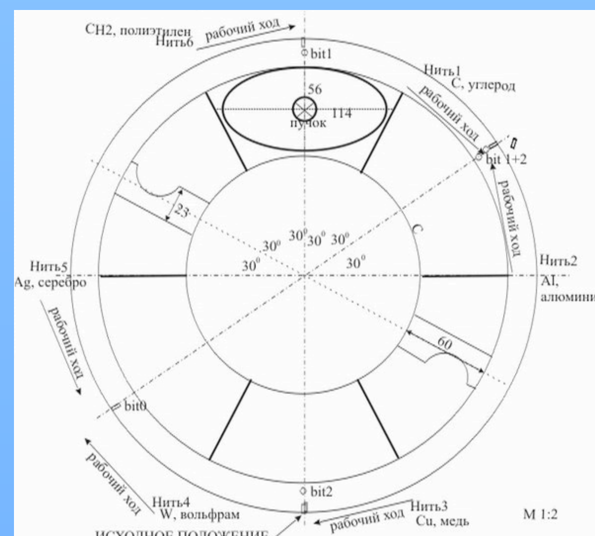
Target -2 -- ^{27}Al, 1 mm strip x 10 mkm

Target -3 - - ^{64}Cu, 8 wire x 50 mkm

Target -4 - - ^{183}W, 1 wire x 20 mkm

Target -5 -- ^{108}Ag, 1 mm strip x 20 mkm

Target -6 -- CH_2, 1 mm strip x 10 mkm



PMT
for light control

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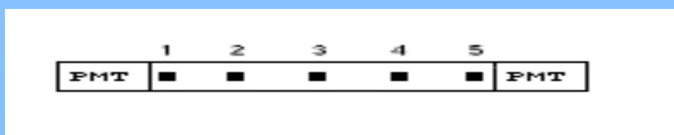
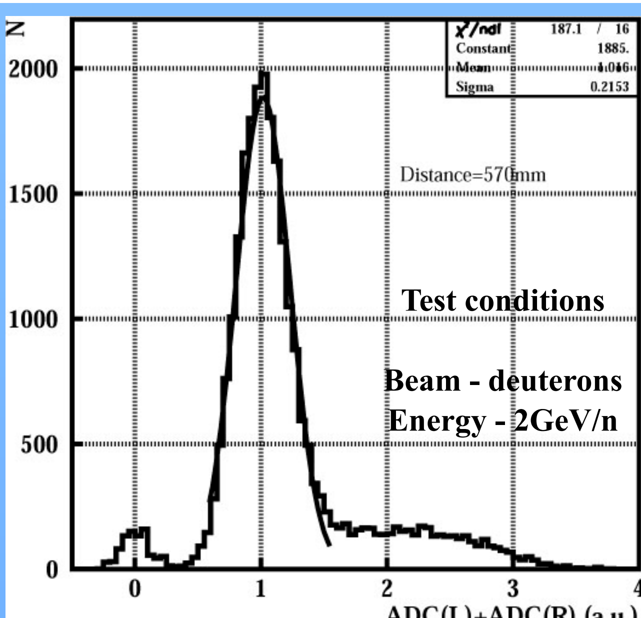
P4(K4) - detectors

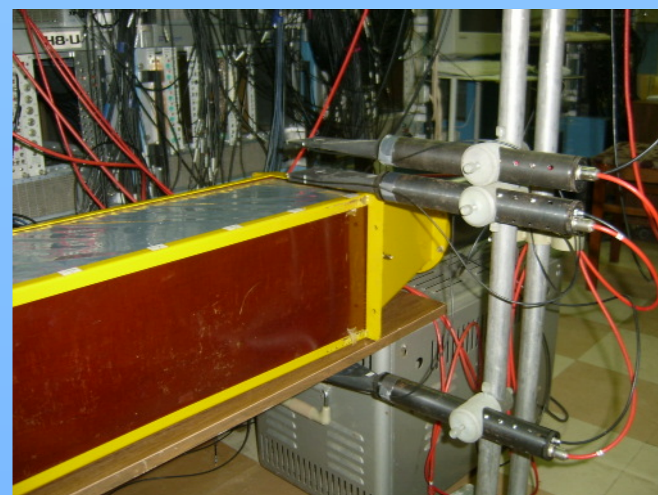
<u>Scintillator</u>
K-arm - 1150x200x200mm^2
P-arm - 2x(600x200x200mm^2)

<u>PMT</u>
K-arm - ФЭУ-63
P-arm - XP2041

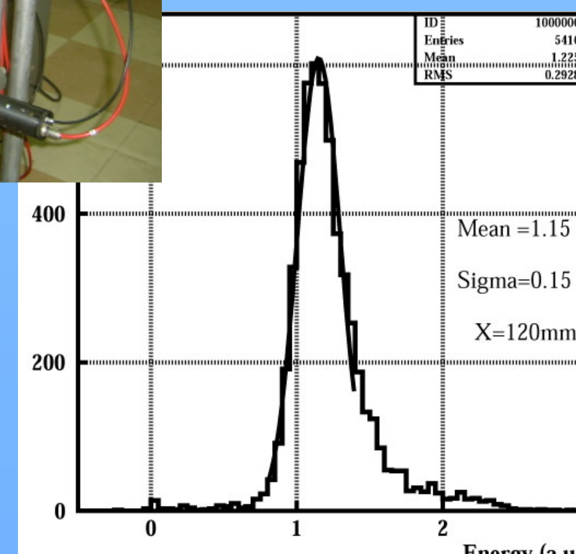
Beam test March'05







Cosmic test



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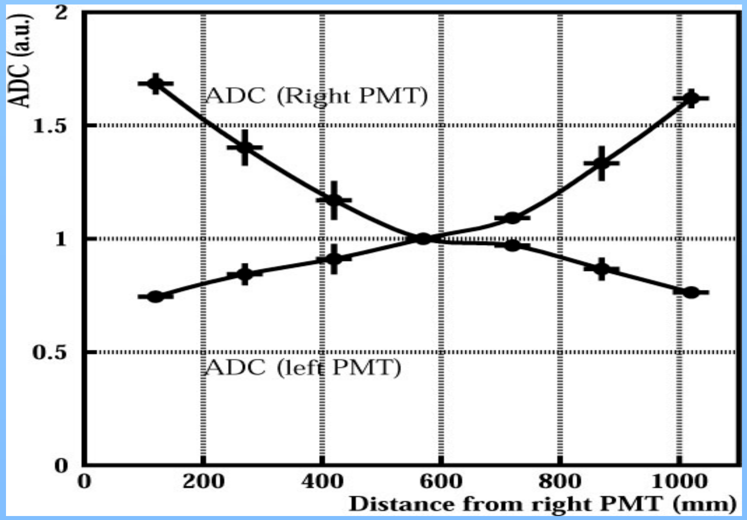
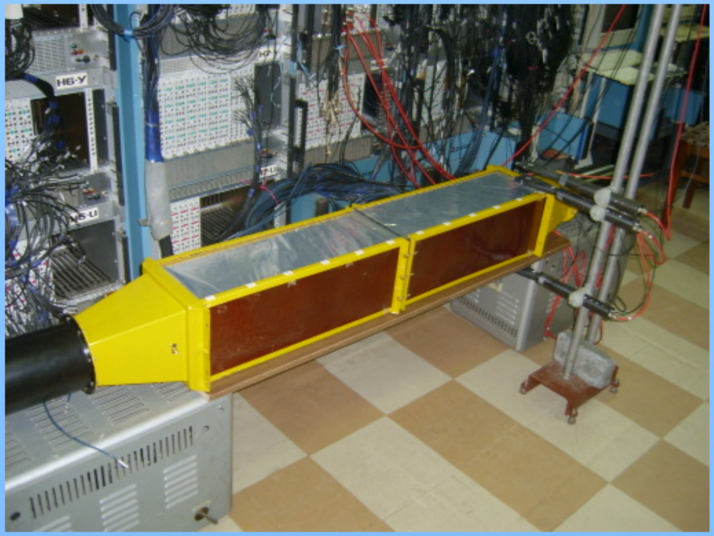
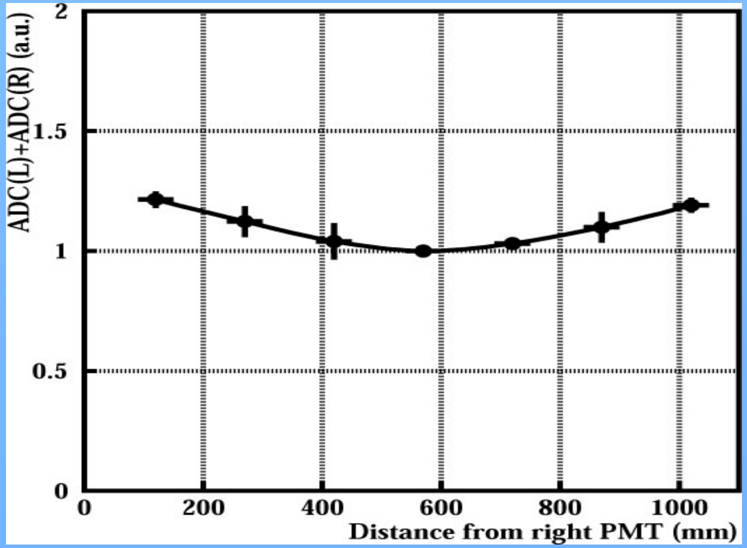
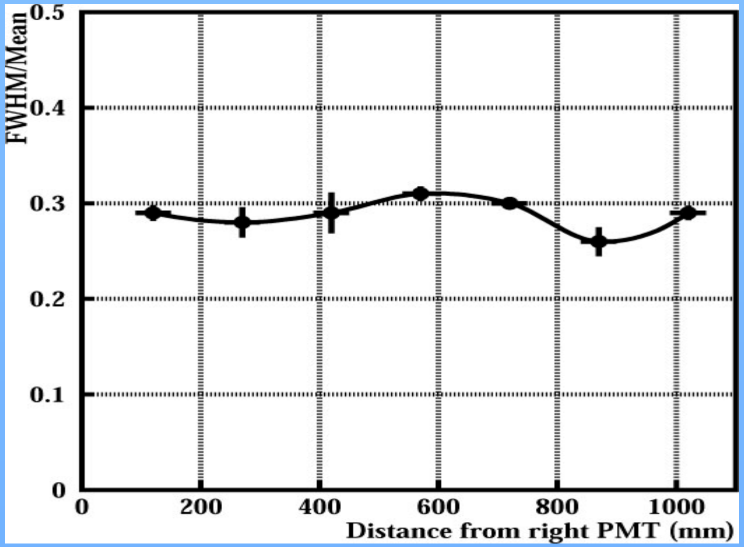
Cosmic test April'05









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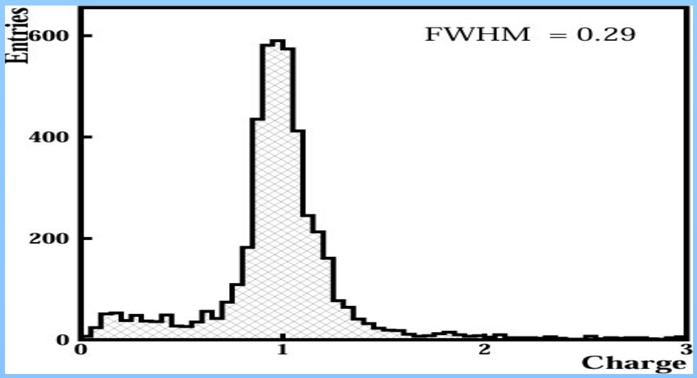
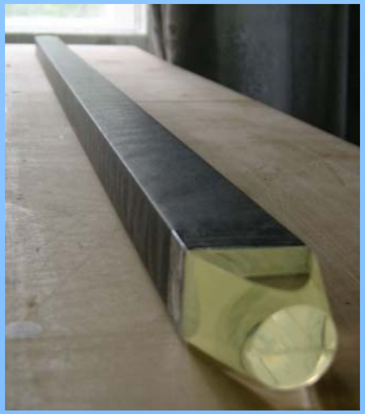
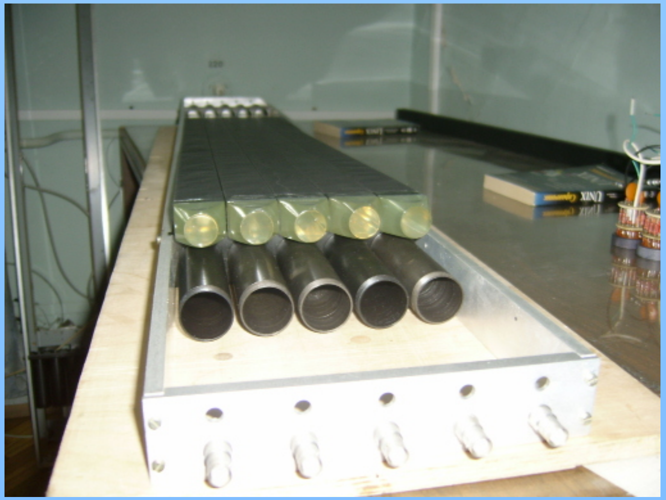
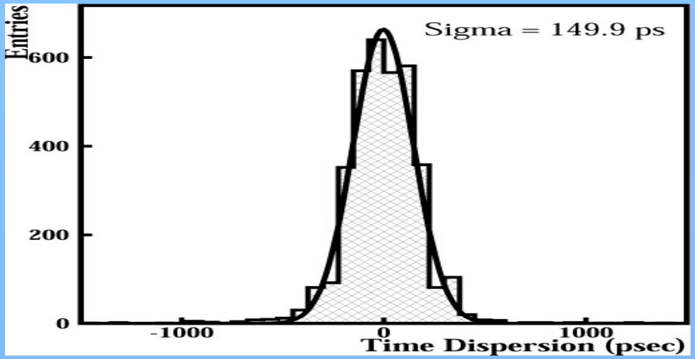
TOF - detectors K3,P3

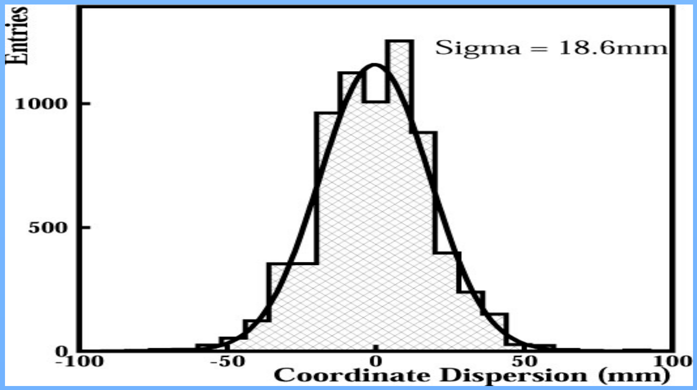


Scintillator - 1000x35x25mm^2
PMT - ФЭУ-87









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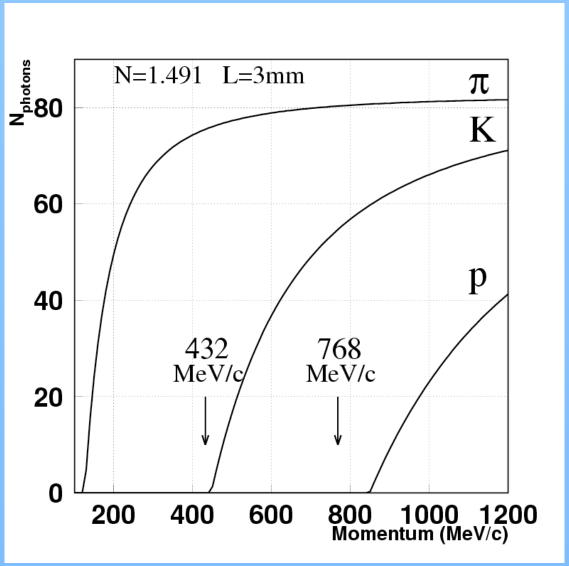
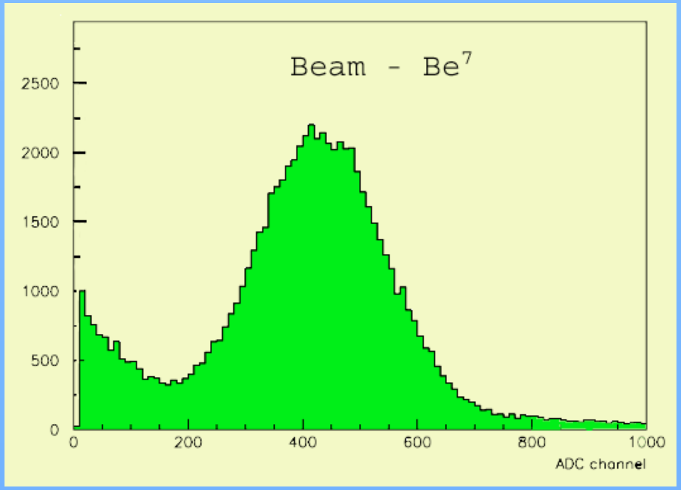
Experimental search modes



π N pair carries the kinetic energy of about 400 MeV and zero 3-momentum Pp=-Pπ= 430MeV/c;

in $S_{11}N \rightarrow NN$ mode the NN pair have energies of about 270 MeV and 3-momentum Pp=-Pp=770 MeV/c



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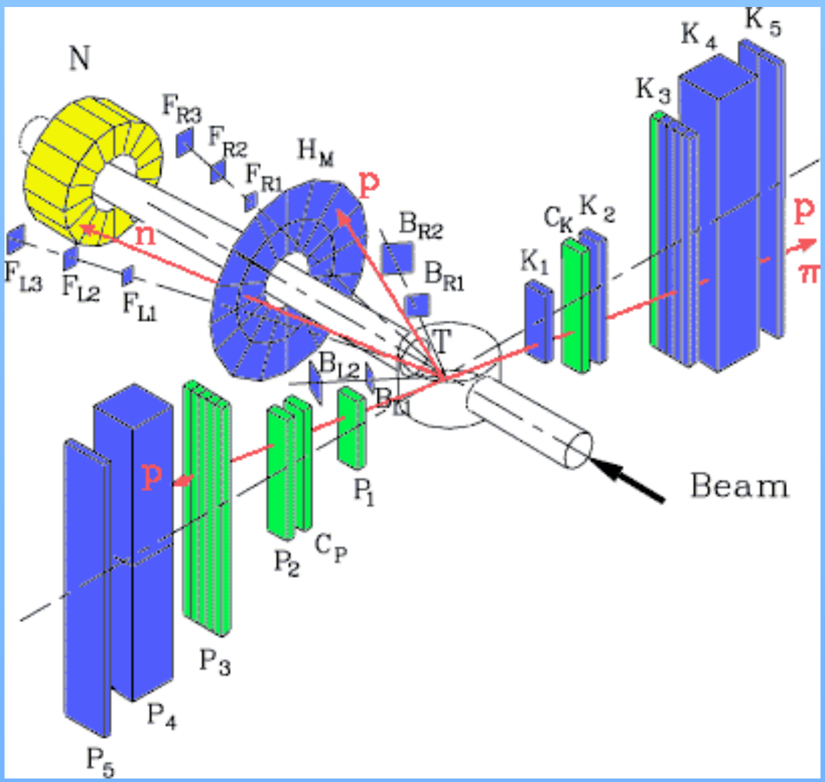
P5 (K5) detectors



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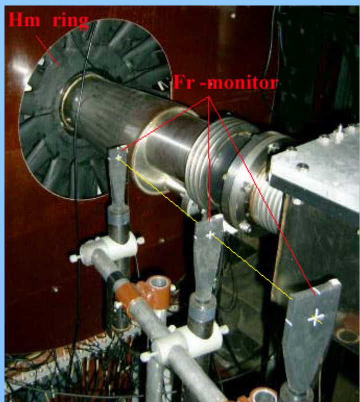
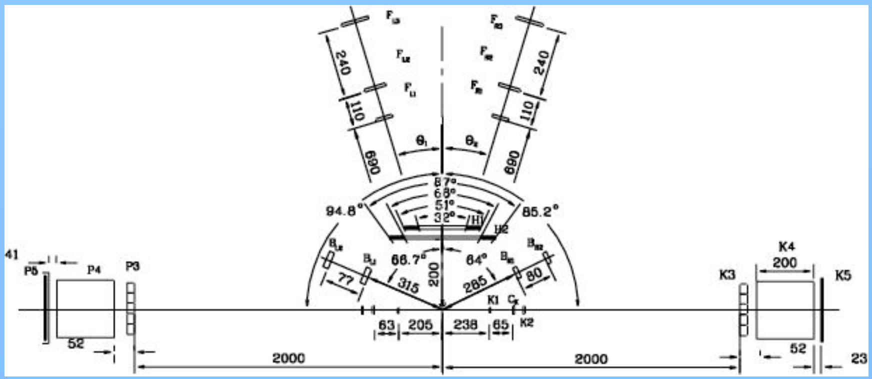
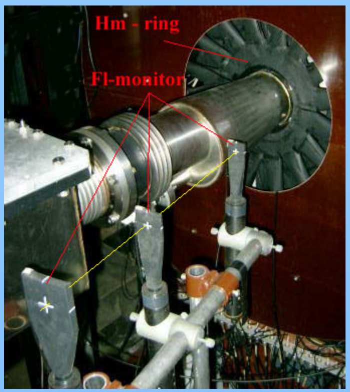
Setup of the experimental RUN

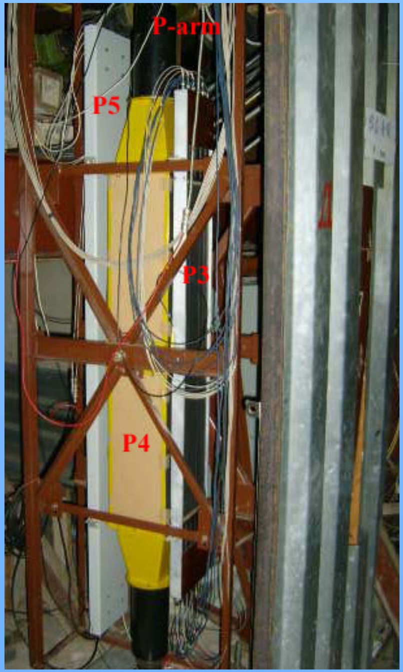


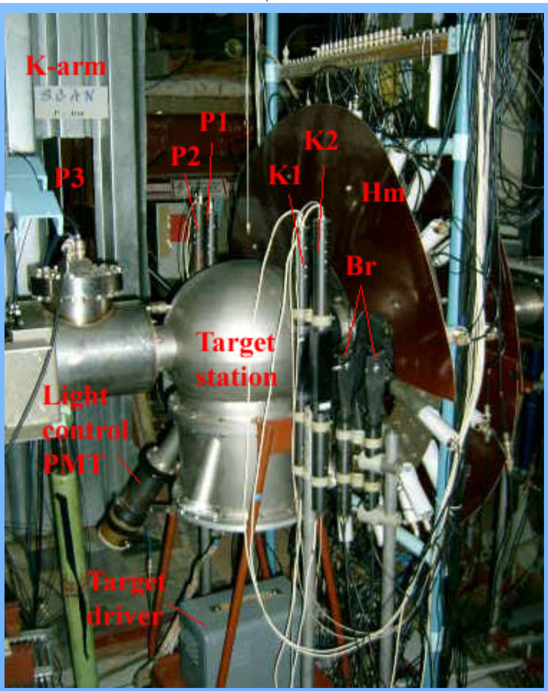
The geometry of the experiment





P-arm





K-arm

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Trigger

Inputs

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
1K2 1P2 K2c P2c K3 P3 K5 P5 Hm N Na NCU KCU CLR X X

Outputs

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
K3o P3o Nao -------DTRIG---------- --------BLTRIG--------- SPL PNCU PKCU

F(16)A(0)
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
--------TRIG NUMBER----- K3o P3o Nao X X X X X PNCU PKCU

F(0)A(0)
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
--------TRIG NUMBER----- K3o P3o Nao SPL TRIG KCU X X PNCU PKCU

F(0)A(1) – Triggers counter
F(0)A(2) – 1K2 counter (15:0)
F(0)A(3) 1K2 counter(23:16)
F(0)A(4) – 1P2 counter (15:0)
F(0)A(5) 1P2 counter(23:16)
F(0)A(6) – K3 counter (15:0)
F(0)A(7) K3 counter(23:16)
F(0)A(8) – P3 counter (15:0)
F(0)A(9) P3 counter(23:16)

F(9)A(0) – Clear VETO and LAM

DTRIG –DIRRECT TRIGGER(W/O BLOCK)
BLTRIG - TRIGGER WITH BLOCK
SPL – SPILL
PNCU – PROGRAMMABLE NCU
PKCU – PROGRAMMABLE KCU

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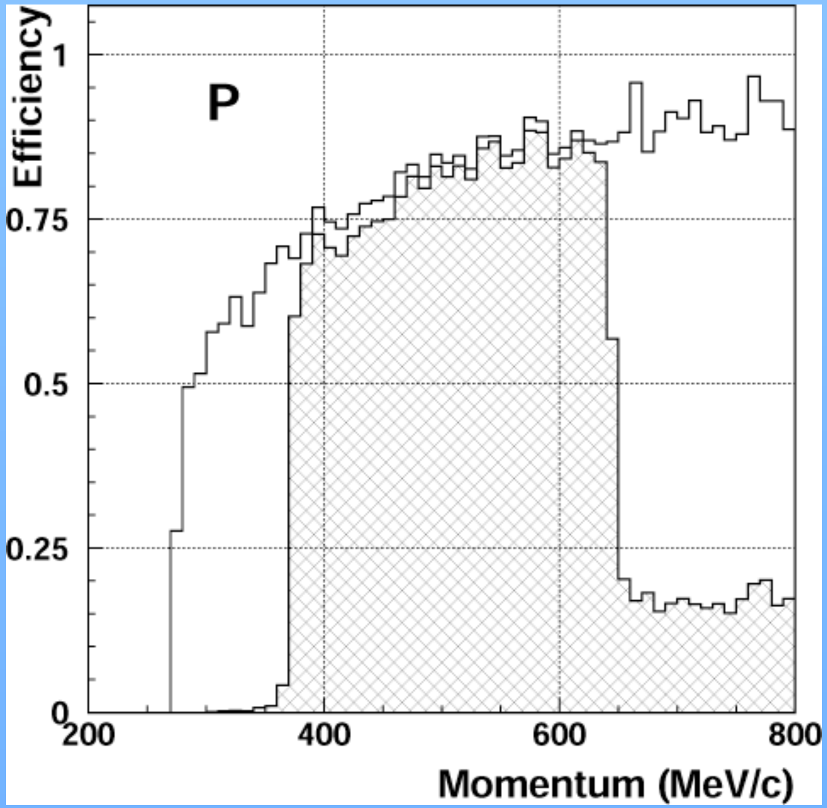
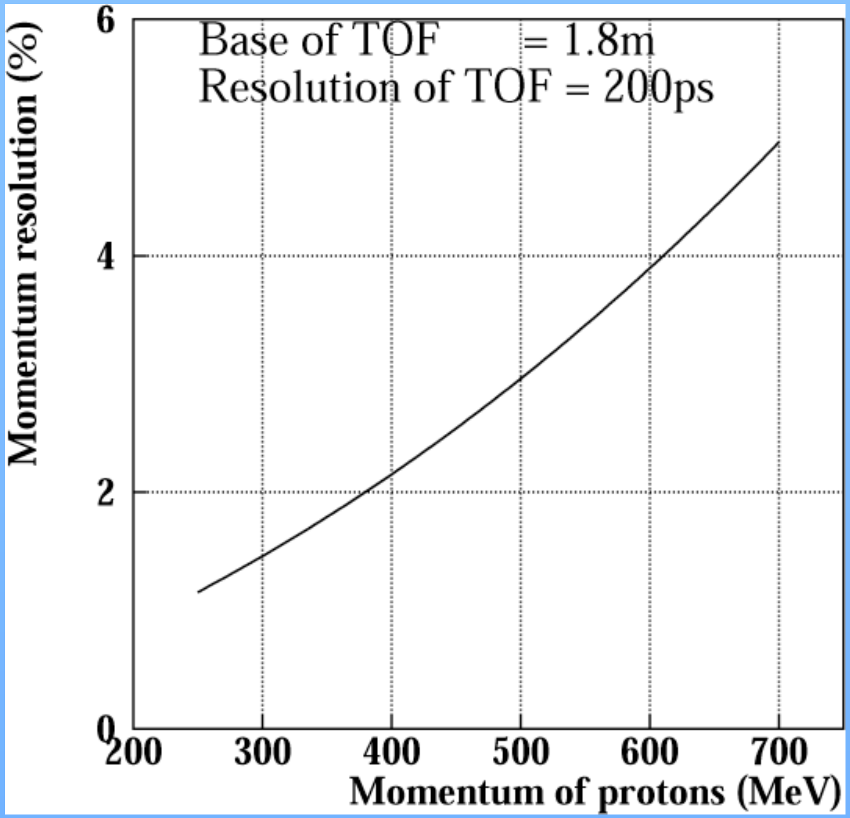
Spectrometer information

Efficiency for p registration in $P_4(K_4)$



Momentum resolution for
time-of-flight distance - 1.8m



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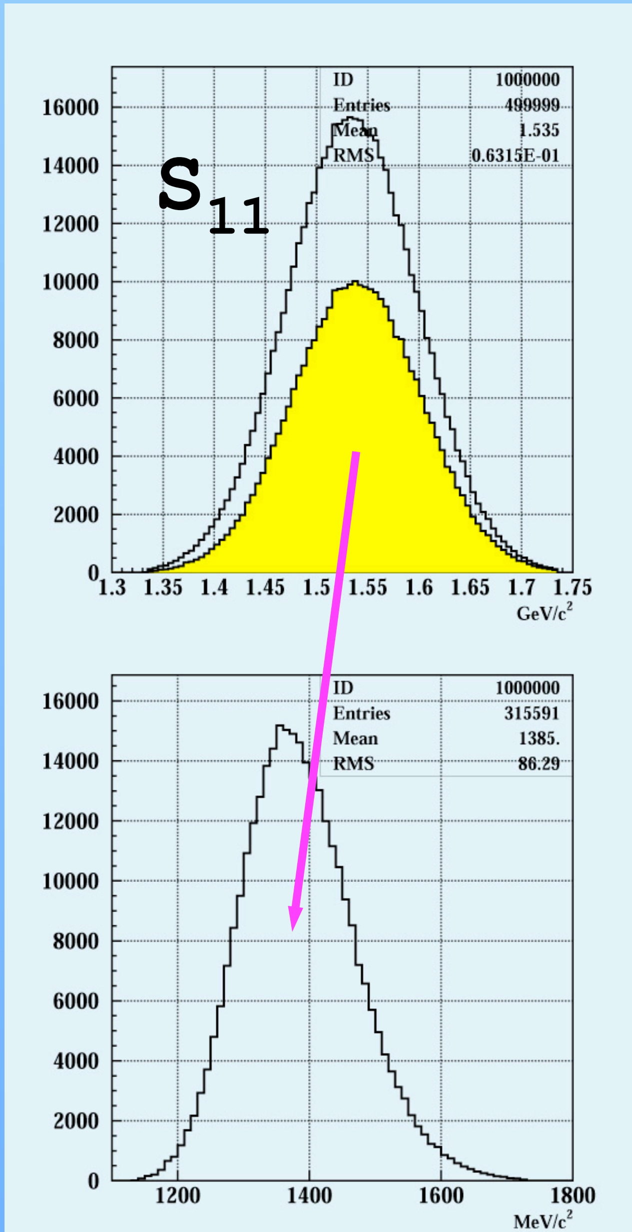
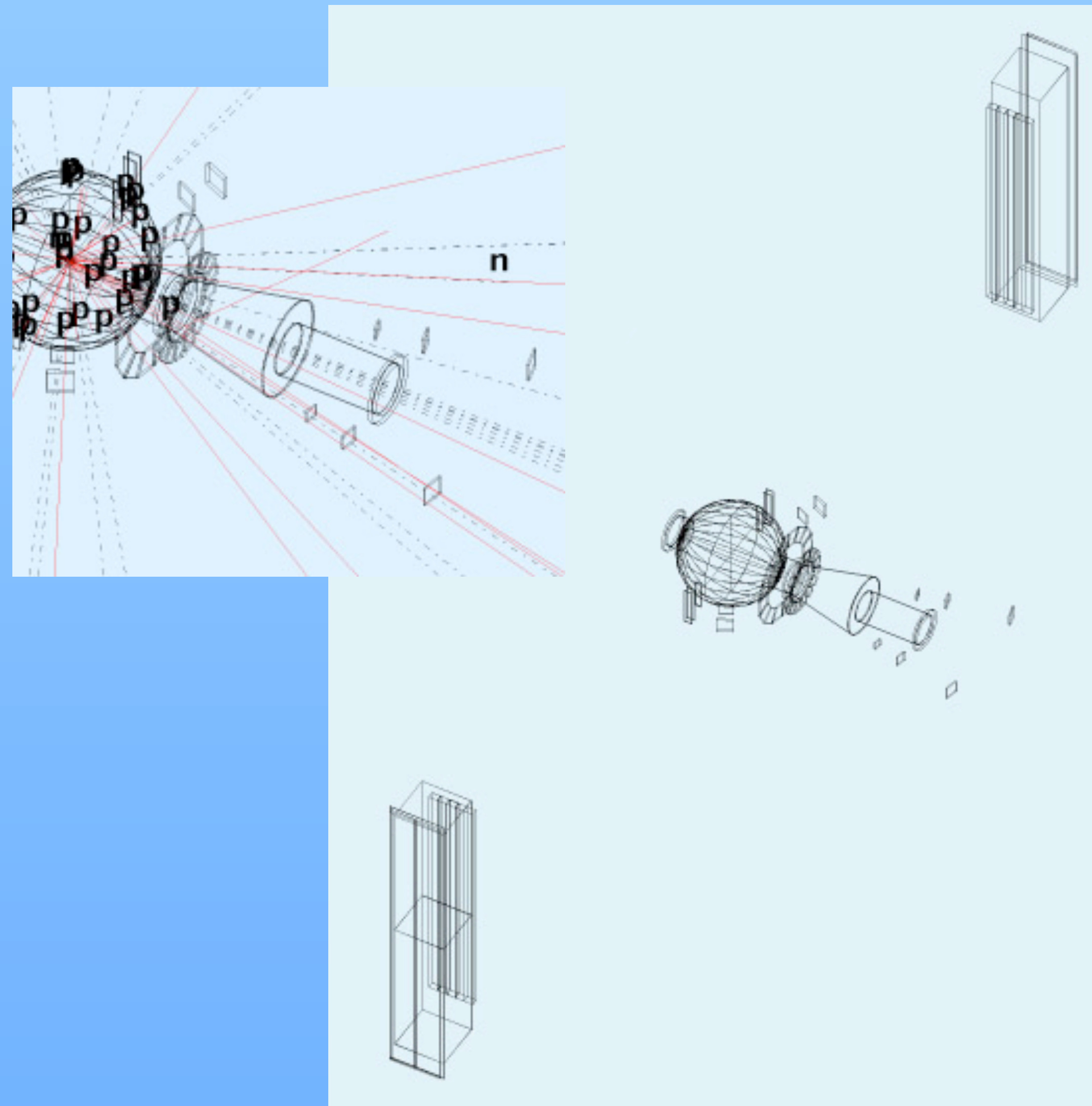
GEANT-3 simulation





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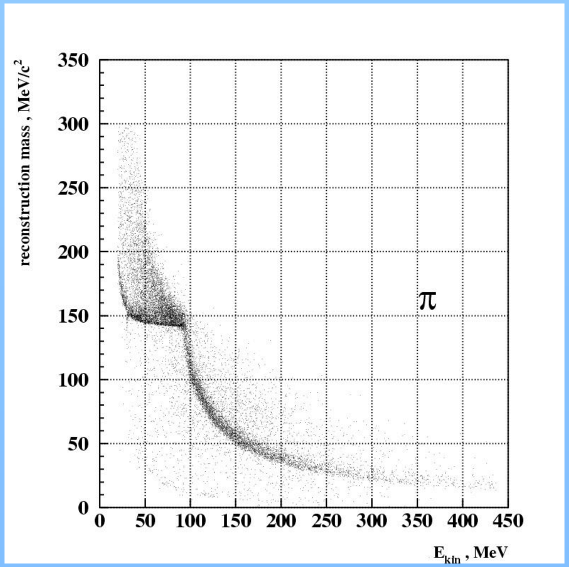
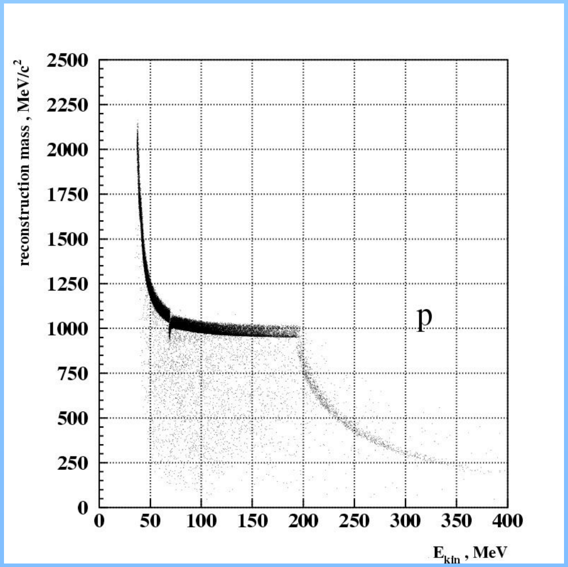
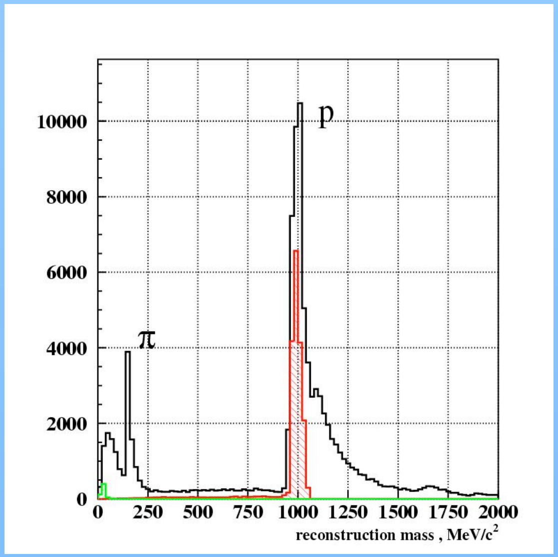
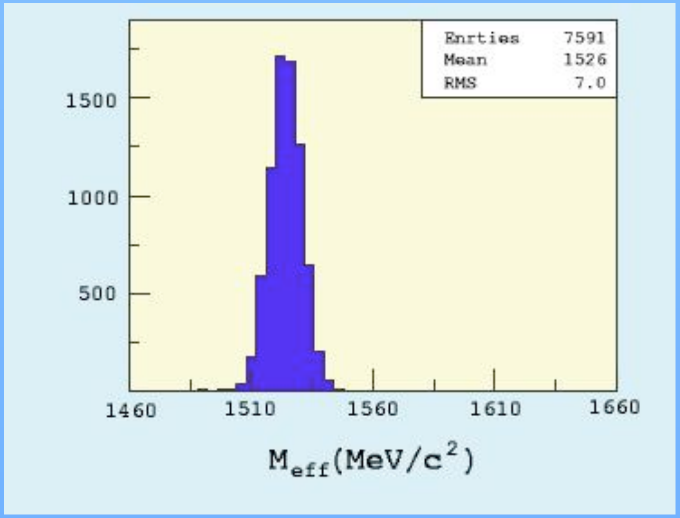
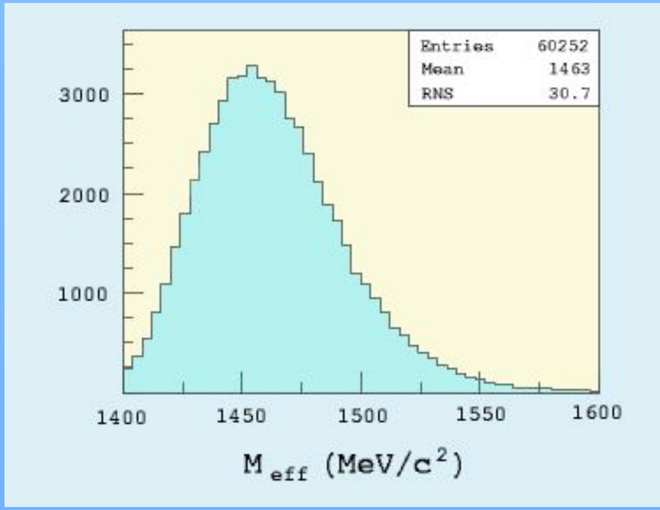
GEANT simulation











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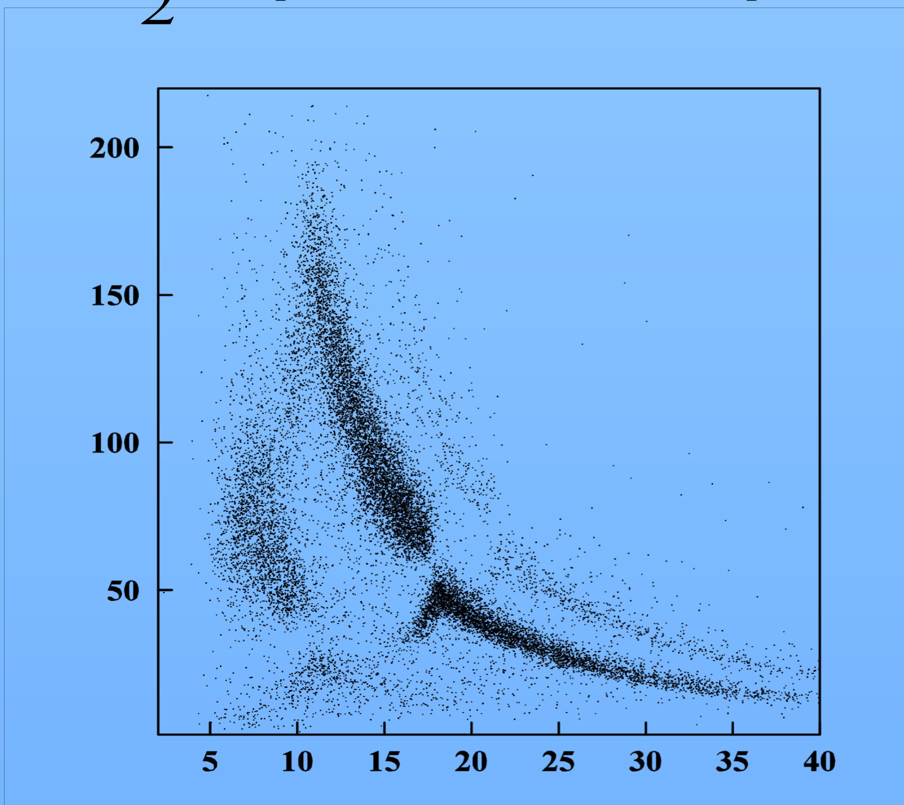
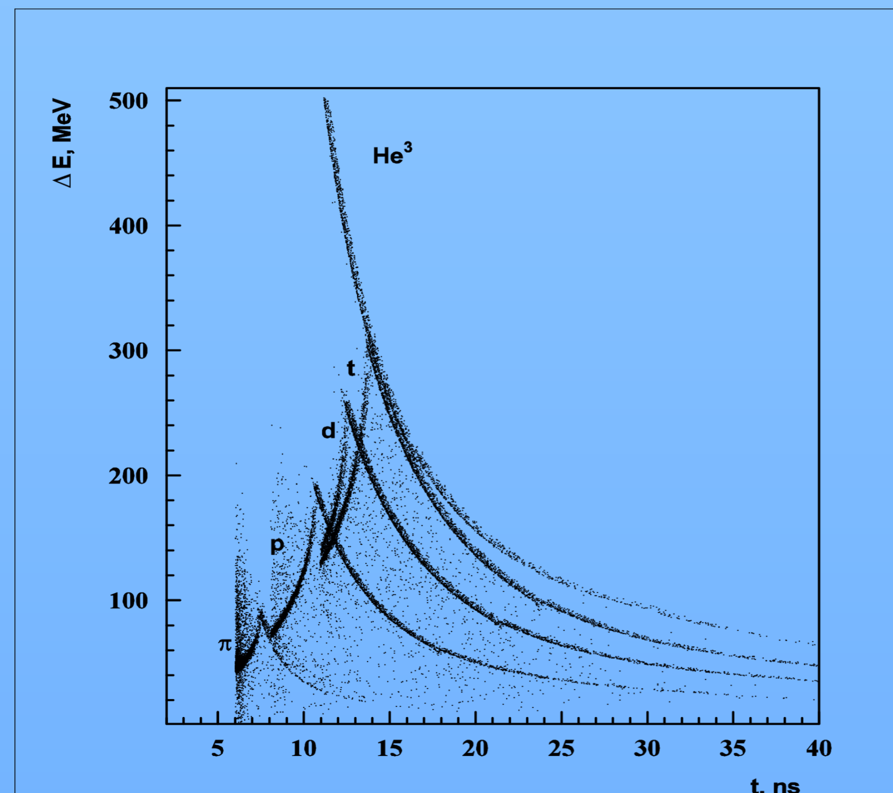
Reconstraction proceeding

The time of flight of a single particle on the basis of P3-P1/K3-K1

$$t = \frac{1}{2}\left[\left(t_{top}^{P3} + t_{bot}^{P3}\right) - \left(t_{top}^{P1} + t_{bot}^{P1}\right)\right] + t_0 \qquad \sigma_t = 0.15 \div 0.2\acute{\imath}\,\tilde{n}$$





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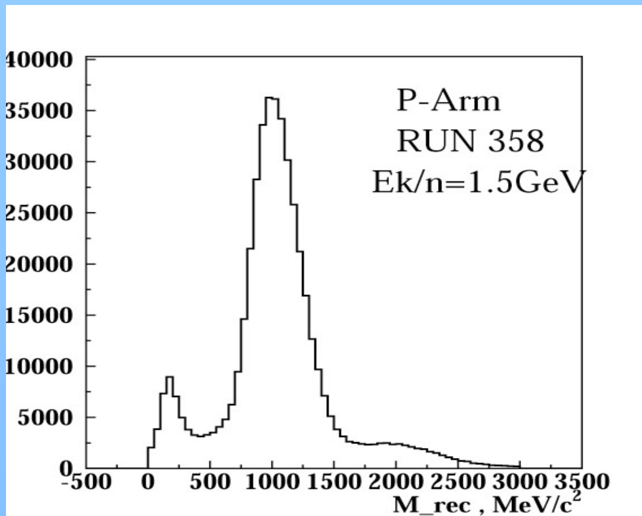


Reconstracted mass
(confidence level > 95%)

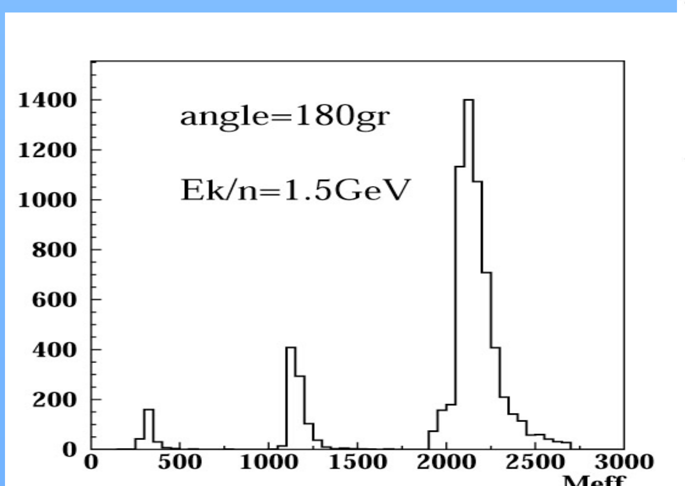
$$M_{recon} = T\frac{\sqrt{1-\beta^2}}{1-\sqrt{1-\beta^2}}$$

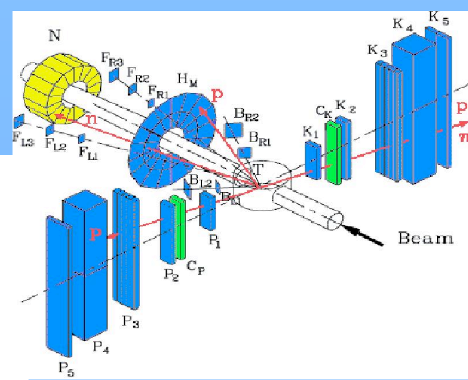
Effective mass

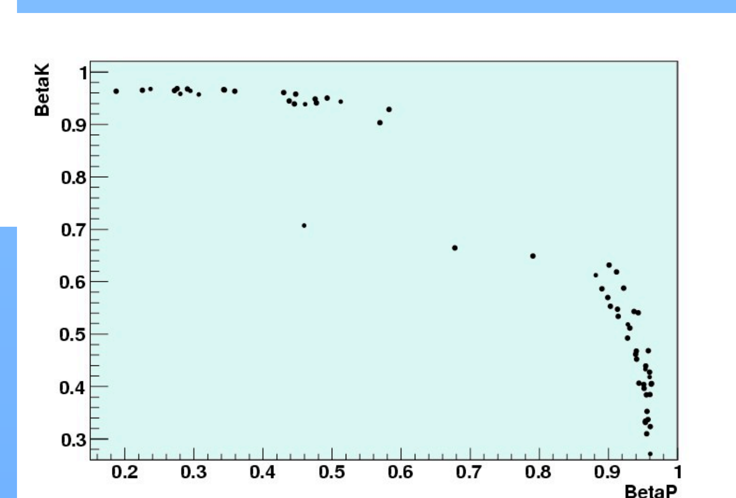
$$M_{eff}^{1,2} = E_1 + E_2 = \frac{m_1}{\sqrt{1-\beta_1^2}} + \frac{m_2}{\sqrt{1-\beta_2^2}}$$

$\sigma_{TOF} \approx 0.2$ ns

$\sigma_M \approx 10$ MeV/c^2







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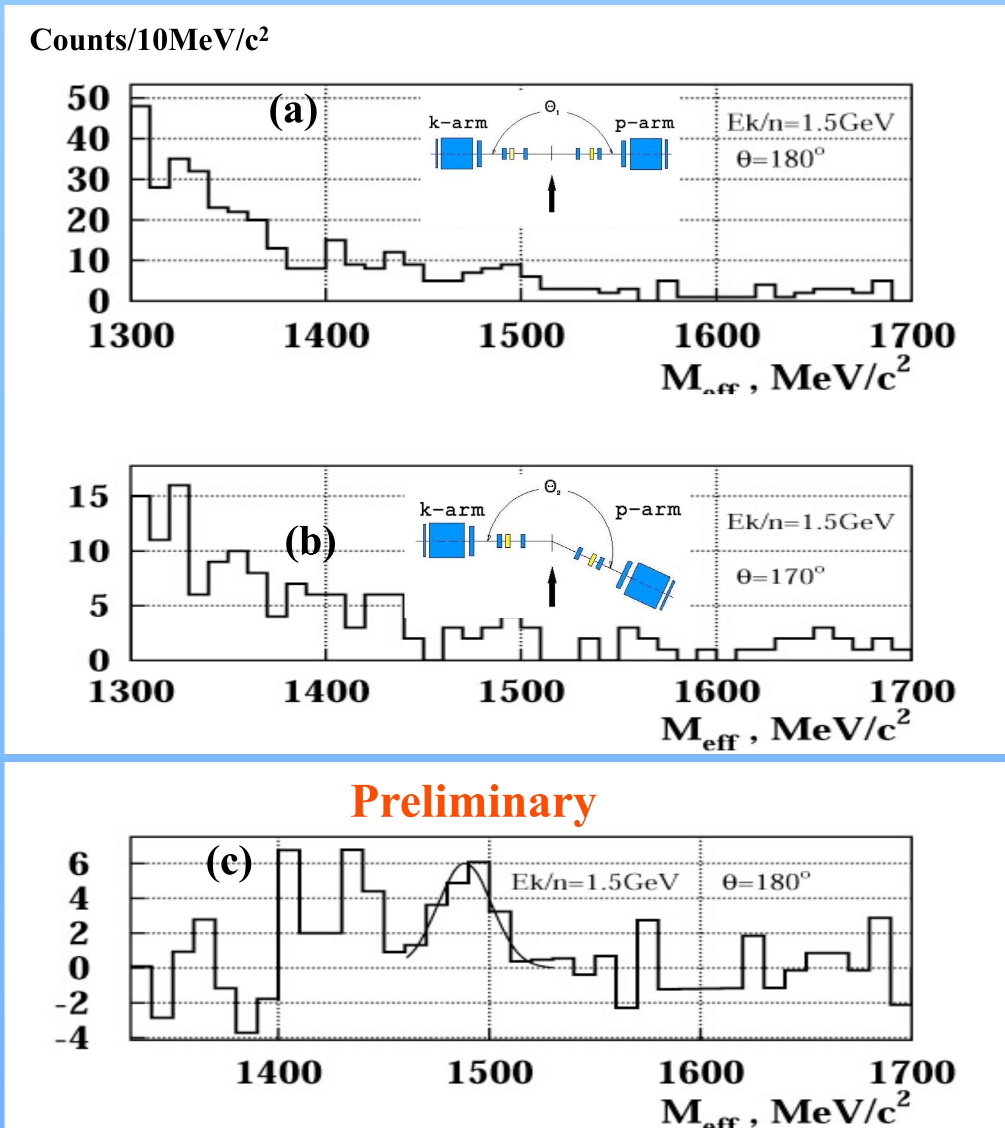
Effective mass formation in dA reaction at the energy 1.5 GeV/nuc



The distributions of the NN pair yields are shown in Fig.(a,b) versus M_{eff} of the pair nucleons. The histogram Fig.(b) shows the contamination obtained at the arm angle 170^{o}.The Fig.(a) corresponds to a back-to-back correlation coming from the two-body decay. The histogram Fig.(c) is the result of subtraction the back-to-back (180^{o}) and the contamination measurements.

The ratio of the nucleon pair numbers was N{170}/N{180}=0.42 + 0.08(stat) in the mass region of $1450 < M_{eff} < 1550$ MeV/c^{2}.

New data are collected.
They are include 10^5 pairs coming from target in d+Cu and d+C reactions at the energy of primary beam 1.5GeV/nuc and 1.9Gev/nuc.

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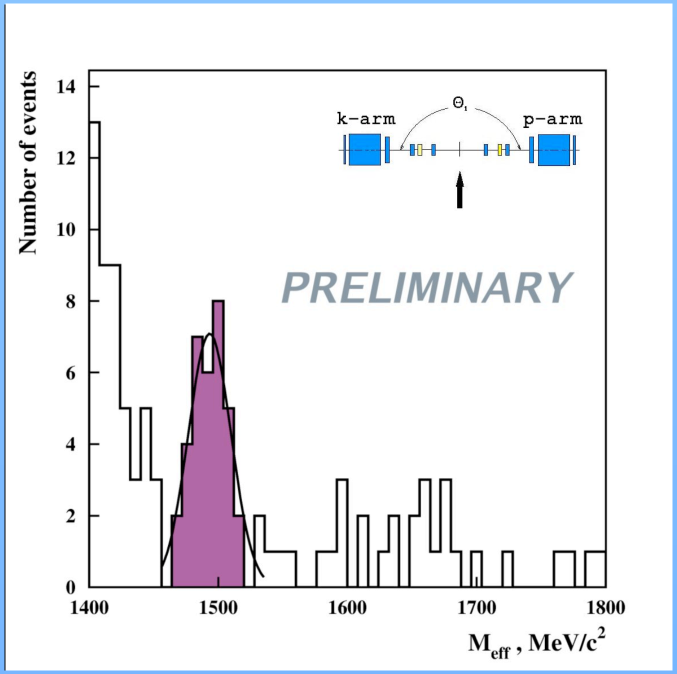
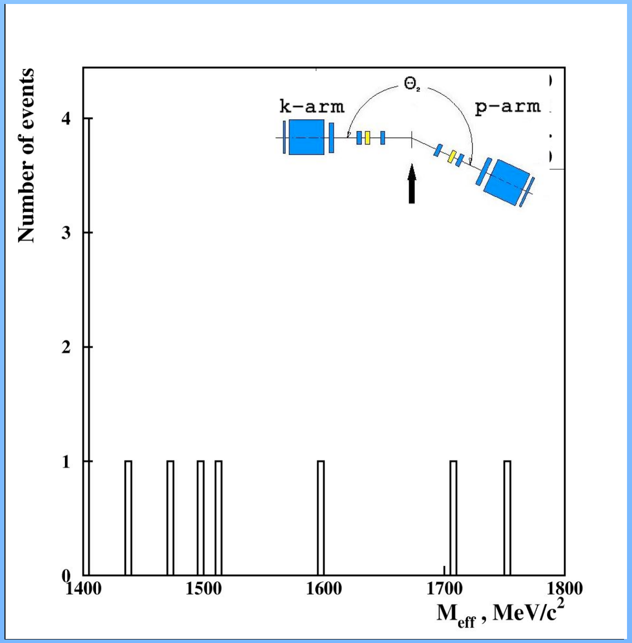
The yield of proton-pion pairs: $Y(\pi,p) \propto 1.4 \div 1.8\ GeV/c^2$

Effective mass formation in dC reaction at the energy 2.0 GeV/nuc



$\theta_{\pi p} \approx 180^0$



$\theta_{\pi p} \approx 170^0$

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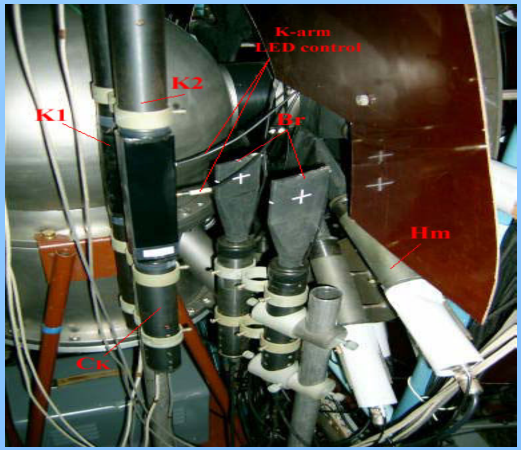
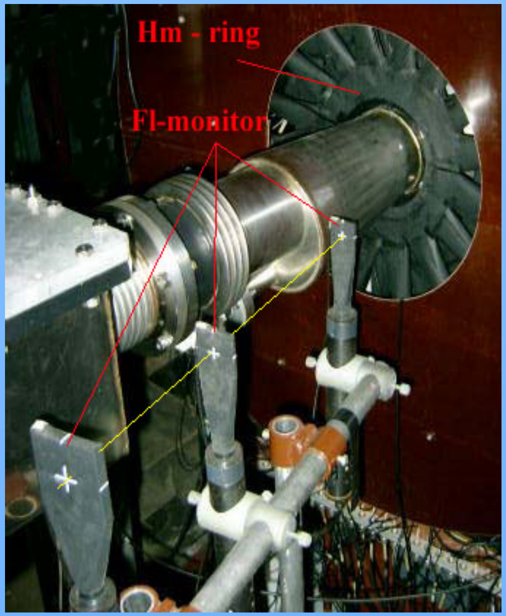
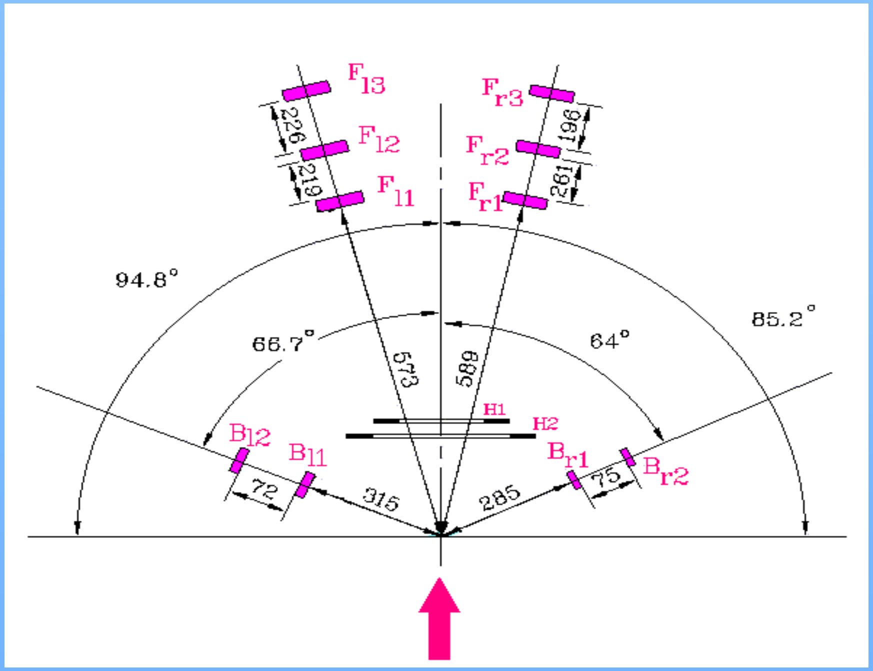


$F_{R1;L1}$ = 30 x 30 x 5 мм
$F_{R2;L2}$ = 40 x 40 x 5 мм
$F_{R3;L3}$ = 60 x 60 x 5 мм
$B_{R1;L1}$ = 50 x 50 x 5 мм
$B_{R2;L2}$ = 60 x 60 x 10мм





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The value of the total cross-section of the process can be found based on the number of inelastic interactions dC, measured on the accounts of monitor telescopes, and the simulation results using the software package GEANT and RQMD.

Inelastic interaction : $N_{in} = 1.5\text{-}2.2 * 10^9$;

Solid angle: Ω; $8 \cdot 10^{-3}$str

Cross-section of dC inelastic interactions at the

energy 2.1 GeV / n: $\sigma_{in} = 426 \pm 22$ mb

Total cross-section:

$$\sigma_{A\eta} = (\sigma_{in} * (N_{eff} - N_{fon}))/(\Omega * N_{in}) = 426*32.5*4\pi/8*10^{-3}*1.85*10^{9} = 11.6 \pm 7.5\ \mu b$$

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Conclusions

- Setup tested and first data are obtained
- Data analyses are shown resonance structure formed in the target at the energy region of primary beam 1.5-2.0 GeV/nucl.
- It is found background exceed at the effective mass region around 1.5 GeV/c^2
- The value of the total cross-section is estimated ≈10μb.

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Thank you

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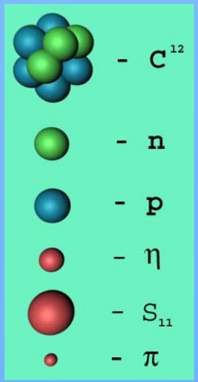
- **Formation in pn or np interaction in the reaction $+A \rightarrow n+p+{}_{\eta}(A-1)$**
- **Evolution in the elementary process $p + n^* \rightarrow n + S^{+}_{11}(1535)^* \rightarrow n + p + \eta^*$**
- **Decay to the π-N, N-N and γ -γ channels**



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- **Formation in pn or np interaction in the reaction $+A \rightarrow n+p+{}_{\eta}(A-1)$**
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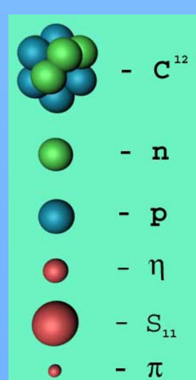

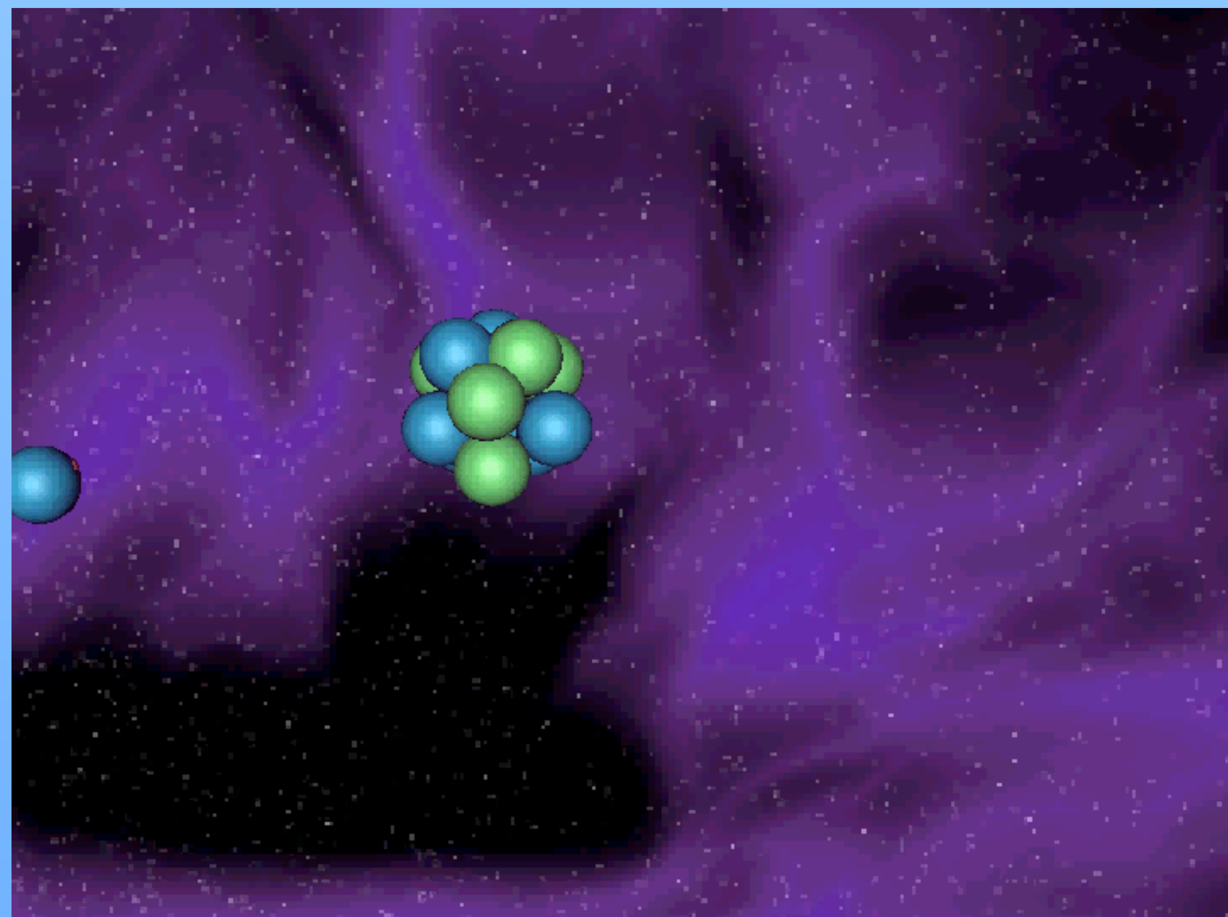

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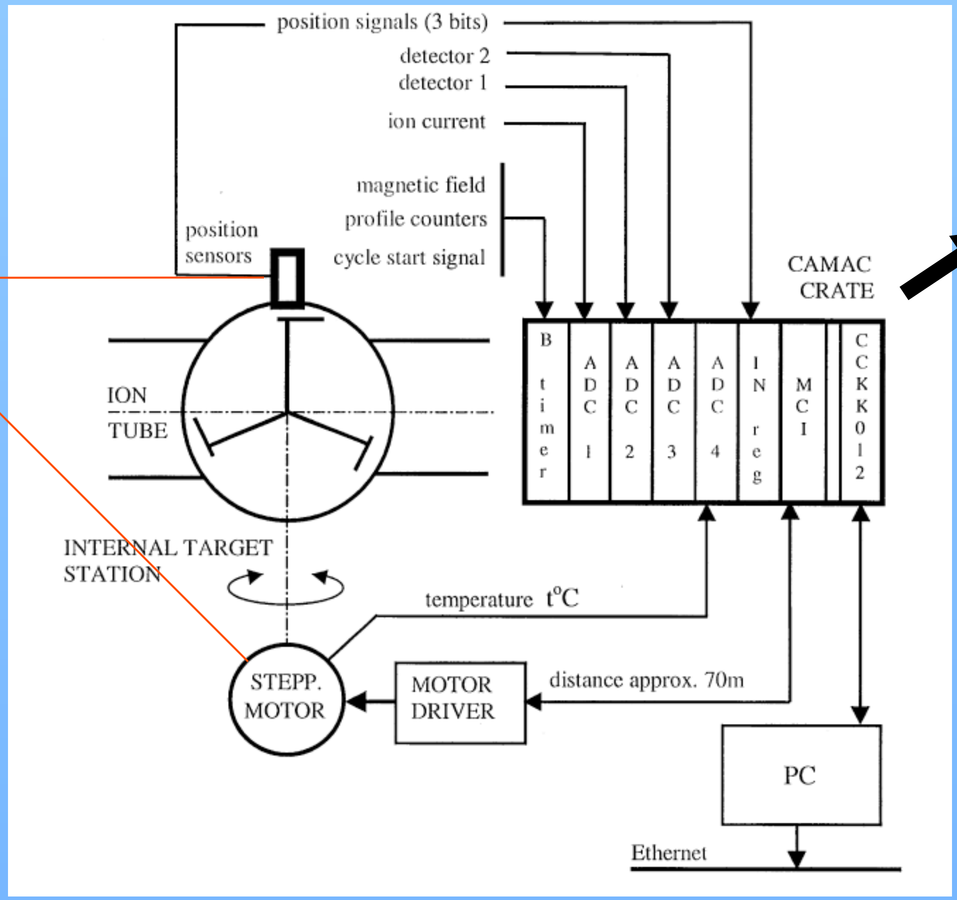
A block diagram of the control system.

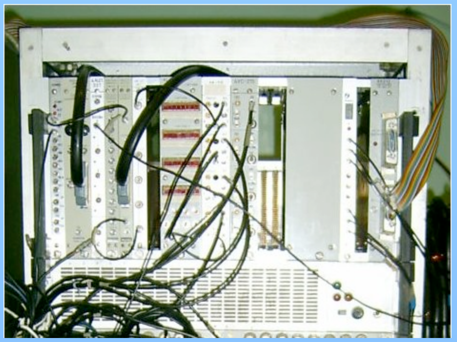
Control of the target position 2009

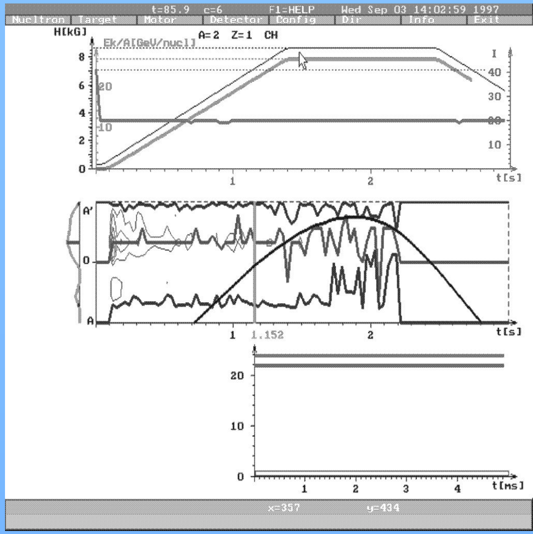
On-Line PC

Internet

To accelerator main control room







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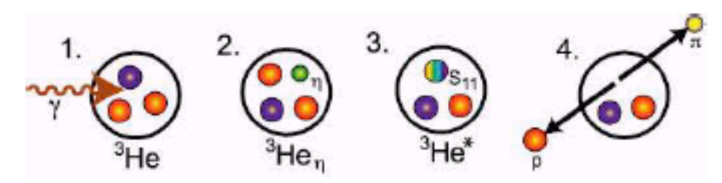
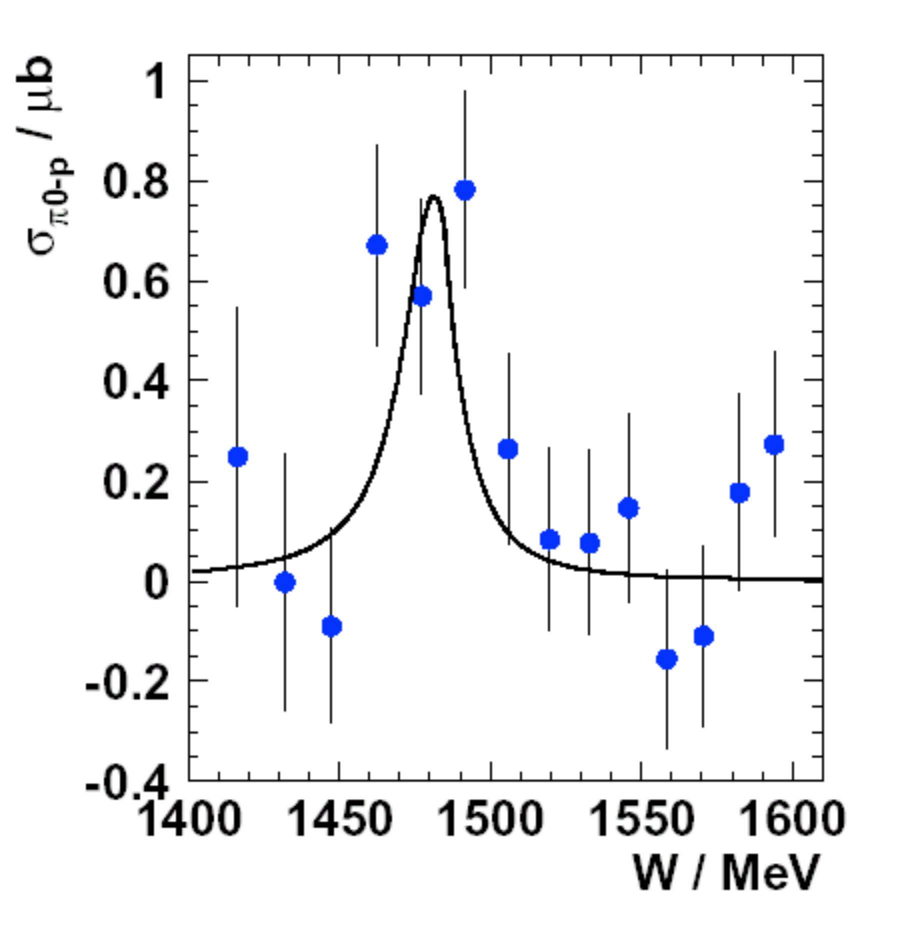
Photoproduction of mesons from nuclei
- In-medium properties of hadrons
B. Krusche,
nucl-ex/0411033



Formation of an
η mesic nucleus and its decay
via emission of back-to-back
nucleon-pion pairs.



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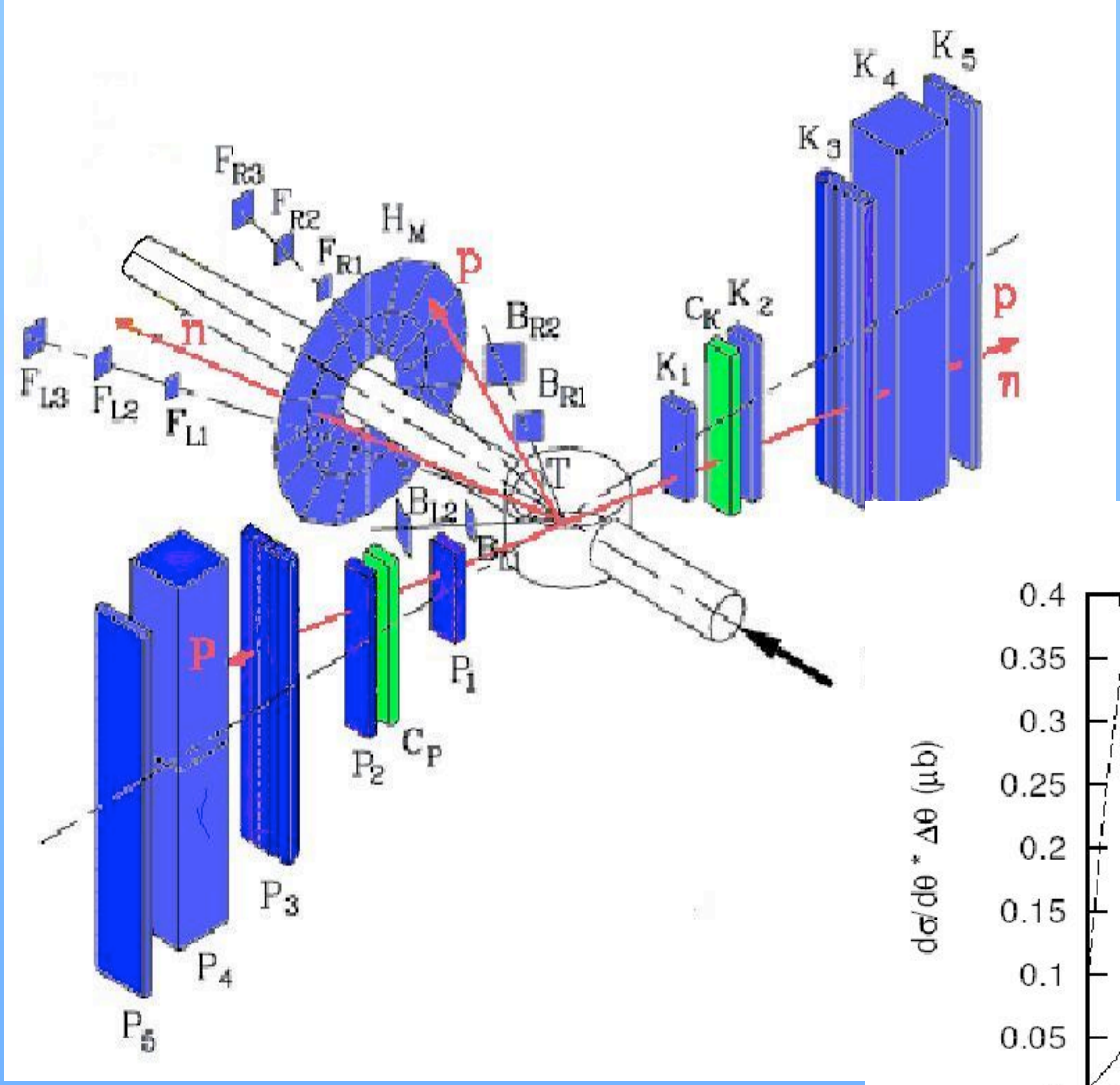
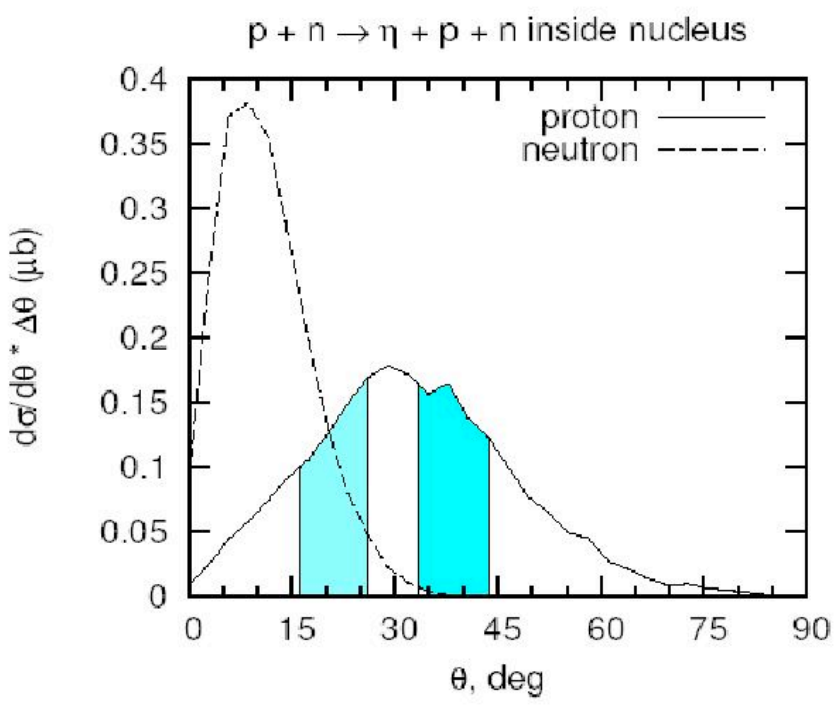
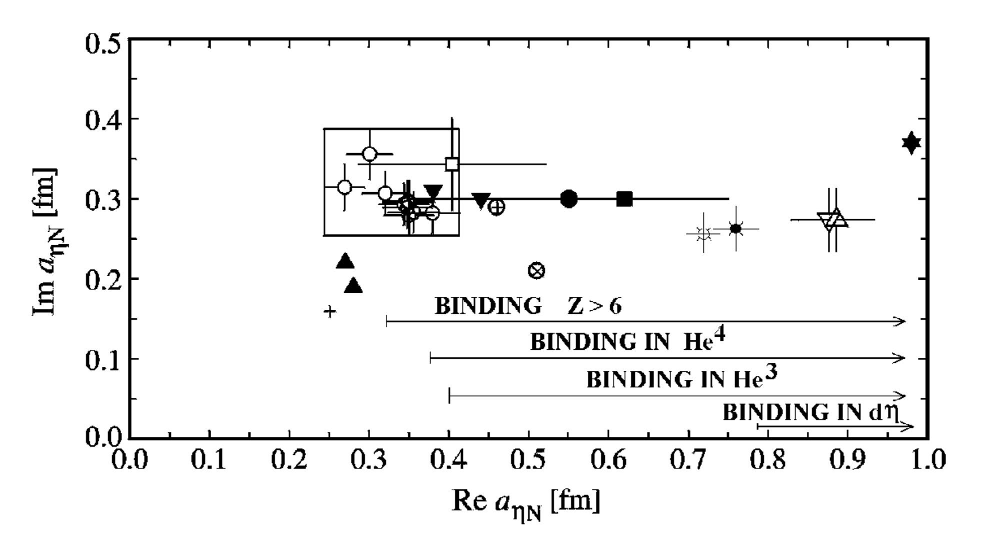
Установка СКАН





Theoretical prediction

The problem of extremely poorly determinedvalue of the real part of the ηN S-wave scattering length has been known for years, and the limits have been 0.2 fm< Real (*aN*) <0.98 fm. ***(Pic. from nucl-th/0009024)***



ηN S-wave scattering length.
The symbols for all extracted values are taken over from (*M.Batinic and A.Svarc, Few Body Syst. 20, 69 (1996);* **crossed empty circles** *(M.Batinic, et al., Physica Scripta 58, 15 (1998);* **crossed full circles - (***A.M.Green and S.Wycech, Phys. Rev. C 55, R2167 (1997))* **Lines given on the gure indicate for which values there is a probability for the -light nuclei bound states - (***S. Wycech, Workshop on Physics with the WASA Detector, S¨atra Brunn, June 17-19, 1996, Sweeden)*

η- & η'-mesic nuclei and $U_A(1)$ anomaly at finite density

Hideko Nagahiro,[1] Makoto Takizawa,[2] and Satoru Hirenzaki[3]

[1] *Research Center for Nuclear Physics(RCNP), Osaka University, Ibaraki, Osaka, 567-0047, Japan*
[2] *Showa Pharmaceutical University, Machida, Tokyo, 194-8543, Japan*
[3] *Department of Physics, Nara Women's University, Nara, 630-8506, Japan*

We discuss theoretically the possibility of observing the bound states of the η and $\eta'(958)$ mesons in nuclei. We apply the NJL model to study the η and η' meson properties at finite density and calculate the formation cross sections of the η and η' bound states with the Green function method for (γ,p) reaction. We also discuss the experimental feasibility at photon facilities like SPring-8. The contributions due to the ω meson production are also included to obtain the realistic (γ,p) spectra. We conclude that we can expect to observe resonance peaks in (γ,p) spectra for the formation of meson bound states and we can deduce new information on η and η' properties at finite density. These observations are believed to be essential to know the possible mass shift of η' and deduce new information on the effective restoration of the $U_A(1)$ anomaly in the nuclear medium.

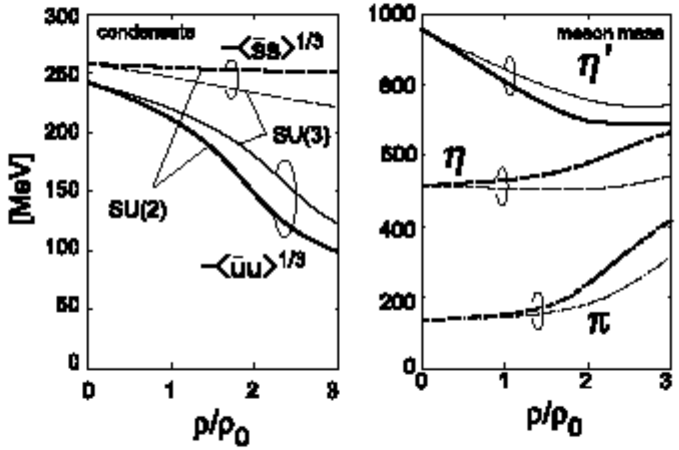


FIG. 3: Density dependence of the quark condensates (left panel) and the meson masses (right panel) are shown for the SU(2) symmetric matter (thick lines) and the SU(3) symmetric matter (thin lines). The nucleon density ρ is defined in Eq. (7) and ρ_0 is the normal nuclear density $\rho_0 = 0.17$ fm^{-3}.

CONCLUSIONS

The present evaluation is the first theoretical results for the formation reaction of the η- and η'-mesic nuclei based on the NJL model results to know the behavior of $U_A(1)$ anomaly in the medium. We believe that the present theoretical results is much important to stimulate both theoretical and experimental activities to study the $U_A(1)$ anomaly at finite density and to obtain the deeper insights of QCD symmetry breaking pattern and the meson mass spectrum.

Nuclear Physics A670 (2000) 198c-201 c

Study o f ω, η, η' and D⁻-mesic nuclei

K. Tsushima

Physics Letters B 443 1998 26–32

Are η- and ω-nuclear states bound ?

K. Tsushima , D.H. Lu , A.W. Thomas, K. Saito

Table 1

η, ω and η' bound state energies (in MeV), $E_j = Re(E_j^* - m_j)$ $(j = \eta, \omega, \eta')$, where all widths for the η' are set to zero. The eigenenergies are given by, $E_j^* = E_j + m_j - i\Gamma_j/2$.

		$\gamma_\eta = 0.5$		$\gamma_\omega = 0.2$		$\gamma_{\eta'} = 0$
		E_η	Γ_η	E_ω	Γ_ω	$E_{\eta'}$
^6_jHe	1s	-10.7	14.5	-55.6	24.7	* (not calculated)
$^{11}_j$B	1s	-24.5	22.8	-80.8	28.8	*
$^{26}_j$Mg	1s	-38.8	28.5	-99.7	31.1	*
	1p	-17.8	23.1	-78.5	29.4	*
	2s	—	—	-42.8	24.8	*
$^{16}_j$O	1s	-32.6	26.7	-93.4	30.6	-41.3
	1p	-7.72	18.3	-64.7	27.8	-22.8
$^{40}_j$Ca	1s	-46.0	31.7	-111	33.1	-51.8
	1p	-26.8	26.8	-90.8	31.0	-38.5
	2s	-4.61	17.7	-65.5	28.9	-21.9
$^{90}_j$Zr	1s	-52.9	33.2	-117	33.4	-56.0
	1p	-40.0	30.5	-105	32.3	-47.7
	2s	-21.7	26.1	-86.4	30.7	-35.4
$^{208}_j$Pb	1s	-56.3	33.2	-118	33.1	-57.5
	1p	-48.3	31.8	-111	32.5	-52.6
	2s	-35.9	29.6	-100	31.7	-44.9

Table 3

Calculated η meson single-particle energies, $E = Re(E_\eta - m_\eta)$, and full widths, Γ, (both in MeV), in various nuclei, where the complex eigenenergies are, $E_\eta = E + m_\eta - i\Gamma/2$. See Eq. (13) for the definition of γ_η. Note that the free space width of the η is 1.18 keV, which corresponds to $\gamma_\eta = 0$

		$\gamma_\eta = 0$		$\gamma_\eta = 0.5$		$\gamma_\eta = 1.0$	
		E	Γ	E	Γ	E	Γ
$^{16}_\eta$O	1s	−33.1	0	−32.6	26.7	−31.2	53.9
	1p	−8.69	0	−7.72	18.3	−5.25	38.2
$^{40}_\eta$Ca	1s	−46.5	0	−46.0	31.7	−44.8	63.6
	1p	−27.4	0	−26.8	26.8	−25.2	54.2
	2s	−6.09	0	−4.61	17.7	−1.24	38.5
$^{90}_\eta$Zr	1s	−53.3	0	−52.9	33.2	−51.8	66.4
	1p	−40.5	0	−40.0	30.5	−38.8	61.2
	2s	−22.3	0	−21.7	26.1	−19.9	53.1
$^{208}_\eta$Pb	1s	−56.6	0	−56.3	33.2	−55.3	66.2
	1p	−48.7	0	−48.3	31.8	−47.3	63.5
	2s	−36.3	0	−35.9	29.6	−34.7	59.5
$^6_\eta$He	1s	−11.4	0	−10.7	14.5	−8.75	29.9
$^{11}_\eta$B	1s	−25.0	0	−24.5	22.8	−22.9	46.1
$^{26}_\eta$Mg	1s	−39.2	0	−38.8	28.5	−37.6	57.3
	1p	−18.5	0	−17.8	23.1	−15.9	47.1

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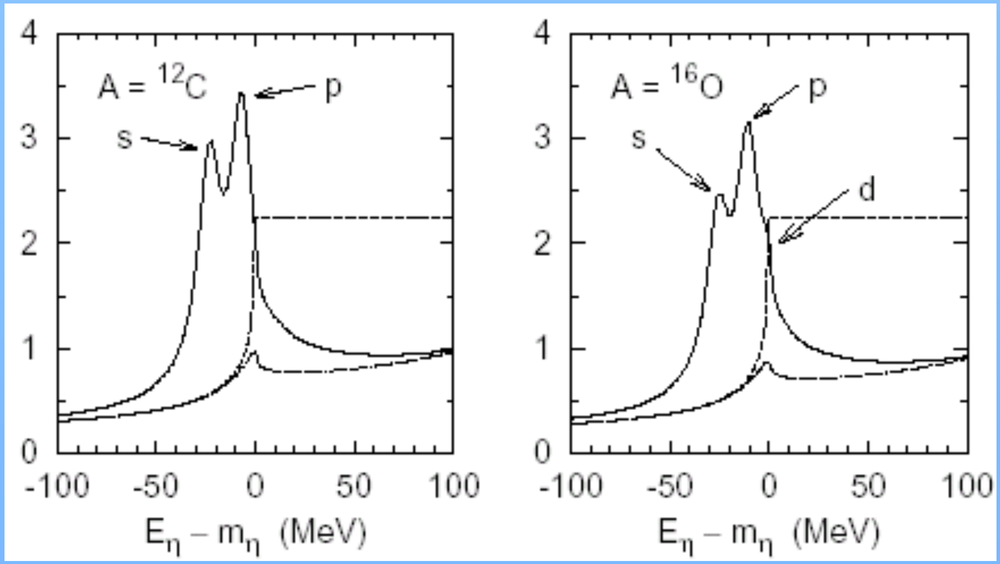
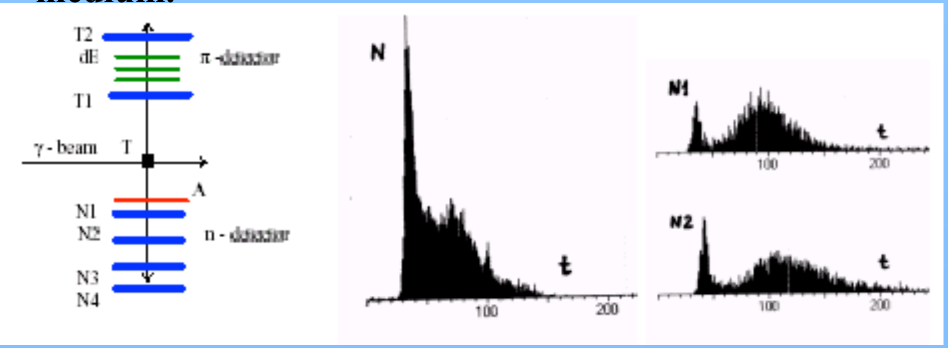
PRODUCTION AND DECAY OF ETA-MESIC NUCLEI
A. I. L'VOV
nucl-th/9809054



LPI experiment

The method consists in detection and energymeasurements of components of N pairs from S11-resonance decays in the nuclear medium.



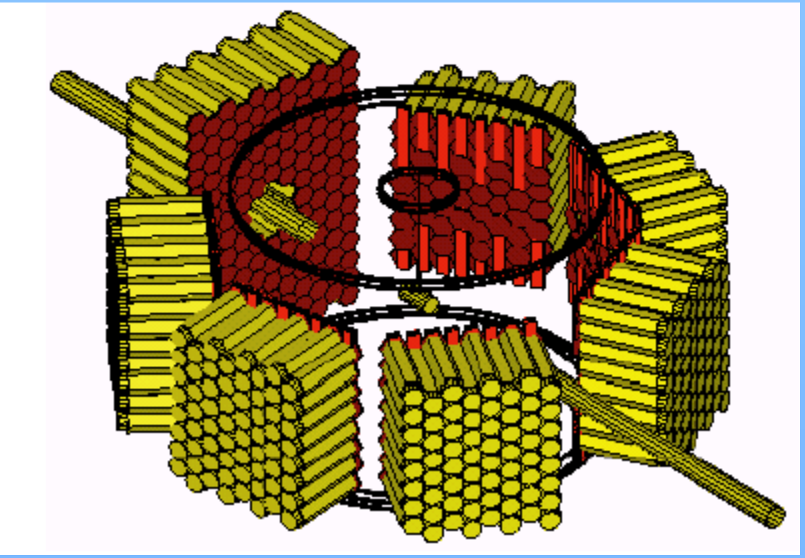
$$\gamma + {}^{12}\mathrm{C} \to p(n) + {}^{11}_{\eta}\mathrm{B}\ ({}^{11}_{\eta}\mathrm{C}) \to \pi^+ + n + X,$$

Layout of the experimental setup. Shown also are the time-of-flight spectra in the (left) and n (right) spectrometers.

MAMI accelerator in Mainz

Such pion - nucleon pairs have been searched for in the channel πo - p, which is best suited for the TAPS detector.

$$\gamma + A \to N_1 + (A-1)_\eta \to N_1 + (N_2 + \pi) + (A-2)$$



Setup of the TAPS detector at the Mainz MAMI accelerator. ***Krusche, B nucl-ex/0411033***

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