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The Role of Constituent Quark Masses in the Standard Model.

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THE ROLE OF CONSTITUENT QUARK MASS IN THE STANDARD MODEL

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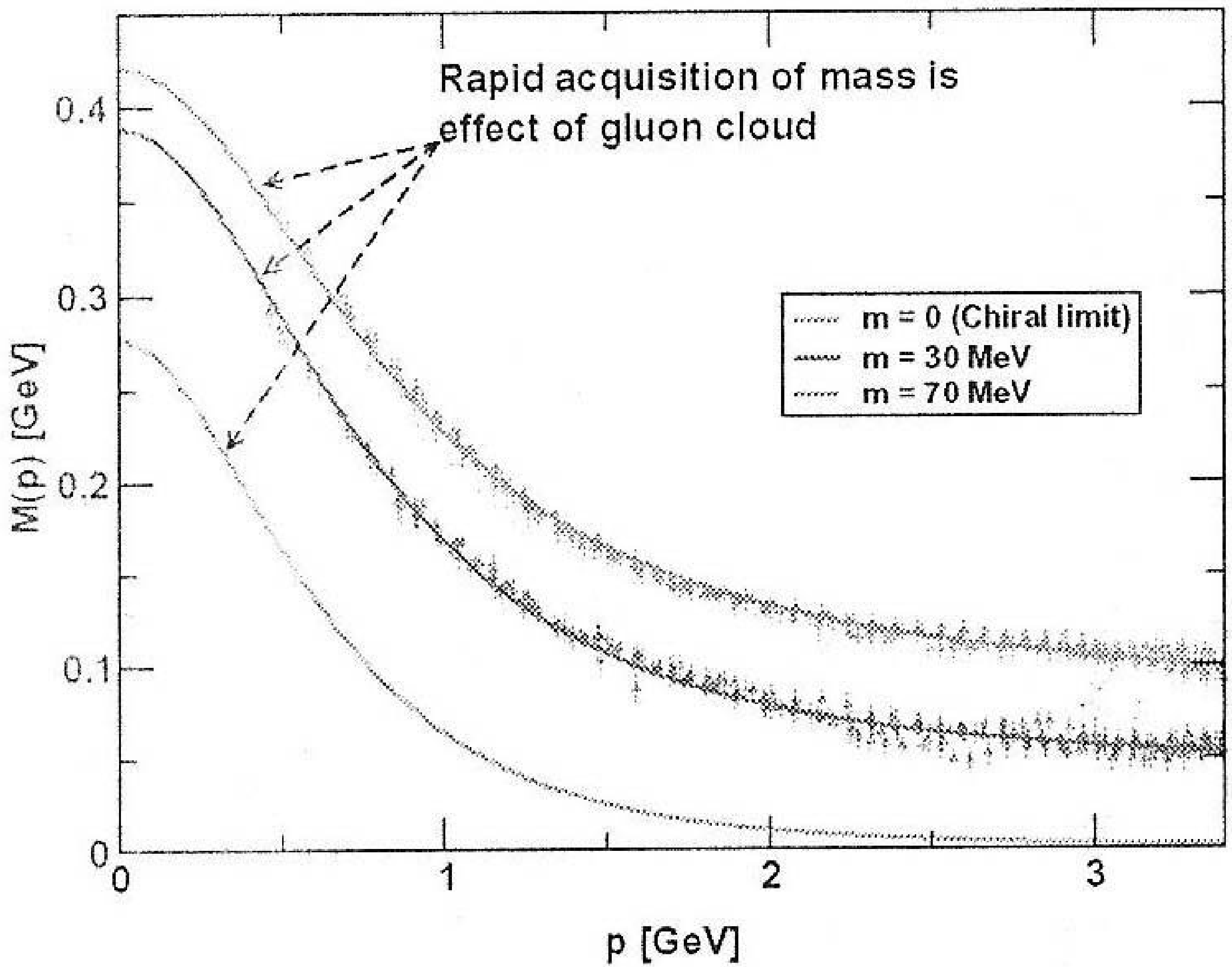


Fig.1. QCD gluon-quark-dressing effect calculated with Dyson-Schwinger Equation [9,13-17], initial masses m=0, 30 and 70 MeV; the constituent-quark mass arisses from a cloud of low-momentum gluons attaching themselves to the current-quark; this is dynamical chiral symmetry breacking: an nonperturbative effect that generates a quark mass from nothing even at chiral limit m=0, bottom curve) [9]..

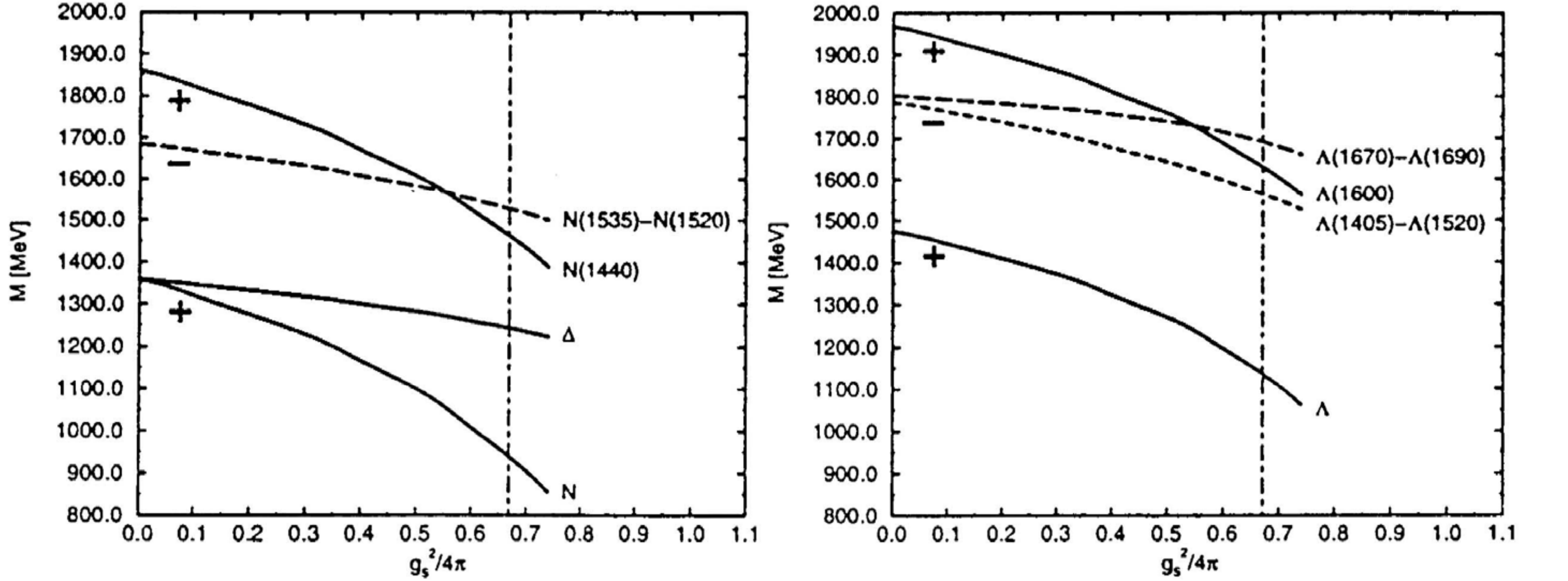


Fig.2. Calculation of nonstrange baryon masses (left) and Λ-hyperon masses as a function of interaction strength within GBECQM – Goldstone Boson Exchange interaction Constituent Quark Model [19]; initial baryon mass 1350 MeV=3×450 MeV=$3M_q$ is near the bottom "+" on the left vertical axis.

Table 1. Discussed in the literature closeness of masses or mass differences to the integer numbers (k) of the pion mass value $m_\pi^{\pm}$=139.5 MeV or to $2m_\pi^{\pm}+m_\pi^{\circ}=\kappa_T$=409 MeV.

Particle	Λ		Ω		(bb)(2S-1S)		(bb)(4S-2S)		ΔE_B	
Mass or ΔM (MeV)	1115.683(6)		1672.45(29)		10023-9460 =563		10579-10023 =556		408.9	
km_π or $2m_\pi^{\pm}+m_\pi^{\circ}=\kappa_T$	1116	k=8	1672	k=12	558	k=4	558	k=4	409	κ_T
difference, reference	0, [1,23-26]		0, [1,25,26]		-5, [1,26]		-2, [1,27]		0, [28]	

Table 2. Discussed in the literature closeness of particle masses or mass differences to the integer numbers (k) of the nucleon Δ-excitation parameter Δ_Δ=147 MeV [23].

Particle	(cc) (2S-1S)	(cc) (1S)	Ξ^-	ω_3-ω	K_3^*-$K^*(892)$	ΔE_B
Mass or	3686.1-3096.9	3096.92(1)	1321.3	1667(4)-782.7	1776(7)-891.7	441.5 (Fig.4)
ΔM (MeV)	=589.2 k=4	3087 k=21	k=9	884(4) k=6	=884(7) k=6	k=4
kΔM_Δ	588	588	1323	882	882	441
diff., ref.	1,[1,25,29]	1,[1,25,29]	-2,[??]	2(4),[1,25,29]	2(7),[1,25,29]	0,[28]

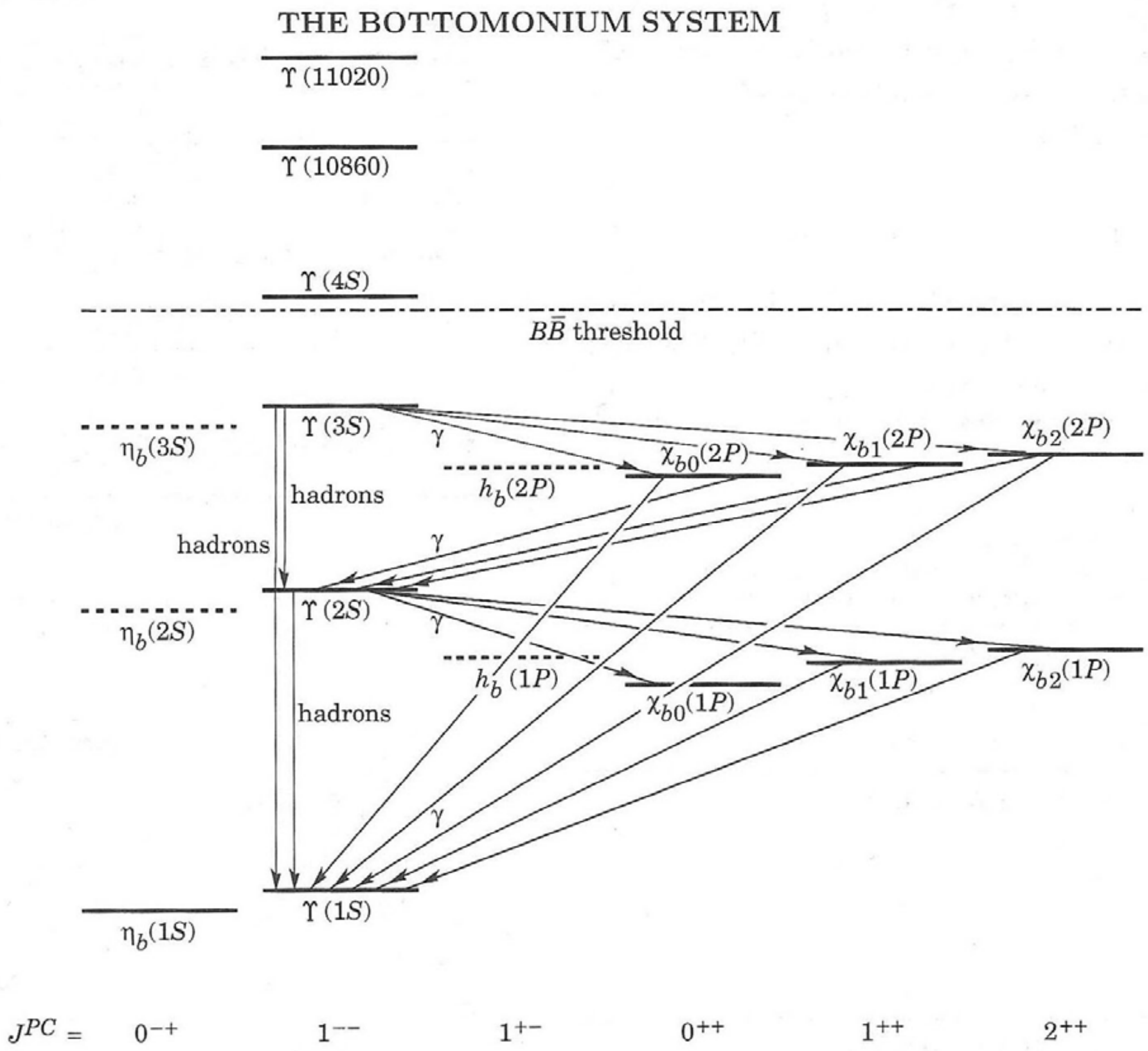
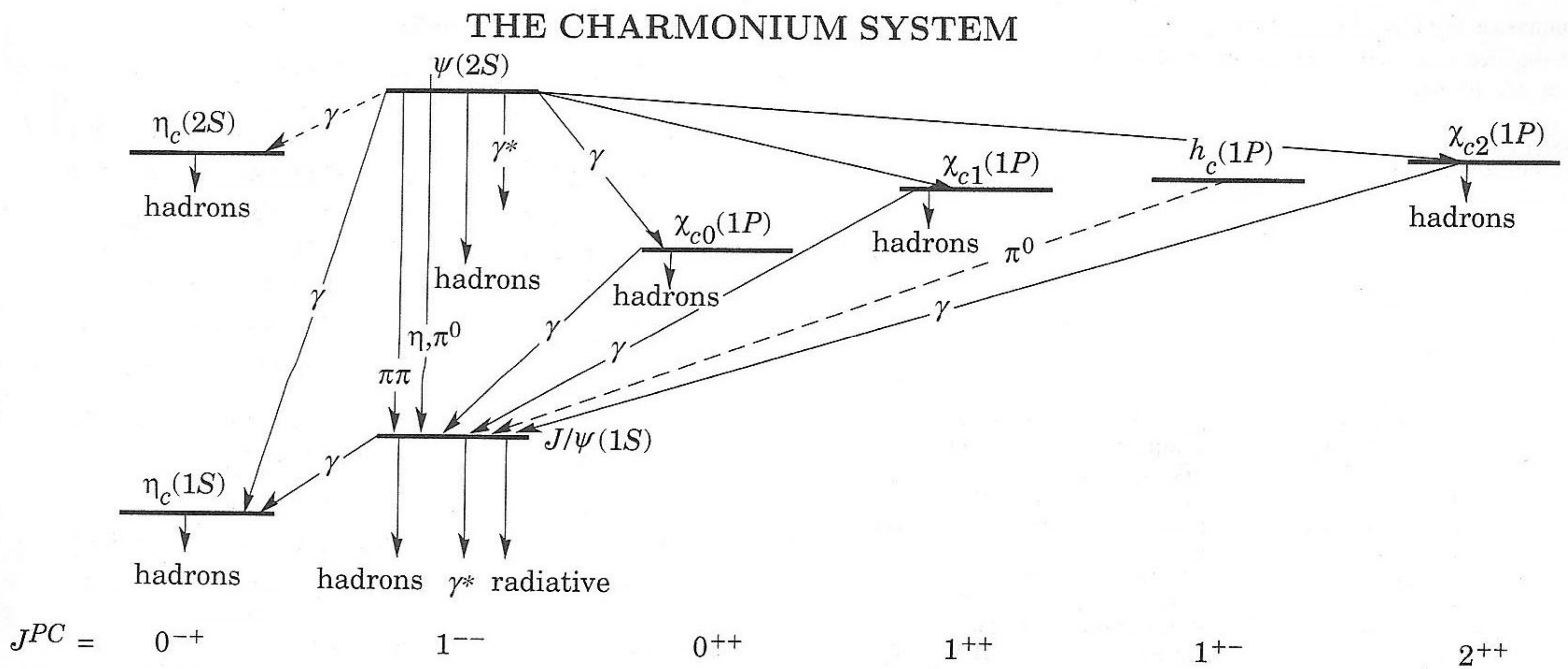


Fig.3. *Top* Mesons of (bb)-structure with radial excitations n=1 and n=1-3 close to $4m_\pi$ [1,27]; *Bottom* Mesons of (cc)-structure with radial excitation (n=1) close to $4\Delta M_\Delta$=4×147 MeV=588 MeV.



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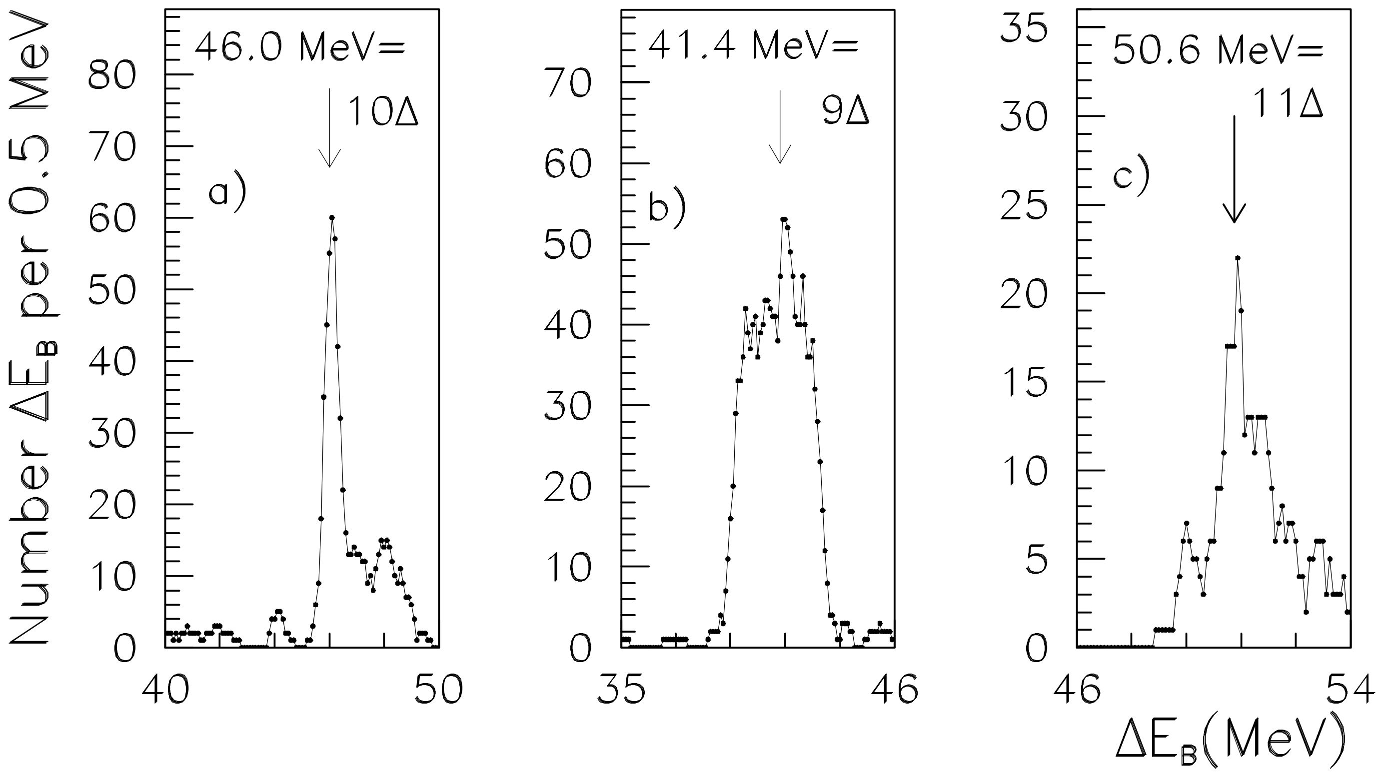
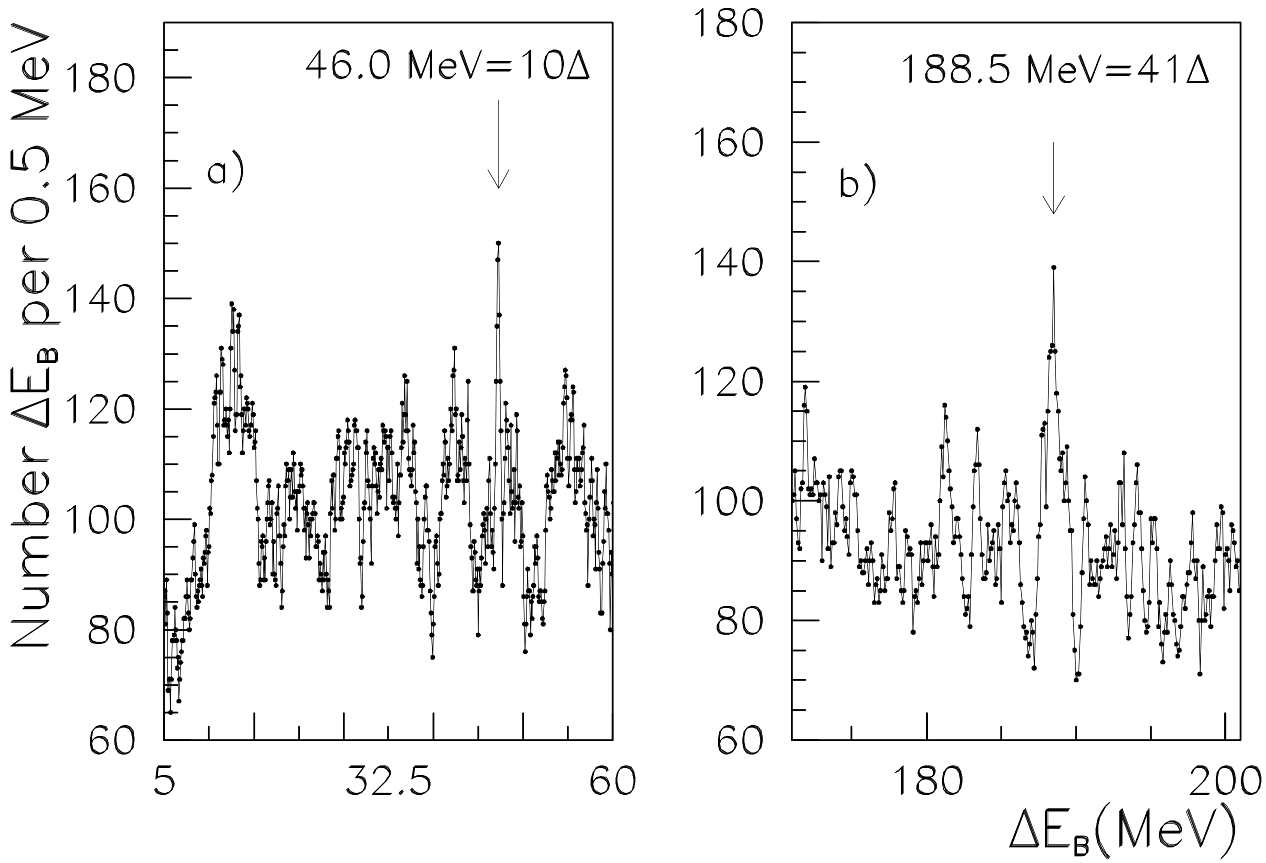


Fig. 4, *Top:* Distribution of ΔE_B in nuclei with $\Delta Z=2$, $\Delta N=4$, $Z=50$-58, 64-82 and $Z\leq28$ [26]
Bottom: The same in all even-even and nuclei [26], in even-even nuclei with $Z\leq58$ [29].



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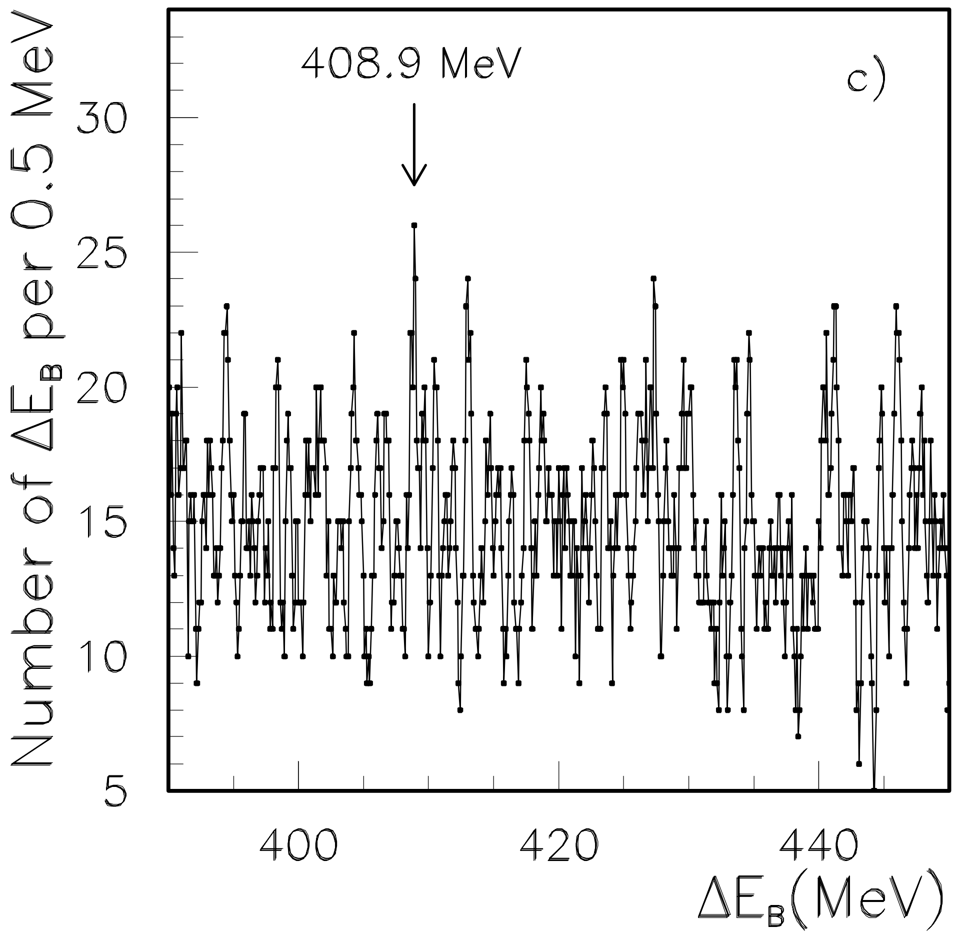

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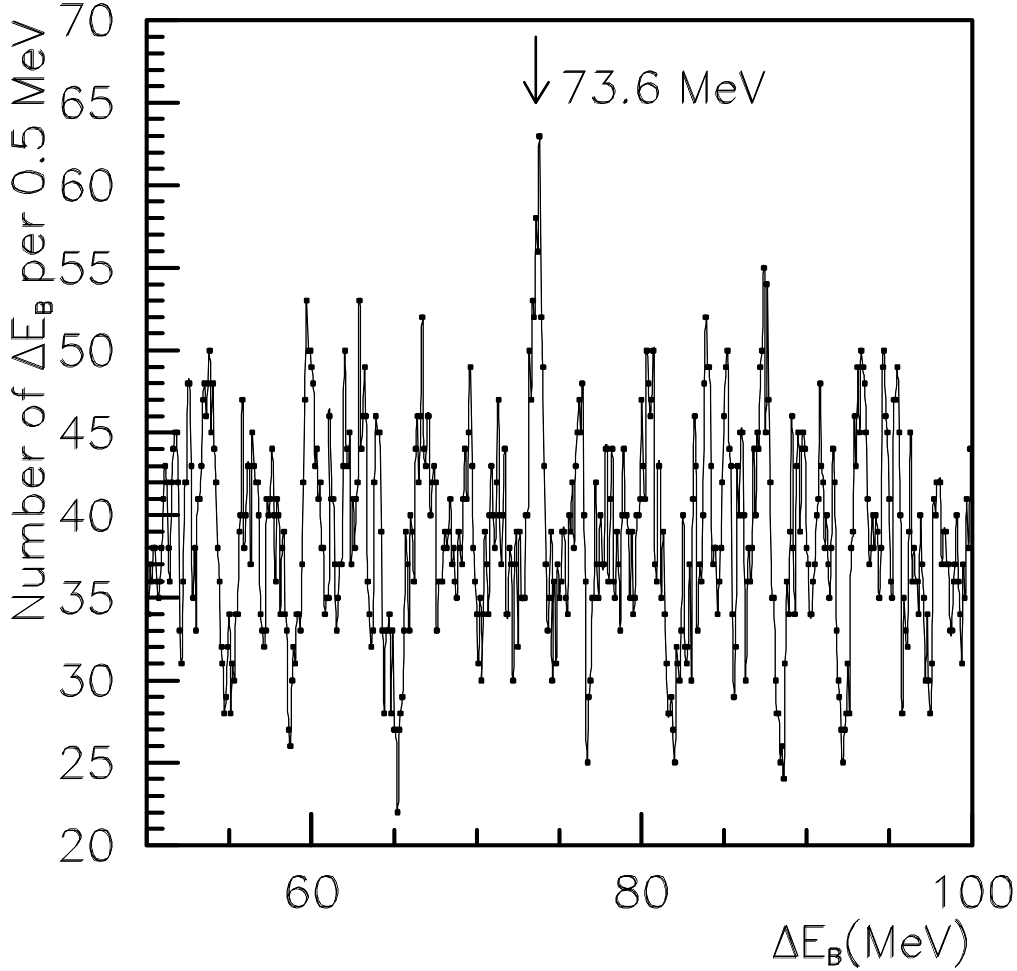


Fig. 5, *top:* Distribution of ΔEB in nuclei with ΔZ≤26; 4α- 2α-config. and all nuclei [6]);
center: Distribution of adjacent intervals ΔEB-AIM in nuclei with Z≤26 for x=147.2 and 73.6 MeV [6]);
bottom: Distribution of ΔEB in nuclei with ΔZ=8, ΔN=14 (Z=50-82); Distribution of ΔEB-AIM in nuclei with ΔZ=65-81 for x=147.1 MeV [6]; Distribution of ΔEB in all odd-odd nuclei [26].

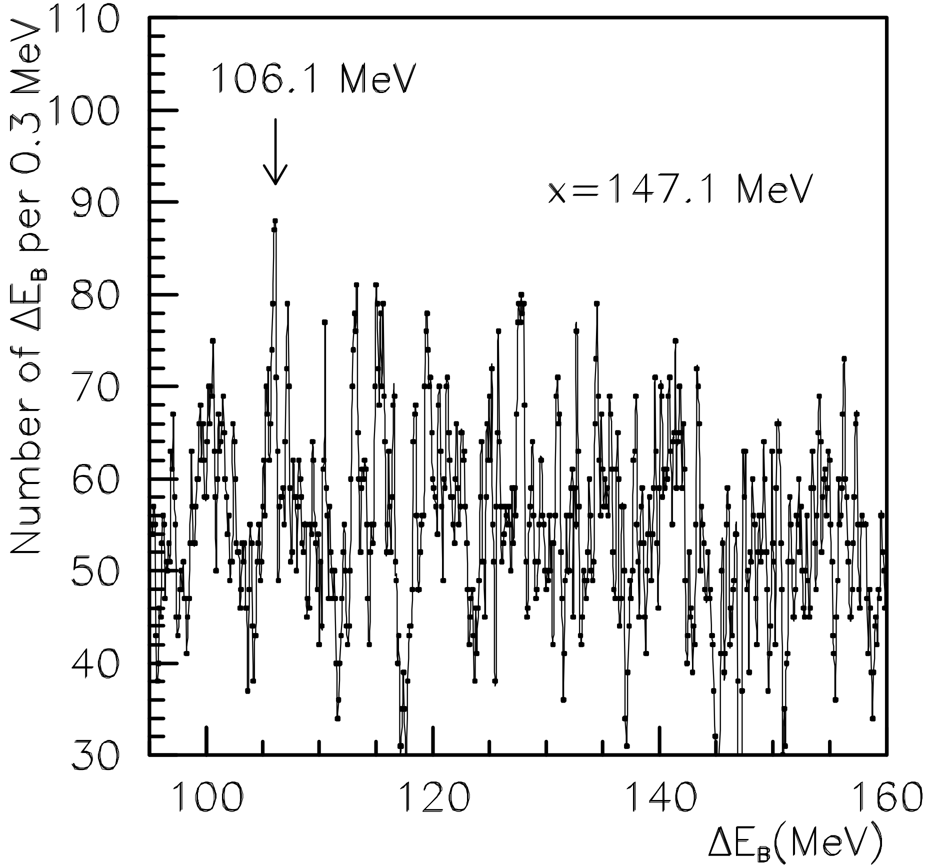
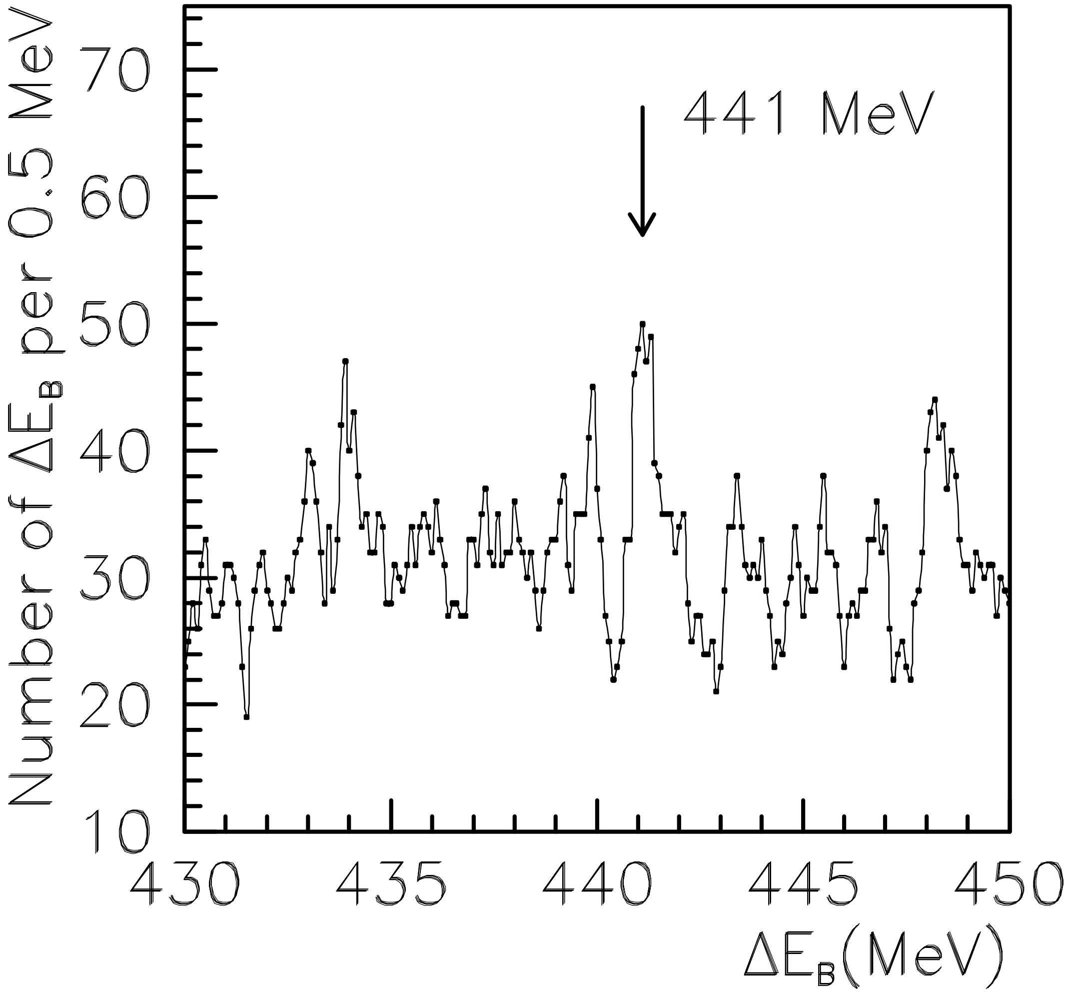


Fig. 5, *top:* Distribution of ∆EB in nuclei with ∆Z≤26; 4α- 2α-config. and all nuclei [6]);
center: Distribution of adjacent intervals ∆EB-AIM in nuclei with Z≤26 for x=147.2 and 73.6 MeV [6]);
bottom: Distribution of ∆EB in nuclei with ∆Z=8, ∆N=14 (Z=50-82); Distribution of ∆EB-AIM in nuclei with ∆Z=65-81 for x=147.1 MeV [6]; Distribution of ∆EB in all odd-odd nuclei [26].



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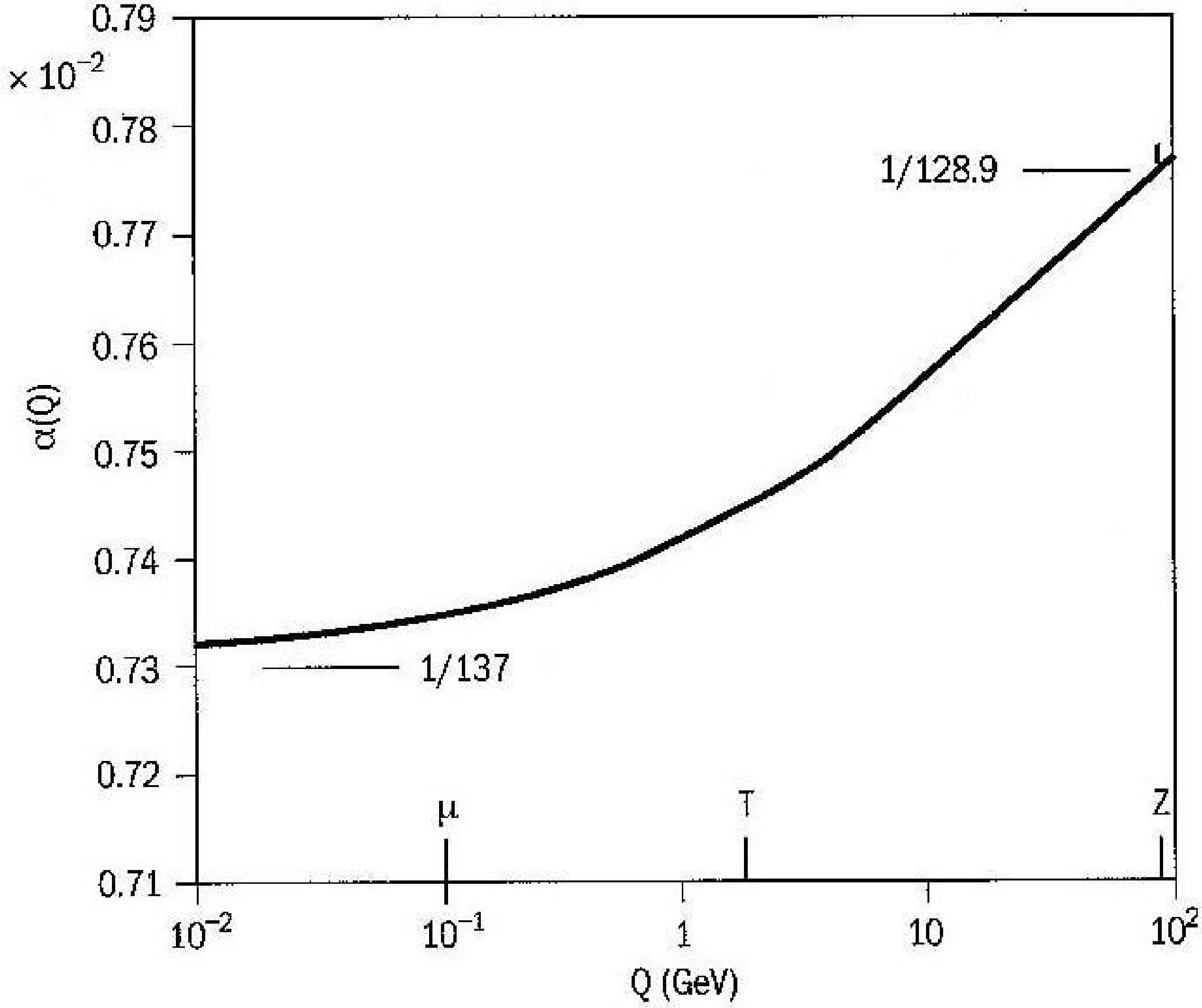


Fig.6. Momentum transfer evolution of QED effective electron charge squired. The momotonically rising theoretical curve is confronted with precise measurements at the Z mass at CERN LEP collider

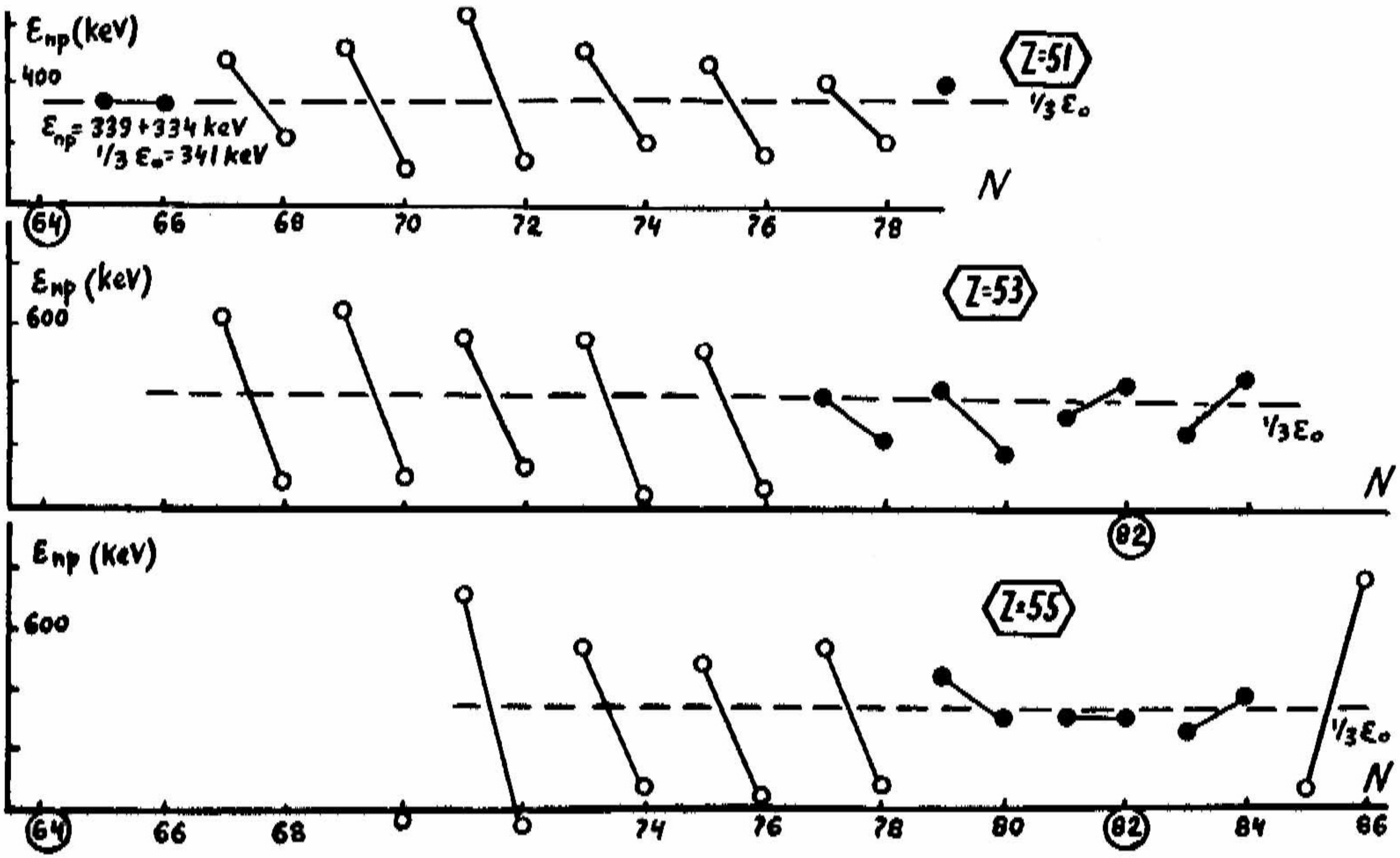
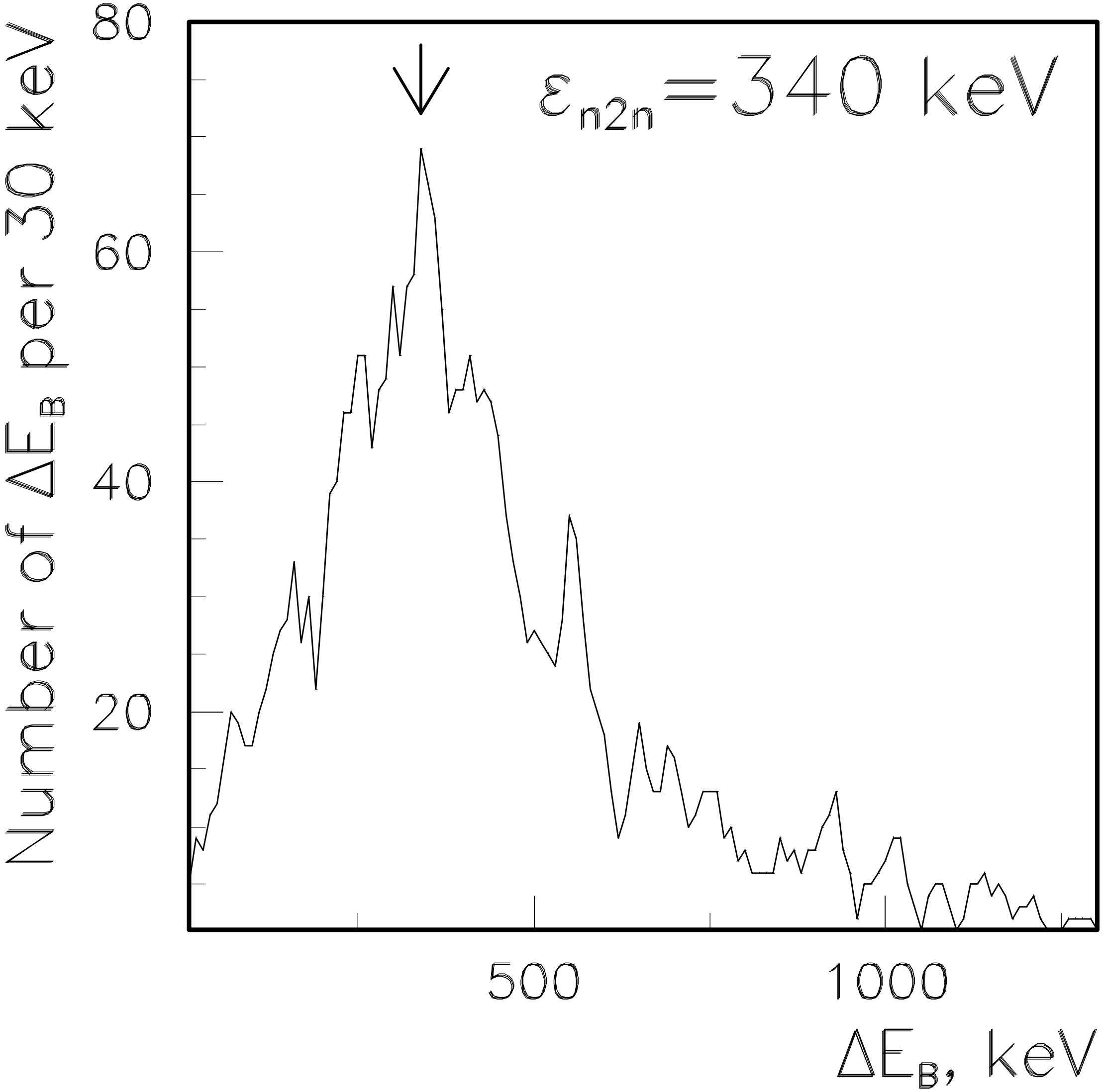
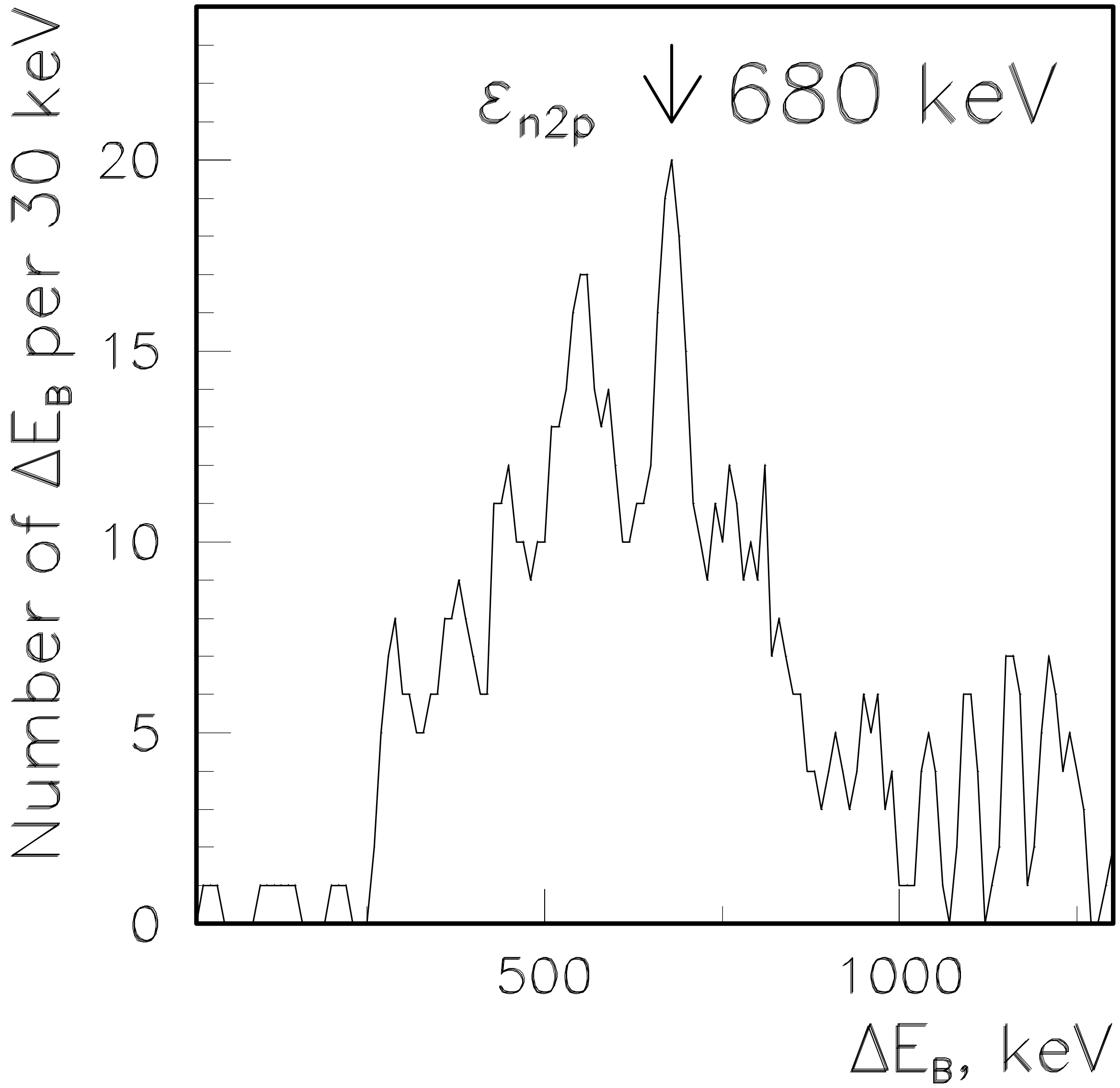


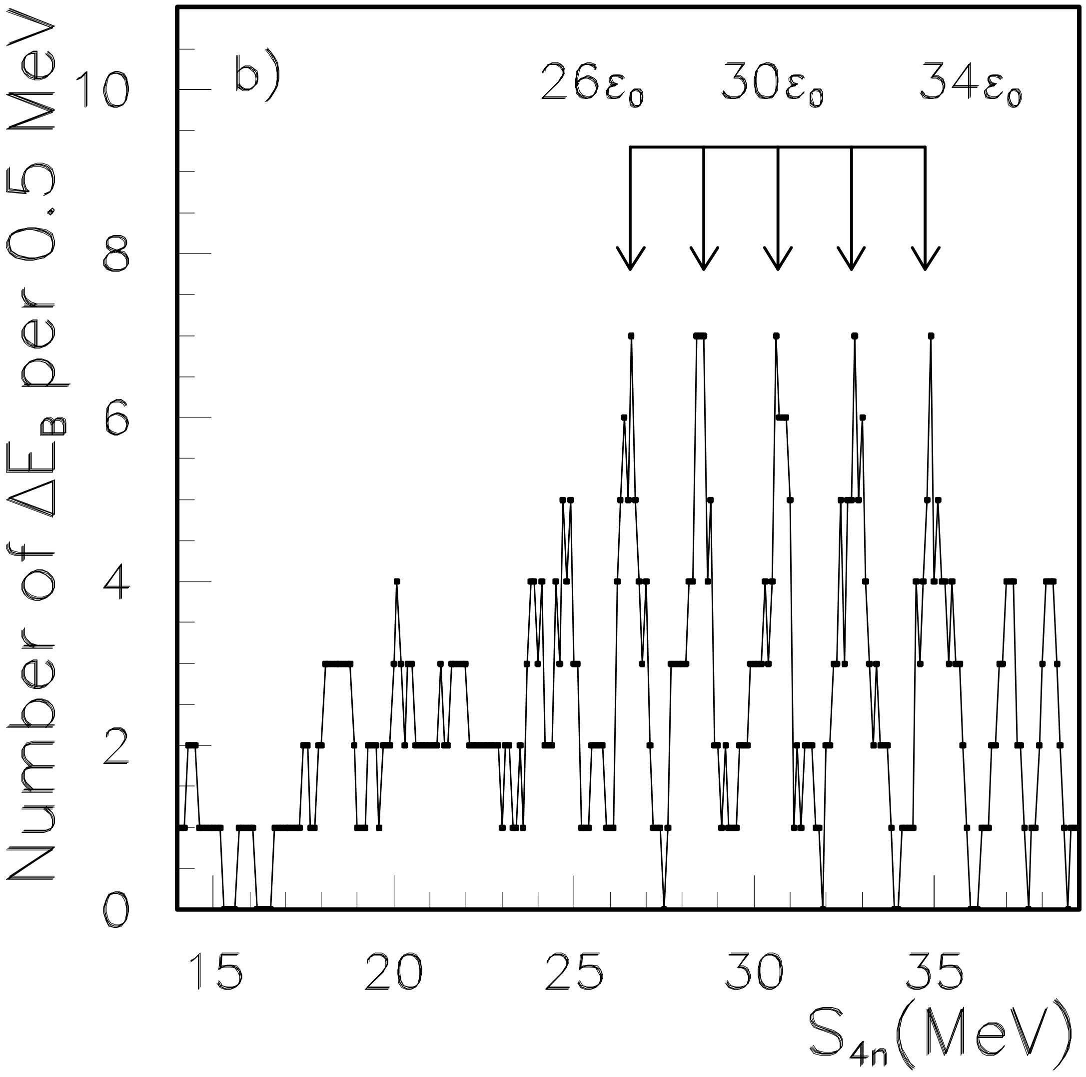
Fig.7. Parameters of the residual interaction ε_{np} from differences of S_p in Z-odd nuclei ($\Delta N = 1$). The value $\varepsilon_o/3$=341 keV is given by horizontal line



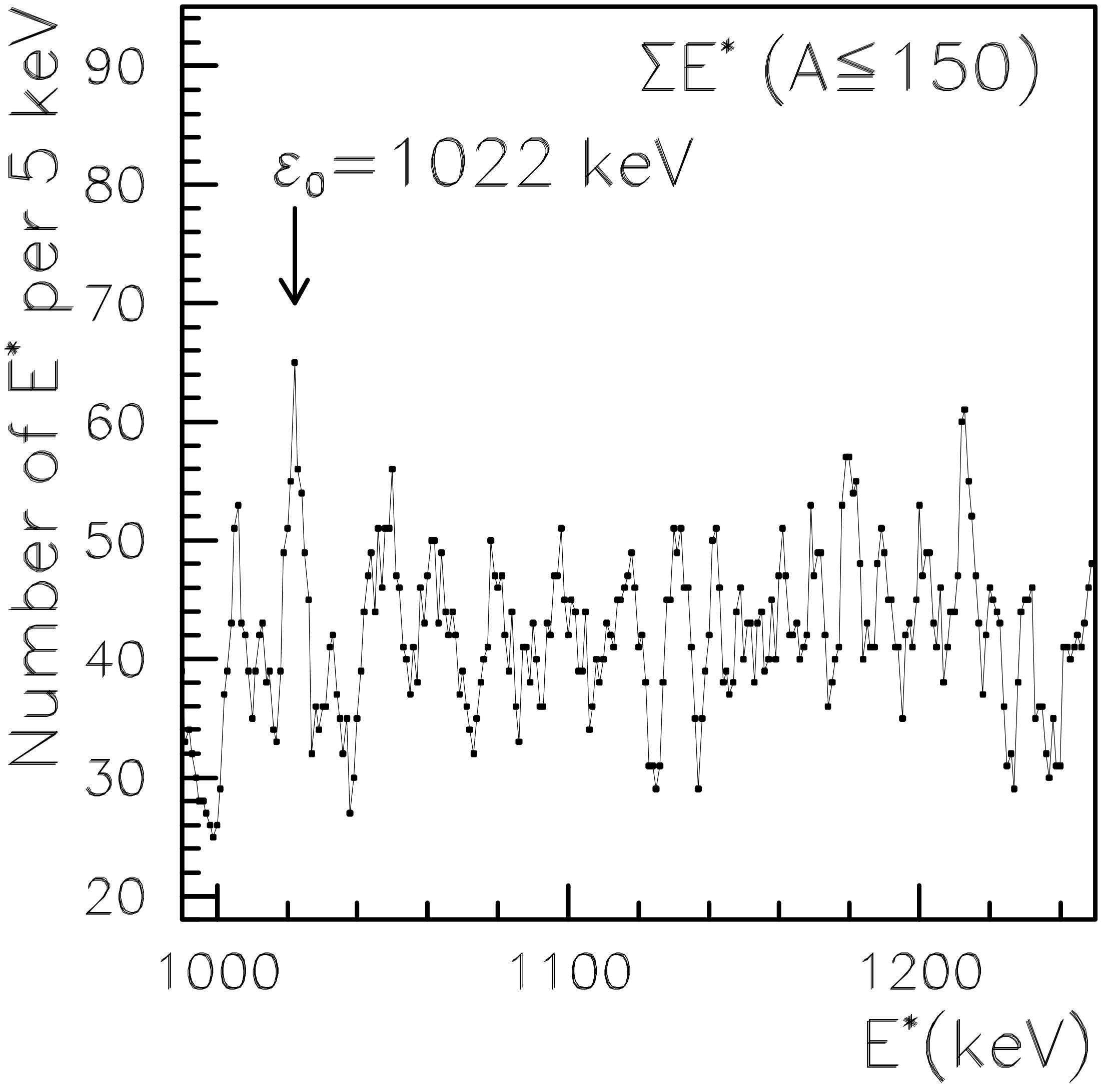
ε_{n2n}=340 keV
Number of ΔE_B per 30 keV
ΔE_B, keV
80
60
40
20
500
1000



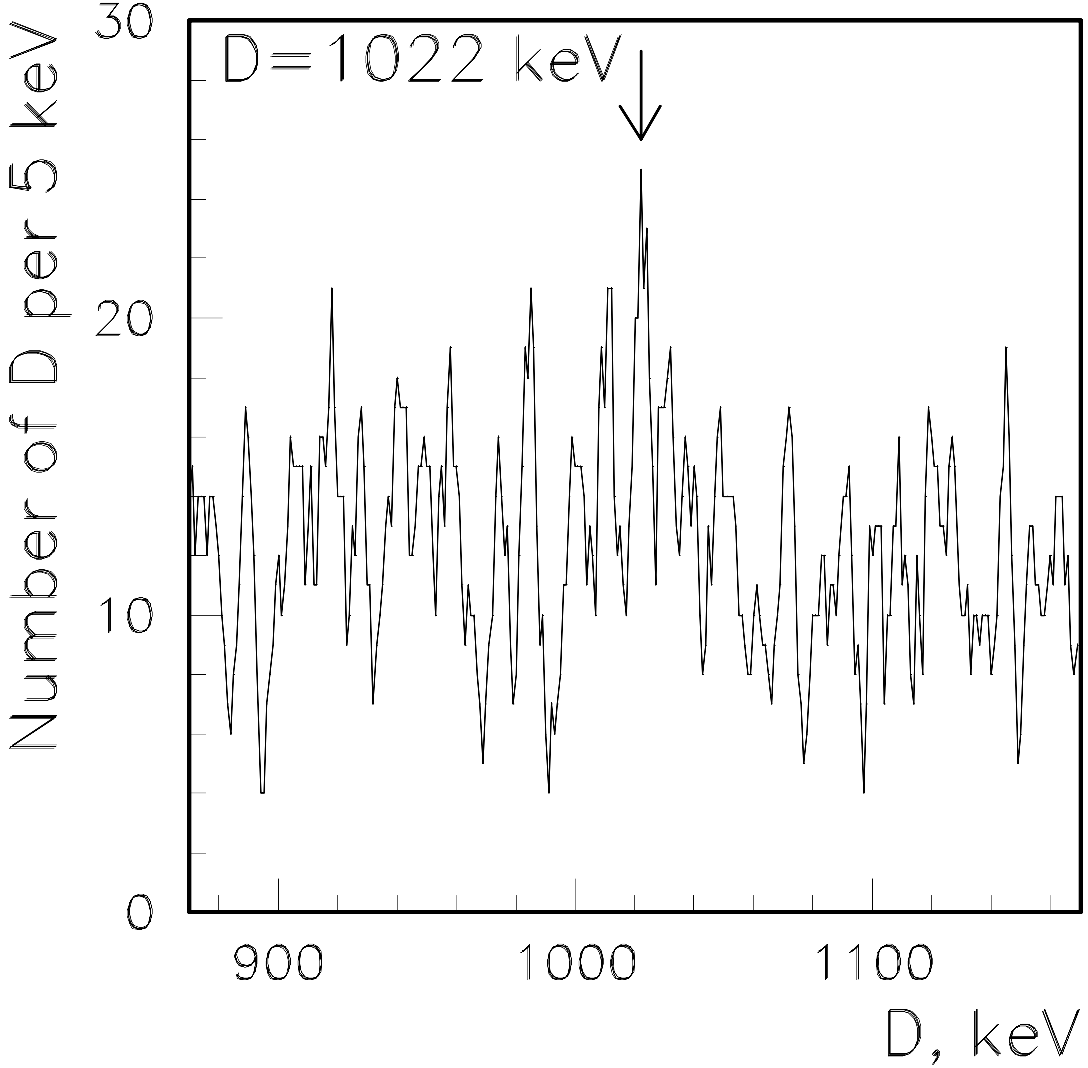
ε_{n2p} 680 keV
Number of ΔE_B per 30 keV
0
5
10
15
20
500
1000
ΔE_B, keV



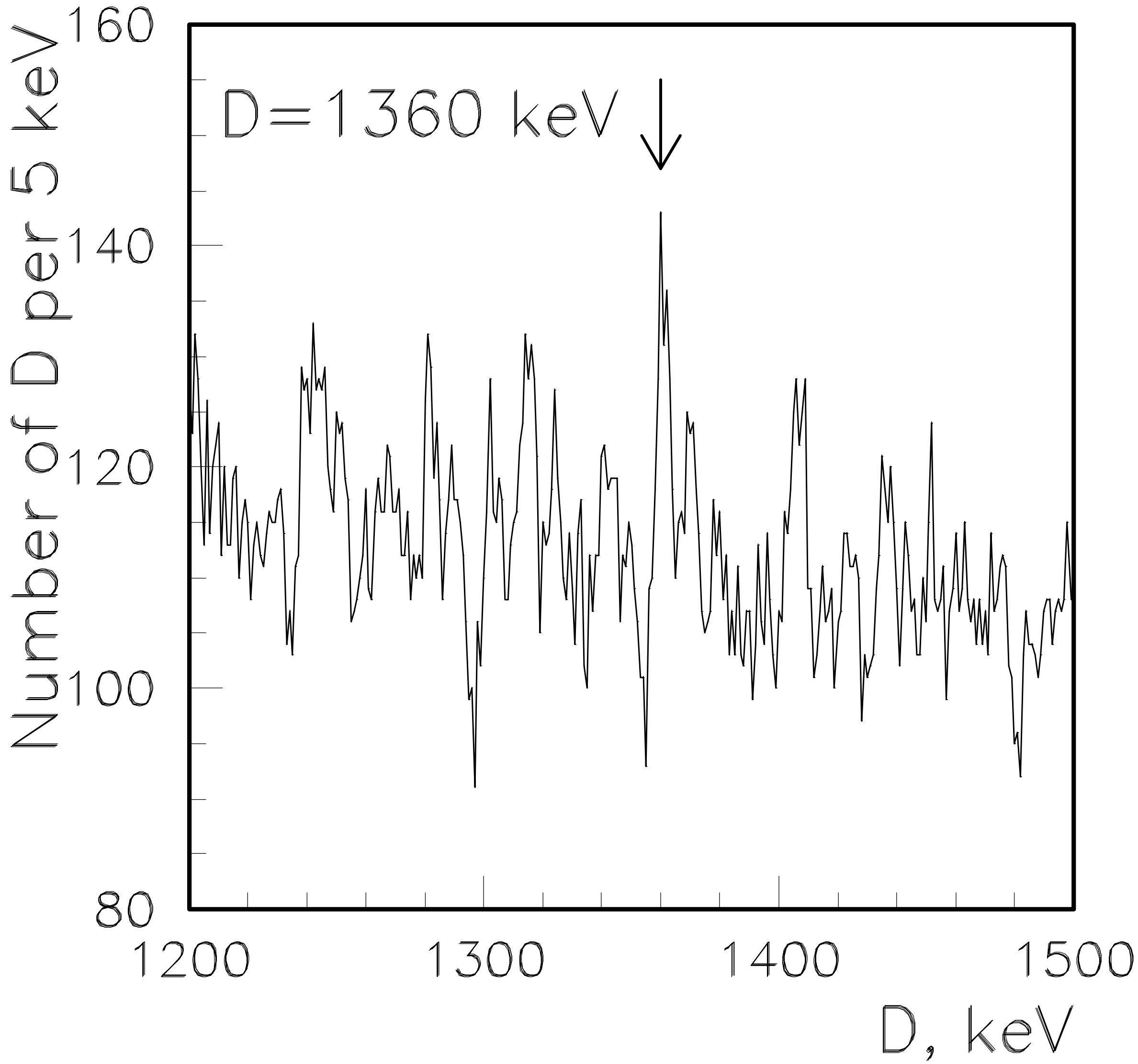
b)
26ε0
30ε0
34ε0
Number of ΔE_B per 0.5 MeV
S_4n(MeV)



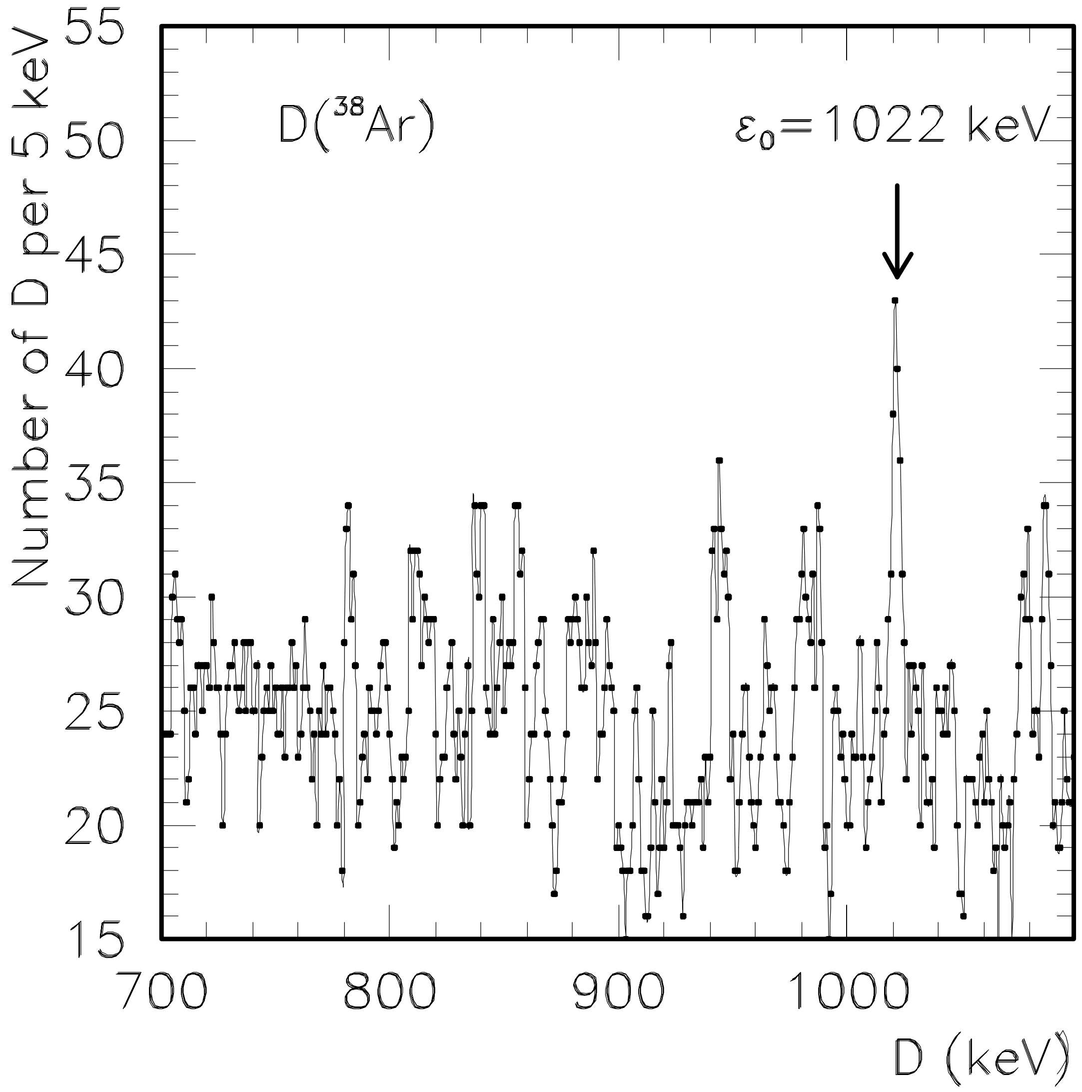
ΣE* (A≦150)
ε0=1022 keV
Number of E* per 5 keV
20
30
40
50
60
70
80
90
1000
1100
1200
E*(keV)



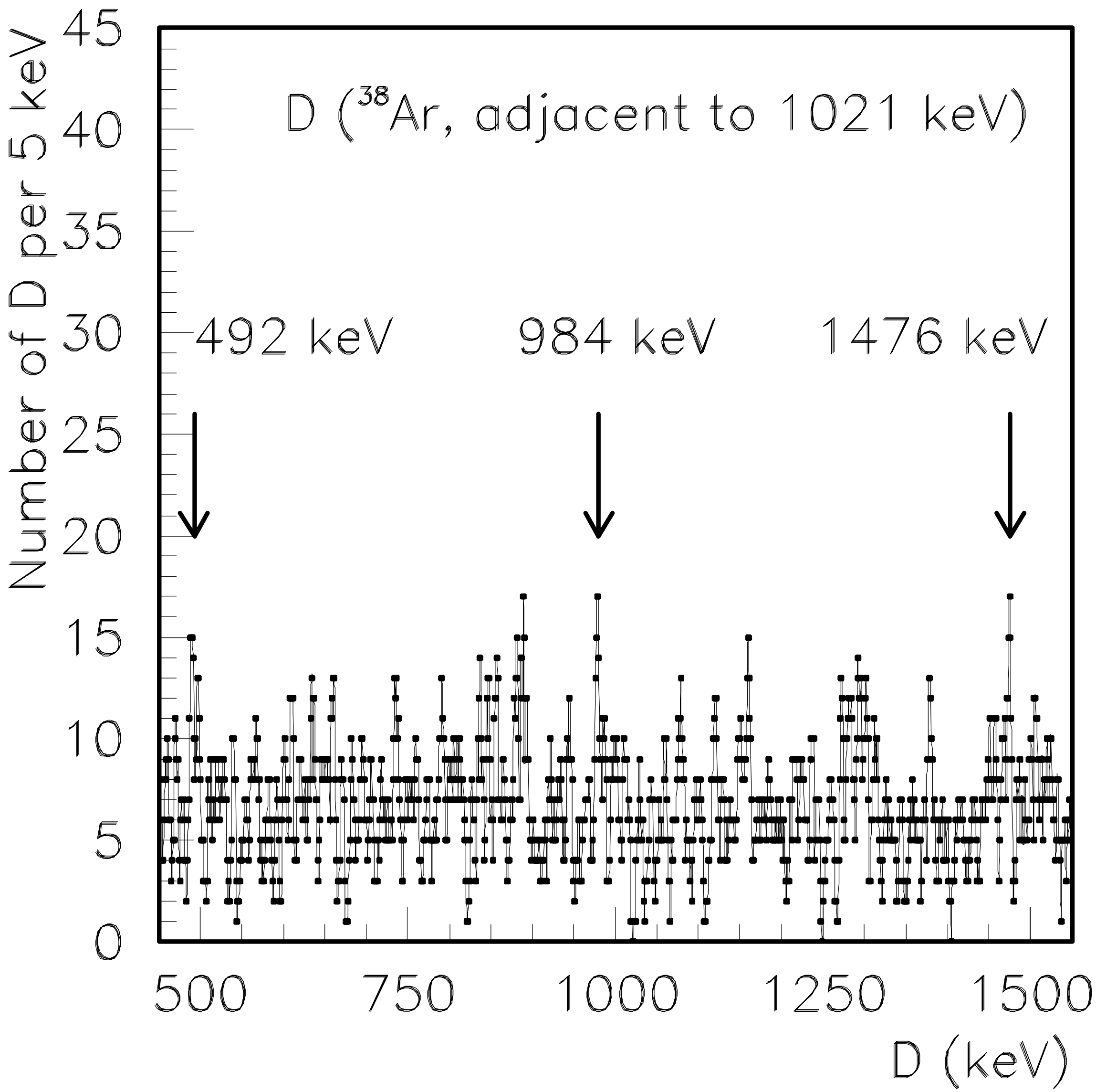
D=1022 keV
30
20
10
0
900
1000
1100
D, keV
Number of D per 5 keV



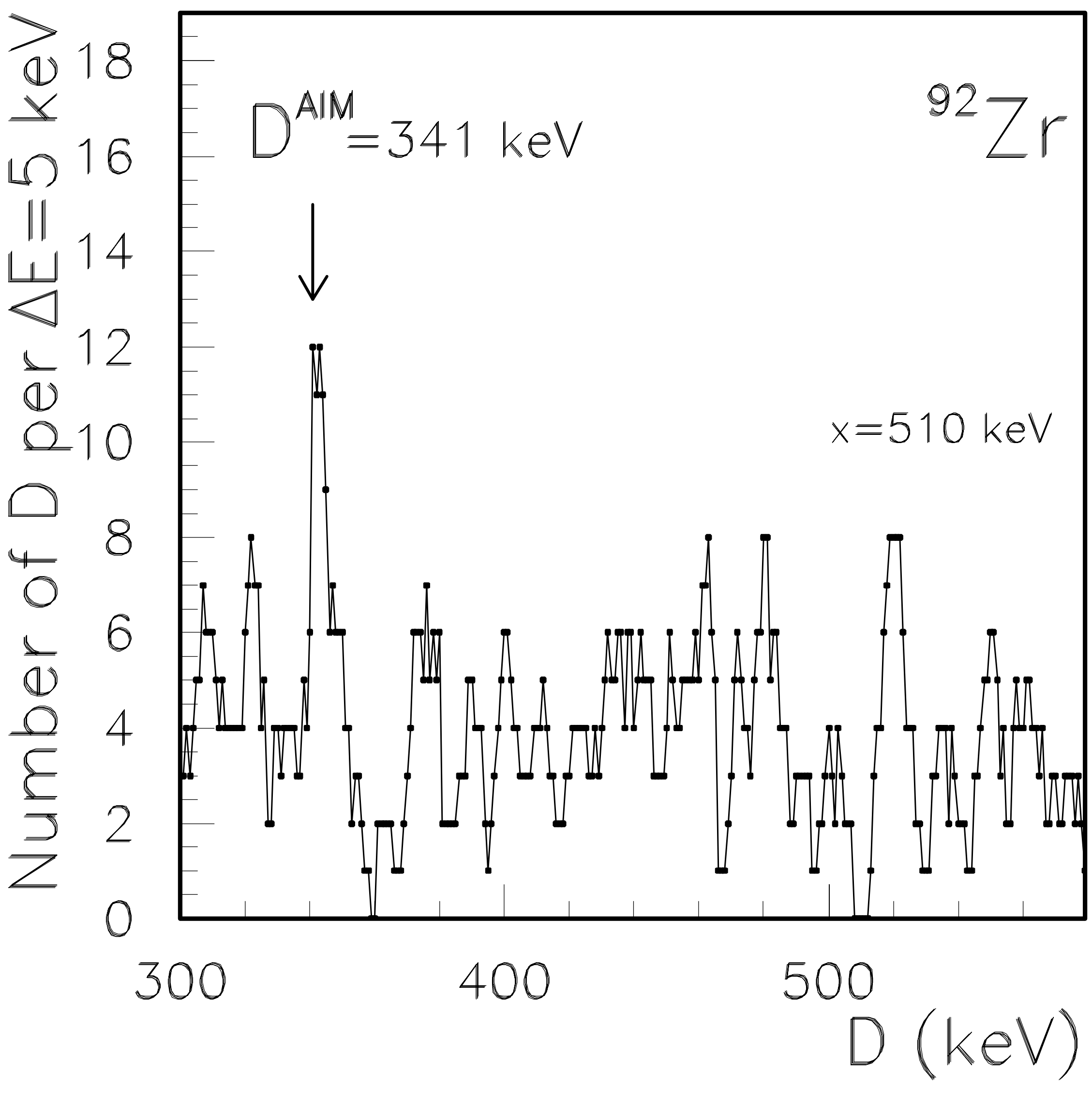
D=1360 keV
Number of D per 5 keV
160
140
120
100
80
1200
1300
1400
1500
D, keV



Number of D per 5 keV
D(^{38}Ar)
ε_0=1022 keV
55
50
45
40
35
30
25
20
15
700
800
900
1000
D (keV)



D (^{38}Ar, adjacent to 1021 keV)
492 keV
984 keV
1476 keV
Number of D per 5 keV
0
5
10
15
20
25
30
35
40
45
500
750
1000
1250
1500
D (keV)



Number of D per ΔE=5 keV
18
16
14
12
10
8
6
4
2
0
300
400
500
D (keV)
D^AIM=341 keV
92Zr
x=510 keV

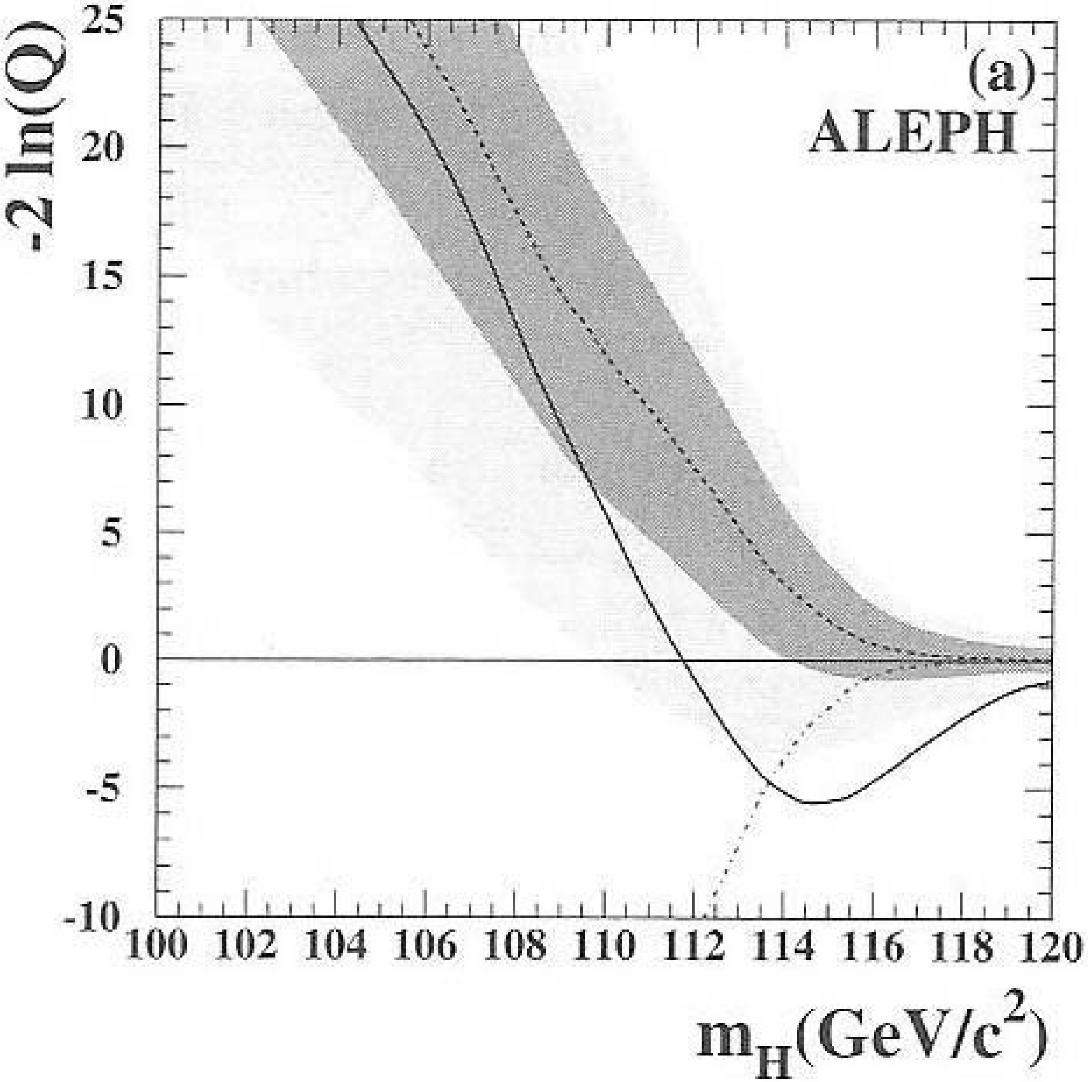


Fig.8. ALEPH results with about 3 standard deviation at mass 115 GeV; observed (solid line) and the expected behaviors of the test statistic (dark region) are presented and discussed in [1].

Table 3. Representation of parameters of tuning effects in particle masses (upper part) and in nuclear data by the expression $(n\times m_e(\alpha/2\pi)^x)\times m$ with α=137^{-1} [5]. Asterisk marks stable intervals observed in low-energy excitations and neutron resonances; ε_{np}=340 keV is discussed in the text, Fig.7

x	m	n=1/8	n=1	n=13	n=16	n=17	n=18
-1	1			M_Z=91.188	M_H=115		
GeV	3				$2m_t$=348		
0	1	$2m_e$	$16m_e$	m_μ=105.658		m_π-m_e	147=ΔM_Δ
MeV	1	ε_o	δ	106.4=ΔE_B	130=ΔE_B	140=ΔE_B	147=ΔE_B
	3				$M_q''=m_\rho/2\approx m_\omega/2$	M_q'=420	M_q=441=ΔE_B
1	1	1.2*	9.48=δ'*	123*	152*	161*	170*
keV	2			246*	303*	321*	ε_{np}=340=$\varepsilon_o/3$
	3			368*	455*	481*	511=$\varepsilon_o/2$
	8	9.5*	76*	984, Fig.8	1212*	1293=D_o	1360, Fig.8
2	1		11*	143*	176*	187*	D in neutron
eV	4	5.5*	44*	572*		750 - 1500*	resonances

Lepton ratio as the distinguished parameter

Earlier, as a realization of Nambu's suggestion to search for empirical mass relations needed for SM-development, it was noticed in [5,6] that

1) the well-known lepton ratio L=m_μ/m_e=206.77 becomes the integer 207=9*23=13*16-1 after a small QED radiative correction applied to m_e (it becomes $m_\mu/m_e(1-\alpha/2\pi)$=207.01)

2) the same ratio L=207 exists between masses of vector bosons M_Z=91.188(2) GeV and M_W=80.40(3) GeV and two above discussed estimates of baryon/meson constituent quark masses M_q=441 MeV=$m_{\Xi^-}/3$=(3/2)(m_Δ-m_N) and

M''_q =$m_\rho/2$=775.5(4) MeV/2=387.8(2) MeV

[1] (M_Z/441 MeV=206.8; $M_W/(m_\rho/2)$=207.3 [5,6]). The origin of these effects should be considered in the complex analysis of tunung effects in particle masses and in nuclear data [5,6].

Conclusions

The QCD-based estimates of the constituent quark masses (M^0_q=420 MeV, M_q=441 MeV, M''_q) could play important role in the description of Standard Model dynamics if the observed now empirical relations in particle masses (and value M_H) would be confirmed in the experiment.

Nuclear data can provide some important additional information on fundamental properties of strong nucleon interactions and nuclear matter as well as general properties of fermion systems.