Compilation of Nuclear Binding Energies MDF

S.I. Sukhoruchkin, D.S. Sukhoruchkin

Petersburg Nuclear Physics Institute, 188300 Gatchina

Abstract

The role of pion-exchange dynamics in tuning effects in nuclear binding energies was studied with data from the compilation MDF (Mass Difference File).

1 Introduction

In this report we describe data analysis from the compilation MDF (Mass Difference File) [1] in connection with A.Arima and A.Bohr remark that nuclear binding energies and nuclear excitations are results of the same nucleon interaction. Hence positions of neutron resonances being the difference between them could provide additional information on properties of nucleon interaction. Correlations in neutron resonance positions were reported by M.Ohkubo, K.Ideno, G.Rohr, F.Belyaev and others (see [2] and the previous previous ISINN). According to Arima-Bohr suggestion the same parameters should be used for the description of few-nucleon effects in both nuclear characteristics E^* and E_B.

It was noticed by C. Detraz: "...the force at work between nucleons is not the genuine strong force but only what spills over from the quark bag. This leads to setting for an effective force ... should not be taken to mean that nuclear science is completely understood ... First, one lesson from a hundred years ago is that a breakthrough is not always foreseen ... The hadronization of quarks ... can best be clarified when quarks are studied within a collective state, i.e. in the nucleus... Concerning point 2 ... it is probably insufficient known that nuclear physics ... has provided illuminating insight into some of the most basic properties of matter. For one of its properties at least, the nucleus exhibits of a pure interaction. It is the weak interaction, as occurs in Fermi transition between two analogous 0^+ states" [3]. This remark permits to distinguish in the nuclear spectra the 0^+ state. In the ^{10}B it is a member of $\pi p_{3/2}\nu p_{3/2}$ multiplet and beside states 0^+-1^+-2^+-3^+ the remaining 1_1^+ state corresponds to the spin-flip effect of $1p$ nucleons. The corresponding distance ε_o=$E^*(0^+)$-$E^*(1_1^+)$ coincides within 10^{-4} with $2m_e$. Presented in Table 1 excitations in light nuclei and standard parameters ε_{2n2p} of the residual interaction of valence nucleons in this region [4] are rational to the ε_o. Relations in any mass/energy data with $2m_e$ and with nucleon and pion mass differences were named "tuning effect".

Table 1. Comparison of E^* and ΔE_B (keV) in near-magic nuclei with multiples of ε_o=$2m_e$

^{A}Z	^{10}B	^{10}B	^{10}B	^{12}C	(T=2)	^{16}O	^{18}Ne	^{18}Ne	^{18}Ne	^{18}Ne	^{20}Ne	^{8}Be
J^π	$^+0$-$^+1$	2^-	3^-	0_1^+	0^+	3^-	0_1^+	0_2^+	2^+		$\frac{\varepsilon_{2n2p}}{4}$	$\frac{\varepsilon_{2n2p}}{4}$
E*	$\boxed{1021.8(2)}$	5110	6127	7654	27595	6130	3576	4590	5106	6137	4076	7151
n(ε_o)	$\boxed{1}$	5	6	15/2	27	6	7/2	9/2	5	6	4	7
n·ε_o	1022.0	5110	6132	7665	27594	6132	3577	4599	5110	6132	4088	7154
Diff.	0.2(2)	0.3	3	11	1(2)	2	1(2)	9(8)	4(8)	5	-12	-3

2 The role of cluster effects

Cluster effect in binding energies is one of the ways for a study of tuning effect. The stability of experimental differences of binding energies ΔE_B in nuclei with N≤82 is clearly seen as a sharp maximum in Figure 1 [4] at 46.0 MeV=$45\varepsilon_o$. It corresponds to the grouping of ΔE_B in nuclei differing with ΔZ=2, ΔN=4 (^{6}He cluster, Fig.2 left [5]).

In Tables 2 a long-range correlations in values ΔE_B with the parameter ε_o are seen from their proximity to the integer number of ε_o (small boxed values in the central part of Table 2). Theoretical values ΔE_B from all existing models do not show such effect (large differences at the bottom). Similar correlation was observed in the near-magic light nuclei during the study 4α and 2α clusters (two first columns of Table 3 and Fig 3 top).

Table 2. Comparison of ΔE_B, keV in nuclei differing by 2ΔZ=ΔN=4 with $45\varepsilon_o$=45990 keV.

Nucl.	^{133}Cs	^{135}Cs	^{137}Cs	^{135}La	^{137}La	^{139}La	^{136}Ce	^{138}Ce	^{140}Ce	^{139}La
N	78	80	$\boxed{82}$	78	80	$\boxed{82}$	78	80	$\boxed{82}$	$\boxed{82}$
ΔE_B	45952	45946	45970	46018	45927	46024	46087	45997	45996	91975
diff.	-38	-44	$\boxed{-20}$	28	-63	$\boxed{34}$	97	$\boxed{7}$	$\boxed{6}$	$\boxed{-5}$
Theory	46143	46353	46550	45933	46203	46673	46373	46573	47063	92816
diff.	153	363	$\boxed{563}$	-57	213	$\boxed{683}$	383	583	$\boxed{1073}$	$\boxed{836}$

Table 3. Comparison of E^* and ΔE_B (in keV) of some near-magic nuclei with n×ε_o

^{A}Z	^{36}K	^{39}K	^{39}Ca	^{119}Sb	^{118}Sn	^{101}Sn	^{103}Sn	^{116}Sn	^{118}Sn	^{118}Sn	^{117}Sn
N	17	$\boxed{20}$	$\boxed{19}$	69	68	$\boxed{51}$	53	66	68	68	67
$2J_o^\pi$,J_o^π	ΔE_B	ΔE_B	ΔE_B	ΔE_B	ΔE_B	7^+	7^+	0^+	0^+	0^+	1^+
$2J^\pi$,J^π	4α	4α	S_n	S_p	S_{p2n}	5^+	5^+	0^+	2^+	0^+	5^+
E^*, ΔE_B	147152	147160	13289	5109	25547	$\boxed{171.7}$	168.0	2027	2043	2057	1020
n(ε_o)	16×9	16×9	13	5	25	1/6	1/6	2	2	2	1
n×ε_o	147168	147168	13286	5110	25550	170	170	2044	2044	2044	1022
diff.	16(10)	$\boxed{-8(2)}$	$\boxed{3(5)}$	-1	-3(4)	$\boxed{1}$	-1	17	-1	13	-2

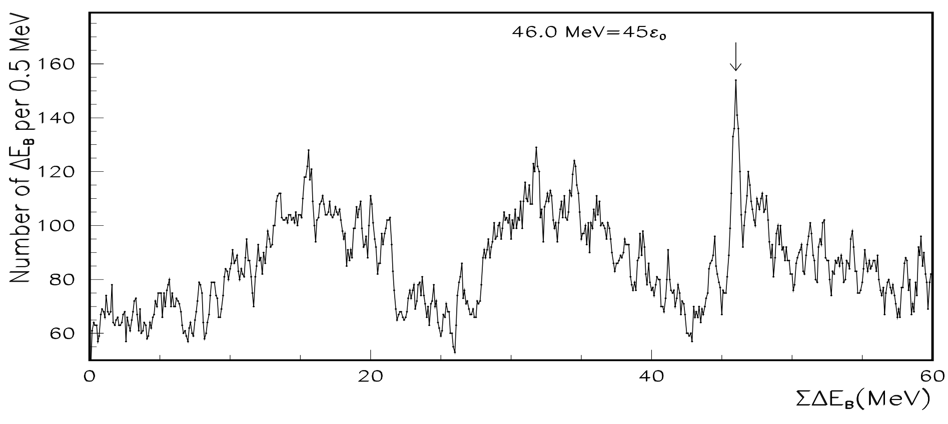

Fig.1. Distribution of differences of binding energies ΔE_B in nuclei with Z≤58; the maximum at $45\varepsilon_o$=46.0 MeV corresponds to the grouping of ΔE_B in nuclei differing with ΔZ=2, ΔN=4.

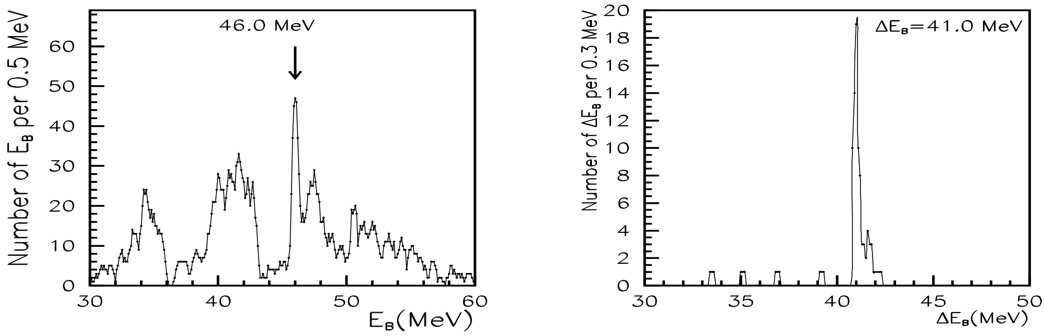

Fig. 2 ΔE_B-distributions connected with ^{6}He-clusters in nuclei with N≤82 and Z=78,82 [5].

Stability of differences of E_B (values ΔE_B) in light nuclei differing with ΔZ=ΔN=2 (α-cluster) was noticed by F.Everling. It results in maxima in ΔE_B-distributions at 73.6 MeV=9×8ε_o and 147.3 MeV=18×8ε_o in nuclei differing with 2α- and 4α-clusters (ΔZ=δN=4 and ΔZ=ΔN=8, Fig.3 top). Simultaneously the grouping effect in values ΔE_B was found in all even-even nuclei at 409 MeV (close to 50×8ε_o=50δ, δ=8ε_o) and in all odd-odd nuclei at 3×147 MeV=441 MeV (close to 54×8ε_o=3×18=54δ, Fig.2 bottom [5]). Parameter δ=8ε_o=16m_e is close to the doubled value of the pion β-decay energy (2δm_π-2m_e) due to the proximity of the pion mass splitting δm_π to 9m_e=Δ [6,7]. In Fig 4 other observed correlations in values E_B with parameters Δ=9m_e and δ=16m_e are presented [5].

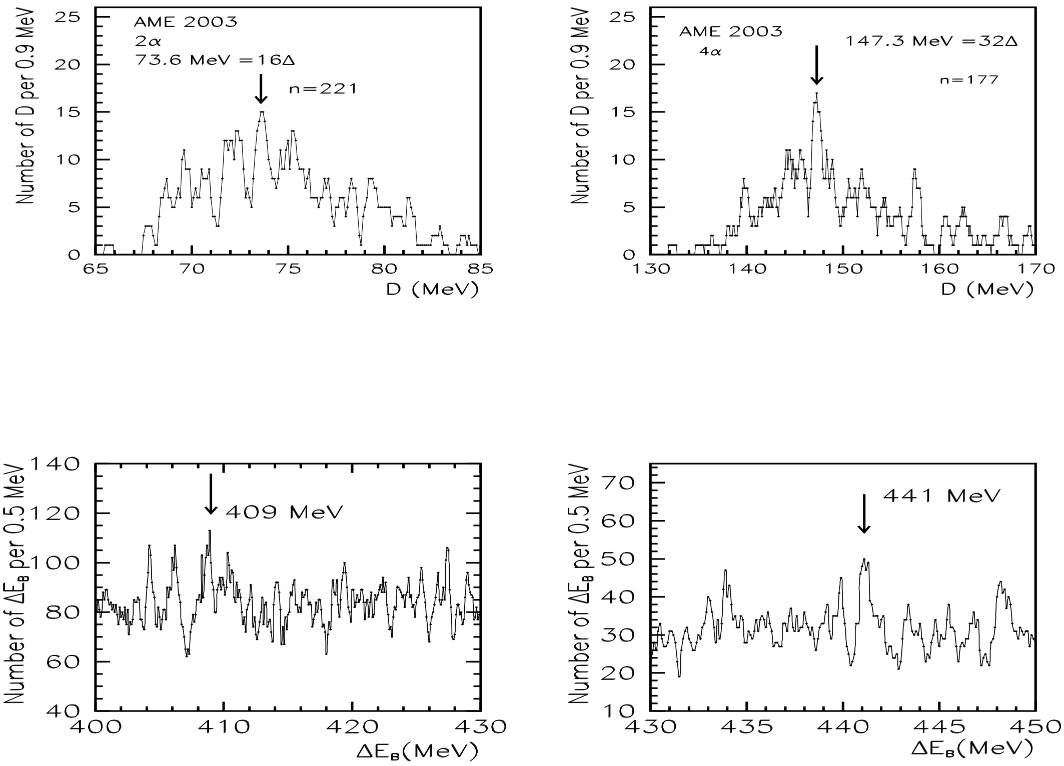

Fig. 3 ΔE_B-distribution of 2α- and 4α-clusters in light nuclei Z≤26 (top) [5].
ΔE_B-distribution in all even-even and all odd-odd nuclei separately (bottom).

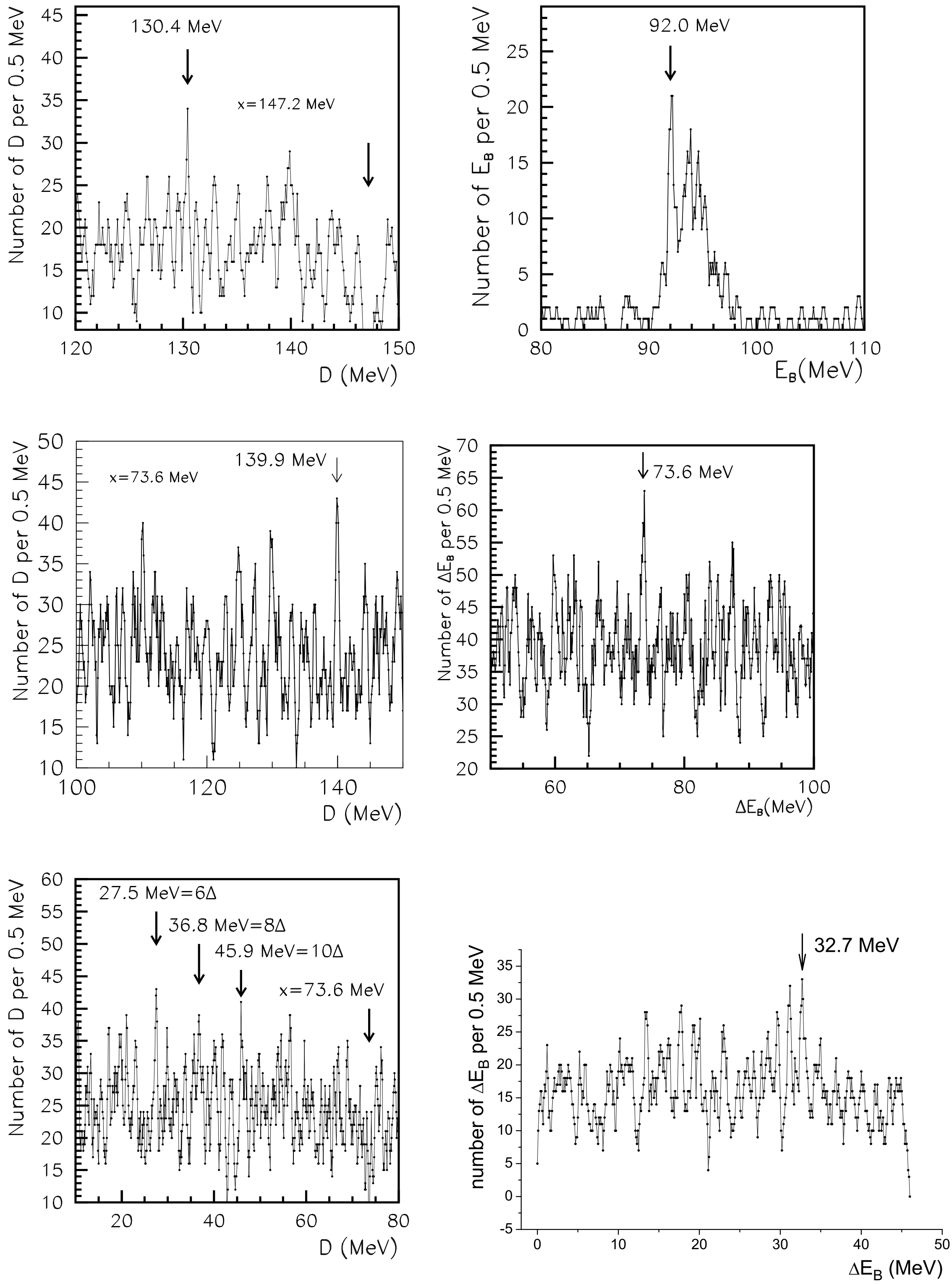

Fig. 4 *Top left:* Adjacent Interval Method (AIM) analysis of E_B for all nuclei with Z≤26 and x=147.2 MeV=18δ=32Δ=144ε_o with the maximum at 130.4 MeV=16δ. *Top right:* ΔE_B-distributions for $2\Delta Z = \Delta N$=8 , N even. *Center left:* AIM analysis of all nuclei with Z≤26 and x=73.6 MeV=8δ, the maximum at 139.9 MeV=17δ. *Center right:* AIM analysis of all nuclei Z≤26 and x=147.2 MeV=18δ, the maximum at 73.6 MeV=8δ. *Bottom left:* AIM analysis of all nuclei Z≤26 and x=73.6 MeV=8δ=16Δ. *Bottom right:* AIM analysis of odd-even nuclei and x=46.0 MeV=45ε_o with maxima at 31.2 MeV and 32.7 MeV=32ε_o (data AME2012).

AIM method was used to check the tuning effect in E_B of odd-even nuclei. Using x=46.0 MeV=$45\varepsilon_o$ (the maximum in Fig.2) the maximum was found at ΔE_B^{AIM}=32.7 MeV=$32\varepsilon_o$.

The interval ΔE_B=147.1 MeV=$18\times8\varepsilon_o$ was found also in all heavy nuclei differing with ΔZ=8, ΔN=14 (two neutron less than 4^6He, Fig.7 top). This effect preserves in new data from AME2012 [8]due to the fact that maxima in distributions are located at nearly the same energy ΔE_B for all types of nuclei (Fig.8 center and bottom).

Periods ε_o and $\Delta=9m_e$ were observed in ΔE_B-distributions in N-even and N-odd nuclei Z=50-82 corresponding to four proton separation energies (Fig.6 top) as well as in all N-even and odd-odd nuclei (Fig.6 bottom, data from MDF).

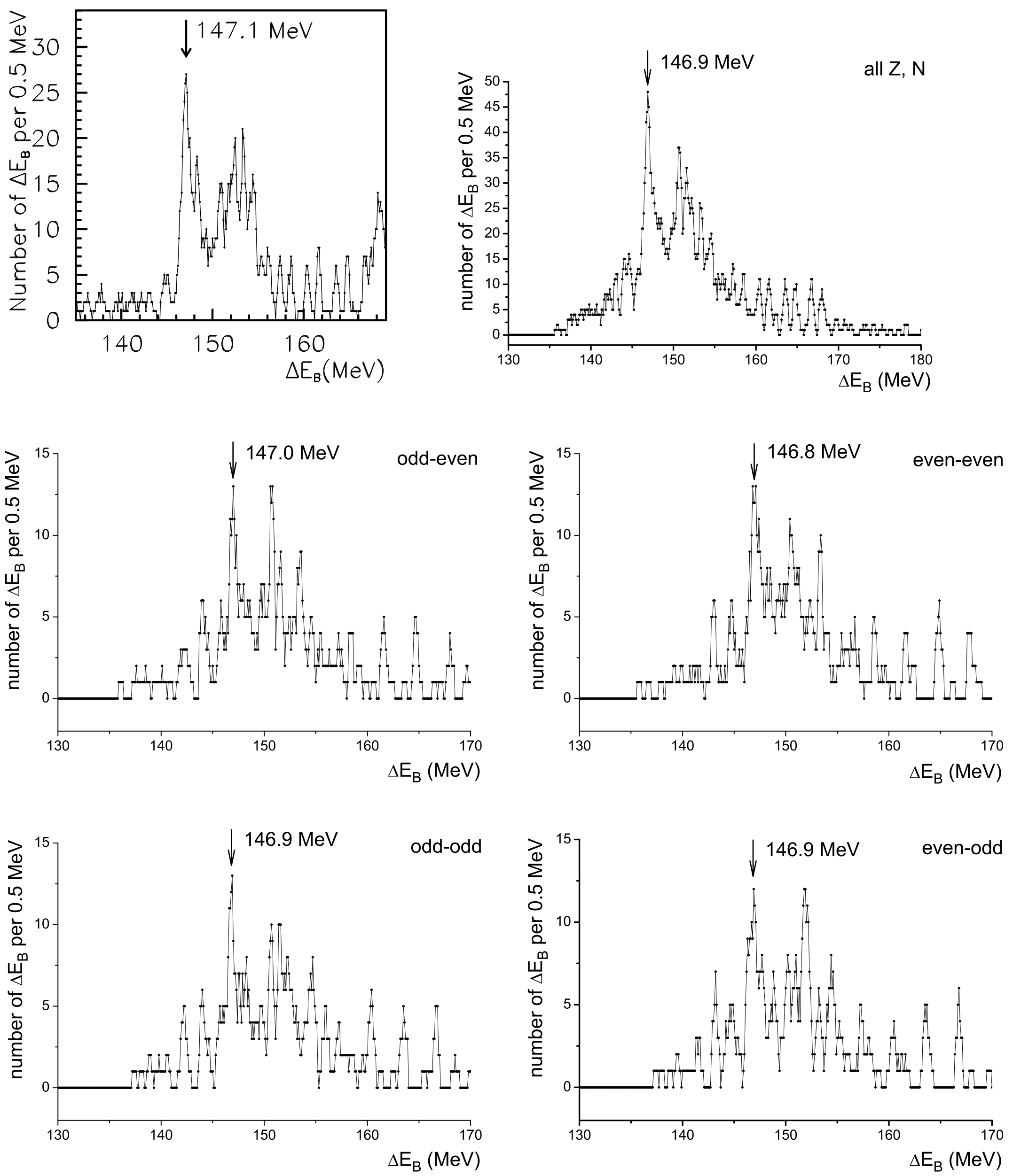

Fig. 5 *Top:* ΔE_B-distributions in all nuclei with ΔZ=8, ΔN=14 and N=82-126 with data from MDF (*left*) and from AME2012 [8] (*right*). *Center and bottom:* Parts of total ΔE_B-distribution for different types of heavy (N=82-126) nuclei: odd-even, even-even, odd-odd and even-odd nuclei separately (data from AME2012).

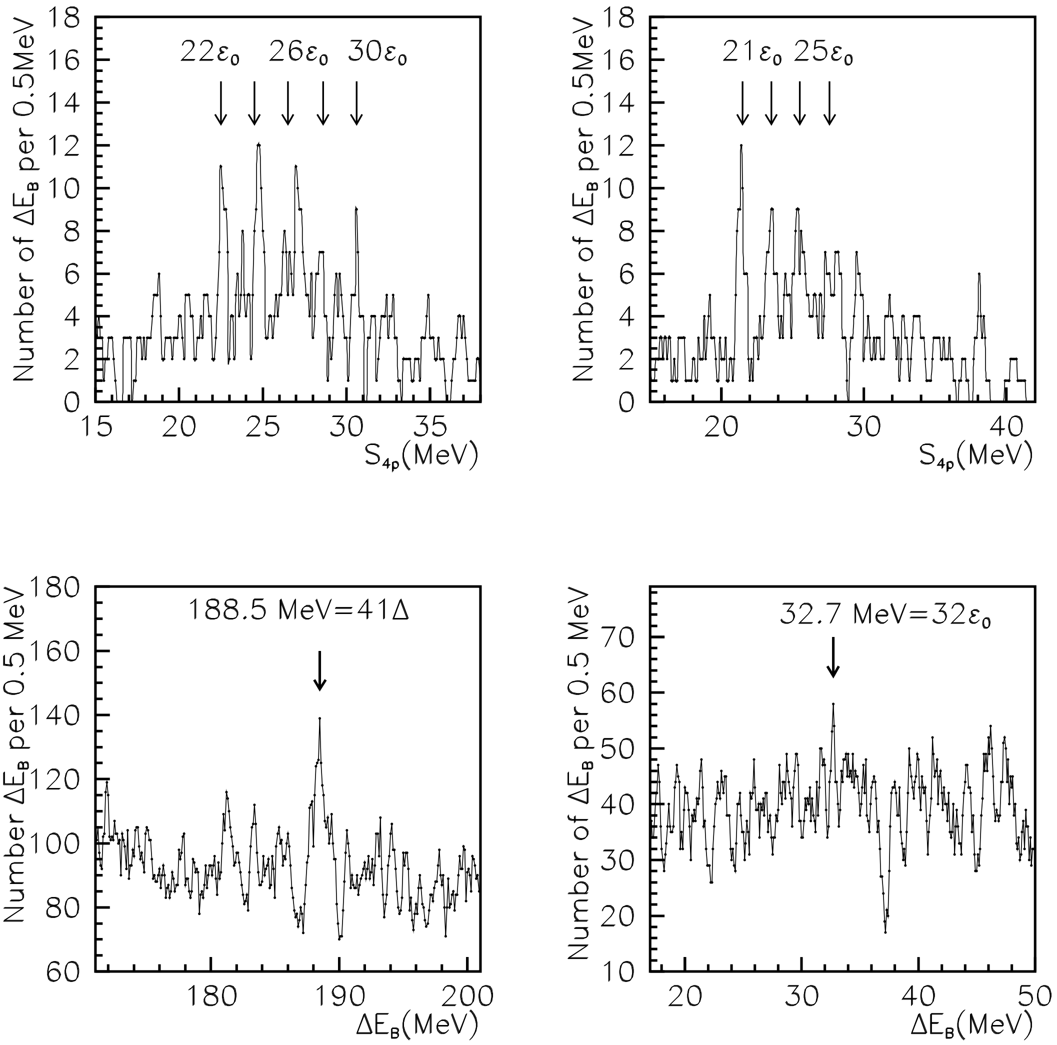

Fig. 6 *Top:* ΔE_B-distributions in N-even and N-odd nuclei Z=50-82 corresponding to four proton separation energies (period ε_o is marked, data from MDF). *Bottom:* ΔE_B-distributions in all N-even and all odd-odd nuclei, arrows mark integer numbers of periods ε_o and Δ=$9m_e$.

3 Confirmation of the Devons suggestion

At the 1961 Rutherford Conference Samuel Devons stated a suggestion [9]: "it is a natural temptation to make comparisons between the present stage in the study of nuclear structure with the exploration of atomic structure in Rutherford's time... the study of optical spectra, ... became a fruitful means of examining the refined details of atomic structure after Rutherford's direct approach led to the Bohr theory, and the subsequent development of quantum mechanics. ... there are still to be discovered subtle features of complex nuclei... which may even prove difficult to observe in direct study of the elementary particles themselves ... cases as the study of some elementary-particle ... can be facilitated by observation of phenomena involving complex nuclei, the fullest possible understanding of nuclear structure becomes a prerequisite".

The confirmation of Devons suggestion [10-11] is based on the fact that nucleon mass difference m_n-m_p=δm_N=1293.3 keV is a well-known parameter of the nucleon structure. There is a systematical observation of this value as the stable nuclear excitation in Z,N-regions where pion-exchange dominates [10-15]). In data from 5-volumes compilation CRF [14] in three (out of five) independent E^*-distributions there are maxima at 1291–1294 keV ($\approx \delta m_N$=1293 keV) and a sequence of maxima at E^*=161 keV – 483 keV – 644 keV (Fig,7 bottom) [15].

This effect of stable excitations was noticed initially in Sb-isotopes as a linear trend in E^* for N=72-82 (small deviation from 161 keV×n in Table 4 center). It was explained [12] as a stable character of an interaction between $1g_{7/2}$ proton and pairs of $1h_{11/2}$ neutrons, namely, parallel spins and opposite direction of orbitals of interacting nucleons strongly enhance tensor forces due to the pion-exchange [14]. The observed slope 161 keV manifests itself also as a maximum at D=160 keV in D-distribution of neighbour isotopes ^{122,124}Sb (Fig. 7 top left).

The presence of maxima in D-distributions due to very stable and simple dynamics could be reflected in nonstatistical effects in spacing of higher excitations seen as neutron resonances. Maxima in spacing distribution of resonances in the same ^{124}Sb (Fig.8 top left) correspond to numbers n=2×17 and n=4×13 of the period δ''=11 eV observed by K.Ideno [16].

Table 4. Comparison of E^* in Z = 51 nuclei with n×(161 keV=1293 keV/8).

^{A}Z	^{123}Sb	^{125}Sb	^{127}Sb	^{129}Sb	^{131}Sb	^{133}Sb	^{125}Sb	^{119}Sb	^{116}Sn	^{116}Sn
(N-70)/2	1	2	3	4	5	6				
E^*, keV	$\boxed{160.3}$	$\boxed{332.1}$	$\boxed{491.2}$	$\boxed{645.2}$	$\boxed{798.4}$	$\boxed{962.0}$	644	644.0	$\boxed{1293.6}$	1292.0
E^*-$\frac{\delta m_N}{8}$	$\boxed{-1}$	-9	+7	$\boxed{-1}$	-10	-7	-2	-2	$\boxed{1}$	$\boxed{-1}$
n$\frac{\delta m_N}{8}$	161	323	484	646	808	969	646	646	1293	1293
E^*,Fig.4	160		483	644			644	644		

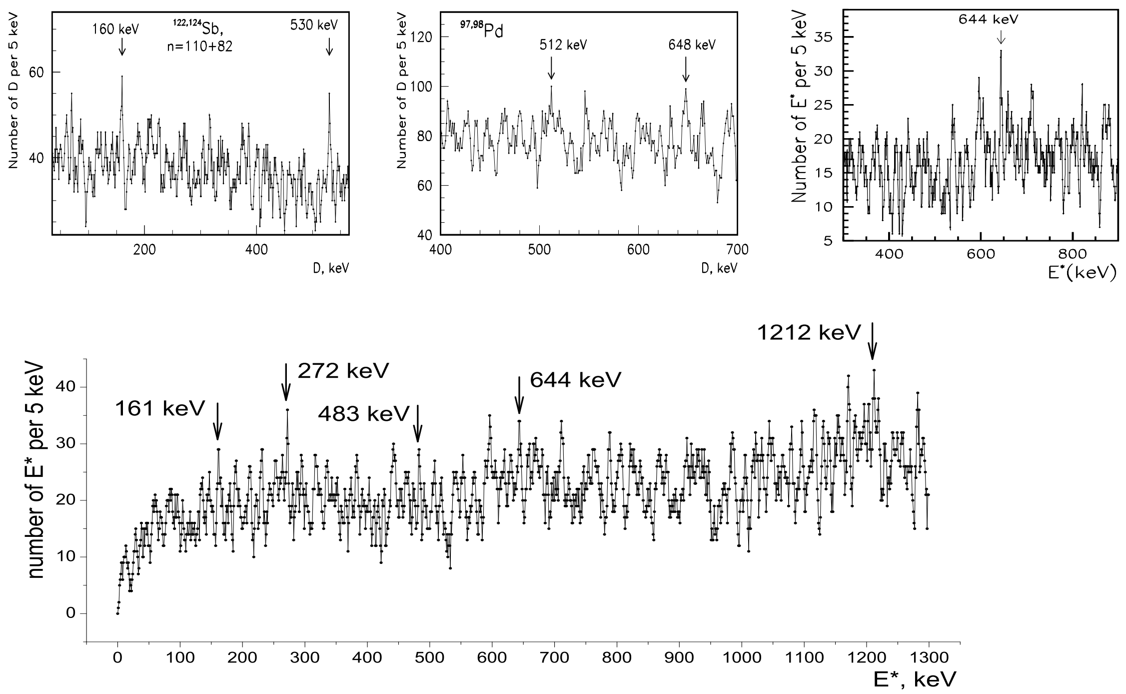

Fig.7. *Top left*: Sum D-distribution in ^{122,124}Sb and the same in ^{97,98}Pd with maxima at 512 keV=ε_o/2 and 648-δm_N/2. *Top fight*: Sum E^*-distribution in Z-odd nuclei Z=47-57. *Bottom*: Sum E^*-distribution of all nuclei with Z=48-60 (ΔE=5 keV) [14,15], Table 4 bottom line.

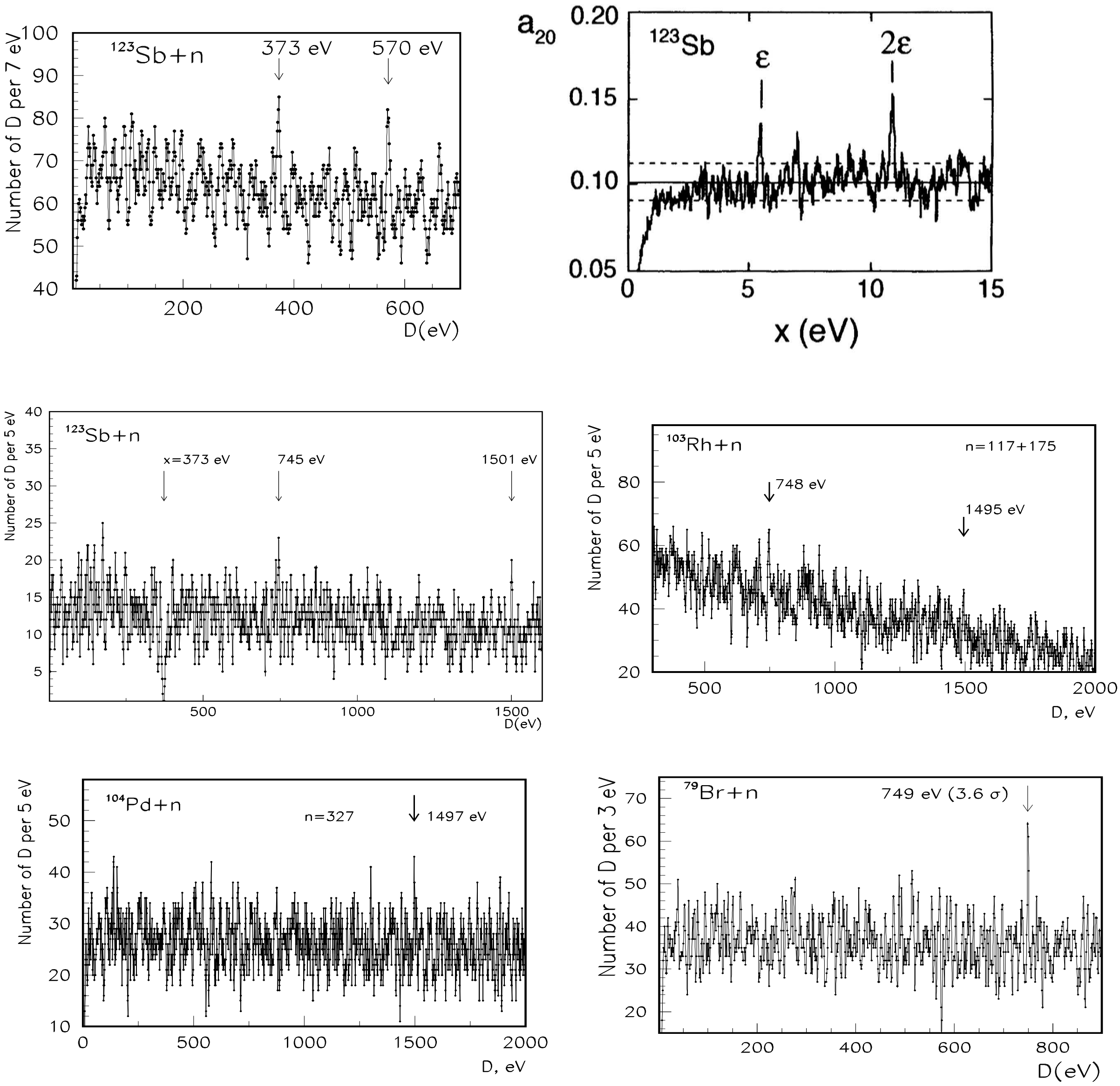

Fig. 8. *Top left:* Spacing distribution in neutron resonances of ^{123}Sb. *Top right:* Performed by K.Ideno [16] search for a periodicity in ^{123}Sb resonances: the period 2ε=11 eV corresponds to $8\times\varepsilon''$=11 eV introduced in [7].) *Center:* Spacing distribution of resonances in ^{123}Sb adjacent to x=D=373 eV, the ratio 1:2:4. *Bottom:* D-distributions in resonances of ^{103}Rh, ^{104}Pd, ^{79}Br.

Intervals 373–745–1501 eV (ratio 1:2:4) in ^{124}Sb were found by the Adjacent Interval Method [17] (they are forming triplets, Fig.8 center). Such small stable intervals D=750-1500 eV were found also in D-distributions of neutron resonances in ^{104}Rh, ^{105}Pd, ^{80}Br etc. (Fig.8 bottom). In data for low-lying levels of ^{97,98}Pd observed stable interval D=648=4×161 keV (Fig.4 top center) and D=1293 keV=δm_N [18] correspond to the equidistant excitations in ^{97}Pd (N=51) [14].

We come to conclusion that stable character of a part of nucleon interaction which resulted in observed common nonstatistical effects in different nuclei (at low energies and at high excitations as well) could be considered by taking into account the fact that the mass of the charged pion is a natural parameter in pion-exchange processes. The ratios between common intervals 161 keV=$\delta m_N/8$ and $m_{\pi^\pm}$=140 MeV ($1.15\cdot 10^{-5}$) and the ratio between D=1500 eV (in resonances) and δm_N are close to the well-known QED radiative correction $\alpha/2\pi$=$1.159\cdot 10^{-5}$.

The above mentioned radiative correction of the type $g/2\pi$ is used frequently for the comparison of effects with different scales [19]. In Table 5 some of such examples are given starting with the coincidence of the ratio m_μ/M_Z with $\alpha/2\pi$ used in construction of Table 6 to represent together particle masses (upper part of Table 6), parameters of NRCQM model and stable intervals in E_B, the discussed nuclear intervals of fine and superfine structures and the ratio m_s/M_H between the mass of the current strange quark m_s=147-150 MeV in NRCQM and the preliminary value M_H of the SM-scalar from ATLAS-experiment [20] (bottom line of Table 5).

Table 5. Comparison of the parameter $\alpha/2\pi$ with ratios between mass/energy values.

No	Parameter	Components of the ratio	Value $\times 10^5$
	$\Delta\mu_e/\mu_e$	$=\alpha/2\pi$-0,328 α^2/π^2	115.965
	$\delta(\delta m_\pi)/9m_e$	$\boxed{[\Delta\text{-4593,66(48)keV}]/(9m_e=\Delta)}$	116(10)
	$\delta m_\mu/m_\mu$	$[(23\text{x}9m_e\text{-}m_\mu]/m_\mu$ [7]	112.1
	$\eta_{+-}/2$	$2.285(19)\times10^{-3}/2$ [21]	114(1)
1	m_μ/M_Z	$\boxed{m_\mu/M_Z\text{=91161(31) MeV}}$	$\boxed{115{,}90(4)}$
2	$\varepsilon''/\varepsilon'$	1,35(2) eV/1,16(1) keV [7]	116(3)
	$\varepsilon'/\varepsilon_o$	1,16(1)keV/ε_o=1022 keV [7]	114(1)
	$\varepsilon_o/2M_q$	$\varepsilon_o/3(m_\Delta\text{-}m_N)$ [7]	116.02
3	$\delta m_n/m_\pi$	$\boxed{(\text{nx}m_e\text{-}m_n)/m_\pi\text{=161,7(2) keV}/m_\pi}$	115.86
4	m_s/M_H	147 keV/126 GeV [20]	117

Table 6. Presentation of parameters of tuning effects in particle masses and nuclear data (in lines marked X=-1, 0, 1, 2 at left) by the common expression n$\cdot$16m$_e(\alpha/2\pi)^X$M with the QED radiative correction $\alpha/2\pi$ (α=137^{-1}). Values m$_\pi$-m$_e$, m$_e$/3, the neutron mass shift N$\delta - m_n - m_e$, m_s and the possible Higgs boson mass [20] are boxed. Stable intervals in excitations (E*, D_{ij}, X=1) and in neutron resonances (X=2) are considered as indirect confirmation of relations in particle masses (X=-1). The value Δ° ≈4 GeV close to m_b was observed at TEVATRON [23].

X	M	n = 1	n = 13	n = 16	n = 17	n = 18
-1	3/2			m_t=171.2		
GeV	1	$2\Delta^\circ$-2M_q	M_Z=91.2	M_H=115 [22]		$\boxed{M_H=126}$ [20]
0	1	16$m_e=\delta$	m_μ = 105.7	f_π=131	$\boxed{m_\pi\text{-}m_e}$	$\boxed{m_s=147\text{-}150}$
MeV	1	2Δ-ε_0	106 = ΔE_B	130 = ΔE_B	140 = ΔE_B	147.2 = ΔE_B
	1					m_Δ-m_n/2=147
	3			M"$_q$ = $m_\rho/2$	NRCQM	M_q=441=ΔE_B
1	1				$\boxed{N\delta\text{-}m_n\text{-}m_e=161.6(1)}$	$\boxed{170 = m_e/3}$
keV	1	9.5	123	152	161 (^{18}F, Sb)	512 (Co, Pd)
	4		492		648 (^{97,98}Pd)	682(Co)
	8		984	1212	1293 (Pd), ΣE^*	1360 (Te)
2	1	11	143	176	187, 749 (^{79}Br)	D in neutron
eV	4	44	570 (Sb)		1500 (Sb,Pd,Rh)	resonances

4 Estimation of nucleon structure parameters

In Fig 9 the position of the nucleon mass (N, 940 MeV) among other masses is shown. The nucleon mass in nuclear medium is about 8 MeV below it on line between ω and Ω.

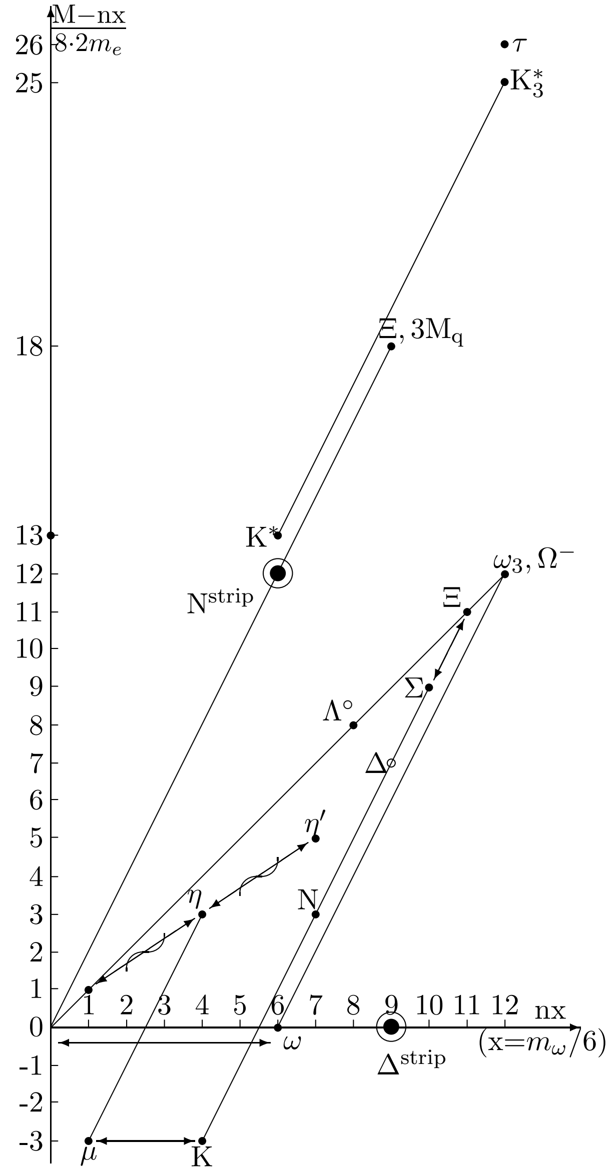

Fig.9. Position of different mass intervals and τ-lepton mass in two-dimensional presentation with the horizontal axis in units $16 \cdot 16 m_e$ close to $m_\omega/6$. The values M_i-k$\times$($16 \cdot 16 m_e$=δ) are displayed along the vertical axis in $16 m_e$ units. τ-lepton is somewhat above the integer number of M_q=$m_{\Xi^-}/3$ (its mass is twice the mass of K*-meson). Two lines with different slopes correspond to the pion mass (140 MeV=$m_\omega/6+\delta$) and to the stable intervals $m_{\eta'}$-m_η=m_η-$m_\pi^\pm$ (n=50 in units δ=$16 m_e$, crossed arrows). Δ^{strip} and N^{strip}=880 MeV are considered in [5]. The proximity of nucleon Δ-excitation $m_\omega/6+2\delta$=2$\times$147 MeV to stable interval between masses of the decuplet baryons (value m_s=147-150 MeV) gives the long line from kaon to Ξ. The lines corresponding to 2^+ excitation of both vector mesons (J^π=1^- – J^π=3^-, from K^* to K_3^* and from ω to ω_3) are parallel with the Sternheimer's interval M_q close to ΔM_Δ (these intervals are between η-meson – muon, kaon – nucleon, nucleon – Σ-hyperon).

Additional support for the Devons suggestion was found in the extension of the above discussed long-range correlations in nuclear data with the parameter ε_o, Table 1 for E^*, Tables 2,3 for ΔE_B). Boxed in Tables 5-7 are important relations between the accurately measured masses of the neutron and the electron (from m_p/m_er ratio and nucleon mass difference). The shift of the neutron mass relative to the integer number of δ=16m_e (115δ − m_e) is determined with the accuracy of 0.1 keV and within such uncertainty it accounts 161.6=(1/8)δm_N. The ratio 8·1.0003(2) exists between δm_N and the shift. Such shift was found also in nuclear data.

The confirmation of the value $M_{\rm H}$=126 GeV permits a consideration of additional relations with parameters m_s=ΔM_Δ=ΔE_B=147 MeV. Part of them is shown in Fig.9 (and Table 1 in [5]). Possible shift in masses of neutral octet baryons Σ° and Ξ° (Table 7 boxed) zre considered.

Table 7. Comparison of particle masses with periods 3m$_e$ and 16m$_e$=δ=8176.0 MeV (N periods), neutron Δ°-excitation is compared with 2ΔE_B; asterisk marks values considered elsewhere.

Particle	m$_i$, MeV	m$_i$/3m$_e$	N·16m$_e$	N	N-16m$_e$	Comments
μ	105.658367(4)	68.92*	106.2878	13	-0.6294	-0.511-0.118
π^o	134.9766(6)	88.05*	138.9917	17	-4.0174	
$\pi^\pm$	139.5702(4)	91.04*		17	+0.57624	+0.511+0.065
p	938.2720(1)	612.05*	940.2380(1)	115	-1.96660	$\boxed{\text{-m}_\text{e}\text{-(9/8)}\delta\text{m}_\text{N}}$
n	939.5654(1)	612.89*		115	-0.6726(1)	$\boxed{\text{-m}_\text{e}\text{-(1/8)}\delta\text{m}_\text{N}}$
Σ°	1192.64(2)	777.98	1193.693	146	$\boxed{\text{-1.05(2)}}$	-0.51·2=-1.02
Ξ°	1314.86(20)	857.71	1316.333	161	$\boxed{\text{-1.47(20)}}$	-0.51·3=-1.53
ρ	775.49(34)	505.87	784.8943	96	-9.40(34)	-9.20 = -2Δ
Δ^o	1233.8(2)	804.83	1234.57	151	-0.8(2)	
Δ°-n	294.2(2)	191.9	294.3	36		2ΔE$_B$=294.4

The tuning effect in particle data is connected with the doubled value of the pion β-decay energy δ=16m_e. The pion mass $m_{\pi^\pm}$, its parameter f_π=131 MeV, the muon mass and the value ΔM_Δ=147 MeV were found to be close to integers of δ=16m_e (n=17,16,13,18, Table 7 [10,11]).

Recent understanding of nucleon structure is based on the Standard Model (SM) where the scalar field (Higgs boson with estimated mass M_H) is responsible for fundamental fermion masses (families of quarks/leptons) and masses of vector fields (M_Z, M_W). Light quarks (together with the electron and neutrino) are the lightest SM-family and the QCD (as a part of SM) describes strong interaction between quarks (and the resulted nucleon interactions). The gluon-quark-dressing effect [24] produces constituent masses out of small initial quark masses (of several MeV). Three constituent masses (M_q) are forming baryon mass and two constituent quark masses (M_q'') are forming masses of vector mesons (m_ω, m_ρ). The pion and ρ-meson are important for understanding of nucleon structure and their interaction. The pion is a QCD's Goldstone mode [25] and the pion exchange between constituent quarks [26] gives the nucleon Δ-excitation (m^o_Δ-m_n=294 MeV=2ΔM_Δ) corresponding to the spin-flip of baryon quarks.

The inclusion of the electron mass into comparison with the other energy/mass intervals is based mainly on results obtained with nuclear data. V.Belokurov and D.Shirkov [28] suggested that QED radiative correction ($\alpha/2\pi$) similar to that in the magnetic moment of the electron μ_e could be assigned to m_e. It should be noticed that there exists the results of the analysis of particle masses performed by R.Frosch who found a period of 3m_e [27] in a search for the periodicity in masses. In Table 7 relations between δ=16m_e, 3m_e and some particle masses are shown.

There exists the coincidence of the lepton ratio L=m_μ/m_e=206.77 with the integer L=207=13$\cdot$16-1 after a small QED correction, namely $m_\mu/m_e(1-\alpha/2\pi)$=207.01. The same ratio exists between masses of vector bosons M_Z=91.188(2) GeV and M_W=80.40(3) GeV and two estimates of baryon and meson constituent quark masses M_q=441 MeV=(3/2)(m_Δ-m_N)$\approx m_\Xi/3=3m_s$ and $M_q''=m_\rho/2$=775.5(4) MeV/2=387.8(2) MeV. These ratios are M_Z/441 MeV=206.8 and $M_W/(m_\rho/2)$=207.3 [10,11]. These empirical relations are in accordance with Y.Nambu suggestion [29] that mass relation can be useful for further development of the Standard Model.

5 Conclusions

Described here study of nonstatistical effects in complex spectra of many nuclei permits the confirmation of the Samuel Devons suggestion about the fundamental aspect in the analysis of accurately measured nuclear data. Recent understanding of strong interaction as a part of the Standard Model and the role of pion-exchange dynamics permitted to distinguish regions of the nuclear chart where observed tuning effect could be explained. Combined analysis of data from three compilations of nuclear data (MDF, CRF, NRF) can provide the material for the development of the fundamental physics.

6 References

1. H.Schopper (Ed.), Landoldt-Boernstein New Series 2009 **vol. I/22A**. Springer.
2. H.Schopper (Ed.), Landoldt-Boernstein New Series 2009 **vol. I/24**. Springer.
3. C.Detraz, Nucl. Phys. A 583 (1995) 3.
4. S.I.Sukhoruchkin, D.S.Sukhoruchkin, *J. Int. Mod. Phys.* E **20** 906, 2011.
5. S.I.Sukhoruchkin, *Int. Rev. Phys. (IREPHY)* **2** 239, 2008.
6. S.I.Sukhoruchkin, *Proc. 2nd Conf. Neutr. Cross Section*, Washington DC **Vol.2** 923, 1968.
7. S.I.Sukhoruchkin, *Stat. Properties of Nuclei* ed. Garg G (Plenum Press) 215, 1972.
8. J.Audi *et al.*, *AME 2012* (to be publ.).
9. S.Devons, *Proc. Int. Rutherford Jubilee Conf.*, Manchester (Heywood) 611, 1961.
10. S.I.Sukhoruchkin, *Proc. Rutherford Centennial Conf.*, Manchester, 2011. *JPCS*, IOP, 2012.
11. S.I.Sukhoruchkin, http://cgc.physics.miami.edu/Miami2011/Sukhoruchkin.ppt.
12. T.Otsuka, T.Suzuku, Y.Utsino, *Nucl. Phys.* A **805** 127c, 2008.
13. J.Schiffer, *Proc. Rutherford Centennial Conf.*, Manchester, 2011. *JPCS*, IOP, 2012.
14. H.Schopper (Ed.), Landoldt-Boernstein New Series 2012 **vol. I/25A**. Springer.
15. S.I.Sukhoruchkin, Z.N.Soroko, D.S.Sukhoruchkin, *these Proc.*
16. K.Ideno, *Proc. Int. Conf. Neutr. Research*, Crete, 1997. SPIE **Vol. 2867**, p.398.
17. S.I.Sukhoruchkin, Proc. ISINN-13, p. 83, 2005. JINR E3-2006-7.
18. S.I.Sukhoruchkin, Z.N.Soroko, D.S.Sukhoruchkin, Proc. ISINN-17, p. 209, 2009.
19. I.T.Dyatlov, *Yad. Phys.* **52** 152, 1990.
20. M.Wielers, http://cgc.physics.miami.edu/Miami2011/Wielers.ppt.
21. J.Bernstein, *Elem. Particles, Currents.* Freeman, 1968.
22. P.Igo-Kemenes, *J. Phys.* G **33** 388, 2006.
23. V.M.Abazov *et al*, arXiv: 0905.3381v2[hep-ex] 20 May 2009.
24. H.L.L.Roberts *et al*, *Phys. Rev.* C **83** 065206, 2011.
25. L.Glozman, *Nucl. Phys.* A **629** 121c, 1998.
26. C.Itoh *et al*, *Phys. Rev.* D **40** 3660, 1989.
27. R.Frosch, *Nuovo Cim.* **104** 913, 1991.
28. V.V.Belokurov, D.V.Shirkov, *The theory of Particle Interactions.* AIP, 1991.
29. Y.Nambu, *Nucl. Phys.* A **629** 3c, 1998.