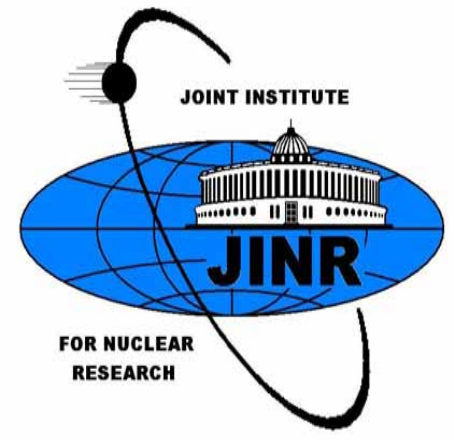


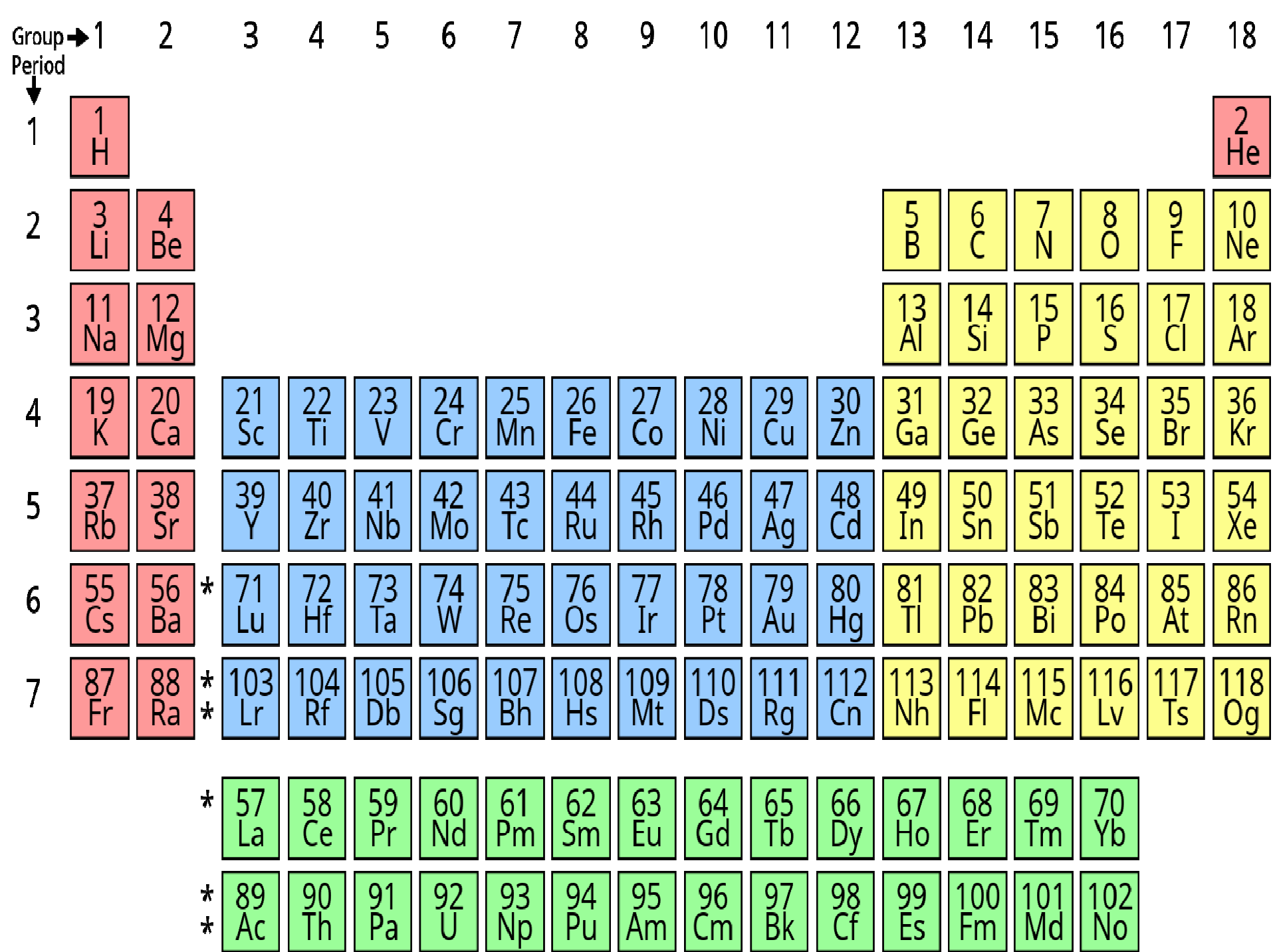
Where is the magic mountain located on the island of stability?

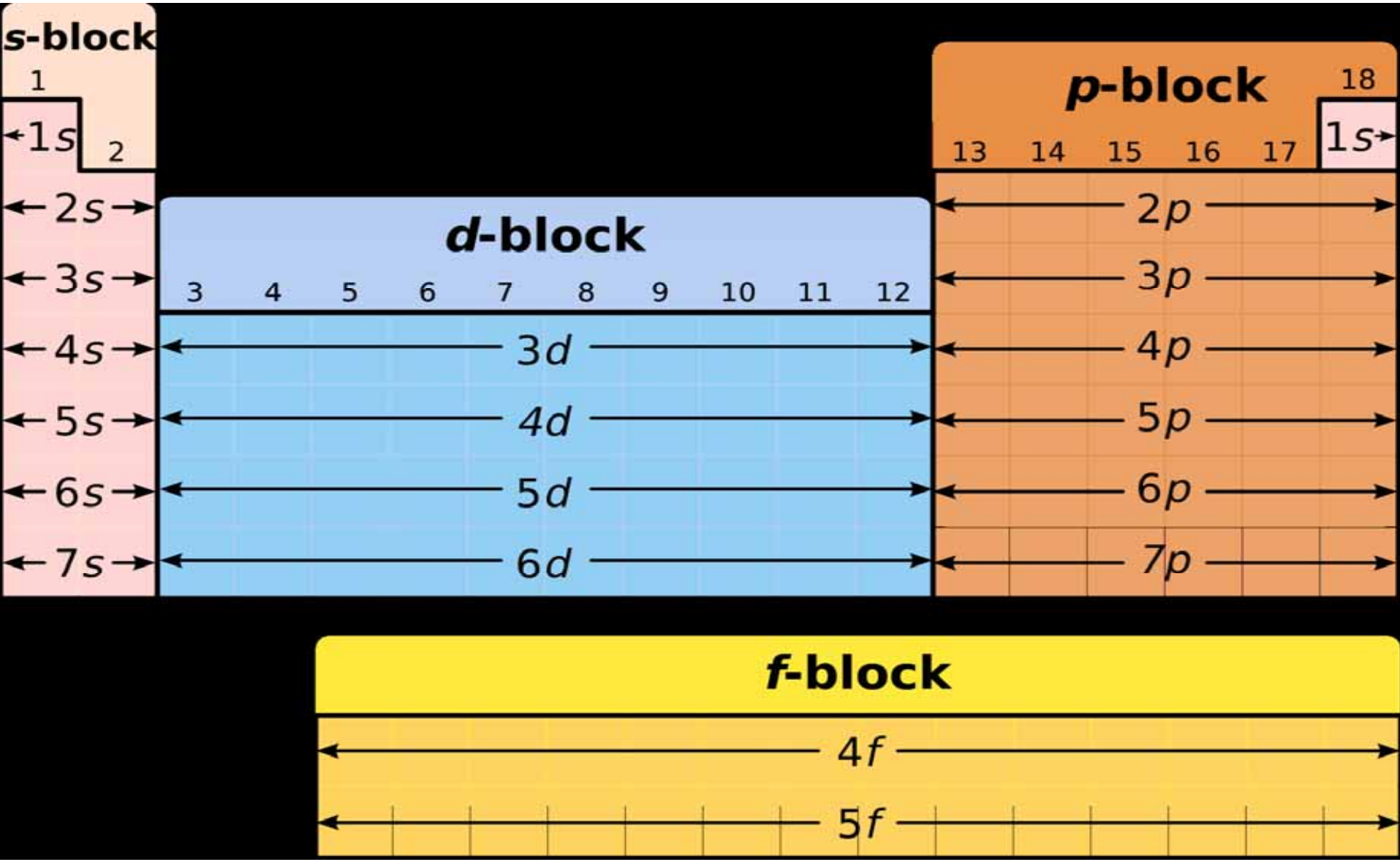
L.Malov, G.Adamian, N.Antonenko, H.Lenske

In nature 5 double magic nuclei

4He, 16O, 40Ca, 48Ca, 208Pb

with high stability and high abundance


Group → 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
Period
1 1 H 2 He
2 3 Li 4 Be 5 B 6 C 7 N 8 O 9 F 10 Ne
3 11 Na 12 Mg 13 Al 14 Si 15 P 16 S 17 Cl 18 Ar
4 19 K 20 Ca 21 Sc 22 Ti 23 V 24 Cr 25 Mn 26 Fe 27 Co 28 Ni 29 Cu 30 Zn 31 Ga 32 Ge 33 As 34 Se 35 Br 36 Kr
5 37 Rb 38 Sr 39 Y 40 Zr 41 Nb 42 Mo 43 Tc 44 Ru 45 Rh 46 Pd 47 Ag 48 Cd 49 In 50 Sn 51 Sb 52 Te 53 I 54 Xe
6 55 Cs 56 Ba * 71 Lu 72 Hf 73 Ta 74 W 75 Re 76 Os 77 Ir 78 Pt 79 Au 80 Hg 81 Tl 82 Pb 83 Bi 84 Po 85 At 86 Rn
7 87 Fr 88 Ra * 103 Lr 104 Rf 105 Db 106 Sg 107 Bh 108 Hs 109 Mt 110 Ds 111 Rg 112 Cn 113 Nh 114 Fl 115 Mc 116 Lv 117 Ts 118 Og
* 57 La 58 Ce 59 Pr 60 Nd 61 Pm 62 Sm 63 Eu 64 Gd 65 Tb 66 Dy 67 Ho 68 Er 69 Tm 70 Yb
* 89 Ac 90 Th 91 Pa 92 U 93 Np 94 Pu 95 Am 96 Cm 97 Bk 98 Cf 99 Es 100 Fm 101 Md 102 No


s-block
1
1s
2
2s
3s
4s
5s
6s
7s
d-block
3 4 5 6 7 8 9 10 11 12
3d
4d
5d
6d
p-block
18
1s
13 14 15 16 17
2p
3p
4p
5p
6p
7p
f-block
4f
5f

Periodic Table 1-172

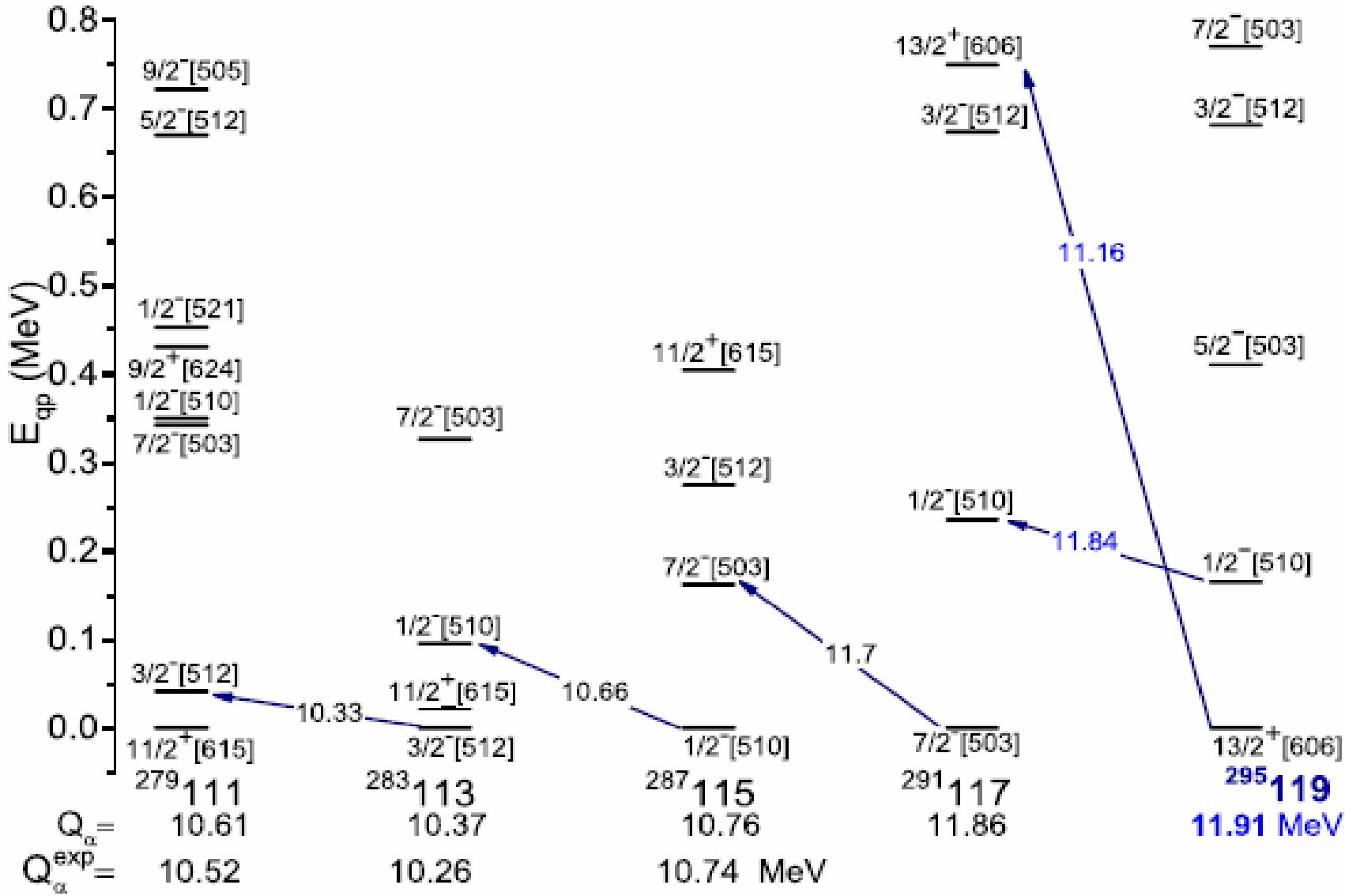
Period	1												13	14	15	16	17	18	Orbitals
1	1 H	2																2 He	1s
2	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne	2s2p
3	11 Na	12 Mg	3	4	5	6	7	8	9	10	11	12	13 Al	14 Si	15 P	16 S	17 Cl	18 Ar	3s3p
4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr	4s3d4p
5	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe	5s4d5p
6	55 Cs	56 Ba	57-71	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn	6s5d6p
7	87 Fr	88 Ra	89-103	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Nh	114 Fl	115 Mc	116 Lv	117 Ts	118 Og	7s6d7p
8	119	120	121-	156	157	158	159	160	161	162	163	164	139	140	169	170	171	172	8s7d8p
9	165	166											167	168					9s9p

6	57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu	4f
7	89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr	5f
8	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	6f

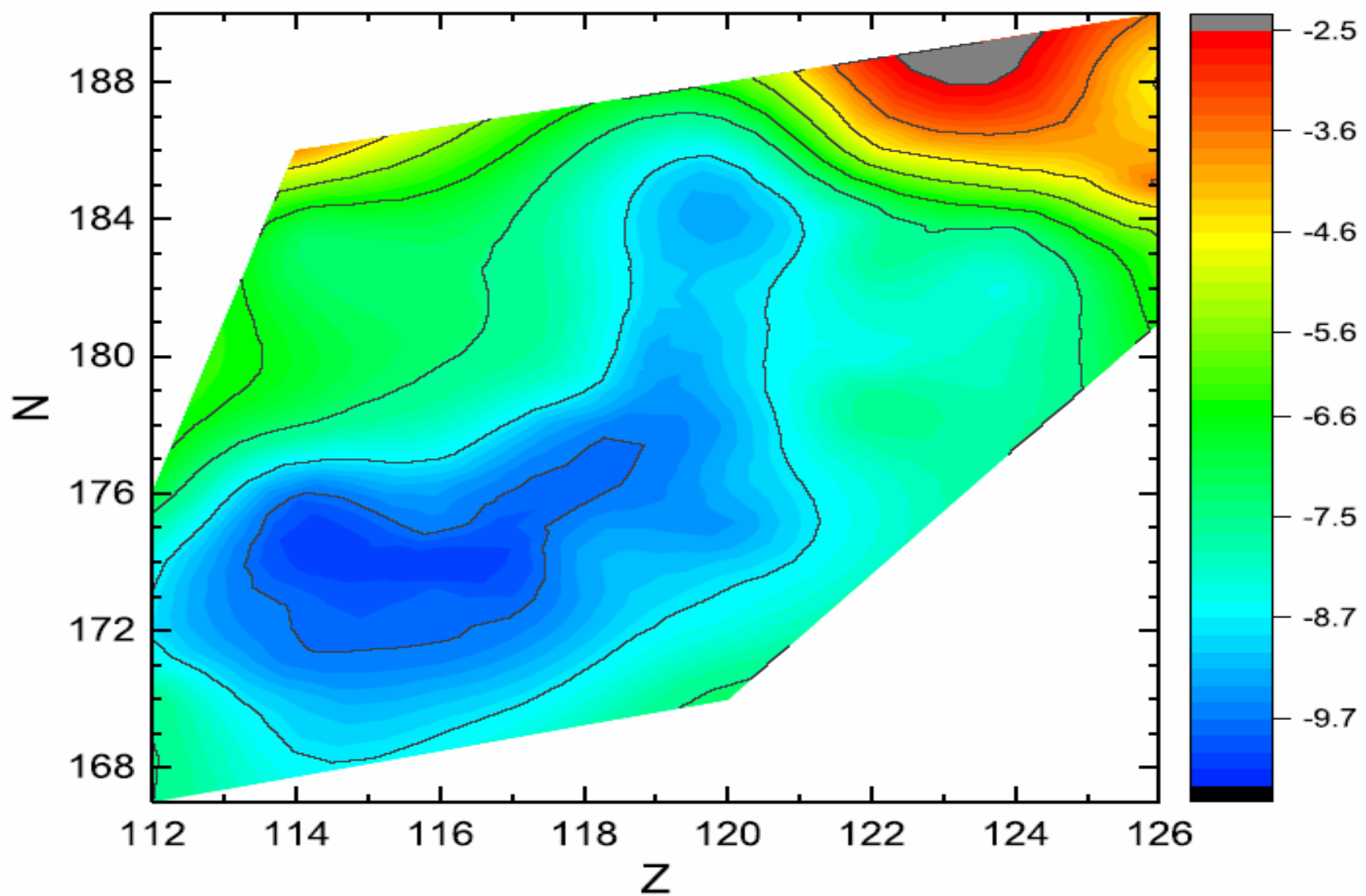
8	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	5g

Self-consistent Giessen EDF theory

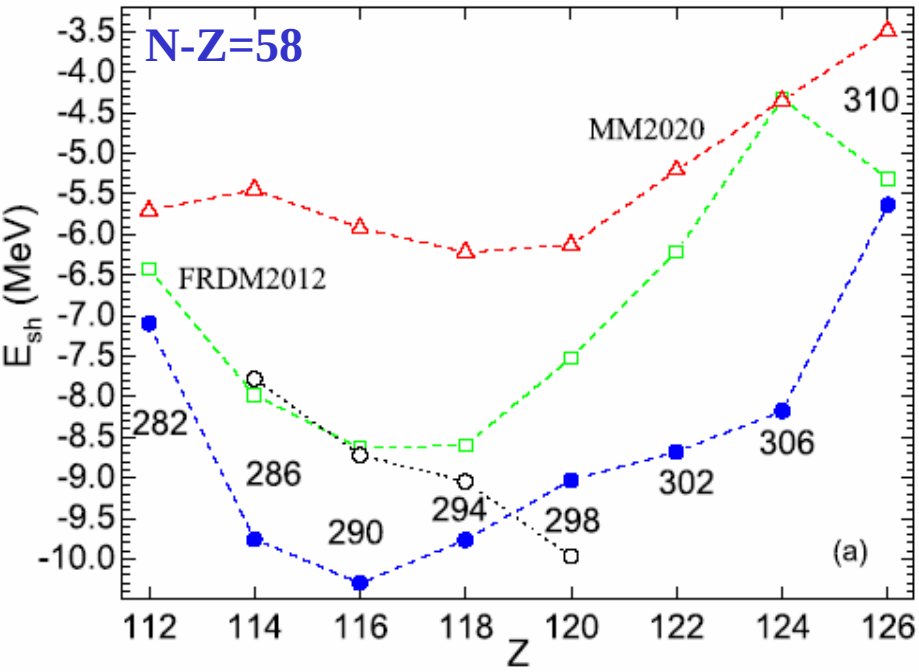
The validity of the EDF is confirmed by a successful description of the data all over the mass table, not only of nuclear ground state but also of spectral properties of stable and exotic nuclei

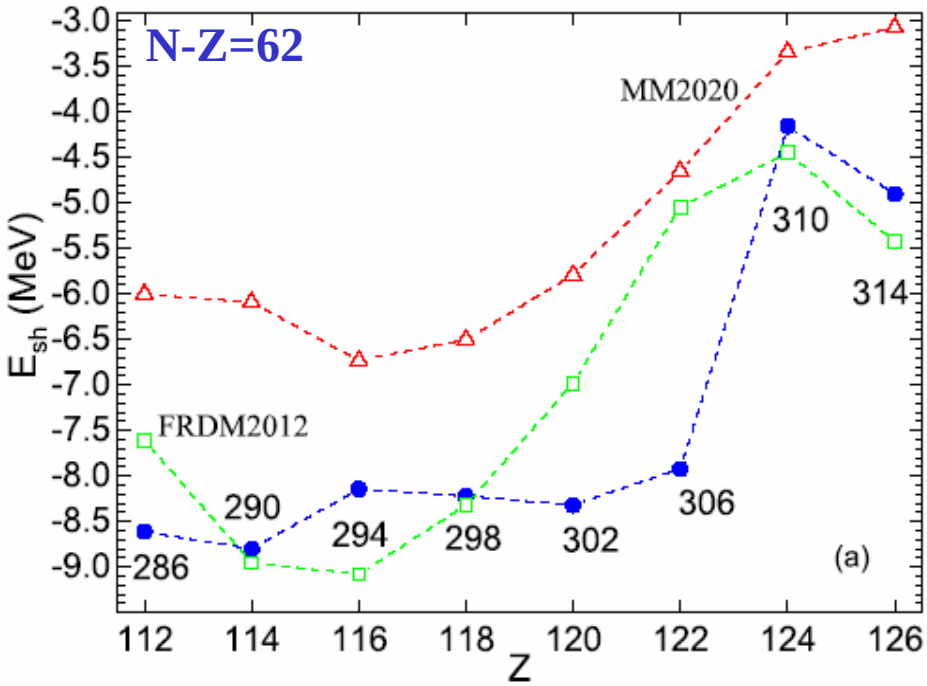

0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
E_qp (MeV)
9/2⁻[505]
5/2⁻[512]
1/2⁻[521]
9/2⁺[624]
1/2⁻[510]
7/2⁻[503]
3/2⁻[512]
11/2⁺[615]
279 111
Q_α= 10.61
Q_α^exp= 10.52
10.33
1/2⁻[510]
11/2⁺[615]
3/2⁻[512]
283 113
Q_α= 10.37
Q_α^exp= 10.26
10.66
7/2⁻[503]
3/2⁻[512]
11/2⁺[615]
1/2⁻[510]
287 115
Q_α= 10.76
Q_α^exp= 10.74 MeV
11.7
1/2⁻[510]
7/2⁻[503]
13/2⁺[606]
3/2⁻[512]
291 117
Q_α= 11.86
11.84
11.16
7/2⁻[503]
3/2⁻[512]
5/2⁻[503]
1/2⁻[510]
13/2⁺[606]
295 119
11.91 MeV

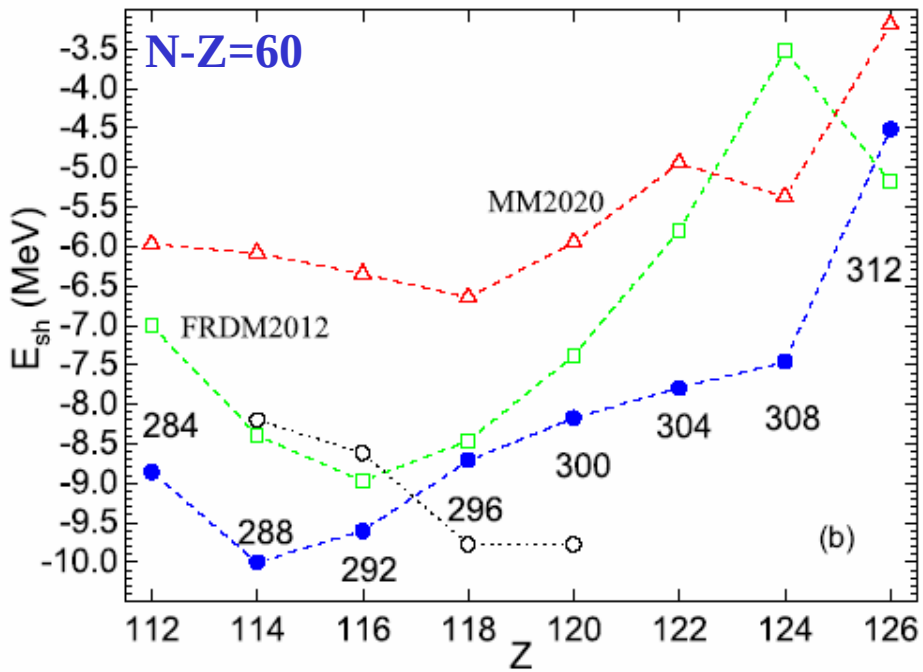
Landscape of the shell correction energy

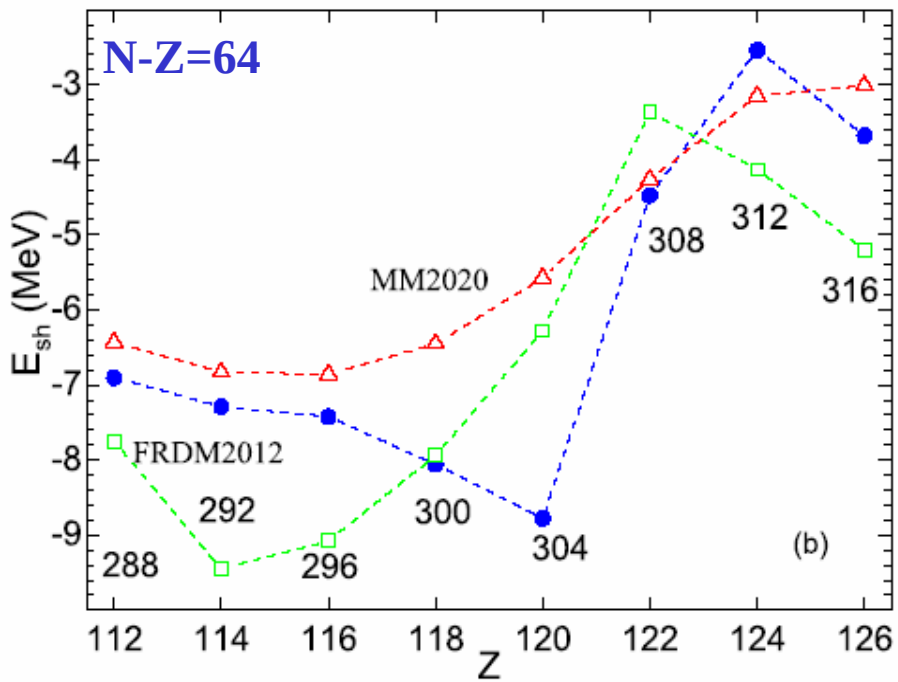


|the shell correction energy| = fission barrier height


N-Z=58
MM2020
FRDM2012
310
282
286
290
294
298
302
306
(a)
E_{sh} (MeV)
Z


N-Z=62
MM2020
FRDM2012
310
314
286
290
294
298
302
306
(a)
E_{sh} (MeV)
Z

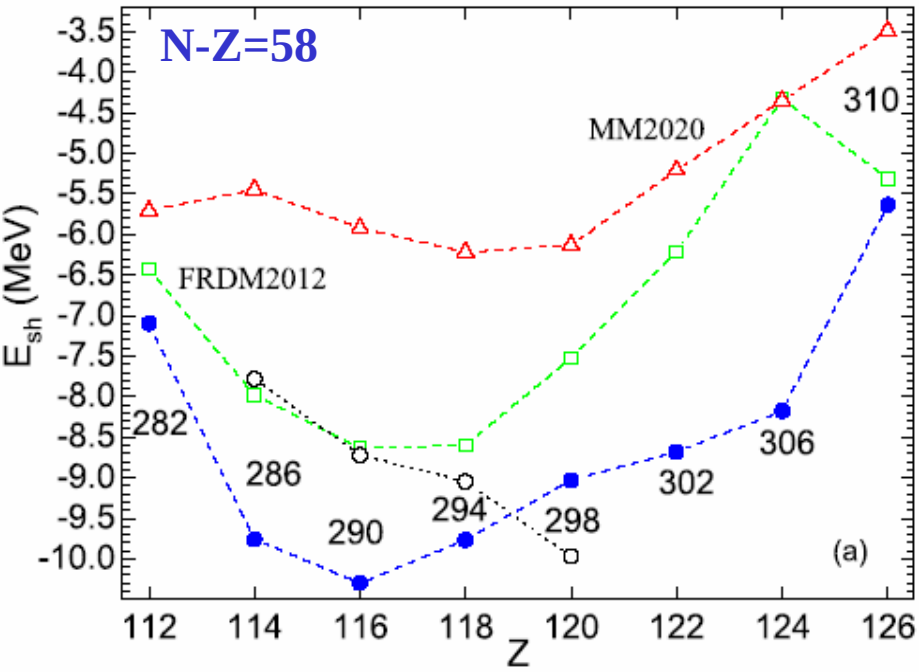

N-Z=60
MM2020
FRDM2012
312
284
288
292
296
300
304
308
(b)
E_{sh} (MeV)
Z

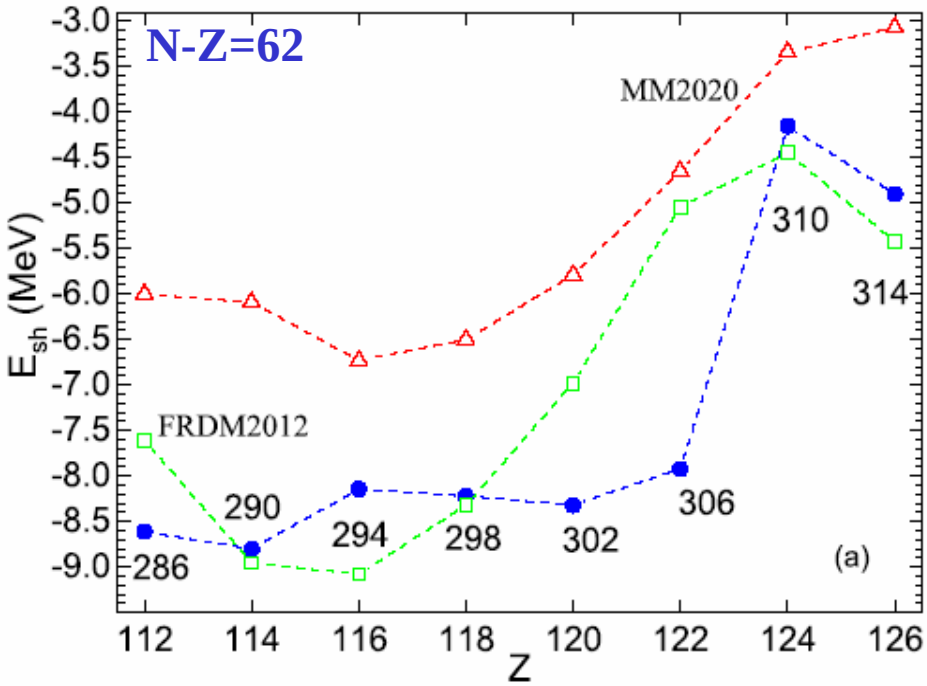

N-Z=64
MM2020
FRDM2012
308
312
316
288
292
296
300
304
(b)
E_{sh} (MeV)
Z

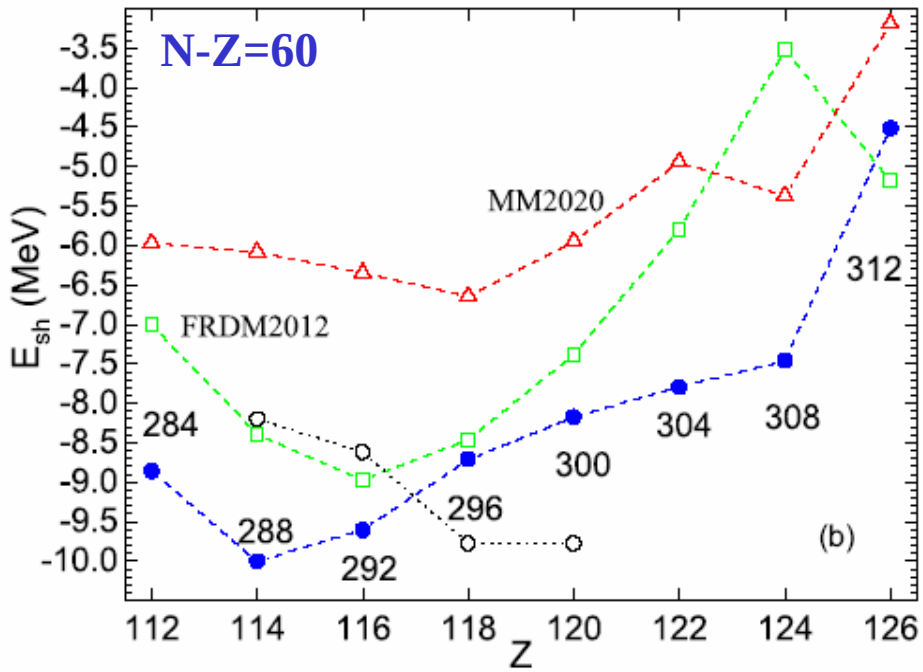
1. Proton/Neutron shell closures appear at 114/174 and 120/184 with a more pronounced closure in Fl

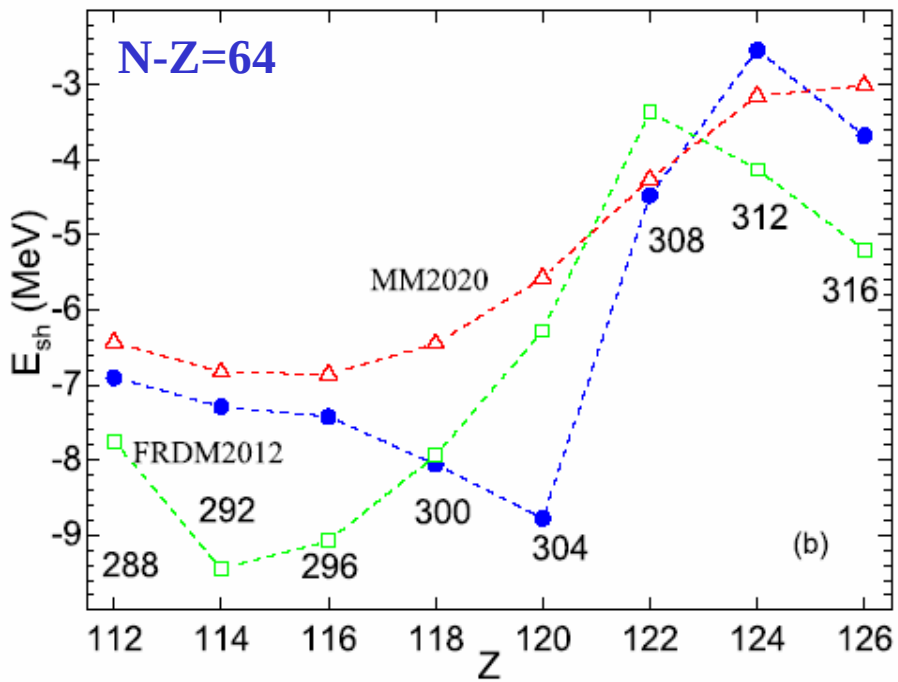
2. The competition between proton and neutron shell effects at Z=114 – 120 region acts like a stabilization effect, inducing a rather weak dependence of the shell correction on Z

So the island of stability is more like an island of coral reef origin than a volcanic one.

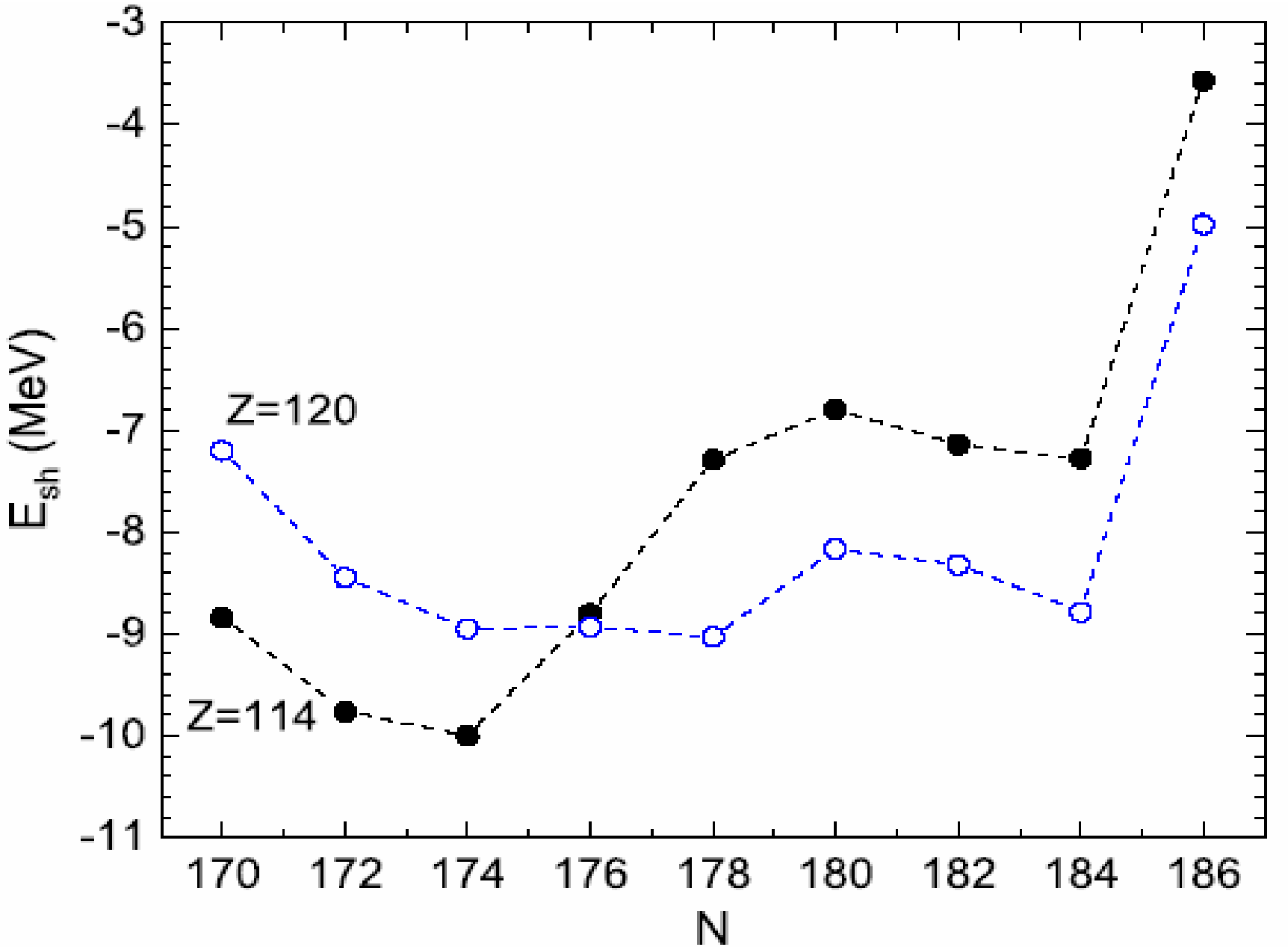

N-Z=58
MM2020
FRDM2012
310
282
286
290
294
298
302
306
(a)
E_{sh} (MeV)
Z


N-Z=62
MM2020
FRDM2012
310
314
286
290
294
298
302
306
(a)
E_{sh} (MeV)
Z


N-Z=60
MM2020
FRDM2012
312
284
288
292
296
300
304
308
(b)
E_{sh} (MeV)
Z


N-Z=64
MM2020
FRDM2012
308
312
316
288
292
296
300
304
(b)
E_{sh} (MeV)
Z

Interplay of Proton and Neutron Shell Dynamics



- **The strong influence of the neutron shell structure on the position of the double magic SHN. The shift of the proton shell closure from Z=114 to Z=120 is clearly seen with increasing N from 174 to 184**

288Fl (N=174) is the most likely candidate for the next double magic nucleus beyond 208Pb

El. 120 (N=184) is highly likely candidate for award of the next-to-next double magic nucleus

Fl is homolog of Pb and Sn (in the same group):

Z(Fl) - **Z**(Pb) = **Z**(Pb) - **Z**(Sn) = **32**

N(Fl) - **N**(Pb) = **N**(Pb) - **N**(Sn) = **50**

N(Fl)=**176**, **A**(Fl)=**290** the most stable isotope

120 is homolog of Ra and Ba:

Z(120) - **Z**(Ra) = **Z**(Ra) - **Z**(Ba) = **32**

N(120) - **N**(Ra) = **N**(Ra) - **N**(Ba) = **50**

N(120)=**182**, **A**(120)=**302**

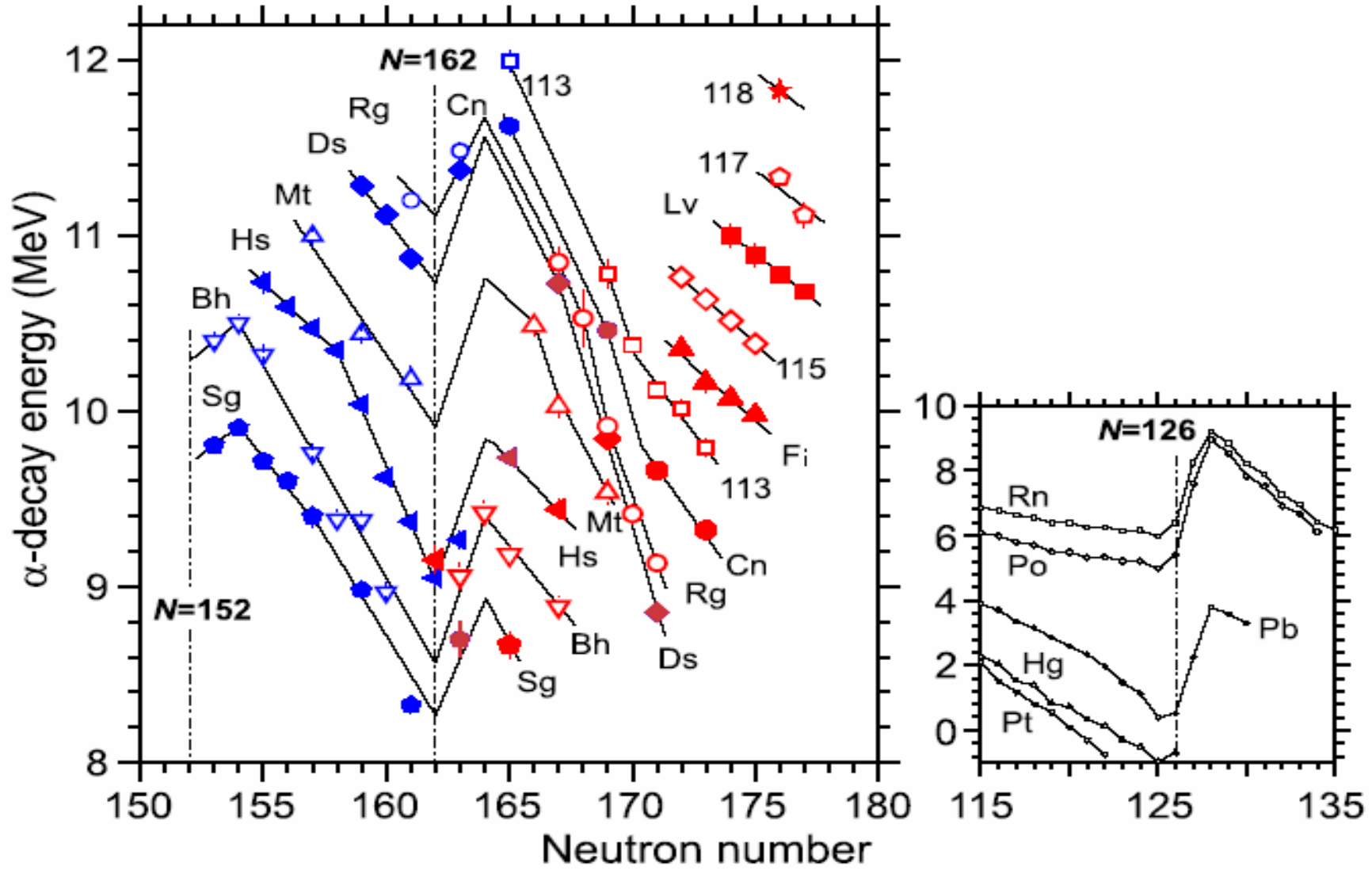
Conclusions

- **Rather strong shell effects are predicted in the Z=114-120 region, resulting from the interplay of the proton shell closures at Z=114, Z=120 and the neutron shell closures at N=174, N=184.**

- **Quite weak dependence of the shell correction on the charge number Z. So the island of stability looks like an island of coral reef origin with the border Z=114 - 120 and N=174 - 184.**

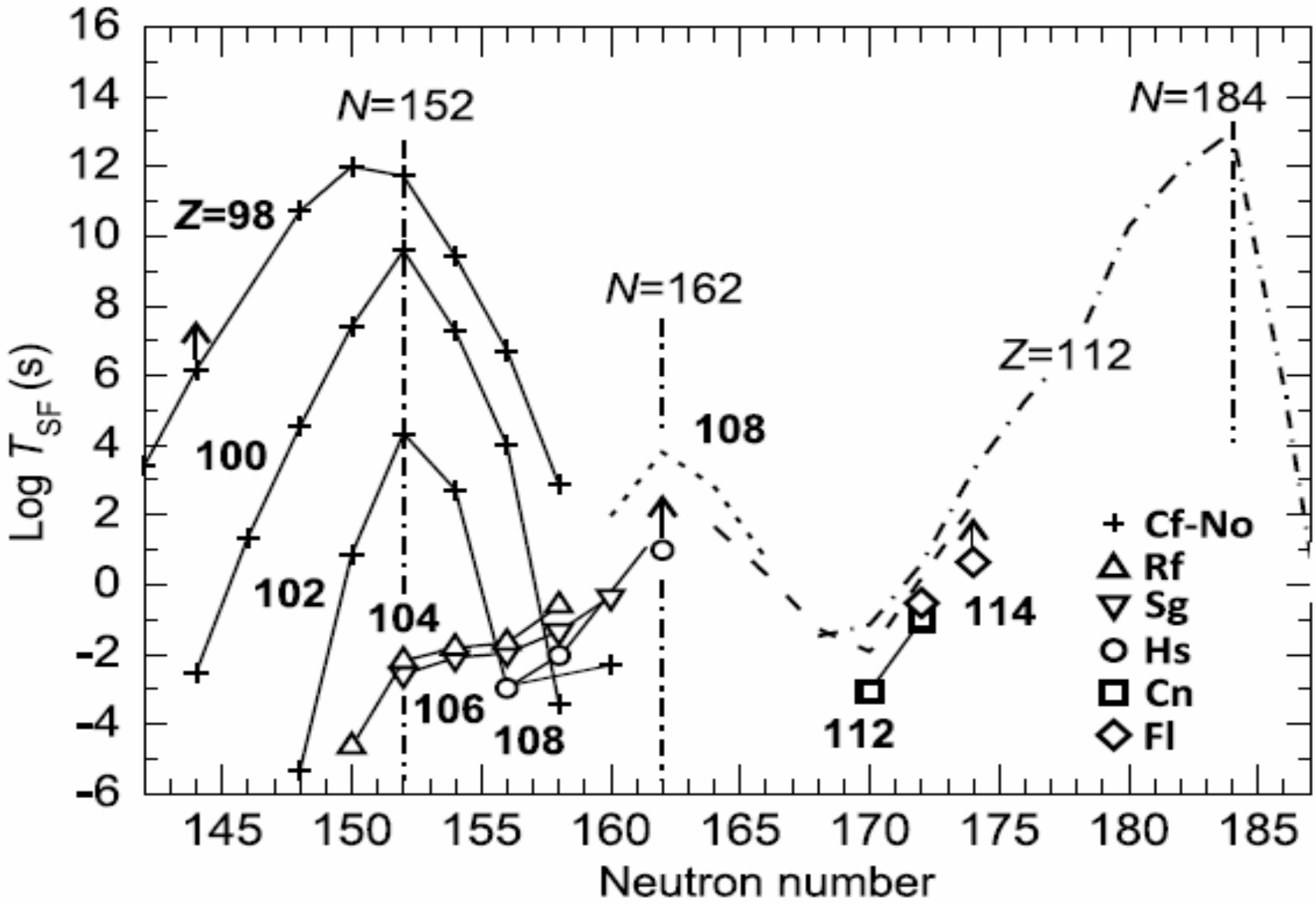
- **This prediction supports the attempt to produce SHN with Z=119, 120 and to check if they belong to the main reef of the island of stability.**

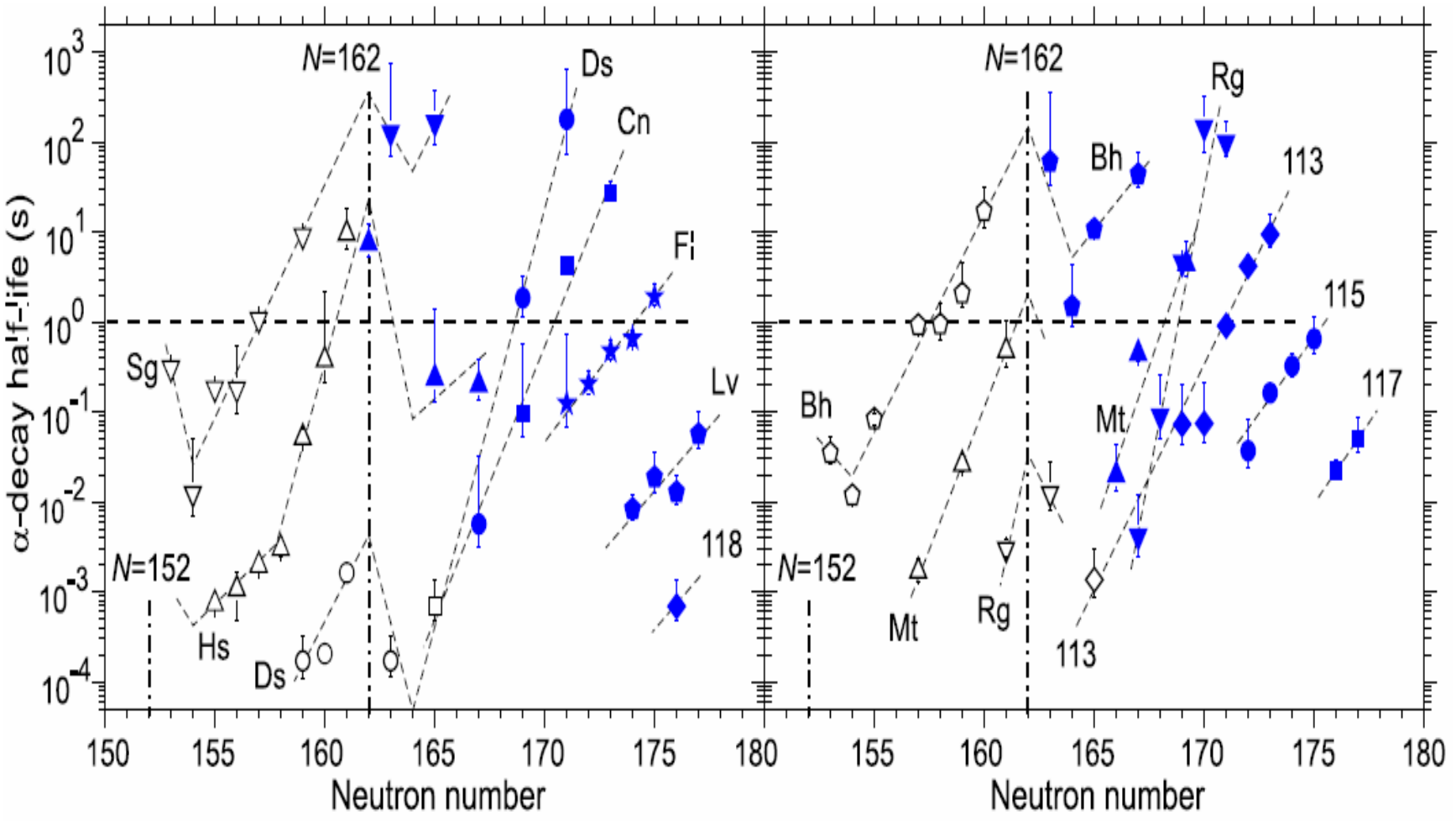
Thank you for your attention !

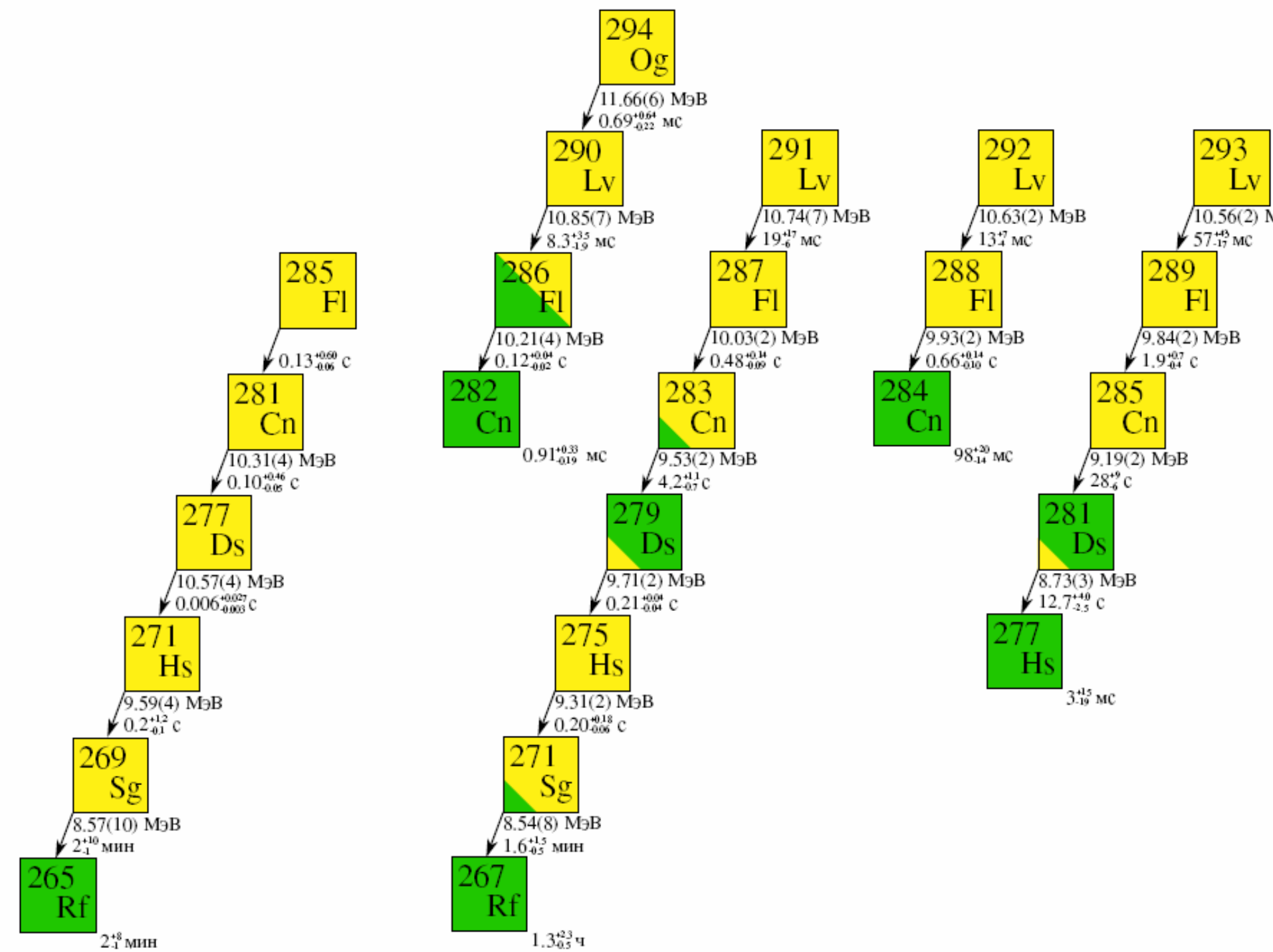

α-decay energy (MeV)
Neutron number
N=162
N=152
N=126
Rg
Cn
113
Ds
Mt
Hs
Bh
Sg
118
117
Lv
115
Fi
Rn
Po
Pb
Hg
Pt

No discontinuity in Q(alpha) and lifetimes was observed when the proton number 114 is crossed at neutron numbers from N=172 to N=176

The nuclei are expected to be quite unstable beyond Z=120.

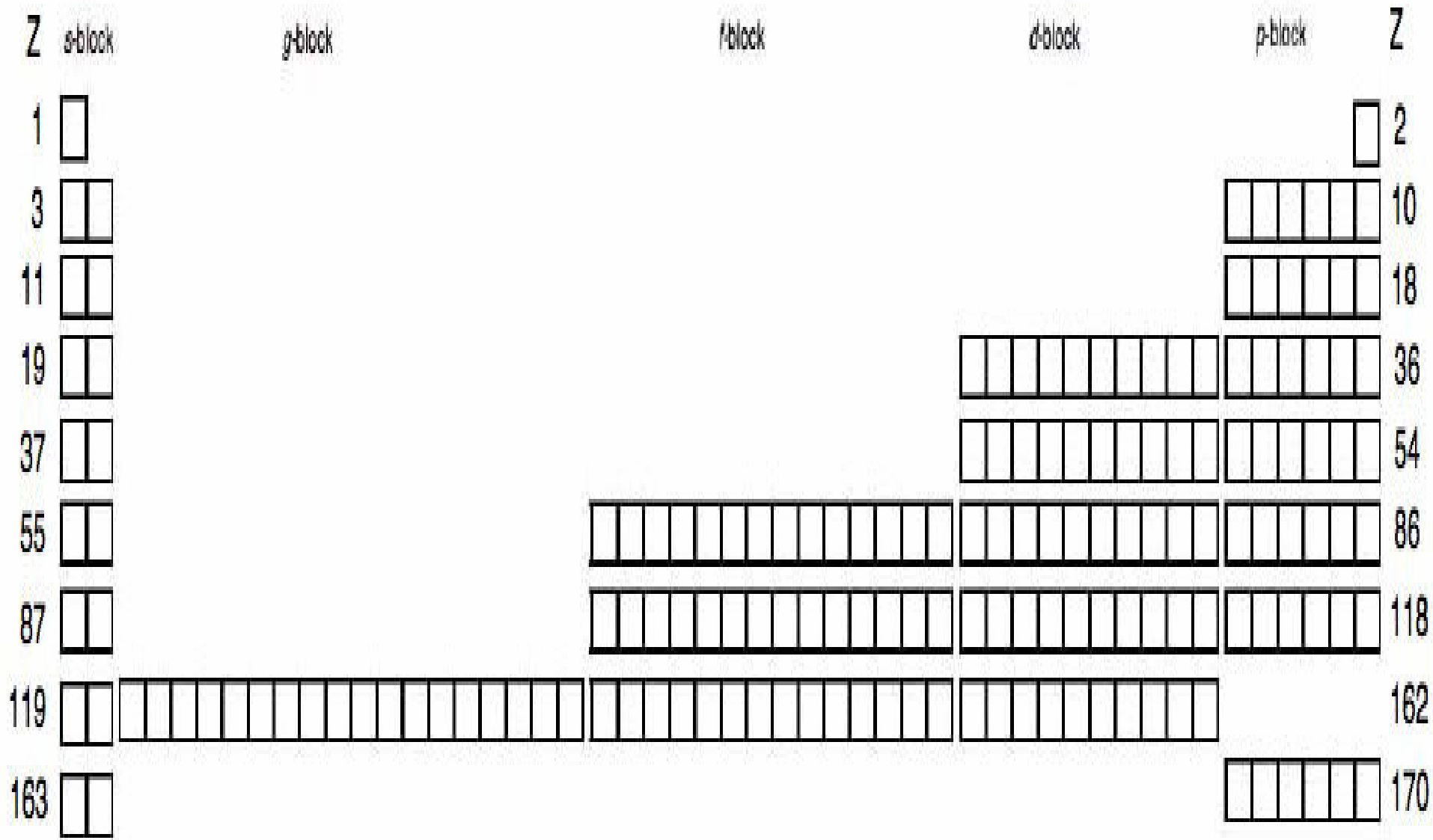

N=152
N=162
N=184
Z=98
Z=112
100
102
104
106
108
108
112
114
Cf-No
Rf
Sg
Hs
Cn
Fl
Log T_{SF} (s)
Neutron number
16
14
12
10
8
6
4
2
0
-2
-4
-6
145
150
155
160
165
170
175
180
185


α-decay half-life (s)
Neutron number
N=162
N=152
Sg
Hs
Ds
Ds
Cn
Fl
Lv
118
Bh
Mt
Rg
Rg
Bh
113
115
117
Mt
113

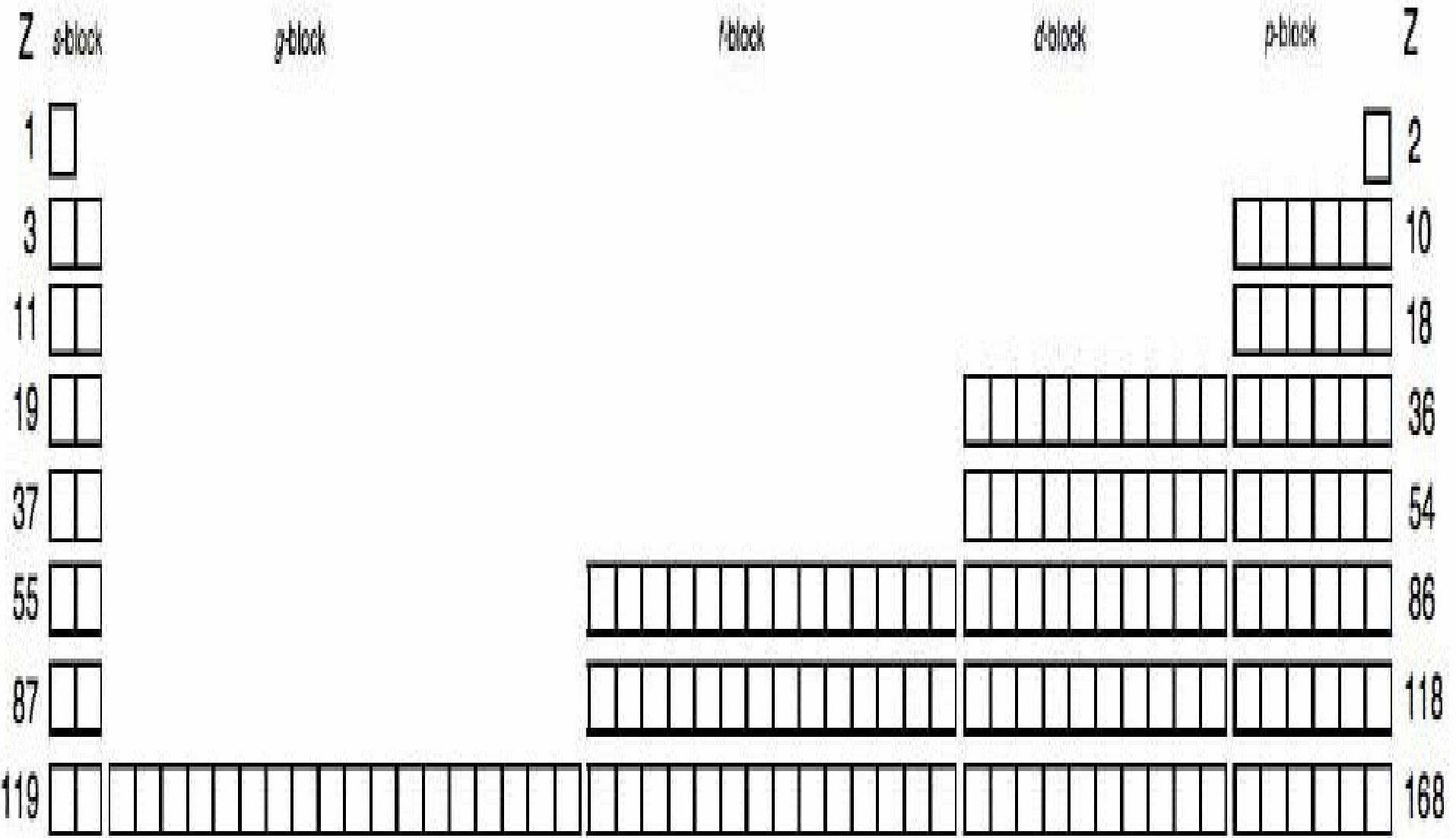

294 Og
11.66(6) МэВ
0.69$^{+0.64}_{-0.22}$ мс
290 Lv
10.85(7) МэВ
8.3$^{+3.5}_{-1.9}$ мс
291 Lv
10.74(7) МэВ
19$^{+17}_{-6}$ мс
292 Lv
10.63(2) МэВ
13$^{+7}_{-4}$ мс
293 Lv
10.56(2) М
57$^{+43}_{-17}$ мс
285 Fl
0.13$^{+0.60}_{-0.06}$ с
286 Fl
10.21(4) МэВ
0.12$^{+0.04}_{-0.02}$ с
287 Fl
10.03(2) МэВ
0.48$^{+0.14}_{-0.09}$ с
288 Fl
9.93(2) МэВ
0.66$^{+0.14}_{-0.10}$ с
289 Fl
9.84(2) МэВ
1.9$^{+0.7}_{-0.4}$ с
281 Cn
10.31(4) МэВ
0.10$^{+0.46}_{-0.05}$ с
282 Cn
0.91$^{+0.33}_{-0.19}$ мс
283 Cn
9.53(2) МэВ
4.2$^{+1.1}_{-0.7}$ с
284 Cn
98$^{+20}_{-14}$ мс
285 Cn
9.19(2) МэВ
28$^{+9}_{-6}$ с
277 Ds
10.57(4) МэВ
0.006$^{+0.027}_{-0.003}$ с
279 Ds
9.71(2) МэВ
0.21$^{+0.04}_{-0.04}$ с
281 Ds
8.73(3) МэВ
12.7$^{+4.0}_{-2.5}$ с
271 Hs
9.59(4) МэВ
0.2$^{+1.2}_{-0.1}$ с
275 Hs
9.31(2) МэВ
0.20$^{+0.18}_{-0.06}$ с
277 Hs
3$^{+15}_{-19}$ мс
269 Sg
8.57(10) МэВ
2$^{+10}_{-1}$ мин
271 Sg
8.54(8) МэВ
1.6$^{+1.5}_{-0.5}$ мин
265 Rf
2$^{+8}_{-1}$ мин
267 Rf
1.3$^{+2.3}_{-0.5}$ ч

V. Karapetoff
Journal of Franklin Institute ***210****, 609–614,* ***1930****: "A chart of consecutive sets of electronic orbits within atoms of chemical elements"*

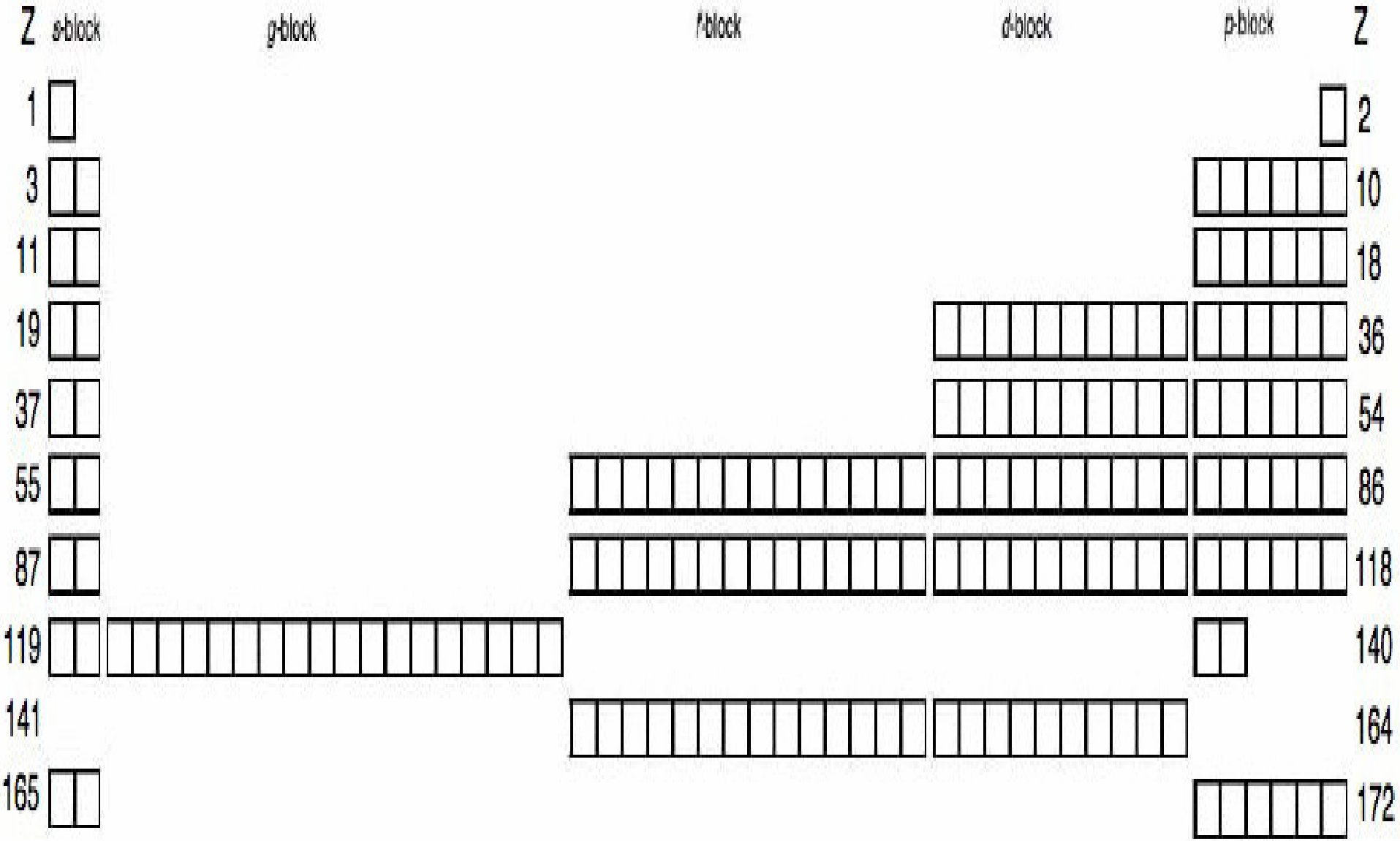
Fricke et al periodic table

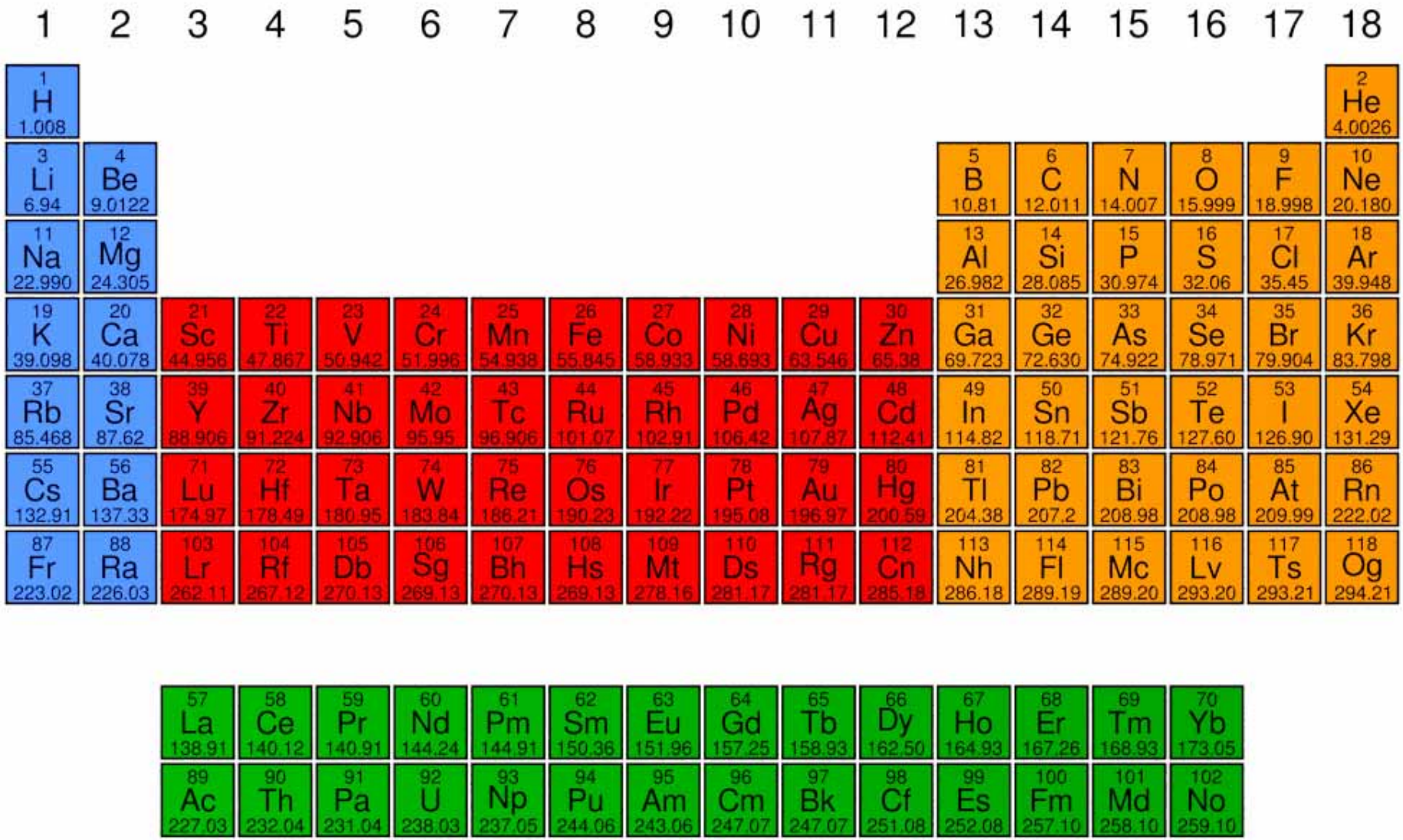


Seaborg periodic table



Pyykko periodic table.





Periodic Table

www.webelements.com