Seminarium FIz. Jądra At. UW,
Warszawa, 30. 03. 2017

Predictions for the nucleus ^{296}118

A. Sobiczewski

NCBJ – Warsaw, GSI – Darmstadt, JINR - Dubna

1. **Introduction**
2. **State of experiments**
3. **Theoretical description**
   a) **test of it by exp results for ^{294}118**
   b) **predictions for ^{296}118**
4. **Results and discusion**
5. **Conclusions**

1. Introduction

A big activity of experimentalists needs some support of theoreticians. Only the interaction of these two sides of science may lead to progress.

First, we test the model by existing exp. data (this was done in: A. S., J. Phys. G 43, 095106 (2016) using exp data obtained for the heaviest nucleus ^{294}118 observed up to now)

As the test was positive, we can use the model for predictions for the nucleus ^{296}118 not-yet-observed, which is only by 2 neutrons heavier than the nucleus used for the test (the results of this study were published in: A. S., Phys.Rev. C 94, 051302(R) (2016)).

Continuing a big activity in SHN reasearch:

Dubna: 2 intern. groups (phys. and chem.)
GSI: 2 intern. groups (phys. and chem.)
Berkeley, RIKEN

Heaviest element observed: 118 (Dubna)

exp. on 119 - unsuccessful
after few unsuccessful exp. on 120, one (GSI) gave some result (1 chain) – some problems with interpretation

Dubna: construction of a new lab. („SHN factory”) with high-intensity beam cyclotron (DC280)

Because of these problems, experimentalists often ask theoreticians for realistic pedictions for both: decay properties and cross sections of SHN

3. Theoretical model for Tα

$$\log_{10} T_\alpha^{\mathrm{th}}(Z,N) = aZ[Q_\alpha(Z,N)]^{-1/2} + bZ + c,$$

$$a = 1.5372, \quad b = -0.1607, \quad c = -36.573.$$

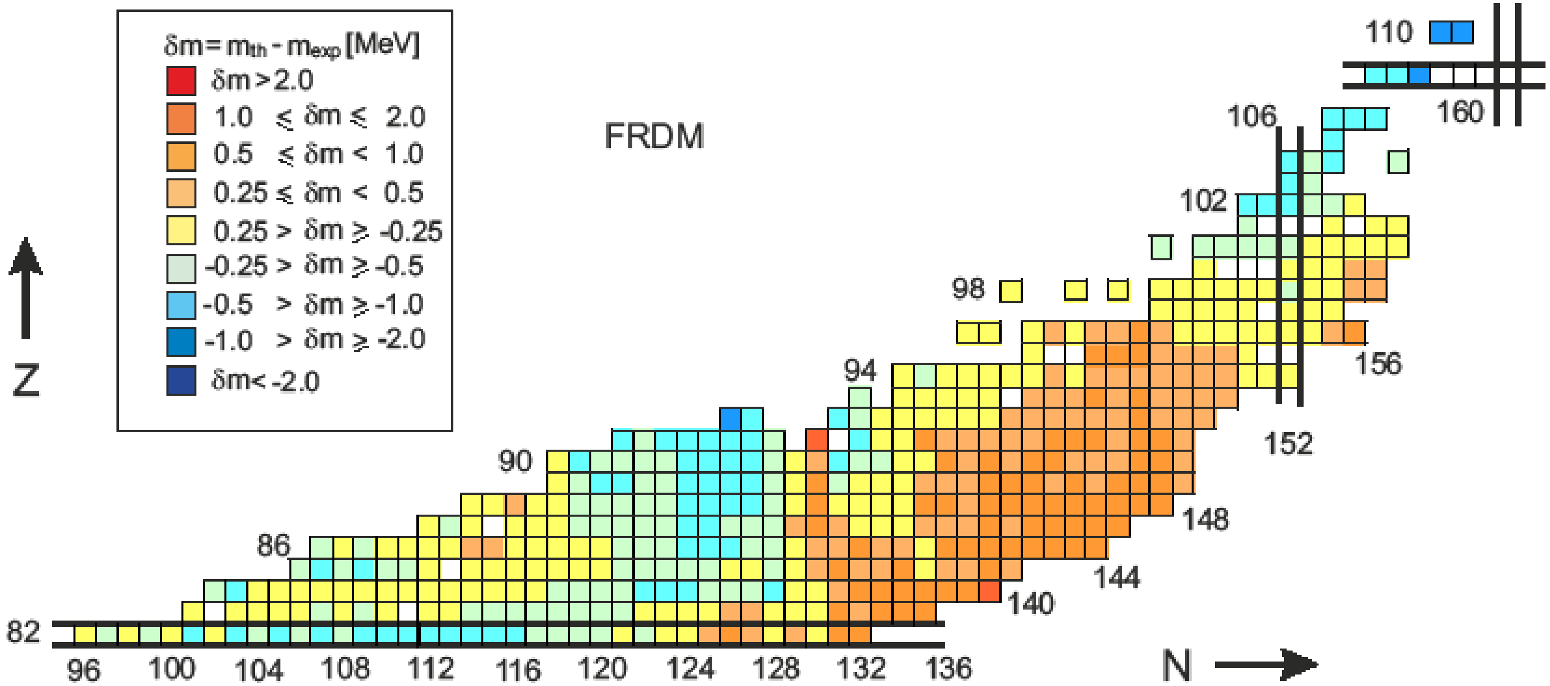
This is probably the simplest formula for Tα (only 3 parameters), and still realistic

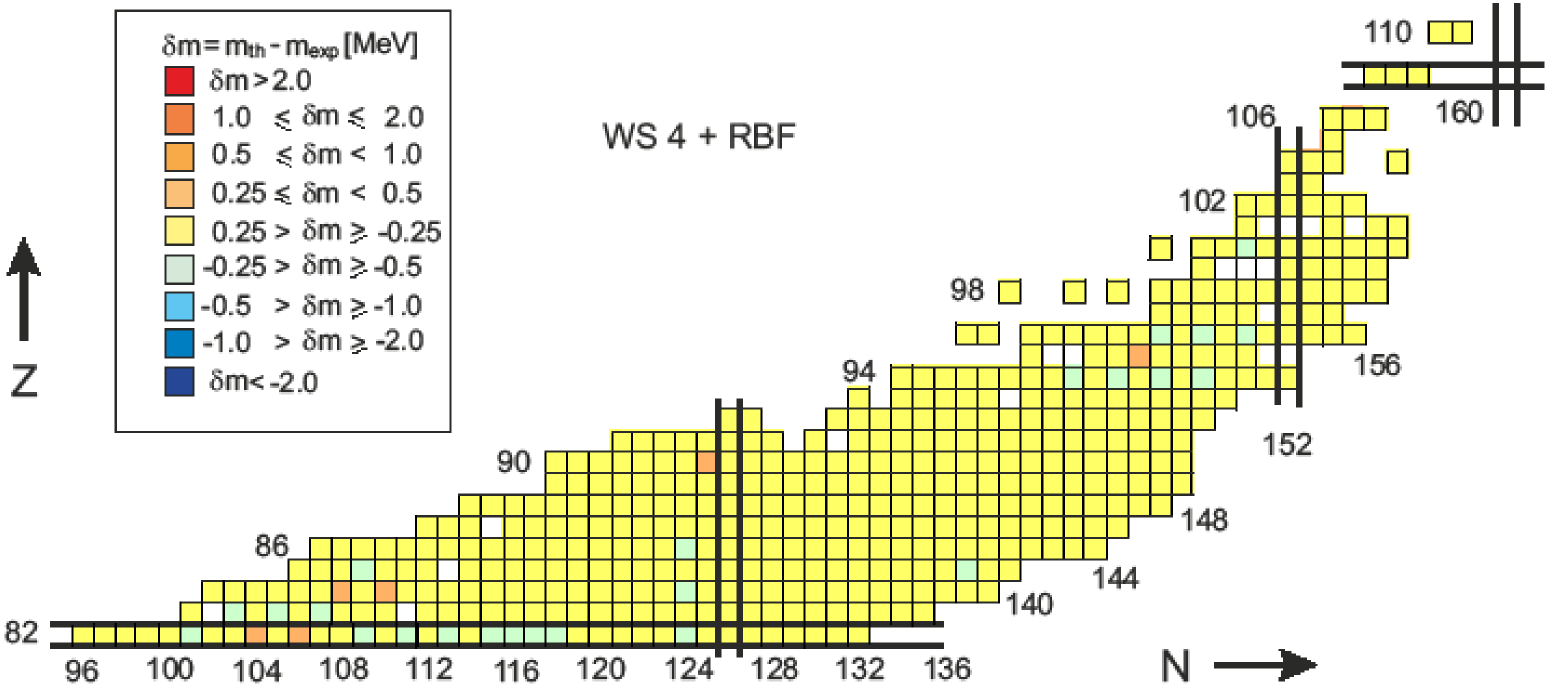
Care for a proper Qα

Table 1. The rms (in keV) of the discrepancies between measured and calculated masses. The latter are obtained with the use of the indicated models for the regions of global ($Z, N \geq 8$), heavy ($Z \geq 82, N \geq 126$) and very heavy ($Z \geq 100$) nuclei. The year of publication of each model, as well as the number of nuclei with measured masses in each region, $N_{\rm nucl}$, are also specified.

Model	frdm	frdm16	DZ	NS	WS3+	WS4+	HN	$N_{\rm nucl}$
Year	1995	2016	1995	2012	2010	2014	2001	-
$Z, N \geq 8$	654	579	394	362	248	170	-	2353
$Z \geq 82, N \geq 126$	484	412	398	258	136	115	355	312
$Z \geq 100$	676	690	828	471	126	130	118	36

[12] Wang N and Liu M 2011 *Phys. Rev.* **C 84** 051303(R).
[13] Wang N, Liu M, Wu X and Meng J 2014 *Phys. Lett.* **B 734** 215


δm = m_th - m_exp [MeV]
δm > 2.0
1.0 ≤ δm ≤ 2.0
0.5 ≤ δm < 1.0
0.25 ≤ δm < 0.5
0.25 > δm ≥ -0.25
-0.25 > δm ≥ -0.5
-0.5 > δm ≥ -1.0
-1.0 > δm ≥ -2.0
δm < -2.0
FRDM
Z
N
82
86
90
94
98
102
106
110
96
100
104
108
112
116
120
124
128
132
136
140
144
148
152
156
160

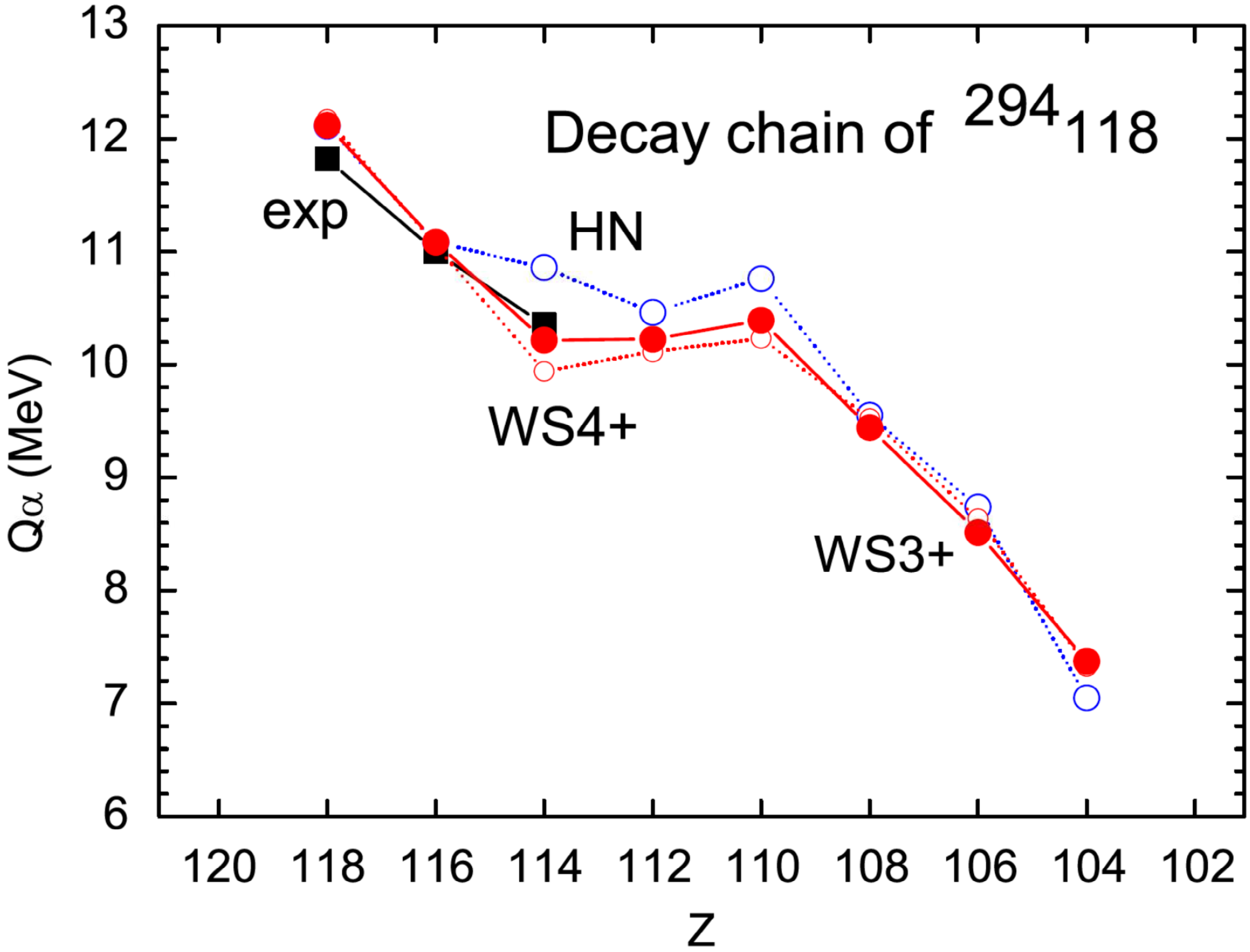


δm = m_th - m_exp [MeV]
δm > 2.0
1.0 ≤ δm ≤ 2.0
0.5 ≤ δm < 1.0
0.25 ≤ δm < 0.5
0.25 > δm ≥ -0.25
-0.25 > δm ≥ -0.5
-0.5 > δm ≥ -1.0
-1.0 > δm ≥ -2.0
δm < -2.0
WS 4 + RBF
Z
N
82
86
90
94
98
102
106
110
96
100
104
108
112
116
120
124
128
132
136
140
144
148
152
156
160

Results

Table 2. Calculated and measured values of the α-decay energies Q_α (in MeV), α-decay and spontaneous-fission half-lives, T_α and T_{sf}, for the decay chain of the nucleus $^{294}118$. Some quantities derived from them are also given (see text).

Nucleus	$^{294}118$	^{290}Lv	^{286}Fl	^{282}Cn
Q_α(WS3+)	12.12	11.09	10.21	10.22
Q_α(WS4+)	12.17	11.06	9.94	10.11
Q_α(HN)	12.11	11.08	10.86	10.46
Q_α(exp)	11.82	11.00	10.35	
δQ_α(WS3+)	0.30	0.09	-0.14	
δQ_α(WS4+)	0.35	0.06	-0.41	
δQ_α(HN)	0.29	0.08	0.51	
T_α(WS3+)	0.38 ms	22 ms	0.87 s	0.19 s
T_α(WS4+)	0.29 ms	26 ms	4.9 s	0.37 s
T_α(HN)	0.39 ms	23 ms	19 ms	46 ms
f(WS3+)	1.8	2.6	4.4	
f(WS4+)	2.4	3.1	24	
f(HN)	1.8	2.8	11	
T_α(exp)	0.69 ms	8.3 ms	0.20 s	
$T_{\mathrm{sf}}^{\mathrm{th}}$	$1.3 \cdot 10^3 s$	$7.4 \cdot 10^2$ s	1.5 s	71 ms
$T_{\mathrm{sf}}^{\mathrm{exp}}$			0.30 s	0.91 ms



Decay chain of $^{294}118$
exp
HN
WS4+
WS3+
Qα (MeV)
Z
13
12
11
10
9
8
7
6
120
118
116
114
112
110
108
106
104
102

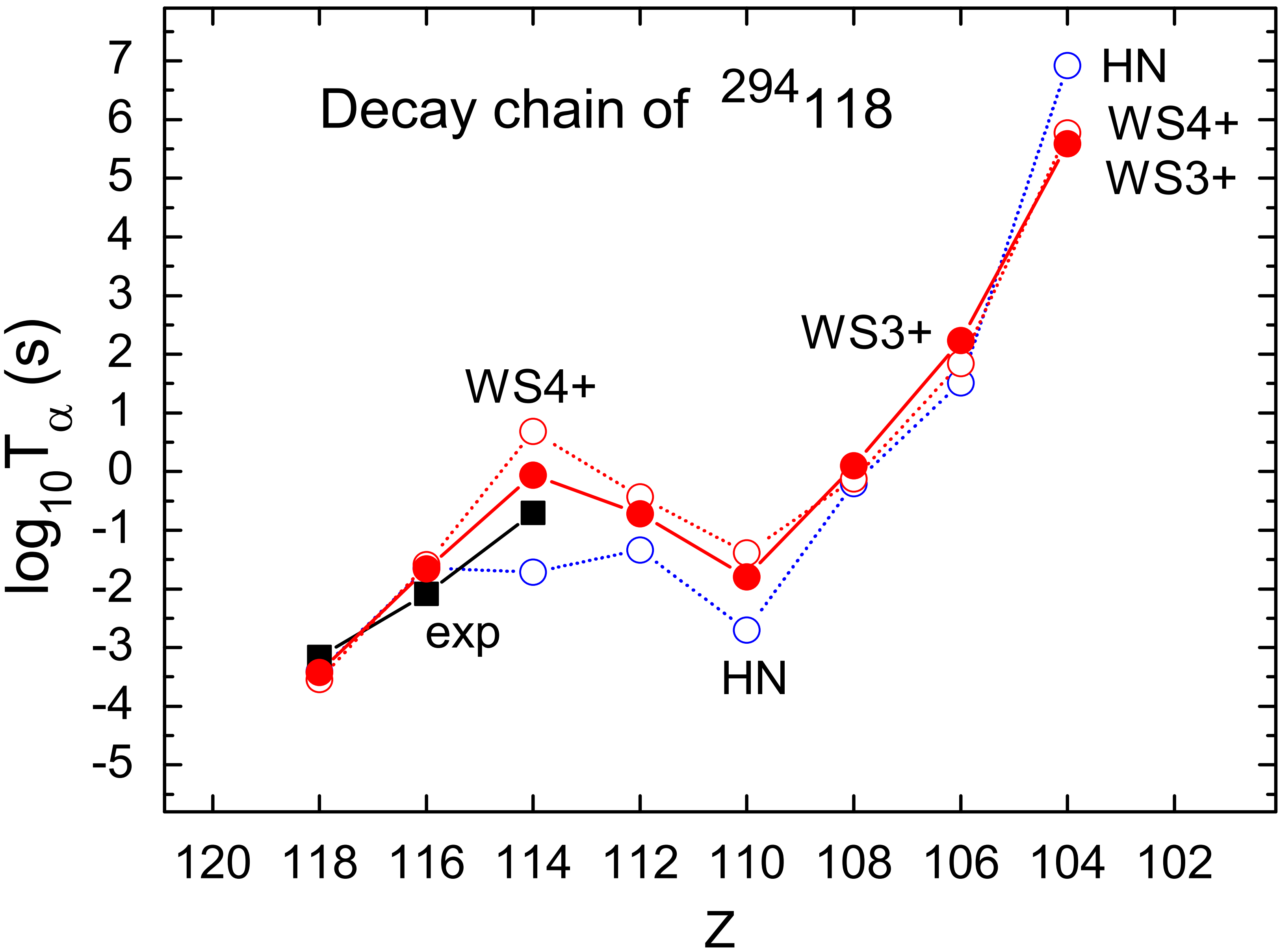
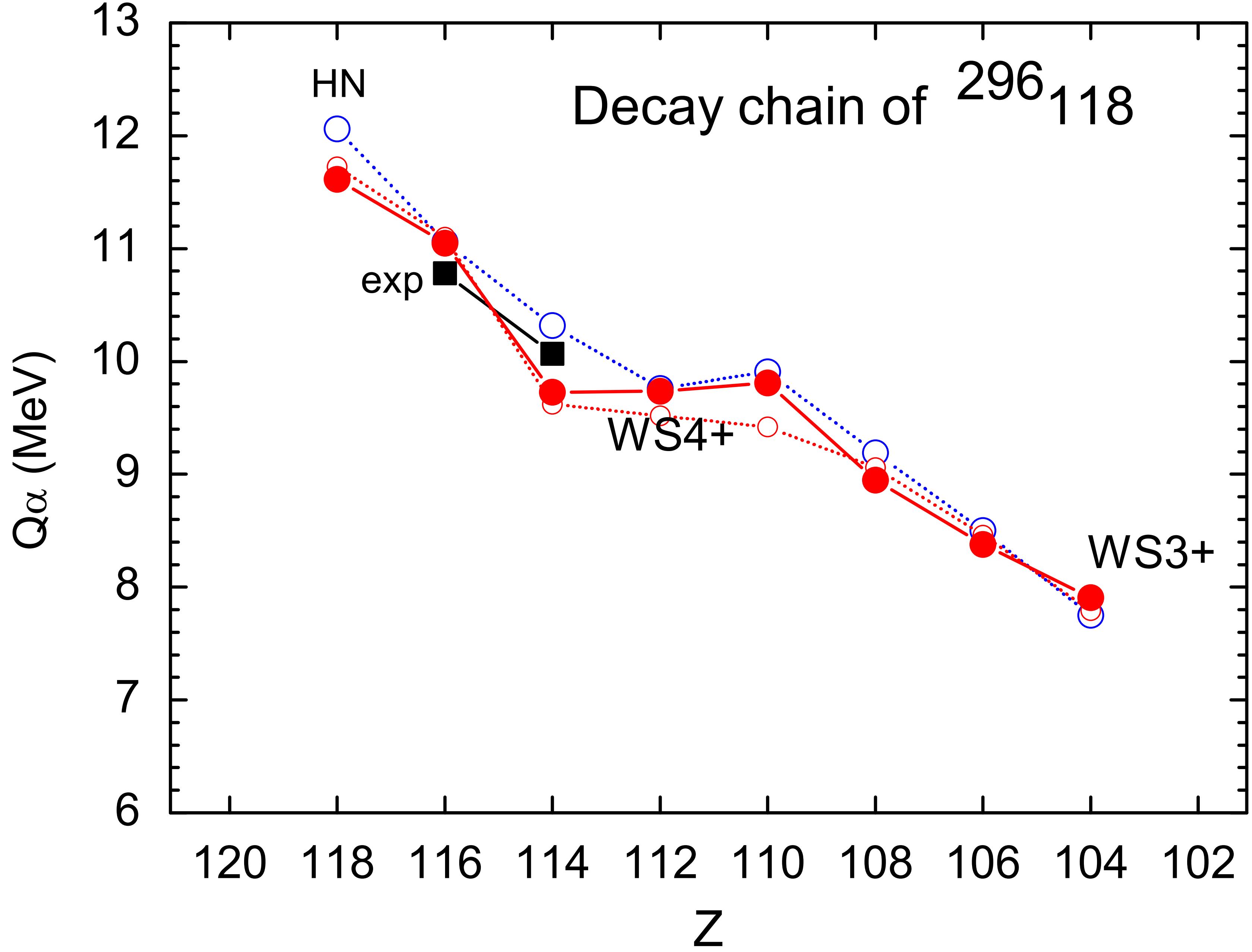
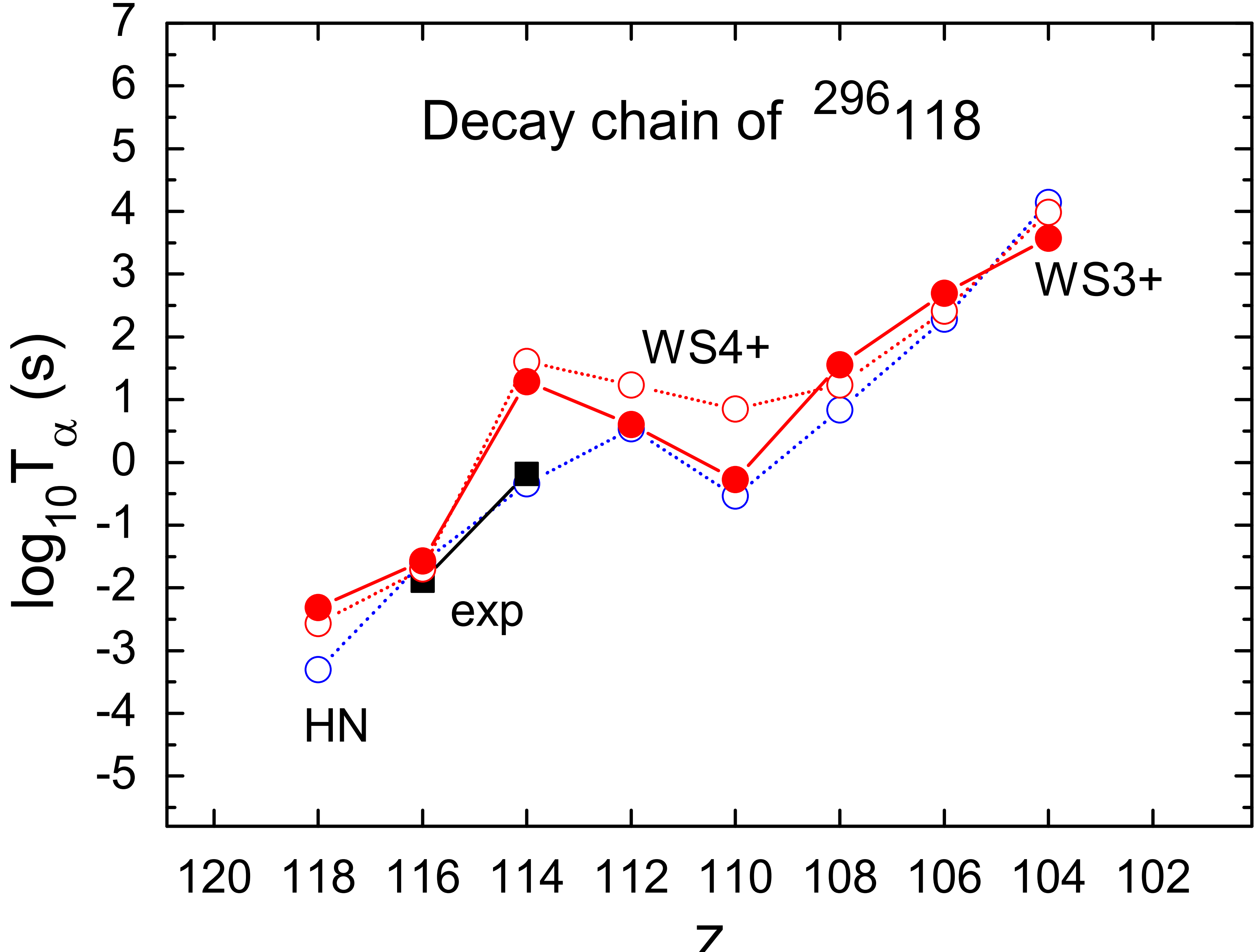

Decay chain of $^{294}118$
HN
WS4+
WS3+
WS4+
WS3+
exp
HN
$\log_{10}T_\alpha$ (s)
Z
7
6
5
4
3
2
1
0
-1
-2
-3
-4
-5
120
118
116
114
112
110
108
106
104
102

Table 3: Calculated and measured values of the α-decay energies Q_α (in MeV), α-decay and spontaneous-fission half-lives, T_α and $T_{\rm sf}$, for the decay chain of the nucleus $^{296}118$. Some quantities derived from them are also given (see text).

Nucleus	$^{296}118$	^{292}Lv	^{288}Fl	^{284}Cn
Q_α(WS3+)	11.62	11.05	9.73	9.74
Q_α(WS4+)	11.73	11.10	9.62	9.52
Q_α(HN)	12.06	11.06	10.32	9.76
Q_α(exp)	-	10.78	10.07	
δQ_α(WS3+)	-	0.27	-0.34	
δQ_α(WS4+)	-	0.32	-0.45	
δQ_α(HN)	-	0.28	0.25	
T_α(WS3+)	0.48 ms	27 ms	19 s	4.0 s
T_α(WS4+)	2.7 ms	20 ms	41 s	17 s
T_α(HN)	0.50 ms	25 ms	0.45 s	3.4 s
f(WS3+)	-	2.1	29	
f(WS4+)	-	1.5	62	
f(HN)	-	1.9	1.5	
$T_\alpha^{\rm exp}$	-	13 ms	0.66 s	
$T_{\rm sf}^{\rm th}$	$1.3{\cdot}10^4 s$	$1.4{\cdot}10^5$ s	$2.1{\cdot}10^3$ s	4.0 s
$T_{\rm sf}^{\rm exp}$			0.30 s	98 ms



Decay chain of $^{296}118$
HN
exp
WS4+
WS3+
Qα (MeV)
Z
13
12
11
10
9
8
7
6
120
118
116
114
112
110
108
106
104
102



Decay chain of $^{296}118$
$\log_{10} T_\alpha$ (s)
Z
WS4+
WS3+
exp
HN
7
6
5
4
3
2
1
0
-1
-2
-3
-4
-5
120
118
116
114
112
110
108
106
104
102

Conclusions

1. Intensive studies of SHN are continued.

2. In particular, 4 decay chains (with 3 α decays in each) were observed in Dubna for the nucleus 294-118.

3. Three consecutive Qα measured for 294-118 are reproduced by the calculations with an average accuracy: 180, 270 and 290 keV by using WS3+, WS4+ and HN mass models,respectively, i.e. very reasonably.

4. The respective Tα are reproduced within average factors: 2.9, 9.8 and 5.2 within the variants: WS3+, WS4+ and HN,respectively, i.e. with equally good accuracy.

5. The length of the chain is reproduced correctly.

6. Predictions done with the same model for the unobserved-yet nucleus 296-118 indicate that it should be observed.