19th Nuclear Physics Workshop, Sept. 26-30, 2012
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Quality of theoretical masses in various regions of the nuclear chart

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1. **Introduction**
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1. Introduction

- **Illustration of the quality of descrption of exp. masses by theor. models**

- **Exp. masses of 2011 (evaluated by G. Audi and Wang Meng)**

- **Motivation:**

1) to see realistic models for making predictions in specific regions of nuclear chart

2) Possible help in improvement of the models

2. Considered models

Older and new + Global and local + Semi-empirical, macro-micro, purely micro (self-consistent) + Other

Global models: LSD, FRDM, TF, FRLDM – macro-micro;

Sk-HFB21; G-HFB – purely micro

Local models: LMZ – semi-empirical, HN (Warsaw) – macro-micro

Other: DZ, KTUY, WS3.6, WS3.3

LSD: K. Pomorski and J. Dudek, PRC **67** (2003) 044316
FRDM, FRLDM: P. Möller et al., ADNDT **59** (1995) 185
TF: W.D. Myers and W.J. Świątecki, Nucl. Phys. A **601** (1996) 141
Sk-HFB21: S. Goriely et al., PRC **82** (2010) 035804
G-HFB: S. Goriely et al., PRL **102** (2009) 242501

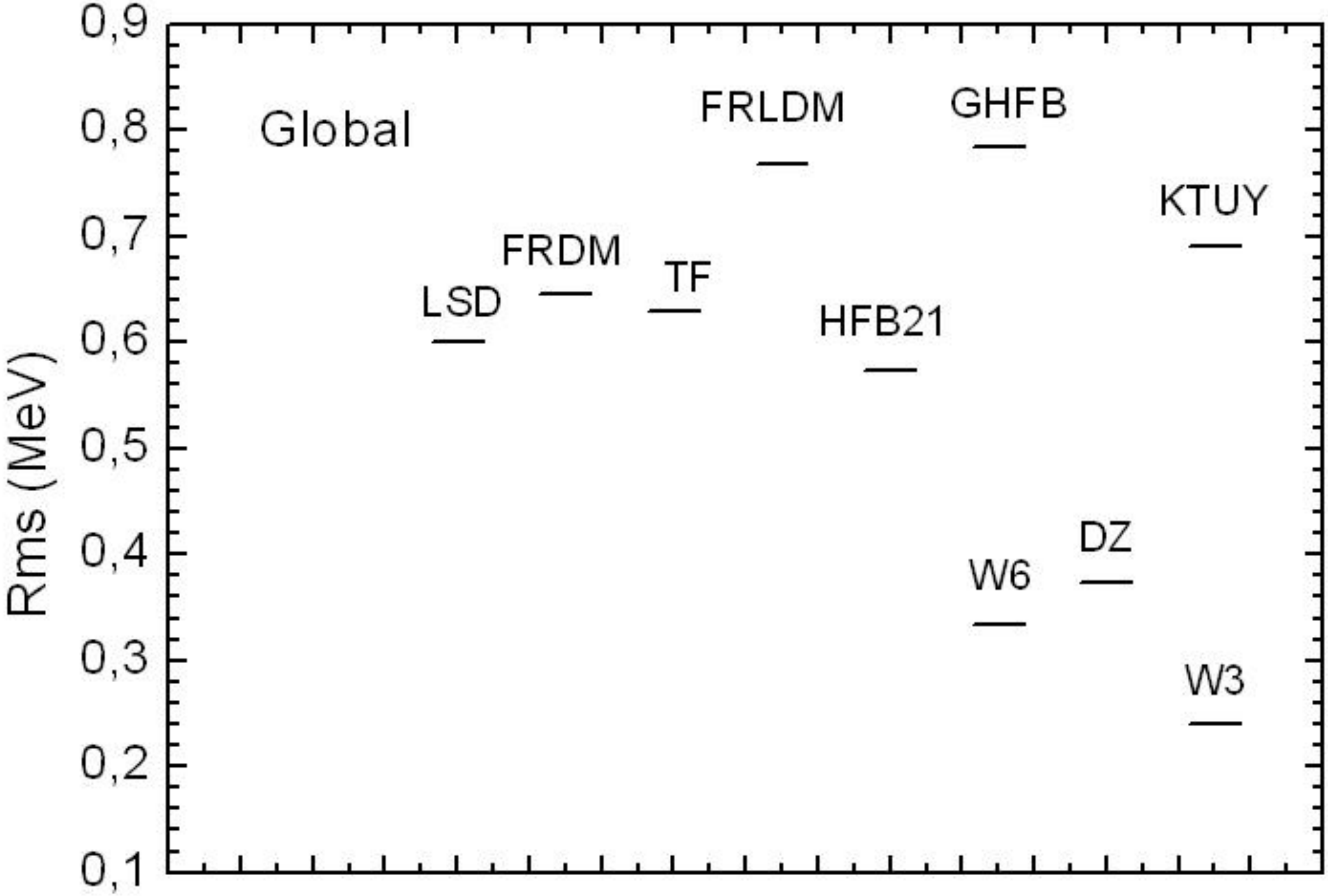
LMZ: S. Liran, A. Marinov, N. Zeldes., PRC **62** (2000) 47301
HN (Warsaw): I. Muntian et al., Acta Phys. Pol. B **32** (2001) 691

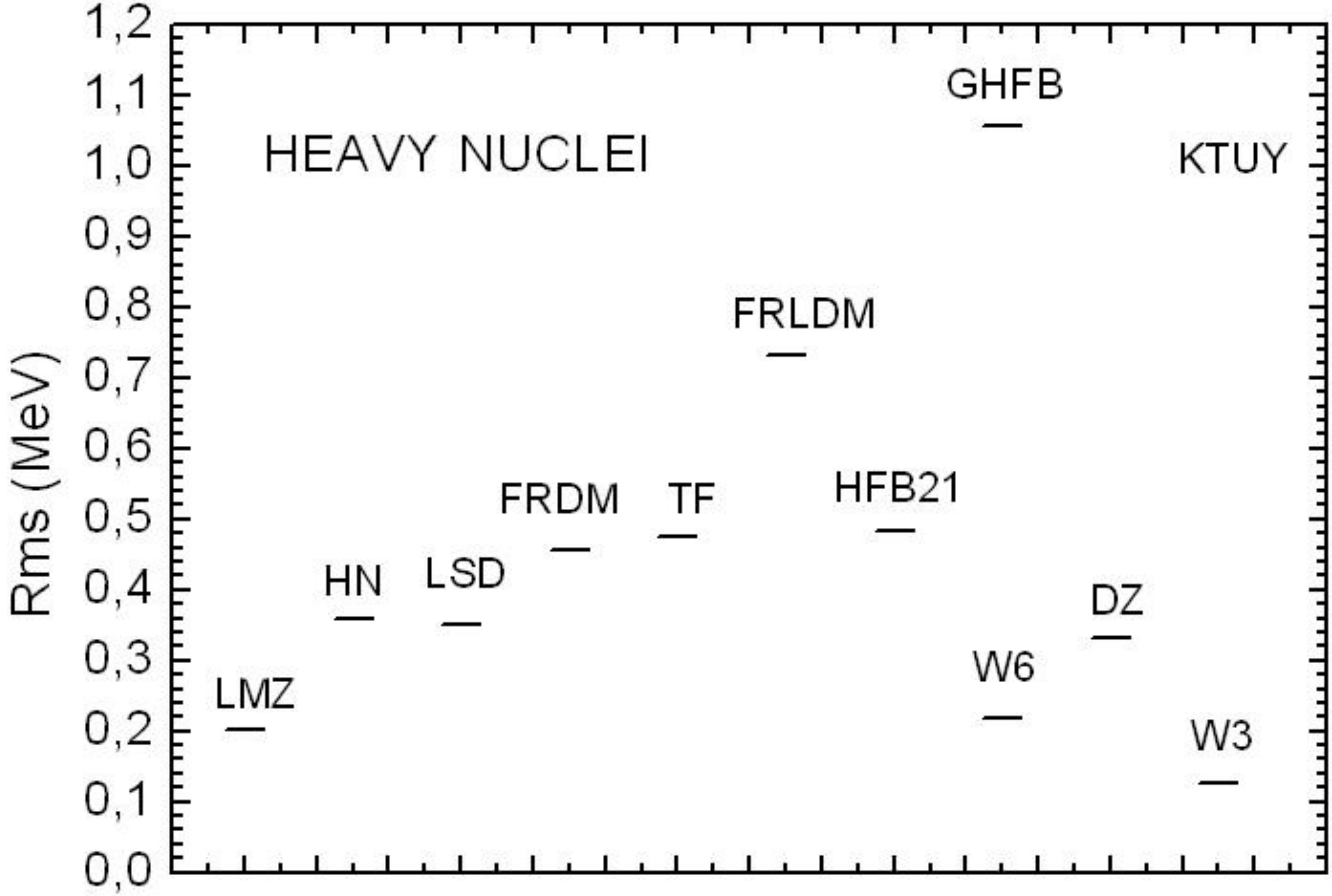
DZ: J. Duflo and A.P. Zuker, PRC **52** (1995) R23
KTUY: H. Koura et al., Prog. Theor. Phys. **113** (2005) 305
WS3.6 (W6): Min Liu et al.., PRC 84 (2011) 014333
WS3.3 (W3): Ning Wang et al.., PRC (2010) 044304

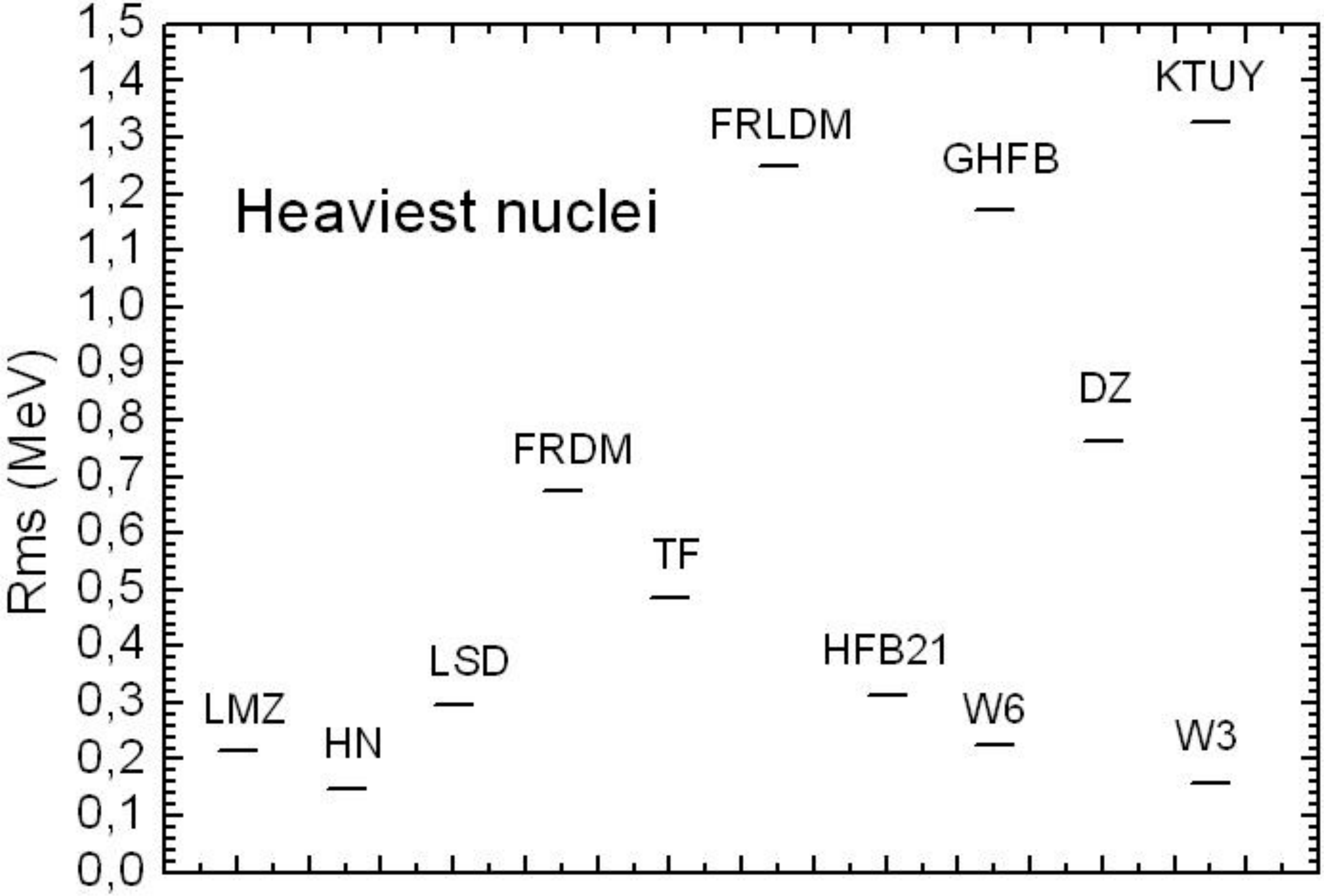
3. Accuracy of the description

Table 1. The Rms, average discrepancy, $\bar{\delta}$, and maximum of the absolute values of the discrepancies, Max $|\ \delta\ |$ (all given in MeV), calculated for all ($Z, N \geq 8$), heavy ($Z \geq 82$, $N \geq 126$), and heaviest ($Z > 100$) nuclei, with the use of the specified models. The year of publication of each model and the number of nuclei with measured mass in each of the considered regions, N_{nucl}, are also indicated.

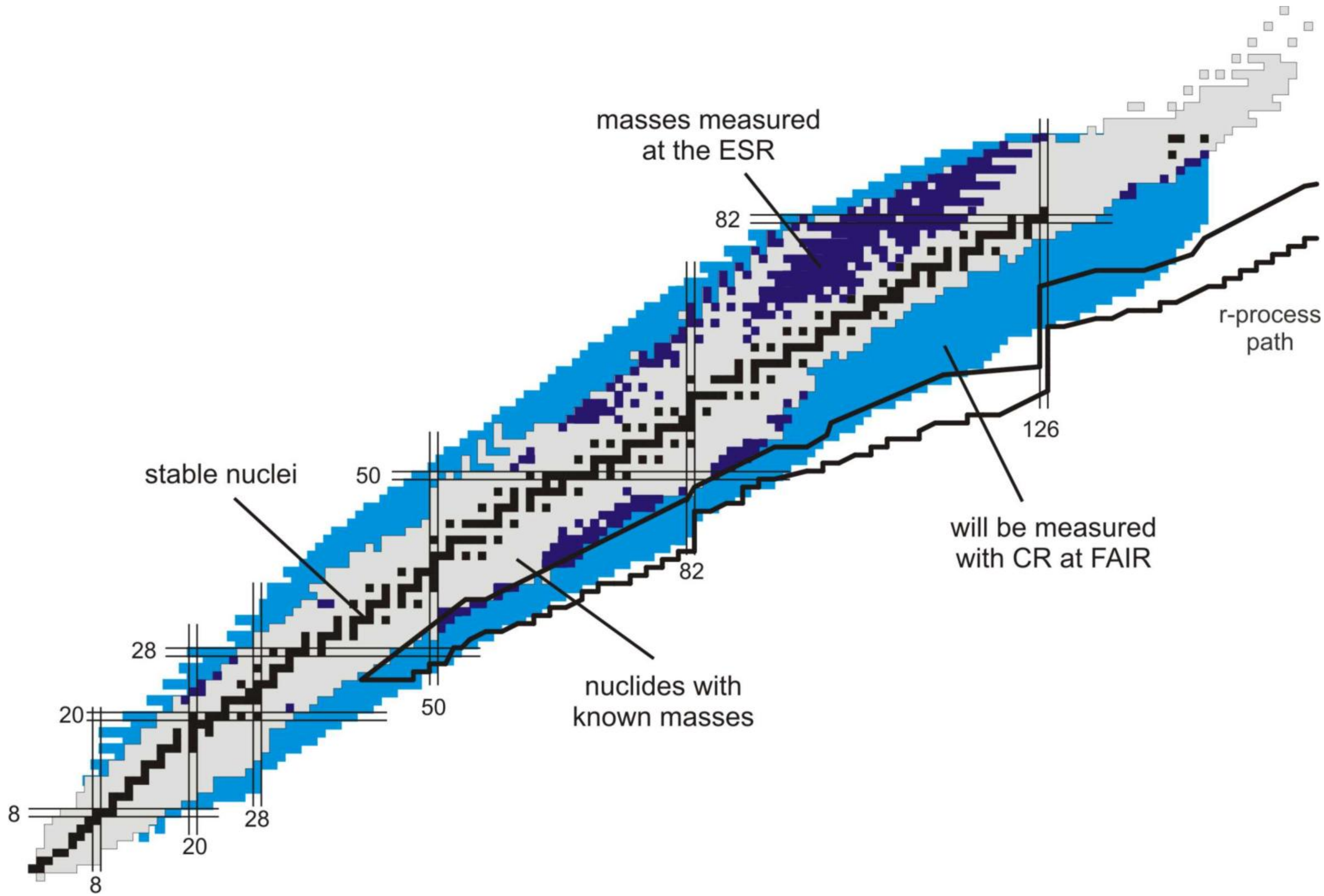
Model	LMZ (2000)	HN (2001)	LSD (2003)	FRDM (1995)	TF (1996)	FRLDM (1995)	HFB21 (2010)	GHFB (2009)	DZ (1995)	KTUY (2005)
$N_{nucl}(Z \geq 8)$	-	-	2267	2294	2293	2294	2294	2294	2294	2294
Rms	-	-	0.600	0.645	0.629	0.768	0.574	0.784	0.374	0.690
$\bar{\delta}$	-	-	-0.028	-0.062	0.027	0.057	0.031	-0.108	-0.029	-0.048
Max $\|\ \delta\ \|$	-	-	4.34	3.64	4.61	4.17	3.20	3.23	3.01	2.63
$N_{nucl}(Z \geq 82)$	297	297	289	297	296	297	297	297	297	297
Rms	0.202	0.358	0.352	0.455	0.476	0.731	0.484	1.057	0.333	0.986
$\bar{\delta}$	0.028	-0.133	0.163	0.131	0.340	0.562	0.132	-0.118	-0.011	-0.307
Max $\|\ \delta\ \|$	1.12	1.13	1.43	1.95	1.75	1.92	1.33	3.23	3.01	2.38
$N_{nucl}(Z > 100)$	24	24	23	24	23	24	24	24	24	24
Rms	0.215	0.147	0.295	0.676	0.484	1.251	0.314	1.172	0.761	1.326
$\bar{\delta}$	-0.140	-0.063	-0.157	-0.525	0.457	1.218	-0.095	1.046	-0.151	1.303
Max $\|\ \delta\ \|$	0.69	0.39	1.09	1.95	0.82	1.92	0.92	1.70	3.01	1.93


Global
FRLDM
GHFB
KTUY
FRDM
TF
LSD
HFB21
DZ
W6
W3
Rms (MeV)
0,9
0,8
0,7
0,6
0,5
0,4
0,3
0,2
0,1

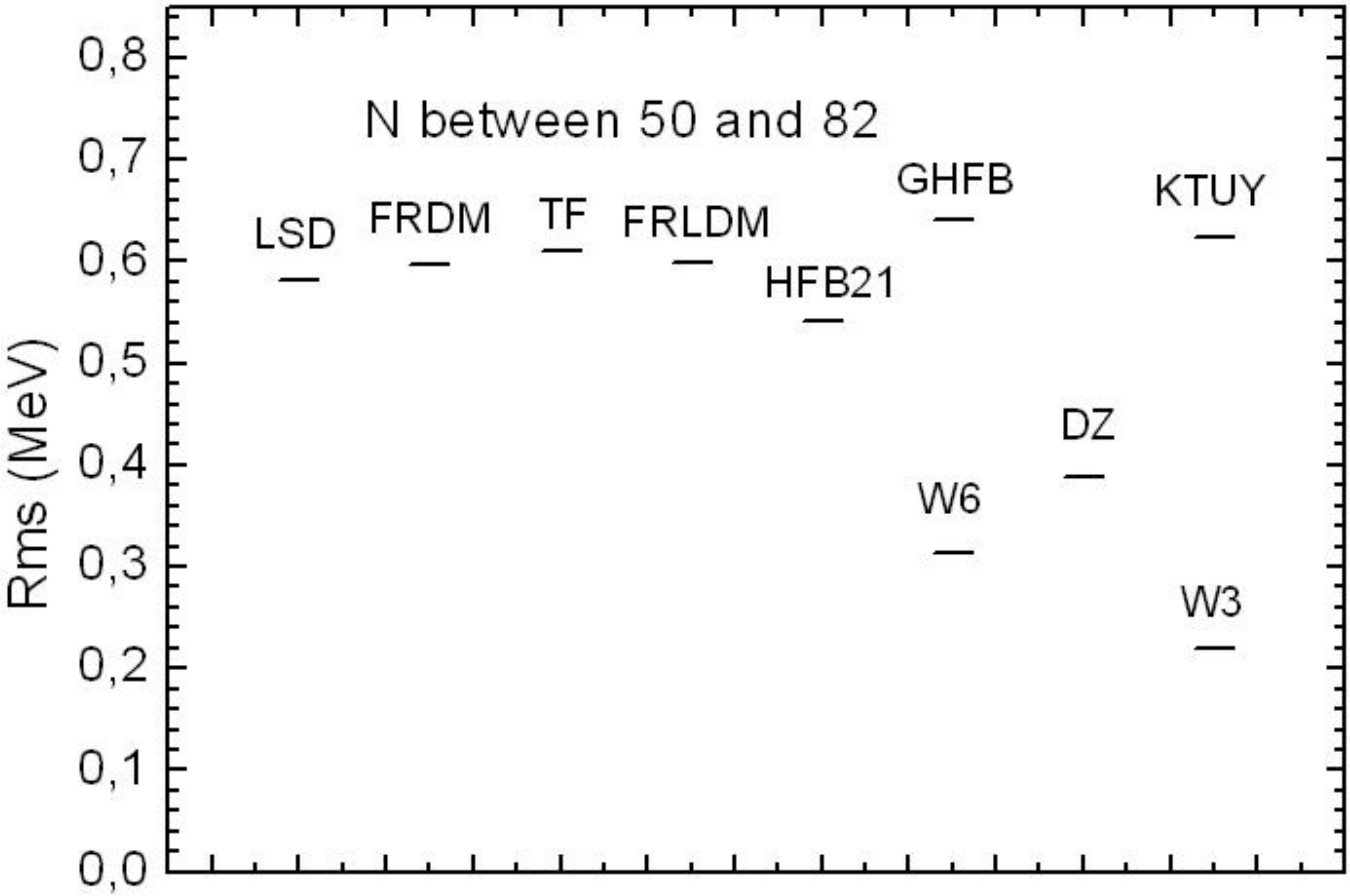

HEAVY NUCLEI
Rms (MeV)
1,2
1,1
1,0
0,9
0,8
0,7
0,6
0,5
0,4
0,3
0,2
0,1
0,0
LMZ
HN
LSD
FRDM
TF
FRLDM
HFB21
GHFB
W6
DZ
KTUY
W3



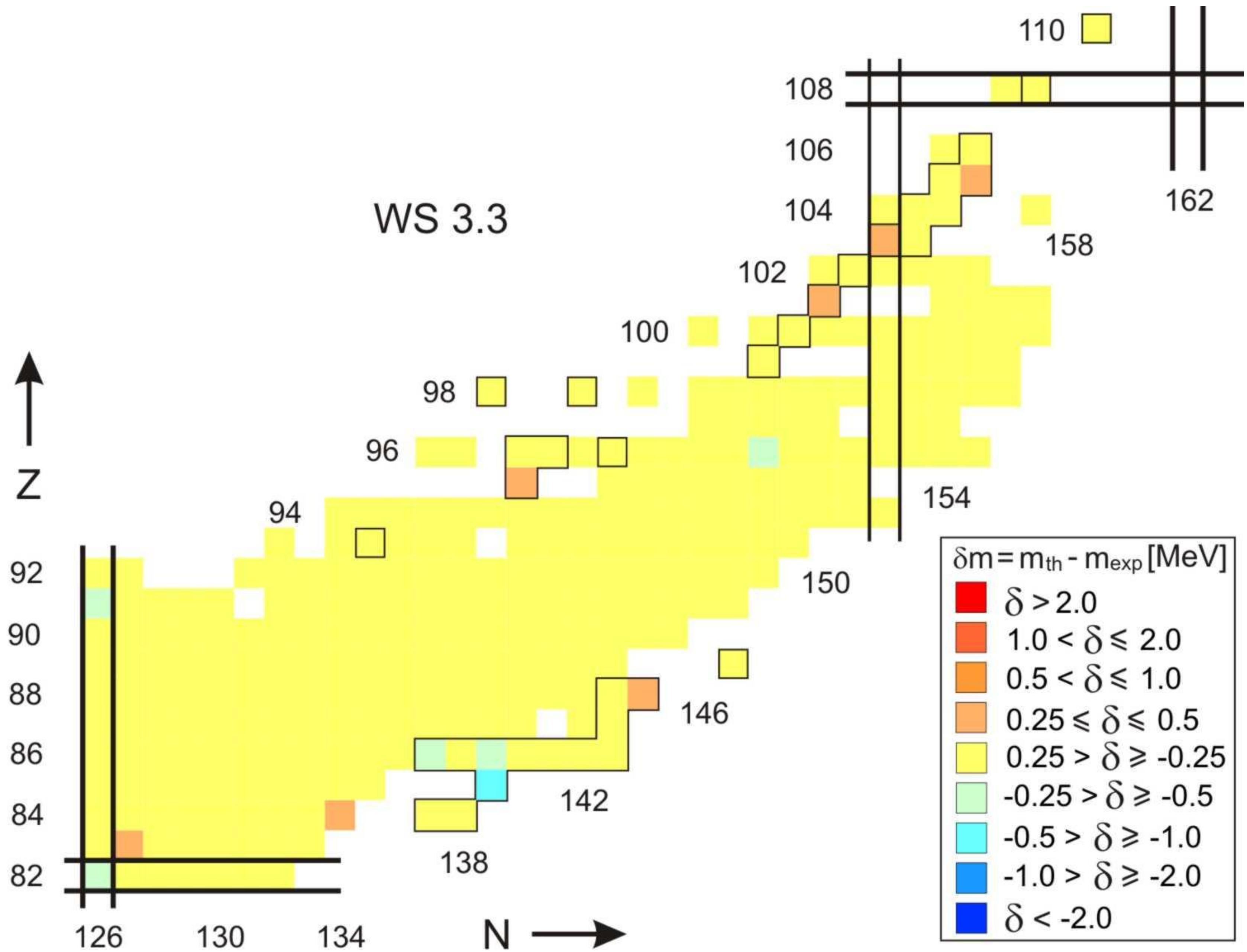
Heaviest nuclei
Rms (MeV)
1,5
1,4
1,3
1,2
1,1
1,0
0,9
0,8
0,7
0,6
0,5
0,4
0,3
0,2
0,1
0,0
LMZ
HN
LSD
FRDM
TF
FRLDM
HFB21
GHFB
W6
DZ
KTUY
W3



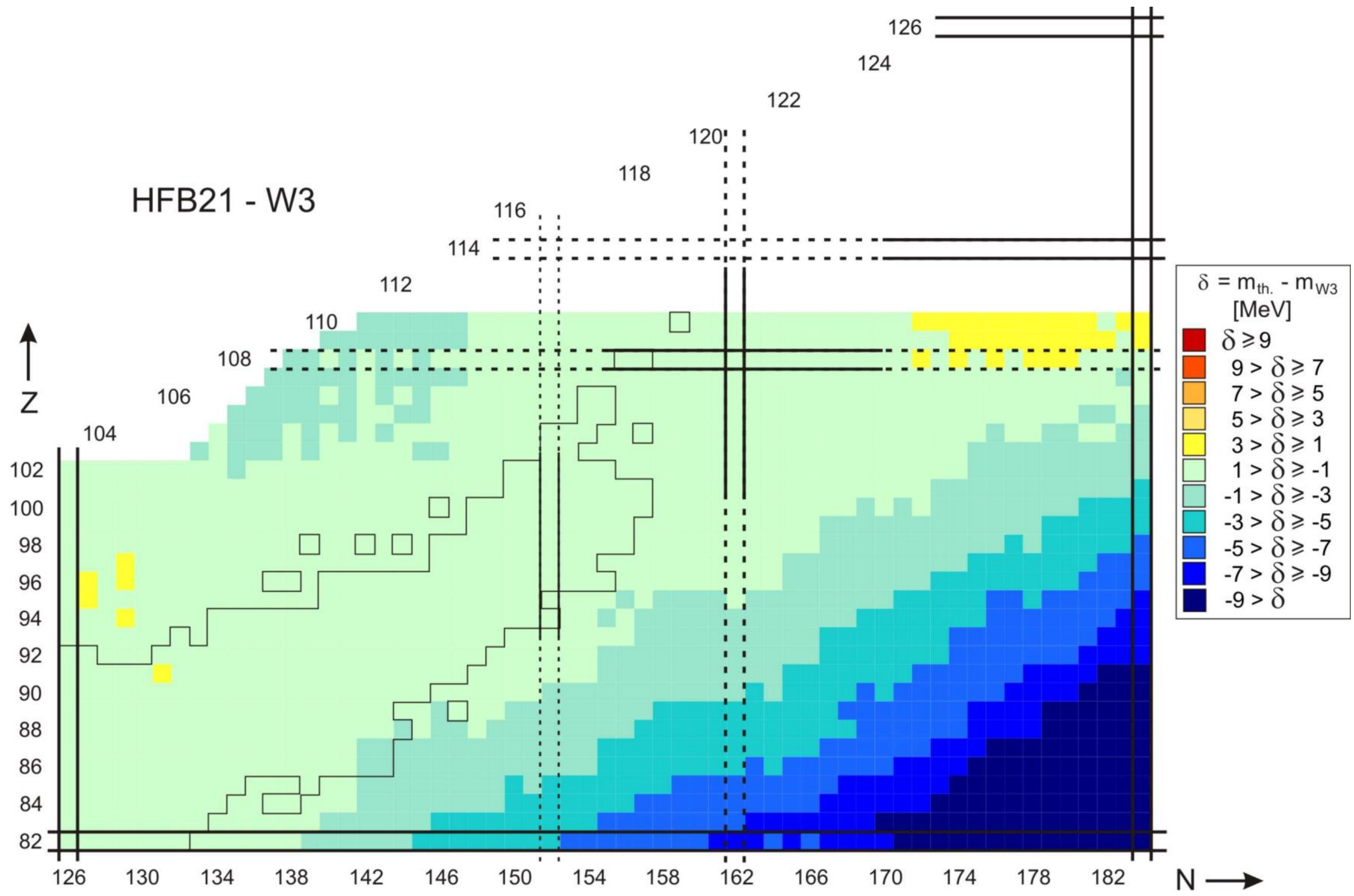
masses measured
at the ESR
82
stable nuclei
50
126
r-process
path
will be measured
with CR at FAIR
82
28
50
nuclides with
known masses
20
8
28
20
8



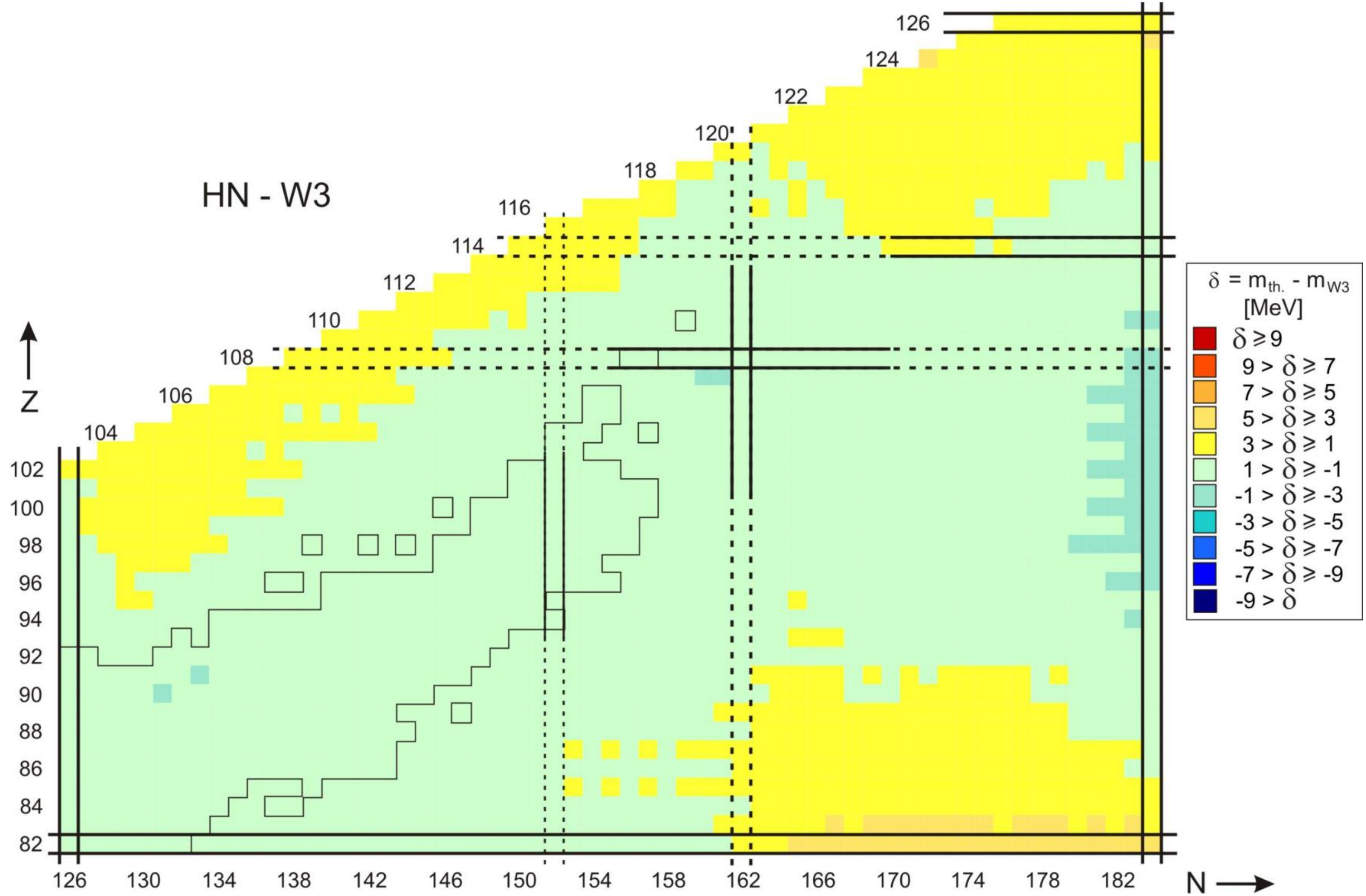
N between 50 and 82
Rms (MeV)
0,0
0,1
0,2
0,3
0,4
0,5
0,6
0,7
0,8
LSD
FRDM
TF
FRLDM
HFB21
GHFB
W6
DZ
KTUY
W3



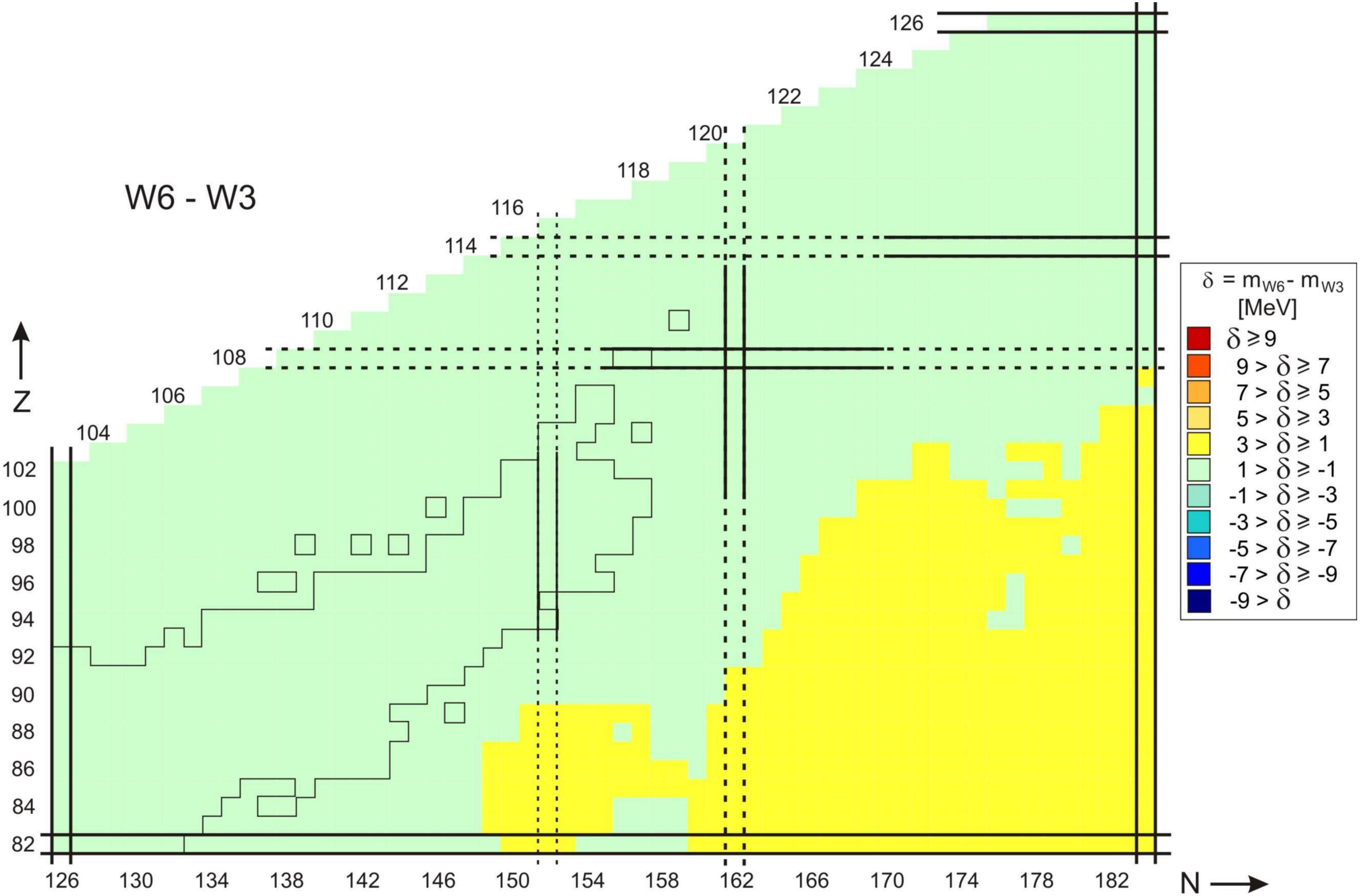
WS 3.3
Z
N
82
84
86
88
90
92
94
96
98
100
102
104
106
108
110
126
130
134
138
142
146
150
154
158
162
δm = m_th - m_exp [MeV]
δ > 2.0
1.0 < δ ≤ 2.0
0.5 < δ ≤ 1.0
0.25 ≤ δ ≤ 0.5
0.25 > δ ≥ -0.25
-0.25 > δ ≥ -0.5
-0.5 > δ ≥ -1.0
-1.0 > δ ≥ -2.0
δ < -2.0



HFB21 - W3
δ = m_th. - m_W3
[MeV]
δ ≥ 9
9 > δ ≥ 7
7 > δ ≥ 5
5 > δ ≥ 3
3 > δ ≥ 1
1 > δ ≥ -1
-1 > δ ≥ -3
-3 > δ ≥ -5
-5 > δ ≥ -7
-7 > δ ≥ -9
-9 > δ
Z
N
126 130 134 138 142 146 150 154 158 162 166 170 174 178 182
82 84 86 88 90 92 94 96 98 100 102
104 106 108 110 112 114 116 118 120 122 124 126



HN - W3
δ = m_th. - m_W3
[MeV]
δ ≥ 9
9 > δ ≥ 7
7 > δ ≥ 5
5 > δ ≥ 3
3 > δ ≥ 1
1 > δ ≥ -1
-1 > δ ≥ -3
-3 > δ ≥ -5
-5 > δ ≥ -7
-7 > δ ≥ -9
-9 > δ
Z
N
126 130 134 138 142 146 150 154 158 162 166 170 174 178 182
82 84 86 88 90 92 94 96 98 100 102
104 106 108 110 112 114 116 118 120 122 124 126



W6 - W3
Z
N
126
124
122
120
118
116
114
112
110
108
106
104
102
100
98
96
94
92
90
88
86
84
82
126
130
134
138
142
146
150
154
158
162
166
170
174
178
182
δ = m_W6 - m_W3
[MeV]
δ ≥ 9
9 > δ ≥ 7
7 > δ ≥ 5
5 > δ ≥ 3
3 > δ ≥ 1
1 > δ ≥ -1
-1 > δ ≥ -3
-3 > δ ≥ -5
-5 > δ ≥ -7
-7 > δ ≥ -9
-9 > δ

Conclusions

1. Masses of about 2.300 nuclei are already measured. One likes to describe them by theoretical models with a rather small number of adjustable parameters (~15).

2. Twelve models of different type have been checked by us. Rms is roughly in the range: 500 - 800 keV in the global region.

3. But this number is only very general. If we like to use a model in a specific region of nuclei, we should check it just in this region.

4. An interesting question is the predictive power of a given model.

5. Present accuracy of theoretical models (~ 600 keV) is much smaller than that of measurement (~ 50 keV). This is a real challenge for theoreticians.

6. One should stress a recent progress in the accuracy of purely microscopic (self-consistent) models.