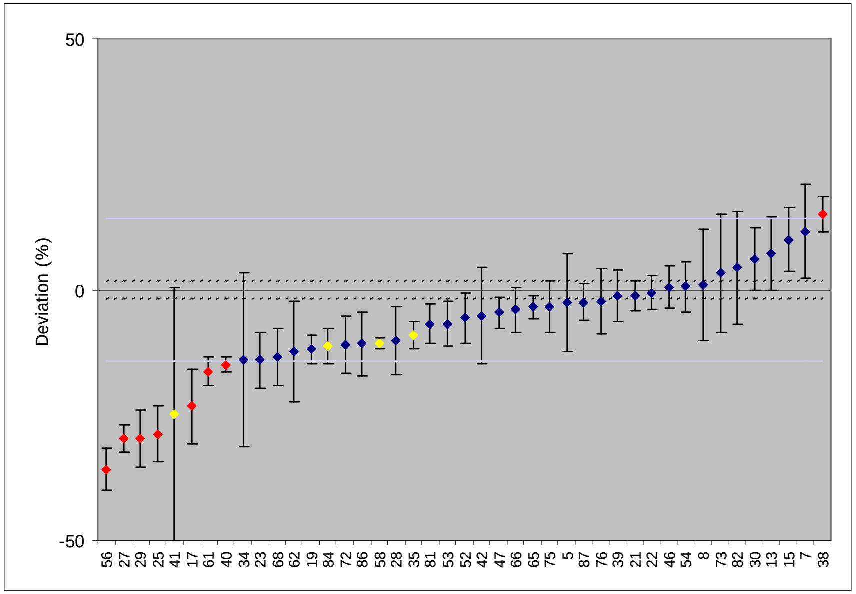
GL and GH samples 2008



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National Physical Laboratory

27 January 2009

Radionuclides in GL and GH

8 nuclides:

^{22}Na, ^{60}Co, ^{95}Zr, ^{95}Nb, ^{133}Ba, ^{134}Cs, ^{137}Cs and ^{152}Eu

Participants:

GL	55	(2007: 45)
GH	44	(2007: 39)

'False' positives

^{40}K	6	
^{46}Sc	1	
^{54}Mn	1	
^{57}Co	2	(^{152}Eu)
^{58}Co	4	(^{152}Eu)
^{65}Zn	1	
^{106}Ru	1	
^{109}Cd	2	
^{154}Eu	4	(^{22}Na)
^{155}Eu	2	
^{170}Tm	2	
^{207}Bi	2	(^{134}Cs)
^{210}Pb	1	

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GL composition (Bq kg^{-1})

	NPL	Labs	*t*-test	Ratio
^{22}Na	**8.19(3)**	7.45(5)	-12.57 D	0.91
^{60}Co	**7.201(22)**	7.24(4)	0.82	1.01
^{95}Zr	**7.30(7)**	7.42(6)	1.28	1.02
^{95}Nb	**13.46(7)**	14.00(11)	4.22 D	1.04
^{133}Ba	**6.12(5)**	5.90(5)	-3.55 D	0.96
^{134}Cs	**11.93(8)**	11.40(5)	-5.49 D	0.96
^{137}Cs	**9.02(6)**	9.17(6)	1.75	1.02
^{152}Eu	**12.35(9)**	12.15(9)	-1.55	0.98

GH composition (Bq g^{-1})

	NPL	Labs	*t*-test	Ratio
^{22}Na	**5.529(20)**	5.28(4)	-6.27 D	0.95
^{60}Co	**4.641(14)**	4.698(21)	2.24	1.01
^{95}Zr	**7.35(8)**	7.61(5)	3.02 D	1.03
^{95}Nb	**13.54(7)**	13.86(9)	2.74 D	1.02
^{133}Ba	**2.754(19)**	2.599(14)	-6.53 D	0.94
^{134}Cs	**4.63(4)**	4.55(3)	-1.81	0.98
^{137}Cs	**9.56(7)**	9.69(5)	1.62	1.01
^{152}Eu	**17.86(12)**	17.31(8)	-3.73 D	0.97

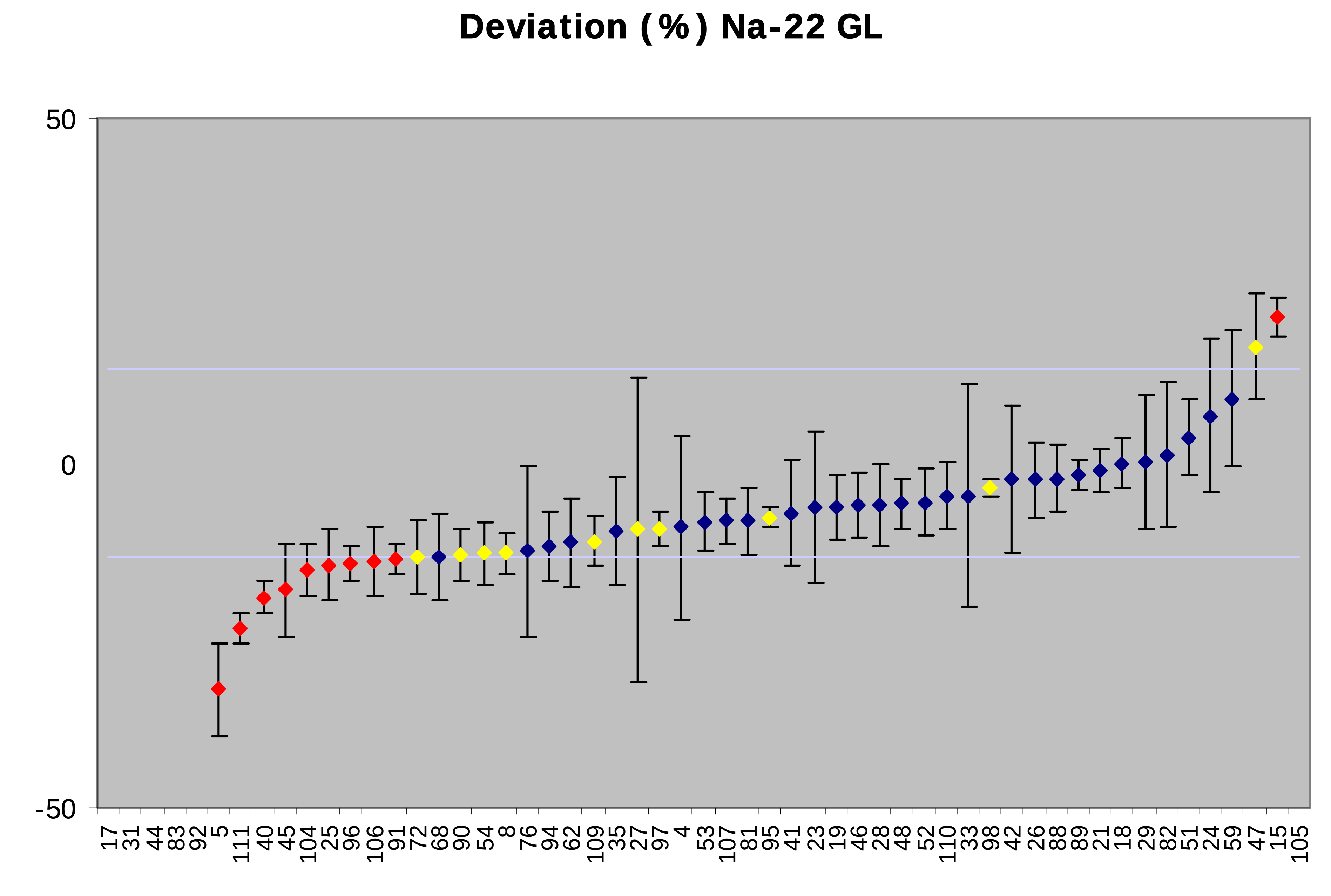
GL and GH in agreement (%)

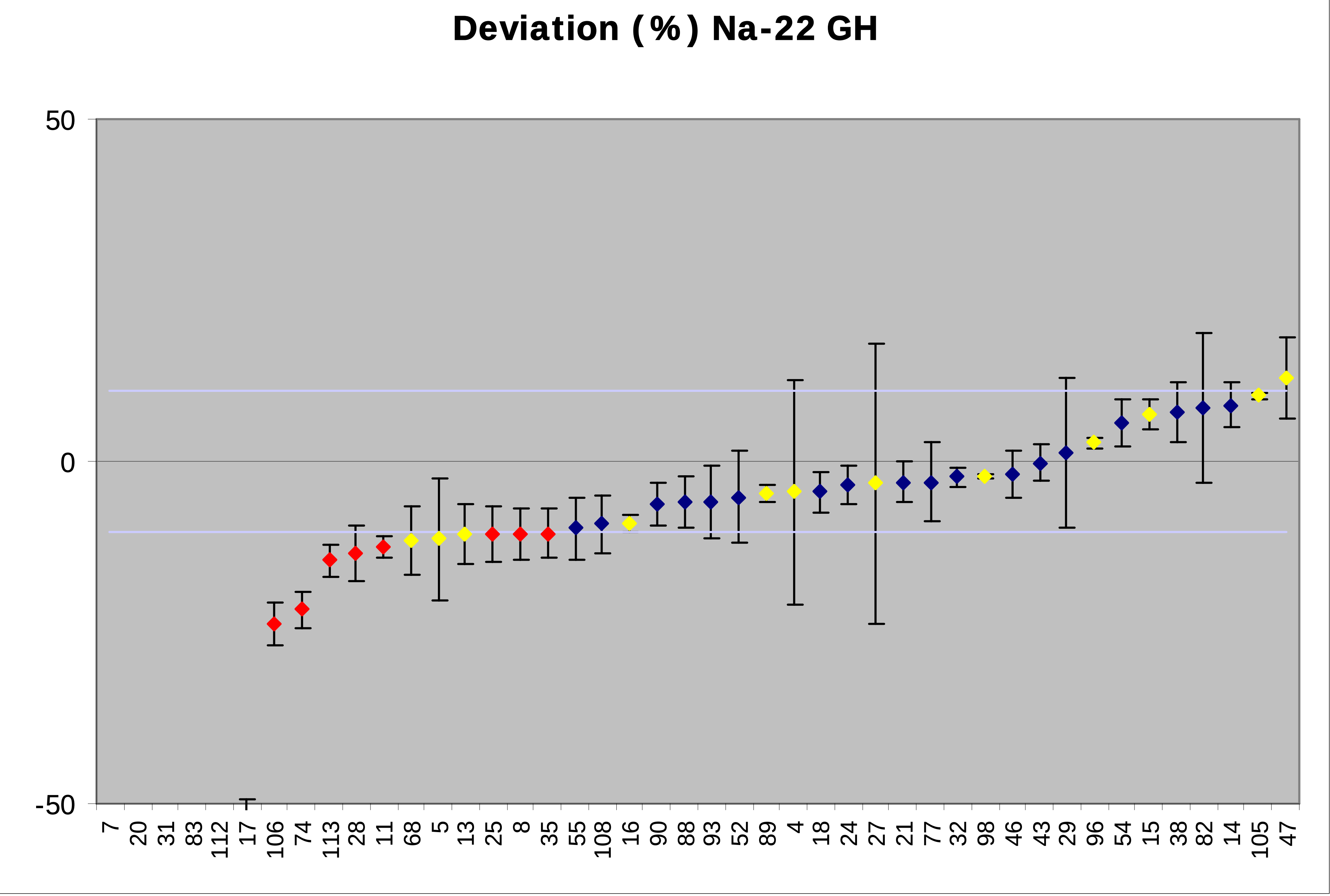
	GL	GH
^{22}Na	**53** (-)	**41** (-)
^{60}Co	**69** (82)	**70** (85)
^{95}Zr	**76** (62)	**66** (74)
^{95}Nb	**62** (29)	**61** (46)
^{133}Ba	**71** (73)	**57** (77)
^{134}Cs	**65** (71)	**68** (64)
^{137}Cs	**76** (89)	**68** (79)
^{152}Eu	**69** (64)	**55** (77)

(x) refers to 2007 values

Results

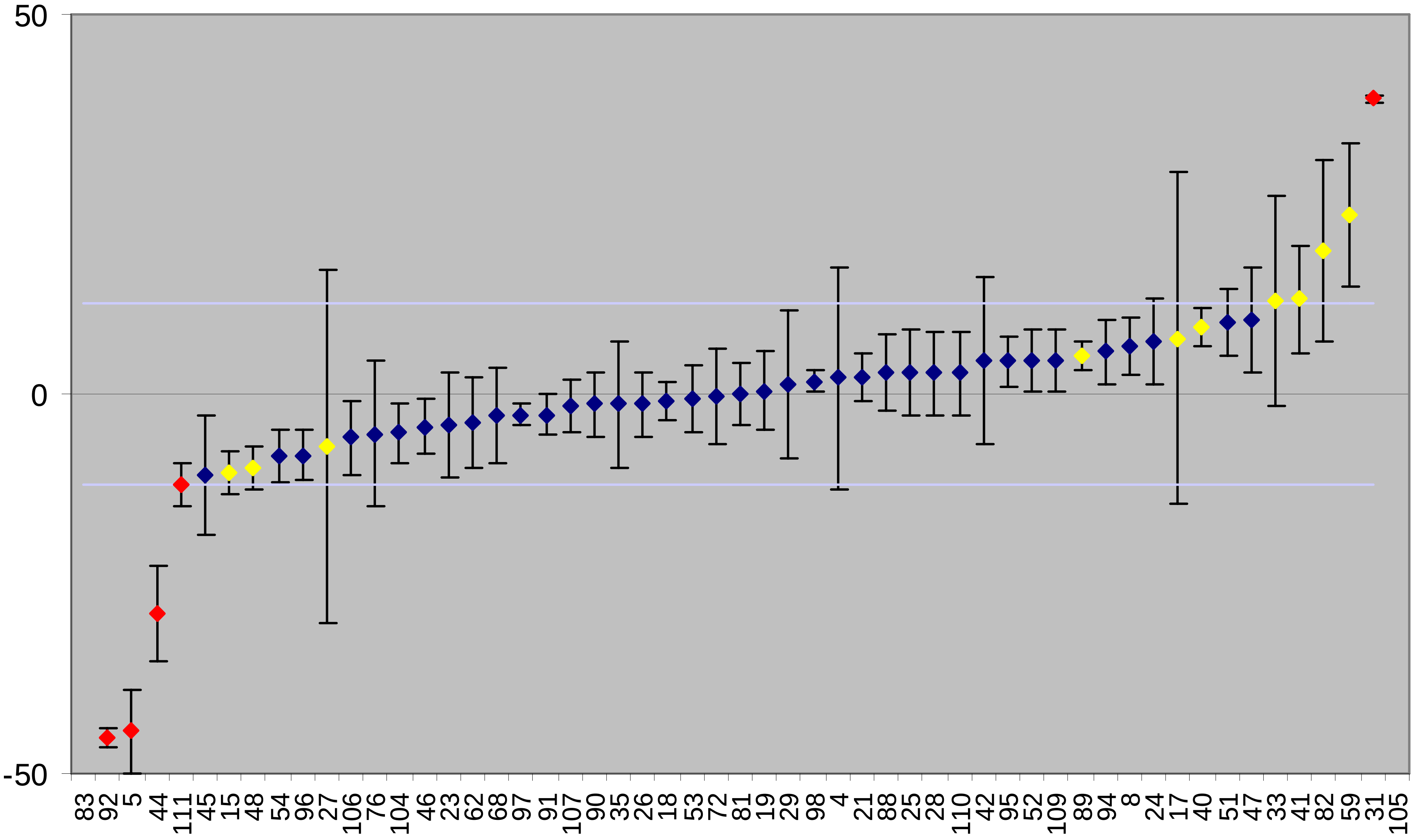
GL			(2007)
	68%	‘in agreement’	72%
	15%	‘questionable’	12%
	13%	‘discrepant’	10%
	4%	‘missing’	6%
GH			
	61%	‘in agreement’	76%
	22%	‘questionable’	9%
	14%	‘discrepant’	7%
	3%	‘missing’	8%


Deviation (%) Na-22 GL
50
0
-50
17
31
44
83
92
5
111
40
45
104
25
96
106
91
72
68
90
54
8
76
94
62
109
35
27
97
4
53
107
81
95
41
23
19
46
28
48
52
110
33
98
42
26
88
89
21
18
29
82
51
24
59
47
15
105

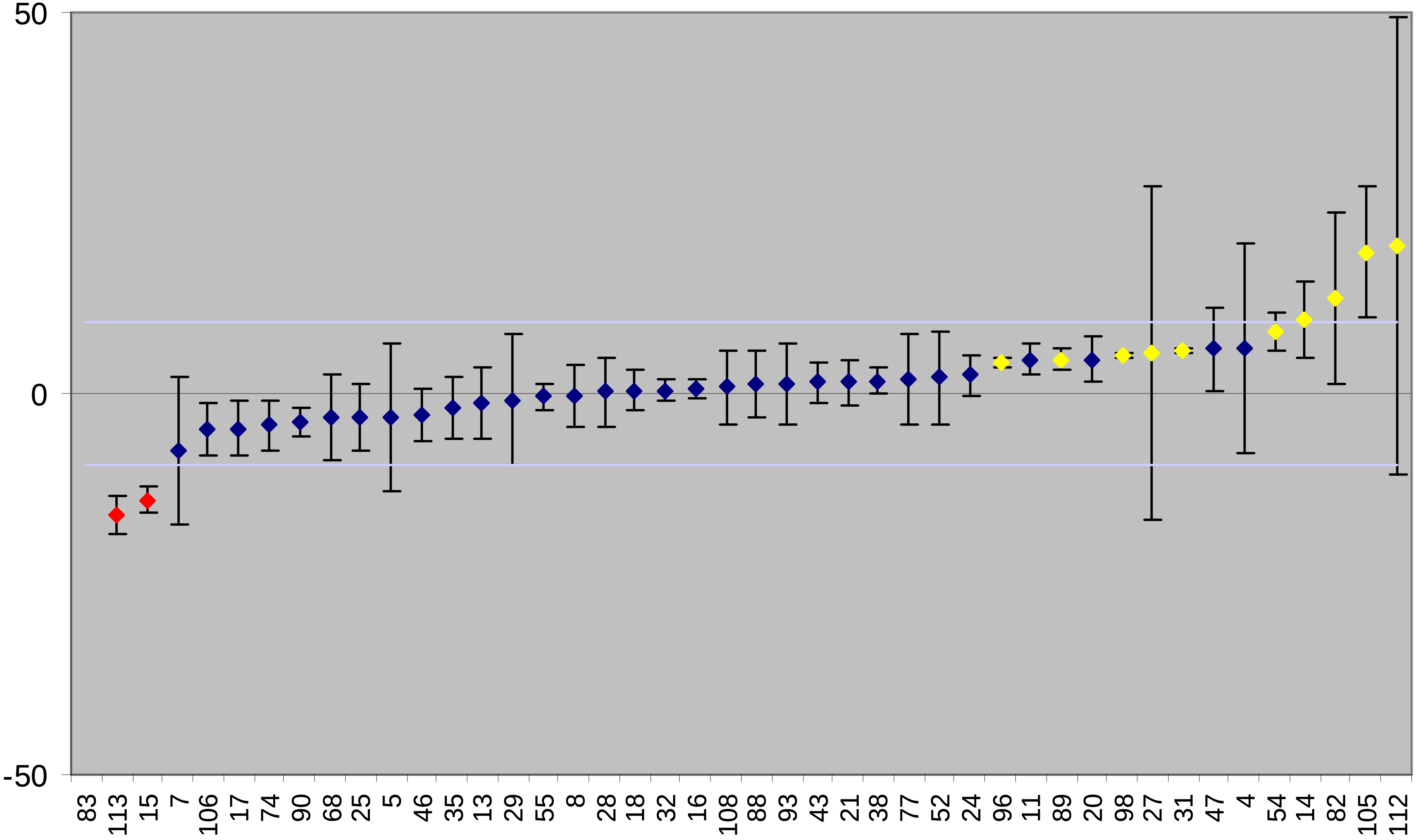


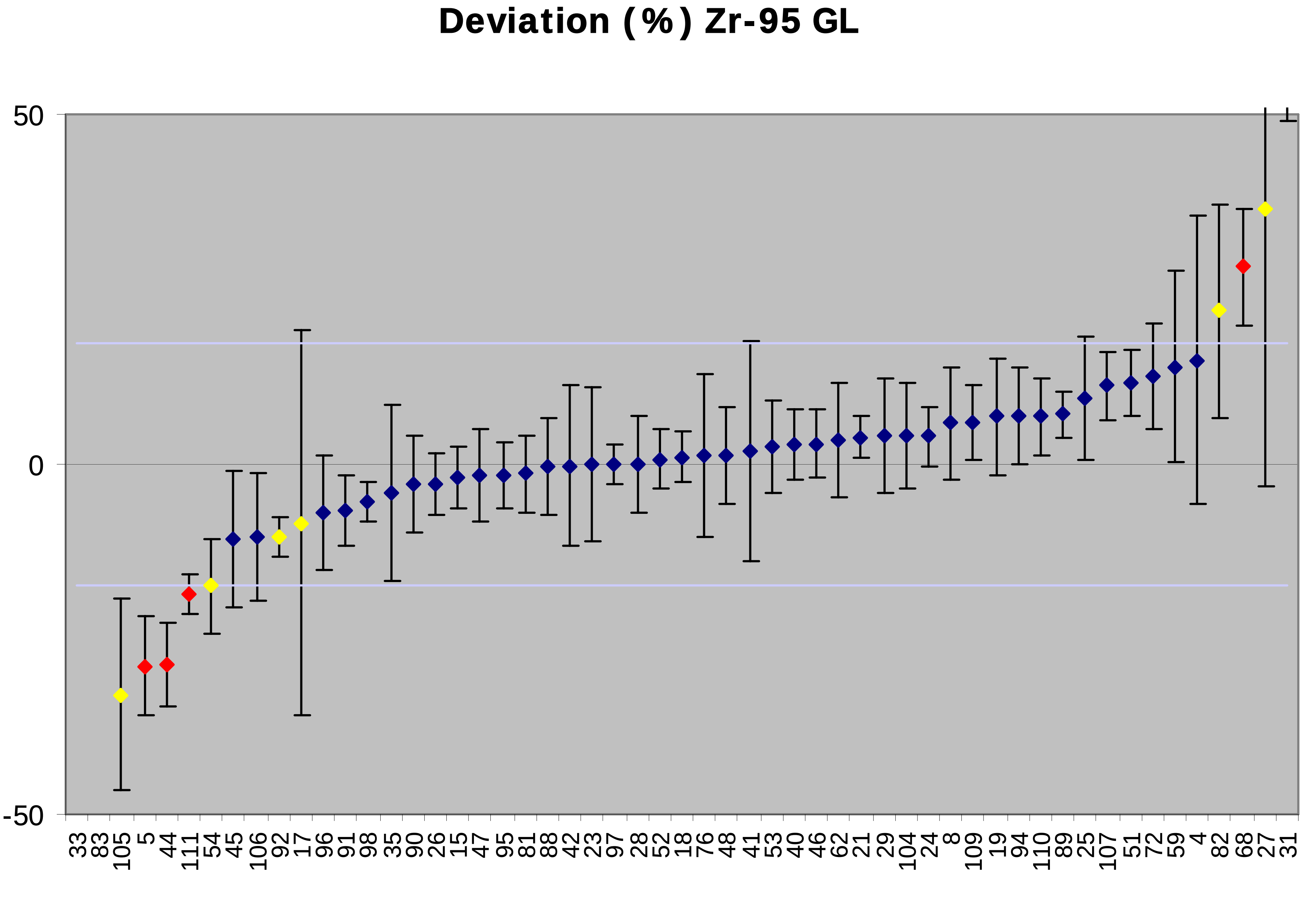
Deviation (%) Na-22 GH
50
0
-50
7
20
31
83
112
17
106
74
113
28
11
68
5
13
25
8
35
55
108
16
90
88
93
52
89
4
18
24
27
21
77
32
98
46
43
29
96
54
15
38
82
14
105
47

Deviation (%) Co-60 GL

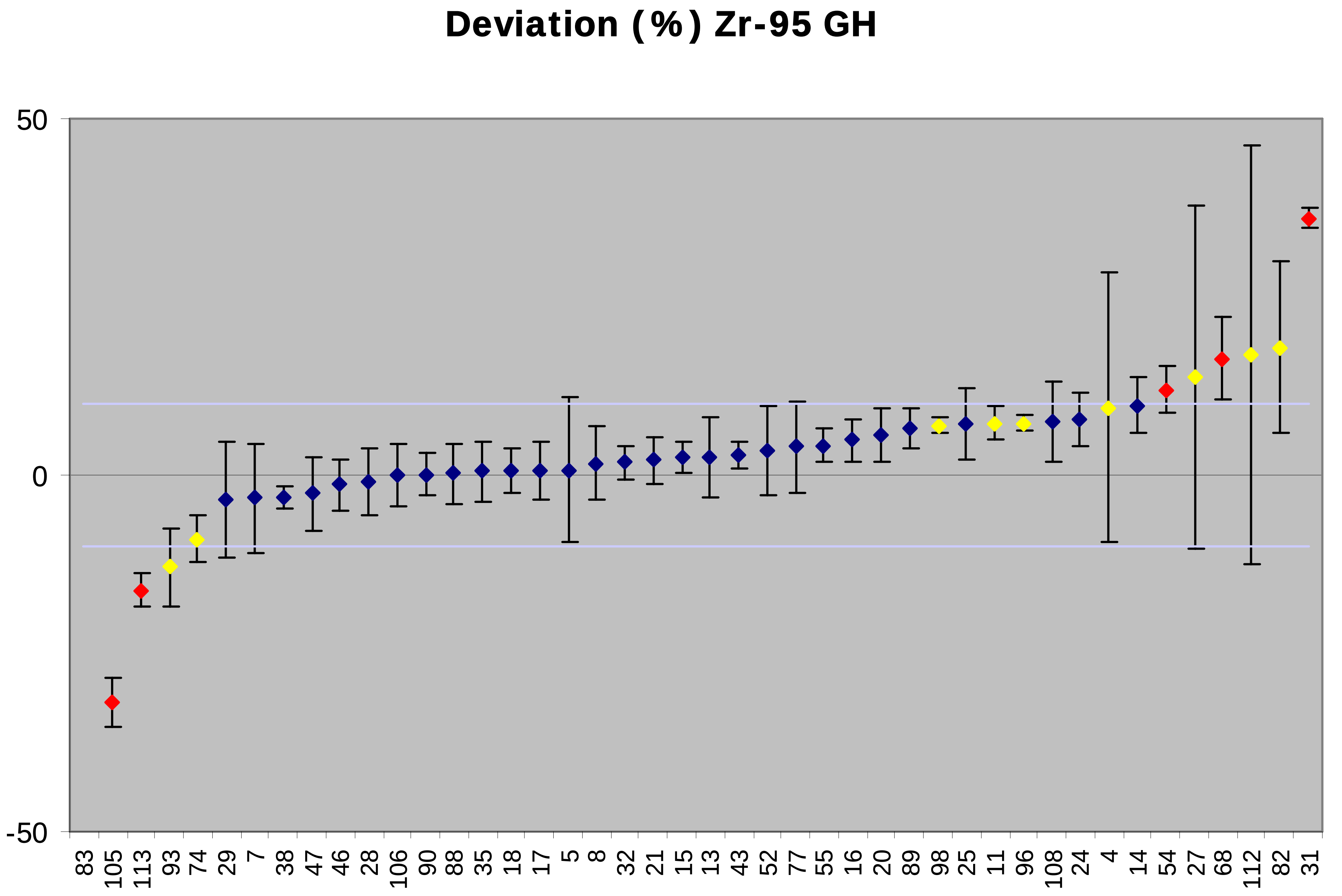


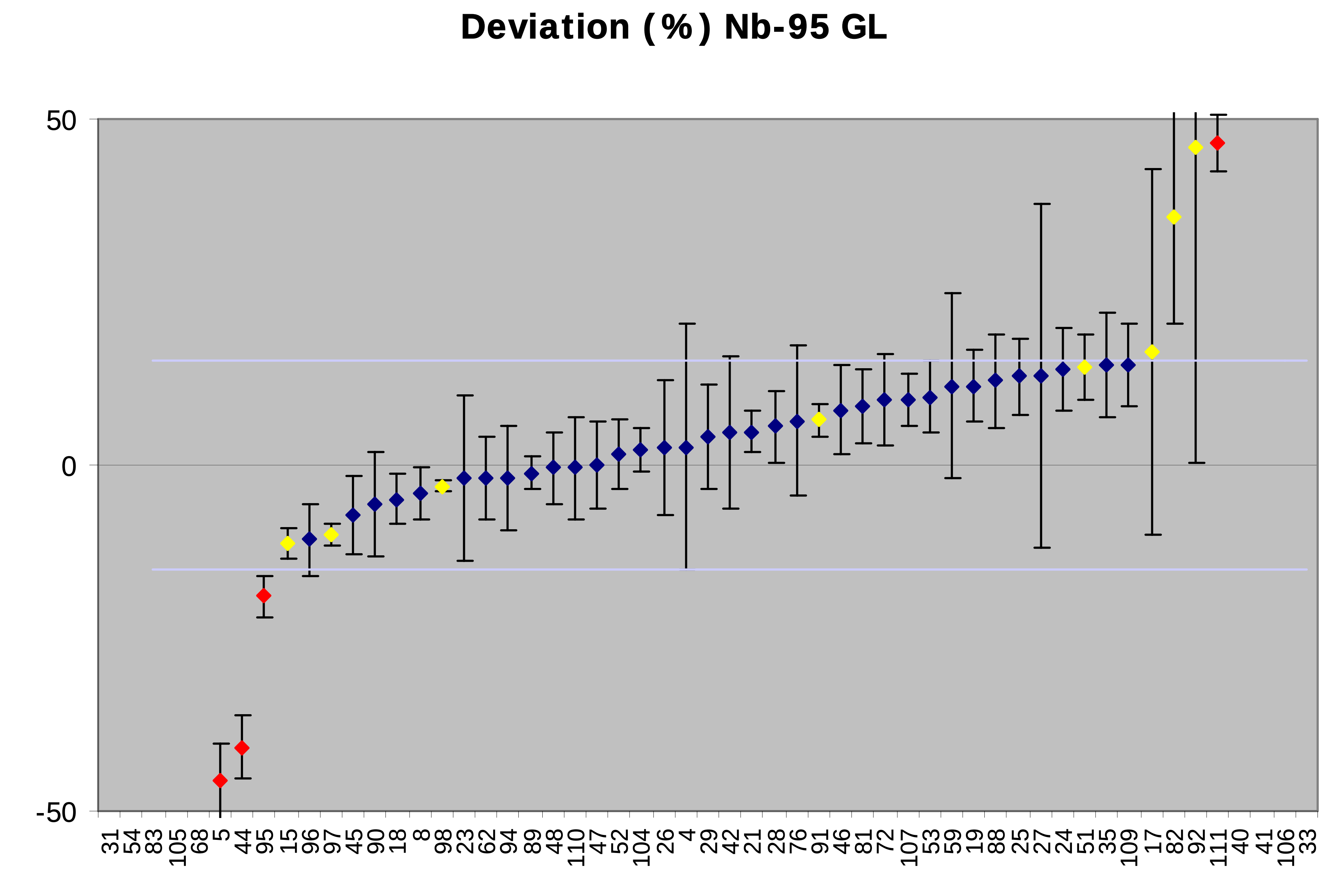
Deviation (%) Co-60 GH





Deviation (%) Zr-95 GL
50
0
-50
33 83 105 5 44 111 54 45 106 92 17 96 91 98 35 90 26 15 47 95 81 88 42 23 97 28 52 18 76 48 41 53 40 46 62 21 29 104 24 8 109 19 94 110 89 25 107 51 72 59 4 82 68 27 31


Deviation (%) Zr-95 GH
50
0
-50
83
105
113
93
74
29
7
38
47
46
28
106
90
88
35
18
17
5
8
32
21
15
13
43
52
77
55
16
20
89
98
25
11
96
108
24
4
14
54
27
68
112
82
31


Deviation (%) Nb-95 GL
50
0
-50
31
54
83
105
68
5
44
95
15
96
97
45
90
18
8
98
23
62
94
89
48
110
147
52
104
26
4
29
42
21
28
76
91
46
81
72
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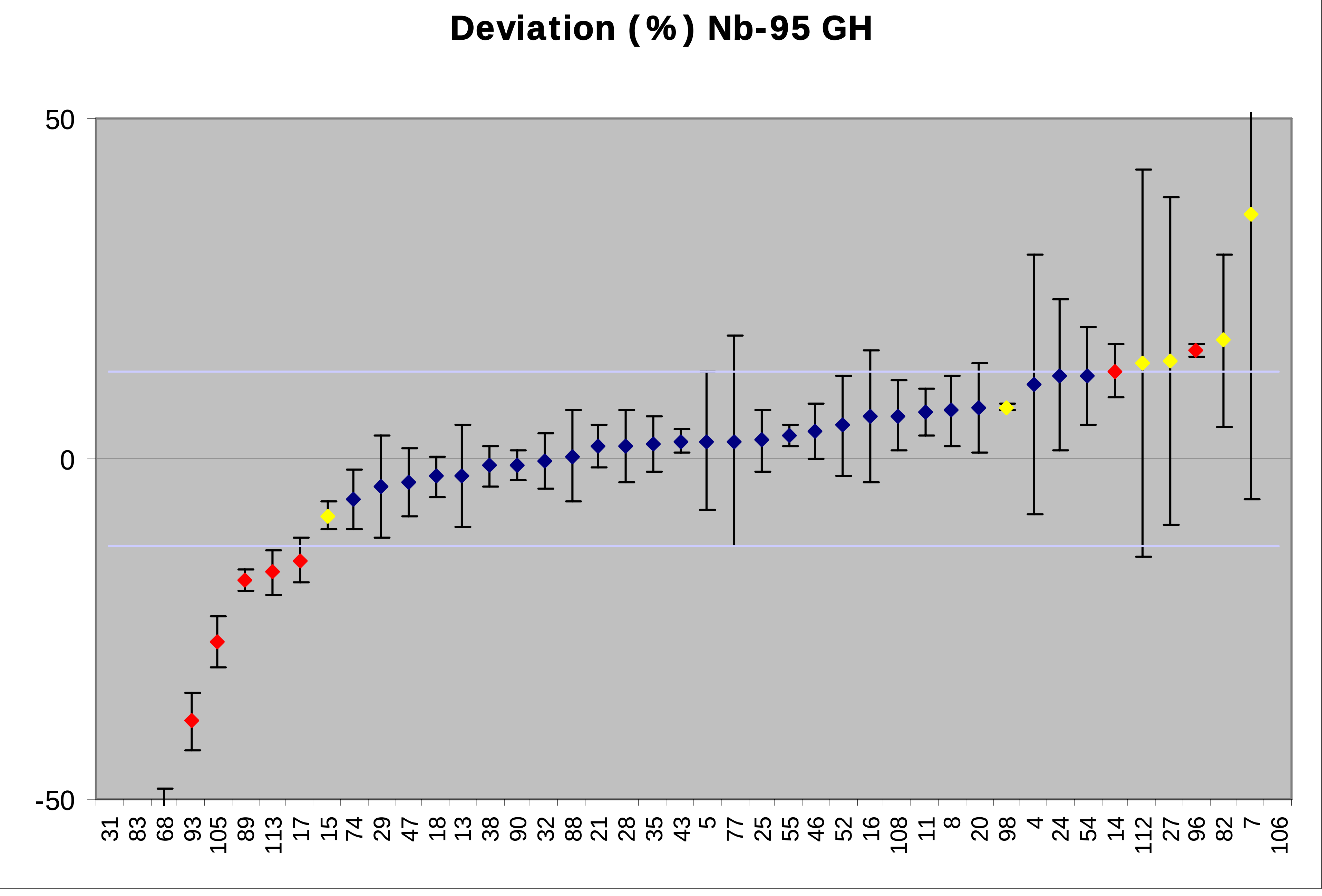
109
17
82
92
111
40
41
106
33



Deviation (%) Nb-95 GH
50
0
-50
31
83
68
93
105
89
113
17
15
74
29
47
18
13
38
90
32
88
21
28
35
43
5
77
25
55
46
52
16
108
11
8
20
98
4
24
54
14
112
27
96
82
7
106

^{95}Nb decay correction

Half-life ^{95}Nb = 34.991(6) d

Half-life ^{95}Zr = 64.032(6) d

At the reference time (1 October 2008 12:00 UTC), the ^{95}Nb / ^{95}Zr ratio was 1.843(21)

The equilibrium value of this ratio is 2.2057(6) (at this point ^{95}Nb decays with a ^{95}Zr half-life)

During the Exercise, ^{95}Nb decayed "slower" than ^{95}Zr!

The 'effective' ^{95}Nb half-life is a function of time

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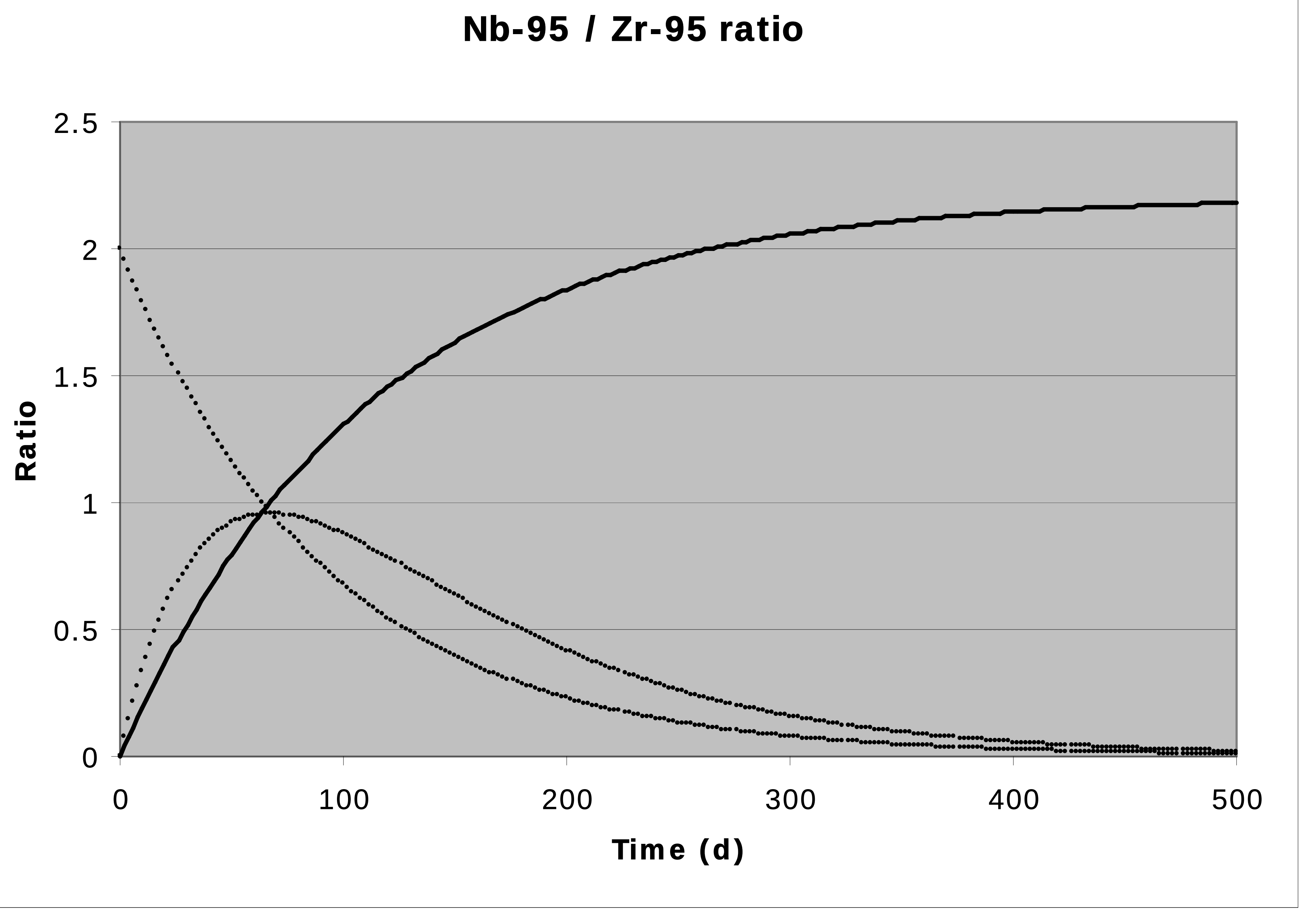
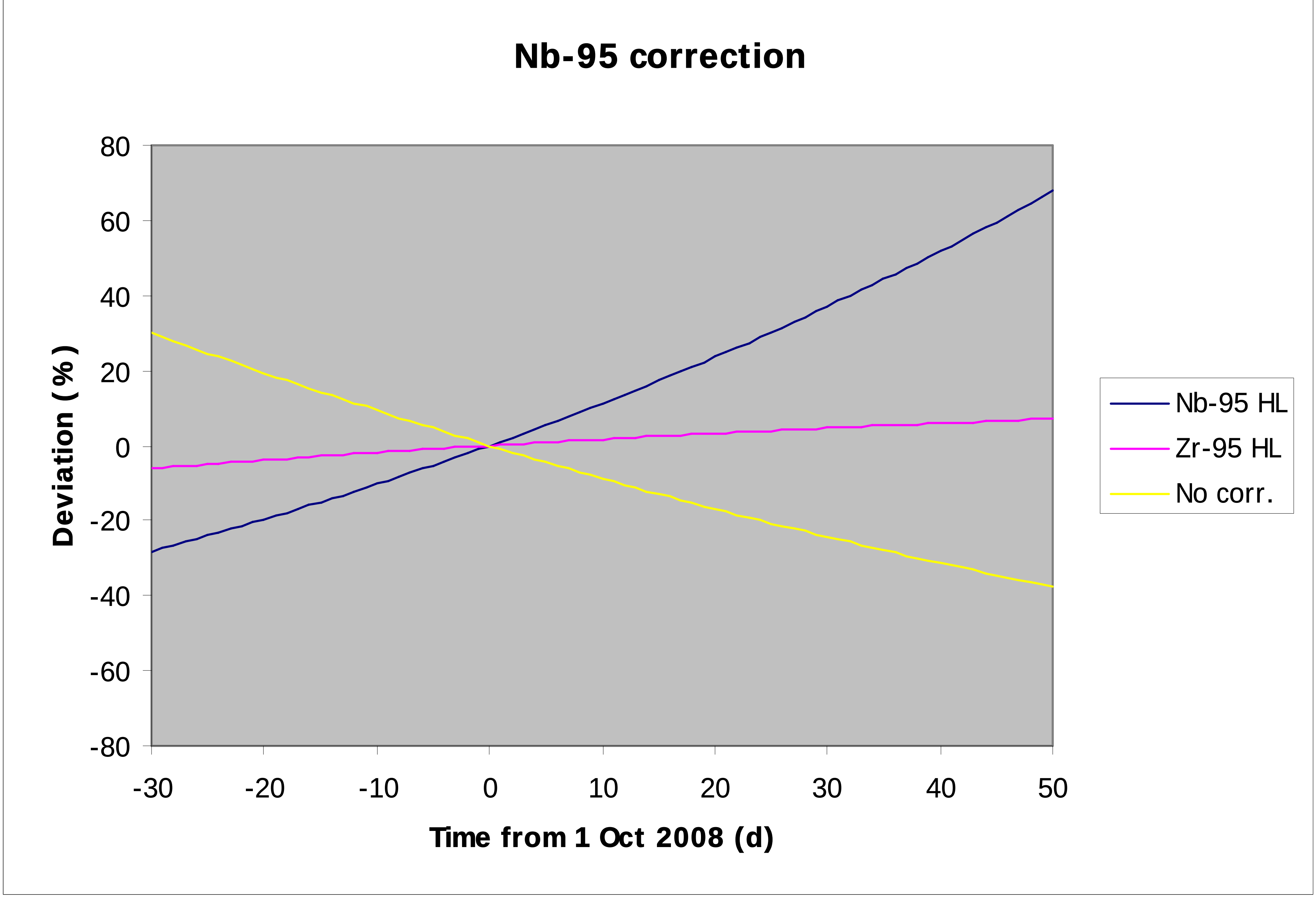


Nb-95 / Zr-95 ratio
Ratio
2.5
2
1.5
1
0.5
0
0
100
200
300
400
500
Time (d)



Nb-95 correction
Deviation (%)
80
60
40
20
0
-20
-40
-60
-80
-30
-20
-10
0
10
20
30
40
50
Time from 1 Oct 2008 (d)
Nb-95 HL
Zr-95 HL
No corr.

Decay of ^{95}Nb (Applied Radiation and Isotopes, in press)

^{95}Zr (1) decays to ^{95}Nb (3) and ^{95m}Nb (2) (p = 0.0112), which in turn decays to ^{95}Nb (3) (q = 0.975) and stable ^{95}Mo

Decay/ingrowth during measurement combined with a decay correction to the reference time of the exercise

$$A_3(t_{ref}) = F_{31}(t_1, t_2, t_{ref})\,C_1 + F_{32}(t_1, t_2, t_{ref})\,C_2 + F_{33}(t_1, t_2, t_{ref})\,C_3$$

$$F_{31}(t_1, t_2, t_{ref}) = \left[\frac{\big((1-p)(\lambda_2-\lambda_1)+q\,p\,\lambda_2\big)(\lambda_1 E_3-\lambda_3 E_1)}{(\lambda_3-\lambda_1)(\lambda_2-\lambda_1)\,E_1}+\frac{q\,p\,\lambda_2(\lambda_3 E_2-\lambda_2 E_3)}{(\lambda_3-\lambda_2)(\lambda_2-\lambda_1)\,E_2}\right]\frac{\lambda_3(t_2-t_1)}{E_3}$$

$$F_{32}(t_1, t_2, t_{ref}) = \frac{q\,\lambda_3(t_2-t_1)}{(\lambda_3-\lambda_2)}\left[\frac{\lambda_2}{E_2}-\frac{\lambda_3}{E_3}\right]$$

$$F_{33}(t_1, t_2, t_{ref}) = \frac{\lambda_3\,(t_2-t_1)}{E_3}$$

$$E_i = e^{-\lambda_i(t_1-t_{ref})} - e^{-\lambda_i(t_2-t_{ref})}$$

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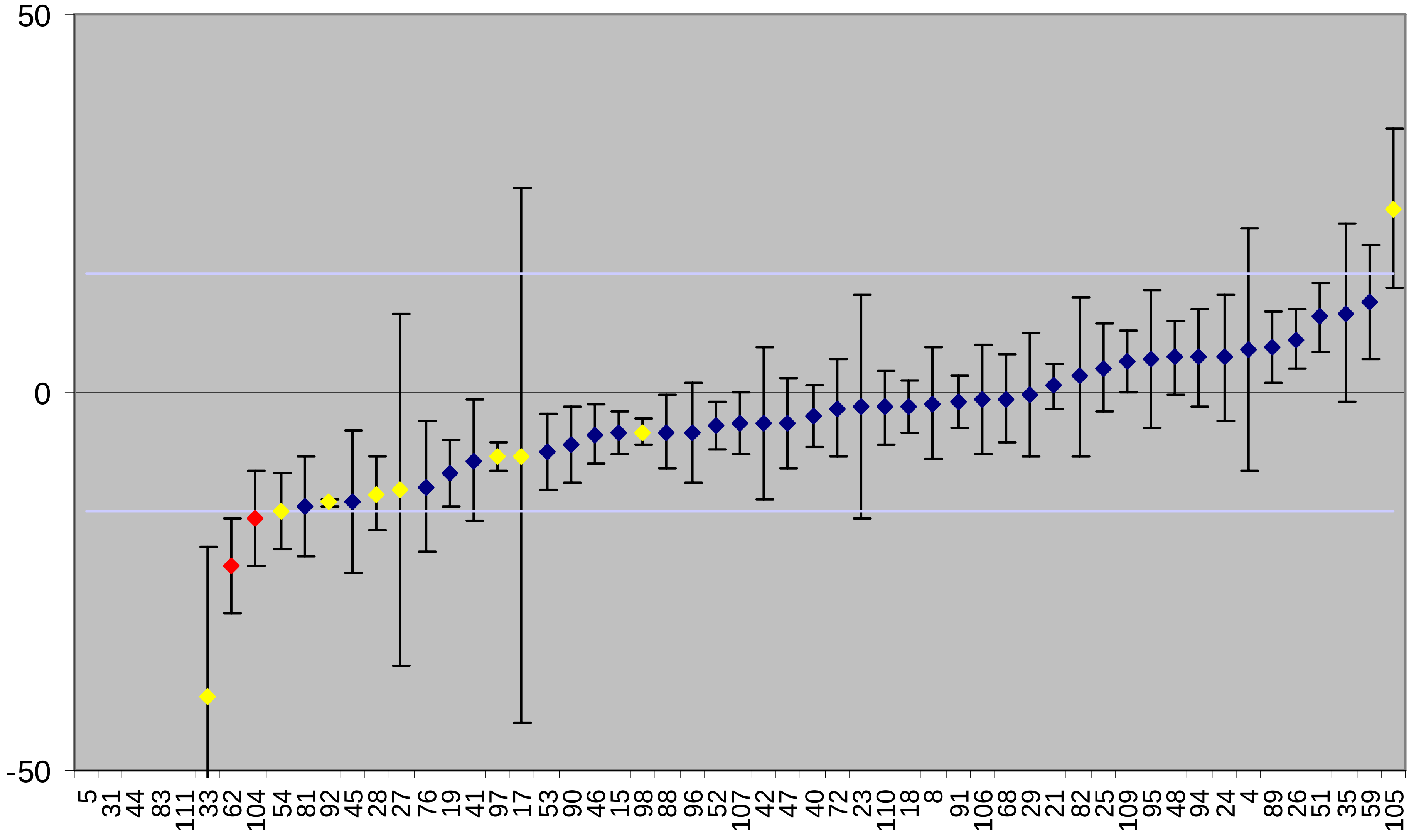
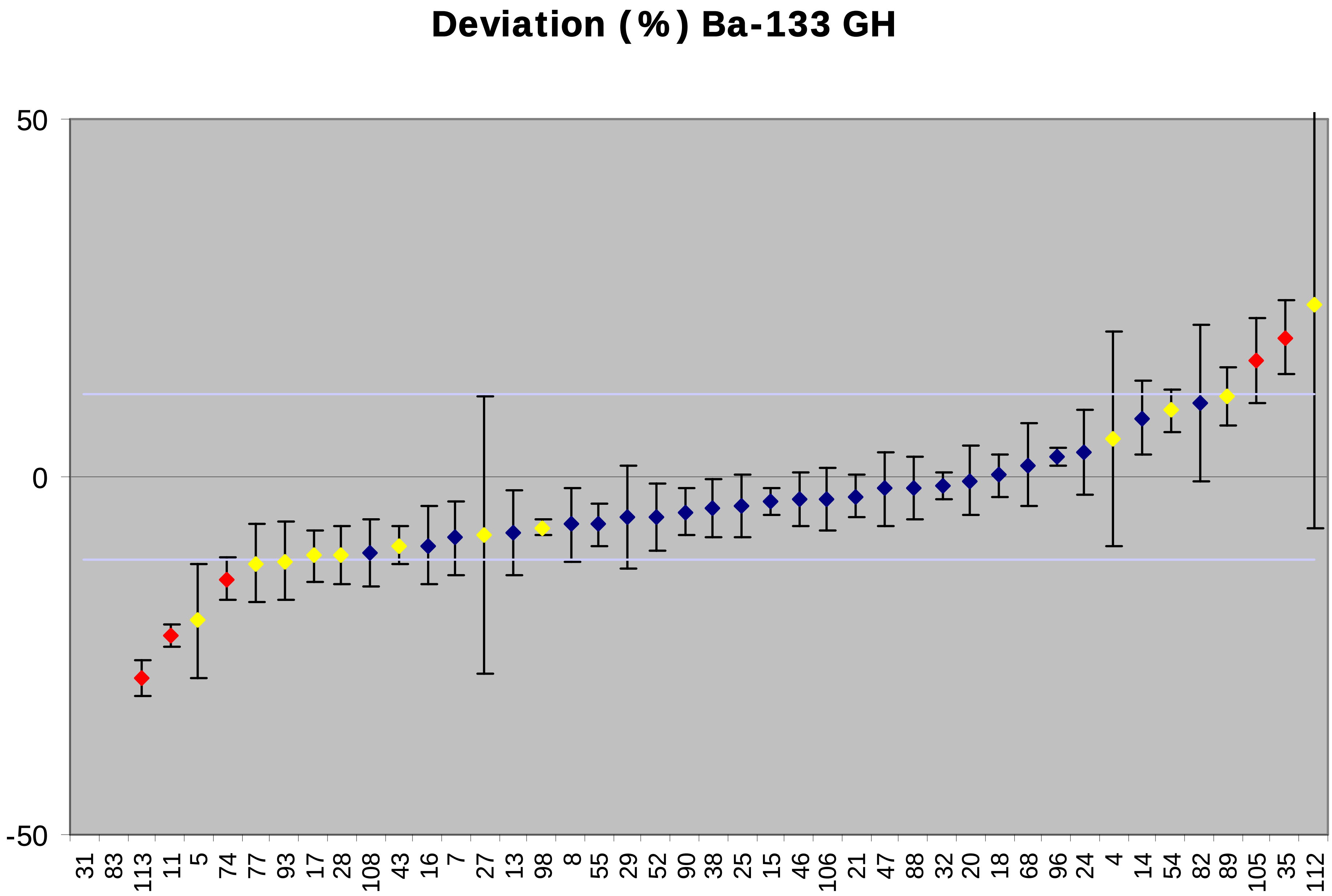
Deviation (%) Ba-133 GL




Deviation (%) Ba-133 GH
50
0
-50
31
83
113
11
5
74
77
93
17
28
108
43
16
7
27
13
98
8
55
29
52
90
38
25
15
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106
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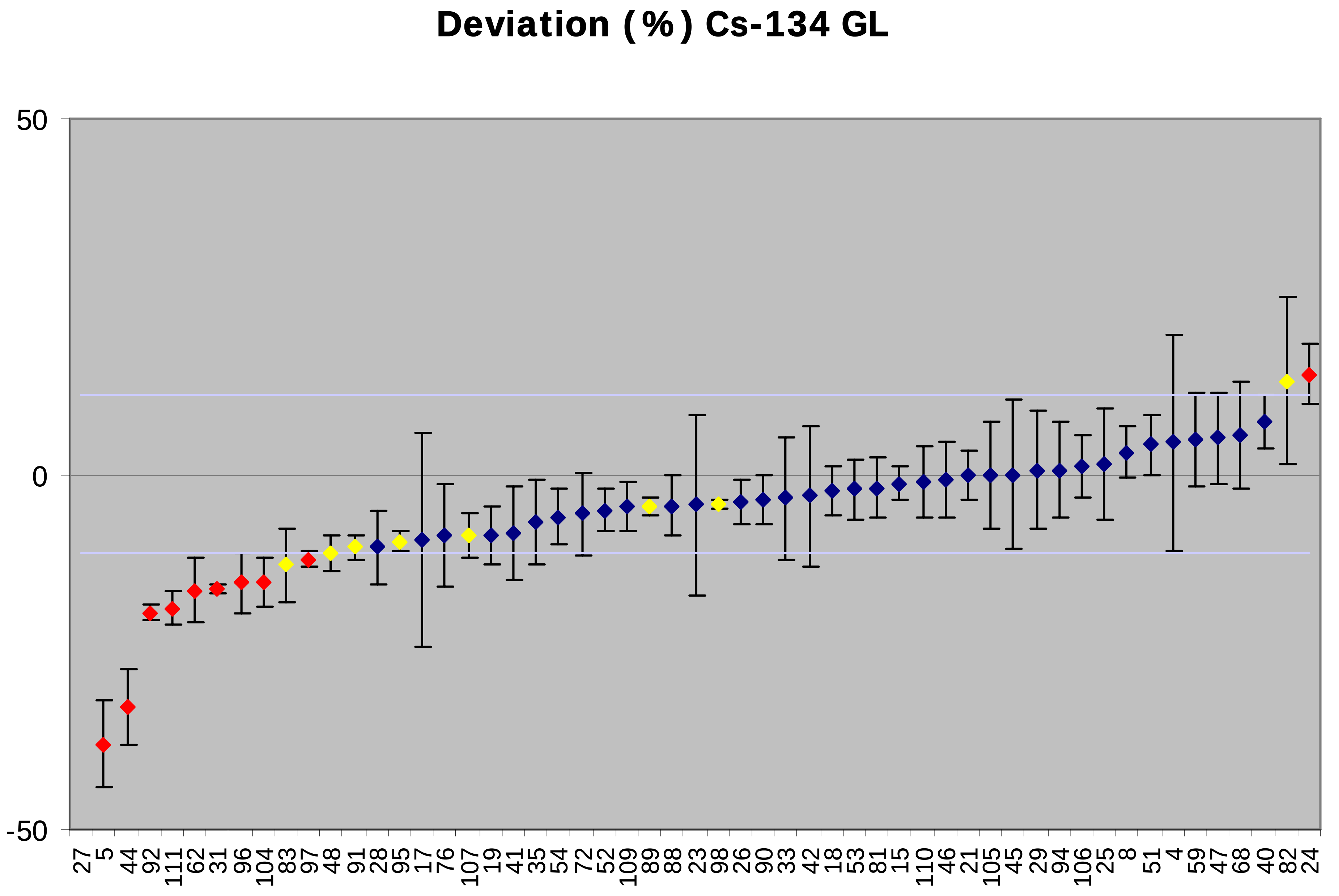
47
88
32
20
18
68
96
24
4
14
54
82
89
105
35
112



Deviation (%) Cs-134 GL
50
0
-50
27
5
44
92
111
62
31
96
104
83
97
48
91
28
95
17
76
107
19
41
35
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72
52
109
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98
26
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33
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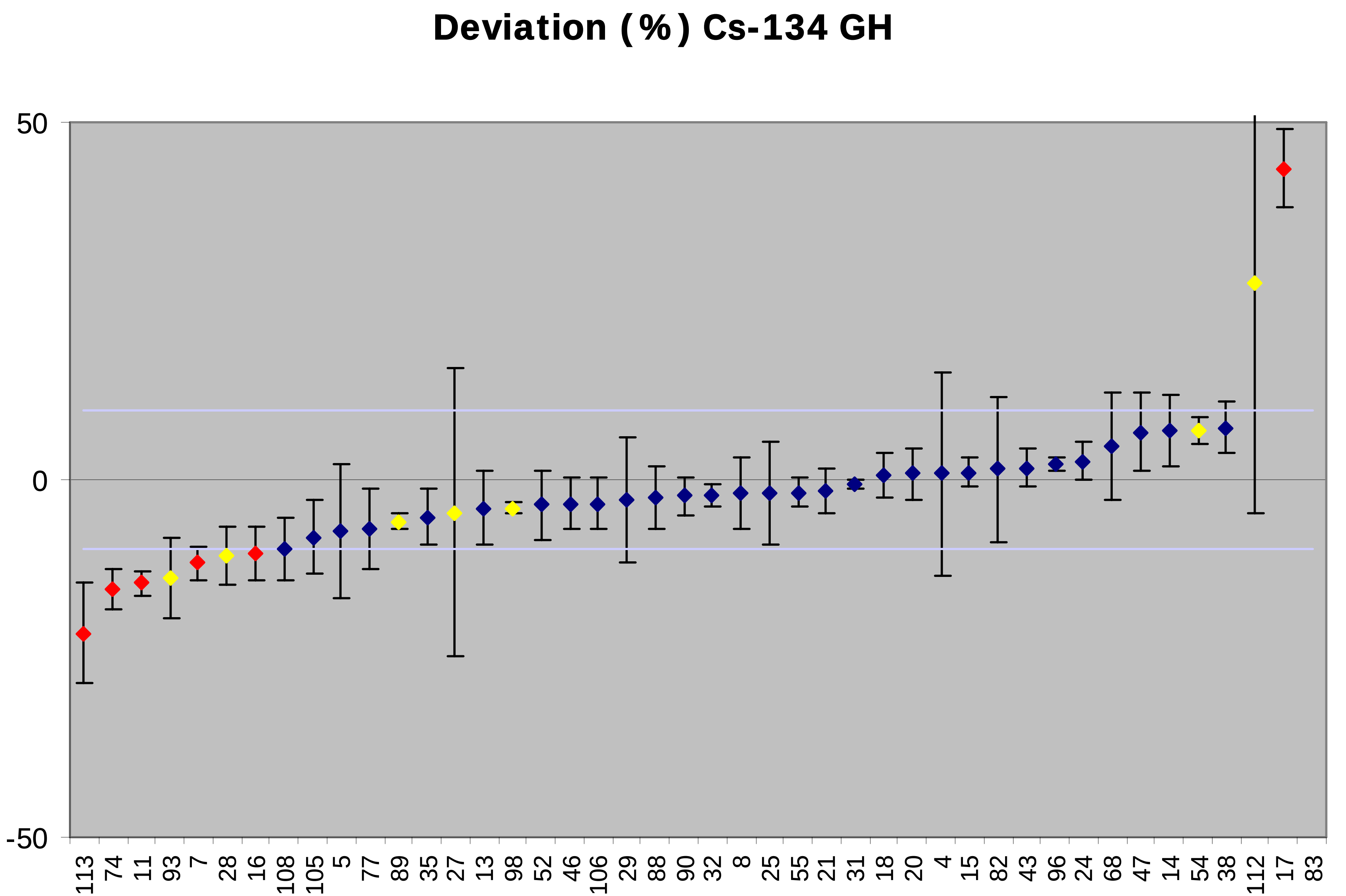
24


Deviation (%) Cs-134 GH
50
0
-50
113
74
11
93
7
28
16
108
105
5
77
89
35
27
13
98
52
46
106
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32
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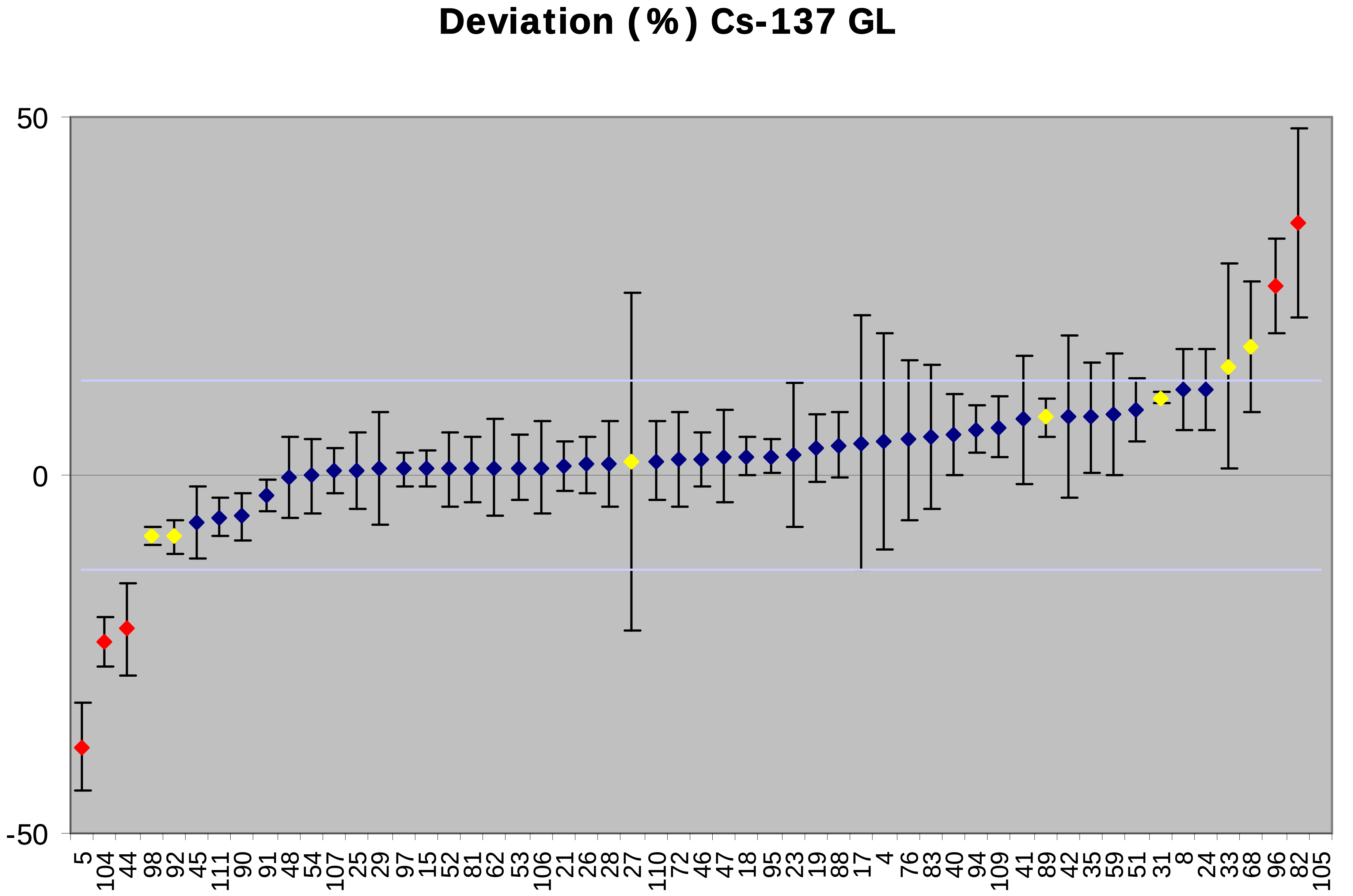
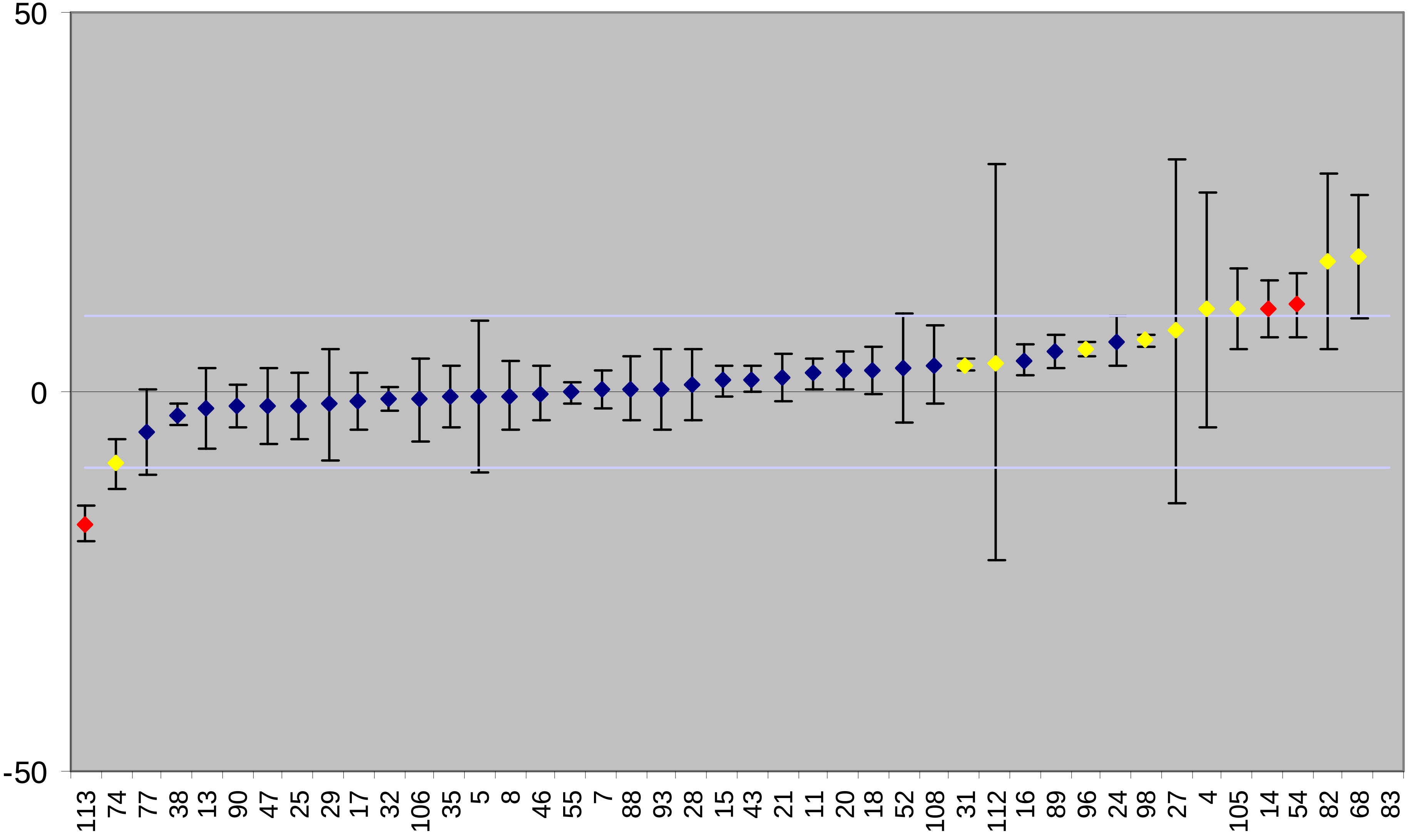
54
38
112
17
83

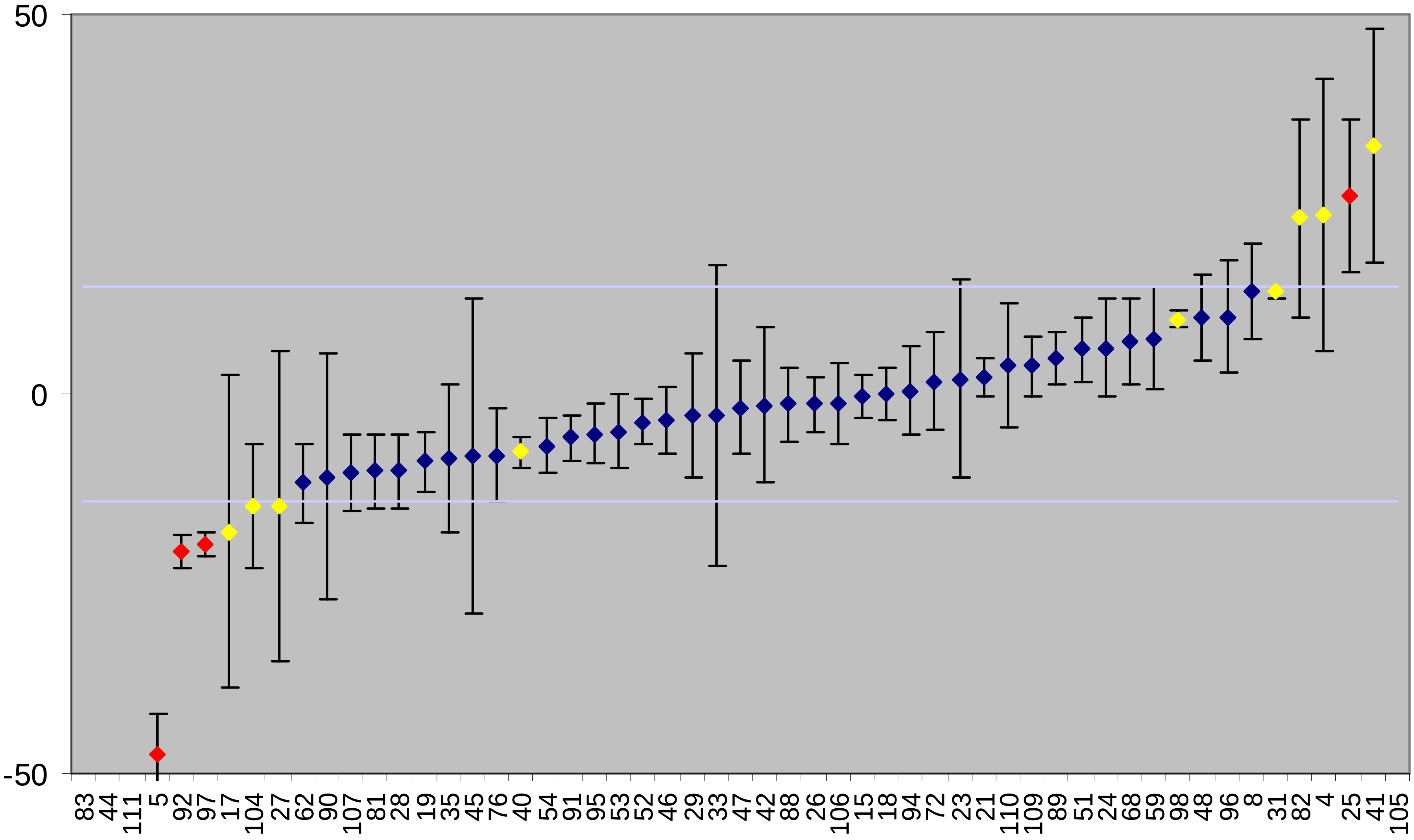


Deviation (%) Cs-137 GL
50
0
-50
5
104
44
98
92
45
111
90
91
48
54
107
25
29
97
15
52
81
62
53
106
21
26
28
27
110
72
46
47
18
95
23
19
88
17
4
76
83
40
94
109
41
89
42
35
59
51
31
8
24
33
68
96
82
105

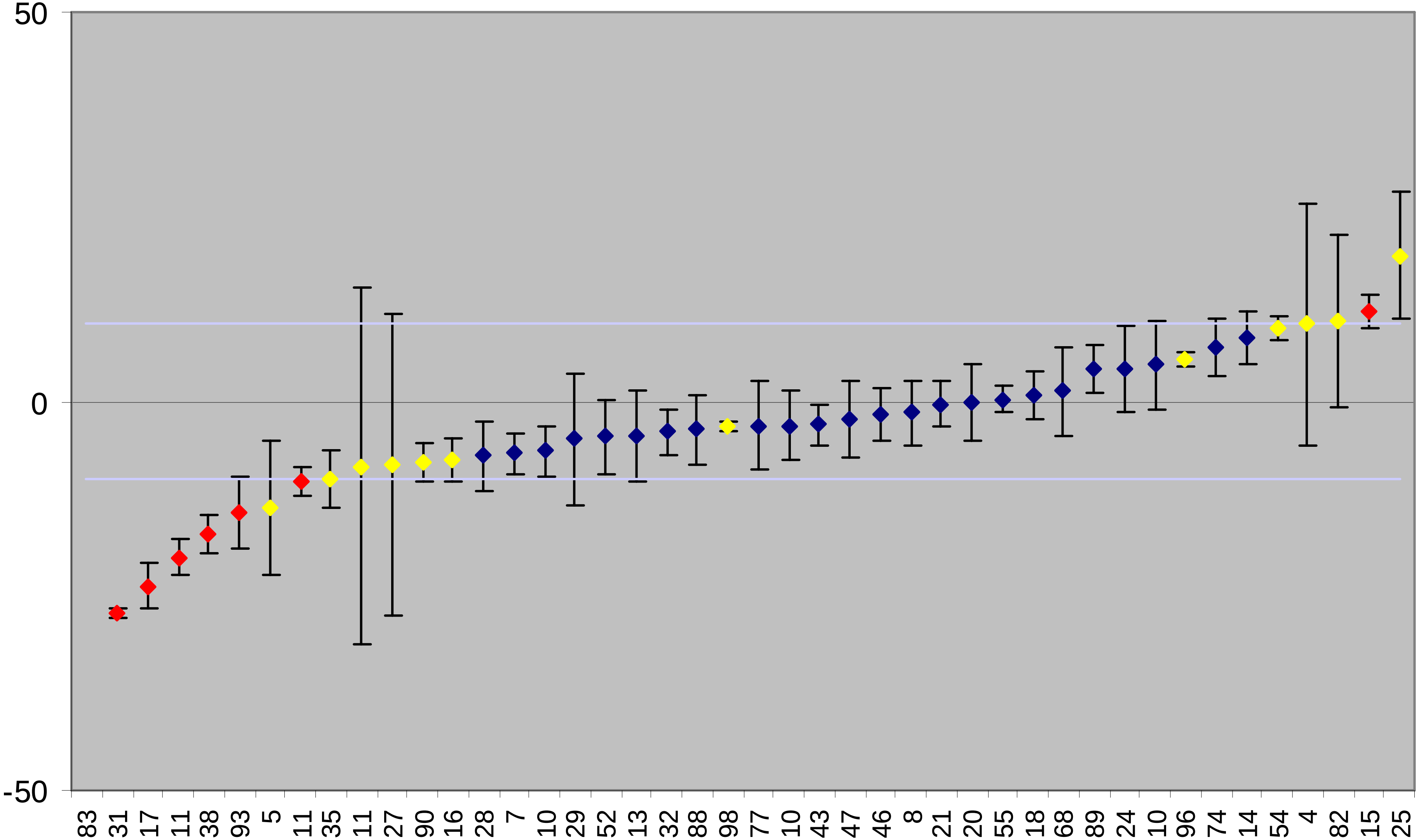
Deviation (%) Cs-137 GH



Deviation (%) Eu-152 GL



Deviation (%) Eu-152 GH



Thank you

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