



National Physical Laboratory

GL and GH samples

NPL Environmental Radioactivity Comparison
Workshop

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Radionuclides in GL and GH

- 10 nuclides:

^{22}Na , ^{60}Co , ^{88}Y , ^{95}Zr , ^{95}Nb , ^{125}Sb , ^{133}Ba , ^{134}Cs , ^{137}Cs and ^{152}Eu

- Two concentration levels:

GL 1 – 20 Bq kg⁻¹

GH 1 – 20 Bq g⁻¹

GL and GH composition

	GL (Bq kg ⁻¹)	GH (Bq g ⁻¹)
²²Na	3.718(14)	2.498(9)
⁶⁰Co	18.84(6)	5.094(16)
⁸⁸Y	3.843(14)	1.204(5)
⁹⁵Zr	1.836(19)	1.176(12)
⁹⁵Nb	3.84(4)	2.456(25)
¹²⁵Sb	6.48(4)	5.39(4)
¹³³Ba	5.74(4)	4.79(4)
¹³⁴Cs	5.30(4)	2.736(19)
¹³⁷Cs	2.884(20)	2.632(18)
¹⁵²Eu	4.19(3)	2.380(16)

Treatment of data

- (i) Deviation D from NPL value (%)

$$D = 100 \frac{L - N}{N} = 100 \left(\frac{L}{N} - 1 \right)$$

- (ii) u-test ($P = 0.01$) and relative uncertainty ratio R_R

$$u = \frac{|L - N|}{\sqrt{u_L^2 + u_N^2}} \quad R_R = \frac{N u_L}{L u_N}$$

$u < 2.58$

$u < 2.58$ but R_R is an outlier

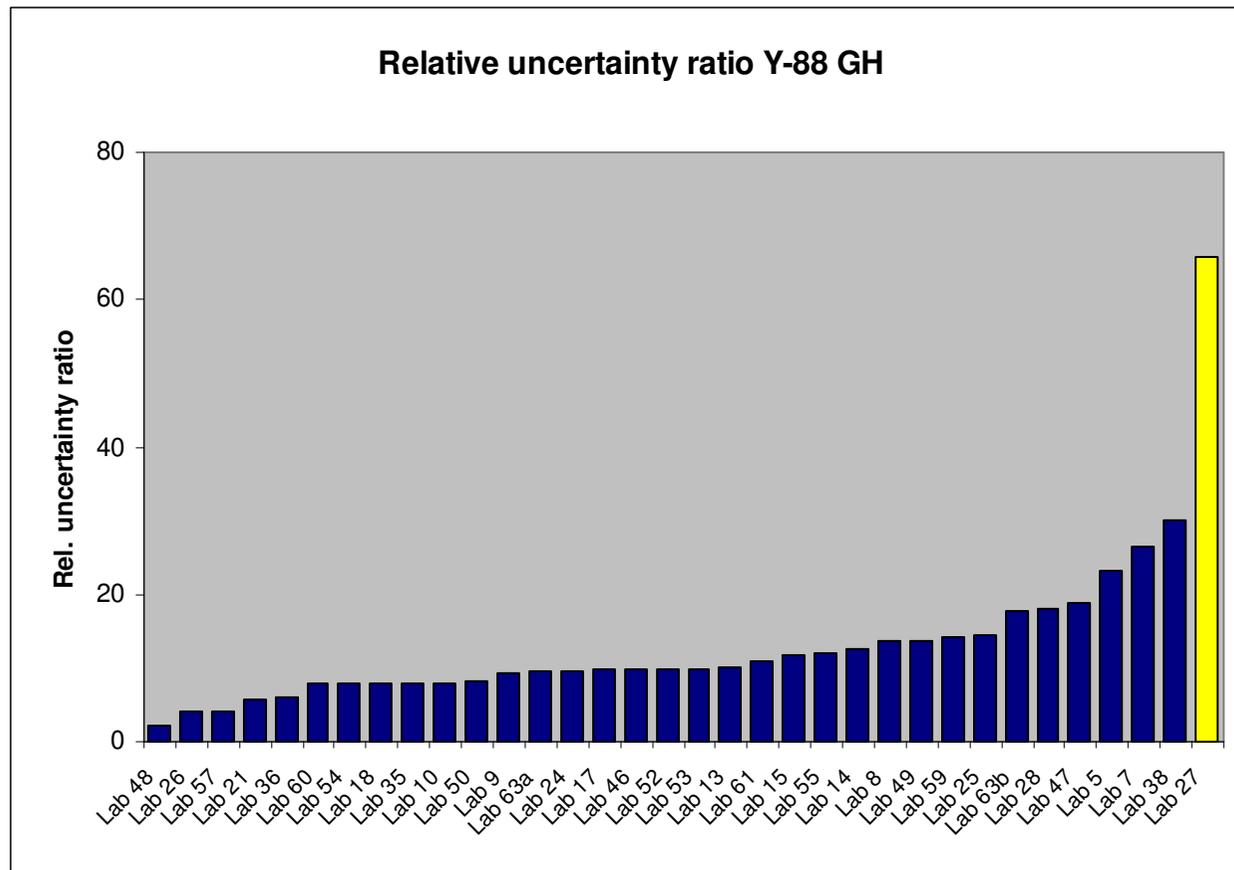
$u > 2.58$

‘in agreement’

‘possibly in agreement’

‘discrepant’

Uncertainty ratio outlier



Na-22 results

GL

30 results

80% of the results 'in agreement'

Deviation mean: $(-7.6 \pm 4.5) \%$ * Deviation median: -10%

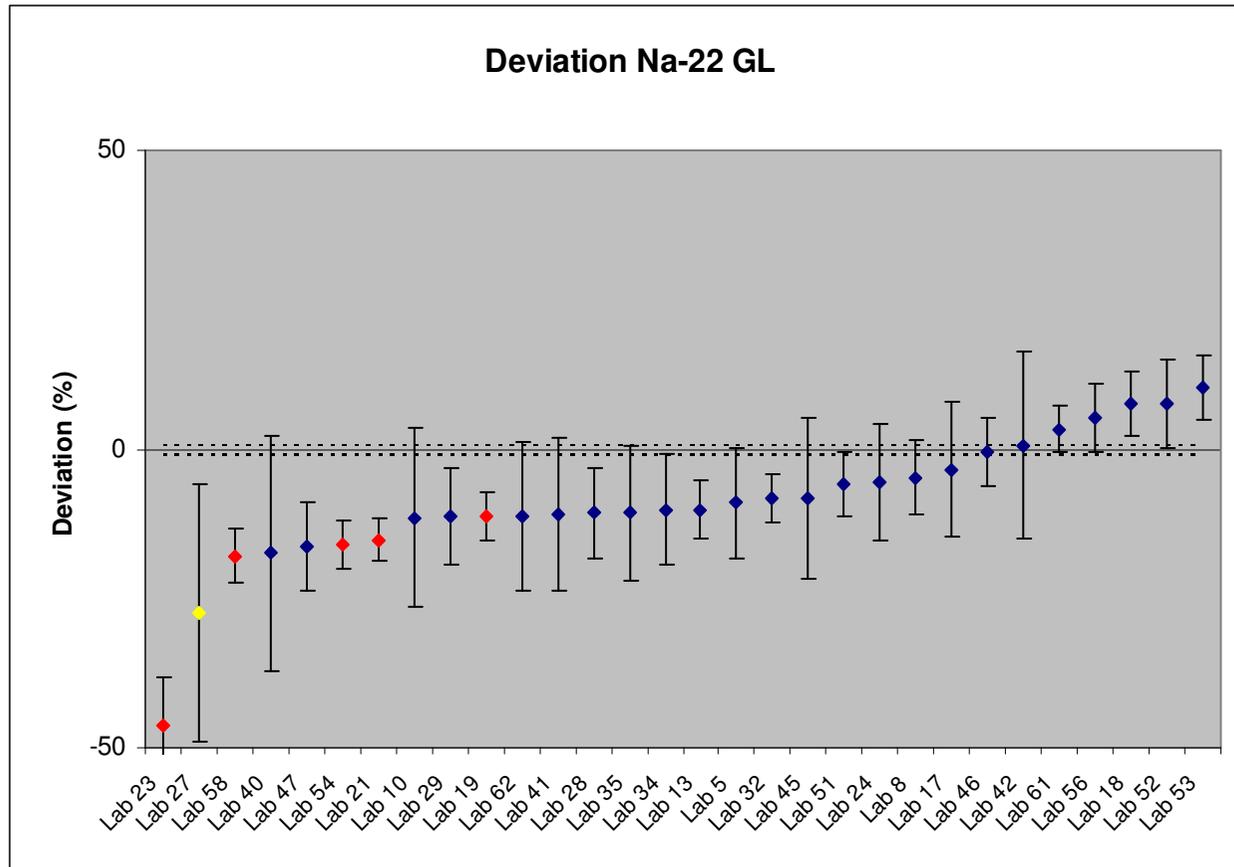
GH

33 results

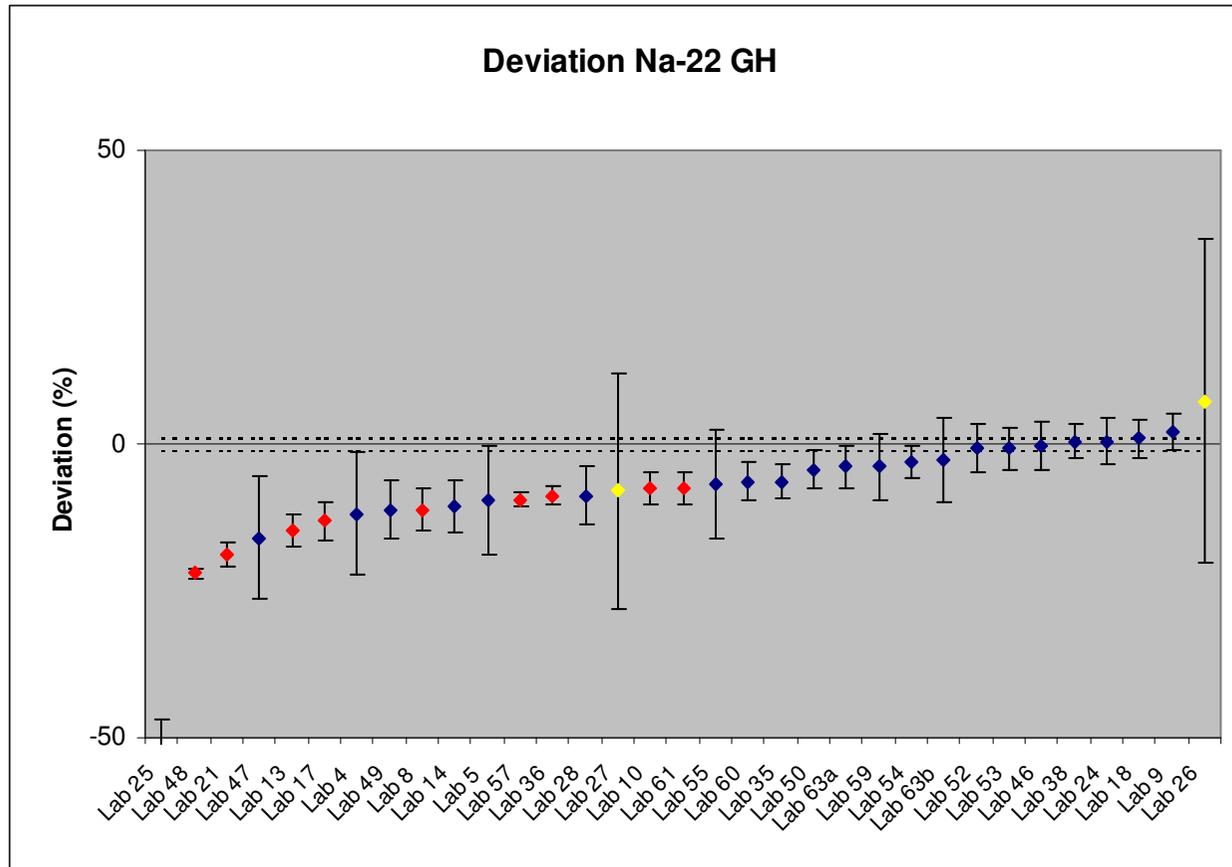
64% of the results 'in agreement'

Deviation mean: $(-6.8 \pm 3.1) \%$ * Deviation median: -8%

Na-22 GL



Na-22 GH



Co-60 results

GL

33 results

82% of the results 'in agreement'

Deviation mean: $(-1.8 \pm 4.9) \%$ Deviation median: 0%

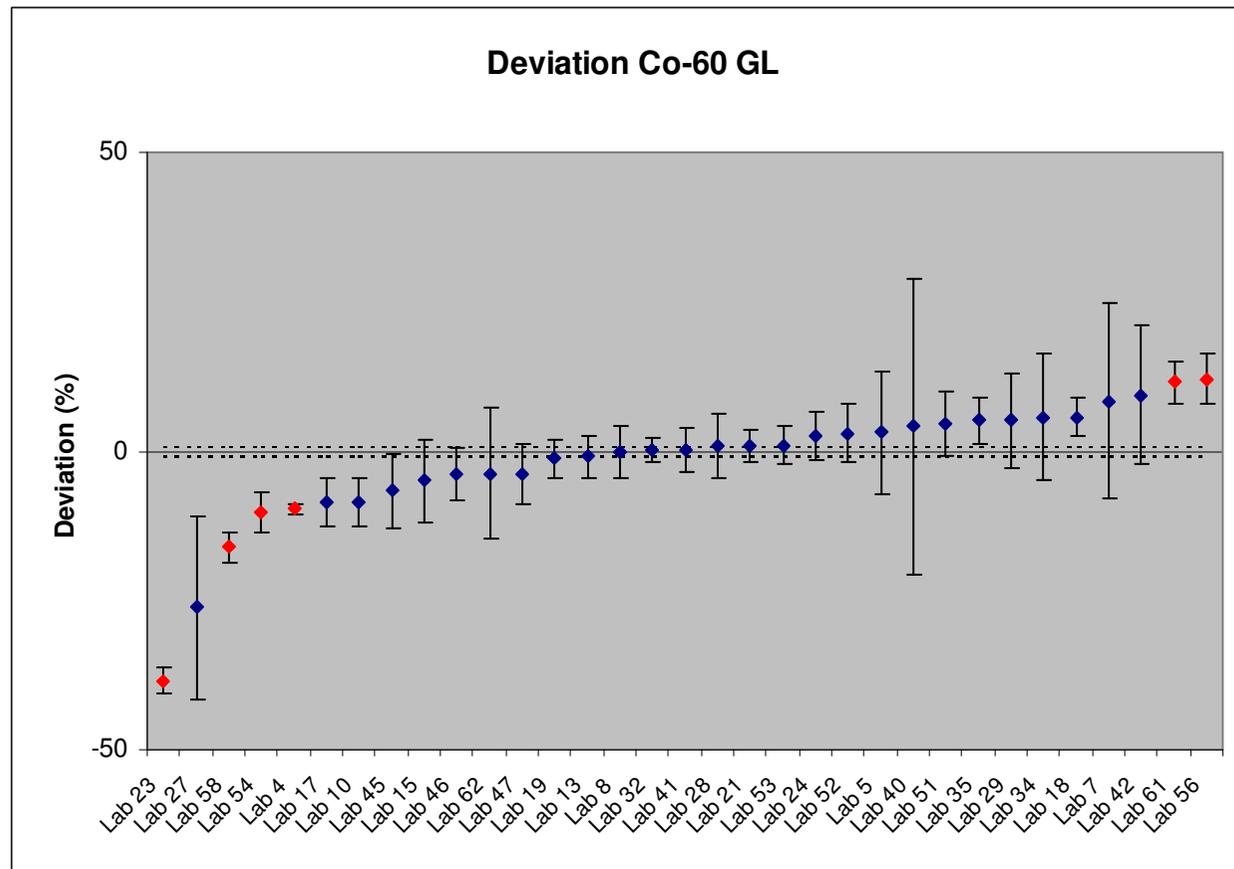
GH

35 results

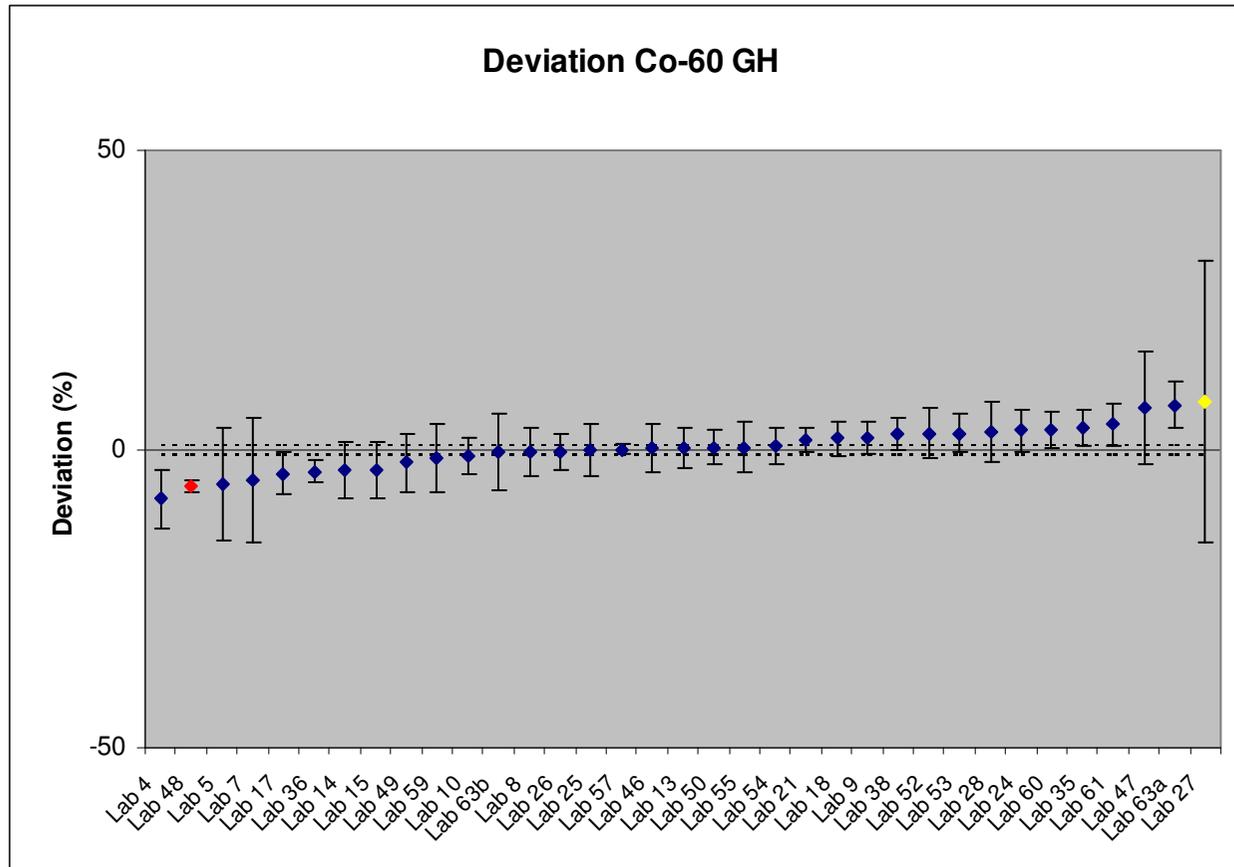
94% of the results 'in agreement'

Deviation mean: $(0.2 \pm 1.7) \%$ Deviation median: 0%

Co-60 GL



Co-60 GH



Y-88 results

GL

31 results

87% of the results 'in agreement'

Deviation mean: $(-1 \pm 6) \%$

Deviation median: 1.5%

GH

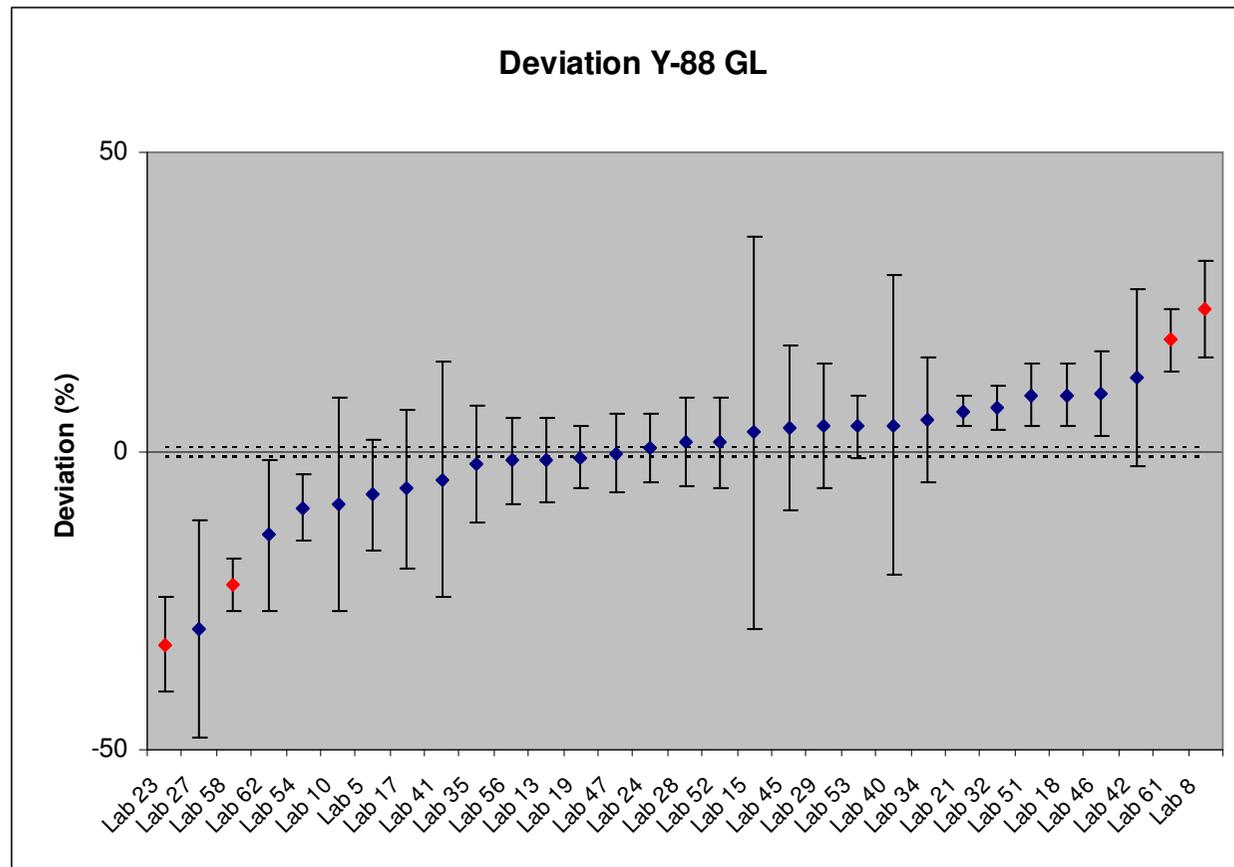
34 results

91% of the results 'in agreement'

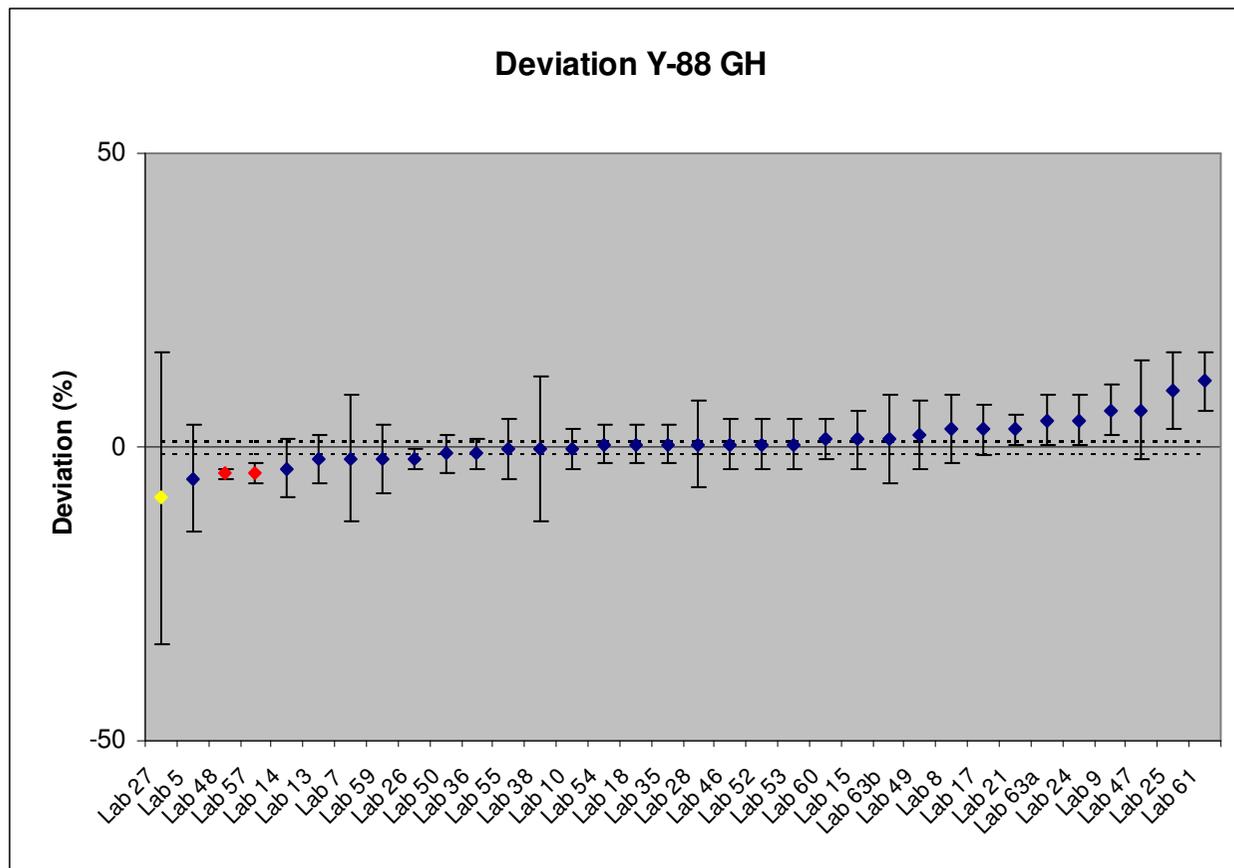
Deviation mean: $(0.7 \pm 1.9) \%$

Deviation median: 0.5%

Y-88 GL



Y-88 GH



Zr-95 results

GL

27 results

93% of the results 'in agreement'

Deviation mean: $(5 \pm 12) \%$

Deviation median: 4%

GH

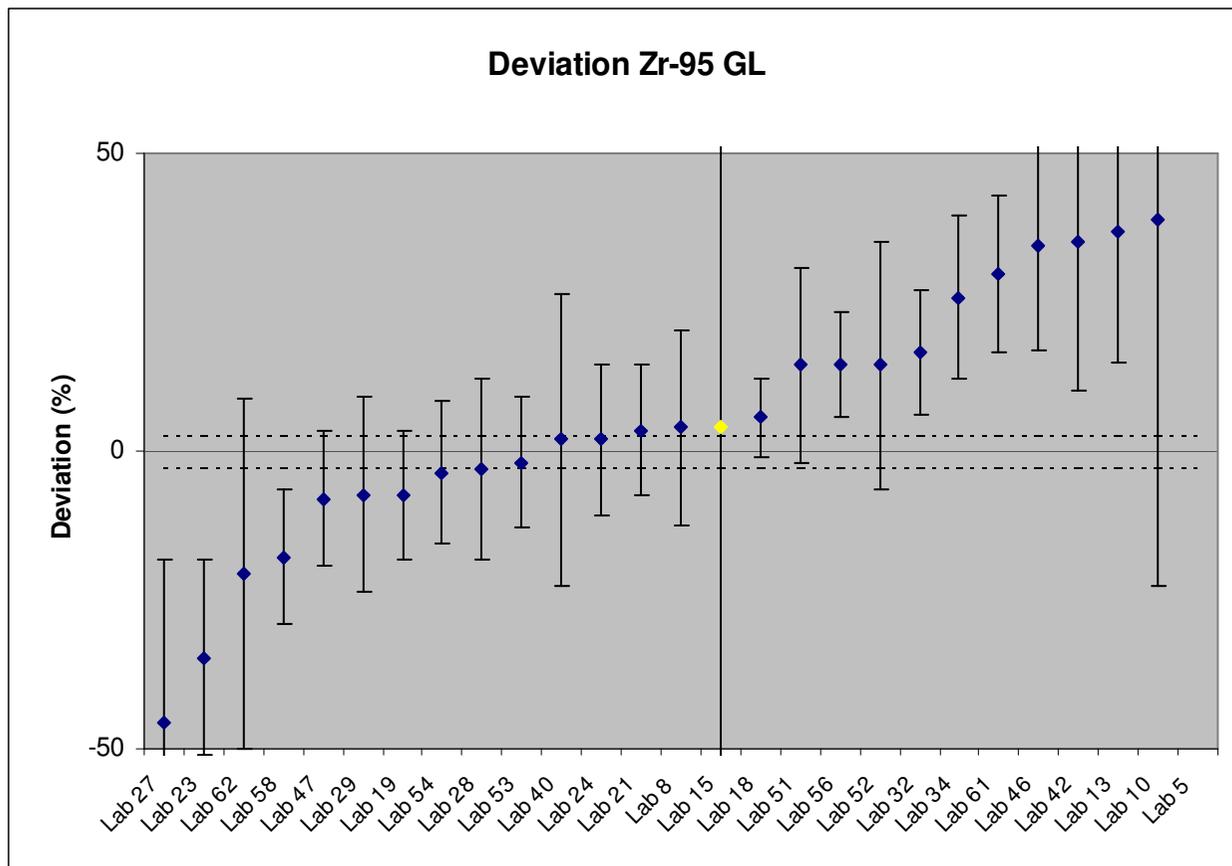
35 results

83% of the results 'in agreement'

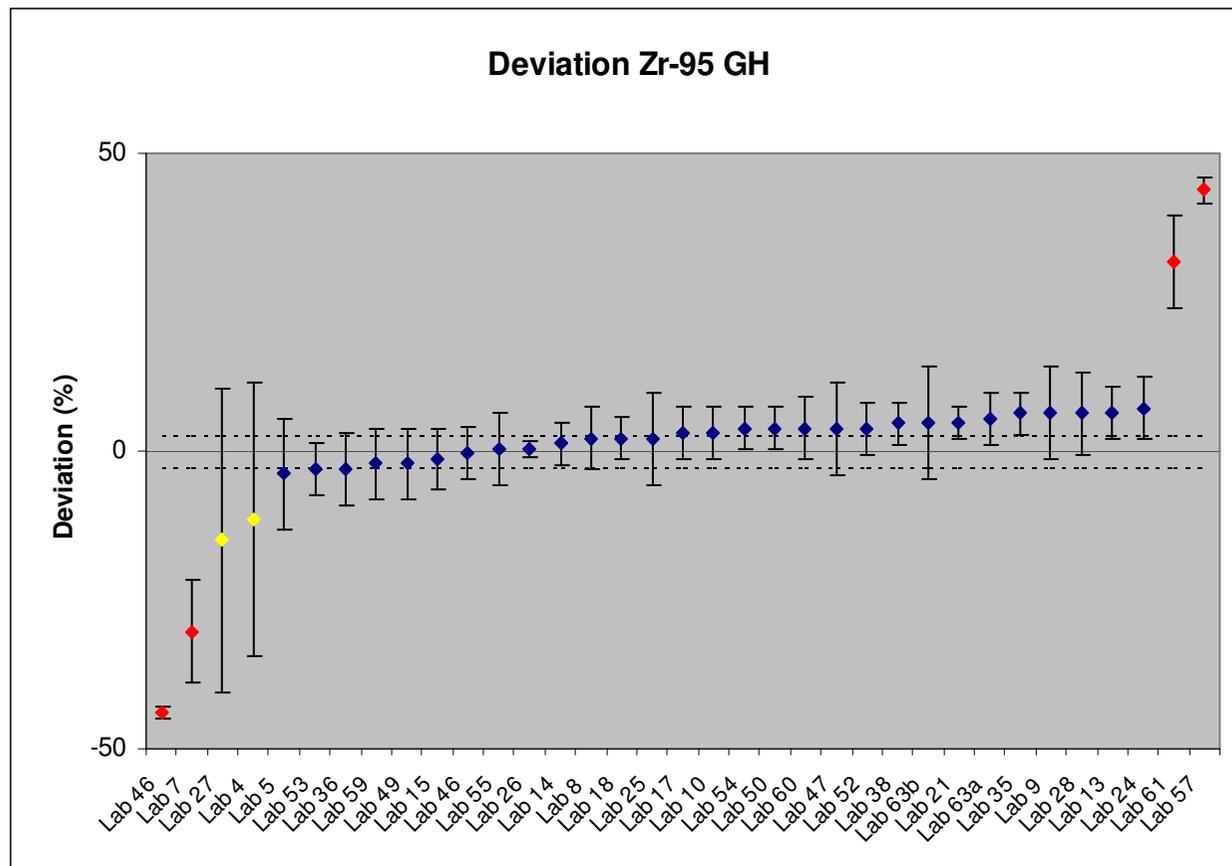
Deviation mean: $(1.4 \pm 2.5) \%$

Deviation median: 3%

Zr-95 GL



Zr-95 GH



Nb-95 results

GL

28 results

64% of the results 'in agreement'

Deviation mean: $(24 \pm 28) \%$

Deviation median: 9%

GH

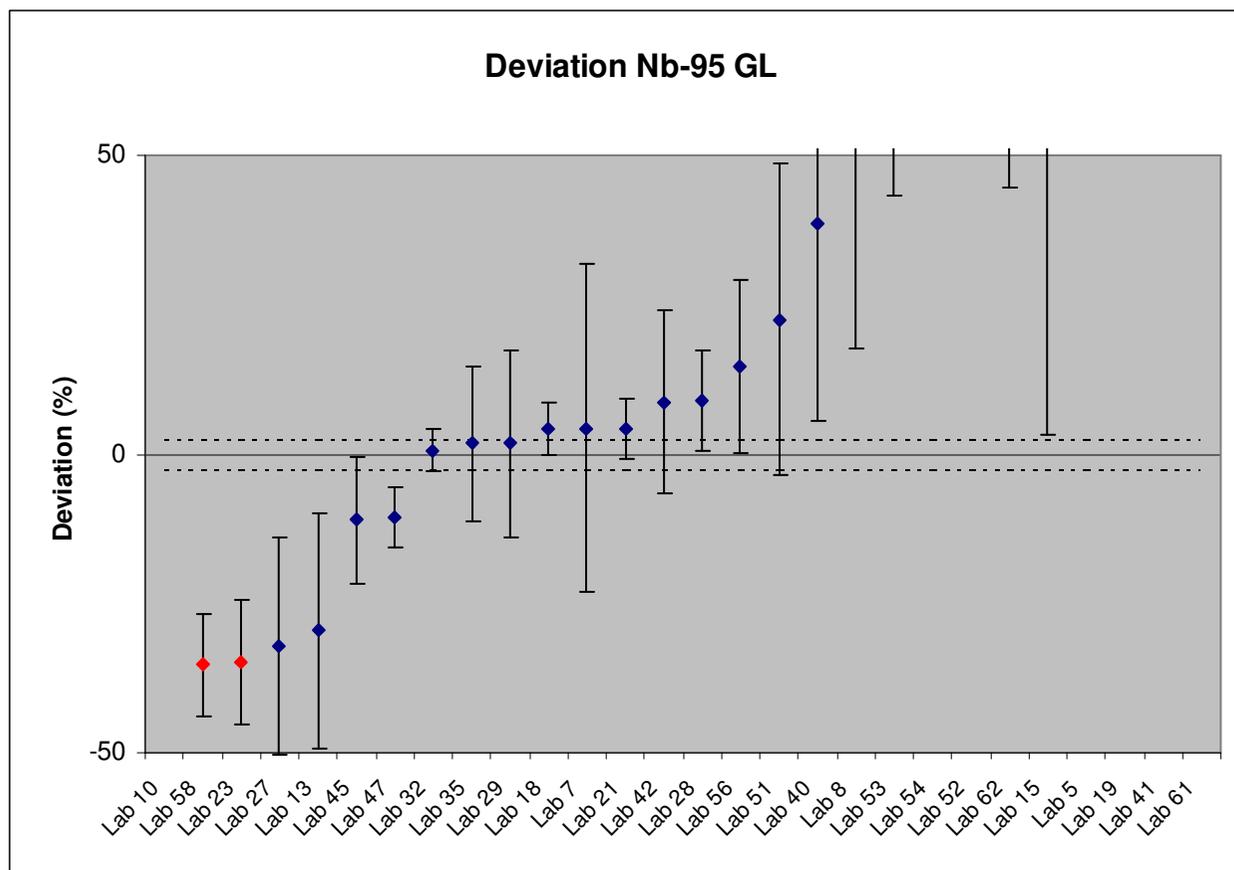
30 results

43% of the results 'in agreement'

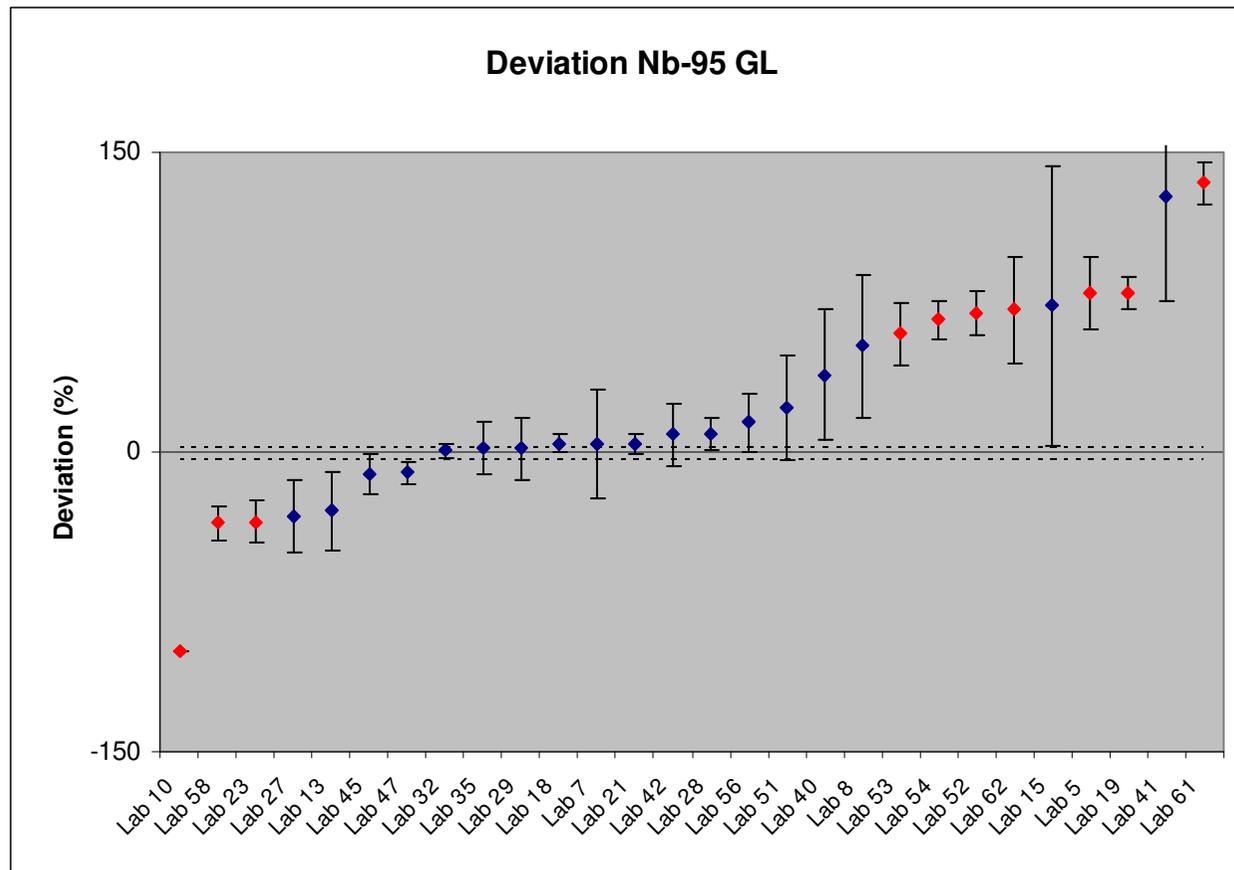
Deviation mean: $(22 \pm 22) \%$

Deviation median: 3%

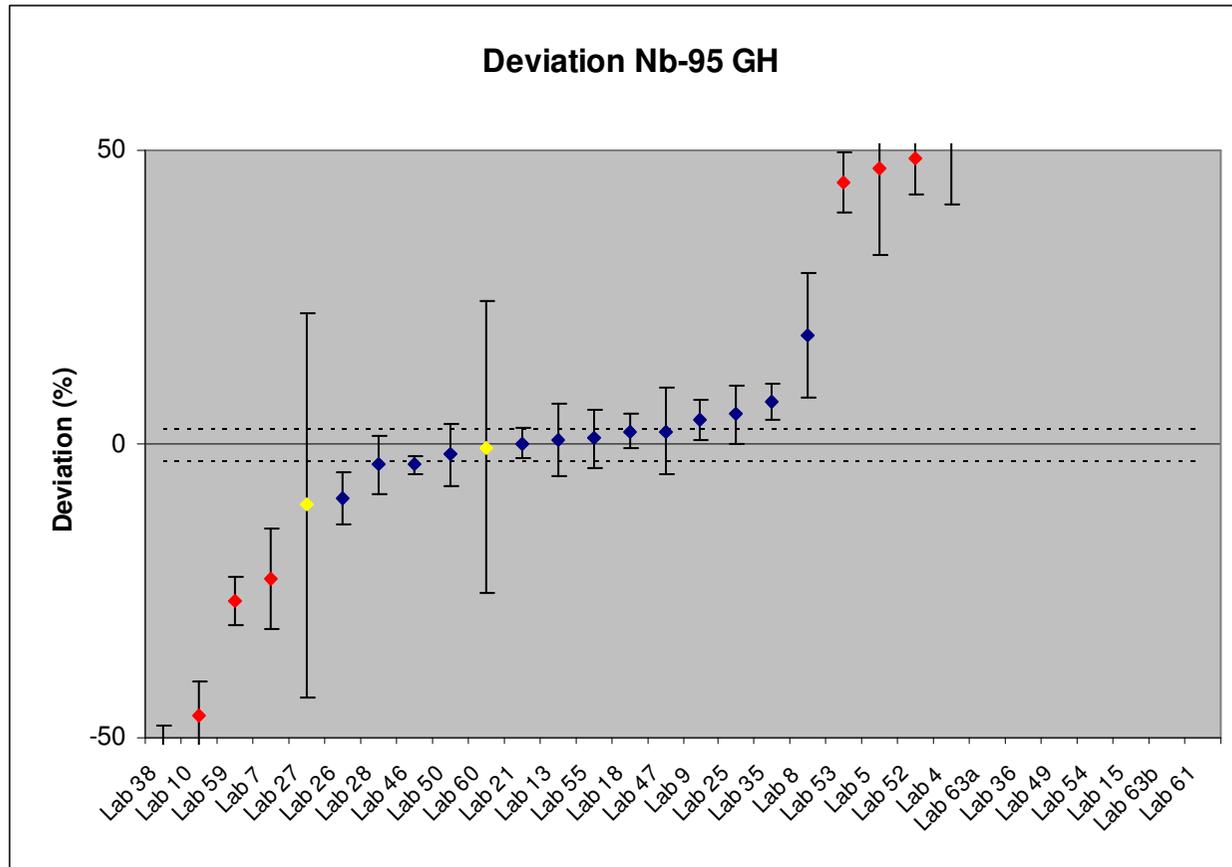
Nb-95 GL



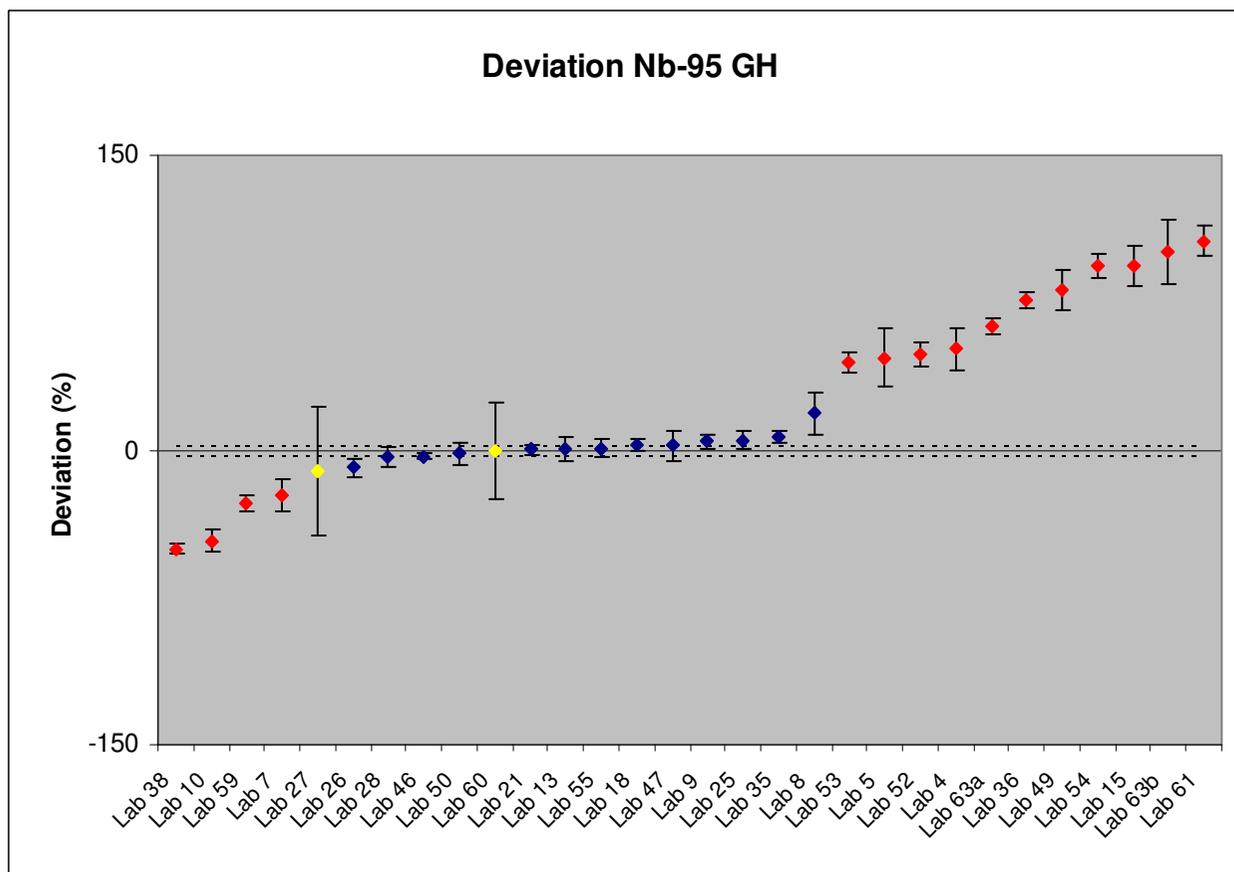
Nb-95 GL (II)



Nb-95 GH



Nb-95 GH (II)



Sb-125 results

GL

31 results

90% of the results 'in agreement'

Deviation mean: $(1 \pm 7) \%$

Deviation median: 3%

GH

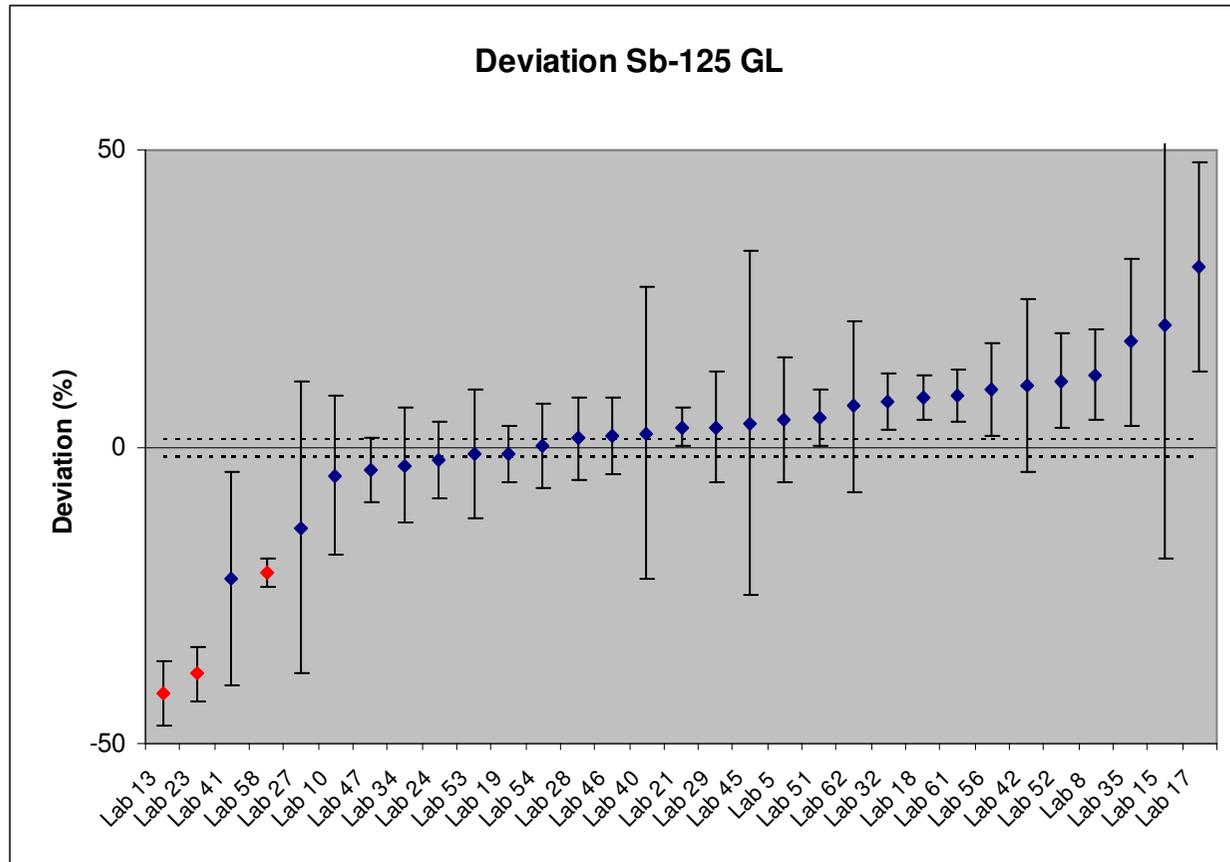
35 results

86% of the results 'in agreement'

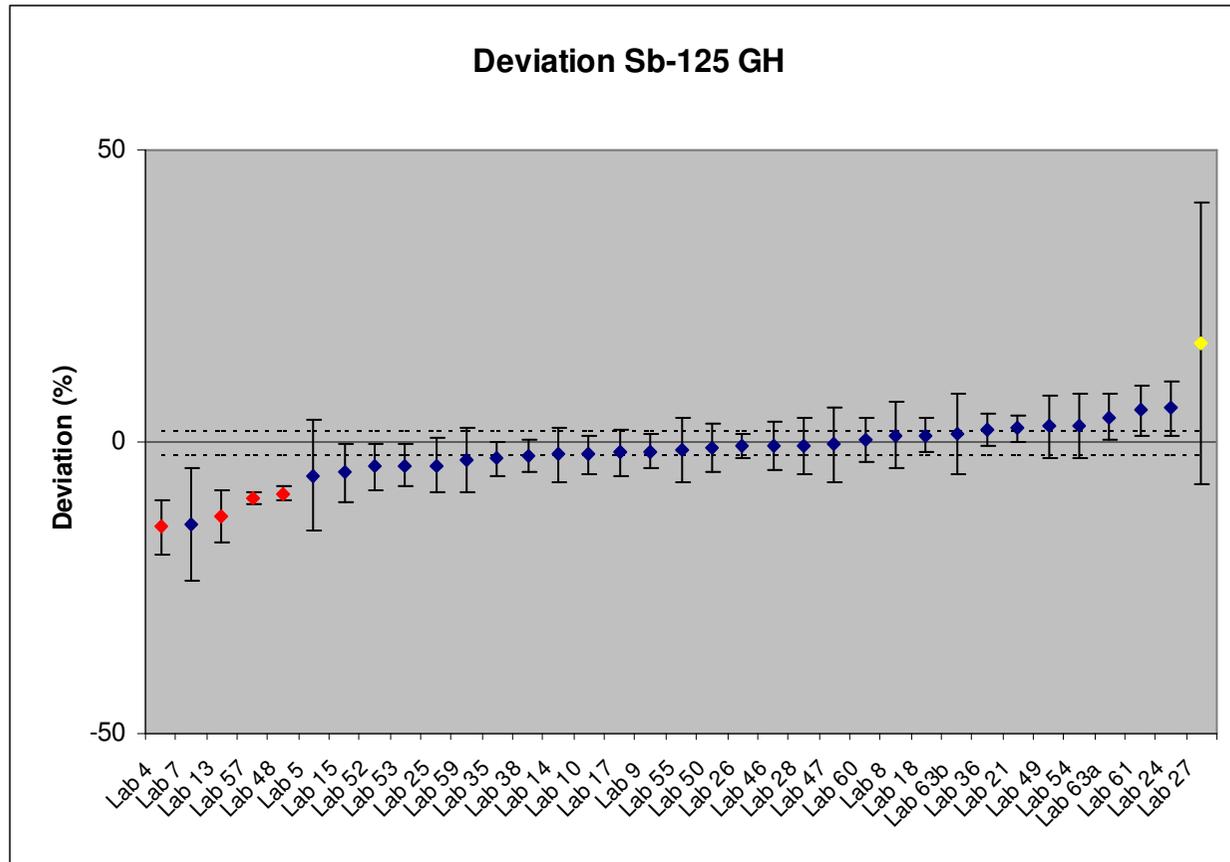
Deviation mean: $(-1.7 \pm 2.8) \%$

Deviation median: -1%

Sb-125 GL



Sb-125 GH



Ba-133 results

GL

32 results

84% of the results 'in agreement'

Deviation mean: $(-5 \pm 7) \%$

Deviation median: -6%

GH

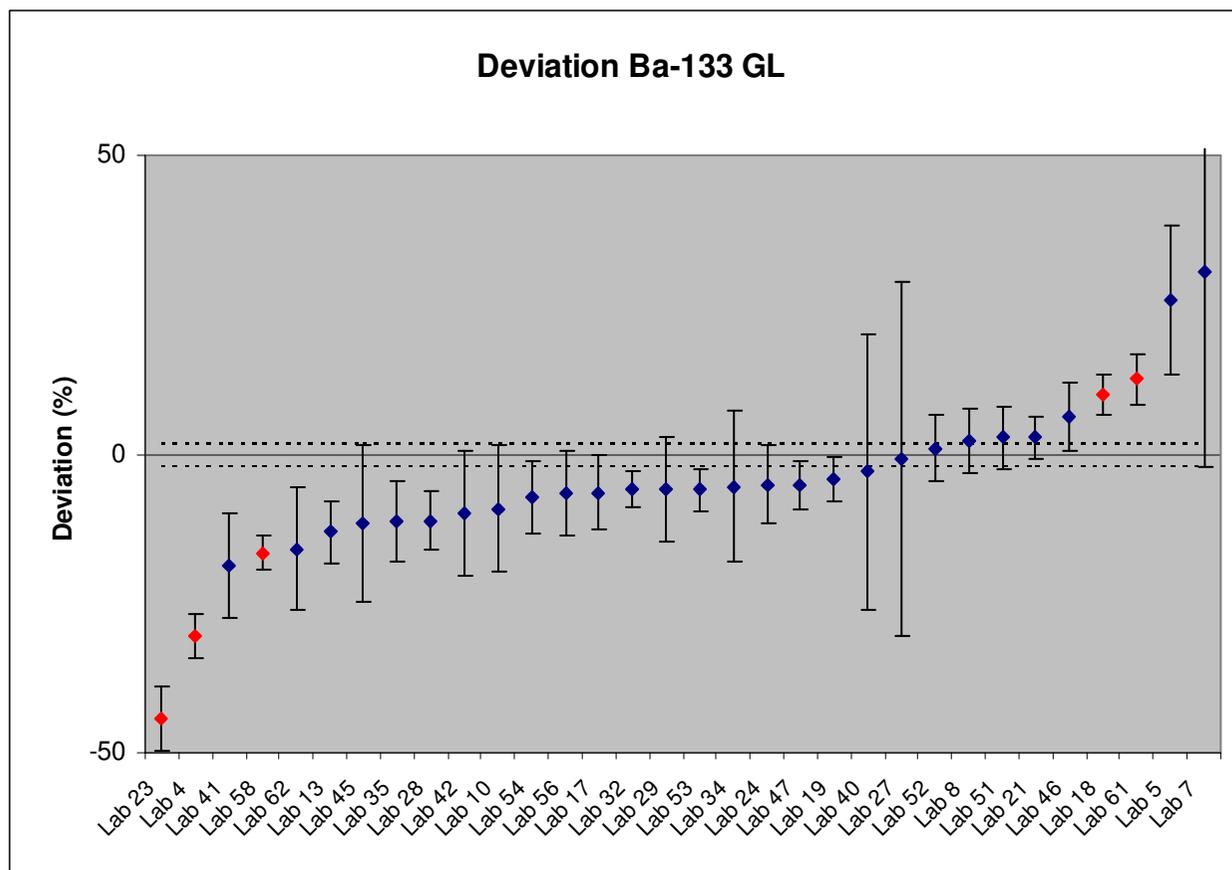
34 results

74% of the results 'in agreement'

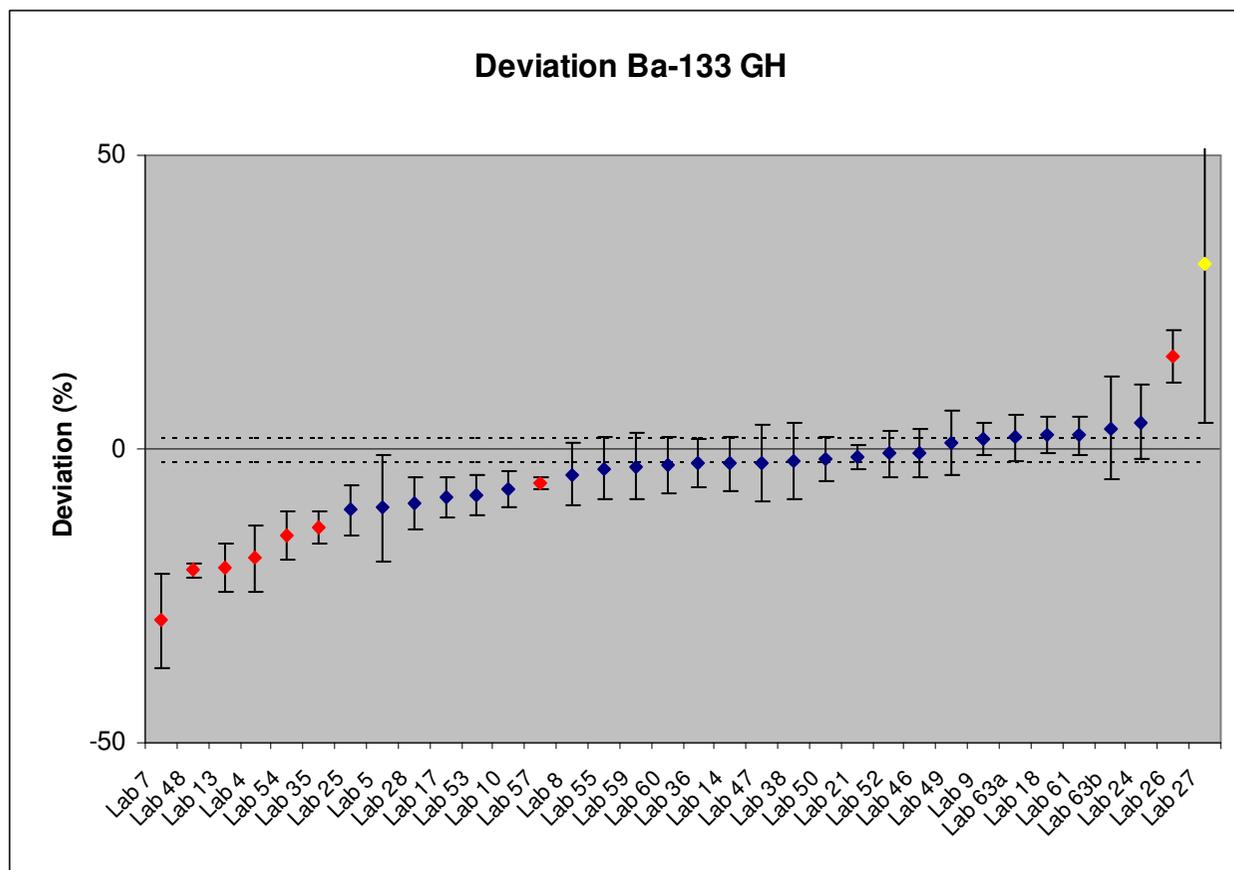
Deviation mean: $(-5.1 \pm 4.2) \%^*$

Deviation median: -3%

Ba-133 GL



Ba-133 GH



Cs-134 results

GL

33 results

85% of the results 'in agreement'

Deviation mean: $(-4 \pm 6) \%$

Deviation median: -4%

GH

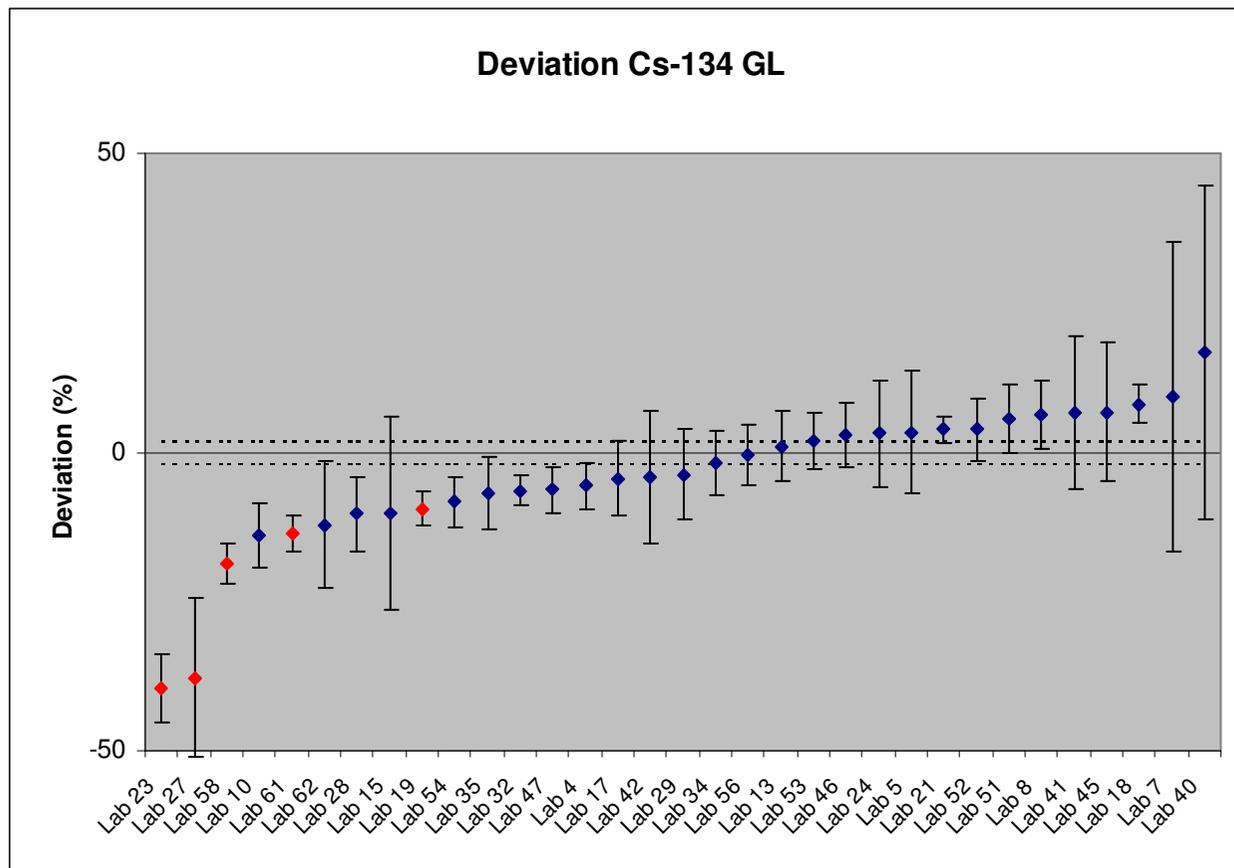
35 results

80% of the results 'in agreement'

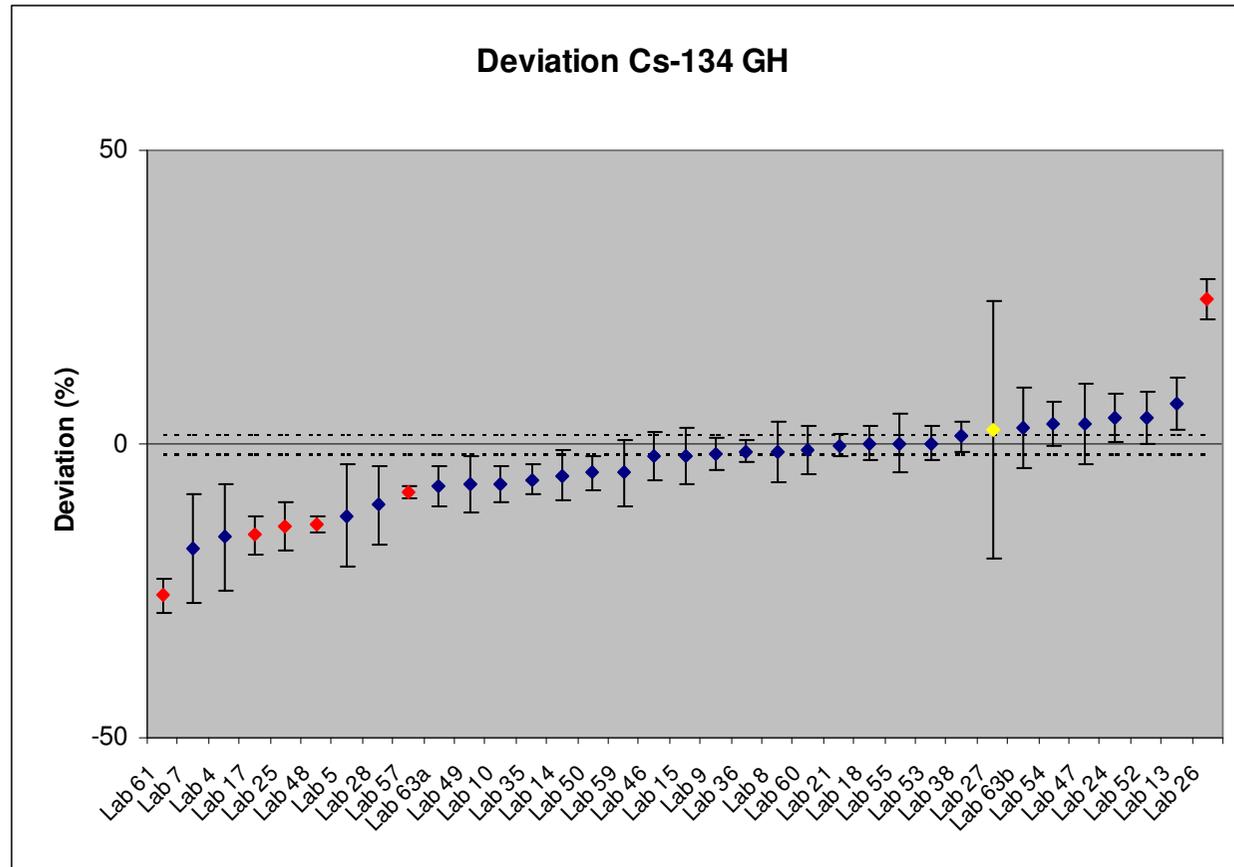
Deviation mean: $(-3.7 \pm 4.1) \%$

Deviation median: -2%

Cs-134 GL



Cs-134 GH



Cs-137 results

GL

32 results

84% of the results 'in agreement'

Deviation mean: $(3 \pm 7) \%$

Deviation median: 4%

GH

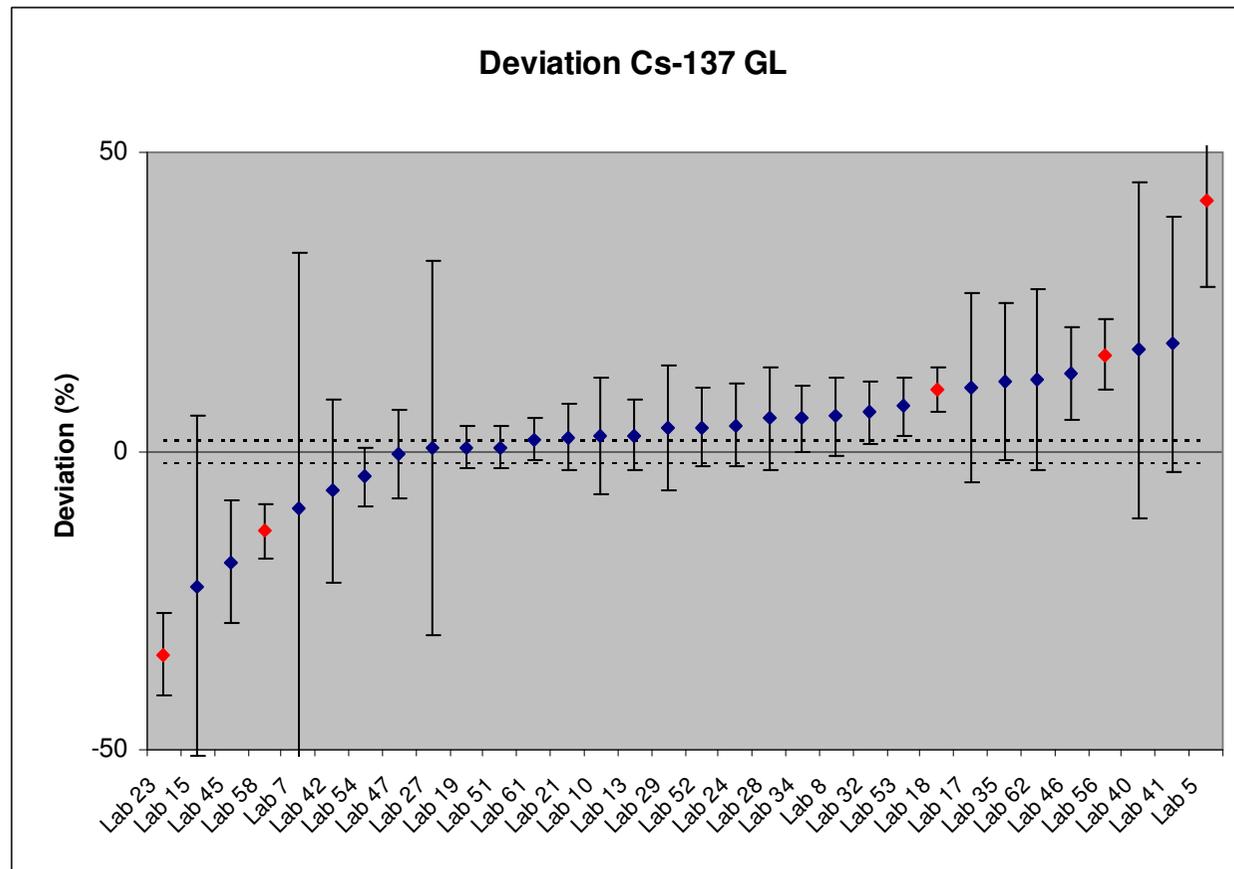
35 results

91% of the results 'in agreement'

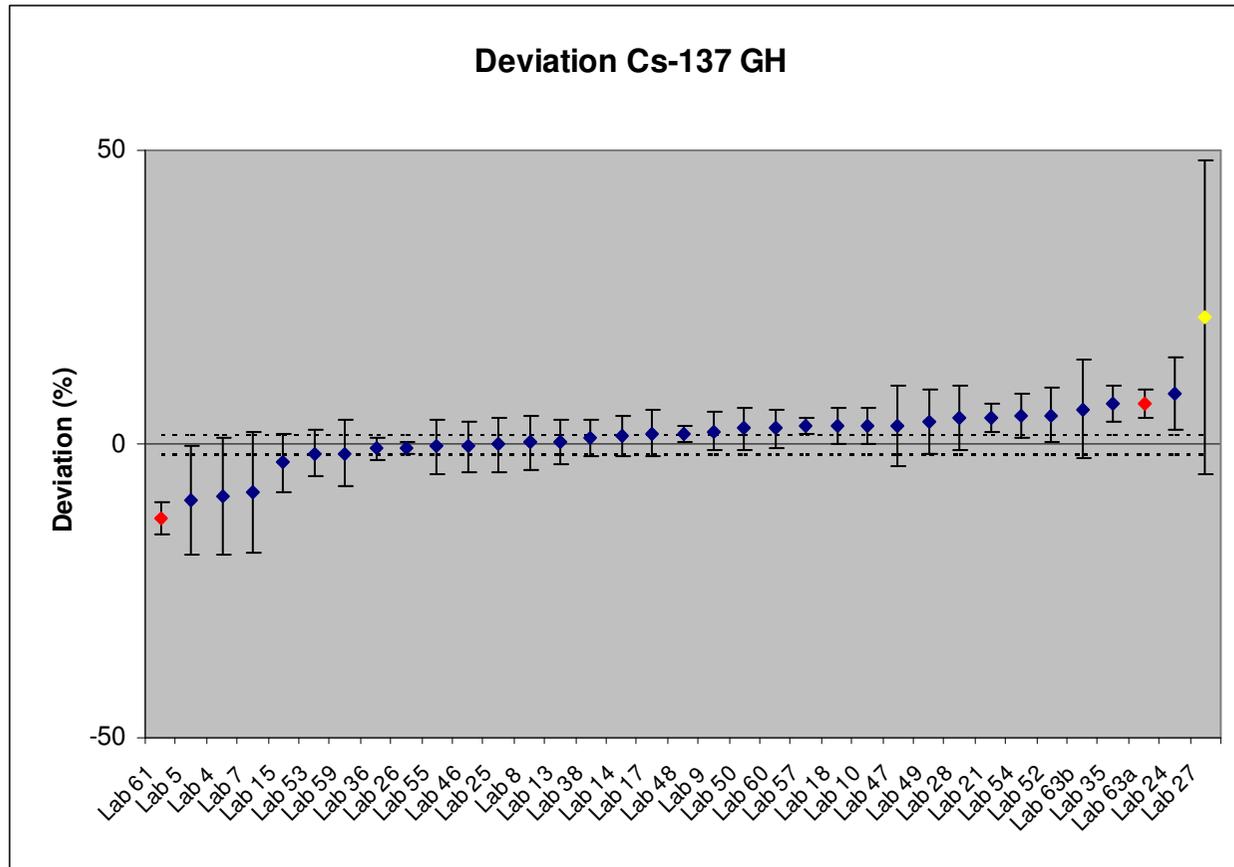
Deviation mean: $(0.8 \pm 2.2) \%$

Deviation median: 2%

Cs-137 GL



Cs-137 GH



Eu-152 results

GL

25 results

76% of the results 'in agreement'

Deviation mean: $(-8 \pm 11) \%$

Deviation median: -5%

GH

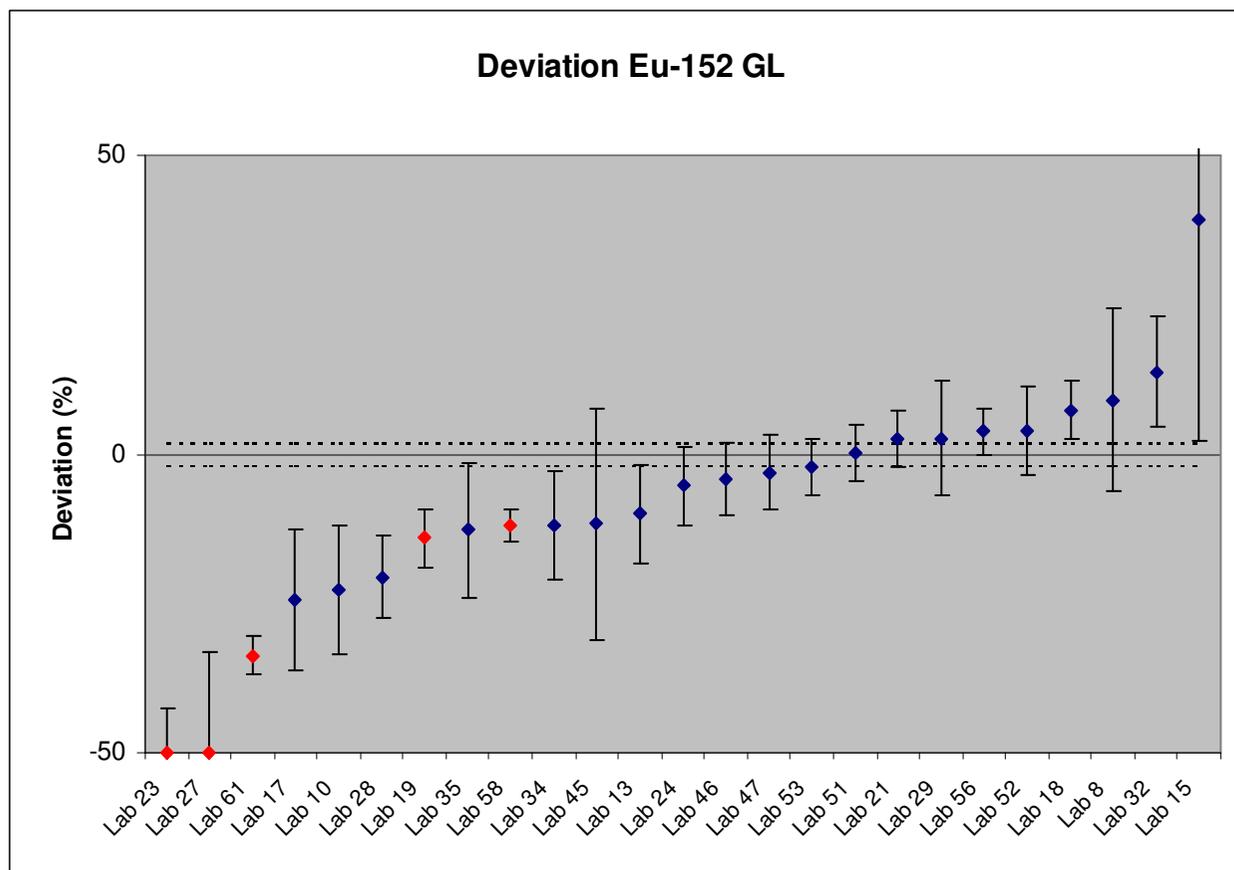
32 results

84% of the results 'in agreement'

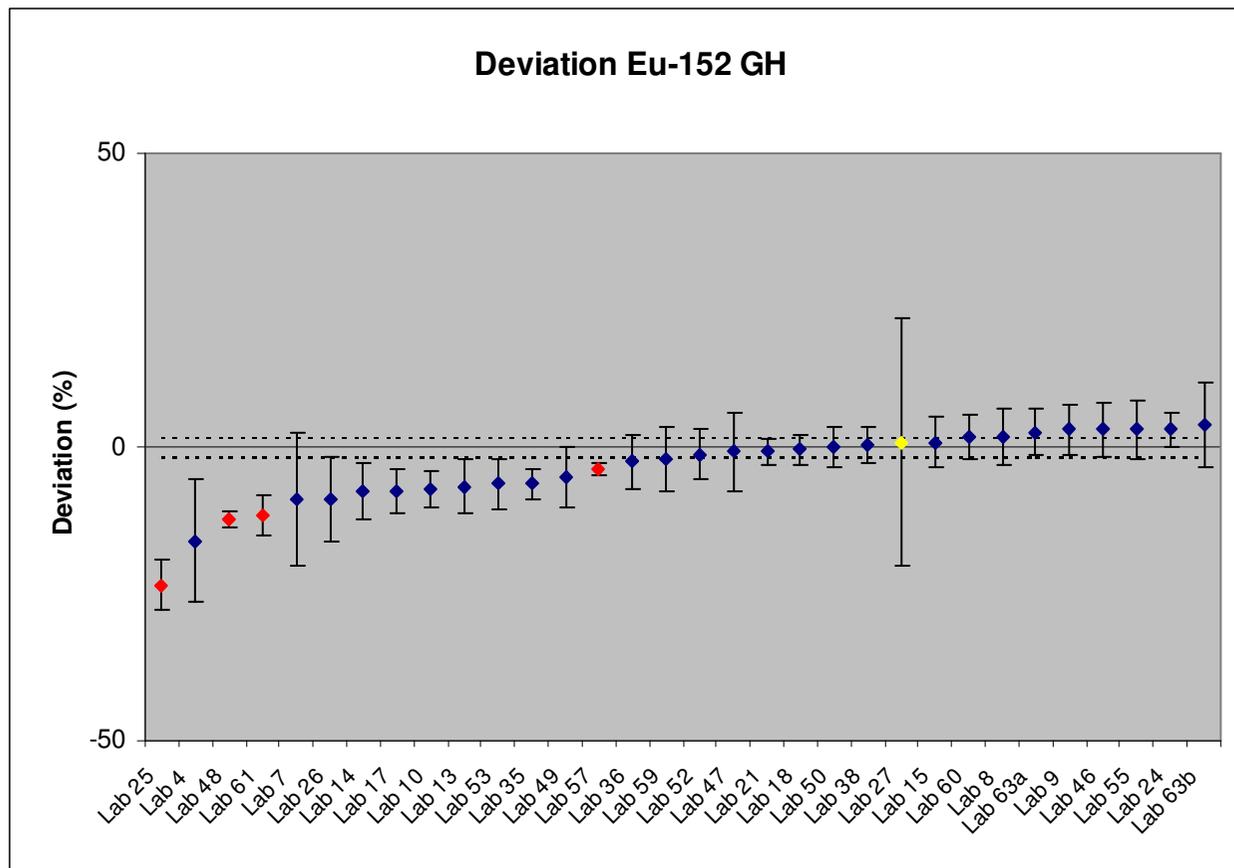
Deviation mean: $(-3.6 \pm 3.0) \%^*$

Deviation median: -2%

Eu-152 GL



Eu-152 GH



Results GL

Results

75%

'in agreement'

1%

'probably in agreement'

15%

'discrepant'

8%

'missing'

Problematic nuclides:

^{22}Na , ^{95}Nb and ^{152}Eu

Less problematic:

^{60}Co , ^{88}Y , ^{95}Zr , ^{125}Sb , ^{133}Ba ,
 ^{134}Cs and ^{137}Cs

Results GH

Results

77%	'in agreement'
4%	'probably in agreement'
16%	'discrepant'
3%	'missing'

Problematic nuclides: ^{22}Na , ^{95}Nb , ^{133}Ba and ^{134}Cs

Less problematic: ^{60}Co , ^{88}Y , ^{95}Zr , ^{125}Sb , ^{137}Cs and ^{152}Eu

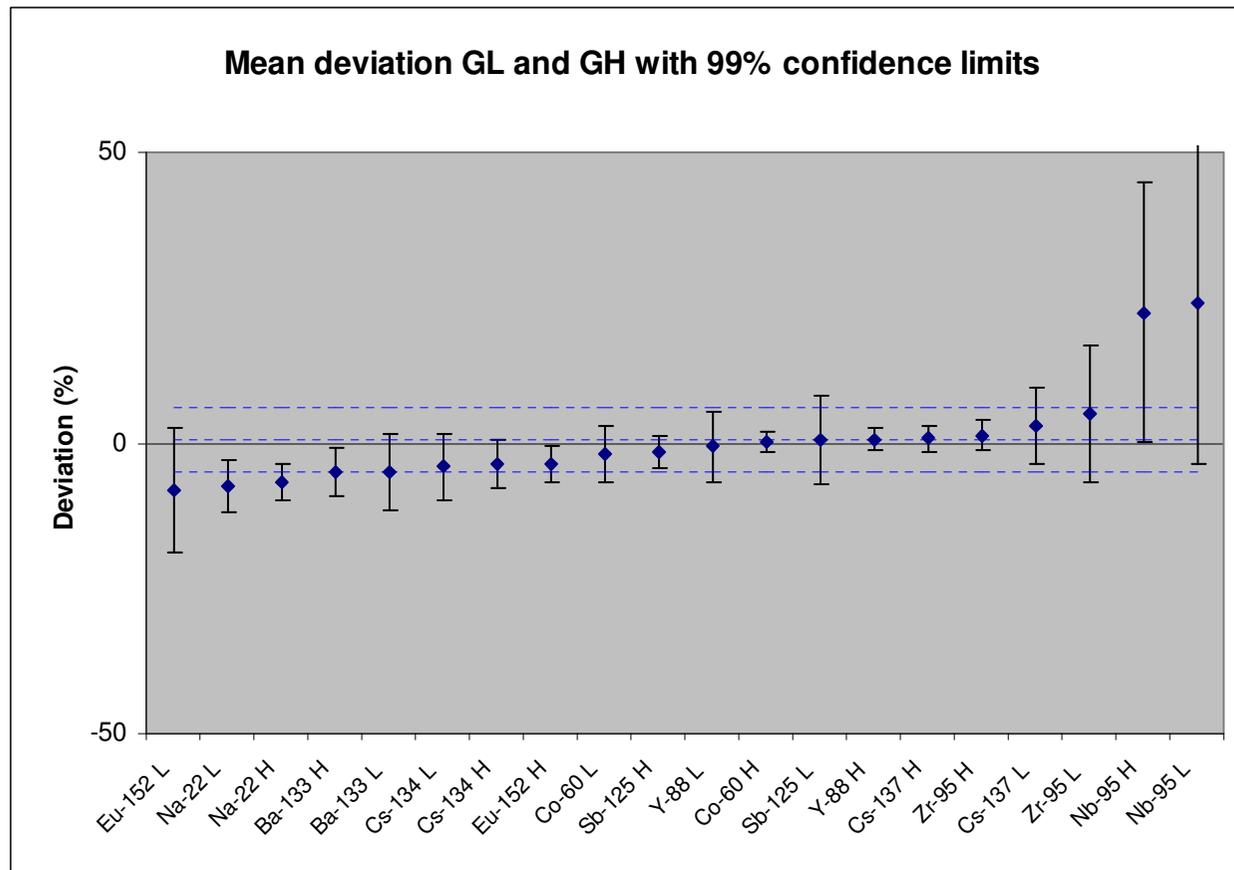
False positive identifications

Co-57 5 GL and 1 GH
(was **Eu-152**)

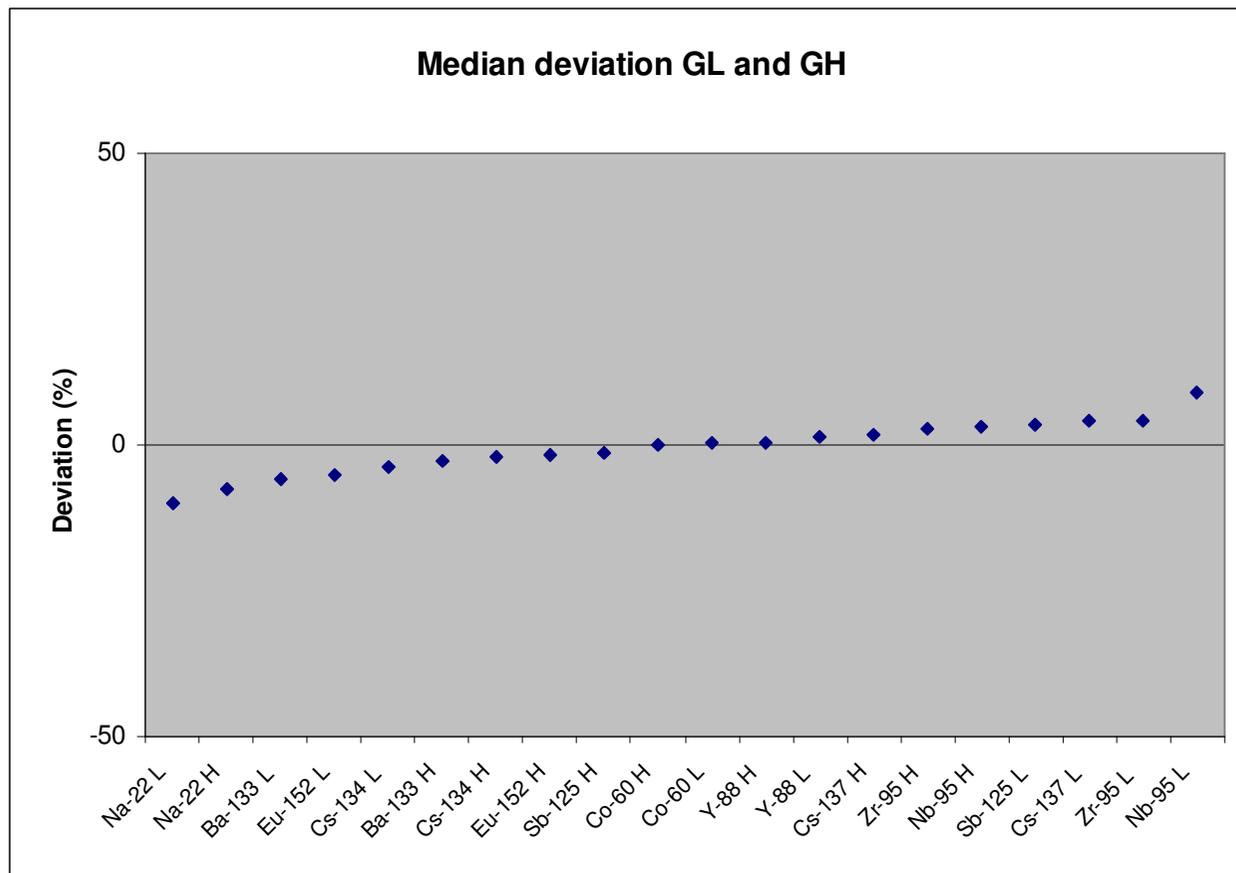
Sn-113 1 GL
(**?**)

Eu-154 2 GL and 2 GH
(was **Eu-152**)

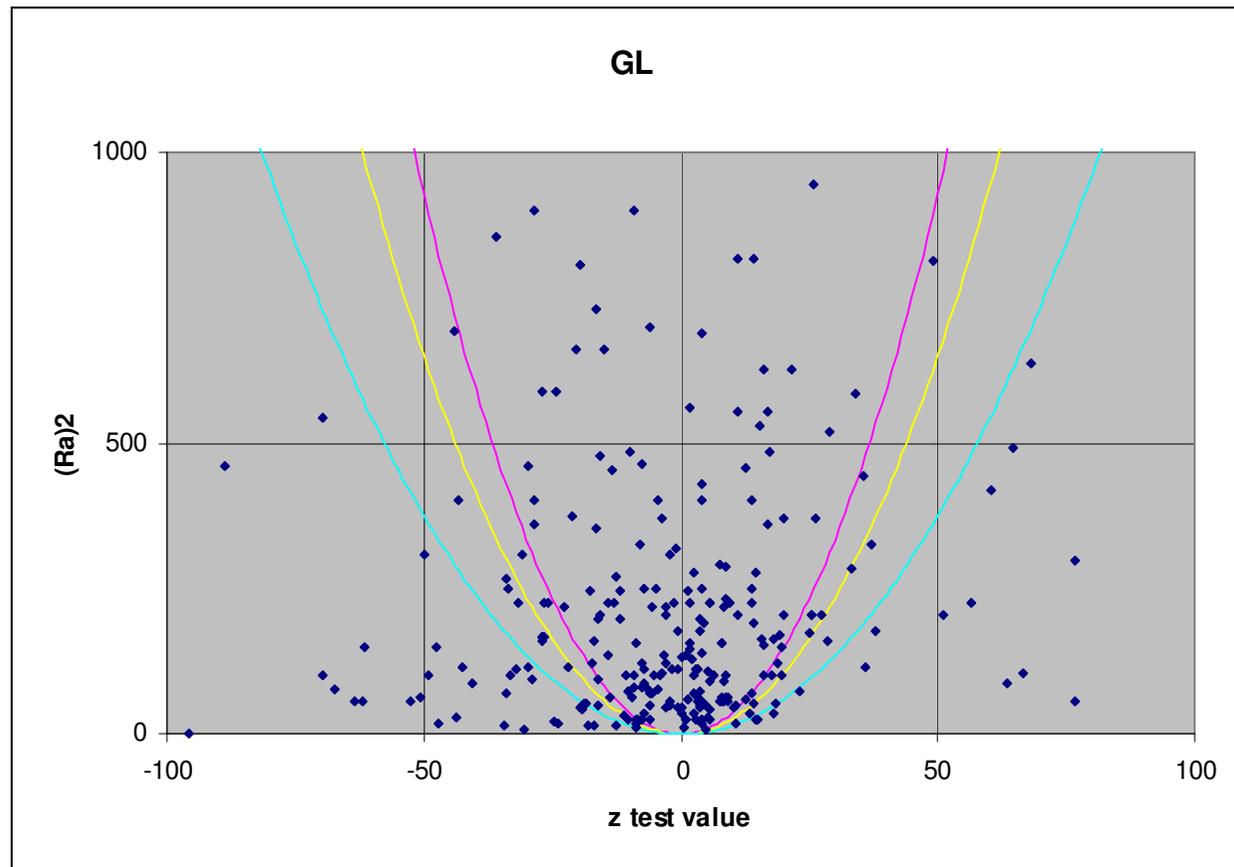
Mean deviation GL and GH with 99% confidence limits



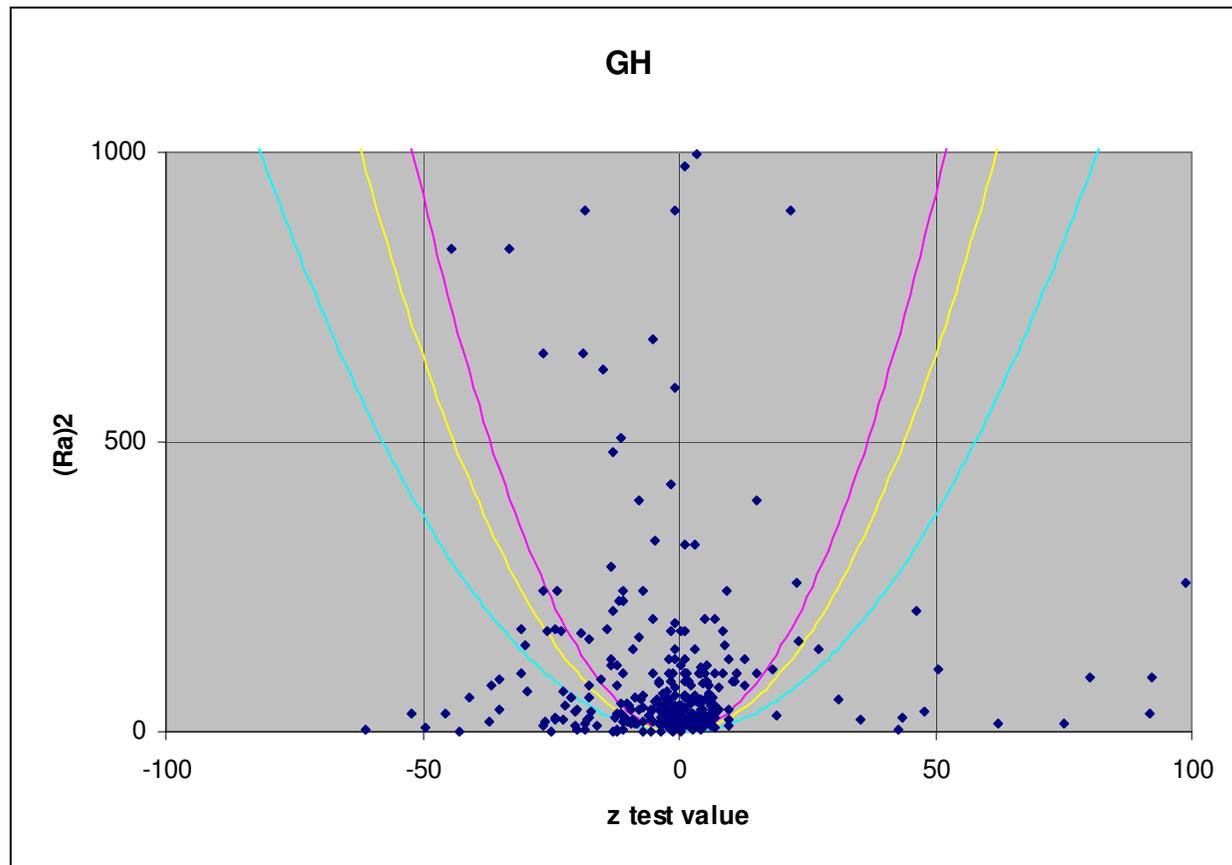
Median deviation GL and GH



Naji plot GL



Naji plot GH



Thank you