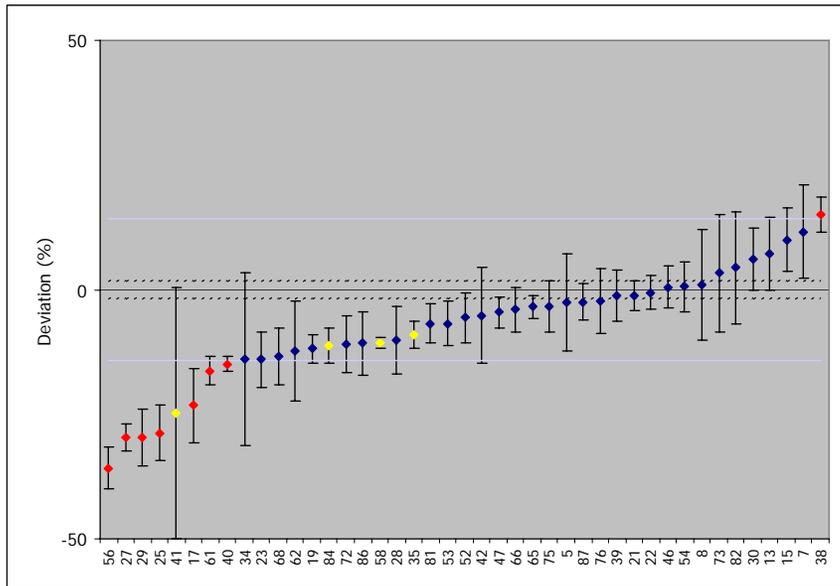


Concrete samples 2008



Arvic Harms
National Physical Laboratory
27 January 2009

Overview

C samples not a proficiency test but a comparison with 34 participants (27 in 2007)

Assigned values are based on the participant values

C samples originate from samples taken from a concrete bioshield of a decommissioned nuclear reactor which ceased operation ~27 years ago after ~20 years of operation.

The concrete contains nuclides formed by neutron activation of concrete components

Preparation C samples

Concrete core samples were crushed, mixed and sieved to <0.25 mm to form a homogeneous powder (~6.3 kg)

The powder was then heated overnight to 150 °C to remove ^3H present as mobile tritiated water

All 62 samples (100 g each) were measured with gamma spectrometry to assess homogeneity (^{60}Co , ^{133}Ba , ^{152}Eu and ^{154}Eu)

Chemical composition C with INAA

		(2007)	
Ca	28.7(4)%	26.0(3)%	⁴¹ Ca
Si	11(4)%	15(3)%	
Al	1.150(23)%	1.21(3)%	
Fe	0.649(7)%	0.680(8)%	⁵⁵ Fe
K	0.544(6)%	0.53(2)%	⁴⁰ K
Mg	0.44(3)%	0.44(3)%	
Na	0.2180(22)%	0.222(3)%	
Ba	160(16) ppm	192(12) ppm	¹³³ Ba
Co	2.52(8) ppm	2.70(6) ppm	⁶⁰ Co
Eu	0.378(11) ppm	0.372(11) ppm	^{152/154} Eu

and 25 other elements (including Cs, Th and U)

Assigned values C samples

No assigned traceable NPL values are available

Nuclide only evaluated if 5 or more results were received

N^* consensus value participants:

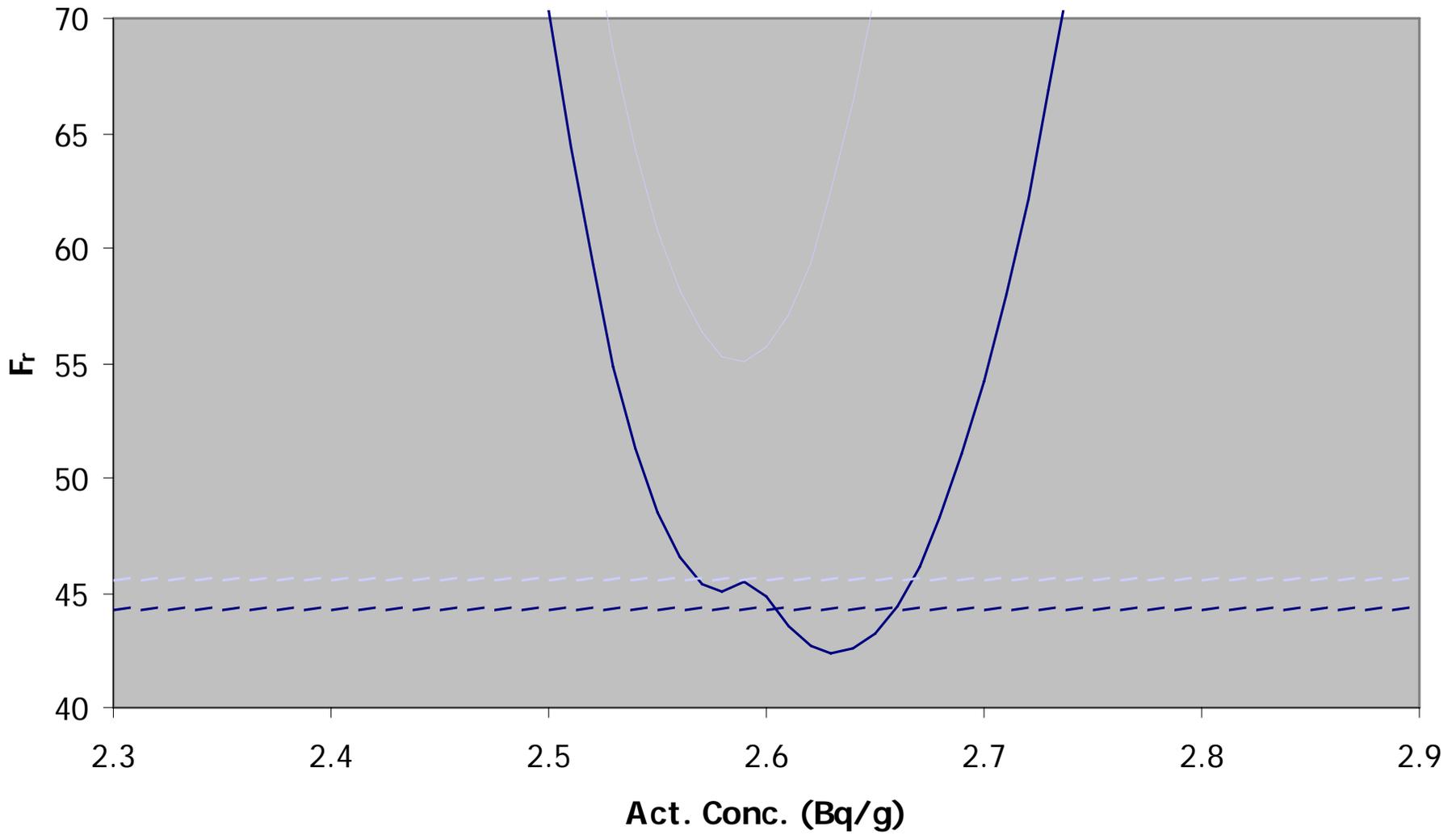
- (a) weighted mean of the Largest Consistent Subset (Cox, 2007)
- (b) robust mean (ISO 13528; but ignores uncertainties!)

Method (a) if the LCS contains 75% or more of the results, otherwise (b)

u_{N^*} : combination of u_{cons,N^*} , u_{hum} (0.5%) and u_{hom}

u_{hom} : measuring all 62 samples once (gamma spectrometry) and one sample 8 times

Eu-152 (n=26 and 27)



Homogeneity uncertainty

Measure each samples once:

$$u_{bb} = \sqrt{\frac{\sum_i (x_i - \bar{x}_i)^2}{n-1}} \left(\frac{100}{\bar{x}_i} \right)$$

Measure one sample m times:

$$u_{meas} = \sqrt{\frac{\sum_j (x_j - \bar{x}_j)^2}{m-1}} \left(\frac{100}{\bar{x}_j} \right)$$

Internal (counting) uncertainty:

$$u_{int} = 100 \text{ mean} \left(\frac{u_i}{x_i} \right)$$

Homogeneity uncertainty:

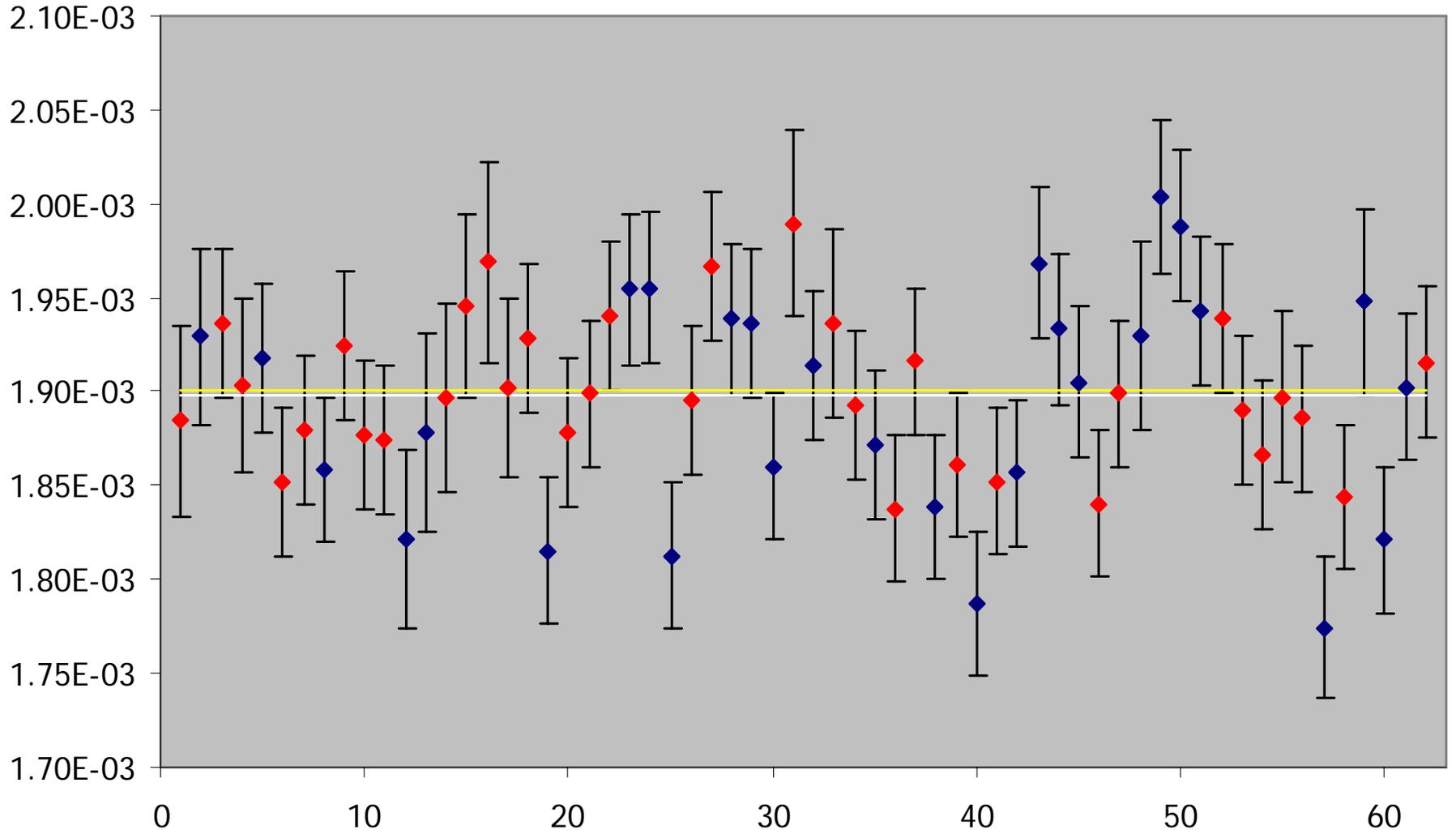
$$u_{hom}^2 = u_{bb}^2 - u_{meas}^2$$

or

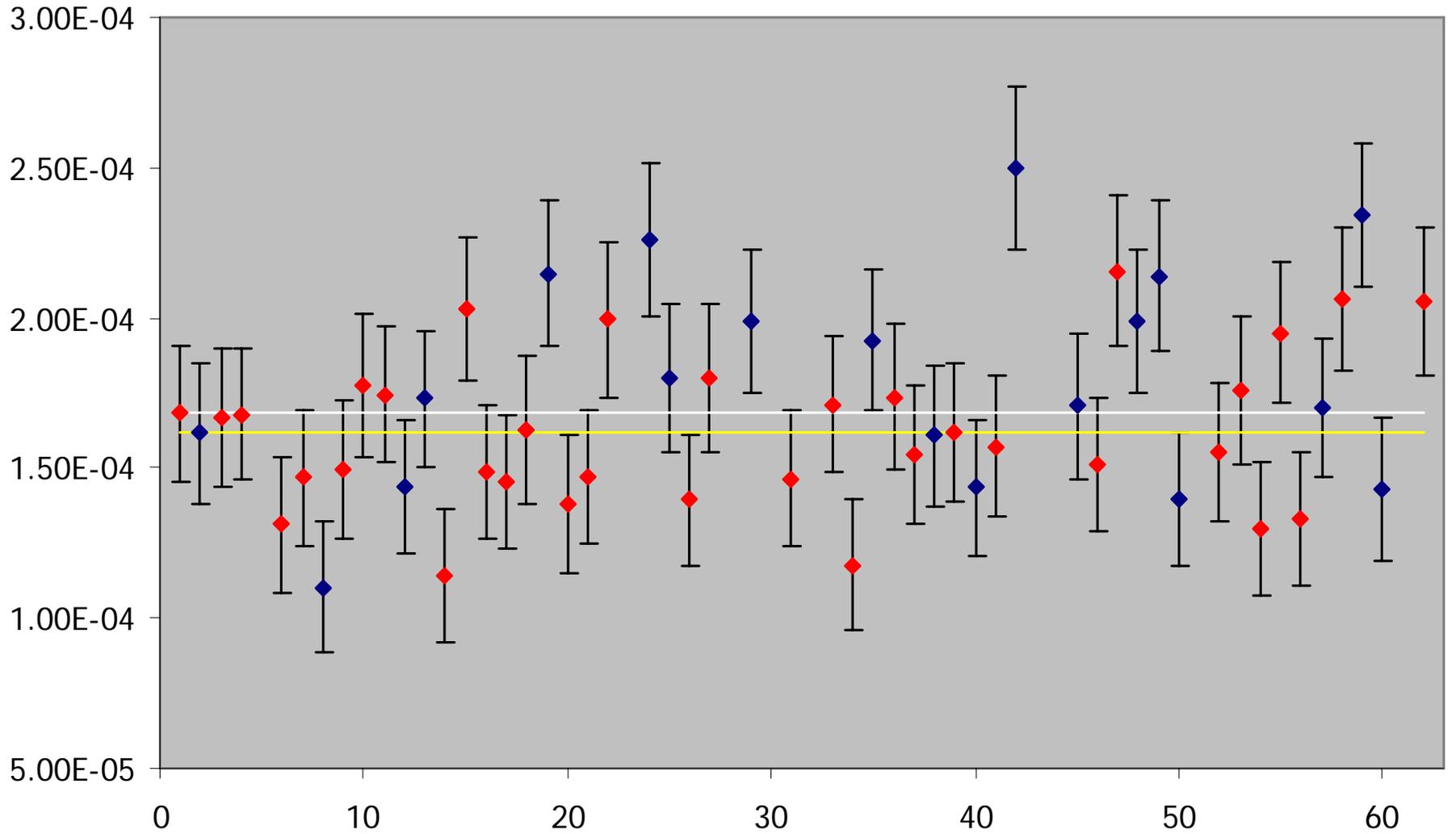
$$u_{hom}^2 = u_{bb}^2 - u_{int}^2$$

whichever gives the lowest result

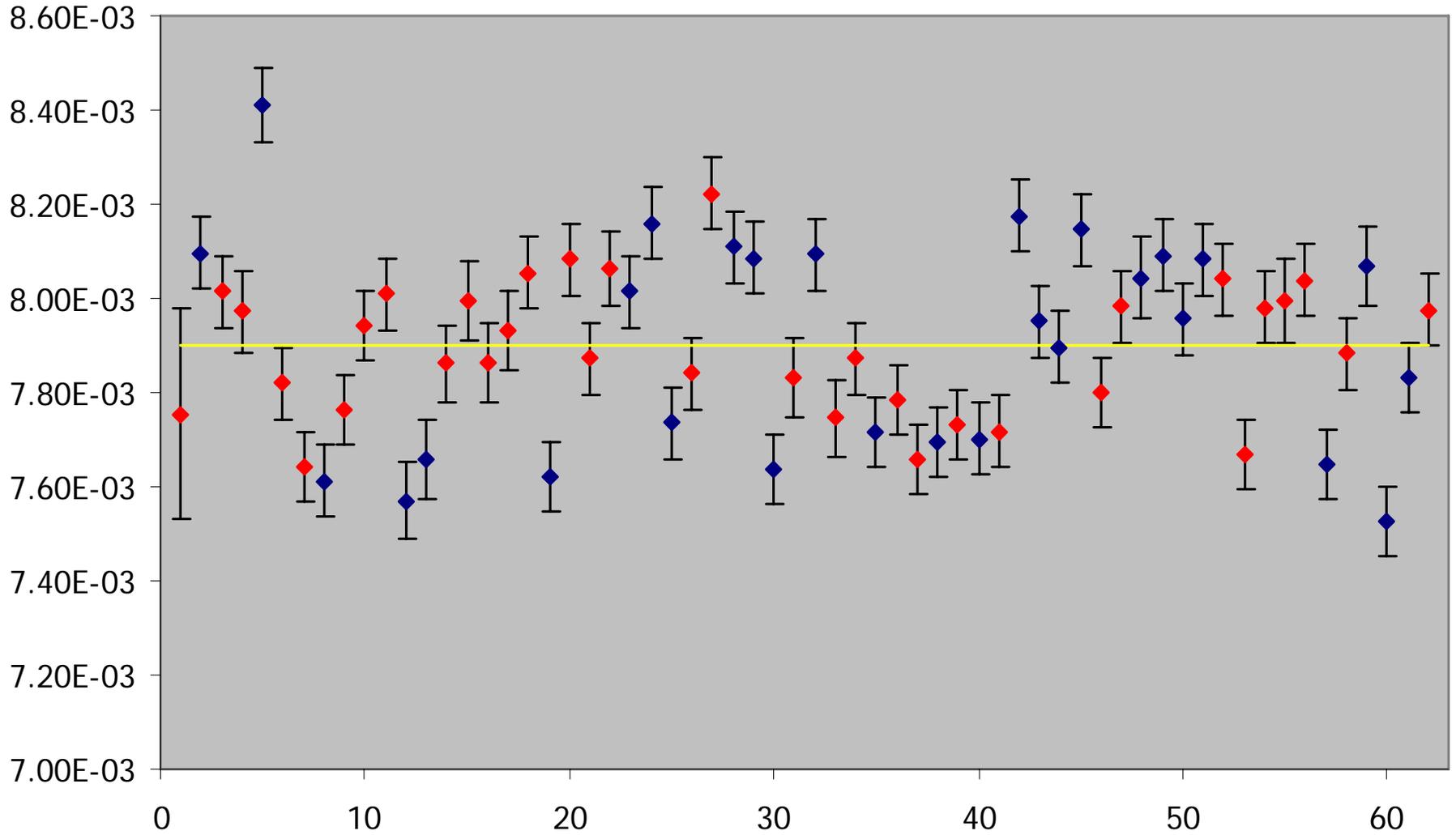
Co-60



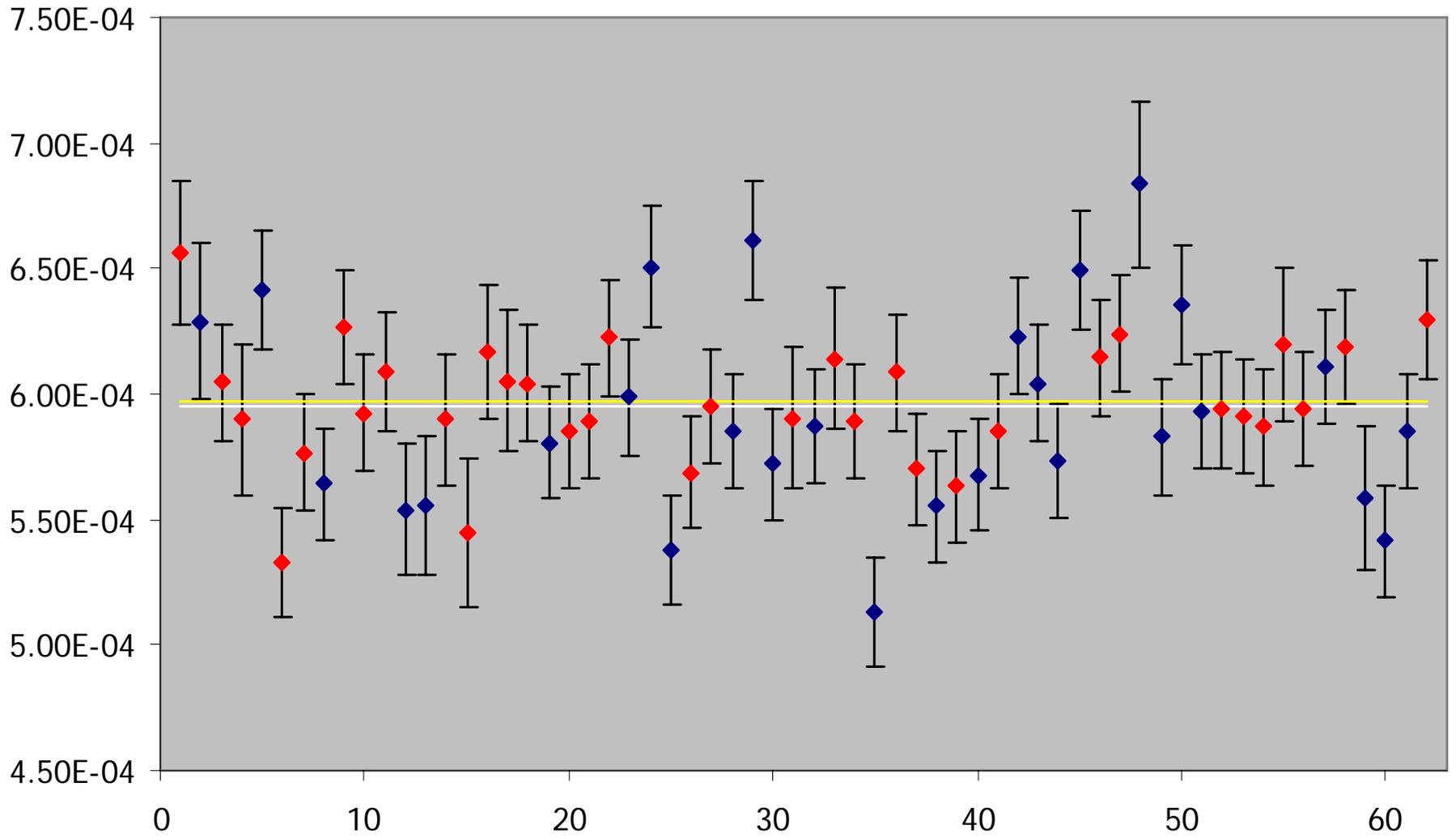
Ba-133



Eu-152



Eu-154



Homogeneity uncertainty

	u_{bb} (%)	u_{meas} (%)	u_{int} (%)	u_{hom} (%)
<u>Despatched</u>				
^{60}Co	1.98	2.55*	2.21	0
^{133}Ba	15.6	18.9*	14.6	0
^{152}Eu	1.77	3.17*	1.04	0
^{154}Eu	4.05	2.71	4.09*	0
<u>All</u>				
^{60}Co	2.64	2.55*	2.19	0.68
^{133}Ba	18.5	18.9*	14.2	0
^{152}Eu	2.37	3.17*	1.01	0
^{154}Eu	5.55	2.71	4.07*	3.77

C assigned values (Bq g⁻¹)

	Ass value	WM LCS	%	Rob Mean
³ H total (14)	18(10)	24.3(8)	43	18(10)*
³ H leach (5)	3(4)	2.87(7)	40	3(4)*
¹⁴ C (12)	0.06(5)	0.0495(25)	42	0.06(5)*
⁴⁰ K (7)	0.18(8)	0.160(8)	57	0.18(8)*
⁵⁵ Fe (5)	0.055(5)	0.055(5)*	80*	0.066(22)
⁶⁰ Co (31)	0.1041(10)	0.1041(8)*	87*	0.108(11)
⁶³ Ni (6)	0.04(3)	0.026(4)	50	0.04(3)*
¹³³ Ba (15)	0.00704(25)	0.00704(25)*	87*	0.0074(15)
¹⁵² Eu (31)	2.631(24)	2.631(20)*	84*	2.59(21)
¹⁵⁴ Eu (28)	0.1029(15)	0.1029(14)*	79*	0.106(18)
Gross beta (6)	1.2(8)	1.29(3)	60	1.2(8)*

C in agreement (%)

^3H total	100	(100)
^3H leach	100	(80)
^{14}C	83	(100)
^{40}K	100	(100)
^{55}Fe	80	(100)
^{60}Co	68	(73)
^{63}Ni	67	(67)
^{133}Ba	87	(83)
^{152}Eu	71	(84)
^{154}Eu	71	(86)
Gross beta	83	(-)

(x) refers to 2007 values

Results

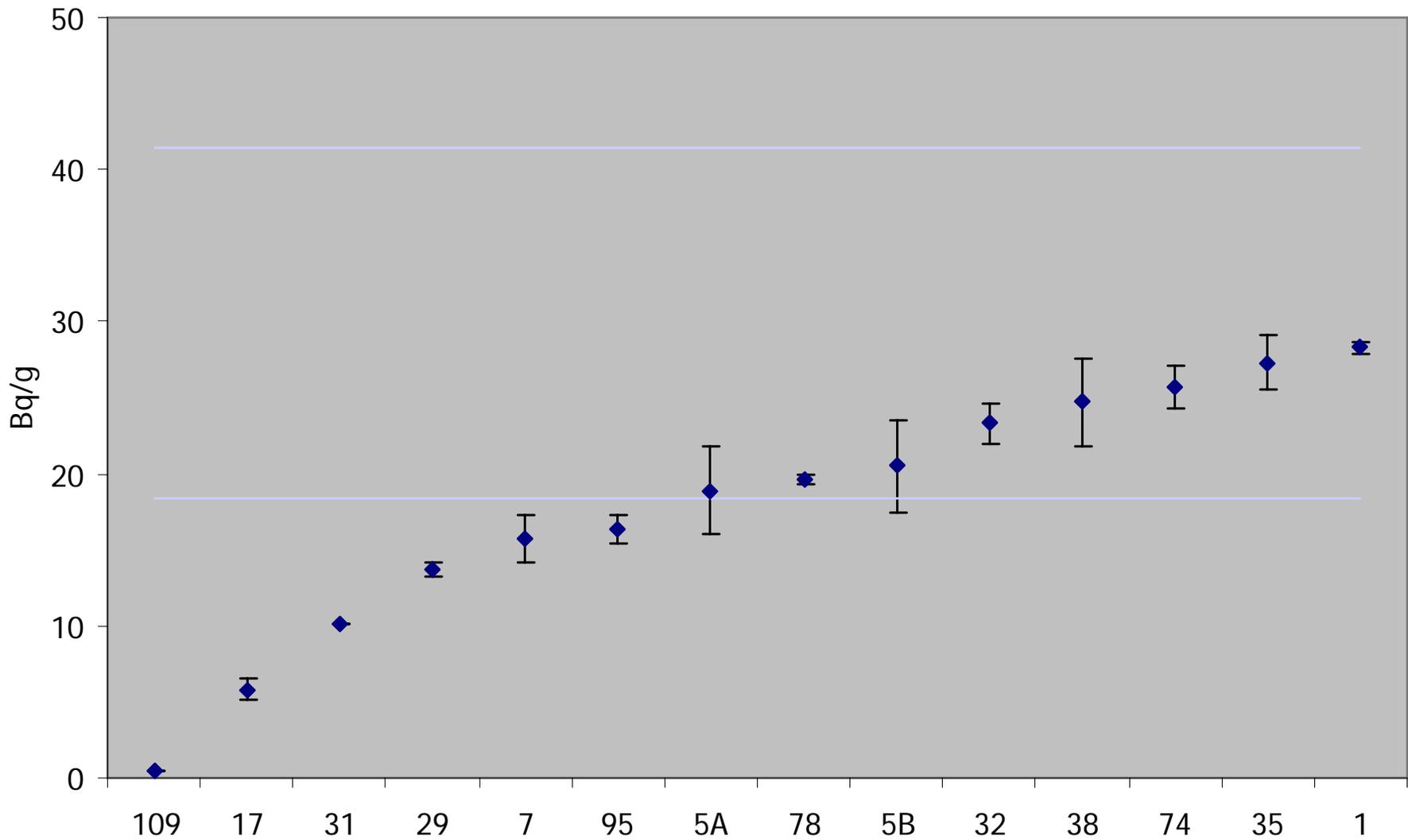
170 results received

		(2007)
78%	‘in agreement’	(85%)
12%	‘questionable’	(7%)
10%	‘discrepant’	(7%)

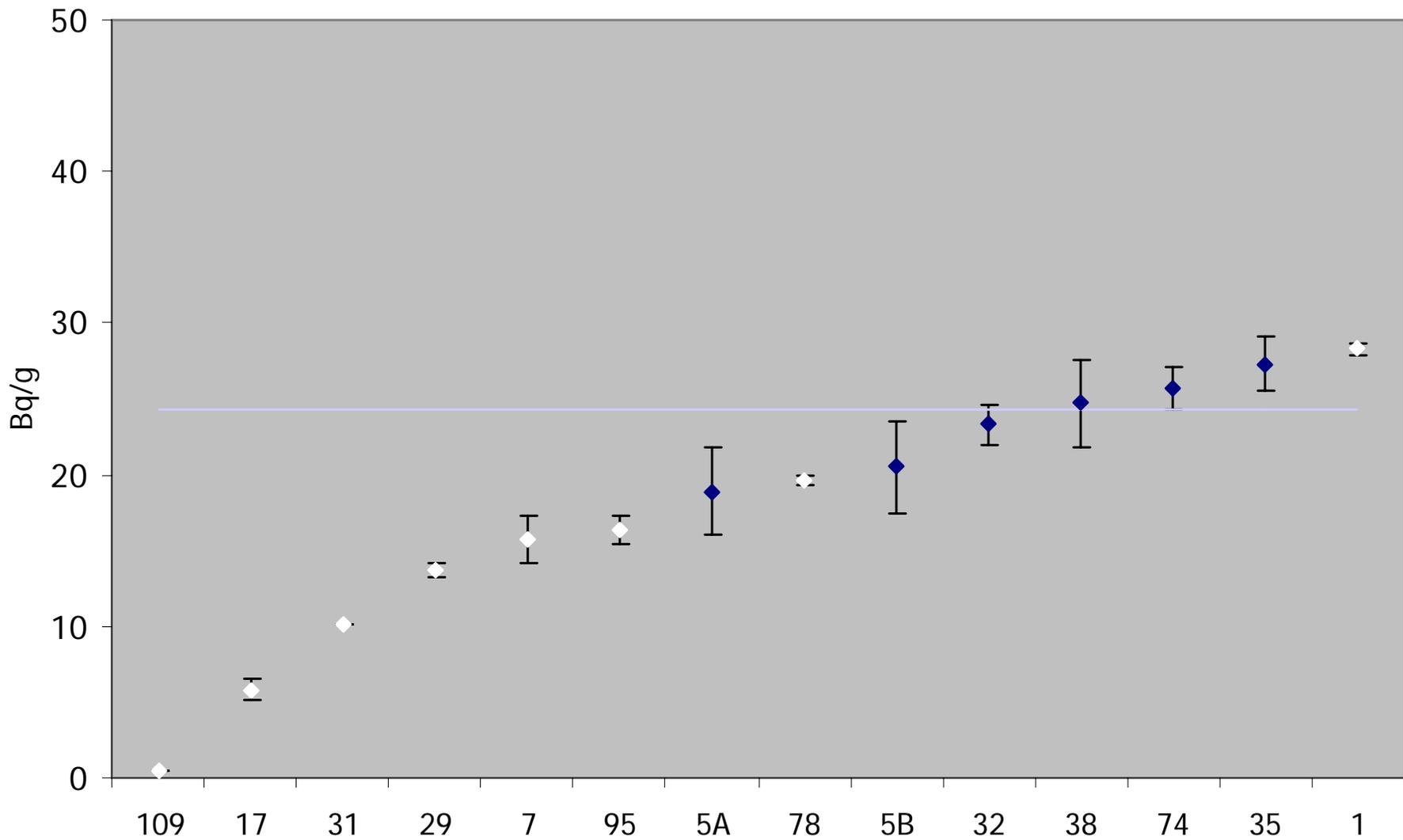
10 results ‘not evaluated’: ^3H fixed (3 results), ^{22}Na , ^{36}Cl , ^{137}Cs , ^{226}Ra , ^{228}Ra , ^{228}Th and ^{238}U

No ^{41}Ca result was submitted

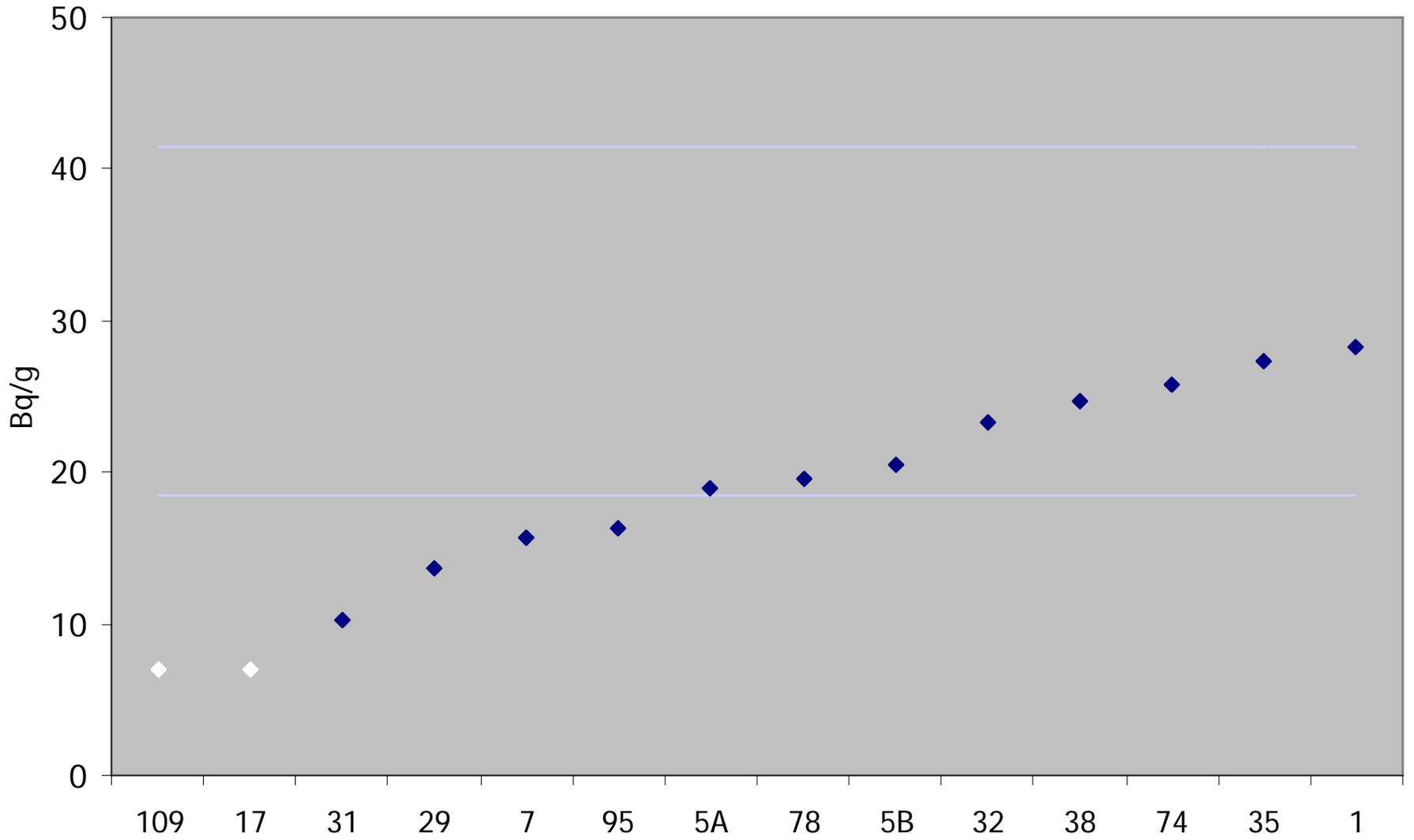
H-3 total C



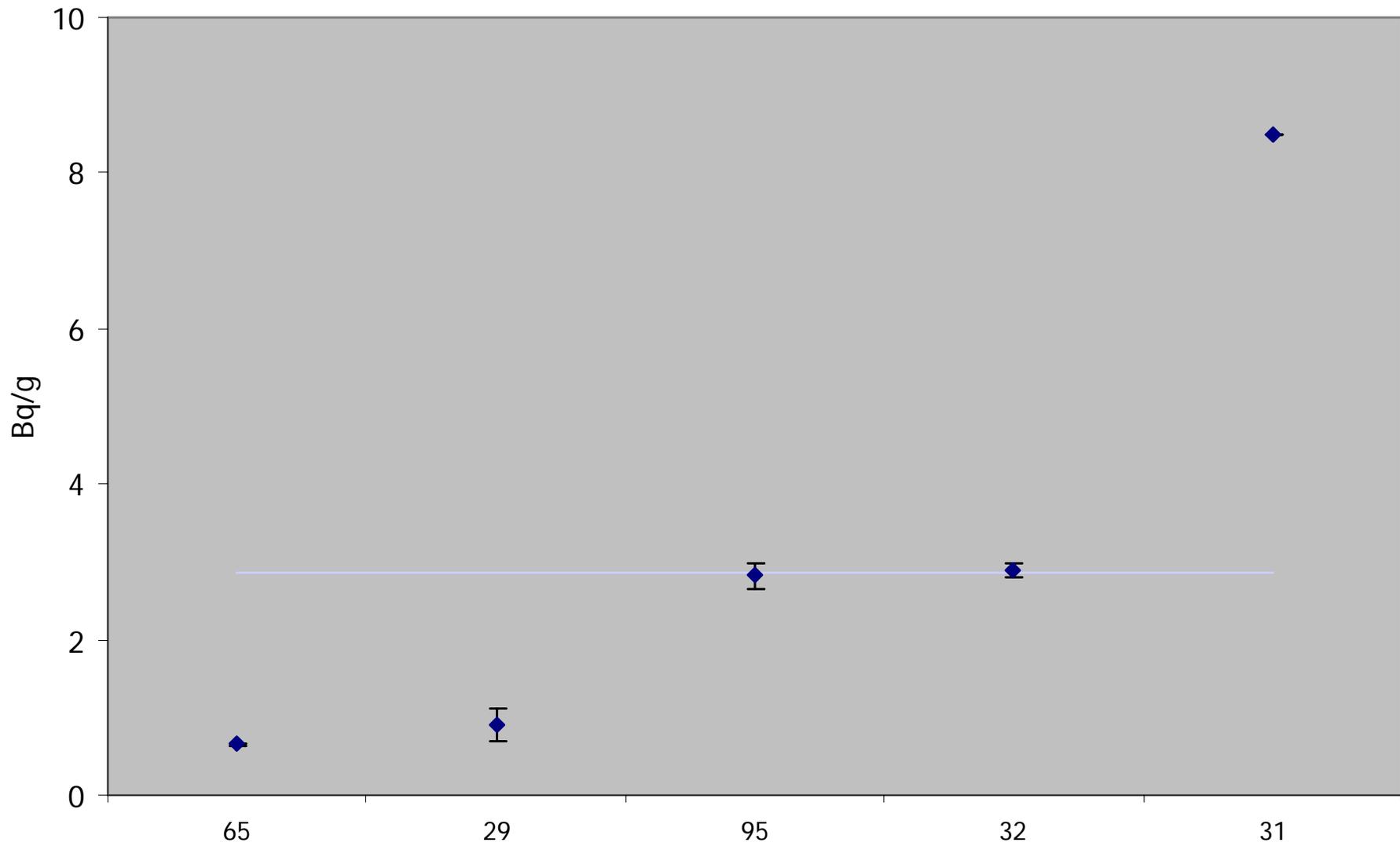
H-3 total C LCS



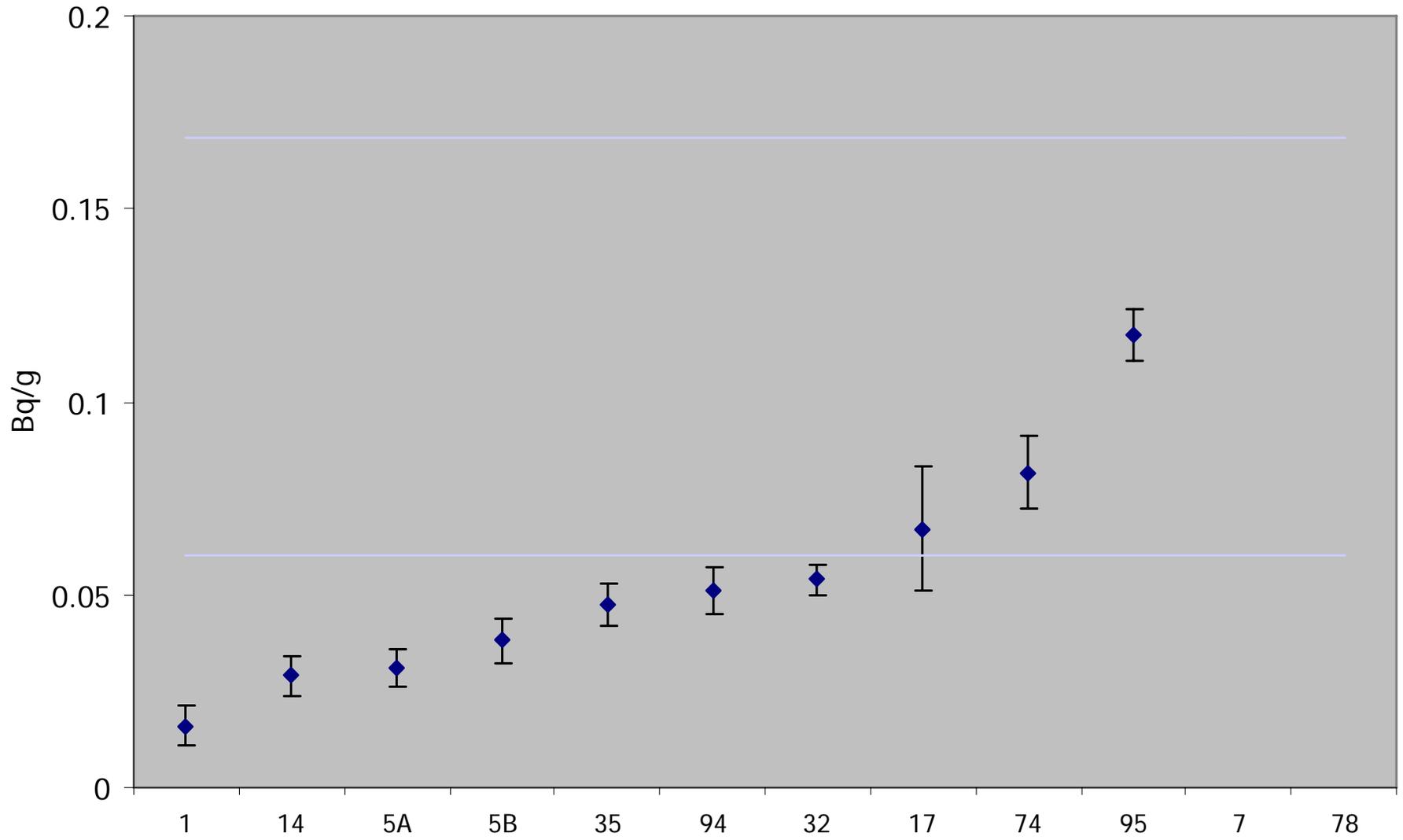
H-3 total C robust mean



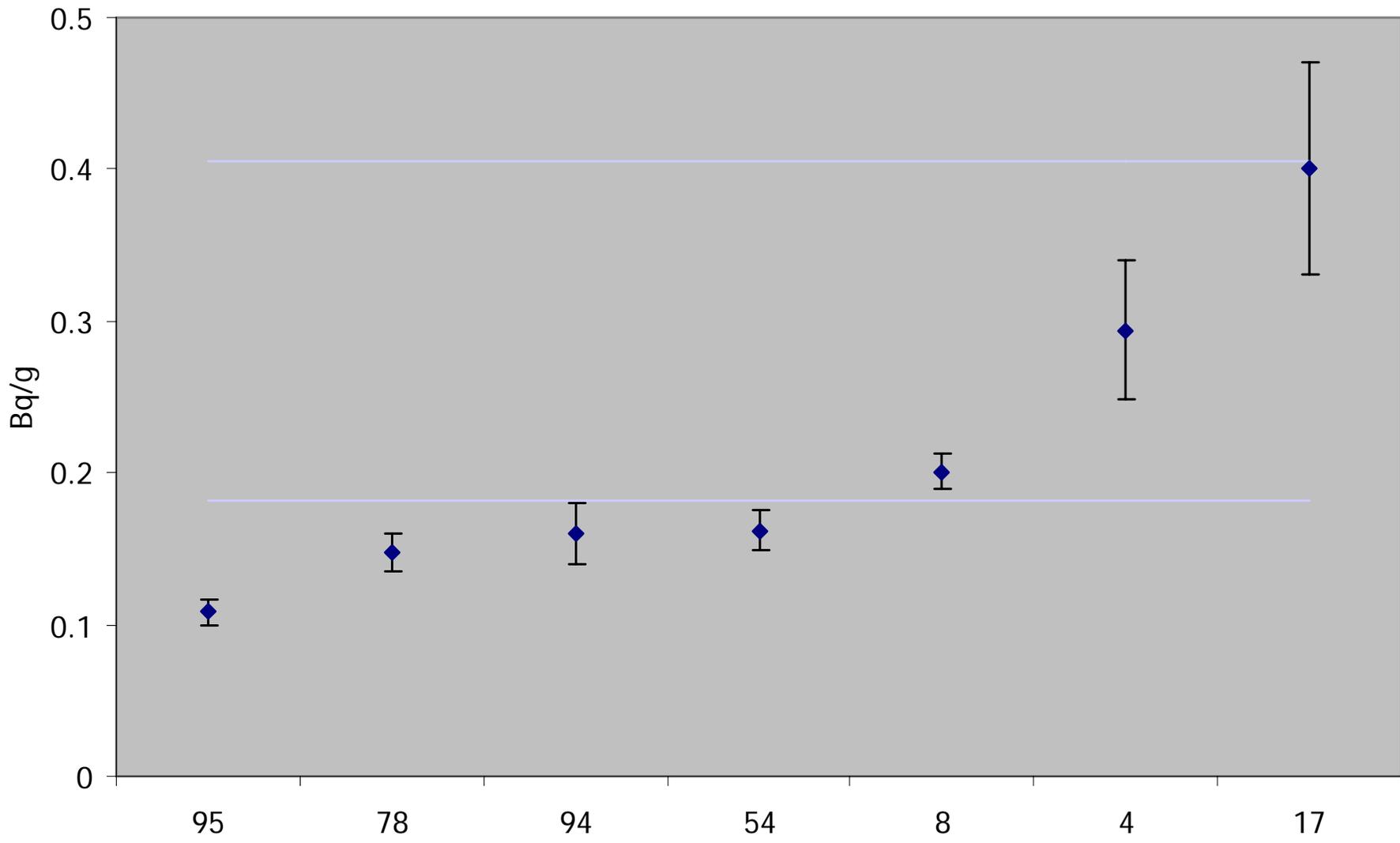
H-3 leach C



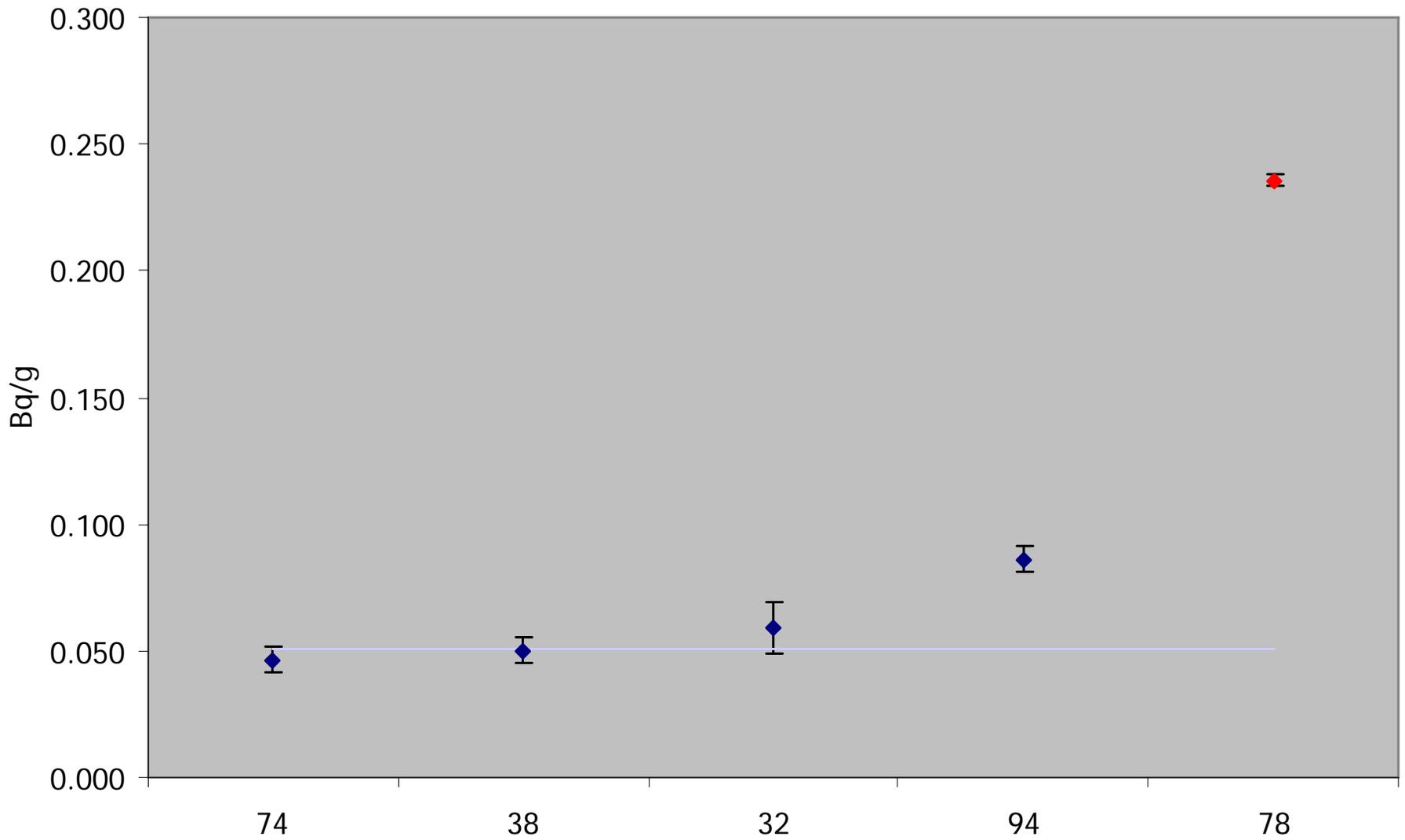
C-14 C



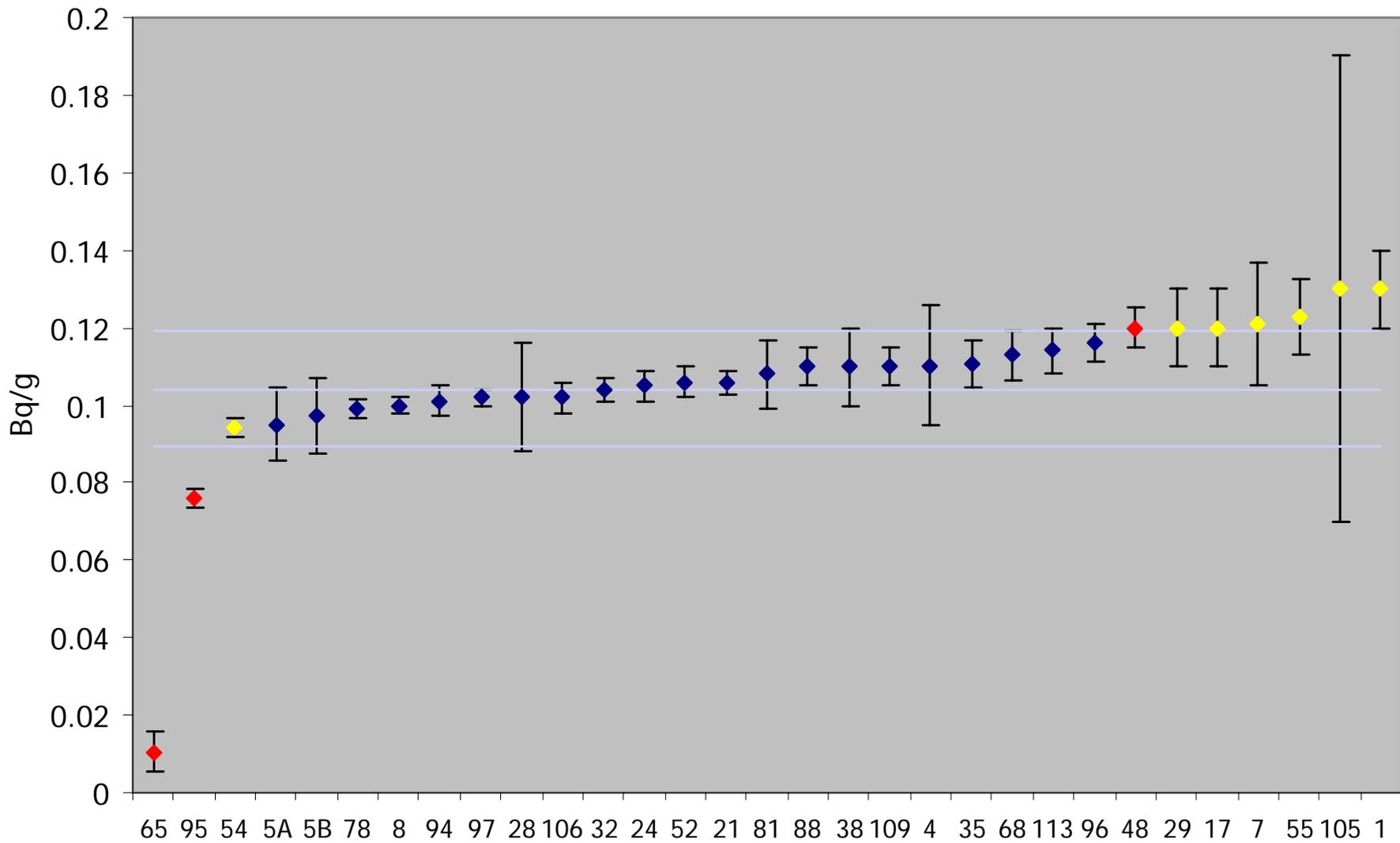
K-40 C



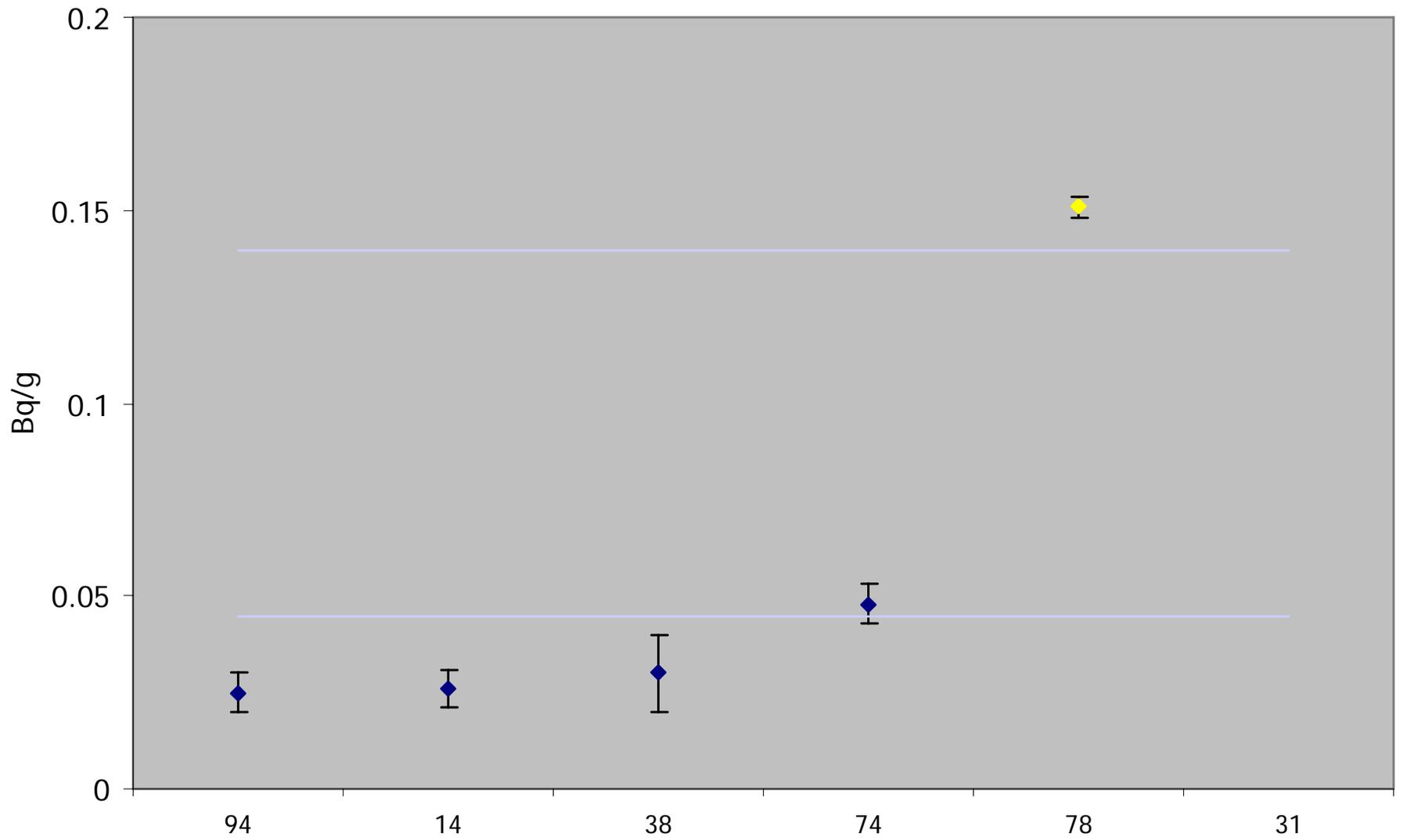
Fe-55 C



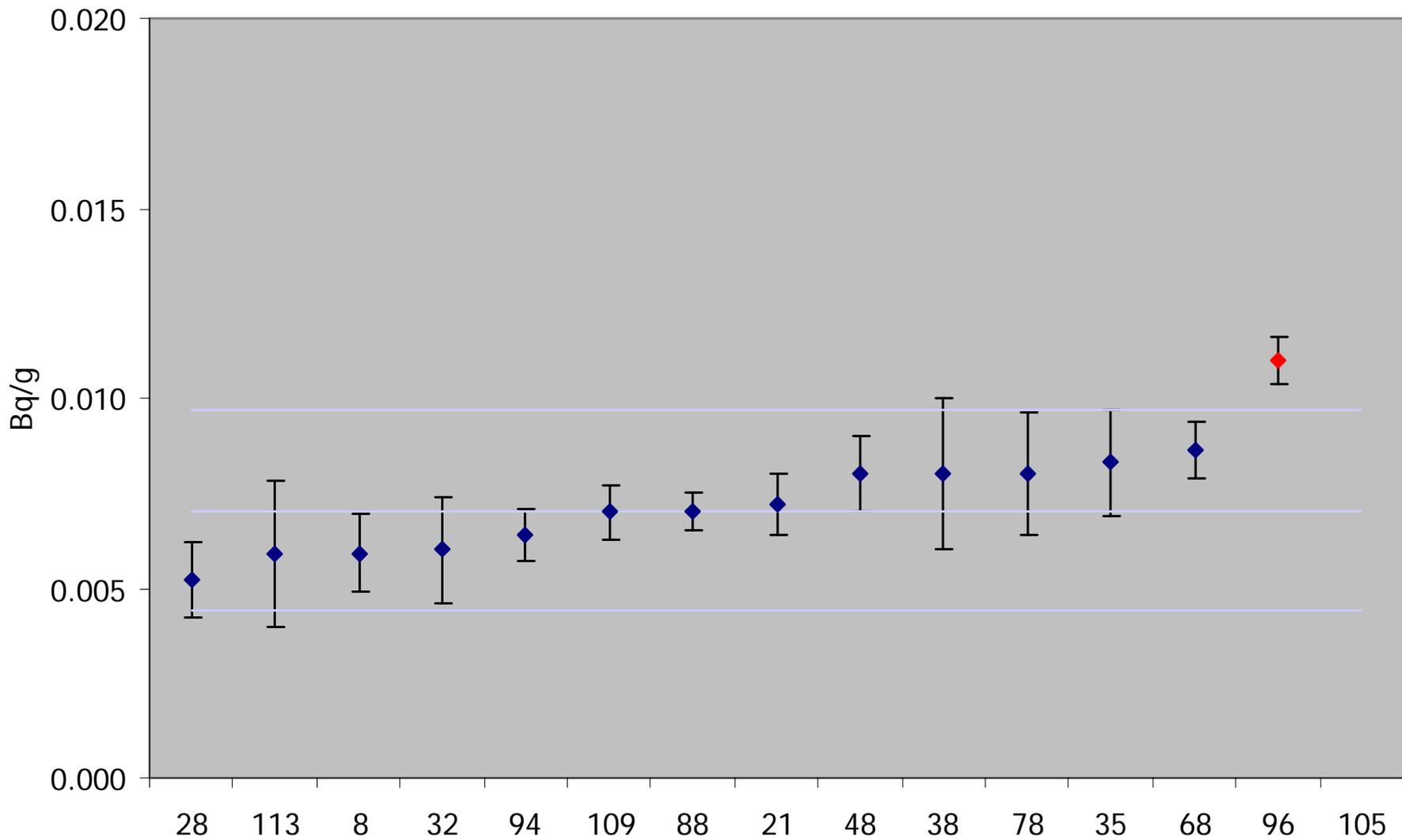
Co-60 C



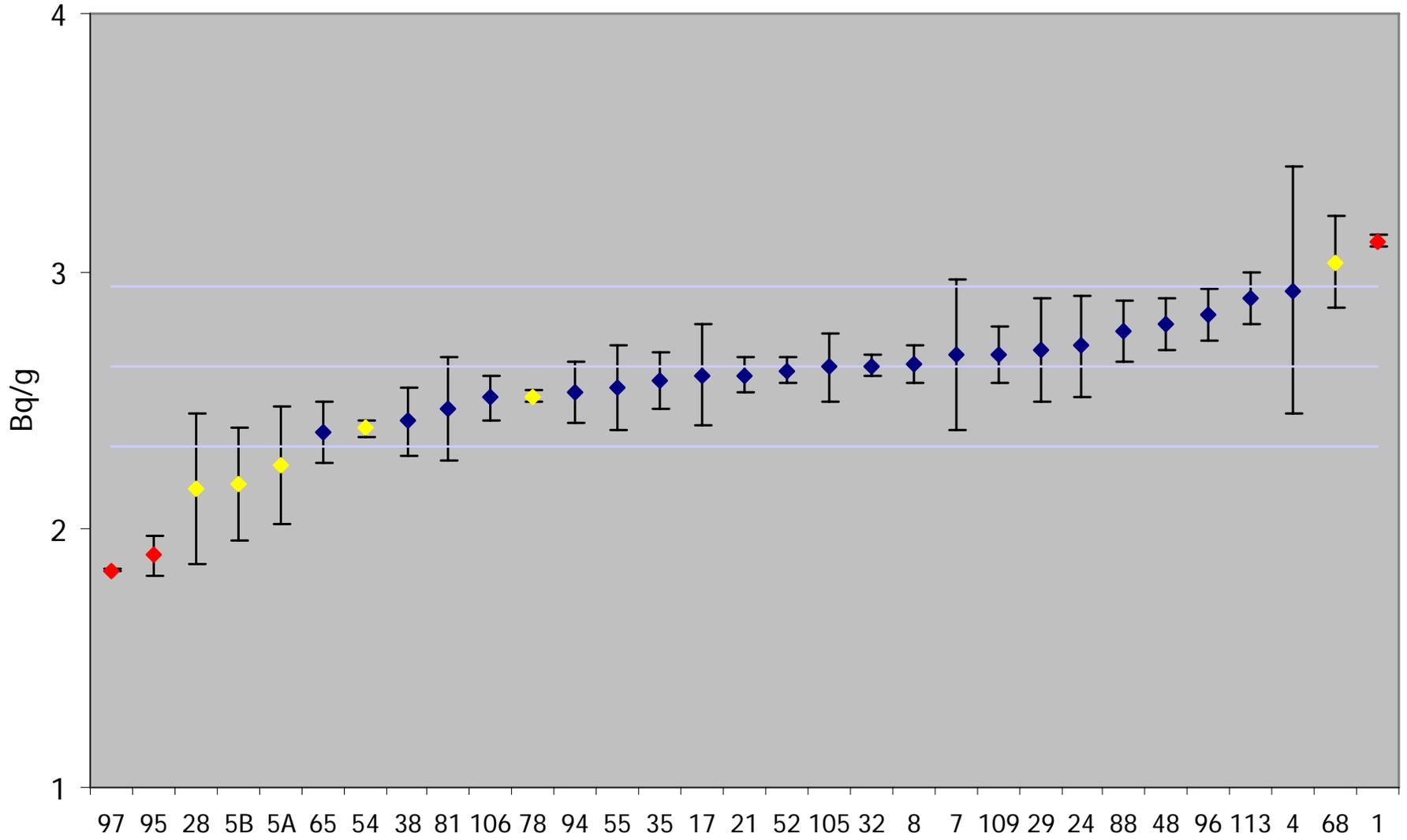
Ni-63 C



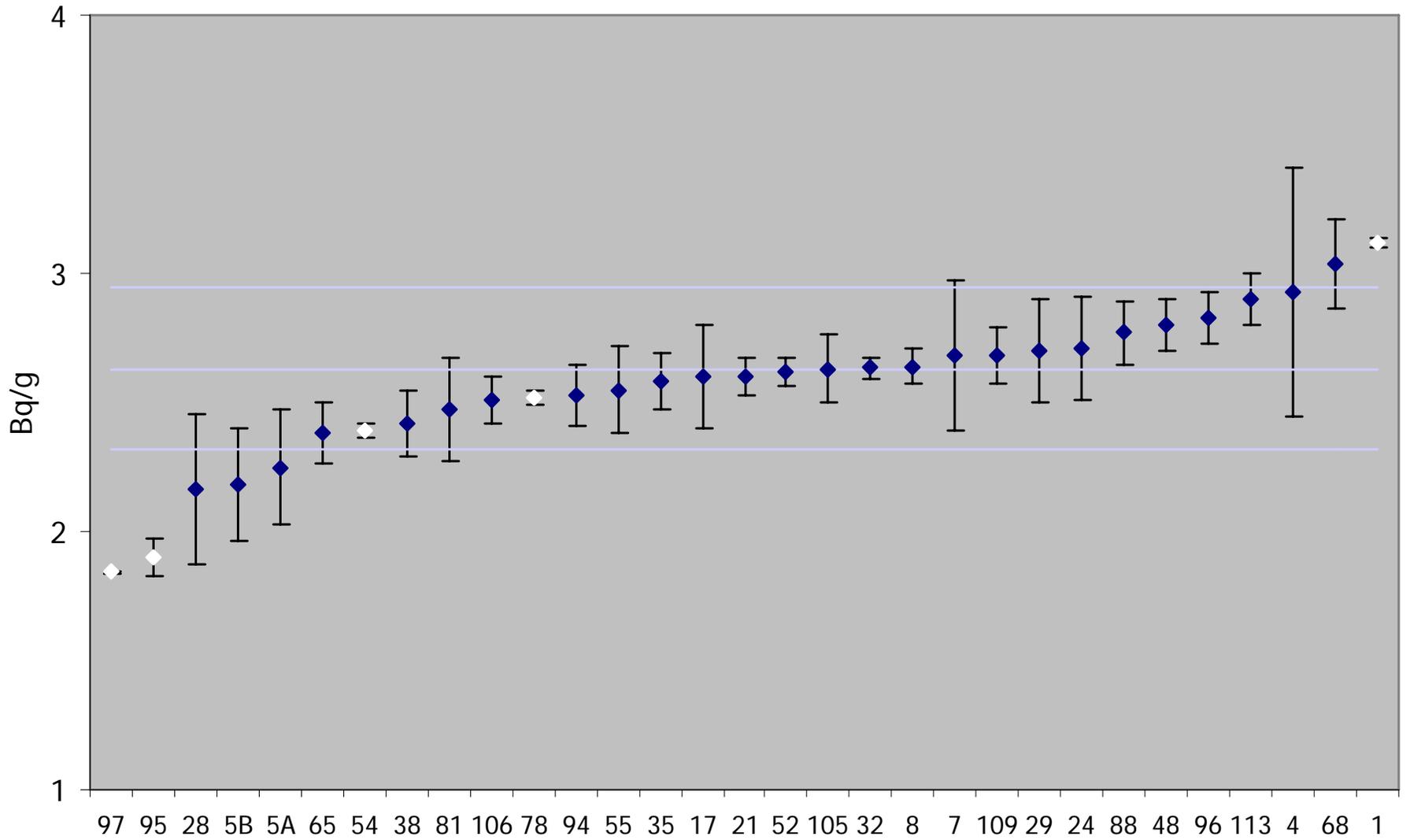
Ba-133 C



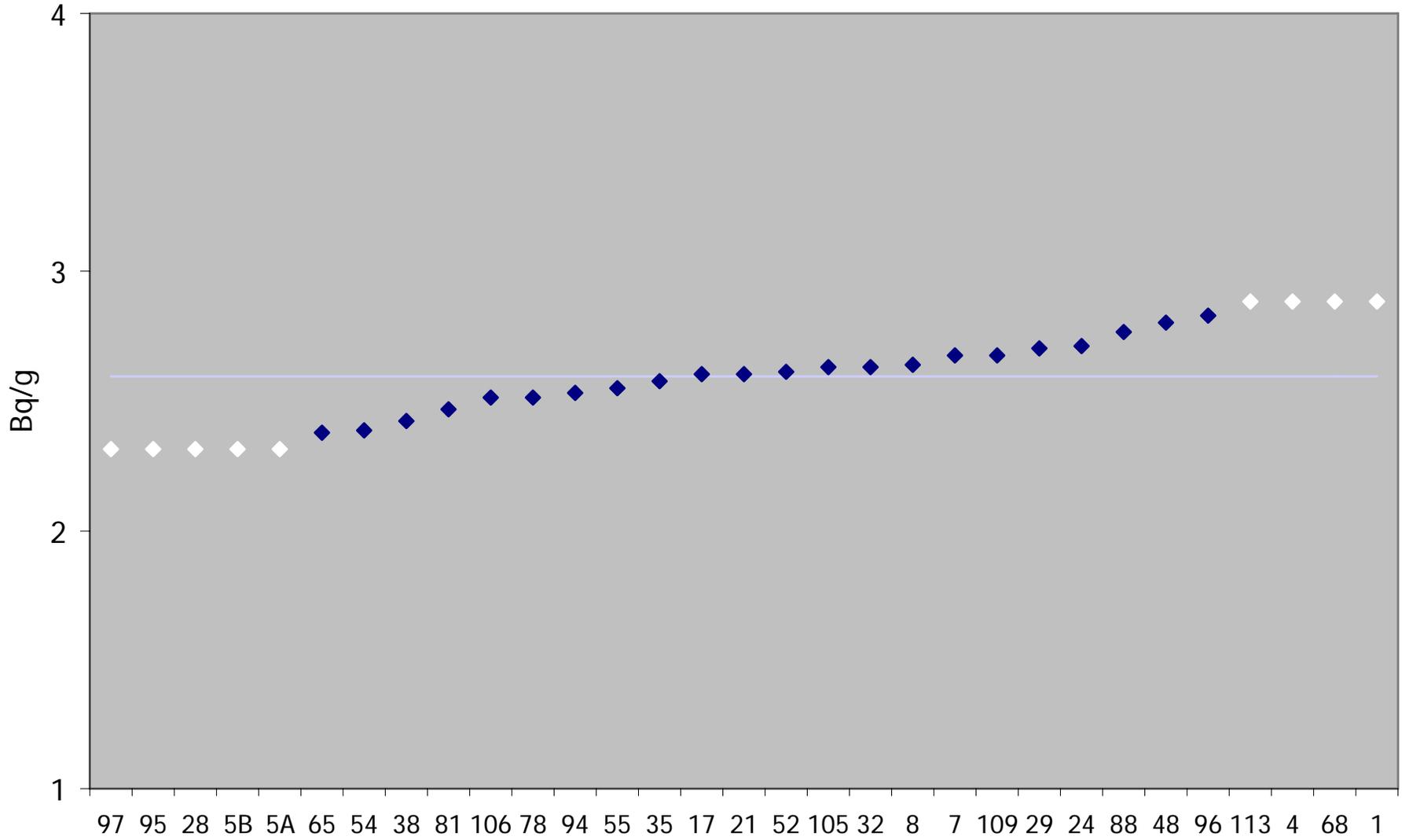
Eu-152 C



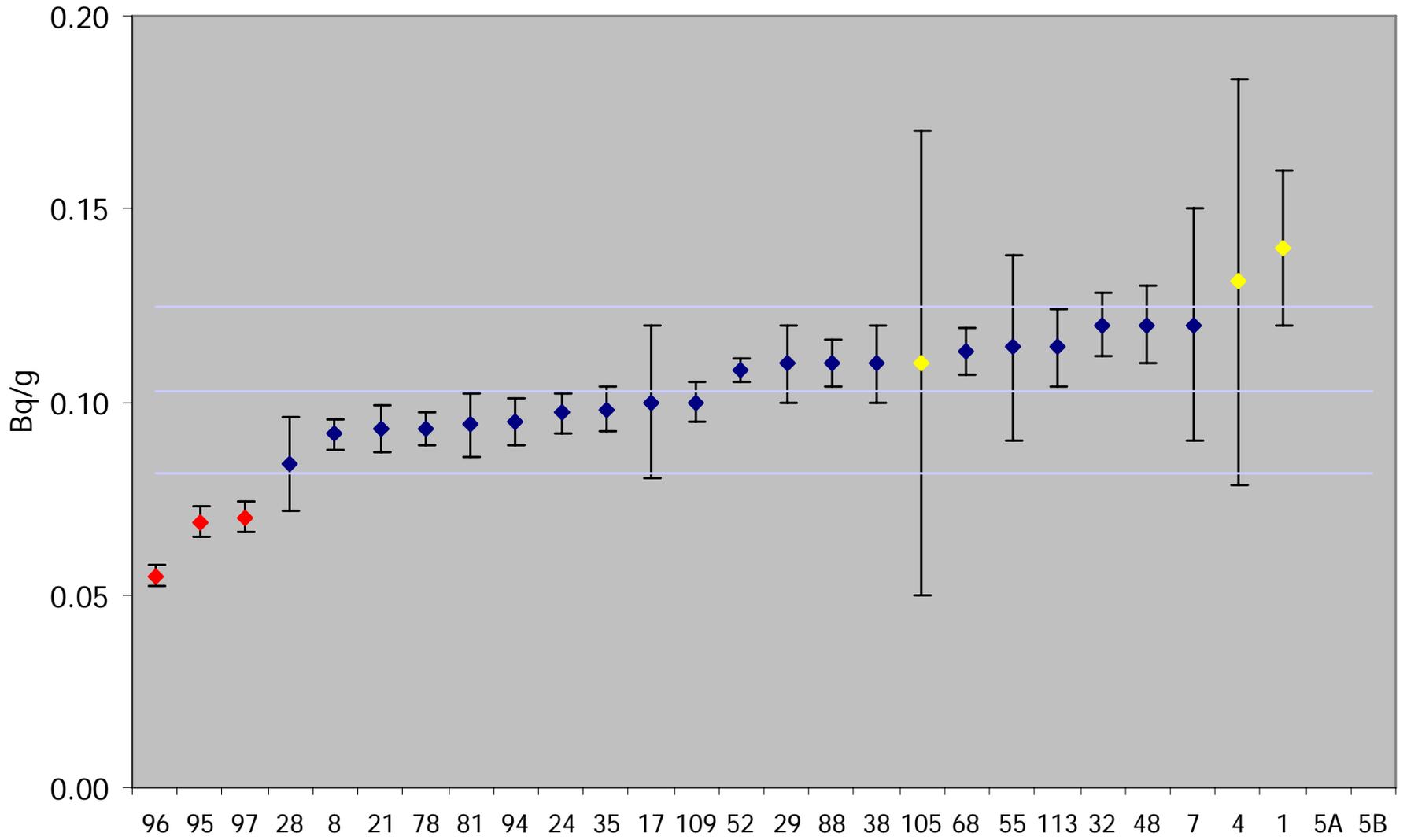
Eu-152 C LCS



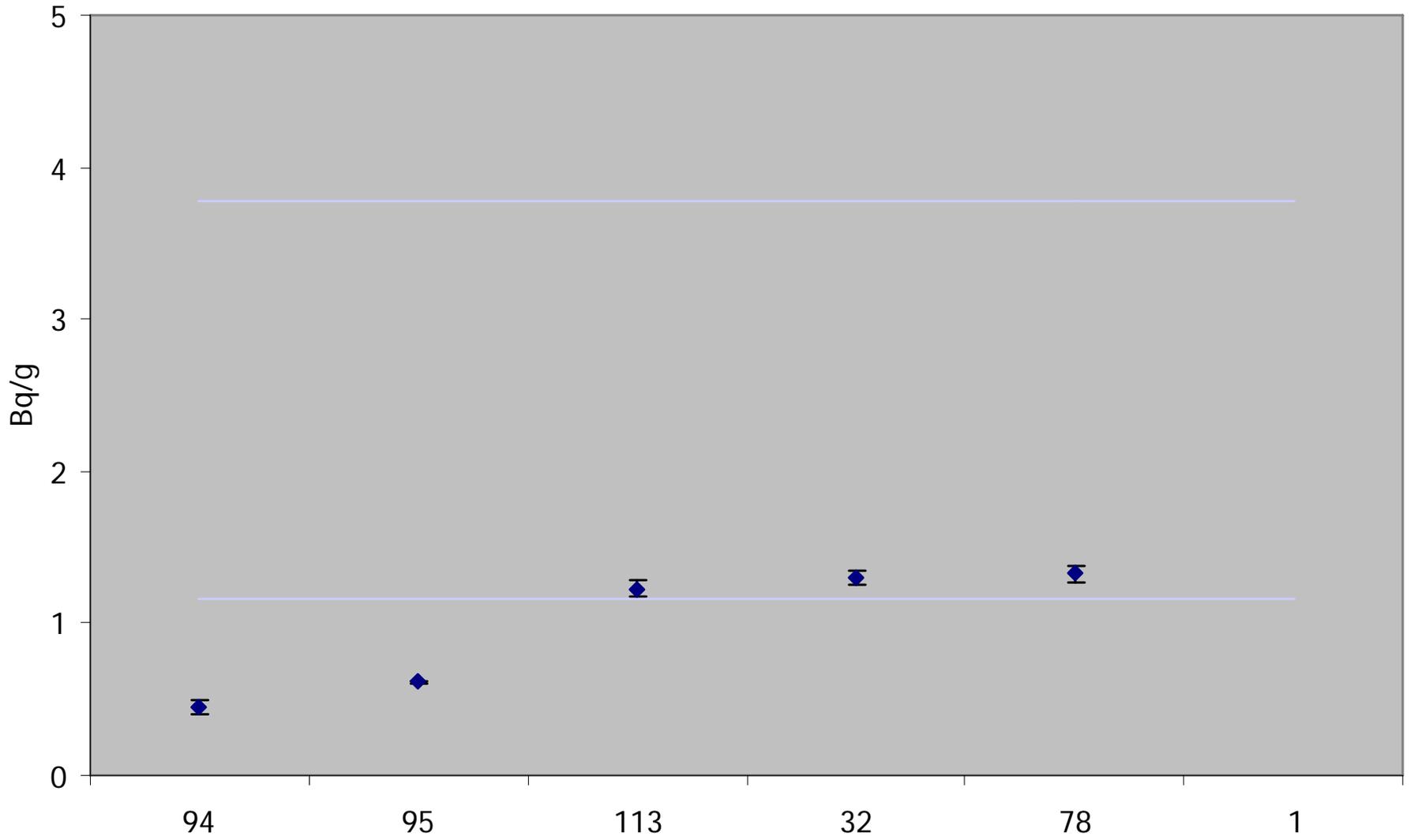
Eu-152 C robust mean



Eu-154 C



Gross beta C



Thank you