R. Collé

Radioactivity Group

NIST Physics Lab

Notes for ICRM LS Techniques WG

Paris 8-9 January 2007

LS & otherwise

^{209}Po and ^{210}Pb problems

+ ^{63}Ni highlights if interested

LS works !

Thanks to: L. Laureano-Perez; R. Fitzgerald; I. Outola

^{209}Po

World needs a Po tracer standard !

^{210}Po	0.4 a	5.3 MeV α
^{208}Po	2.9 a	5.1 MeV α
^{209}Po	102 a	4.9 MeV α + *junk*

Andre, Huizenga, et al. 1956 *Phys Rev.* 101, 645-651

^{208}Po/^{209}Po mass ratio 1.14 %

^{208}Po/^{209}Po activity ratios 5 %

} “private communication”

with $T_{1/2}(^{208}\text{Po}) = (2.93 \pm 0.03)$ a,

got $T_{1/2}(^{208}\text{Po}) = 103$ a

Compiler M. Martin,1991

must be wrong

with $T_{1/2}(^{208}\text{Po}) = 2.898 \pm 0.002$ a,

got $T_{1/2}(^{208}\text{Po}) = (102 \pm 5)$ a 4.9 %

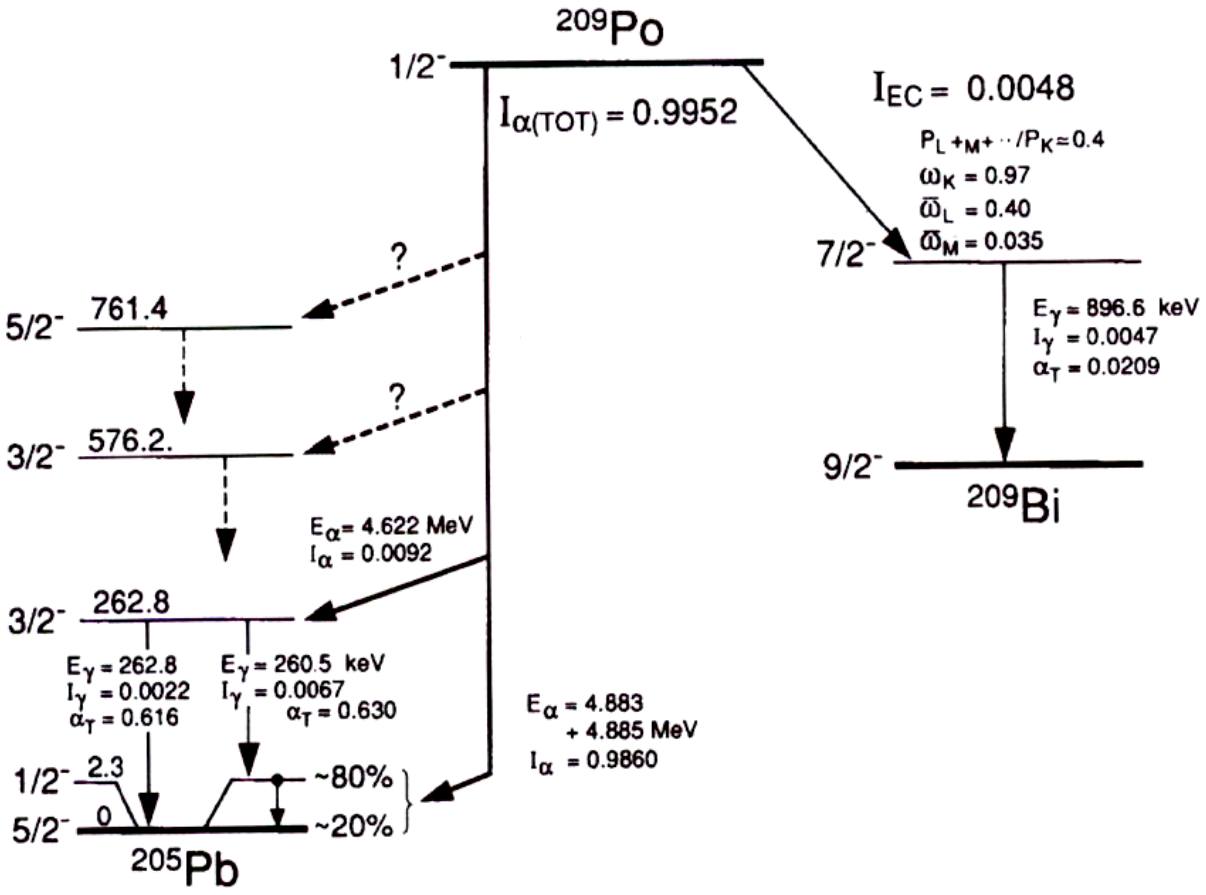


Fig. 2. Partial decay scheme for the ^{209}Po alpha and electron capture branch decays.

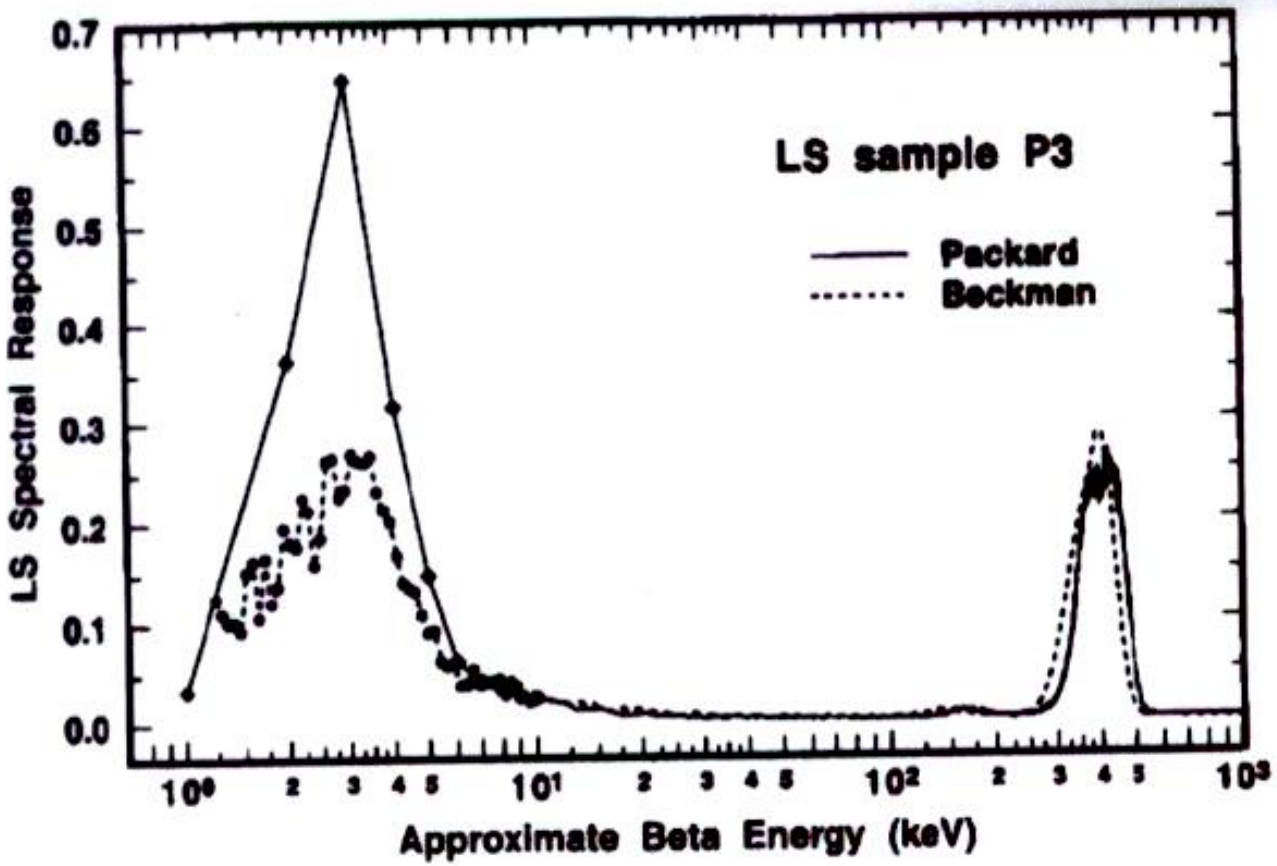


Fig. 6. Comparison of the ^{210}Po LS spectra obtained with the Beckman and Packard instruments

1995

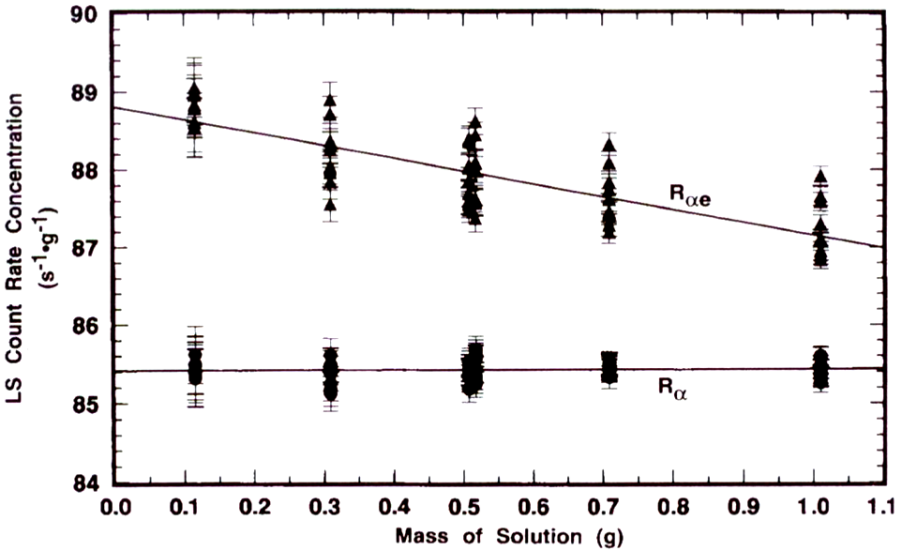


Fig. 12. LS counting rate concentrations $R_{\alpha e}$ and R_{α} as a function of m_s (analogous to that of Fig. 11) as obtained with the Packard instrument.

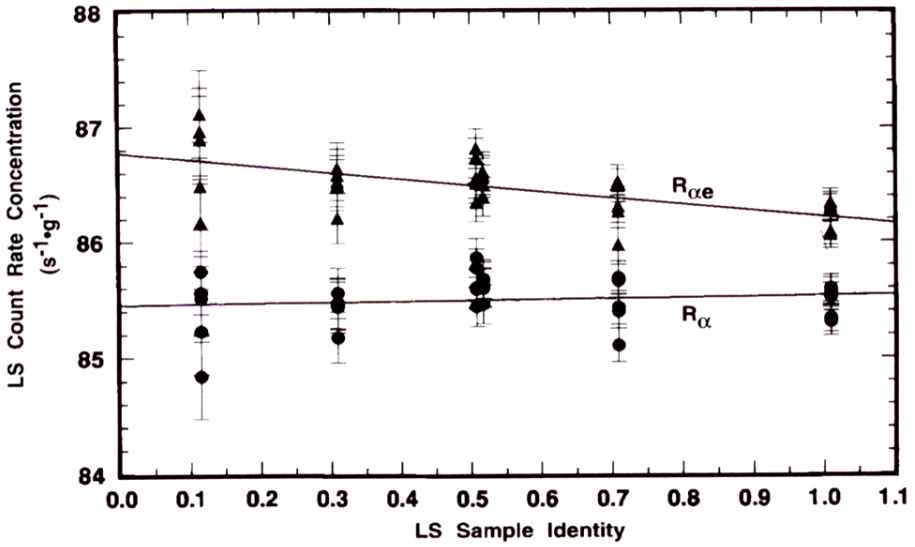


Fig. 11. LS counting rate concentrations $R_{\alpha e}$ (closed triangles) and R_{α} (closed circles) obtained with the Beckman instrument for the N series samples as a function of m_s (and sample quenching). The solid lines are linear regressions fitted to the data.

Same
in 2005

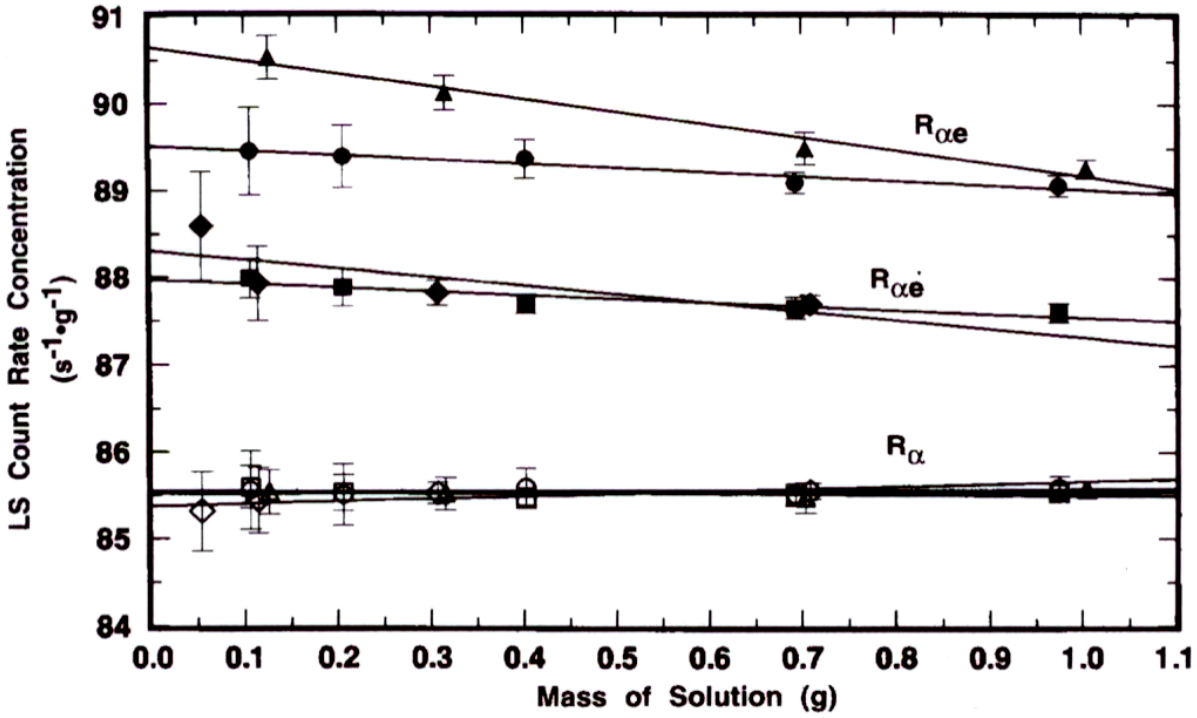


Fig. 13. LS counting rate concentrations $R_{\alpha e}$ and R_{α} obtained with the two LS systems for the P and Q series samples in 1994. Closed squares ($R_{\alpha e}$) and open squares (R_{α}) represent the mean values for samples Q5 through Q8 with the Packard; closed and open triangles represent $R_{\alpha e}$ and R_{α}, respectively, for samples P1 through P5 with the Packard; closed and open triangles ($R_{\alpha e}$ and R_{α}) are for samples Q1 through Q4 with the Beckman; and closed and open circles ($R_{\alpha e}$ and R_{α}) are for samples P1 through P5 with the Beckman. Each plotted value corresponds to the mean of 5 to 18 replicate measurements on each sample. The error bars represent standard deviation uncertainty intervals on the means. The solid lines are unweighted linear fits to the data. Although the $R_{\alpha e}$ values vary with the instrument used to perform the measurements (Packard or Beckman) and with sample compositions, all of the R_{α} values are statistically equivalent and invariant.

15 march 1994
R_α = (85.42 ± 0.18) $s^{-1}g^{-1}$

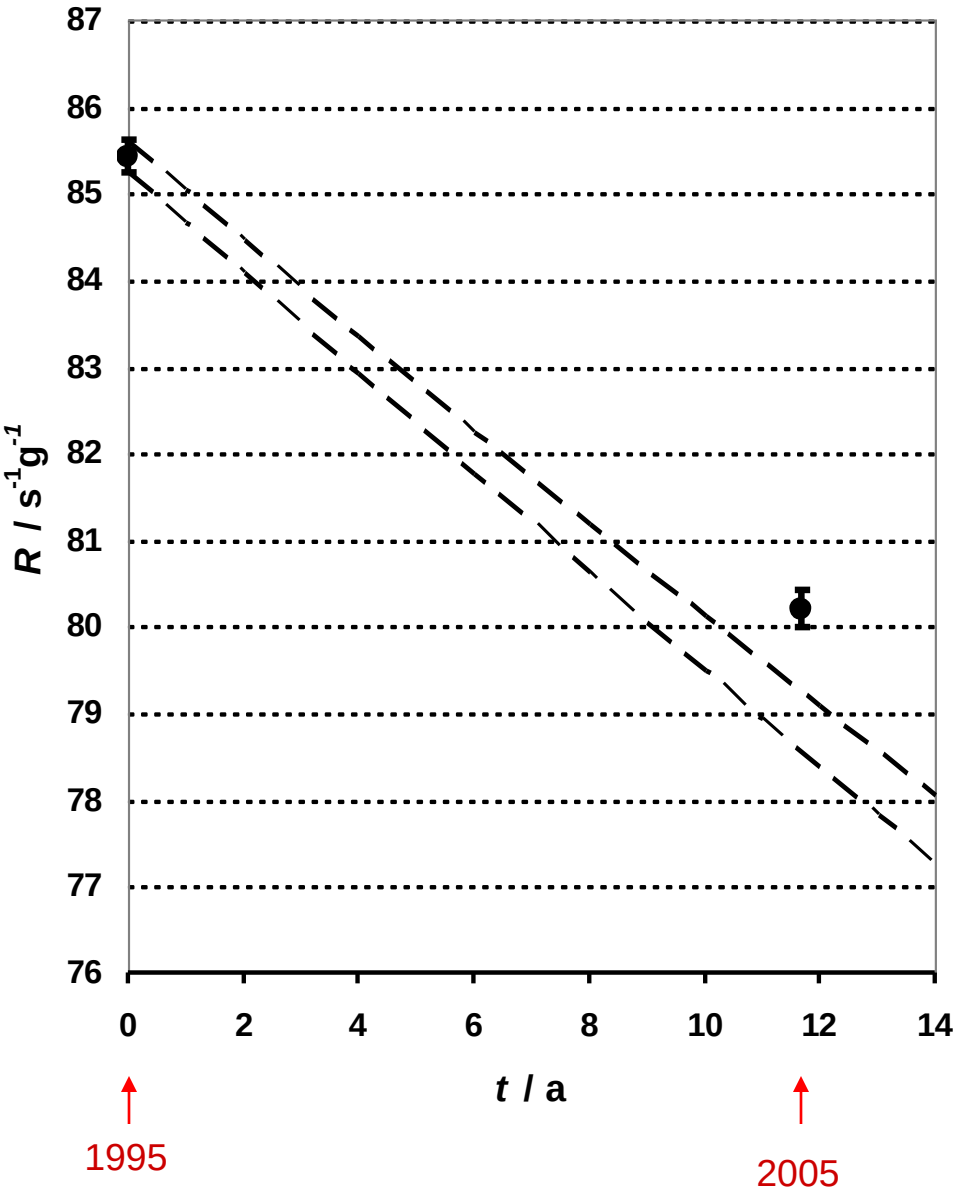
15 November 2005
R_α = (80.20 ± 0.22) s-1g-1

2 point fit gives

$T_{1/2}$ = 128 a

U = 5.5 % (7 a)

<u>Not</u> considered a new determination



^{209}Po half-life in error by 25 % !!

Result supported by work on ^{210}Pb – next story

Collé, Laureano, Outola, *Appl. Radiat. Isot.* In press

New determination urgently needed

$$A / N = \lambda$$

(link)

Collaboration with Polish Academy of Sciences labs

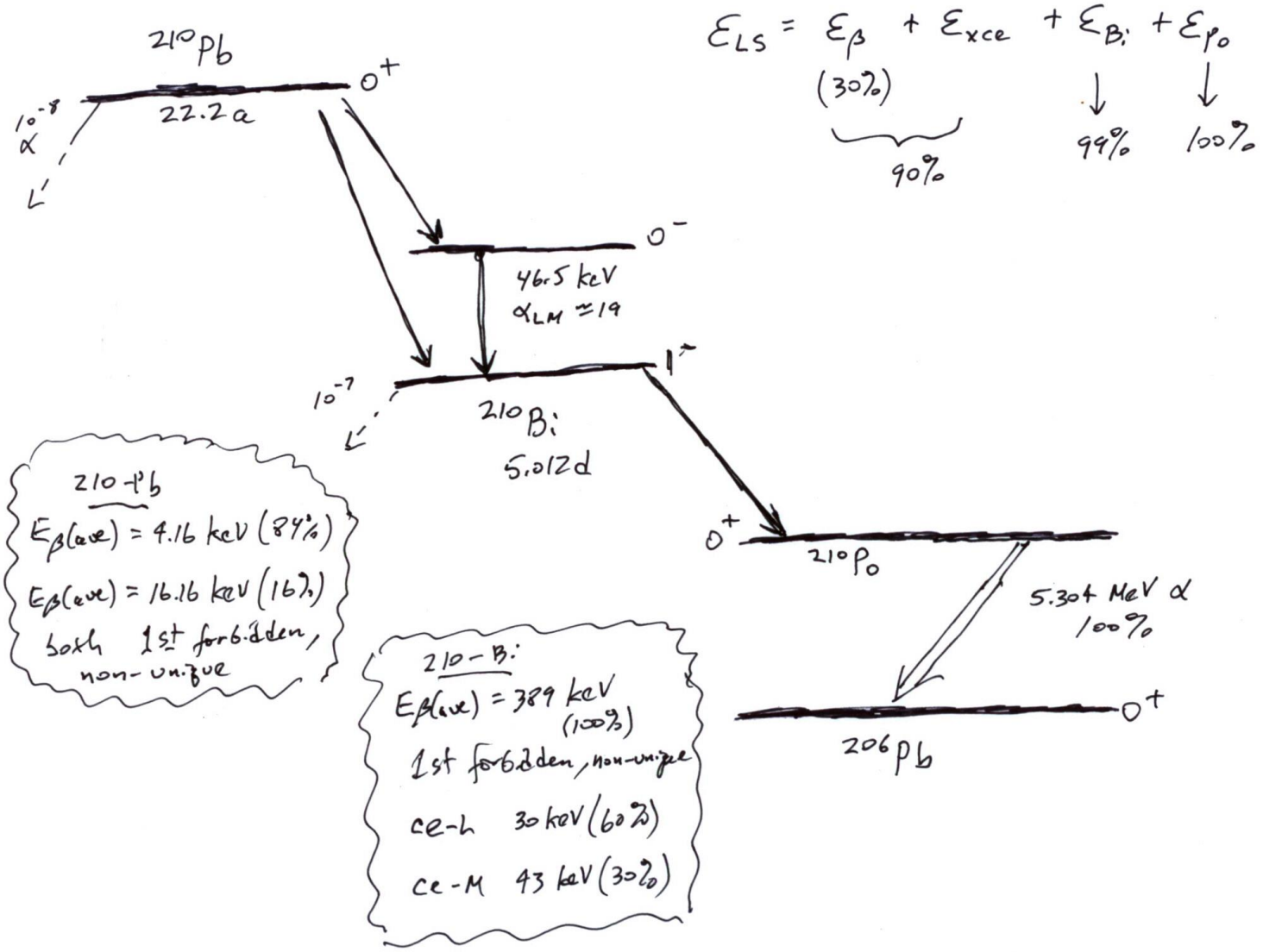
Institute of Nuclear Physics (Krakow)

Institute of Geological Sciences (Warsaw)

not going well ...

^{210}Pb

^{210}Pb


210Pb
0+
22.2a
10-8
α
L'
0-
46.5 keV
αLM ≈ 19
1-
10-7
L'
210Bi
5.012d
0+
210Po
5.304 MeV α
100%
0+
206Pb
εLS = εβ + εxce + εBi + εpo
(30%)
90%
99%
100%
210-Pb
Eβ(ave) = 4.16 keV (84%)
Eβ(ave) = 16.16 keV (16%)
both 1st forbidden, non-unique
210-Bi
Eβ(ave) = 389 keV (100%)
1st forbidden, non-unique
ce-L 30 keV (60%)
ce-M 43 keV (30%)

LS results (CN2003 code)

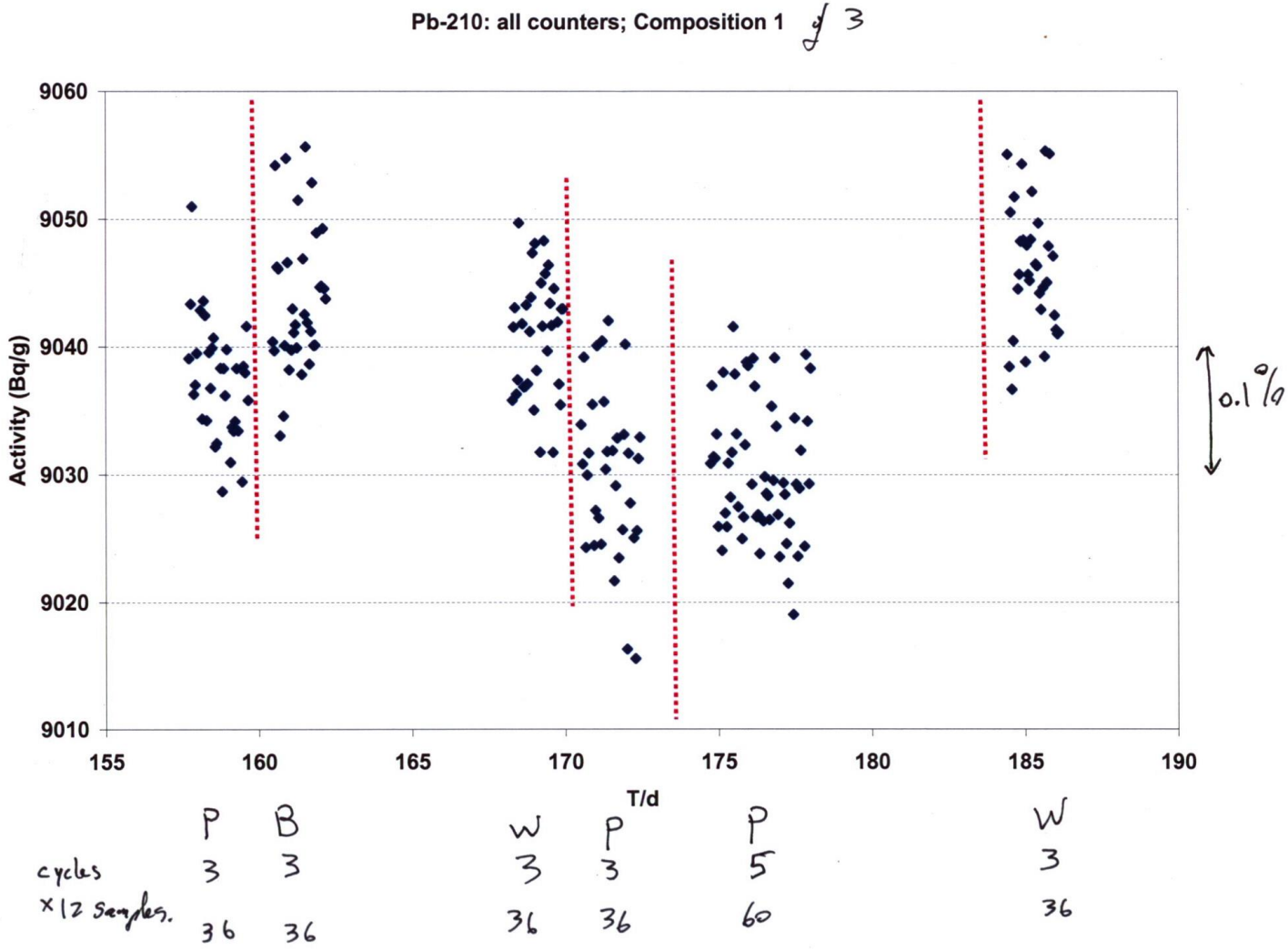
Pb-210

Series	Average	sd (%)	Normal	nc	ns	Counter	Scint	Age start	Age end	f_{H2O}	ε_{H-3}
1	9037.397	0.029	Y	3	11	Packard	HS	0.21	2.12	0.1	0.36-0.30
	9043.779	0.008	Y	3	11	Beckman	HS	2.95	4.65		
	9041.030	0.014	Y	3	11	Wallac	HS	10.76	12.4		
	9030.169	0.021	Y*	3	11	Packard	HS	13	14.9		
	9030.377	0.017	Y*	5	11	Packard	HS	17.22	20.46		
	9046.129	0.007	Y*	3	11	Wallac	HS	26.93	28.57		
2	9034.269	0.031	N	5	7	Packard	PCS	0.11	4.06	0.01	0.40-0.22
	9035.597	0.035	Y	5	7	Packard	PCS	0.11	4.06	0.04	
	9039.466	0.027	N	3	7	Wallac	PCS	4.78	6.91	0.01	
	9044.048	0.014	Y	3	7	Wallac	PCS	4.78	6.91	0.04	
	9040.539	0.026	no	3	7	Beckman	PCS	10.74	12.83	0.01	
	9041.935	0.026	yes	3	7	Beckman	PCS	10.74	12.83	0.04	
	9032.072	0.056	no	5	7	Packard	PCS	14.17	18.6	0.01	
	9026.263	0.034	yes	5	7	Packard	PCS	14.17	18.6	0.04	

* Data normal after removing sample with unstable cocktail

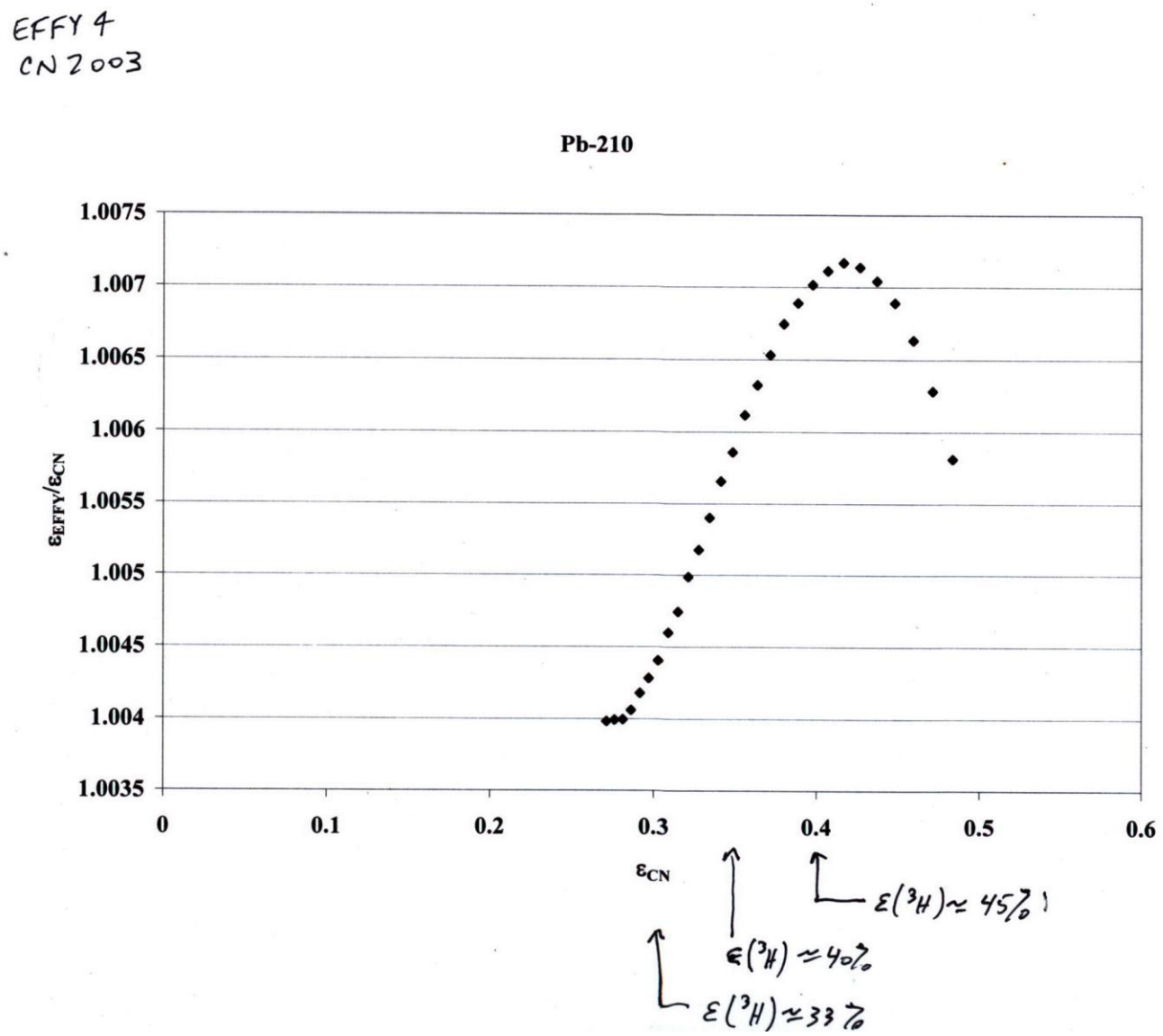
436 determinations

Series	Average	SD	SD (%)	Normal
1	9038.147	6.7577	0.07477	Yes
2	9036.774	5.8702	0.06496	Yes
Total	9037.362	6.0511	0.06696	Yes

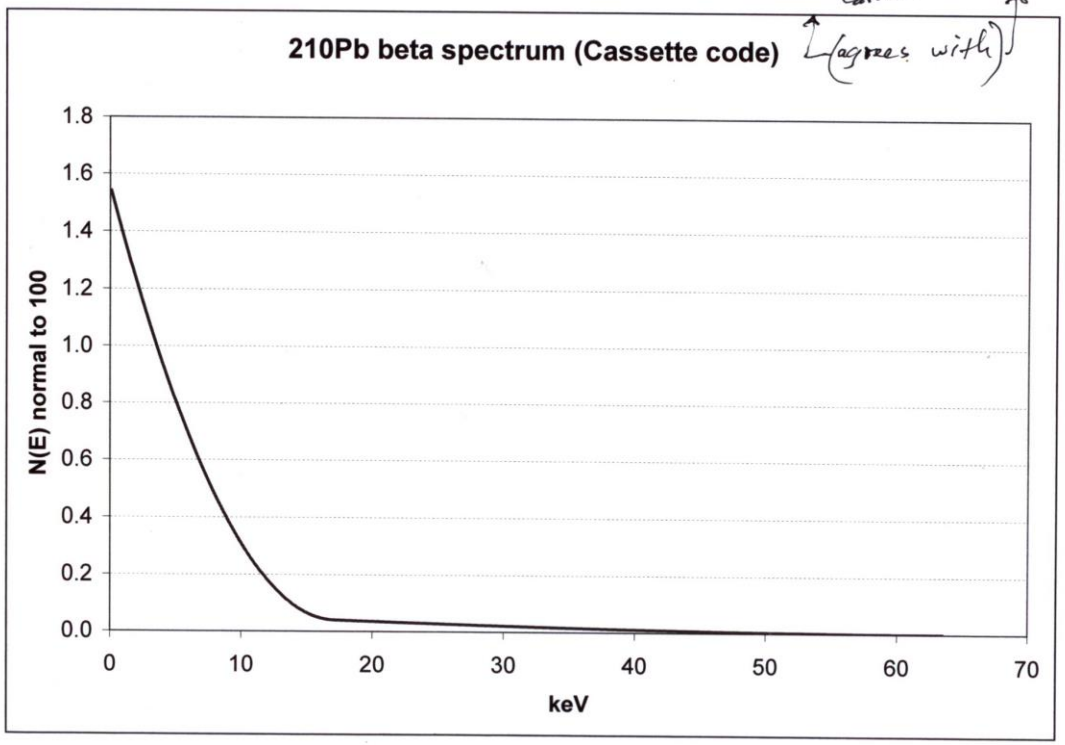

Pb-210: all counters; Composition 1 of 3
9060
9050
9040
9030
9020
9010
Activity (Bq/g)
155
160
165
170
175
180
185
190
T/d
0.1%
P B W P P W
cycles 3 3 3 3 5 3
x12 samples. 36 36 36 36 60 36

CN2003 vs EFFY4 code differences

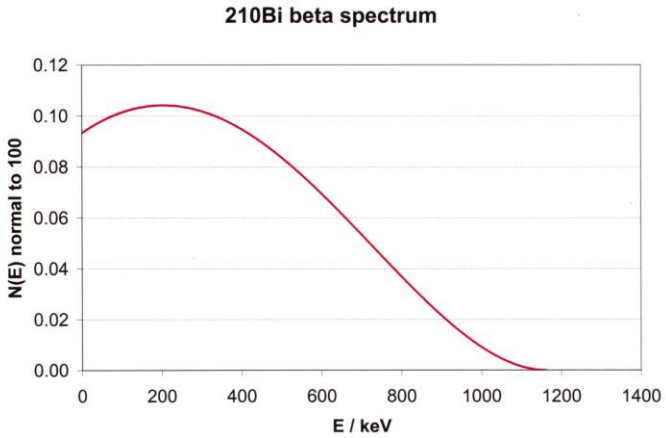
(just Beta efficiency part)



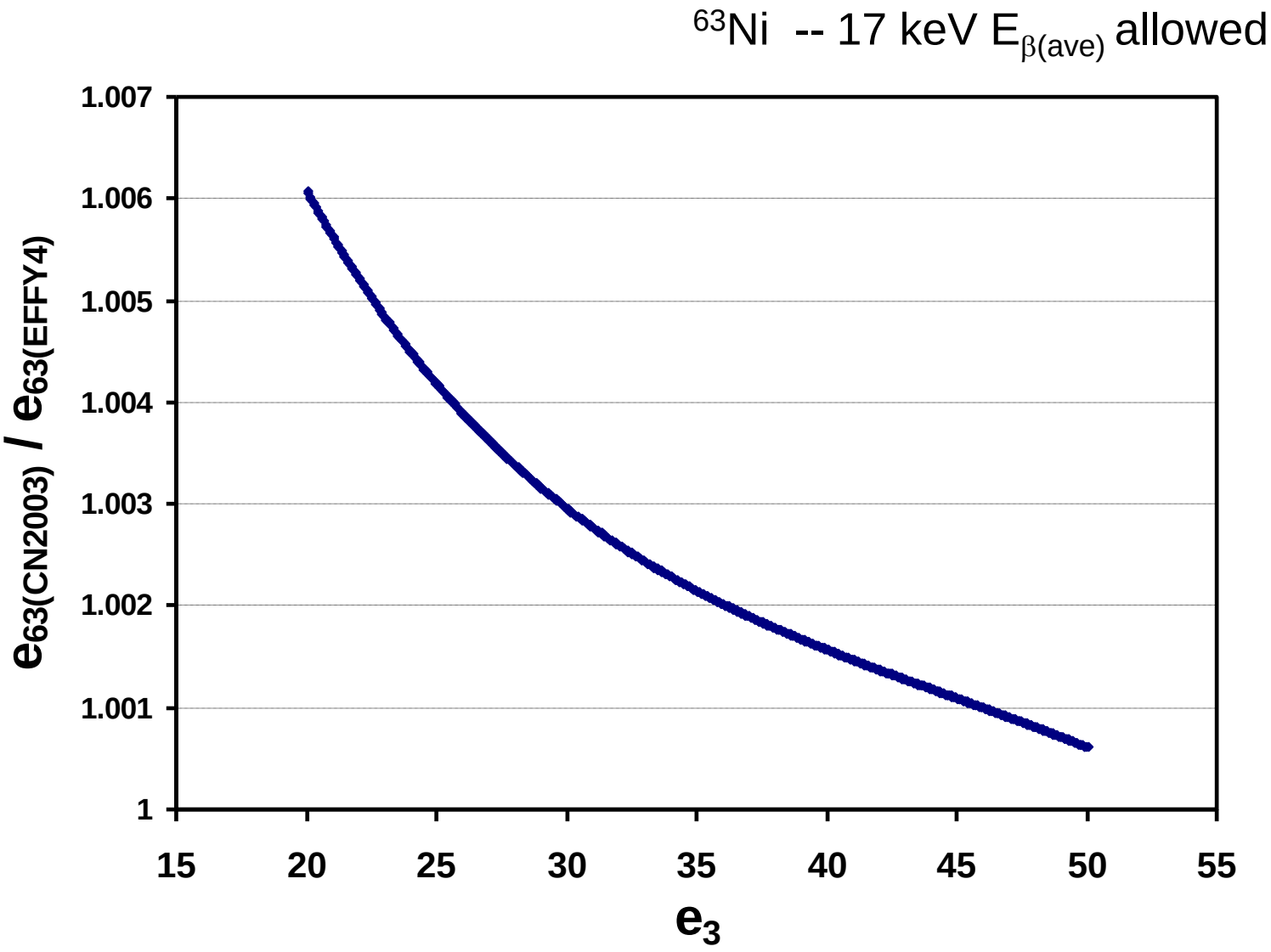
EFFY 4
CN2003 ← low E cut off
Carine
(agrees with)



differences not due to spectra



CN2003 vs EFFY4 code differences – due to assumed Quench function



^{210}Pb massic activity results

	kBq/g (k = 2)	diff from LS	
LS (CN2003)	9.037 ± 2.4 %	----	
γ-spect (HPGe)	9.46 ± 8.3 %	+ 4.7 %	Big unc. if don't use ^{210}Pb γ std
$4\pi\beta$(LS)-γ(NaI) anticoincidence *(attempt)*	9.10 ± 3.3 %	+ 0.7 %	might be wishful thinking
α-spect (Po tracer)	8.77 ± 1 % 8.92	- 3.0 % - 1.3 %	$T_{1/2}$ = 102 a $T_{1/2}$ = 128 a

Relatively large 2.4 % uncertainty because of

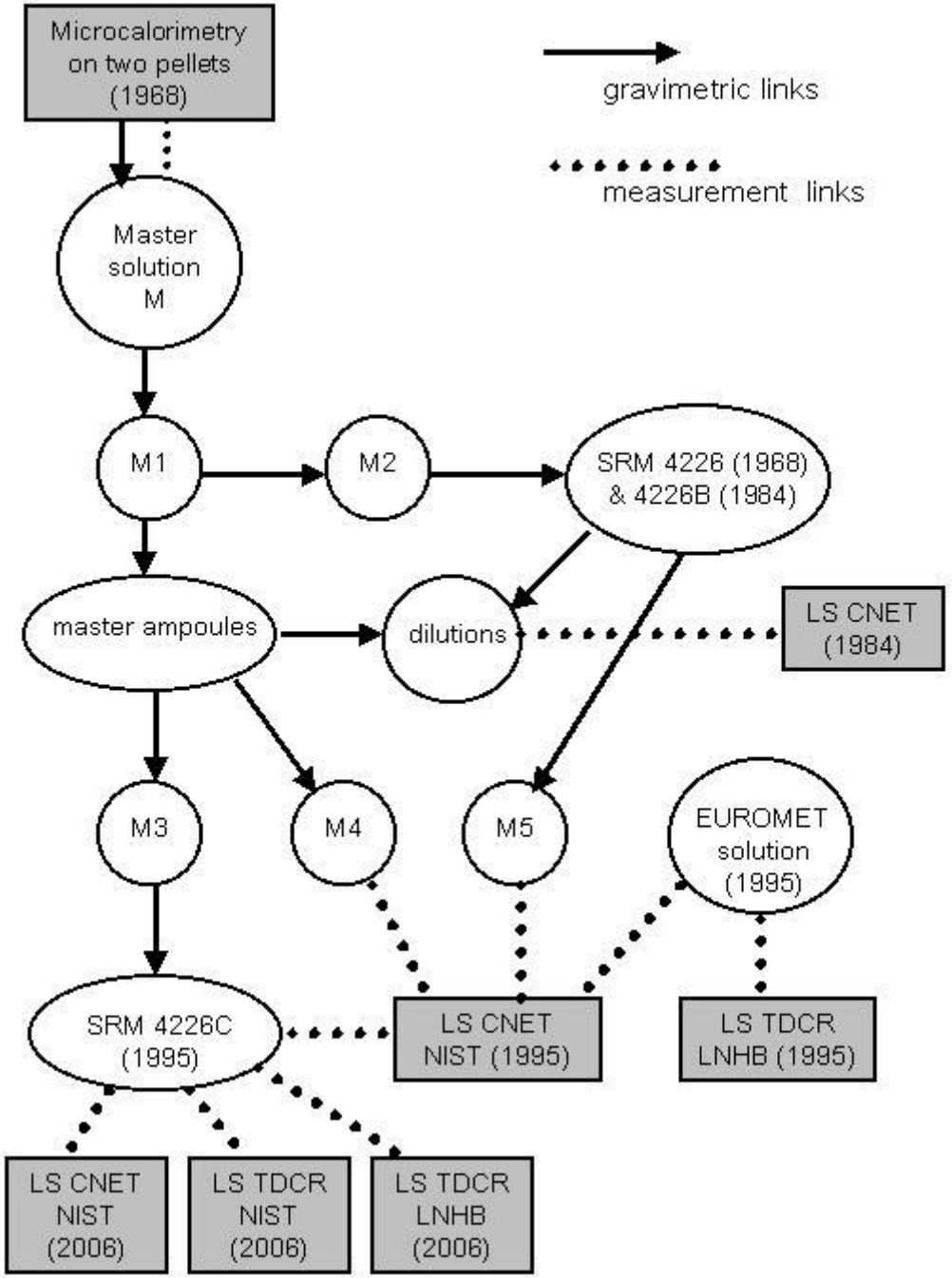
(1) LS cocktail composition effects

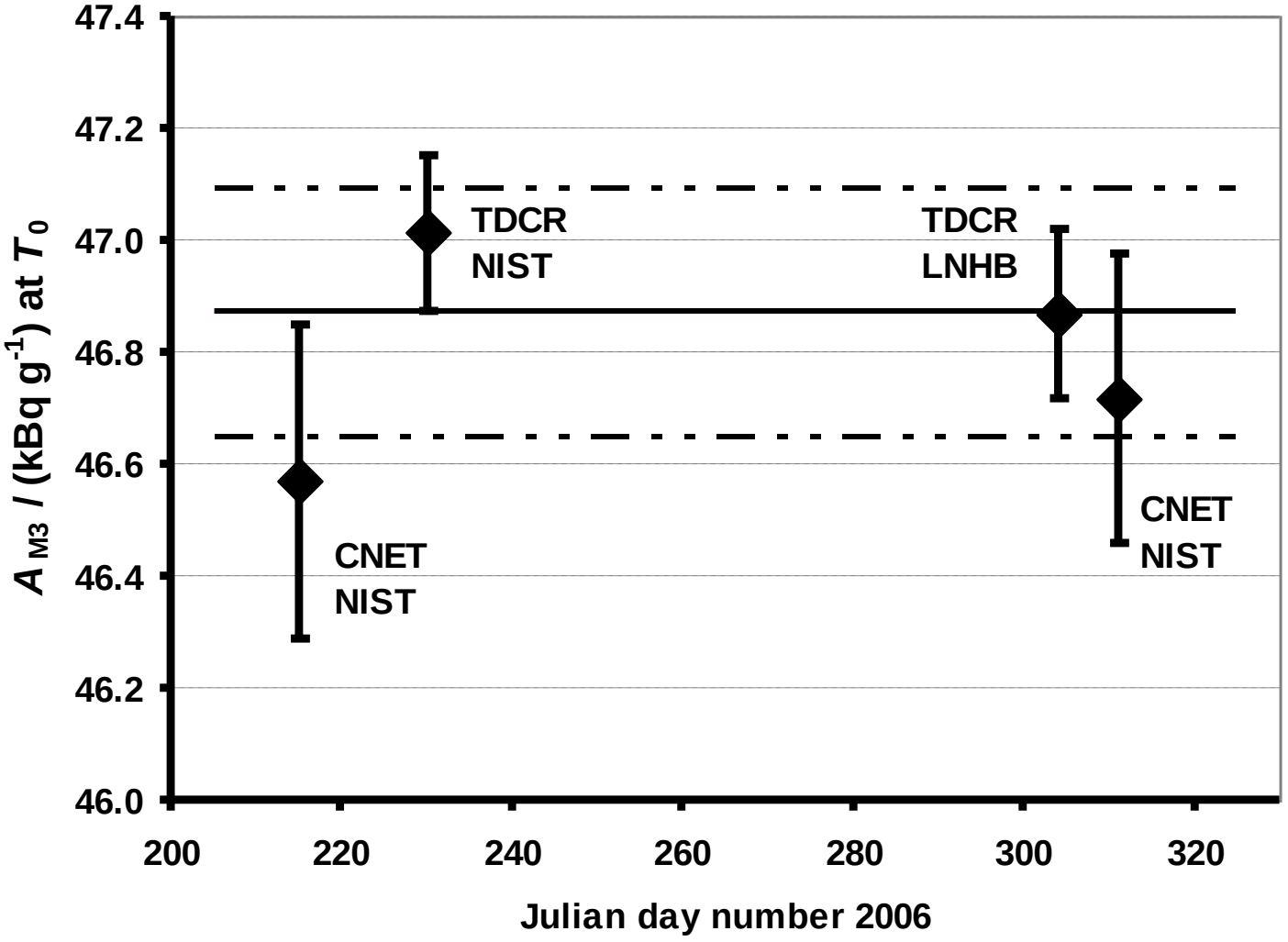
(2) tracing code differences & assumptions,

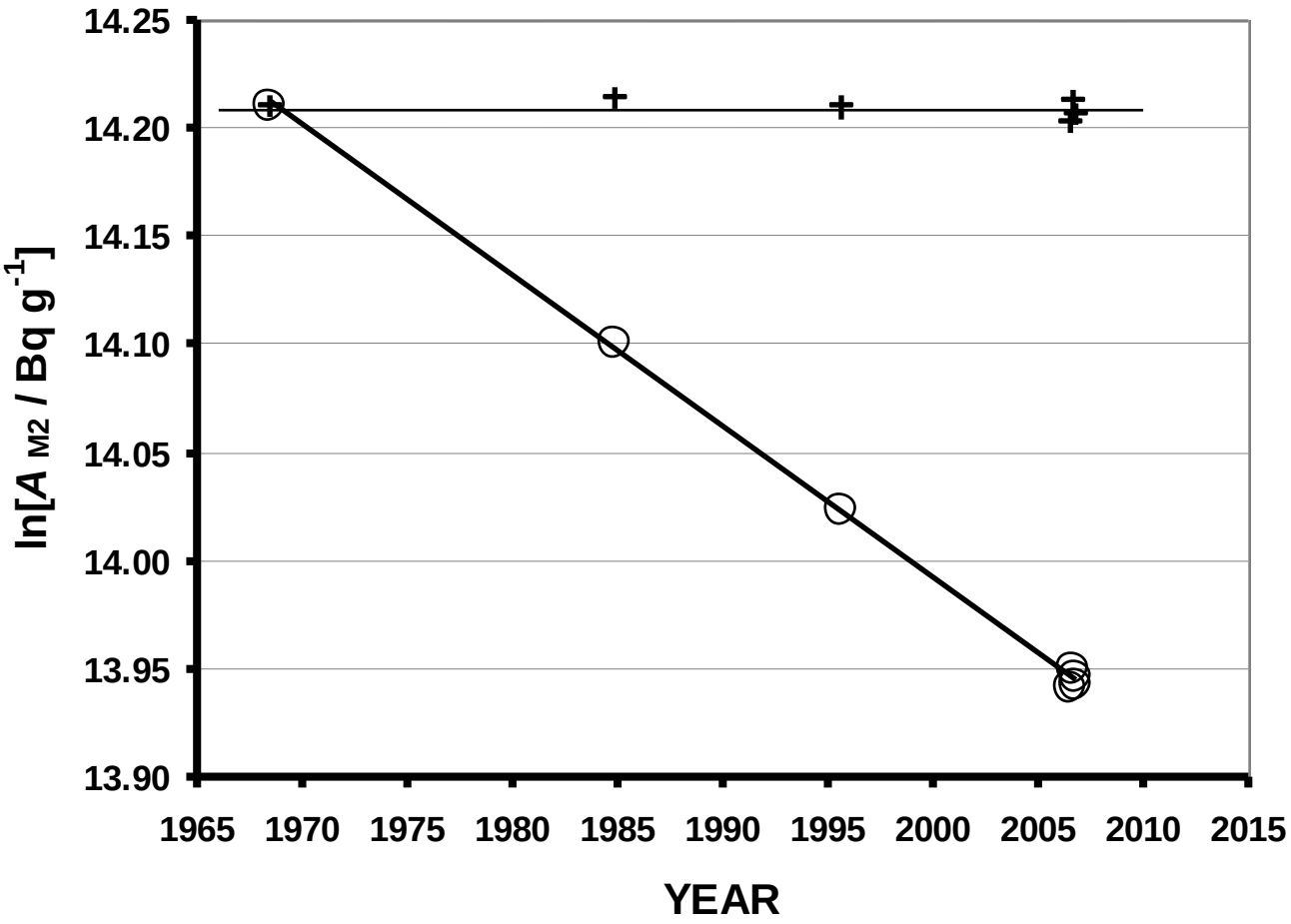
(3) lack of good confirmatory measurements,

^{63}Ni

38 years of ^{63}Ni results




47.4
47.2
47.0
46.8
46.6
46.4
46.2
46.0
200
220
240
260
280
300
320
A_{M3} / (kBq g^{-1}) at T_0
Julian day number 2006
TDCR
NIST
TDCR
LNHB
CNET
NIST
CNET
NIST


14.25
14.20
14.15
14.10
14.05
14.00
13.95
13.90
ln[A M2 / Bq g-1]
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
YEAR

Fin