

~~8~~ May 2013

15th

R. Collé

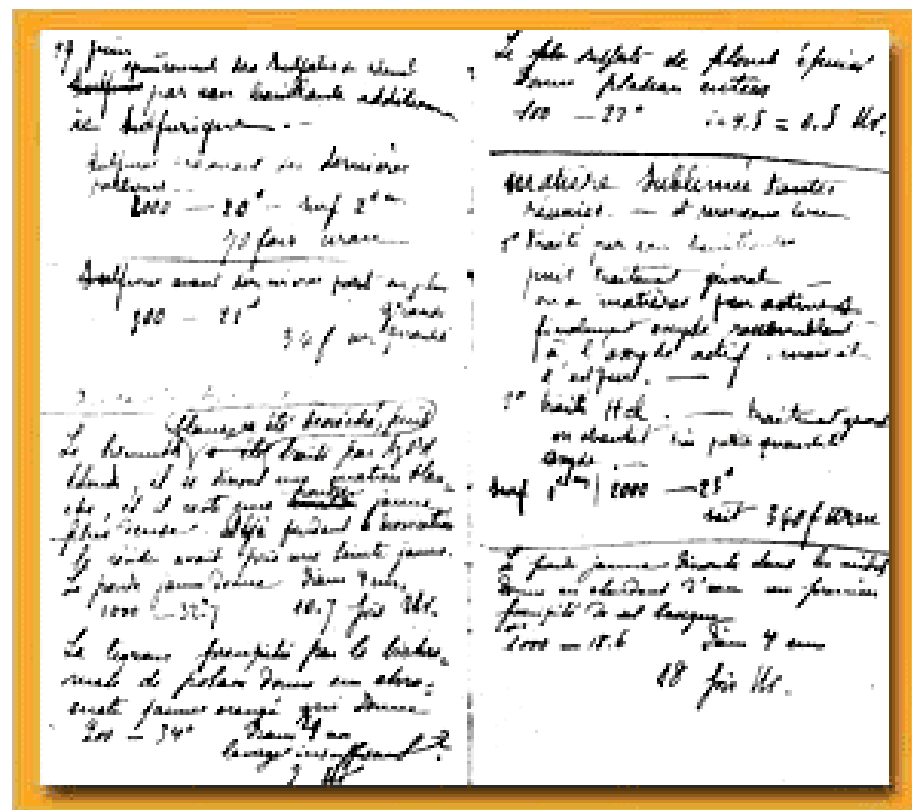
Radioactivity Group

NIST Physics Measurement Lab



# $^{209}\text{Po}$ News

Po 208 2.898 a $\alpha$ 5.1152... $\gamma$ (292; 571...)	Po 209 102 a $\alpha$ 4.881... $\gamma$ (895; 261; 263...)	Po 210 138.38 d $\alpha$ 5.30438... $\gamma$ (803); $\sigma$ <0.0005 $\sigma_0$ , $\alpha$ 0.002; $\sigma_1$ <0.1	Po 211 25.2 s $\alpha$ 7.275; 8.383... $\gamma$ 570; 1064... $\sigma_0$ , $\alpha$ 0.002; $\sigma_1$ <0.1
Bi 207 31.55 a $\beta^+$ ... $\gamma$ 570; 1064; 1770...	Bi 208 3.00... $\gamma$ 2615	Bi 209 100... $\sigma$ 0.011 + 0.023 $\sigma_0$ , $\alpha$ <3E-7	Po 210 3.0-10 <sup>6</sup> a $\alpha$ 4.946; 4.908... $\gamma$ 256; 304... $\sigma$ 0.054
Pb 206 24.1	Pb 207 22.1	Pb 208 52.4 $\sigma$ 0.00023	Pb 209 3.253 h $\beta^-$ 0.6

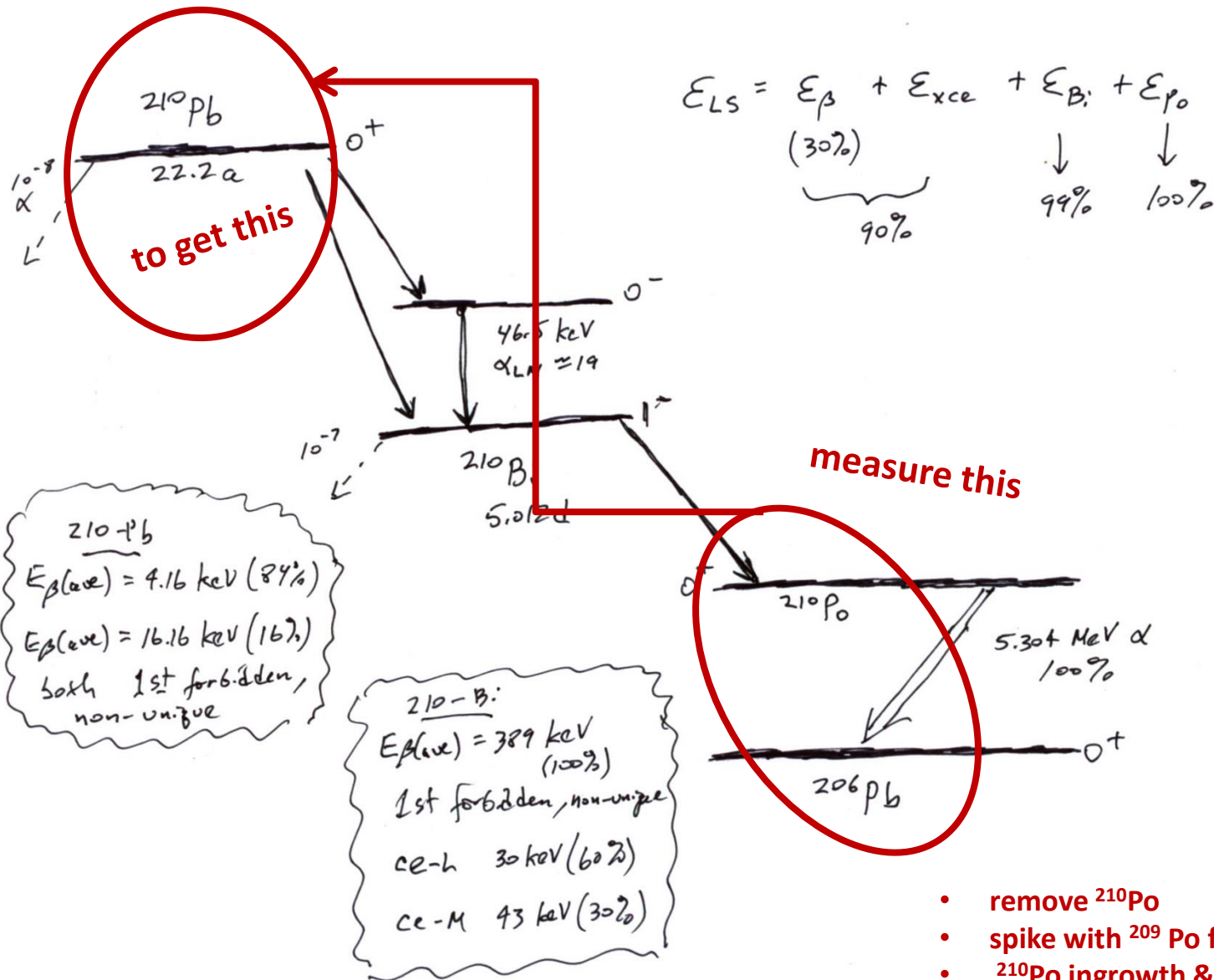


Pages from the laboratory notebooks of the Curies (June, 1898). Experiments made shortly before the publication of the discovery of polonium, written alternately by Marie and Pierre Curie.

World needs a Po tracer standard !

$^{210}\text{Po}$	0.4 a	5.3 MeV $\alpha$
$^{208}\text{Po}$	2.9 a	5.1 MeV $\alpha$
$^{209}\text{Po}$	<del>102 a</del> ?	4.9 MeV $\alpha$ + <i>junk</i>

# $^{210}\text{Pb}$ assay



- remove  $^{210}\text{Po}$
- spike with  $^{209}\text{Po}$  for yield
- $^{210}\text{Po}$  ingrowth & measure both

PAPER

### Long-Term Stability of Carrier-Free Polystyrene Solutions

159

• *For additional insight, examine the Federal Reserve's recent release of Survey Data regarding economic activity and the "Global" part of Survey Data.*

**T**he long-term effects of the use of a specific type of patient-controlled analgesia (PCA) on the development of tolerance to the analgesic effects of the drug have not been fully investigated. The purpose of this study was to determine the effects of a specific type of PCA on the development of tolerance to the analgesic effects of the drug. The study was conducted in a hospital setting and involved 20 patients who were scheduled for elective surgery. The patients were randomly assigned to two groups: a control group and an experimental group. The control group received a standard dose of the analgesic drug, while the experimental group received a PCA system that allowed them to administer the drug as needed. The results of the study showed that the experimental group experienced a significant reduction in the development of tolerance to the analgesic effects of the drug compared to the control group. This suggests that the use of a specific type of PCA may be beneficial in managing pain and reducing the risk of tolerance development in patients undergoing surgery.

1991

< 1990

208p

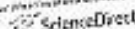
210p

1993-94 ↓

\_\_\_\_\_ of the National Institute of Standards and Technology  
 \_\_\_\_\_  
 \_\_\_\_\_

## Preparation and Calibration of Carrier-Free $^{233}\text{Po}$ Solution Standards

2005 ↓

[illegible]

Approved for release by NSA on 09-10-2013 pursuant to E.O. 13526

Control type

A note on the half-life of  $^{209}\text{Po}$

R. Cullis, Loughborough University, Leicestershire

**R. Calkins**, *University of Michigan, Ann Arbor*

Applied  
pollution and  
budget.

Volume 100

**Relevance**

January-February 1984

R. C. M., J. H. K. M., F. J.  
K. M., P. A. R. D., I. G., I.  
H. M., J. H. K. M., F. J.  
and R. A. L. M.

Platinum University of Studies  
and Technology  
6666 Yonge, 222 2004-2005

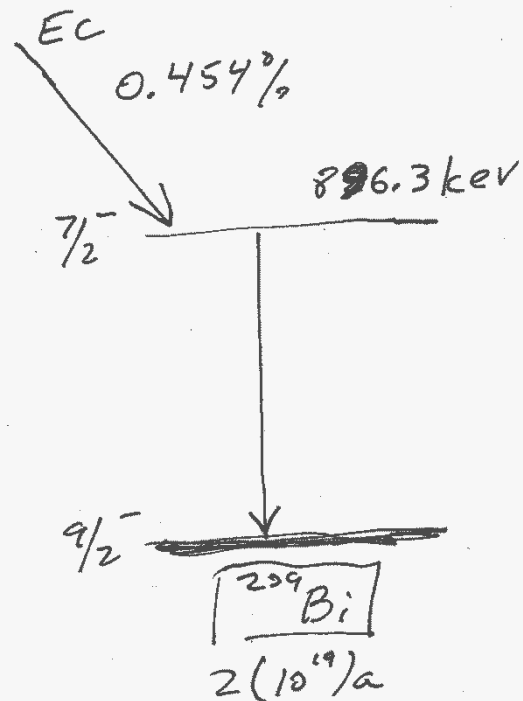
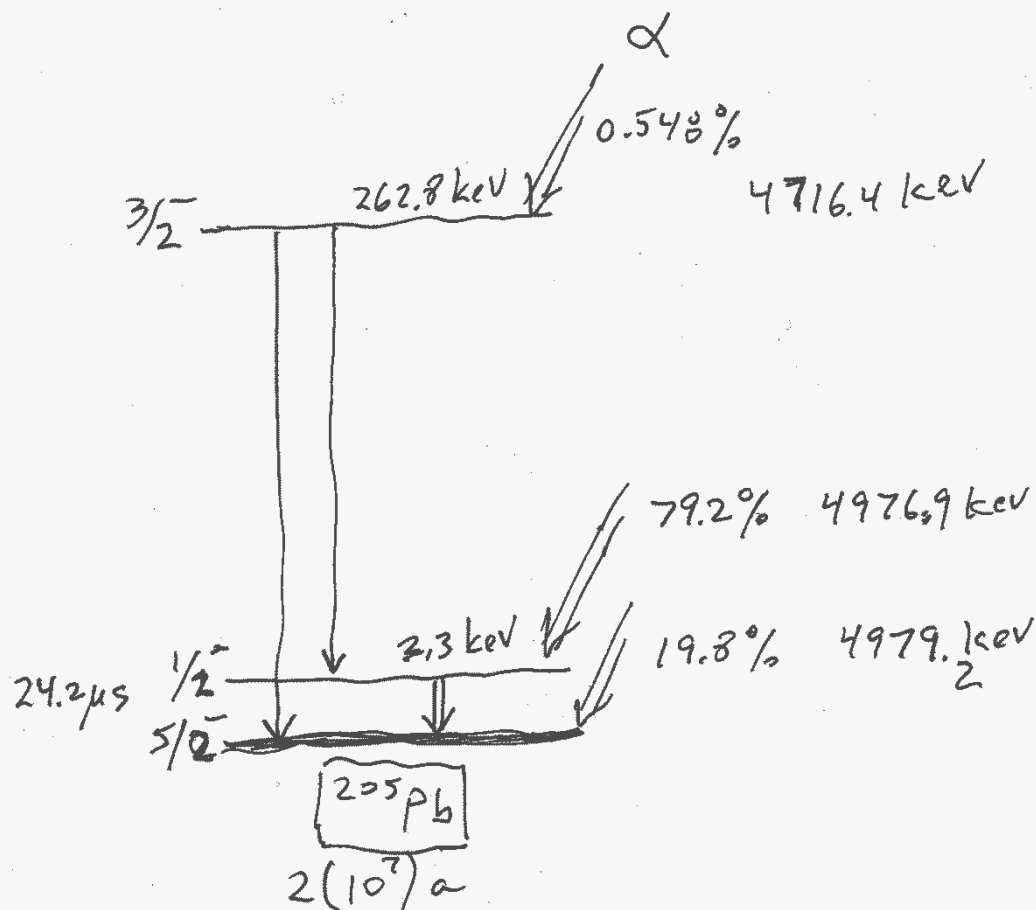
"I don't see why anyone should  
 have to be a doctor. I don't see  
 why anyone should have to be  
 a nurse. I don't see why anyone  
 should have to be a teacher. I  
 don't see why anyone should  
 have to be a policeman. I don't  
 see why anyone should have to  
 be a soldier. I don't see why  
 anyone should have to be a  
 farmer. I don't see why anyone  
 should have to be a worker. I  
 don't see why anyone should  
 have to be a mother. I don't  
 see why anyone should have to  
 be a father. I don't see why  
 anyone should have to be a  
 citizen. I don't see why anyone  
 should have to be a human being."

[The following is a reproduction of the text from the page, which is heavily faded and difficult to read. The text appears to be a list or index of names and titles, possibly related to the "List of Members" mentioned in the caption.]

NPL  
2011-2012

NOW!

$\frac{1}{2}^-$   $^{209}_{80}\text{Po}$      $128$   
 ~~$115 \pm 13$~~      $102 \pm 5 \alpha$



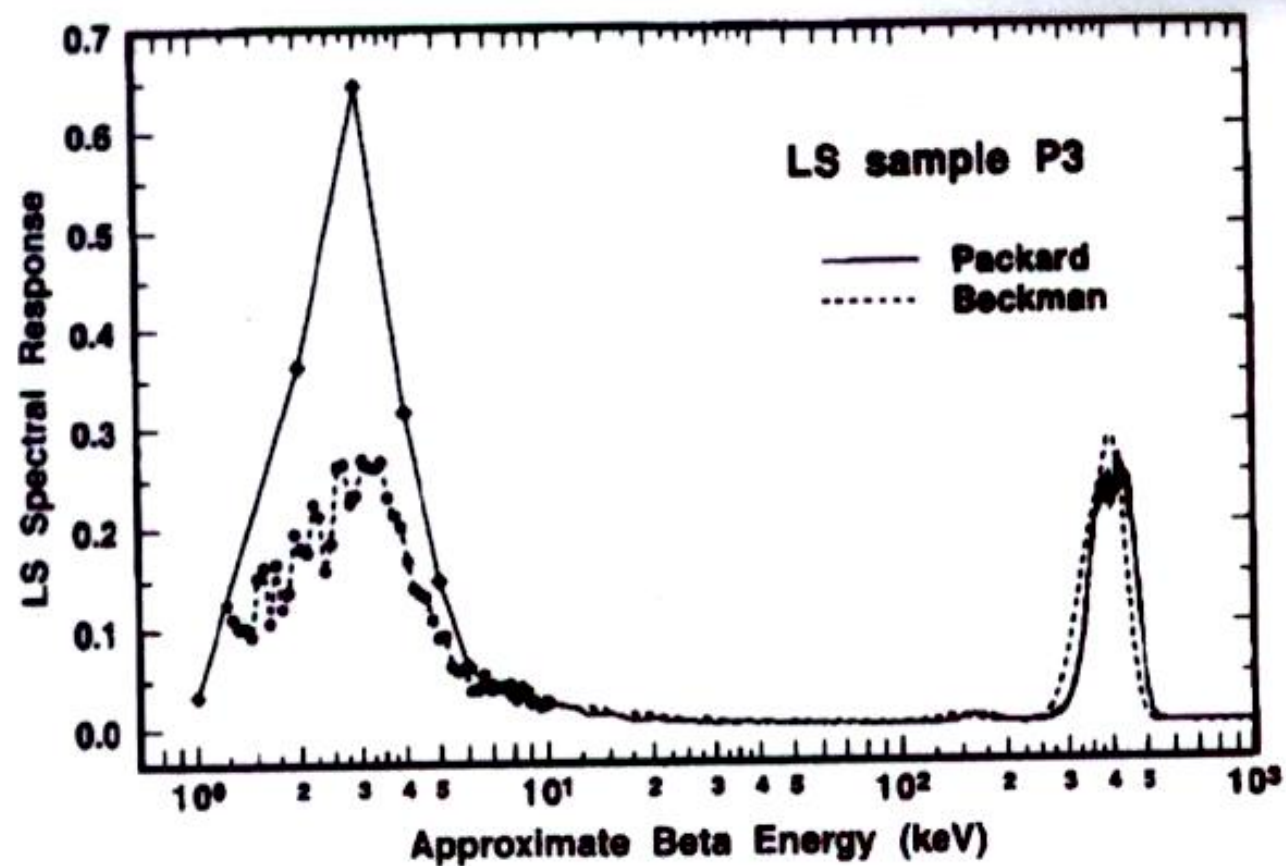


Fig. 6. Comparison of the  $^{210}\text{Po}$  LS spectra obtained with the Beckman and Packard instruments.

1995

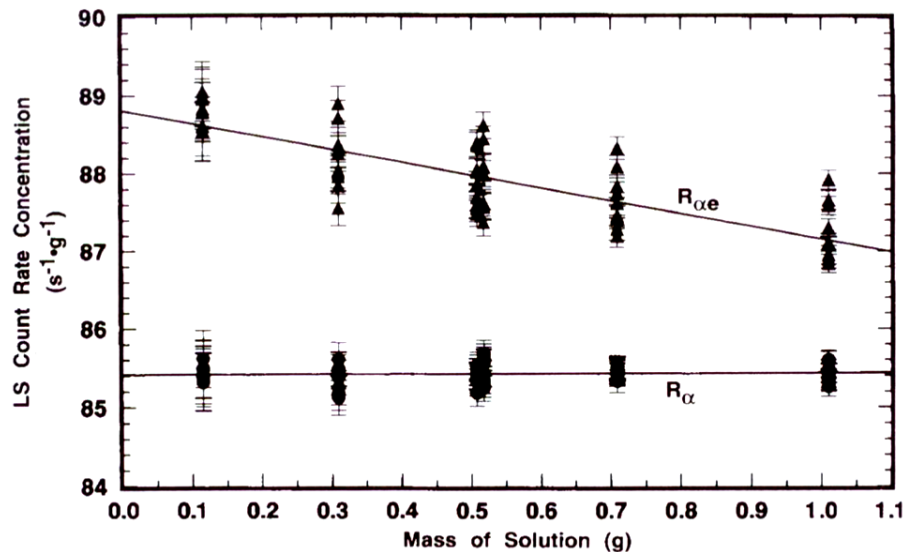


Fig. 12. LS counting rate concentrations  $R_{\alpha e}$  and  $R_{\alpha}$  as a function of  $m_s$  (analogous to that of Fig. 11) as obtained with the Packard instrument.

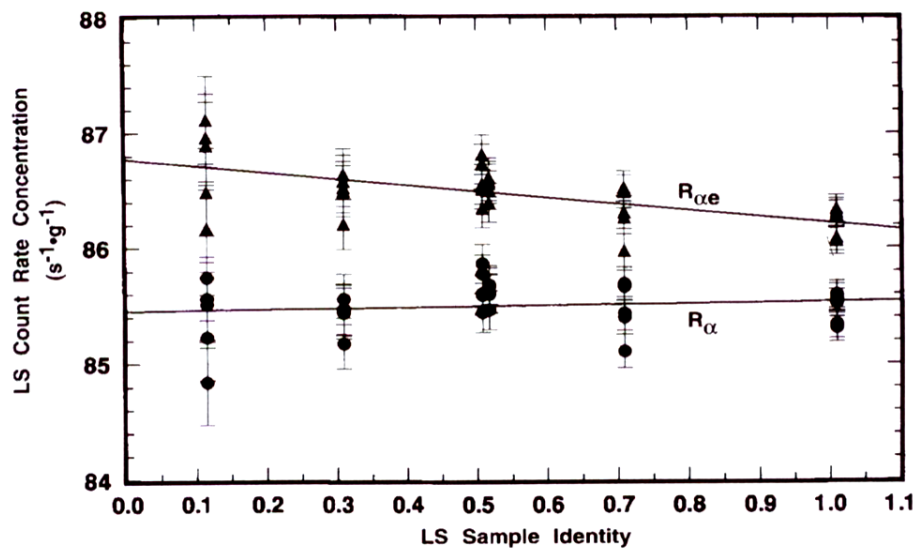
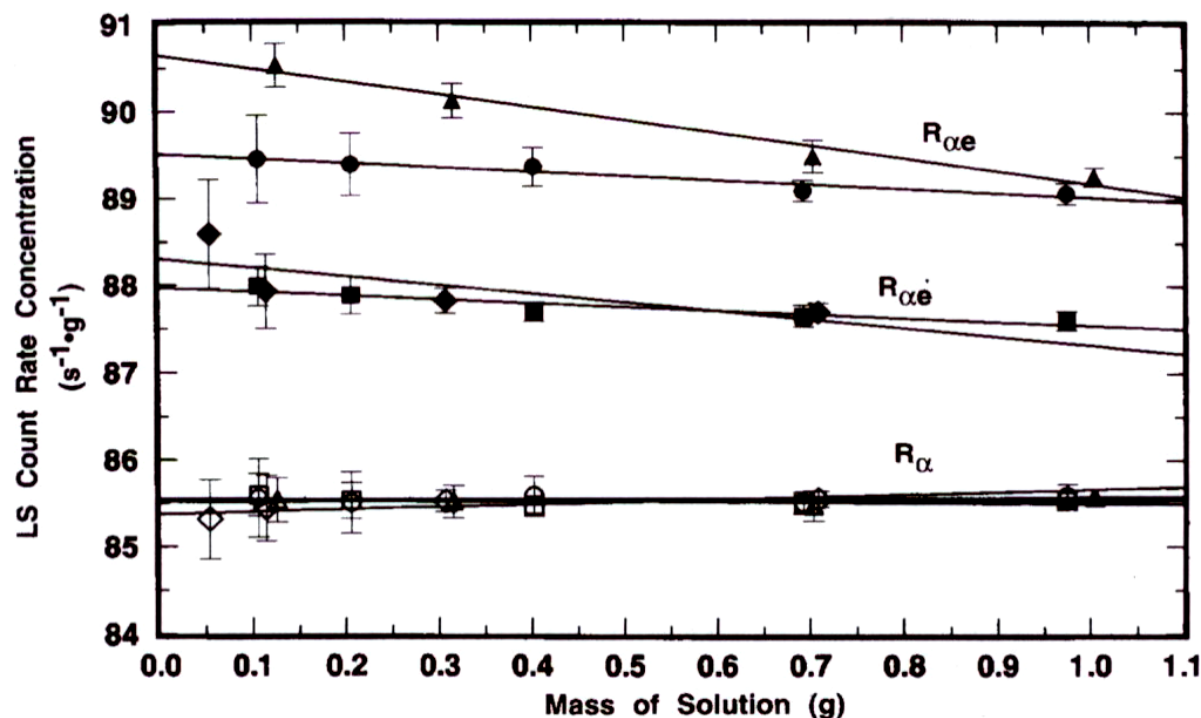


Fig. 11. LS counting rate concentrations  $R_{\alpha e}$  (closed triangles) and  $R_{\alpha}$  (closed circles) obtained with the Beckman instrument for the N series samples as a function of  $m_s$  (and sample quenching). The solid lines are linear regressions fitted to the data.

Same  
in 2005



**Fig. 13.** LS counting rate concentrations  $R_{\alpha e}$  and  $R_{\alpha}$  obtained with the two LS systems for the P and Q series samples in 1994. Closed squares ( $R_{\alpha e}$ ) and open squares ( $R_{\alpha}$ ) represent the mean values for samples Q5 through Q8 with the Packard; closed and open triangles represent  $R_{\alpha e}$  and  $R_{\alpha}$ , respectively, for samples P1 through P5 with the Packard; closed and open triangles ( $R_{\alpha e}$  and  $R_{\alpha}$ ) are for samples Q1 through Q4 with the Beckman; and closed and open circles ( $R_{\alpha e}$  and  $R_{\alpha}$ ) 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  $R_{\alpha}$  values are statistically equivalent and invariant.



from 2005

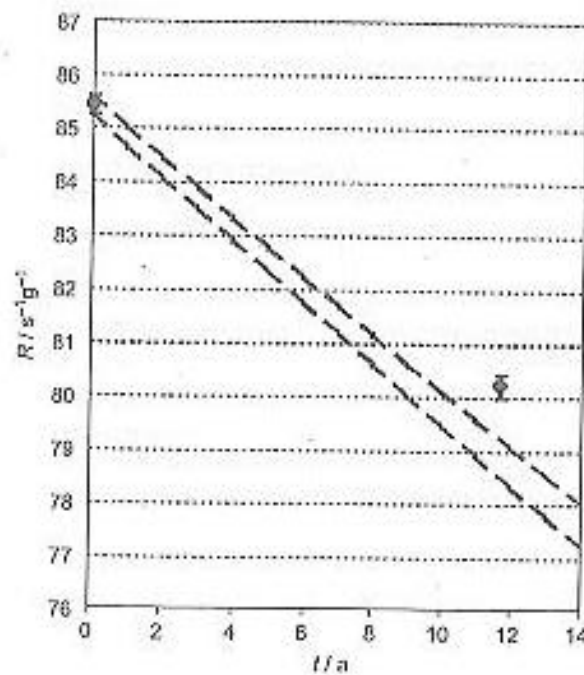


Fig. 1. The massic alpha particle emission rate  $R$  (in units of alphas per second per gram) for the standardized  $^{210}\text{Po}$  solution standard as a function of time  $t$  (in years). The two data points are from the primary standardizations conducted 11.7 years apart and exhibit an apparent half-life of about 128 years. The error bars show the combined standard uncertainty intervals on the two measurements. The broken curves correspond to the upper and lower uncertainty bounds (for the combined standard uncertainty) on the decay of the 1994 value of  $R$  using a half-life of  $(102 \pm 5)\text{a}$ . Refer to the text for additional detail.

Collé, Laureano-Perez, Otolá

Appl. Radiat. Isot. 65, 728-730 (2007)

15 march 1994

$$R_{\alpha} = (85.42 \pm 0.18) \text{ s}^{-1}\text{g}^{-1}$$

15 November 2005

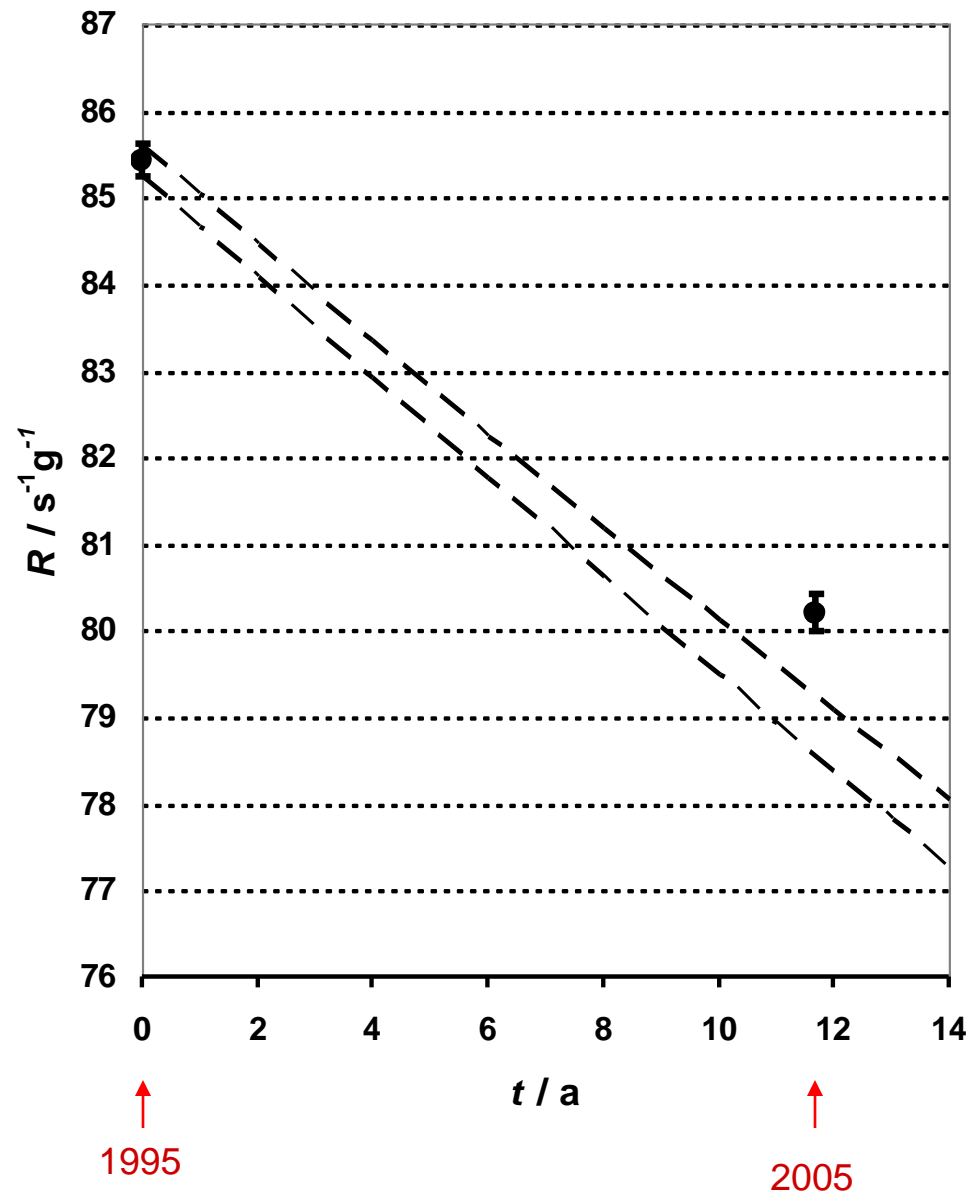
$$R_{\alpha} = (80.20 \pm 0.22) \text{ s}^{-1}\text{g}^{-1}$$

2 point fit gives

$$T_{1/2} = 128 \text{ a}$$

$$U = 5.5 \% (7 \text{ a})$$

Not considered a new  
determination



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

$^{208}\text{Po}/^{209}\text{Po}$  mass ratio      1.14 %

$^{208}\text{Po}/^{209}\text{Po}$  activity ratios      5 %

} “private communication”

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

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

Compiler M. Martin, 1991

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

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

4.9 %

 must be wrong

# $^{209}\text{Po}$ half-life in error by 25 % !!

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

Collé, Laureano, Outola, *Appl. Radiat. Isot.* **65**, 728-730 (2007)

New determination urgently needed

$$\frac{A}{N} = \lambda$$

(link)

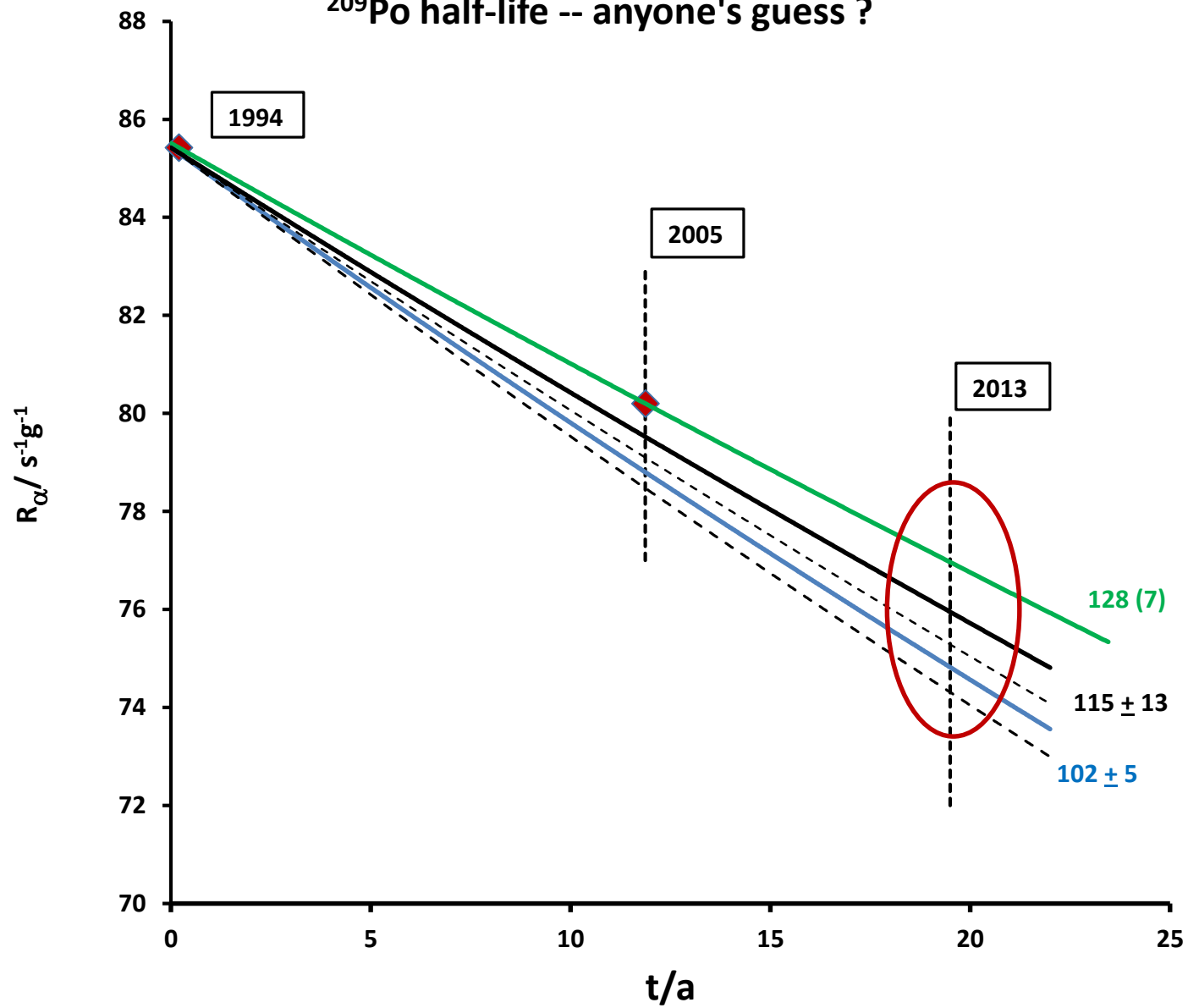
Collaboration with Polish Academy of Sciences labs

Institute of Nuclear Physics (Krakow)

Institute of Geological Sciences (Warsaw)

not going well ...

# <sup>209</sup>Po half-life -- anyone's guess ?



Oak Ridge  
stock solution



transfer warm  
2 mol/L HCl

solution D



+ 2 mol/L HCl  
to 30 mL

LS quick  
assay



series  
X1-X3

$2\pi\alpha$   
On Ag (M)

solution M

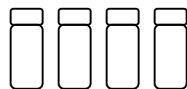


$\gamma$ -point  
HPGe

## $^{209}\text{Po}$ Production and Standardization of SRM 4326a

- primary standardization by  $4\pi\alpha$  LS spectrometry
- 7 series of LS sources (A – G) used to evaluate solution stability as function of time
- confirmatory measurements and  $\alpha$ -impurity analyses by  $2\pi\alpha$  Si spectrometry
- $\gamma$ -Impurity analyses & weak  $\gamma$  search by HPGe
- evaluation of half-life discrepancy from comparison to 1994 and 2005 LS measurements on SRM 4326

LS test for  
stability



series  
L1-L3

silver discs for  
 $2\pi\alpha$  spectrometry  
Si barrier detector

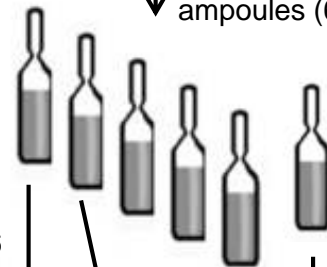


A1-A3

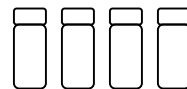
point sources  
 $\gamma$  spectrometry  
HPGe



Master  
ampoules (6)



series  
M61-63

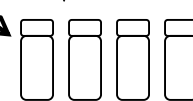


#6

#2

#4

series  
M41-43  
M21-23



LS sources

3 sets of LS sources,  
each from one ampoule



LS sources

+ 2 mol/L HCl  
to 1050 g

dispense

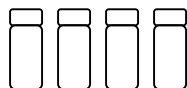
solution S

SRM 4326a Master

SRM  
4326  
ampoule

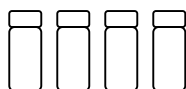


LS sources

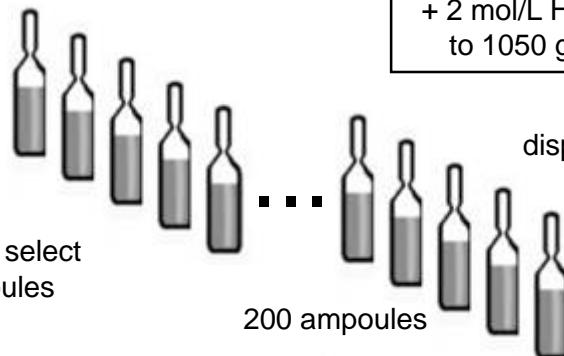


direct comparison with  
previous 1994 issue

series  
E, F, G



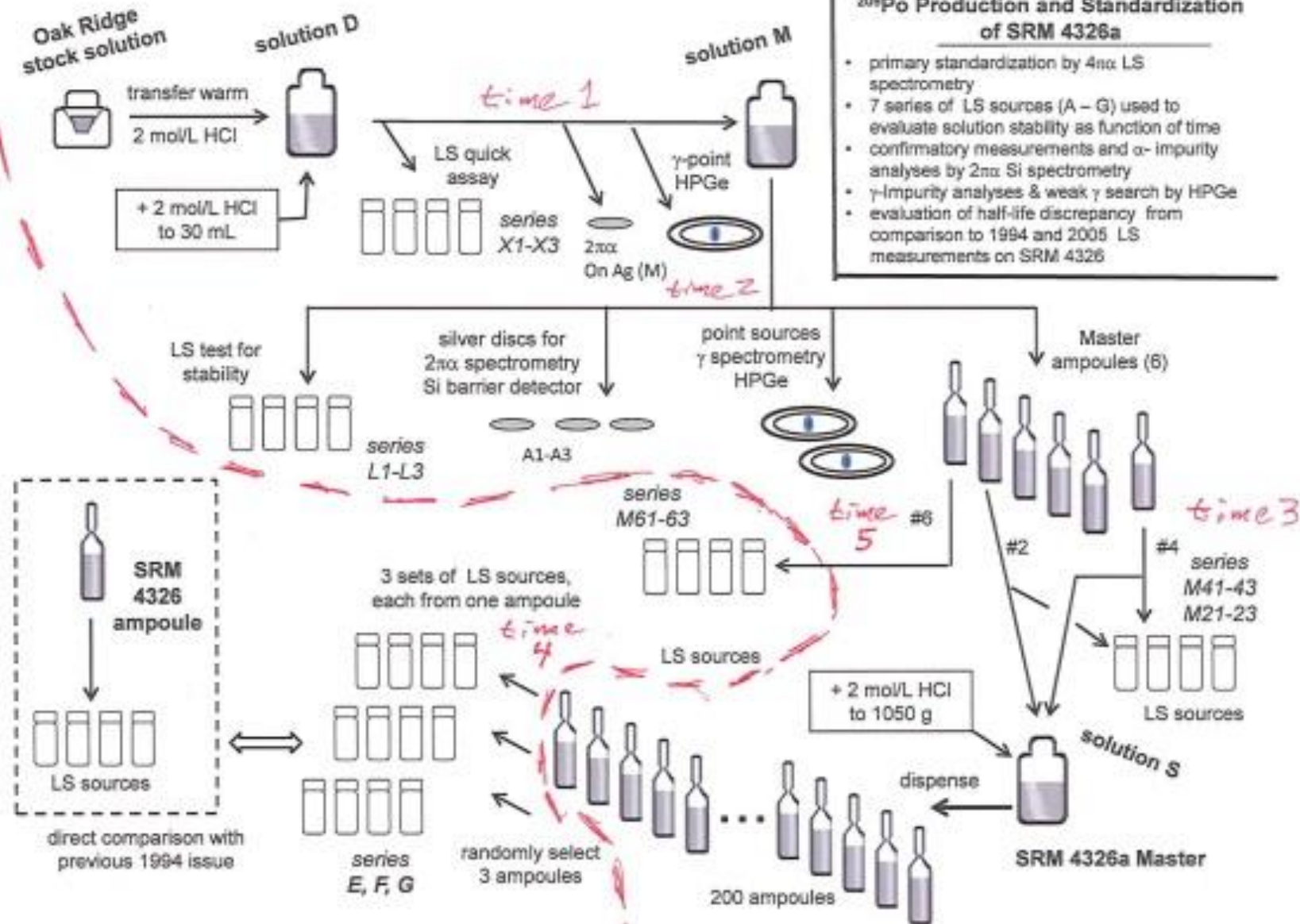
randomly select  
3 ampoules



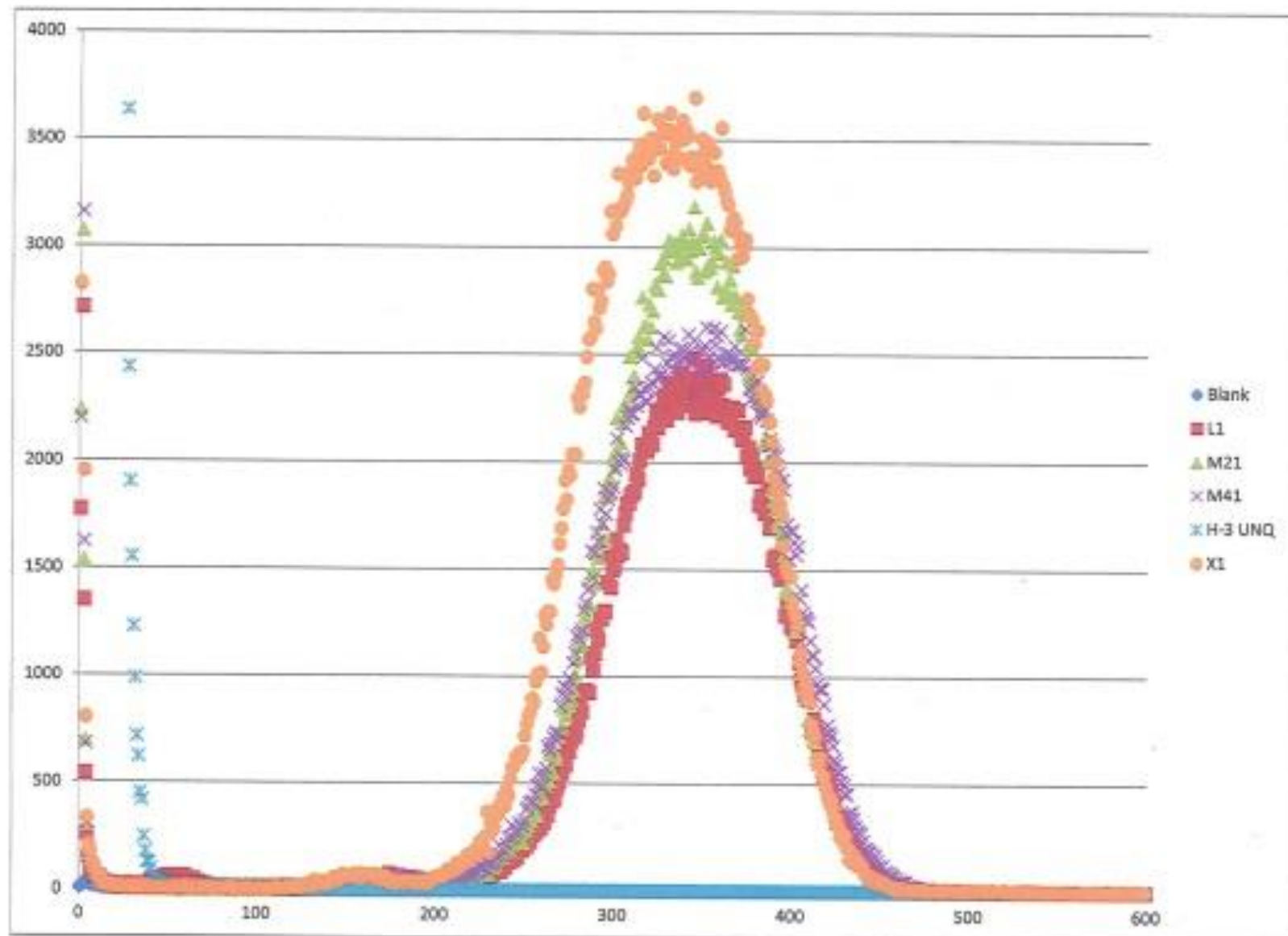
200 ampoules

## <sup>209</sup>Po Production and Standardization of SRM 4326a

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- 7 series of LS sources (A – G) used to evaluate solution stability as function of time
- confirmatory measurements and  $\alpha$ -impurity analyses by 2 $\pi$  Si spectrometry
- $\gamma$ -impurity analyses & weak  $\gamma$  search by HPGe
- evaluation of half-life discrepancy from comparison to 1994 and 2005 LS measurements on SRM 4326

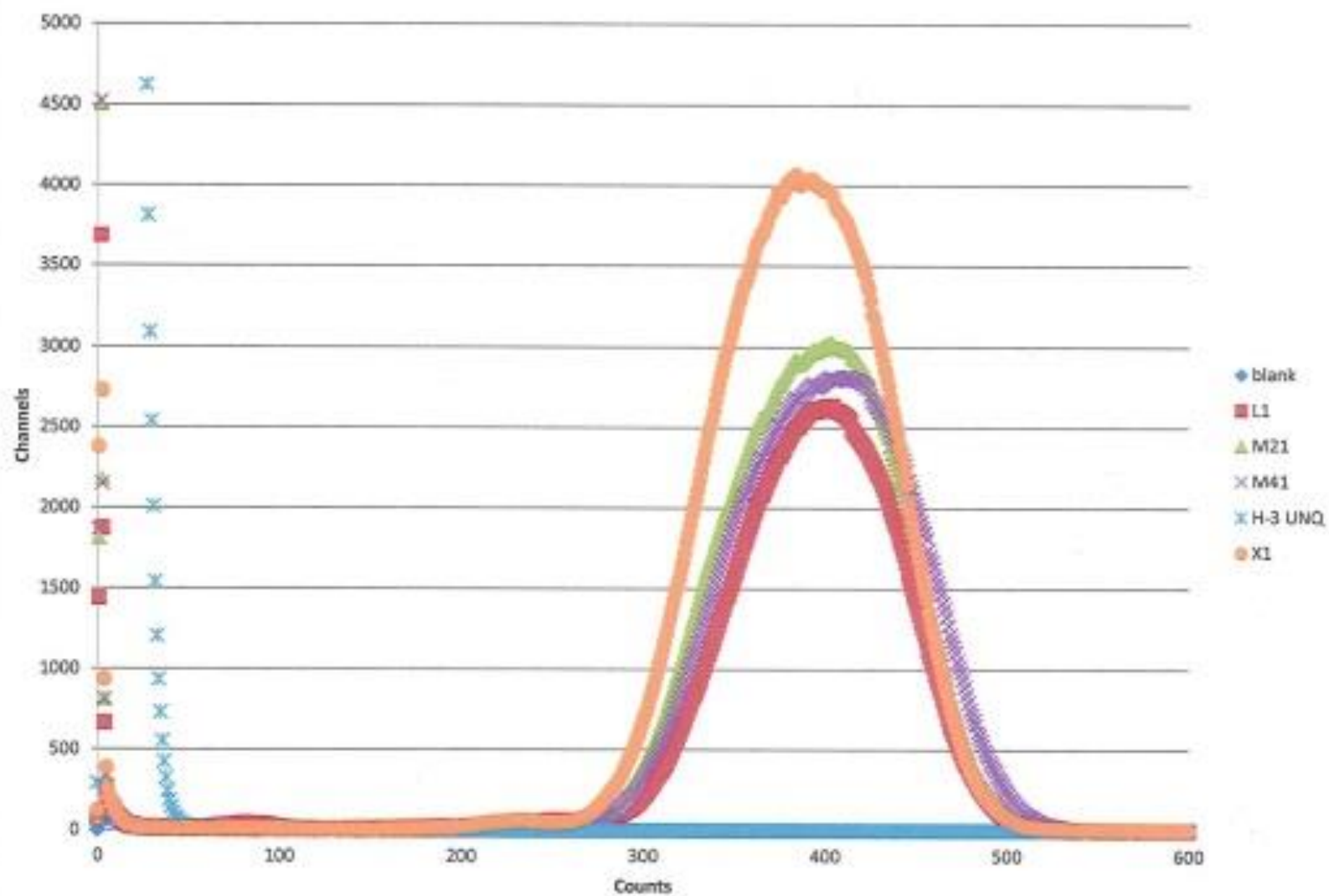


WALLAC

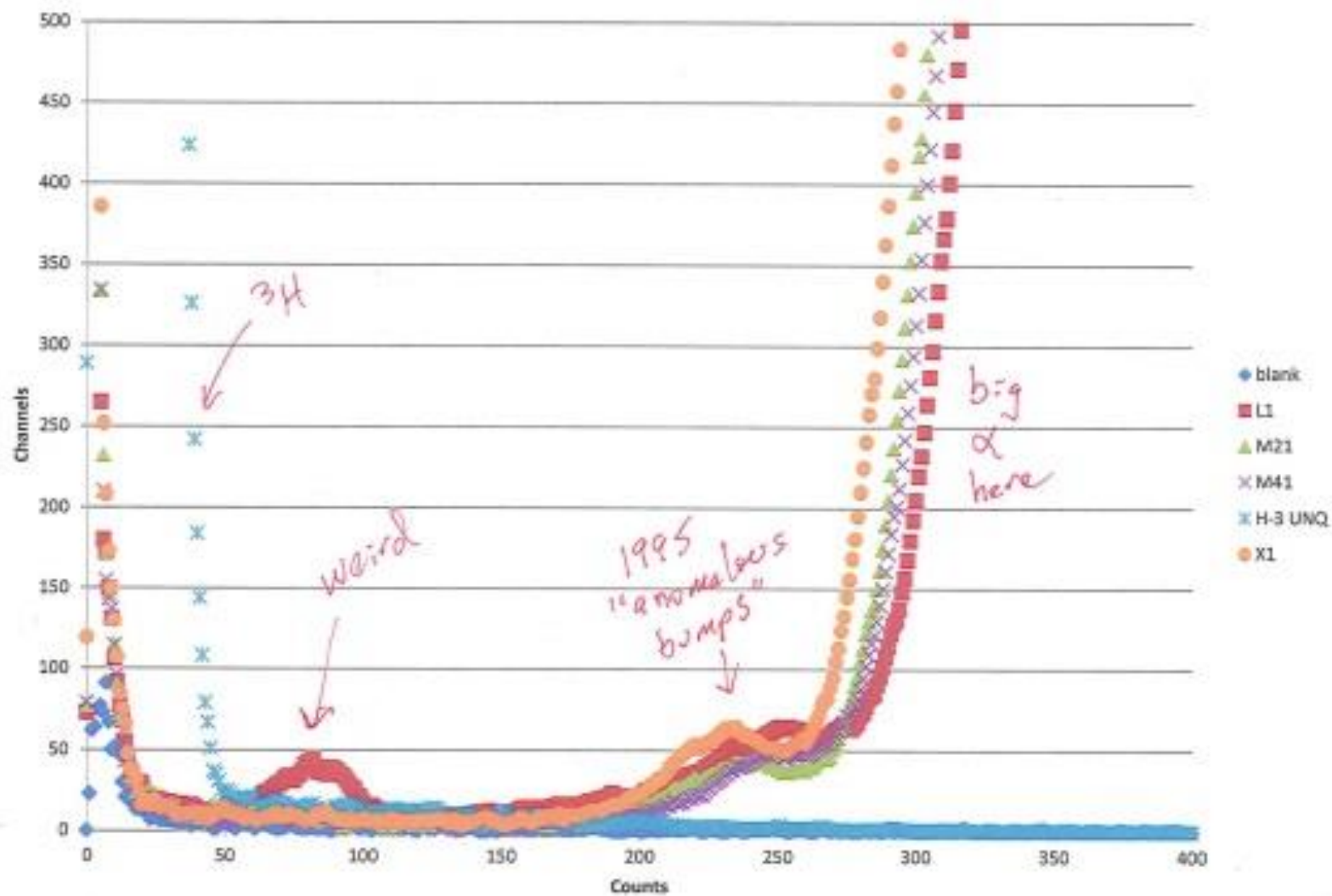




Beckman Linear Plot



Beckman Linear Plot



all  $^{209}\text{Po}$   
radiations

want this

$\alpha$	4622	0.548%
	4883	79.2
	4885	19.8

EC branch

Cut-off

small

$e$	5.4 - 16.3	0.224	L ( $\beta^-$ )
$e$	57.5 - 63.4	0.0418	KL
	70.0 - 77.1		KLX ( $\beta^-$ )
	82.5 - 90.5		KXY

Cut-off

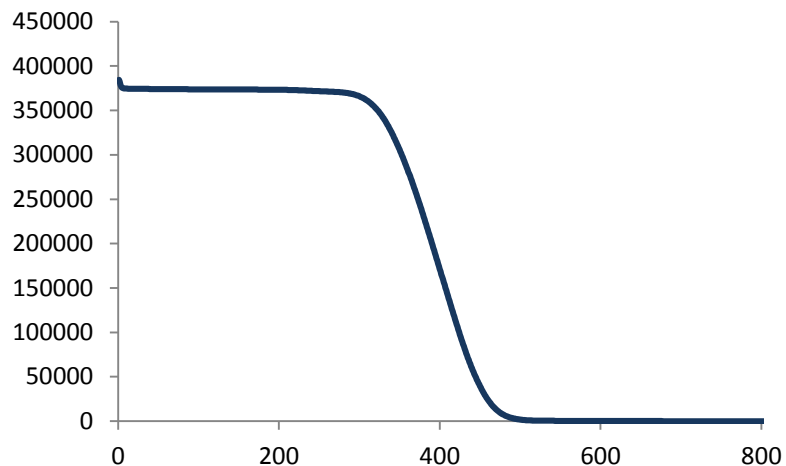
to figure out !

	5.3 - 15.8	0.1044	L ( $\beta^-$ )
	56.0 - 61.7	0.0063	KL
	68.2 - 75.0		KLX ( $\beta^-$ )
	80.3 - 88		KXY
	172.5	0.1278	EC $2,1$ K
	174.8	0.0425	EC $2,0$ K
$\gamma$	260.5	0.254	$2 \rightarrow 1$ ( $\beta^-$ )
	262.8	0.085	$2 \rightarrow 0$ ( $\beta^-$ )
	896.28	0.445	$1 \rightarrow 0$ ( $\beta^-$ )

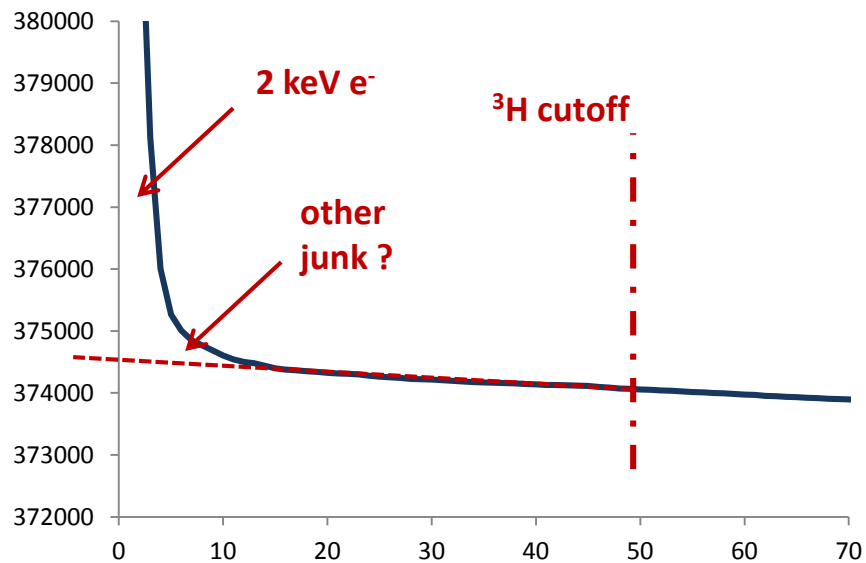
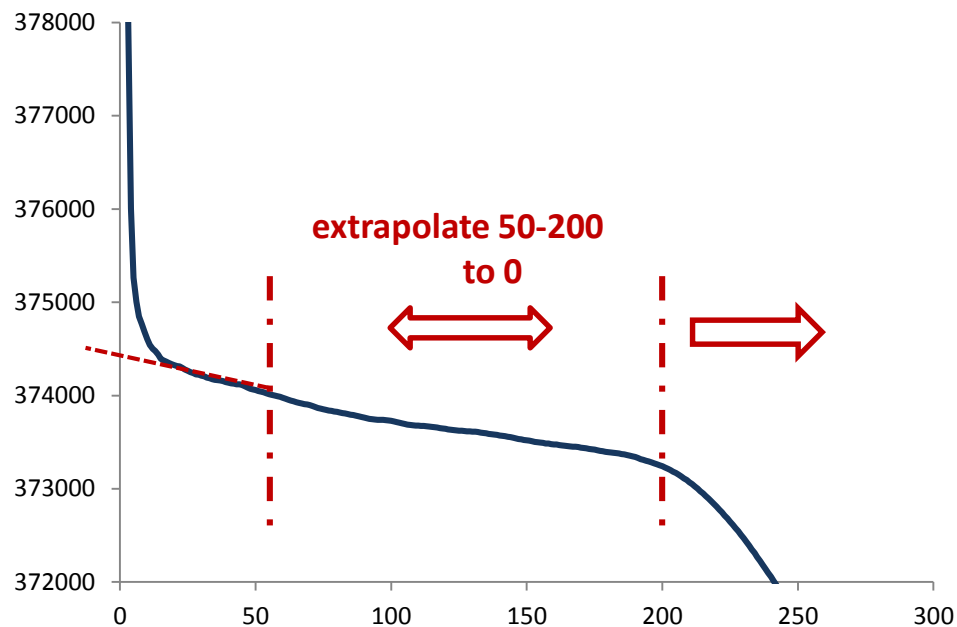
< 10 %  
(Zimmerman)

XL ( $\beta^-$ )	9.4 - 15.7	0.1411
XK ( $\beta^-$ )	74.8 - 90.4	0.3172
XL ( $\beta^-$ )	9.2 - 15.2	0.0631
XK ( $\beta^-$ )	72.8 - 87.9	0.164

~~0.085~~



INTEGRAL LS SPECTRUM  $^{209}\text{Po}$   
(M21 on Beckman)

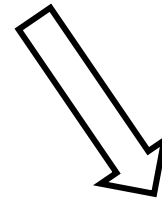


2.7 % below 50

0.21 % in 50-200 region  $\rightarrow$  + 0.28 % to 0

# Fin

*thanks*



**Lizbeth Laureano-Perez**  
*principal worker bee*

**Ryan Fitzgerald**  
*project's devil's advocate*

**Dan Golas**  
*ampoule-sealer extraordinaire*

