Radioactivity Group Meeting

9 January 2008

Advances in the SRM Program

+ some metrology

Brought to you by

Ron Collé

Lizbeth Laureano-Perez

Includes <u>major</u> contributions by

Ryan Fitzgerald

Iisa Outola

Brian Zimmerman

And some <u>minor</u> ones by

Dan Golas	Jerry LaRosa
Leticia Pibida	Evan Crawford
Ken Inn	Lynne King
Nicholas Perichon	Bruce Norman

ASK HOW YOU TOO CAN BE INCLUDED IN NEXT YEAR’S LIST !

Last time (29 march 2007) we talked about

new SRM production & standardization
^{60}Co ^{137}Cs ^{55}Fe ^{210}Pb ^{166m}Ho ^{90}Sr(2)

new SRMS of others --nat'l matrix (2); ^{226}Ra-Rn (6)

re-certifications (w & w/o meas.)

ongoing & future SRMs

^{55}Fe std. + BIPM intercomparison (link to calorimetry)

completed work

^{209}Po / ^{210}Pb problems papers

^{209}Po half-life (Poland, France, NIST ?) died

^{63}Ni standardization & half-life --38 years (LNHB) paper

calorimetry / ^{14}C half-life / (Columbia Univ.) died

Si(Li) x-ray detection It's here – no time !

measurement comparison compilations lots more

New stuff

Standardizations & SRMs

^{230}Th
^{241}Am
^{241}Pu
fin

^{229}Th
^{99}Tc
underway

NEXT (approx. order)

^{228}Ra

^{239}Pu

^{209}Po

^{244}Cm

^{63}Ni

^{238}Pu

^{243}Am

Other projects:

LS α wall effect studies (w/ Ryan)

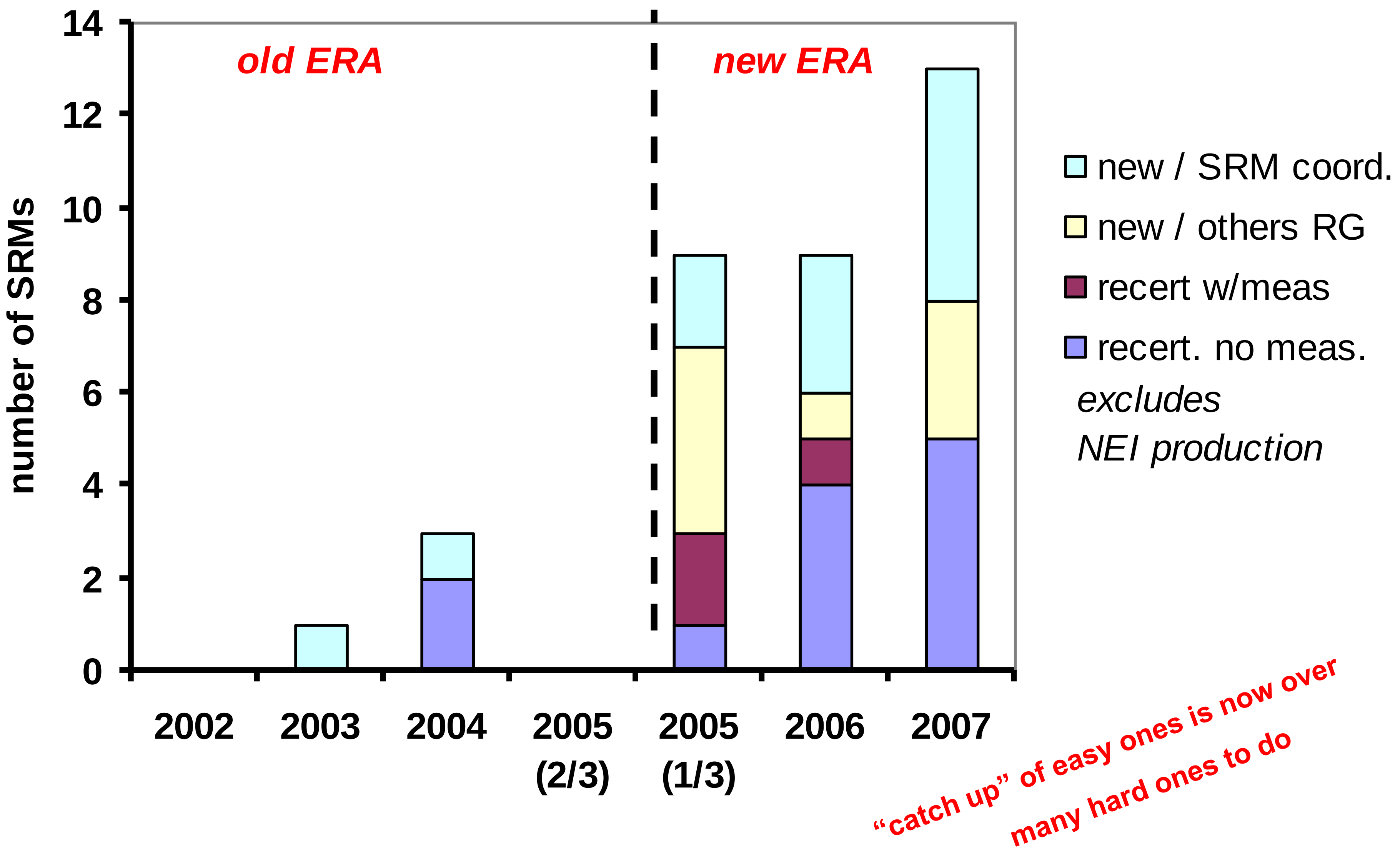
NPL / NIST ^{210}Pb std. comparison

Si(Li) detector system (w/ Brian)

cryogenic cal. α spect. (collaboration with Boulder / Los Alamos / LNHB)

measurement comparisons (w/ Ryan, Brian, lisa, others)
- **^{241}Am links – 4 std solutions – LS & anticoin.**
- **^{241}Pu LS CNET & TDCR / NIST & LNHB / ^{241}Am ingrowth**
- **^{229}Th – LS – CNET & TDCR & anticoin. – LNHB, Los alamos**
- **^{99}Tc – CNET & TDCR & anticoin.**

SRMs to Inventory



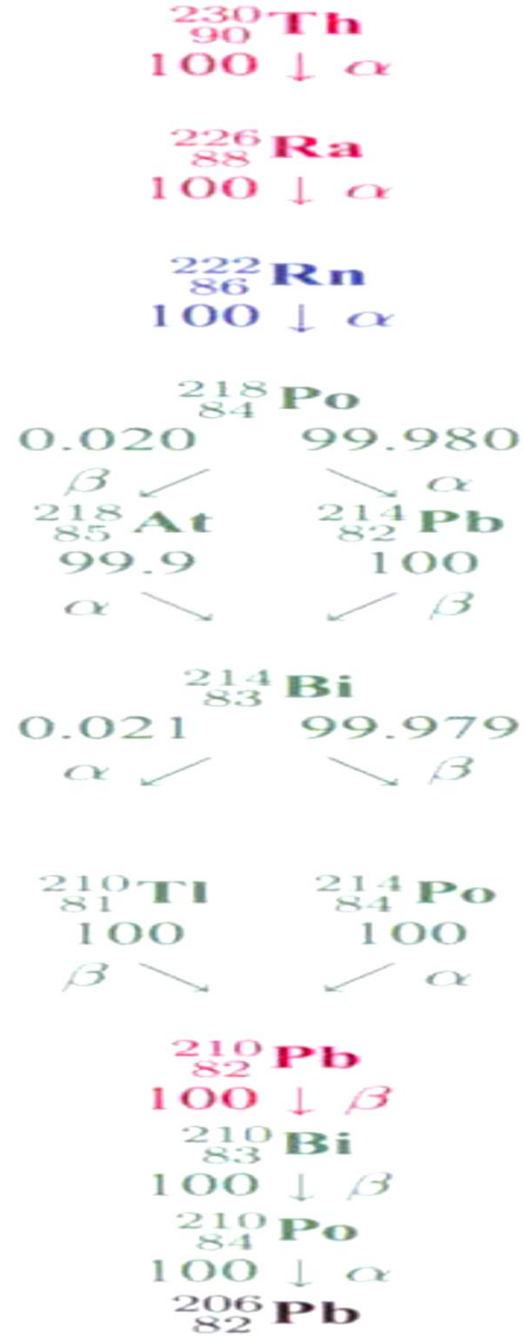
Lizbeth

^{230}Th

^{241}Am

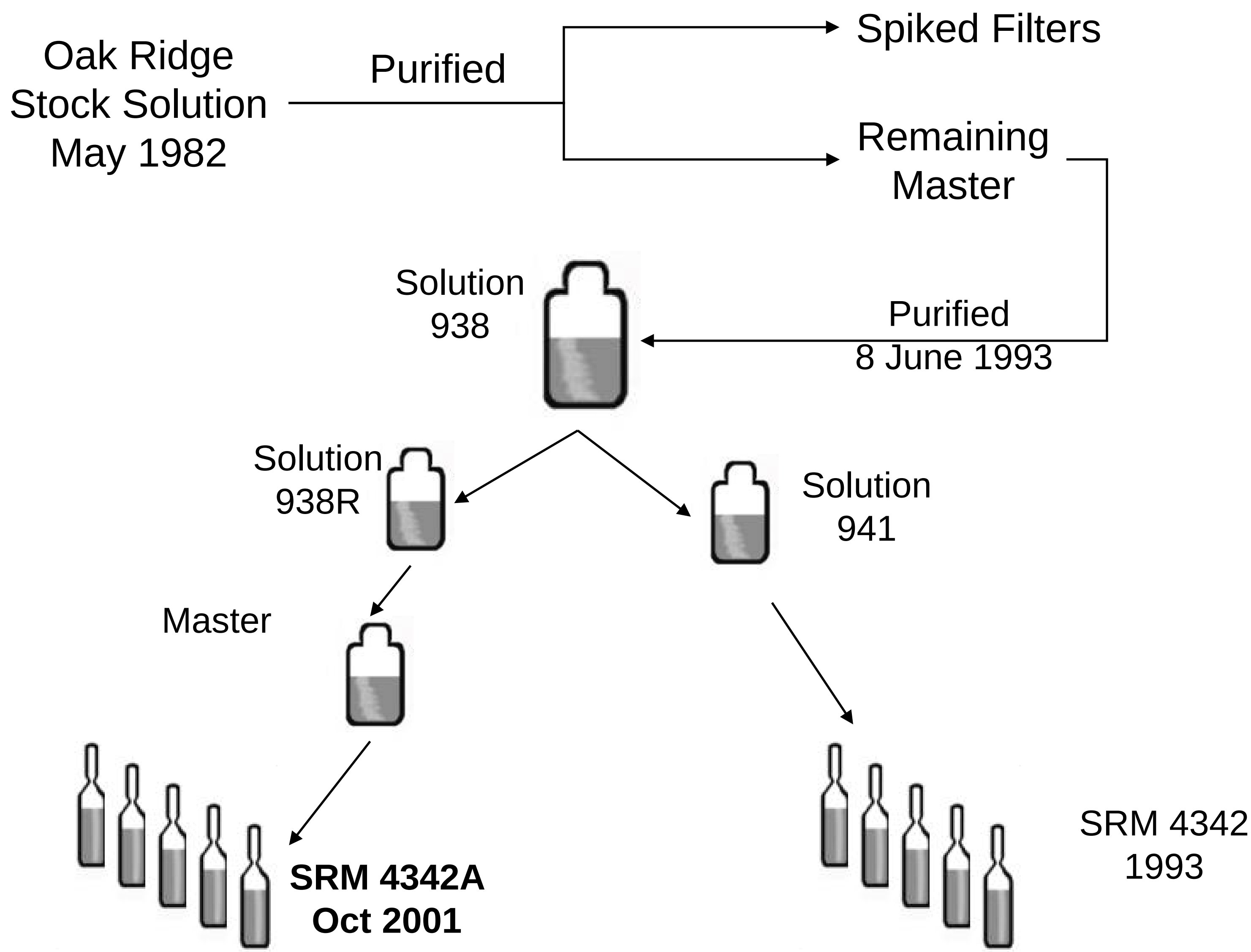
^{241}Pu

Th-230



$^{230}_{90}$Th
100 ↓ α
$^{226}_{88}$Ra
100 ↓ α
$^{222}_{86}$Rn
100 ↓ α
$^{218}_{84}$Po
0.020
99.980
β
α
$^{218}_{85}$At
$^{214}_{82}$Pb
99.9
100
α
β
$^{214}_{83}$Bi
0.021
99.979
α
β
$^{210}_{81}$Tl
$^{214}_{84}$Po
100
100
β
α
$^{210}_{82}$Pb
100 ↓ β
$^{210}_{83}$Bi
100 ↓ β
$^{210}_{84}$Po
100 ↓ α
$^{206}_{82}$Pb

Thorium-230


Oak Ridge
Stock Solution
May 1982
Purified
Spiked Filters
Remaining
Master
Solution
938
Purified
8 June 1993
Solution
938R
Solution
941
Master
SRM 4342A
Oct 2001
SRM 4342
1993

Th-230

- LS Measurement
  - Corrected for Ra-226 subseries ingrowth

    69 determinations; variables include:

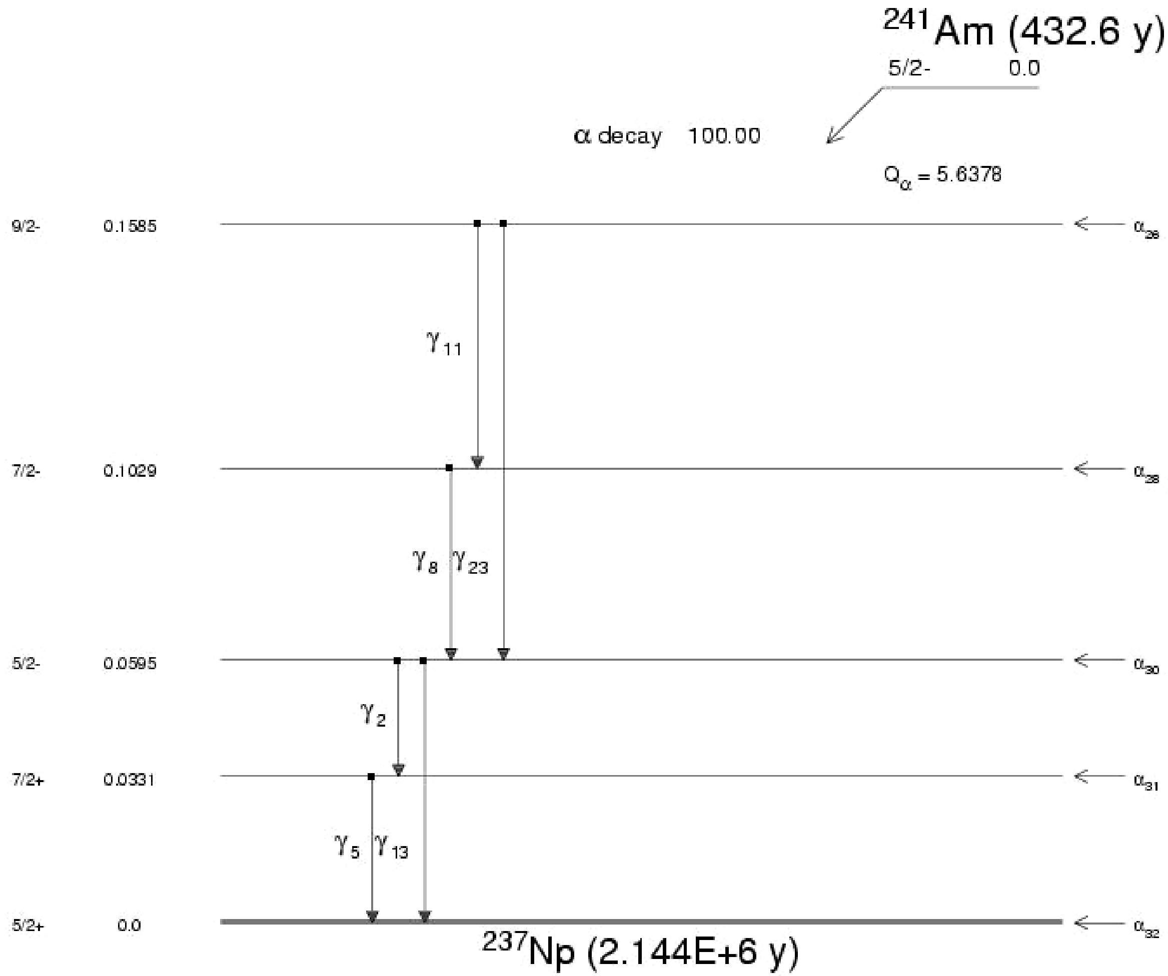
    - 3 counters
    - 1 composition
    - 3 sources per composition
    - 1 to 5 cycles / 60 to 360 minutes per measurement
    - 5 - 40 days of aging

- Impurities
  - Alpha Spectrometry

Th-230 Results

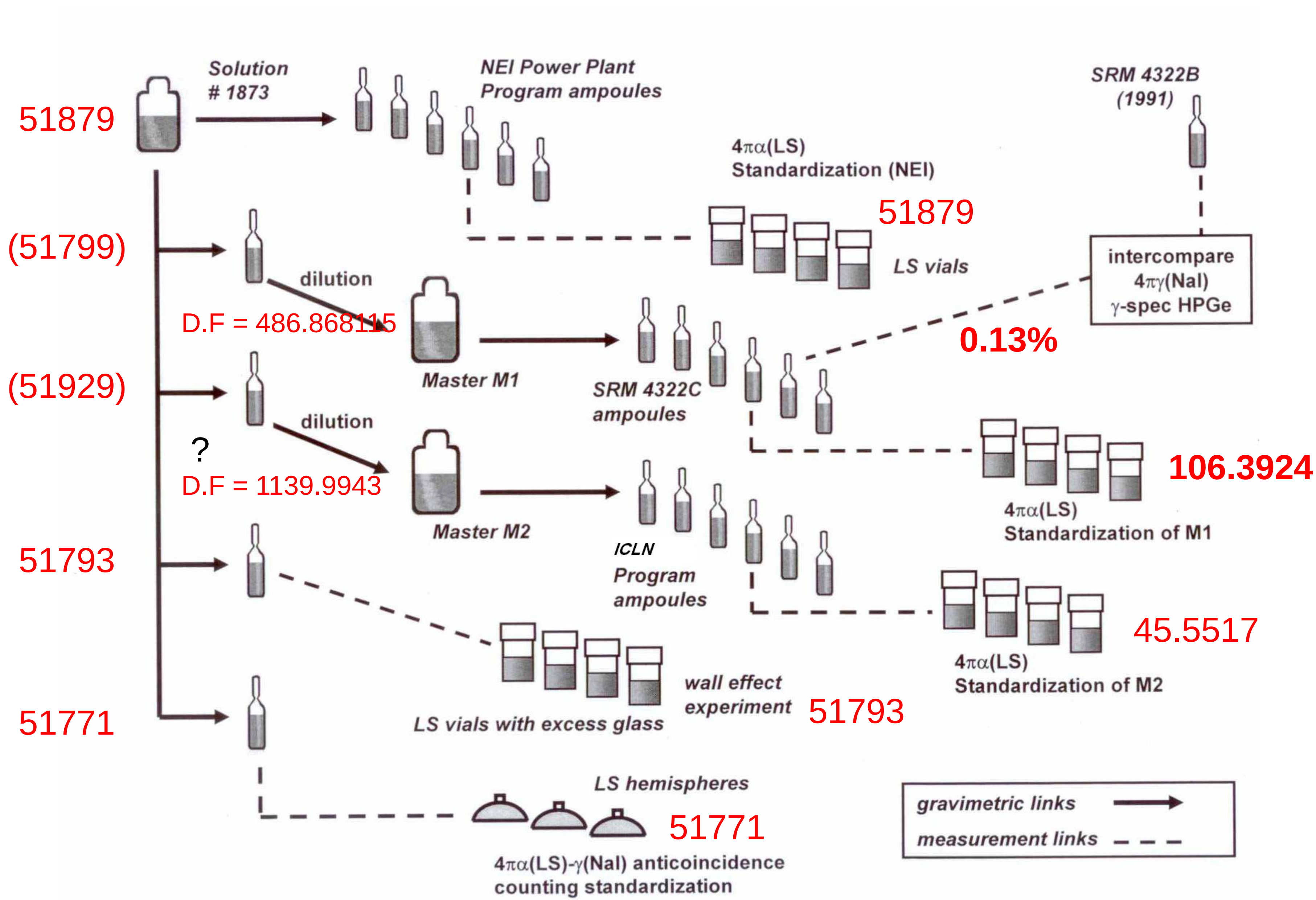
- Certified activity = 40.83 ± 0.16 $Bq \bullet g^{-1}$ at 1200EST 1 April 2007
- Preliminary Measurement by Lucas, A= 40.90 $Bq \bullet g^{-1}$ at 1200EST 1 April 2007
- Activity by α spectrometry = 41.0 ± 1.2 $Bq \bullet g^{-1}$ – lisa
- Attempted confirmation by Ingrowth of Ra-226 with PIC measurements were 9% different -Peter

Am-241



241Am (432.6 y)
5/2- 0.0
α decay 100.00
Qα = 5.6378
9/2- 0.1585
7/2- 0.1029
5/2- 0.0595
7/2+ 0.0331
5/2+ 0.0
γ11
γ8 γ23
γ2
γ5 γ13
α26
α28
α30
α31
α32
237Np (2.144E+6 y)

Am-241

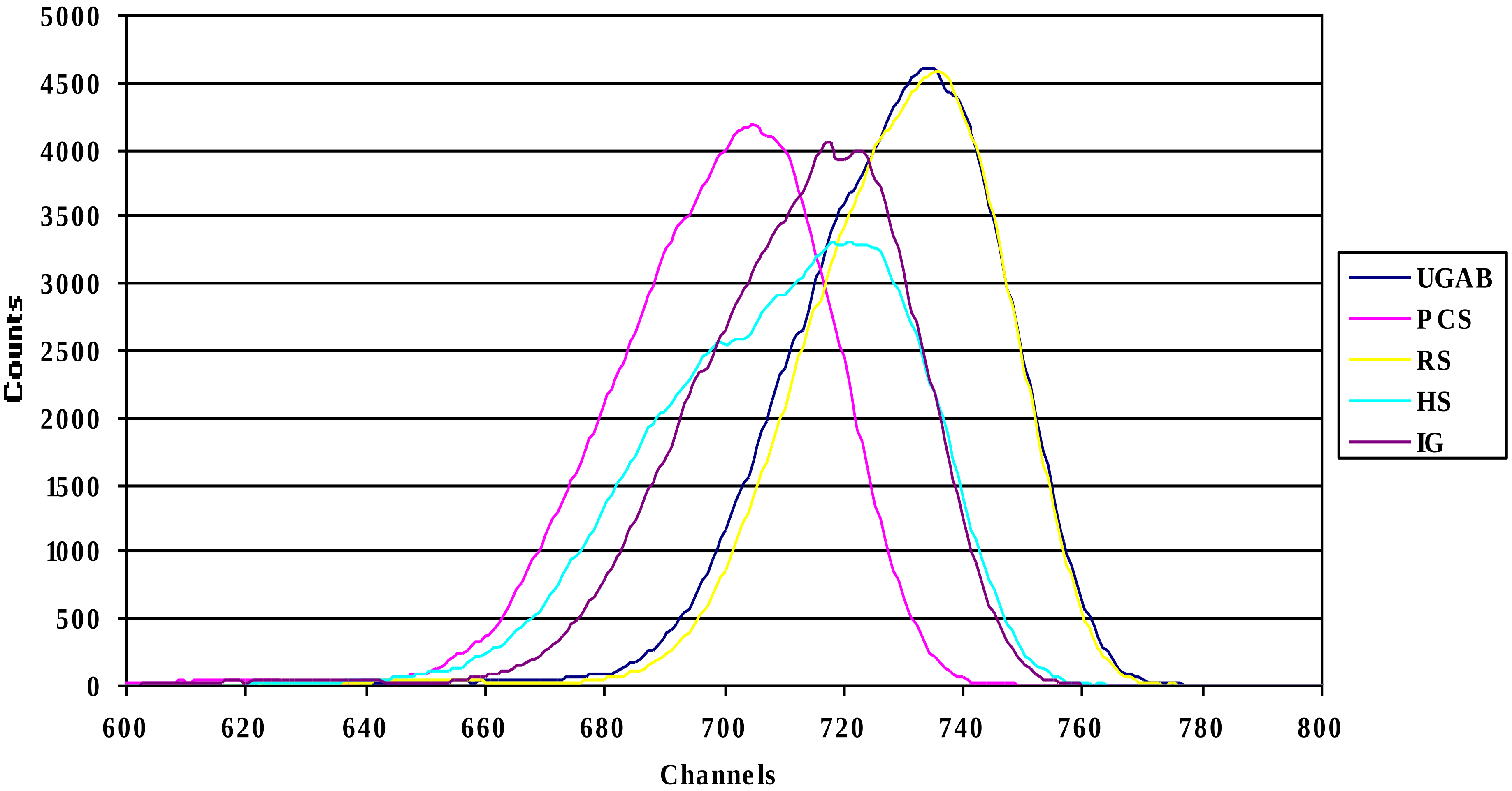


51879
(51799)
(51929)
51793
51771
Solution # 1873
NEI Power Plant Program ampoules
SRM 4322B (1991)
4πα(LS) Standardization (NEI)
51879
LS vials
intercompare 4πγ(NaI) γ-spec HPGe
dilution
D.F = 486.868115
Master M1
SRM 4322C ampoules
0.13%
dilution
?
D.F = 1139.9943
Master M2
106.3924
4πα(LS) Standardization of M1
ICLN Program ampoules
45.5517
4πα(LS) Standardization of M2
wall effect experiment
51793
LS vials with excess glass
LS hemispheres
51771
4πα(LS)-γ(NaI) anticoincidence counting standardization
gravimetric links
measurement links

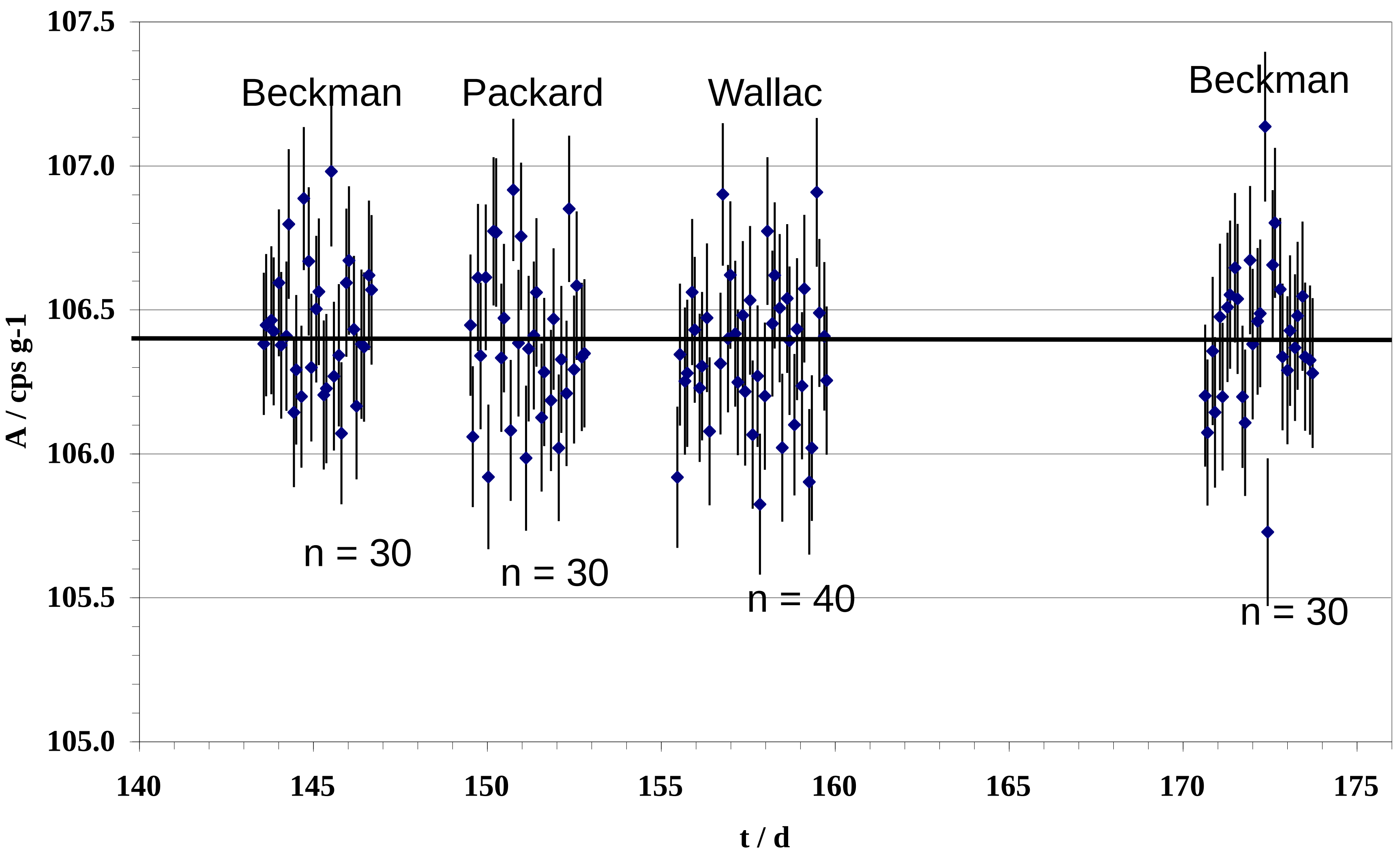
LS CNET

- 130 determinations; variables include:
  - 3 counters
  - 5 compositions
  - 5 scintillants
  - 2 sources per composition
  - 3 to 5 cycles / 100 minutes per measurement
  - 30 days of aging

Am-241 Spectra

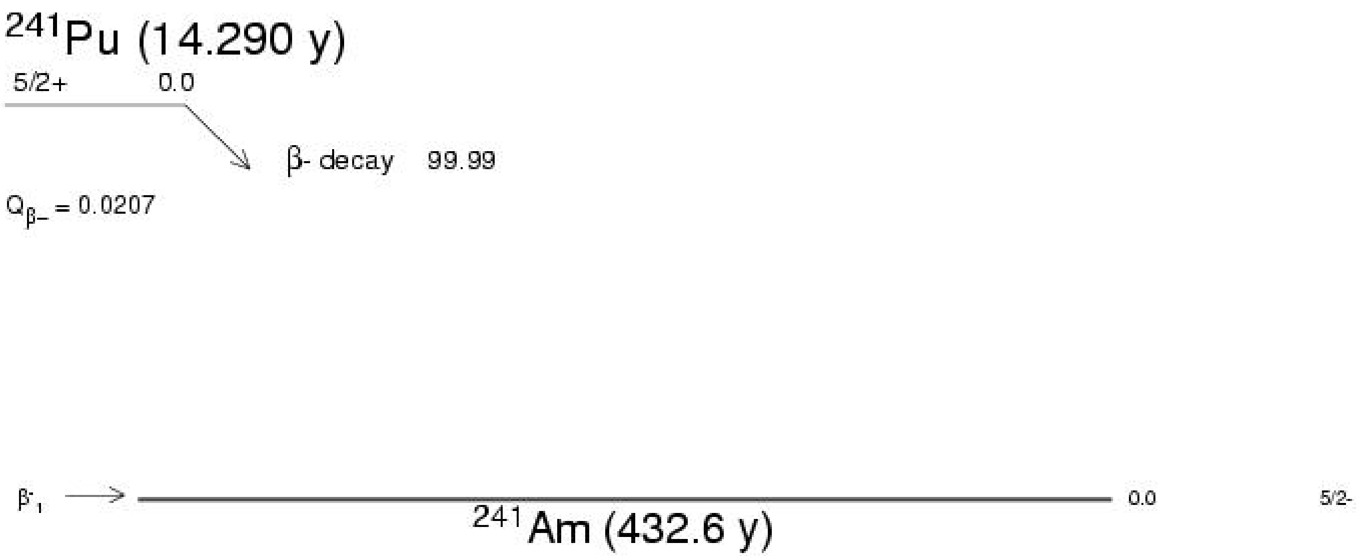


Am-241

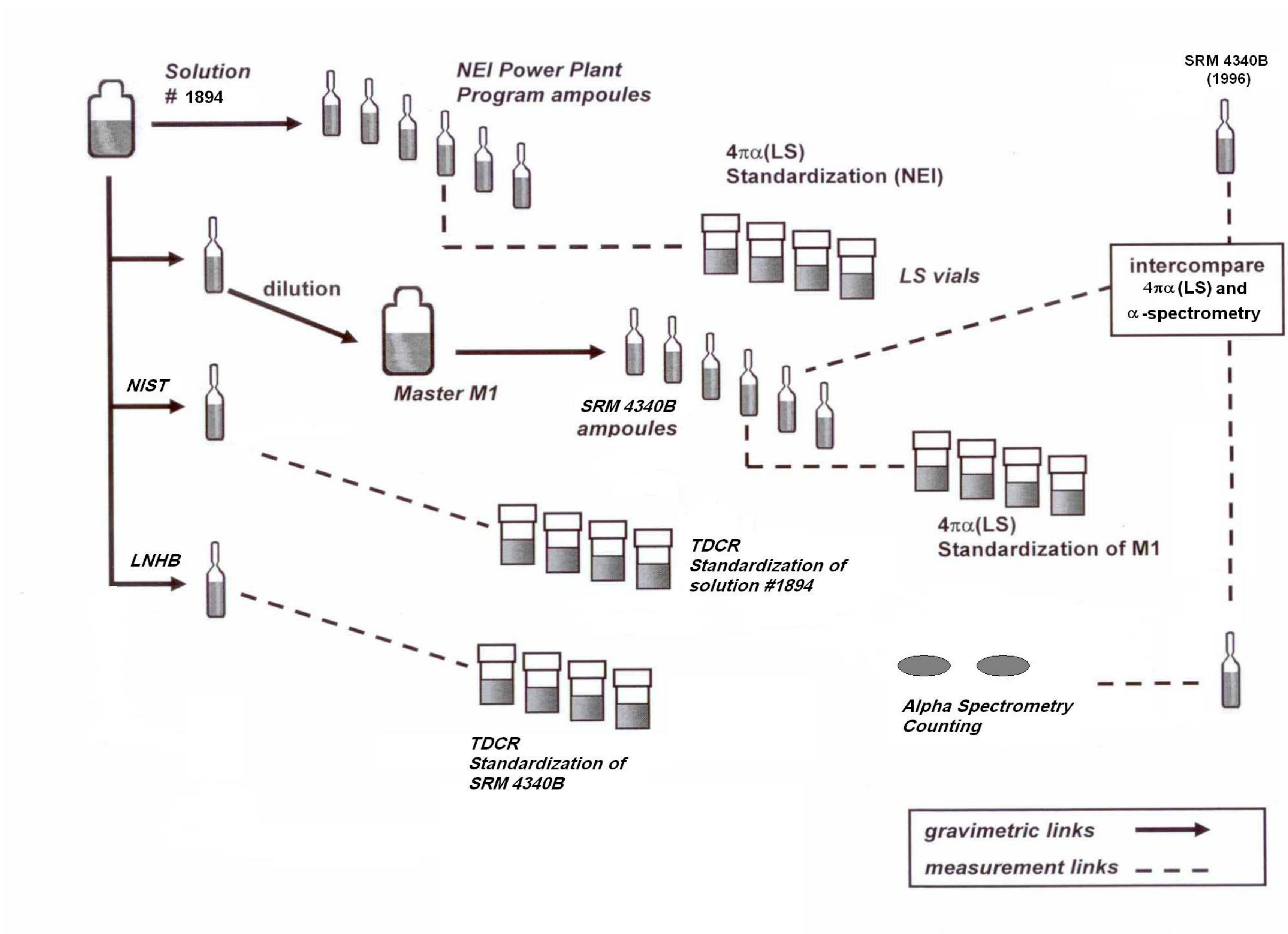


107.5
107.0
106.5
106.0
105.5
105.0
A / cps g-1
Beckman
Packard
Wallac
Beckman
n = 30
n = 30
n = 40
n = 30
140
145
150
155
160
165
170
175
t / d

Pu-241



Pu-241



Solution
1894
NEI Power Plant
Program ampoules
SRM 4340B
(1996)
4πα(LS)
Standardization (NEI)
dilution
LS vials
intercompare
4πα (LS) and
α -spectrometry
NIST
Master M1
SRM 4340B
ampoules
4πα(LS)
Standardization of M1
TDCR
Standardization of
solution #1894
LNHB
Alpha Spectrometry
Counting
TDCR
Standardization of
SRM 4340B
gravimetric links
measurement links

Pu-241 Results

Measurement Method	Activity ($Bq \cdot g^{-1}$)	Uncertainty (%)
LS CNET	258.5	0.5+
TDCR (NIST)	239.6	2.1
TDCR (LNHB)	240.1	1.3

LS CNET

312 determinations; variables include:

- 3 counters
- 3 compositions
- 5 to 6 sources per composition
- 2 activity levels/solutions
- 2 to 10 cycles / 60 to 100 minutes per measurement
- 69 days of aging

Pu-241 Results

- CNET and TDCR in serious disagreement (7.7%)
  - Presumably based on same model
  - NOT due to spectrum
  - EFFY and CN2003 codes small differences
  - CN2003 invariant of kB number
  - CN2003 agrees with LNHB tracer code

Pu-241 Results

- CNET results correct based on
  - Agreement with old certificate
    - Based on Am-241 Ingrowth
  - Confirmation based on Am-241 Ingrowth determined
    - LS CNET
    - Alpha Spectrometry
    - LS Spectra

	Activity ($Bq \cdot g^{-1}$)	**Difference (%)**
Old Certificate (SRM 4340A)	250.4	-
LS CNET	253.3	1.4
Alpha Spectrometry	258.0	3
LS Spectra	253.9	1.4

Ron

^{90}Sr -- history

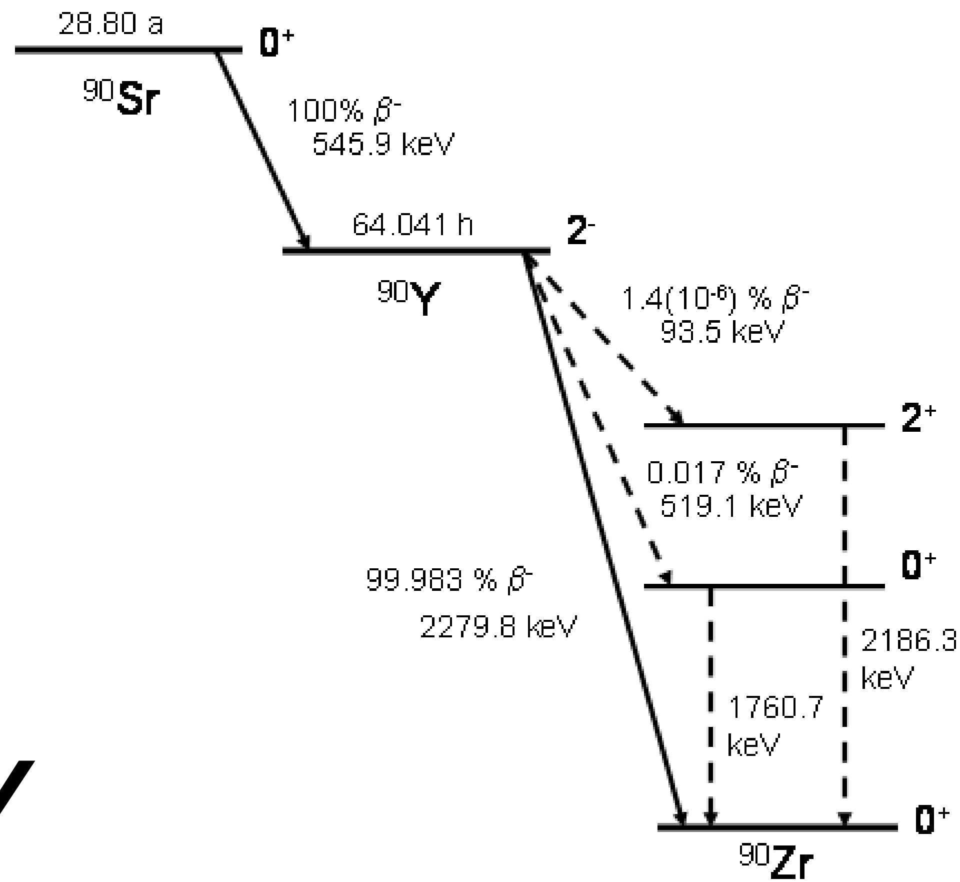
^{210}Pb – NPL / NIST

LS wall effect for α's

Si(Li) detector

Cryogenic calorimeter (α spectrometry)

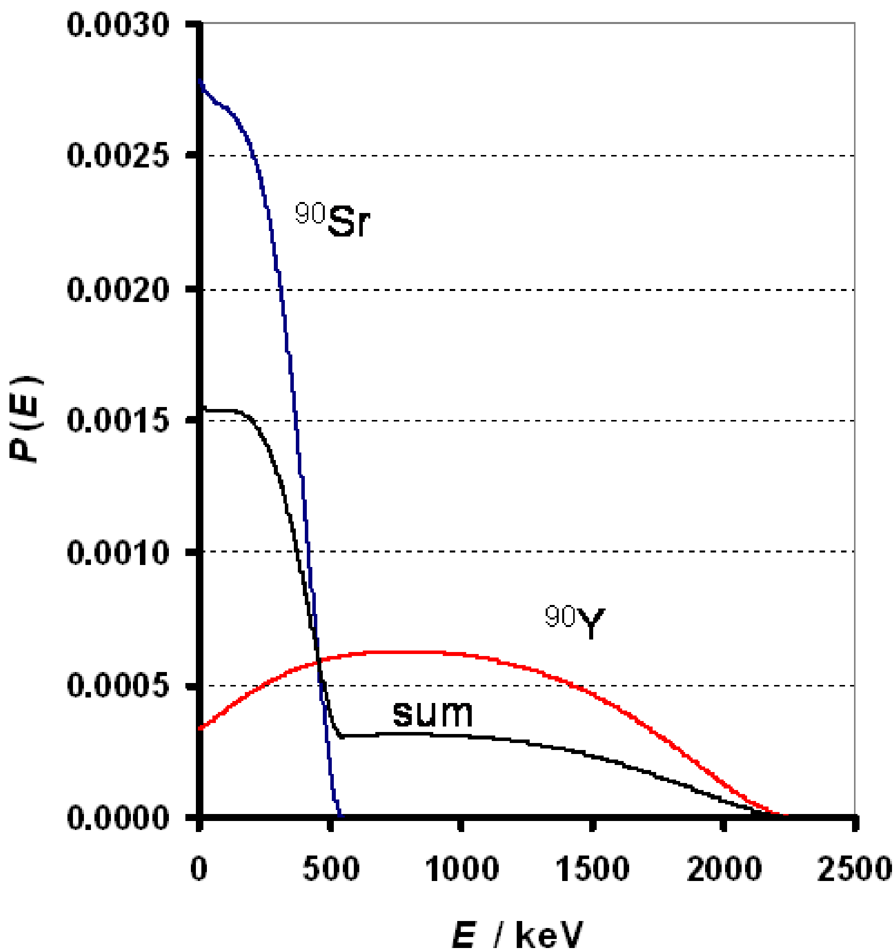
^{229}Th

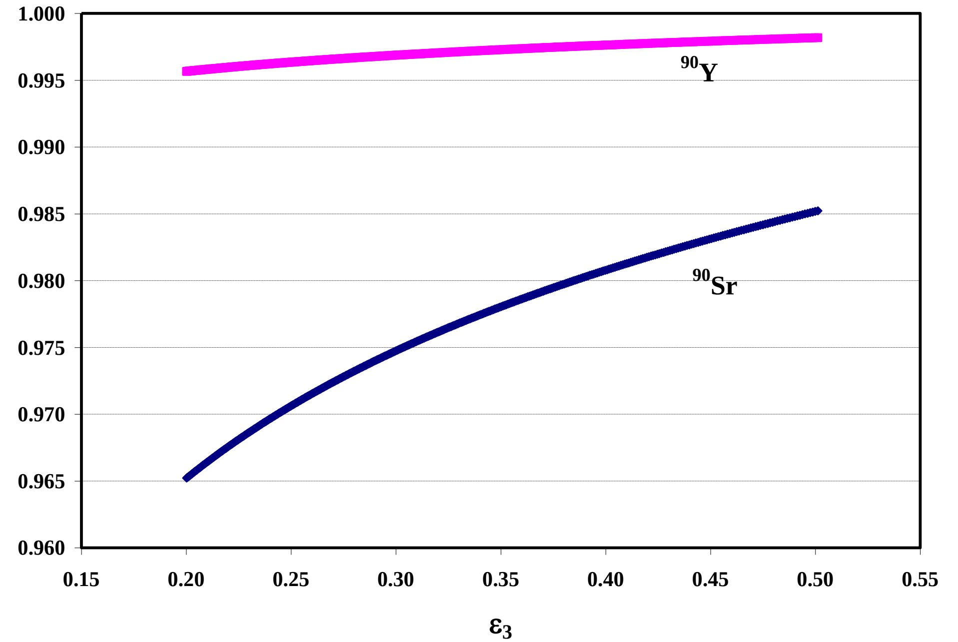


28.80 a
0+
90Sr
100% β-
545.9 keV
64.041 h
2-
90Y
1.4(10-6) % β-
93.5 keV
2+
0.017 % β-
519.1 keV
0+
99.983 % β-
2279.8 keV
2186.3
keV
1760.7
keV
0+
90Zr

^{90}Sr-^{90}Y

fairly easy case





^{90}Sr

2 new SRMs (Dec 2006)

4919I = 4.261 kBq g^{-1} ± 0.48 % (k = 2)

4239 = 31.79 kBq g^{-1} ± 0.46 %

(LS CNET 3 cocktail compositions / 3 counters)

precision < 0.1 % (ν_{eff} = 293); normal

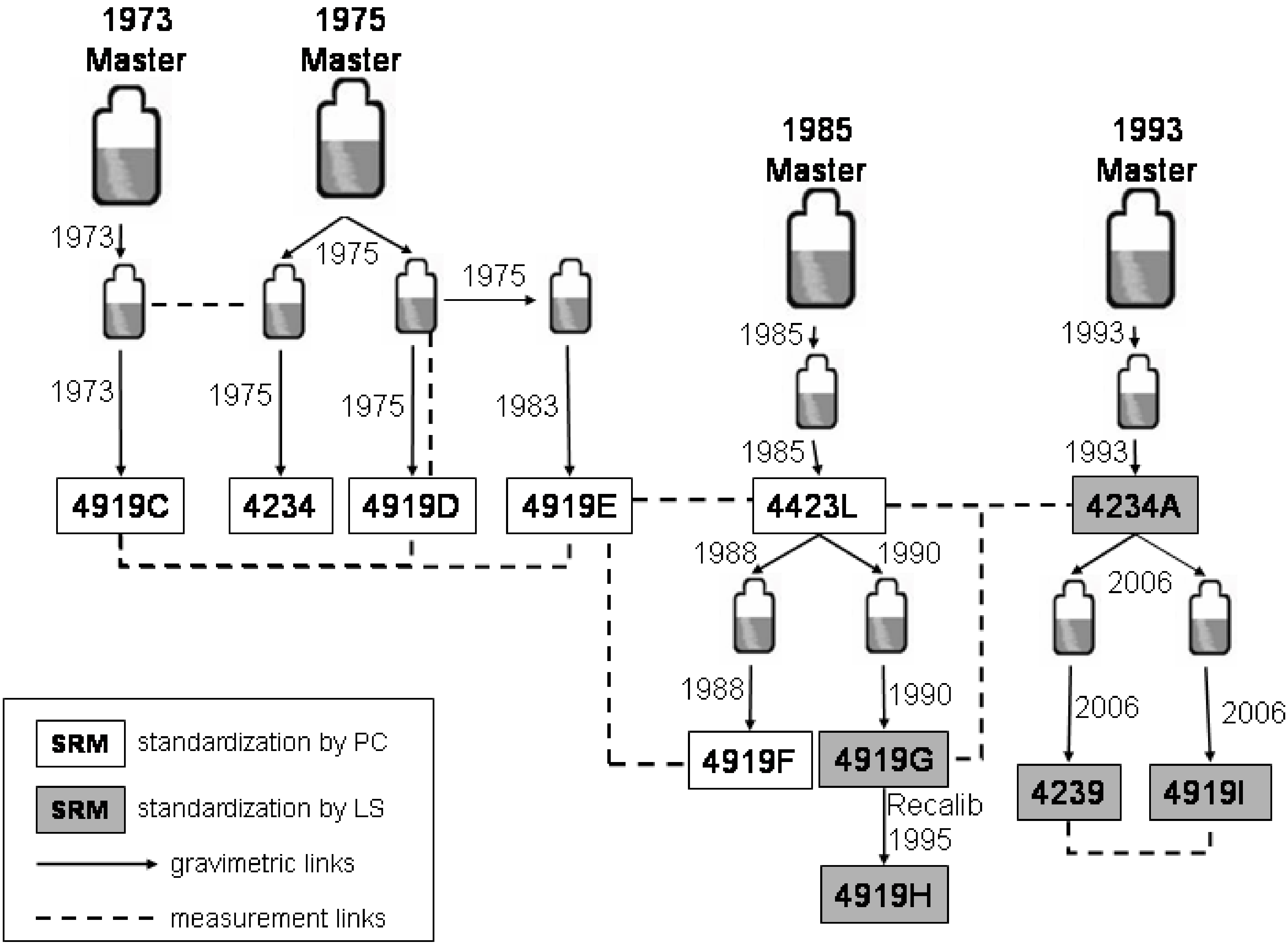
Measurement comparison

CNET/TDCR = 1.00094 ± 0.55 % (k = 1)

A Half-Century of Radioactivity Solution Standards of ^{90}Sr-^{90}Y

R. Collé, L. Laureano-Perez, and B.E. Zimmerman

Series	Instrument	Age / d	N d	ε_{H-3}	ε_{Sr-90}	ε_{Y-90}	Average / $kBq\cdot g^{-1}$	s / %
I	B	2	35	0.29 - 0.43	0.974 - 0.983	0.997 - 0.998	31.82	0.02
	P	6	21	0.23 - 0.35	0.968 - 0.979	0.996 - 0.997	31.77	0.02
	W	9	21	0.23 - 0.35	0.968 - 0.979	0.996 - 0.998	31.78	0.02
	B	14	21	0.30 - 0.43	0.974 - 0.982	0.997 - 0.998	31.83	0.02
II	B	2	35	0.28 - 0.41	0.973 - 0.981	0.997 - 0.998	31.82	0.03
	P	6	21	0.21 - 0.33	0.966 - 0.977	0.996 - 0.997	31.78	0.03
	W	9	21	0.21 - 0.33	0.966 - 0.977	0.996 - 0.998	31.78	0.04
	B	14	21	0.28 - 0.40	0.972 - 0.981	0.997 - 0.998	31.81	0.04
III	B	2	35	0.28 - 0.42	0.973 - 0.982	0.997 - 0.998	31.79	0.04
	P	6	21	0.21 - 0.34	0.966 - 0.977	0.996 - 0.997	31.73	0.01
	W	9	21	0.21 - 0.34	0.966 - 0.977	0.996 - 0.998	31.75	0.05
	B	14	21	0.28 - 0.41	0.972 - 0.982	0.997 - 0.998	31.81	0.02
All	Unweighted grand mean						**31.79**	--
All	relative standard deviation of mean (n=12)						--	**0.10**

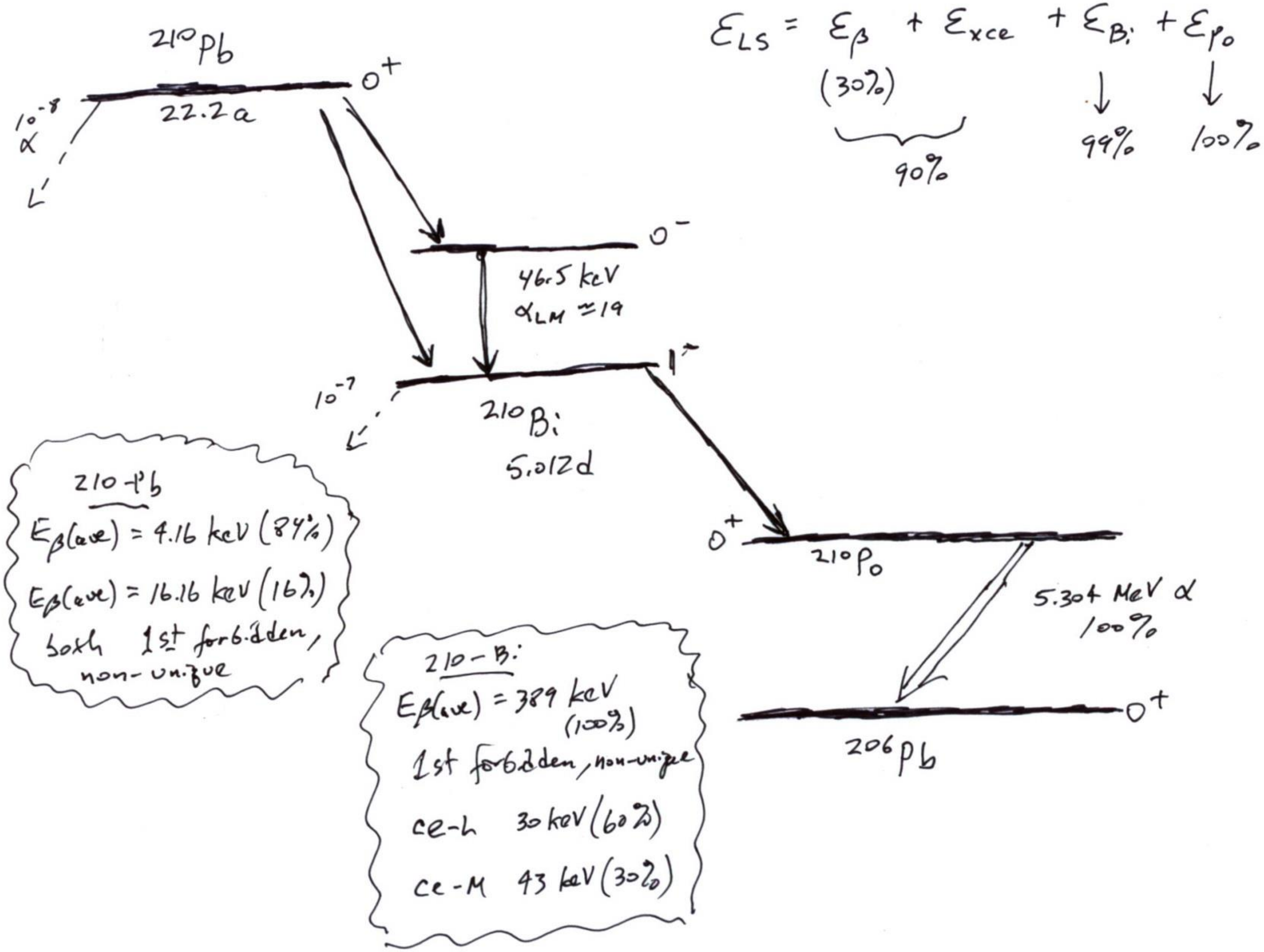


1973 Master
1975 Master
1985 Master
1993 Master
1973
1975
1975
1973
1975
1975
1983
1985
1985
1993
1993
4919C
4234
4919D
4919E
4423L
4234A
1988
1990
2006
1988
1990
2006
2006
4919F
4919G
4239
4919I
Recalib 1995
4919H
SRM standardization by PC
SRM standardization by LS
gravimetric links
measurement links

Table 1. Solution standards of ^{90}Sr-^{90}Y disseminated by NBS/NIST from c.1950 to 2007.

SRM	Reference time	Primary standardization method	Solution [a] $^{90}Sr/Sr$ / $^{90}Y/Y$	^{90}Sr massic activity $kBq \cdot g^{-1}$	Reported uncertainty	Uncertainty method
4919	(c. 1950)	?	?	? [b]	?	?
4919A	(1953)	4π PC	(10^{-4}) / (10^{-7})	≈ 5 [b]	(≈ 2 %)	? [c]
4919B	(1957)	4π PC	(10^{-4}) / (10^{-7})	≈ 5 [b]	(≈ 2 %)	? [c]
4919C	1973 19 march	4π PC	$1.3(10^{-6})$ / $2.9(10^{-10})$	0.1120 [b]	2.0 %	LC [d]
4919D	1975 26 april	4π PC	$7.7(10^{-6})$ / $2.0(10^{-9})$	2.017 [b]	2.1 %	LC [d]
4234	1975 4 august	4π PC	$1.6(10^{-3})$ / $4.2(10^{-7})$	626.0 [b]	1.47 %	LC [d]
4919E	1983 1 may	4π PC	$1.3(10^{-5})$ / $3.3(10^{-9})$	3.375	1.77 %	LC2 [e]
4423L	1985 16 november	4π PC	$4.1(10^{-3})$ / $1.0(10^{-6})$	4403	1.05 %	3×QC [f]
4919F	1988 1 may	4π PC	$4.7(10^{-5})$ / $1.3(10^{-8})$	4.094	1.16 %	3×QC [f]
4919G	1990 1 august	4π LS	$9.1(10^{-6})$ / $2.3(10^{-9})$	4.514	1.05 %	3×QC [f]
4234A	1995 13 march	4π LS	$1.7(10^{-3})$ / $4.5(10^{-7})$	2494.	0.56 %	2×QC [g]
4919H	1995 1 july	4π LS	$6.9(10^{-6})$ / $2.2(10^{-9})$	4.010	0.74 %	2×QC [g]
4919I	2006 25 december	4π LS	$4.1(10^{-5})$ / $9.1(10^{-9})$	4.261	0.48 %	2×QC [g]
4239	2006 25 december	4π LS	$2.5(10^{-4})$ / $6.0(10^{-8})$	31.79	0.46 %	2×QC [g]

^{210}Pb



ε_LS = ε_β + ε_xce + ε_Bi + ε_Po
(30%)
90%
99%
100%
210Pb
0+
22.2a
10^-8
α
0-
46.5 keV
α_LM ≈ 19
1-
10^-7
210Bi
5.012d
210-Pb
Eβ(ave) = 4.16 keV (84%)
Eβ(ave) = 16.16 keV (16%)
both 1st forbidden,
non-unique
0+
210Po
5.304 MeV α
100%
0+
206Pb
210-Bi
Eβ(ave) = 389 keV
(100%)
1st forbidden, non-unique
ce-L 30 keV (60%)
ce-M 43 keV (30%)

^{210}Pb

Liz, et alia, *ARI* **65**, 1368 (2007)

Old stuff

SRM 4337 = 9.037 Bq g^{-1} ± 1.2 % (k=1)

Compare to CNET

anticoin.	= + 0.7 %
^{210}Po α Spect	= - 3.0 % (^{209}Po 102 a)
	= - 1.3 % (128 a)
HPGe	= + 4.7 %

new stuff

NPL Standard (333 Bq g^{-1}) – based on dilution of PTB std.

PTB did ^{210}Po α Spect

NPL confirm with ^{210}Bi ingrowth by Cerenkov (CNET for ^{210}Bi efficiency)

NPL / NIST ^{210}Pb

Cert.= 0.037484 ± 1.5 % (*k* = 1)

$4\pi\alpha\beta$ LS	= 0.037542 ± 0.17 %	(+ 0.15 %)
$4\pi\gamma$(NaI)	= 0.037373 ± 0.30 %	(- 0.30 %)
^{210}Po assay	= 0.03736 ± 0.7 %	(- 0.30 %)
HPGe	= 0.03754 ± 0.7 %	(+ 0.15 %)
Si(Li)	= 0.0374 ± > 1 % *incomplete*	

LS WALL EFFECT

Says 0.2 %

My friend

54 P Cassette

Based on ...

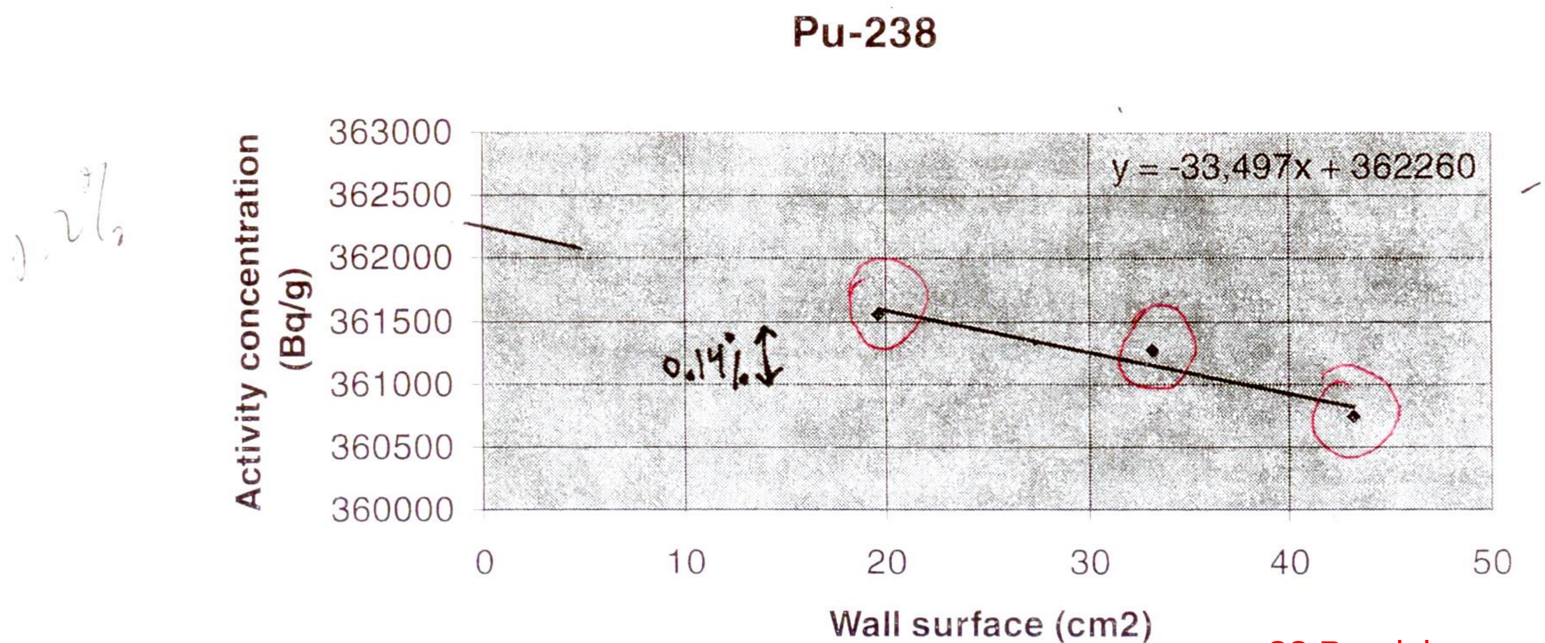


Figure 7 Counting rate of a ^{238}Pu source with different wall surfaces

?? Precision uncertainty

?? Replications

Can not reproduce effect (magnitude) using ^{210}Po & ^{241}Am

3 experiments

Vial – 27.3 cm^2

Glass beads	34.1 – 54.4 cm^2	+ area / volume ratios
Sleeves	34.4 – 39.2 cm^2	
Rods & tubes	36.9 – 45.5 cm^2	

Lots of screwy results

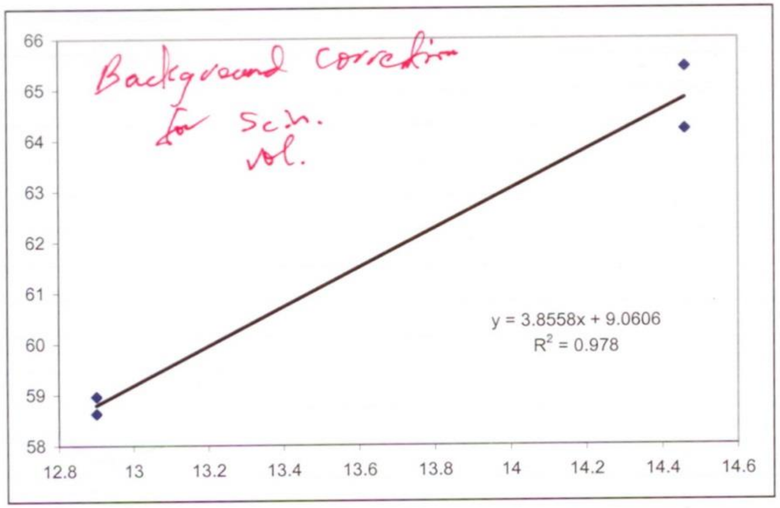
LS imprecision – 0.2 to 0.3 % typical

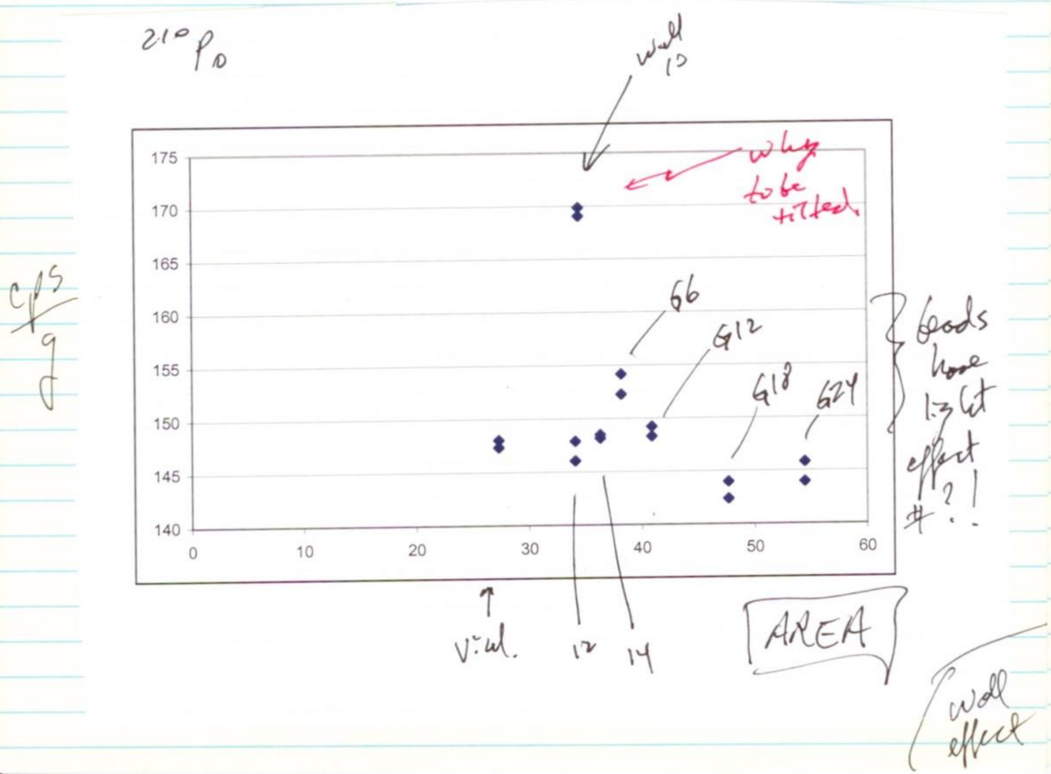
funny light effects – reflections from beads

tilting rods & sleeves – indeterminate volumes

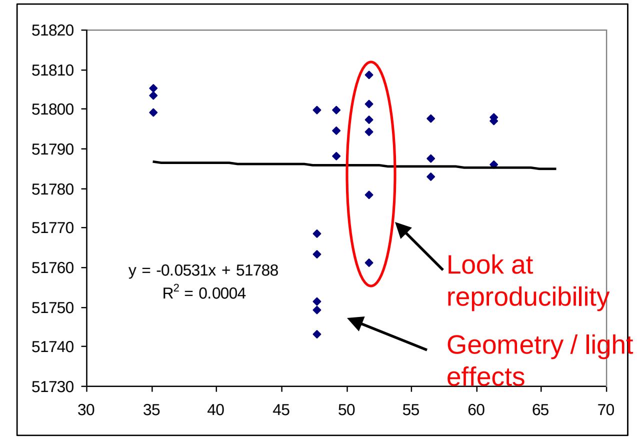
sample masses

cocktail instability



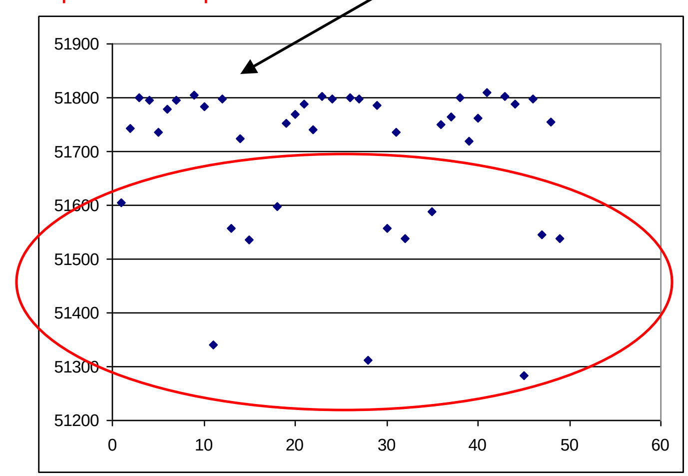


^{241}Am



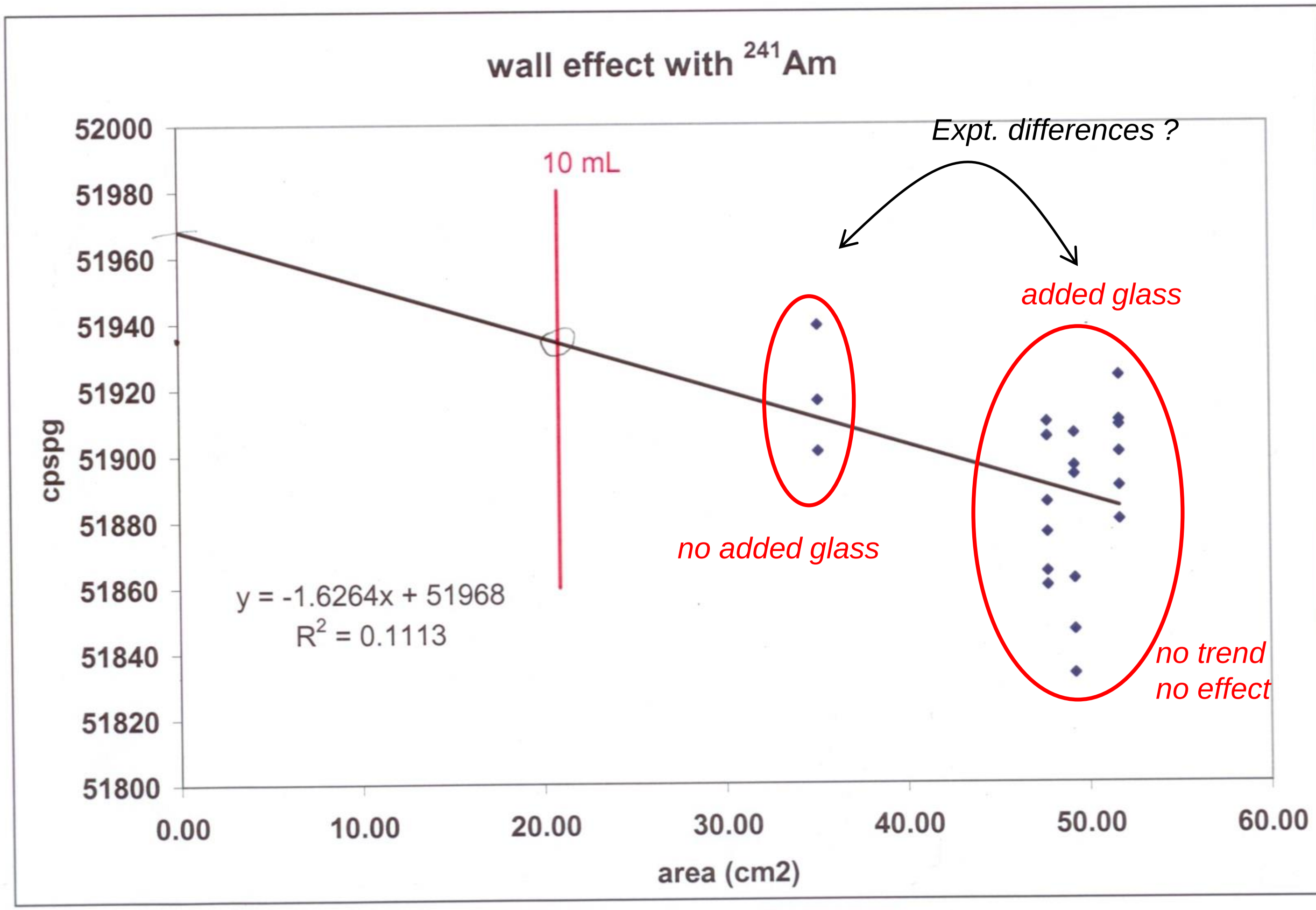
No apparent effect with area

Sequential samples

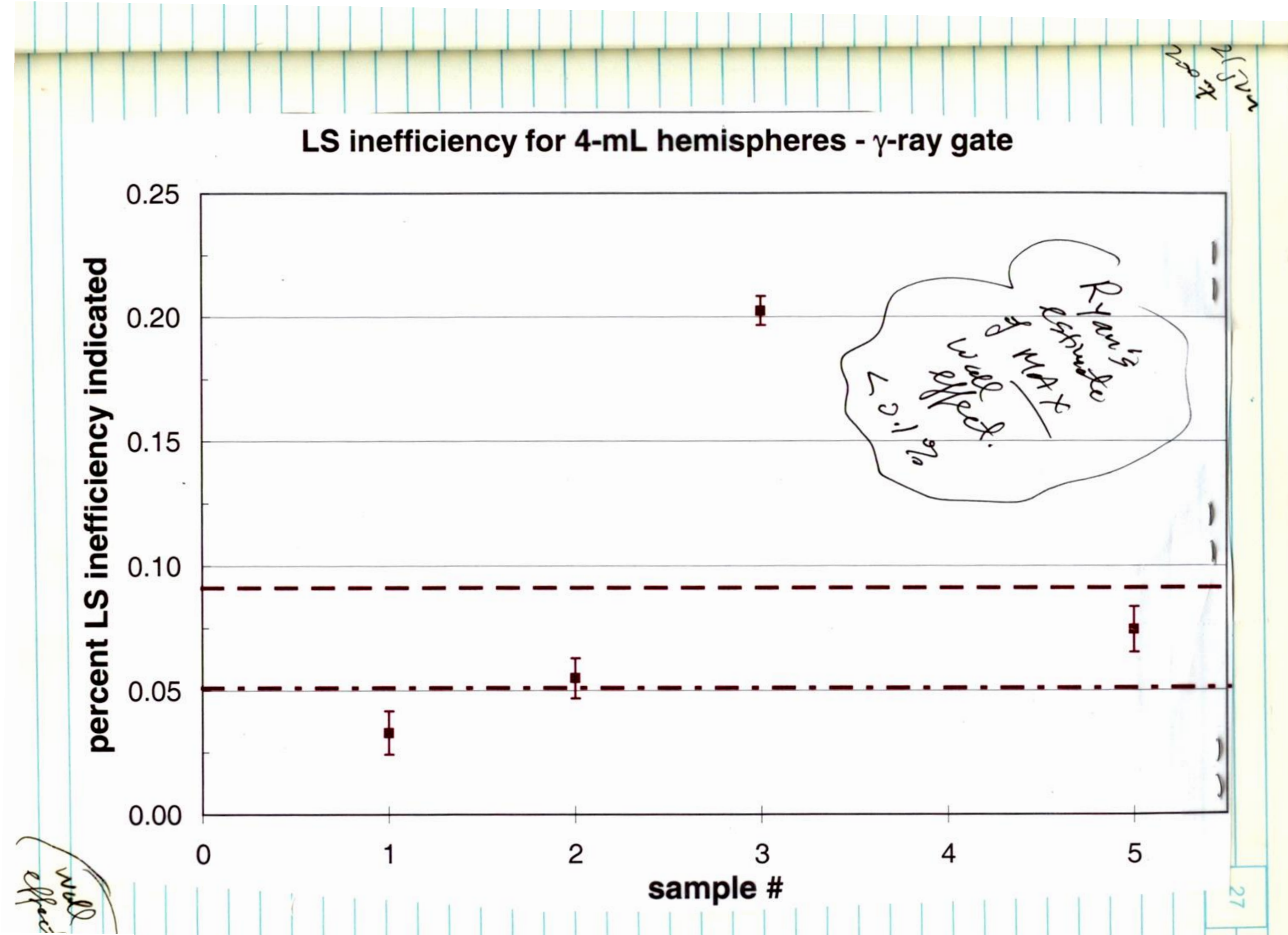


cleanest expt !

< 0.06 % effect



from Ryan


LS inefficiency for 4-mL hemispheres - γ-ray gate
percent LS inefficiency indicated
0.25
0.20
0.15
0.10
0.05
0.00
0
1
2
3
4
5
sample #
Ryan's estimate of MAX wall effect.
< 0.1%
wall effec

With Brian

Si(Li) detector

Set up this past summer

Windowless chamber

Pump problems

We have to move !

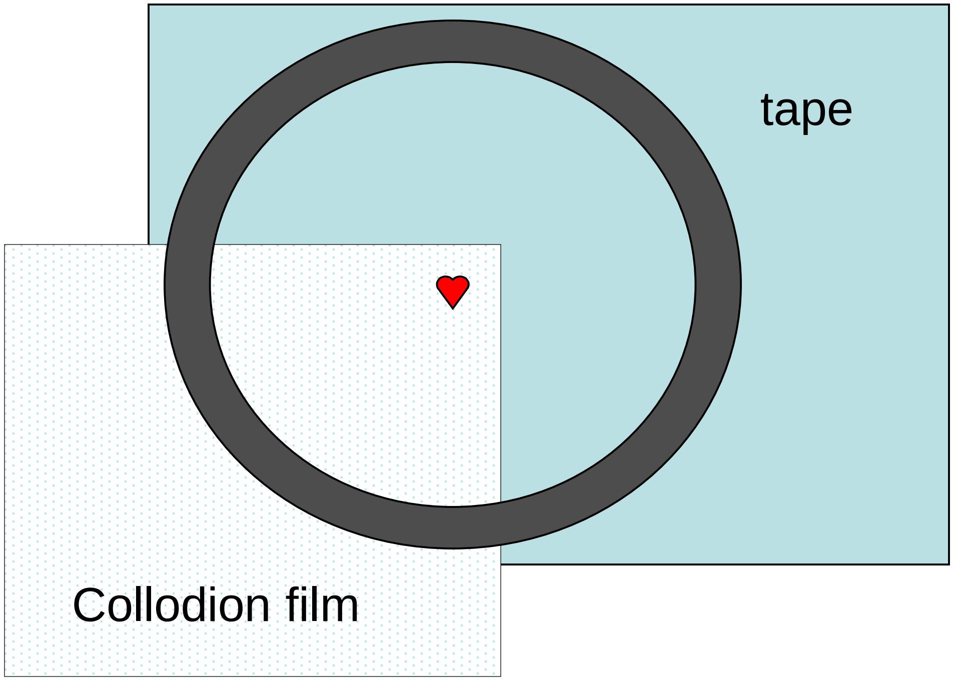
No time to work on

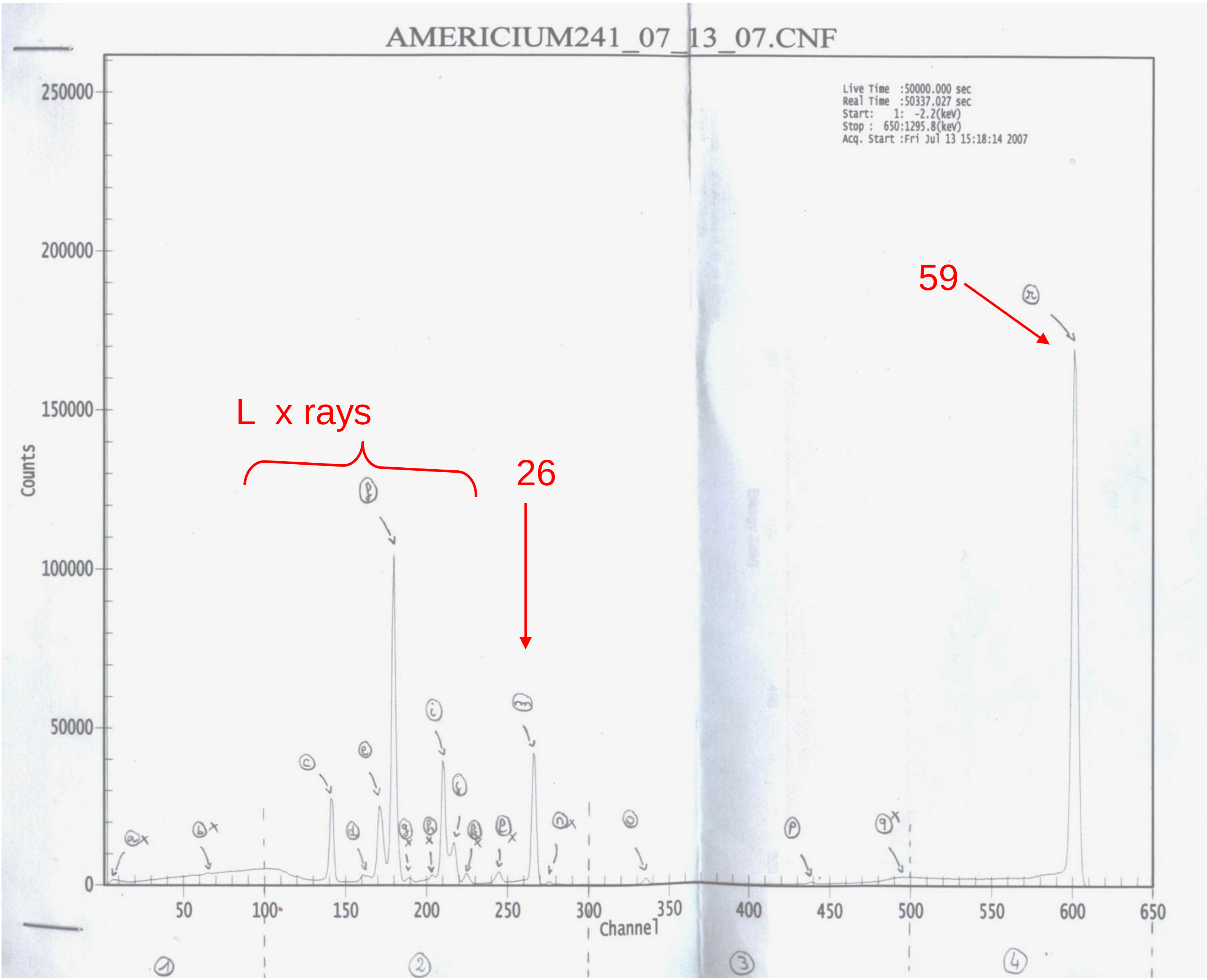
Can <u>see</u> down to Al K x rays – 1.5 keV

Can measure in ampoules

down to ^{241}Am L x rays (> 12 keV)

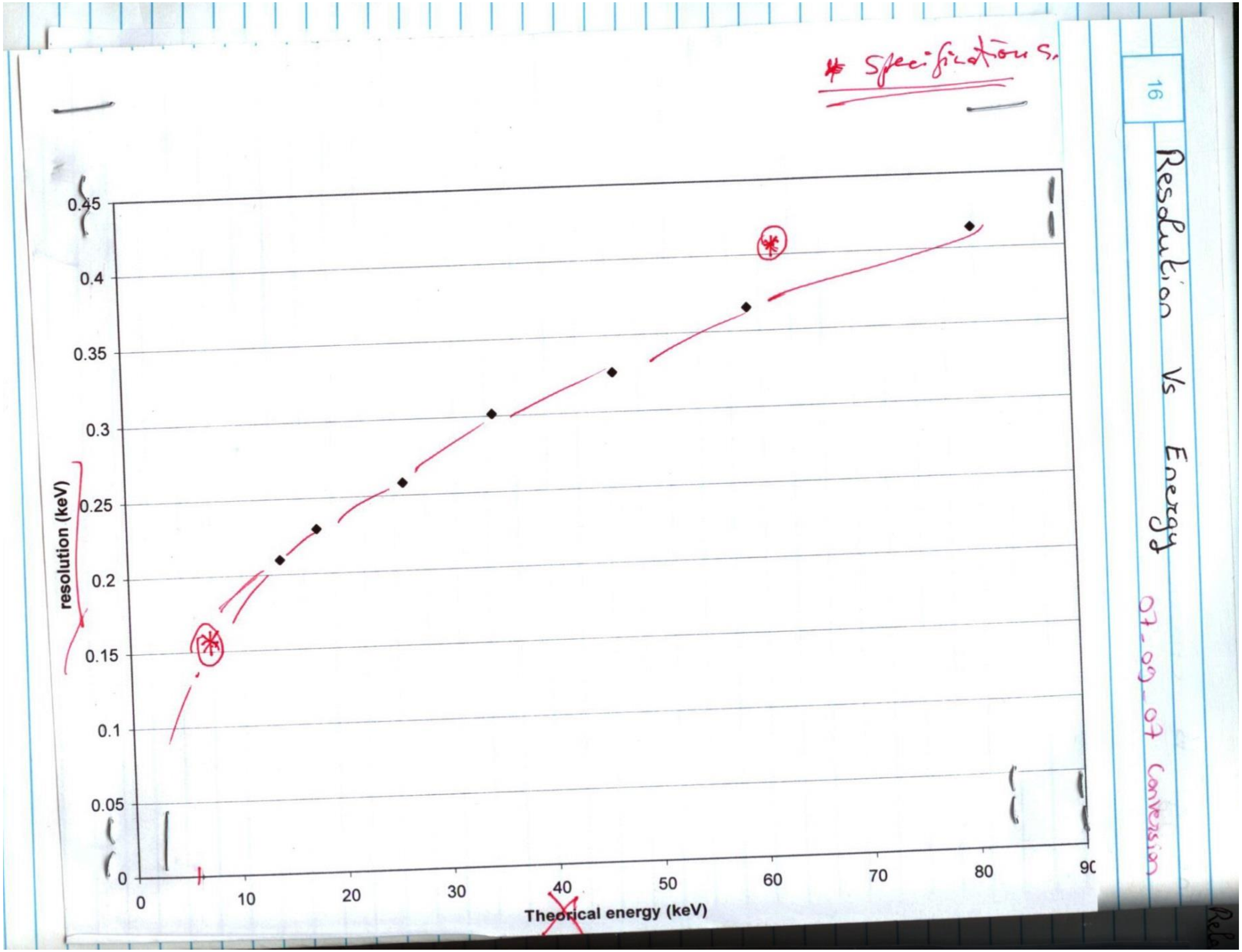
Point sources in range of few keV to > 100 keV





AMERICIUM241_07_13_07.CNF
Live Time :50000.000 sec
Real Time :50337.027 sec
Start: 1: -2.2(keV)
Stop : 650:1295.8(keV)
Acq. Start :Fri Jul 13 15:18:14 2007
Counts
Channel
L x rays
26
59

Detector resolution -- to specs



Cryogenic microcalorimeter for alpha spectroscopy

Collaboration with

NIST Boulder – (Joel ULLOM)

Los Alomos (Steve LAMONT

LNHB (Elvire LEBLANC)

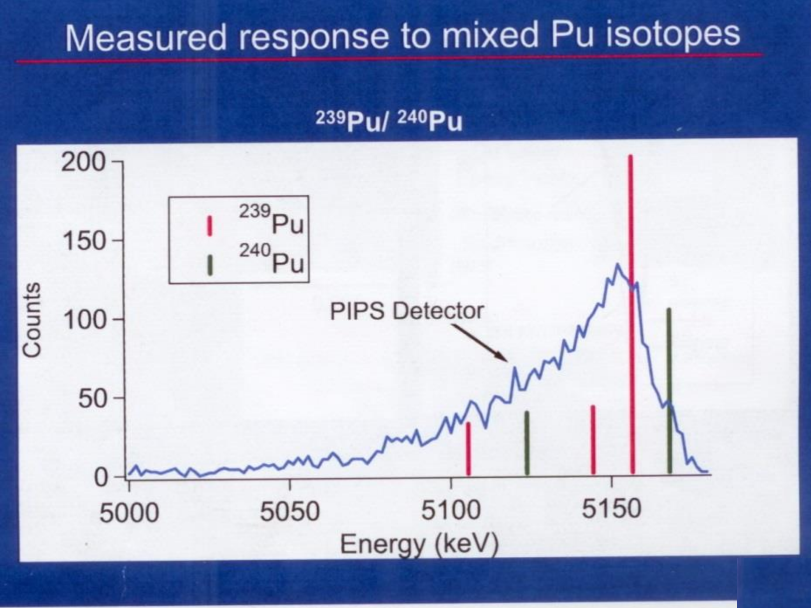
Source prep.

world’s record energy resolution

< 2.5 keV for alphas

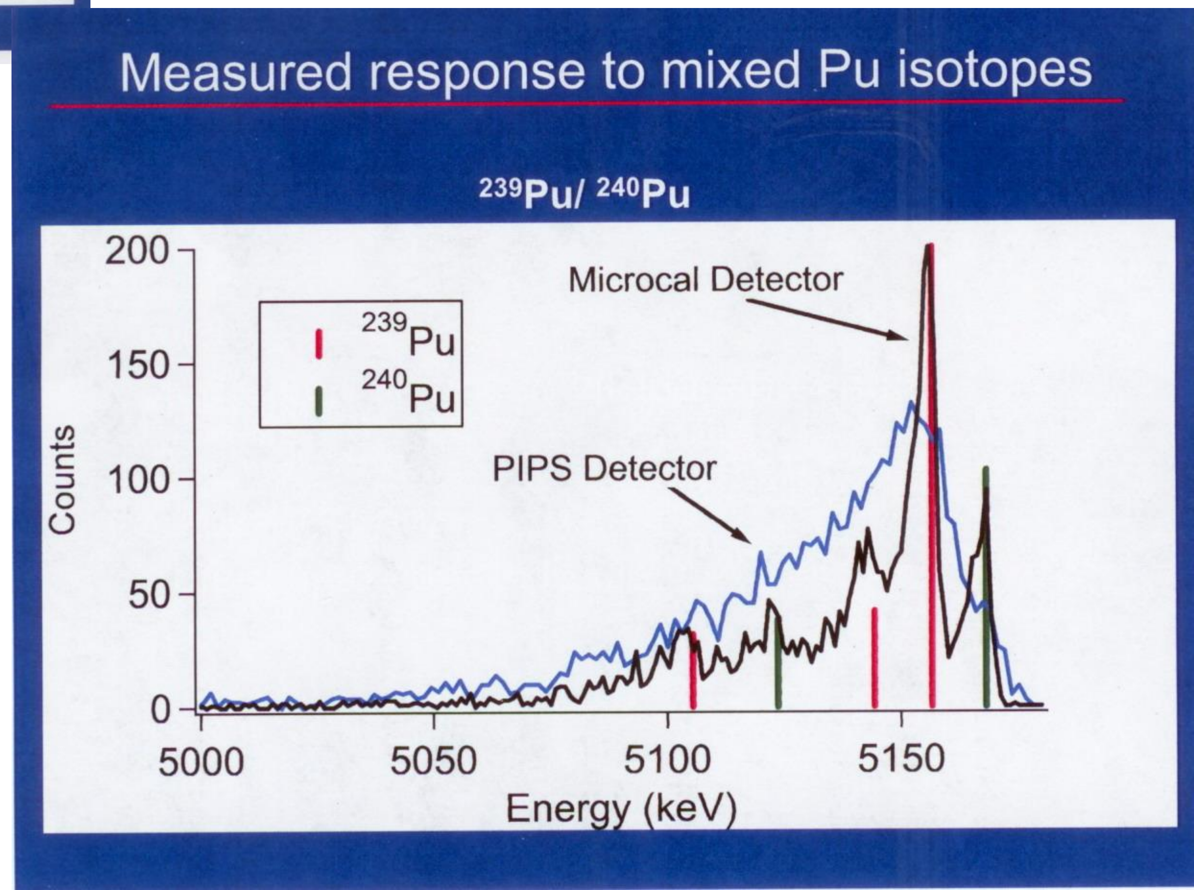
soon

First trials with our ^{229}Th master

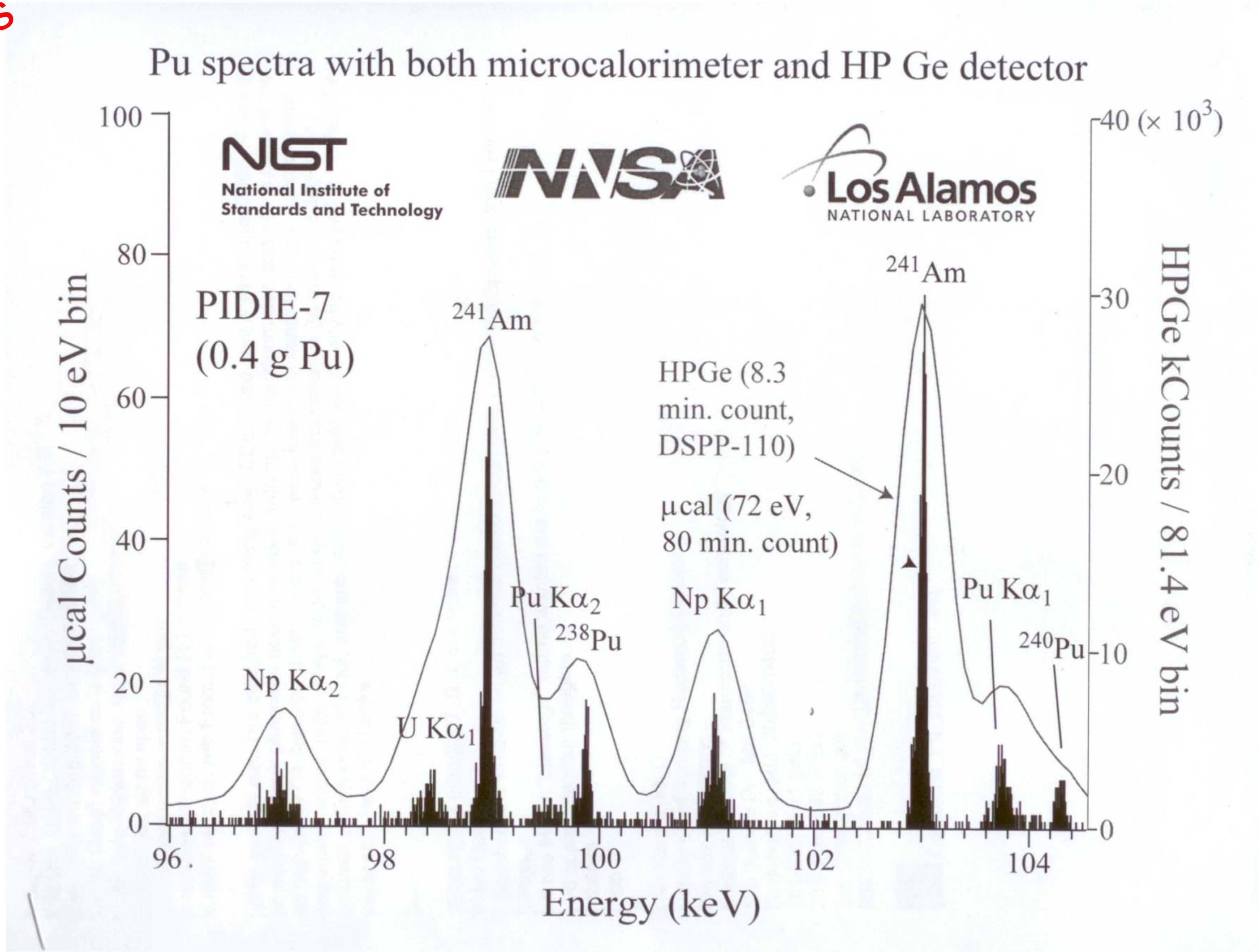


Si detector for 5 unresolved lines

Compare with
cal response



results for photons



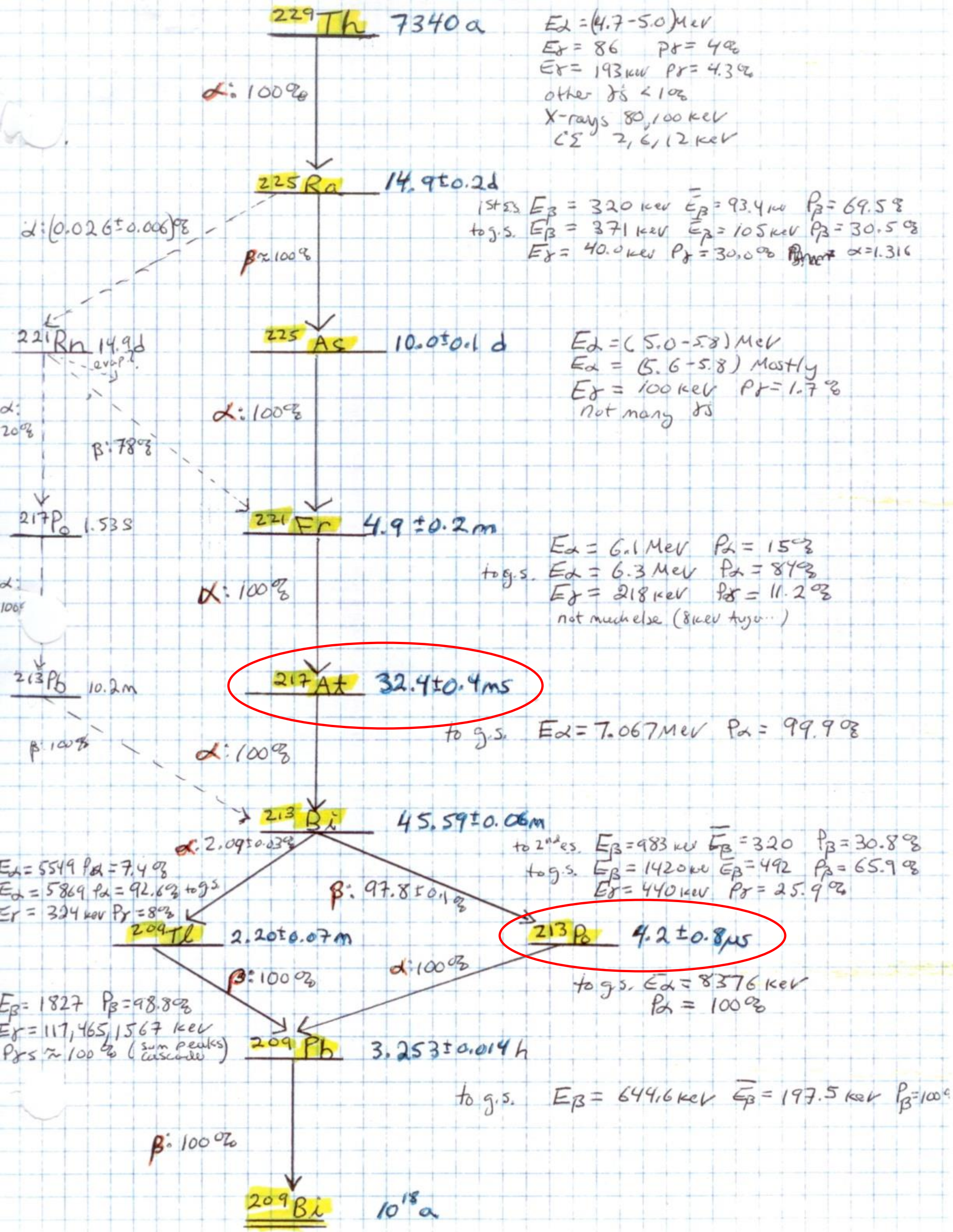
^{229}Th

$ 75K + SRM (fin Dec 2008)

Difficult chain + impurities

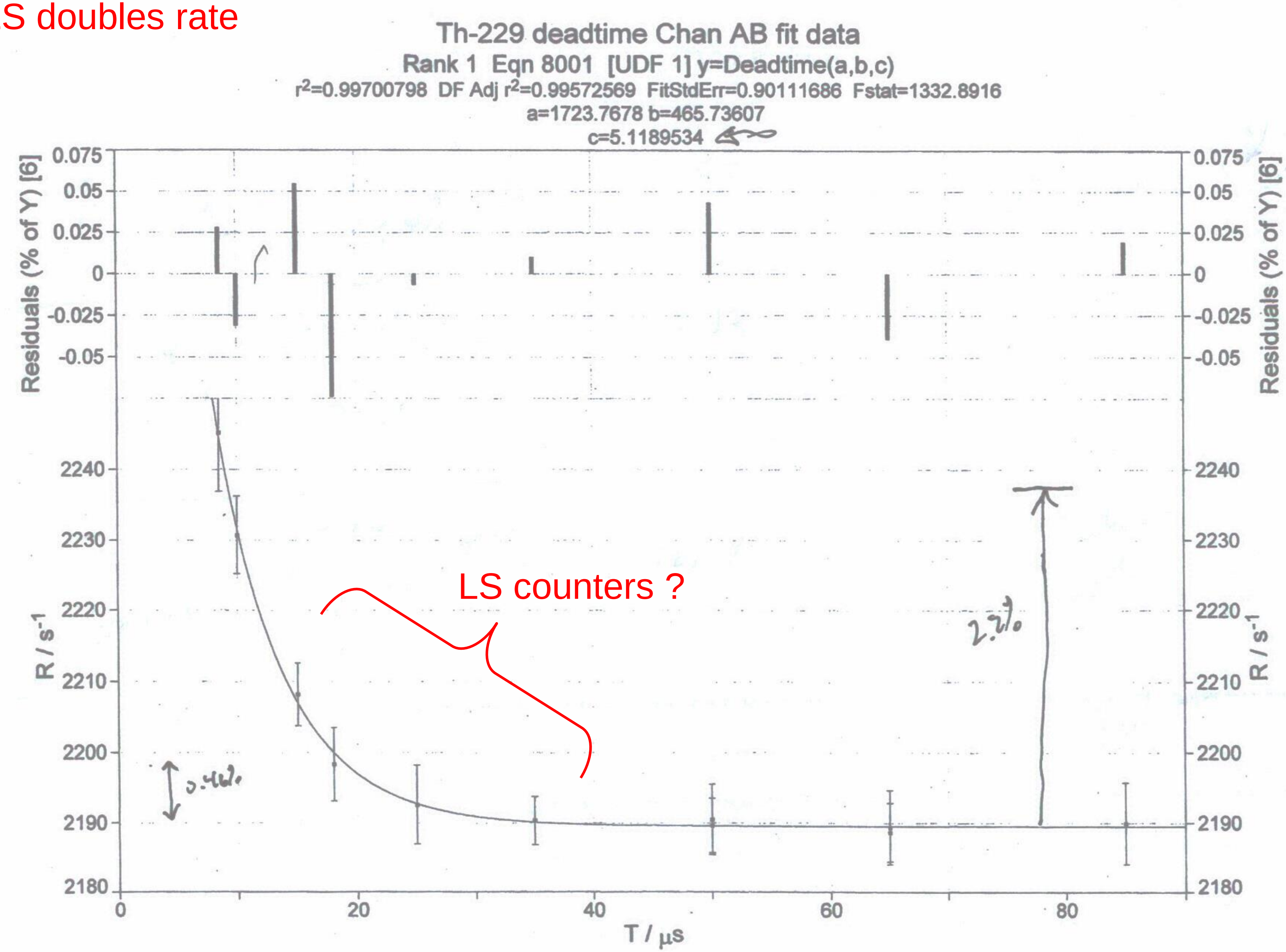
- Ken – made master solution from Oak Ridge ✓
- Liz & I -- made first batch of 280 SRM ampoules (5 year supply !) ✓
- Brian -- used TDCR to look at effect of resolving time on LS doubles rate ✓
- Started LS CNET vs ^{3}H for betas -- ✓
  3 cocktail compositions
  counting done

  many calculations still to do
- Ryan – primary comparison with anticoincidence counting
- Brian – TDCR maybe
- Comparison with LNHB
- Comparison with Los Alamos – maybe ?
  + cal sources for Boulder
- Lynne – made first cut $2\pi\alpha$ pc measurements ✓
- lisa – looked at Si spectrum ✓
- Ryan & I – will redo $2\pi\alpha$ pc with known resolving times
- will need impurity analyses (probably with chemistry)


229Th 7340a
Eα = (4.7-5.0) MeV
Eγ = 86 Pγ = 4%
Eγ = 193 keV Pγ = 4.3%
other γs < 1%
X-rays 80, 100 keV
CΣ 2, 6, 12 keV
α: 100%
225Ra 14.9±0.2d
α: (0.026±0.006)%
1st e.s. Eβ = 320 keV Ēβ = 93.4 keV Pβ = 69.5%
to g.s. Eβ = 371 keV Ēβ = 105 keV Pβ = 30.5%
Eγ = 40.0 keV Pγ = 30.0% α = 1.316
β ≈ 100%
221Rn 14.9d
evap.?
α: 20%
β: 78%
225Ac 10.0±0.1 d
Eα = (5.0-5.8) MeV
Eα = (5.6-5.8) Mostly
Eγ = 100 keV Pγ = 1.7%
not many γs
α: 100%
217Po 1.53s
α: 100%
221Fr 4.9 ±0.2m
Eα = 6.1 MeV Pα = 15%
to g.s. Eα = 6.3 MeV Pα = 84%
Eγ = 218 keV Pγ = 11.2%
not much else (8 keV x-rays...)
α: 100%
213Pb 10.2m
β 100%
217At 32.4±0.4ms
to g.s. Eα = 7.067 MeV Pα = 99.9%
α: 100%
213Bi 45.59±0.06m
α: 2.09±0.03%
Eα = 5549 Pα = 7.4%
Eα = 5869 Pα = 92.6% to g.s
Eγ = 324 keV Pγ = 8%
to 2nd es. Eβ = 983 keV Ēβ = 320 Pβ = 30.8%
to g.s. Eβ = 1420 keV Ēβ = 492 Pβ = 65.9%
Eγ = 440 keV Pγ = 25.9%
β: 97.8±0.1%
209Tl 2.20±0.07m
213Po 4.2±0.8μs
β: 100%
α: 100%
to g.s. Eα = 8376 keV
Pα = 100%
Eβ = 1827 Pβ = 98.8%
Eγ = 117, 465, 1567 keV
Pγs ≈ 100% (sum peaks) (cascade)
209Pb 3.253±0.014 h
to g.s. Eβ = 644.6 keV Ēβ = 197.5 keV Pβ = 100%
β: 100%
209Bi 10^18 a

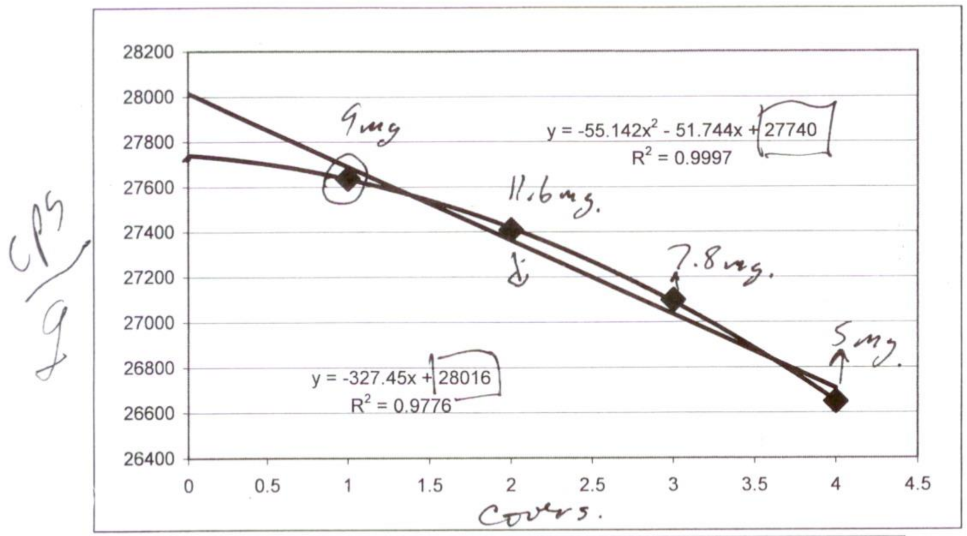
Effect of resolve time on LS doubles rate

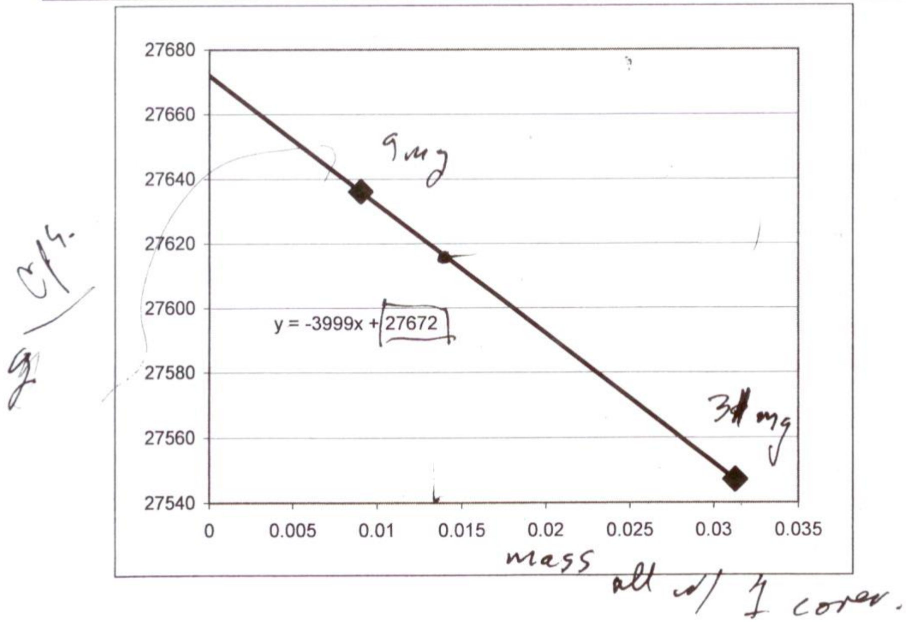
$Y = a + b/(1-e^{-\lambda(c+x)})$



		5.391246			
a1	1	5.38225	0.009005	248.8624	27636.04
a2	2	5.370708	0.011554	316.6593	27407.98
a3	3	5.362959	0.007757	210.1835	27096.85
a4	4	5.357839	0.005125	136.5754	26648.23
b1	1	5.333601	0.024262	x	0
c1	1	5.302373	0.031259	861.0993	27547.04

2πα pc





Rough approx.

Extrapolates to 27.7 cps/g

Assume 2π eff.

No impurities or side branches

Don't know resolve time yet

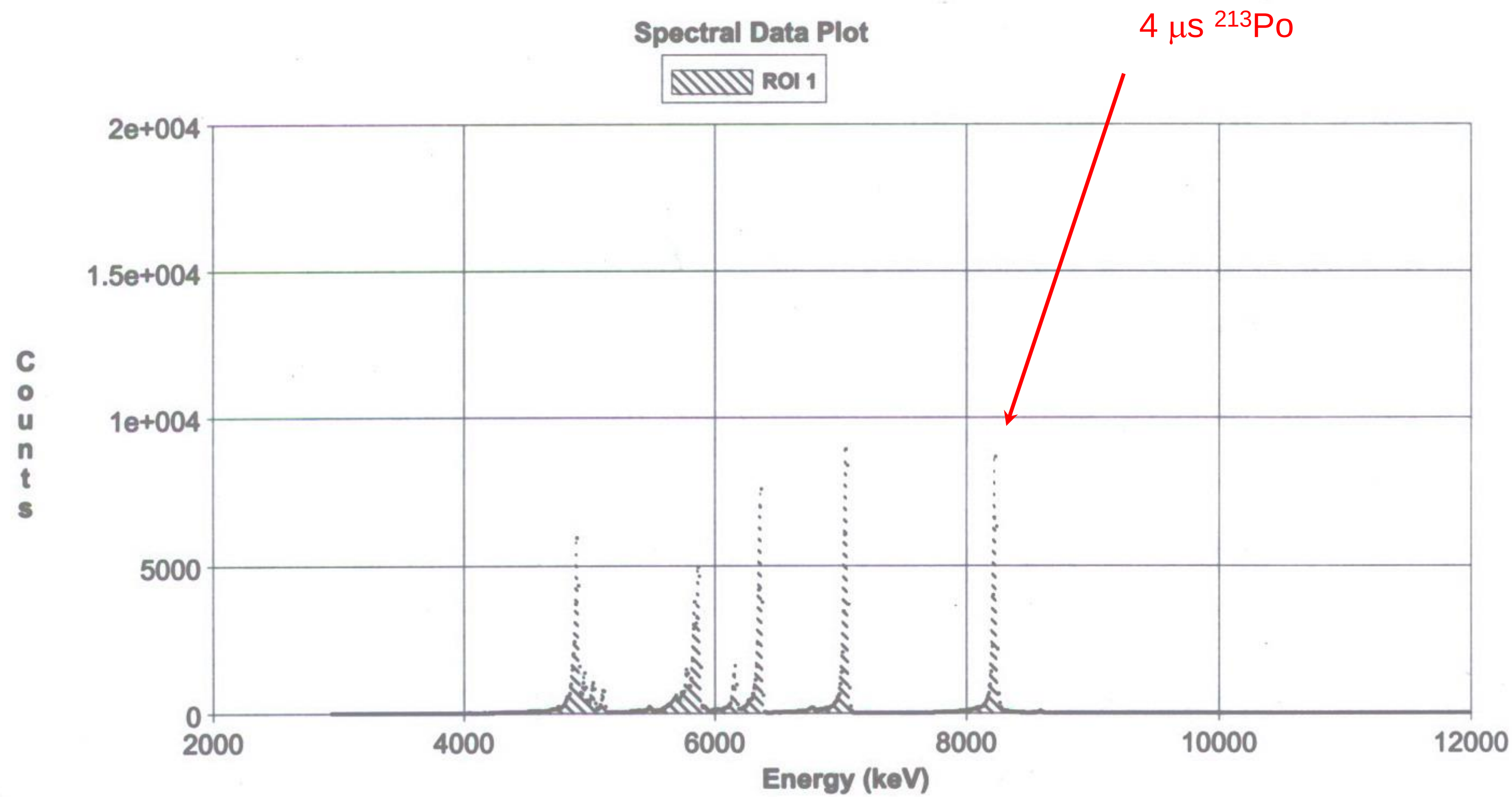
If 5 alphas (see <u>all</u> ^{213}Po)

2(27.7)/ 5 = **11.1** Bq/g

If 4 alphas (see <u>no</u> ^{213}Po)

2(27.7)/ 4 = **13.9** Bq/g

12/21/07 Th spectra



Datasource:	RON TH DET10 DEC2107.CNF
Live Time:	11350 sec
Real Time:	11355 sec
Acq. Start:	12/21/2007 9:54:55 AM
Start:	1 : 2938.99 (keV)
Stop:	1024 : 11963.72 (keV)

$\boxed{\text{LS EFF.}}$

^{229}Th

$\downarrow$ (1)

^{225}Ra

$\downarrow$ (2)

^{225}Ac

$\downarrow$ (3)

^{221}Fr

$\downarrow$ (4)

^{217}At

$\downarrow$ (5)

^{213}Bi

2% (7) α $\swarrow$ $\searrow$ β (6) 98%

^{209}Tl $\qquad$ ^{213}Po

(9) β $\searrow$ $\swarrow$ α (8)

^{209}Pb

$\downarrow$ (10)

$\underline{^{209}Bi:}$ 10^{18} a

$\varepsilon_1 = 1$ α

$\varepsilon_2 = 0.85$ β guess

$\varepsilon_3 = 1$ α

$\varepsilon_4 = 1$ α

$\varepsilon_5 = 1$ α ← 32.4 ms 0.1% loss at 50 μsec

$\varepsilon_6 = 0.98(1)$ $\cancel{\alpha}$ β hi new 100%

$\varepsilon_7 = 0.02(1)$ α ~~[illegible]~~

$\varepsilon_8 = 0.98(?)$ ← α 4.2 μs ← see 19% at 10 μsec, <u>all</u> lost at 50 μs

$\varepsilon_9 = 0.02(0.95)$ β guess

$\varepsilon_{10} = 0.98$ β like ^{90}Sr

$$\varepsilon_{LS} = 6.85 + \varepsilon\begin{pmatrix} 4.2\,\mu s \\ \alpha \end{pmatrix}$$

LS first crude cut

Th-229

	cps/g	sd %	Counter	10 min Cycles	fw
UGAB1	77336.22	0.165257	Packard	3	
UGAB2	77268.92	0.190814	Packard	3	
PCS	77190.91	0.189676	Packard	3	
UGAB1	79106.91	0.223437	Wallac	3	
UGAB2	78903.73	0.146673	Wallac	3	
PCS	78966.62	0.170525	Wallac	3	
UGAB1	79150.64	0.220805	Wallac	3	
UGAB2	78779.36	0.191218	Wallac	3	
PCS	78884.99	0.225582	Wallac	3	
UGAB1	77130.63	0.147437	Beckman	3	
UGAB2	76943.44	0.166699	Beckman	3	
PCS	77015.76	0.177814	Beckman	3	
UGAB1	77365.2	0.184959	Packard	5	
UGAB2	77036.89	0.213024	Packard	5	
PCS	77172.07	0.188474	Packard	5	
H-3 PCS	15251.53	16.78472	Packard		
	15172.27	16.74483	Wallac		
	15242.99	16.60561	Wallac		
	20638.06	14.53723	Beckman		
	15027.26	16.59624	Packard		

2.2 % diff.

same

	Wallac	Packard	Beckman
PCS	78.97 78.88	77.19 77.17	77.02
UGAB w/ acid	79.11 79.15	77.34 77.37	77.13
UGAB w/ 3 rp	78.90 78.78	77.27 77.04	76.94
pcs 3H	15.17 15.24	15.25 15.02	20.6

conclude

- independent of composition (expect for α's & hi β's)
- difference between counters due to differences resolve time (not thresholds – see 3H data)

if assume Packard & Beckman see no 213Po

then

$$\frac{77.14}{6.85} = 11.3 \text{ Bq/g}$$

Difference of 10 & 30 μs could account for observed 2.2 % counter difference

Ken's dilution of <u>Oak Ridge activity</u> → **11.25** Bq g^{-1}

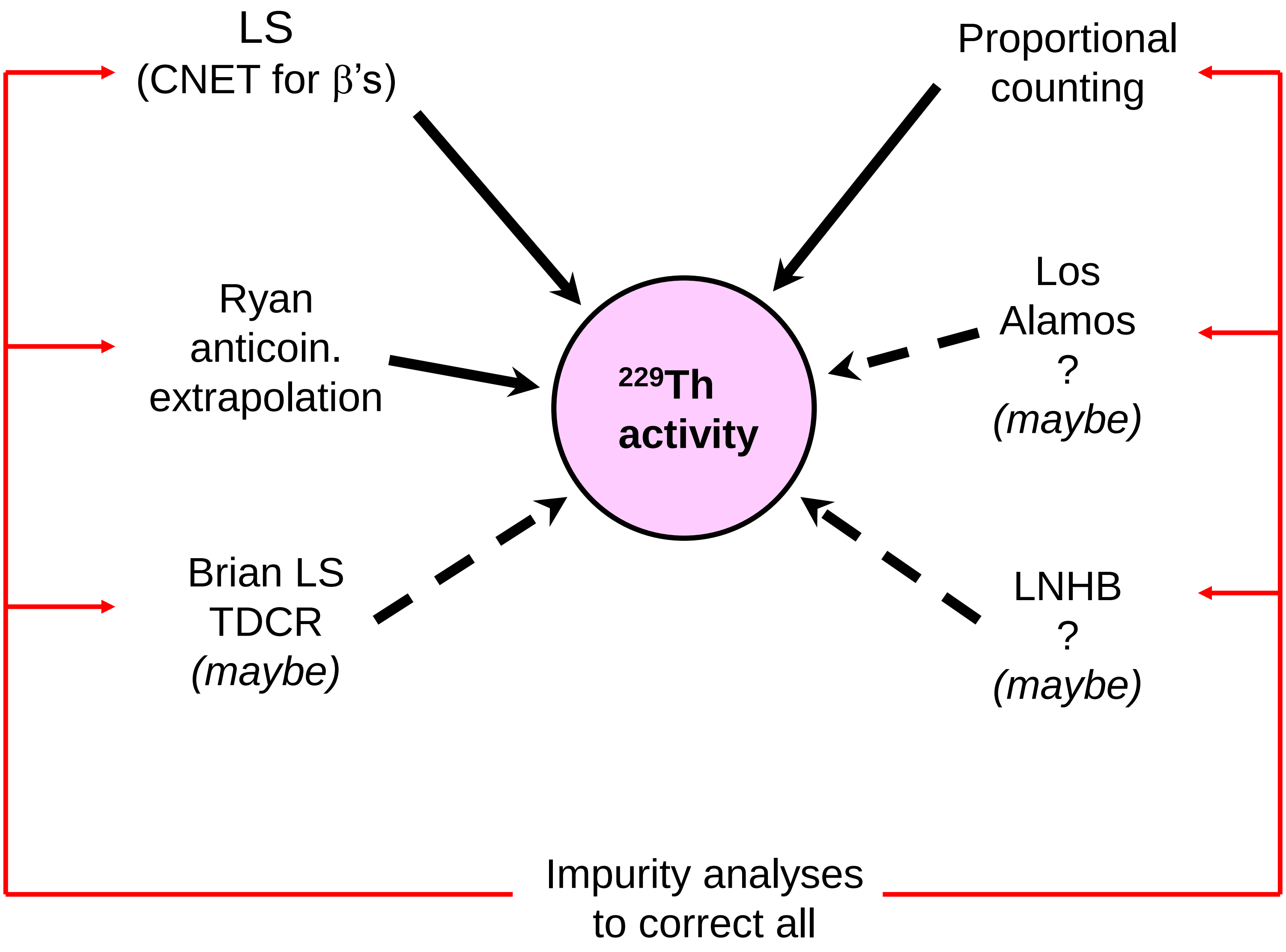
<u>LS</u> eff <u>guess</u> & use Pack & Beck data
only assumes resolve time > 40 μs → **11.3**

Ryan's
<u>first cut</u> → ? → **11.2**

PC / pt sources
<u>approximation</u>
if see all ^{213}Po → **11.1**

Far, far away from being done ....

No corrections yet


LS
(CNET for β's)
Proportional counting
Ryan anticoin. extrapolation
^{229}Th activity
Los Alamos
?
(maybe)
Brian LS TDCR
(maybe)
LNHB
?
(maybe)
Impurity analyses to correct all