NaI Gamma-Ray Spectroscopy

Thursday, January 11, 2018 9:16 AM

Station 2 Partner: Nick Quartemont

Insert 1-5

4] Pre-Lab Prep

IT = Isomeric Transition
→ Gamma Ray or Internal Conversion

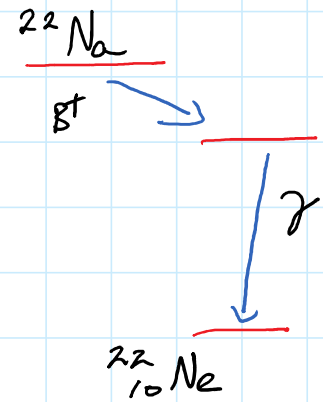
Photo Peak: Full energy deposition

a) Review decay schemes for

^{22}Na

β^+ 215.54 KeV
835.00 KeV

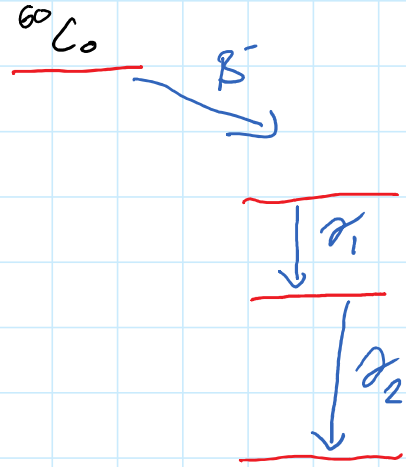
γ 1274 KeV

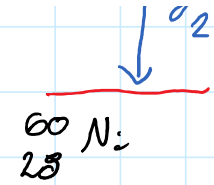


^{60}Co

β^- 317.32

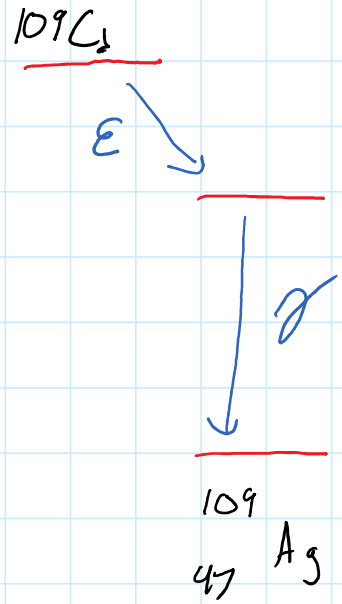
γ_1 1173.24 KeV
γ_2 1332.508





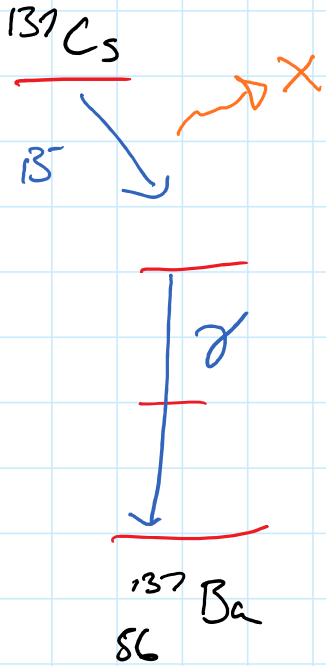
^{109}Cd

ε	100%	
γ	100%	88.0336 KeV
X-ray	22.163	
	21.99	
	2.634 - 3.748	
	24.9118	



^{137}Cs

β^-	513.97	94%
	1175.63	8%
γ	283.5	~0%
	661.659	94.36%
X	32.1939	



b) Gamma Spectra detectable γ and X rays

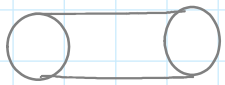
NaI (TI)

La Br_3

6] Procedure

Tuesday, January 16, 2018 1:28 PM

$LaBr_3$



Smaller than the NaI

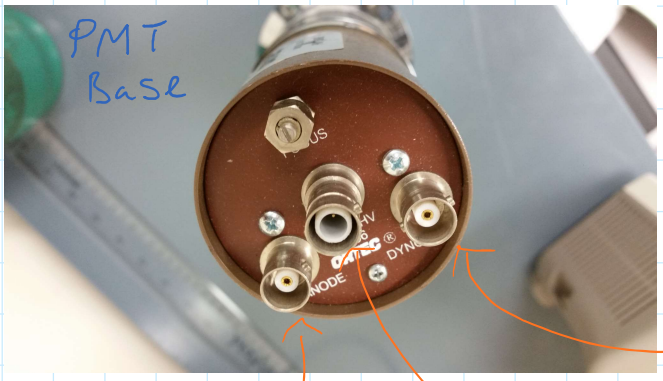
Both require a High voltage connection

NaI(TI) 3"

5] Equipment

2x2 NaI(TI)

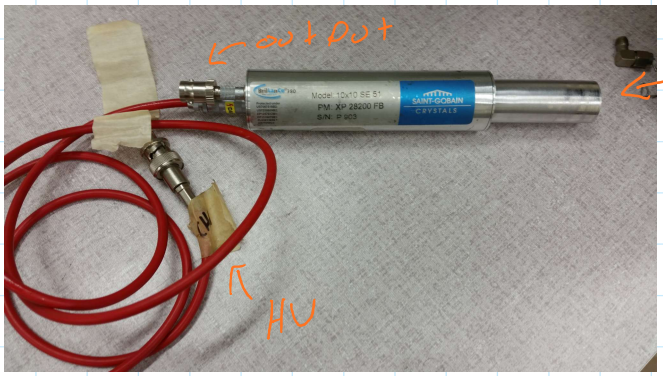
3x3 NaI(TI)



Dynode

Anode

High Voltage



$LaBr_3$

Back contains output for test (Hookup to Pulser)

Back contains output for test (Hookup to Pulser) and output
→ to Oscope
→ to Linear Amp

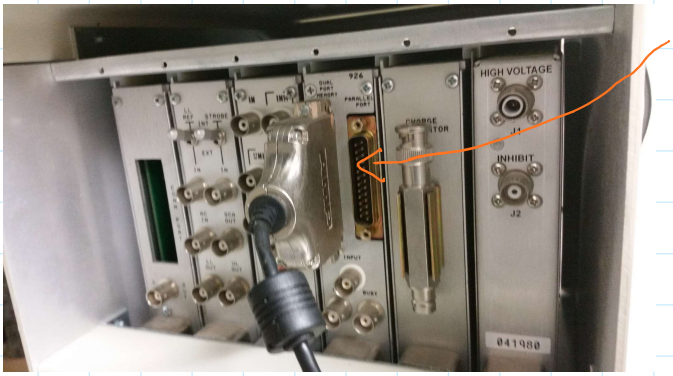
Sources Used

	Activity	Time Rec	Source Num	Uncertainty
22 Na				
57 Co				
60 Co	10.26 μCi 379.6 KBq	15 Sep 2007	1263 - 32 - 3 T125	3%
109 Cd	97.56 μCi 3610 KBq	1 Mar 2013	1647 - 82 - 51	
137 Cs	10.02 μCi 370.7 KBq	1 Aug 98 12 PST	6199 - 442 T-089	3%

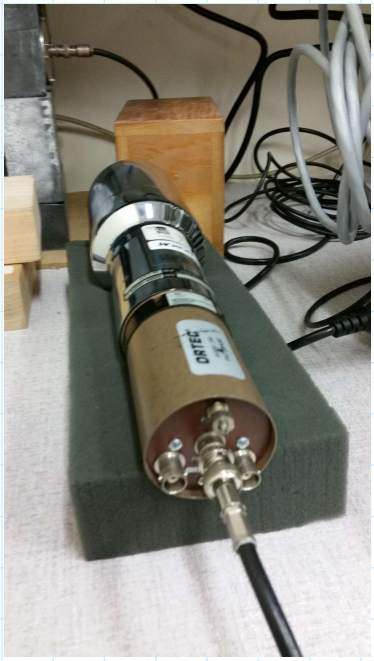
6. Procedure

a) Set up 3x3" NaI (Tl)

1. Set up

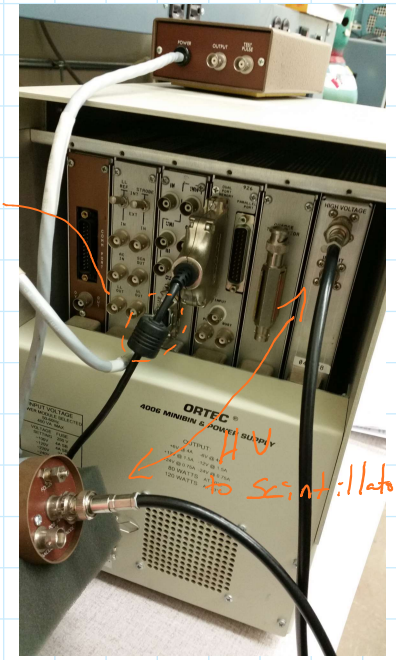


MCB Hookup to Laptop



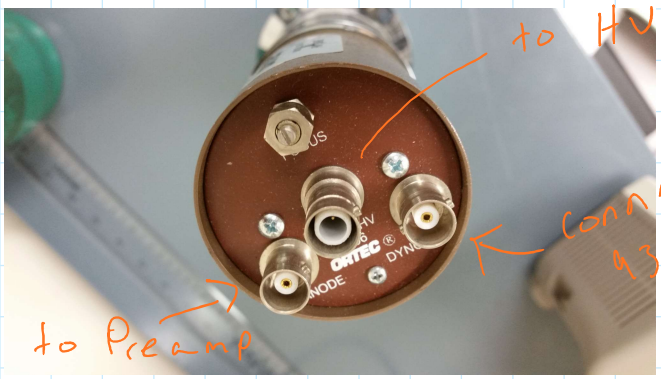
Lie down to prevent rolling. Detection from other side

Pre Amp



HV

to Scintillator

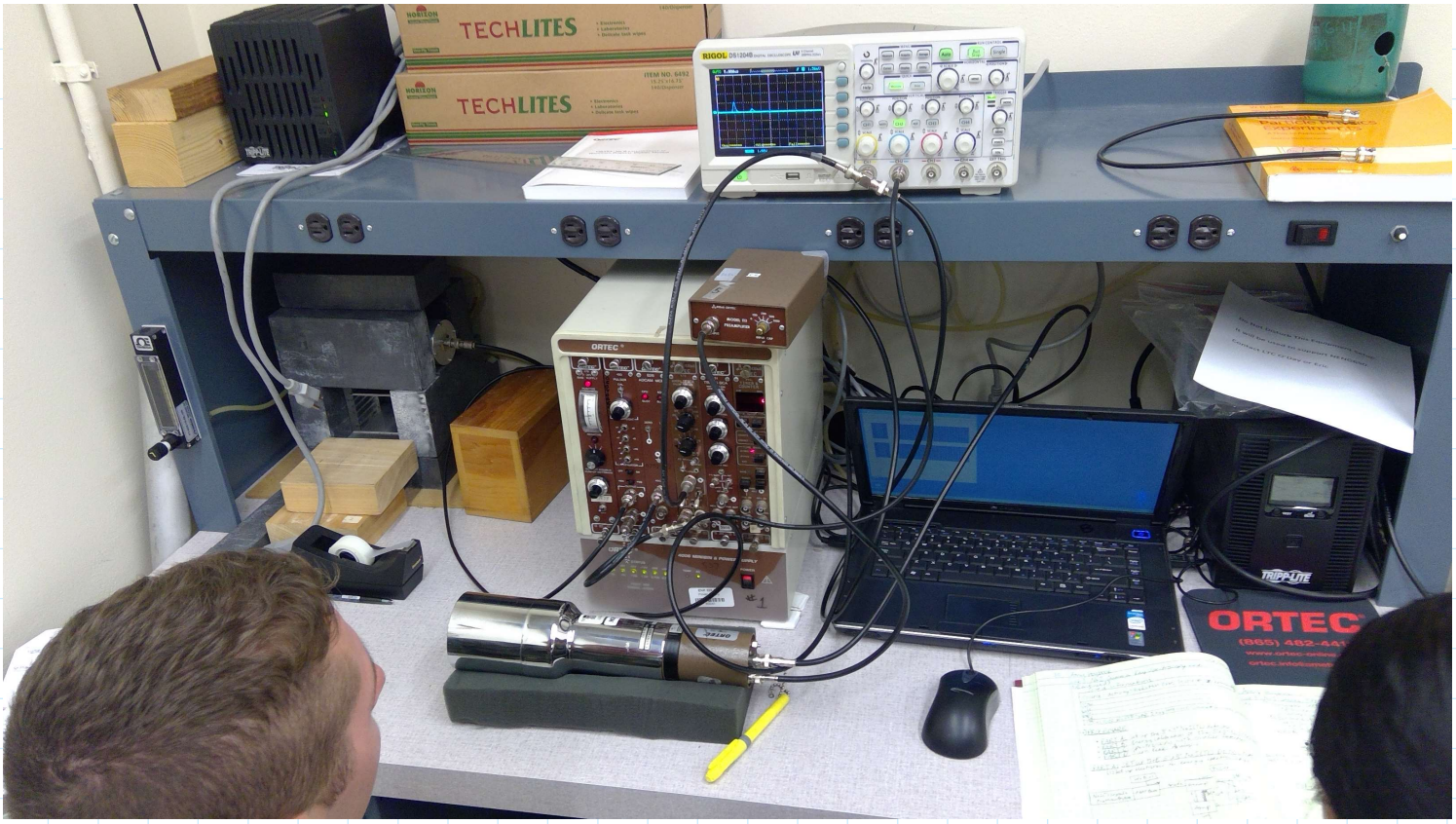


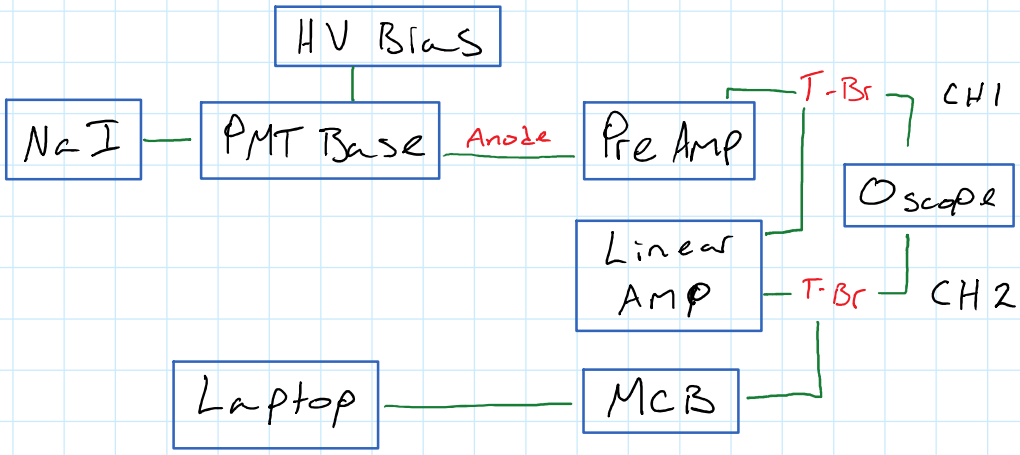
to HV Bias

connect 93 Ω terminator

to Preamp

Note for lab
100 Ω ≈ 93 Ω
Learning only





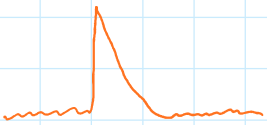
2. On Amp

.5 μs — Shaping time

POS — Input

Uni Polar — Output

Pre amp = 200 pf (capacitance)



increase capacitance

93 Ω Terminator on dynode

Run Gamma Vision

Set Conversion Gain to 1024
(MCB = 1024 channels/bins)
Acquire
↳ MCB Properties
↳ Conversion Gain
↳ arrow select

Note: 10% change in HV bias can change the signal gain by a factor of 2

3. Swapped Oscope to read amplifier output

Vmax = 1.48 v

Pulser	Amplifier
3.34	FG = .68
x1 attenuator	CG = 20
Pos Output	Shape = .5 μs

4. Disconnect Pulser from Pre Amp

Set HV Bias to +1000 v

1 kV

.5

5.00

Note! Make sure everything is at zero when starting

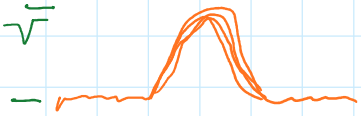
Get 137 Cs Source

TO 89 - Used to look up info in certificate folder

Note: Trigger very Important causes signal to dissapear
Determine wanted signal by seeing it move in accordance to distance

Placed at 25 cm (centered)

4.4 V



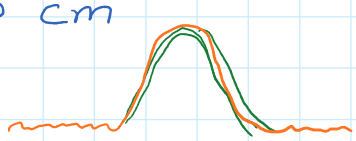
Stable the closer it is to the detector

Amplifier
FG = .5
CG = 20

Shape = .5 μs

Ch 2 = Amplifier Ch 2 = Pre Amp

25 cm



Amp 4.4 V
Rise 800 ns (90% of Amp)
Fall 1.4 μs (90% to 10%)

Jumpy, multiple signals

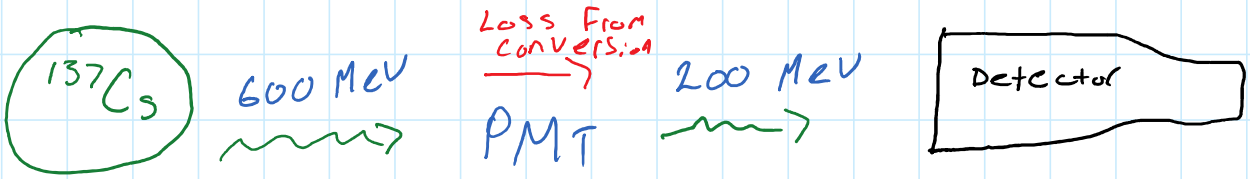
25 cm

Amp 1v

Ignoring since it messes up Amplifier signals
Uses primarily to check for clipping

6. cont] Procedure

4) Set source 25 cm in Front with ~600 V bias



Gamma Ray Vision
- gets spectra
- go, stop, clear on hot bar

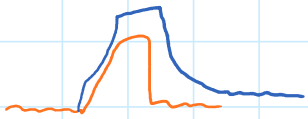
Amp = 200 mV
Trigger = 148 mV

HV Bias	Pulse Amp	Trigger
600 V	200 mV	148 mV
700	656 mV	560 mV
800	1.84 V	1.52 V
900	☆ 4.86 V	3.52 V
1000	☆ 10.2 V	8.2 V
1100	8.6 V	7.6 V
1200	☆ 12.2 V	11.6 V
1300		

change CV

1200 * 12.2 V 11.6 V
1300

* Clipping



ie plateau

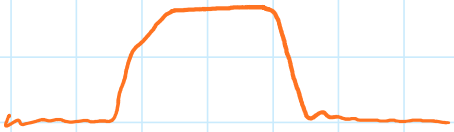
Reduce CG to 20
Keep FG at .5

Pulse Amp = 4.16 V Trigger = 3.76 V

* Redo to see CG change

Bias	Amp	Trigger
900	1.88 V	1.52 V
800	760 mV	688 mV
700	272 mV	248 mV
600	80.8 mV	80

* Obvious clipping on main signal



pic

b) Energy Calibration of 3x3 NaI(Tl)

1. Keep ^{137}Cs at 25 cm
should see a single gamma line at 662 KeV

Adjust FG and CG to get 3v Amp
- lowest achieved was 4.16 v
FG = .5
CG = 20

Gamma Ray vision
marker near channel 300
~ 394
Peak should be 662 keV
1) Highlight Photo peak
- F2 starts arrow keys F2 Stops

2) Calibrate to expected gamma value
- Just Enter

3) Save as a "Spectra" file so it can be analyzed by other programs

① 2. Live time = time detector counts
Real time = actual time

Source	Expected Gamma (kev)	① channel Marker	① Counts
137 Cs	661.659	392.3	75584 ± 388
60 Co	1173.24	676.44	18491 ± 294
	1332.508	764.58	18000 ± 239
109 Cd	88.03	59.92	6047 ± 47

①

109 Cd	88.03	59.92	6047 ± 47

FWHM/Exp γ ↑ Resolution

dead time = Real - Live ↑

	FWHM	Resolution	Real T	Live T
137 Cs	44.22 KeV		182.7	180
60 Co	61.39		182.22	180
* 1332	63.39		"	"
109 Cd	9.01		180.4	180

① 180 s live time = 75757 in acquire

② From pop up not Left-bot corner

Saves

Cesium 137 calibration

① 3. Calibration - Doing this before 2.

① Calibration

1) Select Peak

2) Calibrate -> Energy -> gama expected

3) Save

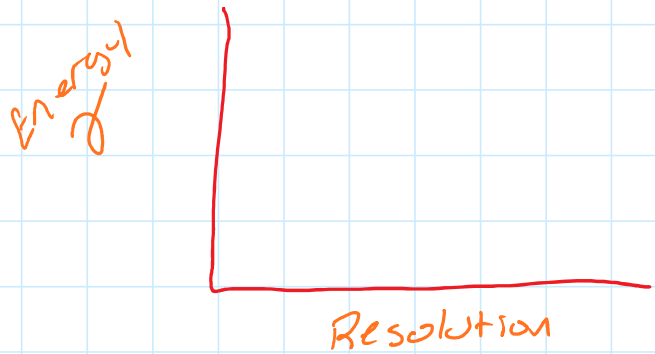
4) 1-3 for new source

5) Merge
→ Perform manual calibration

Note: both files should be open and a drop down menu allows you to swap between them.

4. Recorded/calculated Resolution above

Dependance of resolution on energy

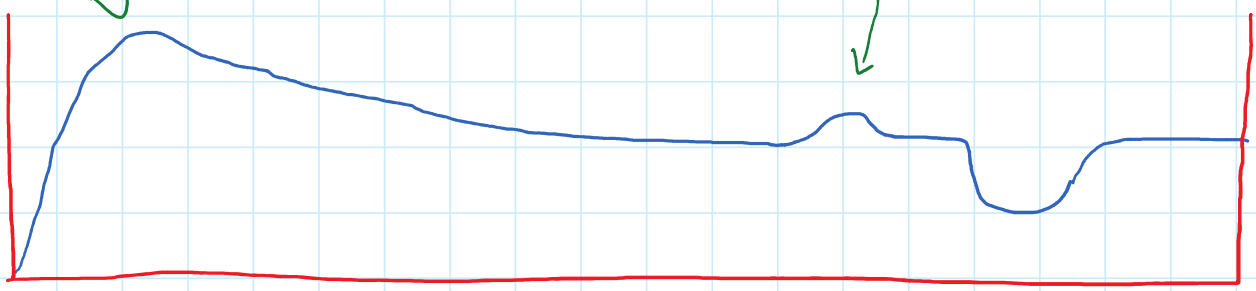


5. Record Background
Acquire
→ MCB settings
→ About
→ Sample txt box
→ My label

Take 180 s background

P.C 10:17 am

Slight peak at
1460 KeV K-40
Noise at lower energies



"K-40 was expected" – Brian Egner

6] C) Smaller Detectors

1. Swap to 2x2 NaI (Tl)
   Set HV Bias to 800 v
   Record Pulse height spectrum for same duration
   - Use Gamma Ray Vision (Laptop)
   - 180 Secs

Live Time →

Oscope
Amp = 3.92 v Trigger = 3.2 v

FG = .5 CG = 200

Removed Calibration

Source	Expected Peak	marker	Peak area Counts	FWHM	Real T
Cs 137	661.659	361.45	697±497		181.16 s

Resolution

requires calibration

2. Swap to $LaBr_3$ 1.5" x 1.5"
Set HV bias to 750 v
Record PHS for same duration
180 s = Live time

Note: This was elevated with a 2x4 wood block

Oscope

distance	Amp	Trigger	FG	CG
25 cm	3.12 v	2.32 v	.6	500
7 cm				

Source	Expected peak	Marker	Real T	distance
Cs 137	661.659	———		25 cm
" "	" "	311.85	180.36 s	7cm

Detected Peak	Counts
543.09	2037 ± 174

d) Sum Peak Analysis

Using 2 x 2" NaI (Tl)
800 HV FG: .5 CG = 100

Source	dist	Expected	Marker	Real	Live
60-Co	5cm	1173	752.13	1545.54	1500.00
		1332			
		2505			

Counts
1325 ± 100

Want to find sum peak expect it to show around $M_1 + M_2$ of the two peaks

channel of 1st peak

7. Analysis

Friday, January 19, 2018 9:46 AM

a) Identify features and their energies in the spectral plots of the 4 sources

Insert pics

b) Compute intrinsic and absolute peak efficiencies of the 3x3 NaI for γs of the 3 std sources

$$\varepsilon_{int} = \frac{\text{events registered}}{\text{events impinging on detector}} \qquad \varepsilon_{tot} = \frac{\text{events registered}}{\text{events emitted by source}}$$

Correct for interfering peaks

Determine the uncertainty in each efficiency due to statistical variation in the counting data

Plot Intrinsic Peak Efficiency = f (energy)

c)

e) beyond uncertainties in counting statistics, what other sources of uncertainty exist in determining efficiency?

Identify do not quantify

Human Error

Source Activity Uncertainty

Experimental set up

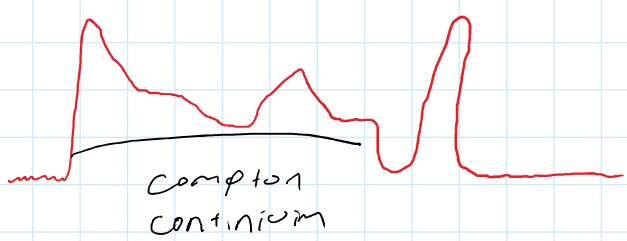
Hardware

→ size of crystal

→ age

→ corrosion

Background noise

f) What produces the counts found between the full energy peak and the Compton edge of a spectrum?

Escaping photons created by compton scattering.