Germanium Detector

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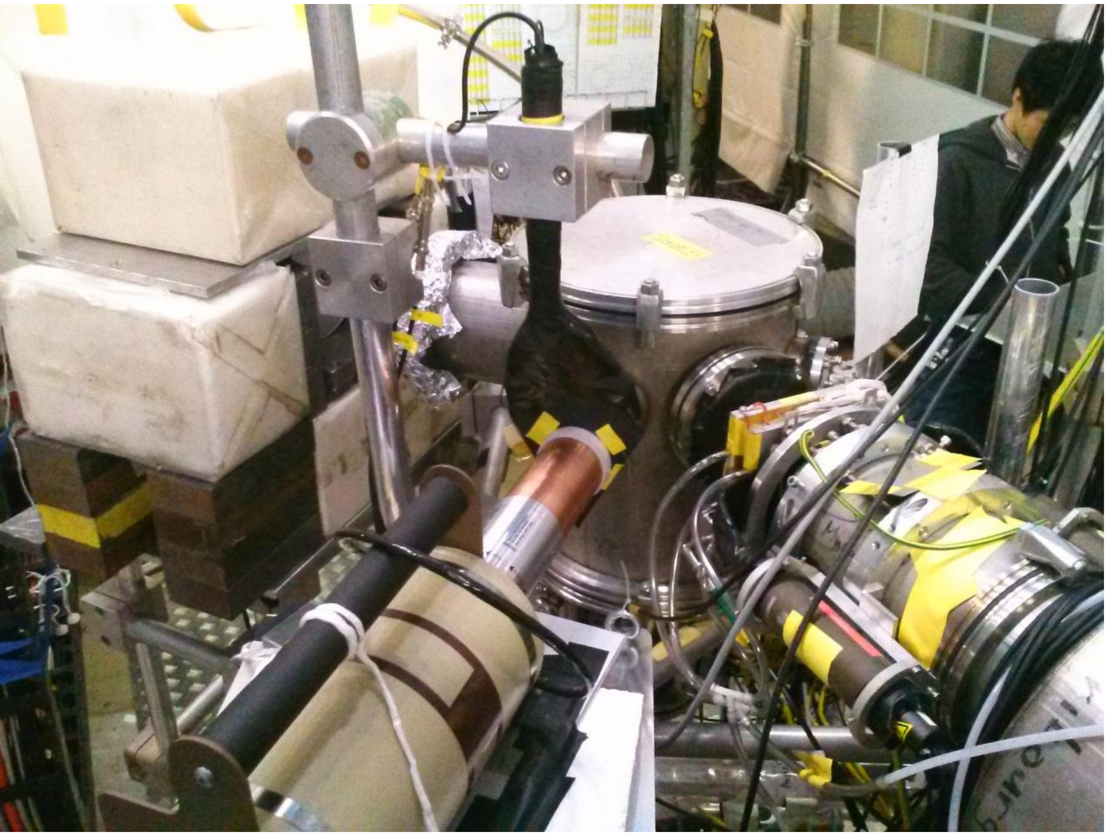
Layout



~23 cm from target, including
1 cm thick Al vacuum plate
5 mm thick (?) Ge veto scintillator
Slow : Ortec Linear Amp (1 us shaping time?)
Fast: Ortec timing filter amp (0.5 us ?)
Fast and slow signals go to
    UH Caen ~16 MHz
These are the only two signals
    going to UH Caen
HV -3500 volts, 1 mA limit, auto reset?

Calculation of Absorption

$$\text{fractional solid angle}=\frac{\pi d^2/4}{4\pi r^2}=0.00325$$

(d=52.5 mm, r=230 mm)

The X-rays of interest are:

- for Al: 346.828 keV (Kα), 66.11 keV (Lα)

- for Si: 400.177 keV (Kα), 76.723 keV (Lα)

We can place the germanium detector either:

- close to the chamber wall (5 mm of stainless steel, 170 mm from the target),

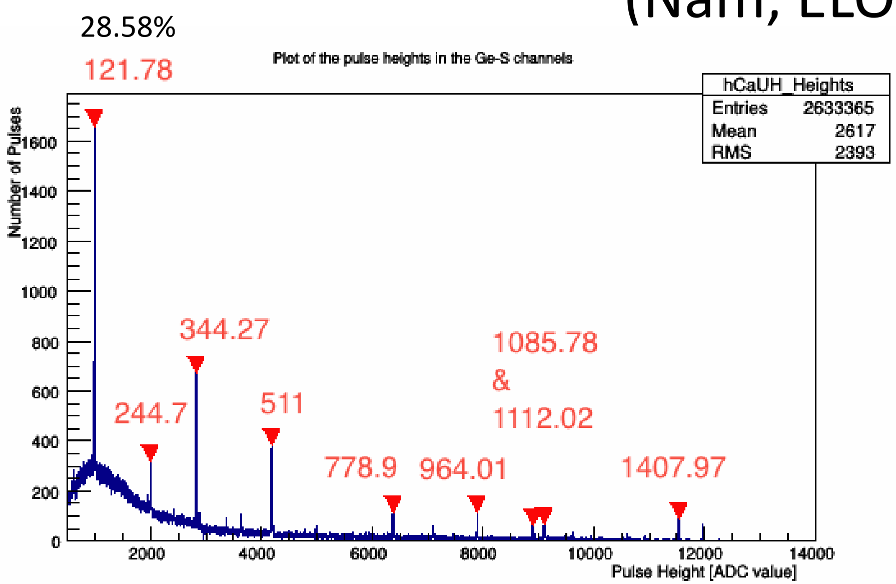
- or at one of the aluminum port (10 mm thick, the closest one is 50 mm from the wall)

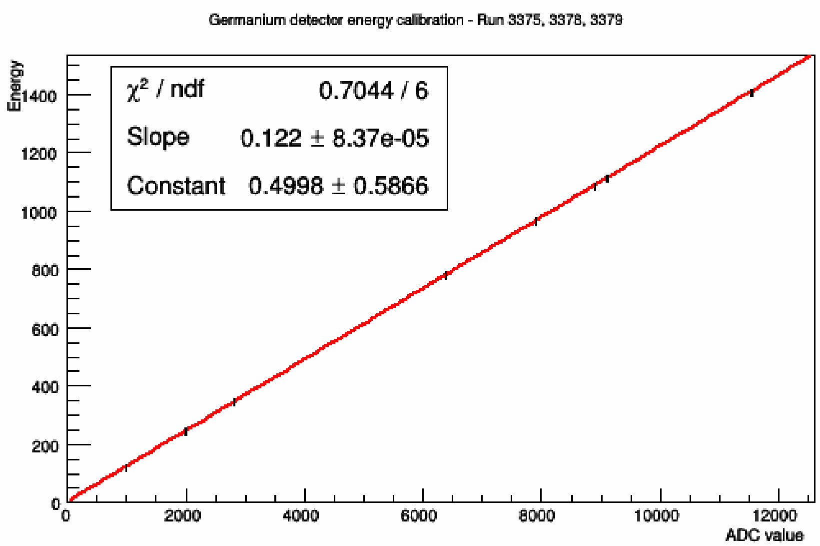
Formula: $I/I_0 = exp(-\mu\rho t)$ where μ is the mass absorption coefficient, ρ is density of the material, t is thickness of the material.

X-ray energy	μ Fe	μ Al	μρt Fe	μρt Al	I/I0 Fe	I/I0 Al	I/I0 Fe	including solid angle Al
0.066	0.945	0.246	3.684	0.664	0.025	0.515	0.025	0.307
0.077	0.650	0.209	2.535	0.564	0.079	0.569	0.079	0.340
0.347	0.101	0.098	0.395	0.265	0.674	0.767	0.674	0.458
0.400	0.094	0.093	0.367	0.250	0.693	0.778	0.693	0.465

Ge Energy Calibration

(Nam, ELOG 365)





Eu 152

Energy: E (keV) = 0.122 x ADC + 0.5

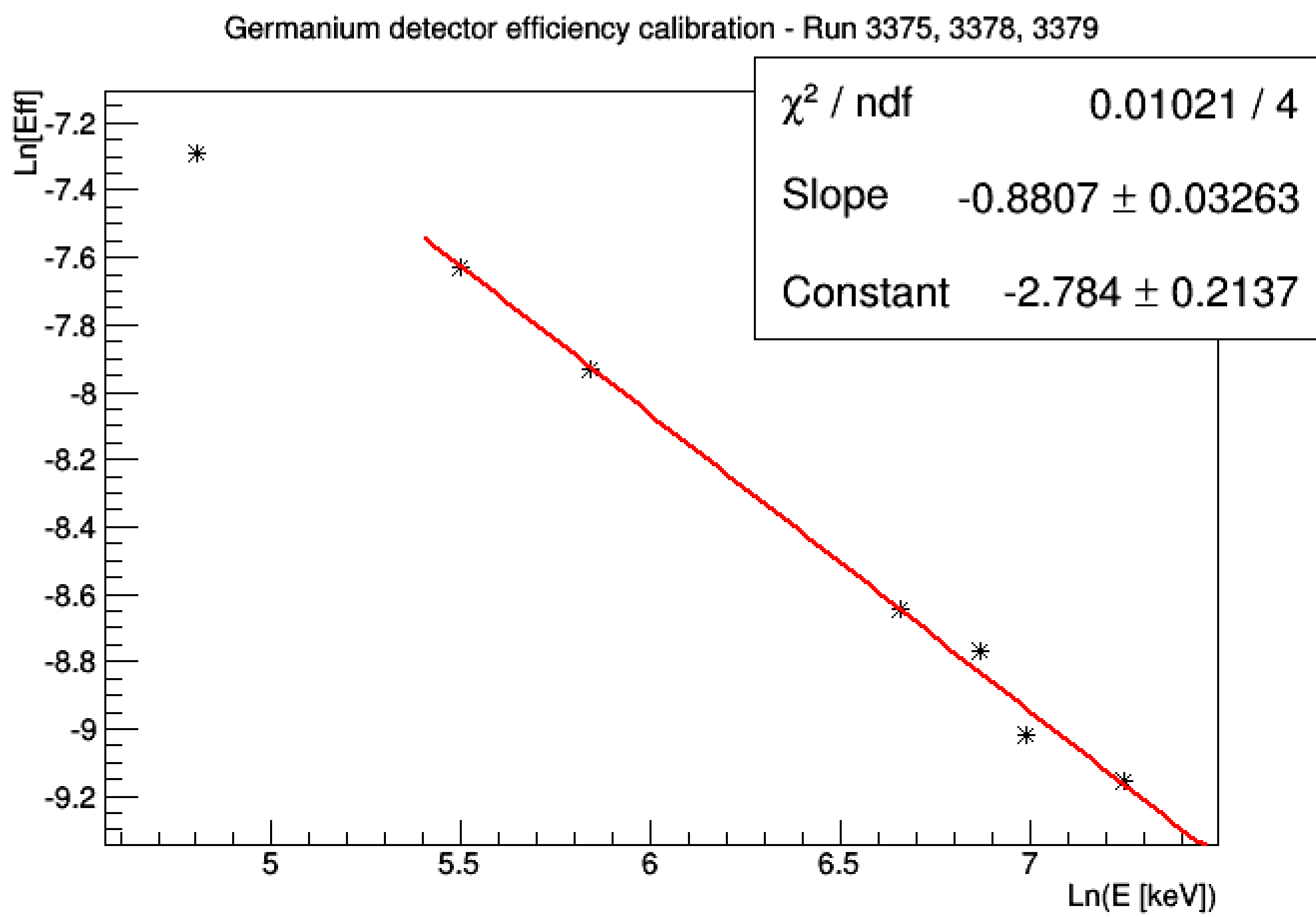
Ge Efficiency (Nam, elog 665)

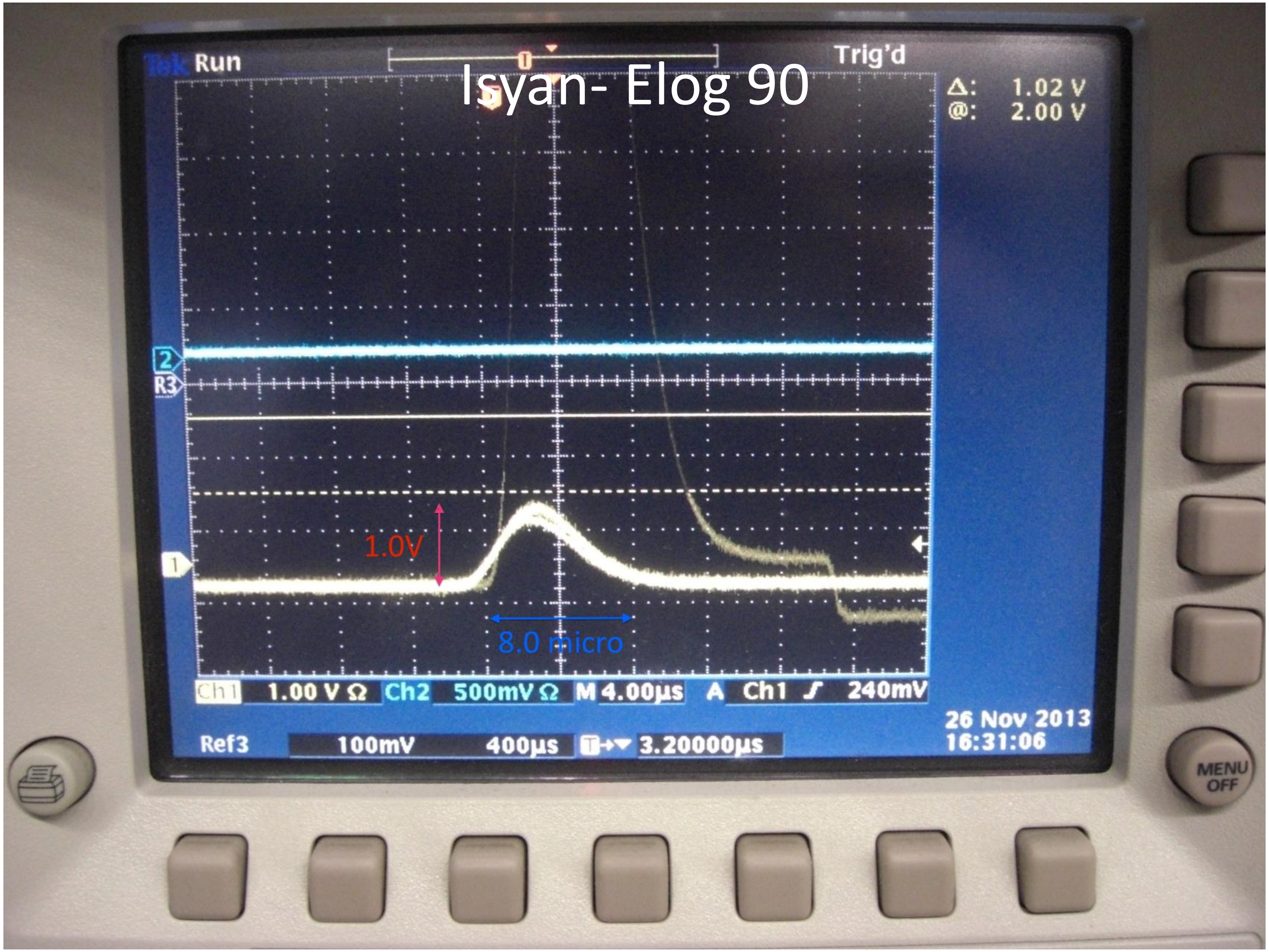
- ~23 cm from target
- ~5.2 cm

dia.

Efficiency: ln(eff) = -0.8807*ln(E[keV]) - 2.784

$$\varepsilon = 0.0618E^{-0.8807}$$




Isyan- Elog 90
Tek Run
Trig'd
Δ: 1.02 V
@: 2.00 V
1.0V
8.0 micro
Ch1 1.00 V Ω Ch2 500mV Ω M 4.00µs A Ch1 ⨍ 240mV
Ref3 100mV 400µs 3.20000µs
26 Nov 2013
16:31:06
MENU OFF

Izyan- ELOG 90

I check the resolution of Ge Detector using 152 Eu at 10cm distance from Ge crystal
Signal from Oscilloscope after increasing HV = [-]3500V

Energy, keV	Resolution (FWHM), keV
122	1.764
245	1.238
344	1.853
779	1.786
964	1.746
1086	1.955
1112	1.993
1408	2.39

Table of energies (Measday)

TABLE I. Gamma-ray and muonic x ray energies used for
calibration, taken from Measday [4], NNDC [14], Helmer and van
der Leun [32], Dewey *et al.* [33], Raman [34], and Revay [35].

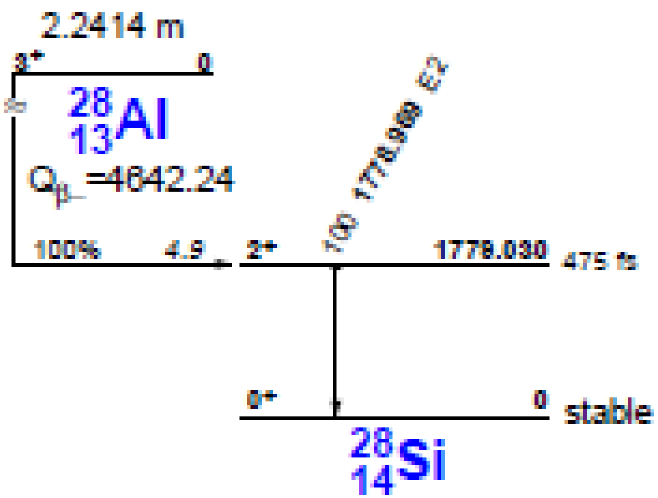
Line Energy(error) in keV Ref.

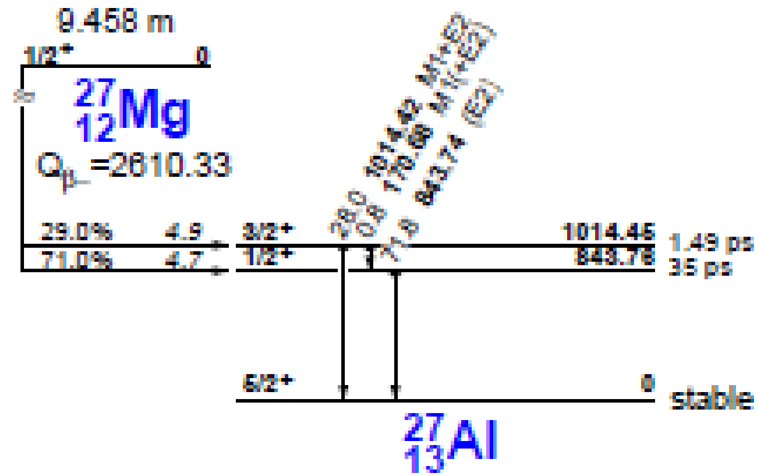
μ-mesic O(2*p*-1*s*) 133.535(2) [4]
μ-mesic Al(2*p*-1*s*) 346.828(2) [4]
μ-mesic Si(2*p*-1*s*) 400.177(5) [4]
Annihilation 510.991 2(14)a [4]
25Mg 585.08(2) [14]
27Al 843.74(3) [14]
28Al 941.72(4) [14]
25Mg 974.83(2) [14]
27Al 1014.42(3) [14]
26Mg 1129.58(5)
60Ni (from60Co *β* decay) 1173.228(3) [32]
41Ar 1293.586(7) [14]
60Ni (from60Co *β* decay) 1332.492(4) [32]
24Mg 1368.633(6) [14]
27Mg 1698.57(5) [14]
28Si (from 28Al *β* decay) 1778.969(12) [14]
26Mg 1808.66(3) [14]
np → *γ d* 2223.248 4(4) [33]
24Mg (from 24Na *β* decay) 2754.03(2) [14]
26Mg 2938.16(4) [14]
16N 6129.14(3) [4]
56Fe(*n, γ*)b 7645.55(3) [34]
7645.49(9) [35]

aThis energy is 7.7(14) eV below the mass of the electron [36].

bA partially resolved doublet, with another line at 7631.1 keV.

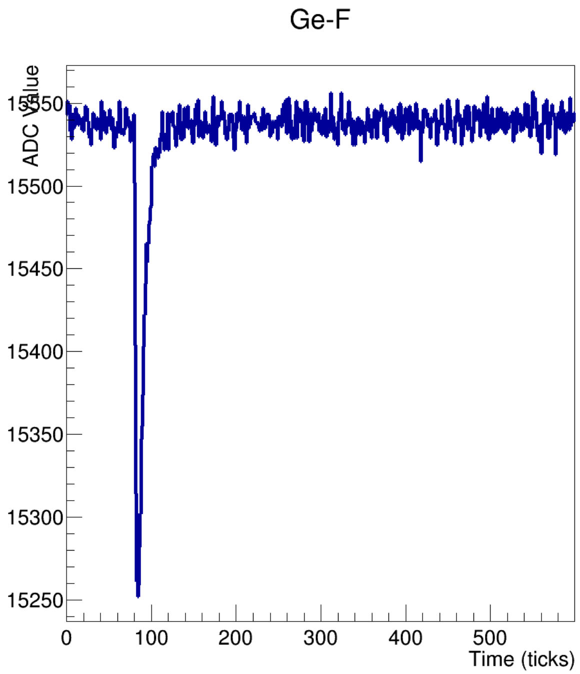
Look for Activation

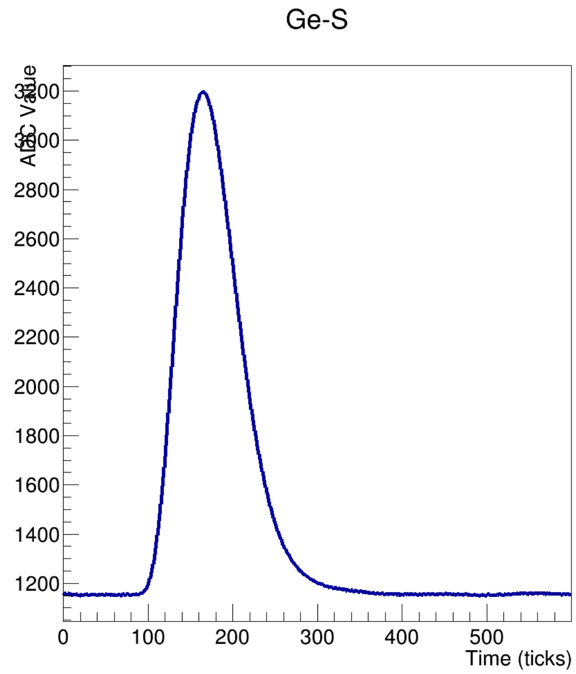




Ge, Run 3742, Fast and Slow FADC Traces

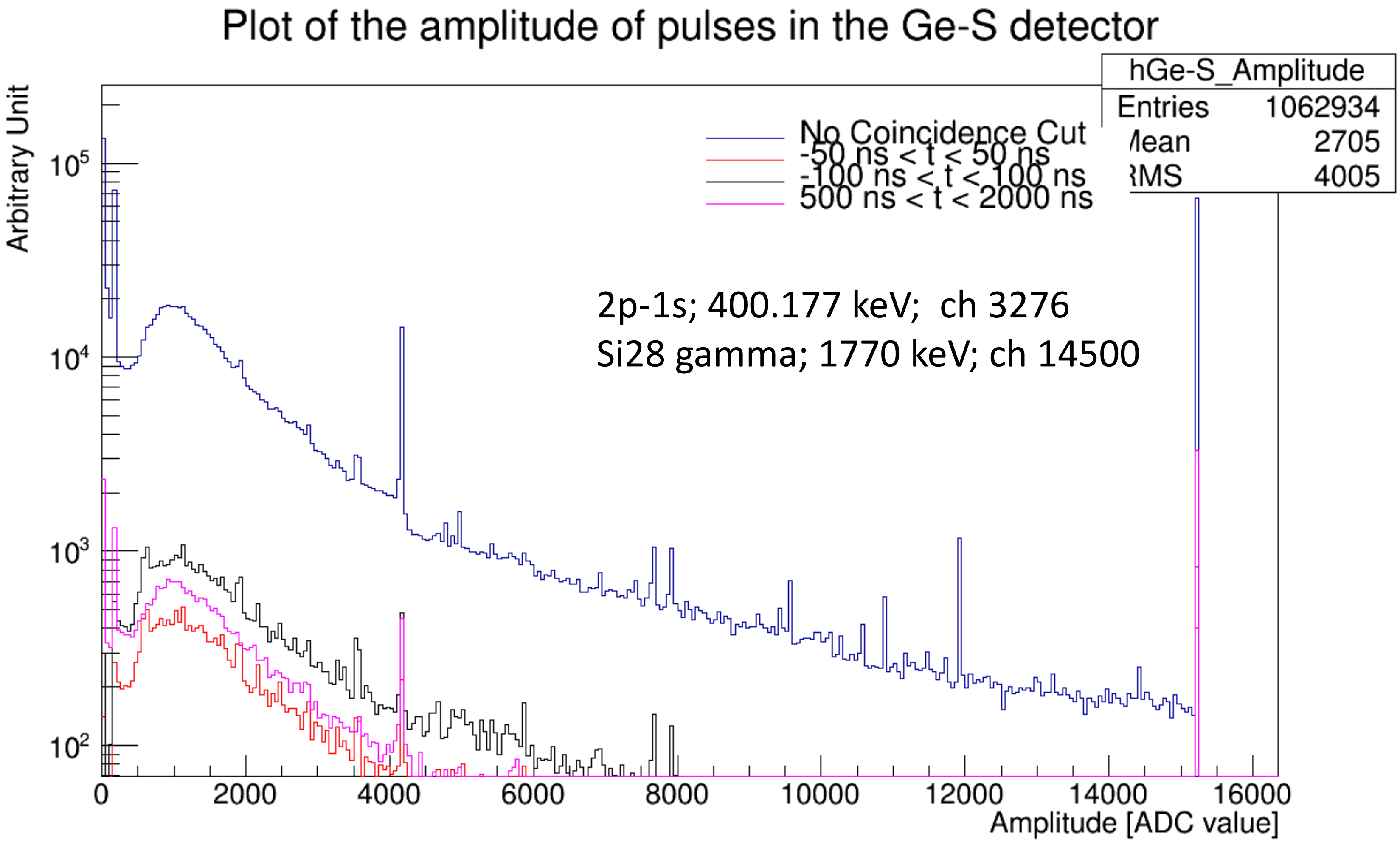
- 16.1290 MHz, 62 ns/bin, UH Caen



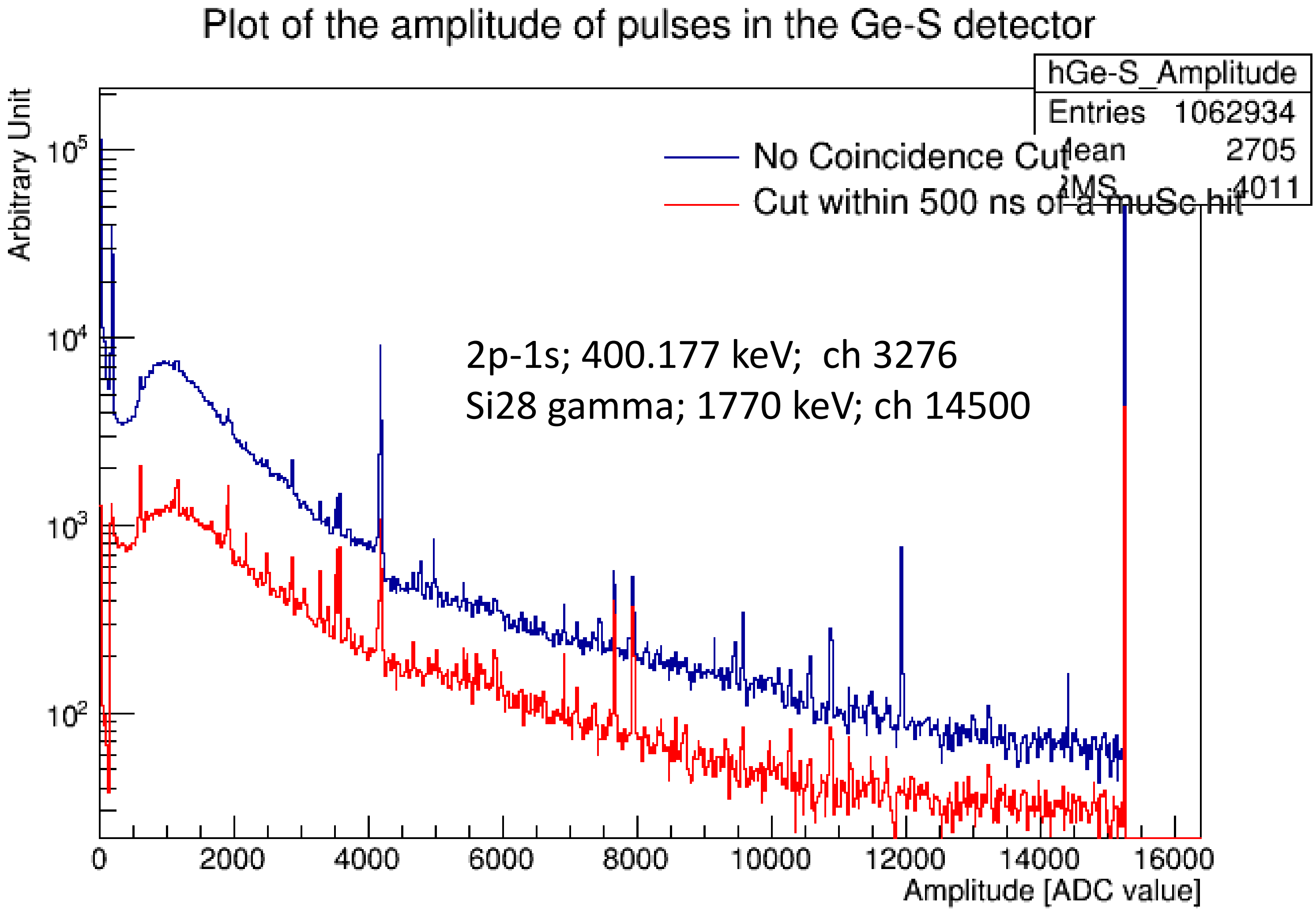


Ge Spectrum- Si16

(Andy, elog 520)



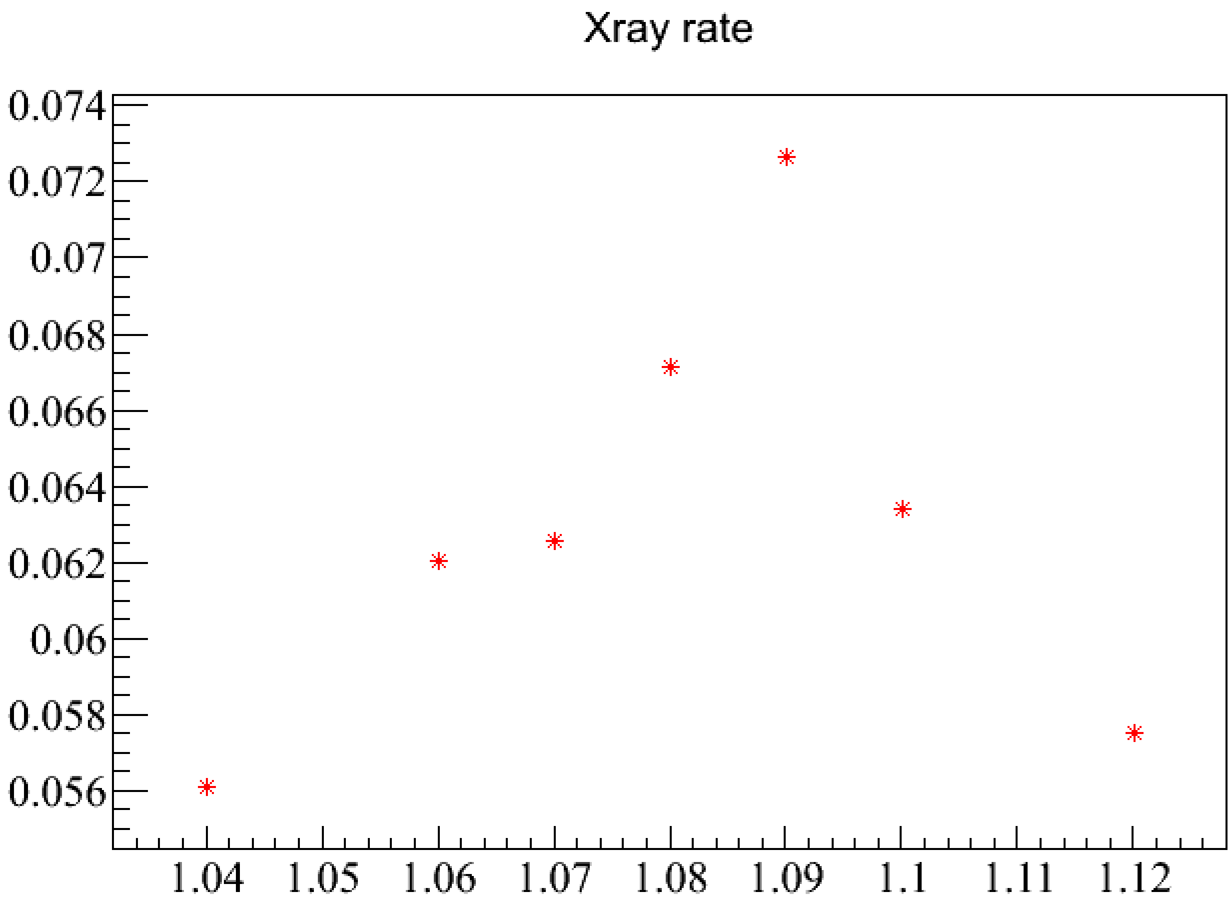
Si16


Plot of the amplitude of pulses in the Ge-S detector
hGe-S_Amplitude
Entries 1062934
Mean 2705
RMS 4011
No Coincidence Cut
Cut within 500 ns of a muSc hit
2p-1s; 400.177 keV; ch 3276
Si28 gamma; 1770 keV; ch 14500
Arbitrary Unit
Amplitude [ADC value]
0
2000
4000
6000
8000
10000
12000
14000
16000

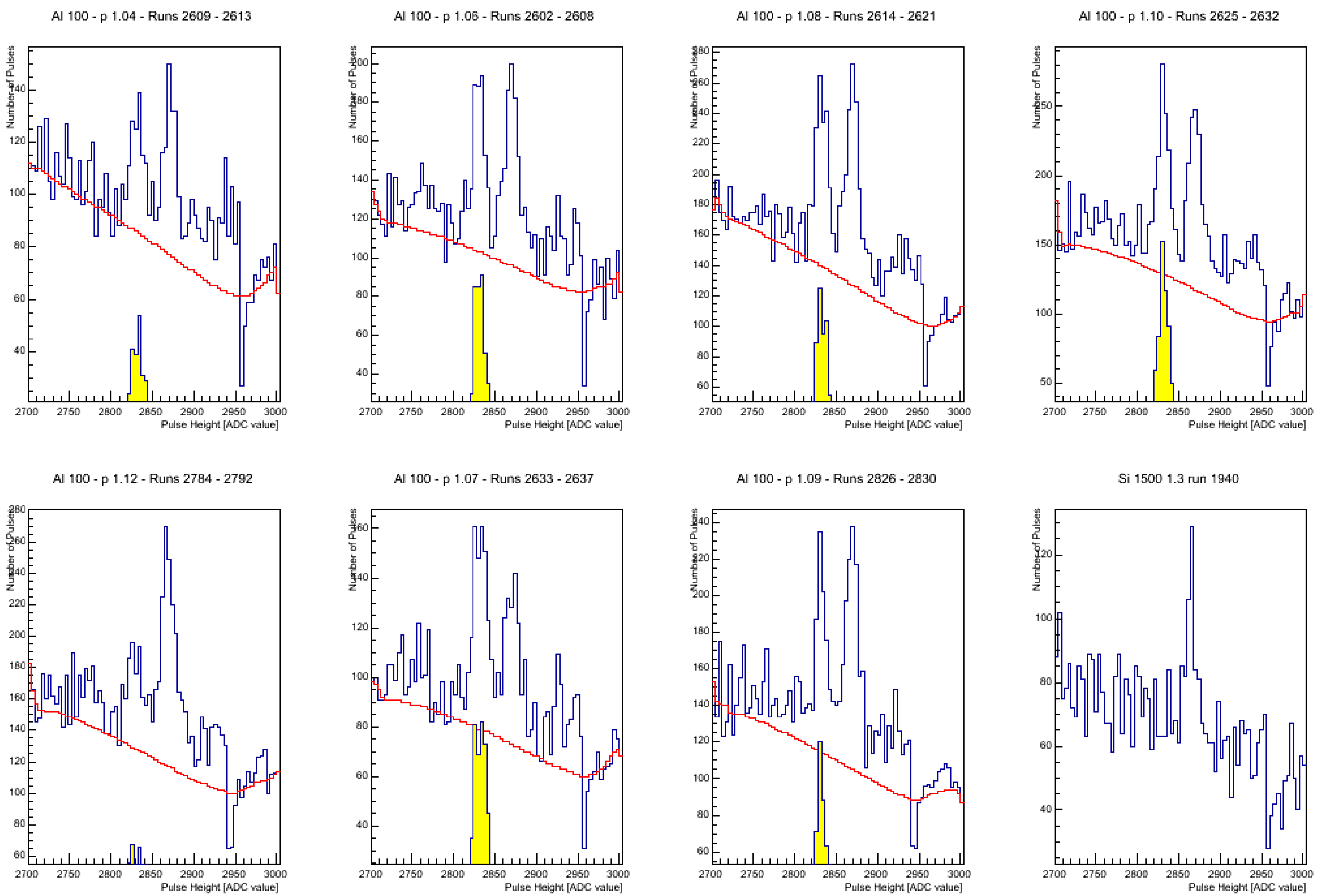
Nam, ELOG 542

I calculated Kα hit rate on the Ge detector. This analysis used the generated online histograms without any time cut.
The peak area is taken as integration from adc value 2820 to 2840. Scripts for this analysis is attached.
Run numbers and run periods are taken from Andy's elog:530:

Momentum	Hit rate (Hz)
1.04	5.61E-2
1.06	6.20E-2
1.08	6.71E-2
1.10	6.34E-2
1.12	5.75E-2
1.07	6.26E-2
1.09	7.26E-2



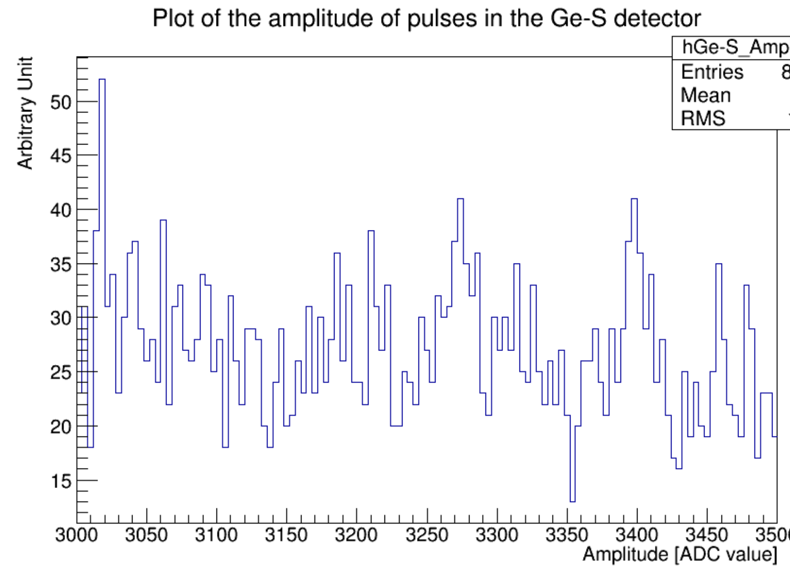
Nam, Elog 542

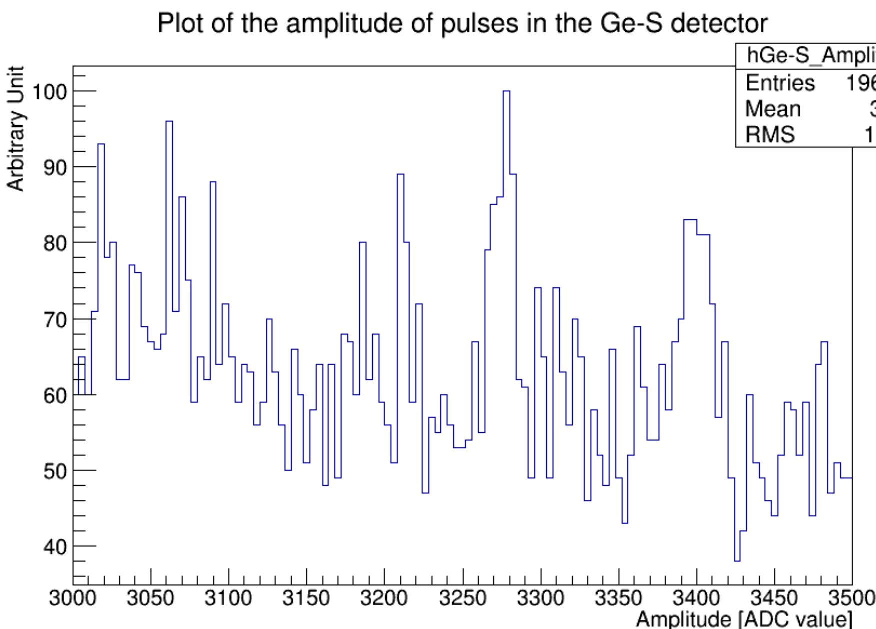

Al 100 - p 1.04 - Runs 2609 - 2613
Al 100 - p 1.06 - Runs 2602 - 2608
Al 100 - p 1.08 - Runs 2614 - 2621
Al 100 - p 1.10 - Runs 2625 - 2632
Al 100 - p 1.12 - Runs 2784 - 2792
Al 100 - p 1.07 - Runs 2633 - 2637
Al 100 - p 1.09 - Runs 2826 - 2830
Si 1500 1.3 run 1940
Number of Pulses
Pulse Height [ADC value]

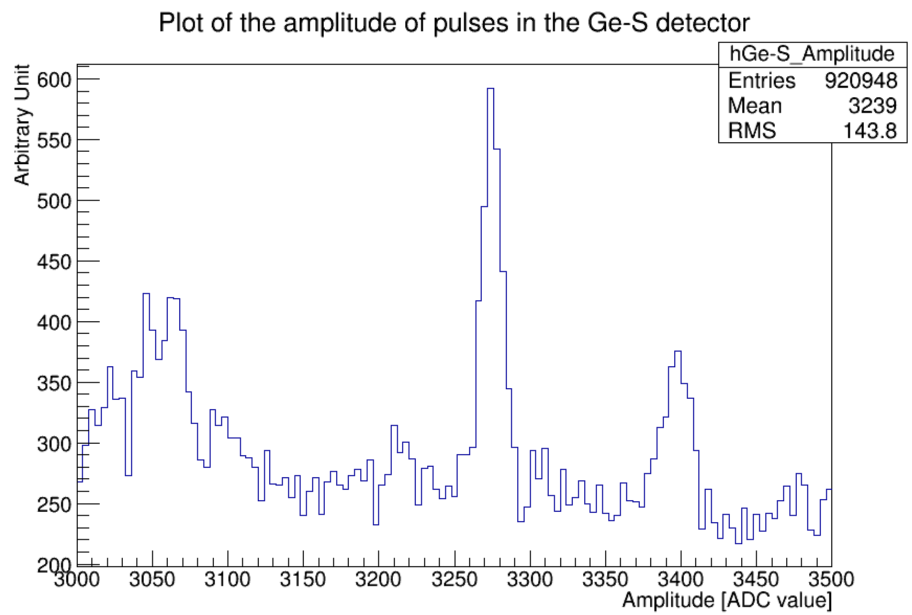
Andy, elog 679, Si Target

- Si 2p-1s
- 50 ns, 100 ns, 500 ns

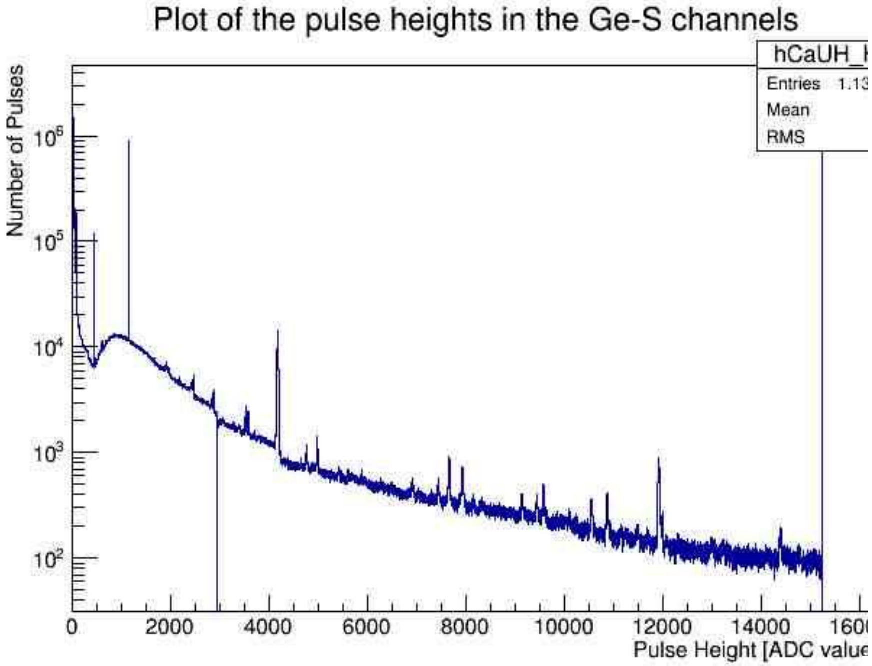
time cuts- don't work very well!

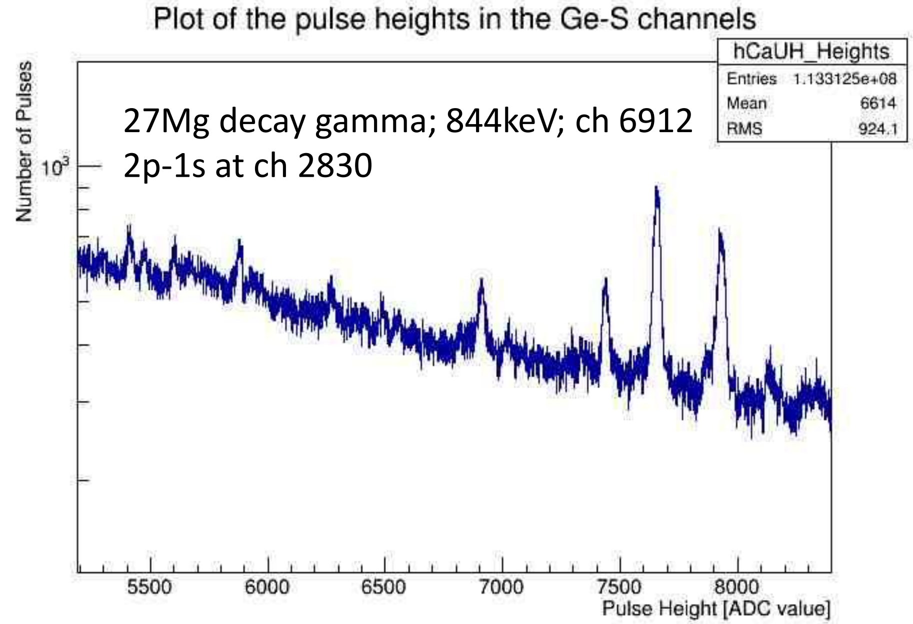




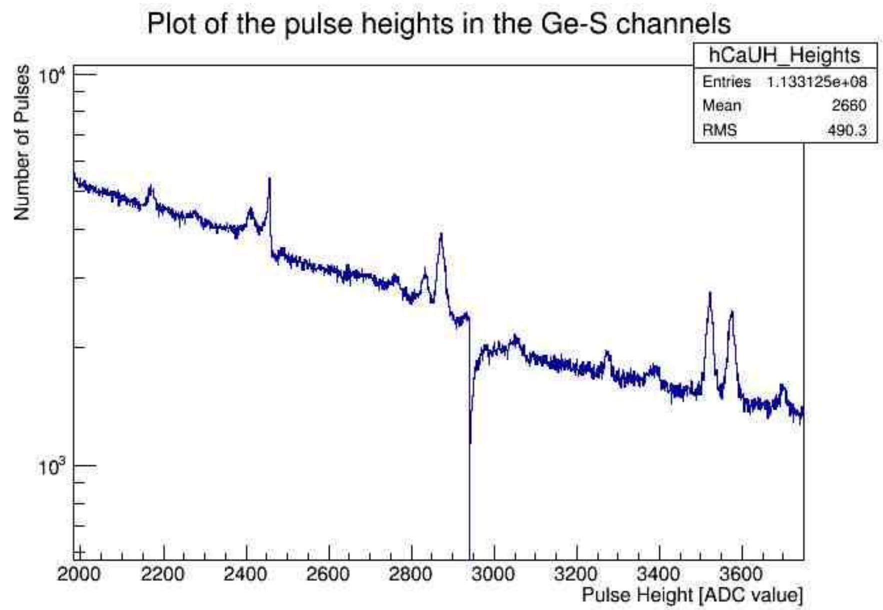


Al spectrum: delayed gamma from 27Mg decay- no time cuts





- Resolution ~ 5 keV FWHM (too big- drifting? Rates?)



Germanium: To do

- Improve timing relative to MuSc
  - Examine double-peaks in timing (problem w/ common Triggering of UH CAEN?)
  - Solve 42 microsecond shift mystery
- Establish acceptance correction for Ge signals
- Establish muon stop total for each run
- Look for out-of-time gammas as an alternative means of normalization
- For future runs, adjust reset preamp
  - Improve (reduce!) reset time
  - Arrange to scale dead time
  - Do we need to gate linear amp for reset dead periods?
- Safety in bringing HV up (current limit)

Issues with Ge timing

- Timing is 42 microseconds late- why?
- Got two timing pulses- during run, this is believed to be due to UH Caen firing when any one channel is above threshold. During the run one was shown to give noise, evidence this is correct, but this needs to be investigated.
- How is timing determined in online plots? Start of island?

Europium Xrays
half-life=13.537 y
46.4 kBq 01.03.2000

121.7817 *3*	28.58 *6*	ε+β+
125.69 *13*	0.016 *5*	ε+β+
148.010 *17*	0.037 *4*	ε+β+
173.17 *15*	0.008 *3*	β-
175.18	0.0040 *11*	ε+β+
192.60 *4*	0.00679 *21*	β-
195.05 *24*	0.0061 *13*	β-
202.74 *13*	0.0051 *11*	ε+β+
207.6 *3*	0.0059 *7*	ε+β+
209.10		ε+β+
209.41 *13*	0.0055 *5*	β-
212.568 *15*	0.0198 *5*	ε+β+
237.31 *5*	0.0094 *13*	ε+β+
239.42 *17*	0.0046 *19*	ε+β+
244.6975 *8*	7.583 *19*	ε+β+
251.630 *7*	0.072 *3*	ε+β+
269.86 *6*	0.0083 *8*	ε+β+
271.131 *8*	0.0729 *21*	β-
275.449 *15*	0.0335 *21*	ε+β+
285.98 *3*	0.0099 *8*	ε+β+
295.9392 *17*	0.447 *5*	ε+β+
315.174 *17*	0.0507 *13*	β-
316.3 *1*	0.0021 *13*	ε+β+
320.03 *15*	0.0016 *5*	ε+β+
324.83 *3*	0.072 *3*	β-
329.425 *21*	0.128 *8*	ε+β+
330.54 *10*	0.0059 *16*	ε+β+
340.40 *14*	0.036 *3*	ε+β+
344.2785 *12*	26.5 *4*	β-
351.66 *4*	0.0093 *13*	β-
357.26 *5*	0.0040 *8*	ε+β+
358.13		ε+β+

367.7887 *16*	0.861 *5*	β-
379.37 *6*	0.00083 *21*	ε+β+
385.69 *20*	0.0051 *8*	ε+β+
387.90 *8*	0.00292 *21*	β-
387.90 *8*	0.00294 *21*	ε+β+
389.07 *11*	0.0035 *13*	ε+β+
391.32 *14*	0.00126 *21*	ε+β+
395.75 *19*	0.008 *3*	ε+β+
406.74 *15*	0.00083 *21*	ε+β+
411.1163 *11*	2.234 *4*	β-
416.048 *8*	0.1100 *19*	ε+β+
423.45 *4*	0.0032 *6*	ε+β+
440.86 *10*	0.0134 *16*	ε+β+
441.00		ε+β+
441.1 *4*	0.0133 *16*	β-
443.96 *4*	0.327 *19*	ε+β+
443.965 *3*	2.821 *19*	ε+β+
482.3 *4*	0.0014 *6*	β-
482.31 *3*	0.0292 *24*	ε+β+
482.43		ε+β+
488.6792 *20*	0.419 *3*	ε+β+
493.508 *20*	0.0294 *21*	ε+β+
494.0 *3*	0.0098 *11*	β-
496.39 *3*	0.0042 *4*	β-
496.39 *3*	0.0051 *8*	ε+β+
503.474 *5*	0.149 *8*	β-
520.227 *5*	0.052 *4*	β-
523.13 *5*	0.0150 *16*	ε+β+
526.881 *20*	0.0131 *6*	β-
534.245 *7*	0.0427 *11*	β-
536.23		ε+β+
538.29 *6*	0.0039 *6*	ε+β+

556.56 *3*	0.0185 *13*	ε+β+
557.91 *17*	0.0045 *19*	β-
561.2 *5*	0.00104 *21*	ε+β+
562.93 *2*	0.0027 *13*	ε+β+
563.990 *7*	0.489 *6*	ε+β+
566.430 *5*	0.1290 *19*	ε+β+
571.6 *5*	0.0048 *8*	ε+β+
586.2648 *25*	0.459 *5*	β-
595.61 *12*	0.032 *11*	ε+β+
615.44 *20*		β-
616.05 *3*	0.0091 *8*	ε+β+
644.37 *5*	0.0062 *8*	ε+β+
656.487 *5*	0.1448 *19*	ε+β+
664.78 *5*	0.0166 *24*	ε+β+
671.151 *13*	0.0195 *16*	ε+β+
674.675 *3*	0.172 *4*	ε+β+
675.1 *2*	0.0170 *16*	β-
678.623 *5*	0.471 *4*	β-
683.32 *11*	0.0032 *8*	ε+β+
686.61 *5*	0.0193 *16*	ε+β+
688.670 *5*	0.857 *8*	ε+β+
696.87 *19*	0.016 *8*	ε+β+
702.96		ε+β+
703.25 *6*	0.0034 *8*	β-
703.54 *5*	0.0016 *5*	β-
712.843 *6*	0.093 *8*	β-
719.349 *4*	0.059 *8*	ε+β+
719.349 *4*	0.278 *8*	ε+β+
727.99 *14*	0.0112 *8*	ε+β+
735.40 *10*	0.0059 *11*	ε+β+
756.12 *9*		ε+β+

764.900 *9*	0.215 *24*	β⁻
768.944 *9*	0.094 *4*	ε+β⁺
778.9040 *18*	12.942 *19*	β⁻
794.81 *3*	0.0263 *21*	β⁻
805.70 *7*	0.0123 *11*	ε+β⁺
810.451 *5*	0.320 *3*	ε+β⁺
839.36 *4*	0.0161 *11*	ε+β⁺
841.570 *5*	0.1660 *24*	ε+β⁺
867.378 *4*	4.245 *19*	ε+β⁺
896.58 *9*	0.0669 *21*	ε+β⁺
901.181 *11*	0.086 *4*	ε+β⁺
905.9 *1*	0.0163 *16*	ε+β⁺
919.330 *3*	0.427 *6*	ε+β⁺
926.317 *15*	0.278 *5*	ε+β⁺
930.580 *15*	0.0729 *19*	β⁻
937.05 *15*	0.0034 *13*	β⁻
958.63 *5*	0.0217 *24*	ε+β⁺
963.390 *12*	0.135 *3*	ε+β⁺
964.079 *18*	14.605 *21*	ε+β⁺
968.00	0.0037 *24*	ε+β⁺
974.09 *4*	0.0141 *8*	β⁻
990.19 *3*	0.0313 *13*	β⁻
1001.1 *3*	0.0046 *8*	ε+β⁺
1005.272 *17*	0.646 *5*	ε+β⁺
1084 *1*	0.246 *8*	ε+β⁺
1085.869 *24*	10.207 *21*	ε+β⁺
1089.737 *5*	1.727 *6*	β⁻
1109.174 *12*	0.186 *8*	β⁻
1112.074 *4*	13.644 *21*	ε+β⁺
1139 *1*	0.00126 *8*	ε+β⁺
1170.93 *11*	0.037 *3*	ε+β⁺

1206.11 *15*	0.0141 *11*	β⁻
1212.948 *11*	1.422 *6*	ε+β⁺
1249.938 *13*	0.188 *4*	ε+β⁺
1261.343 *23*	0.0334 *13*	β⁻
1292.778 *19*	0.105 *5*	ε+β⁺
1299.140 *10*	1.623 *8*	β⁻
1314.67 *1*	0.0050 *11*	β⁻
1315.31 *23*	0.0072 *16*	ε+β⁺
1348.10 *7*	0.0178 *11*	β⁻
1363.77 *5*	0.0257 *11*	ε+β⁺
1390.36 *16*	0.0048 *8*	ε+β⁺
1408.006 *3*	21.005 *24*	ε+β⁺
1457.643 *11*	0.502 *5*	ε+β⁺
1485.9 *3*	0.0056 *24*	ε+β⁺
1528.103 *18*	0.281 *5*	ε+β⁺
1605.61 *7*	0.0082 *5*	β⁻
1608.36 *8*	0.0053 *4*	ε+β⁺
1635.2 *5*	0.00016 *5*	ε+β⁺
1647.41 *14*	0.0063 *6*	ε+β⁺
1674.30 *6*	0.0062 *8*	ε+β⁺
1698.1 *4*	0.0059 *19*	ε+β⁺
1769.09 *5*	0.0096 *4*	ε+β⁺