Using a 5000-series PicoScope PC Oscilloscope as a Multi-channel DAQ

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Hardware

PicoScope 5000 Series ($1.7k - 2.9k)

- 2-4 analog channels
- MSO models: 16 digital channels
- Flexible resolution: 8 to 16-bit
- 60, 100, 200 MHz analog bandwidth
- 1 GS/s sampling at 8-bit resolution
- Up to 512 MS capture memory (**“rapid block” acquisition**)

Software

PicoTech

- PicoScope 6.X (oscilloscope software)
- Python wrappers to the Pico Software Development Kit (SDK)

Data Acquisition (require SDK and Python Wrappers)

- gamma-spectroscopy (2-channel MCA GUI, David Fokkema)

  https://github.com/davidfokkema/gamma-spectroscopy

- udaq (command-line DAQ, Lew Riley)

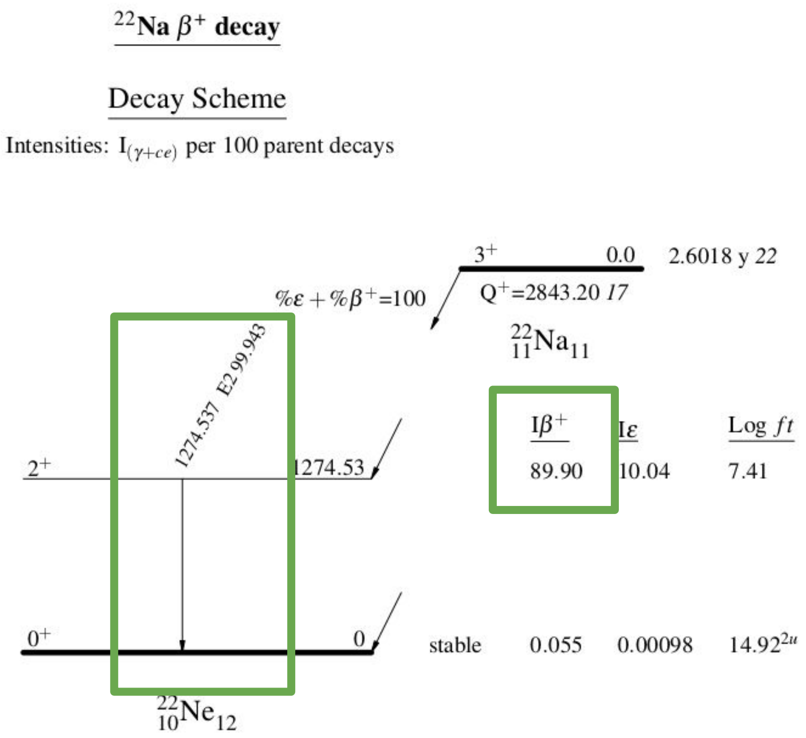
  https://github.com/rileyle/udaq

Both under GPL. Please adopt, adapt, and contribute!

Caveats

- **No on-board persistent RAM**: A dedicated DAQ PC is a good idea.
- **Only relative timing within each event** (no absolute time stamps)
- **Quantifying dead time is an open question** and likely to be an adventure.
- **PicoTech software for MacOS and Linux in beta**
  (This work was done with a Windows 10 DAQ PC)

Gamma-ray Coincidences with 2 NaI Detectors (^{22}Na)



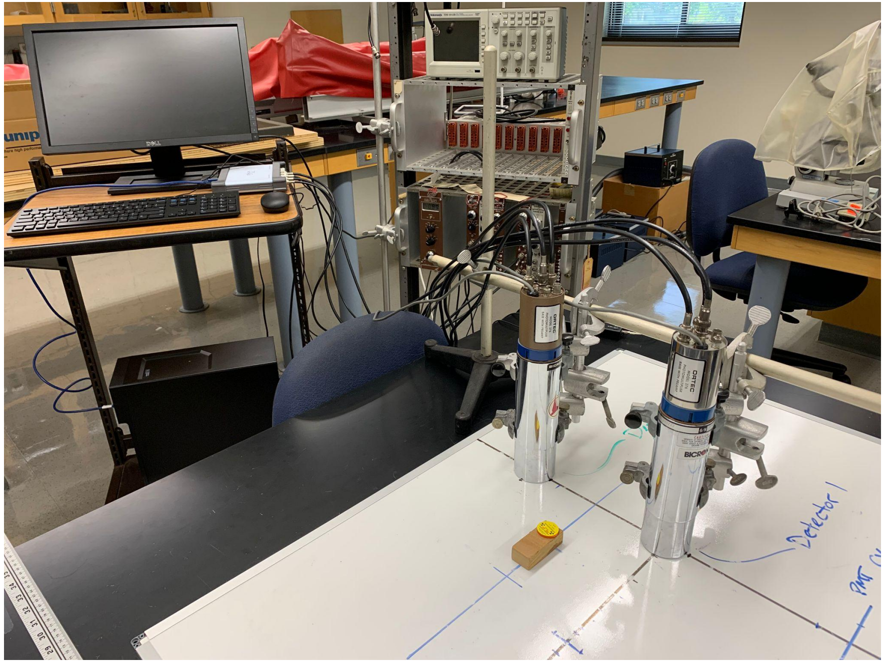
90% of events produce three gamma rays in coincidence:

- 2 @ 511 keV (opposite directions)
- 1 @ 1274 keV

Yu. Khazov and A. Rodionov, F. G. Kondev NDS 112, 855 (2011). Data extracted from the ENSDF database, revision of June 29, 2021.

Gamma-ray Coincidences with 2 NaI Detectors (^{22}Na)

- Bicron 2M2 2”x2” NaI Detectors
- Ortec 267 PMT Bases/Preamps (anode signal good for timing)
- Ortec NIM Spec. Amps (optional, best for pulse heights)
- PicoScope 5334D:
  - A: Detector 1 Spec Amp
  - B: Detector 2 Spec Amp
  - C: Detector 1 Anode
  - D: Detector 2 Anode
  - 5 μs capture window
  - 62.5 MHz sampling rate (16 ns/sample)
  - Trigger: A OR B



Gamma-ray Coincidences with 2 NaI Detectors (^{22}Na)

```
[Run]
Output Path =
Run Time = 3600
Number of Runs = 1

[Sampling]
Pre-Trigger Window  = 1e-6
Post-Trigger Window = 4e-6
Time Base           = 4
Captures Per Block  = 1000
```

```
[Channel A]
Coupling             = AC
Polarity             = 1
Range                = 10
Baseline Correction  = False
Timing               = PEAK
Trigger Enabled      = True
Trigger Type         = LEVEL
Trigger Direction    = RISING
Threshold            = 0.15

[Channel B]
Coupling             = AC
Polarity             = 1
Range                = 10
Baseline Correction  = False
Timing               = PEAK
Trigger Enabled      = True
Trigger Type         = LEVEL
Trigger Direction    = RISING
Threshold            = 0.15
```

```
[Channel C]
Coupling             = AC
Polarity             = -1
Range                = 0.2
Baseline Correction  = False
Timing               = PEAK
Trigger Enabled      = False
Trigger Type         = LEVEL
Trigger Direction    = FALLING
Threshold            = -0.0025

[Channel D]
Coupling             = AC
Polarity             = -1
Range                = 0.5
Baseline Correction  = False
Timing               = PEAK
Trigger Enabled      = False
Trigger Type         = LEVEL
Trigger Direction    = FALLING
Threshold            = -0.005
```

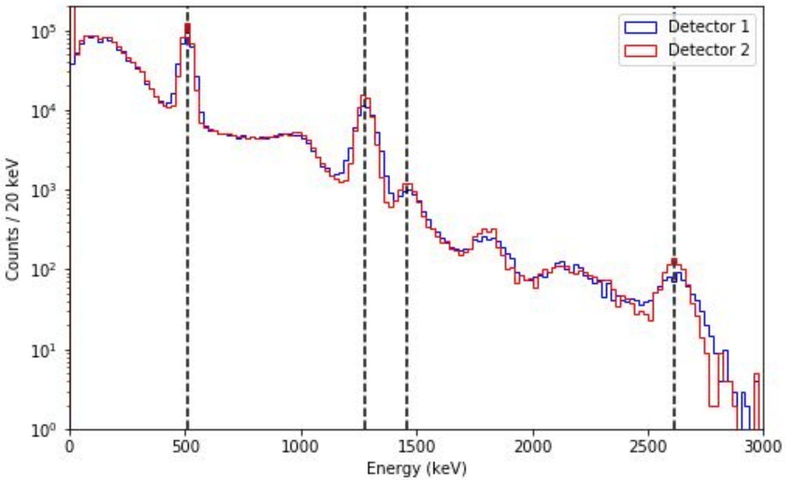
`udaq` input file (uses the Python configparser package)

Gamma-ray Coincidences with 2 NaI Detectors (^{22}Na)

	time_A	pulse_height_A	time_B	pulse_height_B	time_C	pulse_height_C	time_D	pulse_height_D
0	2.400000e-07	127.872555	0.000003	167.241432	4.144000e-06	-0.195318	1.760000e-06	-5.157628
1	6.400000e-08	132.755516	0.000002	172.429579	5.760000e-07	-0.585955	3.968000e-06	-5.890072
2	1.152000e-06	142.521439	0.000003	167.241432	2.000000e-06	-0.488296	4.672000e-06	-5.401776
3	4.688000e-06	147.404401	0.000002	167.241432	4.560000e-06	-0.488296	6.560000e-07	-4.913480
4	2.528000e-06	142.521439	0.000002	177.312540	1.280000e-06	-0.292978	1.280000e-07	-5.401776
...	...	...	...	...	...	...	...	...
3367995	3.120000e-06	83.620716	0.000002	1652.577288	1.904000e-06	1.373333	2.880000e-07	45.777764
3367996	3.440000e-06	78.737754	0.000002	1598.559526	1.552000e-06	1.470992	3.200000e-07	43.565172
3367997	1.808000e-06	285.653249	0.000002	59.205908	6.400000e-08	2.453688	7.520000e-07	1.480148
3367998	2.480000e-06	63.783685	0.000002	547.502060	3.088000e-06	1.470992	6.400000e-08	14.526811
3367999	6.400000e-07	68.971831	0.000002	389.721366	3.152000e-06	1.763970	9.600000e-08	8.621479

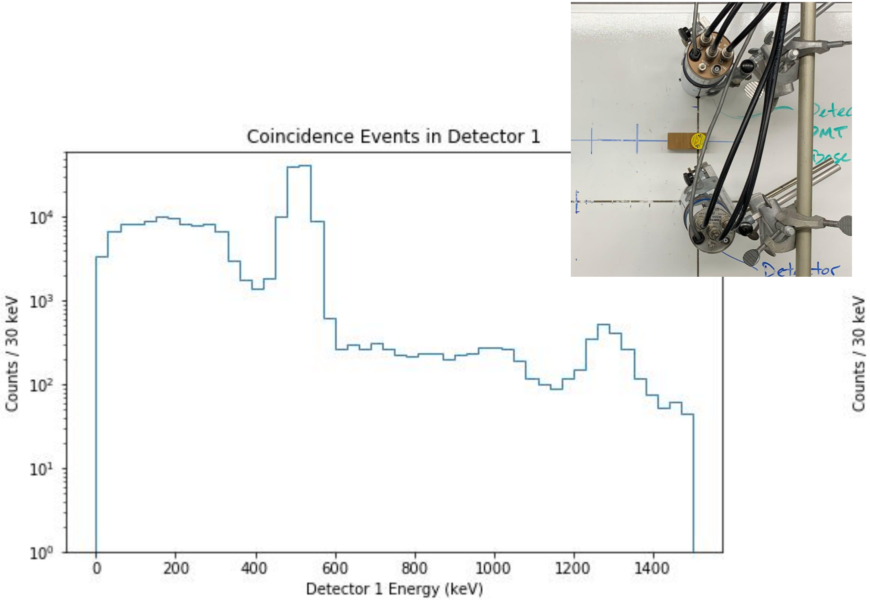
[pandas]() dataframe (*We use Python for most data analysis in our advanced labs.*)

Gamma-ray Coincidences with 2 NaI Detectors (^{22}Na)

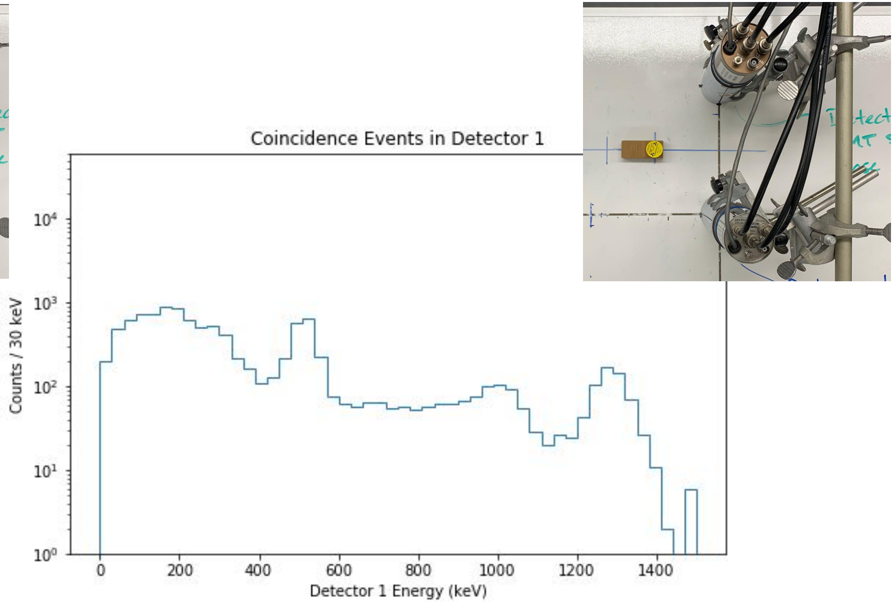


Calibrated Singles Spectra

Gamma-ray Coincidences with 2 NaI Detectors (^{22}Na)

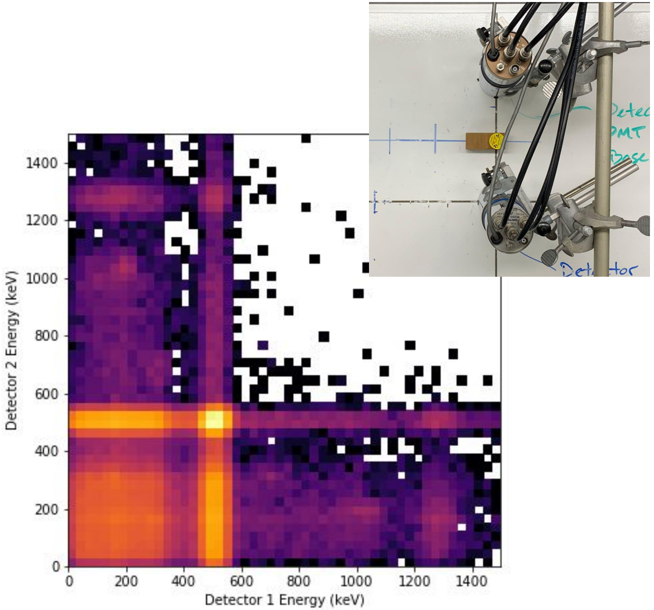


Source Centered



Source at (10 cm, 10 cm)

Gamma-ray Coincidences with 2 NaI Detectors (^{22}Na)



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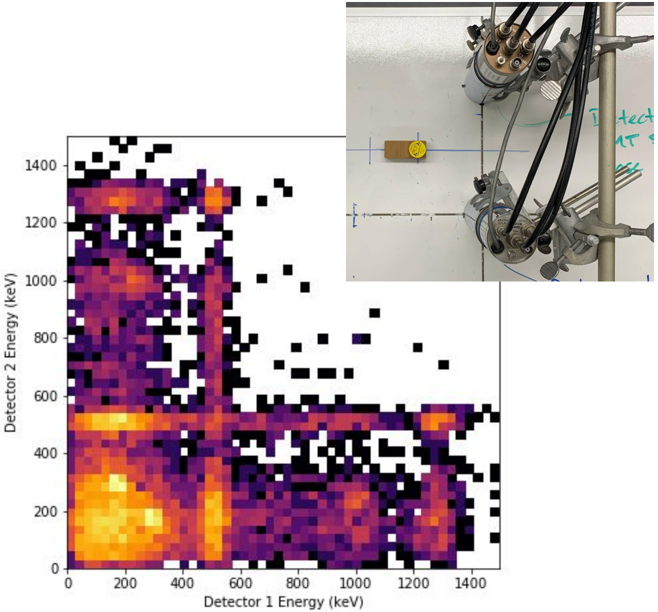
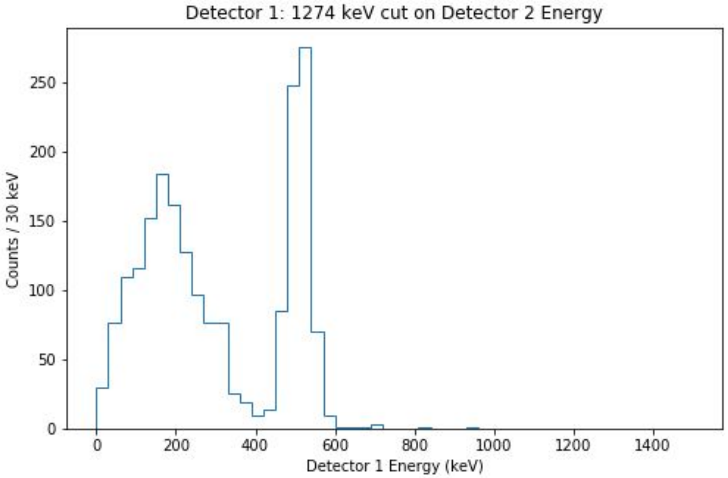


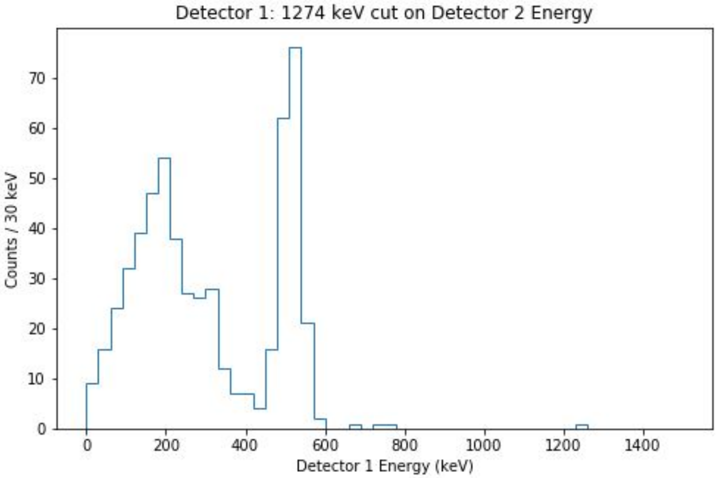
Source at (10 cm, 10 cm)

Gamma-ray Coincidences with 2 NaI Detectors (^{22}Na)

Spectra in coincidence with the 1274 keV gamma ray.



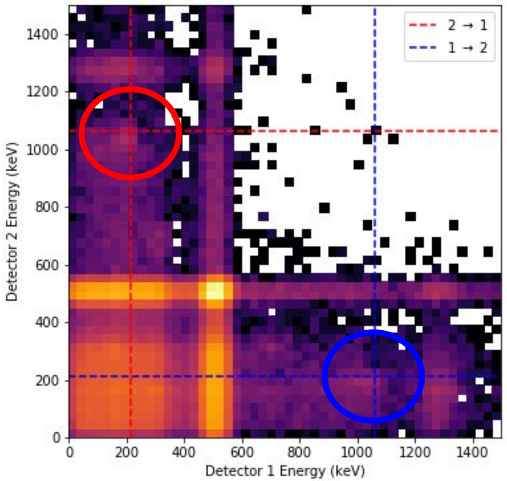
Source Centered



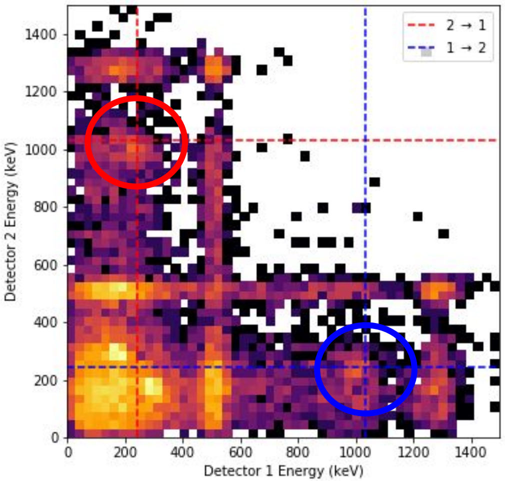
Source at (10 cm, 10 cm)

Gamma-ray Coincidences with 2 NaI Detectors (^{22}Na)

Compton scattering of the 1274 keV gamma ray.



Source Centered



Source at (10 cm, 10 cm)

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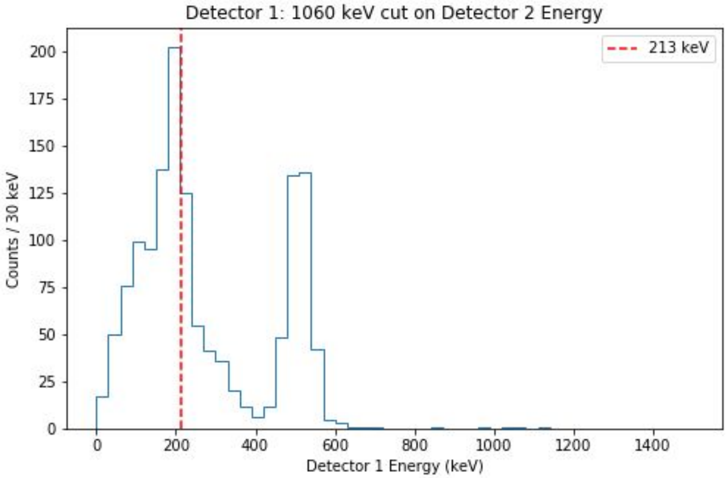
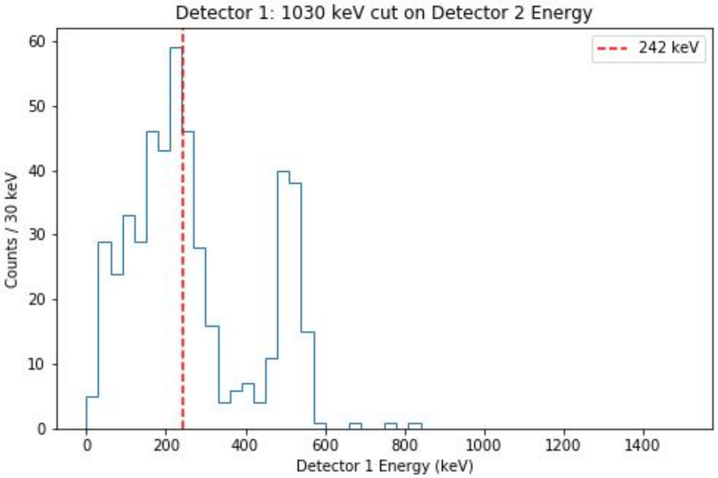


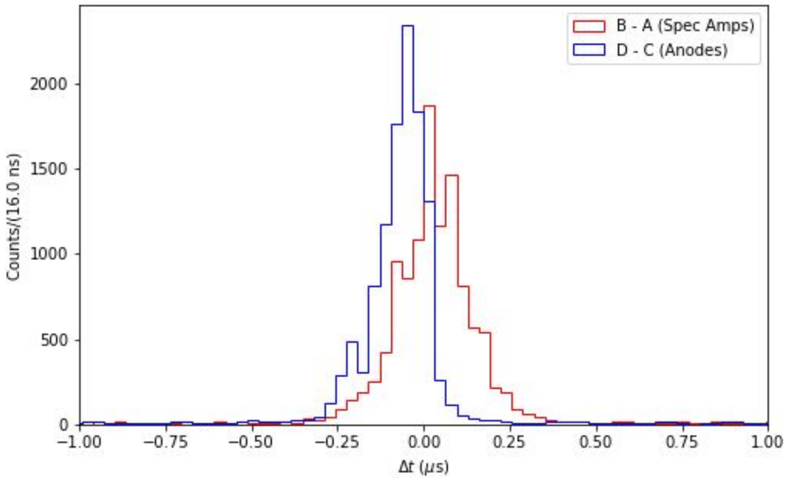
Source Centered



Source at (10 cm, 10 cm)

Gamma-ray Coincidences with 2 NaI Detectors (^{22}Na)

Relative time spectra (≈100 ns resolution)



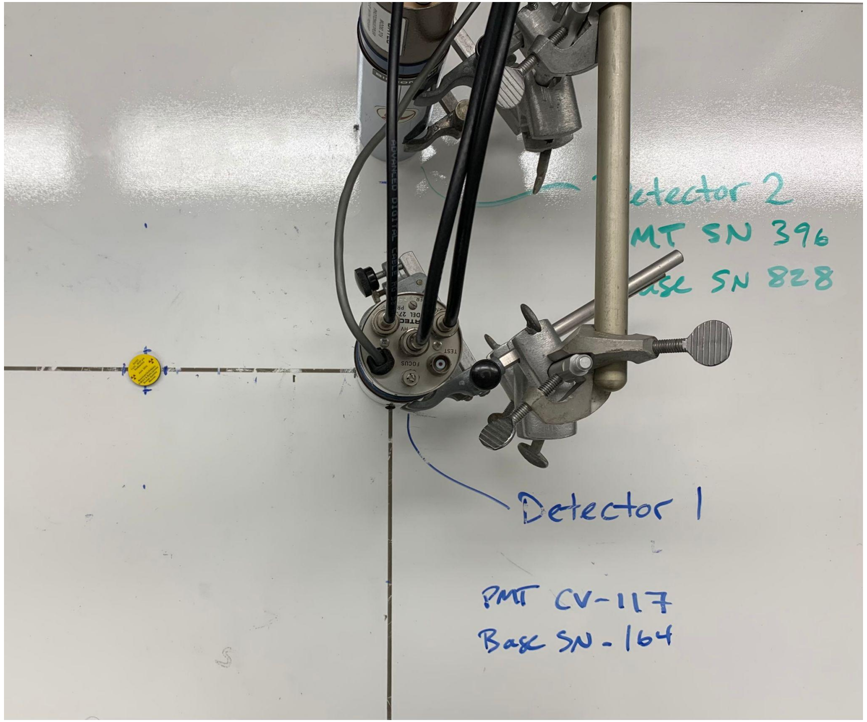
Thank You

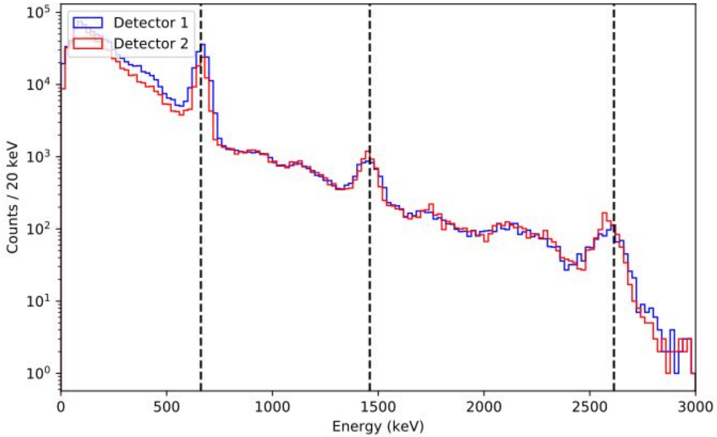
- … for your attention!
- David Fokkema, Vrije Universiteit Amsterdam for developing his gamma-spectroscopy code and inspiring this work.
- Ursinus College Department of Physics & Astronomy

I’m happy to help/collaborate: lriley@ursinus.edu

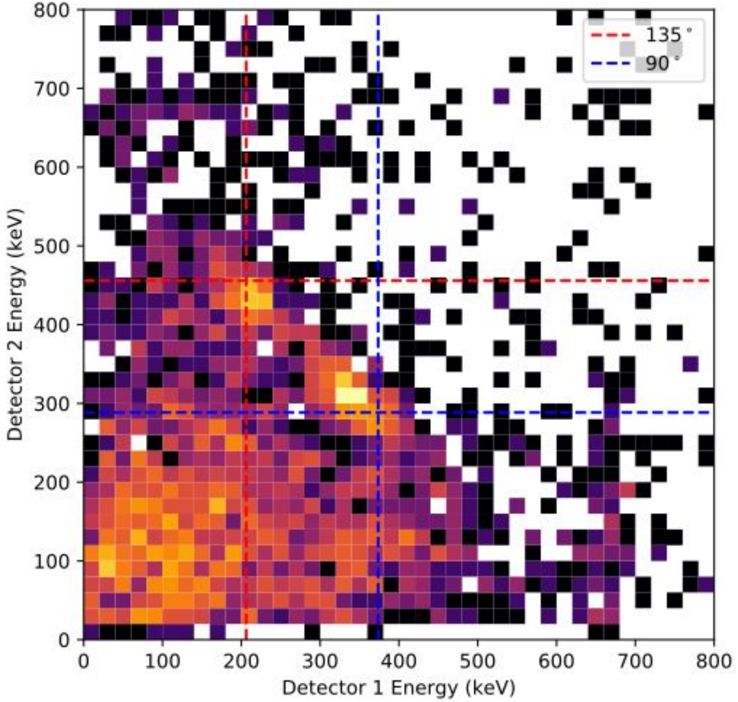
Extras

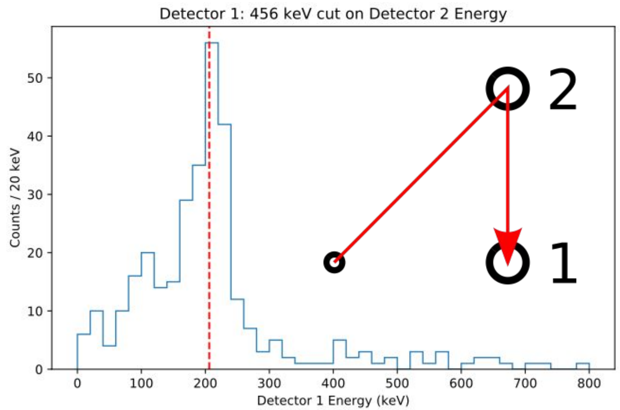
Compton Scattering (^{137}Cs)

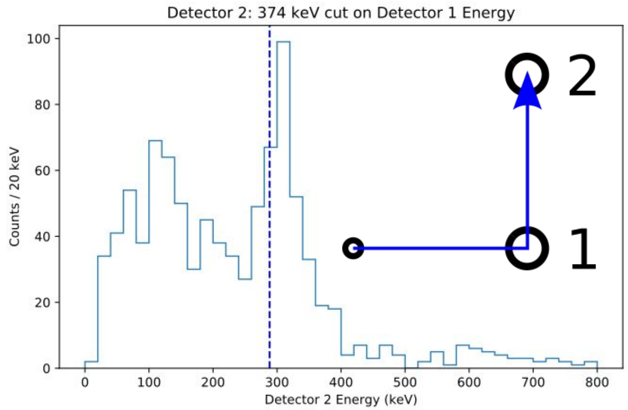




Compton Scattering (^{137}Cs)







Cosmic-Ray Muons

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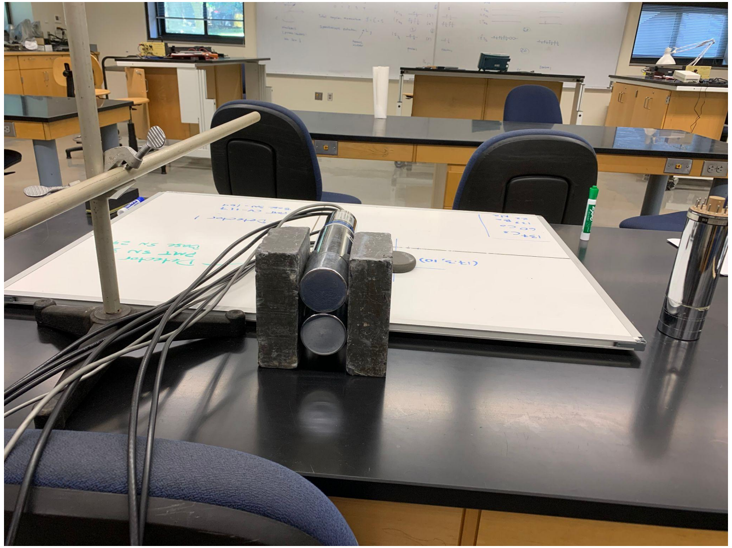
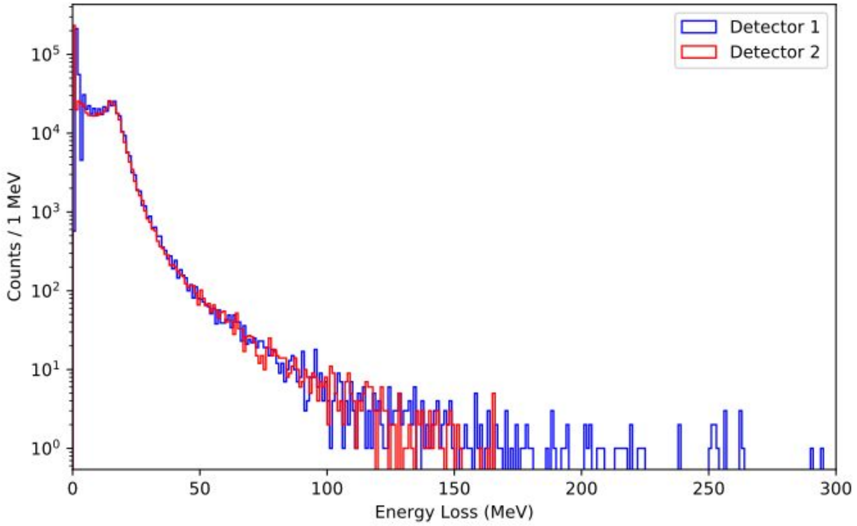
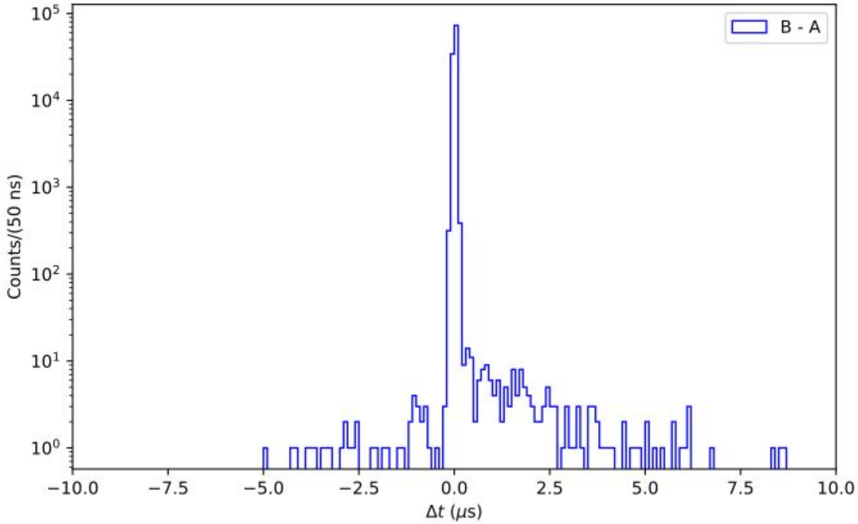


Cosmic-Ray Muons: Energy Loss Spectra



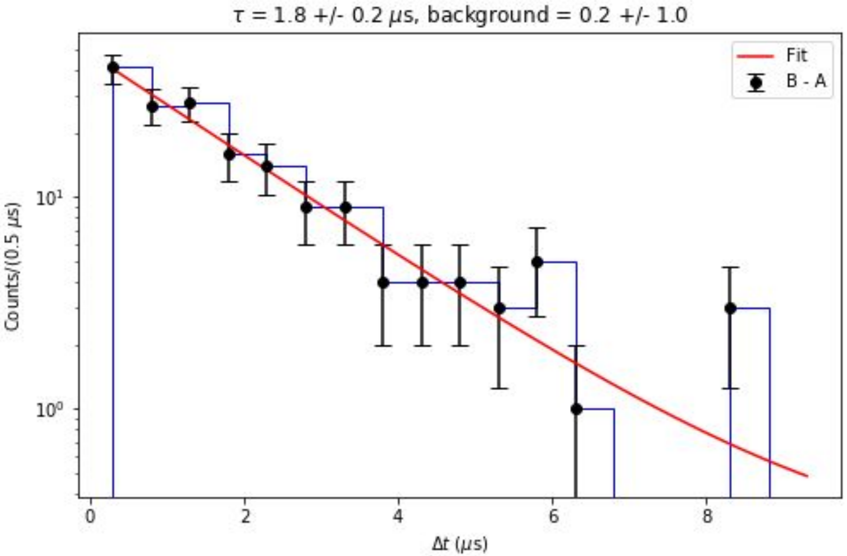
Rough calibration: peak at the average energy loss of 4 GeV muons.

Cosmic-Ray Muons: Time Spectrum

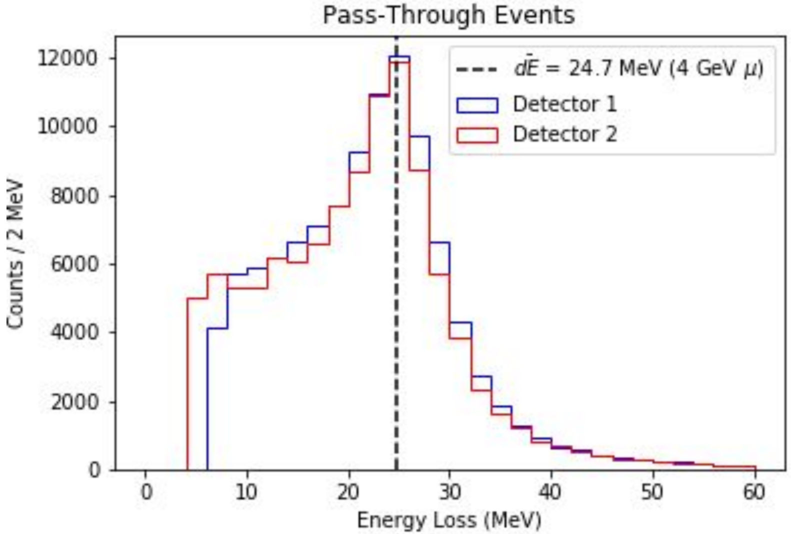


(8.5 day measurement)

Cosmic-Ray Muons: Lifetime

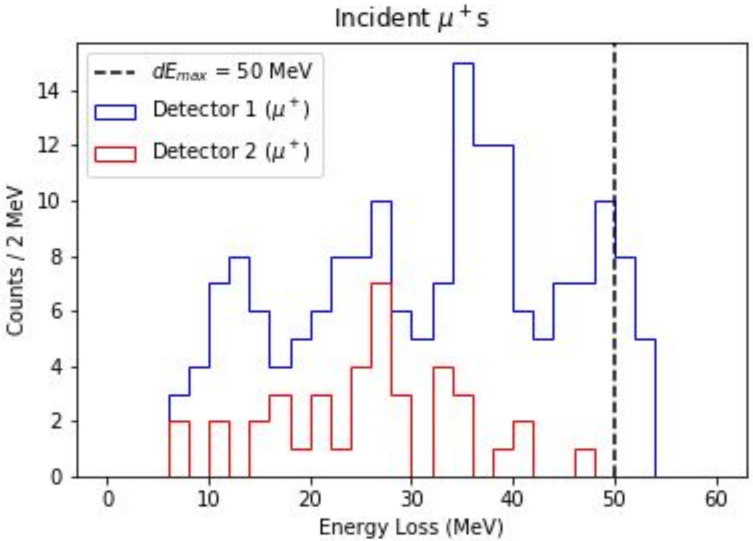


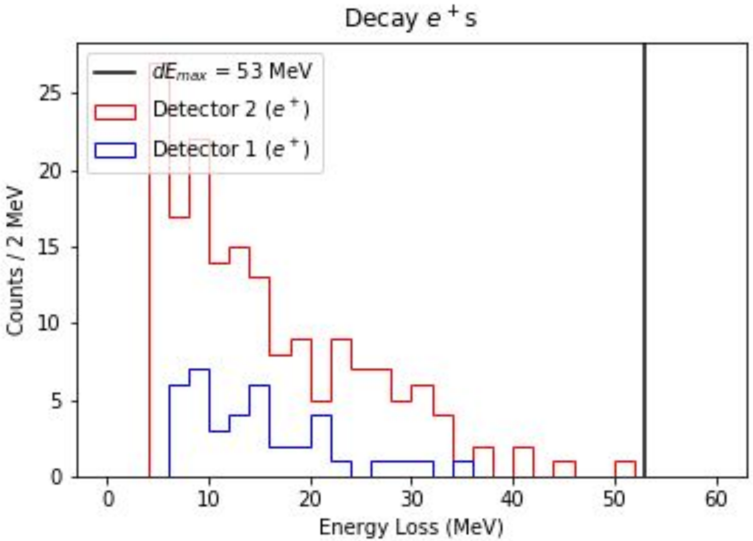
Cosmic-Ray Muons: Prompt Events



$|\Delta t| < 250$ ns

Cosmic-Ray Muons: Decay Events





$|\Delta t| > 250$ ns