Summing gamma spectra: practical approach and examples in the environmental radioactivity

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Outline

1. Spectra summing using Genie 2000 commands
2. Long-term background spectra
3. Marine sediment core

Practical approach in Genie 2000 (pedestrian)

1. Normalization (command: normal)
2. Adding spectra (command: strip)
3. Live- and real-time correction (command: pars)

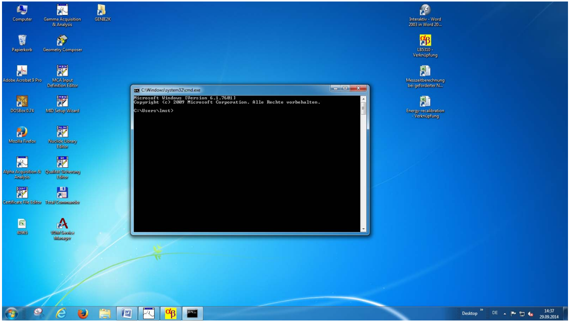


Figure: MS-DOS Command Window (from Start menu), Win 7 screenshot

Command details: Genie 2000 Batch Tools Support (manual)

Step 1: Normalization

- (If all spectra have the same energy calibration, this step can be skipped)
- Spectra with different energy calibrations must be normalized first: command normal

```
DOS> normal c:\Genie2k\camfiles\...\Spectrum1.cnf
/cal=c:\Genie2k\camfiles\...\Spectrum2.cnf
/out=c:\Genie2k\camfiles\...\Spectrum1_2.cnf.
```

- This will convert `Spectrum1.cnf` with energy calibration of `Spectrum2.cnf` into `Spectrum1_2.cnf`
- The channel counts are shifted, counts interpolated, resulting spectra all have the same energy calibration
- Once all spectra have the same energy calibration, they can be summed up

Step 2: Adding spectra

- Adding two spectra: command strip

```
DOS> strip c:\genie2k\camfiles\...\Spectrum3.cnf
c:\genie2k\camfiles\...\Spectrum2.cnf /factor=-1
```

- The `Spectrum2.cnf` will be added to `Spectrum3.cnf`
- This step is to be repeated for each added spectrum separately

Step 3: Live- and real-time correction

- Finally, the live- and real-time values must be reset in the resulting spectrum
- Command pars

```
DOS> pars c:\genie2k\camfiles\...\Spectrum3.cnf
/elive=yyyy /ereal=xxxx
```

A semiautomated process: autosum

- When summing many spectra
- autosum: a batch-file script used in the Radioactivity measurements laboratory, University of Bremen (author Bernd Hettwig)
- autosum.bat normalizes and sums automatically all spectra in a folder into a single spectrum `sumspec.cnf`

```
DOS> autosum [Folder] [Cal. spect. (without .cnf)]
```

- Finally, use command pars for resetting the live- and real-time values
- autosum overwrites the old spectra with new normalization!
- never use the original spectra!

Long-term background spectra

- In the IUP lab an up-to-date background for each detector is collected approximately once a month
- In the individual background spectra (3-4 days), only a limited number of lines is visible: usually ^{40}K and the strongest lines of ^{222}Rn progeny.
- Inspiration: Bossew et al. (2005), A very long-term HPGe-background gamma spectrum

Table: Summing up data.

	Det. 3	Det. 5	Det. 6
Number of summed-up spectra	29	43	46
Time period	8/2005-12/2008	8/2004-12/2008	11/2004-12/2008
Total summed-up time (days)	104.5	159.8	171.9
Count rate 20-2040 keV (s^{-1})	1.35	1.28	1.30

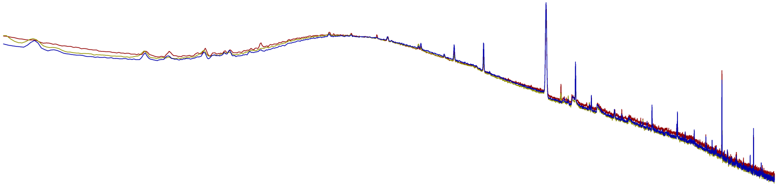
Long-term background spectra

Table: Detectors used for the long background comparison

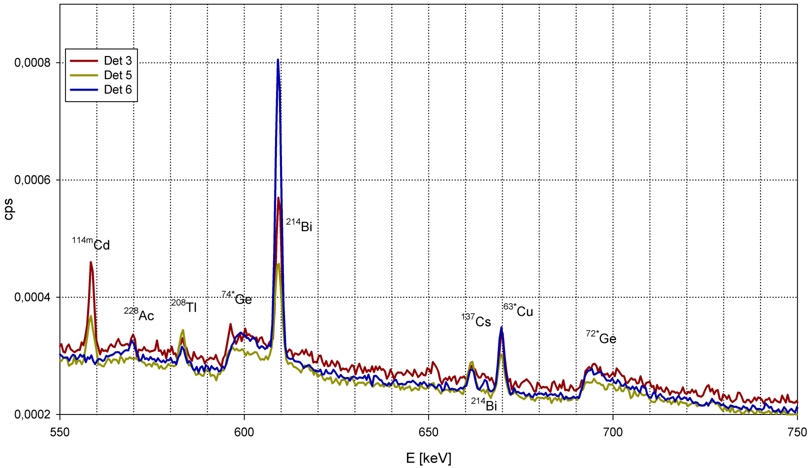
	Det. 3	Det. 5	Det. 6
Description	reverse p-type coaxial Ge detector, Canberra	n-type coaxial Ge detector, Canberra	n-type coaxial Ge detector, Canberra
Size (diameter / length mm)	76 / 60.5	64 / 60	63.5 / 63.5
End- cap	Cu endcap with C epoxy window	Cu endcap with C epoxy window	Cu endcap with C epoxy window
Relative efficiency (%)	51.2	50.8	50.9
FWHM (122 keV / 1332 keV)	0.857 / 1.76	0.931 / 1.87	0.865 / 2.05
Shielding	Pb: 92 mm, Cu: 10 mm, Cd: 1.3 mm, PMMA: 5 mm	Pb: 92 mm, Cu: 10 mm, Cd: 1.3 mm, PMMA: 5 mm	Pb: 100 mm, Cu: 10 mm

Sources of gamma lines in summed up spectra

- Radon and thoron progeny in the measurement chamber: ^{214}Pb and ^{214}Bi (^{222}Rn) and ^{212}Pb and ^{208}Tl (^{220}Rn)
- Natural and artificial radionuclides contained in the detector, its accessories and the shielding: ^{40}K, ^{210}Pb, ^{226}Ra, ^{234}Th and ^{238m}Pa (^{238}U decay chain), ^{228}Ac (^{232}Th decay chain), ^{235}U, ^{137}Cs and ^{60}Co.
- Short-lived activation products formed by reaction of cosmic radiation induced neutrons with material of the detector itself, its accessories and the shielding: isotopes of Ge, Cd, Pb and Cu.
- Other: annihilation peak 511 keV, x-rays and non-identified lines

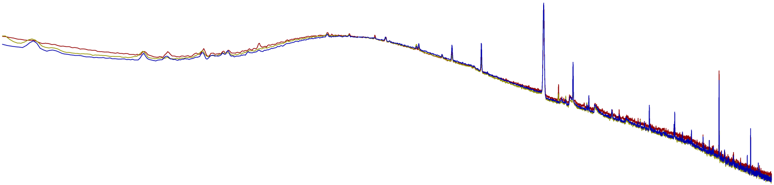


Comparing background spectra of 3 detectors



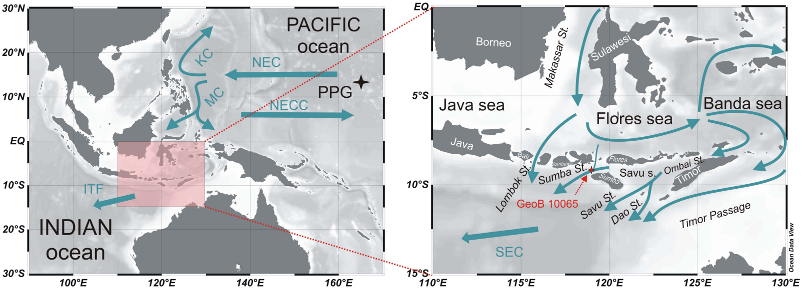
Differences between the compared detectors due to:

- mainly differences in construction design of the housing of the detectors (Rn daughters, Pb x-rays, Cd activation)
- the lowest background contribution to ^{210}Pb peak is at Det. 3 (a low-background Al detector holder)
- detector dimensions - continuum
- possibly differences in the construction material of the detectors and their accessories

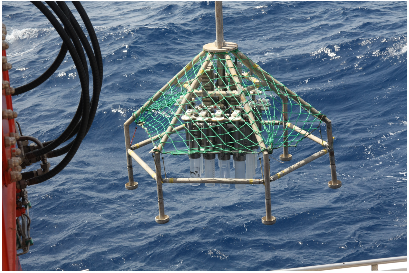


Motivation: understanding climate change

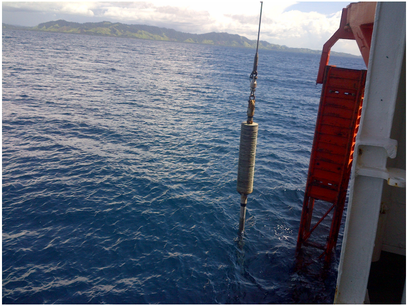
- Multi-decadal to centennial-scale development of the Indonesian-Australian summer monsoon over the last 6,000 years
- Providing sediment cores chronology based on natural and anthropogenic radionuclides



Sampling: sediments



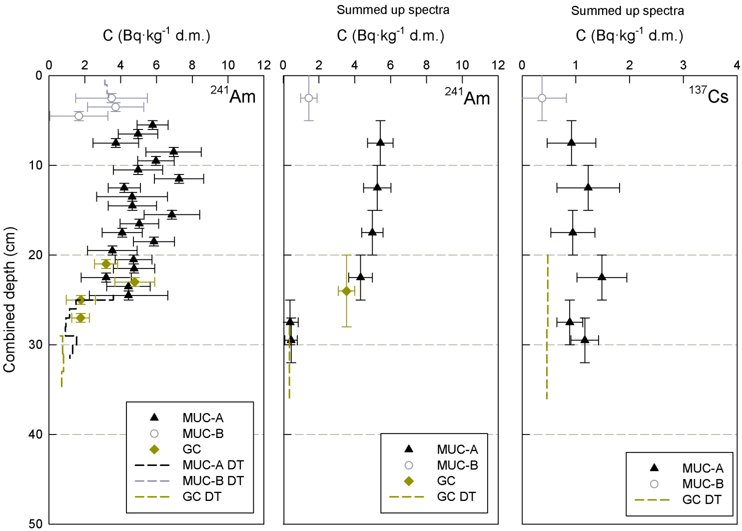
Multicorer (MUC), MSM 20/3



Gravity core (GC), SO 228, photo credit: SO-228 scientific party

- Two parallel MUC and a 9.75 m long GC taken in 2005 (RV SONNE)
- St. GeoB 10065: eastern Lombok Basin NW off the Indonesian Sumba Island, 1280 m water depth

Summing of spectra of several following intervals



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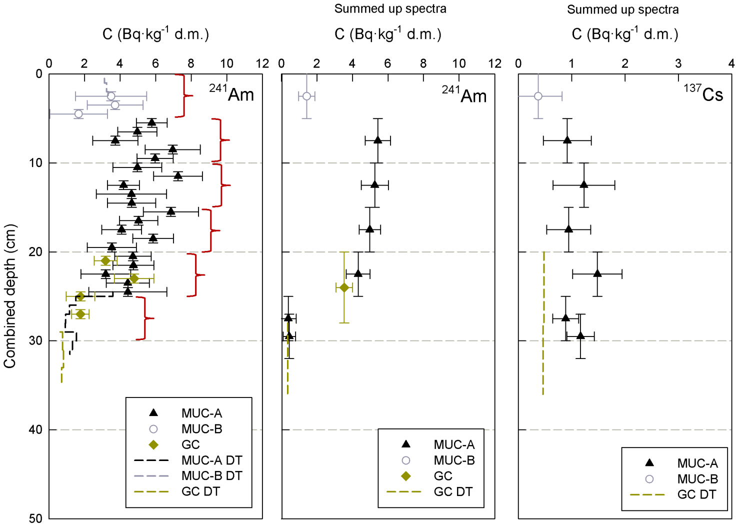

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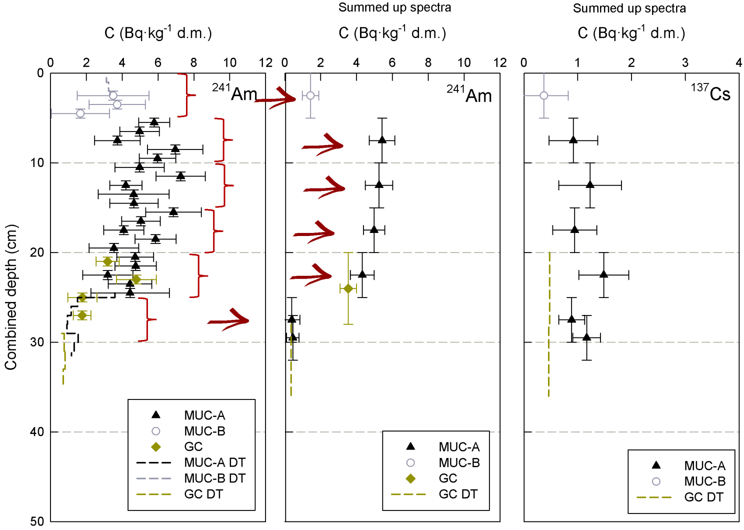

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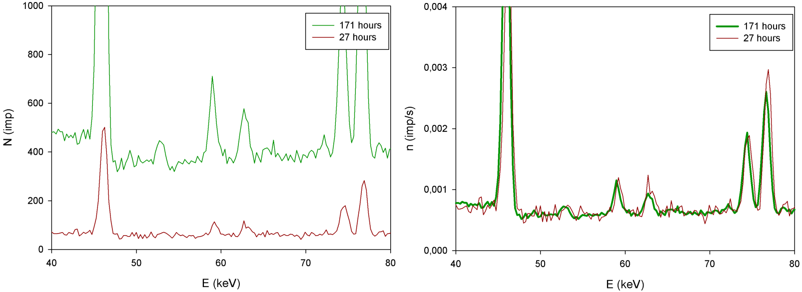

Figure: Close-up of gamma spectra in the area of 60 keV (^{241}Am) before (red) and after (green) summing

Summing of spectra of several following intervals

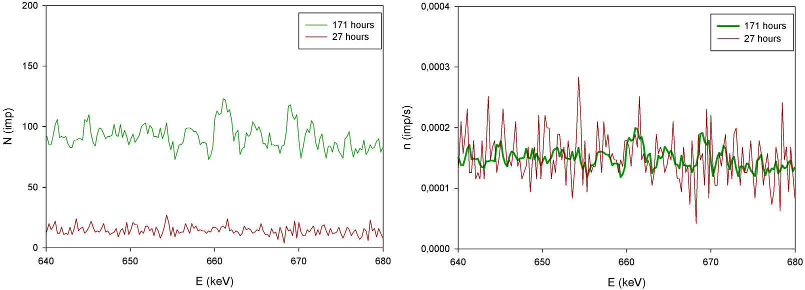

Figure: Close-up of gamma spectra in the area of 662 keV (^{137}Cs) before (red) and after (green) summing. An activation peak of ^{63*}Cu can be seen at 669.3 keV.

Take home message

Summing gamma spectra is a good way to gain additional information from your existing data.

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