



JYVÄSKYLÄN YLIOPISTO  
UNIVERSITY OF JYVÄSKYLÄ

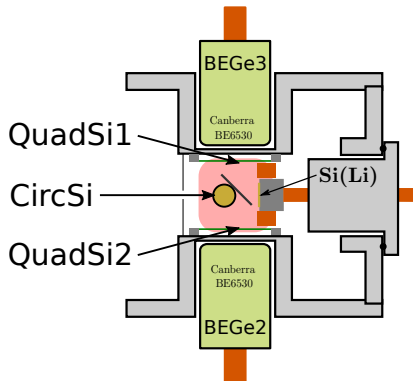
## I262 Setup Detection Efficiency



# Detectors

- 1 → BEGE2020 (Ch. 1)
- 3 → BEGE6530 (Ch. 2-4)
- 2 → QuadSi (Ch. 5-12)
- 1 → CircSi (Ch. 19)
- 1 → Si(Li) (Ch. 17)

**Total → 14 Ch.**



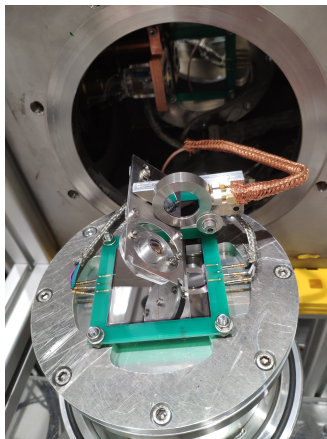


# Sources

1 → 3- $\alpha$  source  
 $^{239}\text{Pu}$  -  $^{241}\text{Am}$  -  $^{244}\text{Cm}$

5 →  $\gamma$  sources  
 $^{133}\text{Ba}$  -  $^{210}\text{Pb}$  -  $^{60}\text{Co}$   
 $^{137}\text{Cs}$  -  $^{152}\text{Eu}$

1 →  $\alpha$ -recoil source  
 $^{223}\text{Ra}$



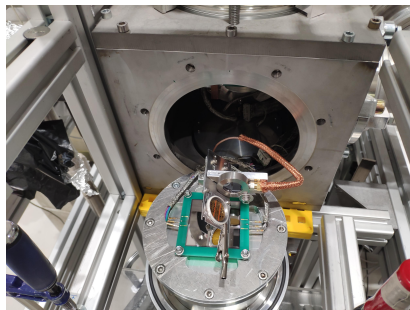


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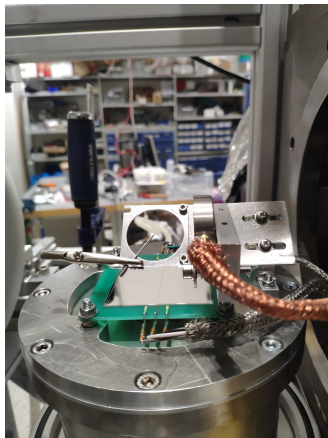


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# BEGE Efficiency

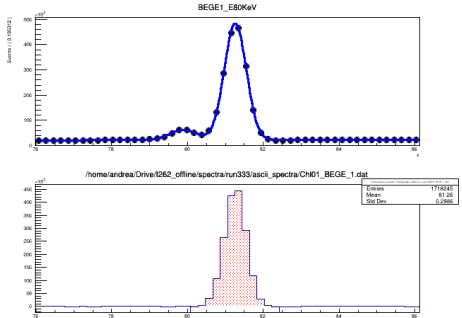
$$\epsilon_{\text{ABS}} = \frac{\text{Peak Area}}{\text{Time} \times \text{Activity} \times \text{Intensity}}$$

→ Peak Area

→ Time

→ Activity

→ Intensity

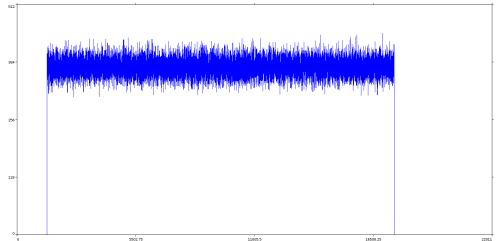




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$$\epsilon_{\text{ABS}} = \frac{\text{Peak Area}}{\text{Time} \times \text{Activity} \times \text{Intensity}}$$

- Peak Area
- Time
- Activity
- Intensity





# BEGE Efficiency

$$\mathcal{E}_{\text{ABS}} = \frac{\text{Peak Area}}{\text{Time} \times \text{Activity} \times \text{Intensity}}$$

- Peak Area
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$$A = A_0 \exp \left( -\ln(2) \frac{\Delta T}{T_{1/2}} \right)$$

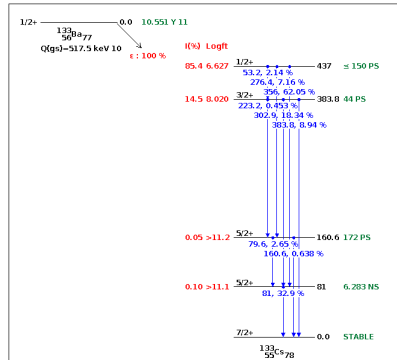




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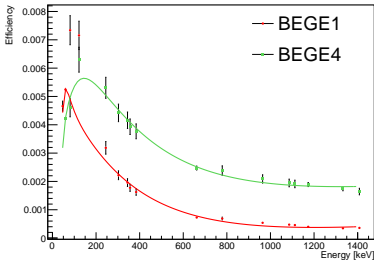
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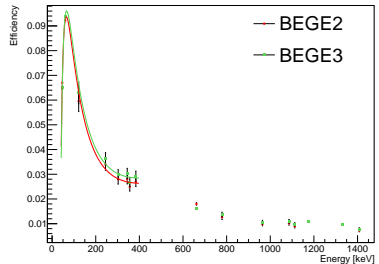


# BEGE Efficiency

## Vertical Axis



## Horizontal Axis



$$^1 \mathcal{E}_{\text{ABS}}(E) = a_1 (\exp(-a_2 E^{a_3}) + \exp(-a_4 E^{a_5})) (1 - \exp(a_6 E^{a_7}))$$

$$^2 \mathcal{E}_{\text{ABS}}(E) = \frac{1}{E} \sum_i a_i (\ln(E))^{i-1}$$

<sup>1</sup> Hurtado Garcia-Lenon Nucl. Instr. and Meth. A 594 (2008) 362–367

<sup>2</sup> P.W. Gray, A. Ahmad, Nucl. Instr. and Meth. A 237 (1985) 577



# Error sources

- Integral error ✓
- acquisition time error  
(negligible ?)
- Half Life time error  
(negligible ?)
- Original Activity Error ✓
- Intensity
  - Intensity error ✓
  - Coincidence summing  $\gamma$
- Geometrical error
  - Isotropic emission
  - Point-like source



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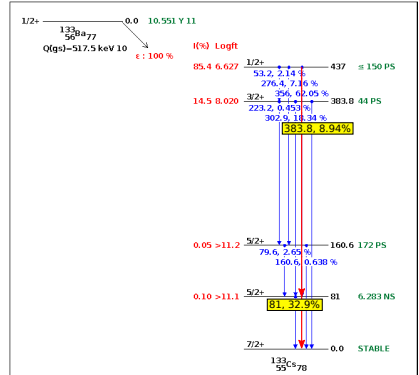
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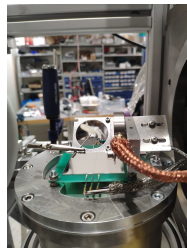
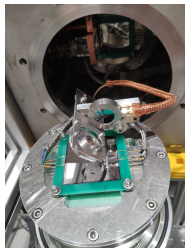
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# $^{223}\text{Ra}$ $\alpha$ -recoil source

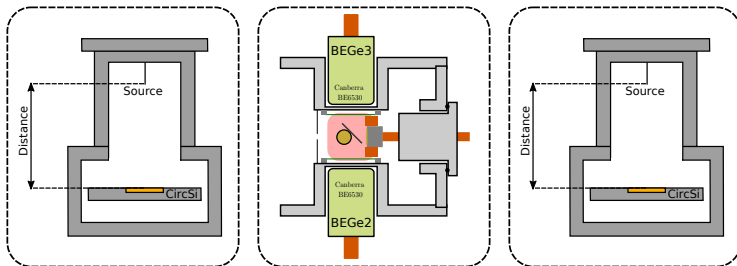
	Ac 213 738 ms	Ac 214 8.2 s	Ac 215 170 ms	Ac 216 440 us	Ac 217 69 ns	Ac 218 1.00 us	Ac 219 11.8 us	Ac 220 26.36 ms	Ac 221 52 ms	Ac 222 5.0 s	Ac 223 2.10 m	Ac 224 2.78 h	Ac 225 9.920 d
88	Ra 212 13.0 s	Ra 213 2.73 m	Ra 214 2.437 s	Ra 215 1.67 ms	Ra 216 182 ns	Ra 217 1.63 us	Ra 218 25.2 us	Ra 219 10 ms	Ra 220 17.9 ms	Ra 221 28 s	Ra 222 33.6 s	Ra 223 11.4377 d	Ra 224 3.6319 d
	Fr 211 3.10 m	Fr 212 20.0 m	Fr 213 34.14 s	Fr 214 5.18 ms	Fr 215 86 ns	Fr 216 700 ns	Fr 217 16.8 us	Fr 218 1.0 ms	Fr 219 20 ms	Fr 220 27.4 s	Fr 221 4.801 m	Fr 222 14.2 m	Fr 223 22.00 m
86	Rn 210 2.4 h	Rn 211 14.6 h	Rn 212 23.9 m	Rn 213 19.5 ms	Rn 214 270 ns	Rn 215 2.30 us	Rn 216 45 us	Rn 217 540 us	Rn 218 33.75 ms	Rn 219 3.96 s	Rn 220 55.6 s	Rn 221 25.7 m	Rn 222 3.8215 d
	At 209 5.42 h	At 210 8.1 h	At 211 7.214 h	At 212 314 ms	At 213 125 ns	At 214 558 ns	At 215 100 us	At 216 300 us	At 217 3.762 ms	At 218 1.5 s	At 219 56 s	At 220 3.71 m	At 221 2.3 m
84	Po 208 2.898 y	Po 209 124 y	Po 210 138.376 d	Po 211 516 ms	Po 212 294.7 ns	Po 213 3.708 us	Po 214 163.72 us	Po 215 1.781 ms	Po 216 145 ms	Po 217 1.514 s	Po 218 3.098 m	Po 219 10.3 m	Po 220 10.3 m
	Bi 207 3120 y	Bi 208 368 ky	Bi 209 100.	Bi 210 5.012 d	Bi 211 2.14 m	Bi 212 60.55 m	Bi 213 44.61 m	Bi 214 19.9 m	Bi 215 7.6 m	Bi 216 2.25 m	Bi 217 98.5 s	Bi 218 33 s	Bi 219 8.7 s
82	Pb 206 24.1	Pb 207 22.1	Pb 208 52.4	Pb 209 3.234 h	Pb 210 22.20 y	Pb 211 36.164 m	Pb 212 10.64 h	Pb 213 10.2 m	Pb 214 27.06 m	Pb 215 2.34 m	Pb 216 1.65 m	Pb 217 20 s	Pb 218 15 s
	Tl 205 70.48	Tl 206 4.202 m	Tl 207 4.77 m	Tl 208 3.053 m	Tl 209 2.162 m	Tl 210 1.30 m	Tl 211 80 s	Tl 212 31 s	Tl 213 24 s	Tl 214 11 s	Tl 215 10 s	Tl 216 6 s	Tl 217 10.3 m
80	Hg 204 6.87	Hg 205 5.14 m	Hg 206 8.32 m	Hg 207 2.9 m	Hg 208 42 m	Hg 209 38 s	Hg 210 64 s	Hg 211 26 s	Hg 212 10.3 m	Hg 213 10.3 m	Hg 214 10.3 m	Hg 215 10.3 m	Hg 216 10.3 m
	124	126	128	130	132	134	136						



## $^{223}\text{Ra}$ $\alpha$ -recoil source

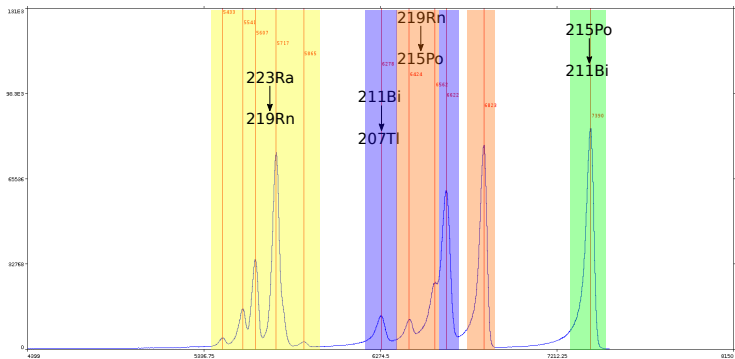
Activity measurement before and after the acquisition with the setup

Before → After





# $^{223}\text{Ra}$ $\alpha$ -recoil source





# To Do List

- Efficiency curves fitting
- Include 3- $\alpha$  source  $^{241}\text{Am}$  low energy  $\gamma$
- Include correction coefficients for coincident summing
- Compute geometrical error contribution
- Compute Si detectors efficiency from  $^{223}\text{Ra}$  source spectra.