253 Absorbtion von α-, β-, γ-Strahlung

```
Needs["ErrorBarPlots`"]
```

1 Inbetriebnahme des Zählrohrs

```
{U0, ΔU0} = Quantity[{540, 5}, "Volts"]
```

{540 V, 5 V}

```
R0 = Quantity[7, "Millimeters"]
```

7 mm

2 Messung des Nullefekts

```
{n0, Δn0} = Quantity[{230, Sqrt[230]} / (5 * 60), "Becquerels"] // N
```

{0.766667 Bq, 0.0505525 Bq}

3 Absorbtion von β-Strahlung in Alluminium

Kennummer des Präperats: 253D

```
{dpr,zr, Δdpr,zr} = Quantity[{6, 0.2}, "Centimeters"]
```

{6 cm, 0.2 cm}

```
Data3 = {{Quantity[0, "Millimeters"], Quantity[1685 / 30, "Becquerels"]},
   {Quantity[0.3, "Millimeters"], Quantity[1069 / 30, "Becquerels"]},
   {Quantity[0.6, "Millimeters"], Quantity[724 / 30, "Becquerels"]},
   {Quantity[0.9, "Millimeters"], Quantity[496 / 30, "Becquerels"]},
   {Quantity[1.2, "Millimeters"], Quantity[322 / 30, "Becquerels"]},
   {Quantity[1.5, "Millimeters"], Quantity[822 / 120, "Becquerels"]},
   {Quantity[1.8, "Millimeters"], Quantity[548 / 120, "Becquerels"]},
   {Quantity[2.1, "Millimeters"], Quantity[334 / 120, "Becquerels"]},
   {Quantity[2.4, "Millimeters"], Quantity[196 / 120, "Becquerels"]},
   {Quantity[2.7, "Millimeters"], Quantity[153 / 120, "Becquerels"]},
   {Quantity[3.0, "Millimeters"], Quantity[135 / 120, "Becquerels"]},
   {Quantity[3.3, "Millimeters"], Quantity[108 / 120, "Becquerels"]},
   {Quantity[3.6, "Millimeters"], Quantity[115 / 120, "Becquerels"]},
   {Quantity[4.6, "Millimeters"], Quantity[237 / 300, "Becquerels"]}} // N
```

```
{{0. mm, 56.1667 Bq}, {0.3 mm, 35.6333 Bq}, {0.6 mm, 24.1333 Bq},
 {0.9 mm, 16.5333 Bq}, {1.2 mm, 10.7333 Bq}, {1.5 mm, 6.85 Bq}, {1.8 mm, 4.56667 Bq},
 {2.1 mm, 2.78333 Bq}, {2.4 mm, 1.63333 Bq}, {2.7 mm, 1.275 Bq},
 {3. mm, 1.125 Bq}, {3.3 mm, 0.9 Bq}, {3.6 mm, 0.958333 Bq}, {4.6 mm, 0.79 Bq}}
```

```
CData3 = Table[{Data3[[i, 1]],
   {Data3[[i, 2]], Quantity[Sqrt[QuantityMagnitude[Data3[[i, 2]]]],
     "Becquerels"]}}, {i, 1, Length[Data3]}]
```

```
{{0. mm, {56.1667 Bq, 7.49444 Bq}}, {0.3 mm, {35.6333 Bq, 5.96937 Bq}},
 {0.6 mm, {24.1333 Bq, 4.91257 Bq}}, {0.9 mm, {16.5333 Bq, 4.06612 Bq}},
 {1.2 mm, {10.7333 Bq, 3.27618 Bq}}, {1.5 mm, {6.85 Bq, 2.61725 Bq}},
 {1.8 mm, {4.56667 Bq, 2.13698 Bq}}, {2.1 mm, {2.78333 Bq, 1.66833 Bq}},
 {2.4 mm, {1.63333 Bq, 1.27802 Bq}}, {2.7 mm, {1.275 Bq, 1.12916 Bq}},
 {3. mm, {1.125 Bq, 1.06066 Bq}}, {3.3 mm, {0.9 Bq, 0.948683 Bq}},
 {3.6 mm, {0.958333 Bq, 0.978945 Bq}}, {4.6 mm, {0.79 Bq, 0.888819 Bq}}}
```

Auswertung

```
xs1 = Transpose[CData3][[1, All]] // QuantityMagnitude
```

```
{0., 0.3, 0.6, 0.9, 1.2, 1.5, 1.8, 2.1, 2.4, 2.7, 3., 3.3, 3.6, 4.6}
```

```
ns1 = Transpose[CData3][[2, All, 1]] - n0 // QuantityMagnitude
```

```
{55.4, 34.8667, 23.3667, 15.7667, 9.96667, 6.08333, 3.8, 2.01667,
 0.866667, 0.508333, 0.358333, 0.133333, 0.191667, 0.0233333}
```

```
cns1 = Transpose[CData3][[2, All, 1]] -
   Transpose[CData3][[2, All, 2]] - (n0 - Δn0) // QuantityMagnitude
```

```
{47.9561, 28.9479, 18.5047, 11.7511, 6.74104, 3.51664, 1.71358, 0.398887,
 -0.3608, -0.570273, -0.651774, -0.764797, -0.736726, -0.814934}
```

```
xsns1 = Table[{xs1[[i]], ns1[[i]]}, {i, 1, Length[xs1]}]
```

```
{{0., 55.4}, {0.3, 34.8667}, {0.6, 23.3667}, {0.9, 15.7667}, {1.2, 9.96667},
 {1.5, 6.08333}, {1.8, 3.8}, {2.1, 2.01667}, {2.4, 0.866667}, {2.7, 0.508333},
 {3., 0.358333}, {3.3, 0.133333}, {3.6, 0.191667}, {4.6, 0.0233333}}
```

```
cxsns1 = Table[{xs1[[i]], cns1[[i]]}, {i, 1, Length[xs1]}]
```

```
{{0., 47.9561}, {0.3, 28.9479}, {0.6, 18.5047},
 {0.9, 11.7511}, {1.2, 6.74104}, {1.5, 3.51664}, {1.8, 1.71358},
 {2.1, 0.398887}, {2.4, -0.3608}, {2.7, -0.570273}, {3., -0.651774},
 {3.3, -0.764797}, {3.6, -0.736726}, {4.6, -0.814934}}
```

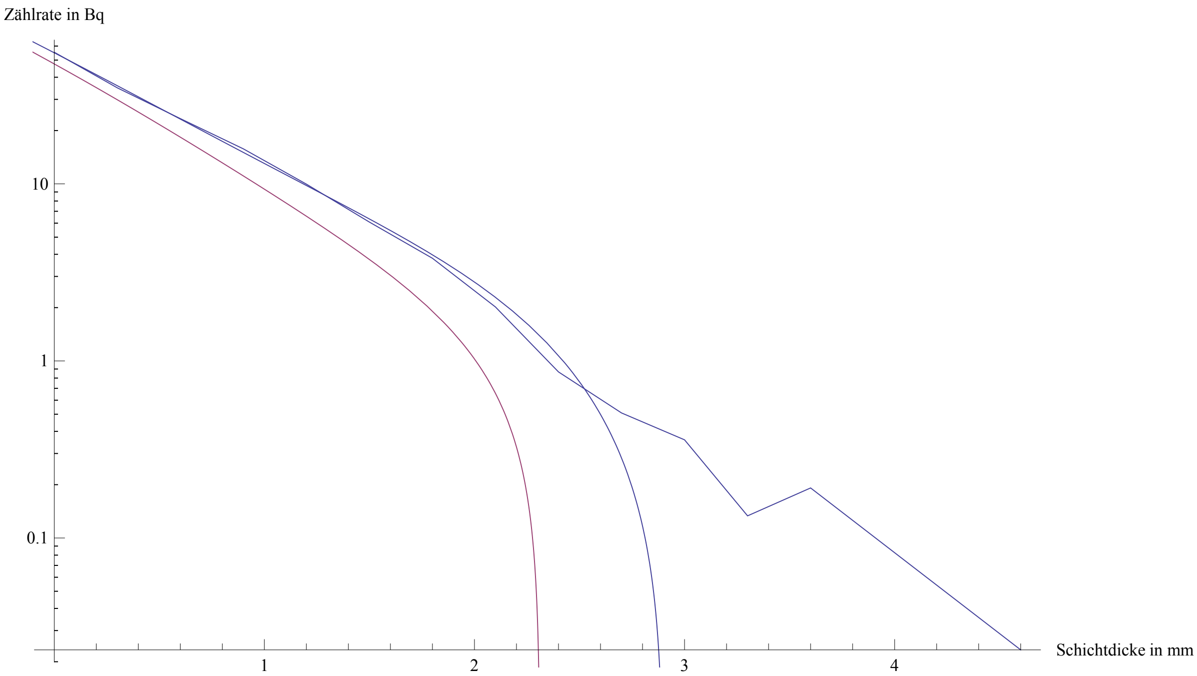
```
ffit = LinearModelFit[xsns1, {1, x, x^2, x^3, x^4, x^5}, x]
```

FittedModel[$54.9949 - 77.5272\,x + \ll 18 \gg \ll 1 \gg - \ll 1 \gg + 3.5114\,x^4 - 0.262863\,x^5$]

```
cffit = LinearModelFit[cxsns1, {1, x, x^2, x^3, x^4, x^5}, x]
```

FittedModel[$47.5777 - 72.0657\,x + \ll 17 \gg \ll 1 \gg - \ll 1 \gg + 3.28215\,x^4 - 0.242071\,x^5$]

```
Show[ListLogPlot[xsns1, Joined → True, ImageSize → Full,
  PlotRange → Full, AxesLabel → {"Schichtdicke in mm", "Zählrate in Bq"}],
 LogPlot[{ffit[x], cffit[x]}, {x, -1, 3}]]
```



Die hier angesetzten Fits sind Polynome in 5. Ordnung. Die Fehlerkurve wurde aus den entsprechenden statistischen Fehlern extrapoliert. Wir lesen ab:

```
{dmax, Δdmax} = Quantity[{2.88, 0.6}, "Millimeters"]
```

{2.88 mm, 0.6 mm}

Daraus lässt sich jetzt die Flächendichte ermitteln. Wir müssen zusätzlich die Fensterdicke berügsichtigen, welche aus Edelstahl und Silber besteht.

R^{β}_{ES} = Quantity[0.130, "Grams" / "Centimeters"^2]

$0.13\ g/cm^2$

```
ρAl = Quantity[2.7, "Grams" / "Centimeters"^3]
```

2.7 g/cm^3

Es gilt nun:

```
{Rβ, ΔRβ} = R^β_ES + {dmax, Δdmax} * ρAl
```

{0.9076 g/cm^2, 0.292 g/cm^2}

```
Rβ ± ΔRβ
```

0.9076 g/cm^2 ± 0.292 g/cm^2

Mithilfe des Diagramms im Anhang der Praktikumsanleitung ergibt sich die Maximalenergie:

```
{Tmax, ΔTmax} = Quantity[{2.00, 0.25}, "Megaelectronvolts"]
```

{2. MeV, 0.25 MeV}

```
Tmax ± ΔTmax
```

2. MeV ± 0.25 MeV

Der zu erwartende Wert kann aus dem Anhang (Abbildung 6) abgelesen werden. 99.98% des Yttrium-Zirkonium-Zerfalls (der als einziger gemessen wird) produziert Elektronen mit einer Maximalenergie von 2.274 MeV.

```
Tmaxtheo = Quantity[2.274, "Megaelectronvolts"]
```

2.274 MeV

Dieser Wert liegt knapp außerhalb der 1-σ-Grenze, passt aber trotzdem in den Rahmen unserer Messgenauigkeit.

4 Absorbtion von γ-Strahlung in Blei

Wir messen erneut den Nullefekt, da die γ-Präperate relativ nah an den Zählrohen standen. Für die eigene Messung sollten zwecks des Vergleiches mit dem Nullefekt die γ-Strahler also nicht zu wesentlich zum Nullefekt beitragen.

```
{n0γ, Δn0γ} = Quantity[{95 / 300, Sqrt[95] / 300}, "Becquerels"] // N
```

{0.316667 Bq, 0.0324893 Bq}

```
{d2, Δd2} = Quantity[{15, 0.2}, "Centimeters"]
```

{15 cm, 0.2 cm}

```
Data4 = {{Quantity[0, "Centimeters"], Quantity[5183 / 60, "Becquerels"]},
   {Quantity[0.5, "Centimeters"], Quantity[3488 / 60, "Becquerels"]},
   {Quantity[1, "Centimeters"], Quantity[2692 / 60, "Becquerels"]},
   {Quantity[1.5, "Centimeters"], Quantity[1947 / 60, "Becquerels"]},
   {Quantity[2, "Centimeters"], Quantity[1482 / 60, "Becquerels"]},
   {Quantity[2.5, "Centimeters"], Quantity[1076 / 60, "Becquerels"]},
   {Quantity[3, "Centimeters"], Quantity[858 / 60, "Becquerels"]},
   {Quantity[3.5, "Centimeters"], Quantity[663 / 60, "Becquerels"]},
   {Quantity[4, "Centimeters"], Quantity[463 / 60, "Becquerels"]},
   {Quantity[4.5, "Centimeters"], Quantity[396 / 60, "Becquerels"]},
   {Quantity[5, "Centimeters"], Quantity[301 / 60, "Becquerels"]}} // N
```

```
{{0. cm, 86.3833 Bq}, {0.5 cm, 58.1333 Bq}, {1. cm, 44.8667 Bq},
 {1.5 cm, 32.45 Bq}, {2. cm, 24.7 Bq}, {2.5 cm, 17.9333 Bq}, {3. cm, 14.3 Bq},
 {3.5 cm, 11.05 Bq}, {4. cm, 7.71667 Bq}, {4.5 cm, 6.6 Bq}, {5. cm, 5.01667 Bq}}
```

```
CData4 = Table[{Data4[[i, 1]],
   {Data4[[i, 2]], Quantity[Sqrt[QuantityMagnitude[Data4[[i, 2]]]],
     "Becquerels"]}}, {i, 1, Length[Data4]}]
```

```
{{0. cm, {86.3833 Bq, 9.29426 Bq}},
 {0.5 cm, {58.1333 Bq, 7.62452 Bq}}, {1. cm, {44.8667 Bq, 6.69826 Bq}},
 {1.5 cm, {32.45 Bq, 5.69649 Bq}}, {2. cm, {24.7 Bq, 4.96991 Bq}},
 {2.5 cm, {17.9333 Bq, 4.23478 Bq}}, {3. cm, {14.3 Bq, 3.78153 Bq}},
 {3.5 cm, {11.05 Bq, 3.32415 Bq}}, {4. cm, {7.71667 Bq, 2.77789 Bq}},
 {4.5 cm, {6.6 Bq, 2.56905 Bq}}, {5. cm, {5.01667 Bq, 2.23979 Bq}}}
```

Auswertung

```
xs2 = Transpose[Data4][[1, All]] // QuantityMagnitude
```

```
{0., 0.5, 1., 1.5, 2., 2.5, 3., 3.5, 4., 4.5, 5.}
```

```
ns2 = Transpose[Data4][[2, All]] - n0γ // QuantityMagnitude
```

```
{86.0667, 57.8167, 44.55, 32.1333,
 24.3833, 17.6167, 13.9833, 10.7333, 7.4, 6.28333, 4.7}
```

```
cns2 = Transpose[CData4][[2, All, 1]] -
   Transpose[CData4][[2, All, 2]] - (n0γ - Δn0γ) // QuantityMagnitude
```

```
{76.8049, 50.2246, 37.8842, 26.4693, 19.4459,
 13.4144, 10.2343, 7.44167, 4.6546, 3.74678, 2.4927}
```

```
xsns2 = Table[{xs2[[i]], ns2[[i]]}, {i, 1, Length[xs2]}]
```

```
{{0., 86.0667}, {0.5, 57.8167}, {1., 44.55},
 {1.5, 32.1333}, {2., 24.3833}, {2.5, 17.6167}, {3., 13.9833},
 {3.5, 10.7333}, {4., 7.4}, {4.5, 6.28333}, {5., 4.7}}
```

```
cxsns2 = Table[{xs2[[i]], cns2[[i]]}, {i, 1, Length[xs2]}]
```

```
{{0., 76.8049}, {0.5, 50.2246}, {1., 37.8842},
 {1.5, 26.4693}, {2., 19.4459}, {2.5, 13.4144}, {3., 10.2343},
 {3.5, 7.44167}, {4., 4.6546}, {4.5, 3.74678}, {5., 2.4927}}
```

```
sfer2 = Transpose[CData4][[2, All, 1]] // QuantityMagnitude
```

{86.3833, 58.1333, 44.8667, 32.45,
 24.7, 17.9333, 14.3, 11.05, 7.71667, 6.6, 5.01667}

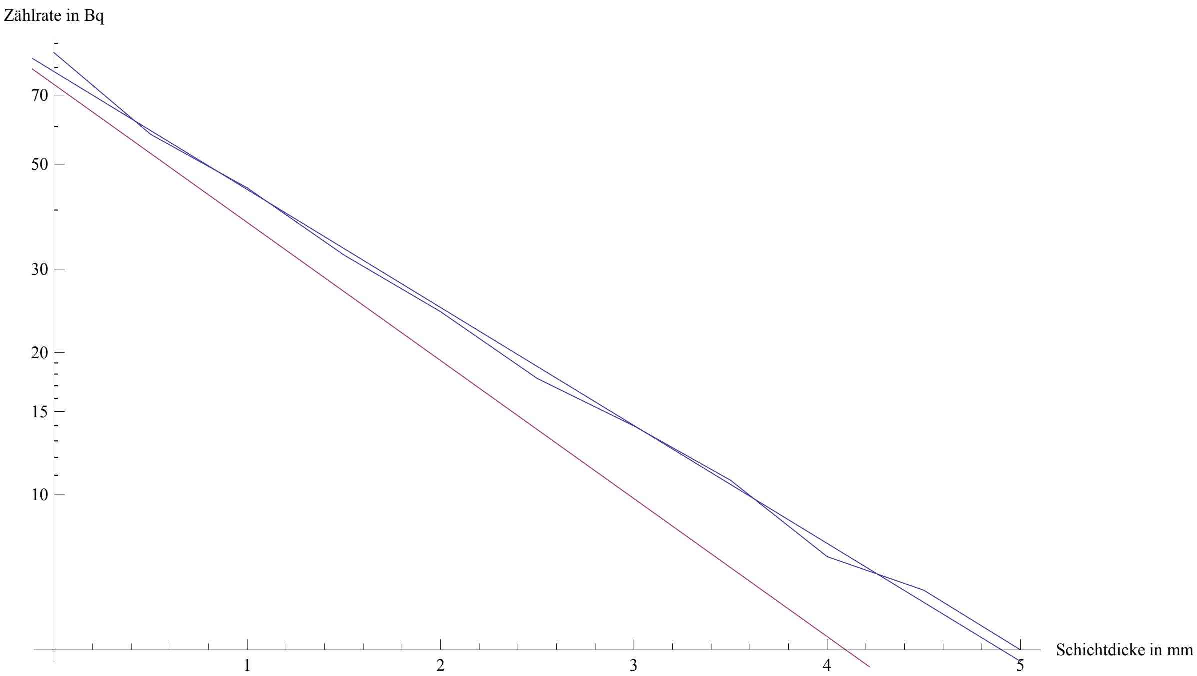
```
sffit = NonlinearModelFit[xsns2, a * Exp[-μ * x], {a, μ},
  x, Weights → 1 / sfer2^2, VarianceEstimatorFunction → (1 &)]
```

FittedModel[$78.4799\, e^{-0.574252 x}$]

```
csffit = NonlinearModelFit[cxsns2, a * Exp[-τ * x], {a, τ},
  x, Weights → 1 / sfer2^2, VarianceEstimatorFunction → (1 &)]
```

FittedModel[$73.7141\, e^{-0.67203 x}$]

```
Show[ListLogPlot[xsns2, Joined → True, ImageSize → Full,
  PlotRange → Full, AxesLabel → {"Schichtdicke in mm", "Zählrate in Bq"}
 ], LogPlot[{sffit[x], csffit[x]}, {x, -1, 5}]]
```



Hier aufgetragen sind nun der gemessene Verlauf, der Fit (Exponential) und die entsprechende veranschaulichende Fehlerkurve. Damit lässt sich der Parameter μ für die Schwächung inklusive Fehler bestimmen. Der Fit wurde direkt in der Form des Lambert-Beer-Gesetzes gefordert. Deswegen können wir die Parameter direkt ablesen. Der Fehler auf μ wird aus der, entsprechend der Fehler, gewichteten Standartabweichung des Fits extrahiert.

```
sffit["ParameterTable"]
```

	Estimate	Standard Error	t-Statistic	P-Value
a	78.4799	45.8136	1.71302	0.120859
μ	0.574252	0.202711	2.83286	0.0196304

```
{μ, Δμ} =
 Quantity[sffit["ParameterTableEntries"][[2, 1 ;; 2]], "Centimeters"^(-1)]
```

{0.574252 reciprocal centimeters, 0.202711 reciprocal centimeters}

$\mu \pm \Delta\mu$

0.574252 reciprocal centimeters ± 0.202711 reciprocal centimeters

Nun bestimmen wir mithilfe des weiteren Diagramms im Anhang die Energie der γ-Photonen abschätzen.

ρ_{Pb} = Quantity[11.342, "Grams" / "Centimeters"^3]

$11.342\ g/cm^3$

{M, ΔM} = {μ, Δμ} / ρ_{Pb}

$\{0.0506306\ cm^2/g,\ 0.0178726\ cm^2/g\}$

{T_γ, ΔT_γ} = Quantity[{1.5, .3}, "Megaelectronvolts"]

{1.5 MeV, 0.3 MeV}

$T_\gamma \pm \Delta T_\gamma$

1.5 MeV ± 0.3 MeV

Aus dem Skript lesen wir für die beiden Übergänge mit γ-Emission 1.173 MeV und 1.333 MeV. Beide liegen entweder knapp innerhalb des 1-σ-Bereichs oder leicht außerhalb. Die Messung war also erfolgreich, wenn auch nicht sehr präzise.

5 Messung der Aktivität

```
Data5 = {{Quantity[{5.5, 0.2}, "Centimeters"],
    Quantity[{71 274 / 60, Sqrt[71 274] / 60}, "Becquerels"]},
   {Quantity[{10, 0.2}, "Centimeters"],
    Quantity[{20 626 / 60, Sqrt[20 626] / 60}, "Becquerels"]},
   {Quantity[{20, 0.2}, "Centimeters"],
    Quantity[{4868 / 60, Sqrt[4868] / 60}, "Becquerels"]}} // N
```

```
{{{5.5 cm, 0.2 cm}, {1187.9 Bq, 4.44953 Bq}},
 {{10. cm, 0.2 cm}, {343.767 Bq, 2.39363 Bq}},
 {{20. cm, 0.2 cm}, {81.1333 Bq, 1.16285 Bq}}}
```

Auswertung

Wir berechnen nun aus diesen Werten jeweils die Aktivität. Die dazu verwendete Formel entnehmen wir dem Skriptum.

```
ϵ = 4 / 100 // N
```

0.04

```
A[n_, d_, r_] := (4 * n * d^2) / (ϵ * r^2)
```

```
ΔA[n_, d_, r_, Δn_, Δd_] = Sqrt[(D[A[n, d, r], n] * Δn)^2 + (D[A[n, d, r], d] * Δd)^2]
```

$$\sqrt{\frac{40\,000.\ d^2\ n^2\ \Delta d^2}{r^4} + \frac{10\,000.\ d^4\ \Delta n^2}{r^4}}$$

```
R = Quantity[7, "Millimeters"]
```

7 mm

```
{A1, ΔA1} =
  {A[First[Data5[[1, 2]]], First[Data5[[1, 1]]], R], ΔA[First[Data5[[1, 2]]],
    First[Data5[[1, 1]]], R, Last[Data5[[1, 2]]], Last[Data5[[1, 1]]]]}
```

$\{7.33346 \times 10^6\ \text{Bq},\ 534\,050.\ \text{Bq}\}$

```
A1 ± ΔA1
```

$7.33346 \times 10^6\ \text{Bq} \pm 534\,050.\ \text{Bq}$

```
{A2, ΔA2} =
  {A[First[Data5[[2, 2]]], First[Data5[[2, 1]]], R], ΔA[First[Data5[[2, 2]]],
    First[Data5[[2, 1]]], R, Last[Data5[[2, 2]]], Last[Data5[[2, 1]]]]}
```

$\{7.01565 \times 10^6\ \text{Bq},\ 284\,846.\ \text{Bq}\}$

```
A2 ± ΔA2
```

$7.01565 \times 10^6\ \text{Bq} \pm 284\,846.\ \text{Bq}$

```
{A3, ΔA3} =
  {A[First[Data5[[3, 2]]], First[Data5[[3, 1]]], R], ΔA[First[Data5[[3, 2]]],
    First[Data5[[3, 1]]], R, Last[Data5[[3, 2]]], Last[Data5[[3, 1]]]]}
```

$\{6.62313 \times 10^6\ \text{Bq},\ 162\,964.\ \text{Bq}\}$

```
A3 ± ΔA3
```

$6.62313 \times 10^6\ \text{Bq} \pm 162\,964.\ \text{Bq}$

Unser Präperat hat eine Halbwertszeit von $T_{1/2} = 5.27\ a$ und hatte 1. 1. 2013 eine Aktivität von 3.28 MBq. Das heißt, dass unsere gemessene Aktivität ungefär um den Faktor 2 zu groß ist.

Wir ermitteln nun den Korrekturfaktor, gemäß der Angaben im Skript, mit korrigiertem Raumwinkel. Die Korrektur wird den gemessenen Wert vermutlich nach oben hin korrigieren. Dies weicht noch mehr von dem tatsächlichen Wert ab.

```
l = Quantity[4, "Centimeters"]
```

4 cm

```
Ak1[n_, d_, r_] := (4 * n * (d + l / 2)^2) / (ϵ * r^2)
```

```
ΔAk1[n_, d_, r_, Δn_, Δd_] =
  Sqrt[(D[Ak1[n, d, r], n] * Δn)^2 + (D[Ak1[n, d, r], d] * Δd)^2]
```

$$\sqrt{\frac{40\,000.\ n^2\ \Delta d^2\ (d+2\ cm)^2}{r^4}+\frac{10\,000.\ \Delta n^2\ (d+2\ cm)^4}{r^4}}$$

Die Korrektur wird für steigendes d immer weniger von der Korrektur betroffen sein, da l/2 gegen d klein wird. Wir rechnen konkret aus.

```
{A1k1, ΔA1k1} =
  {Ak1[First[Data5[[1, 2]]], First[Data5[[1, 1]]], R], ΔAk1[First[Data5[[1, 2]]],
    First[Data5[[1, 1]]], R, Last[Data5[[1, 2]]], Last[Data5[[1, 1]]]]}
```

$\{1.36366\times 10^7$ Bq, 729 077. Bq$\}$

```
A1k1 ± ΔA1k1
```

1.36366×10^7 Bq ± 729 077. Bq

```
{A2k1, ΔA2k1} =
  {Ak1[First[Data5[[2, 2]]], First[Data5[[2, 1]]], R], ΔAk1[First[Data5[[2, 2]]],
    First[Data5[[2, 1]]], R, Last[Data5[[2, 2]]], Last[Data5[[2, 1]]]]}
```

$\{1.01025\times 10^7$ Bq, 344 020. Bq$\}$

```
A2k1 ± ΔA2k1
```

1.01025×10^7 Bq ± 344 020. Bq

```
{A3k1, ΔA3k1} =
  {Ak1[First[Data5[[3, 2]]], First[Data5[[3, 1]]], R], ΔAk1[First[Data5[[3, 2]]],
    First[Data5[[3, 1]]], R, Last[Data5[[3, 2]]], Last[Data5[[3, 1]]]]}
```

$\{8.01399\times 10^6$ Bq, 185 537. Bq$\}$

```
A3k1 ± ΔA3k1
```

8.01399×10^6 Bq ± 185 537. Bq

Nun wird die zweite Korrektur durchgeführt. Wir übernejmen μ/ρ_{Pb} aus dem vorherigen Teil. Da unsere Messung bisher die abgeschirmte Aktivität zum Ergebnis hatte stellen wir die Gleichung (11) aus dem Skript um.

```
x = Quantity[1.4, "Millimeters"]
```

1.4 mm

```
ρabs = Quantity[7.9, "Grams" / "Centimeters"^3]
```

7.9 g/cm^3

$$U = \{M, \Delta M\} = \frac{\{\mu, \Delta\mu\}}{\rho_{Pb}}$$

$\{0.0506306\ cm^2/g,\ 0.0178726\ cm^2/g\}$

$$Ak2[t\_, s\_, z\_] := \frac{Ak1[t, s, z]}{Exp[-First[U] * \rho_{abs} * x]}$$

```
ΔAk2[t_, s_, z_, Δt_, Δs_] =
 Sqrt[(D[Ak2[t, s, z], t] * Δt)^2 + (D[Ak2[t, s, z], s] * Δs)^2]
```

$$\sqrt{\frac{44740.3\, t^2\, \Delta s^2\, (s + 2\text{ cm})^2}{z^4} + \frac{11185.1\, \Delta t^2\, (s + 2\text{ cm})^4}{z^4}}$$

```
{A1k2, ΔA1k2} =
 {Ak2[First[Data5[[1, 2]]], First[Data5[[1, 1]]], R], ΔAk2[First[Data5[[1, 2]]],
   First[Data5[[1, 1]]], R, Last[Data5[[1, 2]]], Last[Data5[[1, 1]]]]}
```

$\{1.4422\times 10^7\text{ Bq}, 771068.\text{ Bq}\}$

```
A1k2 ± ΔA1k2
```

$1.4422\times 10^7\text{ Bq} \pm 771068.\text{ Bq}$

```
{A2k2, ΔA2k2} =
 {Ak2[First[Data5[[2, 2]]], First[Data5[[2, 1]]], R], ΔAk2[First[Data5[[2, 2]]],
   First[Data5[[2, 1]]], R, Last[Data5[[2, 2]]], Last[Data5[[2, 1]]]]}
```

$\{1.06844\times 10^7\text{ Bq}, 363833.\text{ Bq}\}$

```
A2k2 ± ΔA2k2
```

$1.06844\times 10^7\text{ Bq} \pm 363833.\text{ Bq}$

```
{A3k2, ΔA3k2} =
 {Ak2[First[Data5[[3, 2]]], First[Data5[[3, 1]]], R], ΔAk2[First[Data5[[3, 2]]],
   First[Data5[[3, 1]]], R, Last[Data5[[3, 2]]], Last[Data5[[3, 1]]]]}
```

$\{8.47555\times 10^6\text{ Bq}, 196224.\text{ Bq}\}$

```
A3k2 ± ΔA3k2
```

$8.47555\times 10^6\text{ Bq} \pm 196224.\text{ Bq}$

Die hier versammelten Werte sind nun mithilfe aller Korrekturfaktoren ausgerechnet und entsprechen in keinster Weise den Herstellerangaben. Mögliche Gründe dafür werden im Handschriftlichen diskutiert.

6 Absorbtionsmessung und Energiebestimmung von α-Strahlungs

```
p0 = Quantity[21, "Millibars"]
```

21 mbar

```
Data4 = {{Quantity[{21, 3}, "Millibars"], Quantity[13209 / 60, "Becquerels"]},
  {Quantity[{269, 3}, "Millibars"], Quantity[12952 / 60, "Becquerels"]},
  {Quantity[{313, 3}, "Millibars"], Quantity[12863 / 60, "Becquerels"]},
  {Quantity[{410, 3}, "Millibars"], Quantity[7338 / 60, "Becquerels"]},
  {Quantity[{482, 3}, "Millibars"], Quantity[1250 / 60, "Becquerels"]},
  {Quantity[{500, 3}, "Millibars"], Quantity[721 / 60, "Becquerels"]},
  {Quantity[{546, 3}, "Millibars"], Quantity[290 / 60, "Becquerels"]},
  {Quantity[{612, 3}, "Millibars"], Quantity[276 / 60, "Becquerels"]},
  {Quantity[{725, 3}, "Millibars"], Quantity[266 / 60, "Becquerels"]},
  {Quantity[{810, 3}, "Millibars"], Quantity[244 / 60, "Becquerels"]},
  {Quantity[{888, 3}, "Millibars"], Quantity[253 / 60, "Becquerels"]},
  {Quantity[{996, 3}, "Millibars"], Quantity[230 / 60, "Becquerels"]}}
```

$\left\{\left\{\{21\,\text{mbar}, 3\,\text{mbar}\}, \frac{4403}{20}\,\text{Bq}\right\}, \left\{\{269\,\text{mbar}, 3\,\text{mbar}\}, \frac{3238}{15}\,\text{Bq}\right\}, \left\{\{313\,\text{mbar}, 3\,\text{mbar}\}, \frac{12863}{60}\,\text{Bq}\right\}, \left\{\{410\,\text{mbar}, 3\,\text{mbar}\}, \frac{1223}{10}\,\text{Bq}\right\}, \left\{\{482\,\text{mbar}, 3\,\text{mbar}\}, \frac{125}{6}\,\text{Bq}\right\}, \left\{\{500\,\text{mbar}, 3\,\text{mbar}\}, \frac{721}{60}\,\text{Bq}\right\}, \left\{\{546\,\text{mbar}, 3\,\text{mbar}\}, \frac{29}{6}\,\text{Bq}\right\}, \left\{\{612\,\text{mbar}, 3\,\text{mbar}\}, \frac{23}{5}\,\text{Bq}\right\}, \left\{\{725\,\text{mbar}, 3\,\text{mbar}\}, \frac{133}{30}\,\text{Bq}\right\}, \left\{\{810\,\text{mbar}, 3\,\text{mbar}\}, \frac{61}{15}\,\text{Bq}\right\}, \left\{\{888\,\text{mbar}, 3\,\text{mbar}\}, \frac{253}{60}\,\text{Bq}\right\}, \left\{\{996\,\text{mbar}, 3\,\text{mbar}\}, \frac{23}{6}\,\text{Bq}\right\}\right\}$

Auswertung

```
CData4 = Table[{Data4[[i, 1]],
    {Data4[[i, 2]], Quantity[Sqrt[QuantityMagnitude[Data4[[i, 2]]]],
      "Becquerels"]}}, {i, 1, Length[Data4]}] // N
```

```
{{{21. mbar, 3. mbar}, {220.15 Bq, 14.8375 Bq}},
 {{269. mbar, 3. mbar}, {215.867 Bq, 14.6924 Bq}},
 {{313. mbar, 3. mbar}, {214.383 Bq, 14.6418 Bq}},
 {{410. mbar, 3. mbar}, {122.3 Bq, 11.0589 Bq}},
 {{482. mbar, 3. mbar}, {20.8333 Bq, 4.56435 Bq}},
 {{500. mbar, 3. mbar}, {12.0167 Bq, 3.46651 Bq}},
 {{546. mbar, 3. mbar}, {4.83333 Bq, 2.19848 Bq}},
 {{612. mbar, 3. mbar}, {4.6 Bq, 2.14476 Bq}},
 {{725. mbar, 3. mbar}, {4.43333 Bq, 2.10555 Bq}},
 {{810. mbar, 3. mbar}, {4.06667 Bq, 2.0166 Bq}},
 {{888. mbar, 3. mbar}, {4.21667 Bq, 2.05345 Bq}},
 {{996. mbar, 3. mbar}, {3.83333 Bq, 1.95789 Bq}}}
```

```
ps4 = Transpose[CData4][[1, All, 1]] // QuantityMagnitude
```

```
{21., 269., 313., 410., 482., 500., 546., 612., 725., 810., 888., 996.}
```

```
Δps4 = Transpose[CData4][[1, All, 2]] // QuantityMagnitude
```

```
{3., 3., 3., 3., 3., 3., 3., 3., 3., 3., 3., 3.}
```

```
ns4 = Transpose[CData4][[2, All, 1]] - n0 // QuantityMagnitude
```

{219.833, 215.55, 214.067, 121.983, 20.5167,
 11.7, 4.51667, 4.28333, 4.11667, 3.75, 3.9, 3.51667}

```
Δns4 = Transpose[CData4][[2, All, 2]] // QuantityMagnitude // N
```

{14.8375, 14.6924, 14.6418, 11.0589, 4.56435,
 3.46651, 2.19848, 2.14476, 2.10555, 2.0166, 2.05345, 1.95789}

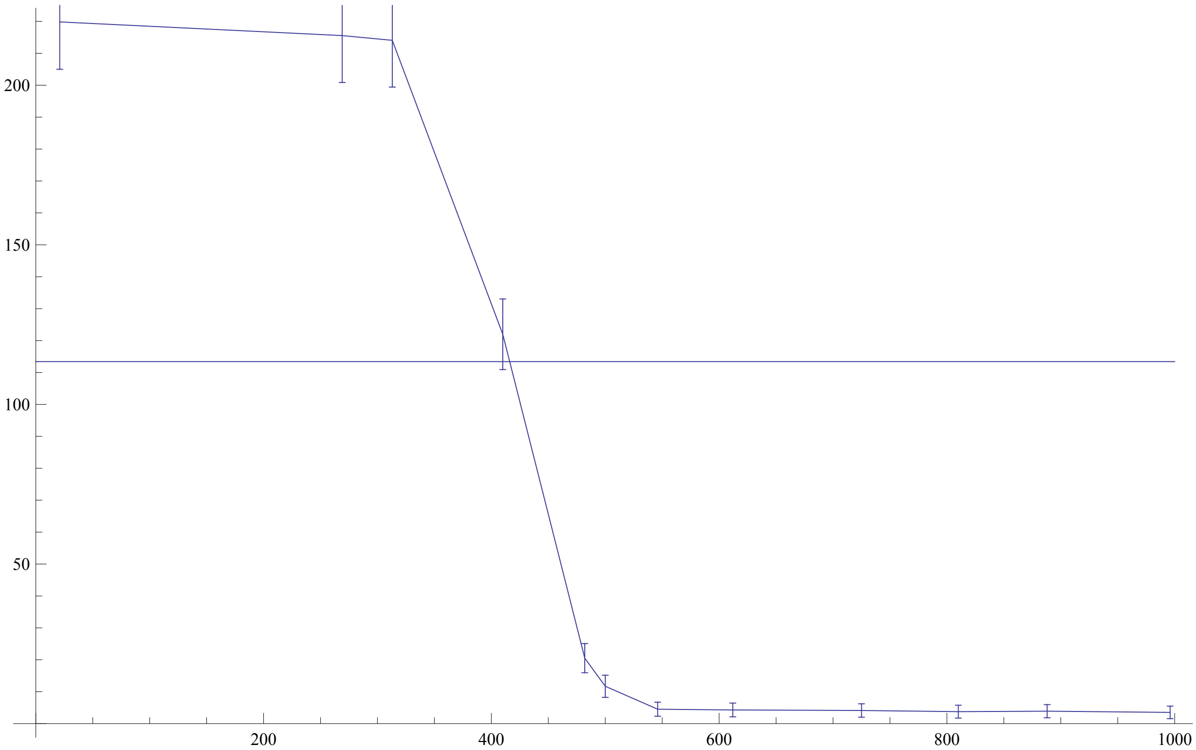
```
sfer4 = Transpose[CData4][[2, All, 2]] // QuantityMagnitude // N
```

{14.8375, 14.6924, 14.6418, 11.0589, 4.56435,
 3.46651, 2.19848, 2.14476, 2.10555, 2.0166, 2.05345, 1.95789}

```
psns4 = Table[{ps4[[i]], ns4[[i]], Δns4[[i]]}, {i, 1, Length[ps4]}] // N
```

{{21., 219.833, 14.8375}, {269., 215.55, 14.6924}, {313., 214.067, 14.6418},
 {410., 121.983, 11.0589}, {482., 20.5167, 4.56435}, {500., 11.7, 3.46651},
 {546., 4.51667, 2.19848}, {612., 4.28333, 2.14476}, {725., 4.11667, 2.10555},
 {810., 3.75, 2.0166}, {888., 3.9, 2.05345}, {996., 3.51667, 1.95789}}

```
Show[ErrorListPlot[psns4, Joined → True, ImageSize → Full],
 Plot[(First[ns4] / 2) + 3.5, {x, 0, 1000}]]
```



Wir lesen auf der Hälfte ab (um die Hälfte genau abzuschätzen habe ich nochmals eine Nulleffektkorrektur durchgeführt indem der Gerade der zuletzt gemessene n-Wert (3.5 Bq) hinzugefügt wurde):

```
Pultimo = {p1/2, Δp1/2} = Quantity[{425, 10}, "Millibars"]
```

{425 mbar, 10 mbar}

Daraus wollen wir nun die Reichweite bestimmen. Gemäß Praktikumsanleitung setzt sich diese aus einem Hauptsummanten und 2 Korrekturen zusammen. In seiner Gesamtheit sieht die Formel dann folgendermaßen aus:

```
Sα[p_, pn_, sn_, ρgl_] :=
  p/pn * sn + ρgl/Quantity[1.43, "Milligrams"/"Centimeters"^2] * Quantity[1, "Centimeters"] +
   Quantity[0.68, "Centimeters"]
```

```
ΔSα[p_, pn_, sn_, ρgl_, Δp_, Δsn_] =
 Sqrt[(D[Sα[p, pn, sn, ρgl], p] * Δp)^2 + (D[Sα[p, pn, sn, ρgl], sn] * Δsn)^2]
```

$$\sqrt{\frac{sn^2\,\Delta p^2}{pn^2}+\frac{p^2\,\Delta sn^2}{pn^2}}$$

```
p0 = Quantity[1013, "Millibars"]
```

1013 mbar

```
s0 = Quantity[{3.95, 0.05}, "Centimeters"]
```

{3.95 cm, 0.05 cm}

```
ρgl = Quantity[2.25, "Milligrams" / "Centimeters"^2]
```

$2.25\ \mathrm{mg/cm^2}$

```
Sultimo = Sα[First[Pultimo], p0, First[s0], ρgl]
```

3.91063 cm

```
ΔSultimo = ΔSα[First[Pultimo], p0, First[s0], ρgl, Last[Pultimo], Last[s0]]
```

0.0442776 cm

```
Sultimo ± ΔSultimo
```

3.91063 cm ± 0.0442776 cm

Mithilfe des Diagramms kommen wir auf eine entsprechende Energie der Alphateilchen.

```
{Tα, ΔTα} = Quantity[{5.5, 0.1}, "Megaelectronvolts"]
```

{5.5 MeV, 0.1 MeV}

```
Tα ± ΔTα
```

5.5 MeV ± 0.1 MeV

Dieser Wert passt perfekt mit jenem zusammen, der im Praktikumsskript angegeben ist (5.48 MeV).