B19-LU 6 analysis with removal of the fading signal component

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1 Input

Analysed file: 3-Permafrost-1mm-63-100-Fsp-pIR290-sample_B19-LU-6-24al.binx

Laboratory dose rate: 0.1053 ± 0.0053 Gy/s

System ID: 306

User: tobias

Date of measurement: 141022

Date of analysis: 2024-01-25

Base name output files: 2024-01-25_B19-LU 6 comp removal

1.1 Data preparation

First, the records are checked for consistency and records with different measurement settings are separated. Second, the unstimulated parts of the measurements are removed.

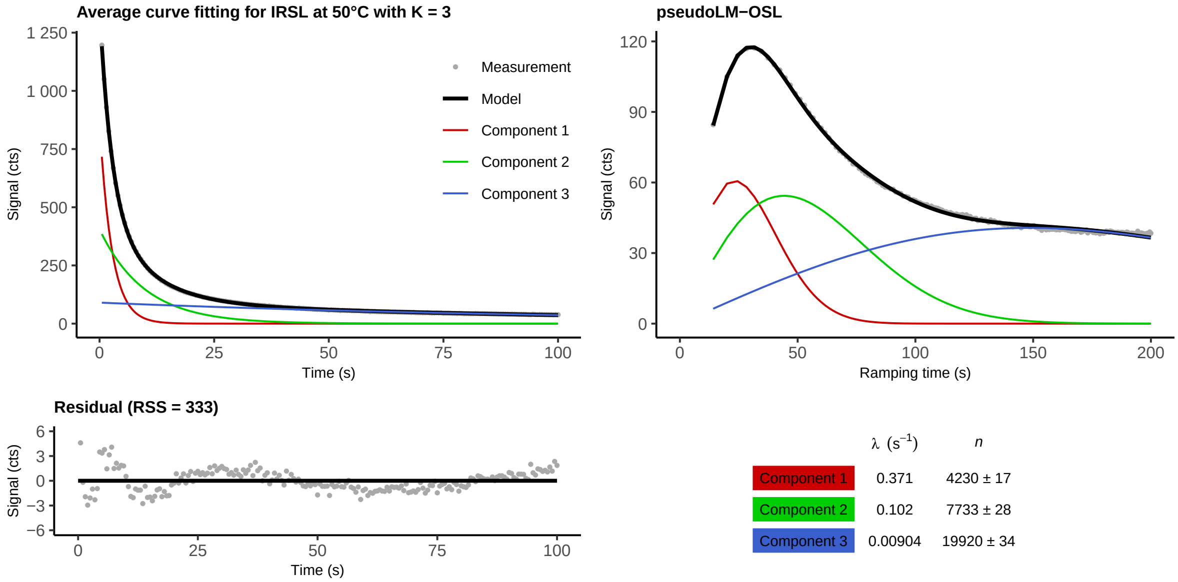
```
CORRECTION STEP 1 ----- Check records for consistency in the detection settings -----
Frequency table of different sets of detection settings (Channels, Channel width):
                settings frequency record_type
1               220, 0.5       336        IRSL
3               420, 0.5       336       IRSL2
2 420, 0.238095238095238       144       IRSL3
RLum.Data.Curve@RecordType changed to IRSL2 or IRSL3 in sequence: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17
Further data manipulations are performed just on IRSL records
(time needed: 1.31 s)

CORRECTION STEP 2 ----- Remove not stimulated measurement parts -----
Measurement parts with stimulation light turned off detected and removed:
 5 s at the beginning and 5 s at the end.
-> Length of 336 IRSL records reduced from 110 s to 100 s
(time needed: 2.83 s)
```

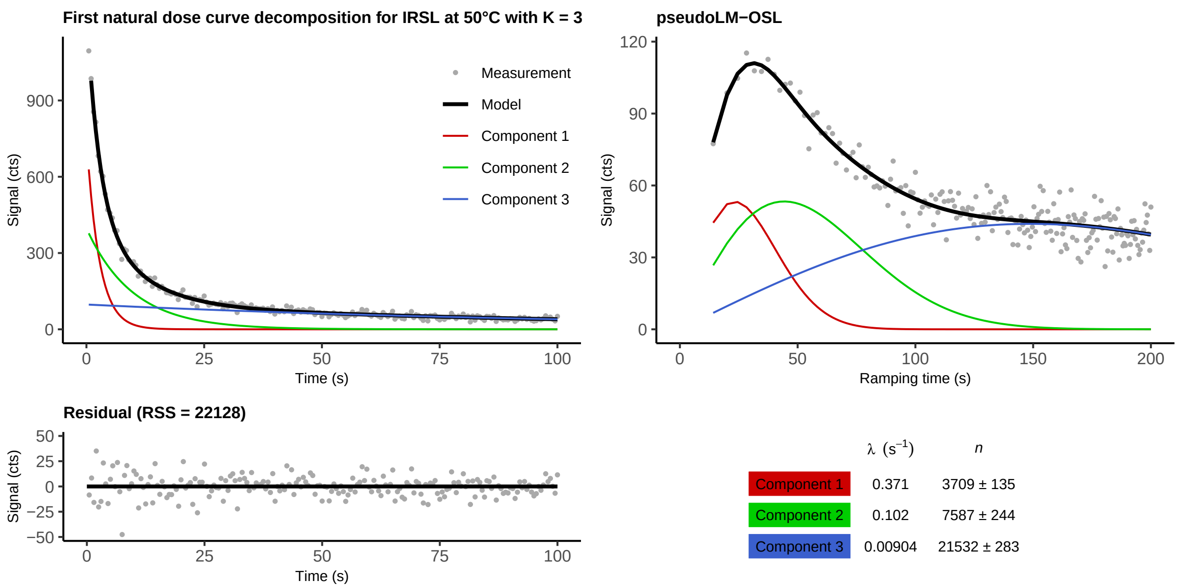
We perform the code again but only for IRSL2 records to clean also 290°C IRSL records.

```
CORRECTION STEP 1 ----- Check records for consistency in the detection settings -----
All IRSL2 records have the same detection settings
(time needed: 0.47 s)

CORRECTION STEP 2 ----- Remove not stimulated measurement parts -----
Measurement parts with stimulation light turned off detected and removed:
 5 s at the beginning and 0 s at the end.
-> Length of 336 IRSL2 records reduced from 210 s to 205 s
(time needed: 4.6 s)
```

1.2 Global curve fitting

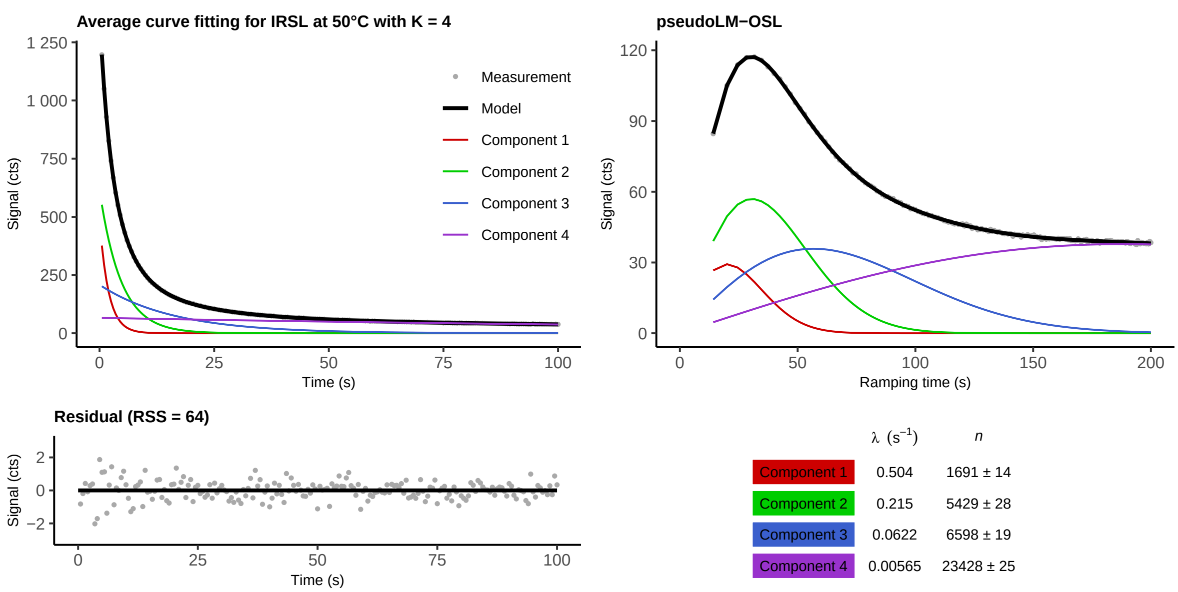
```
----------- Signal components for IRSL at 50°C with K = 3  ------------

STEP 1.1 ----- Build global average curve from all CW-OSL curves -----
Built global average curve from arithmetic means from first 200 data points of all 336 IRSL records
(time needed: 2.05 s)

STEP 1.2 ----- Perform multi-exponential curve fitting -----

Decay rates (s^-1):
Cycle       Comp. 1     Comp. 2     Comp. 3         RSS     F-value
K = 1        0.1282                           6.061e+05         Inf
K = 2        0.2458     0.01839                1.67e+04        3458
K = 3        0.3715      0.1021    0.009038       328.3        4838
Left loop because maximum number of allowed components K is reached
-> The F-test suggests the K = 3 model

Photoionisation cross sections (cm^2):
Cycle     Comp. 1             Comp. 2             Comp. 3
K = 1    8.56e-19
K = 2    1.64e-18            1.23e-19
K = 3    2.48e-18            6.82e-19            6.03e-20
(time needed: 3.66 s)
```

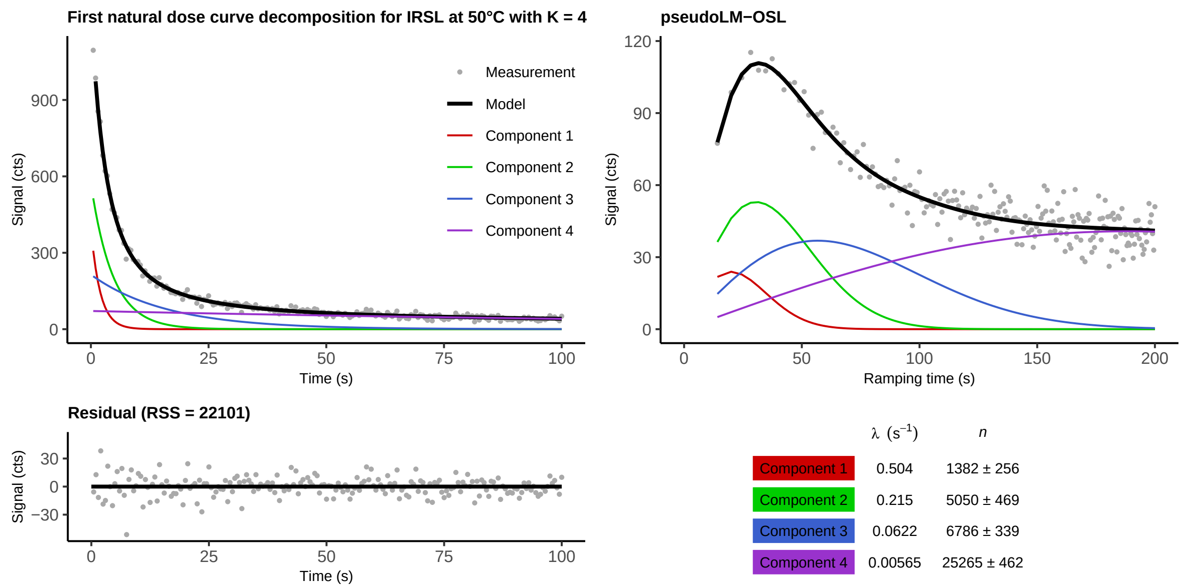




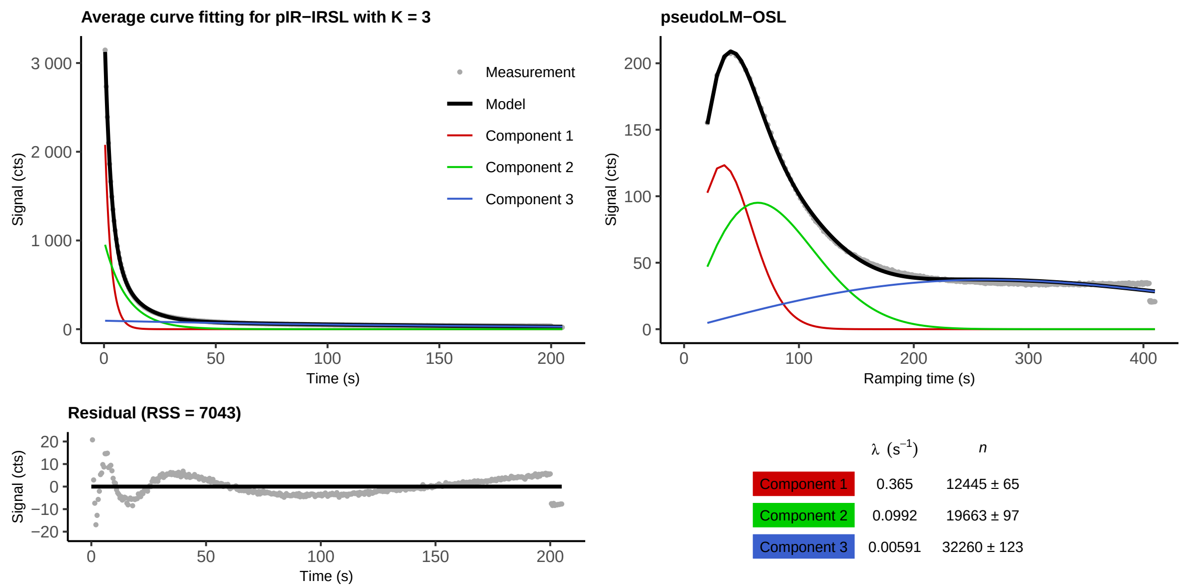

```
----------- Signal components for IRSL at 50°C with K = 4  ------------

STEP 1.1 ----- Build global average curve from all CW-OSL curves -----
Built global average curve from arithmetic means from first 200 data points of all 336 IRSL records
(time needed: 2.72 s)
```

```
STEP 1.2 ----- Perform multi-exponential curve fitting -----

Decay rates (s^-1):
Cycle        Comp. 1     Comp. 2     Comp. 3     Comp. 4          RSS      F-value
K = 1         0.1282                                         6.061e+05         Inf
K = 2         0.2458     0.01839                              1.67e+04        3458
K = 3         0.3715      0.1021    0.009038                     328.3        4838
K = 4         0.5042      0.2146     0.06217    0.005648         63.16         403
Left loop because maximum number of allowed components K is reached
-> The F-test suggests the K = 4 model

Photoionisation cross sections (cm^2):
Cycle      Comp. 1                Comp. 2               Comp. 3               Comp. 4
K = 1     8.56e-19
K = 2     1.64e-18               1.23e-19
K = 3     2.48e-18               6.82e-19              6.03e-20
K = 4     3.37e-18               1.43e-18              4.15e-19              3.77e-20
(time needed: 7.07 s)
```

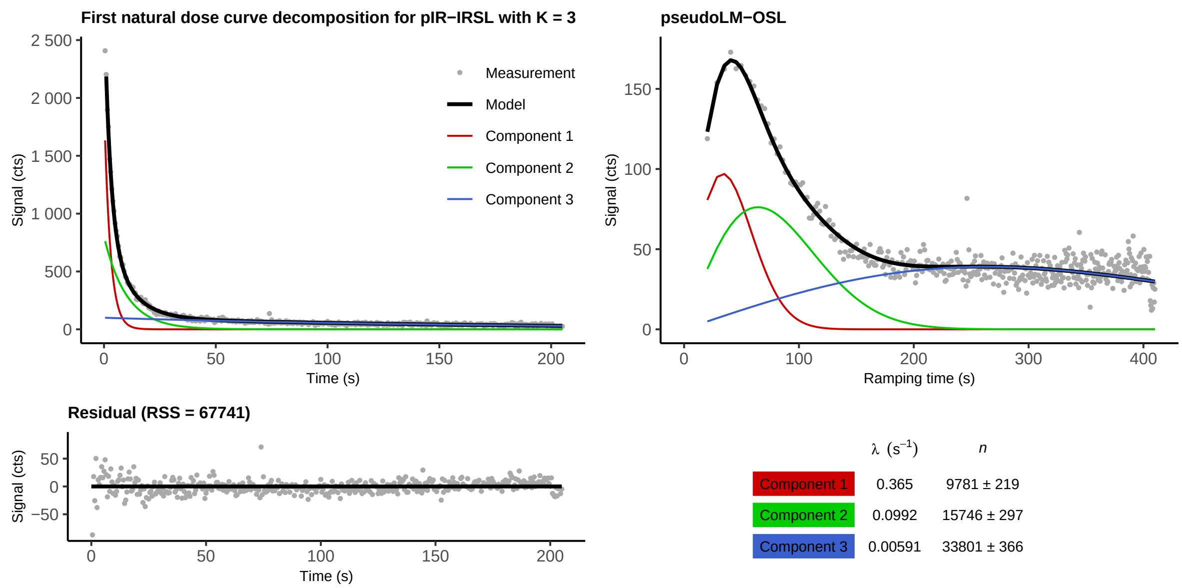





```
----------- Signal components for pIR-IRSL with K = 3  ------------

STEP 1.1 ----- Build global average curve from all CW-OSL curves -----
Built global average curve from arithmetic means from first 410 data points of all 336 IRSL records
(time needed: 4.72 s)

STEP 1.2 ----- Perform multi-exponential curve fitting -----

Decay rates (s^-1):
Cycle        Comp. 1     Comp. 2     Comp. 3          RSS     F-value
K = 1          0.175                             1.963e+06         Inf
K = 2          0.236     0.01426                 2.059e+05        1732
K = 3         0.3654     0.09923    0.005906          6939        5792
Left loop because maximum number of allowed components K is reached
-> The F-test suggests the K = 3 model

Photoionisation cross sections (cm^2):
Cycle      Comp. 1               Comp. 2               Comp. 3
K = 1     1.17e-18
K = 2     1.58e-18             9.52e-20
K = 3     2.44e-18             6.63e-19             3.94e-20
(time needed: 3.78 s)
```



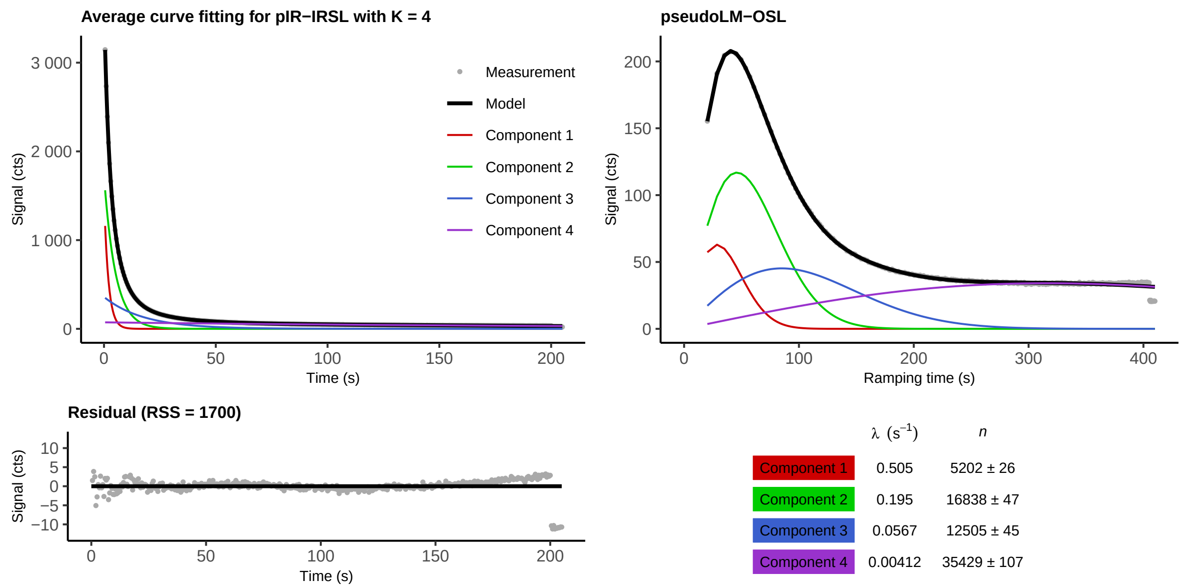
	λ (s^{-1})	*n*
Component 1	0.365	12445 ± 65
Component 2	0.0992	19663 ± 97
Component 3	0.00591	32260 ± 123

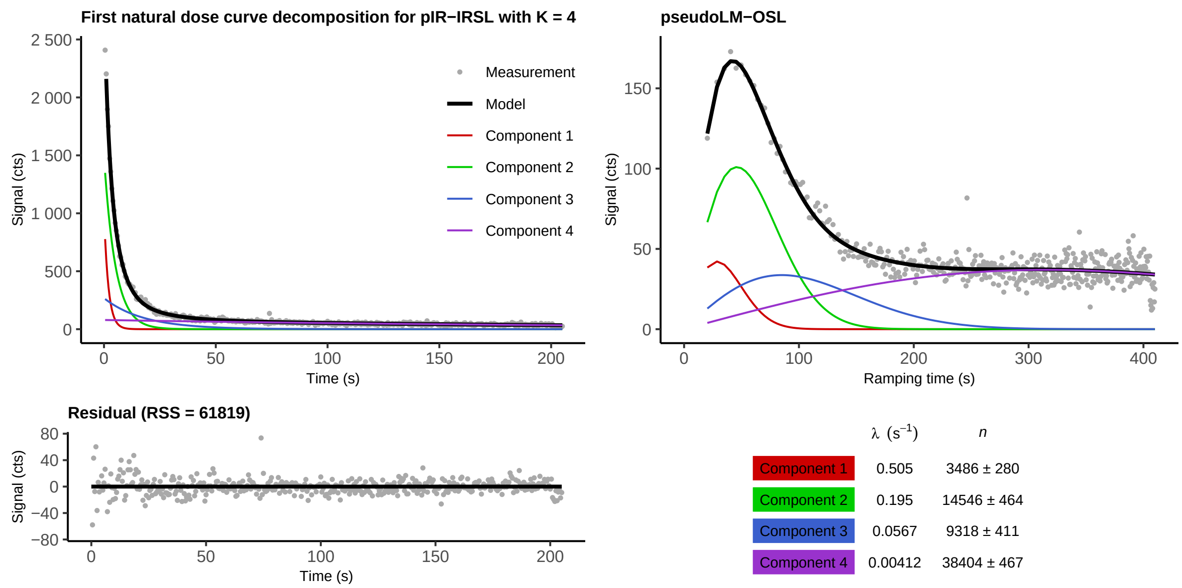


	λ (s^{-1})	*n*
Component 1	0.365	9781 ± 219
Component 2	0.0992	15746 ± 297
Component 3	0.00591	33801 ± 366

```
----------- Signal components for pIR-IRSL with K = 4  ------------

STEP 1.1 ----- Build global average curve from all CW-OSL curves -----
Built global average curve from arithmetic means from first 410 data points of all 336 IRSL records
(time needed: 4.21 s)
```

```
STEP 1.2 ----- Perform multi-exponential curve fitting -----

Decay rates (s^-1):
Cycle        Comp. 1      Comp. 2      Comp. 3      Comp. 4          RSS      F-value
K = 1          0.175                                           1.963e+06          Inf
K = 2          0.236      0.01426                              2.059e+05         1732
K = 3         0.3654      0.09923     0.005906                      6939         5792
K = 4         0.5046       0.1947      0.05666     0.004122         1686        626.3
Left loop because maximum number of allowed components K is reached
-> The F-test suggests the K = 4 model

Photoionisation cross sections (cm^2):
Cycle      Comp. 1               Comp. 2               Comp. 3               Comp. 4
K = 1     1.17e-18
K = 2     1.58e-18             9.52e-20
K = 3     2.44e-18             6.63e-19             3.94e-20
K = 4     3.37e-18             1.3e-18              3.78e-19             2.75e-20
(time needed: 5.86 s)
```





1.3 SETTINGS

```
# Data set to evaluate?
# default: IRSL_corrected <- IRSL_290_data
IRSL_corrected <- IRSL_290_data

# Fitting to use?
# default: components <- components_pIRIR_K3
components <- components_pIRIR_K3

# Component to remove?
# default: k = 1
k = 1

# Integration area (channels)
# default: signal_window_width <- 20
signal_window_width <- 20

# Background limits (start channel, end channel)
# default: background_limits <- c(300, 400)
background_limits <- c(300, 400)

# File suffix
```

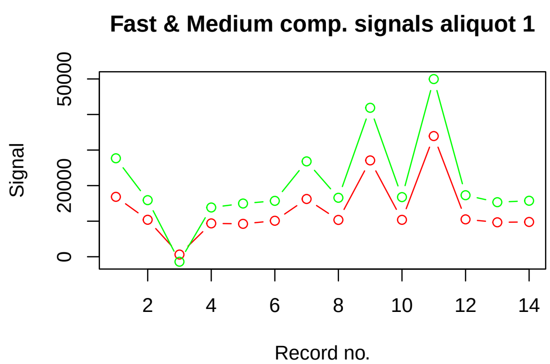
```r
# default: suffix <- "pIRIR K3"
suffix <- "pIRIR K3"

output_path <- paste(output_path, suffix)
```

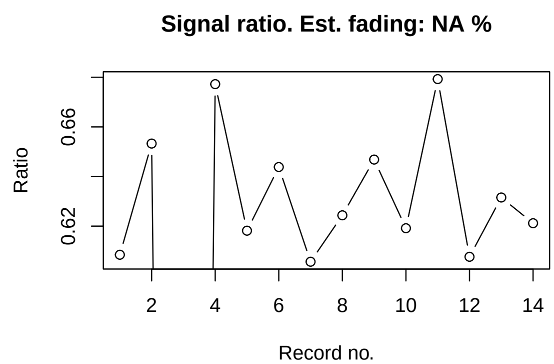
Table 1: Signal components of global curve

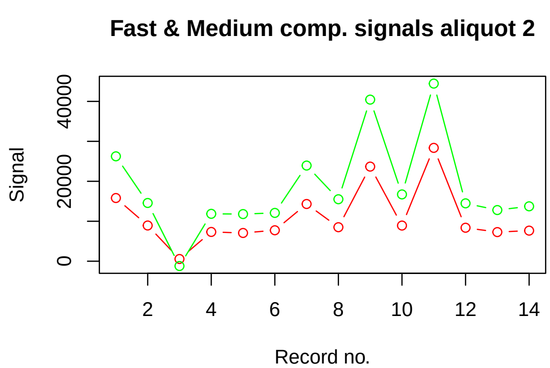
name	lambda	lambda.error	n	n.error	initial.signal
Component 1	0.3654	0.0028	12445	65	0.6650
Component 2	0.0992	0.0012	19663	97	0.3046
Component 3	0.0059	0.0001	32260	123	0.0304

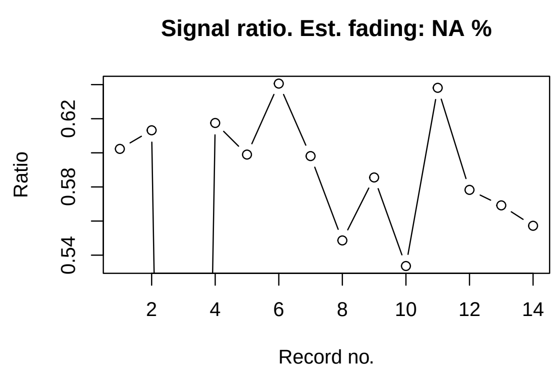
1.4 Fast component removal

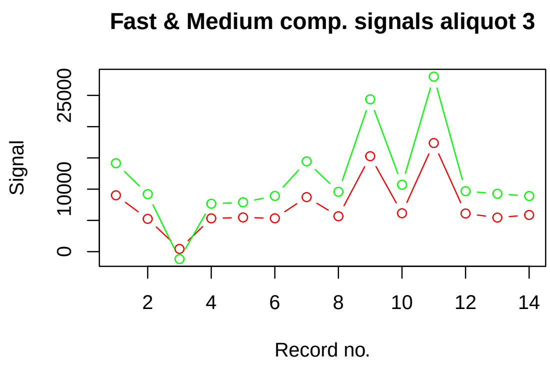
The fast component is now determined for each single curve by `decompose_OSLcurve()` and removed from the record.

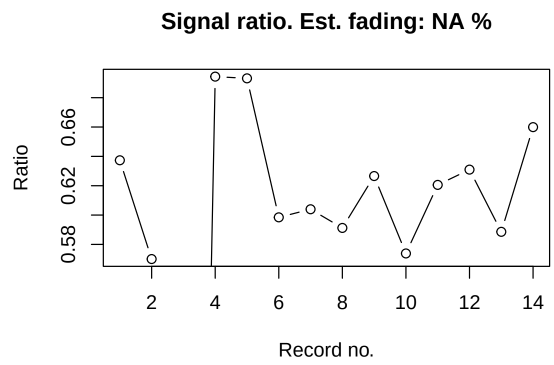


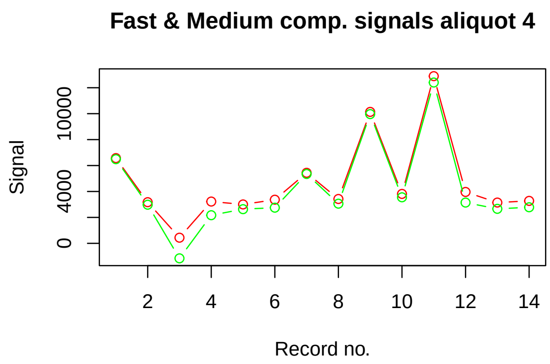


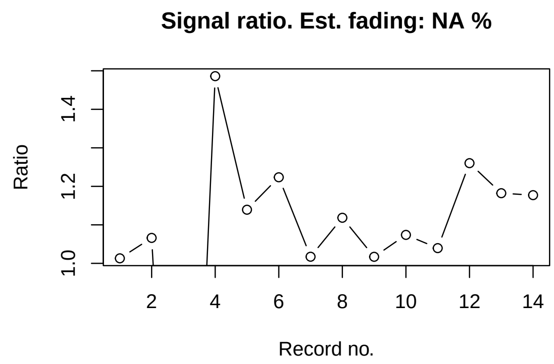


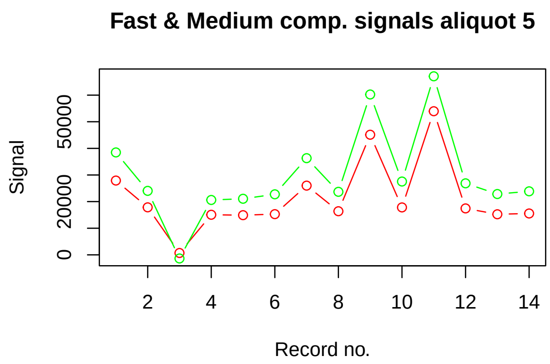


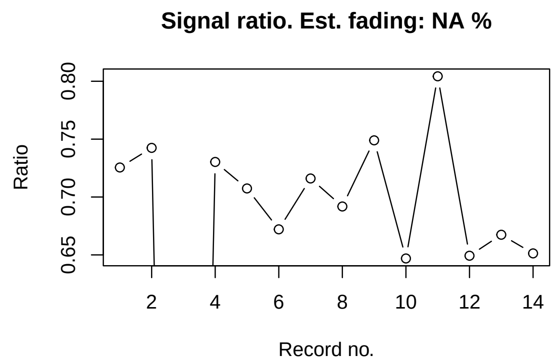

Fast & Medium comp. signals aliquot 3
Signal
Record no.

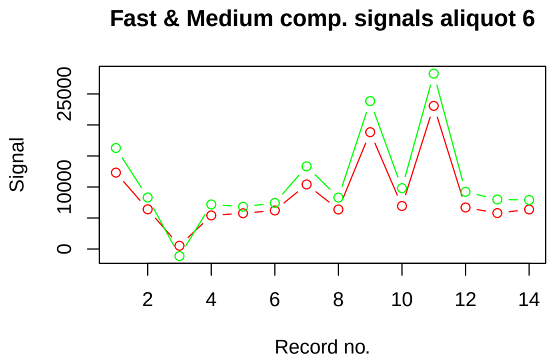

Signal ratio. Est. fading: NA %
Ratio
Record no.

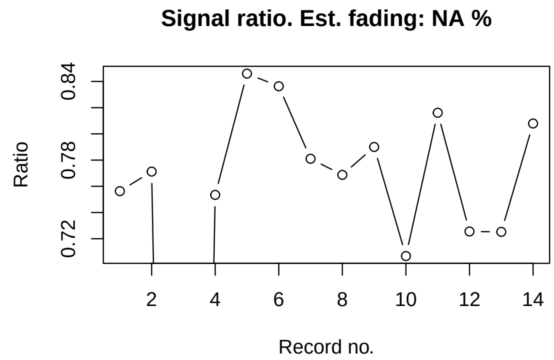

Fast & Medium comp. signals aliquot 4
Signal
Record no.

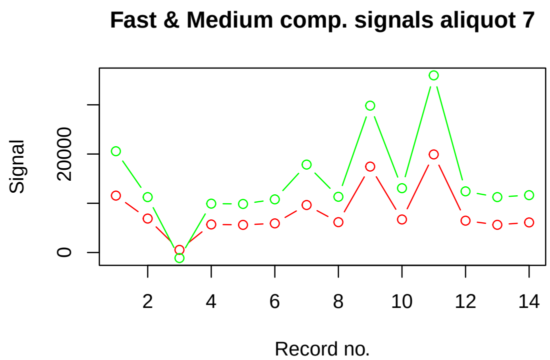

Signal ratio. Est. fading: NA %
Ratio
Record no.

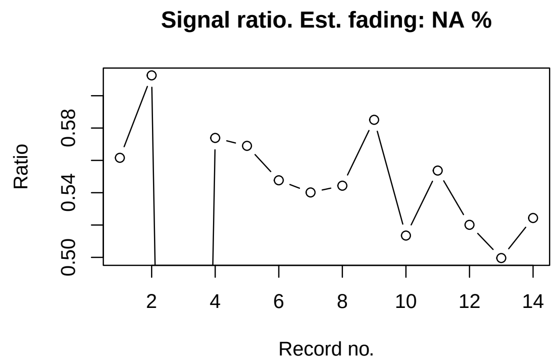

Fast & Medium comp. signals aliquot 5
Signal
Record no.

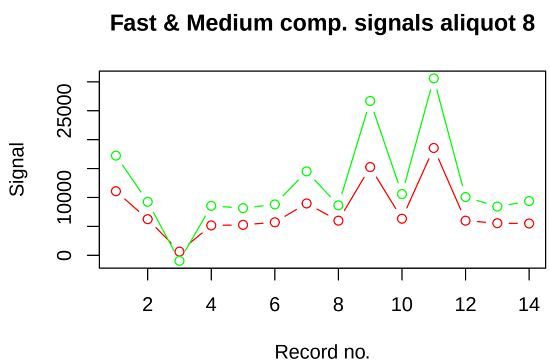

Signal ratio. Est. fading: NA %
Ratio
Record no.

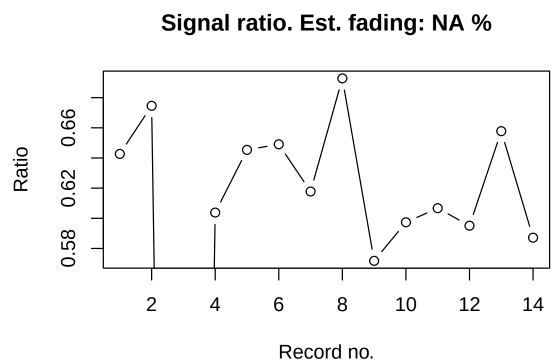

Fast & Medium comp. signals aliquot 6
Signal
0
10000
25000
2
4
6
8
10
12
14
Record no.

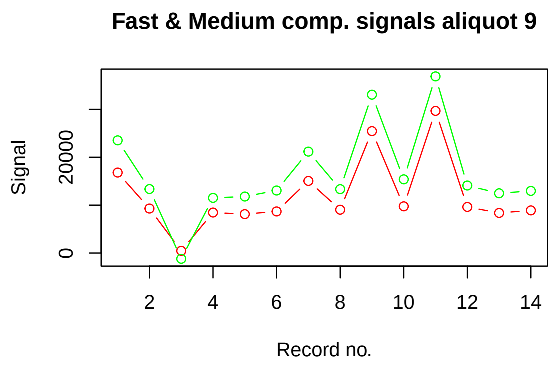

Signal ratio. Est. fading: NA %
Ratio
0.72
0.78
0.84
2
4
6
8
10
12
14
Record no.

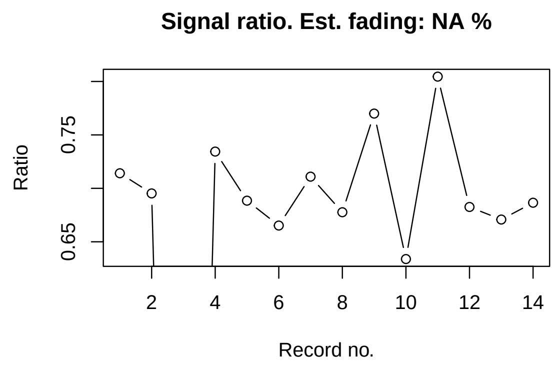

Fast & Medium comp. signals aliquot 7
Signal
0
20000
2
4
6
8
10
12
14
Record no.

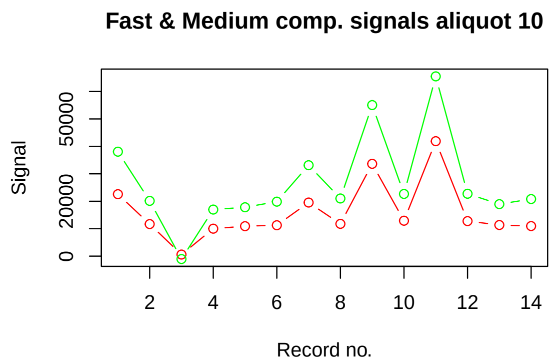

Signal ratio. Est. fading: NA %
Ratio
0.50
0.54
0.58
2
4
6
8
10
12
14
Record no.

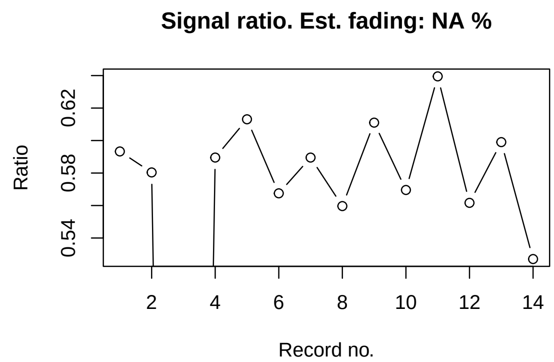

Fast & Medium comp. signals aliquot 8
Signal
0
10000
25000
2
4
6
8
10
12
14
Record no.

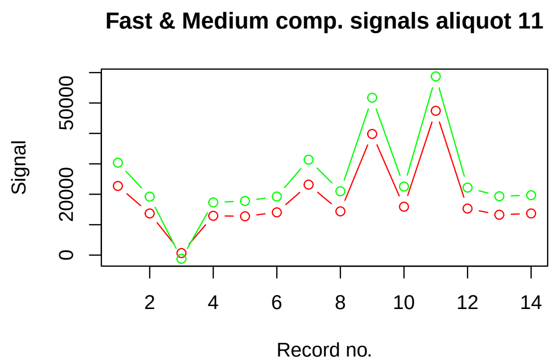

Signal ratio. Est. fading: NA %
Ratio
0.58
0.62
0.66
2
4
6
8
10
12
14
Record no.

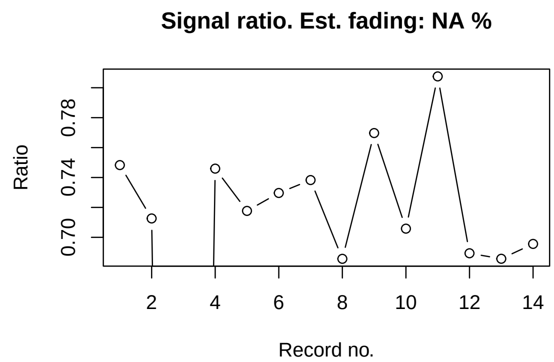

Fast & Medium comp. signals aliquot 9
Signal
0
20000
2
4
6
8
10
12
14
Record no.

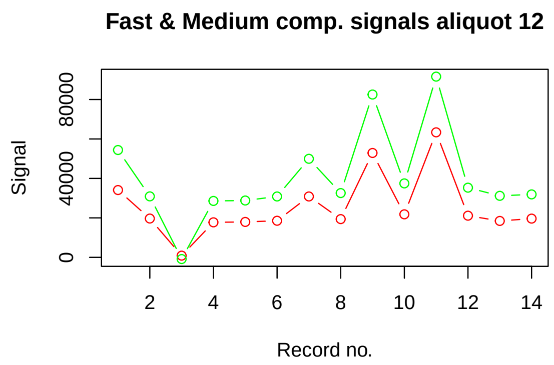

Signal ratio. Est. fading: NA %
Ratio
0.65
0.75
2
4
6
8
10
12
14
Record no.

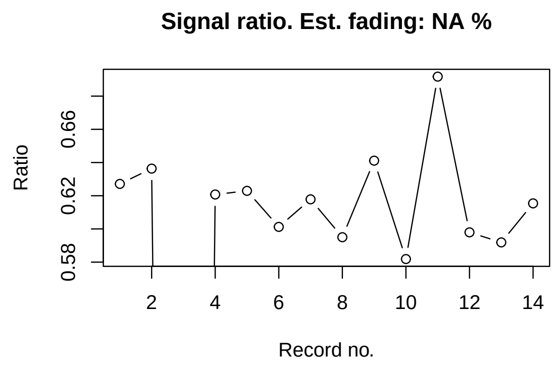

Fast & Medium comp. signals aliquot 10
Signal
0
20000
50000
2
4
6
8
10
12
14
Record no.

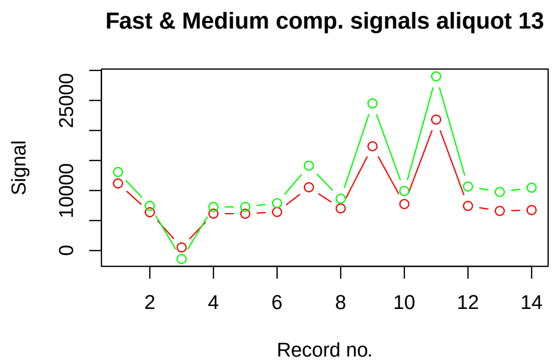

Signal ratio. Est. fading: NA %
Ratio
0.54
0.58
0.62
2
4
6
8
10
12
14
Record no.

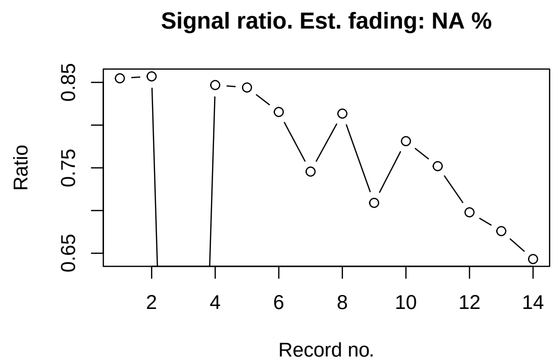

Fast & Medium comp. signals aliquot 11
Signal
0
20000
50000
2
4
6
8
10
12
14
Record no.

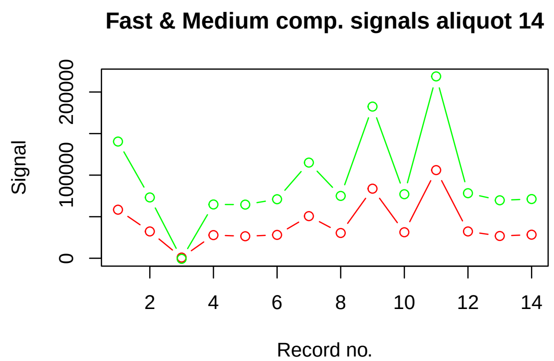

Signal ratio. Est. fading: NA %
Ratio
0.70
0.74
0.78
2
4
6
8
10
12
14
Record no.

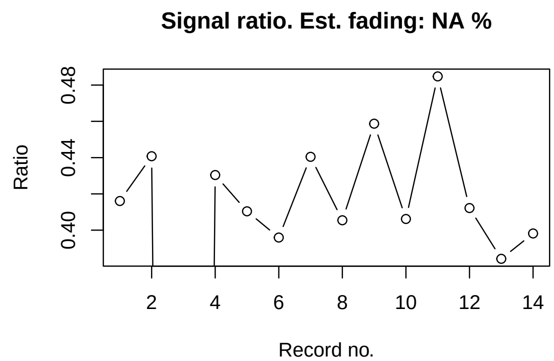

Fast & Medium comp. signals aliquot 12
Signal
0
40000
80000
2
4
6
8
10
12
14
Record no.

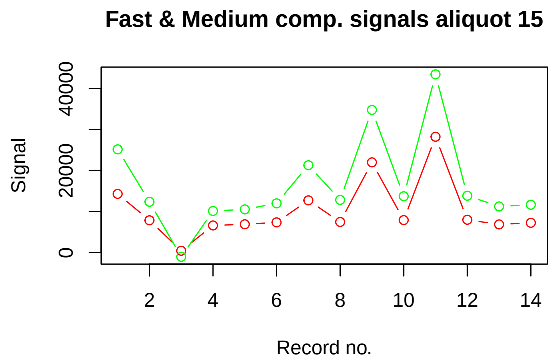

Signal ratio. Est. fading: NA %
Ratio
0.58
0.62
0.66
2
4
6
8
10
12
14
Record no.

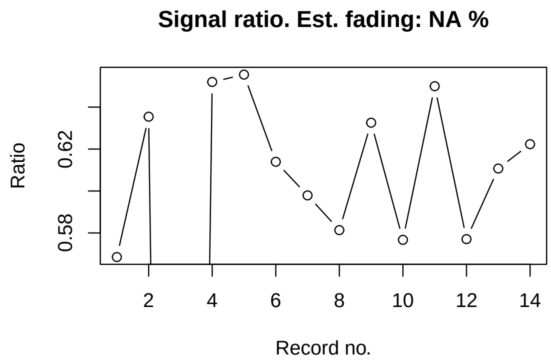

Fast & Medium comp. signals aliquot 13
Signal
0
10000
25000
2
4
6
8
10
12
14
Record no.

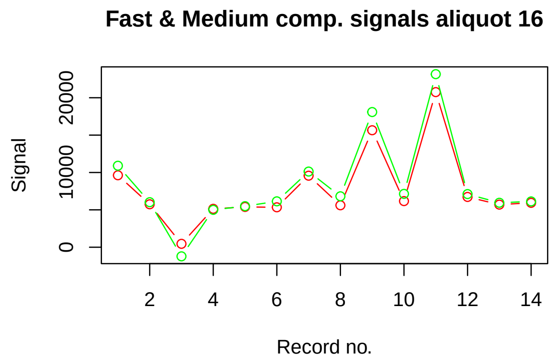

Signal ratio. Est. fading: NA %
Ratio
0.65
0.75
0.85
2
4
6
8
10
12
14
Record no.

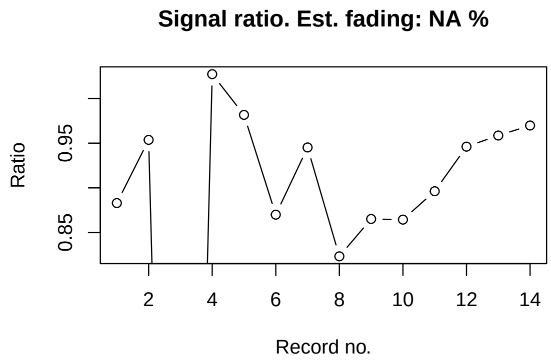

Fast & Medium comp. signals aliquot 14
Signal
0
100000
200000
2
4
6
8
10
12
14
Record no.

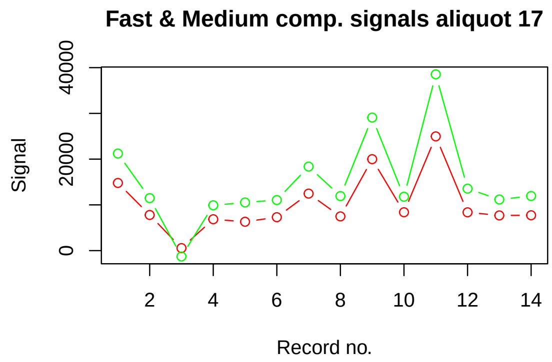

Signal ratio. Est. fading: NA %
Ratio
0.40
0.44
0.48
2
4
6
8
10
12
14
Record no.

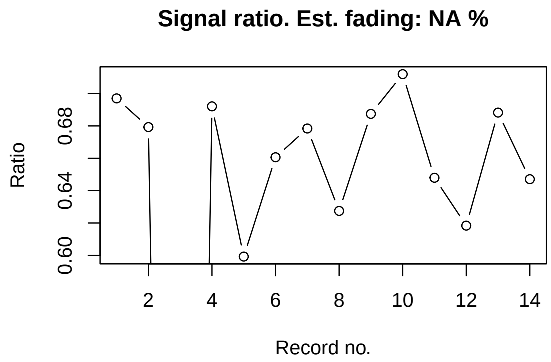

Fast & Medium comp. signals aliquot 15
Signal
0
20000
40000
2
4
6
8
10
12
14
Record no.

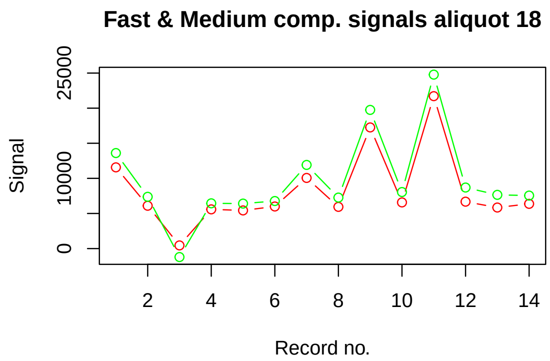

Signal ratio. Est. fading: NA %
Ratio
0.58
0.62
2
4
6
8
10
12
14
Record no.

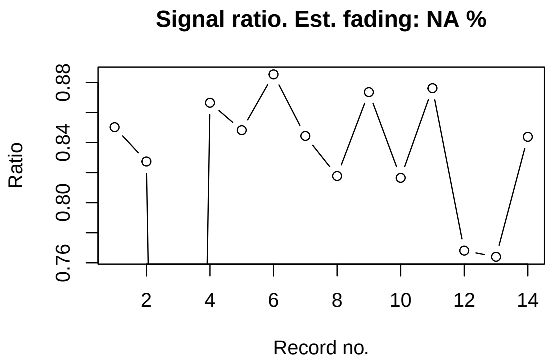

Fast & Medium comp. signals aliquot 16
Signal
0
10000
20000
2
4
6
8
10
12
14
Record no.

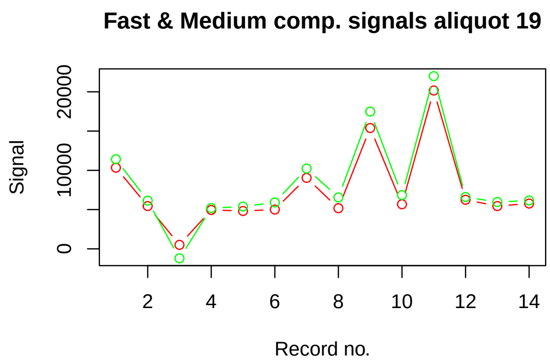

Signal ratio. Est. fading: NA %
Ratio
0.85
0.95
2
4
6
8
10
12
14
Record no.

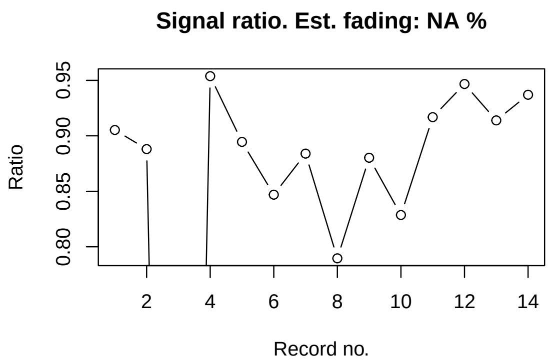

Fast & Medium comp. signals aliquot 17
Signal
0
20000
40000
2
4
6
8
10
12
14
Record no.

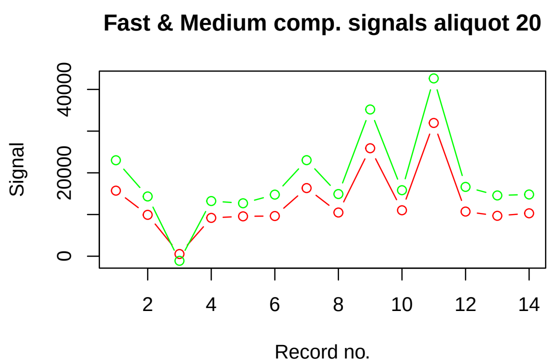

Signal ratio. Est. fading: NA %
Ratio
0.60
0.64
0.68
2
4
6
8
10
12
14
Record no.

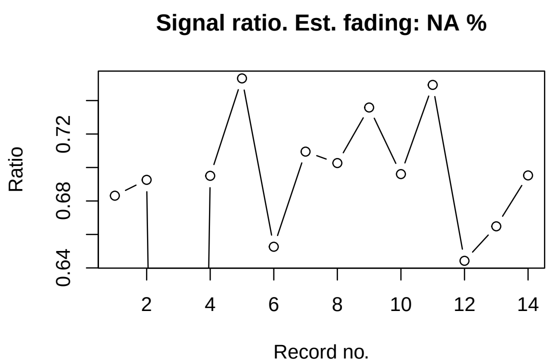

Fast & Medium comp. signals aliquot 18
Signal
0
10000
25000
2
4
6
8
10
12
14
Record no.

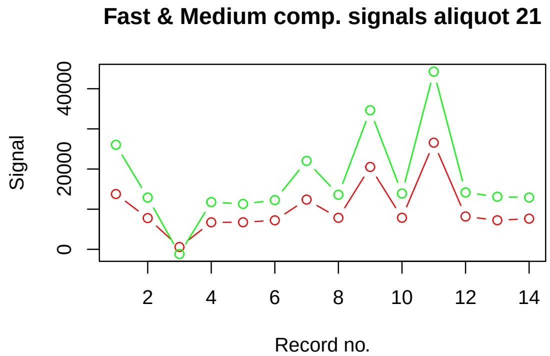

Signal ratio. Est. fading: NA %
Ratio
0.76
0.80
0.84
0.88
2
4
6
8
10
12
14
Record no.

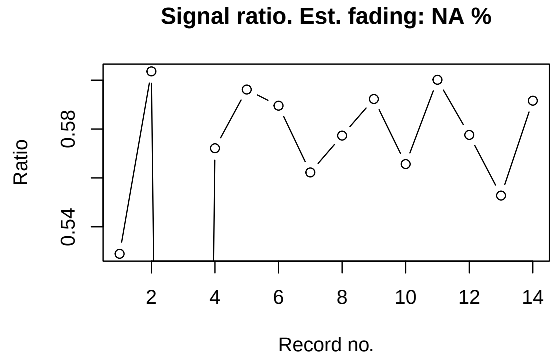

Fast & Medium comp. signals aliquot 19
Signal
0
10000
20000
2
4
6
8
10
12
14
Record no.

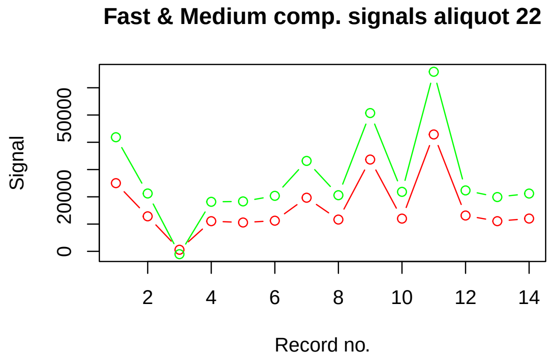

Signal ratio. Est. fading: NA %
Ratio
0.80
0.85
0.90
0.95
2
4
6
8
10
12
14
Record no.

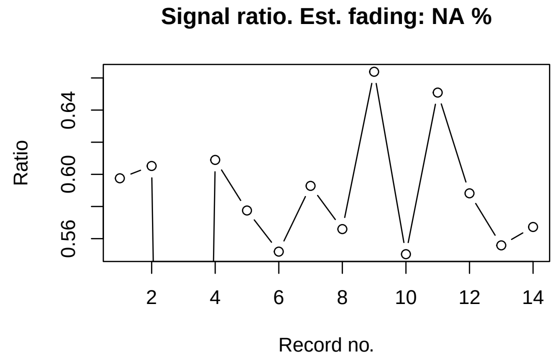

Fast & Medium comp. signals aliquot 20
Signal
0
20000
40000
2
4
6
8
10
12
14
Record no.

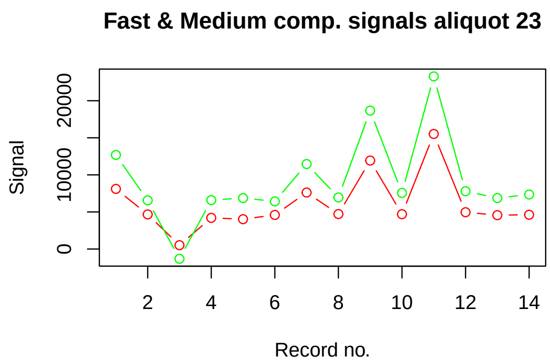

Signal ratio. Est. fading: NA %
Ratio
0.64
0.68
0.72
2
4
6
8
10
12
14
Record no.

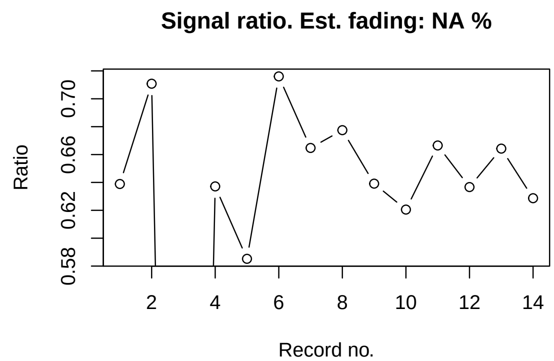

Fast & Medium comp. signals aliquot 21
Signal
0
20000
40000
2
4
6
8
10
12
14
Record no.

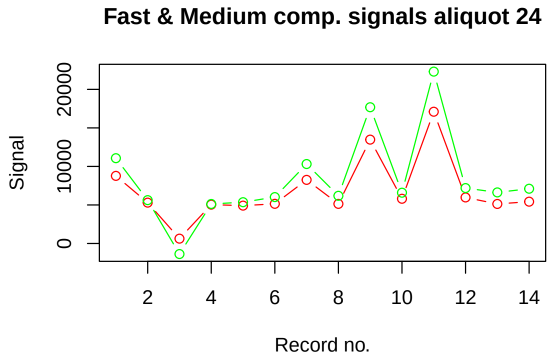

Signal ratio. Est. fading: NA %
Ratio
0.54
0.58
2
4
6
8
10
12
14
Record no.

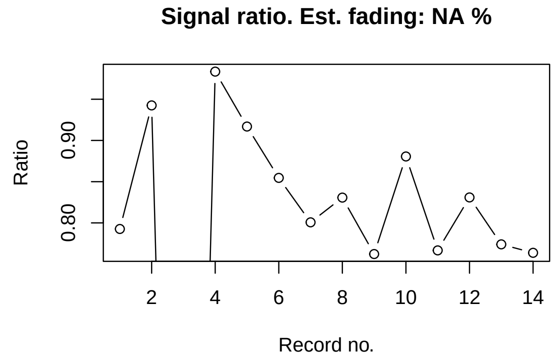

Fast & Medium comp. signals aliquot 22
Signal
0
20000
50000
2
4
6
8
10
12
14
Record no.


Signal ratio. Est. fading: NA %
Ratio
0.56
0.60
0.64
2
4
6
8
10
12
14
Record no.


Fast & Medium comp. signals aliquot 23
Signal
0
10000
20000
2
4
6
8
10
12
14
Record no.


Signal ratio. Est. fading: NA %
Ratio
0.58
0.62
0.66
0.70
2
4
6
8
10
12
14
Record no.

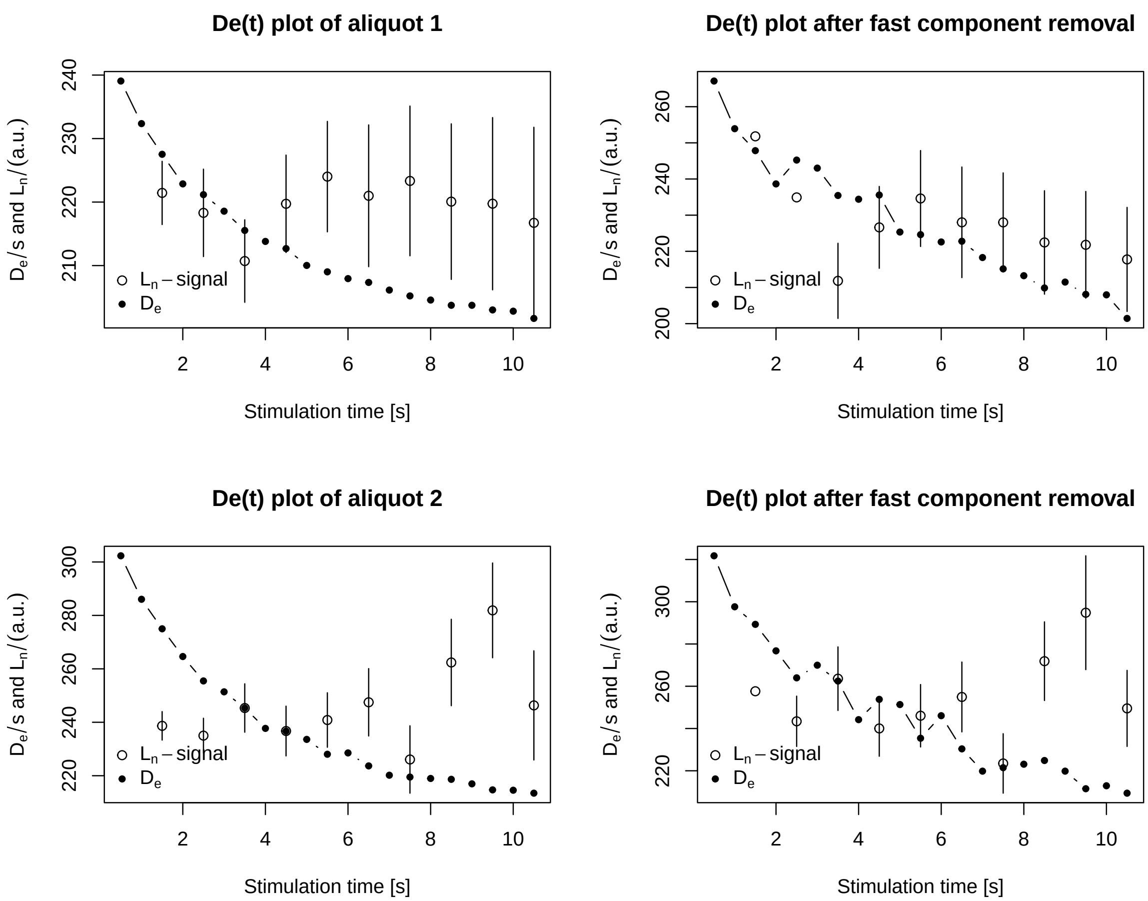

Fast & Medium comp. signals aliquot 24
Signal
0
10000
20000
2
4
6
8
10
12
14
Record no.

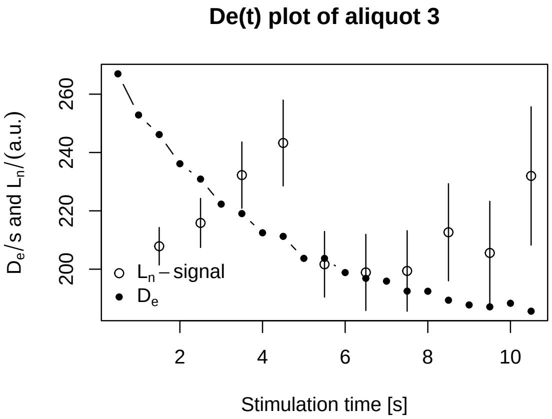

Signal ratio. Est. fading: NA %
Ratio
0.80
0.90
2
4
6
8
10
12
14
Record no.

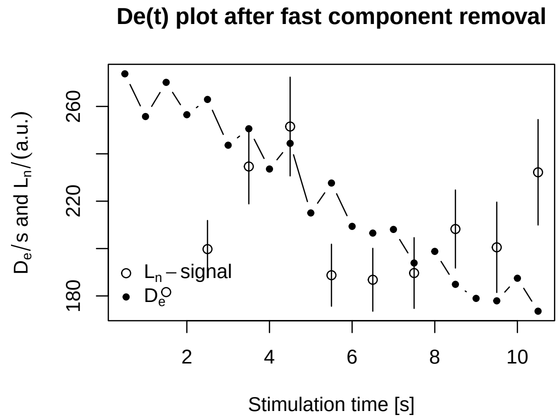
2 Output

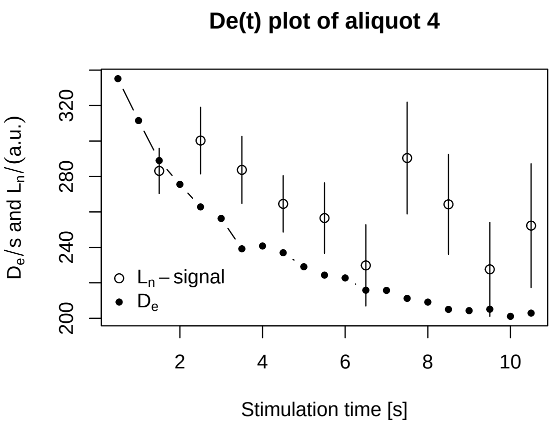
2.1 De(t) plots

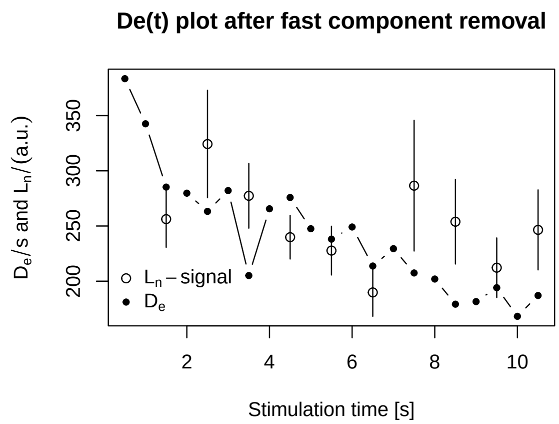
De(t) plotting helps to identify potential age over- or underestimation due to partial signal resetting, unstable signal components or other signal related issues (Bailey et al. 2003). Thus, we evaluated the De(t) plots for the first 10 seconds of stimulation for all measurements using the `plot_DetPlot()` function of the `Luminescence` package. Below are shown the plots of two aliquots as examples:









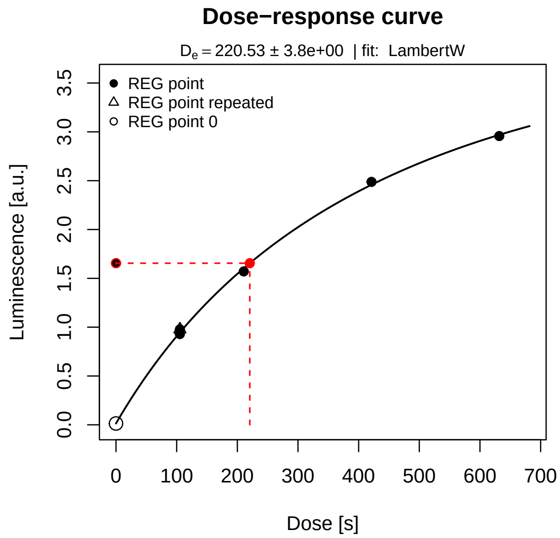


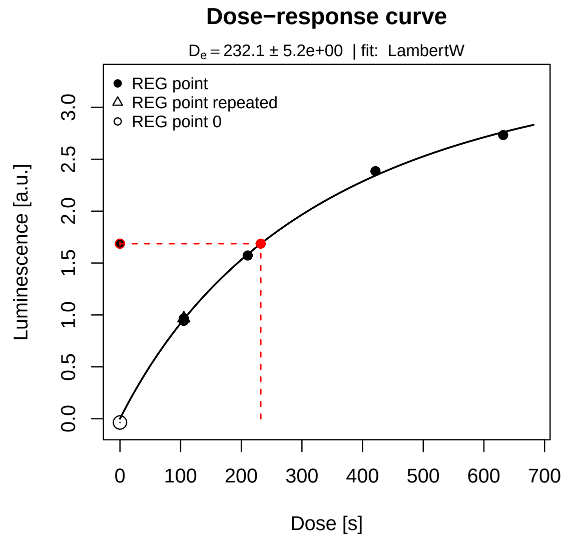
Like for other B19-LU samples the IRSL at 50°C measured equivalent doses are lower than the pIR-IRSL measured, which is a indication of thermal fading of the luminescence signal in the samples and thus also a indication of De underestimation in the IRSL at 50°C signals (Thomsen et al. 2008).

However, the increase in the De values when shifting the signal integration window towards higher values which can be observed for other B19 samples can only be observed a few of the aliquots of this sampleDose-response curve fitting

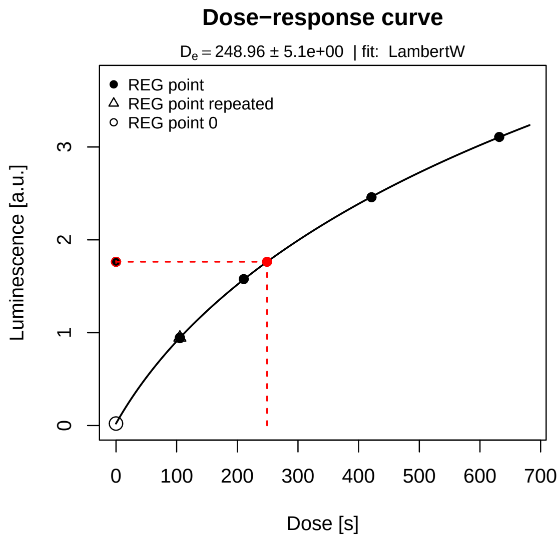
We use as fitting method `fit.method = LambertW` (model by Pagonis et al. (2020)) and integrate over the first seven channels (3.5 seconds). As background integral, we choose the last 100 channels (150 to 200 sec).

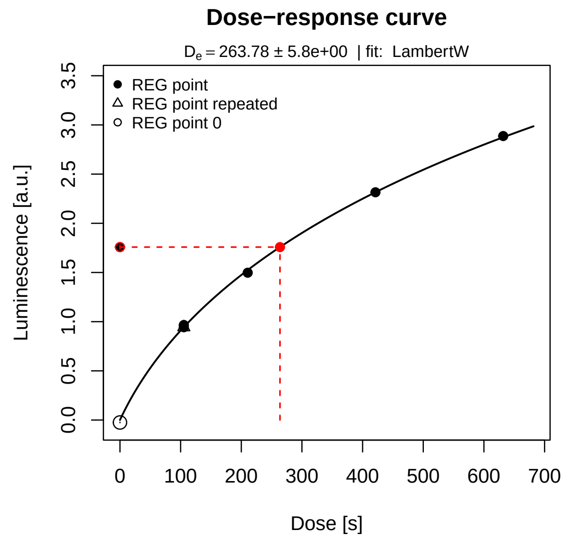
```
--- Dose response curve for aliquot 1 ---
Left: Uncorrected Dose response curve, Right: After fast component removal.
```



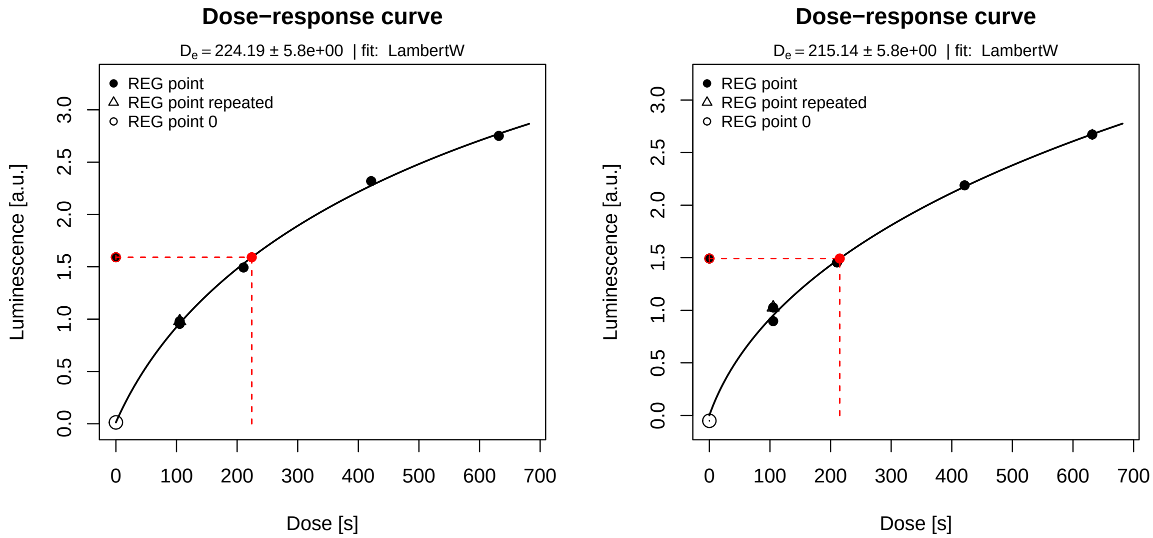



```
--- Dose response curve for aliquot 2 ---
Left: Uncorrected Dose response curve, Right: After fast component removal.
```

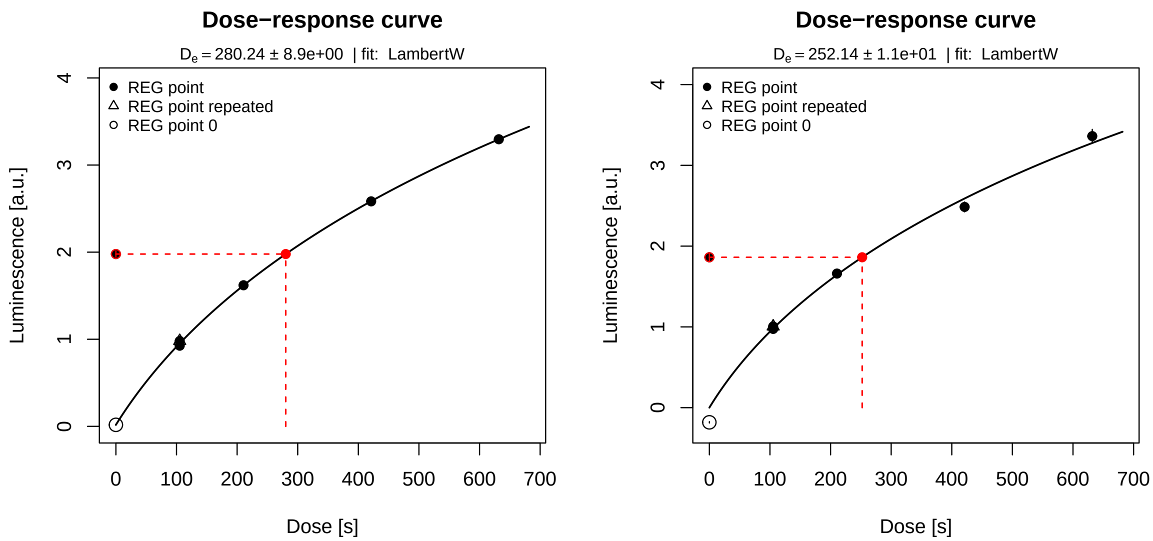




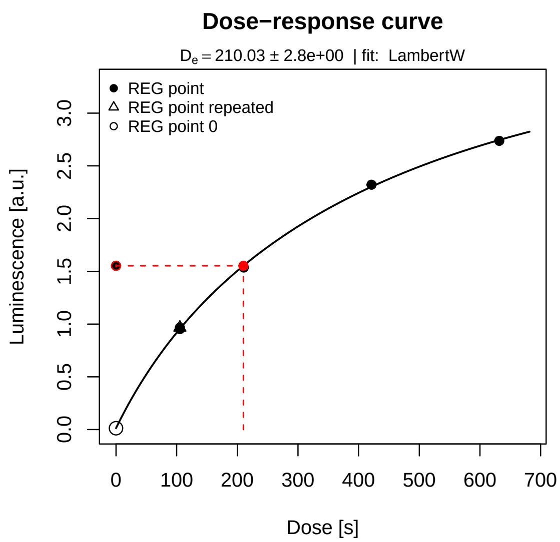

```
--- Dose response curve for aliquot 3 ---
Left: Uncorrected Dose response curve, Right: After fast component removal.
```

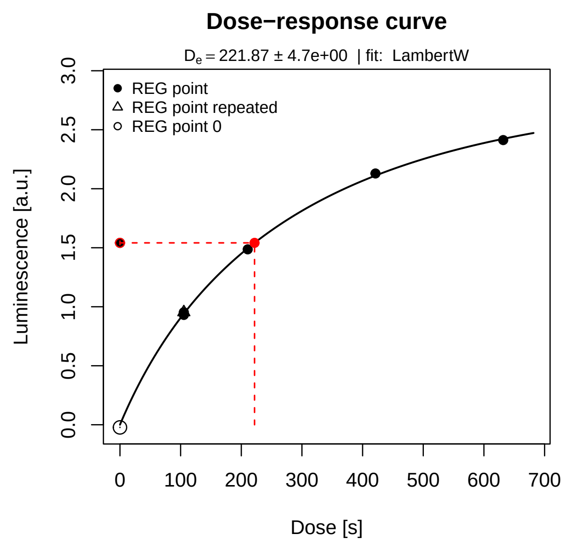



```
--- Dose response curve for aliquot 4 ---
Left: Uncorrected Dose response curve, Right: After fast component removal.
```

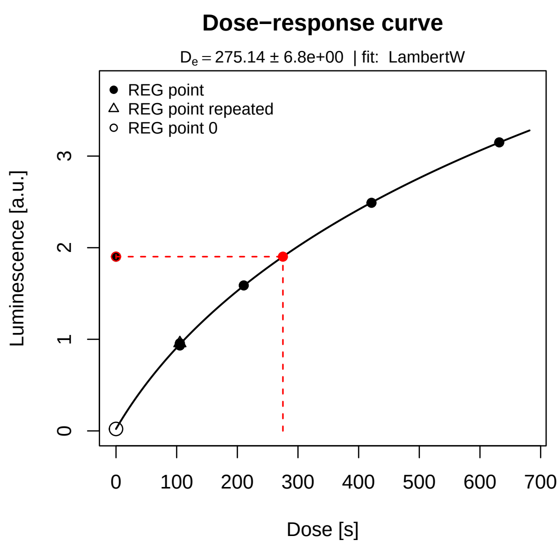


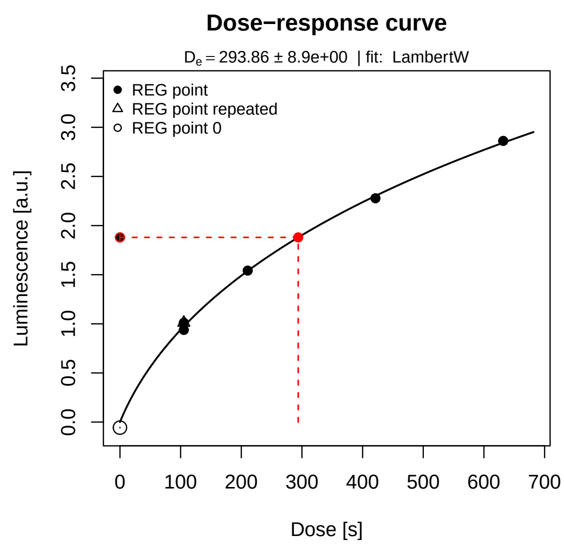

```
--- Dose response curve for aliquot 5 ---
Left: Uncorrected Dose response curve, Right: After fast component removal.
```






```
--- Dose response curve for aliquot 6 ---
Left: Uncorrected Dose response curve, Right: After fast component removal.
```





2.2 De calculation result table

The De values are calculated using the `analyse_SAR.CWOSL()` function of the `Luminescence` package.

Table 2: Equivalent doses

#	De [Gy]	De error [Gy]	Rejection criteria
1	232.10	12.90	OK
2	263.78	14.52	OK
3	215.14	12.77	FAILED
4	252.14	17.17	OK
5	221.87	12.13	OK
6	293.86	16.85	OK
7	273.36	15.93	OK
8	258.28	14.67	OK
9	269.12	15.83	OK
10	273.86	15.06	OK
11	219.98	12.01	OK
12	264.83	14.34	OK
13	234.97	13.95	OK
14	293.12	15.27	OK
15	290.46	16.17	OK
16	253.85	15.67	OK
17	267.92	15.51	OK
18	256.53	15.67	OK
19	254.23	15.08	OK
20	223.51	12.44	FAILED
21	295.78	16.92	OK
22	304.65	16.49	OK
23	274.66	16.38	FAILED
24	270.63	16.96	OK

21 of all aliquots passed the rejection criteria. The results of all aliquots in the table above include the dose rate errors.

2.3 Rejection criteria

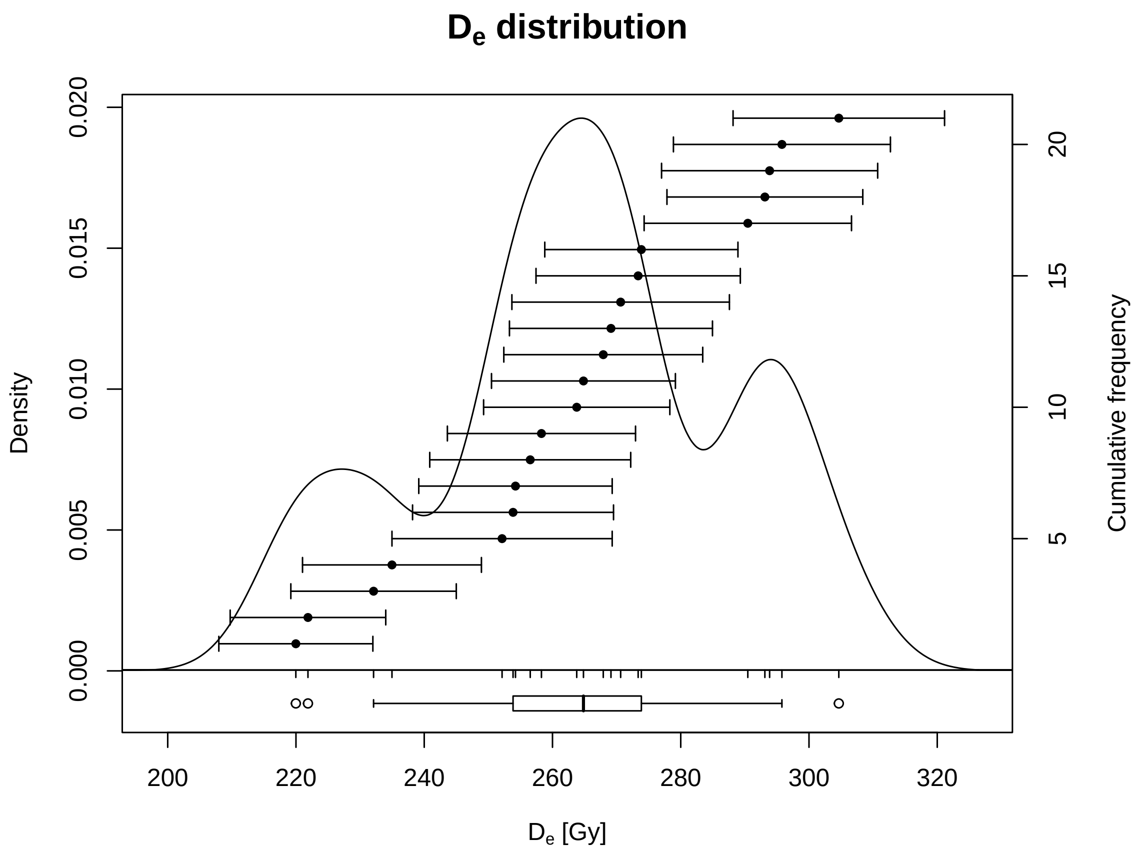
Table 3: Rejection criteria thresholds (left) and results (right)

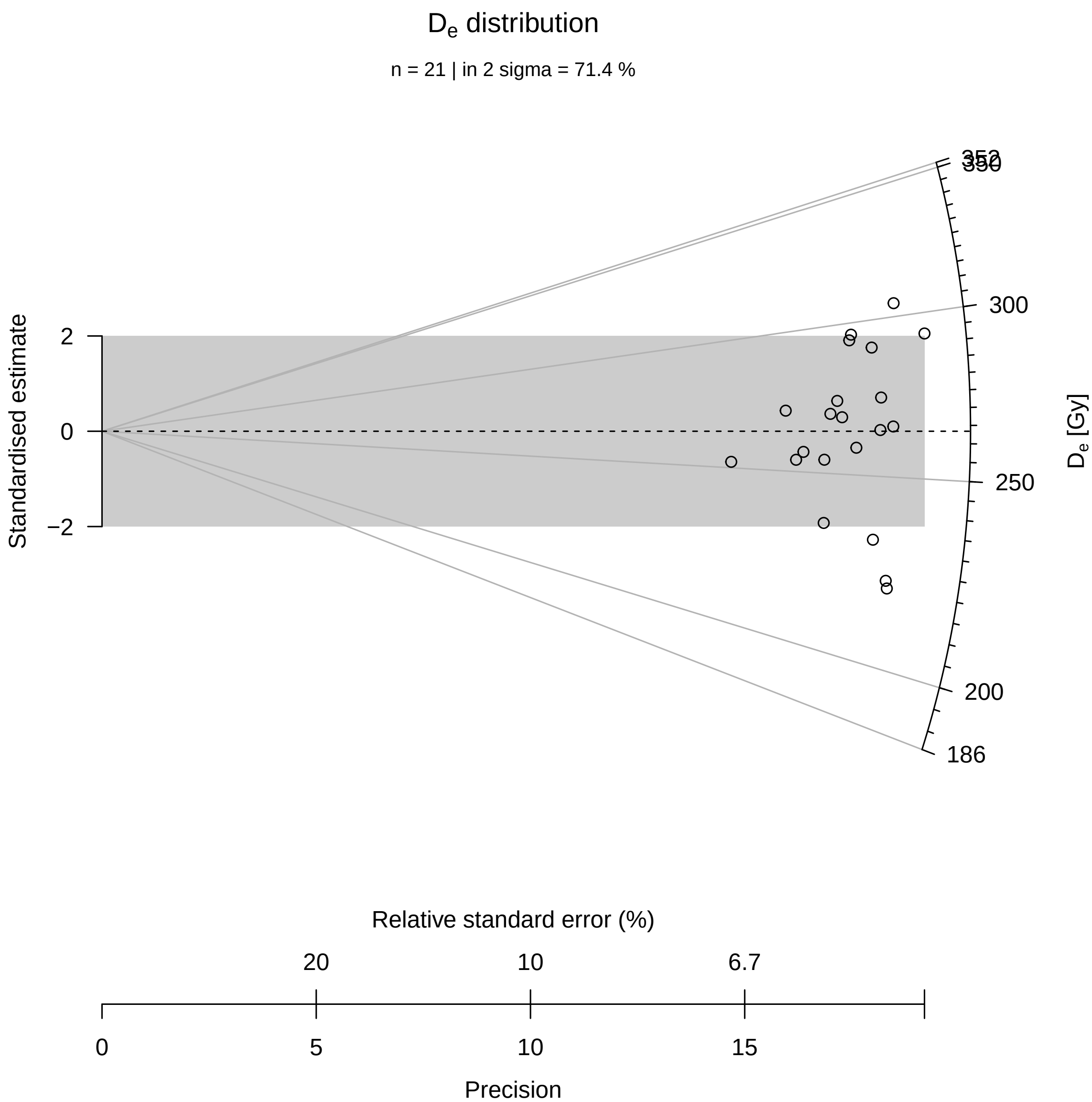
#	Criterium	Threshold
A	Recycling ratio (R5/R1)	0.1
B	Recuperation rate 1	0.1
C	Testdose error	0.1
D	Palaeodose error	0.1
E	De > max. dose point	631.8

#	A	B	C	D	E
1	1.025	-0.021	0.010	0.024	232.104
2	0.976	-0.014	0.010	0.023	263.784
3	1.145	-0.034	0.013	0.032	215.141
4	1.031	-0.098	0.023	0.046	252.144
5	1.024	-0.015	0.008	0.022	221.866
6	1.078	-0.030	0.015	0.028	293.861
7	1.074	-0.021	0.012	0.030	273.362
8	0.980	-0.011	0.013	0.027	258.277
9	1.075	-0.022	0.011	0.031	269.117
10	1.031	-0.009	0.010	0.023	273.859
11	1.079	-0.014	0.010	0.022	219.976
12	1.062	0.000	0.008	0.021	264.825
13	0.989	-0.047	0.014	0.032	234.974
14	1.077	0.003	0.005	0.015	293.119
15	1.068	-0.014	0.011	0.024	290.461
16	1.057	-0.050	0.016	0.036	253.846
17	0.981	-0.025	0.012	0.029	267.921
18	1.081	-0.035	0.014	0.035	256.529
19	1.037	-0.043	0.016	0.032	254.235
20	1.123	-0.018	0.010	0.024	223.511
21	1.053	-0.017	0.012	0.028	295.777
22	1.070	-0.005	0.009	0.021	304.649
23	0.898	-0.040	0.016	0.032	274.655
24	1.057	-0.050	0.017	0.038	270.631

2.4 Dose distribution

The dose distribution is plotted below with the functions `plot_KDE()` and `plot_RadialPlot()` of the `Luminescence` package. Those aliquots which did not passed the rejection criteria, where not included in any of the dose distribution calculations.

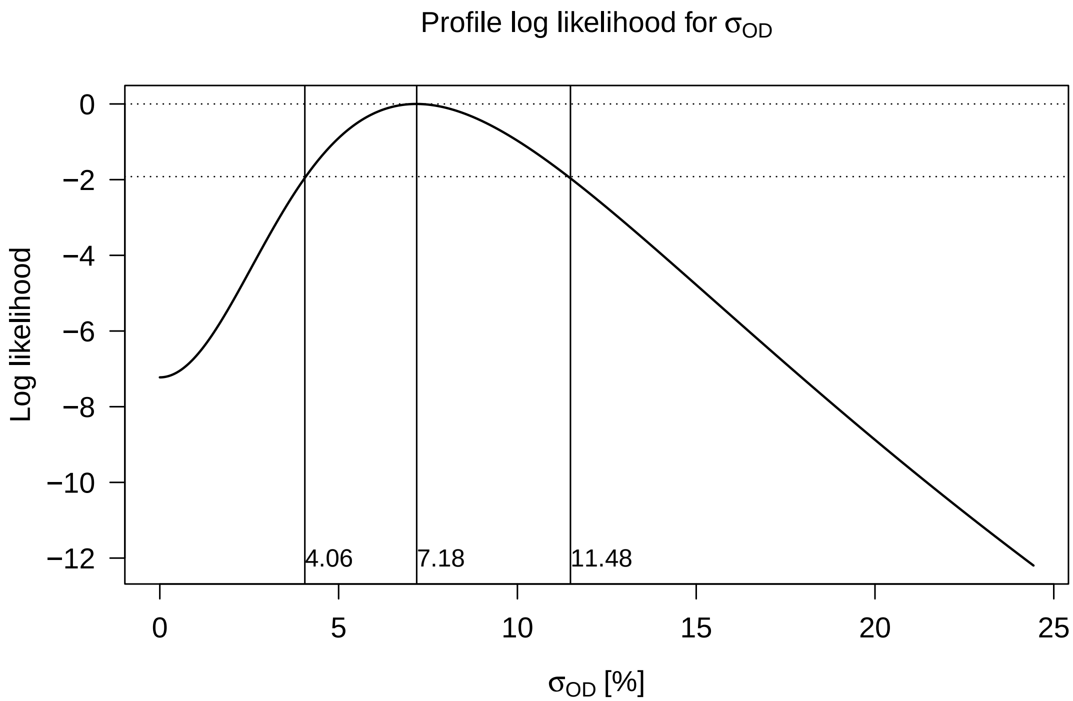



De distribution
n = 21 | in 2 sigma = 71.4 %
Standardised estimate
2
0
−2
352
350
300
250
200
186
De [Gy]
Relative standard error (%)
20
10
6.7
0
5
10
15
Precision

2.5 Central age model

Below is output of the function `calc_CentralDose()` of the `Luminescence` package shown, which calculates the central dose and the over-dispersion of the De distribution in accordance to the model given by Galbraith et al. (1999) .

```
 [calc_CentralDose]

----------- meta data ----------------
 n:                        21
 log:                      TRUE
----------- dose estimate ------------
 abs. central dose:        263.17
 abs. SE:                  5.28
 rel. SE [%]:              2.01
----------- overdispersion -----------
 abs. OD:                  18.88
 abs. SE:                  4.78
 OD [%]:                   7.17
 SE [%]:                   1.82
-------------------------------------
```



SE = standard error, OD = over-dispersion

2.6 Scatter plot

Scatter plot