B19-LU 5 analysis with removal of the fading signal component

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1 Input

Analysed file: 1-Permafrost-1mm-63-100-Fsp-pIR290-sample_B19-LU-5-24al.binx

Laboratory dose rate: 0.0765 ± 0.0038 Gy/s

System ID: 190

User: Tobias

Date of measurement: 290822

Date of analysis: 2024-01-26

Base name output files: 2024-01-26_B19-LU 5 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.

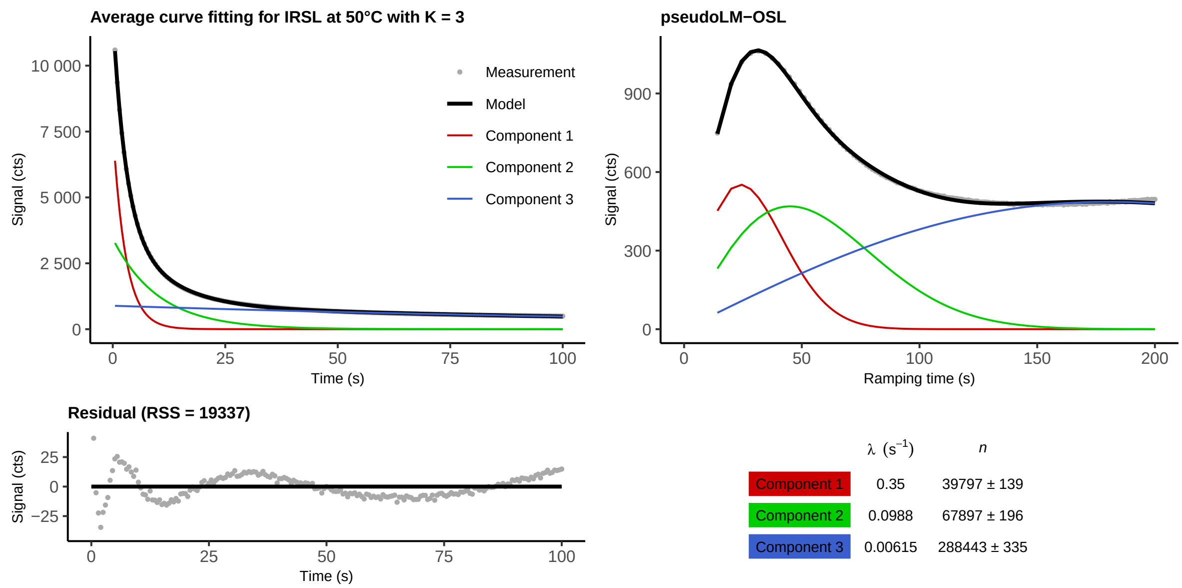
```
CORRECTION STEP 1 ----- Check records for consistency in the detection settings -----
Frequency table of different sets of detection settings (Channels, Channel width):
                settings frequency record_type
1               220, 0.5       336        IRSL
3               420, 0.5       336       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: 0.64 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: 1.68 s)
```

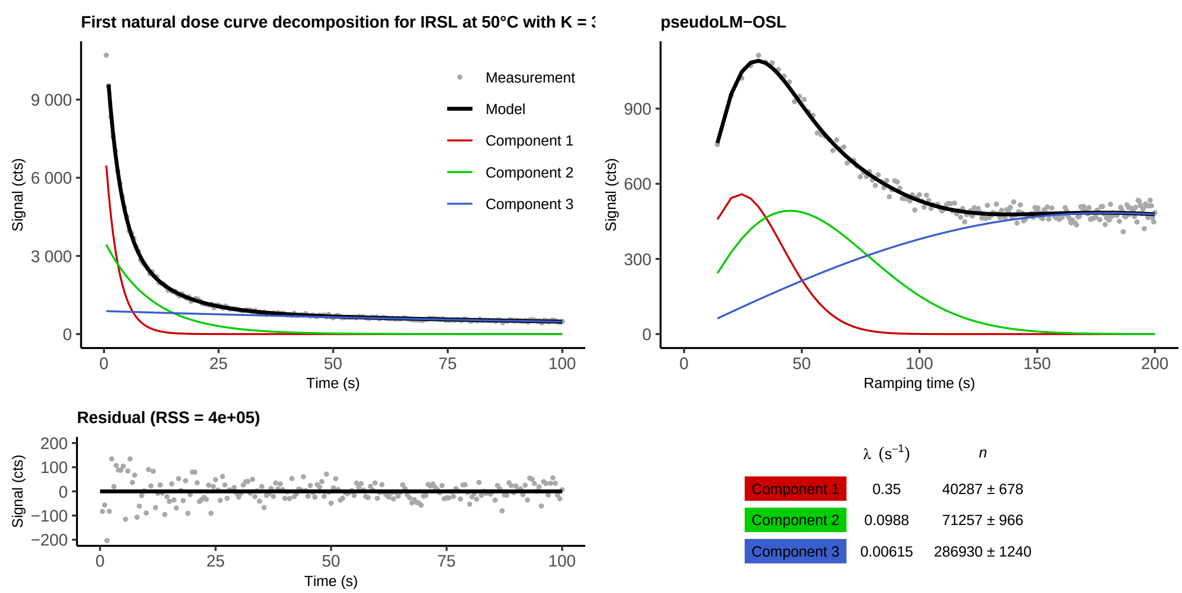
We perform the code again but only for IRSL2 records to clean also 290°C IRSL records.

```
CORRECTION STEP 1 ----- Check records for consistency in the detection settings -----
All IRSL2 records have the same detection settings
(time needed: 0.23 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 IRSL2 records reduced from 210 s to 200 s
(time needed: 2.85 s)
```

1.2 Global curve fitting

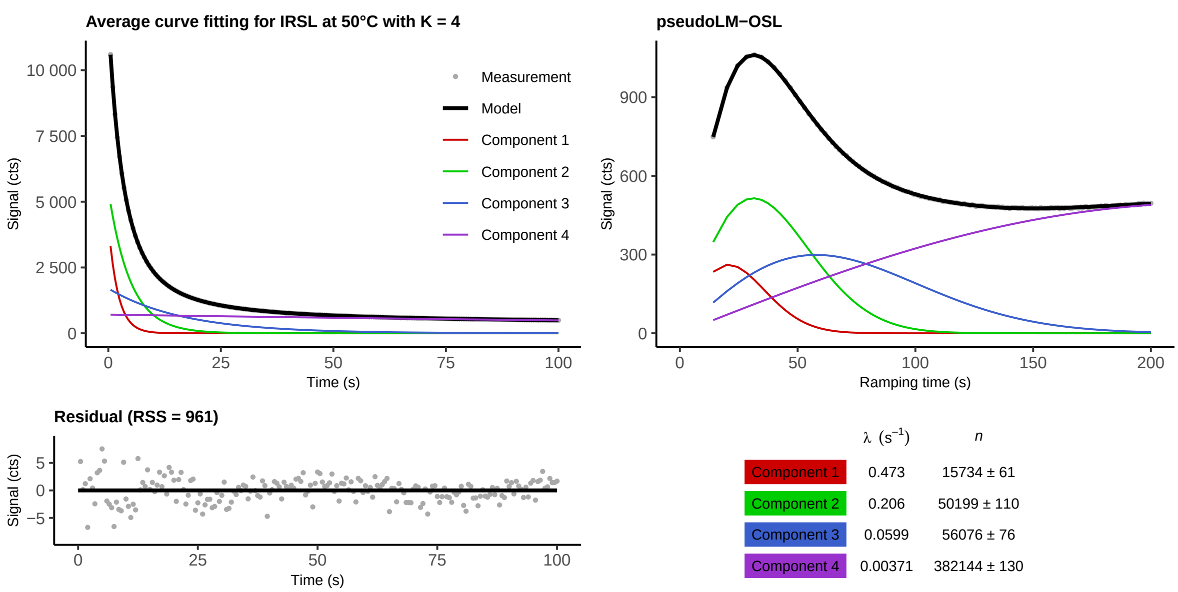
```
----------- Signal components for IRSL at 50°C with K = 3  ------------

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: 1.4 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        0.1123                           6.997e+07         Inf
K = 2        0.2322     0.01304               1.336e+06        5035
K = 3        0.3502     0.09879    0.006155   1.923e+04        6643
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    7.5e-19
K = 2    1.55e-18             8.71e-20
K = 3    2.34e-18             6.6e-19              4.11e-20
(time needed: 1.85 s)
```

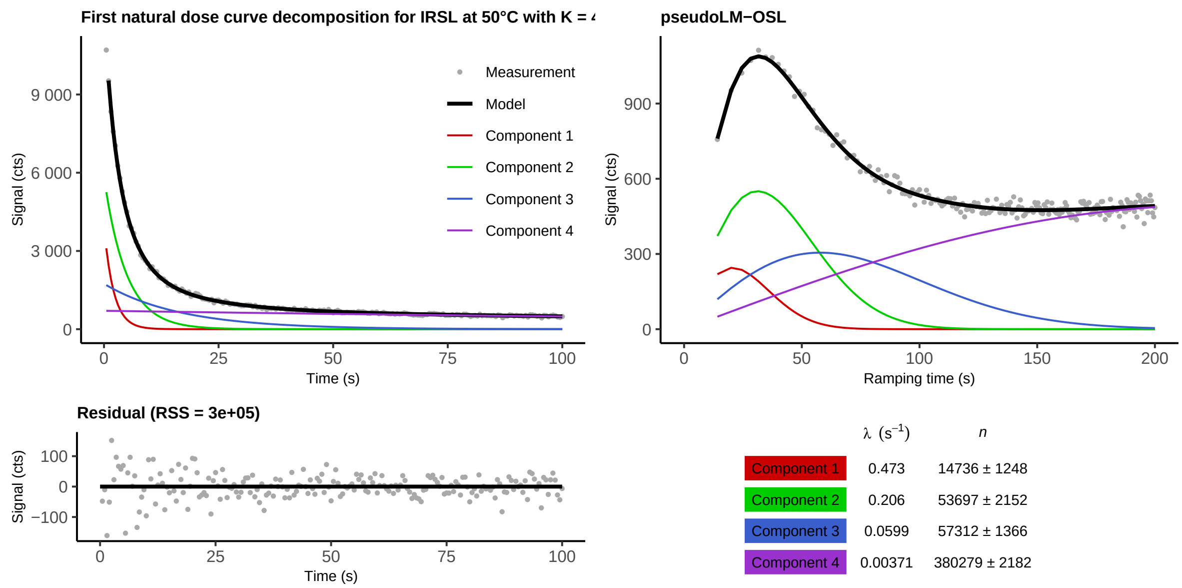




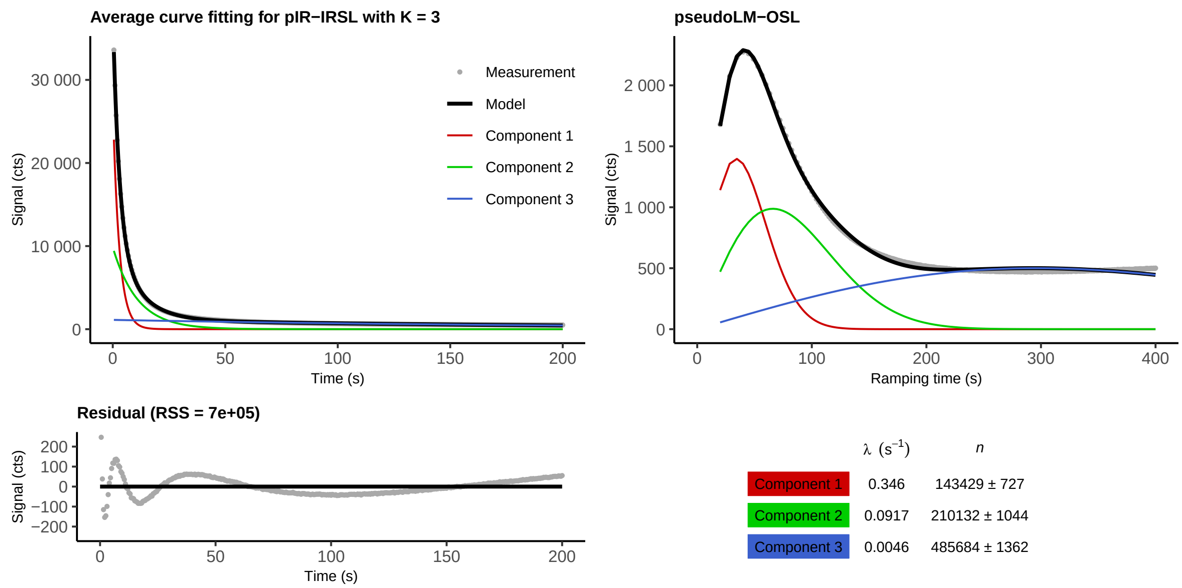

```
----------- Signal components for IRSL at 50°C with K = 4  ------------

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: 1.66 s)
```

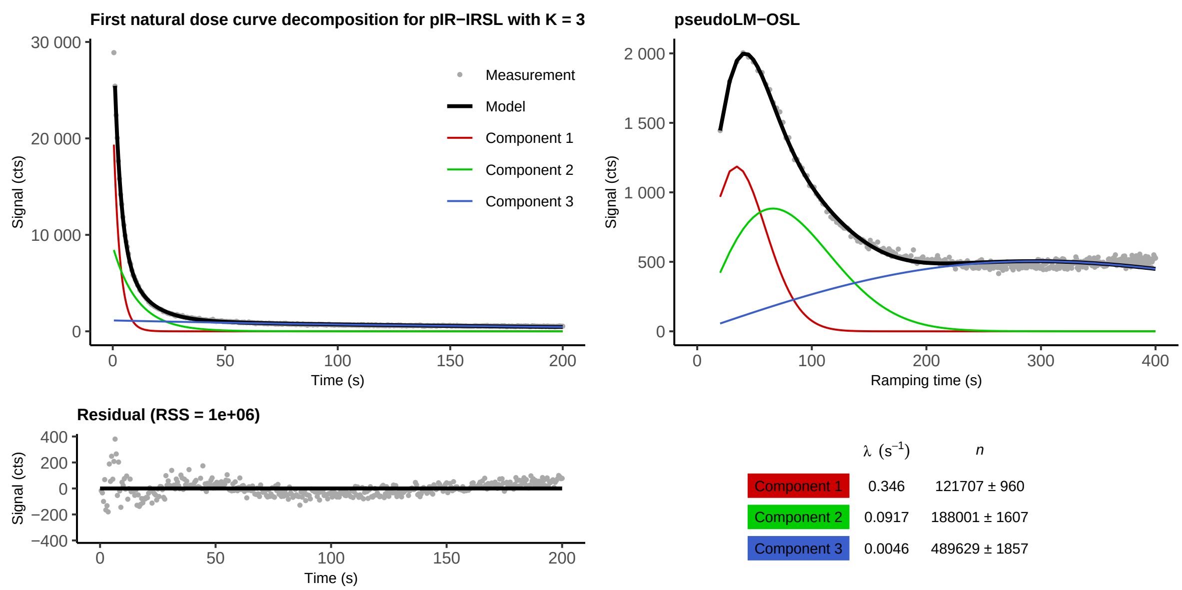
```
STEP 1.2 ----- Perform multi-exponential curve fitting -----

Decay rates (s^-1):
Cycle        Comp. 1     Comp. 2     Comp. 3     Comp. 4          RSS     F-value
K = 1         0.1123                                        6.997e+07         Inf
K = 2         0.2322     0.01304                            1.336e+06        5035
K = 3         0.3502     0.09879    0.006155                1.923e+04        6643
K = 4         0.4728       0.206     0.05985    0.003708        948.5        1850
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    7.5e-19
K = 2    1.55e-18               8.71e-20
K = 3    2.34e-18               6.6e-19                4.11e-20
K = 4    3.16e-18               1.38e-18               4e-19                  2.48e-20
(time needed: 3.63 s)
```





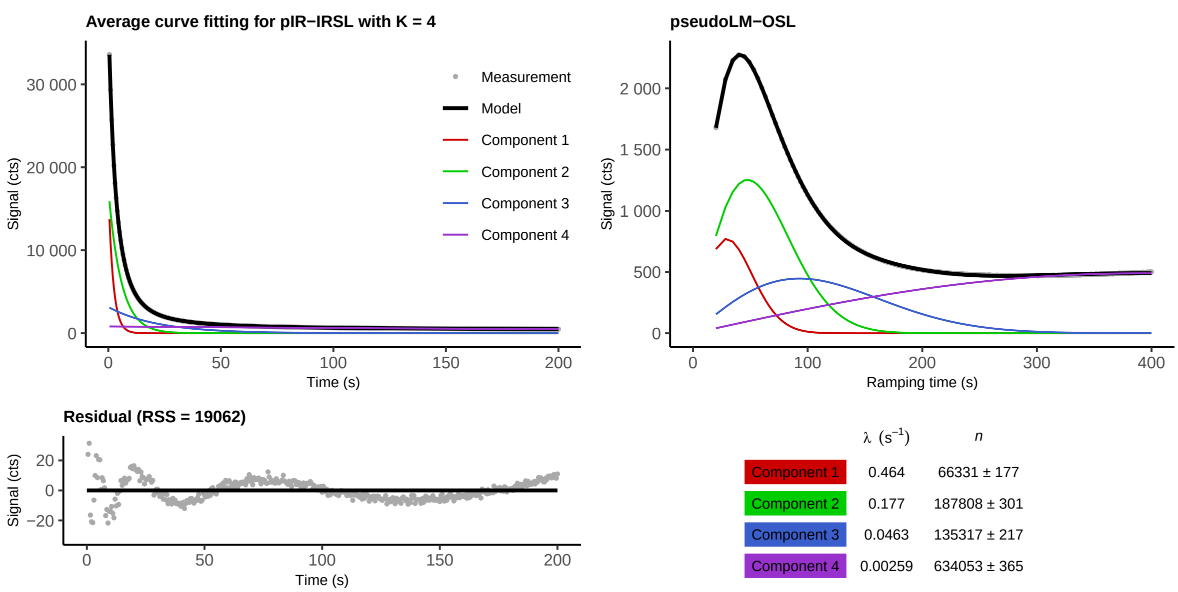

```
----------- Signal components for pIR-IRSL with K = 3  ------------

STEP 1.1 ----- Build global average curve from all CW-OSL curves -----
Built global average curve from arithmetic means from first 400 data points of all 336 IRSL records
(time needed: 3.03 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         0.1662                             2.975e+08         Inf
K = 2         0.2271     0.01113                 2.519e+07        2141
K = 3         0.3464     0.09175    0.004603     7.328e+05        6573
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     1.11e-18
K = 2     1.52e-18             7.43e-20
K = 3     2.31e-18             6.13e-19             3.07e-20
(time needed: 1.89 s)
```

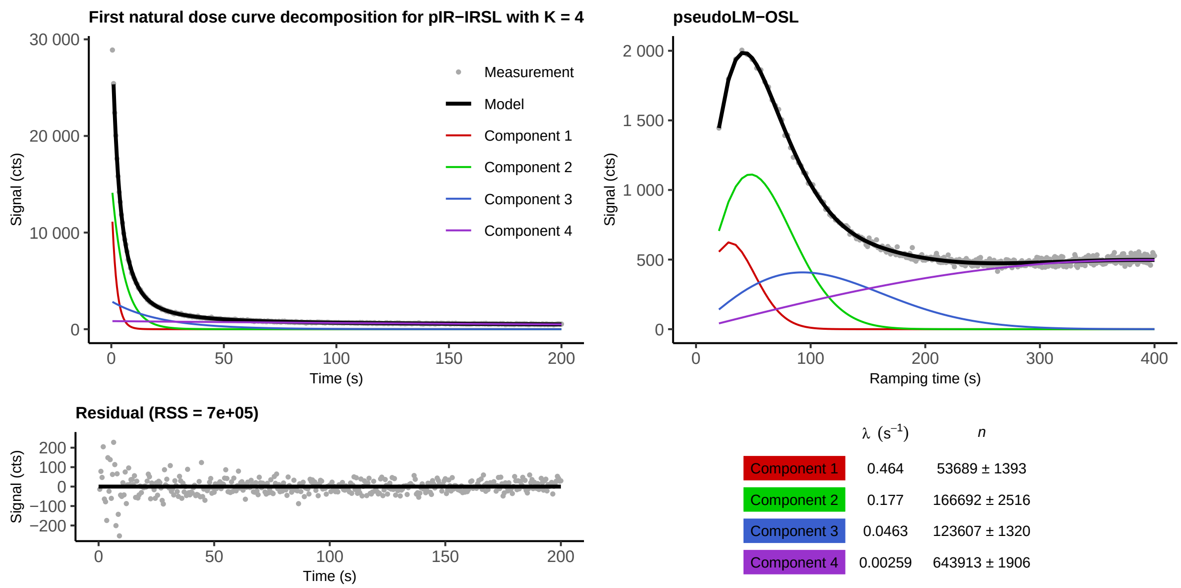





```
----------- Signal components for pIR-IRSL with K = 4  ------------

STEP 1.1 ----- Build global average curve from all CW-OSL curves -----
Built global average curve from arithmetic means from first 400 data points of all 336 IRSL records
(time needed: 2.89 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         0.1662                                        2.975e+08         Inf
K = 2         0.2271     0.01113                            2.519e+07        2141
K = 3         0.3464     0.09175    0.004603                7.328e+05        6573
K = 4         0.4645       0.177      0.0463     0.00259    1.841e+04        7606
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     1.11e-18
K = 2     1.52e-18              7.43e-20
K = 3     2.31e-18              6.13e-19              3.07e-20
K = 4     3.1e-18               1.18e-18              3.09e-19              1.73e-20
(time needed: 3.42 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
```

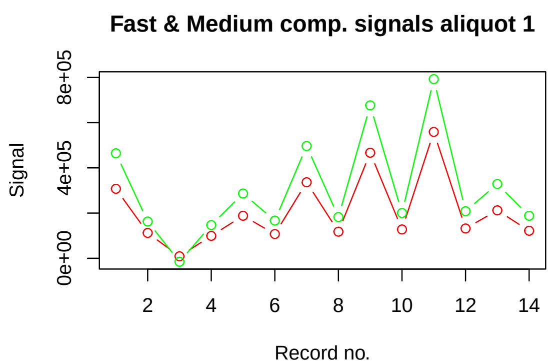
```
# default: suffix <- "pIRIR K3"
suffix <- "pIRIR K3"

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

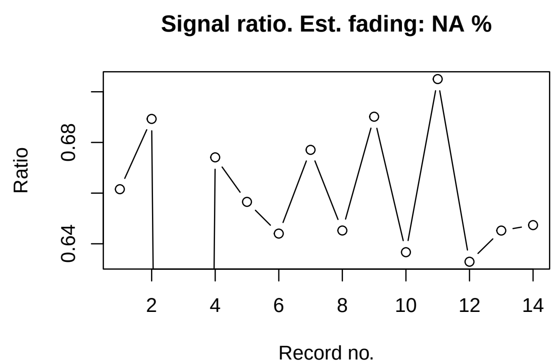
Table 1: Signal components of global curve

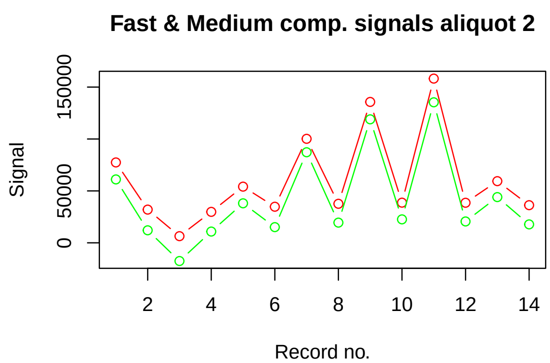
name	lambda	lambda.error	n	n.error	initial.signal
Component 1	0.3464	0.0024	143429	727	0.6840
Component 2	0.0917	0.0011	210132	1044	0.2825
Component 3	0.0046	0.0001	485684	1362	0.0335

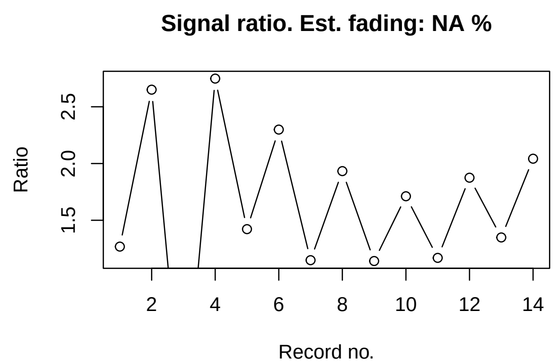
1.4 Fast component removal

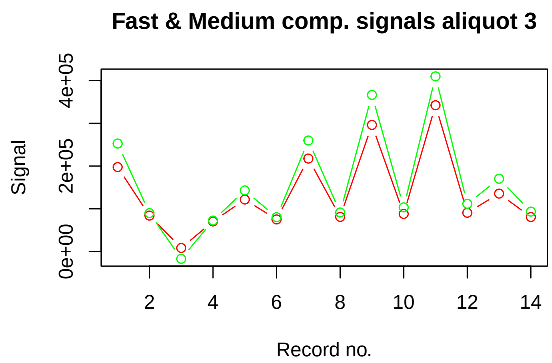
The fast component is now determined for each single curve by `decompose_OSLcurve()` and removed from the record.

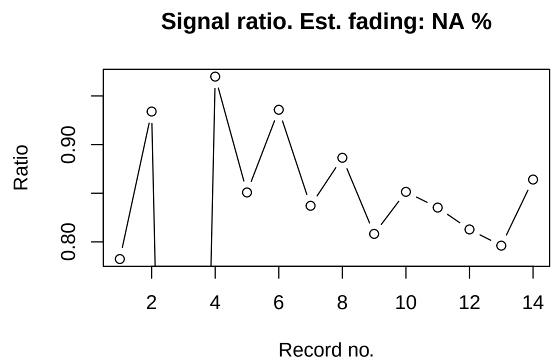


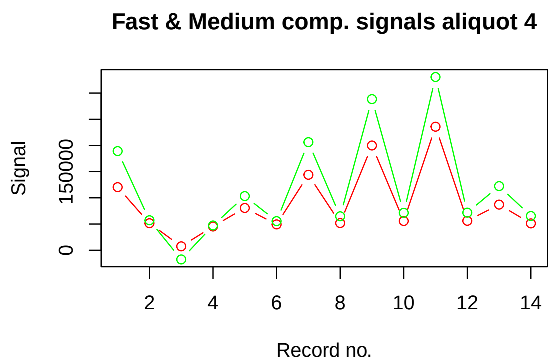


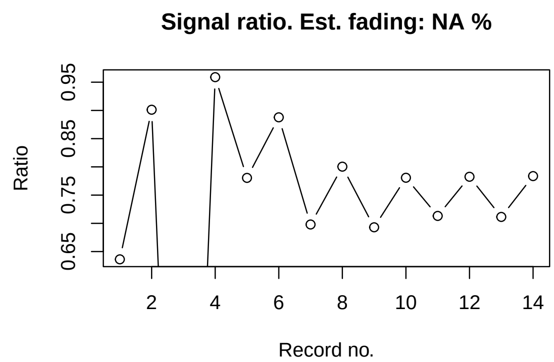


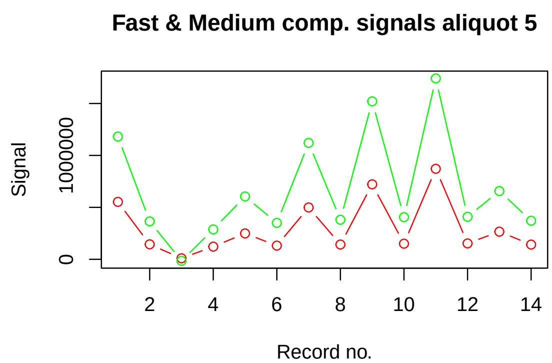


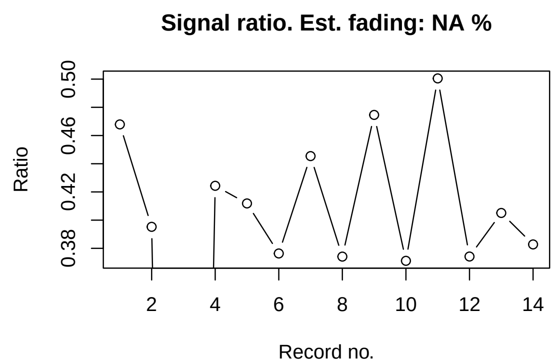

Fast & Medium comp. signals aliquot 3
Signal
0e+00
2e+05
4e+05
2 4 6 8 10 12 14
Record no.

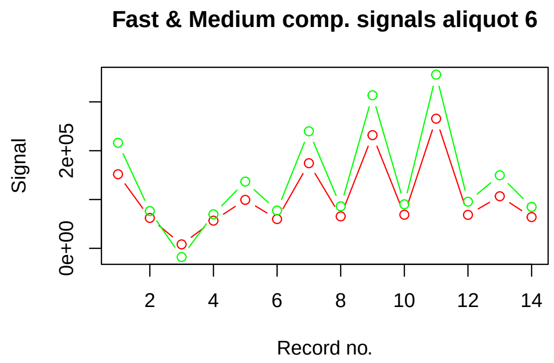

Signal ratio. Est. fading: NA %
Ratio
0.80
0.90
2 4 6 8 10 12 14
Record no.

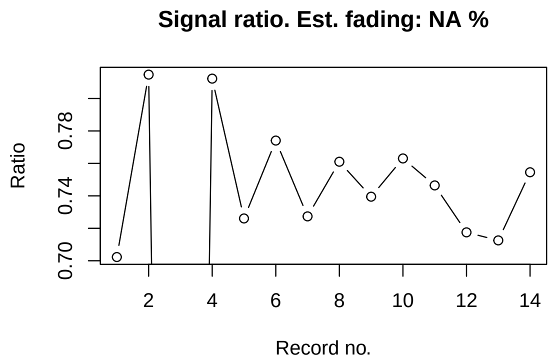

Fast & Medium comp. signals aliquot 4
Signal
0
150000
2 4 6 8 10 12 14
Record no.

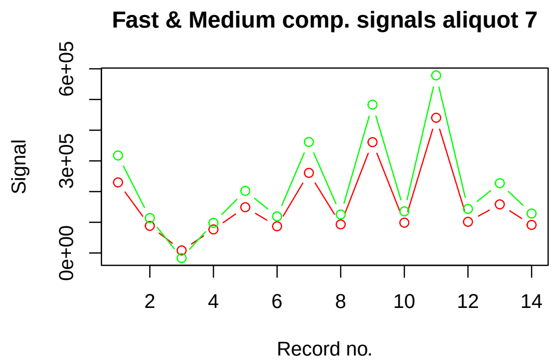

Signal ratio. Est. fading: NA %
Ratio
0.65
0.75
0.85
0.95
2 4 6 8 10 12 14
Record no.

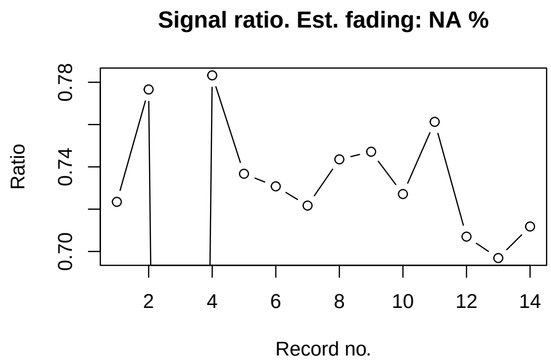

Fast & Medium comp. signals aliquot 5
Signal
0
1000000
2 4 6 8 10 12 14
Record no.

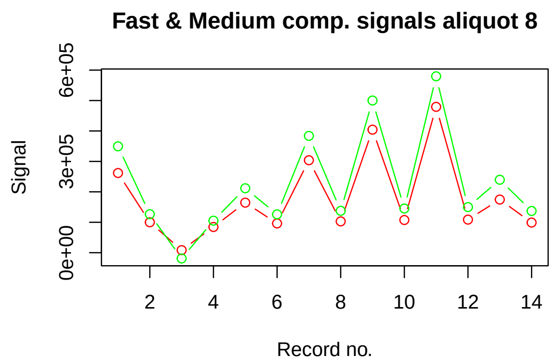

Signal ratio. Est. fading: NA %
Ratio
0.38
0.42
0.46
0.50
2 4 6 8 10 12 14
Record no.

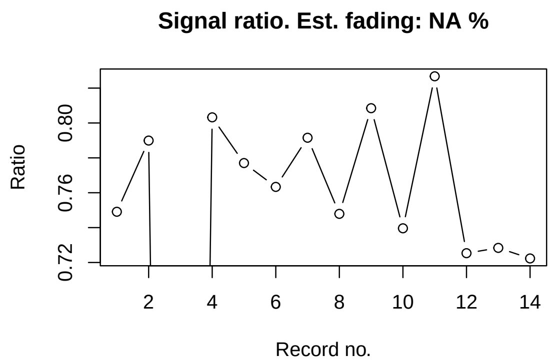

Fast & Medium comp. signals aliquot 6
Signal
0e+00
2e+05
2
4
6
8
10
12
14
Record no.

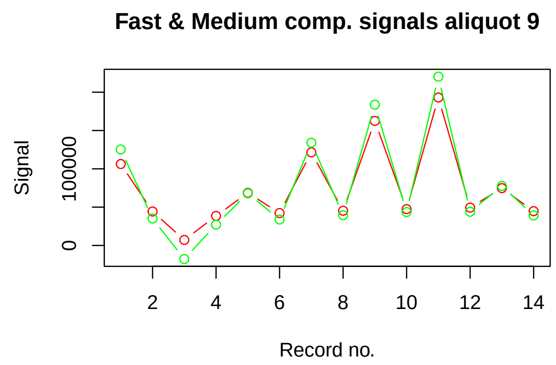

Signal ratio. Est. fading: NA %
Ratio
0.70
0.74
0.78
2
4
6
8
10
12
14
Record no.

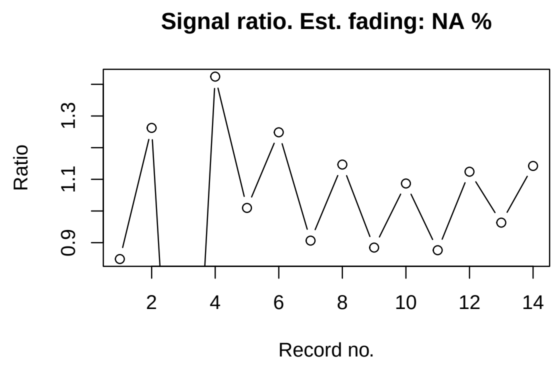

Fast & Medium comp. signals aliquot 7
Signal
0e+00
3e+05
6e+05
2
4
6
8
10
12
14
Record no.

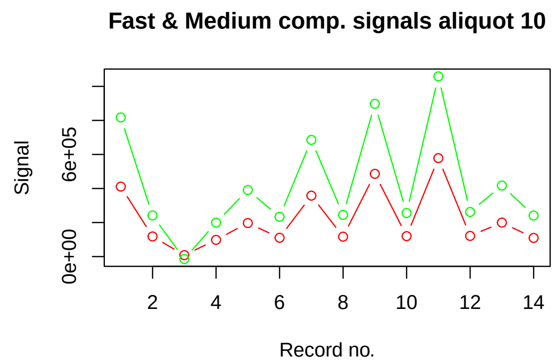

Signal ratio. Est. fading: NA %
Ratio
0.70
0.74
0.78
2
4
6
8
10
12
14
Record no.

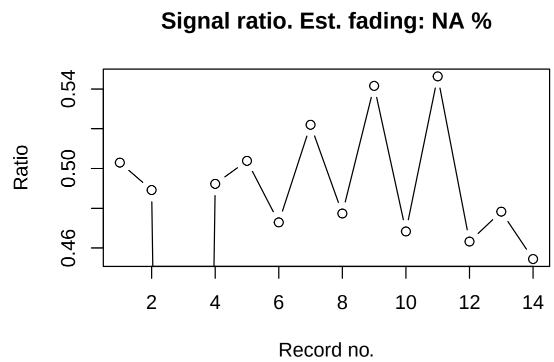

Fast & Medium comp. signals aliquot 8
Signal
0e+00
3e+05
6e+05
2
4
6
8
10
12
14
Record no.

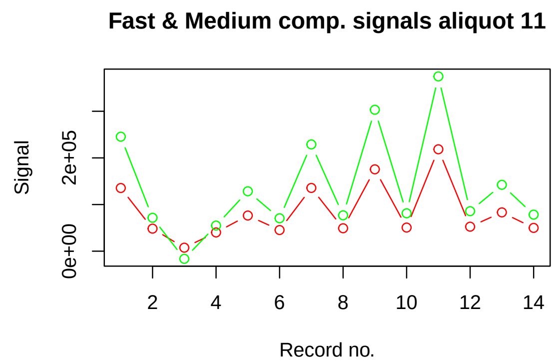

Signal ratio. Est. fading: NA %
Ratio
0.72
0.76
0.80
2
4
6
8
10
12
14
Record no.

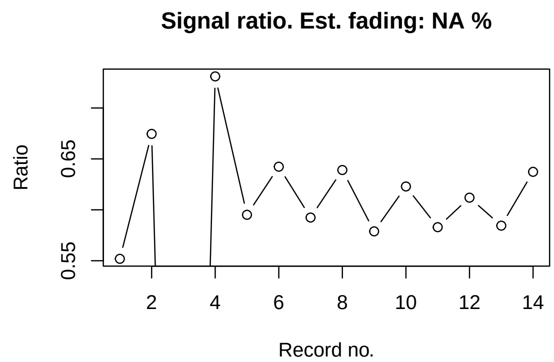

Fast & Medium comp. signals aliquot 9
Signal
0
100000
2
4
6
8
10
12
14
Record no.

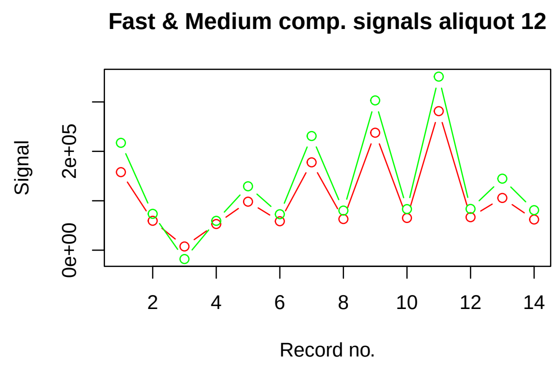

Signal ratio. Est. fading: NA %
Ratio
0.9
1.1
1.3
2
4
6
8
10
12
14
Record no.

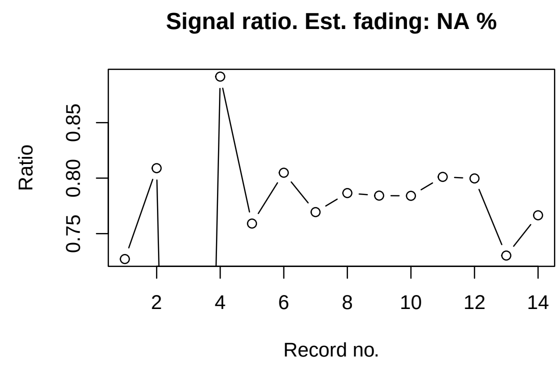

Fast & Medium comp. signals aliquot 10
Signal
0e+00
6e+05
2
4
6
8
10
12
14
Record no.

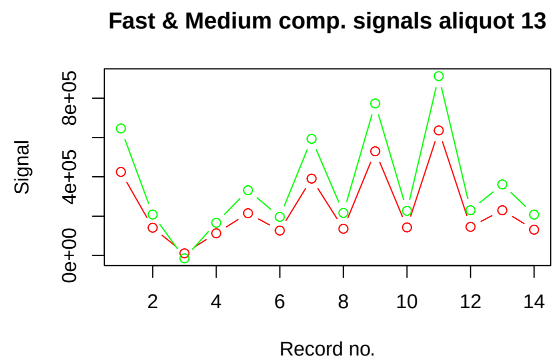

Signal ratio. Est. fading: NA %
Ratio
0.46
0.50
0.54
2
4
6
8
10
12
14
Record no.

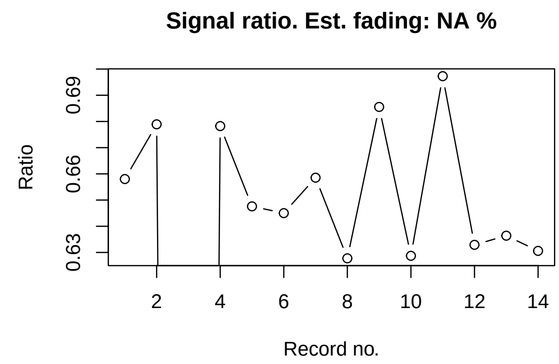

Fast & Medium comp. signals aliquot 11
Signal
0e+00
2e+05
2
4
6
8
10
12
14
Record no.

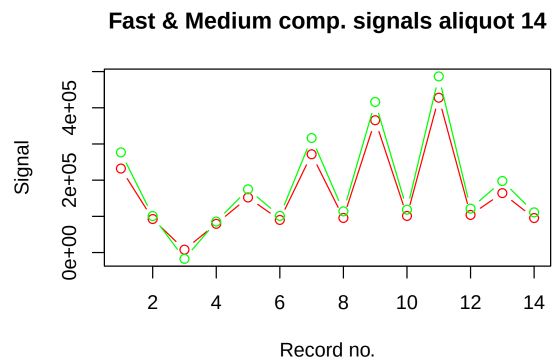

Signal ratio. Est. fading: NA %
Ratio
0.55
0.65
2
4
6
8
10
12
14
Record no.

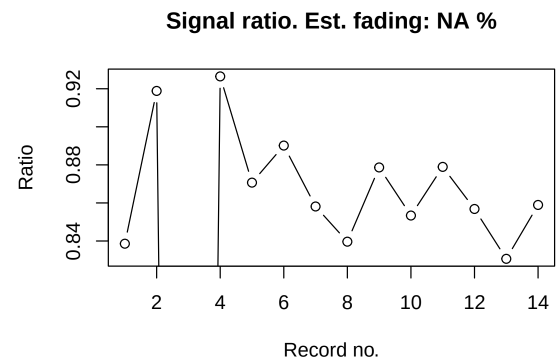

Fast & Medium comp. signals aliquot 12
Signal
0e+00
2e+05
2
4
6
8
10
12
14
Record no.

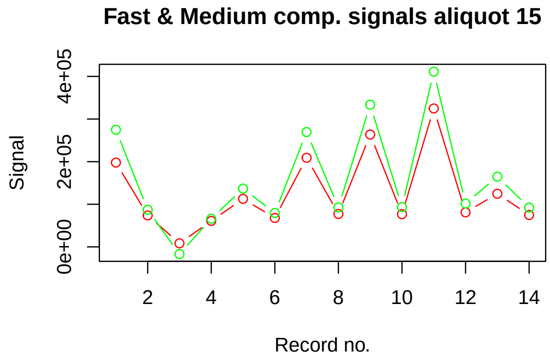

Signal ratio. Est. fading: NA %
Ratio
0.75
0.80
0.85
2
4
6
8
10
12
14
Record no.

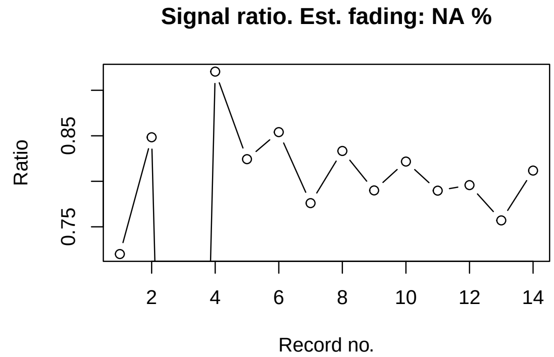

Fast & Medium comp. signals aliquot 13
Signal
0e+00
4e+05
8e+05
2
4
6
8
10
12
14
Record no.

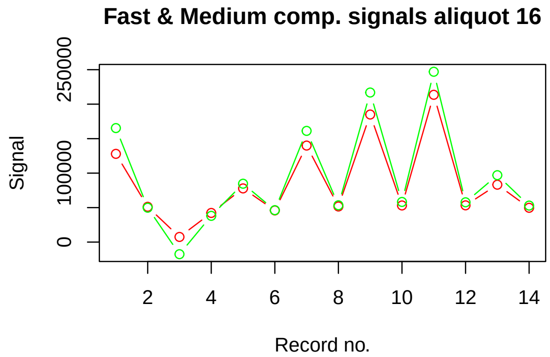

Signal ratio. Est. fading: NA %
Ratio
0.63
0.66
0.69
2
4
6
8
10
12
14
Record no.

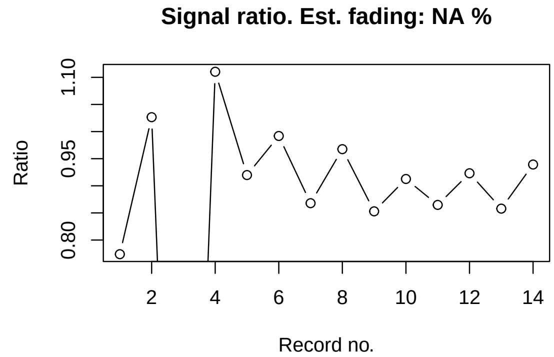

Fast & Medium comp. signals aliquot 14
Signal
0e+00
2e+05
4e+05
2
4
6
8
10
12
14
Record no.

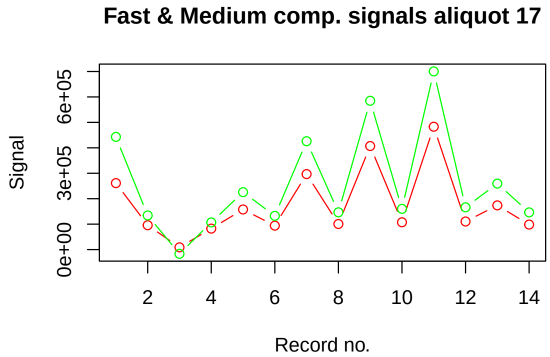

Signal ratio. Est. fading: NA %
Ratio
0.84
0.88
0.92
2
4
6
8
10
12
14
Record no.

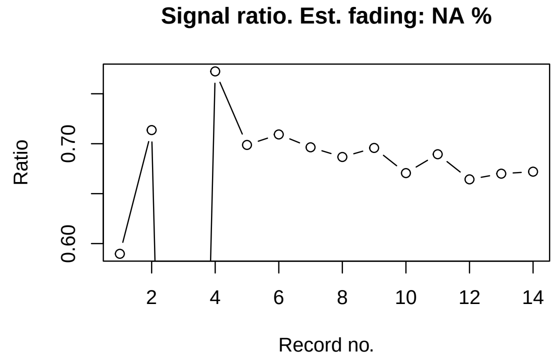

Fast & Medium comp. signals aliquot 15
Signal
0e+00
2e+05
4e+05
2
4
6
8
10
12
14
Record no.

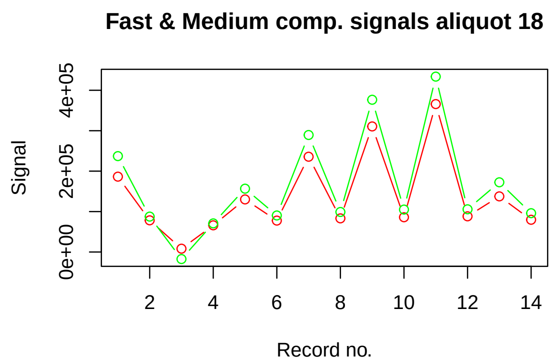

Signal ratio. Est. fading: NA %
Ratio
0.75
0.85
2
4
6
8
10
12
14
Record no.

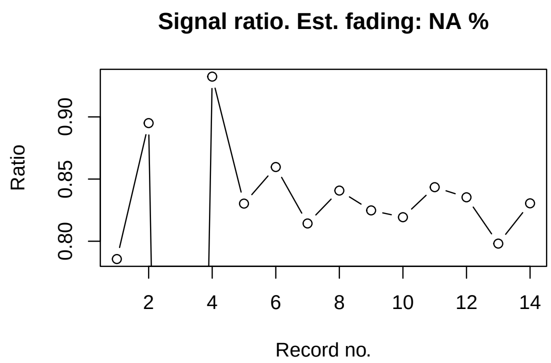

Fast & Medium comp. signals aliquot 16
Signal
0
100000
250000
2
4
6
8
10
12
14
Record no.

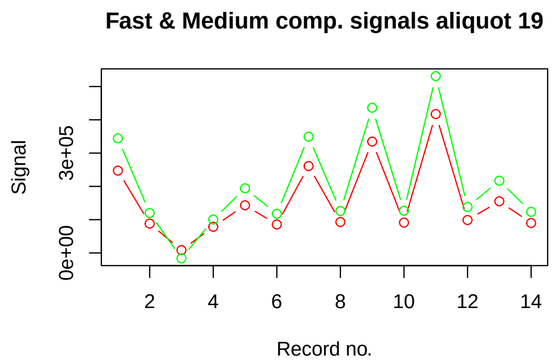

Signal ratio. Est. fading: NA %
Ratio
0.80
0.95
1.10
2
4
6
8
10
12
14
Record no.

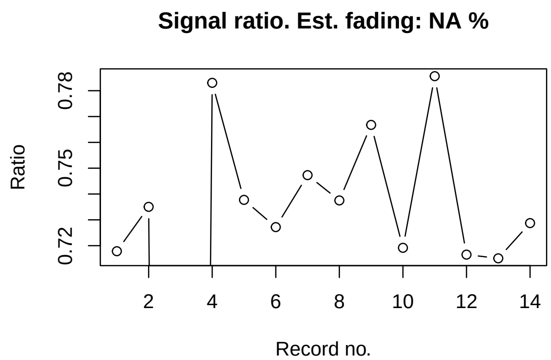

Fast & Medium comp. signals aliquot 17
Signal
0e+00
3e+05
6e+05
2
4
6
8
10
12
14
Record no.

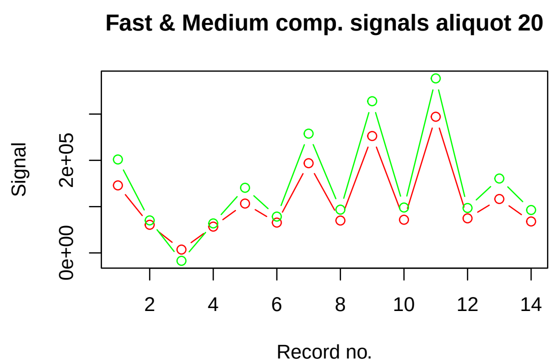

Signal ratio. Est. fading: NA %
Ratio
0.60
0.70
2
4
6
8
10
12
14
Record no.

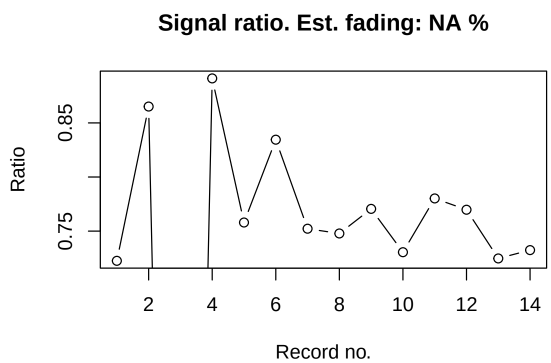

Fast & Medium comp. signals aliquot 18
Signal
0e+00
2e+05
4e+05
2
4
6
8
10
12
14
Record no.

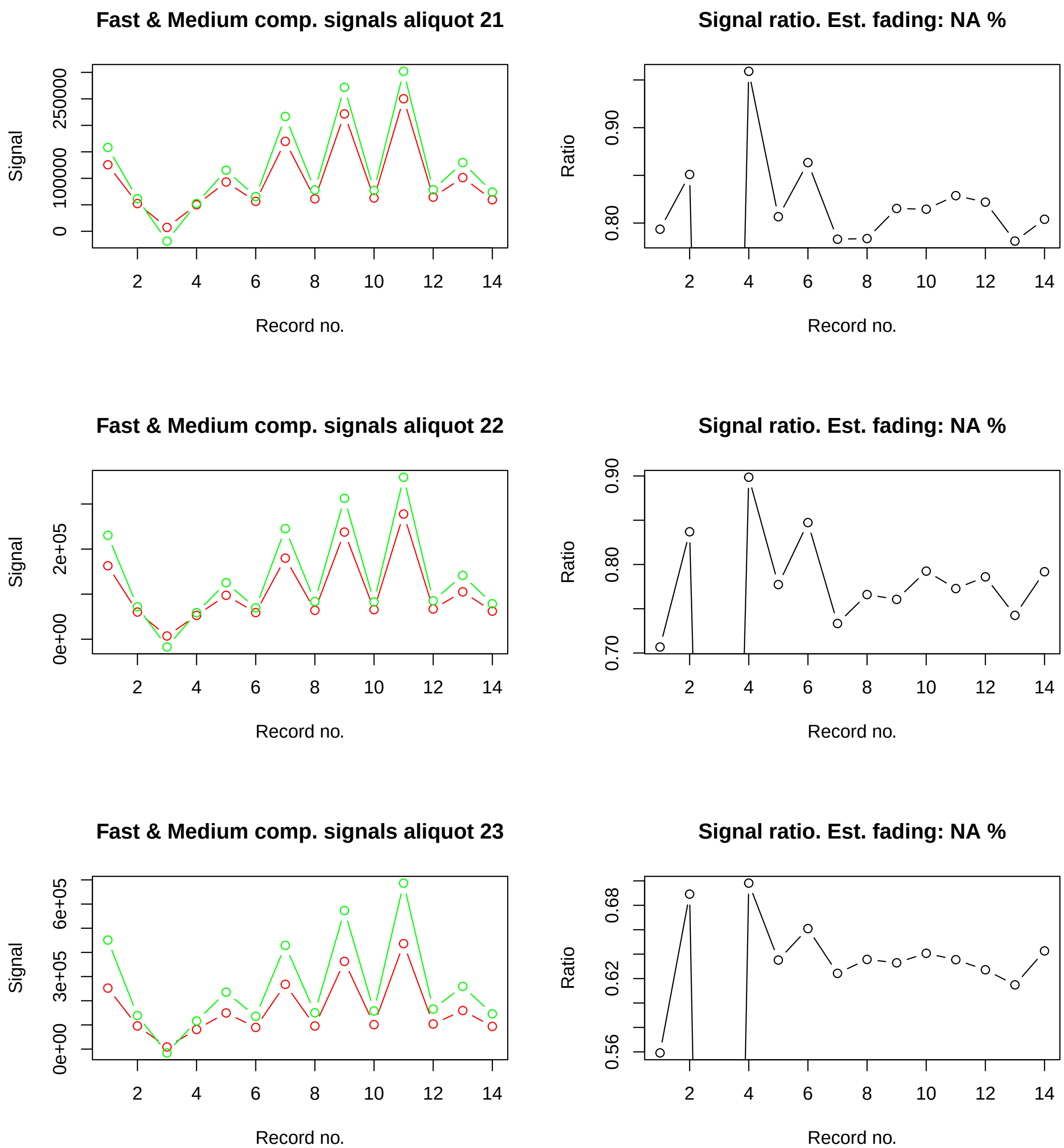

Signal ratio. Est. fading: NA %
Ratio
0.80
0.85
0.90
2
4
6
8
10
12
14
Record no.

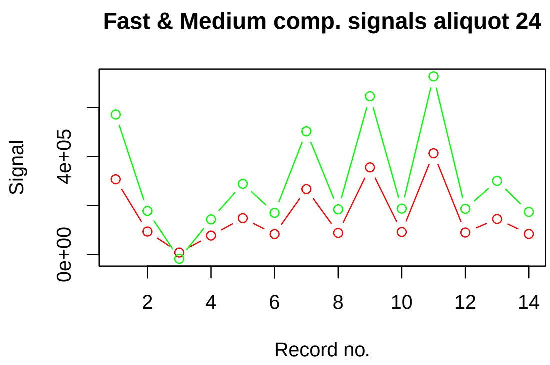

Fast & Medium comp. signals aliquot 19
Signal
0e+00
3e+05
2
4
6
8
10
12
14
Record no.

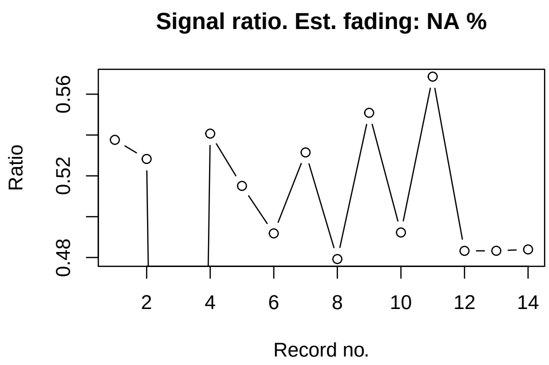

Signal ratio. Est. fading: NA %
Ratio
0.72
0.75
0.78
2
4
6
8
10
12
14
Record no.


Fast & Medium comp. signals aliquot 20
Signal
0e+00
2e+05
2
4
6
8
10
12
14
Record no.


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


Fast & Medium comp. signals aliquot 21
Signal
0
100000
250000
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.
Fast & Medium comp. signals aliquot 22
Signal
0e+00
2e+05
2
4
6
8
10
12
14
Record no.
Signal ratio. Est. fading: NA %
Ratio
0.70
0.80
0.90
2
4
6
8
10
12
14
Record no.
Fast & Medium comp. signals aliquot 23
Signal
0e+00
3e+05
6e+05
2
4
6
8
10
12
14
Record no.
Signal ratio. Est. fading: NA %
Ratio
0.56
0.62
0.68
2
4
6
8
10
12
14
Record no.

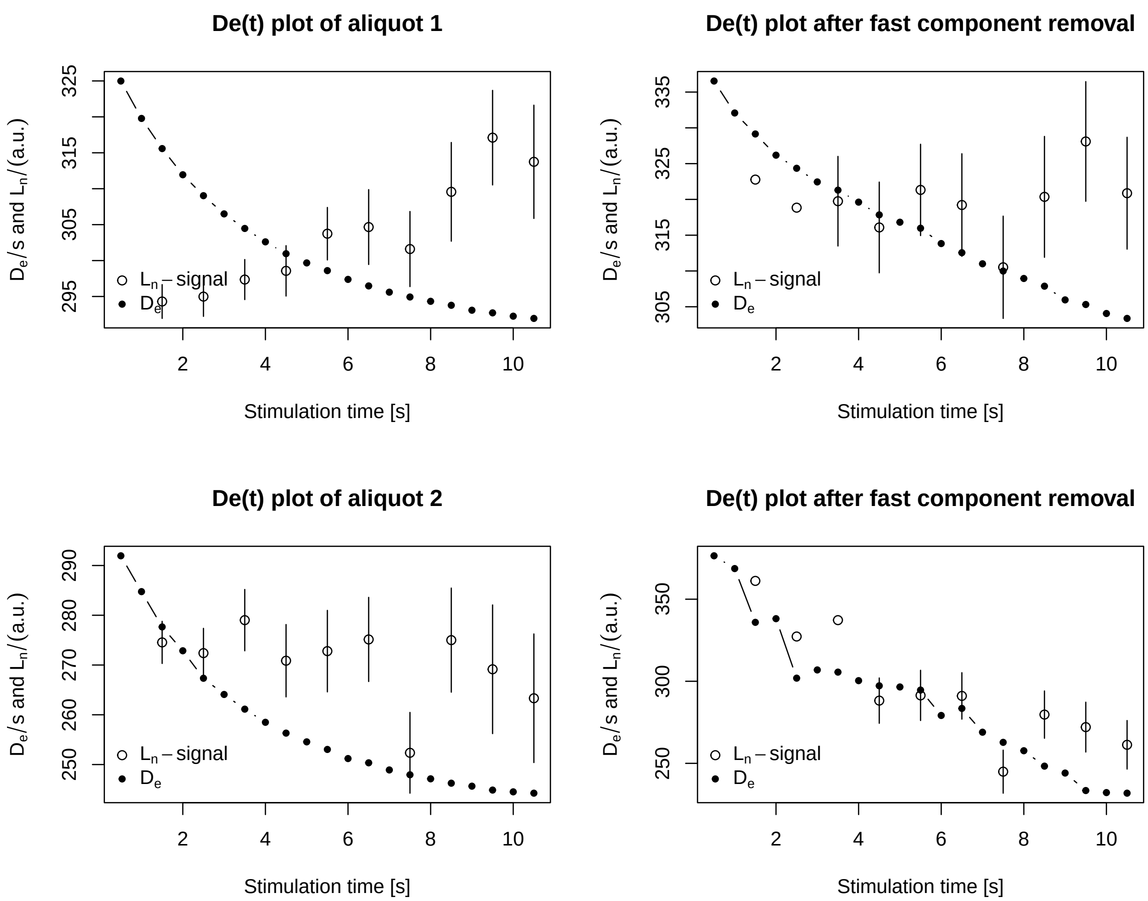

Fast & Medium comp. signals aliquot 24
Signal
0e+00
4e+05
2
4
6
8
10
12
14
Record no.

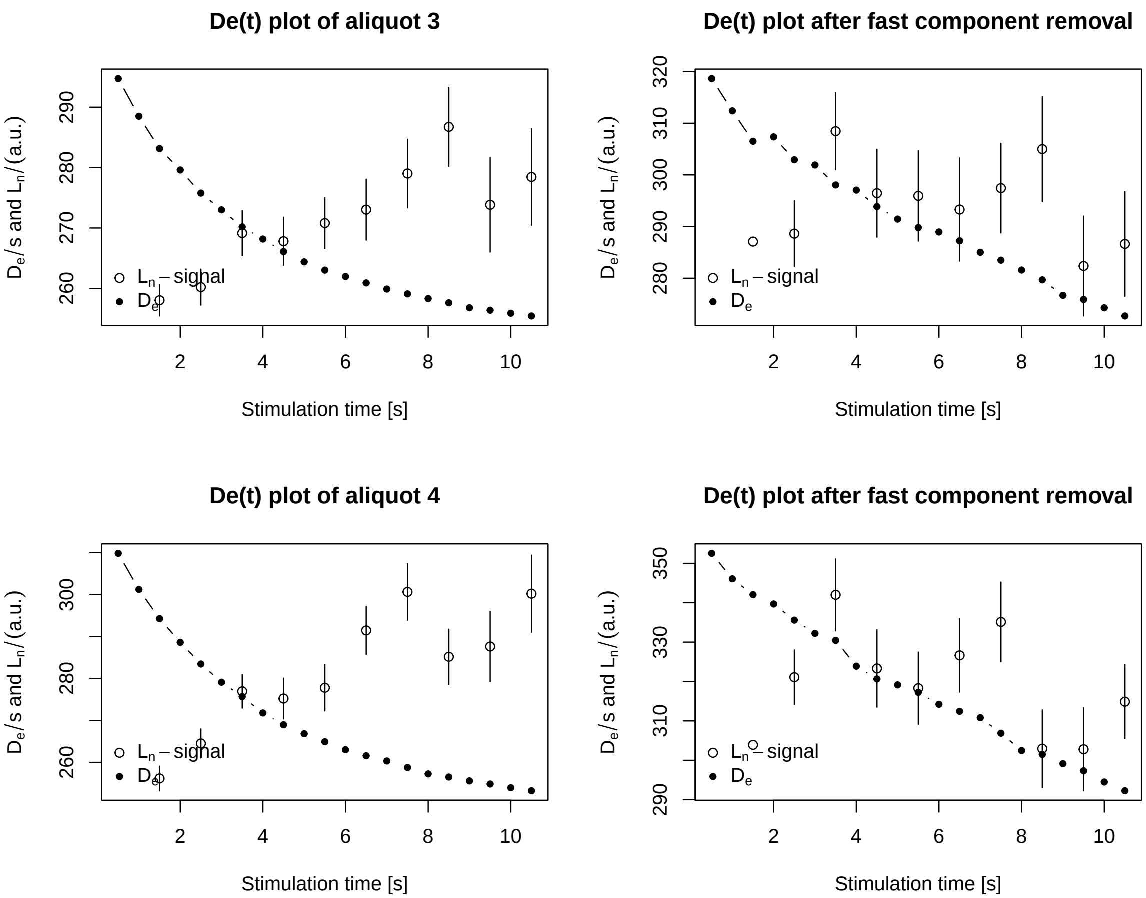

Signal ratio. Est. fading: NA %
Ratio
0.48
0.52
0.56
2
4
6
8
10
12
14
Record no.

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:



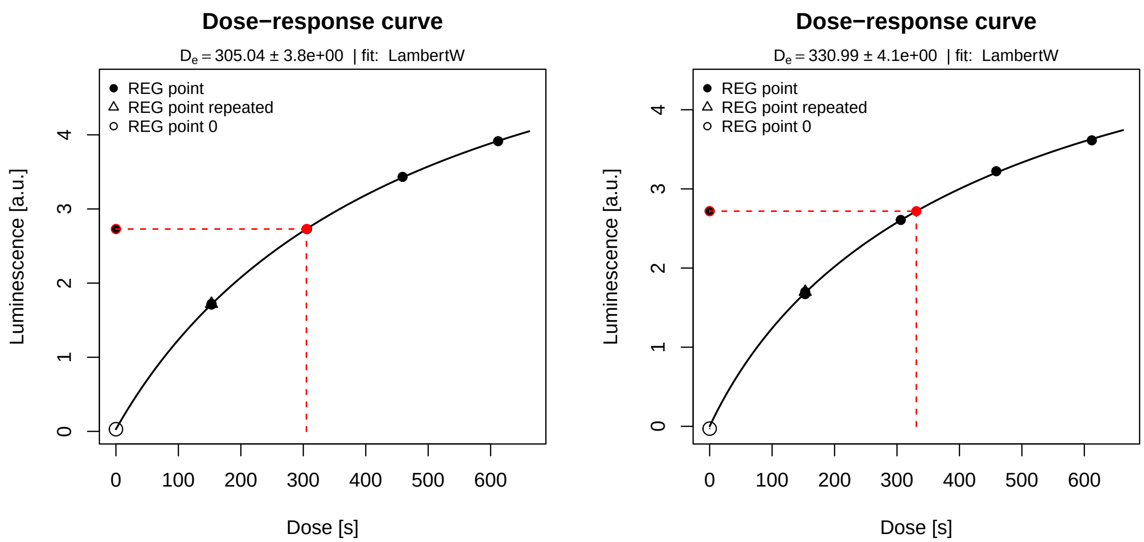


Like for other B19-LU samples the IRSL at 50°C measured equivalent doses are lower than the pIR-IRSL measured, which is a indication of thermal fading of the luminescence signal in the samples and thus also a indication of De underestimation in the IRSL at 50°C signals (Thomsen et al. 2008).

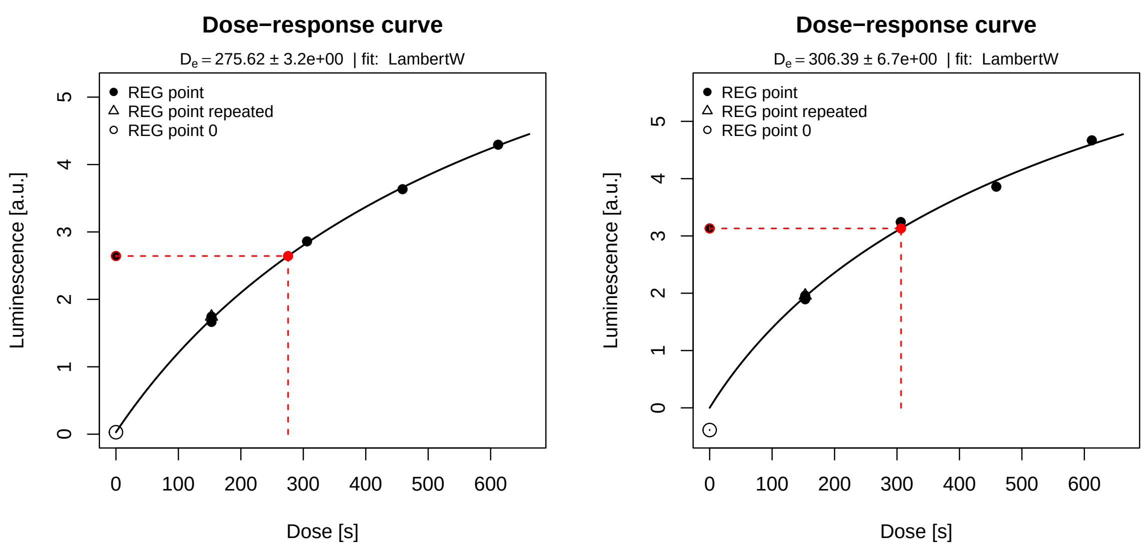
However, the increase in the De values when shifting the signal integration window towards higher values which can be observed for other B19 samples can only be observed a few of the aliquots of this sampleDose-response curve fitting

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).

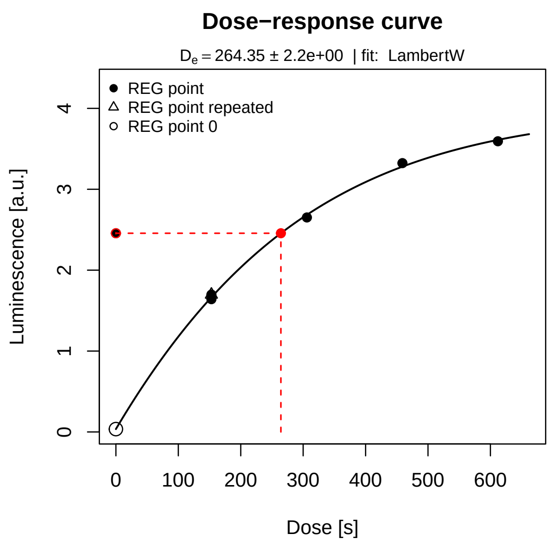
```
--- Dose response curve for aliquot 1 ---
Left: Uncorrected Dose response curve, Right: After fast component removal.
```

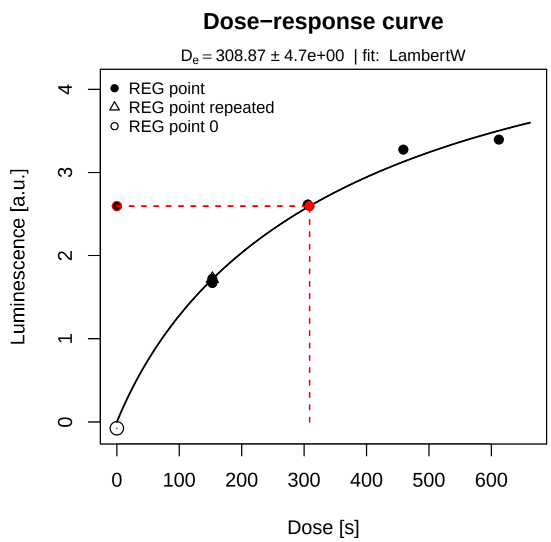



```
--- Dose response curve for aliquot 2 ---
Left: Uncorrected Dose response curve, Right: After fast component removal.
```

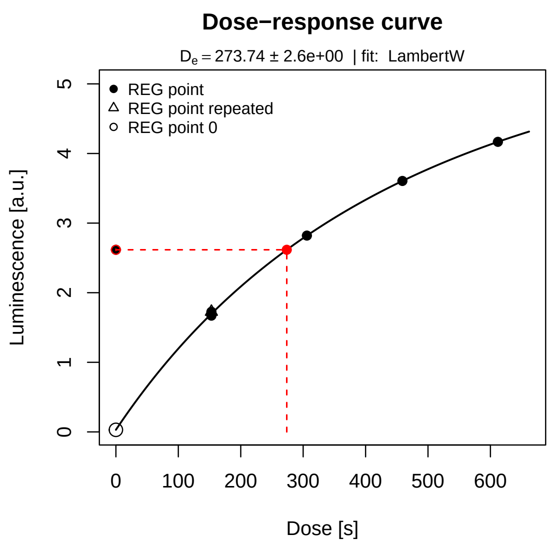


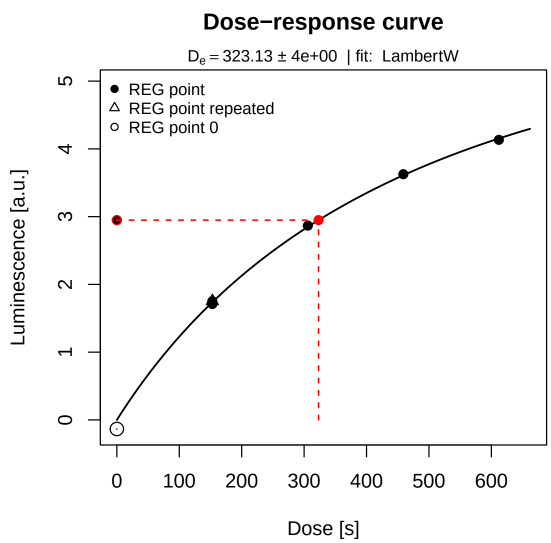

```
--- Dose response curve for aliquot 3 ---
Left: Uncorrected Dose response curve, Right: After fast component removal.
```



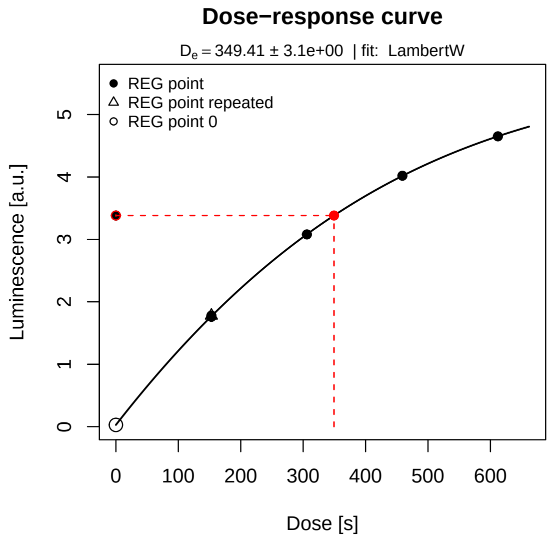


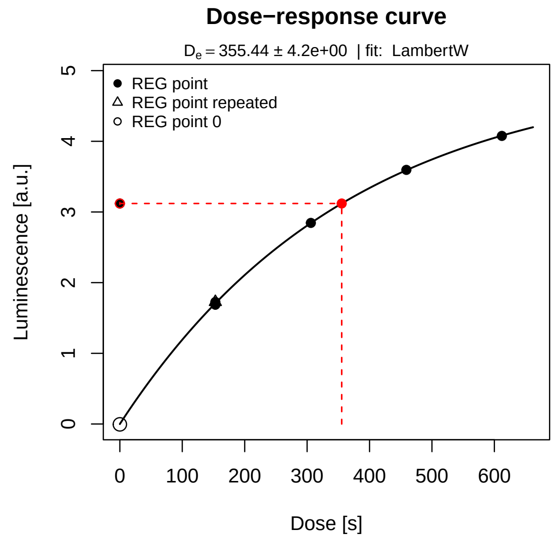

```
--- Dose response curve for aliquot 4 ---
Left: Uncorrected Dose response curve, Right: After fast component removal.
```



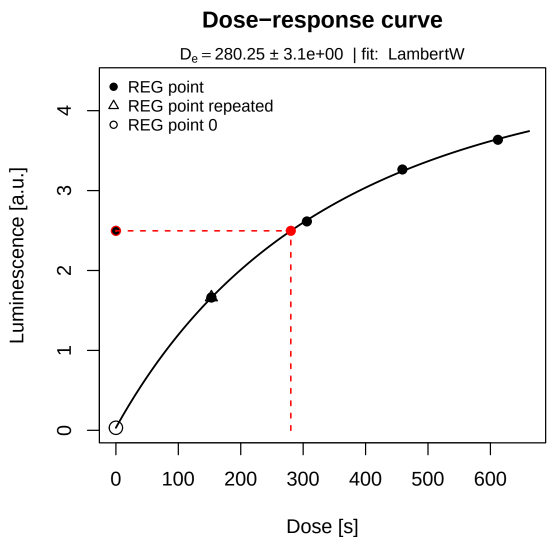


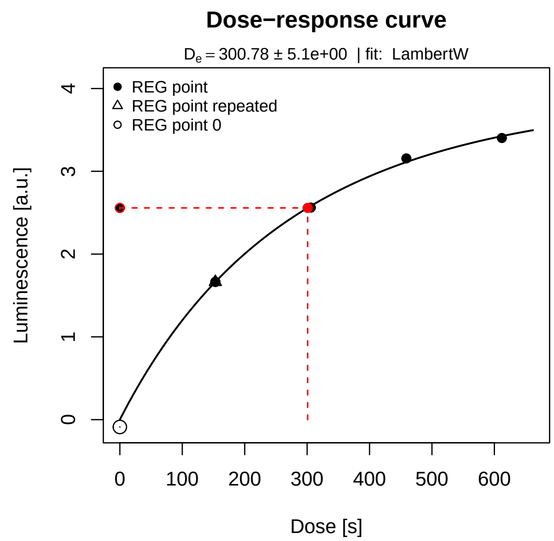

```
--- Dose response curve for aliquot 5 ---
Left: Uncorrected Dose response curve, Right: After fast component removal.
```






```
--- 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	330.99	16.86	OK
2	306.39	16.79	OK
3	308.87	15.98	OK
4	323.13	16.75	OK
5	355.44	18.29	OK
6	300.78	15.71	OK
7	294.72	15.30	OK
8	300.85	15.46	OK
9	321.76	16.87	OK
10	429.54	21.84	OK
11	379.33	19.60	OK
12	316.99	16.39	OK
13	383.72	19.53	OK
14	297.62	15.39	OK
15	360.40	18.50	OK
16	357.36	19.06	OK
17	378.29	19.50	OK
18	274.77	14.08	OK
19	325.21	16.65	OK
20	321.04	16.94	OK
21	261.15	13.59	OK
22	353.54	18.29	OK
23	376.09	19.36	OK
24	403.07	20.65	OK

24 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

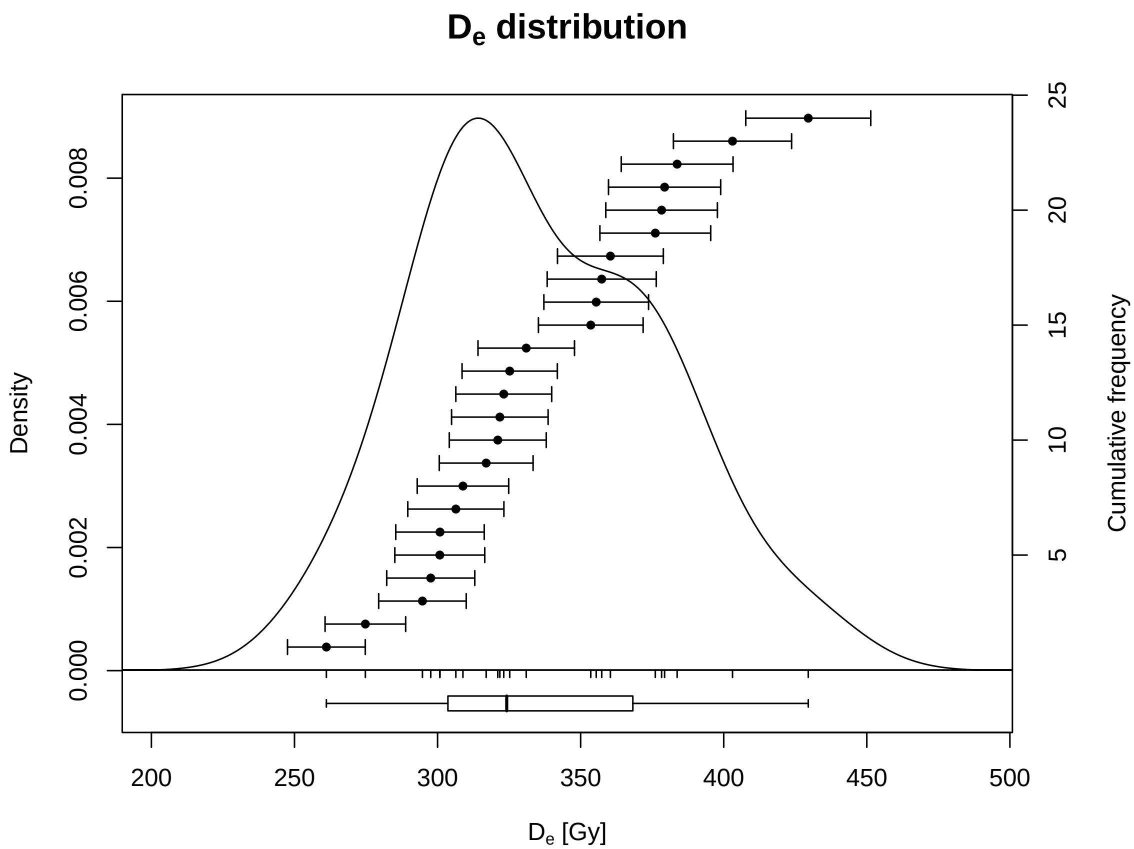
Table 3: Rejection criteria thresholds (left) and results (right)

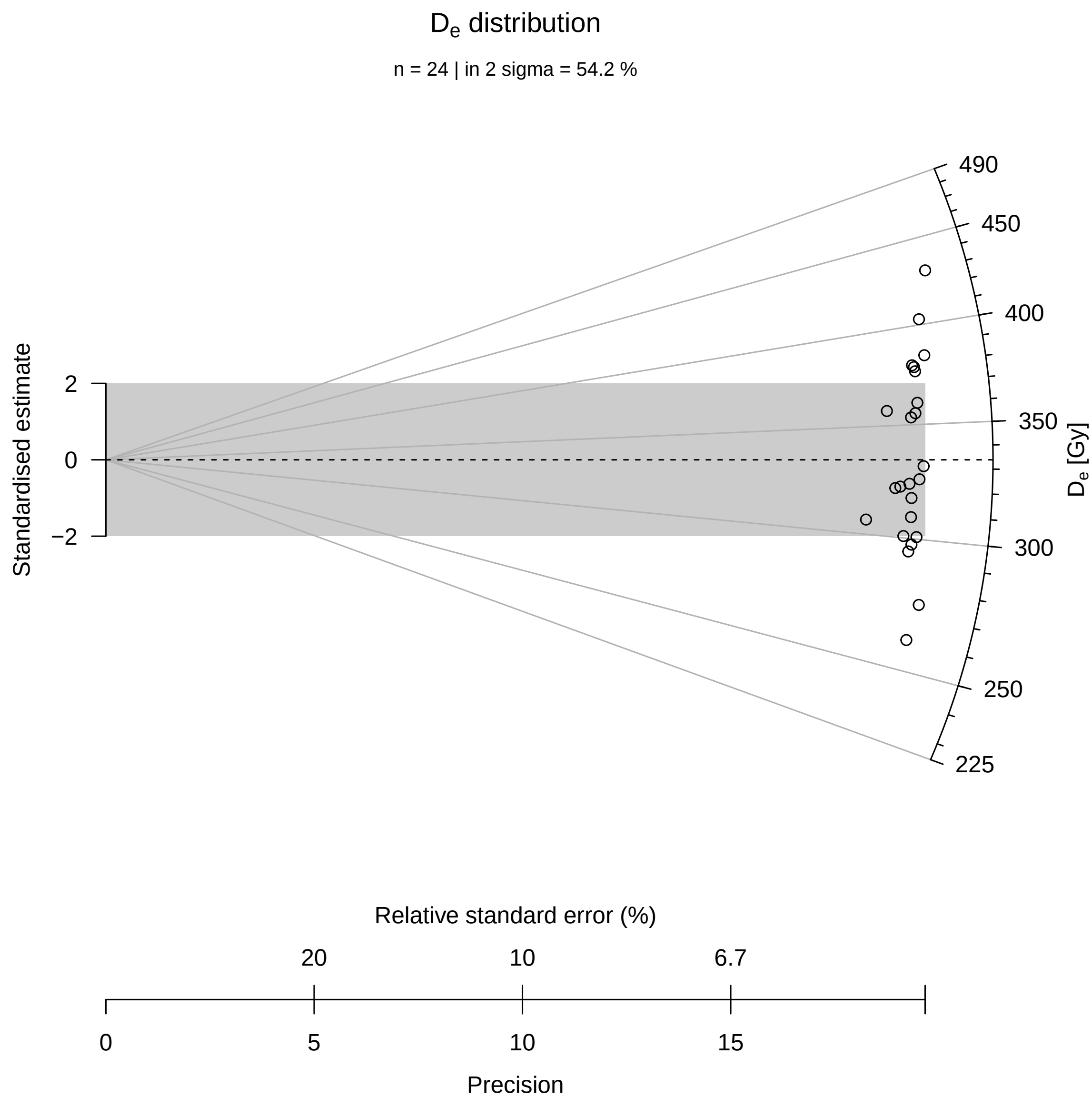
#	Criterium	Threshold
A	Recycling ratio (R5/R1)	0.1
B	Recuperation rate 1	0.1
C	Testdose error	0.1
D	Palaeodose error	0.1
E	De > max. dose point	612.0

#	A	B	C	D	E
1	1.017	-0.011	0.005	0.010	330.989
2	1.034	-0.124	0.012	0.022	306.393
3	1.030	-0.029	0.004	0.013	308.874
4	1.025	-0.045	0.006	0.014	323.134
5	1.023	-0.002	0.004	0.012	355.442
6	0.998	-0.035	0.005	0.015	300.780
7	1.038	-0.020	0.005	0.014	294.721
8	1.043	-0.026	0.005	0.012	300.851
9	1.008	-0.070	0.007	0.016	321.761
10	1.034	-0.006	0.004	0.009	429.543
11	1.001	-0.031	0.005	0.013	379.335
12	1.004	-0.040	0.005	0.013	316.995
13	1.028	-0.007	0.003	0.010	383.724
14	1.026	-0.028	0.006	0.013	297.618
15	1.048	-0.028	0.006	0.012	360.401
16	1.016	-0.055	0.009	0.019	357.359
17	1.044	-0.016	0.005	0.013	378.291
18	1.039	-0.034	0.006	0.011	274.773
19	1.057	-0.019	0.005	0.011	325.212
20	0.982	-0.037	0.007	0.017	321.035
21	1.016	-0.056	0.006	0.014	261.147
22	1.013	-0.035	0.006	0.013	353.545
23	1.020	-0.014	0.004	0.012	376.087
24	1.017	-0.013	0.004	0.011	403.066

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.



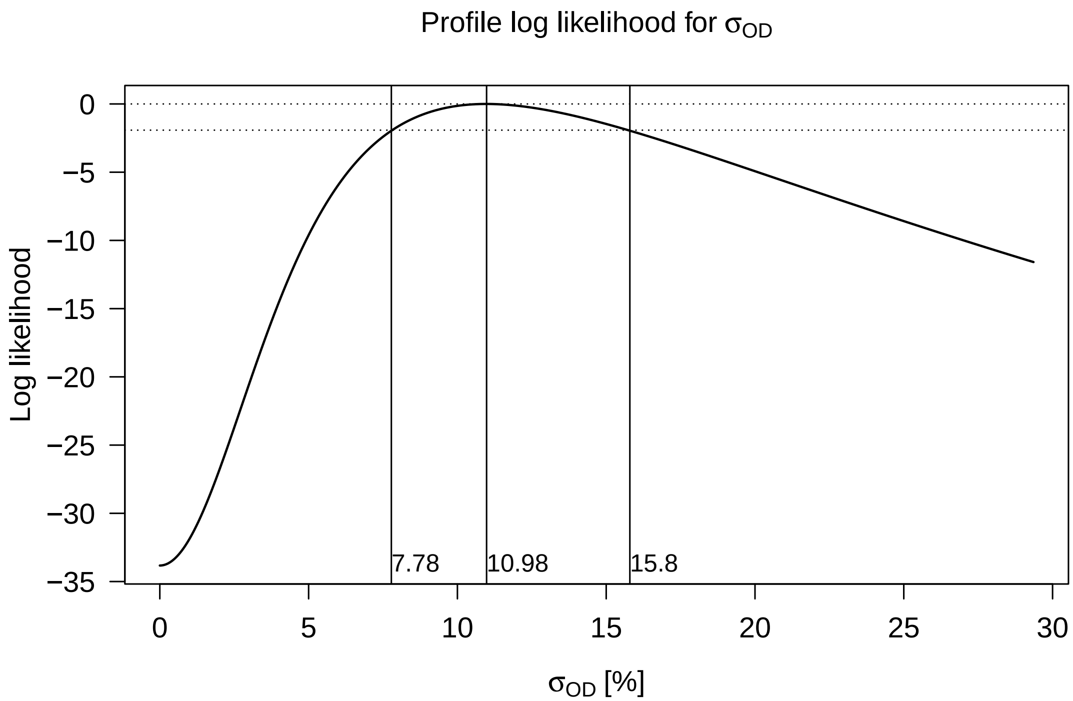


De distribution
n = 24 | in 2 sigma = 54.2 %
490
450
400
350
300
250
225
De [Gy]
Standardised estimate
2
0
−2
Relative standard error (%)
20
10
6.7
0
5
10
15
Precision

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:                         24
 log:                       TRUE
----------- dose estimate ------------
 abs. central dose:         333.49
 abs. SE:                   8.26
 rel. SE [%]:               2.48
----------- overdispersion -----------
 abs. OD:                   36.57
 abs. SE:                   6.46
 OD [%]:                    10.97
 SE [%]:                    1.94
-------------------------------------
```



SE = standard error, OD = over-dispersion

2.6 Scatter plot

Scatter plot