B19-LU 13 analysis with removal of the fading signal component

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1 Input

Analysed file: 3-Permafrost-1mm-63-90-Fsp_LU-13_24al.binx

Laboratory dose rate: 0.104 ± 0.0052 Gy/s

System ID: 306

User: tobias

Date of measurement: 260423

Date of analysis: 2024-01-26

Base name output files: 2024-01-26_B19-LU 13 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       384        IRSL
3               420, 0.5       384       IRSL2
2 420, 0.238095238095238       168       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: 0.8 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 384 IRSL records reduced from 110 s to 100 s
(time needed: 2.18 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: 0.27 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 384 IRSL2 records reduced from 210 s to 205 s
(time needed: 4.73 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 384 IRSL records
(time needed: 1.67 s)

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

Decay rates (s^-1):

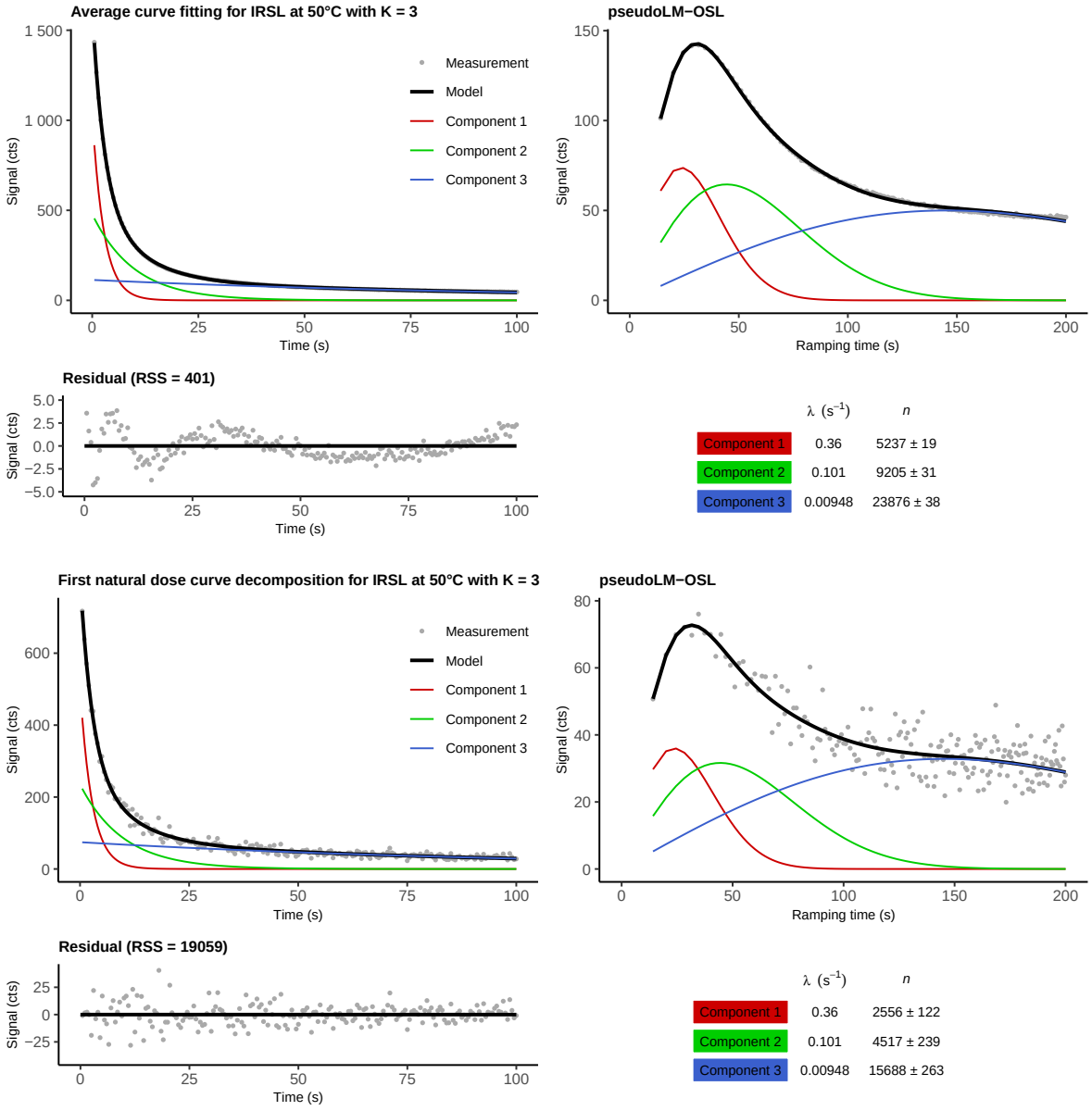
Cycle	Comp. 1	Comp. 2	Comp. 3	RSS	F-value
K = 1	0.125			8.883e+05	Inf
K = 2	0.2416	0.01836		2.174e+04	3905
K = 3	0.3595	0.1014	0.009482	394.3	5252

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	8.35e-19		
K = 2	1.61e-18	1.23e-19	
K = 3	2.4e-18	6.77e-19	6.33e-20

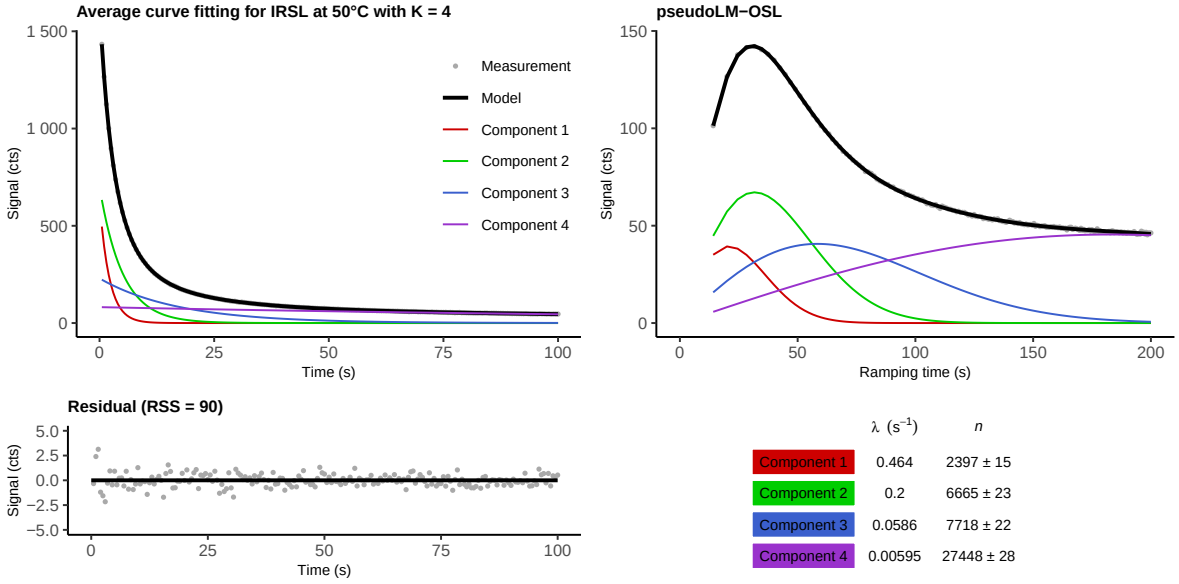
(time needed: 1.87 s)

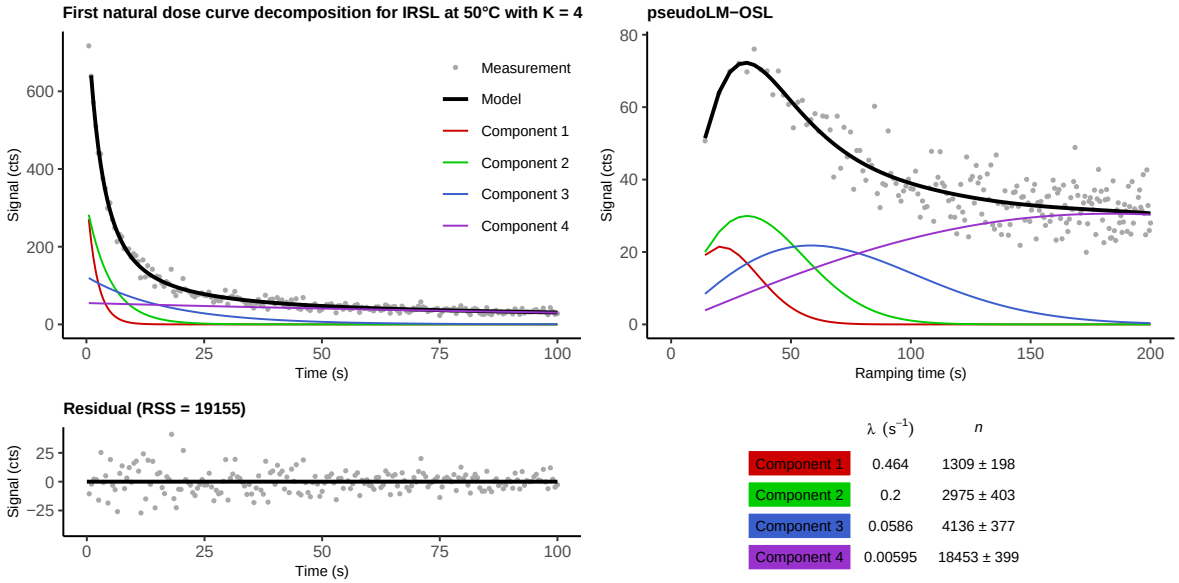


---------- Signal components for IRSL at 50°C with K = 4 ----------

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 384 IRSL records
(time needed: 2.07 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         0.125                                       8.883e+05         Inf
K = 2        0.2416     0.01836                           2.174e+04        3905
K = 3        0.3595      0.1014    0.009482                 394.3        5252
K = 4        0.4637      0.1996      0.0586     0.00595        86.9       339.6
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    8.35e-19
K = 2    1.61e-18             1.23e-19
K = 3    2.4e-18              6.77e-19             6.33e-20
K = 4    3.1e-18              1.33e-18             3.91e-19             3.97e-20
(time needed: 4.15 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 384 IRSL records
(time needed: 4.23 s)

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

Decay rates (s^-1):

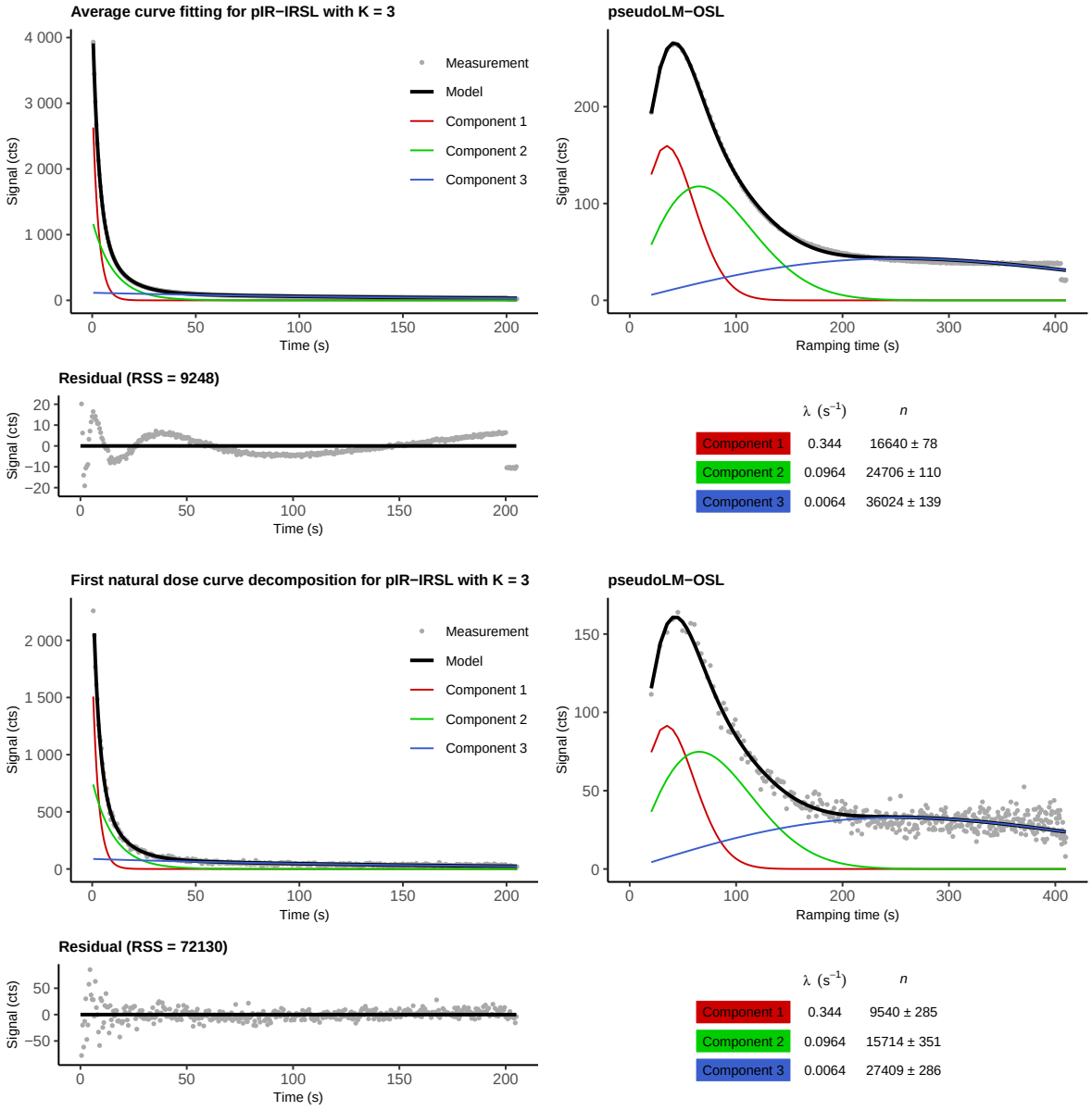
Cycle	Comp. 1	Comp. 2	Comp. 3	RSS	F-value
K = 1	0.1715			2.753e+06	Inf
K = 2	0.2303	0.01573		2.803e+05	1791
K = 3	0.3443	0.0964	0.006398	9101	6019

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	1.14e-18		
K = 2	1.54e-18	1.05e-19	
K = 3	2.3e-18	6.44e-19	4.27e-20

(time needed: 1.41 s)

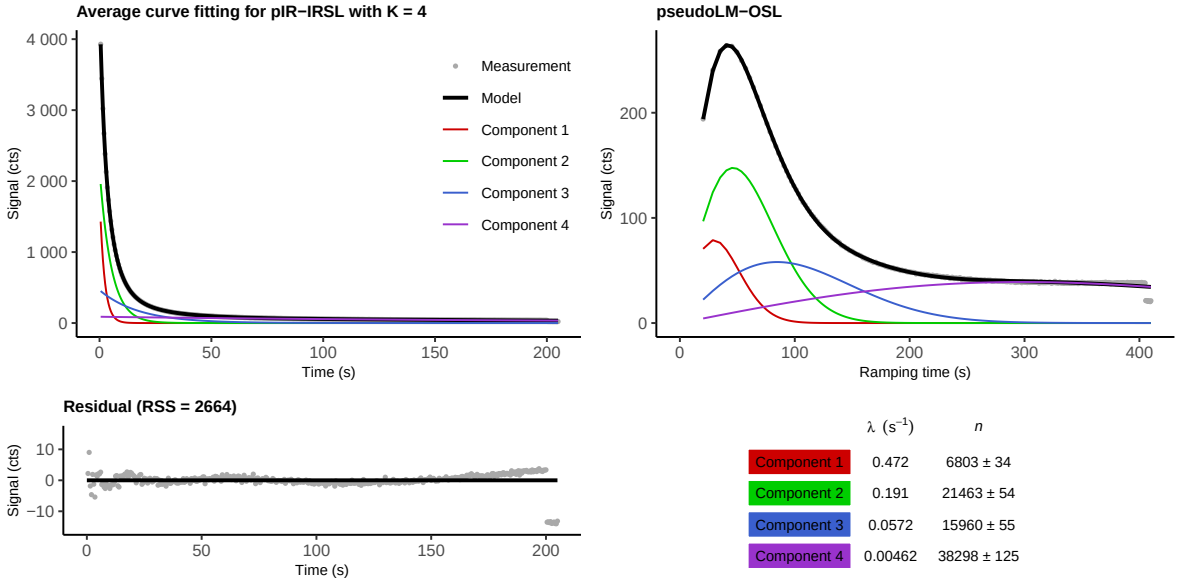


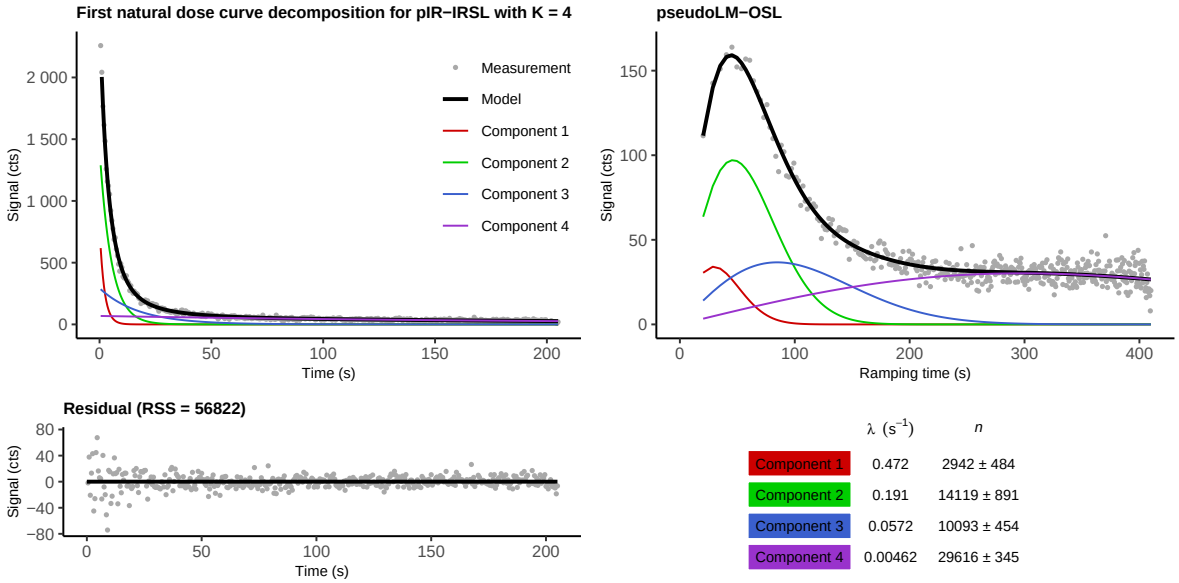
---------- Signal components for pIR-IRSL with K = 4 ------------

STEP 1.1 ----- Build global average curve from all CW-OSL curves -----

Built global average curve from arithmetic means from first 410 data points of all 384 IRSL records (time needed: 4.1 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        0.1715                                      2.753e+06         Inf
K = 2        0.2303     0.01573                          2.803e+05        1791
K = 3        0.3443      0.0964    0.006398                   9101        6019
K = 4        0.4717      0.1914     0.05724    0.004619        2629       494.7
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    1.14e-18
K = 2    1.54e-18             1.05e-19
K = 3    2.3e-18              6.44e-19             4.27e-20
K = 4    3.15e-18             1.28e-18             3.82e-19             3.08e-20
(time needed: 3.83 s)
```





	λ (s^{-1})	*n*
Component 1	0.472	2942 ± 484
Component 2	0.191	14119 ± 891
Component 3	0.0572	10093 ± 454
Component 4	0.00462	29616 ± 345

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
```

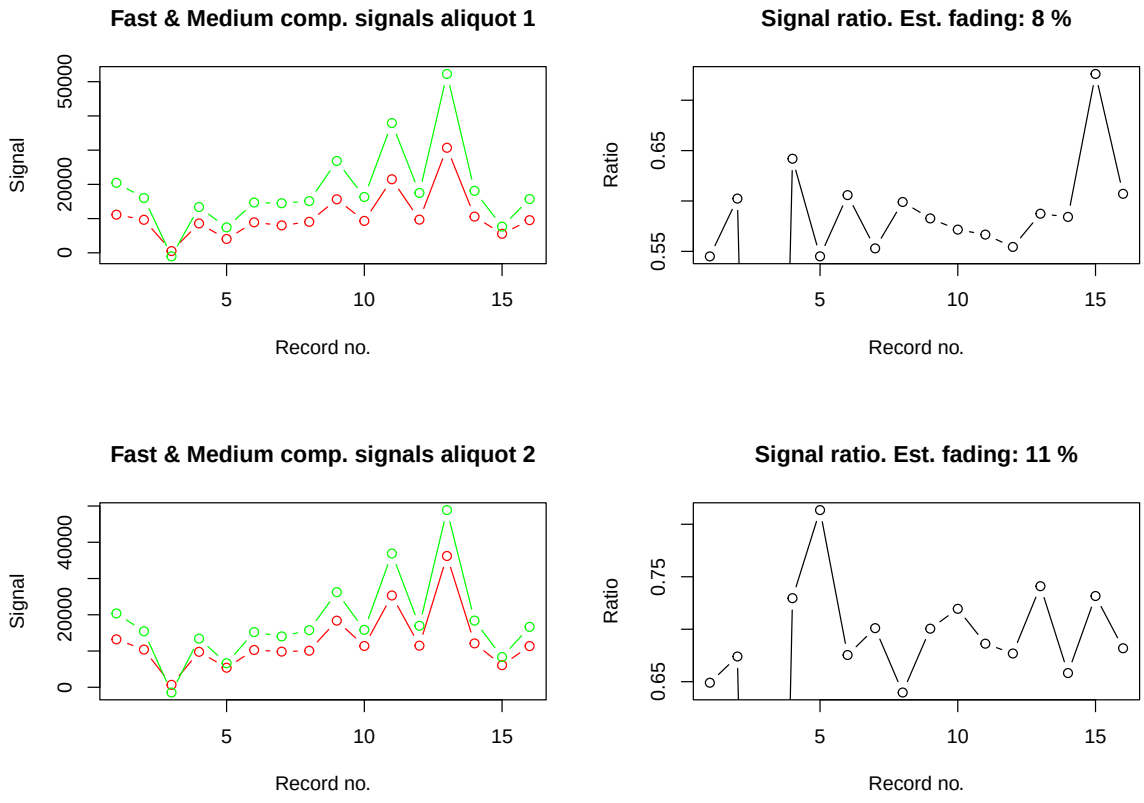
```
# default: suffix <- "pIRIR K3"
suffix <- "pIRIR K3"

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

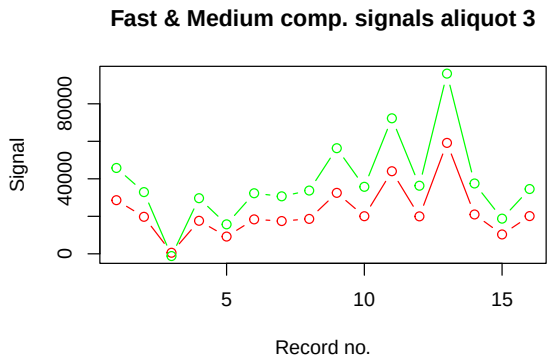
Table 1: Signal components of global curve

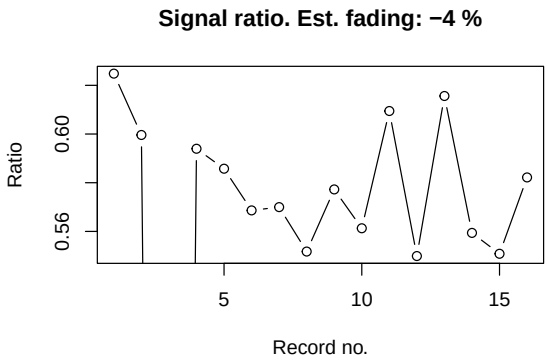
name	lambda	lambda.error	n	n.error	initial.signal
Component 1	0.3443	0.0024	16640	78	0.6732
Component 2	0.0964	0.0011	24706	110	0.2974
Component 3	0.0064	0.0001	36024	139	0.0294

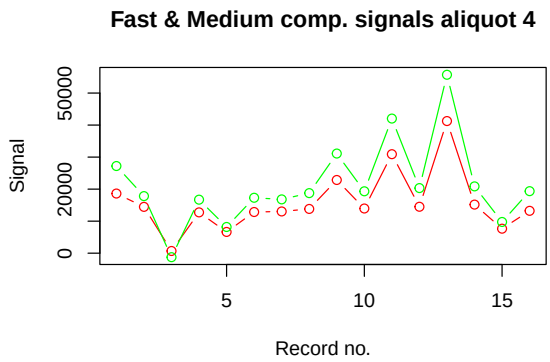
1.4 Fast component removal

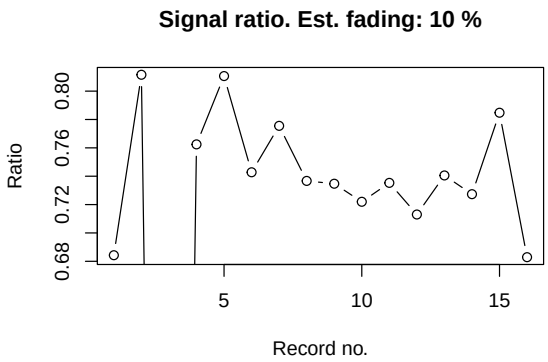
The fast component is now determined for each single curve by `decompose_OSLcurve()` and removed from the record.

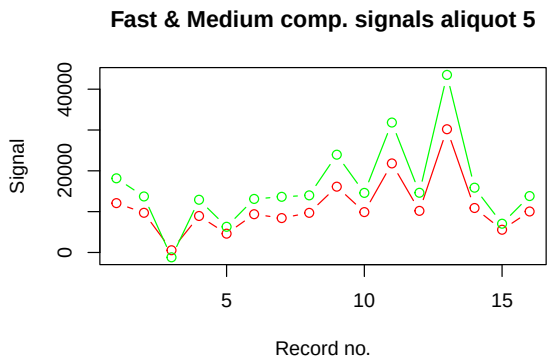


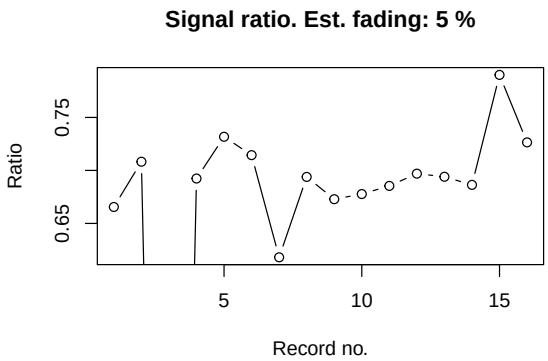

Fast & Medium comp. signals aliquot 3
Signal
0
40000
80000
5
10
15
Record no.

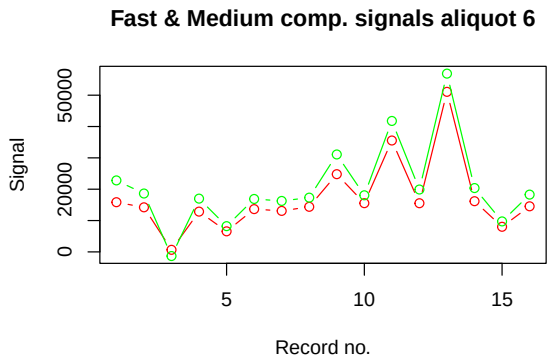

Signal ratio. Est. fading: −4 %
Ratio
0.56
0.60
5
10
15
Record no.

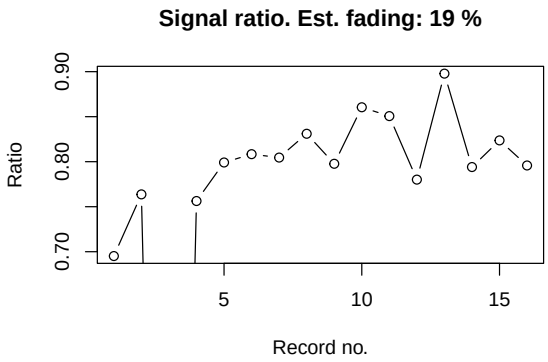

Fast & Medium comp. signals aliquot 4
Signal
0
20000
50000
5
10
15
Record no.

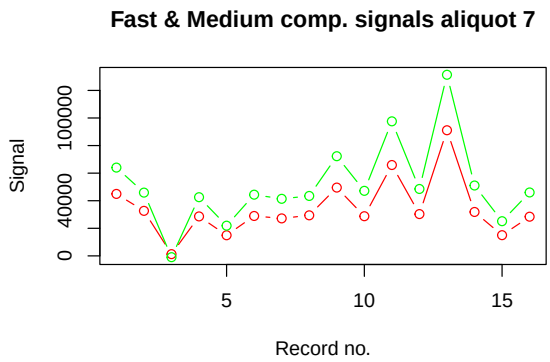

Signal ratio. Est. fading: 10 %
Ratio
0.68
0.72
0.76
0.80
5
10
15
Record no.

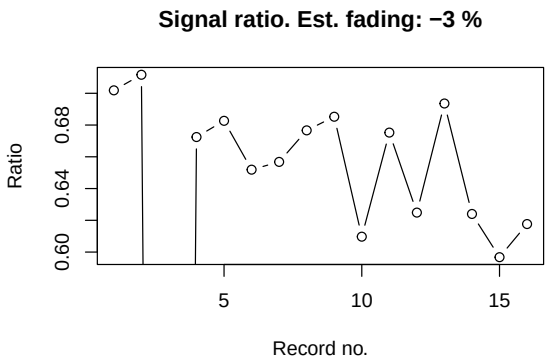

Fast & Medium comp. signals aliquot 5
Signal
0
20000
40000
5
10
15
Record no.

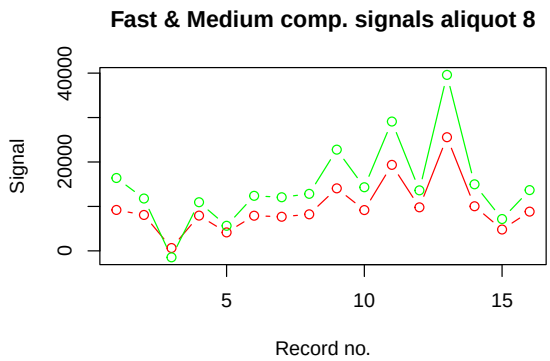

Signal ratio. Est. fading: 5 %
Ratio
0.65
0.75
5
10
15
Record no.

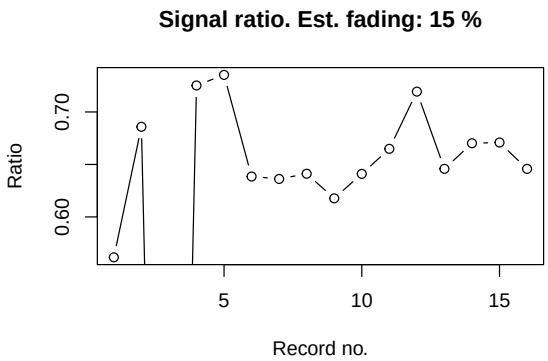

Fast & Medium comp. signals aliquot 6
Signal
0
20000
50000
5
10
15
Record no.

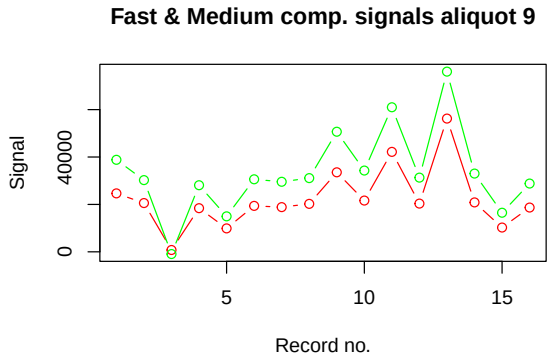

Signal ratio. Est. fading: 19 %
Ratio
0.70
0.80
0.90
5
10
15
Record no.

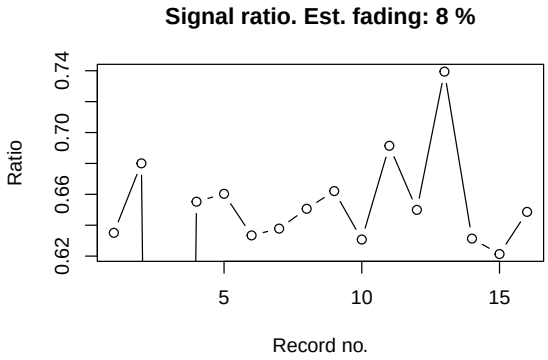

Fast & Medium comp. signals aliquot 7
Signal
0
40000
100000
5
10
15
Record no.

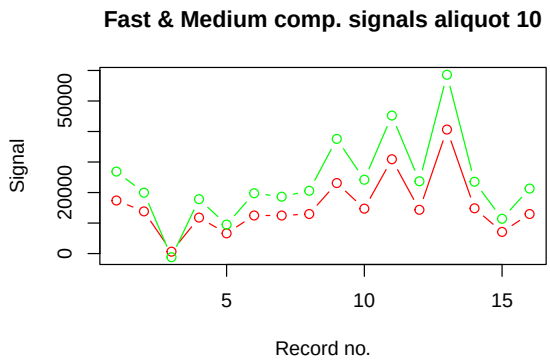

Signal ratio. Est. fading: −3 %
Ratio
0.60
0.64
0.68
5
10
15
Record no.

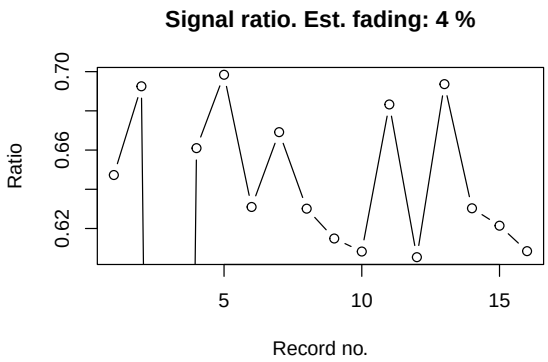

Fast & Medium comp. signals aliquot 8
Signal
0
20000
40000
5
10
15
Record no.

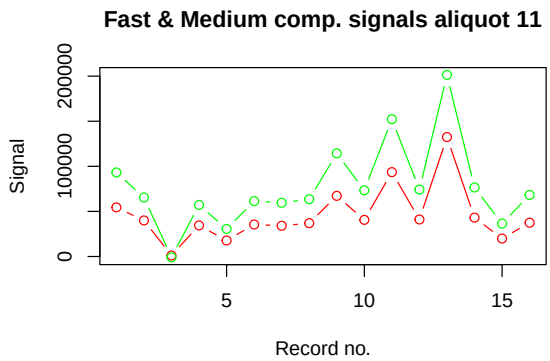

Signal ratio. Est. fading: 15 %
Ratio
0.60
0.70
5
10
15
Record no.

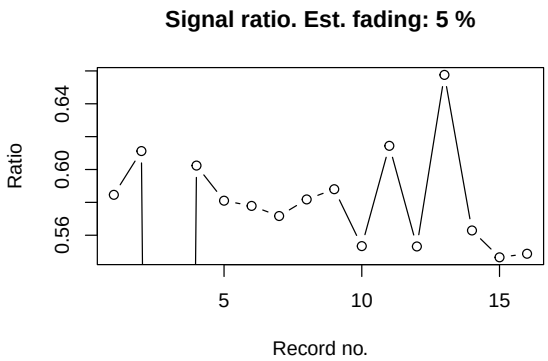

Fast & Medium comp. signals aliquot 9
Signal
0
40000
5
10
15
Record no.

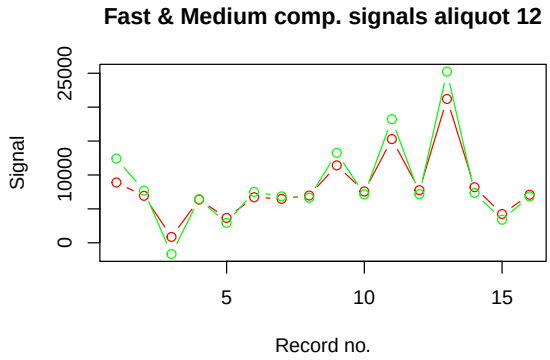

Signal ratio. Est. fading: 8 %
Ratio
0.62
0.66
0.70
0.74
5
10
15
Record no.

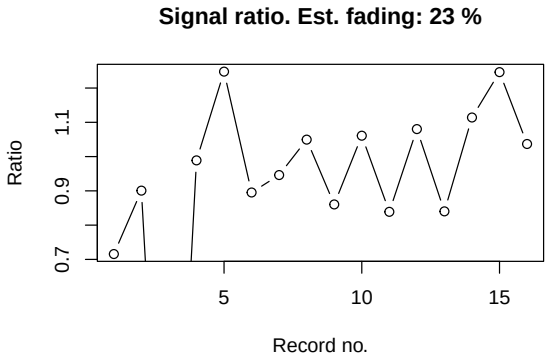

Fast & Medium comp. signals aliquot 10
Signal
0
20000
50000
5
10
15
Record no.

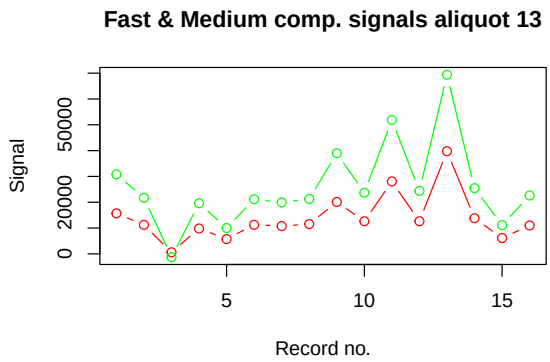

Signal ratio. Est. fading: 4 %
Ratio
0.62
0.66
0.70
5
10
15
Record no.

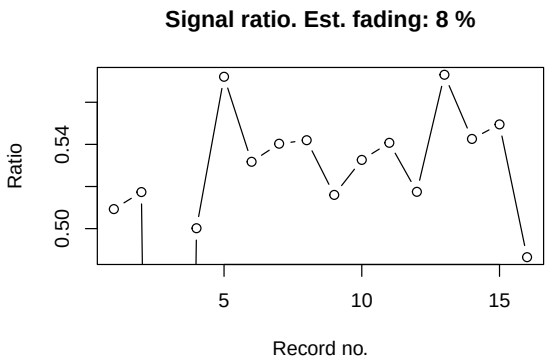

Fast & Medium comp. signals aliquot 11
Signal
0
100000
200000
5
10
15
Record no.

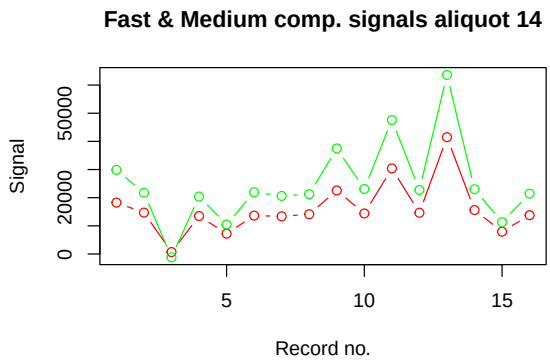

Signal ratio. Est. fading: 5 %
Ratio
0.56
0.60
0.64
5
10
15
Record no.

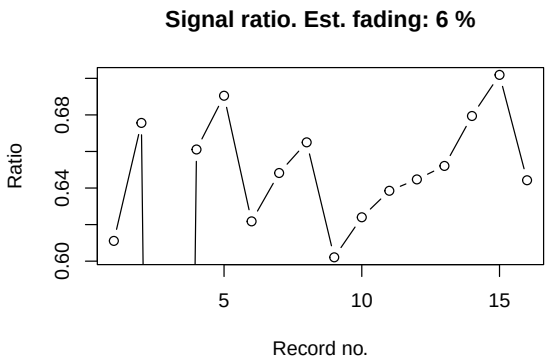

Fast & Medium comp. signals aliquot 12
Signal
0
10000
25000
5
10
15
Record no.

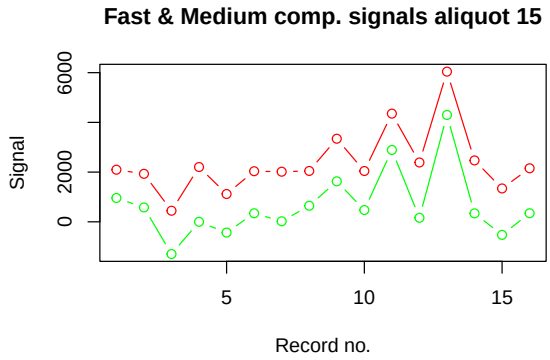

Signal ratio. Est. fading: 23 %
Ratio
0.7
0.9
1.1
5
10
15
Record no.

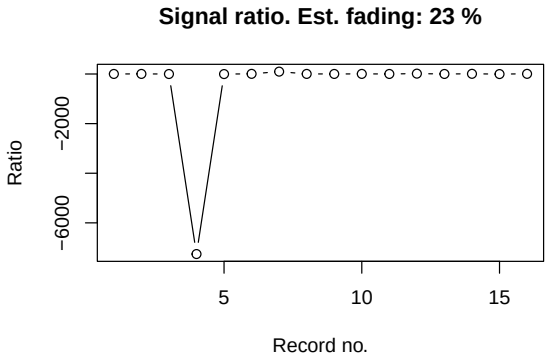

Fast & Medium comp. signals aliquot 13
Signal
0
20000
50000
5
10
15
Record no.

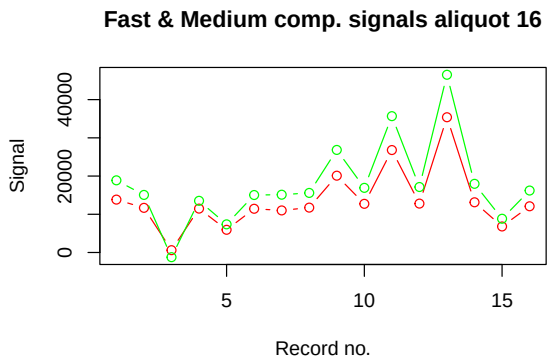

Signal ratio. Est. fading: 8 %
Ratio
0.50
0.54
5
10
15
Record no.

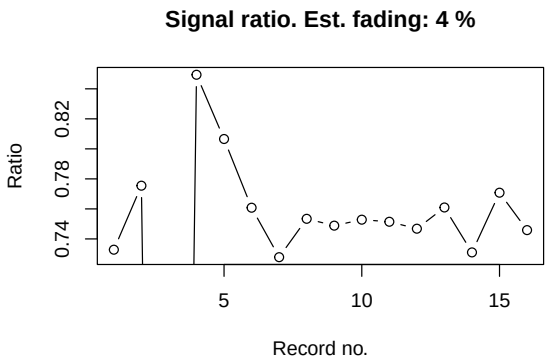

Fast & Medium comp. signals aliquot 14
Signal
0
20000
50000
5
10
15
Record no.

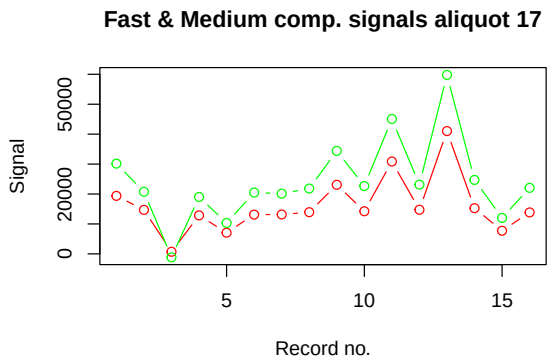

Signal ratio. Est. fading: 6 %
Ratio
0.60
0.64
0.68
5
10
15
Record no.

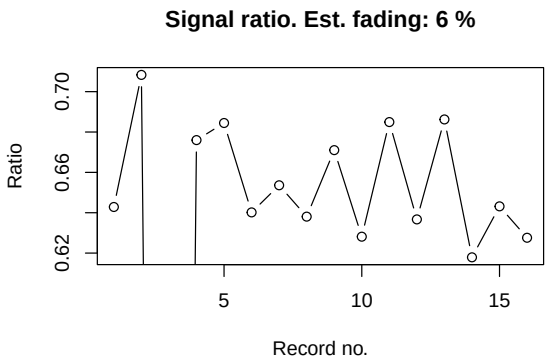

Fast & Medium comp. signals aliquot 15
Signal
0
2000
6000
5
10
15
Record no.

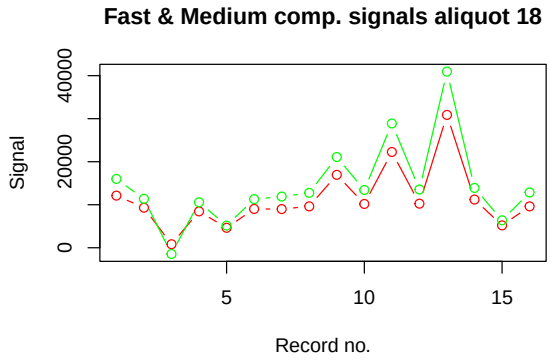

Signal ratio. Est. fading: 23 %
Ratio
−6000
−2000
5
10
15
Record no.

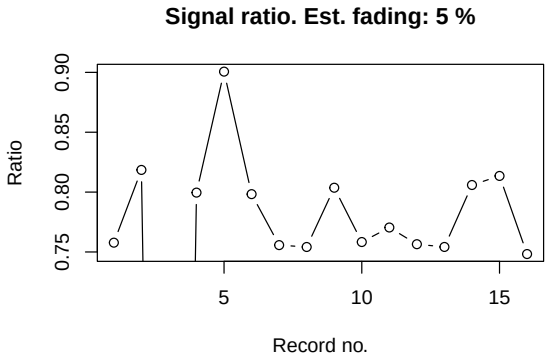

Fast & Medium comp. signals aliquot 16
Signal
0
20000
40000
5
10
15
Record no.

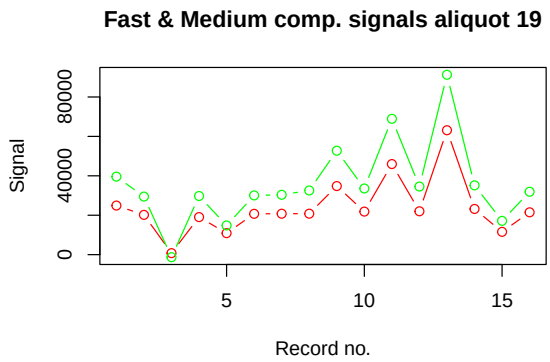

Signal ratio. Est. fading: 4 %
Ratio
0.74
0.78
0.82
5
10
15
Record no.

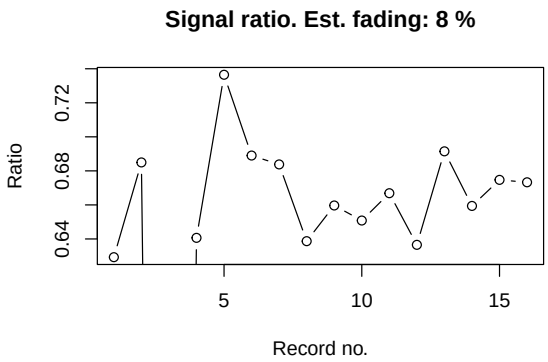

Fast & Medium comp. signals aliquot 17
Signal
0
20000
50000
5
10
15
Record no.

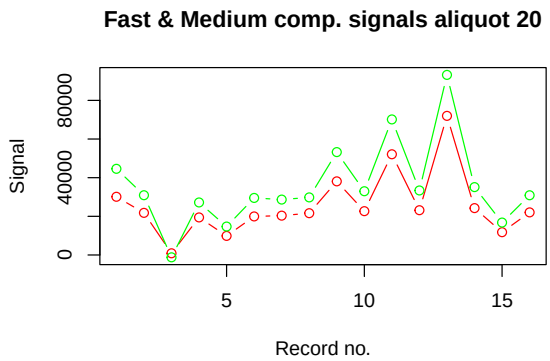

Signal ratio. Est. fading: 6 %
Ratio
0.62
0.66
0.70
5
10
15
Record no.

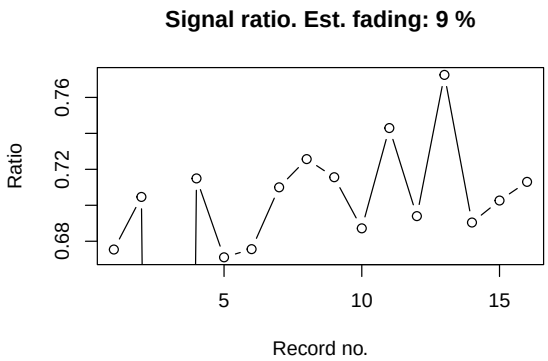

Fast & Medium comp. signals aliquot 18
Signal
0
20000
40000
5
10
15
Record no.

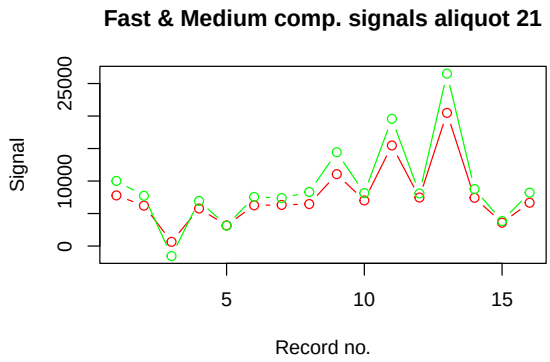

Signal ratio. Est. fading: 5 %
Ratio
0.75
0.80
0.85
0.90
5
10
15
Record no.

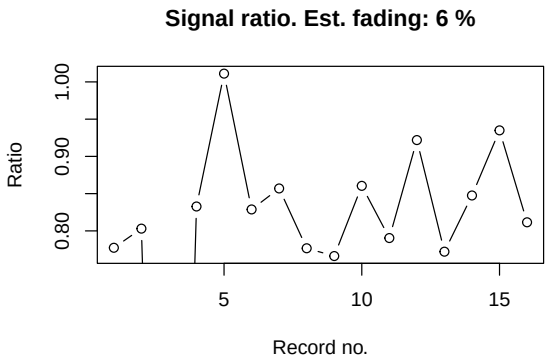

Fast & Medium comp. signals aliquot 19
Signal
0
40000
80000
5
10
15
Record no.

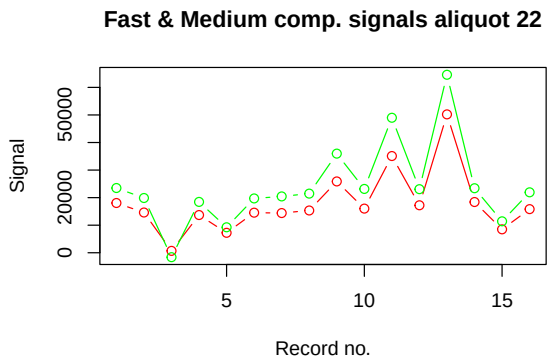

Signal ratio. Est. fading: 8 %
Ratio
0.64
0.68
0.72
5
10
15
Record no.

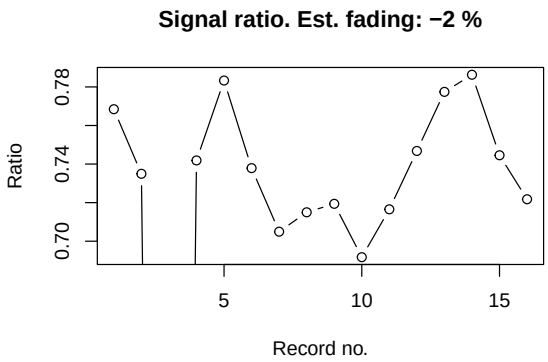

Fast & Medium comp. signals aliquot 20
Signal
0
40000
80000
5
10
15
Record no.

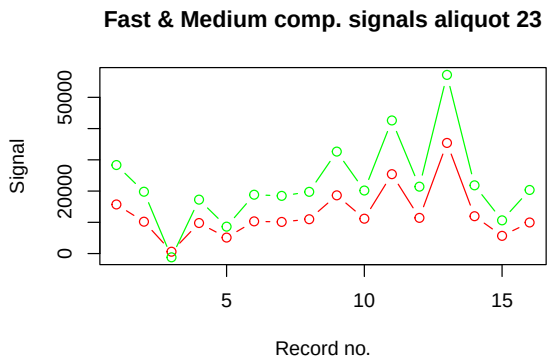

Signal ratio. Est. fading: 9 %
Ratio
0.68
0.72
0.76
5
10
15
Record no.

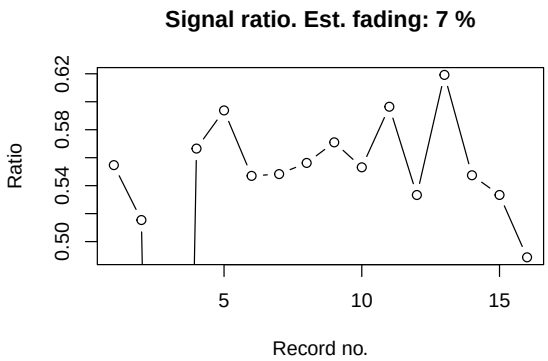

Fast & Medium comp. signals aliquot 21
Signal
0
10000
25000
5
10
15
Record no.

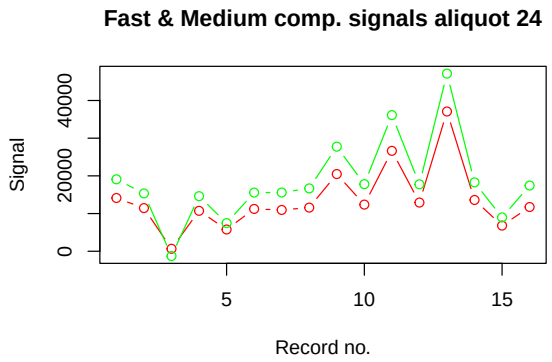

Signal ratio. Est. fading: 6 %
Ratio
0.80
0.90
1.00
5
10
15
Record no.

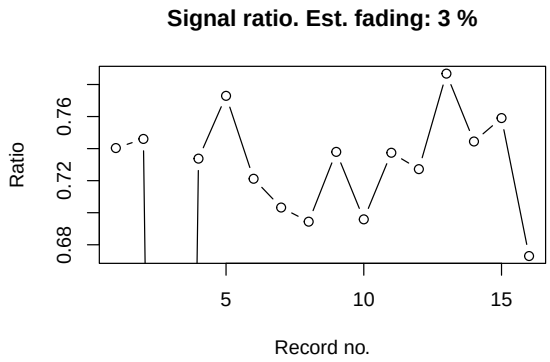

Fast & Medium comp. signals aliquot 22
Signal
0
20000
50000
5
10
15
Record no.


Signal ratio. Est. fading: −2 %
Ratio
0.70
0.74
0.78
5
10
15
Record no.


Fast & Medium comp. signals aliquot 23
Signal
0
20000
50000
5
10
15
Record no.


Signal ratio. Est. fading: 7 %
Ratio
0.50
0.54
0.58
0.62
5
10
15
Record no.

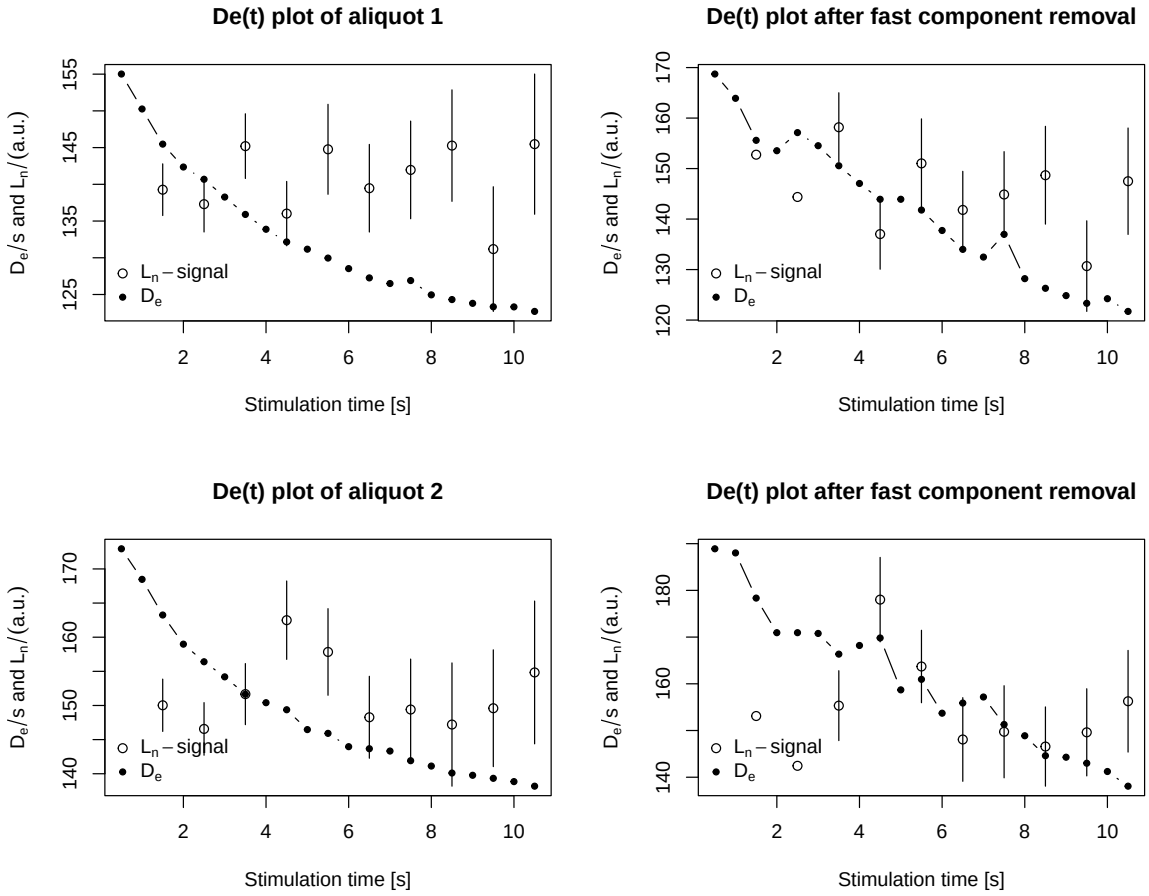

Fast & Medium comp. signals aliquot 24
Signal
0
20000
40000
5
10
15
Record no.

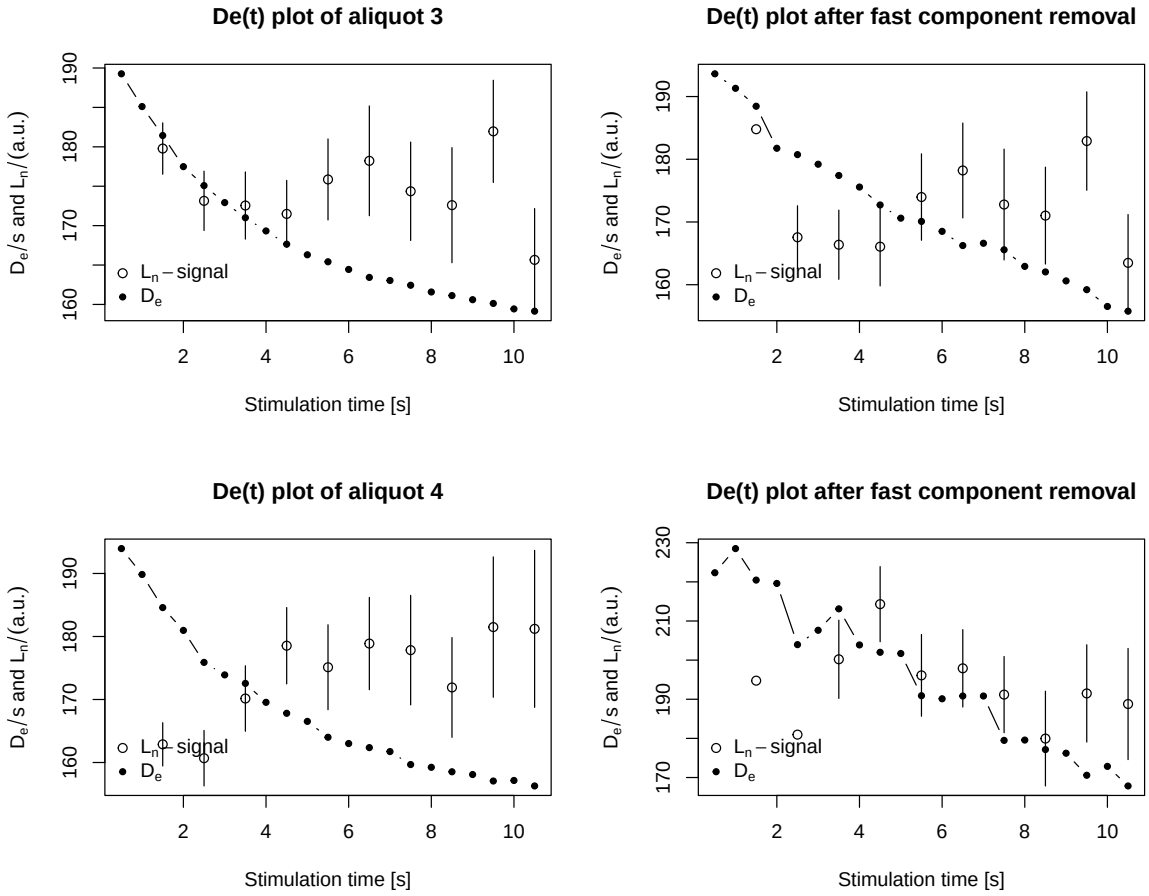

Signal ratio. Est. fading: 3 %
Ratio
0.68
0.72
0.76
5
10
15
Record no.

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:



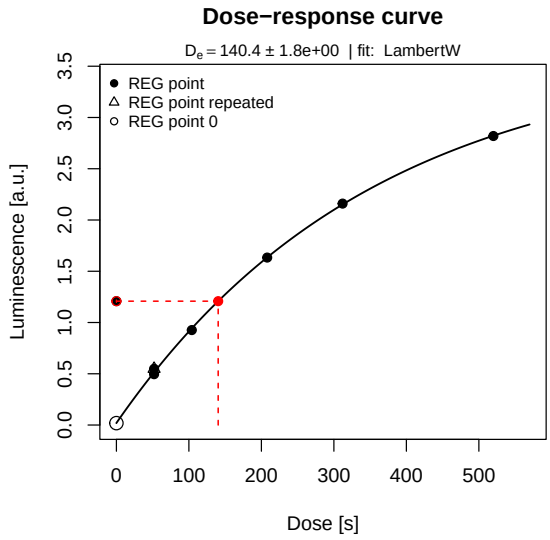


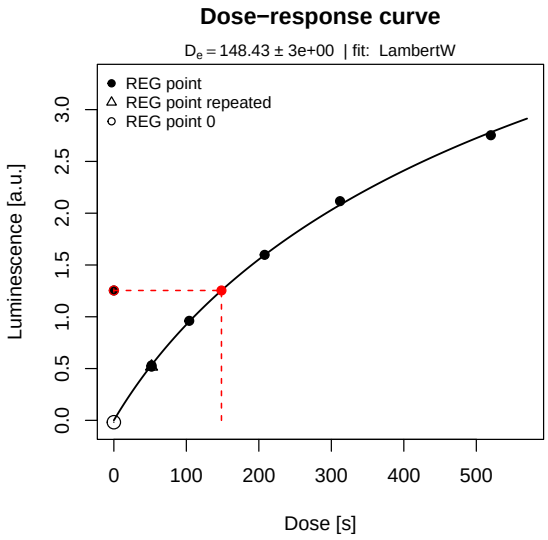
Like for other B19-LU samples the IRSL at 50°C measured equivalent doses are lower than the pIR-IRSL measured, which is a indication of thermal fading of the luminescence signal in the samples and thus also a indication of De underestimation in the IRSL at 50°C signals (Thomsen et al. 2008).

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).

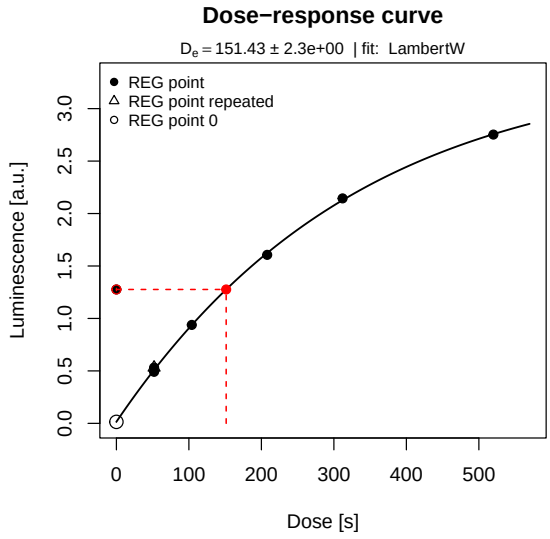
```
--- Dose response curve for aliquot 1 ---
Left: Uncorrected Dose response curve, Right: After fast component removal.
```

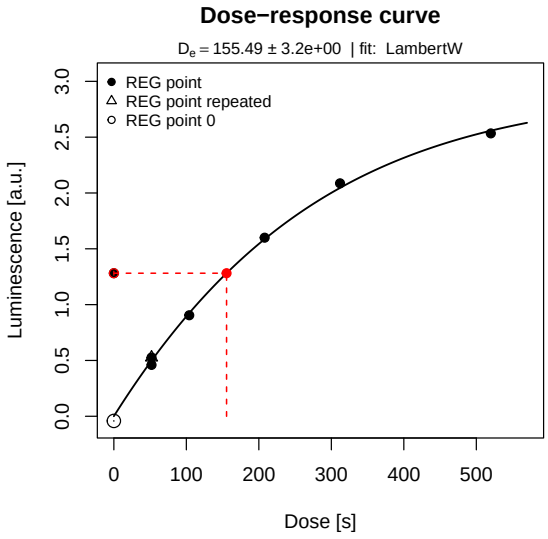




--- Dose response curve for aliquot 2 ---

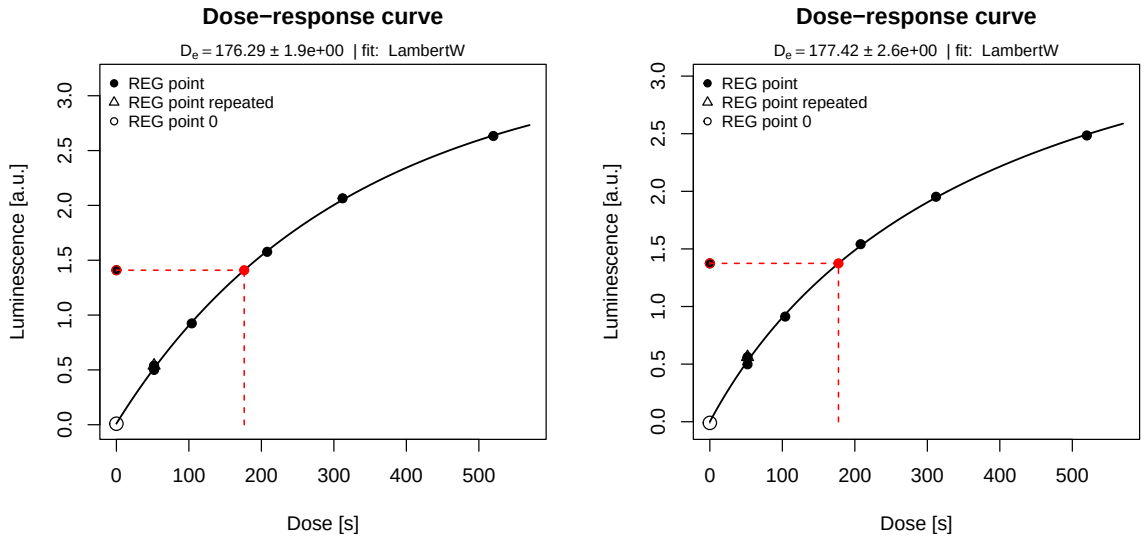
Left: Uncorrected Dose response curve, Right: After fast component removal.





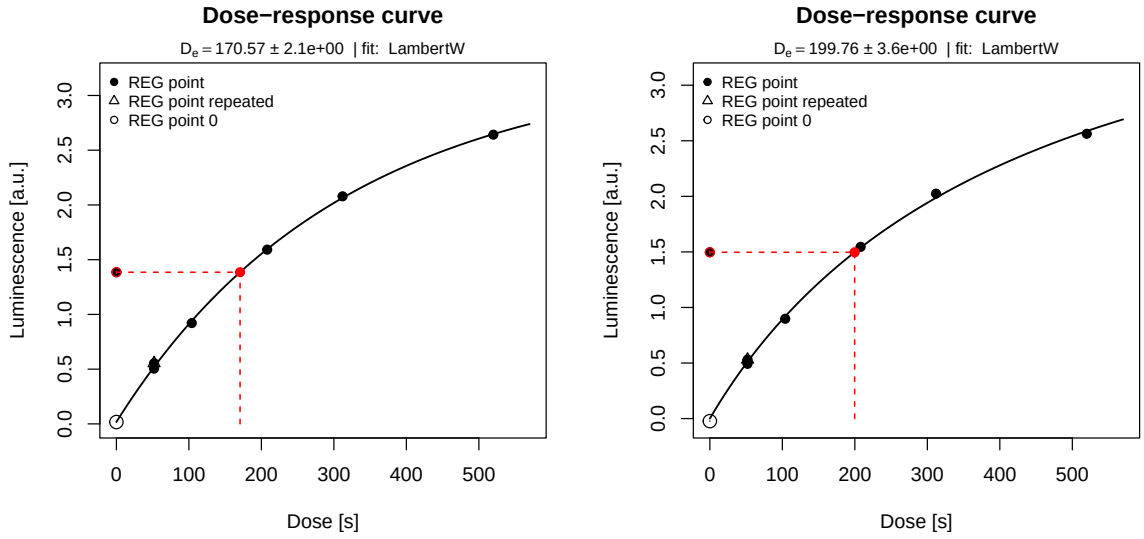
--- Dose response curve for aliquot 3 ---

Left: Uncorrected Dose response curve, Right: After fast component removal.



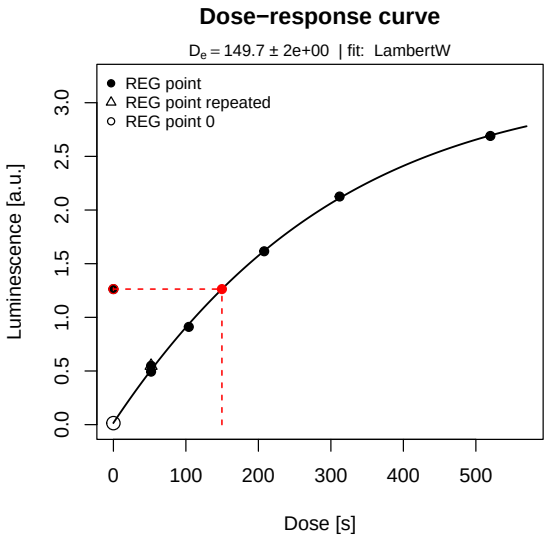
--- Dose response curve for aliquot 4 ---

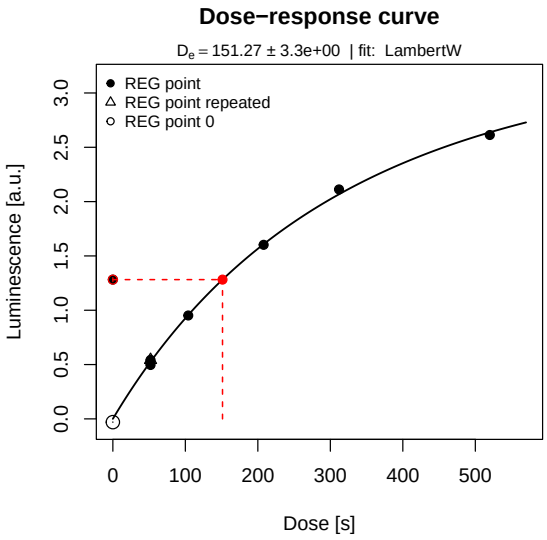
Left: Uncorrected Dose response curve, Right: After fast component removal.



--- Dose response curve for aliquot 5 ---

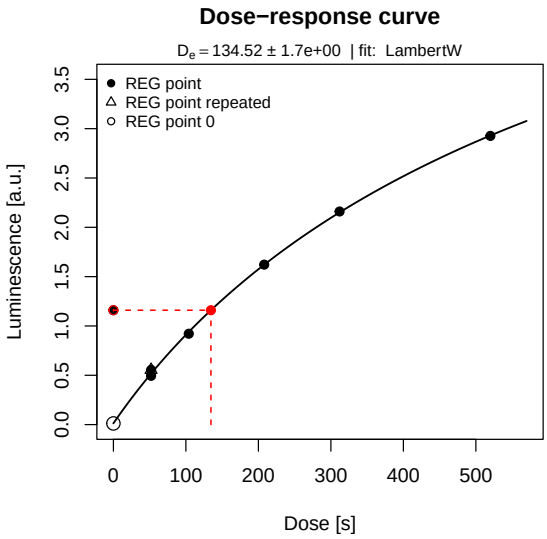
Left: Uncorrected Dose response curve, Right: After fast component removal.

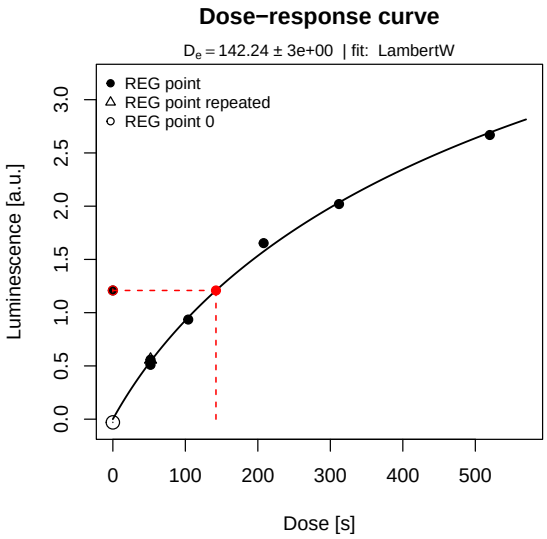




--- Dose response curve for aliquot 6 ---

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	148.43	8.10	OK
2	155.49	8.36	FAILED
3	177.42	9.26	FAILED
4	199.76	10.60	OK
5	151.27	8.50	OK
6	142.24	7.59	OK
7	177.85	9.37	FAILED
8	168.59	9.27	FAILED
9	161.14	8.63	FAILED
10	175.08	9.49	OK
11	180.77	9.31	OK
12	175.62	9.69	FAILED
13	174.23	9.11	OK
14	162.32	8.54	OK
15	150.80	13.20	FAILED
16	147.09	8.07	OK
17	196.52	10.75	OK
18	176.18	9.75	OK
19	169.72	8.93	OK
20	178.04	9.38	OK
21	149.41	8.33	OK
22	141.01	7.63	FAILED
23	178.19	9.42	FAILED
24	153.82	8.30	OK

15 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

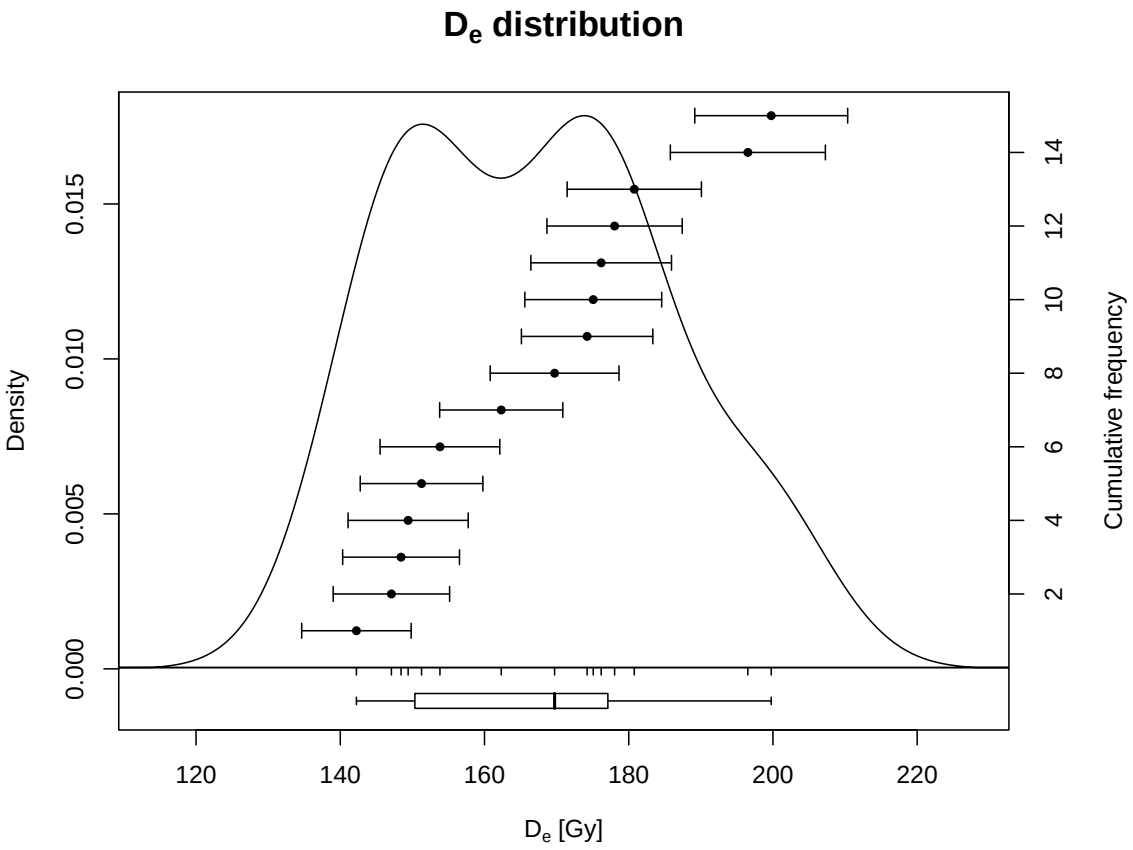
Table 3: Rejection criteria thresholds (left) and results (right)

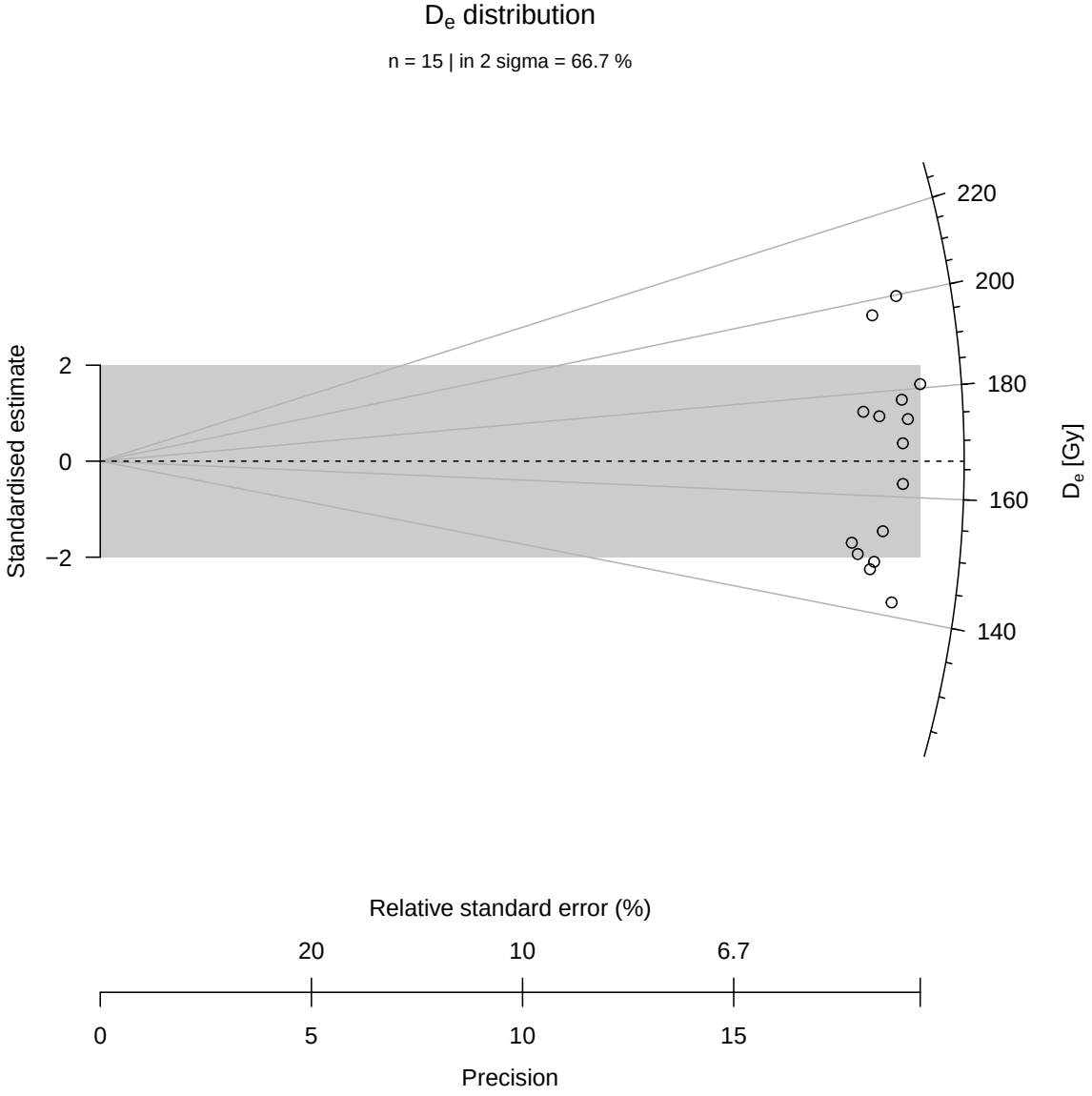
#	Criterium	Threshold
A	Recycling ratio (R6/R1)	0.1
B	Recuperation rate 1	0.1
C	Testdose error	0.1
D	Palaeodose error	0.1
E	De > max. dose point	520.0

#	A	B	C	D	E
1	0.977	-0.014	0.011	0.022	148.431
2	1.144	-0.033	0.010	0.020	155.487
3	1.126	-0.007	0.007	0.015	177.418
4	1.077	-0.015	0.010	0.018	199.758
5	1.092	-0.024	0.011	0.026	151.273
6	1.095	-0.025	0.010	0.019	142.240
7	1.130	0.001	0.007	0.017	177.850
8	1.151	-0.036	0.012	0.023	168.588
9	1.158	-0.002	0.008	0.019	161.138
10	1.094	-0.016	0.009	0.021	175.078
11	1.089	0.000	0.006	0.012	180.768
12	1.255	-0.063	0.014	0.023	175.621
13	1.044	-0.015	0.009	0.015	174.225
14	1.089	-0.011	0.010	0.016	162.320
15	0.695	-0.509	0.046	0.072	150.803
16	1.091	-0.024	0.011	0.023	147.086
17	1.075	-0.013	0.011	0.022	196.524
18	1.046	-0.040	0.013	0.024	176.181
19	1.088	-0.010	0.008	0.016	169.724
20	1.094	-0.008	0.008	0.017	178.037
21	1.079	-0.076	0.014	0.025	149.410
22	1.108	-0.030	0.010	0.021	141.014
23	1.130	-0.018	0.009	0.017	178.186
24	1.031	-0.025	0.011	0.020	153.816

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.

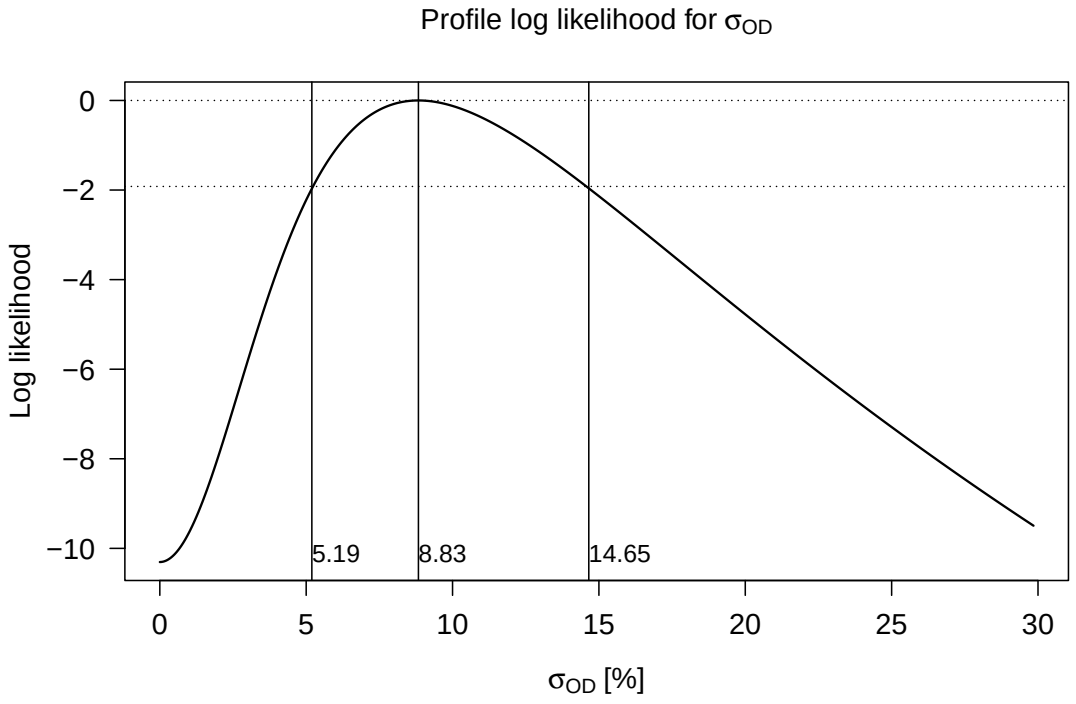



De distribution
n = 15 | in 2 sigma = 66.7 %
Standardised estimate
2
0
−2
220
200
180
160
140
De [Gy]
Relative standard error (%)
20
10
6.7
0
5
10
15
Precision

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:                       15
 log:                     TRUE
----------- dose estimate ------------
 abs. central dose:       166.18
 abs. SE:                 4.44
 rel. SE [%]:             2.67
----------- overdispersion -----------
 abs. OD:                 14.68
 abs. SE:                 3.68
 OD [%]:                  8.83
 SE [%]:                  2.21
-------------------------------------
```



SE = standard error, OD = over-dispersion

2.6 Scatter plot

Scatter plot