B19-LU 14 analysis with removal of the fading signal component

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1 Input

Analysed file: 3-Permafrost-1mm-63-90-Fsp_LU-14_24al.binx

Laboratory dose rate: 0.1039 ± 0.0052 Gy/s

System ID: 306

User: tobias

Date of measurement: 080523

Date of analysis: 2024-01-26

Base name output files: 2024-01-26_B19-LU 14 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.

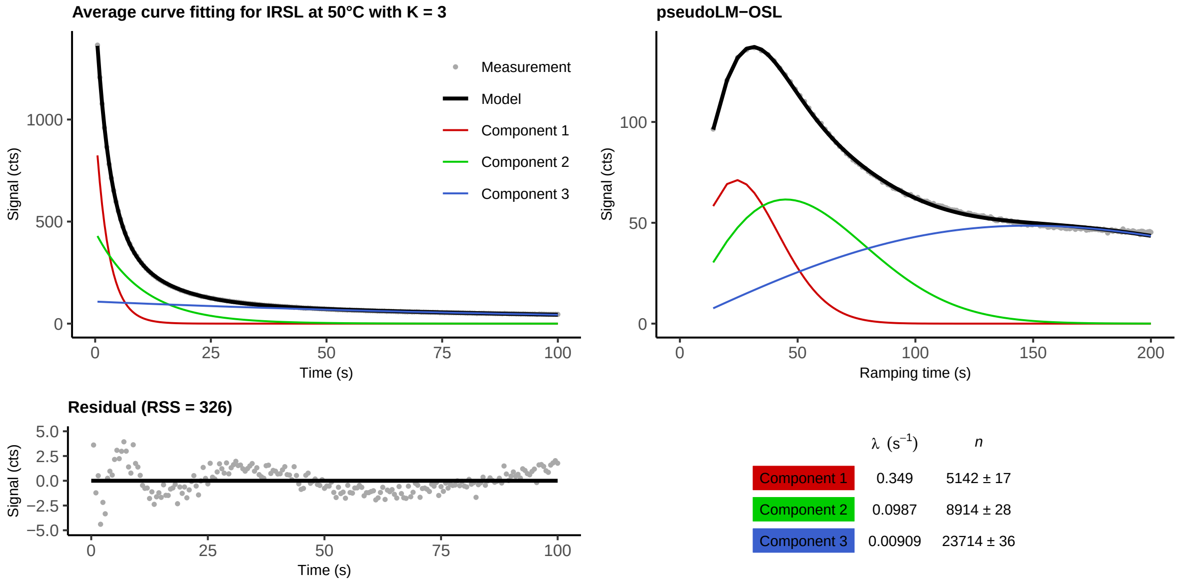
```
CORRECTION STEP 1 ----- Check records for consistency in the detection settings -----
Frequency table of different sets of detection settings (Channels, Channel width):
                settings frequency record_type
1               220, 0.5       384        IRSL
3               420, 0.5       384       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: 0.75 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: 2.16 s)
```

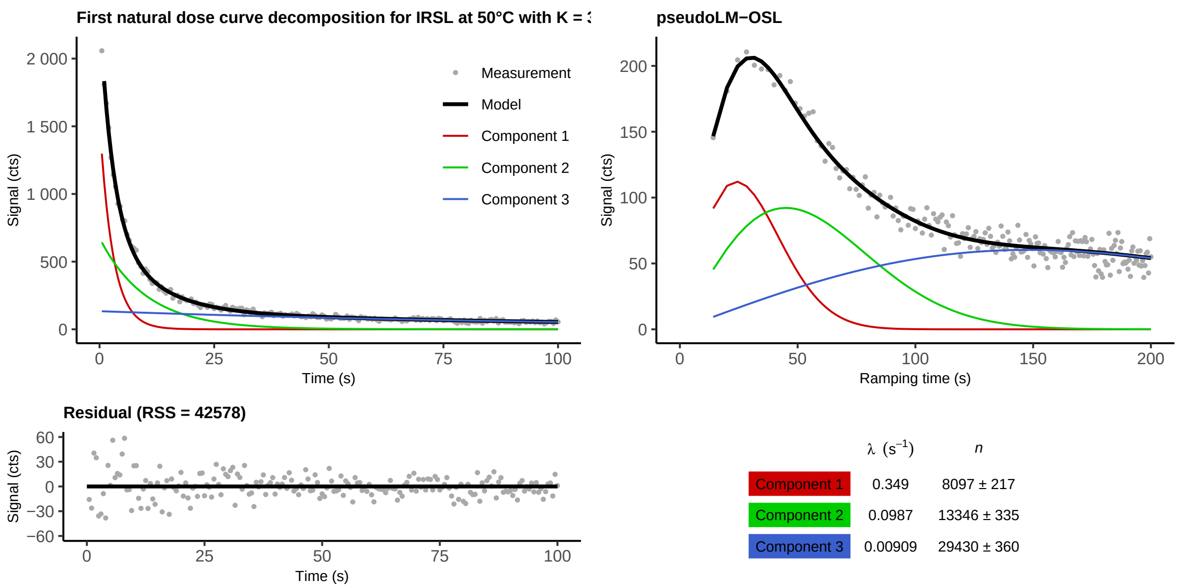
We perform the code again but only for IRSL2 records to clean also 290°C IRSL records.

```
CORRECTION STEP 1 ----- Check records for consistency in the detection settings -----
All IRSL2 records have the same detection settings
(time needed: 0.29 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: 4.69 s)
```

1.2 Global curve fitting

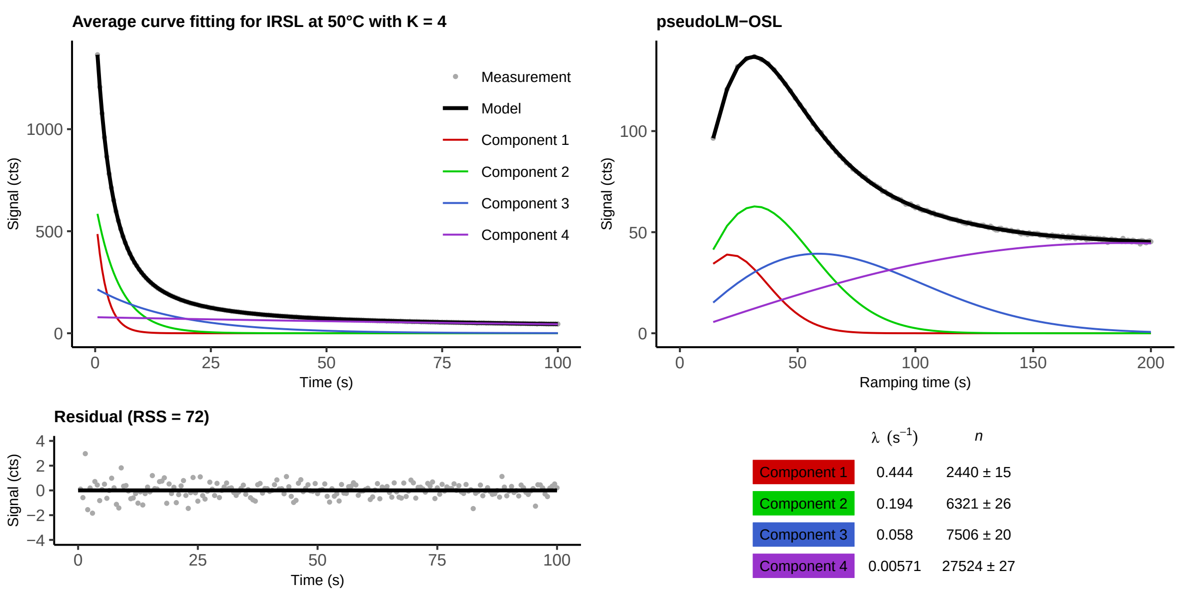
```
----------- Signal components for IRSL at 50°C with K = 3  ------------

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: 1.61 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        0.1217                           8.259e+05         Inf
K = 2        0.2363     0.01792               1.945e+04        4062
K = 3        0.3494      0.0987    0.009087         318        5836
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    8.13e-19
K = 2    1.58e-18             1.2e-19
K = 3    2.33e-18             6.59e-19             6.07e-20
(time needed: 1.82 s)
```

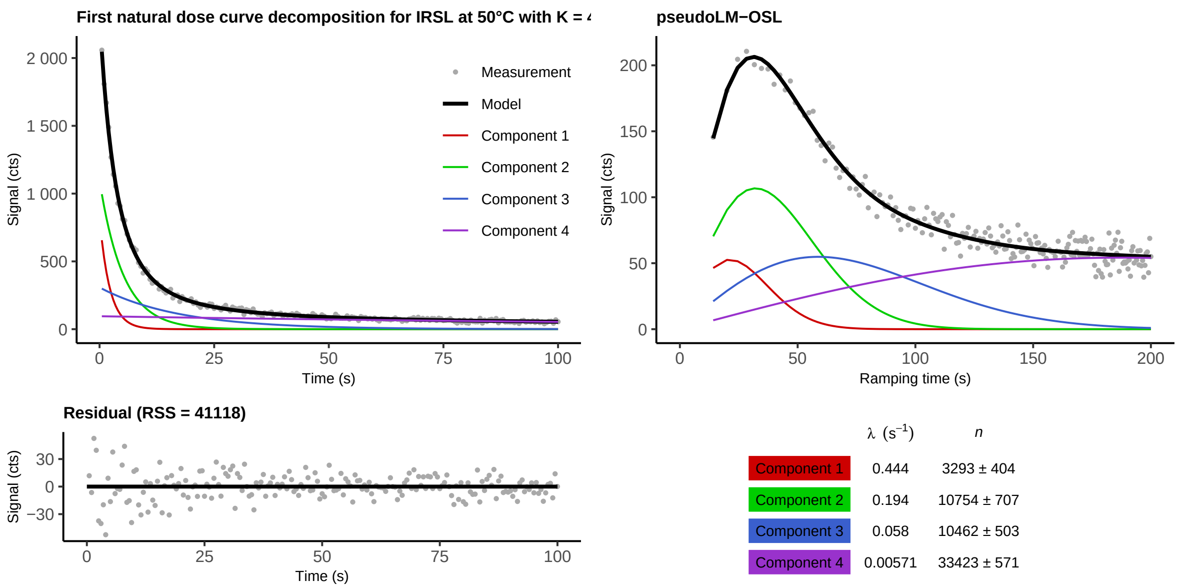




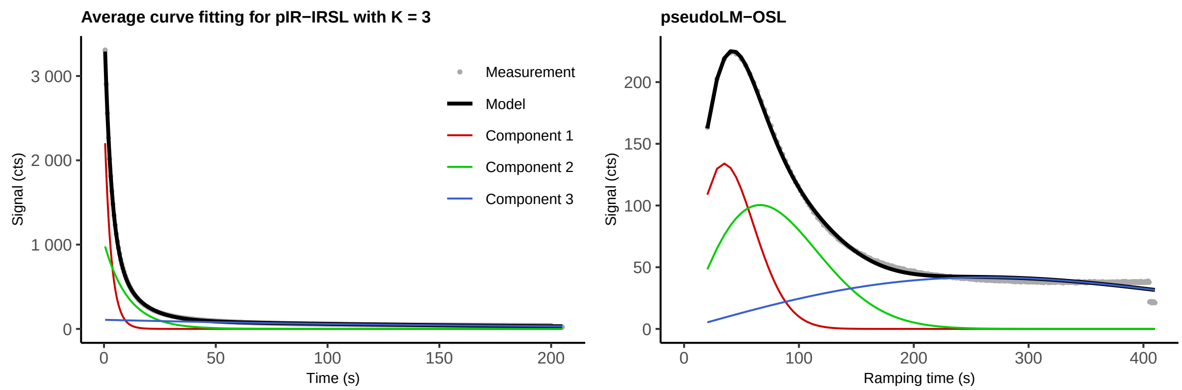

```
----------- Signal components for IRSL at 50°C with K = 4  ------------

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: 1.71 s)
```

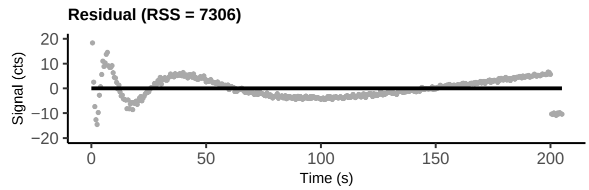
```
STEP 1.2 ----- Perform multi-exponential curve fitting -----

Decay rates (s^-1):
Cycle       Comp. 1     Comp. 2     Comp. 3     Comp. 4          RSS      F-value
K = 1        0.1217                                        8.259e+05          Inf
K = 2        0.2363     0.01792                            1.945e+04         4062
K = 3        0.3494      0.0987    0.009087                      318         5836
K = 4        0.4444      0.1943     0.05804    0.005706        71.57        330.6
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    8.13e-19
K = 2    1.58e-18               1.2e-19
K = 3    2.33e-18               6.59e-19              6.07e-20
K = 4    2.97e-18               1.3e-18               3.88e-19              3.81e-20
(time needed: 3.23 s)
```



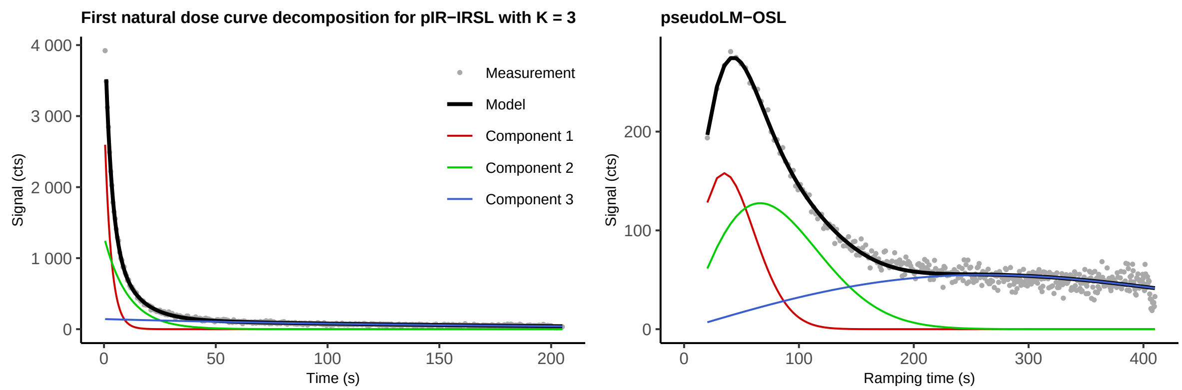


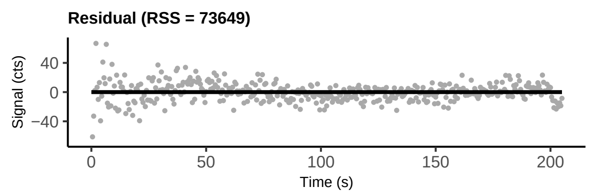

```
----------- Signal components for pIR-IRSL with K = 3  ------------

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: 3.93 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          0.164                            2.374e+06         Inf
K = 2         0.2243     0.01389                2.196e+05        1992
K = 3          0.341     0.09362    0.005999         7195        5964
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     1.1e-18
K = 2     1.5e-18             9.27e-20
K = 3     2.28e-18            6.25e-19             4.01e-20
(time needed: 1.3 s)
```





	λ (s^{-1})	*n*
Component 1	0.341	14056 ± 64
Component 2	0.0936	21402 ± 97
Component 3	0.006	35965 ± 131

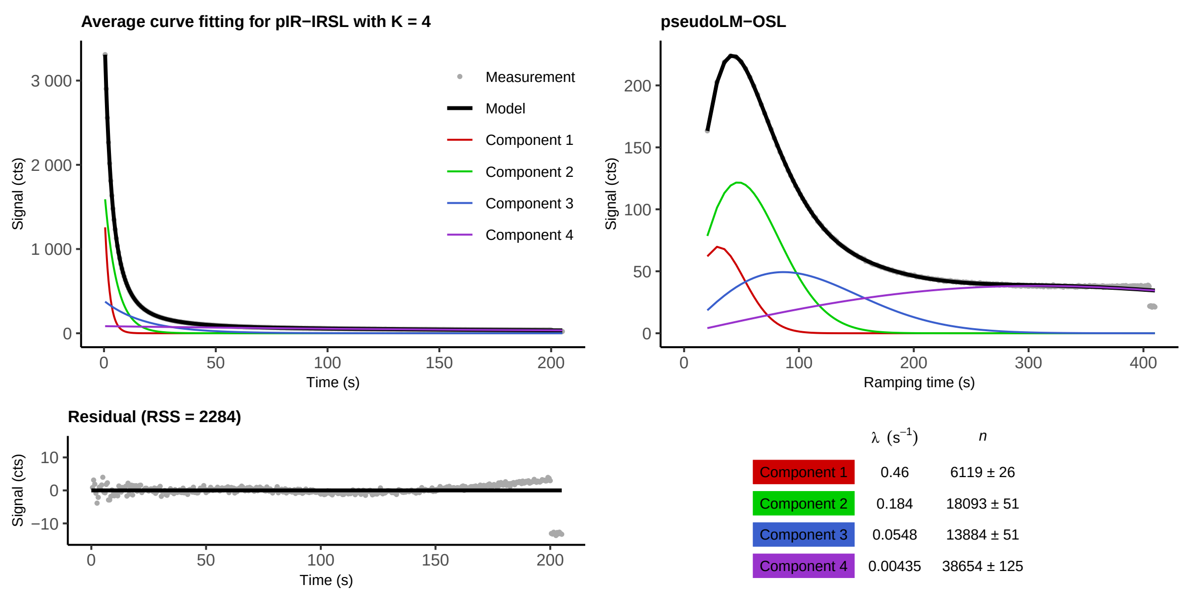


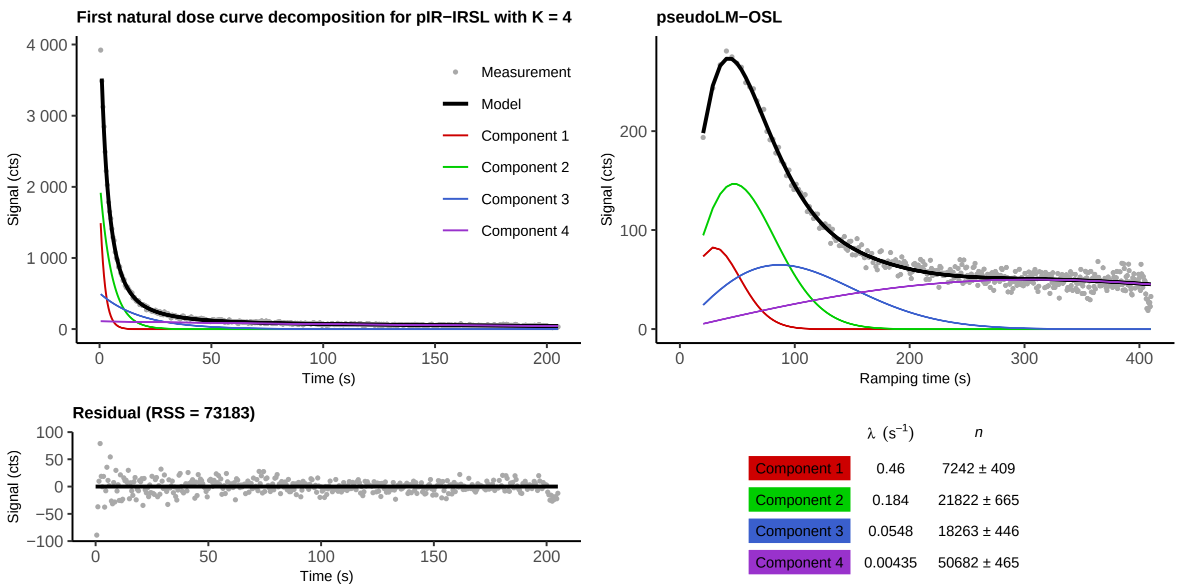


	λ (s^{-1})	*n*
Component 1	0.341	16567 ± 224
Component 2	0.0936	27198 ± 334
Component 3	0.006	47301 ± 387

```
----------- 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: 7.29 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          0.164                                            2.374e+06          Inf
K = 2         0.2243      0.01389                               2.196e+05         1992
K = 3          0.341      0.09362     0.005999                       7195         5964
K = 4           0.46        0.184       0.0548     0.004351          2278        433.7
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     1.1e-18
K = 2     1.5e-18              9.27e-20
K = 3     2.28e-18             6.25e-19              4.01e-20
K = 4     3.07e-18             1.23e-18              3.66e-19              2.91e-20
(time needed: 3.58 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
```

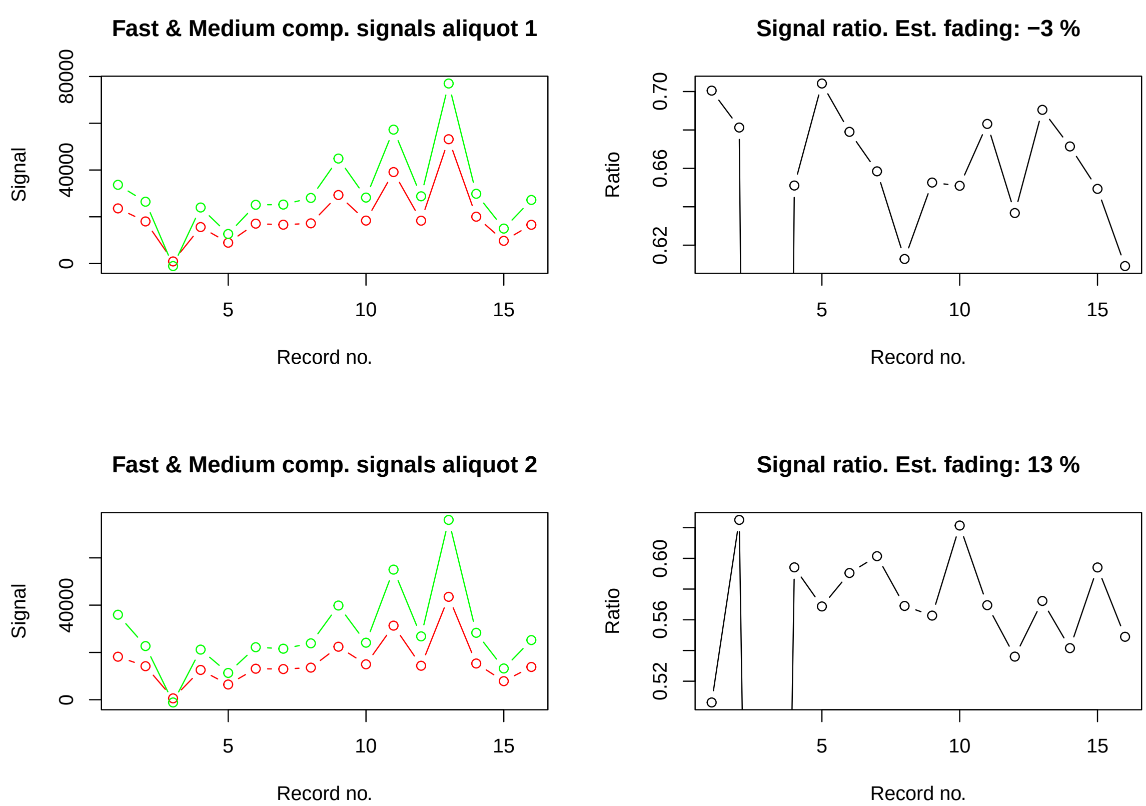
```
# default: suffix <- "pIRIR K3"
suffix <- "pIRIR K3"

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

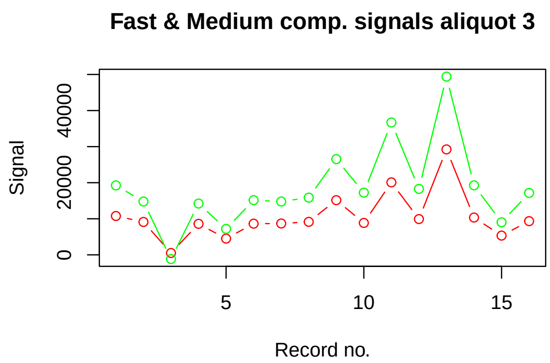
Table 1: Signal components of global curve

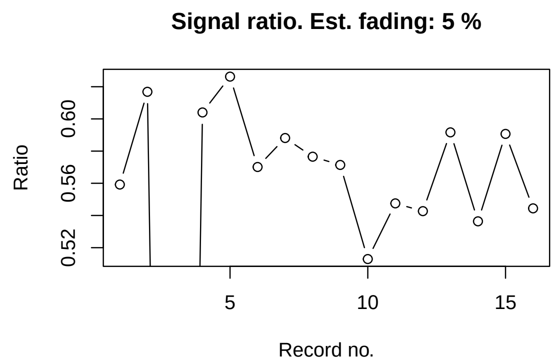
name	lambda	lambda.error	n	n.error	initial.signal
Component 1	0.3410	0.0025	14056	64	0.6697
Component 2	0.0936	0.0011	21402	97	0.2975
Component 3	0.0060	0.0001	35965	131	0.0327

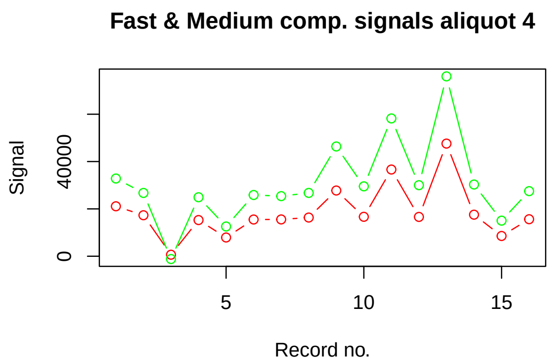
1.4 Fast component removal

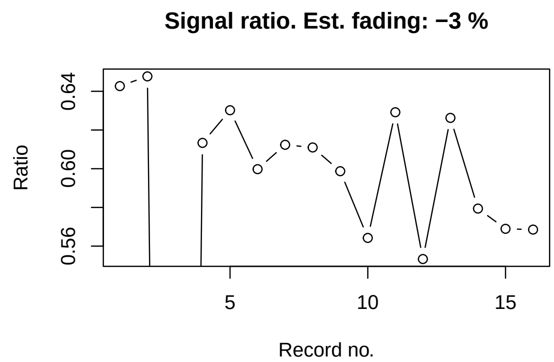
The fast component is now determined for each single curve by `decompose_OSLcurve()` and removed from the record.

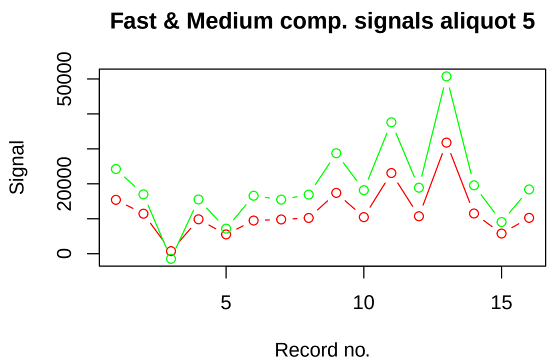


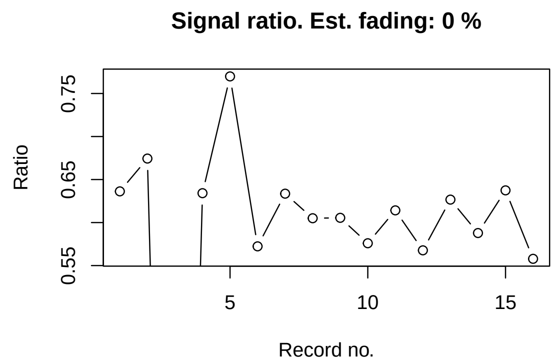

Fast & Medium comp. signals aliquot 3
Signal
0
20000
40000
5
10
15
Record no.

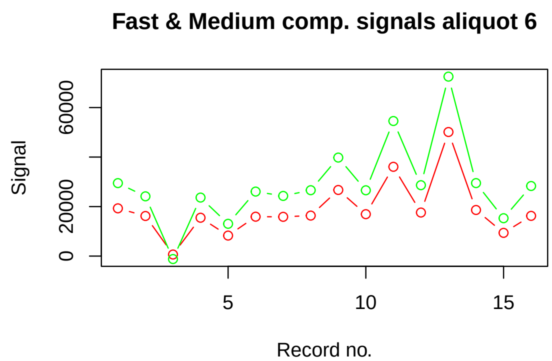

Signal ratio. Est. fading: 5 %
Ratio
0.52
0.56
0.60
5
10
15
Record no.

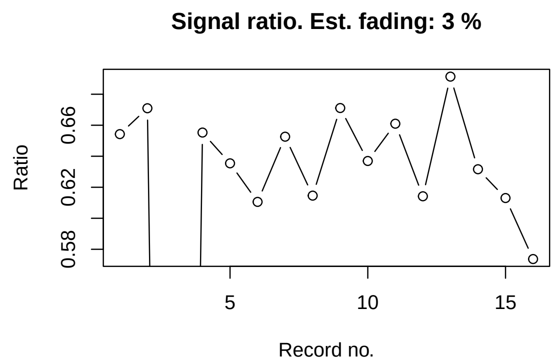

Fast & Medium comp. signals aliquot 4
Signal
0
40000
5
10
15
Record no.

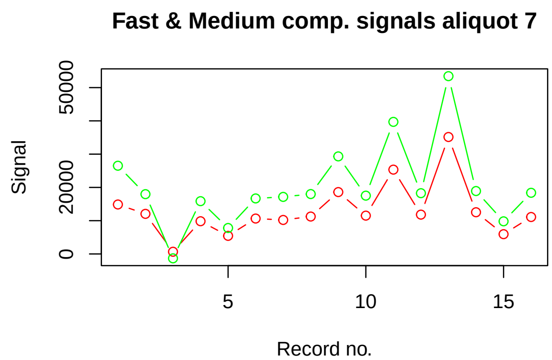

Signal ratio. Est. fading: −3 %
Ratio
0.56
0.60
0.64
5
10
15
Record no.

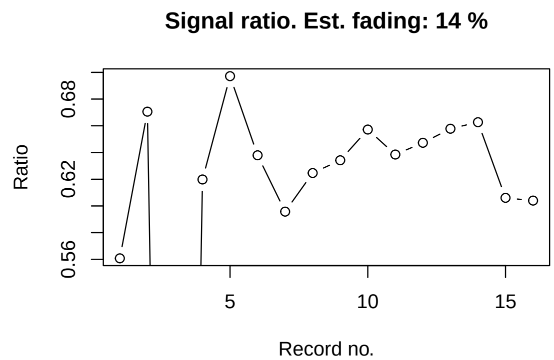

Fast & Medium comp. signals aliquot 5
Signal
0
20000
50000
5
10
15
Record no.

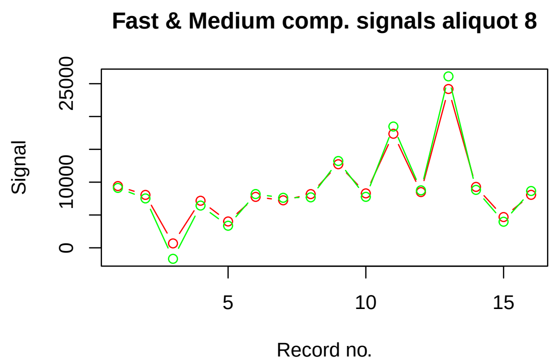

Signal ratio. Est. fading: 0 %
Ratio
0.55
0.65
0.75
5
10
15
Record no.

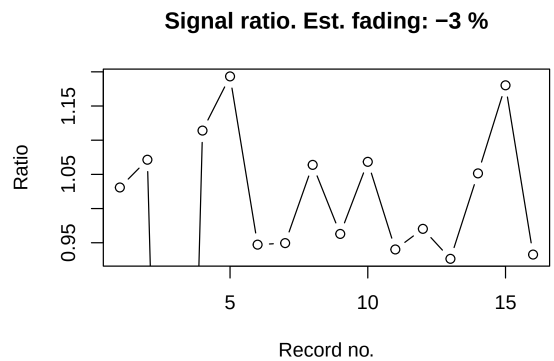

Fast & Medium comp. signals aliquot 6
Signal
0
20000
60000
5
10
15
Record no.

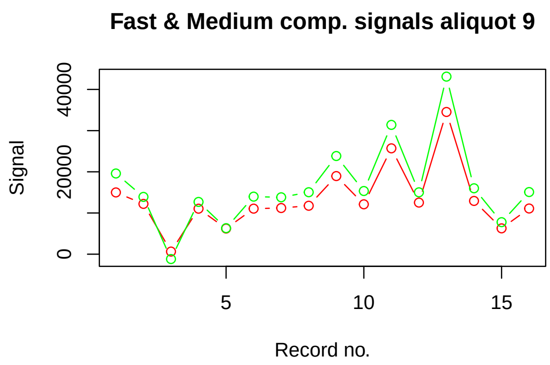

Signal ratio. Est. fading: 3 %
Ratio
0.58
0.62
0.66
5
10
15
Record no.


Fast & Medium comp. signals aliquot 7
Signal
0
20000
50000
5
10
15
Record no.

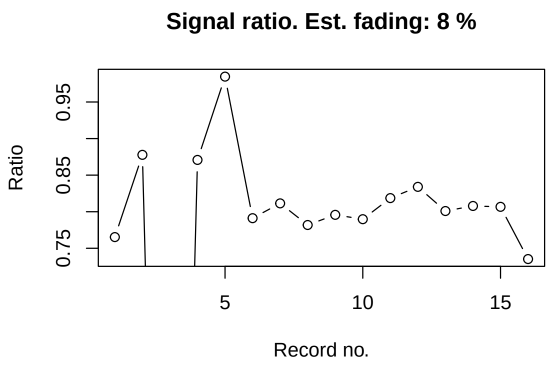

Signal ratio. Est. fading: 14 %
Ratio
0.56
0.62
0.68
5
10
15
Record no.


Fast & Medium comp. signals aliquot 8
Signal
0
10000
25000
5
10
15
Record no.

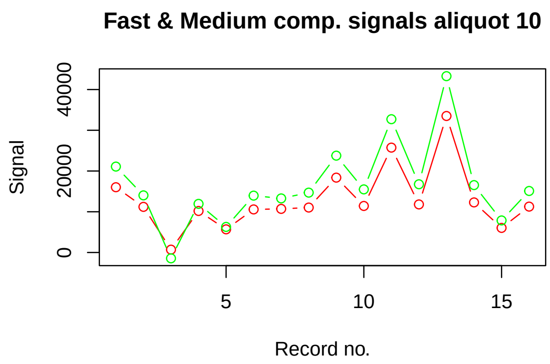

Signal ratio. Est. fading: −3 %
Ratio
0.95
1.05
1.15
5
10
15
Record no.



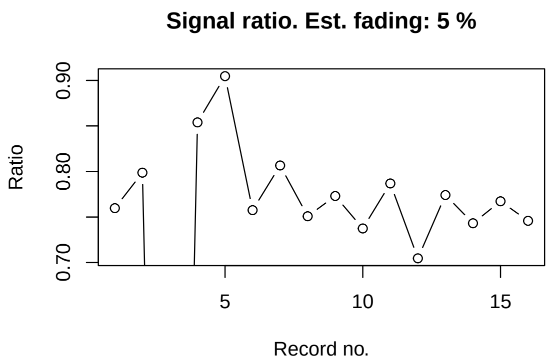
Fast & Medium comp. signals aliquot 9
Signal
0
20000
40000
5
10
15
Record no.



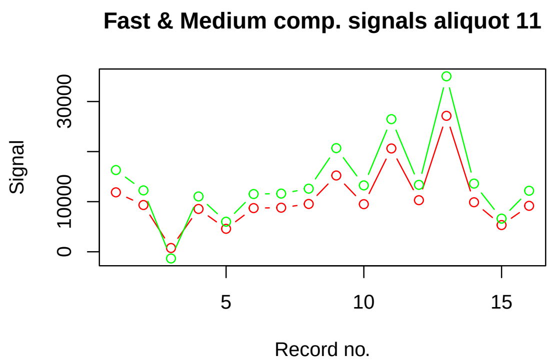
Signal ratio. Est. fading: 8 %
Ratio
0.75
0.85
0.95
5
10
15
Record no.



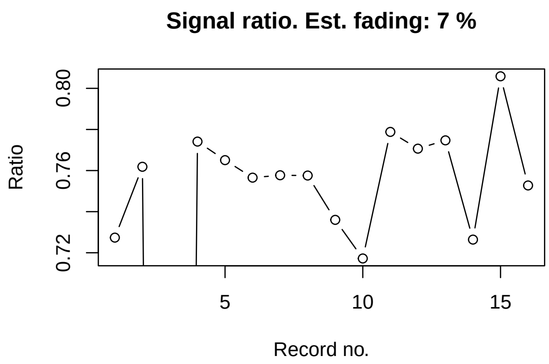
Fast & Medium comp. signals aliquot 10
Signal
0
20000
40000
5
10
15
Record no.



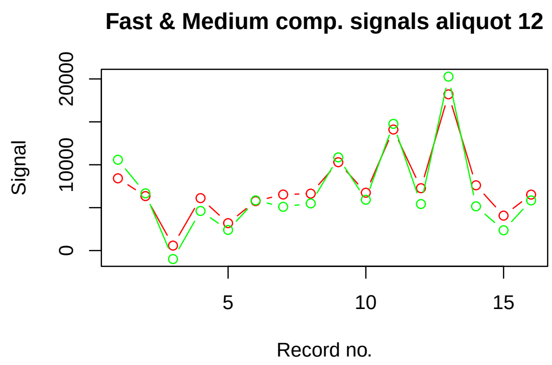
Signal ratio. Est. fading: 5 %
Ratio
0.70
0.80
0.90
5
10
15
Record no.

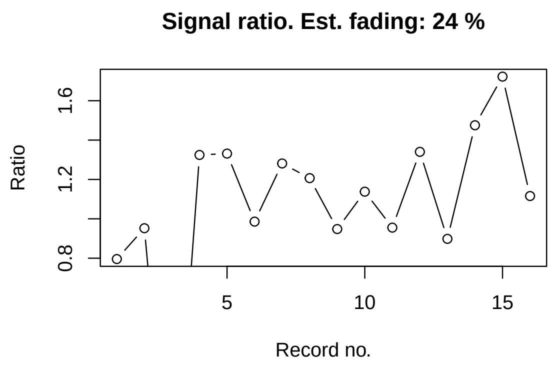


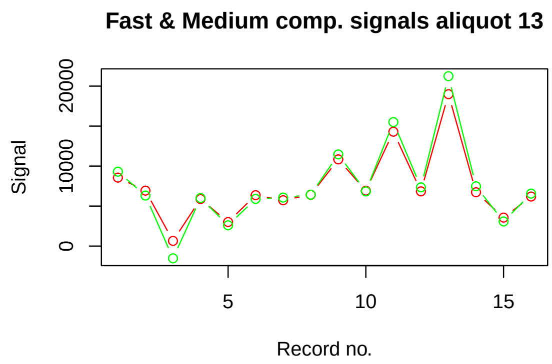
Fast & Medium comp. signals aliquot 11
Signal
0
10000
30000
5
10
15
Record no.

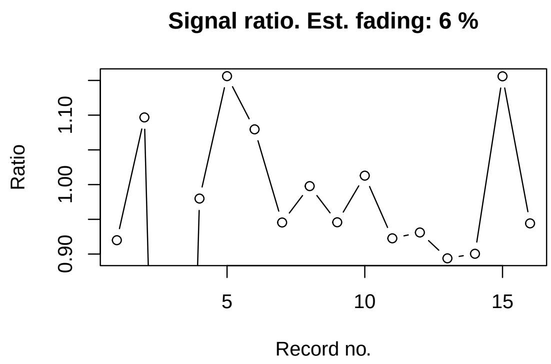


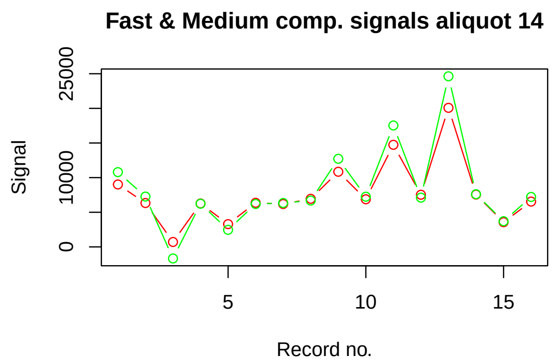
Signal ratio. Est. fading: 7 %
Ratio
0.72
0.76
0.80
5
10
15
Record no.

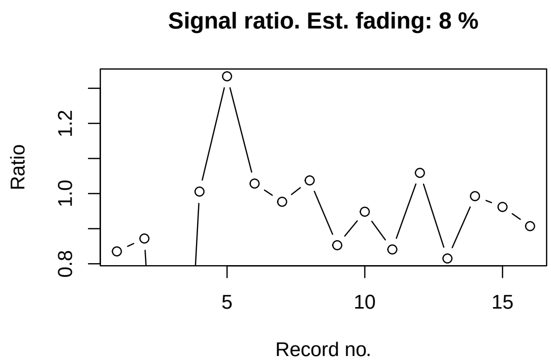

Fast & Medium comp. signals aliquot 12
Signal
0
10000
20000
5
10
15
Record no.

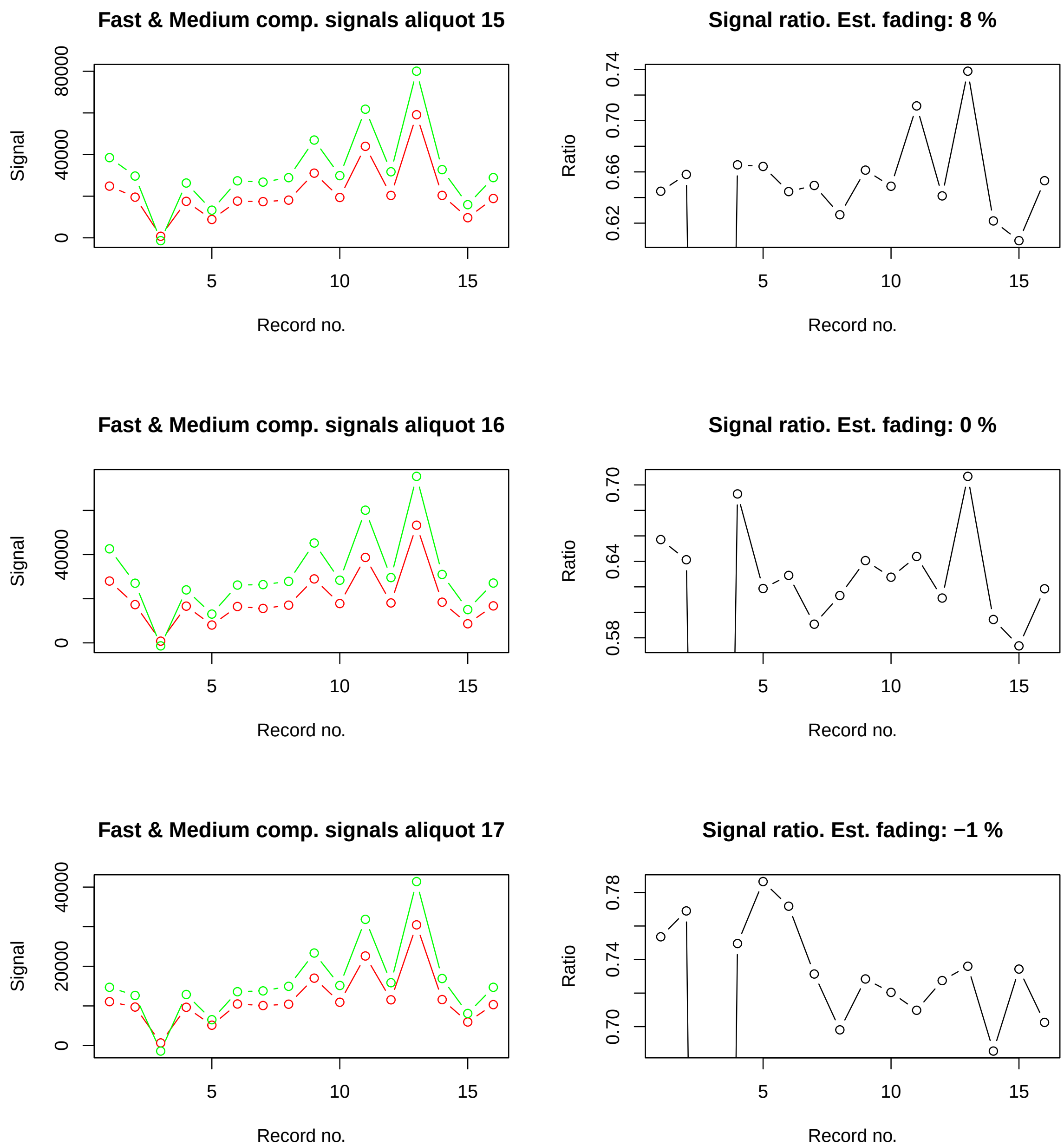

Signal ratio. Est. fading: 24 %
Ratio
0.8
1.2
1.6
5
10
15
Record no.

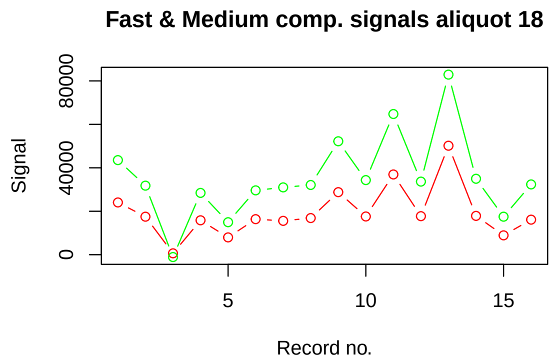

Fast & Medium comp. signals aliquot 13
Signal
0
10000
20000
5
10
15
Record no.

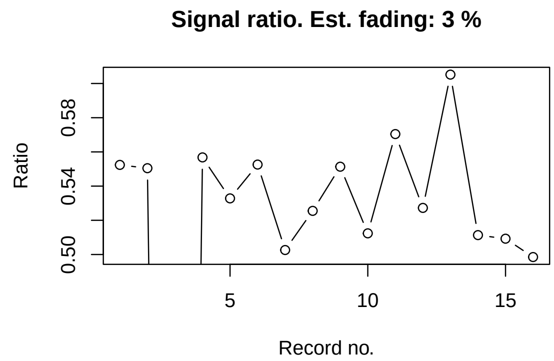

Signal ratio. Est. fading: 6 %
Ratio
0.90
1.00
1.10
5
10
15
Record no.

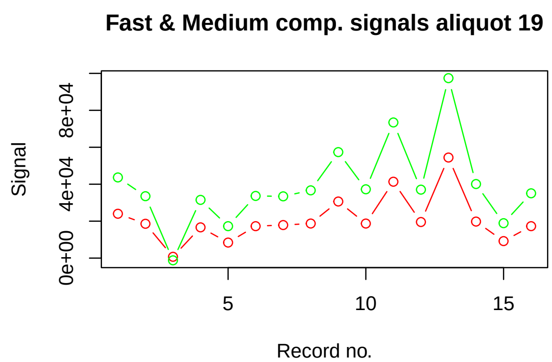

Fast & Medium comp. signals aliquot 14
Signal
0
10000
25000
5
10
15
Record no.

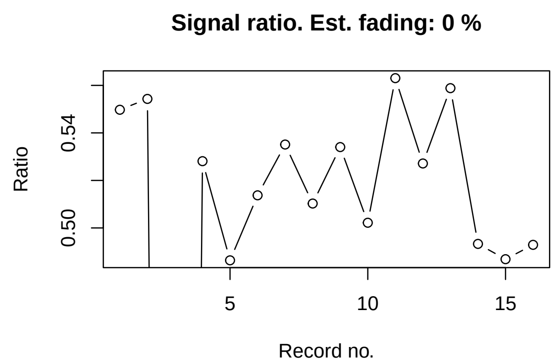

Signal ratio. Est. fading: 8 %
Ratio
0.8
1.0
1.2
5
10
15
Record no.

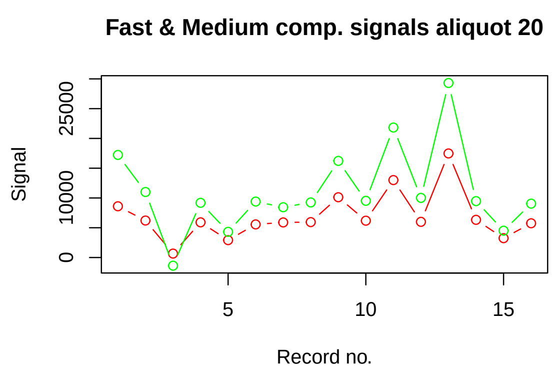

Fast & Medium comp. signals aliquot 15
Signal
Record no.
Signal ratio. Est. fading: 8 %
Ratio
Record no.
Fast & Medium comp. signals aliquot 16
Signal
Record no.
Signal ratio. Est. fading: 0 %
Ratio
Record no.
Fast & Medium comp. signals aliquot 17
Signal
Record no.
Signal ratio. Est. fading: −1 %
Ratio
Record no.

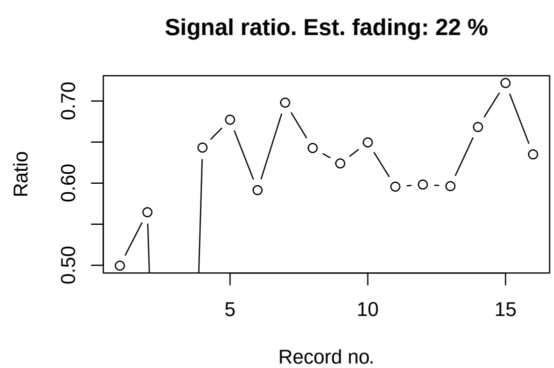

Fast & Medium comp. signals aliquot 18
Signal
0
40000
80000
5
10
15
Record no.

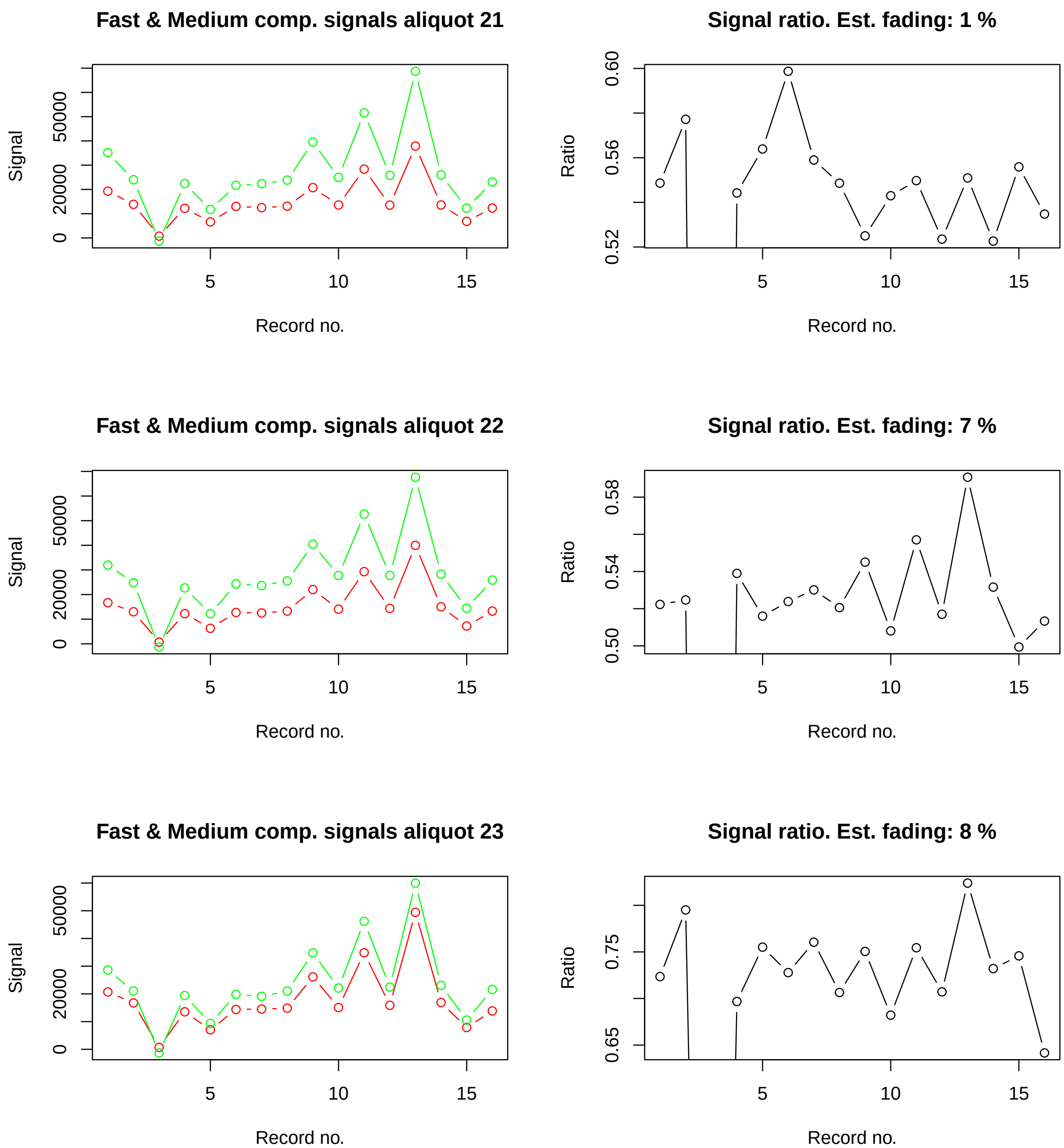

Signal ratio. Est. fading: 3 %
Ratio
0.50
0.54
0.58
5
10
15
Record no.

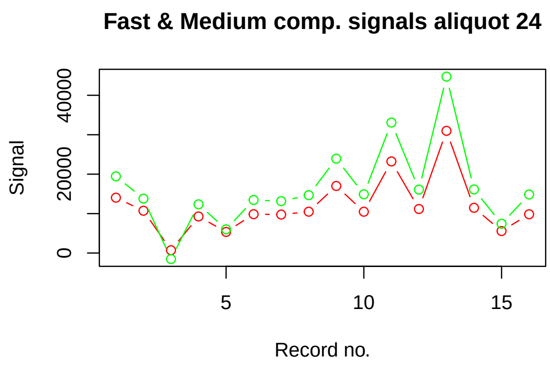

Fast & Medium comp. signals aliquot 19
Signal
0e+00
4e+04
8e+04
5
10
15
Record no.

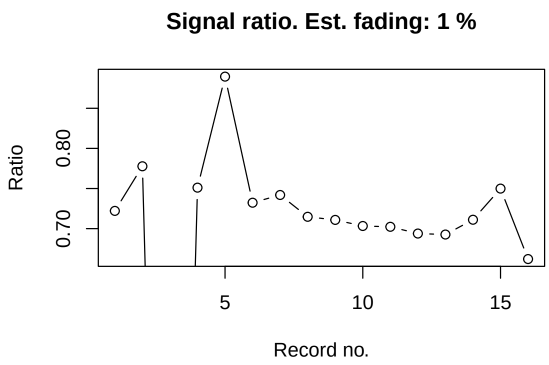

Signal ratio. Est. fading: 0 %
Ratio
0.50
0.54
5
10
15
Record no.


Fast & Medium comp. signals aliquot 20
Signal
0
10000
25000
5
10
15
Record no.


Signal ratio. Est. fading: 22 %
Ratio
0.50
0.60
0.70
5
10
15
Record no.


Fast & Medium comp. signals aliquot 21
Signal ratio. Est. fading: 1 %
Fast & Medium comp. signals aliquot 22
Signal ratio. Est. fading: 7 %
Fast & Medium comp. signals aliquot 23
Signal ratio. Est. fading: 8 %
Signal
Ratio
Record no.
0
20000
50000
0.52
0.56
0.60
0.50
0.54
0.58
0.65
0.75
5
10
15

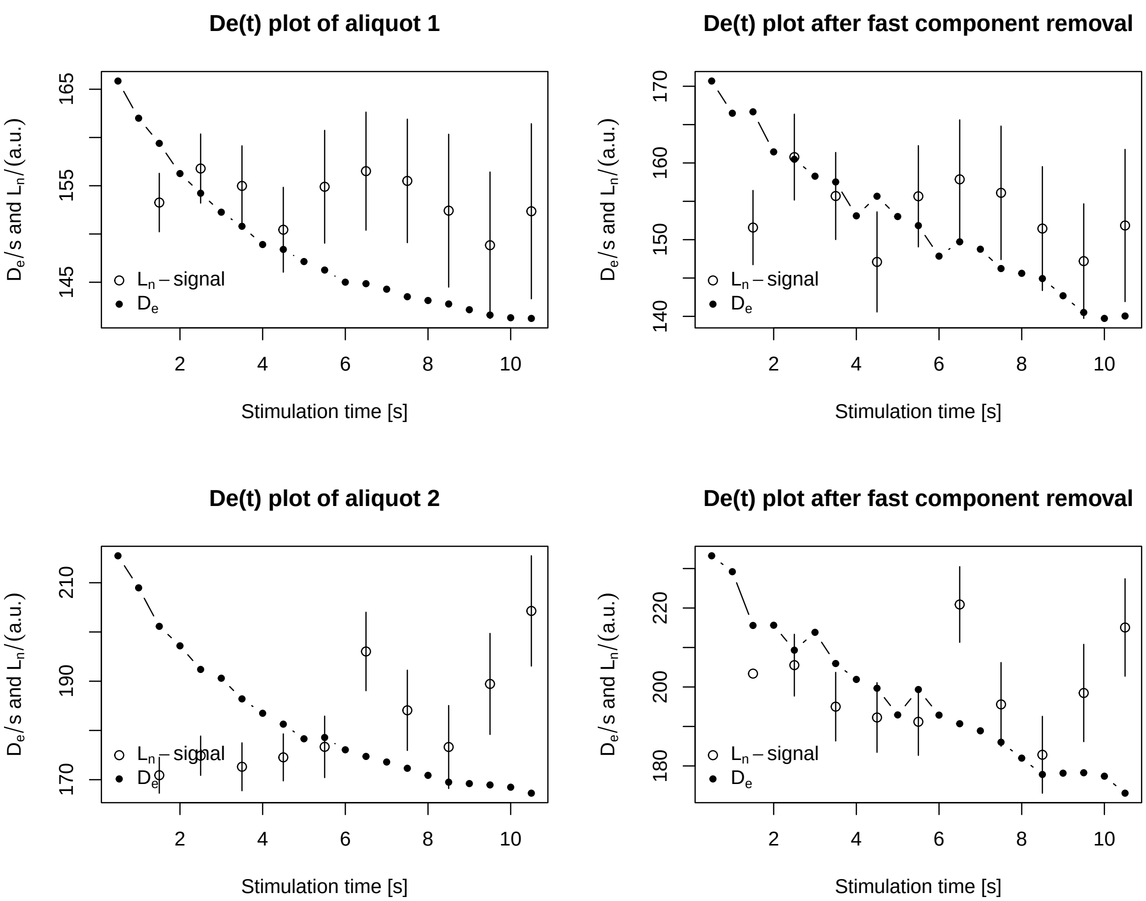

Fast & Medium comp. signals aliquot 24
Signal
0
20000
40000
5
10
15
Record no.

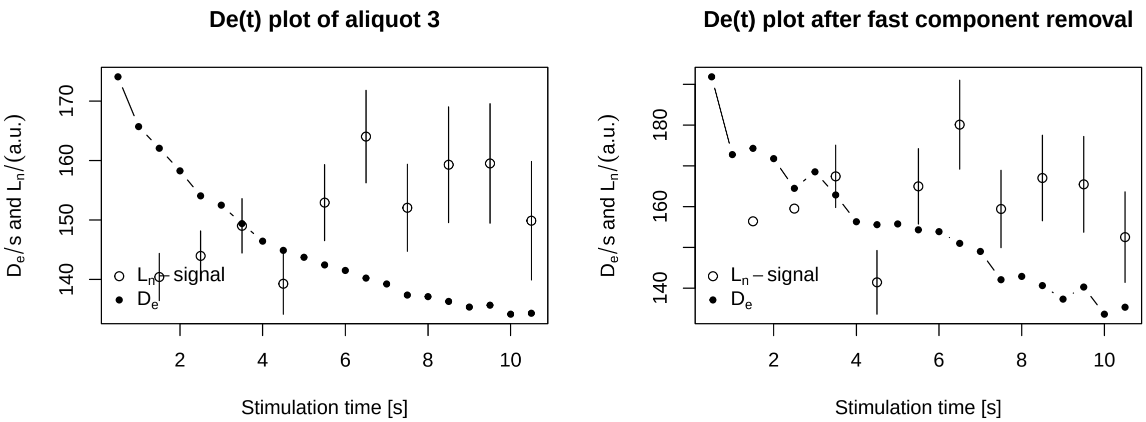

Signal ratio. Est. fading: 1 %
Ratio
0.70
0.80
5
10
15
Record no.

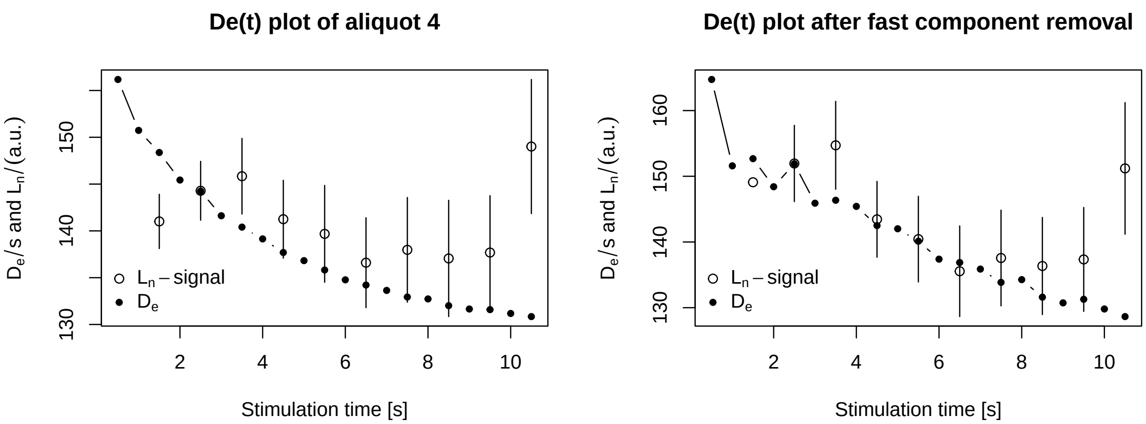
2 Output

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:





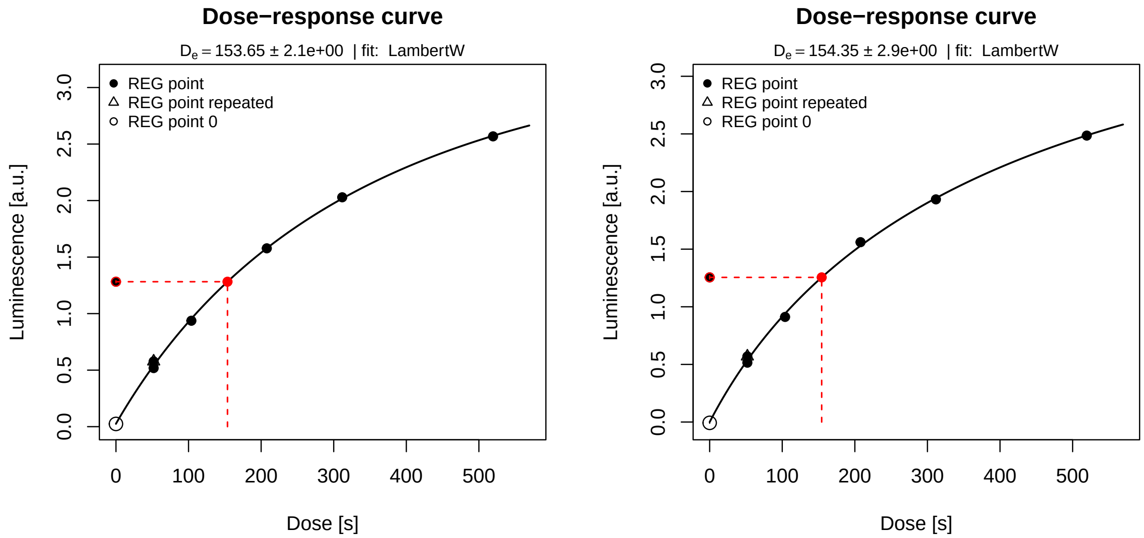


Like for other B19-LU samples the IRSL at 50°C measured equivalent doses are lower than the pIR-IRSL measured, which is a indication of thermal fading of the luminescence signal in the samples and thus also a indication of De underestimation in the IRSL at 50°C signals (Thomsen et al. 2008).

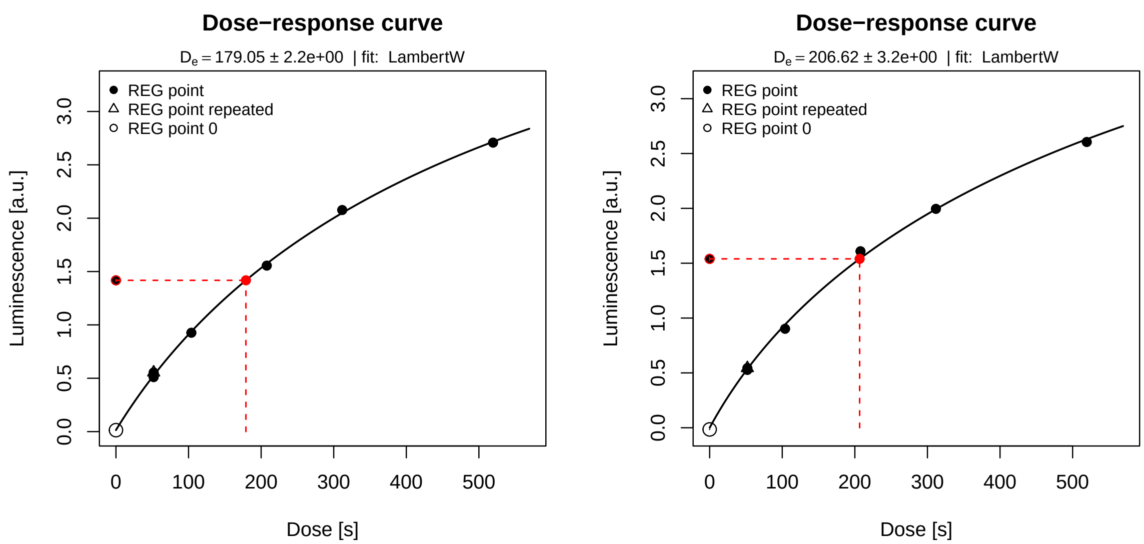
However, the increase in the De values when shifting the signal integration window towards higher values which can be observed for other B19 samples can only be observed a few of the aliquots of this sampleDose-response curve fitting

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).

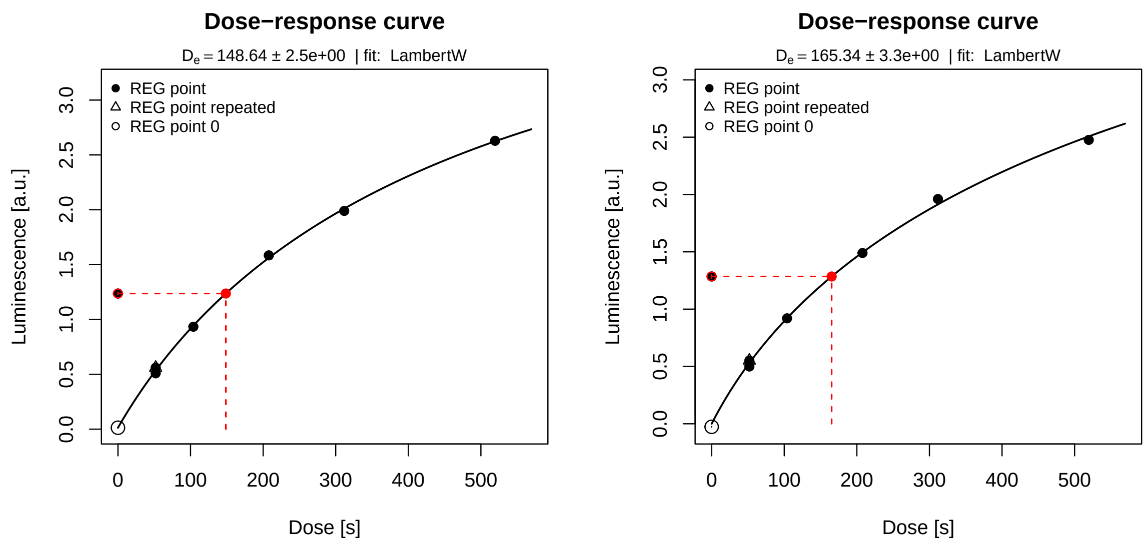
```
--- Dose response curve for aliquot 1 ---
Left: Uncorrected Dose response curve, Right: After fast component removal.
```



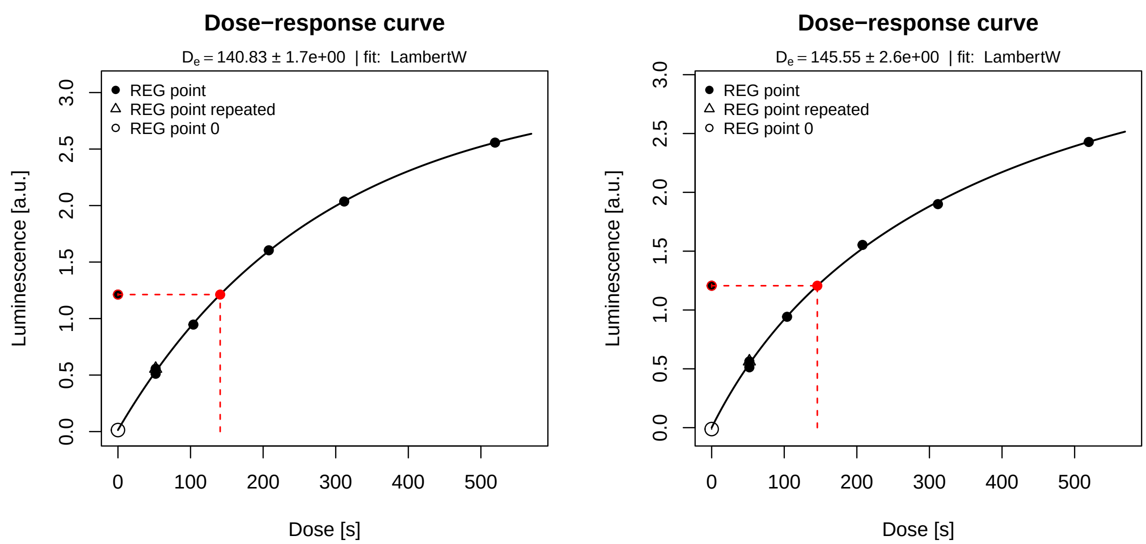

```
--- Dose response curve for aliquot 2 ---
Left: Uncorrected Dose response curve, Right: After fast component removal.
```



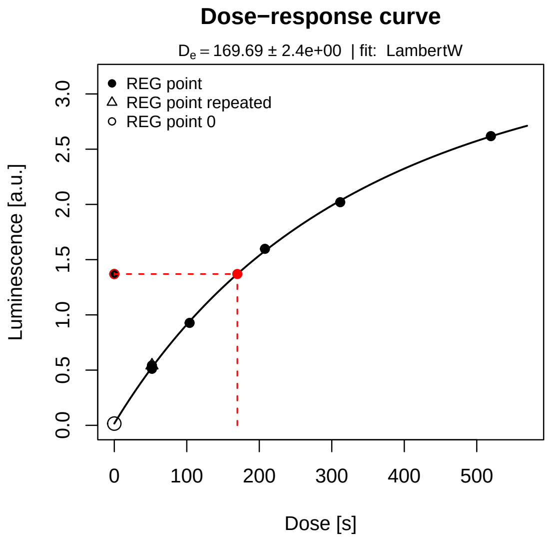

```
--- Dose response curve for aliquot 3 ---
Left: Uncorrected Dose response curve, Right: After fast component removal.
```

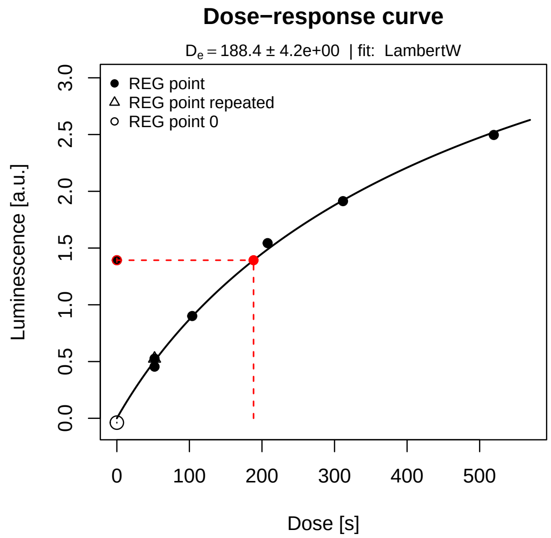



```
--- Dose response curve for aliquot 4 ---
Left: Uncorrected Dose response curve, Right: After fast component removal.
```

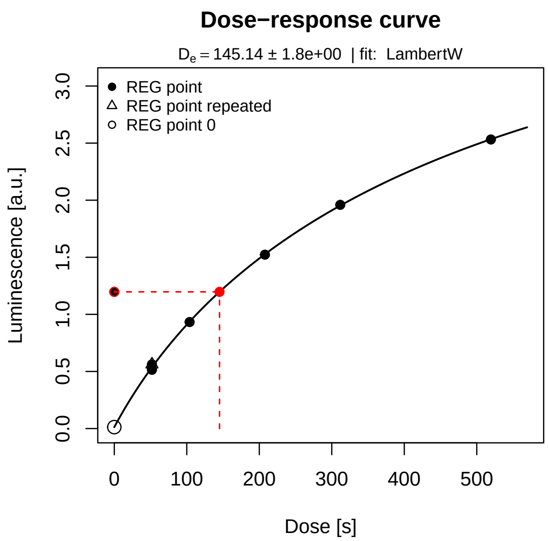


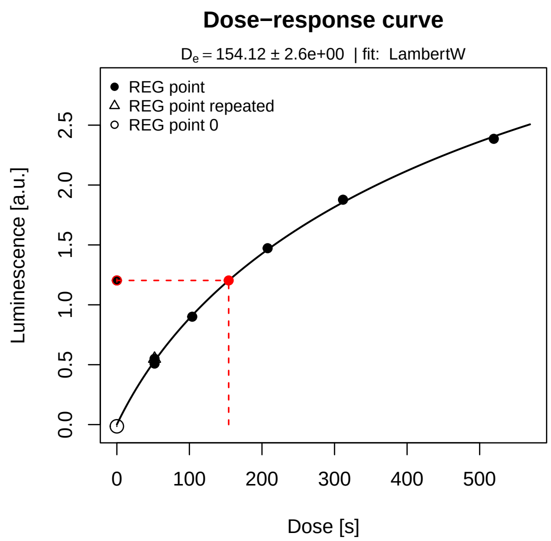

```
--- Dose response curve for aliquot 5 ---
Left: Uncorrected Dose response curve, Right: After fast component removal.
```






```
--- 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	154.35	8.38	FAILED
2	206.62	10.84	OK
3	165.34	9.00	FAILED
4	145.55	7.74	OK
5	188.40	10.10	FAILED
6	154.12	8.14	OK
7	180.67	9.59	FAILED
8	139.43	8.07	OK
9	177.36	9.74	FAILED
10	202.54	11.16	FAILED
11	165.54	9.18	OK
12	181.55	10.51	OK
13	179.80	10.73	OK
14	165.34	9.68	FAILED
15	160.38	8.45	FAILED
16	203.12	10.96	FAILED
17	137.56	7.78	FAILED
18	176.59	9.26	OK
19	160.24	8.45	OK
20	202.21	11.23	OK
21	190.83	10.22	OK
22	166.99	8.80	OK
23	169.09	9.11	OK
24	177.06	9.60	FAILED

13 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

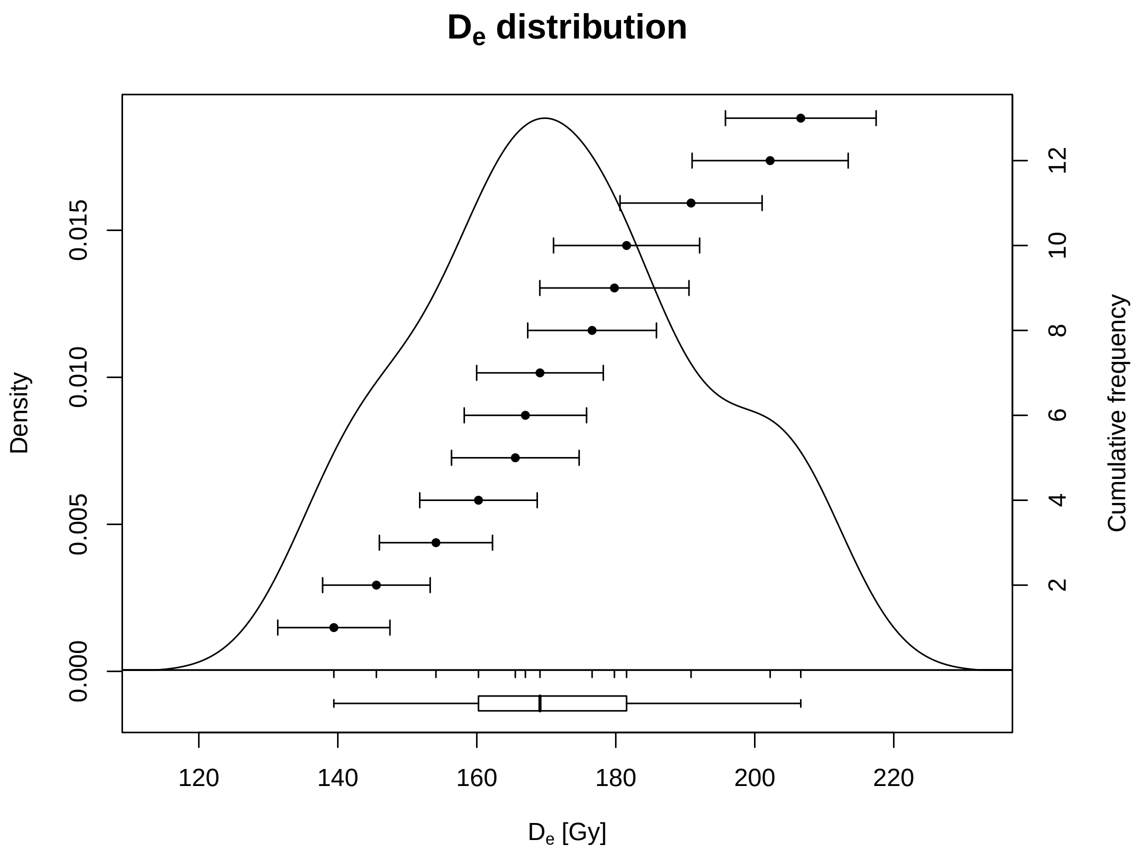
Table 3: Rejection criteria thresholds (left) and results (right)

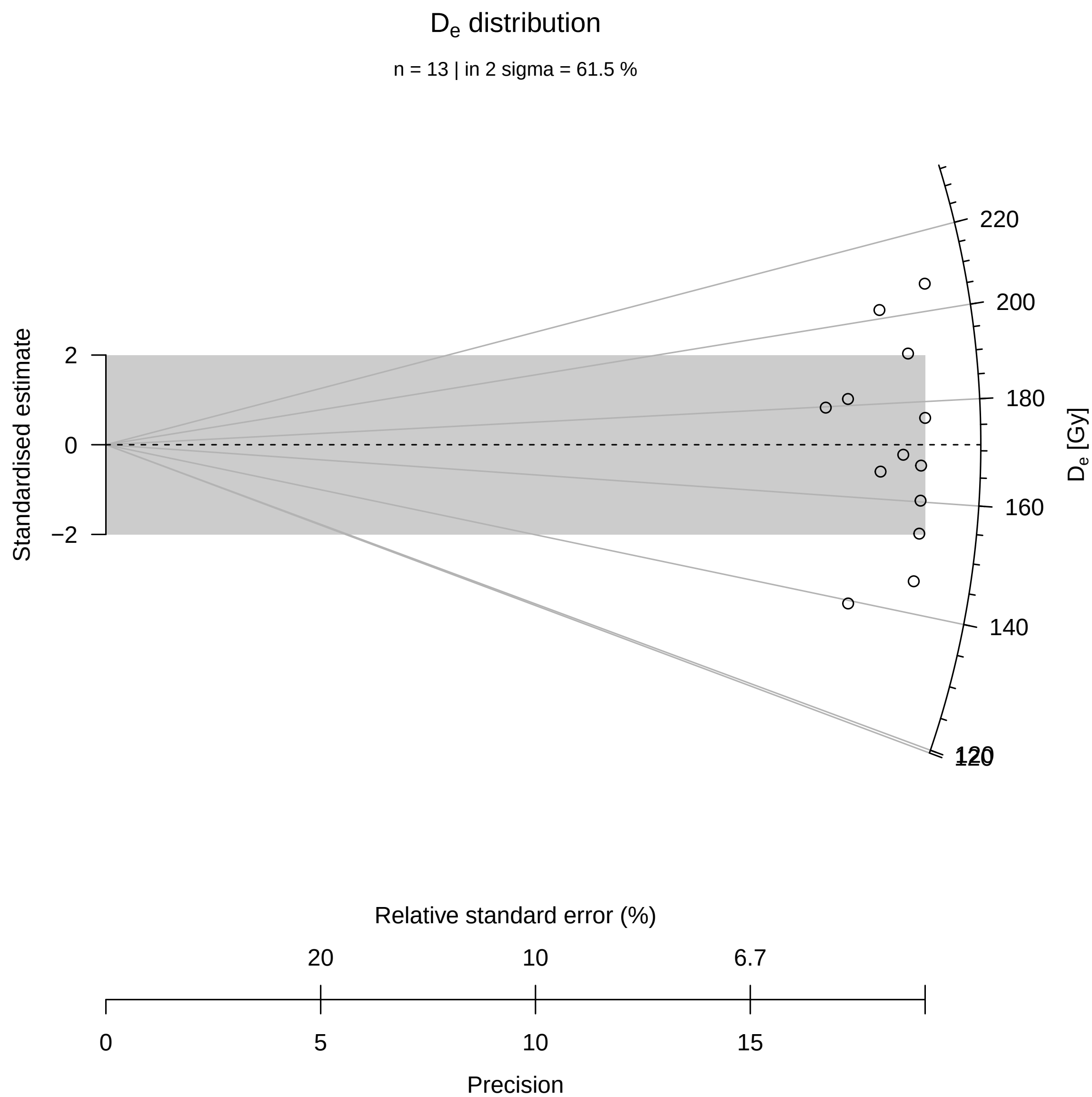
#	Criterium	Threshold
A	Recycling ratio (R6/R1)	0.1
B	Recuperation rate 1	0.1
C	Testdose error	0.1
D	Palaeodose error	0.1
E	De > max. dose point	519.5

#	A	B	C	D	E
1	1.105	-0.006	0.009	0.021	154.350
2	1.031	-0.010	0.008	0.016	206.620
3	1.104	-0.021	0.011	0.021	165.339
4	1.098	-0.010	0.009	0.018	145.551
5	1.155	-0.028	0.010	0.019	188.402
6	1.078	-0.012	0.008	0.017	154.123
7	1.132	-0.019	0.009	0.018	180.673
8	1.092	-0.085	0.015	0.029	139.433
9	1.135	-0.024	0.011	0.023	177.357
10	1.133	-0.032	0.011	0.023	202.537
11	1.042	-0.034	0.011	0.024	165.542
12	0.998	-0.016	0.018	0.029	181.550
13	1.046	-0.072	0.016	0.033	179.800
14	1.240	-0.074	0.015	0.030	165.344
15	1.121	-0.014	0.008	0.017	160.376
16	1.115	-0.013	0.009	0.020	203.117
17	1.126	-0.037	0.011	0.026	137.563
18	1.066	-0.007	0.007	0.016	176.593
19	1.044	-0.005	0.008	0.017	160.241
20	1.082	-0.036	0.012	0.024	202.211
21	0.979	-0.012	0.010	0.019	190.835
22	1.094	-0.010	0.008	0.017	166.990
23	1.027	-0.016	0.010	0.020	169.085
24	1.135	-0.038	0.011	0.021	177.058

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.

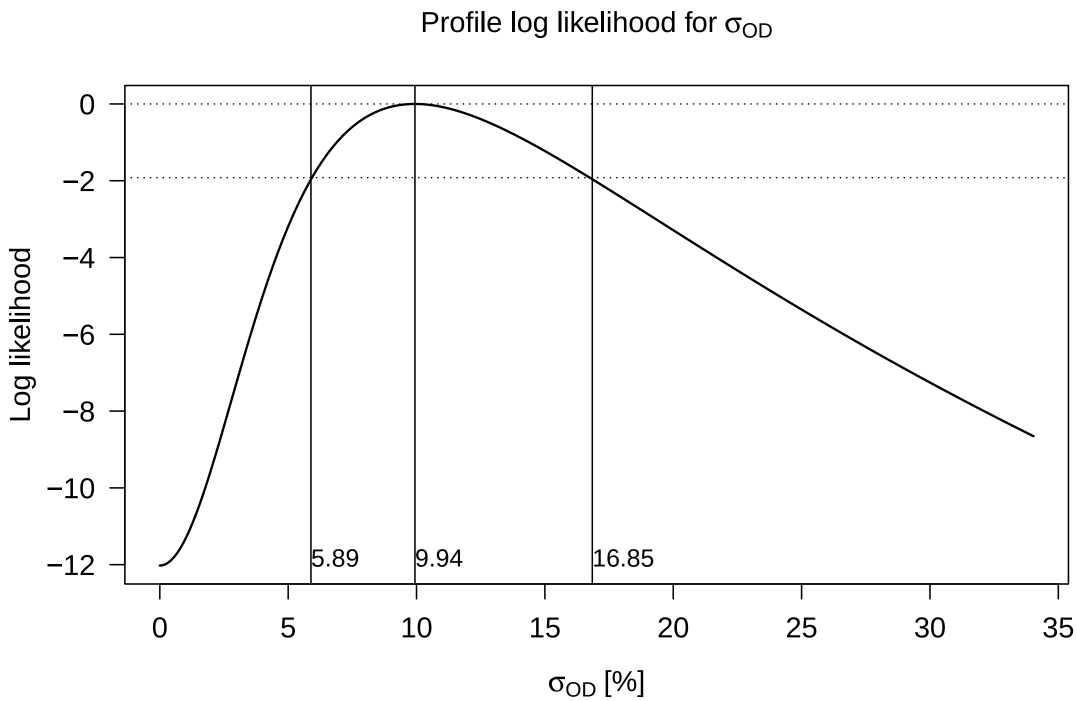



De distribution
n = 13 | in 2 sigma = 61.5 %
Standardised estimate
2
0
−2
220
200
180
160
140
120
De [Gy]
Relative standard error (%)
20
10
6.7
0
5
10
15
Precision

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:                      13
 log:                    TRUE
----------- dose estimate ------------
 abs. central dose:      171.10
 abs. SE:                5.38
 rel. SE [%]:            3.14
----------- overdispersion -----------
 abs. OD:                17.00
 abs. SE:                4.34
 OD [%]:                 9.93
 SE [%]:                 2.54
-------------------------------------
```



SE = standard error, OD = over-dispersion

2.6 Scatter plot

Scatter plot