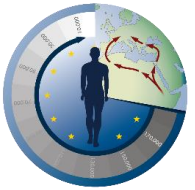


SFB 806 – Our Way to Europe

Universität zu Köln

Using **R** for TL dating

David Strebler[1], Dominik Brill[1], Christoph Burow[1], Helmut Brückner[1]

[1]*Institute of Geography – University of Cologne, Cologne, North Rhine-Westphalia, Germany*

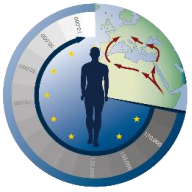
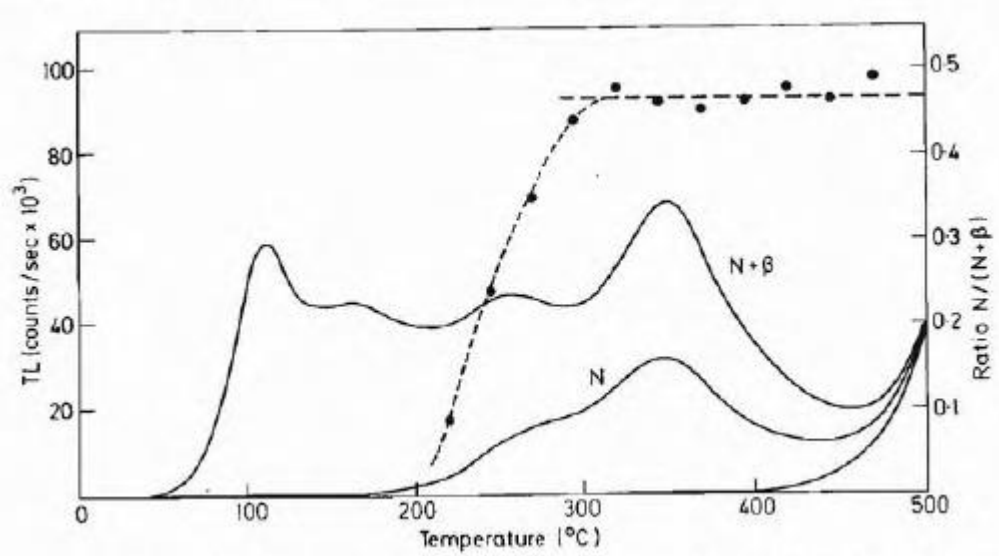


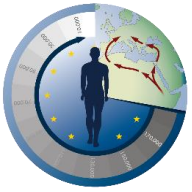
Table of Contents

Introduction

- $Age = \frac{D_e}{\dot{D}}$
- TL dating
  → Luminescence vs. temperature
- Available software
  - Analyst (Duller 2015)
  - Excel
  - MATLAB
  - “Homemade” (C, Java, Pascal,…)
  - **R**
    - *Luminescence* package (Kreutzer et al. 2012)
  - …



Aitken, M.J., Thermoluminescence Dating, Academic Press, London (1985)

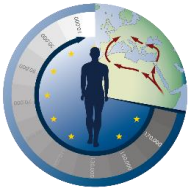


The new **R** package TLdating

Philosophy & main focuses

- TL orientated
- Easy to use
  - BIN-file
- *Compatibility*
  - *Luminescence package*
- Using metadata
  - Data type

- Uncertainty tracking
  - Generated when the object is created
  - Updated when the data are manipulated
  - Only random uncertainty
    - Addition: $\Delta x = \sqrt{\sum_i \Delta x_i^2}$
    - Division: $\frac{\Delta x}{x} = \sqrt{\sum_i \left(\frac{\Delta x_i}{x_i}\right)^2}$



Our new **R** package: *TLdating*

Pretreatment

- Update metadata
  - Two new data types
    - Preheat
    - Testdose
- Select or remove specific discs
  - TL, Preheat, Aliquots,…
- Manipulate data
  - Subtract background
  - Align peaks
- Independent of applied dating protocol

D_e estimation

- Two dating protocols
  - MAAD vs. SAR
  - Output as similar as possible.
- Plateau test
- Fitting
  - Temperature & Dose intervals
  - Different curves
    - Lin., Exp., …
- Two approaches
  - D_e *plateau (DP)* vs. *Growth curve (GC)*

Application: Burnt flints dating

Parameters

For SAR only

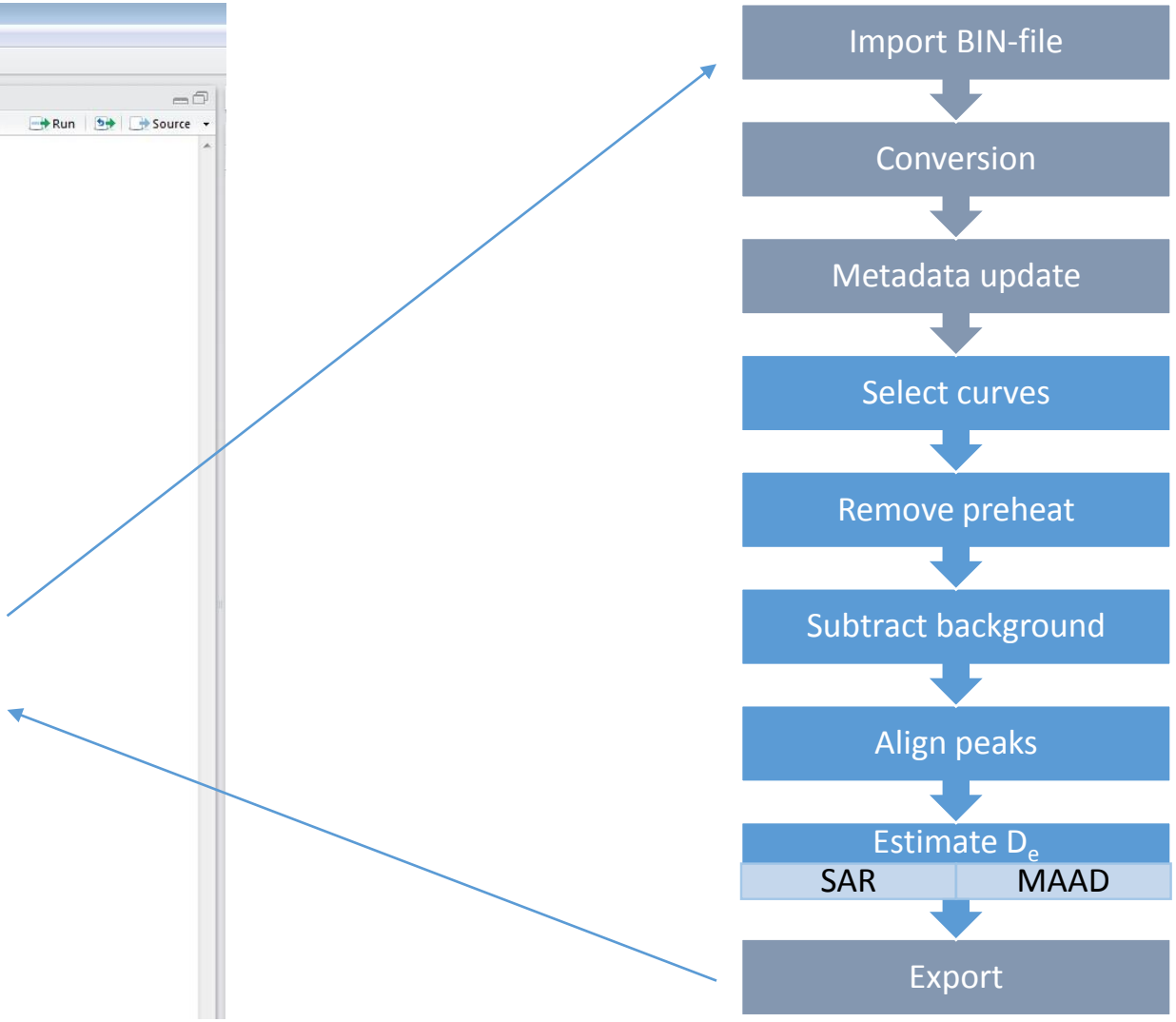
~/R/TLdating - master - RStudio

File Edit Code View Plots Session Build Debug Tools Help

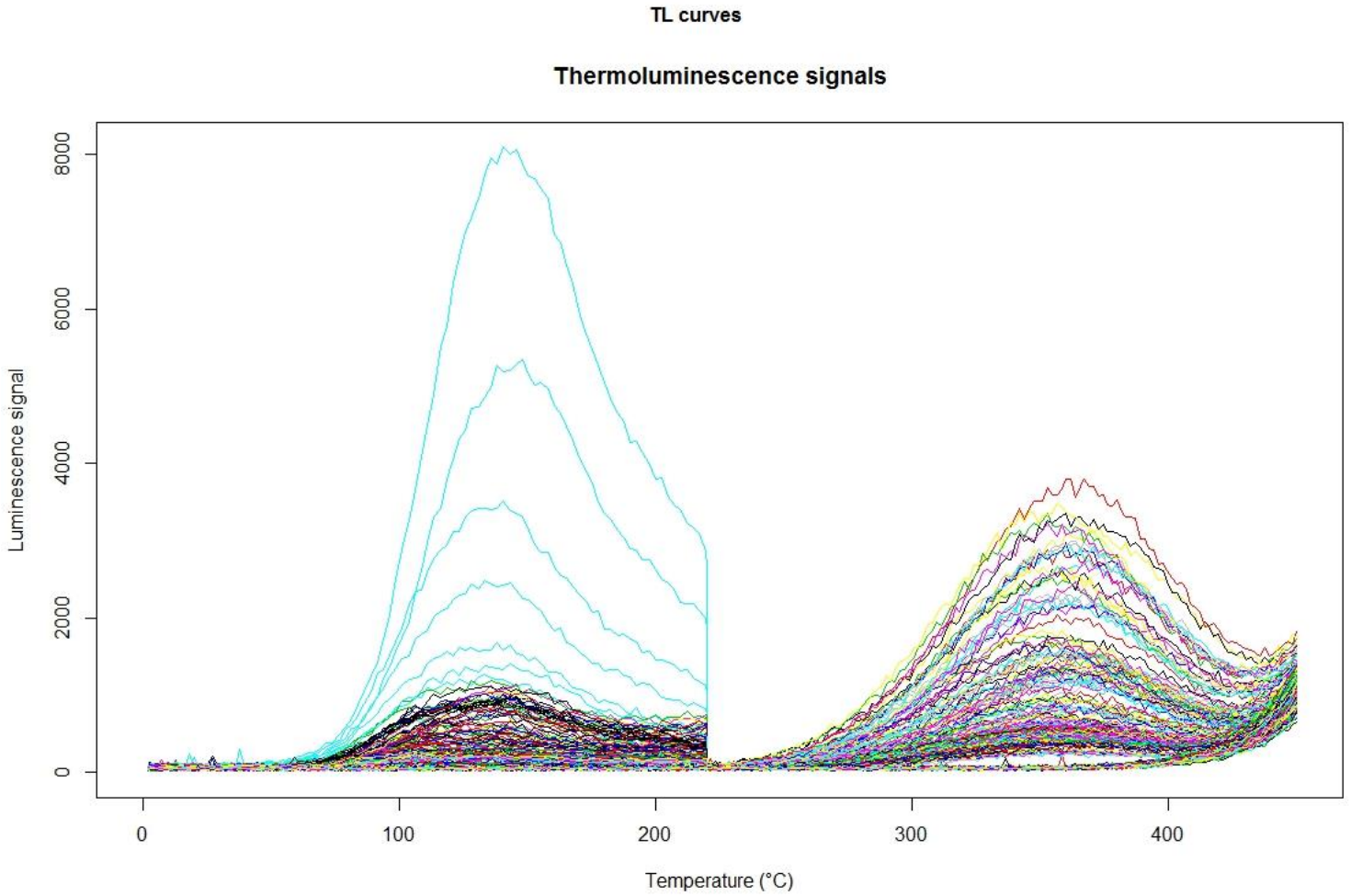
Example MAAD.R | Example SAR.R | Example Fading.R

Source on Save | Run | Source

```
rm(list = ls())
setwd("~/R/test/glasgow")
require("TLdating")
require("Luminescence")

# Parameters #
file.name <- "TAI_19A_QG_TL_SAR"

eval.Tmin <- 340
eval.Tmax <- 380

relative.error <- 0.05

aligning.parameters <- list(peak.Tmin=250,
                            peak.Tmax=400)

fitting.parameters <- list(fit.method="LIN",
                           fit.weighted=TRUE,
                           fit.rDoses.min=150,
                           fit.rDoses.max=800)

plotting.parameters <- list(plot.Tmin=250,
                            plot.Tmax=420)

rejection.criteria <- list(recycling.ratio = 10,
                           recuperation.rate = 10,
                           testdose.error = 10,
                           paleodose.error = 10)

# De estimation #
result <- script_TL.SAR(file.name=file.name,
                        relative.error = relative.error,
                        eval.Tmin=eval.Tmin,
                        eval.Tmax=eval.Tmax,
                        aligning.parameters = aligning.parameters,
                        fitting.parameters=fitting.parameters,
                        plotting.parameters=plotting.parameters)

# De distribution (Luminescence package) #
de.values.DP <- result$de.values.DP
de.values.GC <- result$de.values.GC

plot_AbanicoPlot(de.values.DP,
                 polygon.col=adjustcolor(col="blue2",alpha.f=0.33),
                 bar.col=adjustcolor(col="grey80",alpha.f=0.53),
                 stats=c("min","max"),
                 summary=c("n","mean","median","sdrel"))

plot_AbanicoPlot(de.values.GC,
                 polygon.col=adjustcolor(col="blue2",alpha.f=0.33),
                 bar.col=adjustcolor(col="grey80",alpha.f=0.53),
                 stats=c("min","max"),
                 summary=c("n","mean","median","sdrel"))
```



Burnt flints dating: Curve selection



Curves selection

Preheat removal

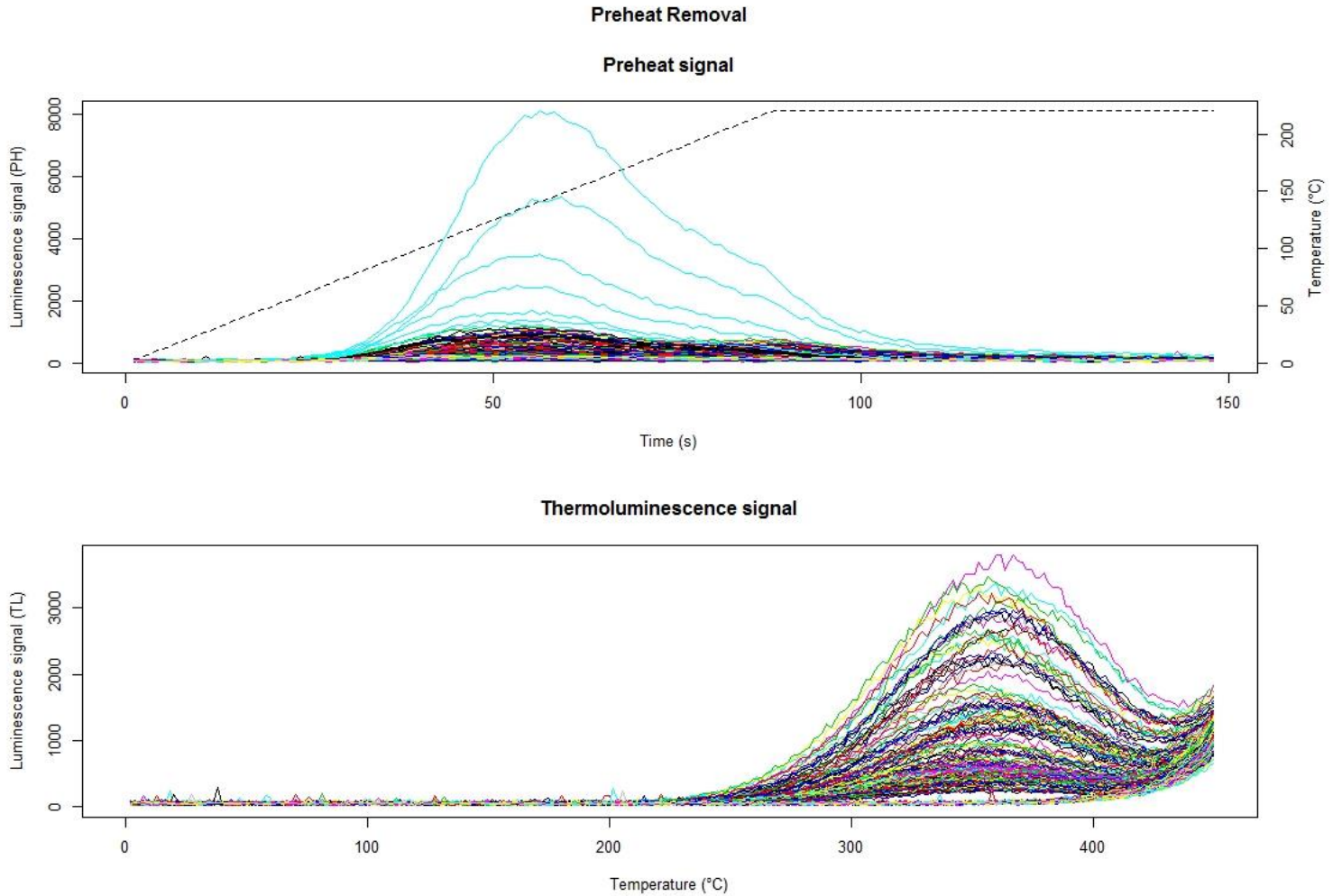
Background subtraction

Peak alignment

D_e estimation

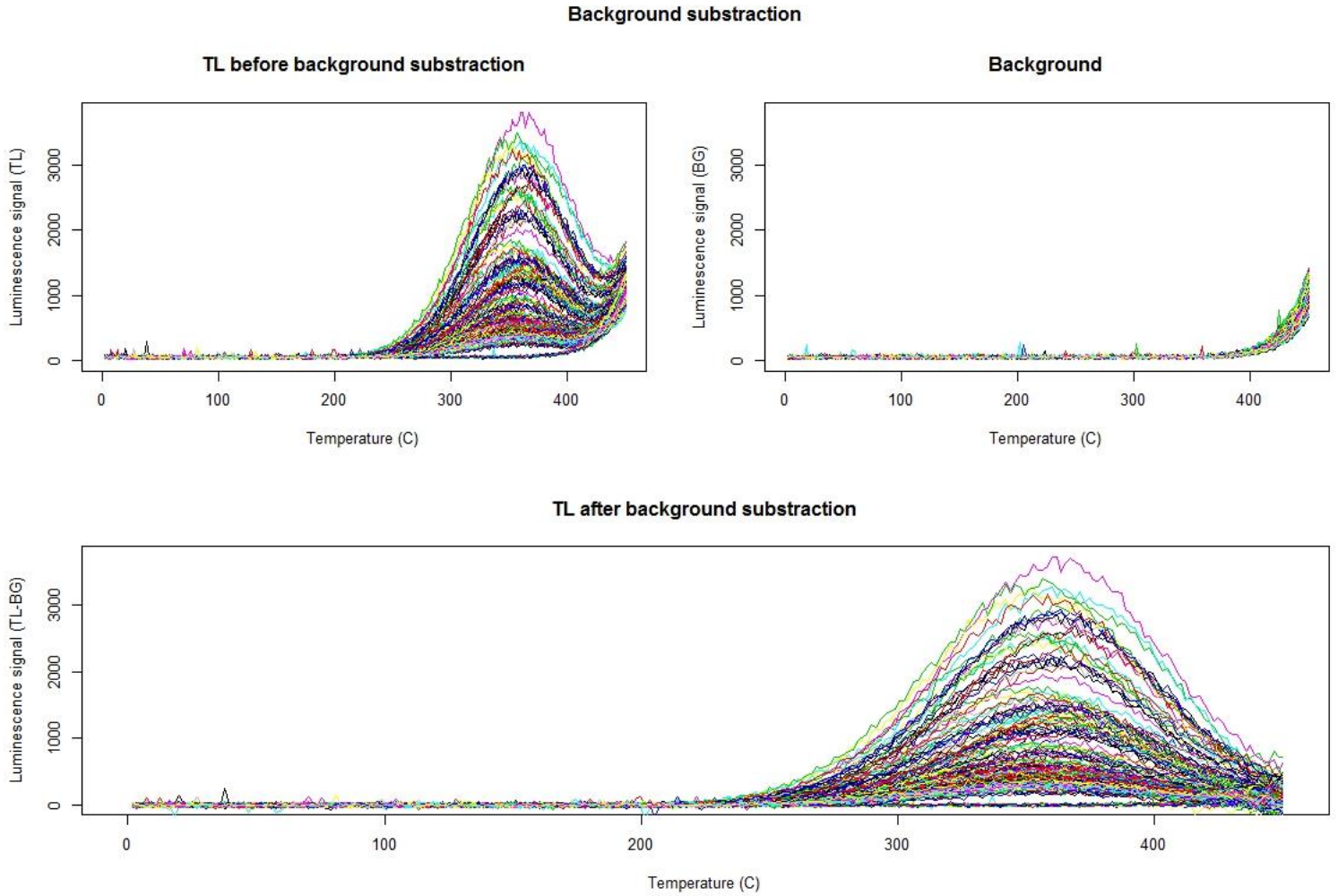
SAR	MAAD

Burnt flints dating: Preheat removal



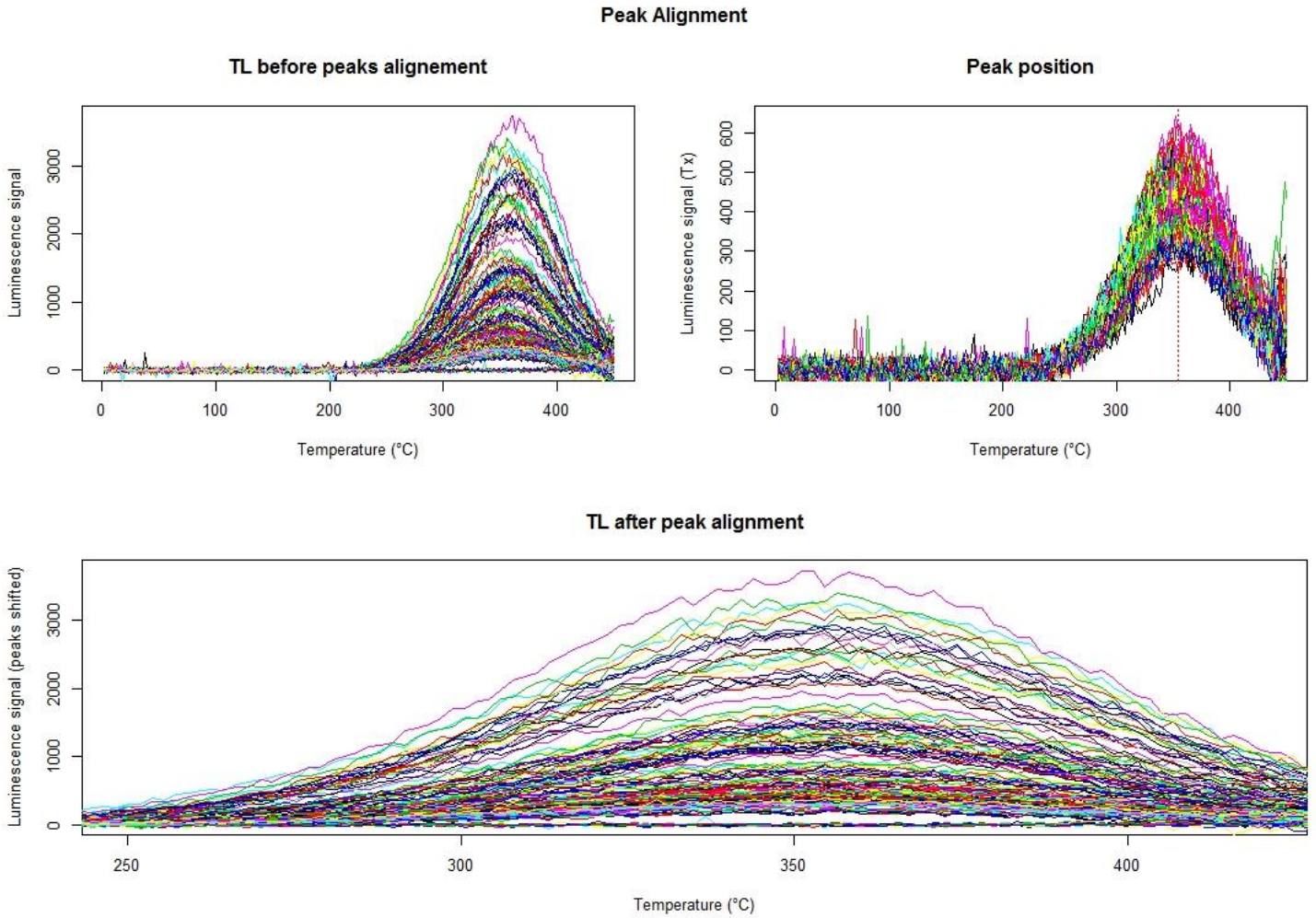
- Curves selection
- **Preheat removal**
- Background subtraction
- Peak alignment
- D_e estimation
  - SAR
  - MAAD

Burnt flints dating: Background subtraction



- Curves selection
- Preheat removal
- **BG subtraction**
- Peak alignment
- D_e estimation
  - SAR
  - MAAD

Burnt flints dating: Peak alignment



Curves selection

Preheat removal

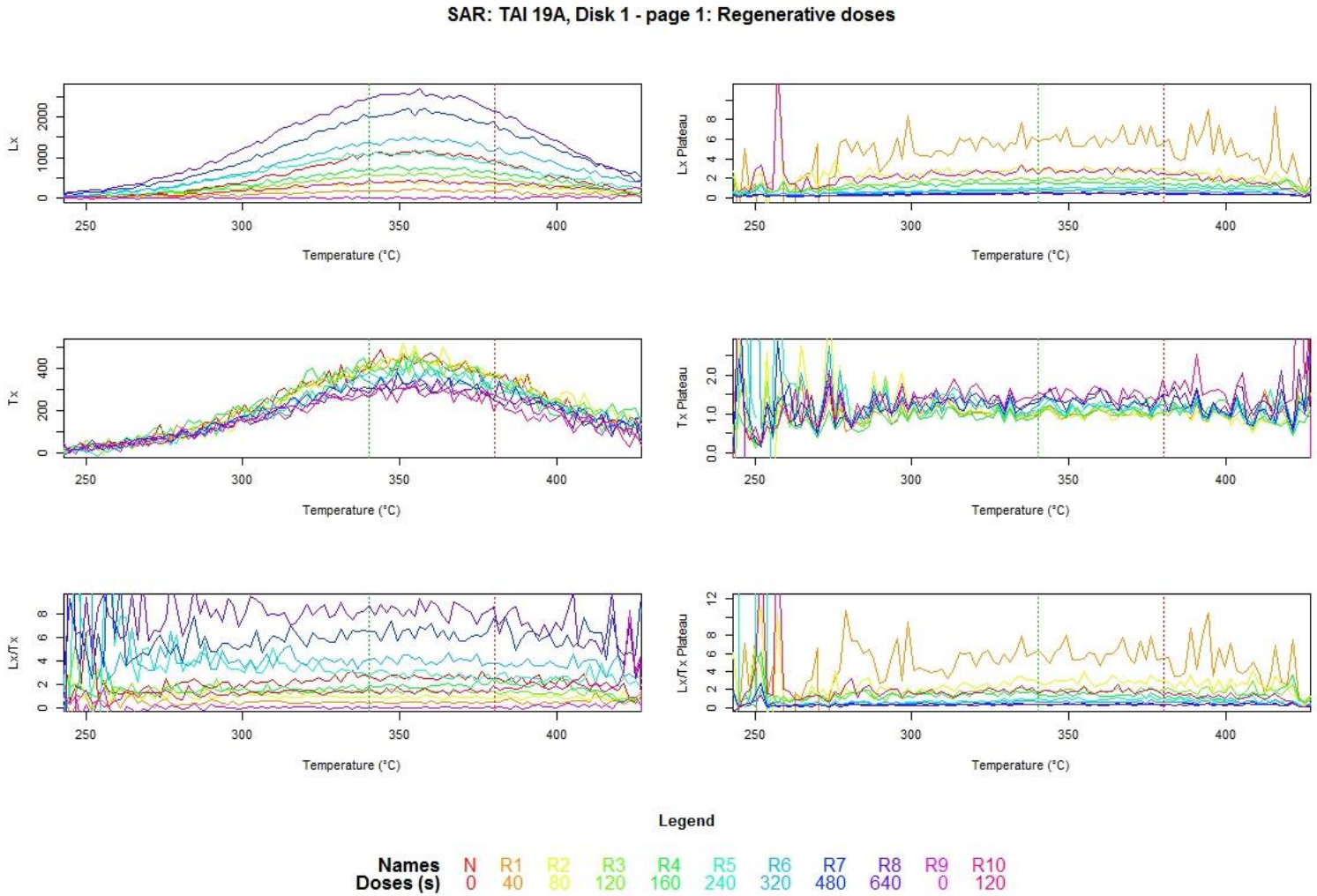
Background subtraction

Peak alignment

D_e estimation

SAR | MAAD

Burnt flints dating: SAR 1



Curves selection

Preheat removal

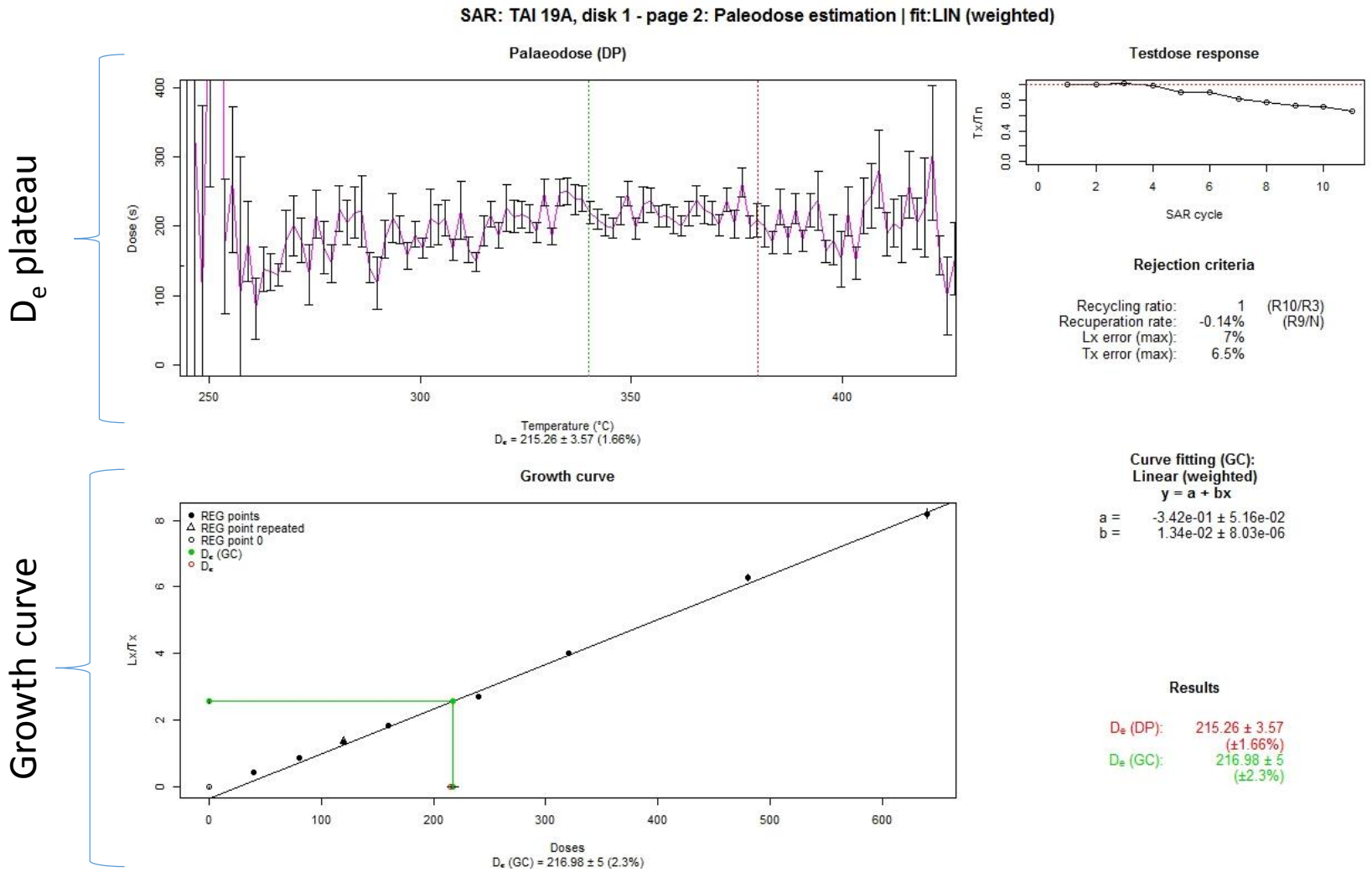
Background subtraction

Peak alignment

D_e estimation

SAR	MAAD

Burnt flints dating: SAR 2

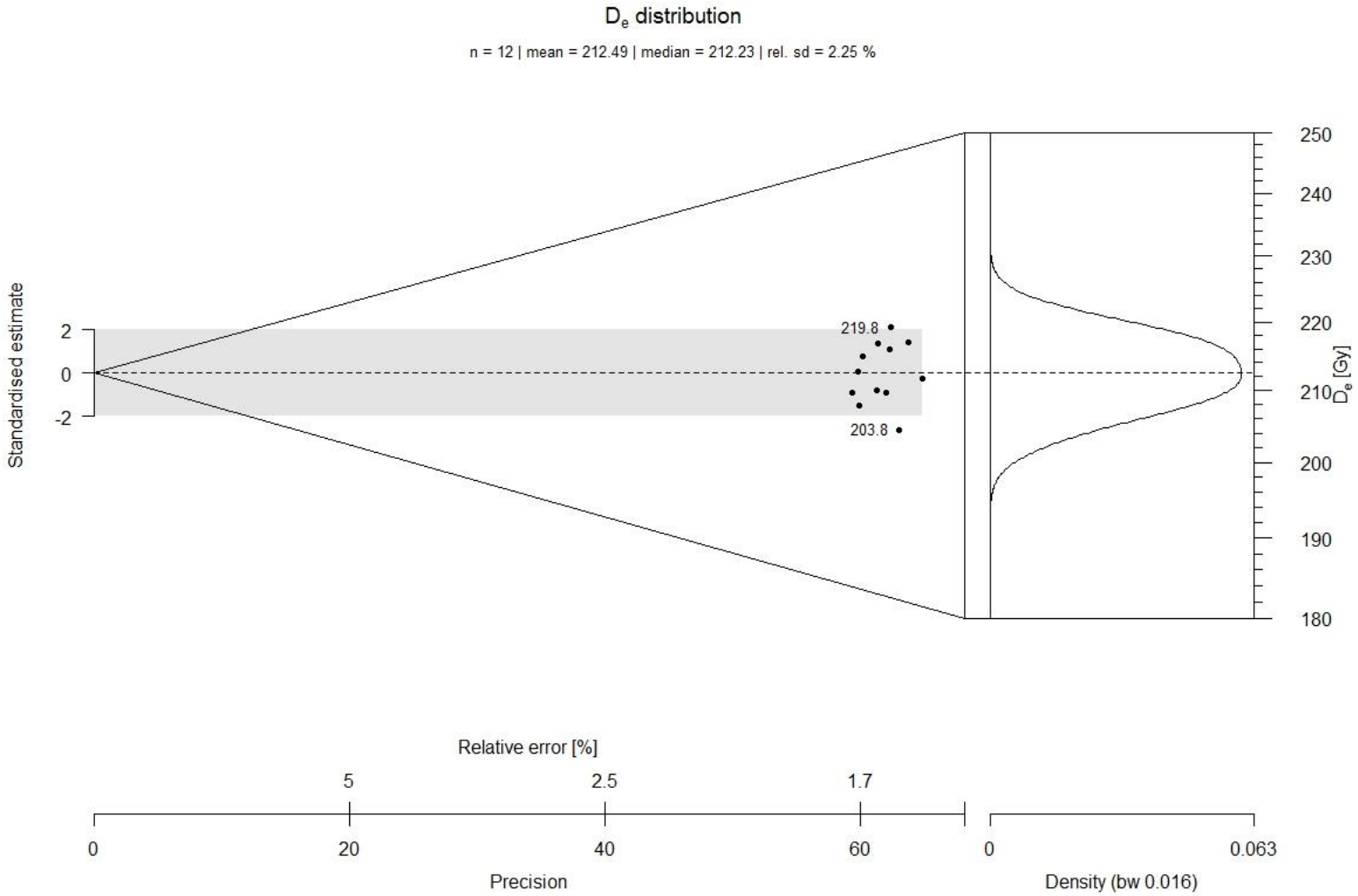


D_e plateau

Growth curve

- Curves selection
- Preheat removal
- Background subtraction
- Peak alignment
- **D_e estimation**
  - **SAR** | MAAD

Burnt flints dating: D_e distribution



Curves selection

Preheat removal

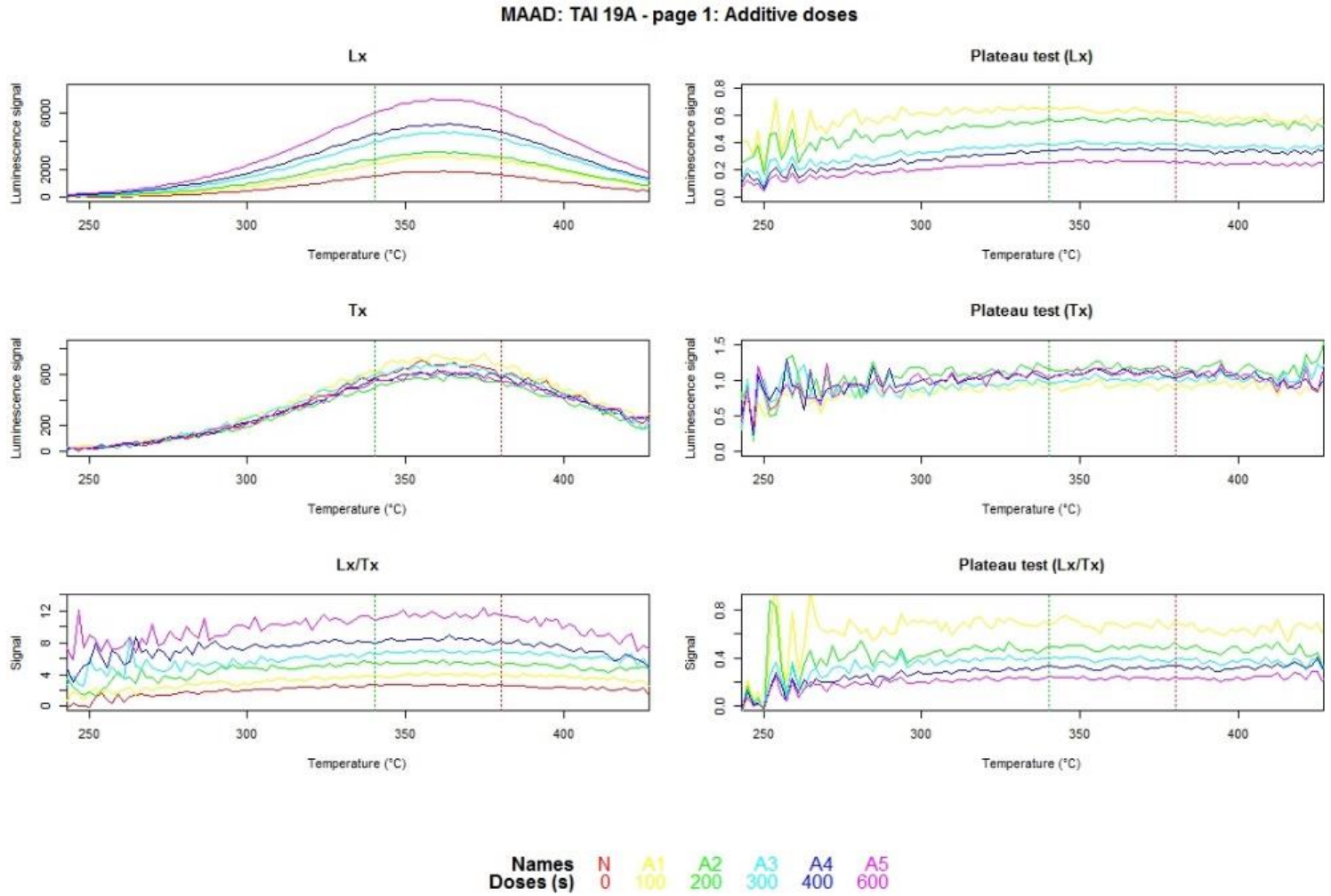
Background subtraction

Peak alignment

D_e estimation

SAR | MAAD

Burnt flints dating: MAAD 1



Curves selection

Preheat removal

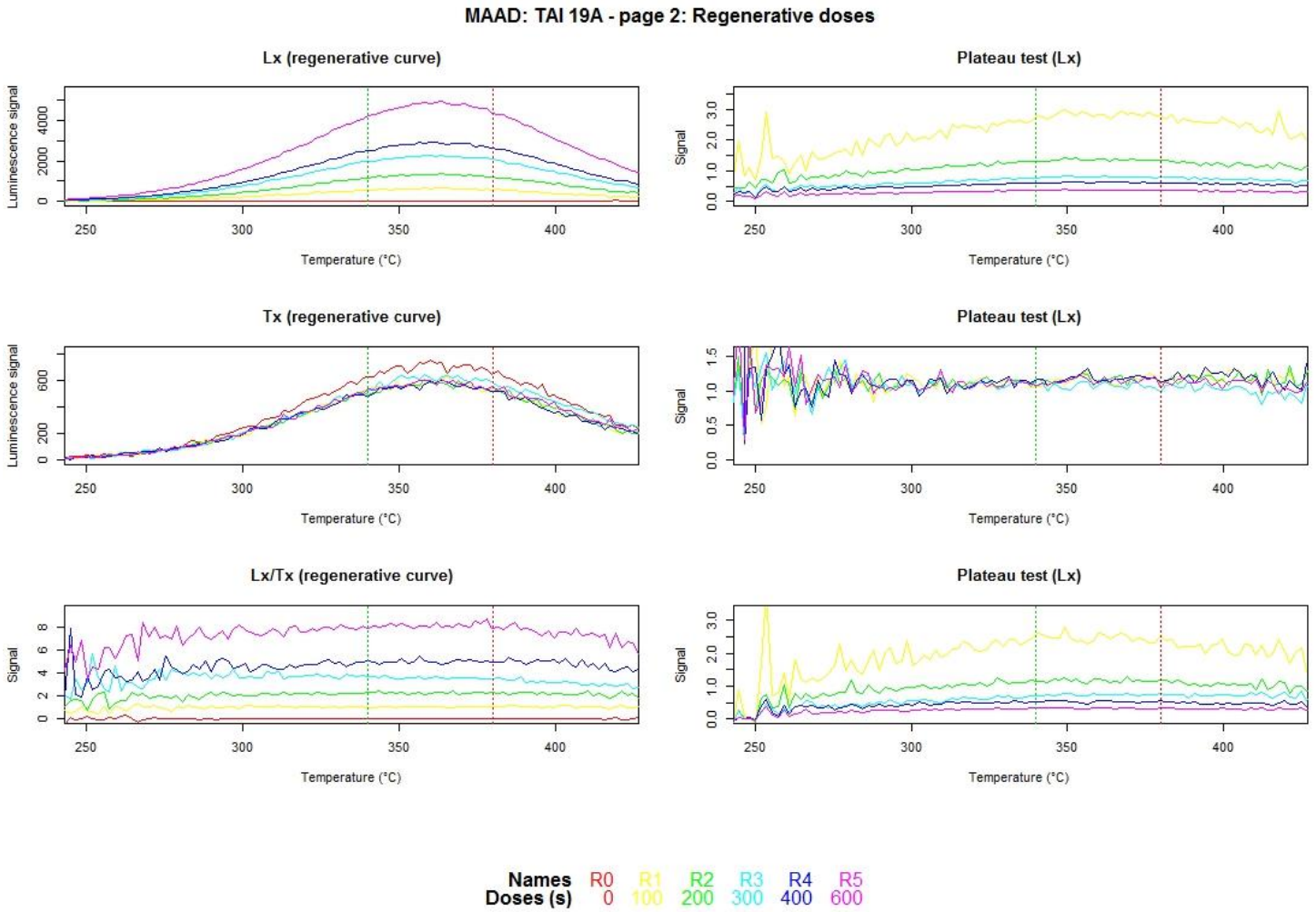
Background subtraction

Peak alignment

D_e estimation

SAR | **MAAD**

Burnt flints dating: MAAD 2



Curves selection

Preheat removal

Background subtraction

Peak alignment

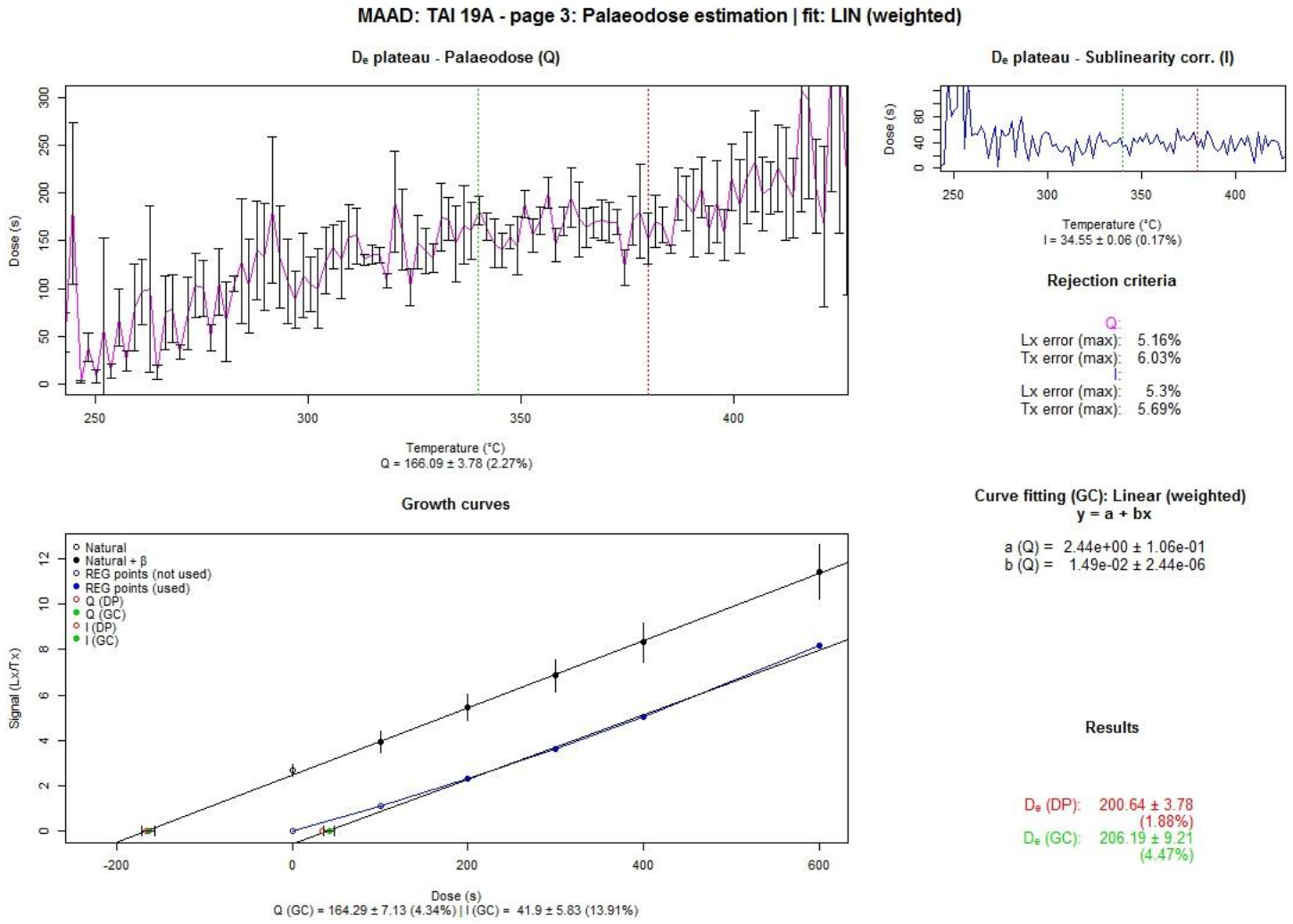
D_e estimation

SAR | **MAAD**

Burnt flints dating: MAAD 3

D_e plateau

Growth curve



Curves selection

Preheat removal

Background subtraction

Peak alignment

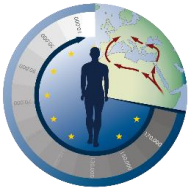
D_e estimation

SAR | **MAAD**

Burnt flints dating: first results

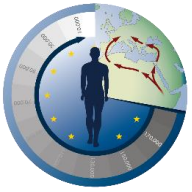
- Difference between SAR-TL and MAAD-TL generally < ±5%
- For SAR-TL: variation < ± 2%
  - Between DP and GC approaches.
  - Between weighted and unweighted linear fitting.
- For MAAD-TL: variation from ±1% to ±20%
  - Probable sources of variation
    - Sublinearity correction estimation
    - Low maximum additive dose

- Both SAR-TL **and** MAAD-TL provide reliable results
- SAR-TL
  - Pro: less material
  - Contra: more machine time
- MAAD-TL
  - sublinearity correction
- DP helps to select the temperature interval
- GC help to select the dose interval.



Conclusion & Outlook

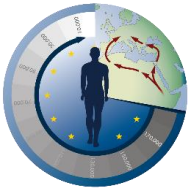
- *TLdating* package still in active development
  - Known bugs
    - Usage of Q slope for I estimation (MAAD).
  - Need improvements
    - Increase *user-friendliness*
    - Add additional fitting models
    - Improve documentation
  - **But**: it is already fully functional and open for use!
- Looking for beta-tester!
  - What functionality would you like to see implemented?



Acknowledgment

- We would like to thank Christoph Schmidt, who collected the flint samples, and Anja Zander, who provides extra TL curves to test the package.

- This project was realized in the context of the CRC 806 “Our way to Europe” funded by the German Research Foundation (DFG).



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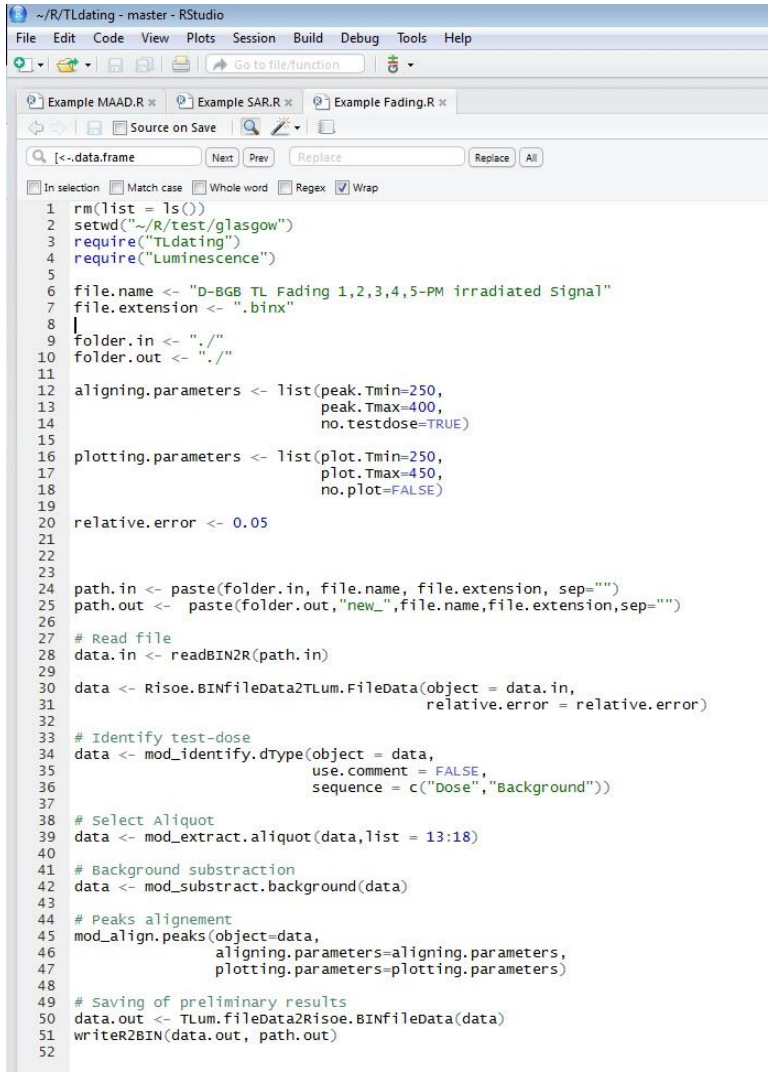
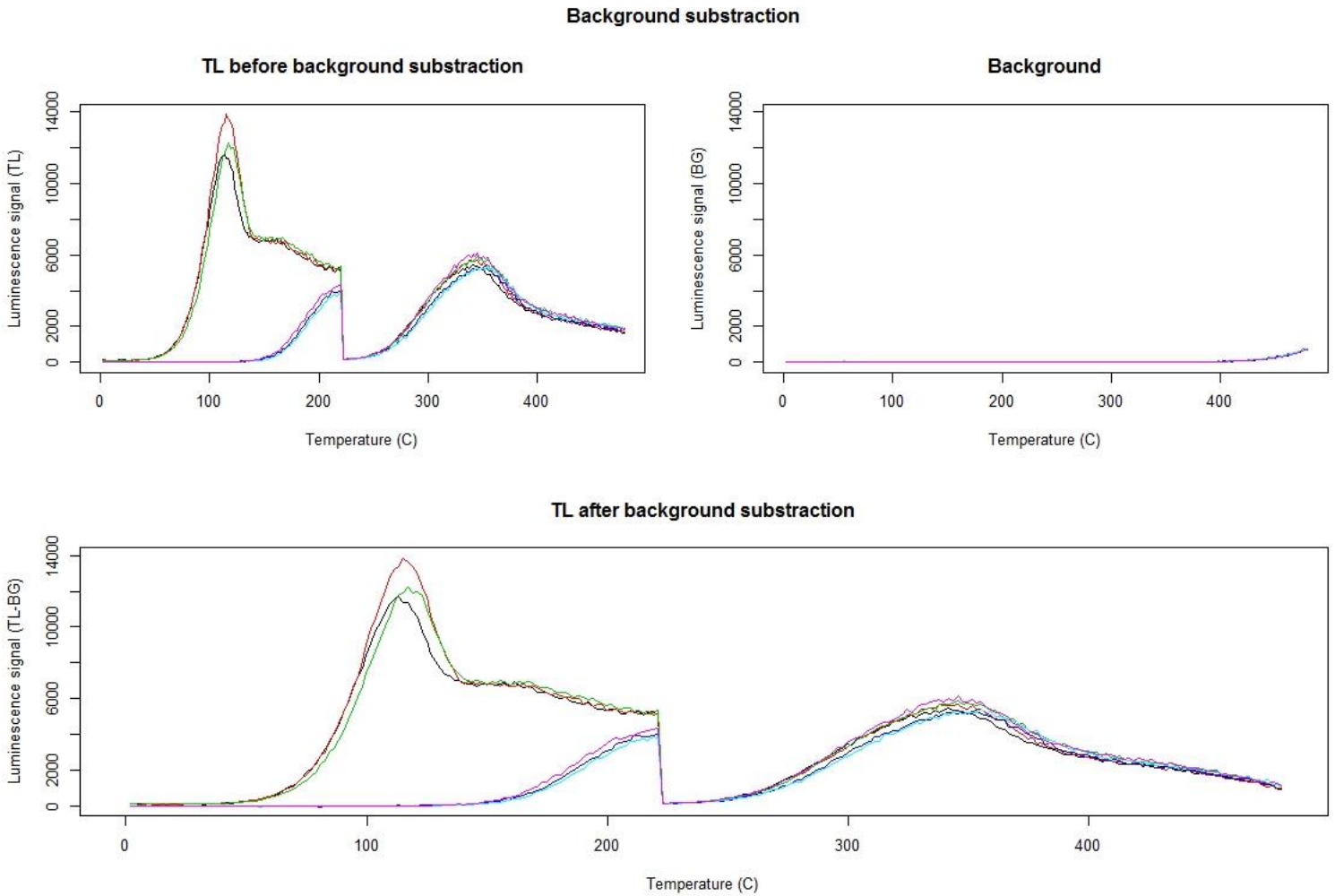
Extra

Application: Looking for Fading



Extra: Looking or Fading



Extra: Looking or Fading