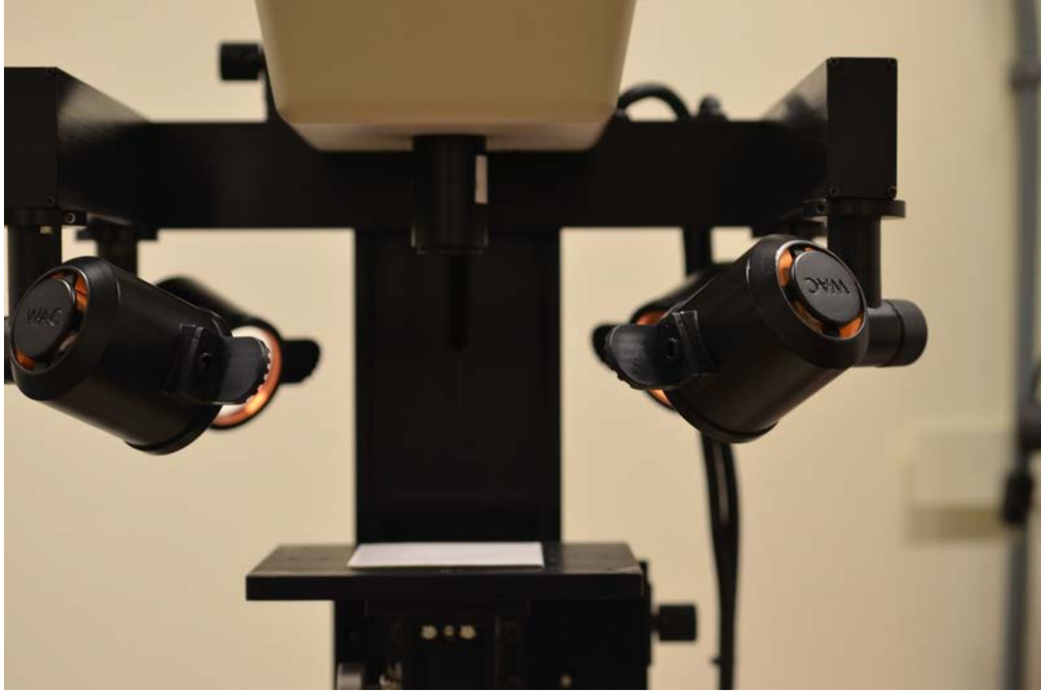
Overview

1. Historical overview, spectroscopic and sampling principles

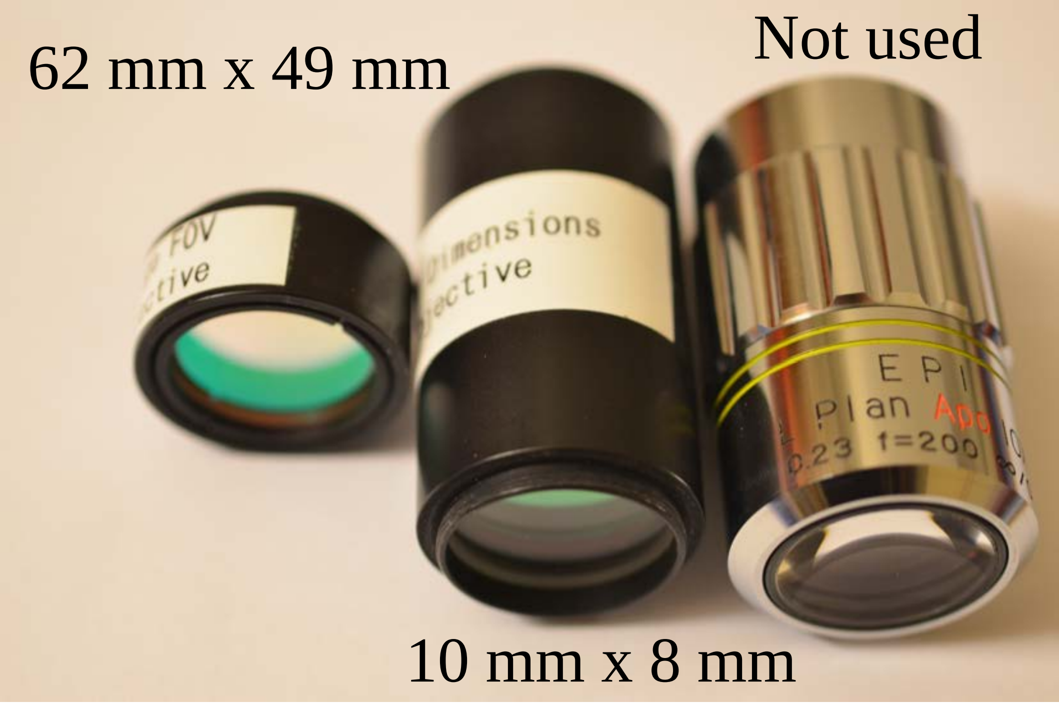
2. Instrumentation with small examples

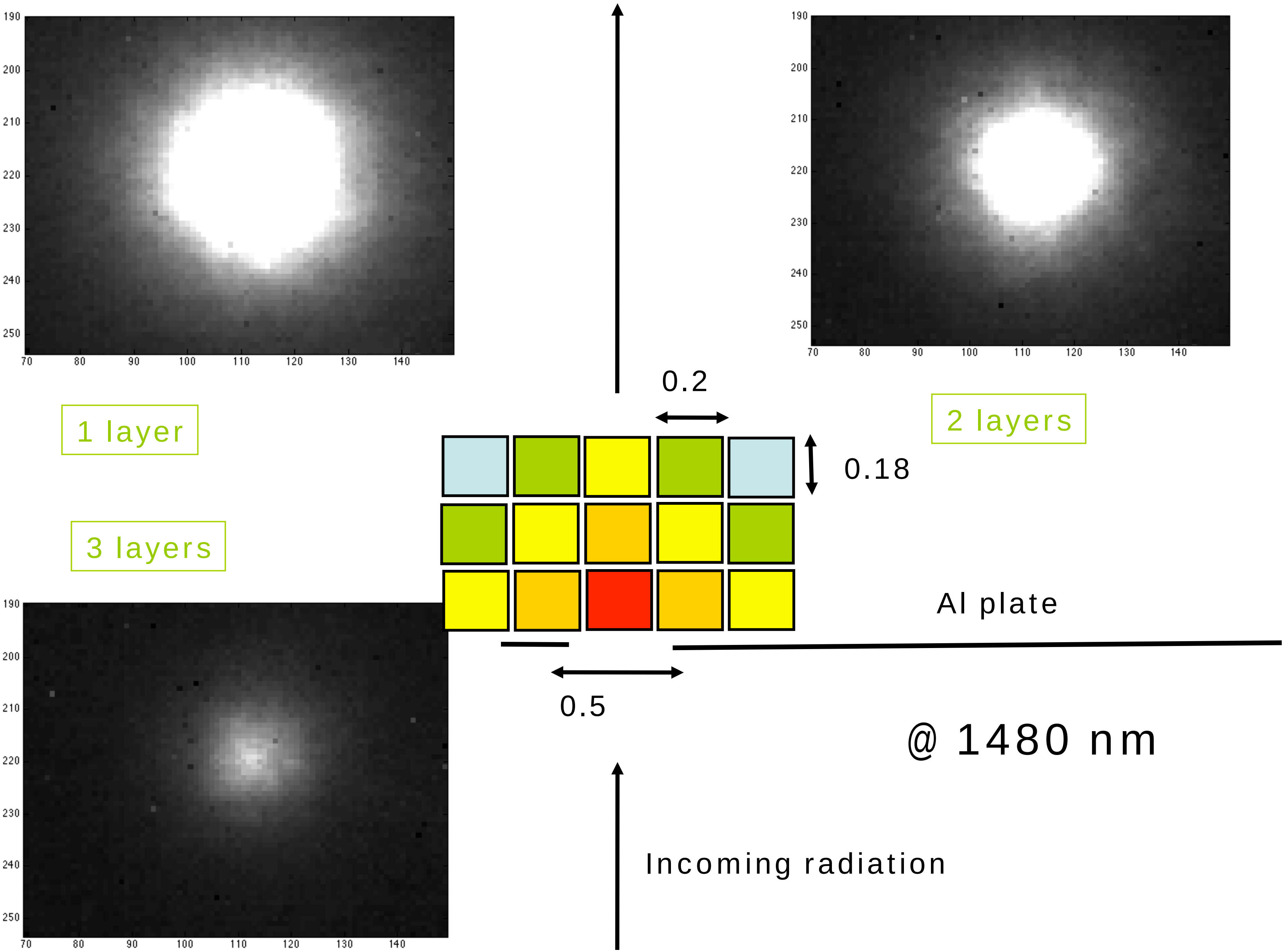
3. Sampling and 3D aspects of Hyperspectral imaging

Penetration depth

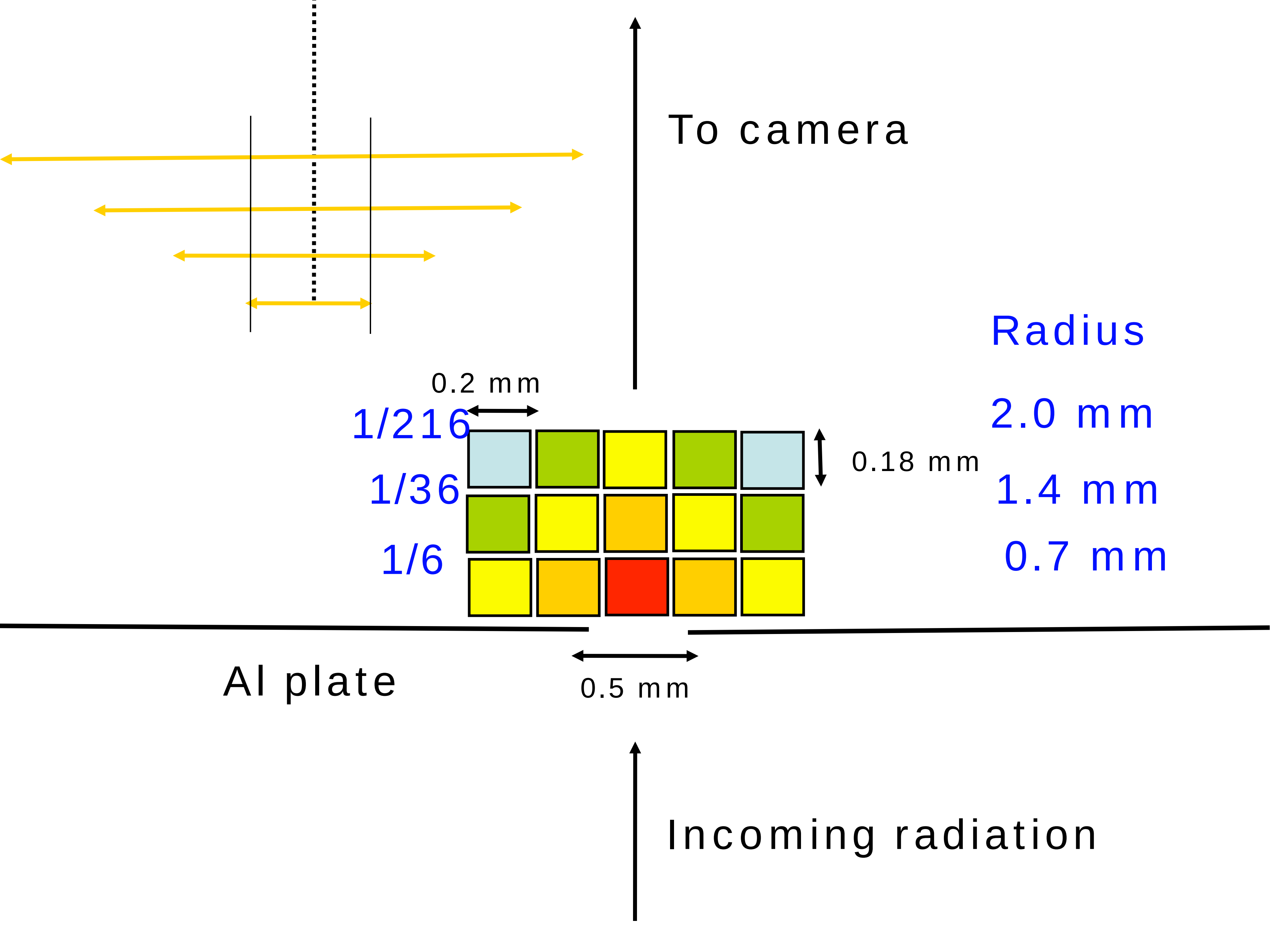


See also
Geladi JNIRS 2008





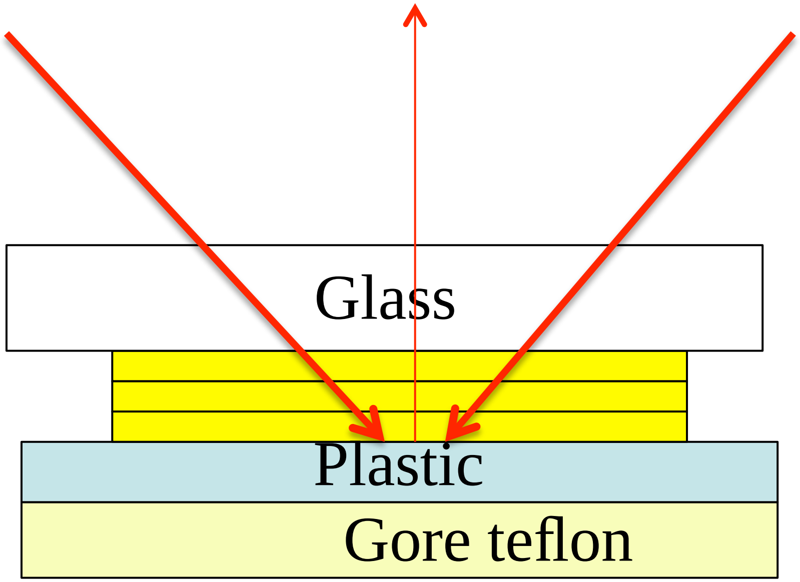
1 layer
2 layers
3 layers
0.2
0.18
0.5
Al plate
@ 1480 nm
Incoming radiation
190
200
210
220
230
240
250
70
80
90
100
110
120
130
140

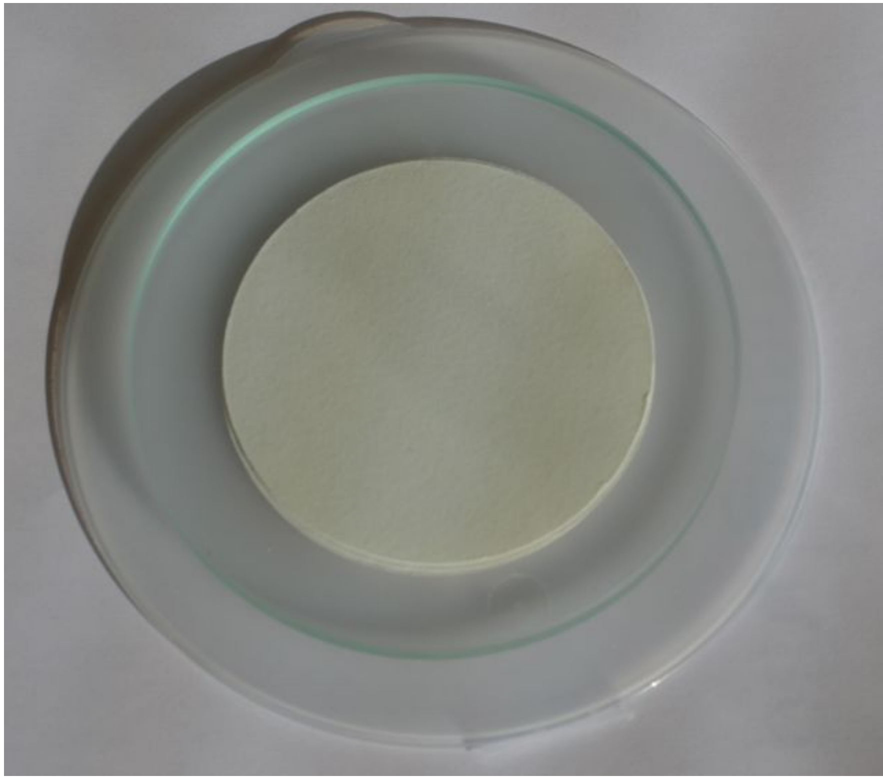

To camera
Radius
0.2 mm
1/216
2.0 mm
0.18 mm
1/36
1.4 mm
1/6
0.7 mm
Al plate
0.5 mm
Incoming radiation

Matrix NIR

- InGaAs camera 960:6:1662 nm
- LCTF filter
- Objectives give 49 mm x 62 mm images of 256x320 pixels (or 8mm x10 mm images)
- 32 ms integration time and 16 x averaging
- Ilumination 4 quartz halogen lamps
- Closed shutter (dark) and Gore teflon (white)
- Pseudo Absorbance

Filter papers on plastic (Gore teflon under)





See also
Esbensen, Geladi, Larsen
NIR news 20012

Filter papers on plastic

- CD box in PP/PE (marked spectrum)
- Pure cellulose filter paper (cellulose spectrum)
- 1 to 4 filter papers (thickness 0.18 mm)
- Glass plate to press it together

- QUESTION: when do we
- see only the cellulose spectrum?
- When are the black texts
- unreadable?
- What about the injection
- moulding spot?

When do we see only cellulose?

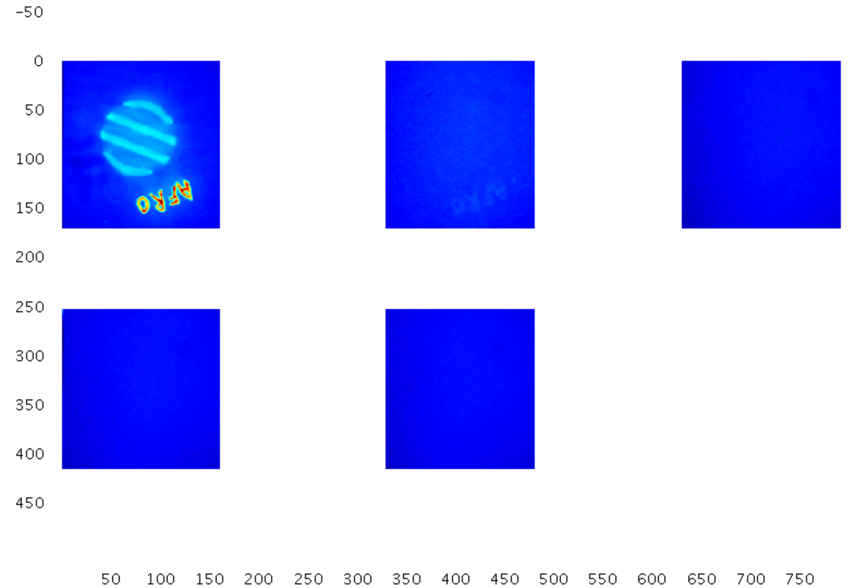
-Do not look at spectra

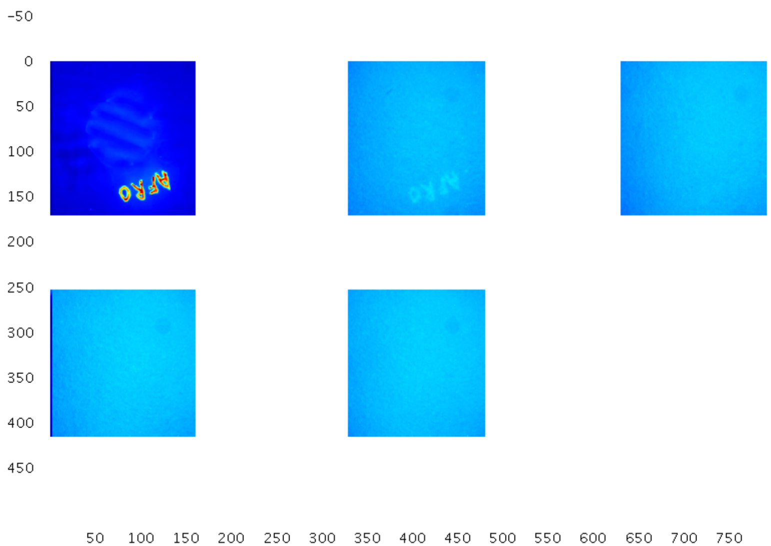
-Multivariate analysis is superior

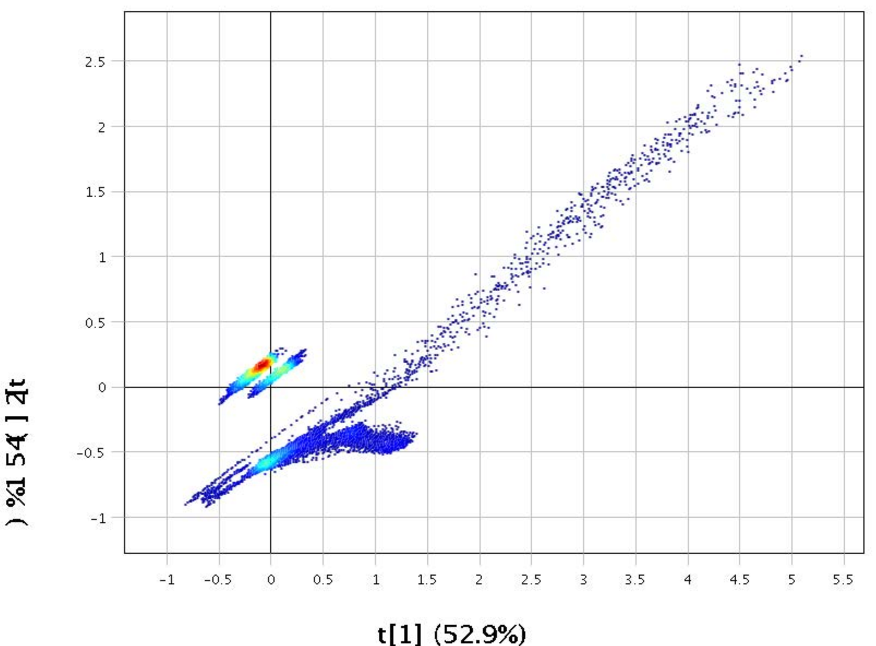
-Look at loadings or spectra AFTER analysis

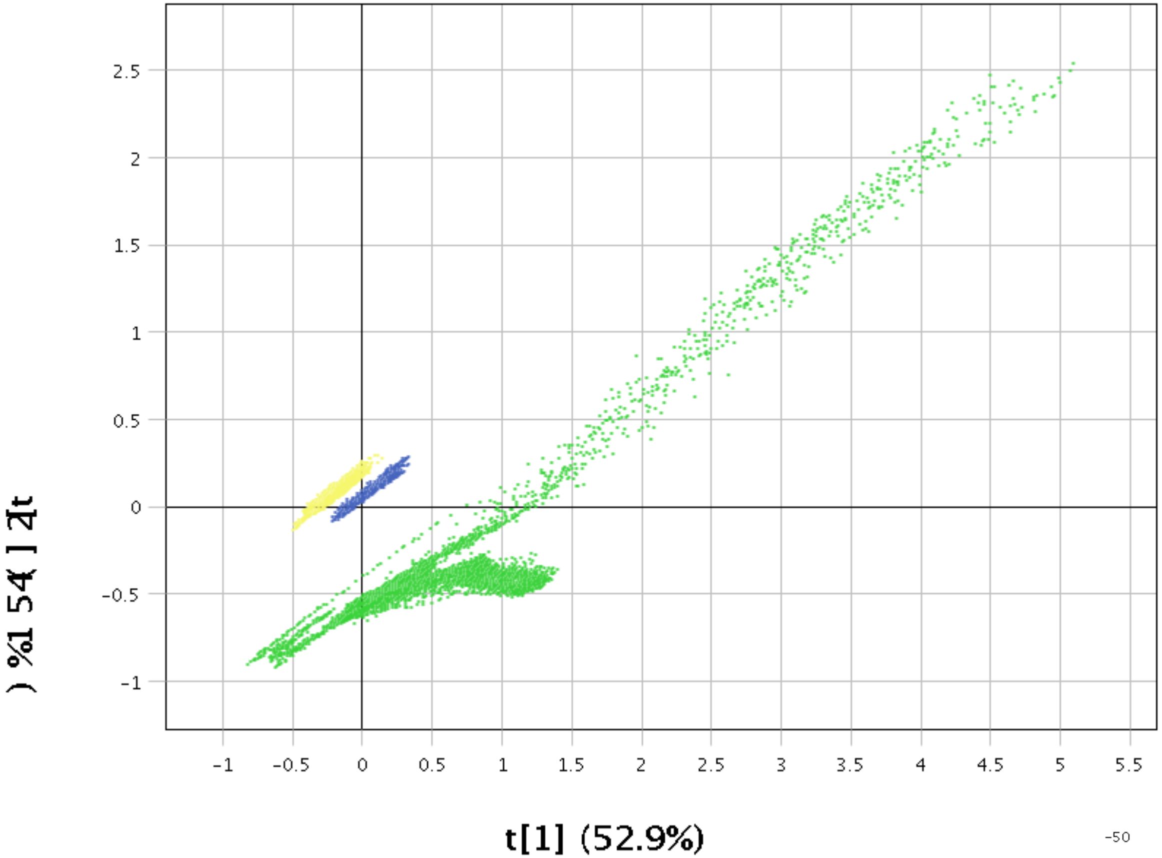
Cellulose vs plastic

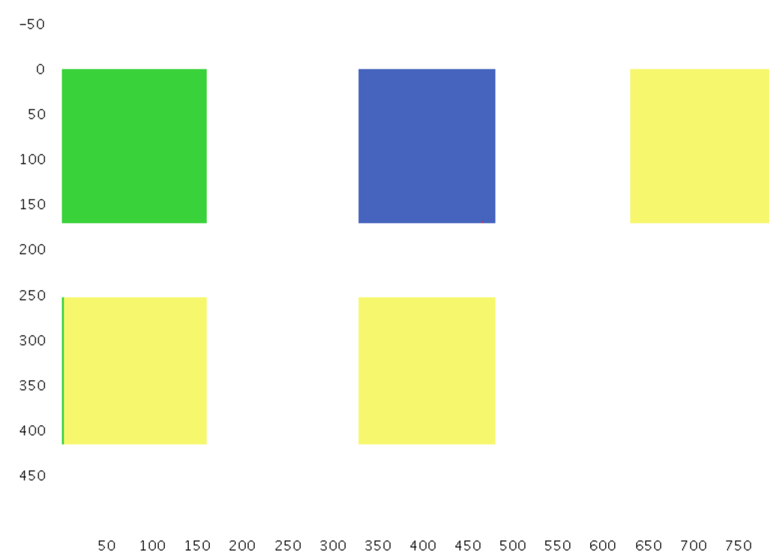
- PC1 and PC2



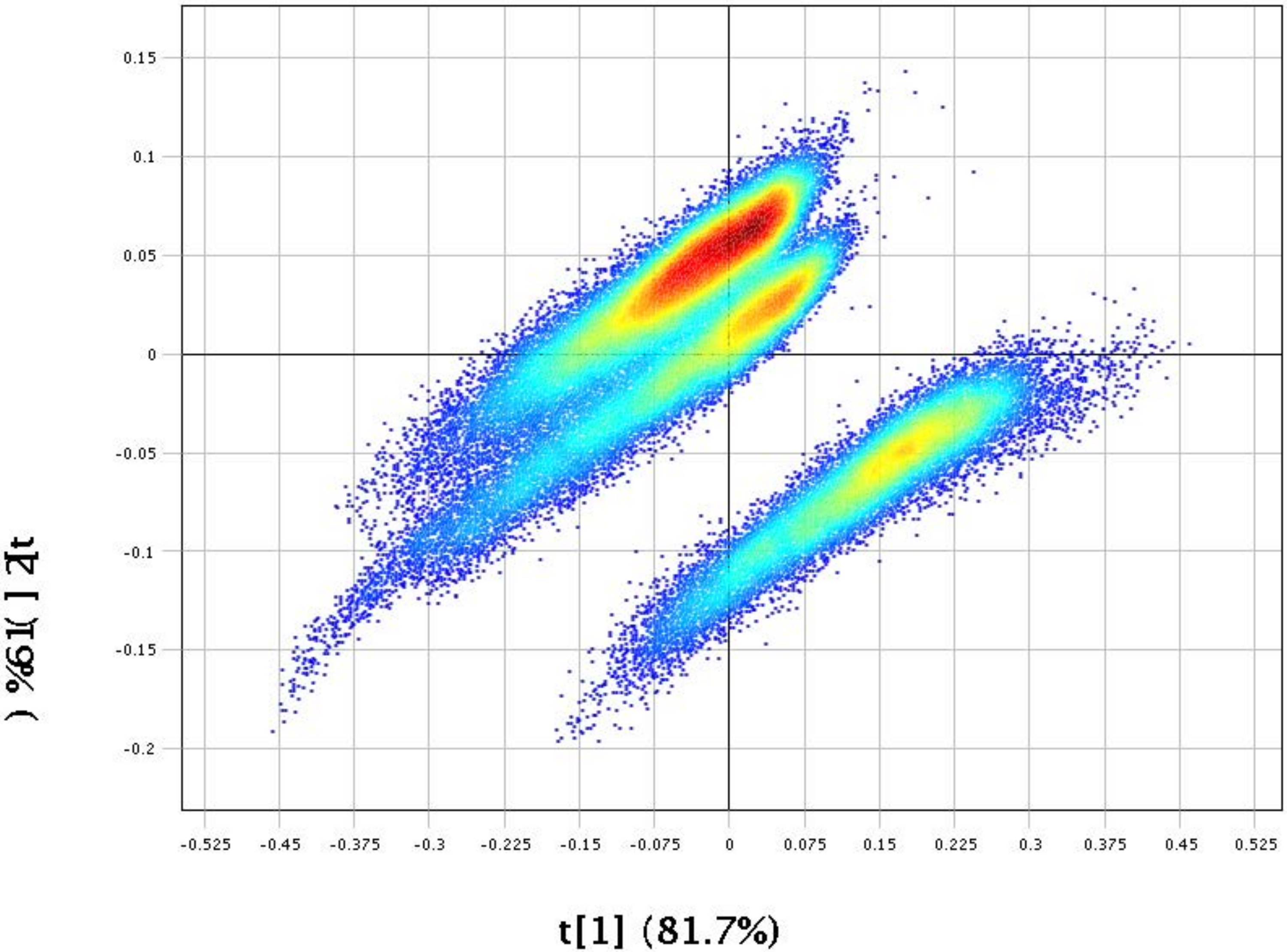


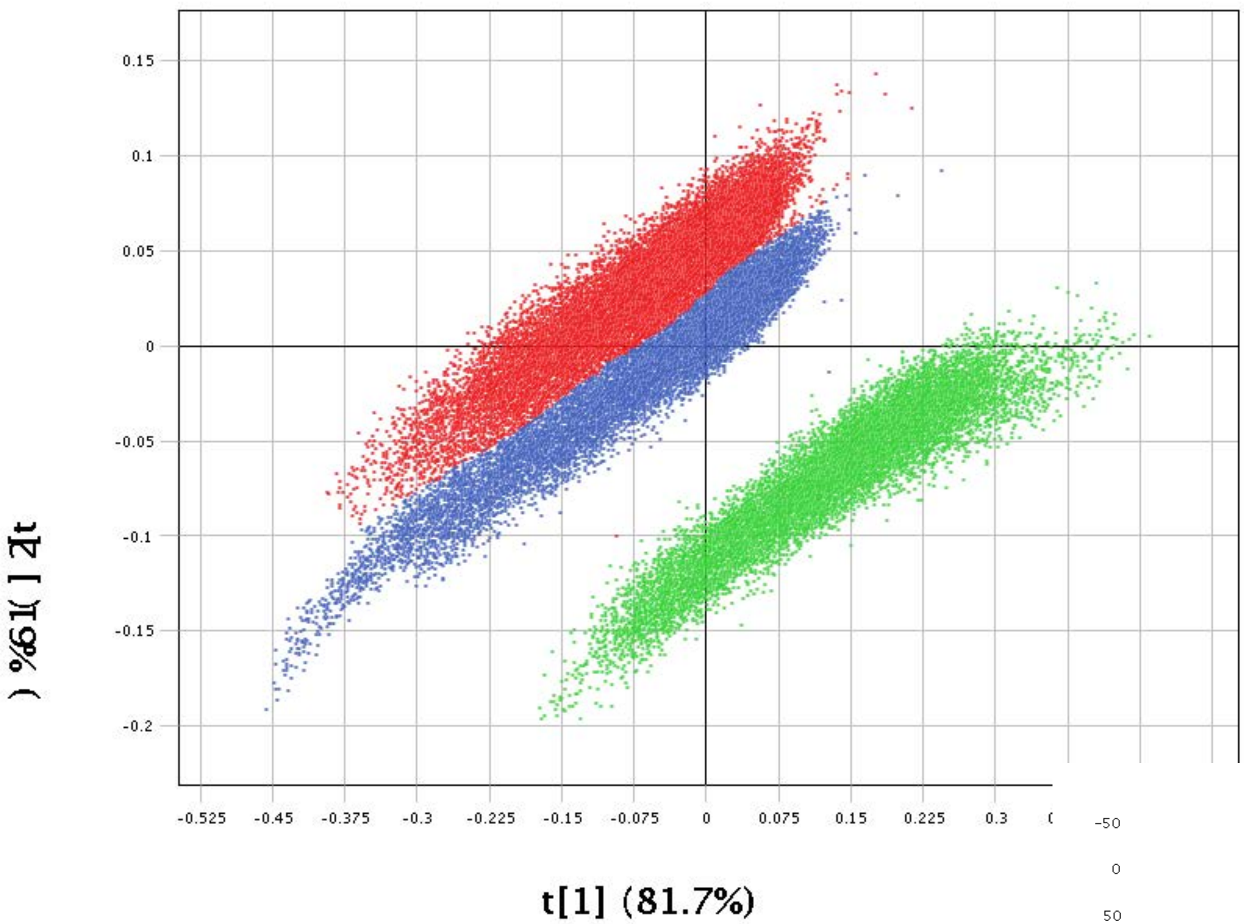


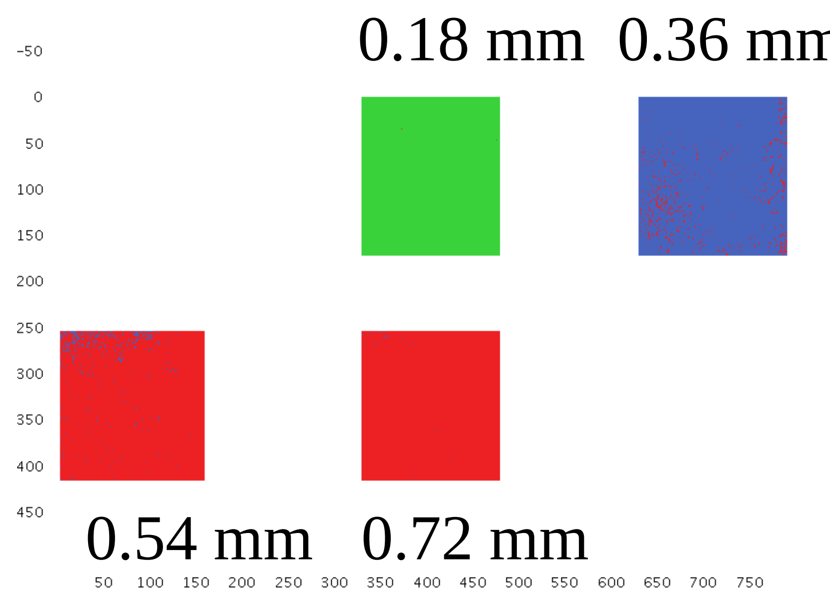

t[1] (52.9%)
2.5
2
1.5
1
0.5
0
-0.5
-1
-1
-0.5
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5


-50
0
50
100
150
200
250
300
350
400
450
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750

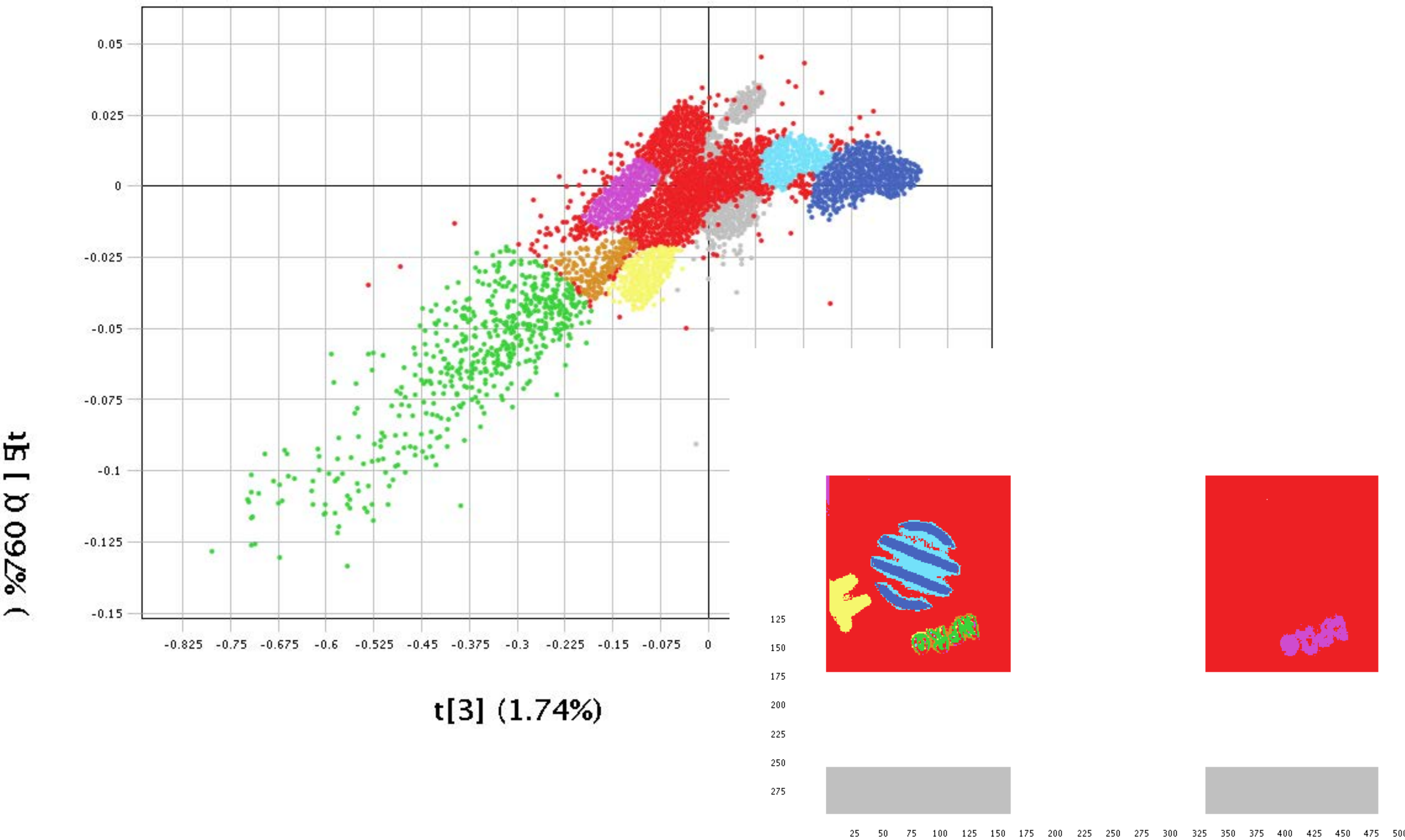
Remove plastic to reveal details in others



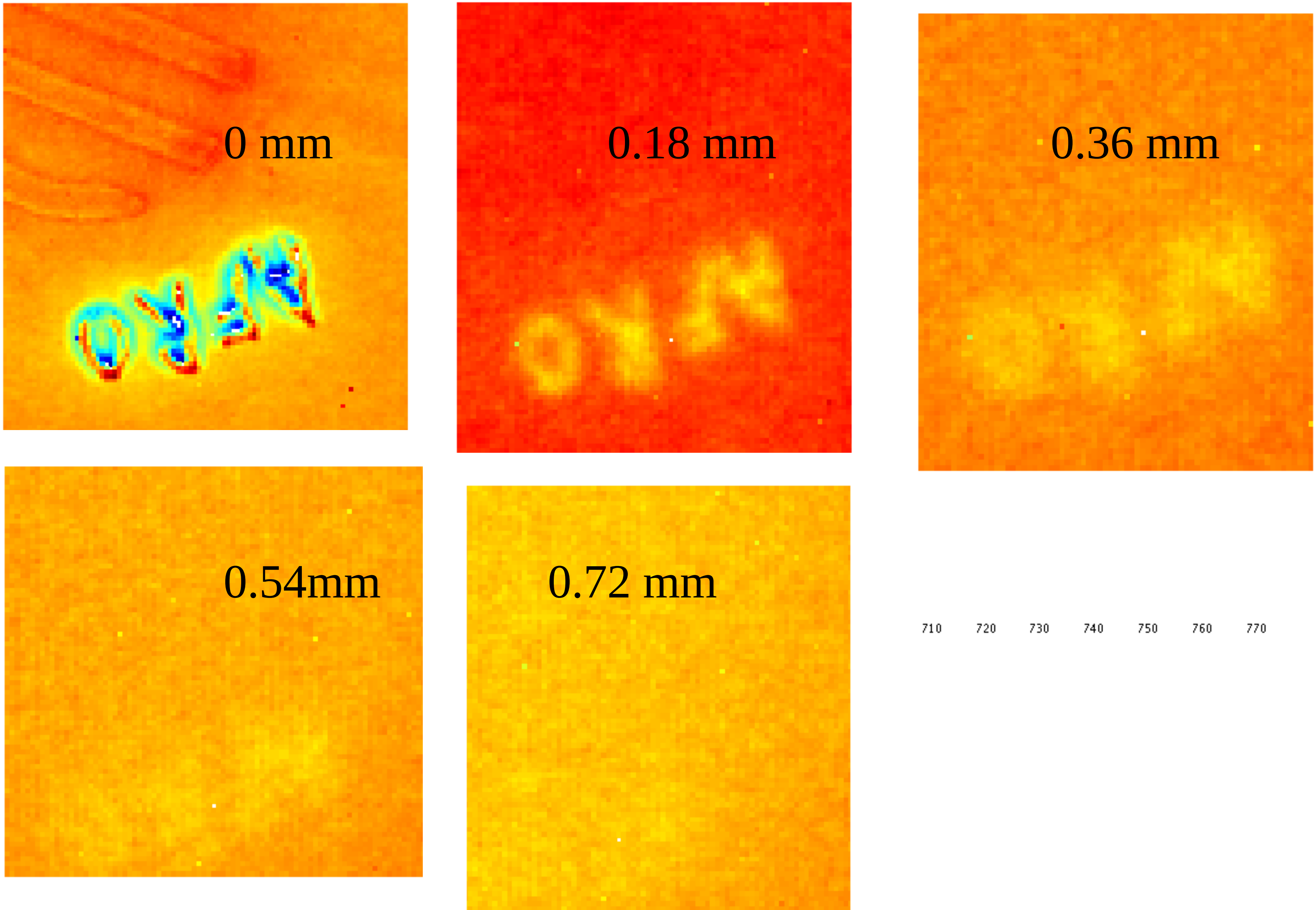

0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.525
-0.45
-0.375
-0.3
-0.225
-0.15
-0.075
0
0.075
0.15
0.225
0.3
t[1] (81.7%)


0.18 mm
0.36
0.54 mm
0.72 mm

Text/injection moulding in T3T5



The text “Afro” in T5



Local conclusions

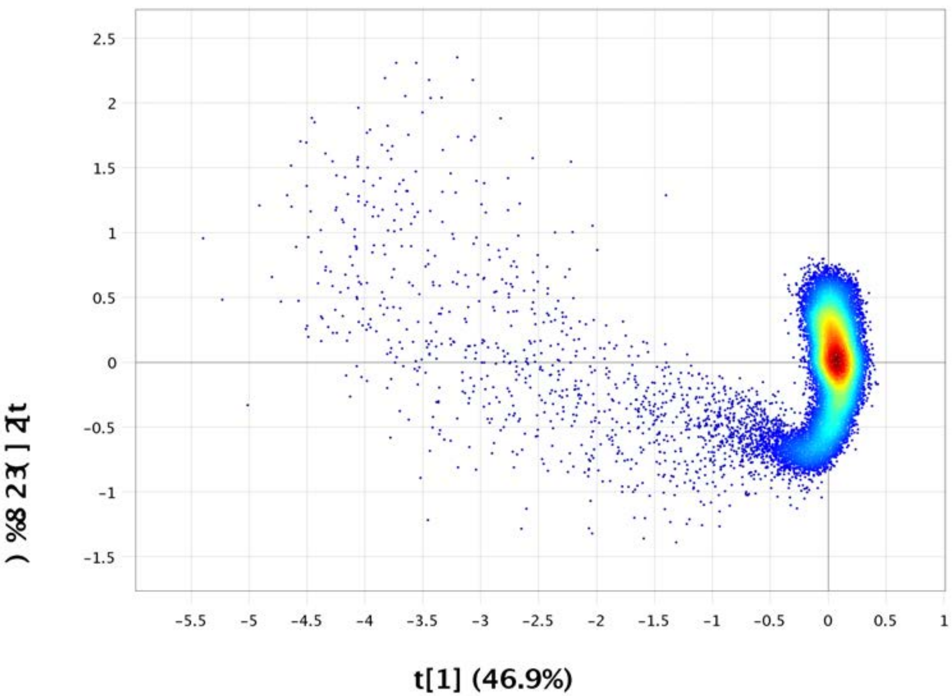
- After 0.50 to 0.75 mm no penetration in cellulose
- Text unreadable because of sideways diffusion after 0.50 mm

Wedge of pinewood

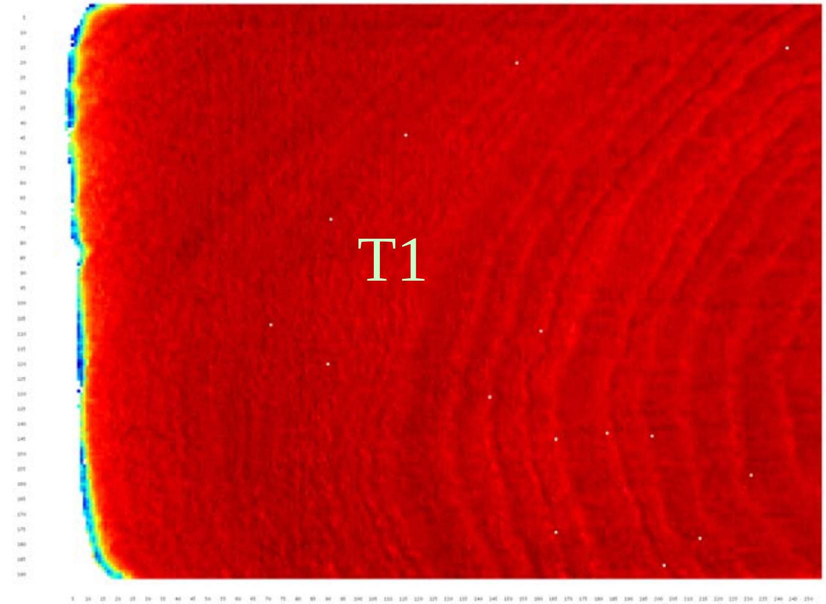
Unpublished

Wedge

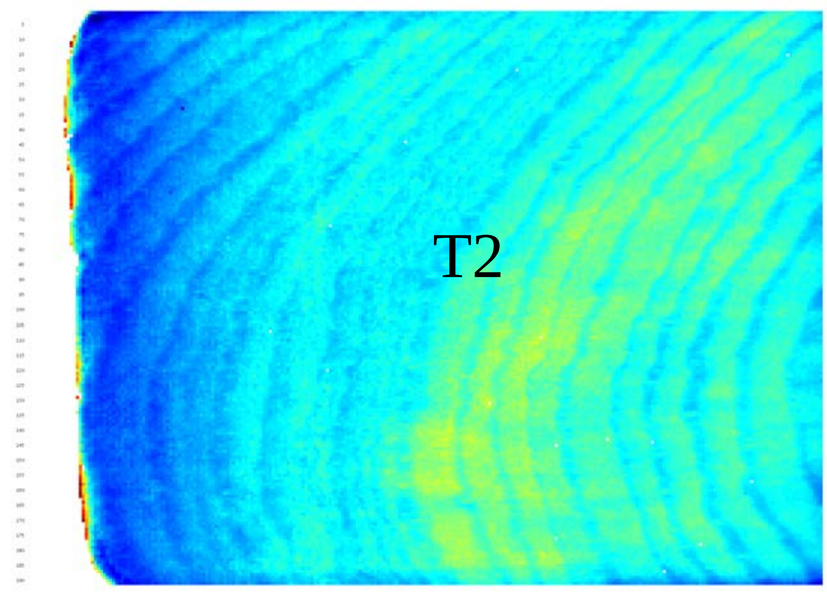
- Wedge on PP/PE cropped
- Cleaning in 4 comp.
- 52473 pixels left
- MC + SNV



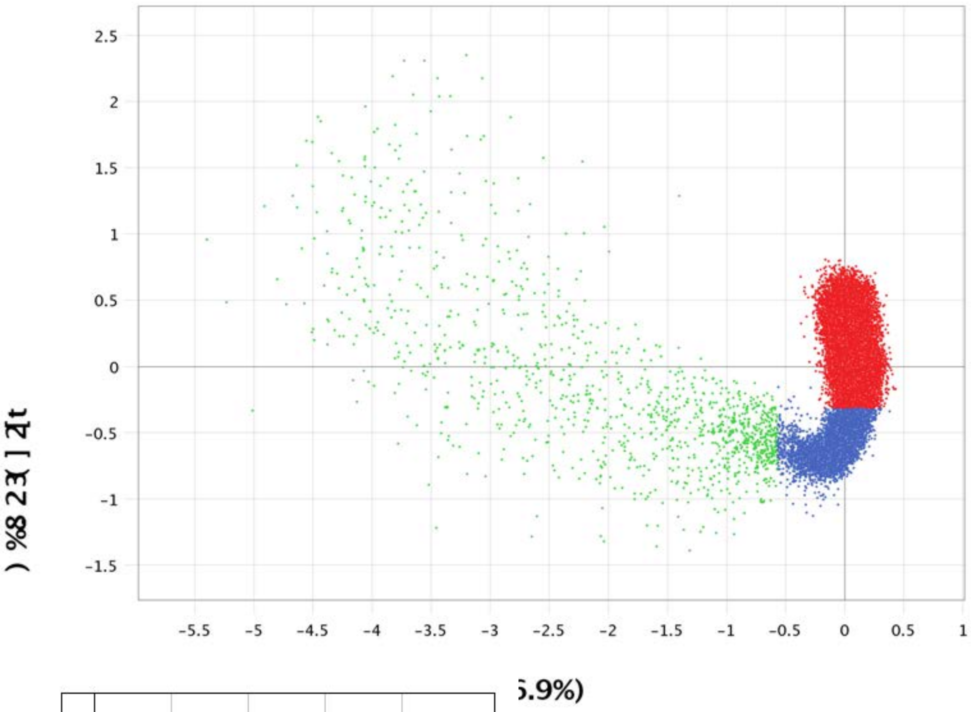
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
-5.5 -5 -4.5 -4 -3.5 -3 -2.5 -2 -1.5 -1 -0.5 0 0.5 1
t[1] (46.9%)

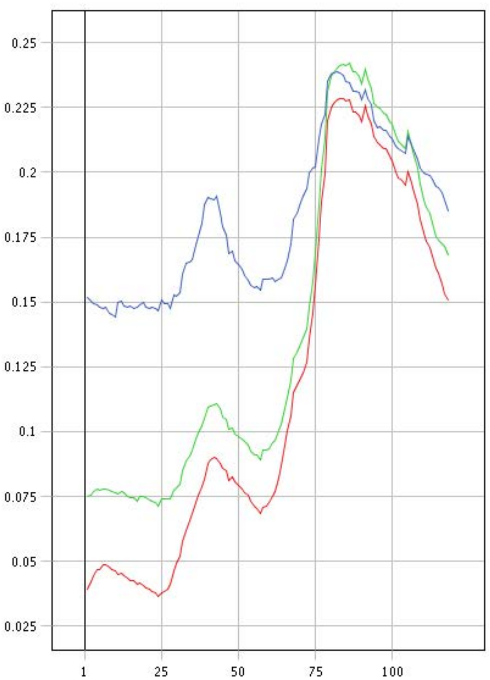


T1



T2

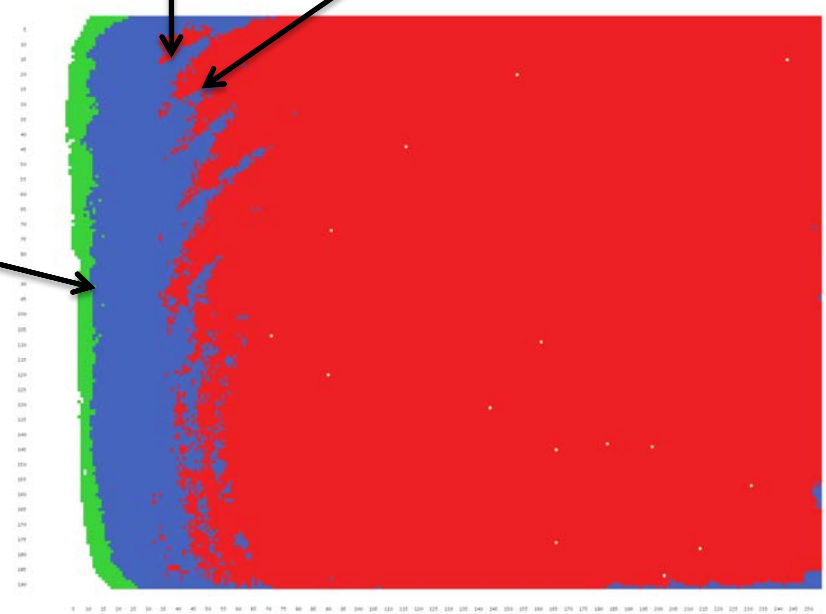




Caliper results 1.3 mm

6.4 mm wide
1.2 mm deep

1.2 mm wide
0.2 mm deep



Conclusions wood

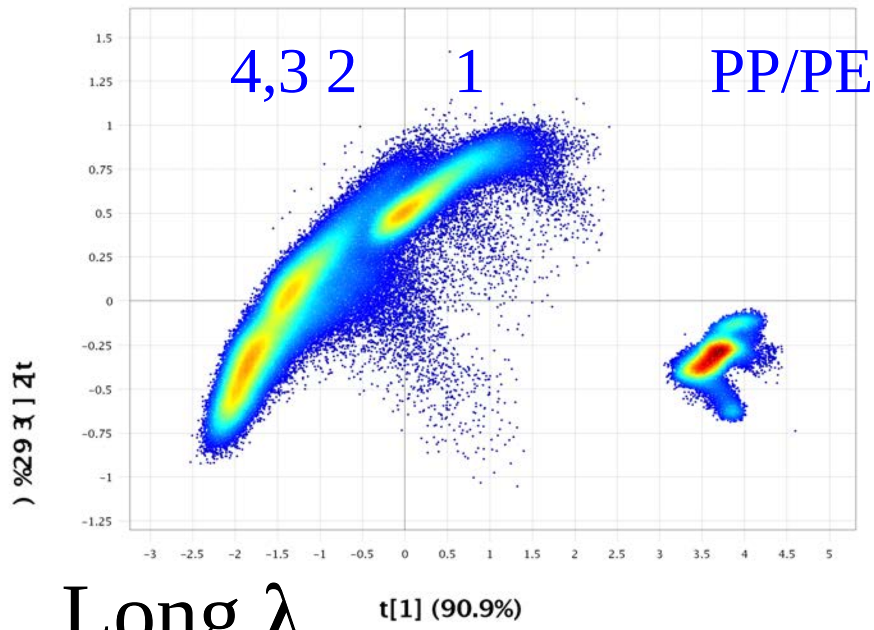
- Very transparent 0.2 mm
- Slightly transparent 1.2 mm
- Much sideways diffusion

The dillemma of imaging

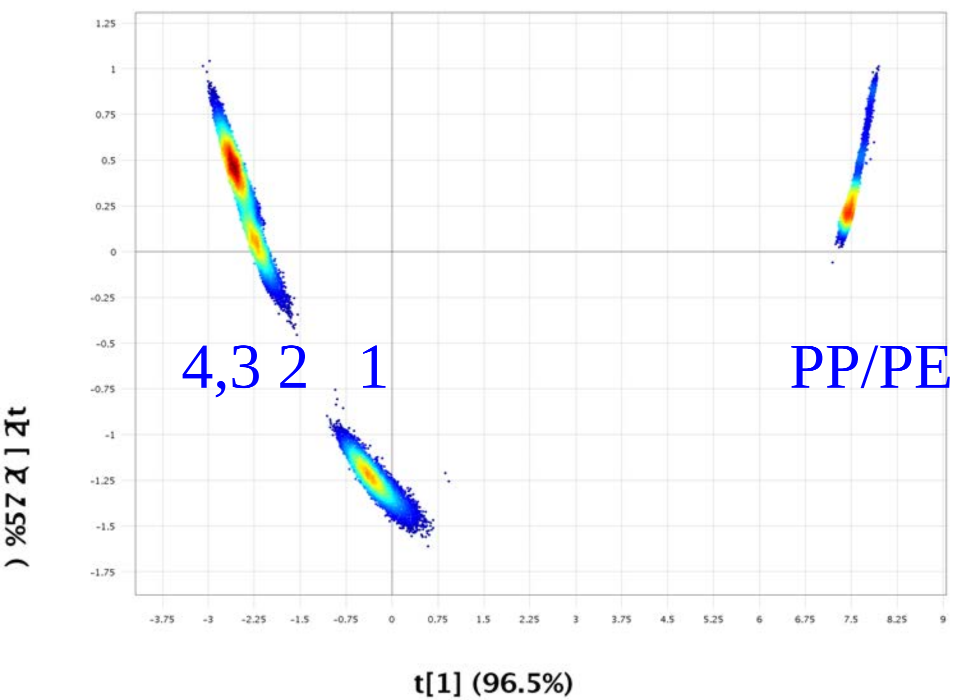
- If a pixel in the data represents a voxel in the material exactly, the measurement is superficial
- If there was penetation depth, the pixel in the data represents a much bigger voxel in the material and neighboring pixels are correlated

Is penetration wavelength dependent?

- 960-1350 nm
- 1356-1662 nm
- Filter paper example



Short λ Long λ



Conclusions

- Penetration depth can be measured
- Multivariate analysis helps a lot
- Cellulose up to 0.75 mm
- Wood 1.3 mm
- Wavelength dependent

- Similar results from Sisuchema 1000-2498 nm

Conclusions penetration depth

- Distance to lens has influence
- Surface topology has influence
- Surface roughness has influence

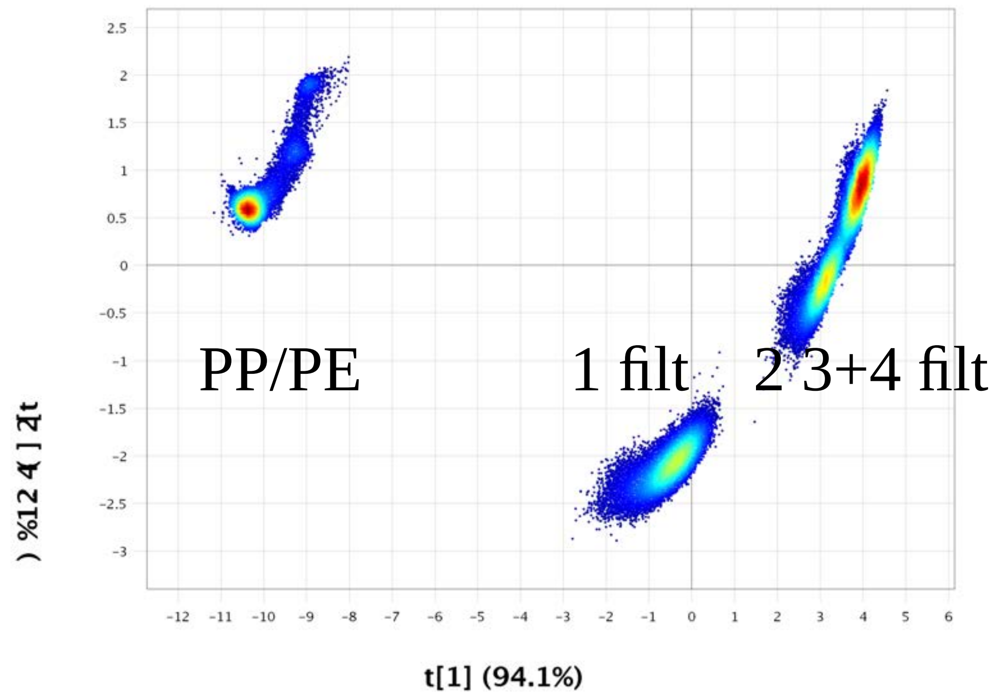
- This is a difficult topic
- Avoided in many publications

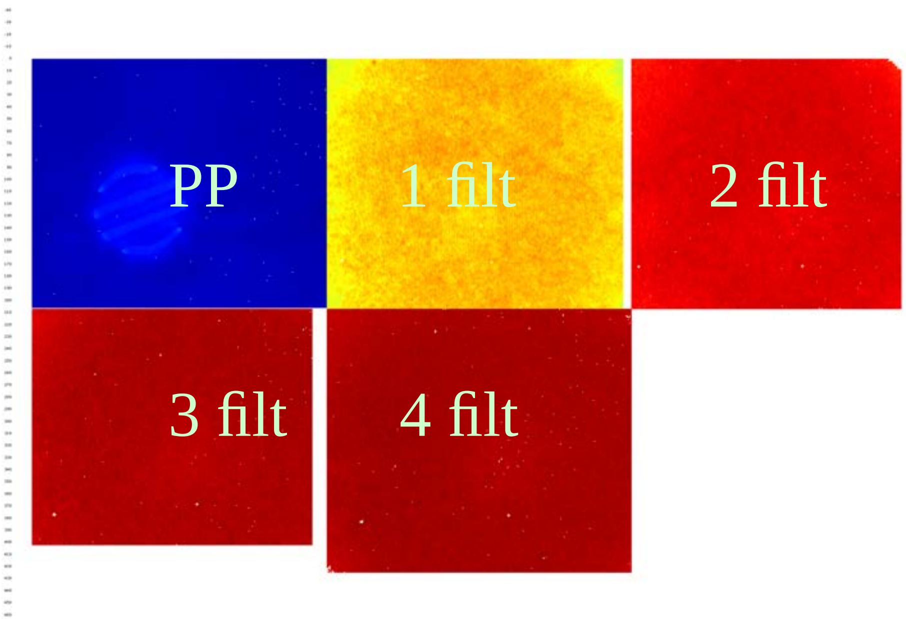
Conclusions in general

- No advanced chemometrics is needed. Just a clever choice of local models
- Think about optical and mechanical aspects and their relation to penetration depth
- Sampling is VERY important also in relation to penetration depth.

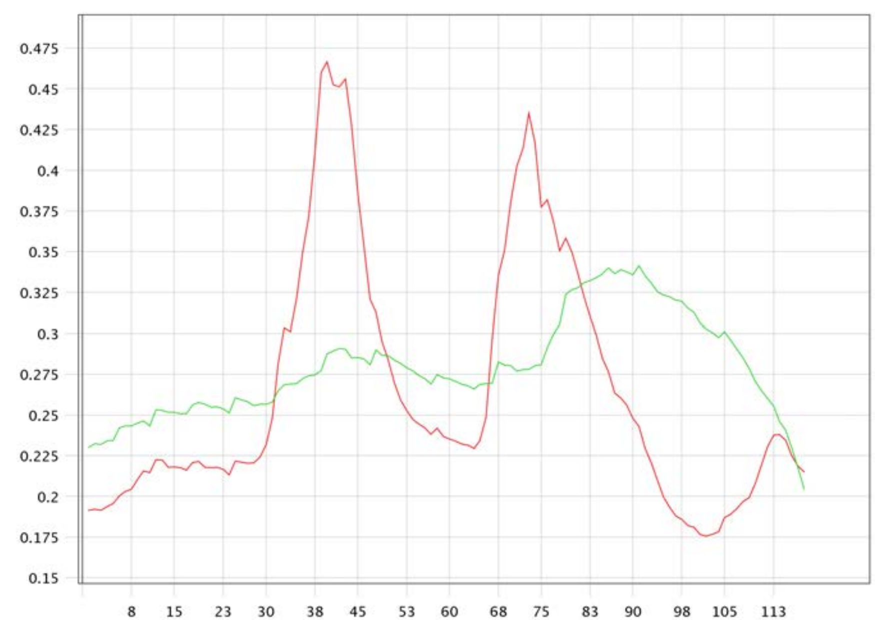
-Clean for ouliers in 4 PC model
-Remove edges (errors)
-246837 pixels left
-Mean-Center + SNV
-1st comp

Conclusion: 0.76 mm deep=
No signal. Nonlinear!





Similar results with Sisuchema



Conclusions

-sample preparation takes much more time than imaging

-data analysis takes much more time than imaging

-images give much spectral and spatial information

-2 types of sampling: lot to imaged sample/ inside imaged sample