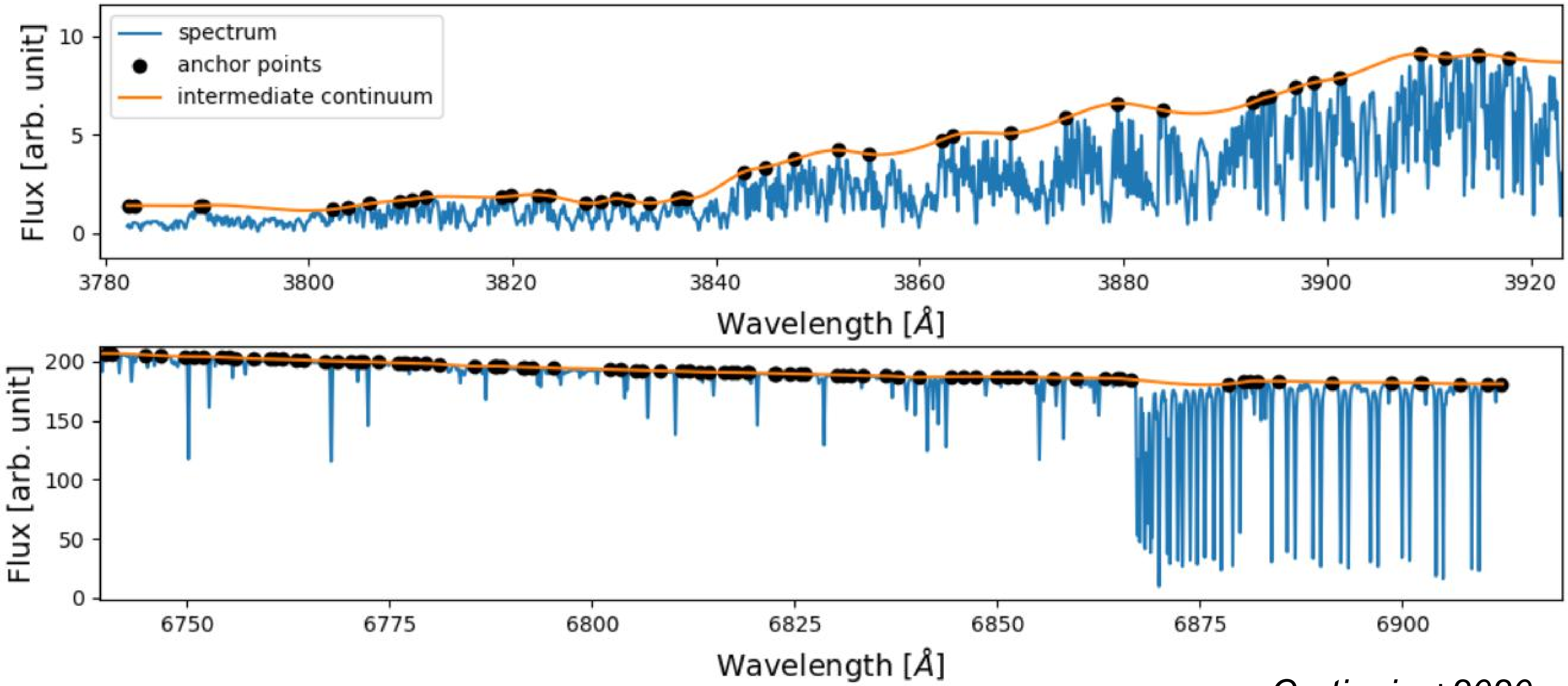
Normalisation

- General methods
- Some examples
- Hydrogen lines

Probably the most tricky and possibly subjective part of stellar spectroscopic analysis

IMHO, the only way to learn it is to do it on as many stars as possible...get experience

General methods: manual setting of the continuum level



Cretignier+2020

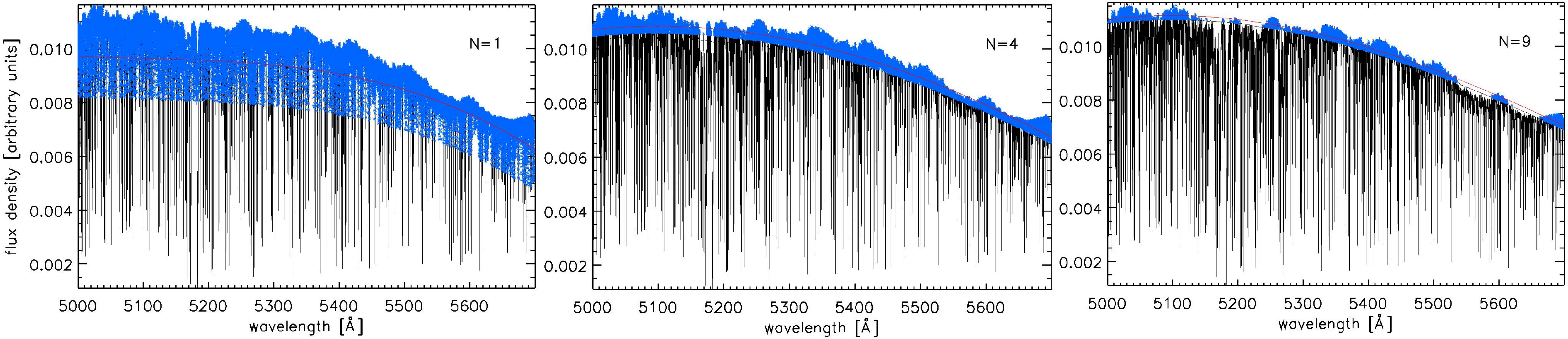
Manually set the position of continuum points along the spectrum
Set a function for the fit (usually polynomial or spline)

E.g. HANDY run in Python
http://rozanskit.com/HANDY/

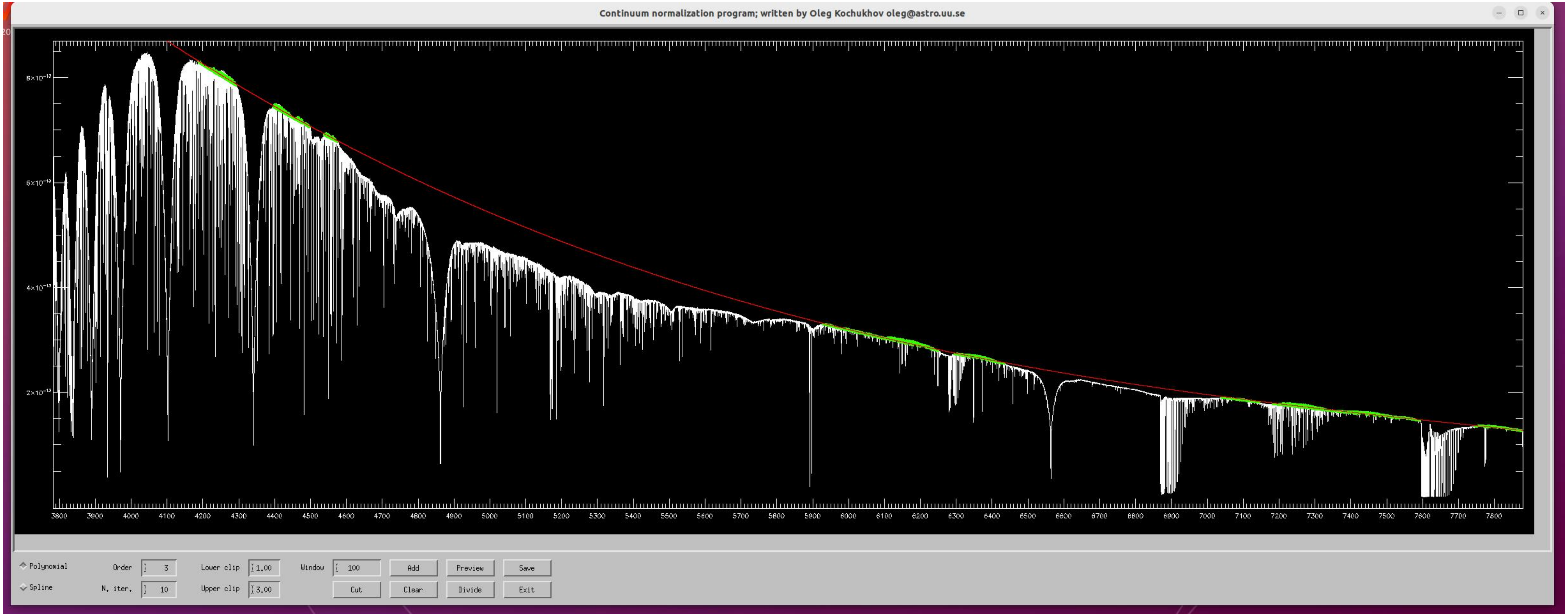
General methods: asymmetric sigma clipping

- Choose a fitting function (polynomial or spline)
- Fit the spectrum
- Clip all points 1 sigma (st. dev.) below the fit and 3 sigma above the fit
- Fit again the spectrum following the sigma clipping
- Clip again
- Fit again
- Repeat N times

At every clip&fit the fitting function will move closer and closer to the continuum points
N depends on many factors, but mainly spectrum S/N and line broadening (e.g. Vsini)



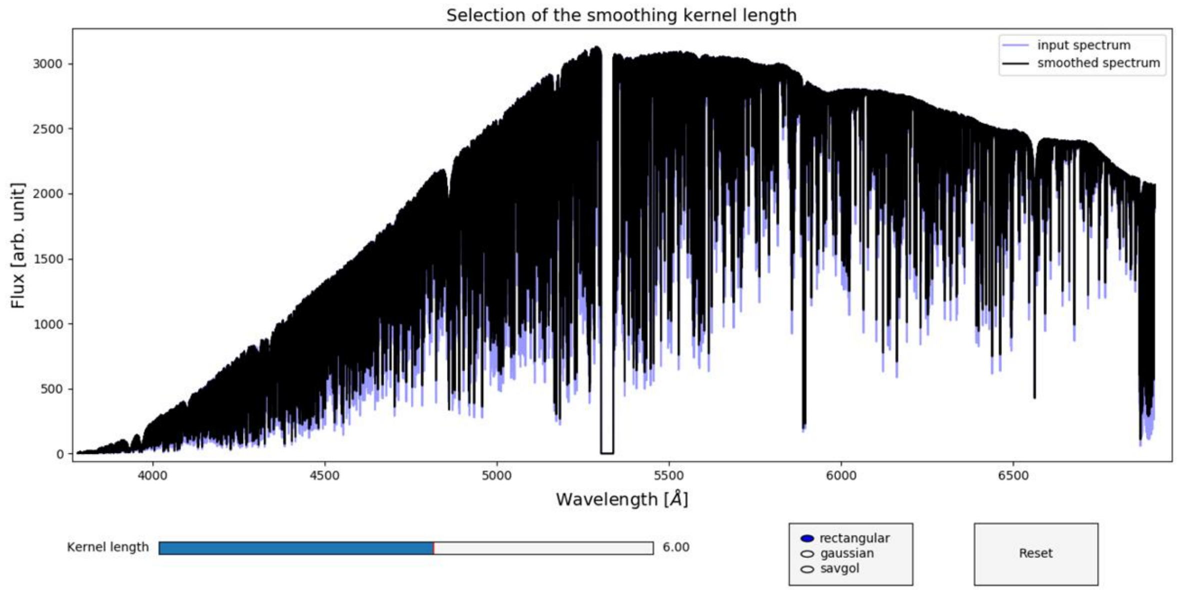
General methods: asymmetric sigma clipping

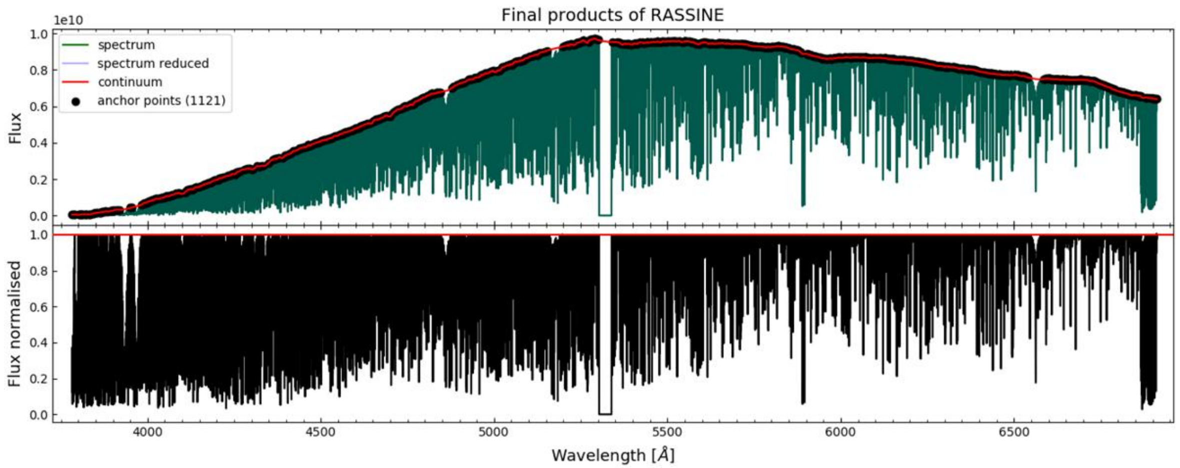


Oleg Kochukhov
IDL

General methods: convex hull

In geometry, the convex hull (convex envelope or closure) of a shape is the smallest convex set that contains it.
Find the shortest line that envelopes the spectrum.

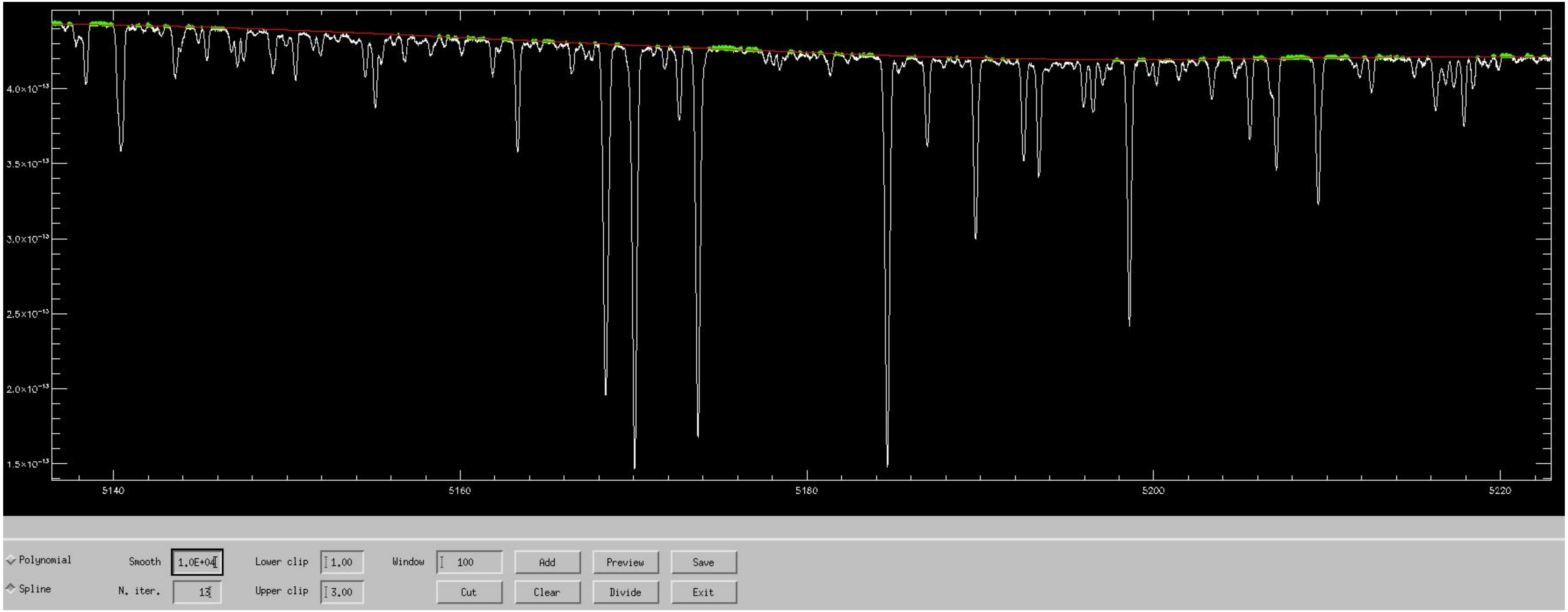




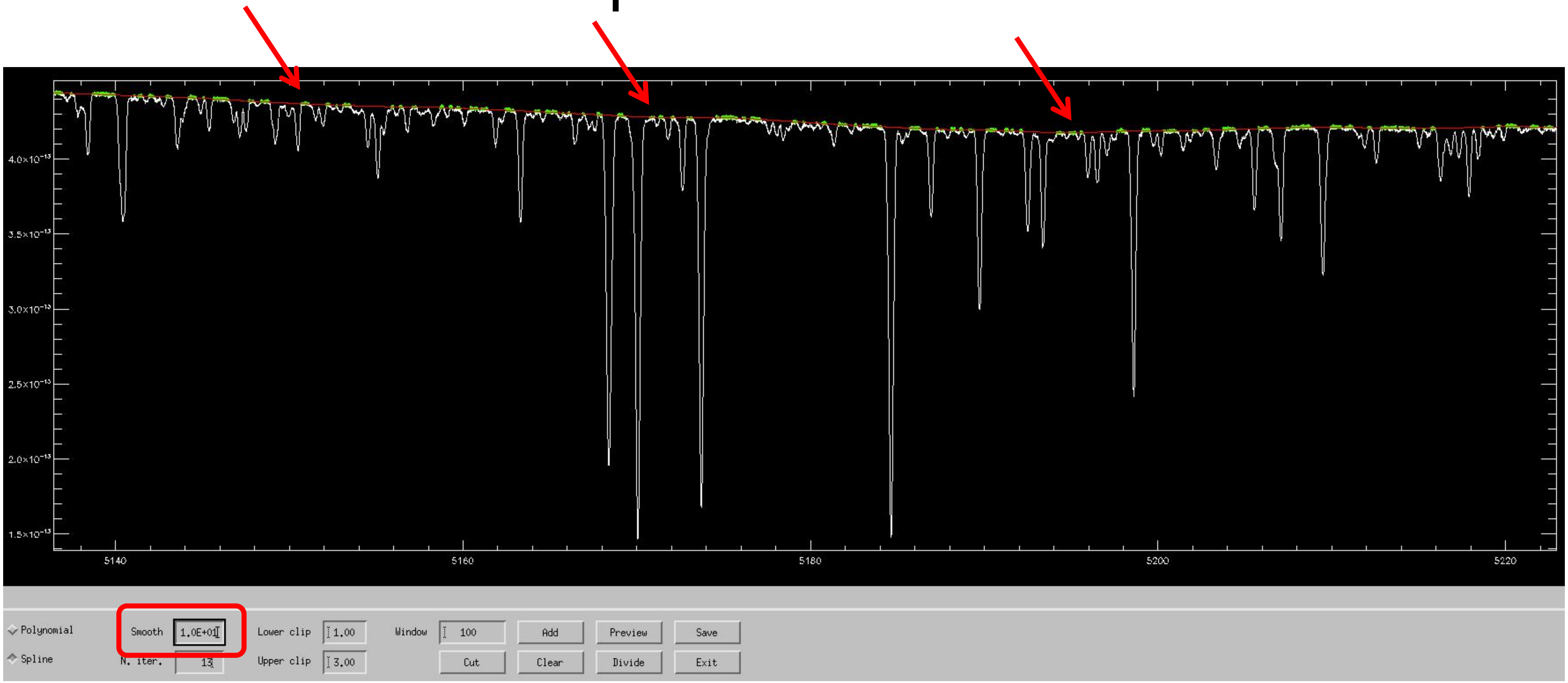
Cretignier+2020

RASSINE code (Cretignier+2020)
Python code with GUI in 5 steps
https://github.com/MichaelCretignier/Rassine_public

Examples: narrow lines

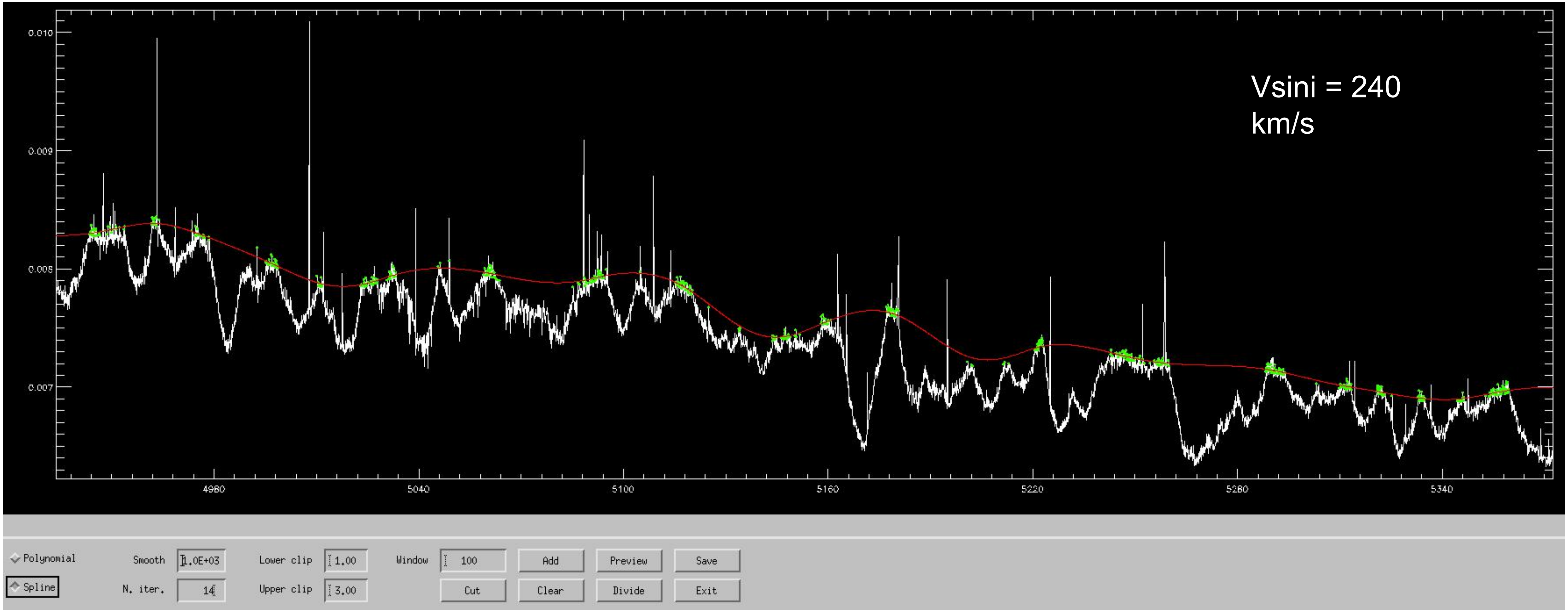


Examples: narrow lines

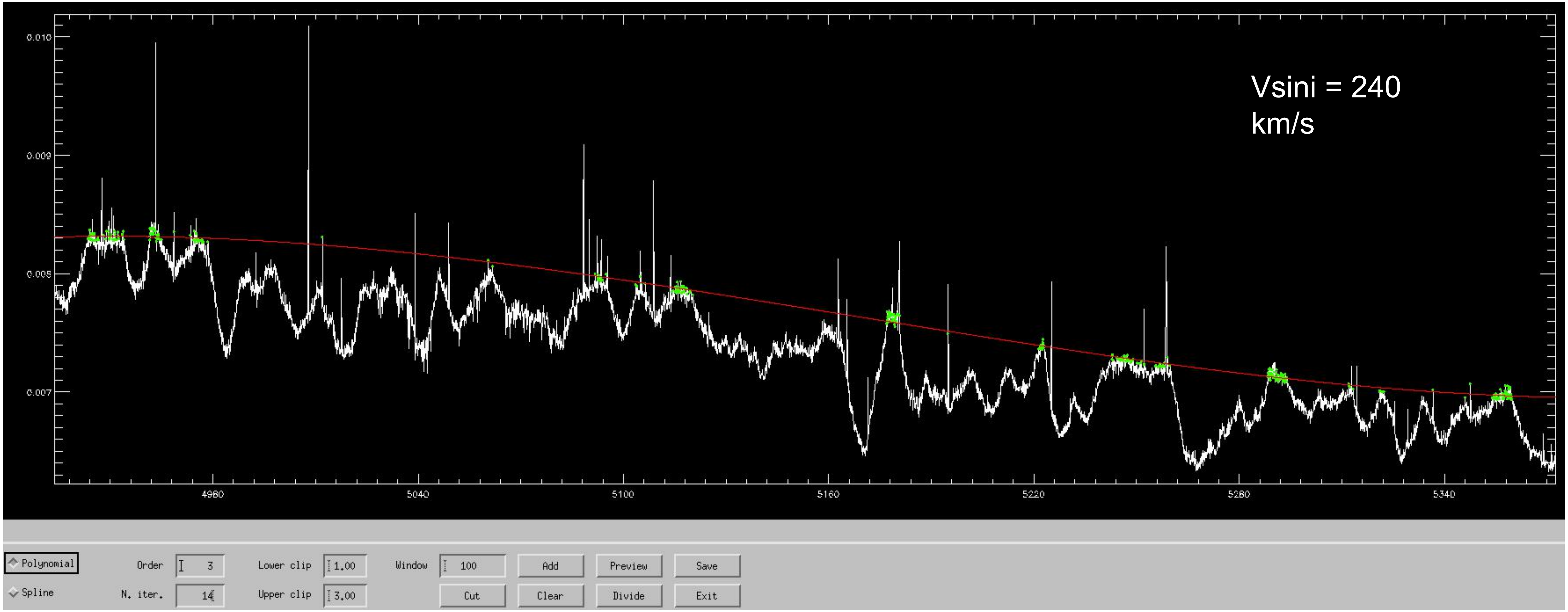


Which of the two is the right normalisation?

Examples: rotationally broadened lines



Examples: rotationally broadened lines



Which of the two is the right normalisation?

What have we learned from these examples?

Need the help of a synthetic spectrum, but which one?

One will have to start from a synthetic spectrum computed using an approximate solution

This approximate solution will improve at some point during the analysis

This might require a new normalisation

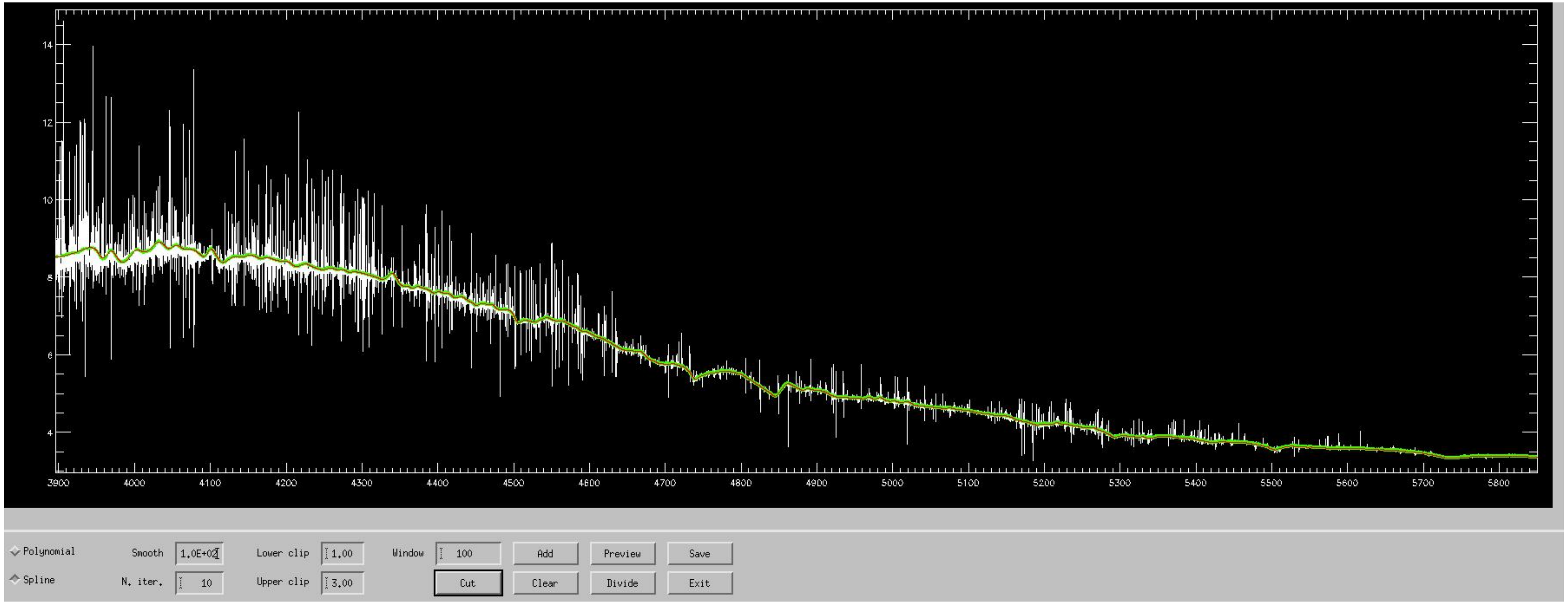
--> Arriving at the finally normalised spectrum might be an iterative process

Experience helps:

- Knowing the spectrograph
- Knowing the spectrograph's pipeline results (flat-fielding and blaze function correction)
- Having previously normalised similar spectra

Normalisation fully guided by a synthetic spectrum

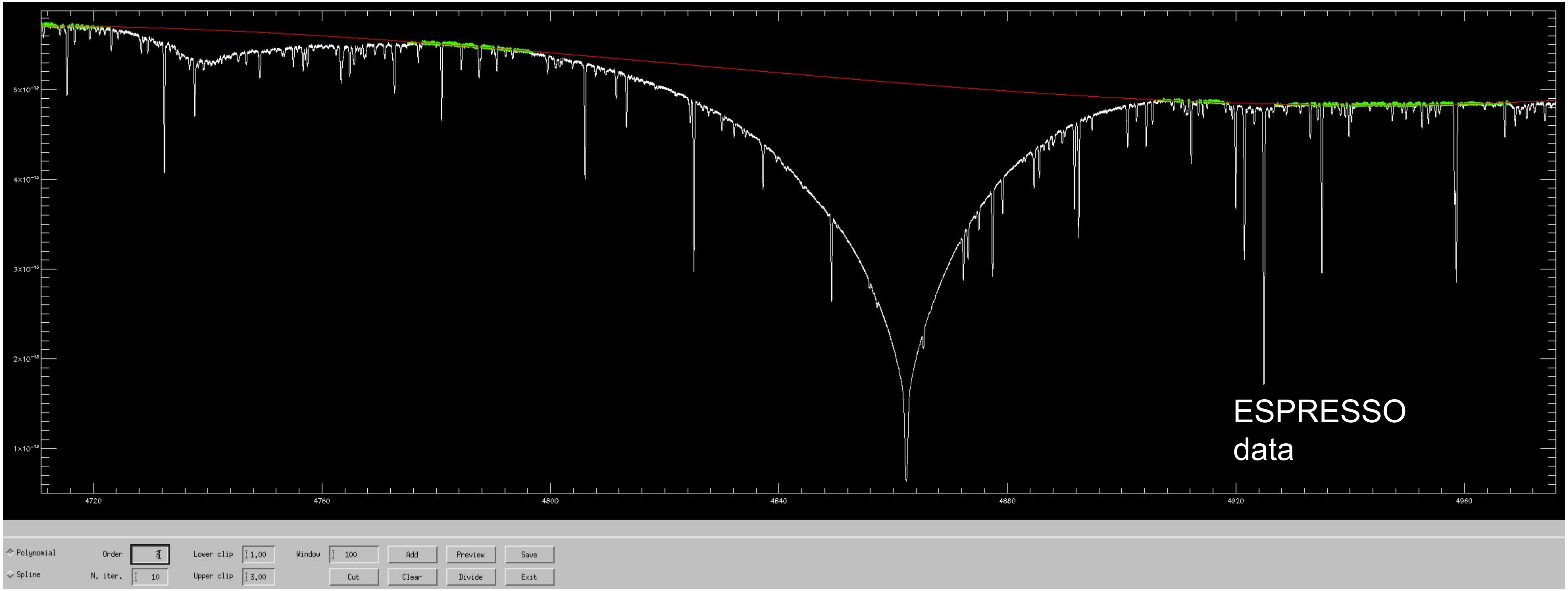
Compute the ratio betwen the observations and the synthetic spectrum
Normalise this ratio, but “passing through”, instead of “passing above”



In doing this operation, a slight wavelength shift between observed and synthetic spectrum helps avoiding affecting line depths, but this depends on the actual Vsini of the star.
Divide the observed spectrum by this normalisation line (the red line in the figure above) --> DONE
Make sure the synthetic spectrum has the right Teff and Vsini

Hydrogen lines

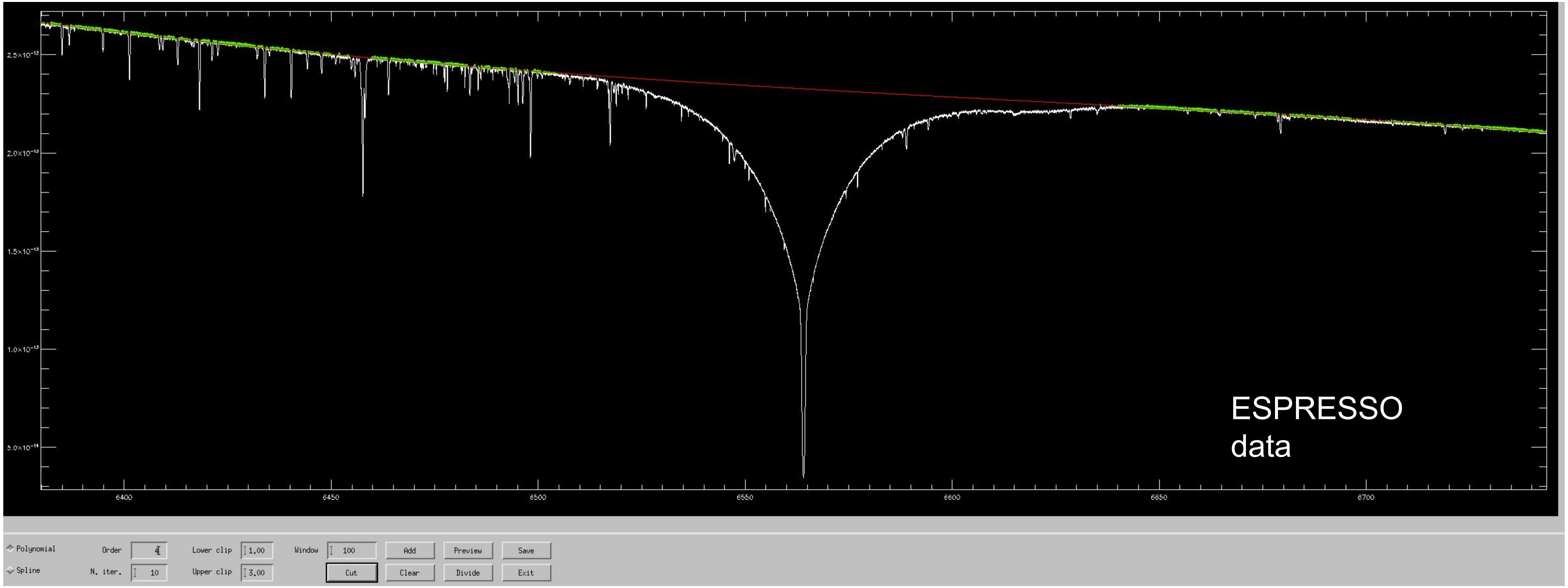
Typically a headache, particularly with echelle spectrographs



Where is the problem?

Hydrogen lines

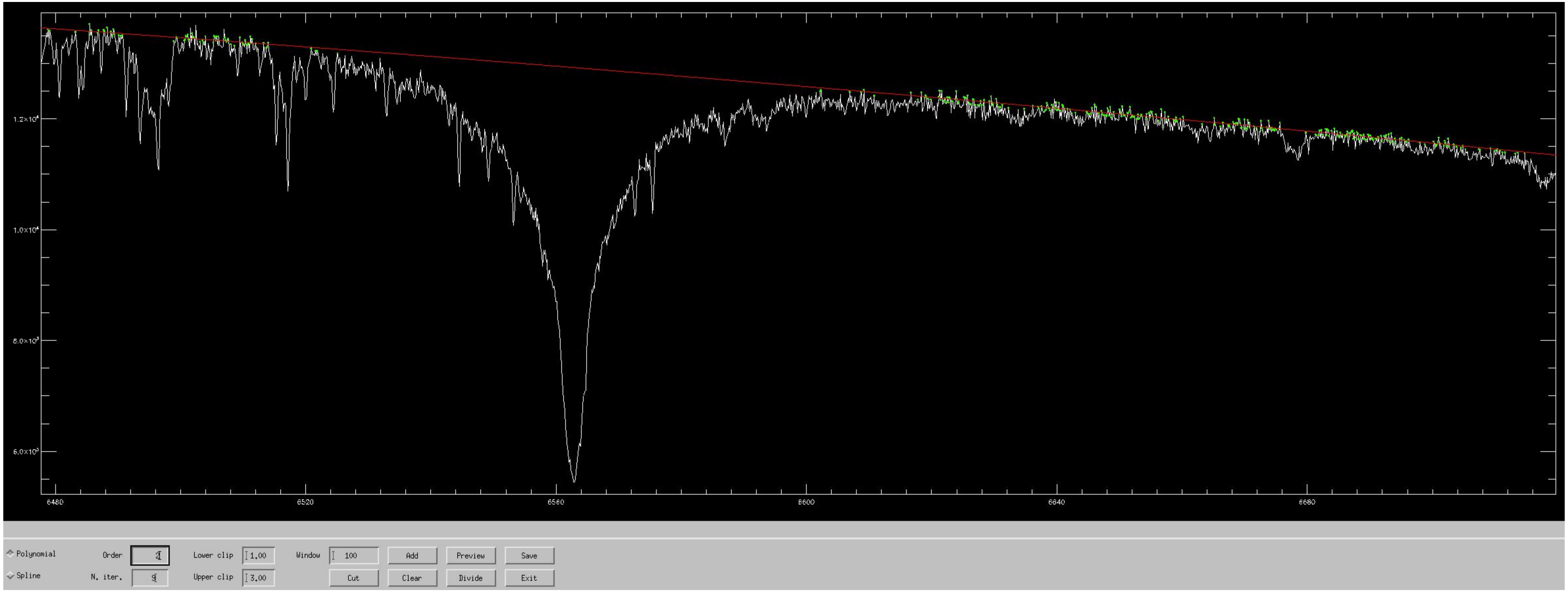
Typically a headache, particularly with echelle spectrographs



Where is the problem?

This is why I like single slit spectrographs with R~10,000 for measuring hydrogen lines

Hydrogen lines

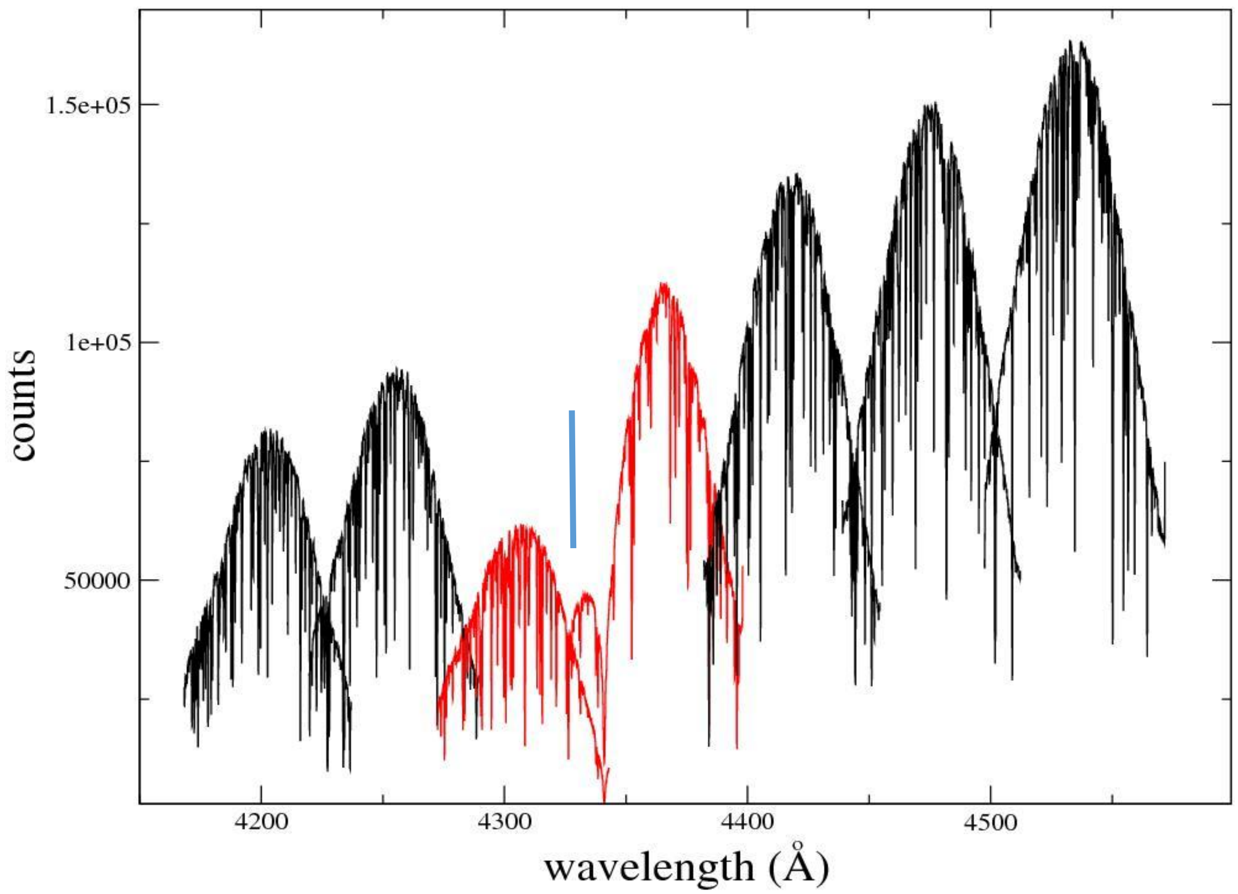


What will tell you that something went wrong in the normalisation?

Typically the two line wings, or different H lines, lead you to different results (Teff and/or logg)

In general line asymmetries are a hint of wrong normalisation

Hydrogen lines: artificial flat-fielding technique



- Make sure to keep the blaze function in the shape of the extracted orders
- Identify the orders that fully contain a hydrogen line (red) and the 2-to-3 adjacent to them on both sides (black) that do not contain H lines (might be a problem around H delta and bluer H lines)
- Find the normalisation line of the “black” orders
- Interpolate among these normalisation lines to find the normalisations lines for the “red” orders
- The interpolation can be done in pixel, or in order number, or both simultaneously
- It does not always work, but worth the shot if everything esle fails