

# Sky-subtraction method

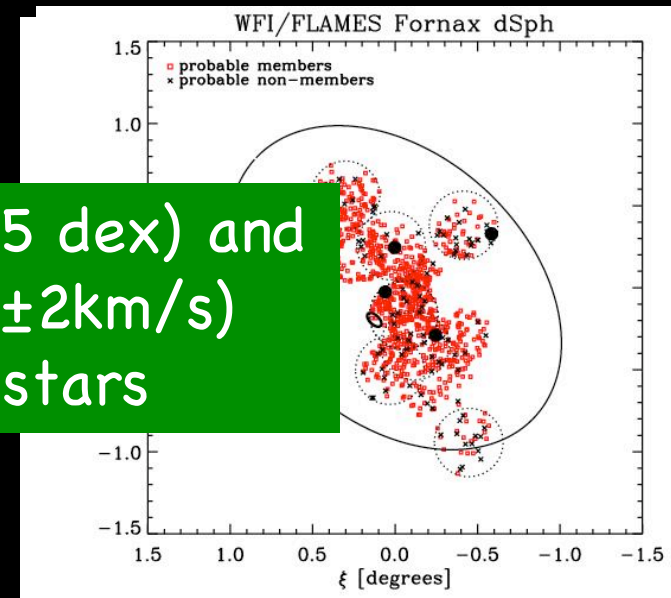
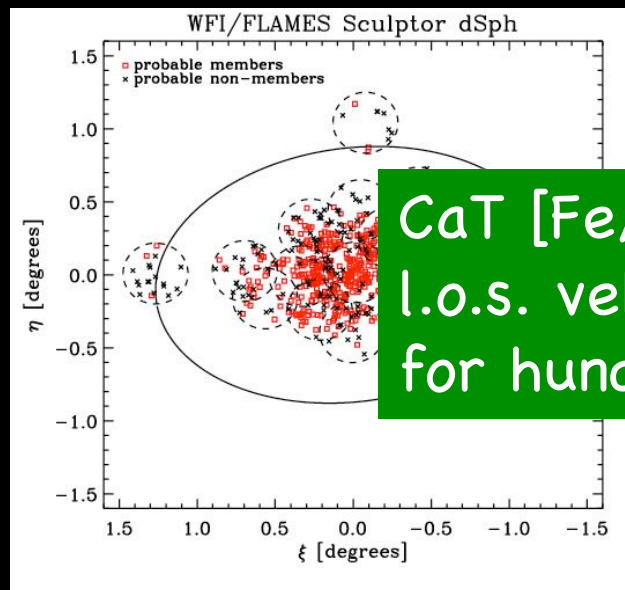
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ESO Garching

Pipeline developed by Mike Irwin

# DATA

FLAMES spectroscopy (Medusa mode) of individual Red Giant Branch stars in a sample of Milky Way dwarf spheroidal galaxies

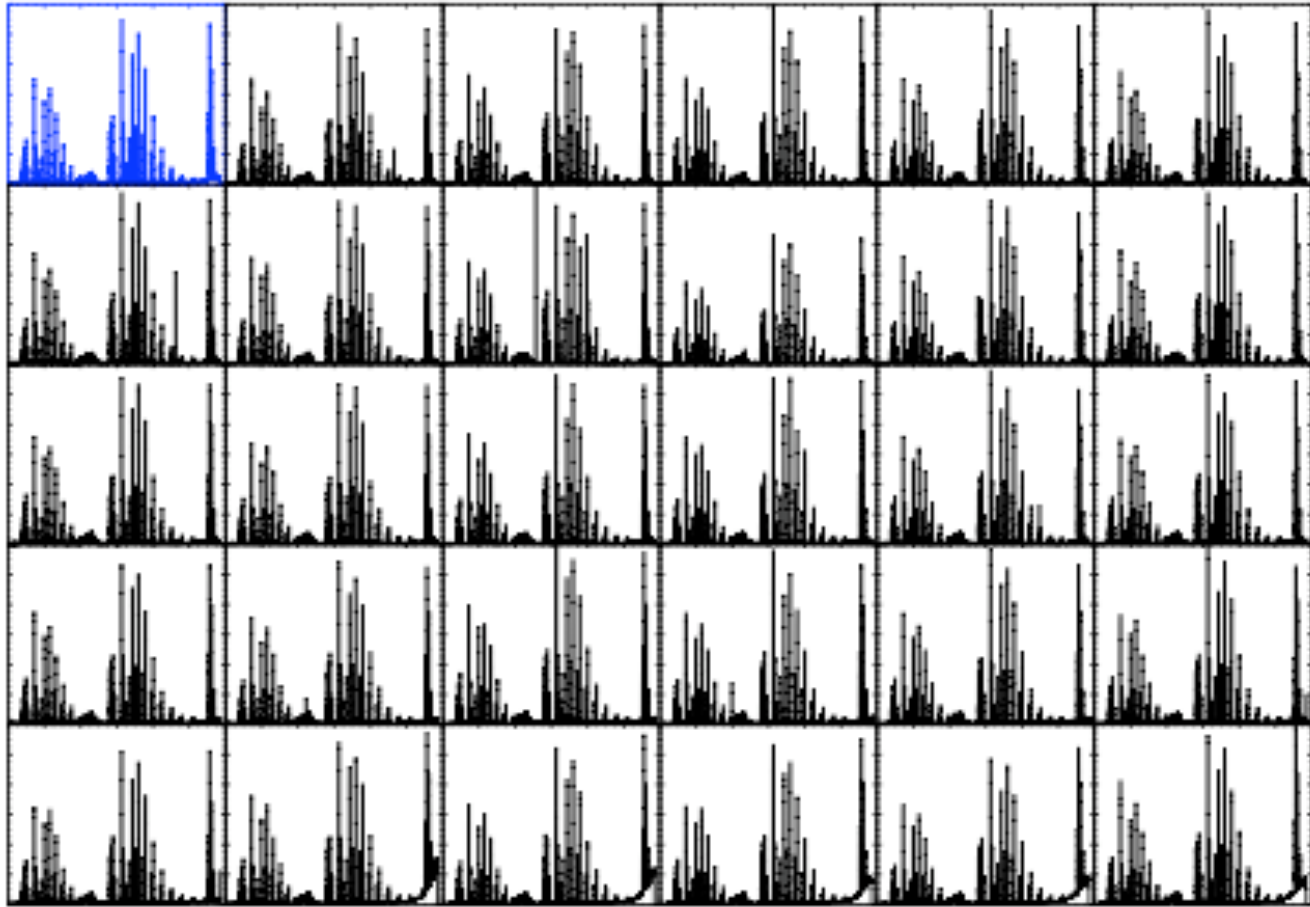
- $V < 20$
- LR8,  $R \sim 6500, 8200-9400 \text{ \AA}$
- NIR CaII triplet (lines at 8498, 8542, 8662  $\text{\AA}$ )
- Typically with 1h exposure time (grey time, seeing = 1.0", airmass < 1.5) we obtain a  $S/N=10/\text{\AA}$  @  $V=19.5$



CaT [Fe/H] ( $\pm 0.15$  dex) and  
l.o.s. velocities ( $\pm 2$  km/s)  
for hundreds of stars

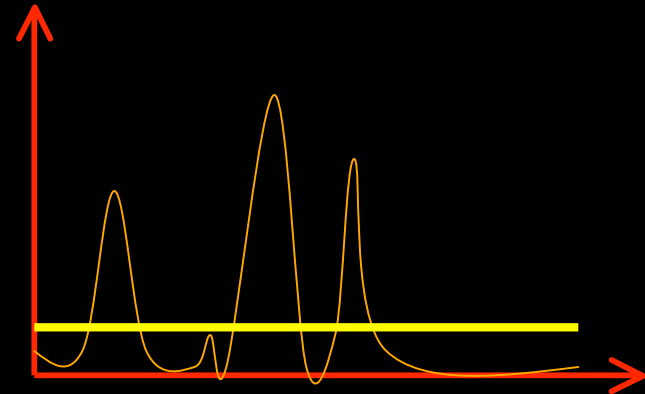
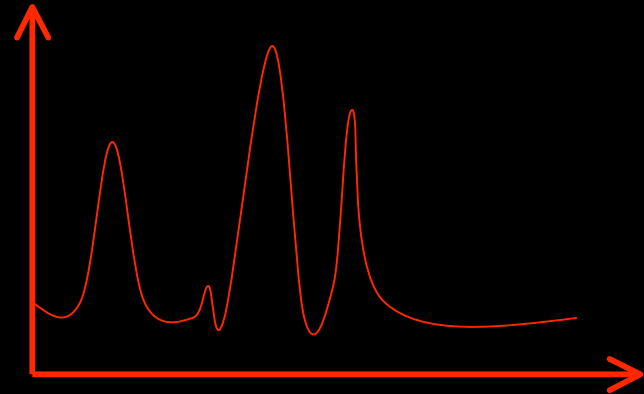
## Methodology I

- We are interested in the CaT lines -> sky-subtraction is optimized for the region 8400-8750 Å
- Typically about 20 sky fibers are allocated per pointing (a minimum of 10) all over the field-of-view
- For each pointing the sky-spectra are combined to produce an "average" sky-spectrum



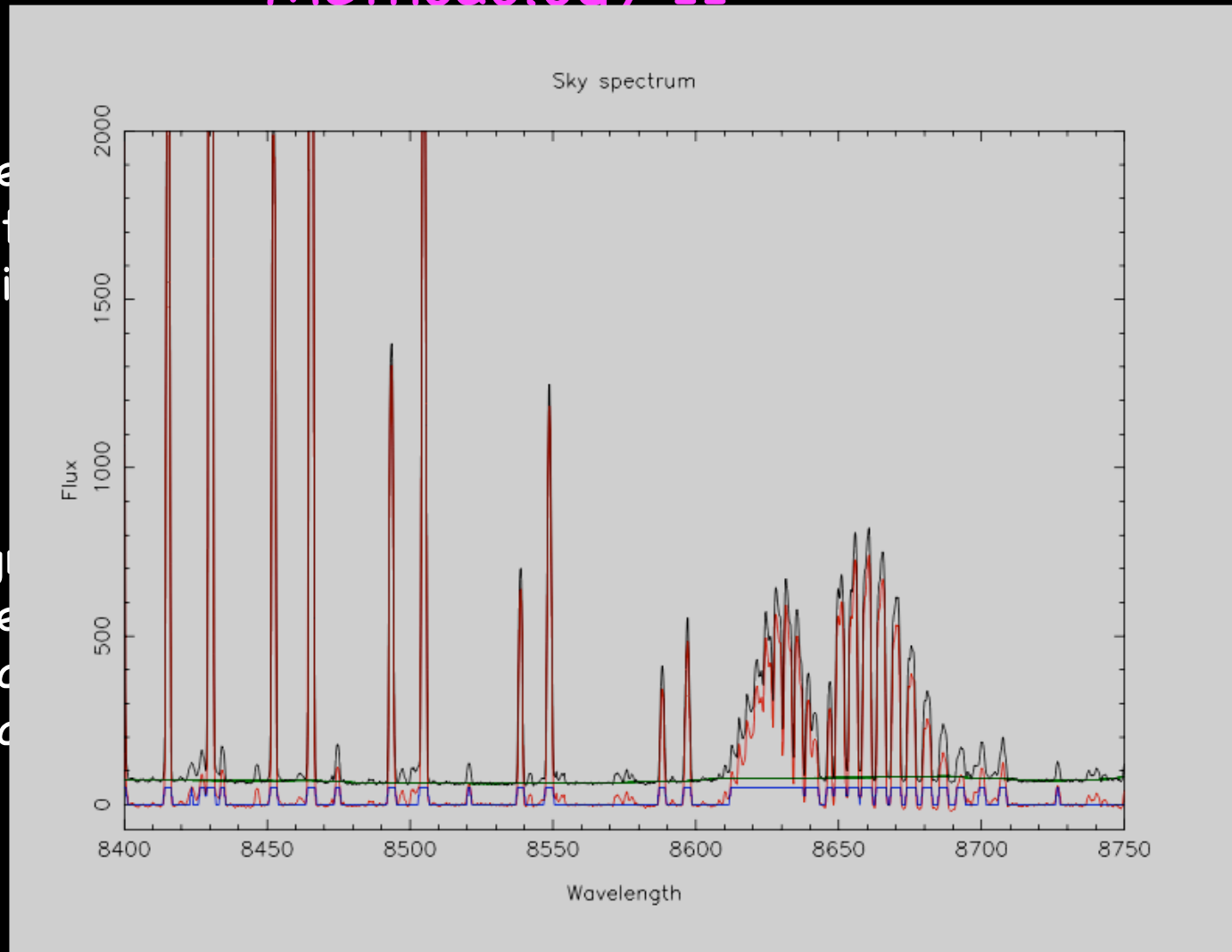
## Methodology II

- The average sky-spectrum is split into a continuum (sky-cont) and a line (sky-line) component
- The significant features of the sky-line spectrum are used to define a sky-mask, i.e. the significant features are isolated and all the rest is masked-out



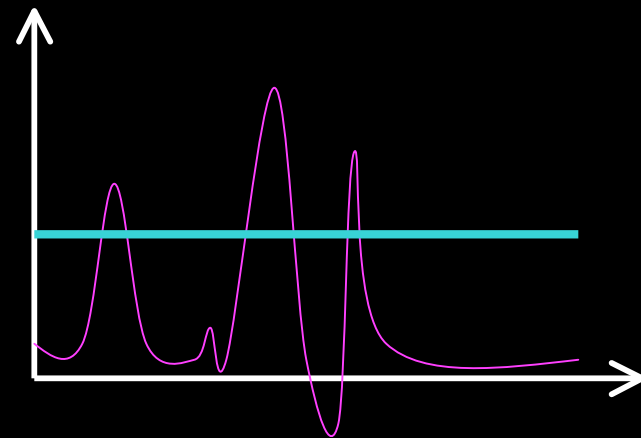
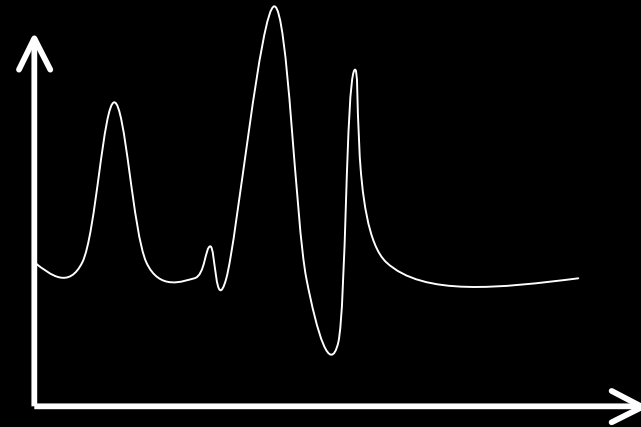
## Methodology II

- The average spectrum is split into two halves and a linear fit is applied to each half.
- The significant sky-line features are defined as significant if they are above the noise level and all other features are below the noise level.



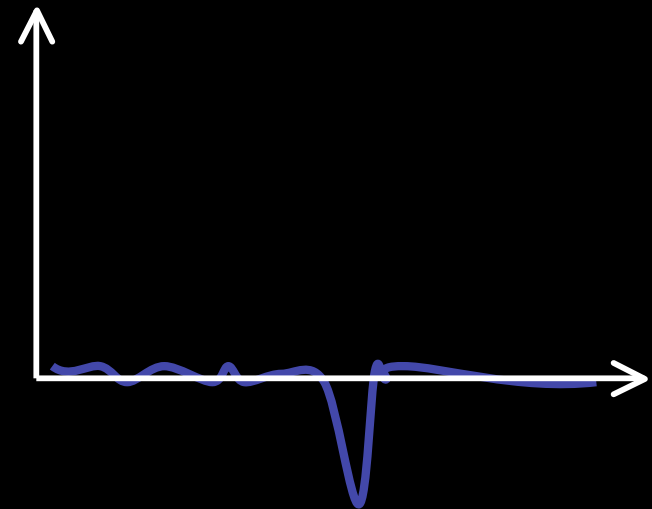
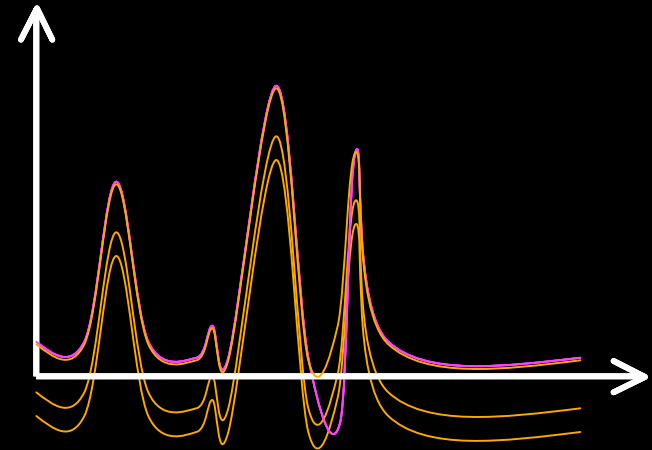
## Processing individual objects

- Each object is divided into a line (obj-line, this includes the sky-lines) and a continuum (obj-cont) component. When finding the continuum, the regions affected by sky-lines are masked out.
- For each object, its obj-line spectrum is cross-correlated with the masked sky-line spectrum
- The obj-line spectrum is re-interpolated to be on the same wavelength scale as the sky-line spectrum



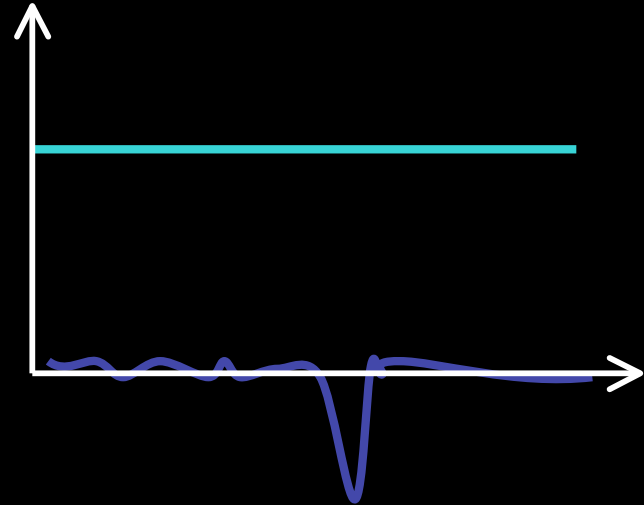
## Sky-subtraction: lines

- The obj-line spectrum and the masked average sky-line spectrum are compared
- The best scale factor between is found by minimizing the absolute deviation, i.e. the L1-norm (this is less sensitive to non-Gaussian outliers wrt to the L2-norm)
- The best scale factor is found through a grid search
- The scaled sky-line spectrum is subtracted to the obj-line spectrum



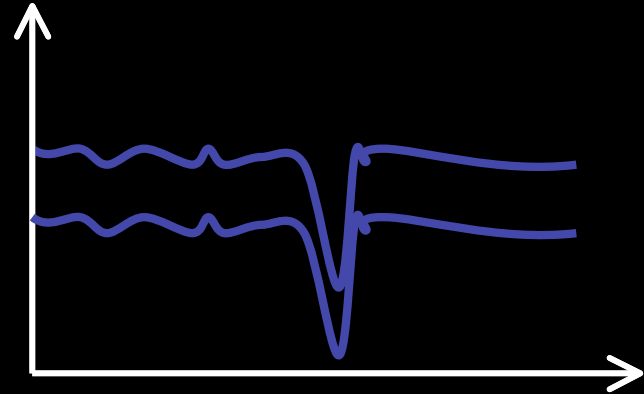
## Sky-subtraction: continuum

- The obj-cont is added back
- The average sky-cont is multiplied by the scale factor found before  $\rightarrow$  this gives the sky continuum to remove to the specific object
- This sky-continuum is finally subtracted from the obj-spectrum



## Sky-subtraction: continuum

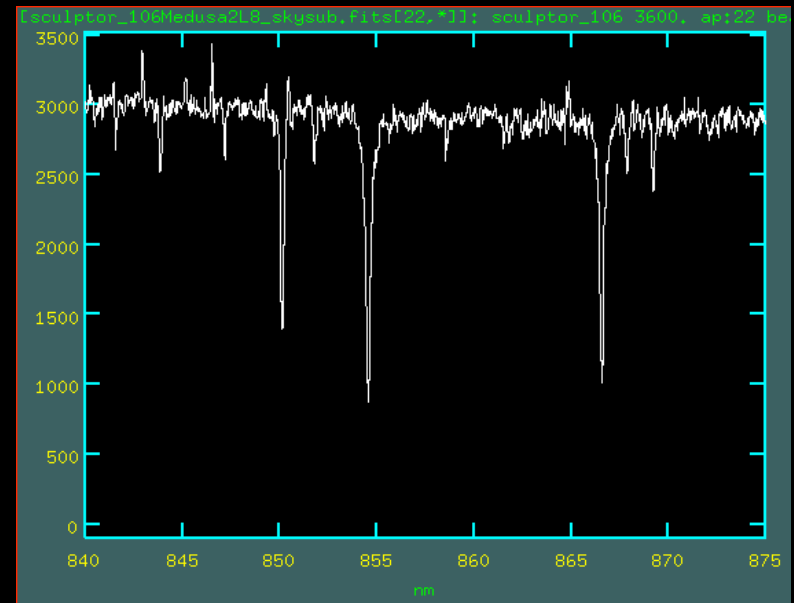
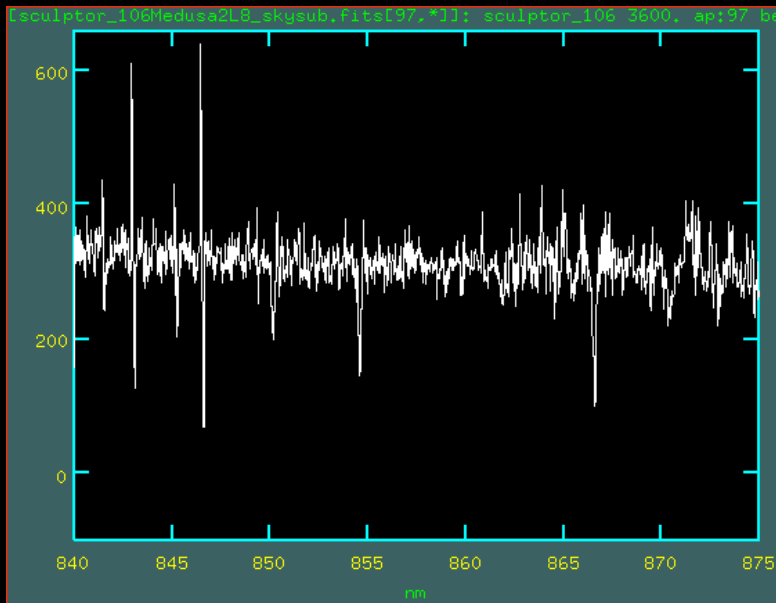
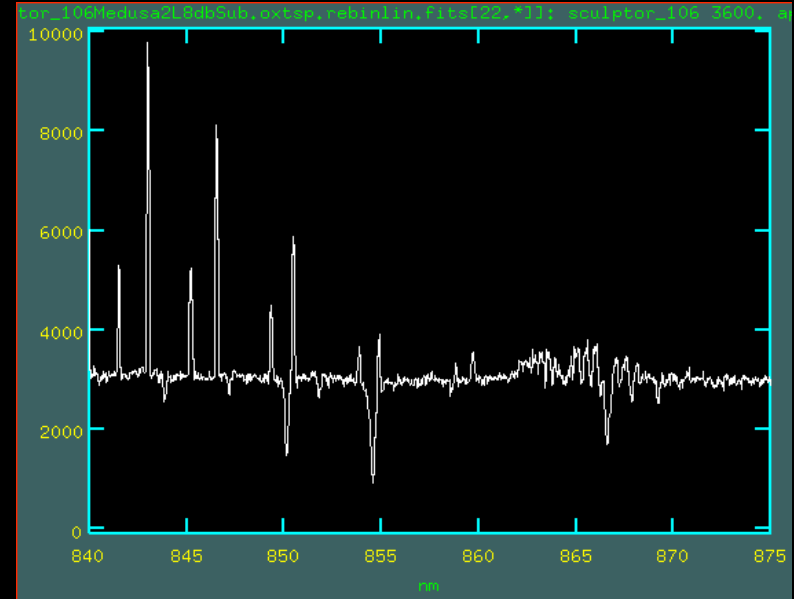
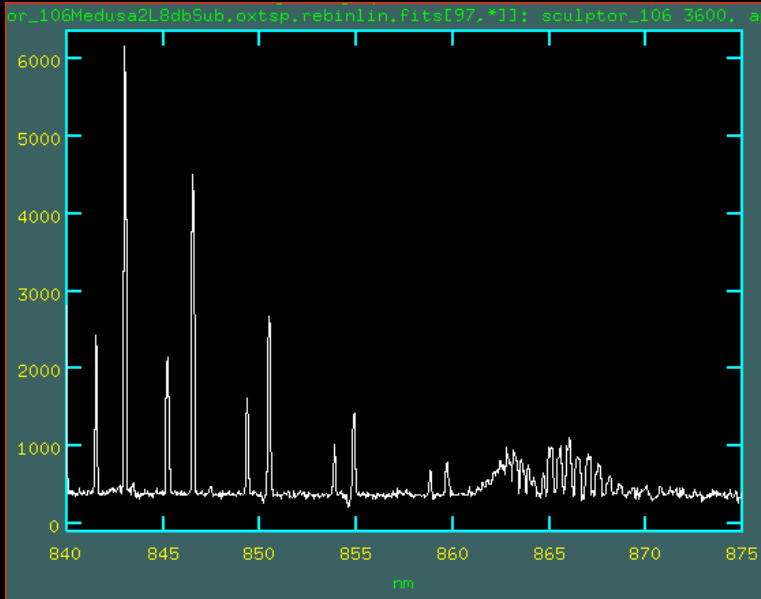
- The obj-cont is added back
- The average sky-cont is multiplied by the scale factor found before -> this gives the sky continuum to remove to the specific object
- This sky-continuum is finally subtracted from the obj-spectrum



# Results

S/N = 18

S/N = 73



# Errors in equivalent width

