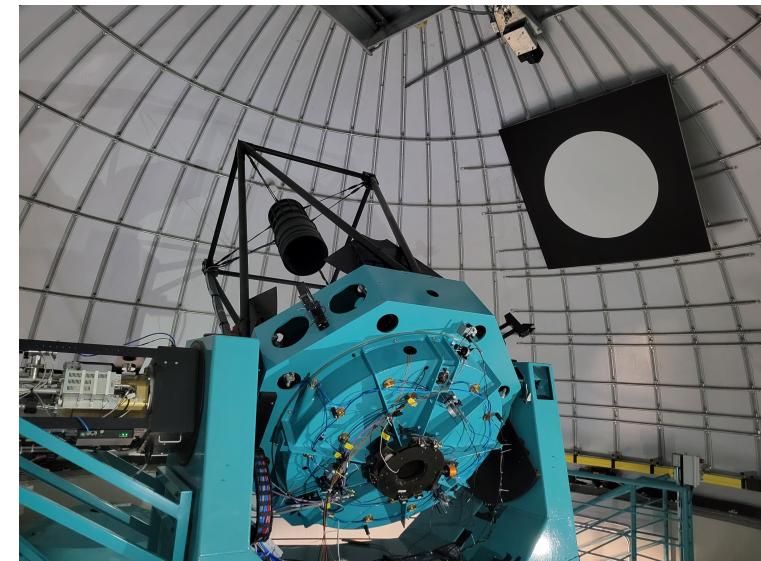


Spectroscopy data processing status/plans

2022/11/01

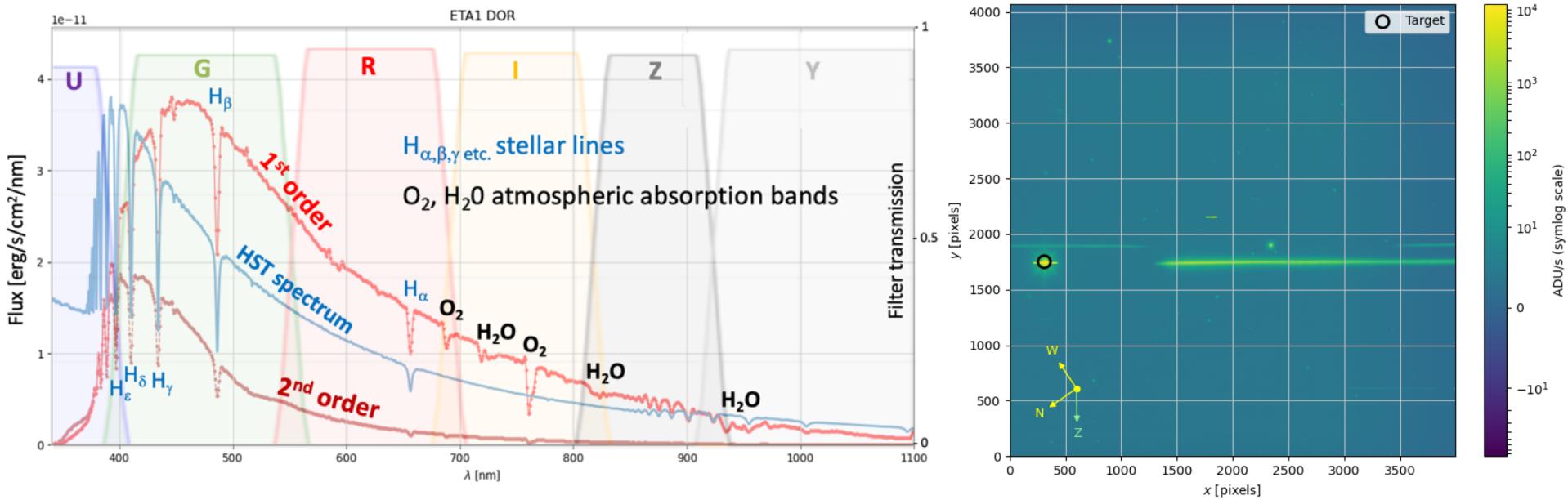
AuxTel

- 1.2m telescope just next to Rubin Observatory, equipped with a slitless spectrograph
- Goal : measure atmospheric transparency using spectrophotometric standards



AuxTel

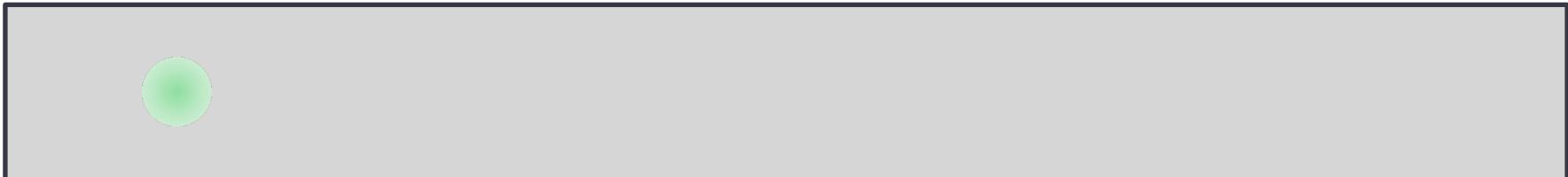
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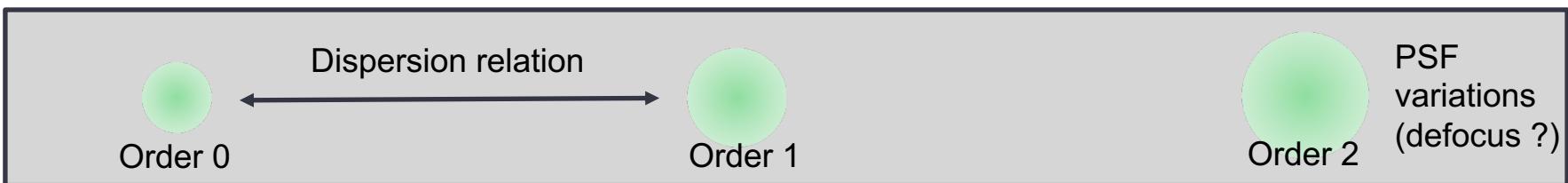
Spectrogram: a dispersed image



Observation of a monochromatic (green) star without a disperser:



Observation of a monochromatic (green) star with a disperser:

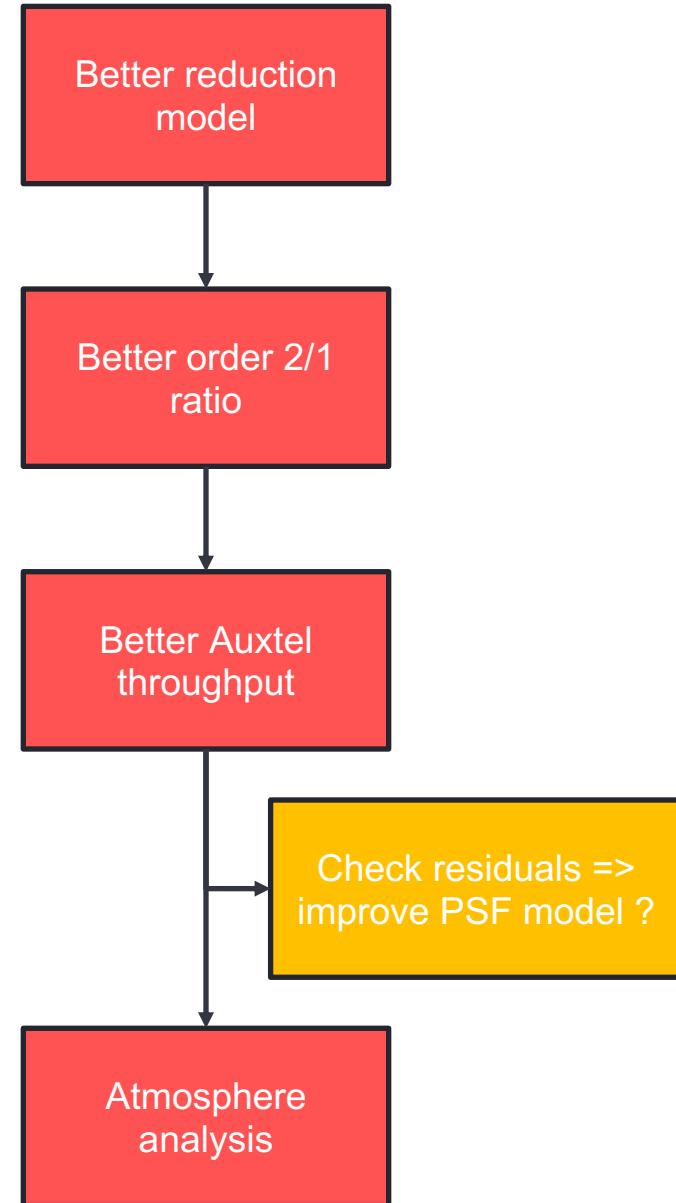


Observation of a polychromatic star with a disperser and ADR:



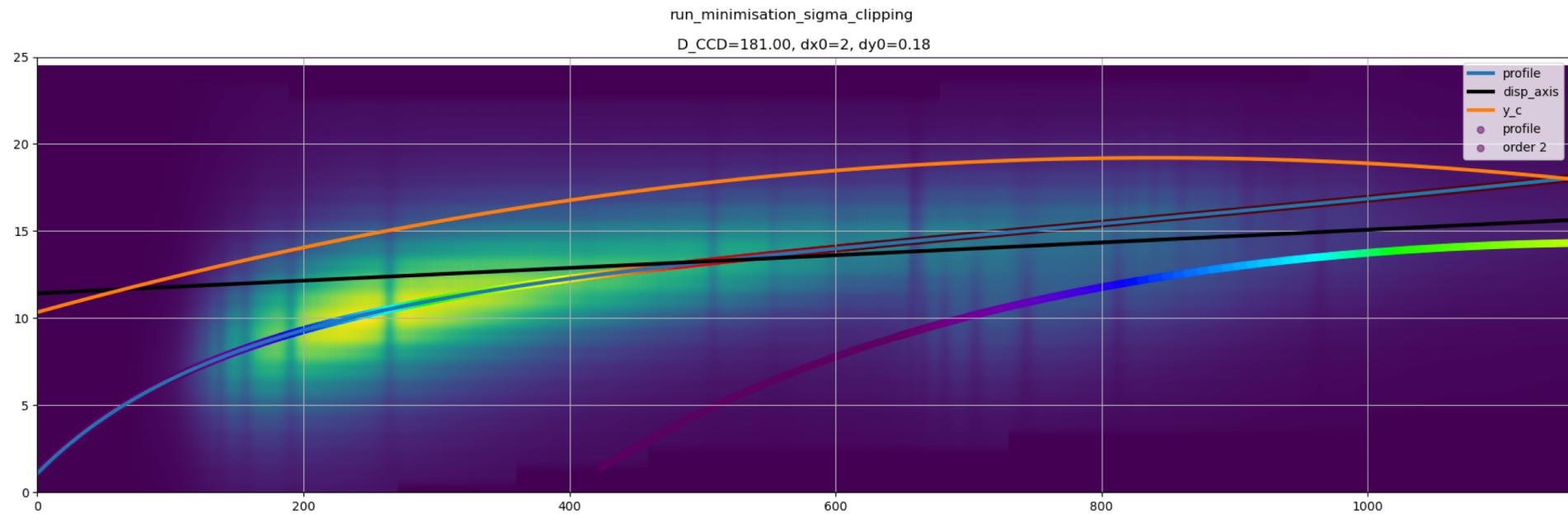
Steps

- Implement the new forward model into DM
 - + 21 new parameters to fit => needs to optimize the code to have a “quick” fit
- Analysis the order 2/1 ratio using exposures with blue filter
 - Extract independently order 2 and order 1 from those images
 - Build a synthetic order 2/1 ratio
 - Check simultaneous extraction on these images
- Get the full spectrum range Auxtel throughput
 - Use this 2/1 ratio to reduce all spectra, especially during the most photometric nights
- Fit libradtran models on spectrogram and spectra to get atmospheric parameters



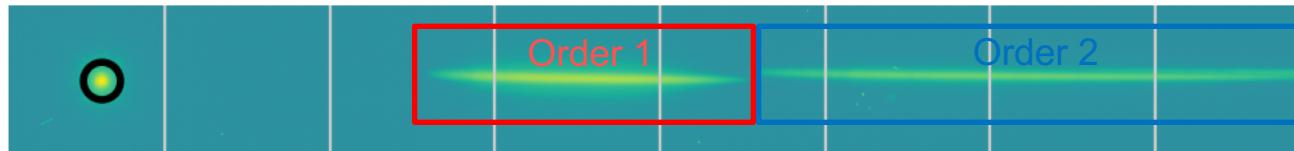
Improvement of the spectrogram model

- New forward model: independent extraction of order 2 and 1
 - Prediction of the spectrograph curvature with Atmospheric Differential Refraction model + two 2nd order polynomials (one for each dispersion order)
 - PSF model is Moffat+Gaussian profile
 - PSF models for order 1 and 2 are now independent
- Strong reduction of the chi2, better subtraction of order 2
- Caveat : only tested with 2x2 rebinning

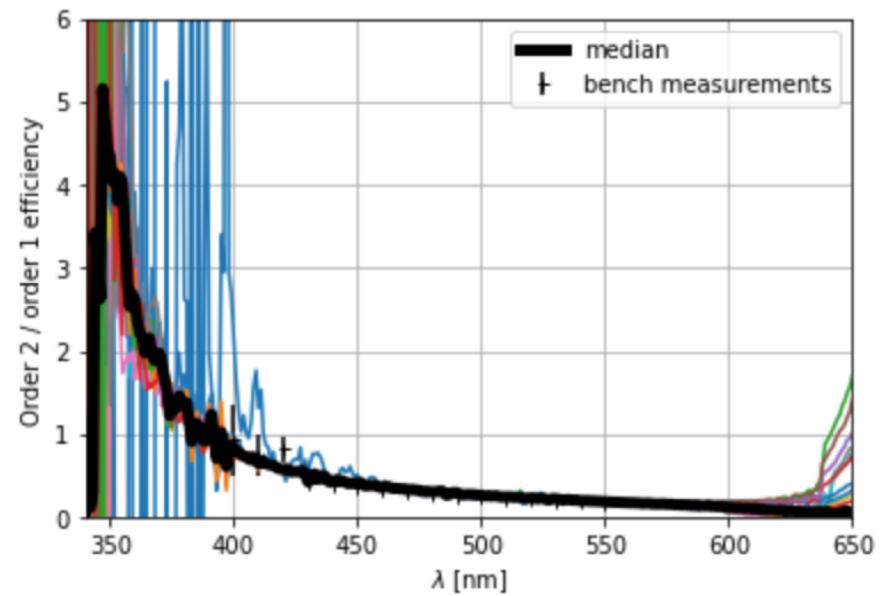
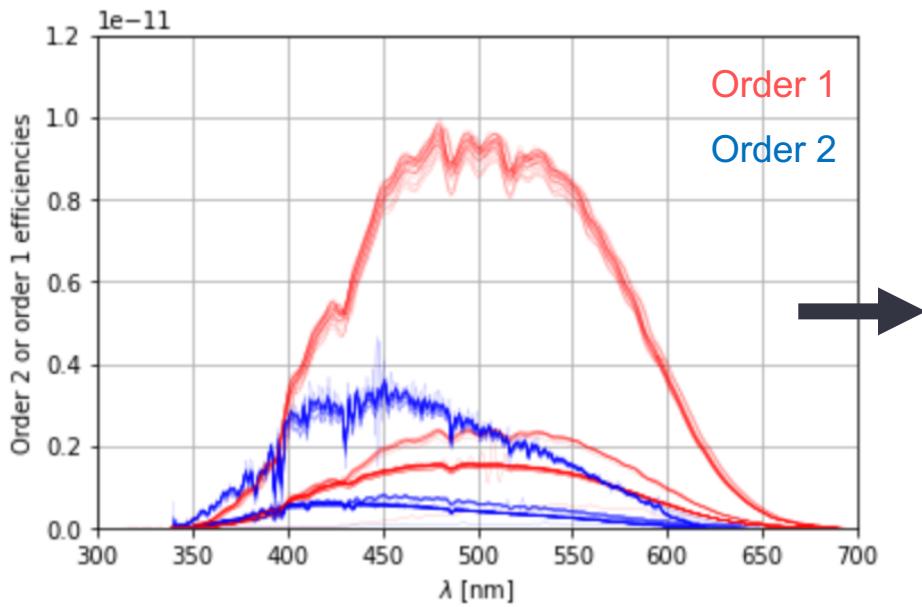


Second diffraction order throughput

- Use all nights with blue BG40 filter, all stars (125 spectra)

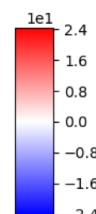
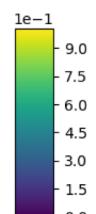
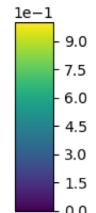
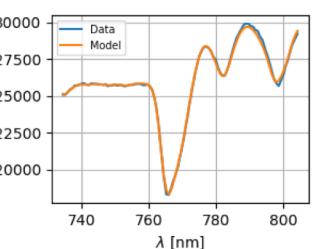
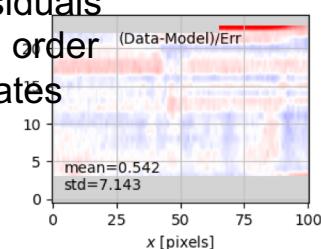
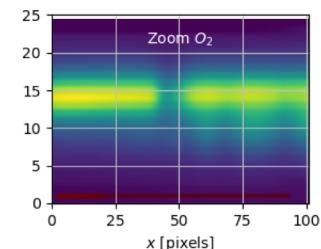
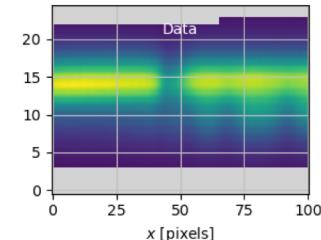
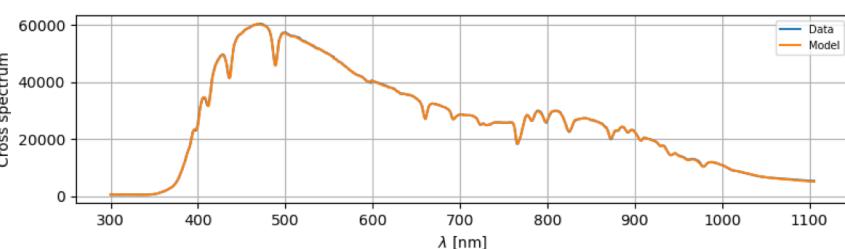
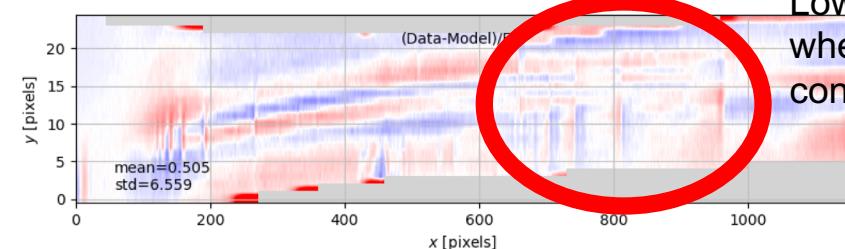
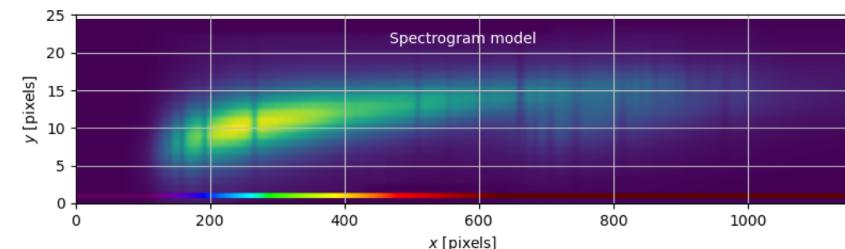
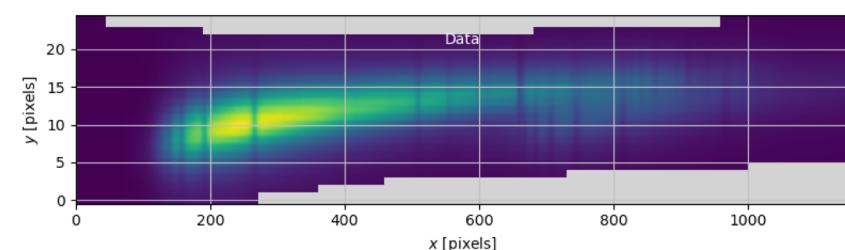


- Independent extraction of both orders and compute the median of the ratios

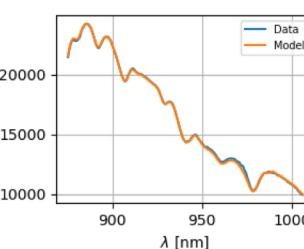
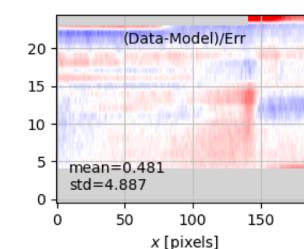
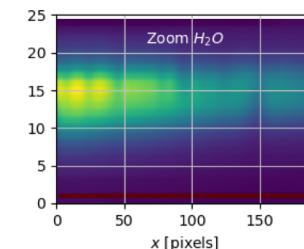
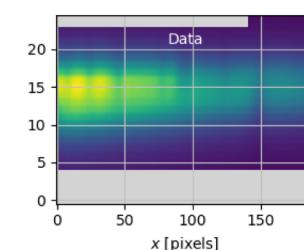


Improvement of the spectrogram model

Examples : reduced chi2 goes from 140 to 22 on this exposure

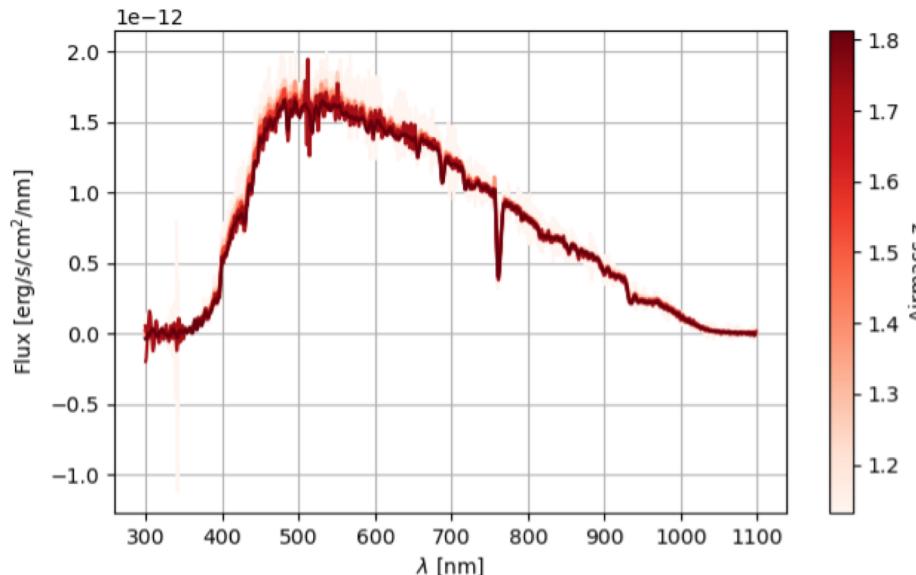


Lower residuals
where 2nd order
contaminates

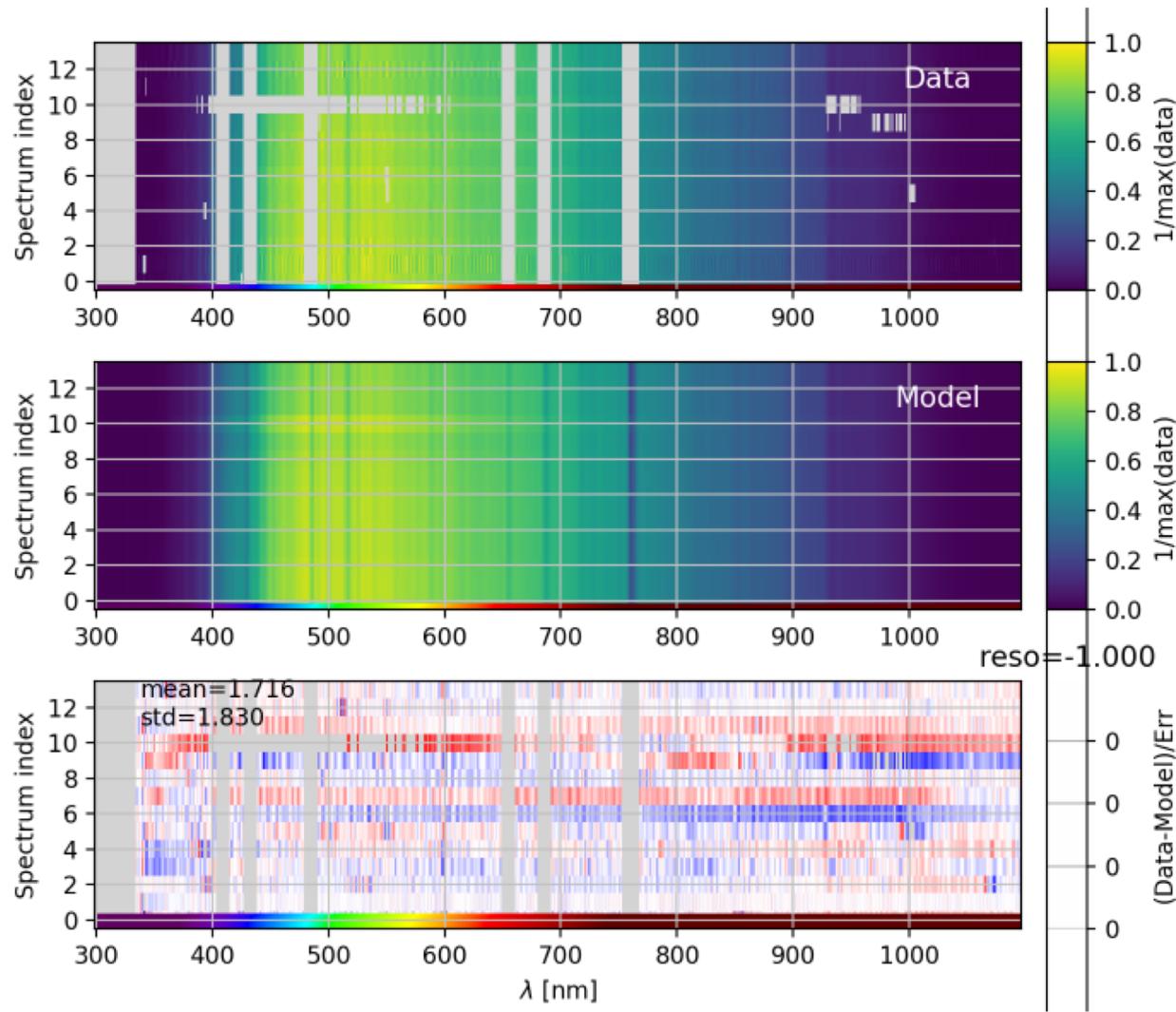


AuxTel throughput

- Use the end of 2022/06/30 night, with no filter and red FELH0600 filter
- Filter outliers (bad spectrum reconstructions) and bin spectra (1nm bins)
- Airmass regression model fitted on all selected spectra with :
 - 1 common libradtran atmospheric model (3 parameters)
 - 1 common free instrumental throughput amplitude (~ 1 per nm)

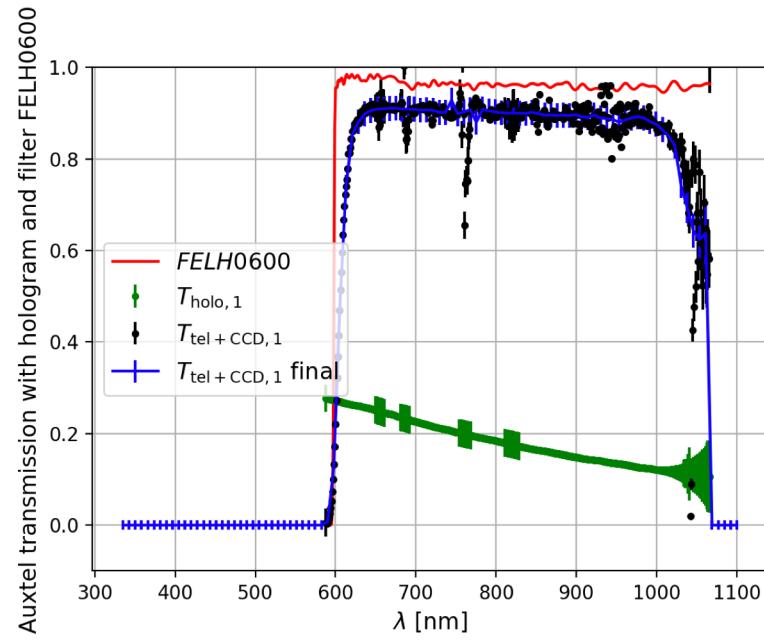
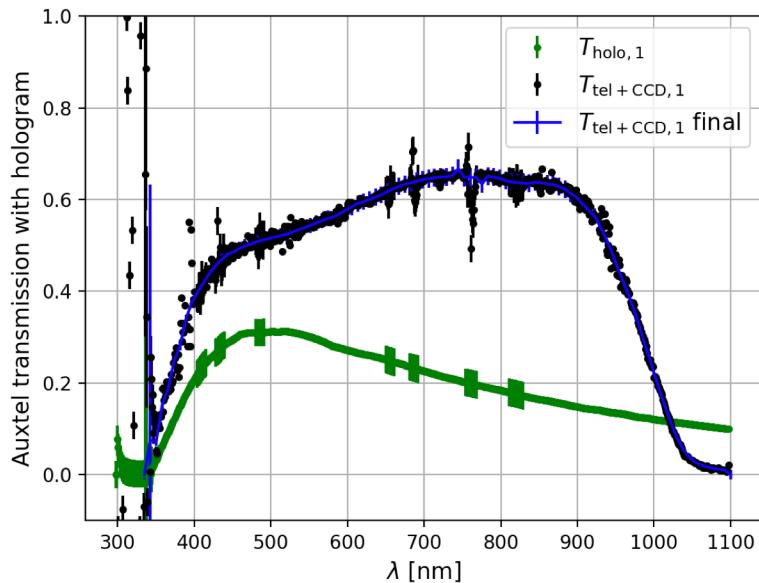


AuxTel throughput



AuxTel throughput

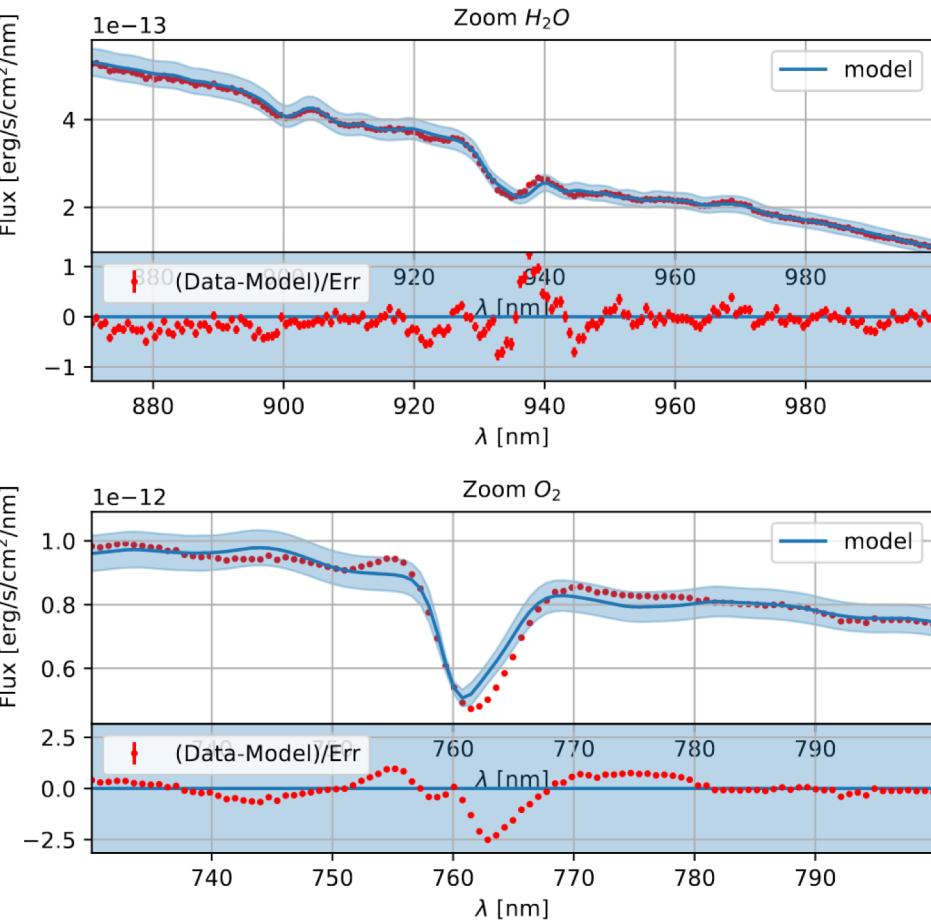
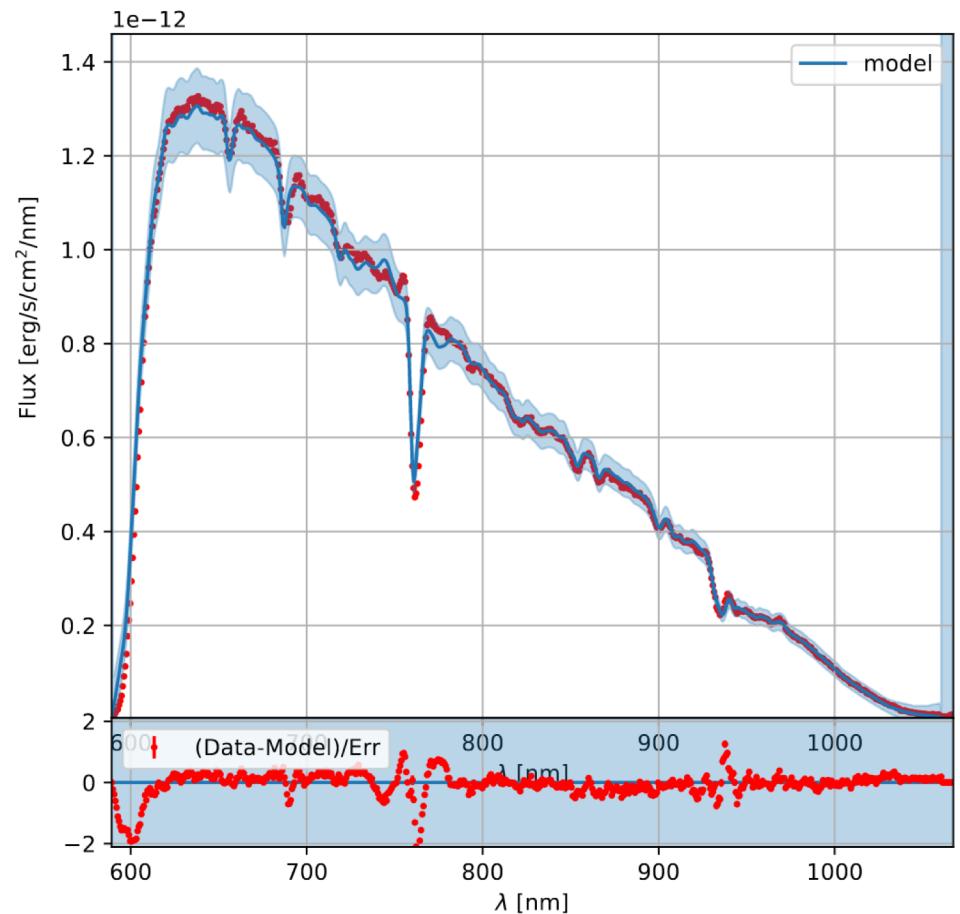
- Find PWV=3.5mm as expected by Sylvie
- Red filter throughput very similar to constructor curve !
- Residuals indicates that something varies during the night (aerosols ? Clouds ?) => biases the throughput estimates and prevents from doing aerosols studies for the moment



Atmospheric studies

chi2: 0.07406555313673573
A1: 0.94 +0.03 - 0.03
ozone: 310 +172 - 172
PWV: 3.1 +0.2 - 0.2
VAOD: 0.00 +0.05 - 0.05
reso [pix]: 1.8 +0.2 - 0.2
D_CCD [mm]: 179.93 +0.03 - 0.03

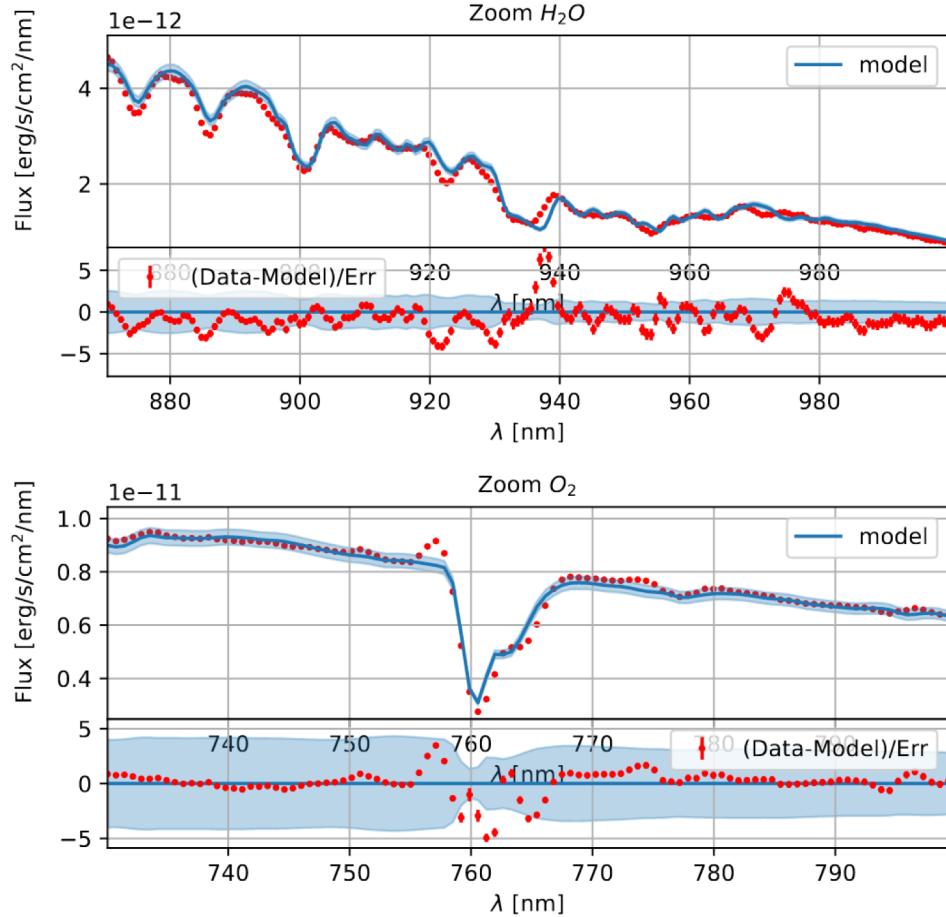
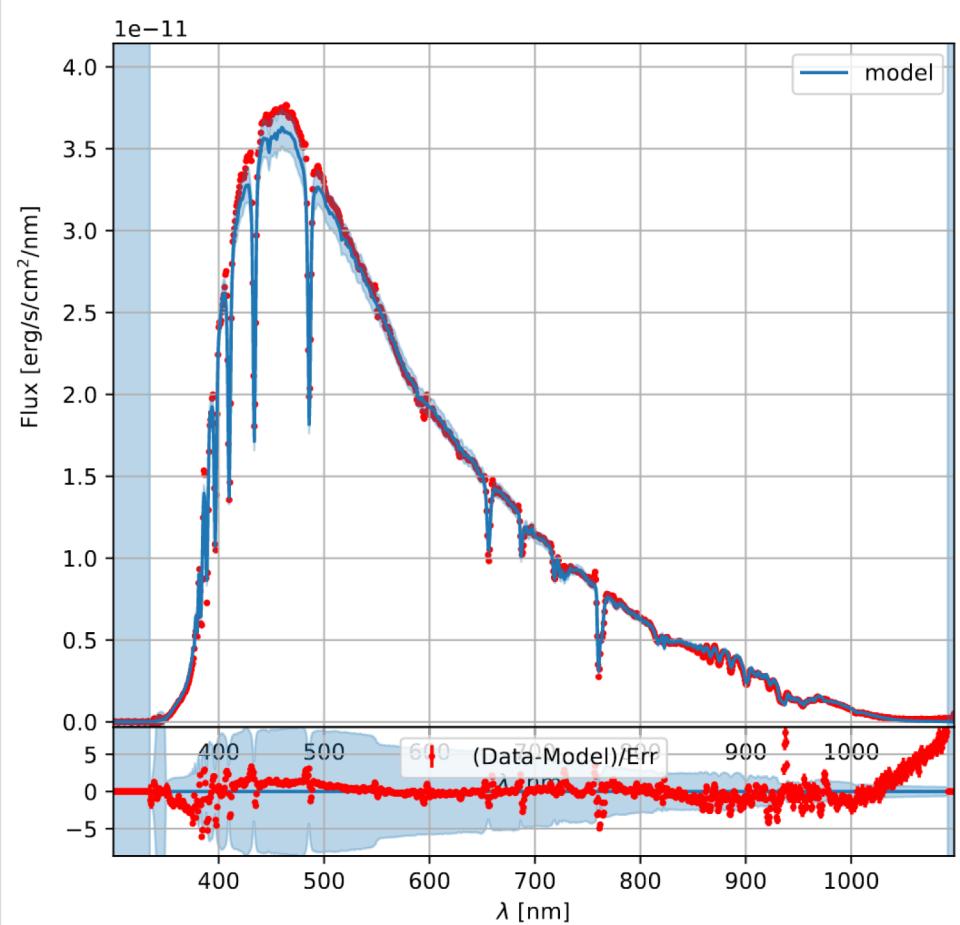
- Given the two instrumental throughputs, fit one atmosphere on every spectra



Atmospheric studies

chi2: 5.750806458690729
A1: 0.966 +0.004 - 0.004
ozone: 108 +20 - 20
PWV: 9.2 +0.1 - 0.1
VAOD: 0.053 +0.003 - 0.003
reso [pix]: 0.65 +0.04 - 0.04
D_CCD [mm]: 181.274 +0.004 - 0.004

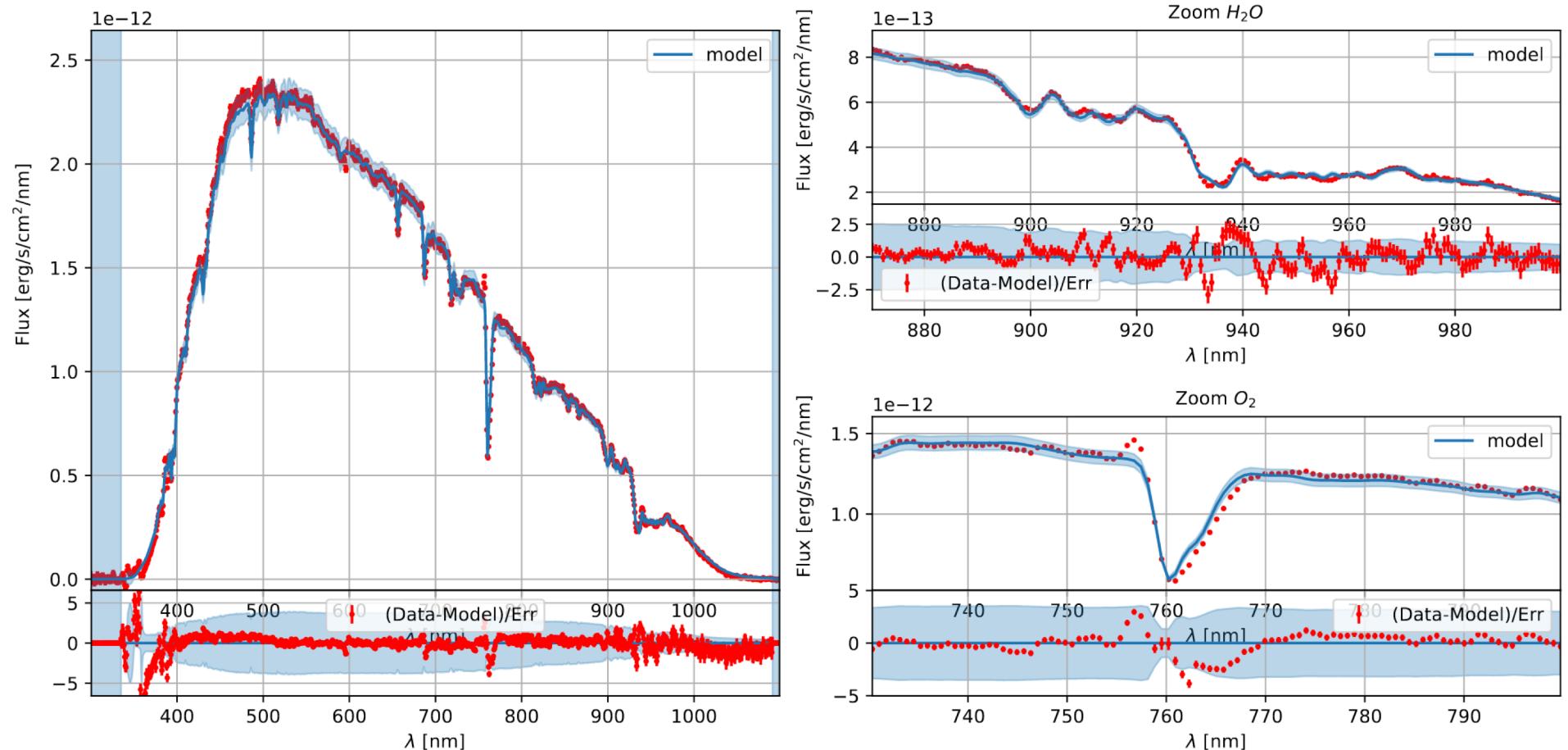
- Given the two instrumental throughputs, fit one atmosphere on every spectra



Atmospheric studies

chi2: 1.5645907610833527
A1: 1.028 +0.004 - 0.004
ozone: 214 +19 - 19
PWV: 7.1 +0.1 - 0.1
VAOD: 0.056 +0.004 - 0.004
reso [pix]: 1.20 +0.05 - 0.05
D_CCD [mm]: 180.836 +0.007 - 0.007

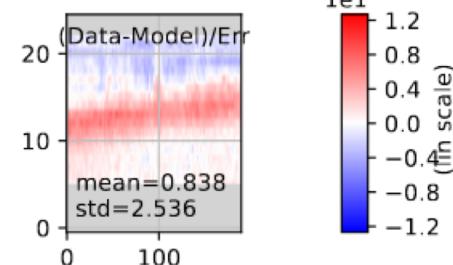
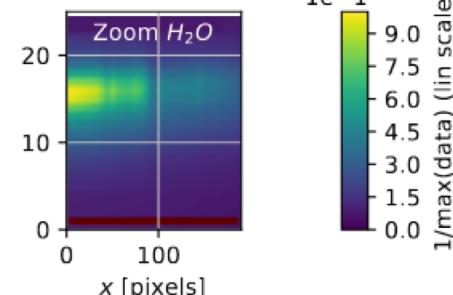
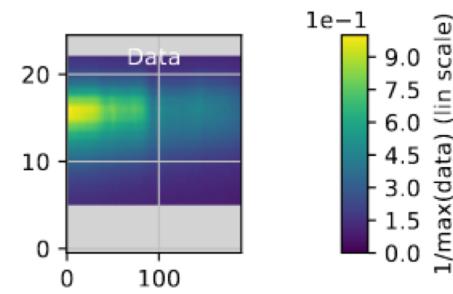
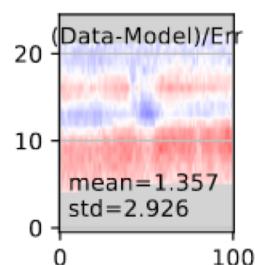
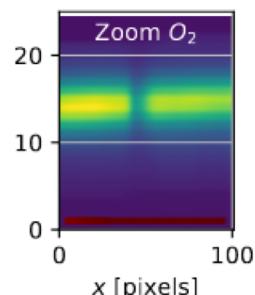
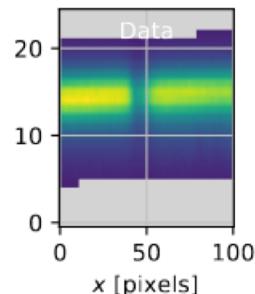
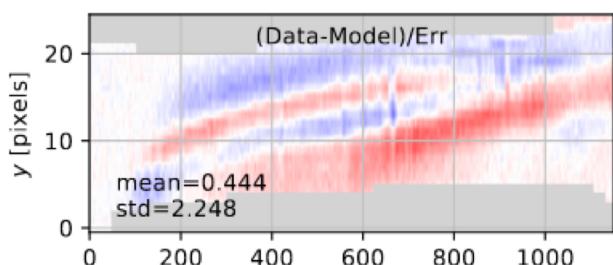
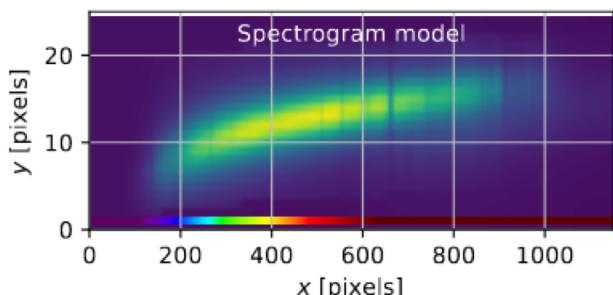
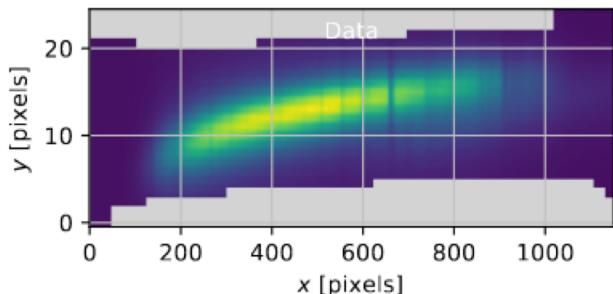
- Given the two instrumental throughputs, fit one atmosphere on every spectra



Atmospheric studies

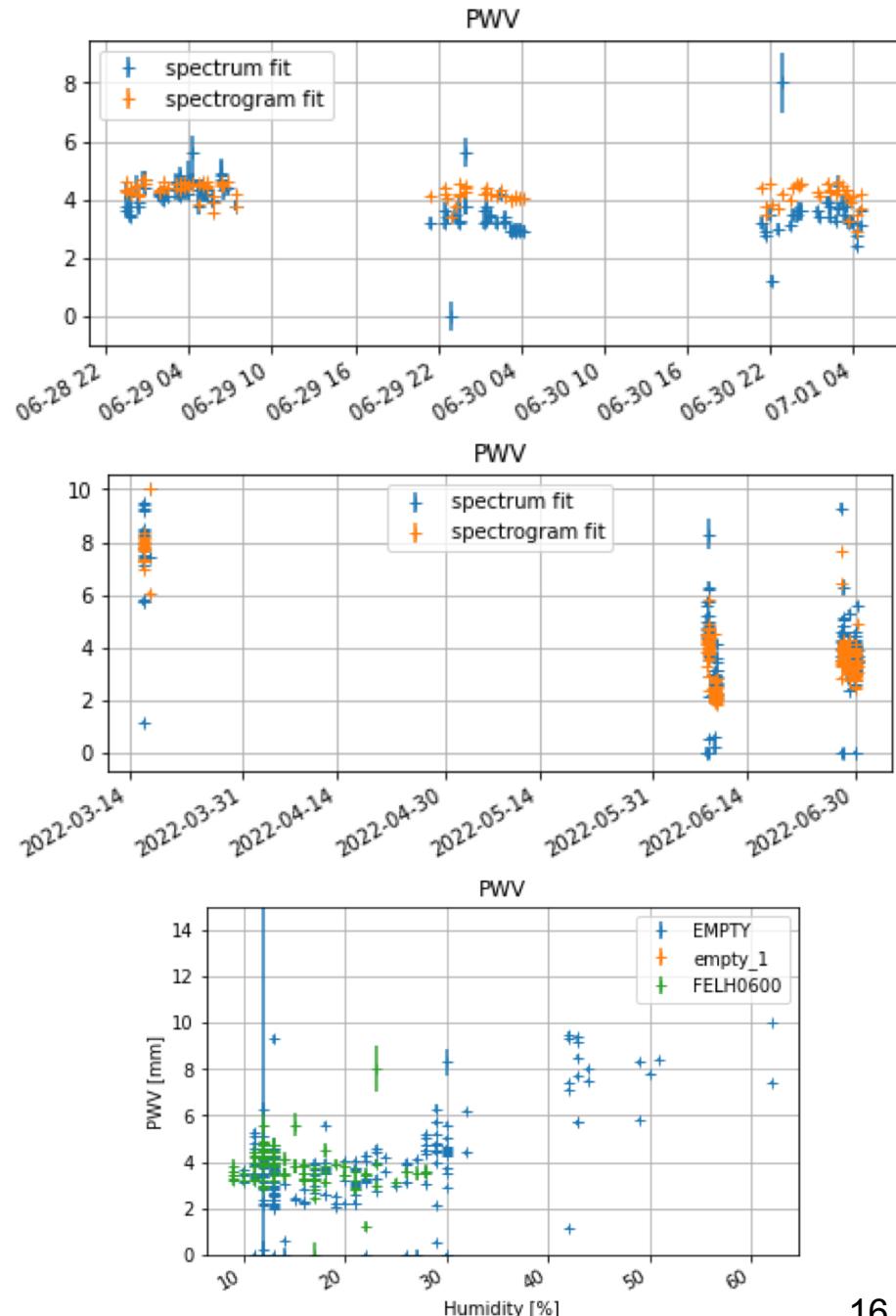
chi2: 3.884344329113549
A1: 1.002 +0.002 - 0.002
ozone [db]: 274 +4 - 4
PWV [mm]: 6.99 +0.04 - 0.04
VAOD: 0.032 +0.002 - 0.002
D_CCD [mm]: 180.895 +0.003 - 0.003

- Atmospheric forward model directly on images (here same spectrum as previous slide)



Atmospheric studies

- Preliminary looks at PWV(t) :
 - With red filter (two fitting methods)
 - Without filter (two fitting methods)
- Correlation with summit humidity ?



Summary

- Outputs of this work:
 - better forward model for AuxTel spectrograph
 - second diffraction order model (not a nuisance : **it is signal**)
 - two instrumental throughputs
 - first try of atmospheric transmission measurement
- Libradtran fit is not the end of a story, but the beginning of another one
- Needs:
 - One beautiful photometric night to get better instrumental throughputs
 - Improve Spectractor speed (because of more parameters) to remove rebinning
 - Investigate reasons for the libradtran bad fits
 - Implement this new Spectractor version in DM