Star Spectra at Auxtel with the hologram program in progress of hologram characterisation

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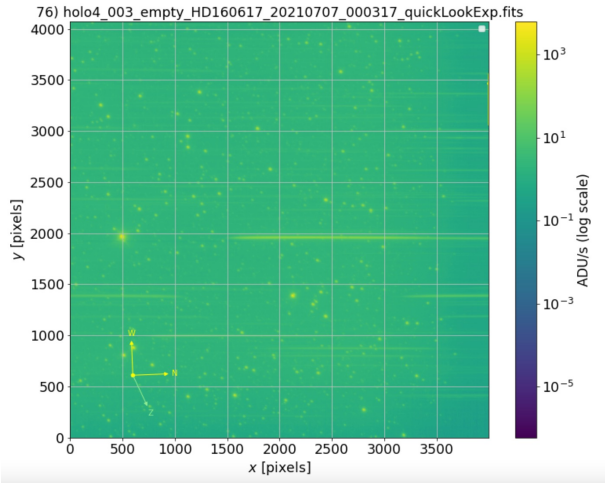
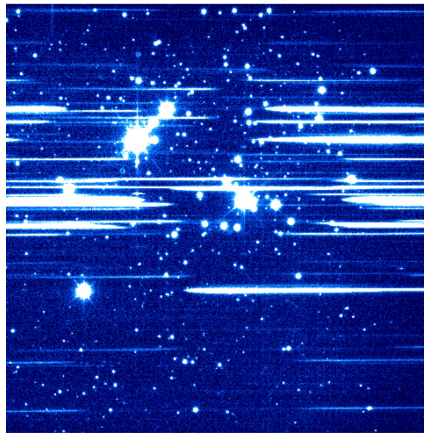
Dominique Boutigny (computing with DM@CC)

New member Martin Monroy (dec. 2021)

IJCLab & LPNHE

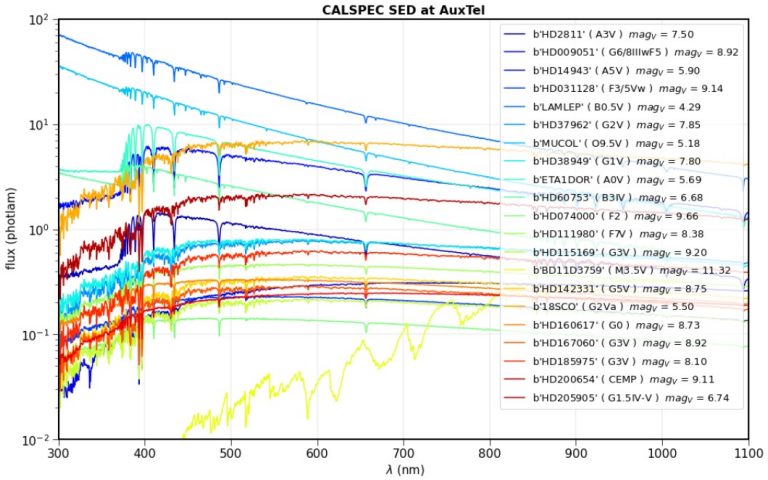
Rubin-LSST France November 22th 2021





Auxtel observations in 2021

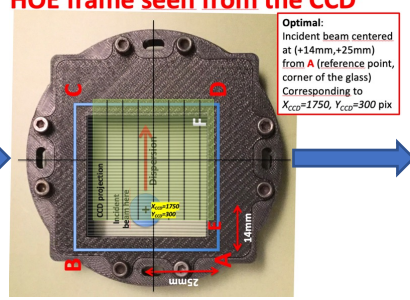
① Observable CALSPEC SED



② Auxiliary telescope (AuxTel)

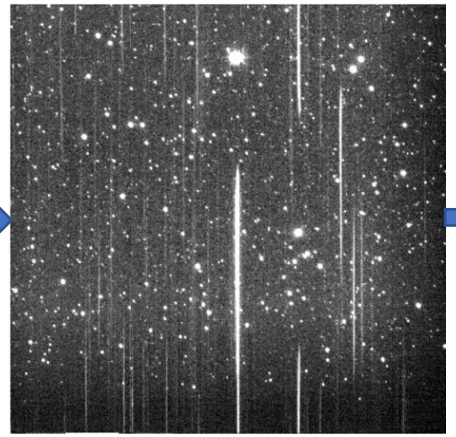
③ beam dispersion

HOE frame seen from the CCD



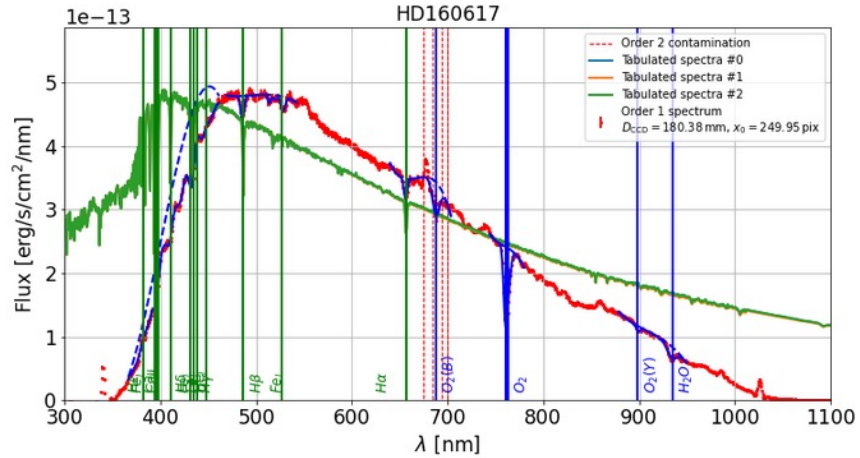
Hologram/ronchi

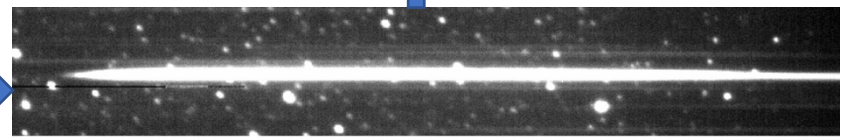
④ CCD



⑤ spectrum

(reconstruction by Spectractor)





spectrogram

Program of characterisation of the hologram (before atmospheric parameters @ atmospheric transparency)

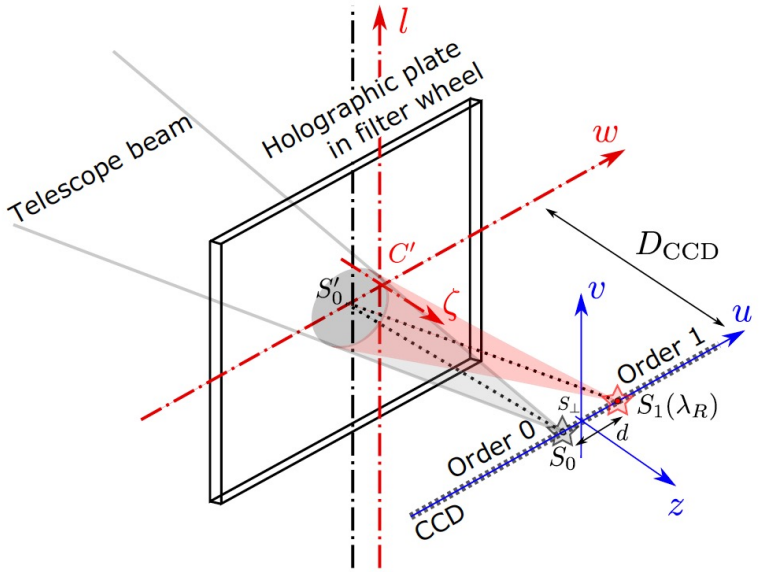
- Step 0 : What is the distance between the hologram-CCD (D_{CCD}) ?
- Step 1 : Where is the optical centre of the Hologram ?
- Step 2 : What are the hologram transmission curves ?
- Step 4 : What is the PSF ? Correction of the model ?
- Step 5 : What is the resolution of the spectrometer ?

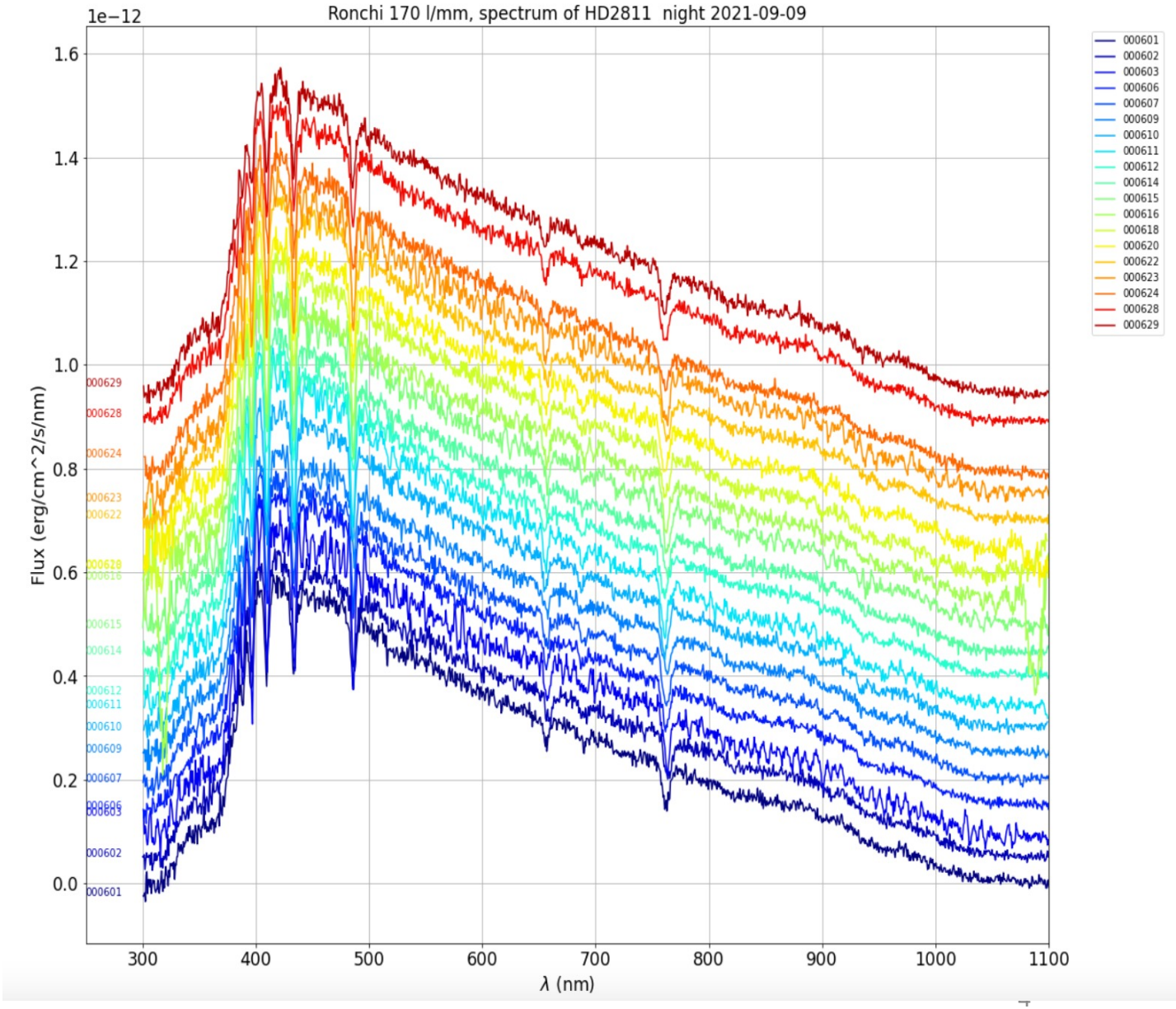
Answers obtained through:

- 1) Pre-characterisation in the optical bench
- 2) Dedicated measurements in Auxtel

Step 0 : Distance Hologram CCD

Ronchi Neff = 170 lines per mm





D_{CCD}(ronchi) = 181.45 ±0.18 mm

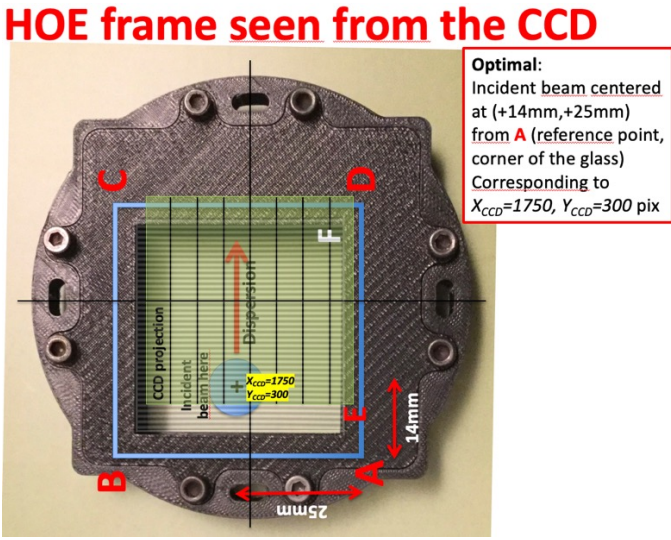
- But $D_{CCD}(ronchi) \neq D_{CCD}(holo)$

Step 1 : Optical center of the Hologram

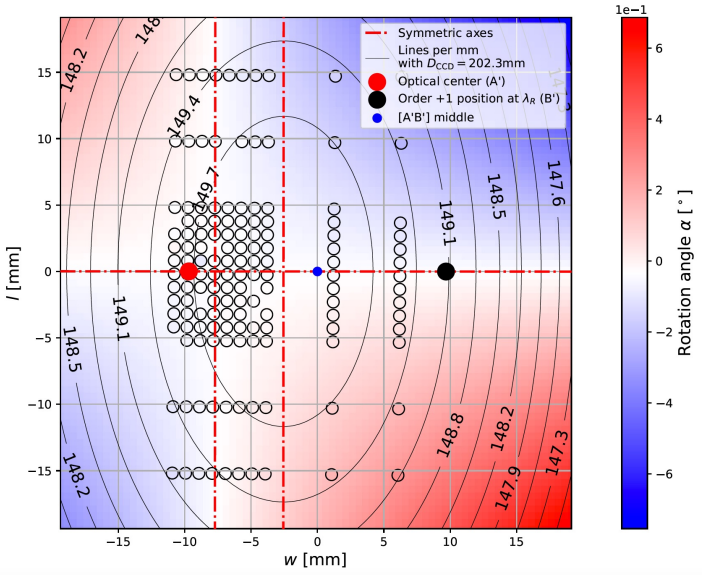
Projected on CCD

Scan on X-Y and measure :

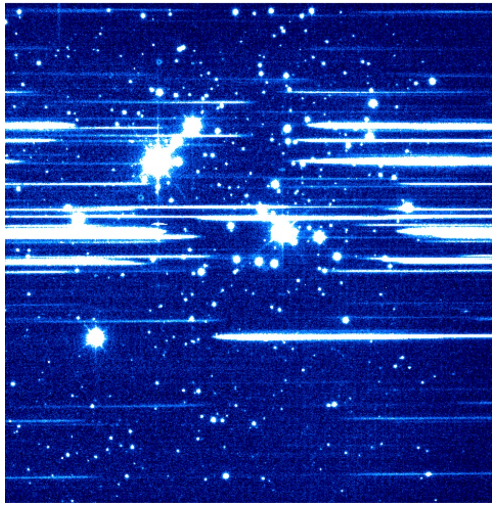
1. Dispersion angle axis
2. Line density N_{eff}



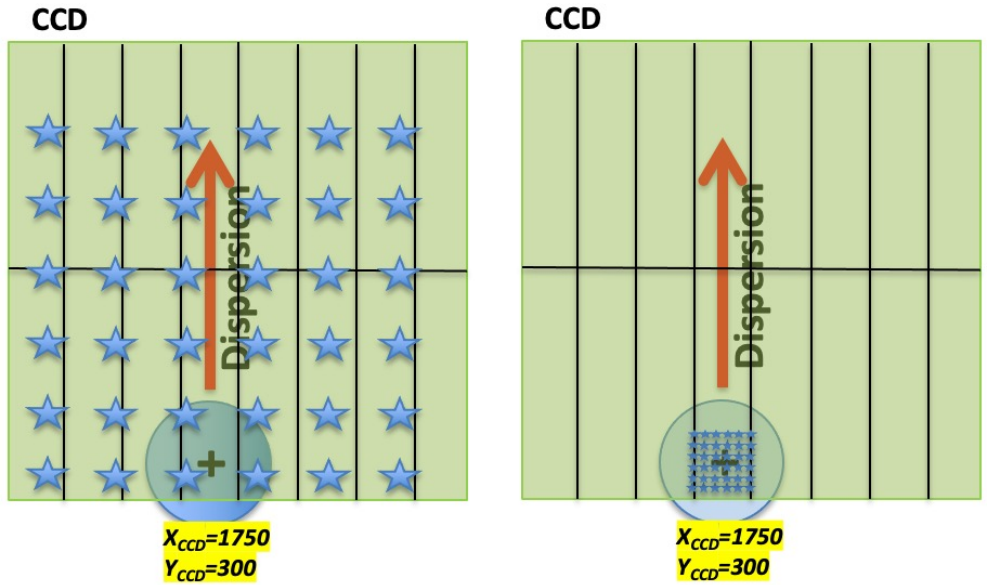
0) Scan in optical bench



a) NGC4755 open cluster
In feb 2021

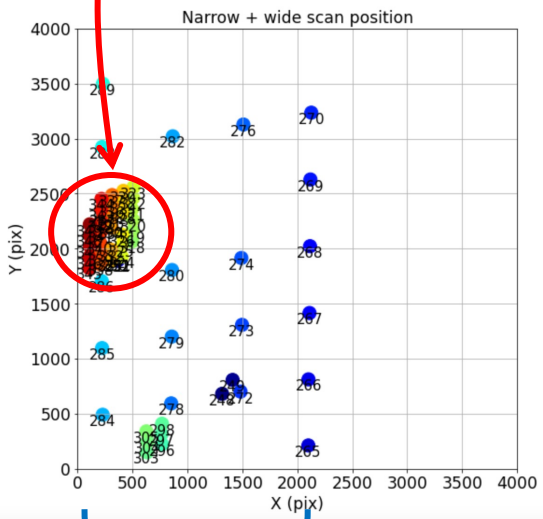


b) Narrow and wide scan with target HD160617 In July 2021

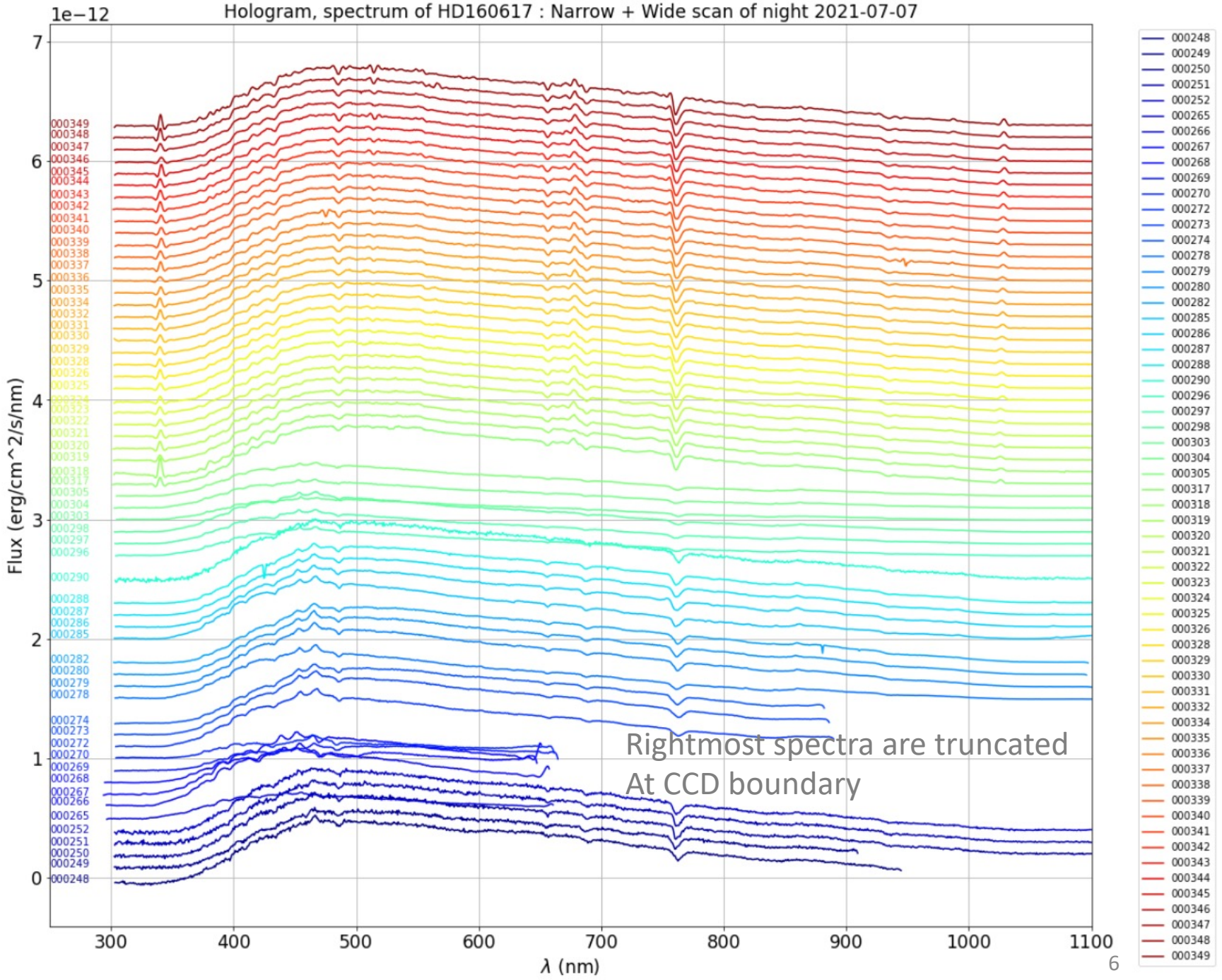


Hologram Spectra from the X-Y scan

Narrow scan



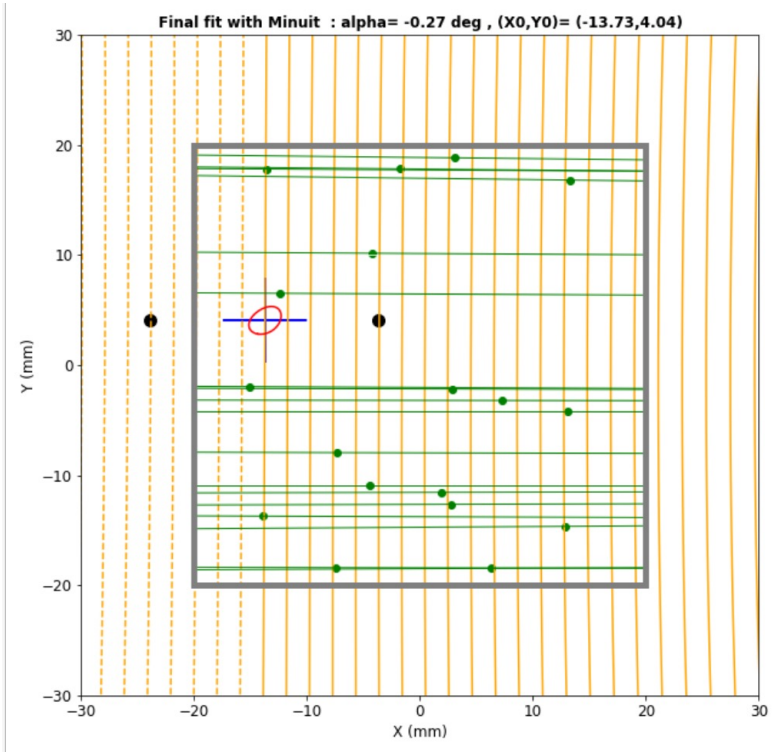
Wide scan



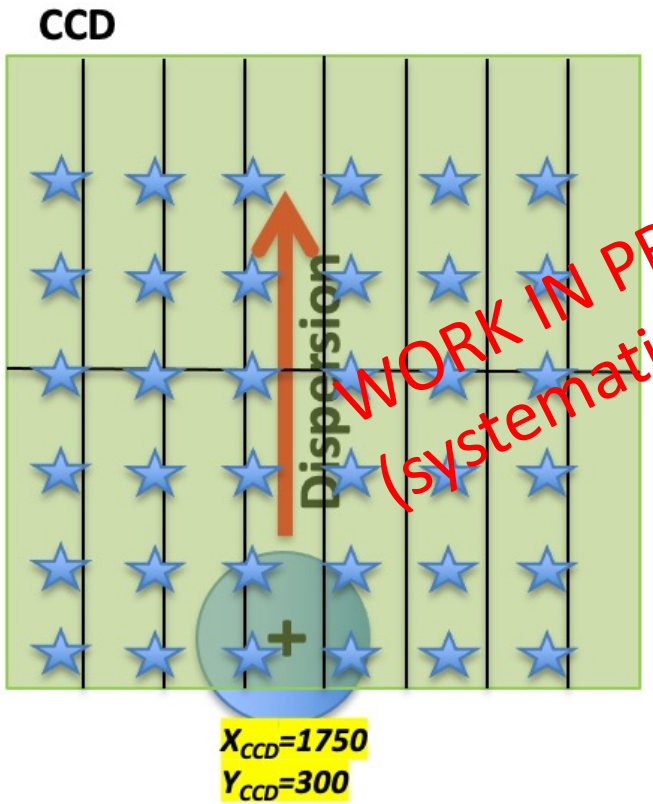
Step 1 : Measurement of the angle of dispersion

From Spectractor (bias : scan not optimal due to Atmospheric Differential refraction effect)

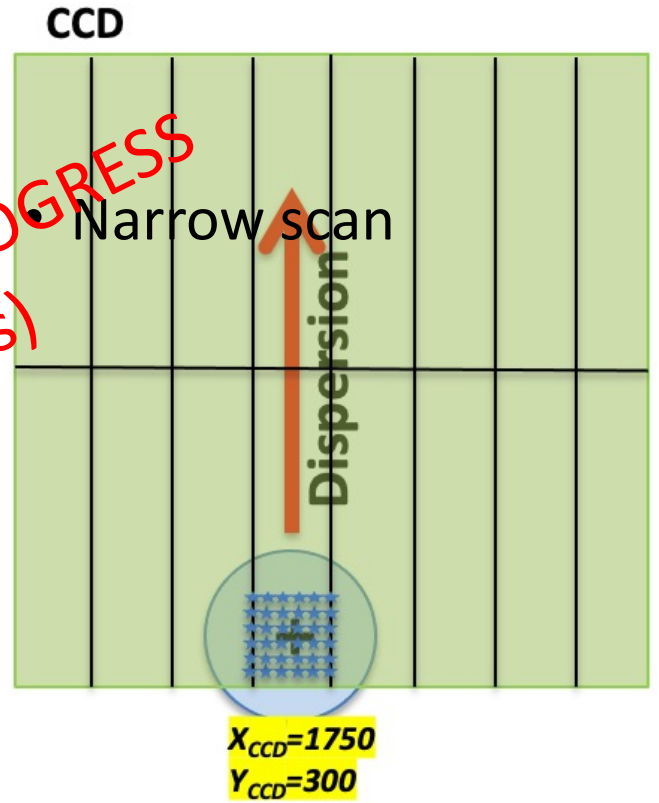
- Open cluster (DS9)



- Narrow + Wide scan



- Narrow scan



WORK IN PROGRESS (systematics)

- Narrow scan

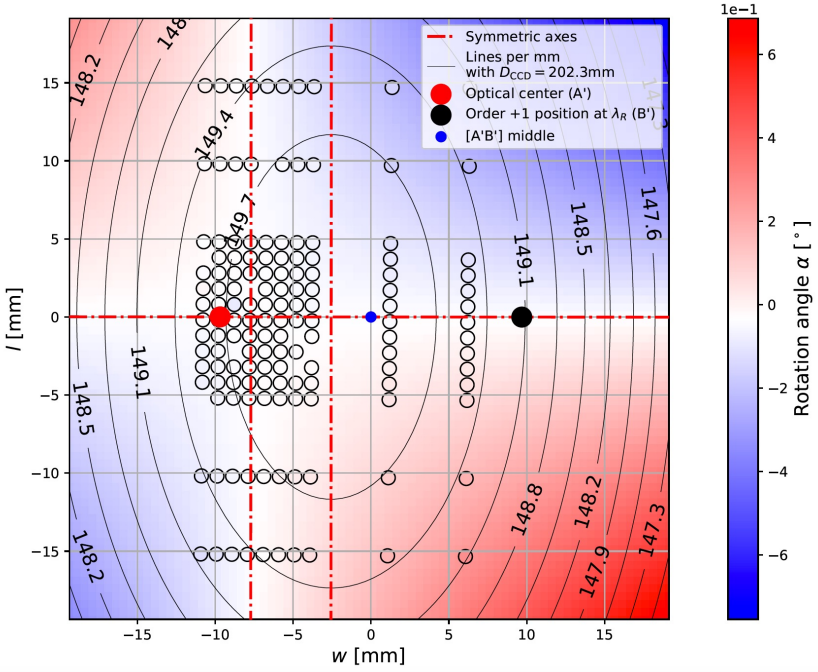
(Need to re-run Spectractor in full resolution mode)

Step 1 : Measurement of line density to localize the center of symmetry

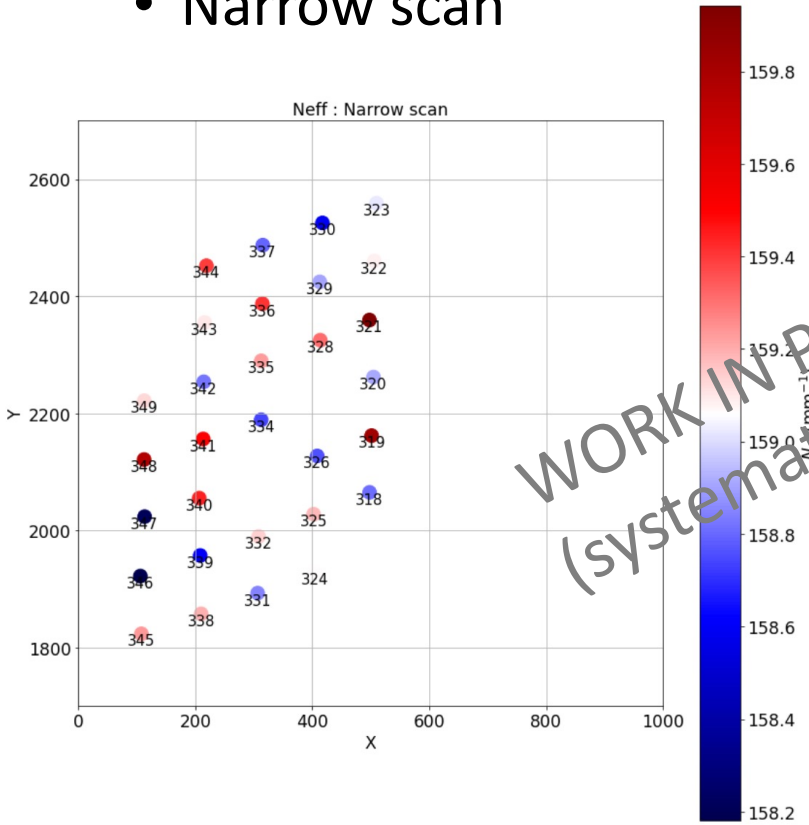
Neff from dispersion relation :

$$\sin\theta_p(\lambda) - \sin\theta_0 = pN_{\text{eff}}\lambda,$$

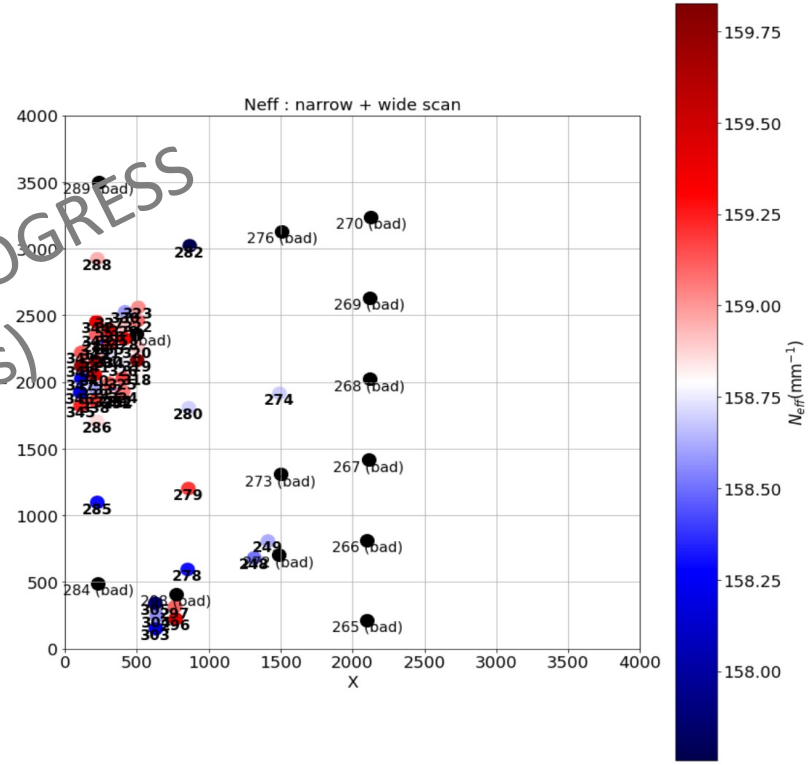
Optical bench



- Narrow scan



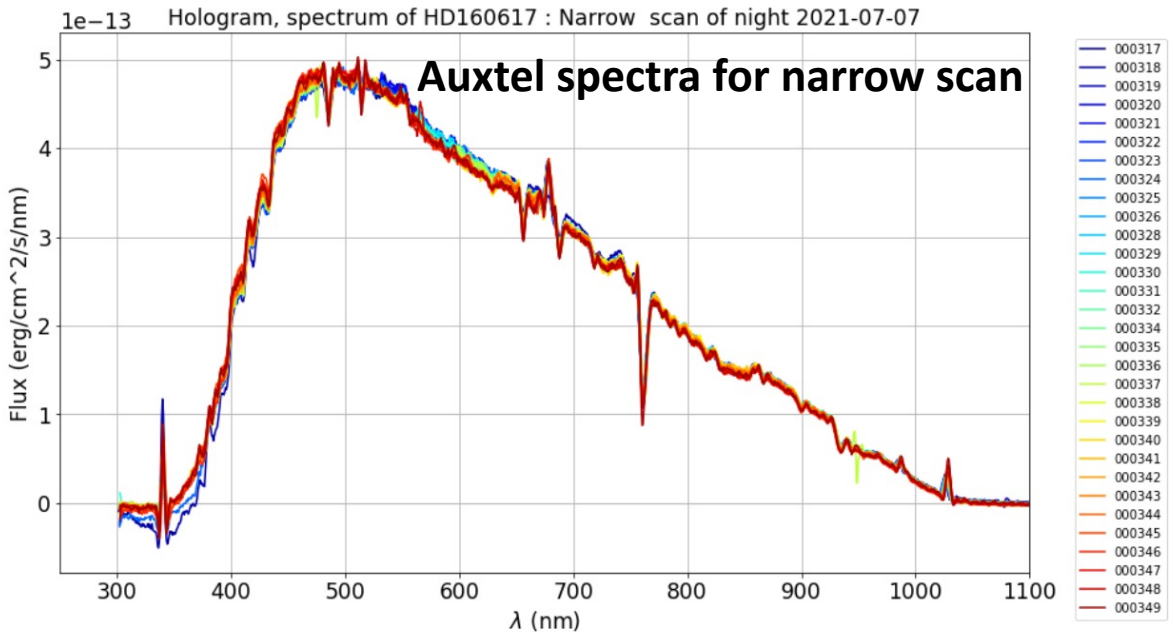
- Narrow + wide scan

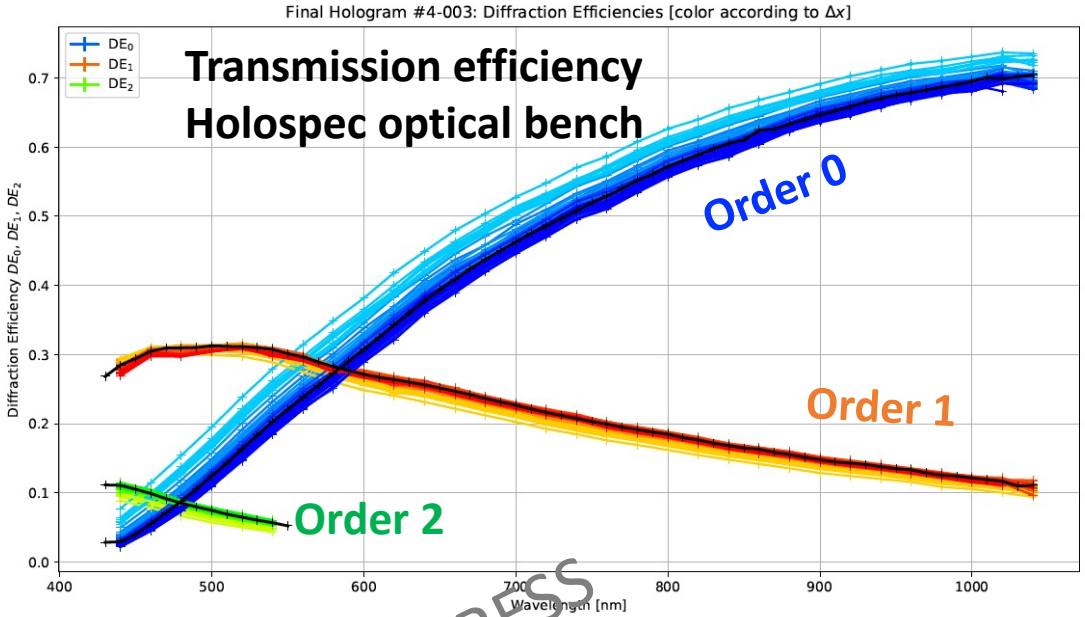


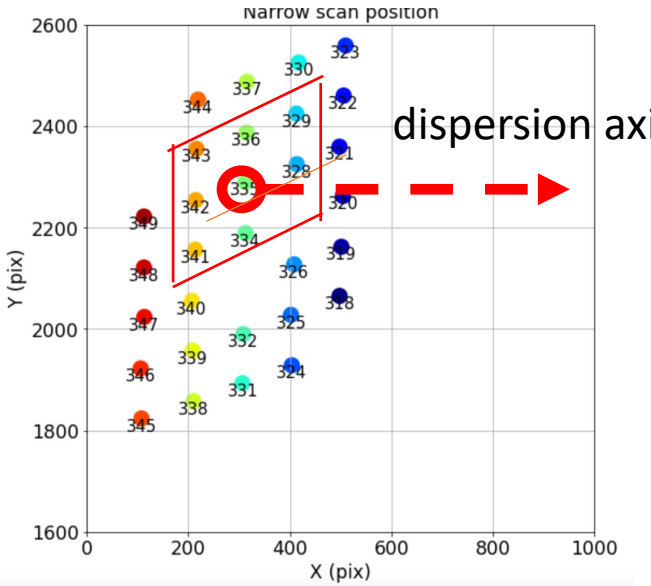
WORK IN PROGRESS (systematics)

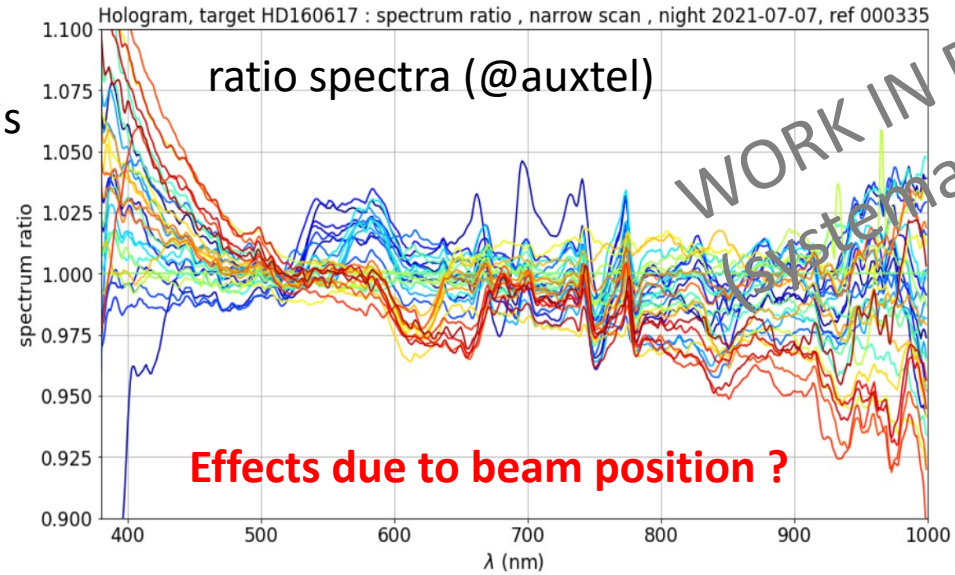
Method less sensitive to atmospheric differential refraction,
However still systematics : need to re-run Spectracor in full resolution mode

Step 2 : Transmission curves of Holograms





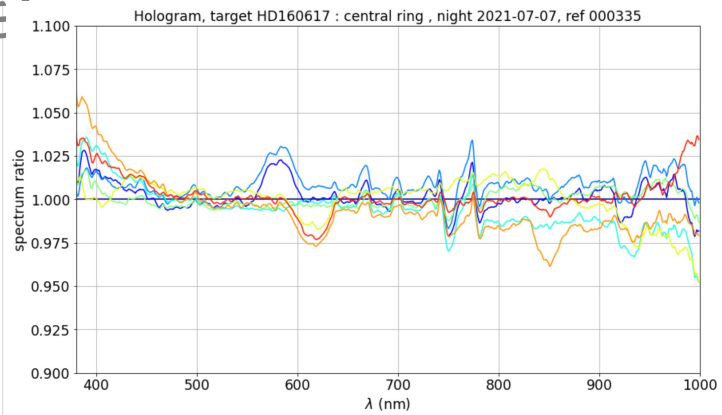




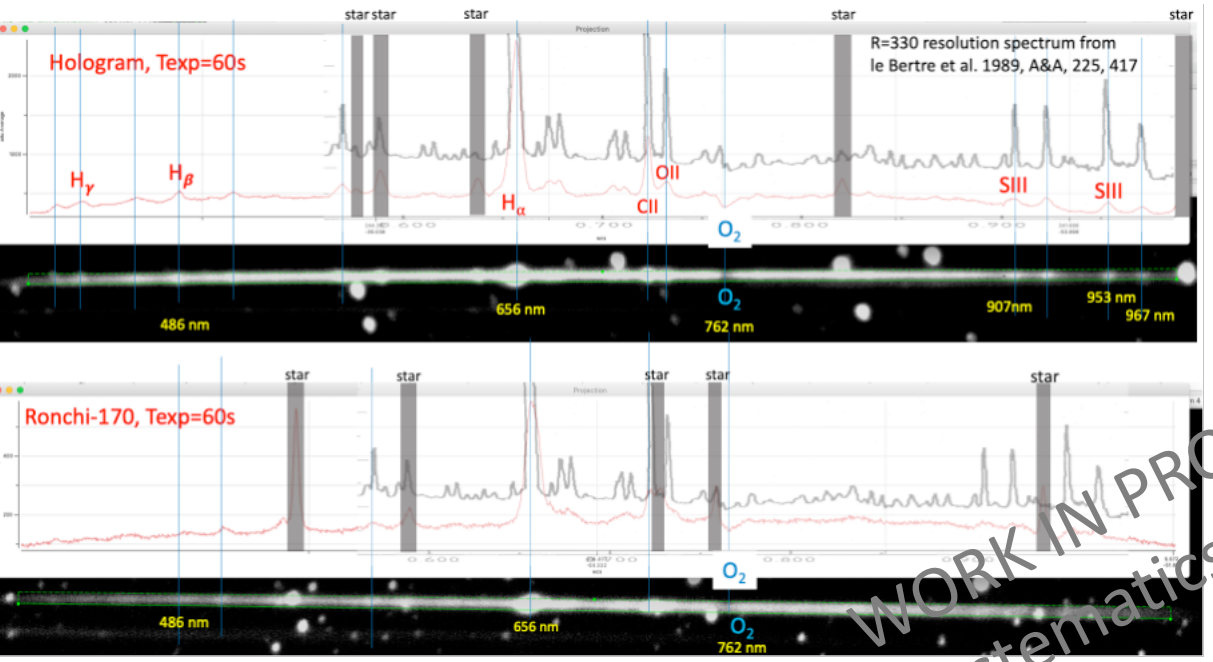
WORK IN PROGRESS

Systematics

1 mm central ring : 2- 3 %

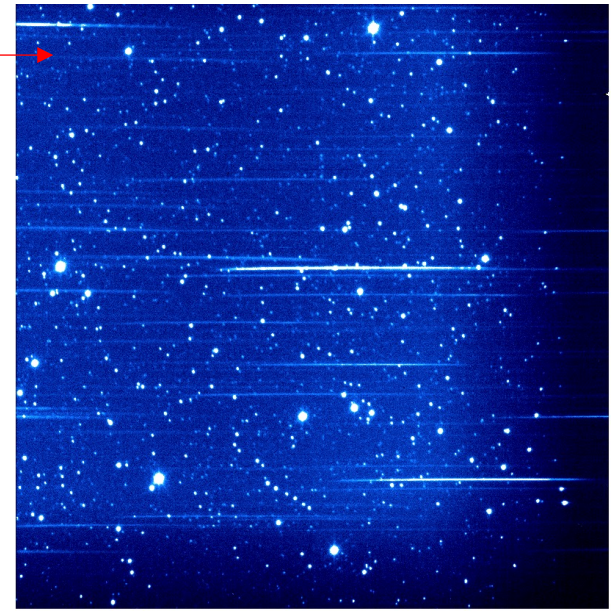


Step 5 : Resolution with Planetary Nebula emission lines



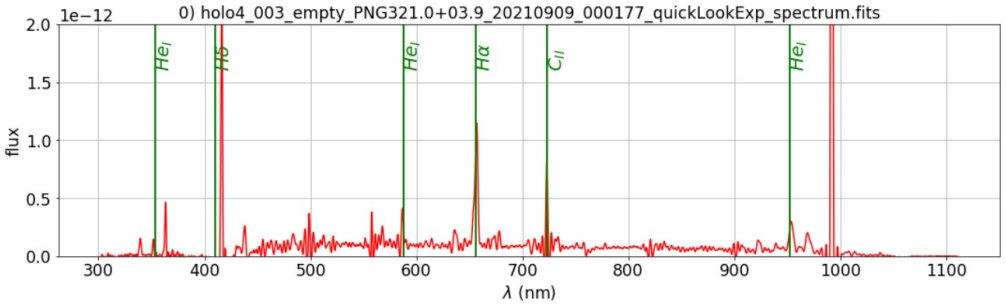
DS9 :
Play with LUT
To select
Emission lines/
Background stars

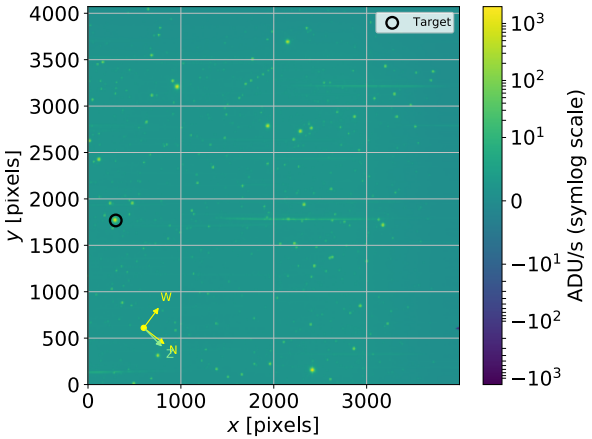
Planetary nebula PNG321.0+03.0



WORK IN PROGRESS
(systematics)

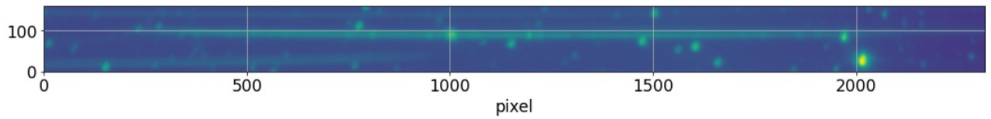
In spectractor :





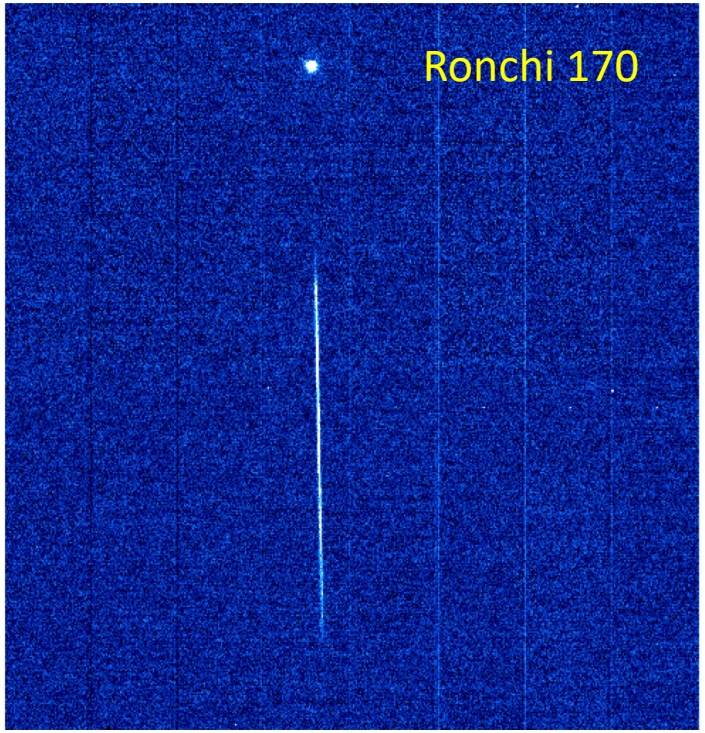
Reconstruction in Spectractor
Is difficult to interpret

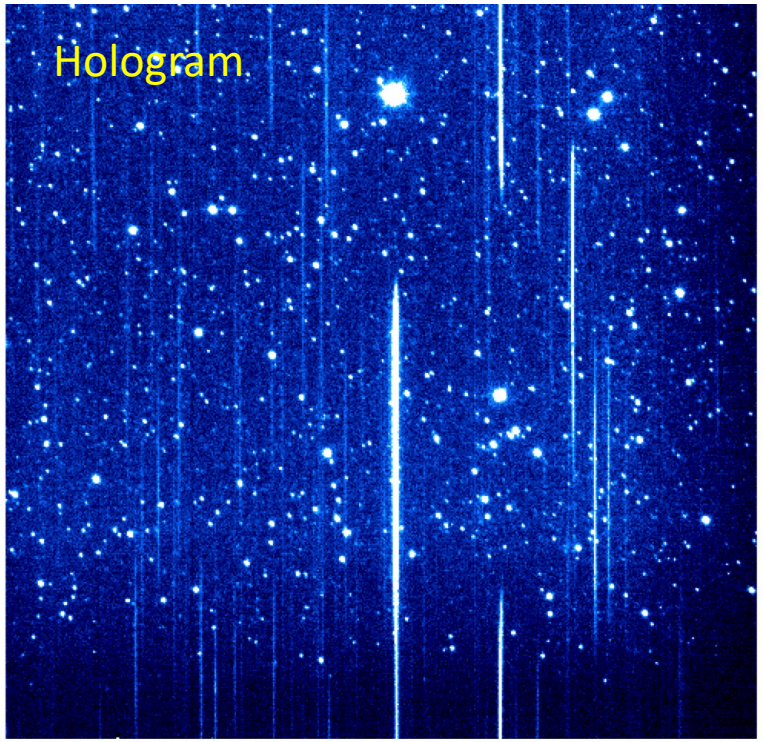
- Need to mask neighbouring stars !

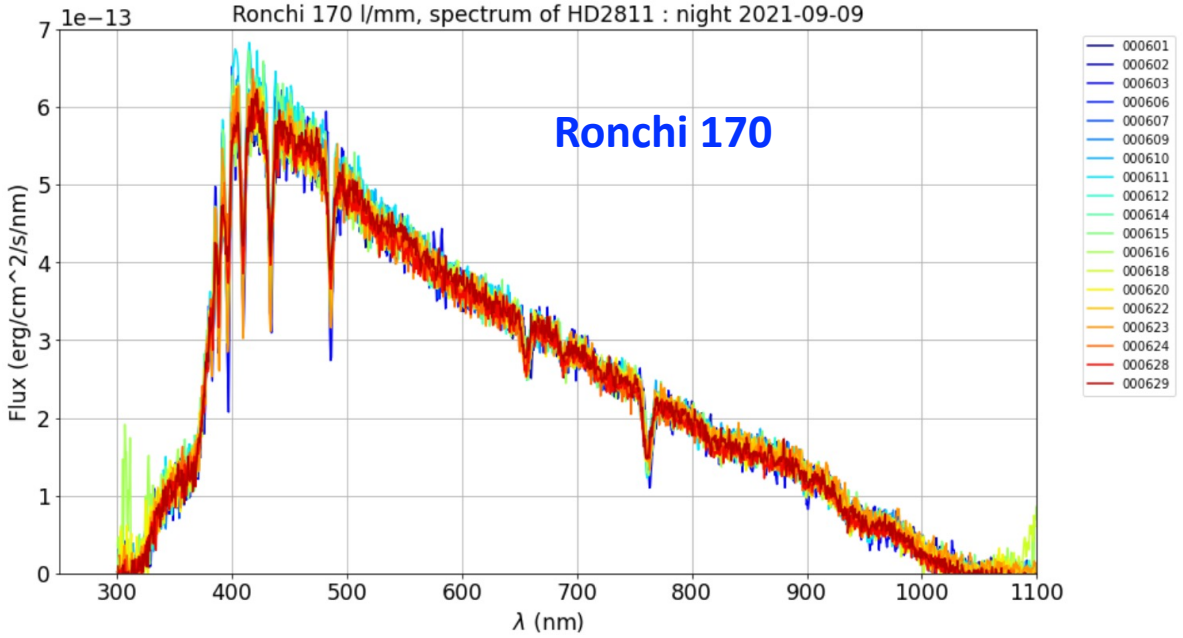


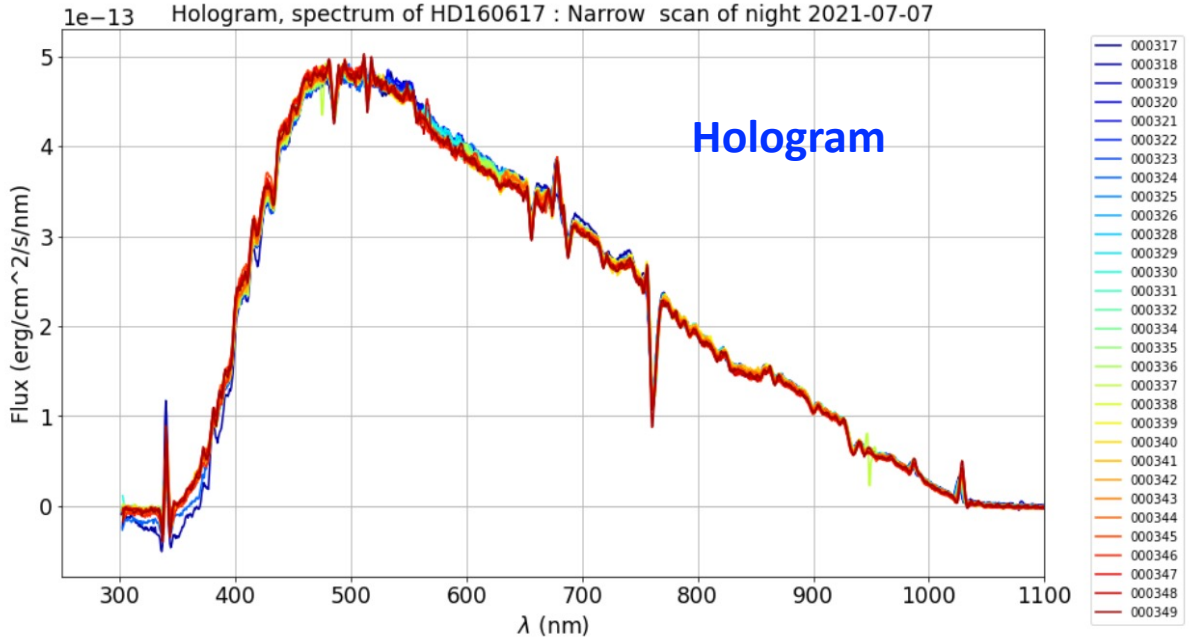
Summary and perspectives on hologram characterisation in Auxtel

- **Need to measure :**
  - DCCD,
  - Optical Centre (dispersion axis angle & Neff),
  - Transmission curves
  - Resolution
  - PSF
- **Observation not optimal** (namely for atmospheric differential refraction)
- **Software:**
  - DM dataproduct not optimal (QuickLookExp) → need to produce DM data-products we want (postISRCCD, flatfielded)
  - **Need to run Spectractor in full resolution mode → avoid notebooks @ NCSA, better run DM-pipeline batches jobs @ CC (Under development with Dominique Boutigny**)


Ronchi 170


Hologram

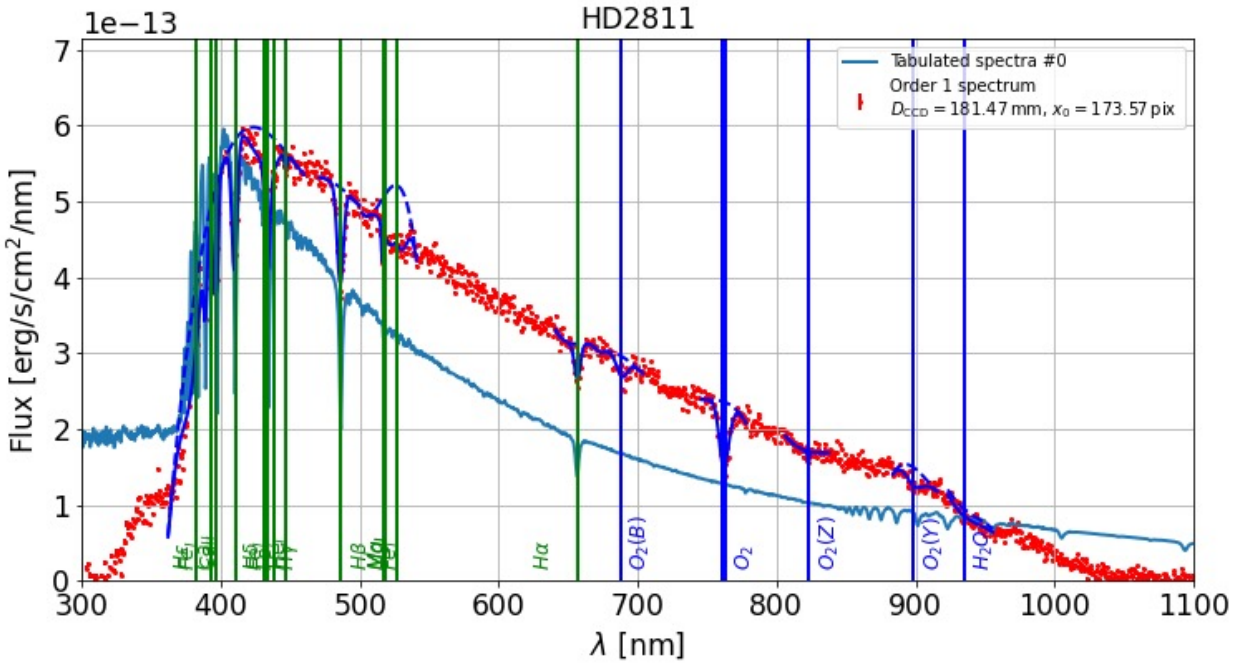

Ronchi 170 l/mm, spectrum of HD2811 : night 2021-09-09
1e−13
Ronchi 170
Flux (erg/cm^2/s/nm)
λ (nm)
000601
000602
000603
000606
000607
000609
000610
000611
000612
000614
000615
000616
000618
000620
000622
000623
000624
000628
000629


Hologram, spectrum of HD160617 : Narrow scan of night 2021-07-07
1e−13
Hologram
Flux (erg/cm^2/s/nm)
λ (nm)
000317
000318
000319
000320
000321
000322
000323
000324
000325
000326
000328
000329
000330
000331
000332
000334
000335
000336
000337
000338
000339
000340
000341
000342
000343
000344
000345
000346
000347
000348
000349

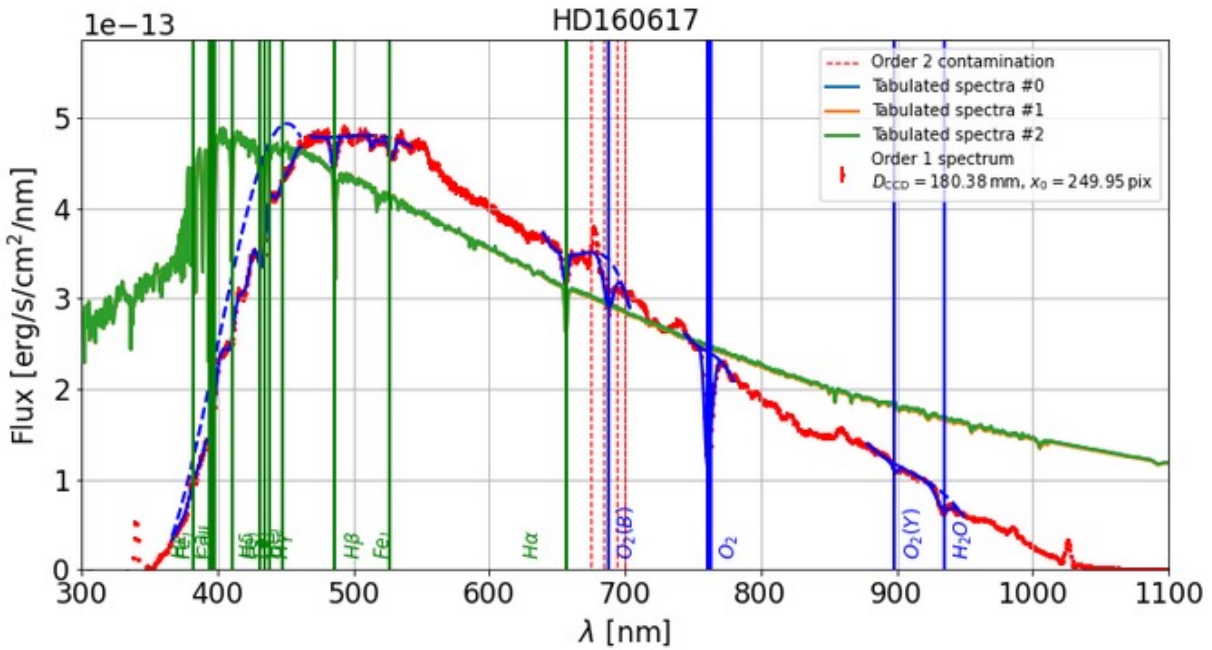
The END

BACKUP

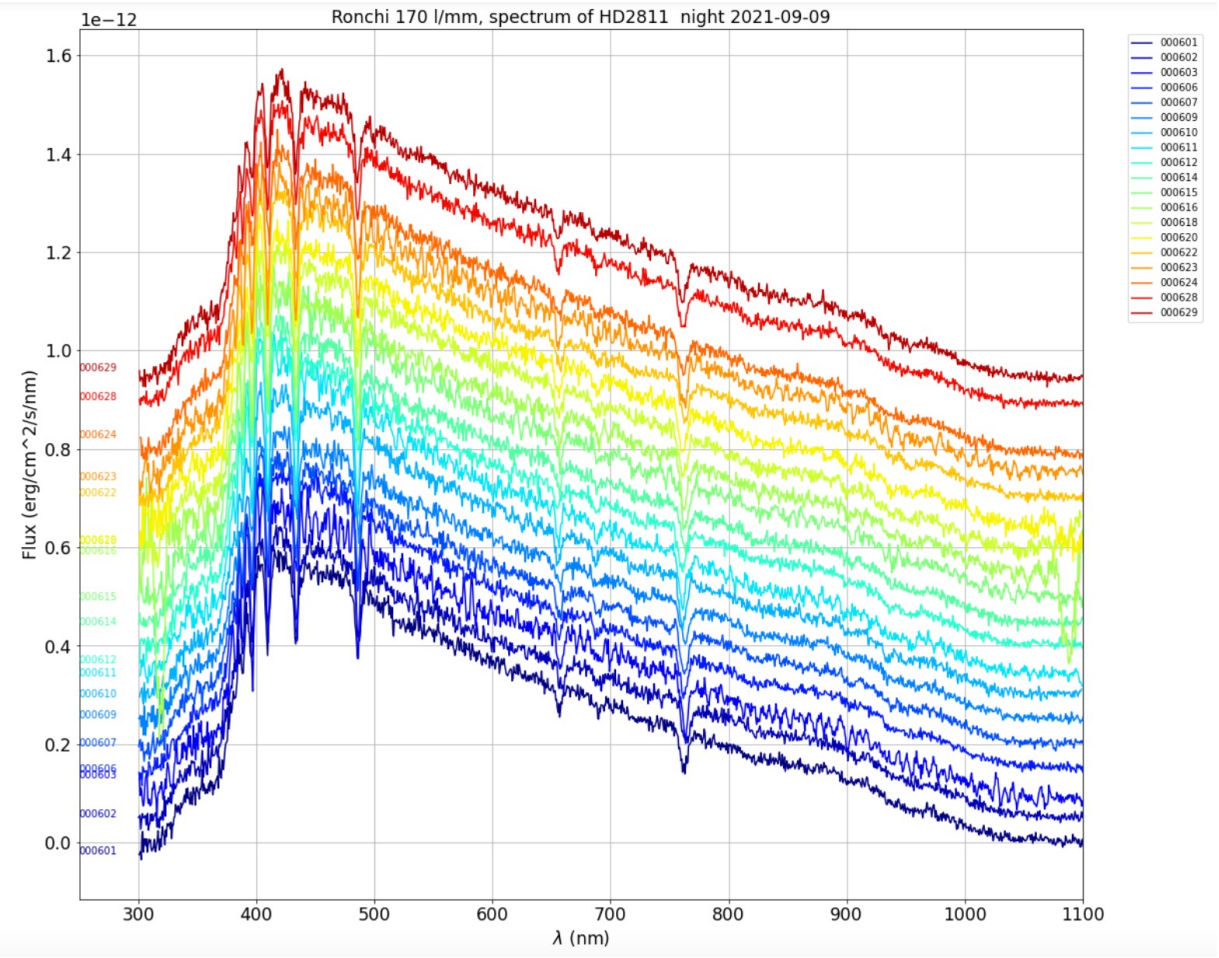
Ronchi 170 lpmm



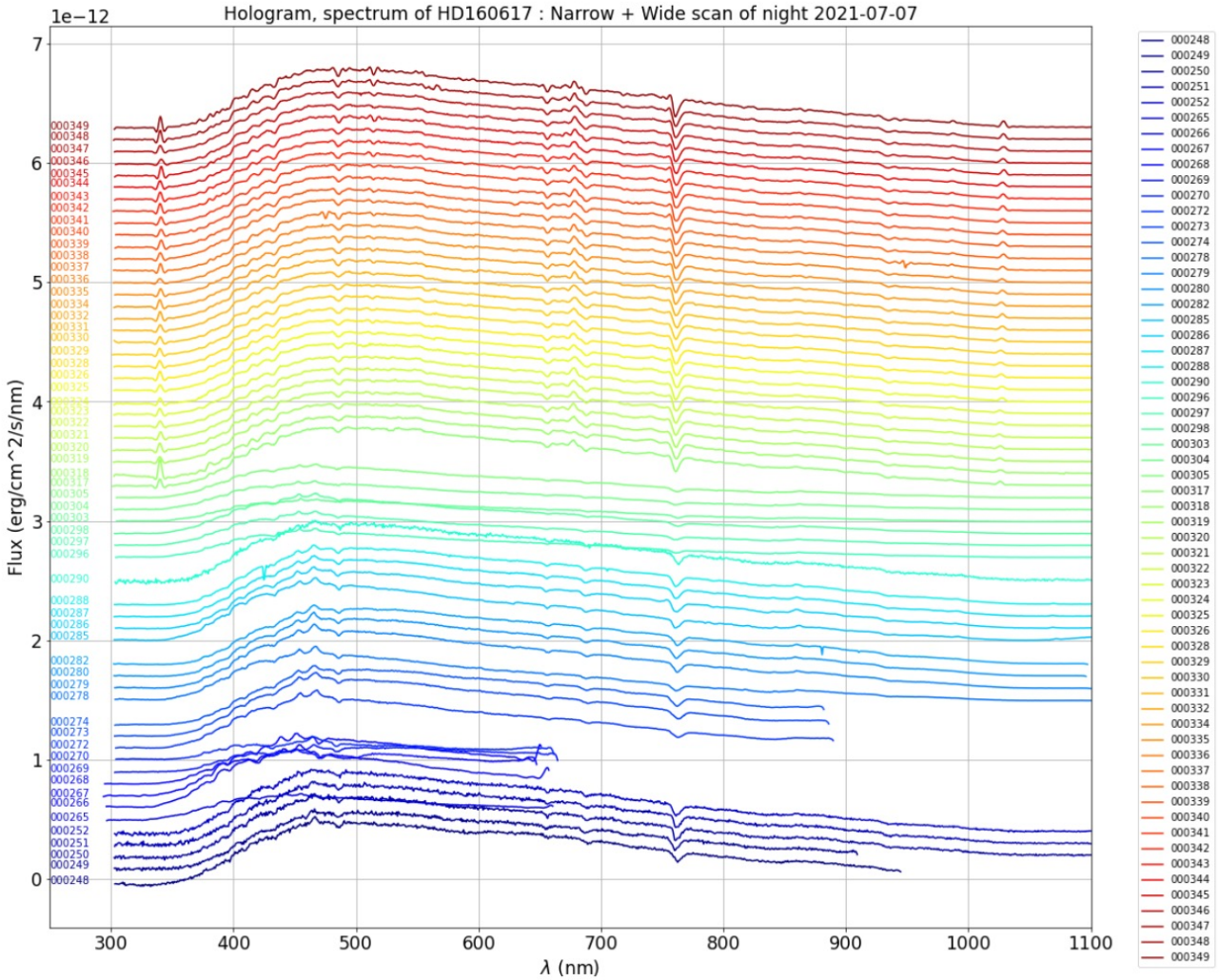
Hologram



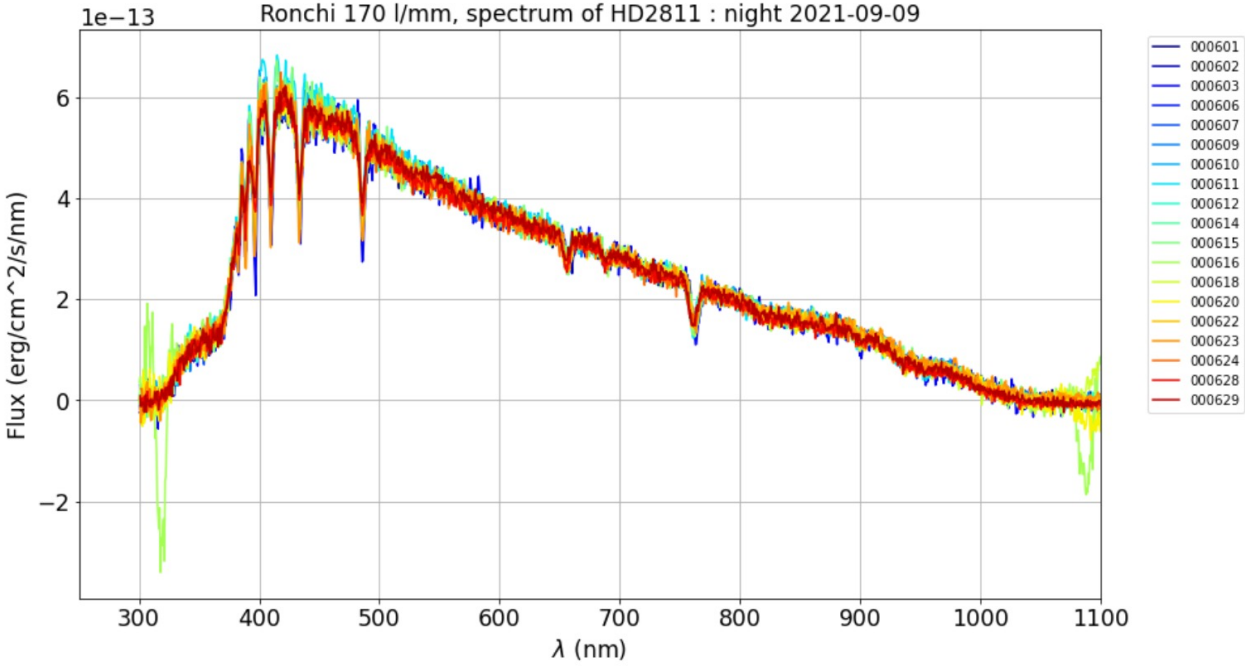
Ronchi 170 lpmm



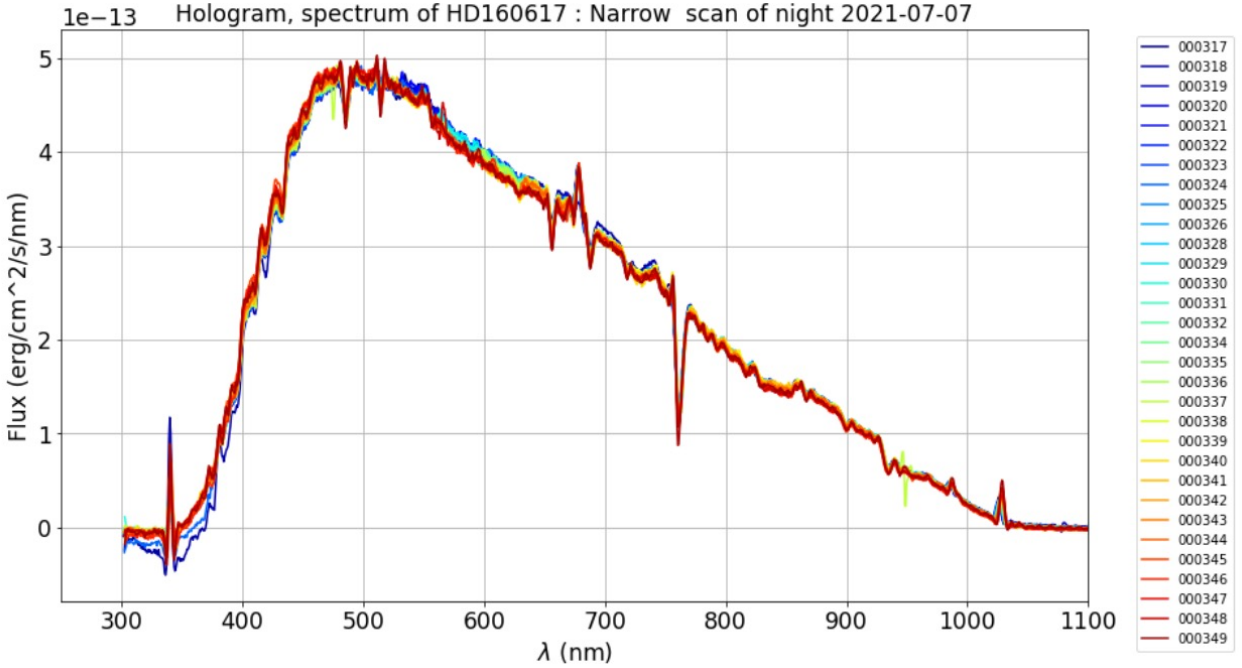
Hologram



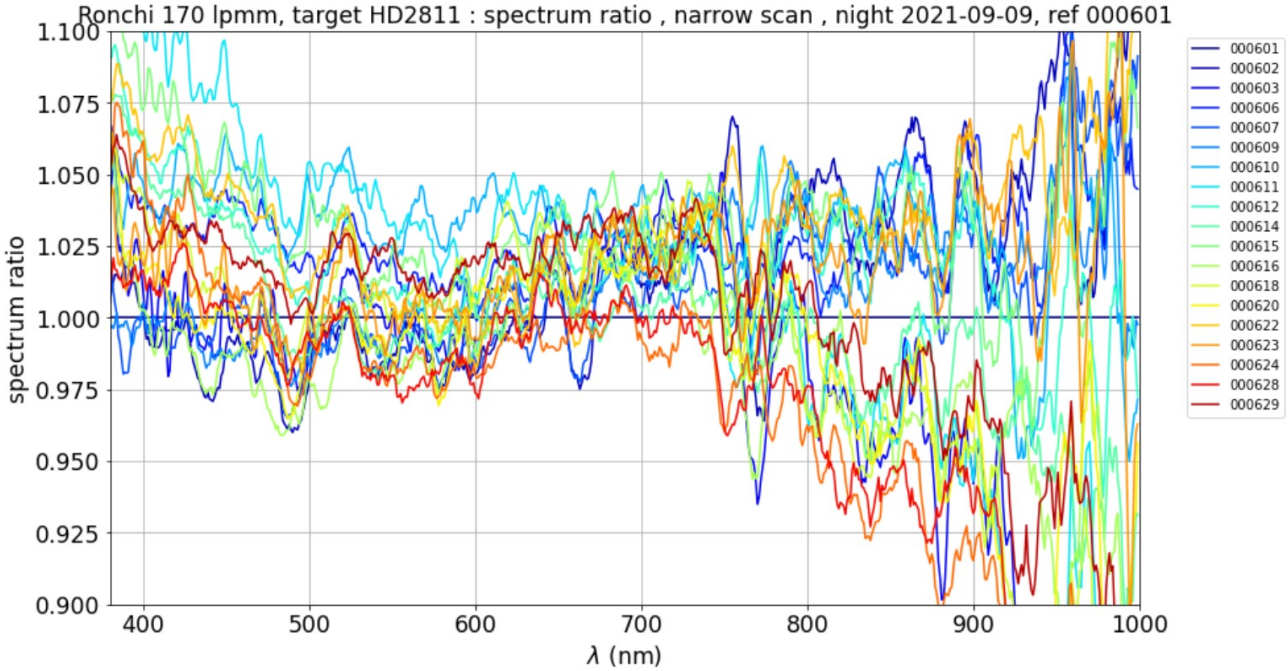
Ronchi 170 lpmm



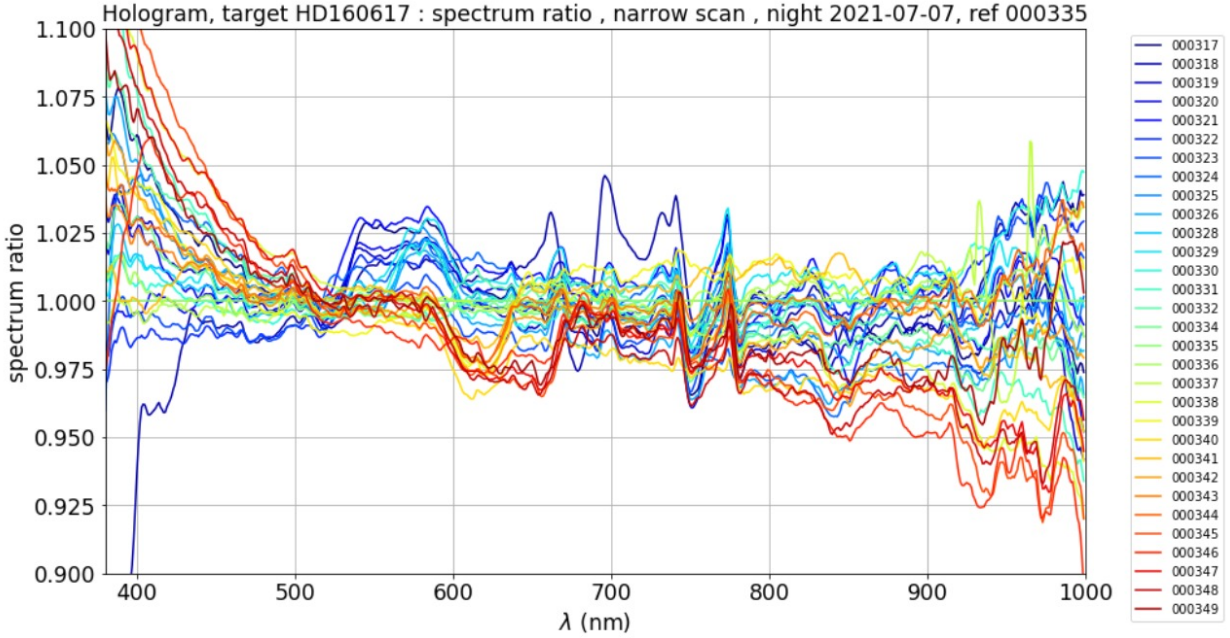
Hologram

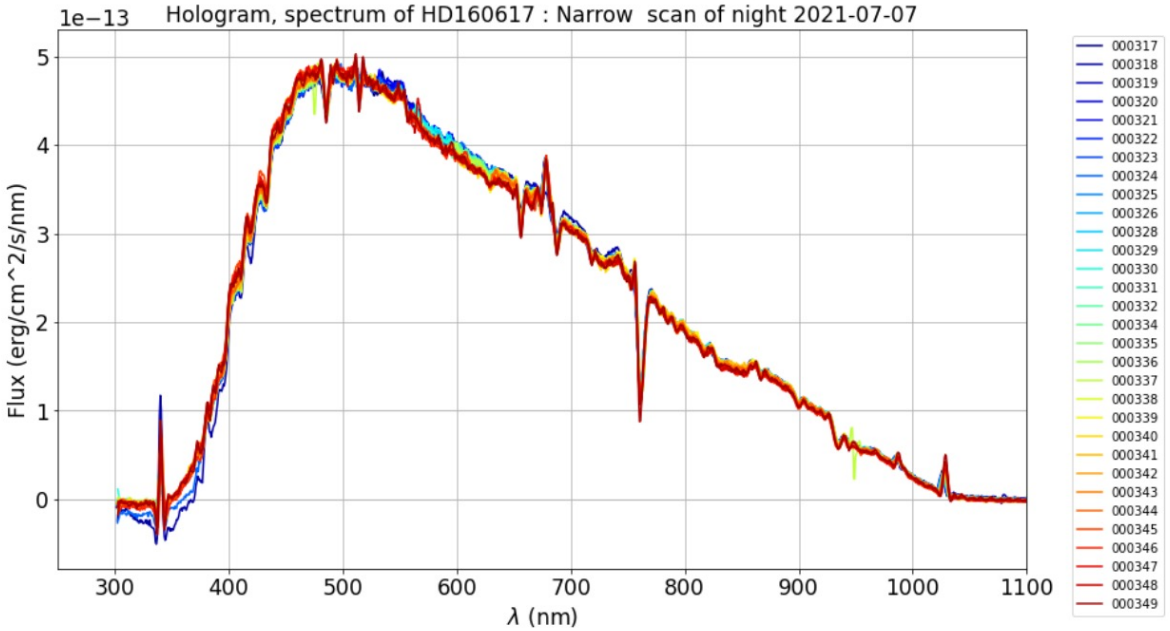


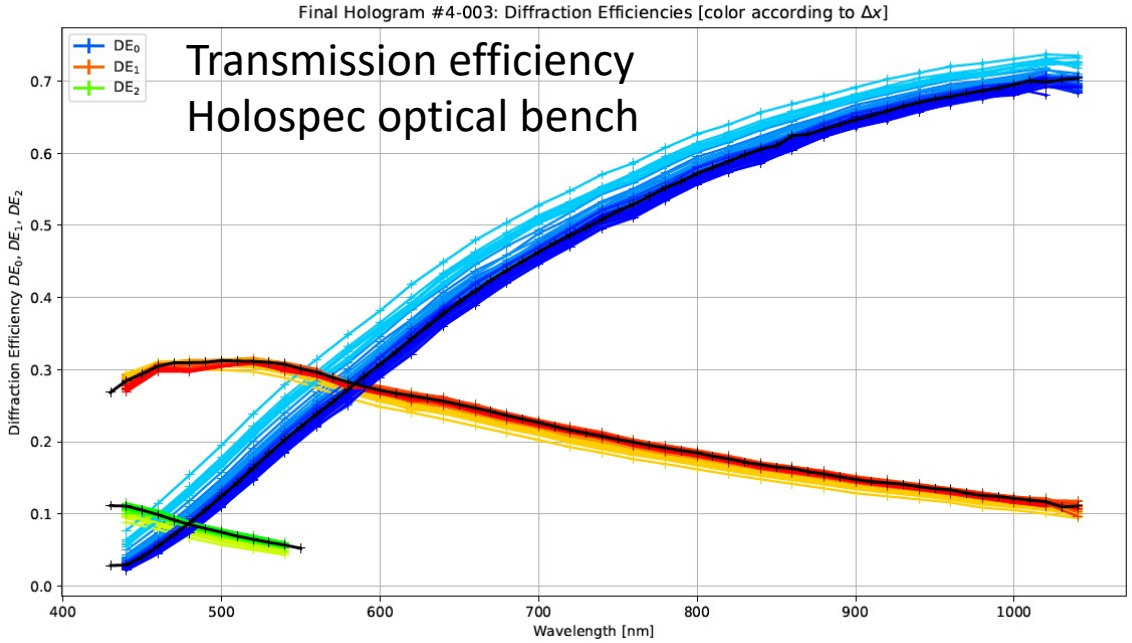
Ronchi 170 lpmm

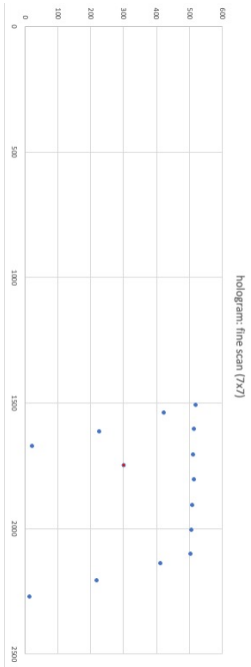


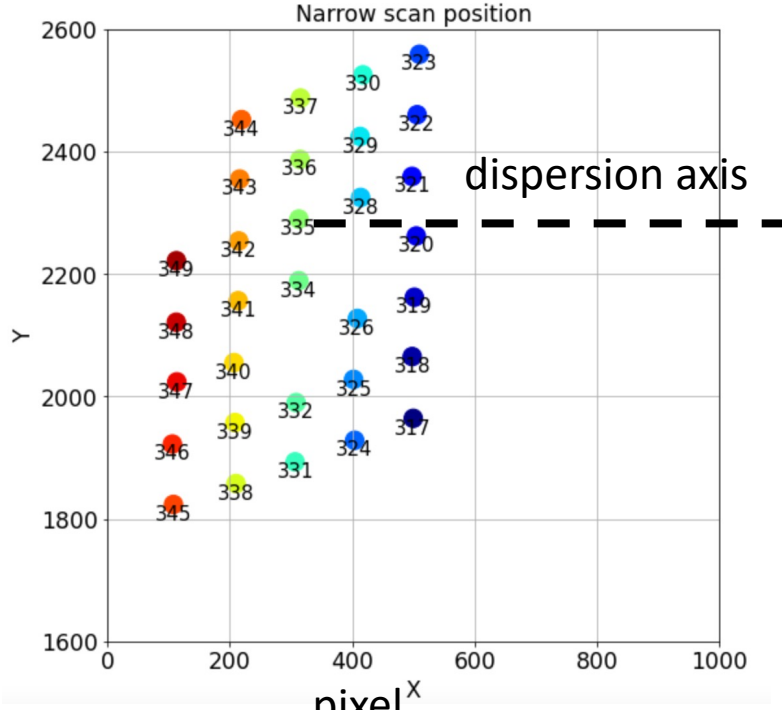
Hologram

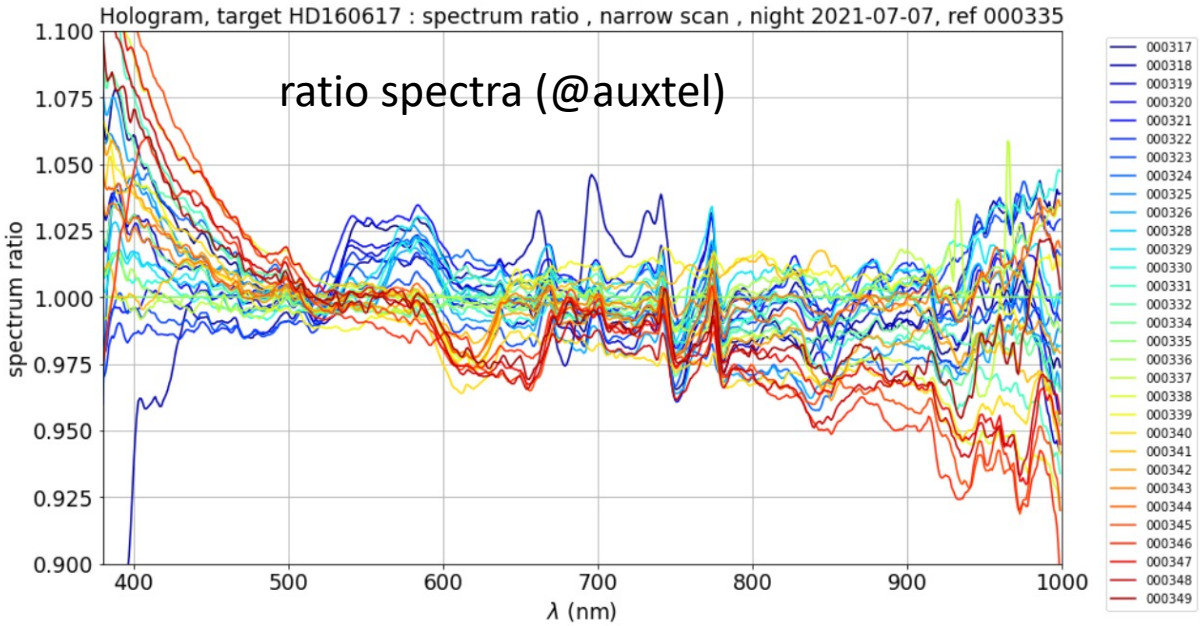



1e−13
Hologram, spectrum of HD160617 : Narrow scan of night 2021-07-07
Flux (erg/cm^2/s/nm)
λ (nm)

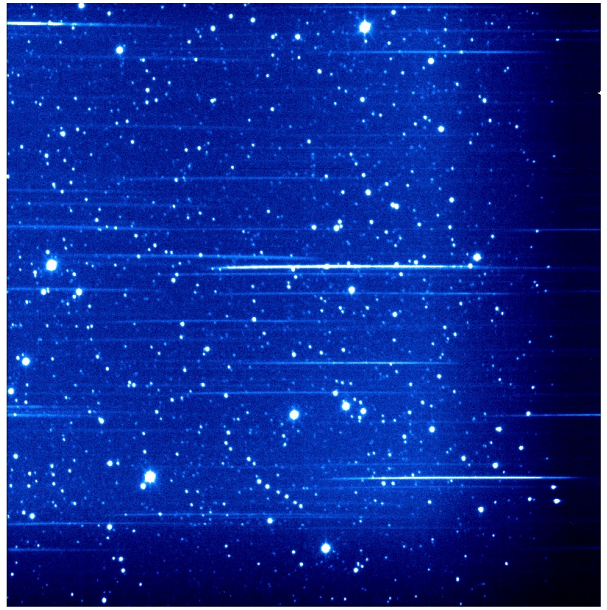

Final Hologram #4-003: Diffraction Efficiencies [color according to Δx]
Transmission efficiency
Holospec optical bench
Diffraction Efficiency DE0, DE1, DE2
Wavelength [nm]



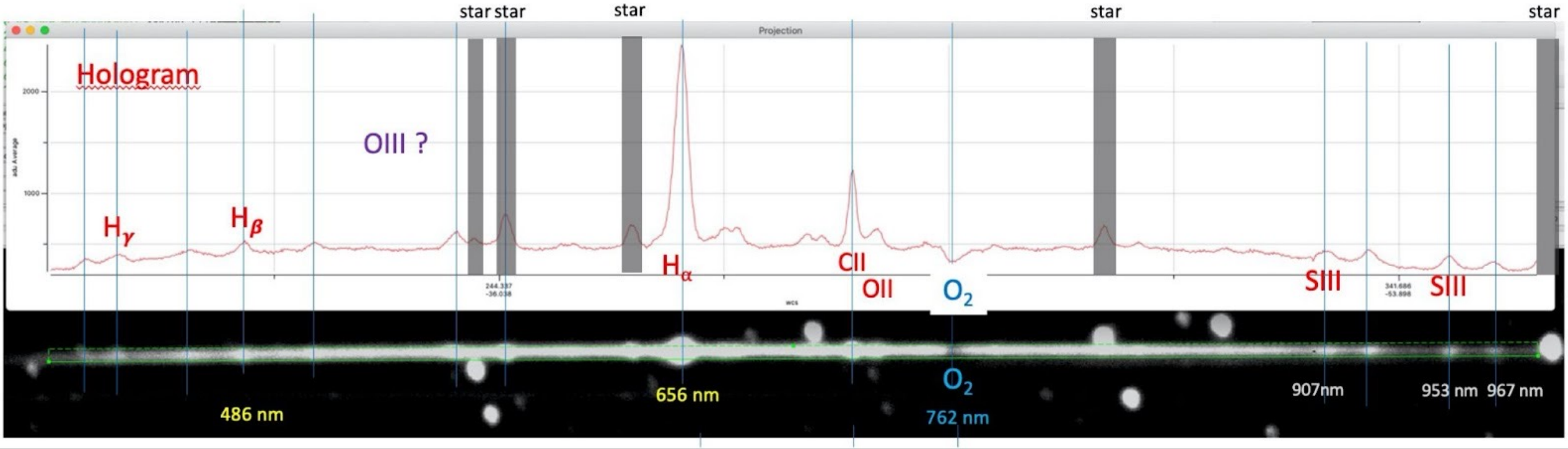

Narrow scan position
dispersion axis
Y
pixel X


Hologram, target HD160617 : spectrum ratio , narrow scan , night 2021-07-07, ref 000335
ratio spectra (@auxtel)
spectrum ratio
λ (nm)

Planetary nebula PNG321.0+03.0



EAP 2021



Good Spectrum Selection

Spectractor fit on spectra from X-Y scan

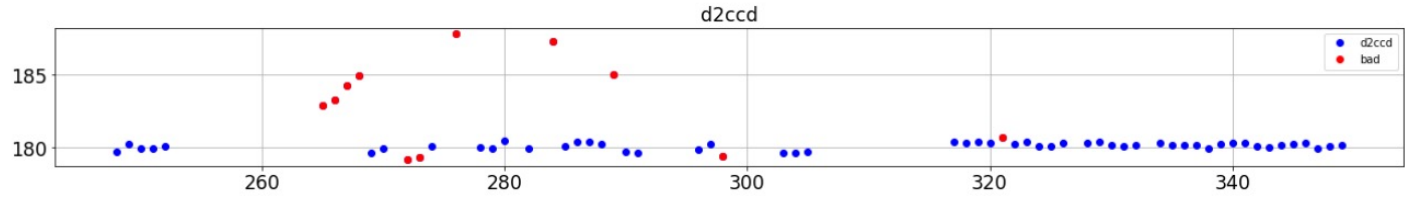
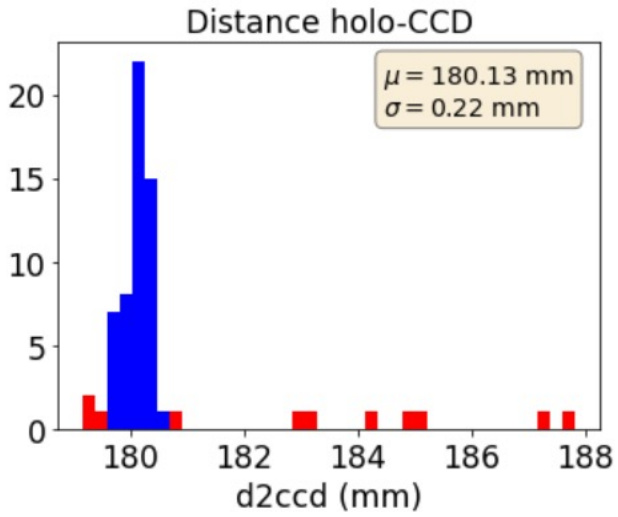
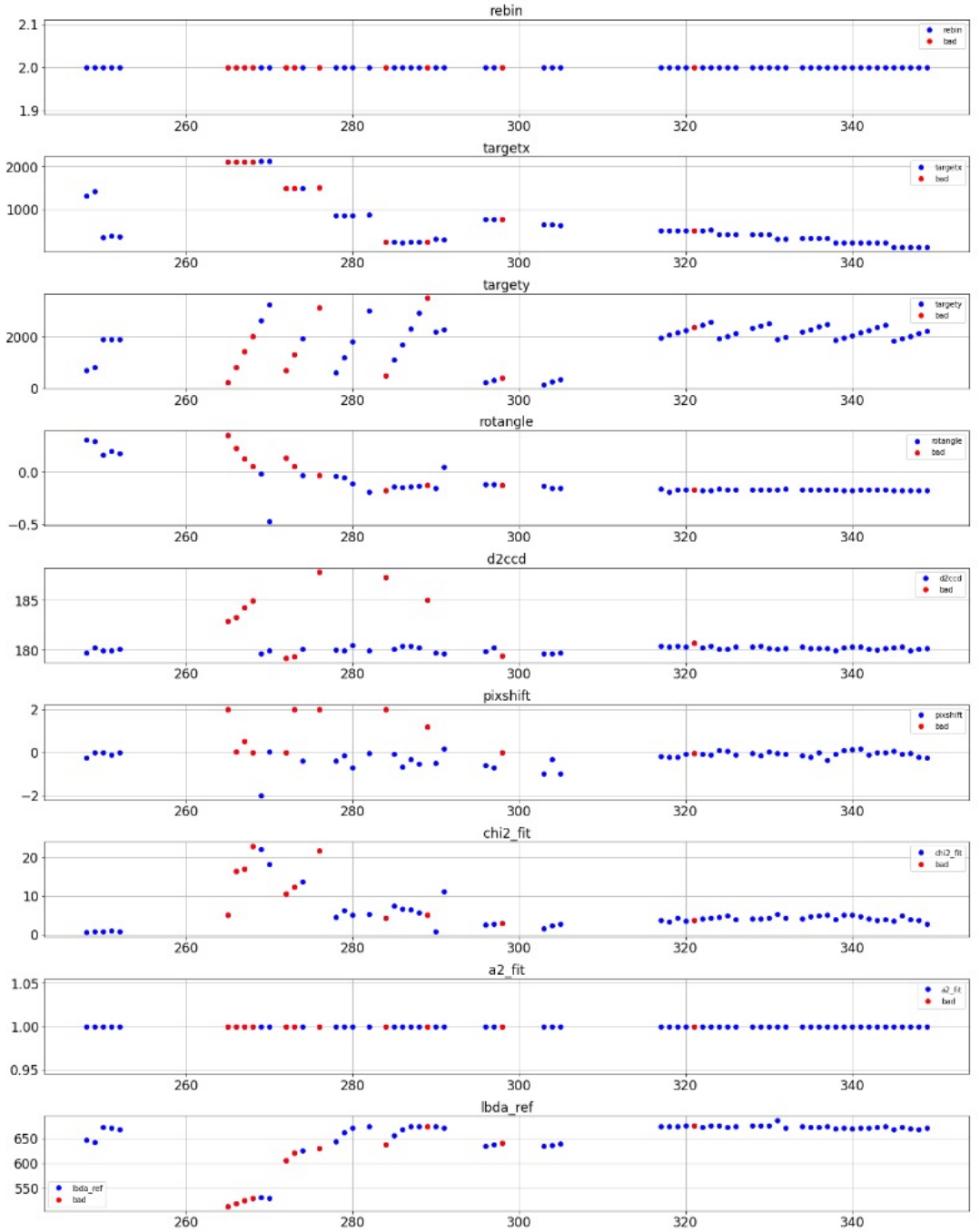


Image number





data statistics

Observations in 2021

- 3 days per month

DATA @ NCSA

- The analysis requires DM_Stack use

size

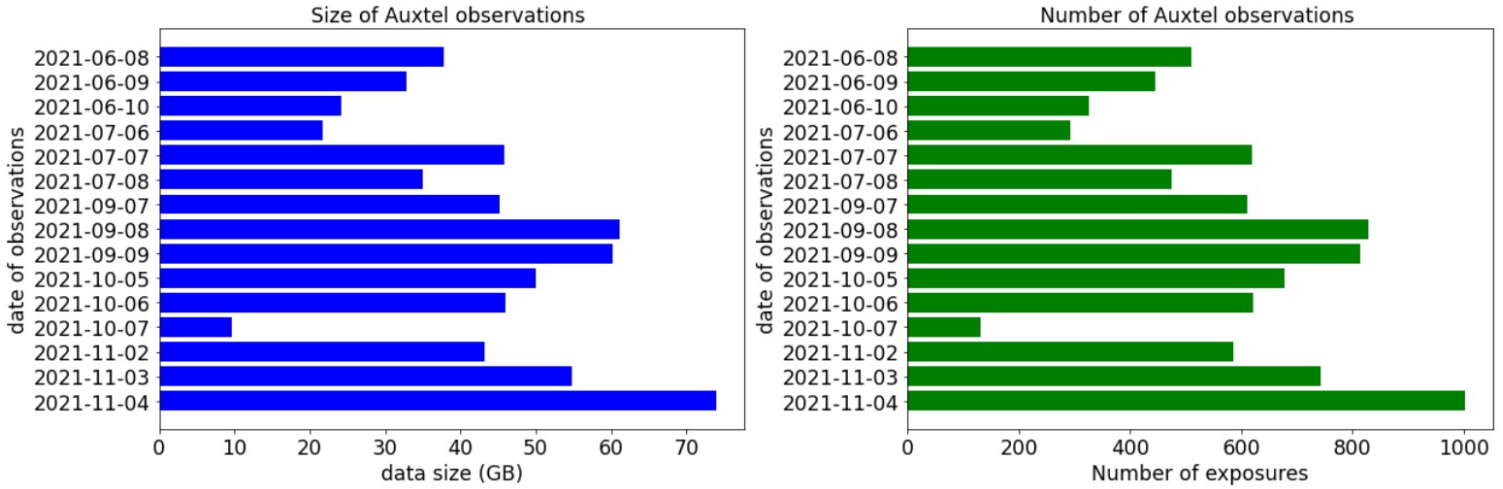
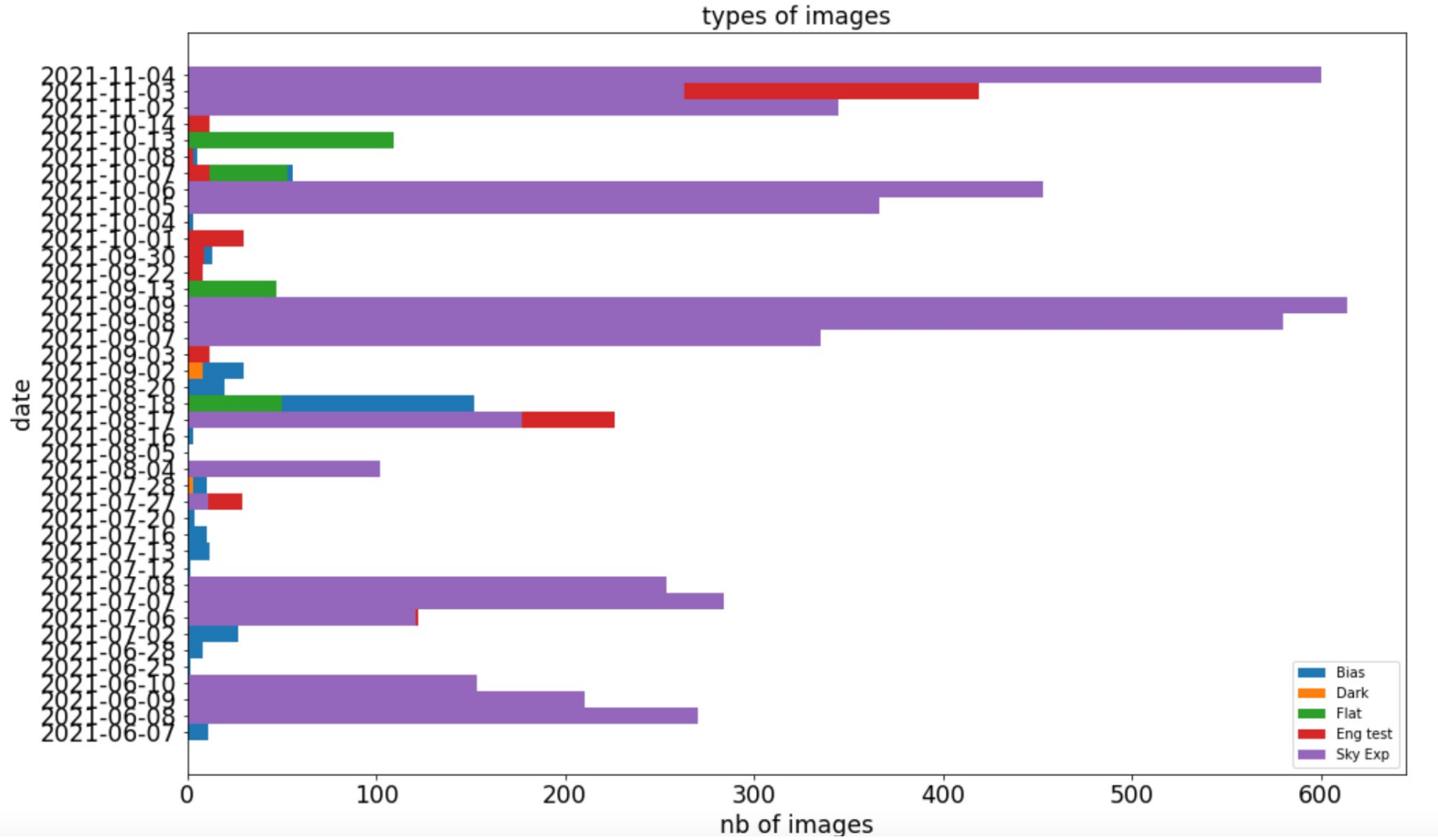


Image type



Reconstruction of Spectractor at CC

Outputs of spectractor

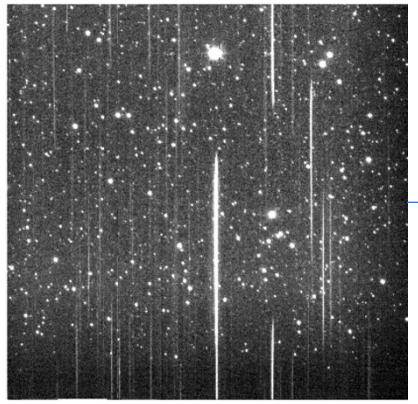
Standalone mode at CC

configuration

arguments

Target position (pix)
(order 0)

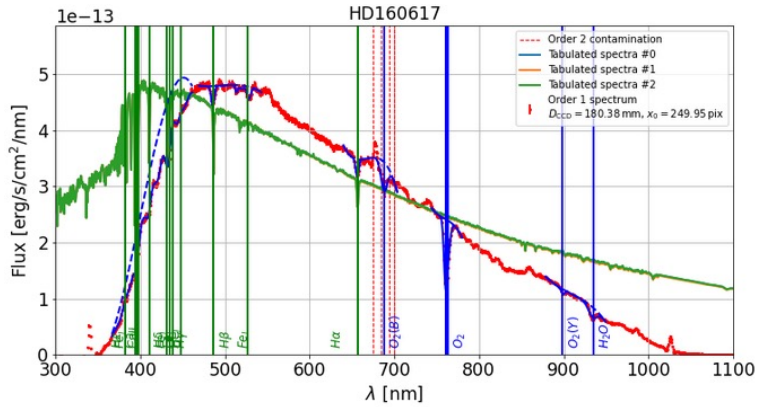
QuickLookExp (bad data product)
Assembled and unbiased



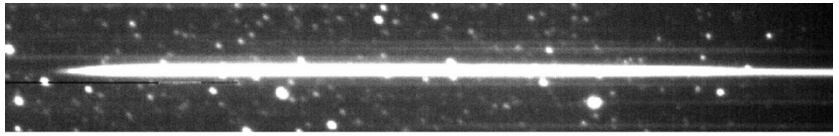
1 LSST-CCD

Spectractor (DESC version)
@CC

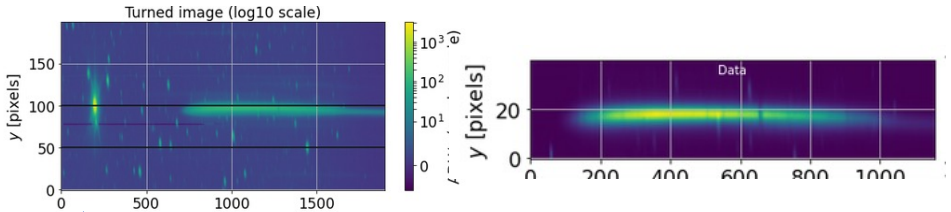
spectrum



spectrogram



holo4_003_empty_HD160617_20210707_000317_quickLookExp_lines.csv
holo4_003_empty_HD160617_20210707_000317_quickLookExp_spectrogram.fits
holo4_003_empty_HD160617_20210707_000317_quickLookExp_spectrum.fits
holo4_003_empty_HD160617_20210707_000317_quickLookExp_table.csv



Star :
Order 0

Star :
Order 1

Run at CC in my anaconda environnement

Each observation → one spectra of the selected target star (CALSPEC)

Reconstruction of Spectractor at NCSA

Outputs of spectractor

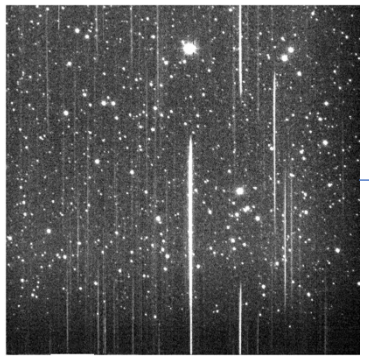
@NCSA, with DM-stack + special python modules

Rapid analysis (DM)
(a kind of logbook)

https://github.com/lsst-sitcom/rapid_analysis.git

In a pickle file

A DM raw



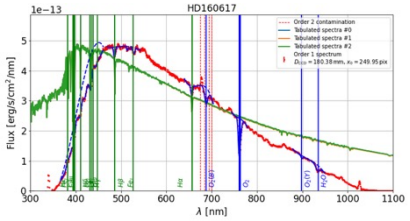
atmospec (DM)
(a DM pipeline)

https://github.com/lsst-dm/atmospec.git

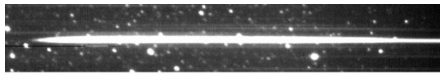
Spectractor (DM version)

https://github.com/lsst-dm/Spectractor.git

spectrum



spectrogram



Instrument : LATISS

1) Spectractor is frozen by DM (we don't have hand on it)
2) Limited access to NCSA (few people)
3) Restriction of use at NCSA for non DM (mostly notebook , no batch access)

GOAL run @CC in DM environnement

Outputs of spectractor

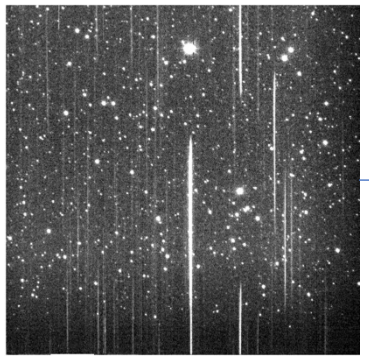
@CC, with DM-stack + special python modules

Rapid analysis (DM)
(a kind of logbook)

https://github.com/lsst-sitcom/rapid_analysis.git

In a pickle file

A DM raw

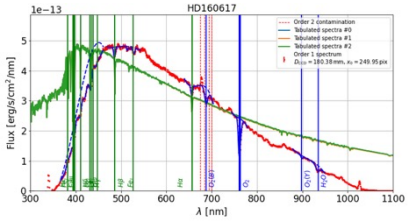


atmospec (DM)
(a DM pipeline)

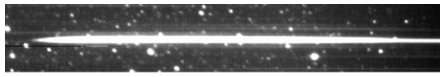
https://github.com/lsst-dm/atmospec.git

Spectractor (a new version compatible with atmospec)

spectrum

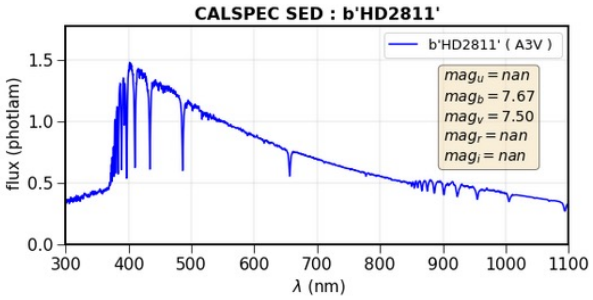


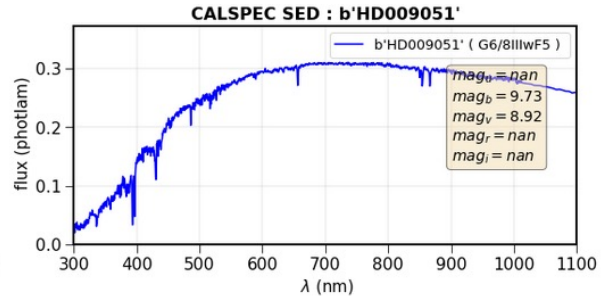
spectrogram

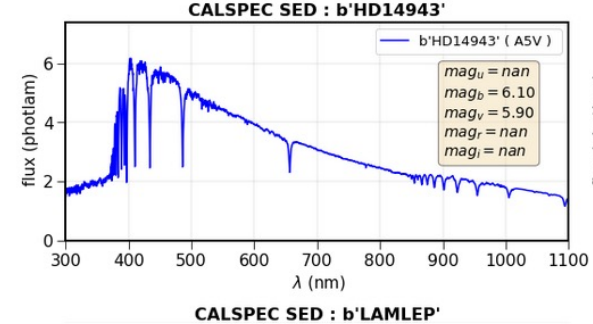


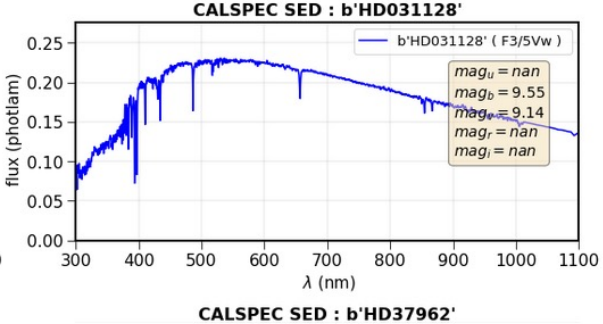
Instrument : LATISS

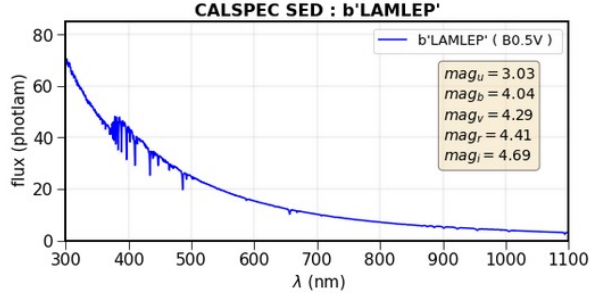
1) More freedom to make Spectractor improvements
2) More people can work on these data in DM
3) Could run long batch

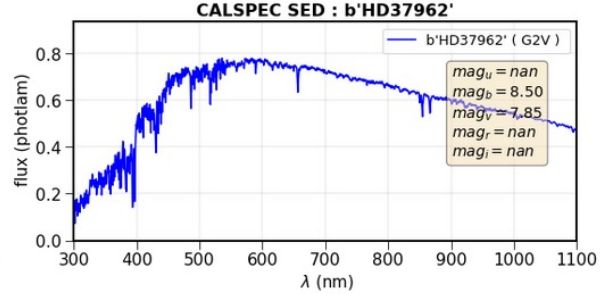

CALSPEC SED : b'HD2811'
b'HD2811' (A3V)
$mag_u = nan$
$mag_b = 7.67$
$mag_v = 7.50$
$mag_r = nan$
$mag_i = nan$
flux (photlam)
λ (nm)

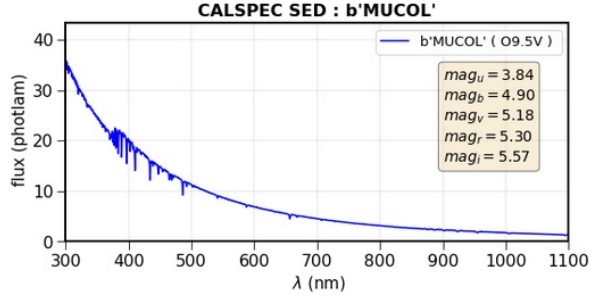

CALSPEC SED : b'HD009051'
b'HD009051' (G6/8IIIwF5)
$mag_u = nan$
$mag_b = 9.73$
$mag_v = 8.92$
$mag_r = nan$
$mag_i = nan$
flux (photlam)
λ (nm)

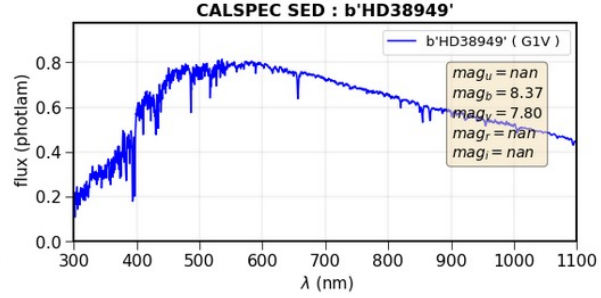

CALSPEC SED : b'HD14943'
b'HD14943' (A5V)
$mag_u = nan$
$mag_b = 6.10$
$mag_v = 5.90$
$mag_r = nan$
$mag_i = nan$
flux (photlam)
λ (nm)

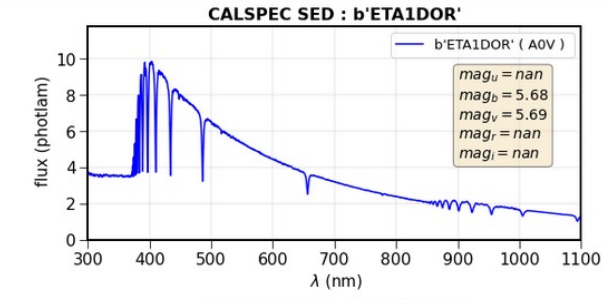

CALSPEC SED : b'HD031128'
b'HD031128' (F3/5Vw)
$mag_u = nan$
$mag_b = 9.55$
$mag_v = 9.14$
$mag_r = nan$
$mag_i = nan$
flux (photlam)
λ (nm)

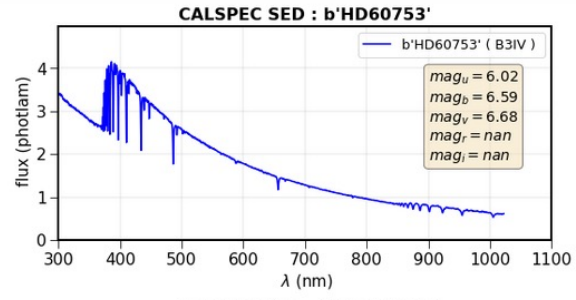

CALSPEC SED : b'LAMLEP'
b'LAMLEP' (B0.5V)
$mag_u = 3.03$
$mag_b = 4.04$
$mag_v = 4.29$
$mag_r = 4.41$
$mag_i = 4.69$
flux (photlam)
λ (nm)

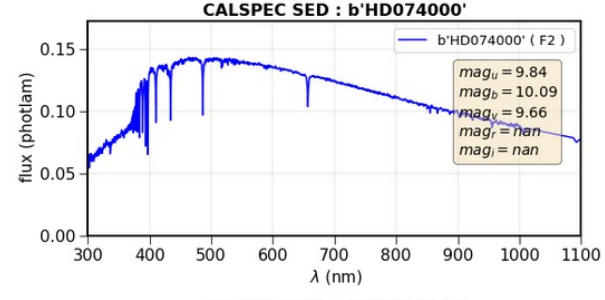

CALSPEC SED : b'HD37962'
b'HD37962' (G2V)
$mag_u = nan$
$mag_b = 8.50$
$mag_v = 7.85$
$mag_r = nan$
$mag_i = nan$
flux (photlam)
λ (nm)

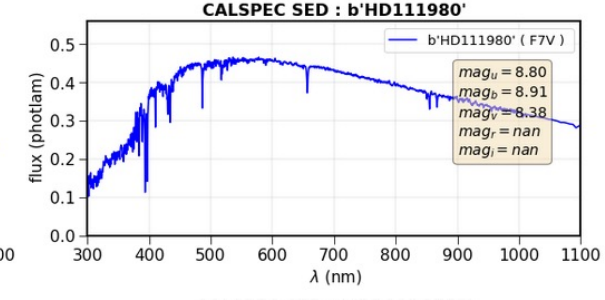

CALSPEC SED : b'MUCOL'
b'MUCOL' (O9.5V)
$mag_u = 3.84$
$mag_b = 4.90$
$mag_v = 5.18$
$mag_r = 5.30$
$mag_i = 5.57$
flux (photlam)
λ (nm)

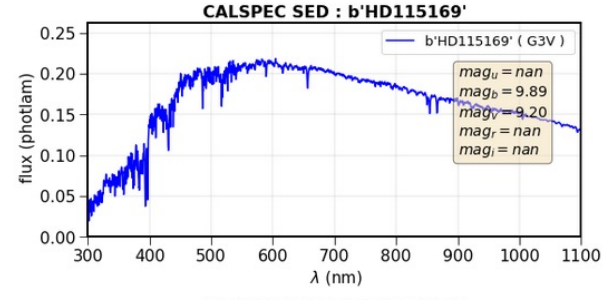

CALSPEC SED : b'HD38949'
b'HD38949' (G1V)
$mag_u = nan$
$mag_b = 8.37$
$mag_v = 7.80$
$mag_r = nan$
$mag_i = nan$
flux (photlam)
λ (nm)

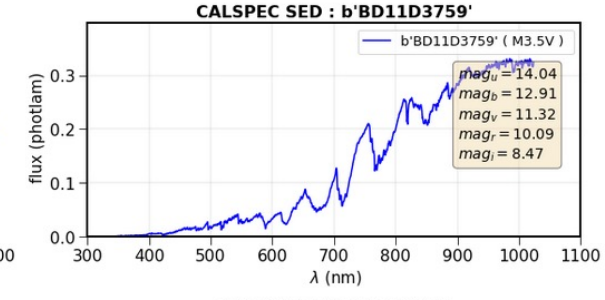

CALSPEC SED : b'ETA1DOR'
b'ETA1DOR' (A0V)
$mag_u = nan$
$mag_b = 5.68$
$mag_v = 5.69$
$mag_r = nan$
$mag_i = nan$
flux (photlam)
λ (nm)

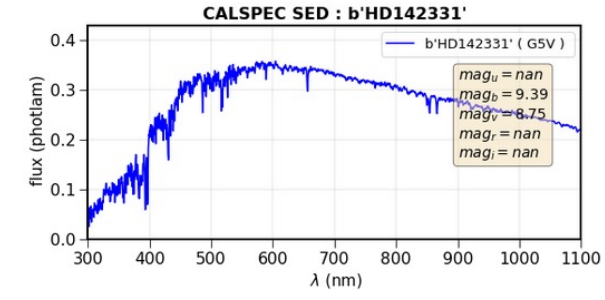

CALSPEC SED : b'HD60753'
b'HD60753' (B3IV)
$mag_u = 6.02$
$mag_b = 6.59$
$mag_v = 6.68$
$mag_r = nan$
$mag_i = nan$
flux (photlam)
λ (nm)

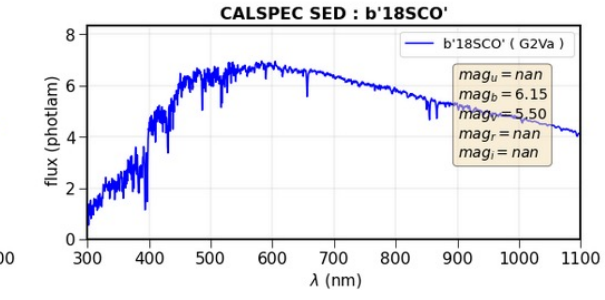

CALSPEC SED : b'HD074000'
b'HD074000' (F2)
$mag_u = 9.84$
$mag_b = 10.09$
$mag_v = 9.66$
$mag_r = nan$
$mag_i = nan$
flux (photlam)
λ (nm)

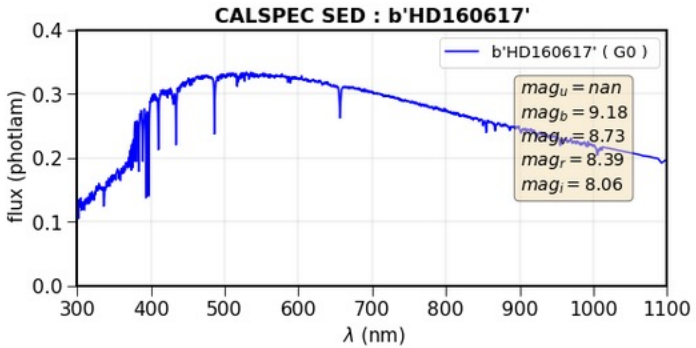

CALSPEC SED : b'HD111980'
b'HD111980' (F7V)
$mag_u = 8.80$
$mag_b = 8.91$
$mag_v = 8.38$
$mag_r = nan$
$mag_i = nan$
flux (photlam)
λ (nm)

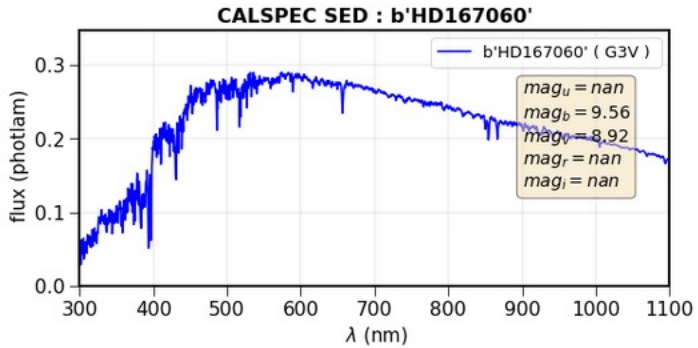

CALSPEC SED : b'HD115169'
b'HD115169' (G3V)
$mag_u = nan$
$mag_b = 9.89$
$mag_v = 9.20$
$mag_r = nan$
$mag_i = nan$
flux (photlam)
λ (nm)

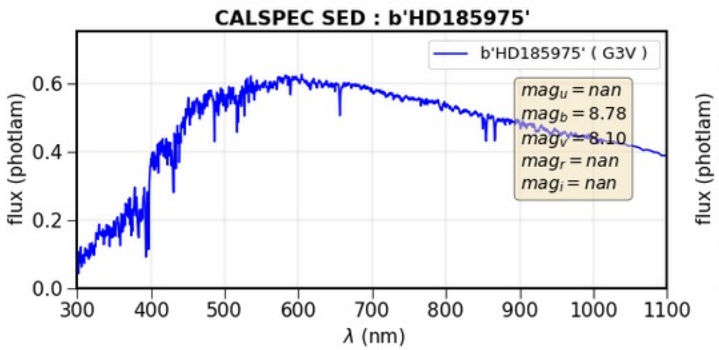

CALSPEC SED : b'BD11D3759'
b'BD11D3759' (M3.5V)
$mag_u = 14.04$
$mag_b = 12.91$
$mag_v = 11.32$
$mag_r = 10.09$
$mag_i = 8.47$
flux (photlam)
λ (nm)

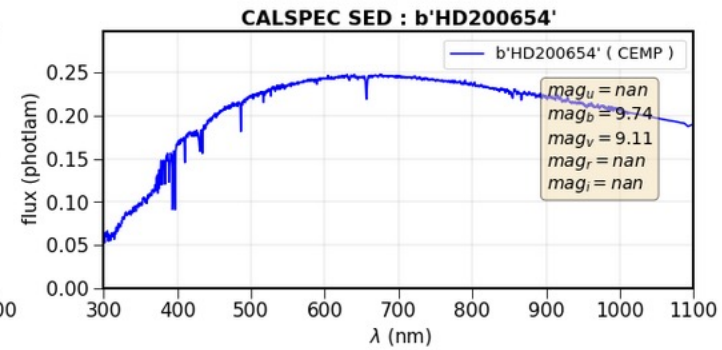

CALSPEC SED : b'HD142331'
b'HD142331' (G5V)
$mag_u = nan$
$mag_b = 9.39$
$mag_v = 8.75$
$mag_r = nan$
$mag_i = nan$
flux (photlam)
λ (nm)

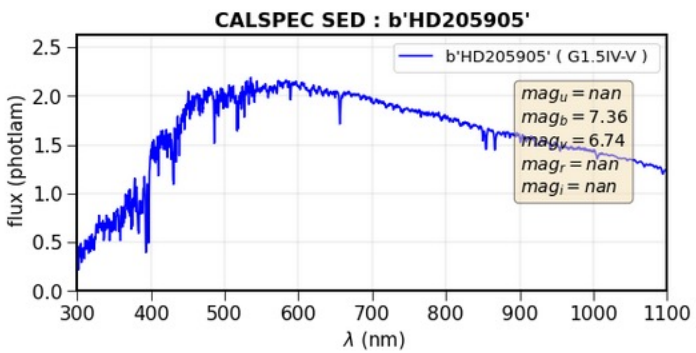

CALSPEC SED : b'18SCO'
b'18SCO' (G2Va)
$mag_u = nan$
$mag_b = 6.15$
$mag_v = 5.50$
$mag_r = nan$
$mag_i = nan$
flux (photlam)
λ (nm)


CALSPEC SED : b'HD160617'
b'HD160617' (G0)
$mag_u = nan$
$mag_b = 9.18$
$mag_v = 8.73$
$mag_r = 8.39$
$mag_i = 8.06$
flux (photlam)
λ (nm)


CALSPEC SED : b'HD167060'
b'HD167060' (G3V)
$mag_u = nan$
$mag_b = 9.56$
$mag_v = 8.92$
$mag_r = nan$
$mag_i = nan$
flux (photlam)
λ (nm)


CALSPEC SED : b'HD185975'
b'HD185975' (G3V)
$mag_u = nan$
$mag_b = 8.78$
$mag_v = 8.10$
$mag_r = nan$
$mag_i = nan$
flux (photlam)
λ (nm)


CALSPEC SED : b'HD200654'
b'HD200654' (CEMP)
$mag_u = nan$
$mag_b = 9.74$
$mag_v = 9.11$
$mag_r = nan$
$mag_i = nan$
flux (photlam)
λ (nm)


CALSPEC SED : b'HD205905'
b'HD205905' (G1.5IV-V)
$mag_u = nan$
$mag_b = 7.36$
$mag_v = 6.74$
$mag_r = nan$
$mag_i = nan$
flux (photlam)
λ (nm)