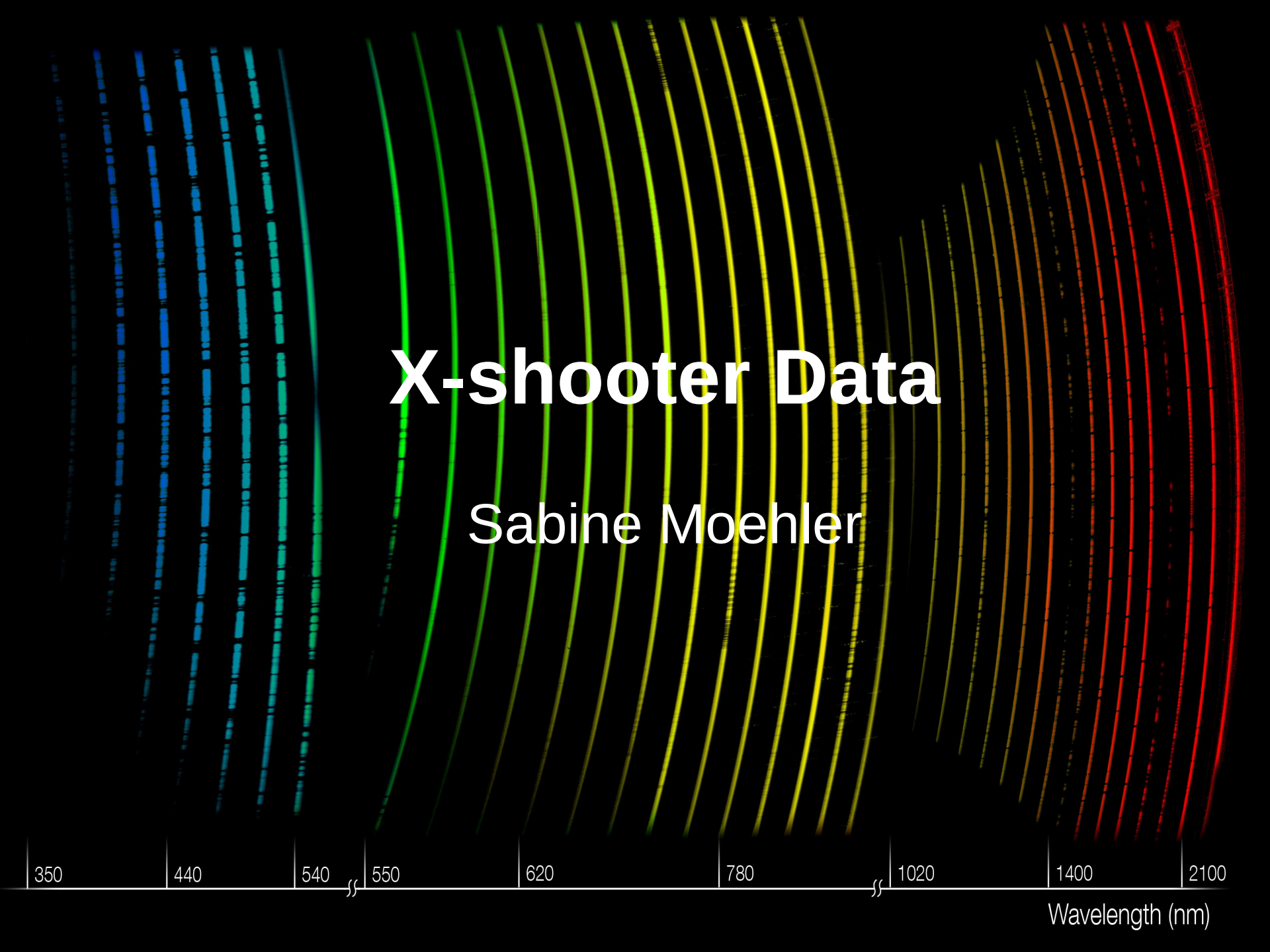
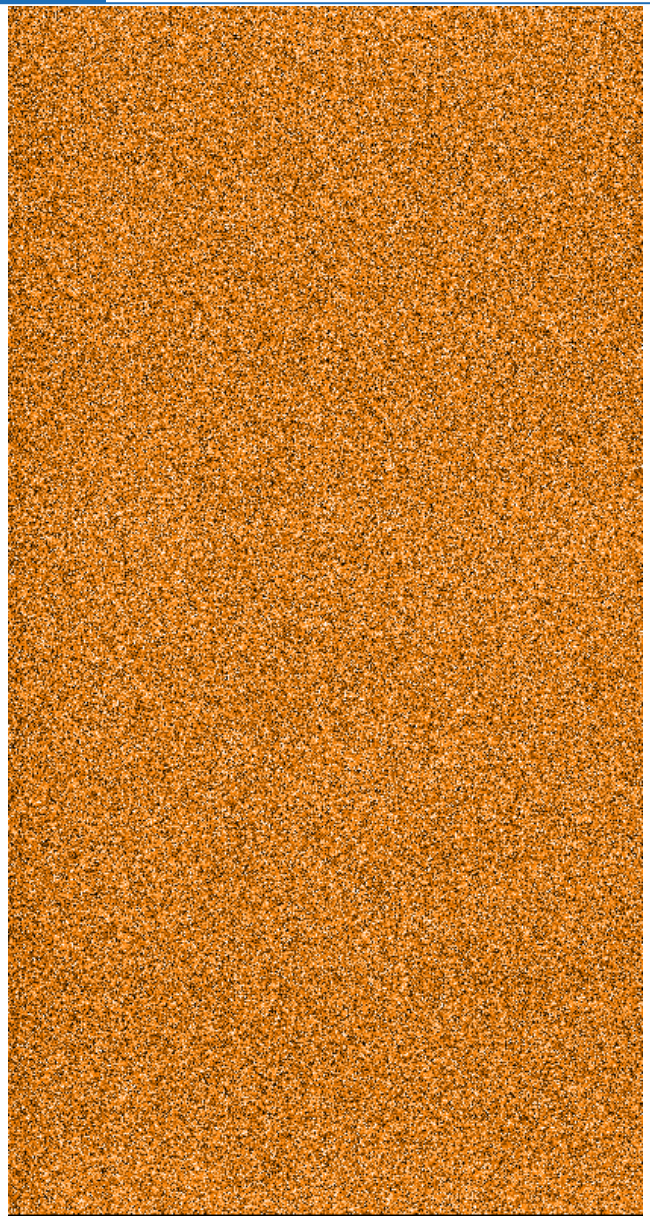
X-shooter Data

Sabine Moehler



X-shooter Data – Detector Calibrations



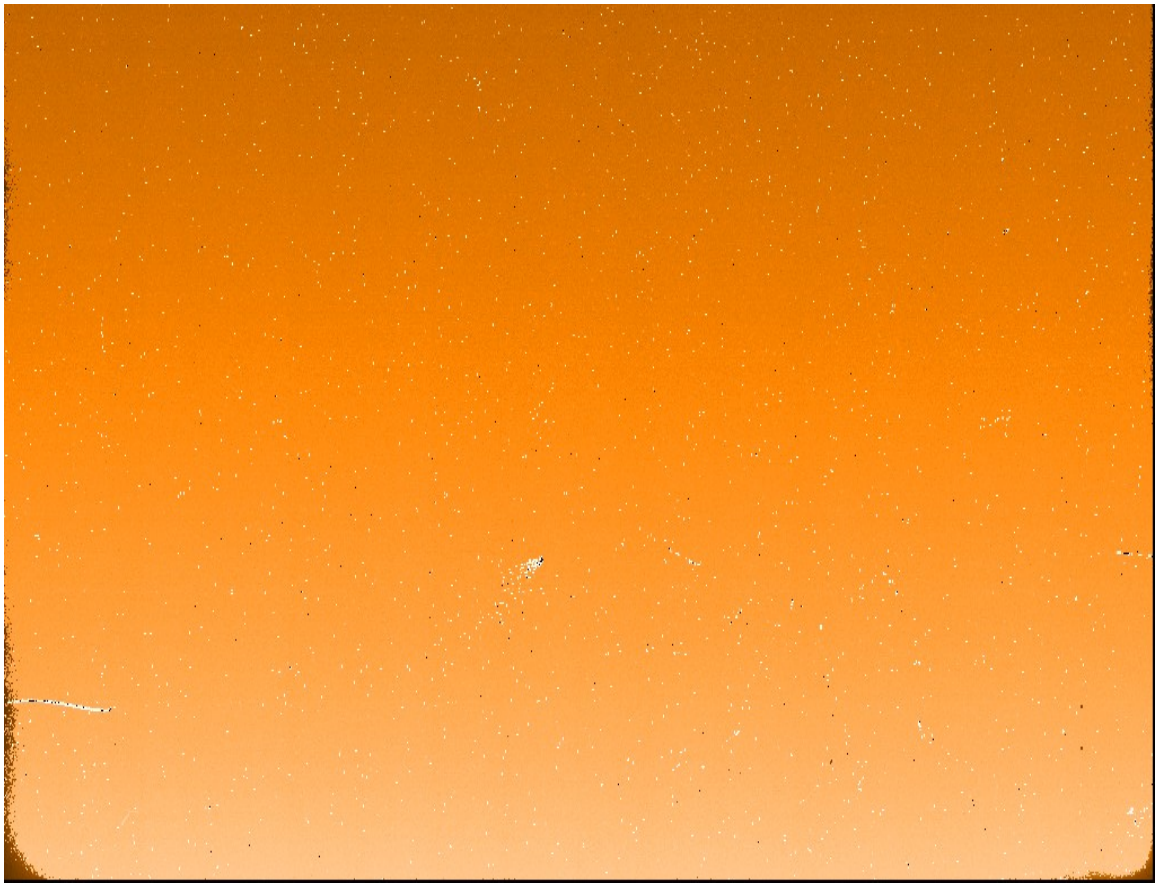
BIAS

- extra signal to avoid negative values in raw frame → subtract
- pre-/overscan regions do not exist physically but record only the added signal
- pre-/overscan regions allow to adjust for variable bias level
- usually 5 or more frames are combined to reduce the noise

X-shooter Data– Detector Calibrations

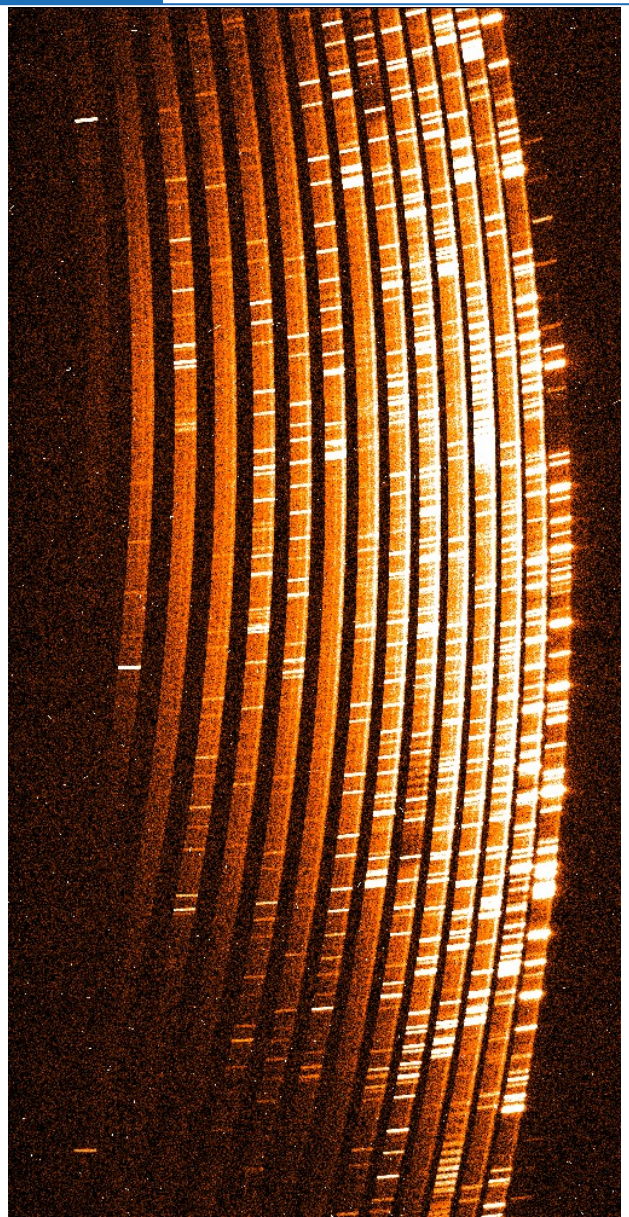
DARK (neglible in UVB/VIS)

- dark current from detector → subtract
- needed only for NIR data
- same DIT* as data to be corrected
- also used to detect bad pixels

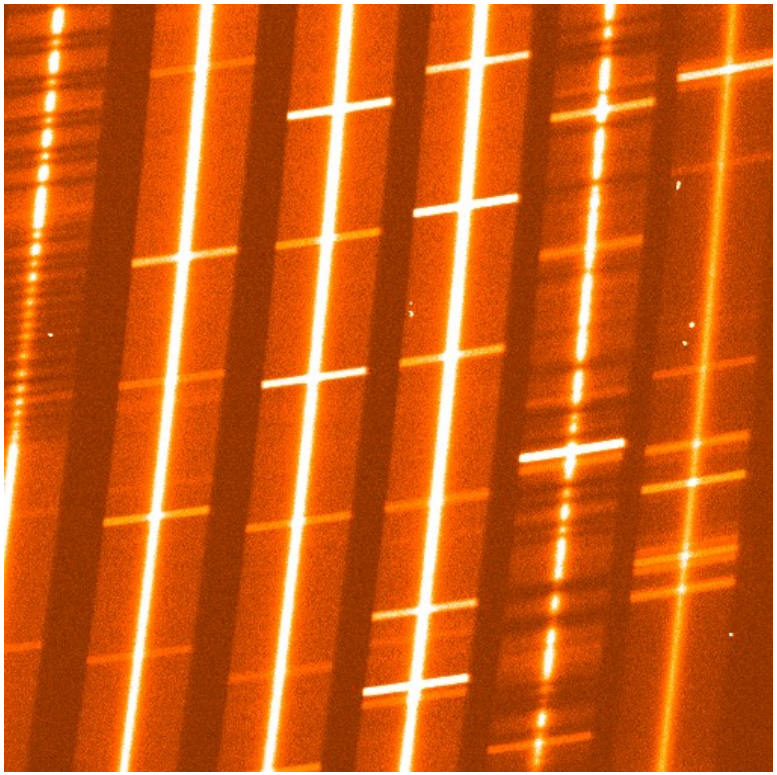


*DIT = Detector Integration Time

Echelle Data



Curved “orders” with tilted lines



Hecht & Zajac: Optics (1974)

Echelle Data

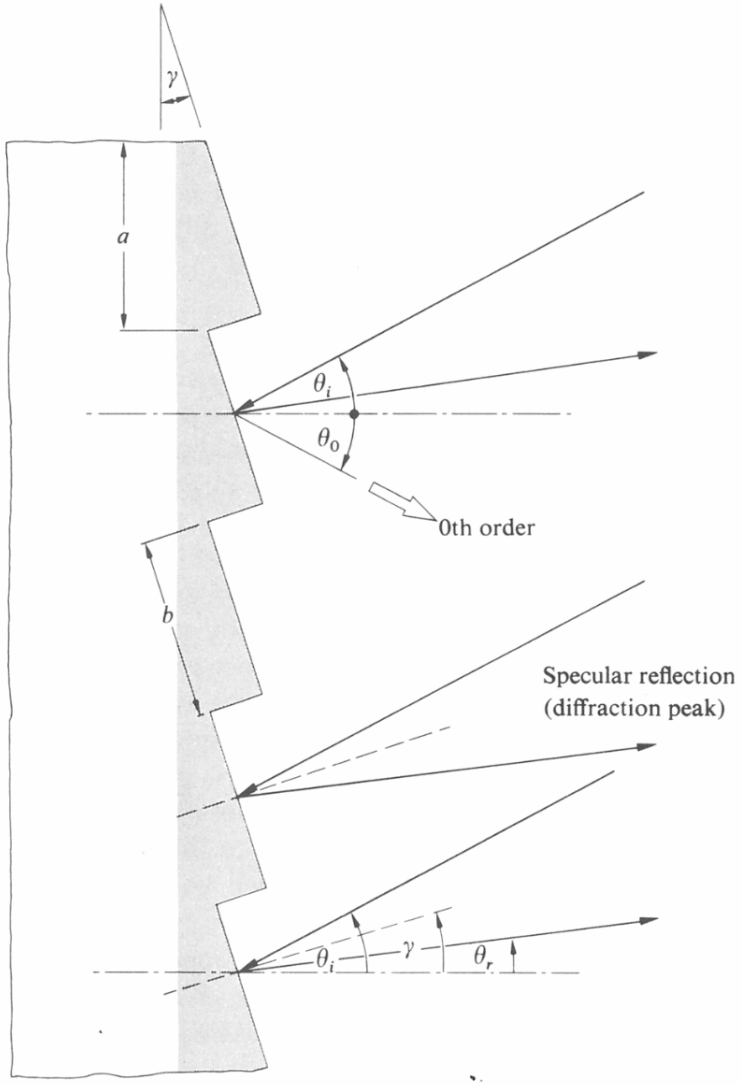


Fig. 10.37 Section of a blazed reflection phase grating. *Hecht & Zajac: Optics (1974)*

Diffraction Grating

- tilted grooves move maximum flux from 0th undispersed (= useless) order to other orders
- γ = blaze angle
  a * sin(γ) = λ_b * m
  m = spectral order
  a,γ fixed → blaze wavelength λ_b for each order with maximum efficiency
- Resolution R = λ/δλ = m * n
  n = total number of grooves
- high resolution requires many grooves and/or high order
- orders overlap
  → cross-disperser (e.g. prism) to separate them
  → curved orders due to prism dispersion

Echelle Data

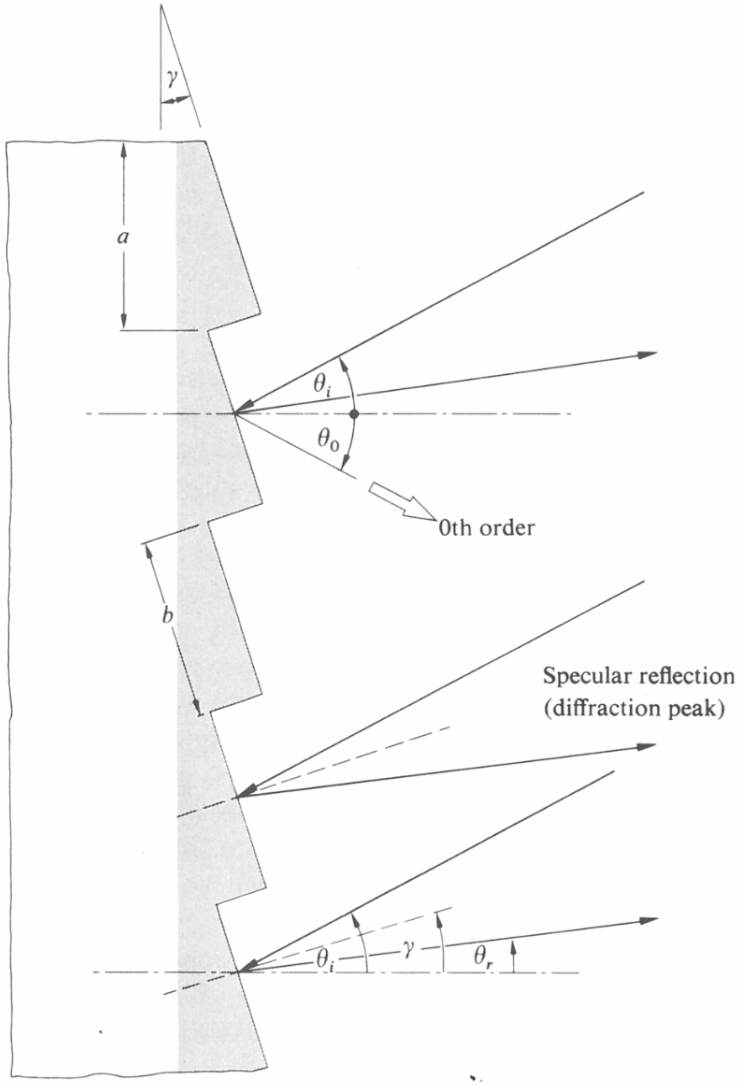
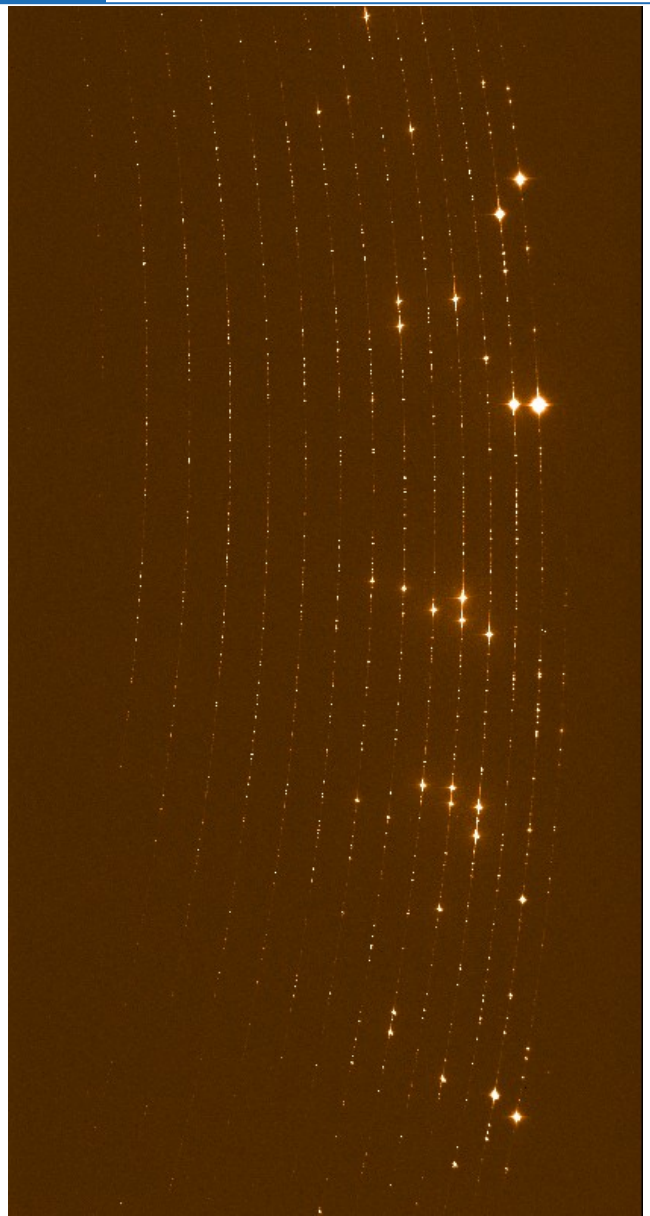


Fig. 10.37 Section of a blazed reflection phase grating. *Hecht & Zajac: Optics (1974)*

Diffraction Grating

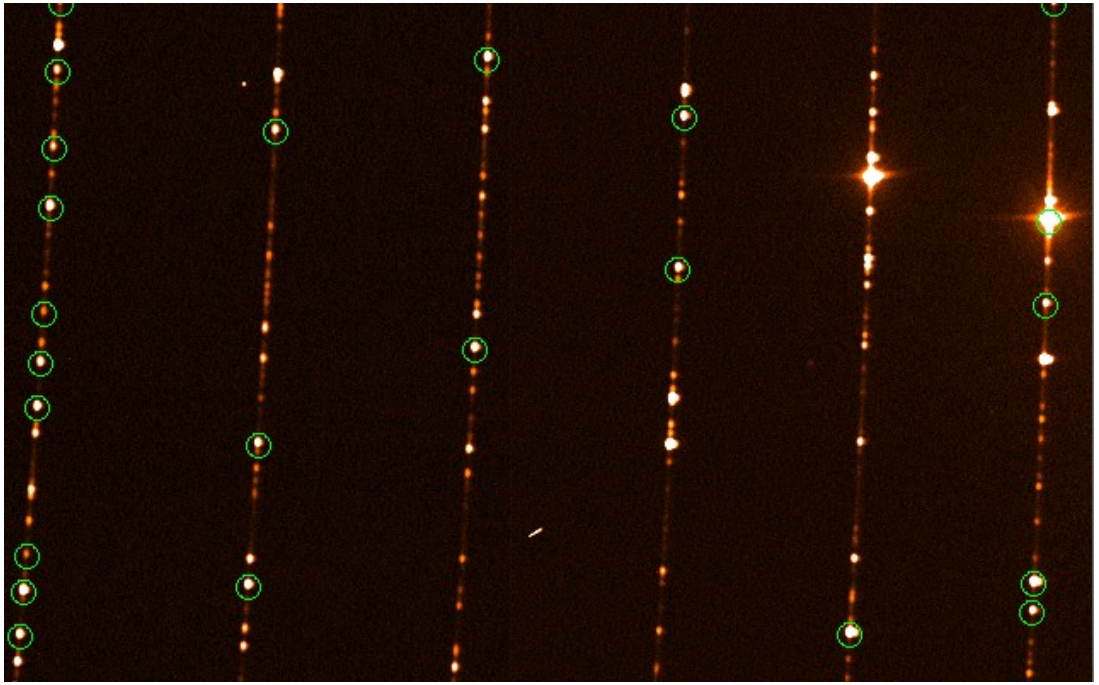
- Resolution R = λ/δλ = m * n
- UVB: grating
  180 grooves/mm
  beam size 100mm at 41.77 deg
  → n = 180 * 100/cos(41.77) ≈ 24000
- UVB: orders 13 – 24
- R ≈ 314000 - 580000
  for an infinitely narrow source
- true resolution is limited by seeing (≥ 0.5”) or slit width (whichever is smaller) to ≤10000

X-shooter Data – Spectral Daytime Calibrations

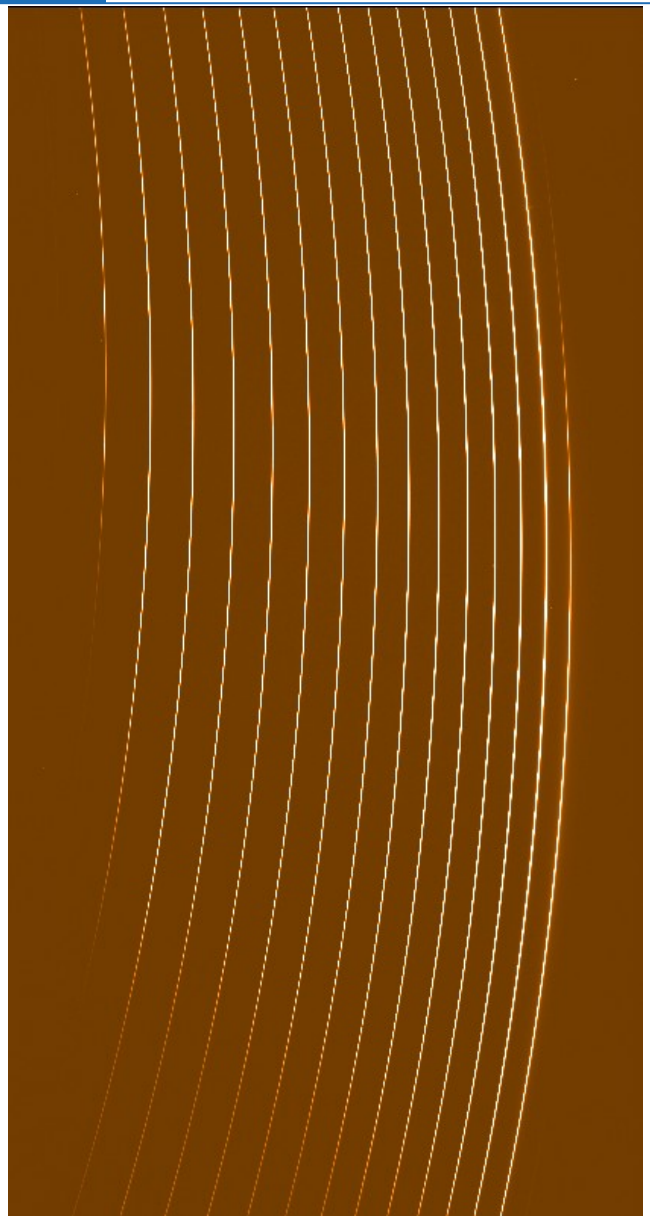


FORMATCHECK

- arc lamp exposed through 1 pinhole at the center of the slit
  - → dots (high precision line positions)
- to verify the spectral format
- → line positions in wavelength (at slit center)
  - → line positions along the slit (order definition)

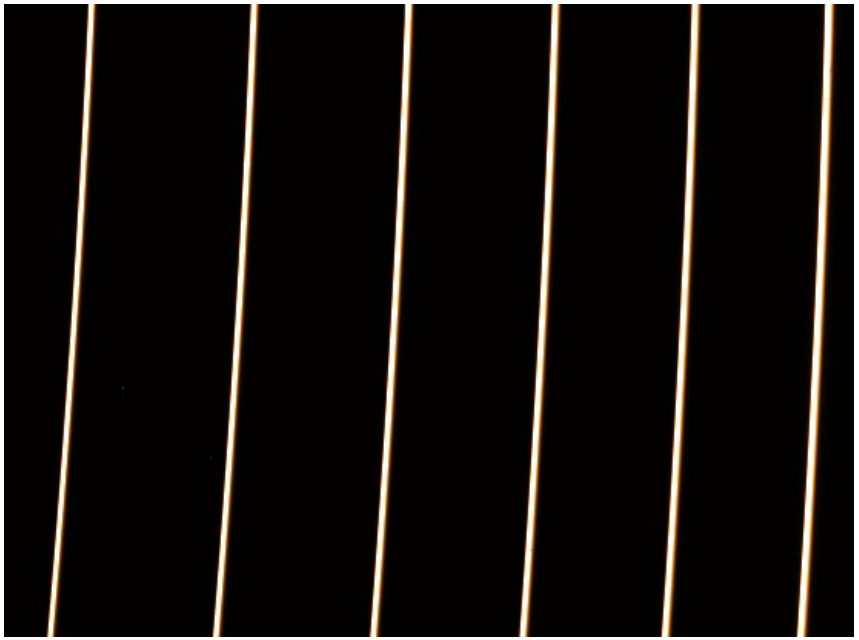


X-shooter Data– Spectral Daytime Calibrations

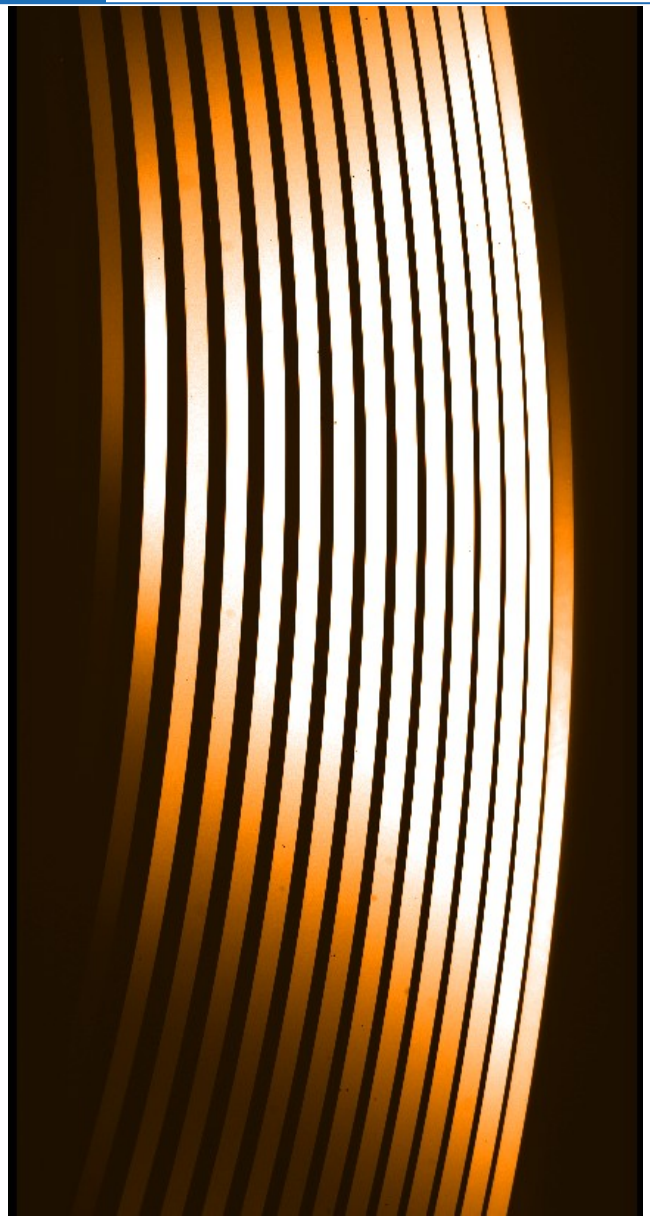


ORDER DEFINITION

- flat field lamp exposed through 1 pinhole at the center of the slit
  → thin trace
- to verify the order position



X-shooter Data– Spectral Daytime Calibrations

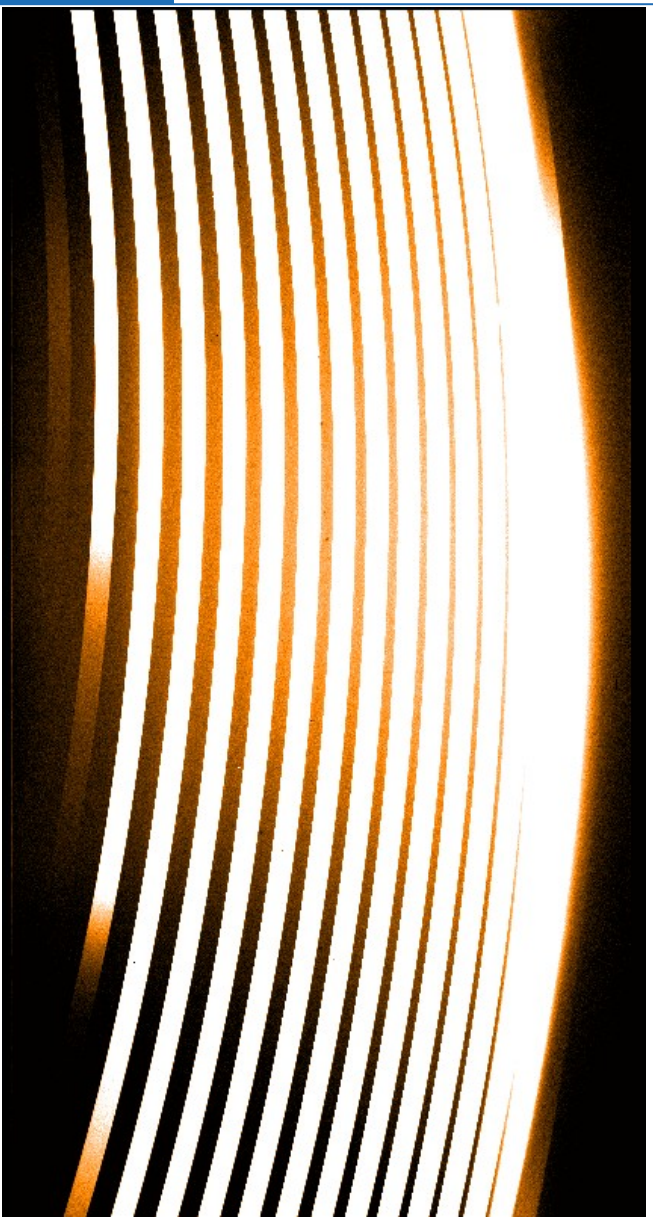


FLAT FIELD

- flat field lamp exposed through slit
- to determine the slit edges (illuminated regions)
- to correct the pixel-to-pixel sensitivity variation and the blaze function → divide

bad column

X-shooter Data– Spectral Daytime Calibrations



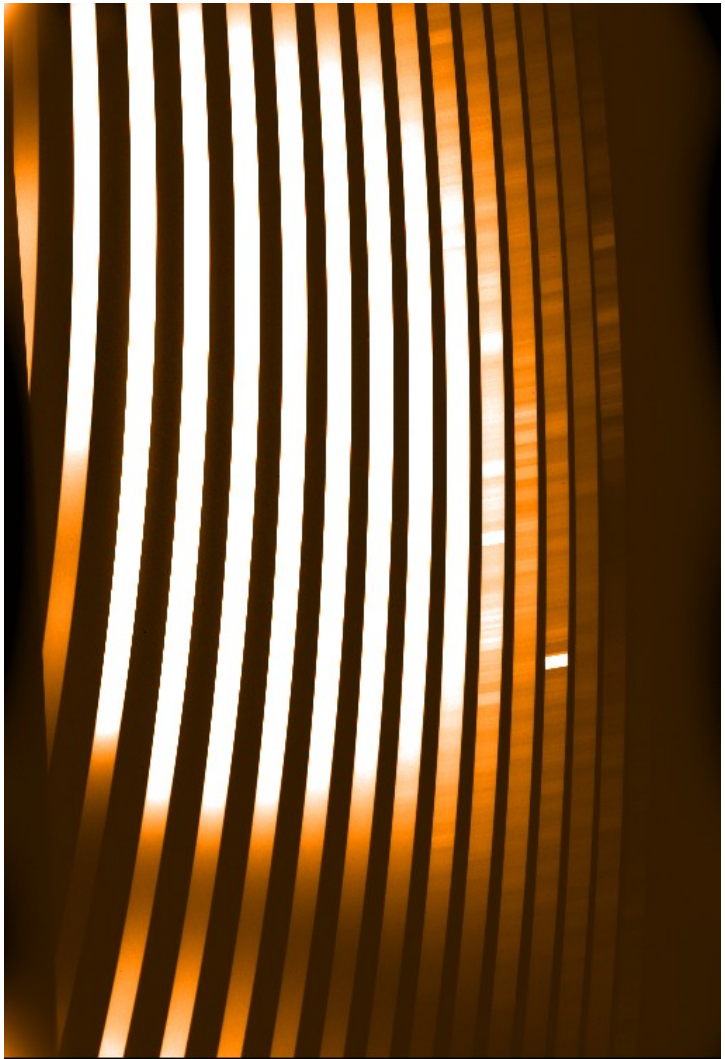
INTERORDER BACKGROUND

- straylight between orders
- additional signal also within orders
- needs to be fit and subtracted

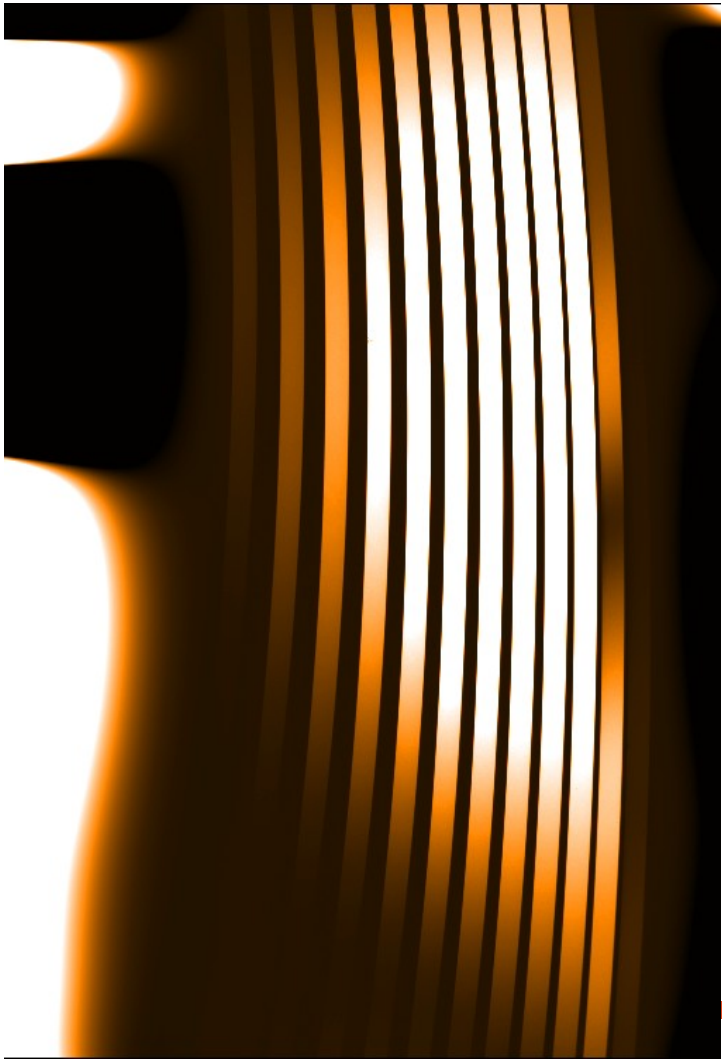
X-shooter Data – Spectral Daytime Calibrations: special cases

FLAT FIELD UVB: 2 flat field lamps used:

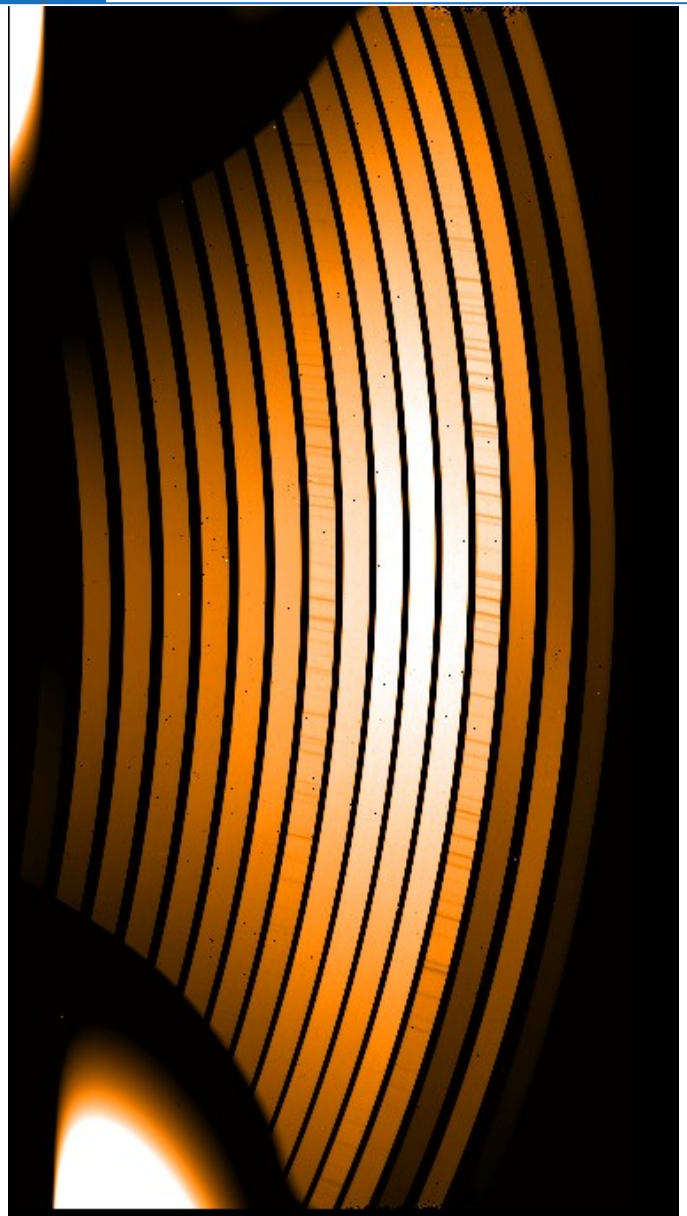
D2 lamp for blue orders



Quartz lamp for redder orders

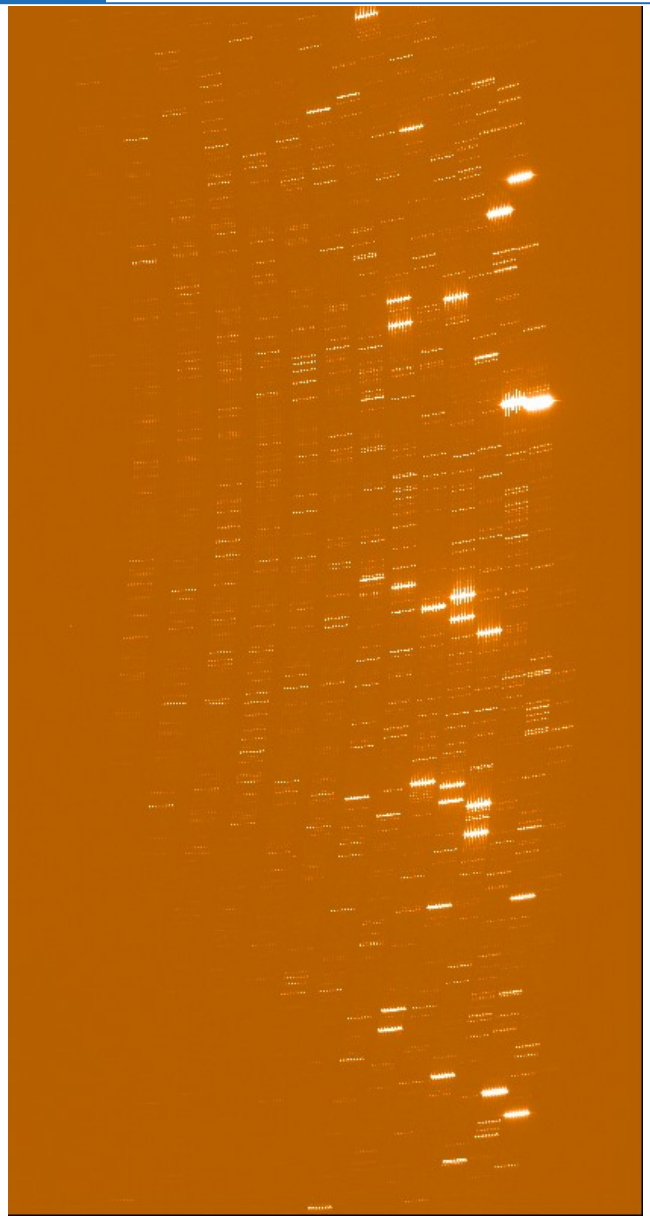


X-shooter Data – Spectral Daytime Calibrations: special cases



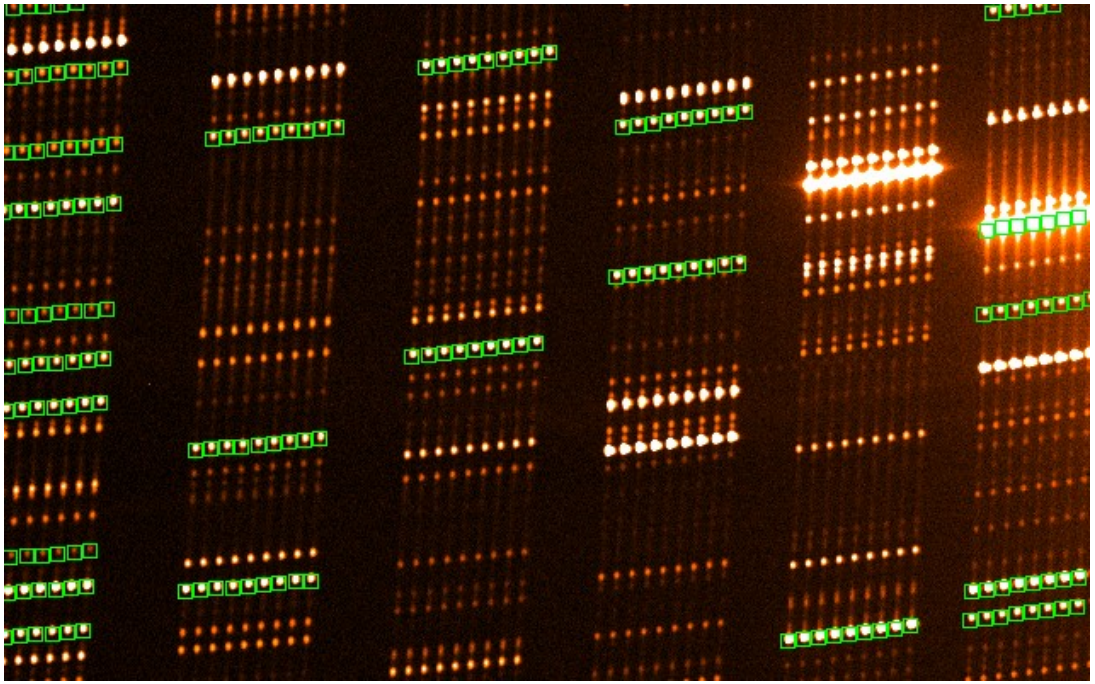
FLAT FIELD NIR: telluric absorption

X-shooter Data– Spectral Daytime Calibrations



2D MAP

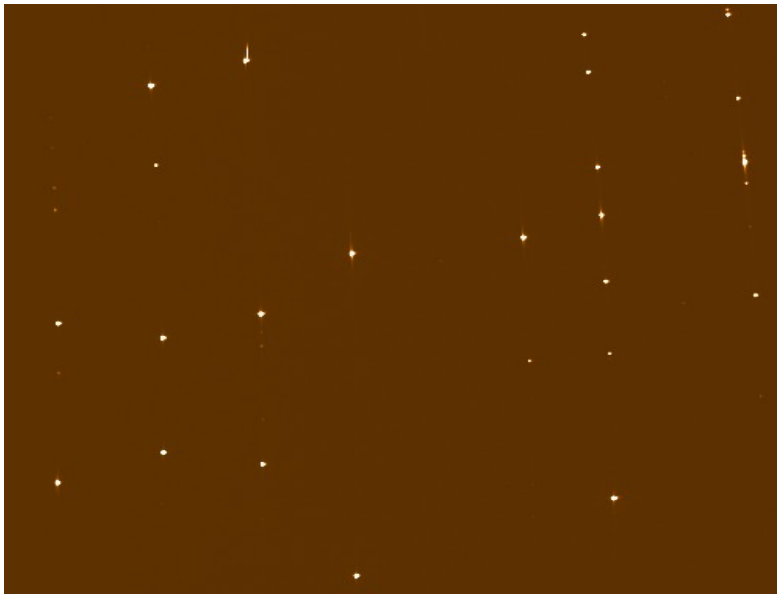
- arc lamp exposed through 9 pinholes along the slit
  → sequence of dots
- to determine the spatial and spectral distortion and the wavelength calibration



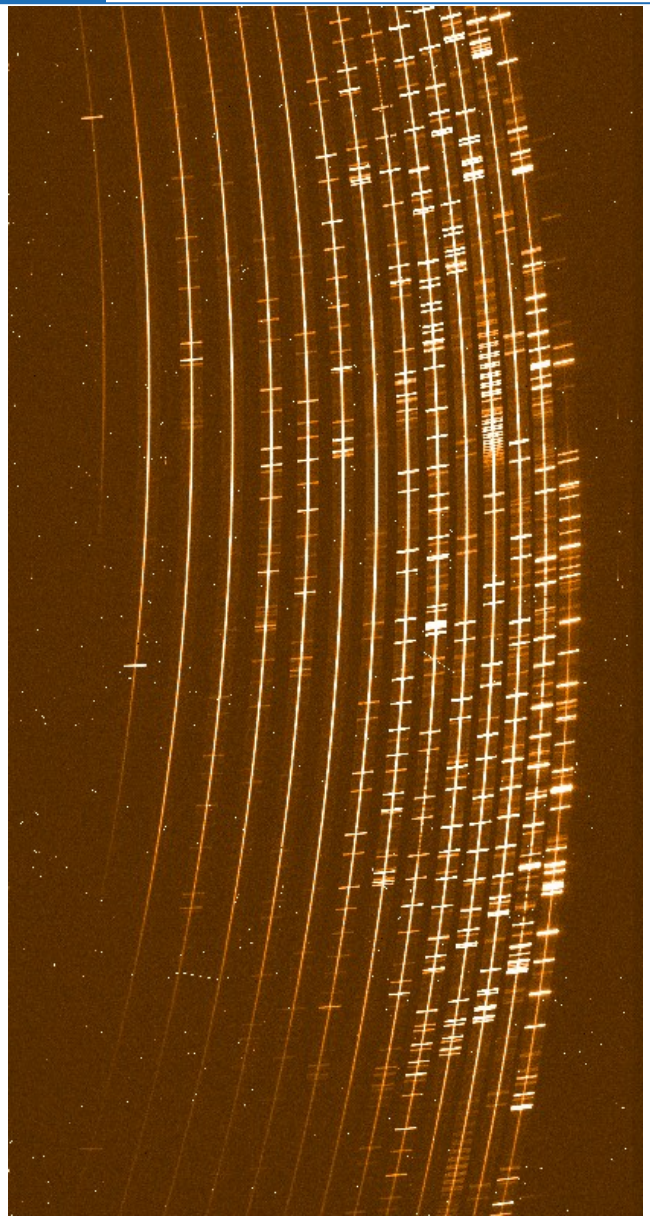
X-shooter Data– Spectral Nighttime Calibrations

FLEXURE COMPENSATION

- arc lamp exposed through 1 pinhole at the center of the slit with the telescope at the target's position (→ flexure)
- to check for shifts due to instrument flexure
- only small window read out for UVB and VIS
- correction at the telescope to have the object at the same position in all arms
- correction later on by the pipeline for shifts w.r.t. daytime calibrations

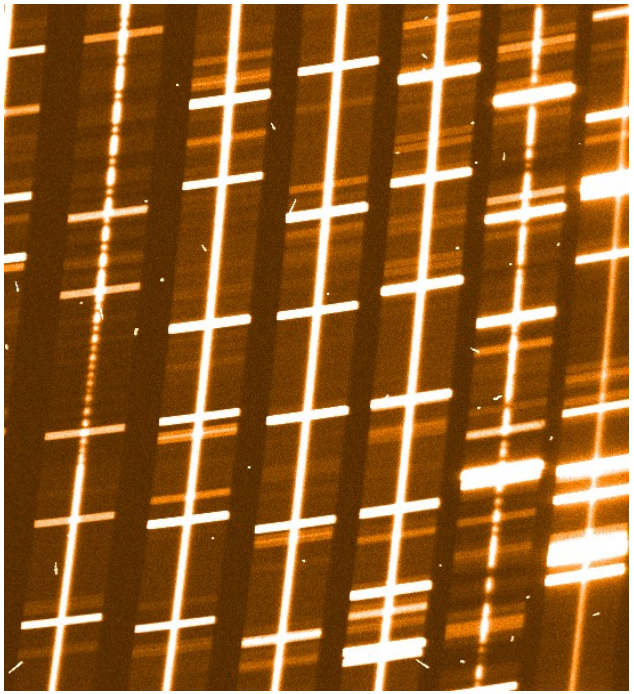


X-shooter Data – Observing Modes

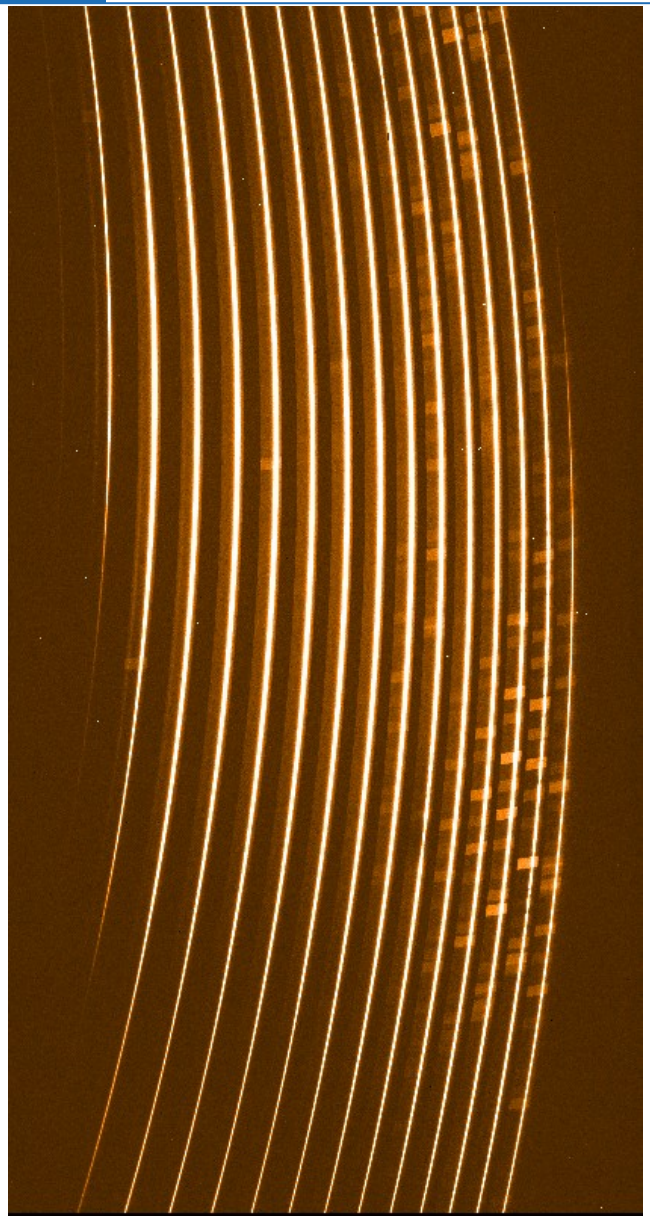


ON-SKY STARE

- target stays at the same position for all exposures
- sky background has to be determined from the same frame
- best suited for UVB data (no sky) or bright targets in the VIS arm
- problematic for NIR data (bright sky)

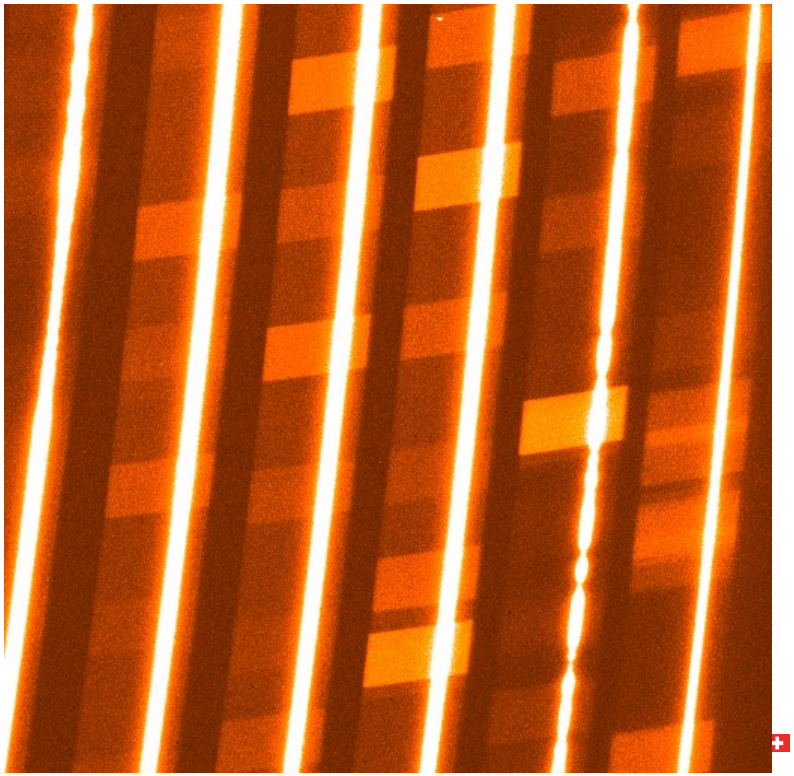


X-shooter Data – Observing Modes

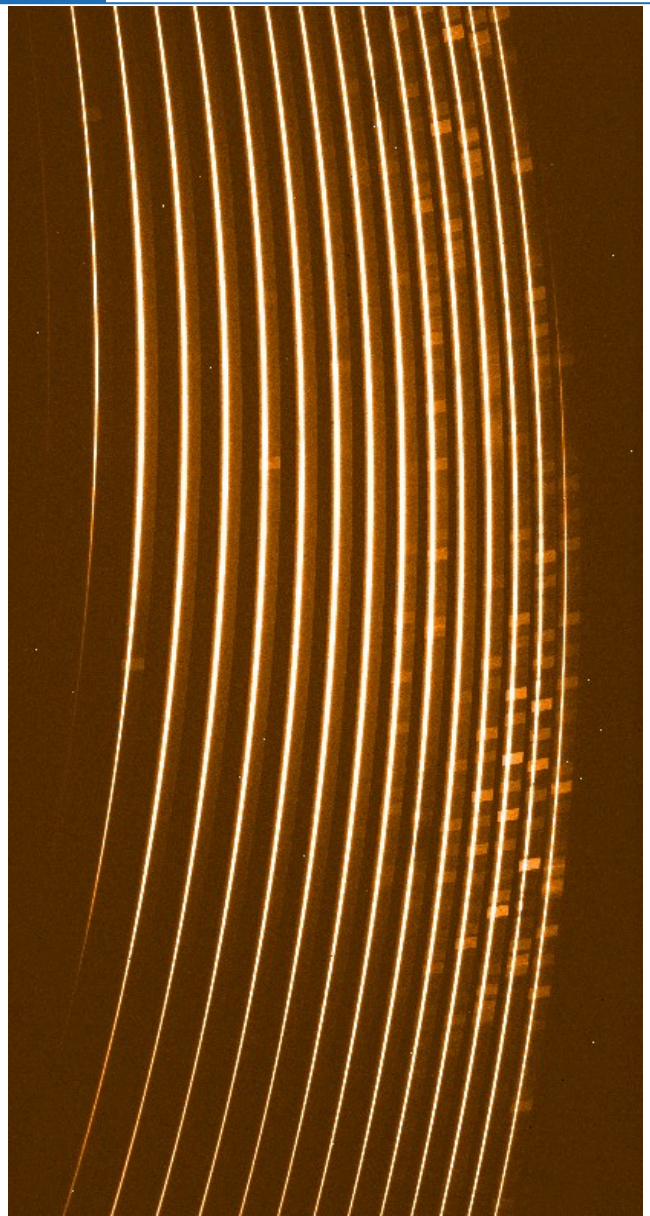


ON-SKY NODDING

- target moved along slit between exposures
- combinations of observations allows to subtract the observed sky at the same position as the target
- best suited for NIR data and faint VIS observations
- exposure times should be short to avoid sky variations



X-shooter Data – Observing Modes



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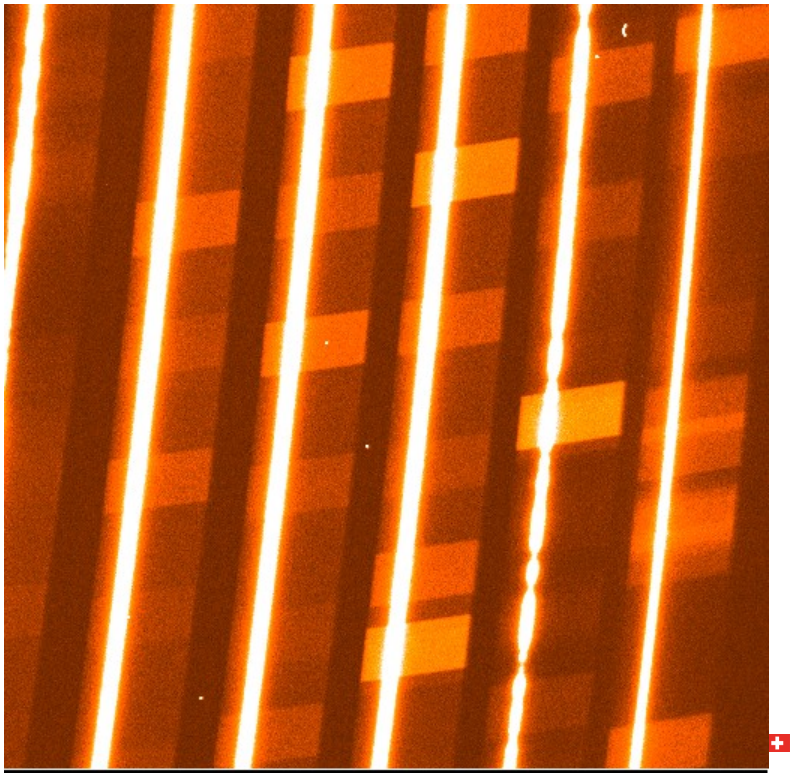
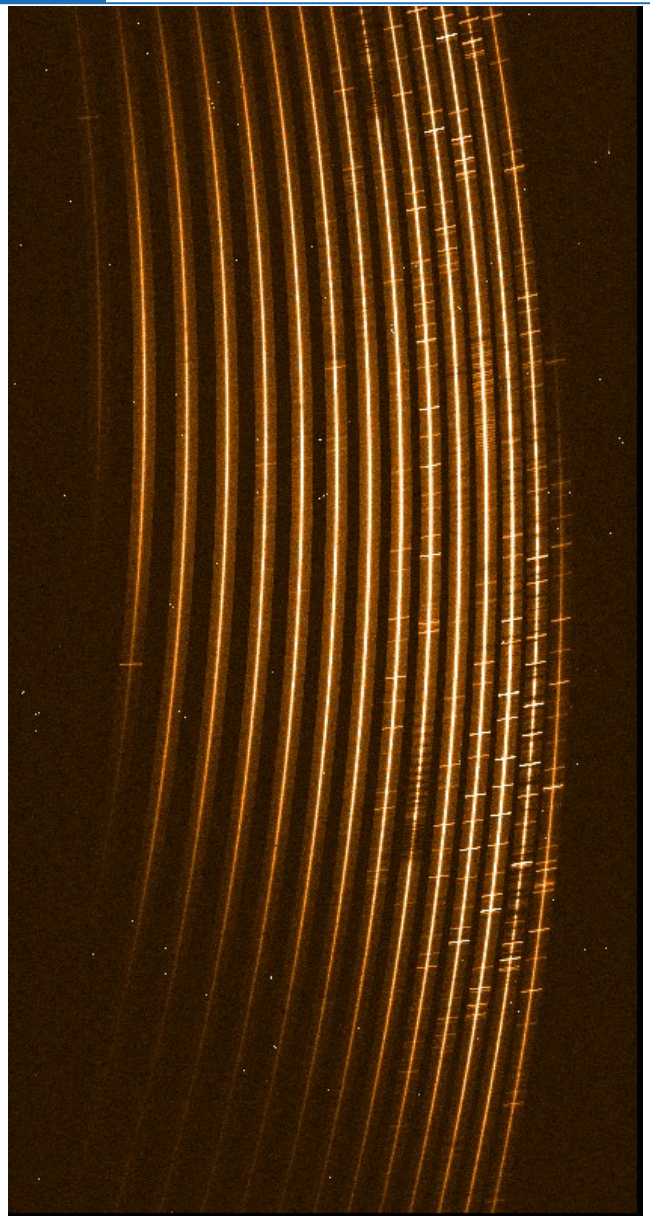
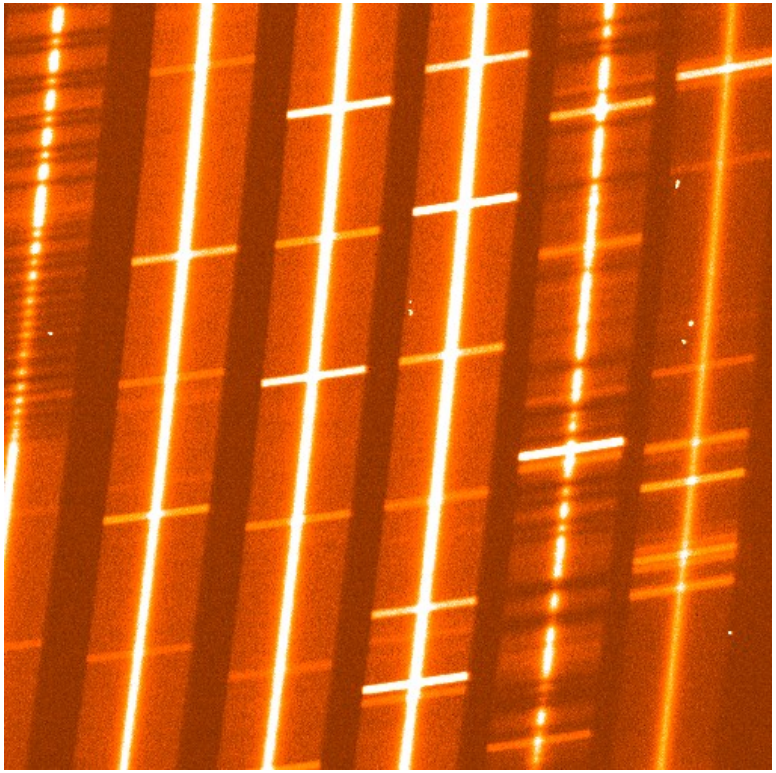


X-shooter Data – Observing Modes

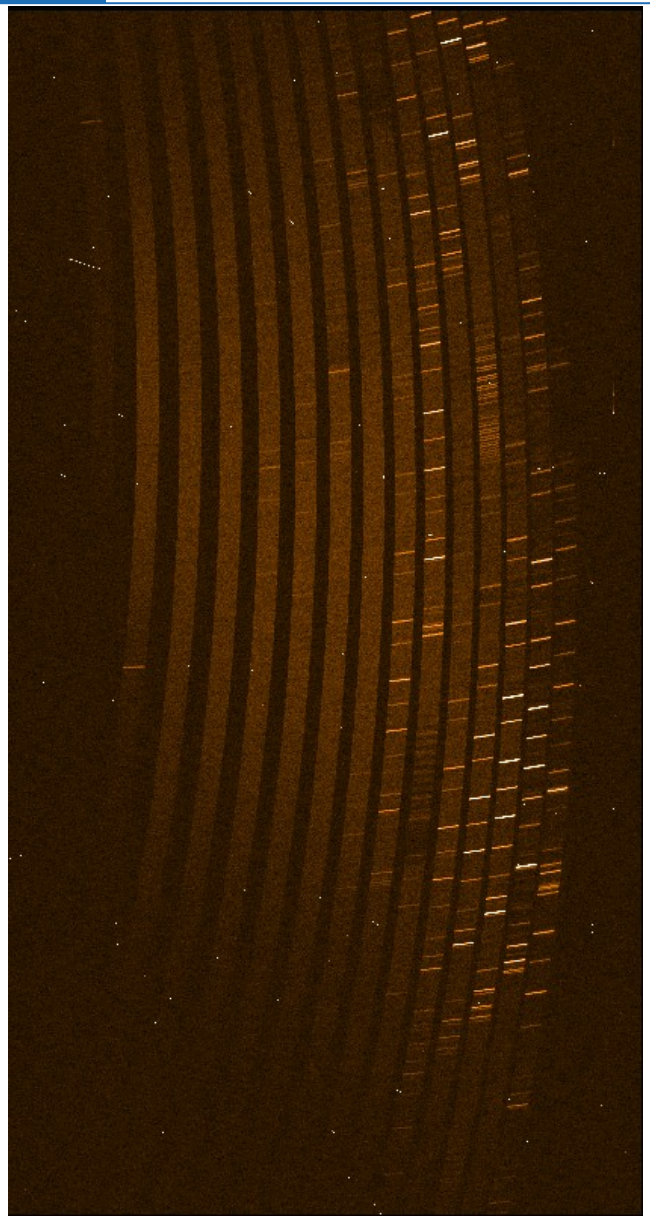


ON-SKY OFFSET

- change between target and separate sky field
- necessary for extended or crowded objects
- exposure times must be short so that the sky does not vary between target and sky exposures



X-shooter Data – Observing Modes



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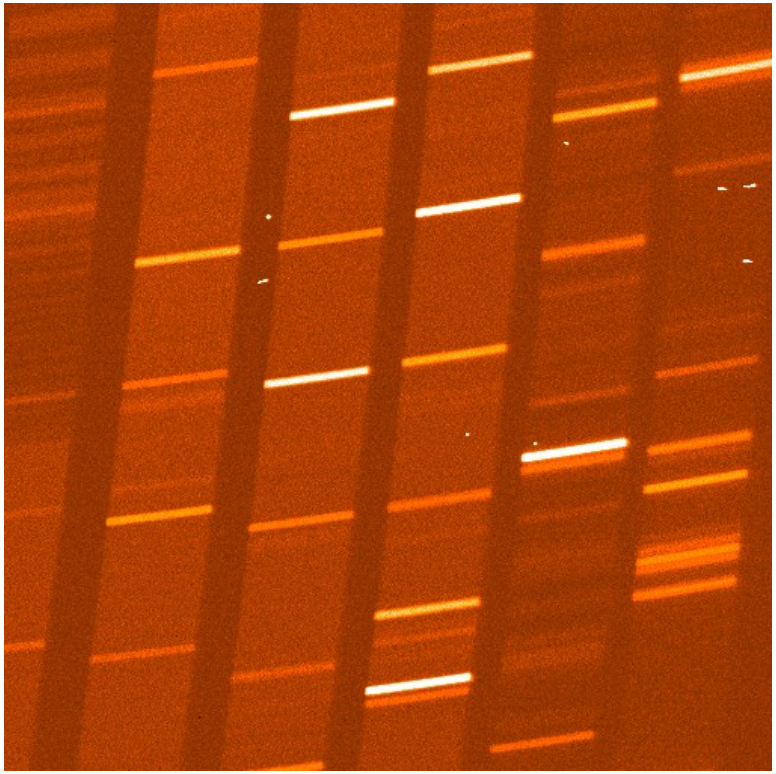
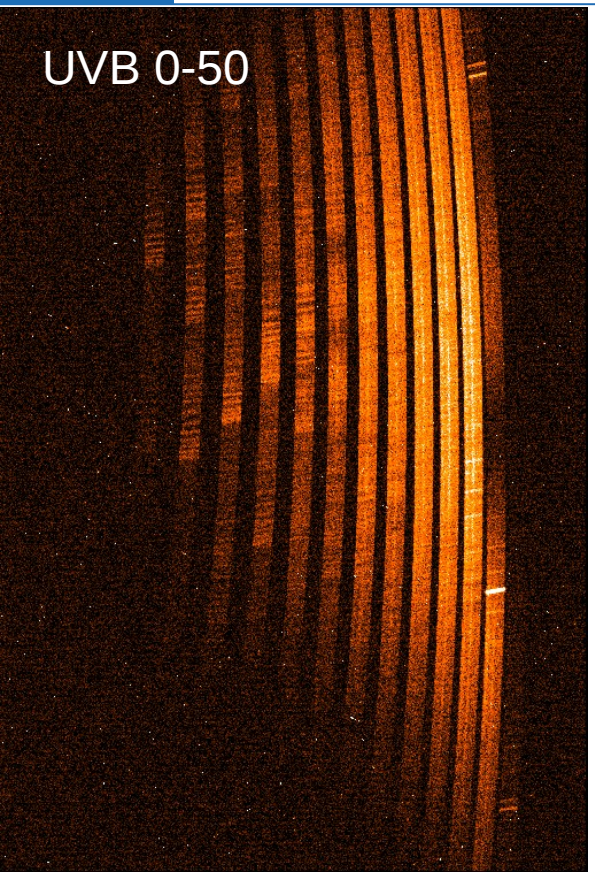
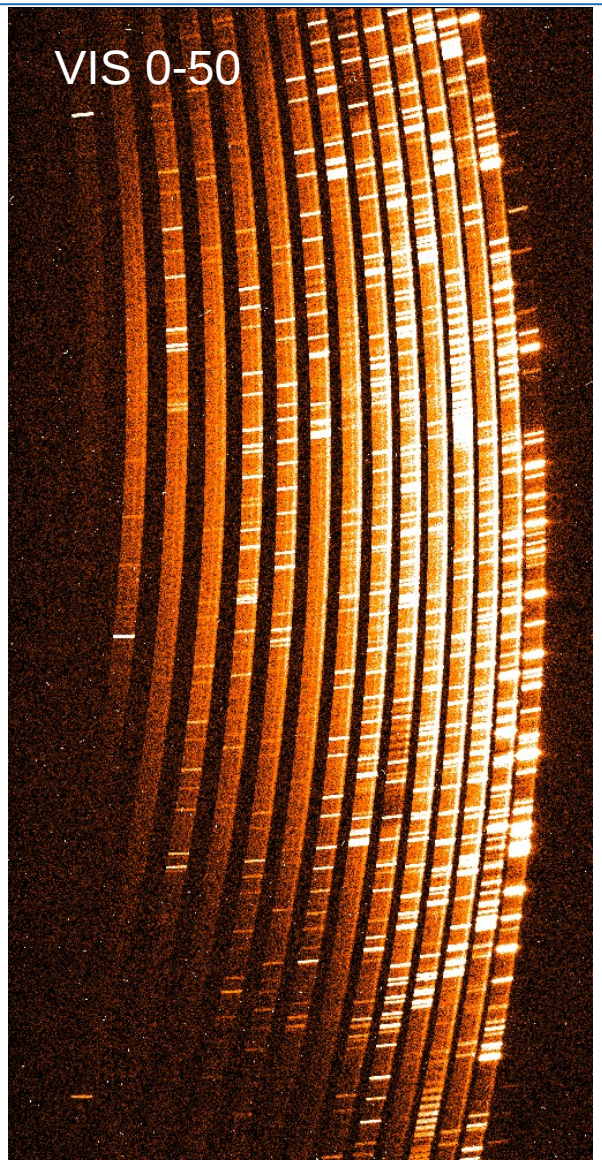
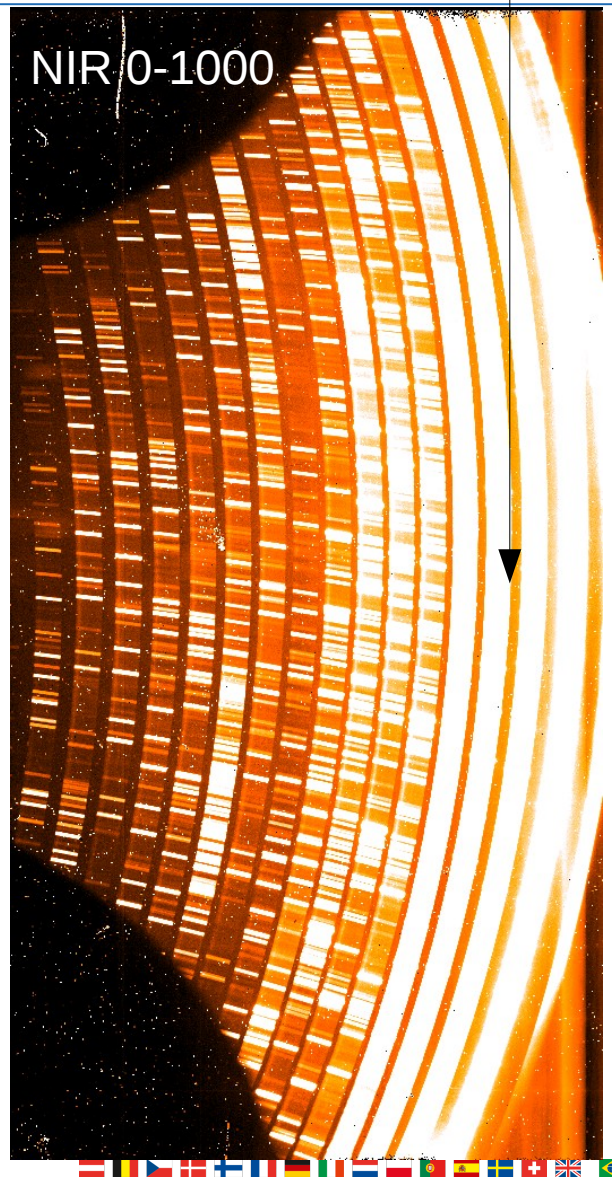


X-shooter Data – Observing Modes







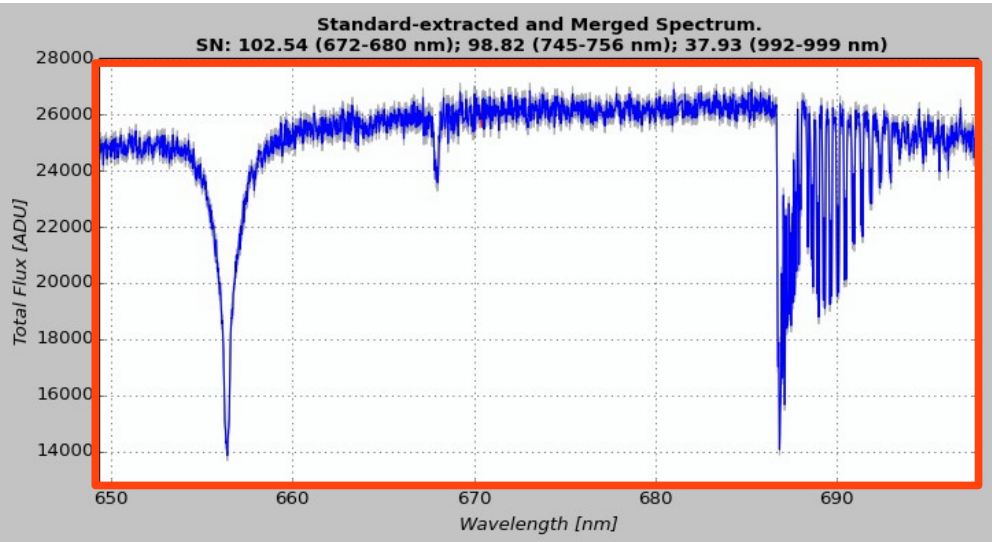
SKY

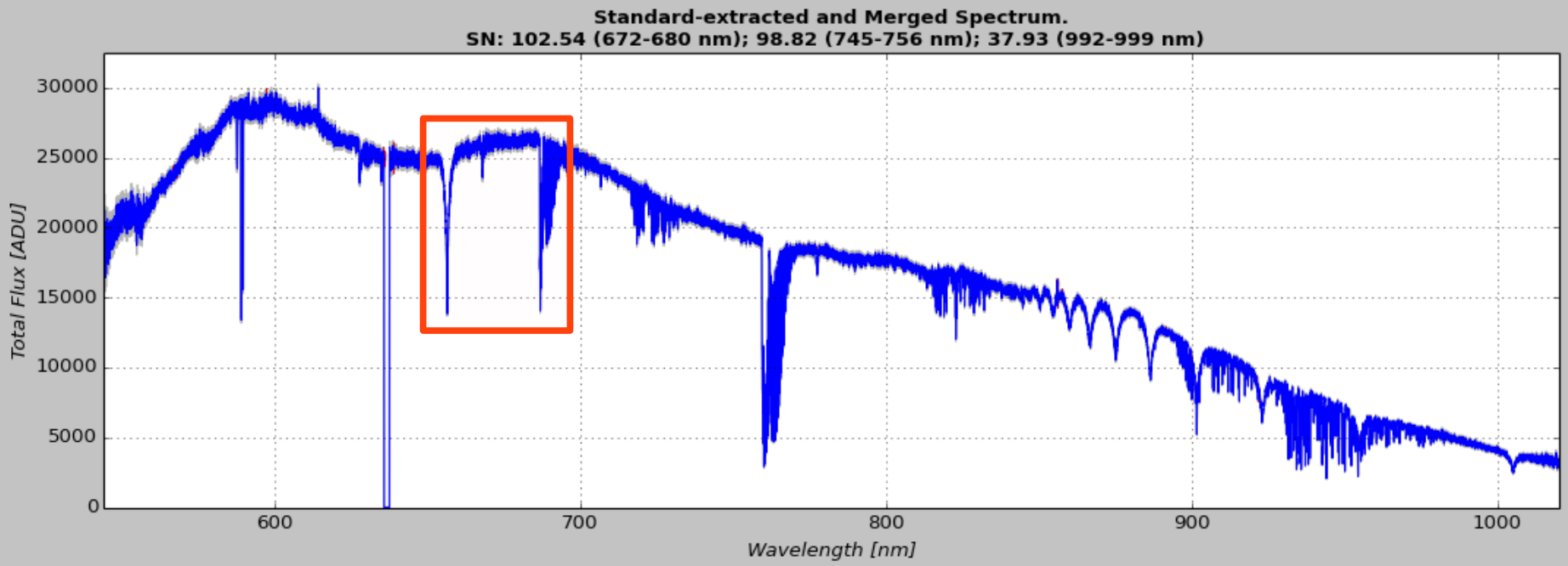
- very different in different arms

X-shooter Data – Nighttime Calibrations

TELLURIC STANDARD STARS

- correct for telluric absorption in VIS/NIR
- early-type stars (B, few lines) or solar analogues
- not variable, no emission lines

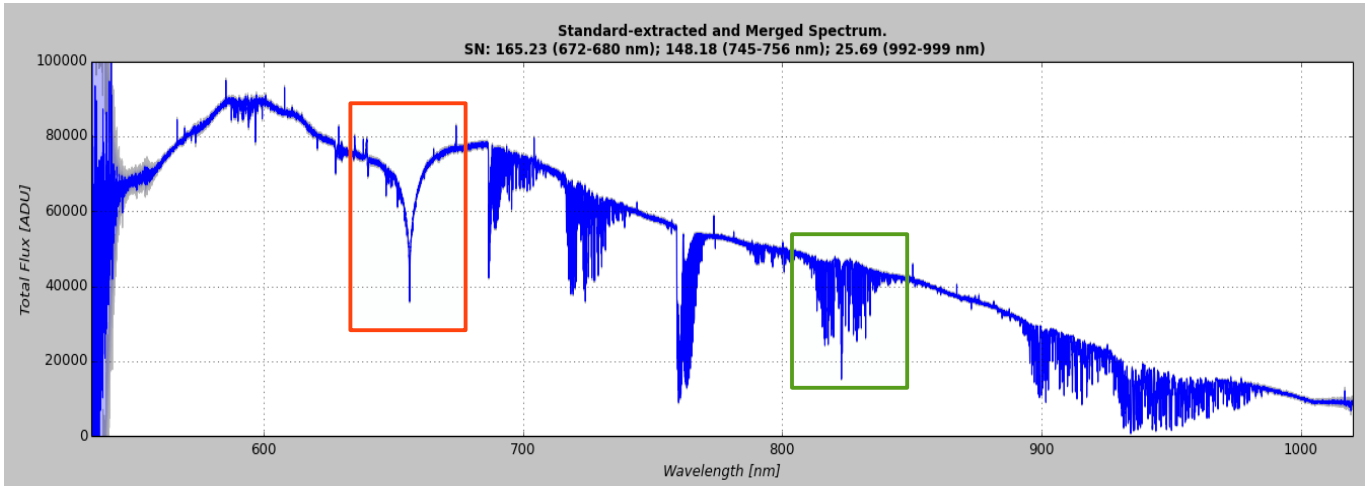


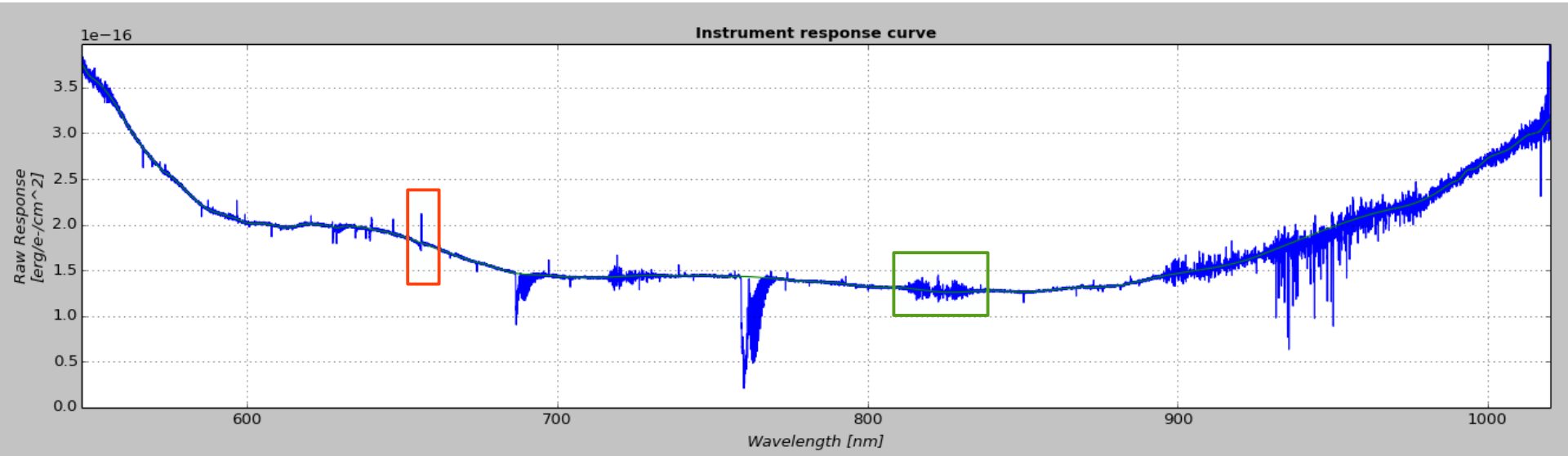


X-shooter Data – Nighttime Calibrations

FLUX STANDARD STARS

- correct for instrument response (observed with 5” slit - slit losses!)
- hot (pre-) white dwarfs





X-shooter Data in the ESO Science Archive Facility (SAF)

- Raw data (science and calibration)
  Master calibrations (delivered together with science files)
  http://archive.eso.org/wdb/wdb/eso/xshooter/form
  + CalSelector http://www.eso.org/sci/archive/calselectorInfo.html

- Science products
  http://archive.eso.org/wdb/wdb/adp/phase3_spectral/form?collection_name=XSHOOTER