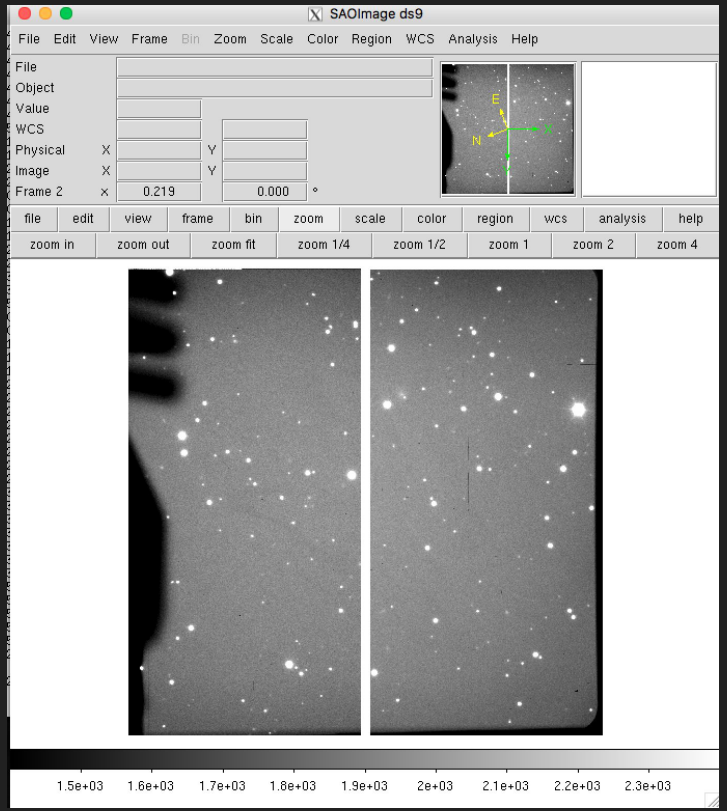
AGA0414 Spectroscopy

Prof. Alessandro Ederoclite

Long slit spectroscopy

Placing a “slit” in the focal plane of the telescope to isolate the object you want to observe.

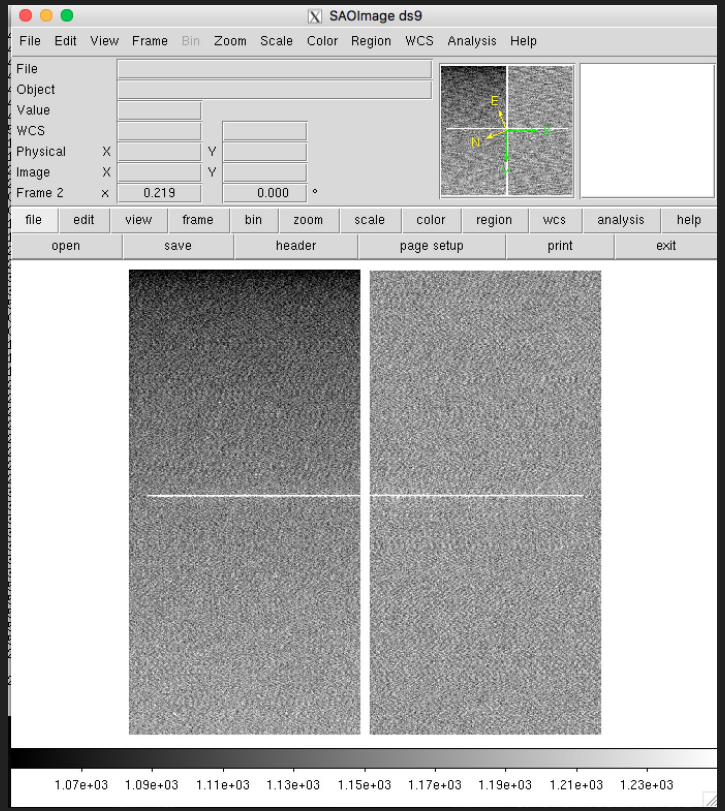
You get a spectrum of every “piece” of sky which passes through the slit.



Long slit spectroscopy

Placing a “slit” in the focal plane of the telescope to isolate the object you want to observe.

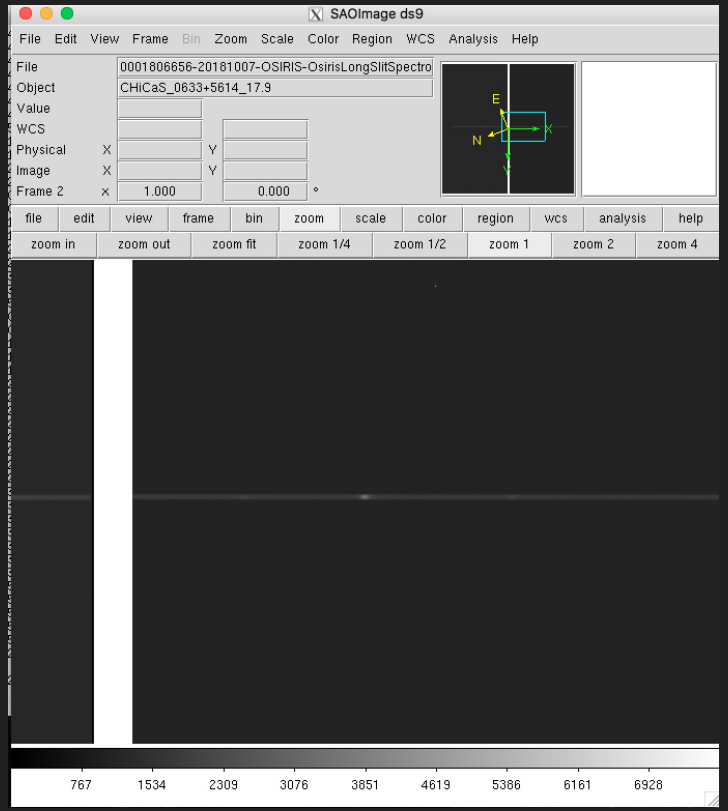
You get a spectrum of every “piece” of sky which passes through the slit.



Long slit spectroscopy

Placing a “slit” in the focal plane of the telescope to isolate the object you want to observe.

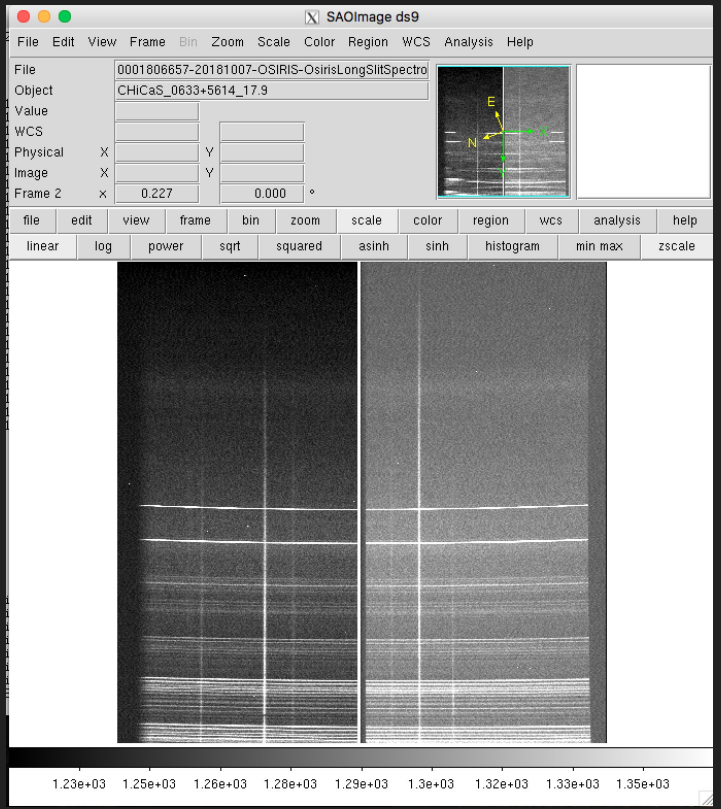
You get a spectrum of every “piece” of sky which passes through the slit.



Long slit spectroscopy

Placing a “slit” in the focal plane of the telescope to isolate the object you want to observe.

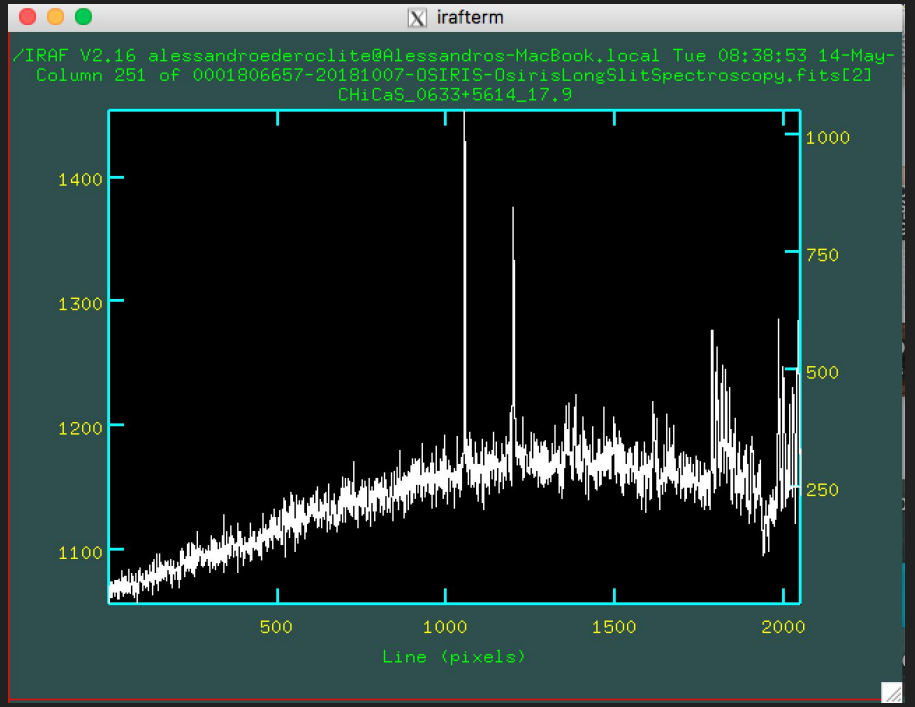
You get a spectrum of every “piece” of sky which passes through the slit.



Long slit spectroscopy

Placing a “slit” in the focal plane of the telescope to isolate the object you want to observe.

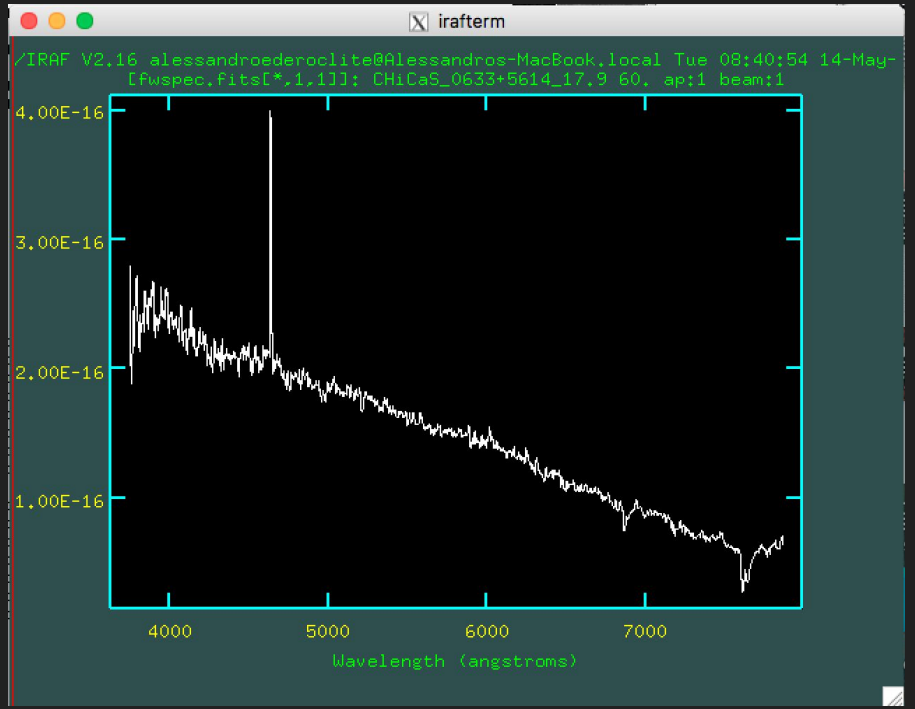
You get a spectrum of every “piece” of sky which passes through the slit.



Long slit spectroscopy

Placing a “slit” in the focal plane of the telescope to isolate the object you want to observe.

You get a spectrum of every “piece” of sky which passes through the slit.



The role of the atmosphere on spectroscopy

The atmosphere acts like a prism. This is called “atmospheric dispersion” *(Ale draw)*.

Many instruments have an “Atmospheric Dispersion Corrector” (ADC) to compensate.

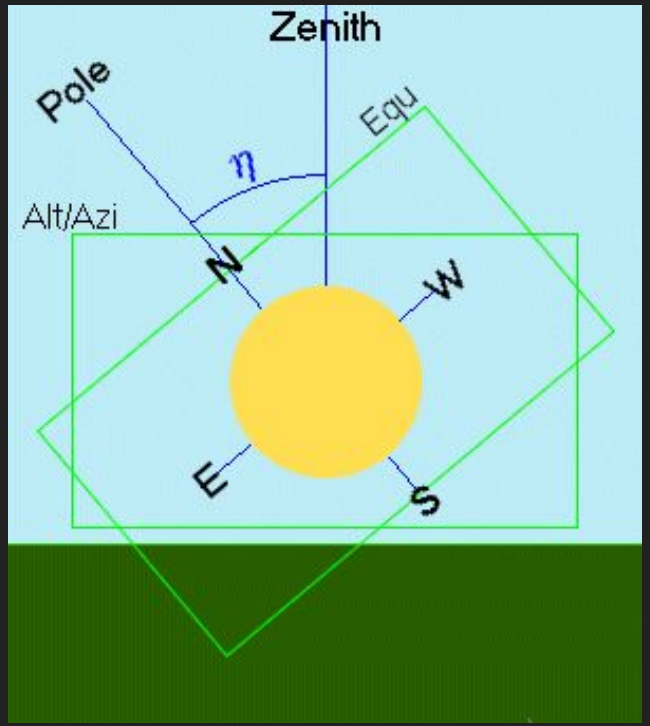
The easy solution, though, is that you observe at “parallactic angle”

The parallactic angle

The “position angle” is the angle between the y-axis of your image and the celestial North.

The parallactic angle is the angle between the “vertical” going through your object and the North pole.

Like this, you have the “images” of the object formed along the slit and you make sure that all the flux gets to the spectrograph.



Multi-Object: Why?

Observing objects “one-by-one” can be very time consuming.

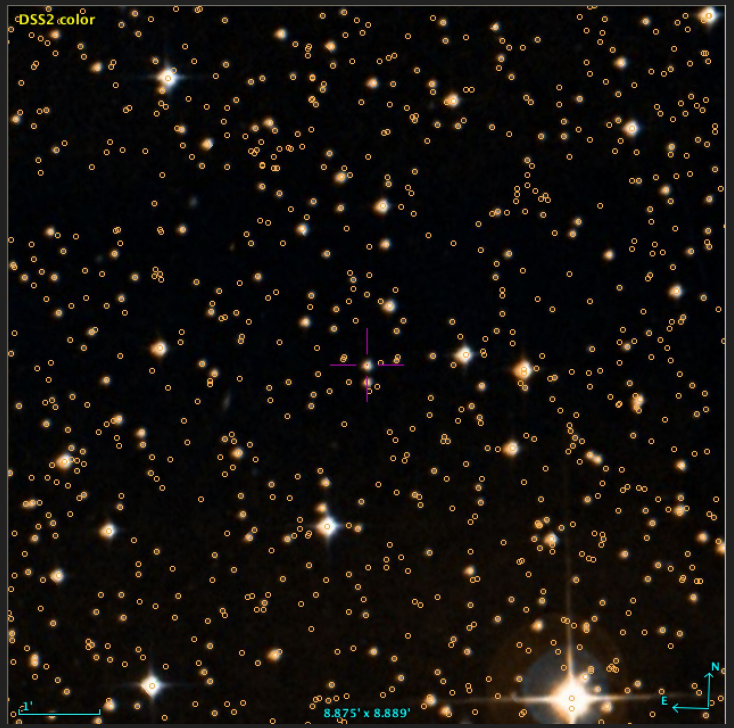
If the density of objects allows, it is a good idea to observe more than one target at a time.

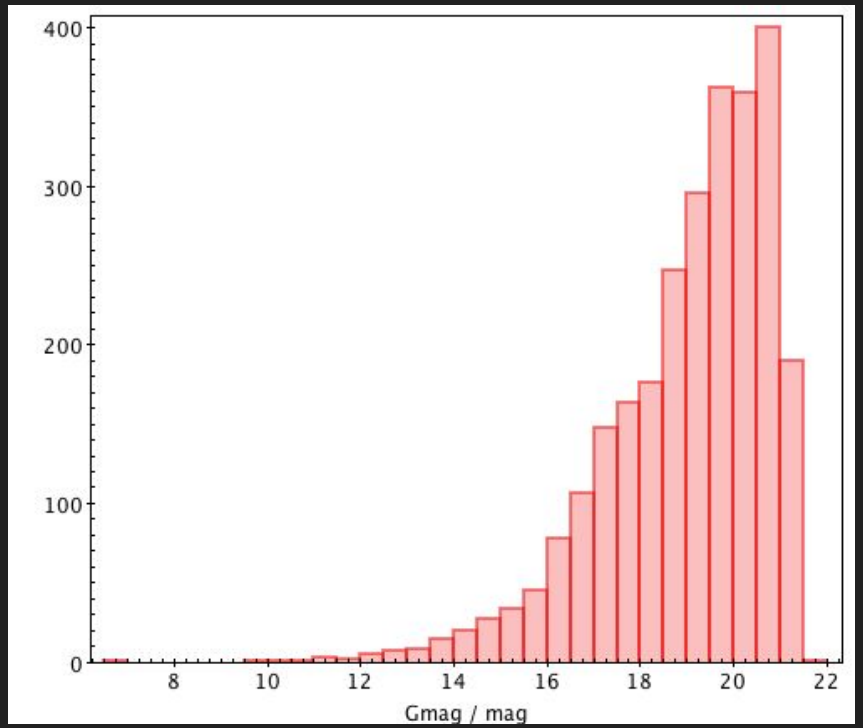
“Wide field spectroscopy” is one of the big “fashion” for large telescopes.

As usual, this does not come for free.

Every time one does MOS: there is a bias due to the selection of targets.

The T Pyx sky area and Gaia magnitudes





MOS Masks

Metallic masks which are drilled to let light of some objects to the spectrograph.

Spectra are distributed across the field of view.

Careful: may have overlap between spectra!

Each mask only makes sense for a project.

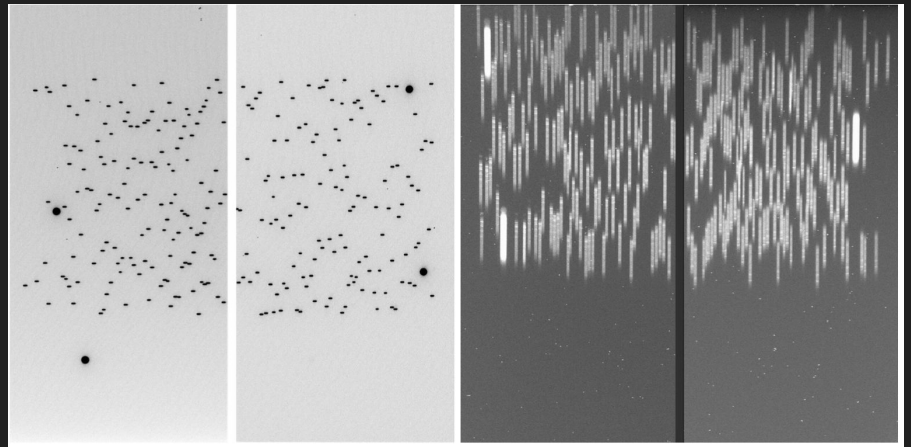


Figure 1. OSIRIS MOS spectroscopy: left) Slits as seen from the detector without adding dispersion elements in the optical path. Right) Result image of an observation showing the spectra of each object.

Vaz Cedillo et al. (2017)

Fibres

Optical fibres are an “efficient” way to carry light.

Is it better to have 25-50m of optical fibre or 2-3 mirrors?

Inconvenients of optical fibres:

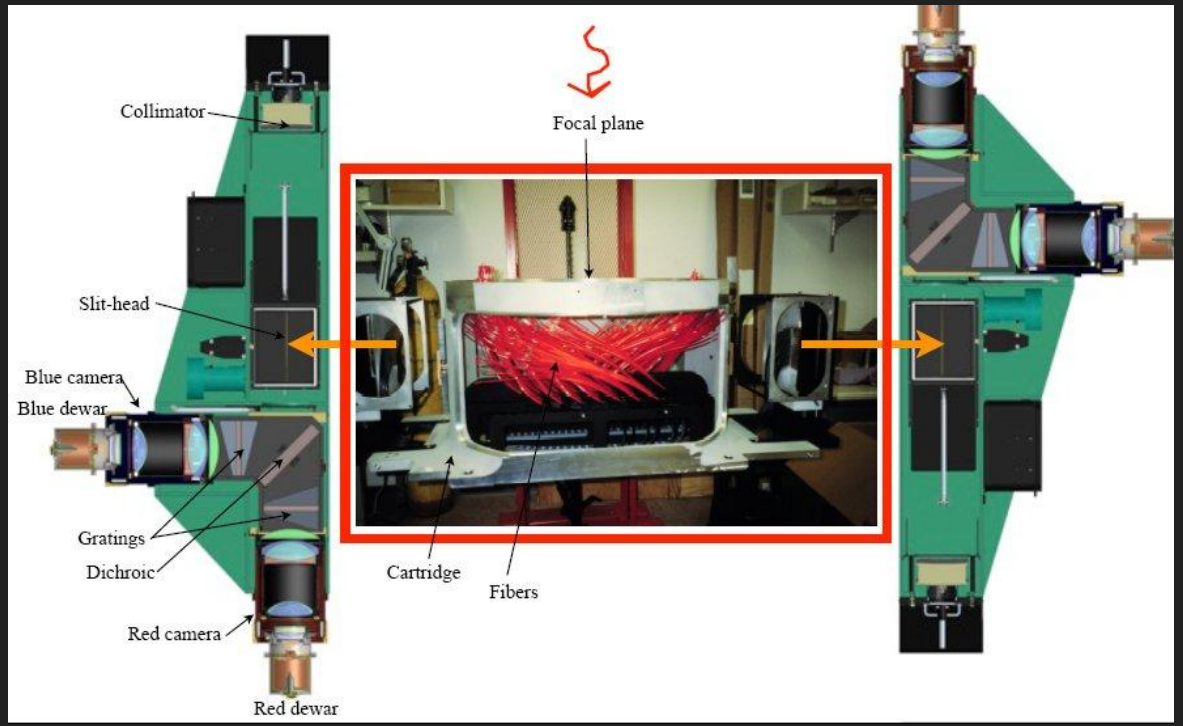
- Transmission depends on λ (poor in the blue)
- Change of F/# at entrance and exit (“focal ratio degradation”: at output, F/# is smaller)

Pros: high flexibility with respect to the masks

SDSS

320 x 2 fibres

3” diameter



SDSS

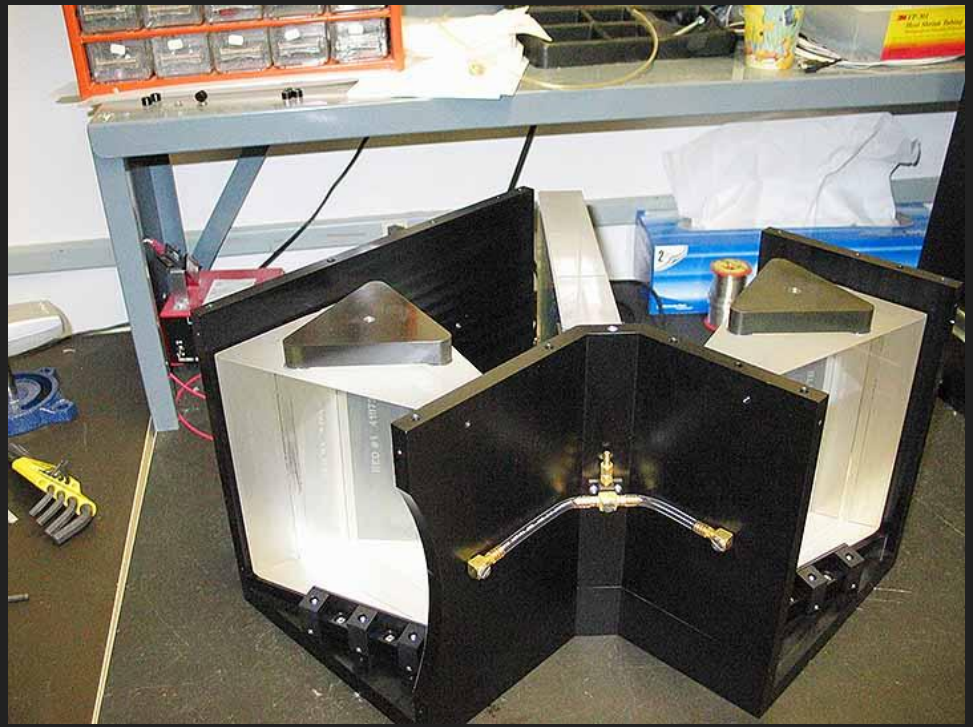
The fibres are located on a plate.

Each plate refers to a specific field.

SDSS

Two channels separated with a dichroic

R ~ 2000



Echelle spectrographs

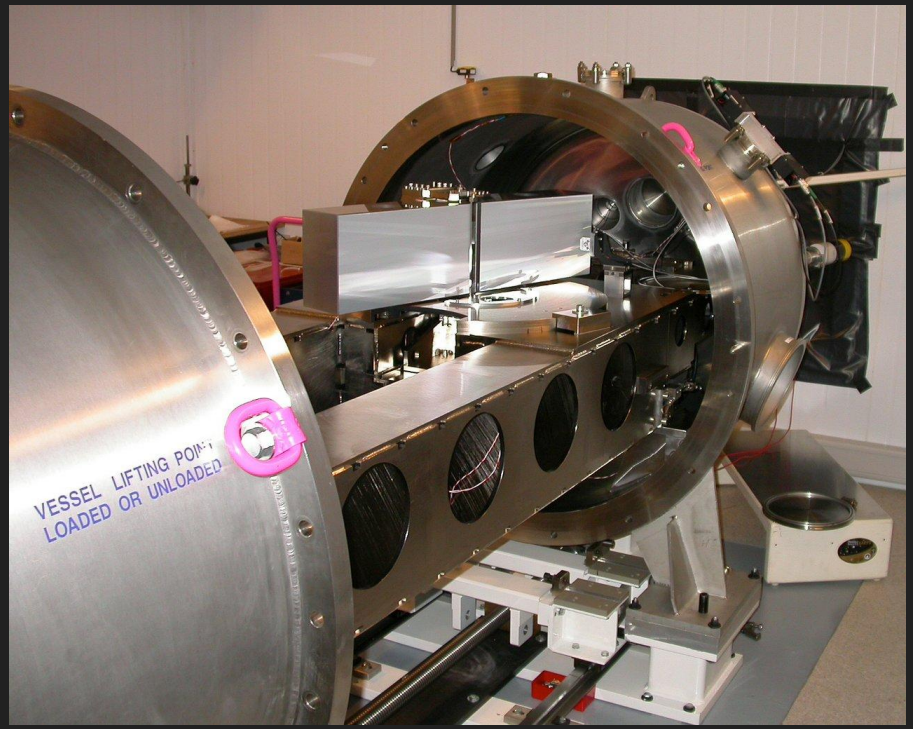
Use reflecting gratings at high orders.

Pros:

- High spectral resolution

Cons:

- “Short” long-slit
- Low efficiency
- Large gratings
- Small spectral range in the CCD
- Orders overlap… and are curved!



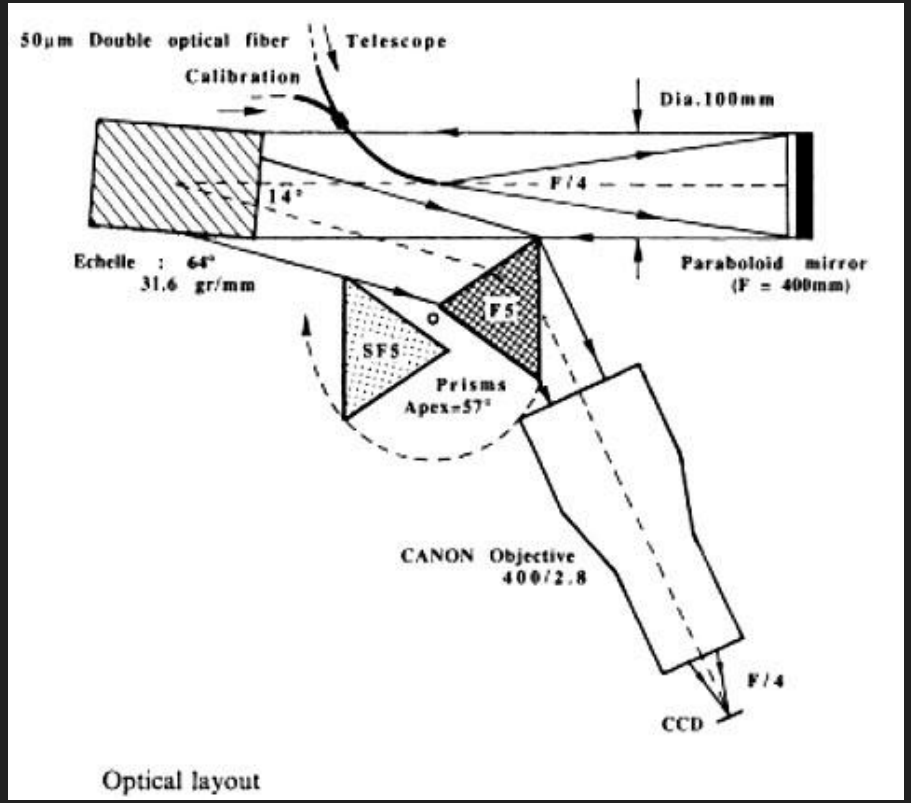
The HARPS grating
(measures 200mm x 800mm)

Cross-dispersion! :-)

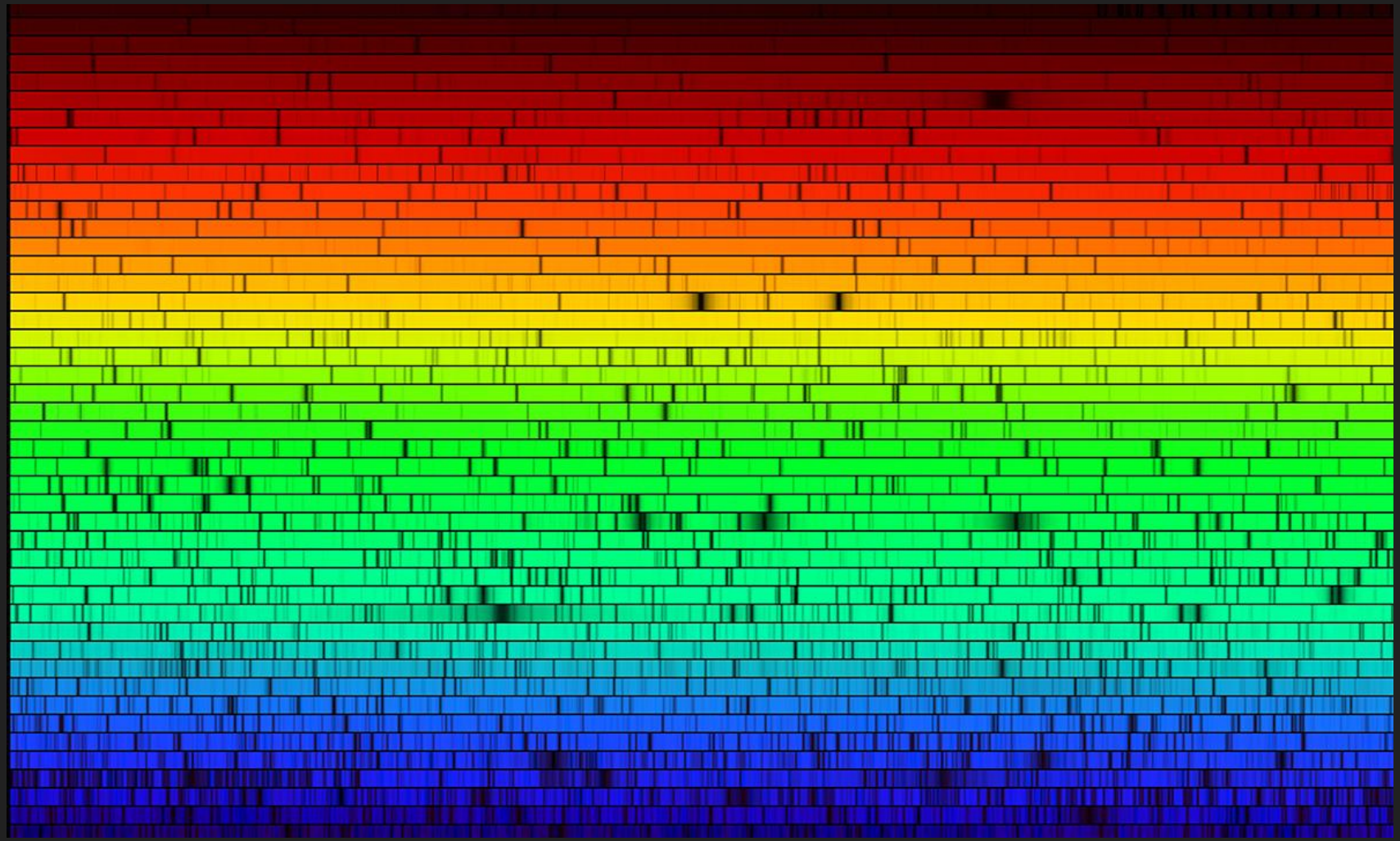
If you add another dispersing element PERPENDICULAR to the dispersion of the first one, you solve the issue.

Most (if not all) high resolution spectrographs work with this principle.

MUSICOS (@ LNA) =>



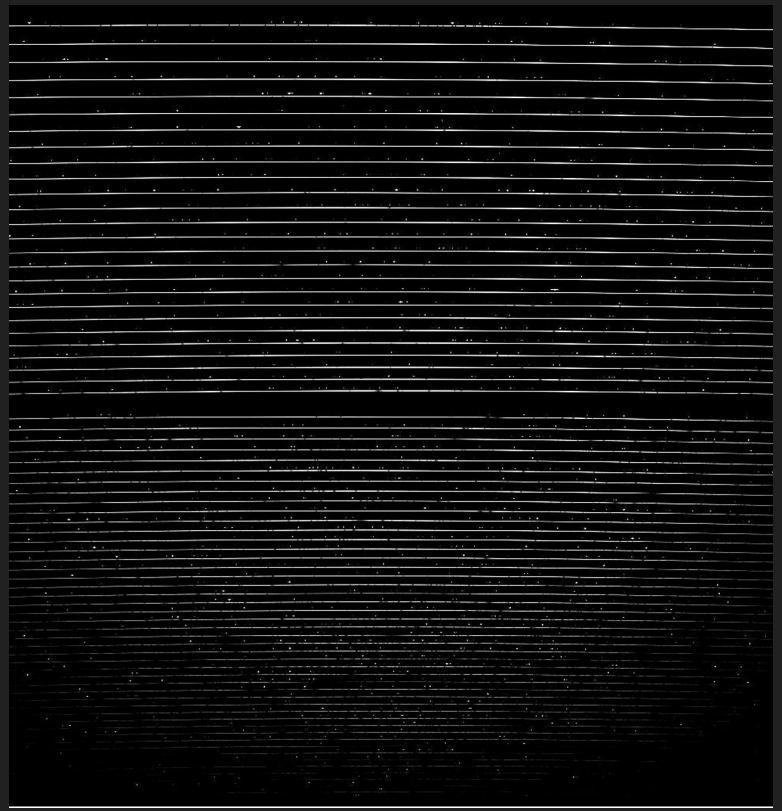
Optical layout



Fibre-fed echelle

Normally, two fibres: one for the science target and one for wavelength calibration (or sky subtraction)

HARPS “first light” =>

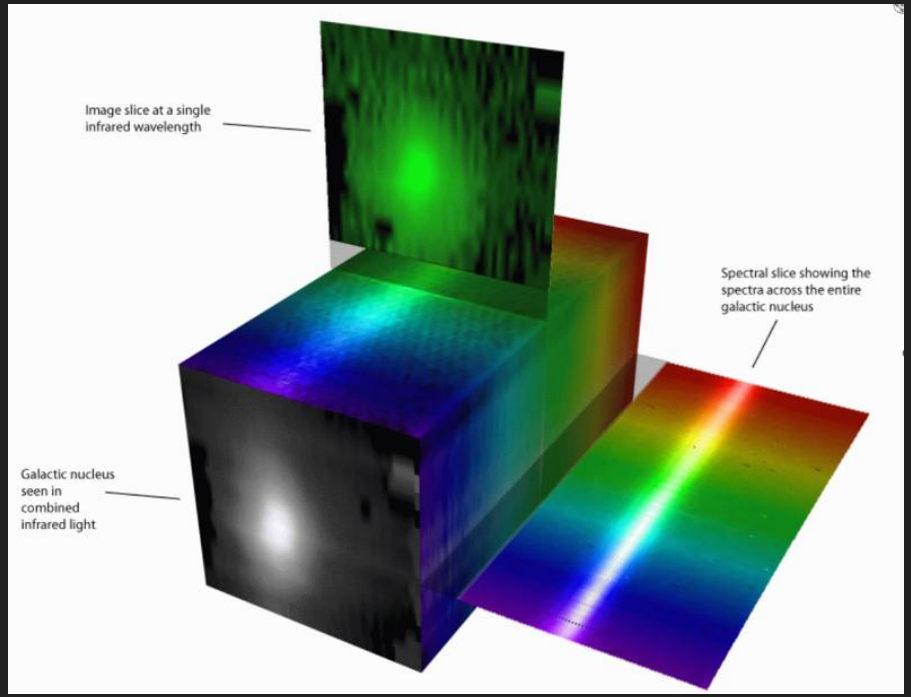


Integral Field Spectroscopy

What happens if you try to make spectra of each and every piece of sky in a small region?

This is what IFS is about.

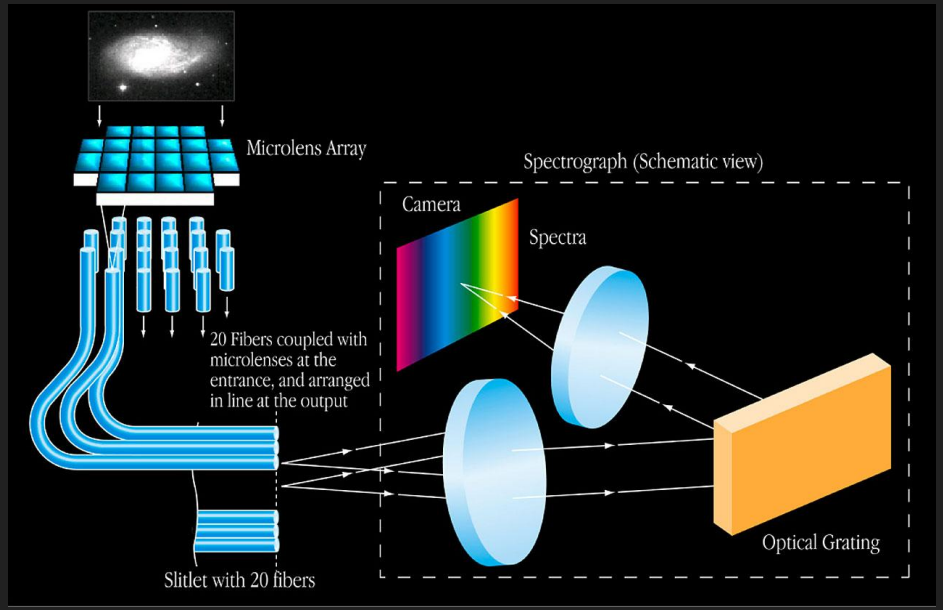
https://www.eso.org/public/teles-instr/technology/ifu/



Integral Field Spectroscopy - with fibres

You can do it putting many fibres together.

This is how many good and successful IFUs work (Gemini/GMOS, VLT/VIMOS, VLT/ARGUS, CAHA 3.6 / PMAS-PPAK, SDSS/MaNGA,...)

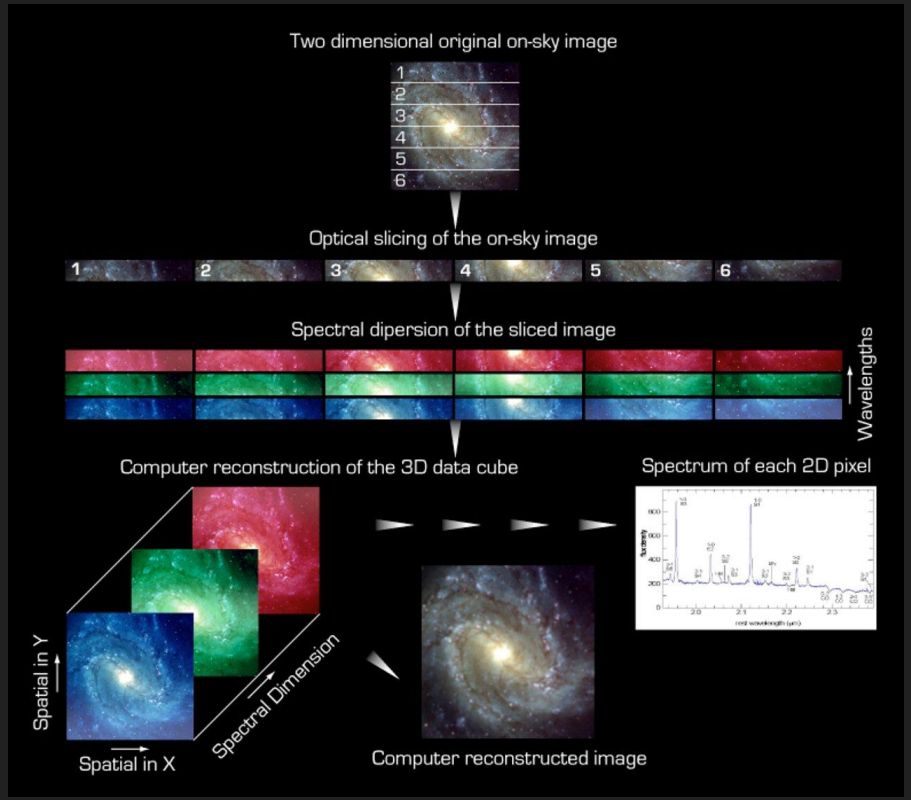


Integral Field Spectroscopy - with field slicer

You slice up the field and send each slice to a spectrograph.

Less used (VLT/MUSE)

Demonstration with QFitsView



...next time

Formation of lines

How to use spectroscopy to do science :-)