MEGARA ONLINE ETC
QUICK START AND REFERENCES GUIDE

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Multi
Espectrógrafo en
GTC de
Alta
Resolución para
Astronomía

GETTING STARTED

This guide was written to get a quick grasp of the MEGARA Online Exposure Time Calculator (ETC), a tool to calculate the signal-to-noise ratio (SNR), and thus, to infer the exposure time necessary for your observations with the IFU camera MEGARA@GTC.

The ETC was kept as simple as it can be in its design and appearance to avoid any cluttered information to avoid confusion. However, doing so hides important information that the user should be aware of, and would be necessary for the unacquainted or novice in observation to interpret the results. This guide is intended to answer the most common questions regarding the ETC by giving a quick explanation for each field, for both inputs and outputs.

While the ETC has been tested on multiple OSes such as Mac OS X and Linux, and internet browsers such as Chrome and Firefox, we haven't tested all possible combinations and it is possible that the appearance may change from one machine to another. We recommend enabling javascript and allowing cookies, if you have them turned off (they are turned on by default in most modern browsers such as Chrome, or Firefox). We strongly recommend to use Chrome or Firefox. The advanced interactive graphical output of the ETC is not supported by Safari.

To start the ETC, go to the following URL:

tajox.fis.ucm.es:8080/etc/

You should see the welcoming title.

Click on the big "START" button on the left to start the ETC.

Figure 1: The welcome screen of the ETC

QUICK START

Using the ETC for the first time.

What you are now seeing is the input form for your observation. Below the form are buttons of which one says “Submit”.

Click on it.

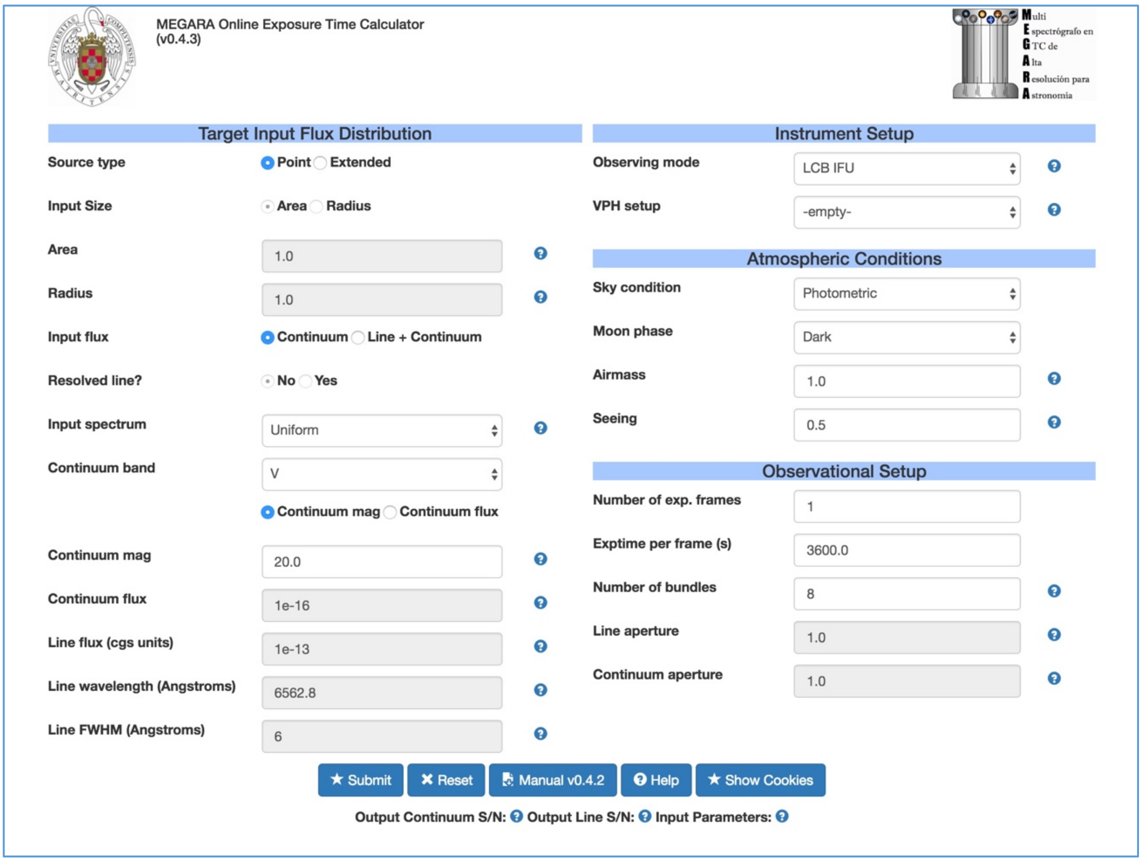

Figure 2: The ETC input form

It complains, with an obvious and annoying pop up alert message, that you must set a “VPH”.

Set a VPH from the pulldown list of the “VPH setup” row in the “Instrument Setup” part of the form.

VPH stands for “Volume Phase Holographic” grating. It is a big slab of glass. MEGARA has 18 types of VPH gratings available. A table of properties can be seen by clicking on the Help button (question marks) next to the right of the VPH selection box.

Click on “Submit” again.

A loading icon should appear. Be patient. It may take, in some cases, up to a minute to load the results. If the results do not appear, and the browser gets stuck with the loading icon, something went wrong and either you should change browsers, and if persisting, contact the system administrator as it may be a network error.

If everything went right, the loading icon should disappear and the results should appear in the same page below the form. There are two interactive plots on the left-hand-side, and tables of results on the right-hand-side.

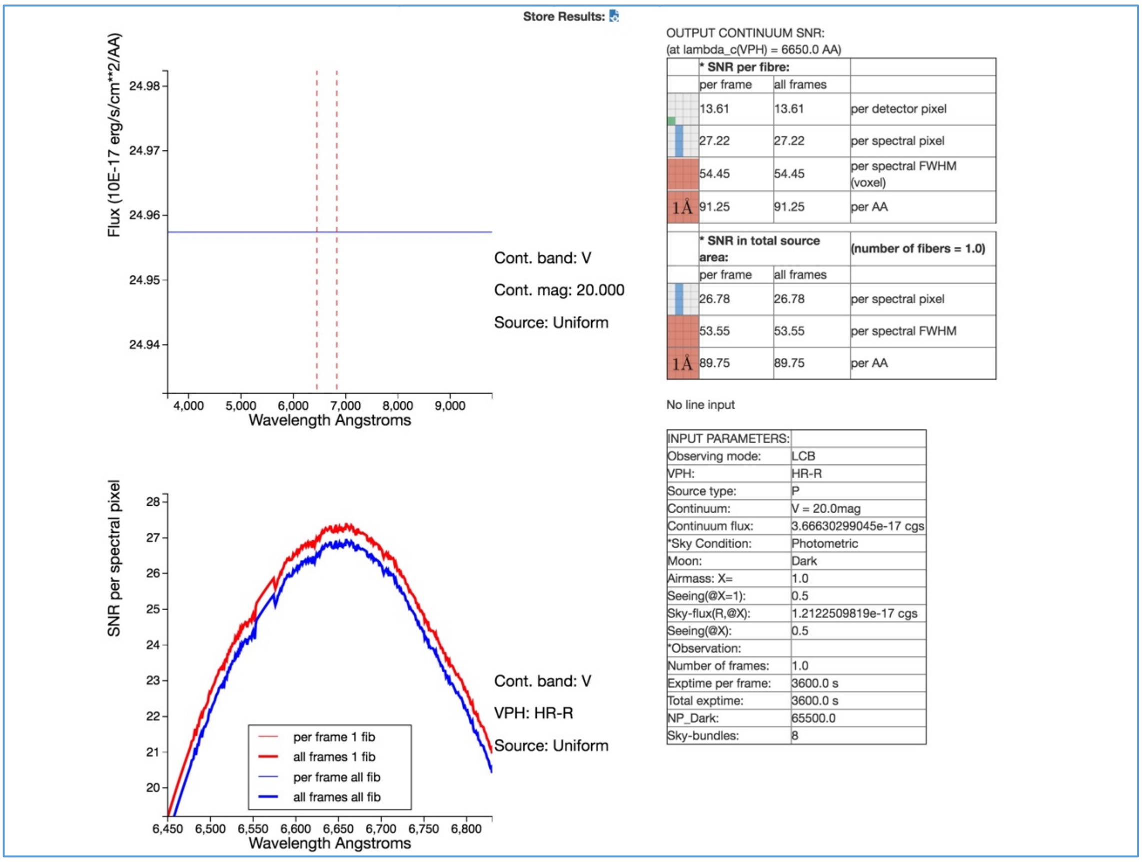

Figure 3: The results layout of computation of the ETC. The results appear in the same page below the form and consist of two interactive graphics to the left and tables of values to the right.

That's it! You have now computed your first observing configuration. We will see in the next section what all these results are.

Pan and Zoom the Interactive Plots

The two plots in the results are interactive and can be zoomed in and out and panned. Put your mouse cursor over one of the plot. You should see small grey icons in the bottom-left corner of the plot. Click on the buttons to activate them.

Figure 4: Interactive plot icons. From left to right: Home, Pan, and Zoom buttons.

There are three buttons. These are the "Home" button (left) that resets the plot to the initial state, the "Pan" button (middle) to move the plot in the plane, and the "Zoom in" button (right) as a magnifying glass to zoom in.

In Chrome and Firefox, scrolling the mouse, while being in pan mode, allows for zooming in and out.

The "Zoom in" button changes the cursor to a cross-hair and allows you to select a rectangular region on the plot by clicking and dragging diagonally from one corner to another over the desired area. Zooming out is not allowed in this mode. In that case, just hit the "Home" button to return to the initial state of the plot. Holding down the option-key on Mac (or alt-key on PC) allows you to select the area from the center of the rectangle.

The Top Figure/Plot

The top plot shows the input spectrum, flux versus wavelength, where the x-axis is the wavelength in Angströms, and the y-axis is the flux expressed in units of 10^{-17} ergs/s/cm^2/Å. The default input spectrum is set to "Uniform", which shows nothing but a constant horizontal flux that is computed based on the "Continuum mag" or "Continuum flux" value. Choose another template spectrum from the pulldown tab of the "Input Spectrum" row and click on "Submit" again to validate your choice.

Another template has now been loaded and you should see the output changed.

The Bottom Figure/Plot

The bottom plot shows the output SNR for the spectrum in the Top Figure, after computation taking into account the other entries.

Cookies

The MEGARA Online ETC stores the form data in ‘cookies’ (and therefore, requires you to enable them in your browser). The cookies are stored only when the “Submit” button is pressed. If a form was filled-in but not submitted, the filled-in values will be lost when closing the browser tab.

You can see the status of your currently stored values by clicking on the “Show Cookies” button.

Delete the cookies by clicking on the “Reset” button.

Cookies expire after 1 year.

** Important remark **

Notice that this tool provides the modelled SNRs for a given exposure time without accounting for instrument and telescope overheads. This means that you must add the typical overheads to the exposure time estimated by the MEGARA ETC for obtaining your required SNR (typical overheads ~ 20-30% of the total exposure time).

A total, uniform coverage of the FoV by the fibers in LCB.

The total transmission curve considers: Atmosphere transmission at La Palma Observatory + GTC 3-Mirrors reflectability + field lens transm. + fiber link transm. + spectrograph transm. (optics + VPHs + detector QE).

INPUT PARAMETERS

Target Input Flux Distribution

This set of parameters is intended to describe the flux distribution of the source to observe.

Source Type:

If the source is point or extended. If point source is chosen, the target object is assumed to be an emitter with negligible angular size. This can be selected for objects with an angular radius of much less than the sky-projected pixel size. If extended source is chosen, the target object is assumed to have a uniform intensity along its whole apparent area. If "Source type=extended", then the input parameter "Size" becomes mandatory.

Input Size:

For extended sources, choose between a direct area input or a radius-based input. The former is used as is, while the latter computes the area of a disk using the given radius value.

Area (sq. arcsec):

For extended sources, apparent projected area of source in arcsec**2. Circular shape is assumed for the source. This parameter is available only if the 'Source Type=Extended' option is set.

Radius (arcsec):

For extended sources, apparent projected area of source in arcsec**2 is calculated from the formula pi*radius**2.

Circular shape is assumed for the source. This parameter is available only if the 'Source Type=Extended' option is set.

Input flux:

Kind of data inserted to get the signal-to-noise. If "Input flux=Continuum", only input data necessary to define the continuum of the source are required for computation. If "Input flux=Line+Continuum", the following input parameters become mandatory too: "Resolved line", "Line flux", "Line wavelength", "Line aperture", and "Continuum aperture".

Resolved line:

This parameter indicates if the line can or not be resolved, and it is relevant only if "Input flux=Line+Continuum". If the line is resolved, the user must insert the line full-width-at-half-maximum (FWHM). Otherwise, the FWHM of the line is determined by the selected VPH.

Input spectrum

The target model can be defined by the target's spectral type. It uses a template spectrum, which is scaled to the provided magnitude and filter. The spectral type is used to make the color correction. ** NOT ACTIVE OPTION YET **

Continuum band:

Band in which the input continuum magnitude or flux is provided. The input template spectrum is scaled to the input magnitude in this band.

Continuum magnitude:

For point sources, Vega apparent magnitude of the source continuum in the selected continuum band. For extended sources, the magnitude must be provided per arcsec**2 in the selected band. Only available if 'Continuum flux' option is not set.

Continuum flux:

For point sources, flux of source continuum in c.g.s. unit system (erg/s/cm**2/AA) in the selected continuum band. For extended sources, this flux is provided per arcsec**2. Only available if the 'Continuum Magnitude' option is not set.

Line flux:

For point sources, flux of line in c.g.s. unit system (erg/s/cm**2). For extended sources, this flux must be provided per arcsec**2. This parameter is available only if the 'Input flux=Continuum+Line' option is set.

Line wavelength:

Line wavelength in Angstrom. This parameter is available only if the 'Input flux=Continuum+Line' option is set.

Line FWHM:

Line FWHM in Angstrom. If the line is not resolved, the nominal FWHM of the selected VPH at its central wavelength is assumed. This parameter is available only if the 'Input flux=Continuum+Line' and 'Resolved line=yes' options are set.

Instrumental setup

MEGARA observing mode:

Select the observing mode that you are going to use (LCB: Large Compact Bundle, or MOS: Multi-Object Spectrograph). This basically sets the radius of fibers and the achieved spectral resolution.

Both, LCB and the MOS modes, use fibers of 0.620 arcsec (100 microns diameter), providing spectral resolutions of 6000, 12000, and 18700 in low-, medium-, and high-resolution VPHs in a diameter enclosing 80% of energy, respectively.

VPH setup:

Consult the characteristics of each spectral setup in the table accessible through the help button (labeled as '?') placed next to the 'VPH setup'. The wavelength of the input spectral line must be located into the wavelength range of the selected VPH. A program warning is shown if this is the case and no computation will be performed.

Atmospheric Conditions

Sky condition:

Options are Photometric, Clear, and Spectroscopic. In magnitudes, Photometric = +0, Clear = +0.4, Spectroscopic = +1.

This value is multiplied to the overall system efficiency, and corresponds to 100% efficiency for photometric, 69.2% for clear, and 39.8% for spectroscopic sky condition.

Moon phase:

The following options for the night brightness are available: dark/grey/bright. The sky magnitude at a dark night in La Palma is initially set in the photometric band nearest to the user-selected VPH (consult Table 2). The typical average extra brightness between a dark and grey or bright night is added, depending on the user-selected moon phase (consult Table 3), assuming that the difference of emission between dark-bright and dark-grey does not depend on the optical band. The average emission due to zodiacal light, airglow, and starlight are also considered. Atmospheric extinction will be considered in next versions.

Table 2: Near-zenith dark-of-moon broad-band sky brightness at La Palma for different bands in mag/arcsec**2 (C.R.Benn & S.L. Ellison 1997, La Palma technical note 115.)

Band # Magnitude/arcsec**2 (*1)

U 22.0

B 22.7

V 21.9

R 21.0

I 20.0

(*1) Values found to be independent of atmospheric extinction, usually do not vary appreciably during the night, but with solar cycle, latitude and airmass.

Table 3: Extra magnitudes to be added to reference values of sky emission in Table 2, for bright, grey, and dark nights in La Palma, in mag/arcsec**2 in the V-band, in order to account for zodiacal light, airglow, and starlight (I. Skillen, 2002, ING Technical Note 127)

Moon phase # Extra emission in mag/arcsec**2

Bright 3.1

Grey   1.5

Dark   0.5

Airmass

Airmass scales the number of photons from the sky background with according to the following expression: (-0.000278719*X**3 - 0.0653841*X**2 + 1.11979*X - 0.0552132).

Seeing at Airmass

Seeing in arcsec. The value refers to the FWHM of the seeing disk in V band, at the previously indicated airmass X. For illustration purposes, the seeing at airmass = 1.0 (zenith) is also computed, assuming that it scales with the airmass X as follows: Seeing(Zenith) = Seeing(X) / X**3/5. Both seeing values are written to the "Input parameters" output window of the "Results" menu.

Observational Setup

Number of exp. Frames:

Number of exposure frames required. It is multiplied to the 'exposure time per frame' value to get the total exposure time.

Exptime per frame (s):

Exposure time per frame in seconds. This exposure time does not take into account instrument and telescope overheads or the dithering required to ensure total coverage of the target (see ** Important remark **, in section 1) of this help).

No. of sky mini-bundles:

Number of sky mini-bundles used to derive the sky spectrum to subtract. The maximum no. is 100. Each sky bundle consists on 7 fibres in a compact distribution (lenslets appended to fibers are hexagonal).

Line aperture:

Aperture to derive line flux in spectrum, in line FWHM units. This parameter is available only if the 'Input flux=Continuum+Line' option is set.

Continuum aperture:

Aperture to estimate continuum around the line for continuum-subtraction, in line FWHM units. This parameter is available only if the 'Input flux=Continuum+Line' option is set.

The meaning of the SNR output tables is somewhat convoluted due to the very nature of the IFU instrument and its capabilities. To make some sense out of the computed values, we devote the entire next section to the explanations of each SNR outputs.

THE OUTPUTS

Quick reminder about MEGARA's spaxels, voxels, and other jargon

The terms 'voxels' and 'spaxels' are found across the literature of the MEGARA IFU, as well as other jargon, and needs a quick reminder here in order to understand the output Signal-to-Noise Ratio (SNR) that are calculated. First of all, a **bundle**, also sometime called a **mini-bundle**, consists of 7 fibers, each of them connected to a hexagonal **microlenslet**.

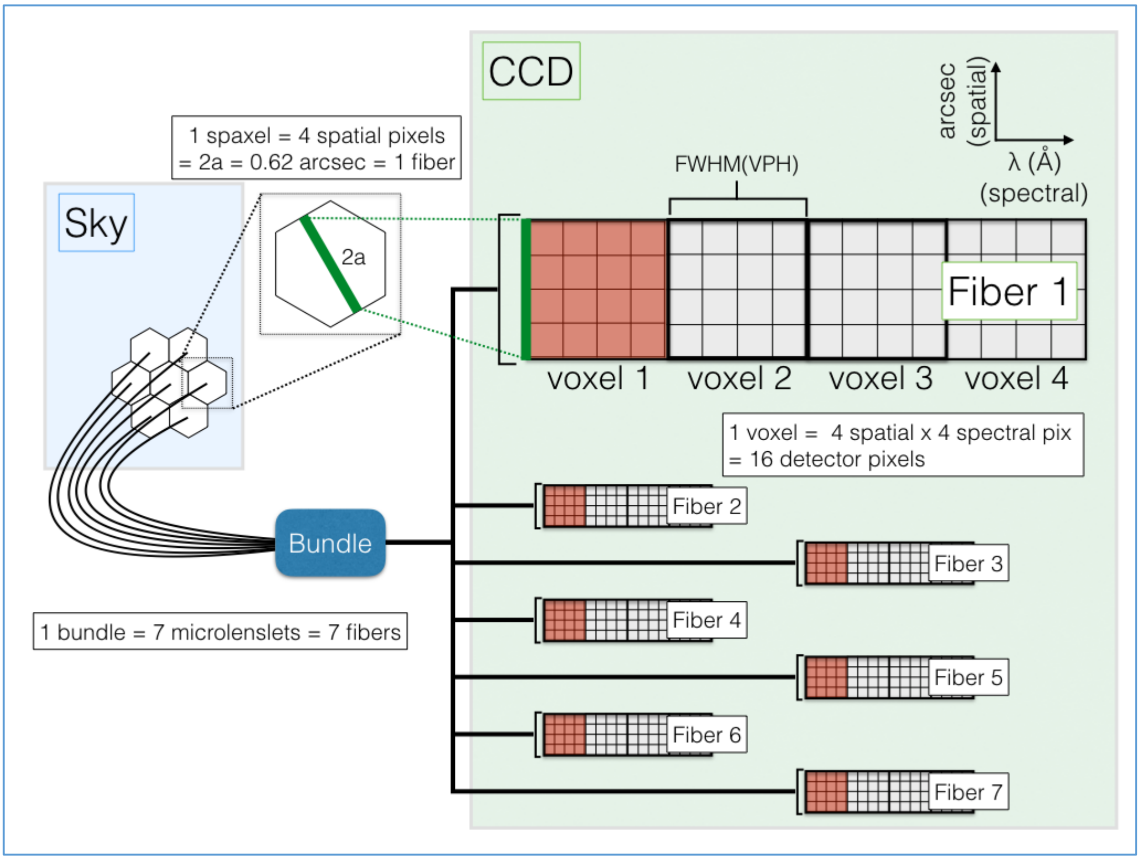

Figure 5: A schematic representation of a bundle (= 7 fibers), microlenslet (hexagon) spaxel, and voxel (red-shaded 4x4 pixels region on the CCD).

These microlenslets are placed on the observing plane, and are called **spaxels**, or **spatial**-picture-elements (and not 'spectral'). This is shown in Figure 5 as a hexagon, representing one microlenslet, attached to the end of each fiber, with a length from one side to the opposite side (or twice the apothem, the distance from the center perpendicularly to one side) corresponding to the diameter of the fiber of 0.62 arc second (the green line of length 2a). The light entering the fiber is then recorded over a 4 pixels-ranged row, corresponding to 0.62 arcsec of sky, giving a plate-scale of 0.155 arcsec-per-pixel.

A single bundle of 7 fibers, thus, covers 7 spaxels of sky and 7x4=28 rows of pixels on the CCD.

As the observation goes on, light entering the spaxel will be recorded onto the CCD in a sequence of **voxels**, or volume-picture-elements, defined to be a 4x4 pixels element, with the above-mentioned 4 spatial pixels, times the 4 spectral pixels due to the FWHM for all the VPH gratings, and hence, are also called **spectral FWHM**.

A set of 4 pixels, in either spatial or spectral direction as shown in Figure 6, is the minimum spatial and spectral resolution element of the observation, and both can also be called a spaxel (in the latter case, it would really be a 'spectral-picture-element').

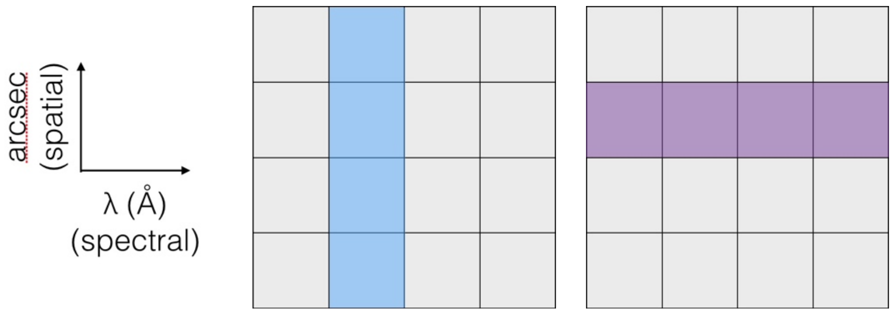

Figure 6: Spatial (left) or spectral (right) pixels could both be called spaxels.

All what the ETC is doing is calculating the SNR of the continuum and a line, and outputting it into various units.

We will now see in the next section the different SNR coming from the different ways of looking at the voxel by looking at the description of the output windows.

OUTPUT TABLES

The calculated dimensionless SNR values are displayed into tables, with the following columns: (1) icon, (2) per single frame exposure, (3) the total exposure time, and (4) the unit. Each outputs are explained below.

Output Continuum SNR

The SNRs of the continuum input flux distribution expected for the input observational and instrumental setup, and for the input atmospheric conditions are provided.

For point source

In case the input source is punctual ('Source Type' = 'Point'), the provided SNRs are for:

- **in one fibre**, per detector pixel, in 4 spectral pixels(*2), in the total collapsed spectrum (spaxel), in 1 Angstrom;
- **the total source area**(*1), in 4 spectral pixels(*2), in the total collapsed spectrum (spaxel), in 1 Angstrom;

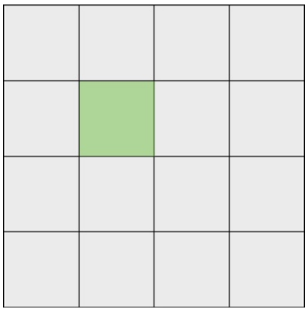

Figure 7: icon representing one detector pixel.

Notice that the SNR in one fibre, considering 4 spectral pixels is, by definition, a SPAXEL(*2), i.e., the minimum spatial and spectral resolution element of the observation.

For extended source

In case of extended sources ('Source Type' = 'Extended'), the following outputs are additionally provided:

- **in 1 seeing disk**, in 4 spectral pixels(*2), in 1 Angstrom, in the total collapsed spectrum (spaxel);
- **in 1 arcsec**2**, in 4 spectral pixels(*2), in 1 Angstrom, in the total collapsed spectrum (spaxel).

Note: (*1) The number of fibres required to sample the whole source is also provided.

(*2) At least, 4 spectral pixels are required to fulfill the Nyquist-Shanon sampling theorem in spectral direction. By construction, MEGARA always projects the VPH FWHM of any selected VPH onto 4 pixels in the spectral direction of the detector.

Other icons:

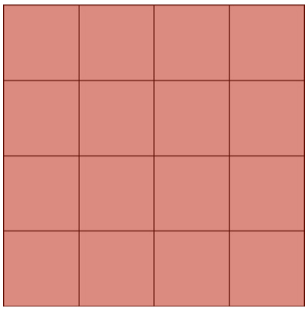

Figure 8: icon representing a voxel (or a spectral FWHM 16 pixels)

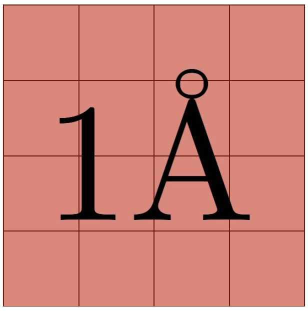

Figure 9: icon representing all the voxels over 1 Angstrom.

Per frame and All frames SNR

The SNR is given into two columns, per frame and all frames. The values in the 'all frames' column are simply the value in the 'per frame' column multiplied by the square-root of the number of frames in the input. E.g. for 100 frames, the 'all frame' value is ten time the 'per frame' value.

Output Line SNR

The SNRs of the line input flux distribution expected for the input observational and instrumental setup, and for the input atmospheric conditions are provided.

For point source

In case the input source is punctual, the provided SNRs are for(*3):

- the total source area, in the selected line spectral aperture(*4);
- per arcsec and per Angstrom in the detector(*5);
- in one fibre, in the selected line spectral aperture(*4);
- in one fibre, per Angstrom(*5);

- per voxel(*6,*7);
- per detector pixel(*8).

For extended source

In case of extended sources, the following outputs are additionally provided:

- for 1 seeing disk, in the selected line spectral aperture(*4);
- for 1 arcsec**2, in the selected line spectral aperture(*4).

Note: (*3) Considering that all the line flux is completely enclosed into the FWHM of the line.

(*4) Assuming the selected spectral apertures for line and continuum subtraction indicated as inputs. If you want to know exactly the SNR in 1 line FWHM, set the spectral apertures of line to 1 (i.e., to one line FWHM).

(*5) Assuming a spectral aperture of 1 Angstrom.

(*6) Assuming 4 spectral pixels as spectral aperture (i.e., the FWHM of the selected VPH).

(*7) A voxel is the minimum spatial and spectral resolution element sampled. In our case, a voxel is the projection of the whole fibre (minimum spatial resolution element) into the FWHM of the VPH in the spectral direction (minimum spectral resolution element according to the Nyquist-Shanon sampling theorem). The FWHM of all VPHs in MEGARA is projected onto 4 spectral pixels by design.

(*8) Assuming 1 spectral pixel as spectral aperture.

Input Parameters

A summary of the selected input parameters is provided here, with some warnings and extra information about the input source flux distribution.

Version

The Preliminary tool, version 0.3.0 was created and designed by M. Carmen Eliche-Moral, Sergio Pascual, Nicolás Cardiel) and subsequently expanded to the current online version as of version 0.4.1 and developed solely on this platform since then. Please, report any comment, complaint, error or bug you find of the tool to the authors (cardiel<at>ucm.es) and/or (abouquin@ucm.es). They all are welcome.