



# PACS Unchopped Spectroscopy

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## Why not chopping ?

### **It is impossible to chop beyond 6 arcmin.**

So, in case of extended sources or crowded fields, the only alternative is using the unchopped mode. Remember also that with a large chopper-throw only the central pixel is usable in pointed observations because of distortions.

### **Unchopping is more time efficient than chop-nodding.**

However, it is very difficult to correct the signal for the varying response of the detector. So, only the strength of the line and not the underlying continuum can be precisely estimated. Also, the imperfect knowledge of the RSRF affects the reduction of unchopped data.

*Users are discouraged to use unchopped modes whenever it is possible to use chop-nod modes.*

## NEW MODE !!!

With this call (AO2), a new unchopped mode is available. This new mode, called **"bright line mode"**, allows one to save up to 30% of the time by cutting the wavelength range by 30%.

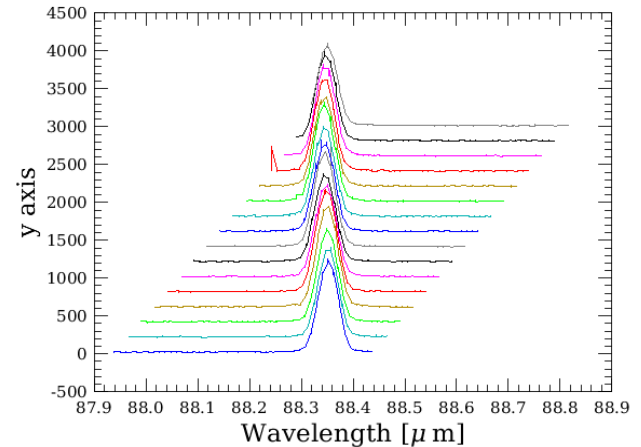
This makes sense only with bright lines since in other cases it is difficult to estimate the underlying continuum to evaluate the strength of the line.

The user is discouraged to adopt this mode when the line is not detected at least at a 10-sigma level.

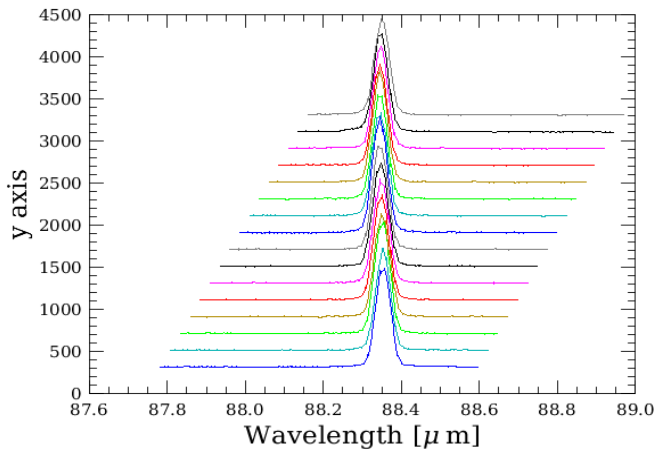
## Wavelength coverage

Standard unchopped has the largest coverage. The bright mode is similar to chop-nod.

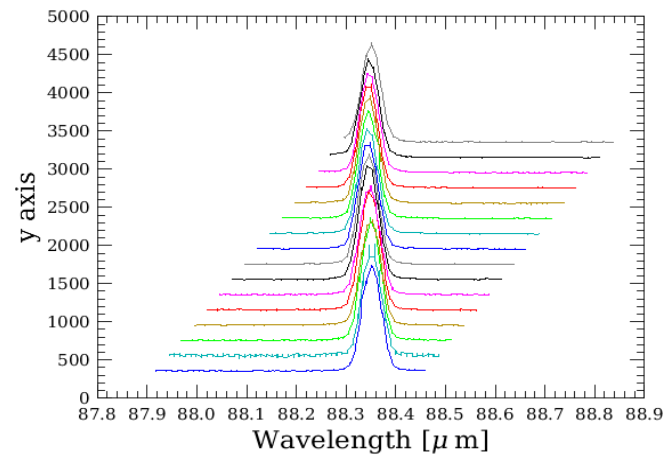
Chop Nod



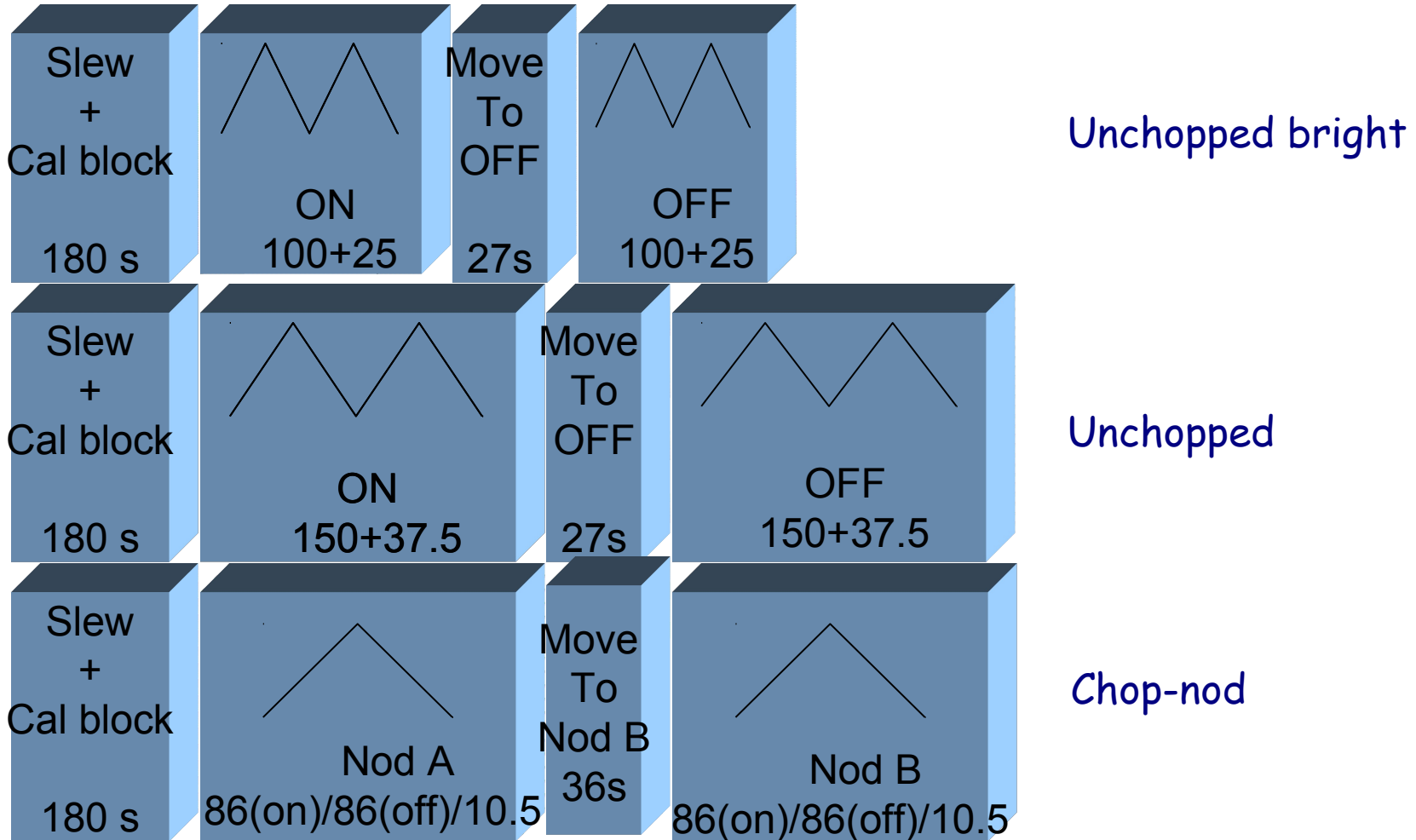
Faint Unchopped



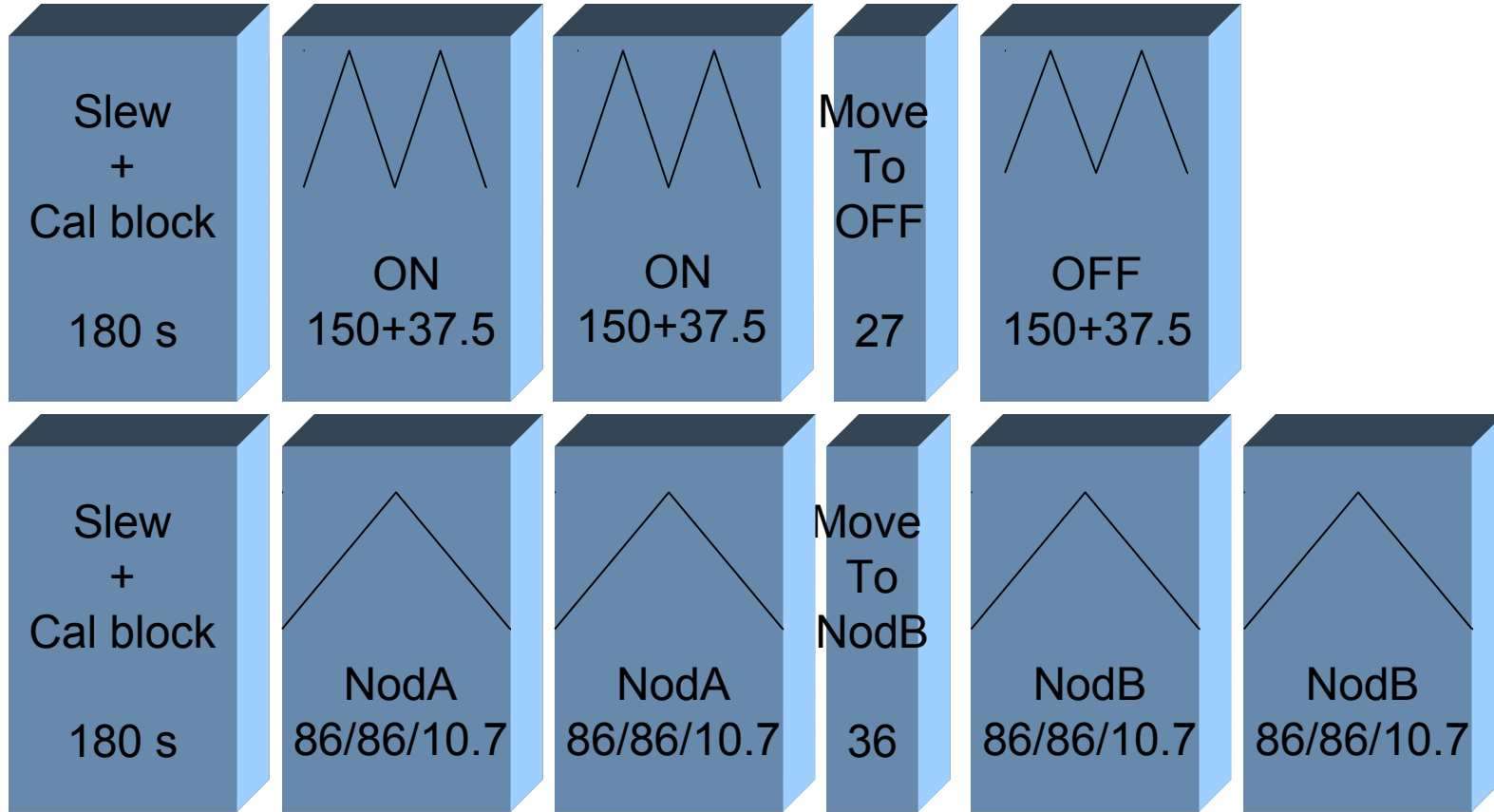
Bright Unchopped



## Time efficiency comparison



## When repeating a scan, the off can be executed only once.



## Pointing and raster modes

Two different strategies are possible:

- a) **pointed observation**: on-source is followed by an off-source observation. The user can repeat the on more times than the off.
  
- b) **mapping observation**: the user can choose the frequency of the off-source observation. It is recommended to have an OFF at least every 30 minutes.

## OFF position

In principle, if interested only in the strength of the line, the OFF position is superfluous. However, there are at least two reasons for which it is recommended to have OFF positions:

### a) **correction of RSRF inaccuracies**

Scaling the off to the on signal and subtracting it corrects for the RSRF imperfections.

### b) **spatial flat field**

In case of a mapping observation, a good flat-field can be obtained using the OFF observation.



## Typical errors

Default values are dangerous !

### a) **forget to define the OFF offset**

The default is OFF by offset and it is set to 0, which means at the center of the observation

### b) **forget to define the frequency of OFF in mapping**

The default is an OFF every 2 raster position, which is usually too much and inflates unnecessarily the length of an observation. In case of small maps (e.g. 3x3) one OFF at the end is enough. Otherwise, for large maps, a solution can be one OFF at the end of each row.

## The challenge

Find the most efficient way to observe a C+ line ( $157.7\mu\text{m}$ ) in the nucleus of an extended object at 10:10:45 + 11:10:20, redshift = 0.01, peakFlux = 3 Jy, width = 250 km/s, continuum = 1 Jy.

Check if the line is unresolved ...

Remember that:  $R = \lambda / \text{FWHM}$ ,  $v[\text{km/s}] = c * \text{FWHM} / \lambda$

For flux:  $\Delta v = c * \text{FWHM} / \lambda^2$

$$F[\text{W/m}^2] \sim \text{fluxPeak}[\text{Jy}] \Delta v[\text{Hz}] 10^{-26}$$

In the following, you can see how to prepare an observation and to check execution time and SNR.

## Where to find more

Hspot manual

<http://herschel.esac.esa.int/Docs/HSPOT/html/hspot-help.html>

PACS observer's manual

[http://herschel.esac.esa.int/Docs/PACS/html/pacs\\_om.html](http://herschel.esac.esa.int/Docs/PACS/html/pacs_om.html)

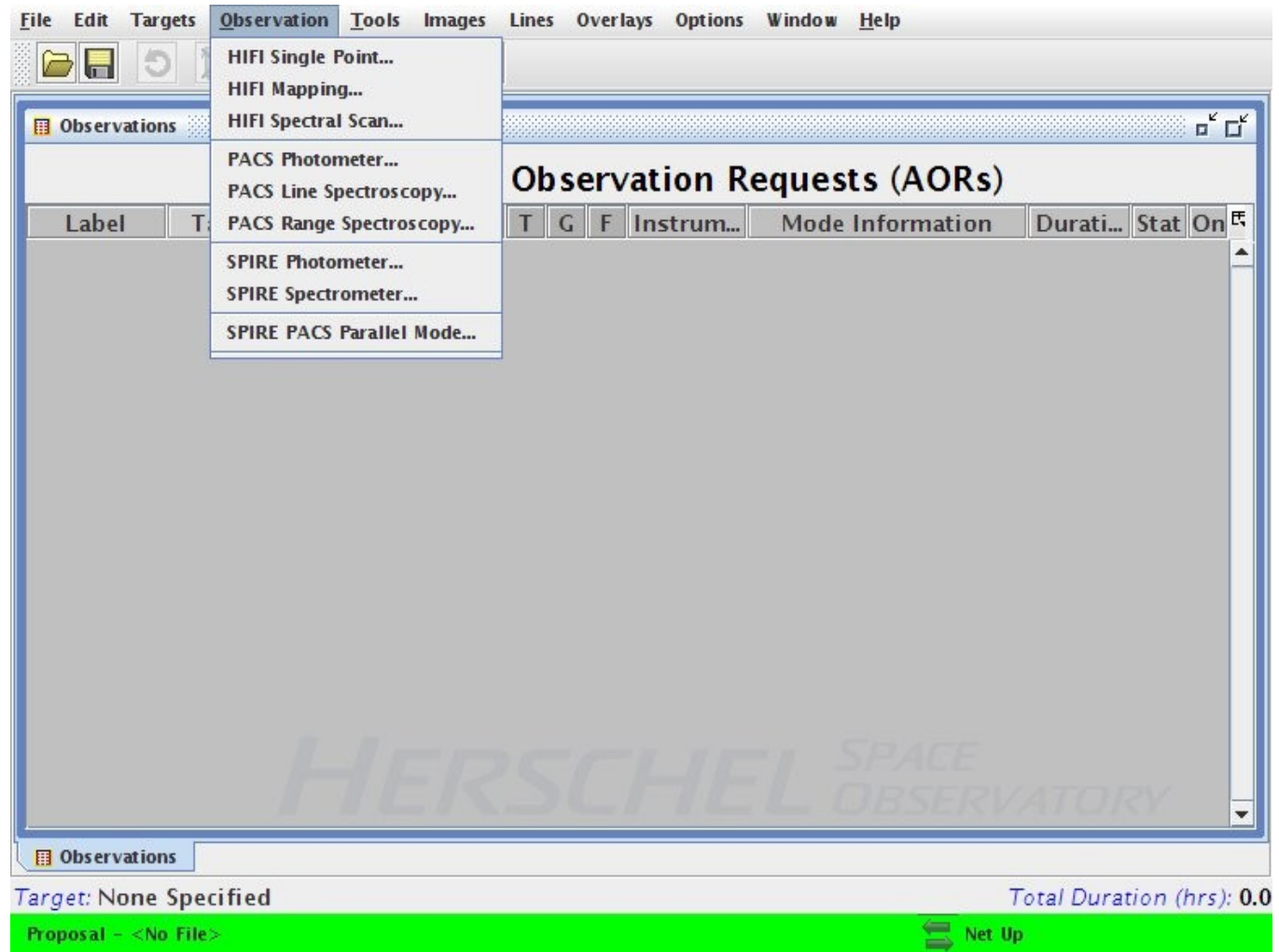
Release notes

<http://herschel.esac.esa.int/AOTsReleaseStatus.shtml#ReleaseNotes>

<http://herschel.esac.esa.int/twiki/bin/view/Public/PacsAotReleaseNotes>

## How to do it

Choose the observation mode.



## How to do it

Set the AOR label and click on "new target" to select your target.

Unique AOR Label:

Target: None Specified

Number of visible stars for the target: None Specified

Wavelength Settings

Selection of wavelength ranges

Wavelength ranges:

PACS Line Editor

Line Id	Wavelength...	Redshifted ...	Line Flux	Line Flux ...	Continuum...	Line Width	Line Wid...	Line Repe...
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Redshift selection

Unit:  Value:

Observing Mode Settings

Source type, chopping and unchopped scan

Nodding, grating scan or mapping cycles

Number of cycles:

To control the absolute sensitivity consider adjusting the number of integration cycles.

## How to do it

Choose the target name. If it is a known object (by NED or Simbad) can be resolved. Otherwise, insert the coordinates.

Target

Target Name (required): NED

Resolve the Name

Target Visibility

Background

Fixed Moving

Coord Sys: Equatorial J2000

RA:

Dec:

Epoch: 2000.00

Proper Motion

Use Proper Motion

PM RA (arcsec/year): 0.000

PM Dec (arcsec/year): 0.000

OK Cancel Help

## How to do it

Now, name the AOR and select the line(s) to observe. Lines can be defined manually or selected from a list.

Unique AOR Label: M82-pointed

Target: M82 Type: Fixed Single  
Position: 9h55m52.73s,+69d40m45.8s

New Target Modify Target Target List...

Number of visible stars for the target: 10  
Star tracker target: Ra: 328.97 degrees Dec:-69.679 degrees

Wavelength Settings

Selection of wavelength ranges

Wavelength ranges [70-220] microns (2nd + 1st orders)

PACS Line Editor

Line Id	Wavelength...	Redshifted ...	Line Flux	Line Flux ...	Continuum...	Line Width	Line Widt...	Line Repeti...
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Add Line Manually Add Line From Database Modify Line Delete Line

Redshift selection

Unit Redshift (z) Value 0.000000

Observing Mode Settings

Source type, chopping and unchopped scan  
Set the Observing Modes

Nodding, grating scan or mapping cycles  
Number of cycles 1

To control the absolute sensitivity consider adjusting the number of integration cycles.

Observation Est... Add Comments... AOR Visibility

OK Cancel Help

## How to do it

When using the line database, select a line by checking the box.

Origin	Name	Transition	Wavelength ...	Line Width	Selected
DEFAULT	OH	2Π1/2J=3/...	163.122	1	<input type="checkbox"/>
DEFAULT	SH	2Π3/2J=5/...	216.784	1	<input type="checkbox"/>
DEFAULT	H $\alpha$	H15 $\alpha$	169.412	1	<input type="checkbox"/>
DEFAULT	H $\alpha$	H16 $\alpha$	204.412	1	<input type="checkbox"/>
DEFAULT	CII	C+	157.741	1	<input checked="" type="checkbox"/>
DEFAULT	HD	1-0	112.07	1	<input type="checkbox"/>

You can add transitions and modify spectral line attributes via the HSpot Line Manager facility: HSpot Menu -> Lines -> Manage Lines

OK Cancel



## How to do it

The selected line appears on the list. It is now time to assign the redshift. To change the number of repetitions, double click on the line.

**PACS Line Spectroscopy**

Unique AOR Label: M82-pointed

Target: M82 Type: Fixed Single  
Position: 9h55m52.73s, +69d40m45.8s

New Target Modify Target Target List...

Number of visible stars for the target: 10  
Star tracker target: Ra: 328.97 degrees Dec: -69.679 degrees

**Wavelength Settings**

Selection of wavelength ranges

Wavelength ranges [70-220] microns (2nd + 1st orders)

**PACS Line Editor**

Line Id	Wavelength...	Redshifted ...	Line Flux	Line Flux ...	Continuum...	Line Width	Line Widt...	Line Repeti...
CII C+	157.741	157.85	0.00	10^-18 ...	0.00	1.00	km/s	1

Add Line Manually Add Line From Database Modify Line Delete Line

Redshift selection

Unit Redshift (z) Value 0.000677

**Observing Mode Settings**

Source type, chopping and unchopped scan

Set the Observing Modes

Nodding, grating scan or mapping cycles

Number of cycles 1

To control the absolute sensitivity consider adjusting the number of integration cycles.

Observation Est... Add Comments... AOR Visibility

OK Cancel Help

## How to do it

In this pop-up window it is possible to set the flux of the line and other features. It is also the place to define the number of line repetitions.

**Update a line**

Spectral line parameters

Line ID	CII C+
Wavelength (µm)	157.741
Line flux unit	10 <sup>-18</sup> W/m <sup>2</sup>
Line flux	0.00
Continuum flux density (mJy)	0.00
Line width unit	km/s
Line width (FWHM)	1.00

Line repetition factor

Line repetition

The relative line strength (fraction of on-source time per line) can be set by the line repetition factor for each line.  
Note: the sum of line repetition factors affects the on-source time per integration cycle.

OK Cancel

## How to do it

It's time to select the observing mode. Clicking on Pointed, you can select between the two unchopped modes. Then, select the off either by offset or by specifying the position.

Observing Modes

Observing Mode Settings  
Choose one of the modes below.

None selected **Pointed** Pointed with dither Mapping

Observing mode selection

- Chopping/nodding
- Chopping/nodding (bright lines)
- Unchopped grating scan
- Unchopped grating scan (bright lines)

Observing mode parameters

Chopper throw

- Small
- Medium
- Large

Chopper avoidance angle

Angle from (degrees) 0.00

Angle to (degrees) 0.00

Off position

Type  By offset  By position

RA offset (arcmins) 0.00

Dec offset (arcmins) 0.00

RA (degrees) 0.0000

Dec (degrees) 0.0000

Choose Position

OK Cancel

## How to do it

If the Mapping mode is selected, one has to choose also the steps and the frequency of the off position.

The default is on OFF after two raster positions, usually too much !

## How to do it

Once the planning is completed, it is possible to make some checks, like computing the total time of the observation.

Note that the on-time source in chop-nod includes the time spent in the off position. In unchopped mode, the off position time is included in the overhead.

The screenshot shows the 'PACS Time Estimation' window with the following data:

Time Estimation Breakdown	
On-source time (s)	300
Calibration time (s)	124
Instrument and observation overhead (s)	290
Observatory overhead (s)	180
<b>Total time (s)</b>	<b>770</b>

Buttons: PACS Time Estimator Messages, Done

Unchopped scan

The screenshot shows the 'PACS Time Estimation' window with the following data:

Time Estimation Breakdown	
On-source time (s)	688
Calibration time (s)	124
Instrument and observation overhead (s)	81
Observatory overhead (s)	180
<b>Total time (s)</b>	<b>949</b>

Buttons: PACS Time Estimator Messages, Done

Chop-nod

## How to do it

It is possible to repeat an observation without retaking the calibration block.  
 In the AOR window, just Change the number of cycles.

In this case, with two cycles and repeating the line twice, It allows to have two OFF positions observed in unchopped scan. Obviously the overhead will be bigger than repeating the line four times.

**PACS Time Estimation**

**Instrument performance summary**

Time Estimation Breakdown

On-source time (s)	600
Calibration time (s)	124
Instrument and observation overhead (s)	576
Observatory overhead (s)	180
<b>Total time (s)</b>	<b>1356</b>

PACS Time Estimator Messages

Done

Unchopped

**PACS Time Estimation**

**Instrument performance summary**

Time Estimation Breakdown

On-source time (s)	1376
Calibration time (s)	124
Instrument and observation overhead (s)	158
Observatory overhead (s)	180
<b>Total time (s)</b>	<b>1714</b>

PACS Time Estimator Messages

Done

Chop-nod

## How to do it

Additional information is available by pressing the "PACS Time Estimator Messages"

If the line flux entered is correct, the SNR of the line will be displayed.

This can help in comparing different techniques of observation.

**PACS Time Estimation**

**Instrument performance summary**

Time Estimation Breakdown

On-source time (s)	1376
Calibration time (s)	124
Instrument and observation overhead (s)	158
Observatory overhead (s)	180
Total time (s)	1714

PACS Time Estimator Messages

**Messages**

**Global AOT durations**

AOT total duration: 1658 [sec]

- CalSlew (with overheads) 124 [sec]
- SRC+REF (with overheads) 1534 [sec]
- AOT cost (includes time for slewing to source): 1534 + 180 [sec] = 1714 [sec]

**LINE setup and CAL summary**

- AOT prologue duration: 26 [sec]
- KeyWave: 150.0 [μm]; CAL duration: 95 [sec]

**SpecLine summary**

CII C+: 157.74 [μm]:

- FWHM at current wavelength: 239.3 [km/s] or 0.126 [μm]
- Continuum RMS: 93 [mJy]
- Continuum S/N: 0.00
- Line RMS: 1.30E-18 [w/m<sup>2</sup>]
- Line S/N: 0.00
- Total duration (SRC+REF+PACS overheads): 1488 [sec]
- SRC+REF (no overheads): 1376 [sec]

Save messages OK Cancel

# How to do it

Label	Target	Position	Type	T	G	F	Instrument	Mode Information	Duration	Stat	On
M82-pointed	M82	9h55m52.7...	Fixed Single	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	PACS Line Spec...	pointed with unchopped grating scan	1356	new	<input checked="" type="checkbox"/>

Once satisfied with the AOR, click OK in the AOR window and a line with the new AOR will appear in the main window. To save, go under "File" and "Save AOR(s) and Target(s)".