PACS Spectrometer AORs

CHOP/NOD Pointed or Mapping

LINE SCAN
and
RANGE SCAN AORS

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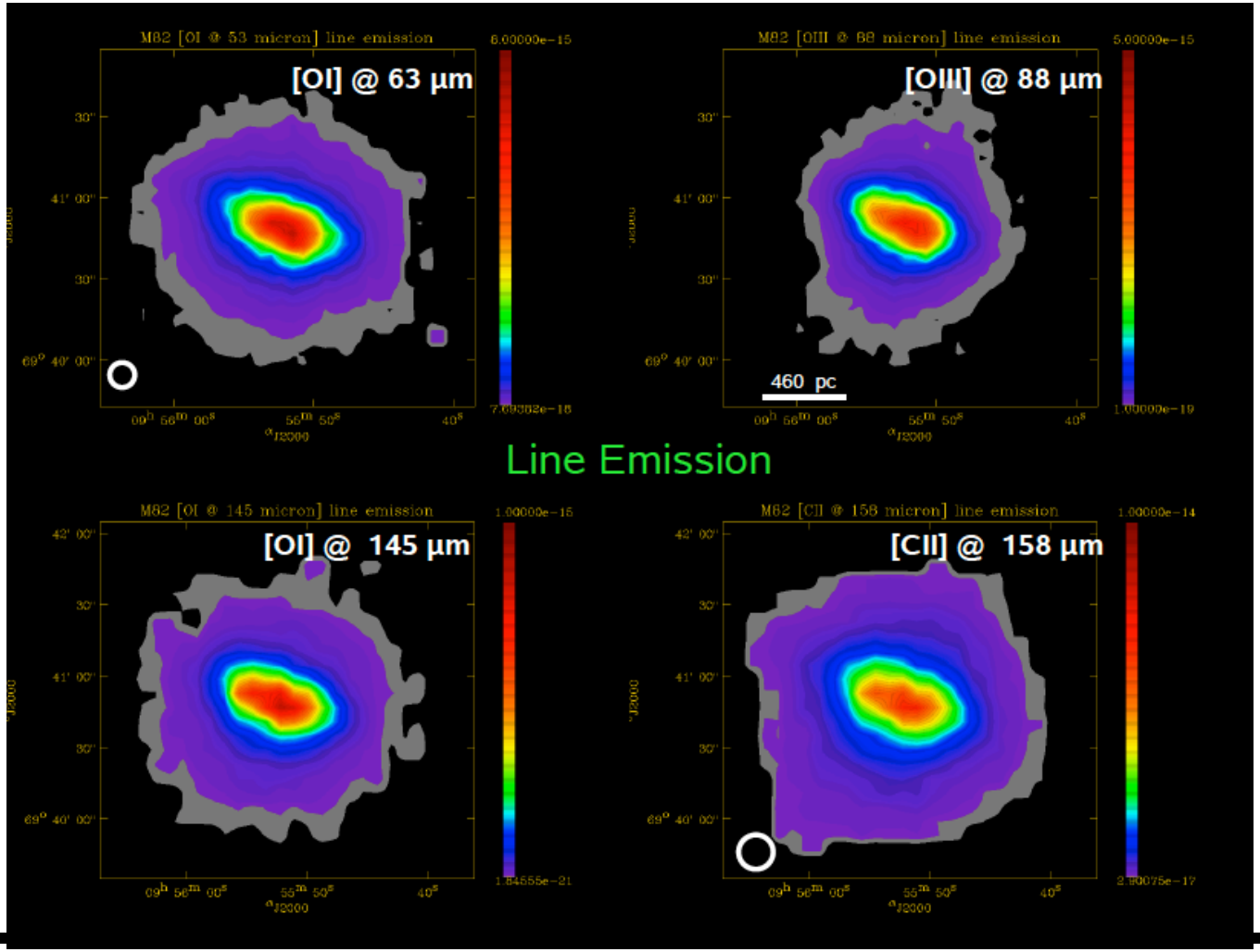
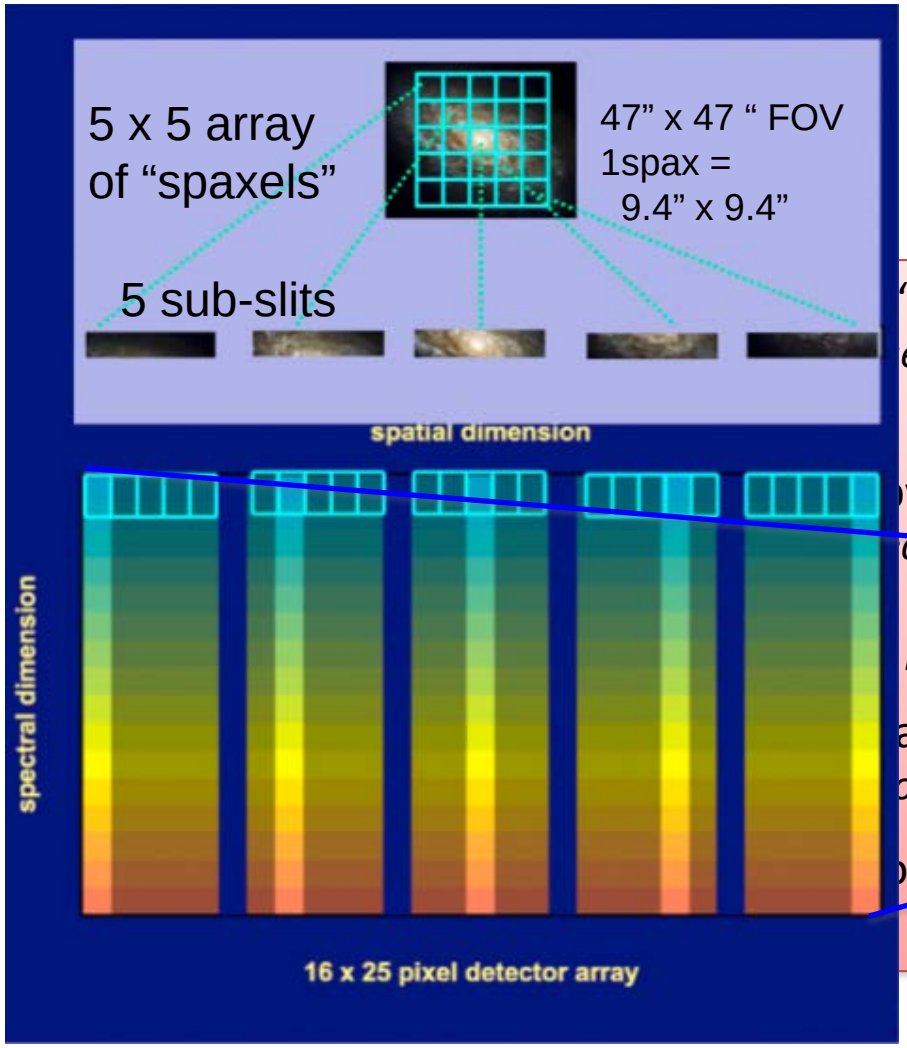
Dario Fadda will cover Unchopped Mode observations in Line and Range scan modes

Example of Spectroscopy with PACS



Spectral Mapping of M82 with PACS from the SHINING team (Contursi et al. 2010)

Prog Name..
KPGT_esturm_1



Spectrometer QUICK OVERVIEW

‘spaxels” cover 47 x 47 arcsec FOV)

ecs and provides a red and blue

y dichroic. *The arrays are Ge-Ga*

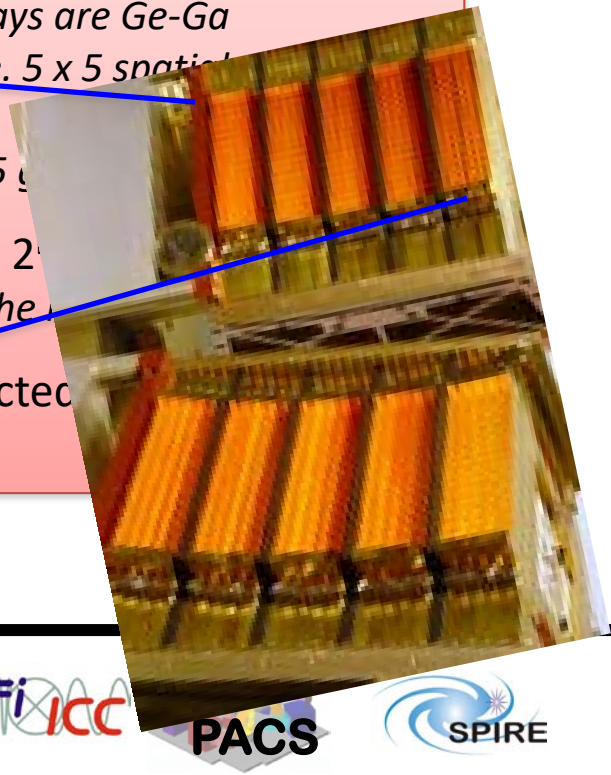
d) 25 x 16 arrays (i.e. 5 x 5 spati

possible (grating 8.5 ş

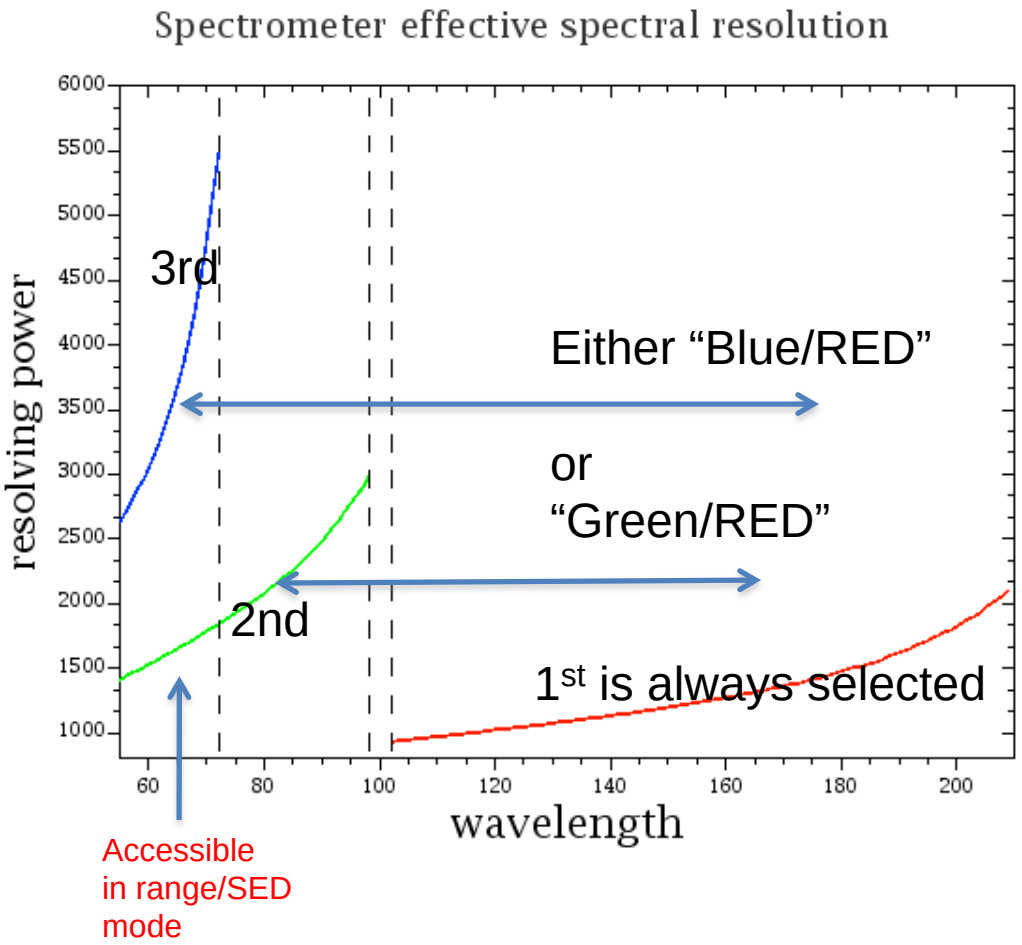
an be sampled 1st, 2

ou want to go with the

r both of the selected



HiFi ICC PACS SPIRE

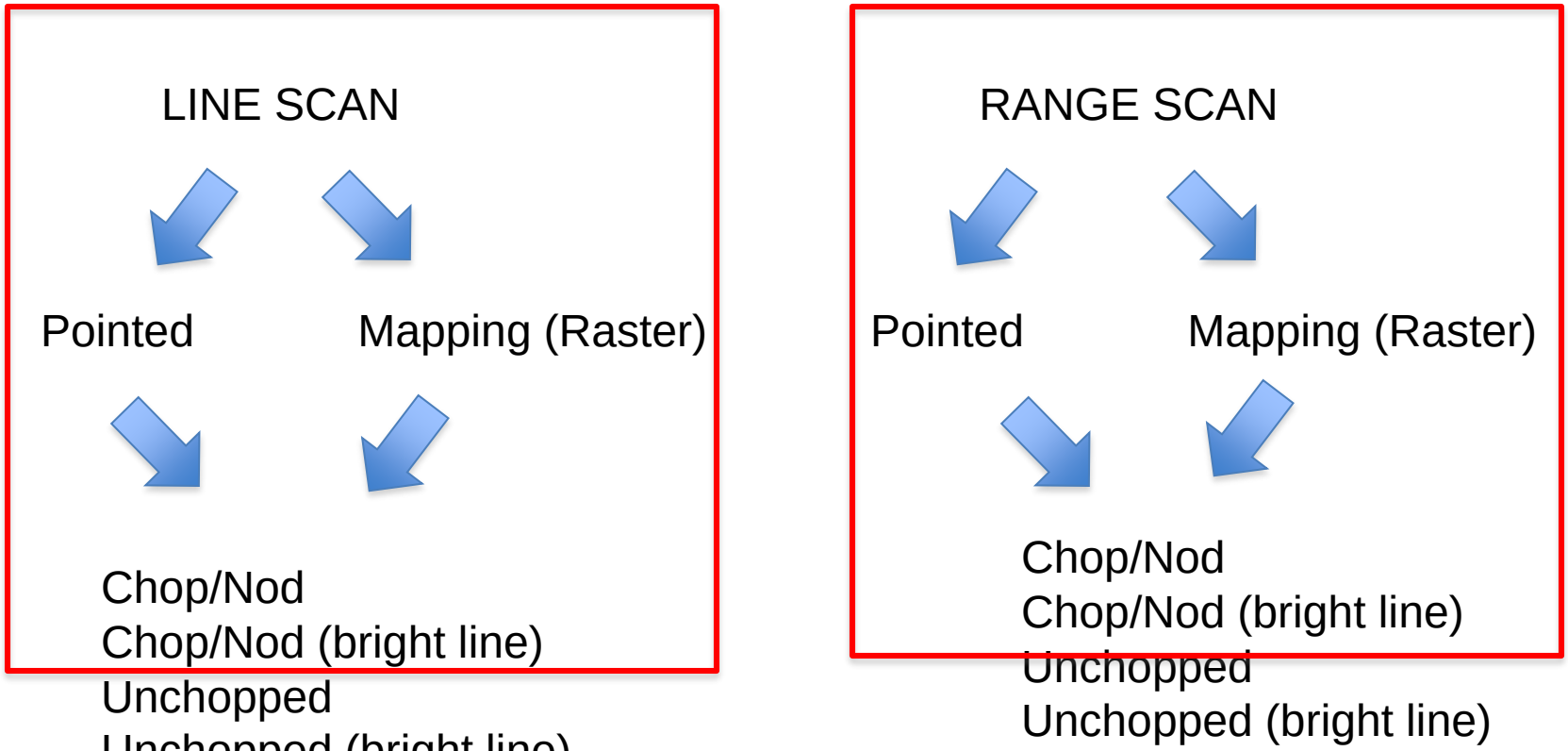


You can only select in any one AOR either the 2nd or 3rd order paired with 1st order

You can select multiple lines per AOR—for each line scanned you will get "for free" an observation in the blue or red band (e. g. If request 2nd/1st ordermodes and you observe [CII]158μm, you wlll "simultaneously" get "blue" observation at 158/2 = 79μm

You can observe the same line 10 times (10 repetitions) or 5 different lines x 2 repetitions, or as many repetition-lines not exceeding 10 total per AOR. To repeat the whole sequence you can add more cycles. Note that calibration block is run at beginning or AOR.

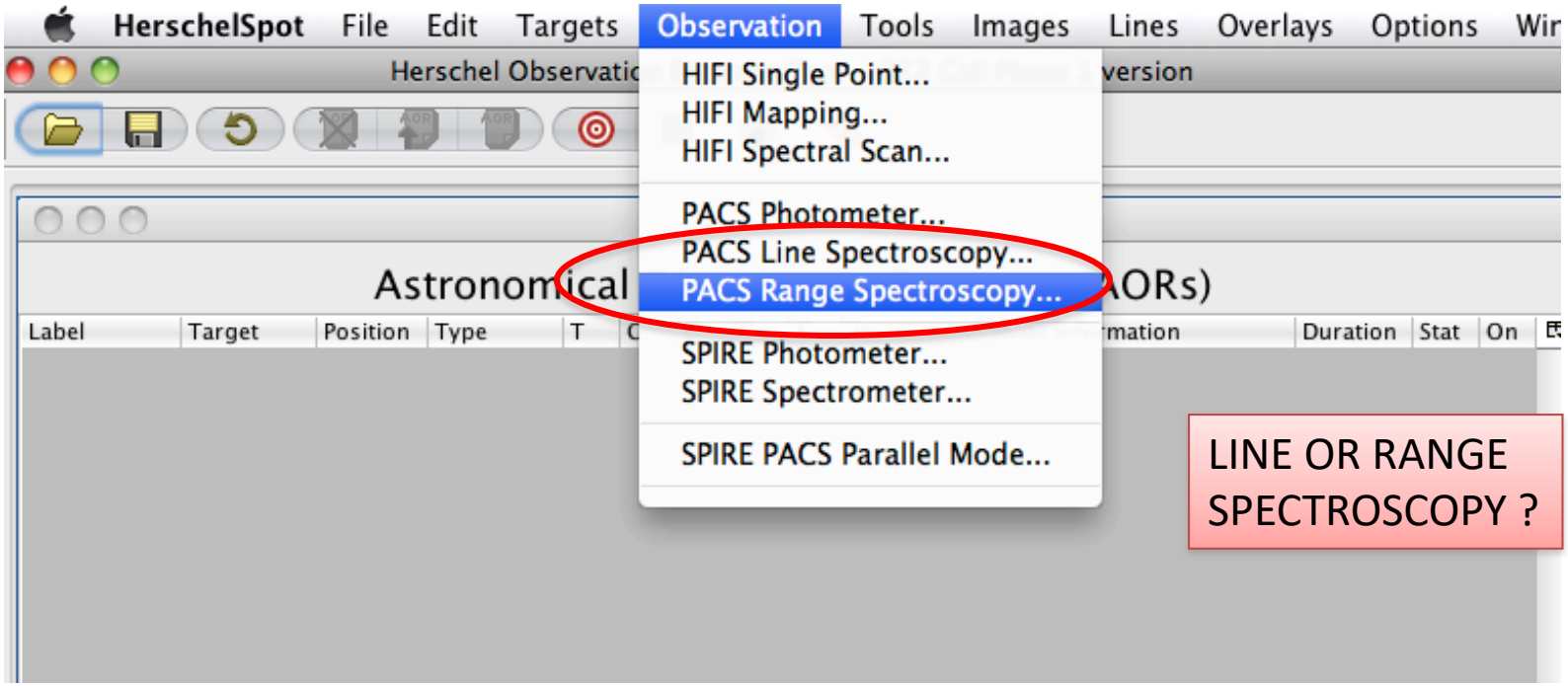
PACS SPECTROSCOPY OPTIONS



THIS TALK

Designing Spectroscopic AORs for PACS

THERE ARE TWO KINDS OF "OBSERVATION" type for PACS SPECTROMETER

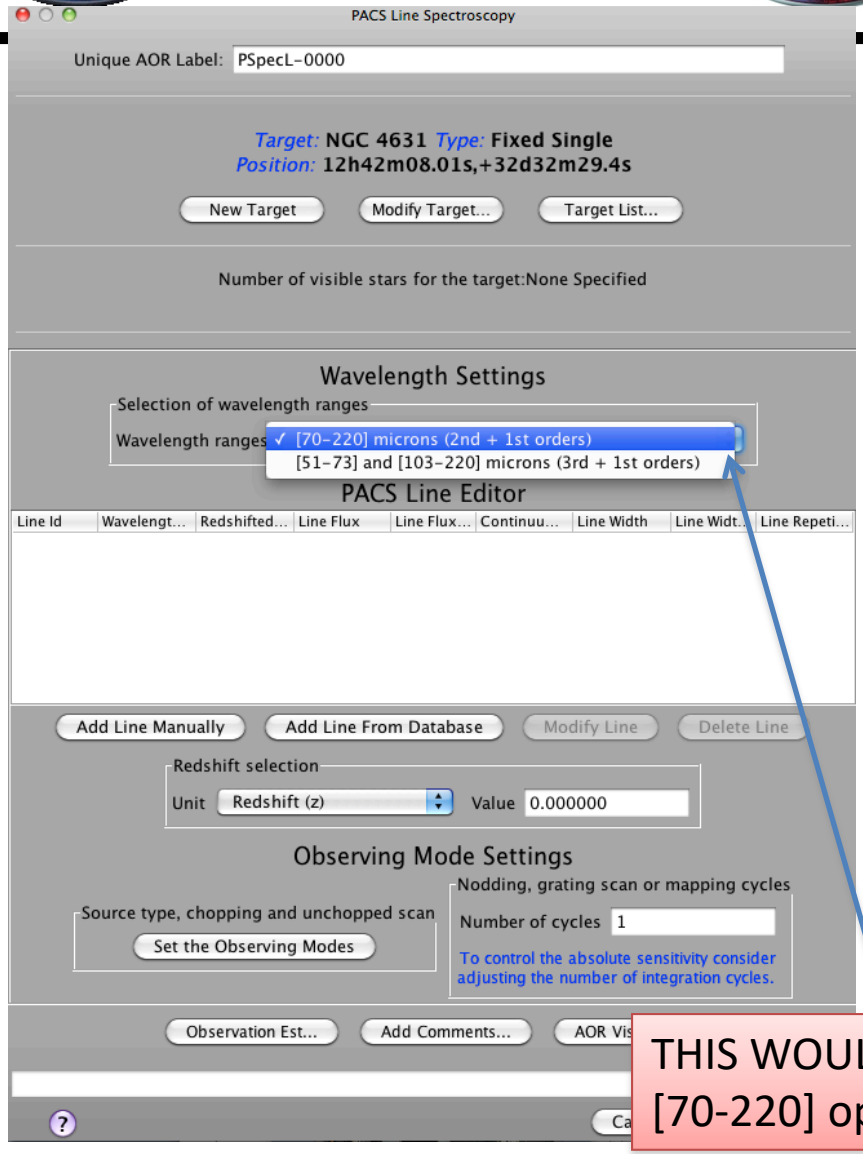


Line

- If your single line in unresolved (narrow)
- If you know the observed line center accurately within ~ 0.35-1.8 microns depending on the order observed

Range

- If your single line in resolved (broad) (SMALL RANGE SCAN)
- If you are unsure of the redshift by more than the width or a normal scan (see Table 6.3 of the PACS OM for details)
- If you have closely space multiple lines
- (SMALL RANGE SCAN)
- If you want to perform an SED-type scan
- (SED or LARGE RANGE SCAN=very expensive)



LINE SPECTROSCOPY EXAMPLE

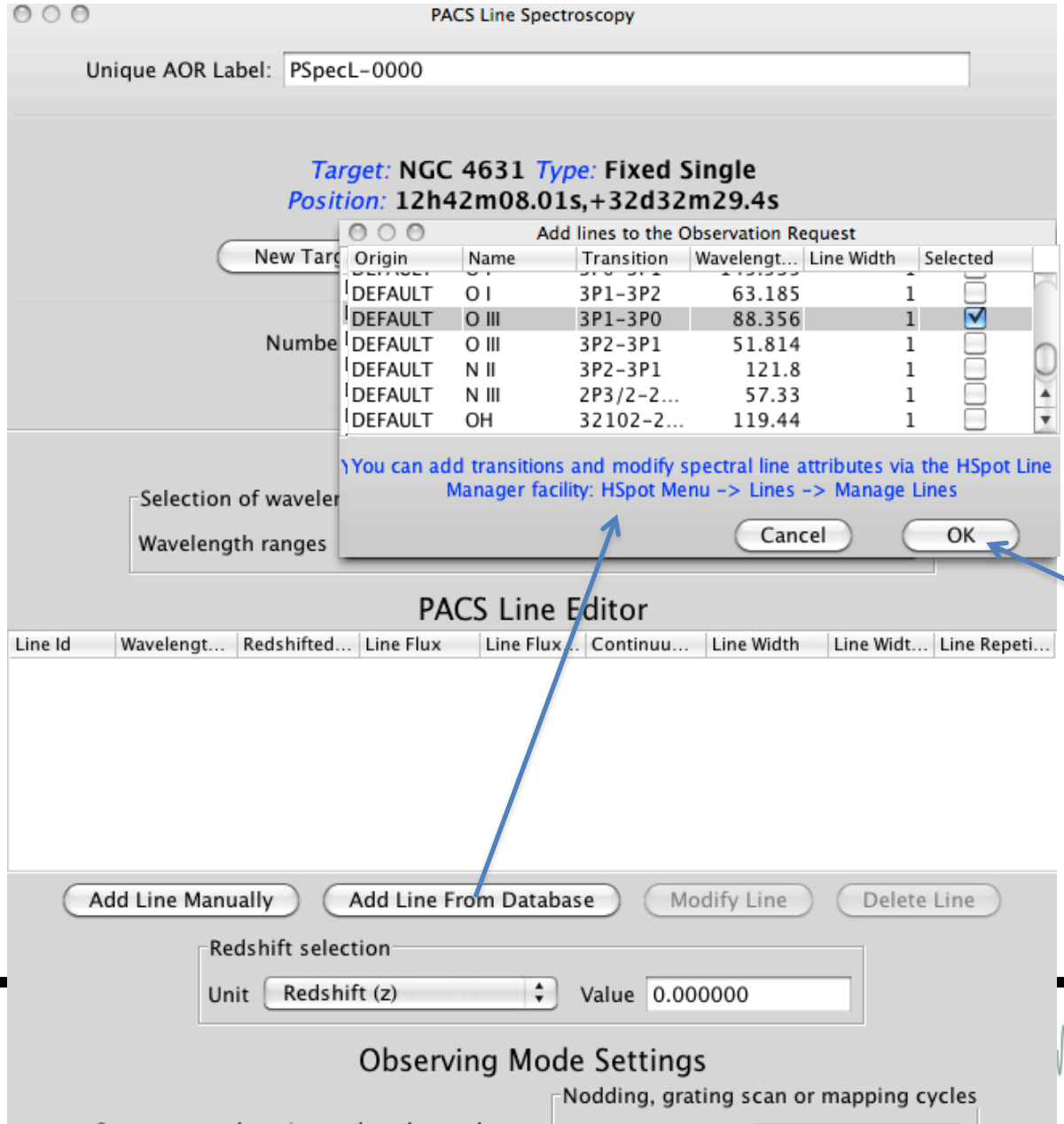
1. Select which order combo you want

TIP: If you want to make a ratio map between two lines in different orders its best to have them in the same AOR because this will minimize pointing differences between the two line "maps"

Lets select [NII]205, and [OIII]88 and [NII]121

The ratio of [NII] provides a low-density ISM discriminator in Far-IR astronomy—but [NII]205 is weak in general—will require more integration

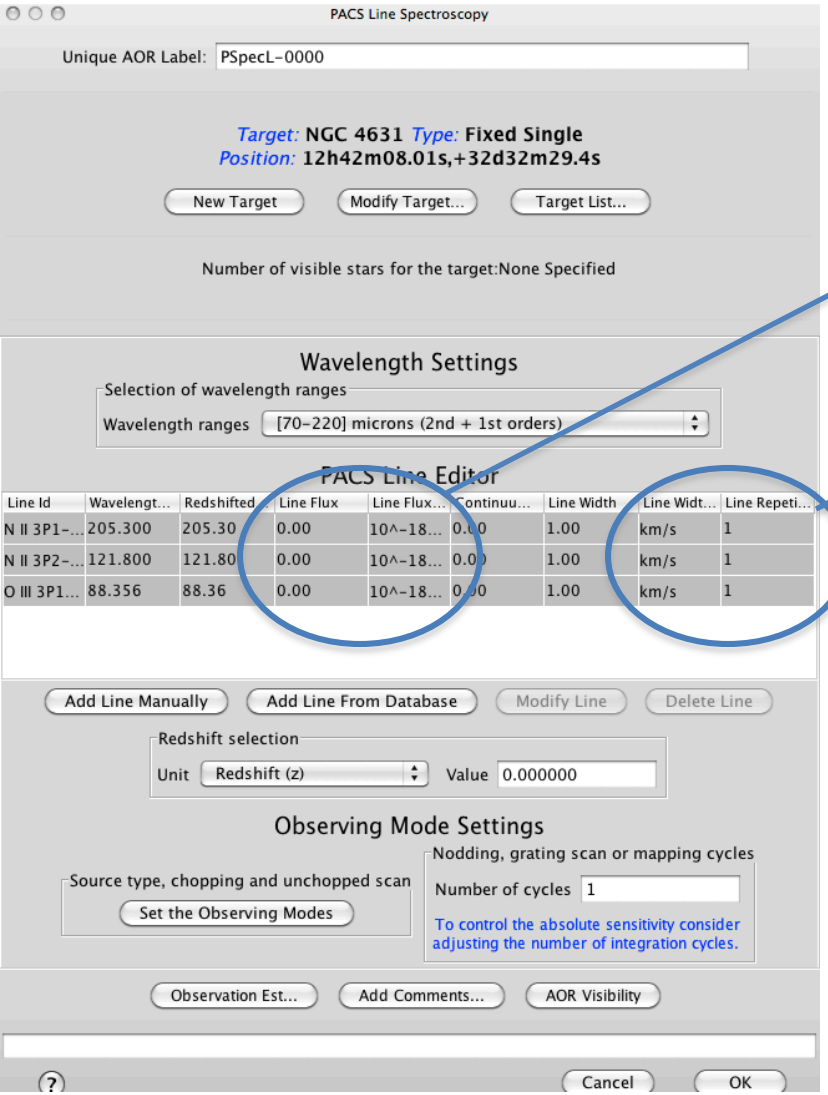
THIS WOULD MEAN 1st and 2nd order [70-220] option as in example



2. Now add the lines either manually or from database ...one at a time.

we will add three

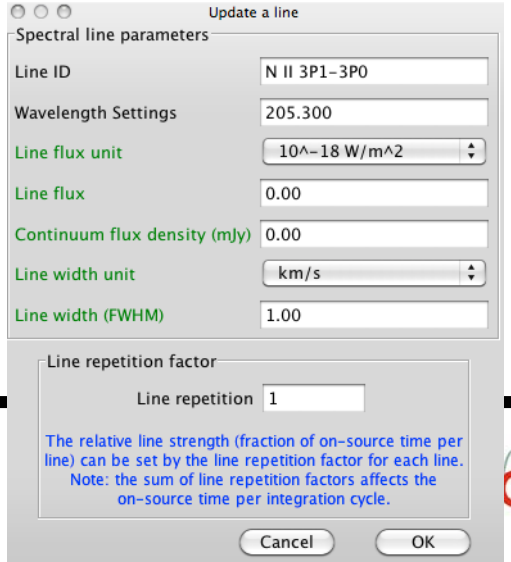
click to add line



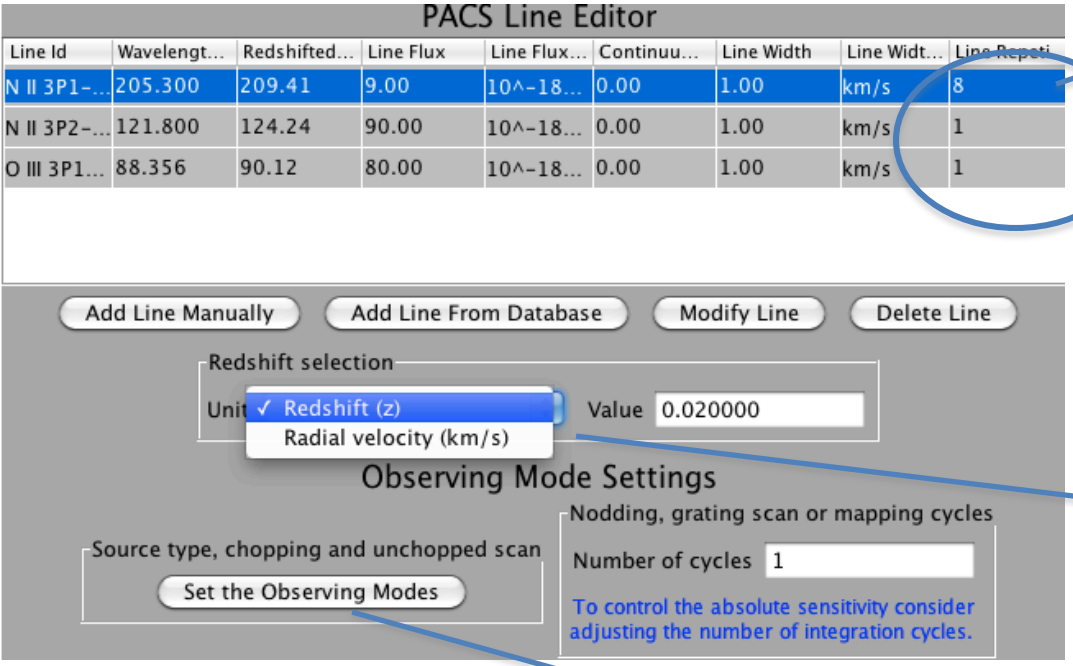
3. Now set the expected line flux in W/m^2 if known and initial guess as number of repetitions on each line

This is done by double-left-mouse clicking on line row

Line Id	Wavelengt...	Redshifted...	Line Flux	Line Flux...	Continuu...	Line Width	Line Widt...	Line Repeti...
N II 3P1-...	205.300	205.30	0.00	10^-18...	0.00	1.00	km/s	1
N II 3P2-...	121.800	121.80	0.00	10^-18...	0.00	1.00	km/s	1
O III 3P1...	88.356	88.36	0.00	10^-18...	0.00	1.00	km/s	1



Other inputs are possible but not essential

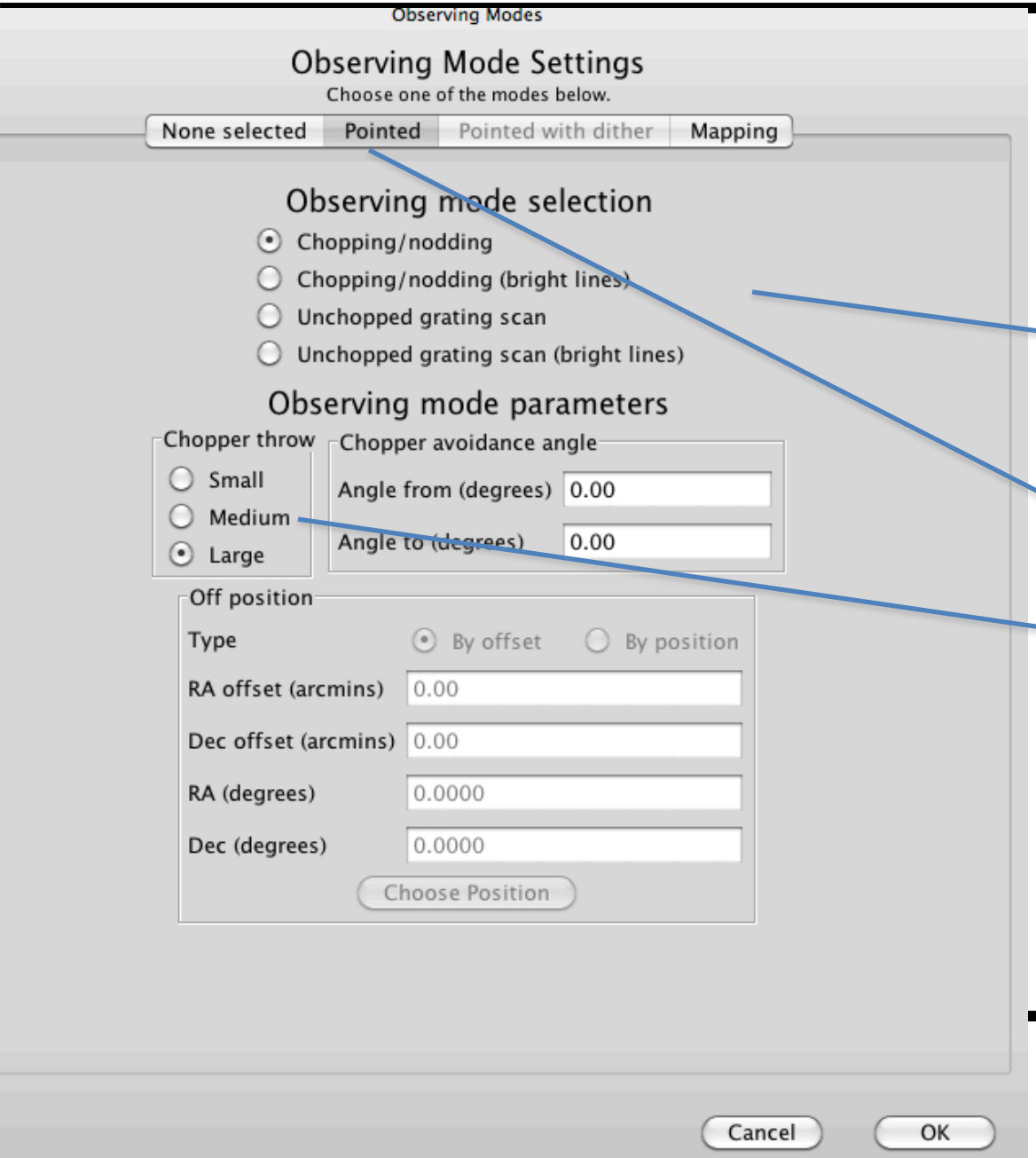


Because the [NII]205 is likely weak, we give it more repetitions—we will come back to this in a moment as this is a guess for now

sum of this column cannot > 10

4. Next add redshift (per line) or radial velocity

5. Now click to select observing mode



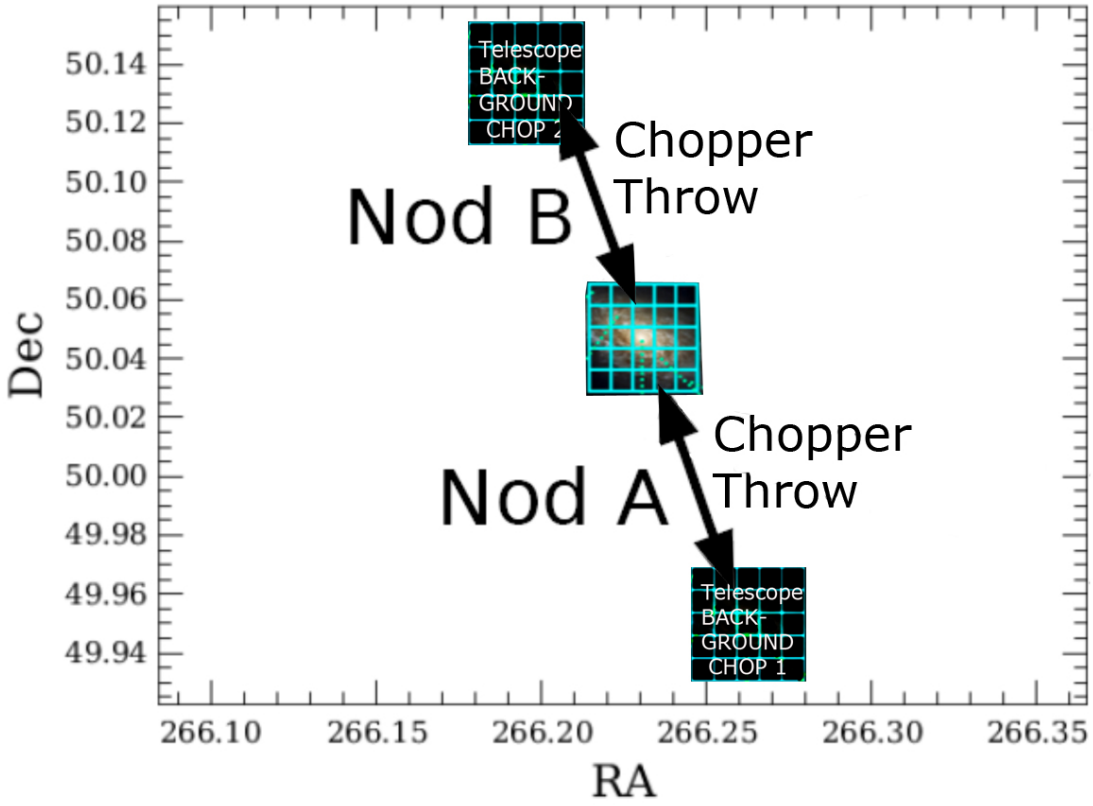
Obs Mode allows choices within chop/nod or unchopped context

pointed or raster map

Chopper throw is also selected (1.5 (S), 3 (M) and 6 (L) arcmin)

If you can't chop off source use Unchopped.

SINGLE POINTED CHOP/NOD



Chop/Nod involves a series of rapid chopping at Nod B, followed by a telescope move which places the target in the opposite chop position (Nod A) followed by a series of new chops

Averaging the result of the chop-differencing should remove temperature variations in the “off chop” positions

This does not work perfectly for PACS because of distortions in the chopper geometry

Chopped distortion on Large Throw

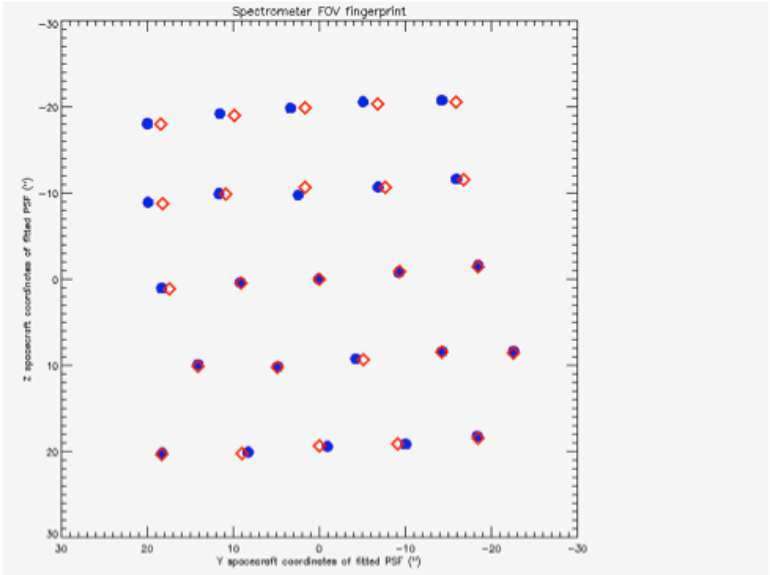
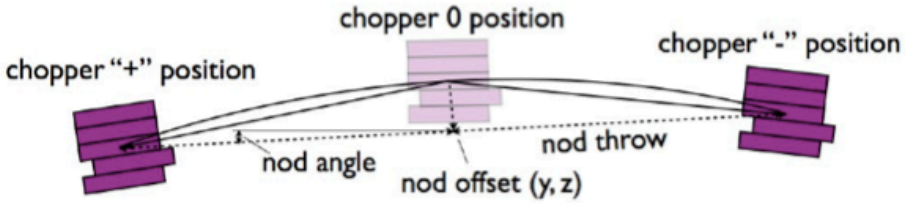


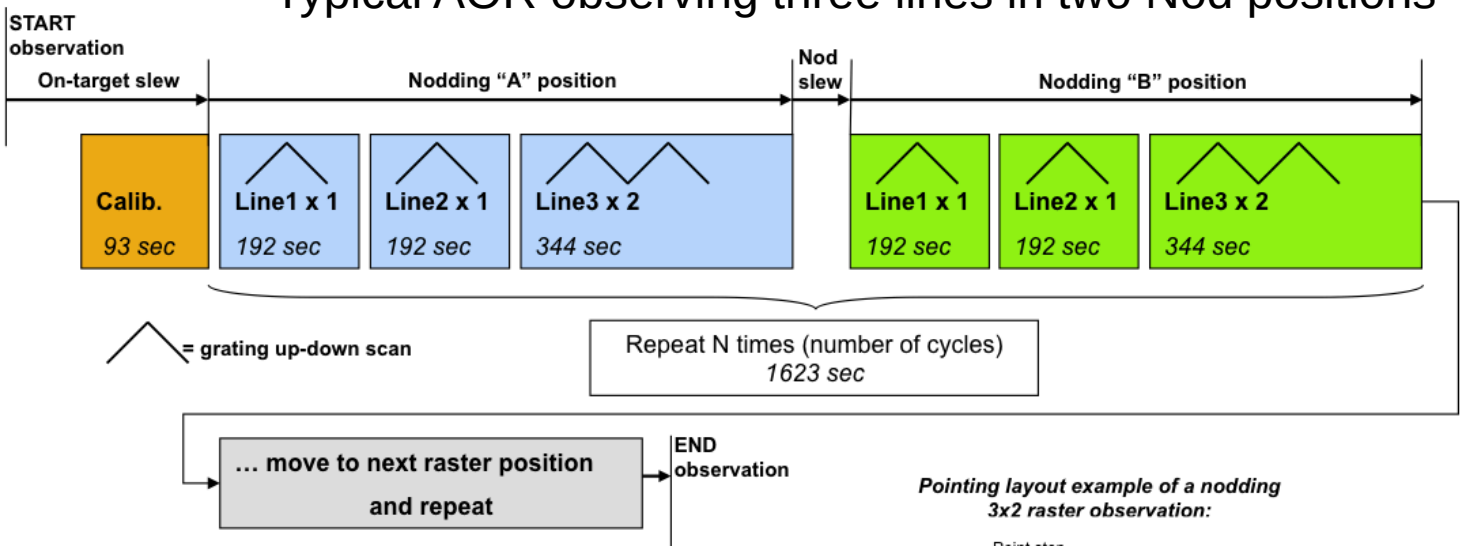
Figure 4.6. Spectrometer field of view for blue (circles) and red (squares) spa



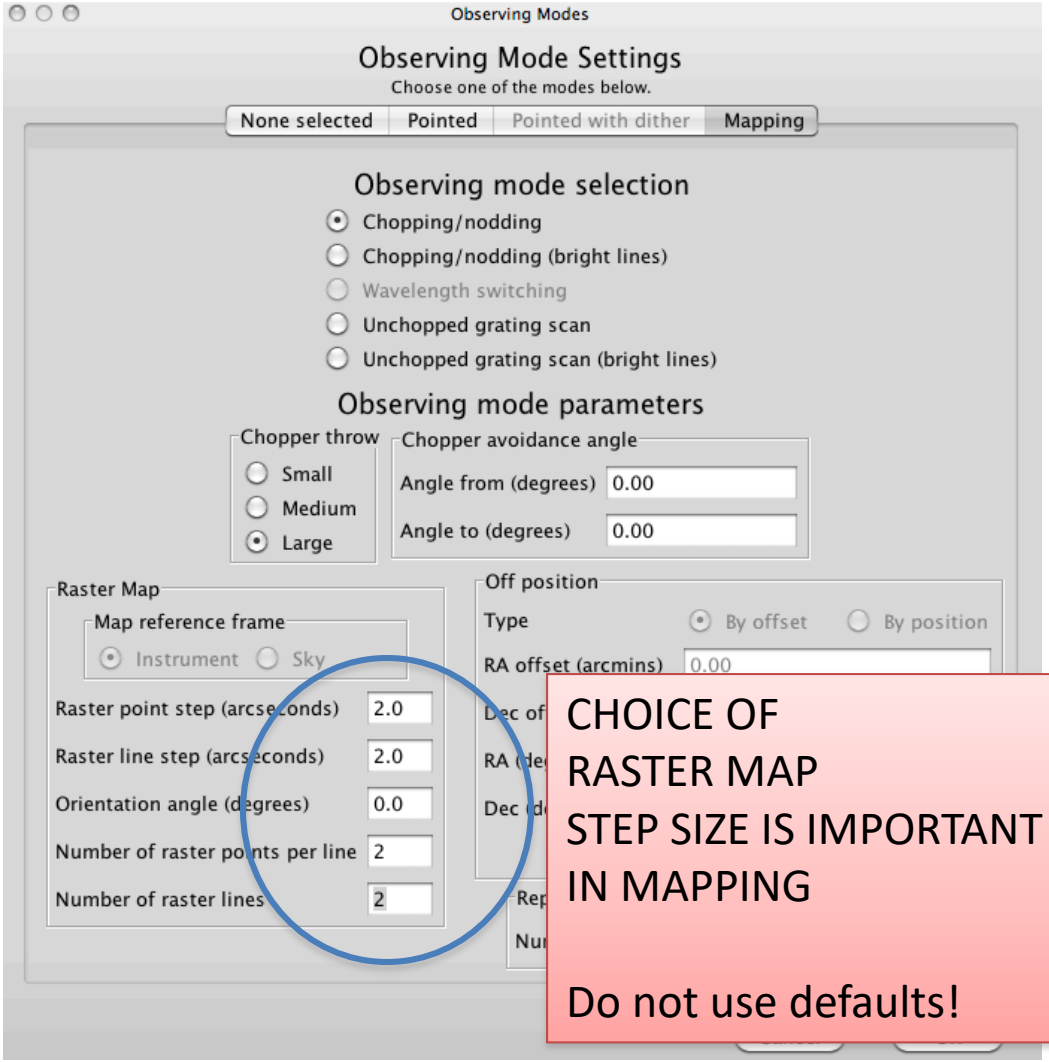
Only the central few pixels are properly aligned for largest (LARGE) chopped throw. Best to use small or medium throw if possible.

If you suspect your source is not a point-source or you are very unsure of its position to 1-2", probably best NOT to use POINTED mode, but a fully sample mapping mode.

Typical AOR observing three lines in two Nod positions



The Spectrometer "scans" by moving the grating up and down over pre-selected intervals. *At each point in the grating scan 16 spectral pixels sample the spectrum during a read-out, then the grating is moved a step and the whole-thing is repeated. A standard "Line scan" usually consists of between 43 and 48 grating steps and the grating scans UP and DOWN once per "scan repetition"*
For a range scan, many more than 43 steps are executed to scan over a much larger range. For SED mode the entire blue or red filter band is sampled



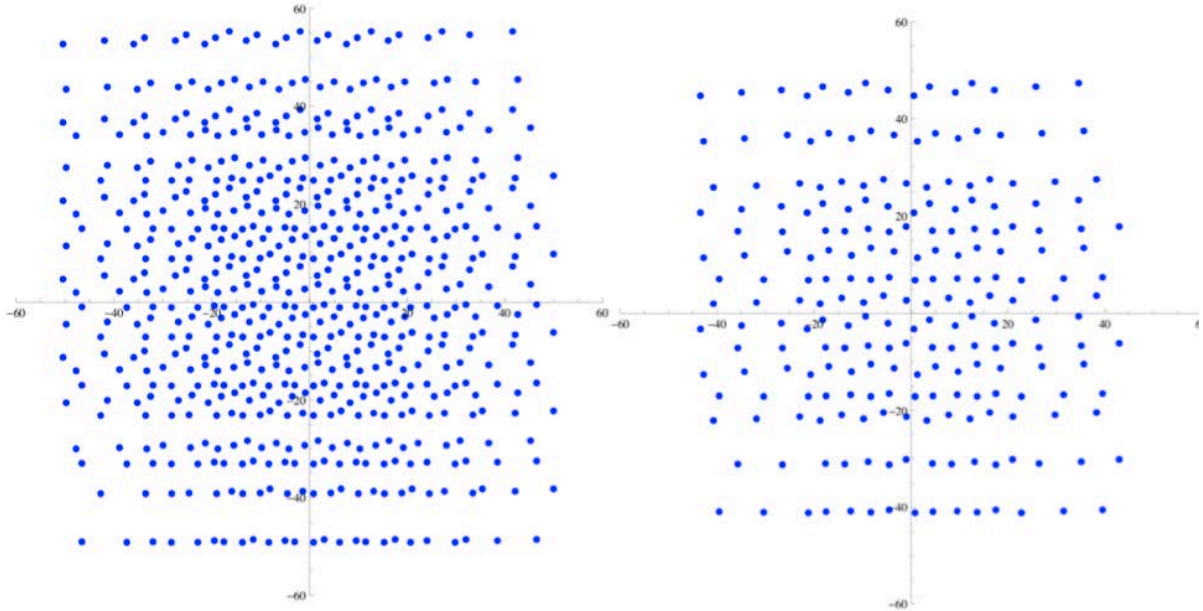
You can request a raster map of your source

Consult the Pacs Observer Manual for the best mapping strategy

Note the same mapping strategy is applied to all lines in same AOR --allows for ratio maps

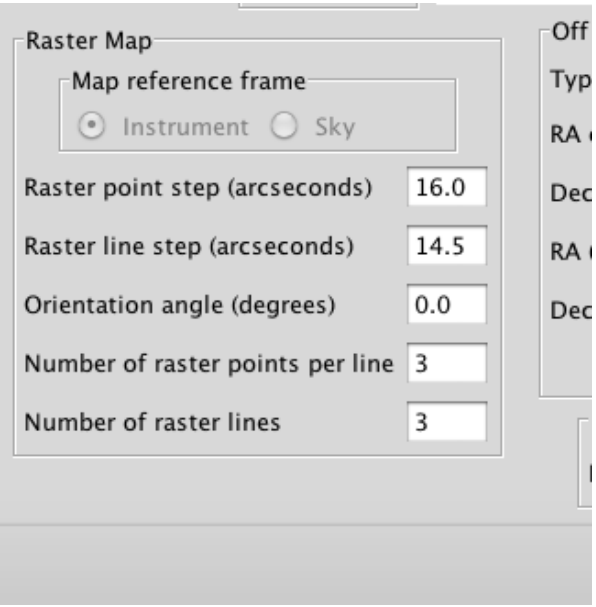
VISUALIZE your map IN HSpot

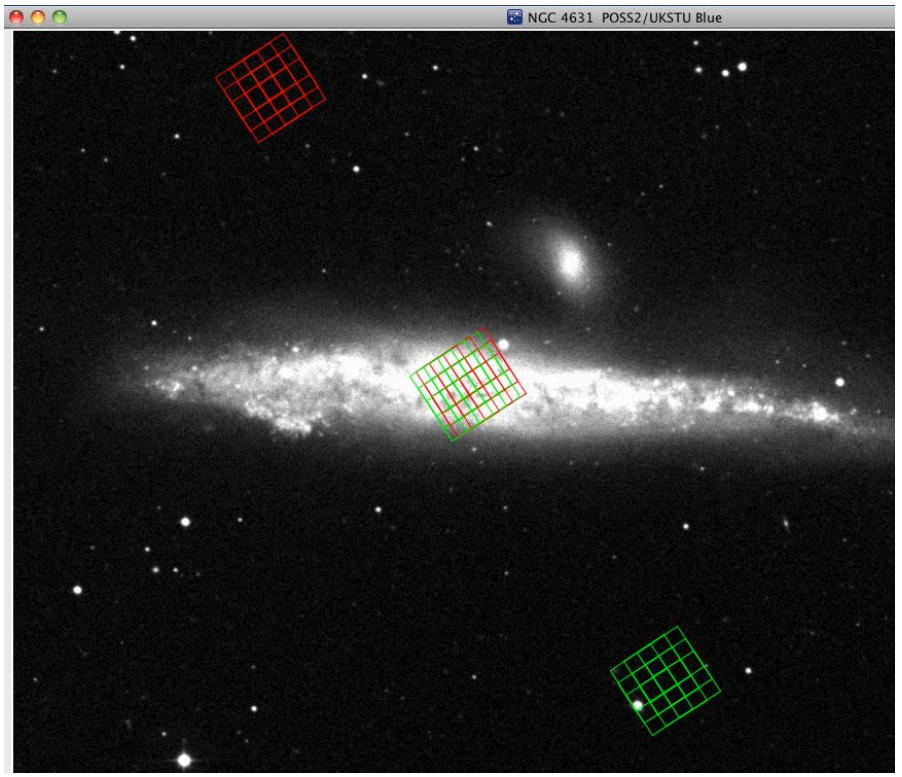
Optimizing Mapping Strategy



LARGE EXTENDED SOURCE USE: 16” point step/14.5” line step BLUE
24” point step/22” line step RED

FULLY SAMPLED MAP (expensive) 3” x 3” BLUE (3 x 3 raster)
But exploits full resolution on almost point sources 4.5” x 4.5” RED (2 x 2 raster)

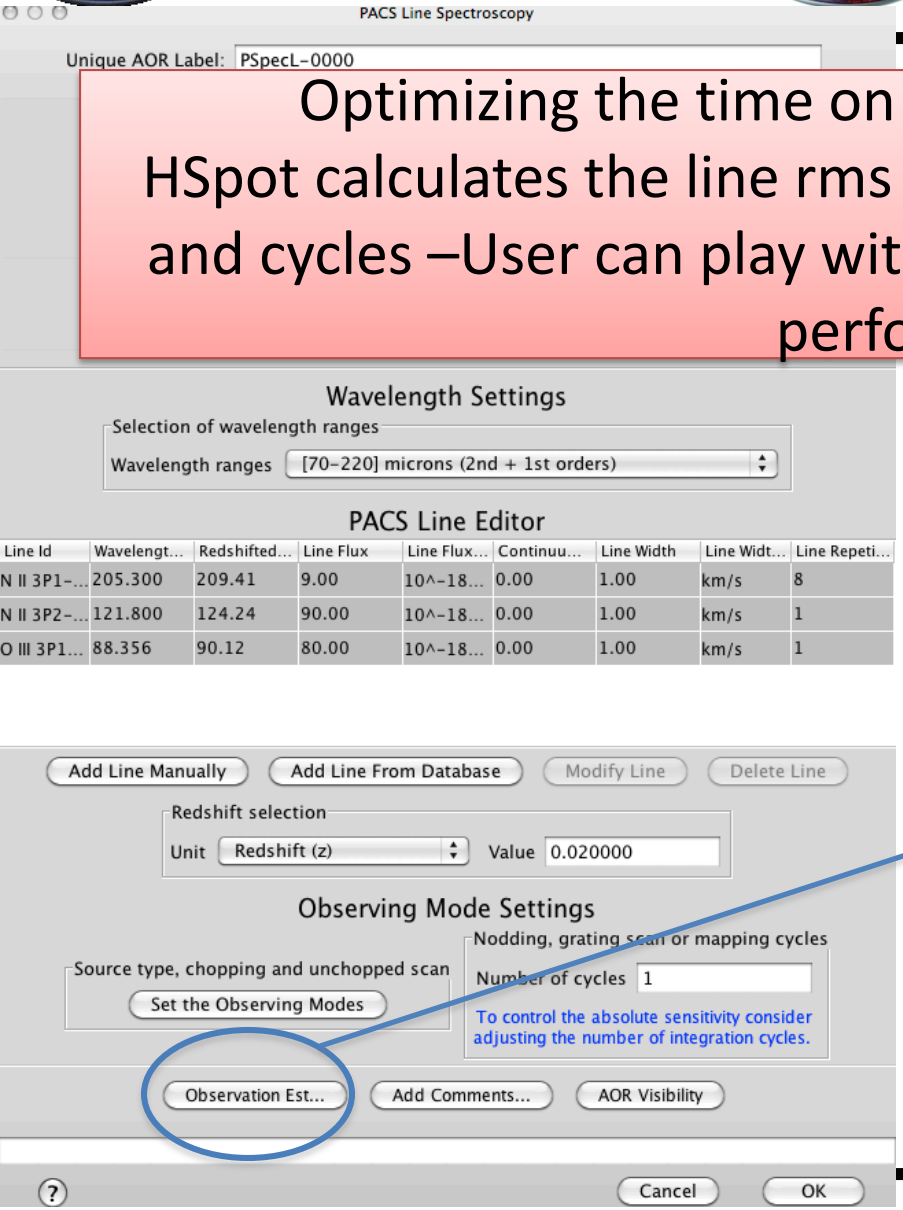


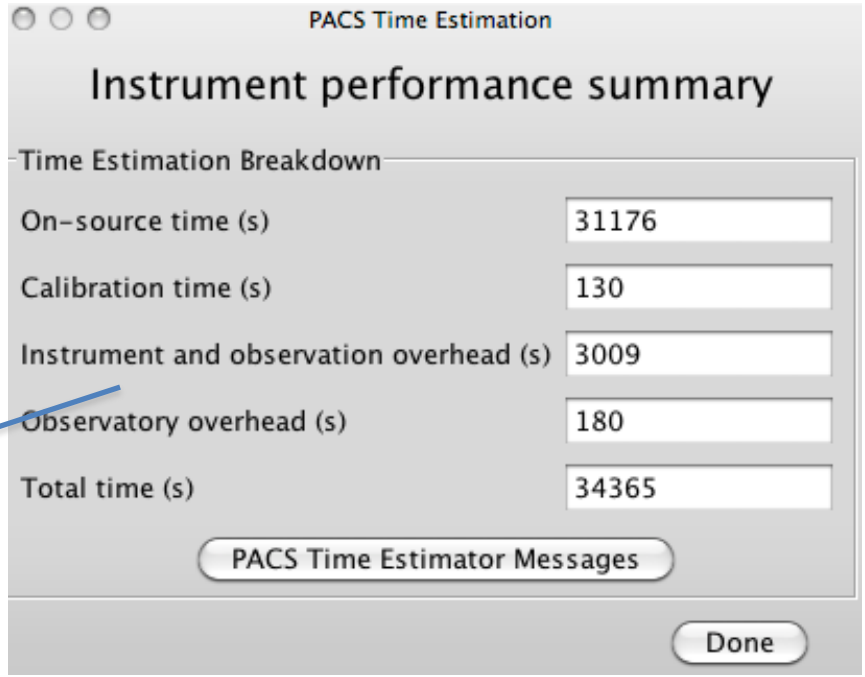


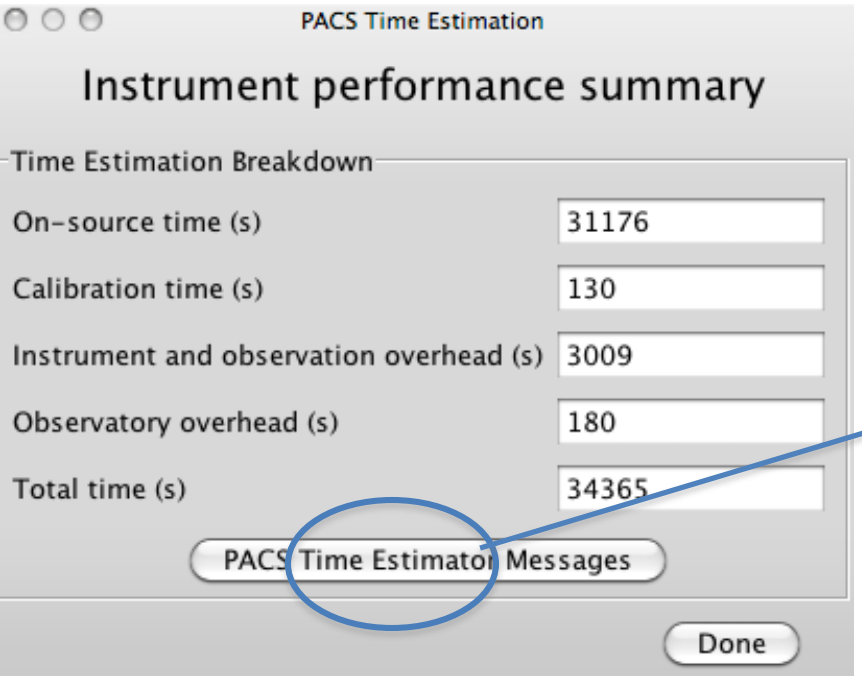
This 3 x 3 map provides small map of nucleus
of this galaxy but chopper angle depends
on time of year since it depend on telescope roll angle

Optimizing the time on each line (Time estimator)

HSpot calculates the line rms for a given set of line repetitions and cycles –User can play with the parameters to get the best performance







clicking on this gives
more details including S/N estimation
for your set of lines, repetitions

SpecLine summary

N II 3P1-3P0: 209.41 [μm]:

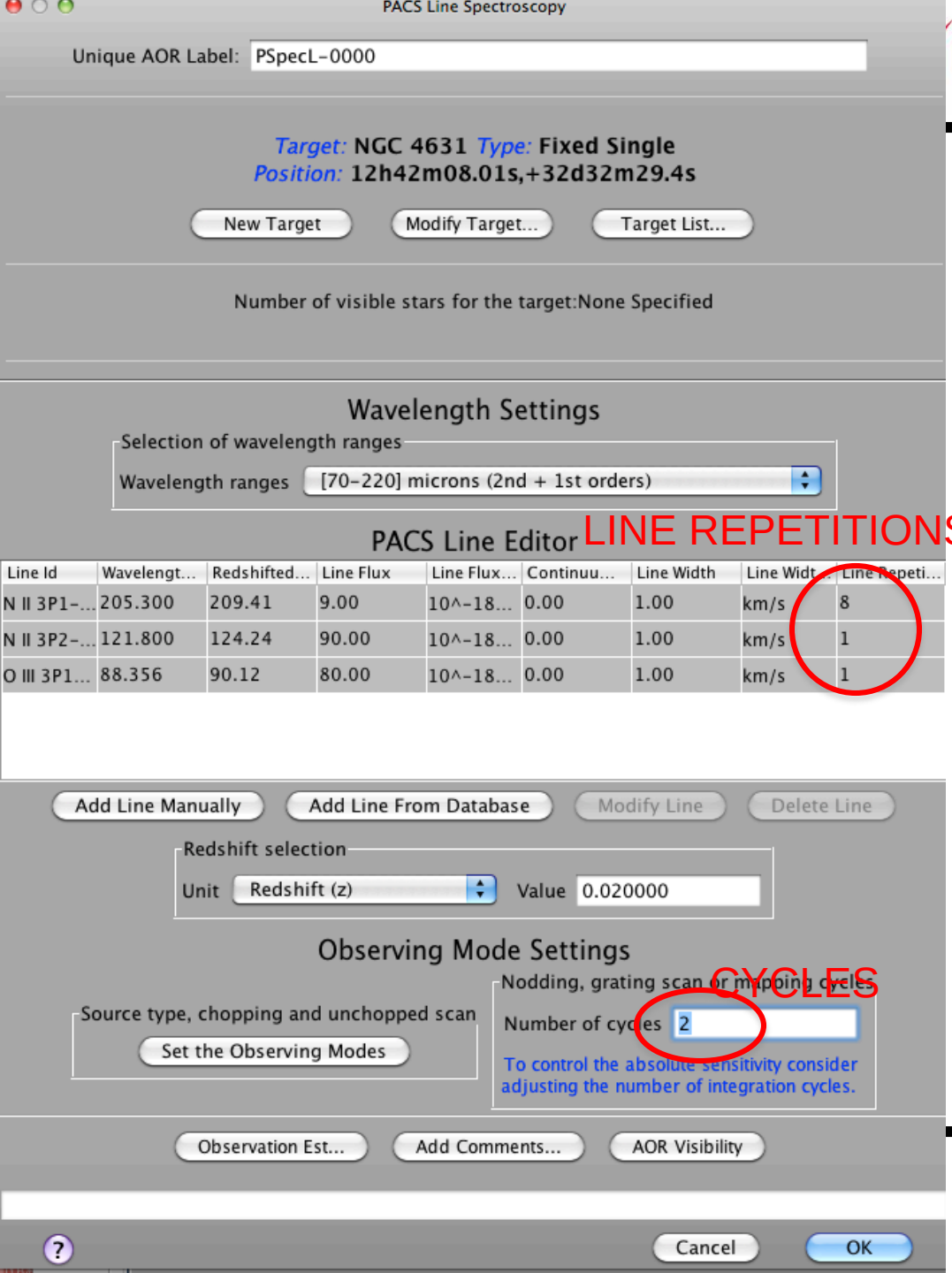
- FWHM at current wavelength: 141.5 [km/s] or 0.099 [μm]
- Continuum RMS : 616 [mJy]
- Continuum S/N: 0.00
- Line RMS: 3.77E-18 [w/m2]
- Line S/N: 2.39
- Total duration (SRC+REF+PACS overheads): 26424 [sec]
- SRC+REF (no overheads): 24768 [sec]

O III 3P1-3P0: 90.12 [μm]:

- FWHM at current wavelength: 120.4 [km/s] or 0.036 [μm]
- Continuum RMS : 415 [mJy]
- Continuum S/N: 0.00
- Line RMS: 5.70E-18 [w/m2]
- Line S/N: 14.04
- Total duration (SRC+REF+PACS overheads): 3690 [sec]
- SRC+REF (no overheads): 3312 [sec]

N II 3P2-3P1: 124.24 [μm]:

- FWHM at current wavelength: 287.7 [km/s] or 0.119 [μm]
- Continuum RMS : 127 [mJy]
- Continuum S/N: 0.00
- Line RMS: 2.80E-18 [w/m2]
- Line S/N: 32.11
- Total duration (SRC+REF+PACS overheads): 3636 [sec]
- SRC+REF (no overheads): 3096 [sec]

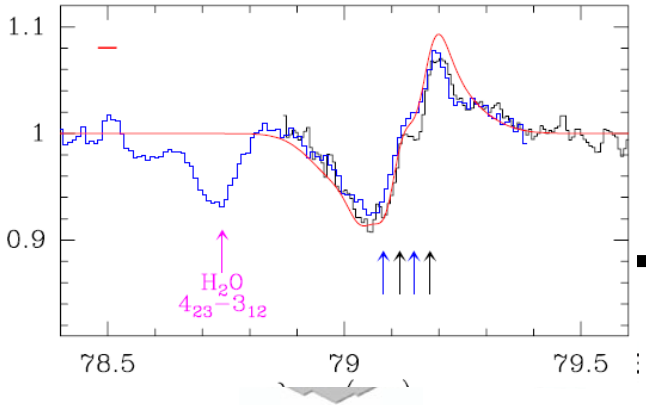


The final rms and S/N you get will depend on a balance of line repetition blocks and the total number of cycles of these blocks you choose. You can increase the total time by requesting more set of data in the cycle window... this will hugely increase your AOR time which cannot go beyond18 hrs

Iteratively adjusting these variables can allow you to get the best S/N for your set of lines in a given AOR.

Range Scan

- User can specify the range of the scan
- Useful for known broad or multiple lines
- Special version is SED mode where Blue/Red or Green Red bands scanned
- Range Scan is only mode that allows exploitation of extended second order



Lets consider two examples

CASE 1: SMALL RANGE OVER from 78.2 to 79.8 (as in example in previous slide)

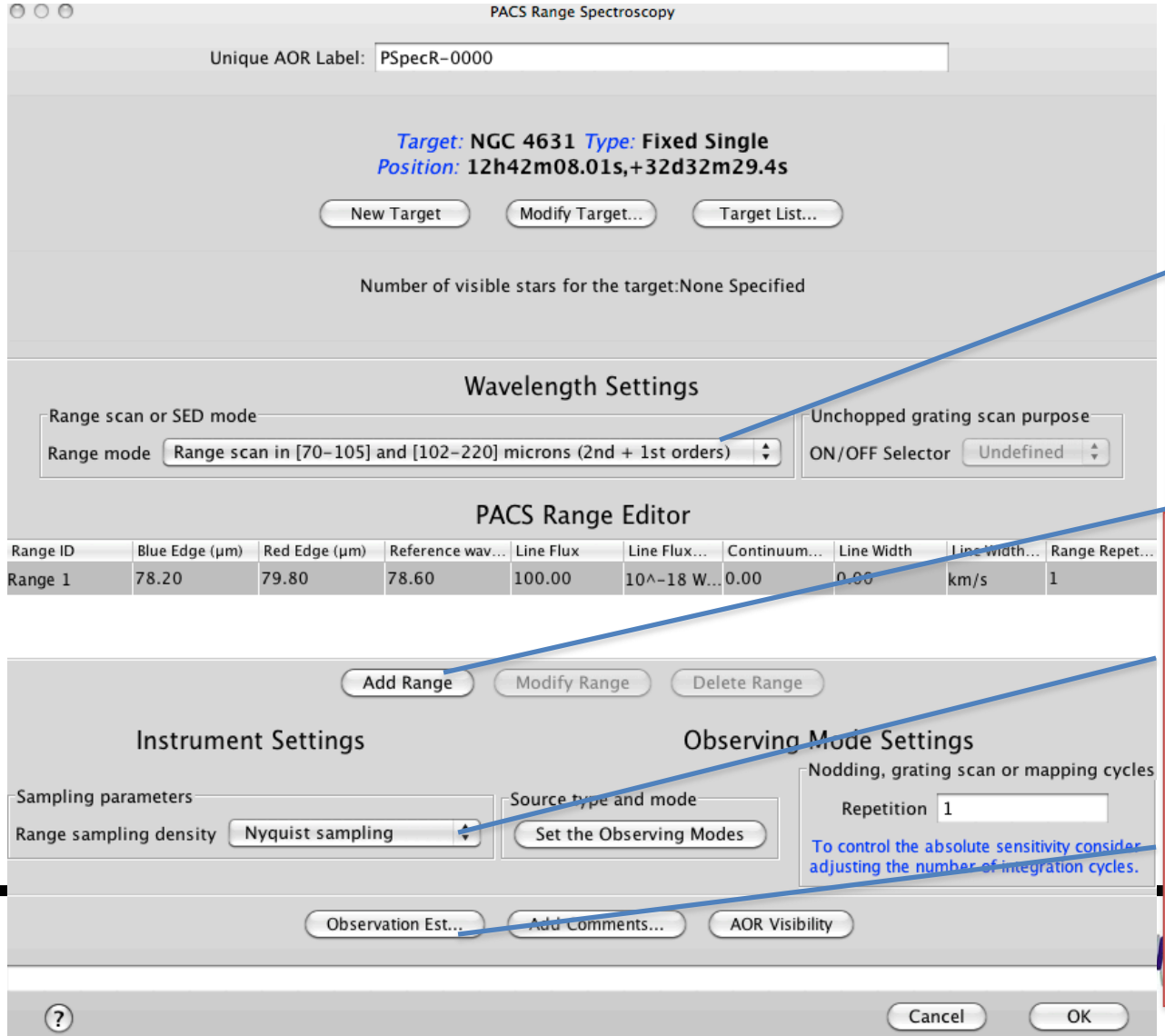
Only a little more expensive than standard line scan*

CASE 2: SED SCAN OVER FULL PACS BAND

Very expensive even for the recommended 2 repetitions

*PITFALL: CHECK THE NUMBER OFSTEPS EXECUTED BY THE GRATING IN THE SMALL RANGE IS LARGER THAN43-48 (the number of steps executed in a normal line scan). This info is in the time estimator dialog box

Small Range Scan Example



1. Choose Range Obs.
2. Enter Target
3. Select range filter set appropriate for range
4. Choose blue and red edge of scan by selecting ADD RANGE

5. Choose sampling of grating -High not Nyquist for small range to match equivalent line scan mode)

6. Proceed as before to set up pointed or mapping mode

Excercise for Workshop

- Create 2 AORs. Target : QUASAR 3C 273 20x10^-18 W/m^2 in [OI]λ63.185 and 50x10^-18 W/M^2 [CII] λ157.74

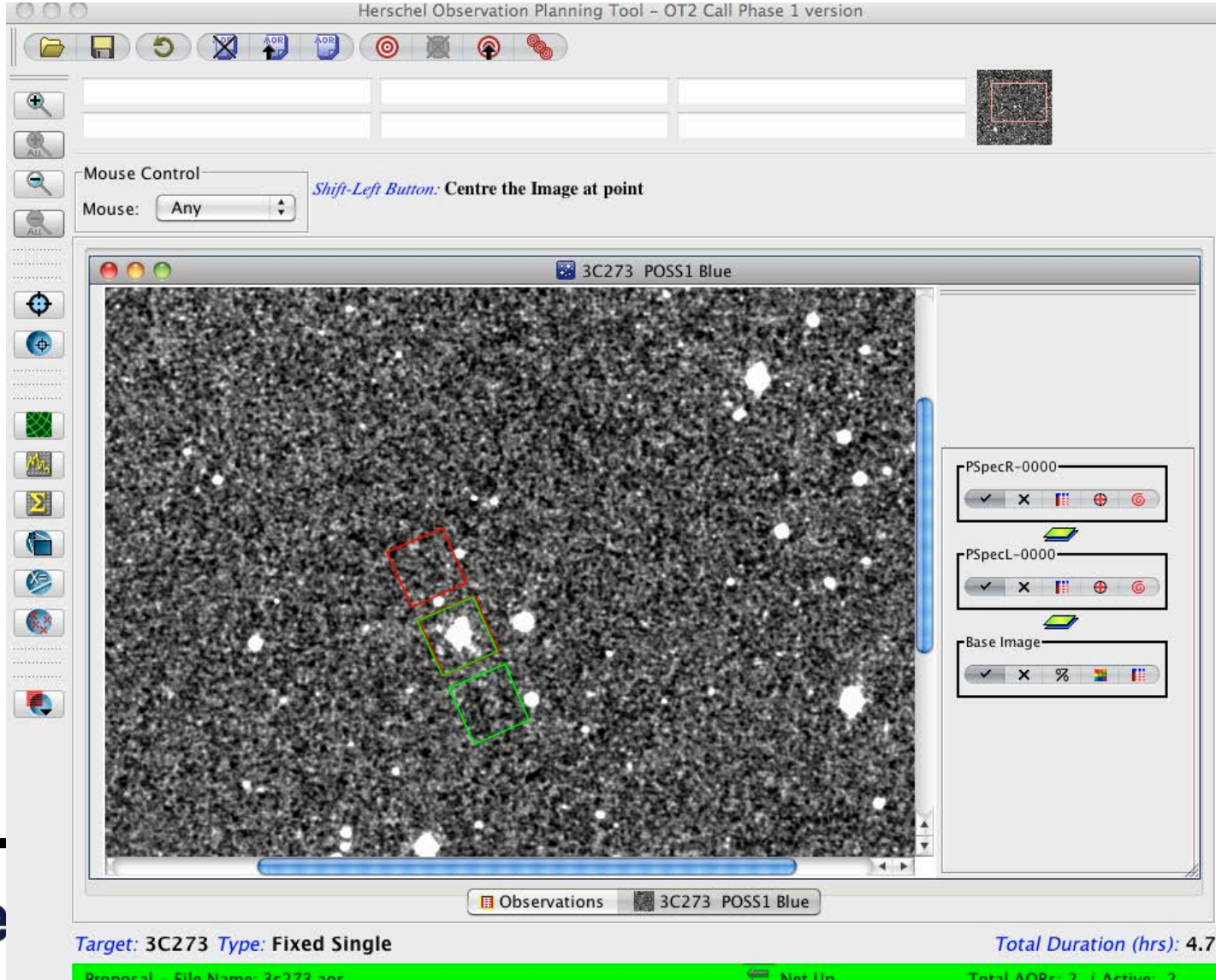
redshift = 0.158

1) Standard C/N line scan of these lines in single pointing mode with small chopper throw to get S/N ≥ 6.5 in each line
2) Small range scan covering 2 microns around each line. High sampling rate

NOW OVER TO DARIO TO EXPLAIN UNCHOPPED MODE

3c273

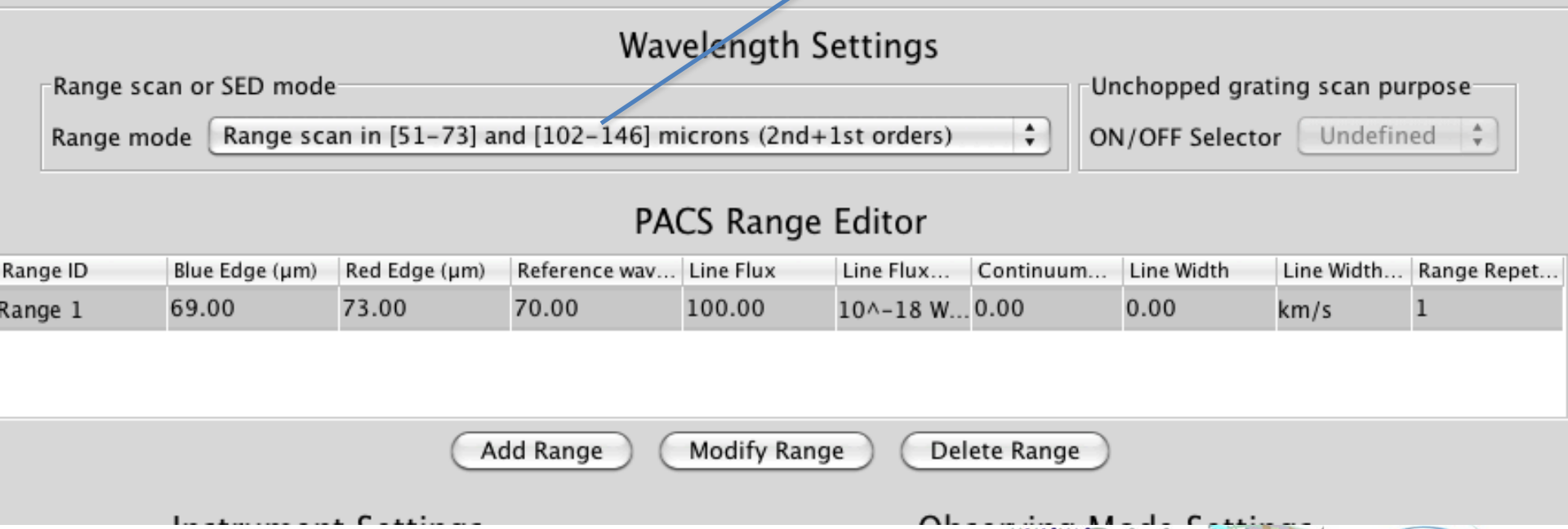
- 3c273.aor



Some considerations in Range-scan mode

1) Choice of filter combinations

Range scan allows user to observe with the 2nd order far into the blue. (Extended Second order). This is not available in line scan mode.



2. Sanity Check that your range is really larger than a normal line scan in time estimator

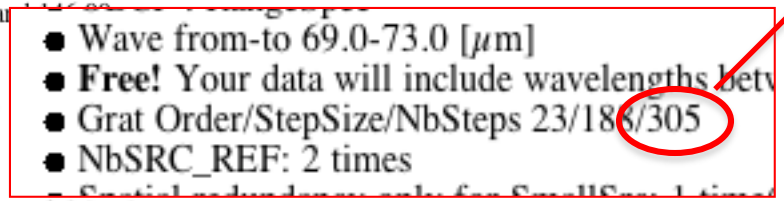
- Number of readouts per ramp: 32
- Number of subramps/ramp: 1
- Fitting algorithm: 0
- Integration capacitor: 0

Blue channel

- Number of readouts per ramp: 32
- Number of subramps/ramp: 1
- Fitting algorithm: 0
- Integration capacitor: 0

Info for range 69.0/73.0 [μm]

- PointReq: Point source (nodding)
- OBCP : RangeSpec
- Wave from-to 69.0-73.0 [μm]
- **Free!** Your data will include wavelengths between 138.00 a
- Grat Order/StepSize/NbSteps 23/188/305
- NbSRC_REF: 2 times
- Spatial redundancy only for SmallSrc: 1 time(s)
- Number ramps/plateau (after synch): 2
- Integration time/plateau: 0.38 [sec]
- NbUpDn/NbNods/NbRepeat: 2/2/1
- Integration time per spectral and/or spatial resolution element:: 3.0 [sec]
- Feature seen 36.7 times (due to spatial or wavelength redundancy)
- Integration time used to estimate RMS: 110.1 [sec]
- Global SRC/REF exposure: 1220/1220 [sec]



This is the number of steps made by the grating to scan over your line.
It far exceeds the maximum of 43-48 steps you get in normal line scan.

YOUR CHOICE OF RANGE SCAN IS JUSTIFIED!!

AOT, PointMode and Nodding info

PACS AOT: PacsRangeSpec

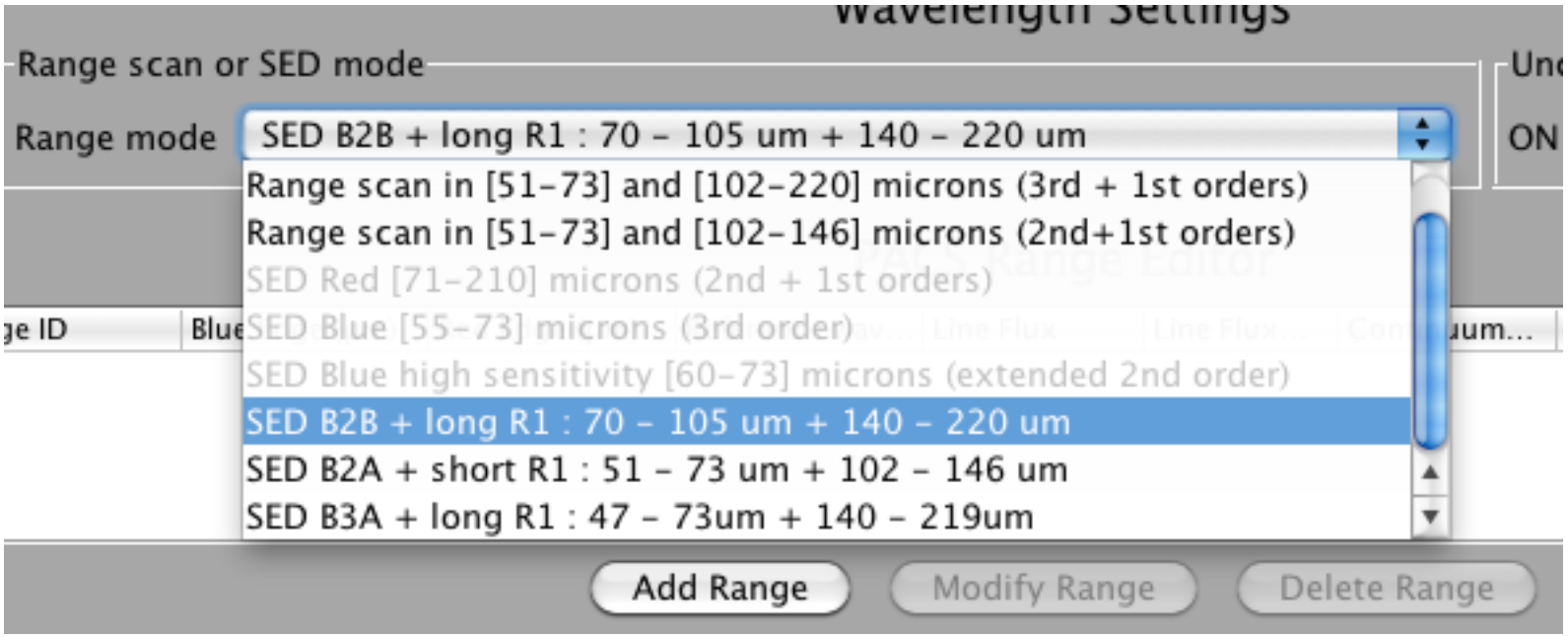
Pointing mode: **Point source (nodding)** with 1 nod cycles

3. As with normal line scan, in small range scan mode, up to 10 ranges are allowable with 1 repetition.
In SED Mode, only one SED scan is allowed per AOR.

Unlike line-scan, there is no redshift calculator—so if you are searching for a line you will need to calculate the observed wavelengths that you want to search over. More than one set of ranges is possible within one AOR. These are specified as separate ranges.

Warning: The step size of the grating is optimized for the "primary" target line. Any "secondary" (i.e. for free) spectrum you may get in parallel may not have the optimal sampling because it is fixed by the primary step size.

FULL SED Range Scan



To perform a full SED you will need to create 2 AORs.
SED B2B +long R1 (70-106 and 140-220 obtained together in same scan)
+ SEB B2A + short R1 (51-73 and 102-146 obtained together in same scan)
alternatively you can obtain a higher res (3rd order) scan in blue but get a shorter range in red (SED B3A + long R1) CLICK ON ADD RANGE after selection of SED range.

The two AORs should be concatenated to ensure the run successively.