Getting your science!

Tips and advice for setting up Nāmakanui MSBs in the JCMTOT with the current non-functional LO2#0

... Updated November 2021 ...

Acronyms used

- **ACSIS**: the Auto-Correlation Spectrometer and Imaging System
- **DMC**: Down converter module - a maximum of 4 DCMs are fed from the same IF. Nāmakanui has 4 IF outputs (4 for ‘Ū‘ū at 230 GHz and 4 for ‘Āweoweo at 350 GHz), while there are 32 DCMs and correlator cards.
- **LO**: Local Oscillator (4.5-6.8GHz for Nāmakanui)
- **LO2**: second Local Oscillator used in ACSIS to down convert signal to the range 2-3GHz.
    - There are two LO2’s: one working in the 6-8GHz range, the other working in the 8-10GHz range.
    - *It is the 8-10GHz synthesiser on the LO2s spectral region xxxxx that is broken.*
- **NU0L**: Namakanui pixels are labeled using the following naming convention: Instrument-insert-polarization-sideband e.g. Nāmakanui – `Ū`ū – P0 – LSB (NU0L)

ACSIS: background

For notes on the ACSIS system see: HARP/ACSIS: a submillimetre spectral imaging system on the James Clerk Maxwell Telescope By Buckle et al. 2009

"A block diagram showing the IF signal path from the switching network (SWN) is given in Fig. 15. The input IF frequencies cover from 3.3 to 7.7 GHz. There are 16 IF signals feeding from HARPand eight feeds from additional receivers. Switching between these inputs is done by an IF switch. Each DCM extracts a nominal 1 or 0.25 GHz wide band from the 3.3–7.7 GHz ACSIS IF band. The frequency range extracted is determined by setting the appropriate second LO (LO2). Four tunable LO2s are fed to each set of four DCMs that can be connected toan IF input. A total of 32 DCMs are available. These two or four DCMs can be placed anywhere in the ACSIS IF band using the four LO2s. Due to the sharing of LO2s the positioning must be the same in all IF inputs.As described in Section 3.2 ACSIS can combine the correlators attached to adjacent DCMs doubling the number of frequency channels while halving the effective numbers of available DCMs."

https://www.eaobservatory.org/jcmt/instrumentation/heterodyne/acsis/

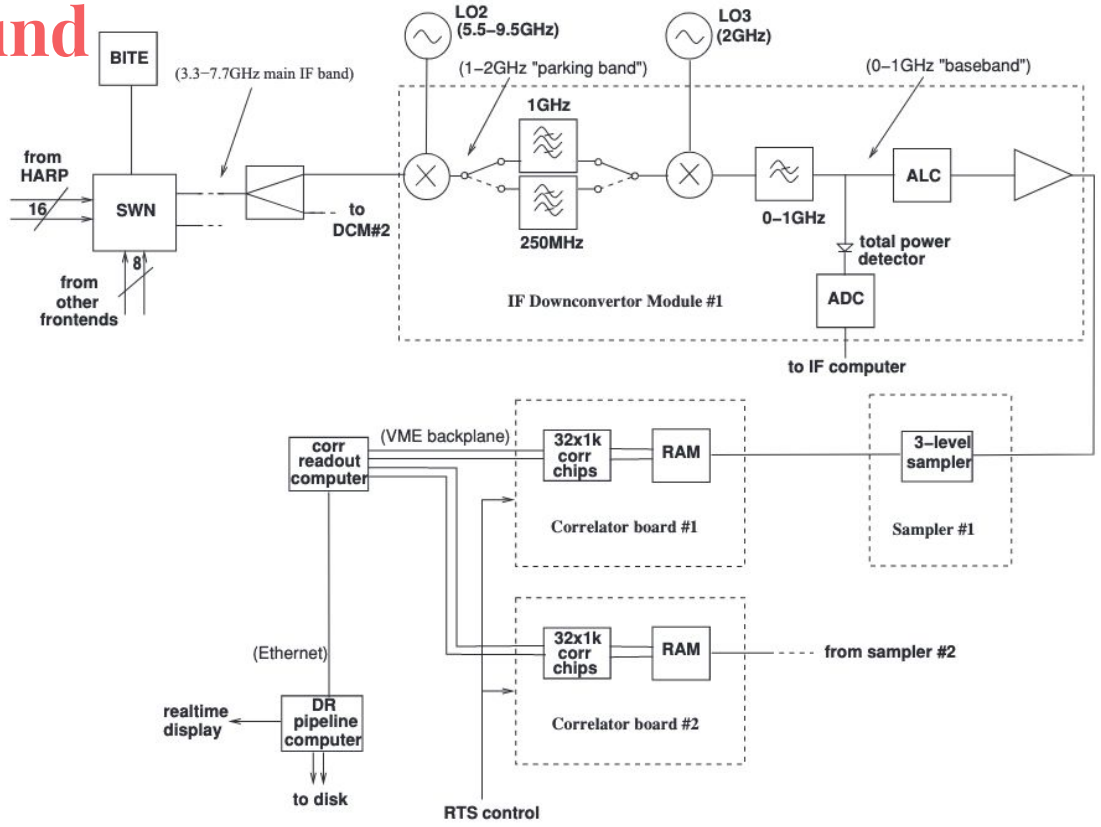


Figure 15. ACSIS overall system hardware block diagram. Only one of the 32 Down Convertor Sampler subsections is shown. The signal path is described in the text.

ACSIS: background

For notes on the ACSIS system see: HARP/ACSIS: a submillimetre spectral imaging system on the James Clerk Maxwell Telescope By Buckle et al. 2009

"In the DCM, each sub-band is amplified, filtered and converted to the sampler frequency range (baseband). The DCMs mix the IF with a tunable LO (LO2). A final LO (LO3) fixed at 2.0 GHz does the final downconversion to the baseband. Rather than having multiple system bandwidth/resolution combinations using many different IF filters, the philosophy is to have only two hardware options, and ensure that these cover most astronomical requirements. Each DCM can therefore switch between a wide-band (1 GHz) and a narrow-band (250 MHz) mode (see Table 1). In practice, the edges of the DCM filtering limit the bandwidth of each DCM to 930 and 220MHz"

https://www.eaobservatory.org/jcmt/instrumentation/heterodyne/acsis/

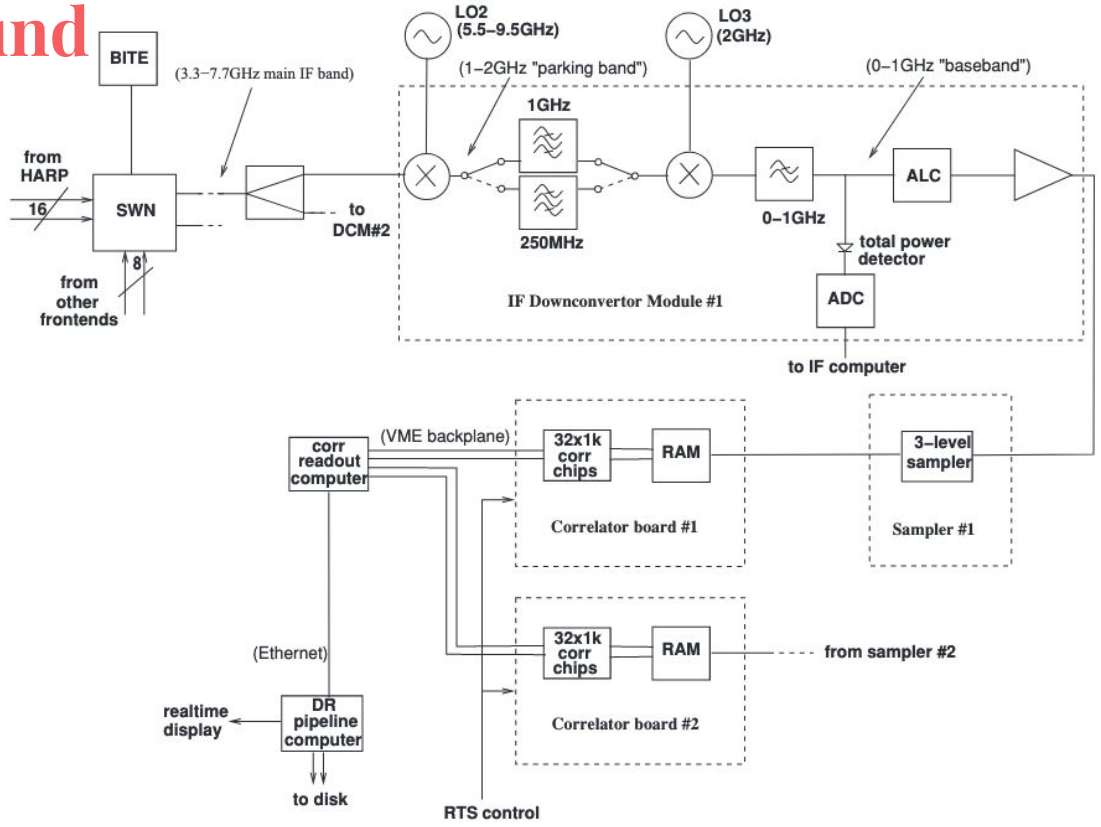


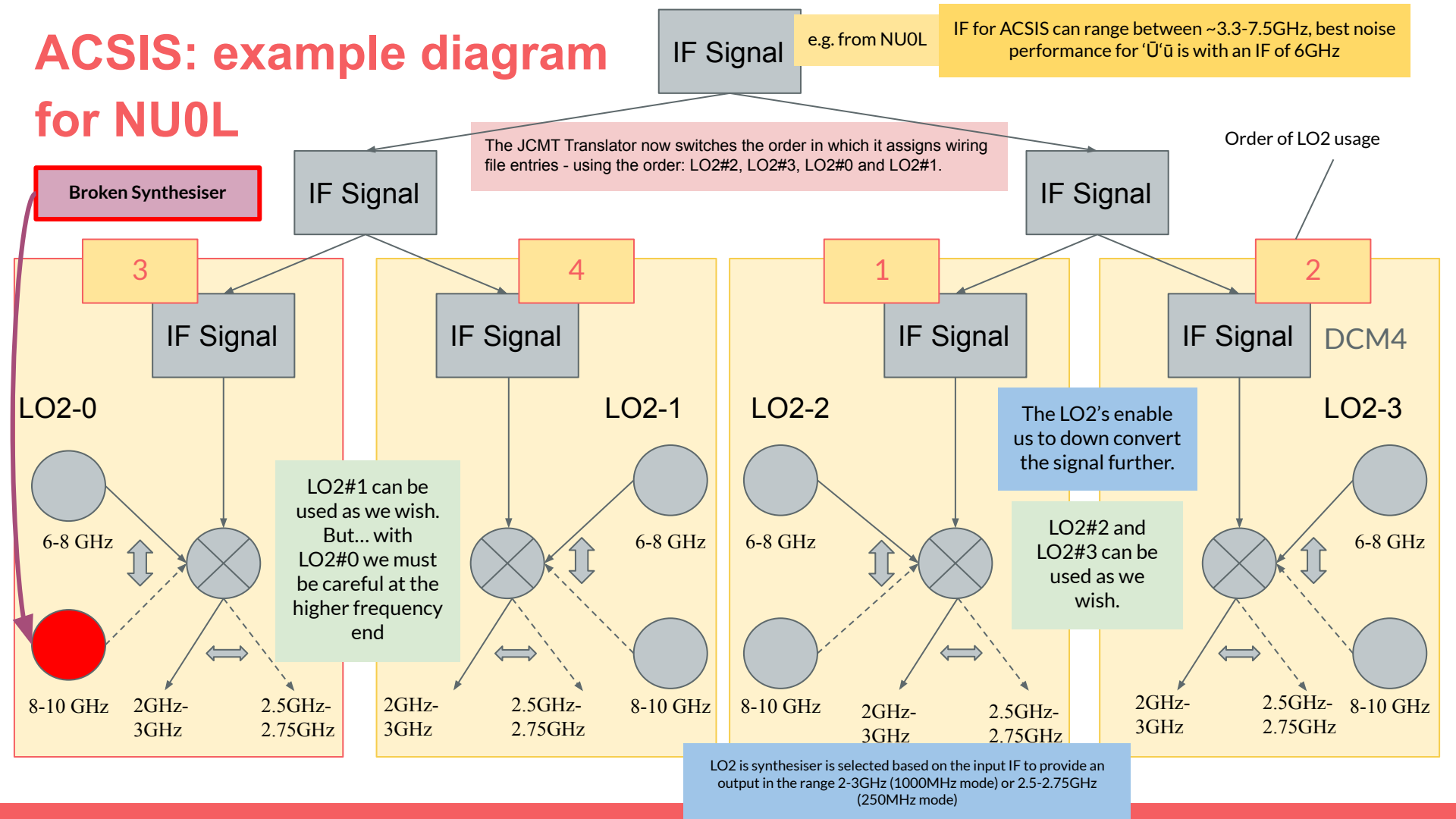
Figure 15. ACSIS overall system hardware block diagram. Only one of the 32 Down Convertor Sampler subsections is shown. The signal path is described in the text.

ACSIS: Broken Synthesiser issue (April/May 2021)

- ACSIS is the backend spectrometer used by HARP and Nāmakanui's `Ū`ū and `Āweoweo.
- Right now there is a broken synthesiser on one of the LO2's LO2#0. This means that there is a limitation on the IF that can be fed into LO2#0.
- For LO2#2 the system can only handle:
  - an IF <5.5GHz (with a bandwidth of 1000MHz)
  - or an IF <5.375GHz (with a bandwidth of 250MHz)
- As of April 30th 2021 the Observatory has shifted the order in which the LO2s are used in ACSIS.
  - The re-ordering will mean that Nāmakanui users that are only using a single standard (250MHz or 1000MHz) spectral region in their MSBs are OK.

Nāmakanui

ACSIS: example diagram for NU0L



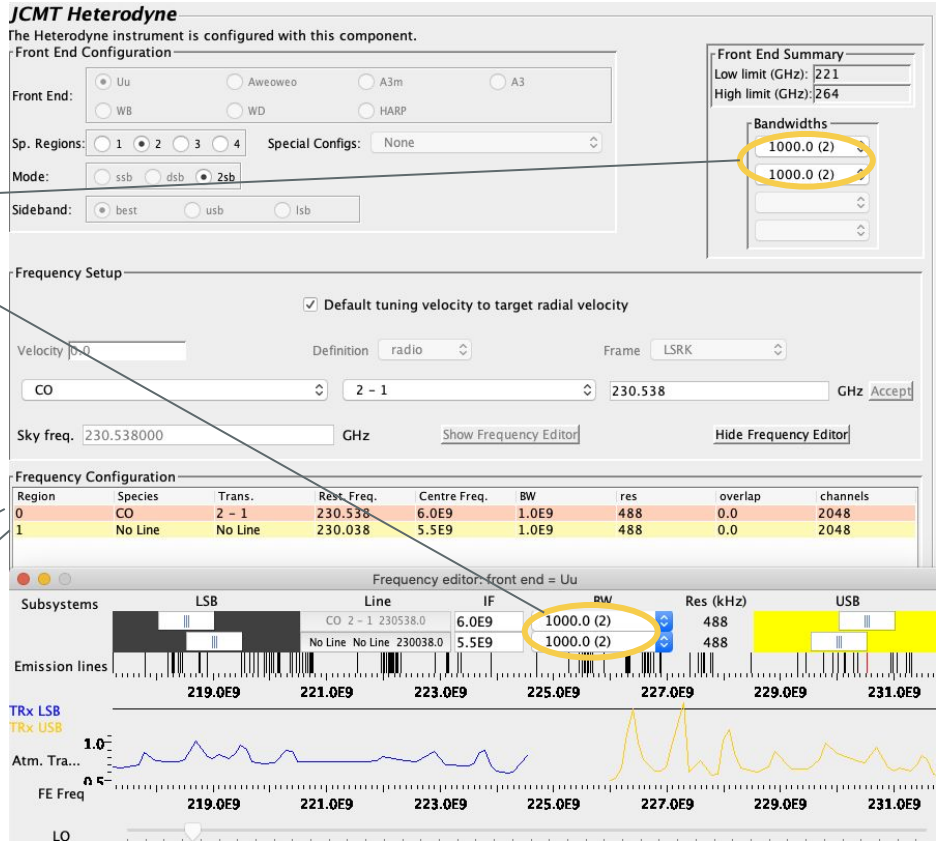
ACSIS: Broken Synthesiser issue (April/May 2021)

ACSIS will use the LO2's in the following order #2,3,0,1.

The number in parentheses after the bandwidth denotes the number of LO2's used in each spectral region set up. In this example: 1000.0 (2) all four LO2s are used.

LO2#2, LO2#3 used with an IF of 6GHz

LO2#0, LO2#1 used with an IF of 5.5GHz



For notes on the ACSIS system see: HARP/ACSIS: a submillimetre spectral imaging system on the James Clerk Maxwell Telescope By Buckle et al. 2009

ACSIS: Broken Synthesiser issue (April/May 2021)

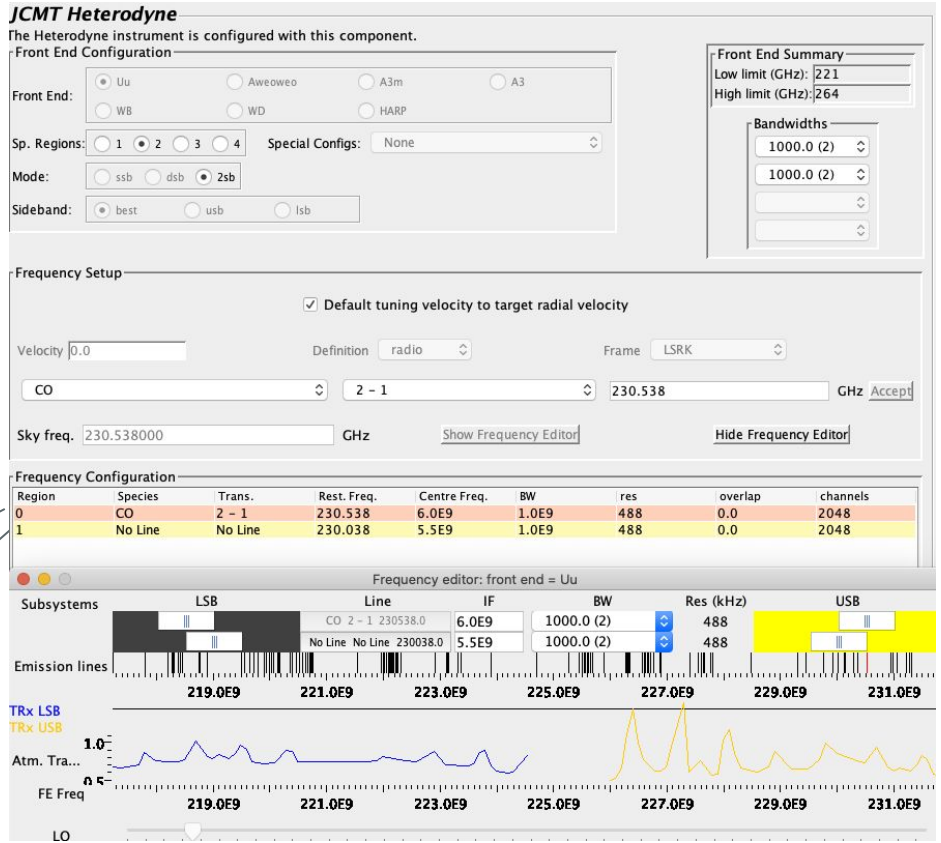
ACSIS will use the LO2's in the following order #2,3,0,1.

In this example LO2#0 - is set with an IF of 5.5GHz and so passes the requirement that the IF:

- <5.5GHz with a bandwidth of 1000MHz
- <5.375GHz with a bandwidth of 250MHz

LO2#2, LO2#3 used for Spectral Region 0

LO2#0, LO2#1 used for Spectral Region 1



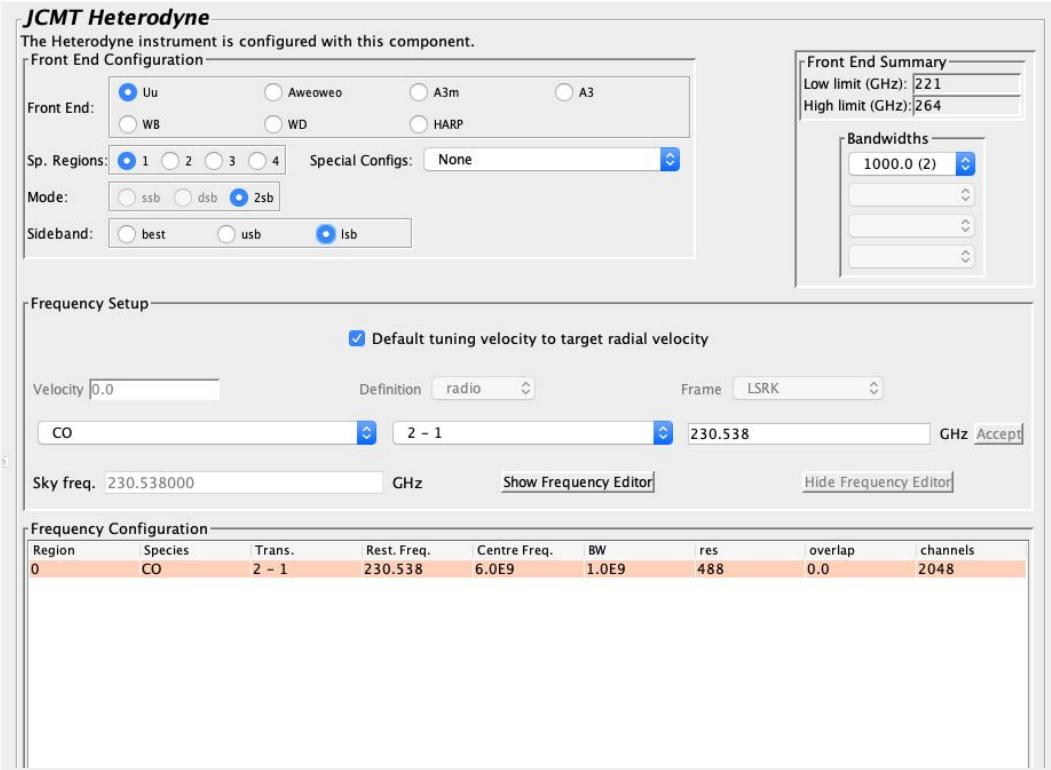
For notes on the ACSIS system see: HARP/ACSIS: a submillimetre spectral imaging system on the James Clerk Maxwell Telescope By Buckle et al. 2009

ACSIS: Example 1 – 1 spectral region

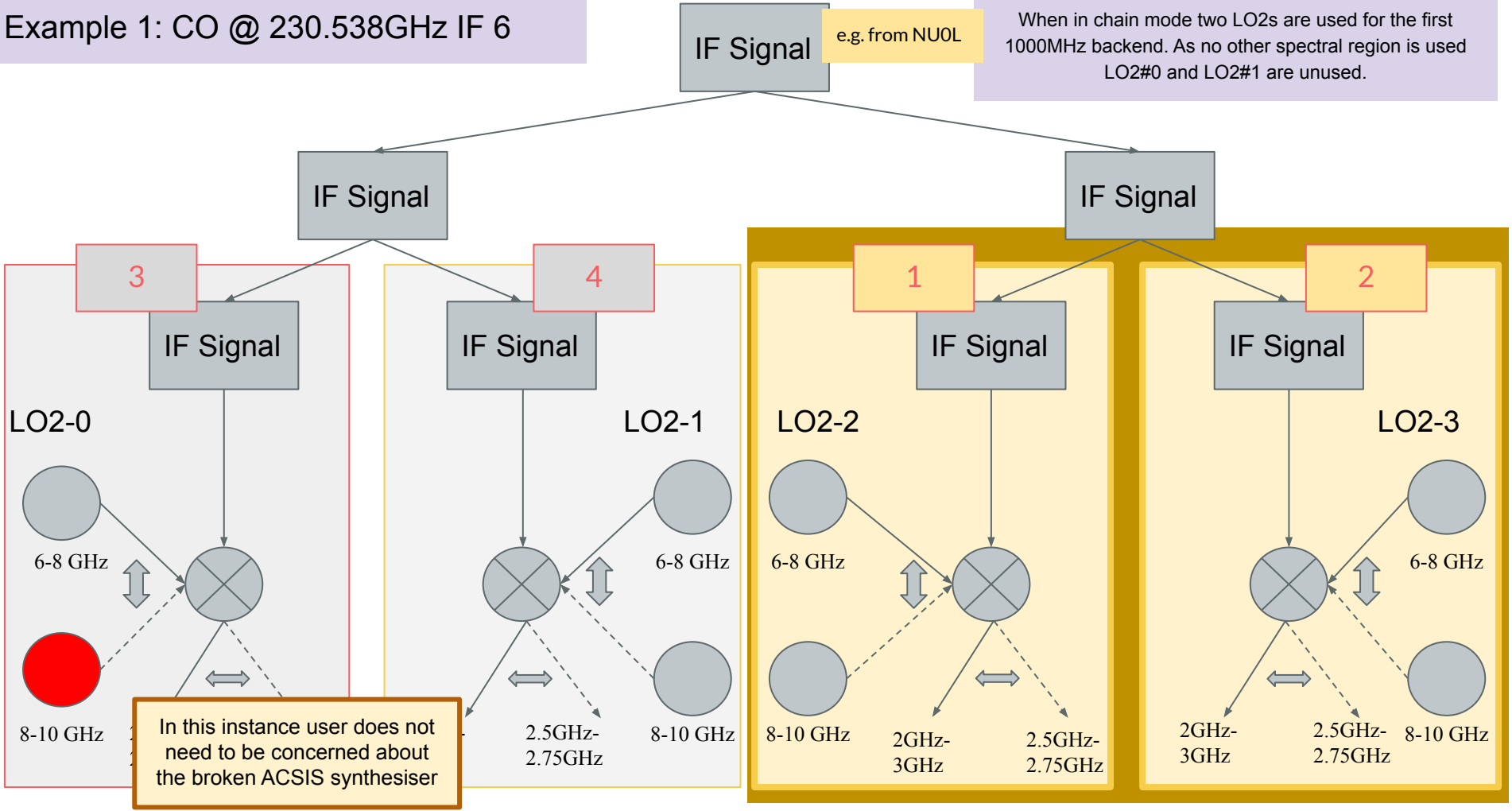
Example 1: CO @ 230.538GHz IF 6

- 1 spectral region
- 1 bandwidth @1000MHz
- 1 region with resolution 488kHz
- 1 region with 2048 channels

In this example two LO2s (LO2#2 and LOS#3) are being “chained” together to get the high resolution of 448kHz. This is denoted by: 1000.0 (2).



Example 1: CO @ 230.538GHz IF 6



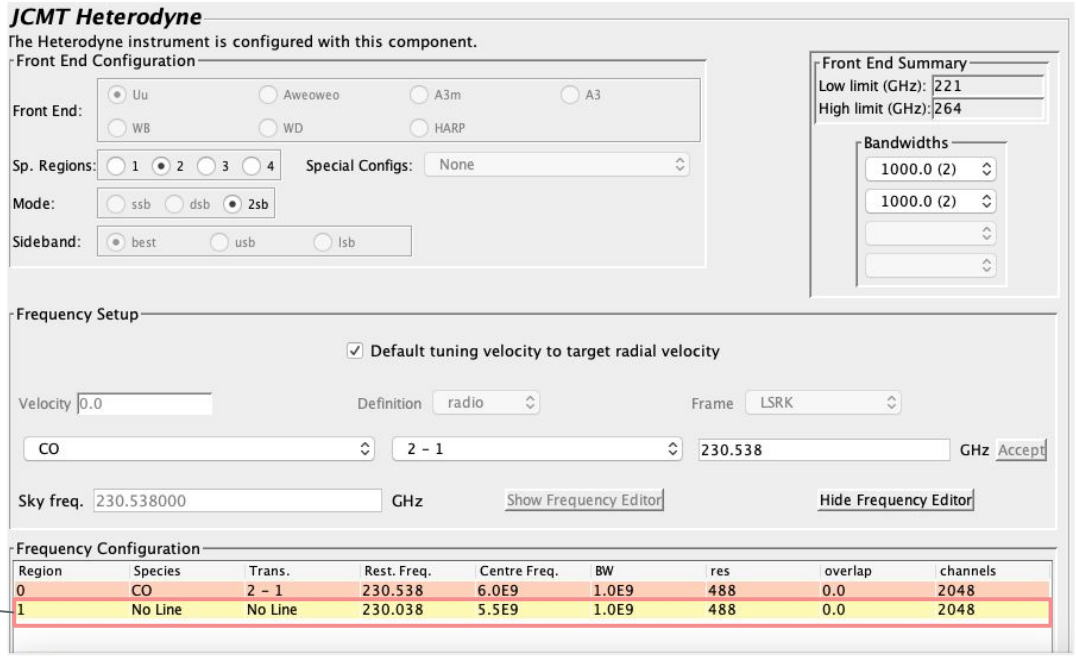
ACSIS: Example 2 – 2 spectral regions

Example 2: CO @ 230.538GHz IF 6

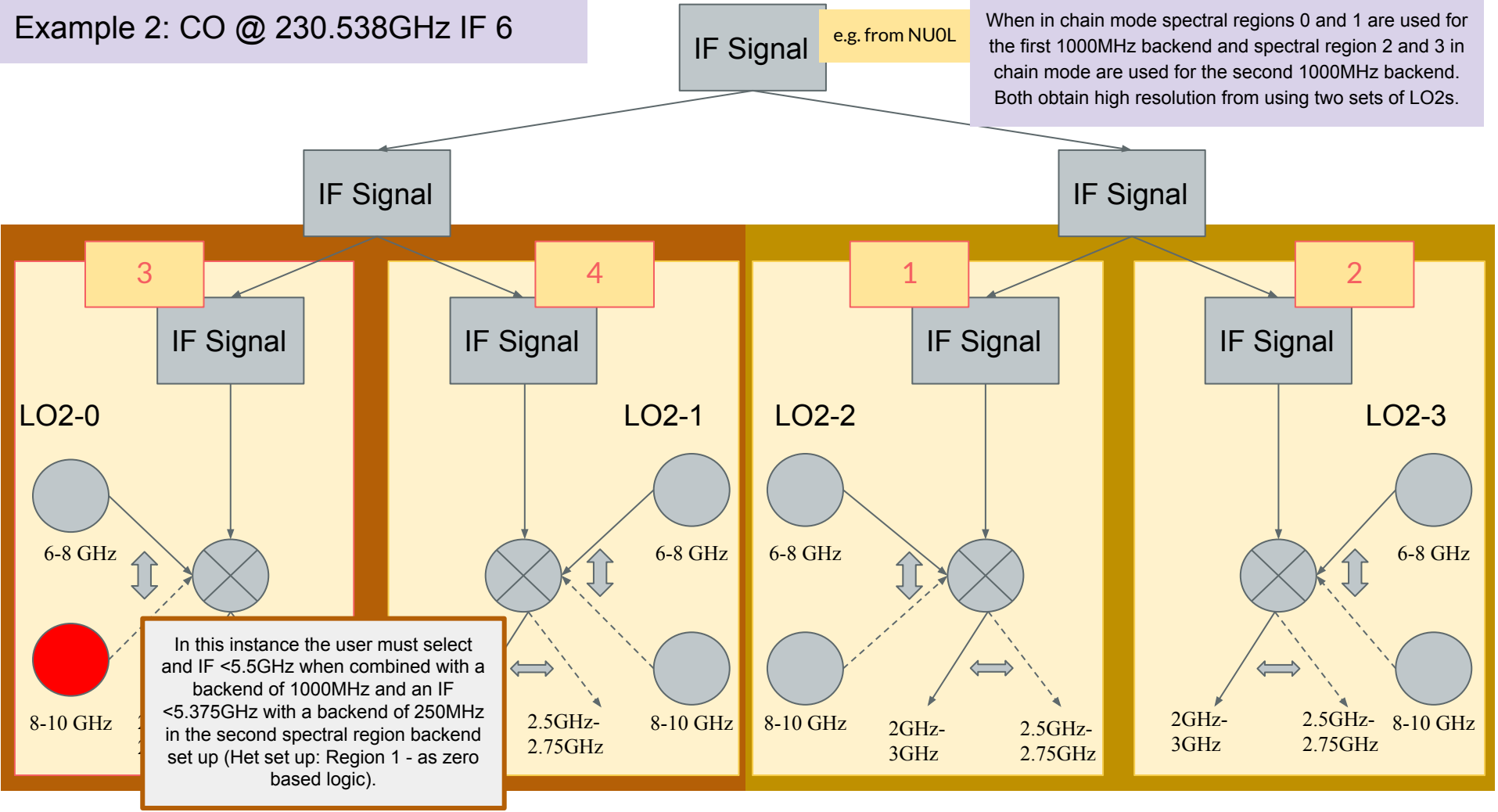
- 2 spectral regions
- 2 bandwidths @1000MHz
- 2 regions with resolution 488kHz
- 2 regions with 2048 channels

In this example we use all four LO2s.
LO2#2, LO2#3 for spectral region 0.
LO2#0, LO2#1 for spectral region 1.

Users will need to use the frequency editor to ensure the spectral region 1 is set with an IF <5.5GHz (when combined with a backend of 1000MHz) or an IF <5.375GHz (with a backend of 250MHz).



Example 2: CO @ 230.538GHz IF 6



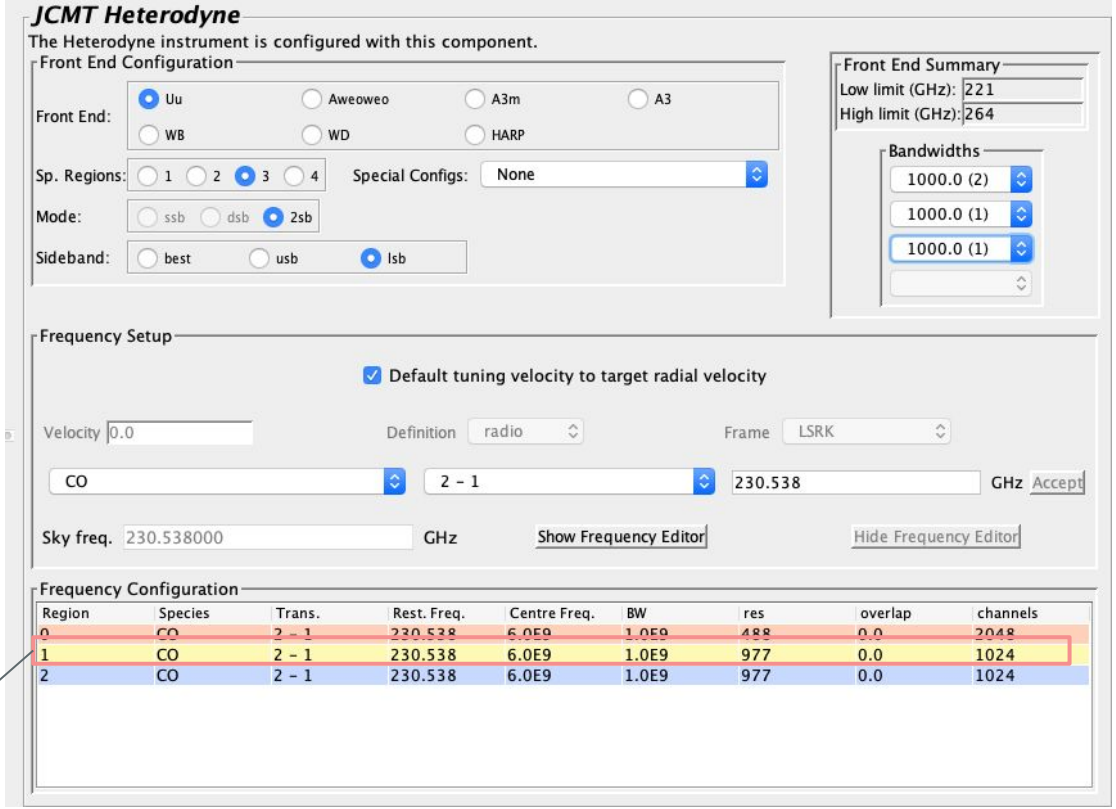
ACSIS: Example 3 – 3 spectral regions

Example 3: CO @ 230.538GHz IF 6

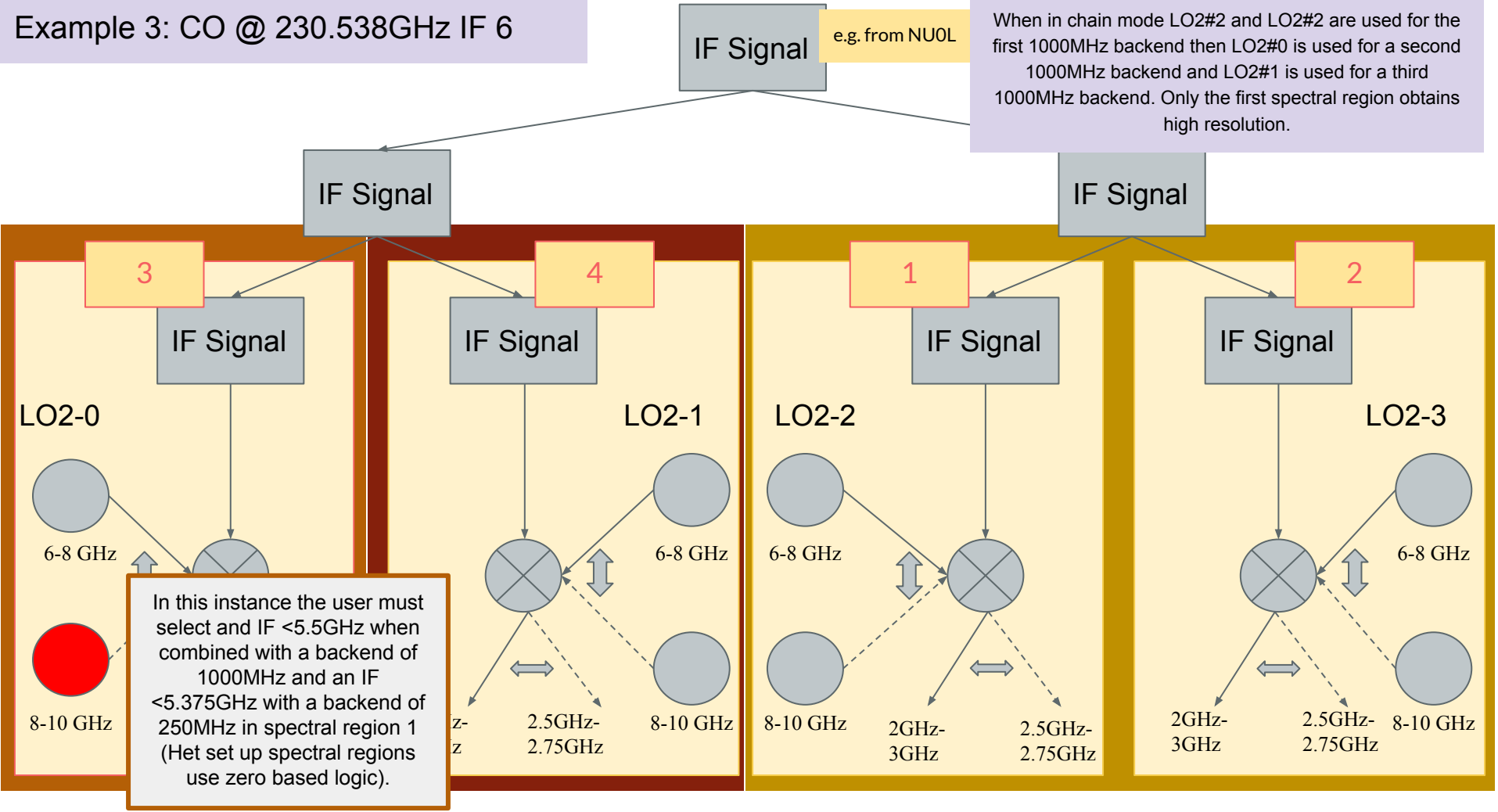
- 3 spectral regions
- 3 bandwidths @1000MHz
- 1 region with resolution 488kHz
- 2 regions with resolution 997kHz
- 1 region with 2048 channels
- 2 regions with 1024 channels

In this example we have four LO2s being used across three spectral regions. Initially two LO2s are used together to give the high 448kHz resolution. The other two spectral regions use a single LO2 each (note the lower resolution).

Users will need to use the frequency editor to ensure the second spectral region an IF <5.5GHz (when combined with a backend of 1000MHz) or an IF <5.375GHz (with a backend of 250MHz).



Example 3: CO @ 230.538GHz IF 6



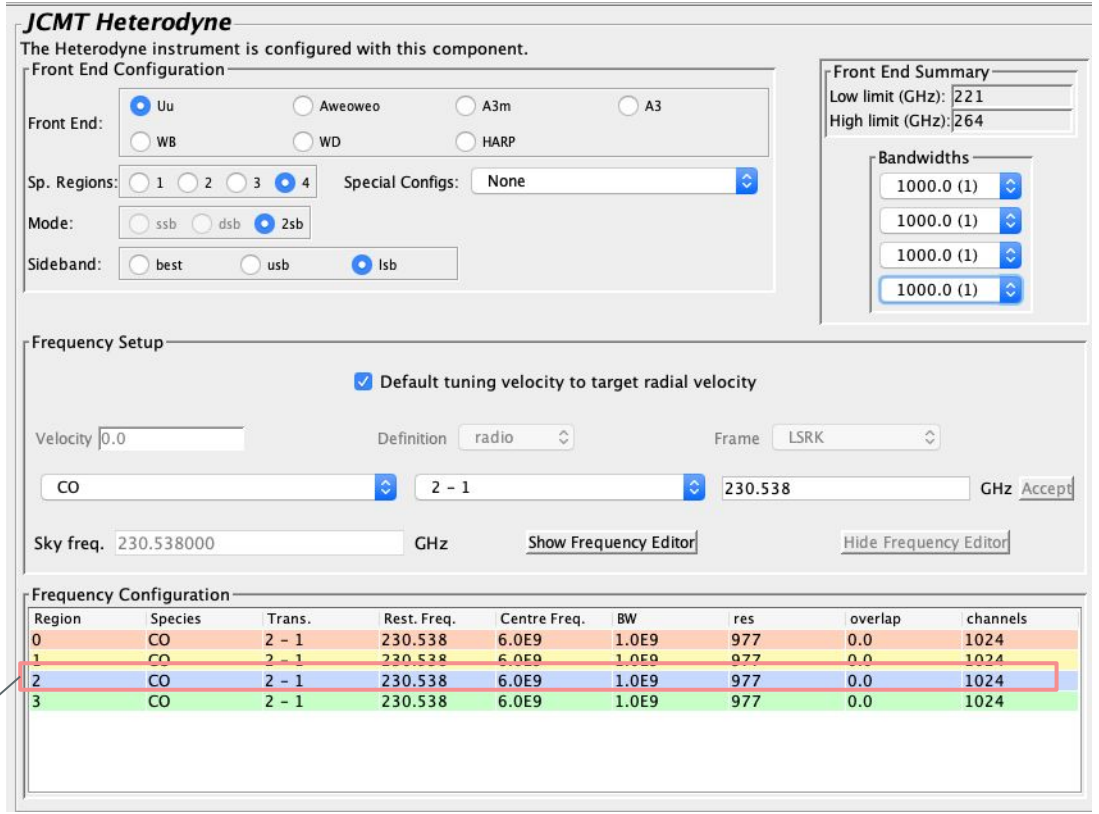
ACSIS: Example 4 – 4 spectral regions

Example 4: CO @ 230.538GHz IF 6

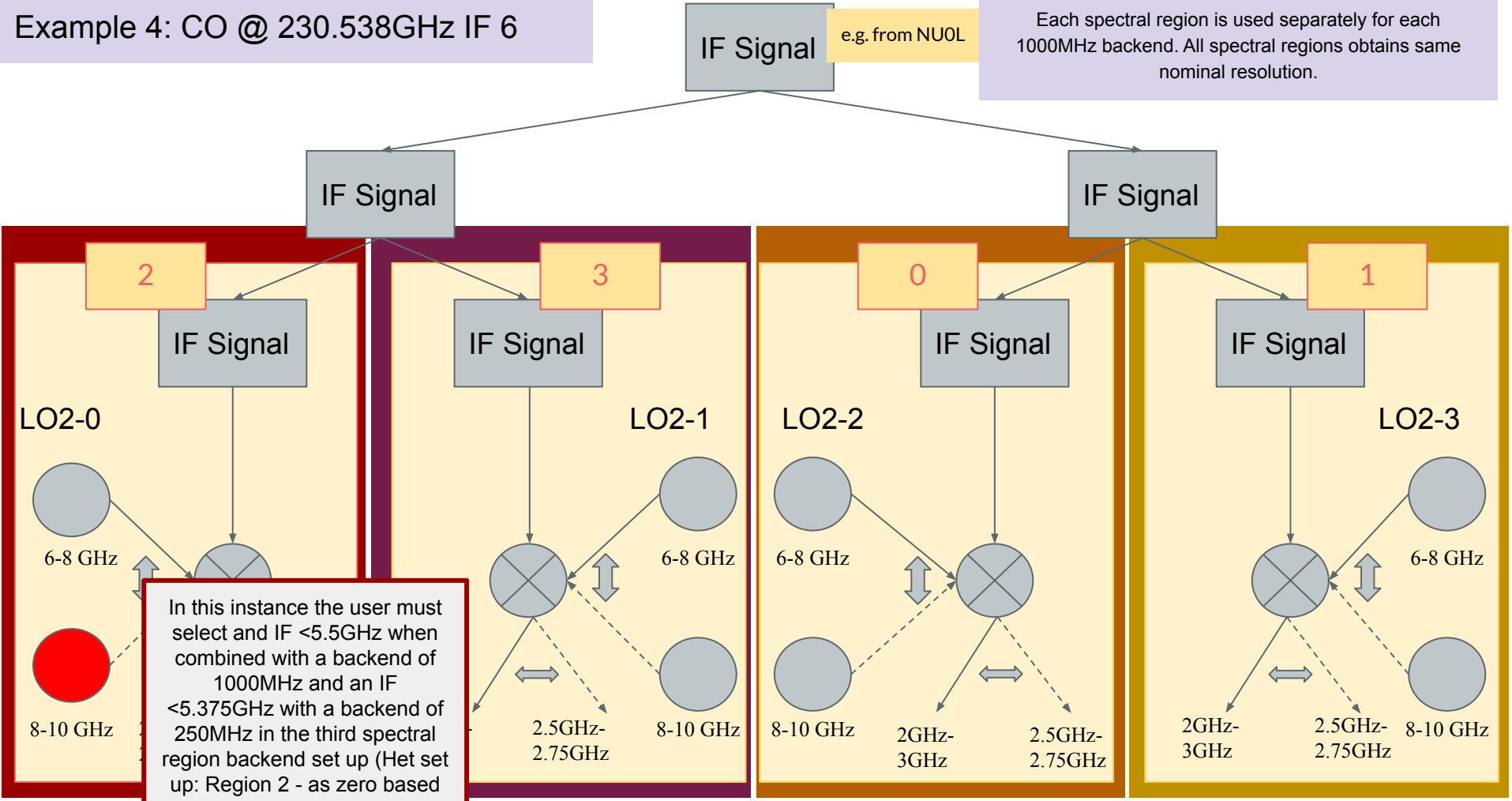
- 4 spectral regions
- 4 bandwidths @1000MHz
- 4 regions with resolution 997kHz
- 4 regions with 1024 channels

In this example we have four DCMs being used. Each DCM must be used for the four spectral regions. No chaining can occur (as we have no spare DCMs) and so all four spectral regions have the same lower resolution of 977kHz.

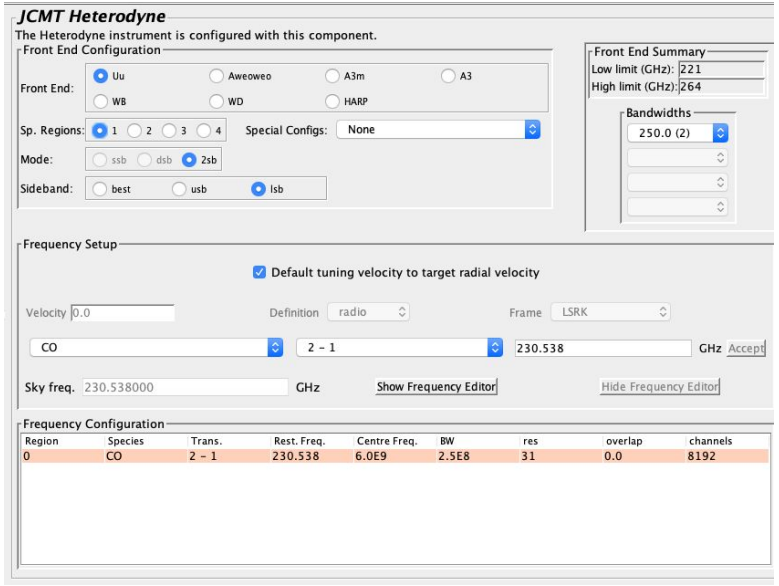
Users will need to use the frequency editor to ensure the second spectral region an IF <5.5GHz (when combined with a backend of 1000MHz) or an IF <5.375GHz (with a backend of 250MHz).

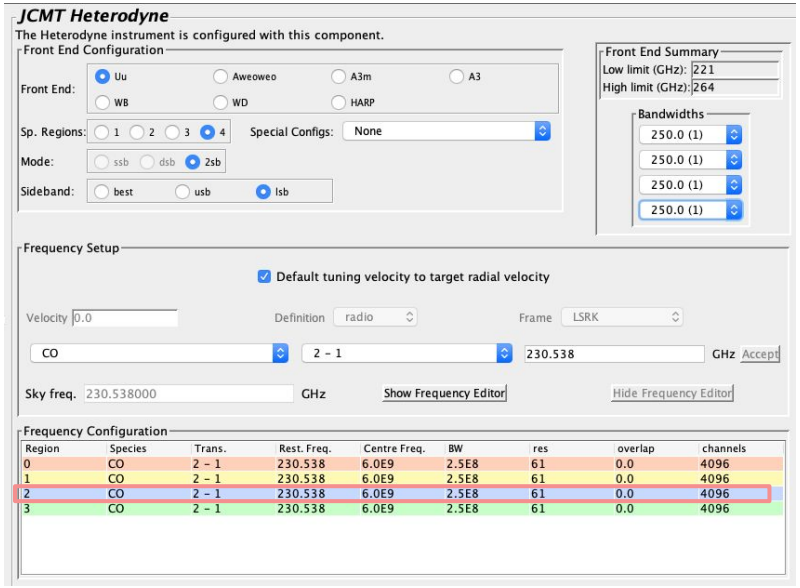


Example 4: CO @ 230.538GHz IF 6



ACSIS: 250MHz examples in the OT





The same is true for the 250MHz (low resolution is 61kHz and 2096 channels, high resolution is 31kHz with 8192 channels). It is also possible to mix the bandwidths and IF selection. Reminder: it is LO2#0 that will need to be set such that the IF <5.5GHz when combined with a backend of 1000MHz or an IF <5.375GHz with a backend of 250MHz.

HARP

ACSIS: example HARP

IF for ACSIS can range between ~3.3-7.5GHz, best noise performance for HARP is with an IF of 5GHz

Broken Synthesiser

IF Signal

e.g. from HARP receptor H04

IF Signal

e.g. from HARP receptor H05

Due to the broken synthesiser and that HARP uses the LO2s in the way outlined all observations need to be set with IF <5.5GHz (for bandwidth 1000MHz) or an IF <5.375GHz (for bandwidth 250MHz).

IF Signal

IF Signal

Order of LO2 usage (with HARP)

1

IF Signal

LO2-0

6-8 GHz

8-10 GHz

2GHz-3GHz

2.5GHz-2.75GHz

2

IF Signal

LO2-1

6-8 GHz

2GHz-3GHz

2.5GHz-2.75GHz

8-10 GHz

1

IF Signal

LO2-2

6-8 GHz

8-10 GHz

2GHz-3GHz

2.5GHz-2.75GHz

2

IF Signal

LO2-3

6-8 GHz

2GHz-3GHz

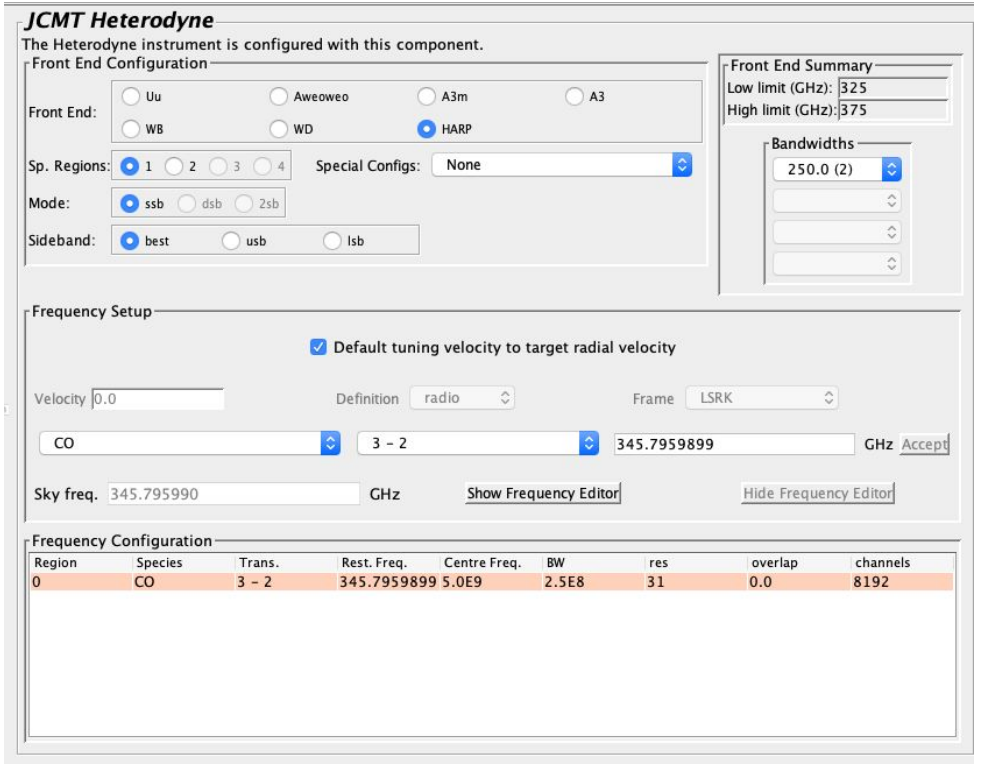
2.5GHz-2.75GHz

8-10 GHz

ACSIS: Broken Synthesiser issue (April/May 2021)

ACSIS will use the LO2's in the following order #0,1 with half of HARP receptors and #2,3 with the other half of HARP receptors. As 5GHz is the default IF for HARP this CO example passes the requirement that the LO2#0 has an IF:

- <5.5GHz with a bandwidth of 1000MHz
- <5.375GHz with a bandwidth of 250MHz



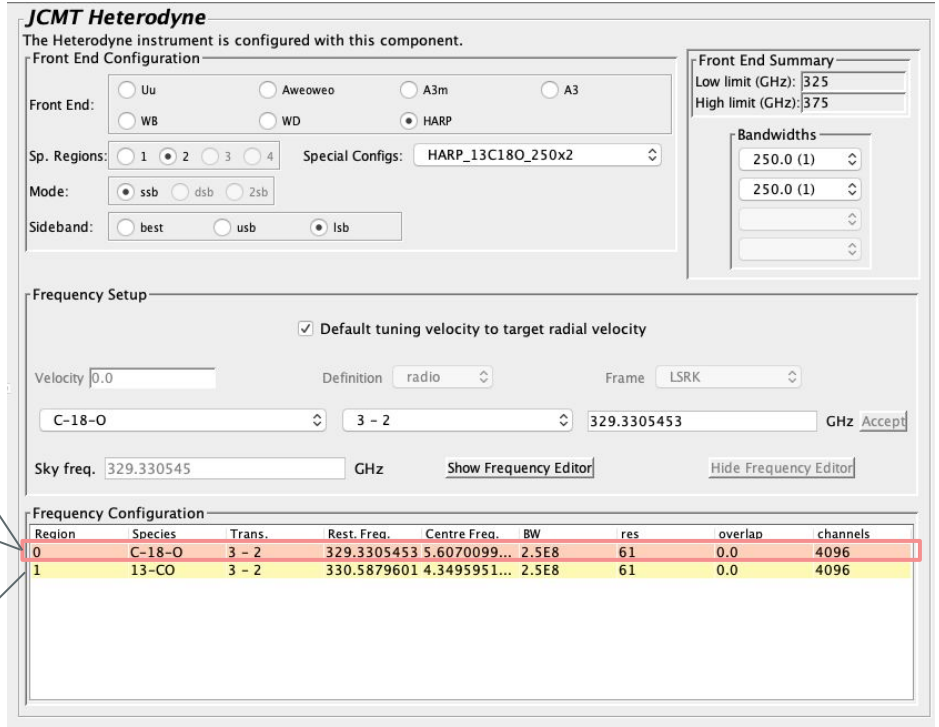
ACSIS: Broken Synthesiser issue (April/May 2021)

ACSIS will use the LO2's in the following order LO2#0, LO2#1 with half of HARP receptors and LO2#2, LO2#3 with the other half of HARP receptors. In this example the IF must be shifted for Spectral Regions 0 to:

- <5.5GHz with a bandwidth of 1000MHz
- <5.375GHz with a bandwidth of 250MHz

LO2#0 used for Spectral Region 0 on half of HARP receptors. LO2#2 used for Spectral Region 0 for half of HARP receptors.

LO2#1 used for Spectral Region 0 on half of HARP receptors. LO2#3 used for Spectral Region 1 for half of HARP receptors.



Layout of the ACSIS System

Receiver Cabin Recep.	Nasmyth Switch In	HARP Recep.	Nasmyth Switch In	Nasmyth Switch Out	ACSIS In	Quad Switch In Crate / Port	Quad Switch Out Crate / Port	DCM ID	DCM Crate/ Slot	Sampler Crate / Slot / AorB	CM ID	Corr. Crate / Slot
A	W4	G / H06	H4	A4	4	1 / 1	1 / 5	1	1 / 0	1 / 0 / B	0	1 / 0
							1 / 6	2				
		B / H01	H3	A3	3	1 / 3	1 / 7	3				
							1 / 8	4				
	W2	H / H07	H2	A2	2	1 / 2	1 / 9	5				
							1 / 10	6				
		A / H00	H1	A1	1	1 / 4	1 / 11	7				
							1 / 12	8				
	W8	F / H05	H8	A8	8	2 / 1	2 / 5	9				
							2 / 6	10				
		C / H02	H7	A7	7	2 / 3	2 / 7	11				
							2 / 8	12				
	W6	E /H04	H6	A6	6	2 / 2	2 / 9	13				
							2 / 10	14				
		D /H03	H5	A5	5	2 / 4	2 / 11	15				
							2 / 12	16				
BA /DA	W12	J /H09	H12	A12	12	3 / 1	3 / 5	17				
							3 / 6	18				
		O / H14	H11	A11	11	3 / 3	3 / 7	19				
							3 / 8	20				
	W10	I / H08	H10	A10	10	3 / 2	3 / 9	21				
							3 / 10	22				
		P / H15	H9	A9	9	3 / 4	3 / 11	23				
							3 / 12	24				
BB / DB	W16	K / H10	H16	A16	16	4 / 1	4 / 5	25				
							4 / 6	26				
		N / H13	H15	A15	15	4 / 3	4 / 7	27				
							4 / 8	28				
	W14	L / H11	H14	A14	14	4 / 2	4 / 9	29	4 / 4	2 / 4 / A	28	8 / 0
							4 / 10	30	4 / 5	2 / 5 / A	29	8 / 1
		M / H12	H13	A13	13	4 / 4	4 / 11	31	4 / 6	2 / 6 / A	30	8 / 2
							4 / 12	32	4 / 7	2 / 7 / A	31	8 / 3

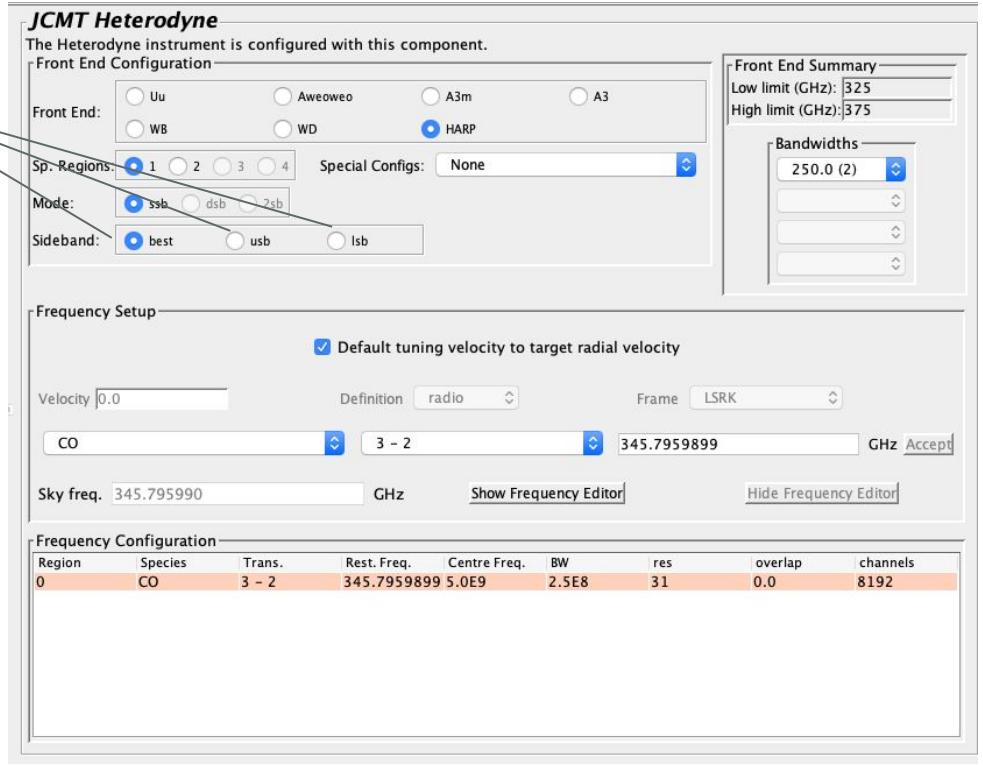
DCM	HARP	Nāmkanui
0, 1	H00	
2, 3	H01	
4, 5	H07	NU1L, NW1L, NA1
6, 7	H06	NU1L, NW1L, NA1
8, 9	H05	
10, 11	H09	
12, 13	H04	NU1U, NW1U
14, 15	H03	NU1U, NW1U
16, 17	H02	
18, 19	H14	
20, 21	H08	NU0U, NW0U
22, 23	H12	NU0U, NW0U
24, 25	H10	NU0L, NW0L, NA0
26, 27	H13	NU0L, NW0L, NA0
28, 29	H11	
30, 31	H15	

A note on “best” sideband

“Best” sideband - in the JCMTOT

The sideband for an observation to be taken in is selected in the JCMT Heterodyne component.

- **Best**: will place line in USB or LSB for the best noise performance.
- **LSB**: will place the line in LSB with IF selected.
- **USB**: will place line in USB with IF selected.



In the JCMTOT users can select the IF required by an observation. It is noted that the defaults are selected for best noise performance:

- HARP default IF = 5GHz
- `Āweoweo default IF = 5GHz
- `Ū`ū default IF = 6GHz

“Best” sideband – in the JCMTOT: Beware!

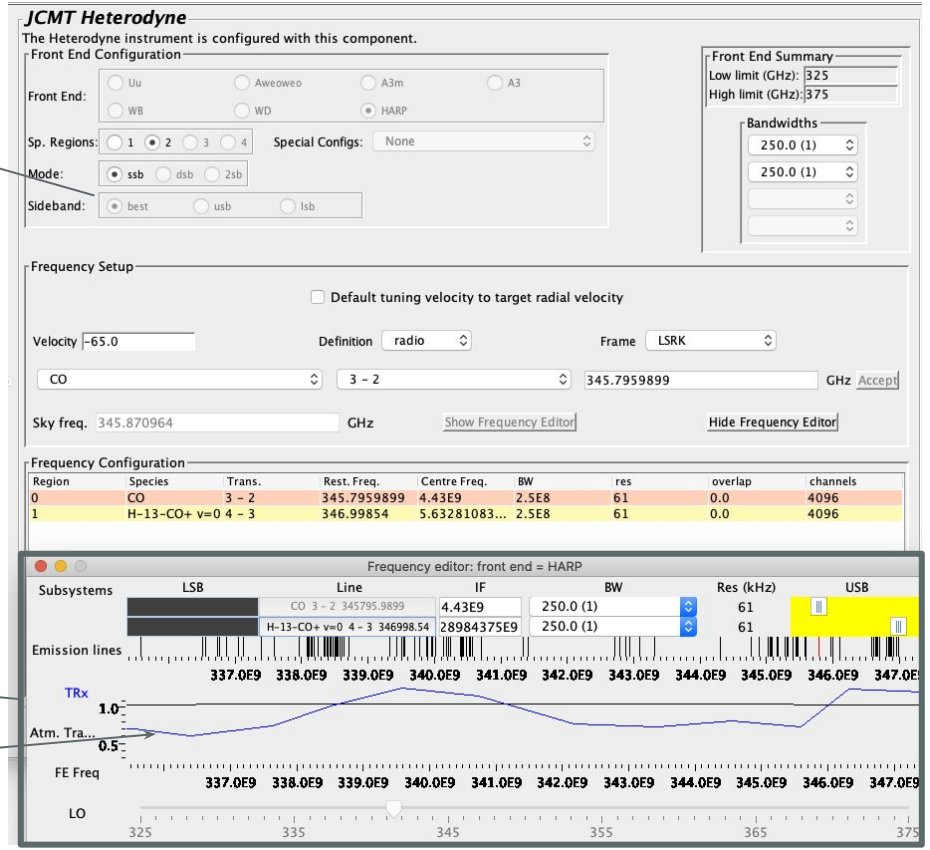
When selecting “Best” and without using the Front End default IF one must be careful!

Example: A user selects the Special Configuration “HARP_CO_H13CO_250x2”.

The JCMTOT automatically selects “best sideband” and the IF for the observation is reported to be set at 4.43GHz and 5.63GHz for the two lines in the Frequency Configuration.

Beware: At these frequencies LSB is the best sideband for use. However the IF selected is assumed to be for USB - *we can see this by inspecting the Frequency Editor*.

Here we see USB selected but by looking at the blue TRx line we see that the LSB has better performance.



“Best” sideband - in the JCMTOT: Beware!

To get the IF for the “best” (in this case the LSB) the system mirrors the IF around the default 5GHz.

- For the CO line with an IF of 4.43GHz, the IF is -0.57GHz off from the mirror IF.
- For the H13CO+ line with an IF of 5.63GHz, the IF is +0.63GHz off from the mirror IF.

The CO observation is therefore executed at an IF of 5.57GHz in the LSB. The H13CO+ observation is executed at an IF of 4.37GHz in the LSB.
e.g. 20210717.004

A better way?
Normally “best” is best! However when avoiding an LO2 issue select either LSB or USB when setting up MSBs so you have a full understanding/control of the set up!