ALMA Science

What spectral resolution will I get for a given channel spacing?

Imported User 25 - 2020-09-21 - General ALMA Queries

The spectral resolution of ALMA data will be two times worse the channel spacing, as the data will be Hanning smoothed by default, when no channel averaging is set (N=1) in the Observing Tool (OT) by the proposers. The OT reports the number of Hanning-smoothed spectral resolution elements per line width (taking into account any spectral averaging) and the width of the representative spectral window. The spectral capability is explained in greater detail in Appendix section "Spectral Capabilities" of Proposer's Guide, and Chapter "The Correlators" of the ALMA Technical Handbook. This smoothing function can be changed or turned off during the Phase 2 process when successful PIs set up their observations.

Channel averaging is available to bin or average spectral channels. Channels can be averaged together; factors of N = 2, 4, 8, or 16 are available. The main purpose is to reduce the data rate to the archive and the total data volume. It also provides a broader spread of correlator functionality between the current TDM (which has only 128 channels in dual polarization) and full FDM (with 3840 channels in dual polarization mode). It might be quite acceptable for those who need something with more resolution than TDM, but where the FDM channels at the full resolution are unnecessary. Please look at Table 1 below (the same as Table 5.2 in the Technical Handbook) about the resolutions (in kHz) for different values of N, using Hanning weighting, in the different bandwidth modes.

Usable bandwidth (MHz)		Spectral resolution (channel spacing) [kHz]				
	N=	1	2	4	8	16
	Channels=	3840	1920	960	480	240
1875		977 (488)	1129 (977)	1938 (1953)	3904 (3906)	7813 (7813)
937.5		488 (244)	564 (488)	969 (977)	1952 (1953)	3906 (3906)
468.8		244 (122)	282 (244)	485 (488)	976 (977)	1953 (1953)
234.4		122 (61)	141 (122)	242 (244)	488 (488)	977 (977)

117.2		61 (31)	71 (61)	121 (122)	244 (244)	488 (488)
58.6		31 (15)	35 (31)	61 (61)	122 (122)	244 (244)

Table 1: Spectral resolution and channel spacing (in parentheses) in kHz for different correlator bandwidth modes (left column) and for different channel averaging factors (columns, N = 1 to 16), using Hanning smoothing. For the case of one spw per baseband, the number of channels can be reduced from 3840 (for the un-averaged case, N = 1) down to 240 (for N = 16). As N increases, the spectral resolution functions of adjoining channels are combined and then the spectral resolution approaches to the channel spacing. Values are given for the 2-polarization case.

Note that the default Hanning window function gives a resolution 2.0 time the channel spacing, so using N=2 (cutting the number of spectral channels from 3840 to 1920) results in negligible loss of final resolution (15%). It is recommended that unless the maximum spectral resolution is required by the observations, to reduce the number of channels when feasible. This is selected in Phase 2 of the Scheduling Block creation. However, note that this is a non-reversible operation!

Another effect of online channel averaging is that it changes the effective noise bandwidth of a channel. With the default Hanning smoothing enabled, the effective noise bandwidth of a channel is actually 8/3 = 2.667 times the physical bandwidth of the channel. This effect arises because the smoothing makes adjacent channels less independent from each other in a statistical sense. As a consequence, the expected image rms obtained by imaging two adjacent channels will **not** be sqrt(2) lower than imaging just one of those channels. Instead, it will be only (3.200/2.667)**0.5 = 1.095 times lower. Online channel averaging has the opposite effect, making the output channels more independent. The effect is quantified in Table 2 below. This effect has been verified by imaging real ALMA data while combining increasing numbers of adjacent channels. The pipeline accounts for this effect properly, but only for data from Cycle 3 onward, since only then did the SPECTRAL_WINDOW table of the measurement sets contain the correct values of effective channel bandwidth for each spectral window. (In Cycles 0-2, the effective channel bandwidths in this table were simply set equal to the physical channel bandwidths.)

N=	1	2	4	8	16
Channels=	3840	1920	960	480	240
Effective bandwidth of one output channel (in units of the output channel bandwidth)	2.667	1.600	1.231	1.104	1.049
Image rms improvement obtained from combining 2 adjacent channels compared to 1	1.095	1.118	1.275	1.346	1.381

Table 2: The effect of online channel averaging (N) on the effective bandwidth of each

channel in the resulting spectrum.