How to prepare Technical Justification (TJ)

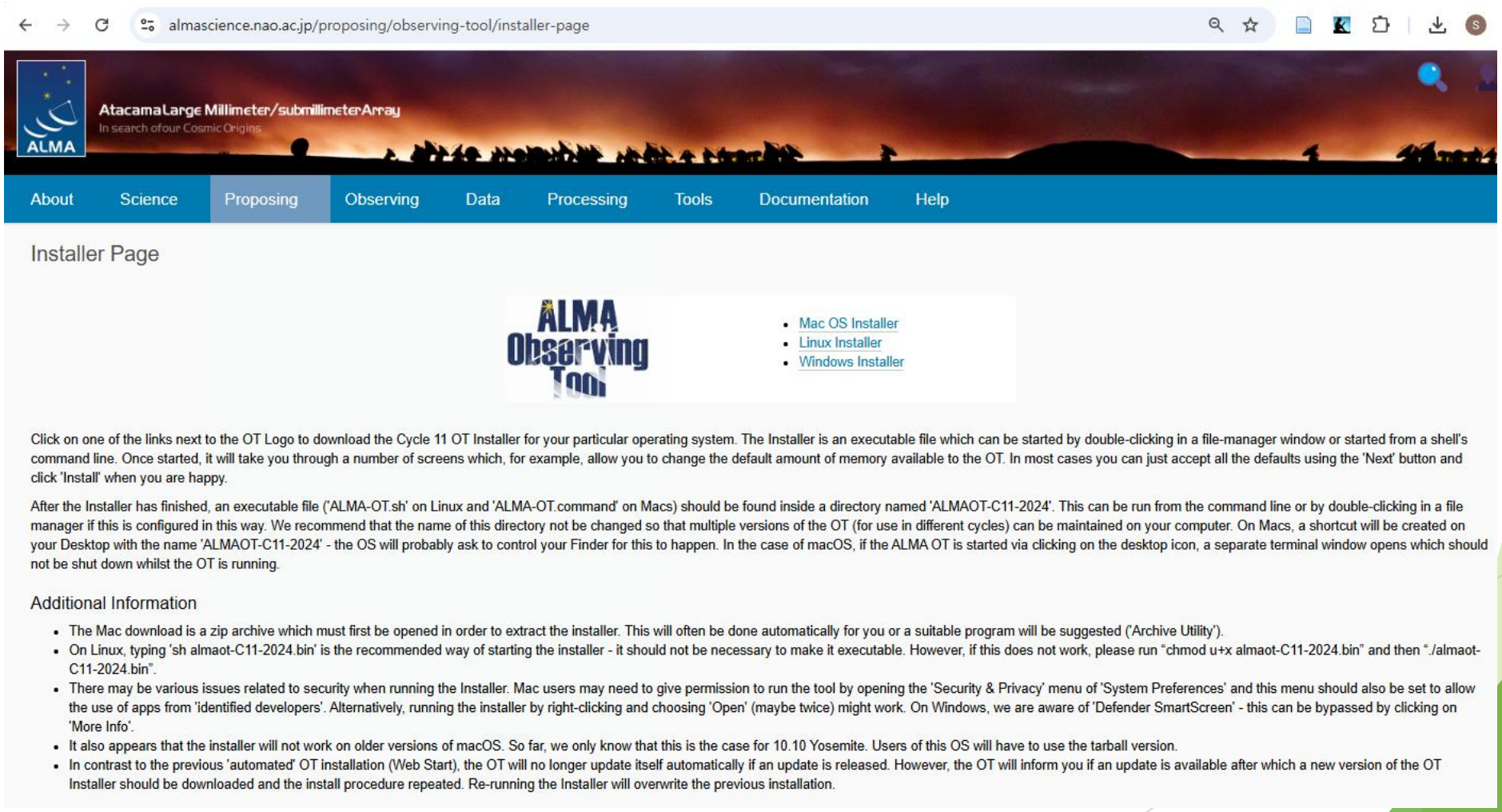
2025. 1. 14.

Seokho Lee (KASI)

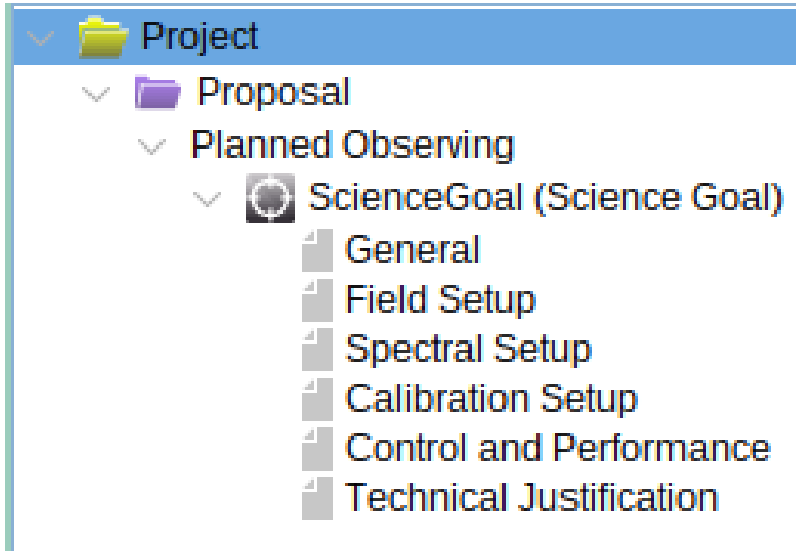
Technical Justification

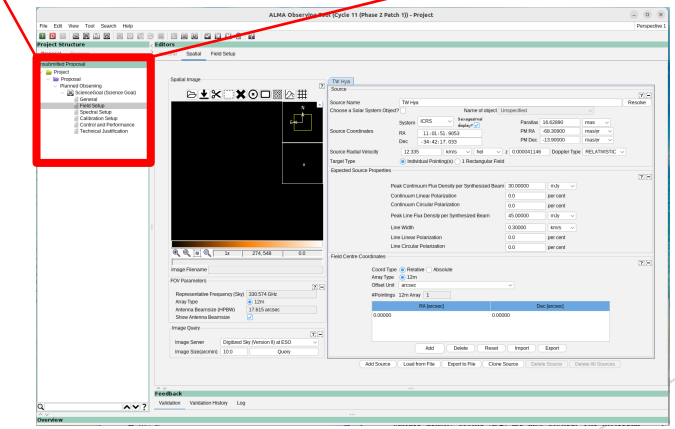
- convinces the reviewer that the observation setups: Sensitivity, Scales, Correlator (Band, lines)
  - can achieve the scientific goals (SGs)
  - is the best setup to achieve the SGs
  - uses ALMA time in the most efficient way

Observing Tool (https://almascience.nao.ac.jp/proposing/observing-tool/installer-page)



Reduce a Number of Science Goal in Observing Tool





S.G. : a set of observational parameters in a single goal. Mulitple lines are observed simultanueously.

Parameters

- Scales
  - Beam size, Largest Angular Scale (LAS), and Field of View (FoV)
- Expected Source Properites
  - Intensities and Line width (Systemic velocity)
- Spectral Setups
  - Bands and lines

Parameters (I)

- Scales (Control and Performance; Field Setup)
  - **Angular Resolution** (beam size) ~ depend on the longest baseline and frequency.
  - **Maximum Recoverable Scale** (MRS)
    - depends on the shortest baseline (~ 10 x beam size)
    - When the scale is loger than MRS, the emission is resolve out
    - **Largest Angular Structure (LAS)**< MRS → single configuration
    - LAS > MRS → multiple configuration or ACA and TP are added.
  - Field of View (FOV)
    - FWHM of the 12m telescope primary beam
    - ~19 arcsec (33 arcsec) @ 300 GHz for 12m (7m)
    - Area of target is larger than 1/3 FOV, mosaic is needed

Cycle 12

Start Date	Configuration	Longest baseline	LST: Best
1-Oct-2025	C-8	8.5 km	22-10
20-Oct-2025	C-7	3.6 km	23-11
10-Nov-2025	C-6	2.5 km	1-13
1-Dec-2025	C-5	1.4 km	2-14
20-Dec-2025	C-4	0.78 km	4-15
10-Jan-2026	C-3	0.50 km	5-17
1-Feb-2026	No observations due to maintenance		
1-Mar-2026	C-1	0.16 km	8-21
26-Mar-2026	C-2	0.31 km	9-23
20-Apr-2026	C-3	0.50 km	11-0
10-May-2026	C-4	0.78 km	12-2
31-May-2026	C-5	1.4 km	13-4
23-Jun-2026	C-6	2.5 km	15-6
28-Jul-2026	C-5	1.4 km	17-7
18-Aug-2026	C-4	0.78 km	19-8
10-Sep-2026	C-3	0.50 km	20-9

Config.	L_{max} / L_{min}	Band / Freq. (GHz)	1 / 40	3 / 100	4 / 150	5 / 185	6 / 230	7 / 345	8 / 460	9 / 650	10 / 870
7-m	45 m	θ_{res} (arcsec)	31.5	12.5	8.35	6.77	5.45	3.63	2.72	1.93	1.44
	9 m	θ_{MRS} (arcsec)	167	66.7	44.5	36.1	29.0	19.3	14.5	10.3	7.67
C-1	161 m	θ_{res} (arcsec)	8.45	3.38	2.25	1.83	1.47	0.98	0.74	0.52	0.39
	15 m	θ_{MRS} (arcsec)	71.2	28.5	19.0	15.4	12.4	8.25	6.19	4.38	3.27
C-2	314 m	θ_{res} (arcsec)	5.75	2.30	1.53	1.24	1.00	0.67	0.50	0.35	0.26
	15 m	θ_{MRS} (arcsec)	56.5	22.6	15.0	12.2	9.81	6.54	4.90	3.47	2.59
C-3	500 m	θ_{res} (arcsec)	3.55	1.42	0.94	0.77	0.62	0.41	0.31	0.22	0.16
	15 m	θ_{MRS} (arcsec)	40.5	16.2	10.8	8.73	7.02	4.68	3.51	2.48	1.86
C-4	784 m	θ_{res} (arcsec)	2.30	0.92	0.61	0.50	0.40	0.27	0.20	0.14	0.11
	15 m	θ_{MRS} (arcsec)	28.0	11.2	7.50	6.08	4.89	3.26	2.44	1.73	1.29
C-5	1.4 km	θ_{res} (arcsec)	1.38	0.55	0.36	0.30	0.24	0.16	0.12	0.084	0.063
	15 m	θ_{MRS} (arcsec)	16.8	6.70	4.47	3.62	2.91	1.94	1.46	1.03	0.77
C-6	2.5 km	θ_{res} (arcsec)	0.78	0.31	0.20	0.17	0.13	0.089	0.067	0.047	0.035
	15 m	θ_{MRS} (arcsec)	10.3	4.11	2.74	2.22	1.78	1.19	0.89	0.63	0.47
C-7	3.6 km	θ_{res} (arcsec)	0.53	0.21	0.14	0.11	0.092	0.061	0.046	0.033	0.024
	64 m	θ_{MRS} (arcsec)	6.45	2.58	1.72	1.40	1.12	0.75	0.56	0.40	0.30
C-8	8.5 km	θ_{res} (arcsec)	0.24	0.096	0.064	0.052	0.042	0.028	0.021	0.015	0.011
	110 m	θ_{MRS} (arcsec)	3.55	1.42	0.95	0.77	0.62	0.41	0.31	0.22	0.16

Band 5 (around 183GHz) and Bands 7-10 are recommended within LST ranges (not Dec-March)

Parameters (I)

- Scales (Control and Performance; Field Setup)
  - **Angular Resolution** (beam size) ~ depend on the longest baseline and frequency.
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    - depends on the shortest baseline (~ 10 x beam size)
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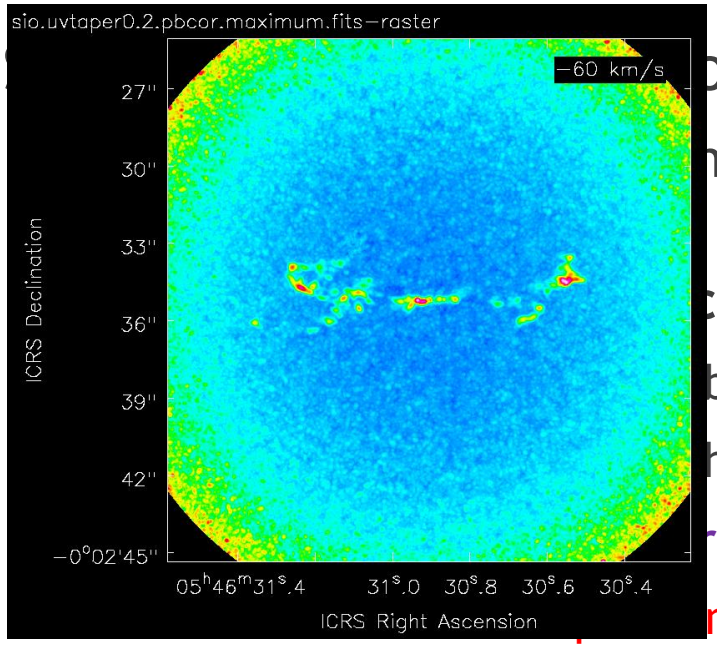
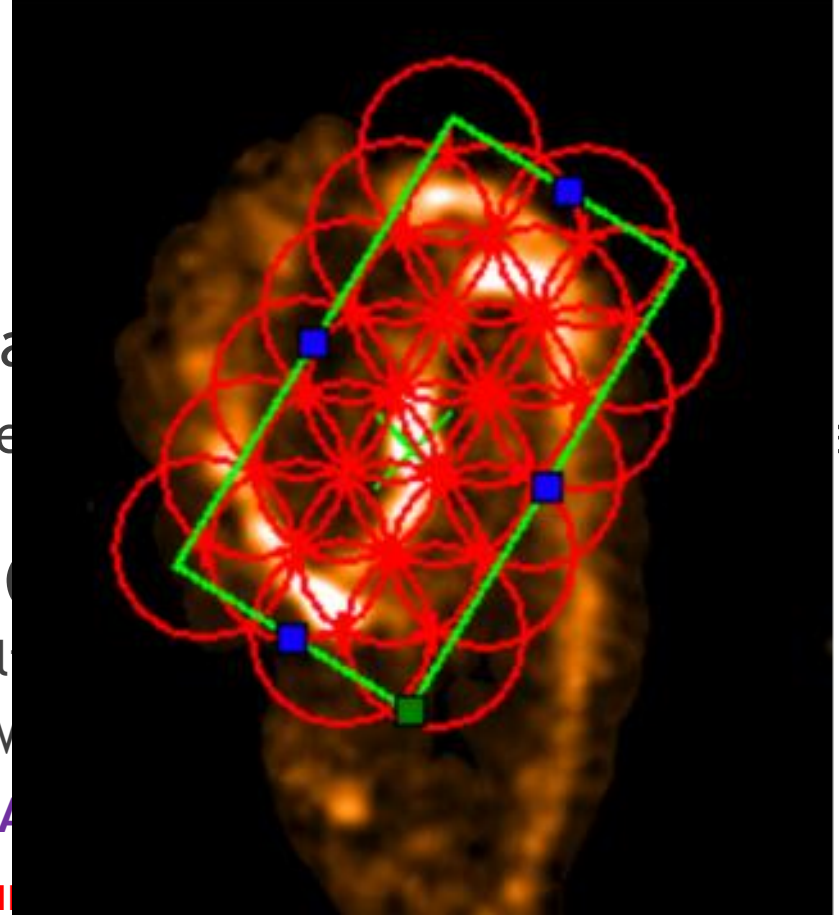
Most Extended configuration	Allowed Compact configuration pairings	Extended 12-m Array Multiplier	Multiplier if compact 12-m Array needed	Multiplier if 7-m Array needed	Multiplier if TP Array needed and allowed (with 7-m Array in 4x4-bit mode)	Multiplier if TP Array needed and allowed (with 7-m Array in 2x2-bit mode)
7-m Array	**TP**			1	1.7	1.4
C-1	**7-m Array & TP**	1		7.0	11.9	9.5
C-2	**7-m Array & TP**	1		4.7	7.9	6.3
C-3	**7-m Array & TP**	1		2.4	4.1	3.3
C-4	**C-1 & 7-m Array & TP**	1	0.34	2.4	4.0	3.2
C-5	**C-2 & 7-m Array & TP**	1	0.26	1.2	2.1	1.7
C-6	**C-3 & 7-m Array & TP**	1	0.25	0.6	1.0	0.8
C-7	**C-4**	1	0.23			
C-8	**C-5**	1	0.22			
C-9	**C-6**	1	0.21			
C-10	–	1				

Table A-2: Allowed Array Combinations and Time Multipliers. See Chapter 7 of the Technical Handbook for relevant equations and detailed considerations. If the array configuration that meets the AR request according to Table A-1 has a MRS that is smaller than the LAS request, the OT checks if adding more compact array configurations, following the restrictions of this Table, fulfills the LAS request. If so, the final setup consists of the selected combination of arrays. Otherwise, the OT returns a validation error.

Parameters (I)





- Field of View (FOV)
  - FWHM of the 12m telescope primary beam
  - ~19 arcsec (33 arcsec) @ 300 GHz for 12m (7m)
  - Area of target is larger than 1/3 FOV, mosaic is needed

Parameters (II)

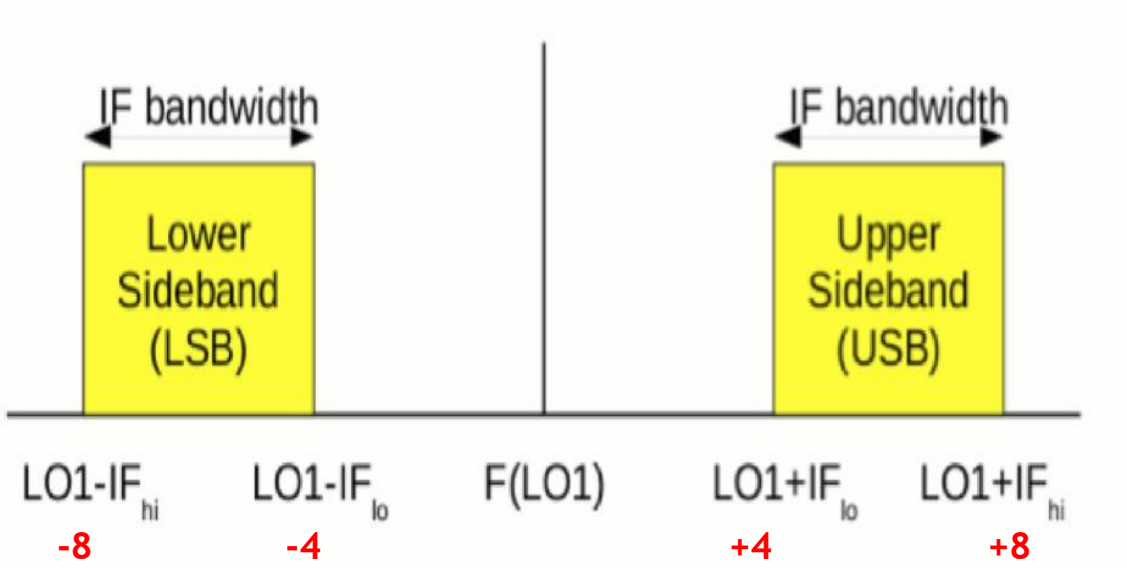
- Expected Source properties (Field Setup)
  - Position, souce velocity
  - **Peak Flux Density per beam** (SNR > 3)
    - RMS (→ integration time)
  - Polarization
    - linear > 0.1% (< 0.3 FOV)
    - circular > 1.8 % (<0.1 FOV)
  - **Line width** > 3 x spectral resolution

You should describe how to derive/adopt these values in Technical Justification

Parameters (III)

- Spectral Setup
  - LSB and/or USB
  - 4 basebands (with 2GHz max. width)
  - 2 or 4 basebands in the one sideband

LSB/USB (<4GHz, ≤4 basebands)
Baseband (<2GHz, ≤4spws)
Spectral window(spw)



Band	Frequency range (GHz)	Wavelength range (mm)	IF range (GHz)	Type
1	35 – 50	8.5 – 6	4 – 12	SSB
3	84 – 116	3.6 – 2.6	4 – 8	2SB
4	125 – 163	2.4 – 1.8	4 – 8	2SB
5	158 – 211	1.9 – 1.4	4 – 8	2SB
6	211 – 275	1.4 – 1.1	4.5 – 10	2SB
7	275 – 373	1.1 – 0.8	4 – 8	2SB
8	385 – 500	0.78 – 0.60	4 – 8	2SB
9	602 – 720	0.50 – 0.42	4 – 12	DSB
10	787 – 950	0.38 – 0.32	4 – 12	DSB

- Spws in a baseband
  - one faction 1
  - two fraction ½
  - four faction ¼
  - one fraction ½ + two fraction ¼
- Spectral windows (SPW) should have the same resolution.

Bandwidth (MHz)	Channel spacing (MHz)	Spectral resolution (MHz)	Number of channels	Correlator mode	Bit Mode
1875	15.6	31.2	120	TDM	
938	0.976	1.952	1024	FDM	4x4 ⋆
1875	0.488	0.976	3840	FDM	2x2
469	0.488	0.976	1024	FDM	4x4
938	0.244	0.488	3840	FDM	2x2
234	0.244	0.488	1024	FDM	4x4
469	0.122	0.244	3840	FDM	2x2
117	0.122	0.244	1024	FDM	4x4
234	0.061	0.122	3840	FDM	2x2
58.6	0.061	0.122	1024	FDM	4x4
117	0.0305	0.061	3840	FDM	2x2
58.6	0.0153	0.0305	3840	FDM	2x2

Table 5.1: Available spectral windows in multi-region mode (dual polarization). Each time the fraction is changed, the number of channels and bandwidth of a particular correlator mode is halved. Each row corresponds to a particular spectral resolution.

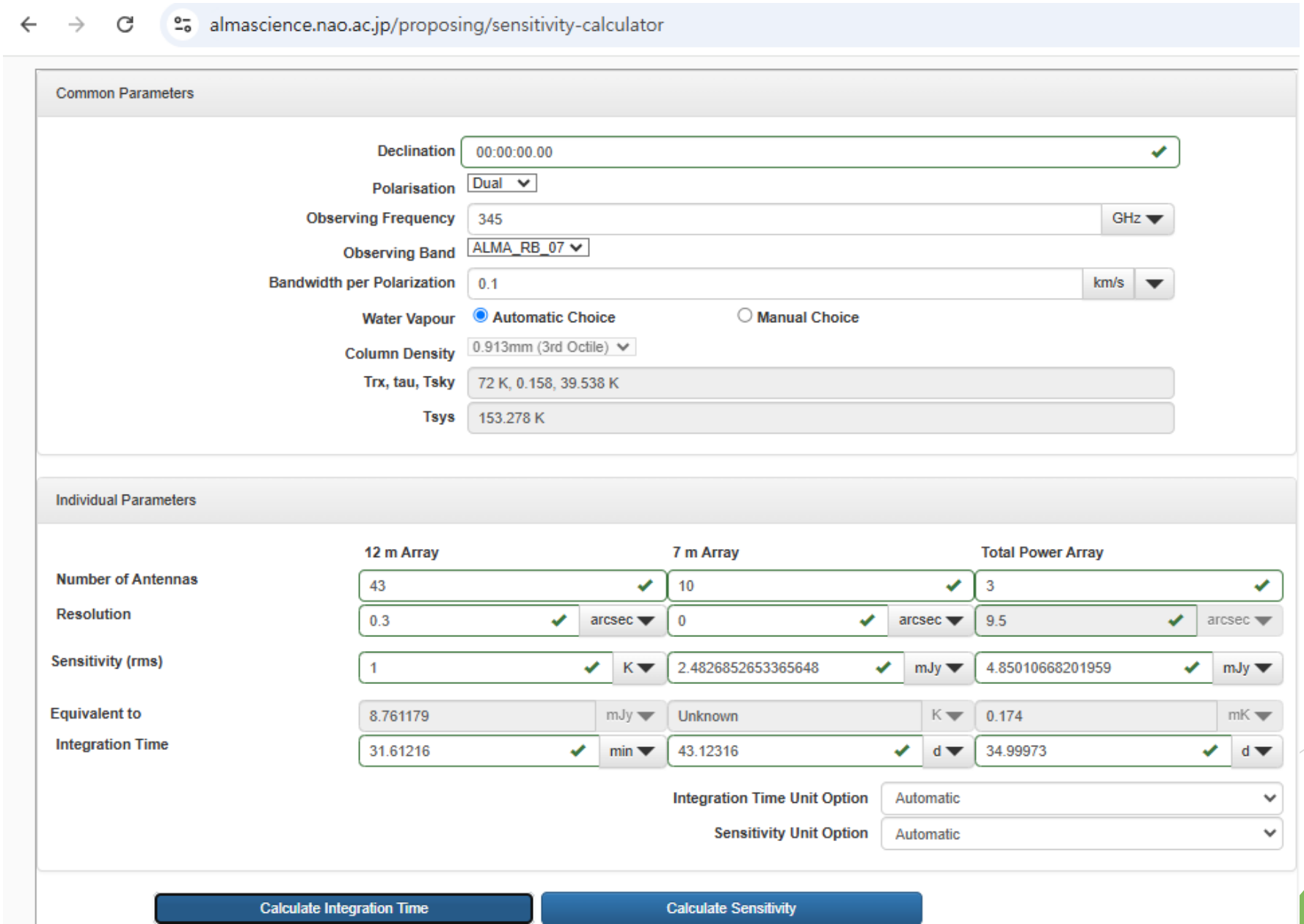
Spectral resolution ∝ 1/ fraction for a given bandwidth

Fraction = 1		Fraction = 1/2		Fraction = 1/4	
Bandwidth (MHz)	# channels	Bandwidth (MHz)	# channels	Bandwidth (MHz)	# channels
1875	4096	937.5	2048	468.75	1024
937.5	4096	468.75	2048	234.375	1024
468.75	4096	234.375	2048	117.118	1024
234.375	4096	117.118	2048	58.594	1024
117.118	4096	58.594	2048	not available	
58.594	4096	not available		not available	

Example

TW Hya with CO observation

ALMA Sensitivity calculator



Installer Page

- Mac OS Installer
- Linux Installer
- Windows Installer

Click on one of the links next to the OT Logo to download the Cycle 11 OT Installer for your particular operating system. The Installer is an executable file which can be started by double-clicking in a file-manager window or started from a shell's command line. Once started, it will take you through a number of screens which, for example, allow you to change the default amount of memory available to the OT. In most cases you can just accept all the defaults using the 'Next' button and click 'Install' when you are happy.

After the Installer has finished, an executable file ('ALMA-OT.sh' on Linux and 'ALMA-OT.command' on Macs) should be found inside a directory named 'ALMAOT-C11-2024'. This can be run from the command line or by double-clicking in a file manager if this is configured in this way. We recommend that the name of this directory not be changed so that multiple versions of the OT (for use in different cycles) can be maintained on your computer. On Macs, a shortcut will be created on your Desktop with the name 'ALMAOT-C11-2024' - the OS will probably ask to control your Finder for this to happen. In the case of macOS, if the ALMA OT is started via clicking on the desktop icon, a separate terminal window opens which should not be shut down whilst the OT is running.

Additional Information

- The Mac download is a zip archive which must first be opened in order to extract the installer. This will often be done automatically for you or a suitable program will be suggested ('Archive Utility').
- On Linux, typing 'sh almaot-C11-2024.bin' is the recommended way of starting the installer - it should not be necessary to make it executable. However, if this does not work, please run “chmod u+x almaot-C11-2024.bin” and then “./almaot-C11-2024.bin”.
- There may be various issues related to security when running the Installer. Mac users may need to give permission to run the tool by opening the 'Security & Privacy' menu of 'System Preferences' and this menu should also be set to allow the use of apps from 'identified developers'. Alternatively, running the installer by right-clicking and choosing 'Open' (maybe twice) might work. On Windows, we are aware of 'Defender SmartScreen' - this can be bypassed by clicking on 'More Info'.
- It also appears that the installer will not work on older versions of macOS. So far, we only know that this is the case for 10.10 Yosemite. Users of this OS will have to use the tarball version.
- In contrast to the previous 'automated' OT installation (Web Start), the OT will no longer update itself automatically if an update is released. However, the OT will inform you if an update is available after which a new version of the OT Installer should be downloaded and the install procedure repeated. Re-running the Installer will overwrite the previous installation.

WARNING: Oracle have reported a serious incompatibility between macOS Sonoma 14.4 and Java which may result in the OT terminating unexpectedly – there is no workaround. Users are advised to avoid using Sonoma 14.4 and the OT if possible. If this is not possible and a user encounters this problem, the OT does have a project auto-backup facility which can be used as a recovery mechanism. Please contact the helpdesk should more information be required.

Integration time for CO with 1 K

CO transition	Freq. (GHz)	ALMA Band	RMS (mJy) @0.3" w/ 1K	Integration time (0.1km/s)	ALMA configuration
1-0	115.271	3	0.98	3.7d/ 2.68 d/ 9.2 d	C-7 (0.092 km/s)
2-1	230.538	6	3.9	1.47h/1.13h/3.59 h	C-5 (0.092 km/s)
3-2	345.796	7	8.8	31.5m/23.7m/ 1.36h	C-5 (0.122 km/s)
4-3	461.041	8	15.6	76.9 min/55.4m/2.75h	C-4 (0.092km/s)
5-4	576.267	X			
6-5	691.473	9	35.2	2.93h/1.58h/5.22h	C-3 (0.122 km/s)
7-6	806.652	10	47.8	3.85h/2.48h/7.37h	C-3 (0.105km/s)
8-7	921.7997	10	62.5	30.7h/16.35h/1.96d (A/ B/ C)	C-2 (0.092km/s)

Integration time:

A: on-source time using sentitivity calucator

B: on-source time using OT

C: total observing time (B + time for calibration + etc)

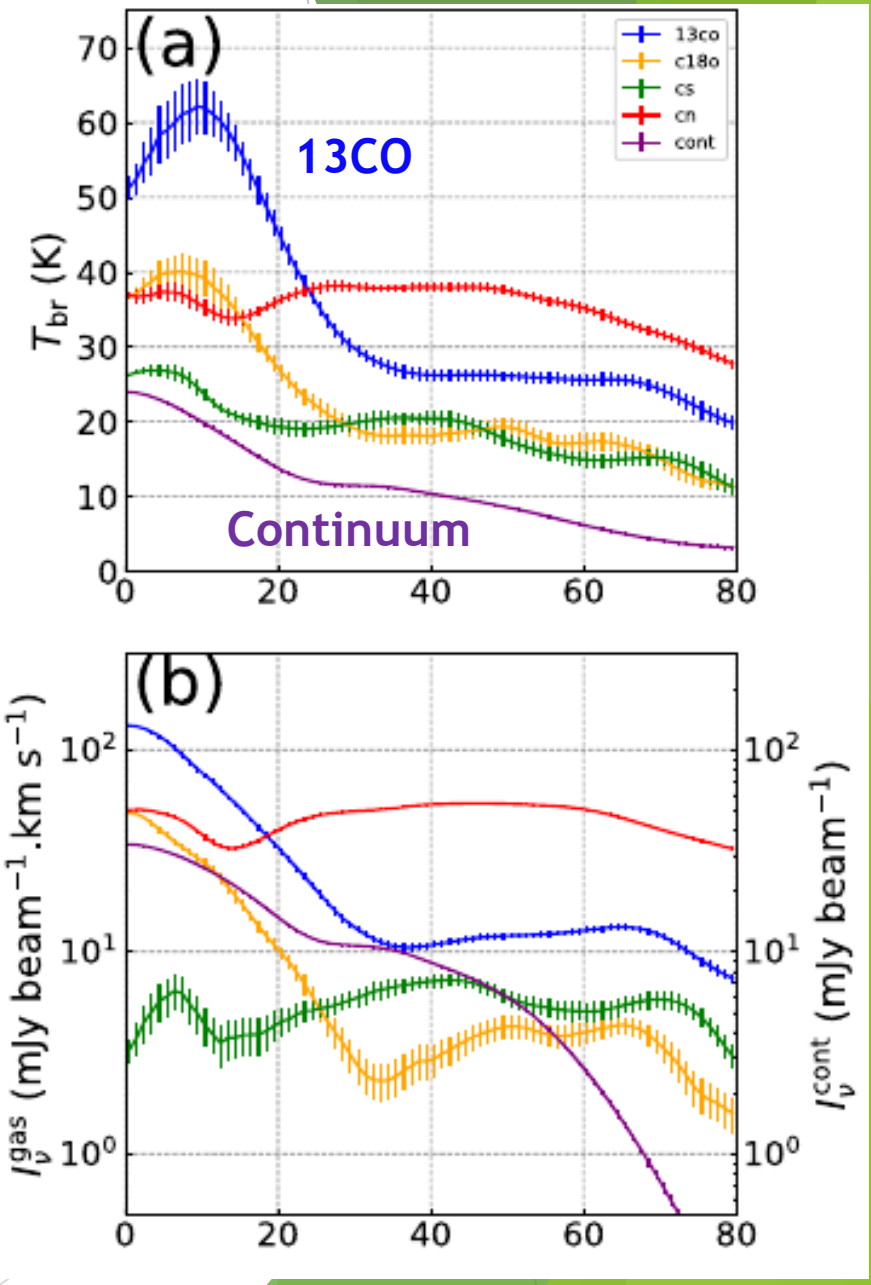
Which band is chosen?

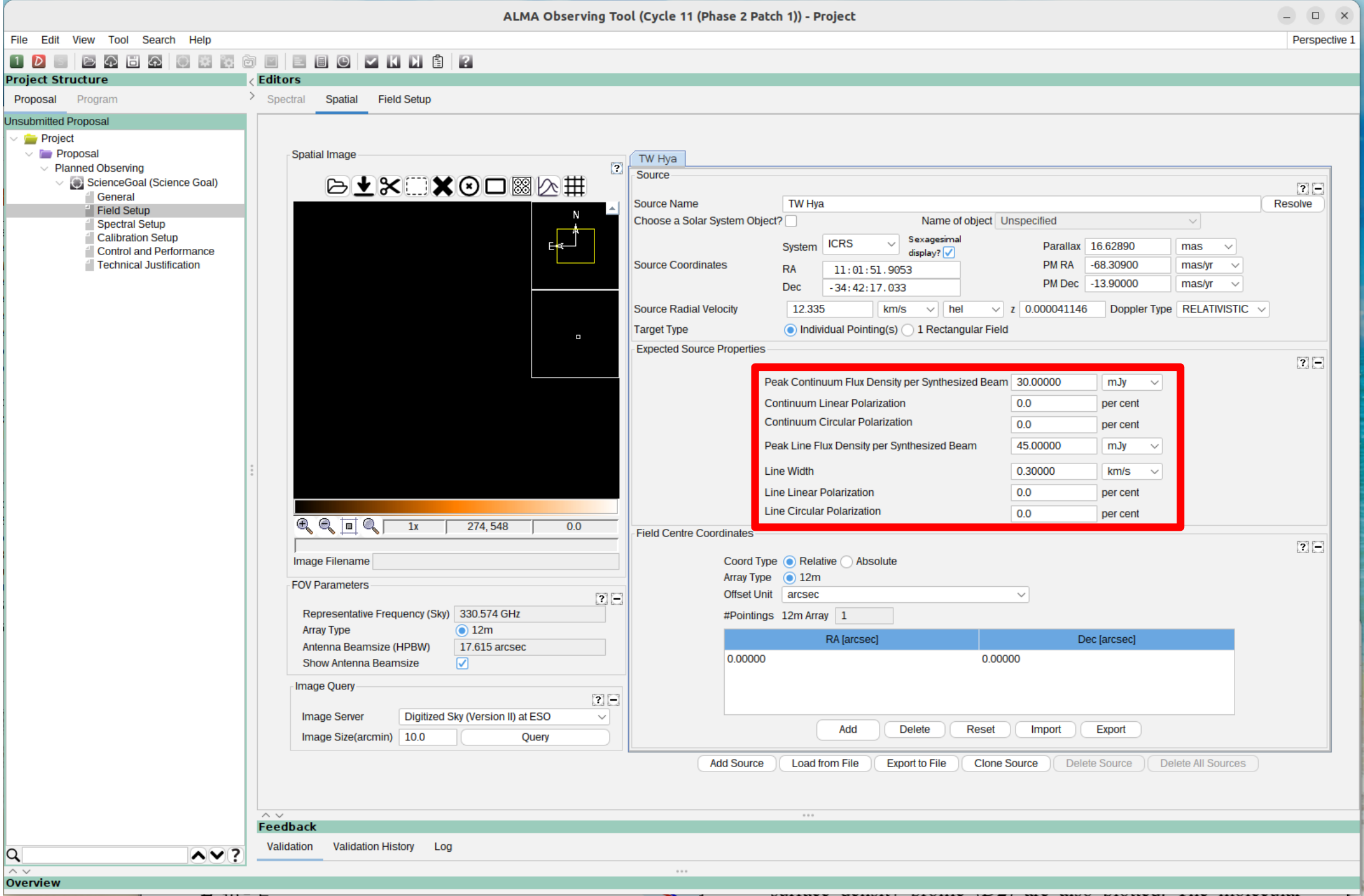
- CO transitions can be convered in the Bands 3, 6, and 7. You should describe why the band is chosen.
  - For a given integration time, band # provides the highest SNR.
  - Other interesting lines can be covered within 1 S.G.s.
  - A relation use the CO 1-0 line..
  - Optically thin line is located only in Band #.
  - When considering of interstellar extinction (optical depth of continuum emission), the line in Band # can trace the midplane of target ...

TW Hya/ Band 7/ 0.15”
Assuming Line Width (FWHM) = 0.3 km/s

You are interested in the continuum peak or 40-60 au:

	0 au	40-60 au
Continuum	30 mJy/beam	7 mJy/beam
13CO	60 K /130 mJy	26 K / 57 mJy




ALMA Observing Tool (Cycle 11 (Phase 2 Patch 1)) - Project
File Edit View Tool Search Help
Perspective 1
Project Structure
Proposal Program
Unsubmitted Proposal
Project
Proposal
Planned Observing
ScienceGoal (Science Goal)
General
Field Setup
Spectral Setup
Calibration Setup
Control and Performance
Technical Justification
Editors
Spectral Spatial Field Setup
Spatial Image
N
E
1x 274, 548 0.0
Image Filename
FOV Parameters
Representative Frequency (Sky) 330.574 GHz
Array Type 12m
Antenna Beamsize (HPBW) 17.615 arcsec
Show Antenna Beamsize
Image Query
Image Server Digitized Sky (Version II) at ESO
Image Size(arcmin) 10.0 Query
TW Hya
Source
Source Name TW Hya Resolve
Choose a Solar System Object? Name of object Unspecified
System ICRS Sexagesimal display?
Source Coordinates RA 11:01:51.9053 Dec -34:42:17.033
Parallax 16.62890 mas
PM RA -68.30900 mas/yr
PM Dec -13.90000 mas/yr
Source Radial Velocity 12.335 km/s hel z 0.000041146 Doppler Type RELATIVISTIC
Target Type Individual Pointing(s) 1 Rectangular Field
Expected Source Properties
Peak Continuum Flux Density per Synthesized Beam 30.00000 mJy
Continuum Linear Polarization 0.0 per cent
Continuum Circular Polarization 0.0 per cent
Peak Line Flux Density per Synthesized Beam 45.00000 mJy
Line Width 0.30000 km/s
Line Linear Polarization 0.0 per cent
Line Circular Polarization 0.0 per cent
Field Centre Coordinates
Coord Type Relative Absolute
Array Type 12m
Offset Unit arcsec
#Pointings 12m Array 1
RA [arcsec] Dec [arcsec]
0.00000 0.00000
Add Delete Reset Import Export
Add Source Load from File Export to File Clone Source Delete Source Delete All Sources
Feedback
Validation Validation History Log
Overview

ALMA Observing Tool (Cycle 11 (Phase 2 Patch 1)) - Project

File Edit View Tool Search Help | Perspective 1

Project Structure

Proposal Program

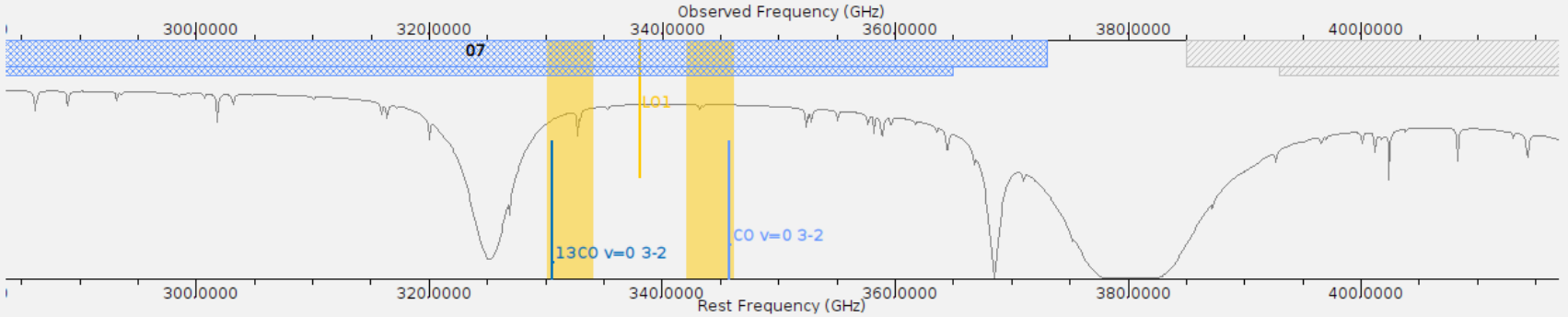
Unsubmitted Proposal

- Project
  - Proposal
    - Planned Observing
      - ScienceGoal (Science Goal)
        - General
        - Field Setup
        - Spectral Setup
        - Calibration Setup
        - Control and Performance
        - Technical Justification

Editors

Spectral Spatial Spectral Setup

To zoom in/out, click on the visualizer and then click left/right, grab sliding bar to pan
Note: Moving LO1 here is for experimentation only - the actual setup is determined by the spectral windows



Overlays: Receiver Bands | Transmission | DSB Image | Spectral Lines | Select Lines to Overlay

Water Vapour Column Density: Automatic Choice | Manual Choice | 0.913mm (3rd Octile)

Viewport: Pan to Spectral Window | Zoom to Band | Reset

Spectral Type

Spectral Type: Spectral Line | Single Continuum | Spectral Scan

Produce image sidebands (Bands 9 and 10 only)

Polarization products desired: XX | DUAL | FULL

Spectral Setup Errors

Spectral Line

Baseband-1

Fraction	Centre Freq (rest,hel)	Centre Freq (sky,hel)	Transition	Bandwidth, Resolution (smoothed)	Spec. Avg.	Representative Window
1(Full)	345.79599 GHz	345.78176 GHz	CO v=0 3-2	234.375 MHz(203 km/s), 141.113 kHz(0.122 km/s) (2-bit)	2	

Add spectral window centred on a spectral line | Add spectral window manually | Delete | Show image spectral windows

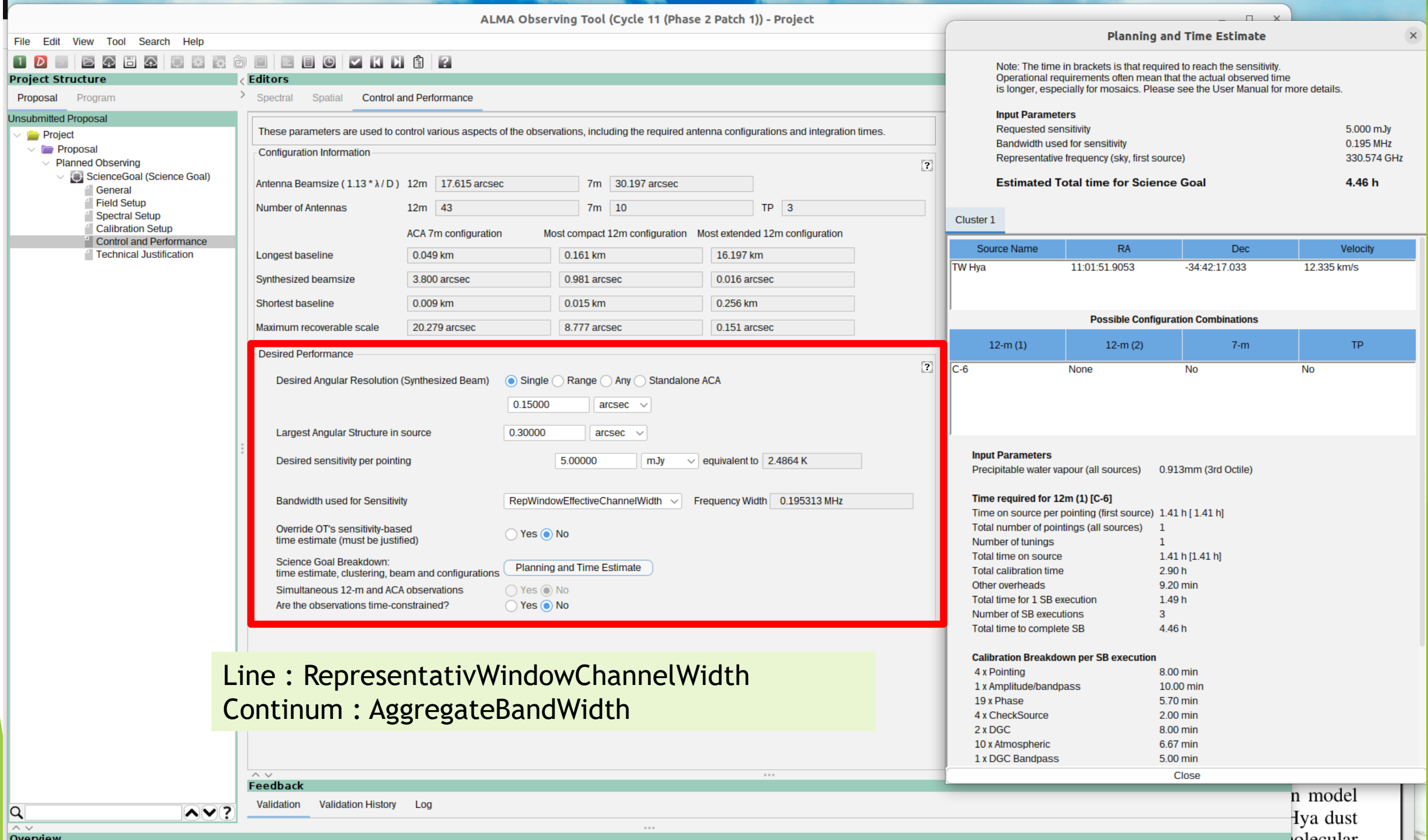
Baseband-2

1(Full)	330.58797 GHz	330.57436 GHz	13CO v=0 3-2	234.375 MHz(213 km/s), 141.113 kHz(0.128 km/s) (2-bit)	2	

Feedback

Validation Validation History Log

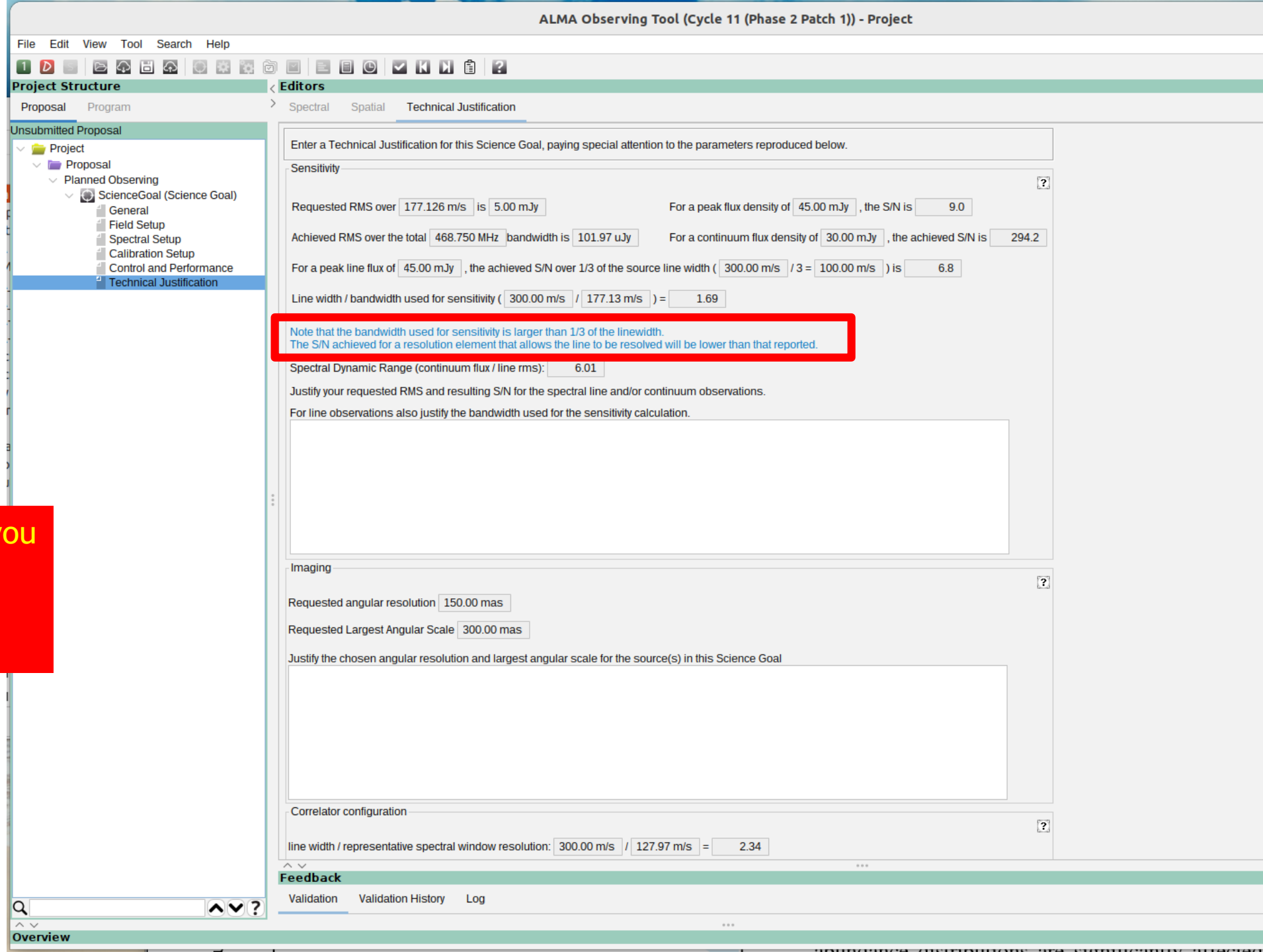
Overview

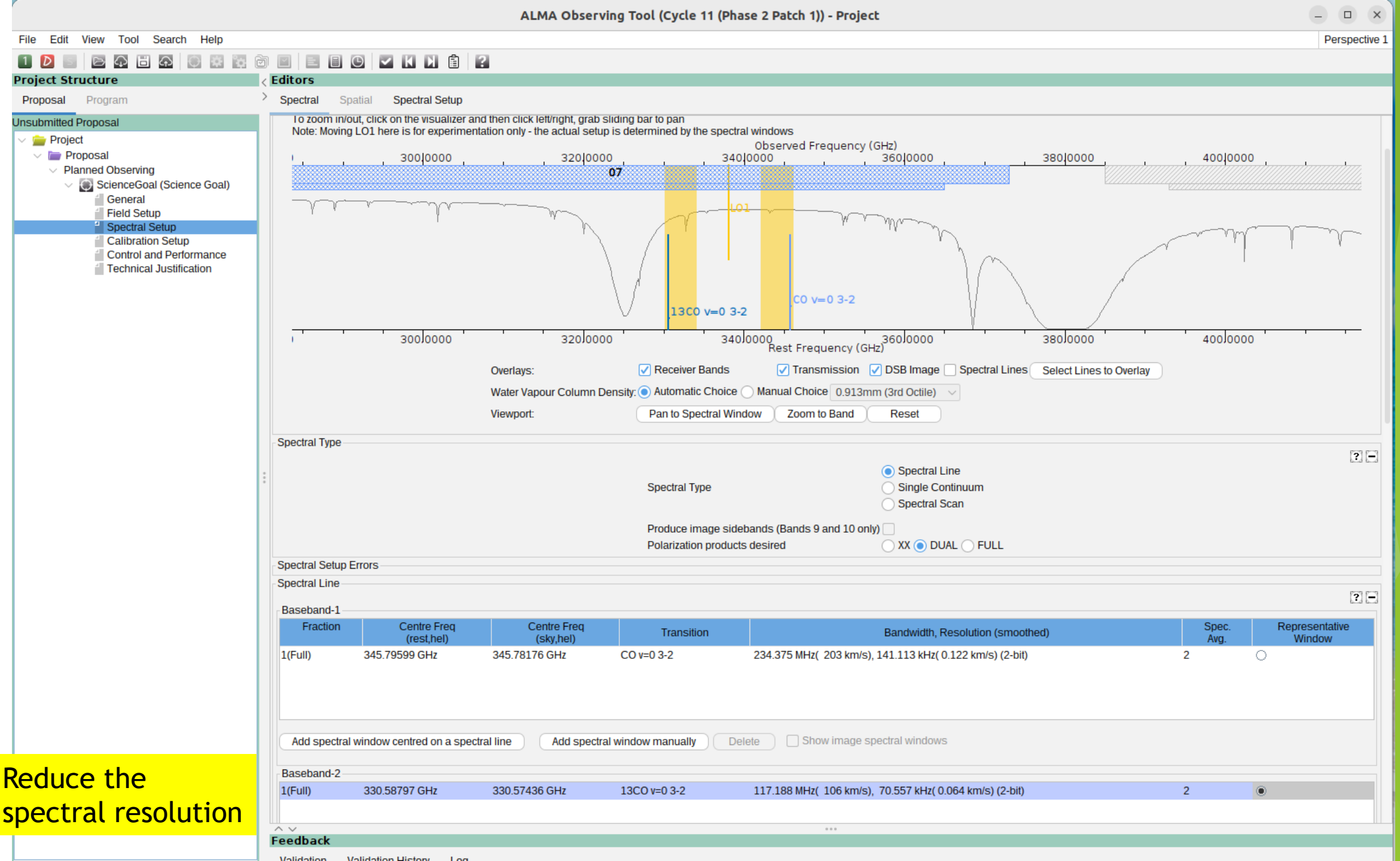


Line : RepresentativWindowChannelWidth
Continum : AggregateBandWidth

Technical Justificaiton

If the blue text appears, you **should** describe why that parameter is requested,
Or change the parameter.





Reduce the spectral resolution

ALMA Observing Tool (Cycle 11 (Phase 2 Patch 1)) - Project

File Edit View Tool Search Help

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        - Control and Performance
        - Technical Justification

Editors

Spectral Spatial Control and Performance

These parameters are used to control various aspects of the observations, including the required antenna configurations and integration times.

Configuration Information

Antenna Beamsize (1.13 * λ / D)	12m	17.615 arcsec	7m	30.197 arcsec	
Number of Antennas	12m	43	7m	10	TP 3

	ACA 7m configuration	Most compact 12m configuration	Most extended 12m configuration
Longest baseline	0.049 km	0.161 km	16.197 km
Synthesized beamsize	3.800 arcsec	0.981 arcsec	0.016 arcsec
Shortest baseline	0.009 km	0.015 km	0.256 km
Maximum recoverable scale	20.279 arcsec	8.777 arcsec	0.151 arcsec

Desired Performance

Desired Angular Resolution (Synthesized Beam) ◉ Single ○ Range ○ Any ○ Standalone ACA

0.15000 arcsec

Largest Angular Structure in source 0.30000 arcsec

Desired sensitivity per pointing 7.07 mJy equivalent to 3.5157 K

Bandwidth used for Sensitivity RepWindowEffectiveChannelWidth Frequency Width 0.097656 MHz

Override OT's sensitivity-based time estimate (must be justified) ○ Yes ◉ No

Science Goal Breakdown: time estimate, clustering, beam and configurations [Planning and Time Estimate]

Simultaneous 12-m and ACA observations ○ Yes ◉ No

Are the observations time-constrained? ○ Yes ◉ No

Validation Validation History Log

Planning and Time Estimate

Note: The time in brackets is that required to reach the sensitivity.
Operational requirements often mean that the actual observed time is longer, especially for mosaics. Please see the User Manual for more details.

Input Parameters

Requested sensitivity	7.070 mJy
Bandwidth used for sensitivity	0.098 MHz
Representative frequency (sky, first source)	330.574 GHz
Estimated Total time for Science Goal	**4.46 h**

Cluster 1

Source Name	RA	Dec	Velocity
TW Hya	11:01:51.9053	-34:42:17.033	12.335 km/s

Possible Configuration Combinations

12-m (1)	12-m (2)	7-m	TP
C-6	None	No	No

Input Parameters

Precipitable water vapour (all sources)	0.913mm (3rd Octile)

Time required for 12m (1) [C-6]

Time on source per pointing (first source)	1.41 h [1.41 h]
Total number of pointings (all sources)	1
Number of tunings	1
Total time on source	1.41 h [1.41 h]
Total calibration time	2.90 h
Other overheads	9.20 min
Total time for 1 SB execution	1.49 h
Number of SB executions	3
Total time to complete SB	4.46 h

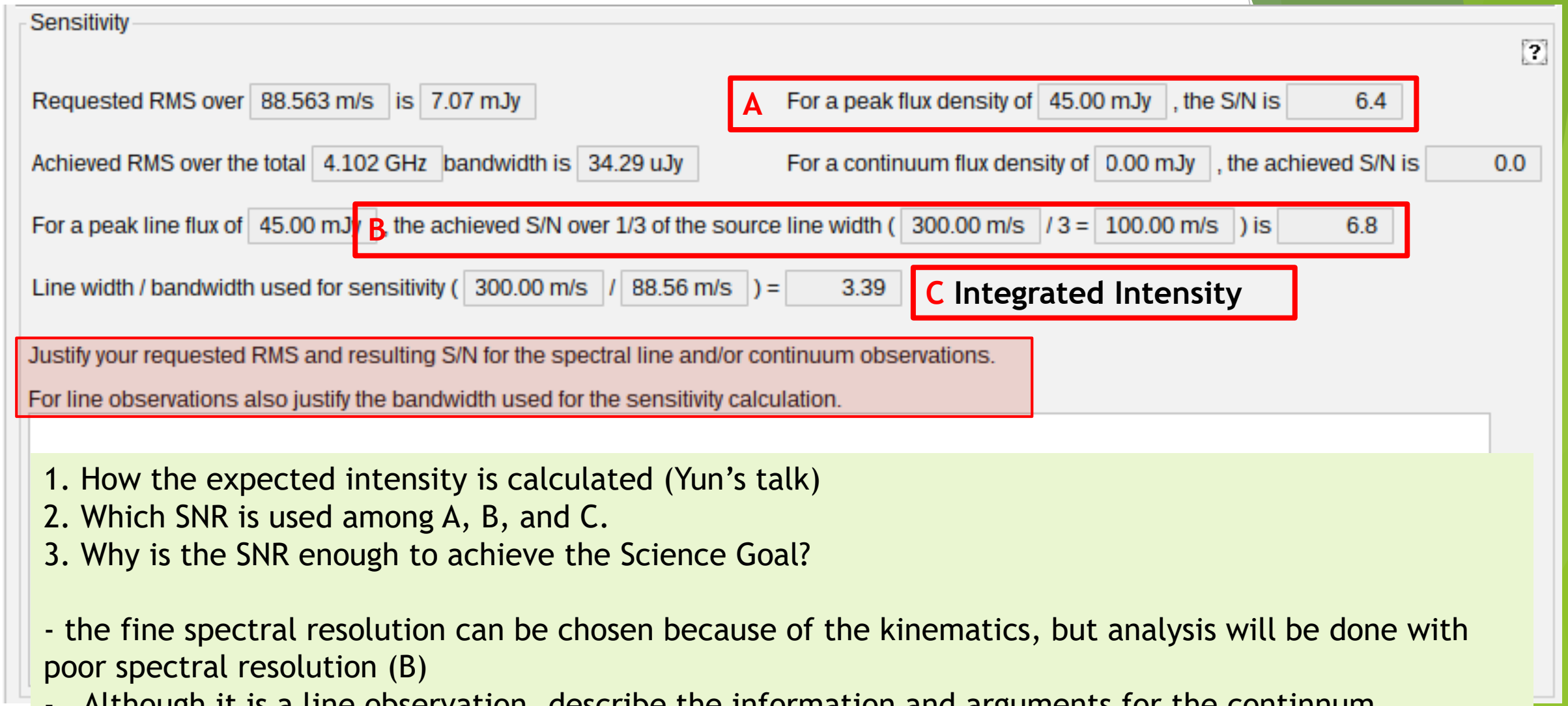
Calibration Breakdown per SB execution

4 x Pointing	8.00 min
1 x Amplitude/bandpass	10.00 min
19 x Phase	5.70 min
4 x CheckSource	2.00 min
2 x DGC	8.00 min
10 x Atmospheric	6.67 min
1 x DGC Bandpass	5.00 min

Close

For the same integration time,

$$\frac{RMS(NEW)}{RMS(OLD)} = \sqrt{\frac{\Delta v(old)}{\Delta v(new)}}$$



1. How the expected intensity is calculated (Yun's talk)
2. Which SNR is used among A, B, and C.
3. Why is the SNR enough to achieve the Science Goal?

- the fine spectral resolution can be chosen because of the kinematics, but analysis will be done with poor spectral resolution (B)
- Although it is a line observation, describe the information and arguments for the continnum

Tip: You can refer the figures in S.J. and/or cite references (XX et al. ApJ, ###, ###)

Sensitivity

Requested RMS over 88.563 m/s is 7.07 mJy

For a peak flux density of 45.00 mJy , the S/N is 6.4

Achieved RMS over the total 4.102 GHz bandwidth is 34.29 uJy

For a continuum flux density of 0.00 mJy , the achieved S/N is 0.0

For a peak line flux of 45.00 mJy , the achieved S/N over 1/3 of the source line width (300.00 m/s / 3 = 100.00 m/s) is 6.8

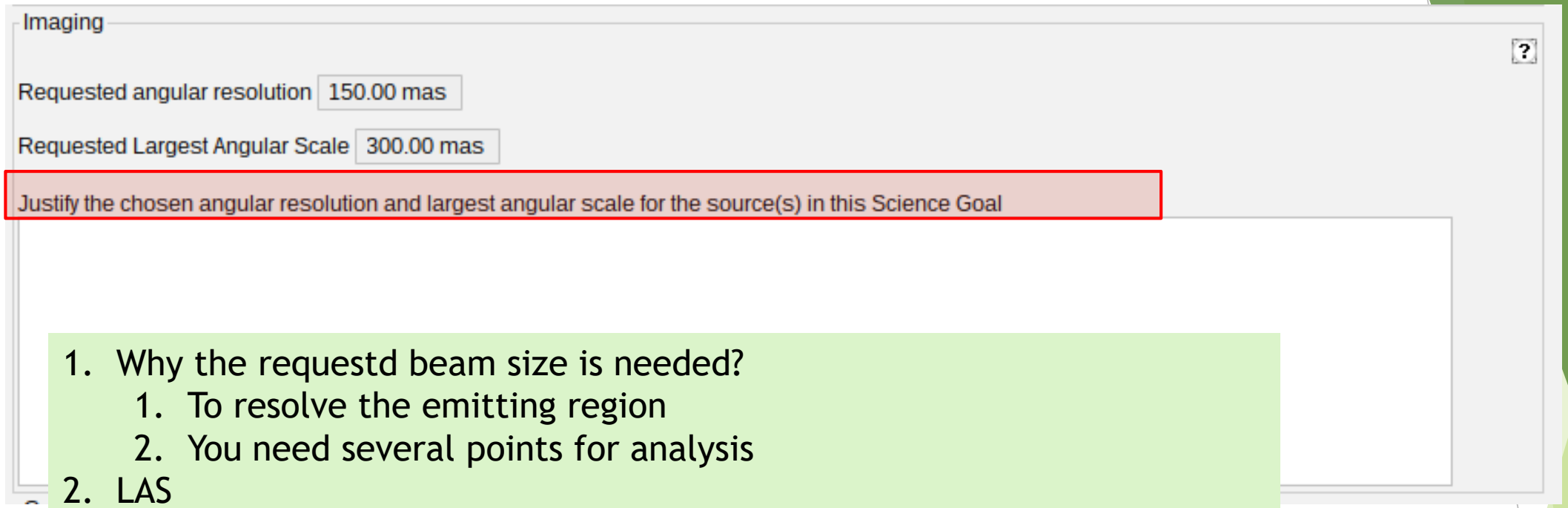
Line width / bandwidth used for sensitivity (300.00 m/s / 88.56 m/s) = 3.39

Spectral dynamic range

Justify your requested RMS and resulting S/N for the spectral line and/or continuum observations.

For line observations also justify the bandwidth used for the sensitivity calculation.

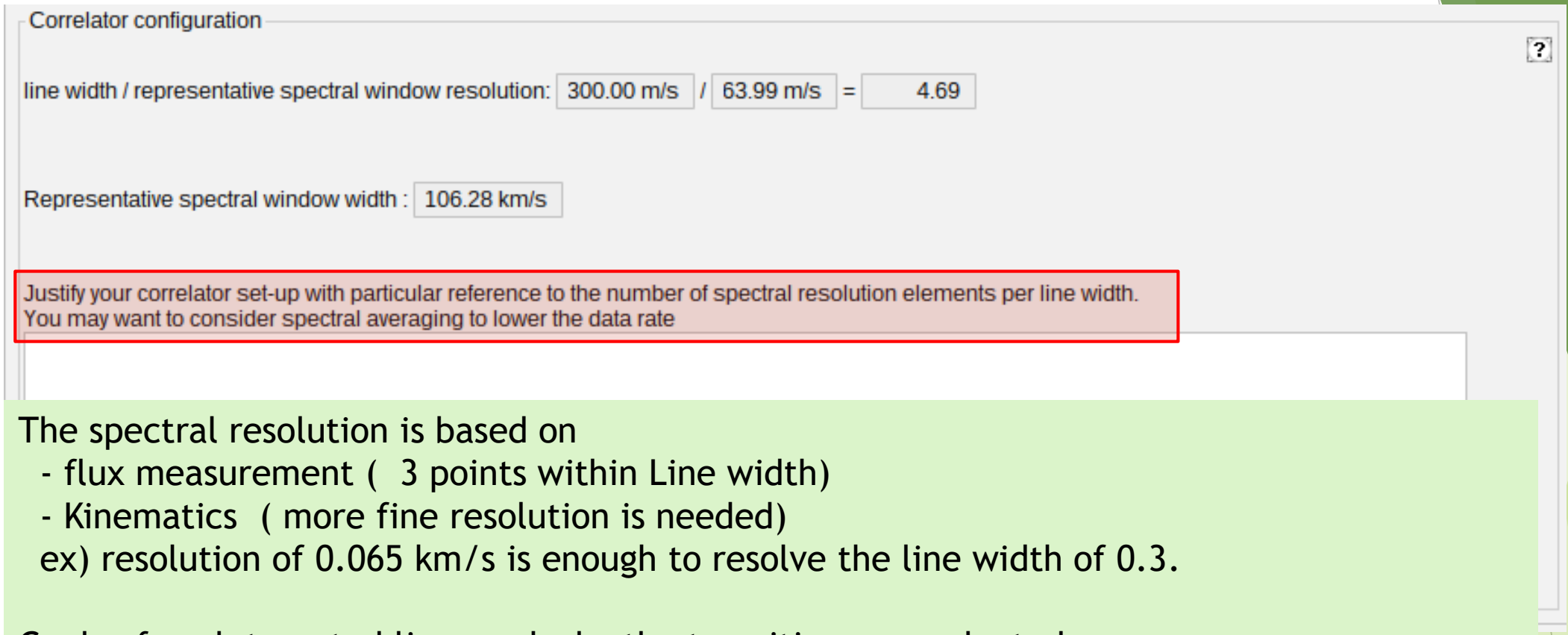
Spectral dynamic range is related with the bandpass accuracy.
It is 1000 (B3-B6), 400 (B7), 250 (B8), 170 (B9), and 150 (B10).



1. Why the requestd beam size is needed?
    1. To resolve the emitting region
    2. You need several points for analysis
2. LAS
    1. Garantees No flux missing, i.e., if the total flux is important in your science, you shoud set LAS as the largest emitting area
    2. If not, LAS can be smaller than the latter, but you describe that you are interested in just morphorology, ...

The expected emitting area is ~0.3”, thus the requested angular resolution **can resolve** the emitting area by a factor of two, which can ...

The disk is extended up to 0.3”, and we set LAS of 0.3”.



The spectral resolution is based on
- flux measurement (3 points within Line width)
- Kinematics (more fine resolution is needed)

ex) resolution of 0.065 km/s is enough to resolve the line width of 0.3.

Goals of each targeted lines and why the transitions are selected

CO and 13CO lines are chosen for ...

Furthermore, the lines in the Band 7 provide the highest SNR for a given observing time.

SO and HCO+ are set for bonous lines, which can provide ...

Tips) Atleast One baseband is set to continnum for the (self) calibration

Thank you!