

# ALMA OT hands on session

Case study: Gas and dust in local minor merger remnants



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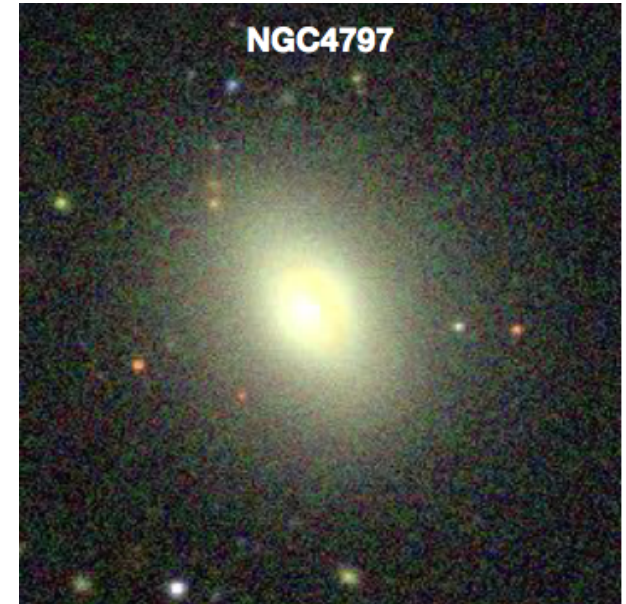
Atacama Large Millimeter/submillimeter Array  
Expanded Very Large Array  
Very Long Baseline Array



## Overview

Science case – Minor mergers are an important process in galaxy evolution. Whilst major mergers often enhance star-formation, minor mergers have been shown to suppress star-formation (Davis et al. 2015). We will use ALMA to determine the underlying physical cause of this intriguing effect.

Goal – This proposal aims to study the gas velocity and distribution in a minor merger remnant (NGC 4797), to distinguish between dynamical suppression, gravitational heating and AGN/starburst feedback (van de Voort et al. 2018)



# Science case I – mapping CO(1-0)

- Methodology – Using a single pointing, obtain a spectral line observation of the 12CO(1-0) line at 10 km/s resolution. The CO gas traces molecular hydrogen gas and will be used to map the gas velocity and distribution.
- Source – NGC 4797
- RA, Dec = 12:54:55.166, +27:24:45.55
- $z = 0.0262$
- Requirements –  $S/N=5$  on the 12CO(1-0) line (rest frequency 115.271 GHz).
  - Peak line flux of 4.60 mJy/beam.
  - Desired sensitivity per pointing of 920  $\mu$ Jy/beam.
  - Line width = 450 km/s.
- Dual polarization products.
- Correlator setup: band 3, 1875 MHz bandwidth, 1.129 kHz (3 km/s) resolution.
- Set the bandwidth used for sensitivity to 10 km/s because we will spectrally average to this channel width during data reduction.
- Largest angular scale (LAS) = 2.0", resolution = 1.5". The LAS of the CO gas in NGC4797 is 2" because in early-type galaxies such as NGC 4797 the gas is usually found within 0.5 effective radii (Davis et al. 2013).

# Science case I - Spectral line setup

ALMA Observing Tool (Cycle6) - Project

File Edit View Tool Search Help Perspective 1

**Project Structure**

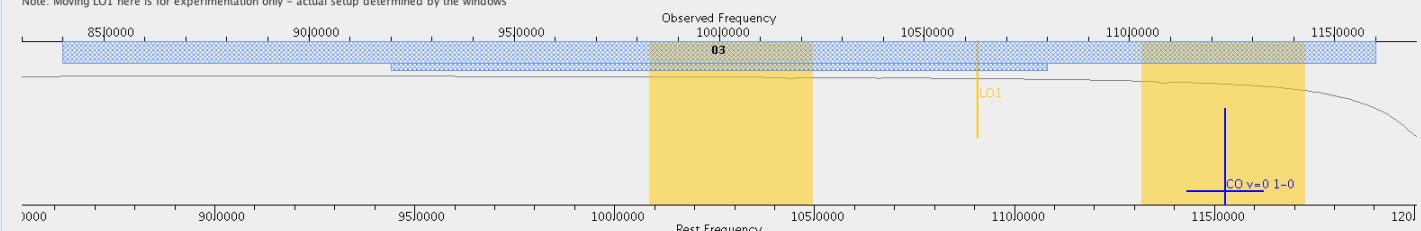
- Insubmitted Proposal
  - Project
    - Proposal
      - Planned Observing
        - ScienceGoal (Science Goal)
          - General
          - Field Setup
          - Spectral Setup
          - Calibration Setup
          - Control and Performance
          - Technical Justification

**Editors** Spectral Spatial Spectral Setup

Visualisation

In the table below, it is possible to define up to 16 spectral windows, 4 per baseband as long as the total Fraction per baseband is no more than 1. Each baseband is 2GHz wide and can be separately configured i.e. each spectral window can have a different bandwidth and resolution. Note that for bands 3 to 8, it is not possible to put 3 basebands in one sideband and the fourth one in the other.

Left/right click to zoom in/out, grab sliding bar to pan  
Note: Moving LO1 here is for experimentation only - actual setup determined by the windows



Observed Frequency: 850000, 900000, 950000, 1000000, 1050000, 1100000, 1150000

Rest Frequency: 900000, 950000, 1000000, 1050000, 1100000, 1150000, 1200000

Overlays:  Receiver Bands  Transmission  DSB Image  Spectral Lines

Water Vapour Column Density:  Automatic Choice  Manual Choice [5.186mm (7th Octile)]

Viewport:

Spectral Type

Spectral Line  Single Continuum  Spectral Scan

Produce image sidebands (Bands 9 and 10 only)

Polarization products desired  XX  DUAL  FULL

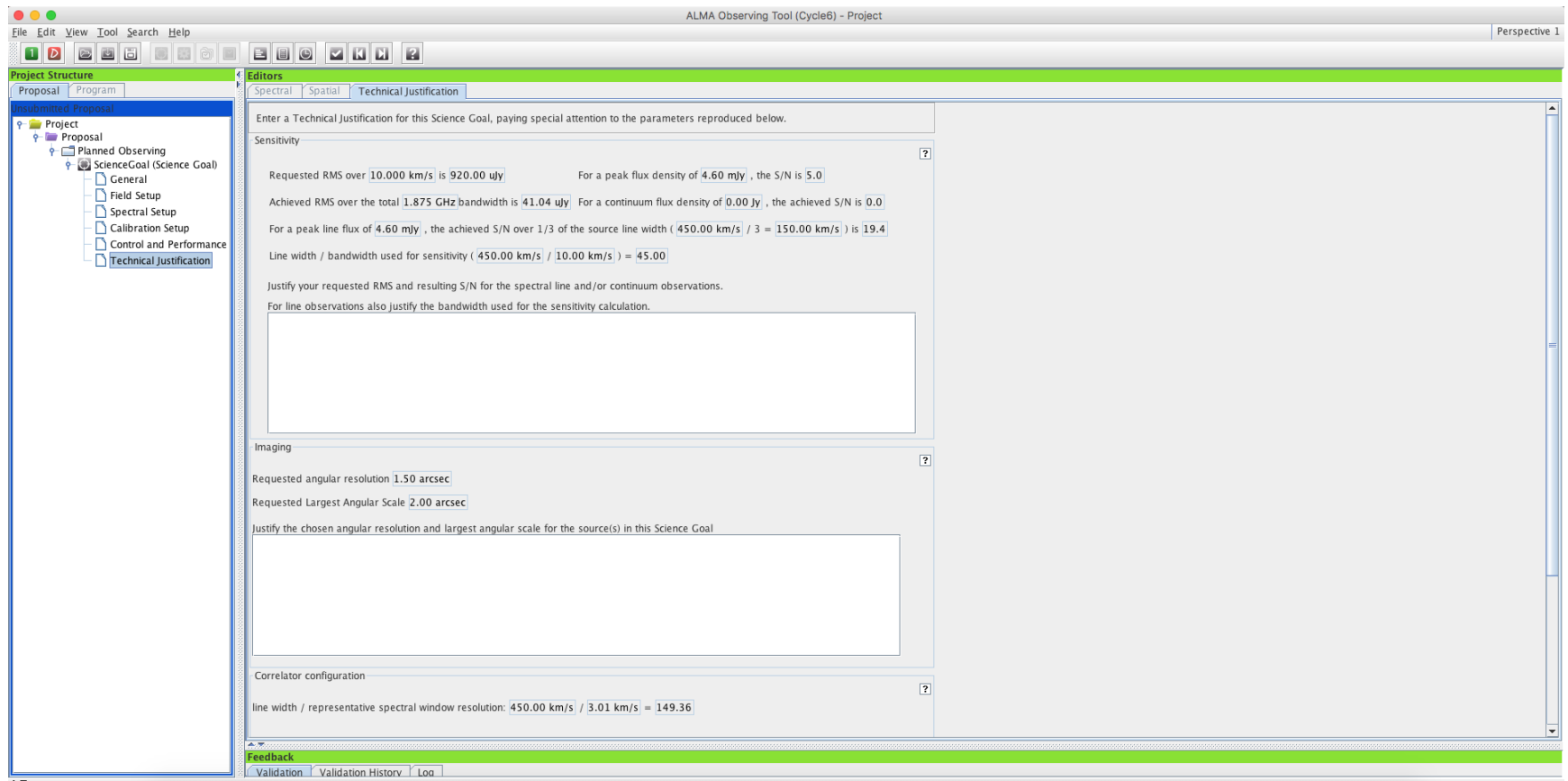
Spectral Setup Errors

Spectral Line

Baseband-1	Fraction	Centre Freq (rest, hel)	Centre Freq (sky, hel)	Transition	Bandwidth, Resolution (smoothed)	Spec. Avg.	Representative Window
1(Full)		115.27120 GHz	112.33258 GHz	CO v=0 1-0	1875.000 MHz( 5004 km/s), 1.129 MHz( 3.013 km/s)	2	<input checked="" type="radio"/>

Feedback

# Science case I - Technical case




Estimated time 1.15h



## Science case I - continuum

Set the peak continuum flux sensitive per synthesized beam to 0.304 mJy/beam (this was estimated from fitting a modified blackbody to fluxes at shorter wavelengths).

Now add 3 spectral windows to record continuum in band 3. Use the lowest spectral resolution correlator mode, and use the full 7.5 GHz bandwidth.

What is the continuum flux density S/N? (Hint – use the Technical Justification tab).

Change the largest angular structure to 20". What is the integration time now, and why is it longer?

# Science case I - continuum

ALMA Observing Tool (Cycle6) - Project

File Edit View Tool Search Help

Perspective 1

**Project Structure**

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

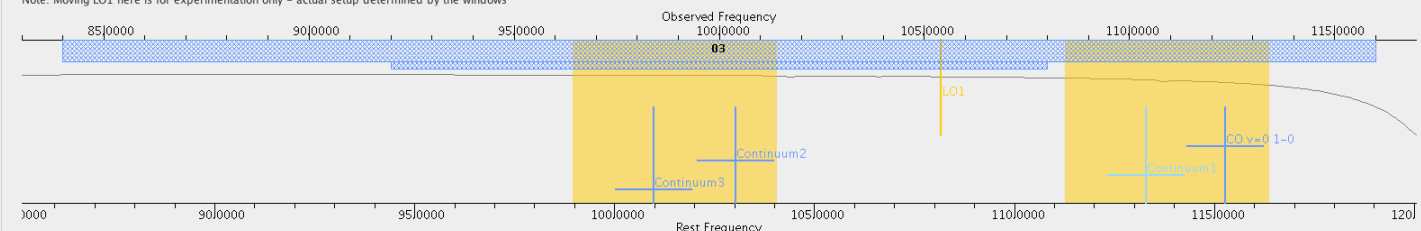
**Editors**

Spectral Spatial Spectral Setup

Visualisation

In the table below, it is possible to define up to 16 spectral windows, 4 per baseband as long as the total Fraction per baseband is no more than 1. Each baseband is 2GHz wide and can be separately configured i.e. each spectral window can have a different bandwidth and resolution. Note that for bands 3 to 8, it is not possible to put 3 basebands in one sideband and the fourth one in the other.

Left/right click to zoom in/out, grab sliding bar to pan  
Note: Moving LO1 here is for experimentation only - actual setup determined by the windows



Overlays:  Receiver Bands  Transmission  DSB Image  Spectral Lines

Water Vapour Column Density:  Automatic Choice  Manual Choice

Viewport:

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

Fraction	Centre Freq (rest, hel)	Centre Freq (sky, hel)	Transition	Bandwidth, Resolution (smoothed)	Spec. Avg.	Representative Window
1(Full)	115.27120 GHz	112.33258 GHz	CO v=0 1-0	1875.000 MHz( 5004 km/s), 1.129 MHz( 3.013 km/s)	2	<input checked="" type="radio"/>

**Feedback**

# Science case I - continuum

ALMA Observing Tool (Cycle6) - Project

File Edit View Tool Search Help

Perspective 1

**Project Structure**

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

**Editors**

Spectral Spatial Spectral Setup

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)	115.27120 GHz	112.33258 GHz	CO v=0 1-0	1875.000 MHz( 5004 km/s), 1.129 MHz( 3.013 km/s)	2	<input checked="" type="radio"/>	
<p>Add spectral window centred on a spectral line    Add spectral window manually    Delete    <input type="checkbox"/> Show image spectral windows</p>							
Baseband-2	113.28806 GHz	110.4 GHz/Continuum1		1875.000 MHz( 5092 km/s), 31.250 MHz(84.860 km/s)	1	<input type="radio"/>	
<p>Add spectral window centred on a spectral line    Add spectral window manually    Delete    <input type="checkbox"/> Show image spectral windows</p>							
Baseband-3	103.02646 GHz	100.40000 GHz	Continuum2	1875.000 MHz( 5599 km/s), 31.250 MHz(93.312 km/s)	1	<input type="radio"/>	
<p>Add spectral window centred on a spectral line    Add spectral window manually    Delete    <input type="checkbox"/> Show image spectral windows</p>							
Baseband-4	100.97414 GHz	98.40000 GHz	Continuum3	1875.000 MHz( 5713 km/s), 31.250 MHz(95.208 km/s)	1	<input type="radio"/>	
<p>Add spectral window centred on a spectral line    Add spectral window manually    Delete    <input type="checkbox"/> Show image spectral windows</p>							

**Representative Frequency**

The representative frequency is used in conjunction with the sensitivity entered on the 'Control and Performance' page to estimate the required observing time and to set the size of the antenna beam shown in the 'Spatial Visual' editor. If the transition you are most interested in does not fall in the centre of the chosen spectral window, its frequency can be changed here. The centre of the representative frequency can

**Feedback**

Validation Validation History Log



# Science case I - continuum

ALMA Observing Tool (Cycle6) - Project

File Edit View Tool Search Help Perspective 1

**Project Structure**

- Unsubmitted Proposal
  - Project
    - Proposal
      - Planned Observing
        - ScienceGoal (NGC 4797 gas)
          - General
          - Field Setup
          - Spectral Setup
          - Calibration Setup
          - Control and Performance
          - Technical Justification
        - ScienceGoal (NGC 4797 dust)
          - General
          - Field Setup
          - Spectral Setup
          - Calibration Setup
          - Control and Performance
          - Technical Justification

**Editors**

Spectral Spatial **Technical Justification**

Enter a Technical Justification for this Science Goal, paying special attention to the parameters reproduced below.

**Sensitivity**

Requested RMS over 10.000 km/s is 920.00  $\mu$ Jy For a peak flux density of 4.60 mJy, the S/N is 5.0

Achieved RMS over the total 7.500 GHz bandwidth is 20.52  $\mu$ Jy For a continuum flux density of 304.00  $\mu$ Jy, the achieved S/N is 14.8

For a peak line flux of 4.60 mJy, the achieved S/N over 1/3 of the source line width ( 450.00 km/s / 3 = 150.00 km/s ) is 19.4

Line width / bandwidth used for sensitivity ( 450.00 km/s / 10.00 km/s ) = 45.00

Spectral Dynamic Range (continuum flux / line rms): 0.33

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.

**Imaging**

Requested angular resolution 1.50 arcsec

Requested Largest Angular Scale 2.00 arcsec

Justify the chosen angular resolution and largest angular scale for the source(s) in this Science Goal

**Correlator configuration**

line\_width / representative\_spectral\_window\_resolution: 450.00 km/s / 3.01 km/s = 149.36

**Feedback**

Validation Validation History Log

# Science case 2 – high frequency continuum



Science case – Map the dust continuum to look for extended dust emission, and to do radiative transfer modelling to reveal the sources of dust heating.

Goal – Image the dust continuum at high resolution to match the spatial resolution of existing optical data. The dust continuum will be brightest at high frequency.

## Science case 2 – high frequency continuum

Methodology – Image the central region with a single pointing.

Copy the science goal and give it a new name.

Change the spectral setup to observe continuum in band 9. Note the mirror images of the spectral windows.

Set the peak continuum flux to 0.89 mJy/beam and the peak line flux to zero.

Set the desired angular resolution to 0.6" and the largest angular scale to 2.0".

What is the desired sensitivity needed to reach a S/N of 5 for the continuum? (Hint, the integration time is 8.8 hours).



## Science case 2 – make a mosaic

- We want to make a map of the dust a larger region than one pointing.
- In field setup, change to a rectangular field and make a 7"x7" mosaic. Use Nyquist spacing (the default) between the pointings. This is the spacing of samples on the sky needed to get good imaging of large-scale low surface brightness emission. Use the spatial image tool to help you visualize the pointing positions.
- How long is the integration time now?

# Science case 2 – make a mosaic

ALMA Observing Tool (Cycle6) - Project

File Edit View Tool Search Help

Perspective 1

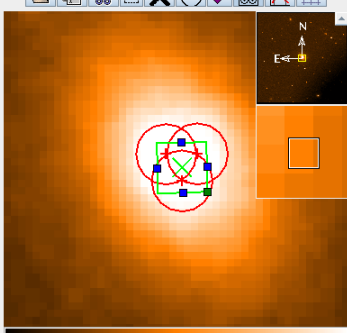
**Project Structure**

- Proposed
- Program
- InsSubmitted Proposal
- Project
  - Proposal
    - Planned Observing
      - ScienceGoal (NGC 4797 gas)
        - General
        - Field Setup
        - Spectral Setup
        - Calibration Setup
        - Control and Performance
      - ScienceGoal (NGC 4797 dust)
        - General
        - Field Setup
        - Spectral Setup
        - Calibration Setup
        - Control and Performance
        - Technical Justification

**Editors**

Spectral Spatial Field Setup

Spatial Image



8x 310.1, 290.2 10770.0  
12:54:54.282, +27:24:37.28 (J2000)  
Image Filename: i/.jksky3/cache/jksky6496681906318473697.fits

FOV Parameters

Representative Frequency (Sky) 682.000 GHz  
Antenna Diameter 12m  
Antenna Beamsize (HPBW) 8.538 arcsec  
Show Antenna Beamsize

Image Query

Image Server Digitized Sky (Version II) at ESO  
Image Size(arcmin) 10.0 Query

NGC 4797

Source

Source Name NGC 4797 Resolve

Choose a Solar System Object  Name of object Unspecified

System ICRS Sexagesimal display?  Parallax 0.00000 mas

Source Coordinates RA 12:54:55.1660 PM RA 0.00000 mas/yr  
Dec 27:24:45.550 PM DEC 0.00000 mas/yr

Source Radial Velocity 7740.024 km/s hel z 0.026160000 Doppler Type RELATIVISTIC

Target Type  Individual Pointing(s)  1 Rectangular Field

Expected Source Properties

Peak Continuum Flux Density per Synthesized Beam 0.89000 mJy  
Continuum Linear Polarization 0.0 per cent  
Continuum Circular Polarization 0.0 per cent  
Peak Line Flux Density per Synthesized Beam 0.00000 mJy  
Line Width 0.00000 km/s  
Line Linear Polarization 0.0 per cent  
Line Circular Polarization 0.0 per cent

Rectangle

Coords Type  Relative  Absolute

Field Center Coordinates  
Offset(Longitude) 0.00000 arcsec  
Offset(Latitude) 0.00000 arcsec

p length 7.00000 arcsec  
q length 7.00000 arcsec  
Position Angle 0.00000 deg

Spacing 0.51093 fraction of antenna beamsize Reset to Nyquist  
#Pointings 12m Array 3 Export

Feedback

Validation Validation History Log

