

Estimation of expected intensity

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The ALMA Proposal Preparation Workshop

Estimating the expected intensity

- Need to specify a desired rms noise level in our ALMA proposals

ALMA Observing Tool (Cycle 11 (Phase1)) - Project

File Edit View Tool Search Help Perspective 1

Project Structure: Unsubmitted Proposal, Example, Proposal, Planned Observing, ScienceGoal (How can we estimate the expected intensity?), General, Field Setup, Spectral Setup, Calibration Setup, 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 0.000 arcsec 7m 0.000 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	0.000 arcsec	0.000 arcsec	0.000 arcsec
Shortest baseline	0.009 km	0.015 km	0.256 km
Maximum recoverable scale	0.000 arcsec	0.000 arcsec	0.000 arcsec

Desired Performance

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

0.5 arcsec to 0.1 arcsec

Largest Angular Structure in source 5.0 arcsec

Desired sensitivity per pointing ?? Jy equivalent to and

Bandwidth used for Sensitivity RepWindowEffective mK with Frequency Width 0.000000 GHz

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

Estimating the expected intensity

- Need to specify a desired rms noise level in our ALMA proposals

ALMA Observing Tool (Cycle 11 (Phase1)) - Example

File Edit View Tool Search Help Perspective 1

Project Structure

Unsubmitted Proposal

Example

Proposal

Planned Observing

ScienceGoal (How can we estimate the expected intensity)

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 531.311 m/s is 1.00 mJy For a peak flux density of 1.00 Jy, the S/N is 1000.0

The proposed observations exceed the nominal limits for the Continuum Imaging Dynamic Range for at least one source

Achieved RMS over the total 234.375 MHz bandwidth is 28.79 uJy, 2.90 mK-11.60 mK For a continuum flux density of 1.00 Jy, 100.67 K-402.69 K, the achieved S/N is 1123.1

For a peak line flux of 1.00 Jy, the achieved S/N over 1/3 of the source line width (2.00 km/s / 3 = 666.67 m/s) is 1123.1

The proposed observations exceed the nominal limits for the Line Imaging Dynamic Range for at least one source

Line width / bandwidth used for sensitivity (2.00 km/s / 531.31 m/s) = 3.76

Spectral Dynamic Range (continuum flux / line rms): 1002.62

Note that the dynamic range is higher than that offered for the chosen band in this cycle. Please double-check your input and/or address the issue below.

The proposed observations exceed the nominal limits for the Spectral Dynamic Range for at least one source

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.

- All parameters should be explained with acceptable reasoning processes.

How can we estimate the expected intensities?

1. From an archival data for a similar target
 2. From data with poorer angular resolutions
 3. From data in different frequency ranges
 4. From a model
- ✓ You might need combine some of them to derive your expected intensities
 - ✓ Keeping a plausibility laid out a logical basis is the most important thing.

From an archival data for a similar target

- Aim to observe the source that did not observed at a given frequency previously
- Find a source which has physical properties similar with those of your target from the ALMA archive
- Adopt the measured intensities as expected intensities for a given angular resolutions.

From an archival data for a similar target

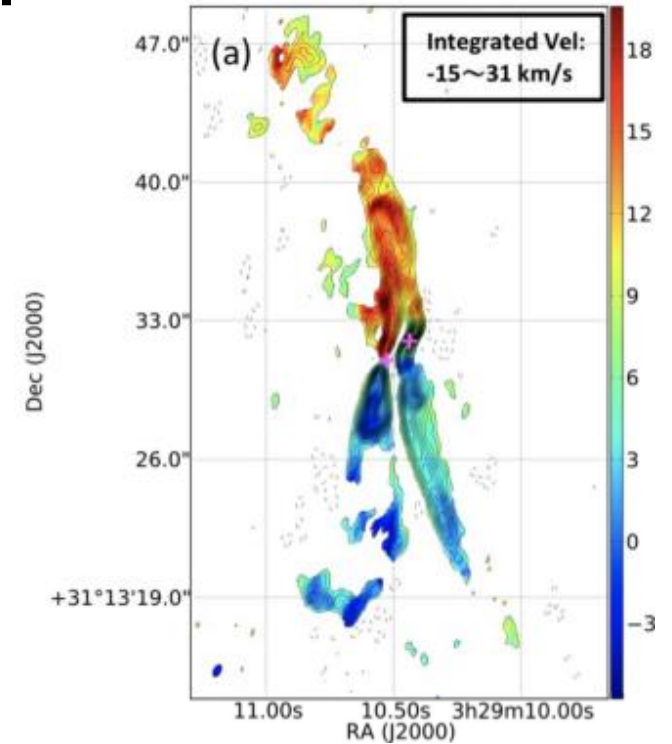
- Example : Class 0 protostar L1455 IRS4
- $T_{\text{bol}} = 60 \text{ K}$, $L_{\text{bol}} = 1.7 L_{\odot}$, $M_{\text{env}} = 0.5 M_{\odot}$
- Aim: study of outflowing gas near L1455 IRS4.

Table 2
Bolometric Temperatures, Luminosities, and Envelope Masses of Embedded Protostars in Perseus

ID	c2d Name/Position (SSTc2dJ...)	T_{bol} (K)	L_{bol} (L_{\odot})	α_{IR}	M_{env} (M_{\odot})	Bolocam ID	Other Names
Class 0							
Per-emb 20	J032743.23+301228.8	60 (14)	1.7 (0.01)	2.39 (0.06)	0.5 (0.03)	Bolo 23	L1455-IRS 4
Per-emb 22	J032522.33+304514.0	63 (11)	1.7 (1.1)	2.34 (0.07)	1.41 (0.14)	Bolo 5	L 1448-IRS2

From an archival data for a similar target

- Example : Class 0 protostar NGC1333 IRS 4A (L1448 IRS2)
- Embedded Class 0 protostar
- In the Perseus cloud
- Well developed outflows are detected in CO and SO with a $0.''65 \times 0.''35$ beam



Chuang et al. (2021)

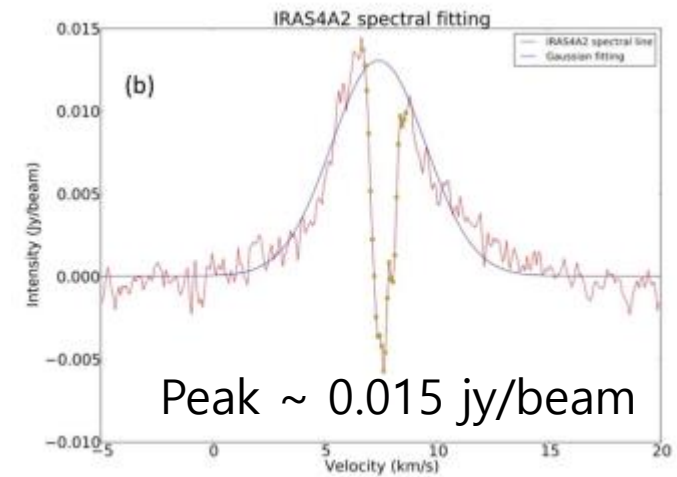
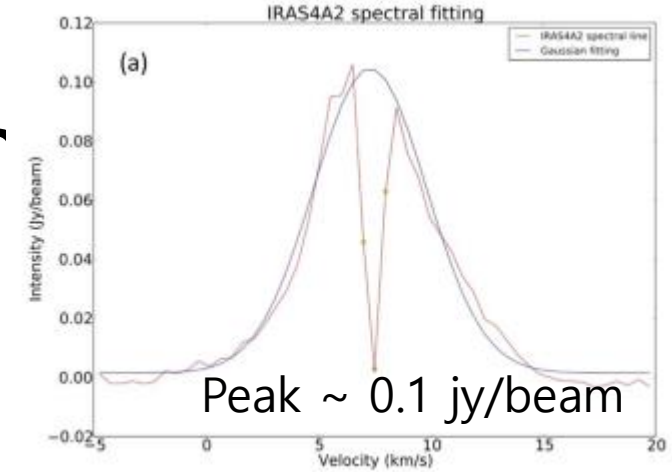
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Enoch et al. (2009)

From an archival data for a sim target

- Example : Class 0 protostar NGC1333 IRS 4A (L1448 IRS2)
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Enoch et al. (2009)

From a previous observation (with a poorer resolution)

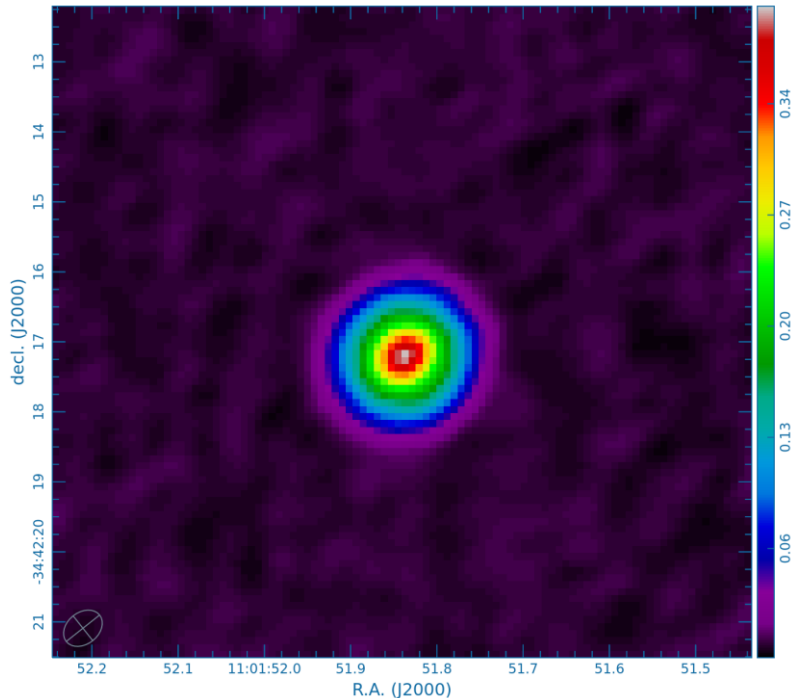
- When you have a data with a poorer angular resolution (Ω_p)
- Aim to resolve a specific structure with a higher angular resolution (Ω_b)
- You can scale the observed intensity (in K unit) by multiplying a correction factor of,

$$f = \frac{\Omega_b}{\Omega_p}$$

From a previous observation (with a poorer resolution)

- Example : The disk of a 10 Myr old K6 star, TW Hya
- Continuum image at 372 GHz (used in the CASA tutorial of ALMA)

TWH ya 372 GHz continuum



- Beam size = $\sim 0.''5$
- Aim to resolve detailed structure with higher angular resolution of $\sim 0.''02$

$$f = \frac{\Omega_b}{\Omega_p} = 0.0016$$

Caution!

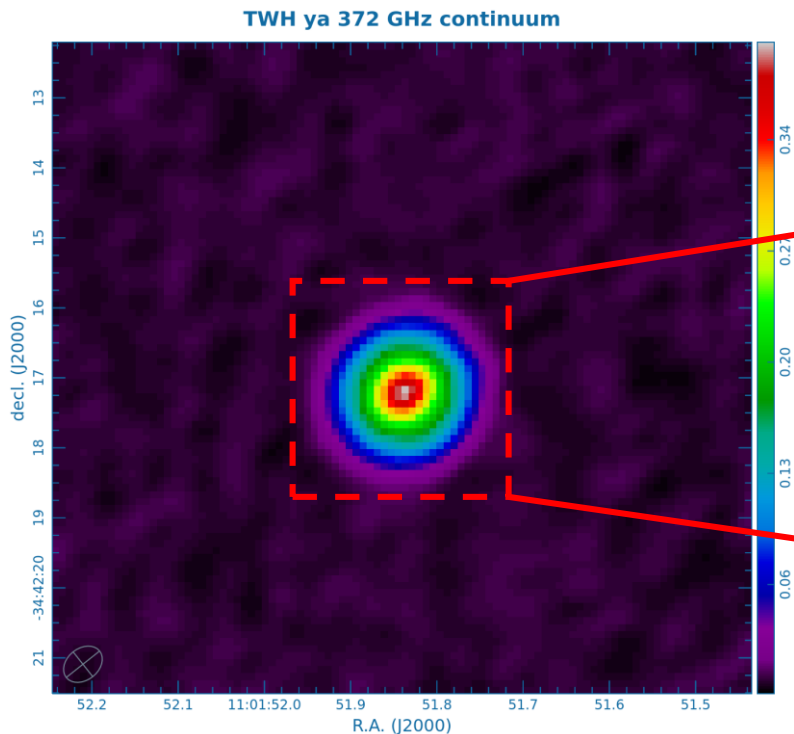
When you start from the single-dish observation, a large gap between Ω_p and Ω_b will result in undetectable expected intensities.

From a previous observation (with a poorer resolution)

- Example : The disk of a 10 Myr old K6 star, TW Hya
- Continuum image at 372 GHz (used in the CASA tutorial of ALMA)

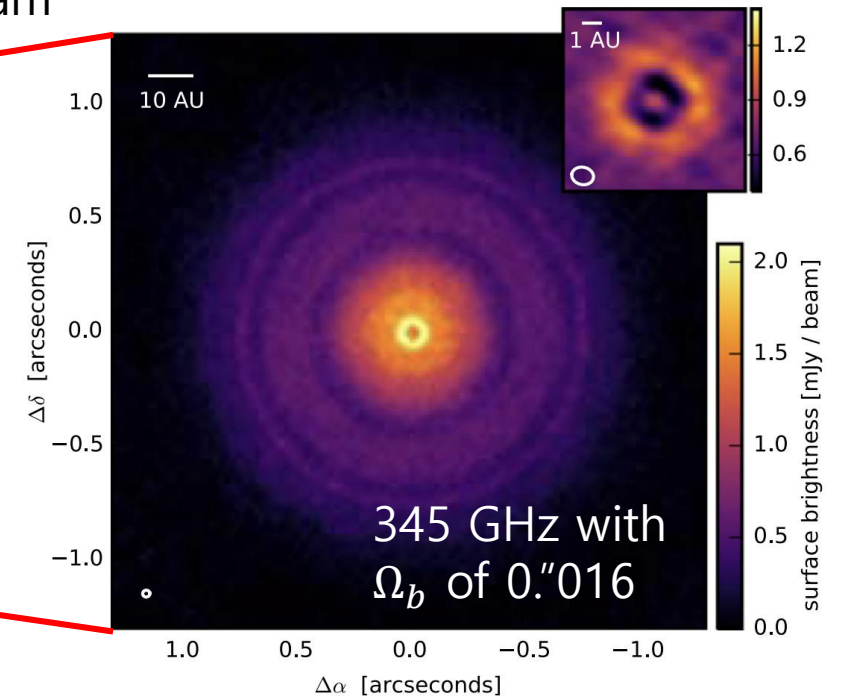
~ 35 K \longrightarrow ~ 0.06 K
< 0.1 mJy/beam

From Andrews et al. (2016)



Caution!

The expected intensity is much weaker than detected.



From data in different frequency ranges

For a continuum observation,

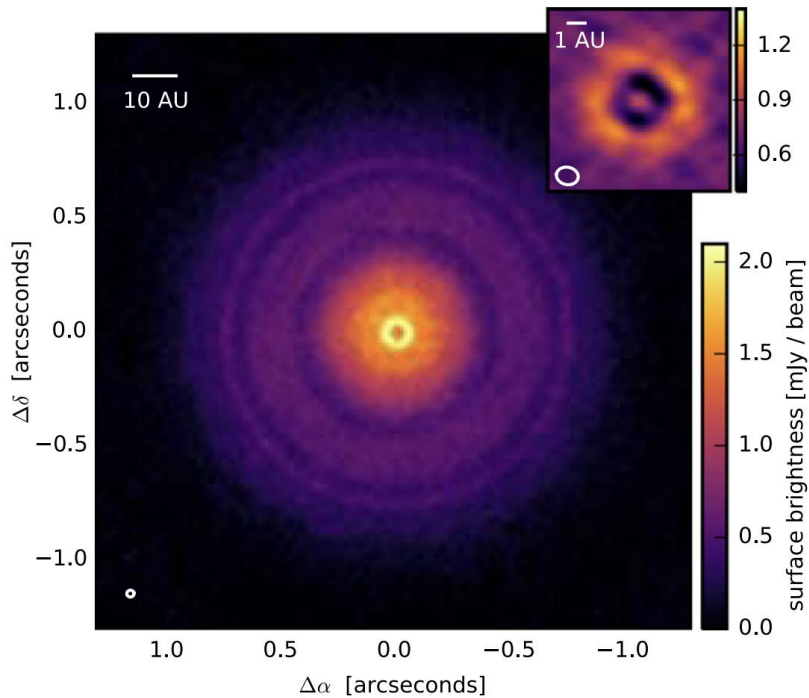
- Continuum flux is proportional with κT (κ =dust absorption coefficient, T =temperature)
- Typically, κ follows a power-law relation of ,

$$\kappa \propto \kappa_0 (\nu/\nu_0)^\beta$$

- Adopt β from literature

From data in different frequency ranges

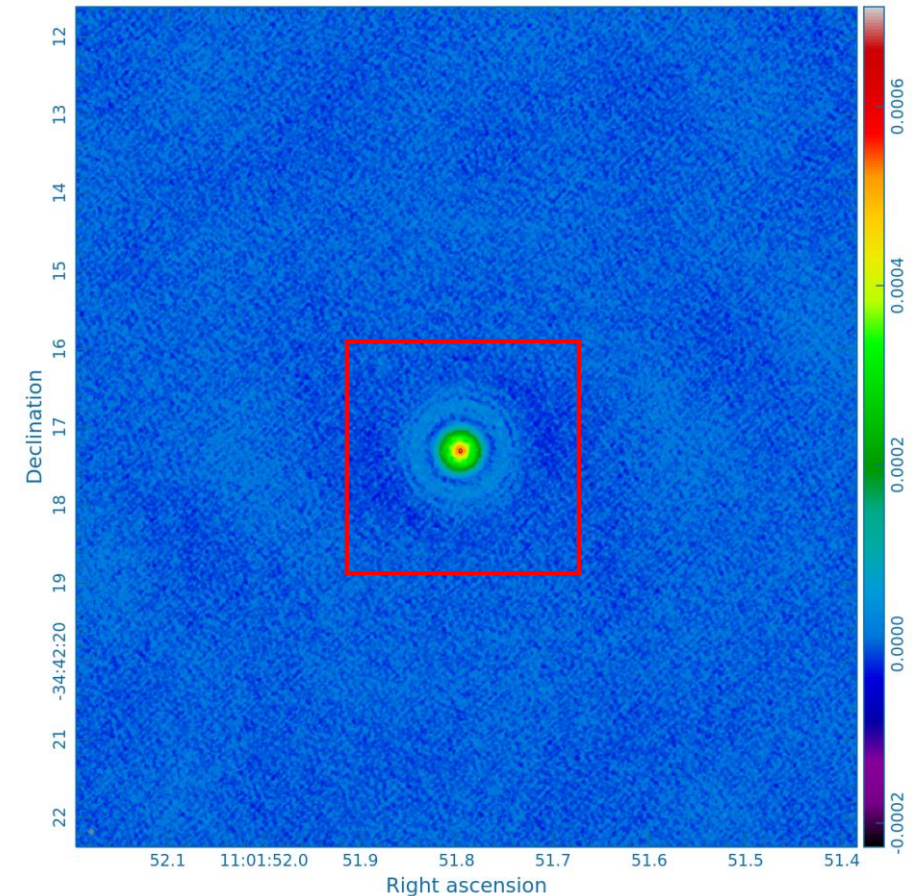
Continuum image at 345 GHz
From Andrews et al. (2016)



$$\kappa \propto \kappa_0 (\nu/\nu_0)^\beta$$

Search
acceptable β
from the
literature

Continuum image at 104 GHz
With a beam size of $\sim 0.''05$

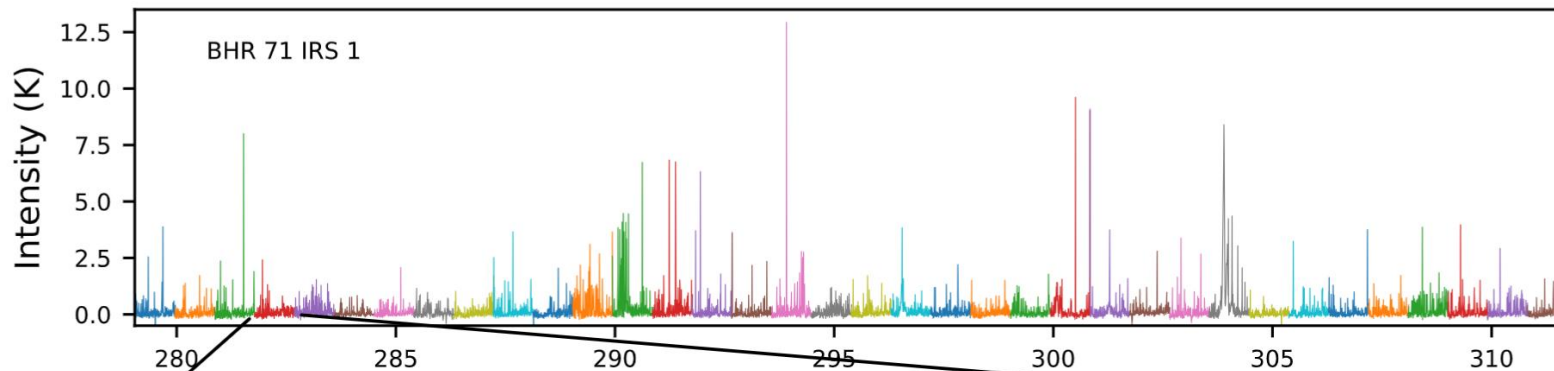


From data in different frequency ranges

For a line observation,

- Multiple transition lines would be observed in different frequency regimes.
- Adopt their intensity ratios and compare it with the model spectra
- Possible models : LTE codes (XCLASS, MADCUBA, CASSIS, ...)

RADEX on-line ([Radex on-line: Main Page](#))



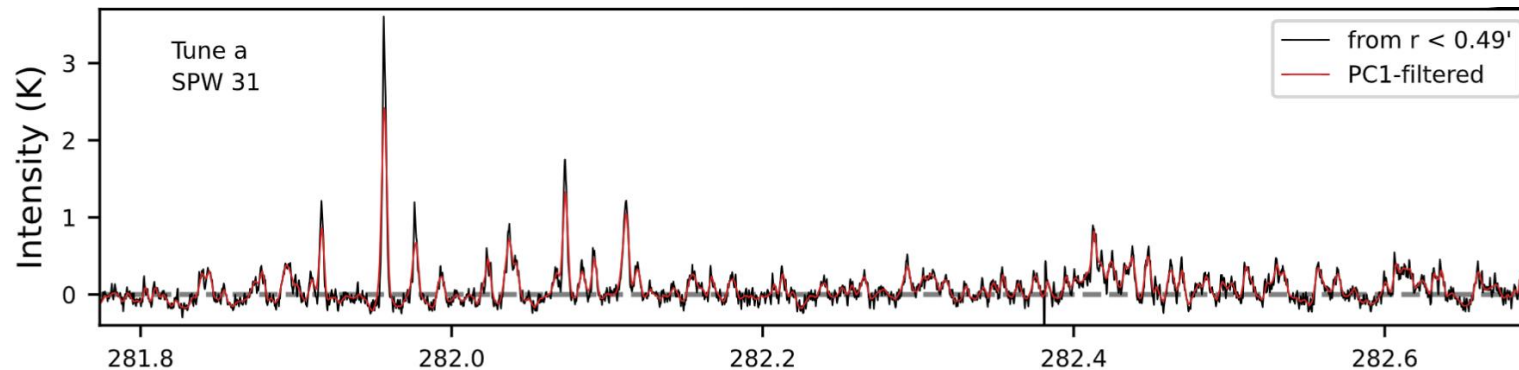
Spectral scan observation toward a protostar BHR 71 IRS1

From data in different frequency ranges

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RADEX on-line ([Radex on-line: Main Page](#))



Spectral scan observation toward a protostar BHR 71 IRS1

RADEX on-line

- On-line tool.
- Easy to calculate the line intensity ratios

RADEX

Non-LTE molecular radiative transfer in an isothermal homogeneous medium

This program is free to use for everybody, provided that publications make a reference to our paper: Van der Tak, F.F.S., Black, J.H., Schöier, F.L., Jansen, D.J., van Dishoeck, E.F., 2007, A&A 468, 627-635.

Molecule / Data file

Spectral Range

[Minimum frequency](#) (GHz)

[Maximum frequency](#) (GHz)

Excitation Conditions

[Background temperature](#) (K)

[Kinetic temperature](#) (K)

[H₂ density](#) (cm⁻³)

Put 10^{10} cm⁻³ to achieve the LTE condition

Radiative Transfer Parameters

[Column density](#) (cm⁻²)

[Line width](#) (km s⁻¹)

If you want to run more extensive calculations, please use the [offline version](#) of RADEX.

Click [here](#) for the 18-page manual in PDF

Send comments / questions to [Floris van der Tak](mailto:Floris.van.der.Tak@srn.nl) (vdtak @ sron.nl)

Program version: December 2011

Datafile version: January 2016

RADEX on-line

- On-line tool.
- Easy to calculate the line intensity ratios
- Adopt the modeled intensities and derive their ratios.

Radex on-line: Results

Molecule: CO
Minimum frequency: 50 GHz
Maximum frequency: 500 GHz
Kinetic temperature: 30 K
Background temperature: 2.73 K
Number density: 1e10 cm⁻³
Column density: 1e14 cm⁻²
Line width: 1.0 km s⁻¹

Warning: Ortho-para ratio out of valid range (0-3)

	<u>Transition</u>	<u>Frequency</u>	<u>T_{ex}</u>	<u>tau</u>	<u>T_R</u>
		(GHz)	(K)		(K)
1	-- 0	115.2712	30.000	2.139E-03	5.658E-02
2	-- 1	230.5380	30.000	6.512E-03	1.597E-01
3	-- 2	345.7960	30.000	9.300E-03	2.076E-01
4	-- 3	461.0408	30.000	8.741E-03	1.765E-01
	--				

Send comments / questions to Floris van der Tak (vdtak @ sron.nl)

From a model spectra

- The most hardest way to estimate an expected intensity
- Fully model-based estimation.
- Adopt estimated physical and chemical structure of targets.
- Solve radiative transfer for a given physical and chemical structures and get the model spectra.