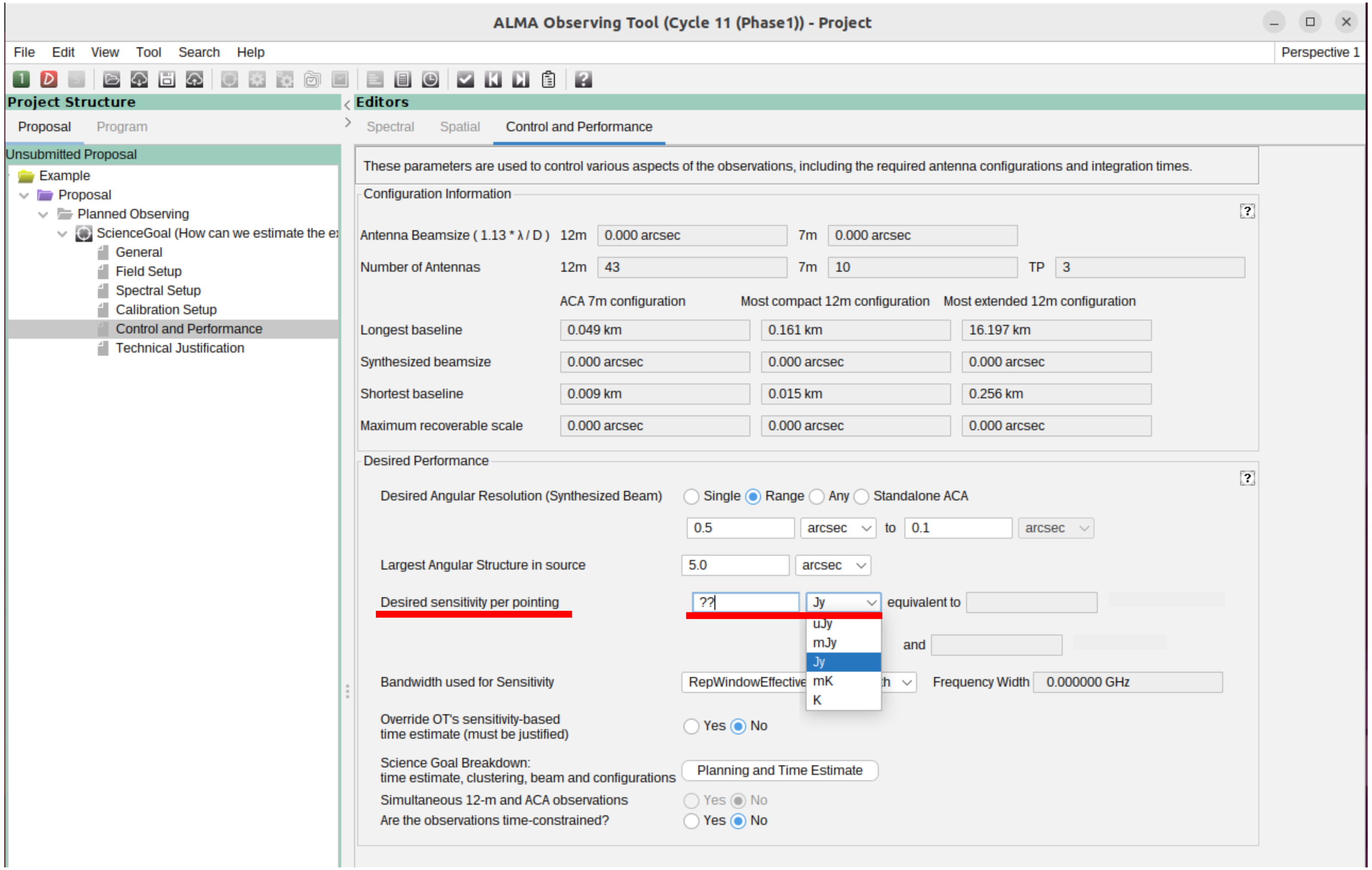
Estimation of expected intensity

Hyeong-Sik Yun

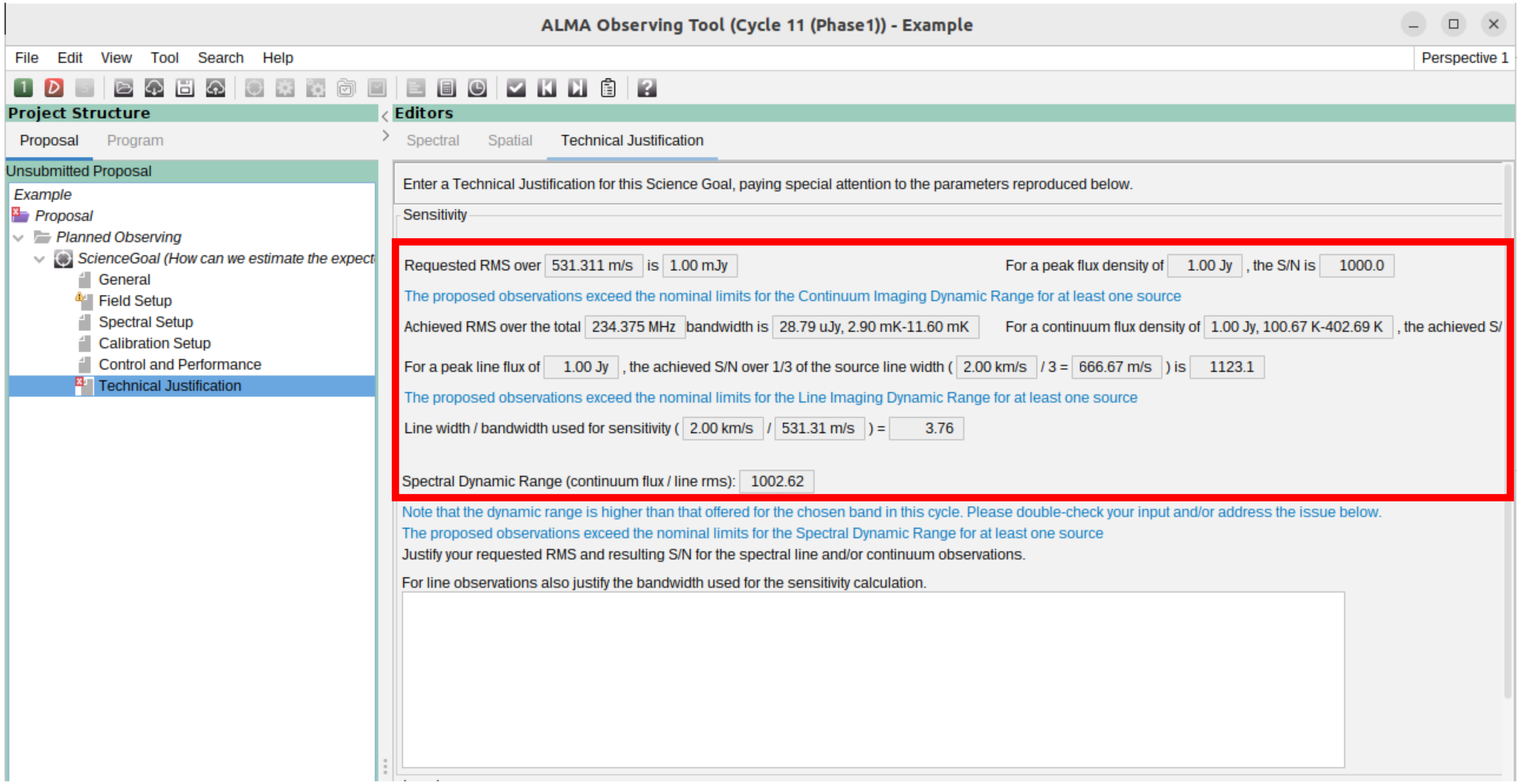
The ALMA Proposal Preparation Workshop

Estimating the expected intensity



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

Estimating the expected intensity



- Need to specify a desired rms noise level in our ALMA proposals
- 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_{bol} = 60 K, L_{bol} = 1.7 $L_{\odot}$, M_{env} = 0.5 $M_{\odot}$
- Aim: study of outflowing gas near L1455 IRS4.

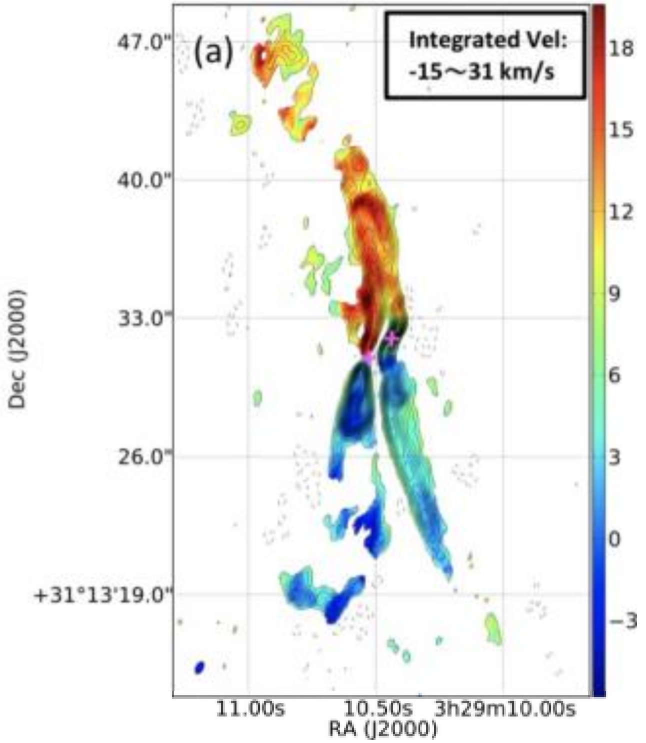
Table 2
Bolometric Temperatures, Luminosities, and Envelope Masses of Embedded Protostars in Perseus

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

Enoch et al. (2009)

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.″65x0.″35 beam



Chuang et al. (2021)

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From an archival data for a sim target

- Example : Class 0 protostar NGC1333 IRS 4A (L1448 IRS2)
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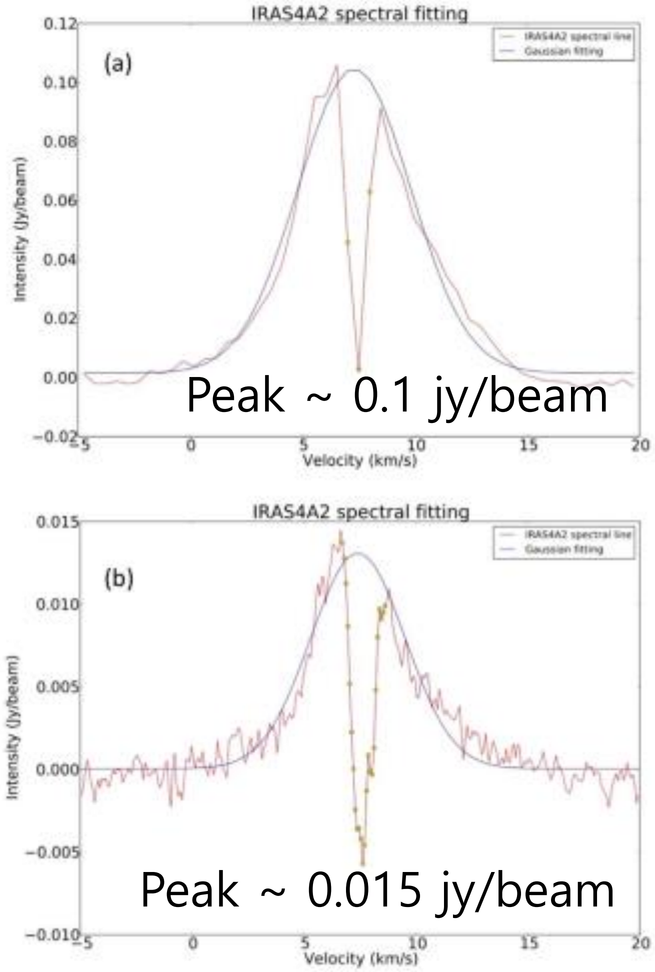

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Enoch et al. (2009)

From a previous observation (with a poorer resolution)

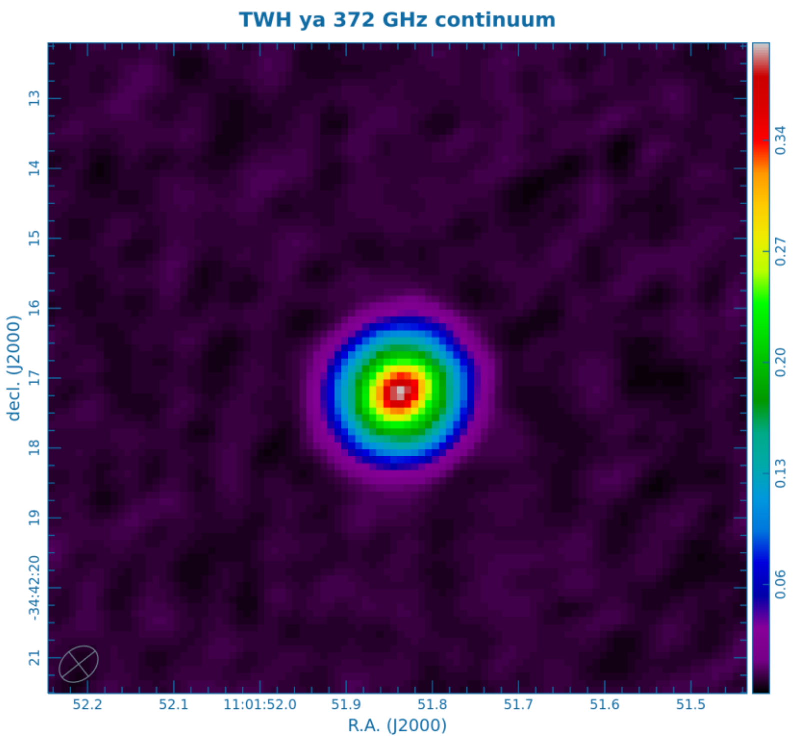
- When you have a data with a poorer angular resolution (Ω_p)
- Aim to resolve a specific structure with a higher angular resolution (Ω_b)

- 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)



- Beam size = ~ 0.″5
- Aim to resolve detailed structure with higher angular resolution of ~ 0.″02

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

Caution!
When you star from the single-dish observation, a large gap between Ω_p and Ω_b will results in undetectable expected intensities.

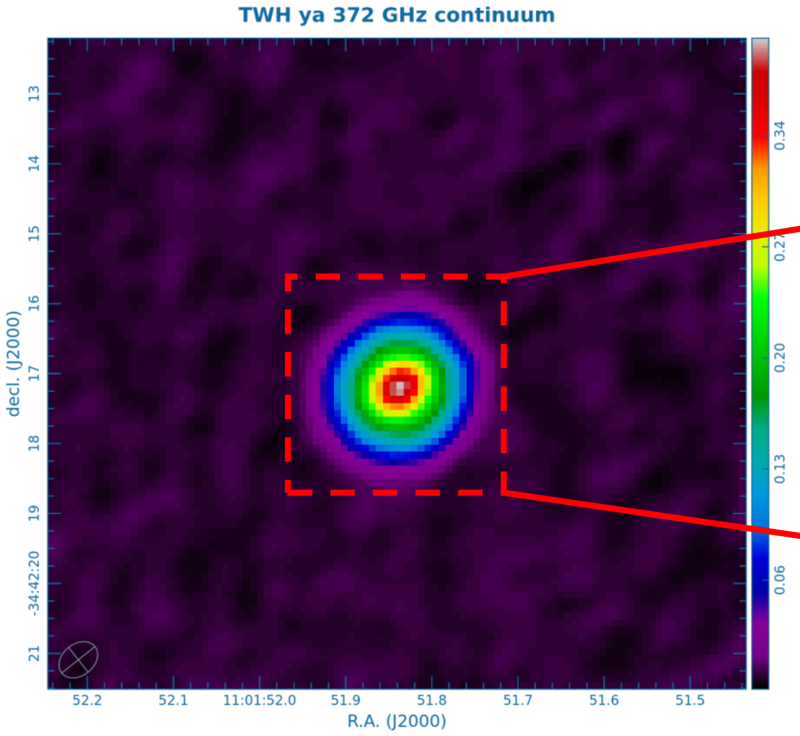
From a previous observation (with a poorer resolution)

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

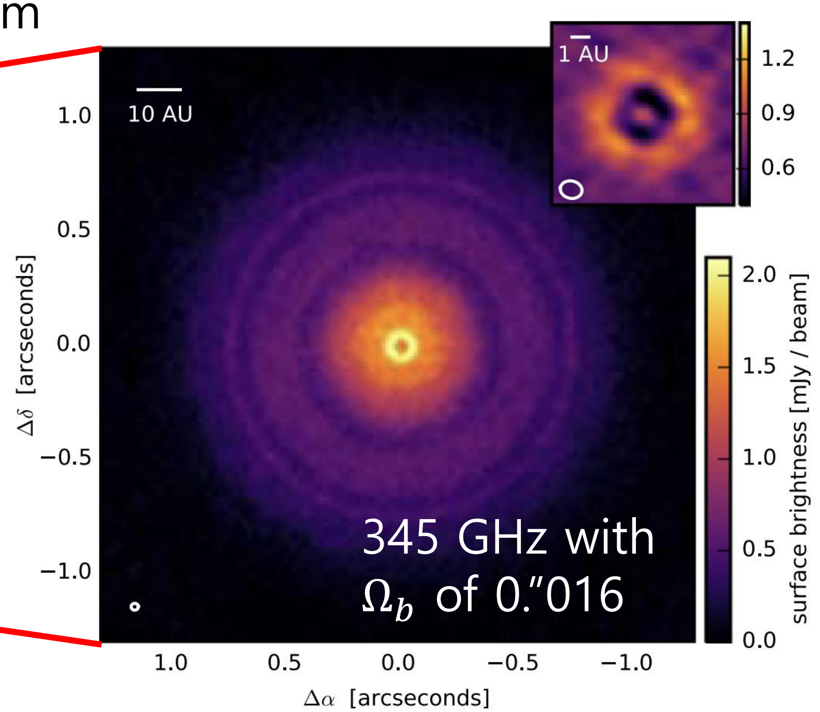
~ 35 K → ~ 0.06 K

< 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,

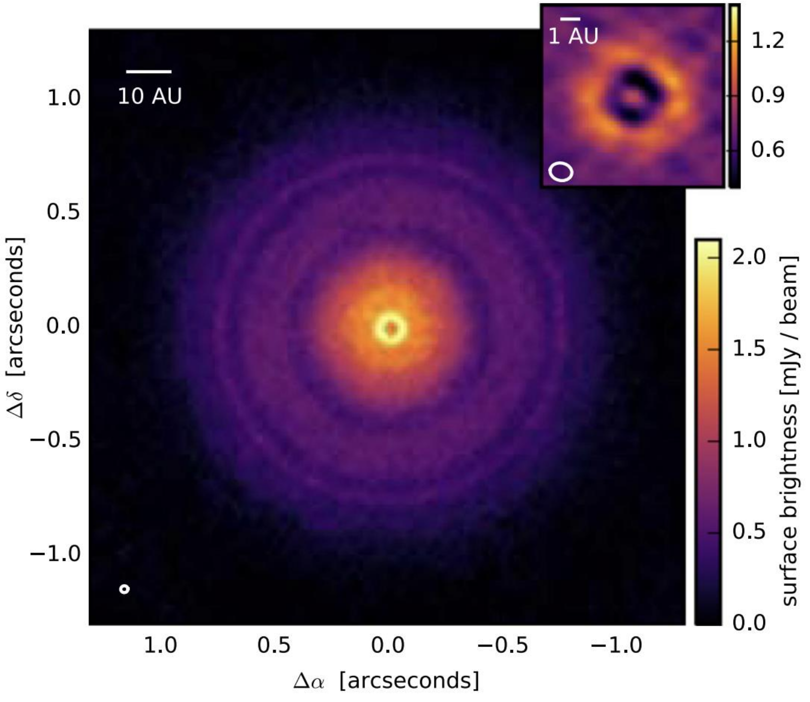
- Continuum flux is proportional with κT (κ=dust absorption coefficient, T=temperature)
- Typically, κ follows a power-law relation of ,

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

- Adopt β from literature

From data in different frequency ranges

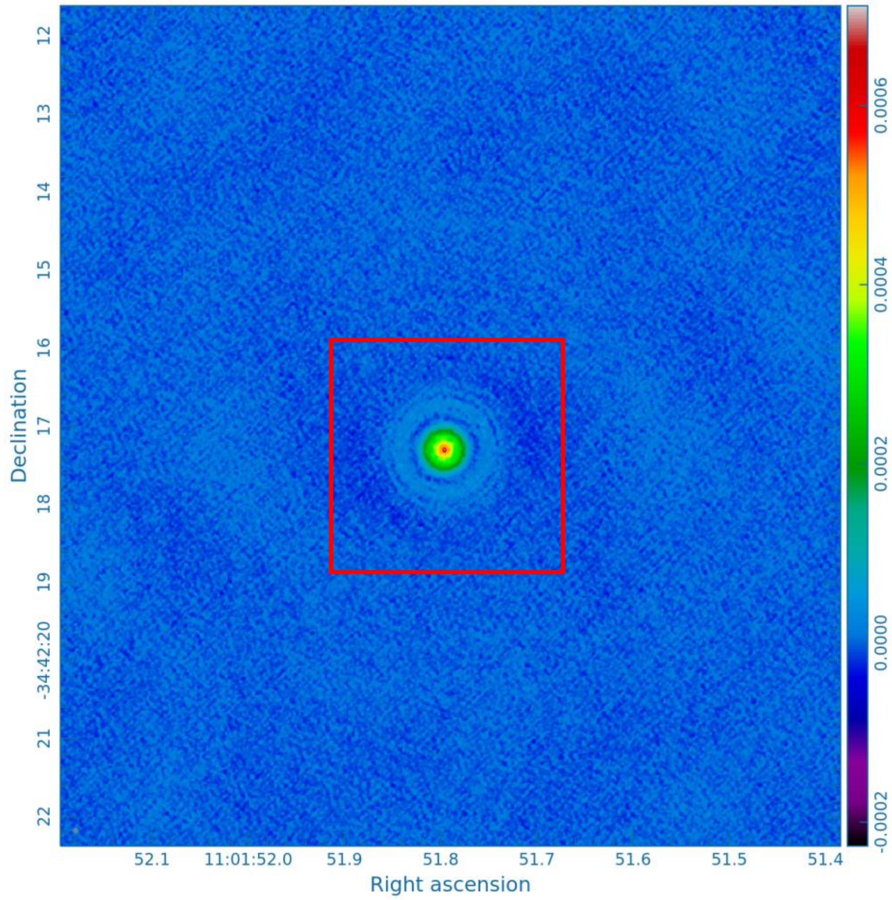
Continuum image at 345 GHz
From Andrews et al. (2016)



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

Search acceptable β from the literature

Continuum image at 104 GHz
With a beam size of ~0.″05

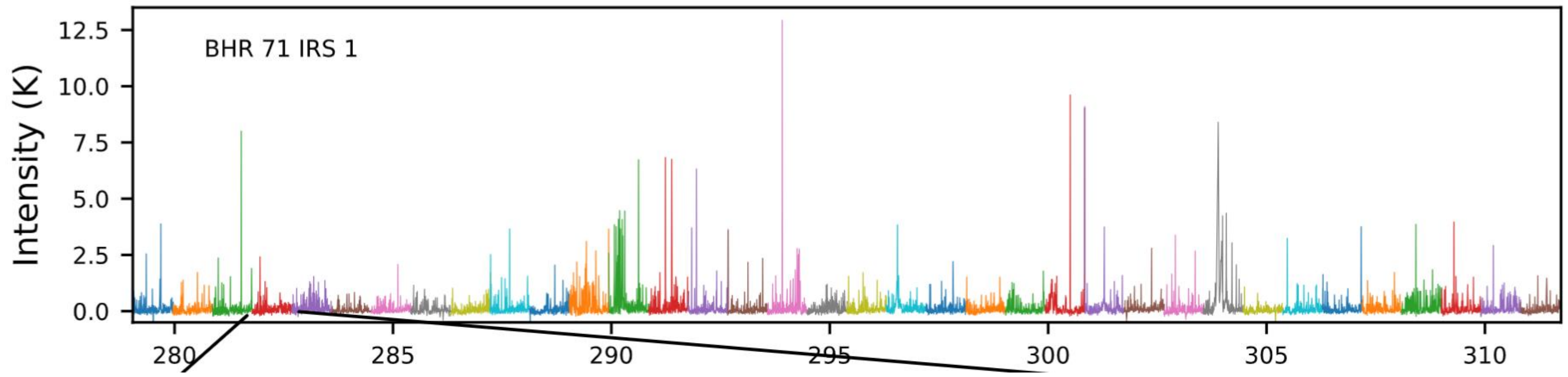


From data in different frequency ranges

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

For a line observation,

- Multiple transition lines would be observed in different frequency regimes.
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- Possible models : LTE codes (XCLASS, MADCUBA, CASSIS, ...)

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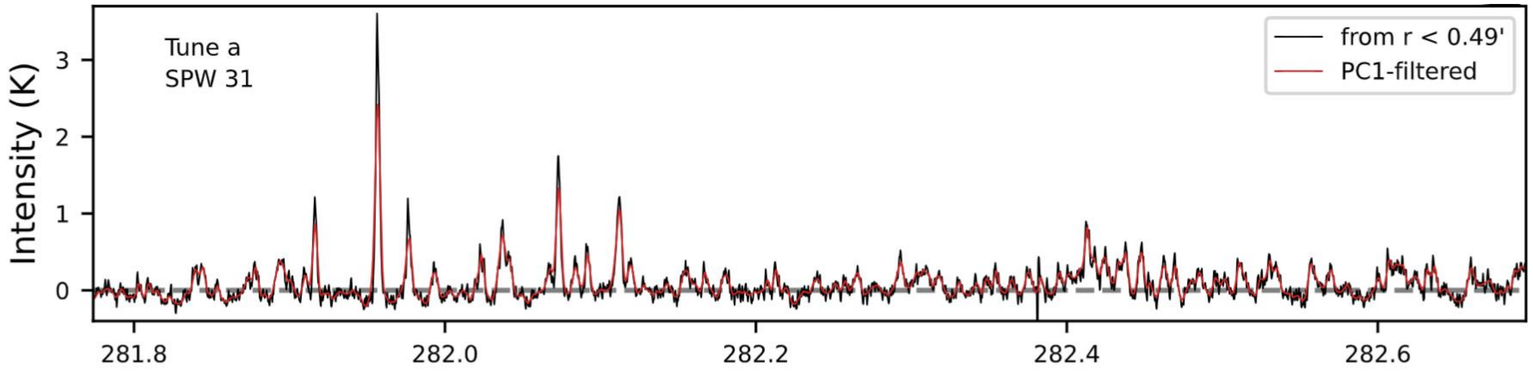

Spectral scan observation toward a protostar BHR 71 IRS1

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 CO

Spectral Range

Minimum frequency (GHz) 50

Maximum frequency (GHz) 500

Excitation Conditions

Background temperature (K) 2.73

Kinetic temperature (K) 30

H_2 density (cm^{-3}) 1e4

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

Radiative Transfer Parameters

Column density (cm^{-2}) 1e14

Line width (km s^{-1}) 1.0

Get Line Intensities

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 (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)

Transition			Frequency (GHz)	T_{ex} (K)	tau	T_R (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.