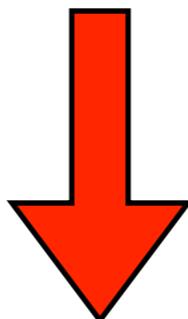


# CASSIS

Centre d'Analyse Scientifique de Spectres Infrarouges et Submillimétrique



Centre d'Analyse Scientifique de Spectres Instrumentaux et Synthétiques

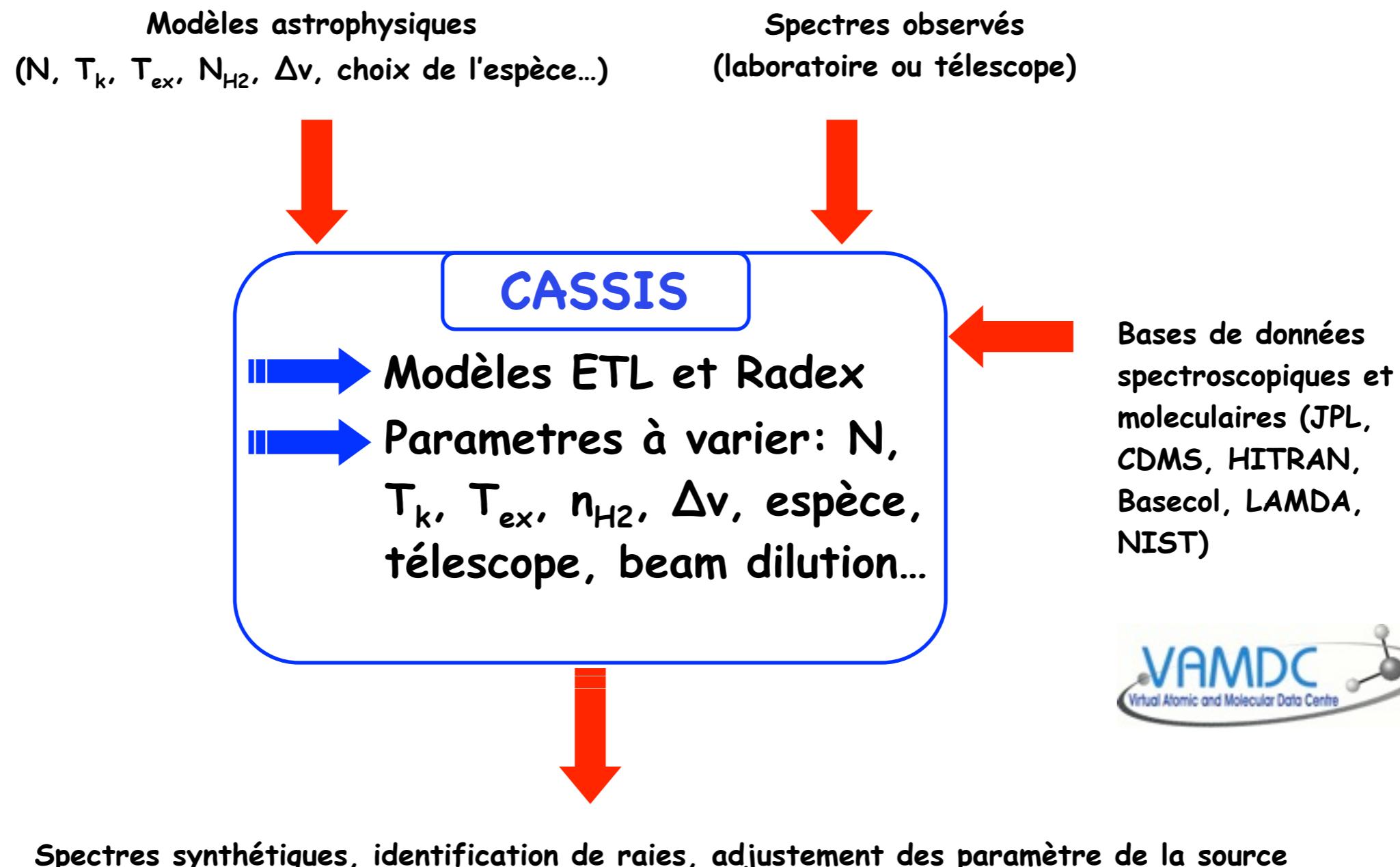


Charlotte Vastel  
et la CASSIS team



# CASSIS: Centre d'Analyse Scientifique de Spectres Instrumentaux et Synthétiques

- Développé à l'IRAP depuis 2005: <http://cassis.irap.omp.eu>
- Service labellisé en 2013 par l'insu
- PI: **E. Caux**; Chef de projet: **Jean-Michel Glorian**
- Scientifiques du projet: **Sandrine Bottinelli, Charlotte Vastel**



# CASSIS in a nutshell

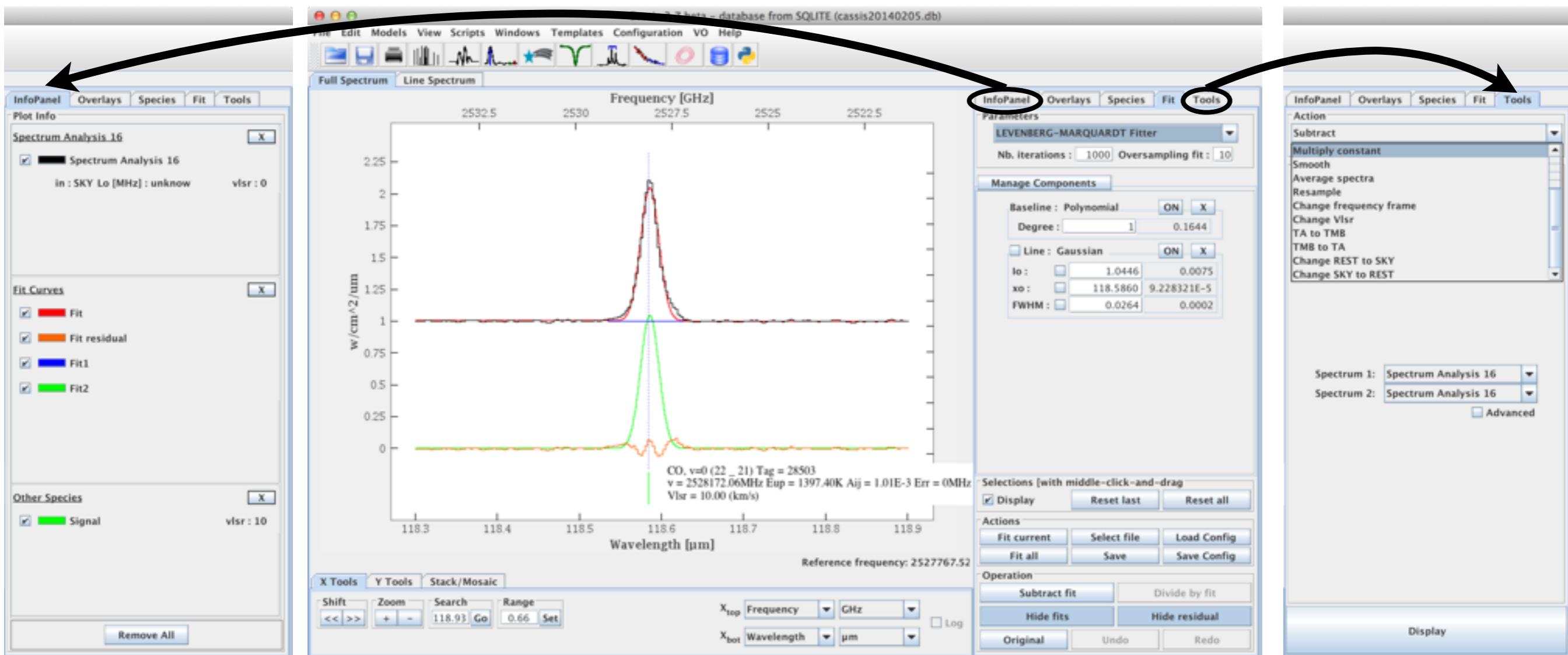
- Display any kind of data, whatever the units are
- Manipulation

AND

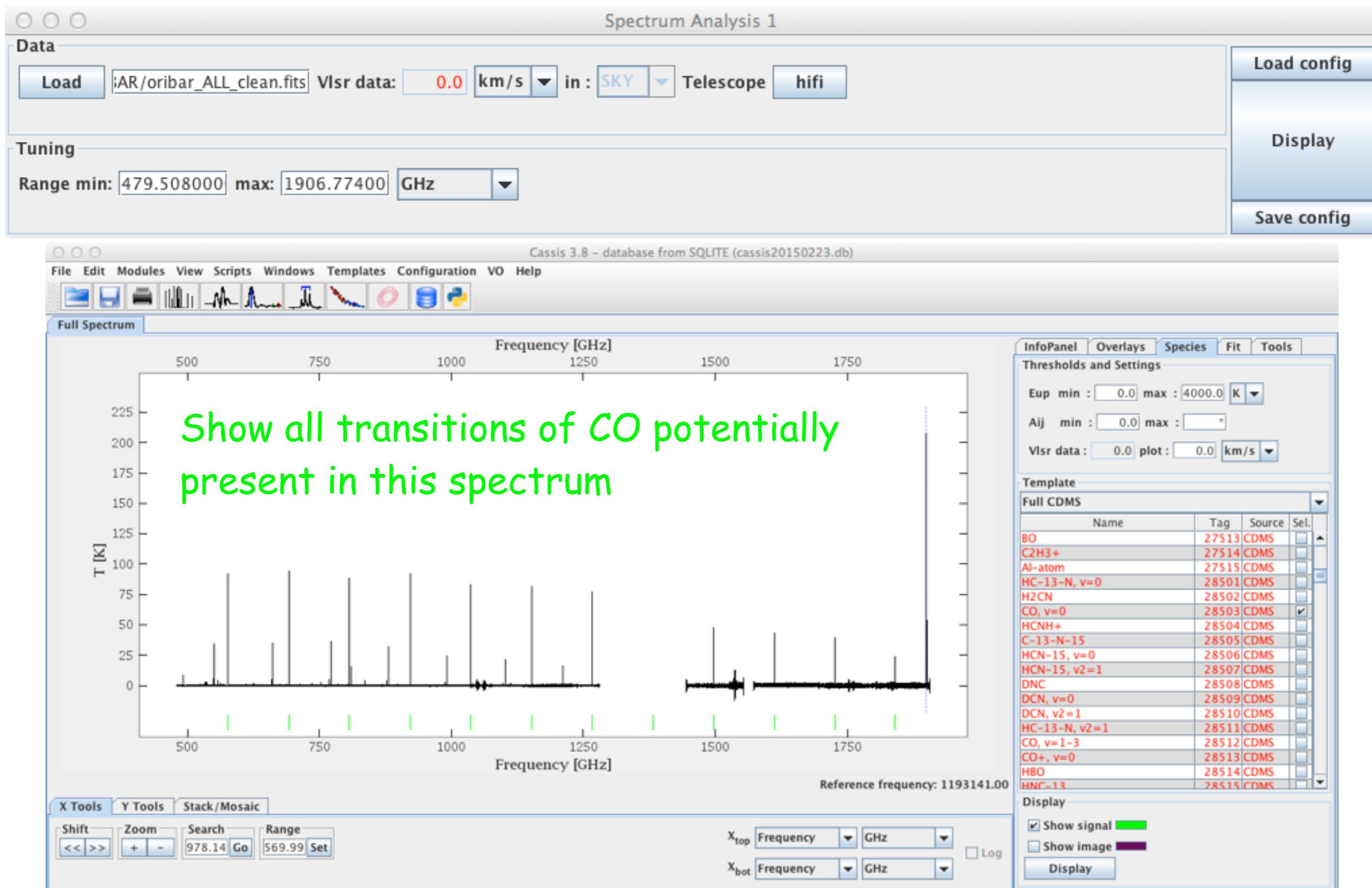
analysis

↓  
re-sampling, average, operations, ...

↓  
Line identification, best model ( $\chi^2$ )



# Use case on a Herschel/HIFI spectral survey



# What to do if we decide to work on CO:

**Line Analysis 1**

**Data**

Load: `iAR/oribar_ALL_clean.fits` Vlsr data: `0.0 km/s` in: `SKY` Telescope: `hifi`

**Tuning**

Range min: `479.508000` max: `1906.77400` GHz Band: `60.0 km/s`

**Threshold**

Eup min: `0.0` max: `1000.0 K` Aij min: `0.0` max: `*`

Jup min: `*` max: `*` Kup min: `*` max: `*` Lup min: `*` max: `*` Mup min: `*` max: `*`

**Template**

ISM		
Name	Tag	Sel.
HCN, v3=1	27509	
HCN, v1=1	27510	
HCCD	27511	
HNC-13	28005	
HN-15-C	28006	
CO+	28009	
HC-13-N, v=0	28501	
H2CN	28502	
CO, v=0	28503	<input checked="" type="checkbox"/>
HCNH+	28504	
C-13-N-15	28505	
HCN-15 .. 0	28506	

**Load config**

**Display**

**Save config**

**LTE-RADEX**

**Parameters**

Telescope: `hifi` Tmb->Ta conv: `hifi`

Noise rms: `0.0 mK`

Oversampling: `3.0`

**Component 1**

Mode: `Full LTE` Interacting:

Molecules: `-- Operations --` Geometry: `Sphere` Tbg [K]: `2.73` N(H<sub>2</sub>) [cm<sup>-2</sup>]: `7.5E22`

V<sub>lsr</sub>: `0.0 km/s`

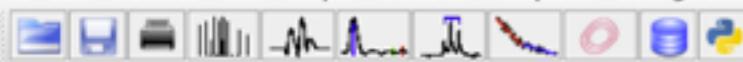
Continuum: Continuum 0 [K]

**Species** **Tag** **Database** **Compute** **N(Sp) (cm<sup>-2</sup>)** **Abundance (/H<sub>2</sub>)** **Tex (K)** **FWHM (km/s)** **Size (")**

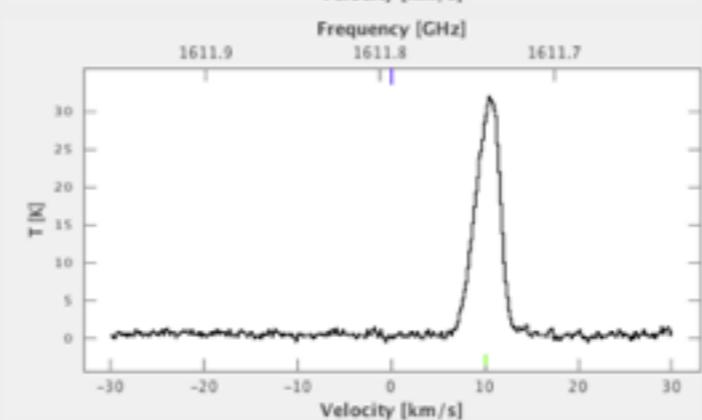
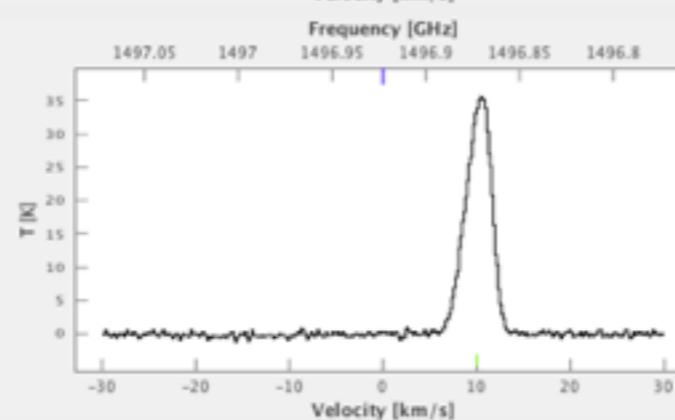
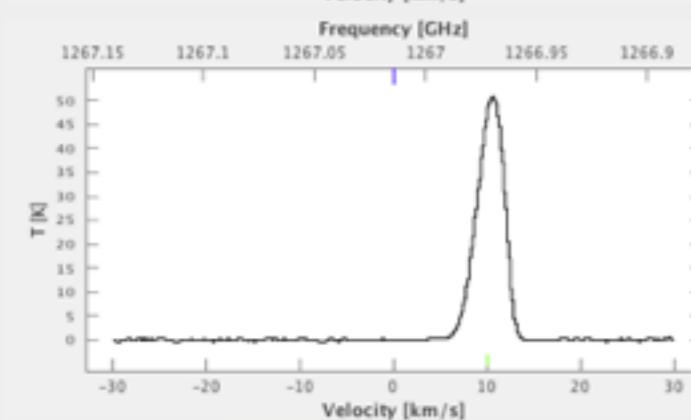
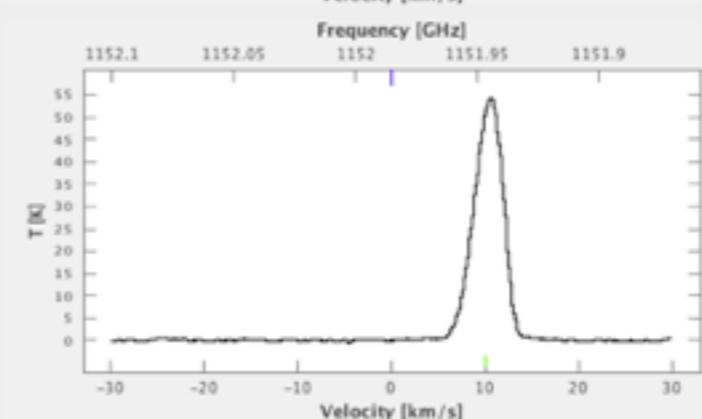
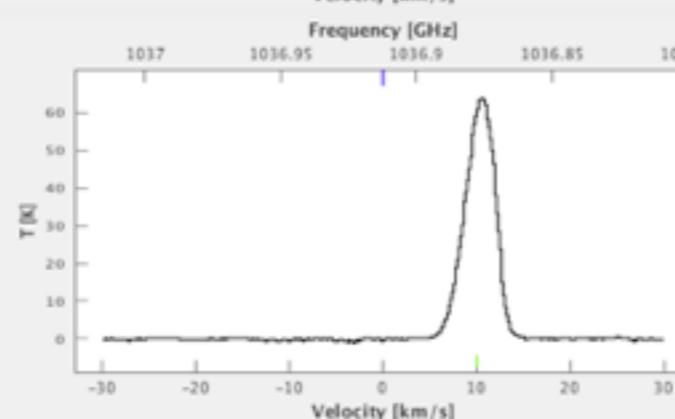
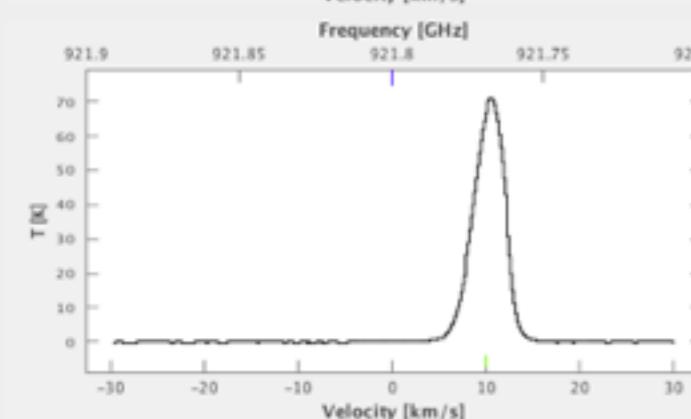
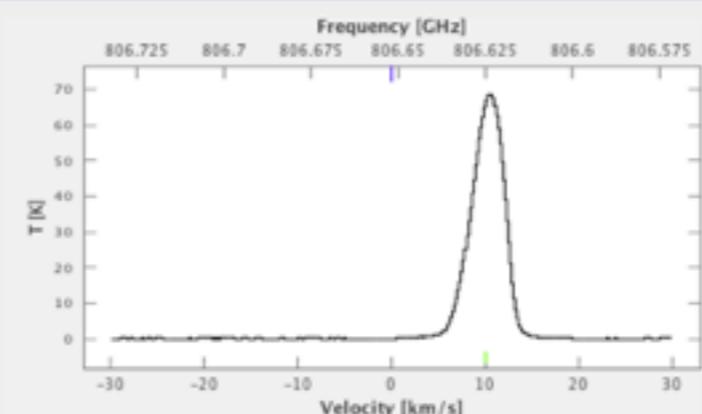
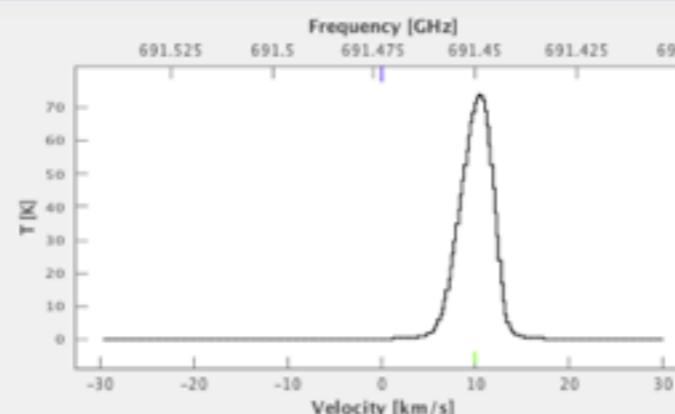
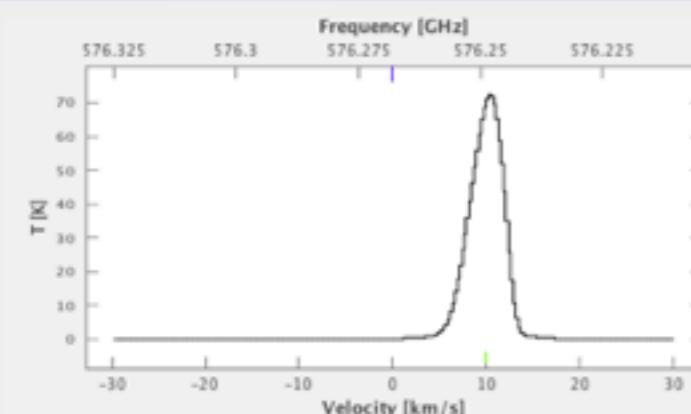
CO, v=0	28503	CDMS	<input checked="" type="checkbox"/>	7.00E14	1.00E-8	100.00	1.00	3.00
---------	-------	------	-------------------------------------	---------	---------	--------	------	------

## Cassis 3.8 – database from SQLITE (cassis20150223.db)

File Edit Modules View Scripts Windows Templates Configuration VO Help



Full Spectrum Line Spectrum



InfoPanel Overlays Species Fit Tools

## Thresholds and Settings

Eup min : 0.0 max : 1000.0 K

Aij min : 0.0 max :

Vlsr data : 0.0 plot: 10.0 km/s

## Template

## ISM

Name	Tag	Source	Sel.
HCN, v=0	27501	CDMS	
HNC, v=0	27502	CDMS	
HCN, v2=1	27503	CDMS	
HNC, v2=1	27504	CDMS	
C-13-N	27505	CDMS	
CN-15	27506	CDMS	
HCN, v2=2	27507	CDMS	
HCN, v2=3	27508	CDMS	
HCN, v3=1	27509	CDMS	
HCN, v1=1	27510	CDMS	
HCCD	27511	CDMS	
HC-13-N, v=0	28501	CDMS	
H2CN	28502	CDMS	
CO, v=0	28503	CDMS	
HCNH+	28504	CDMS	
C-13-N-15	28505	CDMS	
HCN-15, v=0	28506	CDMS	
HCN-15, v2=1	28507	CDMS	
DNC	28508	CDMS	
DCN, v=0	28509	CDMS	
DCN, v2=1	28510	CDMS	
HC-13-N, v2=1	28511	CDMS	
C-13-O	29501	CDMS	
HCND+	29502	CDMS	
CO-17	29503	CDMS	
HOC+, v2=0	29504	CDMS	
HOC+, v2=1	29505	CDMS	
N2H+, v=0; recommended	29506	CDMS	
HCO+, v=0	29507	CDMS	
HCO+, v2=1	29508	CDMS	

## Display

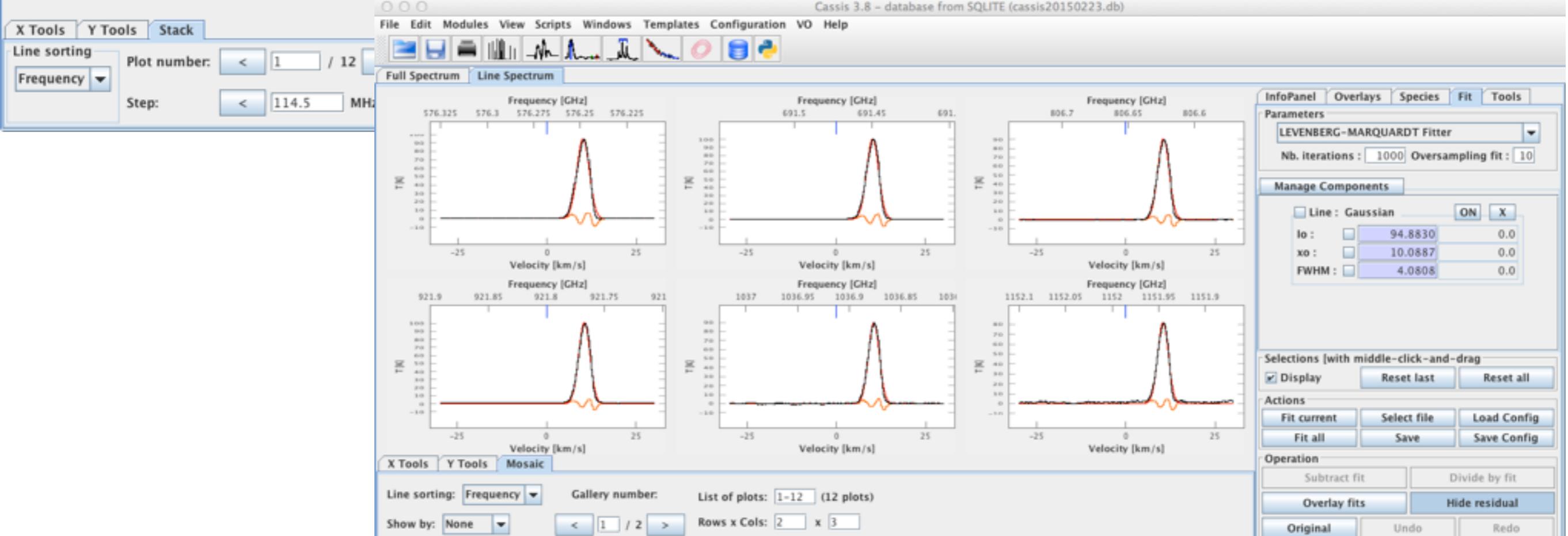
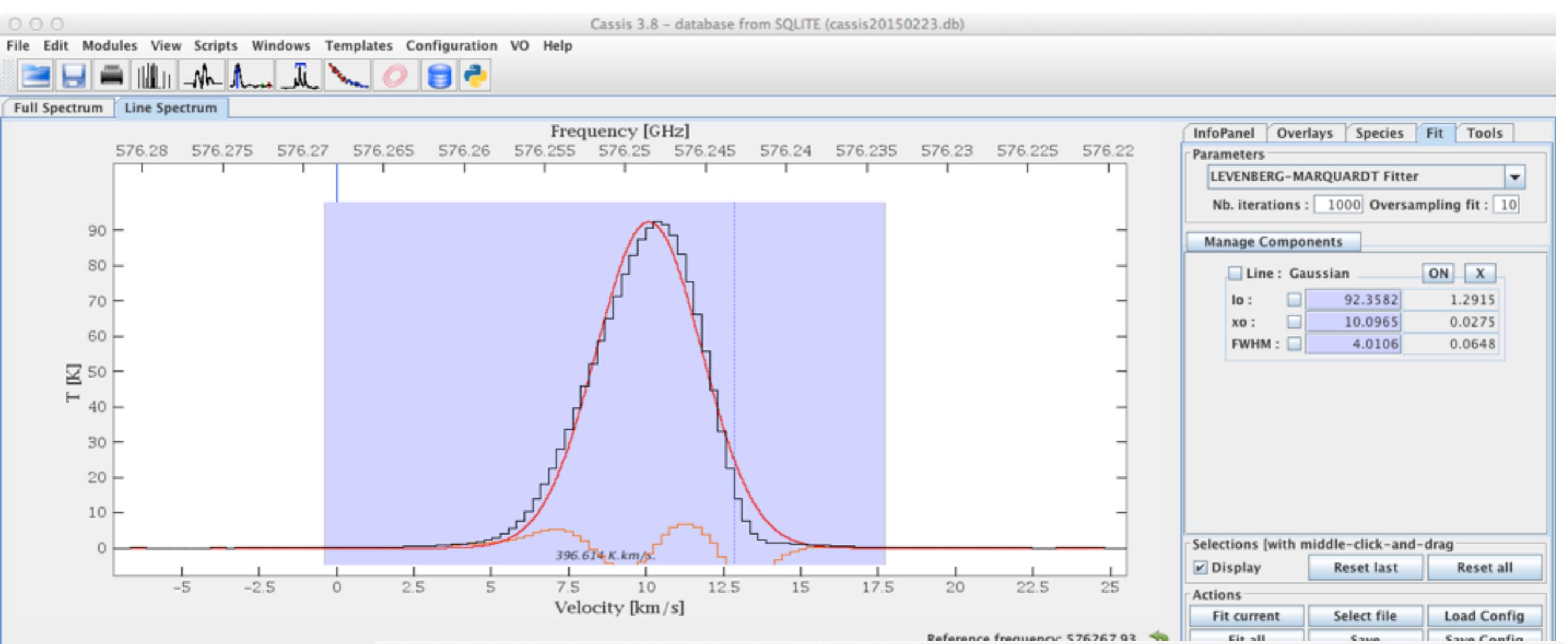
 Show

Display

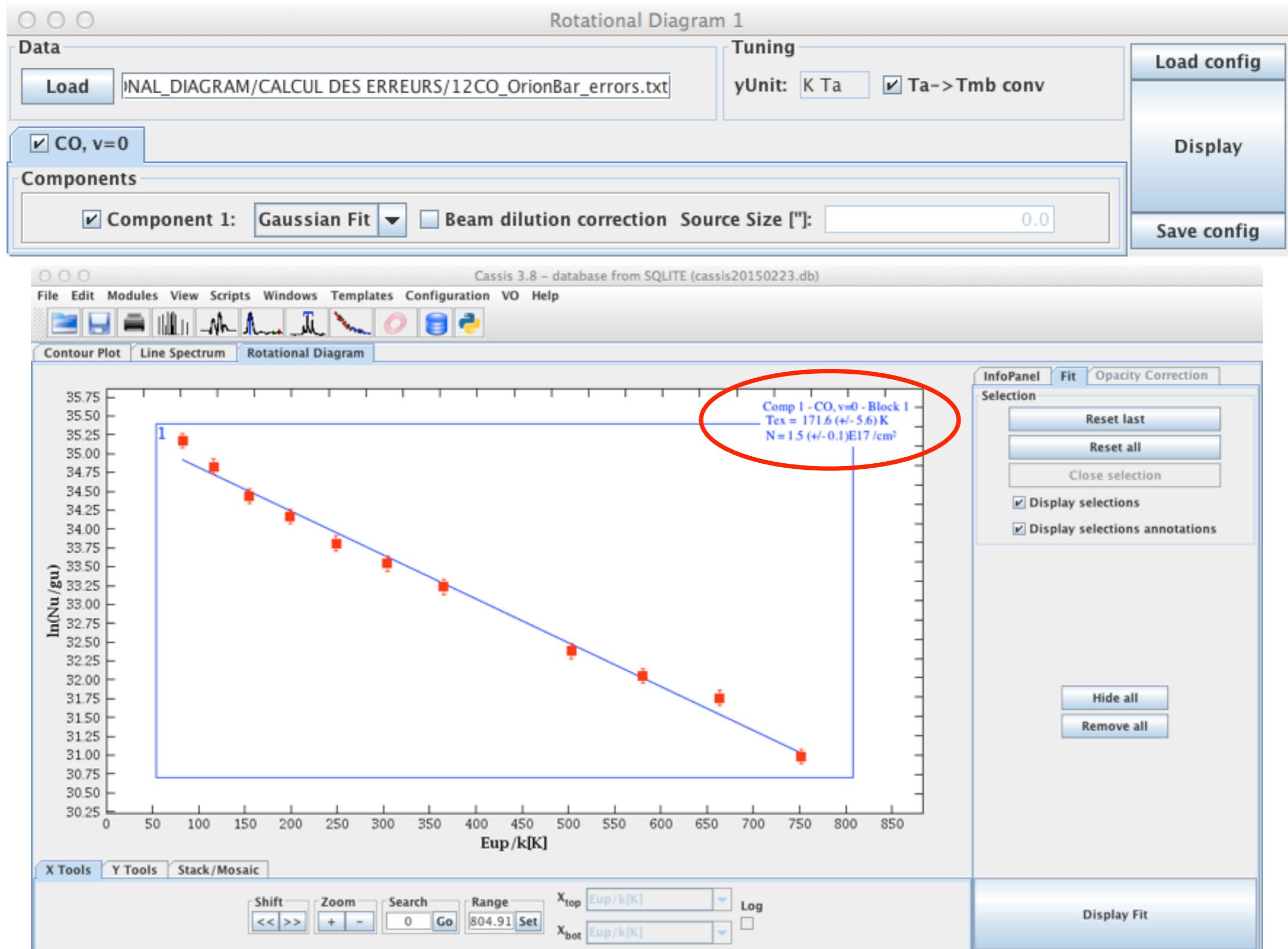
X Tools Y Tools Mosaic

Line sorting: Frequency ▾ Gallery number: List of plots: 1-11 (11 plots)

Show by: None ▾ &lt; 1 / 2 &gt; Rows x Cols: 3 x 3



# Analysis with the rotational diagram module



NB: you can zoom on each point to see the error bars

# Let's inject the values found in the RD module into the LTE modeling tool

Line Analysis 2

Data

Load: sis-oribar\_ALL\_clean.fus Vlsr data: 0.0 km/s in: SKY Telescope: hifi

Tuning

Range min: 479.508 max: 1906.77350 GHz Band: 60.0 km/s

Threshold

Eup min: 0.0 max: 1000.0 K Aij min: 0.0 max: \*

Jup min: \* max: \* Kup min: \* max: \* Lup min: \* max: \* Mup min: \* max: \*

LTE-RADEX

Parameters

Telescope: hifi Tmb->Ta conv: hifi

Noise

rms: 0.0 mK

Oversampling

Oversampling: 3.0

Component 1  +

Mode: Full LTE  Interacting

Molecules: -- Operations -- Geometry: Sphere

Tbg [K]: 2.73 N(H<sub>2</sub>) [cm<sup>-2</sup>]: 7.5E22

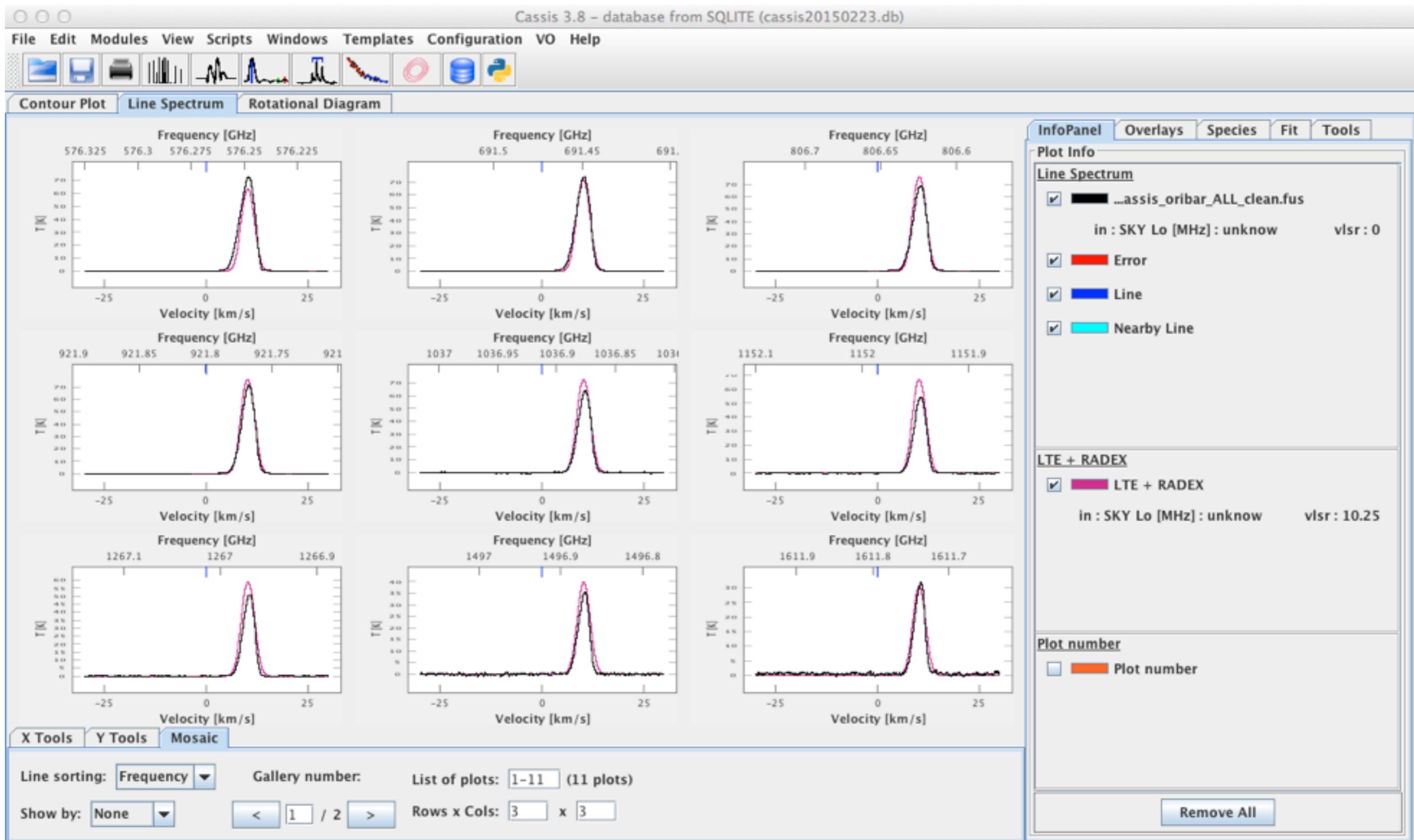
V<sub>lsr</sub>: 10.1 km/s

Continuum

Continuum 0 [K]

Species	Tag	Database	Compute	N(Sp) (cm <sup>-2</sup> )	Abundance (/H2)	Tex (K)	FWHM (km/s)	Size (")
CO, v=0	28503	CDMS	<input checked="" type="checkbox"/>	1.50E17	2.00E-6	171.60	4.00	3000.00

# Let's inject the values found in the RD module into the LTE modeling tool



Good agreement with the data considering that we only used one velocity component.

## Collisions Files and Partners Densities

Collision Files: co.dat

Partners Densities:

H2

p-H2 1.0E04

o-H2 1.0E04

e

H

He

H+

## non-LTE modeling

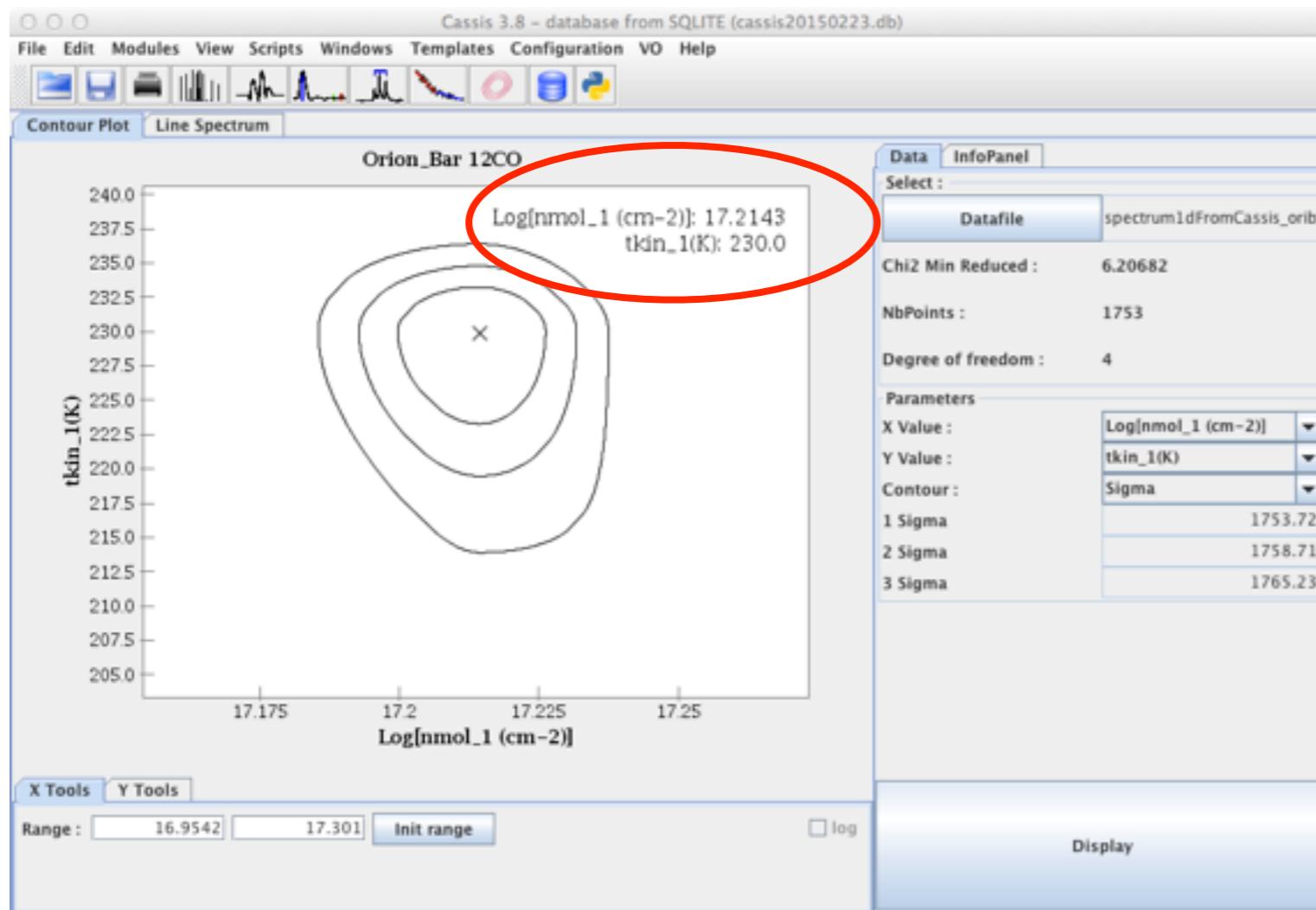
**Line Analysis 1**

Data			Template																			
<input type="button" value="Load"/>	r_ALL_QuickAndDirty.fits	Vlsr data: 0.0 km/s	in: SKY	Telescope ???																		
Tuning																						
Range min: 479.514	max: 1906.77400	GHz	Band: 60.0	km/s																		
Threshold																						
Eup min: 0.0	max: 1000.0	K	Aij min: 0.0	max: *																		
Jup min: *	max: *	Kup min: *	max: *	Lup min: *	max: *	Mup min: *	max: *															
<input checked="" type="checkbox"/> LTE-RADEX																						
Parameters					Noise	Oversampling																
Telescope: apex	<input type="checkbox"/> Tmb->Ta conv	apex	rms: 0.0 mK	3.0																		
<input checked="" type="checkbox"/> Component 1 <input type="button" value="X"/> <input type="button" value="+"/> <table border="1"> <tr> <td>Mode: Full Radex</td> <td><input checked="" type="checkbox"/> Interacting</td> <td>Tbg [K]: 2.73</td> <td>N(H<sub>2</sub>) [cm<sup>-2</sup>]: 7.5E22</td> <td>Continuum</td> </tr> <tr> <td>Molecules: -- Operations --</td> <td>Geometry: Sphere</td> <td>V<sub>lsr</sub>: 0.0 km/s</td> <td>Continuum 0 [K]</td> </tr> <tr> <td>Species: CO, v=0</td> <td>Tag: 28503 CDMS</td> <td>Database: co.dat&amp;(p-H2;...</td> <td>Compute: <input checked="" type="checkbox"/></td> <td>N(Sp) (cm<sup>-2</sup>): 1.50E17</td> <td>Abundance (/...): 2.00E-6</td> <td>TKin (K): 170.00</td> <td>FWHM (km/s): 4.00</td> <td>Size (''): 3000.00</td> </tr> </table>					Mode: Full Radex	<input checked="" type="checkbox"/> Interacting	Tbg [K]: 2.73	N(H <sub>2</sub> ) [cm <sup>-2</sup> ]: 7.5E22	Continuum	Molecules: -- Operations --	Geometry: Sphere	V <sub>lsr</sub> : 0.0 km/s	Continuum 0 [K]	Species: CO, v=0	Tag: 28503 CDMS	Database: co.dat&(p-H2;...	Compute: <input checked="" type="checkbox"/>	N(Sp) (cm <sup>-2</sup> ): 1.50E17	Abundance (/...): 2.00E-6	TKin (K): 170.00	FWHM (km/s): 4.00	Size (''): 3000.00
Mode: Full Radex	<input checked="" type="checkbox"/> Interacting	Tbg [K]: 2.73	N(H <sub>2</sub> ) [cm <sup>-2</sup> ]: 7.5E22	Continuum																		
Molecules: -- Operations --	Geometry: Sphere	V <sub>lsr</sub> : 0.0 km/s	Continuum 0 [K]																			
Species: CO, v=0	Tag: 28503 CDMS	Database: co.dat&(p-H2;...	Compute: <input checked="" type="checkbox"/>	N(Sp) (cm <sup>-2</sup> ): 1.50E17	Abundance (/...): 2.00E-6	TKin (K): 170.00	FWHM (km/s): 4.00	Size (''): 3000.00														

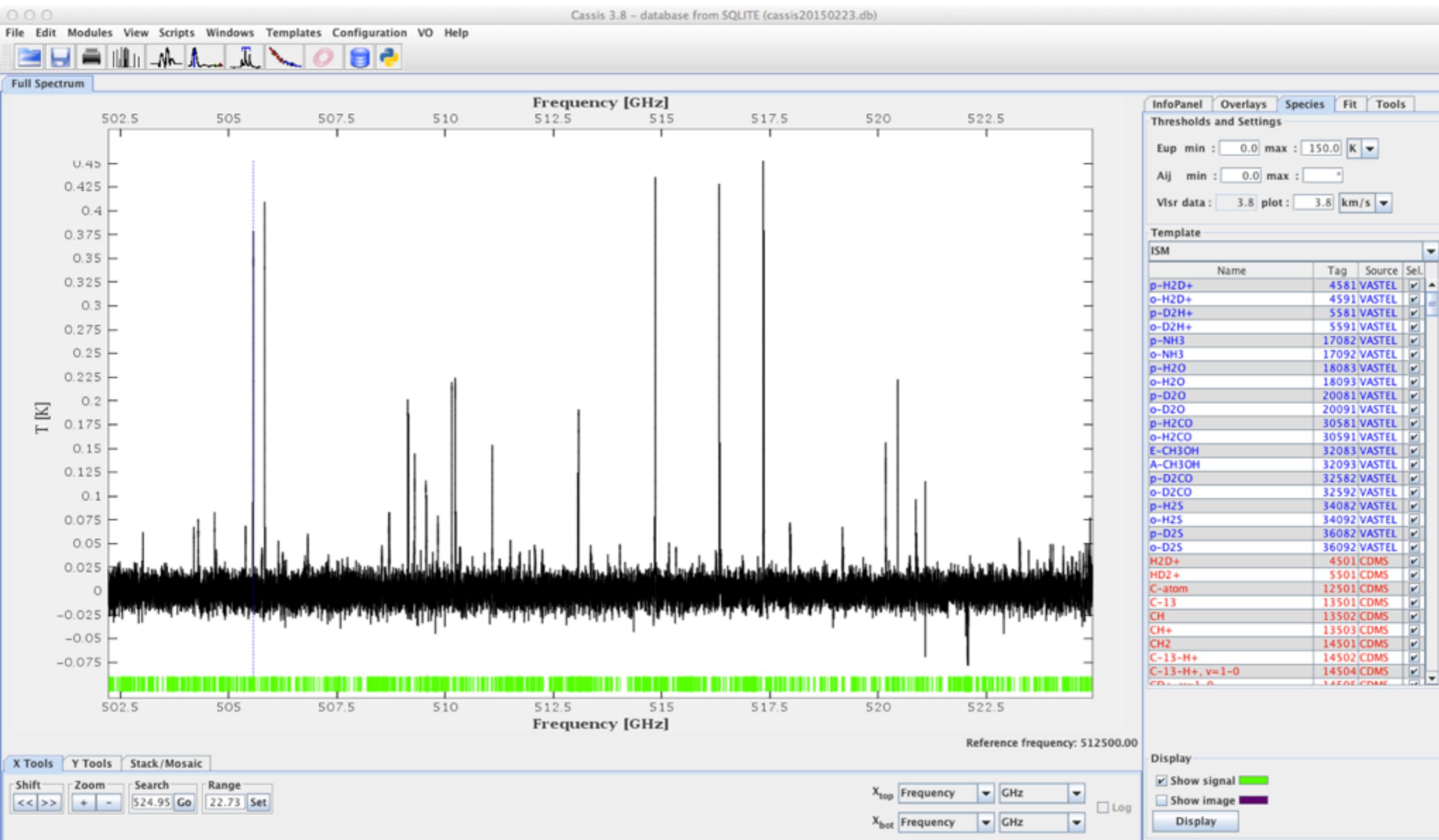
# Parameters exploration with python scripts:

- MCMC (Markov Chain Monte Carlo)
- Regular Grid

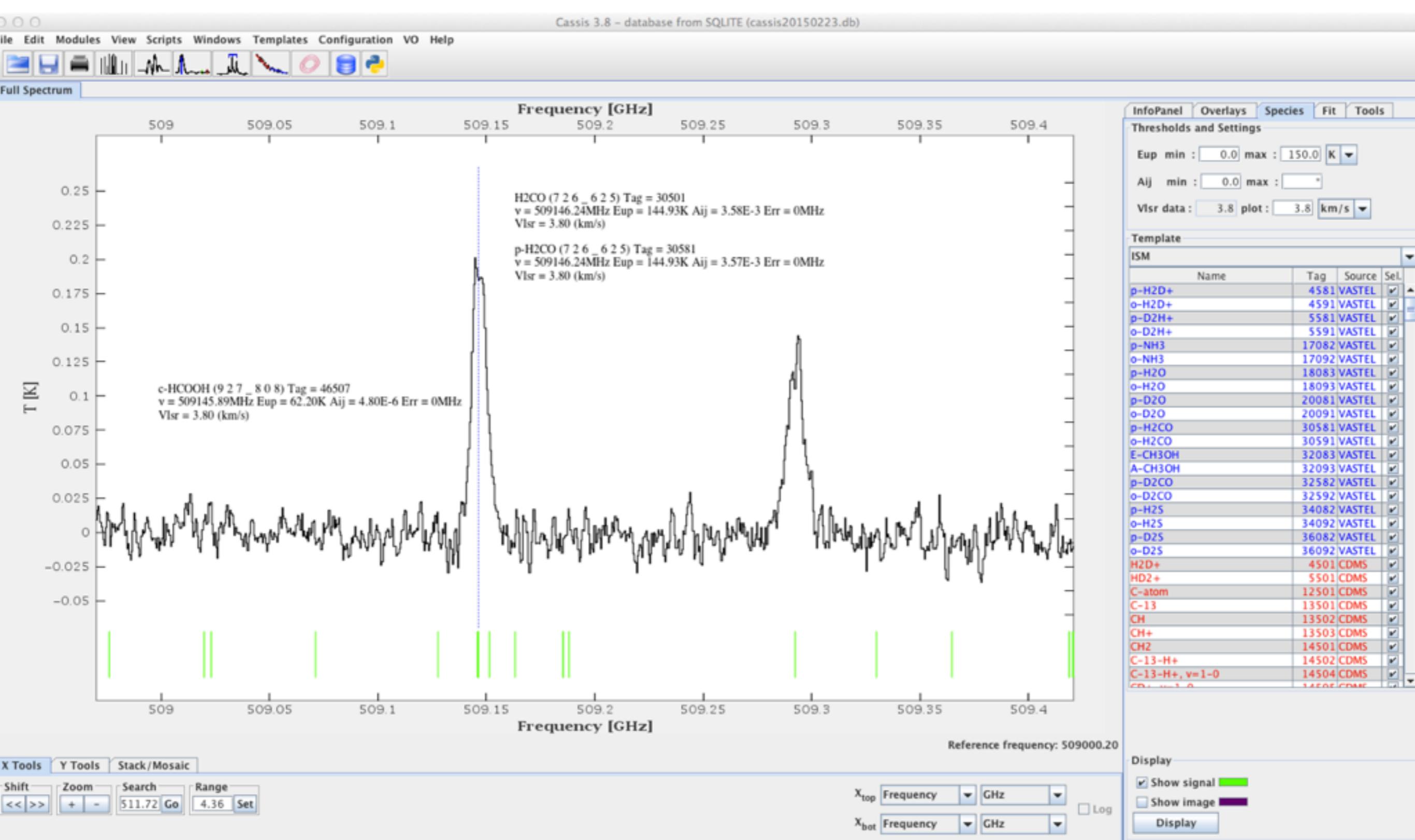
Variation of many parameters: column density, excitation temperature (LTE), kinetic temperature and density (non-LTE) followed by a  $\chi^2$  minimization

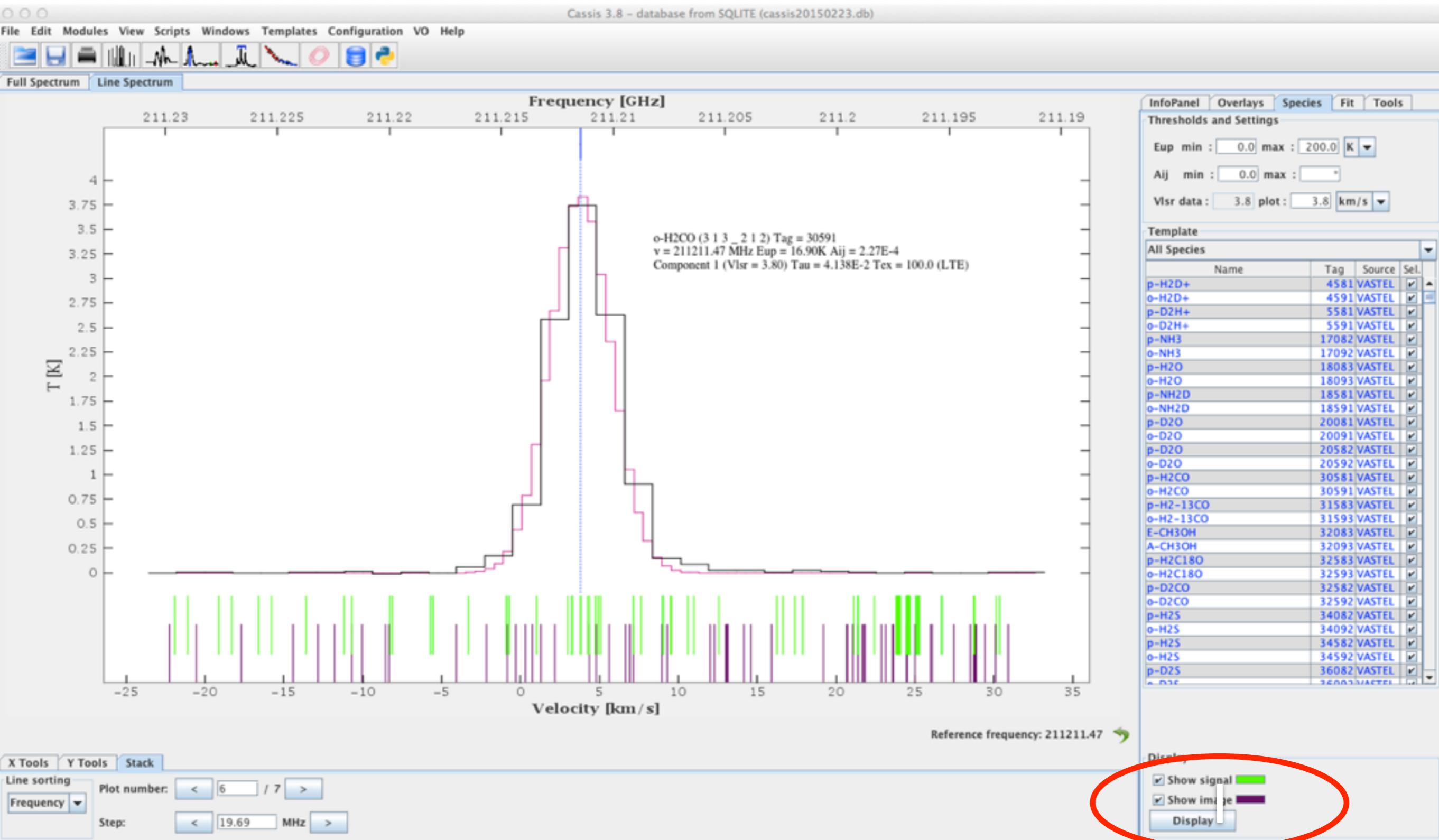


# Very useful for large spectral surveys



# Very useful for large spectral surveys (zoom)





# Databases and interoperability

Our needs: atomic, molecular, collisional databases



Local database (SQLite), built on CDMS, JPL, NIST, and private databases (lab or computations), database with nuclear spin state (ortho, para, A and E)



Access to the CDMS, JPL and VALD databases linked through VAMDC



SSAP (Single Spectral Access Protocol) request through a CASSIS module allowing to access the IVOA services to retrieve and display any spectra (Hubble, Corot, Splatatalogue, ISO, etc; <http://registry.euro-vo.org>)

# SSAP requests module

Simple Spectral Access (SSA)

Registry & Services selection

Registry: <http://registry.euro-vo.org/services/RegistrySearch> Query

The ISO Data Archive InterOperability System →

The NASA/IPAC Extragalactic Database SED Data Discov...

TheoSSA - Theoretical Stellar Spectra Access

TLUSTY BSTAR2006

TLUSTY OSTAR2002

TLUSTY OSTAR2002+BSTAR2006

Tübingen Echelle Spectra

Deselect all Select all Add service

Request

Global Parameters

Object name:  Resolve

RA:  DEC:

SIZE:

BAND:

TIME:

FORMAT:

Optional Parameters

Use	Name	Value
<input type="checkbox"/>	APERTURE	
<input type="checkbox"/>	author	
<input type="checkbox"/>	Collection	
<input type="checkbox"/>	COMPRESS	
<input type="checkbox"/>	Contact	
<input type="checkbox"/>	coord	
<input type="checkbox"/>	coord_obs	
<input type="checkbox"/>	coord_targ	
<input type="checkbox"/>	cr_ident	
<input type="checkbox"/>	CreationType	
<input type="checkbox"/>	Creator	
<input type="checkbox"/>	CREATORID	

Query

<SERVER>?REQUEST=queryData&POS=83.82208,-5.39111 Advanced Query

Results

FEROS SSAP × HEROS OND CUTOUT × HEROS OND × Flash/Heros SSAP × theossa × ISO SSAP ×

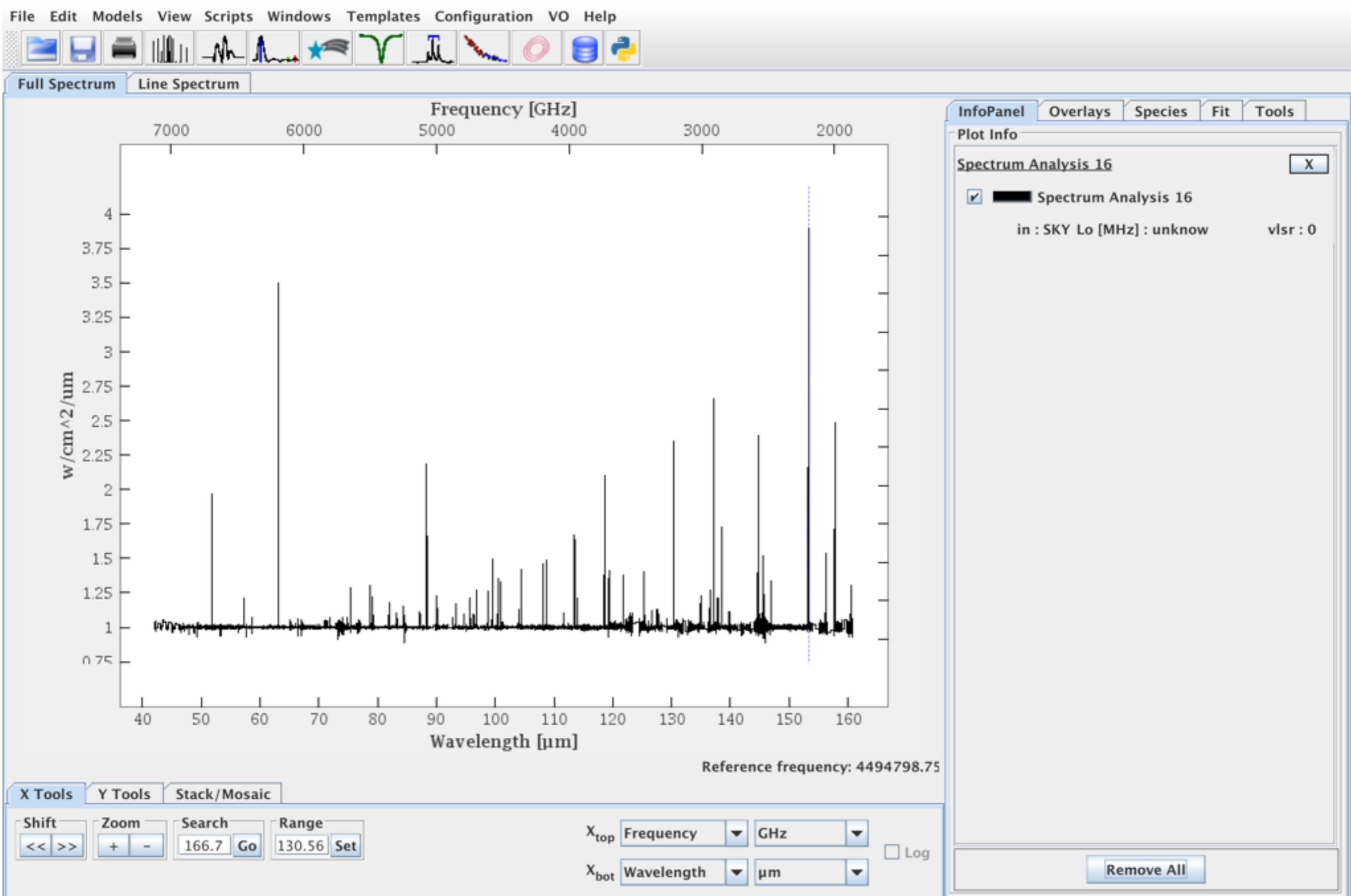
IUE × TBL Narval × mlqso bidi ssa × Upfihps × NOVA WR35a Optical Spectra ×

castor × NOVA HD 165052 Optical Spectra × HST STIS Spectra × HST.GHRS Spectra × HST.FOS Spectra × Ihps × HST Spectra × Polarbase SSAP ×

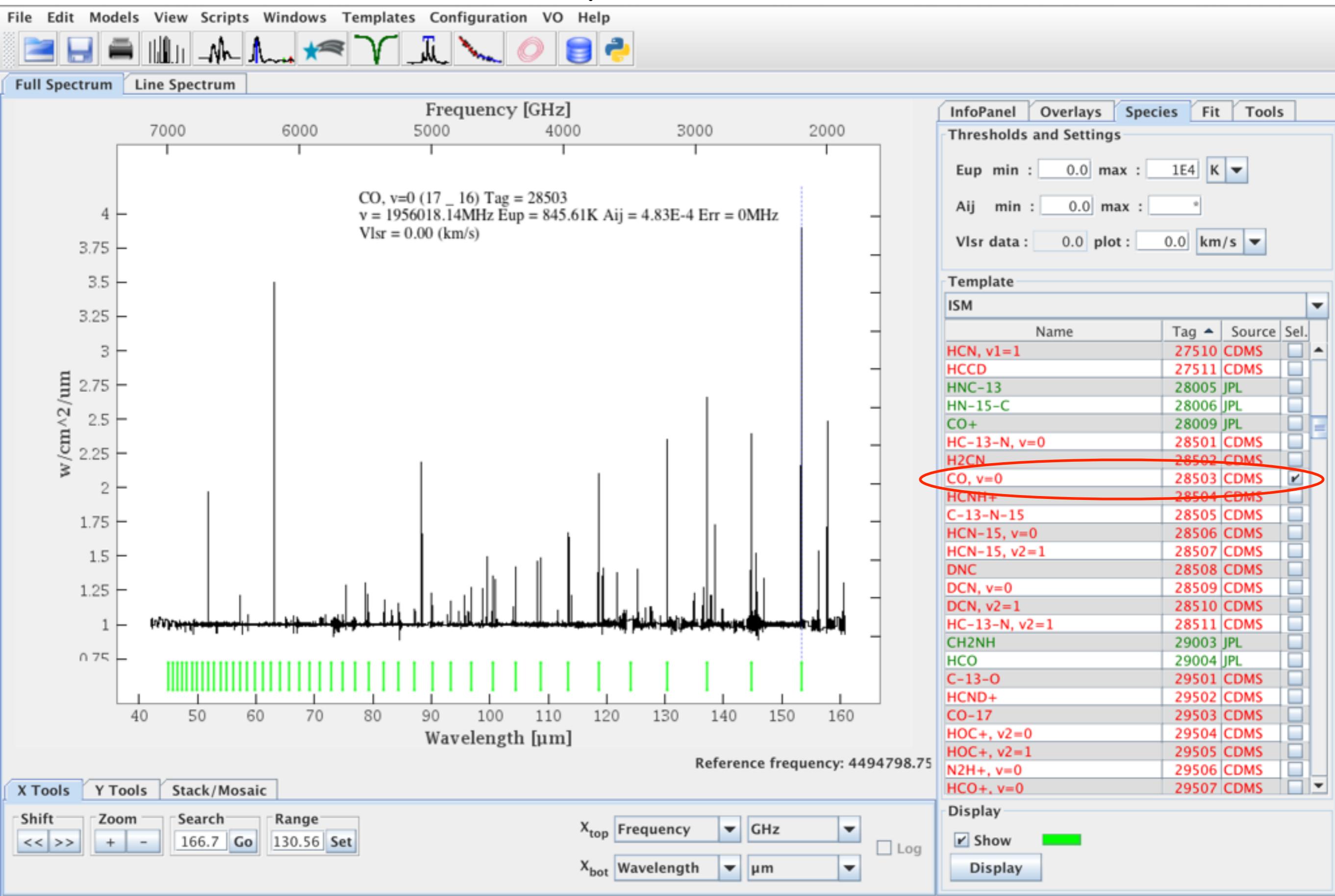
Index	ObsId	Reference	Target_Name	Date
11	70101216	<a href="http://archives.esac.esa.int/ida/aio/jsp/product.jsp?obsno=70101216&amp;protocol=HTTP&amp;name=lsan&amp;level=Custom">http://archives.esac.esa.int/ida/aio/jsp/product.jsp?obsno=70101216&amp;protocol=HTTP&amp;name=lsan&amp;level=Custom</a>	ISO LWS04 Spectrum Target: ORIAIRC2	1997-10-01
12	70101512	<a href="http://archives.esac.esa.int/ida/aio/jsp/product.jsp?obsno=70101512&amp;protocol=HTTP&amp;name=lsph&amp;level=Custom">http://archives.esac.esa.int/ida/aio/jsp/product.jsp?obsno=70101512&amp;protocol=HTTP&amp;name=lsph&amp;level=Custom</a>	ISO LWS01 Spectrum Target: ORIAIRC2	1997-10-01
13	70101609	<a href="http://archives.esac.esa.int/ida/aio/jsp/product.jsp?obsno=70101609&amp;protocol=HTTP&amp;name=lsph&amp;level=Custom">http://archives.esac.esa.int/ida/aio/jsp/product.jsp?obsno=70101609&amp;protocol=HTTP&amp;name=lsph&amp;level=Custom</a>	ISO LWS01 Spectrum Target: ORIAIRC2	1997-10-01
14	69602317	<a href="http://archives.esac.esa.int/ida/aio/jsp/product.jsp?obsno=69602317&amp;protocol=HTTP&amp;name=lsp&amp;level=Custom">http://archives.esac.esa.int/ida/aio/jsp/product.jsp?obsno=69602317&amp;protocol=HTTP&amp;name=lsp&amp;level=Custom</a>	ISO LWS04 Spectrum Target: ORIAIRC2	1997-10-01
15	70101611	<a href="http://archives.esac.esa.int/ida/aio/jsp/product.jsp?obsno=70101611&amp;protocol=HTTP&amp;name=lsph&amp;level=Custom">http://archives.esac.esa.int/ida/aio/jsp/product.jsp?obsno=70101611&amp;protocol=HTTP&amp;name=lsph&amp;level=Custom</a>	ISO LWS01 Spectrum Target: ORIAIRC2	1997-10-01
16	70101708	<a href="http://archives.esac.esa.int/ida/aio/jsp/product.jsp?obsno=70101708&amp;protocol=HTTP&amp;name=lsph&amp;level=Custom">http://archives.esac.esa.int/ida/aio/jsp/product.jsp?obsno=70101708&amp;protocol=HTTP&amp;name=lsph&amp;level=Custom</a>	ISO LWS03 Spectrum Target: ORION BN/KL	1997-10-01
17	70101704	<a href="http://archives.esac.esa.int/ida/aio/jsp/product.jsp?obsno=70101704&amp;protocol=HTTP&amp;name=lsph&amp;level=Custom">http://archives.esac.esa.int/ida/aio/jsp/product.jsp?obsno=70101704&amp;protocol=HTTP&amp;name=lsph&amp;level=Custom</a>	ISO LWS03 Spectrum Target: ORION BN/KL	1997-10-01
18	70001209	<a href="http://archives.esac.esa.int/ida/aio/jsp/product.jsp?obsno=70001209&amp;protocol=HTTP&amp;name=lsph&amp;level=Custom">http://archives.esac.esa.int/ida/aio/jsp/product.jsp?obsno=70001209&amp;protocol=HTTP&amp;name=lsph&amp;level=Custom</a>	ISO LWS03 Spectrum Target: ORION BN/KL	1997-10-01
19	70001127	<a href="http://archives.esac.esa.int/ida/aio/jsp/product.jsp?obsno=70001127&amp;protocol=HTTP&amp;name=lsph&amp;level=Custom">http://archives.esac.esa.int/ida/aio/jsp/product.jsp?obsno=70001127&amp;protocol=HTTP&amp;name=lsph&amp;level=Custom</a>	ISO LWS03 Spectrum Target: ORION BN/KL	1997-10-01

Deselect all Download selected Download all Display selected Display all Open with... Clear results

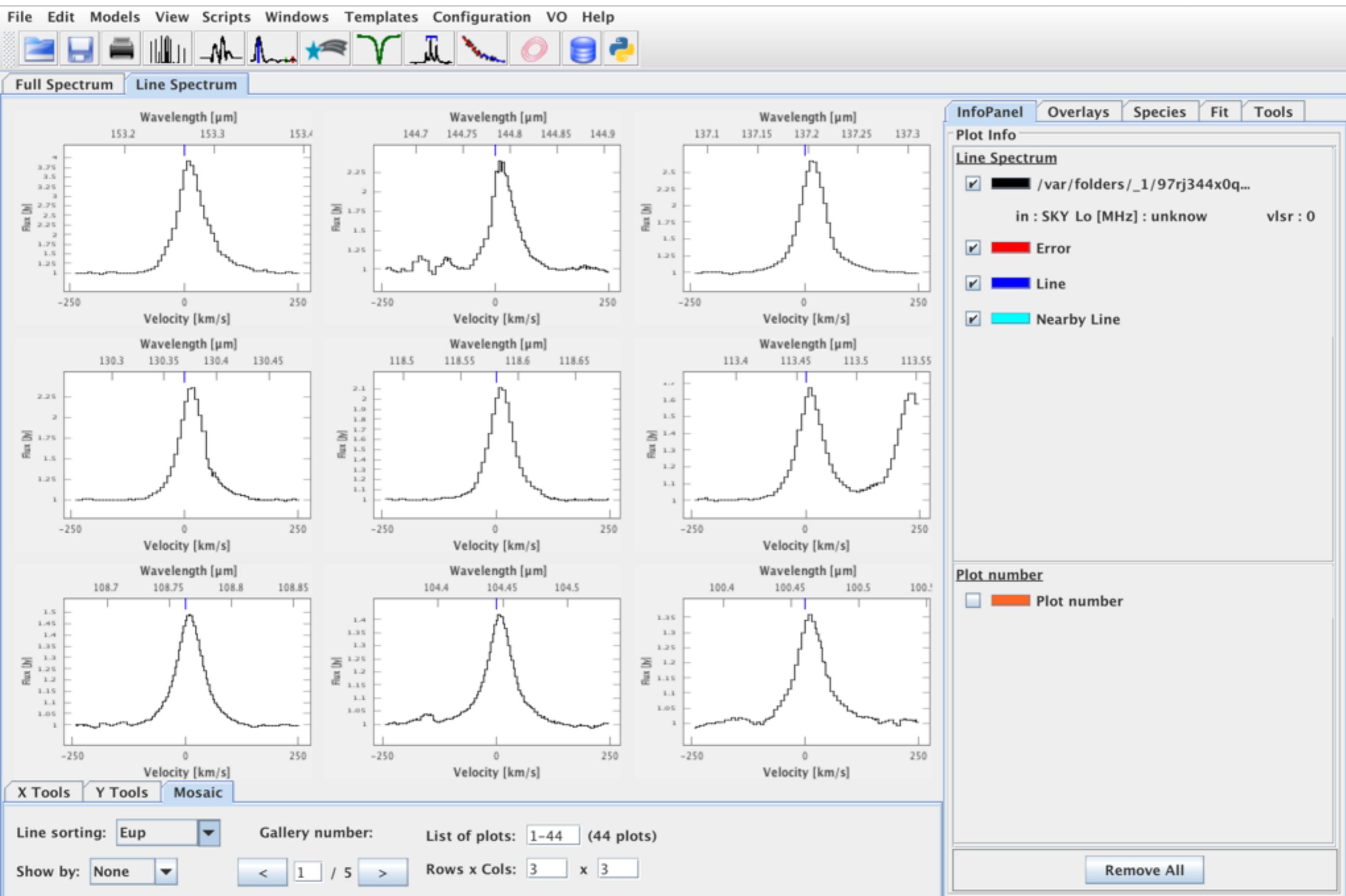
# SSAP requests module



# SSAP requests module



# "Line Analysis" module



# VAMDC requests

User Configuration

**Database**

Database Type: VAMDC

Database Path: <http://cdms.ph1.uni-koeln.de/cdms/tap/>

In-memory database:

**Radex**

Radex Max Part: 7

Radex Max Temp: 99

Radex Max Lev: 305

Radex Max Line: 2350

Radex Max Coll: 19999

**Species sources colors**

NIST  JPL  CDMS  VASTEL

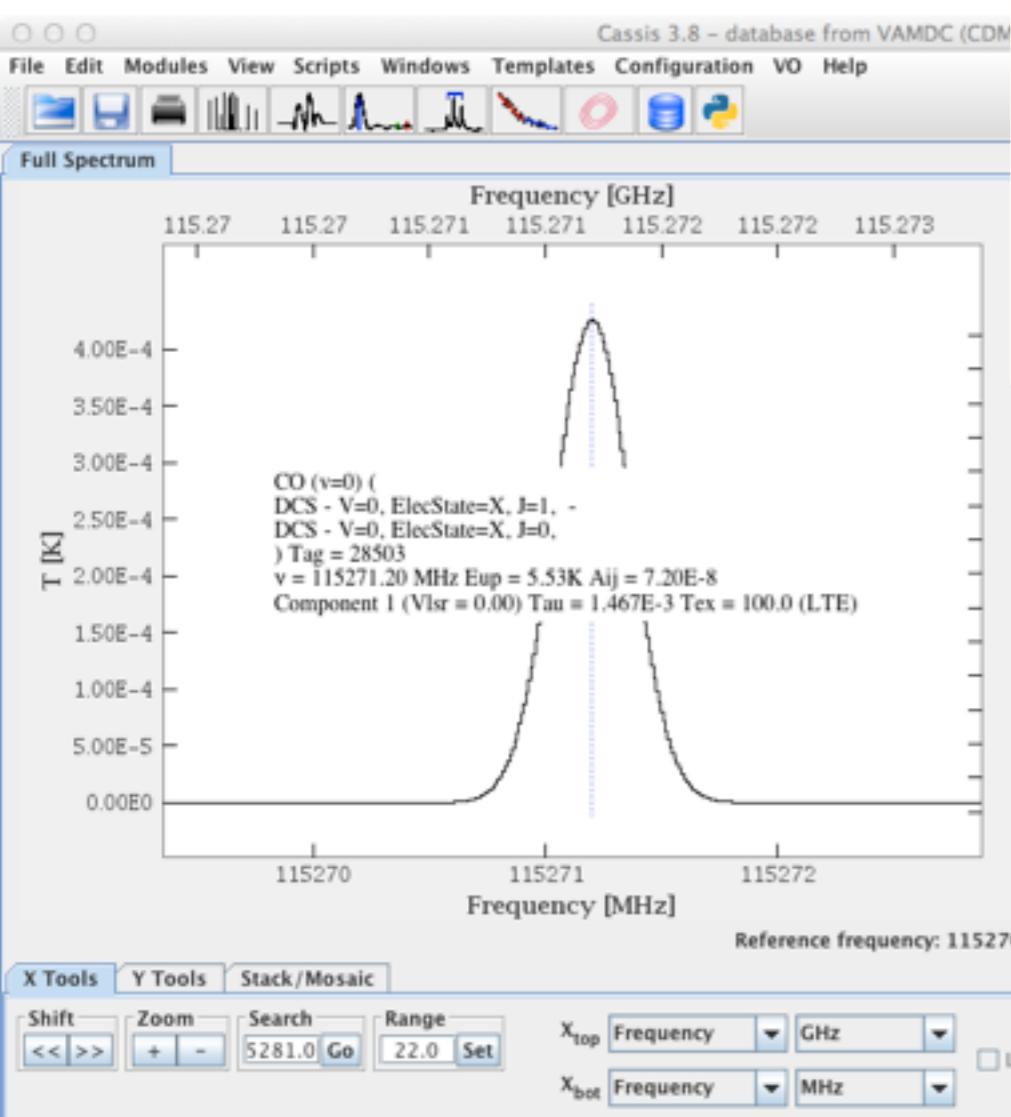
**General Settings**

Autostart Samp: true

Force direct opening: false

**Buttons**

Save  Cancel



LTE + RADEX 1

**Tuning**

Range min: 115.26 max: 115.28 GHz dv: 0.01 MHz

Line: 115.5 Bandwidth: 4.0 GHz DSB: LSB LO freq: 119.5 Telescope: apex

**Threshold**

Eup min: 0.0 max: 150.0 K Aij min: 0.0 max: \*

Jup min: \* max: \* Kup min: \* max: \* Lup min: \* max: \* Mup min: \* max: \*

**LTE-RADEX**

**Parameters**

Telescope: apex  Tmb->Ta conv apex

Noise rms: 0.0 mK  Frequency Scale Rest. frequency

**Component 1**

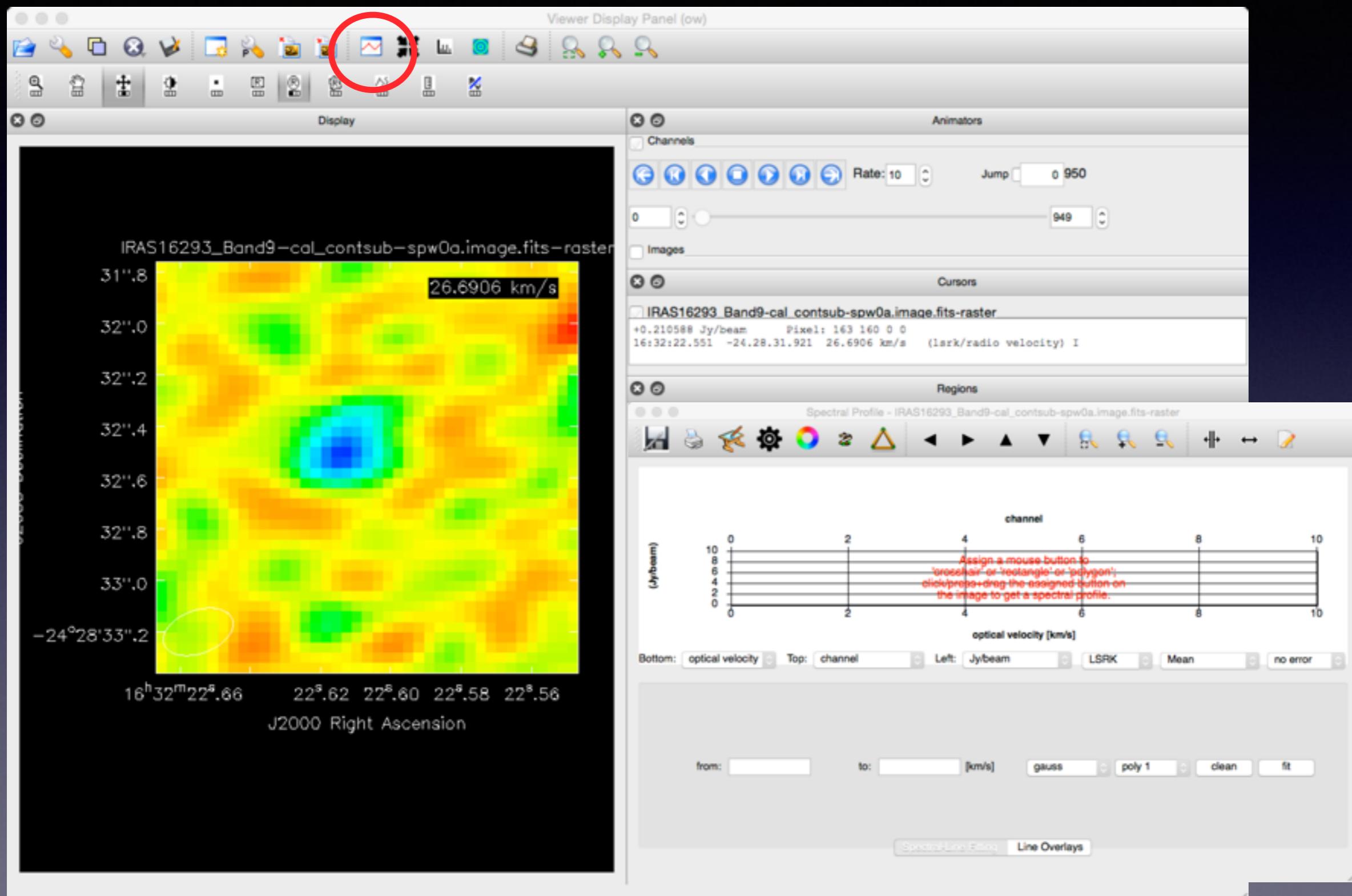
Mode:	Full LTE	Interacting	Tbg [K]:	2.73	N(H <sub>2</sub> ) [cm <sup>-2</sup> ]:	7.5E22	Continuum	
Molecules:	COs	Geometry:	Sphere	V <sub>lsr</sub> :	0.0 km/s	Continuum 0 [K]		
Species	Tag	Database	Compute	N(Sp) (cm <sup>-2</sup> )	Abundance (/H <sub>2</sub> )	Tex (K)	PWHM (km/s)	Size (")
CO, v=0	28503 CDMS	<input checked="" type="checkbox"/>	<input type="checkbox"/>	7.00E14	1.00E-8	100.0	1.00	3.00
C-13-O	29501 CDMS	<input type="checkbox"/>	<input type="checkbox"/>	7.00E14	1.00E-8	100.0	1.00	3.00
CO-17	29503 CDMS	<input type="checkbox"/>	<input type="checkbox"/>	7.00E14	1.00E-8	100.0	1.00	3.00
CO-18	30502 CDMS	<input type="checkbox"/>	<input type="checkbox"/>	7.00E14	1.00E-8	100.0	1.00	3.00
C-13-O-17	30503 CDMS	<input type="checkbox"/>	<input type="checkbox"/>	7.00E14	1.00E-8	100.0	1.00	3.00
C-13-O-18	31502 CDMS	<input type="checkbox"/>	<input type="checkbox"/>	7.00E14	1.00E-8	100.0	1.00	3.00

Remove All

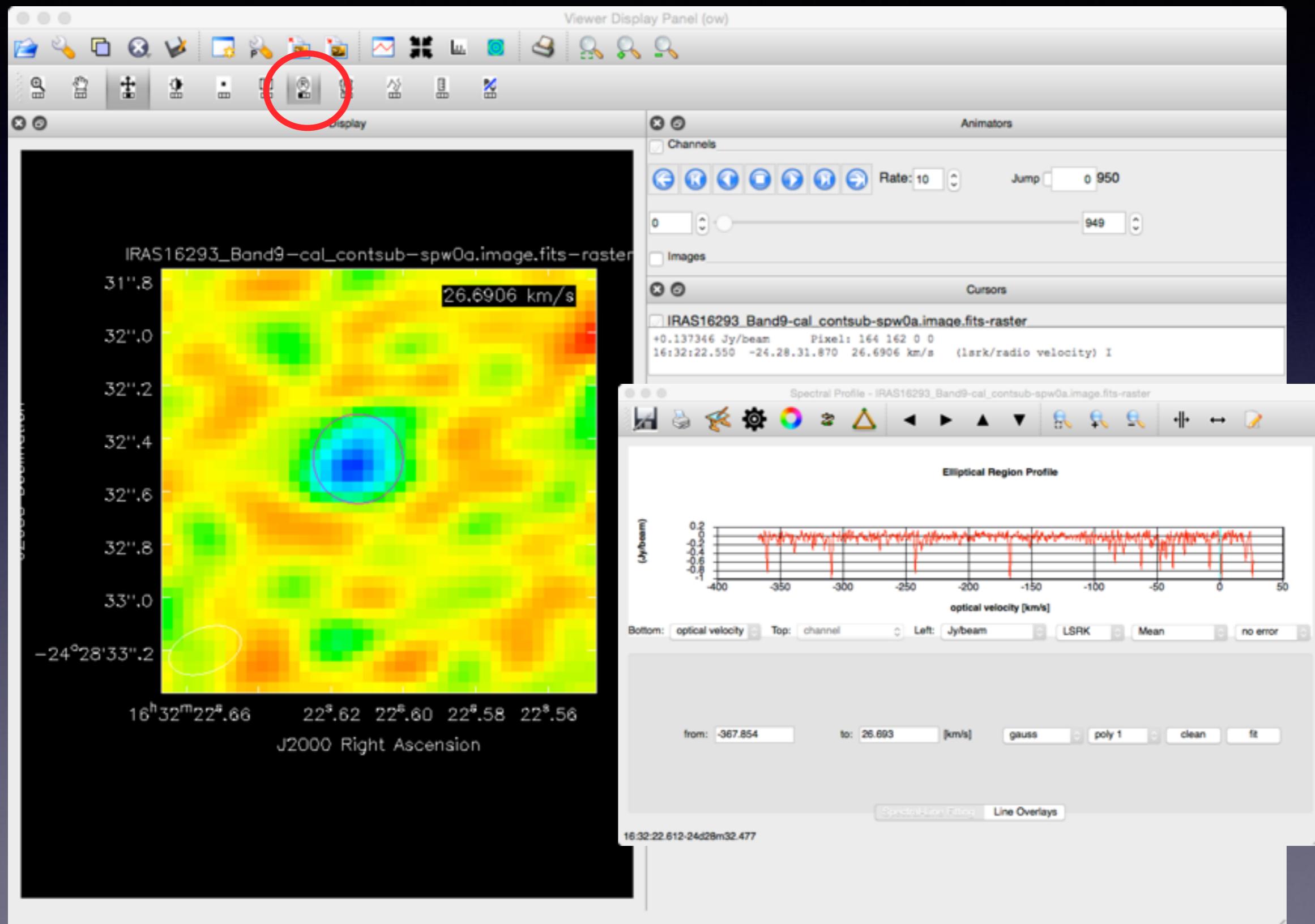
Load config  Display  Save config

How to create in CASA a  
spectrum file  
that CASSIS can read

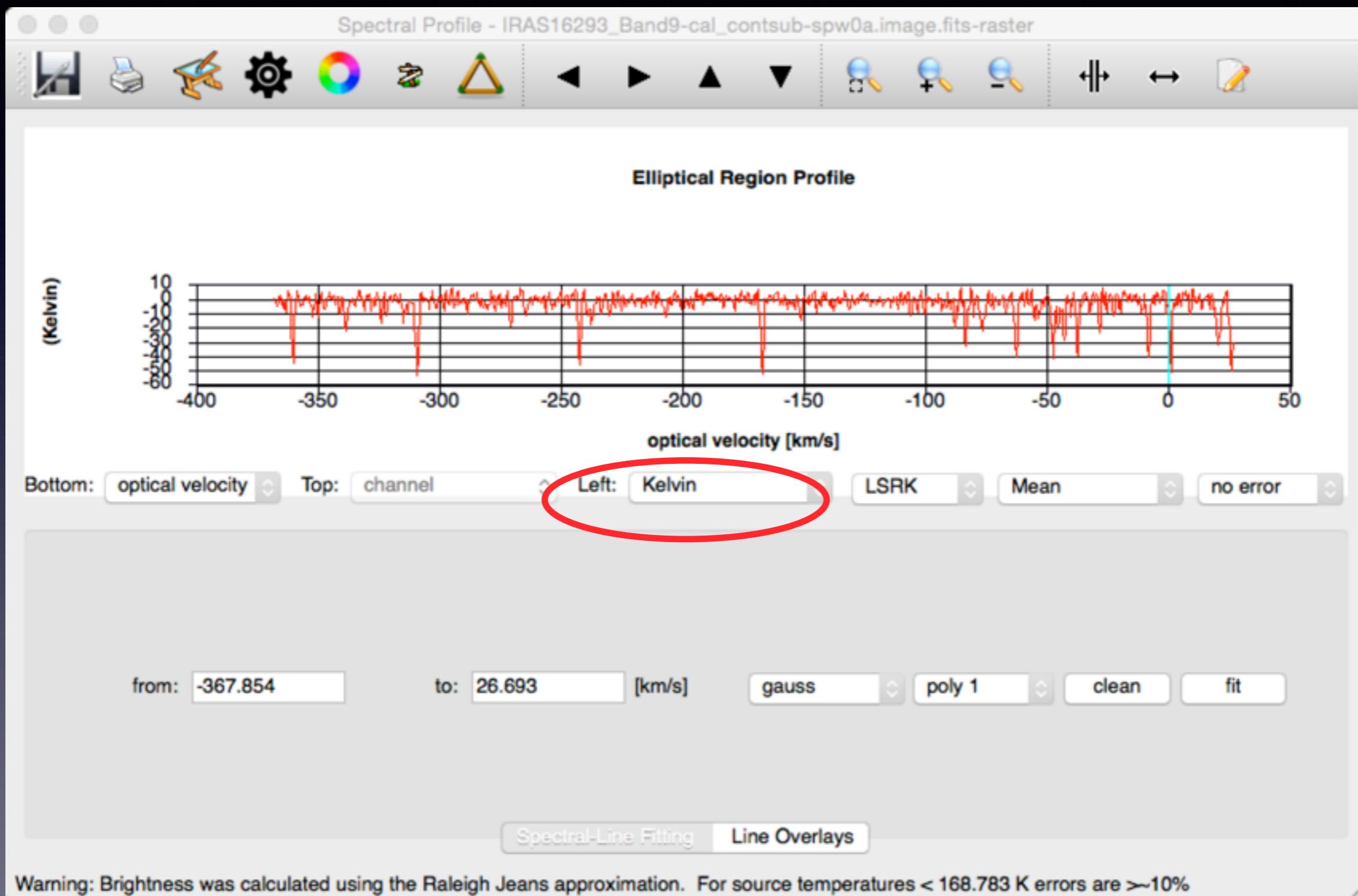
# Open an image and choose the Spectral Profile Tool



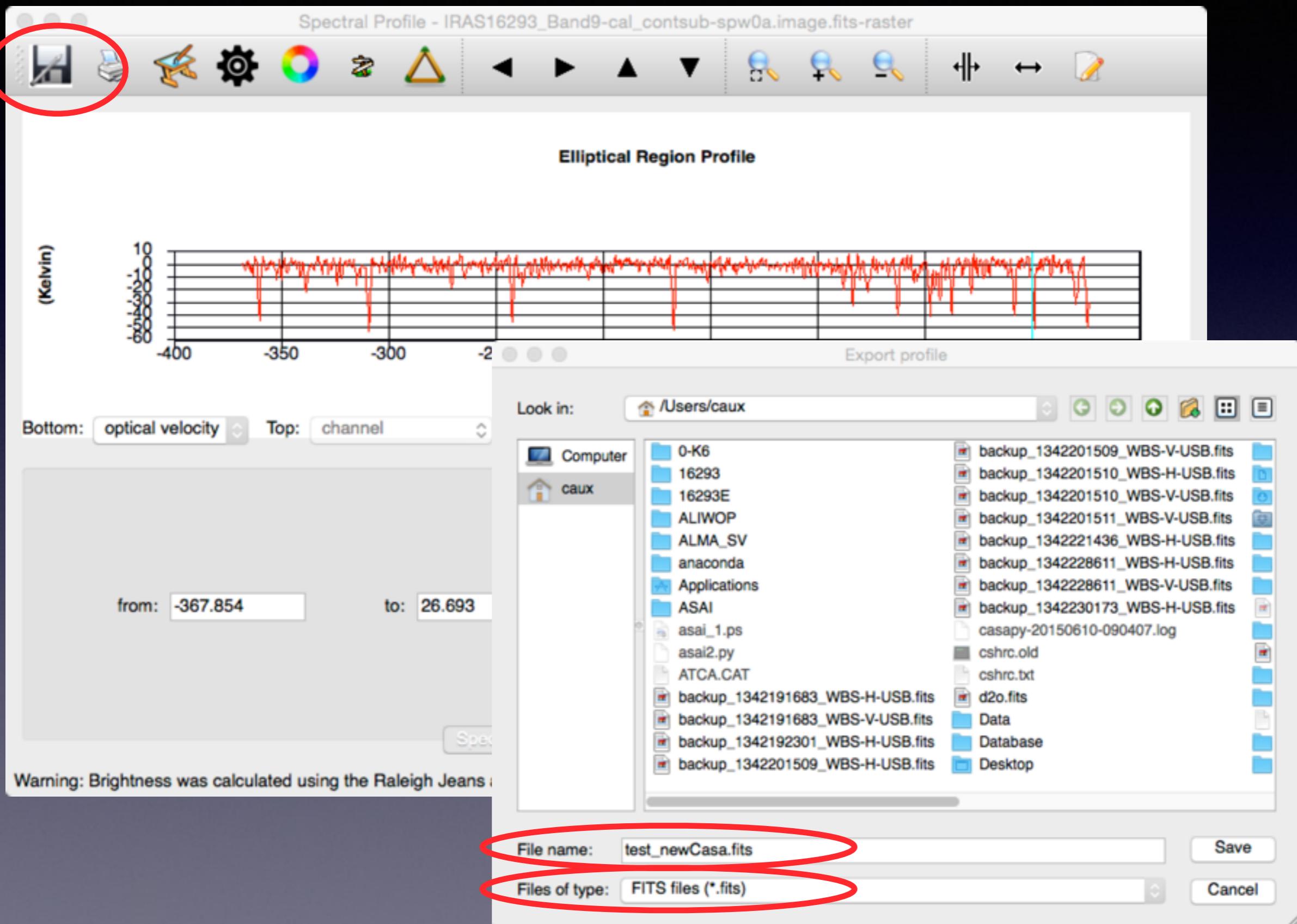
# Choose a drawing tool and encircle your source



# Change the intensity units to Kelvin



Write the spectrum in a fits file that CASSIS will read



## Nos besoins

- ➊ Diagramme rotationnel pour les données type Herschel/PACS (en cours)
- ➋ Collaboration avec les développeurs de l'outil spectol afin de récupérer les fichiers de collisions utilisables par RADEX avec mise à jour régulière
- ➌ Modélisation ETL des spectres dont les unités ne sont pas en Kelvins
- ➍ Manpower...