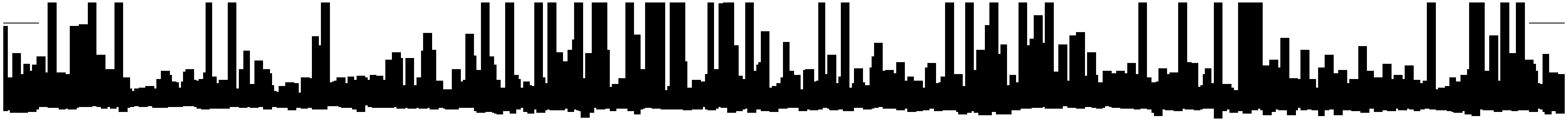
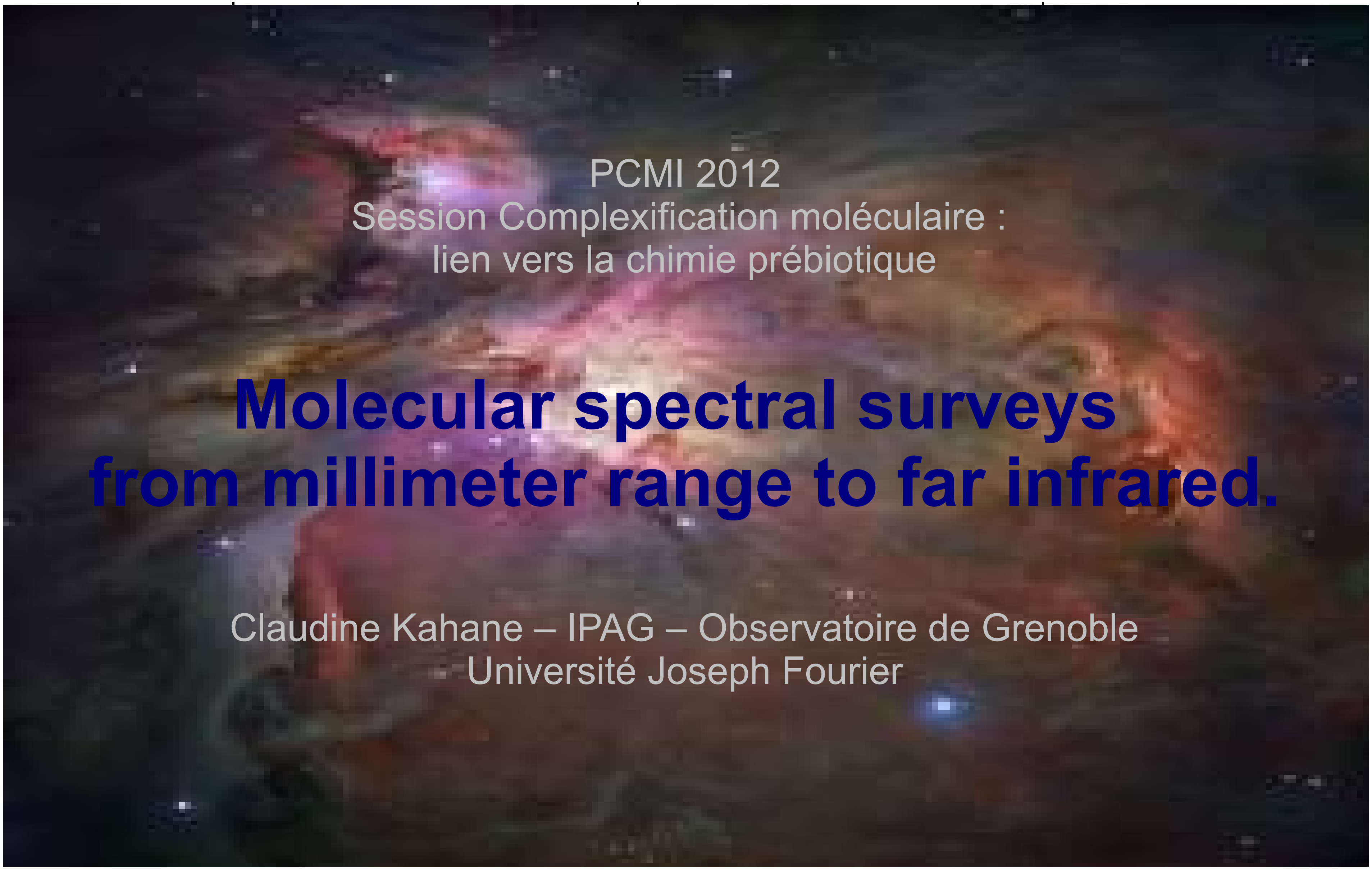




PCMI 2012
Session Complexification moléculaire :
lien vers la chimie prébiotique

Molecular spectral surveys from millimeter range to far infrared.

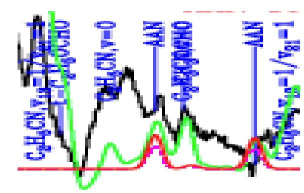
Claudine Kahane – IPAG – Observatoire de Grenoble
Université Joseph Fourier

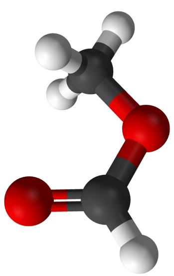
1. Telescopes & frequencies

2. Main « prototype » surveys

see : http://www.gb.nrao.edu/~thunter/terahertzLineList.html *(T. Hunter)*

3. Line identification

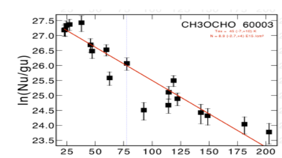


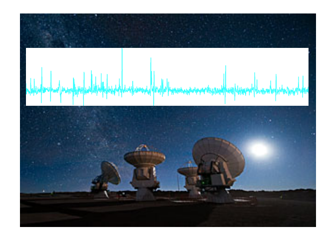


4. Molecular content

see : http://www.astro.uni *(H.S.P. Müller)*

5. What can we learn ?

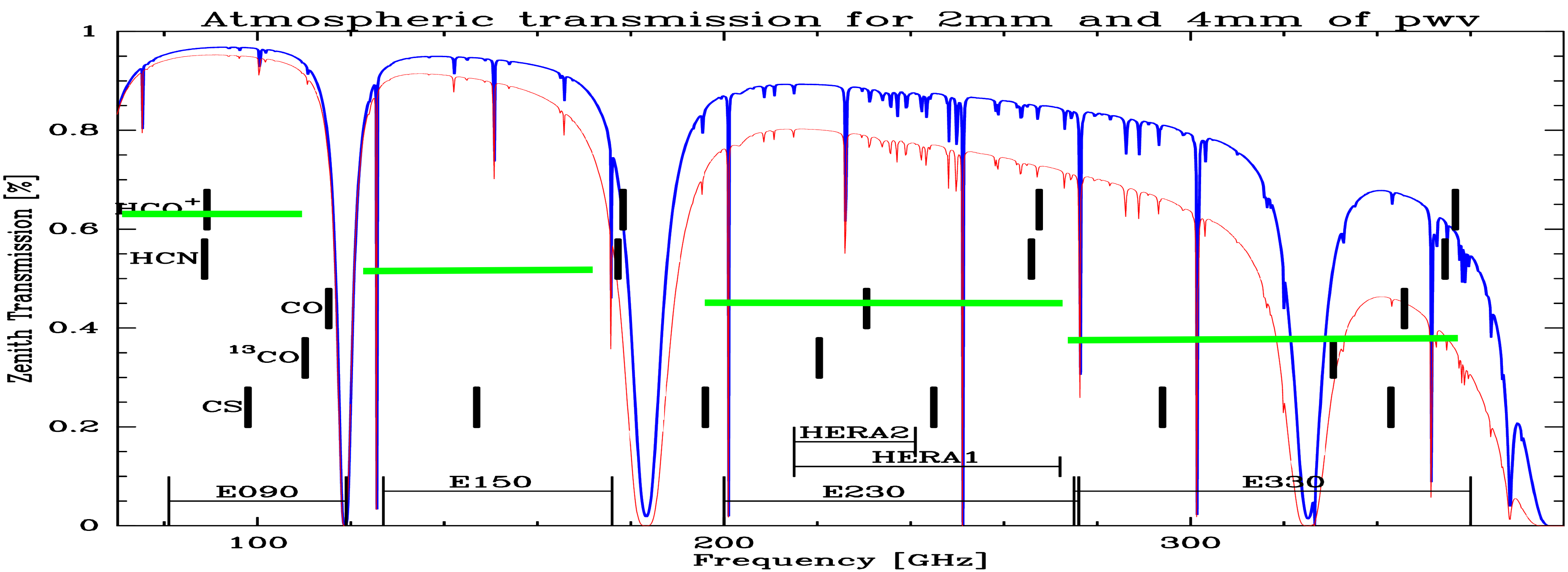


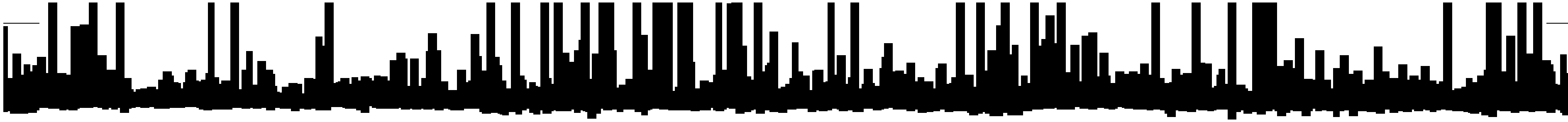


6. Perspectives, prospective

Telescopes and frequencies (1)

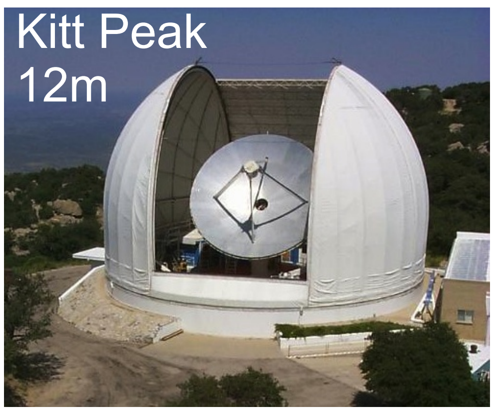
receiver	Frequency(GHz)	Width(GHz)	Trec (K)
E0	83 - 117	8 (0.5)	50
E1	129 - 174	4 (0.5)	50
E2	202 - 274	8 (0.5)	80
E3	277 - 358	8 (0.5)	80





Telescopes and frequencies (2)

Frequency	Band Width (GHz)
0.3 – 1.2 GHz	0.240
1 – 15 GHz	1 - 3
18 – 50 GHz	4

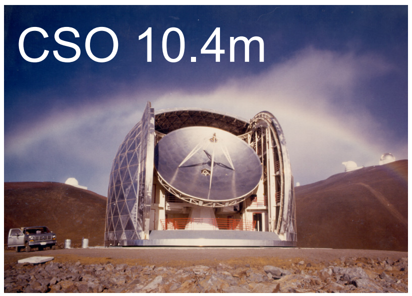


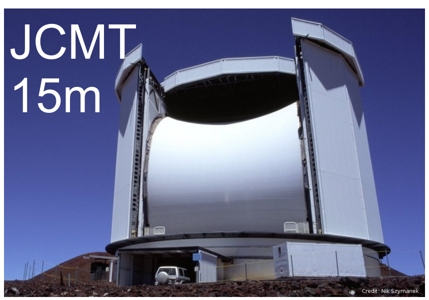
Frequency (GHz)	Band width (MHz)
83 - 116*	≤ 600
68 - 90	≤ 600
90 - 116	≤ 600
133 - 180	≤ 600

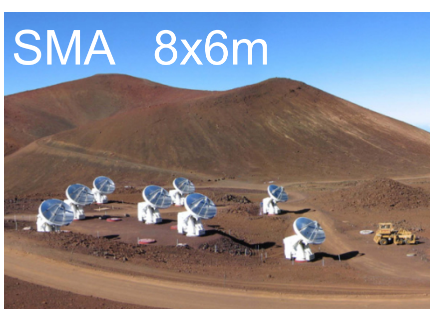
* type ALMA Band 3

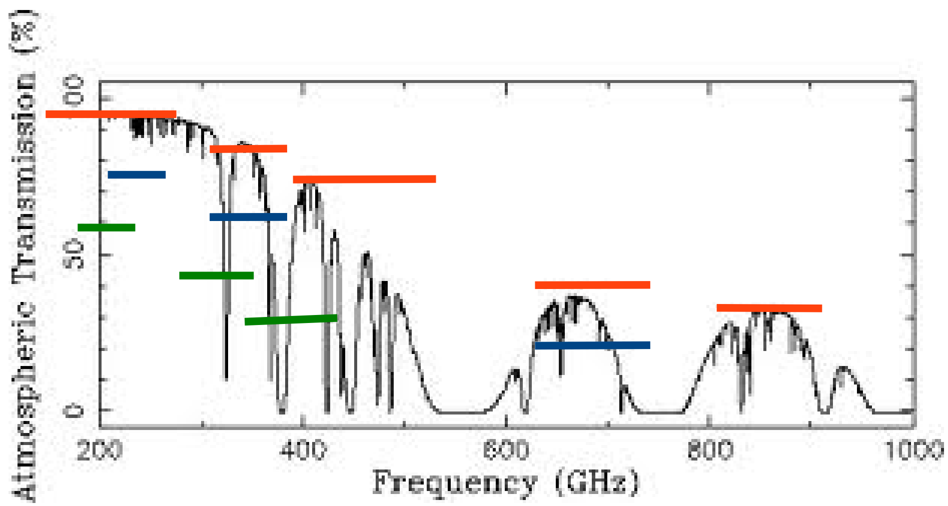
Frequency (GHz)	Band width
20.0 - 25.0	4 MHz to 2 GHz
42 - 44	4 MHz to 2 GHz
35 - 50	4 MHz to 2 GHz
72 - 120	4 MHz to 2 GHz

Telescopes and frequencies (3)







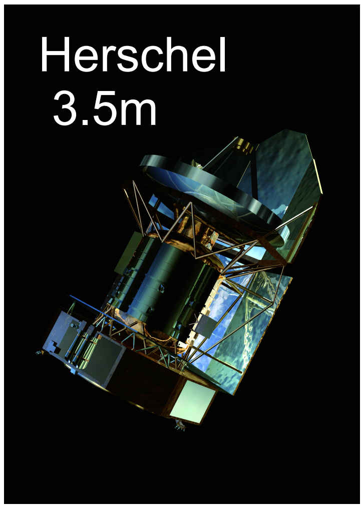


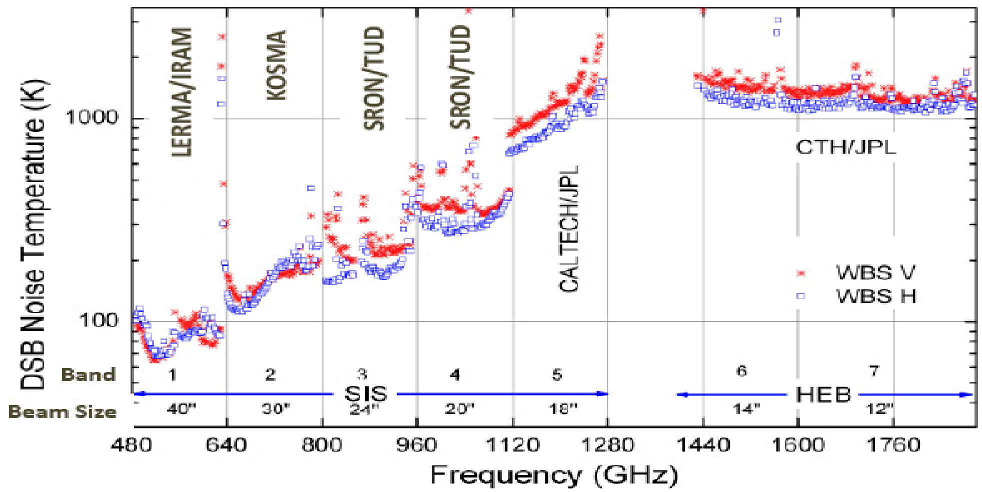
CSO receivers(GHz)
177 - 286
315 - 380
382 - 532
620 - 730
810 - 900

JCMT receivers(GHz)
211 - 272
315 - 375
630 - 710

Receiver	Frequency (GHz)	1984 Noise (K)	1992 Noise (K)	CSO 2012
230	186-242	300	60	40 K
345	272-350	900	150	90 K
400	330-420			
460	425 – 510	2000	200	40 K
650	600 – 720	5000		230 K
850	800 – 900	8000	750	400 K

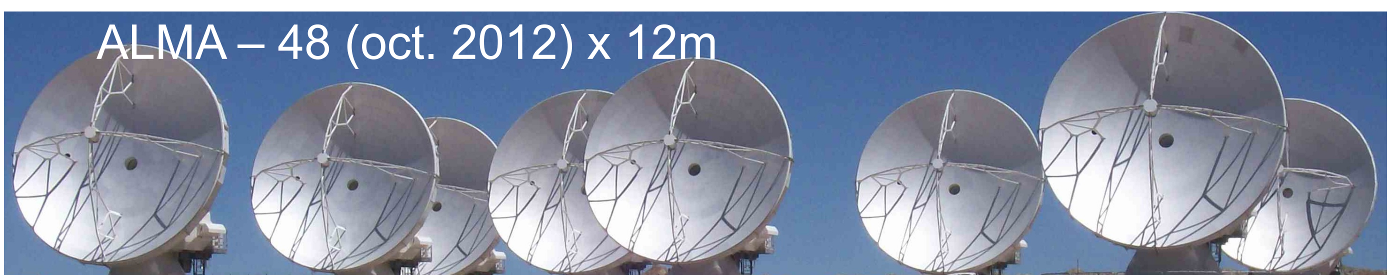
Telescopes and frequencies (4)

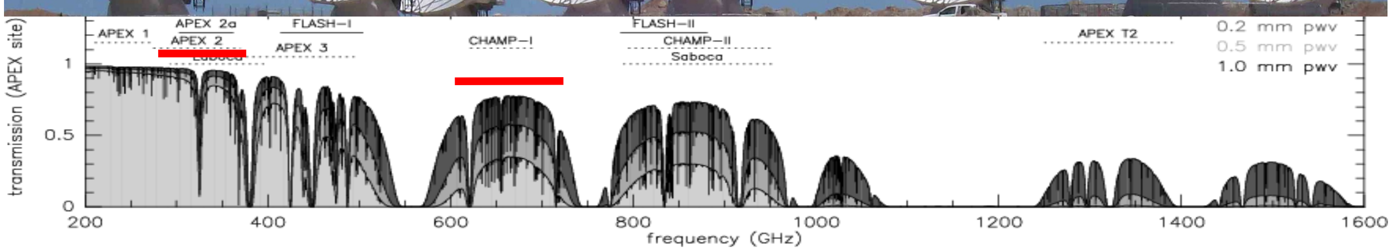




Herschel HiFi receivers(GHz)

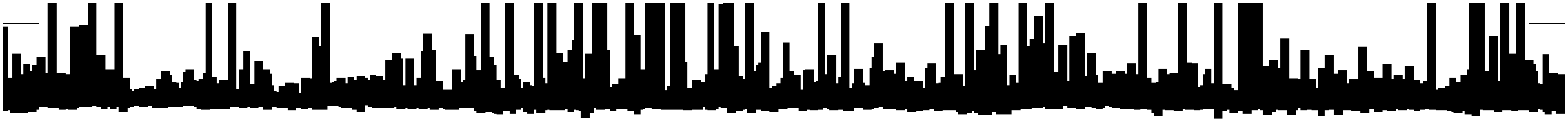
#1 : 480 – 640
#2 : 640 – 800
#3 : 800 – 960
#4 : 960 – 1120
#5 : 1120 – 1250
#6 : 1410 – 1703
#7 : 1703 – 1910





ALMA receivers(GHz)

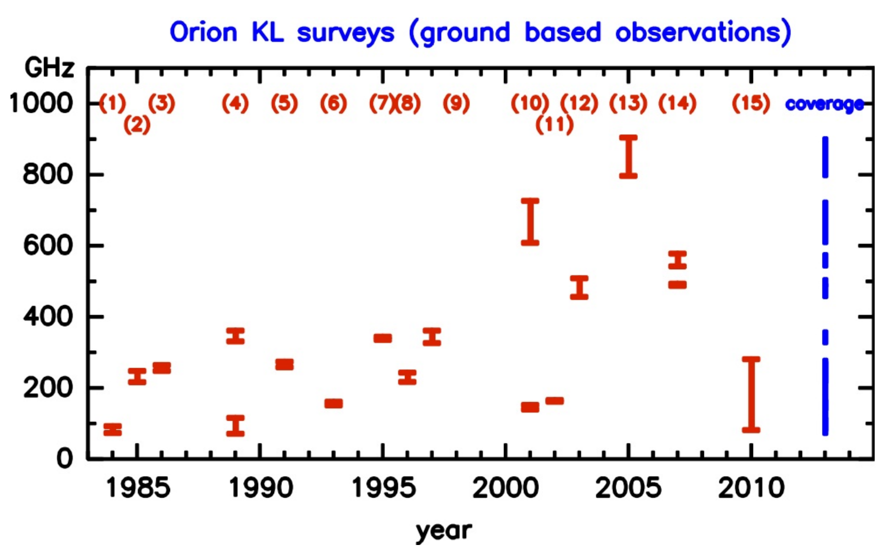
#3 : 84 - 116
#6 : 211 - 215
#7 : 275 - 373
#9 : 602 - 720



Prototypical surveys (1)

Orion K-L: closest massive star forming region, 4 main components

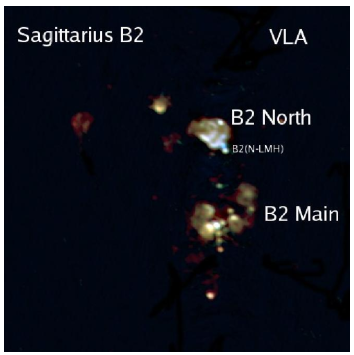
- > 15 surveys in the mm range published since 1984
- Complete frequency coverage from earth : 72 – 930 GHz
- Herschel survey (HEXOS, ref. 16) : 490-1240, 1430-1900 GHz
- 2D spectral survey IRAM 30m, 200-282 GHz (ref. 17)
- ALMA SV : band #6 (211 – 215 GHz)
- Molecule searches : 29 first identifications



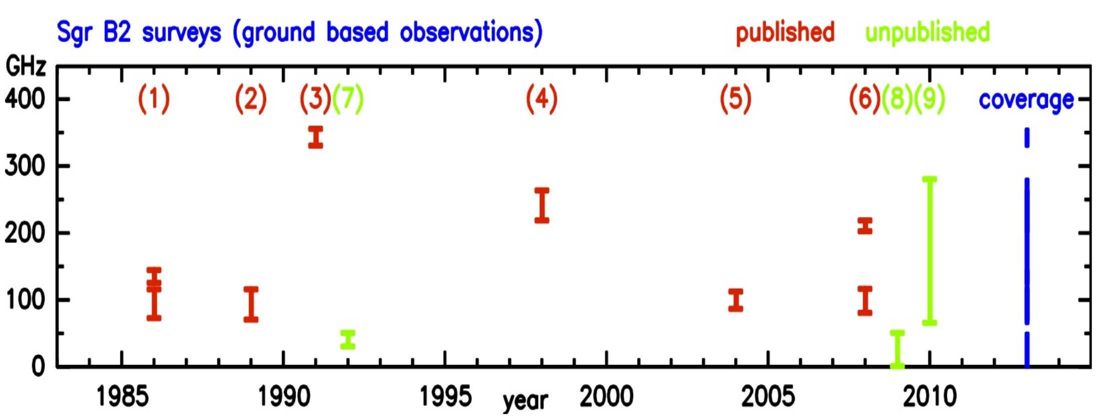
(1)	Onsala 20m	Johansson et al. 1984
(2)	OVRO 10.4m	Sutton et al. 1985
(3)	OVRO 10.4m	Blake et al. 1986
(4)	KP 12m	Turner 1989
(5)	JCMT 15m	Greaves et al. 1991
(6)	FCRAO 14m	Ziurys et al. 1993
(7)	JCMT 15m	Sutton et al. 1995
(8)	OVRO Array	Blake et al. 1996
(9)	CSO 10.4m	Schilke et al. 1997
(10)	CSO 10.4m	Schilke et al. 2001
(11)	TRAO 14m	Lee et al. 2001, 2002
(12)	JCMT 15m	White et al. 2003
(13)	CSO 10.4m	Comito et al. 2005
(14)	Odin 1.1m	Olofsson et al. 2007
(15)	IRAM 30m	Tercero et al. 2010, 2011
(16)	Herschel (HEXOS)	Bergin et al 2010
(17)	IRAM 30m	Marcelino et al. 2012

Prototypical surveys (2)

SgrB2 : massive star forming region, complex geometry and velocity structures, 2 main cores (M,N), foreground clouds



- 5 surveys in the mm-range published since 1986
- Almost complete frequency coverage from 72 to 355 GHz
- GBT survey: 0.3-50 GHz (http://www.cv.nrao.edu/~aremijan/PRIMOS)
- Herschel survey (HEXOS, ref. 10) : 714 – 801 GHz
- Molecular searches : 66 first identifications

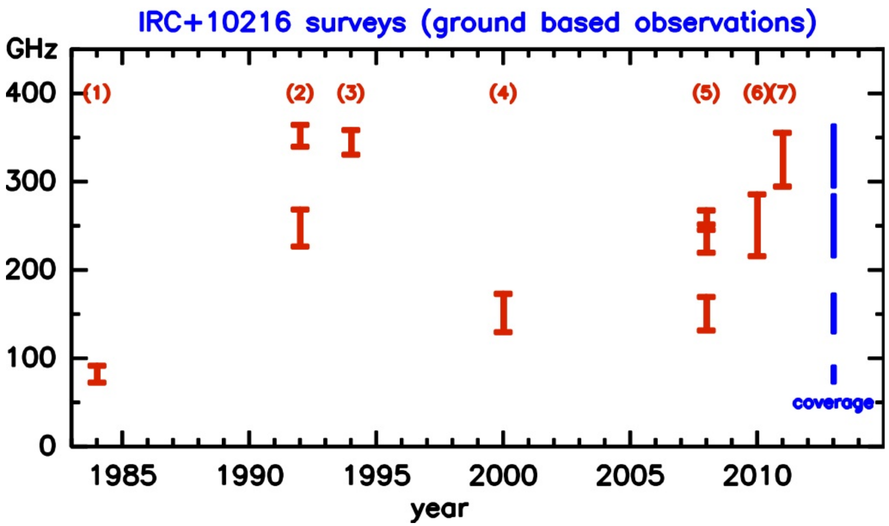


(1)	BTL 7m	Cummins et al. 1986
(2)	KP 12m	Turner 1989
(3)	CSO 10.4m, JCMT 15m	Sutton et al. 1991
(4)	SEST 15m	Nummelin et al. 1998
(5)	KP 12m	Friedel et al. 2004
(6)	IRAM 30m	Belloche et al. 2008
(7)	NRO 45m	Ohishi 1992 (unpublished)
(8)	GBT 100m	Remijan 2009 (unpublished)
(9)	KP 12m	Halfen 2010 (unpublished)
(10)	Herschel (HEXOS)	Neill 2012 (unpublished)

Prototypical surveys (3)

IRC+10216 : closest AGB star (C-rich)

- 7 surveys in the mm-range published since 1984
- Frequency coverage from earth : 72 – 364 GHz
- Herschel survey (ref. 8) : 488 to 1901 GHz
- Molecule searches : 42 first identifications



(1)	Onsala 20m	Johansson et al. 1984
(2)	JCMT 15m	Avery et al. 1992
(3)	CSO 10.4m	Groesbeck et al 1994
(4)	IRAM 30m	Cernicharo et al. 2000
(5)	KP 12m	He et al. 2008
(6)	SMT 10m	Tenenbaum et al. 2010
(7)	SMA	Patel et al. 2011
(8)	Herschel	Cernicharo et al. 2010

Prototypical surveys (4)

IRAS16293-2422 : close low mass binary protostar, prototype of super-deuteration & « hot corino »

- 3 surveys in the mm-range since 1994
- Frequency coverage from earth : 72 – 364 GHz
- Herschel CHESS survey (ref. 4) : 488 to 1901 Ghz
- ALMA SV : band #6 (211 – 215) & band #9 (602 - 720)
- Molecule searches : no first identifications (except D-isotopes)

(1) JCMT 15m, CSO 10.4m Blake et al. 1994
(2) IRAM 30m, JCMT 15m Caux et al. 2011
(3) **SMA 8x6m** Jorgensen et al. 2011
(4) Herschel (CHESS) Ceccarelli et al. 2010

TMC1 : cold dark cloud, low mass star forming region

- 1 survey in the mm-range published to date (Kaifu et al. 2004)
- Frequency coverage : 8.8 - 50 GHz with NRO 45m
- Molecule searches : 29 first identifications

Other recent & on going surveys (1)

CHEMICAL HERSCHEL SURVEYS OF STAR FORMING REGIONS — Herschel HiFi KP

L1544	« Cold » pre-stellar core	→ See also A. Bacmann (poster n°1)
I16293E	« Warm » pre-stellar core	
L1157-B1	outflow shock spot	→ See B. Le Floch 's talk
IRAS 16293	Class 0 low mass protostar	
OMC2-FIR4	Intermediate mass protostar	→ See A. Sepulcre 's poster n°41
AFGL 2591	High mass protostar	
NGC 6334I	High mass protostar	
W51e	High mass protostar	

The global nightmare !

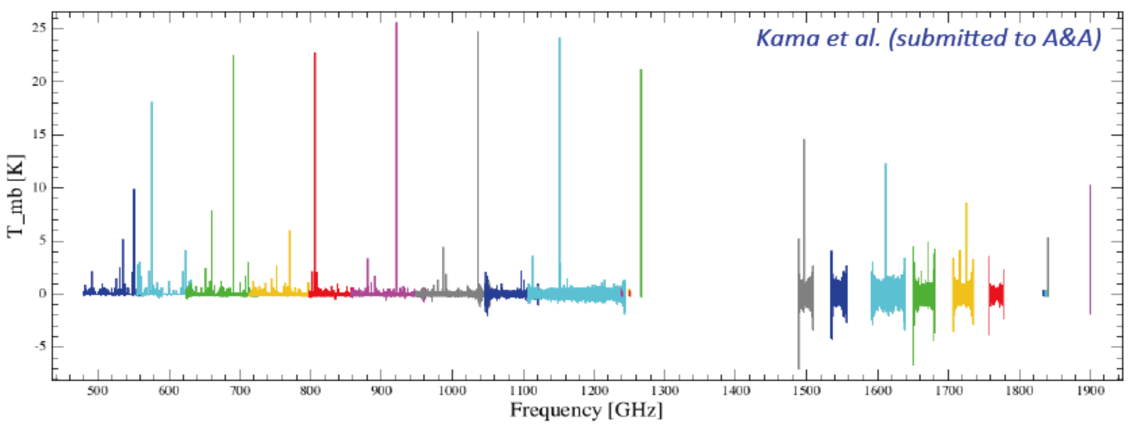
HEXOS : Herschel HiFi KP : survey of Ori-KL and SgrB2

See also D. Despois (poster n°18)

JCMT Spectral **L**egacy **S**urvey: 330-360 GHz 2D + complementary maps 360-373 GHz
4 targets : Orion Bar, NGC1333-IRAS4A, W49, AFGL2591

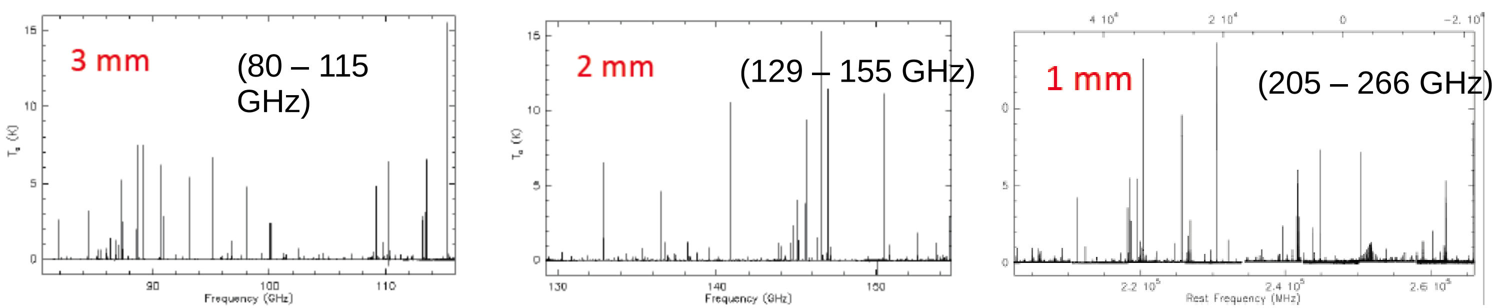
ASAI : IRAM 30m Large Program (survey on 10 sources) → See this talk

OMC2 – FIR4 surveys



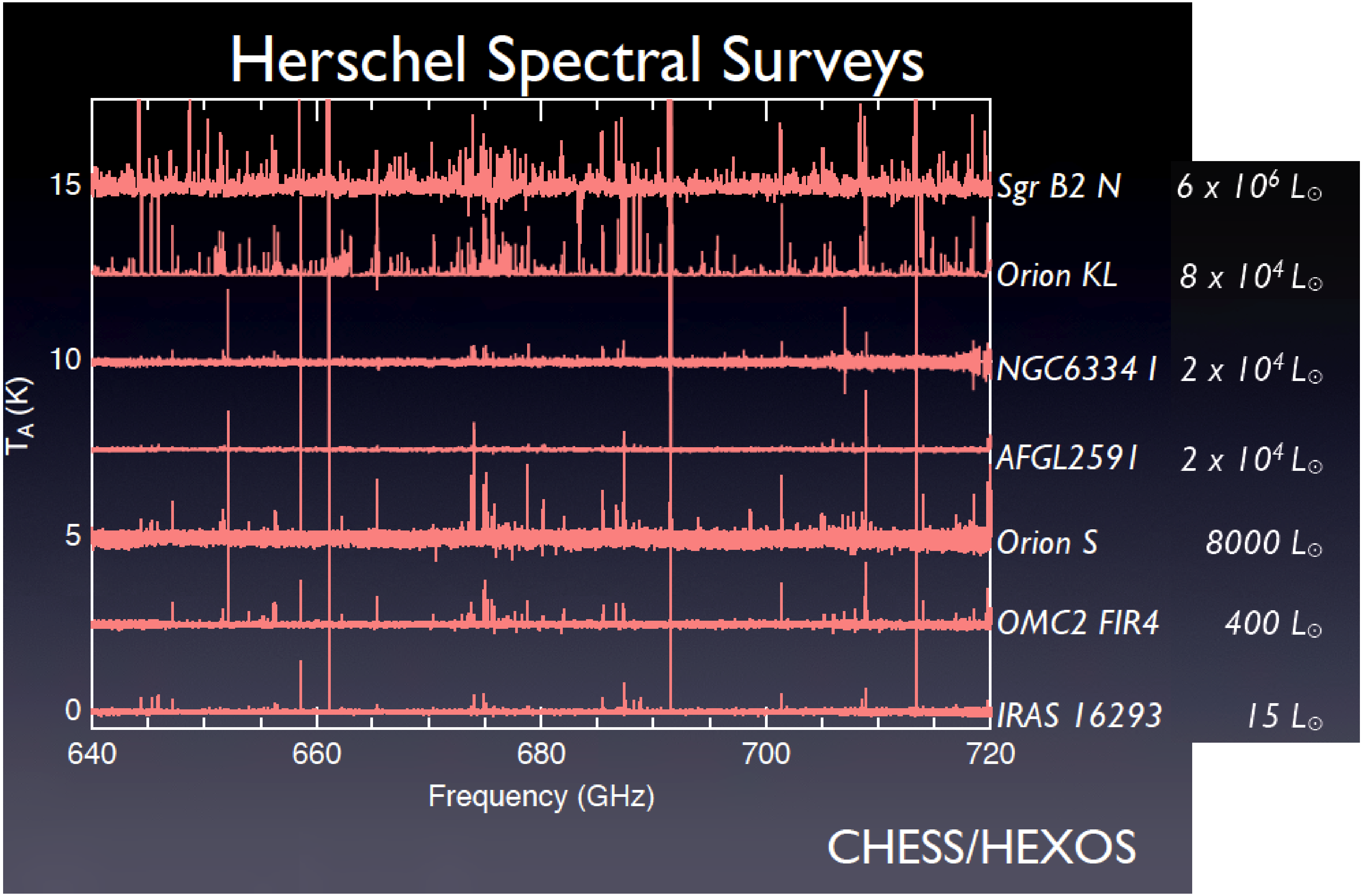
CHESS HiFi survey

718 lines identified :
58% from CH_3OH ! 10% from H_2CO !
26 species (+ 14 isotopes)
Eup = 24 – 752 K
Several kinematical components



IRAM 30-m spectral survey

(A. López-Sepulcre et al., in preparation)


Herschel Spectral Surveys
15
10
5
0
T_A (K)
640
660
680
700
720
Frequency (GHz)
Sgr B2 N
Orion KL
NGC6334 I
AFGL2591
Orion S
OMC2 FIR4
IRAS 16293
6 x 10^6 L⊙
8 x 10^4 L⊙
2 x 10^4 L⊙
2 x 10^4 L⊙
8000 L⊙
400 L⊙
15 L⊙
CHESS/HEXOS

Other recent & going on surveys (2)

Galactic surveys

- The Horsehead WHISPER line survey → See Gratier's talk and V. Guzman's poster n°30
- Ultra compact HII region (MonR2) : IRAM 30m, 1mm & 2mm survey (Ginard et al. 2012)
- NRO 45m line surveys in the 3mm range : low mass protostars (L1157B1, L1527), IR dark cloud (G28.34+0.06)

Extra Galactic surveys

- Starbust galaxy (NGC 253) : IRAM 30m, 2mm survey (Martin et al. 2006)
- ULIR galaxy (Arp 220) : SMA, 1mm survey (Martin et al. 2011)
- Starbust galaxy (M82) : IRAM 30m, 1mm & 2mm survey (Aladro et al. 2011)
- NRO 45m line survey in the 3mm range : NGC 1068, NGC 253.

Species identification (1)

From a small number of lines ... can still be efficient when

- Lines are strong ... or S/N large
- Lines are isolated ... or good spectral resolution available
- Molecular spectrum is simple ... or spectroscopy well known

- Exemple of C_5H (IRC+10216, Cernicharo et al. 1986)

Telescope | Chemistry | Spectroscopy

- Prediction: C_5H is likely to be **abundant** enough; **accurate spectrum** can be predicted
- Observations: 6 doublets (2 partially blended) : « **tentative** » detection
- Confirmation: **Laboratory** observation of C_5H spectrum; **Additional** space observations (more lines, different source)

- Recent exemples : anions identification

C_6H^- : identification in 2006, but 1st observation in 1995 (« B1335 ») ; C_4H^- (2007), C_8H^- (2007), C_3N^- (2008), C_5N^- (2008).

cf. posters : K. Béroff (n°2), L. Biennier (n°5) F. Lique (n°41)

Species identification (2)

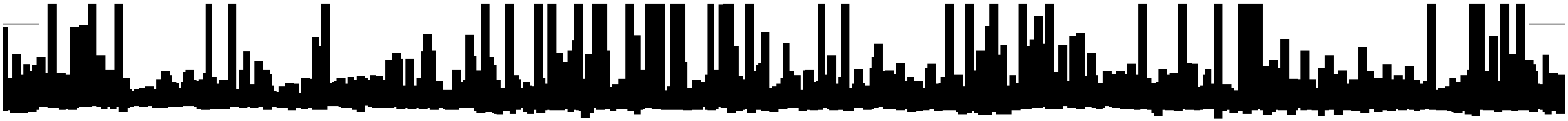
From a large number of lines ... is more and more often mandatory because, for not yet identified species,

- Lines are weak ... or S/N low
- Lines are blended ... or spectral resolution limited
- Molecular spectrum is complex ... and spectroscopy tricky

Exemple of acetone $(CH_3)_2CO$ spectro telescope

15 yrs !

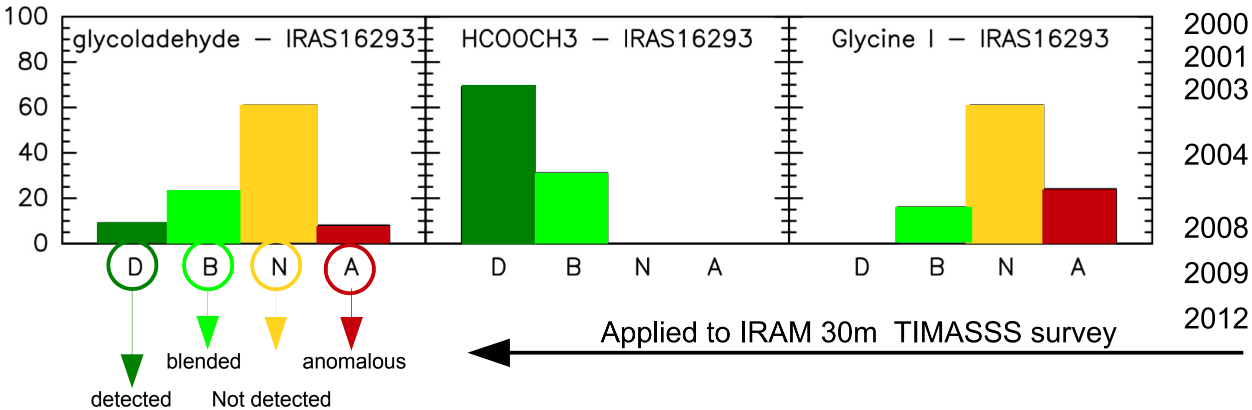
- 1987 (Combes et al.) lab. frequencies ; 4 lines (IRAM30m, KP12m) : detection
  LTE model : abundance 5 10^{-11} ; formation : $CH_3^+ + CH_3CHO$
  chemistry
- 1990 (Herbst et al.) : new calculations + measurements of the rate
  reaction too slow / observed abundance ; role of grain chemistry ?
- 2002 (Snyder et al.) : new measured + calculated frequencies spectro
  32 new lines (KP12 m + BIMA) : confirmation of identification telescope
  x=(4-30) 10^{-10} : confirmation of chemistry problem chemistry
- 2008 ... Torsional states, spectro telescope formation in plasma decharge ... chemistry



Species identification (3)

- **LTE modelisation of molecular emission : which detection criterion ?**

ex : glycolaldehyde ((HCOCH2OH) in IRAS 16293-2422

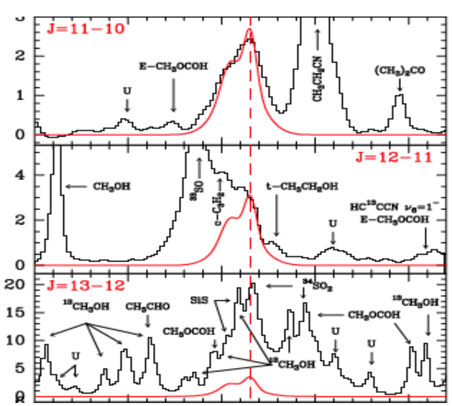


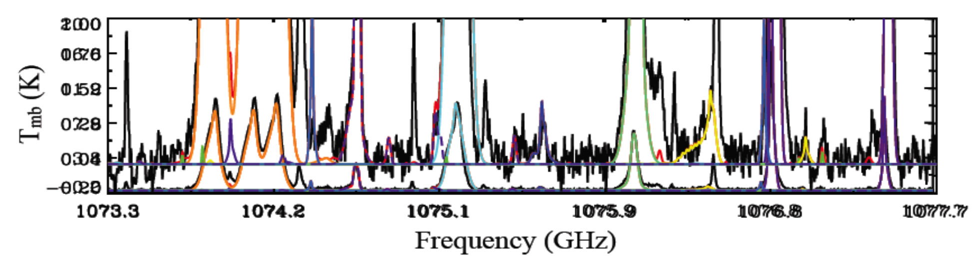
glycolaldehyde detection ?

2000 SgrB2 : 6 +/- blended lines (KP12m)
2001 SgrB2 : Extended emission of 1 line (BIMA)
2003 SgrB2 : predicted lines are missing (KP12m)
Ori : 8 lines but doubtful extrapolated frequ.
2004 SgrB2 : 40 lines observed (KP12m) :
8 lines D (20%) ; 32 lines B + N (80%).
2008 GC MC : detection of 3 lines / 4 observed freq.
2009 Hot core : 2 or 3 detections / 3 observed freq.
2012 IRAS16293 : detection of 13 transitions (ALMA)
LTE modelling

- **Global modelisation : multiple components / species** (cf. J. Cernicharo's talk)

SiS in Orion-KL
(IRAM 30m survey)
Modeling :
Hot core (LTE) +
plateau (LVG) +
narrow feature (LVG)
from Tercero et al. 2011

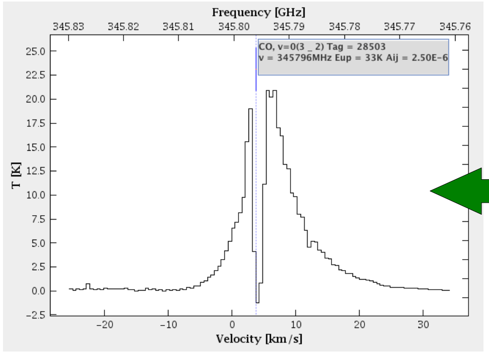




HEXOS survey in Orion-KL : detail of Band 4b
Simultaneous modeling of 64 species (isotopes included)
Here : CH_3OH, SO_2, $^{33}SO_2$, SO, C_2H_5OH, CH_3OCH_3, CS, H_2CS, HNCO
from Crockett 2012 (Herschel meeting in Grenoble)

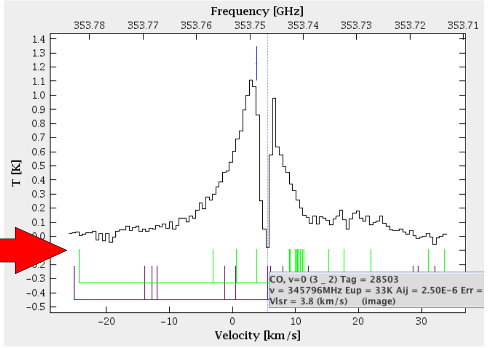
Species identification (4)

Some frequent tricks



Lines from the image band

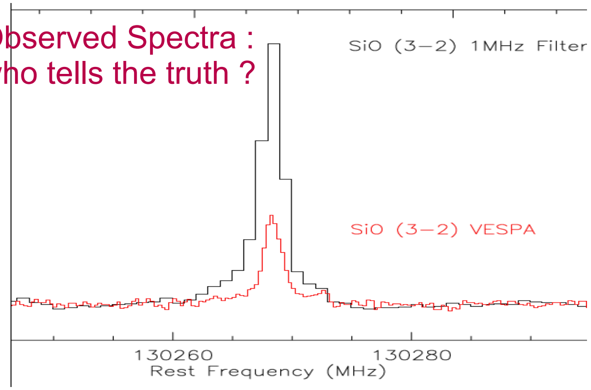
With a rejection of 13dB ...
a line of 20 K in the signal band
is a line of 1 K in the image band !
Shifted spectra are useful !



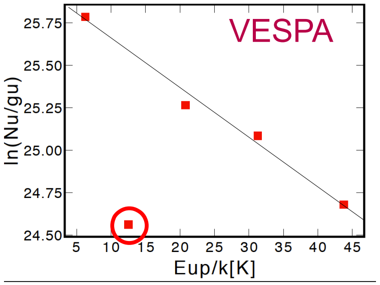
Calibration problems

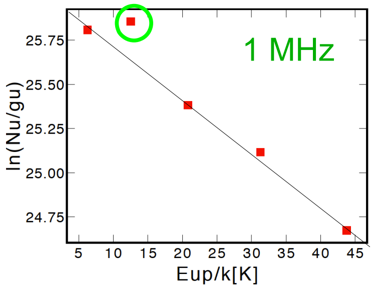
not always easy to detected and solve !
Calibrators are useful !

Observed Spectra :
who tells the truth ?



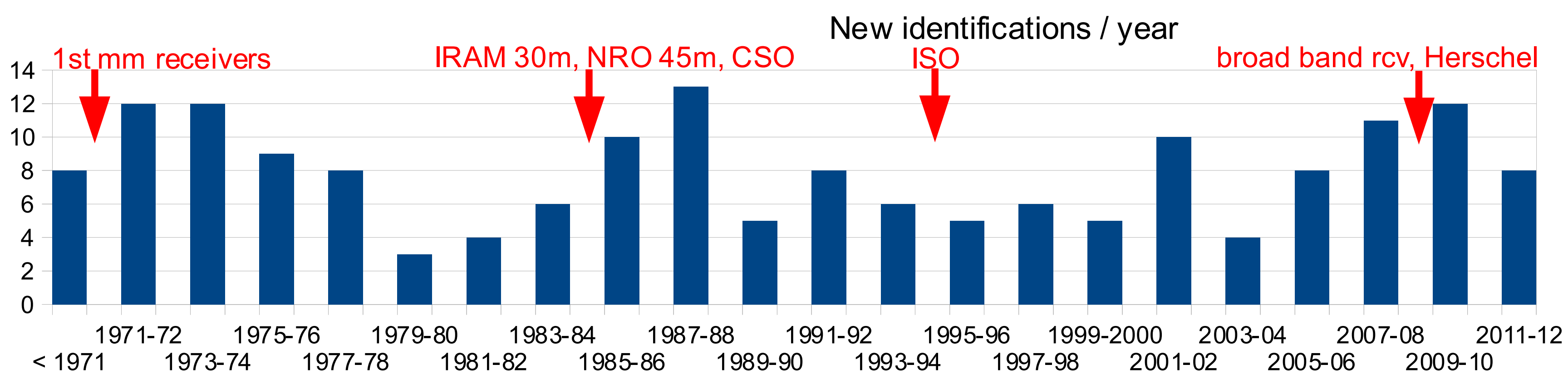
LTE modeling
(Rotational diagrams)
helps to know
(not always so simple!)

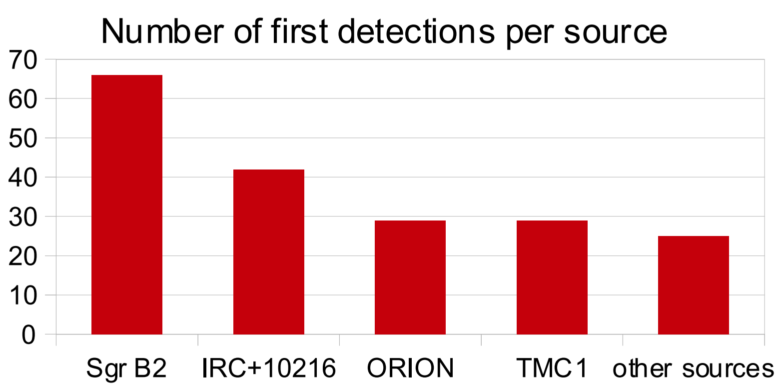


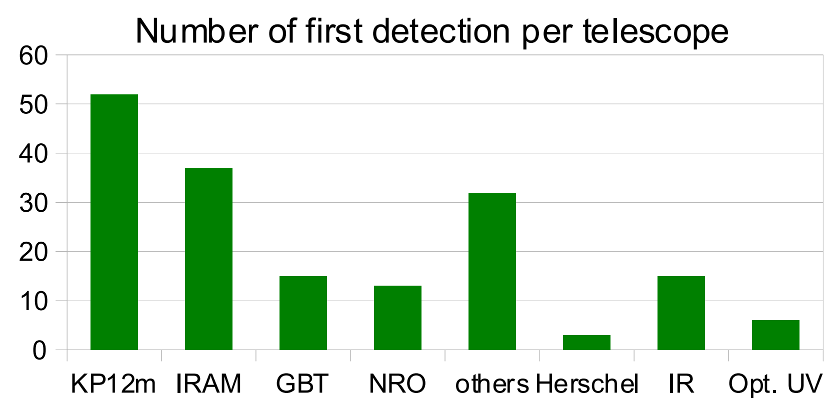


Galactic molecular census (1) (oct 2012)

Methods : survey or / and dedicated observations







Galactic Molecular Census (2)

(173 detections, oct. 2012)

Molecules in the Interstellar Medium or Circumstellar Shells (as of 10/2012)

2 atoms	3 atoms	4 atoms	5 atoms	6 atoms	7 atoms	8 atoms	9 atoms	10 atoms	11 atoms	12 atoms	13 atoms
38	36	24	20	16	9	10	9	4	3	3	1
CH	H2O	NH3	HC3N	CH3CN	CH3CHO	HC(O)OCH3	(CH3)2O	CH3C5N	HC9N	c-C6H6 *	HC11N
CH+	HCN	H2CO	HCOOH	CH3OH	CH3NH2	CH3C3N	CH3CH2OH	(CH3)2CO	CH3C6H	C2H5OCH3 ?	
CN	OCS	HNCO	H2CNH	NH2CHO	CH2CHCN	CH3COOH	CH3CH2CN	(CH2OH)2	C2H5OCHO	n-C3H7CN	
OH	H2S	H2CS	H2NCN	CH3SH	HC5N	C7H	HC7N	CH3CH2CHO			
CO	HNC	C2H2*	H2C2O	C2H4*	CH3C2H	C6H2	CH3C4H				
SiO	HNO	HNCS	C4H	C5H	C6H	l-HC6H *	C8H				
CS	C2H	C3N	CH4 *	CH3NC	c-C2H4O	CH2CHCHO (?)	CH3C(O)NH2				
H2	HCO+	HOCO+	SiH4 *	HC2CHO	H2CCHOH	CH2CCHCN	C8H–				
SO	N2H+	C3O	c-C3H2	L-H2C4	C6H–	H2NCH2CN	C3H6				
HD	SO2	l-C3H	H2CCN	HC3NH+		CH2OHCHO					
NS	HCS+	HCNH+	C5 *	C5N							
SiS	c-SiC2	H3O+	C4Si	l-HC4H *							
C2**	C2O	c-C3H	l-C3H2	l-HC4N							
NO	HCO	C3S	HC2NC	c-H2C3O							
HCl	MgNC	HCCN	HNC3	H2CCNH (?)							
AlF	C2S	H2CN	H2COH+	C5N–							
AlCl	C3 *	c-SiC3	C4H–								
KCl	CO2 *	CH3 *	HC(O)CN								
NaCl	NH2	C3N–	HNCNH								
PN	N2O	PH3 ?	CH3O								
SiC	NaCN	HCNO									
CP	CH2	HOCN									
NH	HOC+	HSCN									
SO+	MgCN	H2O2									
SiN	H2D+										
CO+	SiCN										
HF	AlNC										
SiH ?	SiNC										
FeO ?	HCP										
O2	CCP										
CF+	AlOH										
PO	H2O+										
AlO	H2Cl+										
OH+	KCN										
CN–	FeCN										
SH+	HO2										
SH											
HCl+											

Orion	IRC+10216
SgrB2	TMC1
Orion + SgrB2	IRC + TMC1

anions

Complex Organic Molecules « COMs »

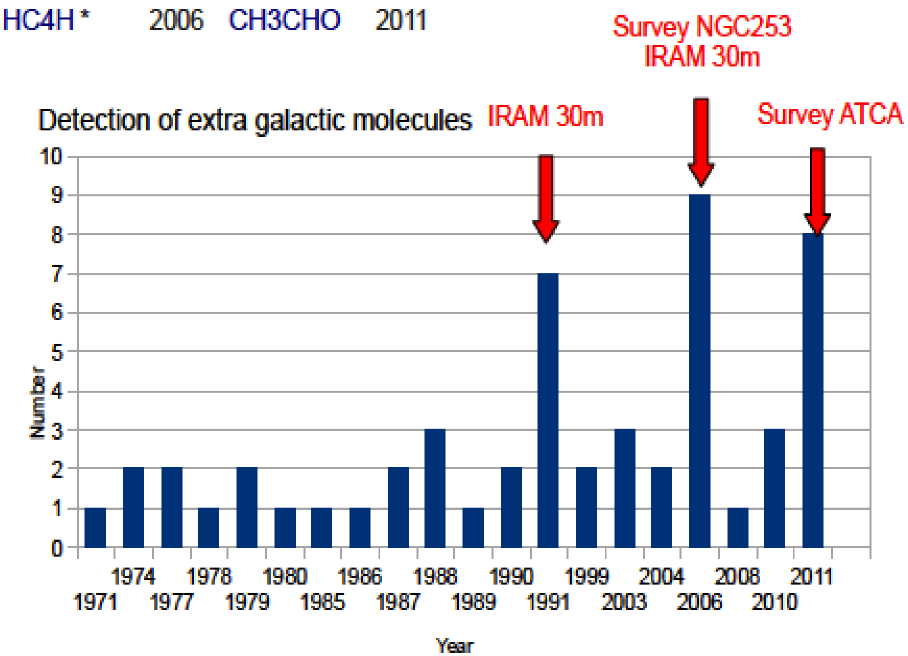
Carbon chains

metal-bearing

Extra galactic molecular census

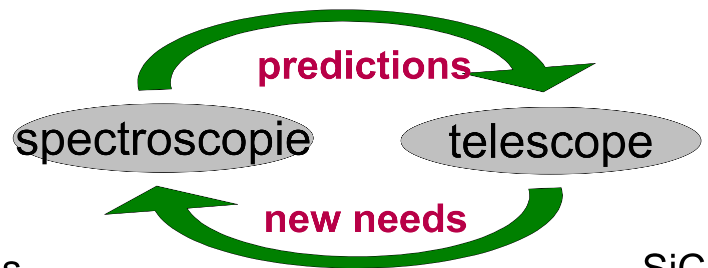
(54 at the end of 2011)

2 atoms	date	3 atoms	date	4 atoms	date	5 atoms	date	6 atoms	date	7 atoms	date	8 atoms	date	>8 atoms	date
16		13		9		8		3		3		1		1	
OH	1971	H2O	1977	H2CO	1974	c-C3H2	1986	CH3OH	1987	CH3CCH	1991	HC6H	2006	c-C6H6 *	2006
CO	1974	HCN	1977	NH3	1979	HC3N	1990	CH3CN	1991	CH3NH2	2011				
H2 *	1978	HCO+	1979	HNCO	1990	CH2NH	2006	HC4H *	2006	CH3CHO	2011				
CH	1980	C2H	1988	C2H2 *	1999	NH2CN	2006								
CS	1985	HNC	1988	H2CS ?	1999	l-C3H2	2011								
CH+ **	1987	H2S	1989	HOCO+	2006	H2CCN	2011								
CN	1988	N2H+	1991	c-C3H	2006	H2CCO	2011								
SO	1991	OCS	1991	H3O+	2008	C4H	2011								
SiO	1991	HCO	1991	l-C3H	2011										
NO	2003	SO2	2003												
NS	2003	HOC+	2004												
NH	2004	C2S	2006												
CO+	2006	H2O+	2010												
OH+	2010														
HF	2010														
SO+	2011														

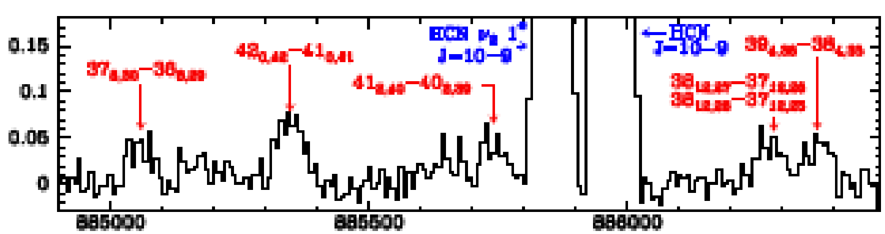


What can we learn from surveys ? (1)

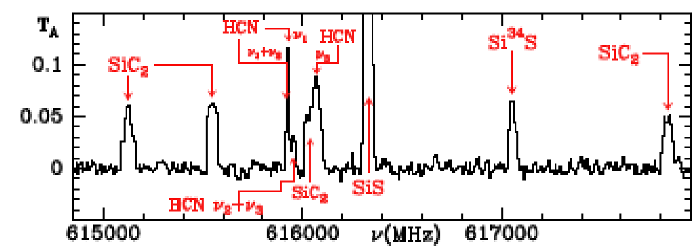
- **Line frequencies** (see also J. Cernicharo's talk)



CH_3CH_2CN excited lines in Orion (HEXOS) *Muller et al. 2012*



SiC_2 lines in IRC+10216 (Herschel-HiFi) *Cernicharo et al. 2010*



Need for	- New species frequencies (including isotopes)
	- High excitation frequencies (torsion, vibration)

poster n°7 A. Bouchez-Giret

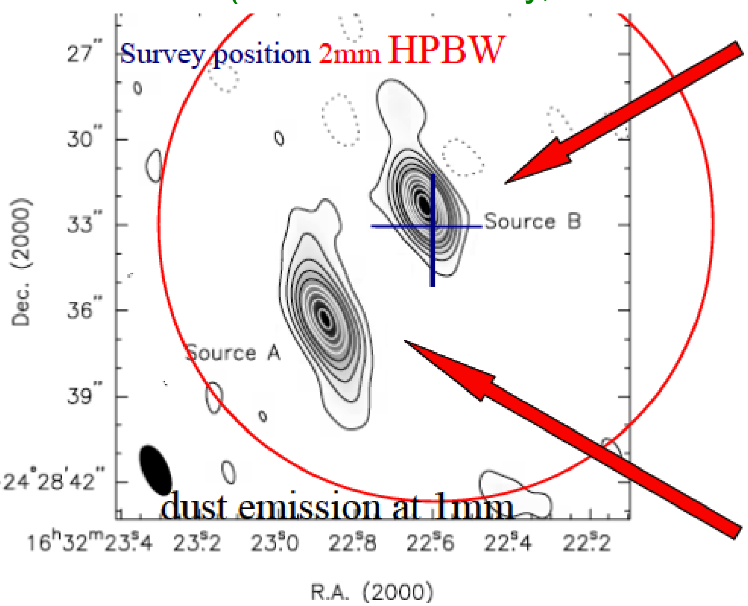
What can we learn from surveys ? (2)

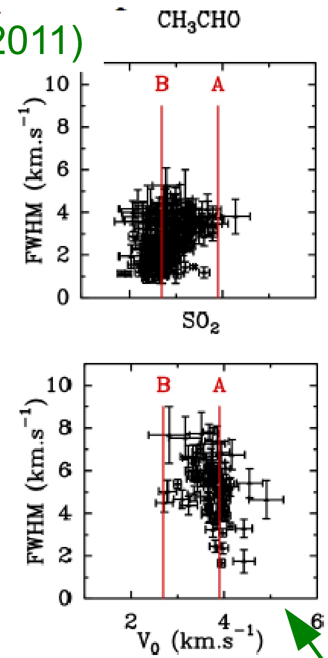
- **Gas kinematics** (see also B. Lefloch's talk)

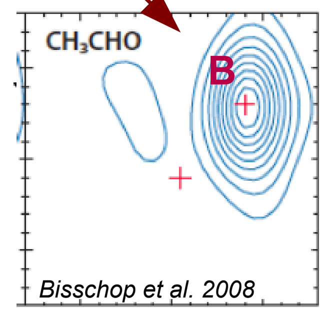
Origin of dominant emission

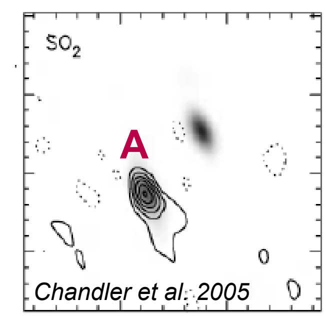
Super spectral and spatial resolutions !

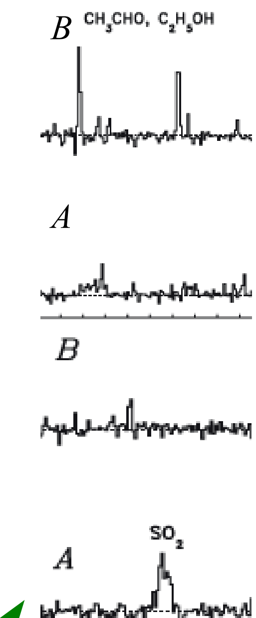
IRAS16293 (TIMASSS survey, Caux et al. 2011)











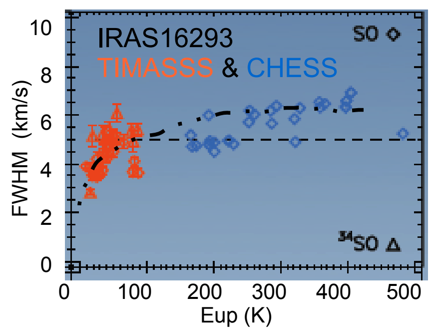
Jorgensen et al. 2011

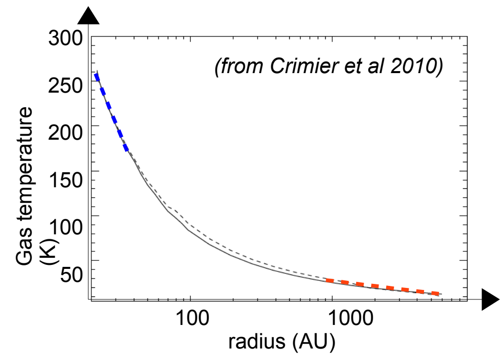
Line kinematical signature

What can we learn from surveys ? (3)

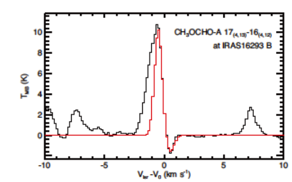
- **Gas excitation and dynamics** (see also B. Lefloch's talk)

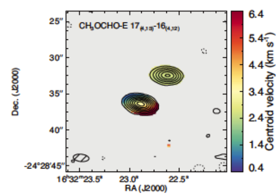
IRAS16293 : free fall hot corino ? Rotating disk ?





ALMA SV (band 6)





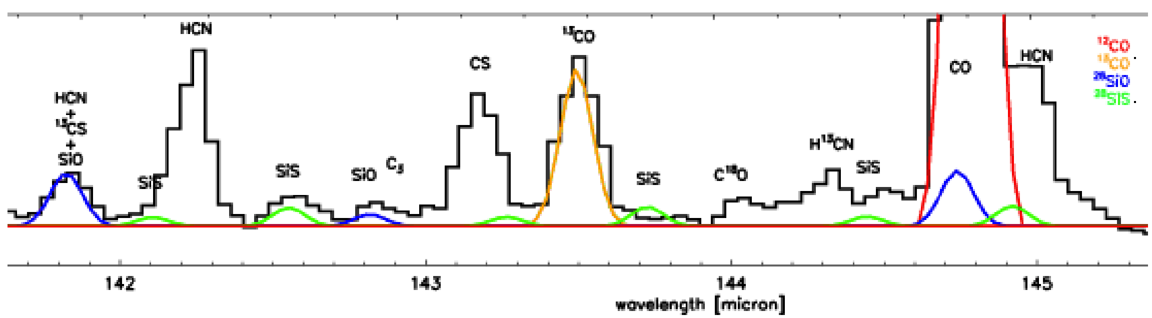
Core B : inverse P Cygni = free fall

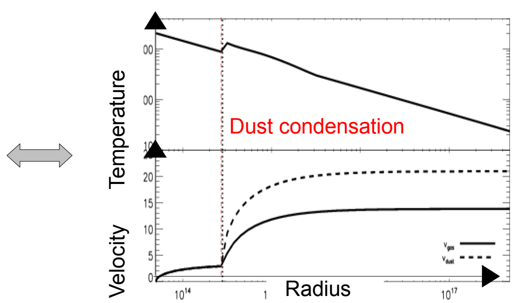
Core A : velocity gradient rotating disk ?

(Pineda et al 2010)

Multi line modeling may help to estimate the source size

Gas acceleration in the inner envelope of IRC+10216





from Decin et al 2010, Herschel « MESS » KP

PCMI 2012
C. Kahane

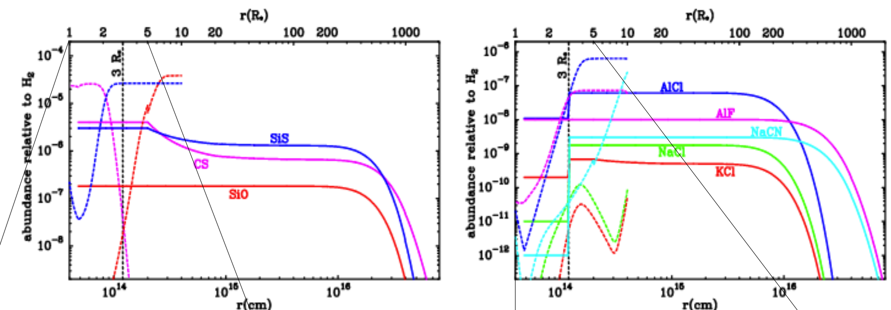
What can we learn from surveys ? (4)

- **Molecular abundances & chemistry**

IRC+10216 – IRAM 30m survey (80 – 357.5 Ghz)

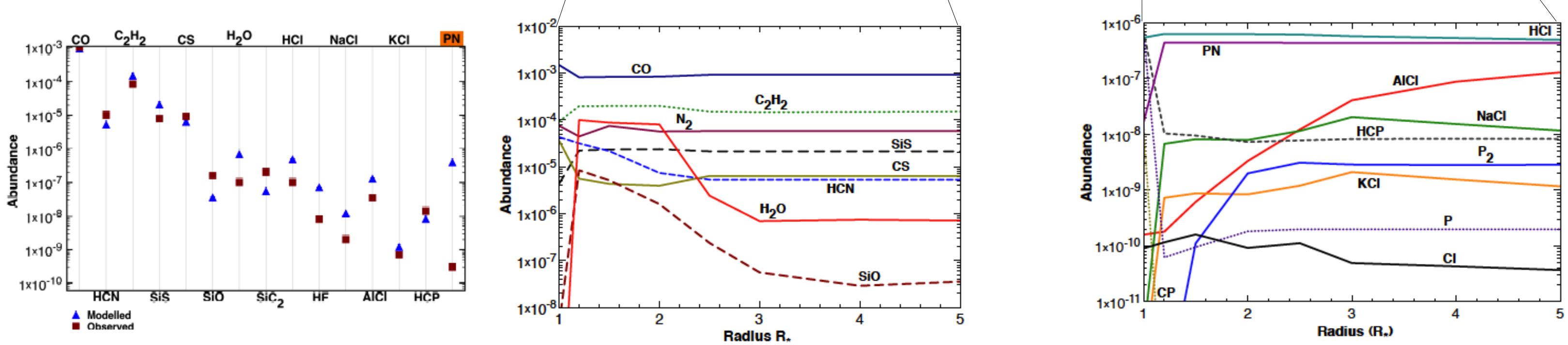
(Agundez et al. 2012)

CS, SiO, SiS, NaCl, KCl, AlCl, AlF, NaCN observations of rotational lines v=0, v=1, v=2, v=3	**+**	LVG modeling including Inelastic collision rates Infra red pumping Rotational transitions & ro-vibration transitions	**=**



Inner wind chemistry *(Cherchneff 2012)*

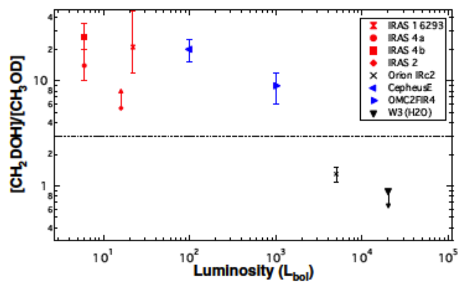
- Model : shock induced non equilibrium chemistry (1R* to 5R*)
- Results : very good agreement with abundances derived from surveys



What can we learn from surveys ? (5)

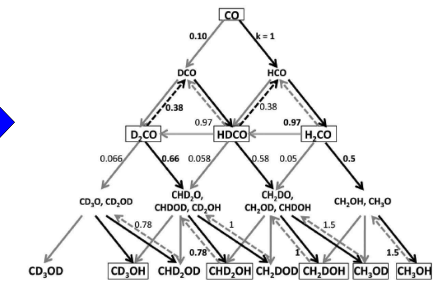
- **Isotopic ratios & chemistry** (see also V. Taquet's talk)

Methanol D/H ratio



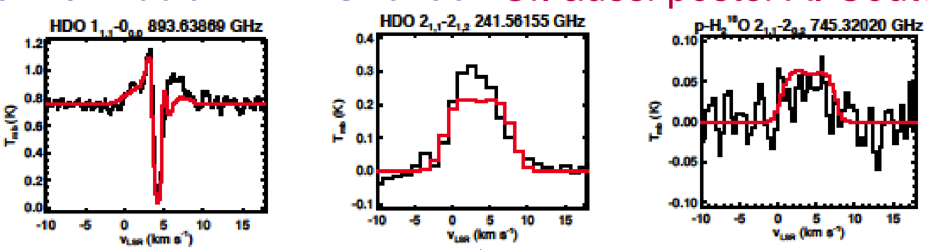
Observations *(from Ratajczak et al. 2011)*

Laboratory experiments on gas-surface exchanges



Gas-Grain chemistry *(from Taquet et al. 2012b)*

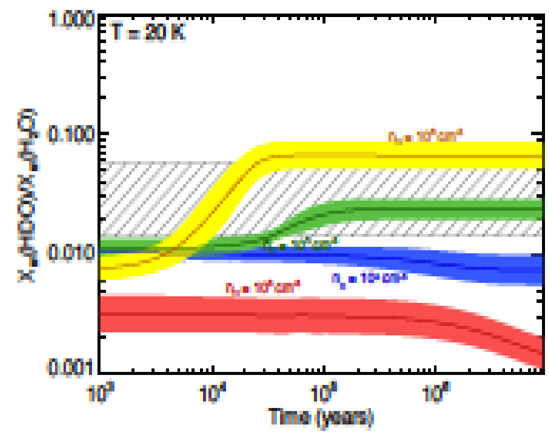
Water D/H ratio in IRAS16293 Cf. aussi poster A. Coutens (n°14)



Collision rates

	Hot corino		Outer envelope		Photodesorption layer
	Best fit	3σ	Best fit	3σ	$A_V \sim 1$ - 4 mag
HDO	1.7×10^{-7}	1.5 - 2.2×10^{-7}	8×10^{-11}	4.6 - 10.0×10^{-11}	$\sim$ 0.6 - 2.4×10^{-8}
H_2O	5×10^{-6}	3.8 - 10.5×10^{-6}	1.5×10^{-8}	4.5 - 24.5×10^{-9}	$\sim$ 1.3 - 5.3×10^{-7}
HDO/H_2O	3.4%	1.4% - 5.8%	0.5%	0.2% - 2.2%	$\sim$ 4.8%[a]

CHESS and TIMASSS observations *(from Coutens et al. 2012)*



Gas-Grain chemistry *(from Taquet et al. 2012c)*

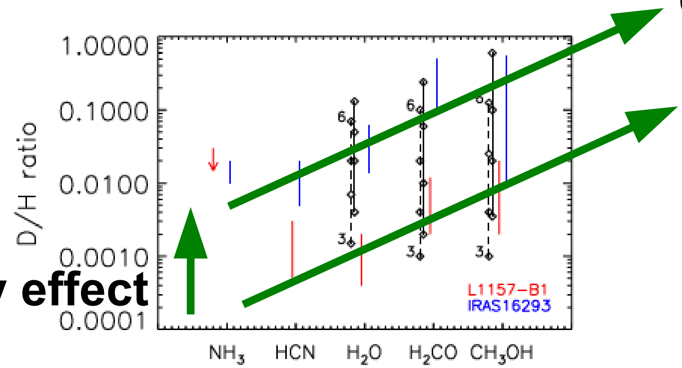
What can we learn from surveys ? (6)

- **Abundances & source history**

D/H ratios as star formation fossils

Cloud evolution

Density effect



Codella et al. 2012

IRAM 30m + CHESS surveys

- IRAS16293 (hot corino)
- L1157-B1 (pre shock gas)

+

GRAINOBLE chemical model

12C/13C ratios as AGB evolution tracers

IRAM 30m survey of CRL 618

80-116 GHz, 131-179 GHz, 204-275 GHz.

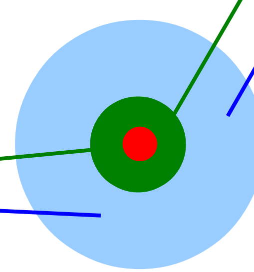
AGB star

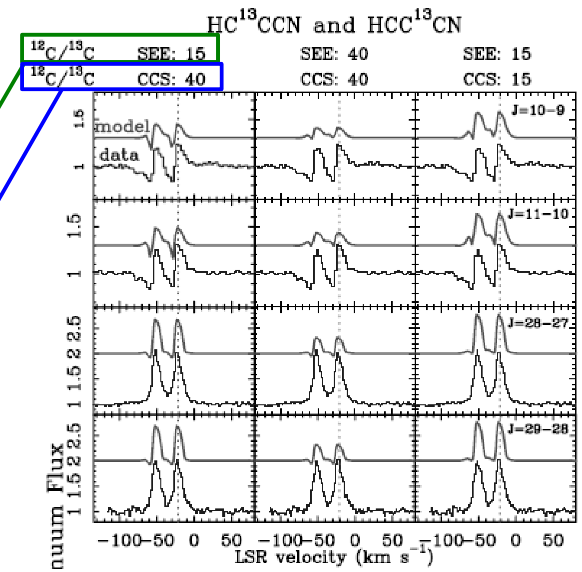
LTE modeling with 2 components

13C enrichment By AGB pulse ? SEE : slowly expanding envelope

CCS : cold circumstellar shell

(Pardo et al. 2004, 2005, 2007)

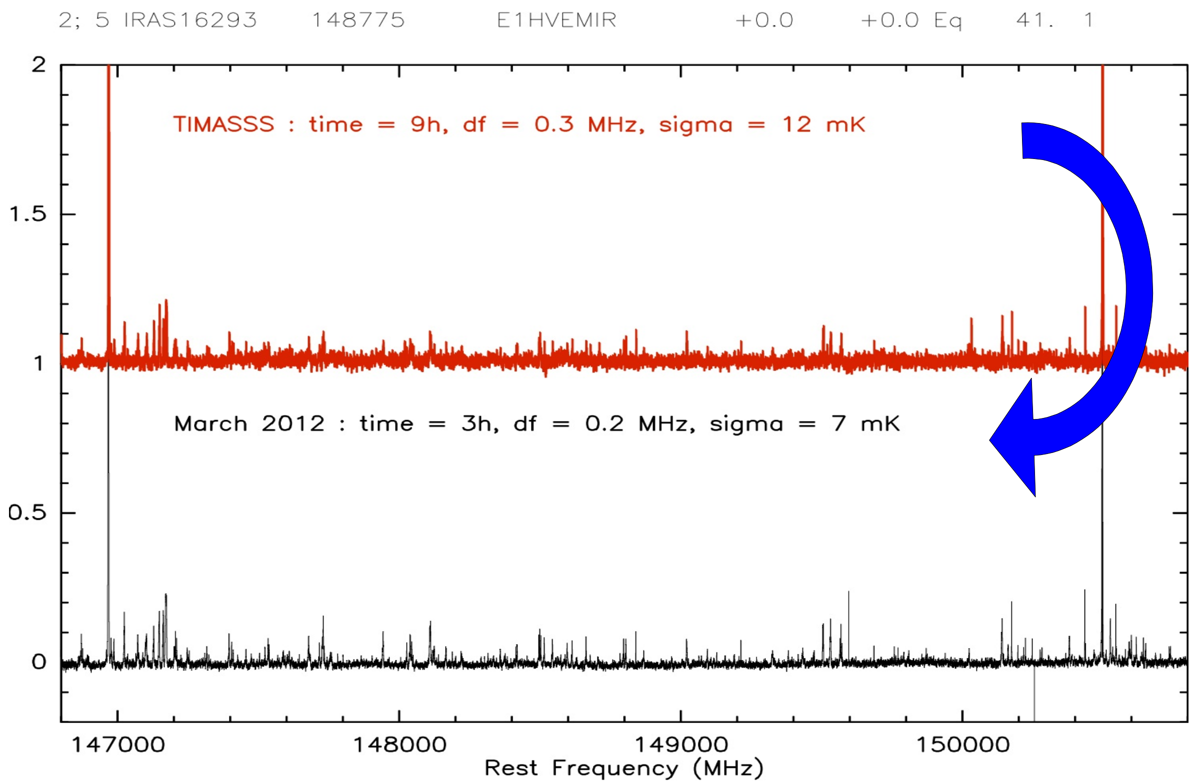




Perspectives and Prospective (1)

- **Spectral surveys on many more objects**

Huge gains in receivers sensitivity and band widths



IRAM 30m telescope
from 2005 to 2012,

gain of a factor 12 !

in integration time for

the same resolution,
the same bandwidth
the same sensitivity

Perspectives and Prospective (2)

Astrochemical Surveys At IRAM 30m (ASAI)

A Legacy Chemical Survey of Star-Forming Regions to study the evolution of molecular complexity in protostellar environments

Large Program (338h, 4 semesters) ; French (Lefloch) & Spanish (Bachiller) PI-ship
36 participants from 11 institutes : France (20), Spain (9), others (7)

Goal : unbiased surveys (80-280 Ghz), rms=6mK for dV=1km/s (0.25km/s for PSC)
10 targets sampling different stages of solar-type star formation

Astrochemical Surveys At Iram

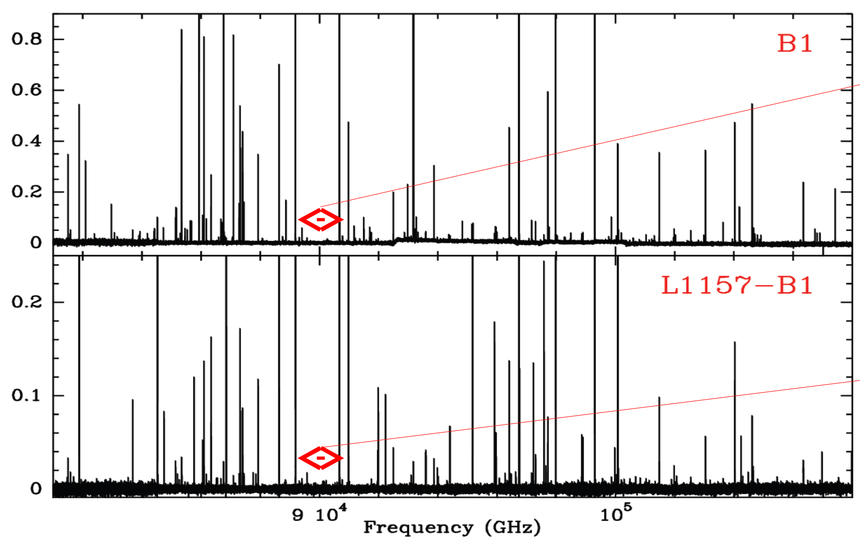
Type	Source	Ref.	d (pc)	L ($L_\odot$)	3mm	2mm	1.3mm	Herschel	Comment
PSC	L1544	1	140	-	X	-	-	C, W	Evolved: high deuteration
	TMC1	2	140	-	done	X	-	OT1	Young: hydrocarbon rich
Class 0	B1	3	200	-	X	X	X	-	Early: no outflow, high deuteration
	IRAS4A	4	250	7.7	X	X	X	C,OT1	Hot Corino
	L1527	5	140	2	done	X	X	W	WCCC
	L1157mm	6	250	4	done	done	X	W	WCCC ? comparison with B1
Class I	SVS13A	7	250	43	X	X	X	W	Evolved
Class I-II	AB Aur	8	145	-	X	X	X	OT1	residual envelope, warm disk
Jet	L1448	9	250	(11.6)	X	X	X	W,OT1	EHV bullets
Bowshock	L1157-B1	10	220	(4)	done	X	done	C,W	MHD shock prototype

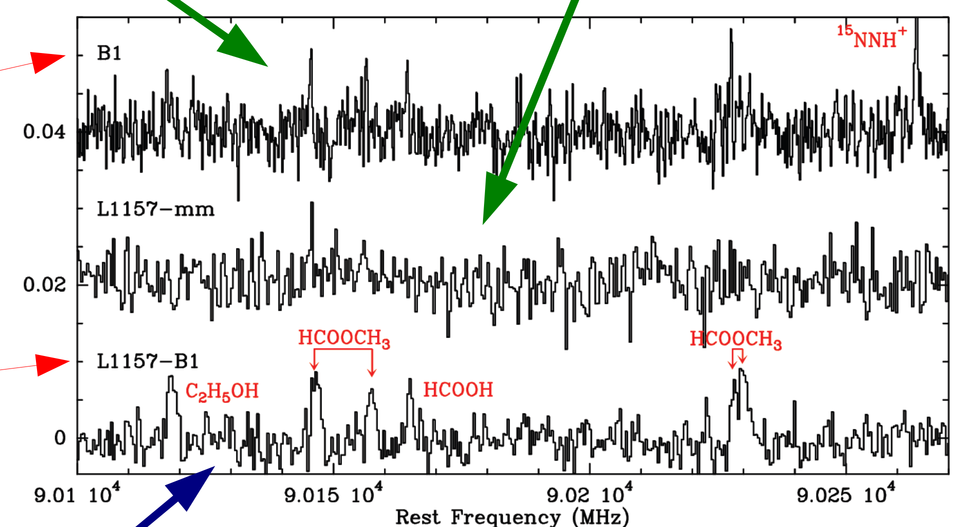
Perspectives and Prospective (3)

ASAI first promising results

Aug -Sep 2012 : B1, IRAS4A, L1157mm, L1157-B1, L1527 at 3mm and 2mm

Chemical differentiation between young protostars :
B1 exhibits a hot corino; L1157-mm does not



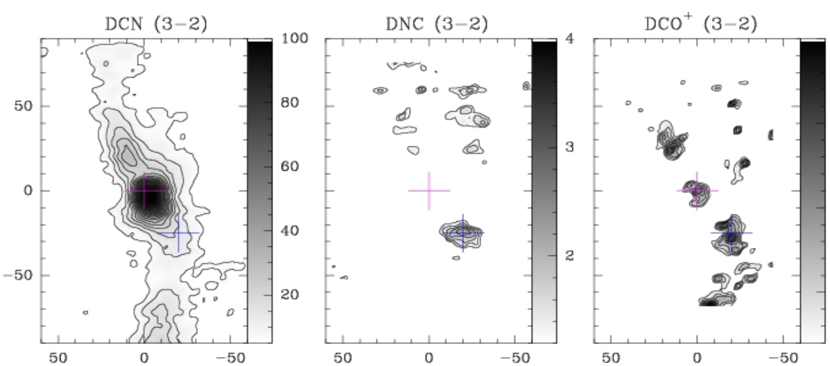


Production of COMs in the protostellar shock L1157-B1

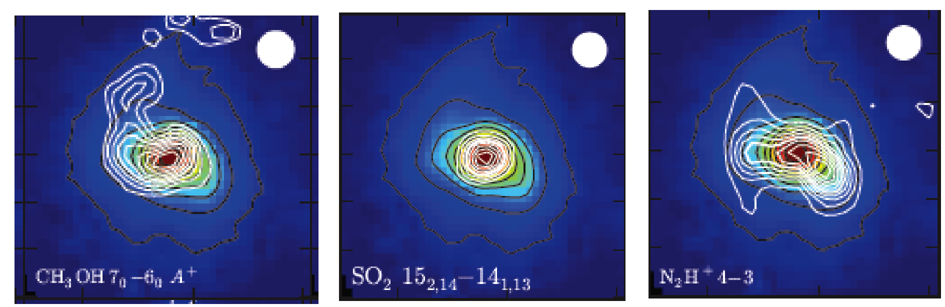
Perspectives and Prospective (4)

- **Many 2D Spectral surveys become possible**

Single dish surveys (selected lines mapping) : for extended sources

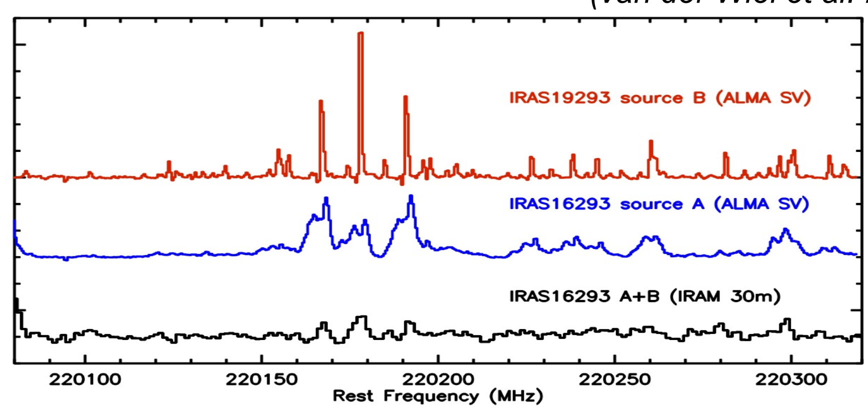


Orion : 2'x2' IRAM 30m survey at 1mm
(Marcelino et al. 2012)



AFGL2591 : JCMT SLS 2'x2' maps at 330-380 GHz
(van der Wiel et al. 2011)

Interferometer surveys : mandatory for small sources



→ **A lot of projects to come for NOEMA, ALMA... !**

Perspectives and Prospective (5)

Which strategy, why tools to share spectra?

- Private collaborations : which frame ? financial supports ?
- Public archives : which delay ? (what about IRAM data ?)

Which data, which tools to analyze the spectra ?

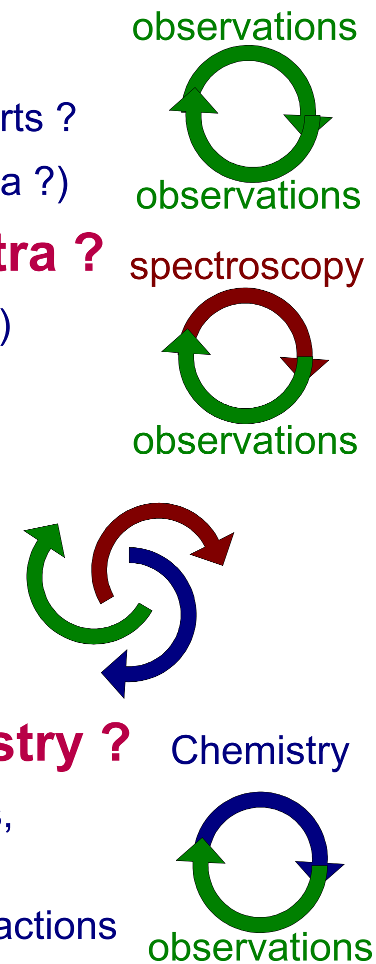
- Frequency databases (CDMS, JPL, Spatalog, private)
- Spectra analysis tools (CASSIS, CLASS,...)
- Needs for more spectral data

Which data, which tools to model the lines ?

- Radiative transfer : LTE, LVG codes, 1D to 3D
- Needs for more collision rates

Which data, which tools to model the chemistry ?

- Chemistry codes : steady-state / time dependant, gas, gas-grain, PDR, shocks...
- Need for reaction rates, radiation / gas / surface interactions



Many Posters to visit !

Databases
ML Dubernet n°20, 21

Collision, reaction rates
Chabot n°11, Capron n°9, Denis-Alpizard n°17, Dumouchel n°22, Faure n°24 Hochlaf n°31, Kaliguna n°33 Lanza n°36, Lattelais n°37 Minisalle n°46, Rist n°55, Schneider n°59, Kalugina n°66

Grain chemistry
Bertin n°4, Bron n°8 Chaabouni n°10,Congiu n°13, Danger n°15, Gavilan n°25, 26 Noble n°50, Pernet n°51, Pilmé n°52, Vinogradoff n°63, Teillet-Billy n°61

Gas chemistry
Ghesquière n°27, Krim n°35, LeGal n°39, Mokrane n°47 Romanzin n°56, Sims n°60 Thi n°62