

Context ALMA

ALMA is the most important completed project in astronomy of recent years
US, Europe, Japan In North of Chile, 5000 m altitude

66 radiotelescopes 12m diameter, frequency range from 100 GHz to 800 GHz
(Terahertz region of spectrum = 0.1 to 10 THz)

Astronomy is a strong driver of THz technology



The LLAMA radiotelescope





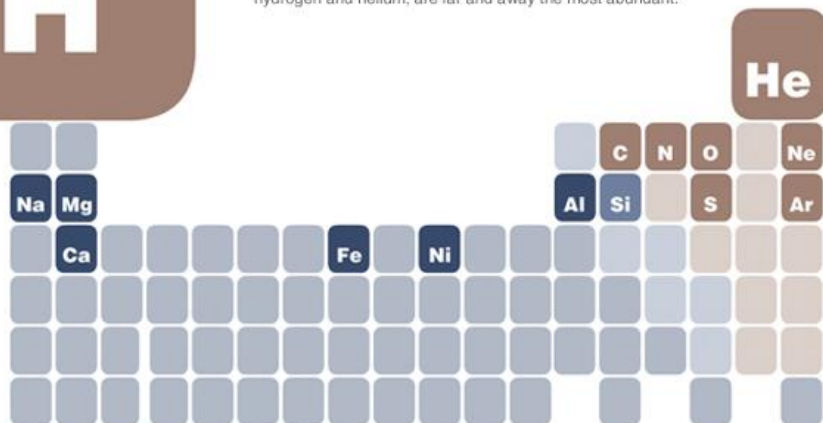
LLAMA to be installed this year, will resemble APEX

The Universe as a Chemistry Lab



The Periodic Table for Astronomy

A graphic representation of the abundances of the elements is shown in this "astronomers" version of the periodic table. What leaps out of this table is that the simplest elements, hydrogen and helium, are far and away the most abundant.

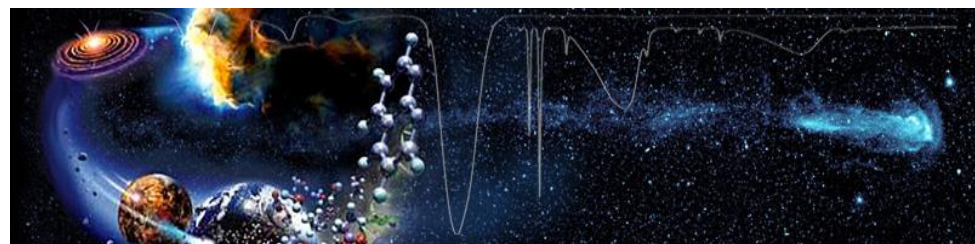


http://chandra.harvard.edu/resources/flash/periodic_tables.html

*Around 200 chemical species have been observed in the Interstellar Medium

Alcohols, sugars, inorganics, pre-biotics, Ions, neutrals...

*Radiotelescopes play a crucial role collecting spectral signatures to understand our chemical origins

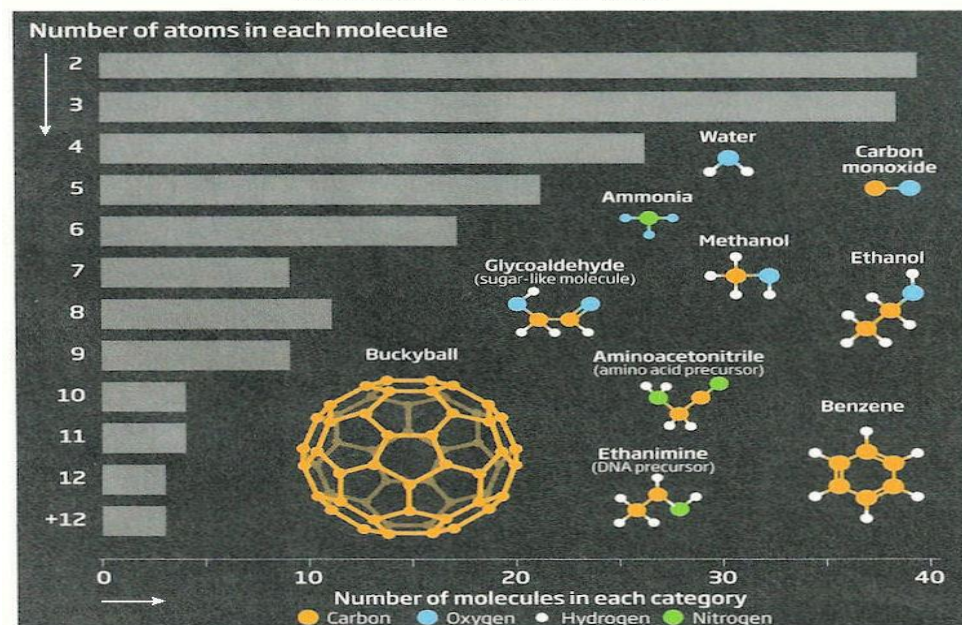


<https://astrochem.org>

From atoms to complex molecules!!!

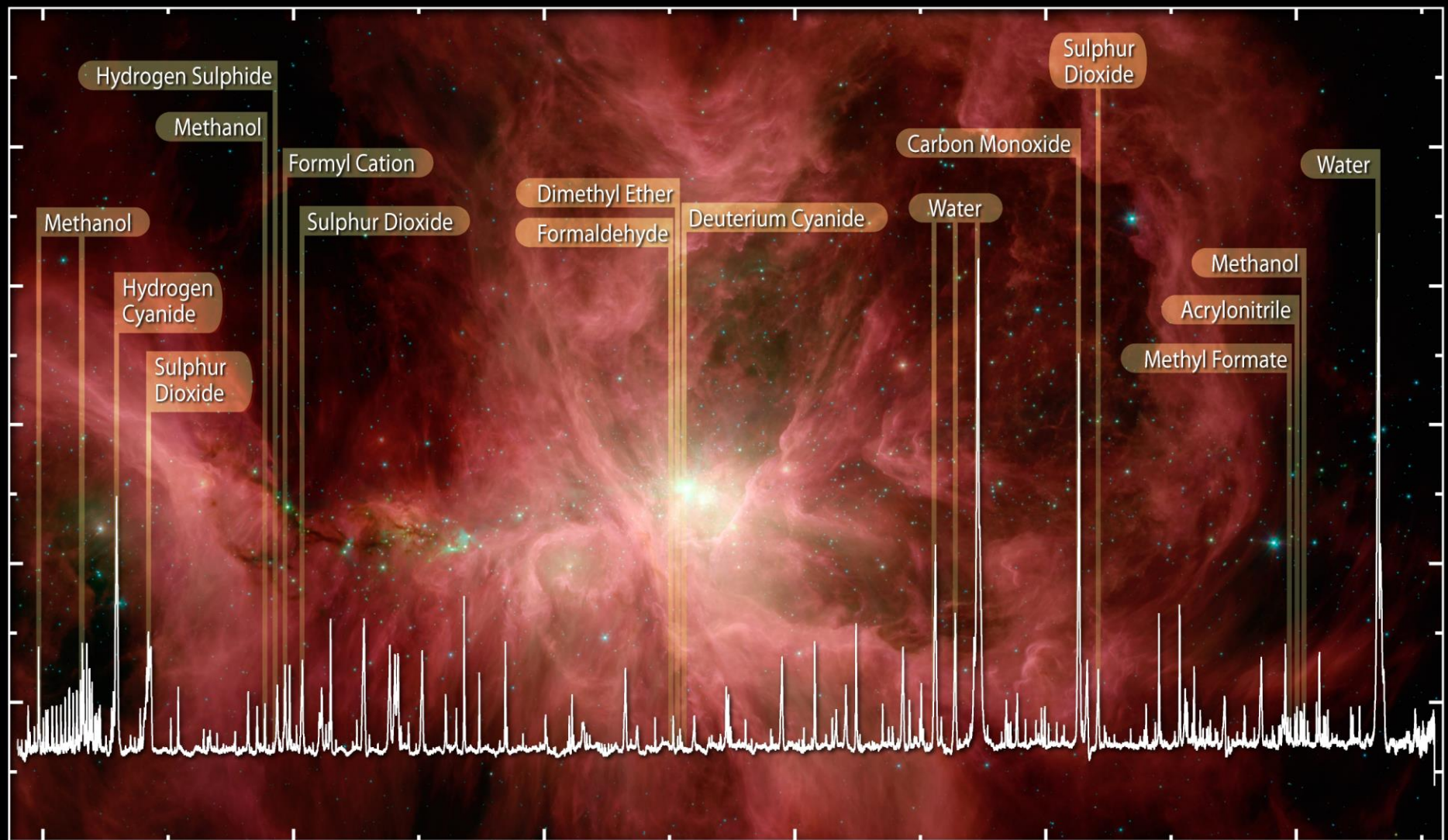
Now we are equipped to study the Chemistry of the Space

Molecules in Space, 2013



The 180 or so molecules found in space so far are mainly small. Besides very simple molecules such as water, these include sugar-like molecules, simple alcohols, hydrocarbons and precursors of proteins and DNA

<https://universe-review.ca/F11-monocell.htm>



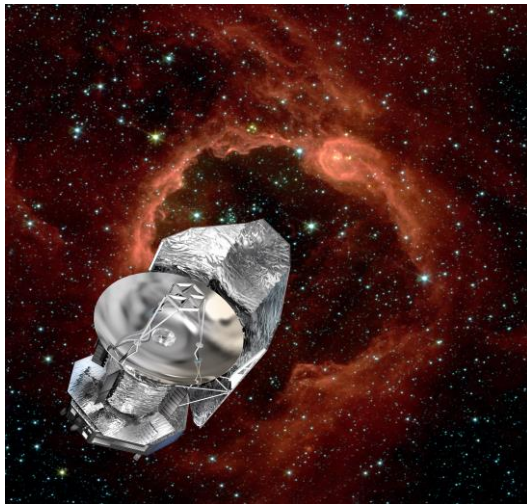
HIFI Spectrum of Water and
Organics in the Orion Nebula

© ESA, HEXOS and the HIFI consortium
E. Bergin

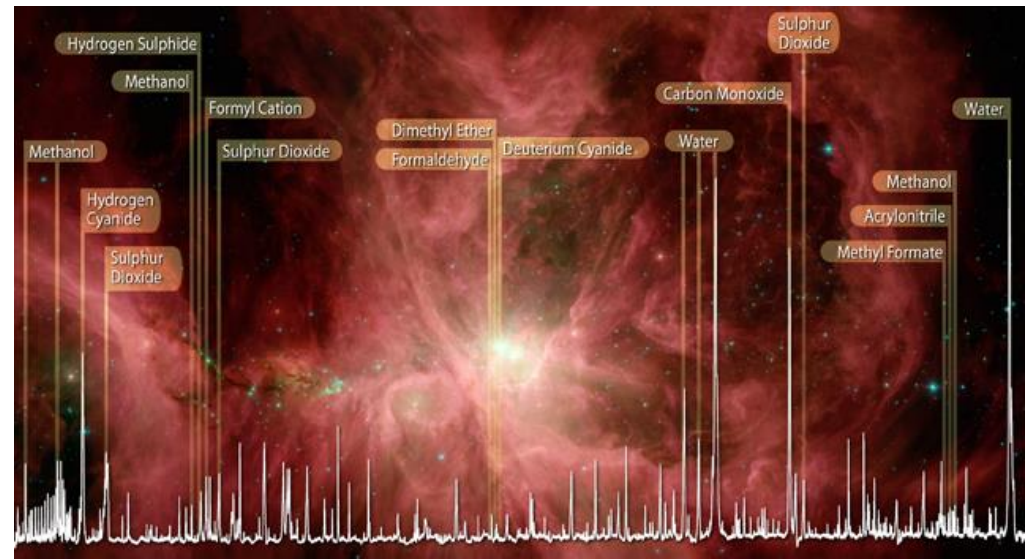
“Collecting Interstellar Samples”



ALMA observatory: Located in Chile, the interferometer operates at mm and sub-mm wavelengths
http://alma.mtk.nao.ac.jp/e/news/alma/2010/0522post_11.html



The Herschel Space Observatory was launched with instruments Sensitive from the far infrared to sub-mm wavelengths
<http://www.jpl.nasa.gov/missions/herschel-space-observatory/>



A new generation of instruments – ground-based, in space or even on planes – has allowed to explore “molecular links” between numerous protostellar systems



SOFIA, observatory on a Boeing designed for Infrared Astronomy
https://www.nasa.gov/mission_pages/SOFIA/13-05.html

How to analyze???

Various friendly softwares and tools have been developed to reduce and analyze data

GILDAS → <https://www.iram.fr/IRAMFR/GILDAS/>

CASA → <https://casa.nrao.edu/>

HIPE → <https://www.cosmos.esa.int/web/herschel/hipe-download>

CASSIS → <http://cassis.irap.omp.eu/>

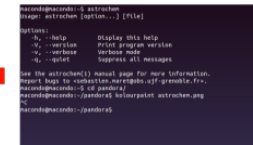
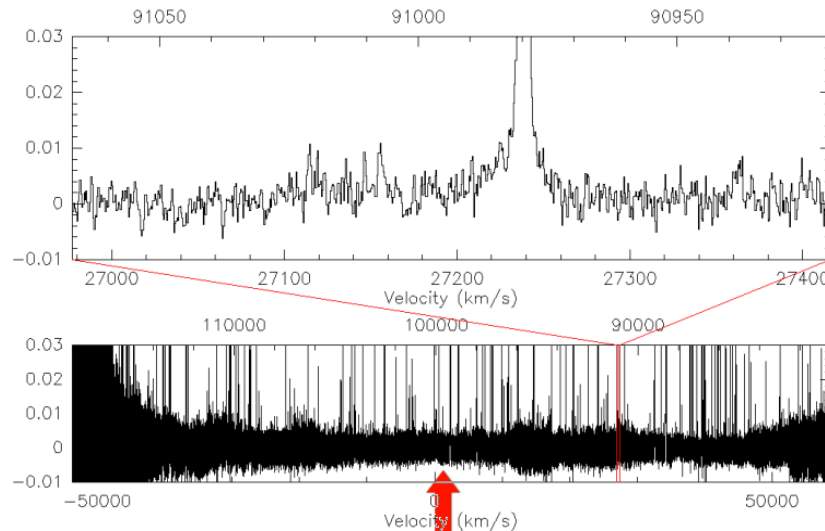
AIPS → <http://www.aips.nrao.edu/index.shtml>

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Our Lab: indentifying molecules



Observations

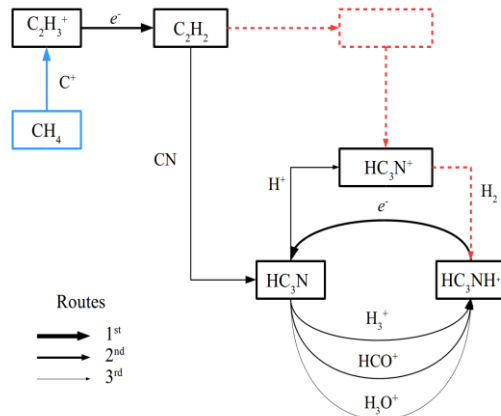
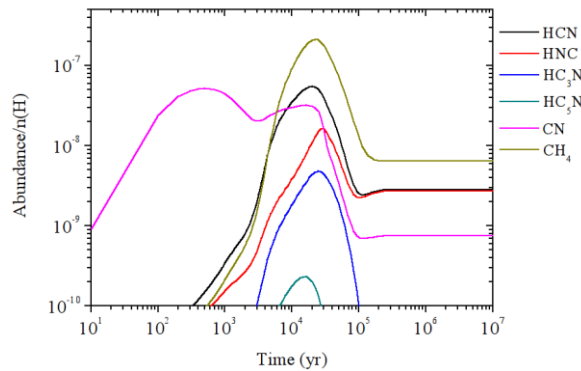


Software
GILDAS
Class
...
CASSIS



Combining different approaches: A common exercise in Astrochemistry

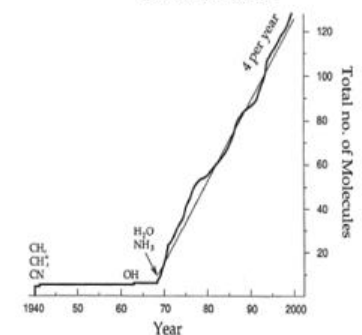
Observations, experiments and models offer relevant information about the presence of species and their chemical properties in the Interstellar Medium



Known Interstellar and Circumstellar Molecules (July 2000)

Number of Atoms							
2	3	4	5	6	7	8	9
H ₂	H ₂ O	NH ₃	SiH ₄	CH ₃ OH	CH ₃ CHO	CH ₃ CO ₂ H	CH ₃ CH ₂ OH
OH	H ₂ S	H ₂ O ⁺	CH ₄	NH ₂ CHO	CH ₃ NH ₂	HCO ₂ CH ₃	(CH ₃) ₂ O
SO	SO ₂	H ₂ CO	CHOOH	CH ₃ CN	CH ₃ CCH	CH ₃ C ₂ CN	CH ₃ CH ₂ CN
SO ⁺	HN ₂ ⁺	H ₂ CS	HC≡CCN	CH ₃ NC	CH ₂ CHCN	C ₇ H	H(C≡C) ₃ CN
SiO	HNO	HNCO	CH ₂ NH	CH ₃ SH	HC ₄ CN	H ₂ C ₆	H(C≡C) ₂ CH ₃
SiS	SiH ₂ ?	HNCS	NH ₂ CN	C ₃ H	C ₆ H		C ₈ H
NO	NH ₂	CCCN	H ₂ CCO	HC ₂ CHO	c-CH ₂ OCH ₂		
NS	H ₃ ⁺	HCO ₂ ⁺	C ₄ H	CH ₂ =CH ₂	C ₇ ?		
HCl	NNO	CCCH	c-C ₃ H ₂	H ₂ CCCC			
NaCl	HCO	c-CCCH	CH ₂ CN	HC ₃ NH ⁺			
KCl	HCO ⁺	CCCO	C ₅	C ₆ N			
AlCl	OCS	CCCS	SiC ₄	C ₅ S?			
AlF	CCH	HCCH	H ₂ CCC				
PN	HCS ⁺	HCNH ⁺	HCCNC				
SiN	c-SiCC	HCCN	HNCCC				
NH	CCO	H ₂ CN	H ₃ CO ⁺				
CH	CCS	c-SiC ₃					
CH ⁺	C ₃	CH ₃					
CN	MgNC	CH ₂ D ⁺ ?					
CO	NaCN						
CS	CH ₂						
C ₂	MgCN						
SiC	HOC ⁺						
CP	HCN						
CO ⁺	HNC						
HF	SiCN						
	KCN?						

— Carbon chains
— Complex Organic Molecules
— Tracers of shocks and UV-irradiation

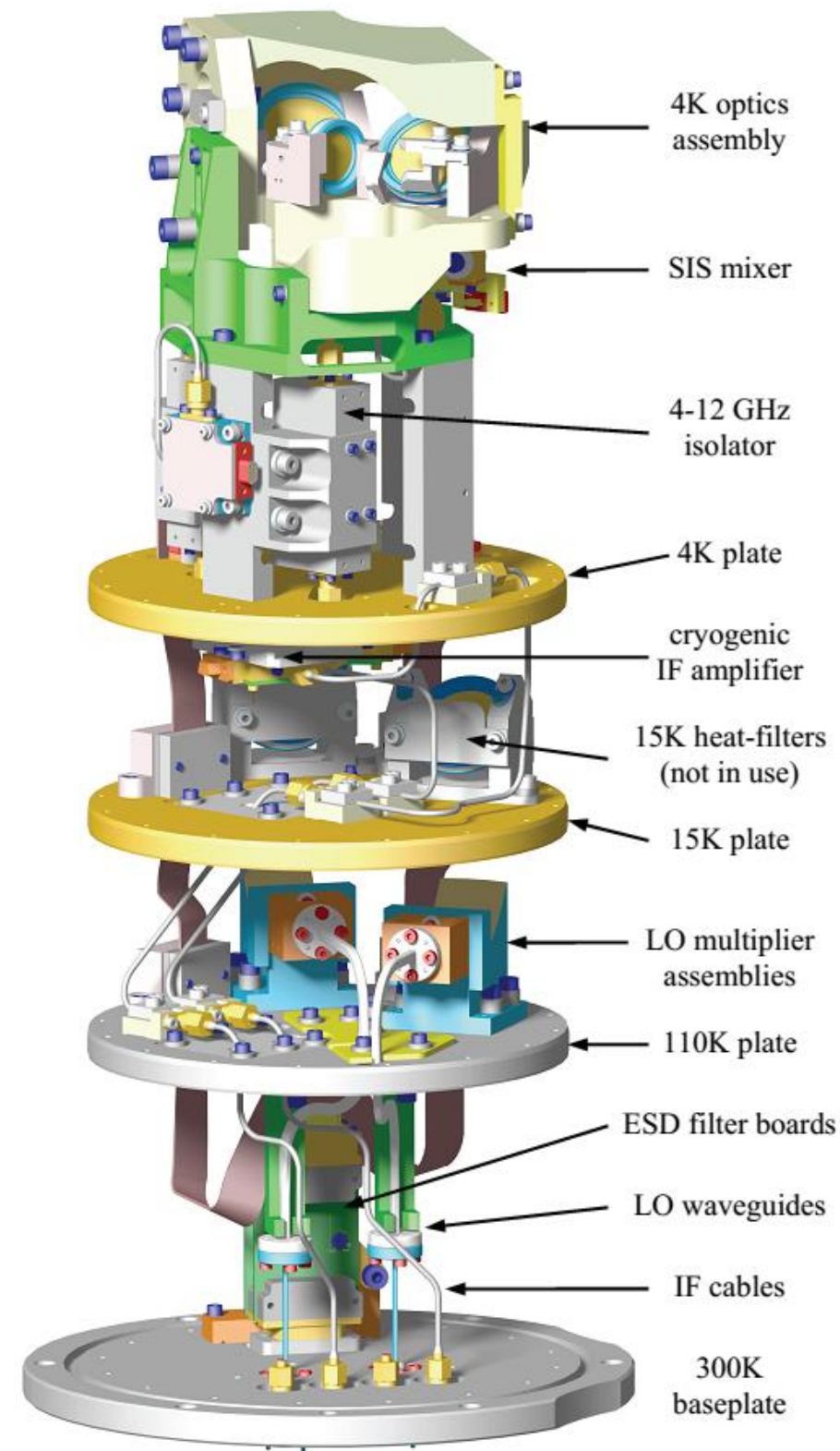


Receiver Demonstration Lab

The cryogenic portion of an ALMA receiver (Band 9)

IF bandwidth 4-12 GHz

Total power receiver noise temperature < 169 K over 80% of the band



We will present a very simple version of a radio-astronomy receiver, with the main elements: horn mixer, amplifier, and demonstrate the principle of calibration load, to calibrate the temperature scale of the observations.

Contacts for “radio” labs at IAG Department of Astronomy

- Radio receiver demonstration

Danilo Zanella danilo.zanella@iag.usp.br

- Molecular line identification

Edgar Mendoza emendoza@usp.br

- General

Jacques Lepine jacques.lepine@iag.usp.br

Better contact us to be sure that we will be there