

# The early stages of Solar-type protostars: large carbon chains, an important missing piece of the puzzle

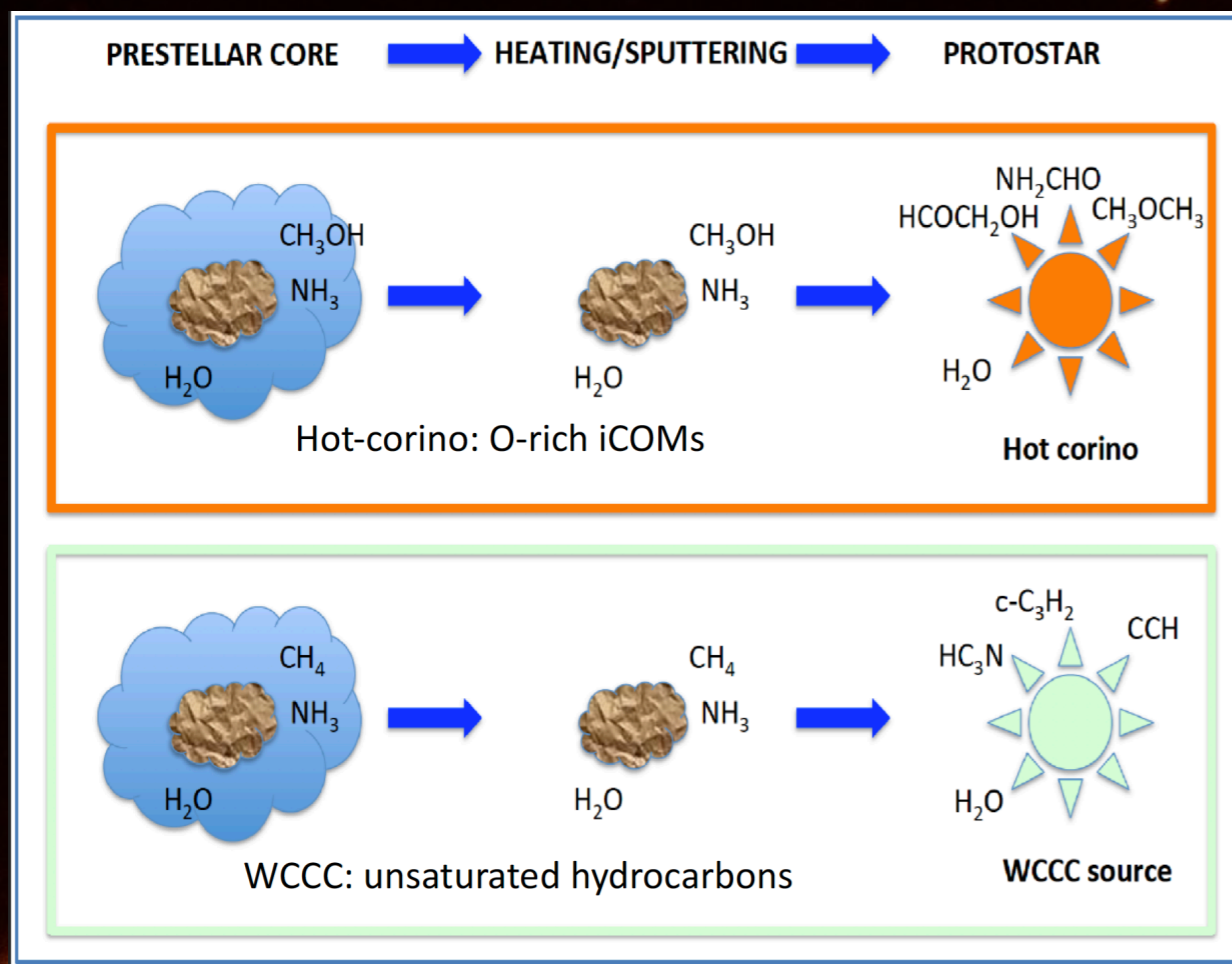
**Eleonora Bianchi**

Univ. Grenoble Alpes, IPAG- INAF, Arcetri

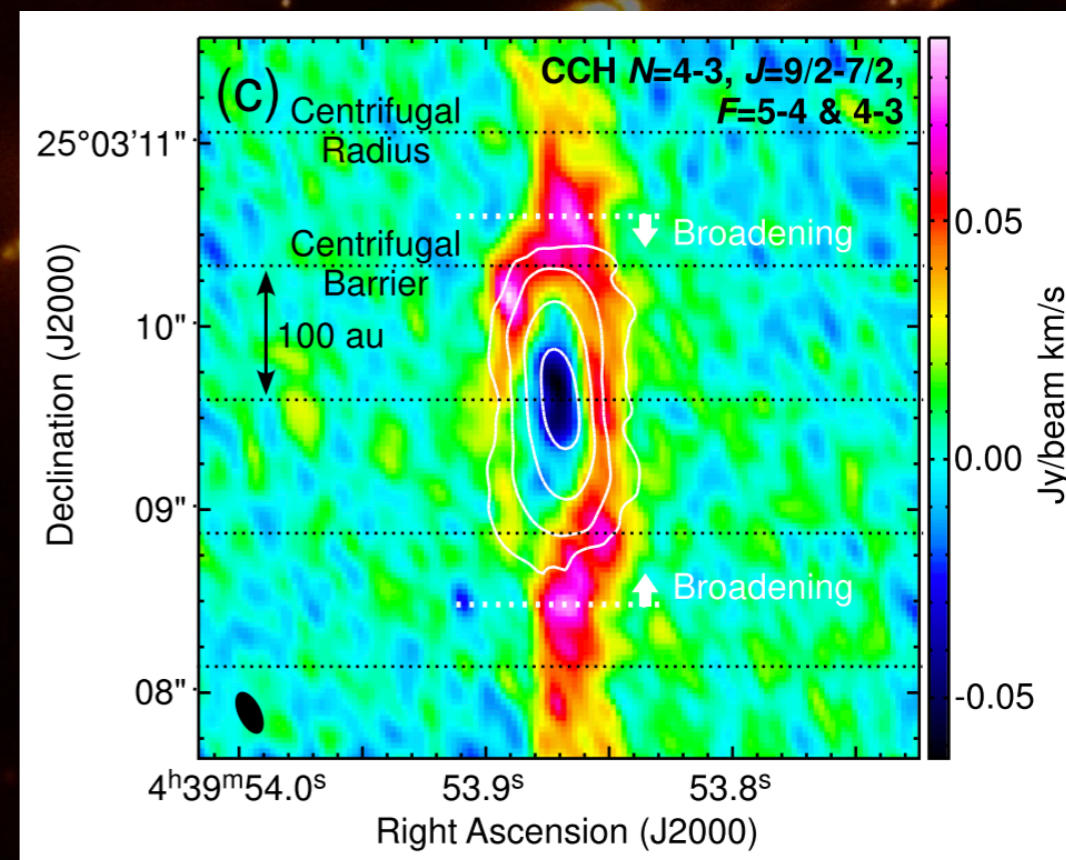
C. Codella, C. Ceccarelli, P. Caselli, N. Balucani, E. Herbst, B. McGuire, A. Remijan, S. Spezzano

# Chemical diversity => Hot corino vs WCCC

## Warm Carbon Chain Chemistry (WCCC)



L1527 Sakai et al. 2008, 2014, 2017



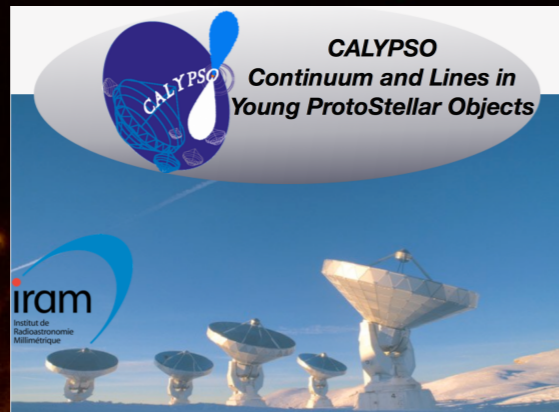
- Collapse timescale?  
Sakai & Yamamoto 2013
- UV illumination?  
Spezzano et al. 2016

Not all protostars have a hot corino.  
 Why?  
 Different grain mantles composition?

# OBSERVATIONAL CAMPAIGNS



IRAM PdBI



Herschel



2019



GBT PILOT PROJECT



IRAM NOEMA



IRAM 30m



2009



The Italian route to the SKAO revolution

Eleonora Bianchi

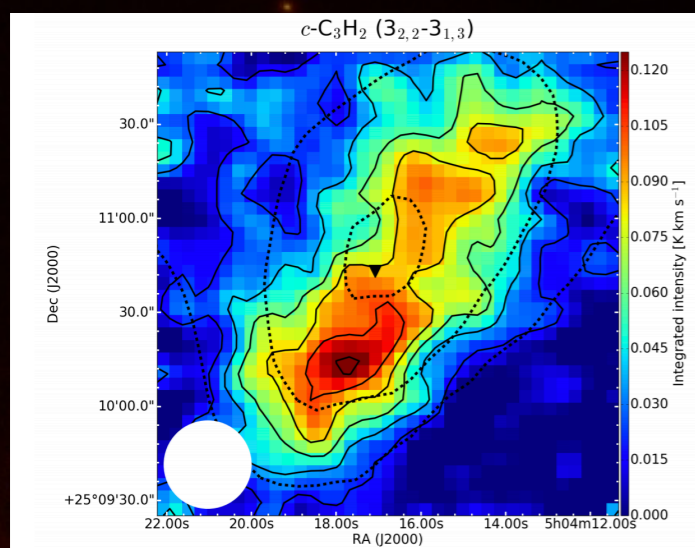


# Carbon chains hunt with GBT!



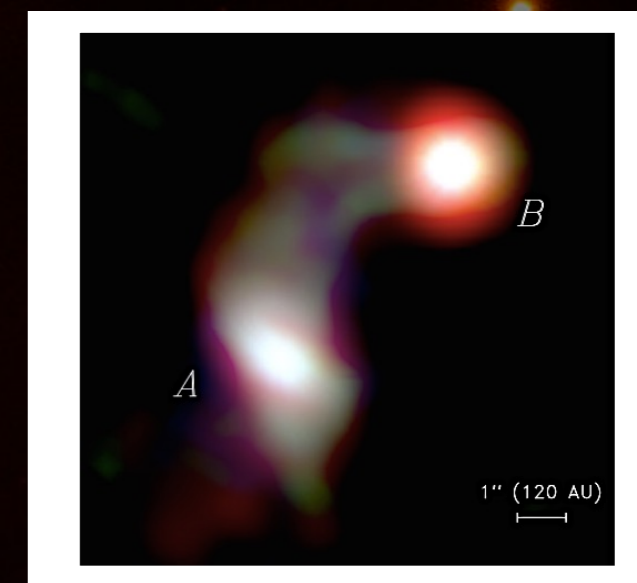
**GBT Pilot Project** 53 hours

**L1544**  
prestellar core



Survey of  
Ku-band ~ 13.9-15.4 GHz  
+  
follow up of L1544 in  
X-band ~ 8-11.5 GHz  
rms ~ 1-2 mK

**IRAS 16293-2422**  
protostar



**Low density shell rich in  
iCOMs and Carbon Chains**

Vastel et al. 2014, Jiménez-Serra et al. 2016,  
Spezzano et al. 2017, Urso et al. 2019

**Hot corino  
rich in iCOMs**

Cazaux et al. 2003, Bottinelli et al. 2004,  
Jaber et al. 2017, Jørgensen et al. 2016

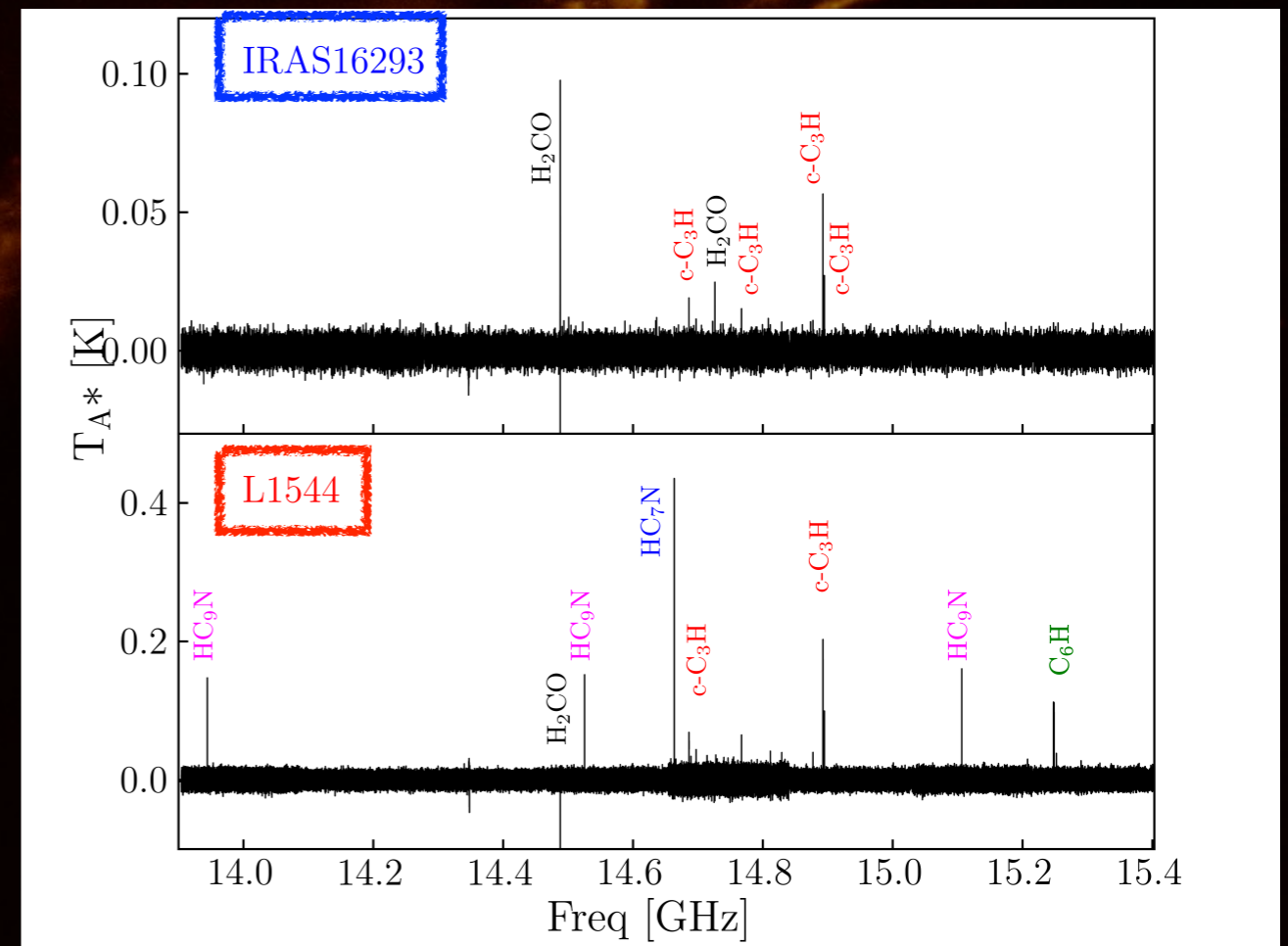
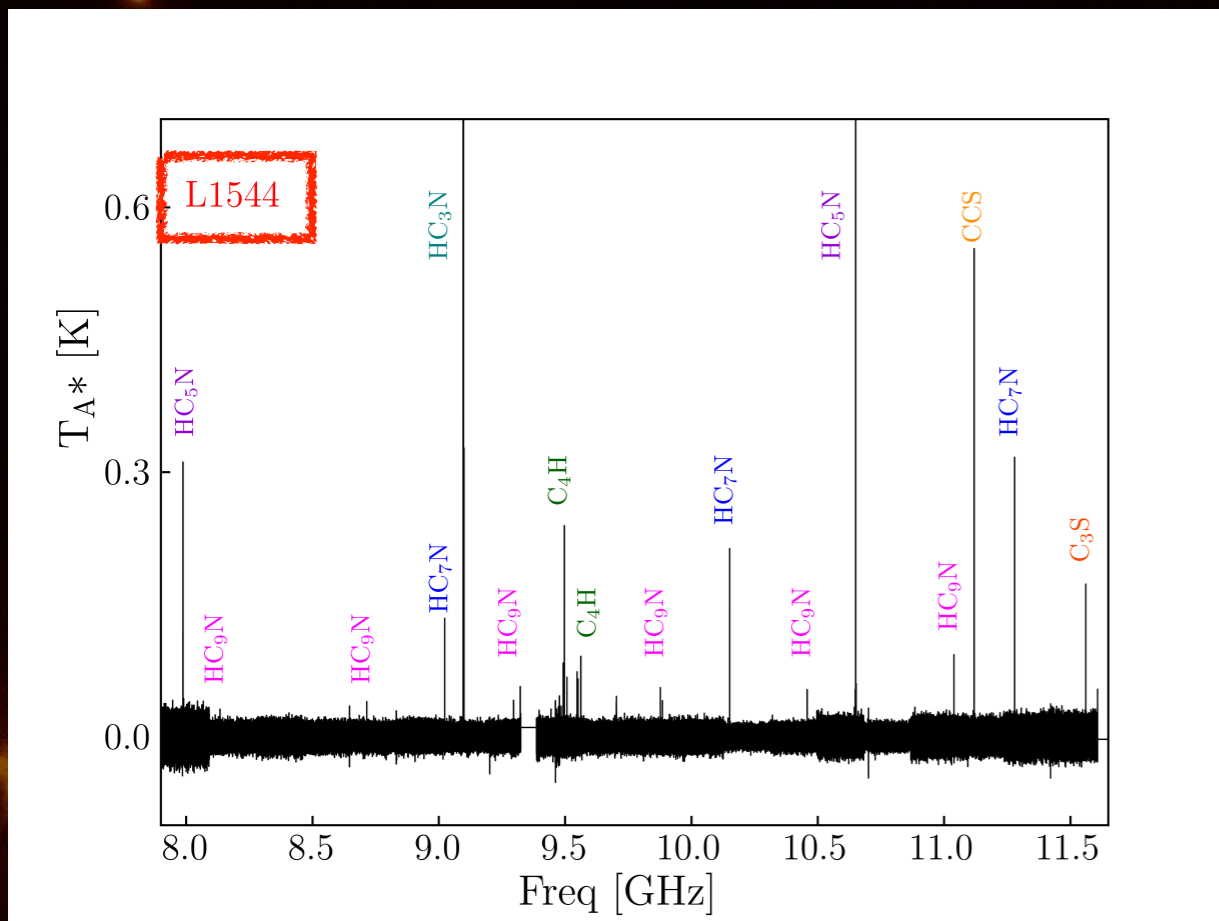
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X-band

Ku-band

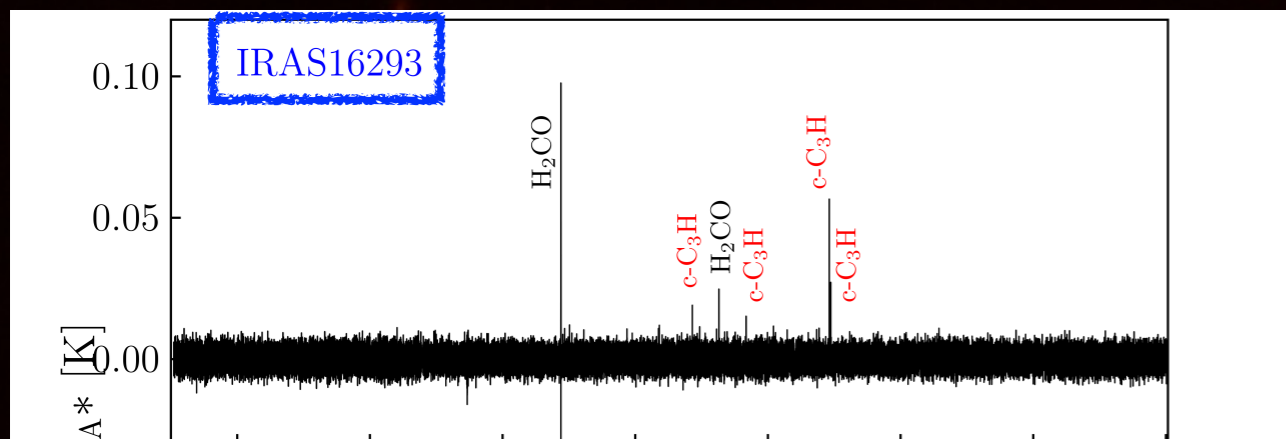


Analysis in progress...

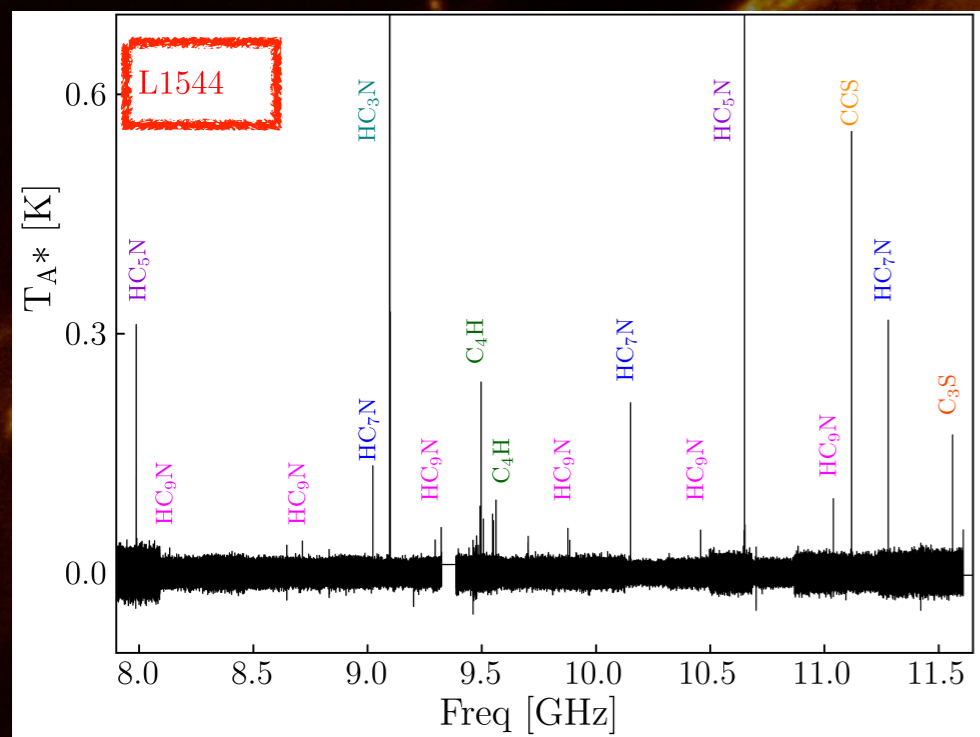
# Carbon chains hunt with GBT!



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Detected  
 $H_2CO$  IRAS16293 B  
 $c-C_3H$  envelope/parental cloud



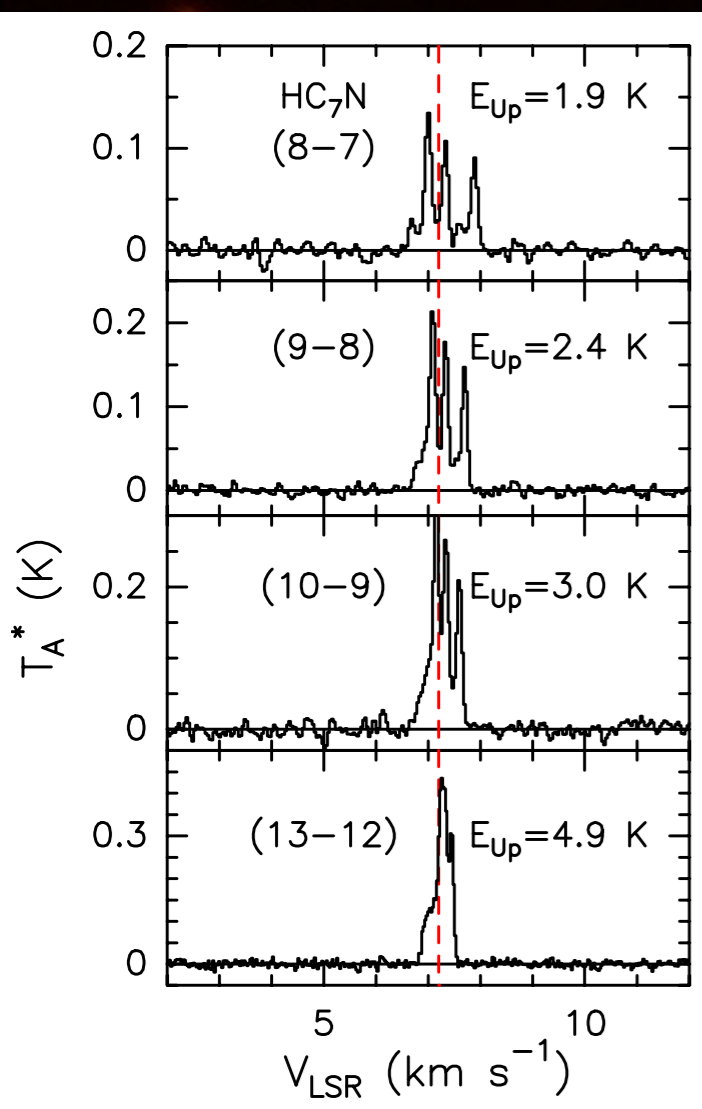
Detected  
 $H_2CO$   
 $c-C_3H$ ,  $C_4H$ ,  $C_6H$ ,  
 $HC_3N$ ,  $HC_5N$ ,  $HC_7N$ ,  $HC_9N$ ,  
 $CCS$ ,  $C_3S$

# Carbon chains hunt with GBT!

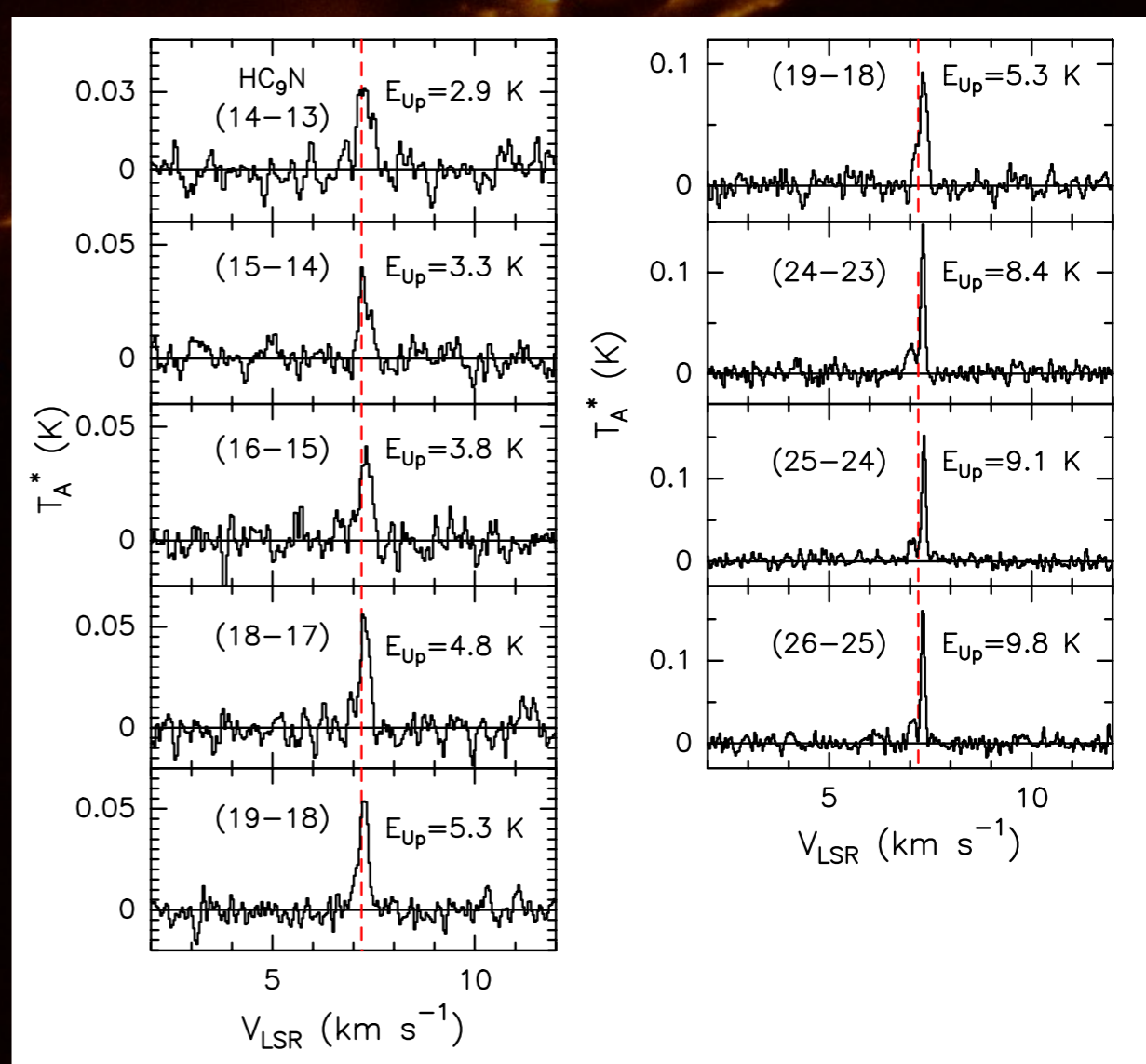
**GBT Pilot Project 53 hours**



**L1544**



**$\text{HC}_7\text{N}$  and  $\text{HC}_9\text{N}$   
bright emission  
First detection of  
 $\text{HC}_9\text{N}$  towards the  
source,  
derived upper  
limit for  $\text{HC}_{11}\text{N}$**

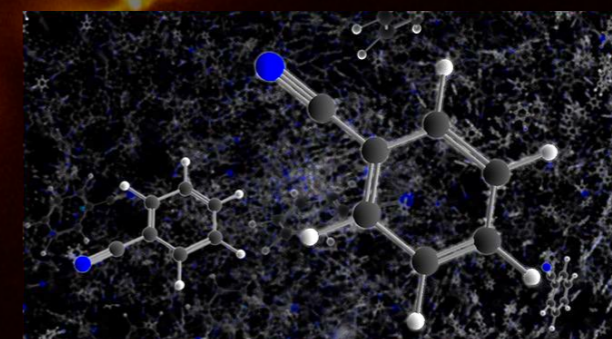
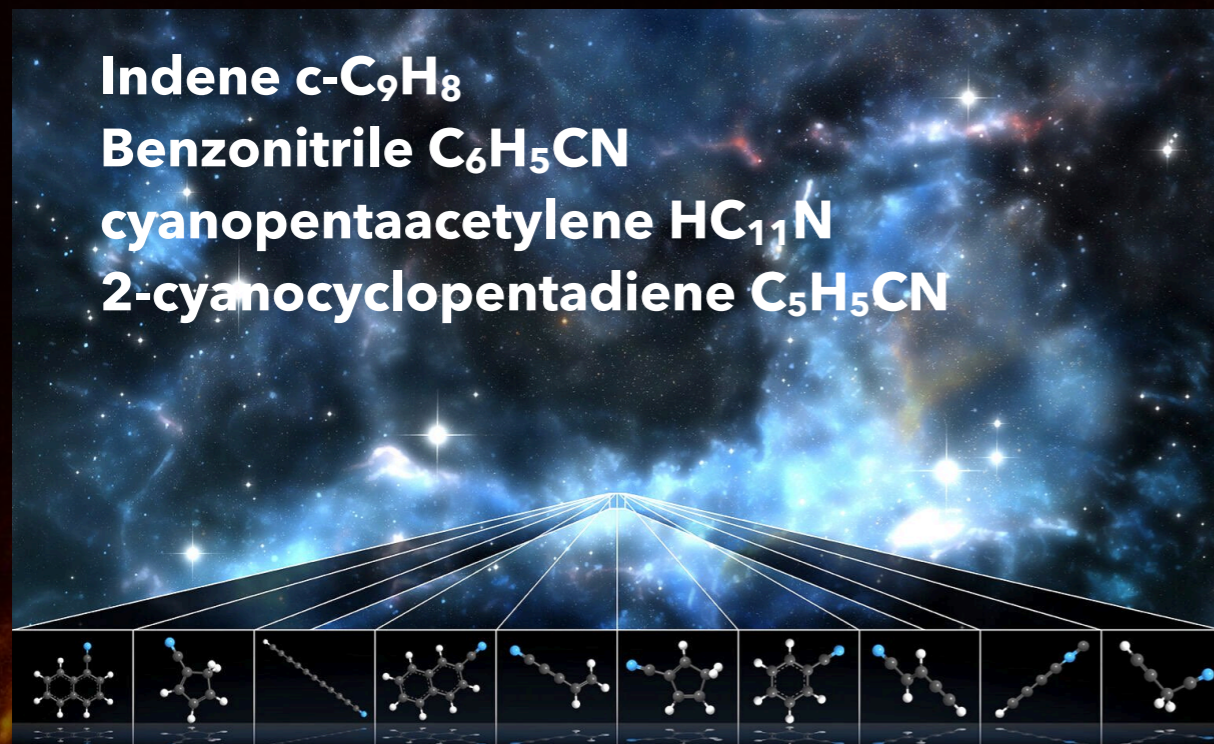


# Carbon chains hunt with GBT!



**GBT Pilot Project** 53 hours

**We can start to do comparisons on carbon chains chemistry**



Aromatic chemistry: benzonitrile detected in 4 prestellar cores. Abundances underpredicted. What about protostellar regions?

Top-down or bottom-up formation?

**GBT GOTHAM: TMC-1; McGuire et al. 2020**

**GBT ARKHAM: 4 sources; Burkhardt et al. 2021**

**YEBES 40m QUIJOTE: TMC-1; Cernicharo et al. 2021**





# TAKE HOME & FUTURE PERSPECTIVES

- **Exploration of C-chains content of L1544 & IRAS16293.**  
GBT sampled spatial scales 7000 - 11200 au
- L1544 is rich in cyanopolynes (up to  $\text{HC}_9\text{N}$ ) and heavy carbon chains ( $\text{C}_6\text{H}$ ). The IRAS16293 **envelope** shows a less rich carbon chemistry. Why? External irradiation/evolution/environment ?
- SKA is mandatory to **explore heavy C-chains on a Solar System scale around protostars**



## SKA unveiling heavy carbon chains chemistry Cradle Of Life WG

### 1.1 PROJECT NAME

PROJECT DETAILS	
Title	<b>SKA unveiling heavy carbon chains chemistry in OMC-2, the closest analogue to our Sun's birth environment</b>
Principal Investigator	<b>Eleonora Bianchi</b>
Co-Authors	<b>Cradle Of Life Team</b>
Time Request	~ 1000 hours

FACILITY		Preconditions
	SKA1-LOW	
<b>x</b>	SKA1-MID	Band 5b frequency coverage in 2 windows 2.5 GHz broad (9 -11.5 GHz and 13-15.5 GHz) + four narrower zoom windows on selected lines. Some aspects would benefit from Band 5+.

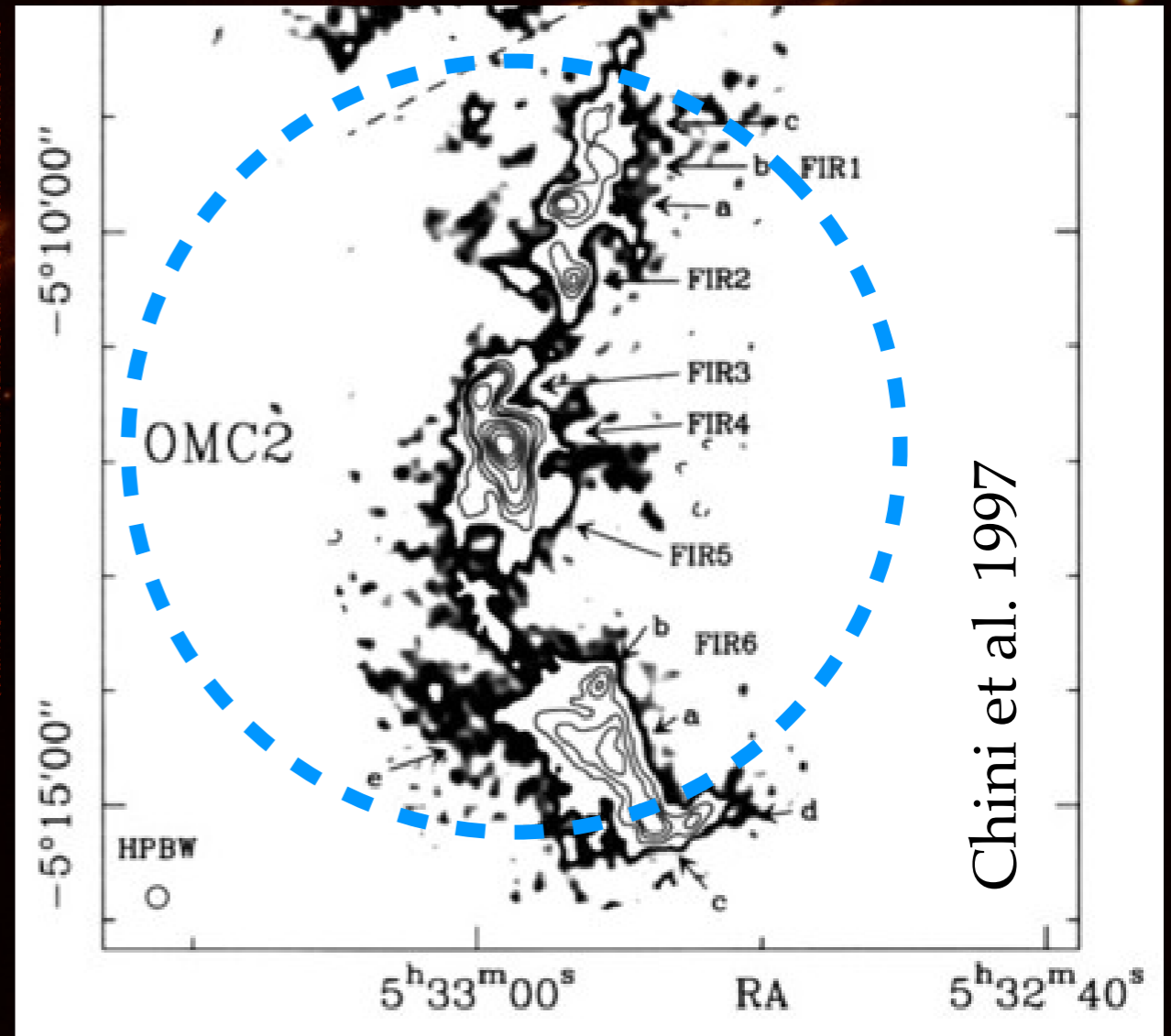
# SKA unveiling heavy carbon chains chemistry in OMC-2, the closest analogue to our Sun's birth environment



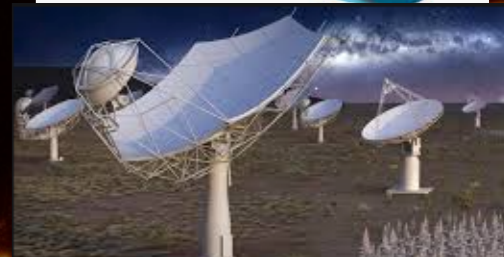
PI: Bianchi, E. & CoL WG

Orion Molecular Cloud 2

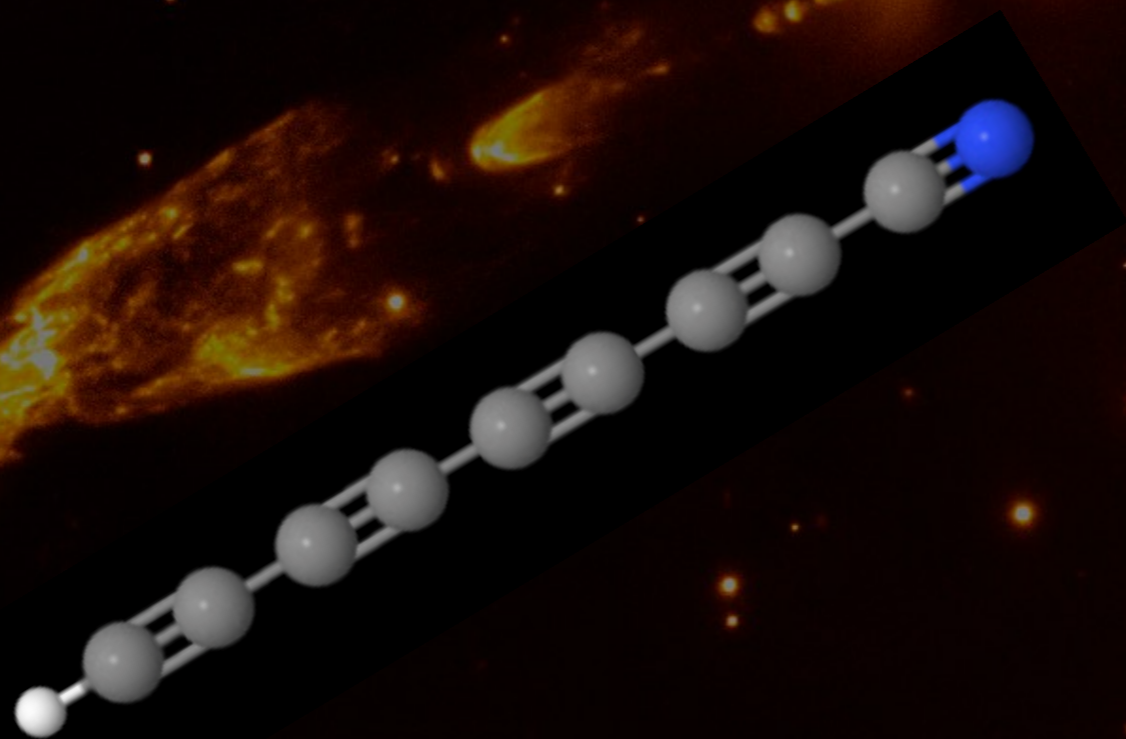
SKA MID Band 5 ~ 1000 hr  
 9.0-11.5 GHz + 13.0-15.5 GHz  
 spectral resolution ~ 1.9 km/s  
 +  
 4 narrow zoom windows  
 on selected lines  
 angular resolution <math><0.5''</math> (< 200 au)



**OMC2-FIR4 protocluster**  
 a similar chemistry than that of  
 our early Solar System.



THANKS!



*The Italian route to the SKAO revolution*

**Eleonora Bianchi**

