

***GENESIS-SKA:
General conNditions in Early
planetary Systems for the rISe
of life with SKA***

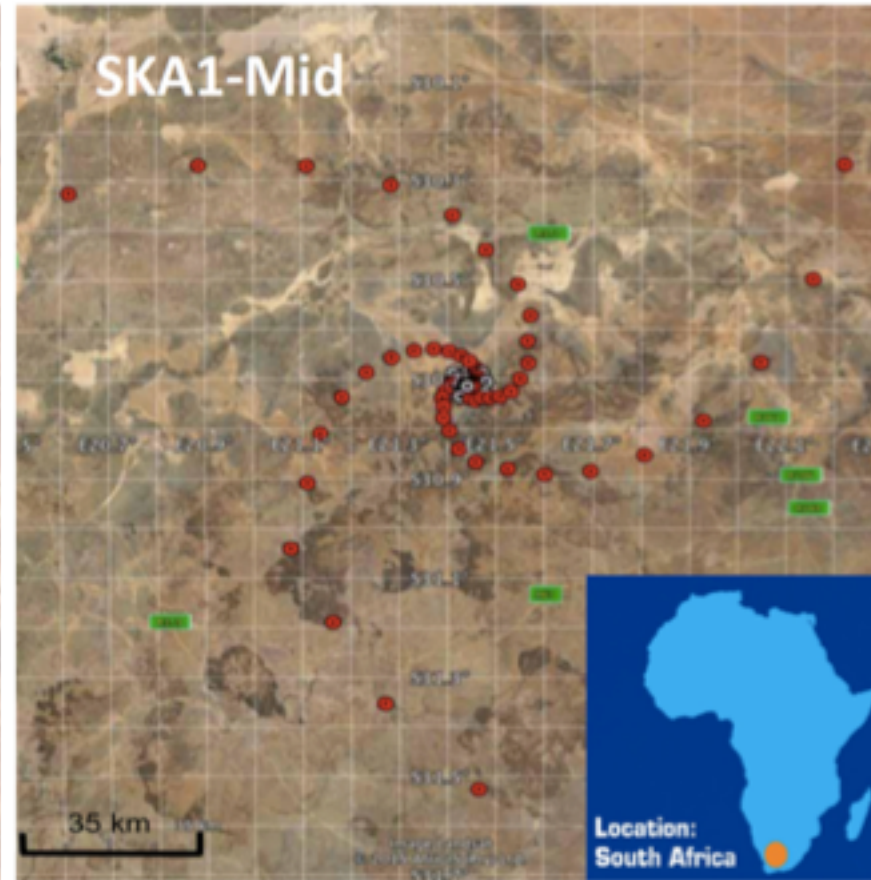
C. Codella
(INAF – OAA)



The Cradle of Life



SKA1-Low -> 50 MHz to 350 MHz
SKA1-Mid -> 350 MHz to 15 GHz



Antennas: 512
Max. baseline: 65 km
Down to 3"

Antennas: 133
Max. baseline: 150 km
Down to 10 mas

Science verification: 2024; PI proposals: 2025-2026

Low-mass (Sun-like) star formation

The Cradle of Life



General context, Key questions:

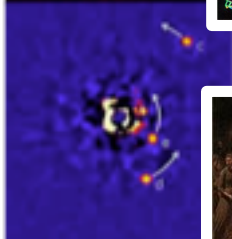
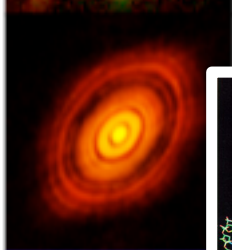
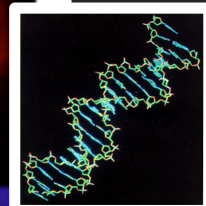
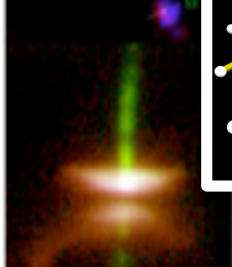
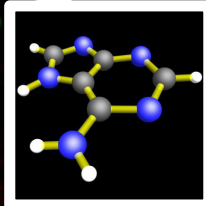
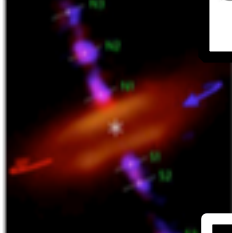
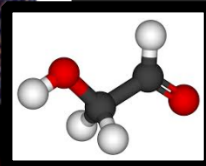
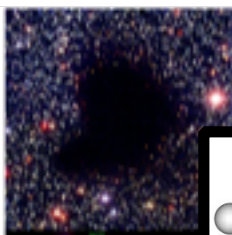
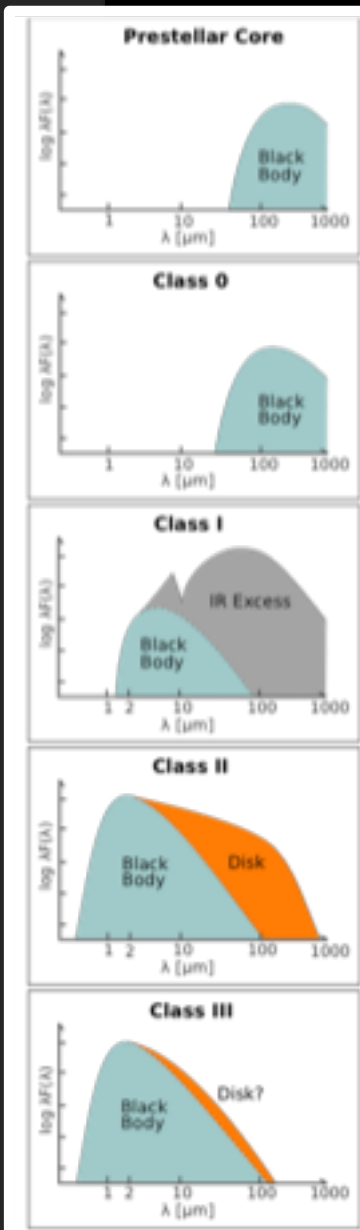
→ Solve the **angular momentum problem** from core-collapse to proto-planetary disks;

→ Study the **evolution of circumstellar disks** in solar-type stars from proto-stellar to planet formation phase;

→ Disk dispersal mechanisms: **accretion, jets, winds**;

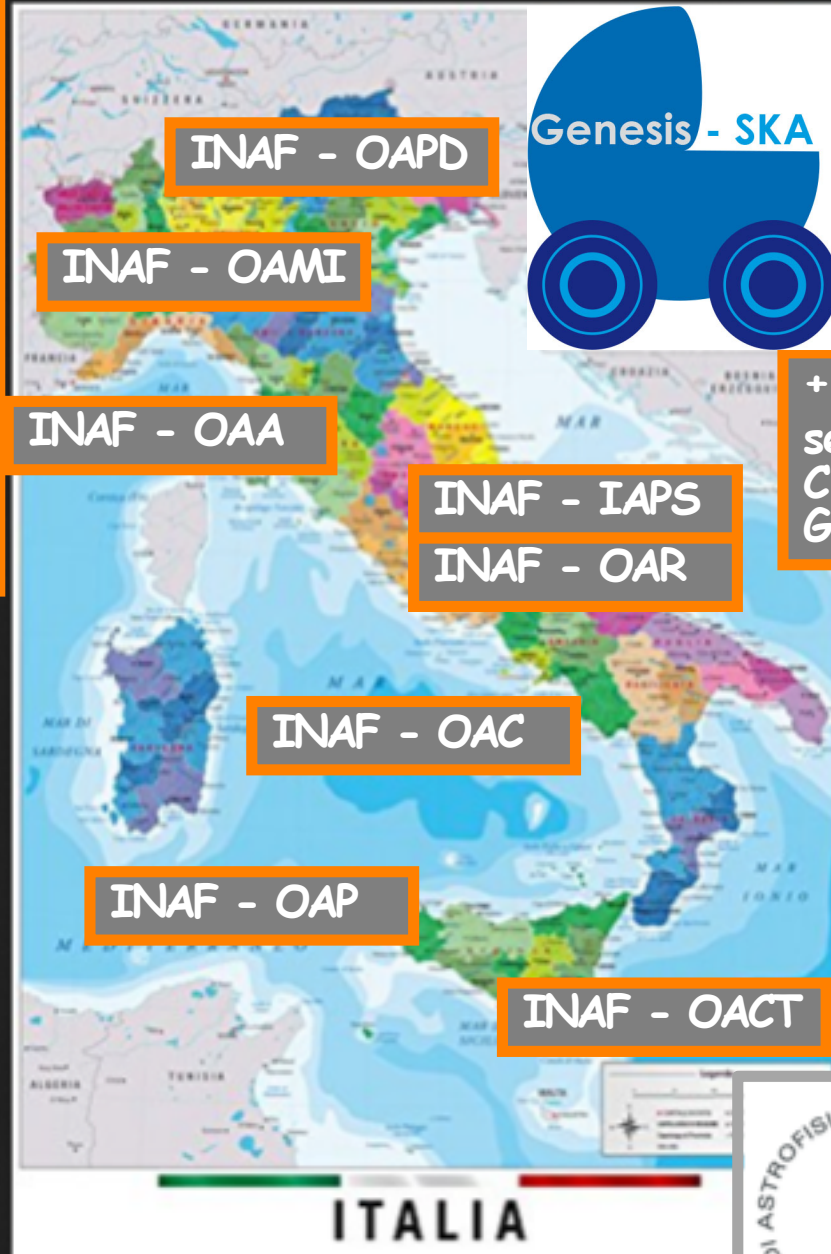
→ Prebiotic molecular bricks: **the emergency of life**;

→ Settle the initial condition for **planets formation**.



A PRIN-INAF 2016
(PI C. Codella)
synergy between the
following INAF nodes:

Arcetri
Palermo
Catania
Capodimonte
IAPS
Monteporzio
Padova
Brera



+ OUTREACH:
see
C. Boccato's talk +
GENESIS poter



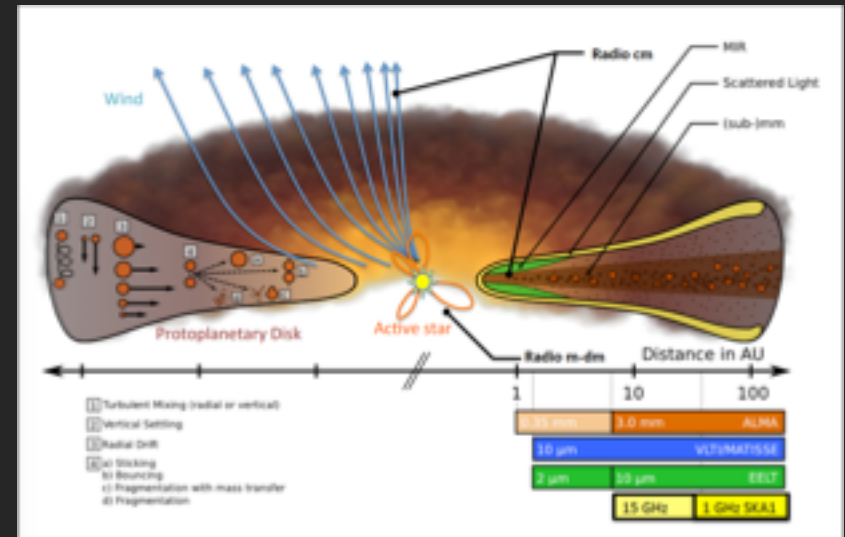


The context:

1. Planet formation:
Models, simulations, & observations

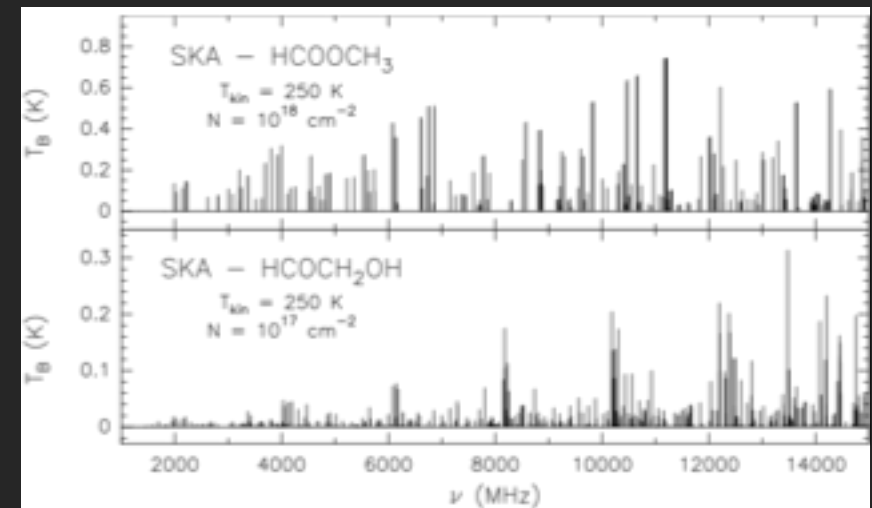
2. Volatiles evolution: Complex
Organics as the building blocks of
life

3. Laboratory experiments



Our groups are carrying out
(since several years):

- complementary observational programs
(e.g. ALMA, VLA, LBT, VLT),
- laboratory experiments, and
- simulation, physical and chemical modeling
to prepare SKA science
(e.g. AASKA14: Codella et al. 2015;
Testi et al. 2015)





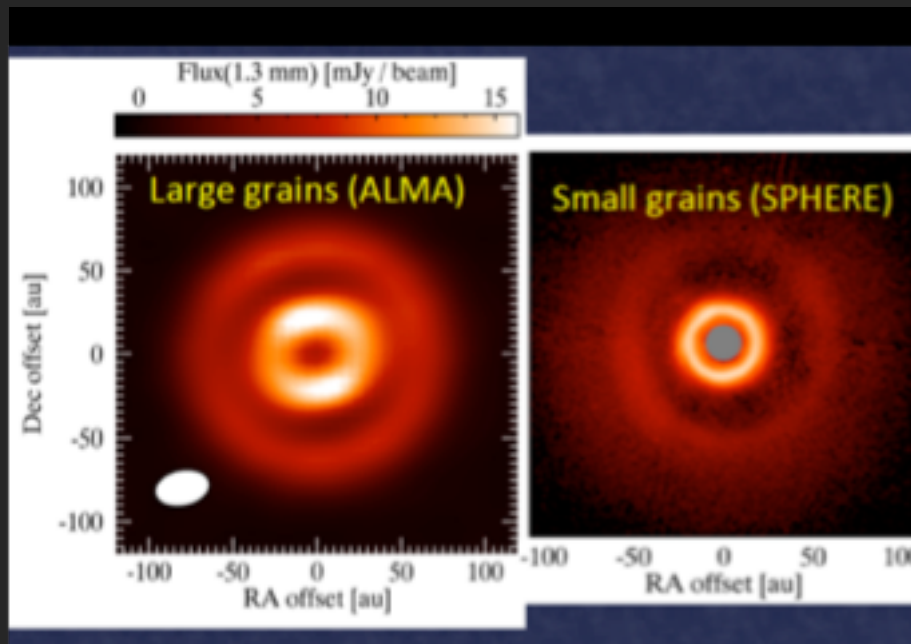
GENESIS - SKA (continuum)



1. Planet formation: Models, simulations, & observations

Multi-wavelength information
essential: probe different
components

Numerical simulations of gas and dust
to decipher observations



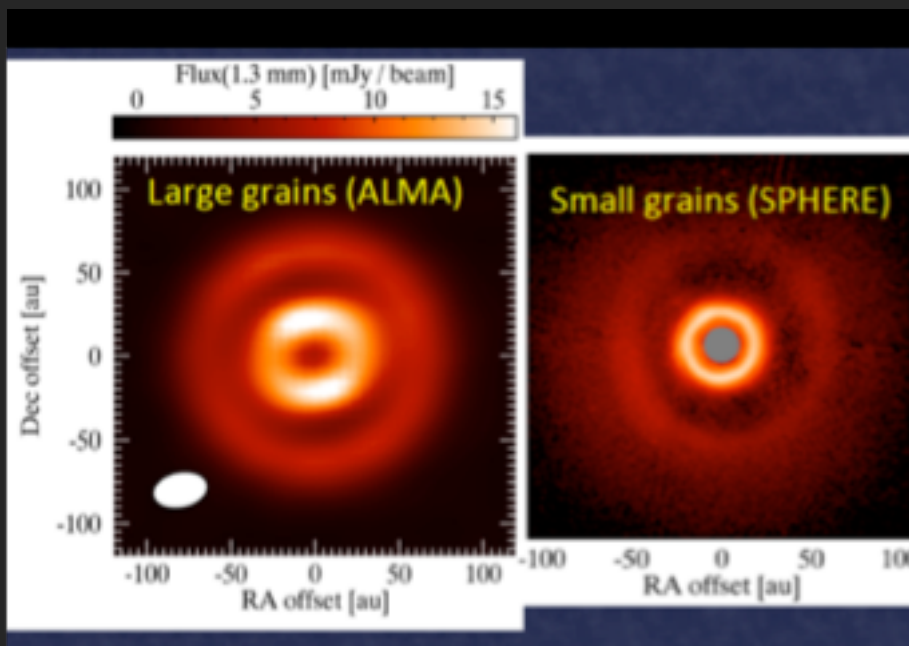
Fedele et al. (2017)



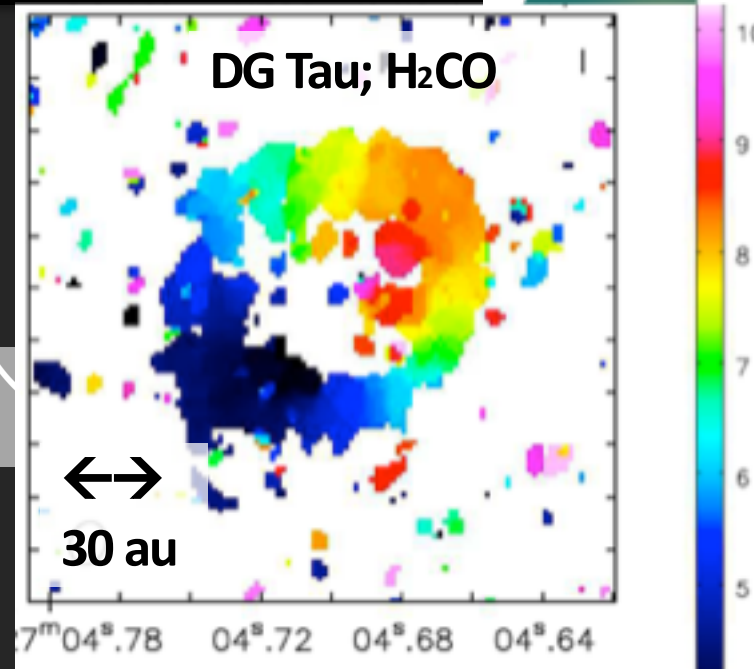
GENESIS - SKA (continuum)

1. Planet formation: models & observations

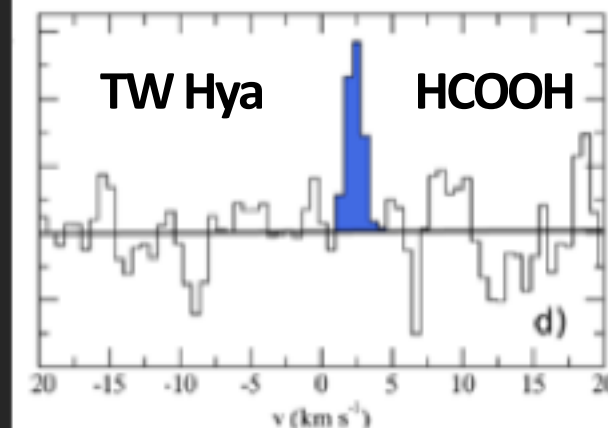
Multi-wavelength information
essential: probe different
components



Fedele et al. (2017)

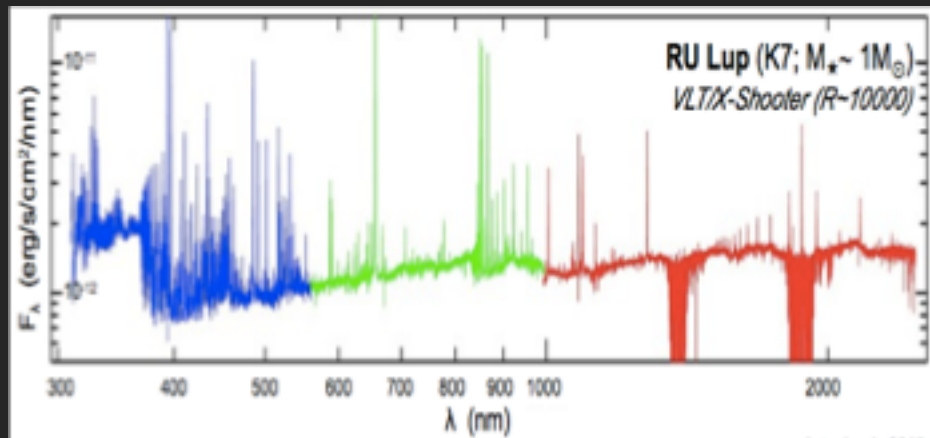


Podio et al. (2018)

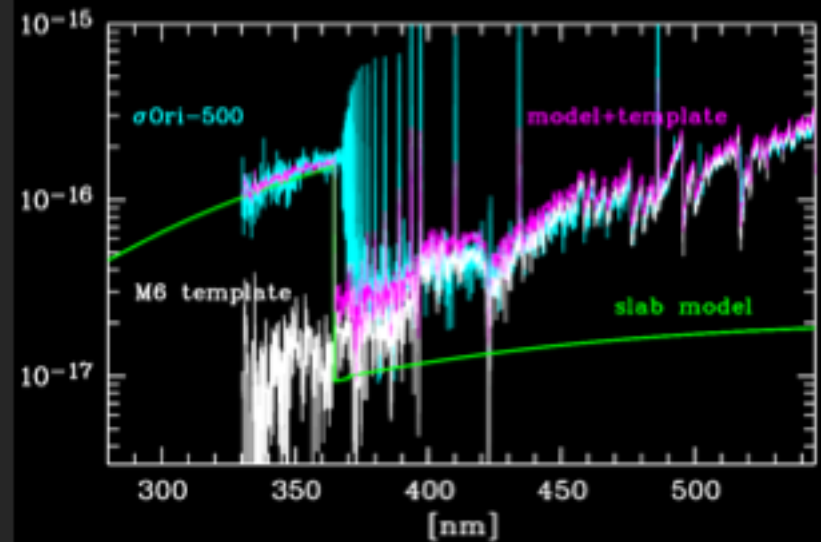


Favre et al. (2018)

Characterization of YSOs and their disks through optical/IR spectroscopy



Flux [$\text{erg s}^{-1} \text{cm}^{-2} \text{nm}^{-1}$]

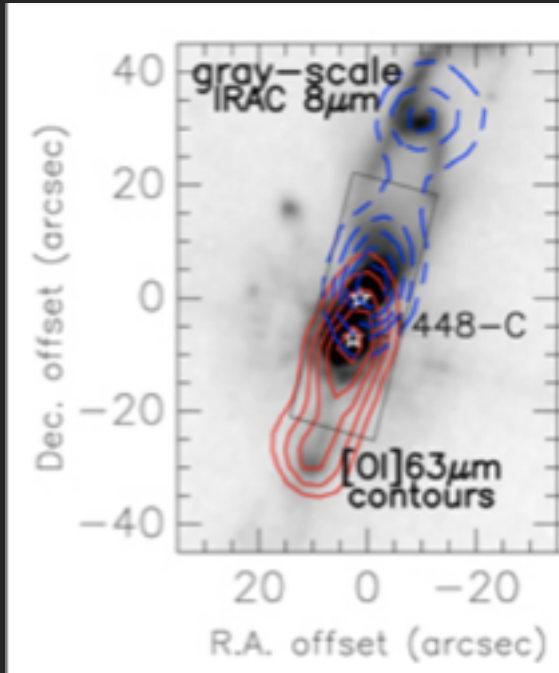


- GOAL: Homogeneous and self-consistent measurement of stellar, accretion and ejection parameters in candidate SKA samples

- X-shooter/VLT survey of Lupus/Chamaeleon (Alcala' + 2014, 2017; Manara + 2016, 2017)
- GHOST (GIARPS High-resolution Observations of T Tauri stars) survey of Taurus (Antonucci + 2016)
- Synergies with ALMA surveys (e.g. talk of Carlo Manara)

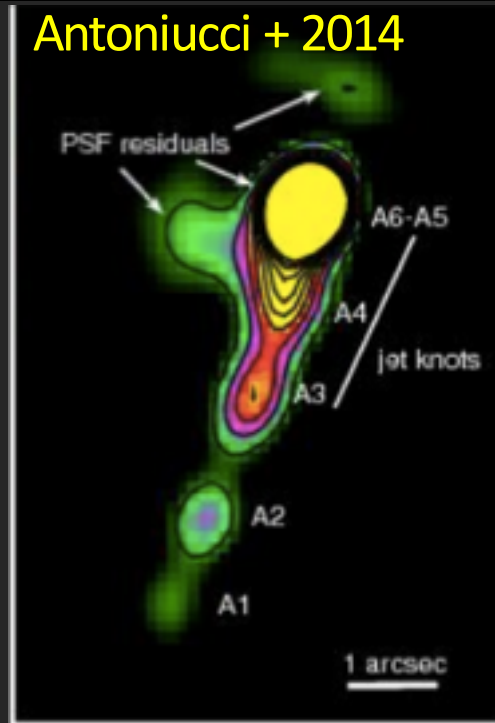
Multi-wavelength observations of jets from YSOs

Nisini + 2014



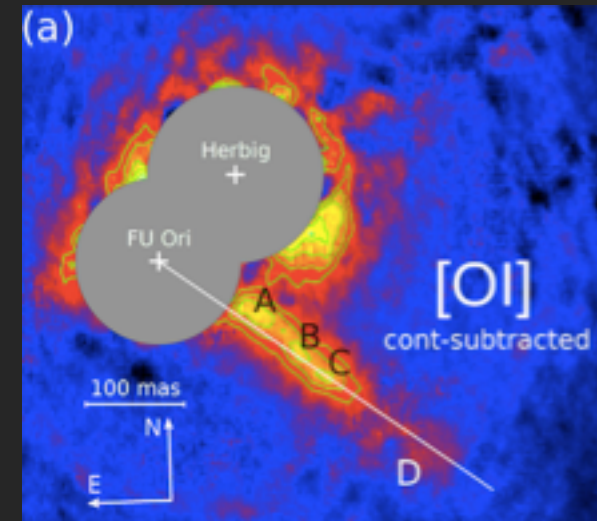
L1448-Class 0
[OI]63um **Herschel-PACS**

Antoniucci + 2014



HH34-Class I
[FeII]1.64um **LBT-LUCI**

Antoniucci + 2017



ZCmA-Class II
[OI]630nm **VLT-SPHERE**

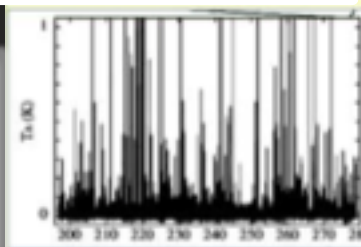
- Wavelength/tracers depend on source/jet evolution (VLT/LBT, HST, Spitzer, Herschel → JWST)
- Complementary to radio-jet studies with SKA



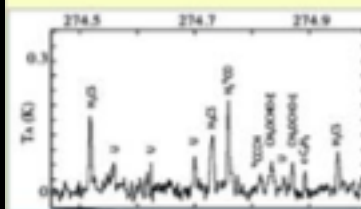
2. Volatiles evolution: Complex Organics as the building blocks of life



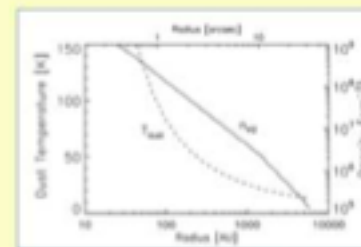
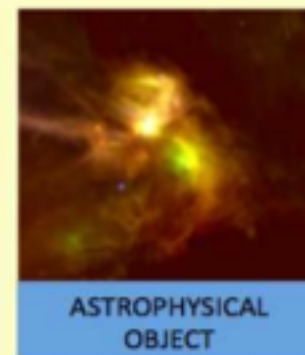
STARS IN THE CAOS



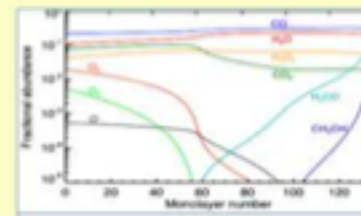
STEP 1: Observe the spectrum of the source.
Tool: telescope



STEP 2: Identify the lines and species.
Tool: spectroscopic data



STEP 3: Derive the physical and chemical structure.
Tool: collisional coefficients



STEP 4: Understand the chemical structure.
Tool: reaction pathways and rate coefficients

collaboration
SNS@Pisa - SOLIS@Arcetri,
Bologna (Ciamician) and
Perugia Universities
to model COMs in gas phase
PRIN-MIUR: STARS IN THE
CHAOS
PRIN-INAF: GENESIS-SKA



1st Italian Workshop on Astrochemistry
**Astronomical Complex Organic Molecules
in different environments**
Palazzo Strozzi
Firenze, Italy
March 10-11, 2016

2nd ITALIAN WORKSHOP ON ASTROCHEMISTRY

JUNE 13-16 : CHEMICAL EVOLUTION IN OUR GALAXY
2018 : Spectroscopy, Observations and Reactivity

The smoking gun of gas-phase at work

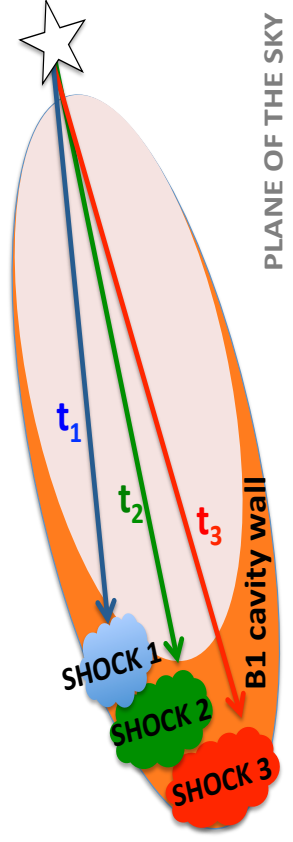


Codella et al. (2017)



Barone et al. (2015)
Vazart et al. (2016)

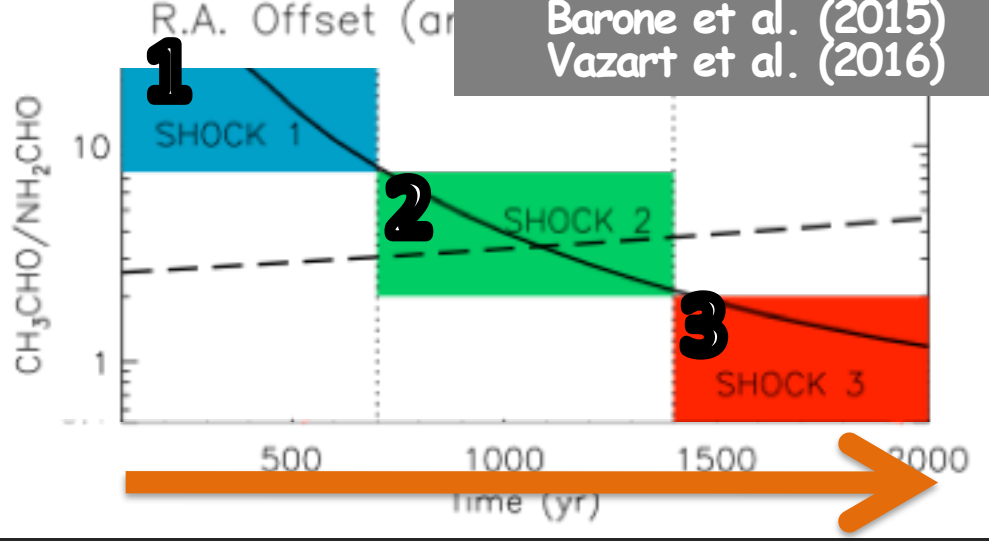
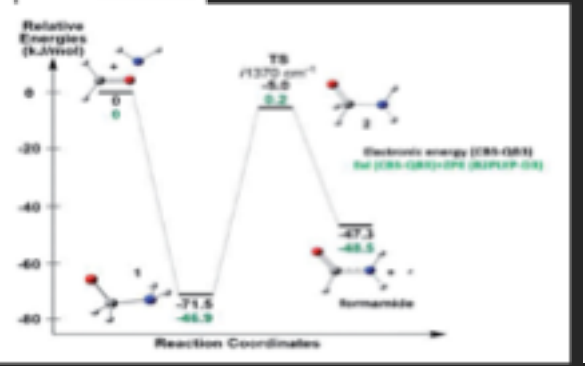
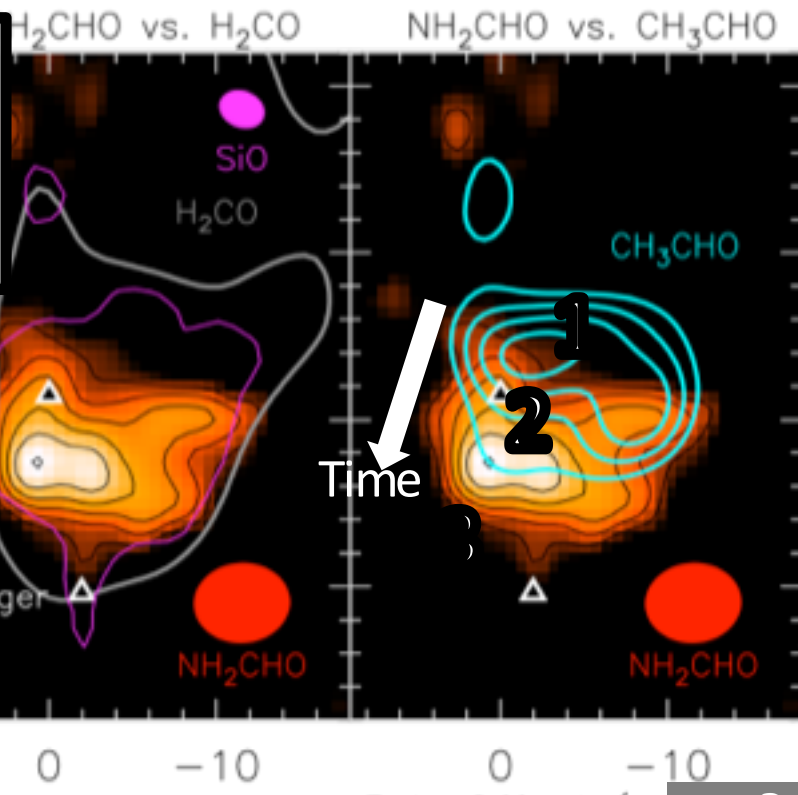
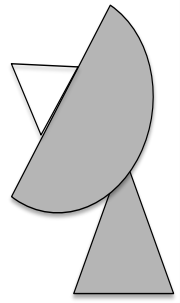
L1557-mm



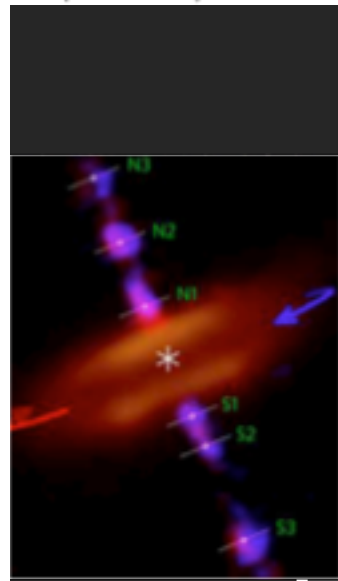
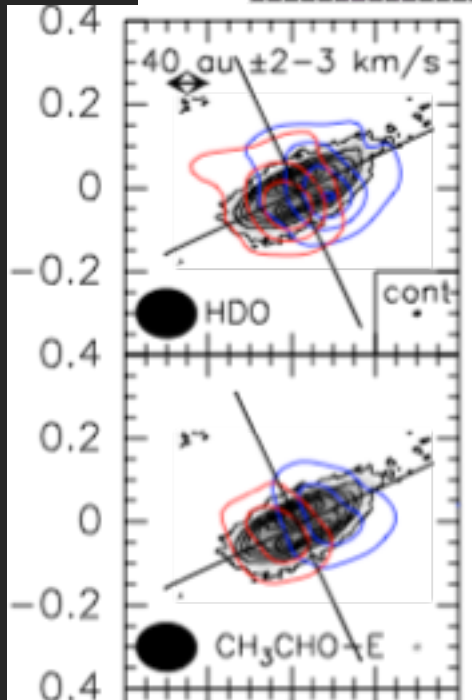
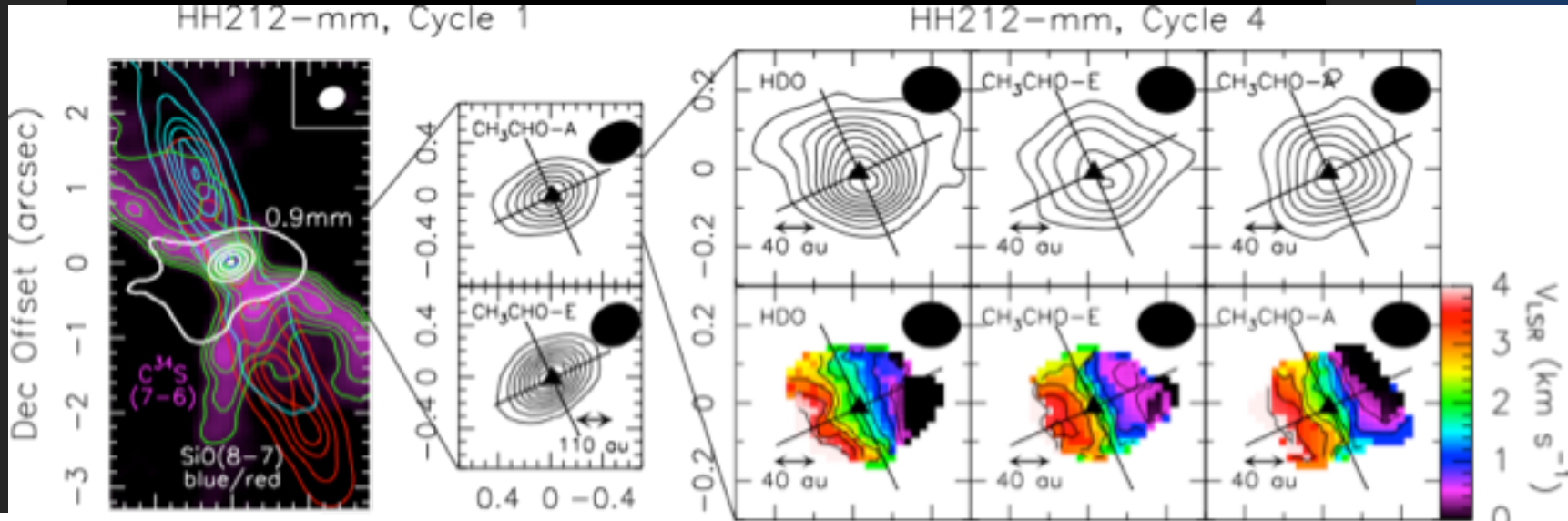
$$t_1 < t_2 < t_3$$



PLANE OF THE SKY

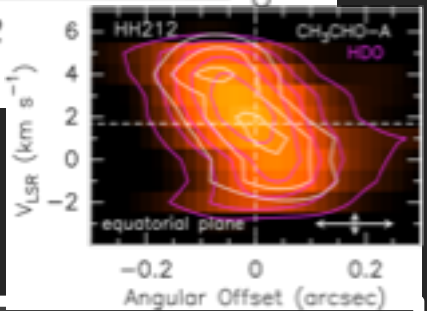


The inner 50 AU of a Sun-like protostar: HDO & CH₃CHO



Lee et al. (2017)
Codella et al. (2018)

Size, about 70 au
(i.e. Solar System scale);
T ~ 80-100 K;
n > 10⁸ cm⁻³;
Velocity gradient along the equatorial plane
(connected with the disk)



GENESIS supported projects...

The FAUST synergy
Fifty AU Study of Protosun Analogues
ALMA & VLA Large Programs



C. Codella (INAF-Arcetri)
C. Ceccarelli (IPAG, Grenoble)



S. Yamamoto (Tokyo University)
N. Sakai (RIKEN)



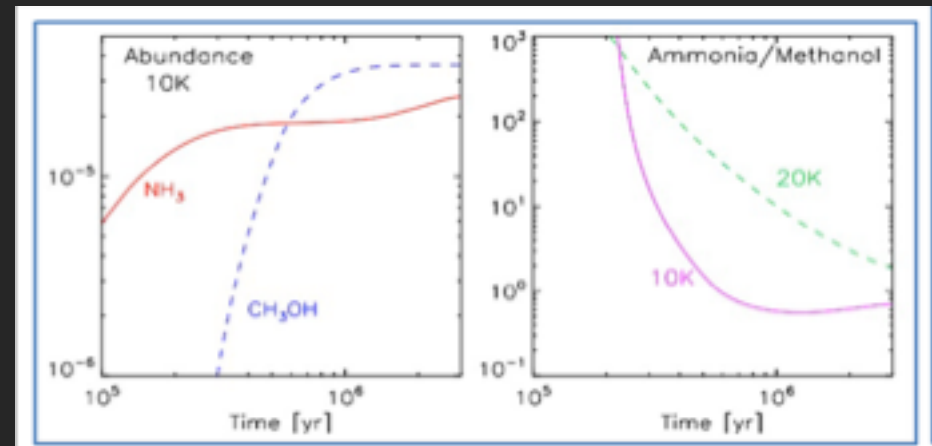
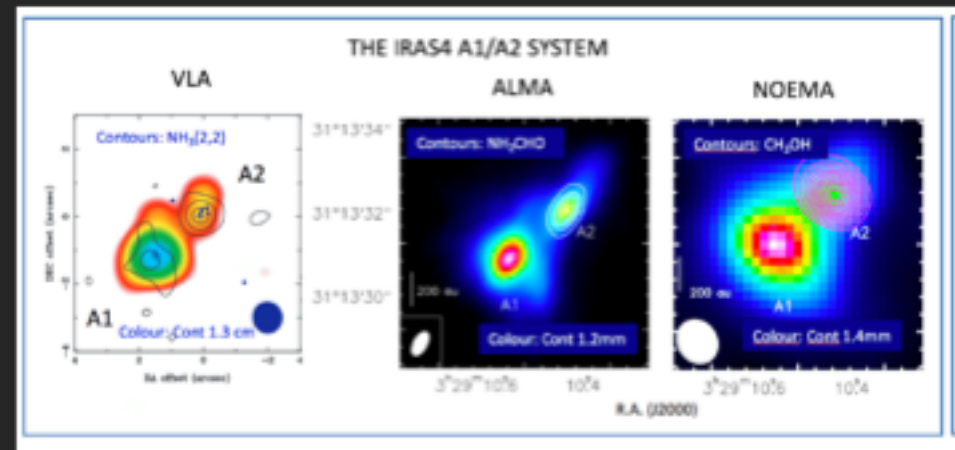
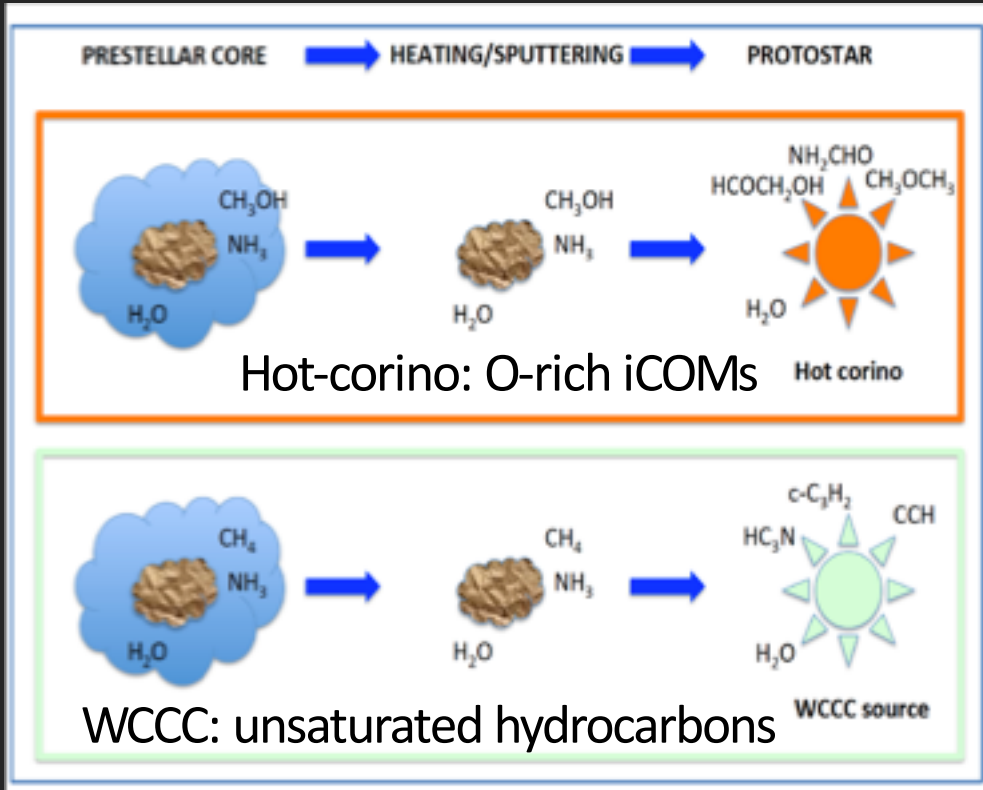
C. Chandler (NRAO)



Goethe et al. (1831)



Back to the cm-window with new perspectives



Tracing ice mantle history in
Solar-type protostars



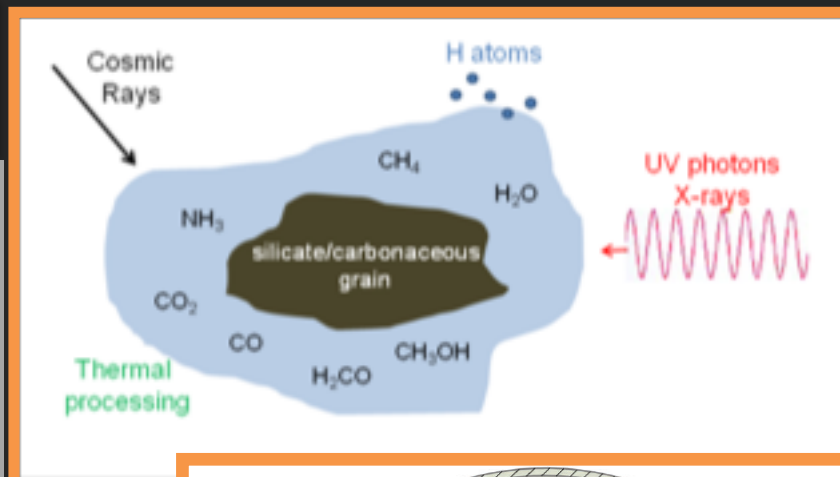
(Examples of) Predictions in the grain mantles
(as a function of T and time)

Laboratory Activity



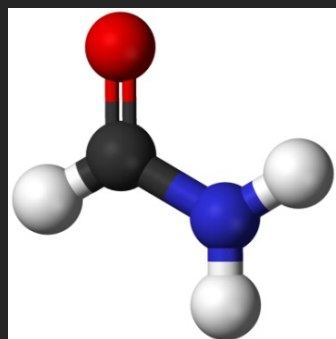
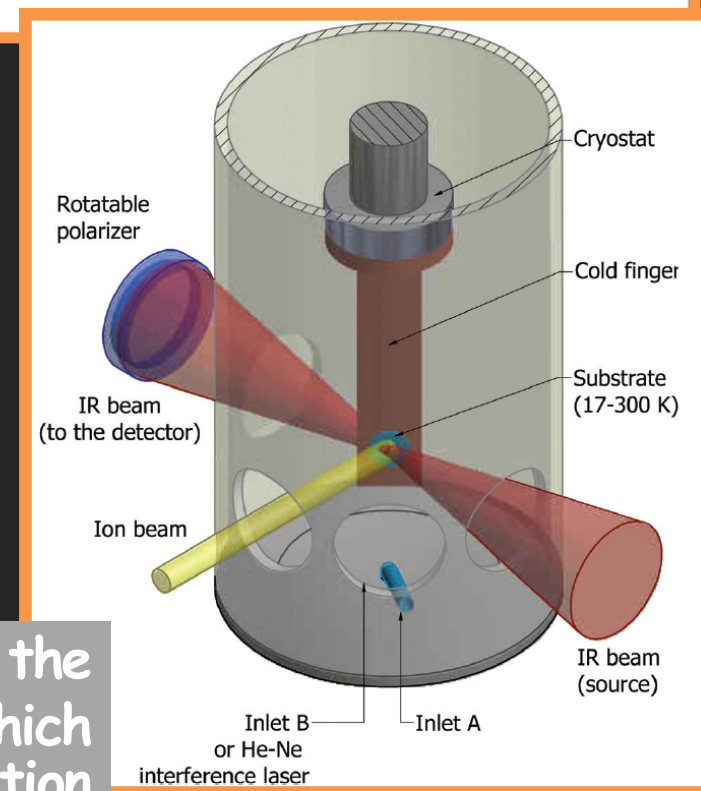
In space solid phase molecules suffer from

- ✓ Cosmic-ray bombardment
- ✓ UV and X-ray irradiation
- ✓ Atom irradiation
- ✓ Thermal annealing



In the laboratory these processes are simulated in vacuum chambers and samples are analyzed by different techniques

- ✓ UV-Vis-IR spectroscopy
- ✓ Mass spectrometry
- ✓ Raman spectroscopy
- ✓ Scanning electron microscopy



Within the GENESIS project, the main goal is to investigate which processes contribute to the formation and the survival of formamide in conditions as harsh as those encountered in star forming regions

GENESIS – SKA

Early planetary systems & the rise of life

www.genesis.inaf.it

Topics

- Birth of stars & protoplanetary systems in our Galaxy
- Protoplanetary disks & planet formation
- Volatiles & complex organic molecules
- Observations, modeling, & laboratory Astrophysics
- Communication & Industrial Outreach Activities

